

Qi
Enhanced
DIGITAL
VERSION
Included

THIRD EDITION

GRAY'S BASIC ANATOMY

REGIONAL



CLINICAL



IMAGING



SURFACE



Richard L. Drake | A. Wayne Vogl | Adam W. M. Mitchell

Any screen. Any time. Anywhere.

Activate the eBook version
of this title at no additional charge



Elsevier eBooks for Medical Education gives you the power to browse and search content, view enhanced images, highlight and take notes—both online and offline.

Unlock your eBook today.

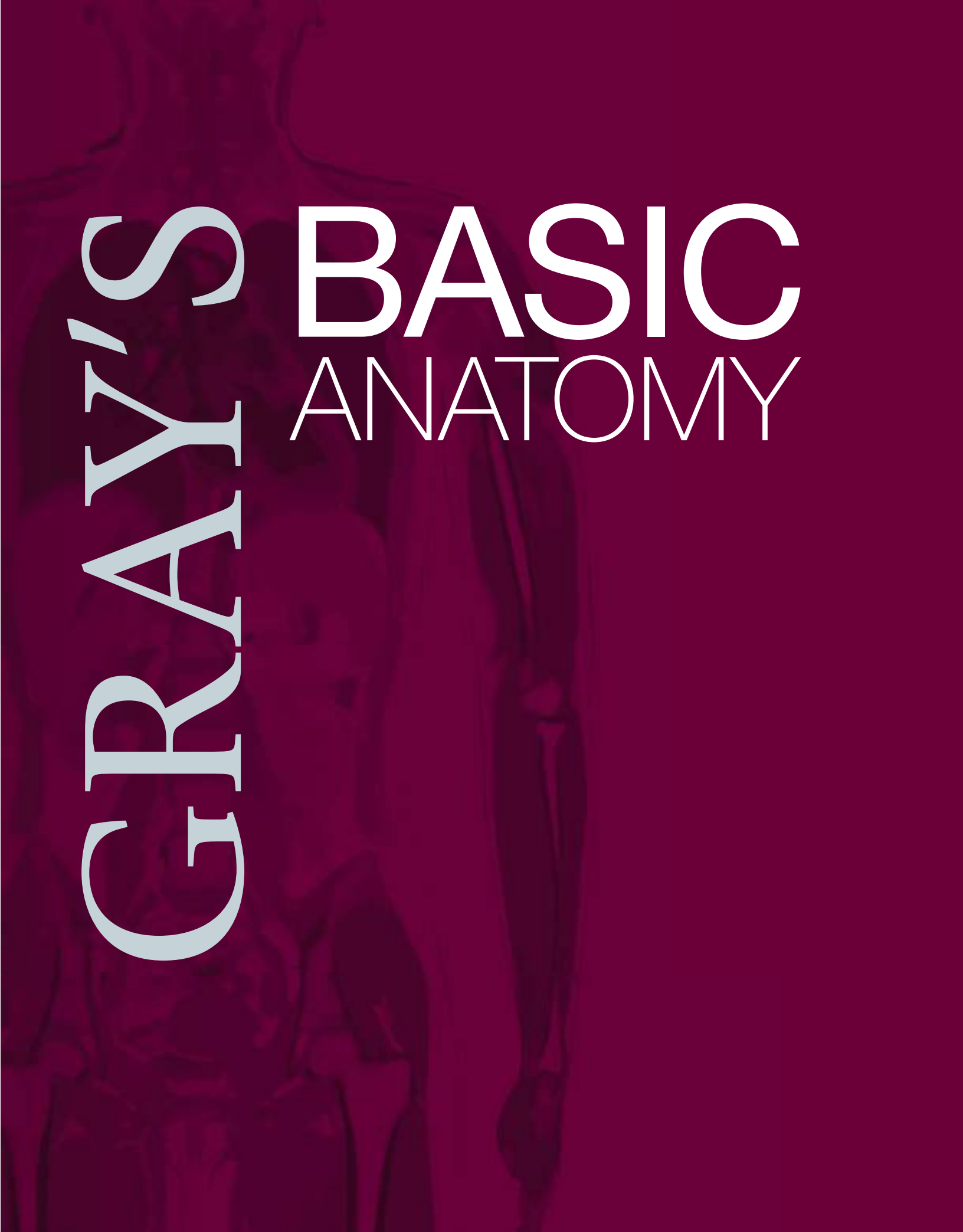
1. Visit studentconsult.inkling.com/redeem
2. Scratch box below to reveal your code
3. Type code into “Enter Code” box
4. Click “Redeem”
5. Log in or Sign up
6. Go to “My Library”

It's that easy!

For technical assistance:
email studentconsult.help@elsevier.com
call 1-800-401-9962 (inside the US)
call +1-314-447-8300 (outside the US)

Place Peel Off
Sticker Here

Use of the current edition of the electronic version of this book (eBook) is subject to the terms of the nontransferable, limited license granted on studentconsult.inkling.com. Access to the eBook is limited to the first individual who redeems the PIN, located on the inside cover of this book, at studentconsult.inkling.com and may not be transferred to another party by resale, lending, or other means.



GRAY'S

BASIC
ANATOMY

THIRD EDITION

GRAY'S BASIC ANATOMY

Richard L. Drake, PhD, FAAA

Professor Emeritus of Surgery
Cleveland Clinic Lerner College of Medicine
Case Western Reserve University
Cleveland, Ohio

A. Wayne Vogl, PhD, FAAA

Professor of Anatomy and Cell Biology
Department of Cellular and Physiological Sciences
Faculty of Medicine
University of British Columbia
Vancouver, British Columbia

Adam W.M. Mitchell, MBBS, FRCS, FRCR

Consultant Radiologist
Director of Radiology
Fortius Clinic
London, United Kingdom

Illustrations by

Richard Tibbitts and Paul Richardson

Photographs by

Ansell Horn



Elsevier
1600 John F. Kennedy Blvd.
Ste 1800
Philadelphia, PA 19103-2899

GRAY'S BASIC ANATOMY, THIRD EDITION
Copyright © 2023 by Elsevier, Inc. All rights reserved.

ISBN: 978-0-323-83442-1

First Edition copyrighted 2012 by Churchill Livingstone, an imprint of Elsevier, Inc.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: www.elsevier.com/permissions.

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

Notice

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds or experiments described herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made. To the fullest extent of the law, no responsibility is assumed by Elsevier, authors, editors or contributors for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

Previous editions copyrighted 2018 and 2012.

Publisher: Jeremy Bowes
Director, Content Development: Rebecca Gruliow
Publishing Service Manager: Shereen Jameel
Senior Project Manager: Beula Christopher
Design Direction: Amy Buxton

Printed in India

9 8 7 6 5 4 3 2 1



Working together
to grow libraries in
developing countries

www.elsevier.com • www.bookaid.org

*To my parents who guide me,
To my wife who supports me,
To my students who challenge me*

RLD

To my family, my colleagues, my mentors, and my students

AWV

To all my family, Cathy, Max and Elsa, and my colleagues

AWMM

Acknowledgments

Any book, no matter the size, is a major undertaking, and we want to thank all of the individuals who have helped move this project to completion. These include William Schmitt and Rebecca Gruliow, who both helped in initially evaluating the need for this type of concise textbook and in moving the first edition forward to completion. Jeremy Bowes and Rebecca Gruliow guided the third edition through to completion. We also appreciate the contributions of our illustrators, Richard Tibbitts and Paul Richardson, who did all of the artwork.

We'd also like to thank Professor Richard A. Buckingham of the Abraham Lincoln School of Medicine, University of Illinois, for [Fig. 8.100B](#); Dr. Murray Morrison, Dr. Joanne Matsubara, Dr. Brian Westerberg, Laura Hall, and Jing Cui for

contributing images for the head and neck chapter; and Dr. Bruce Crawford and Logan Lee for help with images for the surface anatomy of the upper limb. We also want to thank Dr. Bradley Little and Dr. Arlo Adams for contributing non-binary and transgender elements to the text and Clinical Apps to make the book more inclusive.

Finally, we are very appreciative of the numerous individuals, anatomists, and educators who provided feedback on the first and second editions and whose suggestions were included in this third edition.

Richard L. Drake
A. Wayne Vogl
Adam W.M. Mitchell

Preface

Gray's Basic Anatomy was developed in response to students and colleagues from around the world who requested a more concise description of anatomy than that presented in *Gray's Anatomy for Students*. To accomplish this goal, we reworked the material to focus mainly on regional anatomy and integrated the clinical material, imaging, and surface anatomy information directly into the text as:

- **Clinical apps**, which give students context for why a strong anatomical background helps facilitate the solving of clinical problems;
- **Imaging apps**, which offer students a great introduction to the different techniques and modalities available for imaging relevant anatomy; and
- **Surface anatomy boxes**, which help students visualize the relationship between anatomical structures and surface landmarks necessary for any kind of patient examination.

In addition, at the beginning of each chapter students are directed to additional learning resources available on Student Consult (Elsevier's online educational website).

Summarizing, *Gray's Basic Anatomy* uses a regional approach, similar to *Gray's Anatomy for Students*, with eight

chapters: The Body, Back, Thorax, Abdomen, Pelvis and Perineum, Lower Limb, Upper Limb, and Head and Neck. The artwork presents the same familiar illustrations from *Gray's Anatomy for Students*, but they have been resized to fit within a smaller format while retaining a close physical location to the text with which each figure is associated. Finally, while some verbiage has been sacrificed in keeping with the goal of presenting a concise textbook of anatomy (e.g., muscle descriptions have for the most part been incorporated into tables with no loss of content), additional clinical and imaging material has been added to enhance learning in context.

This third edition includes numerous edits resulting from reader feedback, some new and revised figures, and revisions based on current research in the field of the anatomical sciences.

We hope you will continue to find this new edition a useful and valuable resource whether you are an educator or a student.

Richard L. Drake
A. Wayne Vogl
Adam W.M. Mitchell

Index of Clinical Apps, Imaging Apps, and Surface Anatomy Boxes

1

The Body

CLINICAL APPS

Bone marrow transplants 10
Bone fractures 11
Avascular necrosis 11
Osteoporosis 11
Epiphyseal fractures 11
Joint replacement 13
Degenerative joint disease 14
Arthroscopy 15
The importance of fascias 15
Muscle paralysis 16
Muscle atrophy 16
Muscle injuries and strains 16
Atherosclerosis 17
Varicose veins 17
Anastomoses and collateral circulation 17
Lymph nodes 19
Dermatomes and myotomes 23
Referred pain 33

IMAGING APPS

Determination of skeletal age 10

Osteoporosis 44
Back pain 45
Herniation of intervertebral discs 45
Joint diseases 46
Ligamenta flava 47
Vertebral fractures 47
Pars interarticularis fractures 48
Surgical procedures on the back 48
Nerve injuries affecting superficial back muscles 49
Lumbar cerebrospinal fluid tap 59
Anesthesia within the vertebral canal 60
Herpes zoster 60

IMAGING APPS

Typical cervical vertebrae 36
Typical thoracic vertebrae 37
Typical lumbar vertebrae 37
Articulation between atlas and axis 40

SURFACE ANATOMY

How to identify specific vertebral spinous processes 41
Primary and secondary curvatures in the sagittal plane 43
Visualizing the inferior ends of the spinal cord and subarachnoid space 58

2

Back

CLINICAL APPS

Spina bifida 43
Vertebroplasty 43
Scoliosis 44
Kyphosis 44
Lordosis 44
Variation in vertebral numbers 44
The vertebrae and cancer 44

3

Thorax

CLINICAL APPS

Axillary process of breast 65
Breast cancer 66
Thoracic outlet syndrome 67
Cervical ribs 72
Rib fractures 72
Collection of sternal bone marrow 73

Index of Clinical Apps, Imaging Apps, and Surface Anatomy Boxes

The manubriosternal joint as reference 75
Surgical access to the chest 82
Thoracostomy (chest) tube insertion 82
Intercostal nerve block 83
The arrangement of pleural cavities is clinically significant 85
Innervation of parietal and visceral pleura 86
Pleural recesses 87
Pleural effusion 88
Pneumothorax 88
Inhaled objects 94
Lung cancer 101
Pneumonia 101
Pericardial innervation 104
Pericarditis 104
Pericardial effusion 105
Constrictive pericarditis 105
Valve disease 116
Common congenital heart defects 117
Cardiac auscultation 117
Clinical terminology for coronary arteries 120
Cardiac conduction system 121
Heart attack 124
Classic symptoms of heart attack 124
Referred pain 125
Are heart attack symptoms the same in men and women? 125
Ectopic parathyroid glands in the thymus 127
Left brachiocephalic vein 129
Venous access for central and dialysis lines 130
Using the superior vena cava to access the inferior vena cava 130
Coarctation of the aorta 131
Traumatic injury to the aorta 131
Aortic dissection 132
Aortic arch and its anomalies 132
Abnormal origin of great vessels 133
The vagus nerves, recurrent laryngeal nerves, and hoarseness 134
Esophagus constrictions 136
Esophageal cancer 137
Esophageal rupture 137

IMAGING APPS

Visualizing the pulmonary trunk by computed tomography 96
Visualizing the lungs 98
Plain chest radiograph 100
Visualizing the heart 108
Visualizing the chambers of the heart 110
Visualizing the left atrium and pulmonary veins 113

Visualizing structures in the superior mediastinum 128
Visualizing structures at the TIV vertebral level 132
Visualizing the mediastinum in the axial plane 141

SURFACE ANATOMY

The breast in women 67
How to count ribs 76
Visualizing structures at the TIV/V vertebral level 76
Visualizing the pleural cavities and lungs, pleural recesses, and lung lobes and fissures 91
Where to listen for lung sounds 93
Visualizing the margins of the heart 110
Where to listen for heart sounds 116
Visualizing structures in the superior mediastinum 134

4

Abdomen

CLINICAL APPS

Preperitoneal vs. retroperitoneal 153
Surgical incisions 160
Cremasteric reflex 161
Masses around the groin 161
Inguinal hernias 162
Indirect inguinal hernias 162
Direct inguinal hernias 162
Femoral hernias 162
Umbilical hernias 163
Incisional hernias 163
Sportsmen's groin/sportsmen's hernia 163
Other hernias 163
Potential problem of hernias 163
The peritoneum 164
Innervation of peritoneum 164
Ventriculoperitoneal shunts 164
Hemodialysis and peritoneal dialysis 164
Peritoneal spread of disease 164
Perforated bowel 165
The greater omentum 166
Epithelial transition between the abdominal esophagus and stomach 171
Surgery for obesity 172
Duodenal ulceration 172
Examination of the bowel lumen 172
Meckel's diverticulum 172
Carcinoma of the stomach 172

Index of Clinical Apps, Imaging Apps, and Surface Anatomy Boxes

Appendicitis 175
Congenital disorders of the gastrointestinal tract 178
Bowel obstruction 178
Diverticular disease 178
Ostomies 182
Segmental anatomy of the liver 182
Anular pancreas 184
Pancreatic cancer 185
Gallstones 186
Jaundice 186
Spleen disorders 187
Vascular supply to the gastrointestinal system 193
Portosystemic anastomosis 195
Hepatic cirrhosis 195
Psoas muscle abscess 205
Diaphragmatic hernias 205
Hiatal hernia 206
Urinary tract stones 210
Urinary tract cancer 210
Kidney transplant 210
Abdominal aortic stent graft 213
Inferior vena cava filter 215
Retroperitoneal lymph node surgery 217

IMAGING APPS

Visualizing the stomach 169
Visualizing the jejunum and ileum 171
Visualizing the large intestine 173
Endoscopic examination of the abdominal gastrointestinal tract 179
Visualizing the liver 181
Visualizing the pancreas 184
Visualizing the diaphragm 205
Investigation of the urinary tract 211

SURFACE ANATOMY

Using abdominal quadrants to locate major viscera 147
Defining surface regions to which pain from the gut is referred 147
How to find the superficial inguinal ring 161
Visualizing the position of major blood vessels 215

5

Pelvis and Perineum

CLINICAL APPS

Bone marrow biopsy 226
Common problems with the sacro-iliac joints 228
Pelvic fracture 230
Pelvic measurements in obstetrics 232
Defecation 234
Episiotomy 236
Digital rectal examination 237
Carcinoma of the colon and rectum 237
Bladder cancer 239
Bladder stones 240
Suprapubic catheterization 240
Bladder infection 241
Urethral catheterization 241
Undescended testes 242
Hydrocele of the testis 243
Testicular tumors 243
Vasectomy 243
Prostate problems 244
Ovarian cancer 245
Hysterectomy 246
Tubal ligation 246
Carcinoma of the cervix and uterus 247
The recto-uterine pouch 250
Pudendal block 254
Prostatectomy and impotence 258
Hemorrhoids 262
Abscesses in the ischio-anal fossae 265
Urethral rupture 271

IMAGING APPS

Visualizing the male pelvic cavity and perineum in the axial plane 276
Visualizing the female pelvic cavity and perineum in the sagittal plane 279
Visualizing the female pelvic cavity and perineum in the coronal plane 281
Visualizing the female pelvic cavity and perineum in the axial plane 282

Index of Clinical Apps, Imaging Apps, and Surface Anatomy Boxes

SURFACE ANATOMY

Defining the margins of the perineum 264
Superficial features of the external genitalia in women 267
Superficial features of the external genitalia in men 269

6

Lower Limb

CLINICAL APPS

Pelvic fractures 290
Femoral neck fractures 292
Intertrochanteric fractures 293
Femoral shaft fractures 293
Varicose veins 298
Deep vein thrombosis 298
Harvesting veins for grafts 299
Vascular access in the lower limb 303
Trendelenburg's sign 305
Intramuscular injection in the gluteal region: avoiding the sciatic nerve 307
Shin splints 313
Quadriceps injury 315
Hamstring injuries 317
Compartment syndrome 317
Peripheral vascular disease 320
Soft tissue injuries to the knee 328
Clinical tests for tears in the cruciate ligaments 328
Arthroscopy 328
Foot drop 340
Fracture of the talus 342
Calcaneal (Achilles) tendon rupture 343
Ankle injuries 348
Bunions 350
Morton's neuroma 361
Dermatomes and myotomes in the lower limb 362
Testing sensory innervation carried by major peripheral nerves in the lower limb 363
Tendon taps in the lower limb 364
Gait and gait defects 364

IMAGING APPS

Visualizing the hip joint 296
Visualizing the knee joint 328
Visualizing the bones of the foot 344
Visualizing the ankle joint 347

SURFACE ANATOMY

Finding the femoral artery in the femoral triangle 303
Visualizing the contents of the popliteal fossa 331
Finding the tarsal tunnel—the gateway to the foot 352
Finding the dorsalis pedis artery 359
Pulse points 365

7

Upper Limb

CLINICAL APPS

Fracture of the proximal humerus 372
Fractures of the clavicle and dislocations of the acromioclavicular and sternoclavicular joints 376
Dislocations of the glenohumeral joint 377
Rotator cuff disorders 377
Quadrangular space syndrome 380
“Winging” of the scapula 384
Trauma to the arteries in and around the axilla 389
Central venous access via the subclavian/axillary vein 389
Damage to long thoracic nerve 393
Injuries to the brachial plexus 397
Lymphatic drainage and breast cancer 398
Rupture of biceps tendon 401
Median nerve injury in the arm 402
Radial nerve injury in the arm 403
Supracondylar fracture of the humerus 407
Pulled elbow 407
Fracture of the head of radius 407
“Tennis” and “golfer’s” elbow (epicondylitis) 407
Ulnar nerve injury at the elbow 408
Construction of a dialysis fistula 409
Blood pressure measurement 409
Fractures of the radius and ulna 412
Fracture of the scaphoid and avascular necrosis of the proximal scaphoid 426
Knuckle cracking 426
De Quervain syndrome 427
Carpal tunnel syndrome 428
Tenosynovitis 429
Trigger finger 429
Allen's test 435
Ulnar nerve injury 436
Radial nerve injury 439
Dermatomes and myotomes in the upper limb 439
Tendon taps in the upper limb 439
Testing sensory innervation carried by major peripheral nerves in the upper limb 440

Index of Clinical Apps, Imaging Apps, and Surface Anatomy Boxes

IMAGING APPS

Visualizing the sternoclavicular joint 373
Visualizing the acromioclavicular joint 374
Visualizing the glenohumeral joint 375
Visualizing the rotator cuff muscles 376
Developmental changes in the elbow joint 406
Visualizing the elbow joint 407
Visualizing the forearm 411
Visualizing the hand and wrist joint 424

SURFACE ANATOMY

Locating the brachial artery in the right arm 404
Identifying tendons and locating major vessels and nerves in the distal forearm 421
Position of the flexor retinaculum and the recurrent branch of the median nerve 427
Motor function of the median and ulnar nerves in the hand 438
Pulse points 441

8

Head and Neck

CLINICAL APPS

Medical imaging of the head 461
Fractures of the skull vault 461
Cerebrospinal fluid leak 466
Hydrocephalus 466
Meningitis 466
Endarterectomy 468
Stroke 468
Intracerebral aneurysms 468
Emissary veins 472
Head injury 472
Concussion 472
Types of intracranial hemorrhage 473
Scalp and meninges 474
Cranial nerve lesions 481

Overview of cranial nerves 481
Parotid gland—tumors and stones 490
Trigeminal neuralgia 491
Facial nerve [VII] palsy (Bell's palsy) 496
Scalp laceration 500
Orbital fracture 502
Full and partial ptosis 505
Horner's syndrome 505
The H-test 514
Ophthalmoscopy 519
Glaucoma 520
Cataracts 520
Swimmer's ear 524
Surfer's ear 524
Examination of the ear 525
Mastoiditis 528
Temporomandibular joint disorders 539
Lingual nerve injury 546
Anesthesia of the inferior alveolar nerve 546
Middle meningeal artery and extradural hematoma 550
Spread of infection from the pterygoid plexus into the cranial cavity 550
Dry eye 555
Spread of neck infections 560
Central venous access 561
Tracheobronchial injury 569
Thyroidectomy 571
Goiter 572
Hyperparathyroidism 572
Ectopic parathyroid glands 572
Recurrent laryngeal nerve palsy 580
Clinical lymphatic drainage of the head and neck 584
Laryngoscopy 593
Cricothyrotomy 597
Exogenous testosterone and vocal cord mass 601
Tracheostomy 603
Deviated nasal septum 606
Surgical approach to the pituitary gland 609
Epistaxis 614
Oral cancer 617
Test for cranial nerve XII 624
Test for cranial nerve X 631

Index of Clinical Apps, Imaging Apps, and Surface Anatomy Boxes

IMAGING APPS

Visualizing the skull—anterior view 447
Visualizing the skull—lateral view 449
Visualizing the internal carotid and vertebral arteries 468
Visualizing the muscles of the eyeball 512
Visualizing the nasal cavities and paranasal sinuses 608

SURFACE ANATOMY

Anatomical position of the head and major landmarks 450
Estimating the position of the middle meningeal artery 461
Major features of the face 497
The eye and lacrimal apparatus 506
How to outline the anterior and posterior triangles of the neck 558
How to find the thyroid gland 572
How to locate the cricothyroid ligament 597
Pulse points 639

Contents

1 *The Body*

What is anatomy? 2

How can gross anatomy be studied? 2

Important anatomical terms 2

Imaging 3

Diagnostic imaging techniques 3

Image interpretation 7

Plain radiography 7

Computed tomography 8

Magnetic resonance imaging 8

Nuclear medicine imaging 8

Safety in imaging 8

Body systems 9

Skeletal system 9

Cartilage 9

Bone 9

Joints 11

Skin and fascias 15

Skin 15

Fascia 15

Muscular system 15

Cardiovascular system 16

Lymphatic system 18

Lymphatic vessels 18

Lymph nodes 18

Lymphatic trunks and ducts 19

Nervous system 20

Central nervous system 20

Functional subdivisions of the CNS 21

Other systems 33

2 *Back*

Regional anatomy 36

Skeletal framework 36

Vertebrae 36

Intervertebral foramina 40

Posterior spaces between vertebral
arches 41

Curvatures of vertebral column 41

Joints 42

Joints between vertebrae in the back 42

Ligaments 46

Anterior and posterior longitudinal ligaments 46

Ligamenta flava 46

Supraspinous ligament and ligamentum nuchae 46

Interspinous ligaments 47

Back musculature 48

Superficial group of back muscles 48

Intermediate group of back muscles 50

Deep group of back muscles 51

Thoracolumbar fascia 53

Spinal cord 55

Vasculature 56

Meninges 57

Arrangement of structures in the vertebral canal 58

Spinal nerves 58

3 *Thorax*

Regional anatomy 64

Pectoral region 64

Breast 64

Muscles of the pectoral region 66

Thoracic wall 66

Superior thoracic aperture 67

Inferior thoracic aperture 67

Skeletal framework 68

Intercostal spaces 75

Diaphragm 81

Venous drainage 83

Innervation 83

Movements of the thoracic wall and diaphragm during
breathing 84

Pleural cavities 84

Pleura 84

Lungs 88

Mediastinum 97

Anterior mediastinum 102

Middle mediastinum 102

Superior mediastinum 126

Posterior mediastinum 135

4

Abdomen

Regional anatomy 146

Surface topography 146

Four-quadrant pattern 146

Nine-region pattern 146

Abdominal wall 147

Superficial fascia 148

Anterolateral muscles 149

Extraperitoneal fascia 152

Peritoneum 153

Innervation 153

Arterial supply and venous drainage 155

Lymphatic drainage 155

Groin 156

Inguinal canal 157

Abdominal viscera 163

Peritoneum 163

Peritoneal cavity 164

Organs 167

Arterial supply to the gastrointestinal tract 187

Venous drainage 193

Lymphatics 196

Innervation 196

Posterior abdominal region 201

Posterior abdominal wall 201

Viscera 206

Vasculature 212

Lymphatic system 216

Nervous system in the posterior abdominal region 217

Sympathetic trunks and splanchnic nerves 217

Perineum 262

Borders and ceiling 263

Ischio-anal fossae and their anterior recesses 264

Anal triangle 265

Urogenital triangle 265

Somatic nerves 271

Visceral nerves 271

Blood vessels 272

Veins 274

Lymphatics 274

6

Lower Limb

Regional anatomy 286

The hip 287

Bony pelvis 287

Proximal femur 290

Hip joint 292

Gateways to the lower limb 295

Nerves 297

Arteries 297

Veins 298

Lymphatics 299

Deep fascia and the saphenous opening 300

Femoral triangle 301

Gluteal region 303

Muscles 303

Nerves 305

Arteries 308

Veins 308

Lymphatics 308

Thigh 309

Bones 309

Muscles 313

Arteries 317

Veins 321

Nerves 321

Knee joint 323

Tibiofibular joint 329

Popliteal fossa 329

Leg 331

Bones 331

Joints 333

Posterior compartment of leg 333

Lateral compartment of leg 337

Anterior compartment of leg 338

Foot 340

Bones 340

Joints 344

5

Pelvis and Perineum

Regional anatomy 224

Pelvis 224

Bones 224

Joints 227

Orientation 229

Differences between men and women 229

True pelvis 230

Viscera 236

Fascia 247

Peritoneum 248

Nerves 251

Blood vessels 258

Lymphatics 262

Tarsal tunnel, retinacula, and arrangement of major structures at the ankle 351
 Arches of the foot 352
 Plantar aponeurosis 353
 Fibrous sheaths of toes 353
 Extensor hoods 354
 Intrinsic muscles 355
 Arteries 357
 Veins 359
 Nerves 359

7 Upper Limb

Regional anatomy 368

Shoulder 370
 Bones 370
 Joints 372
 Muscles 377
 Posterior scapular region 379
 Gateways to the posterior scapular region 379
 Nerves 380
 Arteries and veins 381
 Axilla 381
 Axillary inlet 382
 Anterior wall 382
 Medial wall 383
 Lateral wall 384
 Posterior wall 384
 Gateways in the posterior wall 386
 Floor 386
 Contents of the axilla 386
 Arm 398
 Bones 398
 Muscles 401
 Nerves 401
 Arteries and veins 403
 Elbow joint 405
 Cubital fossa 408
 Forearm 410
 Bones 410
 Joints 412
 Anterior compartment of the forearm 414
 Muscles 414
 Arteries and veins 414
 Nerves 417
 Posterior compartment of the forearm 418
 Muscles 418
 Arteries and veins 418
 Nerves 421

Hand 422
 Bones 423
 Joints 425
 Carpal tunnel and structures at the wrist 426
 Palmar aponeurosis 427
 Anatomical snuffbox 428
 Fibrous digital sheaths 429
 Extensor hoods 429
 Muscles 430
 Arteries and veins 432
 Nerves 435

8 Head and Neck

Regional anatomy 445

Head 446
 Neck 446
 Skull 446
 Anterior view 446
 Lateral view 448
 Posterior view 451
 Superior view 451
 Inferior view 452
 Cranial cavity 454
 Roof 455
 Floor 455
 Meninges 462
 Cranial dura mater 462
 Arachnoid mater 465
 Pia mater 465
 Meningeal spaces 465
 Brain and its blood supply 466
 Brain 466
 Blood supply 467
 Venous drainage 469
 Cranial nerves 475
 Olfactory nerve [I] 475
 Optic nerve [II] 475
 Oculomotor nerve [III] 477
 Trochlear nerve [IV] 478
 Trigeminal nerve [V] 478
 Ophthalmic nerve [V₁] 478
 Maxillary nerve [V₂] 479
 Mandibular nerve [V₃] 479
 Abducent nerve [VI] 479
 Facial nerve [VII] 479
 Vestibulocochlear nerve [VIII] 479
 Glossopharyngeal nerve [IX] 480
 Vagus nerve [X] 480

Contents

Accessory nerve [XI]	480
Hypoglossal nerve [XII]	484
Face	484
Muscles	484
Parotid gland	487
Innervation	489
Vessels	492
Scalp	496
Layers	496
Innervation	498
Vessels	499
Lymphatic drainage	500
Orbit	501
Bony orbit	501
Eyelids	502
Lacrimal apparatus	505
Sensory innervation	506
Fissures and foramina	507
Fascial specializations	509
Muscles	510
Vessels	513
Innervation	515
Eyeball	519
Ear	522
External ear	522
Middle ear	526
Internal ear	530
Temporal and infratemporal fossae	535
Bony framework	536
Temporomandibular joints	538
Masseter muscle	540
Temporal fossa	540
Infratemporal fossa	541
Pterygopalatine fossa	550
Skeletal framework	551
Gateways	551
Contents	552
Neck	557
Fascia	558
Superficial venous drainage	560
Anterior triangle of the neck	561
Posterior triangle of the neck	572
Root of the neck	577
Pharynx	584
Skeletal framework	585
Pharyngeal wall	586
Fascia	587
Gaps in the pharyngeal wall and structures passing through them	587
Nasopharynx	588
Oropharynx	590

Laryngopharynx	590
Tonsils	590
Vessels	590
Nerves	591
Larynx	592
Laryngeal cartilages	593
Extrinsic ligaments	595
Intrinsic ligaments	596
Laryngeal joints	597
Cavity of the larynx	598
Intrinsic muscles	600
Function of the larynx	601
Vessels	602
Nerves	603
Nasal cavities	604
Lateral wall	605
Regions	605
Skeletal framework	606
External nose	606
Paranasal sinuses	607
Walls, floor, and roof	609
Nares	611
Choanae	611
Gateways	611
Vessels	613
Innervation	614
Oral cavity	616
Skeletal framework	617
Walls: the cheeks	620
Floor	621
Salivary glands	627
Roof—palate	629
Oral fissure and lips	633
Oropharyngeal isthmus	634
Teeth and gingivae	634



9

Neuroanatomy (e-only)

Jennifer M. McBride, PhD

Cleveland Clinic, Cleveland Clinic Lerner College of Medicine

To access this BONUS chapter PLUS the complete enhanced eBook - see the inside front cover for instructions + your unique PIN code.

Index 641

1

The Body

**ADDITIONAL LEARNING RESOURCES
FOR CHAPTER 1, *THE BODY*,
CAN BE FOUND ON THE ACCOMPANYING
EBOOK:**

- Short Questions—These are questions requiring short responses, Chapter 1
- Clinical Case
Appendicitis

***What is anatomy?* 2**

How can gross anatomy be studied? 2

Important anatomical terms 2

***Imaging* 3**

Diagnostic imaging techniques 3

Image interpretation 7

Plain radiography 7

Computed tomography 8

Magnetic resonance imaging 8

Nuclear medicine imaging 8

Safety in imaging 8

***Body systems* 9**

Skeletal system 9

Cartilage 9

Bone 9

Joints 11

Skin and fascias 15

Skin 15

Fascia 15

Muscular system 15

Cardiovascular system 16

Lymphatic system 18

Lymphatic vessels 18

Lymph nodes 18

Lymphatic trunks and ducts 19

Nervous system 20

Central nervous system 20

Functional subdivisions of the CNS 21

Other systems 33

What is anatomy?

Anatomy includes those structures that can be seen grossly (without the aid of magnification) and microscopically (with the aid of magnification). Typically, when used by itself, the term *anatomy* tends to mean gross or macroscopic anatomy—that is, the study of structures that can be seen without using a microscope. Microscopic anatomy, also called histology, is the study of cells and tissues using a microscope.

Observation and visualization are the primary techniques a student should use to learn anatomy. Anatomy is much more than just memorization of lists of names. Although the language of anatomy is important, the network of information needed to visualize the position of physical structures in a patient goes far beyond simple memorization. Knowing the names of the various branches of the external carotid artery is not the same as being able to visualize the course of the lingual artery from its origin in the neck to its termination in the tongue. An understanding of anatomy requires an understanding of the context in which the terminology can be remembered.

HOW CAN GROSS ANATOMY BE STUDIED?

The term *anatomy* is derived from the Greek word *temnein*, meaning “to cut.” Clearly, at its root, the study of anatomy is linked to dissection. Dissection of cadavers by students is now augmented, or even in some cases replaced, by viewing prosected (previously dissected) material and plastic models or using computer teaching modules, virtual and augmented reality experiences, and other learning aids.

Anatomy can be studied following either a regional or a systemic approach.

- With a **regional approach**, each *region* of the body is studied separately and all aspects of that region are studied at the same time. For example, if the thorax is to be studied, all of its structures are examined. This includes the vasculature, nerves, bones, muscles, and all other structures and organs located in the region of the body defined as the thorax. After studying this region, the other regions of the body (i.e., the abdomen, pelvis, lower limb, upper limb, back, head, and neck) are studied in a similar fashion.
- In contrast, in a **systemic approach**, each *system* of the body is studied and followed throughout the entire body. For example, a study of the cardiovascular system looks at the heart and all of the blood vessels in the body. This approach continues for the whole body until every system, including the nervous, skeletal, muscular, gastrointestinal, respiratory, lymphatic, and reproductive systems, has been studied.

IMPORTANT ANATOMICAL TERMS

The anatomical position

The anatomical position is the standard reference position of the body used to describe the location of structures (Fig. 1.1). The body is in the anatomical position when standing upright with feet together, hands by the side, and face looking forward. The mouth is closed and the facial expression is neutral. The rim of bone under the eyes is in the same horizontal plane as the top of the opening to the ear, and the eyes are open and focused on something in the distance. The palms of the hands face forward with the fingers straight and together and with the pad of the thumb turned 90° to the pads of the fingers. The toes point forward.

Anatomical planes

Three major groups of planes pass through the body in the anatomical position (Fig. 1.1).

- **Coronal planes** are oriented vertically and divide the body into anterior and posterior parts.

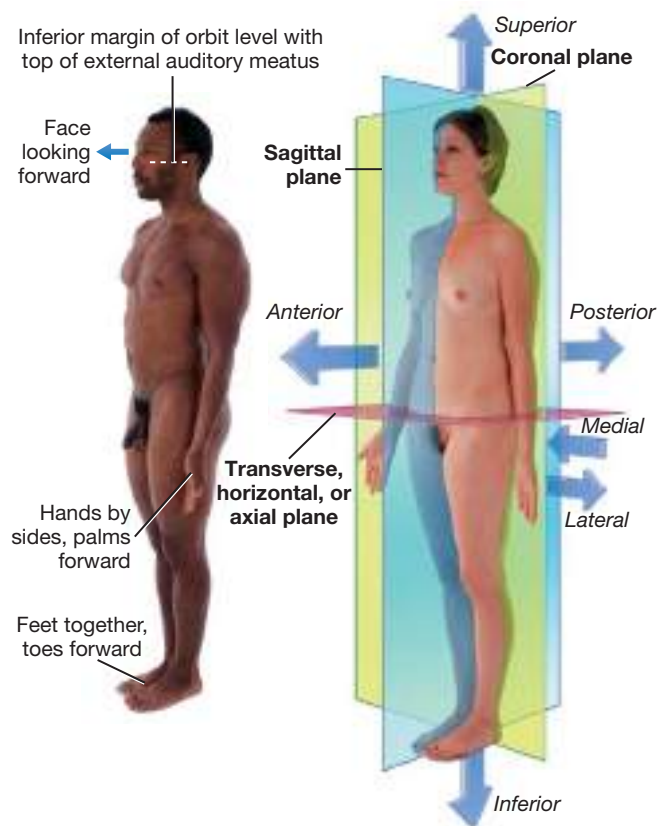


Fig. 1.1 The anatomical position, planes, and terms of location and orientation.

- **Sagittal planes** also are oriented vertically, but are at right angles to the coronal planes and divide the body into right and left parts. The plane that passes through the center of the body dividing it into equal right and left halves is termed the **median sagittal plane**.
- **Transverse, horizontal, or axial planes** divide the body into superior and inferior parts.

Terms to describe location

Anterior (ventral) and posterior (dorsal), medial and lateral, superior and inferior

Three major pairs of terms are used to describe the location of structures relative to the body as a whole or to other structures (Fig. 1.1).

- **Anterior** (or **ventral**) and **posterior** (or **dorsal**) describe the position of structures relative to the “front” and “back” of the body. For example, the nose is an anterior (ventral) structure, whereas the vertebral column is a posterior (dorsal) structure.
- **Medial** and **lateral** describe the position of structures relative to the median sagittal plane and the sides of the body. For example, the thumb is lateral to the little finger.
- **Superior** and **inferior** describe structures in reference to the vertical axis of the body. For example, the head is superior to the shoulders.

Proximal and distal, cranial and caudal, and rostral

Other terms used to describe positions include proximal and distal, cranial and caudal, and rostral.

- **Proximal** and **distal** are used with reference to being closer to or farther from a structure’s origin, particularly in the limbs. For example, the hand is distal to the elbow joint. These terms are also used to describe the relative positions of branches along the course of linear structures, such as airways, vessels, and nerves. For example, distal branches occur farther away toward the ends, whereas proximal branches occur closer to and toward the origin.
- **Cranial** (toward the head) and **caudal** (toward the tail) are sometimes used instead of superior and inferior, respectively.
- **Rostral** is used, particularly in the head, to describe the position of a structure with reference to the nose. For example, the forebrain is rostral to the hindbrain.

Superficial and deep

Two other terms used to describe the position of structures in the body are **superficial** and **deep**. These terms are used to describe the relative positions of two structures with respect to the surface of the body. For example, the sternum is superficial to the heart.

Trans/Non-Binary Anatomical Terminology

While anatomy is classically discussed in binary terms (female and male), many individuals do not fit into these models. These can include intersex individuals or non-binary/transgender individuals who may undergo various degrees of gender-affirming care (e.g., hormones, surgery). Clinically, the anatomical terminology preferred by the patient should be used, which may include non-binary terms for classically gendered anatomy. In general, it is appropriate to use gender inclusive anatomical language when engaging with non-binary/transgender patients. Some common examples are as follows:

Preferred term	Instead of
Upper body	Chest/breast
Erectile tissue	Penis/clitoris
Gonads	Testes/ovaries

Clinicians should not assume, based on an individual’s gender presentation, which anatomical features are present. In the clinic, acquiring a history of the patient’s relevant anatomy should be considered including the patient’s preferred terminology to guide appropriate and sensitive care. Clinicians should proceed to screen and treat patients based on the anatomy present if the criteria to do so are met.

Imaging

DIAGNOSTIC IMAGING TECHNIQUES

In 1895 Wilhelm Röntgen used the X-rays from a cathode ray tube to expose a photographic plate and produce the first radiographic exposure of his wife’s hand. Over the past 35 years there has been a revolution in medical imaging that has been paralleled by developments in computer technology.

Plain radiography

X-rays are photons (a type of electromagnetic radiation) and are generated from a complex X-ray tube, which is a type of cathode ray tube (Fig. 1.2). The X-rays are then collimated (i.e., directed through lead-lined shutters to stop them from fanning out) to the appropriate area of the body. As the X-rays pass through the body they are attenuated (reduced in energy) by the tissues. Those X-rays that pass through the tissues interact with the photographic film.

In the body:

- Air attenuates X-rays a little.
- Fat attenuates X-rays more than air but less than water.
- Bone attenuates X-rays the most.

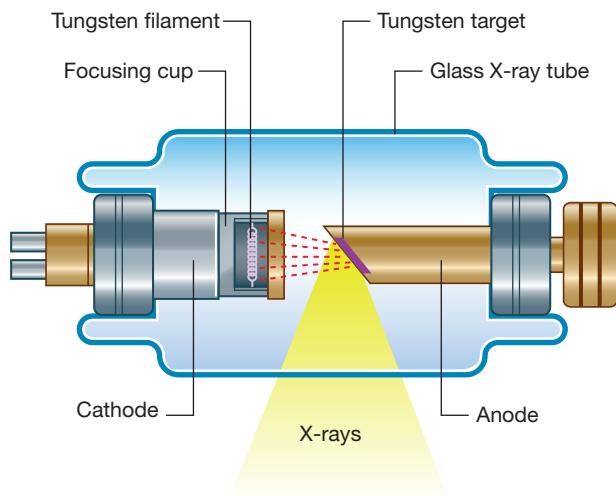


Fig. 1.2 Cathode ray tube for the production of X-rays.



Fig. 1.3 Fluoroscopy unit.

These differences in attenuation result in differences in the level of exposure of the film. When the photographic film is developed, bone appears white on the film because this region of the film has been exposed to the least amount of X-rays. Air appears dark on the film because these regions were exposed to the greatest number of X-rays. Modifications to this X-ray technique allow a continuous stream of X-rays to be produced from the X-ray tube and collected on an input screen to allow real-time visualization of moving anatomical structures, barium studies, angiography, and fluoroscopy (Fig. 1.3).

Contrast agents

To demonstrate specific structures, such as bowel loops or arteries, it may be necessary to fill these structures with a substance that attenuates X-rays more than bowel loops or arteries do normally. It is, however, extremely important that these substances are nontoxic. Barium sulfate, an



Fig. 1.4 Barium sulfate follow-through.

insoluble salt, is a nontoxic, relatively high-density agent that is extremely useful in the examination of the gastrointestinal tract. When a **barium sulfate suspension** is ingested it attenuates X-rays and can therefore be used to demonstrate the bowel lumen (Fig. 1.4).

For some patients it is necessary to inject contrast agents directly into arteries or veins. In this case, iodine-based molecules are suitable contrast agents. **Iodine** is chosen because it has a relatively high atomic mass and so markedly attenuates X-rays, but also, importantly, it is naturally excreted via the urinary system. Intra-arterial and intravenous contrast agents are extremely safe and are well tolerated by most patients. These agents not only help in visualizing the arteries and veins, but, because they are excreted by the urinary system, they can also be used to visualize the kidneys, ureter, and bladder in a process known as **intravenous urography**.

Subtraction angiography

During angiography it is often difficult to appreciate the contrast agent in the vessels through the overlying bony structures. To circumvent this, the technique of subtraction angiography has been developed. Simply, one or two images are obtained before the injection of contrast media. These images are inverted (such that a negative is created from the positive image). After injection of the contrast media into the vessels, a further series of images are obtained,

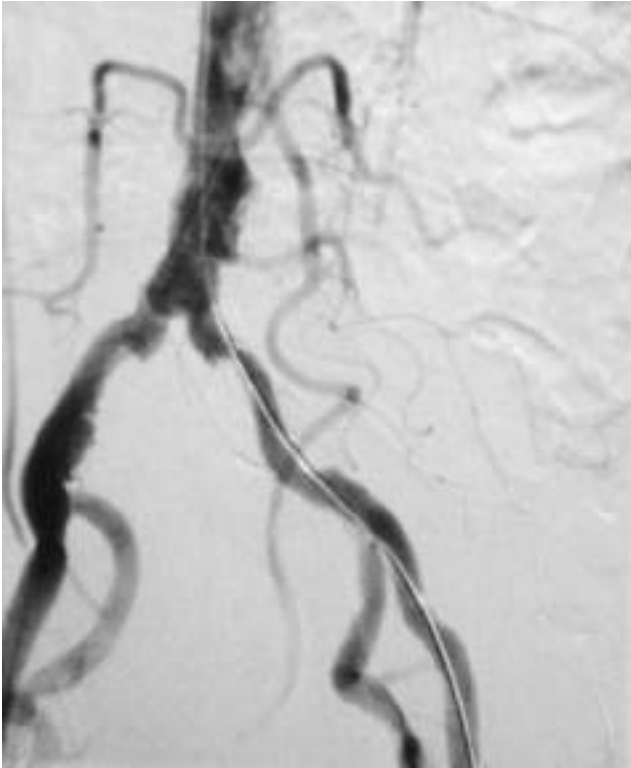


Fig. 1.5 Digital subtraction angiogram.

demonstrating the passage of the contrast through the arteries and into the veins. By adding the “negative pre-contrast image” to the positive post-contrast images, the bones and soft tissues are subtracted to produce a solitary image of contrast only (Fig. 1.5).

Ultrasound

Ultrasonography of the body is widely used for all aspects of medicine (Fig. 1.6).

Ultrasound is a very high frequency sound wave (not electromagnetic radiation) generated by piezoelectric materials, such that a series of sound waves is produced. Importantly, the piezoelectric material can also receive the sound waves that bounce back from the internal organs. The sound waves are then interpreted by a powerful computer, and a real-time image is produced on the display panel.

Developments in ultrasound technology, including the size of the probes and the frequency range, mean that a broad range of areas can now be scanned.

Traditionally ultrasound is used for assessing the abdomen (Fig. 1.6) and the fetus in pregnant women. Ultrasound is also widely used to assess the eyes, neck, soft tissues, and peripheral musculoskeletal system. Probes have been placed on endoscopes, and endoluminal ultrasound of the esophagus, stomach, and duodenum is now routine. Endocavity



Fig. 1.6 Ultrasound examination of the abdomen.

ultrasound is carried out most commonly to assess the genital tract in women using a transvaginal or transrectal route. In men, transrectal ultrasound is the imaging method of choice to assess the prostate in those with suspected prostate hypertrophy or malignancy.

Doppler ultrasound

Doppler ultrasound enables determination of flow, its direction, and its velocity within a vessel using simple ultrasound techniques. Sound waves bounce off moving structures and are returned. The degree of frequency shift determines whether the object is moving away from or toward the probe and the speed at which it is traveling.

Computed tomography

A computed tomography (CT) scanner obtains a series of images of the body (slices) in the axial plane. The patient lies on a bed, an X-ray tube passes around the body (Fig. 1.7), and a series of images are obtained. A computer carries out a complex mathematical transformation on the multitude of images to produce the final image (Fig. 1.8).

Magnetic resonance imaging

The process of magnetic resonance imaging (MRI) is dependent on the free protons in the hydrogen nuclei in molecules of water (H_2O). Because water is present in almost all biological tissues, the hydrogen proton is ideal. The protons within a patient's hydrogen nuclei should be regarded



Fig. 1.7 Computed tomography scanner.



Fig. 1.8 Computed tomography scan of the abdomen at vertebral level L2.

as small bar magnets, which are randomly oriented in space. The patient is placed in a strong magnetic field, which aligns the bar magnets. When a pulse of radio waves is passed through the patient the magnets are deflected, and as they return to their aligned position they emit small radio pulses. The strength and frequency of the emitted pulses and the time it takes for the protons to return to their pre-excited state produces a signal. These signals are analyzed by a powerful computer, and an image is created (Fig. 1.9).

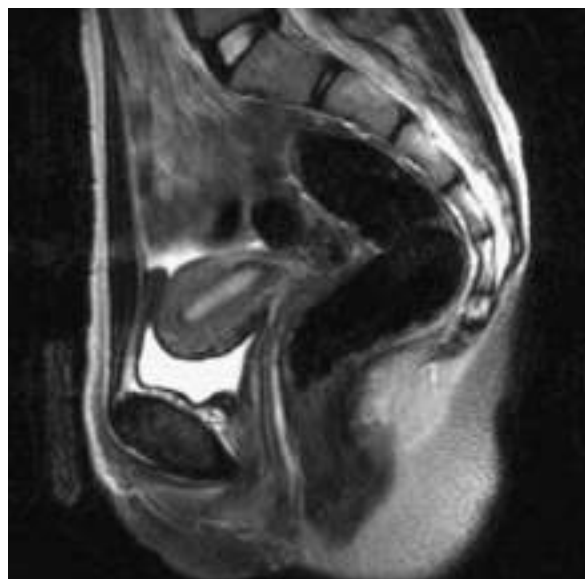


Fig. 1.9 A T2-weighted MR image in the sagittal plane of the pelvic viscera in a woman.

By altering the sequence of pulses to which the protons are subjected, different properties of the protons can be assessed. These properties are referred to as the “weighting” of the scan. By altering the pulse sequence and the scanning parameters, T1-weighted images (Fig. 1.10A) and T2-weighted images (Fig. 1.10B) can be obtained. These two types of imaging sequences provide differences in image contrast, which accentuate and optimize different tissue characteristics.

From the clinical point of view:

- Most T1-weighted images show dark fluid and bright fat—for example, within the brain the cerebrospinal fluid (CSF) is dark.
- T2-weighted images demonstrate a bright signal from fluid and an intermediate signal from fat—for example, in the brain the CSF appears white.

MRI can also be used to assess flow within vessels and to produce complex angiograms of the peripheral and cerebral circulation.

Nuclear medicine imaging

Nuclear medicine involves imaging using gamma rays, which are another type of electromagnetic radiation. The important difference between gamma rays and X-rays is that gamma rays are produced from within the nucleus of an atom when an unstable nucleus decays, whereas X-rays are produced by bombarding an atom with electrons.

For an area to be visualized, the patient must receive a gamma-ray emitter, which must have a number of

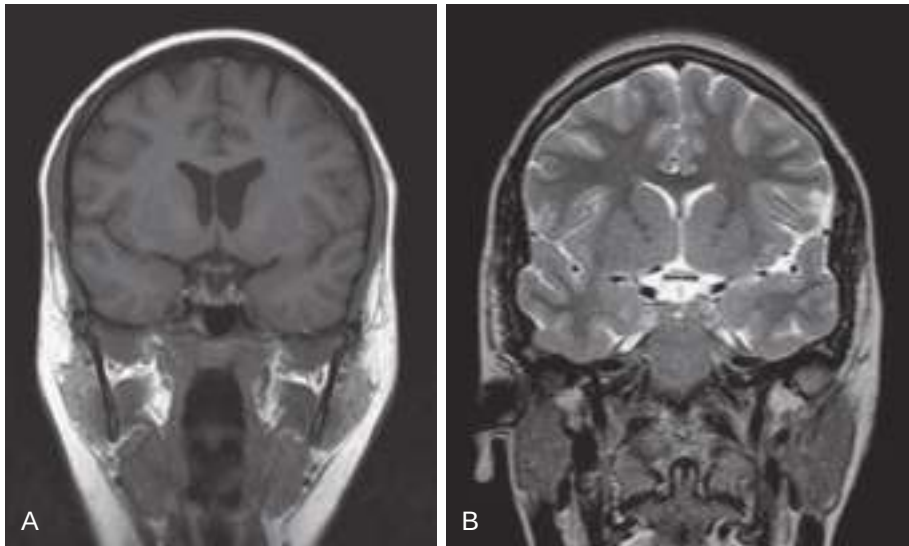


Fig. 1.10 T1-weighted (A) and T2-weighted (B) MR images of the brain in the coronal plane.

properties to be useful, including a reasonable half-life (e.g., 6 to 24 hours); an easily measurable gamma ray; and an energy deposition in as low a dose as possible in the patient's tissues.

The most commonly used radionuclide (radioisotope) is technetium-99m. This may be injected as a technetium salt or combined with other complex molecules. For example, by combining technetium-99m with methylene diphosphonate (MDP), a radiopharmaceutical is produced. When injected into the body this radiopharmaceutical specifically binds to bone, allowing assessment of the skeleton. Similarly, combining technetium-99m with other compounds permits assessment of other parts of the body; for example, the urinary tract and cerebral blood flow.

Images obtained using a gamma camera are dependent on how the radiopharmaceutical is absorbed, distributed, metabolized, and excreted by the body after injection.

Positron emission tomography

Positron emission tomography (PET) is an imaging modality for detecting positron-emitting radionuclides. A positron is an anti-electron, which is a positively charged particle of antimatter. Positrons are emitted from the decay of proton-rich radionuclides. Most of these radionuclides are made in a cyclotron and have extremely short half-lives.

The most commonly used PET radionuclide is fluorodeoxyglucose (FDG) labeled with fluorine-18 (a positron emitter). Tissues that are actively metabolizing glucose take up this compound, and the resulting localized high concentration of this molecule compared to background emission is detected as a "hot spot."

PET has become an important imaging modality in the detection of cancer and the assessment of its treatment and recurrence.

IMAGE INTERPRETATION

Plain radiography

Plain radiographs are undoubtedly the most common form of image obtained in a hospital or local practice. Before interpretation, it is important to know about the imaging technique and the standard views obtained.

In most instances (apart from chest radiography), the X-ray tube is 1 m away from the X-ray film. The object in question, for example a hand or a foot, is placed upon the film. When describing subject placement for radiography, the part closest to the X-ray tube is referred to first and that closest to the film is referred to second. For example, when positioning a patient for an anteroposterior (AP) radiograph, the more anterior part of the body is closest to the tube and the posterior part is closest to the film.

When X-rays are viewed on a viewing box, the right side of the patient is placed to the observer's left; therefore the observer views the radiograph as though looking at a patient in the anatomical position.

Chest radiograph

The chest radiograph is one of the most commonly requested plain radiographs. An image is taken with the patient erect and placed posteroanteriorly (PA chest radiograph); that is, with the patient's back closest to the X-ray tube.

Occasionally, when patients are too unwell to stand erect, films are obtained on the bed in an AP position. These films are less standardized than PA films, and caution should always be taken when interpreting AP radiographs.

A good quality chest radiograph will demonstrate the lungs, cardiomedastinal contour, diaphragm, ribs, and peripheral soft tissues.



Abdominal radiograph

Plain abdominal radiographs are obtained in the AP supine position. From time to time an erect plain abdominal radiograph is obtained when small bowel obstruction is suspected.

Gastrointestinal contrast examinations

High-density contrast medium is ingested to opacify the esophagus, stomach, small bowel, and large bowel. The bowel is insufflated with air (or carbon dioxide) to provide a double-contrast study. In many countries, endoscopy has superseded upper gastrointestinal imaging, but the mainstay for imaging the large bowel is the double-contrast barium enema. Typically the patient needs to undergo bowel preparation in which powerful cathartics are used to empty the bowel. At the time of the examination a small tube is placed into the rectum and a barium suspension is run into the large bowel. The patient undergoes a series of twists and turns so that the contrast passes through the entire large bowel. The contrast is emptied and air is passed through the same tube to insufflate the large bowel. A thin layer of barium coats the normal mucosa, allowing mucosal detail to be visualized (see Fig. 1.4).

Urological contrast studies

Intravenous urography is the standard investigation for assessing the urinary tract. Intravenous contrast medium is injected, and images are obtained as the medium is excreted through the kidneys. A series of films are obtained during this period from immediately after the injection up to approximately 20 minutes later, when the bladder is full of contrast medium.

This series of radiographs demonstrates the kidneys, ureters, and bladder and enables assessment of the retroperitoneum and other structures that may press on the urinary tract.

Computed tomography

CT is the preferred terminology rather than computerized tomography, though physicians use both terms interchangeably.

Most images are acquired in the axial plane and viewed such that the observer looks from below and upward toward the head (from the foot of the bed). By implication:

- the right side of the patient is on the left side of the image; and
- the uppermost border of the image is anterior.

Many patients are given oral and intravenous contrast media to differentiate bowel loops from other abdominal organs and to assess the vascularity of normal anatomical structures. When intravenous contrast is given, the earlier

the images are obtained, the greater the likelihood of arterial enhancement. As the time is delayed between injection and image acquisition, a venous phase and an equilibrium phase are also obtained.

The great advantage of CT scanning is the ability to extend and compress the gray scale to visualize the bones, soft tissues, and visceral organs. Altering the window settings and window centering provides the physician with specific information about these structures.

Magnetic resonance imaging

There is no doubt that MRI has revolutionized the understanding and interpretation of the brain and its coverings (Fig. 1.10). Furthermore, it has significantly altered the practice of musculoskeletal medicine and surgery. Images can be obtained in any plane and in most sequences. Typically the images are viewed using the same principles as CT. Intravenous contrast agents are also used to further enhance tissue contrast. Typically, MRI contrast agents contain paramagnetic substances (e.g., gadolinium and manganese).

Nuclear medicine imaging

Most nuclear medicine images are functional studies. Images are usually interpreted directly from a computer, and a series of representative films are obtained for clinical use.

SAFETY IN IMAGING

Whenever a patient undergoes an X-ray or nuclear medicine investigation, a dose of radiation is given (Table 1.1). As a general principle, it is expected that the dose given is as low as reasonably possible for a diagnostic image to be obtained. Numerous laws govern the amount of radiation exposure that a patient can undergo for a variety of procedures, and these are monitored to prevent any excess or additional dosage.

Imaging modalities such as ultrasound and MRI are ideal because they do not impart significant risk to the patient.

Table 1.1 The approximate dosage of radiation exposure as an order of magnitude

Examination	Typical effective dose (mSv)	Equivalent duration of background exposure
Chest radiograph	0.02	3 days
Abdomen	1.00	6 months
Intravenous urography	2.50	14 months
CT scan of head	2.30	1 year
CT scan of abdomen and pelvis	10.00	4.5 years

Moreover, ultrasound imaging is the modality of choice for assessing the fetus.

Body systems

SKELETAL SYSTEM

The skeleton can be divided into two subgroups, the axial skeleton and the appendicular skeleton. The axial skeleton consists of the bones of the skull (cranium), vertebral column, ribs, and sternum, whereas the appendicular skeleton consists of the bones of the upper and lower limbs (Fig. 1.11).

The skeletal system consists of cartilage and bone.



Fig. 1.11 The axial skeleton and the appendicular skeleton.

Cartilage

Cartilage is an avascular form of connective tissue consisting of extracellular fibers embedded in a matrix that contains cells localized in small cavities. The amount and kind of extracellular fibers in the matrix vary depending on the type of cartilage. In heavy weight-bearing areas or areas prone to pulling forces, the amount of collagen is greatly increased and the cartilage is almost inextensible. In contrast, in areas where weight-bearing demands and stress are less, cartilage containing elastic fibers and fewer collagen fibers are common. The functions of cartilage are to:

- support soft tissues,
- provide a smooth, gliding surface for bone articulations at joints, and
- enable the development and growth of long bones.

There are three types of cartilage:

- hyaline—most common; matrix contains a moderate amount of collagen fibers (e.g., articular surfaces of bones);
- elastic—matrix contains collagen fibers along with a large number of elastic fibers (e.g., external ear);
- fibrocartilage—matrix contains a limited number of cells and ground substance amidst a substantial amount of collagen fibers (e.g., intervertebral discs).

Cartilage is nourished by diffusion and has no blood vessels, lymphatics, or nerves.

Bone

Bone is a calcified, living, connective tissue that forms the majority of the skeleton. It consists of an intercellular calcified matrix, which also contains collagen fibers, and several types of cells within the matrix. Bones function as:

- supportive structures for the body,
- protectors of vital organs,
- reservoirs of calcium and phosphorus,
- levers on which muscles act to produce movement, and
- containers for blood-producing cells.

There are two types of bone, compact and spongy (trabecular or cancellous). Compact bone is dense bone that forms the outer shell of all bones and surrounds spongy bone. Spongy bone consists of spicules of bone enclosing cavities containing blood-forming cells (marrow). Classification of bones is by shape.

- Long bones are tubular (e.g., humerus in the upper limb; femur in the lower limb).
- Short bones are cuboidal (e.g., bones of the wrist and ankle).
- Flat bones consist of two compact bone plates separated by spongy bone (e.g., skull).
- Irregular bones are bones with various shapes (e.g., bones of the face).
- Sesamoid bones are round or oval bones that develop in tendons.

Bones are vascular and are innervated. Generally, an adjacent artery gives off a nutrient artery, usually one per bone, which directly enters the internal cavity of the bone and supplies the marrow, spongy bone, and inner layers of compact bone. In addition, all bones are covered externally, except in the area of a joint where articular cartilage is present, by a fibrous connective tissue membrane called the periosteum, which has the unique capability of forming new bone. This membrane receives blood vessels whose branches supply the outer layers of compact bone. A bone stripped of its periosteum will not survive. Nerves accompany the vessels that supply the bone and the periosteum. Most of the nerves passing into the internal cavity with the nutrient artery are vasomotor fibers that regulate blood flow. Bone itself has few sensory nerve fibers. On the other hand, the periosteum is supplied with numerous sensory nerve fibers and is very sensitive to any type of injury.

Developmentally, all bones come from mesenchyme by either intramembranous ossification in which mesenchymal models of bones undergo ossification, or endochondral ossification in which cartilaginous models of bones form from mesenchyme and undergo ossification.

Imaging app

Determination of skeletal age

Throughout life the bones develop in a predictable way to form the skeletally mature adult at the end of puberty. In western countries, skeletal maturity tends to occur between the ages of 20 and 25 years.

Up until the age of skeletal maturity, bony growth and development follow a typically predictable ordered state, which can be measured through either ultrasound, plain radiographs, or MRI scanning. Typically, the nondominant (left hand) is radiographed and is compared with a series of standard radiographs. From these images the bone age can be determined (Fig. 1.12).



Fig. 1.12 A developmental series of radiographs showing the progressive ossification of carpal (wrist) bones from 3 (A) to 10 (D) years of age.

Clinical app

Bone marrow transplants

There are two types of bone marrow, red marrow (otherwise known as myeloid tissue) and yellow marrow. Red blood cells, platelets, and most white blood cells arise from within red marrow. In yellow marrow a few white cells are made; however, this marrow is dominated by large fat globules (producing its yellow appearance).

From birth most of the body's marrow is red; however, as the subject ages, more red marrow is converted into yellow marrow within the medulla of the long and flat bones.

There are a number of diseases that may involve the bone marrow, including infection and malignancy. In patients who develop a bone marrow malignancy (e.g., leukemia), it may be possible to harvest nonmalignant cells from the patient's bone marrow or cells from another person's bone marrow. The patient's own marrow can be destroyed with chemotherapy or radiation and the new cells infused. This treatment is referred to as a bone marrow transplant.

Clinical app

Bone fractures

Fractures occur in normal bone because of abnormal load or stress in which the bone gives way. Fractures may also occur in bone that is of poor quality (osteoporosis). In these cases, a normal stress is placed upon a bone that is not of sufficient quality to withstand this force and subsequently fractures.

In children whose bones are still developing, fractures may occur across the growth plate or across the shaft. These shaft fractures typically involve partial cortical disruption, similar to breaking a branch of a young tree; hence they are termed *greenstick* fractures.

Clinical app

Avascular necrosis

Avascular necrosis is cellular death of bone resulting from a temporary or permanent loss of blood supply to that bone. A typical site for avascular necrosis is a fracture across the femoral neck in an elderly patient. In these patients blood flow to the femoral head is compromised. It subsequently undergoes necrosis and collapses. In these patients it is necessary to replace the femoral head with a prosthesis.

Clinical app

Osteoporosis

Osteoporosis is a disease in which the bone mineral density is significantly reduced. This renders the bone significantly more at risk of fracture. Typically, osteoporotic fractures occur in the femoral necks, the vertebrae, and the wrists. Although osteoporosis may occur in men, especially elderly men, the typical patients are postmenopausal women. However, transgender or gender-diverse patients who undergo gender-affirming gonadectomy or those who are hypogonadal as part of gender-affirming hormonal therapy are also at risk.

Clinical app

Epiphyseal fractures

As the skeleton develops, there are stages of intense growth typically around the ages of 7 to 10 years and later in puberty. These growth spurts are associated with increased cellular activity around the growth plate and the metaphyseal region. This increase in activity renders the growth plates and metaphyseal regions more vulnerable to injuries such as dislocation across a growth plate or fracture through a growth plate. Occasionally an injury may result in growth plate compression, destroying that region of the growth plate, which may result in asymmetric growth.

Joints

The sites where two skeletal elements come together are termed *joints*. The two general categories of joints (Fig. 1.13) are those in which:

- the skeletal elements are separated by a cavity (i.e., **synovial joints**); and
- there is no cavity and the components are held together by connective tissue (i.e., **solid joints**).

Blood vessels that cross over a joint and nerves that innervate muscles acting on a joint usually contribute articular branches to that joint.

Synovial joints

Synovial joints are connections between skeletal components where the elements involved are separated by a narrow articular cavity. In addition to containing an articular cavity, these joints have a number of characteristic features (Fig. 1.14).

First, a layer of cartilage, usually **hyaline cartilage**, covers the articulating surfaces of the skeletal elements. In other words, bony surfaces do not normally contact one another directly. As a consequence, when these joints are viewed in normal radiographs, a wide gap seems to separate the adjacent bones because the cartilage that covers the articulating surfaces is more transparent to X-rays than bone.

A second characteristic feature of synovial joints is the presence of a **joint capsule** consisting of an inner **synovial membrane** and an outer **fibrous membrane**.

- The synovial membrane attaches to the margins of the joint surfaces at the interface between the cartilage and bone and encloses the articular cavity. The synovial

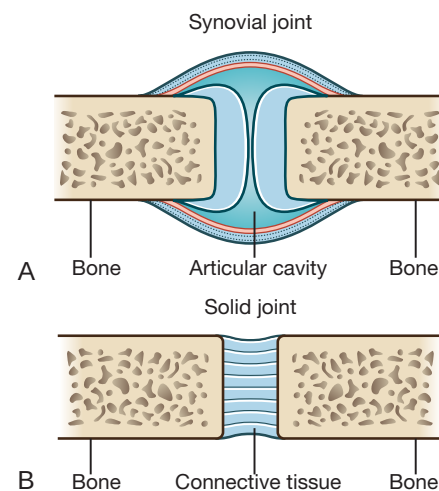


Fig. 1.13 Joints. A. Synovial joint. B. Solid joint.

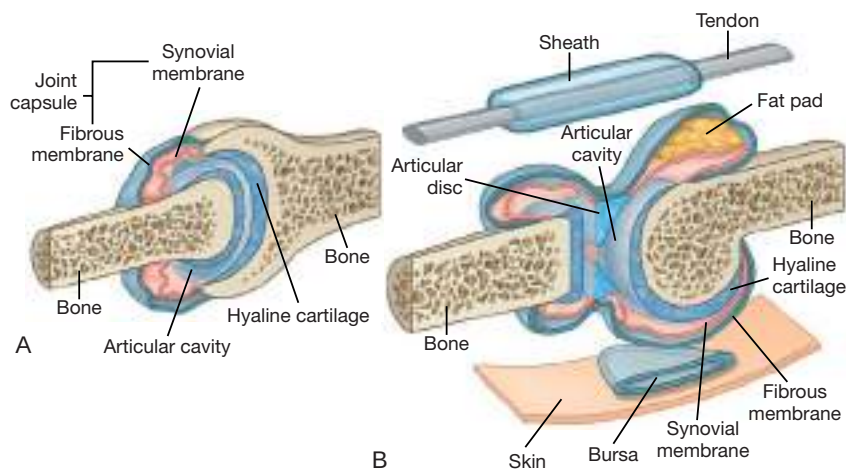


Fig. 1.14 Synovial joints. **A.** Major features of a synovial joint. **B.** Accessory structures associated with synovial joints.

membrane is highly vascular and produces synovial fluid, which percolates into the articular cavity and lubricates the articulating surfaces. Closed sacs of synovial membrane also occur outside joints where they form synovial bursae or tendon sheaths. Bursae often intervene between structures, such as tendons and bone, tendons and joints, or skin and bone, and reduce the friction of one structure moving over the other. Tendon sheaths surround tendons and also reduce friction.

- The **fibrous membrane** is formed by dense connective tissue and surrounds and stabilizes the joint. Parts of the fibrous membrane may thicken to form ligaments, which further stabilize the joint. Ligaments outside the capsule usually provide additional reinforcement.

Another common but not universal feature of synovial joints is the presence of additional structures within the area enclosed by the capsule or synovial membrane:

- **Articular discs** (usually composed of fibrocartilage) absorb compression forces, adjust to changes in the contours of joint surfaces during movements, and increase the range of movements that can occur at joints.
- **Fat pads** occur between the synovial membrane and the capsule and move into and out of regions as joint contours change during movement.
- **tendons.**

Descriptions of synovial joints based on shape and movement

Synovial joints are described based on shape and movement:

- Based on the shape of their articular surfaces, synovial joints are described as plane (flat), hinge, pivot, bicondylar (two sets of contact points), condylar (ellipsoid), saddle, and ball and socket (Fig. 1.15).

- Based on movement, synovial joints are described as uni-axial (movement in one plane), bi-axial (movement in two planes), and multi-axial (movement in three planes).

Hinge joints are uni-axial, whereas ball-and-socket joints are multi-axial.

Specific types of synovial joints (Fig. 1.15)

- **Plane joints**—allow sliding or gliding movements when one bone moves across the surface of another (e.g., acromioclavicular joint)
- **Hinge joints**—allow movement around one axis that passes transversely through the joint; permit flexion and extension (e.g., elbow [humeroulnar] joint)
- **Pivot joints**—allow movement around one axis that passes longitudinally along the shaft of the bone; permit rotation (e.g., atlanto-axial joint)
- **Bicondylar joints**—allow movement mostly in one axis with limited rotation around a second axis; formed by two convex condyles that articulate with concave or flat surfaces (e.g., knee joint)
- **Condylar (ellipsoid) joints**—allow movement around two axes that are at right angles to each other; permit flexion, extension, abduction, adduction, and circumduction (limited) (e.g., wrist joint)
- **Saddle joints**—allow movement around two axes that are at right angles to each other; the articular surfaces are saddle shaped; permit flexion, extension, abduction, adduction, and circumduction (e.g., carpometacarpal joint of the thumb)
- **Ball-and-socket joints**—allow movement around multiple axes; permit flexion, extension, abduction, adduction, circumduction, and rotation (e.g., hip joint)

Solid joints

Solid joints are connections between skeletal elements where the adjacent surfaces are linked together either by

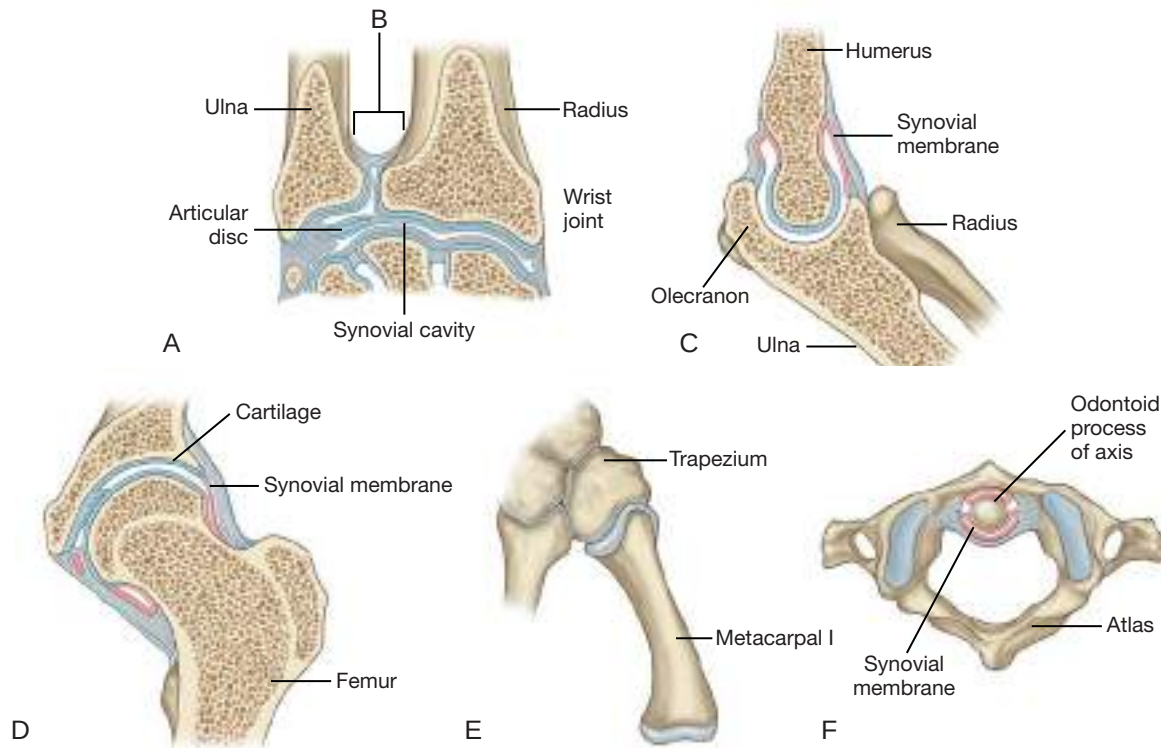


Fig. 1.15 Various types of synovial joints. **A.** Condylar (wrist). **B.** Gliding (radioulnar). **C.** Hinge or ginglymus (elbow). **D.** Ball and socket (hip). **E.** Saddle (carpometacarpal of thumb). **F.** Pivot (atlanto-axial).

fibrous connective tissue or by cartilage, usually fibrocartilage (Fig. 1.16). Movements at these joints are more restricted than at synovial joints.

Fibrous joints include sutures, gomphoses, and syndesmoses.

- **Sutures** occur only in the skull where adjacent bones are linked by a thin layer of connective tissue termed a *sutural ligament*.
- **Gomphoses** occur only between the teeth and adjacent bone. In these joints, short collagen tissue fibers in the periodontal ligament run between the root of the tooth and the bony socket.
- **Syndesmoses** are joints in which two adjacent bones are linked by a ligament. Examples are the ligamentum flavum, which connects adjacent vertebral laminae, and an interosseous membrane, which links, for example, the radius and ulna in the forearm.

Cartilaginous joints include synchondroses and symphyses.

- **Synchondroses** occur where two ossification centers in a developing bone remain separated by a layer of cartilage, for example, the growth plate that occurs between the head and shaft of developing long bones. These joints allow bone growth and eventually become completely ossified.

- **Symphyses** occur where two separate bones are interconnected by cartilage. Most of these types of joints occur in the midline and include the pubic symphysis between the two pelvic bones and intervertebral discs between adjacent vertebrae.

Clinical app

Joint replacement

Joint replacement is undertaken for a variety of reasons. These predominantly include degenerative joint disease and joint destruction. Joints that have severely degenerated or lack their normal function are painful. In some patients, the pain may be so severe that it prevents them from leaving the house and undertaking even the smallest of activities without discomfort.

Large joints are commonly affected, including the hip, knee, and shoulder. However, with ongoing developments in joint replacement materials and surgical techniques, even small joints of the fingers can be replaced.

Typically, both sides of the joint are replaced. In the hip joint the acetabulum will be reamed, and a plastic or metal cup will be introduced. The femoral component will be fitted precisely to the femur and cemented in place (Fig. 1.17).

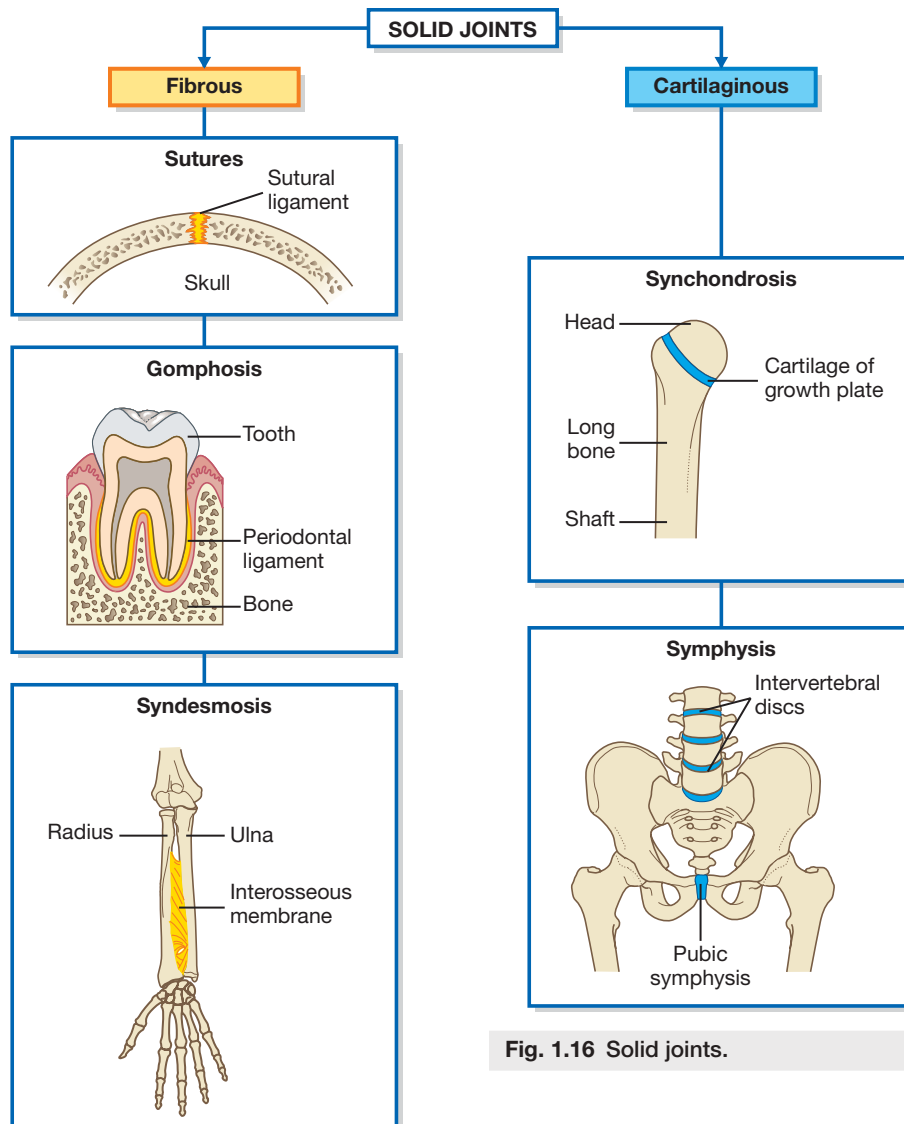


Fig. 1.16 Solid joints.

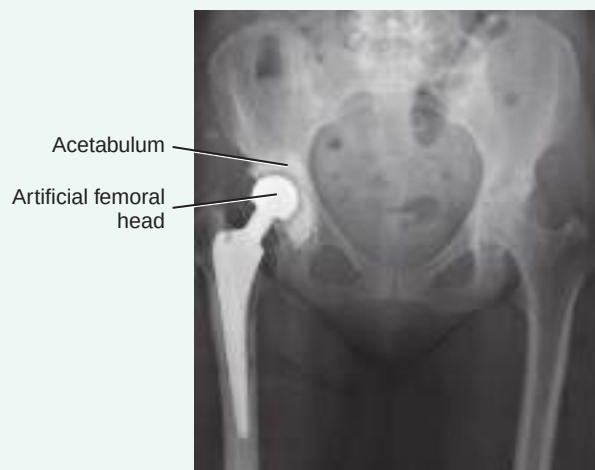


Fig. 1.17 This is a radiograph, anterior-posterior view, of the pelvis after a right total hip replacement. There are additional significant degenerative changes in the left hip joint, which will also need to be replaced.

Clinical app

Degenerative joint disease

Degenerative joint disease is commonly known as osteoarthritis or osteoarthrosis. The disorder is related to aging but not caused by aging. Typically, there are decreases in water and proteoglycan content within the cartilage. The cartilage becomes more fragile and more susceptible to mechanical disruption. As the cartilage wears, the underlying bone becomes fissured and also thickens. Synovial fluid may be forced into small cracks that appear in the bone's surface, which produces large cysts. Furthermore, reactive juxta-articular bony nodules are formed (osteophytes). As these processes occur, there is slight deformation, which alters the biomechanical forces through the joint. This, in turn, creates abnormal stresses, which further disrupt the joint (Fig. 1.18).

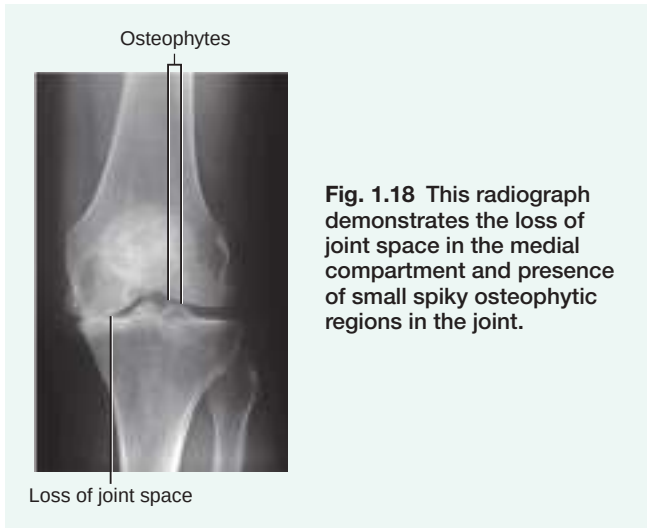


Fig. 1.18 This radiograph demonstrates the loss of joint space in the medial compartment and presence of small spiky osteophytic regions in the joint.

Clinical app

Arthroscopy

Arthroscopy is a technique of visualizing the inside of a joint using a small camera placed through a tiny incision in the skin. Arthroscopy can be performed in most joints, including the elbow and wrist joints. However, it is most commonly performed in the knee, shoulder, ankle, and hip joints.

Arthroscopy allows the surgeon to view the inside of the joint and its contents. Notably, in the knee, the menisci and the ligaments are easily seen, and it is possible using separate puncture sites and specific instruments to remove the menisci and repair the cruciate ligaments. The advantages of arthroscopy are that it is performed through small incisions, it enables patients to quickly recover and return to normal activity, and it only requires either a light anesthetic or regional anesthesia during the procedure.

SKIN AND FASCIAS

Skin

The skin is the largest organ of the body. It consists of the epidermis and the dermis. The epidermis is the outer cellular layer of stratified squamous epithelium, which is avascular and varies in thickness. The dermis is a dense bed of vascular connective tissue.

The skin functions as a mechanical and permeability barrier and as a sensory and thermoregulatory organ. It also can initiate primary immune responses.

Fascia

Fascia is connective tissue containing varying amounts of fat that separates, supports, and interconnects organs and structures, enable movement of one structure relative to

another, and allow the transit of vessels and nerves from one area to another. There are two general categories of fascia: superficial and deep.

- Superficial (subcutaneous) fascia lies just deep to and is attached to the dermis of the skin. It is made up of loose connective tissue, usually containing a large amount of fat. The thickness of the superficial fascia (subcutaneous tissue) varies considerably, both from one area of the body to another and from one individual to another. The superficial fascia allows movement of the skin over deeper areas of the body, acts as a conduit for vessels and nerves coursing to and from the skin, and serves as an energy (fat) reservoir.
- Deep fascia usually consists of dense, organized connective tissue. The outer layer of deep fascia is attached to the deep surface of the superficial fascia and forms a thin fibrous covering over most of the deeper region of the body. Inward extensions of this fascial layer form intermuscular septa that compartmentalize groups of muscles with similar functions and innervations. Other extensions surround individual muscles and groups of vessels and nerves, forming an investing fascia. Near some joints the deep fascia thickens, forming retinacula. These fascial retinacula hold tendons in place and prevent them from bowing during movements at the joints. Finally, there is a layer of deep fascia separating the membrane lining the abdominal cavity (the parietal peritoneum) from the fascia covering the deep surface of the muscles of the abdominal wall (the transversalis fascia). This layer is referred to as **extraperitoneal fascia**. A similar layer of fascia in the thorax is termed the **endothoracic fascia**.

Clinical app

The importance of fascias

Clinically, fascias are extremely important because they often limit the spread of infection and malignant disease. When infection or malignant diseases cross a fascial plane, a primary surgical clearance may require a far more extensive dissection to render the area free of tumor or infection.

MUSCULAR SYSTEM

The muscular system is generally regarded as consisting of one type of muscle found in the body—skeletal muscle. However, there are two other types of muscle tissue found in the body, smooth muscle and cardiac muscle, which are important components of other systems. These three types of muscle can be characterized by whether they are controlled voluntarily or involuntarily, whether they appear striated (striped) or smooth, and whether they are associated with the body wall (somatic) or with organs and blood vessels (visceral).



The Body

- Skeletal muscle forms the majority of the muscle tissue in the body. It consists of parallel bundles of long, multinucleated fibers with transverse stripes, is capable of powerful contractions, and is innervated by somatic and branchial motor nerves. This muscle is used to move bones and other structures, provides support, and gives form to the body. Individual skeletal muscles are often named on the basis of shape (e.g., rhomboid major muscle), attachments (e.g., sternohyoid muscle), function (e.g., flexor pollicis longus muscle), position (e.g., palmar interosseous muscle), or fiber orientation (e.g., external oblique muscle).
- Cardiac muscle is striated muscle found only in the walls of the heart (myocardium) and in some of the large vessels close to where they join the heart. It consists of a branching network of individual cells linked electrically and mechanically to work as a unit. Its contractions are less powerful than those of skeletal muscle, and it is resistant to fatigue. Cardiac muscle is innervated by visceral motor nerves.
- Smooth muscle (absence of stripes) consists of elongated or spindle-shaped fibers capable of slow and sustained contractions. It is found in the walls of blood vessels (tunica media), associated with hair follicles in the skin, located in the eyeball, and found in the walls of various structures associated with the gastrointestinal, respiratory, genitourinary, and urogenital systems. Smooth muscle is innervated by visceral motor nerves.

Clinical app

Muscle paralysis

Muscle paralysis is the inability to move a specific muscle or muscle group and may be associated with other neurologic abnormalities, including loss of sensation. Paralysis may be due to abnormalities in the brain, the spinal cord, and the nerves supplying the muscles. Major causes include stroke, trauma, poliomyelitis, and iatrogenic factors. Paralysis may also be caused by drugs that affect the neurotransmitters at the nerve endings and their action on the muscle themselves.

In the long term, muscle paralysis will produce secondary muscle wasting and overall atrophy of the region due to disuse.

Clinical app

Muscle atrophy

Muscle atrophy is a wasting disorder of muscle. It can be produced by a variety of causes, which include nerve damage to the muscle and disuse.

Muscle atrophy is an important problem in patients who have undergone long-term rest or disuse, requiring extensive rehabilitation and muscle-building exercises to maintain normal activities of daily living.

Clinical app

Muscle injuries and strains

Muscle injuries and strains tend to occur in specific muscle groups and usually are related to a sudden exertion and muscle disruption. They typically occur in athletes.

CARDIOVASCULAR SYSTEM

The cardiovascular system consists of the heart, which pumps blood throughout the body, and the blood vessels, which are a closed network of tubes that transport the blood. There are three types of blood vessels:

- arteries, which transport blood away from the heart;
- veins, which transport blood toward the heart; and
- capillaries, which connect the arteries and veins, are the smallest of the blood vessels and are where oxygen, nutrients, and wastes are exchanged within the tissues.

The walls of the blood vessels of the cardiovascular system usually consist of three layers or tunics:

- tunica externa (adventitia)—the outer connective tissue layer,
- tunica media—the middle smooth muscle layer (may also contain varying amounts of elastic fibers in medium and large arteries), and
- tunica intima—the inner endothelial lining of the blood vessels.

Arteries are usually further subdivided into three classes according to the variable amounts of smooth muscle and elastic fibers contributing to the thickness of the tunica media, the overall size of the vessel, and its function.

- Large elastic arteries contain substantial amounts of elastic fibers in the tunica media, allowing expansion and recoil during the normal cardiac cycle. This helps maintain a constant flow of blood during diastole. Examples of large elastic arteries are the aorta and the brachiocephalic trunk.
- Medium muscular arteries are composed of a tunica media that contains mostly smooth muscle fibers. This characteristic allows these vessels to regulate their diameter and control the flow of blood to different parts of the body. Examples of medium muscular arteries are most of the named arteries, including the femoral, axillary, and radial arteries.
- Small arteries and arterioles control the filling of the capillaries and directly contribute to the arterial pressure in the vascular system.

Veins also are subdivided into three classes.

- Large veins contain some smooth muscle in the tunica media, but the thickest layer is the tunica externa. Examples of large veins are the superior vena cava, the inferior vena cava, and the portal vein.
- Small and medium veins contain small amounts of smooth muscle, and the thickest layer is the tunica externa. Examples of small and medium veins are superficial veins in the upper and lower limbs and deeper veins of the leg and forearm.
- Venules are the smallest veins and drain the capillaries.

Although veins are similar in general structure to arteries, they have a number of distinguishing features.

- The walls of veins, specifically the tunica media, are thin.
- The luminal diameters of veins are large.
- There often are multiple veins (venae comitantes) closely associated with arteries in peripheral regions.
- Valves often are present in veins, particularly in peripheral vessels inferior to the level of the heart. These are usually paired cusps that facilitate blood flow toward the heart.

More specific information about the cardiovascular system and how it relates to the circulation of blood throughout the body will be discussed, where appropriate, in each of the succeeding chapters of the text.

Clinical app

Atherosclerosis

Atherosclerosis is a disease that affects arteries. There is a chronic inflammatory reaction in the walls of the arteries, with deposition of cholesterol and fatty proteins. This may in turn lead to secondary calcification, with reduction in the diameter of the vessels impeding distal flow. The plaque itself may be a site for attraction of platelets that may “fall off” (embolize) distally. Plaque fissuring may occur, which allows fresh clots to form and occlude the vessel.

Clinical app

Varicose veins

Varicose veins are tortuous dilated veins that typically occur in the legs, although they may occur in the superficial veins of the arm and in other organs.

In normal individuals the movement of leg muscles pumps the blood in the veins to the heart. Blood also moves

from the superficial veins through the investing layer of fascia of the leg into the deep veins. Valves in these perforating veins may become damaged, allowing blood to pass in the opposite direction. This increased volume and pressure produces dilatation and tortuosity of the superficial veins (Fig. 1.19).



Fig. 1.19 Photograph demonstrating varicose veins.

Clinical app

Anastomoses and collateral circulation

All organs require a blood supply from the arteries and drainage by veins. Within most organs there are multiple ways of perfusing the tissue such that if the main vessel feeding the organ or vein draining the organ is blocked, a series of smaller vessels (collateral vessels) continue to supply and drain the organ.

Some organs have more than one vessel perfusing them, such as the hand, which is supplied by the radial and ulnar arteries. Loss of either the radial or the ulnar artery may not produce any symptoms of reduced perfusion to the hand. The brain also has multiple vessels supplying it, dominated by the carotid arteries and the vertebral arteries. However, vessels within the brain are end arteries and have a poor collateral circulation; hence any occlusion will produce long-term cerebral damage.

Normal vascular anastomoses associated with an organ are important. Some organs, such as the duodenum, have a dual blood supply arising from the branches of the celiac trunk and from the branches of the superior mesenteric artery. Should either of these vessels be damaged, blood supply to the organ will be maintained.

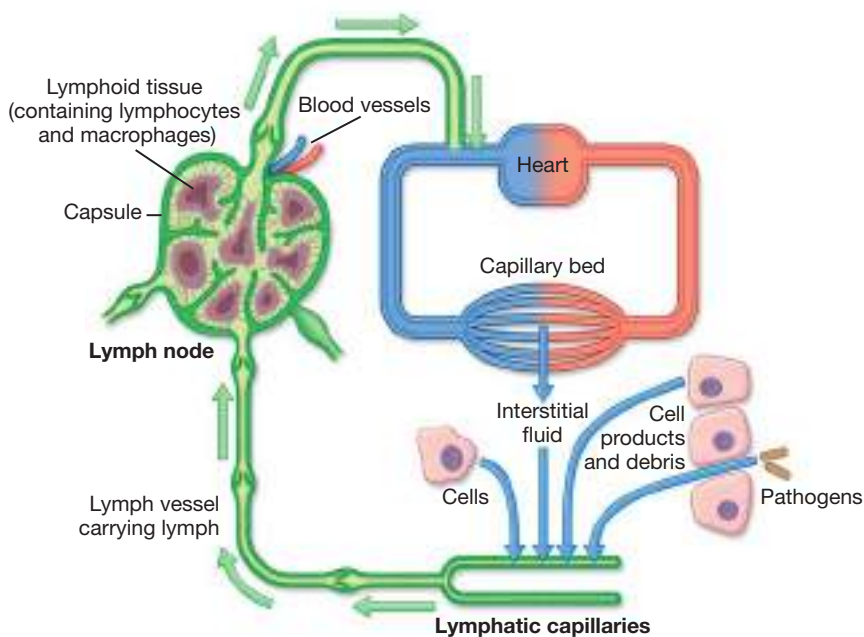


Fig. 1.20 Overview of the structure and function of the lymphatic system.

LYMPHATIC SYSTEM

Lymphatic vessels

Lymphatic vessels form an extensive and complex interconnected network of channels, which begins as “porous” blind-ended lymphatic capillaries in tissues of the body and converges to form a number of larger vessels, which ultimately connect with large veins in the root of the neck.

Lymphatic vessels mainly collect fluid lost from vascular capillary beds during nutrient exchange processes and deliver it back to the venous side of the vascular system (Fig. 1.20). Also included in this interstitial fluid that drains into the lymphatic capillaries are pathogens, cells of the lymphocytic system, cell products (such as hormones), and cell debris.

In the small intestine, certain fats absorbed and processed by the intestinal epithelium are packaged into protein-coated lipid droplets (**chylomicrons**), which are released from the epithelial cells and enter the interstitial compartment. Together with other components of the interstitial fluid, the chylomicrons drain into lymphatic capillaries (known as **lacteals** in the small intestine) and are ultimately delivered to the venous system in the neck. The lymphatic system is therefore also a major route of transport for fat absorbed by the gut.

The fluid in most lymphatic vessels is clear and colorless and is known as **lymph**. That carried by lymphatic vessels from the small intestine is opaque and milky because of the presence of chylomicrons and is termed **chyle**.

There are lymphatic vessels in most areas of the body, including associated with the central nervous system (CNS).^{*} Exceptions include bone marrow and avascular tissues such as epithelia and cartilage.

The movement of lymph through the lymphatic vessels is generated mainly by the indirect action of adjacent structures, particularly by contraction of skeletal muscles and pulses in arteries. Unidirectional flow is maintained by the presence of valves in the vessels.

Lymph nodes

Lymph nodes are small (0.1 to 2.5 cm long), encapsulated structures that interrupt the course of lymphatic vessels and contain elements of the body’s defense system, such as clusters of lymphocytes and macrophages. They act as elaborate filters that trap and phagocytose particulate matter in the lymph that percolates through them. In addition, they detect and defend against foreign antigens that are also carried in the lymph.

Because lymph nodes are efficient filters and flow through them is slow, cells that metastasize from (migrate away from) primary tumors and enter lymphatic vessels often lodge and grow as secondary tumors in lymph nodes. Lymph nodes that drain regions that are infected or contain other forms of disease can enlarge or undergo certain physical changes, such as becoming “hard” or “tender.” These changes can be used by clinicians to detect pathological changes or to track spread of disease.

^{*}Louveau A et al. *Nature* 2015;523:337; Aspelund A et al. *J Exp Med* 2015;212:991; Absinta M et al. *eLIFE* 2017;6:e29738.

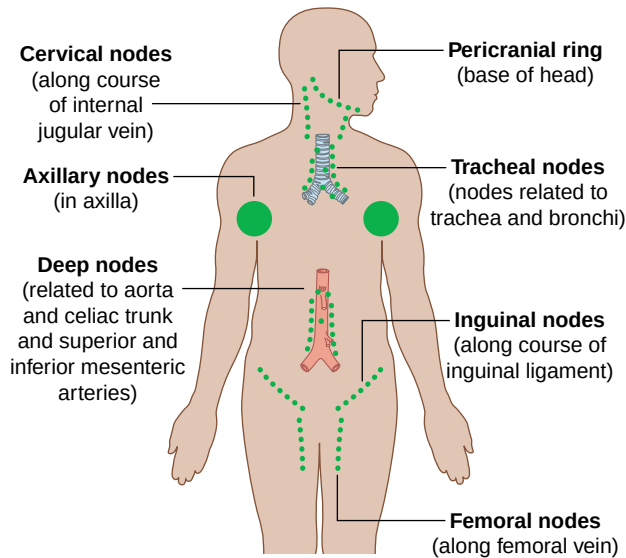


Fig. 1.21 Regions associated with clusters or a particular abundance of lymph nodes.

A number of regions in the body are associated with clusters or a particular abundance of lymph nodes (Fig. 1.21). Not surprisingly, nodes in many of these regions drain the body's surface, the digestive system, or the respiratory system. All three of these areas are high-risk sites for the entry of foreign pathogens.

Lymph nodes are abundant and accessible to palpation in the axilla, the groin and femoral region, and the neck (Fig. 1.21). Deep sites that are not palpable include those associated with the trachea and bronchi in the thorax and with the aorta and its branches in the abdomen.

Lymphatic trunks and ducts

All lymphatic vessels coalesce to form larger trunks or ducts, which drain into the venous system at sites in the neck where the internal jugular veins join the subclavian veins to form the brachiocephalic veins (Fig. 1.22):

- Lymph from the right side of the head and neck, the right upper limb, and the right side of the thorax is carried by lymphatic vessels that connect with veins on the right side of the neck.
- Lymph from all other regions of the body is carried by lymphatic vessels that drain into veins on the left side of the neck.

Specific information about the organization of the lymphatic system in each region of the body is discussed in the appropriate chapter.

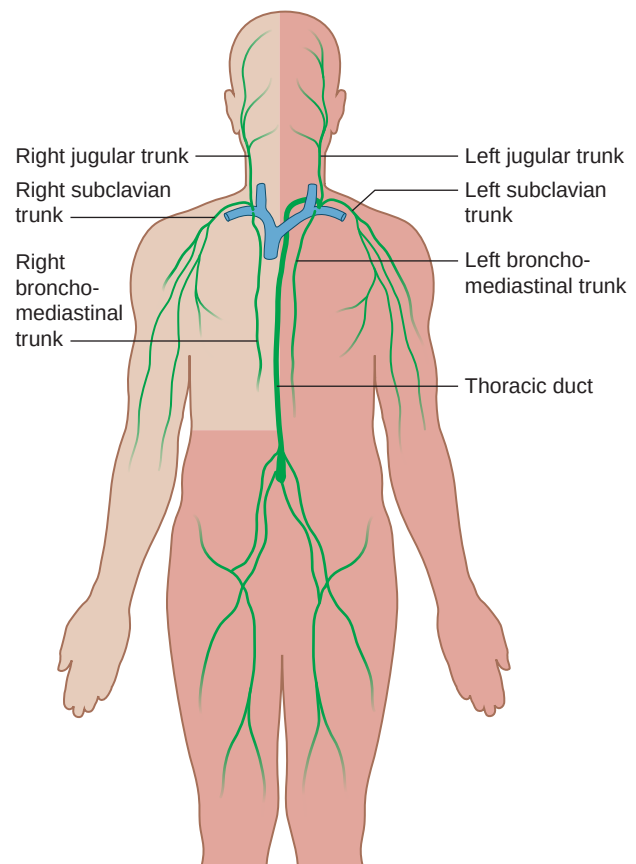


Fig. 1.22 Major lymphatic vessels that drain into large veins in the neck.

Clinical app

Lymph nodes

Lymph nodes are efficient filters and have an internal honeycomb of reticular connective tissue filled with lymphocytes. These lymphocytes act on bacteria, viruses, and other bodily cells to destroy them. Lymph nodes tend to drain specific areas, and if infection occurs within a drainage area, the lymph node will become active. The rapid cell turnover and production of local inflammatory mediators may cause the node to enlarge and become tender. Similarly, in patients with malignancy, the lymphatics may drain metastasizing cells to the lymph nodes. These can become enlarged and inflamed and will need to be removed if clinically symptomatic.

Lymph nodes may become diffusely enlarged in certain systemic illnesses (e.g., viral infection), or local groups may become enlarged with primary lymph node malignancies, such as lymphoma.

NERVOUS SYSTEM

The nervous system can be separated into parts based on structure and on function:

- Structurally, it can be divided into the CNS and the peripheral nervous system (PNS) (Fig. 1.23).
- Functionally, it can be divided into somatic and visceral parts.

The CNS is composed of the brain and spinal cord, both of which develop from the neural tube in the embryo.

The PNS is composed of all nervous structures outside the CNS that connect the CNS to the body. Elements of this system develop from neural crest cells and as outgrowths of the CNS. The PNS consists of the spinal and cranial nerves, visceral nerves and plexuses, and the enteric system. The detailed anatomy of a typical spinal nerve is described in Chapter 2, as is the way spinal nerves are numbered. Cranial nerves are described in Chapter 8. The details of nerve plexuses are described in chapters dealing with the specific regions in which the plexuses are located.

Central nervous system

Brain

The parts of the brain are the cerebral hemispheres, the cerebellum, and the brainstem. The cerebral hemispheres consist of an outer portion, or the **gray matter**, containing cell bodies; an inner portion, or the **white matter**, made up of axons forming tracts or pathways; and the **ventricles**, which are spaces filled with CSF.

The cerebellum has two lateral lobes and a midline portion. The components of the brainstem are classically defined as the diencephalon, midbrain, pons, and medulla. However, in common usage today, the term *brainstem* usually refers to the midbrain, pons, and medulla.

A further discussion of the brain can be found in Chapter 8.

Spinal cord

The spinal cord is the part of the CNS in the superior two-thirds of the vertebral canal. It is roughly cylindrical in shape, and is circular to oval in cross-section with a central canal. A further discussion of the spinal cord can be found in Chapter 2.

Meninges

The meninges (Fig. 1.24) are three connective tissue coverings that surround, protect, and suspend the brain and spinal cord within the cranial cavity and vertebral canal. They consist of:

- the dura mater, which is the thickest and most external of the coverings;

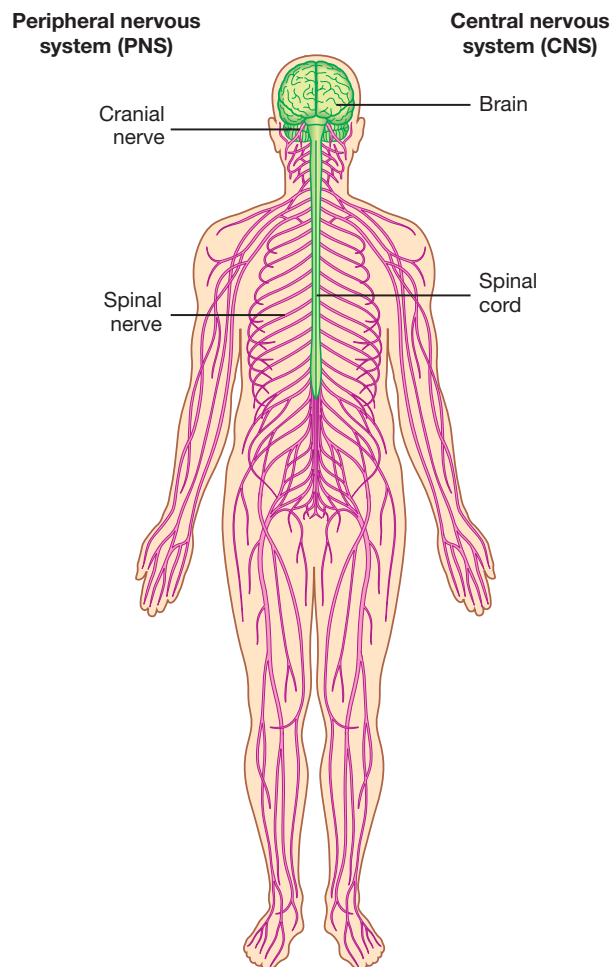


Fig. 1.23 CNS and PNS.

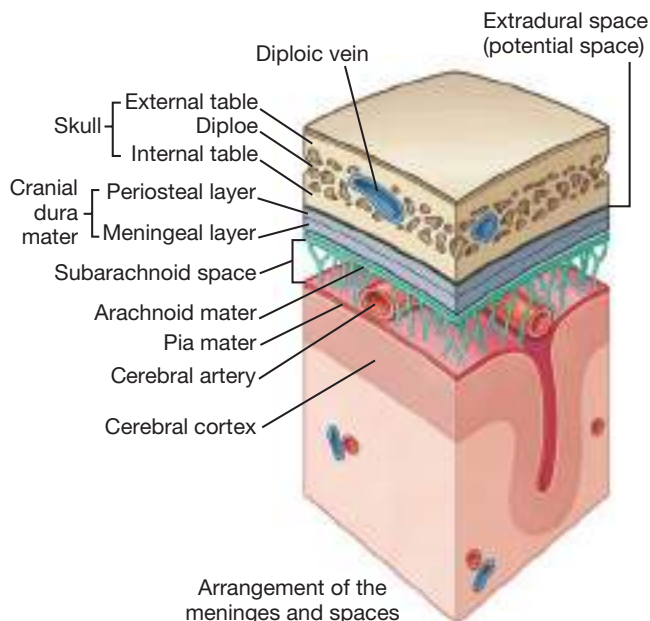


Fig. 1.24 Arrangement of meninges in the cranial cavity.

- the arachnoid mater, which is against the internal surface of the dura mater; and
- the pia mater, which is adherent to the brain and spinal cord.

Between the arachnoid and pia mater is the subarachnoid space, which contains CSF.

A further discussion of the cranial meninges can be found in [Chapter 8](#) and of the spinal meninges in [Chapter 2](#).

Functional subdivisions of the CNS

Functionally, the nervous system can be divided into somatic and visceral parts.

- The **somatic part** (*soma*, from the Greek for “body”) innervates structures (skin and most skeletal muscle) derived from somites in the embryo and is mainly involved with receiving and responding to information from the external environment.
- The **visceral part** (*viscera*, from the Greek for “guts”) innervates organ systems in the body and other visceral elements, such as smooth muscle and glands, in peripheral regions of the body. It is concerned mainly with detecting and responding to information from the internal environment.

Somatic part of the nervous system

The somatic part of the nervous system consists of:

- nerves that carry conscious sensations from peripheral regions back to the CNS, and
- nerves that innervate voluntary muscles.

Somatic nerves arise segmentally along the developing CNS in association with **somites**, which are themselves arranged segmentally along each side of the neural tube. Part of each somite (the **dermatomyotome**) gives rise to skeletal muscle and the dermis of the skin. As cells of the dermatomyotome differentiate, they migrate into posterior (dorsal) and anterior (ventral) areas of the developing body.

- Cells that migrate anteriorly give rise to muscles of the limbs and trunk (**hypaxial muscles**) and to the associated dermis.
- Cells that migrate posteriorly give rise to the intrinsic muscles of the back (**epaxial muscles**) and the associated dermis.

Developing nerve cells within anterior regions of the neural tube extend processes peripherally into posterior and anterior regions of the differentiating dermatomyotome of each somite ([Fig. 1.25](#)).

Simultaneously, derivatives of neural crest cells (cells derived from neural folds during formation of the neural tube) differentiate into neurons on each side of the neural tube and extend processes both medially and laterally ([Fig. 1.25](#)).

- Medial processes pass into the posterior aspect of the neural tube.
- Lateral processes pass into the differentiating regions of the adjacent dermatomyotome.

Neurons that develop from cells within the spinal cord are **motor neurons**, and those that develop from neural crest cells are **sensory neurons**.

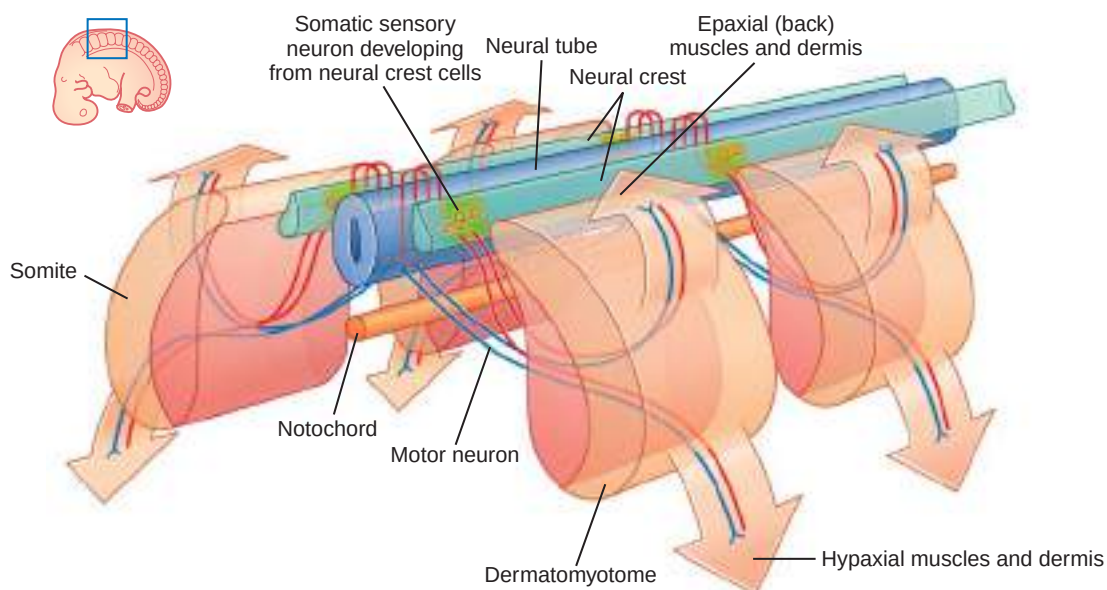


Fig. 1.25 Somatic sensory and motor neurons. *Blue lines* indicate motor neurons and *red lines* indicate sensory neurons.

Somatic sensory and somatic motor fibers that are organized segmentally along the neural tube become parts of all spinal nerves and some cranial nerves.

The clusters of sensory nerve cell bodies derived from neural crest cells and located outside the CNS form sensory ganglia.

Generally, all sensory information passes into the posterior aspect of the spinal cord, and all motor fibers leave anteriorly.

Somatic sensory fibers carry information from the periphery into the CNS and are also called **somatic sensory afferents** or **general somatic afferents (GSAs)**. The modalities carried by these nerves include temperature, pain, touch, and proprioception. Proprioception is the sense of determining the position and movement of the

musculoskeletal system detected by special receptors in muscles and tendons.

Somatic motor fibers carry information away from the CNS to skeletal muscles and are also called **somatic motor efferents** or **general somatic efferents (GSEs)**. Like somatic sensory fibers that come from the periphery, somatic motor fibers can be very long. They extend from cell bodies in the spinal cord to the muscle cells they innervate.

Dermatomes

Because cells from a specific somite develop into the dermis of the skin in a precise location, somatic sensory fibers originally associated with that somite enter the posterior region of the spinal cord at a specific level and become part of one specific spinal nerve (Fig. 1.26). Each spinal nerve therefore

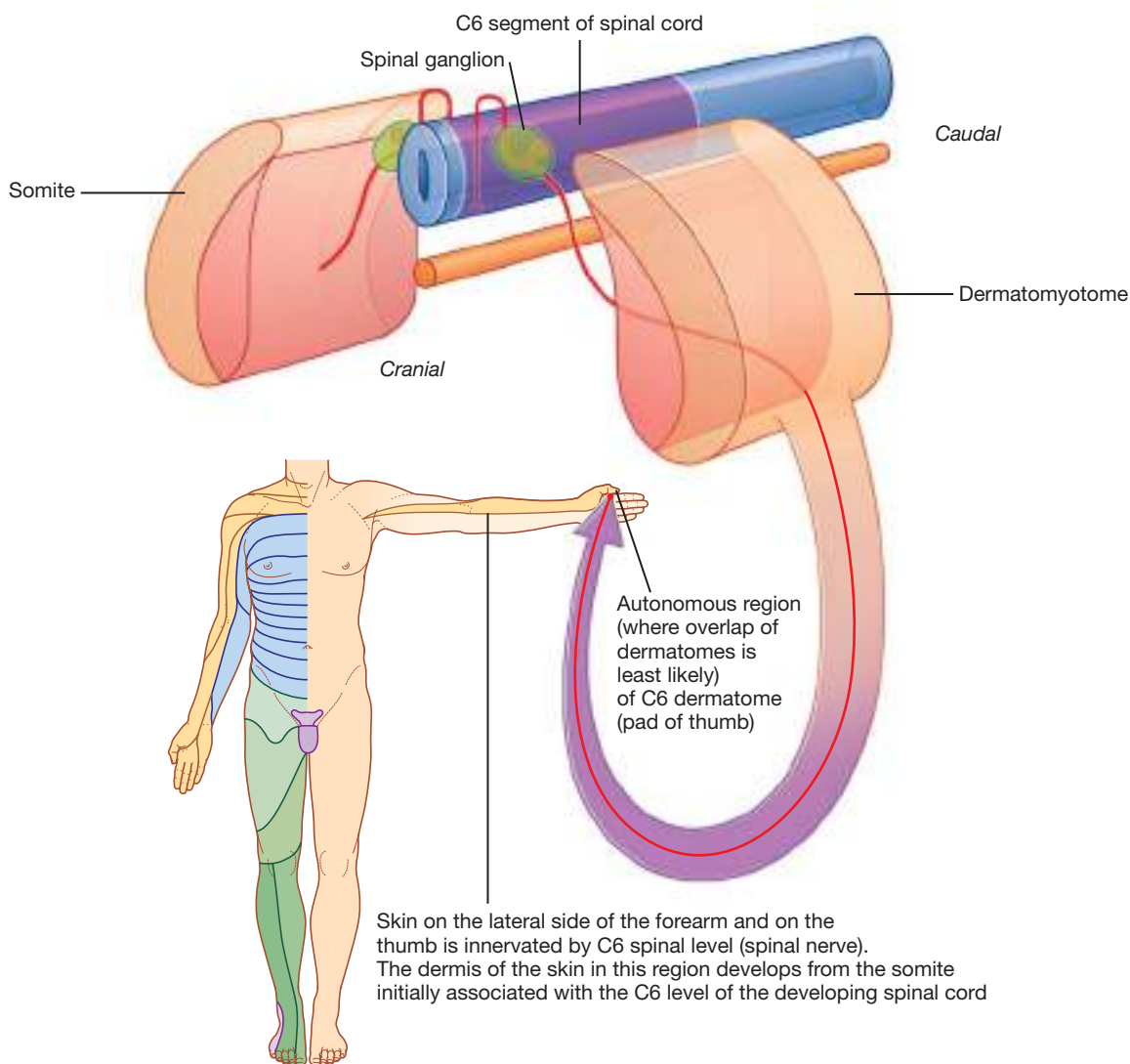


Fig. 1.26 Dermatomes.

carries somatic sensory information from a specific area of skin on the surface of the body. A **dermatome** is that area of skin supplied by a single spinal cord level or, on one side, by a single spinal nerve.

There is overlap in the distribution of dermatomes, but usually a specific region within each dermatome can be identified as an area supplied by a single spinal cord level. Testing touch in these autonomous zones in a conscious patient can be used to localize lesions to a specific spinal nerve or to a specific level in the spinal cord.

Myotomes

Somatic motor nerves that were originally associated with a specific somite emerge from the anterior region of the spinal cord and, together with sensory nerves from the same level, become part of one spinal nerve. Therefore each spinal nerve carries somatic motor fibers to muscles that originally developed from the related somite. A **myotome** is that portion of a skeletal muscle innervated by a single spinal cord level or, on one side, by a single spinal nerve.

Myotomes are generally more difficult to test than dermatomes, because each skeletal muscle in the body often develops from more than one somite and is therefore innervated by nerves derived from more than one spinal cord level (Fig. 1.27).

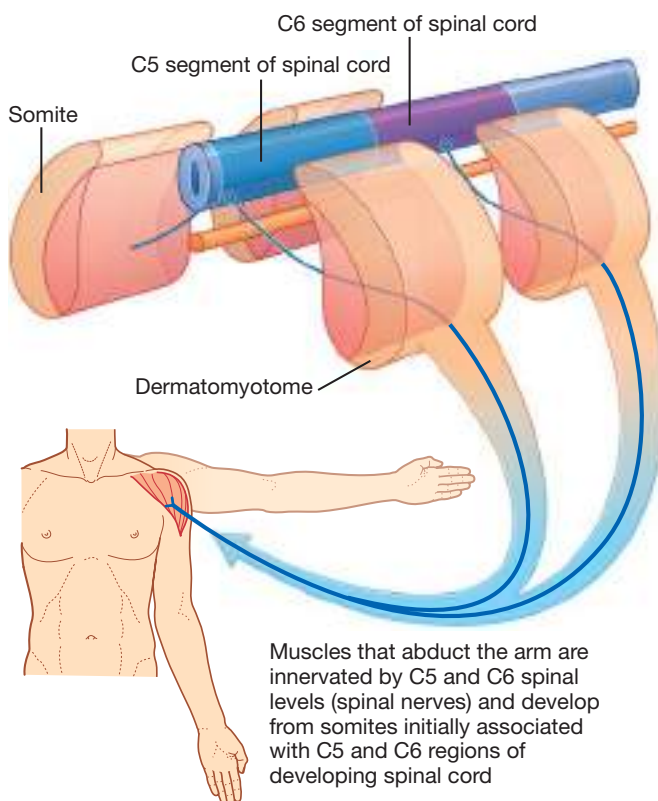


Fig. 1.27 Myotomes.

Clinical app

Dermatomes and myotomes

A knowledge of dermatomes and myotomes is absolutely fundamental to carrying out a neurologic examination. A typical dermatome map is shown in Fig. 1.28.

Clinically, a dermatome is that area of skin supplied by a single spinal nerve or spinal cord level. A myotome is that region of skeletal muscle innervated by a single spinal nerve or spinal cord level. Most individual muscles of the body are innervated by more than one spinal cord level, so the evaluation of myotomes is usually accomplished by testing movements of joints or muscle groups.

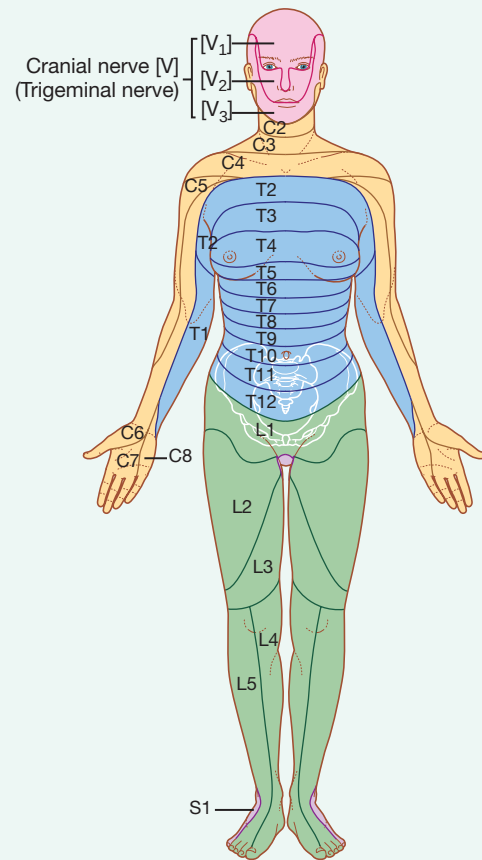


Fig. 1.28 Dermatomes (anterior view).

Visceral part of the nervous system

The visceral part of the nervous system, as in the somatic part, consists of motor and sensory components:

- Sensory nerves monitor changes in the viscera.
- Motor nerves mainly innervate smooth muscle, cardiac muscle, and glands.

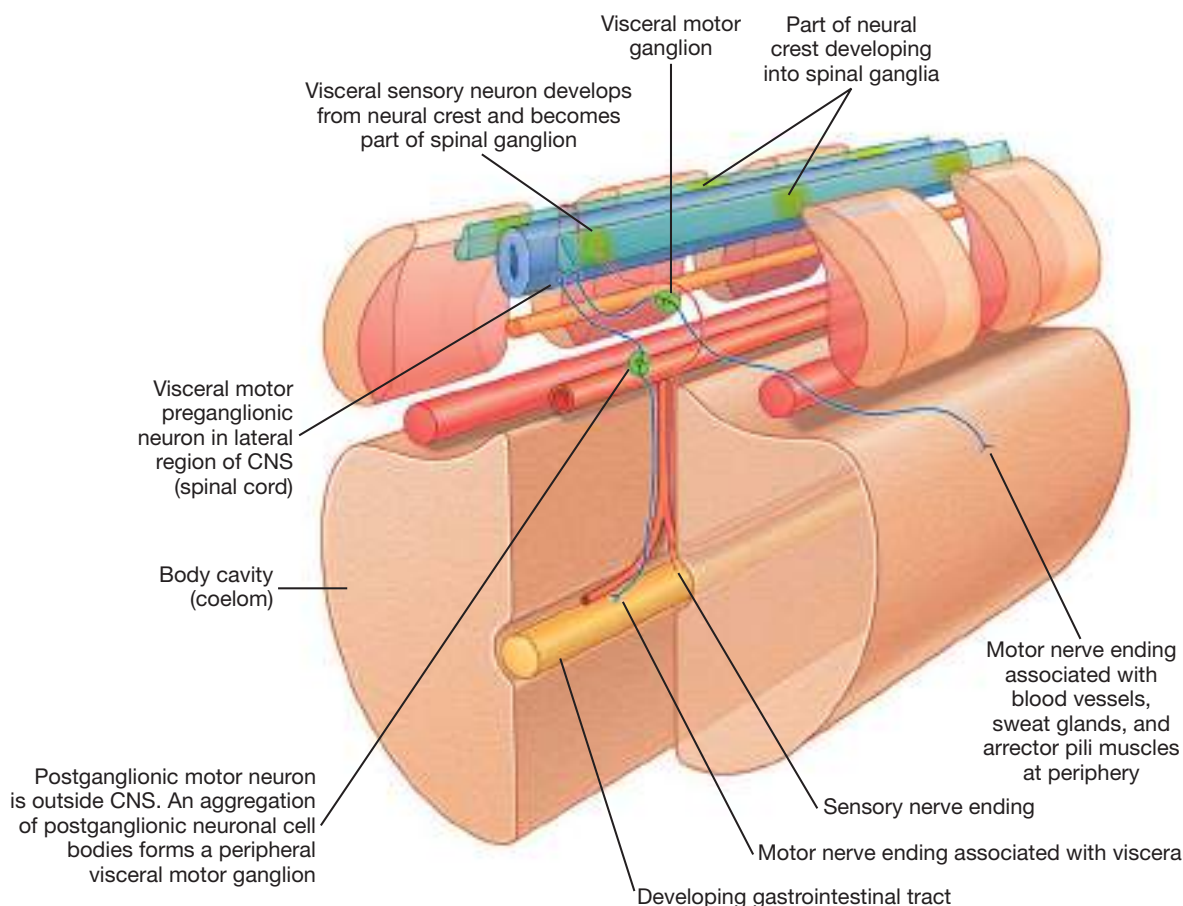


Fig. 1.29 Development of the visceral part of the nervous system.

The visceral motor component is commonly referred to as the **autonomic division of the PNS** and is subdivided into **sympathetic** and **parasympathetic** parts.

Like the somatic part of the nervous system, the visceral part is segmentally arranged and develops in a parallel fashion (Fig. 1.29).

Visceral sensory neurons that arise from neural crest cells send processes medially into the adjacent neural tube and laterally into regions associated with the developing body. Although these sensory neurons and their processes, referred to as **general visceral afferent fibers (GVAs)**, are associated primarily with chemoreception, mechanoreception, and stretch reception, they also are associated with visceral pain reception.

Visceral motor neurons that arise from cells in lateral regions of the neural tube send processes out of the anterior aspect of the tube. Unlike in the somatic part, these processes, containing **general visceral efferent fibers (GVEs)**, synapse with other cells—usually other visceral motor neurons—that develop outside the CNS from neural crest cells that migrate away from their original positions close to the developing neural tube.

The visceral motor neurons located in the spinal cord are referred to as preganglionic motor neurons, and their axons are called **preganglionic fibers**; the visceral motor neurons located outside the CNS are referred to as *postganglionic motor neurons*, and their axons are called **postganglionic fibers**.

The cell bodies of the visceral motor neurons outside the CNS often associate with each other in a discrete mass called a **ganglion**.

Visceral sensory and motor fibers enter and leave the CNS with their somatic equivalents (Fig. 1.30). Visceral sensory fibers enter the spinal cord together with somatic sensory fibers through posterior roots of spinal nerves. Preganglionic fibers of visceral motor neurons exit the spinal cord in the anterior roots of spinal nerves along with fibers from somatic motor neurons.

Postganglionic fibers traveling to visceral elements in the periphery are found in the posterior and anterior rami (branches) of spinal nerves.

Visceral motor and sensory fibers that travel to and from viscera form named visceral branches that are separate from the somatic branches. These nerves generally form plexuses from which arise branches to the viscera.

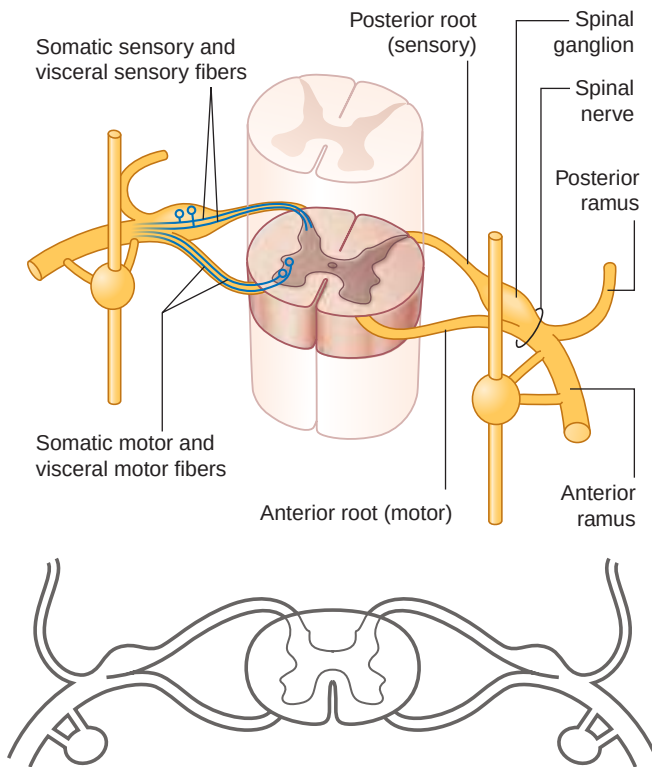


Fig. 1.30 Basic anatomy of a thoracic spinal nerve.

Visceral motor and sensory fibers do not enter and leave the CNS at all levels (Fig. 1.31):

- In the cranial region, visceral components are associated with four of the twelve cranial nerves (visceral efferents with CN III, VII, IX, and X; visceral afferents with IX and X).
- In the spinal cord, visceral components enter and leave the cord at levels T1 to L2 and S2 to S4.

Visceral motor components associated with spinal levels T1 to L2 are termed **sympathetic**. Those visceral motor components in cranial and sacral regions, on either side of the sympathetic trunk, are termed **parasympathetic**:

- the sympathetic system innervates structures in peripheral regions of the body and viscera; and
- the parasympathetic system is more restricted to innervation of the viscera only.

Sympathetic system

The sympathetic part of the autonomic division of the PNS leaves thoracolumbar regions of the spinal cord with the somatic components of spinal nerves T1 to L2 (Figs. 1.31, 1.32). On each side, a paravertebral sympathetic trunk extends from the base of the skull to the inferior end of the vertebral column where the two trunks converge anteriorly to the coccyx at the ganglion impar. Each trunk is attached

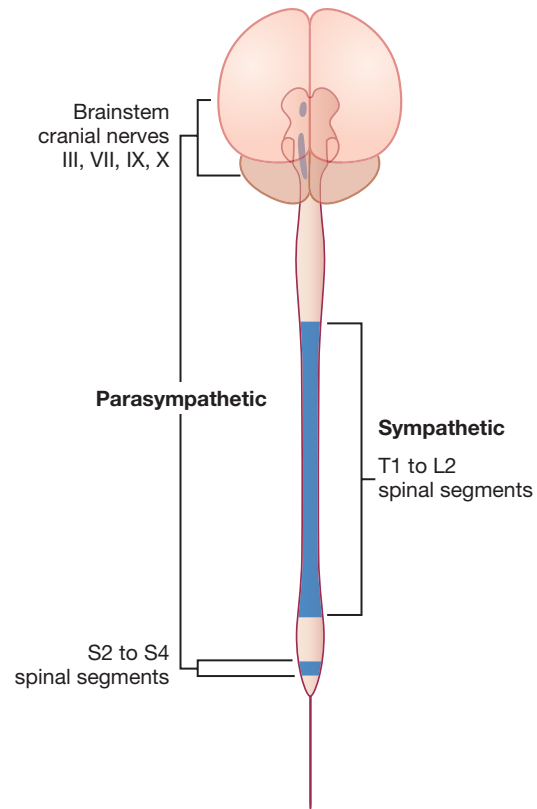


Fig. 1.31 Parts of the central nervous system associated with visceral motor components.

to the anterior rami of spinal nerves and becomes the route by which sympathetics are distributed to the periphery and all viscera.

Visceral motor preganglionic fibers leave the T1 to L2 part of the spinal cord in anterior roots. The fibers then enter the spinal nerves, pass through the anterior rami and into the sympathetic trunks. One trunk is located on each side of the vertebral column (paravertebral) and positioned anterior to the anterior rami. Along the trunk is a series of segmentally arranged ganglia formed from collections of postganglionic neuronal cell bodies where the preganglionic neurons synapse with postganglionic neurons. Anterior rami of T1 to L2 are connected to the sympathetic trunk or to a ganglion by a **white ramus communicans**, which carries preganglionic sympathetic fibers and appears white because the fibers it contains are myelinated (Fig. 1.33).

Preganglionic sympathetic fibers that enter a paravertebral ganglion or the sympathetic trunk through a white ramus communicans may take the following four pathways to target tissues:

1. Peripheral sympathetic innervation at the level of origin of the preganglionic fiber

Preganglionic sympathetic fibers may synapse with postganglionic motor neurons in ganglia associated with the

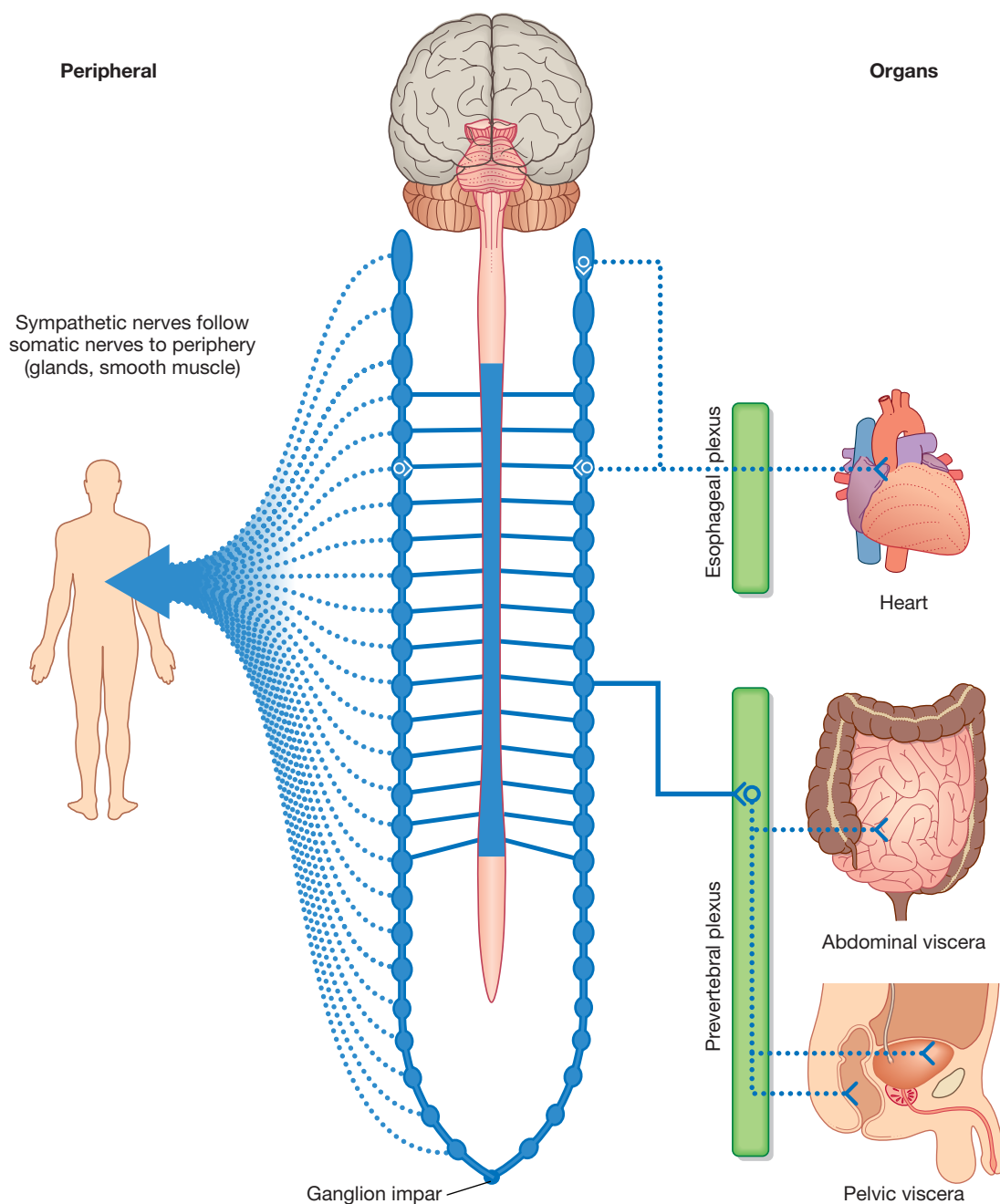


Fig. 1.32 Sympathetic part of the autonomic division of the PNS.

sympathetic trunk, after which postganglionic fibers enter the same anterior ramus and are distributed with peripheral branches of the posterior and anterior rami of that spinal nerve (Fig. 1.33). The fibers innervate structures at the periphery of the body in regions supplied by the spinal nerve. The **gray ramus communicans** connects the sympathetic trunk or a ganglion to the anterior ramus and contains the postganglionic sympathetic fibers. It appears gray because postganglionic fibers are nonmyelinated. The gray ramus communicans is positioned medial to the white ramus communicans.

2. Peripheral sympathetic innervation above or below the level of origin of the preganglionic fiber

Preganglionic sympathetic fibers may ascend or descend to other vertebral levels where they synapse in ganglia associated with spinal nerves that may or may not have visceral motor input directly from the spinal cord (i.e., those nerves other than T1 to L2) (Fig. 1.34).

The postganglionic fibers leave the distant ganglia via gray rami communicantes and are distributed along the posterior and anterior rami of the spinal nerves.

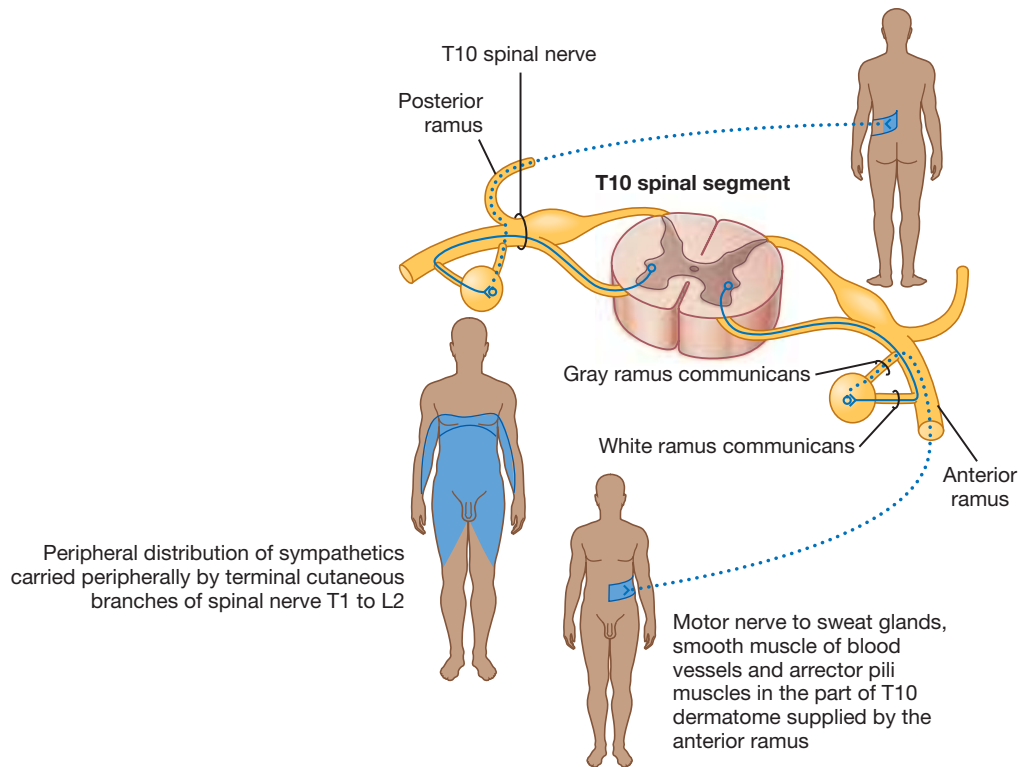


Fig. 1.33 Course of sympathetic fibers that travel to the periphery in the same spinal nerves in which they travel out of the spinal cord.

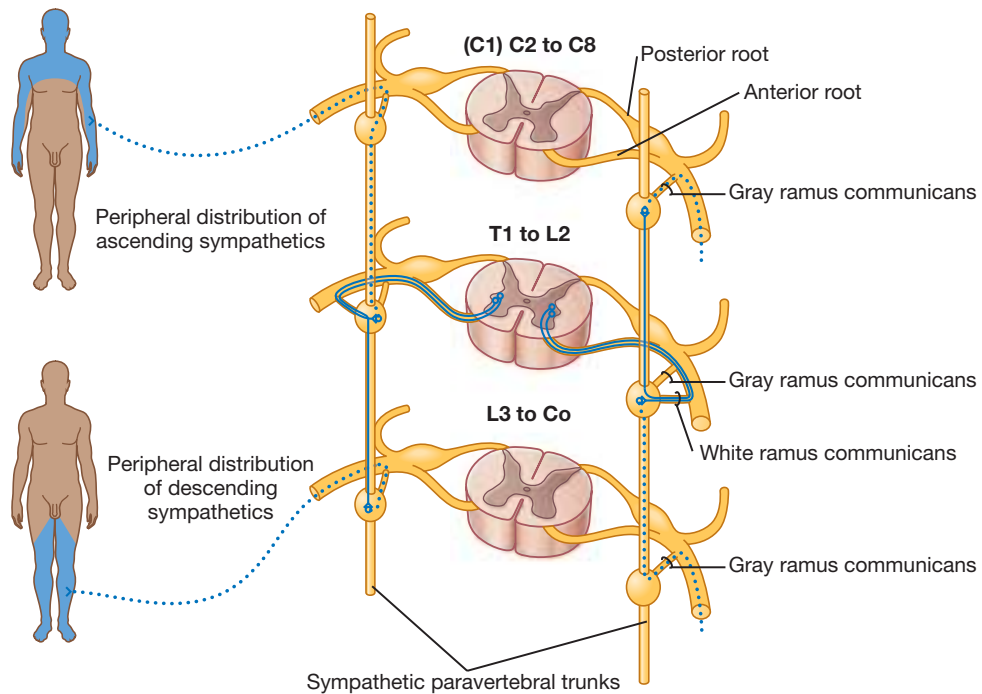


Fig. 1.34 Course of sympathetic nerves that travel to the periphery in spinal nerves that are not the ones through which they left the spinal cord.

The ascending and descending fibers, together with all the ganglia, form the **paravertebral sympathetic trunk**, which extends the entire length of the vertebral column (Fig. 1.32). The formation of this trunk, on each side, enables visceral motor fibers of the sympathetic part of the autonomic division of the PNS, which ultimately emerge from only a small region of the spinal cord (T1 to L2) to be distributed to peripheral regions innervated by all spinal nerves.

White rami communicantes only occur in association with spinal nerves T1 to L2, whereas gray rami communicantes are associated with all spinal nerves.

Fibers from spinal cord levels T1 to T5 pass predominantly superiorly, whereas fibers from T5 to L2 pass inferiorly. All sympathetics passing into the head have preganglionic fibers that emerge from spinal cord level T1 and ascend in the sympathetic trunks to the highest ganglion in the neck (the **superior cervical ganglion**) where they synapse. Postganglionic fibers then travel along blood vessels to target tissues in the head, including blood vessels, sweat glands, small smooth muscles associated with the upper eyelids, and the dilator of the pupil.

3. Sympathetic innervation of thoracic and cervical viscera

Preganglionic sympathetic fibers may synapse with postganglionic motor neurons in ganglia and then leave the ganglia medially to innervate thoracic or cervical viscera (Fig. 1.35). They may ascend in the trunk before synapsing; after synapsing, the postganglionic fibers may combine with those from other levels to form named visceral nerves, such as cardiac nerves. Often, these nerves join branches from the parasympathetic system to form plexuses on or near the surface of the target organ (e.g., the cardiac and pulmonary plexuses). Branches of the plexus innervate the organ. Spinal cord levels T1 to T5 mainly innervate cranial, cervical, and thoracic viscera.

4. Sympathetic innervation of the abdomen and pelvic regions and the adrenals

Preganglionic sympathetic fibers may pass through the sympathetic trunk and paravertebral ganglia without synapsing and, together with similar fibers from other levels, form **splanchnic nerves** (**greater, lesser, least, lumbar, and sacral**),

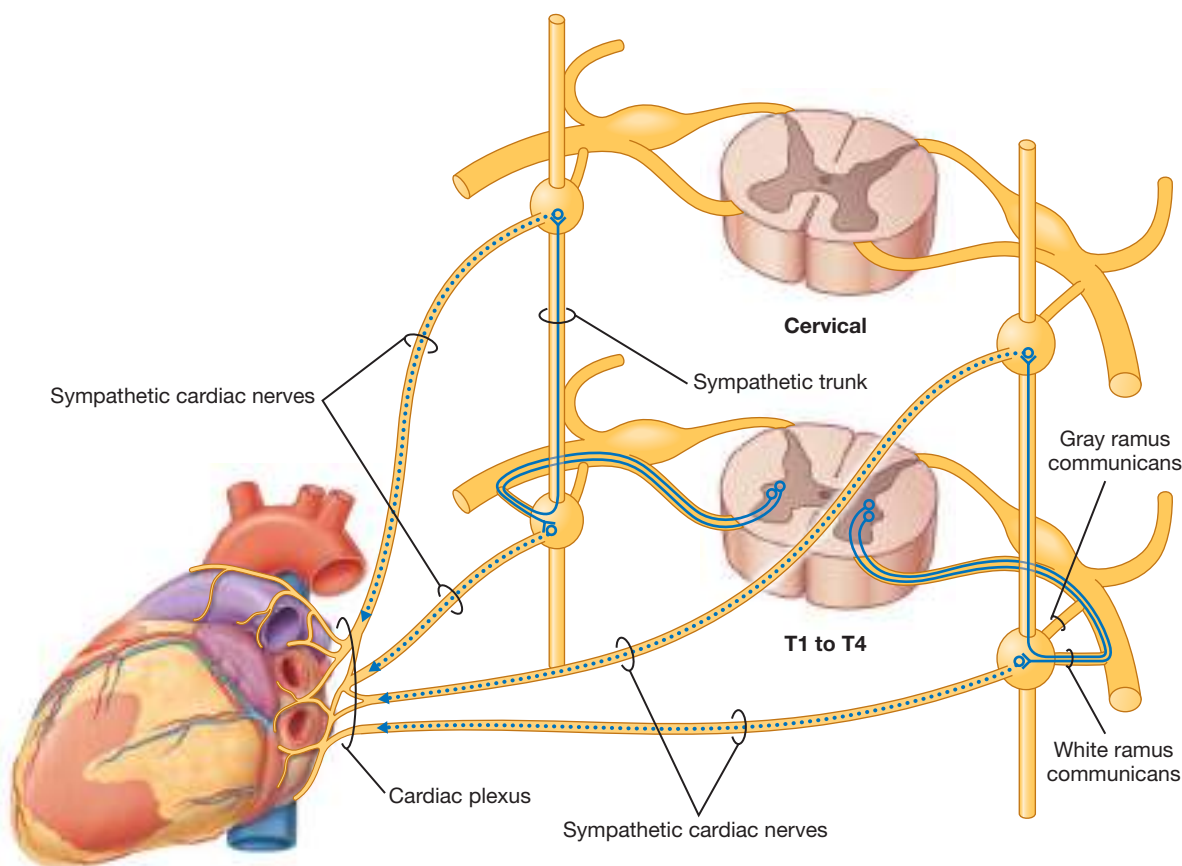


Fig. 1.35 Course of sympathetic nerves traveling to the heart.

which pass into the abdomen and pelvic regions (Fig. 1.36). The preganglionic fibers in these nerves are derived from spinal cord levels T5 to L2.

The splanchnic nerves generally connect with sympathetic ganglia around the roots of major arteries that branch from the abdominal aorta. These ganglia are part of a large prevertebral plexus that also has input from the parasympathetic part of the autonomic division of the PNS. Postganglionic sympathetic fibers are distributed in extensions of this plexus, predominantly along arteries, to viscera in the abdomen and pelvis.

Some of the preganglionic fibers in the prevertebral plexus do not synapse in the sympathetic ganglia of the plexus but pass through the system to the adrenal gland where they synapse directly with cells of the adrenal medulla. These cells are homologues of sympathetic postganglionic neurons and secrete adrenaline and noradrenaline into the vascular system.

Parasympathetic system

The parasympathetic part of the autonomic division of the PNS (Fig. 1.37) leaves cranial and sacral regions of the CNS in association with:

- cranial nerves III, VII, IX, and X: III, VII, and IX carry parasympathetic fibers to structures within the head and neck only, whereas X (the vagus nerve) also innervates thoracic and most abdominal viscera; and
- spinal nerves S2 to S4: sacral parasympathetic fibers innervate inferior abdominal viscera, pelvic viscera, and the arteries associated with erectile tissues of the perineum.

Like the visceral motor nerves of the sympathetic part, the visceral motor nerves of the parasympathetic part generally have two neurons in the pathway. The preganglionic neurons are in the CNS, and fibers leave in the cranial nerves or pelvic splanchnic nerves.

Sacral preganglionic parasympathetic fibers

In the sacral region, the preganglionic parasympathetic fibers form special visceral nerves (the **pelvic splanchnic nerves**), which originate from the anterior rami of S2 to S4 and enter pelvic extensions of the large prevertebral plexus formed around the abdominal aorta. These fibers are distributed to pelvic and abdominal viscera mainly along blood vessels. The

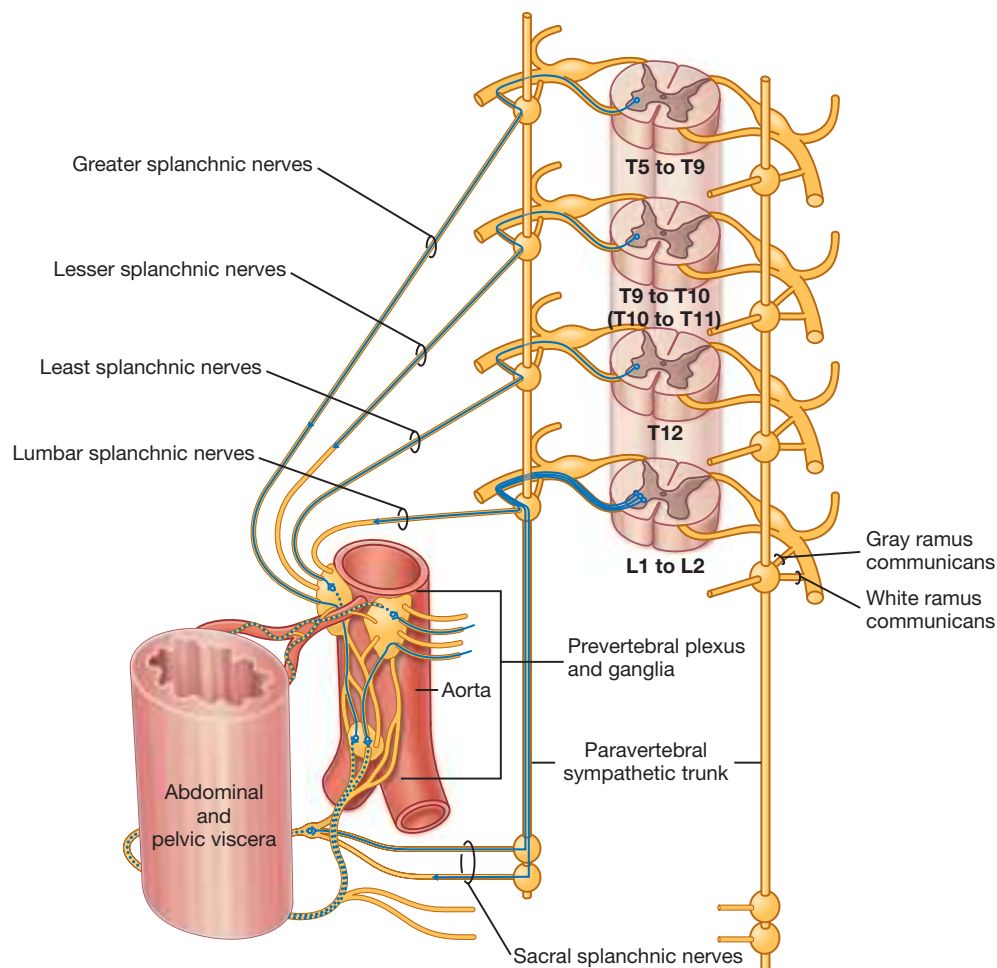


Fig. 1.36 Course of sympathetic nerves traveling to abdominal and pelvic viscera.

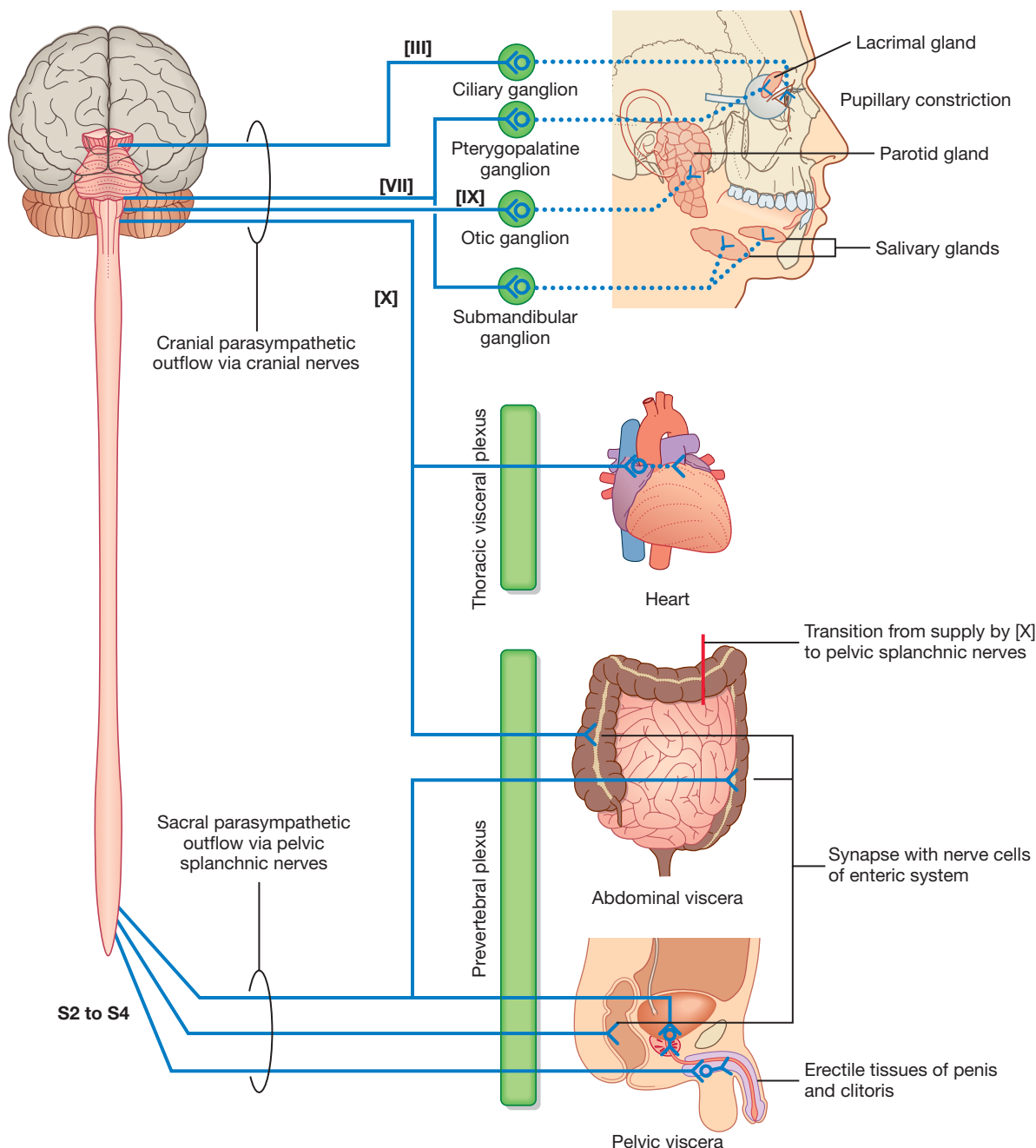


Fig. 1.37 Parasympathetic part of the autonomic division of the PNS.

postganglionic motor neurons are in the walls of the viscera. In organs of the gastrointestinal system, preganglionic fibers do not have a postganglionic parasympathetic motor neuron in the pathway; instead, preganglionic fibers synapse directly on neurons in the ganglia of the enteric system.

Cranial nerve preganglionic parasympathetic fibers

The preganglionic parasympathetic motor fibers in CN III, VII, and IX separate from the nerves and connect with one of four distinct ganglia, which house postganglionic motor

neurons. These four ganglia are near major branches of the trigeminal nerve [V]. Postganglionic fibers leave the ganglia, join the branches of the trigeminal nerve [V], and are carried to target tissues (salivary, mucous, and lacrimal glands; constrictor muscle of the pupil; and ciliary muscle in the eye) with these branches.

The vagus nerve [X] gives rise to visceral branches along its course. These branches contribute to plexuses associated with thoracic viscera or to the large prevertebral plexus in the abdomen and pelvis. Many of these plexuses also contain sympathetic fibers.

When present, postganglionic parasympathetic neurons are in the walls of the target viscera.

Visceral sensory innervation (visceral afferents)

Visceral sensory fibers generally accompany visceral motor fibers.

Visceral sensory fibers accompanying sympathetic fibers

Visceral sensory fibers follow the course of sympathetic fibers entering the spinal cord at similar spinal cord levels. However, visceral sensory fibers may also enter the spinal cord at levels other than those associated with motor output. For example, visceral sensory fibers from the heart may enter at levels higher than spinal cord level T1. Visceral sensory fibers that accompany sympathetic fibers are mainly concerned with detecting pain.

Visceral sensory fibers accompanying parasympathetic fibers

Visceral sensory fibers accompanying parasympathetic fibers are carried mainly in the glossopharyngeal nerve [IX] and the vagus nerve [X] and in spinal nerves S2 to S4. These fibers primarily relay information to the CNS about the status of normal physiologic processes and reflex activities.

Visceral sensory fibers in the glossopharyngeal nerve [IX] carry information from chemoreceptors and baroreceptors

associated with the walls of major arteries in the neck and from receptors in the pharynx.

Visceral sensory fibers in the vagus nerve [X] include those from cervical viscera and major vessels and viscera in the thorax and abdomen.

Visceral sensory fibers from pelvic viscera and the distal parts of the colon are carried in S2 to S4.

The enteric system

The enteric nervous system consists of motor and sensory neurons and their support cells, which form two interconnected plexuses, the **myenteric** and **submucous nerve plexuses**, within the walls of the gastrointestinal tract (Fig. 1.38). Each of these plexuses is formed by:

- ganglia, which house the nerve cell bodies and associated cells; and
- bundles of nerve fibers, which pass between ganglia and from the ganglia into surrounding tissues.

Neurons in the enteric system are derived from neural crest cells originally associated with occipitocervical and sacral regions. Interestingly, more neurons are reported to be in the enteric system than in the spinal cord itself.

Sensory and motor neurons within the enteric system control reflex activity within and between parts of the gastrointestinal system. These reflexes regulate peristalsis, secretomotor activity, and vascular tone. These activities can

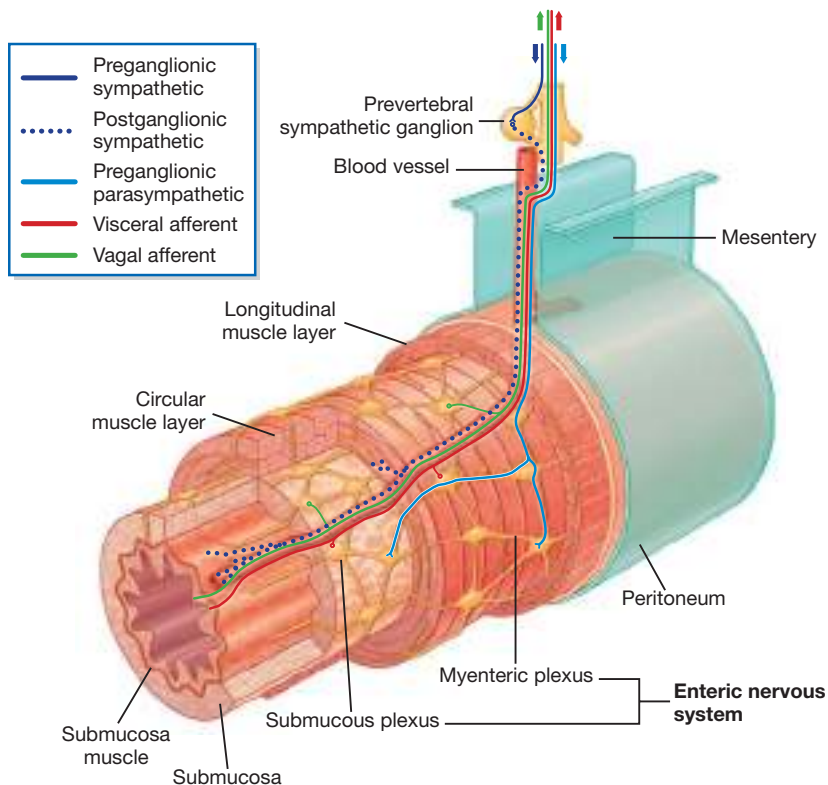


Fig. 1.38 Enteric part of the nervous system.

occur independently of the brain and spinal cord but can also be modified by input from preganglionic parasympathetic and postganglionic sympathetic fibers.

Sensory information from the enteric system is carried back to the CNS by visceral sensory fibers.

Nerve plexuses

Nerve plexuses are either somatic or visceral and combine fibers from different sources or levels to form new nerves with specific targets or destinations (Fig. 1.39). Plexuses of the enteric system also generate reflex activity independent of the CNS.

Somatic plexuses

Major somatic plexuses formed from the anterior rami of spinal nerves are the cervical (C1 to C4), brachial (C5 to T1),

lumbar (L1 to L4), sacral (L4 to S4), and coccygeal (S5 to Co) plexuses (Fig. 1.39). Except for spinal nerve T1, the anterior rami of thoracic spinal nerves remain independent and do not participate in plexuses.

Visceral plexuses

Visceral nerve plexuses are formed in association with viscera and generally contain efferent (sympathetic and parasympathetic) and afferent components (Fig. 1.39). These plexuses include cardiac and pulmonary plexuses in the thorax and a large prevertebral plexus in the abdomen anterior to the aorta, which extends inferiorly onto the lateral walls of the pelvis. The massive prevertebral plexus supplies input to and receives output from all abdominal and pelvic viscera.

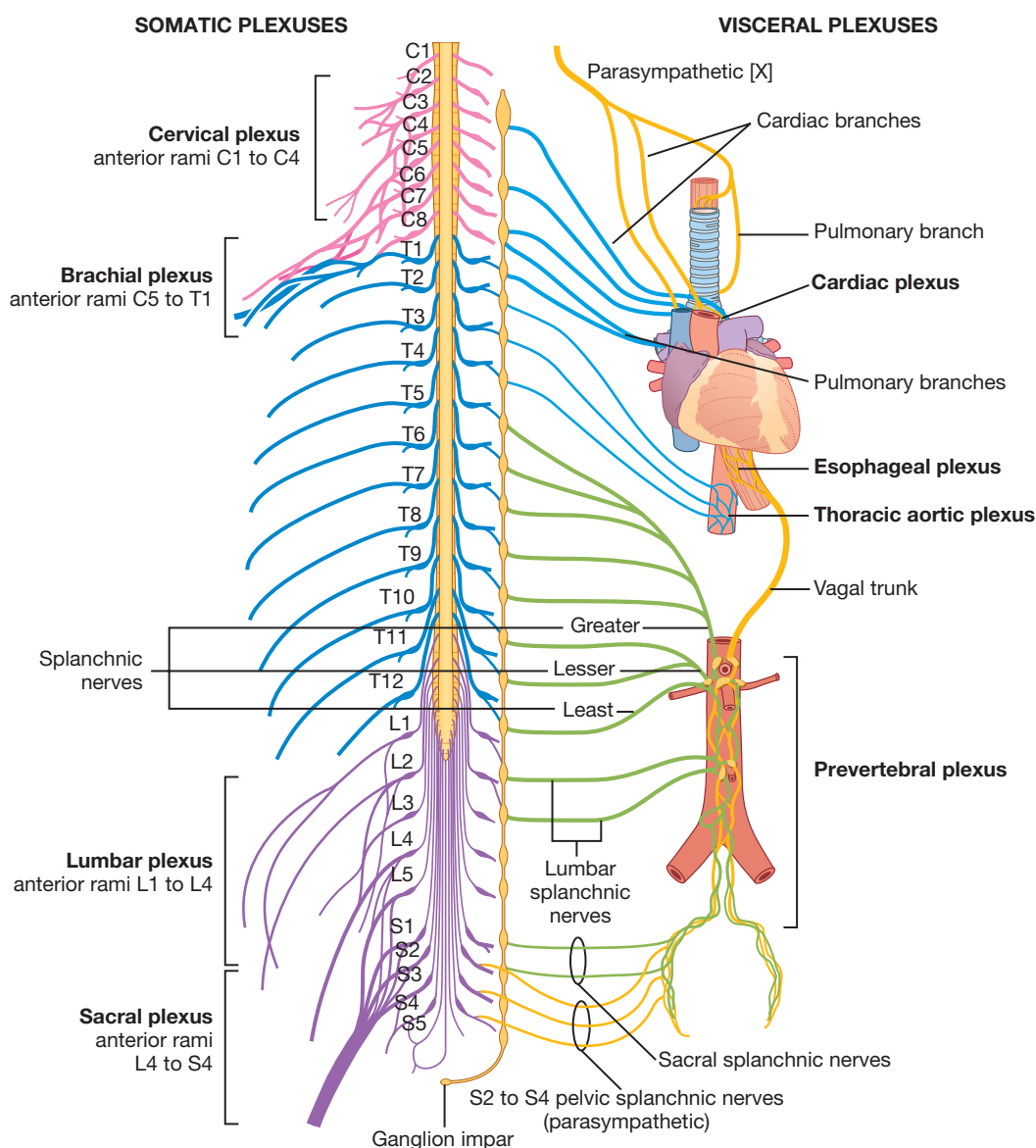


Fig. 1.39 Nerve plexuses.

Clinical app

Referred pain

Referred pain occurs when sensory information comes to the spinal cord from one location but is interpreted by the CNS as coming from another location innervated by the same spinal cord level. Usually, this happens when the pain information comes from a region, such as the gut, which has a low amount of sensory output. These afferents converge on neurons at the same spinal cord level that receive information from the skin, which is an area with a high amount of sensory output. As a result, pain from the normally low output region is interpreted as coming from the normally high output region.

Pain is most often referred from a region innervated by the visceral part of the nervous system to a region innervated, at the same spinal cord level, by the somatic side of the nervous system.

Pain can also be referred from one somatic region to another. For example, irritation of the peritoneum on the inferior surface of the diaphragm, which is innervated by the phrenic nerve, can be referred to the skin on the top of the shoulder, which is innervated by other somatic nerves arising at the same spinal cord level.

OTHER SYSTEMS

Specific information about the organization and components of the respiratory, gastrointestinal, and urogenital systems will be discussed in each of the succeeding chapters of this text.

2

Back

ADDITIONAL LEARNING RESOURCES FOR CHAPTER 2, *BACK*, CAN BE FOUND ON THE ACCOMPANYING EBOOK:

- Self-Assessment—National Board style multiple-choice questions, Chapter 2
- Short Questions—these are questions requiring short responses, Chapter 2
- PT Case Studies
 - Low back instability
 - Stenosis
 - Herniated nucleus pulposus
 - Atlanto-occipital dysfunction
 - Atlanto-axial dysfunction
 - Mid-cervical dysfunction
 - Cauda equina syndrome
 - Cervical degenerative joint disease
 - Cervical radiculopathy
- Clinical Cases
 - Ankylosing spondylitis
 - Atlas fracture
 - Cervical facet syndrome
 - Lumbar puncture
 - Spinal cord infarction
 - Sciatica versus lumbago
 - Cervical spinal cord injury
 - Psoas abscess
 - Dissecting thoracic aneurysm
 - Sacral tumor

Regional anatomy 36

Skeletal framework 36

- Vertebrae 36
- Intervertebral foramina 40
- Posterior spaces between vertebral arches 41
- Curvatures of vertebral column 41

Joints 42

- Joints between vertebrae in the back 42

Ligaments 46

- Anterior and posterior longitudinal ligaments 46
- Ligamenta flava 46
- Supraspinous ligament and ligamentum nuchae 46
- Interspinous ligaments 47

Back musculature 48

- Superficial group of back muscles 48
- Intermediate group of back muscles 50
- Deep group of back muscles 51
- Thoracolumbar fascia 53

Spinal cord 55

- Vasculature 56
- Meninges 57
- Arrangement of structures in the vertebral canal 58
- Spinal nerves 58

Regional anatomy

The back consists of the posterior aspect of the body and provides the musculoskeletal axis of support for the trunk. The back also contains the spinal cord and proximal parts of the spinal nerves, which send and receive information to and from most of the body.

SKELETAL FRAMEWORK

Skeletal components of the back consist mainly of the vertebrae and associated intervertebral discs. The skull, scapulae, pelvic bones (ileum, ischium, pubis), and ribs also contribute to the bony framework of the back and provide sites for muscle attachment.

Vertebrae

There are approximately 33 vertebrae, which are subdivided into five groups based on morphology and location (Fig. 2.1):

- The seven cervical vertebrae between the thorax and skull are characterized mainly by their small size, bifid spinous processes, and the presence of a foramen in each transverse process (Figs. 2.1, 2.2).
- The 12 thoracic vertebrae are characterized by their articulated ribs (Figs. 2.1, 2.3); ribs are separate bones and articulate via synovial joints with the vertebral bodies and transverse processes of the associated vertebrae; although

Imaging app

Typical cervical vertebrae

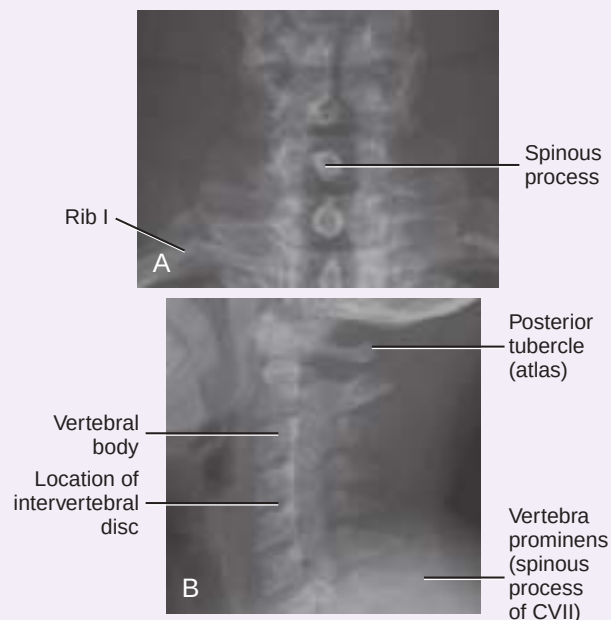
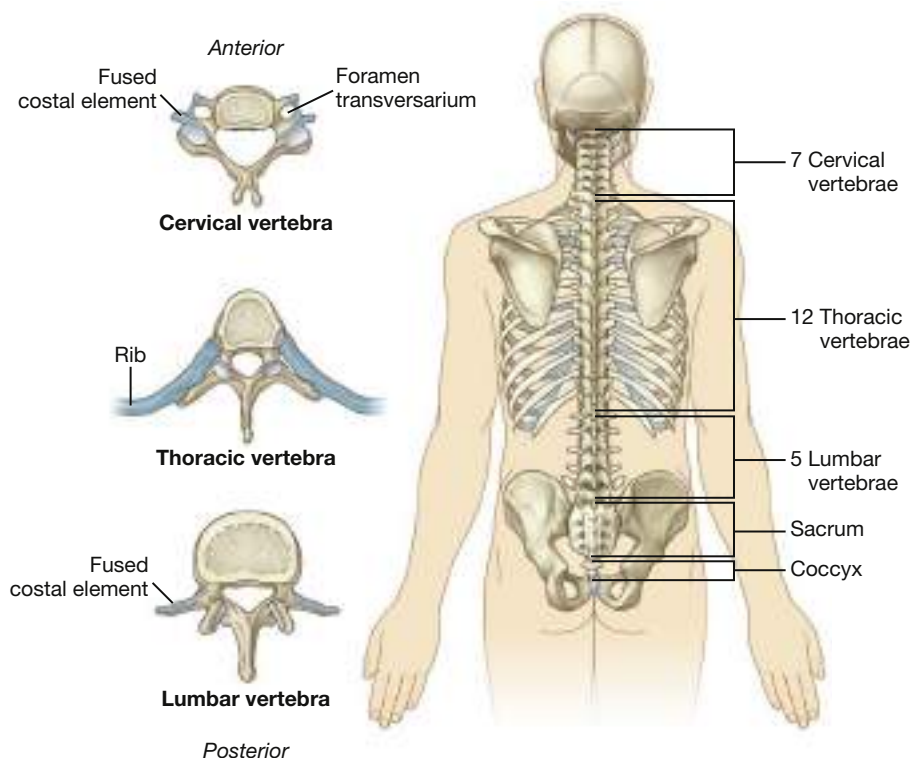


Fig. 2.2 Radiographs of cervical region of vertebral column. **A.** Anterior-posterior view. **B.** Lateral view.

all vertebrae have rib elements, these elements are small and are incorporated into the transverse processes in regions other than the thorax.

Fig. 2.1 Vertebrae.



Imaging app

Typical thoracic vertebrae

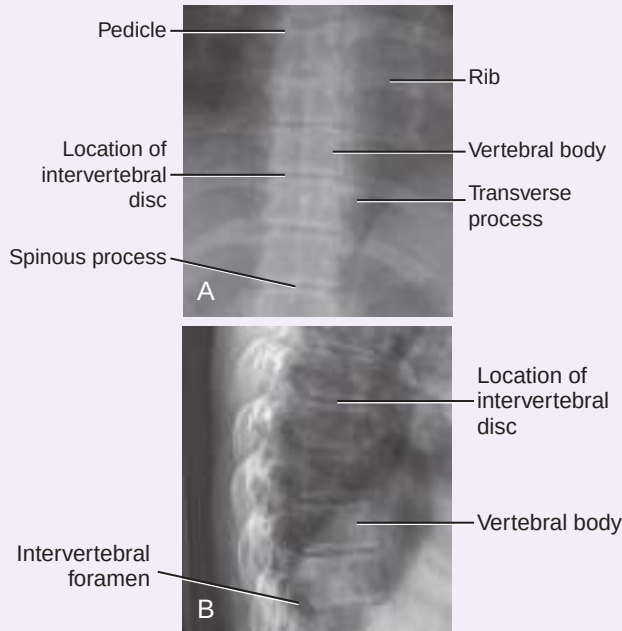


Fig. 2.3 Radiograph of thoracic region of vertebral column. **A.** Anterior-posterior view. **B.** Lateral view.

Imaging app

Typical lumbar vertebrae

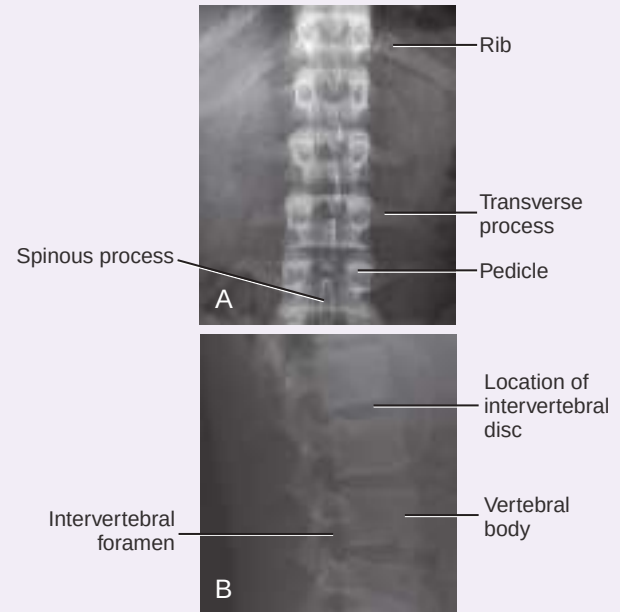


Fig. 2.4 Radiograph of lumbar region of vertebral column. **A.** Anterior-posterior view. **B.** Lateral view.

- Inferior to the thoracic vertebrae are five lumbar vertebrae, which form the skeletal support for the posterior abdominal wall and are characterized by their large size (Figs. 2.1, 2.4).
- Next are five sacral vertebrae fused into one single bone called the sacrum, which articulates on each side with a pelvic bone and is a component of the pelvic wall.
- Inferior to the sacrum is a variable number, usually four, of coccygeal vertebrae, which fuse into a single small triangular bone called the *coccyx*.

Typical vertebra

A typical vertebra consists of a vertebral body and a posterior vertebral arch (Fig. 2.5). Extending from the vertebral arch are a number of processes for muscle attachment and articulation with adjacent bones.

The **vertebral body** is the weight-bearing part of the vertebra and is linked to adjacent vertebral bodies by intervertebral discs and ligaments. The size of vertebral bodies increases inferiorly as the amount of weight supported increases.

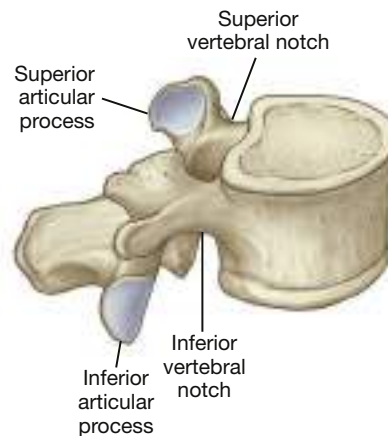
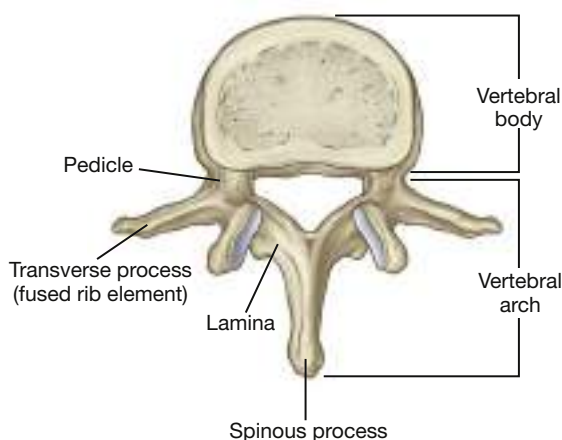


Fig. 2.5 Typical vertebra.

The **vertebral arch** forms the lateral and posterior parts of the vertebral foramen.

The vertebral foramina of all the vertebrae together form the **vertebral canal**, which contains and protects the spinal cord. Superiorly, the vertebral canal is continuous through the foramen magnum of the skull, with the cranial cavity of the head.

The vertebral arch of each vertebra consists of pedicles and laminae (Fig. 2.5):

- The two **pedicles** are bony pillars that attach the vertebral arch to the vertebral body.
- The two **laminae** are flat sheets of bone that extend from each pedicle to meet in the midline and form the roof of the vertebral arch.

A **spinous process** projects posteriorly and inferiorly from the junction of the two laminae and is a site for muscle and ligament attachment.

A **transverse process** extends posterolaterally from the junction of the pedicle and lamina on each side and is a site for muscle and ligament attachment and articulation with ribs in the thoracic region.

Also projecting from the region where the pedicles join the laminae are **superior** and **inferior articular processes** (Fig. 2.5), which articulate with the inferior and superior articular processes, respectively, of adjacent vertebrae.

Between the vertebral body and the origin of the articular processes, each pedicle is notched on its superior and inferior surfaces. These **superior** and **inferior vertebral notches** participate in forming intervertebral foramina.

Cervical vertebrae

The seven cervical vertebrae are characterized by their small size and by the presence of a foramen in each transverse process. A typical cervical vertebra has the following features (Fig. 2.6A):

- The vertebral body is short in height and square shaped when viewed from above and has a concave superior surface and a convex inferior surface.
- Each transverse process is trough shaped and perforated by a round **foramen transversarium**.
- The spinous process is short and bifid.
- The vertebral foramen is triangular.

The first and second cervical vertebrae—the atlas and axis—are specialized to accommodate movement of the head.

Atlas and axis

Vertebra CI (the **atlas**) articulates with the head (Figs. 2.6B, 2.7). Its major distinguishing feature is that it lacks a

vertebral body (Fig. 2.6B). In fact, the vertebral body of CI fuses onto the body of CII during development to become the dens of CII. As a result, there is no intervertebral disc between CI and CII. When viewed from above, the atlas is ring shaped and composed of two **lateral masses** interconnected by an **anterior arch** and a **posterior arch**.

Each lateral mass articulates above with an occipital **condyle** of the skull and below with the superior articular process of vertebra CII (the **axis**). The **superior articular facets** are bean shaped and concave, whereas the **inferior articular facets** are almost circular and flat.

The **atlanto-occipital joint** allows the head to nod up and down on the vertebral column.

The posterior surface of the anterior arch has an articular facet for the **dens**, which projects superiorly from the vertebral body of the axis. The dens is held in position by a strong **transverse ligament of atlas** posterior to it and spanning the distance between the oval attachment facets on the medial surfaces of the lateral masses of the atlas (Fig. 2.6B).

The dens acts as a pivot that allows the atlas and attached head to rotate on the axis, side to side.

The transverse processes of the atlas are large and protrude farther laterally than those of the other cervical vertebrae. They act as levers for muscle action, particularly for muscles that move the head at the **atlanto-axial joints**.

The axis is characterized by the large tooth-like dens, which extends superiorly from the vertebral body (Figs. 2.6B, 2.7). The anterior surface of the dens has an oval facet for articulation with the anterior arch of the atlas.

The two superolateral surfaces of the dens possess circular impressions that serve as attachment sites for strong alar ligaments, one on each side, which connect the dens to the medial surfaces of the occipital condyles. These **alar ligaments** check excessive rotation of the head and atlas relative to the axis (Fig. 2.6B).

Thoracic vertebrae

The twelve thoracic vertebrae are all characterized by their articulation with ribs. A typical thoracic vertebra has two partial facets (superior and inferior costal facets) on each side of the vertebral body for articulation with the head of its own rib and the head of the rib below (Fig. 2.6C). The superior costal facet is much larger than the inferior costal facet.

Each transverse process also has a facet (transverse costal facet) for articulation with the tubercle of its own rib. The vertebral body of the vertebra is somewhat heart-shaped when viewed from above, and the vertebral foramen is circular.

Lumbar vertebrae

The five lumbar vertebrae are distinguished from vertebrae in other regions by their large size (Fig. 2.6D). Also, they lack

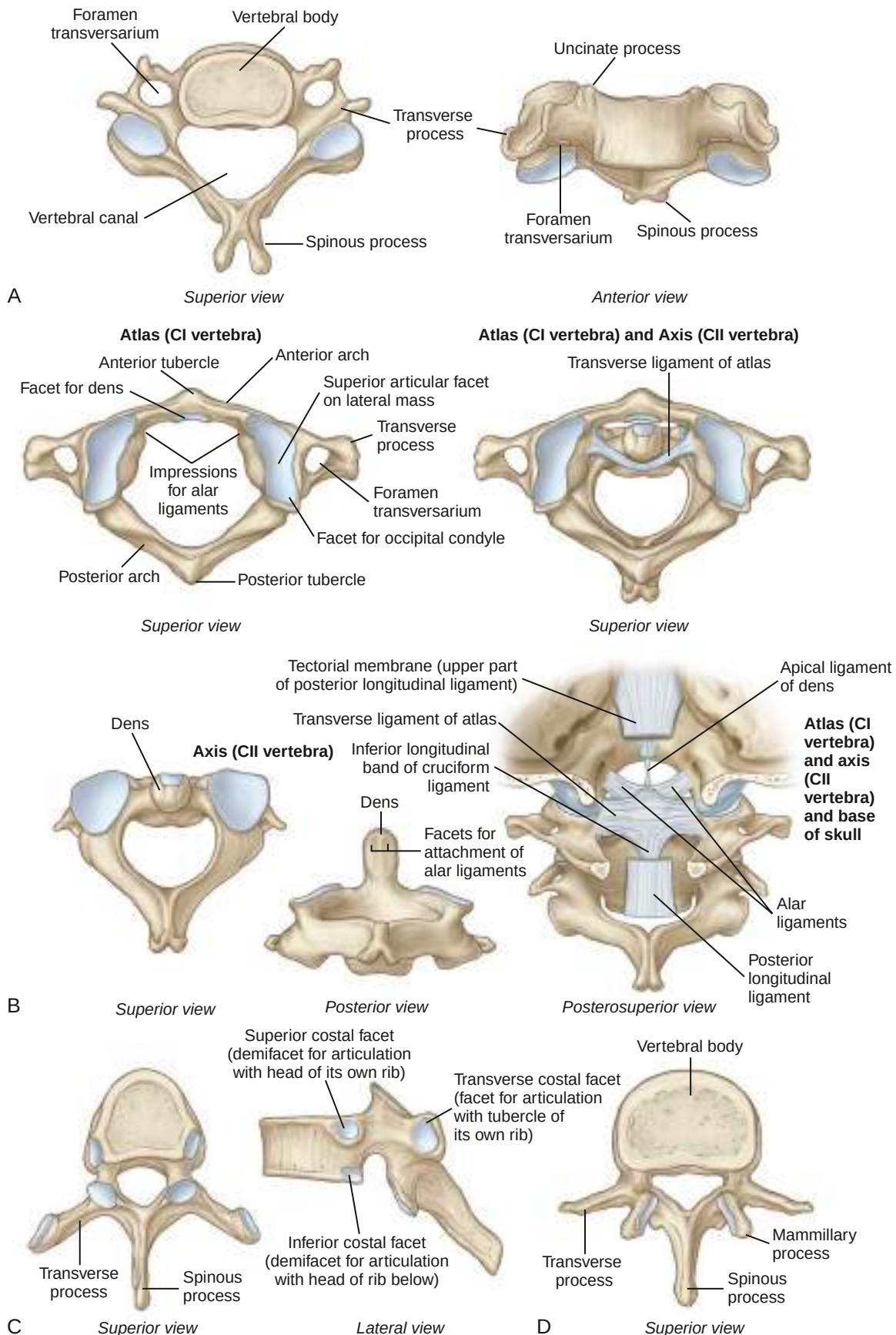


Fig. 2.6 Regional vertebrae. **A.** Typical cervical vertebra. **B.** Atlas and axis. **C.** Typical thoracic vertebra. **D.** Typical lumbar vertebra.

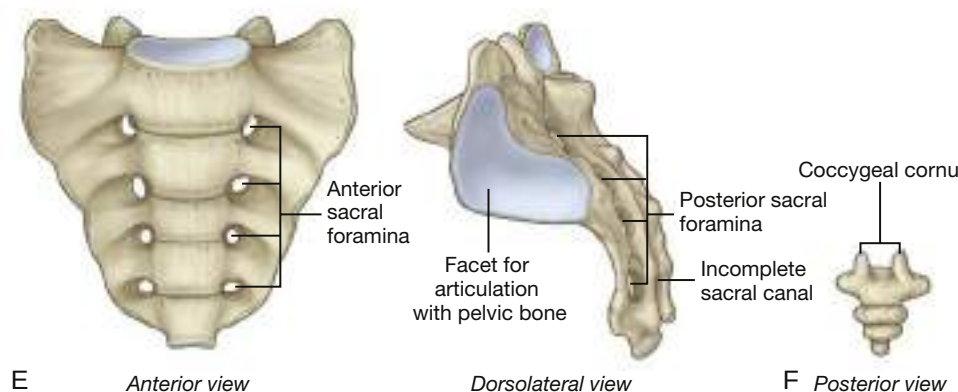


Fig. 2.6, cont'd Regional vertebrae. E. Sacrum. F. Coccyx.

Imaging app

Articulation between atlas and axis



Superior articular facet of CII Dens Inferior articular facet on lateral mass of CI

Fig. 2.7 Radiograph showing CI (atlas) and CII (axis) vertebrae. Open mouth, anterior-posterior (odontoid peg) view.

facets for articulation with ribs. The transverse processes are generally thin and long, with the exception of those on vertebra LV, which are massive and somewhat cone-shaped for the attachment of **iliolumbar ligaments** to connect the transverse processes to the pelvic bones.

The vertebral body of a typical lumbar vertebra is cylindrical and the vertebral foramen is triangular in shape and larger than in the thoracic vertebrae.

Sacrum

The sacrum is a single bone that represents the five fused sacral vertebrae (Fig. 2.6E). It is triangular in shape with the **apex** pointed inferiorly and is curved so that it has a concave anterior surface and a correspondingly convex posterior

surface. It articulates above with vertebra LV and below with the coccyx. It has two large L-shaped facets, one on each lateral surface, for articulation with the pelvic bones.

The posterior surface of the sacrum has four pairs of posterior sacral foramina, and the anterior surface has four pairs of anterior sacral foramina for the passage of the posterior and anterior rami, respectively, of S1 to S4 spinal nerves.

The posterior wall of the vertebral canal may be incomplete near the inferior end of the sacrum.

Coccyx

The coccyx is a small triangular bone that articulates with the inferior end of the sacrum and represents three to four fused coccygeal vertebrae (Fig. 2.6F). It is characterized by its small size and by the absence of vertebral arches and therefore a vertebral canal.

Intervertebral foramina

Intervertebral foramina are formed on each side between adjacent parts of vertebrae and associated intervertebral discs (Fig. 2.9). The foramina allow structures, such as spinal nerves and blood vessels, to pass in and out of the vertebral canal.

An intervertebral foramen is formed by the inferior vertebral notch on the pedicle of the vertebra above and the superior vertebral notch on the pedicle of the vertebra below. The foramen is bordered:

- posteriorly by the zygapophysial joint between the articular processes of the two vertebrae, and
- anteriorly by the intervertebral disc and adjacent vertebral bodies.

Each intervertebral foramen is a confined space surrounded by bone, ligaments, and joints. Pathology in any of these structures, and in the surrounding muscles, can affect structures within the foramen.

Surface anatomy

How to identify specific vertebral spinous processes

Identification of vertebral spinous processes (Fig. 2.8A) can be used to differentiate between regions of the vertebral column and facilitate visualizing the position of deeper structures, such as the inferior ends of the spinal cord and subarachnoid space.

The spinous process of vertebra CII can be identified through deep palpation as the most superior bony protuberance in the midline inferior to the skull.

Most of the other spinous processes, except for that of vertebra CVII, are not readily palpable because they are obscured by soft tissue.

The spinous process of CVII is usually visible as a prominent eminence in the midline at the base of the neck (Fig. 2.8B), particularly when the neck is flexed.

Inferior to the spinous process of CVII is the spinous process of TI, which is also usually visible as a midline protuberance. Often it is more prominent than the spinous process of CVII.

The root of the spine of the scapula is at the same level as the spinous process of vertebra TIII, and the inferior angle of the scapula is level with the spinous process of vertebra TVII.

The spinous process of vertebra TXII is level with the midpoint of a vertical line between the inferior angle of the scapula and the iliac crest.

A horizontal line between the highest point of the iliac crest on each side crosses through the spinous process of vertebra LIV. The LIII and LV vertebral spinous processes can be palpated above and below the LIV spinous process, respectively.

The sacral dimples that mark the position of the posterior superior iliac spine are level with the SII vertebral spinous process.

The tip of the coccyx is palpable at the base of the vertebral column between the gluteal masses.

The tips of the vertebral spinous processes do not always lie in the same horizontal plane as their corresponding vertebral bodies. In thoracic regions, the spinous processes are long and sharply sloped downward so that their tips lie at the level of the vertebral

body below. In other words, the tip of the TIII vertebral spinous process lies at vertebral level TIV.

In lumbar and sacral regions, the spinous processes are generally shorter and less sloped than in thoracic regions, and their palpable tips more closely reflect the position of their corresponding vertebral bodies. As a consequence, the palpable end of the spinous process of vertebra LIV lies at approximately the LIV vertebral level.

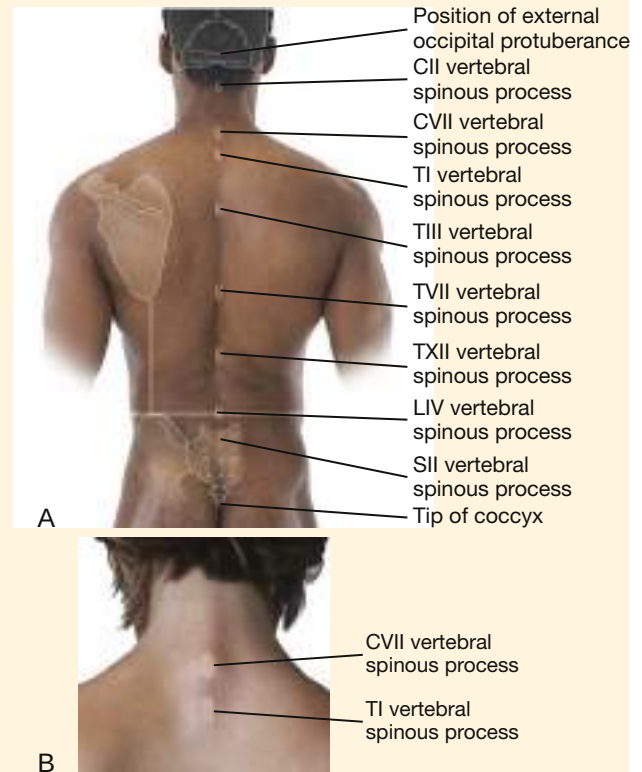


Fig. 2.8 The back with the positions of vertebral spinous processes and associated structures indicated. **A.** In a man. **B.** In a woman with neck flexed. The prominent CVII and TI vertebral spinous processes are labeled.

Posterior spaces between vertebral arches

In most regions of the vertebral column, the laminae and spinous processes of adjacent vertebrae overlap to form a reasonably complete bony posterior (dorsal) wall for the vertebral canal. However, in the lumbar region, large gaps exist between the posterior components of adjacent vertebral arches (Fig. 2.10). These gaps between adjacent laminae and spinous processes become increasingly wide from vertebra LI to vertebra LV. The spaces can be widened further by flexion of the vertebral column. These gaps allow relatively easy access to the vertebral canal for clinical procedures.

Curvatures of vertebral column

The vertebral column has a number of curvatures (Fig. 2.11):

- The primary curvature of the vertebral column is concave anteriorly, reflecting the original shape of the embryo, and is retained in the thoracic and sacral regions in adults.
- Secondary curvatures, which are concave posteriorly, form in the cervical and lumbar regions and bring the center of gravity into a vertical line, which allows the body's weight to be balanced on the vertebral column in a way that expends the least amount of muscular energy to maintain an upright bipedal stance.

Fig. 2.9 Intervertebral foramen.

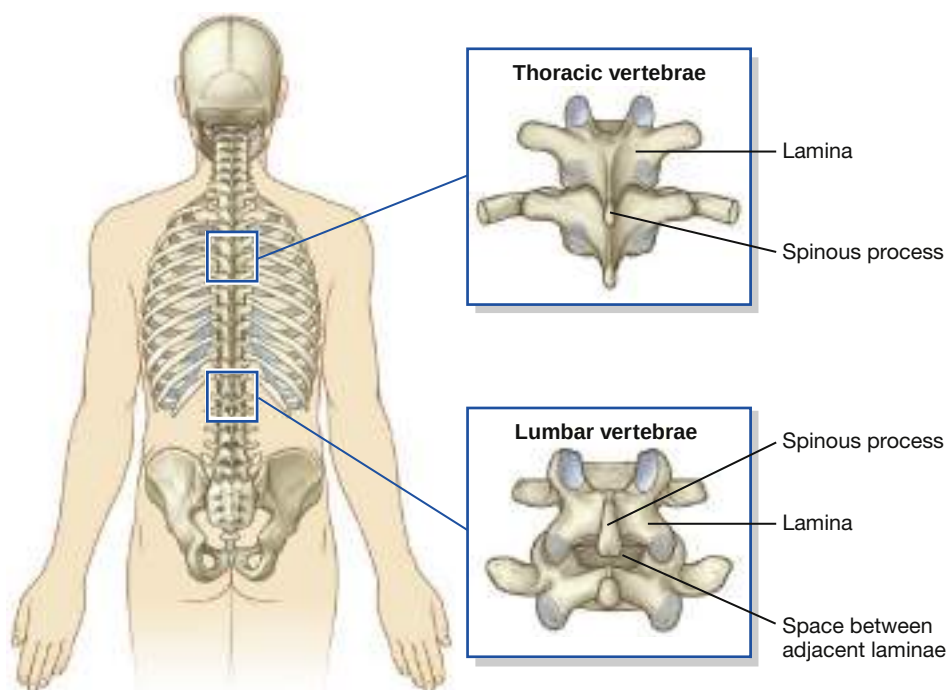


Fig. 2.10 Spaces between adjacent vertebral arches in the lumbar region.

JOINTS

Joints between vertebrae in the back

The two major types of joints between vertebrae are:

- symphyses between vertebral bodies, and
- synovial joints between articular processes.

A typical vertebra has a total of six joints with adjacent vertebrae: four synovial joints (two above and two below) and two symphyses (one above and one below). Each symphysis includes an intervertebral disc.

Although the movement between any two vertebrae is limited, the summation of movement among all vertebrae results in a large range of movement by the vertebral column.

Movements by the vertebral column include flexion, extension, lateral flexion, rotation, and circumduction.

Movements by vertebrae in a specific region (cervical, thoracic, and lumbar) are determined by the shape and orientation of joint surfaces on the articular processes and on the vertebral bodies.

Symphyses between vertebral bodies (intervertebral discs)

The symphysis between adjacent vertebral bodies is formed by a layer of hyaline cartilage on each vertebral body and an intervertebral disc, which lies between the layers.

The **intervertebral disc** consists of an outer anulus fibrosus, which surrounds a central nucleus pulposus (Fig. 2.14).

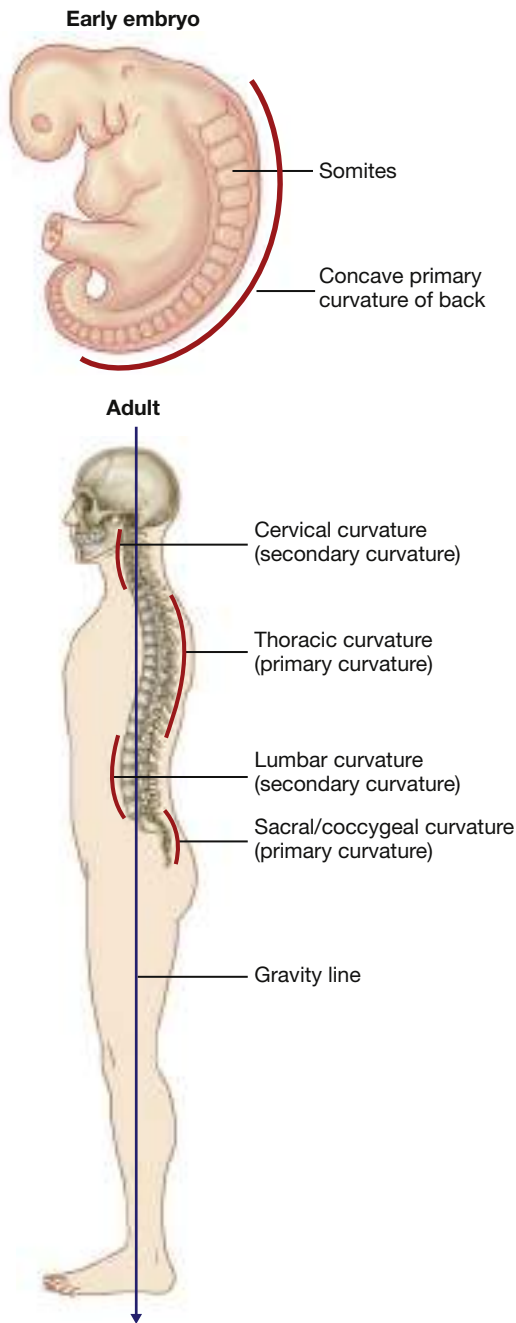


Fig. 2.11 Curvatures of the vertebral column.

- The **anulus fibrosus** consists of an outer ring of collagen surrounding a wider zone of fibrocartilage arranged in a lamellar configuration. This arrangement of fibers limits rotation between vertebrae.
- The **nucleus pulposus** fills the center of the intervertebral disc, is gelatinous, and absorbs compression forces between vertebrae.

Degenerative changes in the anulus fibrosus can lead to herniation of the nucleus pulposus. Posterolateral herniation can impinge on the roots of a spinal nerve in the intervertebral foramen (Fig. 2.17).

Surface anatomy

Primary and secondary curvatures in the sagittal plane

When viewed from the side, the normal vertebral column has primary curvatures in the thoracic and sacral/coccygeal regions and secondary curvatures in the cervical and lumbar regions (Fig. 2.12). The primary curvatures are concave anteriorly. The secondary curvatures are concave posteriorly.

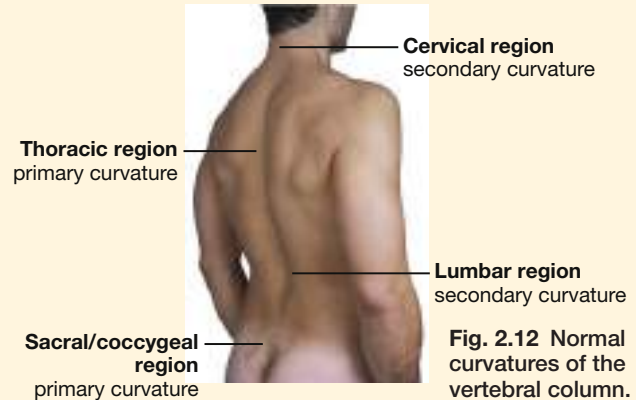


Fig. 2.12 Normal curvatures of the vertebral column.

Clinical app

Spina bifida

Spina bifida is a disorder in which the two sides of vertebral arches, usually in lower vertebrae, fail to fuse during development, resulting in an “open” vertebral canal. There are two types of spina bifida.

- The commonest type is spina bifida occulta in which there is a defect in the vertebral arch of LV or SI. This defect occurs in as many as 10% of individuals and results in failure of the posterior arch to fuse in the midline. Clinically, the patient is asymptomatic, although there may be a tuft of hair over the spinous processes.
- The more severe form of spina bifida involves complete failure of fusion of the posterior arch at the lumbosacral junction with a large outpouching of the meninges. This may contain cerebrospinal fluid (CSF; a **meningocele**) or a portion of the spinal cord (a **myelomeningocele**). These abnormalities may result in a variety of neurologic deficits, including problems with walking and bladder function.

Clinical app

Vertebroplasty

Vertebroplasty is a relatively new technique in which the body of a vertebra can be filled with bone cement (typically methyl methacrylate). The indications for the technique include

vertebral body collapse and pain from the vertebral body, which may be secondary to tumor infiltration. The procedure is most commonly performed for osteoporotic wedge fractures, which are a considerable cause of morbidity and pain in older patients. These types of fractures typically occur in the thoracolumbar region.

Clinical app

Scoliosis

Scoliosis is an abnormal lateral curvature of the vertebral column (Fig. 2.13).

A true scoliosis involves not only the (right- or left-sided) curvature but also a rotational element of one vertebra on another.

The commonest types of scoliosis are those for which we have little understanding about how or why they occur and are termed *idiopathic scoliosis*. These are never present at birth and tend to occur in either the infantile, juvenile, or adolescent age groups. The vertebral bodies and posterior elements (pedicles and laminae) are normal in these patients.



Fig. 2.13 Volume-rendered CT, anterior view.

Clinical app

Kyphosis

Kyphosis is abnormal curvature (exaggerated anterior concavity) of the vertebral column in the thoracic region, producing a “hunchback” deformity. This condition occurs in certain disease states, the most dramatic of which is usually secondary to tuberculosis infection of a thoracic vertebral body in which the kyphosis becomes angulated at the site of the lesion.

Clinical app

Lordosis

Lordosis is abnormal curvature (exaggerated posterior concavity) of the vertebral column in the lumbar region, producing a swayback deformity.

Clinical app

Variation in vertebral numbers

There are usually seven cervical vertebrae, although in certain diseases these may be fused. Fusion of cervical vertebrae can be associated with other abnormalities in which there is abnormal fusion of vertebrae C1 and C2 or C5 and C6.

Variations in the number of thoracic vertebrae are well described.

One of the commonest abnormalities in the lumbar vertebrae is a partial fusion of vertebra L5 with the sacrum (sacralization of the lumbar vertebra). Partial separation of vertebra S1 from the sacrum (lumbarization of first sacral vertebra) may also occur.

A hemivertebra occurs when a vertebra develops only on one side.

Clinical app

The vertebrae and cancer

The vertebrae are common sites for metastatic disease (secondary spread of cancer cells). When cancer cells grow within the vertebral bodies and the posterior elements, they destroy the mechanical properties of the bone. Importantly, vertebrae that contain extensive metastatic disease may extrude fragments of tumor into the vertebral canal, compressing the nerves and spinal cord.

Clinical app

Osteoporosis

Osteoporosis is a pathophysiologic condition in which bone quality is normal, but the quantity of bone is deficient. It is a metabolic bone disorder that commonly occurs in women in their 50s and 60s and in men in their 70s.

Typical complications of osteoporosis include “crush” vertebral body fractures, distal radial fractures, and hip fractures.

Joints between vertebral arches (zygapophysial joints)

The synovial joints between superior and inferior articular processes on adjacent vertebrae are the zygapophysial joints (Fig. 2.15). A thin articular capsule attached to the margins of the articular facets encloses each joint.

In cervical regions, the zygapophysial joints slope inferiorly from anterior to posterior and their shape facilitates

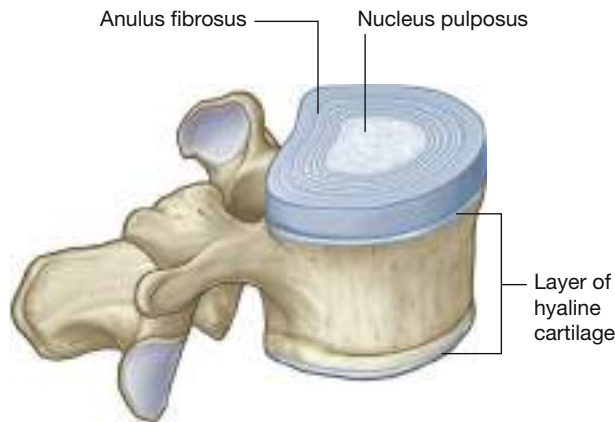


Fig. 2.14 Intervertebral joints.

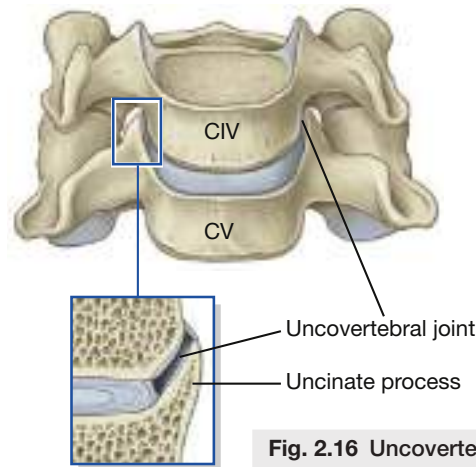


Fig. 2.16 Uncovertebral joint.

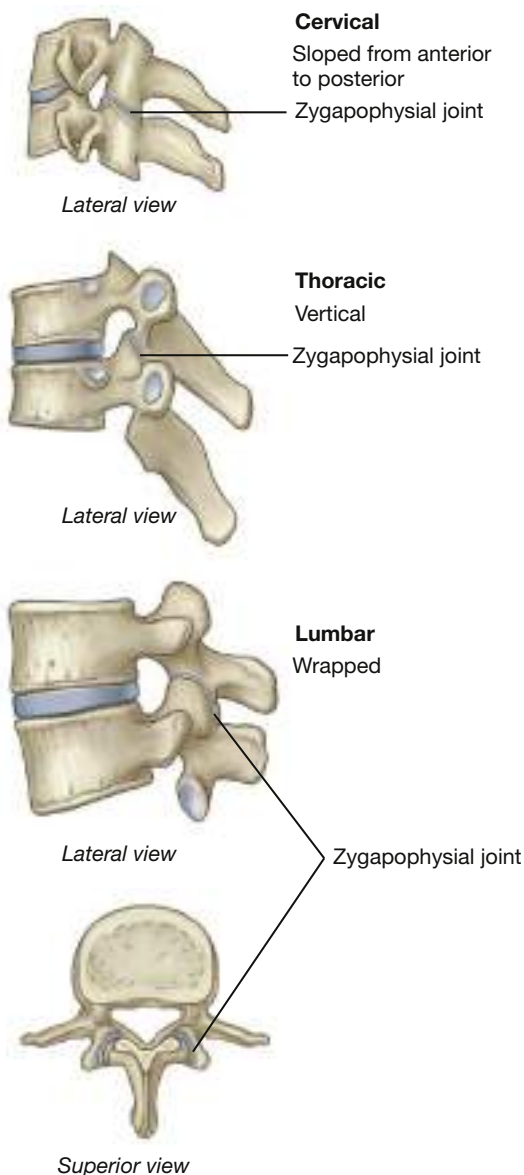


Fig. 2.15 Zygapophysial joints.

flexion and extension. In thoracic regions, the joints are oriented vertically and their shape limits flexion and extension but facilitates rotation. In lumbar regions, the joint surfaces are curved and adjacent processes interlock, thereby limiting range of movement, although flexion and extension are still major movements in the lumbar region.

“Uncovertebral” joints

The lateral margins of the upper surfaces of typical cervical vertebrae are elevated into crests or lips termed *uncinate processes*. These may articulate with the body of the vertebra above to form small “uncovertebral” synovial joints (Fig. 2.16).

Clinical app

Back pain

Back pain is an extremely common disorder. It can be related to mechanical problems or to a disc protrusion impinging on a nerve. In cases involving discs, it may be necessary to operate and remove the disc that is pressing on the nerve.

Clinical app

Herniation of intervertebral discs

The discs between the vertebrae are made up of a central portion (the nucleus pulposus) and a complex series of fibrous rings (anulus fibrosus). A tear can occur within the anulus fibrosus through which the material of the nucleus pulposus can track. After a period of time, this material may track into the vertebral canal or into the intervertebral foramen to impinge on neural structures (Fig. 2.17). This is a common cause of back pain. A disc may protrude posteriorly to directly impinge on the cord or the roots of the lumbar nerves, depending on the level, or may protrude posterolaterally adjacent to the pedicle and impinge on the descending root.

In cervical regions of the vertebral column, cervical disc protrusions often become ossified and are termed *disc osteophyte bars*.

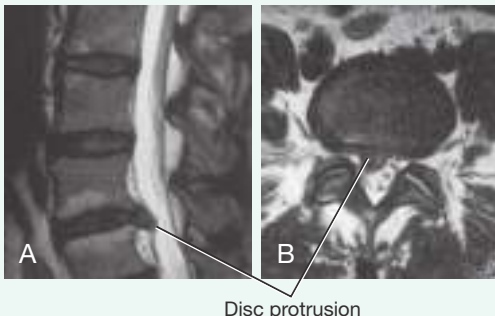


Fig. 2.17 Disc protrusion—T2-weighted magnetic resonance images of the lumbar region of the vertebral column. **A.** Sagittal plane. **B.** Axial plane.

Clinical app

Joint diseases

Some diseases have a predilection for synovial joints rather than symphyses. A typical example is rheumatoid arthritis, which primarily affects synovial joints and synovial bursae, resulting in destruction of the joint and its lining. Symphyses are usually preserved.

LIGAMENTS

Joints between vertebrae are reinforced and supported by numerous ligaments, which pass between vertebral bodies and interconnect components of the vertebral arches.

Anterior and posterior longitudinal ligaments

The anterior and posterior longitudinal ligaments are on the anterior and posterior surfaces of the vertebral bodies and extend along most of the vertebral column (Fig. 2.18).

The **anterior longitudinal ligament** is attached superiorly to the base of the skull and extends inferiorly to attach to the anterior surface of the sacrum. Along its length, it is attached to the vertebral bodies and intervertebral discs.

The **posterior longitudinal ligament** is on the posterior surfaces of the vertebral bodies and lines the anterior surface of the vertebral canal. Like the anterior longitudinal ligament, it is attached along its length to the vertebral bodies and intervertebral discs. The upper part of the posterior longitudinal ligament that connects CII to the intracranial aspect of the base of the skull is termed the **tectorial membrane**.



Fig. 2.18 Anterior and posterior longitudinal ligaments of vertebral column.

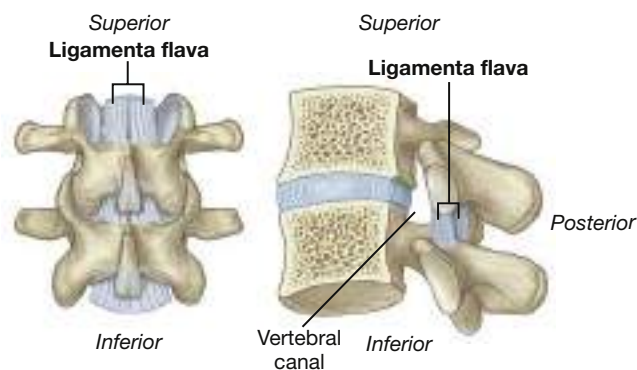


Fig. 2.19 Ligamenta flava.

Ligamenta flava

The **ligamenta flava**, on each side, pass between the laminae of adjacent vertebrae (Fig. 2.19). These thin, broad ligaments consist predominantly of elastic tissue and form part of the posterior surface of the vertebral canal. Each ligamentum flavum runs between the posterior surface of the lamina on the vertebra below to the anterior surface of the lamina of the vertebra above. The ligamenta flava resist separation of the laminae in flexion and assist in extension back to the anatomical position.

Supraspinous ligament and ligamentum nuchae

The supraspinous ligament connects and passes along the tips of the vertebral spinous processes from vertebra CVII

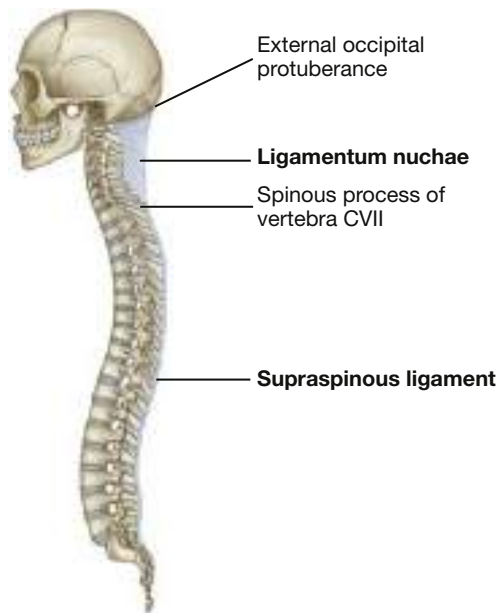


Fig. 2.20 Supraspinous ligament and ligamentum nuchae.

to the sacrum (Fig. 2.20). From vertebra CVII to the skull, the ligament becomes structurally distinct from more caudal parts of the ligament and is called the *ligamentum nuchae*.

The **ligamentum nuchae** is a triangular, sheet-like structure in the median sagittal plane:

- The base of the triangle is attached to the skull, from the external occipital protuberance to the foramen magnum.
- The apex is attached to the tip of the spinous process of vertebra CVII.
- The deep side of the triangle is attached to the posterior tubercle of vertebra CI and the spinous processes of the other cervical vertebrae.

The ligamentum nuchae supports the head. It resists flexion and facilitates returning the head to the anatomical position. The broad lateral surfaces and the posterior edge of the ligament provide attachment for adjacent muscles.

Interspinous ligaments

Interspinous ligaments pass between adjacent vertebral spinous processes (Fig. 2.21). They attach from the base to the apex of each spinous process and blend with the supraspinous ligament posteriorly and the ligamenta flava anteriorly on each side.

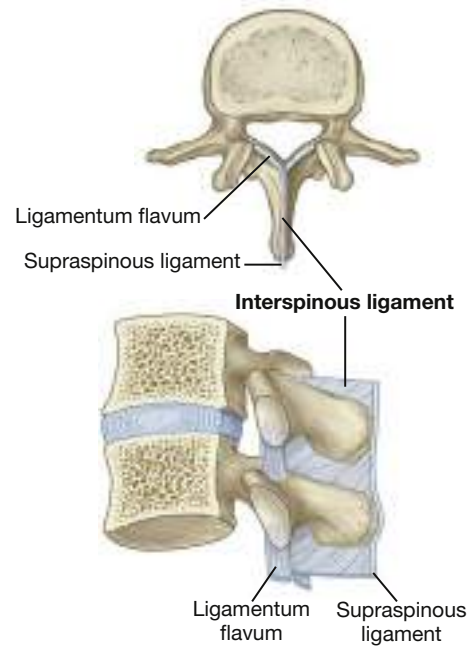


Fig. 2.21 Interspinous ligaments.

Clinical app

Ligamenta flava

In degenerative conditions of the vertebral column, the ligamenta flava may hypertrophy. This is often associated with hypertrophy and arthritic change of the zygapophysial joints. In combination, zygapophysial joint hypertrophy, ligamenta flava hypertrophy, and a mild disc protrusion can reduce the dimensions of the vertebral canal.

Clinical app

Vertebral fractures

Vertebral column stability is divided into three arbitrary clinical “columns:” the **anterior column** consists of the vertebral bodies and the anterior longitudinal ligament; the **middle column** comprises the vertebral body and the posterior longitudinal ligament; and the **posterior column** is made up of the ligamenta flava, interspinous ligaments, supraspinous ligaments, and the ligamentum nuchae in the cervical vertebral column.

Destruction of one of the clinical columns is usually a stable injury requiring little more than rest and appropriate analgesia. Disruption of two columns is likely to be unstable and requires fixation and immobilization. A three-column spinal injury usually results in a significant neurologic event and requires fixation to prevent further extension of the neurologic defect and to create vertebral column stability.

Clinical app

Pars interarticularis fractures

The *pars interarticularis* is a clinical term used to describe the specific region of a vertebra between the superior and inferior facet (zygapophysial) joints. This region is susceptible to trauma, especially in athletes.

If a fracture occurs around the pars interarticularis, the vertebral body may slip anteriorly and compress the vertebral canal. The most common sites for pars interarticularis fractures are the LIV and LV levels. It is possible for a vertebra to slip anteriorly on its inferior counterpart without a pars interarticularis fracture. Usually this is related to abnormal anatomy of the facet joints: facet joint degenerative change. This disorder is termed **spondylolisthesis**.

Clinical app

Surgical procedures on the back

Discectomy

A prolapsed intervertebral disc may impinge on the meningeal (thecal) sac, cord, and most commonly the nerve root, producing symptoms attributable to that level. In some instances the disc protrusion will undergo a degree of involution that may allow symptoms to resolve without intervention. In some instances, pain, loss of function, and failure to resolve may require surgery to remove the disc protrusion.

Spinal fusion

Spinal (vertebral) fusion is performed when it is necessary to fuse one vertebra with the corresponding superior or inferior vertebra, and in some instances multilevel fusion may be necessary. Indications are varied, although they include stabilization after fracture, stabilization related to tumor infiltration, and stabilization when mechanical pain is produced either from the disc or from the posterior elements.

BACK MUSCULATURE

Muscles of the back are organized into superficial, intermediate, and deep groups.

Muscles in the superficial and intermediate groups are extrinsic muscles because they originate embryologically from locations other than the back. They are innervated by anterior rami of spinal nerves:

- The superficial group consists of muscles related to and involved in movements of the upper limb.
- The intermediate group consists of muscles attached to the ribs and may serve a respiratory function.

Muscles of the deep group are intrinsic muscles because they develop in the back. They are innervated by posterior

rami of spinal nerves and are directly related to movements of the vertebral column and head.

Superficial group of back muscles

The muscles in the superficial group are immediately deep to the skin and superficial fascia. They attach the superior part of the appendicular skeleton (clavicle, scapula, and humerus) to the axial skeleton (skull, ribs, and vertebral column). Because these muscles are primarily involved with movements of this part of the appendicular skeleton, they are sometimes referred to as the **appendicular group**.

Muscles in the superficial group include the **trapezius**, **latissimus dorsi**, **rhomboid major**, **rhomboid minor**, and **levator scapulae** (Fig. 2.22). Rhomboid major, rhomboid minor, and levator scapulae are located deep to the trapezius in the superior part of the back.

Trapezius

Each **trapezius** muscle is flat and triangular, with the base of the triangle situated along the vertebral column (the muscle's origin) and the apex pointing toward the tip of the

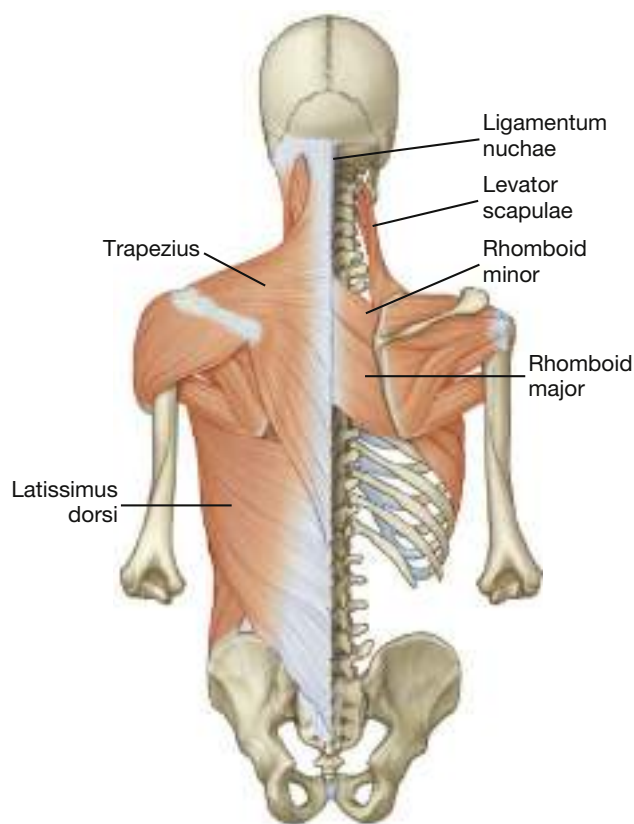
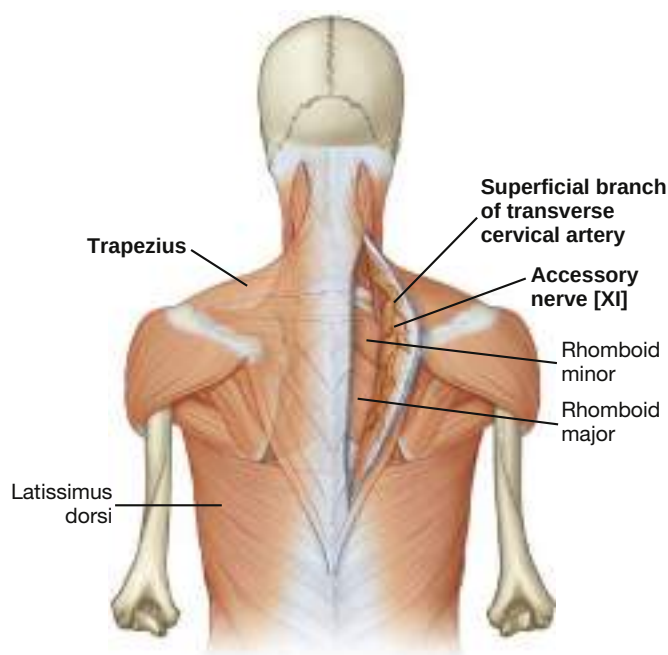


Fig. 2.22 Superficial group of back muscles—trapezius and latissimus dorsi with rhomboid major, rhomboid minor, and levator scapulae located deep to trapezius in the superior part of the back.

Table 2.1 Superficial (appendicular) group of back muscles

Muscle	Origin	Insertion	Innervation	Function
Trapezius	Superior nuchal line, external occipital protuberance, ligamentum nuchae, spinous processes of CVII to TXII	Lateral one-third of clavicle, acromion, spine of scapula	Motor—accessory nerve [XI]; proprioception—C3 and C4	Assists in rotating the scapula during abduction of humerus above horizontal; upper fibers elevate, middle fibers adduct, and lower fibers depress scapula
Latissimus dorsi	Spinous processes of TVII to LV and sacrum, iliac crest, ribs X to XII	Floor of intertubercular sulcus of humerus	Thoracodorsal nerve (C6 to C8)	Extends, adducts, and medially rotates humerus
Levator scapulae	Transverse processes of C1 to CIV	Upper portion medial border of scapula	C3 to C4 and dorsal scapular nerve (C4, C5)	Elevates scapula
Rhomboid major	Spinous processes of TII to TV	Medial border of scapula between spine and inferior angle	Dorsal scapular nerve (C4, C5)	Retracts (adducts) and elevates scapula
Rhomboid minor	Lower portion of ligamentum nuchae, spinous processes of CVII and T1	Medial border of scapula at the spine of scapula	Dorsal scapular nerve (C4, C5)	Retracts (adducts) and elevates scapula

**Fig. 2.23** Innervation and blood supply of trapezius.

shoulder (the muscle's insertion) (Table 2.1, Fig. 2.22). The muscles on both sides together form a trapezoid.

Motor innervation of the trapezius is by the accessory nerve [XI], which descends from the neck onto the deep surface of the muscle (Fig. 2.23). Proprioceptive fibers from trapezius pass in the branches of the cervical plexus and enter the spinal cord at spinal cord levels C3 and C4.

The blood supply to trapezius is from the superficial branch of the transverse cervical artery (Fig. 2.23), the acromial branch of the suprascapular artery, and dorsal branches of posterior intercostal arteries.

Clinical app

Nerve injuries affecting superficial back muscles

Weakness in the trapezius caused by an interruption of the accessory nerve [XI] may appear as drooping of the shoulder, inability to raise the arm above the head because of impaired rotation of the scapula, or weakness in attempting to raise the shoulder (i.e., shrug the shoulder against resistance).

A weakness in, or an inability to use, the latissimus dorsi resulting from an injury to the thoracodorsal nerve diminishes the capacity to pull the body upward while climbing or doing a pull-up.

Latissimus dorsi

Latissimus dorsi is a large, flat triangular muscle that begins in the lower portion of the back and tapers as it ascends to a narrow tendon that attaches to the humerus anteriorly (Table 2.1, Fig. 2.22).

The thoracodorsal nerve of the brachial plexus innervates the latissimus dorsi muscle. Associated with this nerve is the thoracodorsal artery, which is the primary blood supply of the muscle. Additional small arteries come from dorsal branches of posterior intercostal and lumbar arteries.

Levator scapulae

Levator scapulae is a slender muscle that descends from the transverse processes of the upper cervical vertebrae to the upper portion of the scapula on its medial border at the superior angle (Table 2.1, Fig. 2.22). It is innervated by branches from the anterior rami of spinal nerves C3 and C4 and the dorsal scapular nerve, and its arterial supply consists

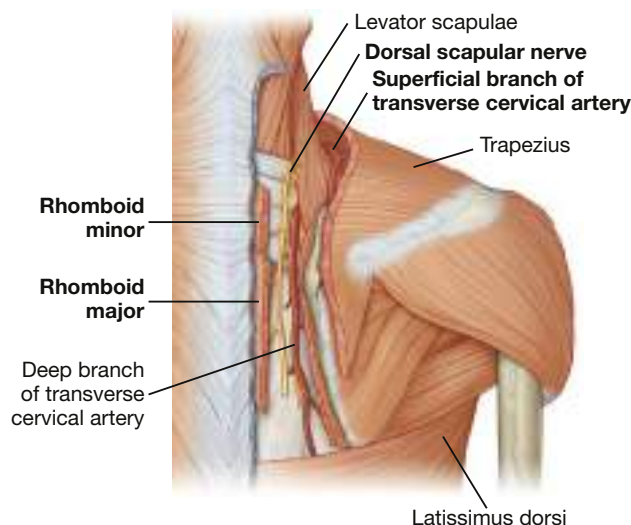


Fig. 2.24 Innervation and blood supply of the rhomboid muscles.

of branches primarily from the transverse and ascending cervical arteries.

Rhomboid minor and rhomboid major

The two rhomboid muscles are inferior to levator scapulae (Table 2.1, Fig. 2.22).

The two rhomboid muscles work together to retract or pull the scapula toward the vertebral column. The dorsal scapular nerve, a branch of the brachial plexus, innervates both rhomboid muscles (Fig. 2.24).

An injury to the dorsal scapular nerve, which innervates the rhomboids, may result in a lateral shift in the position of the scapula on the affected side (i.e., the normal position of the scapula is lost because of the affected muscle's inability to prevent antagonistic muscles from pulling the scapula laterally).

Intermediate group of back muscles

The muscles in the intermediate group of back muscles consist of two thin muscular sheets in the superior and

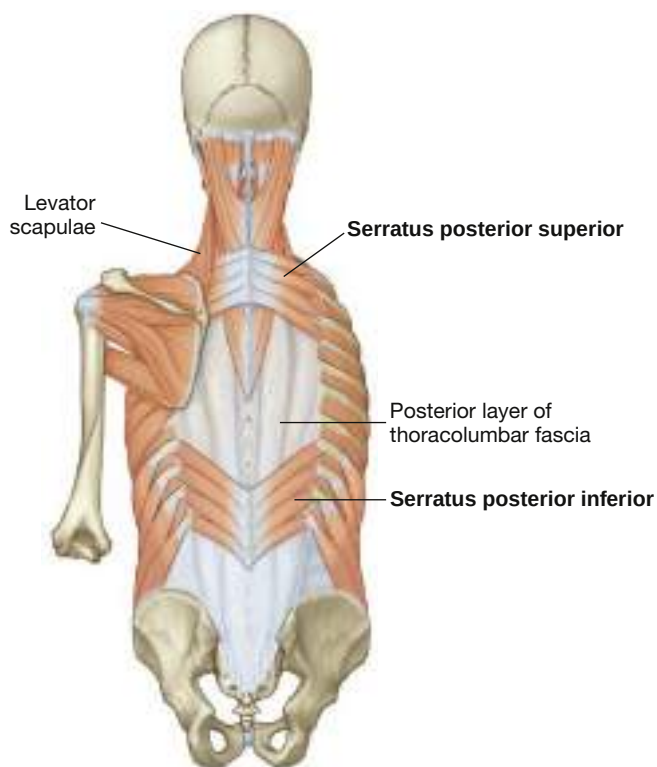


Fig. 2.25 Intermediate group of back muscles—serratus posterior muscles.

inferior regions of the back, immediately deep to the muscles in the superficial group (Table 2.2, Fig. 2.25). Fibers from these two serratus posterior muscles (**serratus posterior superior** and **serratus posterior inferior**) pass obliquely outward from the vertebral column to attach to the ribs. This positioning suggests a respiratory function, and, at times, these muscles have been referred to as the respiratory group.

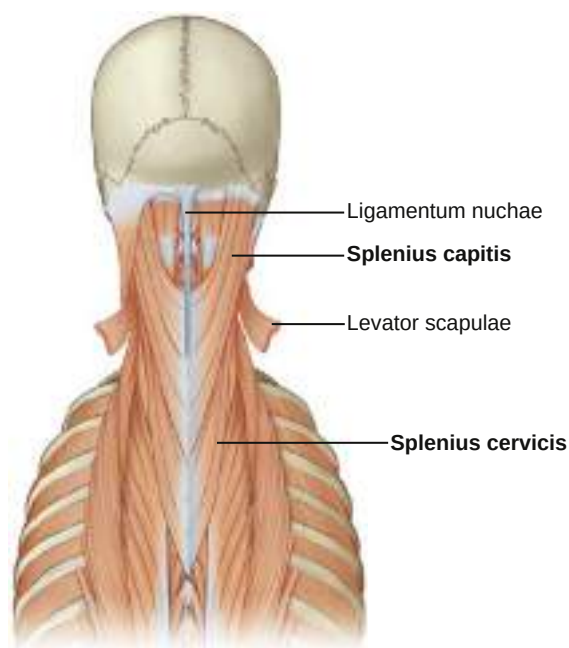
Serratus posterior superior is deep to the rhomboid muscles, whereas serratus posterior inferior is deep to the latissimus dorsi. They are innervated by segmental branches of the anterior rami of intercostal nerves. Their vascular supply is provided by a similar segmental pattern through the intercostal arteries.

Table 2.2 Intermediate (respiratory) group of back muscles

Muscle	Origin	Insertion	Innervation	Function
Serratus posterior superior	Lower portion of ligamentum nuchae, spinous processes of CVII to TIII and supraspinous ligaments	Upper border of ribs II to V just lateral to their angles	Anterior rami of upper thoracic nerves (T2 to T5)	Elevates ribs II to V
Serratus posterior inferior	Spinous processes of TXI to LIII and supraspinous ligaments	Lower border of ribs IX to XII just lateral to their angles	Anterior rami of lower thoracic nerves (T9 to T12)	Depresses ribs IX to XII and may prevent lower ribs from being elevated when the diaphragm contracts

Table 2.3 Spinotransversales muscles

Muscle	Origin	Insertion	Innervation	Function
Splenius capitis	Lower half of ligamentum nuchae, spinous processes of CVII to TIV	Mastoid process, skull below lateral one-third of superior nuchal line	Posterior rami middle cervical nerves	Together—draw head backward, extending neck; individually—draw and rotate head to one side (turn face to same side)
Splenius cervicis	Spinous processes of TIII to TVI	Transverse processes of CII to CIII	Posterior rami lower cervical nerves	Together—extend neck; individually—draw and rotate head to one side (turn face to same side)

**Fig. 2.26** Deep group of back muscles—spinotransversales muscles (splenius capitis and splenius cervicis).

Deep group of back muscles

The deep or intrinsic muscles of the back extend from the pelvis to the skull and are innervated by segmental branches of the posterior rami of spinal nerves. Muscles in this group include the spinotransversales, erector spinae, transversospinales, segmental, and suboccipital muscles.

Spinotransversales muscles

The two spinotransversales muscles run from the spinous processes and ligamentum nuchae upward and laterally (Table 2.3, Fig. 2.26):

- **Splenius capitis** is a broad muscle attached to the occipital bone and mastoid process of the temporal bone.
- **Splenius cervicis** is a narrow muscle attached to the transverse processes of the upper cervical vertebrae.

Erector spinae muscles

The erector spinae is the largest group of intrinsic back muscles. The muscles lie posterolaterally to the vertebral column between the spinous processes medially and the angles of the ribs laterally (Table 2.4, Fig. 2.27). In the upper lumbar region, the erector spinae divides into three vertical columns of muscle, each of which is further subdivided regionally (lumborum, thoracis, cervicis, and capitis), depending on where the muscles attach superiorly.

- The outer or most laterally placed column of the erector spinae muscles is the **iliocostalis**.
- The middle or intermediate column is the **longissimus**.
- The most medial muscle column is the **spinalis**.

The muscles in the erector spinae group are the primary extensors of the vertebral column and head. Acting bilaterally, they straighten the back, returning it to the upright position from a flexed position, and pull the head posteriorly. They also participate in controlling vertebral column flexion by contracting and relaxing in a coordinated fashion. Acting unilaterally, they bend the vertebral column laterally. In addition, unilateral contractions of muscles attached to the head turn the head to the actively contracting side.

Transversospinales muscles

The transversospinales muscles run obliquely upward and medially from transverse processes to spinous processes, filling the groove between these two vertebral projections (Table 2.5, Fig. 2.28). They are deep to the erector spinae and consist of three major subgroups—the semispinalis, multifidus, and rotatores muscles.

- The **semispinalis** muscles are the most superficial collection of muscle fibers in the transversospinales group. They begin in the lower thoracic region and end by attaching to the skull, crossing between four and six vertebrae.
- Deep to the semispinalis is the second group of muscles, the **multifidus**. Muscles in this group span the length

Table 2.4 Erector spinae group of back muscles

Muscle	Origin	Insertion
Iliocostalis lumborum	Sacrum, spinous processes of lumbar and lower two thoracic vertebrae and their supraspinous ligaments, and the iliac crest	Angles of the lower six or seven ribs
Iliocostalis thoracis	Angles of the lower six ribs	Angles of the upper six ribs and the transverse process of CVII
Iliocostalis cervicis	Angles of ribs III to VI	Transverse processes of CIV to CVI
Longissimus thoracis	Blends with iliocostalis in lumbar region and is attached to transverse processes of lumbar vertebrae	Transverse processes of all thoracic vertebrae and just lateral to the tubercles of the lower nine or ten ribs
Longissimus cervicis	Transverse processes of upper four or five thoracic vertebrae	Transverse processes of CII to CVI
Longissimus capitis	Transverse processes of upper four or five thoracic vertebrae and articular processes of lower three or four cervical vertebrae	Posterior margin of the mastoid process
Spinalis thoracis	Spinous processes of TX or TXI to LII	Spinous processes of TI to TVIII (varies)
Spinalis cervicis	Lower part of ligamentum nuchae and spinous process of CVII (sometimes TI to TII)	Spinous process of CII (axis)
Spinalis capitis	Usually blends with semispinalis capitis	With semispinalis capitis

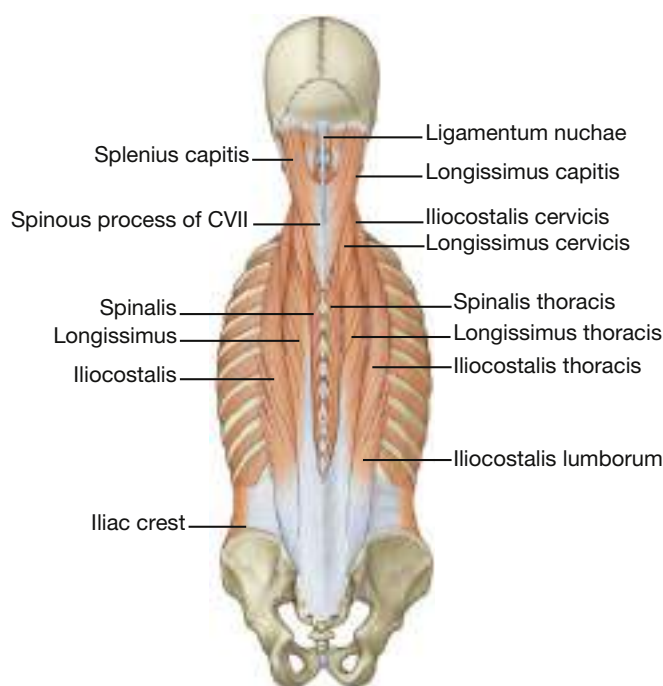


Fig. 2.27 Deep group of back muscles—erector spinae muscles.

of the vertebral column spanning between two and four vertebrae.

- The small **rotatores** muscles are the deepest of the transversospinales group and span the length of the vertebral column, crossing two vertebrae (long rotators) or attaching to adjacent vertebra (short rotators).

When muscles in the transversospinales group contract bilaterally, they extend the vertebral column, an action similar to that of the erector spinae group. However,

when muscles on only one side contract, they pull the spinous processes toward the transverse processes on that side, causing the trunk to turn or rotate in the opposite direction.

One muscle in the transversospinales group, the **semi-spinalis capitis**, has a unique action because it attaches to the skull. Contracting bilaterally, this muscle pulls the head posteriorly, whereas unilateral contraction pulls the head posteriorly and turns it, causing the chin to move superiorly and turn toward the side of the contracting muscle.

Segmental muscles

The two groups of segmental muscles (Table 2.6, Fig. 2.28) are deeply placed in the back and innervated by posterior rami of spinal nerves.

- The first group of segmental muscles are the **levator costarum** muscles.
- The second group of segmental muscles are the true segmental muscles of the back—the **interspinales** and the **intertransversarii**.

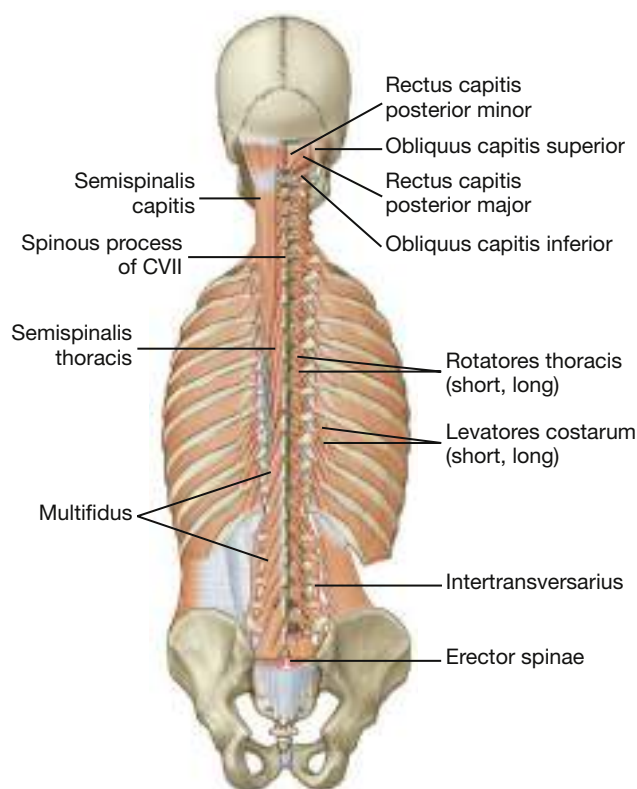
Suboccipital muscles

A small group of deep muscles in the upper cervical region at the base of the occipital bone move the head. Because of their location they are sometimes referred to as suboccipital muscles (Table 2.7, Figs. 2.28, 2.29). They include, on each side:

- **rectus capitis posterior major**,
- **rectus capitis posterior minor**,
- **obliquus capitis inferior**, and
- **obliquus capitis superior**.

Table 2.5 Transversospinales group of back muscles

Muscle	Origin	Insertion
Semispinalis thoracis	Transverse processes of TVI to TX	Spinous processes of upper four thoracic and lower two cervical vertebrae
Semispinalis cervicis	Transverse processes of upper five or six thoracic vertebrae	Spinous processes of CII (axis) to CV
Semispinalis capitis	Transverse processes of T1 to TVI (or TVII) and CVII and articular processes of CIV to CVI	Medial area between the superior and inferior nuchal lines of occipital bone
Multifidus	Sacrum, origin of erector spinae, posterior superior iliac spine, mammillary processes of lumbar vertebrae, transverse processes of thoracic vertebrae, and articular processes of lower four cervical vertebrae	Base of spinous processes of all vertebrae from LV to CII (axis)
Rotatores lumborum	Mammillary processes of lumbar vertebrae	Spinous processes of lumbar vertebrae
Rotatores thoracis	Transverse processes of thoracic vertebrae	Spinous processes of thoracic vertebrae
Rotatores cervicis	Articular processes of cervical vertebrae	Spinous processes of cervical vertebrae

**Fig. 2.28** Deep group of back muscles—transversospinales and segmental muscles.

Contraction of the suboccipital muscles extends and rotates the head at the atlanto-occipital and atlanto-axial joints, respectively.

The suboccipital muscles are innervated by the posterior ramus of the first cervical nerve, which enters the area between the vertebral artery and the posterior arch of the atlas (Fig. 2.29). The vascular supply to the muscles in this area is from branches of the vertebral and occipital arteries.

The suboccipital muscles form the boundaries of the **suboccipital triangle** (Fig. 2.29):

- Rectus capitis posterior major forms the medial border of the triangle.
- Obliquus capitis superior muscle forms the lateral border.
- Obliquus capitis inferior muscle forms the inferior border.

The suboccipital triangle contains several important structures:

- Posterior ramus of C1,
- Vertebral artery, and
- Veins

Thoracolumbar fascia

The **thoracolumbar fascia** covers the deep muscles of the back and trunk (Fig. 2.30). This fascial layer is critical to the overall organization and integrity of the region:

- Superiorly, it passes anteriorly to the serratus posterior superior muscle and is continuous with deep fascia in the neck.
- In the thoracic region, it covers the deep muscles and separates them from the muscles in the superficial and intermediate groups.
- Medially, it attaches to the spinous processes of the thoracic vertebrae and, laterally, to the angles of the ribs.

In the lumbar region, the thoracolumbar fascia consists of three layers:

- The posterior layer is thick and is attached to the spinous processes of the lumbar vertebrae, sacral vertebrae, and

Table 2.6 Segmental back muscles

Muscle	Origin	Insertion	Function
Levatores costarum	Short paired muscles arising from transverse processes of CVII to TXI	The rib below vertebra of origin near tubercle	Contraction elevates rib
Interspinales	Short paired muscles attached to the spinous processes of contiguous vertebrae, one on each side of the interspinous ligament		Postural muscles that stabilize adjoining vertebrae during movements of vertebral column
Intertransversarii	Small muscles between the transverse processes of contiguous vertebrae		Postural muscles that stabilize adjoining vertebrae during movements of vertebral column

Table 2.7 Suboccipital group of back muscles

Muscle	Origin	Insertion	Innervation	Function
Rectus capitis posterior major	Spinous process of axis (CII)	Lateral portion of occipital bone below inferior nuchal line	Posterior ramus of C1	Extension of head; rotation of face to same side as muscle
Rectus capitis posterior minor	Posterior tubercle of atlas (CI)	Medial portion of occipital bone below inferior nuchal line	Posterior ramus of C1	Extension of head
Obliquus capitis superior	Transverse process of atlas (CI)	Occipital bone between superior and inferior nuchal lines	Posterior ramus of C1	Extension of head and bends it to same side
Obliquus capitis inferior	Spinous process of axis (CII)	Transverse process of atlas (CI)	Posterior ramus of C1	Rotation of face to same side

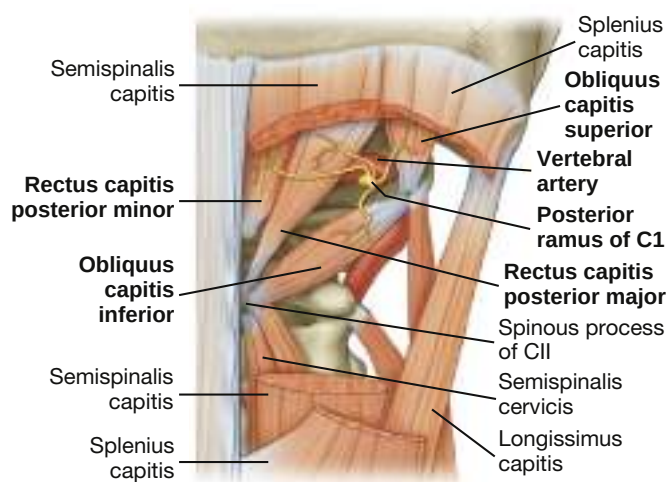


Fig. 2.29 Deep group of back muscles—suboccipital muscles. This also shows the borders of the suboccipital triangle.

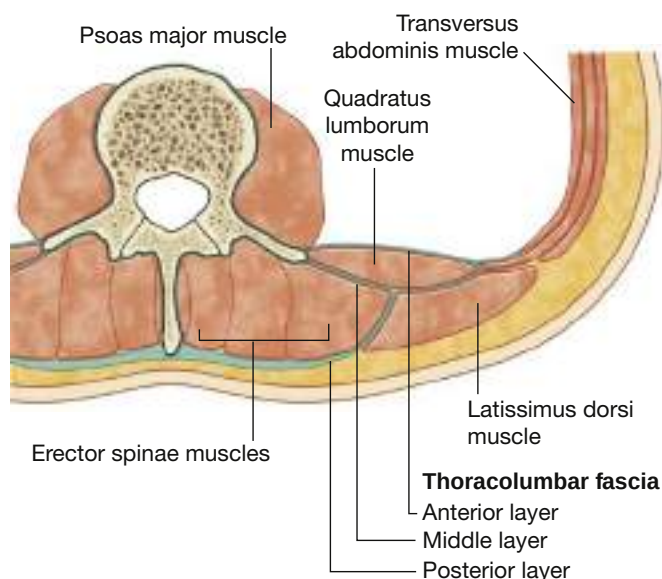


Fig. 2.30 Thoracolumbar fascia and the deep back muscles in the lumbar region (transverse section).

the supraspinous ligament—from these attachments, it extends laterally to cover the erector spinae.

- The middle layer is attached medially to the tips of the transverse processes of the lumbar vertebrae and intertransverse ligaments—inferiorly it is attached to the iliac crest and superiorly to the lower border of rib XII.

- The anterior layer covers the anterior surface of the quadratus lumborum muscle (a muscle of the posterior abdominal wall) and is attached medially to the transverse processes of the lumbar vertebrae—inferiorly, it is attached to the iliac crest, and superiorly, it forms the lateral arcuate ligament for attachment of the diaphragm.

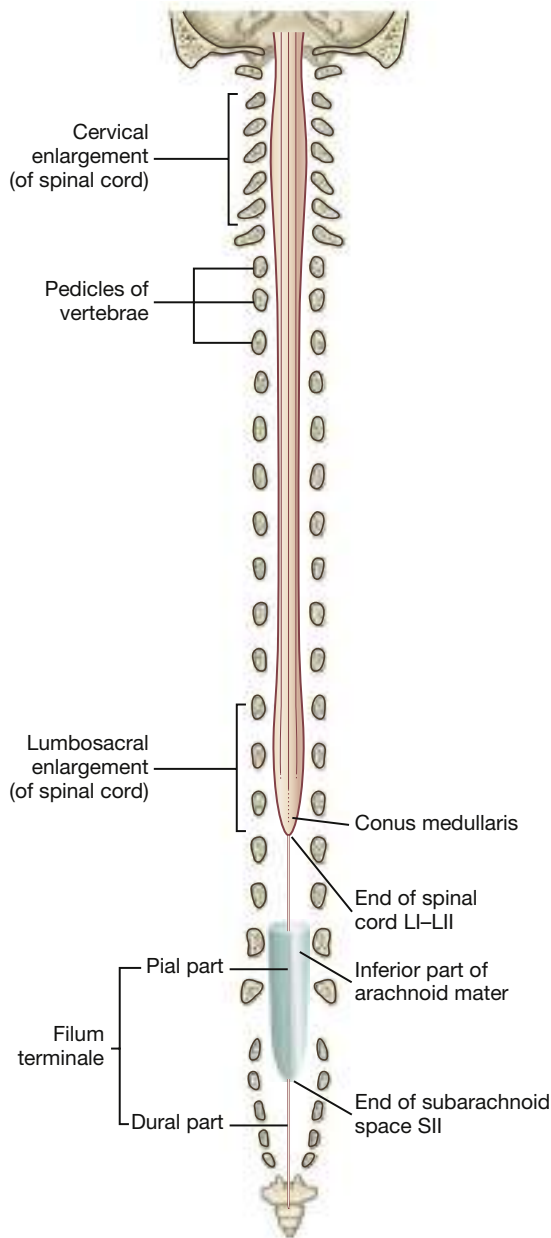


Fig. 2.31 Spinal cord.

The posterior and middle layers of the thoracolumbar fascia come together at the lateral margin of the erector spinae (Fig. 2.30). At the lateral border of the quadratus lumborum, the anterior layer joins them and forms the aponeurotic origin for the transversus abdominis muscle of the abdominal wall.

SPINAL CORD

The spinal cord extends from the foramen magnum to approximately the level of the disc between vertebrae LI and LII in adults, although it can end as high as vertebra TXII or

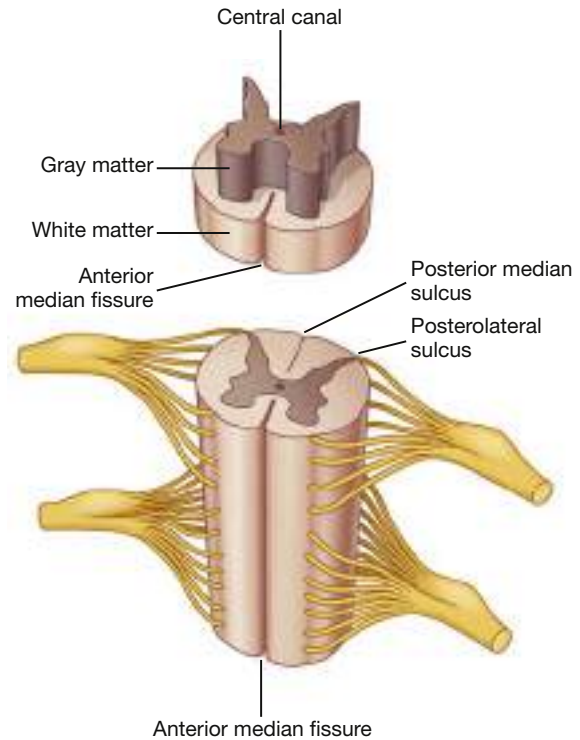


Fig. 2.32 Features of the spinal cord.

as low as the disc between vertebrae LII and LIII (Fig. 2.31). In neonates, the spinal cord extends approximately to vertebra LIII but can reach as low as vertebra LIV. The distal end of the cord (the **conus medullaris**) is cone shaped. A fine filament of connective tissue (the pial part of the **filum terminale**) continues inferiorly from the apex of the **conus medullaris**.

The spinal cord is not uniform in diameter along its length. It has two major swellings or enlargements in regions associated with the origin of spinal nerves that innervate the upper and lower limbs. A **cervical enlargement** occurs in the region associated with the origins of spinal nerves C5 to T1, which innervate the upper limbs. A **lumbo-sacral enlargement** occurs in the region associated with the origins of spinal nerves L1 to S3, which innervate the lower limbs (Fig. 2.31).

The external surface of the spinal cord is marked by a number of fissures and sulci (Fig. 2.32):

- The **anterior median fissure** extends the length of the anterior surface.
- The **posterior median sulcus** extends along the posterior surface.
- The **posterolateral sulcus** on each side of the posterior surface marks where the posterior rootlets of spinal nerves enter the cord.

Internally, the cord has a small central canal surrounded by gray and white matter (Fig. 2.32):

- The gray matter is rich in nerve cell bodies, which form longitudinal columns along the cord, and in cross-section, these columns form a characteristic H-shaped appearance in the central regions of the cord.
- The white matter surrounds the gray matter and is rich in nerve cell processes, which form large bundles or tracts that ascend and descend in the cord to other spinal cord levels or carry information to and from the brain.

Vasculature

Arteries

The arterial supply to the spinal cord comes from two sources (Fig. 2.33A). It consists of:

- longitudinally oriented vessels, arising superior to the cervical portion of the cord, that descend on the surface of the cord; and
- feeder arteries that enter the vertebral canal through the intervertebral foramina at every level; these feeder vessels, or **segmental spinal arteries**, arise predominantly from the vertebral and deep cervical arteries in the neck, the posterior intercostal arteries in the thorax, and the lumbar arteries in the abdomen.

After entering an intervertebral foramen, the segmental spinal arteries give rise to **anterior** and **posterior radicular arteries** (Fig. 2.33). This occurs at every vertebral level. The radicular arteries follow and supply the anterior and posterior roots. At various vertebral levels, the **segmental spinal arteries** also give off **segmental medullary arteries** (Fig. 2.33B). These vessels pass directly to the longitudinally oriented vessels, reinforcing these.

The longitudinal vessels consist of:

- a single **anterior spinal artery**, which originates within the cranial cavity as the union of two vessels that arise from the vertebral arteries—the resulting single anterior spinal artery passes inferiorly approximately parallel to the anterior median fissure along the surface of the spinal cord; and
- two **posterior spinal arteries**, which also originate in the cranial cavity, usually arising directly from a terminal branch of each vertebral artery (the posterior inferior cerebellar artery)—the right and left posterior spinal arteries descend along the spinal cord, each as two branches that bracket the posterolateral sulcus and the connection of posterior roots with the spinal cord.

The anterior and posterior spinal arteries are reinforced along their length by 8 to 10 segmental medullary arteries (Fig. 2.33). The largest of these is the **arteria radicularis**

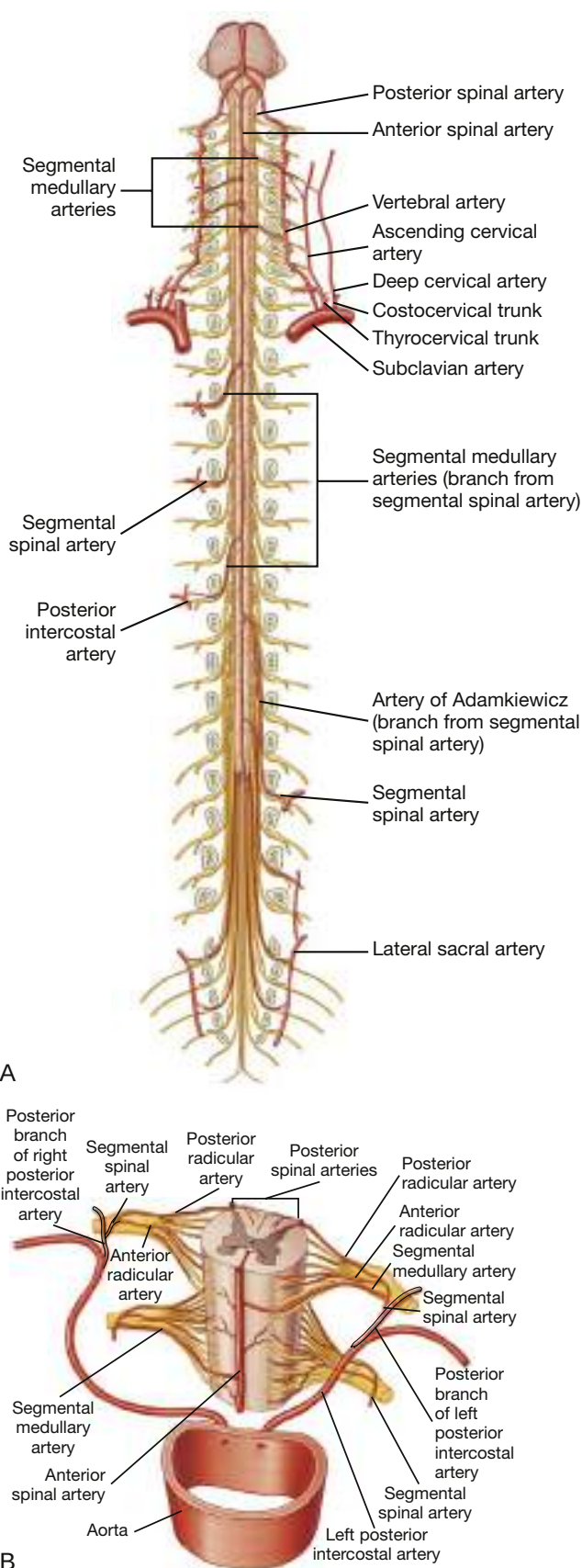


Fig. 2.33 Arteries that supply the spinal cord. **A.** Anterior view of spinal cord (not all segmental spinal arteries are shown). **B.** Segmental supply of the spinal cord.

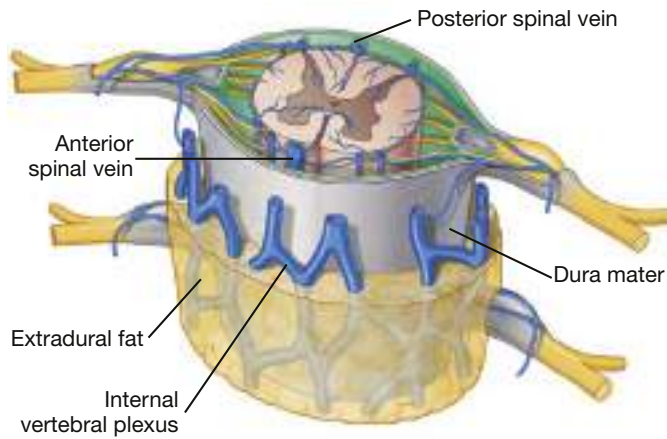


Fig. 2.34 Veins that drain the spinal cord.

magna or the **artery of Adamkiewicz** (Fig. 2.33A). This vessel arises in the lower thoracic or upper lumbar region, usually on the left side, and reinforces the arterial supply to the lower portion of the spinal cord, including the lumbar enlargement.

Veins

Veins that drain the spinal cord form a number of longitudinal channels (Fig. 2.34):

- two pairs of veins on each side bracket the connections of the posterior and anterior roots to the cord;
- one midline channel parallels the anterior median fissure; and
- one midline channel passes along the posterior median sulcus.

These longitudinal channels drain into an extensive internal vertebral plexus in the extradural (epidural) space of the vertebral canal, which then drains into segmentally arranged vessels that connect with major systemic veins, such as the azygos system in the thorax. The internal vertebral venous plexus also communicates with intracranial veins.

Meninges

Spinal dura mater

The **spinal dura mater** (Fig. 2.35) is the outermost meningeal membrane and is separated from the bones forming the vertebral canal by an extradural (epidural) space. Superiorly, it is continuous with the inner meningeal layer of cranial dura mater at the foramen magnum of the skull. Inferiorly, the dural sac dramatically narrows at the level of the lower border of vertebra SII and forms an investing sheath for the pial part of the filum terminale of the spinal cord. This

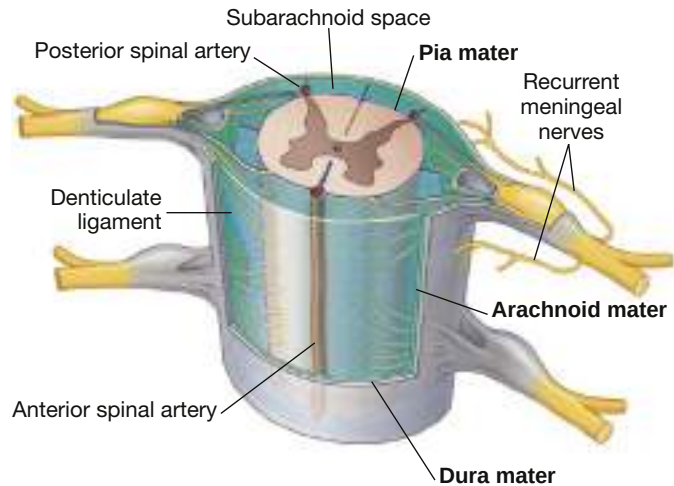


Fig. 2.35 Meninges.

terminal cord-like extension of dura mater (the dural part of the filum terminale) attaches to the posterior surface of the vertebral bodies of the coccyx.

As spinal nerves and their roots pass laterally, they are surrounded by tubular sleeves of dura mater, which merge with and become part of the outer covering (epineurium) of the nerves.

Arachnoid mater

The **arachnoid mater** is a thin delicate membrane against, but not adherent to, the deep surface of the dura mater (Fig. 2.35). It is separated from the pia mater by the subarachnoid space. The arachnoid mater ends at the level of vertebra SII (see Fig. 2.31).

Subarachnoid space

The subarachnoid space between the arachnoid and pia mater contains CSF (Fig. 2.35). The subarachnoid space around the spinal cord is continuous at the foramen magnum with the subarachnoid space surrounding the brain. Inferiorly, the subarachnoid space terminates at approximately the level of the lower border of vertebra SII (see Fig. 2.31).

Delicate strands of tissue (**arachnoid trabeculae**) are continuous with the arachnoid mater on one side and the pia mater on the other, span the subarachnoid space, and interconnect the two adjacent membranes. Large blood vessels are suspended in the subarachnoid space by similar strands of material, which expand over the vessels to form a continuous external coat.

The subarachnoid space extends further inferiorly than the spinal cord. The spinal cord ends at approximately the disc between vertebrae LI and LII, whereas the subarachnoid space extends to approximately the lower border of vertebra SII (see Fig. 2.31). The subarachnoid space is largest in the region inferior to the terminal end of the spinal cord where it surrounds the cauda equina. As a consequence, CSF can be

withdrawn from the subarachnoid space in the lower lumbar region without endangering the spinal cord (Fig. 2.36).

Surface anatomy

Visualizing the inferior ends of the spinal cord and subarachnoid space

The spinal cord does not occupy the entire length of the vertebral canal. Normally in adults, it terminates at the level of the disc between vertebrae LI and LII; however, it may end as high as TXII or as low as the disc between vertebrae LII and LIII. The subarachnoid space ends at approximately the level of vertebra SII (Fig. 2.36A).

Because the subarachnoid space can be accessed in the lower lumbar region without endangering the spinal cord, it is important to be able to identify the position of the lumbar vertebral spinous processes. The LIV vertebral spinous process is level with a horizontal line between the highest points on the iliac crests. In the lumbar region, the palpable ends of the vertebral spinous processes lie opposite their corresponding vertebral bodies. The subarachnoid space can be accessed between vertebral levels LIII and LIV and between LIV and LV without endangering the spinal cord (Fig. 2.36B). The subarachnoid space ends at vertebral level SII, which is level with the sacral dimples marking the posterior superior iliac spines.

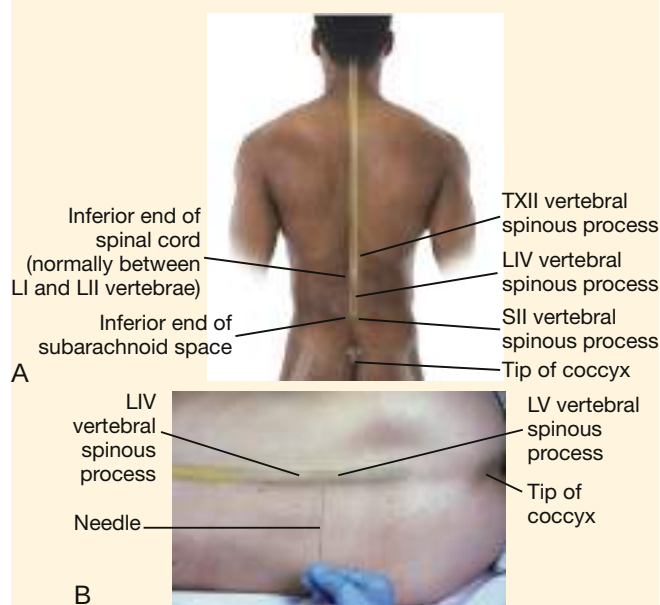


Fig. 2.36 Back with the ends of the spinal cord and subarachnoid space indicated. **A.** In a man. **B.** In a woman lying on her side in a fetal position, which accentuates the lumbar vertebral spinous processes and opens the spaces between adjacent vertebral arches. Cerebrospinal fluid can be withdrawn from the subarachnoid space in lower lumbar regions without endangering the spinal cord.

Pia mater

The spinal pia mater is a vascular membrane that firmly adheres to the surface of the spinal cord (Fig. 2.35). It extends into the anterior median fissure and reflects as sleeve-like coatings onto posterior and anterior rootlets and roots as they cross the subarachnoid space. As the roots exit the space, the sleeve-like coatings reflect onto the arachnoid mater.

On each side of the spinal cord, a longitudinally oriented sheet of pia mater (the **denticulate ligament**) extends laterally from the cord toward the arachnoid and dura mater (Fig. 2.35).

- Medially, each denticulate ligament is attached to the spinal cord in a plane that lies between the origins of the posterior and anterior rootlets.
- Laterally, each denticulate ligament forms a series of triangular extensions along its free border, with the apex of each extension being anchored through the arachnoid mater to the dura mater.

The denticulate ligaments generally occur between the exit points of adjacent posterior and anterior rootlets and position the spinal cord in the center of the subarachnoid space.

Arrangement of structures in the vertebral canal

The vertebral canal is bordered:

- anteriorly by the bodies of the vertebrae, intervertebral discs, and the posterior longitudinal ligament (Fig. 2.37);
- laterally, on each side by the pedicles and intervertebral foramina; and
- posteriorly by the laminae and ligamenta flava and in the median plane the roots of the interspinous ligaments and vertebral spinous processes.

Between the walls of the vertebral canal and the dural sac is an extradural space containing a vertebral plexus of veins embedded in fatty connective tissue.

Spinal nerves

Each spinal nerve is connected to the spinal cord by posterior and anterior roots (Fig. 2.38):

- The **posterior root** contains the processes of sensory neurons carrying information to the central nervous system (CNS). The cell bodies of the sensory neurons,

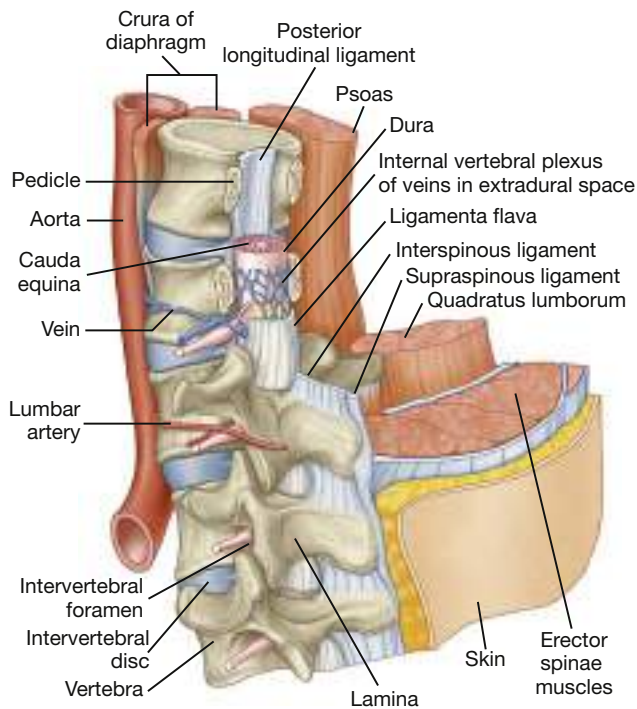


Fig. 2.37 Arrangement of structures in the vertebral canal and the back.

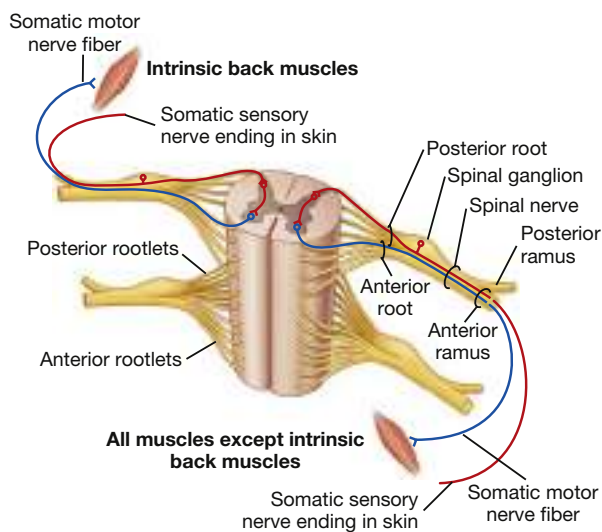


Fig. 2.38 Basic organization of a spinal nerve.

which are derived embryologically from neural crest cells, are clustered in a **spinal ganglion** at the distal end of the posterior root, usually in the intervertebral foramen.

- The **anterior root** contains motor nerve fibers, which carry signals away from the CNS. The cell bodies of the primary motor neurons are in anterior regions of the spinal cord.

Medially, the posterior and anterior roots divide into rootlets, which attach to the spinal cord.

A **spinal segment** is the area of the spinal cord that gives rise to the **posterior** and **anterior rootlets**, which will form a single pair of spinal nerves. Laterally, the posterior and anterior roots on each side join to form a spinal nerve.

Each spinal nerve divides, as it emerges from an intervertebral foramen, into two major branches: a small posterior ramus and a much larger anterior ramus (Fig. 2.38):

- The **posterior rami** innervate only intrinsic back muscles (the epaxial muscles) and an associated narrow strip of skin on the back.
- The **anterior rami** innervate most other skeletal muscles (the hypaxial muscles) of the body, including those of the limbs and trunk, and most remaining areas of the skin, except for certain regions of the head.

Near the point of division into anterior and posterior rami, each spinal nerve gives rise to two to four small recurrent meningeal (sinuvertebral) nerves (see Fig. 2.35). These nerves re-enter the intervertebral foramen to supply dura, ligaments, intervertebral discs, and blood vessels.

All major somatic plexuses (cervical, brachial, lumbar, and sacral) are formed by anterior rami.

Because the spinal cord is much shorter than the vertebral column, the roots of spinal nerves become longer and pass more obliquely from the cervical to coccygeal regions of the vertebral canal (Fig. 2.39).

In adults, the spinal cord terminates at a level approximately between vertebrae LI and LII, but this can range between vertebra TXII and the disc between vertebrae LII and LIII. Consequently, posterior and anterior roots forming spinal nerves emerging between vertebrae in the lower regions of the vertebral column are connected to the spinal cord at higher vertebral levels.

Below the end of the spinal cord, the posterior and anterior roots of lumbar, sacral, and coccygeal nerves pass inferiorly to reach their exit points from the vertebral canal. This terminal cluster of roots is the **cauda equine** (Fig. 2.39).

Clinical app

Lumbar cerebrospinal fluid tap

A lumbar tap (puncture) is carried out to obtain a sample of CSF for examination. In addition, passage of a needle or conduit into the subarachnoid space (CSF space) is used to inject antibiotics, chemotherapeutic agents, and anesthetics. The lumbar region is an ideal site to access the subarachnoid space because the spinal cord terminates around the level of the disc between vertebrae LI and LII in the adult. The subarachnoid space extends to the region of the lower border of the SII vertebra.

Continued

There is therefore a large CSF-filled space containing lumbar and sacral nerve roots but no spinal cord.

Depending on the clinician's preference, the patient is placed in the lateral or prone position. A needle is passed in the midline in between the spinous processes into the extradural space. Further advancement punctures the dura and arachnoid mater to enter the subarachnoid space. Most needles push the roots away from the tip without causing the patient any symptoms. Once the needle is in the subarachnoid space, fluid can be aspirated. In some situations, it is important to measure CSF pressure.

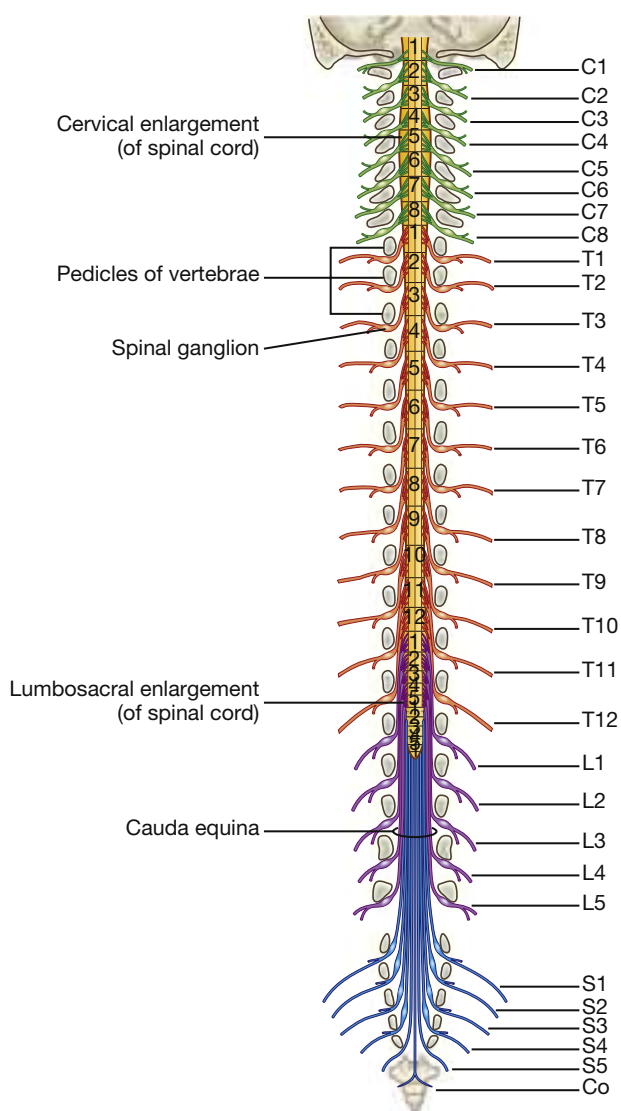


Fig. 2.39 Course of spinal nerves in the vertebral canal.

Clinical app

Anesthesia within the vertebral canal

Local anesthetics can be injected into the extradural space (extradural or epidural anesthesia) or the subarachnoid space (spinal anesthesia) in the lower lumbar region to anesthetize the sacral and lumbar nerve roots. Such anesthesia is useful for operations on the pelvis and the legs, which can then be carried out without the need for general anesthesia.

When doing epidural anesthesia, a needle is placed through the skin, supraspinous ligament, interspinous ligament, and ligamenta flava into the areolar tissue and fat around the dura mater. Anesthetic agent is introduced and diffuses around the vertebral canal to anesthetize the exiting nerve roots.

In spinal anesthesia, the needle continues through the dura and associated arachnoid into the subarachnoid space to directly anesthetize the nerve roots.

Nomenclature of spinal nerves

There are approximately 31 pairs of spinal nerves (Fig. 2.39) named according to their position with respect to associated vertebrae:

- eight cervical nerves—C1 to C8,
- twelve thoracic nerves—T1 to T12,
- five lumbar nerves—L1 to L5,
- five sacral nerves—S1 to S5, and
- one coccygeal nerve—Co.

The first cervical nerve (C1) emerges from the vertebral canal between the skull and vertebra C1 (Fig. 2.40). Therefore cervical nerves C2 to C7 also emerge from the vertebral canal above their respective vertebrae. Because there are only seven cervical vertebrae, C8 emerges between vertebrae CVII and T1. As a consequence, all remaining spinal nerves, beginning with T1, emerge from the vertebral canal below their respective vertebrae.

Clinical app

Herpes zoster

Herpes zoster is the virus that produces chickenpox in children. In some patients the virus remains dormant in the cells of the spinal ganglia. Under certain circumstances, the virus becomes activated and travels along the neuronal bundles to the areas supplied by that nerve (the dermatome). A rash ensues, which is characteristically exquisitely painful.

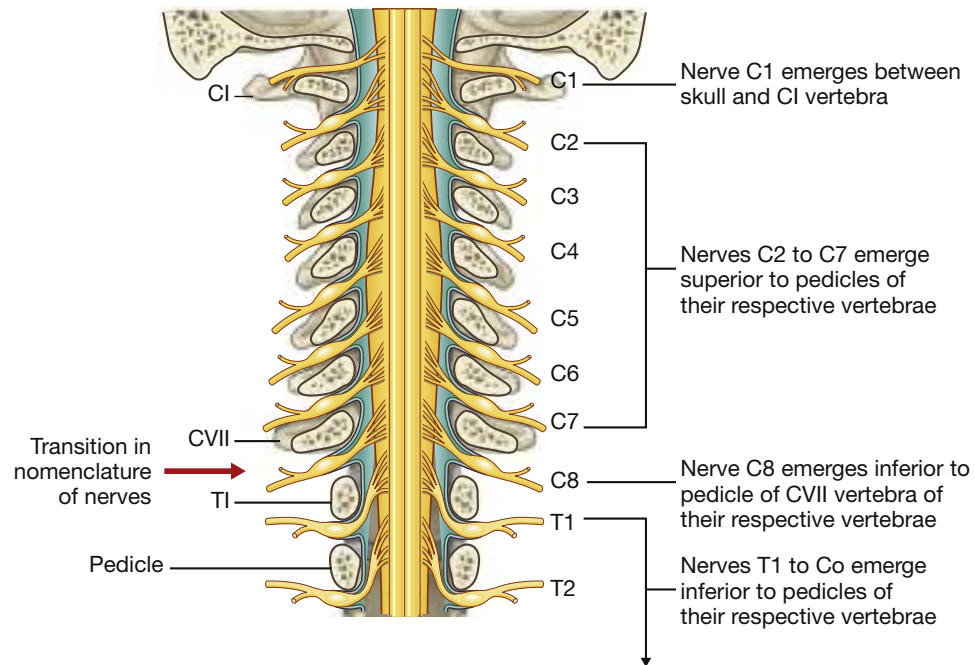


Fig. 2.40 Nomenclature of the spinal nerves.

3

Thorax

**ADDITIONAL LEARNING RESOURCES
FOR CHAPTER 3, *THORAX*,
CAN BE FOUND ON THE ACCOMPANYING
EBOOK:**

- Self-Assessment (scored) — National Board style multiple-choice questions, Chapter 3
- Short Questions (not scored) — these are questions requiring short responses, Chapter 3
- Clinical Cases
 - Cardiac tamponade
 - Patent ductus arteriosus
 - Subclavian steal syndrome
 - Sinus of Valsalva aneurysm
 - Cervical rib
 - Lung cancer
 - Chest wound
 - Myocardial infarction
 - Broken pacemaker
 - Coarctation of the aorta
 - Aortic dissection
 - Pneumonia
 - Esophageal cancer
 - Venous access

Regional anatomy 64

Pectoral region 64

- Breast 64
- Muscles of the pectoral region 66

Thoracic wall 66

- Superior thoracic aperture 67
- Inferior thoracic aperture 67
- Skeletal framework 68
- Intercostal spaces 75

Diaphragm 81

- Venous drainage 83
- Innervation 83

Movements of the thoracic wall and diaphragm during breathing 84

Pleural cavities 84

- Pleura 84
- Lungs 88

Mediastinum 97

- Anterior mediastinum 102
- Middle mediastinum 102
- Superior mediastinum 126
- Posterior mediastinum 135

Regional anatomy

The **thorax** is an irregularly shaped cylinder with a narrow opening (superior thoracic aperture) superiorly and a relatively large opening (inferior thoracic aperture) inferiorly (Fig. 3.1). The thorax consists of:

- a wall,
- two pleural cavities,
- the lungs, and
- the mediastinum.

The thorax:

- houses and protects the heart, lungs, and great vessels;
- acts as a conduit for structures passing between the neck and the abdomen; and
- plays a principal role in breathing.

The thorax also provides support for the upper limb. Muscles anchored to the anterior thoracic wall provide some of this support and, together with their associated connective tissues, nerves, and vessels and the overlying skin and superficial fascia, define the pectoral region.

PECTORAL REGION

The pectoral region is external to the anterior thoracic wall and helps anchor the upper limb to the trunk. It consists of:

- a superficial compartment containing skin, superficial fascia, and breasts; and
- a deep compartment containing muscles and associated structures.

Breast

The breasts consist of mammary glands, associated skin, and connective tissues. The **mammary glands** are modified sweat glands in the superficial fascia anterior to the pectoral muscles and the anterior thoracic wall (Fig. 3.2).

The mammary glands consist of ducts and associated secretory lobules. These converge, forming 15 to 20 **lactiferous ducts**, which open independently onto the **nipple**. The nipple is surrounded by a circular pigmented area of skin, the **areola** (Fig. 3.2).

A well-developed, connective tissue stroma surrounds the ducts and lobules of the mammary gland. In certain regions, this stroma condenses, forming well-defined

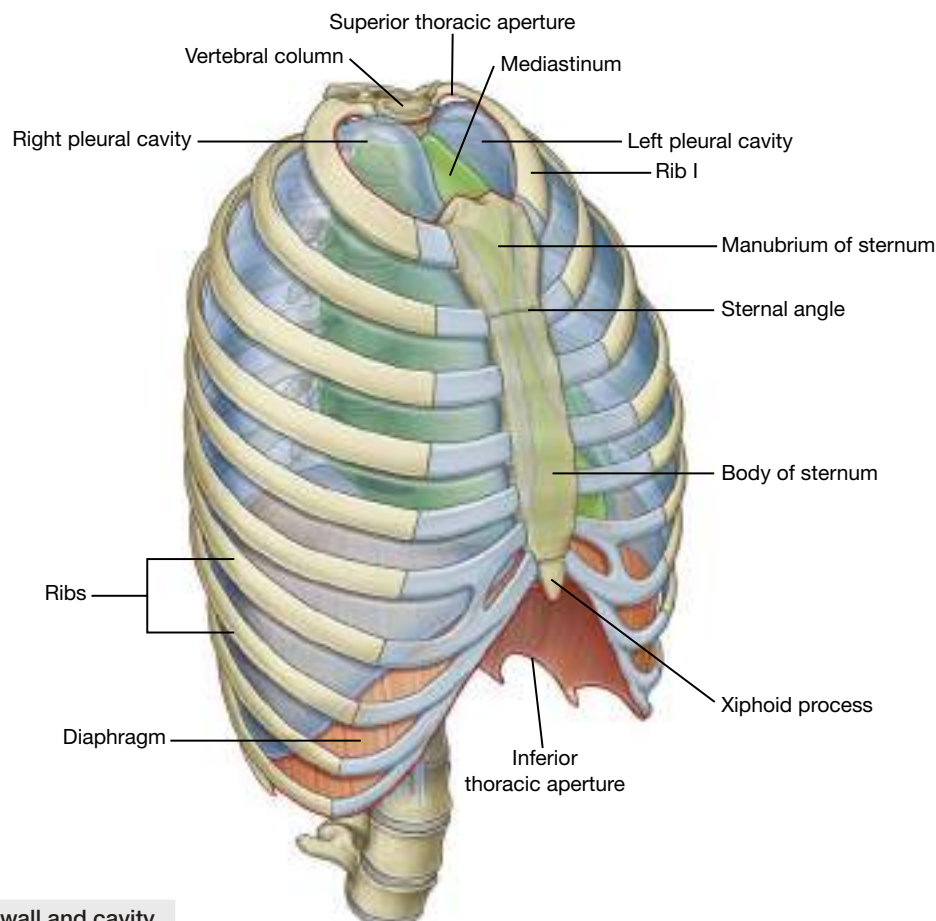


Fig. 3.1 Thoracic wall and cavity.

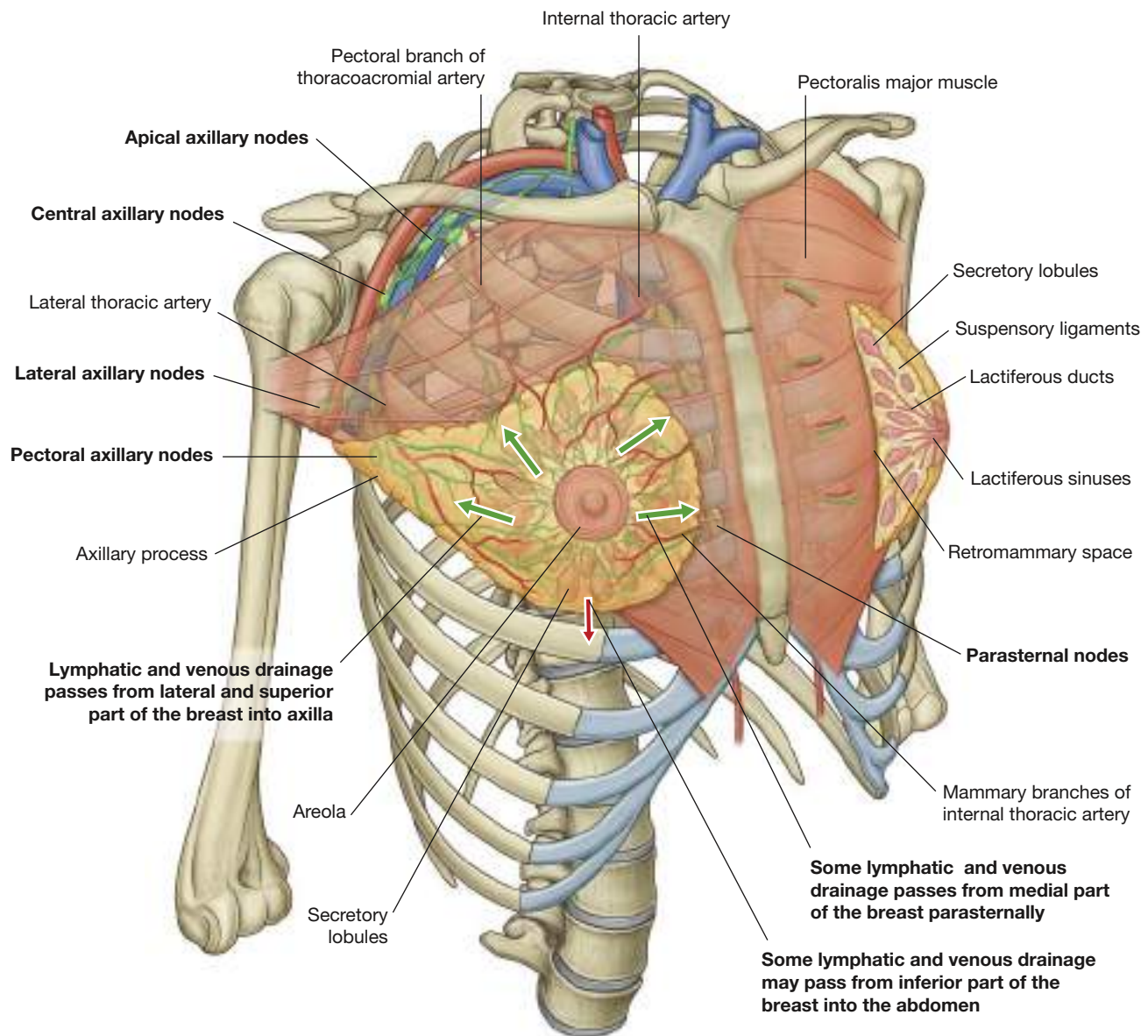


Fig. 3.2 Breasts.

ligaments, the **suspensory ligaments of breast**, which are continuous with the dermis of the skin and support the breast.

In nonlactating women, the predominant component of the breasts is fat, whereas glandular tissue is more abundant in lactating women.

The breast lies on the deep fascia of the pectoralis major muscle and other surrounding muscles. A layer of loose connective tissue (the **retromammary space**) separates the breast from the deep fascia and provides some degree of movement over underlying structures.

The base, or attached surface, of each breast extends vertically from ribs II to VI and transversely from the sternum to as far laterally as the midaxillary line.

Clinical app

Axillary process of breast

It is important for clinicians to remember, when evaluating the breast for pathology, that the upper lateral region of the mammary gland and supporting tissues can project around the lateral margin of the pectoralis major muscle and into the axilla. This axillary process (axillary tail) may perforate deep fascia and extend as far superiorly as the apex of the axilla (Fig. 3.2).

Arterial supply

The breast is related to the thoracic wall and to structures associated with the upper limb; therefore vascular supply and drainage can occur by multiple routes (Fig. 3.2):

- laterally, vessels from the axillary artery—superior thoracic, thoracoacromial, lateral thoracic, and subscapular arteries;
- medially, branches from the internal thoracic artery; and
- from the second to fourth intercostal arteries via branches that perforate the thoracic wall and overlying muscle.

Venous drainage

Veins draining the breast parallel the arteries and ultimately drain into the axillary, internal thoracic, and intercostal veins.

Innervation

Innervation of the breast is via anterior and lateral cutaneous branches of the second to sixth intercostal nerves. The nipple is innervated by the fourth intercostal nerve.

Lymphatic drainage

Lymphatic drainage of the breast is as follows:

- Approximately 75% is via lymphatic vessels that drain laterally and superiorly into **axillary nodes** (see Fig. 3.2).
- Most of the remaining drainage is into parasternal nodes deep to the anterior thoracic wall and associated with the internal thoracic artery.
- Some drainage may occur via lymphatic vessels that follow the lateral branches of posterior intercostal arteries and connect with intercostal nodes situated near the heads and necks of ribs.

Axillary nodes drain into the subclavian trunks, parasternal nodes drain into the bronchomediastinal trunks, and intercostal nodes drain either into the thoracic duct or into the bronchomediastinal trunks.

Breast in men

The breast in men is rudimentary. The mammary gland consists only of small ducts, often composed of cords of cells, which normally do not extend beyond the areola. Breast cancer can occur in men.

Clinical app

Breast cancer

Breast cancer is one of the most common malignancies in women. Breast cancer develops in the cells of the acini, lactiferous ducts, and lobules of the breast. Tumor growth and spread depend on the exact cellular site of origin of the cancer. Breast tumors spread via the lymphatics and veins or by direct invasion.

Subcutaneous lymphatic obstruction and tumor growth pull on connective tissue ligaments, the suspensory ligaments, in the breast resulting in the appearance of an orange peel texture (**peau d'orange**) on the surface of the breast. Further subcutaneous

spread can induce a rare manifestation of breast cancer that produces a hard, woody texture to the skin (**cancer en cuirasse**).

Patients who have undergone chest masculinization surgery (e.g., some transgender men) may not have had all breast tissue removed. If an irregularity is palpated over the chest wall, clinical suspicion for breast pathology should remain and needs to be investigated. Ultrasound is the favored imaging modality rather than mammography because of the technical difficulties of mammography with a masculinized chest. Because the lymphatics remain intact, malignancies in the breast can still spread into the thorax via the axilla. In patients on feminizing hormones (e.g., some transgender women), estrogen and progesterone stimulates the growth of breast tissue. Extended lengths of time on feminizing hormones may increase the risk of breast cancer to those levels seen in cisgender women.

Muscles of the pectoral region

Each pectoral region contains the **pectoralis major**, **pectoralis minor**, and **subclavius muscles** (Table 3.1, Fig. 3.4). All originate from the anterior thoracic wall and insert into bones of the upper limb.

A continuous layer of deep fascia, **clavipectoral fascia**, encloses the subclavius and pectoralis minor and attaches to the clavicle above and to the floor of the axilla below.

The muscles of the pectoral region form the anterior wall of the axilla, a region between the upper limb and the neck through which all major structures pass.

THORACIC WALL

The **thoracic wall** consists of skeletal elements and muscles (see Fig. 3.1):

- Posteriorly, it is made up of 12 thoracic vertebrae and their intervening intervertebral discs.
- Laterally, the wall is formed by **ribs** (12 on each side) and three layers of flat muscles, which span the intercostal spaces between adjacent ribs, move the ribs, and provide support for the intercostal spaces.
- Anteriorly, the wall is made up of the **sternum**, which consists of the manubrium of sternum, body of sternum, and xiphoid process.

The thoracic wall extends between:

- the superior thoracic aperture bordered by vertebra T1, rib I, and the manubrium of sternum; and
- the inferior thoracic aperture bordered by vertebra TXII, rib XII, the end of rib XI, the costal margin, and the xiphoid process of the sternum.

Surface anatomy

The breast in women

Although breasts vary in size, they are normally positioned on the thoracic wall between ribs II and VI and overlie the pectoralis major muscles. Each mammary gland extends superolaterally around the lower margin of the pectoralis major muscle and enters the axilla (Fig. 3.3). This portion of the gland is the axillary tail or axillary process. The positions of the nipple and areola vary relative to the chest wall depending on breast size.

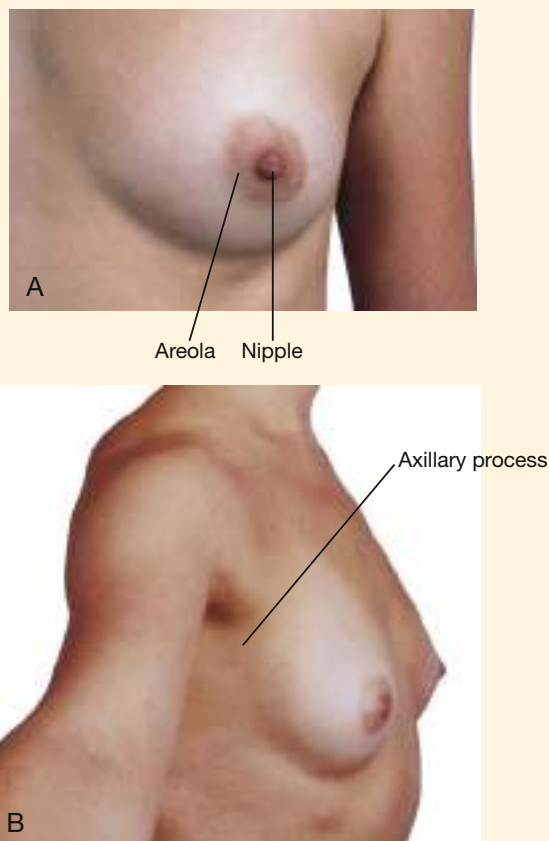


Fig. 3.3 A. Close-up view of the nipple and surrounding areola of the breast. B. Lateral view of the chest wall of a woman showing the axillary process of the breast.

Superior thoracic aperture

The **superior thoracic aperture** (Fig. 3.5; also see Fig. 3.1) consists of:

- the body of vertebra T1 posteriorly,
- the medial margin of rib I on each side, and
- the manubrium anteriorly.

The superior margin of the manubrium is in approximately the same horizontal plane as the intervertebral disc between vertebrae TII and TIII.

The first ribs slope inferiorly from their posterior articulation with vertebra T1 to their anterior attachment to the manubrium. Consequently, the plane of the superior thoracic aperture is at an oblique angle, facing somewhat anteriorly (Fig. 3.5).

At the superior thoracic aperture, the superior aspects of the pleural cavities, which surround the lungs, lie on either side of the entrance to the mediastinum (Fig. 3.6).

Structures that pass between the upper limb and thorax pass over rib I and the superior part of the pleural cavity as they enter and leave the mediastinum (Fig. 3.6). Structures that pass between the neck and head and the thorax pass more vertically through the superior thoracic aperture (Fig. 3.5).

Inferior thoracic aperture

The **inferior thoracic aperture** is large and expandable, and bone, cartilage, and ligaments form its margin (Fig. 3.7). It is closed by the diaphragm (Fig. 3.7B), and structures passing between the abdomen and thorax pierce or pass posteriorly to this structure. Skeletal elements of the inferior thoracic aperture are:

- the body of vertebra TXII posteriorly,
- rib XII and the distal end of rib XI posterolaterally,
- the distal cartilaginous ends of ribs VII to X, which unite to form the costal margin anterolaterally, and
- the xiphoid process anteriorly.

Clinical app

Thoracic outlet syndrome

Clinically, thoracic outlet syndrome is used to describe symptoms resulting from abnormal compression of the brachial plexus of nerves as it passes over the first rib and through the axillary inlet into the upper limb. The anterior ramus of T1 passes superiorly out of the superior thoracic aperture to join and become part of the brachial plexus. A connective tissue band that can extend from the tip of a cervical rib to rib I is one cause of thoracic outlet syndrome by putting upward stresses on the lower parts of the brachial plexus as they pass over the first rib.

Joints between the costal margin and sternum lie roughly in the same horizontal plane as the intervertebral disc between vertebrae TIX and TX. Thus the posterior margin of the inferior thoracic aperture is inferior to the anterior margin.

Fig. 3.4 Muscles and fascia of the pectoral region.

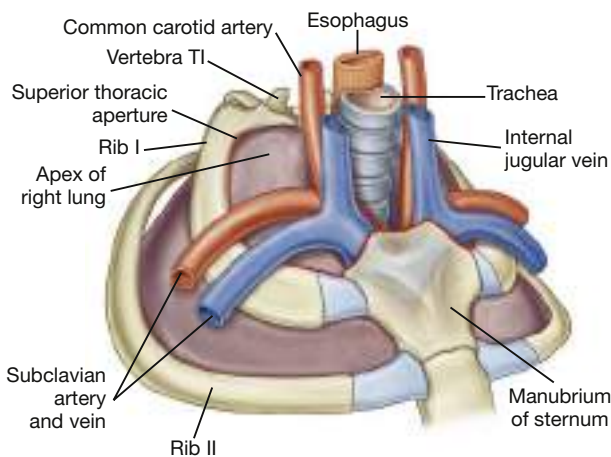
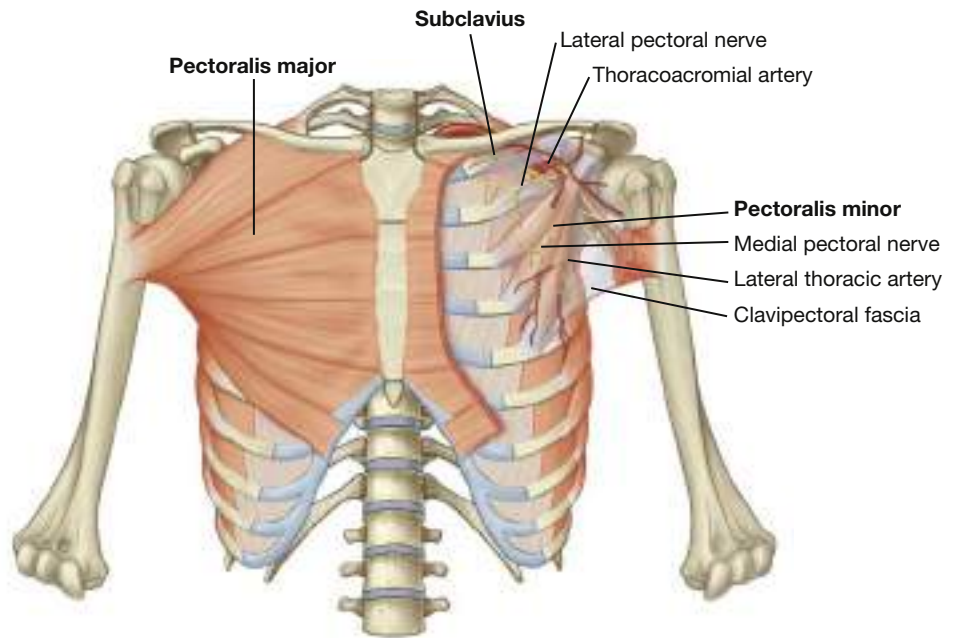


Fig. 3.5 Superior thoracic aperture.

Skeletal framework

The skeletal elements of the thoracic wall consist of thoracic vertebrae, intervertebral discs, ribs, and sternum.

Thoracic vertebrae

There are 12 **thoracic vertebrae**, each of which is characterized by articulations with the ribs.

A typical thoracic vertebra

A typical thoracic vertebra has a heart-shaped **vertebral body**, with roughly equal dimensions in the transverse and anteroposterior directions and a long spinous process (Fig. 3.8). The **vertebral foramen** is generally circular,

and the **laminae** are broad and overlap with those of the vertebra below. The **superior articular processes** are flat, with their articular surfaces facing almost directly posteriorly, whereas the **inferior articular processes** project from the laminae and their articular facets face anteriorly. The **transverse processes** are club shaped and project posterolaterally.

Articulation with ribs

A typical thoracic vertebra has three sites for articulations with ribs on each side (Fig. 3.8).

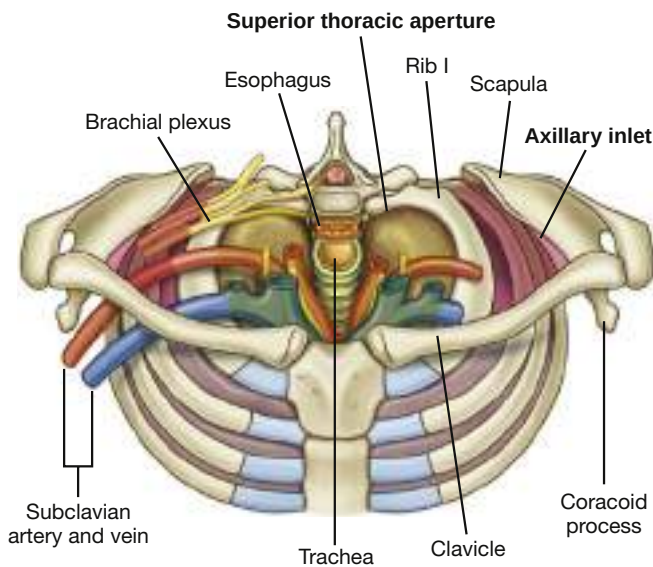
- Two demifacets (i.e., partial facets) located on the superior and inferior aspects of the body for articulation with corresponding sites on the heads of adjacent ribs. The **superior costal facet** articulates with part of the head of its own rib, and the **inferior costal facet** articulates with part of the head of the rib below.
- An oval facet (**transverse costal facet**) at the end of the transverse process articulates with the tubercle of its own rib.

Not all vertebrae articulate with ribs in the same fashion (Fig. 3.9):

- The superior costal facets on the body of vertebra T1 are complete and articulate with a single facet on the head of its own rib—in other words, the head of rib I does not articulate with vertebra CVII.
- Similarly, vertebra TX (and often TIX) articulates only with its own ribs and therefore lacks inferior demifacets on the body.

Table 3.1 Muscles of the pectoral region

Muscle	Origin	Insertion	Innervation	Function
Pectoralis major	Medial half of clavicle and anterior surface of sternum, first seven costal cartilages, aponeurosis of external oblique	Lateral lip of intertubercular sulcus of humerus	Medial and lateral pectoral nerves	Adduction, medial rotation, and flexion of the humerus at the shoulder joint
Subclavius	Rib I at junction between rib and costal cartilage	Groove on inferior surface of middle third of clavicle	Nerve to subclavius	Pulls clavicle medially to stabilize sternoclavicular joint; depresses tip of shoulder
Pectoralis minor	Anterior surfaces of the third, fourth, and fifth ribs and deep fascia overlying the related intercostal spaces	Coracoid process of scapula	Medial pectoral nerves	Depresses tip of shoulder; protracts scapula

**Fig. 3.6** Superior thoracic aperture and axillary inlet.

- Vertebrae TXI and TXII articulate only with the heads of their own ribs—they lack transverse costal facets and have only a single complete facet on each side of their bodies.

Ribs

There are 12 pairs of ribs, each terminating anteriorly in a costal cartilage (Fig. 3.10).

Although all ribs articulate with the vertebral column, only the costal cartilages of the upper seven ribs, known as **true ribs**, articulate directly with the sternum. The remaining five pairs of ribs are **false ribs**:

- The costal cartilages of ribs VIII to X articulate anteriorly with the costal cartilages of the ribs above.
- Ribs XI and XII have no anterior connection with other ribs or with the sternum and are often called **floating ribs**.

A typical rib consists of a curved shaft with anterior and posterior ends (Fig. 3.11). The anterior end is continuous

with its costal cartilage. The posterior end articulates with the vertebral column and is characterized by a head, neck, and tubercle.

The **head** is somewhat expanded and typically presents two articular surfaces separated by a **crest**. The smaller superior surface articulates with the inferior costal facet on the body of the vertebra above, whereas the larger inferior facet articulates with the superior costal facet of its own vertebra.

The **neck** is a short flat region of bone that separates the head from the tubercle.

The **tubercle** projects posteriorly from the junction of the neck with the shaft and consists of two regions, an articular part and a nonarticular part:

- The articular part is medial and has an oval facet for articulation with a corresponding facet on the transverse process of the associated vertebra.
- The raised nonarticular part is roughened by ligament attachments.

The shaft is generally thin and flat with internal and external surfaces.

The superior margin is smooth and rounded, whereas the inferior margin is sharp. The shaft bends forward just laterally to the tubercle at a site termed the **angle**. It also has a gentle twist around its longitudinal axis so that the external surface of the anterior part of the shaft faces somewhat superiorly relative to the posterior part. The inferior margin of the internal surface is marked by a distinct **costal groove**.

Distinct features of upper and lower ribs

The upper and lower ribs have distinct features (Fig. 3.12).

Rib I

Rib I is flat in the horizontal plane and has broad superior and inferior surfaces. From its articulation with vertebra TI, it slopes inferiorly to its attachment to the manubrium of sternum. The head articulates with the

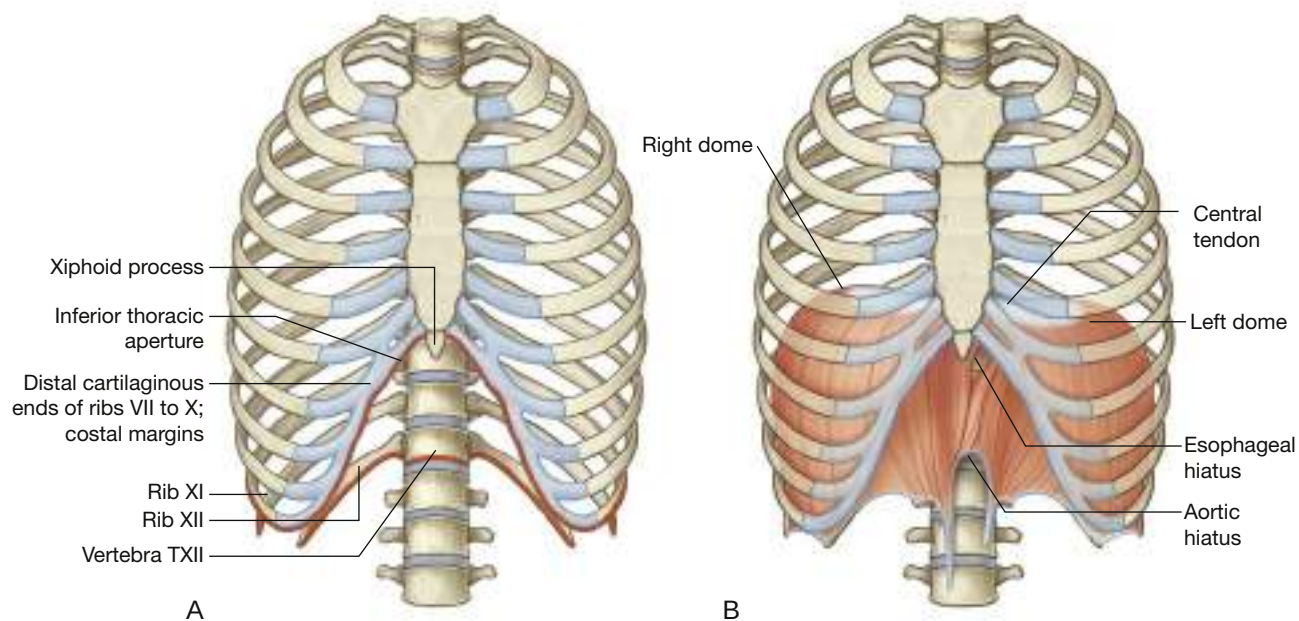


Fig. 3.7 A. Inferior thoracic aperture. B. Diaphragm.

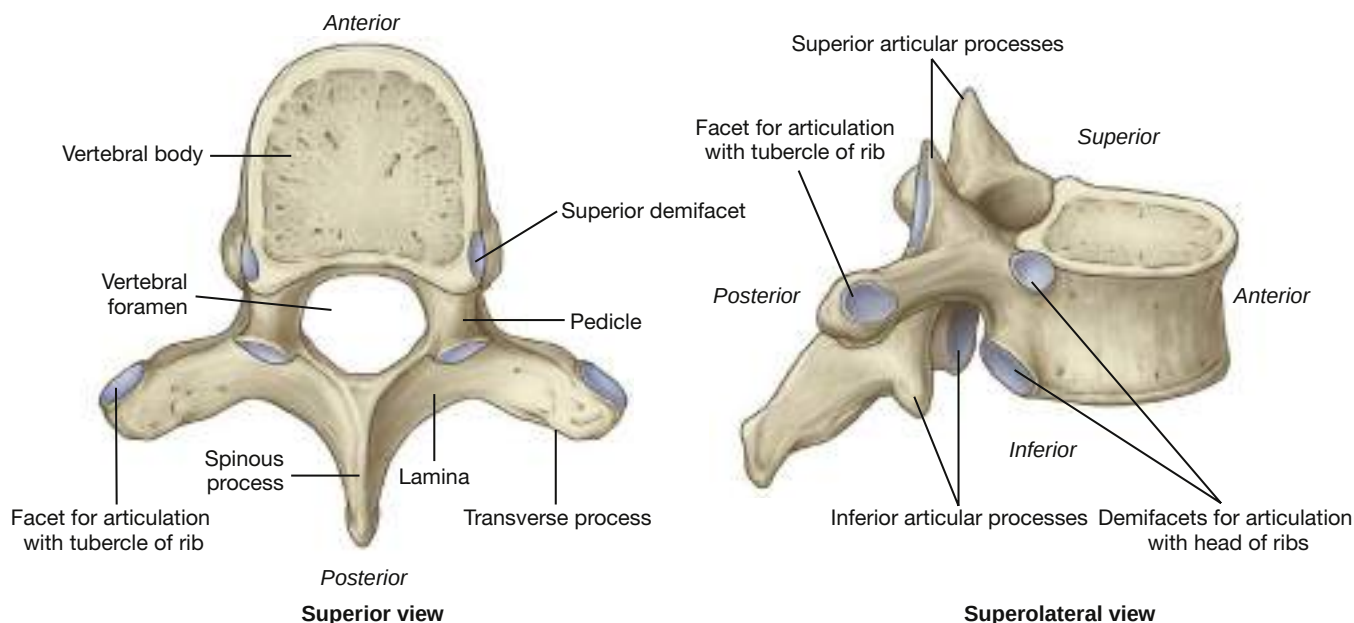


Fig. 3.8 Typical thoracic vertebra.

body of vertebra T1 and has only one articular surface. The tubercle has a facet for articulation with the transverse process. The superior surface of the rib is characterized by a distinct tubercle, the **scalene tubercle**, which separates two smooth grooves that cross the rib approximately midway along the shaft. The anterior groove is caused by the subclavian vein, and the posterior groove is

caused by the subclavian artery. Anterior and posterior to these grooves, the shaft is roughened by muscle and ligament attachments.

Rib II

Rib II, like rib I, is flat but twice as long. It articulates with the vertebral column in a way typical of most ribs.

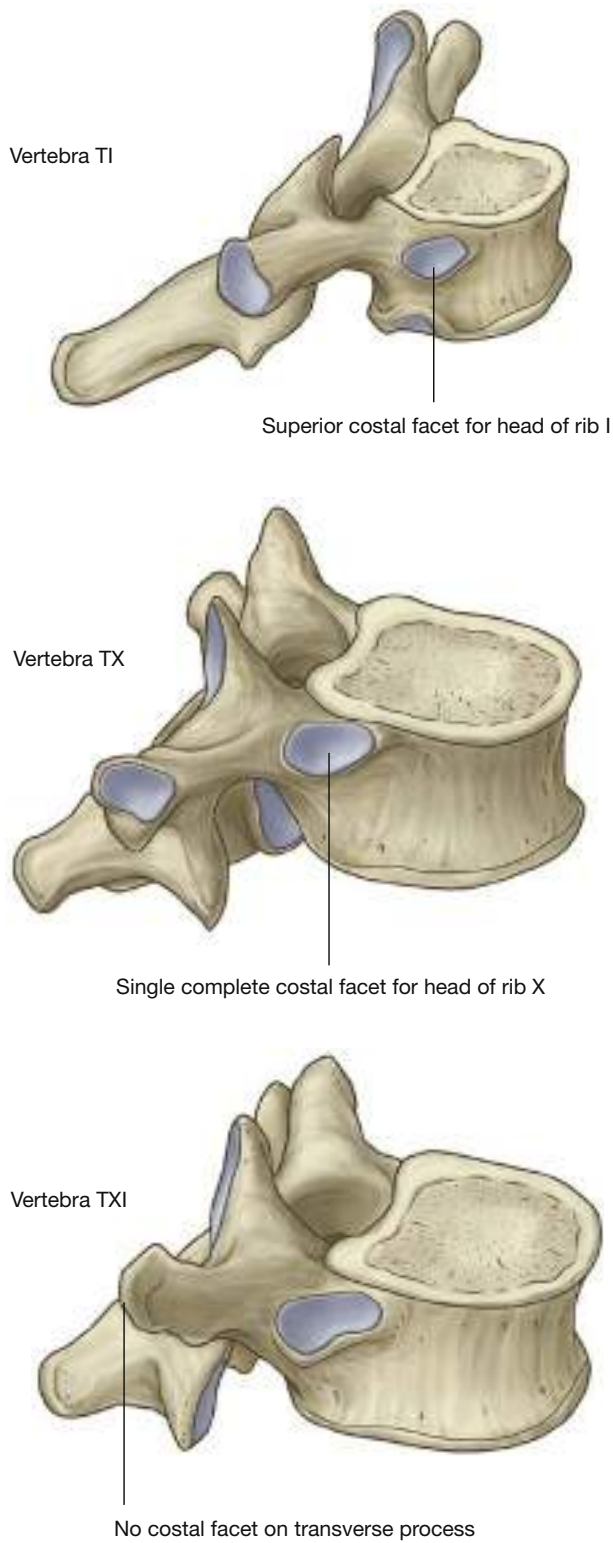


Fig. 3.9 Thoracic vertebrae.

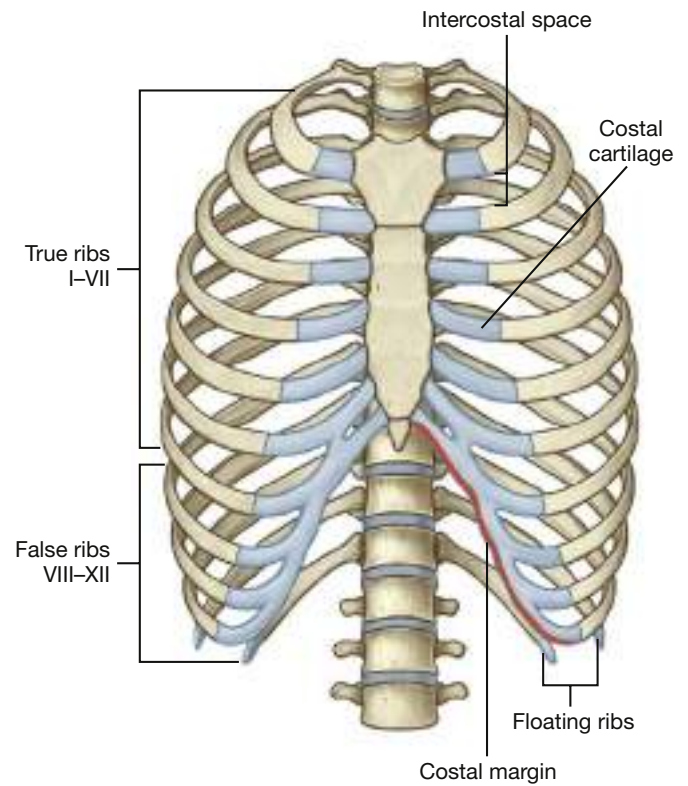


Fig. 3.10 Ribs.

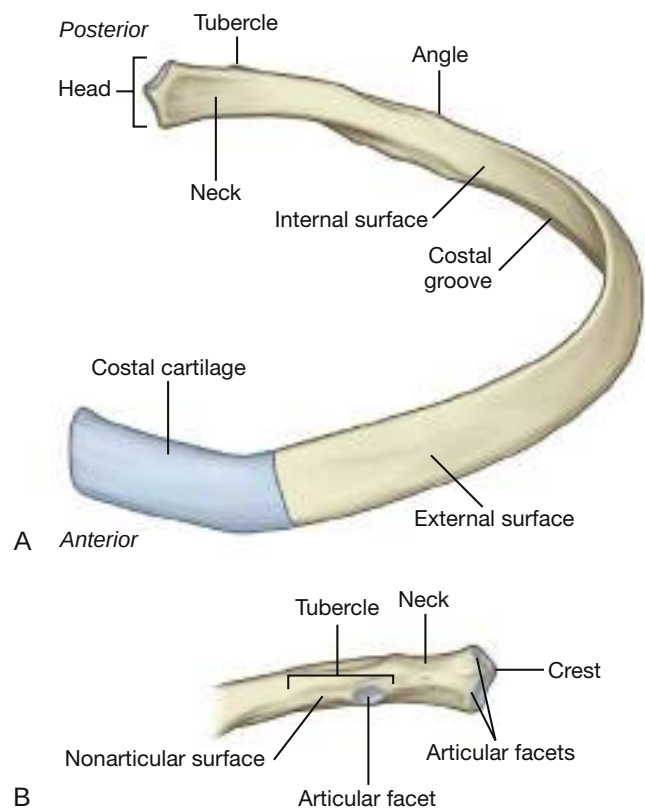


Fig. 3.11 A typical rib. A. Anterior view. B. Posterior view of proximal end of rib.

Rib X

The head of **rib X** has a single facet for articulation with its own vertebra.

Ribs XI and XII

Ribs XI and XII articulate only with the bodies of their own vertebrae and have no tubercles or necks. Both ribs are short, have little curve, and are pointed anteriorly.

Clinical apps

Cervical ribs

Cervical ribs are present in approximately 1% of the population.

A cervical rib is an accessory rib articulating with vertebra CVII; the anterior end attaches to the superior border of the anterior aspect of rib I.

Plain radiographs may demonstrate cervical ribs as small horn-like structures.

It is often not appreciated by clinicians that a fibrous band commonly extends from the anterior tip of the small cervical ribs to rib I, producing a “cervical band” that is not visualized on radiography. In patients with cervical ribs and cervical bands, structures that normally pass over rib I are elevated by, and pass over, the cervical rib and band.

Clinical apps

Rib fractures

Single rib fractures are of little consequence, though extremely painful.

After severe trauma, ribs may be broken in two or more places. If enough ribs are broken, a loose segment of chest wall, a flail segment (**flail chest**), is produced. When the patient takes a deep inspiration, the flail segment moves in the opposite direction to the chest wall, preventing full lung expansion and creating a paradoxically moving segment. If a large enough segment of chest wall is affected, ventilation may be impaired and assisted ventilation may be required until the ribs have healed.

Sternum

The adult **sternum** consists of three major elements: the broad and superiorly positioned manubrium of sternum, the narrow and longitudinally oriented body of sternum, and the small and inferiorly positioned xiphoid process (Fig. 3.13).

Manubrium of sternum

The **manubrium of sternum** forms part of the bony framework of the neck and the thorax.

The superior surface of the manubrium is expanded laterally and bears a distinct and palpable notch, the **jugular notch (suprasternal notch)**, in the midline (Fig. 3.13). On either side of this notch is a large oval fossa for articulation with the clavicle. Immediately inferior to this fossa, on each lateral surface of the manubrium, is a facet for the attachment of the first costal cartilage. At the lower end of the lateral border is a demifacet for articulation with the upper half of the anterior end of the second costal cartilage.

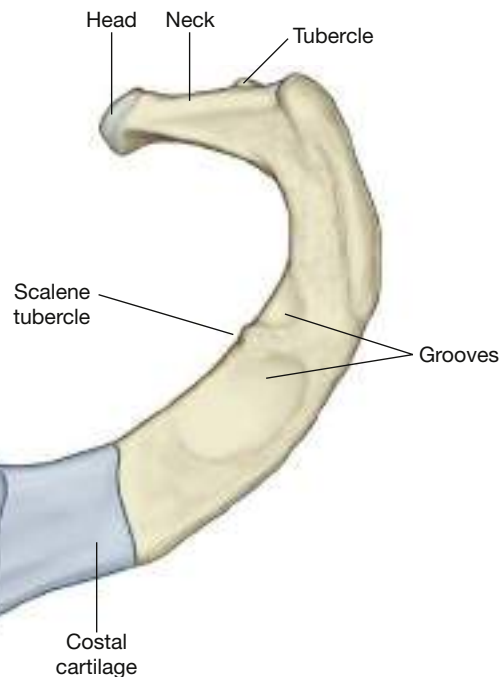
Body of the sternum

The **body of the sternum** is flat (Fig. 3.13).

The anterior surface of the body of the sternum is often marked by transverse ridges that represent lines of fusion between the segmental elements called *sternbrae* from which this part of the sternum arises embryologically.

The lateral margins of the body of the sternum have articular facets for costal cartilages. Superiorly, each lateral margin has a demifacet for articulation with the inferior aspect of the second costal cartilage. Inferior to this demifacet are four facets for articulation with the costal cartilages of ribs III to VI.

Rib I



Rib XII



Fig. 3.12 Atypical ribs.

At the inferior end of the body of the sternum is a demifacet for articulation with the upper demifacet on the seventh costal cartilage. The inferior end of the body of the sternum is attached to the xiphoid process.

Xiphoid process

The **xiphoid process** is the smallest part of the sternum (Fig. 3.13). Its shape is variable: it may be wide, thin, pointed, bifid, curved, or perforated. It begins as a cartilaginous structure, which becomes ossified in the adult. On each side of its upper lateral margin is a demifacet for articulation with the inferior end of the seventh costal cartilage.

Clinical app

Collection of sternal bone marrow

The subcutaneous position of the sternum makes it possible to place a needle through the hard outer cortex into the internal (or medullary) cavity containing bone marrow. Once the needle is in this position, bone marrow can be aspirated. Evaluation of this material under the microscope helps clinicians diagnose certain blood diseases such as leukemia.

Joints

Costovertebral joints

A typical rib articulates with:

- the bodies of adjacent vertebrae, forming a joint with the head of the rib, and
- the transverse process of its related vertebra, forming a **costotransverse joint** (Fig. 3.14).

Together, the costovertebral joints and related ligaments allow the necks of the ribs either to rotate around their longitudinal axes, which occurs mainly in the upper ribs, or to ascend and descend relative to the vertebral column, which occurs mainly in the lower ribs. The combined movements of all of the ribs on the vertebral column are essential for altering the volume of the thoracic cavity during breathing.

Joint with head of rib

The two facets on the head of the rib articulate with the superior facet on the body of its own vertebra and with the inferior facet on the body of the vertebra above (Fig. 3.14). This joint is divided into two synovial compartments by an intra-articular ligament, which attaches the crest to the adjacent intervertebral disc and separates the two articular surfaces

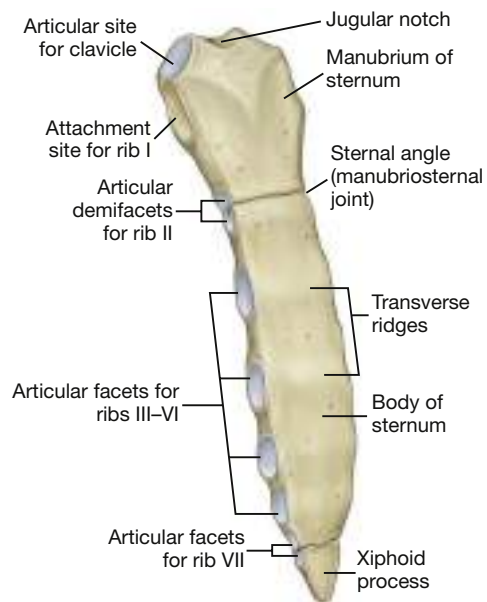


Fig. 3.13 Sternum.

on the head of the rib. The two synovial compartments and the intervening ligament are surrounded by a single joint capsule attached to the outer margins of the combined articular surfaces of the head and vertebral column.

Costotransverse joints

Costotransverse joints are synovial joints between the tubercle of a rib and the transverse process of the related vertebra (Fig. 3.14). The joint is stabilized by two strong extracapsular ligaments that span the space between the transverse process and the rib on the medial and lateral sides of the joint:

- The **costotransverse ligament** is medial to the joint and attaches the neck of the rib to the transverse process.
- The **lateral costotransverse ligament** is lateral to the joint and attaches the tip of the transverse process to the roughened nonarticular part of the tubercle of the rib.

A third ligament, the **superior costotransverse ligament**, attaches the superior surface of the neck of the rib to the transverse process of the vertebra above.

Slight gliding movements occur at the costotransverse joints.

Sternocostal joints

The sternocostal joints are joints between the upper seven costal cartilages and the sternum (Fig. 3.15).

The joint between rib I and the manubrium is not synovial and consists of a fibrocartilaginous connection between

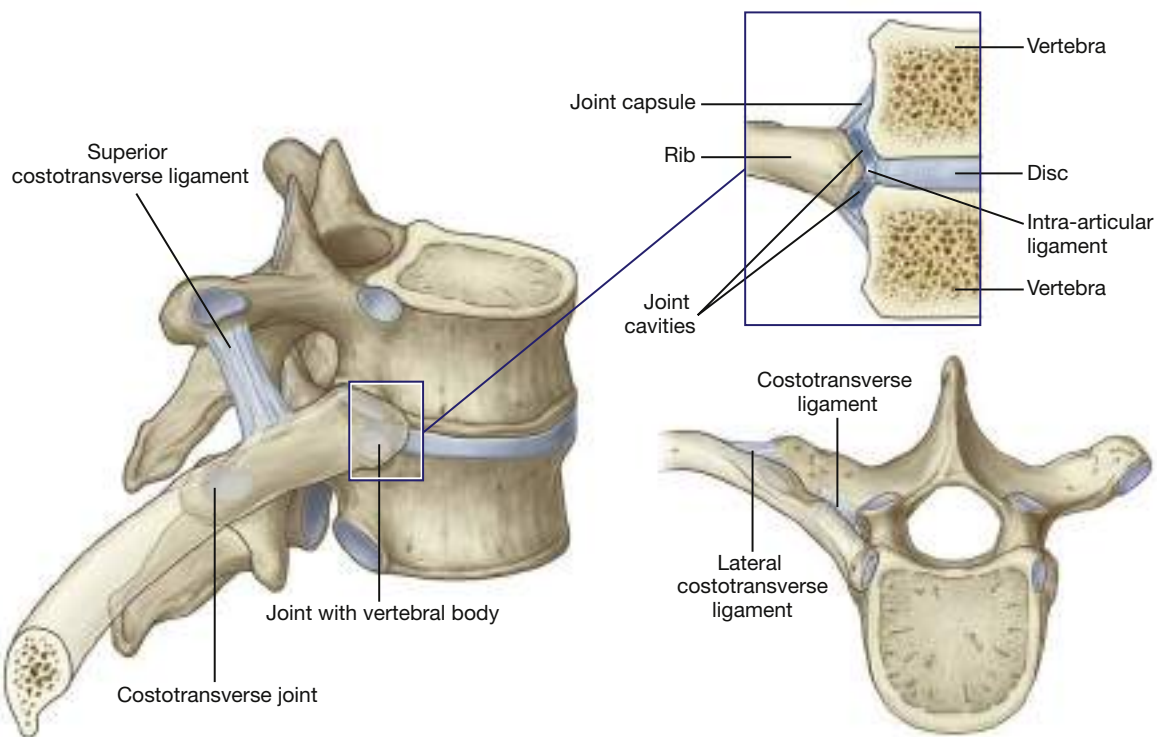


Fig. 3.14 Costovertebral joints.

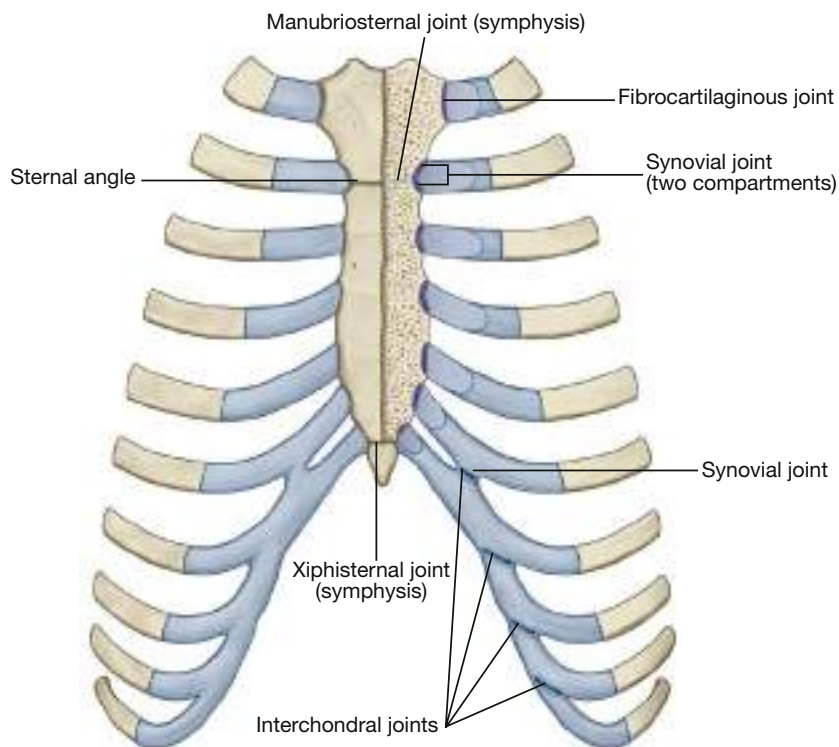


Fig. 3.15 Sternocostal joints.

the manubrium and the costal cartilage. The joints between rib II through VII and the sternum are synovial and have thin capsules reinforced by surrounding sternocostal ligaments.

The joint between the second costal cartilage and the sternum is divided into two compartments by an intra-articular ligament. This ligament attaches the second costal cartilage to the junction of the manubrium and the body of the sternum.

Interchondral joints

Interchondral joints occur between the costal cartilages of adjacent ribs (Fig. 3.15), mainly between the costal cartilages of ribs VII to X but may also involve the costal cartilages of ribs V and VI.

Interchondral joints provide indirect anchorage to the sternum and contribute to the formation of a smooth inferior costal margin. They are usually synovial, and the thin fibrous capsules are reinforced by interchondral ligaments.

Manubriosternal and xiphisternal joints

The joints between the manubrium and body of sternum and between the body of sternum and the xiphoid process are usually symphyses (Fig. 3.15). Only slight angular movements occur between the manubrium and body of sternum during respiration. The joint between the body of sternum and the xiphoid process often becomes ossified with age.

Additionally, the sternal angle is on a horizontal plane that passes through the intervertebral disc between vertebrae TIV and TV (Fig. 3.16). This plane separates the superior mediastinum from the inferior mediastinum and marks the superior border of the pericardium. It also separates the end of the ascending aorta from the beginning of the arch of the aorta, the end of the arch of the aorta from the beginning of the thoracic aorta, and passes through the bifurcation of the trachea just superior to the pulmonary trunk.

Clinical app

The manubriosternal joint as reference

A clinically useful feature of the manubriosternal joint is that it can be palpated easily. This is because the manubrium normally angles posteriorly on the body of sternum, forming a raised feature referred to as the *sternal angle*. This elevation marks the site of articulation of rib II with the sternum. Rib I is not palpable because it lies inferior to the clavicle and is embedded in tissues at the base of the neck. Therefore rib II is used as a reference for counting ribs and can be felt immediately lateral to the sternal angle.

Intercostal spaces

Intercostal spaces lie between adjacent ribs and are filled by intercostal muscles (Fig. 3.19).

Intercostal nerves and associated major arteries and veins lie in the costal groove along the inferior margin of the superior rib and pass in the plane between the inner two layers of muscles (Fig. 3.19). In each space, the vein is the most superior structure and is therefore highest in the costal groove. The artery is inferior to the vein, and the nerve is inferior to the artery and often not protected by the groove. Therefore the nerve is the structure most at risk

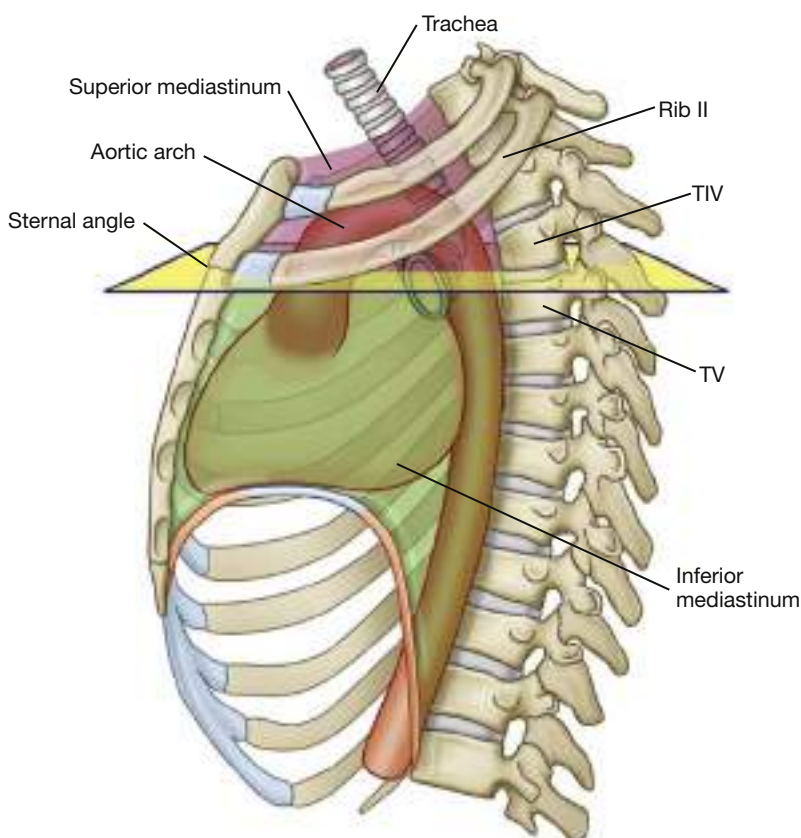


Fig. 3.16 Vertebral level TIV/V.

Surface anatomy

How to count ribs

Knowing how to count ribs is important because different ribs provide palpable landmarks for the positions of deeper structures. To determine the location of specific ribs, palpate the **jugular notch** at the superior extent of the manubrium of the sternum. Move down the sternum until a ridge is felt. This ridge is the

sternal angle, which identifies the articulation between the manubrium of sternum and the body of sternum. The costal cartilage of rib II articulates with the sternum at this location. Identify rib II. Then continue counting the ribs, moving in a downward and lateral direction (Fig. 3.17).

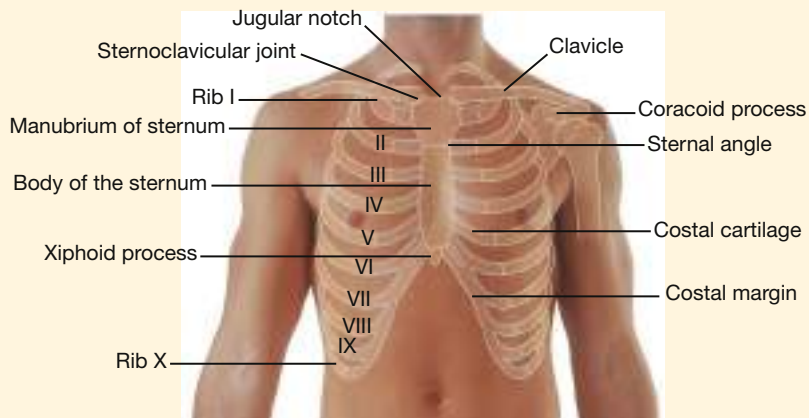


Fig. 3.17 Anterior view of chest wall with the locations of skeletal structures shown. In women, the location of the nipple relative to a specific intercostal space varies depending on the size of the breasts, which may not be symmetric. In men, the location of the nipple is in the fourth intercostal space.

Surface anatomy

Visualizing structures at the TIV/V vertebral level

The TIV/V vertebral level is a transverse plane that passes through the sternal angle on the anterior chest wall and the intervertebral disc between TIV and TV vertebrae posteriorly. This plane can be easily located, because the joint between the manubrium of sternum and the body of sternum forms a distinct bony protuberance that can be palpated. At the TIV/V level (Fig. 3.18):

- The costal cartilage of rib II articulates with the sternum.
- The superior mediastinum is separated from the inferior mediastinum.
- The ascending aorta ends and the arch of aorta begins.
- The arch of aorta ends and the thoracic aorta begins.
- The trachea bifurcates.

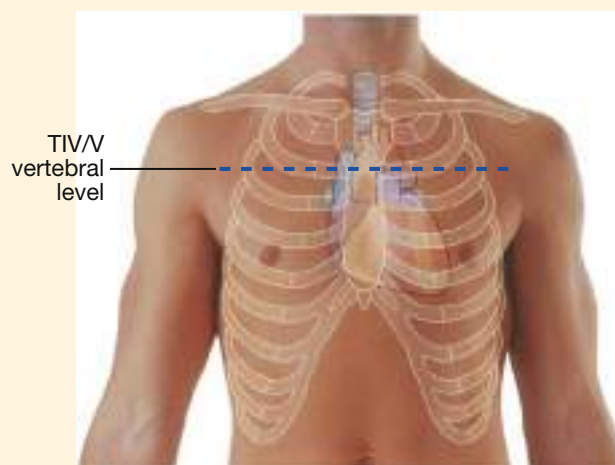


Fig. 3.18 Anterior view of the chest wall of a man showing the locations of various structures related to the TIV/V level.

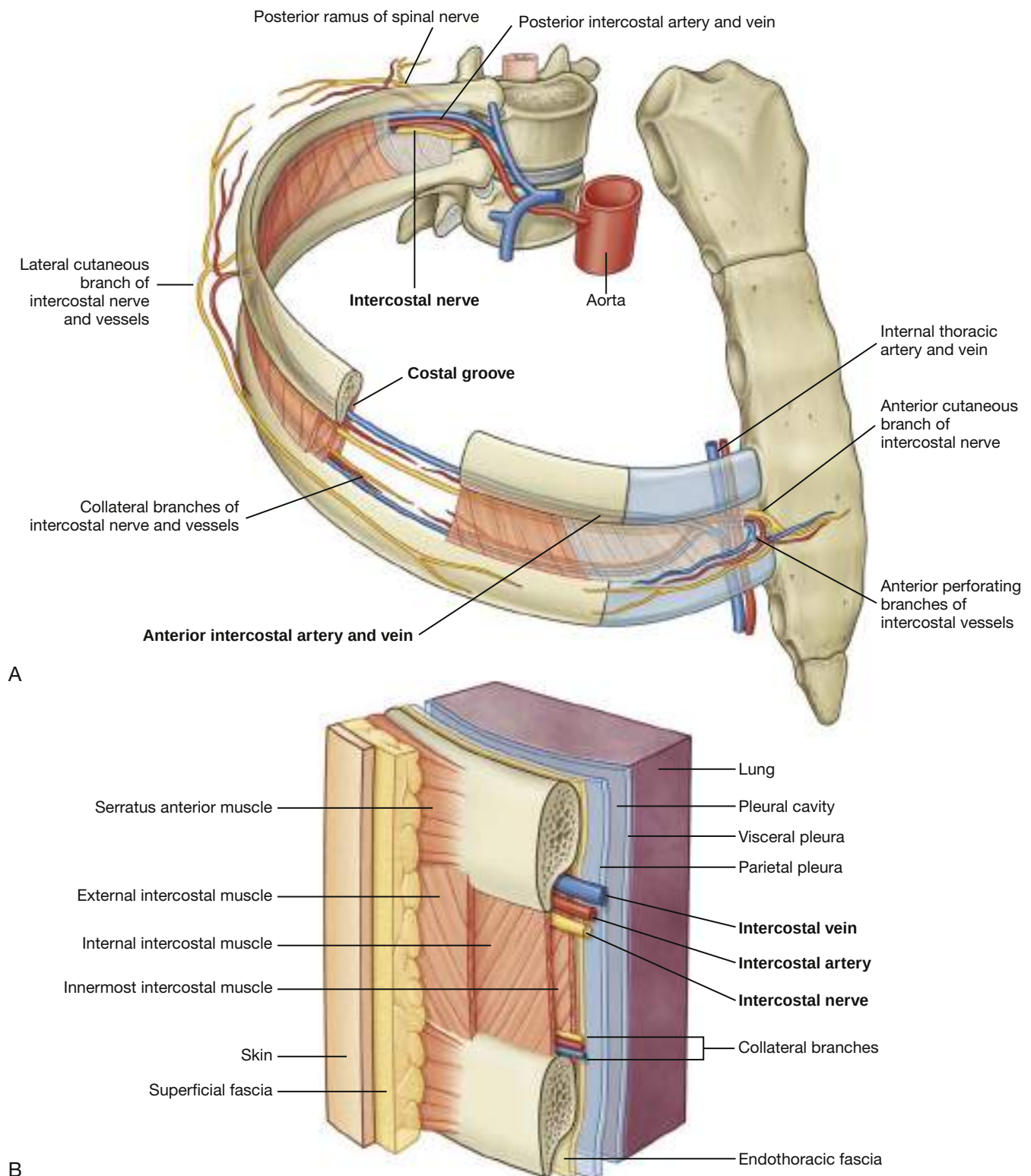


Fig. 3.19 Intercostal space. **A.** Anterolateral view. **B.** Details of an intercostal space and relationships.

when objects perforate the upper aspect of an intercostal space.

Deep to the intercostal spaces and ribs and separating these structures from the underlying pleura is a layer of loose connective tissue called **endothoracic fascia**, which contains variable amounts of fat (Fig. 3.19B).

Muscles

Muscles of the thoracic wall include those that fill and support the intercostal spaces (**external**, **internal**, and **innermost intercostal muscles** [Table 3.2, Figs. 3.19, 3.20]); those that cross several ribs between the costal attachments (**subcostal muscles** [Table 3.2, Fig. 3.21A]); and those that pass between the sternum and the ribs (**transversus thoracis muscles** [Table 3.2, Fig. 3.21B]).

The muscles of the thoracic wall, together with muscles between the vertebrae and ribs posteriorly (i.e., the **levator costarum** and **serratus posterior superior** and **serratus posterior inferior muscles**), alter the position of the ribs and sternum, changing the thoracic volume during breathing. They also reinforce the thoracic wall.

Intercostal muscles

The **intercostal muscles** are three flat muscles found in each intercostal space that pass between adjacent ribs (Figs. 3.19B, 3.20). Individual muscles in this group are named according to their positions:

- The external intercostal muscles are the most superficial and their fibers pass from the rib above anteroinferiorly to the rib below (these muscles extend around the thoracic wall from the regions of the tubercles of the ribs to the costal cartilages where each muscle continues as a thin connective tissue aponeurosis termed the *external intercostal membrane*).

- The internal intercostal muscles are sandwiched between the external and innermost muscles, and their fibers run in the opposite direction to those of the external intercostal muscles (the internal intercostal muscles extend around the thoracic wall from the sternum to the angles of the ribs where each muscle continues as a thin connective tissue aponeurosis termed the *internal intercostal membrane*).
- The innermost intercostal muscles are the deepest of the three muscles and their fibers course in a similar direction as the internal intercostal muscles.

The intercostal muscles are innervated by the related intercostal nerves. As a group, the intercostal muscles provide structural support for the intercostal spaces during breathing. They can also move the ribs.

Arterial supply

Vessels that supply the thoracic wall consist mainly of posterior and anterior intercostal arteries, which pass around the wall between adjacent ribs in intercostal spaces (Fig. 3.19A). These arteries originate from the aorta and internal thoracic arteries, which in turn arise from the subclavian arteries in the root of the neck. Together, the intercostal arteries form a basket-like pattern of vascular supply around the thoracic wall.

Posterior intercostal arteries

Posterior intercostal arteries originate from vessels associated with the posterior thoracic wall. The upper two posterior intercostal arteries on each side come from the **supreme intercostal artery**, which descends into the thorax as a branch of the costocervical trunk in the neck. The **costocervical trunk** is a posterior branch of the subclavian artery (Fig. 3.22).

Table 3.2 Muscles of the thoracic wall

Muscle	Superior attachment	Inferior attachment	Innervation	Function
External intercostal	Inferior margin of rib above	Superior margin of rib below	Intercostal nerves; T1-T11	Most active during inspiration; supports intercostal space; moves ribs superiorly
Internal intercostal	Lateral edge of costal groove of rib above	Superior margin of rib below deep to the attachment of the related external intercostal	Intercostal nerves; T1-T11	Most active during expiration; supports intercostal space; moves ribs inferiorly
Innermost intercostal	Medial edge of costal groove of rib above	Internal aspect of superior margin of rib below	Intercostal nerves; T1-T11	Acts with internal intercostal muscles
Subcostals	Internal surface (near angle) of lower ribs	Internal surface of second or third rib below	Related intercostal nerves	May depress ribs
Transversus thoracis	Inferior margins and internal surfaces of costal cartilages of second to sixth ribs	Inferior aspect of deep surface of body of sternum, xiphoid process, and costal cartilages ribs IV-VII	Related intercostal nerves	Depresses costal cartilages

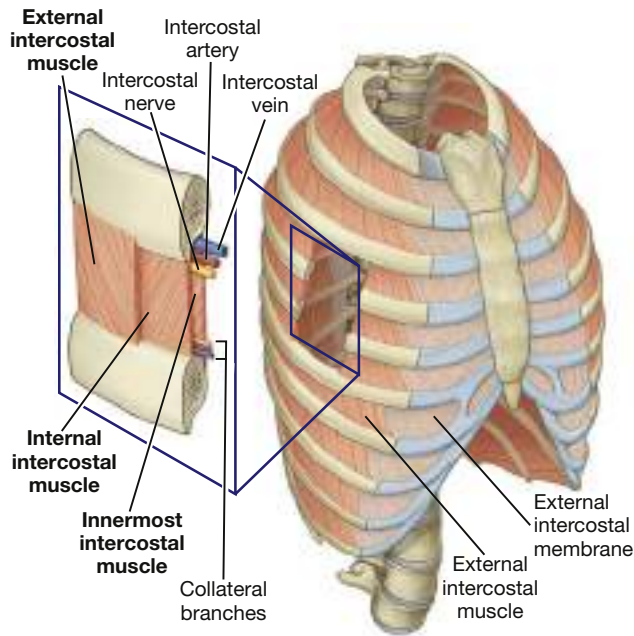


Fig. 3.20 Intercostal muscles.

The remaining nine pairs of posterior intercostal arteries arise from the posterior surface of the thoracic aorta. Because the aorta is on the left side of the vertebral column, those posterior intercostal vessels passing to the right side of the thoracic wall cross the midline anterior to the bodies of the vertebrae and therefore are longer than the corresponding vessels on the left.

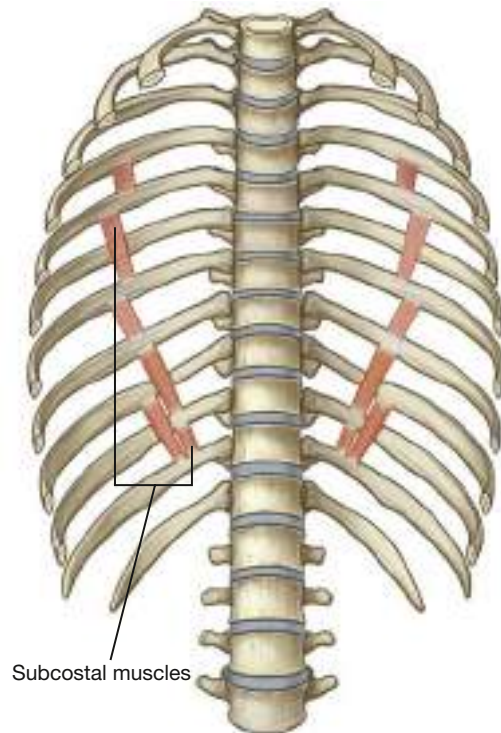
In addition to having numerous branches that supply various components of the wall, the posterior intercostal arteries have branches that accompany lateral cutaneous branches of the intercostal nerves to the superficial regions.

Anterior intercostal arteries

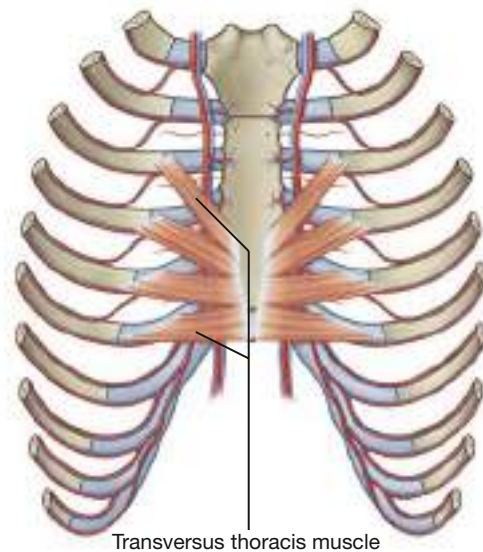
The **anterior intercostal arteries** originate directly or indirectly as lateral branches from the internal thoracic arteries (Fig. 3.22).

Each **internal thoracic artery** arises as a major branch of the subclavian artery in the neck. It passes anteriorly over the cervical dome of pleura and descends vertically through the superior thoracic aperture and along the deep aspect of the anterior thoracic wall. On each side, the internal thoracic artery lies posterior to the costal cartilages of the upper six ribs and about 1 cm lateral to the sternum. At approximately the level of the sixth intercostal space, it divides into two terminal branches (Fig. 3.22):

- the **superior epigastric artery**, which continues inferiorly into the anterior abdominal wall, and



A



B

Fig. 3.21 A. Subcostal muscles. B. Transversus thoracis muscles.

- the **musculophrenic artery**, which passes along the costal margin, goes through the diaphragm, and ends near the last intercostal space.

Anterior intercostal arteries that supply the upper six intercostal spaces arise as lateral branches from the internal thoracic artery, whereas those supplying the lower spaces arise from the musculophrenic artery.

In each intercostal space, the anterior intercostal arteries usually have two branches:

- One passes below the margin of the upper rib.
- The other passes above the margin of the lower rib and meets a collateral branch of the posterior intercostal artery.

The distributions of the anterior and posterior intercostal vessels overlap and can develop anastomotic connections. The anterior intercostal arteries are generally smaller than the posterior vessels.

In addition to anterior intercostal arteries and a number of other branches, the internal thoracic arteries give rise to perforating branches that pass directly forward between the costal cartilages to supply structures external to the thoracic wall. These vessels travel with the anterior cutaneous branches of the intercostal nerves.

Venous drainage

Venous drainage from the thoracic wall generally parallels the pattern of arterial supply (Fig. 3.23).

Centrally, the intercostal veins ultimately drain into the azygos system of veins or into **internal thoracic veins**, which connect with the **brachiocephalic veins** in the neck.

Often the upper posterior intercostal veins on the left side come together and form the **left superior intercostal vein**, which empties into the left brachiocephalic vein.

Similarly, the upper posterior intercostal veins on the right side may come together and form the **right superior intercostal vein**, which empties into the **azygos vein**.

Lymphatic drainage

Lymphatic vessels of the thoracic wall drain mainly into lymph nodes associated with the internal thoracic arteries (**parasternal nodes**), with the heads and necks of ribs (**intercostal nodes**) and with the diaphragm (**diaphragmatic nodes**) (Fig. 3.24). Diaphragmatic nodes are posterior to the xiphoid and at sites where the phrenic nerves penetrate the diaphragm. They also occur in regions where the diaphragm is attached to the vertebral column.

Parasternal nodes drain into **bronchomediastinal trunks**. Intercostal nodes in the upper thorax also drain into bronchomediastinal trunks, whereas intercostal nodes in the lower thorax drain into the **thoracic duct**.

Nodes associated with the diaphragm interconnect with parasternal, prevertebral, juxta-esophageal nodes, **brachiocephalic nodes** (anterior to the brachiocephalic veins in the superior mediastinum), and **lateral aortic/lumbar nodes** (in the abdomen).

Superficial regions of the thoracic wall drain mainly into **axillary lymph nodes** in the axilla or parasternal nodes.

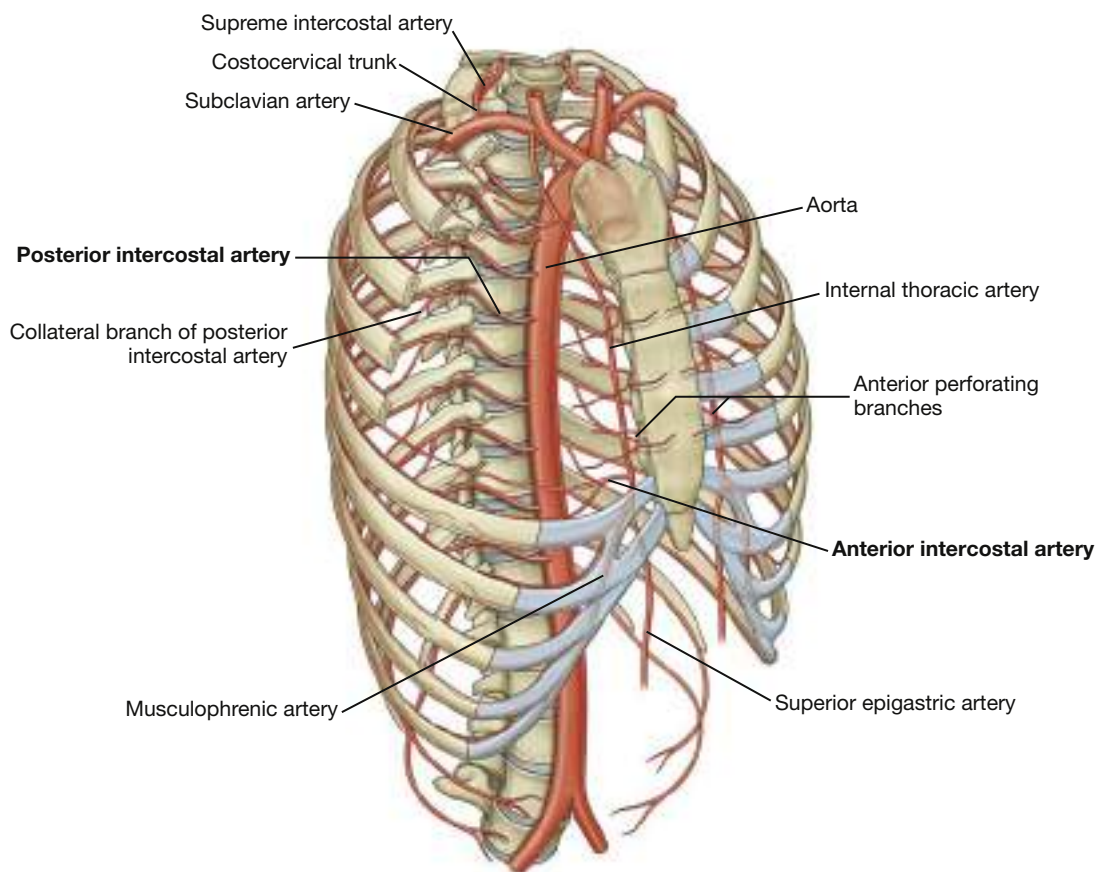


Fig. 3.22 Arteries of the thoracic wall.

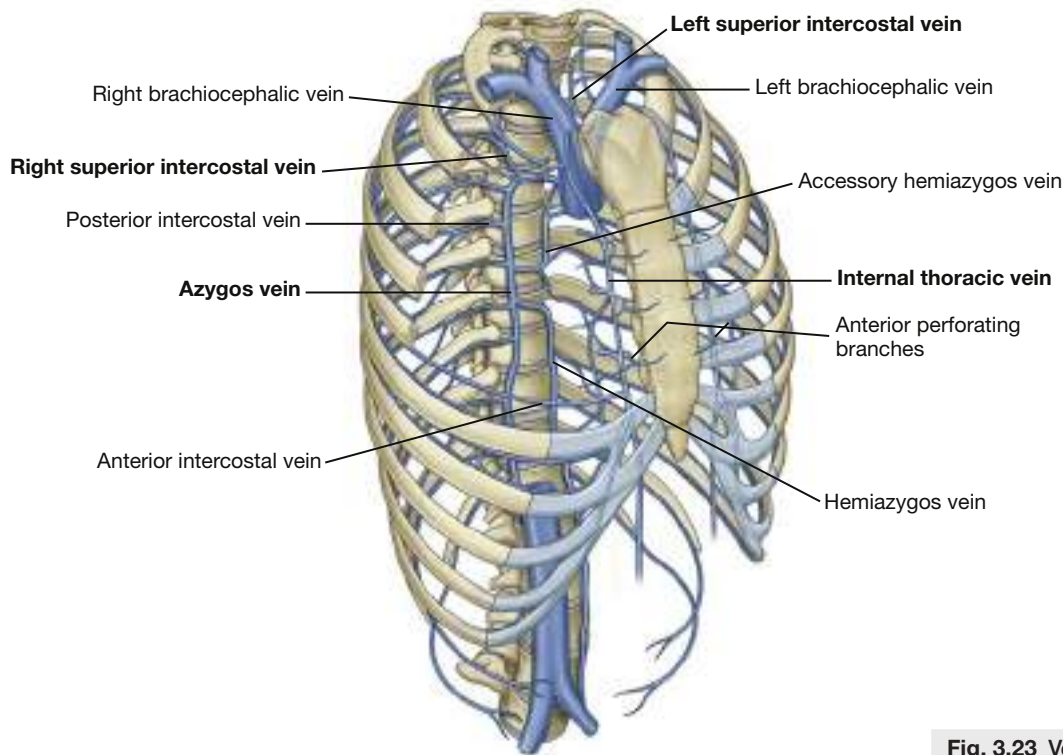


Fig. 3.23 Veins of the thoracic wall.

Innervation

Intercostal nerves

Innervation of the thoracic wall is mainly by the **intercostal nerves**, which are the anterior rami of spinal nerves T1 to T11 and lie in the intercostal spaces between adjacent ribs (Fig. 3.25). The anterior ramus of spinal nerve T12 (the **subcostal nerve**) is inferior to rib XII.

A typical intercostal nerve passes laterally around the thoracic wall in an intercostal space. The largest of the branches is the **lateral cutaneous branch**, which pierces the lateral thoracic wall and divides into an anterior branch and a posterior branch that innervate the overlying skin.

The intercostal nerves end as **anterior cutaneous branches**, which emerge either parasternally between adjacent costal cartilages or laterally to the midline on the anterior abdominal wall to supply the skin.

In addition to these major branches, small collateral branches can be found in the intercostal space running along the superior border of the lower rib.

In the thorax, the intercostal nerves carry:

- somatic motor innervation to the muscles of the thoracic wall (intercostal, subcostal, and transversus thoracis muscles),

- somatic sensory innervation from the skin and parietal pleura, and
- postganglionic sympathetic fibers to the periphery.

Sensory innervation from the skin overlying the upper thoracic wall is supplied by cutaneous branches (supraclavicular nerves), which descend from the cervical plexus in the neck.

In addition to innervating the thoracic wall, intercostal nerves innervate other regions:

- The anterior ramus of T1 contributes to the brachial plexus.
- The lateral cutaneous branch of the second intercostal nerve (the **intercostobrachial nerve**) contributes to cutaneous innervation of the medial surface of the upper arm.
- The lower intercostal nerves supply muscles, skin, and parietal peritoneum of the abdominal wall.

DIAPHRAGM

The **diaphragm** is a thin musculotendinous structure that fills the inferior thoracic aperture and separates the thoracic cavity from the abdominal cavity (Figs. 3.26, 3.27, and see Chapter 4). It is attached peripherally to the:

- xiphoid process of the sternum,
- costal margin of the thoracic wall,
- ends of ribs XI and XII,
- ligaments that span across structures of the posterior abdominal wall, and
- vertebrae of the lumbar region.

Clinical app

Surgical access to the chest

Surgical access is challenging in the chest given the rigid nature of the thoracic cage. Moreover, the access site is also dependent on the organ that is operated upon and its relationships to subdiaphragmatic structures and structures in the neck.

Minimally invasive thoracic surgery (video-assisted thoracic surgery [VATS]) involves making small (1-cm) incisions in the intercostal spaces, inserting a small camera, and manipulating other instruments through additional small incisions. A number of procedures can be performed in this manner, including lobectomy, lung biopsy, and esophagectomy. A standard incision site would include a median sternotomy to obtain access to the heart, including the coronary arteries and the cardiac valves.

A left lateral thoracotomy or a right lateral thoracotomy is an incision through an intercostal space to access the lungs and the more lateral mediastinal structures.

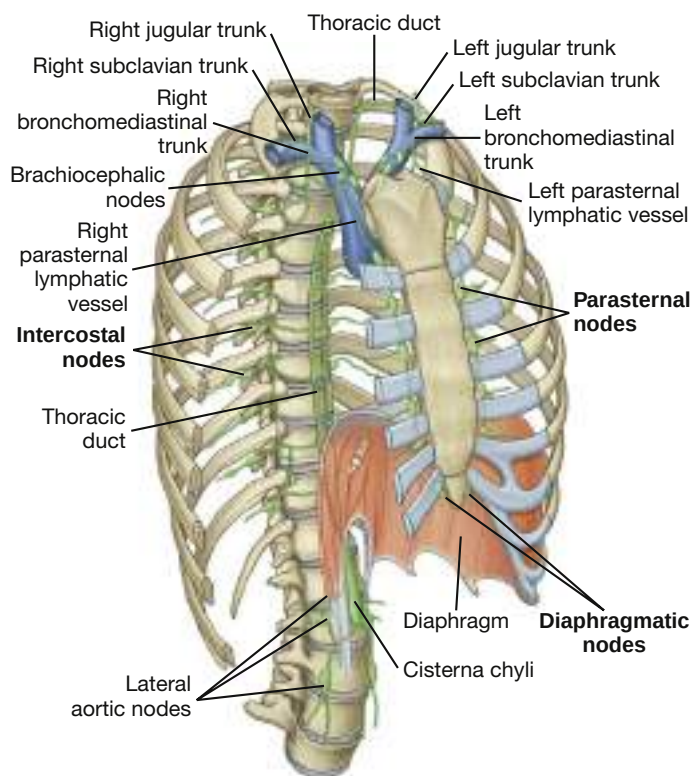


Fig. 3.24 Major lymphatic vessels and nodes of the thoracic wall.

From these peripheral attachments, muscle fibers converge to join the central tendon. The pericardium is attached to the middle part of the central tendon.

In the median sagittal plane, the diaphragm slopes inferiorly from its anterior attachment to the xiphoid, approximately at vertebral level TVIII/IX, to its posterior

Clinical app

Thoracostomy (chest) tube insertion

Insertion of a chest tube is a commonly performed procedure and is indicated to relieve air or fluid trapped in the thorax between the lung and the chest wall (pleural cavity). This procedure is done for pneumothorax, hemothorax, hemopneumothorax, malignant pleural effusion, empyema, hydrothorax, chylothorax, and after thoracic surgery.

The position of the thoracostomy tube should be between the anterior axillary and midaxillary anatomical lines from anterior to posterior and either the fourth or fifth intercostal space from cephalad to caudad. The position of the ribs in this region should be clearly marked. Anesthetic should be applied to the superior border of the rib and the inferior aspect of the intercostal space, including one rib and space above and one rib and space below. The neurovascular bundle runs in the neurovascular plane, which lies in the superior aspect of the intercostal space (just below the rib), hence the reason for positioning the tube on the superior border of a rib (i.e., at the lowest position in the intercostal space).

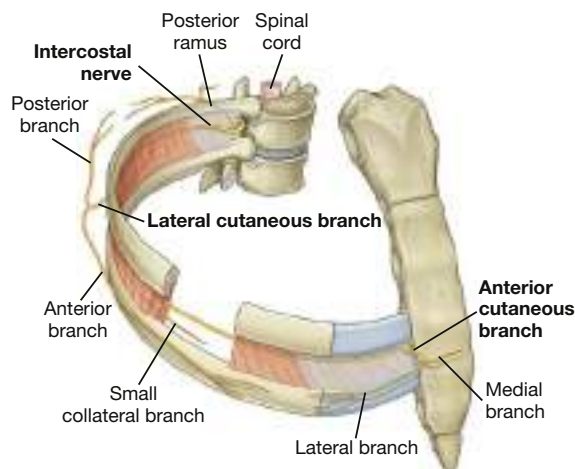


Fig. 3.25 Intercostal nerves.

Clinical app

Intercostal nerve block

Local anesthesia of intercostal nerves produces excellent analgesia in patients with chest trauma and those patients requiring anesthesia for a thoracotomy, mastectomy, and upper abdominal surgical procedures.

The intercostal nerves are situated inferior to the rib borders in the neurovascular bundle. Each neurovascular bundle is situated deep to the external and internal intercostal muscle groups.

The nerve block may be undertaken using a “blind” technique or under direct imaging guidance.

The patient is placed in the appropriate position to access the rib. Typically, under ultrasound guidance, a needle may be advanced into the region of the subcostal groove followed by an injection with local anesthesia. Depending on the type of local anesthetic, analgesia may be short- or long-acting.

Given the position of the neurovascular bundle and the subcostal groove, complications may include puncture of the parietal pleura and an ensuing pneumothorax. Bleeding may also occur if the artery or vein is damaged during the procedure.

attachment to the **median arcuate ligament**, crossing anteriorly to the aorta at approximately vertebral level TXII.

Structures traveling between the thorax and abdomen pass through the diaphragm or between the diaphragm and its peripheral attachments (Figs. 3.26, 3.27):

- The inferior vena cava passes through the central tendon at approximately vertebral level TVIII.
- The esophagus passes through the muscular part of the diaphragm, just to the left of midline, approximately at vertebral level TX.
- The vagus nerves pass through the diaphragm with the esophagus.
- The aorta passes behind the posterior attachment of the diaphragm at vertebral level TXII.
- The thoracic duct passes behind the diaphragm with the aorta.
- The azygos and hemiazygos veins may also pass through the aortic hiatus or through the crura of the diaphragm.

Other structures outside the posterior attachments of the diaphragm lateral to the aortic hiatus include the sympathetic trunks. The greater, lesser, and least splanchnic nerves penetrate the crura.

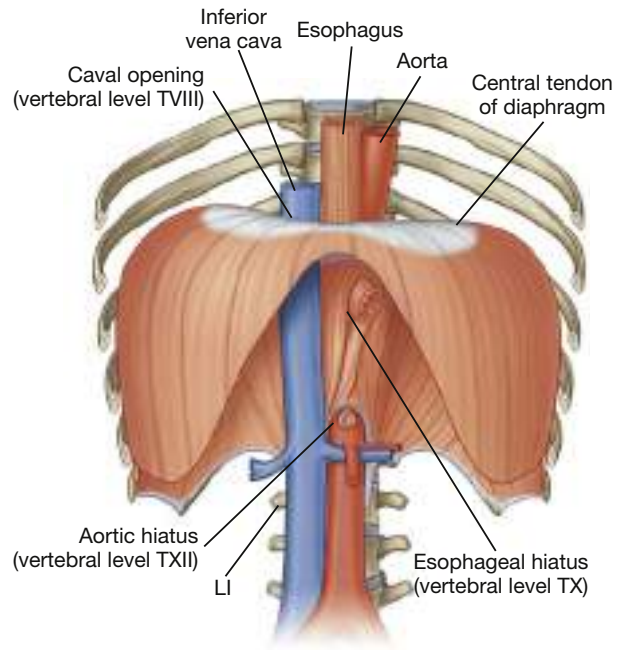


Fig. 3.26 Major structures passing between abdomen and thorax.

Arterial supply

The arterial supply to the diaphragm is from vessels that arise superiorly and inferiorly to it (see Fig. 3.27). From above, pericardiophrenic and musculophrenic arteries supply the diaphragm. These vessels are branches of the internal thoracic arteries. **Superior phrenic arteries**, which arise directly from lower parts of the thoracic aorta, and small branches from intercostal arteries contribute to the supply. The largest arteries supplying the diaphragm arise from below it. These arteries are the **inferior phrenic arteries**, which branch directly from the abdominal aorta.

Venous drainage

Venous drainage of the diaphragm is by veins that generally parallel the arteries. The veins drain into:

- the brachiocephalic veins in the neck,
- the **azygos system of veins**, or
- the abdominal veins (left suprarenal vein and inferior vena cava).

Innervation

The diaphragm is innervated by the **phrenic nerves** (C3, C4, and C5), which penetrate the diaphragm and innervate it from its abdominal surface (Fig. 3.27).

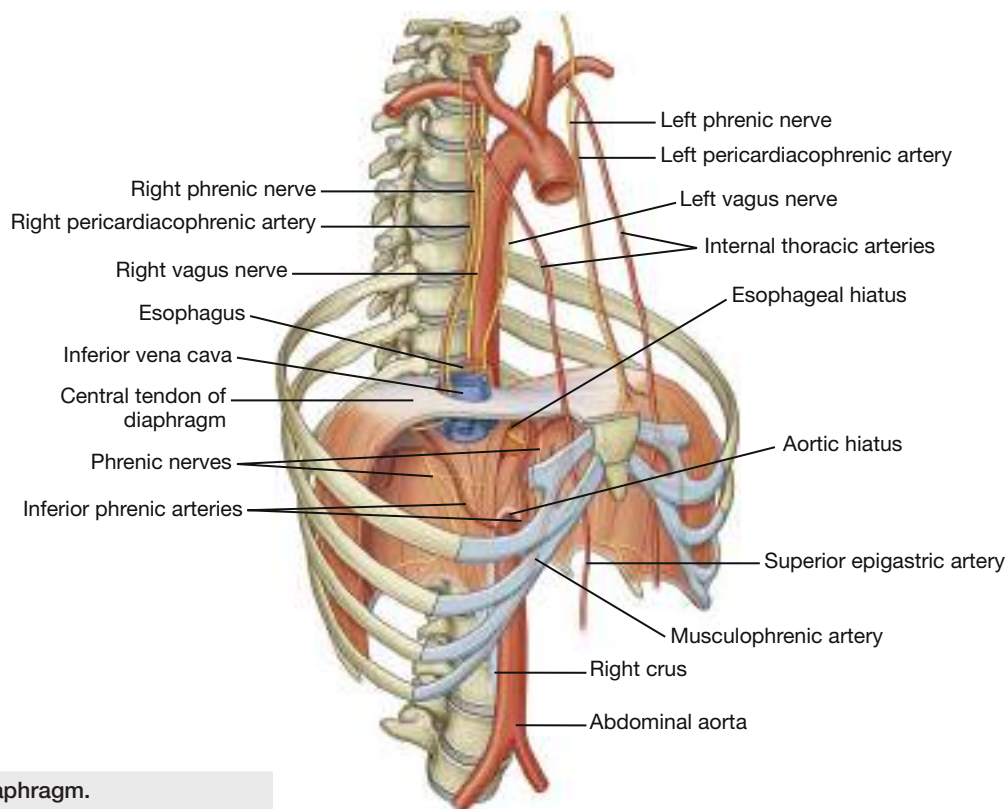


Fig. 3.27 Diaphragm.

Contraction of the domes of the diaphragm flattens the diaphragm, increasing thoracic volume. Movements of the diaphragm are essential for normal breathing.

MOVEMENTS OF THE THORACIC WALL AND DIAPHRAGM DURING BREATHING

During breathing, the dimensions of the thorax change in the vertical, lateral, and anteroposterior directions. Elevation and depression of the diaphragm significantly alter the vertical dimensions of the thorax. Depression results when the muscle fibers of the diaphragm contract. Elevation occurs when the diaphragm relaxes.

Changes in the anteroposterior and lateral dimensions result from elevation and depression of the ribs (Fig. 3.28). The posterior ends of the ribs articulate with the vertebral column, whereas the anterior ends of most ribs articulate with the sternum or adjacent ribs.

Because the anterior ends of the ribs are inferior to the posterior ends, when the ribs are elevated, they move the sternum upward and forward. Also, the angle between the body of the sternum and the manubrium may become slightly less acute. When the ribs are depressed, the sternum moves downward and backward. This “pump handle” movement changes the dimensions of the thorax in the anteroposterior direction (Fig. 3.28A).

As well as the anterior ends of the ribs being lower than the posterior ends, the middle of the shafts tend to be lower than the two ends. When the shafts are elevated, the middle of the shafts move laterally. This “bucket handle” movement increases the lateral dimensions of the thorax (Fig. 3.28B).

PLEURAL CAVITIES

Two **pleural cavities**, one on either side of the mediastinum, surround the lungs (Figs. 3.29, 3.30):

- superiorly, they extend above rib I into the root of the neck;
- inferiorly, they extend to a level just above the costal margin; and
- the medial wall of each pleural cavity is the mediastinum (Fig. 3.31).

Pleura

Each pleural cavity is lined by a single layer of flat cells, mesothelium, and an associated layer of supporting connective tissue; together, they form the pleura.

The **pleura** is divided into two major types based on location:

Clinical app

The arrangement of pleural cavities is clinically significant

The pleural cavities are completely separated from each other by the mediastinum. Therefore abnormal events in one pleural cavity do not necessarily affect the other cavity. This also means that the mediastinum can be entered surgically without opening the pleural cavities.

Another important feature of the pleural cavities is that they extend above the level of rib I. The apex of each lung actually extends into the root of the neck. As a consequence, abnormal events in the root of the neck can involve the adjacent pleura and lung, and events in the adjacent pleura and lung can involve the root of the neck.

- pleura associated with the walls of a pleural cavity is **parietal pleura** (Fig. 3.30), and
- pleura that reflects from the medial wall and onto the surface of the lung is **visceral pleura** (Fig. 3.30), which adheres to and covers the lung.

Each pleural cavity is the potential space enclosed between the visceral and parietal pleurae. They normally contain only a very thin layer of serous fluid. As a result, the surface of the lung, which is covered by visceral pleura, directly opposes and freely slides over the parietal pleura attached to the wall.

Parietal pleura

The names given to the parietal pleura correspond to the parts of the wall with which they are associated (Fig. 3.32):

- Pleura related to the ribs and intercostal spaces is termed the **costal part**.
- Pleura covering the diaphragm is the **diaphragmatic part**.
- Pleura covering the mediastinum is the **mediastinal part**.
- The dome-shaped layer of parietal pleura lining the cervical extension of the pleural cavity is **cervical pleura** (**dome of pleura** or **pleural cupola**).

Covering the superior surface of the cervical pleura is a distinct dome-like layer of fascia, the **suprapleural membrane** (Fig. 3.32). This connective tissue membrane is attached laterally to the medial margin of the first rib and behind to the transverse process of vertebra CVII. Superiorly, the membrane receives muscle fibers from some of the deep muscles in the neck (scalene muscles) that function to keep the membrane taught. The suprapleural membrane provides apical support for the pleural cavity in the root of the neck.

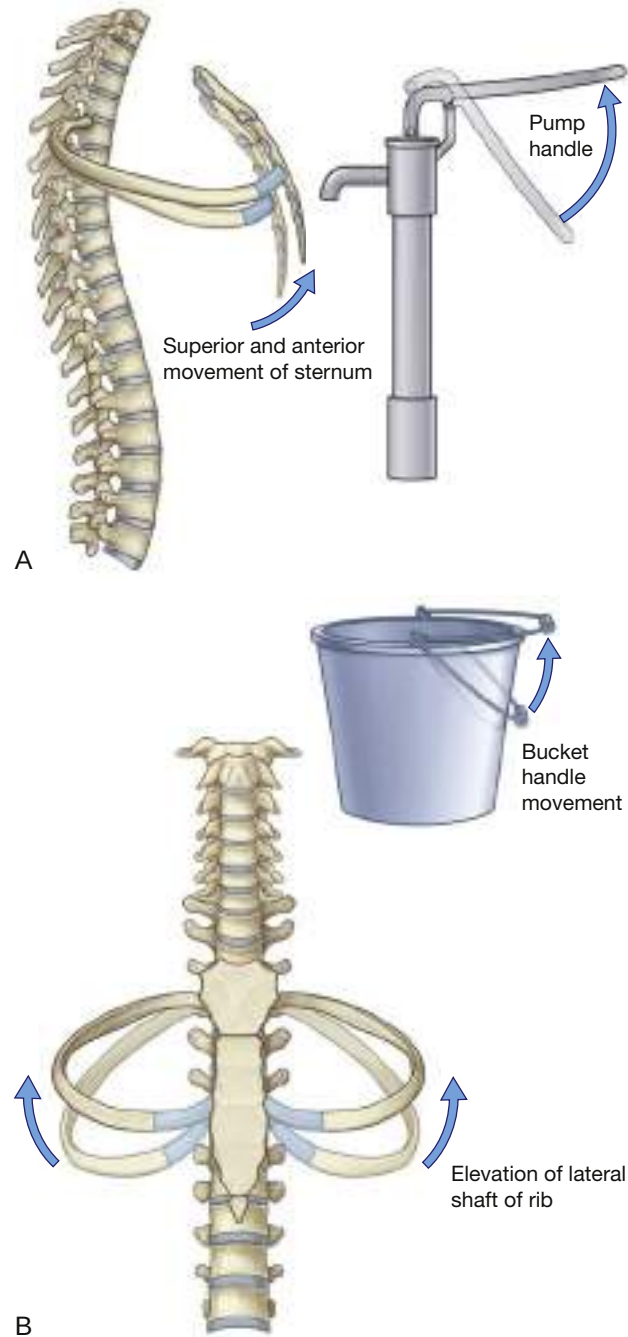


Fig. 3.28 Movement of thoracic wall during breathing. **A.** Pump handle movement of ribs and sternum. **B.** Bucket handle movement of ribs.

In the region of vertebrae TV to TVII, the mediastinal pleura reflects off the mediastinum as a tubular, sleeve-like covering for structures (i.e., airway, vessels, nerves, lymphatics) that pass between the lung and mediastinum. This sleeve-like covering and the structures it contains form the **root of the lung**. The root joins the medial surface of the lung at an area referred to as the **hilum of lung**. Here, the mediastinal pleura is continuous with the visceral pleura.

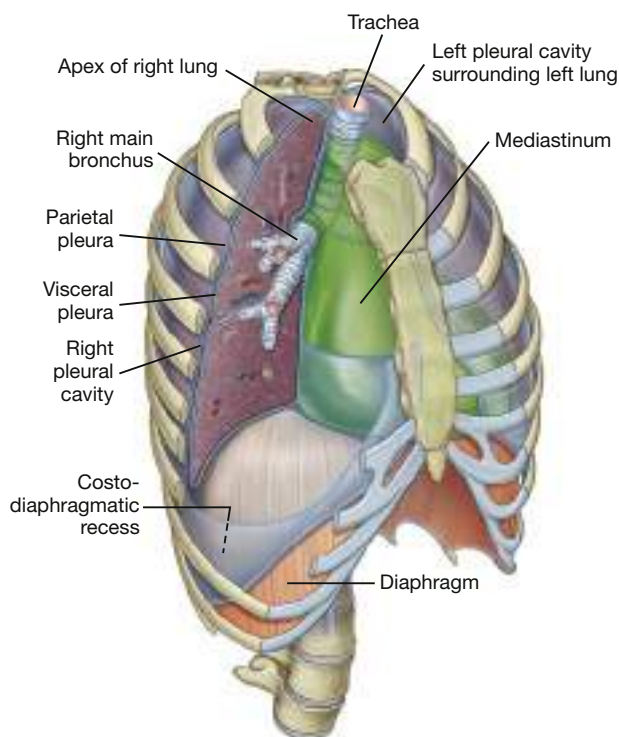


Fig. 3.29 Pleural cavities.

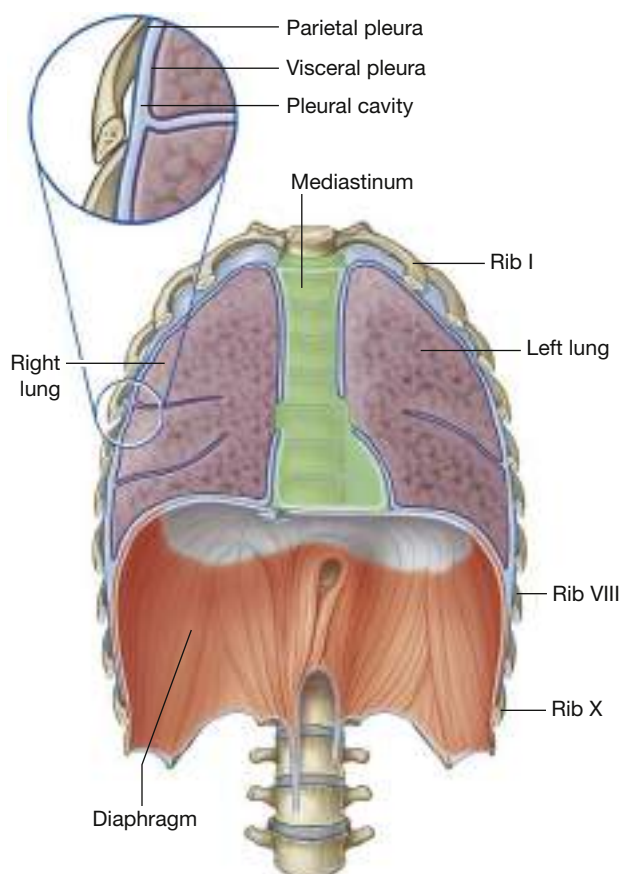


Fig. 3.30 Pleural cavities.

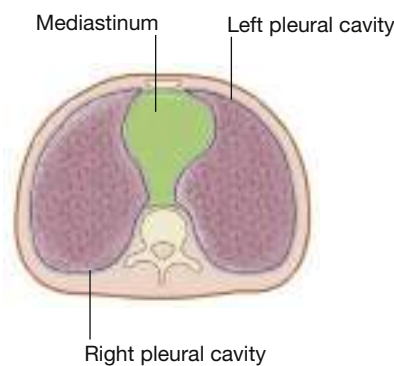


Fig. 3.31 Cross-section of the thorax showing the position of the mediastinum.

Clinical app

Innervation of parietal and visceral pleura

The parietal pleura is innervated by somatic afferent fibers. The costal pleura is innervated by branches from the intercostal nerves, and pain would be felt in relation to the thoracic wall. The diaphragmatic pleura and the mediastinal pleura are innervated mainly by the phrenic nerves (originating at spinal cord levels C3, C4, and C5). Pain from these areas would refer to the C3, C4, and C5 dermatomes (lateral neck and the supraclavicular region of the shoulder).

The visceral pleura is innervated by visceral afferent fibers that accompany bronchial vessels, and pain is generally not elicited from this tissue.

Peripheral reflections

The peripheral reflections of parietal pleura mark the extent of the pleural cavities (Fig. 3.33).

Superiorly, the pleural cavity can project as much as 3 to 4 cm above the first costal cartilage but does not extend above the neck of rib I. This limitation is caused by the inferior slope of rib I to its articulation with the manubrium.

Anteriorly, the pleural cavities approach each other posterior to the upper part of the sternum. However, posterior to the lower part of the sternum, the parietal pleura does not come as close to the midline on the left side as it does on the right because the middle mediastinum, containing the pericardium and heart, bulges to the left.

Inferiorly, the costal pleura reflects onto the diaphragm above the costal margin. In the midclavicular line, the pleural cavity extends inferiorly to approximately rib VIII (Fig. 3.34). In the midaxillary line, it extends to rib X. From this point, the inferior margin courses somewhat horizontally, crossing ribs XI and XII to reach vertebra TXII. From the midclavicular line to the vertebral column, the inferior

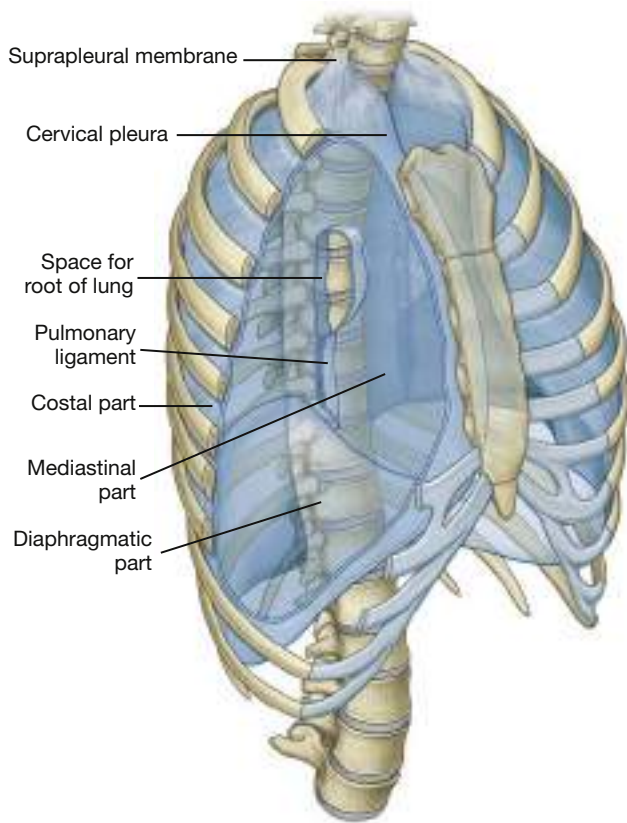


Fig. 3.32 Parietal pleura.

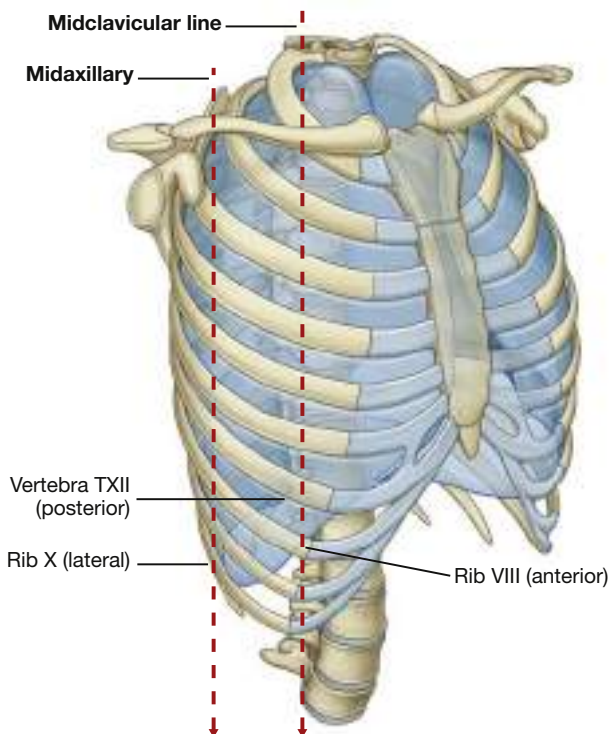


Fig. 3.33 Pleural reflections.

boundary of the pleura can be approximated by a line that runs between rib VIII, rib X, and vertebra TXII.

Visceral pleura

The visceral pleura is continuous with the parietal pleura at the hilum of each lung where structures enter and leave the organ. The visceral pleura is firmly attached to the surface of the lung, including both opposed surfaces of the fissures that divide the lungs into lobes.

Costomediastinal recesses

Anteriorly, a **costomediastinal recess** occurs on each side where the costal pleura is opposed to the mediastinal pleura. The largest is on the left side in the region overlying the heart (Fig. 3.34).

Costodiaphragmatic recesses

The largest and clinically most important recesses are the **costodiaphragmatic recesses**, which occur in each pleural cavity between the costal pleura and diaphragmatic pleura (Fig. 3.34). The costodiaphragmatic recesses are the regions between the inferior margin of the lungs and inferior margin of the pleural cavities. They are deepest after forced expiration and shallowest after forced inspiration.

During quiet respiration, the inferior margin of the lung crosses rib VI in the midclavicular line, rib VIII in the midaxillary line, and then courses somewhat horizontally to reach the vertebral column at vertebral level TX. From the midclavicular line and around the thoracic wall to the vertebral column, the inferior margin of the lung can be approximated by a line running between rib VI, rib VIII, and vertebra TX. The inferior margin of the pleural cavity at the same points is rib VIII, rib X, and vertebra TXII. The costodiaphragmatic recess is the region between the two margins.

During expiration, the inferior margin of the lung rises and the costodiaphragmatic recess becomes larger.

Clinical app

Pleural recesses

The lungs do not completely fill the anterior or posterior inferior regions of the pleural cavities (Fig. 3.34). This results in recesses in which two layers of parietal pleura become opposed. Expansion of the lungs into these spaces usually occurs only during forced inspiration; the recesses also provide potential spaces in which fluids can collect and from which fluids can be aspirated.

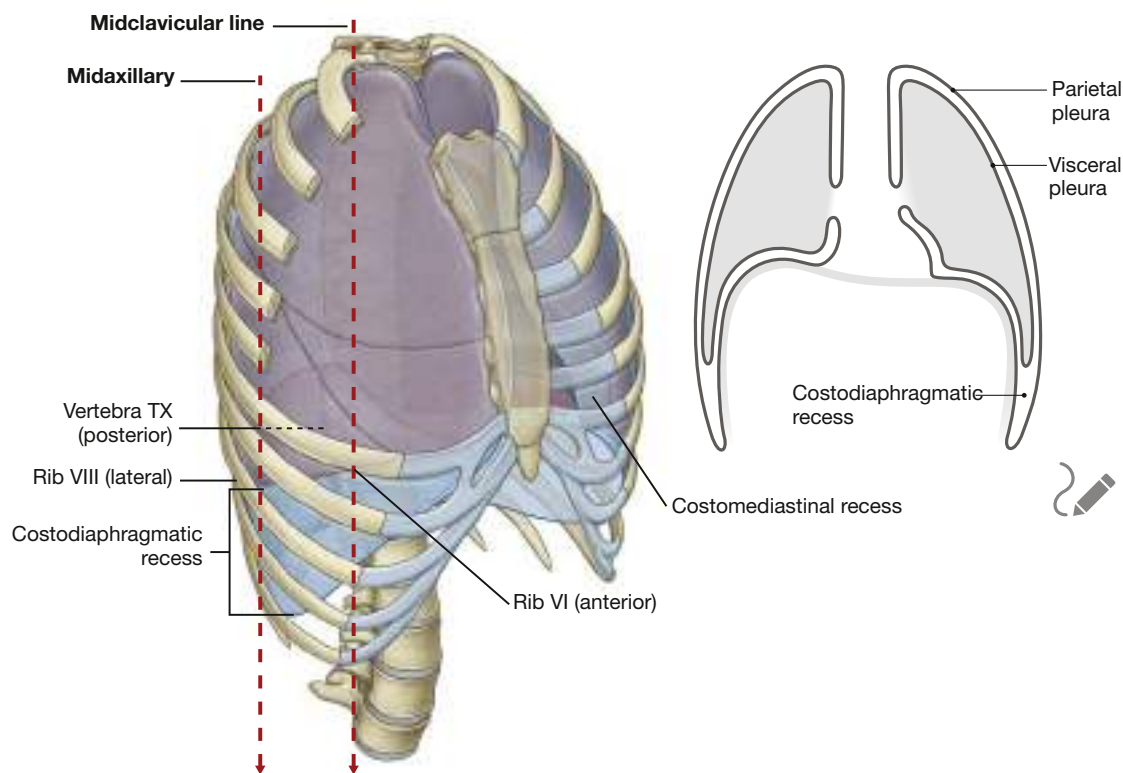


Fig. 3.34 Parietal pleural reflections and recesses.

Clinical app

Pleural effusion

A pleural effusion occurs when excess fluid accumulates within the pleural space. As the fluid accumulates within the pleural space, the underlying lung is compromised and may collapse as the volume of fluid increases. Once a pleural effusion has been diagnosed, fluid often will be aspirated to determine the cause, which can include infection, malignancy, cardiac failure, hepatic disease, and pulmonary embolism.

Lungs

The two lungs are organs of respiration and lie on either side of the mediastinum surrounded by the right and left pleural cavities. Air enters and leaves the lungs via the main bronchi, which are branches of the trachea.

The pulmonary arteries deliver deoxygenated blood to the lungs from the right ventricle of the heart. Oxygenated blood returns to the left atrium via the pulmonary veins.

The right lung is normally a little larger than the left lung because the middle mediastinum, containing the heart, bulges more to the left than to the right.

Each lung has a half-cone shape with a base, apex, two surfaces, and three borders (Fig. 3.35).

Clinical app

Pneumothorax

A pneumothorax is a collection of gas or air within the pleural cavity. When air enters the pleural cavity the tissue elasticity of the parenchyma causes the lung to collapse within the chest, impairing lung function. Occasionally, the gas within the pleural cavity may accumulate to such an extent that the mediastinum is “pushed” to the opposite side, compromising the other lung. This is termed a *tension pneumothorax* and requires urgent treatment.

Most pneumothoraces are spontaneous (i.e., they occur in the absence of pathology and lung disease.) Secondly, pneumothoraces may occur as a result of trauma, inflammation, smoking, and other underlying pulmonary diseases.

The symptoms of pneumothorax are often determined by the degree of air leak and the rate at which the accumulation of gas occurs and the ensuing lung collapse. They include pain, shortness of breath, and cardiorespiratory collapse if severe.

- The **base** sits on the diaphragm.
- The **apex** projects above rib I and into the root of the neck.
- The two surfaces—the **costal surface** lies immediately adjacent to the ribs and intercostal spaces of the thoracic wall. The **mediastinal surface** lies against the mediastinum

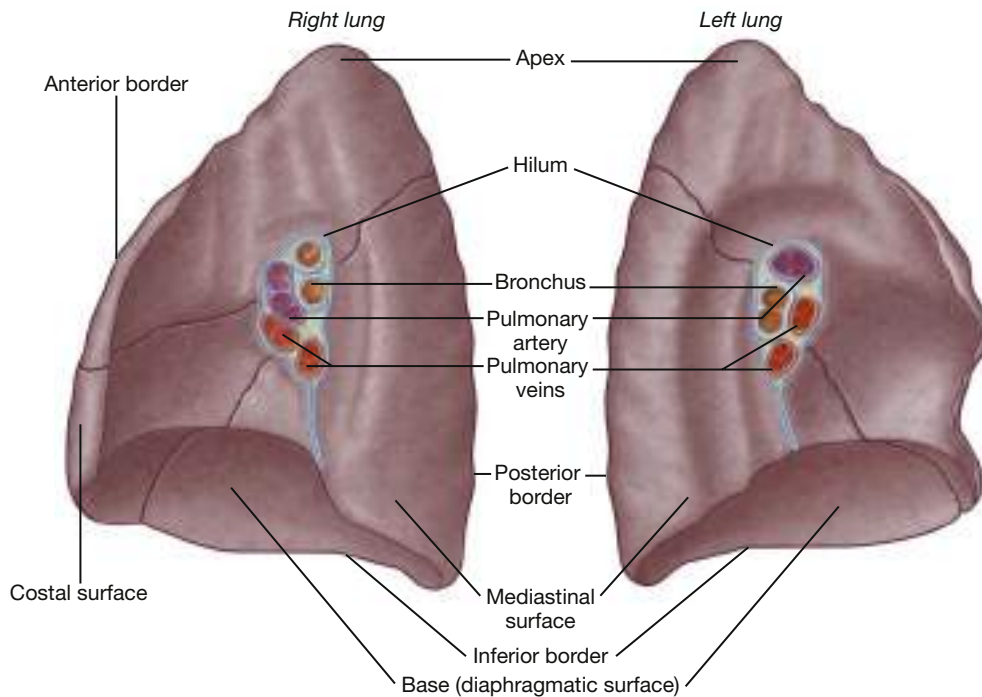


Fig. 3.35 Lungs.

anteriorly and the vertebral column posteriorly and contains the comma-shaped hilum of the lung through which structures enter and leave.

- The three borders—the **inferior border** of the lung is sharp and separates the base from the costal surface. The **anterior** and **posterior borders** separate the costal surface from the medial surface. Unlike the anterior and inferior borders, which are sharp, the posterior border is smooth and rounded.

The lungs lie directly adjacent to and are indented by structures contained in the overlying area. The heart and major vessels form bulges in the mediastinum that indent the medial surfaces of the lung; the ribs indent the costal surfaces. Pathology, such as tumors, or abnormalities in one structure can affect the related structure.

Root and hilum

The **root** of each lung is a short tubular collection of structures that together attach the lung to structures in the mediastinum (Fig. 3.36). It is covered by a sleeve of mediastinal pleura that reflects onto the surface of the lung as visceral pleura. The region outlined by this pleural reflection on the medial surface of the lung is the **hilum** where structures enter and leave.

A thin blade-like fold of pleura projects inferiorly from the root of the lung and extends from the hilum to the mediastinum. This structure is the **pulmonary ligament** (Fig. 3.36). It may stabilize the position of the inferior lobe and may also accommodate the down-and-up translocation of structures in the root during breathing.

In the mediastinum, the vagus nerves pass immediately posterior to the roots of the lungs, while the phrenic nerves pass immediately anterior to them.

Within each root and located in the hilum are:

- a pulmonary artery,
- two pulmonary veins,
- a main bronchus,
- bronchial vessels,
- nerves, and
- lymphatics.

Generally, the pulmonary artery is superior at the hilum, the pulmonary veins are inferior, and the bronchi are somewhat posterior in position.

On the right side, the lobar bronchus to the superior lobe branches from the main bronchus in the root, unlike on the left where it branches within the lung itself and is superior to the pulmonary artery.

Right lung

The **right lung** has three lobes and two fissures (Fig. 3.37A). Normally, the lobes are freely movable against each other because they are separated almost to the hilum by invaginations of visceral pleura. These invaginations form the fissures:

- the **oblique fissure** separates the **inferior lobe (lower lobe)** from the **superior lobe (upper lobe)** and the **middle lobe of the right lung**,

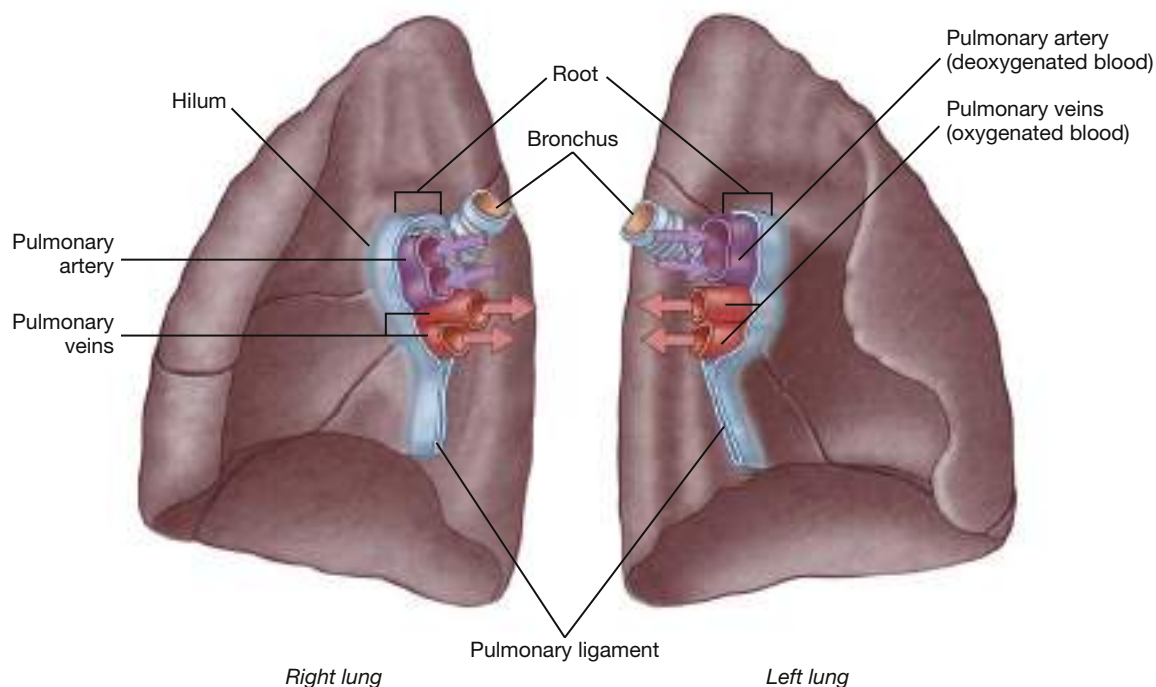


Fig. 3.36 Roots and hila of the lungs.

- the **horizontal fissure** separates the superior lobe (upper lobe) from the middle lobe.

The horizontal fissure follows the fourth intercostal space from the sternum until it meets the oblique fissure as it crosses rib V.

The largest surface of the superior lobe is in contact with the upper part of the anterolateral wall and the apex of this lobe projects into the root of the neck. The surface of the middle lobe lies mainly adjacent to the lower anterior and lateral walls. The costal surface of the inferior lobe is in contact with the posterior and inferior walls.

The medial surface of the right lung lies adjacent to a number of important structures in the mediastinum and the root of the neck (Fig. 3.37B). These include the:

- heart,
- inferior vena cava,
- superior vena cava,
- azygos vein, and
- esophagus.

The right subclavian artery and vein arch over and are related to the superior lobe of the right lung as they pass over the dome of cervical pleura and into the axilla.

Left lung

The **left lung** is smaller than the right lung and has two lobes separated by an oblique fissure (Fig. 3.38A). The **oblique**

fissure of the left lung is slightly more oblique than the corresponding fissure of the right lung.

The largest surface of the **superior lobe** is in contact with the upper part of the anterolateral wall, and the apex of this lobe projects into the root of the neck. The costal surface of the **inferior lobe** is in contact with the posterior and inferior walls.

The inferior portion of the medial surface of the left lung, unlike the right lung, is notched because of the heart's projection into the left pleural cavity from the middle mediastinum.

From the anterior border of the lower part of the superior lobe, a tongue-like extension (the **lingula of left lung**) projects over the heart bulge (Fig. 3.38A).

The medial surface of the left lung lies adjacent to a number of important structures in the mediastinum and root of the neck (Fig. 3.38B). These include the:

- heart,
- aortic arch,
- thoracic aorta, and
- esophagus.

The left subclavian artery and vein arch over and are related to the superior lobe of the left lung as they pass over the dome of the cervical pleura and into the axilla.

Bronchial tree

The **trachea** is a flexible tube that extends from vertebral level CVI in the lower neck to vertebral level TIV/V in the

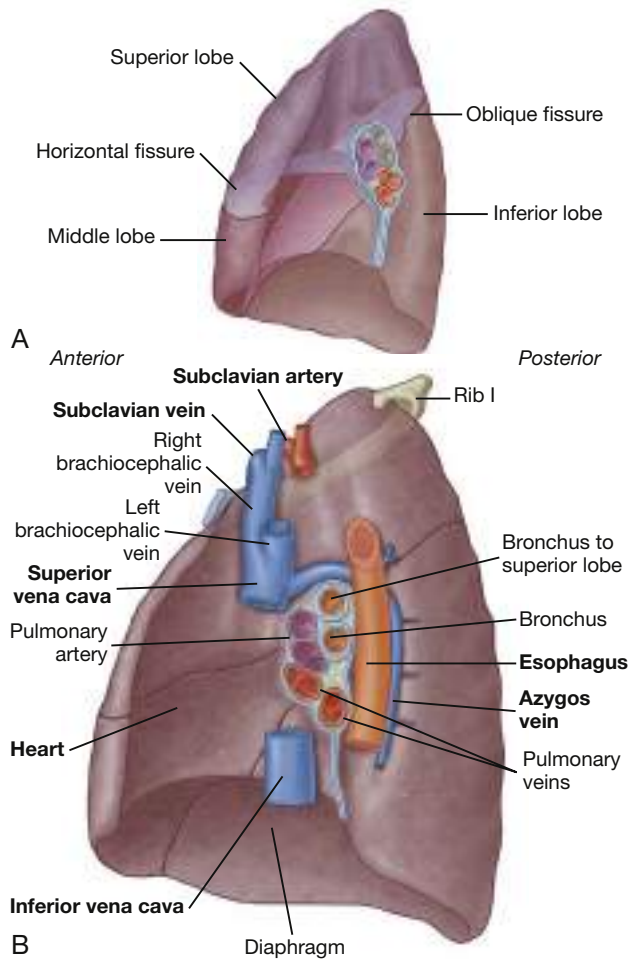


Fig. 3.37 A. Right lung. **B.** Major structures related to the right lung.

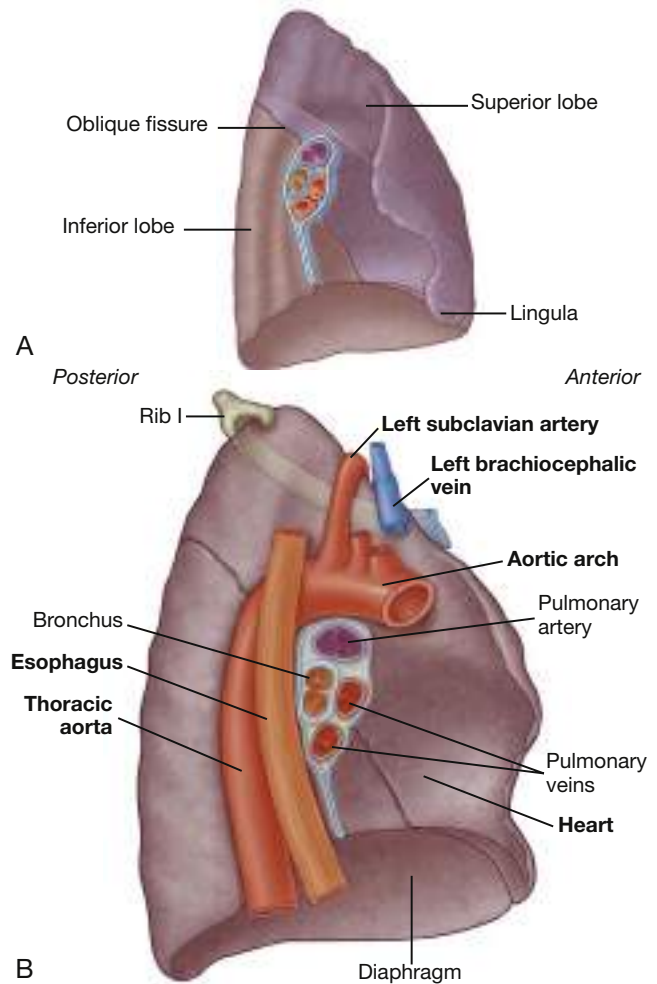


Fig. 3.38 A. Left lung. **B.** Major structures related to the left lung.

Surface anatomy

Visualizing the pleural cavities and lungs, pleural recesses, and lung lobes and fissures

Palpable surface landmarks can be used to visualize the normal outlines of the pleural cavities and the lungs and to determine the positions of the lobes and fissures of each lung.

Superiorly, the parietal pleura projects above the first costal cartilage. Anteriorly, the costal pleura approaches the midline posterior to the upper portion of the sternum. Posterior to the lower portion of the sternum, the left parietal pleura

does not come as close to the midline as it does on the right side. This is because the heart bulges onto the left side (Fig. 3.39A).

Inferiorly, the pleura reflects onto the diaphragm above the costal margin and courses around the thoracic wall following an VIII, X, XII contour (i.e., rib VIII in the midclavicular line, rib X in the midaxillary line, and vertebra TXII posteriorly).

The lungs do not completely fill the area surrounded by the pleural cavities, particularly anteriorly and inferiorly.

Continued

Surface anatomy—cont'd

- Costomediastinal recesses occur anteriorly, particularly on the left side in relationship to the heart bulge (Fig. 3.39A).
- Costodiaphragmatic recesses occur inferiorly between the lower lung margin and the lower margin of the pleural cavity (Fig. 3.39A,B).

In quiet respiration, the inferior margin of the lungs travel around the thoracic wall following a VI, VIII, X contour (i.e., rib VI in the midclavicular line, rib VIII in the midaxillary line, and vertebra TX posteriorly).

In the posterior view, the oblique fissure on both sides is located in the midline near the spine of vertebra TIV (Figs. 3.39B and 3.40A). It moves laterally in a downward direction, crossing the fourth and fifth intercostal spaces and reaches rib VI laterally.

In the anterior view, the horizontal fissure on the right side follows the contour of rib IV and its costal cartilage and the oblique fissures on both sides follow the contour of rib VI and its costal cartilage (Fig. 3.40B).

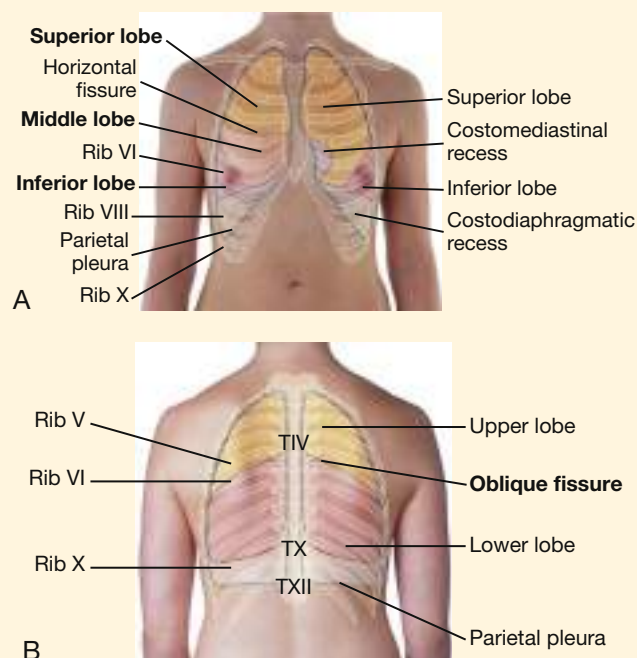
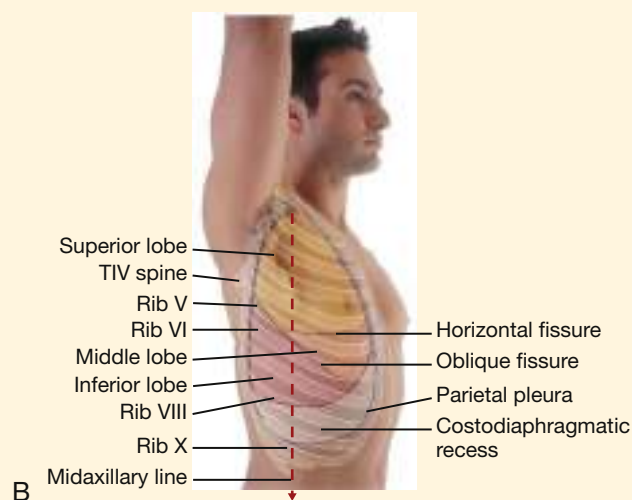


Fig. 3.39 Views of the chest wall showing the surface projections of the lobes and the fissures of the lungs. **A.** Anterior view in a woman. On the right side, the superior, middle, and inferior lobes are illustrated. On the left side, the superior and inferior lobes are illustrated. **B.** Posterior view in a woman. On both sides, the superior and inferior lobes are illustrated. The middle lobe on the right side is not visible in this view.



Fig. 3.40 Views of the chest wall. **A.** Posterior view in a woman with arms abducted and hands positioned behind her head. On both sides, the superior and inferior lobes of the lungs are illustrated. When the scapula is rotated into this position, the medial border of the scapula parallels the position of the oblique fissure and can be used as a guide for determining the surface projection of the superior and inferior lobes of the lungs. **B.** Lateral view in a man with his right arm abducted. The superior, middle, and inferior lobes of the right lung are illustrated. The oblique fissure begins posteriorly at the level of the spine of vertebra TIV and passes inferiorly, crossing rib IV, the fourth intercostal space, and rib V. It crosses the fifth intercostal space at the midaxillary line and continues anteriorly along the contour of rib VI. The horizontal fissure crosses rib V in the midaxillary line and continues anteriorly, crossing the fourth intercostal space and following the contour of rib IV and its costal cartilage to the sternum.



Surface anatomy

Where to listen for lung sounds

The stethoscope placements for listening for lung sounds are shown in Fig. 3.41.

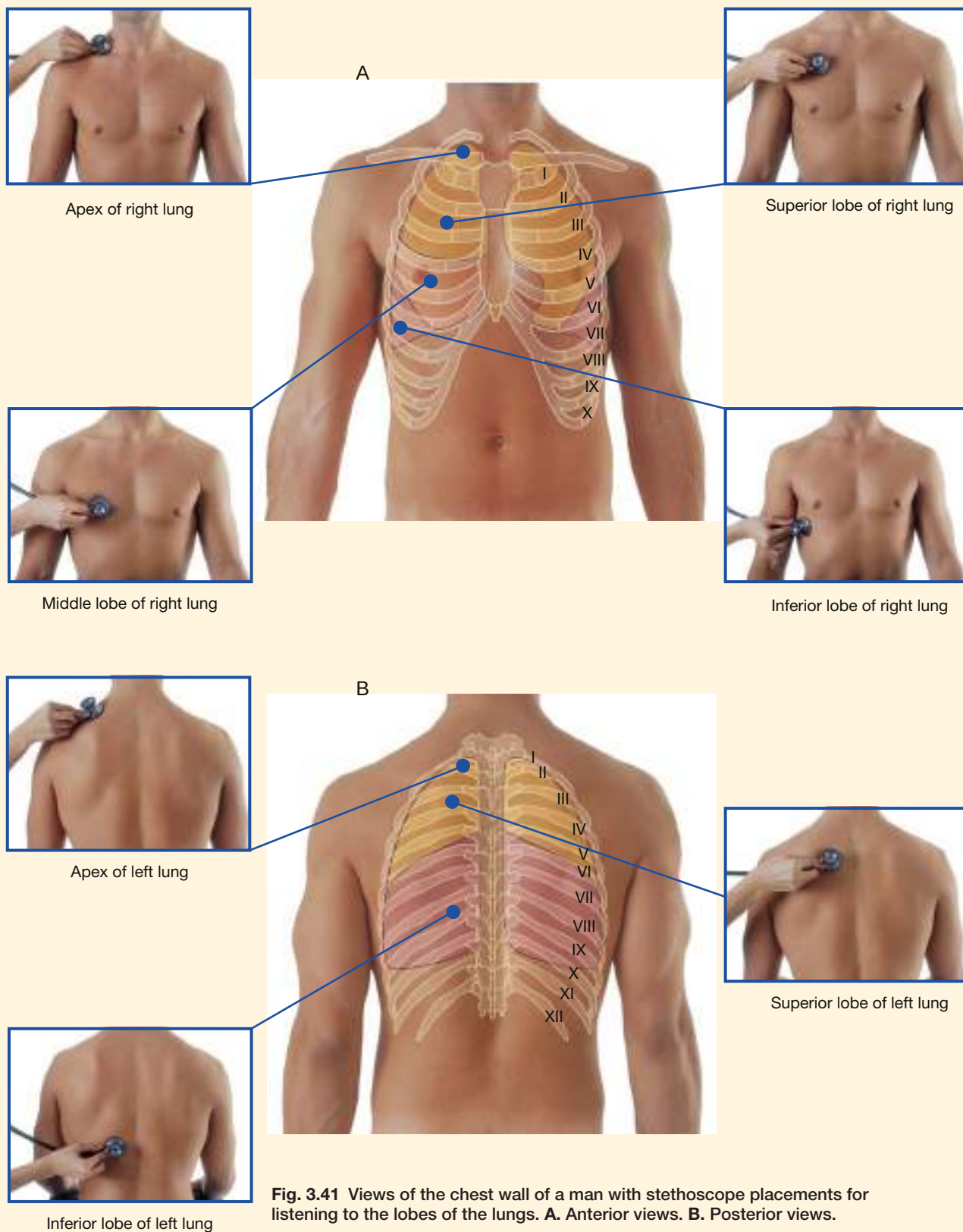


Fig. 3.41 Views of the chest wall of a man with stethoscope placements for listening to the lobes of the lungs. **A.** Anterior views. **B.** Posterior views.

mediastinum where it bifurcates into a right and a left main bronchus (Fig. 3.42). The trachea is held open by C-shaped transverse cartilage rings embedded in its wall—the open part of the C facing posteriorly. The lowest tracheal ring has a hook-shaped structure, the carina, that projects backward in the midline between the origins of the two main bronchi. The posterior wall of the trachea is composed mainly of smooth muscle.

Each main bronchus enters the root of a lung and passes through the hilum into the lung itself.

The main bronchus divides within the lung into **lobar bronchi** (secondary bronchi), each of which supplies a lobe. On the right side, the lobar bronchus to the superior lobe originates within the root of the lung.

The lobar bronchi further divide into **segmental bronchi** (tertiary bronchi), which supply bronchopulmonary segments (Fig. 3.42B).

Within each bronchopulmonary segment, the segmental bronchi give rise to multiple generations of divisions and, ultimately, to bronchioles, which further subdivide and supply the respiratory surfaces. The walls of the bronchi are

held open by discontinuous elongated plates of cartilage, but these are not present in bronchioles.

Clinical app

Inhaled objects

The right main bronchus is wider and takes a more vertical course through the root and hilum than the left main bronchus (Fig. 3.42A). Therefore inhaled foreign bodies tend to lodge more frequently on the right side than on the left.

Bronchopulmonary segments

A **bronchopulmonary segment** is the area of lung supplied by a segmental (tertiary) bronchus and its accompanying pulmonary artery branch.

Tributaries of the pulmonary vein tend to pass intersegmentally between and around the margins of segments.

Each bronchopulmonary segment is shaped like an irregular cone with the apex at the origin of the segmental (tertiary)

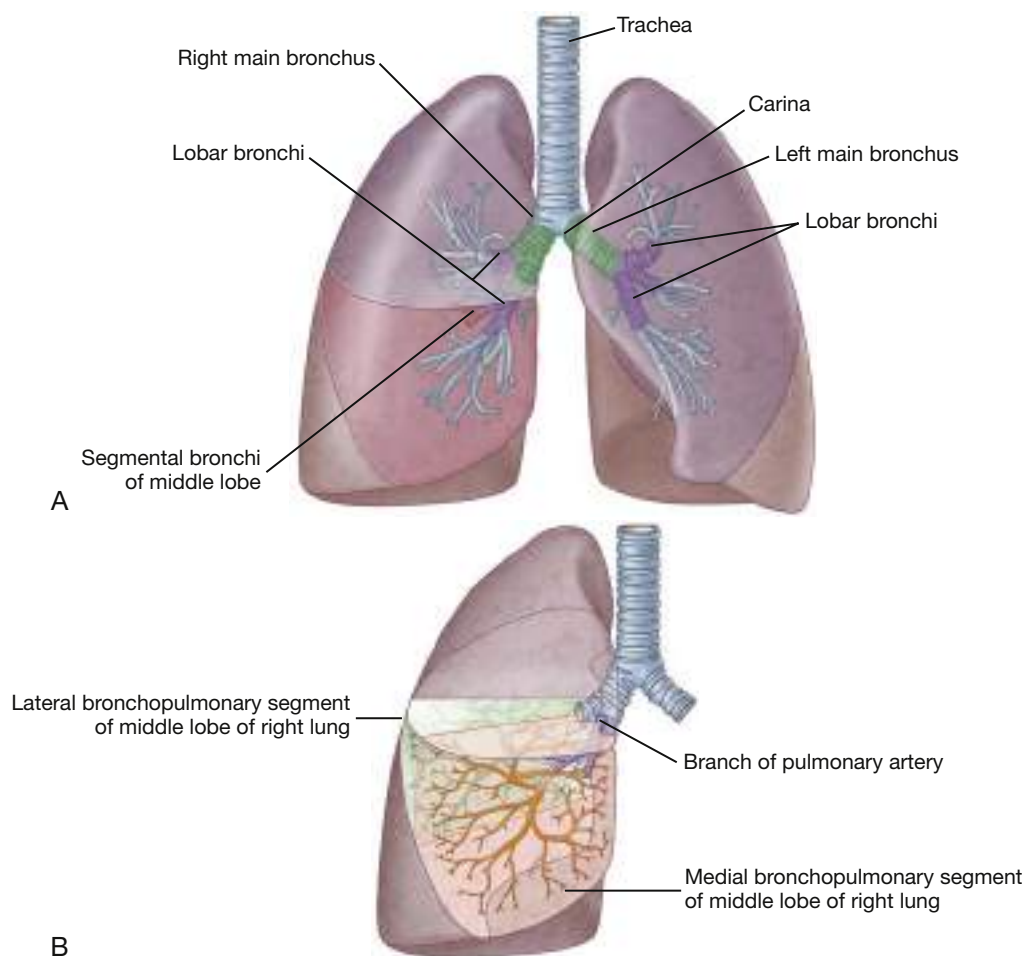


Fig. 3.42 A. Bronchial tree. B. Bronchopulmonary segments.

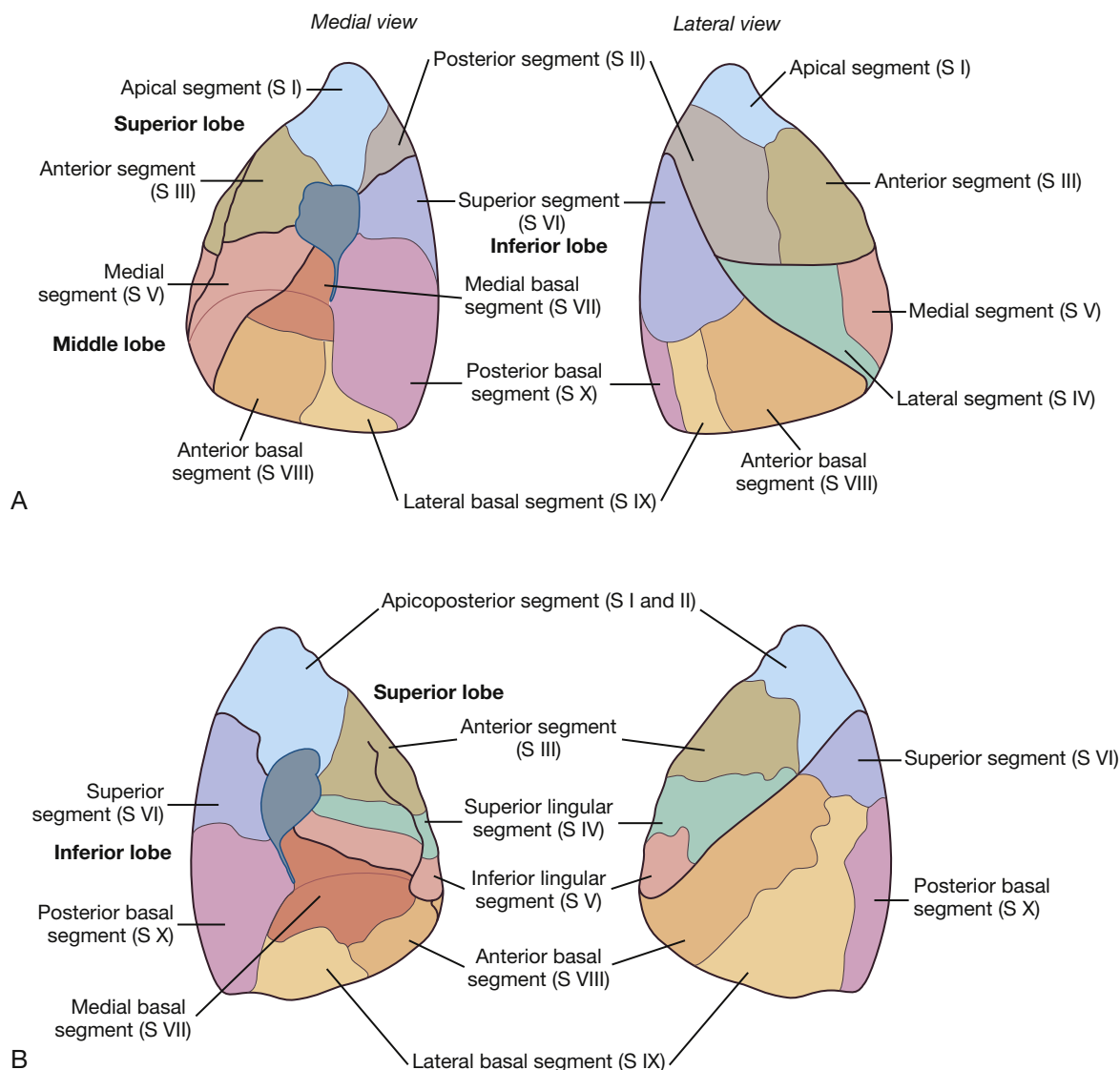


Fig. 3.43 Bronchopulmonary segments. **A.** Right lung. **B.** Left lung. (Bronchopulmonary segments are numbered and named.)

bronchus and the base projected peripherally onto the surface of the lung.

A bronchopulmonary segment is the smallest, functionally independent region of a lung and the smallest area of lung that can be isolated and removed without affecting adjacent regions.

There are 10 bronchopulmonary segments in each lung (Fig. 3.43); some of them fuse in the left lung.

Pulmonary arteries

The right and left pulmonary arteries originate from the **pulmonary trunk** and carry deoxygenated blood to the lungs from the right ventricle of the heart (Fig. 3.44).

The bifurcation of the pulmonary trunk occurs to the left of the midline just inferior to vertebral level TIV/V and anteroinferiorly to the left of the bifurcation of the trachea.

Right pulmonary artery

The **right pulmonary artery** is longer than the left and passes horizontally across the mediastinum (Fig. 3.44). It passes:

- anteriorly and slightly inferiorly to the tracheal bifurcation and anteriorly to the right main bronchus and
- posteriorly to the ascending aorta, superior vena cava, and upper right pulmonary vein.

The right pulmonary artery enters the root of the lung and gives off a large branch to the superior lobe of the lung. The main vessel continues through the hilum of the lung, gives off a second (recurrent) branch to the superior lobe, and then divides to supply the middle and inferior lobes.

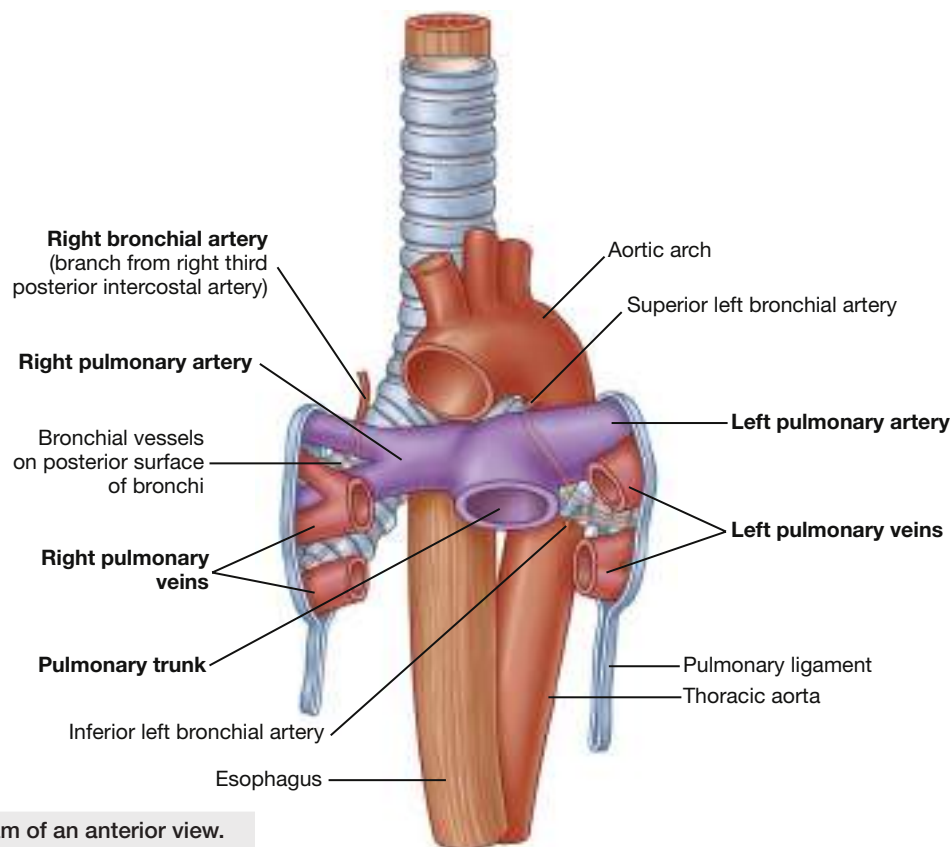


Fig. 3.44 Pulmonary vessels. Diagram of an anterior view.

Imaging app

Visualizing the pulmonary trunk by computed tomography

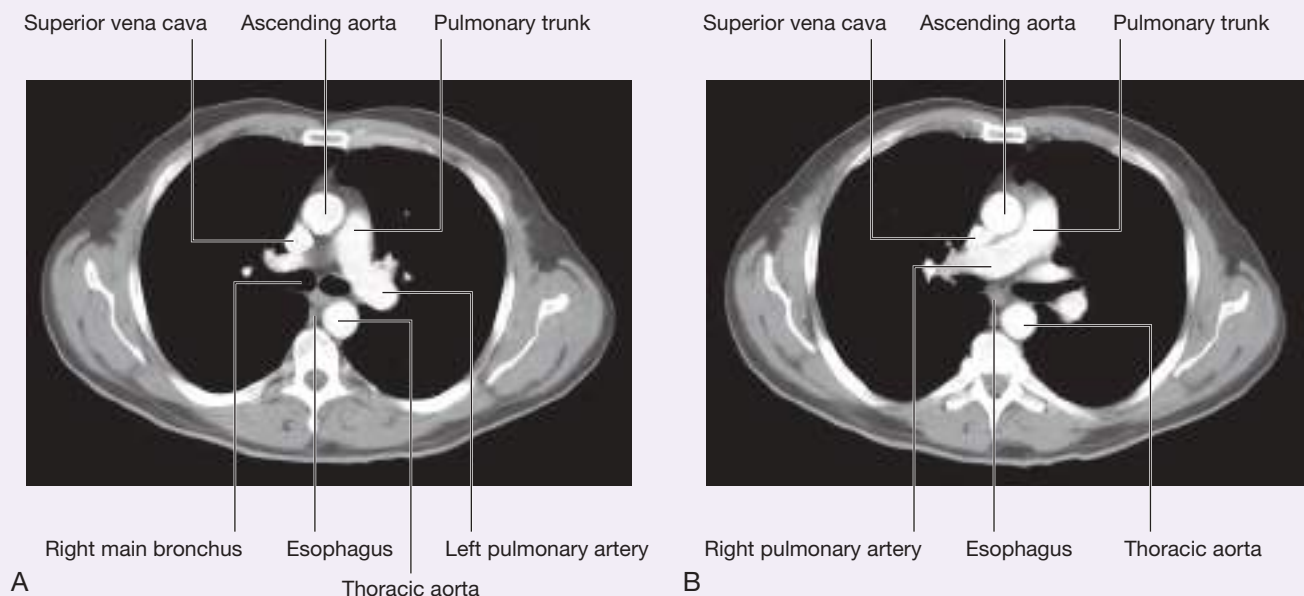


Fig. 3.45 Pulmonary vessels. **A.** Axial computed tomography image showing the left pulmonary artery branching from the pulmonary trunk. **B.** Axial computed tomography image (just inferior to the image in **A**) showing the right pulmonary artery branching from the pulmonary trunk.

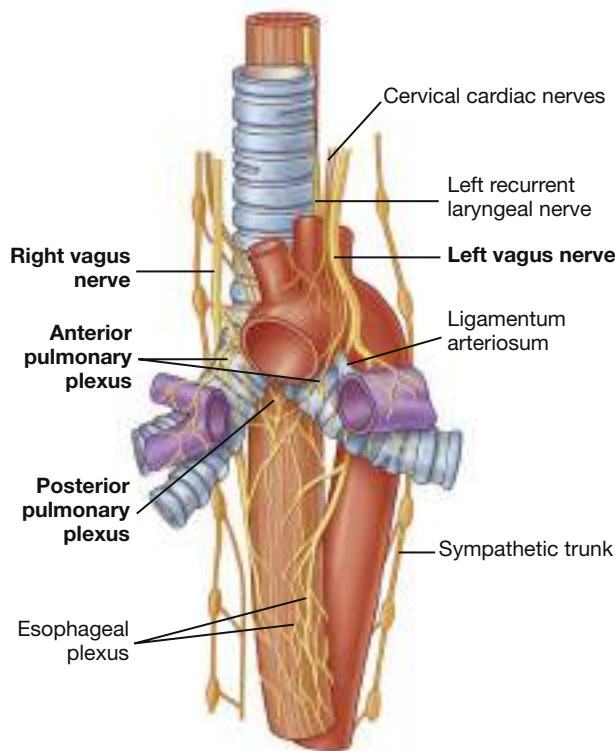


Fig. 3.46 Pulmonary innervation.

Left pulmonary artery

The **left pulmonary artery** is shorter than the right and lies anterior to the descending aorta and posterior to the superior pulmonary vein (Fig. 3.44). It passes through the root and hilum and branches within the lung.

Pulmonary veins

On each side a **superior pulmonary vein** and an **inferior pulmonary vein** carry oxygenated blood from the lungs back to the heart (Fig. 3.44). The veins begin at the hilum of the lung, pass through the root of the lung, and immediately drain into the left atrium.

Bronchial arteries and veins

The bronchial arteries (Fig. 3.44) and veins constitute the “nutritive” vascular system of the pulmonary tissues (bronchial walls and glands, walls of large vessels, and visceral pleura). They interconnect within the lung with branches of the pulmonary arteries and veins.

The bronchial arteries originate from the thoracic aorta or one of its branches:

- A single **right bronchial artery** normally arises from the third posterior intercostal artery, but occasionally it originates from the **upper left bronchial artery**.

- Two **left bronchial arteries** arise directly from the anterior surface of the thoracic aorta—the **superior left bronchial artery** arises at vertebral level TV and the inferior one inferior to the left bronchus.

The bronchial arteries run on the posterior surfaces of the bronchi and ramify in the lungs to supply pulmonary tissues.

The **bronchial veins** drain into:

- either the pulmonary veins or the left atrium and
- into the azygos vein on the right or into the superior intercostal vein or hemiazygos vein on the left.

Innervation

Structures of the lung and the visceral pleura are supplied by visceral afferents and efferents distributed through the anterior pulmonary plexus and posterior pulmonary plexus (Fig. 3.46). These interconnected plexuses lie anteriorly and posteriorly to the tracheal bifurcation and main bronchi. The anterior plexus is much smaller than the posterior plexus.

Branches of these plexuses, which ultimately originate from the sympathetic trunks and vagus nerves, are distributed along branches of the airway and vessels.

Visceral efferents from:

- the vagus nerves constrict the bronchioles;
- the sympathetic system dilates the bronchioles.

Lymphatic drainage

Superficial, or subpleural, and deep lymphatics of the lung drain into lymph nodes called **tracheobronchial nodes** around the roots of lobar and main bronchi and along the sides of the trachea (Fig. 3.47). As a group, these lymph nodes extend from within the lung, through the hilum and root, and into the posterior mediastinum.

Efferent vessels from these nodes pass superiorly along the trachea to unite with similar vessels from parasternal nodes and brachiocephalic nodes, which are anterior to brachiocephalic veins in the superior mediastinum, to form the **right and left bronchomediastinal trunks**. These trunks drain directly into deep veins at the base of the neck or may drain into the right lymphatic trunk or thoracic duct.

MEDIASTINUM

The **mediastinum** is a broad central partition that separates the two laterally placed pleural cavities (Fig. 3.52). It extends:

- from the sternum to the bodies of the vertebrae and
- from the superior thoracic aperture to the diaphragm.

The mediastinum contains the thymus gland, the pericardial sac, the heart, the trachea, and the major arteries and

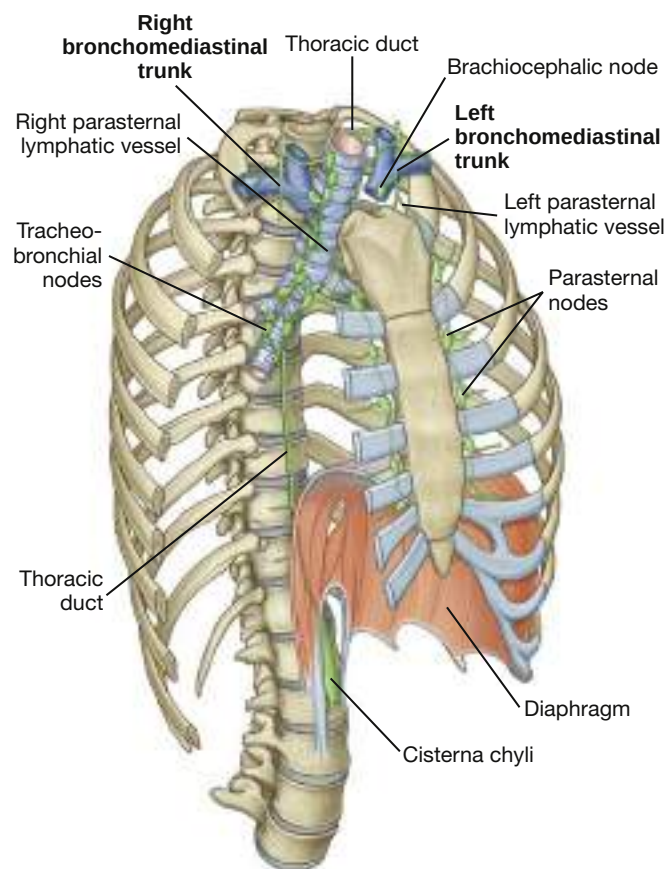


Fig. 3.47 Lymphatic drainage of lungs.

Imaging app

Visualizing the lungs

Medical imaging of the lungs is important because they are one of the commonest sites for disease in the body. While the body is at rest, the lungs exchange up to 5 L of air per minute, and this may contain pathogens and other potentially harmful elements (e.g., allergens).

Techniques to visualize the lung range from bronchoscopy, to high-resolution computed tomography (HRCT), to plain chest radiographs.

Bronchoscopy

Patients who have an endobronchial lesion (i.e., a lesion within a bronchus) may undergo bronchoscopic evaluation of the trachea and its main branches (Fig. 3.48). The bronchoscope is passed

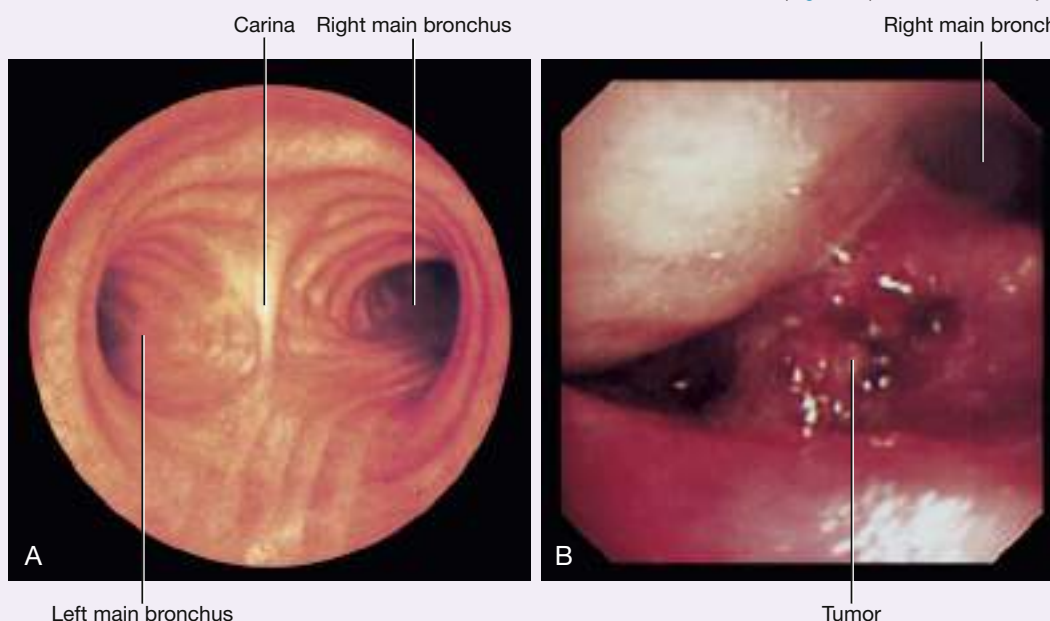


Fig. 3.48 Bronchoscopic evaluation. **A.** Of the lower end of the normal trachea and its main branches. **B.** Of tracheal bifurcation showing a tumor at the carina.

through the nose into the pharynx and is then directed by a control system into the larynx and then past the vocal cords into the trachea. The bronchi are inspected and, if necessary, small biopsies are obtained.

High-resolution lung computed tomography

HRCT is a diagnostic method for assessing the lungs but more specifically the interstitium of the lungs (Fig. 3.49). The

technique involves obtaining narrow cross-sectional slices of 1 to 2 mm. These scans enable the physician and radiologist to view the patterns of disease and their distribution. Diseases that may be easily demonstrated using this procedure include emphysema, pneumoconiosis (coal worker's pneumoconiosis), and asbestosis.

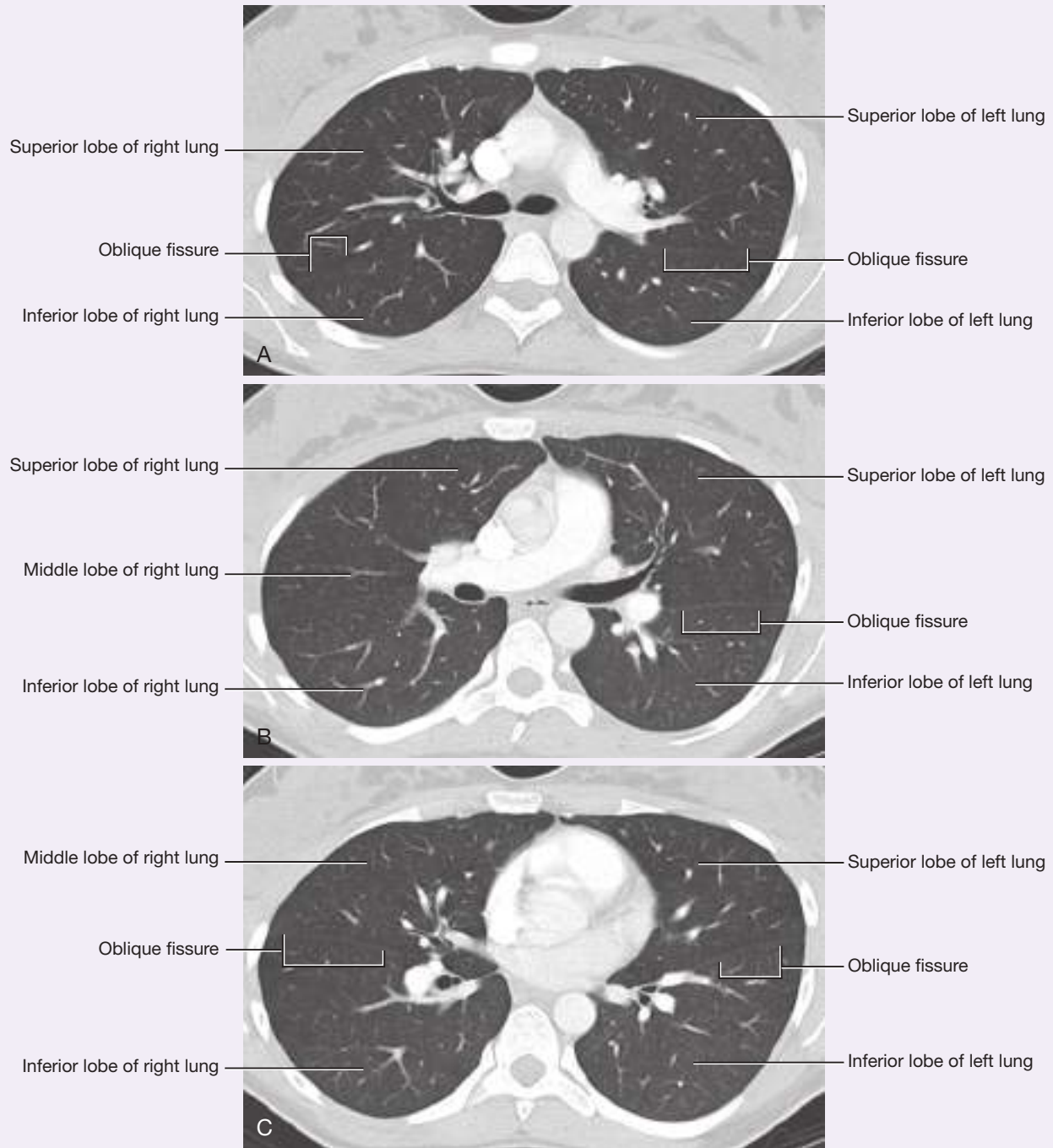


Fig. 3.49 CT images, with contrast, in axial plane: **A.** Right lung and left lung demonstrating superior and inferior lobes. The oblique fissures are visible. **B.** Right lung demonstrating superior, middle, and inferior lobes and the left lung demonstrating superior and inferior lobes. The oblique fissure associated with the left lung is visible. **C.** Right lung demonstrating middle and inferior lobes and the left lung demonstrating superior and inferior lobes. The oblique fissures are visible.

Imaging app

Plain chest radiograph

Plain chest radiographs are the most common method of visualizing the lungs (Fig. 3.50).

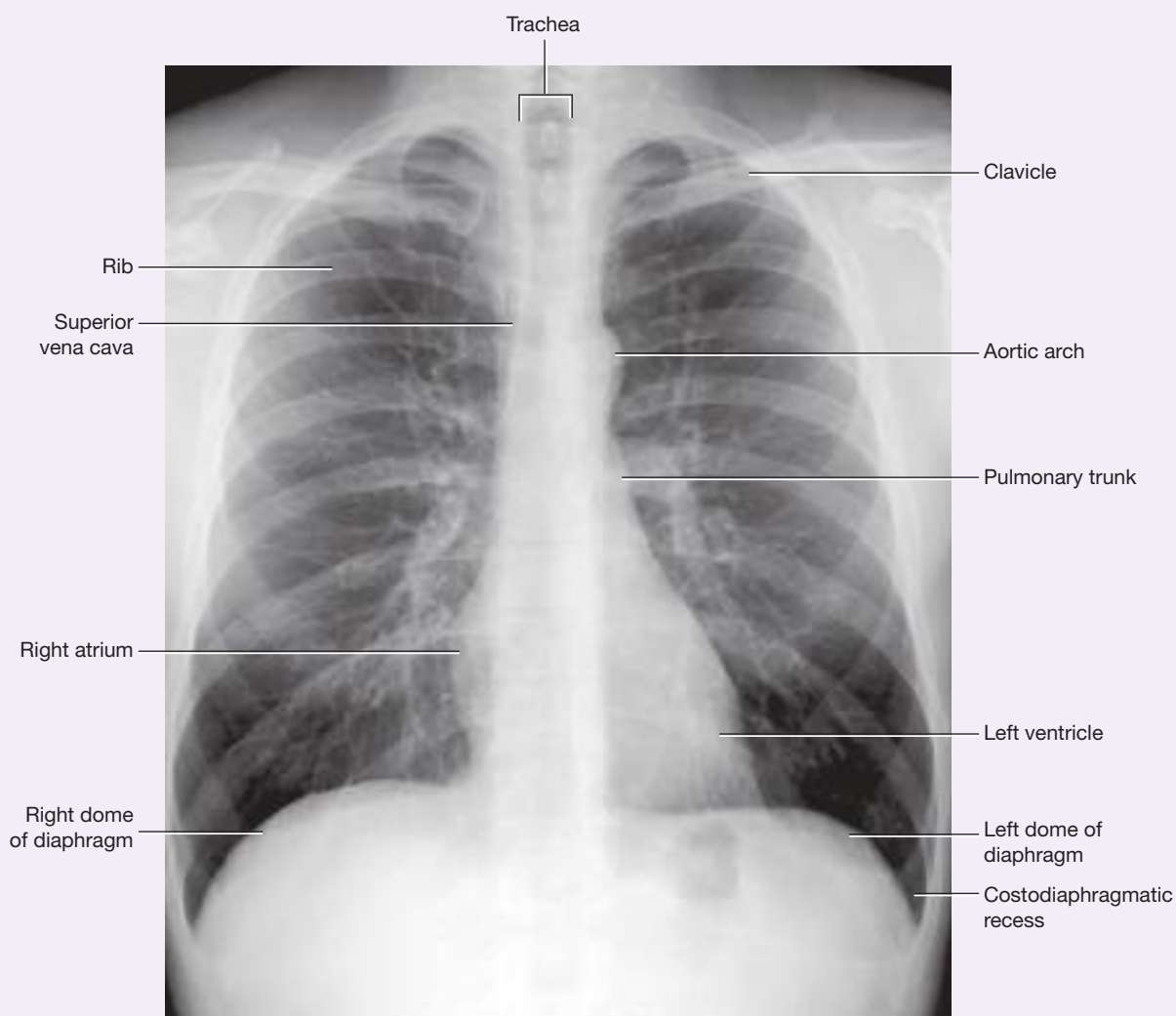


Fig. 3.50 Chest radiograph, anteroposterior view.

Clinical app

Lung cancer

It is important to stage lung cancer because the treatment depends on its stage.

If a small malignant nodule is found within the lung, it can sometimes be excised and the prognosis is excellent. Unfortunately, many patients present with a tumor mass that has invaded structures in the mediastinum or the pleurae or has metastasized. The tumor may then be inoperable and is treated with radiotherapy and chemotherapy.

Spread of the tumor is by lymphatics to lymph nodes within the hila, mediastinum, and root of the neck.

Imaging methods to assess spread include plain radiography, computed tomography (CT) (Fig. 3.51), and magnetic resonance imaging (MRI). Increasingly, radionuclide studies using fluorodeoxyglucose positron emission tomography (FDG-PET) are being used.

In FDG-PET, a gamma radiation emitter is attached to a glucose molecule. In areas of excessive metabolic activity (i.e., the tumor), excessive uptake occurs and is recorded by a gamma camera.



Fig. 3.51 Axial CT image of lungs showing tumor (arrow) in right lung.

Clinical app

Pneumonia

Chest infection is a common disease. In most patients the infection affects the large airways and bronchi. If the infection continues, exudates and transudates are produced, filling the alveoli and the secondary pulmonary lobules. The diffuse, patchy nature of this type of infection is termed *bronchial pneumonia*.

veins. It also serves as a passageway for structures such as the esophagus, thoracic duct, and various components of the nervous system as they traverse the thorax on their way to the abdomen.

For organizational purposes, the mediastinum is subdivided into several smaller regions. A transverse plane extending from the sternal angle (the junction between the manubrium and the body of the sternum) to the intervertebral disc between vertebrae T4 and T5 separates the mediastinum into the (Fig. 3.53):

- **superior mediastinum** and
- **inferior mediastinum**, which is further partitioned into the **anterior**, **middle**, and **posterior mediastinum** by the pericardial sac.

The area anterior to the pericardial sac and posterior to the body of the sternum is the anterior mediastinum. The region

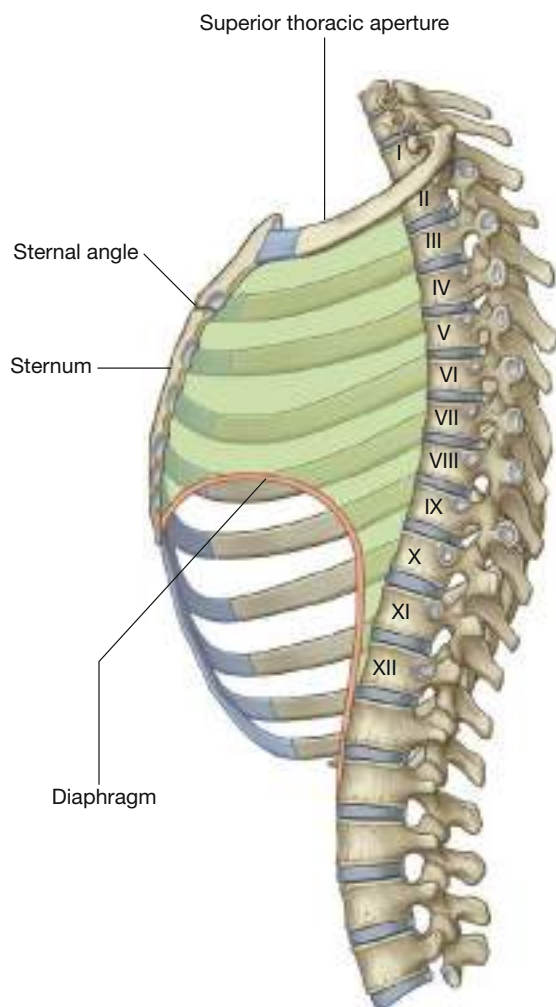


Fig. 3.52 Lateral view of the mediastinum.

posterior to the pericardial sac and the diaphragm and anterior to the bodies of the vertebrae is the posterior mediastinum. The area in the middle, which includes the pericardial sac and its contents, is the middle mediastinum (Fig. 3.53).

Anterior mediastinum

The **anterior mediastinum** is posterior to the body of the sternum and anterior to the pericardial sac (see Fig. 3.53).

- Its superior boundary is a transverse plane passing from the sternal angle to the intervertebral disc between vertebrae TIV and TV, separating it from the superior mediastinum.
- Its inferior boundary is the diaphragm.
- Laterally, it is bordered by the mediastinal part of parietal pleura on either side.

The major structure in the anterior mediastinum is a portion of thymus, described later (see Fig. 3.85). Also present are fat, connective tissue, lymph nodes, mediastinal

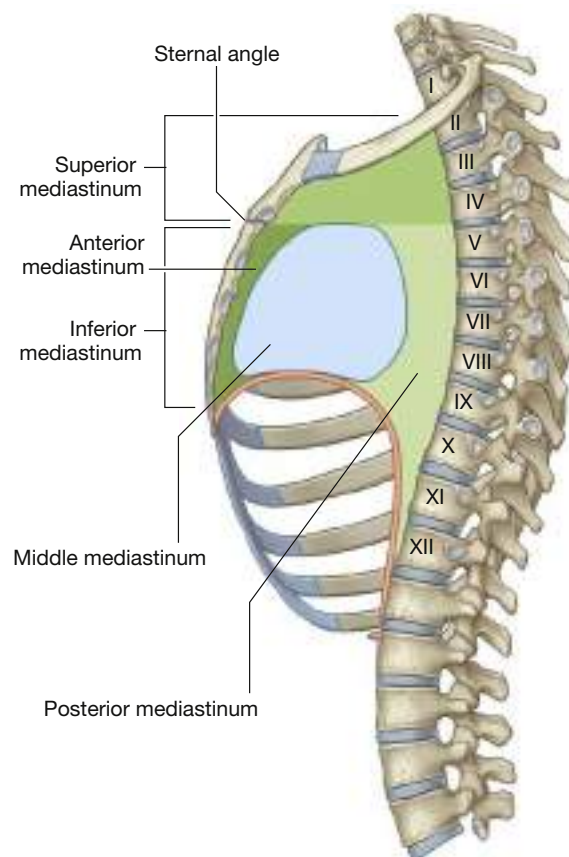


Fig. 3.53 Subdivisions of the mediastinum.

branches of the internal thoracic vessels, and sternopericardial ligaments, which pass from the posterior surface of the body of the sternum to the fibrous pericardium.

Middle mediastinum

The **middle mediastinum** is centrally located in the thoracic cavity. It contains the pericardium, heart, origins of the great vessels, various nerves, and smaller vessels.

Pericardium

The **pericardium** is a fibroserous sac surrounding the heart and the roots of the great vessels. It consists of two components, the fibrous pericardium and the serous pericardium (Fig. 3.54).

The **fibrous pericardium** is a tough connective tissue outer layer that defines the boundaries of the middle mediastinum. The **serous pericardium** is thin and consists of two parts:

- The **parietal layer** lines the inner surface of the fibrous.
- The **visceral layer (epicardium)** of serous pericardium adheres to the heart and forms its outer covering.

The parietal and visceral layers of serous pericardium are continuous at the roots of the great vessels. The narrow space created between the two layers of serous pericardium, containing a small amount of fluid, is the **pericardial cavity**.

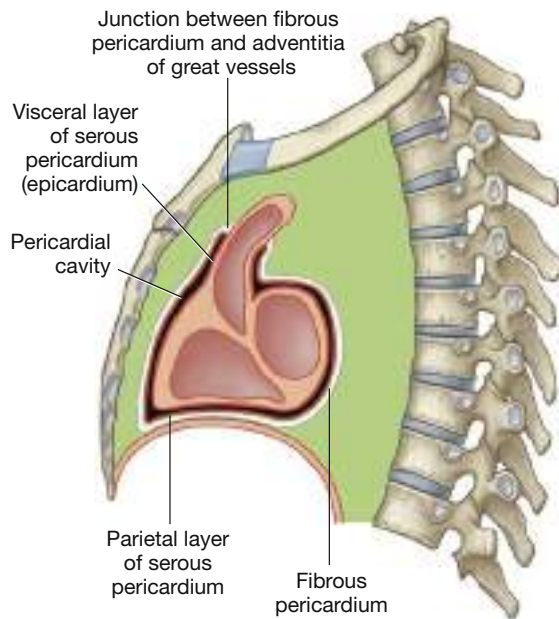


Fig. 3.54 Sagittal section of the pericardium.

This potential space allows for the relatively uninhibited movement of the heart.

Fibrous pericardium

The **fibrous pericardium** is a cone-shaped bag with its base attached to the **central tendon of the diaphragm** and a small muscular area on the left side of the diaphragm and its apex continuous with the **adventitia** of the great vessels (Fig. 3.54). Anteriorly, it is attached to the posterior surface of the sternum by **sternopericardial ligaments**. These attachments help to retain the heart in its position in the thoracic cavity. The sac also limits cardiac distention.

The phrenic nerves, which innervate the diaphragm and originate from spinal cord levels C3 to C5, pass through the fibrous pericardium and innervate this structure as they travel from their point of origin to their final destination (Fig. 3.55). Their location within the fibrous pericardium is directly related to the embryological origin of the diaphragm and the formation of the pericardial cavity. Similarly, the **pericardiophrenic vessels** are also located within and supply the fibrous pericardium as they pass through the thoracic cavity.

Serous pericardium

The parietal layer of serous pericardium is continuous with the visceral layers of serous pericardium around the roots

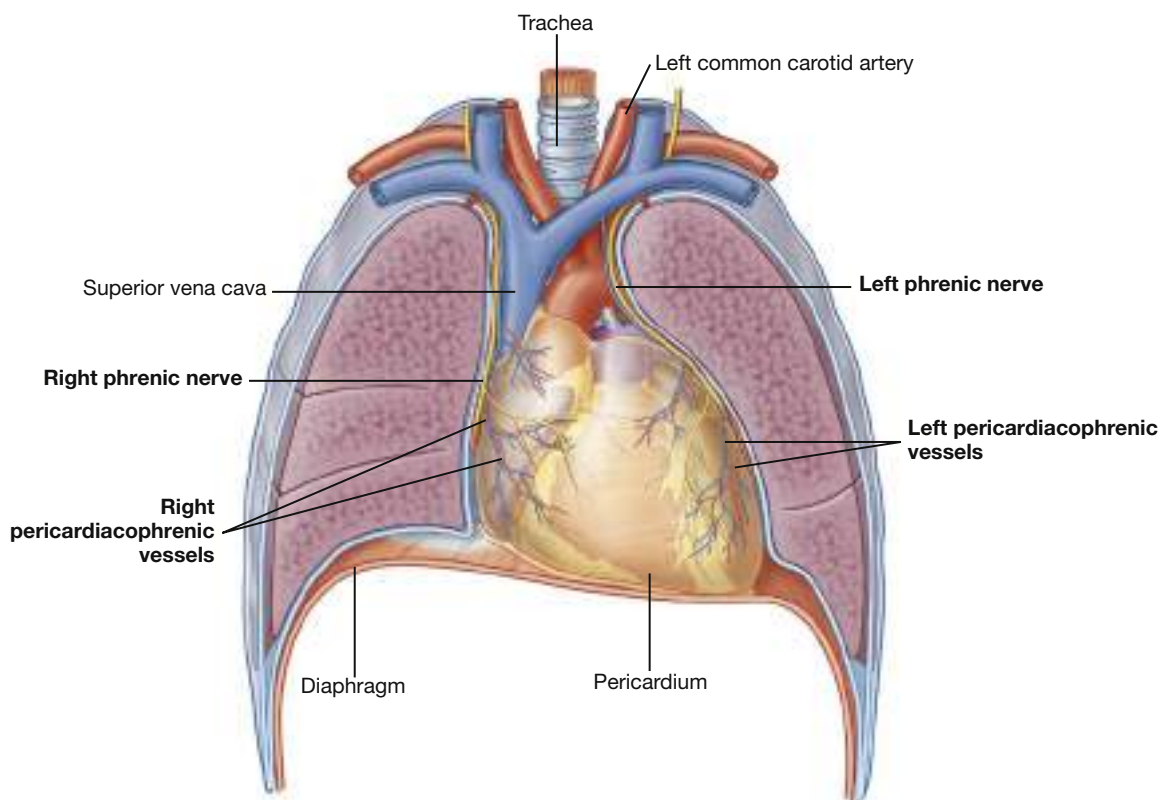


Fig. 3.55 Phrenic nerves and pericardiophrenic vessels.

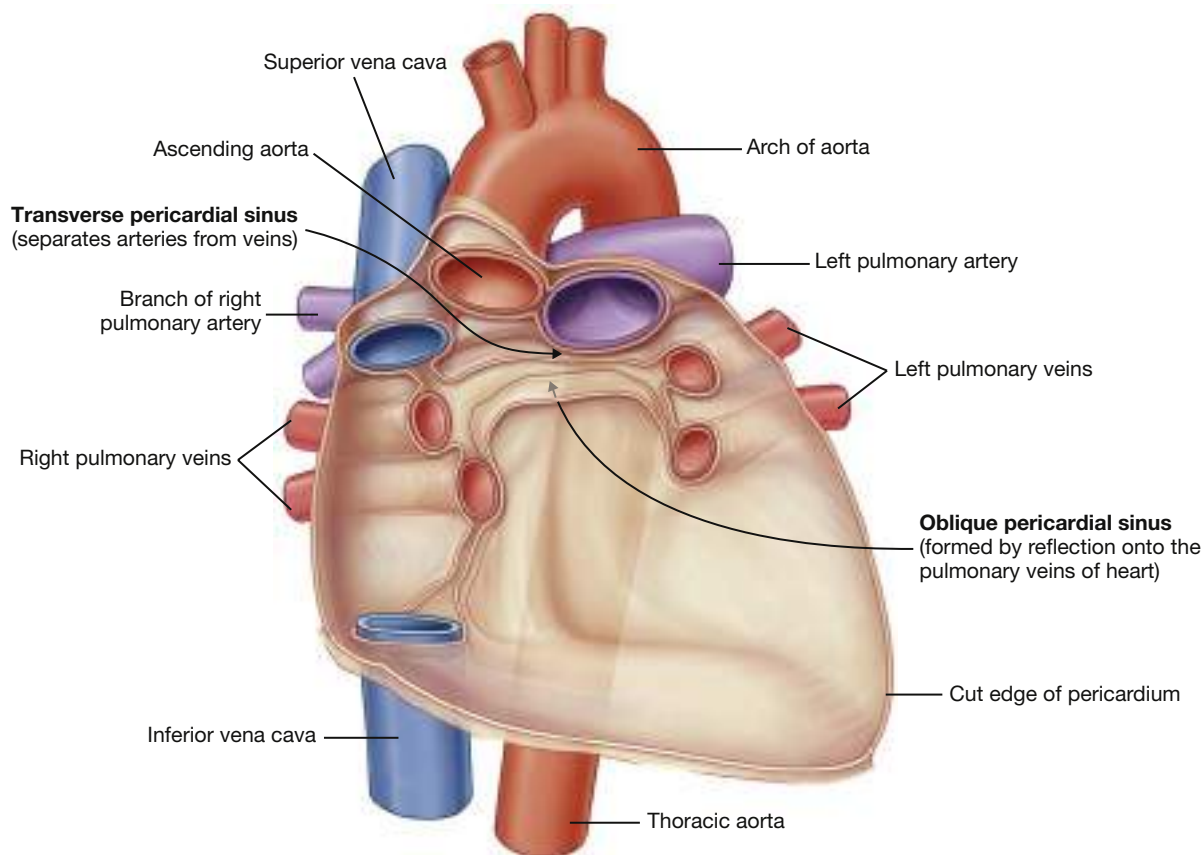


Fig. 3.56 Posterior portion of pericardial sac showing reflections of serous pericardium.

of the great vessels. These reflections of serous pericardium (Fig. 3.56) occur in two locations:

- one superiorly, surrounding the arteries—the aorta and the pulmonary trunk; and
- the second more posteriorly, surrounding the veins—the superior and inferior vena cava and the pulmonary veins.

The zone of reflection surrounding the veins is J-shaped, and the cul-de-sac formed within the J, posterior to the left atrium, is the **oblique pericardial sinus**.

A passage between the two sites of reflected serous pericardium is the **transverse pericardial sinus**. This sinus lies posteriorly to the ascending aorta and the pulmonary trunk, anteriorly to the superior vena cava, and superiorly to the left atrium.

When the pericardium is opened anteriorly during surgery, a finger placed in the transverse sinus separates arteries from veins. A hand placed under the apex of the heart and moved superiorly slips into the oblique sinus.

Vessels and nerves

Arteries supplying the pericardium are branches from the internal thoracic, pericardiophrenic, musculophrenic, and inferior phrenic arteries and the thoracic aorta.

Veins from the pericardium enter the azygos system of veins and the internal thoracic and superior phrenic veins.

Nerves supplying the pericardium arise from the vagus nerve [X], the sympathetic trunks, and the phrenic nerves.

Clinical app

Pericardial innervation

It is important to note that the source of somatic sensation (pain) from the parietal pericardium is carried by somatic afferent fibers in the phrenic nerves. For this reason, “pain” related to a pericardial problem may be referred to the supraclavicular region of the shoulder or lateral neck area, dermatomes for spinal cord segments C3, C4, and C5.

Clinical app

Pericarditis

Pericarditis is an inflammatory condition of the pericardium. Common causes are viral and bacterial infections, systemic illnesses (e.g., chronic renal failure), and postmyocardial infarction.

Clinical app

Pericardial effusion

Normally, only a tiny amount of fluid is present between the visceral and parietal layers of the serous pericardium. In certain situations, this space can be filled with excess fluid (pericardial effusion).

Because the fibrous pericardium is a “relatively fixed” structure that cannot expand easily, a rapid accumulation of excess fluid within the pericardial sac compresses the heart (cardiac tamponade), resulting in biventricular failure. Removing the fluid with a needle inserted into the pericardial sac can relieve the symptoms.

Clinical app

Constrictive pericarditis

Abnormal thickening of the pericardial sac (constrictive pericarditis) can compress the heart, impairing heart function and resulting in heart failure.

Heart

Cardiac orientation

The shape and orientation of the heart is that of a pyramid that has fallen over and is resting on one of its sides. Placed in the thoracic cavity, the apex of this pyramid projects forward, downward, and to the left, whereas the base is opposite the apex and faces in a posterior direction (Fig. 3.57). The sides of the pyramid consist of:

- a diaphragmatic (inferior) surface on which the pyramid rests,
- an anterior (sternocostal) surface oriented anteriorly,
- a right pulmonary surface, and
- a left pulmonary surface.

Base (posterior surface) and apex

The **base of the heart** is quadrilateral and directed posteriorly (Fig. 3.58). It consists of:

- the left atrium,
- a small portion of the right atrium, and
- the proximal parts of the great veins (superior and inferior venae cavae and the pulmonary veins).

Because the great veins enter the base of the heart with the pulmonary veins entering the right and left sides of the left atrium and the superior and inferior venae cavae at the upper and lower ends of the right atrium, the base

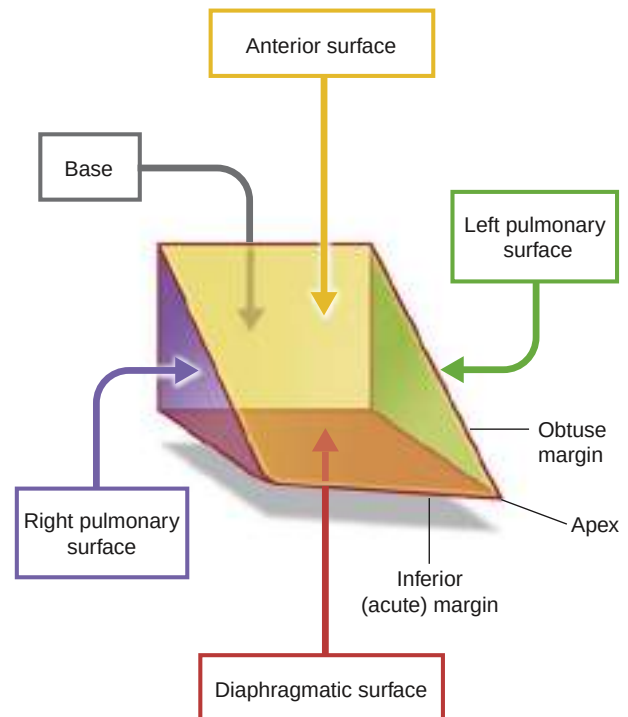


Fig. 3.57 Schematic illustration of the heart showing orientation, surfaces, and margins.

of the heart is fixed posteriorly to the pericardial wall, opposite the bodies of vertebrae T₉ to T₁₂ (T₉ to T₁₂ when standing). The esophagus lies immediately posterior to the base.

From the base the heart projects forward, downward, and to the left, ending in the apex. The **apex of the heart** is formed by the inferolateral part of the left ventricle (Fig. 3.59) and is posterior to the left fifth intercostal space, 8 to 9 cm from the midsternal line.

Surfaces of the heart

The **anterior surface** faces anteriorly and consists mostly of the right ventricle, with some of the right atrium on the right and some of the left ventricle on the left (Fig. 3.59).

The heart in the anatomical position rests on the **diaphragmatic surface**, which consists of the left ventricle and a small portion of the right ventricle separated by the posterior interventricular groove (Fig. 3.60). This surface faces inferiorly, rests on the diaphragm, is separated from the base of the heart by the coronary sinus, and extends from the base to the apex of the heart.

The **left pulmonary surface** faces the left lung, is broad and convex, and consists of the left ventricle and a portion of the left atrium.

The **right pulmonary surface** faces the right lung, is broad and convex, and consists of the right atrium.

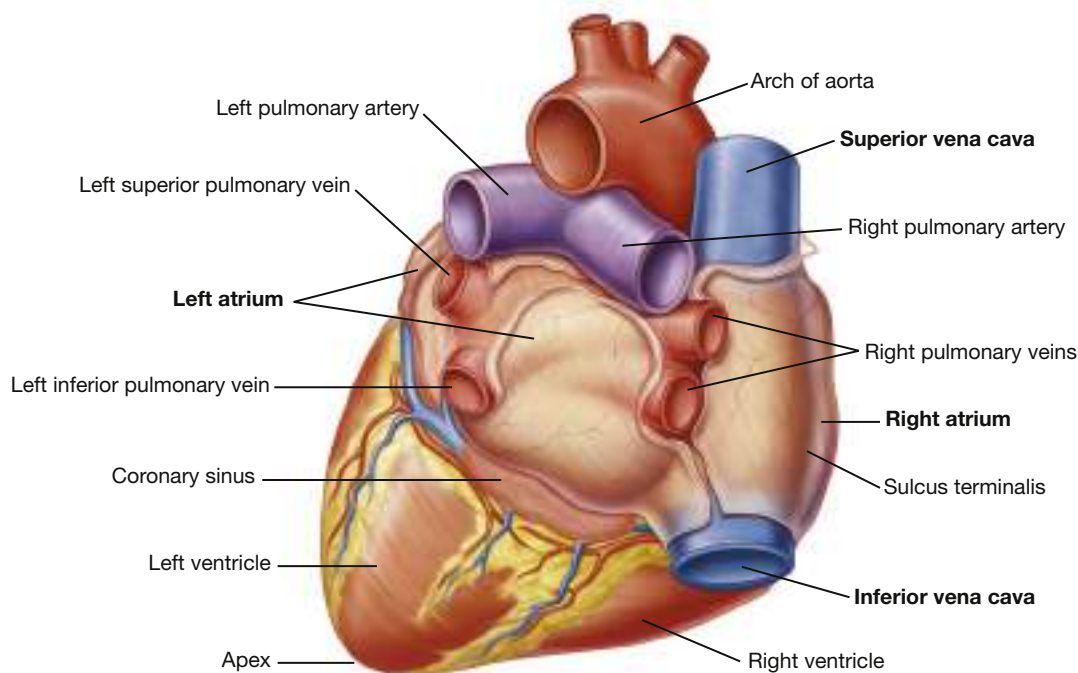


Fig. 3.58 Base of the heart.

Margins and borders

Some general descriptions of cardiac orientation refer to right, left, inferior (acute), and obtuse margins:

- The **right** and **left margins** are the same as the right and left pulmonary surfaces of the heart.
- The **inferior margin** is defined as the sharp edge between the anterior and diaphragmatic surfaces of the heart (Figs. 3.57, 3.59)—it is formed mostly by the right ventricle and a small portion of the left ventricle near the apex.
- The **obtuse margin** separates the anterior and left pulmonary surfaces (Fig. 3.57)—it is round and extends from the left auricle to the cardiac apex (Fig. 3.59) and is formed mostly by the left ventricle and superiorly by a small portion of the left auricle.

External sulci

Internal partitions divide the heart into four chambers (i.e., two atria and two ventricles) and produce surface or external grooves referred to as *sulci*.

- The **coronary sulcus** circles the heart, separating the atria from the ventricles (Fig. 3.62). It contains the right coronary artery, the small cardiac vein, the coronary sinus, and the circumflex branch of the left coronary artery.
- The **anterior** and **posterior interventricular sulci** separate the two ventricles—the anterior interventricular

sulcus on the anterior surface of the heart containing the anterior interventricular artery and the great cardiac vein and the posterior interventricular sulcus on the diaphragmatic surface of the heart containing the posterior interventricular artery and the middle cardiac vein.

These sulci are continuous inferiorly just to the right of the apex of the heart.

Cardiac chambers

Functionally, the heart consists of two pumps separated by a partition (Fig. 3.63).

- The right pump receives deoxygenated blood from the body and sends it to the lungs.
- The left pump receives oxygenated blood from the lungs and sends it to the body.

Each pump consists of an atrium and a ventricle separated by a valve.

The thin-walled atria receive blood coming into the heart, whereas the relatively thick-walled ventricles pump blood out of the heart. More force is required to pump blood through the body than through the lungs, so the muscular wall of the left ventricle is thicker than the right.

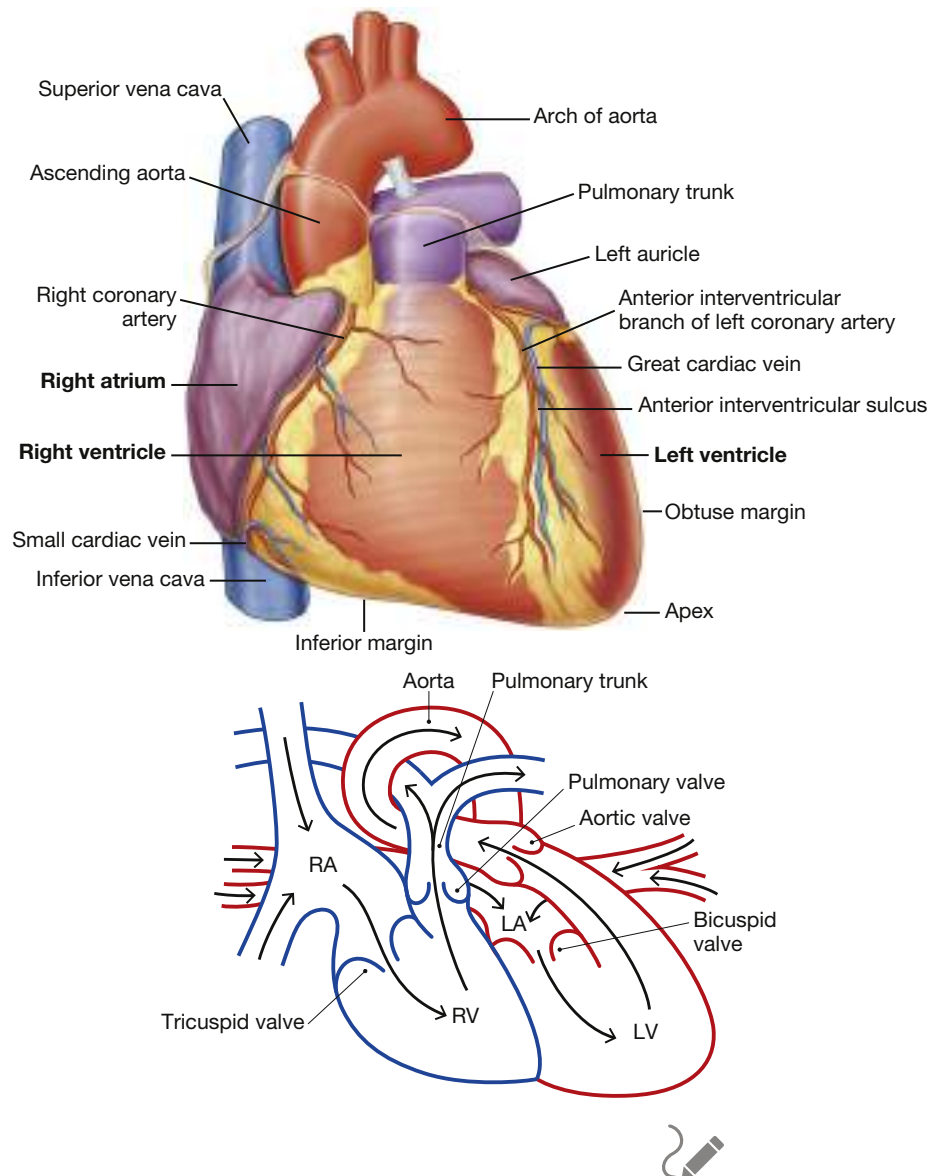


Fig. 3.59 Anterior surface of the heart.

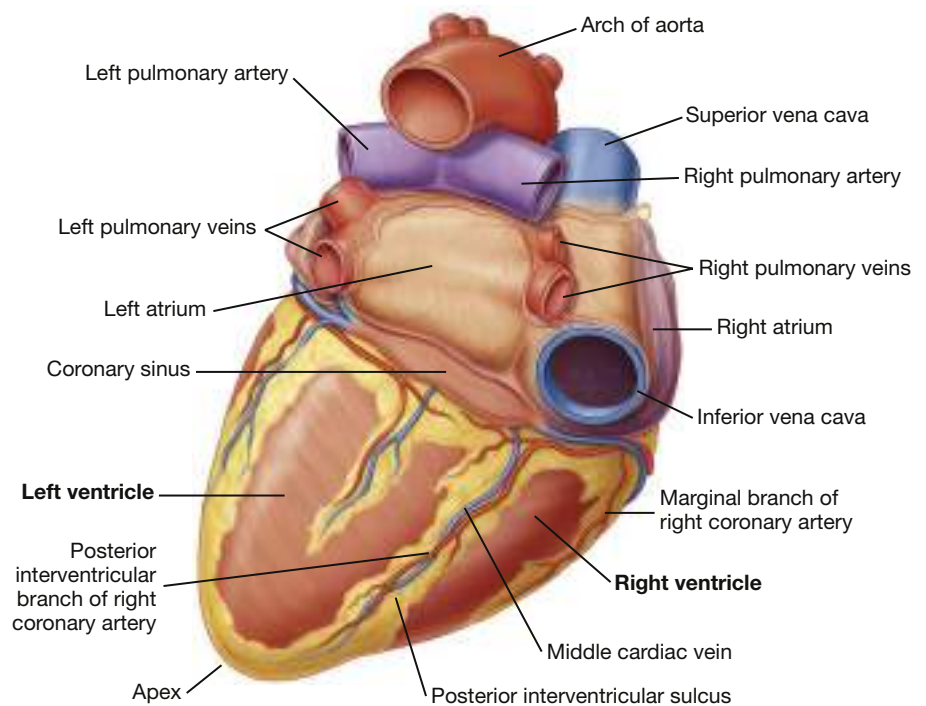


Fig. 3.60 Diaphragmatic surface of the heart.

Imaging app

Visualizing the heart

For radiological evaluations, a thorough understanding of the structures defining the cardiac borders is critical. The right border in a standard posterior–anterior view consists of the superior vena cava, the right atrium, and the inferior vena cava (Fig. 3.61A). The left border in a similar view consists of the arch of the aorta, the

pulmonary trunk, the left auricle, and the left ventricle. The inferior border in this radiological study consists of the right ventricle and the left ventricle at the apex. In lateral views, the right ventricle is seen anteriorly, and the left atrium is visualized posteriorly (Fig. 3.61B).

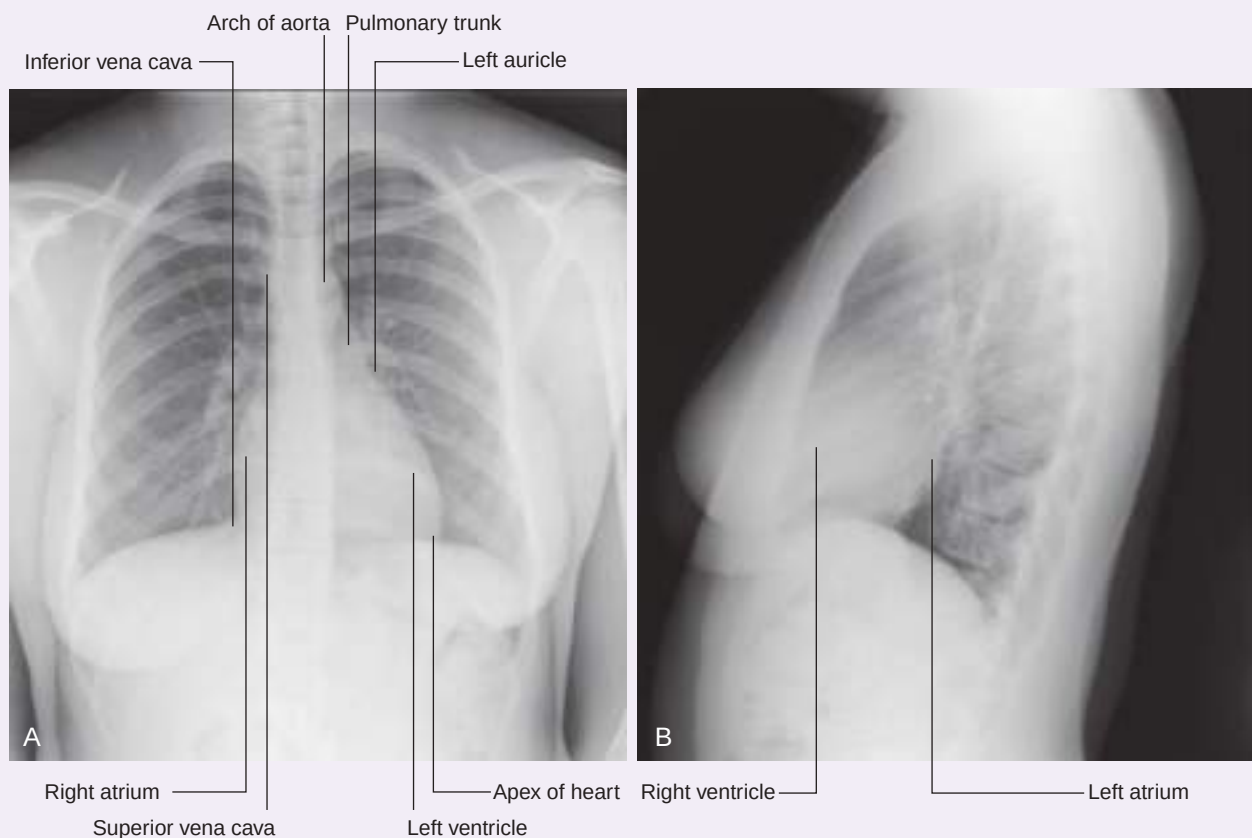


Fig. 3.61 Chest radiographs. **A.** Standard posterior–anterior view of the chest. **B.** Standard lateral view of the heart.

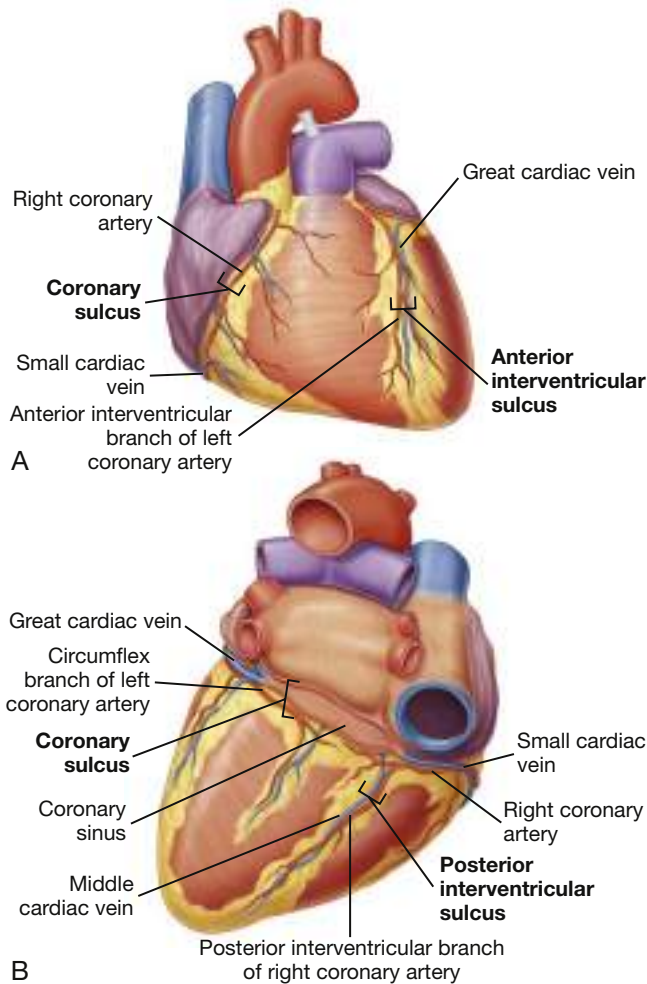


Fig. 3.62 Sulci of the heart. **A.** Anterior surface of the heart. **B.** Diaphragmatic surface and base of the heart.

Interatrial, interventricular, and atrioventricular septa separate the four chambers of the heart (Fig. 3.64). The internal anatomy of each chamber is critical to its function.

Right atrium

In the anatomical position, the **right atrium** forms the right border of the heart and contributes to the right portion of the heart's anterior surface (Fig. 3.66).

Blood returning to the right atrium enters through one of three vessels. These are:

- the superior and inferior venae cavae, which together deliver blood to the heart from the body, and
- the coronary sinus, which returns blood from the walls of the heart itself.

The superior vena cava enters the upper posterior portion of the right atrium, and the inferior vena cava and coronary sinus enter the lower posterior portion of the right atrium (Fig. 3.66).

From the right atrium, blood passes into the right ventricle through the **right atrioventricular orifice**. This opening faces forward and medially and is closed during ventricular contraction by the tricuspid valve.

The interior of the right atrium is divided into two continuous spaces. Externally, this separation is indicated by a shallow, vertical groove (the **sulcus terminalis cordis**), which extends from the right side of the opening of the superior vena cava to the right side of the opening of the inferior vena cava. Internally, this division is indicated by the **crista terminalis** (Fig. 3.66), which is a smooth, muscular ridge that begins on the roof of the atrium just in front of

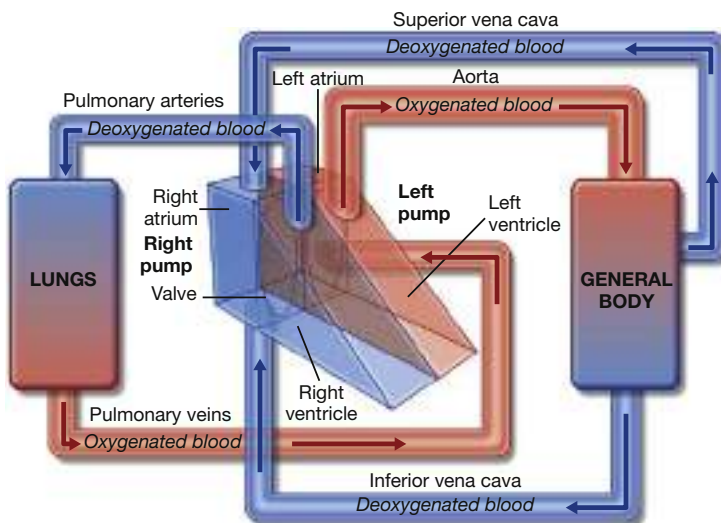


Fig. 3.63 The heart has two pumps.

Imaging app

Visualizing the chambers of the heart

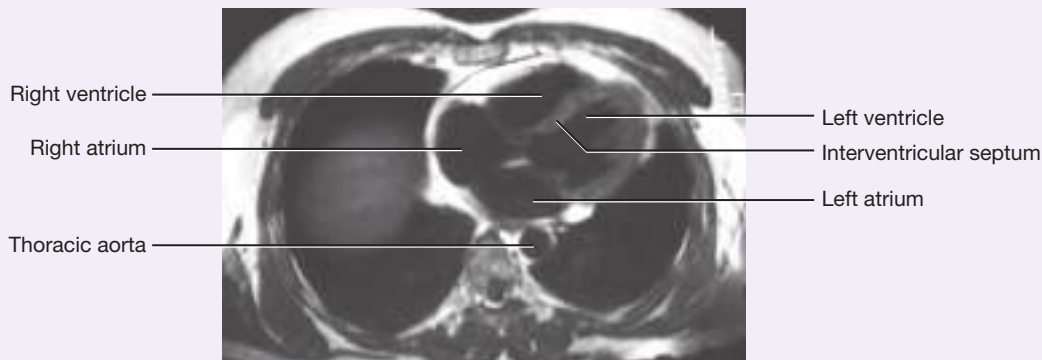


Fig. 3.64 Magnetic resonance image of midthorax showing all four chambers and septa.

Surface anatomy

Visualizing the margins of the heart

Surface landmarks can be palpated to visualize the outline of the heart (Fig. 3.65).

- The upper limit of the heart reaches as high as the third costal cartilage on the right side of the sternum and the second intercostal space on the left side of the sternum.
- The right margin of the heart extends from the right third costal cartilage to near the right sixth costal cartilage.
- The left margin of the heart descends laterally from the second intercostal space to the apex located near the midclavicular line in the fifth intercostal space.
- The lower margin of the heart extends from the sternal end of the right sixth costal cartilage to the apex in the fifth intercostal space near the midclavicular line.

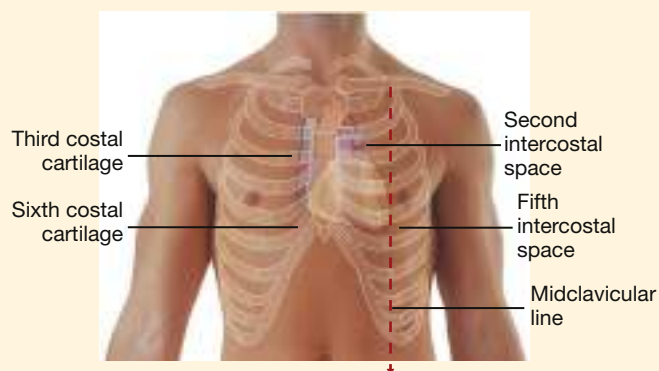


Fig. 3.65 Anterior view of the chest wall of a man showing skeletal structures and the surface projection of the heart.

the opening of the superior vena cava and extends down the lateral wall to the anterior lip of the inferior vena cava.

The space posterior to the crista is the **sinus of venae cavae** and is derived embryologically from the right horn of the sinus venosus. This component of the right atrium has smooth, thin walls, and both venae cavae empty into this space.

The space anterior to the crista, including the **right auricle**, is sometimes referred to as the **atrium proper**. This terminology is based on its origin from the embryonic primitive atrium. Its walls are covered by ridges called the **musculi pectinati (pectinate muscles)**, which fan out from the crista like the “teeth of a comb.” These ridges are also found in the right auricle, which is an ear-like, conical, muscular pouch that externally overlaps the ascending aorta.

An additional structure in the right atrium is the **opening of coronary sinus**, which receives blood from most of the cardiac veins and opens medially to the **opening of inferior vena cava**. Associated with these openings are small folds of tissue derived from the valve of the embryonic sinus venosus (the **valve of coronary sinus** and the **valve of inferior vena cava**, respectively). During development, the valve of inferior vena cava helps direct incoming oxygenated blood through the foramen ovale and into the left atrium.

Separating the right atrium from the left atrium is the **interatrial septum**, which faces forward and to the right because the left atrium lies posteriorly and to the left of the right atrium. A depression is clearly visible in the septum just above the orifice of the inferior vena cava. This is the

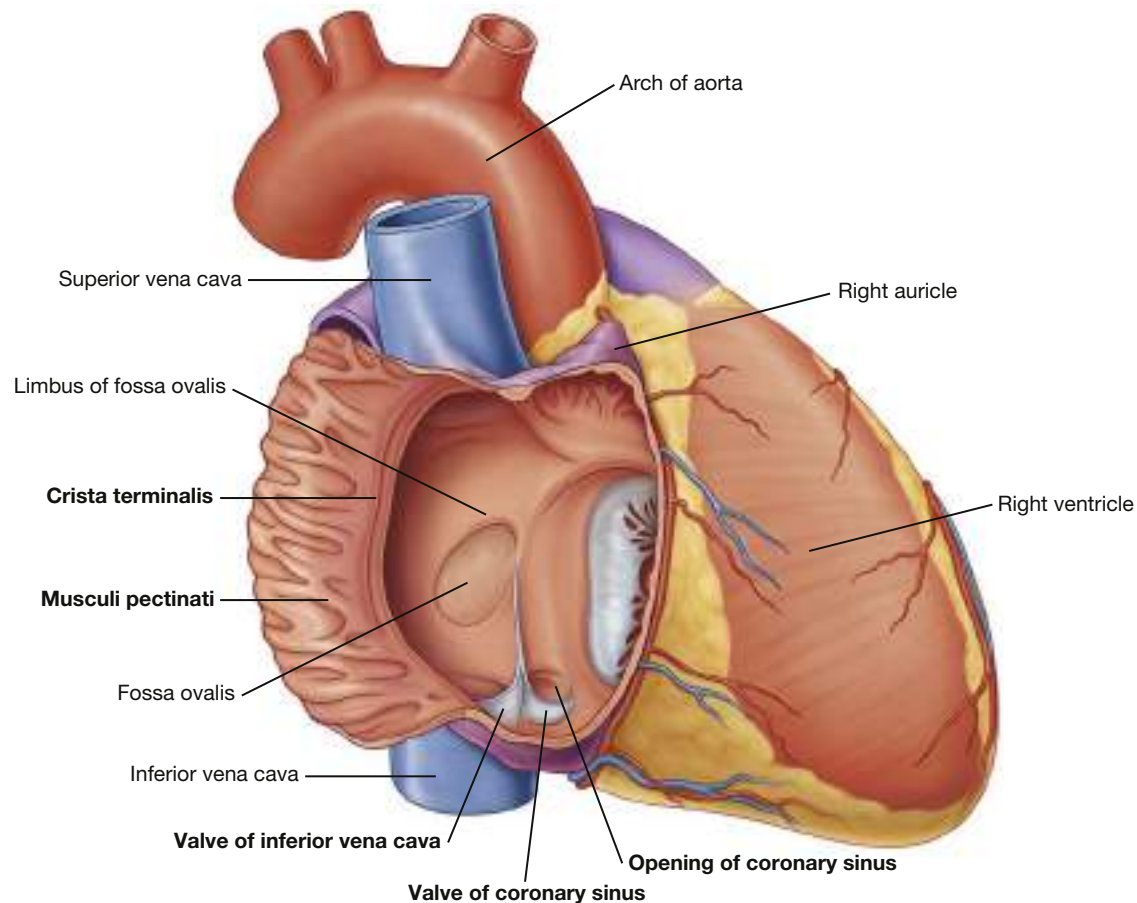


Fig. 3.66 Internal view of right atrium.

fossa ovalis (oval fossa) with its prominent margin, the **limbus fossa ovalis (border of oval fossa)** (Fig. 3.66).

The fossa ovalis marks the location of the embryonic **foramen ovale**, which is an important part of fetal circulation. The foramen ovale allows oxygenated blood entering the right atrium through the inferior vena cava to pass directly to the left atrium and so bypass the lungs, which are nonfunctional before birth.

Finally, numerous small openings—the **openings of the smallest cardiac veins** (the **foramina of the venae cordis minimae**)—are scattered along the walls of the right atrium. These are small veins that drain the myocardium directly into the right atrium.

Right ventricle

In the anatomical position, the right ventricle forms most of the anterior surface of the heart and a portion of the diaphragmatic surface (Fig. 3.67). It is to the right of the right atrium and located in front of and to the left of the right atrioventricular orifice. Blood entering the right ventricle from the right atrium therefore moves in a horizontal and forward direction.

The outflow tract of the right ventricle, which leads to the pulmonary trunk, is the **conus arteriosus (infundibulum)** (Fig. 3.67). This area has smooth walls and derives from the embryonic bulbus cordis.

The walls of the inflow portion of the right ventricle have numerous muscular, irregular structures called **trabeculae carneae** (Fig. 3.67). Most of these are either attached to the ventricular walls throughout their length, forming ridges, or attached at both ends, forming bridges.

A few trabeculae carneae (**papillary muscles**) have only one end attached to the ventricular surface, whereas the other end serves as the point of attachment for tendon-like fibrous cords (the **chordae tendineae**), which connect to the free edges of the cusps of the tricuspid valve.

There are three papillary muscles in the right ventricle. Named relative to their point of origin on the ventricular surface, they are the anterior, posterior, and septal papillary muscles (Fig. 3.67).

- The **anterior papillary muscle** is the largest and most constant papillary muscle and arises from the anterior wall of the ventricle.

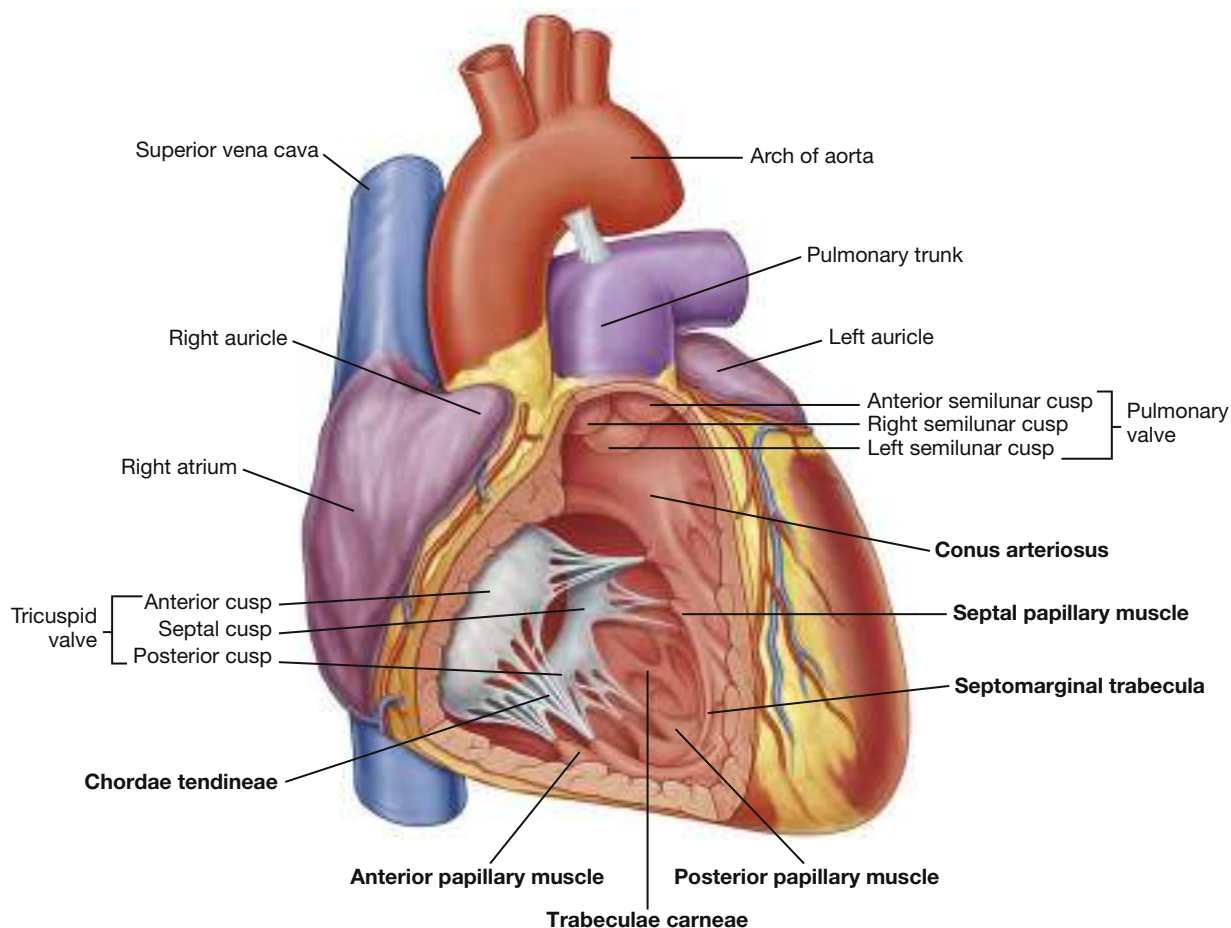


Fig. 3.67 Internal view of the right ventricle.

- The **posterior papillary muscle** may consist of one, two, or three structures with some chordae tendineae arising directly from the ventricular wall.
- The **septal papillary muscle** is the most inconsistent papillary muscle, being either small or absent with chordae tendineae emerging directly from the septal wall.

A single specialized trabeculum, the **septomarginal trabecula (moderator band)**, forms a bridge between the lower portion of the **interventricular septum** and the base of the anterior papillary muscle. The septomarginal trabecula carries a portion of the cardiac conduction system, the right bundle of the atrioventricular bundle, to the anterior wall of the right ventricle.

Tricuspid valve

The right atrioventricular orifice is closed during ventricular contraction by the **tricuspid valve (right atrioventricular valve)**, so named because it usually consists of three cusps or leaflets (Fig. 3.67). The base of each cusp is secured to a fibrous ring surrounding the atrioventricular orifice. This fibrous ring helps maintain the shape of the opening. The

cusps are continuous with each other near their bases at sites termed **commissures**.

The naming of the three cusps, the **anterior, septal, and posterior cusps**, is based on their relative position in the right ventricle (Fig. 3.67). The free margins of the cusps are attached to the chordae tendineae, which arise from the tips of the papillary muscles.

During filling of the right ventricle, the tricuspid valve is open, and the three cusps project into the right ventricle.

Without the presence of a compensating mechanism, when the ventricular musculature contracts, the valve cusps would be forced upward with the flow of blood and blood would move back into the right atrium. However, contraction of the papillary muscles attached to the cusps by chordae tendineae prevent the cusps from being everted into the right atrium.

Simply put, the papillary muscles and associated chordae tendineae keep the valves closed during the dramatic changes in ventricular size that occur during contraction.

In addition, chordae tendineae from two papillary muscles attach to each cusp. This helps prevent separation of the cusps during ventricular contraction. Proper closing of the

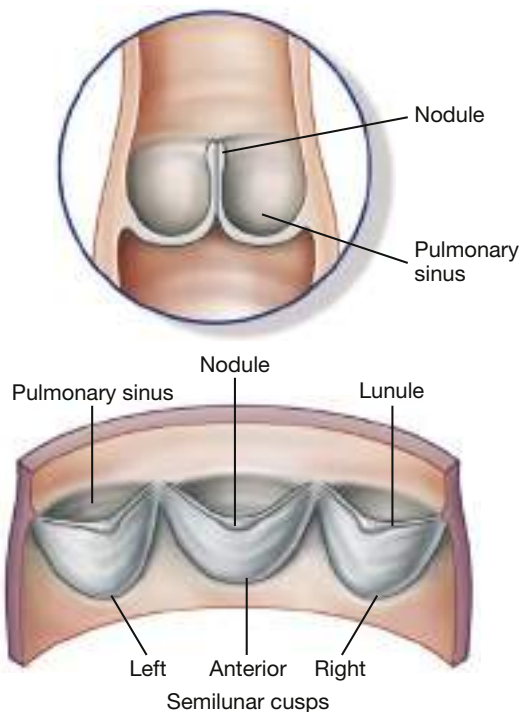


Fig. 3.68 Posterior view of the pulmonary valve.

tricuspid valve causes blood to exit the right ventricle and move into the pulmonary trunk.

Necrosis of a papillary muscle following a myocardial infarction (heart attack) may result in prolapse of the related valve.

Pulmonary valve

At the apex of the infundibulum, the outflow tract of the right ventricle, the opening into the pulmonary trunk is closed by the **pulmonary valve** (Fig. 3.68), which consists of three **semilunar cusps** with free edges projecting upward into the lumen of the pulmonary trunk. The free superior edge of each cusp has a middle, thickened portion, the **nodule of the semilunar cusp**; and a thin lateral portion, the **lunula of the semilunar cusp** (Fig. 3.68).

The cusps are named the **left, right, and anterior semilunar cusps** (see Fig. 3.75). Each cusp forms a pocket-like sinus (Fig. 3.68)—a dilation in the wall of the initial portion of the pulmonary trunk. After ventricular contraction, the recoil of blood fills these **pulmonary sinuses** and forces the cusps closed. This prevents blood in the pulmonary trunk from refilling the right ventricle.

Left atrium

The **left atrium** forms most of the base or posterior surface of the heart.

Imaging app

Visualizing the left atrium and pulmonary veins

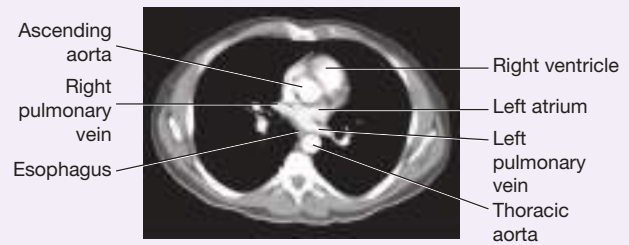


Fig. 3.69 Axial computed tomography image showing the pulmonary veins entering the left atrium.

As with the right atrium, the left atrium is derived embryologically from two structures.

- The posterior half, or inflow portion, receives the four pulmonary veins (Fig. 3.70). It has smooth walls and derives from the proximal parts of the pulmonary veins that are incorporated into the left atrium during development.
- The anterior half is continuous with the left auricle. It contains *musculi pectinati* and derives from the embryonic primitive atrium. Unlike the *crista terminalis* in the right atrium, no distinct structure separates the two components of the left atrium.

The interatrial septum is part of the anterior wall of the left atrium. The thin area or depression in the septum is the valve of the foramen ovale and is opposite the floor of the fossa ovalis in the right atrium.

During development, the **valve of foramen ovale** prevents blood from passing from the left atrium to the right atrium. This valve may not be completely fused in some adults, leaving a “probe patent” passage between the right atrium and the left atrium.

Left ventricle

The left ventricle lies anterior to the left atrium. It contributes to the anterior, diaphragmatic, and left pulmonary surfaces of the heart and forms the apex.

Blood enters the ventricle through the **left atrioventricular orifice** and flows in a forward direction to the apex (Fig. 3.71). The chamber itself is conical, is longer than the right ventricle, and has the thickest layer of **myocardium**. The outflow tract (the **aortic vestibule**) is posterior to the infundibulum of the right ventricle, has smooth walls, and is derived from the embryonic bulbus cordis.

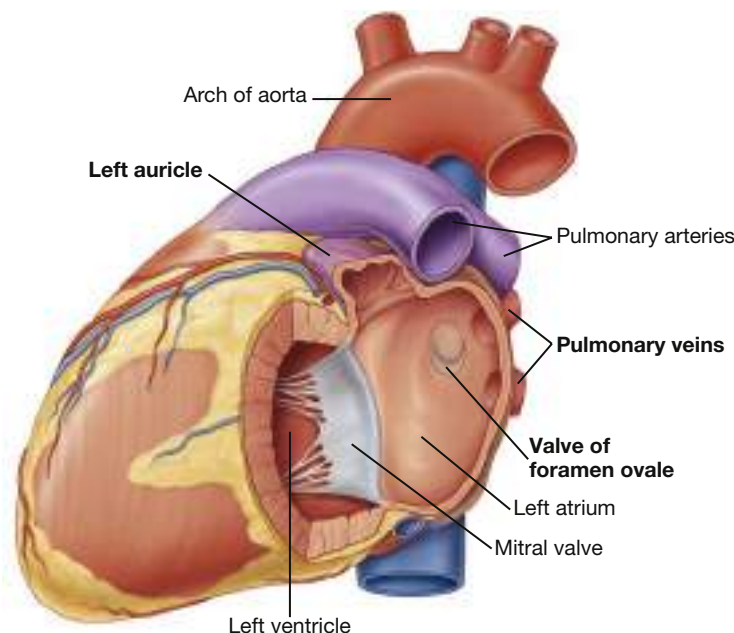


Fig. 3.70 Internal view of left atrium

The **trabeculae carneae** in the left ventricle are fine and delicate in contrast to those in the right ventricle. The general appearance of the trabeculae with muscular ridges and bridges is similar to that of the right ventricle (Fig. 3.71).

Papillary muscles, together with chordae tendineae, are also observed and their structure is as described above for the right ventricle. Two papillary muscles, the **anterior** and **posterior papillary muscles**, are usually found in the left ventricle and are larger than those of the right ventricle (Fig. 3.71).

In the anatomical position, the left ventricle is somewhat posterior to the right ventricle. The interventricular septum therefore forms the anterior wall and some of the wall on the right side of the left ventricle. The septum is described as having two parts:

- a **muscular part**, and
- a **membranous part**.

The muscular part is thick and forms the major part of the septum, whereas the membranous part is the thin, upper part of the septum. A third part of the septum may be considered an atrioventricular part because of its position above the septal cusp of the tricuspid valve. This superior location places this part of the septum between the left ventricle and right atrium.

Mitral valve

The left atrioventricular orifice opens into the posterior right side of the superior part of the left ventricle.

It is closed during ventricular contraction by the **mitral valve (left atrioventricular valve)**, which is also referred to as the bicuspid valve because it has two cusps, the **anterior** and **posterior cusps** (Fig. 3.71). At their base, the cusps are secured to a fibrous ring surrounding the opening and are continuous with each other at the commissures. The coordinated action of the papillary muscles and chordae tendineae is as described for the right ventricle.

Aortic valve

The aortic vestibule, or outflow tract of the left ventricle, is continuous superiorly with the ascending aorta. The opening from the left ventricle into the aorta is closed by the **aortic valve**. This valve is similar in structure to the pulmonary valve. It consists of three **semilunar cusps** with the free edge of each projecting upward into the lumen of the ascending aorta (Fig. 3.72).

Between the semilunar cusps and the wall of the ascending aorta are pocket-like sinuses—the **right, left, and posterior aortic sinuses**. The right and left coronary arteries originate from the right and left aortic sinuses. Because of this, the posterior aortic sinus and cusp are sometimes referred to as the **noncoronary sinus and cusp**.

The functioning of the aortic valve is similar to that of the pulmonary valve with one important additional process: as blood recoils after ventricular contraction and fills the aortic sinuses, it is automatically forced into the coronary arteries because these vessels originate from the right and left aortic sinuses.

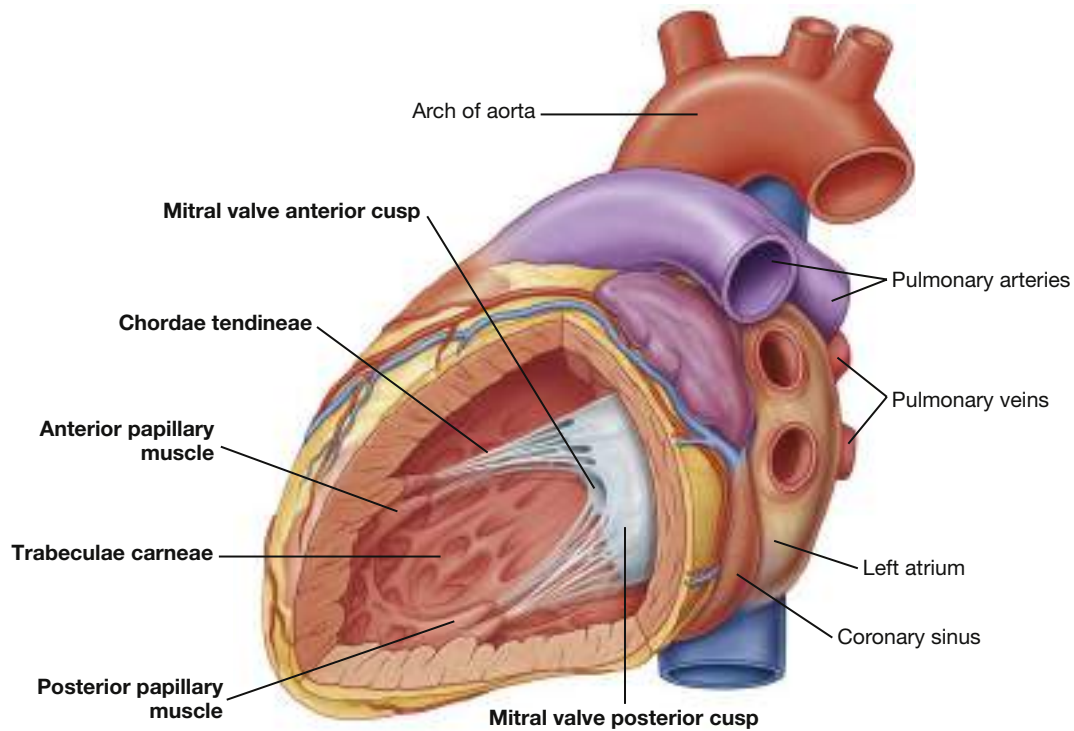


Fig. 3.71 Internal view of the left ventricle.

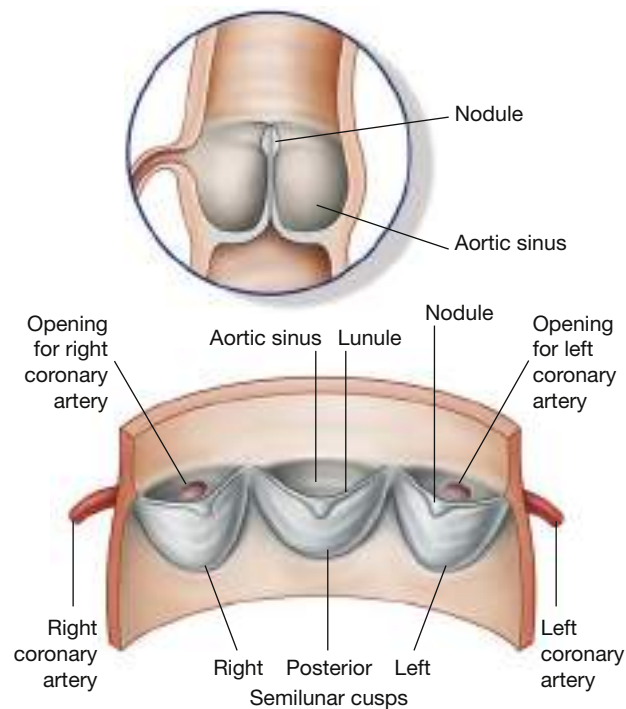


Fig. 3.72 Anterior view of the aortic valve.

Surface anatomy

Where to listen for heart sounds

To listen for valve sounds, position the stethoscope downstream from the flow of blood through the valves (Fig. 3.73).

- The tricuspid valve is heard just to the left of the lower part of the sternum near the fifth intercostal space.

- The mitral valve is heard over the apex of the heart in the left fifth intercostal space at the midclavicular line.
- The pulmonary valve is heard over the medial end of the left second intercostal space.
- The aortic valve is heard over the medial end of the right second intercostal space.

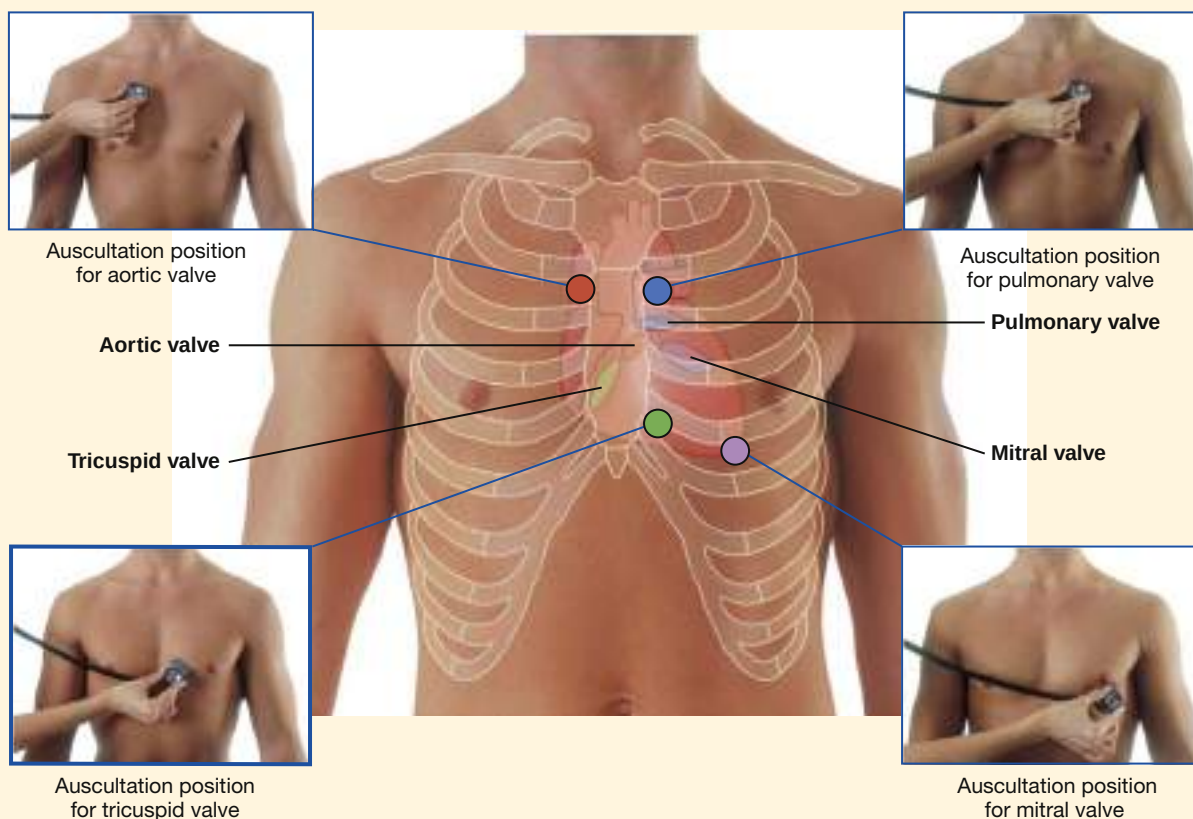


Fig. 3.73 Anterior view of the chest wall of a man showing skeletal structures, heart, location of the heart valves, and auscultation points.

Clinical app

Valve disease

Valve problems consist of two basic types:

- incompetence (insufficiency), which results from poorly functioning valves, and
- stenosis, a narrowing of the orifice caused by the valve's inability to open fully.

Mitral valve disease is usually a mixed pattern of stenosis and incompetence, one of which usually predominates. Both stenosis and incompetence lead to a poorly functioning valve and subsequent heart changes, which include:

- left ventricular hypertrophy (this is appreciably less marked in patients with mitral stenosis),
- increased pulmonary venous pressure,
- pulmonary edema, and
- enlargement (dilation) and hypertrophy of the left atrium.

Aortic valve disease, both aortic stenosis and aortic regurgitation (backflow), can produce heart failure.

Valve disease in the right side of the heart (affecting the tricuspid or pulmonary valve) is most likely caused by infection. The resulting valve dysfunction produces abnormal pressure changes in the right atrium and right ventricle, and these can induce cardiac failure.

Clinical app

Common congenital heart defects

The most common abnormalities that occur during development are those produced by a defect in the interatrial and interventricular septa.

A **defect in the interatrial septum** allows blood to pass from one side of the heart to the other from the chamber with the higher pressure; this is clinically referred to as a shunt. An **atrial septal defect (ASD)** allows oxygenated blood to flow from the left atrium (higher pressure) across the ASD into the right atrium (lower pressure). Many patients with ASD are asymptomatic, but in some cases the ASD may need to be closed surgically or by endovascular devices. The most common of all congenital heart defects are those that occur in the interventricular septum—**ventricular septal defect (VSD)**. These lesions are most frequent in the membranous portion of the septum and they allow blood to move from the left ventricle (higher pressure) to the right ventricle (lower pressure); this leads to right ventricular hypertrophy and pulmonary arterial hypertension. If large enough and left untreated, VSDs can produce marked clinical problems that might require surgery.

Occasionally, the **ductus arteriosus**, which connects the left branch of the pulmonary artery to the inferior aspect of the aortic arch, fails to close at birth. When this occurs, the oxygenated blood in the aortic arch (higher pressure) passes into the left branch of the pulmonary artery (lower pressure) and produces pulmonary hypertension. This is termed a **patent** or **persistent ductus arteriosus (PDA)**.

Cardiac skeleton

The cardiac skeleton consists of dense, fibrous connective tissue in the form of four rings with interconnecting areas between the atria and the ventricles (Fig. 3.75). The four rings surround the two atrioventricular orifices, the aortic orifice, and the opening of the pulmonary trunk. They are the **anulus fibrosus**. The interconnecting areas include:

- the **right fibrous trigone**—a thickened area of connective tissue between the aortic ring and right atrioventricular ring (Fig. 3.75); and
- the **left fibrous trigone**—a thickened area of connective tissue between the aortic ring and the left atrioventricular ring (Fig. 3.75).

The cardiac skeleton helps maintain the integrity of the openings it surrounds and provides points of attachment for the cusps. It also separates the atrial musculature from the ventricular musculature. The atrial myocardium originates from the upper border of the rings, whereas the ventricular myocardium originates from the lower border of the rings.

The cardiac skeleton also serves as a dense connective tissue partition that electrically isolates the atria from the ventricles. The atrioventricular bundle, which passes through

Clinical app

Cardiac auscultation

Auscultation of the heart reveals the normal audible cardiac cycle, which allows the clinician to assess heart rate, rhythm, and regularity. Furthermore, cardiac murmurs that have characteristic sounds within the phases of the cardiac cycle can be demonstrated (Fig. 3.74).

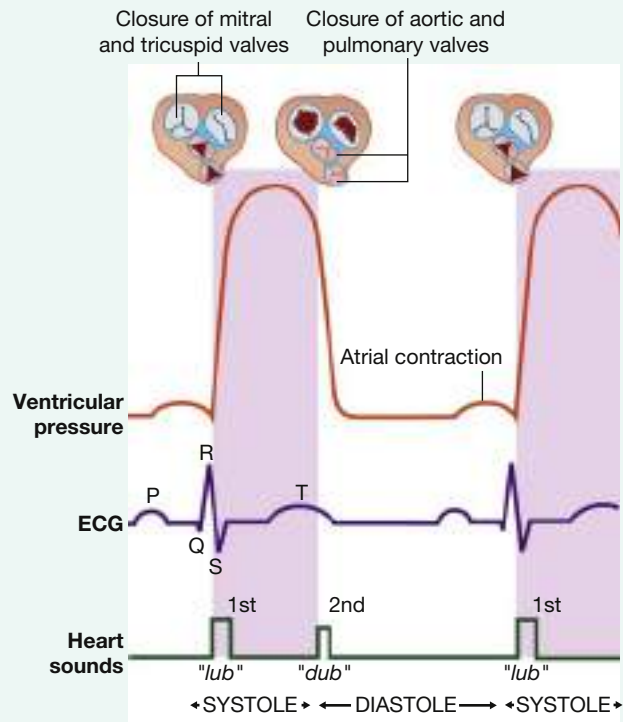


Fig. 3.74 Heart sounds and how they relate to valve closure, the electrocardiogram, and ventricular pressure.

the anulus, is the single connection between these two groups of myocardium.

Coronary vasculature

Two coronary arteries arise from the aortic sinuses in the initial portion of the ascending aorta and supply the muscle and other tissues of the heart. They circle the heart in the coronary sulcus, with marginal and interventricular branches, in the interventricular sulci, converging toward the apex of the heart.

The returning venous blood passes through cardiac veins, most of which empty into the coronary sinus. This large venous structure is located in the coronary sulcus on the posterior surface of the heart between the left atrium and left ventricle. The coronary sinus empties into the right atrium between the opening of the inferior vena cava and the right atrioventricular orifice.

Coronary arteries

The **right coronary artery** branches from the right aortic sinus of the ascending aorta, passing anterior and to the right between the right auricle and the pulmonary trunk. It then

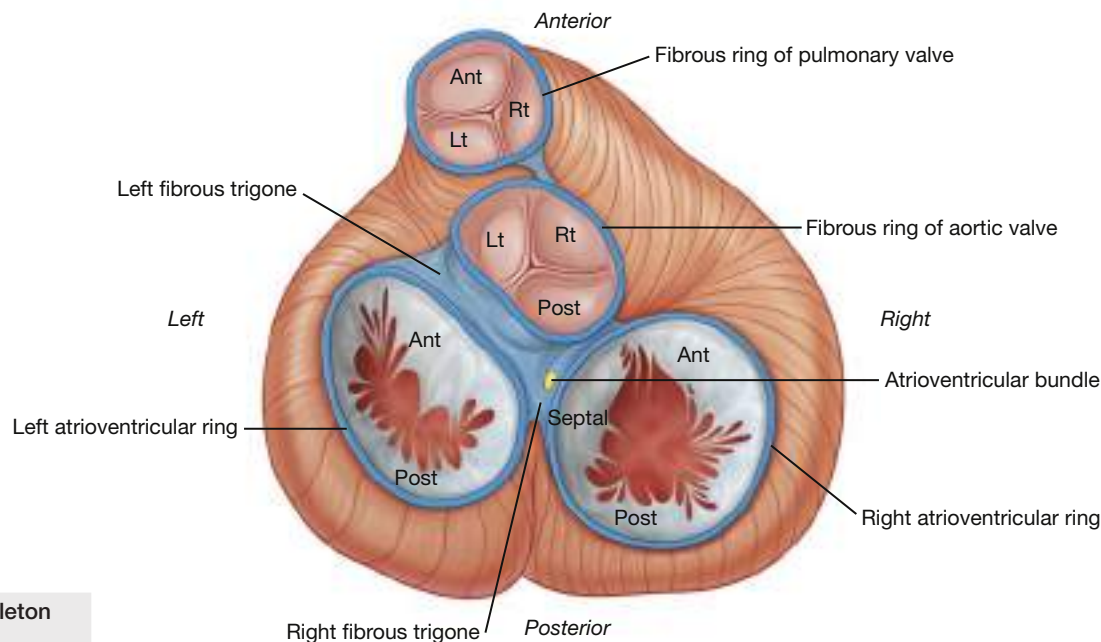


Fig. 3.75 Cardiac skeleton (atria removed).

descends vertically between the right atrium and right ventricle in the coronary sulcus (Fig. 3.76). Reaching the inferior margin of the heart, it turns posteriorly and continues in the sulcus onto the diaphragmatic surface and base of the heart. During this course, the following branches arise:

- an early **atrial branch**, passing between the right auricle and ascending aorta, gives off the **sinu-atrial nodal branch**, which passes posteriorly around the superior vena cava to supply the sinu-atrial node;
- a **right marginal branch** arising as the right coronary artery approaches the inferior (acute) margin of the heart. This branch continues along this border toward the apex of the heart;
- a small branch to the atrioventricular node as the right coronary artery continues on the base/diaphragmatic surface of the heart; and
- the **posterior interventricular branch**, its final branch, which lies in the posterior interventricular sulcus.

The right coronary artery supplies the right atrium and right ventricle, the sinu-atrial and atrioventricular nodes, the interatrial septum, a portion of the left atrium, the posteroinferior one-third of the interventricular septum, and a portion of the posterior part of the left ventricle.

The **left coronary artery** branches from the left aortic sinus of the ascending aorta passing between the pulmonary trunk and the left auricle before entering the coronary sulcus. Posterior to the pulmonary trunk, the artery divides into its two terminal branches, the anterior interventricular and the circumflex (Fig. 3.76).

of the pulmonary trunk and descends obliquely toward the apex of the heart in the anterior interventricular sulcus. During its course, one or two large **diagonal branches** may arise and descend diagonally across the anterior surface of the left ventricle.

- The **circumflex branch** continues to the left in the coronary sulcus and onto the base/diaphragmatic surface of the heart. It usually ends before reaching the posterior interventricular sulcus. A large branch, the **left marginal artery**, usually arises from it and continues across the rounded obtuse margin of the heart.

The left coronary artery supplies most of the left atrium and left ventricle and most of the interventricular septum, including the atrioventricular bundle and its branches.

Variations in the distribution patterns of coronary arteries.

Several major variations in the basic distribution patterns of the coronary arteries occur.

- The distribution pattern described above for both right and left coronary arteries is the most common and consists of a right dominant coronary artery. This means that the posterior interventricular branch arises from the right coronary artery. The right coronary artery therefore supplies a large portion of the posterior wall of the left ventricle, and the circumflex branch of the left coronary artery is relatively small.
- In contrast, in hearts with a left dominant coronary artery, the posterior interventricular branch arises from an enlarged circumflex branch and supplies most of the posterior wall of the left ventricle (Fig. 3.77).
- Another point of variation relates to the arterial supply to the sinu-atrial and atrioventricular nodes. In most

- The **anterior interventricular branch (left anterior descending artery—LAD)** continues around the left side

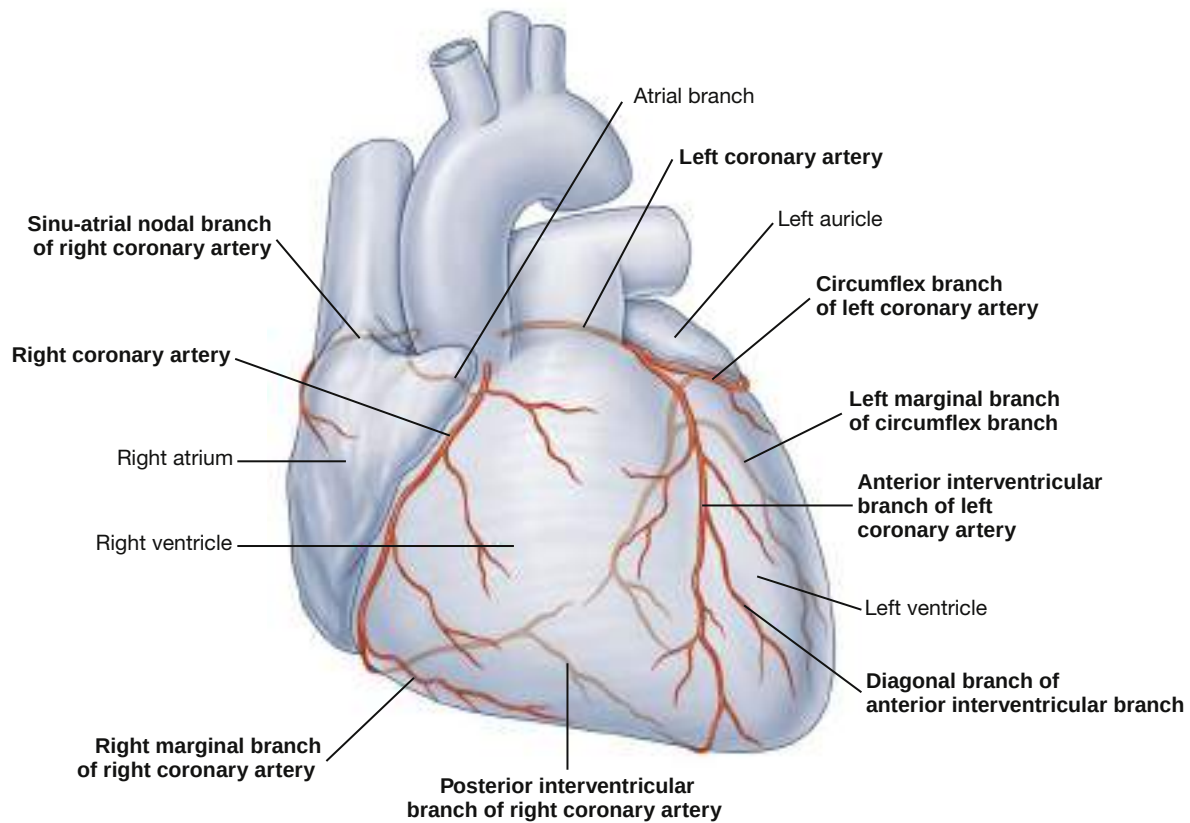


Fig. 3.76 Anterior view of coronary arterial system. Right dominant coronary artery.

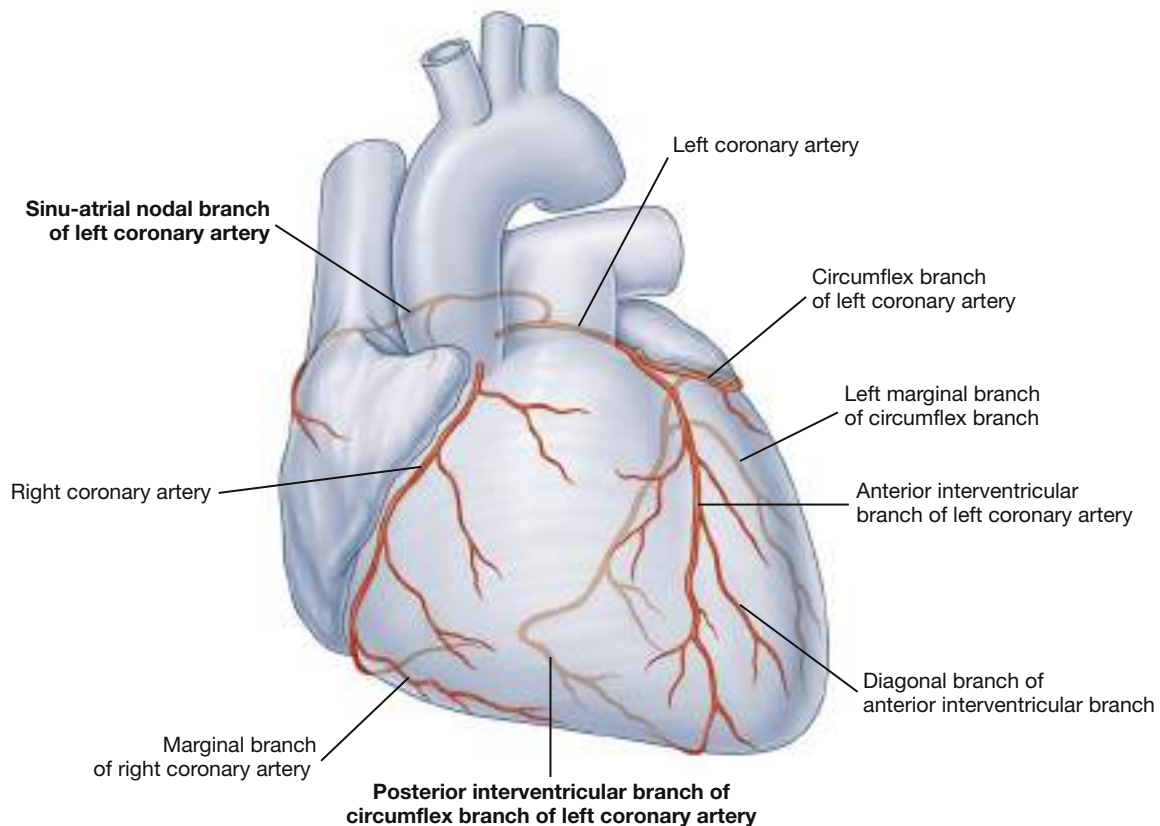


Fig. 3.77 Left dominant coronary artery.

cases, these two structures are supplied by the right coronary artery. However, vessels from the circumflex branch of the left coronary artery occasionally supply these structures.

Clinical app

Clinical terminology for coronary arteries

In practice, physicians use alternative names for the coronary vessels. The short left coronary artery is referred to as the **left main stem vessel**. One of its primary branches, the anterior interventricular artery, is termed the **left anterior descending artery (LAD)**. Similarly, the terminal branch of the right coronary artery, the posterior interventricular artery, is termed the **posterior descending artery (PDA)**.

Cardiac veins

The **coronary sinus** receives four major tributaries: the great, middle, small, and posterior cardiac veins.

The **great cardiac vein** begins at the apex of the heart (Fig. 3.78A) and ascends in the anterior interventricular sulcus where it travels with the anterior interventricular artery. In this location it may be referred to as the **anterior interventricular vein**. At the coronary sulcus, it turns to the left and continues onto the base/diaphragmatic surface of the heart and is associated with the circumflex branch of the left coronary artery. Continuing along its path in the coronary sulcus, the great cardiac vein gradually enlarges becoming the coronary sinus, which enters the right atrium (Fig. 3.78B).

The **middle cardiac vein (posterior interventricular vein)** begins near the apex of the heart and ascends in the posterior interventricular sulcus toward the coronary sinus (Fig. 3.78B). It is associated with the posterior interventricular branch of the right or left coronary artery throughout its course.

The **small cardiac vein** begins in the lower anterior section of the coronary sulcus between the right atrium and right ventricle (Fig. 3.78A). It continues in this groove onto the base/diaphragmatic surface of the heart and enters the coronary sinus at its atrial end. It is a companion of the right coronary artery throughout its course and may receive the **right marginal vein** (Fig. 3.78A). This small vein accompanies the marginal branch of the right coronary artery along the acute margin of the heart. If the right marginal vein does not join the small cardiac vein, it enters the right atrium directly.

The **posterior cardiac vein** lies on the posterior surface of the left ventricle just to the left of the middle cardiac vein

(Fig. 3.78B). It either enters the coronary sinus directly or joins the great cardiac vein.

Other cardiac veins. Two additional groups of cardiac veins are also involved in the venous drainage of the heart.

- The **anterior veins of right ventricle (anterior cardiac veins)** are small veins that arise on the anterior surface of the right ventricle (Fig. 3.78A). They cross the coronary sulcus and enter the anterior wall of the right atrium. They drain the anterior portion of the right ventricle. The right marginal vein may be part of this group if it does not enter the small cardiac vein.
- A group of the smallest cardiac veins (**venae cordis minimae** or **veins of Thebesius**) have also been described. Draining directly into the cardiac chambers, they are numerous in the right atrium and right ventricle, are occasionally associated with the left atrium, and are rarely associated with the left ventricle.

Coronary lymphatics

The lymphatic vessels of the heart follow the coronary arteries and drain mainly into:

- brachiocephalic nodes, anterior to the brachiocephalic veins; and
- tracheobronchial nodes, at the inferior end of the trachea.

Cardiac conduction system

The cardiac conduction system initiates and coordinates contraction of the musculature of the atria and ventricles (Fig. 3.79). It consists of nodes and networks of specialized cardiac muscle cells organized into four basic components:

- the sinu-atrial node,
- the atrioventricular node,
- the atrioventricular bundle with its right and left bundle branches, and
- the subendocardial plexus of conduction cells (the Purkinje fibers).

The unique distribution pattern of the cardiac conduction system is an important unidirectional pathway of excitation/contraction. Throughout its course, large branches of the conduction system are insulated from the surrounding myocardium by connective tissue. This tends to decrease inappropriate stimulation and contraction of cardiac muscle fibers.

Thus a unidirectional wave of excitation and contraction is established, which moves from the papillary muscles and apex of the ventricles to the arterial outflow tracts.

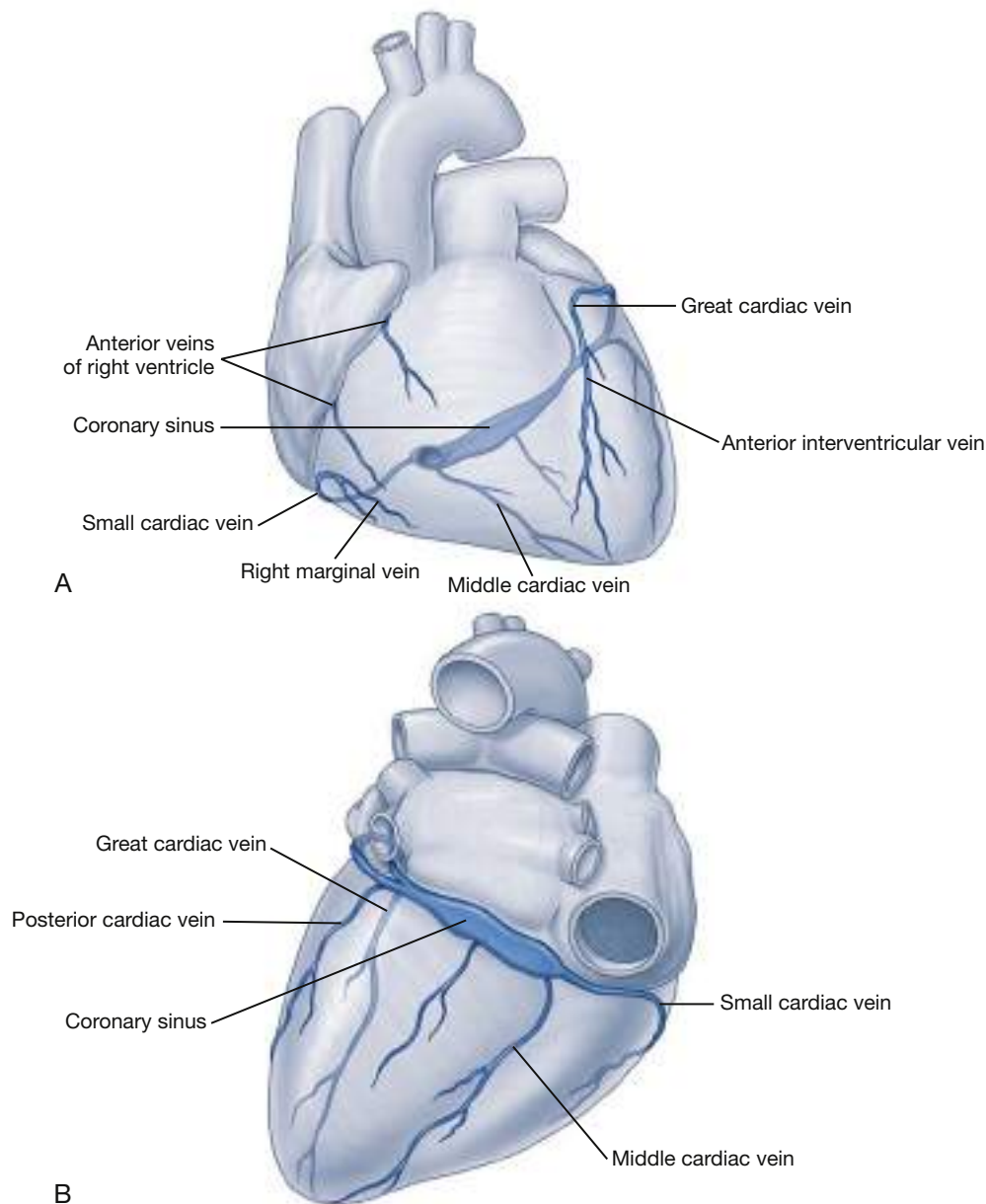


Fig. 3.78 Major cardiac veins. **A.** Anterior view of major cardiac veins. **B.** Posteroinferior view of major cardiac veins.

Clinical app

Cardiac conduction system

The cardiac conduction system can be affected by coronary artery disease. The normal rhythm may be disturbed if the blood supply to the coronary conduction system is disrupted. If a dysrhythmia affects the heart rate or the order in which the chambers contract, heart failure and death may ensue.

Sinu-atrial node

Impulses begin at the **sinu-atrial node**, the cardiac pacemaker. This collection of cells is located at the superior end

of the crista terminalis at the junction of the superior vena cava and the right atrium (Fig. 3.79A). This is also the junction between the parts of the right atrium derived from the embryonic sinus venosus and the atrium proper.

The excitation signals generated by the sinu-atrial node spread across the atria, causing the muscle to contract.

Atrioventricular node

Concurrently, the wave of excitation in the atria stimulates the **atrioventricular node**, which is located near the opening of the coronary sinus, close to the attachment of the septal cusp of the tricuspid valve, and within the atrioventricular septum (Fig. 3.79A).

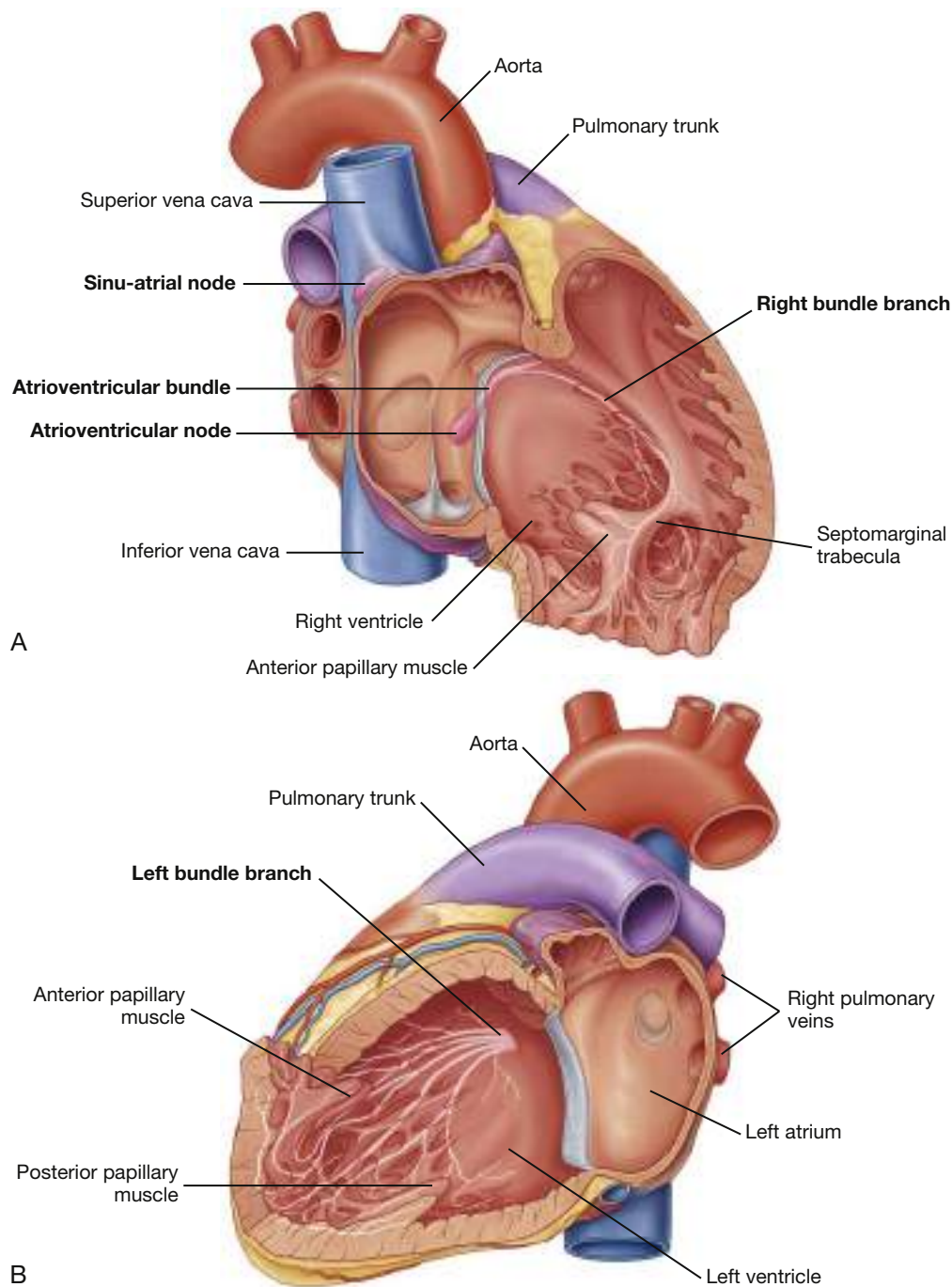


Fig. 3.79 Conduction system of the heart. **A.** Right chambers. **B.** Left chambers.

The atrioventricular node is a collection of specialized cells that form the beginning of an elaborate system of conducting tissue, the atrioventricular bundle, which extends the excitatory impulse to all ventricular musculature.

Atrioventricular bundle

The **atrioventricular bundle** is a direct continuation of the atrioventricular node (Fig. 3.79A). It follows the lower border

of the membranous part of the interventricular septum before splitting into right and left bundles.

The **right bundle branch** continues on the right side of the interventricular septum toward the apex of the right ventricle. From the septum it enters the septomarginal trabecula to reach the base of the anterior papillary muscle. At this point, it divides and is continuous with the final component of the cardiac conduction system, the **subendocardial plexus of ventricular conduction cells (Purkinje fibers)**.

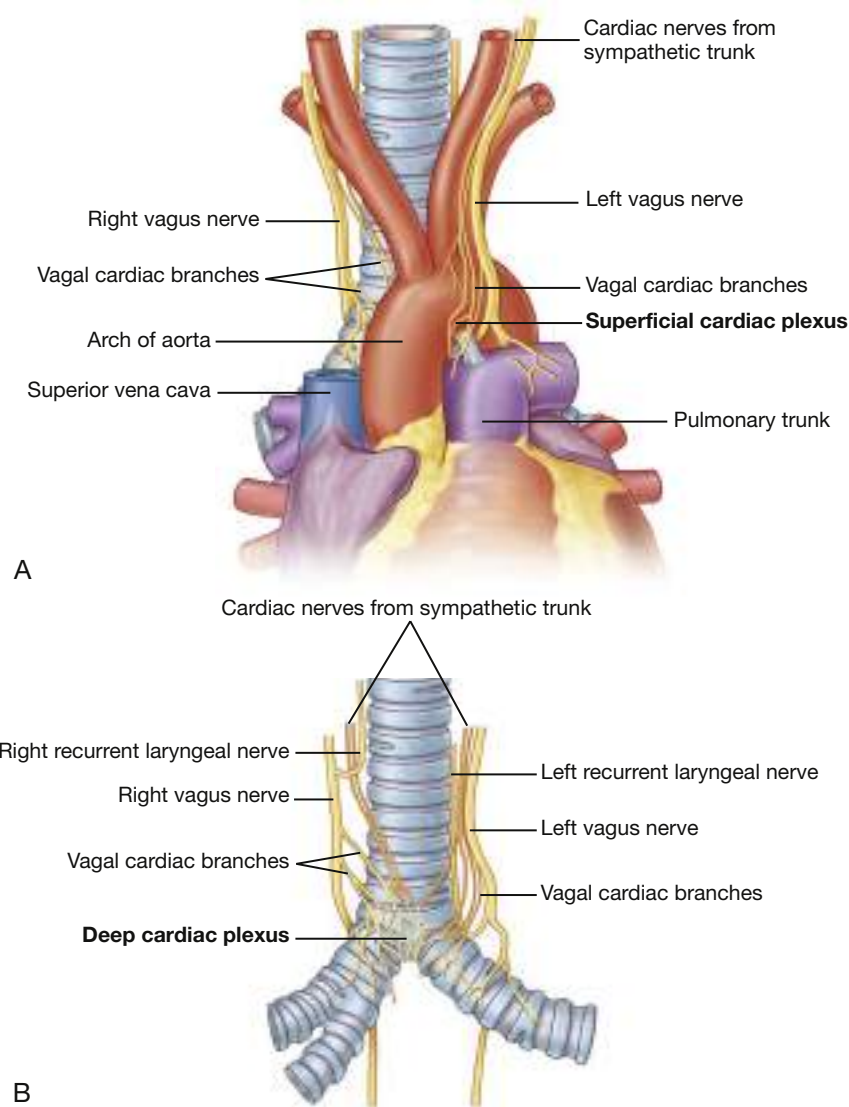


Fig. 3.80 Cardiac plexus. **A.** Superficial. **B.** Deep.

This network of specialized cells spreads throughout the ventricle to supply ventricular musculature including the papillary muscles.

The **left bundle branch** passes to the left side of the muscular interventricular septum and descends to the apex of the left ventricle (Fig. 3.79B). Along its course it gives off branches that eventually become continuous with the **subendocardial plexus of conduction cells (Purkinje fibers)**. As with the right side, this network of specialized cells spreads the excitation impulses throughout the left ventricle.

Cardiac innervation

The autonomic division of the peripheral nervous system is directly responsible for regulating:

- heart rate,
- force of each contraction, and
- cardiac output.

Branches from both the parasympathetic and sympathetic systems contribute to the formation of the **cardiac plexus**. This plexus consists of a **superficial part**, inferior to the aortic arch and between it and the pulmonary trunk (Fig. 3.80A), and a **deep part**, between the aortic arch and the tracheal bifurcation (Fig. 3.80B).

From the cardiac plexus, small branches that are mixed nerves containing both sympathetic and parasympathetic fibers supply the heart. These branches affect nodal tissue and other components of the conduction

system, coronary blood vessels, and atrial and ventricular musculature.

Parasympathetic innervation

Stimulation of the parasympathetic system:

- decreases heart rate,
- reduces force of contraction, and
- constricts the coronary arteries.

The preganglionic parasympathetic fibers reach the heart as cardiac branches from the right and left vagus nerves (Fig. 3.80). They enter the cardiac plexus and synapse in ganglia located either within the plexus or in the walls of the atria.

Sympathetic innervation

Stimulation of the sympathetic system:

- increases heart rate and
- increases the force of contraction.

Sympathetic fibers reach the cardiac plexus through the cardiac nerves from the sympathetic trunk (Fig. 3.80). Preganglionic sympathetic fibers from the upper four or five segments of the thoracic spinal cord enter and move through the sympathetic trunk. They synapse in cervical and upper thoracic sympathetic ganglia, and postganglionic fibers proceed as bilateral branches from the sympathetic trunk to the cardiac plexus.

Visceral afferents

Visceral afferents from the heart are also a component of the cardiac plexus. These fibers pass through the cardiac plexus and return to the central nervous system in the cardiac nerves from the sympathetic trunk and in the vagal cardiac branches.

The afferents associated with the vagal cardiac nerves return to the vagus nerve [X]. They sense alterations in blood pressure and blood chemistry and are therefore primarily concerned with cardiac reflexes.

The afferents associated with the cardiac nerves from the sympathetic trunks return to either the cervical or the thoracic portions of the sympathetic trunk. If they are in the cervical portion of the trunk, they normally descend to the thoracic region where they re-enter the upper four or five thoracic spinal cord segments along with the afferents from the thoracic region of the sympathetic trunk.

Pulmonary trunk

The **pulmonary trunk** is within the pericardial sac (Fig. 3.82A), covered by the visceral layer of serous pericardium

Clinical app

Heart attack

A heart attack occurs when the perfusion to the myocardium is insufficient to meet the metabolic needs of the tissue, leading to irreversible tissue damage. The most common cause is a total occlusion of a major coronary artery.

Coronary artery disease

Occlusion of a major coronary artery, usually due to atherosclerosis, leads to inadequate oxygenation of an area of myocardium and cell death. The severity of the problem will be related to the size and location of the artery involved, whether or not the blockage is complete, and whether there are collateral vessels to provide perfusion to the territory from other vessels. Depending on the severity, patients can develop pain (angina) or a myocardial infarction (MI).

Percutaneous coronary intervention

This is a technique in which a long fine tube (a catheter) is inserted into the femoral artery in the thigh, passed through the external and common iliac arteries and into the abdominal aorta. It continues to be moved upward through the thoracic aorta to the origins of the coronary arteries. The coronaries may also be approached via the radial or brachial arteries. A fine wire is then passed into the coronary artery and is used to cross the stenosis. A fine balloon is then passed over the wire and may be inflated at the level of the obstruction, thus widening it; this is termed *angioplasty*. More commonly, this is augmented by placement of a fine wire mesh (a stent) inside the obstruction to hold it open. Other percutaneous interventions are suction extraction of a coronary thrombus and rotary ablation of a plaque.

Coronary artery bypass grafts

If coronary artery disease is too extensive to be treated by percutaneous intervention, surgical coronary artery bypass grafting may be necessary. The great saphenous vein, in the lower limb, is harvested and used as a graft. It is divided into several pieces, each of which is used to bypass blocked sections of the coronary arteries. The internal thoracic and radial arteries can also be used.

Clinical app

Classic symptoms of heart attack

The typical symptoms are chest heaviness or pressure, which can be severe, lasting more than 20 minutes, and often associated with sweating. The pain in the chest (which may be described as an “elephant sitting on my chest” or by using a clenched fist to describe the pain [Levine sign]) often radiates to the arms (left more common than the right), and can be associated with nausea. The severity of ischemia and infarction depends on the rate at which the occlusion or stenosis has occurred and whether or not collateral channels have had a chance to develop.

Clinical app

Referred pain

When cardiac cells die during an MI, pain fibers (visceral afferents) are stimulated. They detect events at the cellular level as tissue-damaging events (i.e., cardiac ischemia). These visceral sensory fibers follow the course of sympathetic fibers that innervate the heart and enter the spinal cord between T1 and T4 spinal levels. At this level, somatic sensory fibers from spinal nerves T1 to T4 also enter the spinal cord via the posterior roots. Both types of fibers (visceral and somatic) synapse with interneurons, which then synapse with second neurons whose fibers pass across the cord and then ascend to the somatosensory areas of the brain that represent the T1 to T4

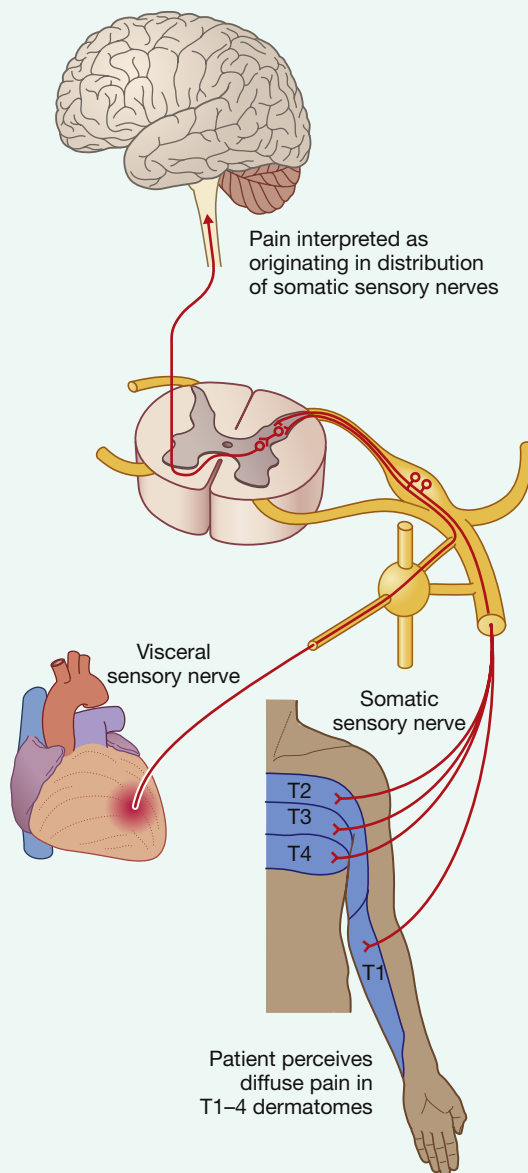


Fig. 3.81 Mechanism for perceiving heart pain in T1–T4 dermatomes.

Clinical app—cont'd

levels. The brain is unable to distinguish clearly between the visceral sensory distribution and the somatic sensory distribution, and therefore the pain is interpreted as arising from the somatic regions rather than the visceral organ (i.e., the heart; [Fig. 3.81](#)).

Clinical app

Are heart attack symptoms the same in men and women?

Although men and women can experience the typical symptoms of severe chest pain, cold sweats, and pain in the left arm, women are more likely than men to have subtler, less recognizable symptoms. These may include abdominal pain, achiness in the jaw or back, nausea, shortness of breath and/or simply fatigue. The mechanism of this difference is not understood, but it is important to consider cardiac ischemia for a wide range of symptoms.

and enclosed in a common sheath with the ascending aorta. Arising from the conus arteriosus of the right ventricle, it is slightly anterior to the aortic orifice and ascends, moving posteriorly and to the left, lying initially anterior and then to the left of the ascending aorta. At approximately the level of the intervertebral disc between vertebrae TV and TVI opposite the left border of the sternum and posterior to the third left costal cartilage, the pulmonary trunk divides into:

- the right pulmonary artery, which passes to the right, posterior to the ascending aorta and the superior vena cava, to enter the right lung ([Fig. 3.82B](#)); and
- the left pulmonary artery, which passes inferiorly to the arch of the aorta and anteriorly to the descending aorta to enter the left lung ([Fig. 3.82A,B](#)).

Ascending aorta

The **ascending aorta** is within the pericardial sac and covered by a visceral layer of serous pericardium, which also surrounds the pulmonary trunk in a common sheath ([Fig. 3.82A](#)).

The origin of the ascending aorta is the aortic orifice at the base of the left ventricle, which is level with the lower edge of the third left costal cartilage and posterior to the left half of the sternum. Moving superiorly, slightly forward, and to the right, the ascending aorta continues to the level of the second right costal cartilage. At this point, it enters the superior mediastinum and is then referred to as the **arch of the aorta**.

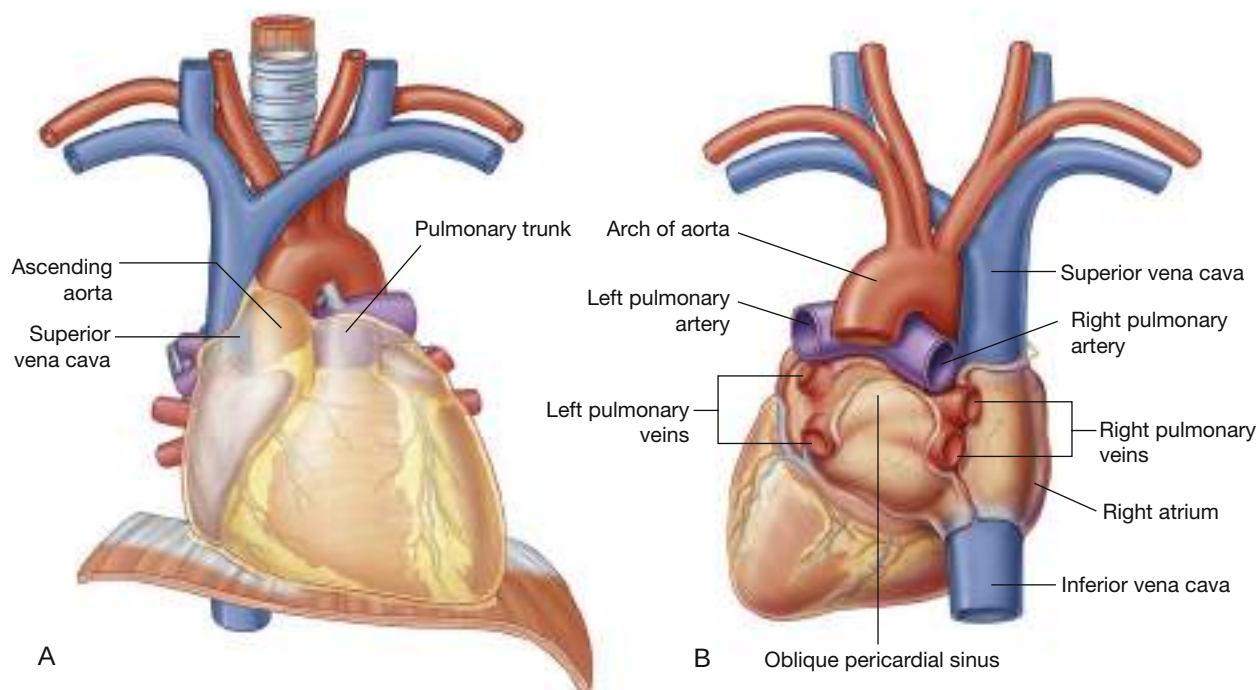


Fig. 3.82 Major vessels within the middle mediastinum. **A.** Anterior view. **B.** Posterior view.

Immediately superior to the point where the ascending aorta arises from the left ventricle are three small outward bulges opposite the semilunar cusps of the aortic valve. These are the posterior, right, and left aortic sinuses. The right and left coronary arteries originate from the right and left aortic sinuses, respectively.

Other vasculature

Passing through the fibrous pericardium at approximately the level of the second costal cartilage, the inferior half of the **superior vena cava** is within the pericardial sac (Fig. 3.82B). It enters the right atrium at the lower level of the third costal cartilage. The portion within the pericardial sac is covered with serous pericardium except for a small area on its posterior surface.

After passing through the diaphragm at approximately the level of vertebra TVIII, the **inferior vena cava** enters the fibrous pericardium. A short portion of this vessel is within the pericardial sac before entering the right atrium. While within the pericardial sac, it is covered by serous pericardium except for a small portion of its posterior surface (Fig. 3.82B).

A very short segment of each of the pulmonary veins is also within the pericardial sac. These veins, usually two from each lung, pass through the fibrous pericardium and enter the superior region of the left atrium on its posterior surface. In the pericardial sac, all but a portion of the posterior surface of these veins is covered by serous pericardium.

In addition, the **oblique pericardial sinus** is between the right and left pulmonary veins within the pericardial sac (Fig. 3.82B).

Superior mediastinum

Posterior to the manubrium of the sternum and anterior to the bodies of the first four thoracic vertebrae is the **superior mediastinum** (see Fig. 3.53).

- Superior border—an oblique plane passing from the jugular notch upward and posteriorly to the superior border of vertebra T1.
- Inferior border—a transverse plane passing from the sternal angle to the intervertebral disc between vertebra TIV/V separates it from the inferior mediastinum.
- Lateral borders—the mediastinal part of the parietal pleura on either side.

The superior mediastinum is continuous with the neck superiorly and with the inferior mediastinum inferiorly.

Major structures found in the superior mediastinum (Figs. 3.83, 3.84) include the:

- thymus,
- right and left brachiocephalic veins,
- left superior intercostal vein,
- superior vena cava,

- arch of the aorta with its three large branches,
- trachea,
- esophagus,
- phrenic nerves,
- vagus nerves,
- left recurrent laryngeal branch of the left vagus nerve,
- thoracic duct, and
- other small nerves, blood vessels, and lymphatics.

Thymus

Lying immediately posterior to the manubrium of the sternum, the thymus, asymmetric and bilobed, is the most anterior component of the superior mediastinum (Fig. 3.85).

The upper extent of the thymus can reach into the neck as high as the thyroid gland, and a lower portion typically extends into the anterior mediastinum over the pericardial sac.

Involved in the early development of the immune system, the thymus is a large structure in the child that begins to atrophy after puberty and shows considerable size variation in the adult. In the elderly adult, it is barely identifiable as an organ, consisting mostly of fatty tissue that is sometimes arranged as two lobulated fatty structures.

Arteries to the thymus are small branches from the internal thoracic arteries. Venous drainage is usually into the left brachiocephalic vein and possibly into the internal thoracic veins.

Lymphatic drainage returns to multiple groups of nodes at one or more of the following locations:

- along the internal thoracic arteries (parasternal),
- at the tracheal bifurcation (tracheobronchial), and
- in the root of the neck.

Clinical app

Ectopic parathyroid glands in the thymus

The parathyroid glands develop from the third pharyngeal pouch, which also forms the thymus. The thymus is therefore a common site for ectopic parathyroid glands and, potentially, ectopic parathyroid hormone production.

Right and left brachiocephalic veins

The **left and right brachiocephalic veins** are located immediately posterior to the thymus and form on each side at the junction between the internal jugular and subclavian veins (see Fig. 3.83). The left brachiocephalic vein crosses the midline and joins with the right brachiocephalic vein to form the superior vena cava (Fig. 3.86).

- The **right brachiocephalic vein** begins posterior to the medial end of the right clavicle and passes vertically downward, forming the superior vena cava when it is joined by the left brachiocephalic vein (Fig. 3.83). Venous tributaries include the vertebral, first posterior intercostal, and internal thoracic veins. The inferior thyroid and thymic veins may also drain into it.
- The **left brachiocephalic vein** begins posterior to the medial end of the left clavicle (Fig. 3.83). It crosses to the right, moving in a slightly inferior direction, and joins with the right brachiocephalic vein to form the superior vena cava posterior to the lower edge of the right first costal cartilage close to the right sternal border. Venous tributaries include the vertebral, first posterior intercostal, left superior intercostal, inferior thyroid, and internal thoracic veins. It may also receive thymic and pericardial veins.

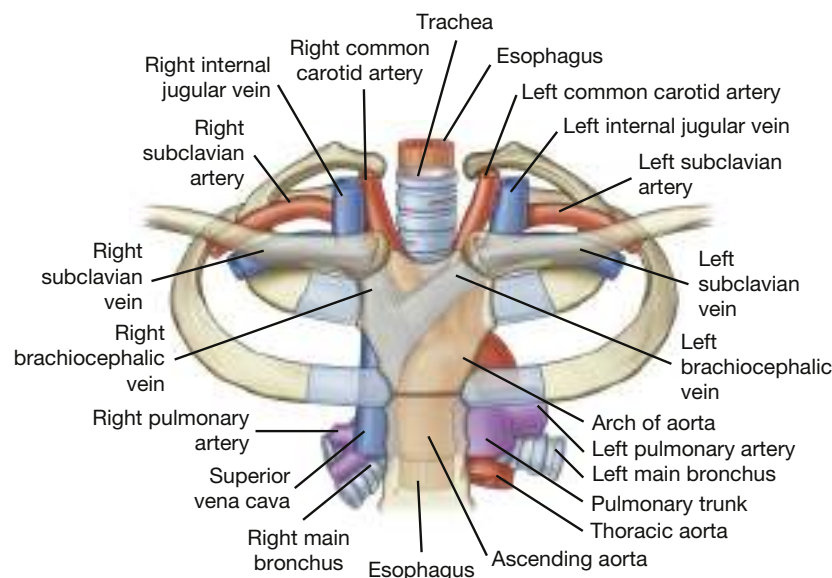


Fig. 3.83 Structures in the superior mediastinum.

Imaging app

Visualizing structures in the superior mediastinum

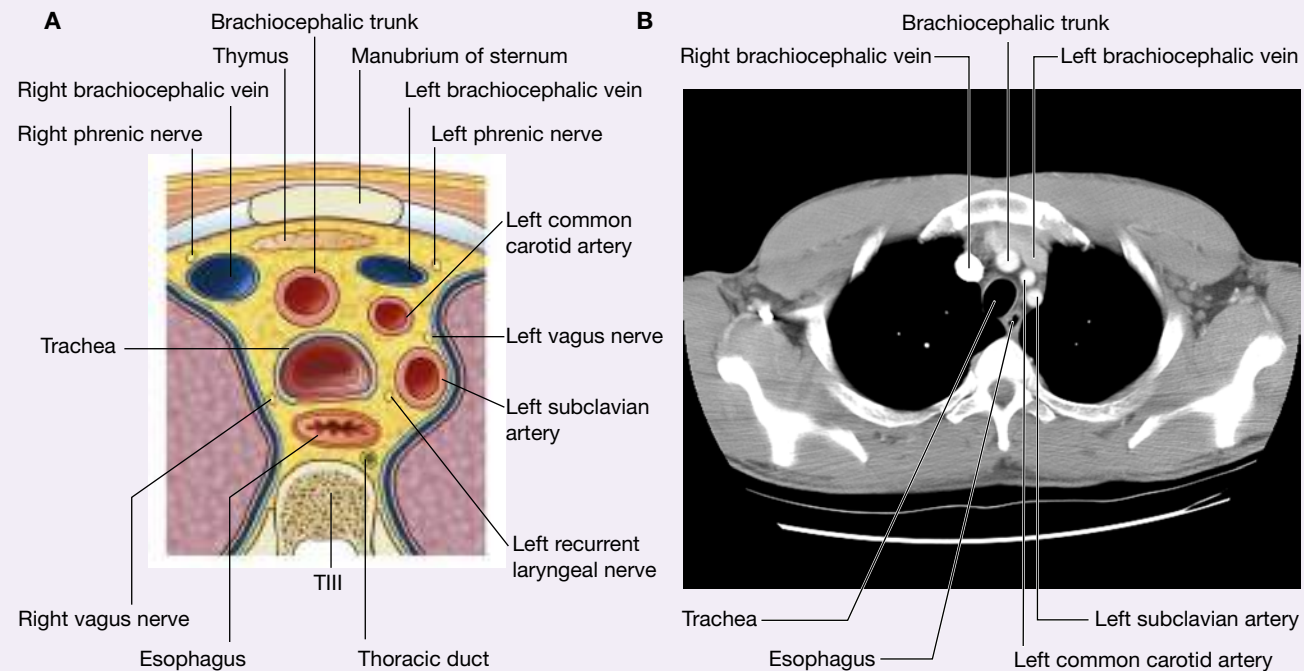


Fig. 3.84 Cross-section through the superior mediastinum at the level of vertebra TIII. **A.** Diagram. **B.** Axial computed tomography image.

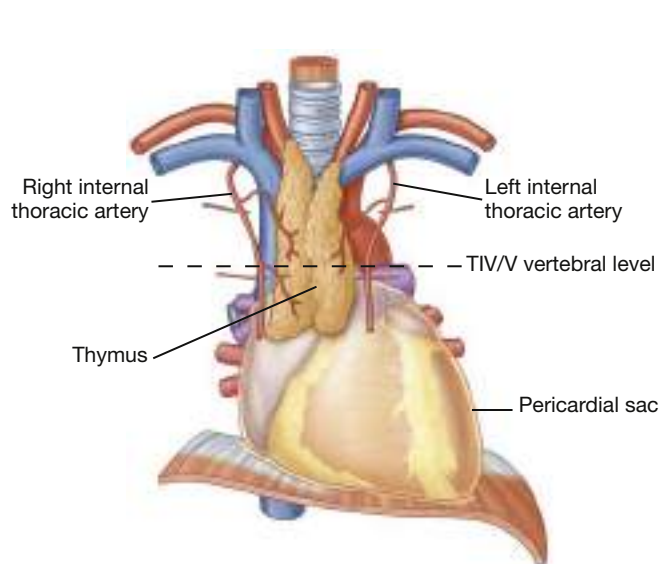


Fig. 3.85 Thymus.

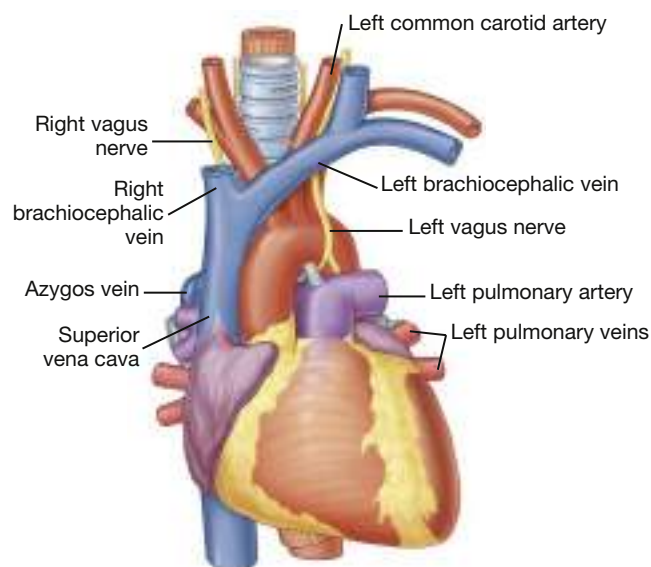


Fig. 3.86 Superior mediastinum with thymus removed.

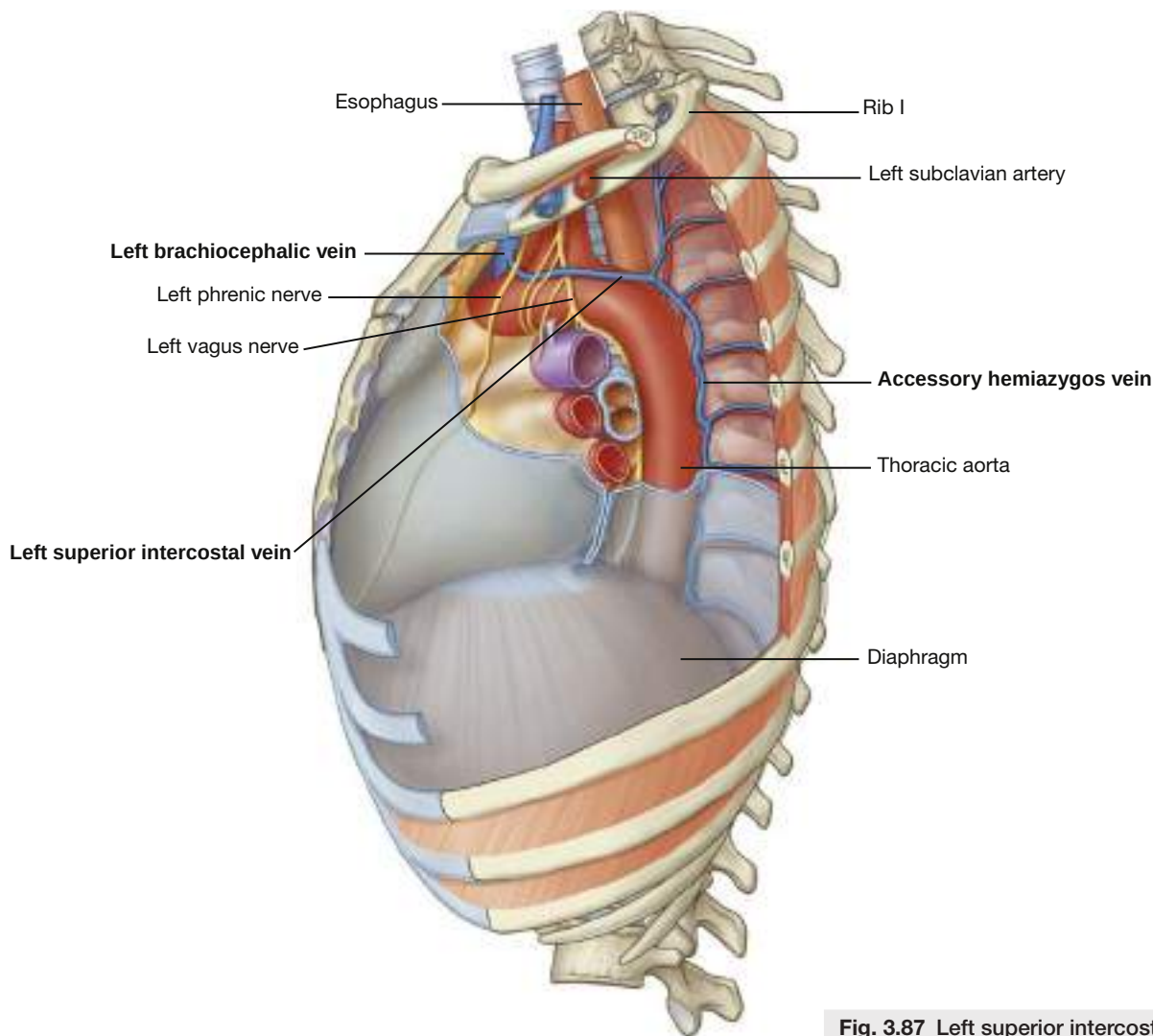


Fig. 3.87 Left superior intercostal vein.

Clinical app

Left brachiocephalic vein

The left brachiocephalic vein crosses the midline posterior to the manubrium in the adult. In infants and children, the left brachiocephalic vein rises above the superior border of the manubrium and therefore is less protected.

Left superior intercostal vein

The **left superior intercostal vein** receives the second, third, and sometimes the left fourth posterior intercostal veins, usually the left bronchial veins, and sometimes the left pericardiophrenic vein. It passes over the left side of the aortic arch, lateral to the left vagus nerve and medial to the left phrenic nerve, before entering the left brachiocephalic vein

(Fig. 3.87). Inferiorly, it may connect with the **accessory hemiazygos vein (superior hemiazygos vein)**. The left first intercostal vein drains directly into the left brachiocephalic vein or into the left vertebral vein.

Superior vena cava

The vertically oriented **superior vena cava** begins posterior to the lower edge of the right first costal cartilage where the right and left brachiocephalic veins join and terminates at the lower edge of the right third costal cartilage where it joins the right atrium (see Fig. 3.83).

The lower half of the superior vena cava is within the pericardial sac and contained in the middle mediastinum.

The superior vena cava receives the azygos vein immediately before entering the pericardial sac and may also receive pericardial and mediastinal veins.

Arch of aorta and its branches

The thoracic portion of the aorta can be divided into **ascending aorta**, **arch of aorta**, and **thoracic (descending) aorta**. Only the arch of the aorta is in the superior mediastinum. It begins when the ascending aorta emerges from the

pericardial sac and courses upward, backward, and to the left as it passes through the superior mediastinum, ending on the left side at vertebral level TIV/V. Extending as high as the midlevel of the manubrium of sternum, the arch is initially anterior and finally lateral to the trachea (Figs. 3.88, 3.89).

Clinical app

Venous access for central and dialysis lines

Large systemic veins are used to establish central venous access for administering large amounts of fluid, drugs, and blood. Most of these lines (small bore tubes) are introduced through venous puncture into the axillary, subclavian, or internal jugular veins. The lines are then passed through the main veins of the superior mediastinum, with the tips of the lines usually residing in the distal portion of the superior vena cava or in the right atrium.

Similar devices, such as dialysis lines, are inserted into patients who have renal failure, so that a large volume of blood can be aspirated through one channel and re-infused through a second channel.

Clinical app

Using the superior vena cava to access the inferior vena cava

Because the superior and inferior vena cava are oriented along the same vertical axis, a guide-wire, catheter, or line can be passed from the superior vena cava through the right atrium and into the inferior vena cava. This is a common route of access for such procedures as:

- transjugular liver biopsy,
- transjugular intrahepatic portosystemic shunts (TIPS), and
- insertion of an inferior vena cava filter to catch emboli dislodged from veins in the lower limb and pelvis (i.e., patients with deep vein thrombosis [DVT]).

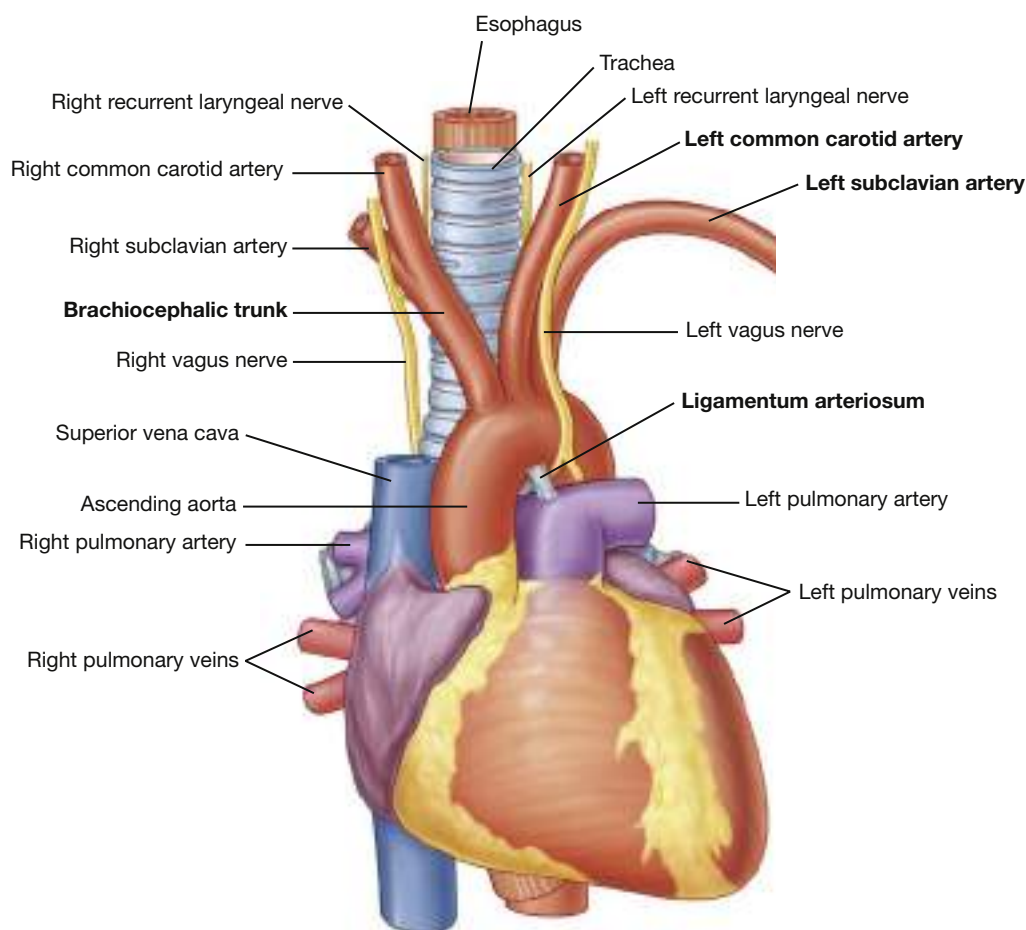


Fig. 3.88 Superior mediastinum with thymus and venous channels removed.

Three branches arise from the superior border of the arch of the aorta and, at their origins, all three are crossed anteriorly by the left brachiocephalic vein.

The first branch

Beginning on the right, the first branch of the arch of aorta is the **brachiocephalic trunk** (Fig. 3.88). It is the largest of the three branches and, at its point of origin behind the manubrium of sternum, is slightly anterior to the other two branches. It ascends slightly posteriorly and to the right. At the level of the upper edge of the right sternoclavicular joint, the brachiocephalic trunk divides into:

- the **right common carotid artery** and
- the **right subclavian artery**.

The arteries mainly supply the right side of the head and neck and the right upper limb, respectively.

Occasionally, the brachiocephalic trunk has a small branch, the **thyroid ima artery**, which contributes to the vascular supply of the thyroid gland.

The second branch

The second branch of the arch of aorta is the **left common carotid artery** (Fig. 3.88). It arises from the arch immediately to the left and slightly posterior to the brachiocephalic trunk and ascends through the superior mediastinum along the left side of the trachea.

The left common carotid artery supplies the left side of the head and neck.

The third branch

The third branch of the arch of the aorta is the **left subclavian artery** (Fig. 3.88). It arises from the arch of aorta immediately to the left of, and slightly posterior to, the left common carotid artery and ascends through the superior mediastinum along the left side of the trachea.

The left subclavian artery is the major blood supply to the left upper limb.

Ligamentum arteriosum

The **ligamentum arteriosum** is also in the superior mediastinum and is important in embryonic circulation, when it is a patent vessel (the **ductus arteriosus**). It connects the pulmonary trunk with the arch of aorta and allows blood to bypass the lungs during development (Fig. 3.88). The vessel closes soon after birth and forms the ligamentous connection observed in the adult.

Trachea and esophagus

The **trachea** is a midline structure that is palpable in the jugular notch as it enters the superior mediastinum.

Clinical app

Coarctation of the aorta

Coarctation of the aorta is a congenital abnormality in which the aortic lumen is constricted just distal to the origin of the left subclavian artery. At this point, the aorta becomes significantly narrowed and the blood supply to the lower limbs and abdomen is diminished. Over time, collateral vessels develop around the chest wall and abdomen to supply the lower body. The coarctation also affects the heart, which has to pump the blood at higher pressure to maintain peripheral perfusion. This in turn may produce cardiac failure.

Clinical app

Traumatic injury to the aorta

The aorta has three fixed points of attachment:

- the aortic valve,
- the ligamentum arteriosum, and
- the point of entry behind the crura of the diaphragm.

A serious deceleration injury (e.g., in a traffic accident) is most likely to cause aortic trauma at these fixed points. The rest of the aorta is relatively free from attachment to other structures of the mediastinum and is less likely to be injured.

Posterior to it is the **esophagus**, which is immediately anterior to the vertebral column (Fig. 3.89; also see Fig. 3.83). Significant mobility exists in the vertical positioning of these structures as they pass through the superior mediastinum.

As the trachea and esophagus pass through the superior mediastinum, they are crossed laterally by the azygos vein on the right side and the arch of aorta on the left side.

The trachea divides into the right and left main bronchi at, or just inferior to, the transverse plane between the sternal angle and vertebral level TIV/V (Fig. 3.90), whereas the esophagus continues into the posterior mediastinum.

Nerves of the superior mediastinum

Vagus nerves

The **vagus nerves** [X] pass through the superior and posterior divisions of the mediastinum on their way to the abdominal cavity. As they pass through the thorax, they provide parasympathetic innervation to the thoracic viscera and carry visceral afferents from the thoracic viscera.

Visceral afferents in the vagus nerves relay information to the central nervous system about normal physiological processes and reflex activities. They do not transmit pain sensation.

Imaging app

Visualizing structures at the TIV vertebral level

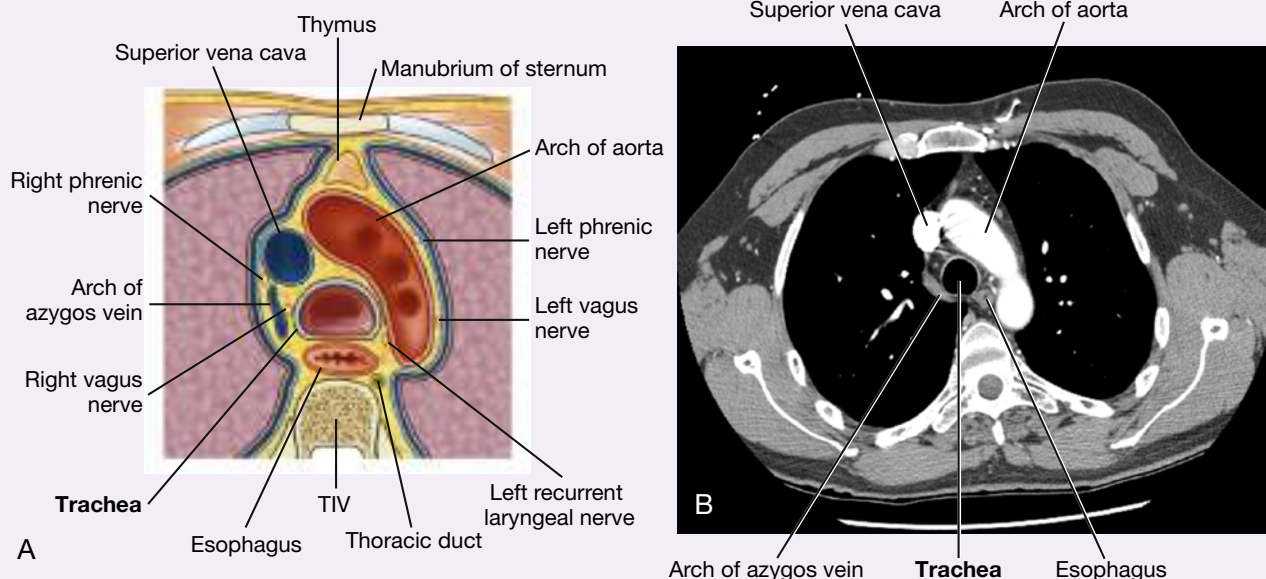


Fig. 3.89 Cross-section through the superior mediastinum at the level of vertebra TIV. **A.** Diagram. **B.** Axial computed tomography image.

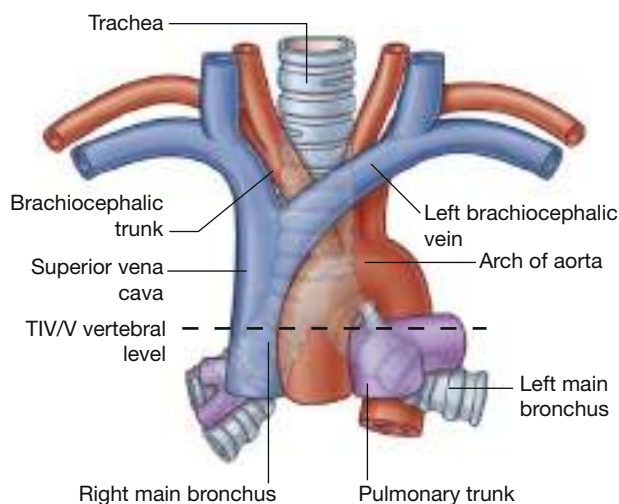


Fig. 3.90 Trachea in the superior mediastinum.

Right vagus nerve

The **right vagus nerve** enters the superior mediastinum between the right brachiocephalic vein and the brachiocephalic trunk. It descends in a posterior direction toward the trachea (Fig. 3.91), crosses the lateral surface of the trachea, and passes posteriorly to the root of the right lung to reach the esophagus. Just before the esophagus, it is crossed by the arch of the azygos vein.

Clinical app

Aortic dissection

In certain conditions, such as in severe arteriovascular disease, the wall of the aorta can split longitudinally, creating a false channel, which may or may not rejoin into the true lumen distally. This aortic dissection occurs between the intima and media anywhere along its length. If it occurs in the ascending aorta or arch of the aorta, blood flow in the coronary and cerebral arteries may be disrupted, resulting in MI or stroke. In the abdomen the visceral vessels may be disrupted, producing ischemia to the gut or kidneys.

Clinical app

Aortic arch and its anomalies

A right-sided arch of aorta occasionally occurs and may be asymptomatic. It can be associated with **dextrocardia** (right-sided heart) and, in some instances, with complete **situs inversus** (left-to-right inversion of the body's organs). It can also be associated with abnormal branching of the great vessels.

Clinical app

Abnormal origin of great vessels

Great vessels occasionally have an abnormal origin, including:

- a common origin of the brachiocephalic trunk and the left common carotid artery,
- the left vertebral artery originating from the aortic arch, and
- the right subclavian artery originating from the distal portion of the aortic arch and passing behind the esophagus to supply the right arm—as a result, the great vessels form a vascular ring around the trachea and the esophagus, which can potentially produce difficulty swallowing.

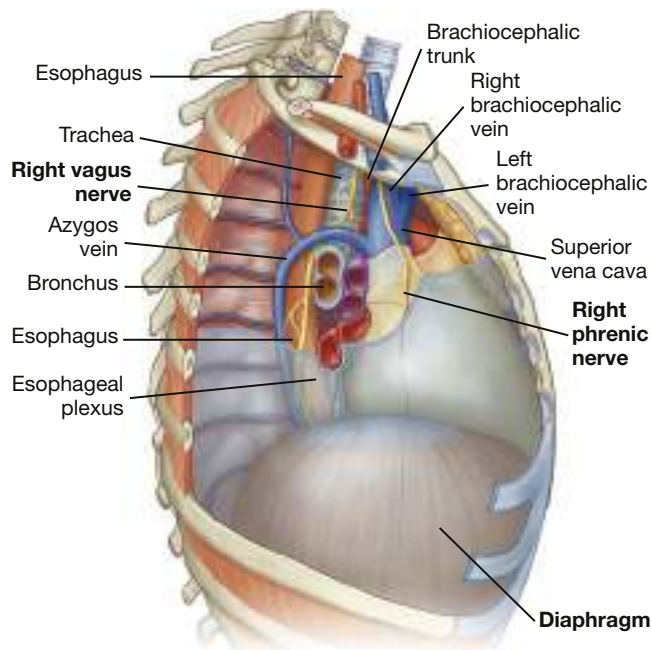


Fig. 3.91 Right vagus nerve passing through the superior mediastinum.

As it passes through the superior mediastinum, branches are given off to the esophagus, cardiac plexus, and pulmonary plexus.

Left vagus nerve

The **left vagus nerve** enters the superior mediastinum posterior to the left brachiocephalic vein between the left common carotid and left subclavian arteries (Fig. 3.92). It passes into the superior mediastinum just deep to the mediastinal part of the parietal pleura and crosses the left side of the arch of aorta. It descends in a posterior direction and passes posterior to the root of the left lung to reach the esophagus in the posterior mediastinum.

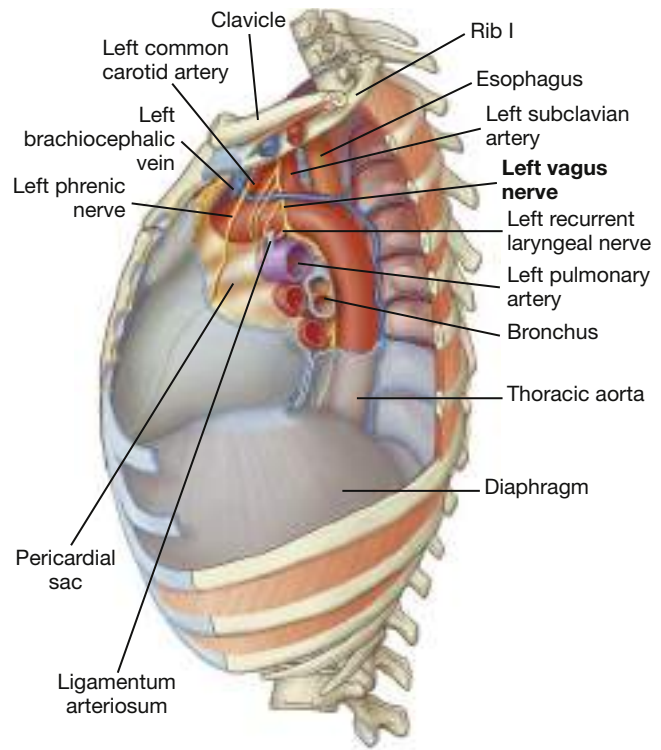


Fig. 3.92 Left vagus nerve passing through the superior mediastinum.

As the left vagus nerve passes through the superior mediastinum, branches go to the esophagus, cardiac plexus, and pulmonary plexus.

The left vagus nerve also gives rise to the **left recurrent laryngeal nerve**, which arises at the inferior margin of the arch of aorta just lateral to the ligamentum arteriosum (Fig. 3.92). The left recurrent laryngeal nerve passes inferior to the arch of aorta before ascending on its medial surface. Entering a groove between the trachea and esophagus, the left recurrent laryngeal nerve continues superiorly to enter the neck and terminate in the larynx (Fig. 3.93).

Phrenic nerves

The phrenic nerves arise in the cervical region from the third, fourth, and fifth cervical spinal cord segments. They descend through the thorax to supply motor and sensory innervation to the diaphragm and its associated membranes. As they pass through the thorax, they provide innervation through somatic afferent fibers to the mediastinal pleura, fibrous pericardium, and parietal layer of the serous pericardium.

Right phrenic nerve

The **right phrenic nerve** enters the superior mediastinum lateral to the right vagus nerve and lateral and slightly posterior to the beginning of the right brachiocephalic vein (see

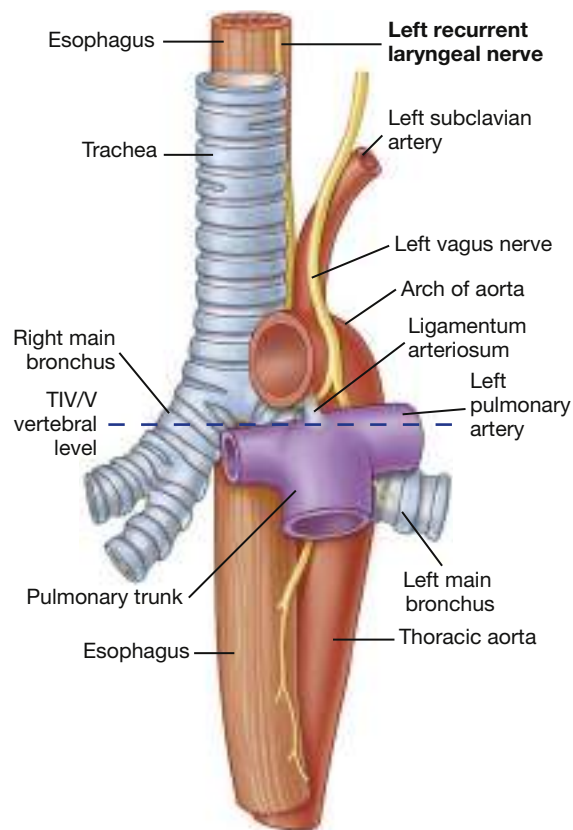


Fig. 3.93 Left recurrent laryngeal nerve passing through the superior mediastinum.

Fig. 3.91). It continues inferiorly along the right side of this vein and the superior vena cava.

On entering the middle mediastinum, the right phrenic nerve descends along the right side of the pericardial sac within the fibrous pericardium, anterior to the root of the right lung. The pericardiophrenic vessels accompany it through most of its course in the thorax (see Fig. 3.55). It leaves the thorax by passing through the diaphragm with the inferior vena cava.

Left phrenic nerve

The **left phrenic nerve** enters the superior mediastinum in a position similar to the path taken by the right phrenic nerve. It lies lateral to the left vagus nerve and lateral and slightly posterior to the beginning of the left brachiocephalic vein (Fig. 3.92) and continues to descend across the left lateral surface of the arch of aorta, passing superficially to the left vagus nerve and the left superior intercostal vein.

On entering the middle mediastinum, the left phrenic nerve follows the left side of the pericardial sac within the fibrous pericardium, anterior to the root of the left lung, and is accompanied by the pericardiophrenic vessels (see Fig. 3.55). It leaves the thorax by piercing the diaphragm near the apex of the heart.

Surface anatomy

Visualizing structures in the superior mediastinum

A number of structures in the superior mediastinum in adults can be visualized based on their positions relative to skeletal landmarks that can be palpated through the skin (Fig. 3.94).

- On each side, the internal jugular and subclavian veins join to form the brachiocephalic veins behind the sternal ends of the clavicles near the sternoclavicular joints.
- The left brachiocephalic vein crosses from left to right behind the manubrium of sternum.
- The brachiocephalic veins unite to form the superior vena cava behind the lower border of the costal cartilage of the right first rib.
- The arch of aorta begins and ends at the transverse plane between the sternal angle anteriorly and vertebral level TIV/V posteriorly. The arch may reach as high as the midlevel of the manubrium of sternum.

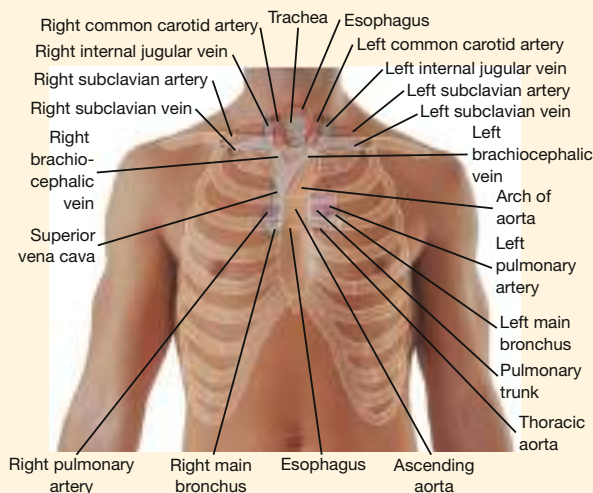


Fig. 3.94 Anterior view of the chest wall of a man showing the locations of different structures in the superior mediastinum as they relate to the skeleton.

Clinical app

The vagus nerves, recurrent laryngeal nerves, and hoarseness

The left recurrent laryngeal nerve is a branch of the left vagus nerve. It passes between the pulmonary artery and the aorta, a region known clinically as the **aortopulmonary window**, and may be compressed in any patient with a pathological mass in this region. This compression results in left vocal cord paralysis and hoarseness of the voice. Lymph node enlargement, often

Clinical app—cont'd

associated with the spread of lung cancer, is a common condition that may produce compression. Chest radiography is therefore usually carried out for all patients whose symptoms include a hoarse voice.

More superiorly, the right vagus nerve gives off the right recurrent laryngeal nerve, which “hooks” around the right subclavian artery at the superior sulcus of the right lung. If a patient has a hoarse voice and a right vocal cord palsy is demonstrated with a laryngoscopy, a chest CT should be obtained to assess for cancer in the right lung apex (**Pancoast's tumor**).

Thoracic duct in the superior mediastinum

The **thoracic duct**, the major lymphatic vessel in the body, passes through the posterior portion of the superior mediastinum (see Figs. 3.84A, 3.89A). It:

- enters the superior mediastinum inferiorly, slightly to the left of the midline, having moved to this position just before leaving the posterior mediastinum opposite vertebral level TIV/V; and
- continues through the superior mediastinum, posterior to the arch of aorta, and the initial portion of the left subclavian artery between the esophagus and the left mediastinal part of the parietal pleura.

Posterior mediastinum

The **posterior mediastinum** is posterior to the pericardial sac and diaphragm and anterior to the bodies of the mid and lower thoracic vertebrae (see Fig. 3.53).

- Its superior boundary is a transverse plane from the sternal angle to the TIV and TV intervertebral disc.
- Its inferior boundary is the diaphragm.
- Laterally, it is bordered by the mediastinal part of parietal pleura on either side.
- Superiorly, it is continuous with the superior mediastinum.

Major structures in the posterior mediastinum include the:

- esophagus and its associated nerve plexus,
- thoracic aorta and its branches,
- azygos system of veins,
- thoracic duct and associated lymph nodes,
- sympathetic trunks, and
- thoracic splanchnic nerves.

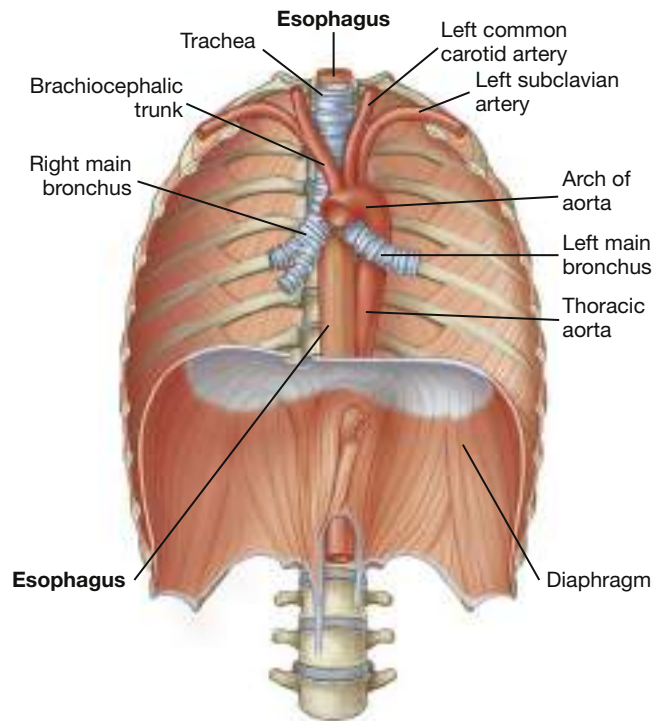


Fig. 3.95 Esophagus.

Esophagus

The **esophagus** is a muscular tube passing between the pharynx in the neck and the stomach in the abdomen. It begins at the inferior border of the cricoid cartilage opposite vertebra CVI and ends at the cardiac opening of the stomach opposite vertebra TXI.

The esophagus descends on the anterior aspect of the bodies of the vertebrae generally in a midline position as it moves through the thorax (Fig. 3.95). As it approaches the diaphragm, it moves anteriorly and to the left, crossing from the right side of the thoracic aorta to a position anterior to it. It passes through the esophageal hiatus, an opening in the muscular part of the diaphragm, at vertebral level TX.

The esophagus has a slight anterior-to-posterior curvature that parallels the thoracic portion of the vertebral column and is secured superiorly in the neck by its attachment to the pharynx and inferiorly in the thorax by its attachment to the diaphragm.

Relationships to important structures in the posterior mediastinum

In the posterior mediastinum, the right side of the esophagus is covered by the mediastinal part of the parietal pleura.

Posterior to the esophagus, the thoracic duct is on the right side inferiorly but crosses to the left more superiorly. Also on the left side of the esophagus is the thoracic aorta.

Clinical app

Esophagus constrictions

The esophagus is a flexible, muscular tube that can be compressed or narrowed by surrounding structures at four locations (Fig. 3.96):

- in the junction of the esophagus with the pharynx in the neck,
- in the superior mediastinum where the esophagus is crossed by the arch of aorta,
- in the posterior mediastinum where the esophagus is compressed by the left main bronchus, and
- in the posterior mediastinum at the esophageal hiatus in the diaphragm.

These constrictions have important clinical consequences. For example, a swallowed object is most likely to lodge at a constricted area. An ingested corrosive substance would move more slowly through a narrowed region, causing more damage at this site than elsewhere along the esophagus. Also, constrictions present problems during the passage of medical instruments.

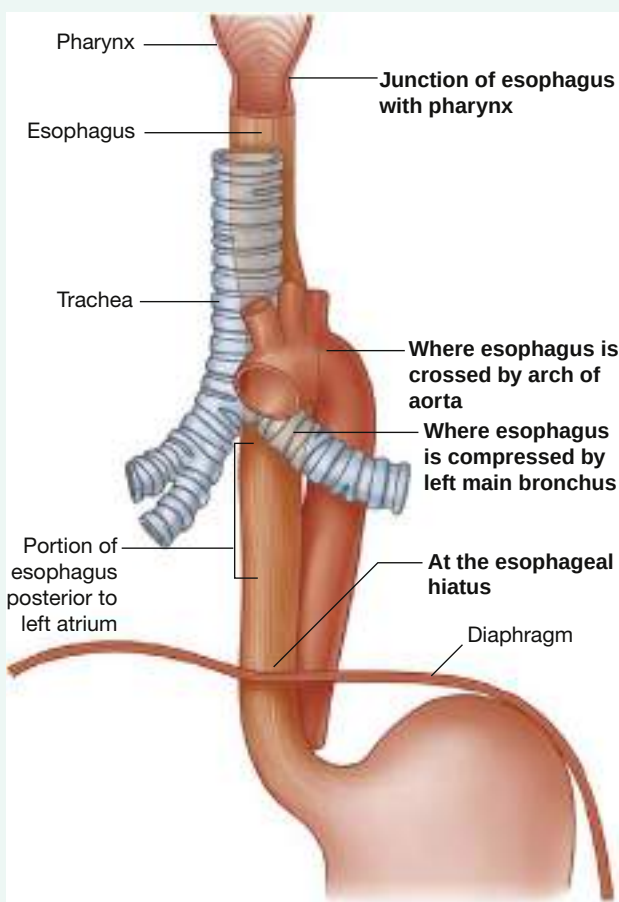


Fig. 3.96 Sites of normal esophageal constrictions.

Anterior to the esophagus, below the level of the tracheal bifurcation, are the right pulmonary artery and the left main bronchus. The esophagus then passes immediately posteriorly to the left atrium, separated from it only by pericardium. Inferior to the left atrium, the esophagus is related to the diaphragm.

Structures other than the thoracic duct posterior to the esophagus include portions of the hemiazygos veins, the right posterior intercostal vessels, and, near the diaphragm, the thoracic aorta.

Arterial supply and venous and lymphatic drainage

The arterial supply and venous drainage of the esophagus in the posterior mediastinum involve many vessels. Esophageal arteries arise from the thoracic aorta, bronchial arteries, and ascending branches of the left gastric artery in the abdomen.

Venous drainage involves small vessels returning to the azygos vein, hemiazygos vein, and esophageal branches to the left gastric vein in the abdomen.

Lymphatic drainage of the esophagus in the posterior mediastinum returns to posterior mediastinal and left gastric nodes.

Innervation

Innervation of the esophagus, in general, is complex. Esophageal branches arise from the vagus nerves and sympathetic trunks.

Striated muscle fibers in the superior portion of the esophagus originate from the branchial arches and are innervated by branchial efferents from the vagus nerves.

Smooth muscle fibers are innervated by cranial components of the parasympathetic part of the autonomic division of the peripheral nervous system, visceral efferents from the vagus nerves. These are preganglionic fibers that synapse in the myenteric and submucosal plexuses of the enteric nervous system in the esophageal wall.

Sensory innervation of the esophagus involves visceral afferent fibers originating in the vagus nerves, sympathetic trunks, and splanchnic nerves.

The visceral afferents from the vagus nerves are involved in relaying information back to the central nervous system about normal physiological processes and reflex activities. They are not involved in the relay of pain recognition.

The visceral afferents that pass through the sympathetic trunks and the splanchnic nerves are the primary participants in detection of esophageal pain and transmission of this information to various levels of the central nervous system.

Esophageal plexus

After passing posteriorly to the root of the lungs, the right and left vagus nerves approach the esophagus. As they reach

the esophagus, each nerve divides into several branches that spread over this structure, forming the **esophageal plexus** (Fig. 3.97). There is some mixing of fibers from the two vagus nerves as the plexus continues inferiorly on the esophagus toward the diaphragm. Just above the diaphragm, fibers of the plexus converge to form two trunks:

- the **anterior vagal trunk** on the anterior surface of the esophagus, mainly from fibers originally in the left vagus nerve, and
- the **posterior vagal trunk** on the posterior surface of the esophagus, mainly from fibers originally in the right vagus nerve.

The vagal trunks continue on the surface of the esophagus as it passes through the diaphragm into the abdomen.

Clinical app

Esophageal cancer

When patients present with esophageal cancer, it is important to note which portion of the esophagus contains the tumor, because tumor location determines the sites to which the disease will spread.

Esophageal cancer spreads quickly to lymphatics, draining to lymph nodes in the neck and around the celiac artery in the abdomen. Endoscopy or barium swallow is used to assess the site. CT and MRI may be necessary to stage the disease.

Once the extent of the disease has been assessed, treatment can be planned.

Clinical app

Esophageal rupture

The first case of esophageal rupture was described by Herman Boerhaave in 1724. This case was fatal, but early diagnosis has increased the survival rate up to 65%. If the disease is left untreated, mortality is 100%.

Typically, the rupture occurs in the lower third of the esophagus with a sudden rise in intraluminal esophageal pressure produced by vomiting together with failure of the cricopharyngeus muscle in the lower neck to relax. Because the tears typically occur on the left, they are often associated with a large left pleural effusion that contains the gastric contents.

Thoracic aorta

The thoracic portion of the descending aorta (**thoracic aorta**) begins at the lower edge of vertebra T12 where it is

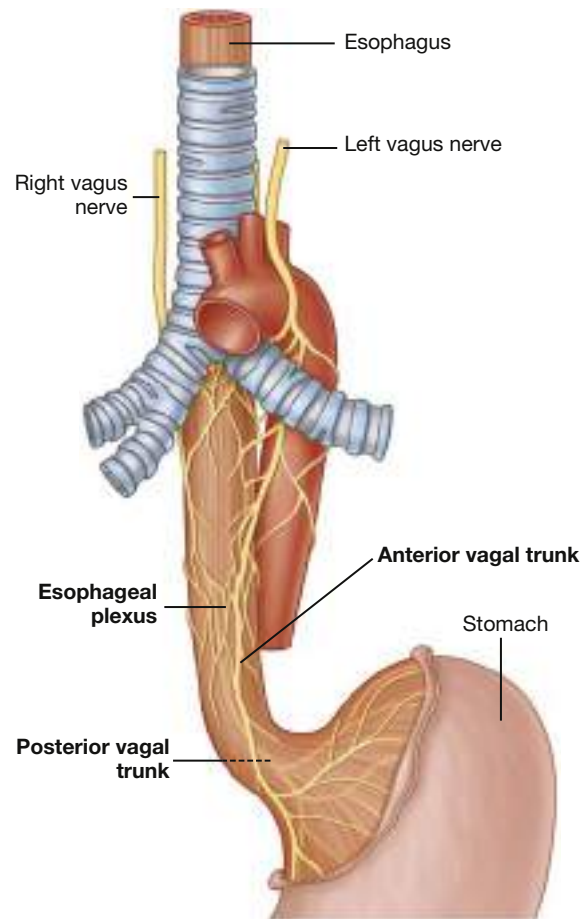


Fig. 3.97 Esophageal plexus.

continuous with the arch of aorta. It ends anterior to the lower edge of vertebrae T12 where it passes through the aortic hiatus posterior to the diaphragm. Situated to the left of the vertebral column superiorly, it approaches the midline inferiorly, lying directly anterior to the lower thoracic vertebral bodies (Fig. 3.98). Throughout its course, it gives off a number of branches, which are summarized in Table 3.3.

Azygos system of veins

The azygos system of veins consists of a series of longitudinal vessels on each side of the body that drain blood from the body wall and move it superiorly to the superior vena cava. Blood from some of the thoracic viscera may also enter the system, and there are anastomotic connections with abdominal veins.

The longitudinal vessels may or may not be continuous and are connected to each other from side to side at various points throughout their course (Fig. 3.99).

The azygos system of veins serves as an important anastomotic pathway capable of returning venous blood from the lower part of the body to the heart if the inferior vena cava is blocked.

The major veins in the system are:

- the azygos vein on the right and
- the hemiazygos vein and the accessory hemiazygos vein on the left.

There is significant variation in the origin, course, tributaries, anastomoses, and termination of these vessels.

Azygos vein

The **azygos vein** arises opposite vertebra LI or LII at the junction of the **right ascending lumbar vein** and the **right subcostal vein** (Fig. 3.99). It may also arise as a direct branch of the inferior vena cava, which is joined by a common trunk from the junction of the right ascending lumbar vein and the right subcostal vein.

The azygos vein enters the thorax through the aortic hiatus of the diaphragm or through or posterior to the right crus of the diaphragm. It ascends through the posterior mediastinum, usually to the right of the thoracic duct. At approximately vertebral level TIV, it arches anteriorly over the root of the right lung to join the superior vena cava before the superior vena cava enters the pericardial sac.

Tributaries of the azygos vein include:

- the **right superior intercostal vein** (a single vessel formed by the second, third, and fourth intercostal veins; the first right intercostal vein drains directly into the right brachiocephalic vein or into the vertebral vein),
- fifth to eleventh right posterior intercostal veins,
- the hemiazygos vein,
- the accessory hemiazygos vein,
- esophageal veins,
- mediastinal veins,
- pericardial veins, and
- right bronchial veins.

Hemiazygos vein

The **hemiazygos vein** (**inferior hemiazygos vein**) usually arises at the junction between the **left ascending lumbar vein** and the **left subcostal vein** (Fig. 3.99). It may also arise

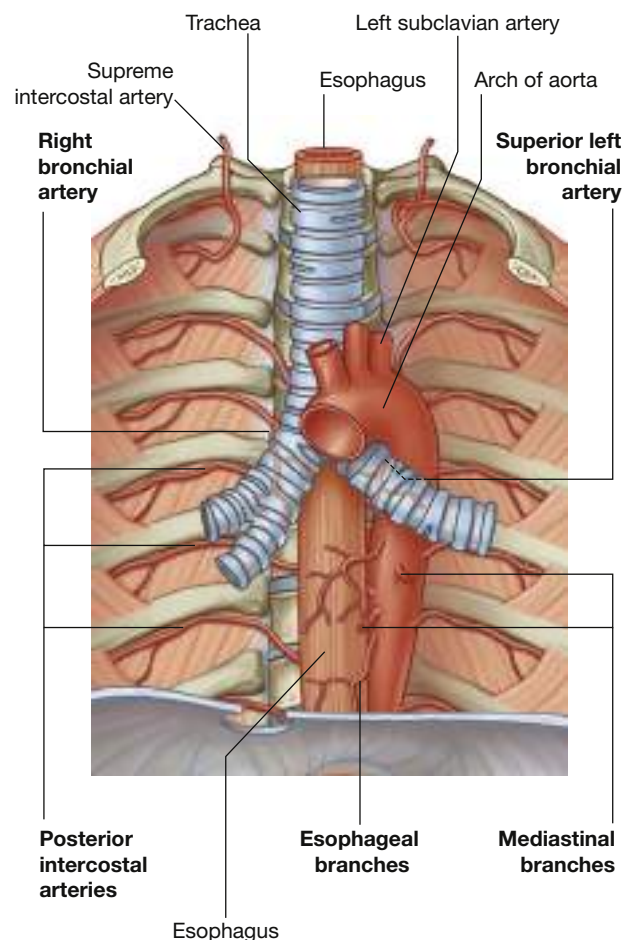


Fig. 3.98 Thoracic aorta and branches.

Table 3.3 Branches of the thoracic aorta

Branches	Origin and course
Pericardial branches	A few small vessels to the posterior surface of the pericardial sac
Bronchial branches	Vary in number, size, and origin—usually two left bronchial arteries from the thoracic aorta and one right bronchial artery from the third posterior intercostal artery or the superior left bronchial artery
Esophageal branches	Four or five vessels from the anterior aspect of the thoracic aorta, which form a continuous anastomotic chain—anastomotic connections include esophageal branches of the inferior thyroid artery superiorly and esophageal branches of the left inferior phrenic and the left gastric arteries inferiorly
Mediastinal branches	Several small branches supplying lymph nodes, vessels, nerves, and areolar tissue in the posterior mediastinum
Posterior intercostal arteries	Usually nine pairs of vessels branching from the posterior surface of the thoracic aorta—usually supply the lower nine intercostal spaces (first two spaces are supplied by the supreme intercostal artery—a branch of the costocervical trunk)
Superior phrenic arteries	Small vessels from the lower part of the thoracic aorta supplying the posterior part of the superior surface of the diaphragm—they anastomose with the musculophrenic and pericardiophrenic arteries
Subcostal artery	The lowest pair of branches from the thoracic aorta located inferior to rib XII

from either of these veins alone and often has a connection to the left renal vein.

The hemiazygos vein usually enters the thorax through the left crus of the diaphragm but may enter through the aortic hiatus. It ascends through the posterior mediastinum on the left side to approximately vertebral level TIX. At this point, it crosses the vertebral column posterior to the thoracic aorta, esophagus, and thoracic duct to enter the azygos vein.

Tributaries joining the hemiazygos vein include:

- the lowest four or five left posterior intercostal veins,
- esophageal veins, and
- mediastinal veins.

Accessory hemiazygos vein

The **accessory hemiazygos vein (superior hemiazygos vein)** descends on the left side from the superior portion of the posterior mediastinum to approximately vertebral level TVIII (Fig. 3.99). At this point, it crosses the vertebral column to join the azygos vein, ends in the hemiazygos vein, or has a connection to both veins. Usually, it also has a connection superiorly to the **left superior intercostal vein**.

Vessels that drain into the accessory hemiazygos vein include:

- the fourth to eighth left posterior intercostal veins and
- sometimes, the left bronchial veins.

Thoracic duct in the posterior mediastinum

The thoracic duct is the principal channel through which lymph from most of the body is returned to the venous system. It begins as a confluence of lymph trunks in the abdomen, sometimes forming a saccular dilation referred to as the **cisterna chyli (chyle cistern)**, which drains the abdominal viscera and walls, pelvis, perineum, and lower limbs.

The thoracic duct extends from vertebra LII to the root of the neck.

Entering the thorax posterior to the aorta through the aortic hiatus of the diaphragm, the thoracic duct ascends through the posterior mediastinum to the right of midline between the thoracic aorta on the left and the azygos vein on the right (Fig. 3.100). It lies posterior to the diaphragm and the esophagus and anterior to the bodies of the vertebrae.

At vertebral level TV, the thoracic duct moves to the left of midline and enters the superior mediastinum. It continues through the superior mediastinum and into the neck.

After being joined, in most cases, by the **left jugular trunk**, which drains the left side of the head and neck, and the **left subclavian trunk**, which drains the left upper limb, the thoracic duct empties into the junction of the left subclavian and left internal jugular veins.

The thoracic duct usually receives the contents from:

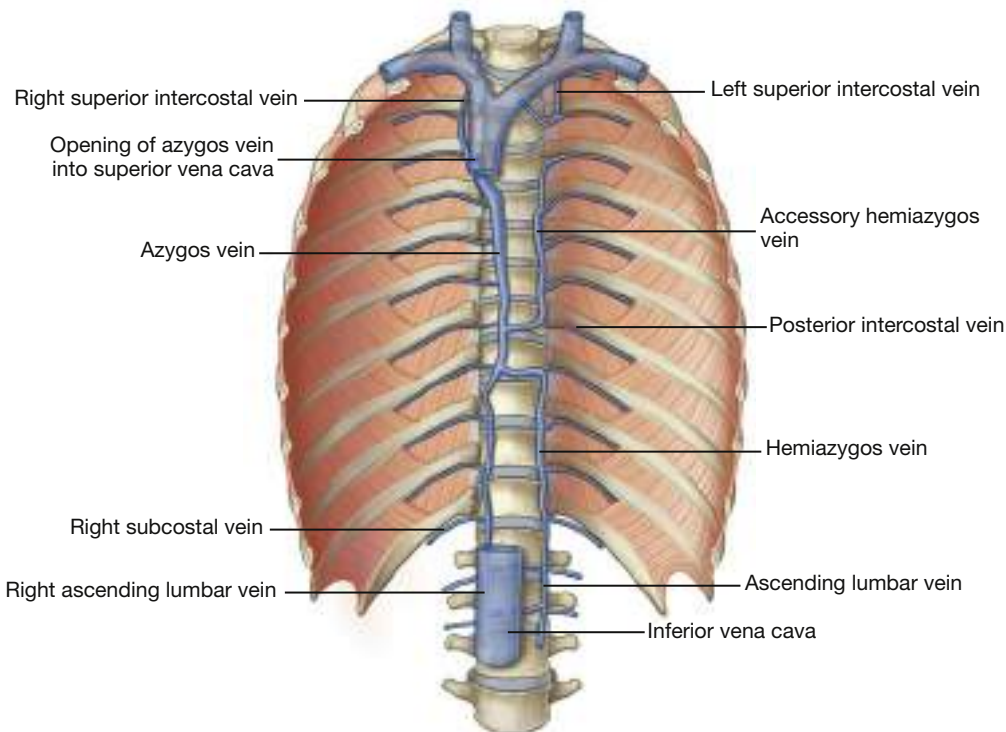


Fig. 3.99 Azygos system of veins.

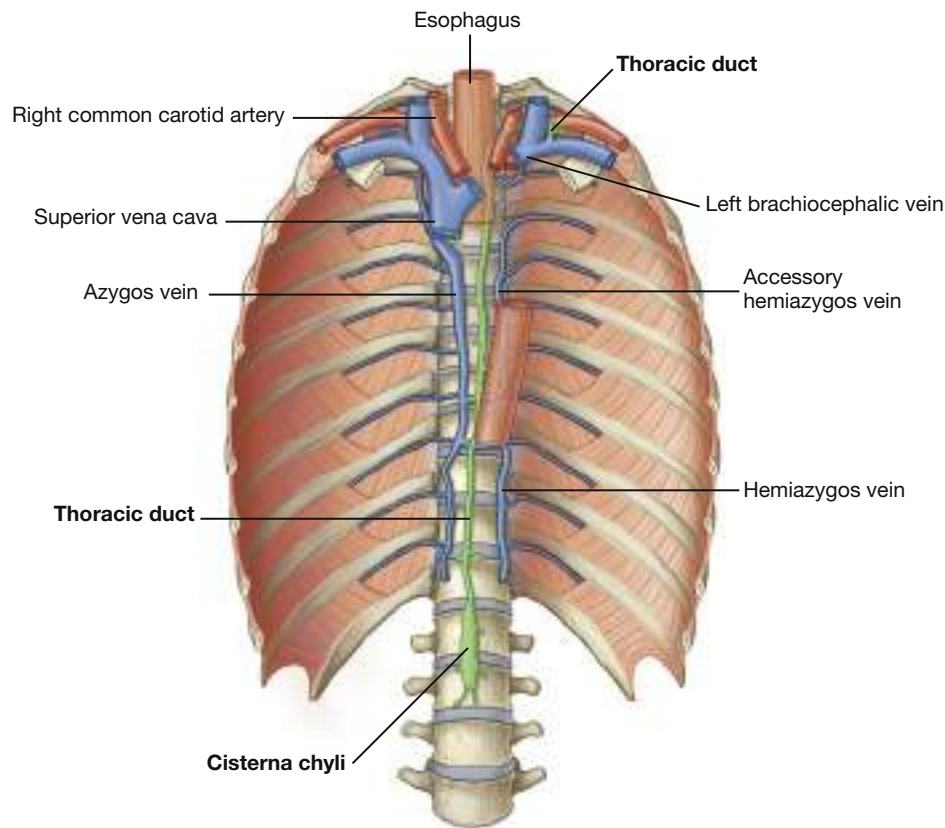


Fig. 3.100 Thoracic duct.

- the confluence of lymph trunks in the abdomen,
- descending thoracic lymph trunks draining the lower six or seven intercostal spaces on both sides,
- upper intercostal lymph trunks draining the upper left five or six intercostal spaces,
- ducts from posterior mediastinal nodes, and
- ducts from posterior diaphragmatic nodes.

Sympathetic trunks

The **sympathetic trunks** are an important component of the sympathetic part of the autonomic division of the peripheral nervous system and are usually considered a component of the posterior mediastinum as they pass through the thorax (also see [Chapter 1, pp. 23–26](#)).

This portion of the sympathetic trunks consists of two parallel cords punctuated by 11 or 12 **ganglia** ([Fig. 3.101](#)). The ganglia are connected to adjacent thoracic spinal nerves by **white** and **gray rami communicantes** and are numbered according to the thoracic spinal nerve with which they are associated.

In the superior portion of the posterior mediastinum, the trunks are anterior to the neck of the ribs. Inferiorly, they

become more medial in position until they lie on the lateral aspect of the vertebral bodies. The sympathetic trunks leave the thorax by passing posterior to the diaphragm under the medial arcuate ligament or through the crura of the diaphragm. Throughout their course the trunks are covered by parietal pleura.

Branches from the ganglia

Two types of medial branches are given off by the ganglia:

- The first type includes branches from the upper five ganglia.
- The second type includes branches from the lower seven ganglia.

The first type includes branches from the upper five ganglia and is mainly postganglionic sympathetic fibers, which supply the various thoracic viscera. These branches are relatively small and contain visceral afferent fibers.

The second type includes branches from the lower seven ganglia and is mainly preganglionic sympathetic fibers, which supply the various abdominal and pelvic viscera. These

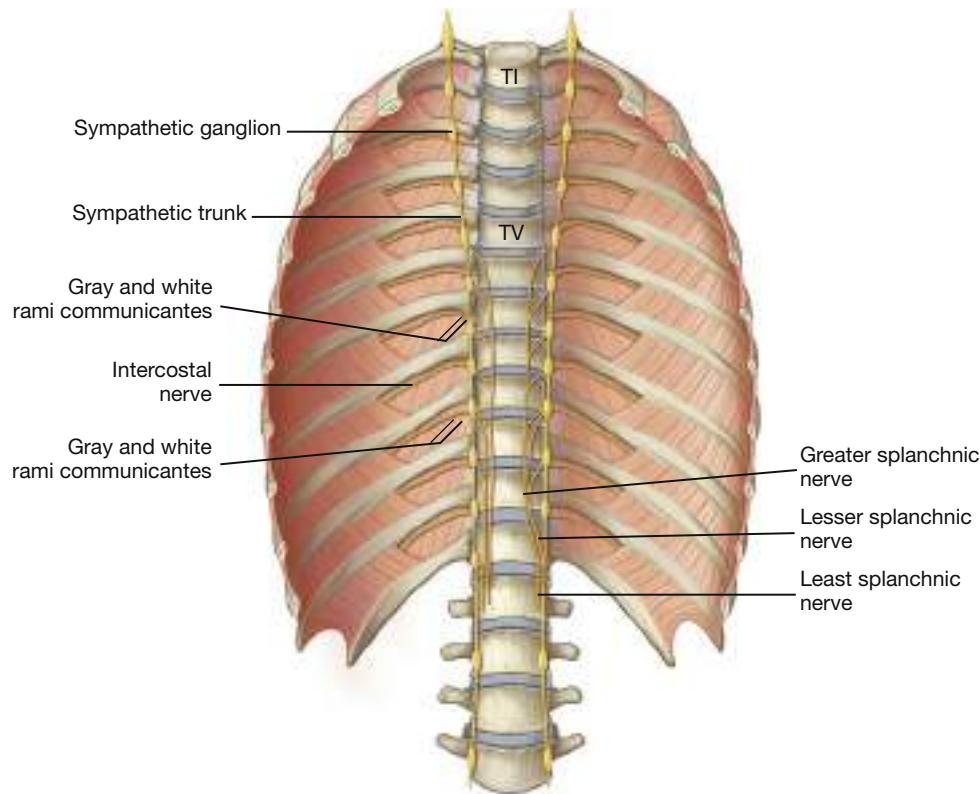


Fig. 3.101 Thoracic portion of sympathetic trunks.

branches are large, carry visceral afferent fibers, and form the three thoracic splanchnic nerves referred to as the greater, lesser, and least splanchnic nerves (Fig. 3.101).

- The **greater splanchnic nerve** on each side usually arises from the fifth to ninth or tenth thoracic ganglia. It descends across the vertebral bodies moving in a medial direction, passes into the abdomen through the crus of the diaphragm, and ends in the celiac ganglion.
- The **lesser splanchnic nerve** usually arises from the ninth and tenth or tenth and eleventh thoracic ganglia. It descends across the vertebral bodies moving in a medial direction and passes into the abdomen through the crus of the diaphragm to end in the aorticorenal ganglion.
- The **least splanchnic nerve (lowest splanchnic nerve)**, when present, usually arises from the twelfth thoracic ganglion. It descends and passes into the abdomen through the crus of the diaphragm to end in the renal plexus.

Imaging app

Visualizing the mediastinum in the axial plane

Fig. 3.102A through I

This is a series of images that pass through the thorax from superior to inferior showing the various mediastinal structures and

their relationships with each other. CT images, with contrast, in axial plane.

Continued

Imaging app—cont'd

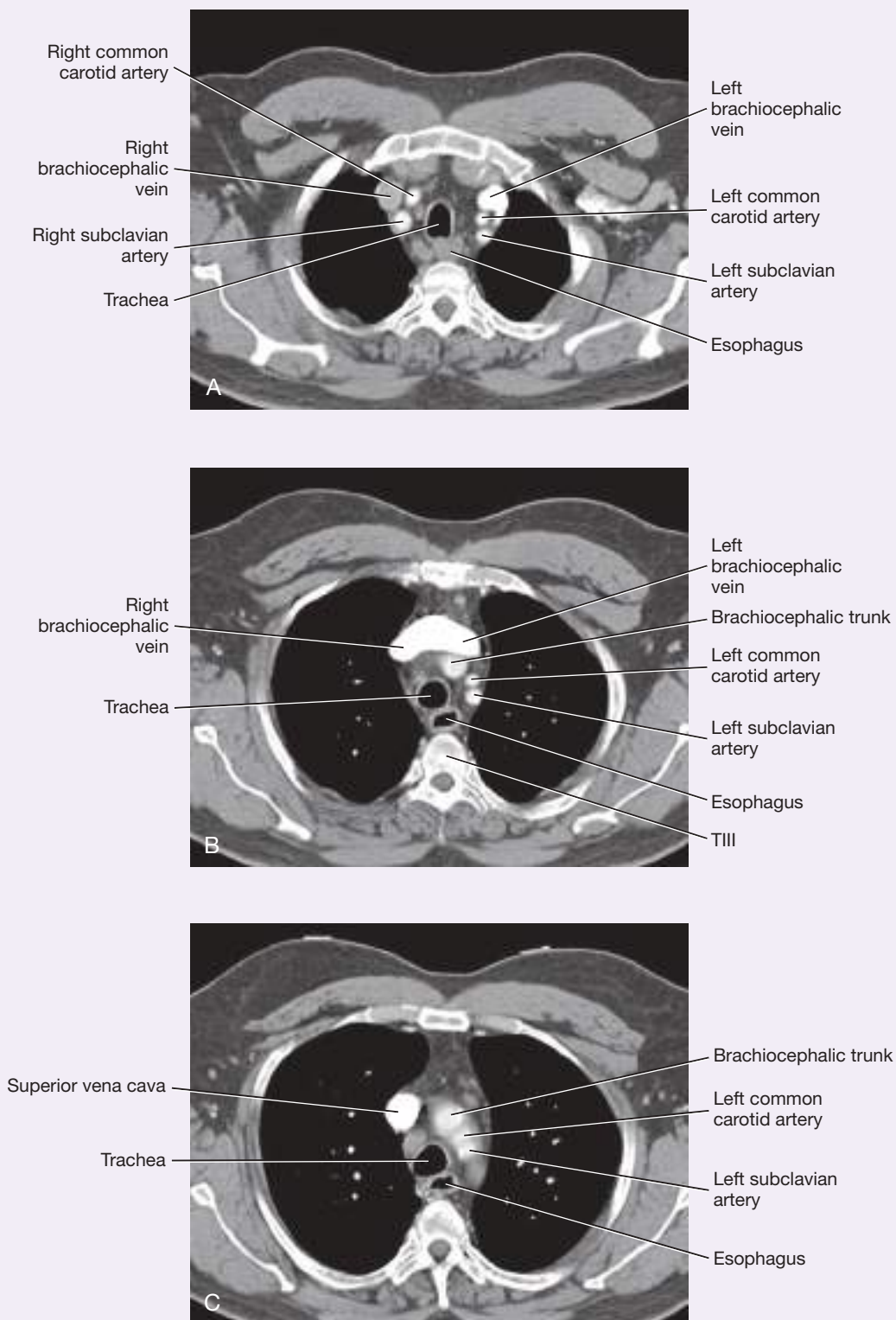


Fig. 3.102

Imaging app—cont'd

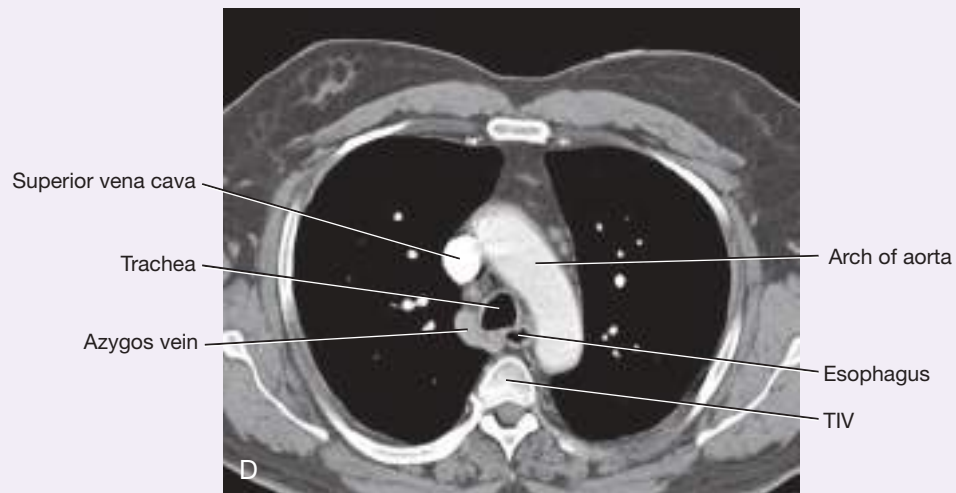


Fig. 3.102, cont'd

Continued

Imaging app—cont'd

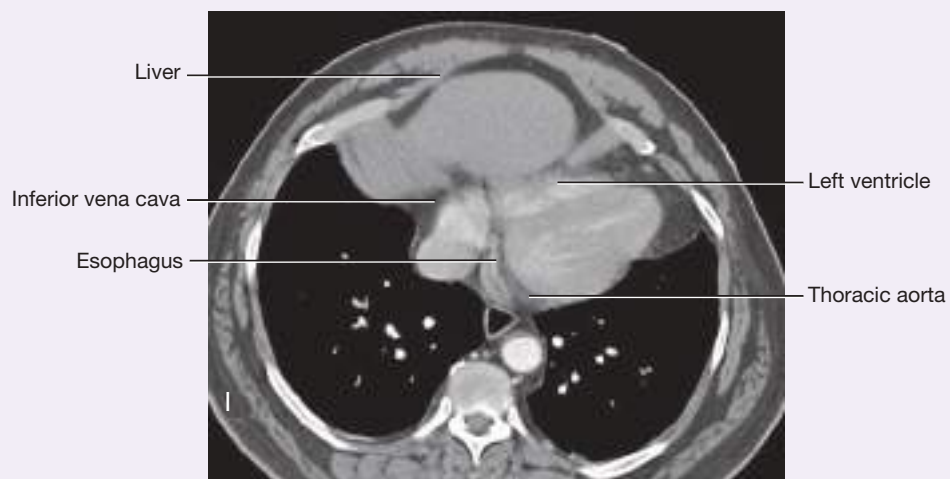


Fig. 3.102, cont'd

4

Abdomen

**ADDITIONAL LEARNING RESOURCES
FOR CHAPTER 4, *ABDOMEN*,
CAN BE FOUND ON THE ACCOMPANYING
EBOOK:**

- Self-Assessment — National Board style multiple-choice questions, Chapter 4
- Short Questions — these are questions requiring short responses, Chapter 4
- Clinical Cases
 - Aorto-iliac occlusive disease
 - Colon cancer
 - Intussusception
 - Zollinger-Ellison syndrome
 - Traumatic rupture of the diaphragm
 - Chronic thrombosis of the inferior vena cava
 - Liver biopsy in patients with suspected liver cirrhosis
 - Hodgkin's lymphoma
 - Inguinal hernia
 - Ureteric stone
 - Intra-abdominal abscess
 - Complications of an abdominoperineal resection
 - Carcinoma of the head of the pancreas
 - Caval obstruction
 - Diverticular disease
 - Endoleak after endovascular repair of abdominal aortic aneurysm
 - Gastrointestinal bleed
 - Metastatic lesions in the liver

***Regional anatomy* 146**

Surface topography 146

Four-quadrant pattern 146

Nine-region pattern 146

Abdominal wall 147

Superficial fascia 148

Anterolateral muscles 149

Extraperitoneal fascia 152

Peritoneum 153

Innervation 153

Arterial supply and venous drainage 155

Lymphatic drainage 155

Groin 156

Inguinal canal 157

Abdominal viscera 163

Peritoneum 163

Peritoneal cavity 164

Organs 167

Arterial supply to the gastrointestinal tract 187

Venous drainage 193

Lymphatics 196

Innervation 196

Posterior abdominal region 201

Posterior abdominal wall 201

Viscera 206

Vasculature 212

Lymphatic system 216

Nervous system in the posterior abdominal region 217

Sympathetic trunks and splanchnic nerves 217

Regional anatomy

The abdomen is the part of the trunk inferior to the thorax (Fig. 4.1). Its musculomembranous walls surround a large cavity (the **abdominal cavity**), which is bounded superiorly by the diaphragm and inferiorly by the pelvic inlet.

The abdominal cavity may extend superiorly as high as the fourth intercostal space and is continuous inferiorly with the pelvic cavity. It contains the **peritoneal cavity** and the abdominal viscera.

SURFACE TOPOGRAPHY

Topographical divisions of the abdomen are used to describe the location of abdominal organs and the pain associated with abdominal problems. The two schemes most often used are:

- a four-quadrant pattern and
- a nine-region pattern.

Four-quadrant pattern

A horizontal transumbilical plane passing through the umbilicus and the intervertebral disc between vertebrae LIII and LIV and intersecting with the vertical median plane

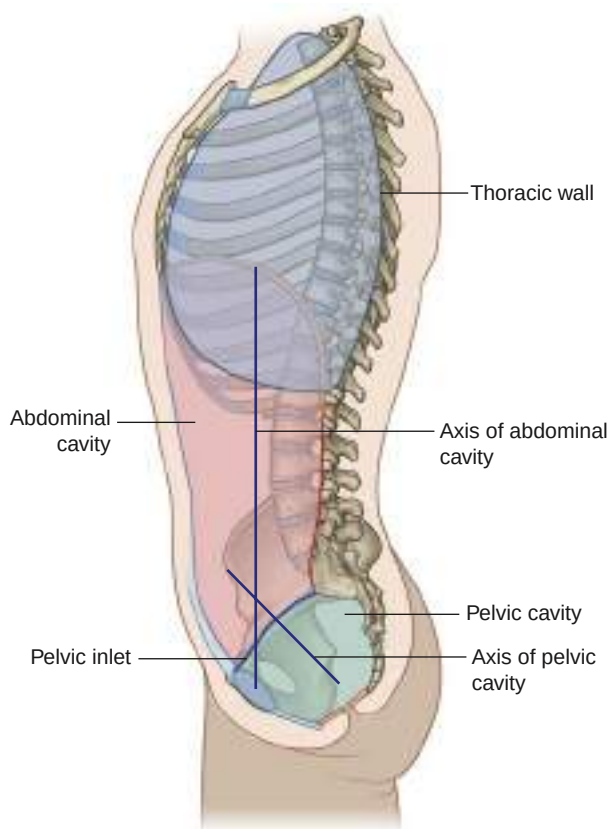


Fig. 4.1 Boundaries of the abdominal cavity.

divides the abdomen into four quadrants—the right upper, left upper, right lower, and left lower quadrants (Fig. 4.2).

Nine-region pattern

The nine-region pattern is based on two horizontal and two vertical planes (Fig. 4.3).

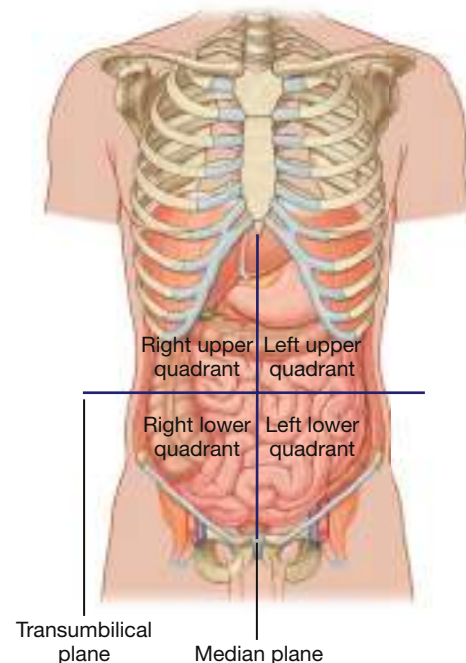


Fig. 4.2 Four-quadrant topographical pattern.

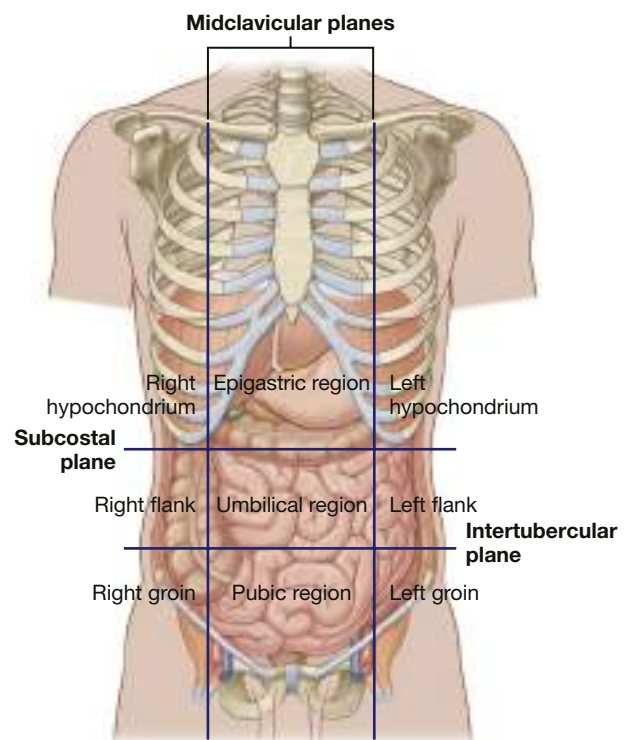


Fig. 4.3 Nine-region organizational pattern.

- The superior horizontal plane (the **subcostal plane**) is immediately inferior to the costal margins, which places it at the lower border of the costal cartilage of rib X and passes posteriorly through the body of vertebra LIII. (Note, however, that sometimes the **transpyloric plane**, halfway between the jugular notch and the symphysis pubis or halfway between the umbilicus and the inferior end of the body of the sternum, passing posteriorly through the lower border of vertebrae LI and intersecting with the costal margin at the ends of the ninth costal cartilages, is used instead.)
- The inferior horizontal plane (the **intertubercular plane**) connects the tubercles of the iliac crests, which are palpable structures 5 cm posterior to the anterior superior iliac spines, and passes through the upper part of the body of vertebra LV.
- The vertical planes pass from the midpoint of the clavicles inferiorly to a point midway between the anterior superior iliac spine and pubic symphysis.

These four planes establish the topographical divisions in the nine-region organization. The following designations are used for each region: superiorly the right hypochondrium, the epigastric region, and the left hypochondrium; inferiorly the right groin (inguinal region), pubic region, and left groin (inguinal region); and in the middle the right flank (lateral region), the umbilical region, and the left flank (lateral region) (Fig. 4.3).

Surface anatomy

Using abdominal quadrants to locate major viscera

The abdomen can be divided into quadrants by a vertical median plane and a horizontal transumbilical plane (Fig. 4.4):

- The liver and gallbladder are in the right upper quadrant.

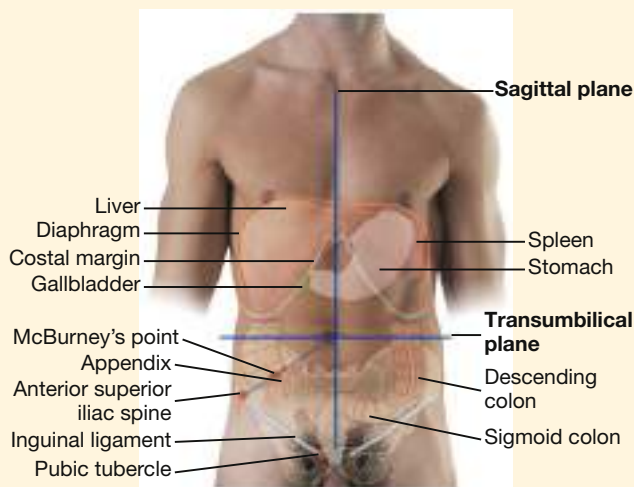


Fig. 4.4 Abdominal quadrants and the positions of major viscera. Anterior view of a man.

- The stomach and spleen are in the left upper quadrant.
- The cecum and appendix are in the right lower quadrant.
- The end of the descending colon and sigmoid colon are in the left lower quadrant.

Most of the liver is under the right dome of the diaphragm and is deep to the lower thoracic wall. The inferior margin of the liver can be palpated descending below the right costal margin when a patient is asked to inhale deeply. On deep inspiration, the edge of the liver can be felt “slipping” under the palpating fingers placed under the costal margin.

A common surface projection of the appendix is **McBurney's point**, which is one-third of the way up a line from the right anterior superior iliac spine to the umbilicus.

Surface anatomy

Defining surface regions to which pain from the gut is referred

The abdomen can be divided into nine regions by a midclavicular sagittal plane on each side and by the subcostal and intertubercular planes, which pass through the body transversely (Fig. 4.5).

Pain from the abdominal part of the foregut is referred to the epigastric region, pain from the midgut is referred to the umbilical region, and pain from the hindgut is referred to the pubic region.

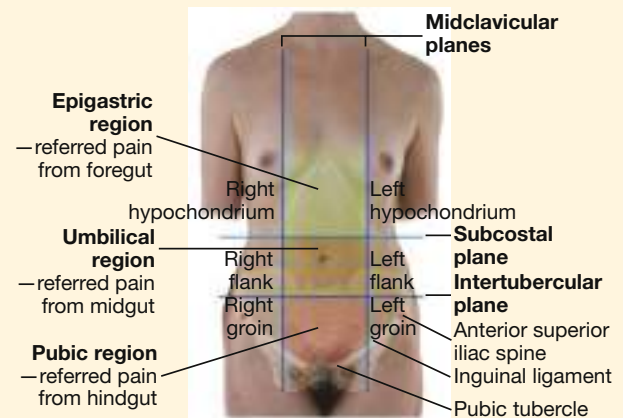


Fig. 4.5 The nine regions of the abdomen. Anterior view of a woman.

ABDOMINAL WALL

The abdominal wall covers a large area. It is bounded superiorly by the xiphoid process and costal margins, posteriorly by the vertebral column, and inferiorly by the upper parts of the pelvic bones.

Its layers consist of skin, superficial fascia (subcutaneous tissue), muscles and their associated deep fascias, extraperitoneal fascia, and parietal peritoneum (Fig. 4.6).

Superficial fascia

The superficial fascia of the abdominal wall (subcutaneous tissue of abdomen) is a layer of fatty connective tissue. It is usually a single layer similar to, and continuous with, the superficial fascia throughout other regions of the body.

However, in the lower region of the anterior part of the abdominal wall, below the umbilicus, it forms two layers: a superficial fatty layer and a deeper membranous layer.

Superficial layer

The superficial fatty layer of superficial fascia (**Camper's fascia**) contains fat and varies in thickness (Figs. 4.7, 4.8). It is continuous over the inguinal ligament with the superficial fascia of the thigh and with a similar layer in the perineum.

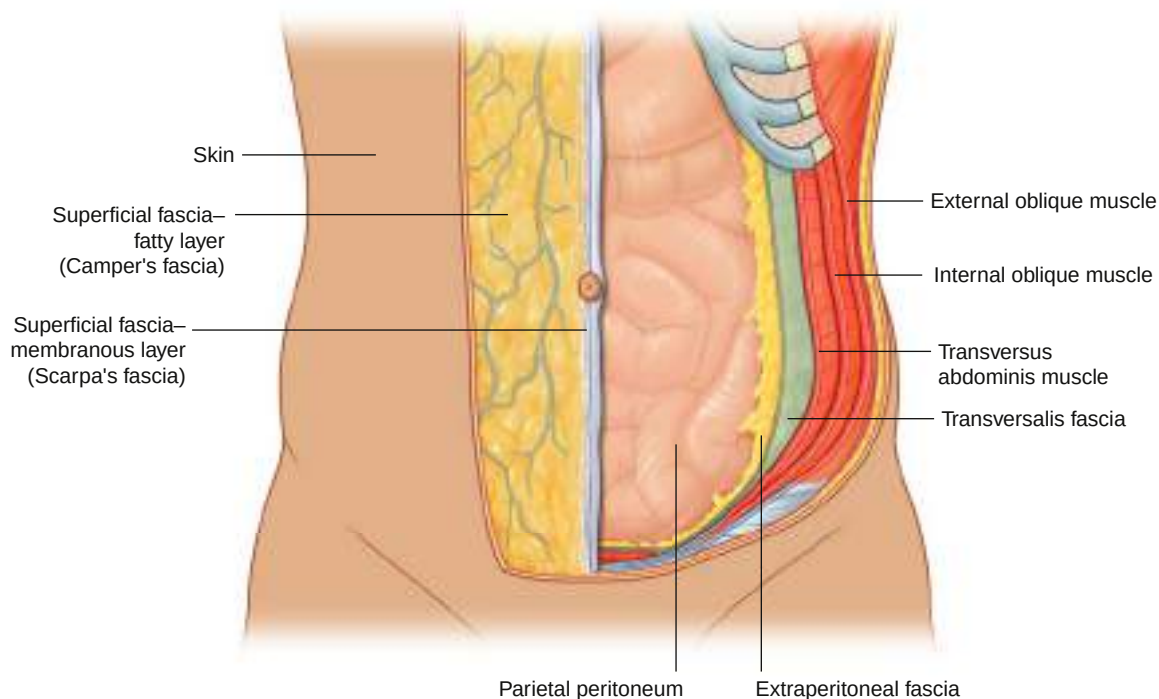


Fig. 4.6 Layers of the abdominal wall.

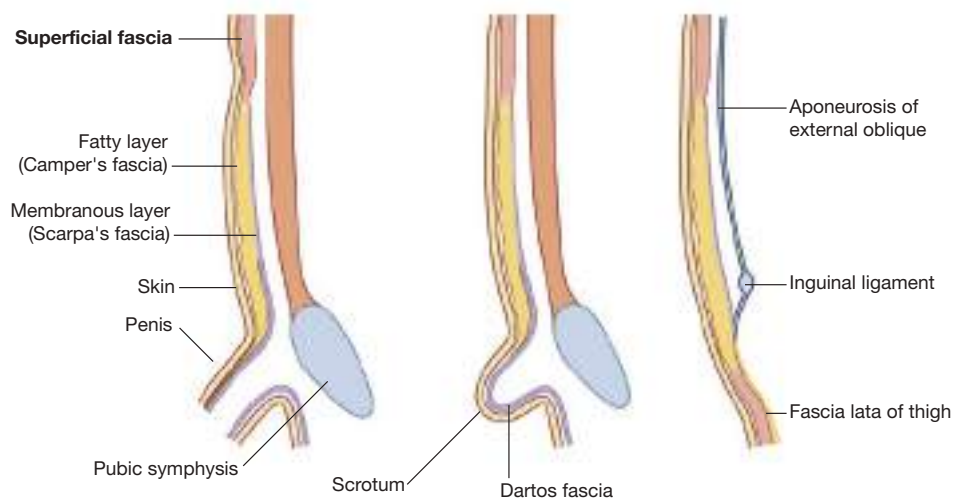


Fig. 4.7 Superficial fascia.

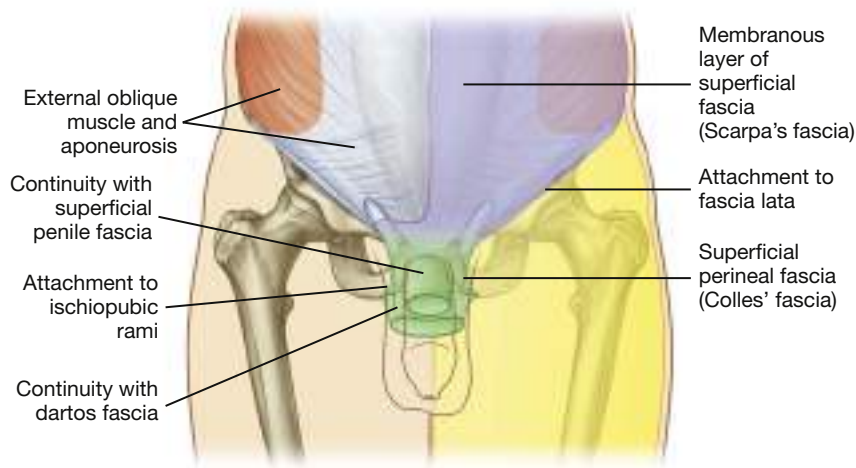


Fig. 4.8 Continuity of membranous layer of superficial fascia into other areas.

In men, this superficial layer continues over the penis and, after losing its fat and fusing with the deeper layer of superficial fascia, continues into the scrotum where it forms a specialized fascial layer containing smooth muscle fibers (the **dartos fascia**). In women, this superficial layer retains some fat and is a component of the labia majora.

Deeper layer

The deeper membranous layer of superficial fascia (**Scarpa's fascia**) is thin and membranous and contains little or no fat (Fig. 4.7). Inferiorly, it continues into the thigh, but just below the inguinal ligament, it fuses with the deep fascia of the thigh (the **fascia lata**; Fig. 4.8). In the midline, it is firmly attached to the linea alba and the pubic symphysis. It continues into the anterior part of the perineum where it is firmly attached to the ischiopubic rami and to the posterior margin of the perineal membrane. Here, it is referred to as the **superficial perineal fascia (Colles' fascia)**.

In men, the deeper membranous layer of superficial fascia blends with the superficial layer as they both pass over the penis, forming the superficial fascia of the penis before they continue into the scrotum where they form the dartos fascia (Figs. 4.7, 4.8). Also in men, extensions of the deeper membranous layer of superficial fascia attached to the pubic symphysis pass inferiorly onto the dorsum and sides of the penis to form the **fundiform ligament of the penis**. In women, the membranous layer of the superficial fascia continues into the labia majora and the anterior part of the perineum.

Anterolateral muscles

There are five muscles in the anterolateral group of abdominal wall muscles (Table 4.1):

- three flat muscles whose fibers begin posterolaterally, pass anteriorly and are replaced by an aponeurosis as the muscle

continues toward the midline—the external oblique, internal oblique, and transversus abdominis muscles and

- two vertical muscles near the midline, which are enclosed within a tendinous sheath formed by the aponeuroses of the flat muscles—the rectus abdominis and pyramidalis muscles.

Each of these five muscles has specific actions, but together the muscles are critical:

- for the maintenance of many normal physiological functions,
- to keep the abdominal viscera within the abdominal cavity,
- to protect the viscera from injury, and
- to help maintain the position of the viscera in the erect posture against the action of gravity.

Contraction of these muscles assists in both quiet and forced expiration by pushing the viscera upward (which helps push the relaxed diaphragm farther into the thoracic cavity) and in coughing and vomiting.

All these muscles are also involved in any action that increases intra-abdominal pressure, including parturition (childbirth), micturition (urination), and defecation (expulsion of feces from the rectum).

Flat muscles

External oblique

The most superficial of the three flat muscles in the anterolateral group of abdominal wall muscles is the **external oblique**, which is immediately deep to the superficial fascia (Table 4.1, Fig. 4.9). Its laterally placed muscle fibers pass in an inferomedial direction, while its large aponeurotic component covers the anterior part of the abdominal wall to the midline. Approaching the midline, the aponeuroses are entwined, forming the linea alba, which extends from the xiphoid process to the pubic symphysis.

Table 4.1 Abdominal wall muscles

Muscle	Origin	Insertion	Innervation	Function
External oblique	Muscular slips from the outer surfaces of the lower eight ribs (ribs V to XII)	Lateral lip of iliac crest; aponeurosis ending in midline raphe (linea alba)	Anterior rami of lower six thoracic spinal nerves (T7 to T12)	Compress abdominal contents; both muscles flex trunk; each muscle bends trunk to same side, turning anterior part of abdomen to opposite side
Internal oblique	Thoracolumbar fascia; iliac crest between origins of external and transversus; lateral two-thirds of inguinal ligament	Inferior border of the lower three or four ribs; aponeurosis ending in linea alba; pubic crest and pectineal line	Anterior rami of lower six thoracic spinal nerves (T7 to T12) and L1	Compress abdominal contents; both muscles flex trunk; each muscle bends trunk and turns anterior part of abdomen to same side
Transversus abdominis	Thoracolumbar fascia; medial lip of iliac crest; lateral one-third of inguinal ligament; costal cartilages lower six ribs (ribs VII to XII)	Aponeurosis ending in linea alba; pubic crest and pectineal line	Anterior rami of lower six thoracic spinal nerves (T7 to T12) and L1	Compress abdominal contents
Rectus abdominis	Pubic crest, pubic tubercle, and pubic symphysis	Costal cartilages of ribs V to VII; xiphoid process	Anterior rami of lower seven thoracic spinal nerves (T7 to T12)	Compress abdominal contents; flex vertebral column; tense abdominal wall
Pyramidalis	Front of pubis and pubic symphysis	Into linea alba	Anterior ramus of T12	Tenses the linea alba

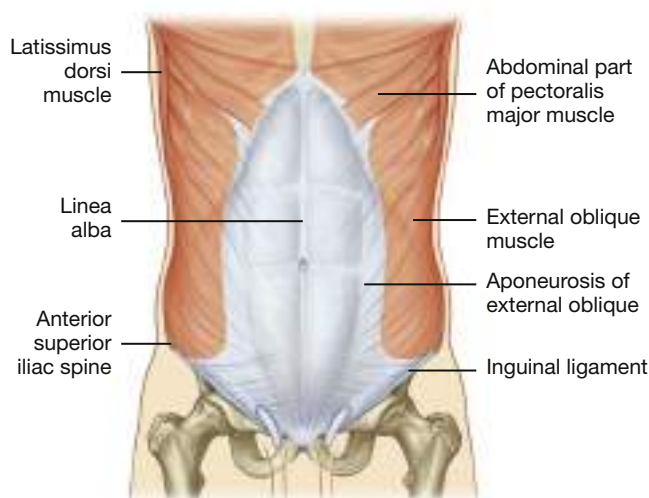


Fig. 4.9 External oblique muscle and its aponeurosis.

Associated ligaments

The lower border of the external oblique aponeurosis forms the **inguinal ligament** on each side (Fig. 4.9). This thickened reinforced free edge of the external oblique aponeurosis passes between the anterior superior iliac spine laterally and the pubic tubercle medially (Fig. 4.10). It folds under itself forming a trough, which plays an important role in the formation of the inguinal canal.

Several other ligaments are also formed from extensions of the fibers at the medial end of the inguinal ligament:

- The **lacunar ligament** is a crescent-shaped extension of fibers at the medial end of the inguinal ligament that pass backward to attach to the **pecten pubis** on the superior ramus of the pubic bone (Figs. 4.10, 4.11).

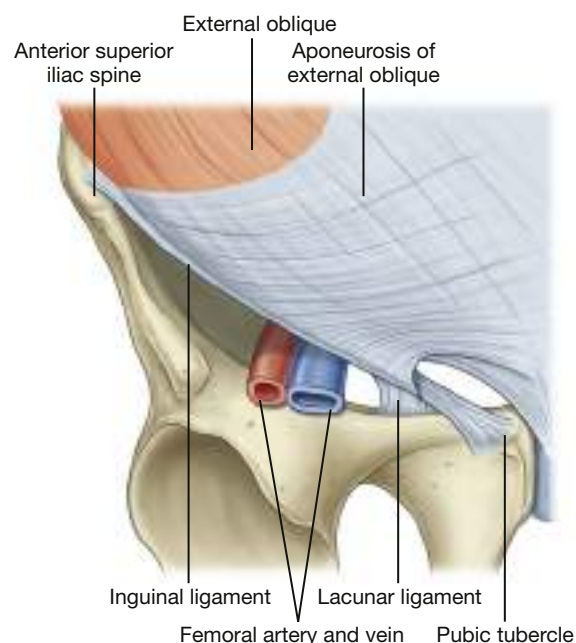


Fig. 4.10 Ligaments formed from the external oblique aponeurosis.

- Additional fibers extend from the lacunar ligament along the pecten pubis of the pelvic brim to form the **pectineal (Cooper's) ligament**.

Internal oblique

Deep to the external oblique muscle is the **internal oblique** muscle, which is the second of the three flat muscles (Table 4.1, Fig. 4.12). This muscle is smaller and thinner than the external oblique, with most of its muscle fibers passing in a superomedial direction. Its lateral muscular components end anteriorly as an aponeurosis that blends into the linea alba at the midline.

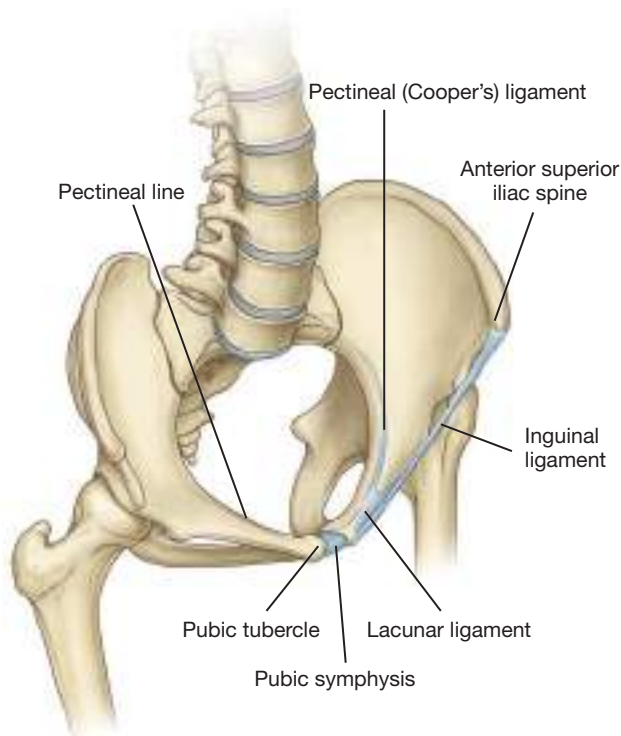


Fig. 4.11 Ligaments of the inguinal region.

Transversus abdominis

Deep to the internal oblique muscle is the **transversus abdominis** muscle (Table 4.1, Fig. 4.13), so named because of the direction of most of its muscle fibers. It ends in an anterior aponeurosis, which blends with the linea alba at the midline.

Transversalis fascia

Each of the three flat muscles is covered on its anterior and posterior surfaces by a layer of deep (or investing) fascia. In general, these layers are unremarkable except for the layer deep to the transversus abdominis muscle (the **transversalis fascia**), which is better developed.

The transversalis fascia is a continuous layer of deep fascia that lines the abdominal cavity and continues into the pelvic cavity. It crosses the midline anteriorly, associating with the transversalis fascia of the opposite side, and is continuous with the fascia on the inferior surface of the diaphragm. It is continuous posteriorly with the deep fascia covering the muscles of the posterior abdominal wall and attaches to the thoracolumbar fascia.

After attaching to the crest of the ilium, the transversalis fascia blends with the fascia covering the muscles associated with the upper regions of the pelvic bones and with similar fascia covering the muscles of the pelvic cavity. At this point, it is referred to as the **parietal pelvic** (or **endopelvic**) **fascia**.

There is therefore a continuous layer of deep fascia surrounding the abdominal cavity that is thick in some areas, thin in others, attached or free, and participates in the formation of specialized structures.

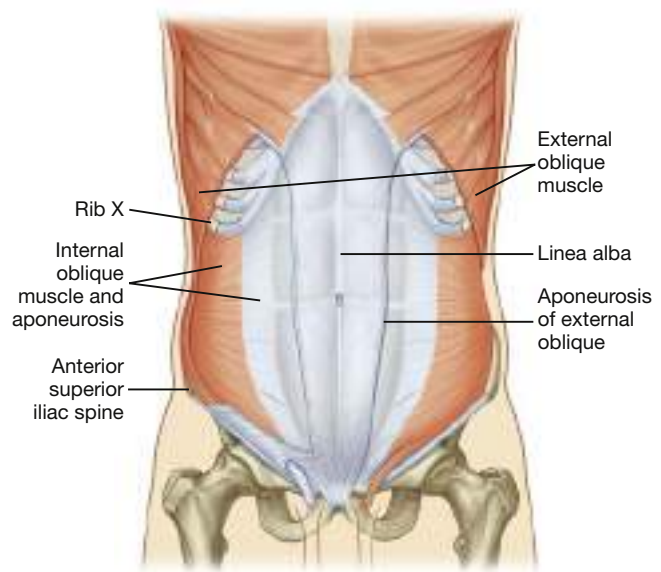


Fig. 4.12 Internal oblique muscle and its aponeurosis.

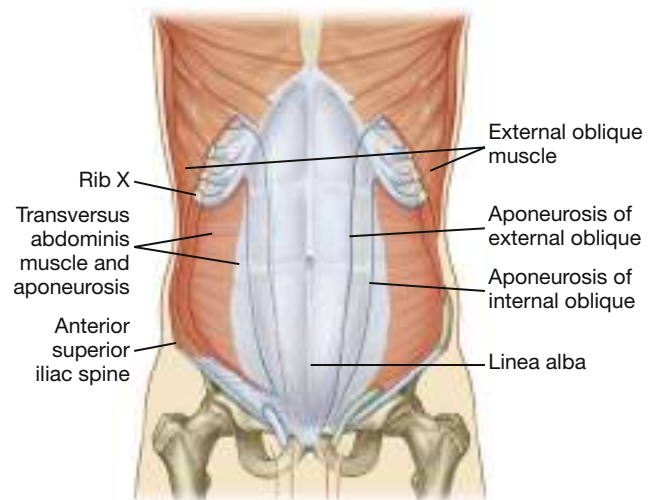


Fig. 4.13 Transversus abdominis muscle and its aponeurosis.

Vertical muscles

The two vertical muscles in the anterolateral group of abdominal wall muscles are the large rectus abdominis and the small pyramidalis (Table 4.1, Fig. 4.14).

Rectus abdominis

The **rectus abdominis** is a long, flat muscle that extends the length of the anterior abdominal wall. It is a paired muscle, separated in the midline by the linea alba, and it widens and thins as it ascends from the pubic symphysis to the costal margin. Along its course, it is intersected by three or four transverse fibrous bands or **tendinous intersections**

(Fig. 4.14). These are easily visible on individuals with a well-developed rectus abdominis muscle.

Pyramidalis

The second vertical muscle is the **pyramidalis**. This small, triangular muscle, which may be absent, is anterior to the rectus abdominis, has its base on the pubis, and its apex is attached superiorly and medially to the linea alba (Fig. 4.14).

Rectus sheath

The rectus abdominis and pyramidalis muscles are enclosed in an aponeurotic tendinous sheath (the **rectus sheath**) formed by a unique layering of the aponeuroses of the external and internal oblique and transversus abdominis muscles (Fig. 4.15).

The rectus sheath completely encloses the upper three-quarters of the rectus abdominis and covers the anterior

surface of the lower one-quarter of the muscle. As no sheath covers the posterior surface of the lower quarter of the rectus abdominis muscle, the muscle at this point is in direct contact with the transversalis fascia.

The formation of the rectus sheath surrounding the upper three-quarters of the rectus abdominis muscle has the following pattern:

- The anterior wall consists of the aponeurosis of the external oblique and half of the aponeurosis of the internal oblique, which splits at the lateral margin of the rectus abdominis.
- The posterior wall of the rectus sheath consists of the other half of the aponeurosis of the internal oblique and the aponeurosis of the transversus abdominis.

At a point midway between the umbilicus and the pubic symphysis, corresponding to the beginning of the lower one-fourth of the rectus abdominis muscle, all of the aponeuroses move anterior to the rectus muscle. There is no posterior wall of the rectus sheath and the anterior wall of the sheath consists of the aponeuroses of the external oblique, the internal oblique, and the transversus abdominis muscles. From this point inferiorly, the rectus abdominis muscle is in direct contact with the transversalis fascia. Marking this point of transition is an arch of fibers (the **arcuate line**; see Fig. 4.14).

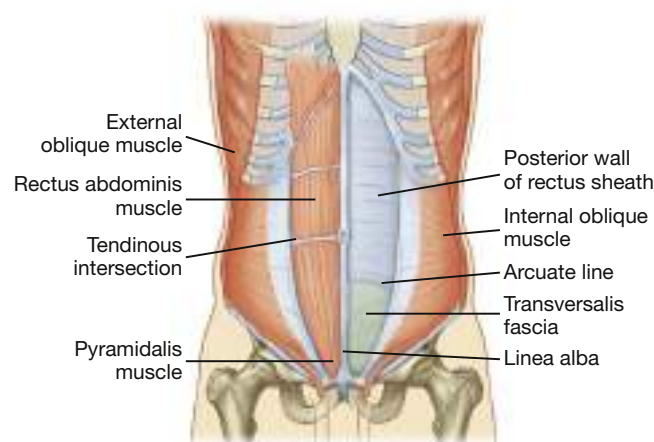


Fig. 4.14 Rectus abdominis and pyramidalis muscles.

Extraperitoneal fascia

Deep to the transversalis fascia is a layer of connective tissue, the **extraperitoneal fascia**, that separates the transversalis fascia from the peritoneum (Fig. 4.16). Containing varying amounts of fat, this layer not only lines the abdominal cavity but is also continuous with a similar layer lining the pelvic

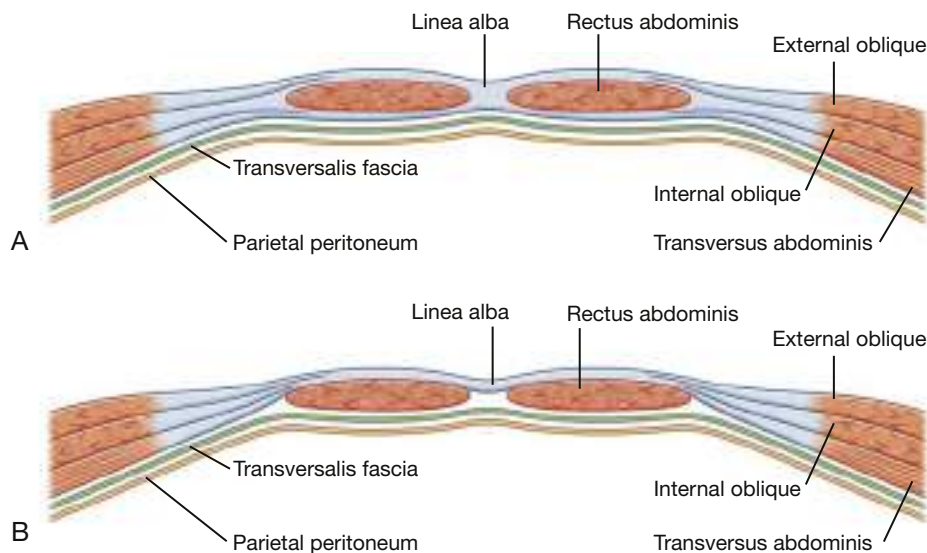


Fig. 4.15 Organization of the rectus sheath. **A.** Transverse section through the upper three-quarters of the rectus sheath. **B.** Transverse section through the lower one-quarter of the rectus sheath.

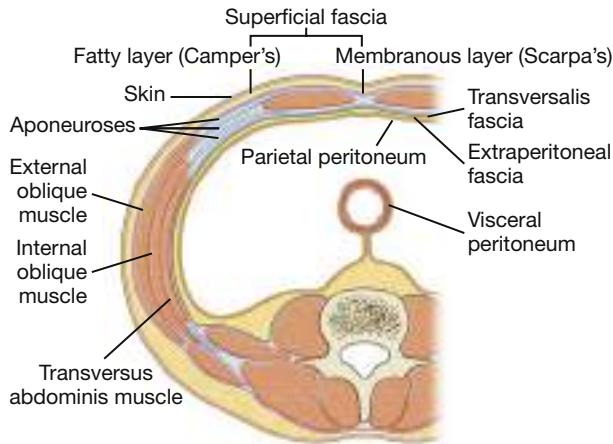


Fig. 4.16 Transverse section showing the layers of the abdominal wall.

cavity. It is abundant on the posterior abdominal wall, especially around the kidneys, continues over organs covered by peritoneal reflections, and, as the vasculature is located in this layer, extends into mesenteries with the blood vessels. Viscera in the extraperitoneal fascia are referred to as **retroperitoneal**.

Clinical app

Preperitoneal vs. retroperitoneal

In the description of specific surgical procedures, the terminology used to describe the extraperitoneal fascia is further modified. The fascia toward the anterior side of the body is described as preperitoneal (or, less commonly, properitoneal), and the fascia toward the posterior side of the body has been described as retroperitoneal (Fig. 4.17). Examples of the use of these terms would be the continuity of fat in the inguinal canal with the preperitoneal fat and a transabdominal preperitoneal laparoscopic repair of an inguinal hernia.

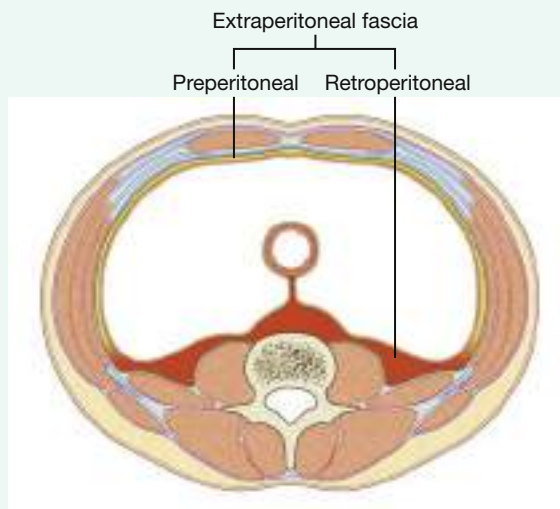


Fig. 4.17 Subdivisions of the extraperitoneal fascia.

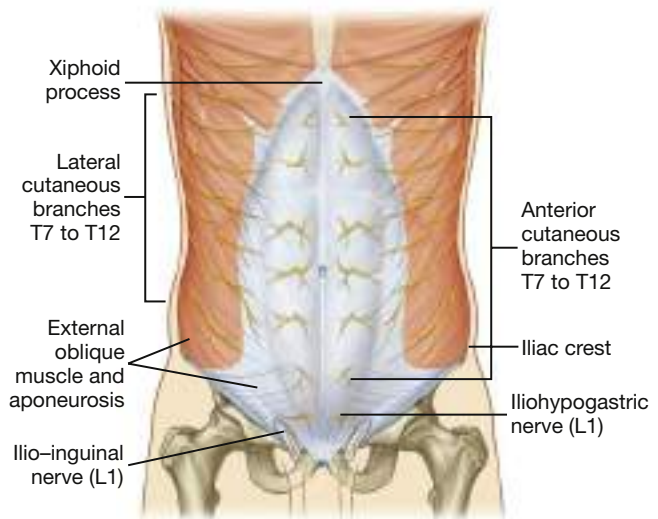


Fig. 4.18 Innervation of the anterolateral abdominal wall.

Peritoneum

Deep to the extraperitoneal fascia is the peritoneum (Fig. 4.16). This thin serous membrane lines the walls of the abdominal cavity and, at various points, reflects onto the abdominal viscera, providing either a complete or a partial covering. The peritoneum lining the walls is the parietal peritoneum; the peritoneum covering the viscera is the visceral peritoneum.

The continuous lining of the abdominal walls by the parietal peritoneum forms a sac. This sac is closed in men but has two openings in women where the uterine tubes provide a passage to the outside. The closed sac in men and the semi-closed sac in women is called the *peritoneal cavity*.

Innervation

The skin, muscles, and parietal peritoneum of the anterolateral abdominal wall are supplied by T7 to T12 and L1 spinal nerves. The anterior rami of these spinal nerves pass around the body, from posterior to anterior, in an inferomedial direction (Fig. 4.18). As they proceed, they give off a lateral cutaneous branch and end as an anterior cutaneous branch.

The intercostal nerves (T7 to T11) leave their intercostal spaces, passing deep to the costal cartilages, and continue onto the anterolateral abdominal wall between the internal oblique and transversus abdominis muscles (Fig. 4.19). Reaching the lateral edge of the rectus sheath, they enter the rectus sheath and pass posterior to the lateral aspect of the rectus abdominis muscle. Approaching the midline, an anterior cutaneous branch passes through the rectus abdominis muscle and the anterior wall of the rectus sheath to supply the skin.

Spinal nerve T12 (the **subcostal nerve**) follows a similar course as the intercostals. Branches of L1 (the **iliohypogastric nerve** and **ilio-inguinal nerve**), which originate from

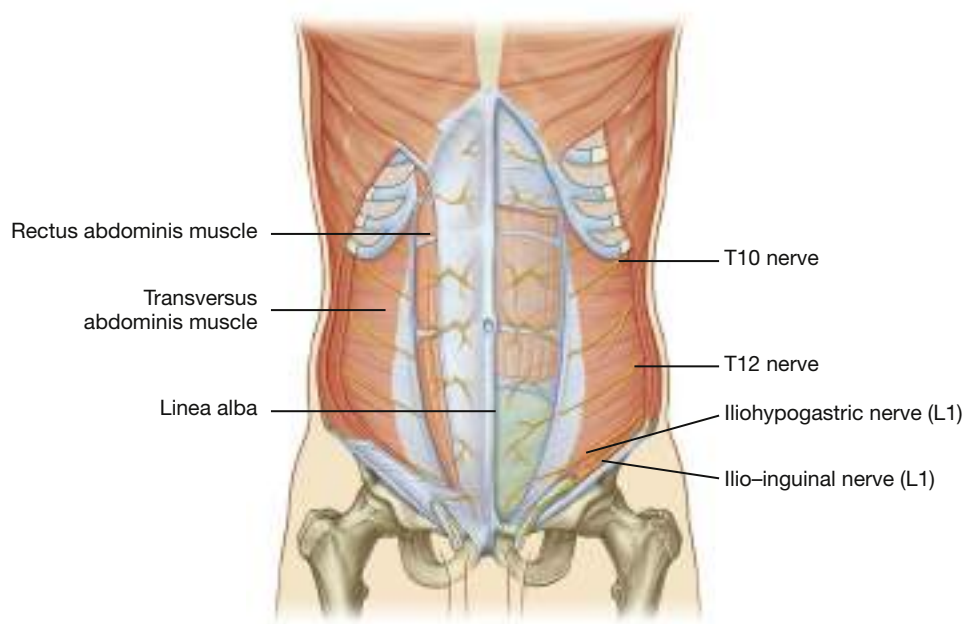


Fig. 4.19 Path taken by the nerves innervating the anterolateral abdominal wall.

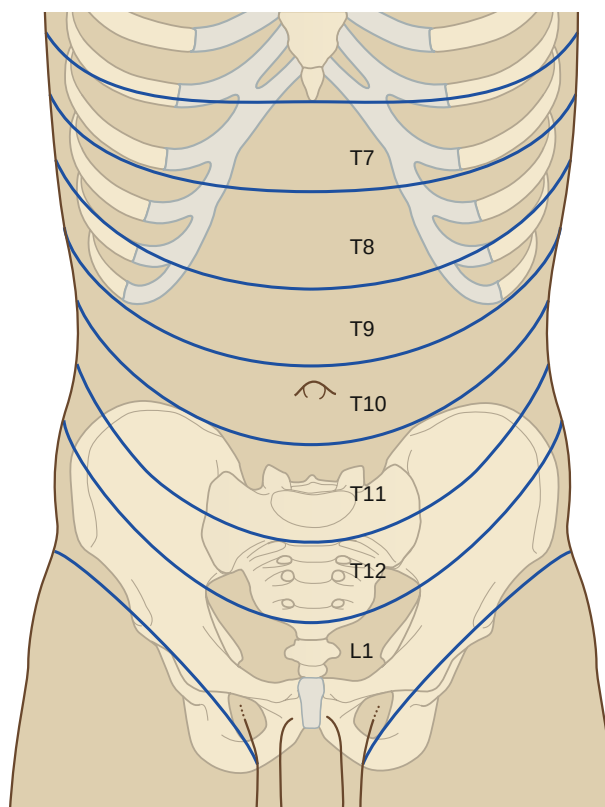


Fig. 4.20 Dermatomes of the anterolateral abdominal wall.

the lumbar plexus, follow similar courses initially but deviate from this pattern near their final destination.

Along their course, nerves T7 to T12 and L1 supply branches to the anterolateral abdominal wall muscles and the underlying parietal peritoneum. All terminate by supplying skin (Fig. 4.20):

- Nerves T7 to T9 supply the skin from the xiphoid process to just above the umbilicus.
- T10 supplies the skin around the umbilicus.
- T11, T12, and L1 supply the skin from just below the umbilicus to, and including, the pubic region.

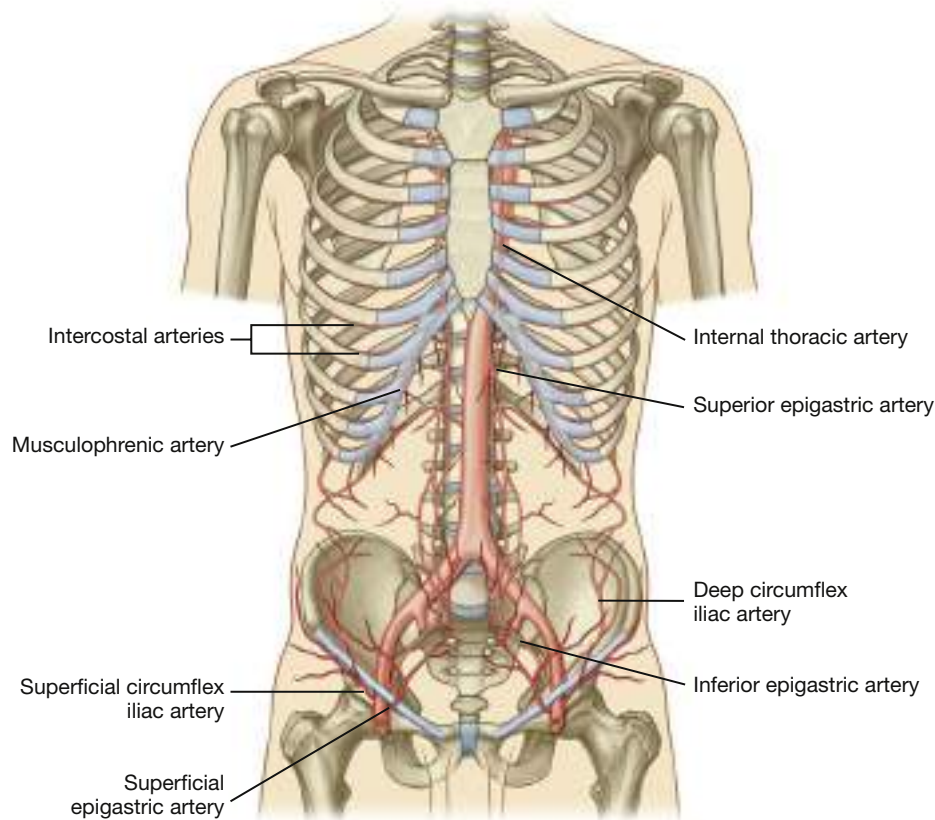


Fig. 4.21 Arterial supply to the anterolateral abdominal wall.

- Additionally, the ilio-inguinal nerve (a branch of L1) supplies the anterior surface of the scrotum or labia majora and sends a small cutaneous branch to the thigh.
- The inferior part of the wall is supplied by the medially placed **inferior epigastric artery** and the laterally placed **deep circumflex iliac artery**, both branches of the **external iliac artery**.

Arterial supply and venous drainage

Numerous blood vessels supply the anterolateral abdominal wall (Fig. 4.21). Superficially:

- The superior part of the wall is supplied by branches from the **musculophrenic artery**, a terminal branch of the **internal thoracic artery**.
- The inferior part of the wall is supplied by the medially placed **superficial epigastric artery** and the laterally placed **superficial circumflex iliac artery**, both branches of the **femoral artery**.

At a deeper level:

- The superior part of the wall is supplied by the **superior epigastric artery**, a terminal branch of the internal thoracic artery.
- The lateral part of the wall is supplied by branches of the **tenth** and **eleventh intercostal arteries** and the **subcostal artery**.

The superior and inferior epigastric arteries both enter the rectus sheath. They are posterior to the rectus abdominis muscle throughout their course and anastomose with each other (Fig. 4.22).

Veins of similar names follow the arteries and are responsible for venous drainage.

Lymphatic drainage

Lymphatic drainage of the anterolateral abdominal wall follows the basic principles of lymphatic drainage:

- Superficial lymphatics above the umbilicus pass in a superior direction to the **axillary nodes**, while drainage below the umbilicus passes in an inferior direction to the **superficial inguinal nodes**.
- Deep lymphatic drainage follows the deep arteries back to **parasternal nodes** along the internal thoracic artery, lumbar nodes along the abdominal aorta, and external iliac nodes along the external iliac artery.

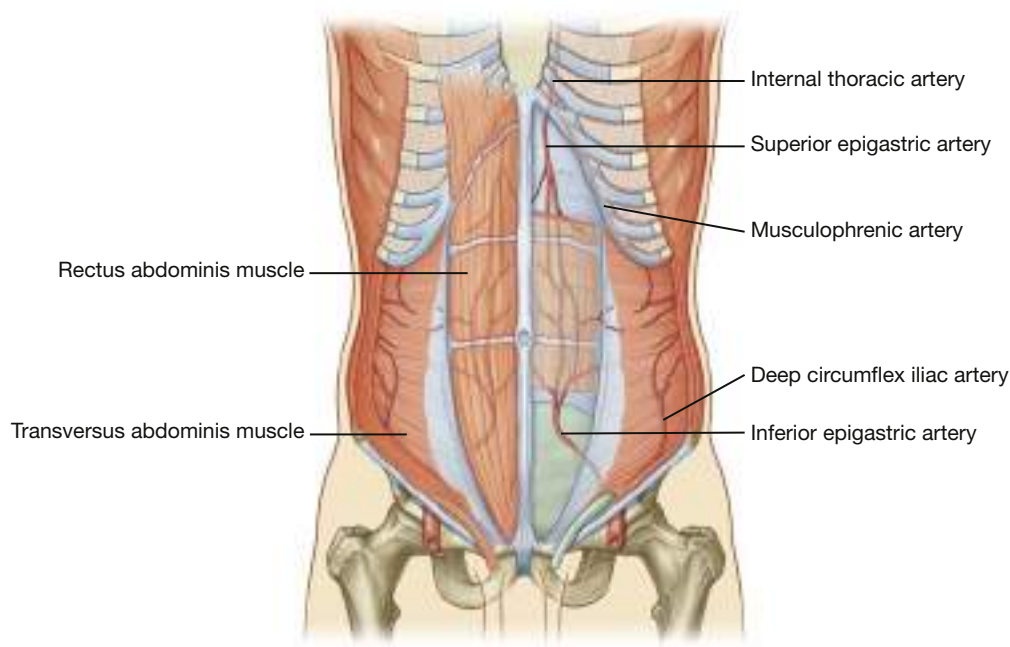


Fig. 4.22 Superior and inferior epigastric arteries.

GROIN

The groin (**inguinal region**) is the area of junction between the anterior abdominal wall and the thigh. In this area, the abdominal wall is weakened from changes that occur during development, and a peritoneal sac or diverticulum, with or without abdominal contents, can therefore protrude through it, creating an inguinal hernia. This type of hernia can occur in both sexes, but it is more common in males.

The inherent weakness in the anterior abdominal wall in the groin is caused by changes that occur during the development of the gonads. Before the descent of the testis and ovaries from their initial position high in the posterior abdominal wall, a peritoneal outpouching (the processus vaginalis) forms (Fig. 4.23), protruding through the various layers of the anterior abdominal wall and acquiring coverings from each:

- The transversalis fascia forms its deepest covering.
- The second covering is formed by the musculature of the internal oblique (a covering from the transversus abdominis muscle is not acquired because the processus vaginalis passes under the arching fibers of this abdominal wall muscle).
- Its most superficial covering is the aponeurosis of the external oblique.

As a result, the processus vaginalis is transformed into a tubular structure with multiple coverings from the layers of the anterior abdominal wall. This forms the basic structure of the **inguinal canal**.

The final event in this development is the descent of the testes into the scrotum or of the ovaries into the pelvic cavity. This

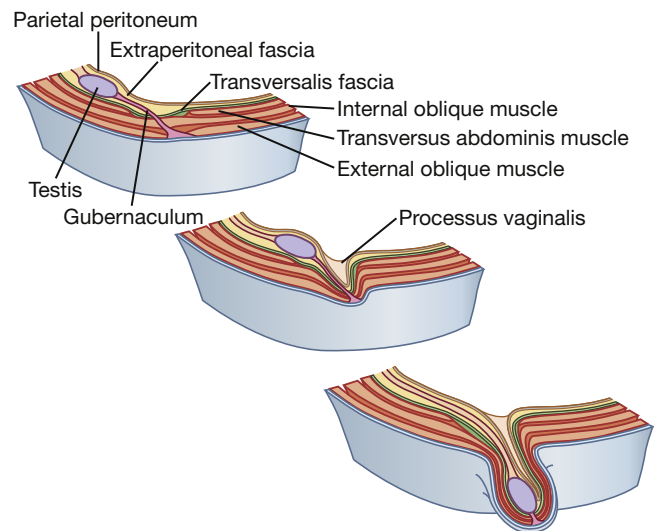


Fig. 4.23 Descent of the testes from week 7 (postfertilization) to birth.

process depends on the development of the **gubernaculum** (Fig. 4.23), which extends from the inferior border of the developing gonad to labioscrotal swellings in the developing perineum.

The processus vaginalis is immediately anterior to the gubernaculum within the inguinal canal.

In men, as the testes descend, the testes and their accompanying vessels, ducts, and nerves pass through the inguinal canal and are therefore surrounded by the same fascial layers of the abdominal wall. Testicular descent completes the formation of the spermatic cord in men.

In women, the ovaries descend into the pelvic cavity and become associated with the developing uterus. Therefore the

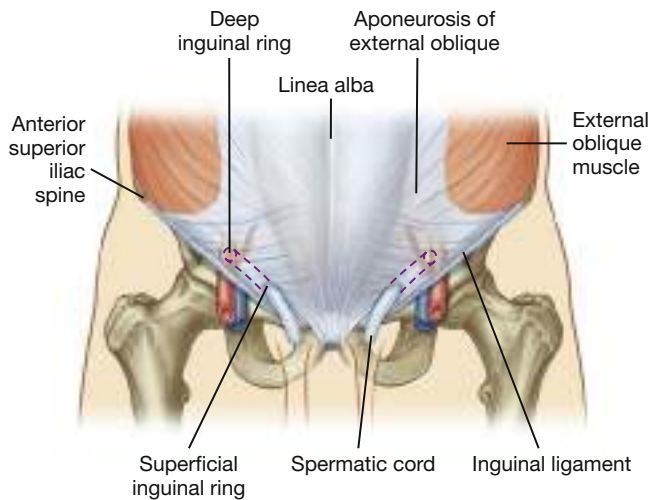


Fig. 4.24 Inguinal canal.

only remaining structure passing through the inguinal canal is the round ligament of the uterus, which is a remnant of the gubernaculum.

The development sequence is concluded in both sexes when the processus vaginalis obliterates. If this does not occur or is incomplete, a potential weakness exists in the anterior abdominal wall and an inguinal hernia may develop. In males, only proximal regions of the processus vaginalis obliterate. The distal end expands to enclose most of the testes in the scrotum. In other words, the cavity of the tunica vaginalis in men forms as an extension of the developing peritoneal cavity that becomes separated off during development.

Inguinal canal

The inguinal canal is a slit-like passage that extends in a downward and medial direction just above and parallel to the lower half of the inguinal ligament. It begins at the deep inguinal ring and continues for approximately 4 cm, ending at the superficial inguinal ring (Fig. 4.24). The contents of the canal are the genital branch of the genitofemoral nerve, the **spermatic cord** in men, and the **round ligament of the uterus** in women. Additionally, in both sexes, the ilio-inguinal nerve passes through part of the canal, exiting through the superficial inguinal ring with the other contents.

Deep inguinal ring

The deep (internal) inguinal ring is the beginning of the inguinal canal and is at a point midway between the anterior superior iliac spine and the pubic symphysis (Fig. 4.25). It is just above the inguinal ligament and immediately lateral to the inferior epigastric vessels. Although sometimes referred to as a defect or opening in the transversalis fascia, it is actually the beginning of the tubular evagination of transversalis fascia that forms one of the coverings (the **internal spermatic fascia**) of the spermatic cord in men or the round ligament of the uterus in women.

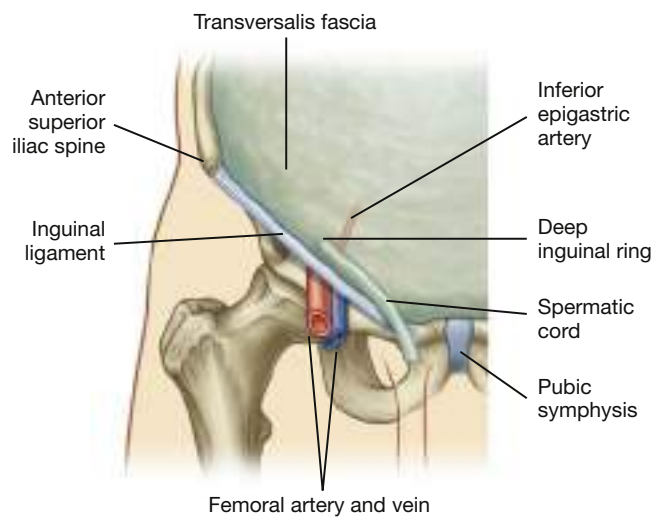


Fig. 4.25 Deep inguinal ring and the transversalis fascia.

Superficial inguinal ring

The superficial (external) inguinal ring is the end of the inguinal canal and is superior to the pubic tubercle (Fig. 4.26). It is a triangular opening in the aponeurosis of the external oblique, with its apex pointing superolaterally and its base formed by the pubic crest. The two remaining sides of the triangle (the **medial crus** and the **lateral crus**) are attached to the pubic symphysis and the pubic tubercle, respectively. At the apex of the triangle the two crura are held together by crossing (intercrural) fibers, which prevent further widening of the superficial ring.

As with the deep inguinal ring, the superficial inguinal ring is actually the beginning of the tubular evagination of the aponeurosis of the external oblique onto the structures traversing the inguinal canal and emerging from the superficial inguinal ring. This continuation of tissue over the spermatic cord is the **external spermatic fascia**.

Anterior wall

The anterior wall of the inguinal canal is formed along its entire length by the aponeurosis of the external oblique muscle (Fig. 4.26). It is also reinforced laterally by the lower fibers of the internal oblique that originate from the lateral two-thirds of the inguinal ligament (Fig. 4.27). This adds an additional covering over the deep inguinal ring, which is a potential point of weakness in the anterior abdominal wall. Furthermore, as the internal oblique muscle covers the deep inguinal ring, it also contributes a layer (the **cremasteric fascia** containing the **cremasteric muscle**) to the coverings of the structures traversing the inguinal canal.

Posterior wall

The posterior wall of the inguinal canal is formed along its entire length by the transversalis fascia (see Fig. 4.25). It is reinforced along its medial one-third by the **conjoint tendon (inguinal falx)** (Fig. 4.27). This tendon is the combined

insertion of the transversus abdominis and internal oblique muscles into the pubic crest and pectineal line.

As with the internal oblique muscle's reinforcement of the area of the deep inguinal ring, the position of the conjoint tendon posterior to the superficial inguinal ring provides additional support to a potential point of weakness in the anterior abdominal wall.

Roof

The roof (superior wall) of the inguinal canal is formed by the arching fibers of the transversus abdominis and internal oblique muscles (Figs. 4.27, 4.28). They pass from their lateral points of origin from the inguinal ligament to their common medial attachment as the conjoint tendon.

Floor

The floor (inferior wall) of the inguinal canal is formed by the medial one-half of the inguinal ligament. This rolled-under, free margin of the lowest part of the aponeurosis of the external oblique forms a gutter or trough on which the contents of the inguinal canal are positioned. The lacunar ligament reinforces most of the medial part of the gutter.

Contents

The contents of the inguinal canal are:

- the spermatic cord in men,
- the round ligament of the uterus in women, and
- the genital branch of the genitofemoral nerve in both men and women.

These structures enter the inguinal canal through the deep inguinal ring and exit it through the superficial inguinal ring.

Additionally, the ilio-inguinal nerve (L1) passes through part of the inguinal canal. This nerve is a branch of the lumbar plexus and enters the abdominal wall posteriorly by piercing the internal surface of the transversus abdominis muscle and continues through the layers of the anterior abdominal wall by piercing the internal oblique muscle. As it continues to pass inferomedially, it enters the inguinal canal. It continues down the canal to exit through the superficial inguinal ring.

Spermatic cord

The spermatic cord begins to form proximally at the deep inguinal ring and consists of structures passing between the

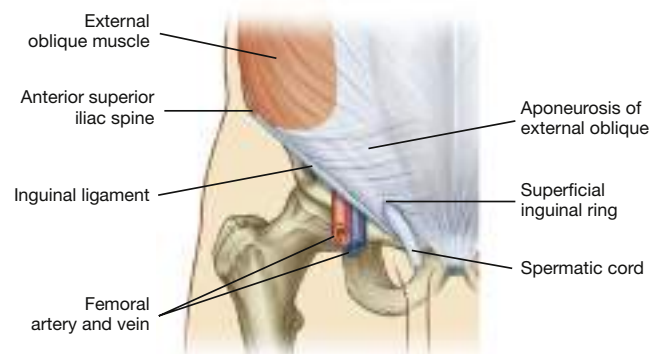


Fig. 4.26 Superficial inguinal ring and the aponeurosis of the external oblique.

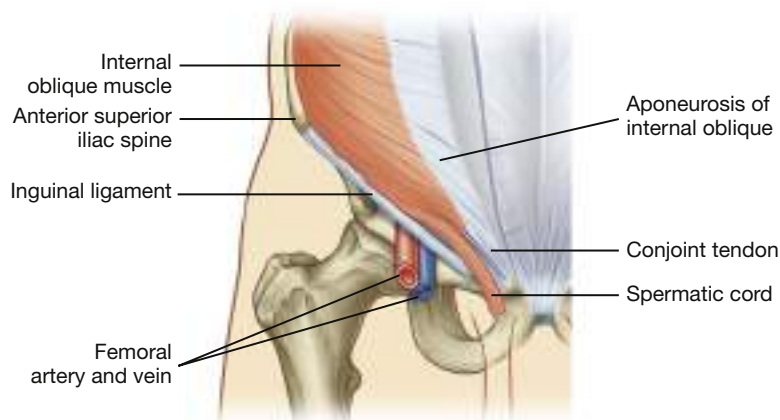


Fig. 4.27 Internal oblique muscle and the inguinal canal.

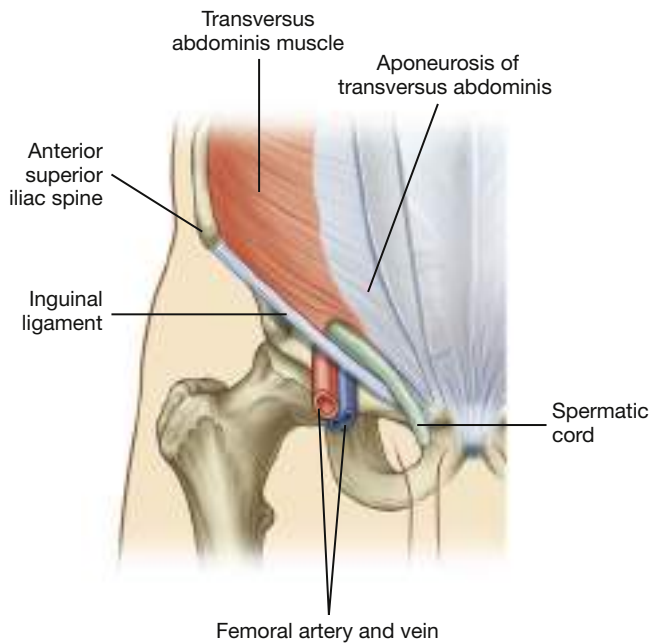


Fig. 4.28 Transversus abdominis muscle and the inguinal canal.

abdominopelvic cavities and the testes and the three fascial coverings that enclose these structures (Fig. 4.29A).

The structures in the spermatic cord include:

- the ductus deferens,
- the artery to ductus deferens (from the inferior vesical artery),
- the testicular artery (from the abdominal aorta),
- the pampiniform plexus of veins (testicular veins),
- the cremasteric artery and vein (small vessels associated with the cremasteric fascia),
- the genital branch of the genitofemoral nerve (innervation to the cremasteric muscle),
- sympathetic and visceral afferent nerve fibers,
- lymphatics, and
- remnants of the processus vaginalis.

These structures enter the deep inguinal ring, proceed down the inguinal canal, and exit from the superficial inguinal ring, having acquired the three fascial coverings during their journey. This collection of structures and fascias

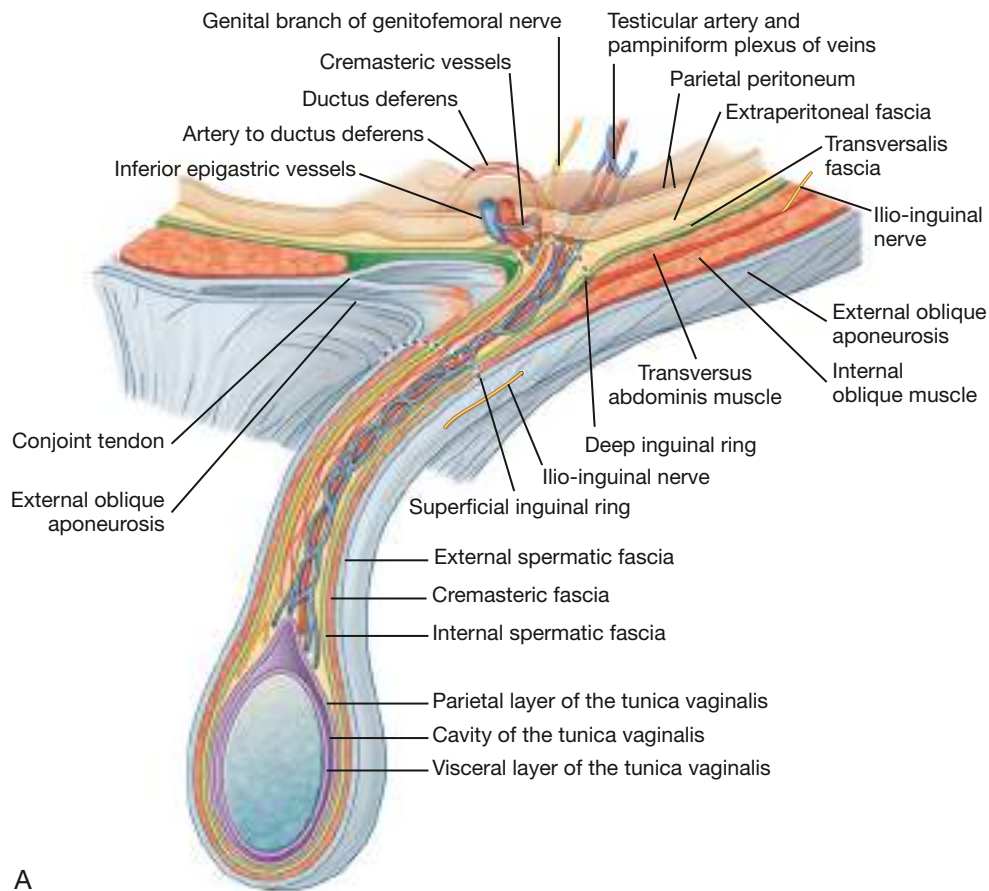


Fig. 4.29 A. Spermatic cord (men).

Continued

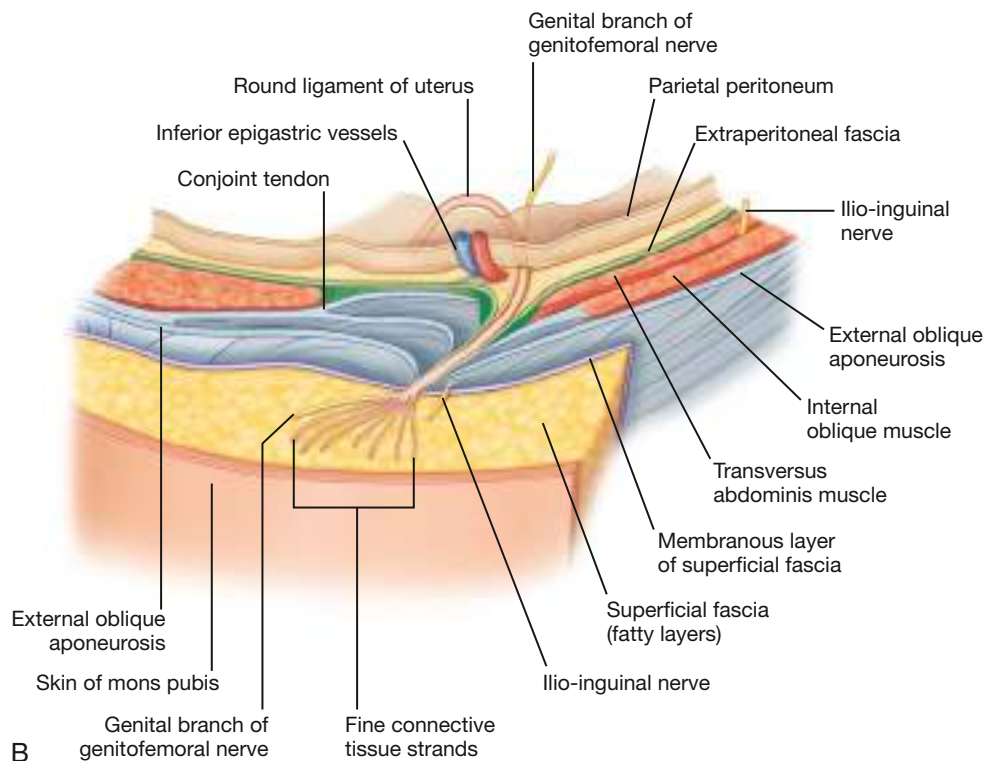


Fig. 4.29, cont'd B. Round ligament of uterus (women).

continues into the scrotum where the structures connect with the testes and the fascias surround the testes.

The fascias enclosing the contents of the spermatic cord include (Fig. 4.29):

- the internal spermatic fascia, which is the deepest layer, arises from the transversalis fascia and is attached to the margins of the deep inguinal ring;
- the cremasteric fascia with the associated cremasteric muscle, which is the middle fascial layer and arises from the internal oblique muscle; and
- the external spermatic fascia, which is the most superficial covering of the spermatic cord, arises from the aponeurosis of the external oblique muscle, and is attached to the margins of the superficial inguinal ring (Fig. 4.29A).

Round ligament of the uterus

The round ligament of the uterus is a cord-like structure that passes from the uterus to the deep inguinal ring where it enters the inguinal canal (Fig. 4.29B). It passes down the inguinal canal and exits through the superficial inguinal ring. At this point, it has changed from a cord-like structure to a few strands of tissue that attach to the connective tissue associated with the labia majora. As it traverses the inguinal canal, it acquires the same coverings as the spermatic cord in men.

The round ligament of the uterus is the long distal part of the original gubernaculum in the fetus that extends

from the ovary to the labioscrotal swellings. From its attachment to the uterus, the round ligament of the uterus continues to the ovary as the ligament of the ovary that develops from the short proximal end of the gubernaculum.

Clinical app

Surgical incisions

Traditionally, incisions have been placed at and around the region of surgical interest. The size of these incisions was usually large to allow good access and optimal visualization of the abdominal cavity.

Currently, the most commonly used large abdominal incision is a central craniocaudal incision from the xiphoid process to the pubic symphysis, which provides wide access to the whole of the abdominal contents and allows an exploratory procedure to be performed (laparotomy).

With the advent of small cameras and the development of minimal access surgery, tiny incisions can be made in the anterior abdominal wall and cameras inserted. The peritoneal cavity is "inflated" with carbon dioxide to increase the space in which the procedure is performed. Further instruments may be inserted through small portholes, and procedures such as cholecystectomy (removal of the gallbladder) and appendectomy (removal of the appendix) can be carried out, allowing the patient to return home sooner.

Surface anatomy

How to find the superficial inguinal ring

The superficial inguinal ring is superior to the pubic crest and tubercle and to the medial end of the inguinal ligament (Fig. 4.30):

- In men, the superficial inguinal ring can be easily located by following the spermatic cord superiorly to the lower abdominal wall—the external spermatic fascia of the spermatic cord is continuous with the margins of the superficial inguinal ring.
- In women, the pubic tubercle can be palpated and the ring is superior and lateral to it.
- The deep inguinal ring, which is the internal opening to the inguinal canal, lies superior to the inguinal ligament midway between the anterior superior iliac spine and pubic symphysis. The pulse of the femoral artery can be felt in the same position but below the inguinal ligament.

Because the superficial inguinal ring is the site where inguinal hernias appear, particularly in men, the ring and related parts of the inguinal canal are often evaluated during physical examination.

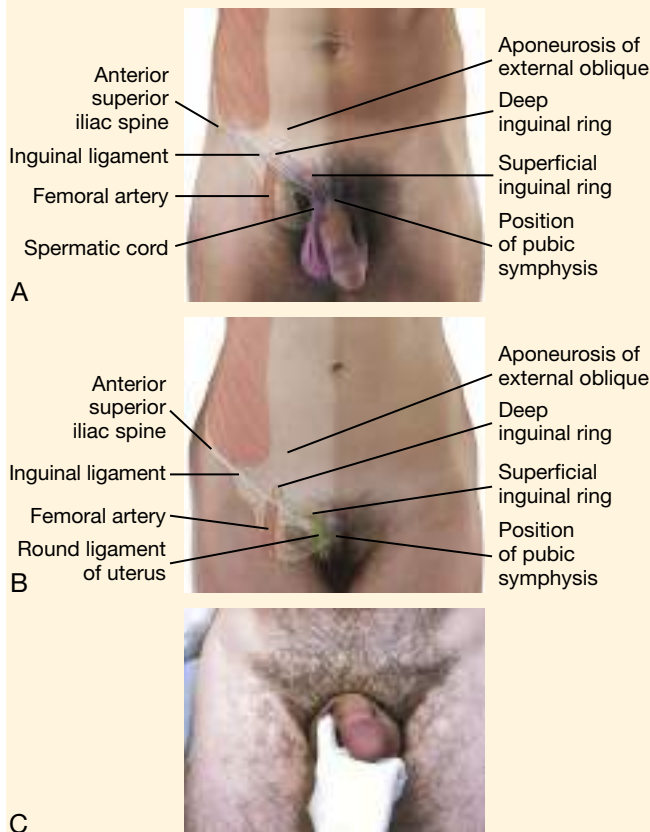


Fig. 4.30 Groin. **A.** In a man. **B.** In a woman. **C.** Examination of the superficial inguinal ring and related regions of the inguinal canal in a man.

Clinical app

Cremasteric reflex

In men, the cremaster muscle and cremasteric fascia form the middle or second covering of the spermatic cord. This muscle and its associated fascia are supplied by the genital branch of the genitofemoral nerve (L1/L2). Contraction of this muscle can be stimulated by a reflex arc. Gentle touch at and around the skin of the medial aspect of the superior part of the thigh stimulates the sensory fibers in the ilio-inguinal nerve. These sensory fibers enter the spinal cord at level L1. At this level, the sensory fibers stimulate the motor fibers carried in the genital branch of the genitofemoral nerve and the testis elevates on the stimulated side.

Clinical app

Masses around the groin

The most common masses in the groin are hernias. A hernia is the protrusion of a viscus, in part or in whole, through a normal or abnormal opening. The viscus usually carries a covering of parietal peritoneum, which forms the lining of the hernial sac.

The key to groin examination is determining the position of the inguinal ligament. The inguinal ligament passes between the anterior superior iliac spine laterally and the pubic tubercle medially. Inguinal hernias are above the inguinal ligament and are usually more apparent on standing. A visual assessment of the lump is necessary, bearing in mind the anatomical landmarks of the inguinal ligament.

In men, it is wise to examine the scrotum to check for a lump. If an abnormal mass is present, an inability to feel its upper edge suggests that it may originate from the inguinal canal and might be a hernia. By placing the hand over the lump and asking the patient to cough, the lump bulges outward.

An attempt should be made to reduce the swelling by applying gentle, firm pressure over the lump. If the lump is reducible, the hand should be withdrawn and careful observation will reveal recurrence of the mass.

The position of an abnormal mass in the groin relative to the pubic tubercle is very important as are the presence of increased temperature and pain, which may represent early signs of strangulation or infection.

As a general rule:

- An inguinal hernia appears through the superficial inguinal ring above the pubic tubercle and crest.
- A femoral hernia appears through the femoral canal below and lateral to the pubic tubercle.

Clinical app

Inguinal hernias

An inguinal hernia is the protrusion or passage of a peritoneal sac, with or without abdominal contents, through a weakened part of the abdominal wall in the groin. It occurs because the peritoneal sac enters the inguinal canal either:

- indirectly through the deep inguinal ring or
- directly through the posterior wall of the inguinal canal.
- Inguinal hernias are therefore classified as either indirect or direct and occur more commonly in men than in women possibly because men have a much larger inguinal canal than women.

Clinical app

Indirect inguinal hernias

The indirect inguinal hernia is the most common of the two types of inguinal hernias and is much more common in men than in women (Fig. 4.31). It usually occurs because some part or all of the embryonic processus vaginalis remains open or patent. It is therefore referred to as being congenital in origin.

The protruding peritoneal sac enters the inguinal canal by passing through the deep inguinal ring just lateral to the inferior epigastric vessels. The extent of its excursion down the inguinal canal depends on the amount of processus vaginalis that remains patent. If the entire processus vaginalis remains patent, the peritoneal sac may traverse the length of the canal, exit the superficial inguinal ring, and continue into the scrotum in men or the labia majus in women. In this case, the protruding peritoneal sac acquires the same coverings as those associated with the spermatic cord in men or the round ligament of the uterus in women.

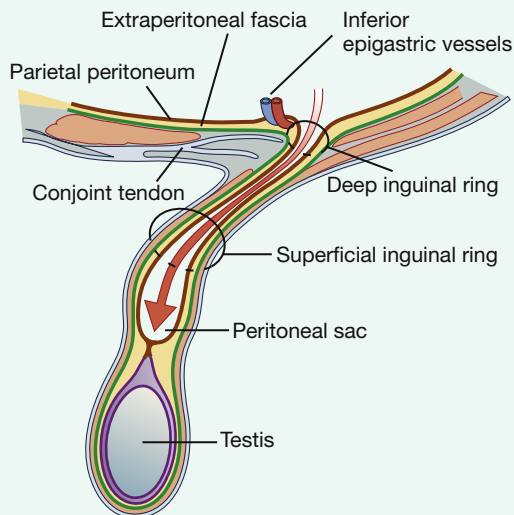


Fig. 4.31 Indirect inguinal hernia.

Clinical app

Direct inguinal hernias

A peritoneal sac that enters the medial end of the inguinal canal directly through a weakened posterior wall is a direct inguinal hernia (Fig. 4.32). It is usually described as acquired because it develops when abdominal musculature has been weakened and is commonly seen in mature men.

This type of inguinal hernia does not traverse the entire length of the inguinal canal but may exit through the superficial inguinal ring. When this occurs, the peritoneal sac acquires a layer of external spermatic fascia and can extend, like an indirect hernia, into the scrotum. Also, unlike indirect inguinal hernias that originate lateral to the inferior epigastric artery, direct inguinal hernias originate medial to the artery (Fig. 4.32).

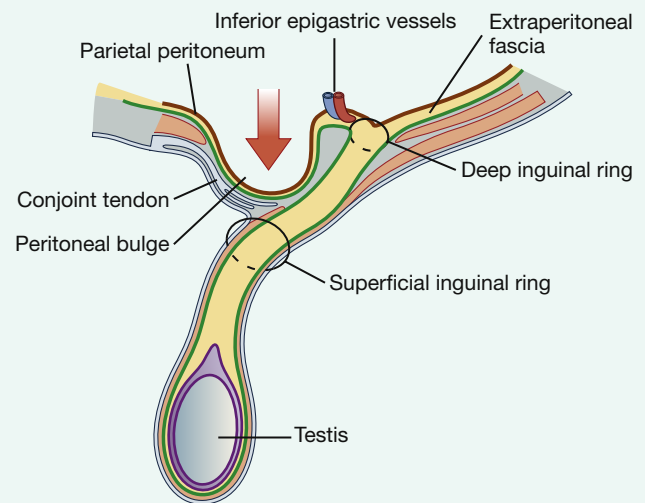


Fig. 4.32 Direct inguinal hernia.

Clinical app

Femoral hernias

A femoral hernia passes through the femoral canal and into the medial aspect of the anterior thigh. The femoral canal lies at the medial edge of the femoral sheath, which contains the femoral artery, femoral vein, and lymphatics. The neck of the femoral canal is extremely narrow and is prone to trapping bowel within the sac, making this type of hernia irreducible and susceptible to bowel strangulation. Femoral hernias are usually acquired, and most commonly occur in middle-aged and elderly populations. In addition, because women generally have wider pelvises than men, they tend to occur more commonly in women.

Clinical app**Umbilical hernias**

Umbilical hernias are rare. Occasionally, they are congenital and result from failure of the small bowel to return to the abdominal cavity from the umbilical cord during development. After birth, umbilical hernias may result from incomplete closure of the umbilicus (navel). Overall, most of these hernias close in the first year of life, and surgical repair is not generally attempted until later.

Para-umbilical hernias may occur in adults at and around the umbilicus and often have small necks, so requiring surgical treatment.

Clinical app**Incisional hernias**

Incisional hernias occur through a defect in a scar of a previous abdominal operation. Usually, the necks of these hernias are wide and do not therefore strangulate the viscera they contain.

Clinical app**Sportsmen's groin/sportsmen's hernia**

The groin can loosely be defined as the area where the leg meets the trunk near the midline. Here the abdominal muscles of the trunk blend in with the adductor muscles of the thigh, the medial end of the inguinal ligament attaches to the pubic tubercle, the pubic symphysis attaches the two pubic bones together, and the superficial (external) inguinal ring occurs. It also is in and around this region where there is considerable translation of force during most athletic and sporting activities. Pain in the groin or pubic region can be due to numerous causes, which include inflammatory changes at the pubic symphysis, insertional problems of the rectus abdominus/adductor longus, and hernias.

Clinical app**Other hernias**

A spigelian hernia passes upward through the arcuate line into the lateral border at the lower part of the posterior rectus sheath. It may appear as a tender mass on one side of the lower anterior abdominal wall.

Abdominopelvic cavity hernias can also develop in association with the pelvic walls, and sites include the obturator canal, the greater sciatic foramen, and above and below the piriformis muscle.

Clinical app**Potential problem of hernias**

One of the potential problems with hernias is that bowel and fat may become stuck within the hernial sac. This can cause appreciable pain and bowel obstruction, necessitating urgent surgery. Another potential risk is **strangulation** of the hernia in which the blood supply to the bowel is cut off at the neck of the hernial sac, rendering the bowel ischemic and susceptible to perforation.

ABDOMINAL VISCERA**Peritoneum**

A thin membrane (the **peritoneum**) lines the walls of the abdominal cavity and covers much of the viscera. The **parietal peritoneum** lines the walls of the cavity, and the **visceral peritoneum** covers the viscera. Between the parietal and visceral layers of peritoneum is a potential space (the **peritoneal cavity**). Abdominal viscera either are suspended in the peritoneal cavity by folds of peritoneum (**mesenteries**) or are outside the peritoneal cavity. Organs suspended in the cavity are referred to as **intraperitoneal** (Fig. 4.33); organs outside

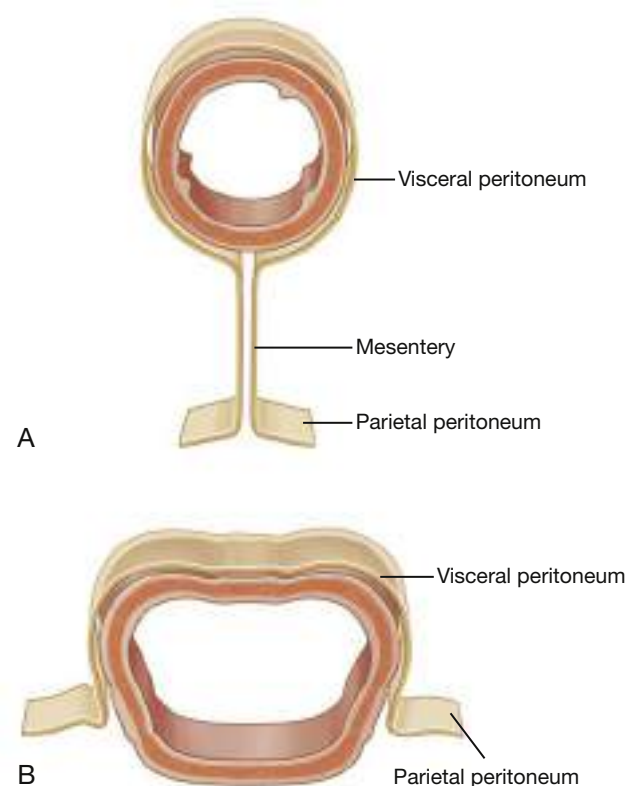


Fig. 4.33 A. Intraperitoneal. B. Retroperitoneal.

the peritoneal cavity, with only one surface or part of one surface covered by peritoneum, are **retroperitoneal**.

Peritoneal cavity

The peritoneal cavity is subdivided into the **greater sac** and the **omental bursa (lesser sac)** (Fig. 4.34).

- The greater sac accounts for most of the space in the peritoneal cavity, beginning superiorly at the diaphragm and continuing inferiorly into the pelvic cavity. It is entered once the parietal peritoneum has been penetrated.
- The omental bursa is a smaller subdivision of the peritoneal cavity posterior to the stomach and liver and is continuous with the greater sac through an opening, the omental (epiploic) foramen (Fig. 4.35).

Surrounding the **omental (epiploic) foramen** are numerous structures covered with peritoneum (Fig. 4.35). They include:

- the portal vein, hepatic artery proper, and bile duct anteriorly;
- the inferior vena cava posteriorly;
- the caudate lobe of the liver superiorly; and
- the first part of the duodenum inferiorly.

Clinical app

The peritoneum

The peritoneum has a large surface area, which facilitates the spread of disease through the peritoneal cavity and over the bowel and visceral surfaces. Conversely, this large surface area can be used for administering certain types of treatment and a number of procedures.

Clinical app

Innervation of peritoneum

The parietal peritoneum associated with the abdominal wall is innervated by somatic afferents carried in branches of the associated spinal nerves and is therefore sensitive to well-localized pain. The visceral peritoneum is innervated by visceral afferents that accompany autonomic nerves (sympathetic and parasympathetic) back to the central nervous system. Activation of these fibers can lead to referred pain and poorly localized sensations of discomfort and to reflex visceral motor activity.

Clinical app

Ventriculoperitoneal shunts

Patients with obstructive hydrocephalus (an excessive accumulation of cerebrospinal fluid within the cerebral ventricular system) require continuous drainage of this fluid. This is achieved by placing a catheter through the skull into the cerebral ventricles and placing the extracranial part of the tube beneath the scalp and skin of the chest wall and then passing it through the abdominal wall into the peritoneal cavity. Cerebrospinal fluid drains through the tube into the peritoneal cavity where it is absorbed.

Clinical app

Hemodialysis and peritoneal dialysis

People who develop renal failure require dialysis to live. There are two methods.

In the first method (**hemodialysis**), blood is taken from the circulation, dialyzed through a complex artificial membrane, and returned to the body. A high rate of blood flow is required to remove excess body fluid, exchange electrolytes, and remove noxious metabolites. To accomplish this, either an arteriovenous fistula is established surgically and is cannulated each time the patient returns for dialysis, or a large-bore cannula is placed into the right atrium through which blood can be aspirated and returned.

In the second method (peritoneal dialysis), the peritoneum is used as the dialysis membrane. The large surface area of the peritoneal cavity is an ideal dialysis membrane for fluid and electrolyte exchange. To accomplish dialysis, a small tube is inserted through the abdominal wall and dialysis fluid is injected into the peritoneal cavity. Electrolytes and molecules are exchanged across the peritoneum between the fluid and blood. Once dialysis is completed, the fluid is drained.

Clinical app

Peritoneal spread of disease

The large surface area of the peritoneal cavity allows infection and malignant disease to spread easily throughout the abdomen. If malignant cells enter the peritoneal cavity by direct invasion (e.g., from colon or ovarian cancer), spread may be rapid. Similarly, a surgeon excising a malignant tumor and releasing malignant cells into the peritoneal cavity may cause an appreciable worsening of the patient's prognosis.

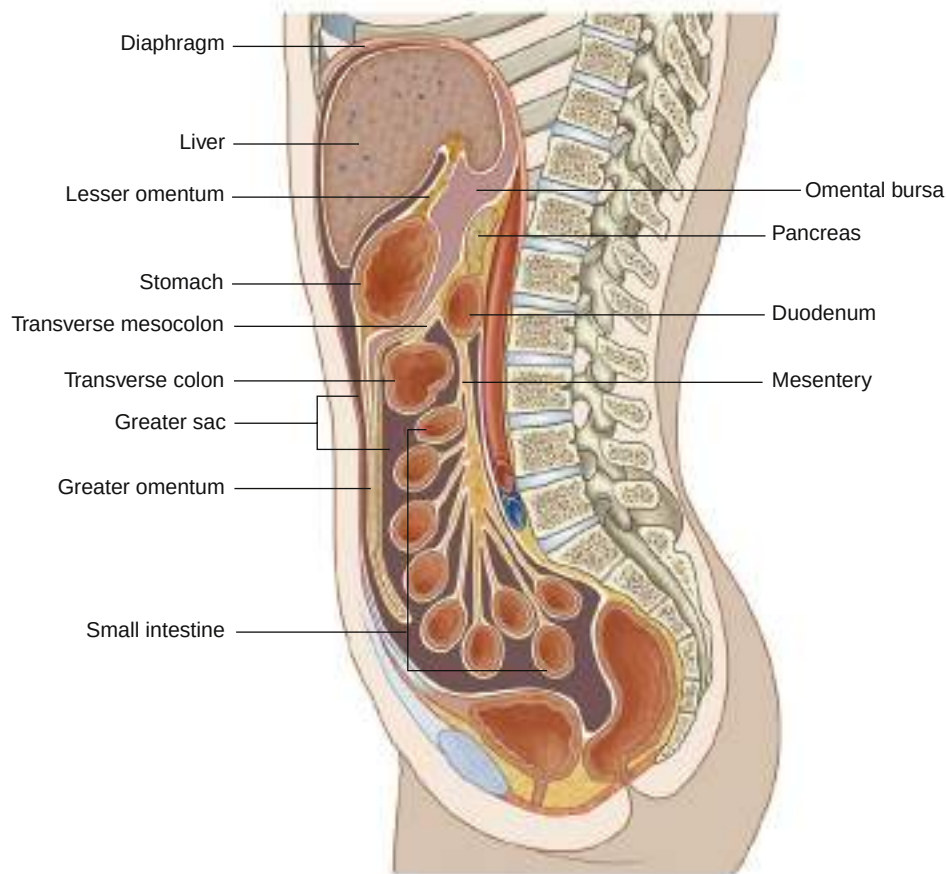


Fig. 4.34 Greater and lesser sacs of the peritoneal cavity.

Clinical app

Perforated bowel

A perforated bowel (e.g., caused by a perforated duodenal ulcer) often leads to the release of gas into the peritoneal cavity. This peritoneal gas can be easily visualized on a chest radiograph with the patient standing, where gas can be demonstrated in extremely small amounts beneath the diaphragm. A patient with severe abdominal pain and subdiaphragmatic gas needs a laparotomy.

Omenta, mesenteries, and ligaments

Throughout the peritoneal cavity, numerous peritoneal folds connect organs to each other or to the abdominal wall. These folds (omenta, mesenteries, and ligaments) develop from the original dorsal and ventral mesenteries, which suspend the developing gastrointestinal tract in the embryonic coelomic cavity. Some contain vessels and nerves supplying the viscera, whereas others help maintain the proper positioning of the viscera.

Omenta

The omenta consist of two layers of peritoneum, which pass from the stomach and the first part of the duodenum to other viscera. There are two:

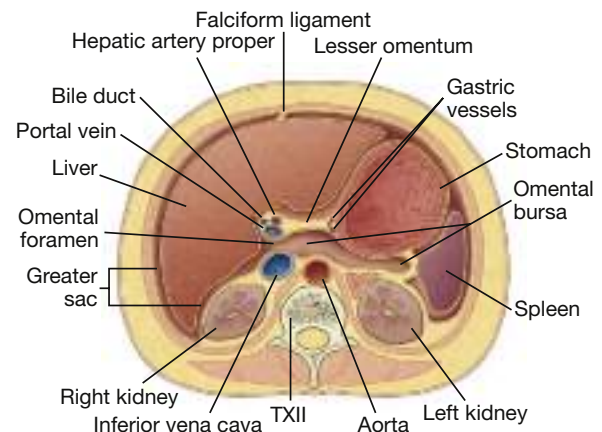


Fig. 4.35 Transverse section illustrating the continuity between the greater and lesser sacs through the omental (epiploic) foramen.

- the greater omentum derived from the dorsal mesentery and
- the lesser omentum derived from the ventral mesentery.

Greater omentum

The **greater omentum** is a large, apron-like, peritoneal fold that attaches to the greater curvature of the stomach and the first part of the duodenum (Fig. 4.36). It drapes inferiorly over the

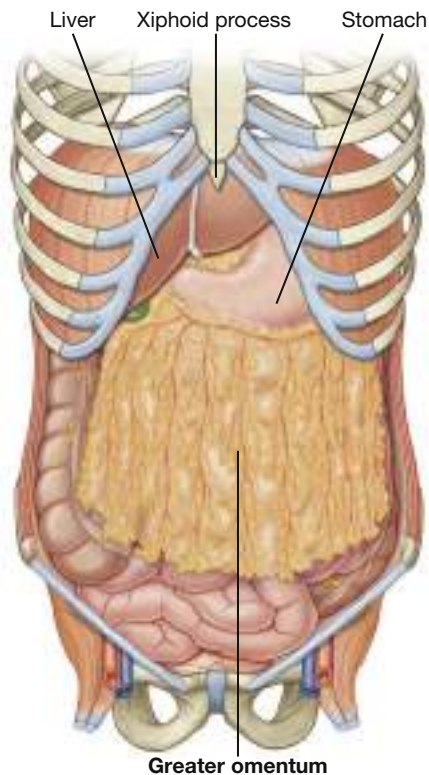


Fig. 4.36 Greater omentum.

transverse colon and the coils of the jejunum and ileum (see Fig. 4.34). Turning posteriorly, it ascends to associate with, and become adherent to, the peritoneum on the superior surface of the transverse colon and the anterior layer of the transverse mesocolon before arriving at the posterior abdominal wall.

Usually a thin membrane, the greater omentum always contains an accumulation of fat, which may become substantial in some individuals. Additionally, there are two arteries and accompanying veins, the **right and left gastro-omental vessels**, between this double-layered peritoneal apron just inferior to the greater curvature of the stomach.

Lesser omentum

The other two-layered peritoneal omentum is the **lesser omentum** (Fig. 4.37). It extends from the lesser curvature of the stomach and the first part of the duodenum to the inferior surface of the liver (Fig. 4.37; also see Fig. 4.34).

A thin membrane continuous with the peritoneal coverings of the anterior and posterior surfaces of the stomach and the first part of the duodenum, the lesser omentum is divided into:

- a medial **hepatogastric ligament**, which passes between the stomach and liver, and
- a lateral **hepatoduodenal ligament**, which passes between the duodenum and liver.

The hepatoduodenal ligament ends laterally as a free margin and serves as the anterior border of the omental foramen (see Fig. 4.35). Enclosed in this free edge are the hepatic artery proper, the bile duct, and the portal vein. Additionally, the right and left gastric vessels are between the layers of the lesser omentum near the lesser curvature of the stomach.

Clinical app

The greater omentum

When a laparotomy is performed and the peritoneal cavity is opened, the first structure usually encountered is the greater omentum. This fatty double-layered vascular membrane hangs like an apron from the greater curvature of the stomach, drapes over the transverse colon, and lies freely suspended within the abdominal cavity. It is often referred to as the *policeman of the abdomen* because of its apparent ability to migrate to any inflamed area and wrap itself around the organ to wall off inflammation.

The greater omentum is also an important site for metastatic tumor spread. Direct omental spread by a transcoelomic route is common for carcinoma of the ovary.

Mesenteries

Mesenteries are peritoneal folds that attach viscera to the posterior abdominal wall. They allow some movement and provide a conduit for vessels, nerves, and lymphatics to reach the viscera and include:

- the mesentery—associated with parts of the small intestine,
- the transverse mesocolon—associated with the transverse colon, and
- the sigmoid mesocolon—associated with the sigmoid colon.

All of these are derivatives of the dorsal mesentery.

Mesentery

The **mesentery** is a large, fan-shaped, double-layered fold of peritoneum that connects the jejunum and ileum to the posterior abdominal wall (Fig. 4.38). Its superior attachment is at the duodenojejunal junction just to the left of the upper lumbar part of the vertebral column. It passes obliquely downward and to the right, ending at the ileocecal junction near the upper border of the right sacro-iliac joint. In the fat between the two peritoneal layers of the mesentery are the arteries, veins, nerves, and lymphatics that supply the jejunum and ileum.

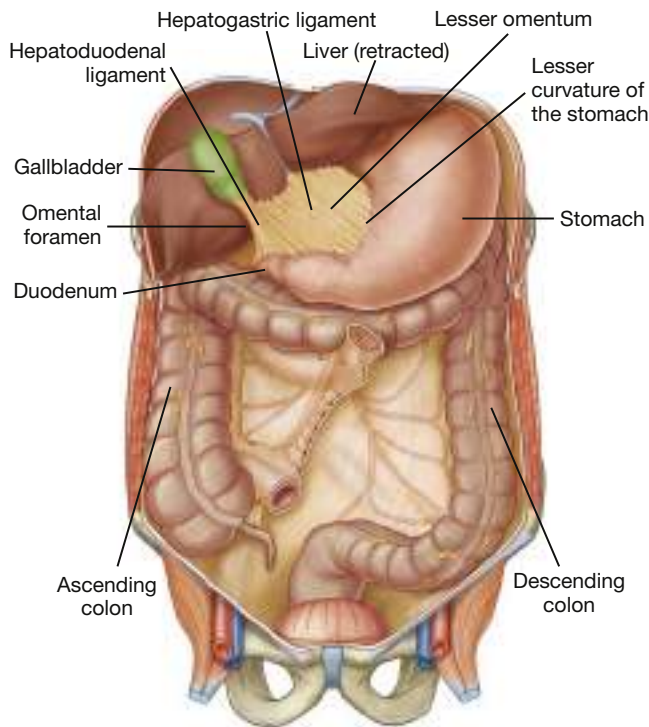


Fig. 4.37 Lesser omentum.

Transverse mesocolon

The **transverse mesocolon** is a fold of peritoneum that connects the transverse colon to the posterior abdominal wall (Fig. 4.38, also see Fig. 4.34). Its two layers of peritoneum leave the posterior abdominal wall across the anterior surface of the head and body of the pancreas and pass outward to surround the transverse colon. Between its layers are the arteries, veins, nerves, and lymphatics related to the transverse colon. The anterior layer of the transverse mesocolon is adherent to the posterior layer of the greater omentum.

Sigmoid mesocolon

The **sigmoid mesocolon** is an inverted, V-shaped peritoneal fold that attaches the sigmoid colon to the abdominal wall (Fig. 4.38). The apex of the V is near the division of the left common iliac artery into its internal and external branches, with the left limb of the descending V along the medial border of the left psoas major muscle and the right limb descending into the pelvis to end at the level of vertebra SIII. The sigmoid and superior rectal vessels, along with the nerves and lymphatics associated with the sigmoid colon, pass through this peritoneal fold.

Ligaments

Peritoneal ligaments consist of two layers of peritoneum that connect two organs to each other or attach an organ to the

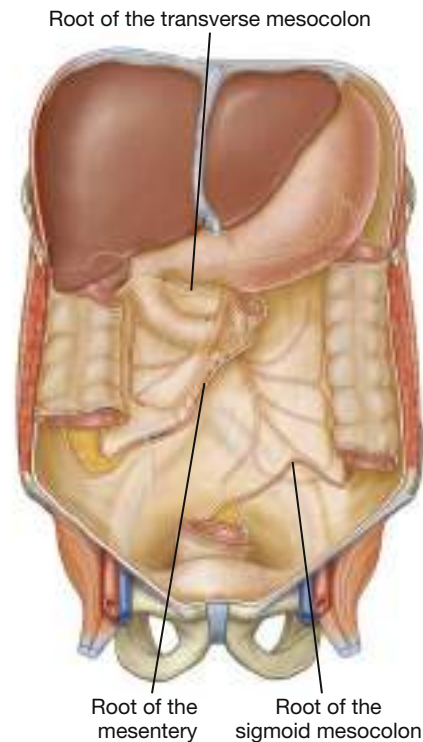


Fig. 4.38 Peritoneal reflections, forming mesenteries, outlined on the posterior abdominal wall.

body wall and may form part of an omentum. They are usually named after the structures being connected. For example, the splenorenal ligament connects the left kidney to the spleen and the gastrophrenic ligament connects the stomach to the diaphragm.

Organs

Abdominal esophagus

The abdominal esophagus represents the short distal part of the esophagus located in the abdominal cavity. Emerging through the right crus of the diaphragm usually at the level of vertebra TX, it passes from the esophageal hiatus to the cardiac orifice of the stomach just left of the midline (Fig. 4.39).

Associated with the esophagus as it enters the abdominal cavity are the anterior and posterior vagal trunks:

- The **anterior vagal trunk** consists of several smaller trunks whose fibers mostly come from the left vagus nerve; rotation of the gut during development moves these trunks to the anterior surface of the esophagus.
- Similarly, the **posterior vagal trunk** consists of a single trunk whose fibers mostly come from the right vagus nerve, and rotational changes during development move this trunk to the posterior surface of the esophagus.

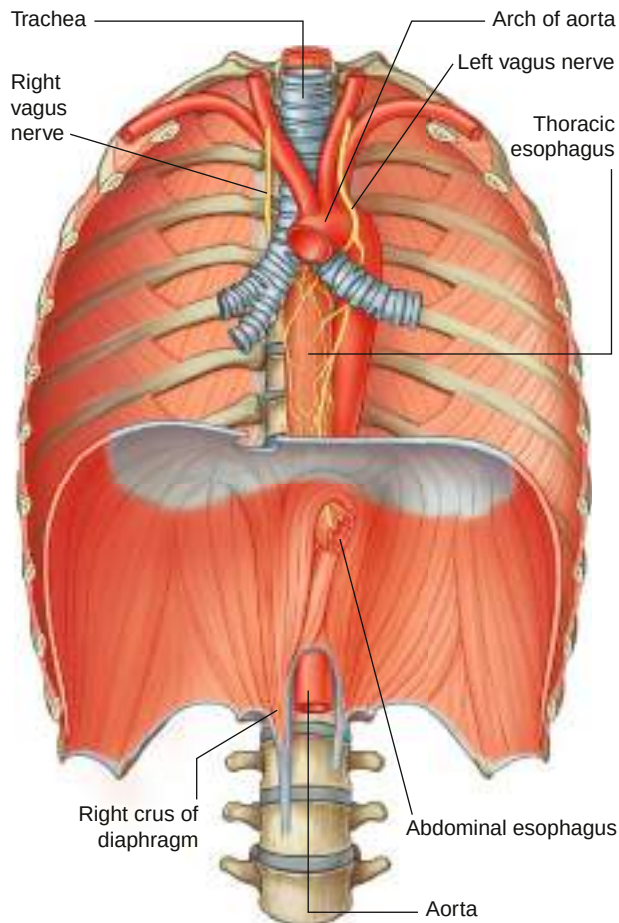


Fig. 4.39 Abdominal esophagus.

The arterial supply to the abdominal esophagus (Fig. 4.40) includes:

- esophageal branches from the left gastric artery (from the celiac trunk) and
- esophageal branches from the left inferior phrenic artery (from the abdominal aorta).

Stomach

The stomach is the most dilated part of the gastrointestinal tract and has a J-like shape (Figs. 4.41, 4.42). Positioned between the abdominal esophagus and the small intestine, the stomach is in the epigastric, umbilical, and left hypochondrium regions of the abdomen.

The stomach is divided into four regions (Fig. 4.41):

- the **cardia**, which surrounds the opening of the esophagus into the stomach,
- the **fundus of stomach**, which is the area above the level of the cardiac orifice,
- the **body of stomach**, which is the largest region of the stomach; and

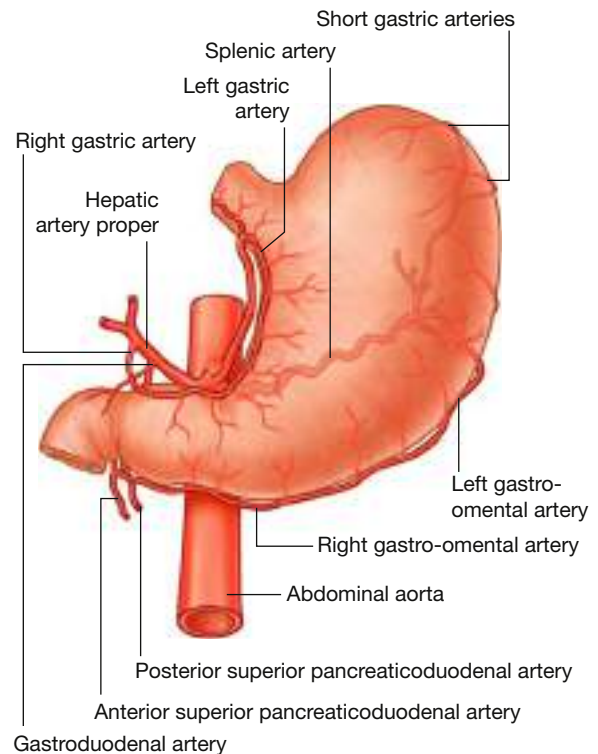


Fig. 4.40 Arterial supply to the abdominal esophagus and stomach.

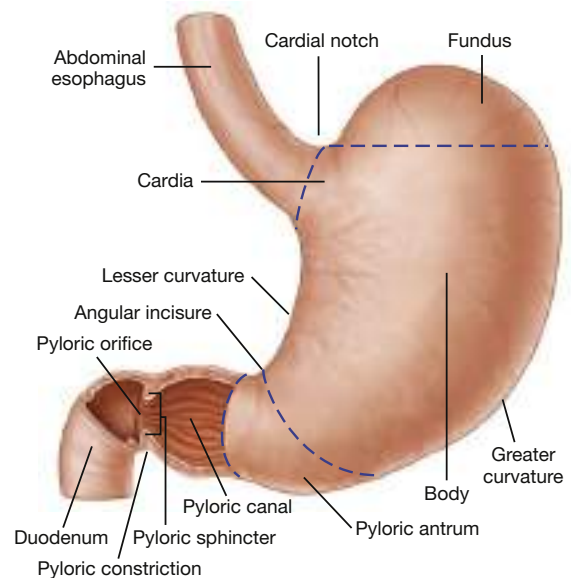


Fig. 4.41 Stomach.

- the **pyloric part**, which is divided into the **pyloric antrum** and **pyloric canal** and is the distal end of the stomach (Fig. 4.41).

The most distal portion of the pyloric part of the stomach is the **pylorus** (Fig. 4.41). It is marked on the surface of the

organ by the **pyloric constriction** and contains a thickened ring of gastric circular muscle, the **pyloric sphincter**, which surrounds the distal opening of the stomach, the **pyloric orifice**. The pyloric orifice is just to the right of midline in a plane that passes through the lower border of vertebra LI (the **transpyloric plane**).

Other features of the stomach include:

- the **greater curvature**, which is a point of attachment for the gastrosplenic ligament and the greater omentum;
- the **lesser curvature**, which is a point of attachment for the lesser omentum;
- the **cardial notch**, which is the superior angle created when the esophagus enters the stomach; and
- the **angular incisure**, which is a bend on the lesser curvature.

The arterial supply to the stomach (Fig. 4.40) includes:

- the left gastric artery from the celiac trunk,
- the right gastric artery often from the hepatic artery proper,
- the right gastro-omental artery from the gastroduodenal artery,
- the left gastro-omental artery from the splenic artery, and
- the posterior gastric artery from the splenic artery (variant and not always present).

Imaging app

Visualizing the stomach

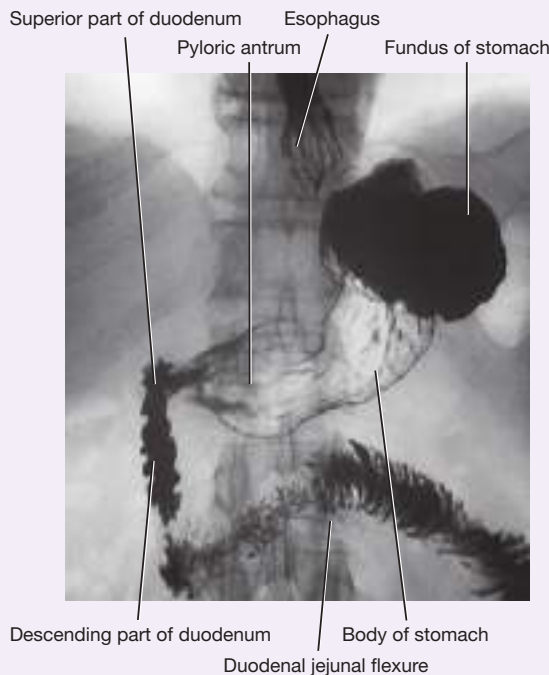


Fig. 4.42 Double-contrast radiograph of the stomach and duodenum.

Small intestine

The small intestine is the longest part of the gastrointestinal tract and extends from the pyloric orifice of the stomach to the ileocecal fold. This hollow tube, which is approximately 6 to 7 m long with a narrowing diameter from beginning to end, consists of the duodenum, the jejunum, and the ileum.

Duodenum

The first part of the small intestine is the duodenum. This C-shaped structure adjacent to the head of the pancreas is 20 to 25 cm long and is above the level of the umbilicus; its lumen is the widest of the small intestine (Fig. 4.43). It is retroperitoneal except for its beginning, which is connected to the liver by the hepatoduodenal ligament, a part of the lesser omentum.

The duodenum is divided into four parts (Fig. 4.43).

- The **superior part** (first part) extends from the pyloric orifice of the stomach to the neck of the gallbladder, is just to the right of the body of vertebra LI, and passes anteriorly to the bile duct, gastroduodenal artery, portal vein, and inferior vena cava. Clinically, the beginning of this part of the duodenum is referred to as the **ampulla** or **duodenal cap**, and most duodenal ulcers occur in this part of the duodenum.
- The **descending part** (second part) of the duodenum is just to the right of midline and extends from the neck of the gallbladder to the lower border of vertebra LIII. Its anterior surface is crossed by the transverse colon, posterior to it is the right kidney, and medial to it is the head of the pancreas. This part of the duodenum contains the **major duodenal papilla**, which is the common entrance for the bile and pancreatic ducts, and the **minor duodenal papilla**, which is the entrance for the accessory pancreatic duct. The junction of the foregut and the midgut occurs just below the major duodenal papilla.
- The **inferior part** (third part) of the duodenum is the longest section crossing the inferior vena cava, the aorta, and the vertebral column (Figs. 4.42, 4.43). It is crossed anteriorly by the superior mesenteric artery and vein.
- The **ascending part** (fourth part) of the duodenum passes upward on, or to the left of, the aorta to approximately the upper border of vertebra LII and terminates at the **duodenojejunal flexure**.

This duodenojejunal flexure is surrounded by a fold of peritoneum containing muscle fibers called the **suspensory muscle (ligament) of duodenum (ligament of Treitz)**.

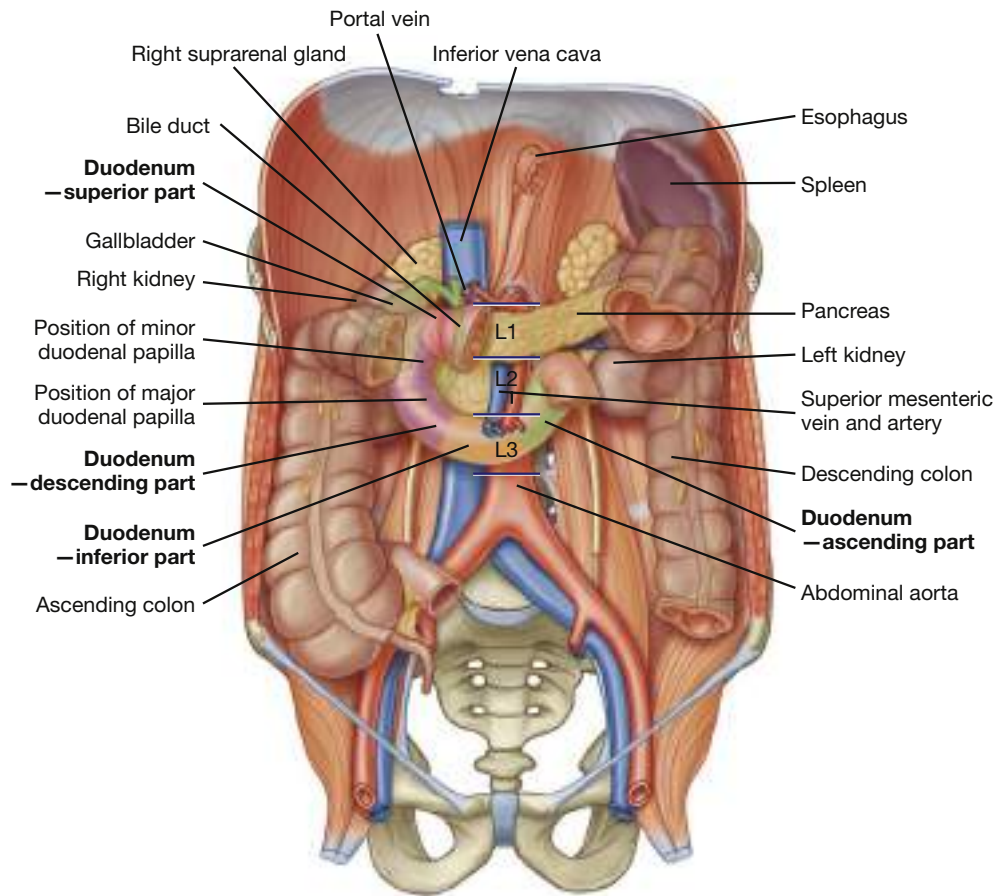


Fig. 4.43 Duodenum.

The arterial supply to the duodenum (Fig. 4.44) includes:

- branches from the gastroduodenal artery,
- the supraduodenal artery from the gastroduodenal artery,
- duodenal branches from the anterior superior pancreaticoduodenal artery (from the gastroduodenal artery),
- duodenal branches from the posterior superior pancreaticoduodenal artery (from the gastroduodenal artery),
- duodenal branches from the anterior inferior pancreaticoduodenal artery (from the inferior pancreaticoduodenal artery—a branch of the superior mesenteric artery),
- duodenal branches from the posterior inferior pancreaticoduodenal artery (from the inferior pancreaticoduodenal artery—a branch of the superior mesenteric artery), and
- the first jejunal branch from the superior mesenteric artery.

Jejunum

The jejunum and ileum make up the last two sections of the small intestine (Fig. 4.45). The jejunum represents the

proximal two-fifths. It is mostly in the left upper quadrant of the abdomen and is larger in diameter and has a thicker wall than the ileum. Additionally, the inner mucosal lining of the jejunum is characterized by numerous prominent folds that circle the lumen (plicae circulares). The less prominent arterial arcades and longer vasa recta (straight arteries) compared with those of the ileum are a unique characteristic of the jejunum (Fig. 4.46).

The arterial supply to the jejunum includes jejunal arteries from the superior mesenteric artery (Fig. 4.47).

Ileum

The ileum makes up the distal three-fifths of the small intestine and is mostly in the right lower quadrant. Compared with the jejunum, the ileum has thinner walls, fewer and less prominent mucosal folds (plicae circulares), shorter vasa recta, more mesenteric fat, and more arterial arcades (Fig. 4.46).

The ileum opens into the large intestine where the cecum and ascending colon join together. Two flaps

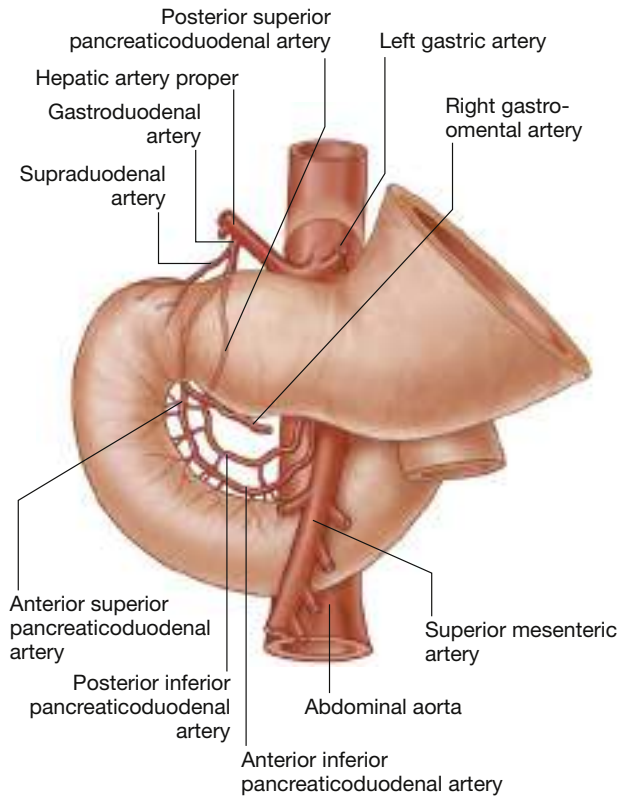


Fig. 4.44 Arterial supply to the duodenum.

Imaging app

Visualizing the jejunum and ileum

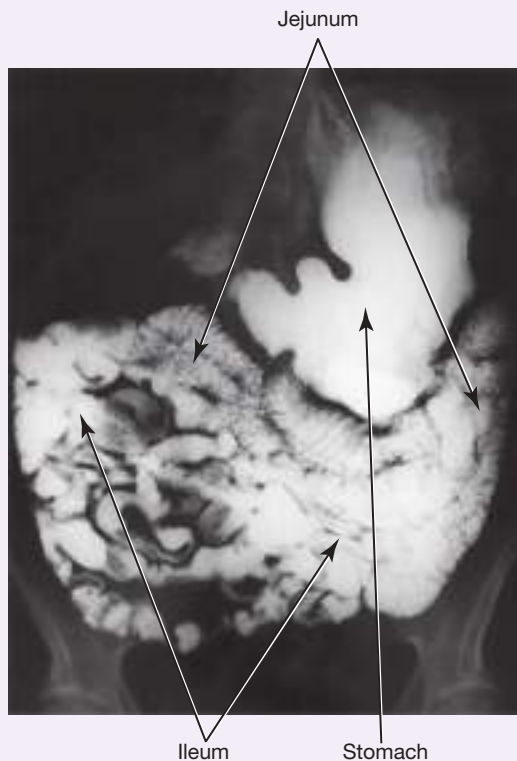


Fig. 4.45 Radiograph of the jejunum and ileum.

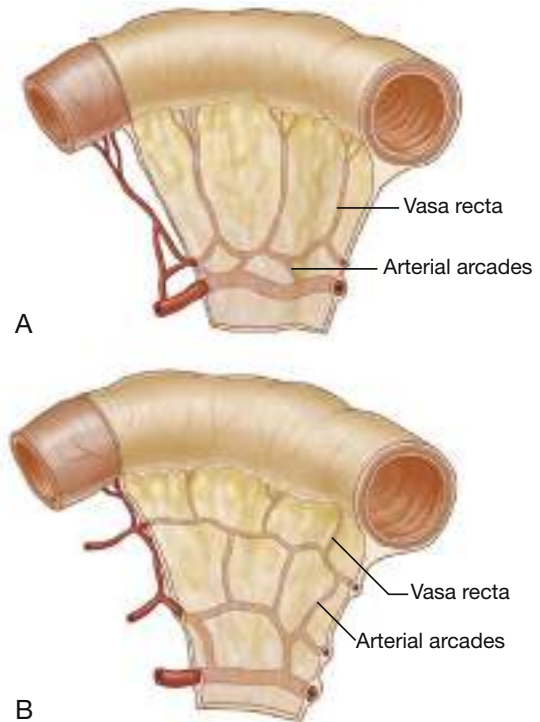


Fig. 4.46 Differences in the arterial supply to the small intestine. A. Jejunum. B. Ileum.

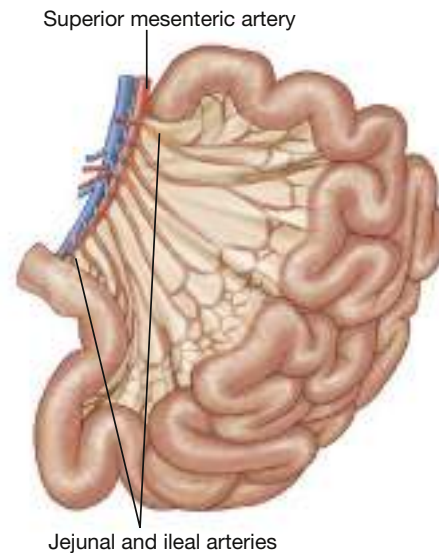


Fig. 4.47 Arterial supply to the ileum and jejunum.

Clinical app

Epithelial transition between the abdominal esophagus and stomach

The gastroesophageal junction is demarcated by a transition from one epithelial type (nonkeratinized stratified squamous

Clinical app—cont'd

epithelium) to another epithelial type (columnar epithelium). In some people, the histological junction does not lie at the anatomical gastroesophageal junction but occurs more proximally in the lower one-third of the esophagus. This may predispose these people to esophageal ulceration and is also associated with an increased risk of adenocarcinoma.

Clinical app

Surgery for obesity

Surgical procedures for obesity are divided into malabsorption and restrictive procedures.

Malabsorption procedures

In these procedures, the stomach is surgically anastomosed to the distal jejunum/ileum so that the stomach contents bypass most of the small intestine. There are certain complications of malabsorption procedures, which include anemia, osteoporosis, and diarrhea.

Restrictive procedures

These procedures involve placing bands around the stomach to reduce the amount of food that can be ingested and also produce an earlier feeling of satiety.

Clinical app

Duodenal ulceration

Duodenal ulcers usually occur in the superior part of the duodenum:

- Posterior duodenal ulcers erode either directly onto the gastroduodenal artery or, more commonly, onto the posterior superior pancreaticoduodenal artery, which can produce torrential hemorrhage and may be fatal in some patients. Treatment may involve extensive upper abdominal surgery with ligation of the vessels or by endovascular means, whereby the radiologist may place a very fine catheter retrograde from the femoral artery into the celiac artery. The common hepatic artery and the gastroduodenal artery are cannulated, and the bleeding area may be blocked using small coils, which stem the flow of blood.
- Anterior duodenal ulcers erode into the peritoneal cavity, causing peritonitis. This intense inflammatory reaction and the local ileus promote adhesion of the greater omentum, which attempts to seal off the perforation. The stomach and duodenum usually contain considerable amounts of gas, which enters the peritoneal cavity and can be observed on a chest radiograph of an erect patient as subdiaphragmatic gas.

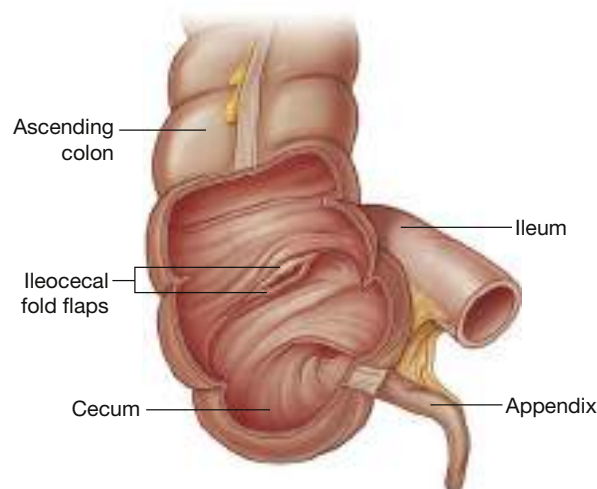


Fig. 4.48 Illustration showing ileocecal junction and the ileocecal fold.

Clinical app

Examination of the bowel lumen

Barium sulfate solutions may be swallowed by the patient and can be visualized using an X-ray fluoroscopy unit. The lumen can be examined for masses (e.g., polyps and tumors), and peristaltic waves can be assessed. Patients may also be given carbon dioxide-releasing granules to fill the stomach so that the barium thinly coats the mucosa, resulting in images displaying fine mucosal detail.

Clinical app

Meckel's diverticulum

A Meckel's diverticulum is the remnant of the proximal part of the yolk stalk (vitelline duct), which extends into the umbilical cord in the embryo and lies on the antimesenteric border of the ileum. Although it is an uncommon finding (occurring in approximately 2% of the population), it is always important to consider the diagnosis of Meckel's diverticulum because it does produce symptoms in a small number of patients.

Clinical app

Carcinoma of the stomach

Carcinoma of the stomach is a common gastrointestinal malignancy. Chronic gastric inflammation (gastritis), pernicious anemia, and polyps predispose to the development of this aggressive cancer, which is usually not diagnosed until late in the course of the disease.

Clinical app—cont'd

The diagnosis may be made using barium and conventional radiology or endoscopy, which allows a biopsy to be obtained at the same time. Ultrasound scanning is used to check the liver for metastatic spread, and, if negative, computed tomography is carried out to assess for surgical resectability. If carcinoma of the stomach is diagnosed early, a curative surgical resection is possible.

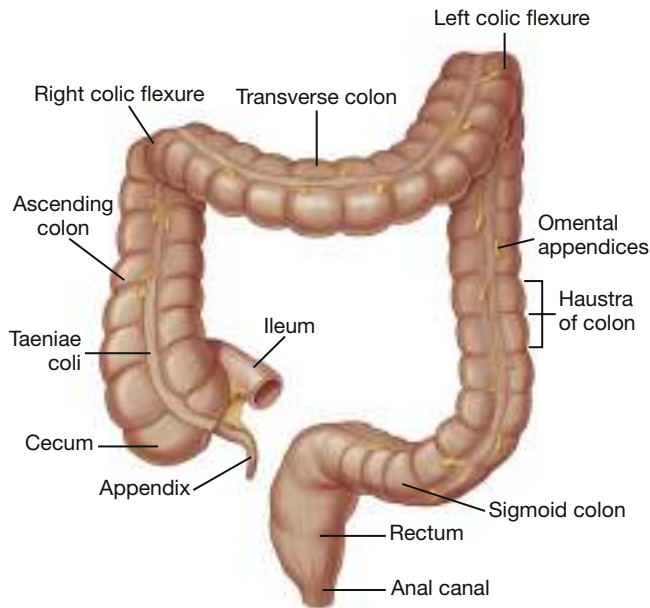


Fig. 4.49 Large intestine.

projecting into the lumen of the large intestine (the **ileocecal fold**) surround the opening (Fig. 4.48). The flaps of the ileocecal fold come together at their end, forming ridges. Musculature from the ileum continues into each flap, forming a sphincter. Possible functions of the ileocecal fold include preventing reflux from the cecum to the ileum and regulating the passage of contents from the ileum to the cecum.

The arterial supply to the ileum (Fig. 4.47) includes:

- ileal arteries from the superior mesenteric artery and
- an ileal branch from the ileocolic artery (from the superior mesenteric artery).

Large intestine

The large intestine extends from the distal end of the ileum to the anus, a distance of approximately 1.5 m in adults. It absorbs fluids and salts from the gut contents, thus forming feces, and consists of the cecum, appendix, colon, rectum, and anal canal (Figs. 4.49, 4.50).

Imaging app

Visualizing the large intestine



Fig. 4.50 Radiograph, using barium, showing the large intestine.

Beginning in the right groin as the cecum with its associated appendix, the large intestine continues upward as the **ascending colon** through the right flank and into the right hypochondrium (Fig. 4.51). Just below the liver it bends to the left, forming the **right colic flexure (hepatic flexure)**, and crosses the abdomen as the **transverse colon** to the left hypochondrium. At this position just below the spleen, the large intestine bends downward, forming the **left colic flexure (splenic flexure)**, and continues as the **descending colon** through the left flank and into the left groin.

It enters the upper part of the pelvic cavity as the sigmoid colon, continues on the posterior wall of the pelvic cavity as the rectum, and terminates as the anal canal.

The general characteristics of most of the large intestine (Fig. 4.49) are:

- its large internal diameter compared to that of the small intestine;
- peritoneal-covered accumulations of fat (the **omental appendices**) are associated with the colon;

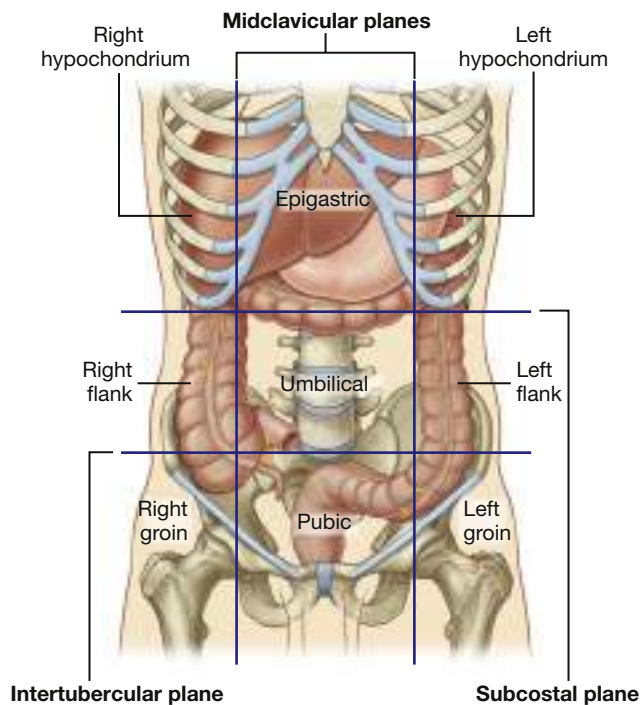


Fig. 4.51 Position of the large intestine in the nine-region organizational pattern.

- the segregation of longitudinal muscle in its walls into three narrow bands (the **taenia coli**), which are primarily observed in the cecum and colon and less visible in the rectum; and
- the sacculations of the colon (the **hastra of colon**).

Cecum and appendix

The **cecum** is the first part of the large intestine (Fig. 4.52). It is inferior to the ileocecal opening and in the right iliac fossa. It is generally considered to be an intraperitoneal structure because of its mobility, even though it normally is not suspended in the peritoneal cavity by a mesentery.

The cecum is continuous with the ascending colon at the entrance of the ileum and is usually in contact with the anterior abdominal wall. It may cross the pelvic brim to lie in the true pelvis. The appendix is attached to the posteromedial wall of the cecum just inferior to the end of the ileum (Fig. 4.52).

The **appendix** is a narrow, hollow, blind-ended tube connected to the cecum. It has large aggregations of lymphoid tissue in its walls and is suspended from the terminal ileum by the **mesoappendix** (Fig. 4.53), which contains the **appendicular vessels**. Its point of attachment to the cecum is consistent with the highly visible free taenia leading directly to the base of the appendix, but the location of the rest of the appendix varies considerably (Fig. 4.54). It may be:

- posterior to the cecum or the lower ascending colon, or both, in a retrocecal or retrocolic position;
- suspended over the pelvic brim in a pelvic or descending position;

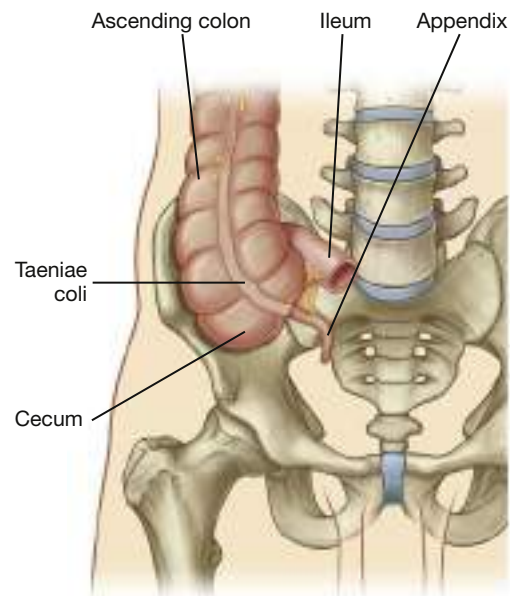


Fig. 4.52 Cecum and appendix.

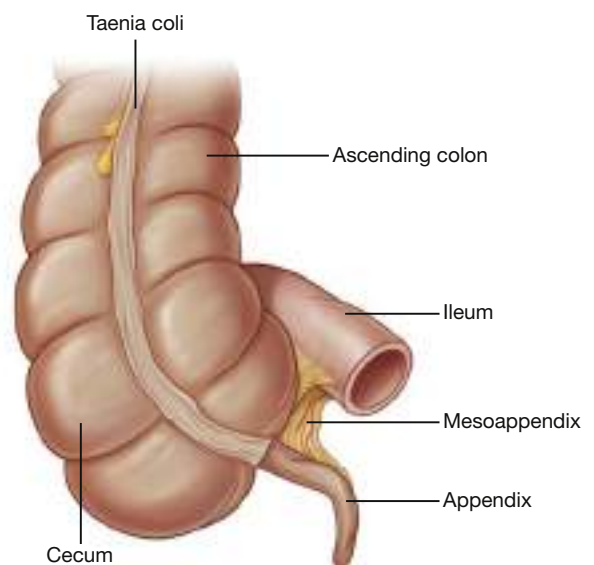


Fig. 4.53 Mesoappendix.

- below the cecum in a subcecal location; or
- anterior to the terminal ileum, possibly contacting the body wall in a preileal position or posterior to the terminal ileum in a postileal position.

The surface projection of the base of the appendix is at the junction of the lateral and middle one-third of a line from the anterior superior iliac spine to the umbilicus (McBurney's point). People with appendicular problems may describe pain near this location.

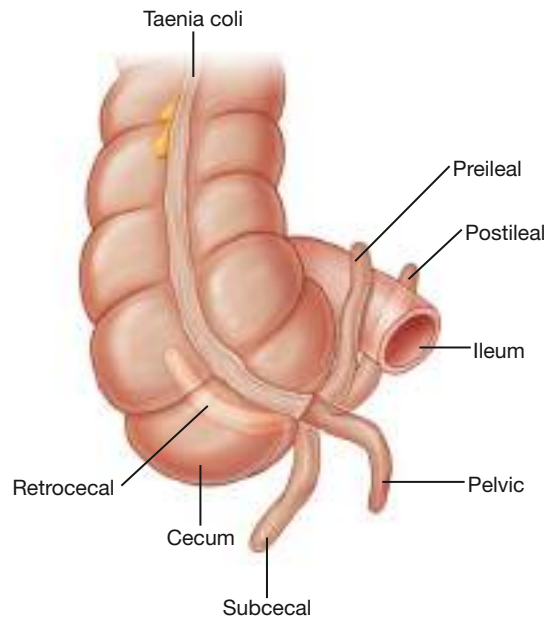


Fig. 4.54 Positions of the appendix.

The arterial supply to the cecum and appendix (Fig. 4.55) includes:

- the anterior cecal artery from the ileocolic artery (from the superior mesenteric artery),
- the posterior cecal artery from the ileocolic artery (from the superior mesenteric artery), and
- the appendicular artery from the ileocolic artery (from the superior mesenteric artery).

Clinical app

Appendicitis

Acute appendicitis is an abdominal emergency. It usually occurs when the appendix is obstructed by either a fecalith or enlargement of the lymphoid nodules. Within the obstructed appendix, bacteria proliferate and invade the appendix wall, which becomes damaged by pressure necrosis. In some instances, this may resolve spontaneously; in other cases, inflammatory change continues and perforation ensues, which may lead to localized or generalized peritonitis.

Most patients with acute appendicitis have localized tenderness in the right groin. Initially, the pain begins as a central/periumbilical, which tends to come and go. As the disease progresses, the pain shifts to the lower right groin and is focal.

When the appendix first becomes inflamed, the visceral sensory fibers are stimulated (Fig. 4.56). These fibers enter the spinal cord at spinal cord level T10. The pain is referred to the dermatome of T10 in the periumbilical region. The pain is diffuse, not focal; every time a peristaltic wave passes through

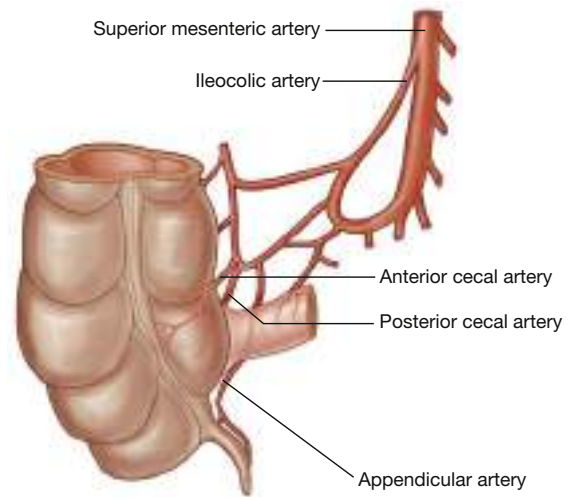


Fig. 4.55 Arterial supply to the cecum and appendix.

the ileocecal region, the pain recurs. This intermittent type of pain is referred to as *colic*.

In later stages of the disease, the appendix contacts and irritates the parietal peritoneum in the right iliac fossa, which is innervated by somatic sensory nerves. This produces a constant focal pain, which predominates over the colicky pain that the patient felt some hours previously, and the patient no longer perceives the referred pain.

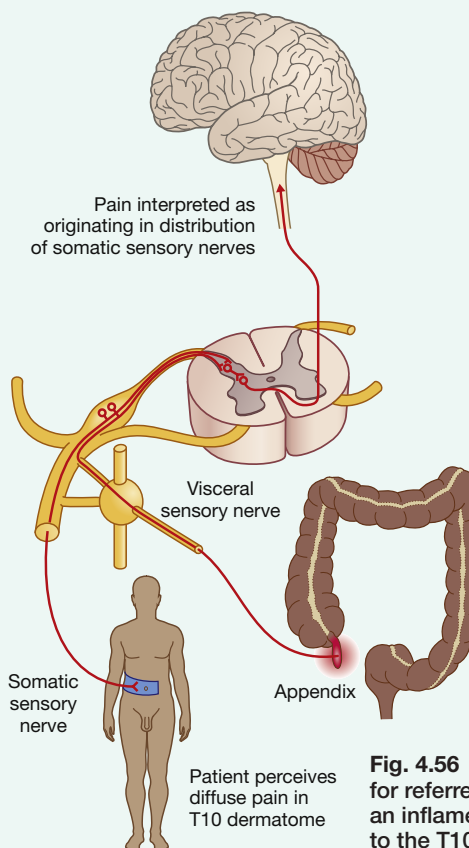


Fig. 4.56 Mechanism for referred pain from an inflamed appendix to the T10 dermatome.

Colon

The colon extends superiorly from the cecum and consists of the ascending, transverse, descending, and sigmoid colon (Fig. 4.57). Its ascending and descending segments are (secondarily) retroperitoneal, and its transverse and sigmoid segments are intraperitoneal.

At the junction of the ascending and transverse colon is the right colic flexure, which is just inferior to the right lobe of the liver (Fig. 4.58). A similar but more acute bend (the left colic flexure) occurs at the junction of the transverse and descending colon (Fig. 4.58). This bend is just inferior to the spleen, higher and more posterior than the right colic flexure, and is attached to the diaphragm by the phrenicocolic ligament.

Immediately lateral to the ascending and descending colons are the **right** and **left paracolic gutters** (Fig. 4.57). These depressions are formed between the lateral margins of the ascending and descending colon and the posterolateral abdominal wall and are gutters through which material can pass from one region of the peritoneal cavity to another. Because major vessels and lymphatics are on the medial or posteromedial sides of the ascending and descending colon, a relatively blood-free mobilization of the ascending and descending colon is possible by cutting the peritoneum along these lateral paracolic gutters.

The final segment of the colon (the sigmoid colon) begins above the pelvic inlet and extends to the level of vertebra SIII where it is continuous with the rectum (Fig. 4.57). This S-shaped structure is quite mobile except at its beginning, where it continues from the descending colon, and at its end, where it continues as the rectum. Between these points, it is suspended by the sigmoid mesocolon.

The arterial supply to the ascending colon includes (Fig. 4.59):

- the colic branch from the ileocolic artery (from the superior mesenteric artery),
- the anterior cecal artery from the ileocolic artery (from the superior mesenteric artery),
- the posterior cecal artery from the ileocolic artery (from the superior mesenteric artery), and
- the right colic artery from the superior mesenteric artery.

The arterial supply to the transverse colon includes (Fig. 4.59):

- the right colic artery from the superior mesenteric artery,
- the middle colic artery from the superior mesenteric artery, and
- the left colic artery from the inferior mesenteric artery.

The arterial supply to the descending colon includes the left colic artery from the inferior mesenteric artery (Fig. 4.59).

The arterial supply to the sigmoid colon includes sigmoidal arteries from the inferior mesenteric artery (Fig. 4.59).

Anastomotic connections between arteries supplying the colon can result in a marginal artery that courses along

the ascending, transverse, and descending parts of the large bowel (Fig. 4.59).

Rectum and anal canal

Extending from the sigmoid colon is the rectum (Fig. 4.60). The rectosigmoid junction is usually described as being at the level of vertebra SIII or at the end of the sigmoid mesocolon because the rectum is a retroperitoneal structure.

The anal canal is the continuation of the large intestine inferior to the rectum.

The arterial supply to the rectum and anal canal includes (Fig. 4.61):

- the superior rectal artery from the inferior mesenteric artery,
- the middle rectal artery from the internal iliac artery, and
- the inferior rectal artery from the internal pudendal artery (from the internal iliac artery).

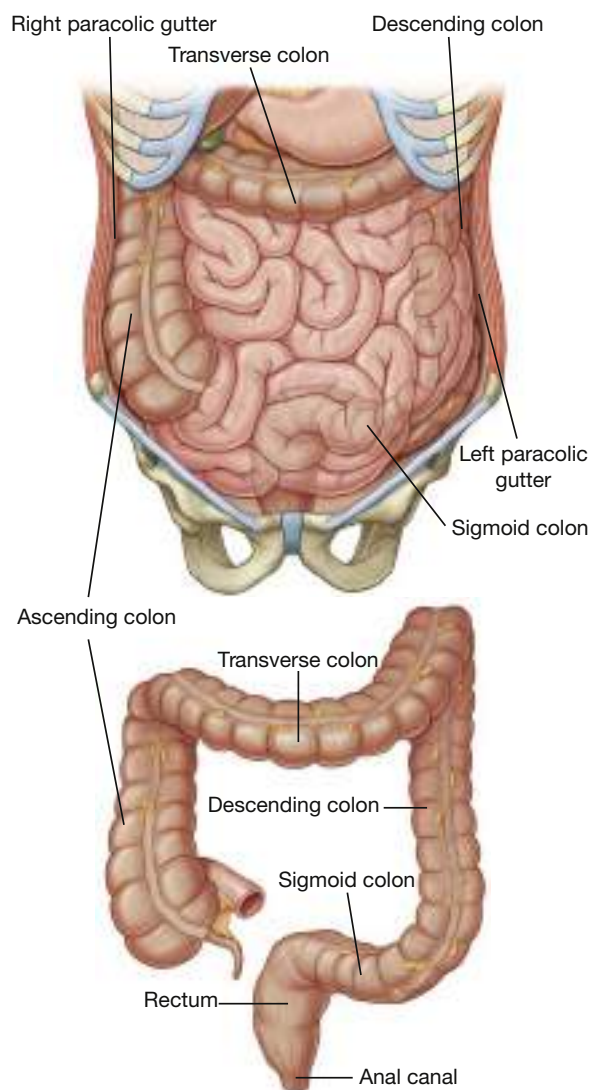


Fig. 4.57 Colon.

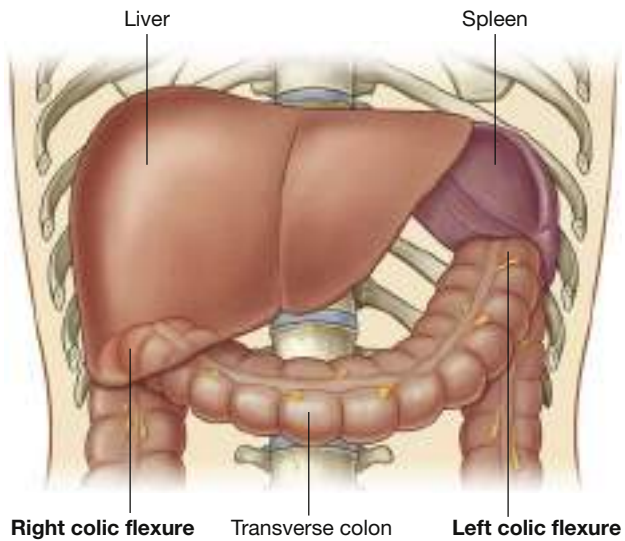


Fig. 4.58 Right and left colic flexures.

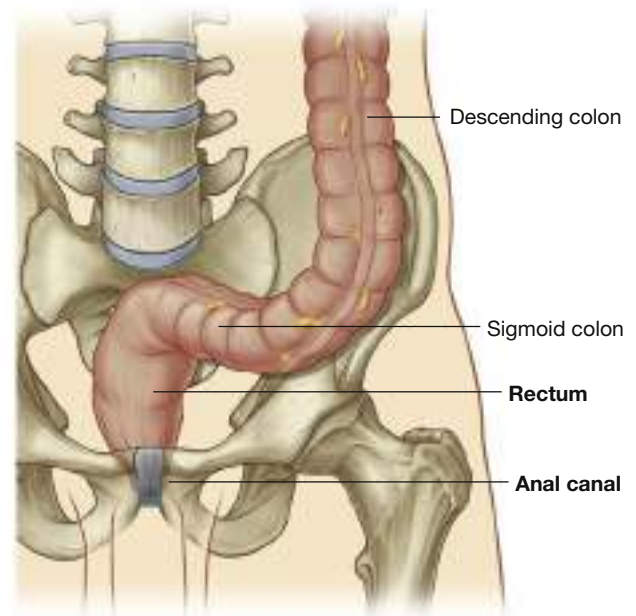


Fig. 4.60 Rectum and anal canal.

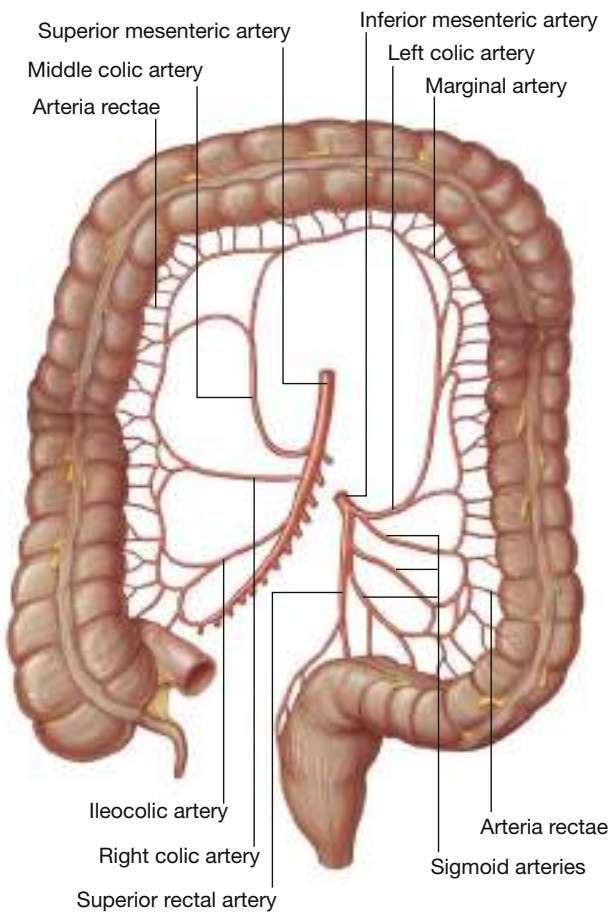


Fig. 4.59 Arterial supply to the colon.

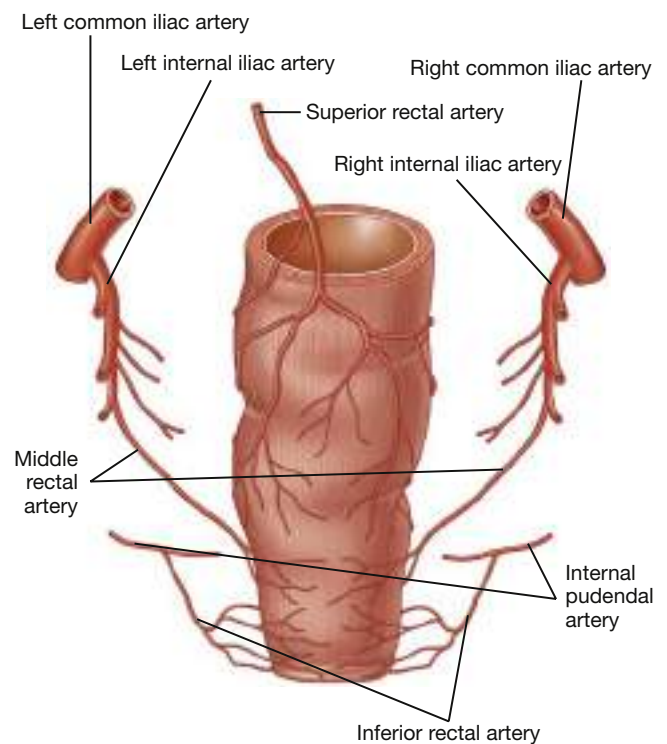


Fig. 4.61 Arterial supply to the rectum and anal canal. Posterior view.

Clinical app

Congenital disorders of the gastrointestinal tract

The normal positions of the abdominal viscera result from a complex series of rotations that the gut tube undergoes and from the growth of the abdominal cavity to accommodate changes in the size of the developing organs.

Malrotation is incomplete rotation and fixation of the midgut after it has passed from the umbilical sac and returned to the abdominal cavity. The proximal attachment of the small bowel mesentery begins at the **suspensory muscle of duodenum (ligament of Treitz)**, which determines the position of the duodenojejunal junction. The mesentery of the small bowel ends at the level of the ileocecal junction in the right lower quadrant. This long line of fixation of the mesentery prevents accidental twists of the gut.

If the duodenojejunal flexure or the cecum does not end up in its usual site, the origin of the small bowel mesentery shortens, which permits twisting of the small bowel around the axis of the superior mesenteric artery. Twisting of the bowel, in general, is termed **volvulus**. Volvulus of the small bowel may lead to a reduction of blood flow and infarction.

Clinical app

Bowel obstruction

A bowel obstruction can be either mechanical or functional:

- Mechanical obstruction is caused by an intraluminal, mural, or extrinsic mass that can be secondary to a foreign body, obstructing tumor in the wall extrinsic compression from an adhesion, or an embryological band.
- A functional obstruction is usually due to an inability of the bowel to peristaltise, which, again, has a number of causes and most frequently is a postsurgical state due to excessive intraoperative bowel handling. Small bowel obstruction is typically caused by adhesions following previous surgery, and history should always be sought for any operations or abdominal interventions (e.g., previous appendectomy). Other causes include bowel passing into hernias (e.g., inguinal) and bowel twisting on its own mesentery (volvulus). Large bowel obstruction is commonly caused by a tumor. Other potential causes include hernias and inflammatory diverticular disease of the sigmoid colon.

Clinical app

Diverticular disease

Diverticular disease is the development of multiple colonic diverticula, predominantly throughout the sigmoid colon, though the whole colon may be affected (Fig. 4.62). The sigmoid colon has the smallest diameter of any portion of the colon and is therefore the site where intraluminal pressure is potentially the highest.

Patients tend to develop symptoms and signs when the neck of the diverticulum becomes obstructed by feces and becomes infected. Inflammation may spread along the wall, causing abdominal pain.

Because of the anatomical position of the sigmoid colon, there are a number of complications that may occur. The diverticula can perforate to form an abscess in the pelvis. The inflammation may produce an inflammatory mass, obstructing the left ureter. Inflammation may also spread to the bladder, producing a fistula between the sigmoid colon and the bladder.

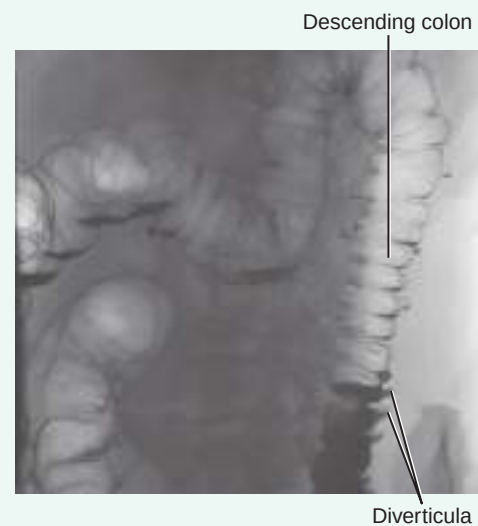


Fig. 4.62 This double-contrast barium enema demonstrates numerous small outpouchings throughout the distal large bowel, predominantly within the descending colon and the sigmoid colon. These small outpouchings are diverticula and in most instances remain quiescent.

Imaging app

Endoscopic examination of the abdominal gastrointestinal tract

Endoscopy is a minimally invasive diagnostic medical procedure that can be used to assess the interior surfaces of an organ by inserting a tube into the body. The instrument is typically made of a flexible plastic material through which a light source and eye piece are attached at one end.

In gastrointestinal and abdominal medicine, an endoscope is used to assess the esophagus, stomach, duodenum, and proximal small bowel (Fig. 4.63A-E). The tube is swallowed by the patient under light sedation and is extremely well tolerated.

Assessment of the colon is performed by passage of the tube through the anus and into the rectum. The whole of the colon can be readily assessed (Fig. 4.63F-J).

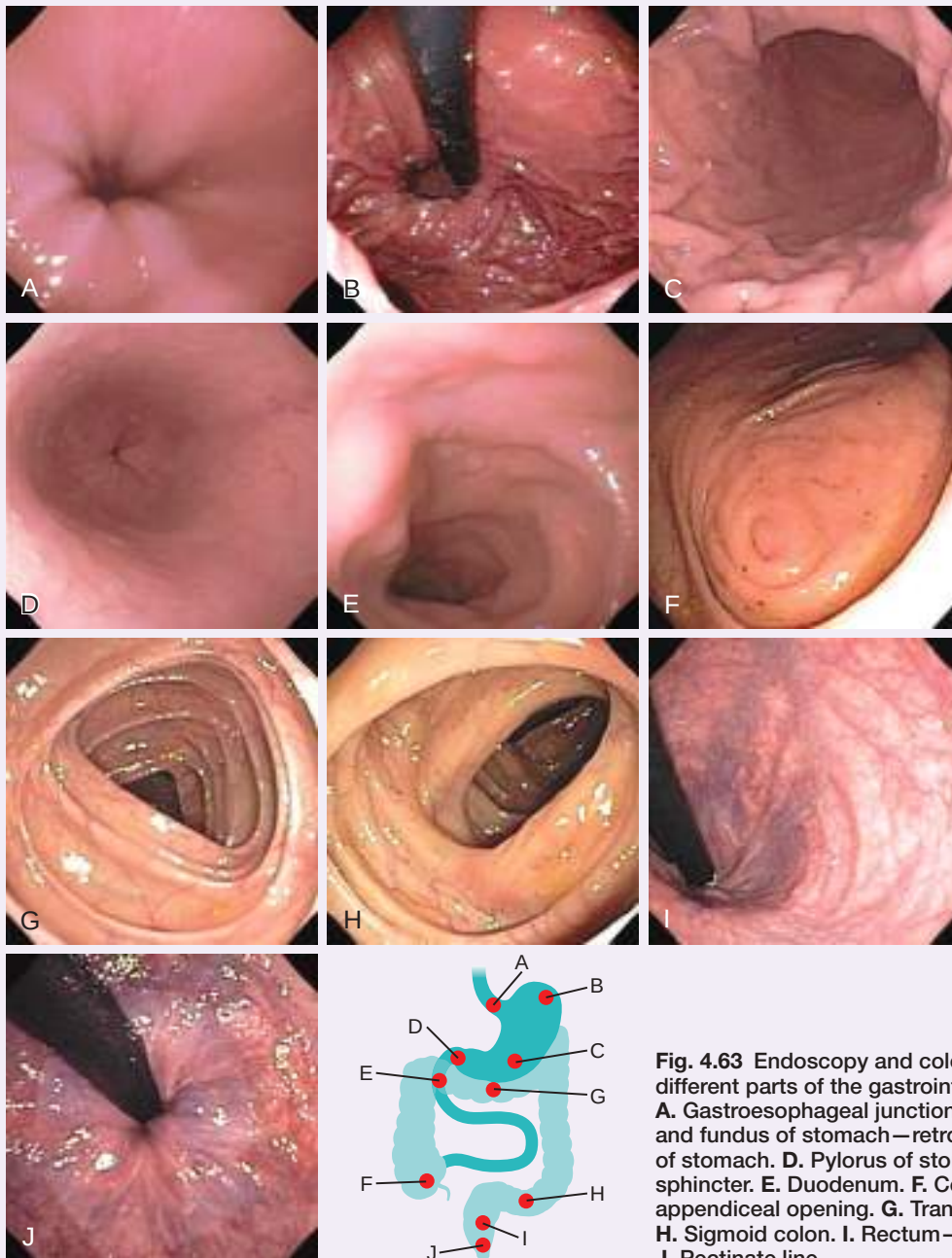


Fig. 4.63 Endoscopy and colonoscopy showing different parts of the gastrointestinal tract. **A.** Gastroesophageal junction. **B.** Cardiac orifice and fundus of stomach—retroflexed view. **C.** Body of stomach. **D.** Pylorus of stomach and pyloric sphincter. **E.** Duodenum. **F.** Cecum showing appendiceal opening. **G.** Transverse colon. **H.** Sigmoid colon. **I.** Rectum—retroflexed view. **J.** Pectinate line.

Liver

The liver is the largest visceral organ in the body and is primarily in the right hypochondrium and epigastric region, extending into the left hypochondrium (or in the right upper quadrant, extending into the left upper quadrant) (see Fig. 4.4).

Surfaces of the liver include:

- a **diaphragmatic surface** in the anterior, superior, and posterior directions and
- a **visceral surface** in the inferior direction (Fig. 4.64).

Diaphragmatic surface

The diaphragmatic surface of the liver, which is smooth and domed, lies against the inferior surface of the diaphragm (Fig. 4.65). Associated with it are the subphrenic and hepatorenal recesses (Fig. 4.64):

- The **subphrenic recess** separates the diaphragmatic surface of the liver from the diaphragm and is divided into right and left areas by the **falciform ligament**, a structure derived from the ventral mesentery in the embryo.
- The **hepatorenal recess** is a part of the peritoneal cavity on the right side between the liver and the right kidney and right suprarenal gland.

The subphrenic and hepatorenal recesses are continuous anteriorly.

Visceral surface

The visceral surface of the liver is covered with visceral peritoneum except in the **fossa for the gallbladder** and at the **porta hepatis** (gateway to the liver; Fig. 4.66). Structures related to it include the following (Fig. 4.66):

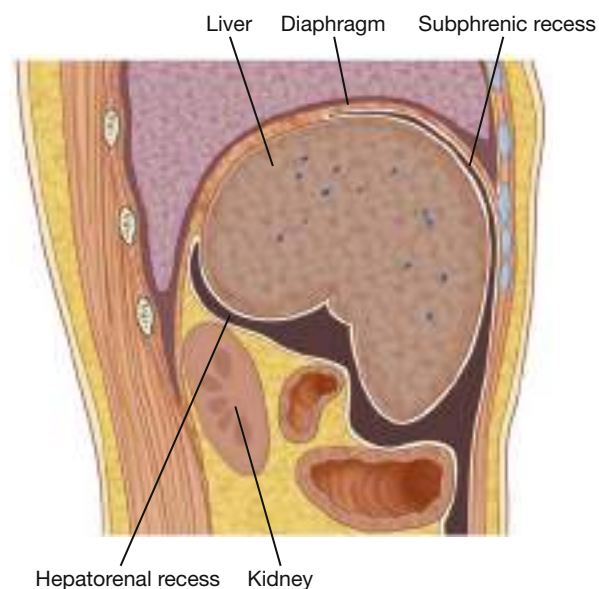


Fig. 4.64 Surfaces of the liver and recesses associated with the liver.

- esophagus,
- right anterior part of the stomach,
- superior part of the duodenum,
- lesser omentum,
- gallbladder,
- right colic flexure,
- right transverse colon,
- right kidney, and
- right suprarenal gland.

The **porta hepatis** serves as the point of entry into the liver for the hepatic arteries and the portal vein and the exit point for the hepatic ducts (Fig. 4.66).

Associated ligaments

The liver is attached to the anterior abdominal wall by the **falciform ligament** and, except for a small area of the liver against the diaphragm (the **bare area**), the liver is almost completely surrounded by visceral peritoneum (Fig. 4.66). Additional folds of peritoneum connect the liver to the stomach (**hepatogastric ligament**), the duodenum (**hepatoduodenal ligament**), and the diaphragm (**right and left triangular ligaments** and **anterior and posterior coronary ligaments**).

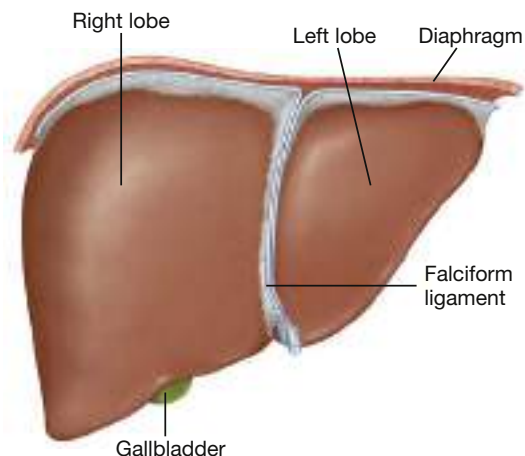


Fig. 4.65 Diaphragmatic surface of the liver.

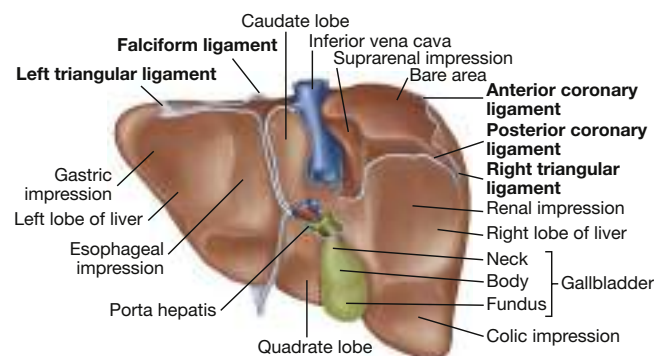


Fig. 4.66 Posterior view of the bare area of the liver and associated ligaments.

The bare area of the liver is a part of the liver on the diaphragmatic surface where there is no intervening peritoneum between the liver and the diaphragm (Fig. 4.66):

- The anterior boundary of the bare area is indicated by a reflection of peritoneum—the anterior coronary ligament.
- The posterior boundary of the bare area is indicated by a reflection of peritoneum—the posterior coronary ligament.
- Where the coronary ligaments come together laterally, they form the right and left triangular ligaments.

Lobes

The liver is divided into right and left lobes by the falciform ligament anterosuperiorly and the fissure for the ligamentum venosum and ligamentum teres on the visceral surface

(Figs. 4.66, 4.67, 4.68). The **right lobe of liver** is the largest lobe, whereas the **left lobe of liver** is smaller. The quadrate and caudate lobes are described as arising from the right lobe of the liver but functionally are distinct.

- The **quadrate lobe** is visible on the anterior part of the visceral surface of the liver and is bounded on the left by the fissure for ligamentum teres and on the right by the fossa for the gallbladder. Functionally it is related to the left lobe of the liver.
- The **caudate lobe** is visible on the posterior part of the visceral surface of the liver. It is bounded on the left by the fissure for the ligamentum venosum and on the right by the groove for the inferior vena cava. Functionally, it is separate from the right and the left lobes of the liver.

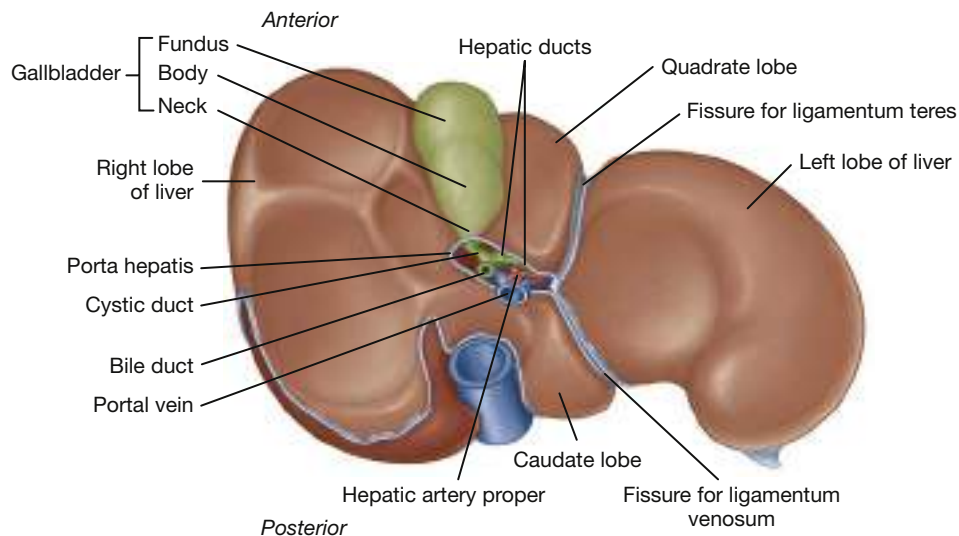


Fig. 4.67 Visceral surface of the liver.

Imaging app

Visualizing the liver

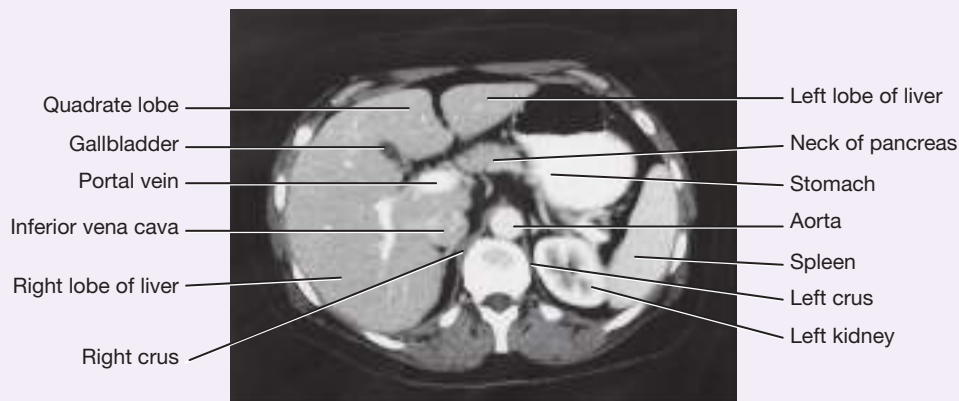


Fig. 4.68 Abdominal computed tomogram with contrast in the axial plane, showing the visceral surface of the liver.

The arterial supply to the liver includes (Fig. 4.69):

- the right hepatic artery from the hepatic artery proper (a branch of the common hepatic artery from the celiac trunk), and
- the left hepatic artery from the hepatic artery proper (a branch of the common hepatic artery from the celiac trunk).

Clinical app

Ostomies

It is occasionally necessary to surgically externalize bowel to the anterior abdominal wall. Externalization of bowel plays an important role in patient management.

Gastrostomy is performed when the stomach is attached to the anterior abdominal wall and a tube is placed through the skin into the stomach. Typically this is performed to feed the patient when it is impossible to take food and fluid orally (e.g., complex head and neck cancer).

In **jejunostomy**, the jejunum is brought to the anterior abdominal wall and fixed. The jejunostomy is used as a site where a feeding tube is placed through the anterior abdominal wall into the proximal efferent small bowel.

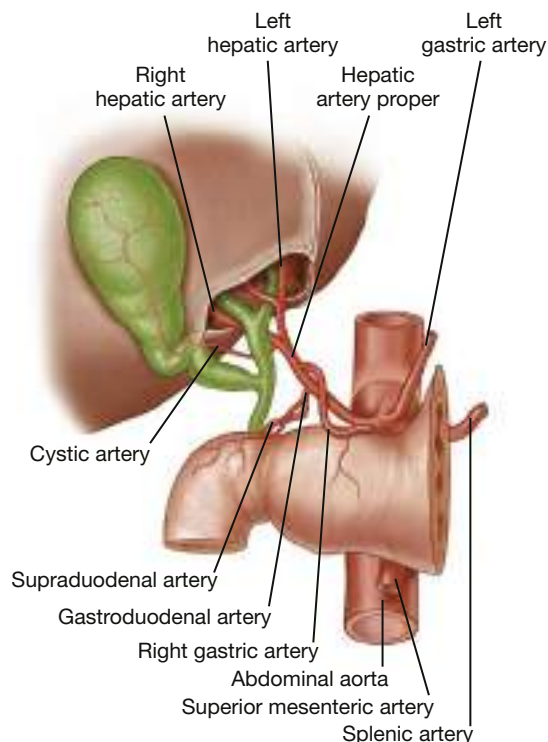


Fig. 4.69 Arterial supply to the liver and gallbladder.

Clinical app

Segmental anatomy of the liver

For many years the segmental anatomy of the liver was of little importance. However, since the development of liver resection surgery, the size, shape, and segmental anatomy of the liver has become clinically important, especially with regard to liver resection for metastatic disease.

The liver is divided by the principal plane, which divides the organ into halves of approximately equal size. This imaginary line is defined by a parasagittal line that passes through the gallbladder fossa to the inferior vena cava. It is in this plane that the middle hepatic vein is found. Importantly, the principal plane divides the left half of the liver from the right half. The lobes of the liver are unequal in size and bear only little relevance to operative anatomy.

The traditional eight segment anatomy of the liver relates to the hepatic arterial, portal, and biliary drainage of these segments (Fig. 4.70).

The caudate lobe is defined as segment I; the remaining segments are numbered in a clockwise fashion up to segment VIII. The features are extremely consistent among individuals.

From a surgical perspective, a right hepatectomy would involve division of the liver in the principal plane in which segments V, VI, VII, and VIII would be removed, leaving segments I, II, III, and IV.

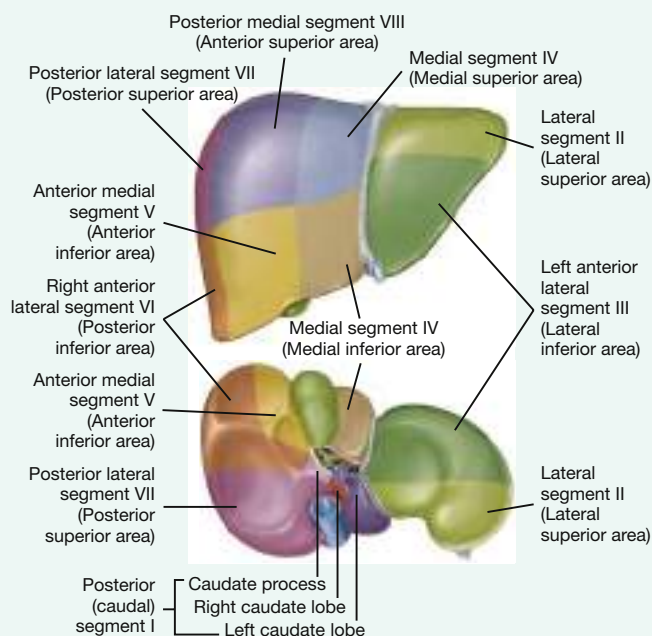


Fig. 4.70 Division of the liver into segments based on the distributions of the bile ducts and hepatic vessels (Couinaud's segments).

Gallbladder

The **gallbladder** is a pear-shaped sac lying on the visceral surface of the right lobe of the liver in a fossa between the right and quadrate lobes (see Fig. 4.67). It has:

- a rounded end (**fundus of gallbladder**), which may project from the inferior border of the liver;
- a major part in the fossa (**body of gallbladder**), which may be against the transverse colon and the superior part of the duodenum; and
- a narrow part (**neck of gallbladder**) with mucosal folds forming the spiral fold.

The arterial supply to the gallbladder (see Fig. 4.69) is the cystic artery from the right hepatic artery (a branch of the hepatic artery proper).

The gallbladder receives, concentrates, and stores bile from the liver.

Pancreas

The pancreas lies mostly posterior to the stomach (Figs. 4.71, 4.73). It extends across the posterior abdominal wall from the duodenum on the right to the spleen on the left.

The pancreas is (secondarily) retroperitoneal except for a small part of its tail and consists of a head, uncinate process, neck, body, and tail (Fig. 4.71).

- The **head of pancreas** lies within the C-shaped concavity of the duodenum.
- Projecting from the lower part of the head is the **uncinate process**, which passes posterior to the superior mesenteric vessels.

- The **neck of pancreas** is anterior to the superior mesenteric vessels. Posterior to the neck of the pancreas, the superior mesenteric and the splenic veins join to form the portal vein.
- The **body of pancreas** is elongate and extends from the neck to the tail of the pancreas.
- The **tail of pancreas** passes between layers of the splenorenal ligament.

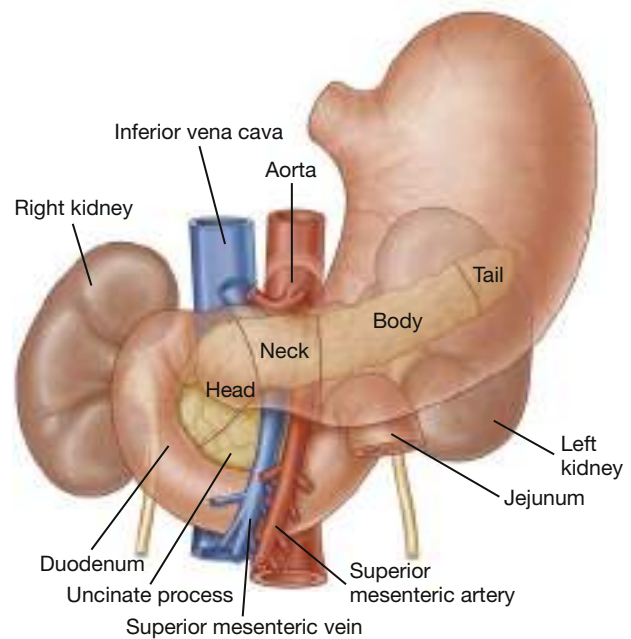


Fig. 4.71 Pancreas.

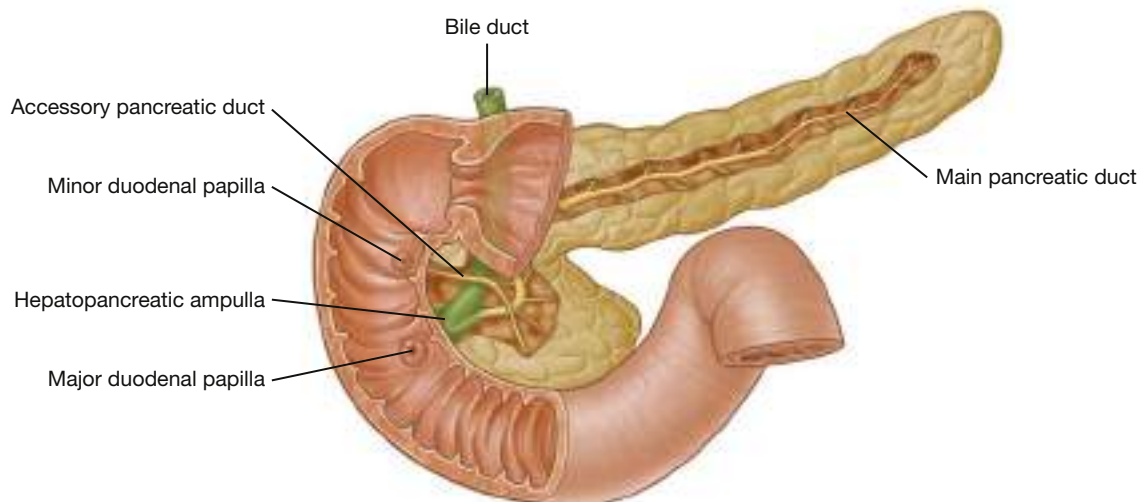


Fig. 4.72 Pancreatic duct system.

The **pancreatic duct** begins in the tail of the pancreas (Fig. 4.72). It passes to the right through the body of the pancreas and, after entering the head of the pancreas, turns inferiorly. In the lower part of the head of pancreas, the pancreatic duct joins the bile duct. The joining of these two structures forms the **hepatopancreatic ampulla** (ampulla of Vater), which enters the descending (second) part of the duodenum at the **major duodenal papilla**. Surrounding the ampulla is the **sphincter of ampulla** (sphincter of Oddi), which is a collection of smooth muscle cells.

The **accessory pancreatic duct** empties into the duodenum just above the major duodenal papilla at the **minor duodenal papilla** (Fig. 4.72). If the accessory duct is followed from the minor papilla into the head of the pancreas, a branch point is discovered:

- One branch continues to the left through the head of the pancreas and may connect with the pancreatic duct at the point where it turns inferiorly.
- A second branch descends into the lower part of the head of the pancreas, anterior to the pancreatic duct, and ends in the uncinuate process.

The main and accessory pancreatic ducts usually communicate with each other. The presence of these two ducts reflects the embryological origin of the pancreas from dorsal and ventral buds from the foregut.

The arterial supply to the pancreas (Fig. 4.74) includes the:

- gastroduodenal artery from the common hepatic artery (a branch of the celiac trunk),
- anterior superior pancreaticoduodenal artery from the gastroduodenal artery,
- posterior superior pancreaticoduodenal artery from the gastroduodenal artery,
- dorsal pancreatic artery from the inferior pancreatic artery (a branch of the splenic artery),
- great pancreatic artery from the inferior pancreatic artery (a branch of the splenic artery),
- dorsal pancreatic and greater pancreatic arteries (branches of the splenic artery),
- anterior inferior pancreaticoduodenal artery from the inferior pancreaticoduodenal artery (a branch of the superior mesenteric artery), and
- posterior inferior pancreaticoduodenal artery from the inferior pancreaticoduodenal artery (a branch of the superior mesenteric artery).

Clinical app

Anular pancreas

The pancreas develops from ventral and dorsal buds from the foregut. The dorsal bud forms most of the head, neck, and body of pancreas. The ventral bud, which consists of right and left portions that normally fuse, rotates posteriorly around the bile duct to form part of the head and the uncinuate process. If the two components of the ventral bud fail to fuse, they may encircle the duodenum. The duodenum is therefore constricted and may even undergo atresia and be absent at birth because of developmental problems. After birth, the child may fail to thrive and vomit due to poor gastric emptying.

Sometimes an anular pancreas is diagnosed in utero by ultrasound scanning. The obstruction of the duodenum may prevent the fetus from swallowing enough amniotic fluid, which may increase the overall volume of amniotic fluid in the amniotic sac surrounding the fetus (**polyhydramnios**).

Imaging app

Visualizing the pancreas

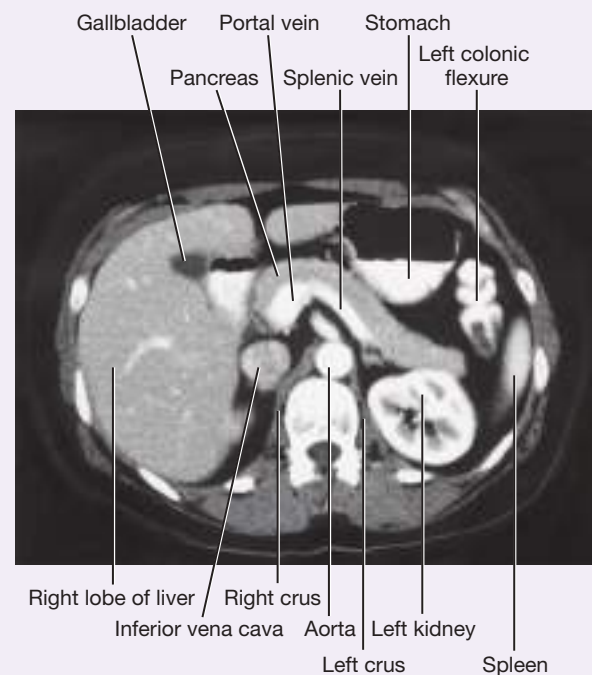


Fig. 4.73 Abdominal computed tomogram with contrast in the axial plane.

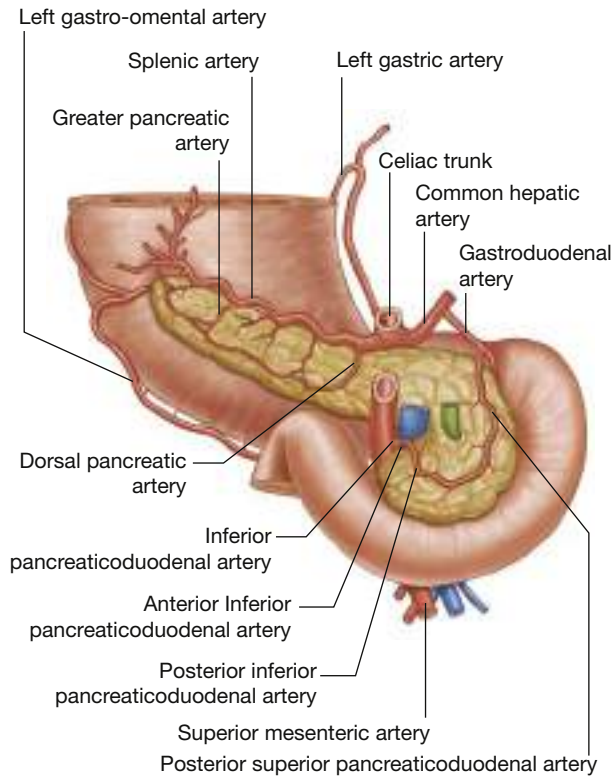


Fig. 4.74 Arterial supply to the pancreas. Posterior view.

Clinical app

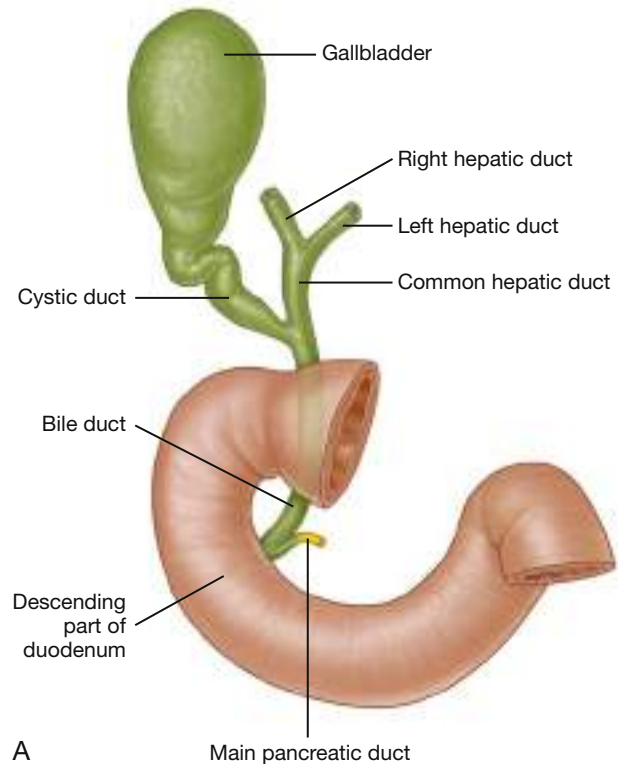
Pancreatic cancer

Pancreatic cancer accounts for a significant number of deaths and is often referred to as the *silent killer*. Malignant tumors of the pancreas may occur anywhere within the pancreas but are most frequent within the head and the neck. There are a number of nonspecific findings in patients with pancreatic cancer, including upper abdominal pain, loss of appetite, and weight loss. Depending on the exact site of the cancer, obstruction of the common bile duct may occur, which can produce obstructive jaundice. Although surgery is indicated in patients where there is a possibility of cure, most detected cancers have typically spread locally, invading the portal vein and superior mesenteric vessels and may extend into the porta hepatis. Lymph node spread also is common, and these factors would preclude curative surgery.

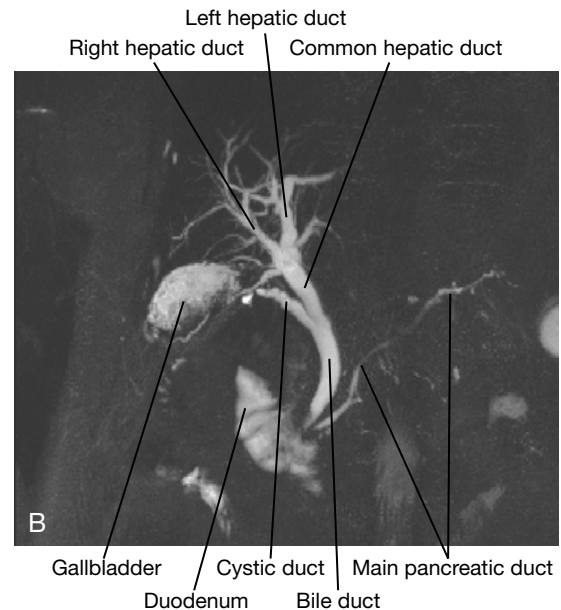
Given the position of the pancreas, a surgical resection is a complex procedure involving resection of the region of pancreatic tumor usually with part of the duodenum necessitating a complex bypass procedure.

Duct system for bile

The duct system for the passage of bile extends from the liver, connects with the gallbladder, and empties into the descending part of the duodenum (Fig. 4.75). The coalescence of



A



B

Fig. 4.75 Bile drainage. A. Duct system for passage of bile. B. Percutaneous transhepatic cholangiogram demonstrating the bile duct system.

ducts begins in the liver parenchyma and continues until the **right** and **left hepatic ducts** are formed. These drain the respective lobes of the liver.

The two hepatic ducts combine to form the **common hepatic duct**, which runs near the liver with the hepatic artery proper and portal vein in the free margin of the lesser omentum.

As the common hepatic duct continues to descend, it is joined by the **cystic duct** from the gallbladder. This completes the formation of the **bile duct**. At this point, the bile duct lies to the right of the hepatic artery proper and usually to the right of and anterior to the portal vein in the free margin of the lesser omentum (see Fig. 4.35). The **omental foramen** is posterior to these structures at this point.

The bile duct continues to descend, passing posteriorly to the superior part of the duodenum before joining with the pancreatic duct to enter the descending part of the duodenum at the major duodenal papilla (Fig. 4.75).

Clinical app

Gallstones

Gallstones are present in approximately 10% of people over the age of 40 and are more common in women. They consist of a variety of components, but are predominantly a mixture of cholesterol and bile pigment. They may undergo calcification, which can be demonstrated on plain radiographs. From time to time, gallstones lodge in the neck of the gallbladder. The gallbladder cannot empty normally and contractions of the gallbladder wall produce severe pain. If this persists, a **cholecystectomy** (removal of the gallbladder) may be necessary.

Sometimes the gallbladder may become inflamed (**cholecystitis**). If the inflammation involves the related parietal peritoneum of the diaphragm, pain may not only occur in the right upper quadrant of the abdomen but may also be referred to the shoulder on the right side (phrenic nerve, C3-C5, innervation of diaphragm).

From time to time, small gallstones pass into the bile duct and are trapped in the region of the sphincter of the ampulla, which obstructs the flow of bile into the duodenum. This, in turn, produces jaundice.

Clinical app

Jaundice

Jaundice is a yellow discoloration of the skin caused by excess bile pigment (bilirubin) within the plasma. The yellow color is best appreciated by looking at the normally white sclerae of the eyes, which turn yellow.

Any obstruction to the biliary tree can produce jaundice, but the two most common causes are gallstones within the bile duct and an obstructing tumor at the head of the pancreas.

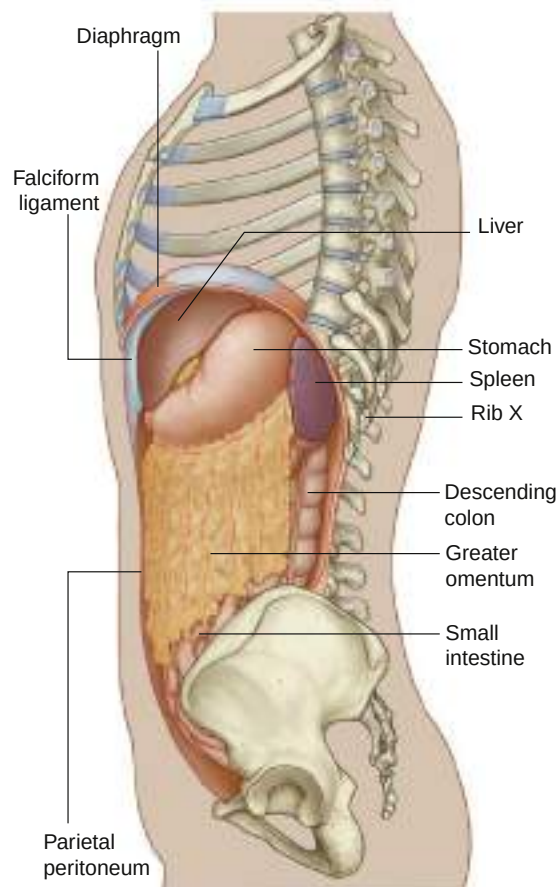


Fig. 4.76 Location of the spleen in a lateral view.

Spleen

The spleen develops as part of the vascular system in the part of the dorsal mesentery that suspends the developing stomach from the body wall. In the adult, the spleen lies against the diaphragm in the area of rib IX to rib X (Fig. 4.76). It is therefore in the left upper quadrant, or left hypochondrium, of the abdomen.

The spleen is connected to the:

- greater curvature of the stomach by the gastrosplenic ligament, which contains the short gastric and gastro-omental vessels; and
- left kidney by the splenorenal ligament (Fig. 4.77), which contains the splenic vessels.

Both these ligaments are parts of the greater omentum.

The spleen is surrounded by visceral peritoneum except in the area of the hilum on the medial surface of the spleen (Fig. 4.78). The **splenic hilum** is the entry point for the splenic vessels, and, occasionally, the tail of the pancreas reaches this area.

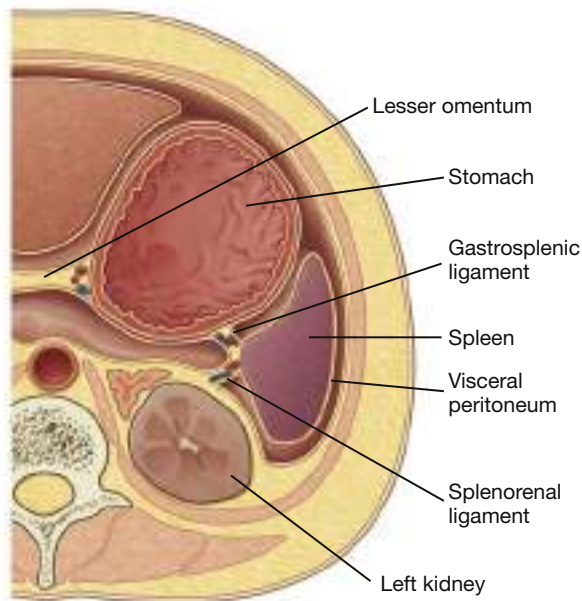


Fig. 4.77 Splenic ligaments and related vasculature.

The arterial supply to the spleen (Fig. 4.79) is the splenic artery from the celiac trunk.

Clinical app

Spleen disorders

From a clinical point of view, there are two main categories of spleen disorders: rupture and enlargement.

Rupture

This tends to occur when there is localized trauma to the left upper quadrant. It may be associated with left lower rib fractures. Because the spleen has such an extremely thin capsule, it is susceptible to injury even when there is no damage to surrounding structures, and because the spleen is highly vascular, when ruptured, it bleeds profusely into the peritoneal cavity.

Splenic enlargement

The spleen is an organ of the reticuloendothelial system involved in hematopoiesis and immunological surveillance. Diseases that affect the reticuloendothelial system (e.g., leukemia or lymphoma) may produce generalized lymphadenopathy and enlargement of the spleen (**splenomegaly**).

Arterial supply to the gastrointestinal tract

The **abdominal aorta** begins at the aortic hiatus of the diaphragm, anterior to the lower border of vertebra TXII (Fig. 4.80). It descends through the abdomen anterior to the

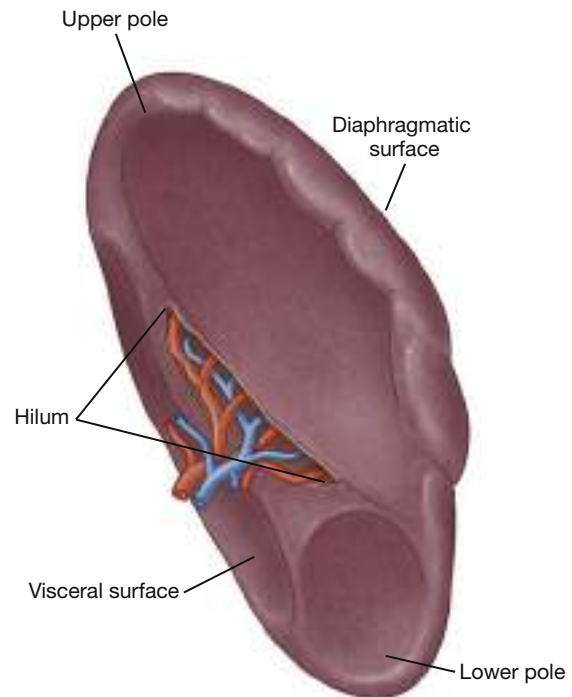


Fig. 4.78 Surfaces and hilum of the spleen.

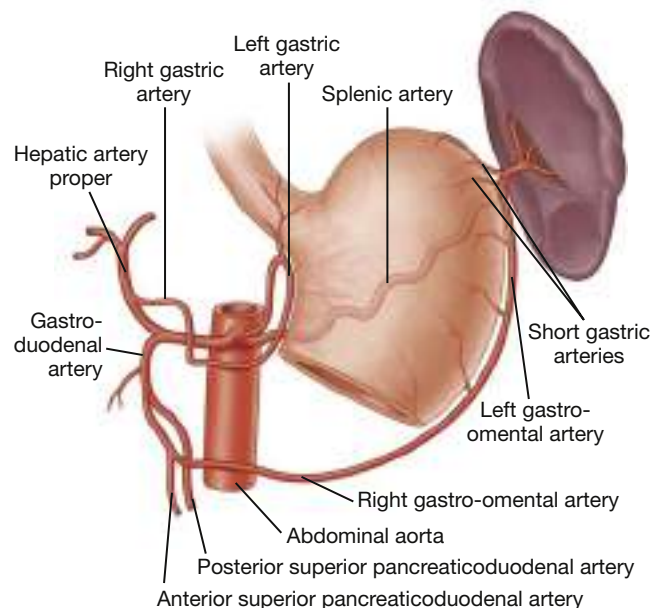


Fig. 4.79 Arterial supply to the spleen.

vertebral bodies, and by the time it ends at the level of vertebra LIV, it is slightly to the left of midline. The terminal branches of the abdominal aorta are the two **common iliac arteries**.

Anterior branches of the abdominal aorta

The abdominal aorta has anterior, lateral, and posterior branches as it passes through the abdominal cavity. The three anterior branches supply the gastrointestinal viscera:

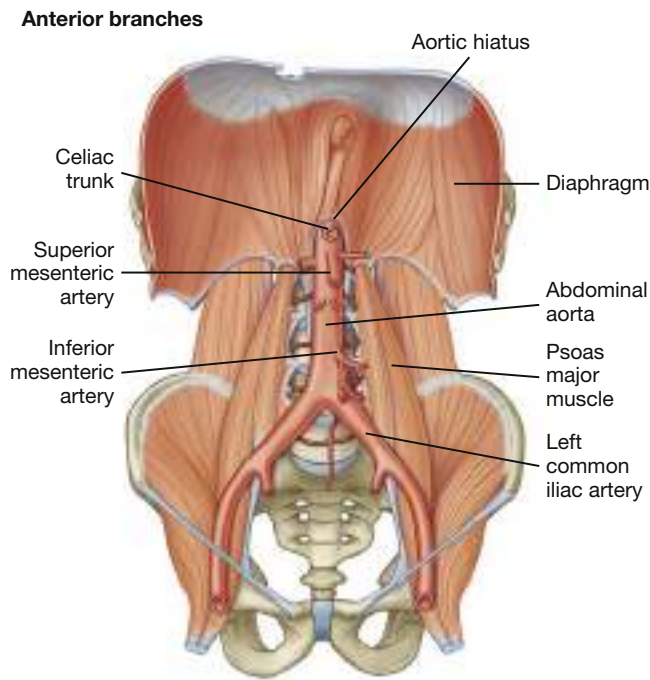


Fig. 4.80 Anterior branches of the abdominal aorta.

the **celiac trunk** and the **superior mesenteric** and **inferior mesenteric arteries** (Fig. 4.80).

The primitive gut tube can be divided into foregut, midgut, and hindgut regions. The boundaries of these regions are directly related to the areas of distribution of the three anterior branches of the abdominal aorta (Fig. 4.81).

- The **foregut** begins with the abdominal esophagus and ends just inferior to the major duodenal papilla midway along the descending part of the duodenum. It includes the abdominal esophagus, stomach, duodenum (superior to the major papilla), liver, pancreas, and gallbladder. The spleen also develops in relation to the foregut region. The foregut is supplied by the celiac trunk (Fig. 4.81).
- The **midgut** begins just inferior to the major duodenal papilla in the descending part of the duodenum and ends at the junction between the proximal two-thirds and distal one-third of the transverse colon. It includes the duodenum (inferior to the major duodenal papilla), jejunum, ileum, cecum, appendix, ascending colon, and the right two-thirds of the transverse colon. The midgut is supplied by the superior mesenteric artery (Fig. 4.81).
- The **hindgut** begins just before the left colic flexure (the junction between the proximal two-thirds and distal one-third of the transverse colon) and ends midway through the anal canal. It includes the left one-third of the transverse colon, descending colon, sigmoid colon, rectum, and upper part of the anal canal. The hindgut is supplied by the inferior mesenteric artery (Fig. 4.81).

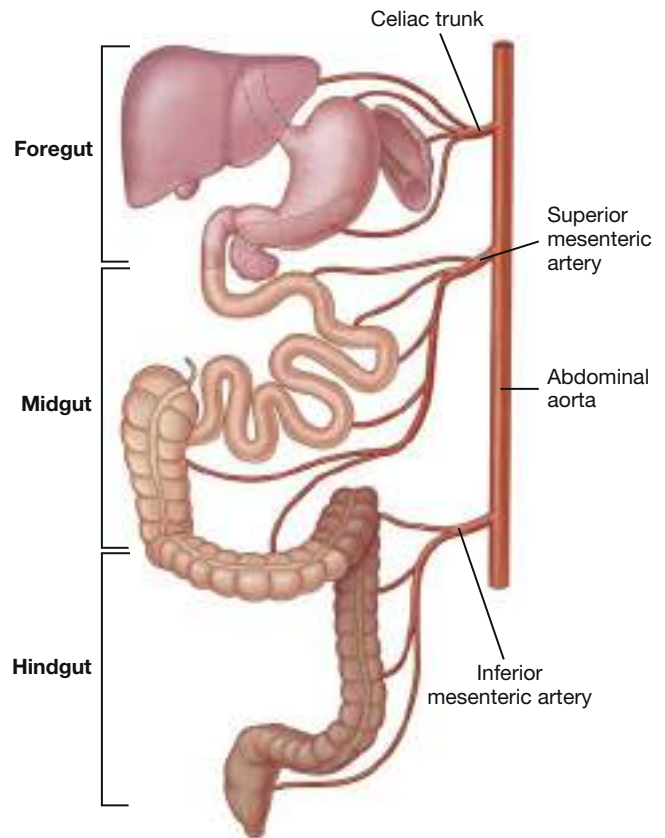


Fig. 4.81 Divisions of the gastrointestinal tract into the foregut, midgut, and hindgut, summarizing the primary arterial supply to each segment.

Celiac trunk

The celiac trunk is the anterior branch of the abdominal aorta supplying the foregut. It arises from the abdominal aorta immediately below the aortic hiatus of the diaphragm (Fig. 4.82) anterior to the upper part of vertebra LI. It immediately divides into the left gastric, splenic, and common hepatic arteries.

Left gastric artery

The left gastric artery is the smallest branch of the celiac trunk. It ascends to the cardioesophageal junction and sends **esophageal branches** upward to the abdominal part of the esophagus (Fig. 4.82). Some of these branches continue through the esophageal hiatus of the diaphragm and anastomose with esophageal branches from the thoracic aorta. The left gastric artery itself turns to the right and descends along the lesser curvature of the stomach in the lesser omentum. It supplies both surfaces of the stomach in this area and anastomoses with the right gastric artery.

Splenic artery

The **splenic artery**, the largest branch of the celiac trunk, takes a tortuous course to the left along the superior border

of the pancreas (Fig. 4.82). It travels in the splenorenal ligament and divides into numerous branches, which enter the hilum of the spleen.

As the splenic artery passes along the superior border of the pancreas, it gives off numerous small branches to supply the neck, body, and tail of the pancreas (Fig. 4.83).

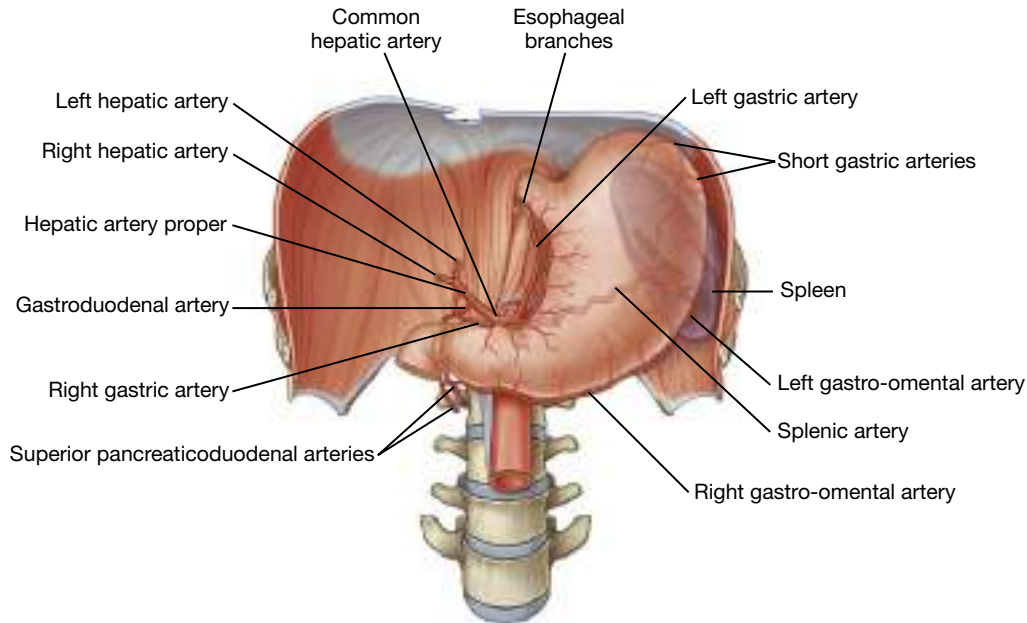


Fig. 4.82 Distribution of the celiac trunk.

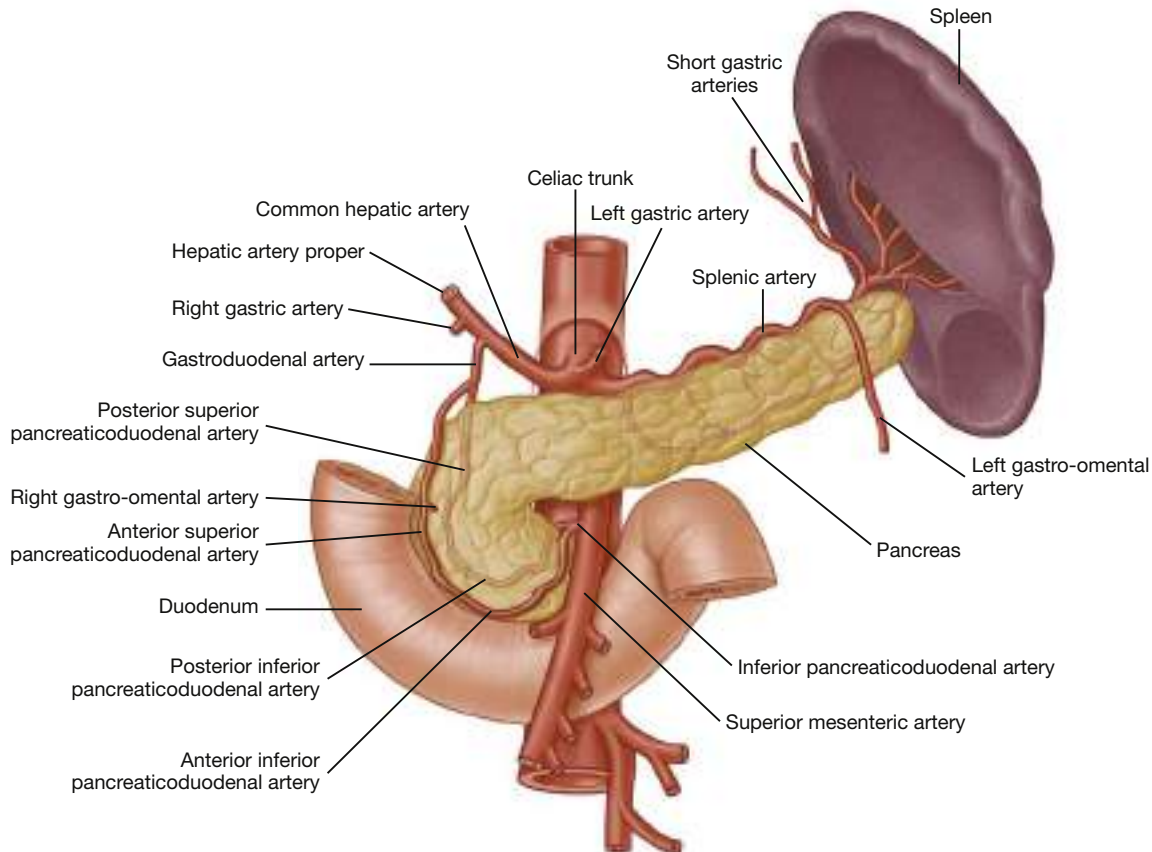


Fig. 4.83 Branches of the gastroduodenal artery.

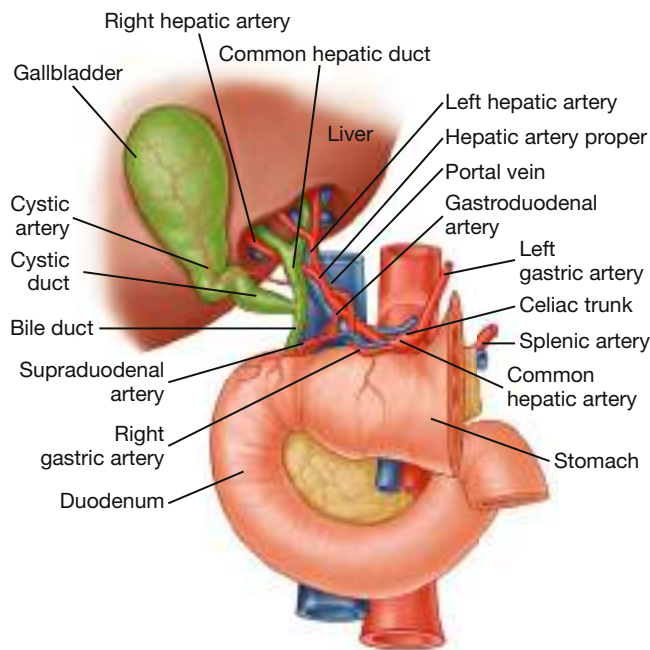


Fig. 4.84 Distribution of the common hepatic artery.

Approaching the spleen, the splenic artery gives off **short gastric arteries**, which pass through the gastrosplenic ligament to supply the fundus of the stomach. It also gives off the **left gastro-omental artery**, which runs to the right along the greater curvature of the stomach and anastomoses with the right gastro-omental artery.

Common hepatic artery

The **common hepatic artery** is a medium-sized branch of the celiac trunk that runs to the right and divides into its two terminal branches, the **hepatic artery proper** and the **gastroduodenal artery** (Figs. 4.82, 4.83).

The hepatic artery proper ascends toward the liver in the free edge of the lesser omentum. It runs to the left of the bile duct and anterior to the portal vein and divides into the **right** and **left hepatic arteries** near the porta hepatis (Fig. 4.84). As the right hepatic artery nears the liver, it gives off the cystic artery to the gallbladder.

A right gastric artery often originates from the hepatic artery proper but can also arise from the common hepatic artery or from the left hepatic, gastroduodenal, or supraduodenal arteries. It courses to the left and ascends along the lesser curvature of the stomach in the lesser omentum, supplies adjacent areas of the stomach, and anastomoses with the left gastric artery.

The gastroduodenal artery may give off the **supraduodenal artery** and does give off the **posterior superior pancreaticoduodenal artery** near the upper border of the superior part of the duodenum. After these branches the gastroduodenal artery continues descending posterior to the superior

part of the duodenum. Reaching the lower border of the superior part of the duodenum, the gastroduodenal artery divides into its terminal branches, the **right gastro-omental artery** and the **anterior superior pancreaticoduodenal artery** (Fig. 4.83).

The right gastro-omental artery passes to the left along the greater curvature of the stomach, eventually anastomosing with the left gastro-omental artery from the splenic artery. The right gastro-omental artery sends branches to both surfaces of the stomach, and additional branches descend into the greater omentum.

The anterior superior pancreaticoduodenal artery descends and, along with the posterior superior pancreaticoduodenal artery, supplies the head of the pancreas and the duodenum (Fig. 4.83). These vessels eventually anastomose with the anterior and posterior branches of the inferior pancreaticoduodenal artery.

Superior mesenteric artery

The superior mesenteric artery is the anterior branch of the abdominal aorta supplying the midgut. It arises from the abdominal aorta immediately below the celiac artery (Fig. 4.85) anterior to the lower part of vertebra L1.

The superior mesenteric artery is crossed anteriorly by the splenic vein and the neck of pancreas. Posterior to the artery are the left renal vein, the uncinate process of the pancreas, and the inferior part of the duodenum (Fig. 4.85). After giving off its first branch (the **inferior pancreaticoduodenal artery**), the superior mesenteric artery gives off **jejunal** and **ileal arteries** on its left (Figs. 4.85, 4.86). Branching from the right side of the main trunk of the superior mesenteric artery are three vessels—the **middle colic**, **right colic**, and **ileocolic arteries**—that supply the terminal ileum, cecum, ascending colon, and two-thirds of the transverse colon (Fig. 4.86).

Inferior pancreaticoduodenal artery

The inferior pancreaticoduodenal artery is the first branch of the superior mesenteric artery (Fig. 4.85). It divides immediately into anterior and posterior branches, which ascend on the corresponding sides of the head of the pancreas. Superiorly, these arteries anastomose with anterior and posterior superior pancreaticoduodenal arteries (Figs. 4.83, 4.85). This arterial network supplies the head and uncinate process of the pancreas and the duodenum.

Jejunal and ileal arteries

Distal to the inferior pancreaticoduodenal artery, the superior mesenteric artery gives off numerous branches. Arising on the left is a large number of jejunal and ileal arteries supplying the jejunum and most of the ileum (Fig. 4.86). These branches leave the main trunk of the artery, pass between

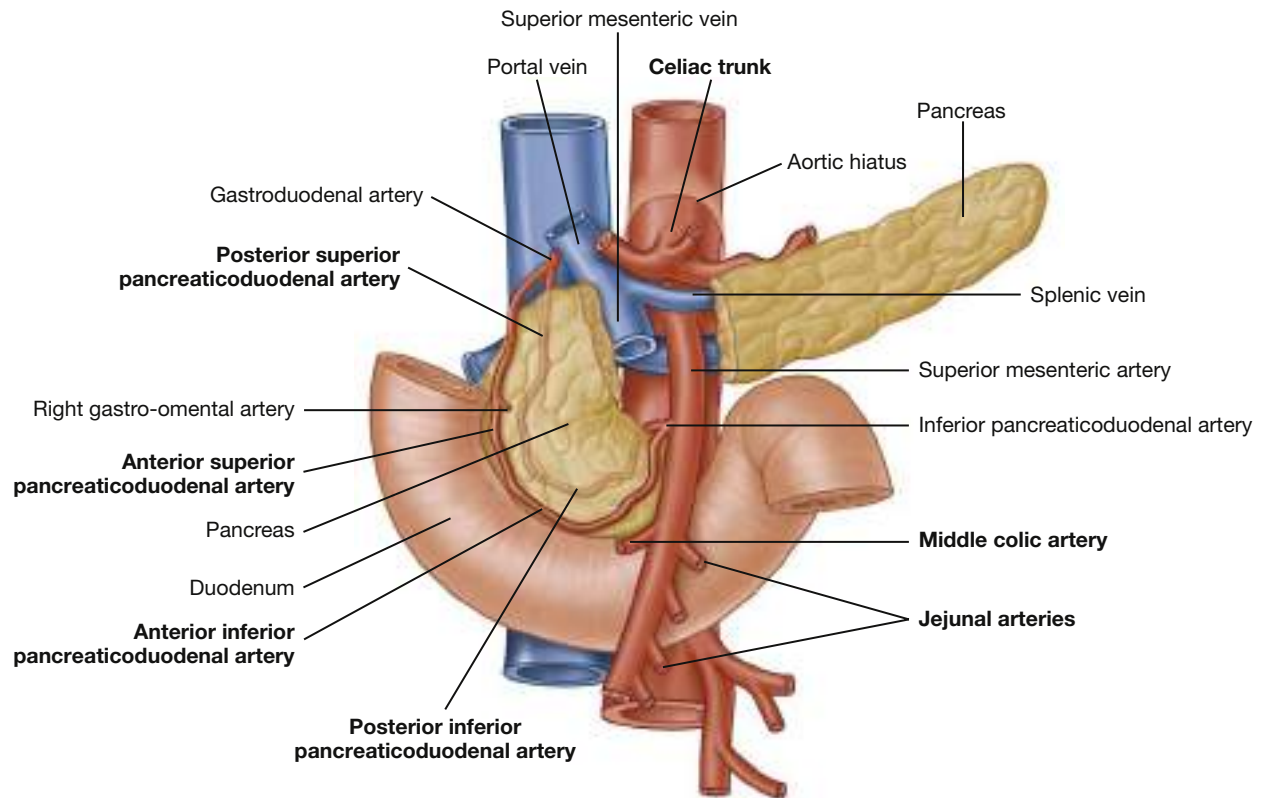


Fig. 4.85 Initial branching and relationships of the superior mesenteric artery.

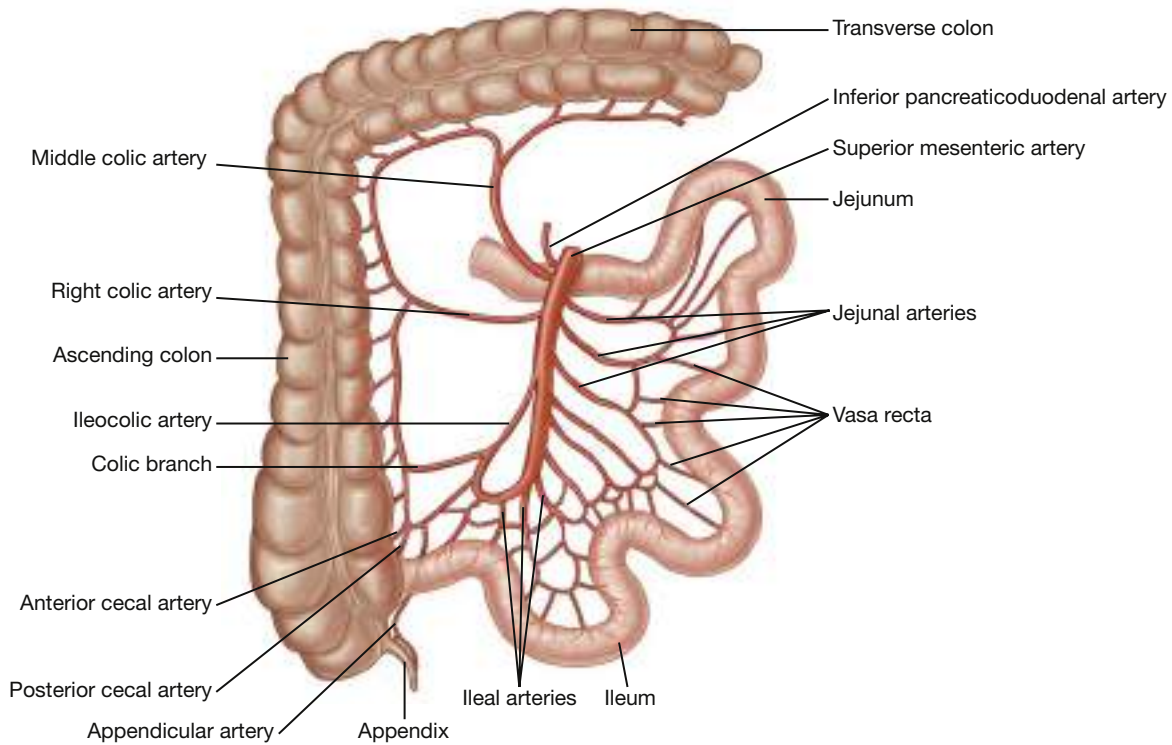


Fig. 4.86 Distribution of the superior mesenteric artery.

two layers of the mesentery, and form anastomosing arches or arcades as they pass outward to supply the small intestine. The number of arterial arcades increases distally along the gut.

There may be single and then double arcades in the area of the jejunum with a continued increase in the number of arcades moving into and through the area of the ileum (Fig. 4.86). Extending from the terminal arcade are **vasa recta** (straight arteries), which provide the final direct vascular supply to the walls of the small intestine. The vasa recta supplying the jejunum are usually long and close together, forming narrow windows visible in the mesentery. The vasa recta supplying the ileum are generally short and far apart, forming low broad windows.

Middle colic artery

The middle colic artery is the first of the three branches from the right side of the main trunk of the superior mesenteric artery (Fig. 4.86). Arising as the superior mesenteric artery emerges from beneath the pancreas, the middle colic artery enters the transverse mesocolon and divides into right and left branches. The right branch anastomoses with the right colic artery, and the left branch anastomoses with the left colic artery, which is a branch of the inferior mesenteric artery.

Right colic artery

Continuing distally along the main trunk of the superior mesenteric artery, the right colic artery is the second of the three branches from the right side of the main trunk of the superior mesenteric artery (Fig. 4.86). It is an inconsistent branch and passes to the right in a retroperitoneal position to supply the ascending colon. Nearing the colon, it divides into a descending branch, which anastomoses with the ileocolic artery and an ascending branch, which anastomoses with the middle colic artery.

Ileocolic artery

The final branch arising from the right side of the superior mesenteric artery is the ileocolic artery (Fig. 4.86). This passes downward and to the right toward the right iliac fossa where it divides into superior and inferior branches:

- The superior branch passes upward along the ascending colon to anastomose with the right colic artery.
- The inferior branch continues toward the ileocolic junction, dividing into **colic, cecal, appendicular, and ileal branches** (Fig. 4.86).

The specific pattern of distribution and origin of these branches are variable:

- The colic branch crosses to the ascending colon and passes upward to supply the first part of the ascending colon.
- Anterior and posterior cecal branches, arising either as a common trunk or as separate branches, supply corresponding sides of the cecum.
- The appendicular branch enters the free margin of and supplies the mesoappendix and the appendix.
- The ileal branch passes to the left and ascends to supply the final part of the ileum before anastomosing with the superior mesenteric artery.

Inferior mesenteric artery

The inferior mesenteric artery is the anterior branch of the abdominal aorta that supplies the hindgut. It is the smallest of the three anterior branches of the abdominal aorta and arises anterior to the body of vertebra LIII. Initially, the inferior mesenteric artery descends anteriorly to the aorta and then passes to the left as it continues inferiorly (Fig. 4.87). Its branches include the **left colic artery, several sigmoid arteries, and the superior rectal artery.**

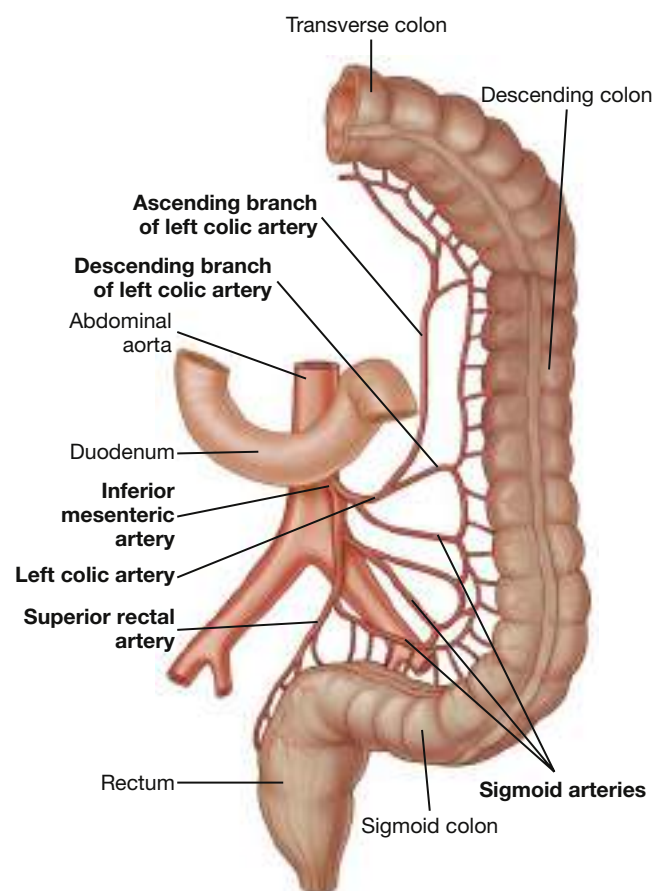


Fig. 4.87 Distribution of the inferior mesenteric artery.

Left colic artery

The left colic artery is the first branch of the inferior mesenteric artery (Fig. 4.87). It ascends retroperitoneally, dividing into ascending and descending branches:

- The ascending branch passes anteriorly to the left kidney, then enters the transverse mesocolon, and passes superiorly to supply the upper part of the descending colon and the distal part of the transverse colon; it anastomoses with branches of the middle colic artery.
- The descending branch passes inferiorly, supplying the lower part of the descending colon and anastomoses with the first sigmoid artery.

Sigmoid arteries

The sigmoid arteries consist of two to four branches, which descend to the left in the sigmoid mesocolon to supply the lowest part of the descending colon and the sigmoid colon (Fig. 4.87). These branches anastomose superiorly with branches from the left colic artery and inferiorly with branches from the superior rectal artery.

Superior rectal artery

The terminal branch of the inferior mesenteric artery is the superior rectal artery (Fig. 4.87). This vessel descends into the pelvic cavity in the sigmoid mesocolon, crossing the left common iliac vessels. Opposite vertebra SIII, the superior rectal artery divides. The two terminal branches descend on each side of the rectum, dividing into smaller branches in the wall of the rectum. These smaller branches continue inferiorly to the level of the internal anal sphincter, anastomosing along the way with branches from the middle rectal arteries (from the internal iliac artery) and the inferior rectal arteries (from the internal pudendal artery).

Clinical app

Vascular supply to the gastrointestinal system

Arteriosclerosis may occur throughout the abdominal aorta and at the openings of the celiac trunk and the superior mesenteric and inferior mesenteric arteries. Not infrequently, the inferior mesenteric artery becomes occluded. Interestingly, many of these patients do not suffer any complications because anastomoses between the right, middle, and left colic arteries gradually enlarge, forming a continuous **marginal artery**. The distal large bowel therefore becomes supplied by this enlarged marginal artery (marginal artery of Drummond), which replaces the blood supply of the inferior mesenteric artery.

Venous drainage

Venous drainage of the spleen, pancreas, gallbladder, and the abdominal part of the gastrointestinal tract, except for the inferior part of the rectum, is through the portal system of veins, which delivers blood from these structures to the liver. Once blood passes through the hepatic sinusoids, it passes through progressively larger veins until it enters the hepatic veins, which return the venous blood to the inferior vena cava just inferior to the diaphragm.

Portal vein

The **portal vein** is the final common pathway for the transport of venous blood from the spleen, pancreas, gallbladder, and the abdominal part of the gastrointestinal tract. It is formed by the union of the **splenic vein** and the **superior mesenteric vein** posterior to the neck of the pancreas at the level of vertebra LII (Figs. 4.88, 4.89).

Ascending toward the liver, the portal vein passes posterior to the superior part of the duodenum and enters the right margin of the lesser omentum. As it passes through this part of the lesser omentum, it is anterior to the omental foramen and posterior to both the bile duct, which is slightly to its right, and the hepatic artery proper, which is slightly to its left (see Fig. 4.84).

On approaching the liver, the portal vein divides into **right** and **left branches**, which enter the liver parenchyma. Tributaries to the portal vein include:

- **right** and **left gastric veins** draining the lesser curvature of the stomach and abdominal esophagus,
- **cystic veins** from the gallbladder, and
- **para-umbilical veins**, which are normally small veins associated with the obliterated umbilical vein and connect to veins on the anterior abdominal wall (Fig. 4.90).

Splenic vein

The splenic vein forms from numerous smaller vessels leaving the hilum of the spleen (Fig. 4.89). It passes to the right, passing through the splenorenal ligament with the splenic artery and the tail of pancreas. Continuing to the right, the large, straight splenic vein is in contact with the body of the pancreas as it crosses the posterior abdominal wall. Posterior to the neck of the pancreas, the splenic vein joins the superior mesenteric vein to form the portal vein.

Tributaries to the splenic vein include:

- **short gastric veins** from the fundus and left part of the greater curvature of the stomach,
- the **left gastro-omental vein** from the greater curvature of the stomach,

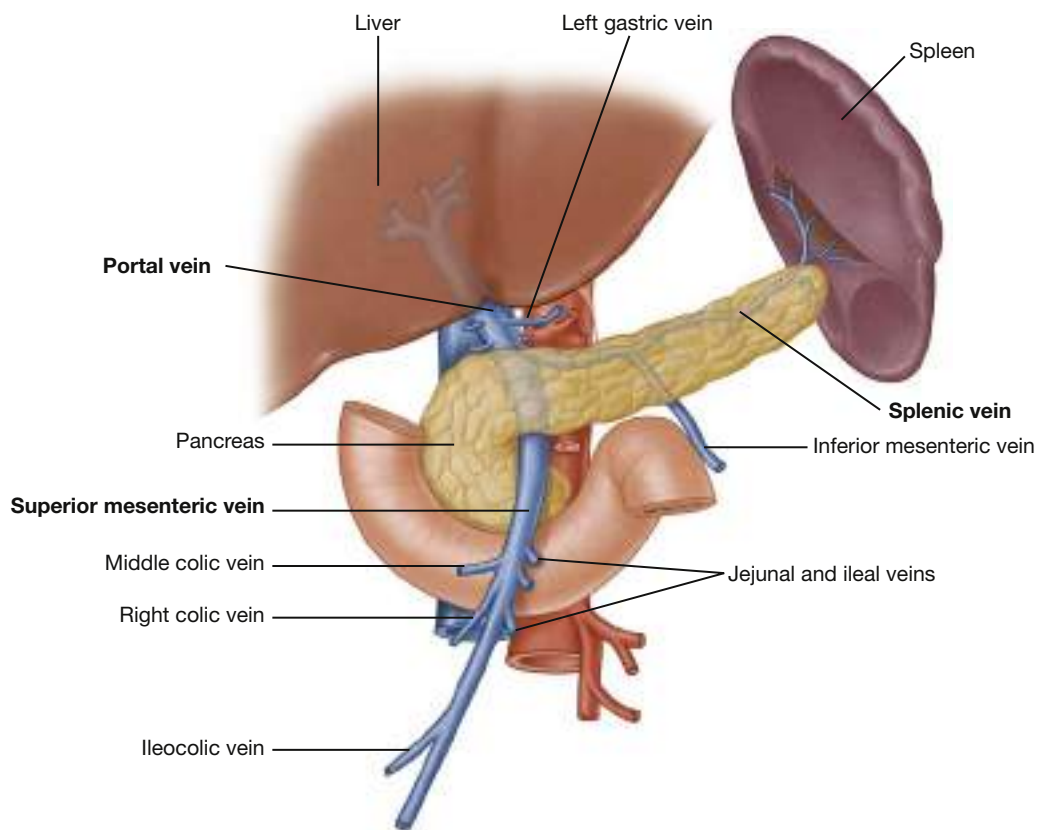


Fig. 4.88 Portal vein.

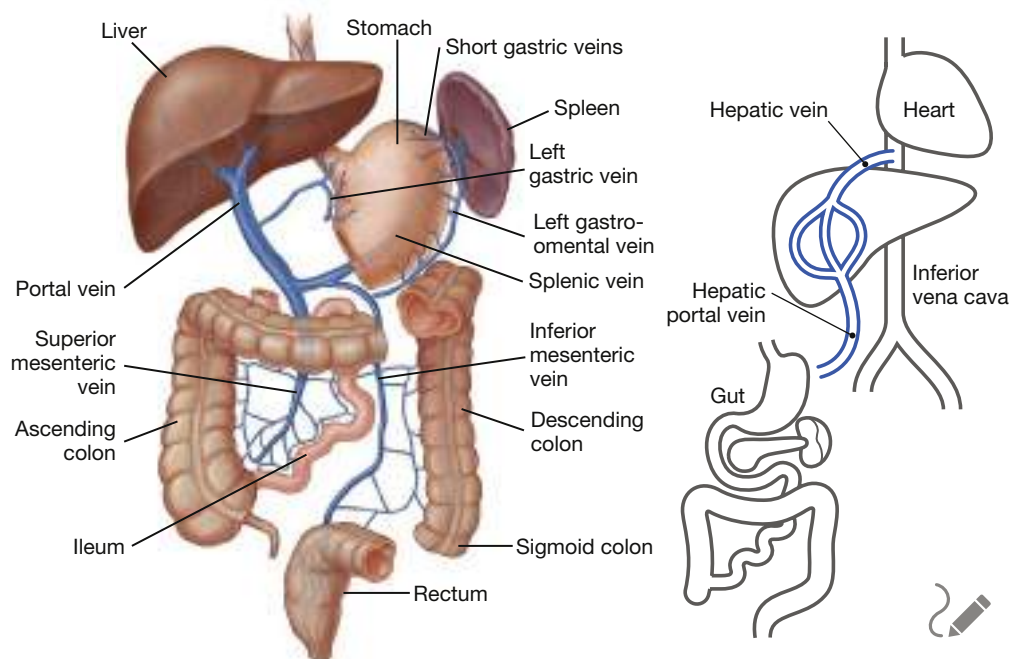


Fig. 4.89 Venous drainage of the abdominal portion of the gastrointestinal tract.

- **pancreatic veins** draining the body and tail of pancreas, and
- usually the **inferior mesenteric vein**.

Superior mesenteric vein

The superior mesenteric vein drains blood from the small intestine, cecum, ascending colon, and transverse colon (Fig. 4.89). It begins in the right iliac fossa as veins draining the terminal ileum, cecum, and appendix join and ascends in the mesentery to the right of the superior mesenteric artery.

Posterior to the neck of the pancreas, the superior mesenteric vein joins the splenic vein to form the portal vein (Fig. 4.88).

As a corresponding vein accompanies each branch of the superior mesenteric artery, tributaries to the superior mesenteric vein include jejunal, ileal, ileocolic, right colic, and middle colic veins. Additional tributaries include:

- the **right gastro-omental vein** draining the right part of the greater curvature of the stomach, and
- the **anterior and posterior inferior pancreaticoduodenal veins**, which pass alongside the arteries of the same

Clinical app

Hepatic cirrhosis

Cirrhosis is a complex disorder of the liver, the diagnosis of which is confirmed histologically. When a diagnosis is suspected, a liver biopsy is necessary.

Cirrhosis is characterized by widespread hepatic fibrosis interspersed with areas of nodular regeneration and abnormal reconstruction of preexisting lobular architecture. The presence of cirrhosis implies previous or continuing liver cell damage. The poorly functioning liver cells (hepatocytes) are unable to break down blood and blood products, leading to an increase in the serum bilirubin level, which manifests as jaundice.

As the cirrhosis progresses, the intrahepatic vasculature is distorted, which, in turn, leads to increased pressure in the portal vein and its draining tributaries (portal hypertension). Portal hypertension produces increased pressure in the splenic venules leading to splenic enlargement. At the sites of portosystemic anastomosis, large dilated varicose veins develop. These veins are susceptible to bleeding and may produce marked blood loss, which, in some instances, can be fatal.

Clinical app

Portosystemic anastomosis

The hepatic portal system drains blood from the visceral organs of the abdomen to the liver. In normal individuals, 100% of the portal venous blood flow can be recovered from the hepatic veins, whereas in patients with elevated portal vein pressure (e.g., portal hypertension from cirrhosis), there is significantly less blood flow to the liver. The rest of the blood enters collateral channels, which drain into the systemic circulation at specific points (Fig. 4.90). The largest of these collaterals occur at:

- the gastroesophageal junction around the cardia of the stomach—where the left gastric vein and its tributaries form a portosystemic anastomosis with tributaries to the azygos system of veins;
- the anus—the superior rectal vein of the portal system anastomoses with the middle and inferior rectal veins of the systemic venous system; and
- the anterior abdominal wall around the umbilicus—the para-umbilical veins anastomose with veins on the anterior abdominal wall.

When the pressure in the portal vein is elevated, venous enlargement (varices) tends to occur at and around the sites of portosystemic anastomoses, and these enlarged veins are called:

- *varices at the anorectal junction*,
- *esophageal varices at the gastroesophageal junction*, and
- *caput medusae at the umbilicus*.

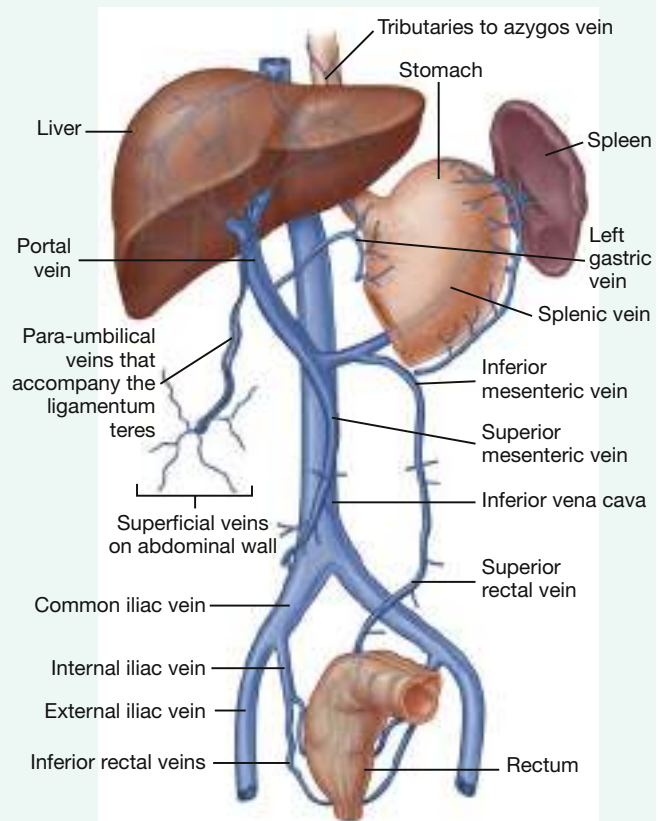


Fig. 4.90 Portosystemic anastomoses.

name; the anterior superior pancreaticoduodenal vein usually empties into the right gastro-omental vein, and the posterior superior pancreaticoduodenal vein usually empties directly into the portal vein.

Inferior mesenteric vein

The **inferior mesenteric vein** drains blood from the rectum, sigmoid colon, descending colon, and **splenic flexure** (Figs. 4.89, 4.90). It begins as the **superior rectal vein** and ascends, receiving tributaries from the sigmoid veins and the **left colic vein**. All these veins accompany arteries of the same name. Continuing to ascend, the inferior mesenteric vein passes posterior to the body of the pancreas and usually joins the splenic vein. Occasionally, it ends at the junction of the splenic and superior mesenteric veins or joins the superior mesenteric vein.

Lymphatics

Lymphatic drainage of the abdominal part of the gastrointestinal tract, as low as the inferior part of the rectum, as

well as the spleen, pancreas, gallbladder, and liver, is through vessels and nodes that eventually end in large collections of **pre-aortic lymph nodes** at the origins of the three anterior branches of the abdominal aorta, which supply these structures. These collections are therefore referred to as the **celiac**, **superior mesenteric**, and **inferior mesenteric** groups of pre-aortic lymph nodes. Lymph from viscera supplied by (Fig. 4.91):

- the celiac trunk (i.e., structures that are part of the abdominal foregut) drains to pre-aortic nodes near the origin of the celiac trunk (Fig. 4.91)—these celiac nodes also receive lymph from the superior mesenteric and inferior mesenteric groups of pre-aortic nodes, and lymph from the celiac nodes enters the **cisterna chyli**;
- the superior mesenteric artery (i.e., structures that are part of the abdominal midgut) drains to pre-aortic nodes near the origin of the superior mesenteric artery (Fig. 4.91)—these superior mesenteric nodes also receive lymph from the inferior mesenteric groups of pre-aortic nodes, and lymph from the superior mesenteric nodes drains to the celiac nodes; and
- the inferior mesenteric artery (i.e., structures that are part of the abdominal hindgut) drains to pre-aortic nodes near the origin of the inferior mesenteric artery (Fig. 4.91), and lymph from the inferior mesenteric nodes drains to the superior mesenteric nodes.

Innervation

Abdominal viscera are innervated by both extrinsic and intrinsic components of the nervous system:

- Extrinsic innervation involves receiving motor impulses from and sending sensory information to the central nervous system.
- Intrinsic innervation involves the regulation of digestive tract activities by a generally self-sufficient network of sensory and motor neurons (the **enteric nervous system**).

Abdominal viscera receiving extrinsic innervation include the abdominal part of the gastrointestinal tract, the spleen, the pancreas, the gallbladder, and the liver. These viscera send sensory information back to the central nervous system through visceral afferent fibers and receive motor impulses from the central nervous system through visceral efferent fibers.

The visceral efferent fibers are part of the sympathetic and parasympathetic parts of the autonomic division of the peripheral nervous system.

Structural components serving as conduits for these afferent and efferent fibers include posterior and anterior

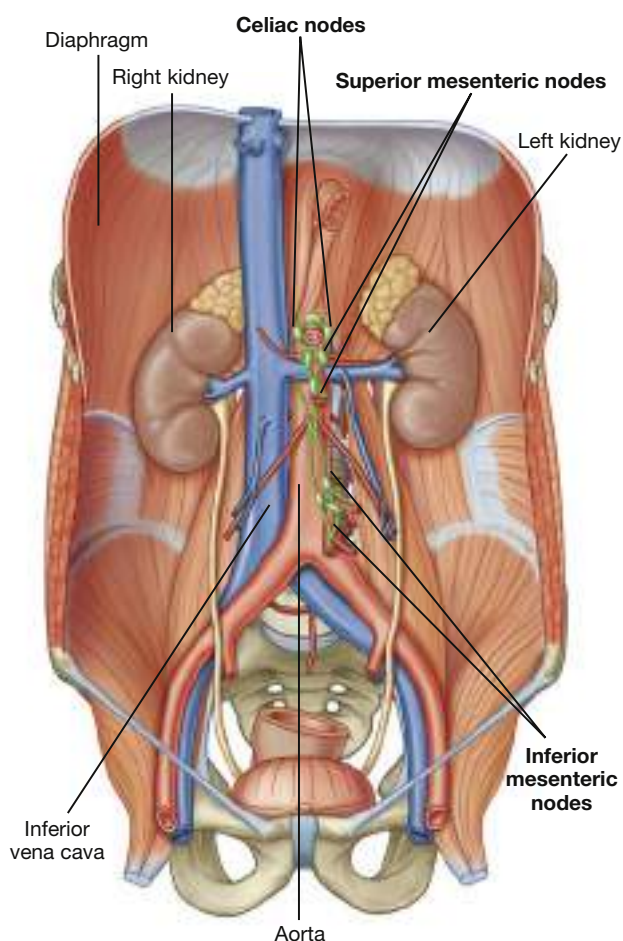


Fig. 4.91 Lymphatic drainage of the abdominal portion of the gastrointestinal tract.

roots of the spinal cord, respectively; spinal nerves; anterior rami; white and gray rami communicantes; the sympathetic trunks; splanchnic nerves carrying sympathetic fibers (thoracic, lumbar, and sacral); parasympathetic fibers (pelvic); the prevertebral plexus and related ganglia; and the vagus nerves [X].

The enteric nervous system consists of motor and sensory neurons in two interconnected plexuses in the walls of the gastrointestinal tract. These neurons control the coordinated contraction and relaxation of intestinal smooth muscle and regulate gastric secretion and blood flow.

Sympathetic trunks

The sympathetic trunks are two parallel nerve cords extending on either side of the vertebral column from the base of the skull to the coccyx (Fig. 4.92). As they pass through the neck, they lie posterior to the carotid sheath. In the upper thorax, they are anterior to the necks of the ribs, whereas in the lower thorax they are on the lateral aspect of the vertebral bodies. In the abdomen, they are anterolateral to the lumbar vertebral bodies and, continuing into the pelvis, they are anterior to the sacrum. The two sympathetic trunks come together anterior to the coccyx to form the **ganglion impar**.

Throughout the extent of the sympathetic trunks, small raised areas are visible. These collections of neuronal cell bodies outside the central nervous system are the paravertebral sympathetic ganglia (Fig. 4.92). There are usually:

- 3 ganglia in the cervical region,
- 11 or 12 ganglia in the thoracic region,
- 3 ganglia in the lumbar region,
- 4 or 5 ganglia in the sacral region, and
- the ganglion impar anterior to the coccyx.

The ganglia and trunks are connected to adjacent spinal nerves by gray rami communicantes throughout the length of the sympathetic trunk and by white rami communicantes in the thoracic and upper lumbar parts of the trunk (T1 to L2). Neuronal fibers found in the sympathetic trunks include **preganglionic** and **postganglionic sympathetic fibers** and **visceral afferent fibers**.

Splanchnic nerves

The splanchnic nerves are important components in the innervation of the abdominal viscera. They pass from the sympathetic trunk or sympathetic ganglia associated with the trunk to the prevertebral plexus and ganglia anterior to the abdominal aorta.

There are two different types of splanchnic nerves, depending on the type of visceral efferent fiber they are carrying:

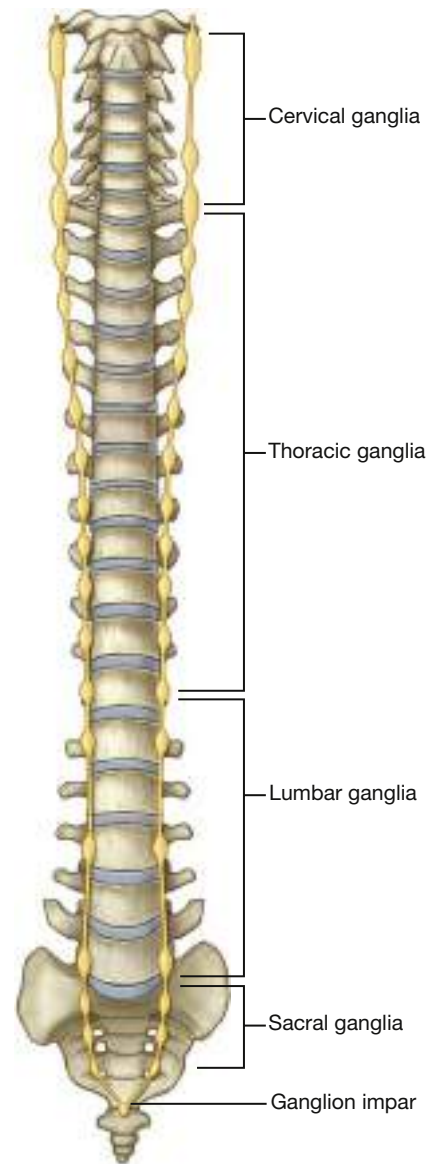


Fig. 4.92 Sympathetic trunks.

- The thoracic, lumbar, and sacral splanchnic nerves carry preganglionic sympathetic fibers from the sympathetic trunk to ganglia in the prevertebral plexus and visceral afferent fibers.
- The pelvic splanchnic nerves carry preganglionic parasympathetic fibers from anterior rami of S2, S3, and S4 spinal nerves to an extension of the prevertebral plexus in the pelvis (the **inferior hypogastric plexus** or **pelvic plexus**).

Thoracic splanchnic nerves

Three **thoracic splanchnic nerves** pass from sympathetic ganglia along the sympathetic trunk in the thorax to the prevertebral plexus and ganglia associated with the abdominal aorta in the abdomen (Fig. 4.93):

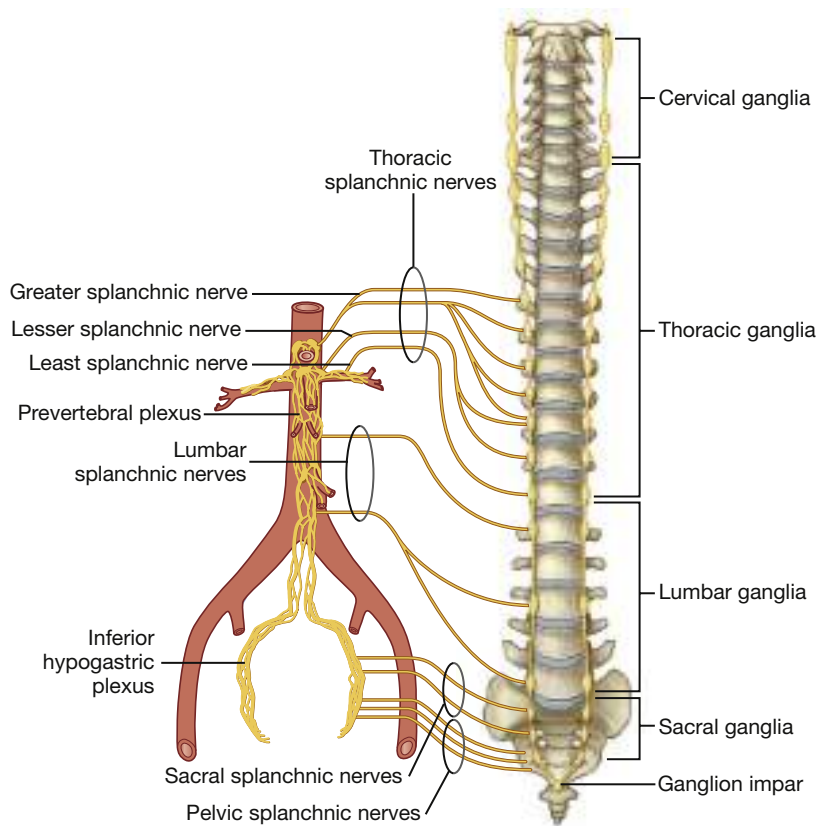


Fig. 4.93 Splanchnic nerves.

- The **greater splanchnic nerve** arises from the fifth to the ninth (or tenth) thoracic ganglia and travels to the celiac ganglion in the abdomen (a prevertebral ganglion associated with the celiac trunk).
- The **lesser splanchnic nerve** arises from the ninth and tenth (or tenth and eleventh) thoracic ganglia and travels to the aorticorenal ganglion.
- The **least splanchnic nerve** arises from the twelfth thoracic ganglion and travels to the renal plexus.

Lumbar and sacral splanchnic nerves

There are usually two to four **lumbar splanchnic nerves**, which pass from the lumbar part of the sympathetic trunk or associated ganglia and enter the prevertebral plexus (Fig. 4.93).

Similarly, the **sacral splanchnic nerves** pass from the sacral part of the sympathetic trunk or associated ganglia and enter the inferior hypogastric plexus, which is an extension of the prevertebral plexus into the pelvis.

Pelvic splanchnic nerves

The **pelvic splanchnic nerves (parasympathetic root)** are unique. They are the only splanchnic nerves that carry parasympathetic fibers. In other words, they do not originate from the sympathetic trunks. Rather, they originate directly from the anterior rami of S2 to S4. Preganglionic

parasympathetic fibers originating in the sacral spinal cord pass from the S2 to S4 spinal nerves to the inferior hypogastric plexus (Fig. 4.93). Once in this plexus, some of these fibers pass upward, enter the abdominal prevertebral plexus, and distribute with the arteries supplying the hindgut. This provides the pathway for innervation of the distal one-third of the transverse colon, the descending colon, and the sigmoid colon by preganglionic parasympathetic fibers.

Abdominal prevertebral plexus and ganglia

The abdominal prevertebral plexus is a collection of nerve fibers that surrounds the abdominal aorta and is continuous onto its major branches. Scattered throughout the length of the abdominal prevertebral plexus are cell bodies of postganglionic sympathetic fibers. Some of these cell bodies are organized into distinct ganglia, whereas others are more random in their distribution. The ganglia are usually associated with specific branches of the abdominal aorta and named after these branches.

The three major divisions of the abdominal prevertebral plexus and associated ganglia are the celiac, aortic, and superior hypogastric plexuses (Fig. 4.94).

- The **celiac plexus** is the large accumulation of nerve fibers and ganglia associated with the roots of the celiac trunk and superior mesenteric artery immediately below the aortic hiatus of the diaphragm. Ganglia associated with the

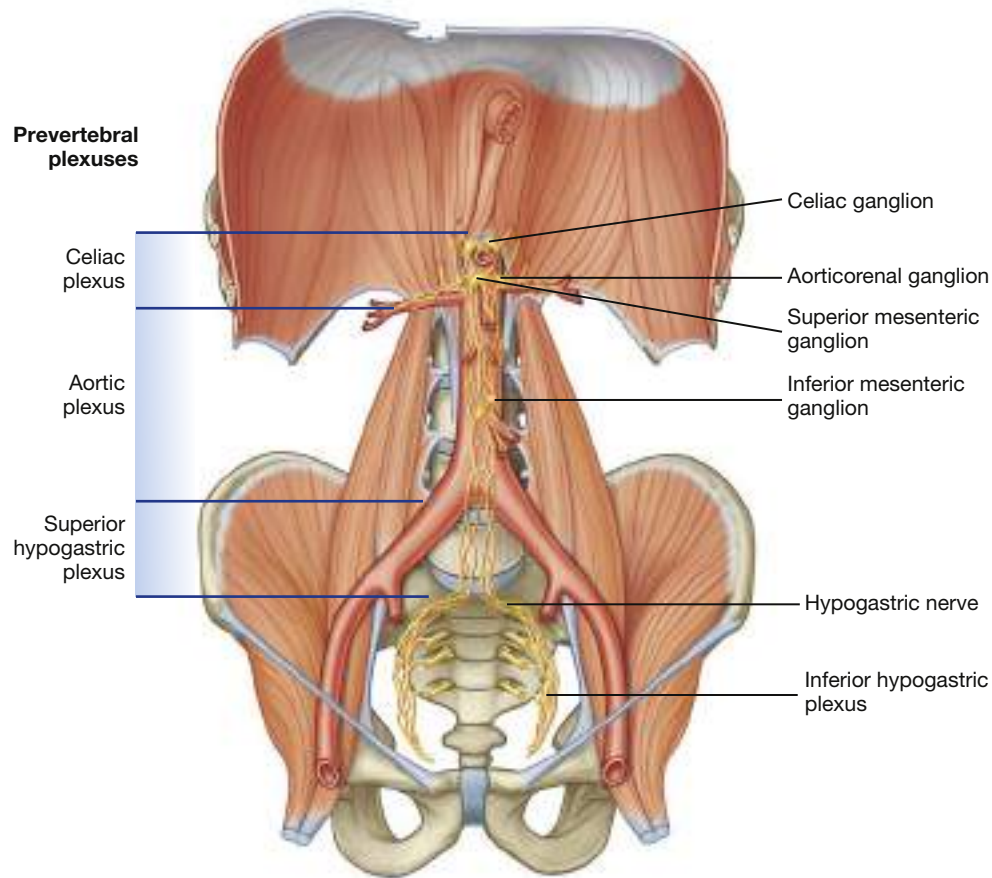


Fig. 4.94 Abdominal prevertebral plexus and ganglia.

celiac plexus include two celiac ganglia, a single superior mesenteric ganglion, and two aorticorenal ganglia.

- The **aortic plexus** consists of nerve fibers and associated ganglia on the anterior and lateral surfaces of the abdominal aorta extending from just below the origin of the superior mesenteric artery to the bifurcation of the aorta and into the two common iliac arteries. The major ganglion in this plexus is the inferior mesenteric ganglion at the root of the inferior mesenteric artery.
- The **superior hypogastric plexus** contains numerous small ganglia and is the final part of the abdominal prevertebral plexus before the prevertebral plexus continues into the pelvic cavity.

Each of these major plexuses gives origin to a number of secondary plexuses, which may also contain small ganglia. These plexuses are usually named after the vessels with which they are associated. For example, the celiac plexus is usually described as giving origin to the superior mesenteric plexus and the renal plexus, as well as other plexuses that extend out along the various branches of the celiac trunk.

Similarly, the aortic plexus has secondary plexuses consisting of the inferior mesenteric plexus, the spermatic plexus, and the external iliac plexus.

Inferiorly, the superior hypogastric plexus divides into the **hypogastric nerves**, which descend into the pelvis and contribute to the formation of the inferior hypogastric or pelvic plexus (Fig. 4.94).

The abdominal prevertebral plexus receives:

- preganglionic parasympathetic and visceral afferent fibers from the vagus nerves [X],
- preganglionic sympathetic and visceral afferent fibers from the thoracic and lumbar splanchnic nerves, and
- preganglionic parasympathetic fibers from the pelvic splanchnic nerves.

Parasympathetic innervation

Parasympathetic innervation of the abdominal part of the gastrointestinal tract and of the spleen, pancreas, gallbladder, and liver is from two sources—the vagus nerves [X] and the pelvic splanchnic nerves.

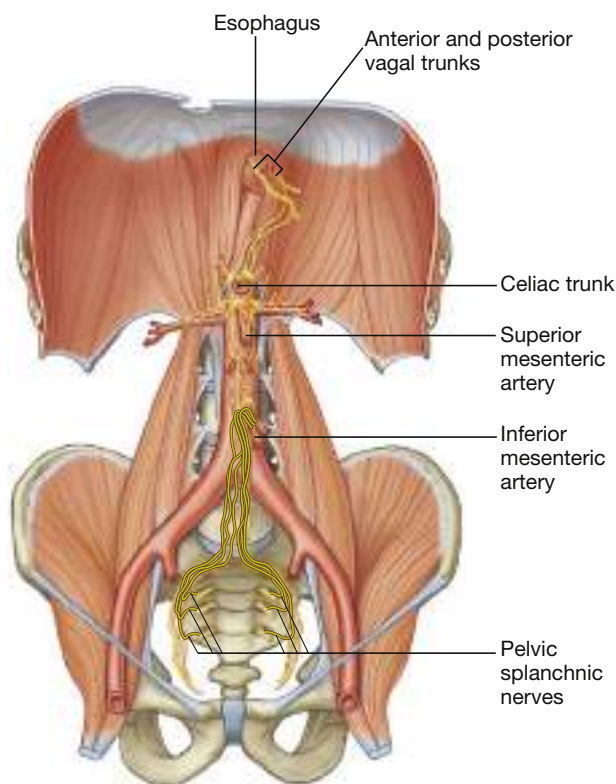


Fig. 4.95 Parasympathetic innervation of the abdominal portion of the gastrointestinal tract.

Vagus nerves

The **vagus nerves** [X] enter the abdomen associated with the esophagus as the esophagus passes through the diaphragm (Fig. 4.95) and provide parasympathetic innervation to the foregut and midgut.

After entering the abdomen as the **anterior** and **posterior vagal trunks**, they send branches to the abdominal prevertebral plexus. These branches contain preganglionic parasympathetic fibers and visceral afferent fibers, which are distributed with the other components of the prevertebral plexus along the branches of the abdominal aorta.

Pelvic splanchnic nerves

The **pelvic splanchnic nerves**, carrying preganglionic parasympathetic fibers from S2 to S4 spinal cord levels, enter the inferior hypogastric plexus in the pelvis. Some of these fibers move upward into the inferior mesenteric part of the prevertebral plexus in the abdomen (Fig. 4.95). Once there, these fibers are distributed with branches of the inferior mesenteric artery and provide parasympathetic innervation to the hindgut.

Enteric system

The enteric system is a division of the visceral part of the nervous system and is a local neuronal circuit in the wall of the gastrointestinal tract. It consists of motor and sensory neurons

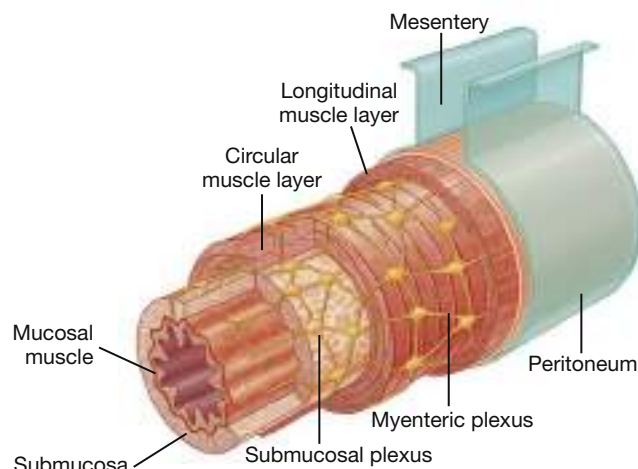


Fig. 4.96 The enteric system.

organized into two interconnected plexuses (the **myenteric** and **submucosal plexuses**) between the layers of the gastrointestinal wall, and the associated nerve fibers that pass between the plexuses and from the plexuses to the adjacent tissue (Fig. 4.96).

The enteric system regulates and coordinates numerous gastrointestinal tract activities, including gastric secretory activity, gastrointestinal blood flow, and the contraction and relaxation cycles of smooth muscle (**peristalsis**).

Although the enteric system is generally independent of the central nervous system, it does receive input from postganglionic sympathetic and preganglionic parasympathetic neurons that modifies its activities.

Example—sympathetic innervation of stomach

The pathway of sympathetic innervation of the stomach is as follows:

- A preganglionic sympathetic fiber originating at the T6 level of the spinal cord enters an anterior root to leave the spinal cord.
- At the level of the intervertebral foramen, the anterior root (which contains the preganglionic fiber) and a posterior root join to form a spinal nerve.
- Outside the vertebral column, the preganglionic fiber leaves the anterior ramus of the spinal nerve through the white ramus communicans.
- The white ramus communicans, containing the preganglionic fiber, connects to the sympathetic trunk.
- Entering the sympathetic trunk, the preganglionic fiber does not synapse but passes through the trunk and enters the greater splanchnic nerve.
- The greater splanchnic nerve passes through the crura of the diaphragm and enters the celiac ganglion.

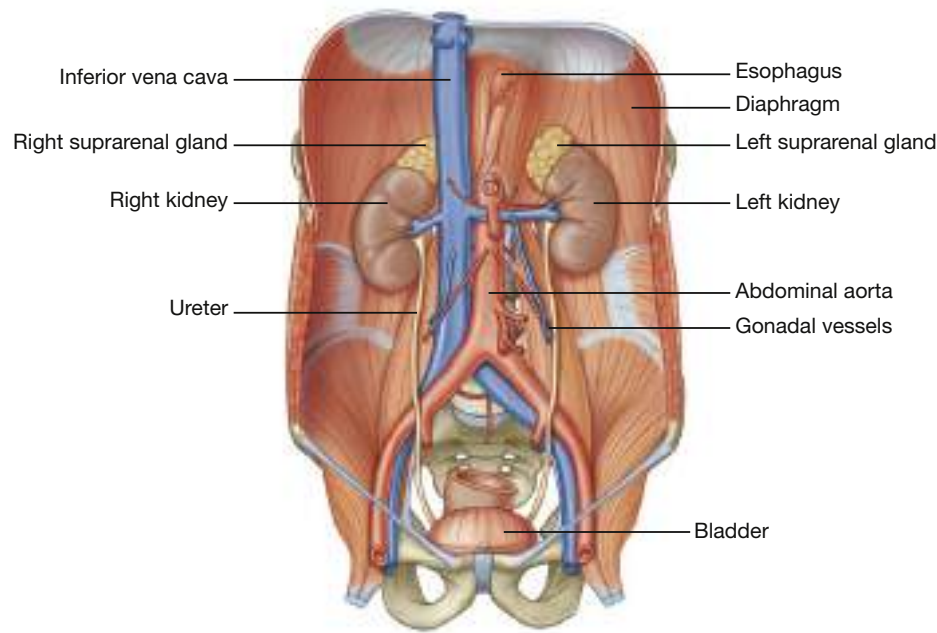


Fig. 4.97 Posterior abdominal region.

- In the celiac ganglion, the preganglionic fiber synapses with a postganglionic neuron.
- The postganglionic fiber joins the plexus of nerve fibers surrounding the celiac trunk and continues along its branches.
- The postganglionic fiber travels through the plexus of nerves accompanying the branches of the celiac trunk, supplying the stomach, and eventually reaches its point of distribution.
- This input from the sympathetic system may modify the activities of the gastrointestinal tract controlled by the enteric nervous system.

POSTERIOR ABDOMINAL REGION

The posterior abdominal region is posterior to the abdominal part of the gastrointestinal tract, the spleen, and the pancreas (Fig. 4.97). This area, bounded by bones and muscles making up the posterior abdominal wall, contains numerous structures that not only are directly involved in the activities of the abdominal contents but also use this area as a conduit between body regions. Examples include the abdominal aorta and its associated nerve plexuses, the inferior vena cava, the sympathetic trunks, and lymphatics. There are also structures originating in this area that are critical to the normal function of other regions of the body (i.e., the lumbar plexus of nerves), and there are organs that associate with this area during development and remain in it in the adult (i.e., the kidneys and suprarenal glands).

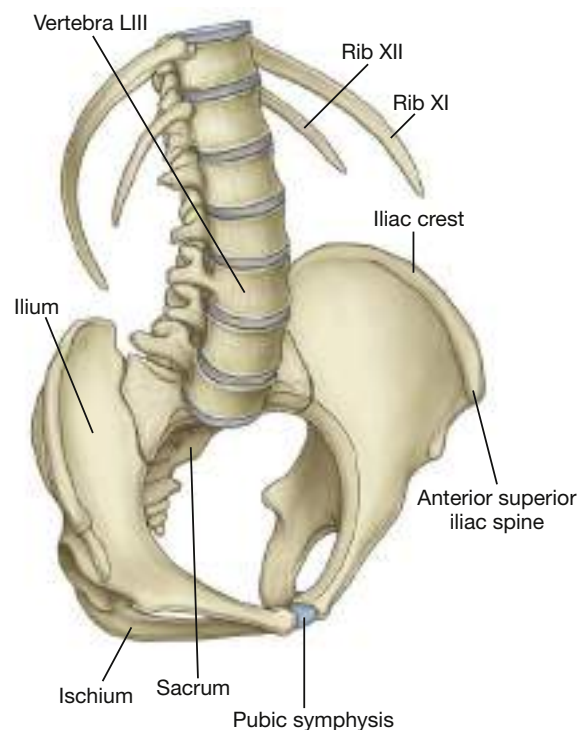


Fig. 4.98 Osteology of the posterior abdominal wall.

Posterior abdominal wall

Bones

Lumbar vertebrae and the sacrum

Projecting into the midline of the posterior abdominal area are the bodies of the five lumbar vertebrae (Fig. 4.98). The

prominence of these structures in this region is due to the secondary curvature (a forward convexity) of the lumbar part of the vertebral column.

The lumbar vertebrae can be distinguished from cervical and thoracic vertebrae because of their size. They are much larger than any other vertebrae in any other region. The vertebral bodies are massive and progressively increase in size from vertebra LI to LV. The pedicles are short and stocky, the transverse processes are long and slender, and the spinous processes are large and stubby. The articular processes are large and oriented medially and laterally, which promotes flexion and extension in this part of the vertebral column.

Between each lumbar vertebra is an intervertebral disc, which completes this part of the midline boundary of the posterior abdominal wall.

The midline boundary of the posterior abdominal wall, inferior to the lumbar vertebrae, consists of the upper margin of the sacrum (Fig. 4.98). The sacrum is formed by the fusion of the five sacral vertebrae into a single, wedge-shaped, bony structure that is broad superiorly and narrows inferiorly. Its concave anterior surface and its convex posterior surface contain anterior and posterior sacral foramina for the anterior and posterior rami of spinal nerves to pass through.

Pelvic bones

The **ilia**, which are components of each pelvic bone, attach laterally to the sacrum at the sacro-iliac joints (Fig. 4.98). The upper part of each ilium expands outward into a thin wing-like area (the **iliac fossa**). The medial side of this region of each iliac bone and the related muscles are components of the posterior abdominal wall.

Ribs

Superiorly, ribs XI and XII complete the bony framework of the posterior abdominal wall (Fig. 4.98). These ribs are unique in that they do not articulate with the sternum, they have a single articular facet on their heads, and they do not have necks or tubercles.

Rib XI is posterior to the superior part of the left kidney, and rib XII is posterior to the superior part of both kidneys. Also, rib XII serves as a point of attachment for numerous muscles and ligaments.

Muscles

Muscles forming the medial, lateral, inferior, and superior boundaries of the posterior abdominal region fill in the bony framework of the posterior abdominal wall (Table 4.2). Medially are the psoas major and minor muscles, laterally is the quadratus lumborum muscle, inferiorly is the iliacus muscle, and superiorly is the diaphragm (Figs. 4.99, 4.100).

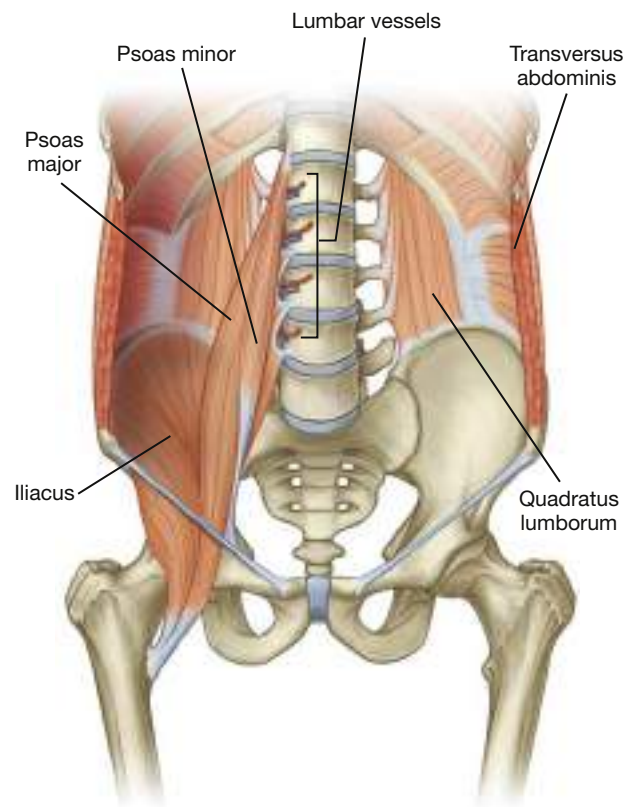


Fig. 4.99 Muscles of the posterior abdominal wall.

Psoas major and minor

Medially, the **psoas major** muscles cover the anterolateral surface of the bodies of the lumbar vertebrae, filling in the space between the vertebral bodies and the transverse processes (Table 4.2, Fig. 4.99). Associated with the psoas major muscle is the **psoas minor** muscle, which is sometimes absent.

Quadratus lumborum

Laterally, the quadratus lumborum muscles fill the space between ribs XII and the iliac crest on both sides of the vertebral column (Table 4.2, Fig. 4.99). They are overlapped medially by the psoas major muscles; along their lateral borders are the transversus abdominis muscles.

Iliacus

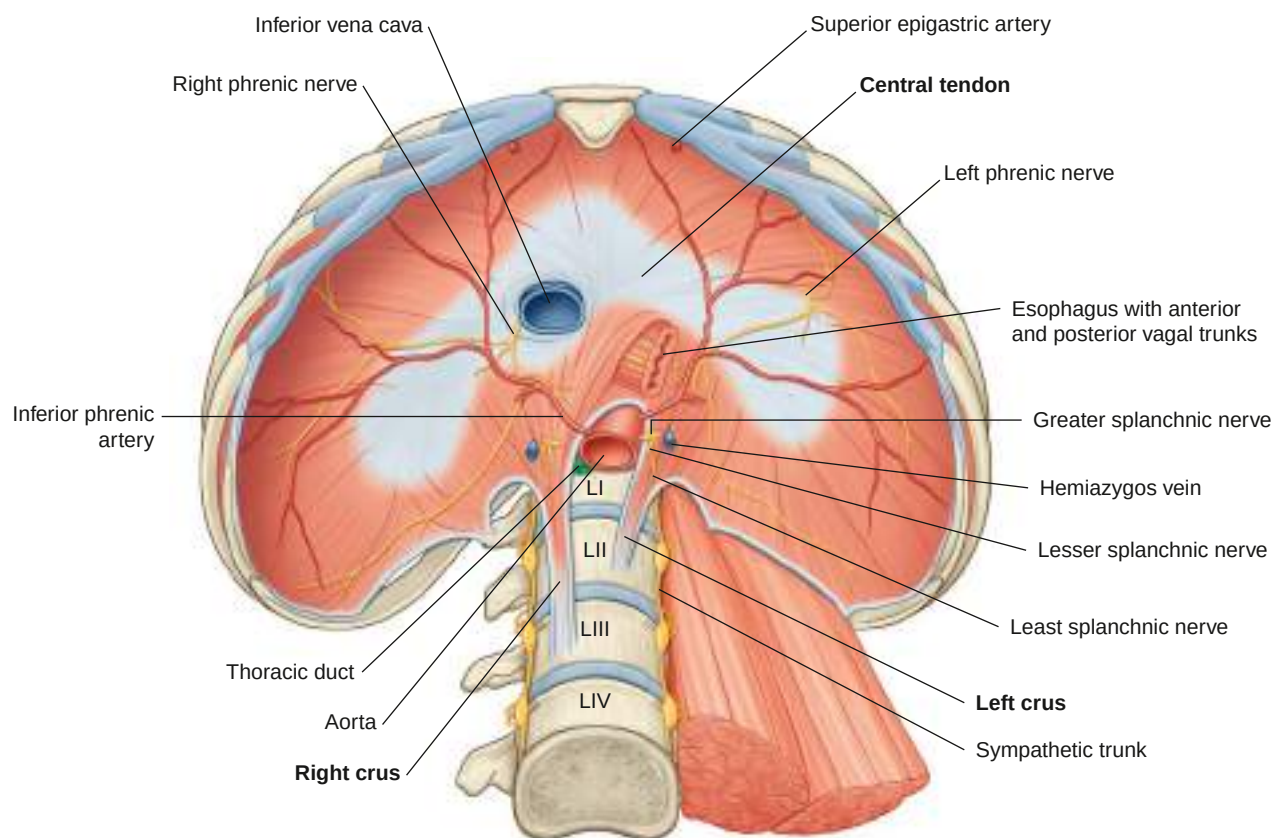
Inferiorly, an **iliacus** muscle fills the iliac fossa on each side (Table 4.2, Fig. 4.99). From this expansive origin covering the iliac fossa, the muscle passes inferiorly, joins with the psoas major muscle, and passes into the thigh. These combined muscles are referred to as the **iliopsoas** muscle.

Diaphragm

Superiorly, the diaphragm forms the boundary of the posterior abdominal region. This musculotendinous sheet also separates the abdominal cavity from the thoracic cavity.

Table 4.2 Posterior abdominal wall muscles

Muscle	Origin	Insertion	Innervation	Function
Psoas major	Lateral surface of bodies of TXII and LI to LV vertebrae, transverse processes of the lumbar vertebrae, and the intervertebral discs between TXII and LI to LV vertebrae	Lesser trochanter of the femur	Anterior rami of L1 to L3	Flexion of thigh at hip joint
Psoas minor	Lateral surface of bodies of TXII and LI vertebrae and intervening intervertebral disc	Pectineal line of the pelvic brim and iliopubic eminence	Anterior rami of L1	Weak flexion of lumbar vertebral column
Quadratus lumborum	Transverse process of LV vertebra, iliolumbar ligament, and iliac crest	Transverse processes of LI to LIV vertebrae and inferior border of rib XII	Anterior rami of T12 and L1 to L4	Depress and stabilize rib XII and some lateral bending of trunk
Iliacus	Upper two-thirds of iliac fossa, anterior sacro-iliac and iliolumbar ligaments, and upper lateral surface of sacrum	Lesser trochanter of femur	Femoral nerve (L2 to L4)	Flexion of thigh at hip joint

**Fig. 4.100** Diaphragm.

Structurally, the diaphragm consists of a central tendinous part into which the circumferentially arranged muscle fibers attach (Fig. 4.100). The diaphragm is anchored to the lumbar vertebrae by musculotendinous crura, which blend with the anterior longitudinal ligament of the vertebral column.

- The **right crus** is the longest and broadest of the **crura** and is attached to the bodies of vertebrae LI to LIII and the intervening intervertebral discs (Fig. 4.101).

- Similarly, the **left crus** is attached to vertebrae LI and LII and the associated intervertebral disc (Fig. 4.101).

The crura are connected across the midline by a tendinous arch (the **median arcuate ligament**), which passes anterior to the aorta (Fig. 4.101).

Lateral to the crura, a second tendinous arch is formed by the fascia covering the upper part of the psoas major muscle. This is the **medial arcuate ligament**, which is attached

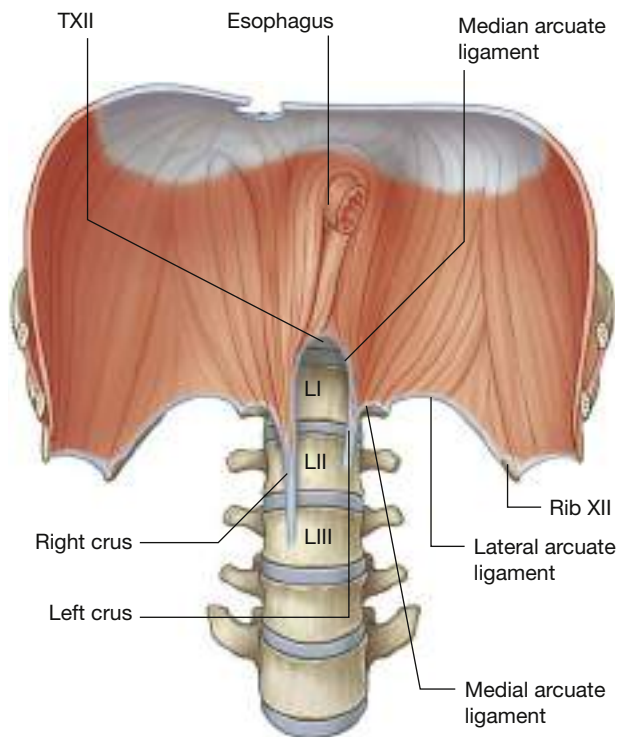


Fig. 4.101 Crura of the diaphragm.

medially to the sides of vertebrae LI and LII and laterally to the transverse process of vertebra LI (Fig. 4.101).

A third tendinous arch, the **lateral arcuate ligament**, is formed by a thickening in the fascia that covers the quadratus lumborum. It is attached medially to the transverse process of vertebra LI and laterally to rib XII (Fig. 4.101).

The medial and lateral arcuate ligaments serve as points of origin for some of the muscular components of the diaphragm.

Structures passing through or around the diaphragm

Numerous structures pass through or around the diaphragm (Fig. 4.100):

- The aorta passes posterior to the diaphragm and anterior to the vertebral bodies at the lower level of vertebra TXII; it is between the two crura of the diaphragm and posterior to the median arcuate ligament just to the left of midline.
- Accompanying the aorta through the aortic hiatus is the thoracic duct and, sometimes, the azygos vein.
- The esophagus passes through the musculature of the right crus of the diaphragm at the level of vertebra TX just to the left of the aortic hiatus.
- Passing through the esophageal hiatus with the esophagus are the anterior and posterior vagal trunks, the esophageal branches of the left gastric artery and vein, and a few lymphatic vessels.

- The third large opening in the diaphragm is the caval opening through which the inferior vena cava passes from the abdominal cavity to the thoracic cavity (Fig. 4.100) at approximately vertebra TVIII in the central tendinous part of the diaphragm.
- Accompanying the inferior vena cava through the caval opening is the right phrenic nerve.
- The left phrenic nerve passes through the muscular part of the diaphragm just anterior to the central tendon on the left side.

Additional structures pass through small openings either in or just outside the diaphragm as they pass from the thoracic cavity to the abdominal cavity (Fig. 4.100):

- The greater, lesser, and least (when present) splanchnic nerves pass through the crura on either side.
- The hemiazygos vein passes through the left crus.
- Passing posterior to the medial arcuate ligament on either side are the sympathetic trunks.
- Passing anterior to the diaphragm just deep to the ribs are the superior epigastric vessels.
- Other vessels and nerves (i.e., the musculophrenic vessels and intercostal nerves) also pass through the diaphragm at various points.

Domes

The classic appearance of the right and left domes of the diaphragm is caused by the underlying abdominal contents pushing these lateral areas upward and by the fibrous pericardium, which is attached centrally, causing a flattening of the diaphragm in this area (Fig. 4.102).

The domes are produced by:

- the liver on the right, with some contribution from the right kidney and the right suprarenal gland, and
- the fundus of the stomach and spleen on the left, with contributions from the left kidney and the left suprarenal gland.

Although the height of these domes varies during breathing, a reasonable estimate in normal expiration places the left dome at the fifth intercostal space and the right dome at rib V. This is important to remember when percussing the thorax.

During inspiration, the muscular part of the diaphragm contracts, causing the central tendon of the diaphragm to be drawn inferiorly. This results in some flattening of the domes, enlargement of the thoracic cavity, and a reduction in intrathoracic pressure. The physiological effects of these changes are that air enters the lungs and venous return to the heart is enhanced.

Imaging app

Visualizing the diaphragm



Fig. 4.102 Right and left domes of the diaphragm. Chest radiograph.

Blood supply

There is blood supply to the diaphragm on its superior and inferior surfaces:

- superiorly, the **musculophrenic** and **pericardiophrenic arteries**, both branches of the **internal thoracic artery**, and the **superior phrenic artery**, a branch of the **thoracic aorta**, supply the diaphragm;
- inferiorly, the **inferior phrenic arteries**, branches of the **abdominal aorta**, supply the diaphragm (see Fig. 4.100).

Venous drainage is through companion veins to these arteries.

Innervation

Innervation of the diaphragm is primarily by the **phrenic nerves**. These nerves, from the C3 to C5 spinal cord levels, provide all motor innervation to the diaphragm and sensory fibers to the central part. They pass through the thoracic cavity, deep to the mediastinal pleura in the fibrous pericardium, to the superior surface of the diaphragm. At

this point, the right phrenic nerve accompanies the inferior vena cava through the diaphragm and the left phrenic nerve passes through the diaphragm by itself (see Fig. 4.100). Additional sensory fibers are supplied to the peripheral areas of the diaphragm by intercostal nerves.

Clinical app

Psoas muscle abscess

At first glance, it is difficult to appreciate why the psoas muscle sheath is of greater importance than any other muscle sheath. The psoas muscle and its sheath arise not only from the lumbar vertebrae but also from the intervertebral discs between each vertebra. This disc origin is of critical importance. In certain types of infection, the intervertebral disc is preferentially affected (e.g., tuberculosis and salmonella discitis). As the infection of the disc progresses, the infection spreads anterolaterally and passes into the psoas muscle sheath. The infection spreads inferiorly in the sheath and may appear below the inguinal ligament as a mass.

Clinical app

Diaphragmatic hernias

To understand why a hernia occurs through the diaphragm, it is necessary to consider the embryology of the diaphragm.

The diaphragm is formed from four structures—the septum transversum, the posterior esophageal mesentery, the pleuroperitoneal membrane, and the peripheral rim—which eventually fuse together, separating the abdominal cavity from the thoracic cavity. The septum transversum forms the central tendon, which develops from a mesodermal origin superior to the embryo's head and then moves to its more adult position during folding of the cephalic portion of the embryo.

Fusion of the various components of the diaphragm may fail, and hernias may occur through the failed points of fusion. The commonest sites are:

- between the xiphoid process and the costal margins on the right (Morgagni's hernia), and
- through an opening on the left when the pleuroperitoneal membrane fails to close the pericardioperitoneal canal (Bochdalek's hernia).

Hernias may also occur through the central tendon and through a congenitally large esophageal hiatus.

Morgagni's and Bochdalek's hernias tend to appear at or around the time of birth or in early infancy. They allow abdominal bowel to enter the thoracic cavity, which may compress the lungs and reduce respiratory function. Most of these hernias require surgical closure of the diaphragmatic defect.

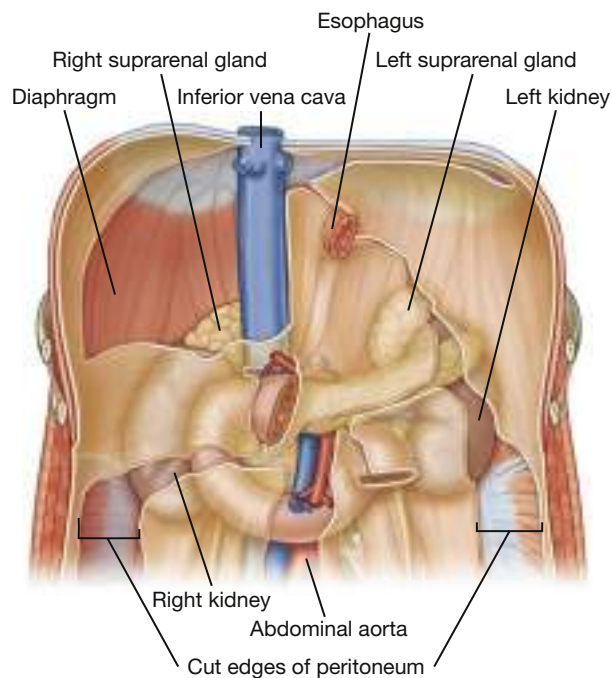


Fig. 4.103 Retroperitoneal position of the kidneys in the posterior abdominal region.

Clinical app

Hiatal hernia

At the level of the esophageal hiatus, the diaphragm may be lax, allowing the fundus of the stomach to herniate into the posterior mediastinum. This typically causes symptoms of acid reflux. Ulceration may occur and may produce bleeding and anemia.

Viscera Kidneys

The bean-shaped kidneys are retroperitoneal in the posterior abdominal region (Fig. 4.103). They lie in the extraperitoneal connective tissue immediately lateral to the vertebral column. In the supine position, the kidneys extend from approximately vertebra TXII superiorly to vertebra LIII inferiorly, with the right kidney somewhat lower than the left because of its relationship with the liver. Although they are similar in size and shape, the left kidney is a longer and more slender organ than the right kidney, and nearer to the midline.

Relationships to other structures

The anterior surface of the right kidney is related to numerous structures, some of which are separated from the kidney by a layer of peritoneum and some of which are directly against the kidney (Fig. 4.104):

- A small part of the **superior pole** is covered by the right suprarenal gland.
- Moving inferiorly, a large part of the rest of the upper part of the **anterior surface** is against the liver and is separated from it by a layer of peritoneum.
- Medially, the descending part of the duodenum is retroperitoneal and contacts the kidney.
- The **inferior pole** of the kidney, on its lateral side, is directly associated with the right colic flexure and, on its medial side, is covered by a segment of the intraperitoneal small intestine.

The anterior surface of the left kidney is also related to numerous structures, some with an intervening layer of peritoneum and some directly against the kidney (Fig. 4.104):

- A small part of the superior pole, on its medial side, is covered by the left suprarenal gland.
- The rest of the superior pole is covered by the intraperitoneal stomach and spleen.
- Moving inferiorly, the retroperitoneal pancreas covers the middle part of the kidney.
- On its lateral side, the lower half of the kidney is covered by the left colic flexure and the beginning of the descending colon and, on its medial side, by the parts of the intraperitoneal jejunum.

Posteriorly, the right and left kidneys are related to similar structures (Fig. 4.105). Superiorly is the diaphragm and inferior to this, moving in a medial to lateral direction, are psoas major, quadratus lumborum, and transversus abdominis muscles.

The superior pole of the right kidney is anterior to rib XII, whereas the same region of the left kidney is anterior to ribs XI and XII. The pleural sacs, and specifically, the costodiaphragmatic recesses, therefore extend posterior to the kidneys.

Also passing posterior to the kidneys are the subcostal vessels and nerves and the iliohypogastric and ilio-inguinal nerves.

Renal fat and fascia

The kidneys are enclosed in and associated with a unique arrangement of fascia and fat. Immediately outside the renal capsule there is an accumulation of extraperitoneal fat—the **perinephric fat (perirenal fat)**, which completely surrounds the kidney (Fig. 4.106). Enclosing the perinephric fat is a membranous condensation of the extraperitoneal fascia (the **renal, or Gerota's, fascia**). The suprarenal glands are also enclosed in this fascial compartment, usually separated from the kidneys by a thin septum. The renal fascia must be incised in any surgical approach to this organ.

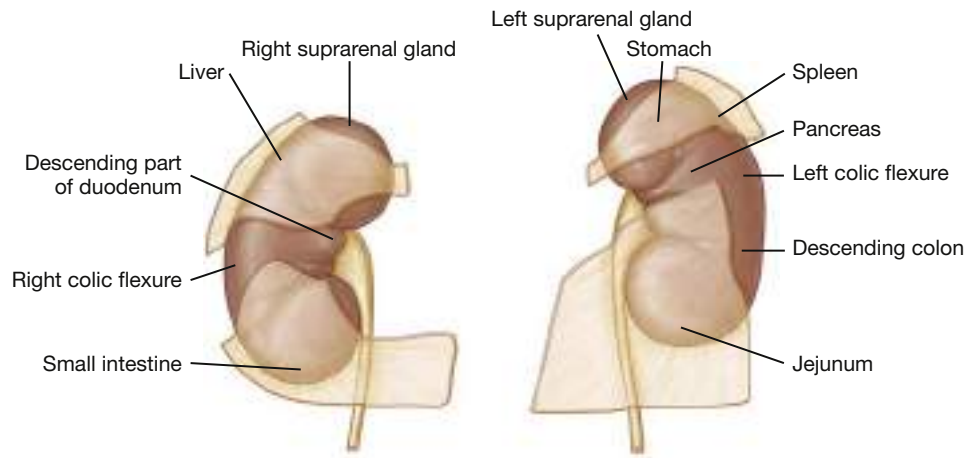


Fig. 4.104 Structures related to the anterior surface of each kidney.

At the lateral margins of each kidney, the anterior and posterior layers of the renal fascia fuse (Fig. 4.106). This fused layer may connect with the transversalis fascia on the lateral abdominal wall.

Above each suprarenal gland, the anterior and posterior layers of the renal fascia fuse and blend with the fascia that covers the diaphragm.

Medially, the anterior layer of the renal fascia continues over the vessels in the hilum and fuses with the connective tissue associated with the abdominal aorta and the inferior vena cava (Fig. 4.106). In some cases, the anterior layer may cross the midline to the opposite side and blend with its companion layer.

The posterior layer of the renal fascia passes medially between the kidney and the fascia covering the quadratus lumborum muscle to fuse with the fascia covering the psoas major muscle.

Inferiorly, the anterior and posterior layers of the renal fascia enclose the ureters.

In addition to perinephric fat and the renal fascia, a final layer of **paranephric fat (pararenal fat)** completes the fat and fascias associated with the kidney (Fig. 4.106). This fat accumulates posterior and posterolateral to each kidney.

Kidney structure

Each kidney has a smooth anterior and posterior surface covered by a fibrous capsule, which is easily removable except during disease.

On the medial margin of each kidney is the **hilum of kidney**, which is a deep vertical slit through which renal vessels, lymphatics, and nerves enter and leave the substance of the kidney (Fig. 4.107). Internally, the hilum is continuous with the renal sinus. Perinephric fat continues into the hilum and sinus and surrounds all structures.

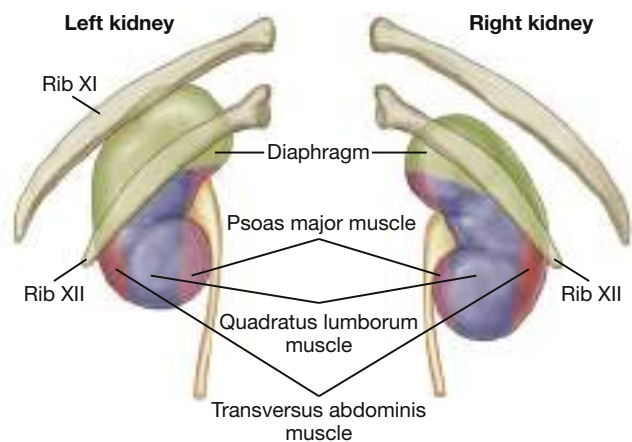


Fig. 4.105 Structures related to the posterior surface of each kidney.

Each kidney consists of an outer **renal cortex** and an inner **renal medulla** (Fig. 4.107). The renal cortex is a continuous band of pale tissue that completely surrounds the renal medulla. Extensions of the renal cortex (the **renal columns**) project into the inner aspect of the kidney, dividing the renal medulla into discontinuous aggregations of triangular-shaped tissue (the **renal pyramids**).

The bases of the renal pyramids are directed outward toward the renal cortex, whereas the apex of each renal pyramid projects inward toward the **renal sinus**. The apical projection (**renal papilla**) contains the openings of the papillary ducts draining the renal tubules and is surrounded by a **minor calyx**.

The minor calices receive urine from the papillary ducts and represent the proximal parts of the tube that will eventually form the ureter (Fig. 4.107). In the renal sinus, several minor calices unite to form a **major calyx**, and two or three major calices unite to form the **renal pelvis**, which is the funnel-shaped superior end of the ureters.

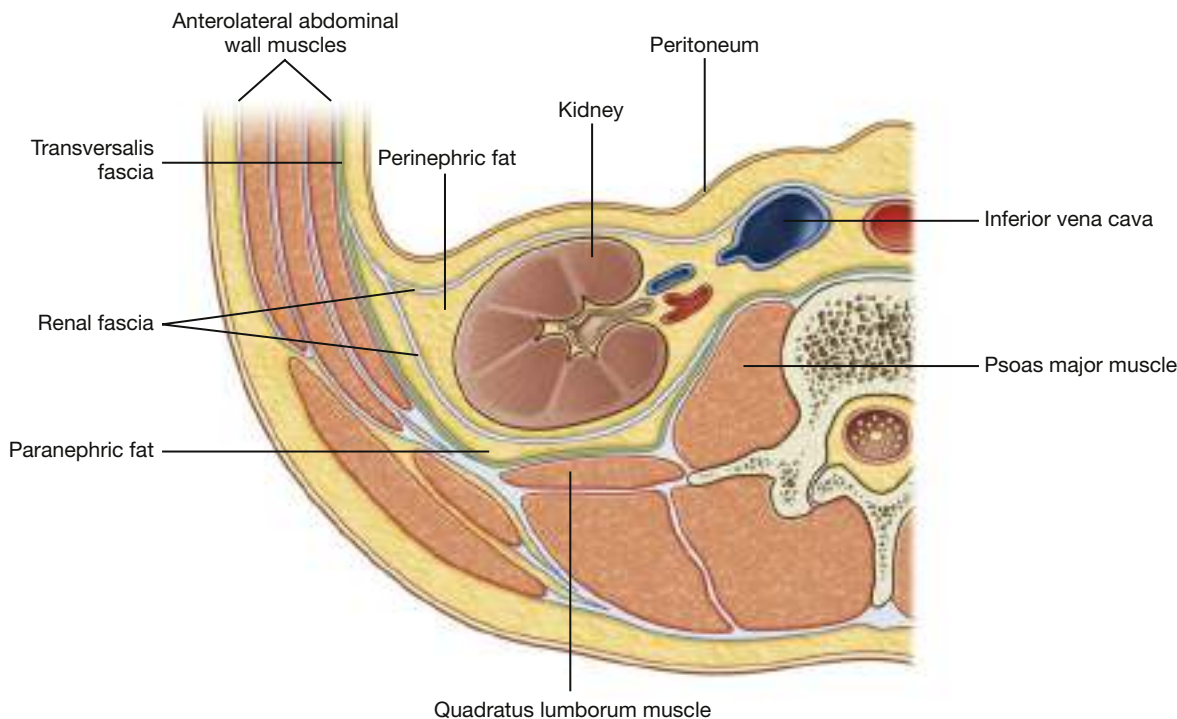


Fig. 4.106 Organization of fat and fascia surrounding the kidney.

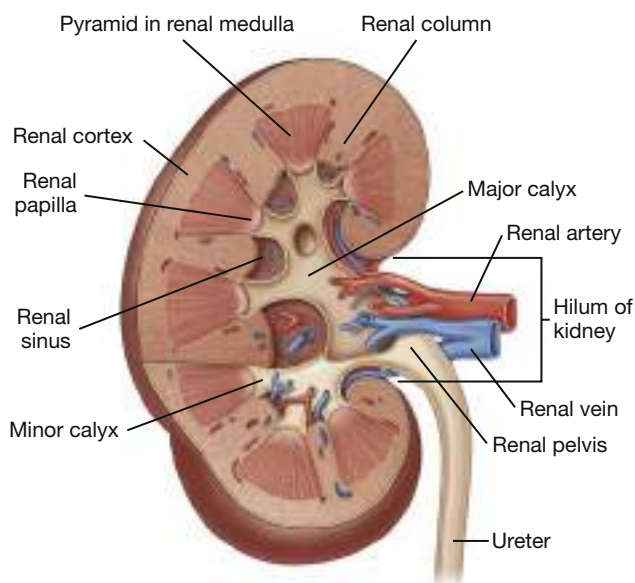


Fig. 4.107 Internal structure of the kidney.

Renal vasculature and lymphatics

A single large **renal artery**, a lateral branch of the abdominal aorta, supplies each kidney. These vessels usually arise just inferior to the origin of the superior mesenteric artery between vertebrae LI and LII (Fig. 4.108). The **left renal artery** usually arises a little higher than the right, and the

right renal artery is longer and passes posterior to the inferior vena cava.

As each renal artery approaches the renal hilum, it divides into anterior and posterior branches, which supply the renal parenchyma. Accessory renal arteries are common. They originate from the lateral aspect of the abdominal aorta either above or below the primary renal arteries, enter the hilum with the primary arteries or pass directly into the kidney at some other level, and are commonly called **extrahilar arteries**.

Multiple renal veins contribute to the formation of the left and **right renal veins**, both of which are anterior to the renal arteries (Fig. 4.108). Importantly, the longer left renal vein crosses the midline anterior to the abdominal aorta and posterior to the superior mesenteric artery and can be compressed by an aneurysm in either of these two vessels.

The lymphatic drainage of each kidney is to the **lateral aortic (lumbar) nodes** around the origin of the renal artery.

Ureters

The ureters are muscular tubes that transport urine from the kidneys to the bladder. They are continuous superiorly with the renal pelvis, which is a funnel-shaped structure in the renal sinus. The renal pelvis is formed from a condensation of two or three major calices, which, in turn, are formed by the condensation of several minor calices (see Fig. 4.107). The minor calices surround a renal papilla.

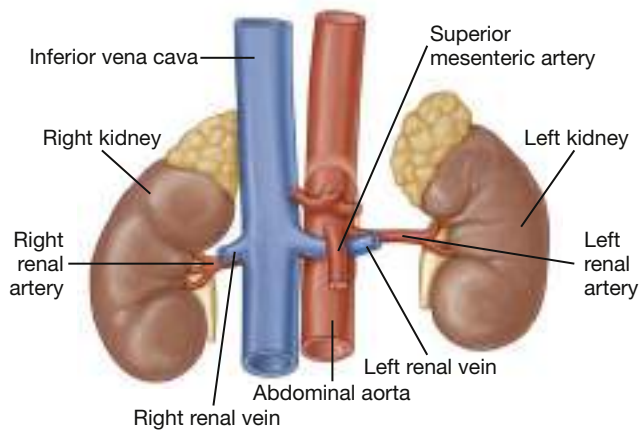


Fig. 4.108 Renal vasculature.

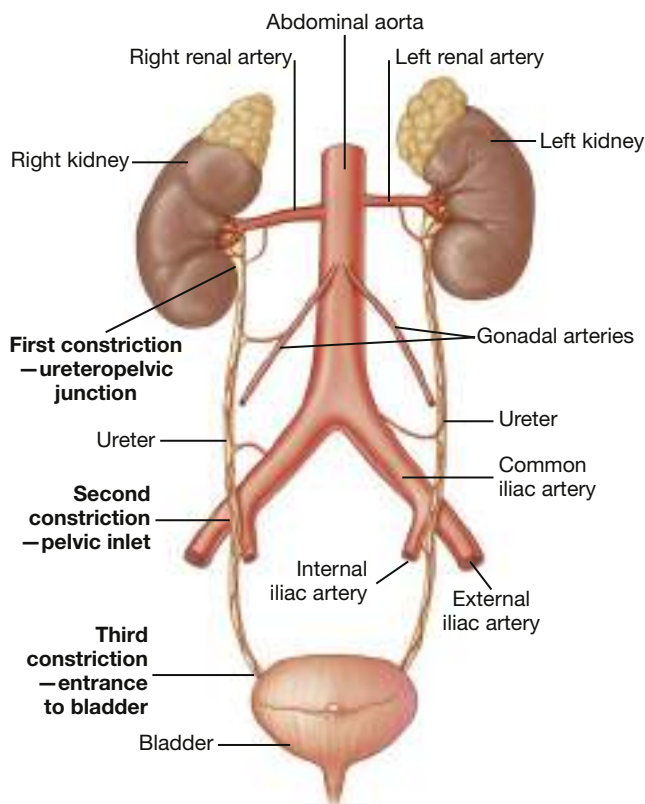


Fig. 4.109 Ureters.

The renal pelvis narrows as it passes inferiorly through the hilum of the kidney and becomes continuous with the ureter at the **ureteropelvic junction** (Fig. 4.109). Inferior to this junction, the ureters descend retroperitoneally on the medial aspect of the psoas major muscle. At the pelvic brim, the ureters cross either the end of the common iliac or the

beginning of the external iliac arteries, enter the pelvic cavity, and continue their journey to the bladder.

At three points along their course the ureters are constricted (Fig. 4.109):

- the first point is at the ureteropelvic junction,
- the second point is where the ureters cross the common iliac vessels at the pelvic brim, and
- the third point is where the ureters enter the wall of the bladder.

Kidney stones can become lodged at these constrictions.

Ureteric vasculature and lymphatics

The ureters receive arterial branches from adjacent vessels as they pass toward the bladder (Fig. 4.109):

- The renal arteries supply the upper end.
- The middle part may receive branches from the abdominal aorta, the testicular or ovarian arteries, and the common iliac arteries.
- In the pelvic cavity, the ureters are supplied by one or more arteries from branches of the internal iliac arteries.

In all cases, arteries reaching the ureters divide into ascending and descending branches, which form longitudinal anastomoses.

Lymphatic drainage of the ureters follows a pattern similar to that of the arterial supply. Lymph from:

- the upper part of each ureter drains to the lateral aortic (lumbar) nodes,
- the middle part of each ureter drains to lymph nodes associated with the common iliac vessels, and
- the inferior part of each ureter drains to lymph nodes associated with the external and internal iliac vessels.

Ureteric innervation

Ureteric innervation is from the renal, aortic, superior hypogastric, and inferior hypogastric plexuses through nerves that follow the blood vessels.

Visceral efferent fibers come from both sympathetic and parasympathetic sources, whereas visceral afferent fibers return to T11 to L2 spinal cord levels. Ureteric pain, which is usually related to distention of the ureter, is therefore referred to cutaneous areas supplied by T11 to L2 spinal cord levels. These areas would most likely include the posterior and lateral abdominal wall below the ribs and above the iliac crest, the pubic region, the scrotum in males, the labia majora in females, and the proximal anterior aspect of the thigh.

Clinical app

Urinary tract stones

Urinary tract stones (calculi) occur more frequently in men than in women, are most common in people aged between 20 and 60 years, and are usually associated with sedentary lifestyles. The stones are polycrystalline aggregates of calcium, phosphate, oxalate, urate, and other soluble salts within an organic matrix. The urine becomes saturated with these salts, and small variations in the pH cause the salts to precipitate.

Typically the patient has pain that radiates from the infrascapular region (loin) into the groin and even into the scrotum or labia majora. Blood in the urine (**hematuria**) may also be noticed.

Clinical app

Urinary tract cancer

Most tumors that arise in the kidney are renal cell carcinomas. These tumors develop from the proximal tubular epithelium. Approximately 5% of tumors within the kidney are transitional cell tumors, which arise from the urothelium of the renal pelvis. Most patients typically have blood in the urine (hematuria), pain in the infrascapular region (loin), and a mass.

Renal cell tumors are unusual because not only do they grow outward from the kidney, invading the fat and fascia, but they also spread into the renal vein. This venous extension is rare for any other type of tumor, so when seen, renal cell carcinoma should be suspected. Transitional cell carcinoma arises from the urothelium. The urothelium is present from the calices to the urethra and behaves as a “single unit.” Therefore when patients develop transitional carcinomas within the bladder, similar tumors may also be present within upper parts of the urinary tract.

Clinical app

Kidney transplant

Renal transplantation is a common procedure undertaken in patients with end-stage renal failure.

An ideal place to situate the transplant kidney is in the left or the right iliac fossa (Fig. 4.110). A curvilinear incision is made paralleling the iliac crest and pubic symphysis. The external oblique muscle, internal oblique muscle, transverse abdominis muscle, and transversalis fascia are divided. The surgeon identifies the parietal peritoneum but does not enter the peritoneal cavity. The

Clinical app—cont'd

parietal peritoneum is medially retracted to reveal the external iliac artery, external iliac vein, and the bladder. In some instances the internal iliac artery of the recipient is mobilized and anastomosed directly as an end-to-end procedure onto the renal artery of the donor kidney. Similarly the internal iliac vein is anastomosed to the donor vein. The ureter is easily tunneled obliquely through the bladder wall with a straightforward anastomosis.

The left and right iliac fossae are ideal locations for the transplant kidney, because a new space can be created without compromise to other structures. The extraperitoneal approach enables patients to make a swift recovery.

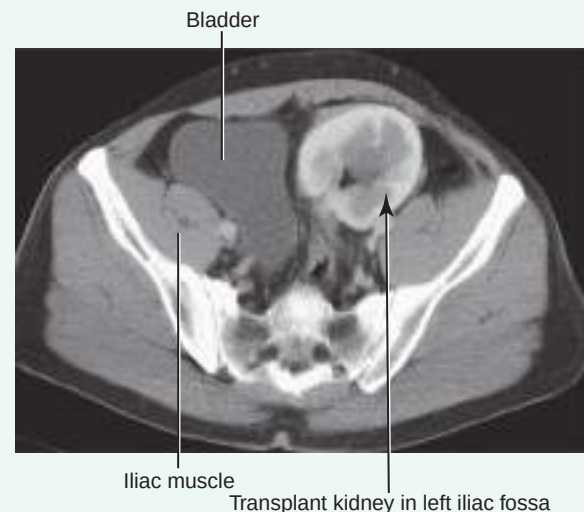


Fig. 4.110 Abdominal computed tomogram in the axial plane showing the transplanted kidney in the left iliac fossa.

Suprarenal glands

The suprarenal glands are associated with the superior pole of each kidney (Fig. 4.112). They consist of an outer cortex and an inner medulla. The right gland is shaped like a pyramid, whereas the left gland is semilunar in shape and the larger of the two.

Anterior to the right suprarenal gland is part of the right lobe of the liver and the inferior vena cava, whereas anterior to the left suprarenal gland is part of the stomach, pancreas, and, on occasion, the spleen. Parts of the diaphragm are posterior to both glands.

The suprarenal glands are surrounded by the perinephric fat and enclosed in the renal fascia, although a thin septum separates each gland from its associated kidney.

Imaging app

Investigation of the urinary tract

After an appropriate history and examination of the patient, including a digital rectal examination to assess the prostate in men, special investigations are required.

Intravenous urogram (IVU)

An IVU is one of the most important and commonly carried out radiological investigations (Fig. 4.111A). The patient is injected with iodinated contrast medium. Most contrast media contain three iodine atoms spaced around a benzene ring. The relatively high atomic number of iodine compared with the atomic number of carbon, hydrogen, and oxygen attenuates the radiation beam. After intravenous injection, contrast media are excreted predominantly by glomerular filtration, although some are secreted by the renal tubules. This allows visualization of the collecting system as well as the ureters and bladder.

Ultrasound

Ultrasound can be used to assess kidney size and the size of the calices, which may be dilated when obstructed. Although the ureters are poorly visualized using ultrasound, the bladder can be easily seen when full. Ultrasound measurements of bladder volume can be obtained before and after micturition.

Computed tomography

Computed tomography can be used to assess the kidneys, ureters, bladder, and adjacent structures and is a powerful tool for staging primary urinary tract tumors (Fig. 4.111B).

Nuclear medicine

Nuclear medicine is an extremely useful tool for investigating the urinary tract, because radioisotope compounds can be used to estimate renal cell mass and function, and assess the parenchyma for renal scarring. These tests are often very useful in children when renal scarring and reflux disease are suspected.

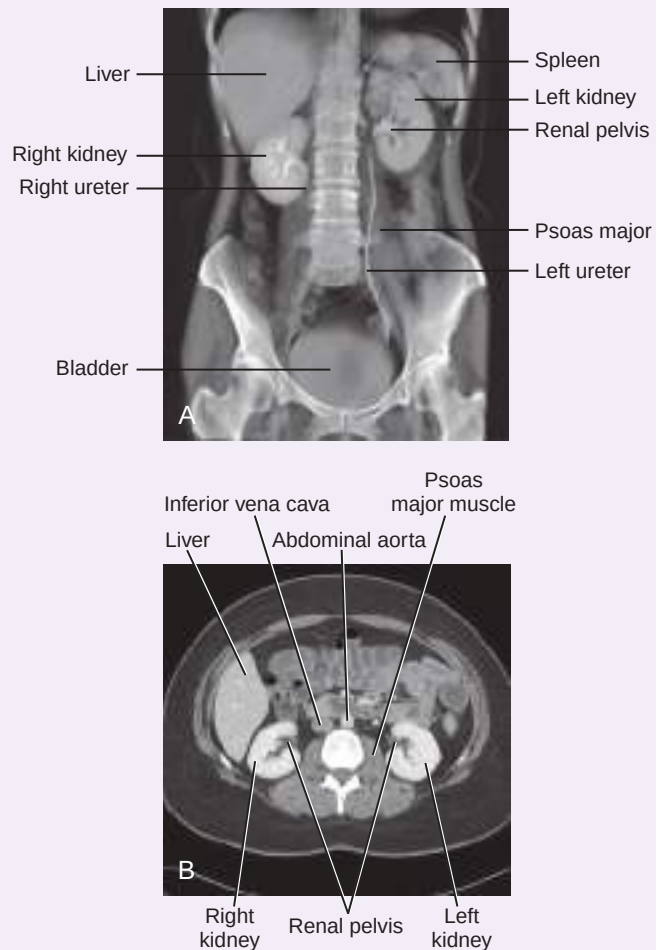


Fig. 4.111 A. Pathway of ureter in relation to other structures. Coronal view of 3-D urogram using multidetector computed tomography (CT). B. Renal pelvis. CT image with contrast in axial plane.

Suprarenal vasculature

The arterial supply to the suprarenal glands is extensive and arises from three primary sources (Fig. 4.112):

- As the bilateral **inferior phrenic arteries** pass upward from the abdominal aorta to the diaphragm, they give off multiple branches (**superior suprarenal arteries**) to the suprarenal glands.
- A middle branch (**middle suprarenal artery**) to the suprarenal glands usually arises directly from the abdominal aorta.
- Inferior branches (**inferior suprarenal arteries**) from the renal arteries pass upward to the suprarenal glands.

In contrast to this multiple arterial supply is the venous drainage, which usually consists of a single vein leaving the

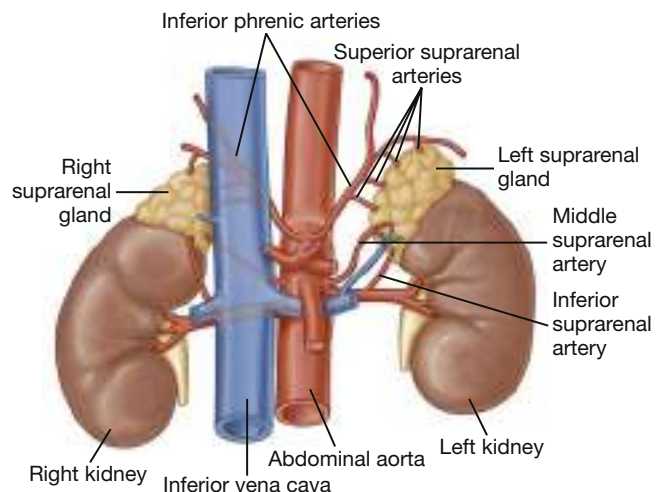


Fig. 4.112 Arterial supply to the suprarenal glands.

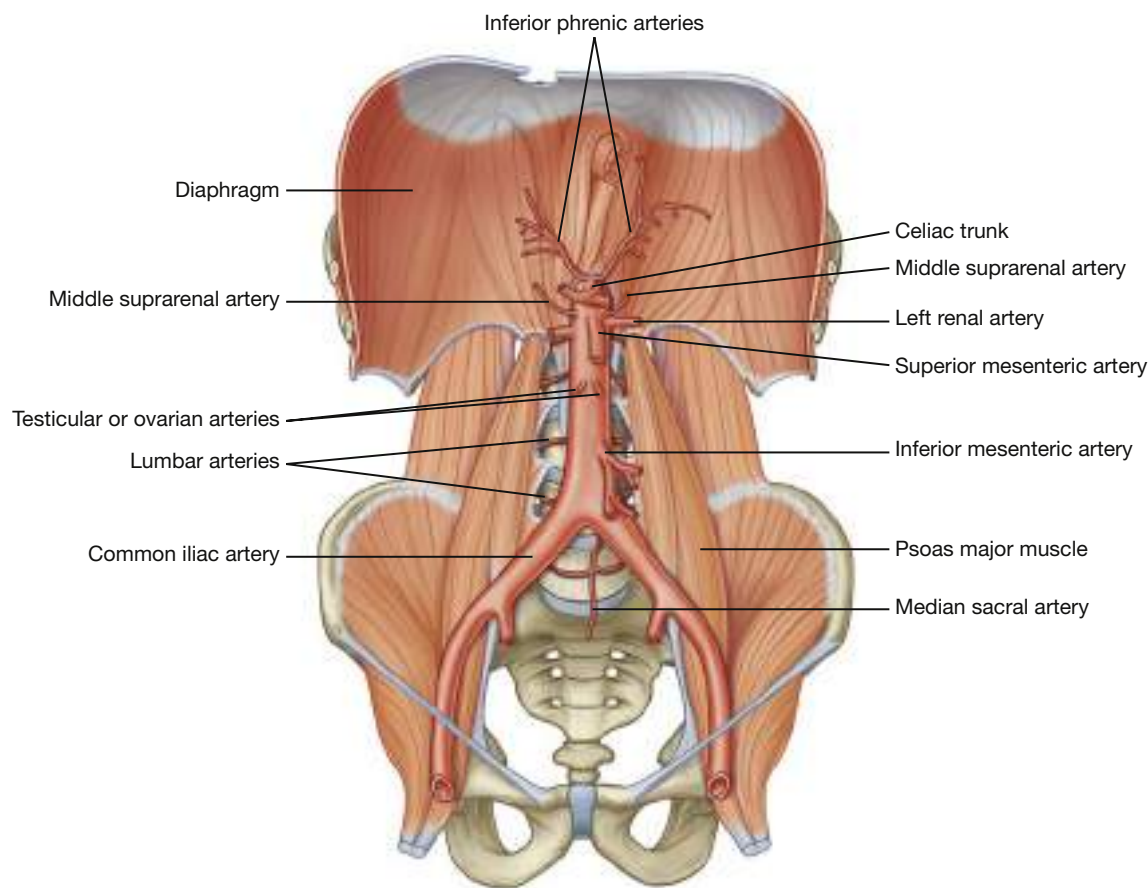


Fig. 4.113 Abdominal aorta.

hilum of each gland. On the right side, the **right suprarenal vein** is short and almost immediately enters the inferior vena cava; whereas on the left side, the **left suprarenal vein** passes inferiorly to enter the left renal vein.

Suprarenal Innervation

The suprarenal gland is mainly innervated by preganglionic sympathetic fibers from spinal levels T8 to L1 that pass through both the sympathetic trunk and the prevertebral plexus without synapsing. These preganglionic fibers directly innervate cells of the adrenal medulla.

Vasculature

Abdominal aorta

The abdominal aorta begins at the aortic hiatus of the diaphragm as a midline structure at approximately the lower level of vertebra TXII (Fig. 4.113). It passes downward on the anterior surface of the bodies of vertebrae LI to LIV, ending just to the left of midline at the lower level of vertebra LIV. At this point, it divides into the **right** and **left common iliac arteries**. This bifurcation can be visualized on the anterior abdominal wall at

a point approximately 2.6 cm below the umbilicus or even with a line extending between the highest points of the iliac crest.

As the abdominal aorta passes through the posterior abdominal region, the prevertebral plexus of nerves and ganglia covers its anterior surface. It is also related to numerous other structures:

- Anterior to the abdominal aorta, as it descends, are the pancreas and splenic vein, the left renal vein, and the inferior part of the duodenum.
- Several lumbar veins cross it posteriorly as they pass to the inferior vena cava.
- On its right side are the cisterna chyli, thoracic duct, azygos vein, right crus of the diaphragm, and the inferior vena cava.
- On its left side is the left crus of the diaphragm.

Branches of the abdominal aorta (Table 4.3) can be classified as:

- visceral branches supplying organs,
- posterior branches supplying the diaphragm or body wall, or
- terminal branches.

Table 4.3 Branches of the abdominal aorta

Artery	Branch	Origin	Parts supplied
Celiac trunk	Anterior	Immediately inferior to the aortic hiatus of the diaphragm	Abdominal foregut
Superior mesenteric artery	Anterior	Immediately inferior to the celiac trunk	Abdominal midgut
Inferior mesenteric artery	Anterior	Inferior to the renal arteries	Abdominal hindgut
Middle suprarenal arteries	Lateral	Immediately superior to the renal arteries	Suprarenal glands
Renal arteries	Lateral	Immediately inferior to the superior mesenteric artery	Kidneys
Testicular or ovarian arteries	Paired anterior	Inferior to the renal arteries	Testes in male and ovaries in female
Inferior phrenic arteries	Lateral	Immediately inferior to the aortic hiatus	Diaphragm
Lumbar arteries	Posterior	Usually four pairs	Posterior abdominal wall and spinal cord
Median sacral artery	Posterior	Just superior to the aortic bifurcation, passes inferiorly across lumbar vertebrae, sacrum, and coccyx	
Common iliac arteries	Terminal	Bifurcation usually occurs at the level of LIV vertebra	

Visceral branches

The visceral branches are either unpaired or paired vessels.

The three unpaired visceral branches that arise from the anterior surface of the abdominal aorta (Table 4.3, Fig. 4.113) are:

- the celiac trunk, which supplies the abdominal foregut,
- the superior mesenteric artery, which supplies the abdominal midgut, and
- the inferior mesenteric artery, which supplies the abdominal hindgut.

The paired visceral branches of the abdominal aorta (Table 4.3; also see Fig. 4.113) include:

- the **middle suprarenal arteries**—small, lateral branches of the abdominal aorta arising just above the renal arteries that are part of the multiple vascular supply to the suprarenal gland,
- the **renal arteries**—lateral branches of the abdominal aorta that arise just inferior to the origin of the superior mesenteric artery between vertebrae LI and LII and supply the kidneys, and
- the **testicular or ovarian arteries**—anterior branches of the abdominal aorta that arise below the origin of the renal arteries and pass downward and laterally on the anterior surface of the psoas major muscle.

Posterior branches

The posterior branches of the abdominal aorta are vessels supplying the diaphragm or body wall and are (Table 4.3; also see Fig. 4.113):

- the **inferior phrenic arteries** arising immediately inferior to the aortic hiatus of the diaphragm, either directly from the abdominal aorta as a common trunk from the

abdominal aorta or from the base of the celiac trunk (see Fig. 4.113). Whatever their origin, they pass upward, provide some arterial supply to the suprarenal gland, and continue onto the inferior surface of the diaphragm.

- four pairs of **lumbar arteries** from the posterior surface of the abdominal aorta (see Fig. 4.113). They run laterally and posteriorly over the bodies of the lumbar vertebrae, continue laterally, passing posterior to the sympathetic trunks and between the transverse processes of adjacent lumbar vertebrae, and reach the abdominal wall. From this point onward, they demonstrate a branching pattern similar to a posterior intercostal artery, which includes providing segmental branches that supply the spinal cord.
- the **median sacral artery** (see Fig. 4.113). This vessel arises from the posterior surface of the abdominal aorta just superior to the bifurcation and passes in an inferior direction, first over the anterior surface of the lower lumbar vertebrae and then over the anterior surface of the sacrum and coccyx.

Clinical app

Abdominal aortic stent graft

An abdominal aortic aneurysm is a dilation of the aorta and generally tends to occur in the infrarenal region (the region at or below the renal arteries). As the aorta expands, the risk of rupture increases, and it is now generally accepted that when an aneurysm reaches 5.6 cm or greater, an operation will significantly benefit the patient.

Treatment of aneurysms prior to rupture can involve inserting an endovascular graft (Fig. 4.114). The technique involves surgically dissecting the femoral artery below the inguinal ligament. A small incision is made in the femoral artery and the pre-loaded compressed graft with metal support struts is passed on a large catheter into the abdominal aorta through the femoral artery. Using X-ray for guidance the graft is opened so that it lines

Clinical app—cont'd

the inside of the aorta. Attachments are made to the graft that extend into the common iliac vessels. This bifurcated tube device effectively excludes the abdominal aortic aneurysm.

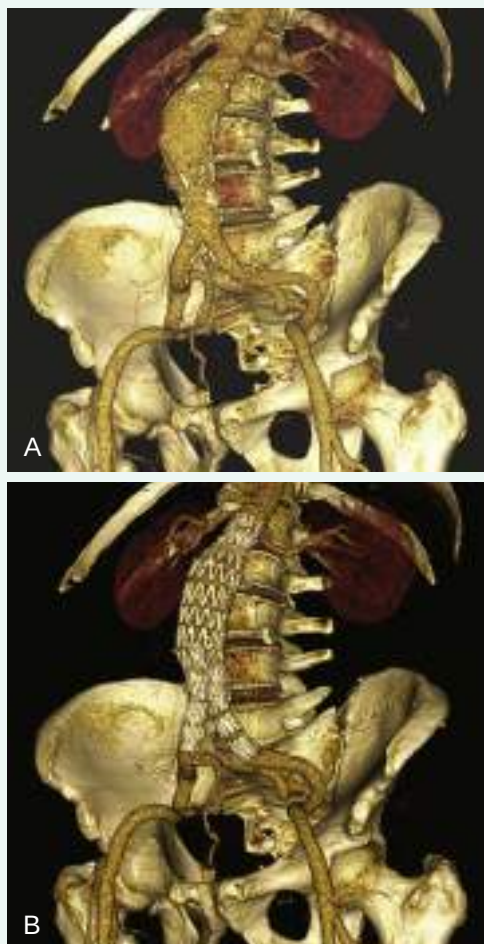


Fig. 4.114 Volume-rendered reconstruction using multidetector computed tomography of a patient with an infrarenal abdominal aortic aneurysm before (A) and after (B) endovascular aneurysm repair. Note the images only demonstrate the intraluminal contrast and not the entire vessel. White patches in the aorta (A) represent intramural calcium.

Inferior vena cava

The inferior vena cava returns blood from all structures below the diaphragm to the right atrium of the heart (Fig. 4.115). It is formed when the two common iliac veins come together at the level of vertebra LV just to the right of the midline. It ascends through the posterior abdominal region anterior to the vertebral column immediately to the right of the abdominal aorta (Fig. 4.115), continues in a superior direction, and leaves the abdomen by piercing the central tendon of the diaphragm at the level of vertebra TVIII.

During its course, the anterior surface of the inferior vena cava is crossed by the right common iliac artery, the root of the mesentery, the right testicular or ovarian artery, the

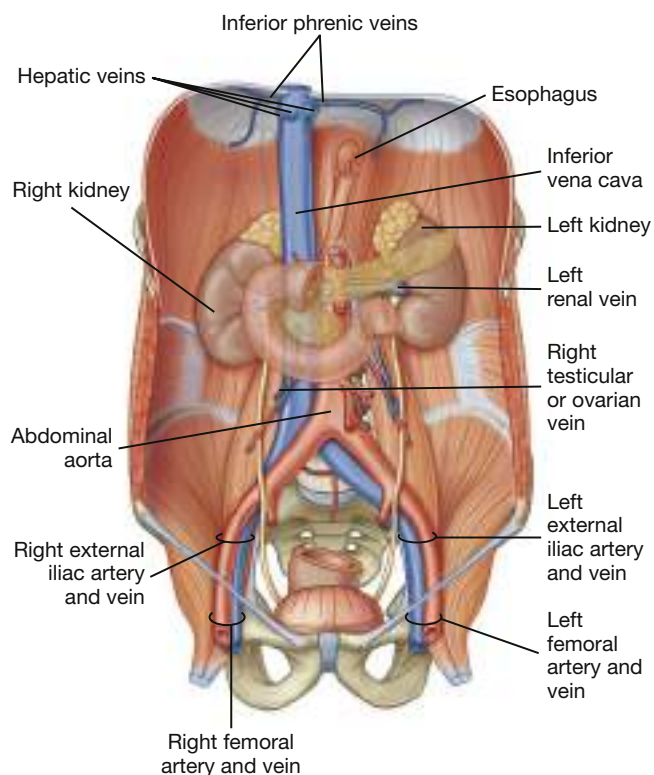


Fig. 4.115 Inferior vena cava.

inferior part of the duodenum, the head of the pancreas, the superior part of the duodenum, the bile duct, the portal vein, and the liver, which overlaps and on occasion completely surrounds the vena cava (Fig. 4.115).

Tributaries to the inferior vena cava include the:

- common iliac veins,
- lumbar veins,
- right testicular or ovarian vein,
- renal veins,
- right suprarenal vein,
- inferior phrenic veins, and
- hepatic veins.

There are no tributaries from the abdominal part of the gastrointestinal tract, the spleen, the pancreas, or the gallbladder, because veins from these structures are components of the portal venous system, which first passes through the liver.

Of the venous tributaries mentioned above, the **lumbar veins** are unique in their connections and deserve special attention. Not all of the lumbar veins drain directly into the inferior vena cava:

- The fifth lumbar vein generally drains into the **iliolumbar vein**, a tributary of the common iliac vein.
- The third and fourth lumbar veins usually drain into the inferior vena cava.

- The first and second lumbar veins may empty into the ascending lumbar veins.

The **ascending lumbar veins** are long, anastomosing, venous channels that connect the common iliac, iliolumbar, and lumbar veins with the azygos and hemiazygos veins of the thorax (Fig. 4.116).

If the inferior vena cava becomes blocked, the ascending lumbar veins become important collateral channels between the lower and upper parts of the body.

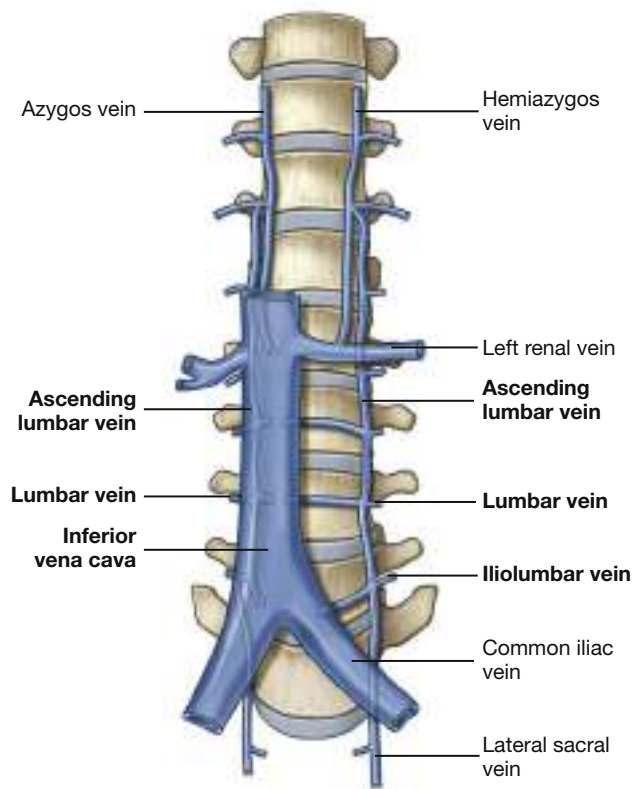


Fig. 4.116 Lumbar veins.

Clinical app

Inferior vena cava filter

Deep vein thrombosis is a potentially fatal condition in which a clot (thrombus) is formed in the deep venous system of the legs and the veins of the pelvis. Common predisposing factors include hospitalization, surgery, oral contraceptives, smoking, and air travel. Other factors include clotting abnormalities (e.g., protein S and protein C deficiency).

The diagnosis of deep vein thrombosis may be difficult to establish with symptoms including leg swelling and pain and discomfort in the calf.

Occasionally the clot may dislodge and pass into the venous system through the right side of the heart and into the main pulmonary arteries. If the clots are of significant size they obstruct blood flow to the lung and may produce instantaneous death.

Other complications include destruction of the normal valvular system in the legs, which may lead to venous incompetency and chronic leg swelling with ulceration.

In certain situations it is not possible to optimize the patient with prophylactic treatment, and it may be necessary to insert a filter into the inferior vena cava that traps any large clots. It may be removed after the risk period has ended.

Surface anatomy

Visualizing the position of major blood vessels

Each of the vertebral levels in the abdomen is related to the origin of major blood vessels (Fig. 4.117):

- The celiac trunk originates from the aorta at the upper border of the L1 vertebra.
- The superior mesenteric artery originates at the lower border of the L1 vertebra.
- The renal arteries originate at approximately the LII vertebra.
- The inferior mesenteric artery originates at the LIII vertebra.
- The aorta bifurcates into the right and left common iliac arteries at the level of the LIV vertebra.
- The left and right common iliac veins join to form the inferior vena cava at the LV vertebral level.

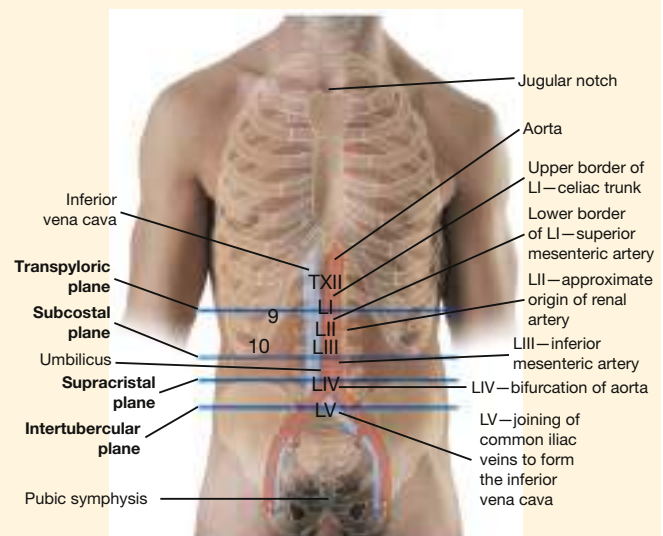


Fig. 4.117 Major vessels projected onto the body's surface. Anterior view of the abdominal region of a man.

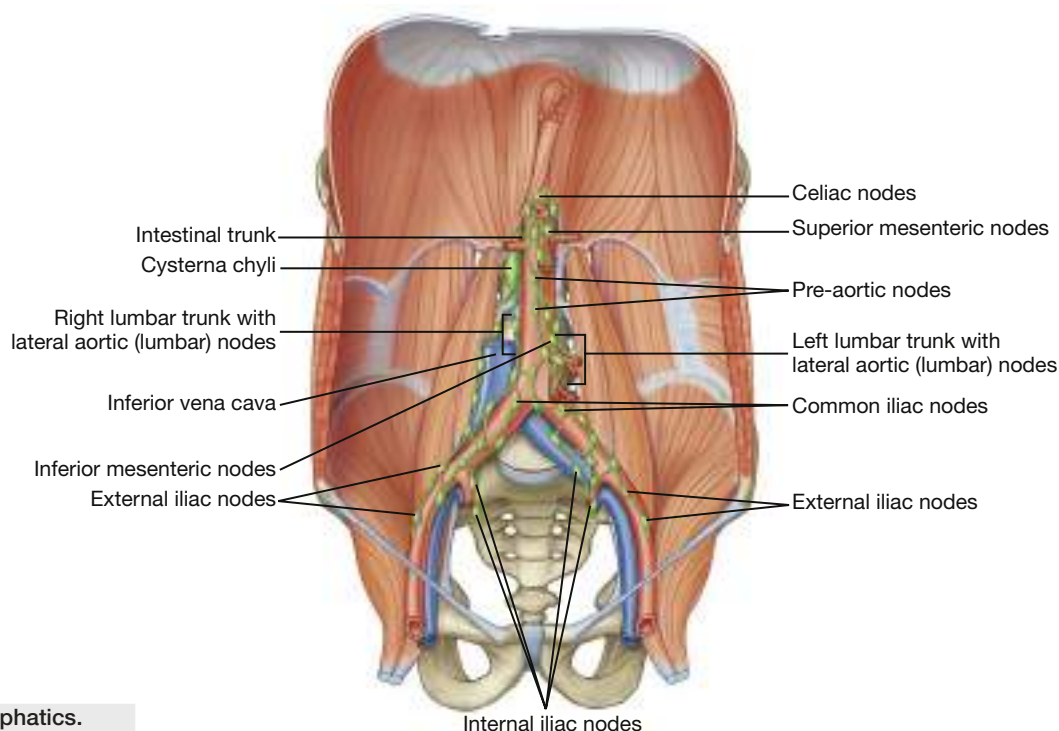


Fig. 4.118 Abdominal lymphatics.

Table 4.4 Summary of lymphatic drainage in the body

Lymphatic vessel	Area drained
Right jugular trunk	Right side of head and neck
Left jugular trunk	Left side of head and neck
Right subclavian trunk	Right upper limb, superficial regions of thoracic and upper abdominal wall
Left subclavian trunk	Left upper limb, superficial regions of thoracic and upper abdominal wall
Right bronchomediastinal trunk	Right lung and bronchi, mediastinal structures, thoracic wall
Left bronchomediastinal trunk	Left lung and bronchi, mediastinal structures, thoracic wall
Thoracic duct	Lower limbs, abdominal walls and viscera, pelvic walls and viscera, thoracic wall

Lymphatic system

Lymphatic drainage from most deep structures and regions of the body below the diaphragm converges mainly on collections of lymph nodes and vessels associated with the major blood vessels of the posterior abdominal region (Fig. 4.118). The lymph then predominantly drains into the thoracic duct (Table 4.4).

Pre-aortic and lateral aortic or lumbar nodes (para-aortic nodes)

Approaching the aortic bifurcation, the collections of lymphatics associated with the two common iliac arteries and veins merge, and multiple groups of lymphatic vessels and nodes associated with the abdominal aorta and inferior vena cava pass superiorly. These collections may be subdivided into **pre-aortic nodes**, which are anterior to the abdominal aorta, and **right** and **left lateral aortic** or **lumbar nodes**

(**para-aortic nodes**), which are positioned on either side of the abdominal aorta (Table 4.4, Fig. 4.118).

As these collections of lymphatics pass through the posterior abdominal region, they continue to collect lymph from a variety of structures. The lateral aortic or lumbar lymph nodes (para-aortic nodes) receive lymphatics from the body wall, the kidneys, the suprarenal glands, and the testes or ovaries.

The pre-aortic nodes are organized around the three anterior branches of the abdominal aorta that supply the abdominal part of the gastrointestinal tract, as well as the spleen, pancreas, gallbladder, and liver. They are divided into celiac, superior mesenteric, and inferior mesenteric nodes and receive lymph from the organs supplied by the similarly named arteries.

Finally, the lateral aortic or lumbar nodes form the right and left lumbar trunks, whereas the pre-aortic nodes form the intestinal trunk (Fig. 4.118). These trunks come together and form a confluence that, at times, appears as a saccular dilation (the cisterna chyli). This confluence of lymph trunks

Clinical app

Retroperitoneal lymph node surgery

From a clinical perspective, retroperitoneal lymph nodes are arranged in two groups. The pre-aortic lymph node group drains lymph from the embryological midline structures, such as the liver, bowel, and pancreas. The para-aortic lymph node group (the lateral aortic or lumbar nodes), on either side of the aorta, drain lymph from bilateral structures, such as the kidneys and adrenal glands. Organs embryologically derived from the posterior abdominal wall also drain lymph to these nodes. These organs include the ovaries and the testes (importantly, the testes do not drain lymph to the inguinal regions).

There are a number of causes for enlarged retroperitoneal lymph nodes. Massively enlarged lymph nodes are a feature of lymphoma, and smaller lymph node enlargement is observed in the presence of infection and metastatic malignant spread of disease (e.g., colon cancer).

The surgical approach to retroperitoneal lymph node resection involves a lateral paramedian incision in the midclavicular line. The three layers of the anterolateral abdominal wall (external oblique, internal oblique, and transversus abdominis) are opened and the transversalis fascia is divided. The next structure the surgeon sees is the parietal peritoneum. Instead of entering the parietal peritoneum, which is standard procedure for most intra-abdominal surgical operations, the surgeon gently pushes the parietal peritoneum toward the midline, which moves the intra-abdominal contents and allows a clear view of the retroperitoneal structures. On the left, the para-aortic lymph node group (lateral aortic or lumbar nodes) are easily demonstrated with a clear view of the abdominal aorta and kidney. On the right the inferior vena cava is demonstrated, which has to be retracted to access to the right para-aortic lymph node chain (lateral aortic or lumbar nodes).

The procedure of the retroperitoneal lymph node dissection is extremely well tolerated and lacks the problems of entering the peritoneal cavity (e.g., paralytic ileus). Unfortunately, the complication of a vertical incision in the midclavicular line is to divide the segmental nerve supply to the rectus abdominis muscle. This produces muscle atrophy and asymmetrical proportions to the anterior abdominal wall.

is posterior to the right side of the abdominal aorta and anterior to the bodies of vertebrae LI and LII. It marks the beginning of the thoracic duct.

Nervous system in the posterior abdominal region

Several important components of the nervous system are in the posterior abdominal region. These include the sympathetic trunks and associated splanchnic nerves, the plexus of

nerves and ganglia associated with the abdominal aorta, and the lumbar plexus of nerves.

Sympathetic trunks and splanchnic nerves

The sympathetic trunks pass through the posterior abdominal region anterolateral to the lumbar vertebral bodies before continuing across the sacral promontory and into the pelvic cavity (Fig. 4.119). Along their course, small raised areas are visible. These represent collections of neuronal cell bodies—primarily postganglionic neuronal cell bodies—which are located outside the central nervous system. They are sympathetic paravertebral ganglia. There are usually four ganglia along the sympathetic trunks in the posterior abdominal (lumbar) region.

Also associated with the sympathetic trunks in the posterior abdominal region are the lumbar splanchnic nerves (Fig. 4.119). These components of the nervous system pass from the sympathetic trunks to the plexus of nerves and ganglia associated with the abdominal aorta. Usually two to four lumbar splanchnic nerves carry preganglionic sympathetic fibers and visceral afferent fibers.

Abdominal prevertebral plexus and ganglia

The abdominal prevertebral plexus is a network of nerve fibers surrounding the abdominal aorta. It extends from the aortic hiatus of the diaphragm to the bifurcation of the aorta into the right and left common iliac arteries. Along its route, it is subdivided into smaller, named plexuses (Fig. 4.119):

- Beginning at the diaphragm and moving inferiorly, the initial accumulation of nerve fibers is referred to as the **celiac plexus**—this subdivision includes nerve fibers associated with the roots of the celiac trunk and superior mesenteric artery.
- Continuing inferiorly, the plexus of nerve fibers extending from just below the superior mesenteric artery to the aortic bifurcation is the **abdominal aortic plexus** (Fig. 4.119).
- At the bifurcation of the abdominal aorta, the abdominal prevertebral plexus continues inferiorly as the **superior hypogastric plexus** (Fig. 4.119).

Throughout its length, the abdominal prevertebral plexus is a conduit for:

- preganglionic sympathetic and visceral afferent fibers from the thoracic and lumbar splanchnic nerves (Fig. 4.120),
- preganglionic parasympathetic and visceral afferent fibers from the vagus nerves [X] (Fig. 4.120), and
- preganglionic parasympathetic fibers from the pelvic splanchnic nerves.

Associated with the abdominal prevertebral plexus are clumps of nervous tissue (the **prevertebral ganglia**), which

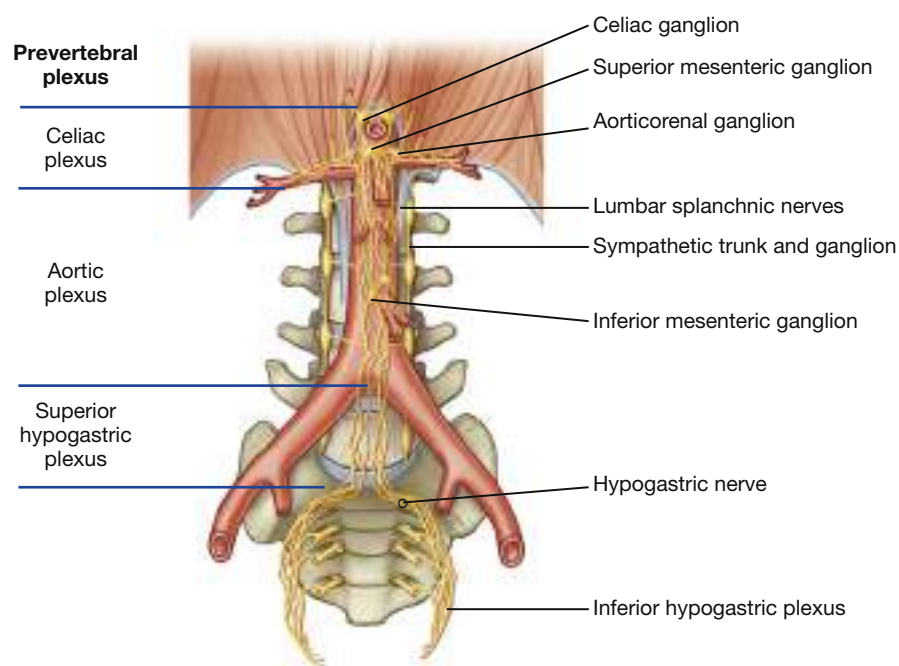


Fig. 4.119 Prevertebral plexus and ganglia in the posterior abdominal region.

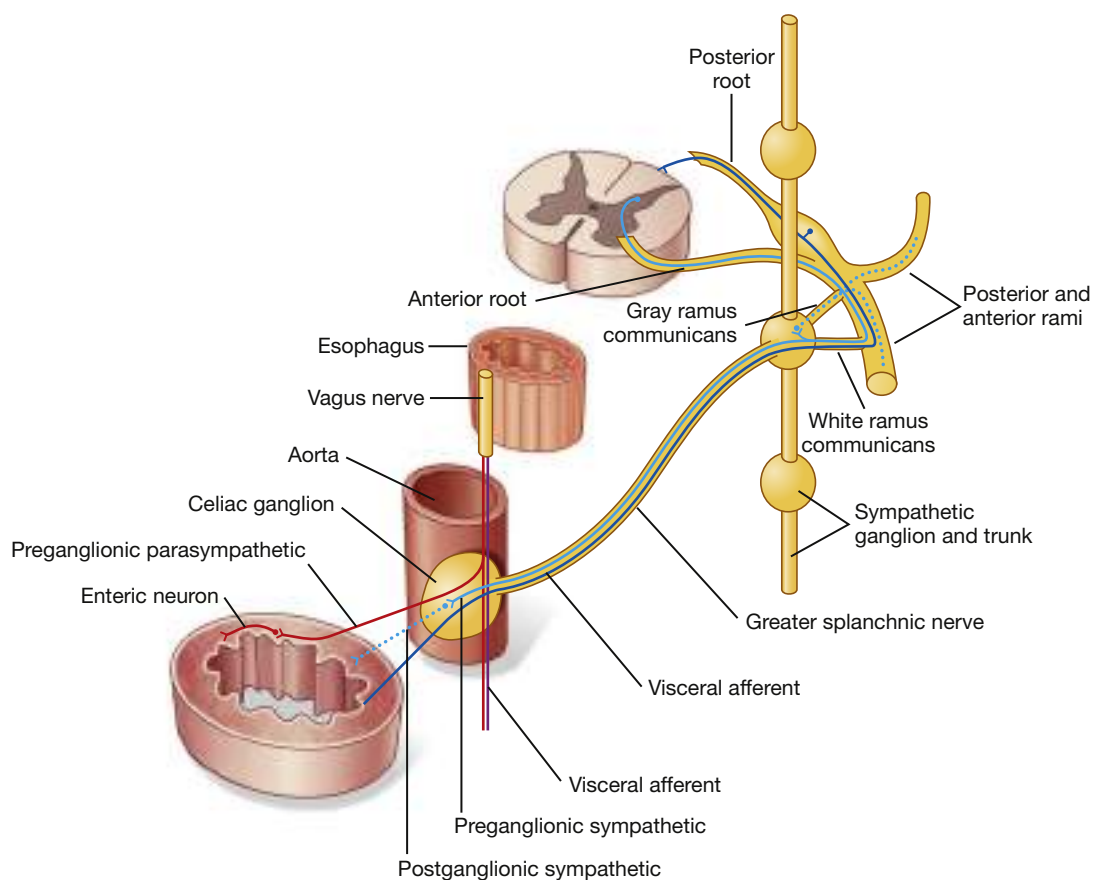


Fig. 4.120 Nerve fibers passing through the abdominal prevertebral plexus and ganglia.

Table 4.5 Referred pain pathways (visceral afferents)

Organ	Afferent pathway	Spinal cord level	Referral area
Heart	Thoracic splanchnic nerves	T1 to T4	Upper thorax and medial arm
Foregut (organs supplied by celiac trunk)	Greater splanchnic nerve	T5 to T9 (or T10)	Lower thorax and epigastric region
Midgut (organs supplied by superior mesenteric artery)	Lesser splanchnic nerve	T9, T10 (or T10, T11)	Umbilical region
Kidneys and upper ureter	Least splanchnic nerve	T12	Flanks (lateral regions) and pubic region
Hindgut (organs supplied by inferior mesenteric artery)	Lumbar splanchnic nerves	L1, L2	Left and right flanks and groins, lateral and anterior thighs

Table 4.6 Branches of the lumbar plexus

Branch	Origin	Spinal segments	Function: motor	Function: sensory
Iliohypogastric	Anterior ramus L1	L1	Internal oblique and transversus abdominis	Posterolateral gluteal skin and skin in pubic region
Ilio-inguinal	Anterior ramus L1	L1	Internal oblique and transversus abdominis	Skin in the upper medial thigh, and either the skin over the root of the penis and anterior scrotum or the mons pubis and labium majus
Genitofemoral	Anterior rami L1 and L2	L1, L2	Genital branch—male cremasteric muscle	Genital branch—skin of anterior scrotum or skin of mons pubis and labium majus; femoral branch—skin of upper anterior thigh
Lateral cutaneous nerve of thigh	Anterior rami L2 and L3	L2, L3		Skin on anterior and lateral thigh to the knee
Obturator	Anterior rami L2 to L4	L2 to L4	Obturator externus, pectineus, and muscles in medial compartment of thigh	Skin on medial aspect of the thigh
Femoral	Anterior rami L2 to L4	L2 to L4	Iliacus, pectineus, and muscles in anterior compartment of thigh	Skin on anterior thigh and medial surface of leg

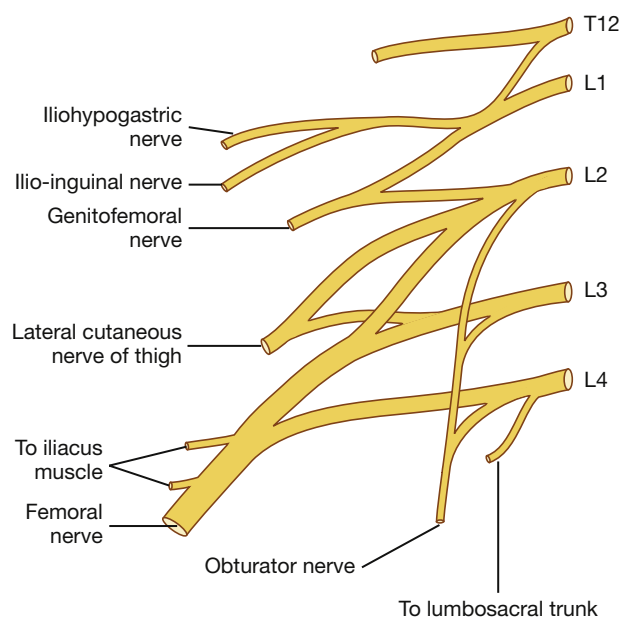
are collections of postganglionic sympathetic neuronal cell bodies in recognizable aggregations along the abdominal prevertebral plexus; they are usually named after the nearest branch of the abdominal aorta. They are therefore referred to as **celiac**, **superior mesenteric**, **aorticorenal**, and **inferior mesenteric ganglia** (Fig. 4.119). These structures, along with the abdominal prevertebral plexus, play a critical role in the innervation of the abdominal viscera.

Common sites for pain referred from the abdominal viscera are given in Table 4.5.

Lumbar plexus

The lumbar plexus is formed by the anterior rami of nerves L1 to L3 and most of the anterior ramus of L4 (Table 4.6, Fig. 4.121). It also receives a contribution from the T12 (subcostal) nerve.

Branches of the lumbar plexus include the iliohypogastric, ilio-inguinal, genitofemoral, lateral cutaneous nerve of thigh (lateral femoral cutaneous), femoral, and obturator nerves. The lumbar plexus forms in the substance of the psoas major muscle anterior to its attachment to the transverse processes of the lumbar vertebrae (Fig. 4.122). Therefore relative to the psoas major muscle, the various branches emerge either:

**Fig. 4.121** Lumbar plexus.

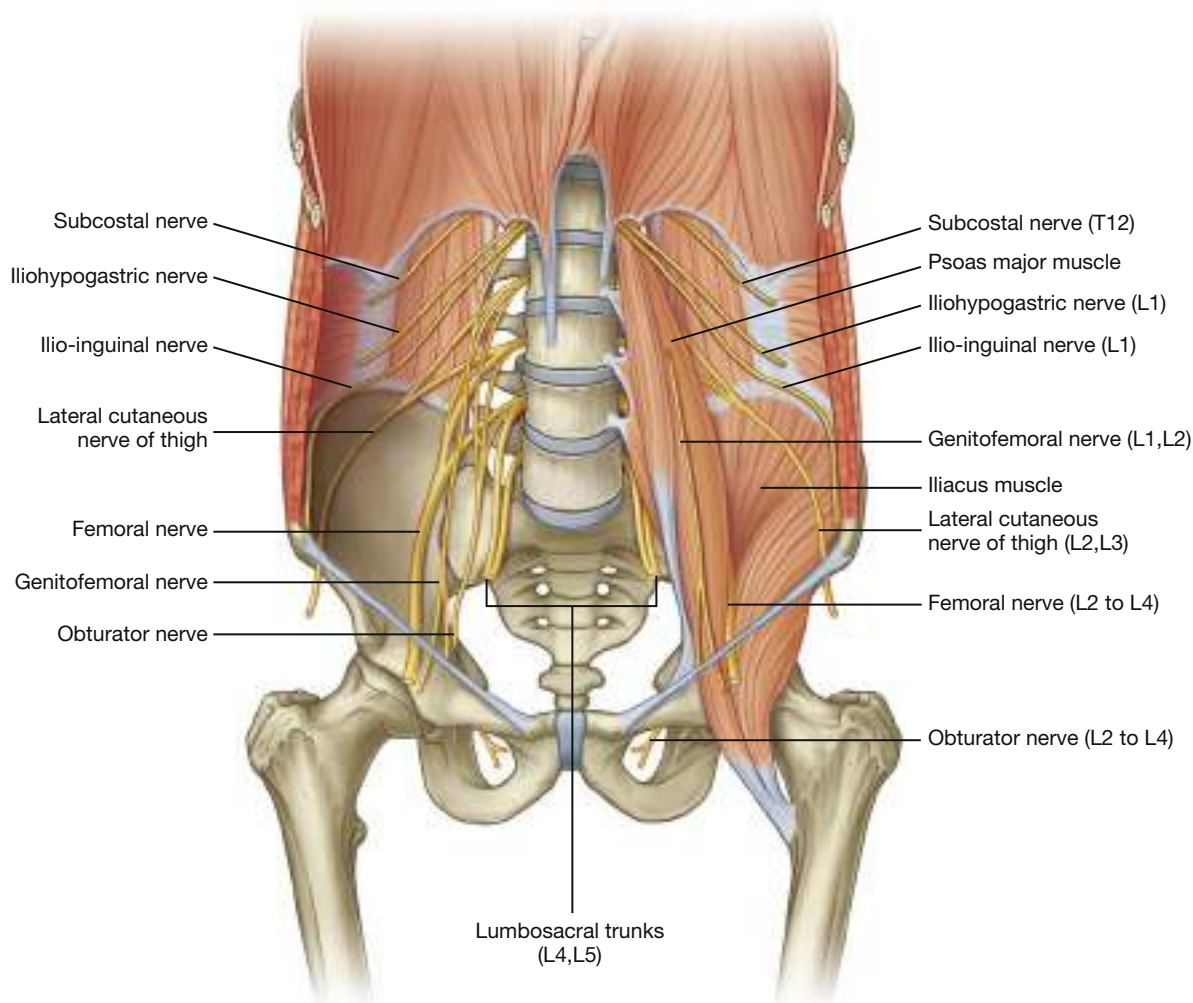


Fig. 4.122 Lumbar plexus in the posterior abdominal region.

- anterior—genitofemoral nerve,
- medial—obturator nerve, or
- lateral—iliohypogastric, ilio-inguinal, and femoral nerves and the lateral cutaneous nerve of the thigh.

Iliohypogastric and ilio-inguinal nerves (L1)

The iliohypogastric and ilio-inguinal nerves arise as a single trunk from the anterior ramus of nerve L1 (Fig. 4.122). Either before or soon after emerging from the lateral border of the psoas major muscle, this single trunk divides into the iliohypogastric and the ilio-inguinal nerves.

Iliohypogastric nerve

The **iliohypogastric nerve** passes across the anterior surface of the quadratus lumborum muscle posterior to the kidney. It pierces the transversus abdominis muscle and continues anteriorly around the body between the transversus abdominis and internal oblique muscles. Above the iliac crest, a **lateral cutaneous branch** pierces the internal and

external oblique muscles to supply the posterolateral gluteal skin (Fig. 4.123).

The remaining part of the iliohypogastric nerve (the **anterior cutaneous branch**) continues in an anterior direction, piercing the internal oblique just medial to the anterior superior iliac spine as it continues in an obliquely downward and medial direction. Becoming cutaneous just above the superficial inguinal ring after piercing the aponeurosis of the external oblique, it distributes to the skin in the pubic region (Fig. 4.123). Throughout its course, it also supplies branches to the abdominal musculature.

Ilio-inguinal nerve

The ilio-inguinal nerve is smaller than, and inferior to, the iliohypogastric nerve as it crosses the quadratus lumborum muscle (Fig. 4.122). Its course is more oblique than that of the iliohypogastric nerve, and it usually crosses part of the iliacus muscle on its way to the iliac crest. Near the anterior end of the iliac crest, it pierces the transversus abdominis

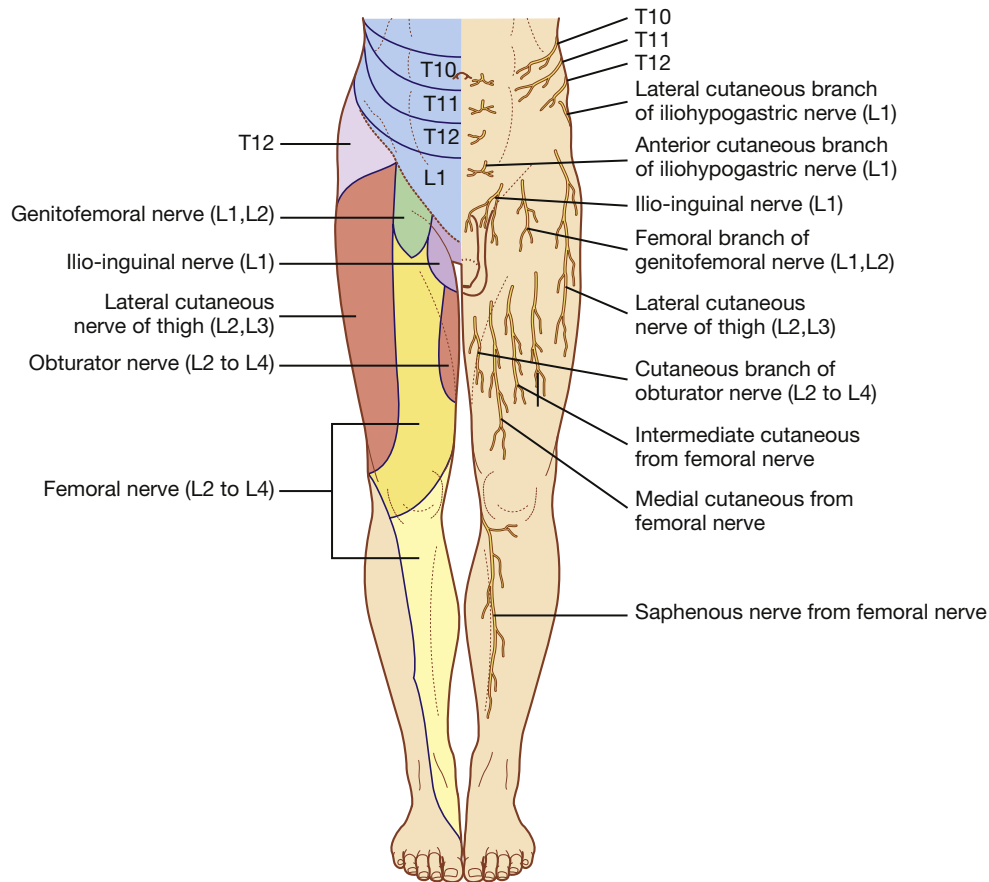


Fig. 4.123 Cutaneous distribution of the nerves from the lumbar plexus.

muscle and then pierces the internal oblique muscle and enters the inguinal canal.

The ilio-inguinal nerve emerges through the superficial inguinal ring, along with the spermatic cord, and provides cutaneous innervation to the upper medial thigh, the root of the penis, and the anterior surface of the scrotum in men or the mons pubis and labium majus in women (Fig. 4.123). Throughout its course, it also supplies branches to the abdominal musculature.

Genitofemoral nerve (L1 and L2)

The genitofemoral nerve arises from the anterior rami of the nerves L1 and L2 (Fig. 4.121). It passes downward in the substance of the psoas major muscle until it emerges on the anterior surface of psoas major. It then descends on the surface of the muscle in a retroperitoneal position, passing posterior to the ureter. It eventually divides into genital and femoral branches.

The **genital branch** continues downward and enters the inguinal canal through the deep inguinal ring. It continues through the canal and:

- in men, innervates the cremasteric muscle and terminates on the skin in the upper anterior part of the scrotum and
- in women, accompanies the round ligament of the uterus and terminates on the skin of the mons pubis and labium majus.

The **femoral branch** descends on the lateral side of the external iliac artery and passes posterior to the inguinal ligament, entering the femoral sheath lateral to the femoral artery. It pierces the anterior layer of the femoral sheath and the fascia lata to supply the skin of the upper anterior thigh (Fig. 4.123).

Lateral cutaneous nerve of thigh (L2 and L3)

The lateral cutaneous nerve of thigh arises from the anterior rami of nerves L2 and L3 (see Fig. 4.121). It emerges from the lateral border of the psoas major muscle, passing obliquely downward across the iliacus muscle toward the anterior superior iliac spine (see Fig. 4.122). It passes posterior to the inguinal ligament and enters the thigh.

The lateral cutaneous nerve of thigh supplies the skin on the anterior and lateral thigh to the level of the knee (Fig. 4.123).

Obturator nerve (L2 to L4)

The obturator nerve arises from the anterior rami of the nerves L2 to L4 (see Fig. 4.121). It descends in the psoas major muscle, emerging from its medial side near the pelvic brim (see Fig. 4.122).

The obturator nerve continues posterior to the common iliac vessels, passes across the lateral wall of the pelvic cavity, and enters the obturator canal, through which the obturator nerve gains access to the medial compartment of the thigh (see Fig. 4.122).

In the area of the obturator canal, the obturator nerve divides into **anterior** and **posterior branches**. On entering the medial compartment of the thigh, the two branches are separated by the obturator externus and adductor brevis muscles. Throughout their course through the medial compartment, these two branches supply:

- articular branches to the hip joint,
- muscular branches to obturator externus, pectineus, adductor longus, gracilis, adductor brevis, and adductor magnus muscles,
- cutaneous branches to the medial aspect of the thigh, and
- in association with the saphenous nerve, cutaneous branches to the medial aspect of the upper part of the leg and articular branches to the knee joint (Fig. 4.123).

Femoral nerve (L2 to L4)

The femoral nerve arises from the anterior rami of nerves L2 to L4 (see Fig. 4.121). It descends through the substance of the psoas major muscle, emerging from the lower lateral border of the psoas major (see Fig. 4.122). Continuing its descent, the femoral nerve lies between the lateral border of the psoas major and the anterior surface of the iliacus muscle. It is deep to the iliacus fascia and lateral to the femoral artery as it passes posterior to the inguinal ligament and enters the anterior compartment of the thigh. Upon entering the thigh, it immediately divides into multiple branches.

Cutaneous branches of the femoral nerve include (Fig. 4.123):

- medial and intermediate cutaneous nerves supplying the skin on the anterior surface of the thigh and
- the **saphenous nerve** supplying the skin on the medial surface of the leg (Fig. 4.123).

Muscular branches innervate the iliacus, pectineus, sartorius, rectus femoris, vastus medialis, vastus intermedius, and vastus lateralis muscles. Articular branches supply the hip and knee joints.

5

Pelvis and Perineum

**ADDITIONAL LEARNING RESOURCES
FOR CHAPTER 5, *PELVIS AND PERINEUM*,
CAN BE FOUND ON THE ACCOMPANYING
EBOOK:**

- Self-Assessment (scored) — National Board style multiple-choice questions, Chapter 5
- Short Questions (not scored) — these are questions requiring short responses, Chapter 5
- Clinical Cases
 - Varicocele
 - Sciatic nerve compression
 - Pelvic kidney
 - Left common iliac artery obstruction
 - Iatrogenic ureteric injury
 - Ectopic pregnancy
 - Uterine tumor

***Regional anatomy* 224**

Pelvis 224

- Bones 224
- Joints 227
- Orientation 229
- Differences between men and women 229
- True pelvis 230
- Viscera 236
- Fascia 247
- Peritoneum 248
- Nerves 251
- Blood vessels 258
- Lymphatics 262

Perineum 262

- Borders and ceiling 263
- Ischio-anal fossae and their anterior recesses 264
- Anal triangle 265
- Urogenital triangle 265
- Somatic nerves 271
- Visceral nerves 271
- Blood vessels 272
- Veins 274
- Lymphatics 274

Regional anatomy

The pelvis and perineum are interrelated regions associated with the pelvic bones and the terminal parts of the vertebral column. The pelvis is divided into two regions (Fig. 5.1):

- The superior region related to upper parts of the pelvic bones and lower lumbar vertebrae is the **false pelvis** (greater pelvis) and is generally considered part of the abdominal cavity.
- The **true pelvis** (lesser pelvis) is related to the inferior parts of the pelvic bones, sacrum, and coccyx and has an inlet and an outlet.

The bowl-shaped **pelvic cavity** (Fig. 5.1) enclosed by the true pelvis consists of the pelvic inlet, walls, and floor. This cavity is continuous superiorly with the abdominal cavity and contains and supports elements of the urinary, gastrointestinal, and reproductive systems.

The **perineum** (Fig. 5.1) is inferior to the floor of the pelvic cavity; its boundaries form the **pelvic outlet**. The perineum

contains and supports the external genitalia and external openings of the genitourinary and gastrointestinal systems.

PELVIS

Bones

The bones of the pelvis consist of the right and left pelvic (hip) bones, the sacrum, and the coccyx. The sacrum articulates superiorly with vertebra LV at the lumbosacral joint. The pelvic bones articulate posteriorly with the sacrum at the sacro-iliac joints and with each other anteriorly at the pubic symphysis.

Pelvic bone

The pelvic bone is irregular in shape and has two major parts separated by an oblique line on the medial surface of the bone (Fig. 5.2A):

- The pelvic bone above this line represents the lateral wall of the false pelvis, which is part of the abdominal cavity.

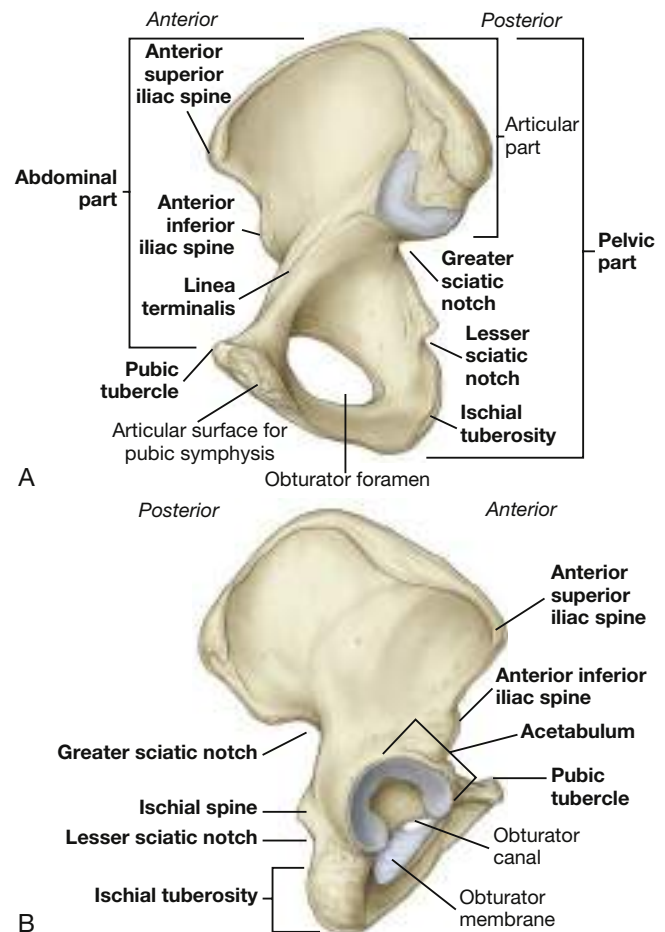
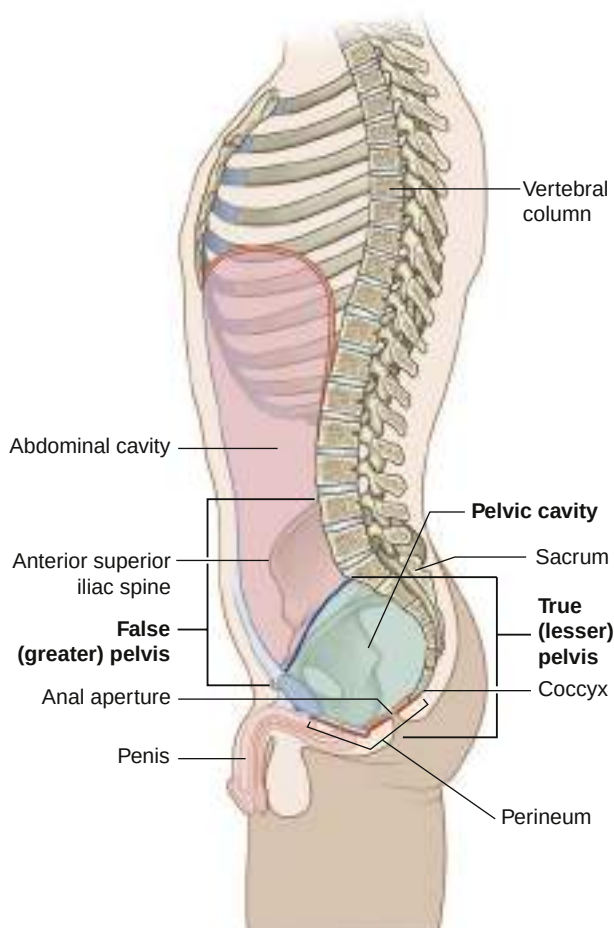


Fig. 5.1 Pelvis and perineum.

Fig. 5.2 Right pelvic bone. A. Medial view. B. Lateral view.

- The pelvic bone below this line represents the lateral wall of the true pelvis, which contains the pelvic cavity.

The **linea terminalis** is the lower two-thirds of this line and contributes to the margin of the pelvic inlet.

The lateral surface of the pelvic bone has a large articular socket, the **acetabulum**, which, together with the head of the femur, forms the hip joint (Fig. 5.2B).

Inferior to the acetabulum is the large **obturator foramen**, most of which is closed by a flat connective tissue membrane, the **obturator membrane**. A small obturator canal remains open superiorly between the membrane and adjacent bone, providing a route of communication between the lower limb and the pelvic cavity.

The posterior margin of the bone is marked by two notches separated by the **ischial spine** (Fig. 5.2):

- the **greater sciatic notch**, and
- the **lesser sciatic notch**.

The posterior margin terminates inferiorly as the large **ischial tuberosity**.

The irregular anterior margin of the pelvic bone is marked by the **anterior superior iliac spine**, the **anterior inferior iliac spine**, and the **pubic tubercle**.

Components of the pelvic bone

Each pelvic bone is formed by three elements: the ilium, pubis, and ischium (Fig. 5.3). At birth, these bones are

connected by cartilage in the area of the acetabulum; later, between 16 and 18 years of age, they fuse into a single bone.

Ilium

Of the three components of the pelvic bone, the **ilium** is the most superior in position.

The ilium is separated into upper and lower parts by a ridge on the medial surface (Fig. 5.4A).

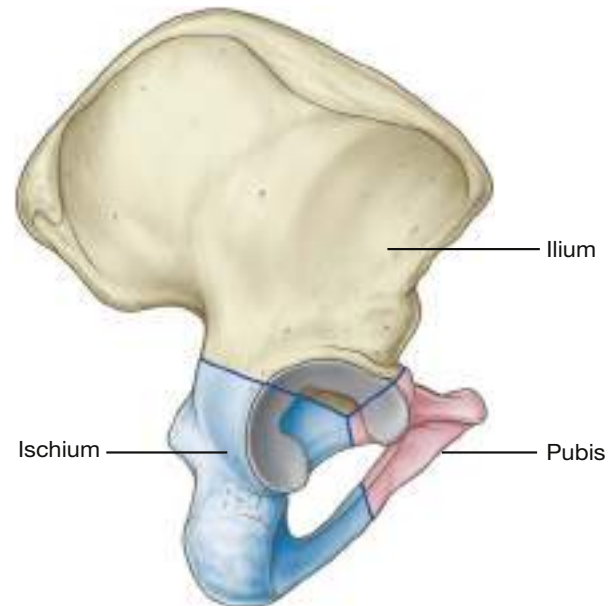


Fig. 5.3 Ilium, ischium, and pubis.

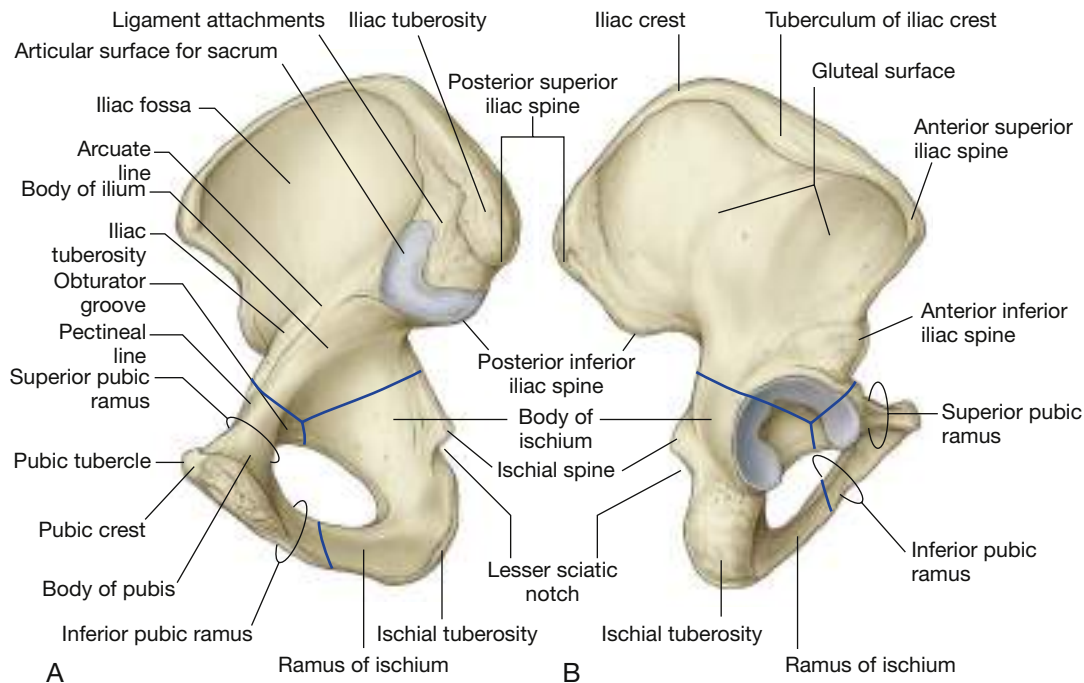


Fig. 5.4 Components of the pelvic bone. A. Medial surface. B. Lateral surface.



Pelvis and Perineum

- Posteriorly, the ridge is sharp and lies immediately superior to the surface of the bone that articulates with the sacrum. This sacral surface has a large L-shaped facet for articulating with the sacrum and an expanded, posterior, roughened area for the attachment of the strong ligaments that support the sacro-iliac joint (Fig. 5.4).
- Anteriorly, the ridge separating the upper and lower parts of the ilium is rounded and termed the **arcuate line** (Fig. 5.4).

The arcuate line forms part of the linea terminalis and the pelvic brim.

The portion of the ilium lying inferiorly to the arcuate line is the pelvic part of the ilium and contributes to the wall of the lesser or true pelvis.

The upper part of the ilium expands to form a flat, fan-shaped “wing,” which provides bony support for the lower abdomen, or false pelvis (Fig. 5.4). This part of the ilium provides attachment for muscles functionally associated with the lower limb. The anteromedial surface of the wing is concave and forms the **iliac fossa**. The external (gluteal surface) of the wing is marked by lines and roughenings and is related to the gluteal region of the lower limb (Fig. 5.4B).

The entire superior margin of the ilium is thickened to form a prominent crest (the **iliac crest**), which is the site of attachment for muscles and fascia of the abdomen, back, and lower limb and terminates anteriorly as the **anterior superior iliac spine** and posteriorly as the **posterior superior iliac spine** (Fig. 5.4).

A prominent tubercle, **tuberculum of iliac crest**, projects laterally near the anterior end of the crest; the posterior end of the crest thickens to form the **iliac tuberosity** (Fig. 5.4).

Inferior to the anterior superior iliac spine of the crest, on the anterior margin of the ilium, is a rounded protuberance called the **anterior inferior iliac spine** (Fig. 5.4). This structure serves as the point of attachment for the rectus femoris muscle of the anterior compartment of the thigh and the iliofemoral ligament associated with the hip joint. A less prominent **posterior inferior iliac spine** (Fig. 5.4) occurs along the posterior border of the sacral surface of the ilium where the bone angles forward to form the superior margin of the greater sciatic notch.

Clinical app

Bone marrow biopsy

In certain diseases (e.g., leukemia), a sample of bone marrow must be obtained to assess the stage and severity of the problem. The iliac crest is often used for such bone marrow biopsies. The iliac crest lies close to the surface, is palpable, and is easily accessed.

Pubis

The anterior and inferior part of the pelvic bone is the **pubis** (Fig. 5.4). It has a body and two arms (rami).

- The **body** is flattened dorsoventrally and articulates with the body of the pubic bone on the other side at the **pubic symphysis**. The body has a rounded pubic crest on its superior surface that ends laterally as the prominent **pubic tubercle**.
- The **superior pubic ramus** projects posterolaterally from the body and joins with the ilium and ischium at its base, which is positioned toward the acetabulum. The sharp superior margin of this triangular surface is termed the **pecten pubis (pectineal line)**, which forms part of the linea terminalis of the pelvic bone and the pelvic inlet. Anteriorly, this line is continuous with the **pubic crest**, which also is part of the linea terminalis and pelvic inlet. The **superior pubic ramus** is marked on its inferior surface by the **obturator groove**, which forms the upper margin of the obturator canal.
- The **inferior ramus** projects laterally and inferiorly to join with the ramus of the ischium.

Ischium

The ischium is the posterior and inferior part of the pelvic bone (Fig. 5.4). It has:

- a large body that projects superiorly to join with the ilium and the superior ramus of the pubis; and
- a ramus that projects anteriorly to join with the inferior ramus of the pubis.

The posterior margin of the bone is marked by a prominent **ischial spine** (Fig. 5.4) that separates the lesser sciatic notch below from the greater sciatic notch above.

The most prominent feature of the ischium is a large tuberosity (the **ischial tuberosity**) on the posteroinferior aspect of the bone (Fig. 5.4). This tuberosity is an important site for the attachment of lower limb muscles and for supporting the body when sitting.

Sacrum

The sacrum, which has the appearance of an inverted triangle, is formed by the fusion of the five sacral vertebrae (Fig. 5.5). The base of the sacrum articulates with vertebra LV, and its apex articulates with the coccyx. Each of the lateral surfaces of the bone bears a large L-shaped facet for articulation with the ilium of the pelvic bone. Posterior to the facet is a large roughened area for the attachment of ligaments that support the sacro-iliac joint. The superior surface of the sacrum is characterized by the superior aspect of the body of vertebra SI

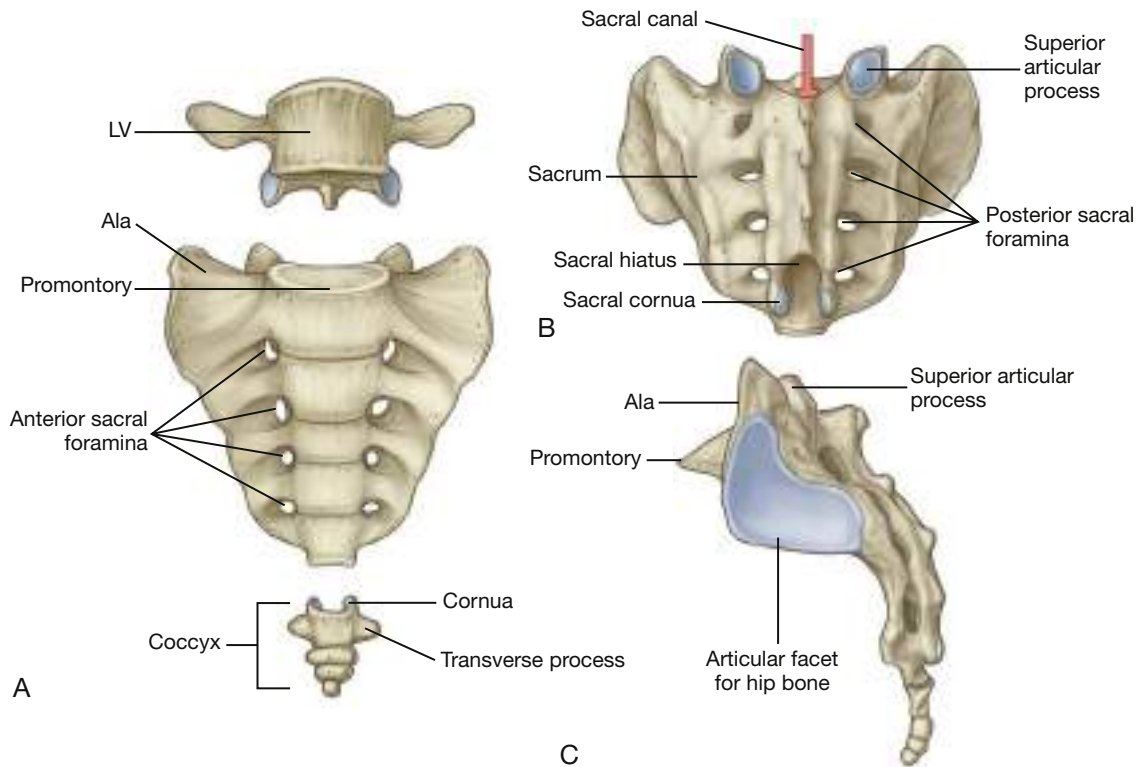


Fig. 5.5 LV vertebra, sacrum, and coccyx. **A.** Anterior view. **B.** Posterior view. **C.** Lateral view.

and is flanked on each side by an expanded wing-like transverse process termed the **ala** (Fig. 5.5A). The anterior edge of the vertebral body projects forward as the **promontory**. The anterior surface of the sacrum is concave; the posterior surface is convex. Because the transverse processes of adjacent sacral vertebrae fuse laterally to the position of the intervertebral foramina and laterally to the bifurcation of spinal nerves into posterior and anterior rami, the posterior and anterior rami of spinal nerves S1 to S4 emerge from the sacrum through separate foramina. There are four pairs of **anterior sacral foramina** on the anterior surface of the sacrum for anterior rami (Fig. 5.5A) and four pairs of **posterior sacral foramina** on the posterior surface for the posterior rami (Fig. 5.5B). The **sacral canal** is a continuation of the vertebral canal that terminates as the **sacral hiatus**.

Coccyx

The small terminal part of the vertebral column is the coccyx, which consists of four fused coccygeal vertebrae (Fig. 5.5A) and, like the sacrum, has the shape of an inverted triangle. The base of the coccyx is directed superiorly. The superior surface bears a facet for articulation with the sacrum and two **horns**, or **cornua**, one on each side, that project upward to articulate or fuse with similar downward-projecting cornua from the sacrum. These processes are modified superior and inferior articular processes that are

present on other vertebrae. Each lateral surface of the coccyx has a small rudimentary transverse process extending from the first coccygeal vertebra. Vertebral arches are absent from coccygeal vertebrae; therefore no bony vertebral canal is present in the coccyx.

Joints

Lumbosacral joints

The sacrum articulates superiorly with the lumbar part of the vertebral column. The lumbosacral joints are formed between vertebra LV and the sacrum and consist of (Fig. 5.6A):

- the two **zygapophyseal joints**, which occur between adjacent inferior and superior articular processes; and
- an intervertebral disc that joins the bodies of vertebrae LV and S1.

These joints are similar to those between other vertebrae, with the exception that the sacrum is angled posteriorly on vertebra LV. As a result, the anterior part of the intervertebral disc between the two bones is thicker than the posterior part.

The lumbosacral joints are reinforced by strong ilio-lumbar and lumbosacral ligaments that extend from the expanded transverse processes of vertebra LV to the ilium and the sacrum, respectively (Fig. 5.6B).

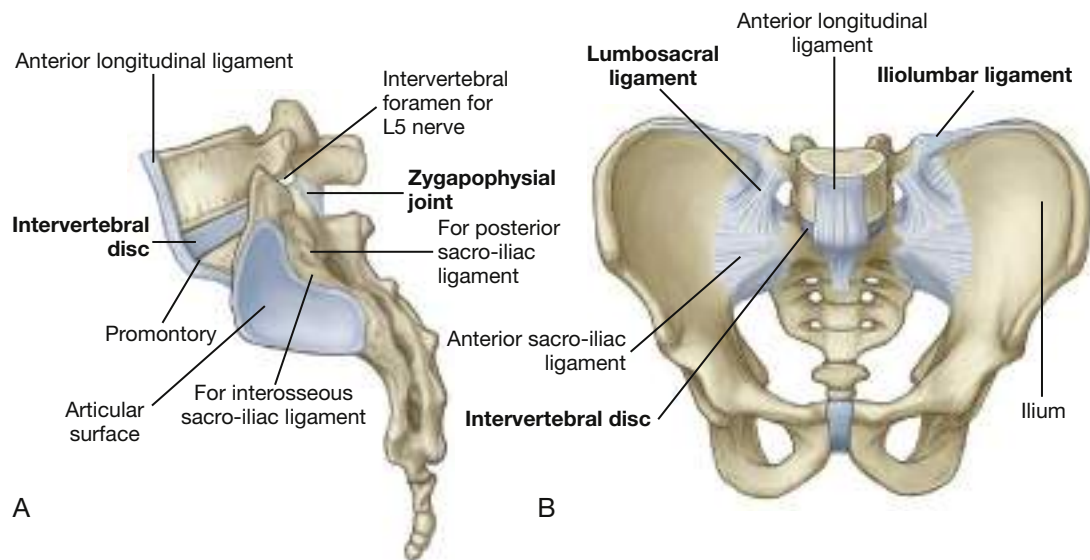


Fig. 5.6 Lumbosacral joints and associated ligaments. **A.** Lateral view. **B.** Anterior view.

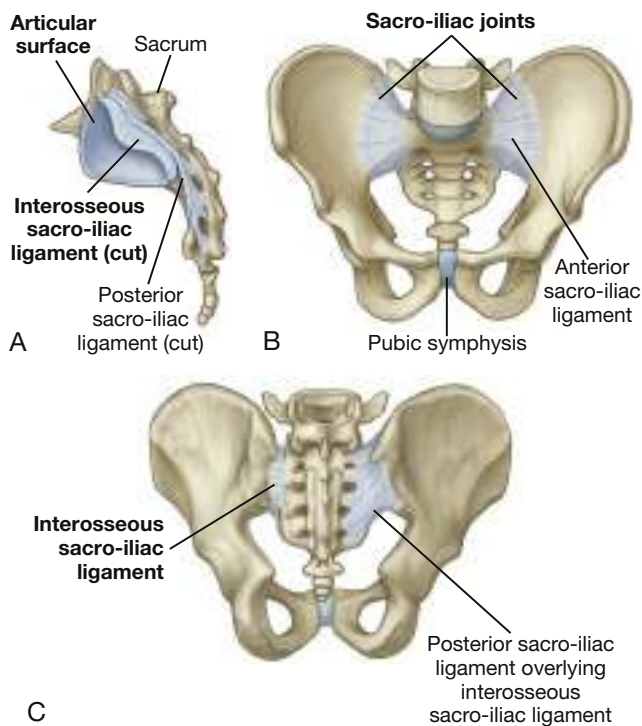


Fig. 5.7 Sacro-iliac joints and associated ligaments. **A.** Lateral view. **B.** Anterior view. **C.** Posterior view.

Sacro-iliac joints

The sacro-iliac joints transmit forces from the lower limbs to the vertebral column. They are synovial joints between the L-shaped articular facets on the lateral surfaces of the sacrum and similar facets on the iliac parts of the pelvic bones (Figs. 5.6A, 5.7A). The joint surfaces have an irregular contour and interlock to resist movement. The joints often become fibrous with age and may become completely ossified.

Each sacro-iliac joint is stabilized by three ligaments:

- the **anterior sacro-iliac ligament**, which is a thickening of the fibrous membrane of the joint capsule and runs anteriorly and inferiorly to the joint (Figs. 5.6B, 5.7B);
- the **interosseous sacro-iliac ligament**, which is the largest, strongest ligament of the three, is positioned immediately posterosuperior to the joint, and attaches to adjacent expansive roughened areas on the ilium and sacrum, thereby filling the gap between the two bones (Fig. 5.7A and 5.7C); and
- the **posterior sacro-iliac ligament**, which covers the interosseous sacro-iliac ligament (Fig. 5.7C).

Clinical app

Common problems with the sacro-iliac joints

As with many weight-bearing joints, degenerative changes may occur with the sacro-iliac joints and cause pain and discomfort in the region. In addition, disorders associated with the major histocompatibility complex antigen HLA B27, such as ankylosing spondylitis, psoriatic arthritis, inflammatory arthritis associated with inflammatory bowel disease, or reactive arthritis (the group referred to as *seronegative spondyloarthropathies*), can produce specific inflammatory changes within these joints.

Pubic symphysis joint

The pubic symphysis lies anteriorly between the adjacent surfaces of the pubic bones (Fig. 5.8). Each of the joint's surfaces is covered by hyaline cartilage and is linked across the midline to adjacent surfaces by fibrocartilage. The joint is

surrounded by interwoven layers of collagen fibers, and the two major ligaments associated with it are (Fig. 5.8):

- the **superior pubic ligament**, located above the joint, and
- the **inferior pubic ligament**, located below it.

Orientation

In the anatomical position, the pelvis is oriented so that the front edge of the top of the pubic symphysis and the anterior

superior iliac spines lie in the same vertical plane (Fig. 5.9). As a consequence, the pelvic inlet, which marks the entrance to the pelvic cavity, is tilted to face anteriorly, and the bodies of the pubic bones and the pubic arch are positioned in a nearly horizontal plane facing the ground.

Differences between men and women

The pelvises of women and men differ in a number of ways, many of which have to do with the passing of a baby through a woman's pelvic cavity during childbirth.

- The pelvic inlet in women is circular (Fig. 5.10A) compared with the more heart-shaped pelvic inlet (Fig. 5.10B) in

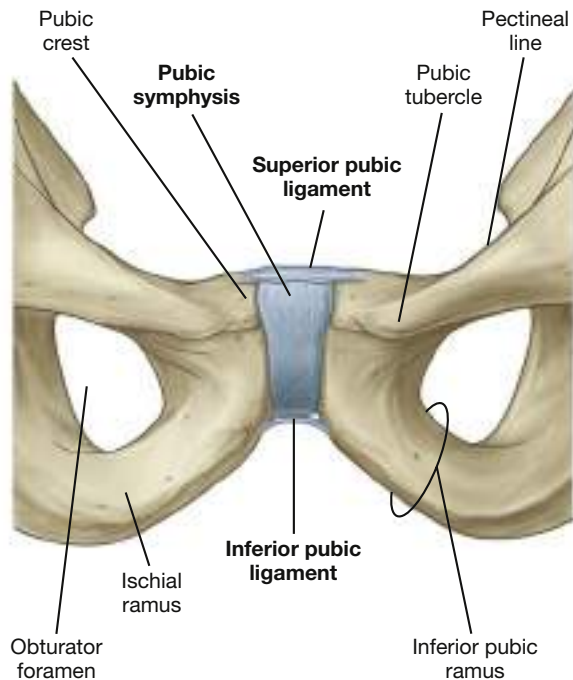


Fig. 5.8 Pubic symphysis and associated ligaments.

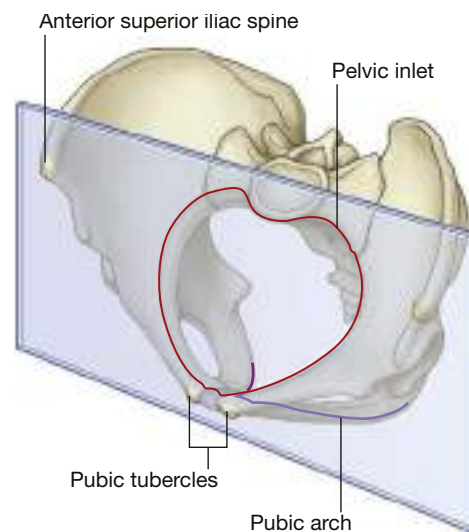


Fig. 5.9 Orientation of the pelvis (anatomical position).

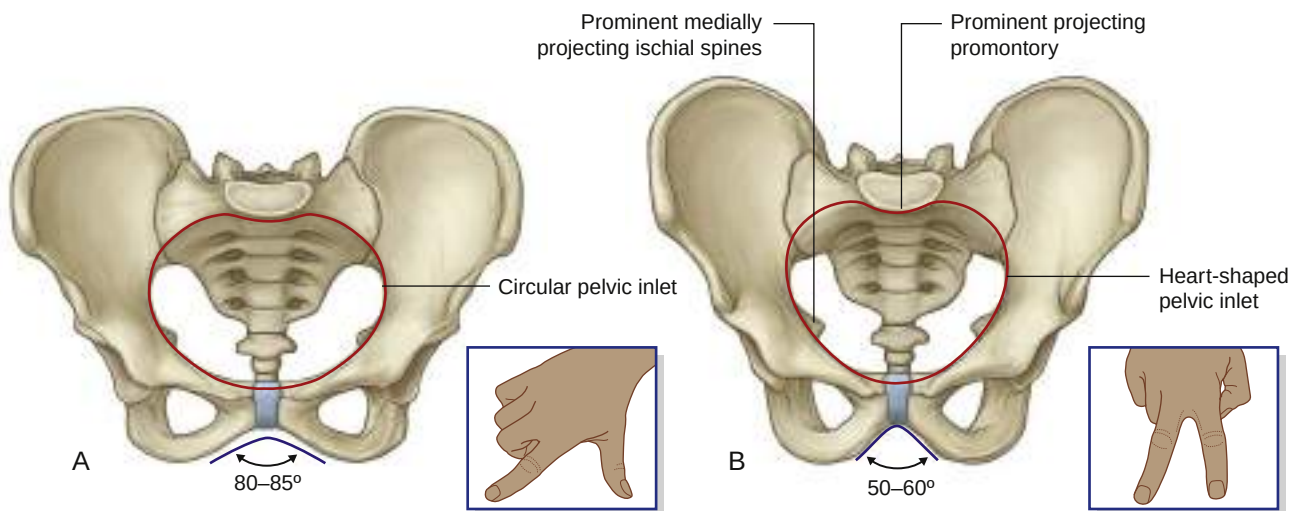


Fig. 5.10 Structure of the bony pelvis. **A.** In women. **B.** In men. The angle formed by the pubic arch can be approximated by the angle between the thumb and index finger for women and the angle between the index finger and middle finger for men, as shown in the insets.



Pelvis and Perineum

men. The more circular shape is partly caused by the less distinct promontory and broader alae in women.

- The angle formed by the two arms of the pubic arch is larger in women (80° to 85°) than it is in men (50° to 60°) (Fig. 5.10).
- The ischial spines generally do not project as far medially into the pelvic cavity in women as they do in men.

True pelvis

The true pelvis is cylindrical and has an inlet, a wall, and an outlet. The inlet is open, whereas the pelvic floor closes the outlet and separates the pelvic cavity above from the perineum below.

Pelvic inlet

The pelvic inlet is the circular opening between the abdominal cavity and the pelvic cavity through which structures traverse between the abdomen and pelvic cavity. It is completely surrounded by bones and joints (Fig. 5.11). The promontory of the sacrum protrudes into the inlet, forming its posterior margin in the midline. On either side of the promontory, the margin is formed by the alae of the sacrum. The margin of the pelvic inlet then crosses the sacro-iliac joint and continues along the linea terminalis (i.e., the arcuate line, the pecten pubis or pectineal line, and the pubic crest) to the pubic symphysis.

Pelvic wall

The walls of the pelvic cavity consist of the sacrum, the coccyx, the pelvic bones inferior to the linea terminalis, two ligaments, and two muscles.

Clinical app

Pelvic fracture

The pelvis can be viewed as a series of anatomical rings. There are three bony rings and four fibro-osseous rings. The major bony pelvic ring consists of parts of the sacrum, ilium, and pubis, which forms the pelvic inlet. Two smaller subsidiary bony rings are the obturator foraminae. The greater and lesser sciatic foraminae, formed by the greater and lesser sciatic notches and the sacrospinous and sacrotuberous ligaments, form the four fibro-osseous rings. It is not possible to break one side of a bony ring without breaking the other side of the ring, which in clinical terms means that if a fracture is demonstrated on one side, a second fracture should always be suspected.

Ligaments of the pelvic wall

The **sacrospinous and sacrotuberous ligaments** (Fig. 5.12A) are major components of the lateral pelvic walls that help define the apertures between the pelvic cavity and adjacent regions through which structures pass.

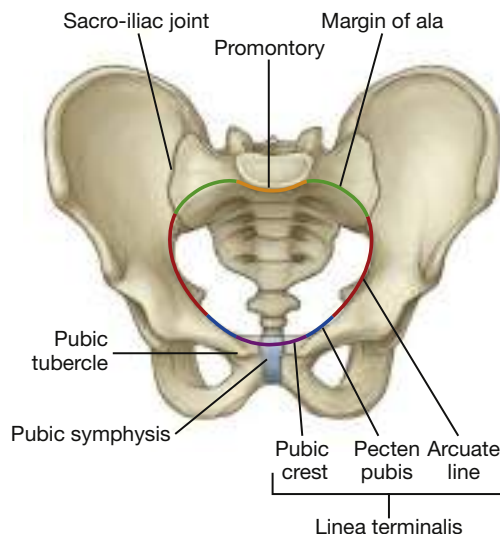


Fig. 5.11 Pelvic inlet.

- The smaller of the two, the sacrospinous ligament, is triangular, with its apex attached to the ischial spine and its base attached to the related margins of the sacrum and the coccyx (Fig. 5.12A).
- The sacrotuberous ligament is also triangular and is superficial to the sacrospinous ligament. Its base has a broad attachment that extends from the posterior superior iliac spine of the pelvic bone, along the dorsal aspect and the lateral margin of the sacrum, and onto the dorsolateral surface of the coccyx. Laterally, the apex of the ligament is attached to the medial margin of the ischial tuberosity (Fig. 5.12A).

These ligaments stabilize the sacrum on the pelvic bones by resisting the upward tilting of the inferior aspect of the sacrum (Fig. 5.12B). They also convert the greater and lesser sciatic notches of the pelvic bone into foramina (Fig. 5.12A,B).

- The **greater sciatic foramen** lies superior to the sacrospinous ligament and the ischial spine.
- The **lesser sciatic foramen** lies inferior to the ischial spine and sacrospinous ligament between the sacrospinous and sacrotuberous ligaments.

Muscles of the pelvic wall

Two muscles, the **obturator internus** and the **piriformis**, contribute to the lateral walls of the pelvic cavity. These muscles originate in the pelvic cavity but attach peripherally to the femur (Table 5.1, Fig. 5.13).

Apertures in the pelvic wall

Each lateral pelvic wall has three major apertures through which structures pass between the pelvic cavity and other regions (Fig. 5.14):

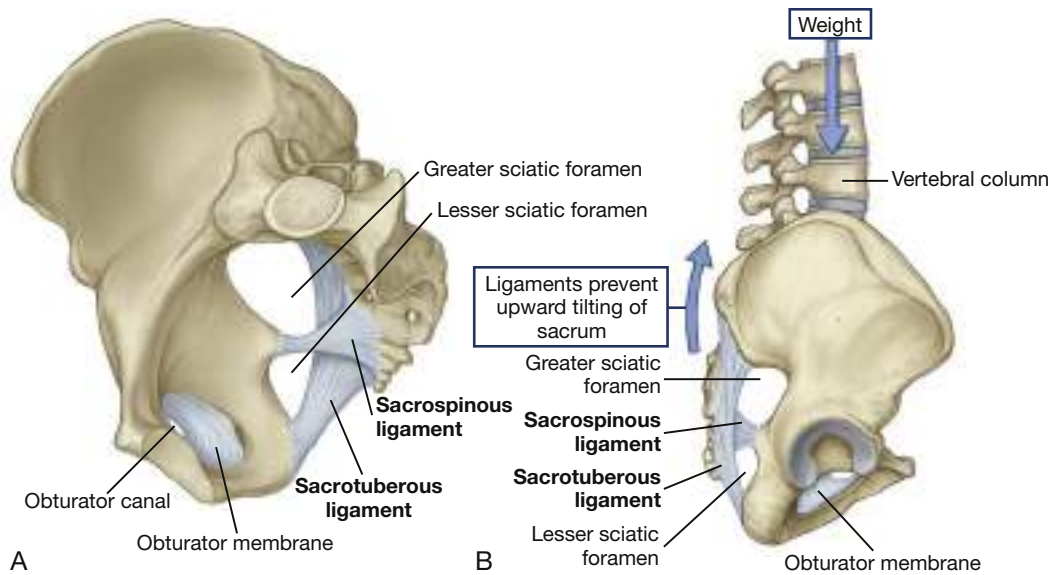


Fig. 5.12 Sacrospinous and sacrotuberous ligaments. **A.** Medial view of right side of pelvis. **B.** Function of the ligaments.

Table 5.1 Muscles of the pelvic walls (spinal segments in bold are the major segments innervating the muscle)

Muscles	Origin	Insertion	Innervation	Function
Obturator internus	Anterolateral wall of true pelvis (deep surface of obturator membrane and surrounding bone). The muscle fibers of the obturator internus converge to form a tendon that leaves the pelvic cavity through the lesser sciatic foramen, makes a 90° bend around the ischium between the ischial spine and ischial tuberosity, and then passes posterior to the hip joint to reach its insertion	Medial surface of greater trochanter of femur	Nerve to obturator internus L5, S1	Lateral rotation of the extended hip joint; abduction of flexed hip
Piriformis	Anterior surface of sacrum between anterior sacral foramina	Medial side of superior border of greater trochanter of femur	Branches from L5, S1 , and S2	Lateral rotation of the extended hip joint; abduction of flexed hip

- the obturator canal,
- the greater sciatic foramen, and
- the lesser sciatic foramen.

Obturator canal

At the top of the obturator foramen is the obturator canal, which is bordered by the obturator membrane, the associated obturator muscles, and the superior pubic ramus (Fig. 5.14). The obturator nerve and vessels pass from the pelvic cavity to the thigh through this canal.

Greater sciatic foramen

The greater sciatic foramen is a major route of communication between the pelvic cavity and the lower limb (Fig. 5.14). It is formed by the greater sciatic notch in the pelvic bone, the sacrotuberous and the sacrospinous ligaments, and the spine of the ischium.

The piriformis muscle passes through the greater sciatic foramen, dividing it into two parts.

- The superior gluteal nerves and vessels pass through the foramen above the piriformis.
- Passing through the foramen below the piriformis are the inferior gluteal nerves and vessels, the sciatic nerve, the pudendal nerve, the internal pudendal vessels, the posterior femoral cutaneous nerves, and the nerves to the obturator internus and quadratus femoris muscles.

Lesser sciatic foramen

The lesser sciatic foramen is formed by the lesser sciatic notch of the pelvic bone, the ischial spine, the sacrospinous ligament, and the sacrotuberous ligament (Fig. 5.14). The tendon of the obturator internus muscle passes through this foramen to enter the gluteal region of the lower limb.

Because the lesser sciatic foramen is positioned below the attachment of the pelvic floor, it acts as a route of communication between the perineum and the gluteal region. The pudendal nerve and internal pudendal vessels pass between the pelvic cavity (above the pelvic floor) and the perineum

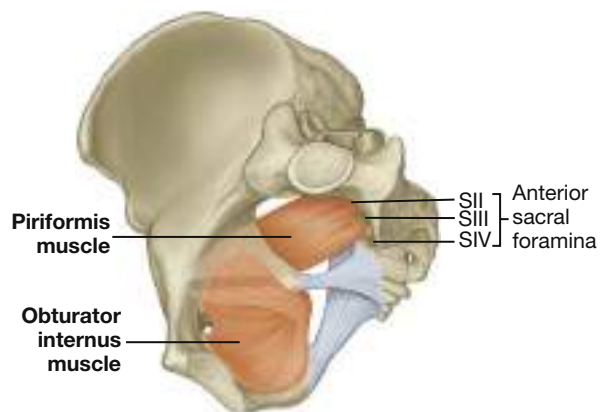


Fig. 5.13 Obturator internus and piriformis muscles (medial view of right side of pelvis).

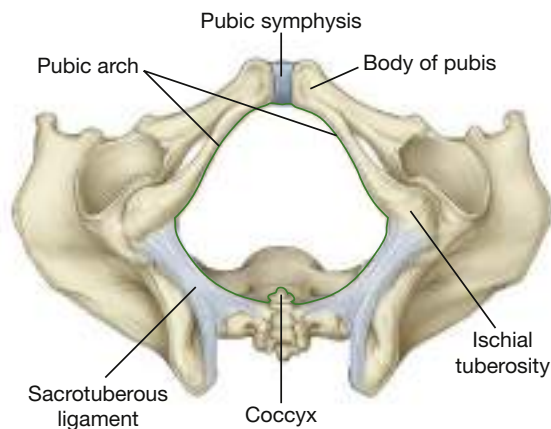


Fig. 5.15 Pelvic outlet.

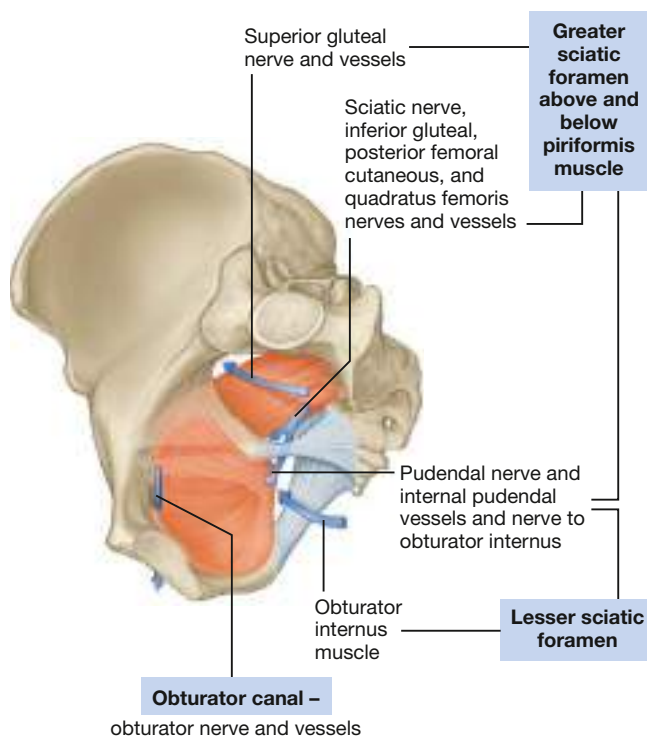


Fig. 5.14 Apertures in the pelvic wall.

(below the pelvic floor) by first passing out of the pelvic cavity through the greater sciatic foramen and then looping around the ischial spine and sacrospinous ligament to pass through the lesser sciatic foramen to enter the perineum. The nerve to obturator internus follows a similar course.

Pelvic outlet

The pelvic outlet is diamond shaped, with the anterior part of the diamond defined predominantly by bone and the posterior part mainly by ligaments (Fig. 5.15). In the mid-line anteriorly, the boundary of the pelvic outlet is the pubic symphysis.

Extending laterally and posteriorly, the boundary on each side is the inferior border of the body of the pubis, the inferior ramus of the pubis, the ramus of the ischium, and the ischial tuberosity. Together, the elements on both sides form the pubic arch.

From the ischial tuberosities, the boundaries continue posteriorly and medially along the sacrotuberous ligament on both sides to the coccyx.

Terminal parts of the urinary and gastrointestinal tracts and the vagina pass through the pelvic outlet.

Clinical app

Pelvic measurements in obstetrics

Accurate measurements of a women's pelvic inlet and outlet can help in predicting the likelihood of a successful vaginal delivery during childbirth. These measurements include:

- the sagittal inlet (between the promontory and the top of the pubic symphysis);
- the maximum transverse diameter of the inlet;
- the bispinous outlet (the distance between ischial spines); and
- the sagittal outlet (the distance between the tip of the coccyx and the inferior margin of the pubic symphysis).

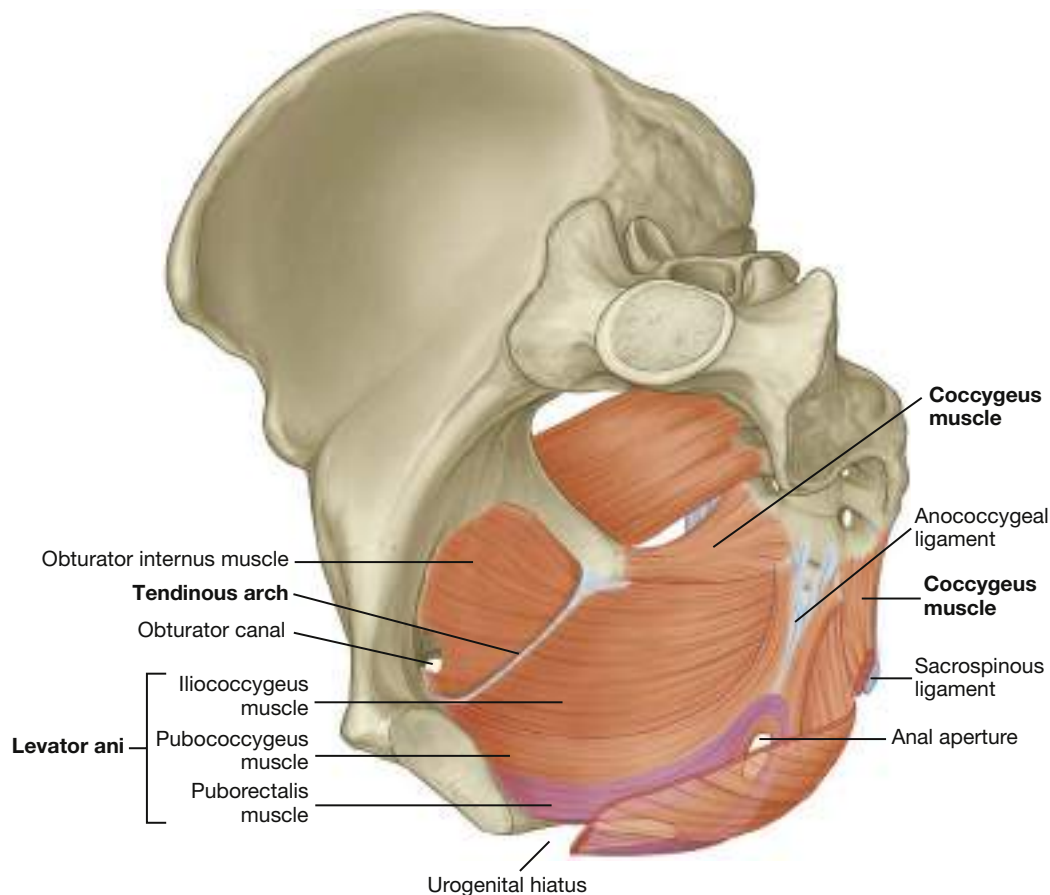
The area enclosed by the boundaries of the pelvic outlet and below the pelvic floor is the **perineum**.

Pelvic floor

The pelvic floor is formed by the **pelvic diaphragm** and, in the anterior midline, the **perineal membrane** and the muscles in the **deep perineal pouch**. The pelvic diaphragm is formed by the **levator ani** and the **coccygeus muscles** from both sides. The pelvic floor separates the pelvic cavity above from the perineum below.

Table 5.2 Muscles of the pelvic diaphragm

Muscles	Origin	Insertion	Innervation	Function
Levator ani	In a line around the pelvic wall beginning on the posterior aspect of the pubic bone and extending across the obturator internus muscle as a tendinous arch (thickening of the obturator internus fascia) to the ischial spine	The anterior part is attached to the superior surface of the perineal membrane; the posterior part meets its partner on the other side at the perineal body, around the anal canal, and along the anococcygeal ligament	Branches direct from the anterior ramus of S4 and by the inferior rectal branch of the pudendal nerve (S2 to S4)	Contributes to the formation of the pelvic floor, which supports the pelvic viscera; maintains an angle between the rectum and anal canal. Reinforces the external anal sphincter and, in women, functions as a vaginal sphincter
Coccygeus	Ischial spine and pelvic surface of the sacrospinous ligament	Lateral margin of coccyx and related border of sacrum	Branches from the anterior rami of S3 and S4	Contributes to the formation of the pelvic floor, which supports the pelvic viscera; pulls the coccyx forward after defecation

**Fig. 5.16** Pelvic diaphragm.

The pelvic diaphragm

The pelvic diaphragm is the muscular part of the pelvic floor. Shaped like a bowl or funnel and attached superiorly to the pelvic walls, it consists of the levator ani and the coccygeus muscles (Table 5.2, Fig. 5.16).

The pelvic diaphragm's circular line of attachment to the cylindrical pelvic wall passes, on each side, between the greater sciatic foramen and the lesser sciatic foramen. Thus:

- the greater sciatic foramen is situated above the level of the pelvic floor and is a route of communication between

the pelvic cavity and the gluteal region of the lower limb; and

- the lesser sciatic foramen is situated below the pelvic floor, providing a route of communication between the gluteal region of the lower limb and the perineum.

Levator ani

The two levator ani muscles originate from each side of the pelvic wall, course medially and inferiorly, and join together in the midline. The attachment to the pelvic wall follows the circular contour of the wall and includes (Fig. 5.16):



Pelvis and Perineum

- the posterior aspect of the body of the pubic bone,
- a linear thickening called the **tendinous arch** in the fascia covering the obturator internus muscle, and
- the spine of the ischium.

At the midline, the muscles blend together posterior to the vagina in women and around the anal aperture in both sexes. Posterior to the anal aperture, the muscles come together as a ligament or raphe called the **anococcygeal ligament (anococcygeal body)** and attaches to the coccyx (Fig. 5.16). Anteriorly, the muscles are separated by a U-shaped defect or gap termed the **urogenital hiatus**. The margins of this hiatus merge with the walls of the associated viscera and with muscles in the deep perineal pouch below. The hiatus allows the urethra (in both men and women) and the vagina (in women) to pass through the pelvic diaphragm (Fig. 5.16).

The levator ani muscles are divided into at least three collections of muscle fibers based on site of origin and relationship to viscera in the midline: the pubococcygeus, the puborectalis, and the iliococcygeus muscles (Fig. 5.16).

- The **pubococcygeus** originates from the body of the pubis and courses posteriorly to attach along the midline as far back as the coccyx. This part of the muscle is further subdivided on the basis of association with structures in the midline into the **puboprostaticus (levator prostatae)**, the **pubovaginalis**, and the **puboanalis muscles**.
- A second major collection of muscle fibers, the **puborectalis** portion of the levator ani muscles, originates, in association with the pubococcygeus muscle, from the pubis and passes inferiorly on each side to form a sling around the terminal part of the gastrointestinal tract. This muscular sling maintains an angle or flexure, called the **perineal flexure**, at the anorectal junction. This angle functions as part of the mechanism that keeps the end of the gastrointestinal system closed.
- The final part of the levator ani muscle is the **iliococcygeus**. This part of the muscle originates from the fascia that covers the obturator internus muscle. It joins the same muscle on the other side in the midline to form a ligament or raphe that extends from the anal aperture to the coccyx.

The levator ani muscles help support the pelvic viscera and maintain closure of the rectum and vagina.

Clinical app

Defecation

At the beginning of defecation, closure of the larynx stabilizes the diaphragm and intra-abdominal pressure is increased by contraction of abdominal wall muscles. As defecation proceeds, the puborectalis muscle surrounding the anorectal junction relaxes, which straightens the anorectal angle. Both the internal and the external anal sphincters also relax to allow feces to move through the anal canal. Normally, the puborectal sling maintains an angle of about 90° between the rectum and the anal canal and acts as a “pinch valve” to prevent defecation. When the puborectalis muscle relaxes, the anorectal angle increases to about 130° to 140°.

The fatty tissue of the ischio-anal fossa allows for changes in the position and size of the anal canal and anus during defecation. During evacuation, the anorectal junction moves down and back and the pelvic floor usually descends slightly.

During defecation, the circular muscles of the rectal wall undergo a wave of contraction to push feces toward the anus. As feces emerge from the anus, the longitudinal muscles of the rectum and levator ani bring the anal canal back up, the feces are expelled, and the anus and rectum return to their normal positions.

The perineal membrane and deep perineal pouch

The **perineal membrane** is a thick fascial, triangular structure attached to the bony framework of the pubic arch (Fig. 5.17A). It is oriented in the horizontal plane and has a free posterior margin. Anteriorly, there is a small gap between the membrane and the **inferior pubic ligament** (a ligament associated with the pubic symphysis).

The perineal membrane is related above to a thin space called the **deep perineal pouch (deep perineal space)** (Fig. 5.17B) which contains a layer of skeletal muscle and various neurovascular elements.

The deep perineal pouch is open above and is not separated from more superior structures by a distinct layer of fascia. The parts of perineal membrane and structures in the deep perineal pouch, enclosed by the urogenital hiatus above therefore contribute to the pelvic floor and support elements of the urogenital system in the pelvic cavity, even though the perineal membrane and deep perineal pouch are usually considered parts of the perineum.

The perineal membrane and adjacent pubic arch provide attachment for the roots of the external genitalia and the muscles associated with them (Fig. 5.17C).

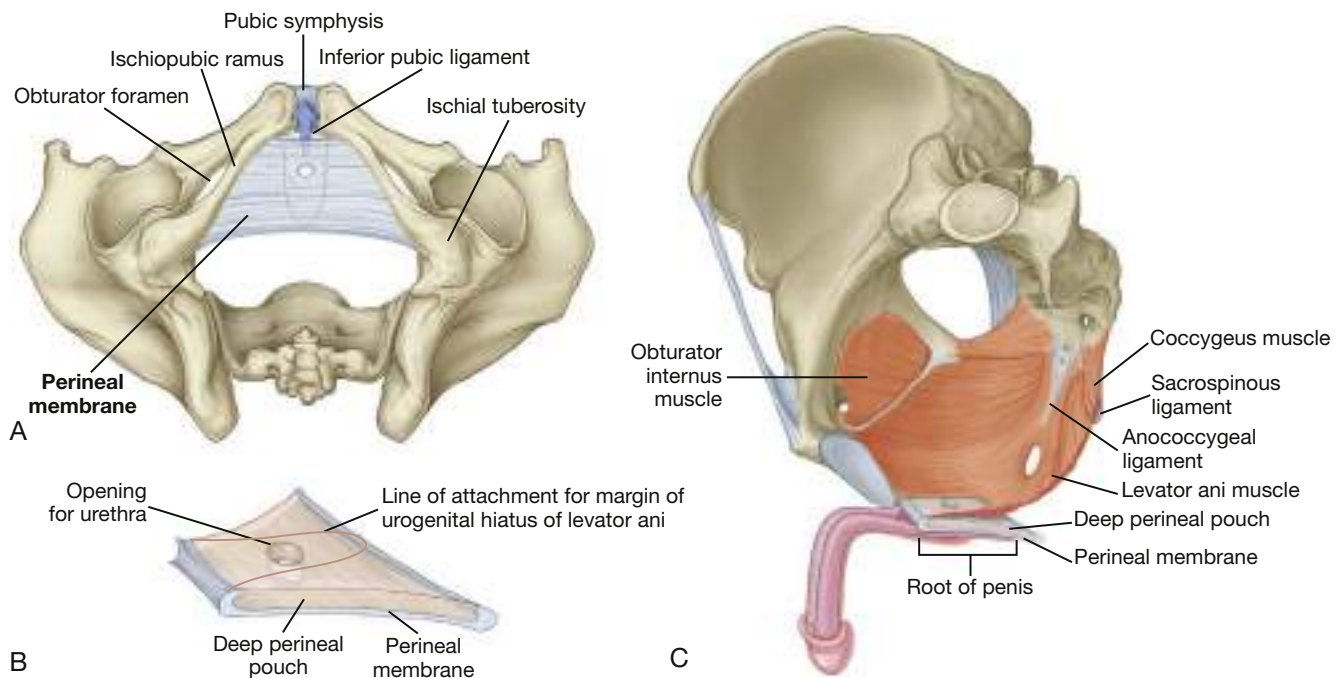


Fig. 5.17 Perineal membrane and deep perineal pouch. **A.** Inferior view. **B.** Superolateral view. **C.** Medial view.

Table 5.3 Muscles within the deep perineal pouch

Muscles	Origin	Insertion	Innervation	Function
External urethral sphincter	From the inferior ramus of the pubis on each side and adjacent walls of the deep perineal pouch	Surrounds membranous part of urethra	Perineal branches of the pudendal nerve (S2 to S4)	Compresses the membranous urethra; relaxes during micturition
Deep transverse perineal	Medial aspect of ischial ramus	Perineal body	Perineal branches of the pudendal nerve (S2 to S4)	Stabilizes the position of the perineal body
Compressor urethrae (in women only)	Ischiopubic ramus on each side	Blends with partner on other side anterior to the urethra	Perineal branches of the pudendal nerve (S2 to S4)	Functions as an accessory sphincter of the urethra
Sphincter urethrovaginalis (in women only)	Perineal body	Passes forward lateral to the vagina to blend with partner on other side anterior to the urethra	Perineal branches of the pudendal nerve (S2 to S4)	Functions as an accessory sphincter of the urethra (also may facilitate closing the vagina)

The urethra penetrates vertically through a circular hiatus in the perineal membrane as it passes from the pelvic cavity above to the perineum below. In women, the vagina also passes through a hiatus in the perineal membrane just posterior to the urethral hiatus.

Within the deep perineal pouch, a sheet of skeletal muscle functions as a sphincter, mainly for the urethra, and as a stabilizer of the posterior edge of the perineal membrane (Table 5.3, Fig. 5.18).

- Anteriorly, a group of muscle fibers surround the urethra and collectively form the **external urethral sphincter** (Fig. 5.18).
- Two additional groups of muscle fibers are associated with the urethra and vagina in women (Fig. 5.18A). One group forms the **sphincter urethrovaginalis**, which surrounds

the urethra and vagina as a unit. The second group forms the **compressor urethrae** on each side, which originate from the ischiopubic rami and meet anterior to the urethra. Together with the external urethral sphincter, the sphincter urethrovaginalis and compressor urethrae facilitate closing of the urethra.

- In both men and women, a **deep transverse perineal muscle** on each side parallels the free margin of the perineal membrane and joins with its partner at the midline. These muscles are thought to stabilize the position of the perineal body, which is a midline structure along the posterior edge of the perineal membrane.

Perineal body

The perineal body is an ill-defined but important connective tissue structure into which muscles of the pelvic floor and

Pelvis and Perineum

the perineum attach (Fig. 5.19). It is positioned in the midline along the posterior border of the perineal membrane to which it attaches. The posterior end of the urogenital hiatus in the levator ani muscles is also connected to it.

The deep transverse perineal muscles intersect at the perineal body; in women, the sphincter urethrovaginalis also attaches to the perineal body. Other muscles that connect to the perineal body include the external anal sphincter, the superficial transverse perineal muscles, and the bulbospongiosus muscles of the perineum.

Clinical app

Episiotomy

During childbirth the perineal body may be stretched and torn. Traditionally it was felt that if a perineal tear is likely, the obstetrician may proceed with an episiotomy. This is a procedure in which an incision is made in the perineal body to allow the head of the fetus to pass through the vagina. There are two types of episiotomies: a median episiotomy cuts through the perineal body, while a mediolateral episiotomy is an incision 45° from the midline. The maternal benefits of this procedure have been thought to be less trauma to the perineum and decreased pelvic floor dysfunction. However, more recent evidence suggests that an episiotomy should not be performed routinely. Review of data has failed to show a decrease in pelvic floor damage with routine use of episiotomies.

Viscera

The pelvic viscera include parts of the gastrointestinal system, the urinary system, and the reproductive system. The viscera are arranged in the midline, from front to back; the neurovascular supply is through branches that pass medially from vessels and nerves associated with the pelvic walls.

Gastrointestinal system

Pelvic parts of the gastrointestinal system consist mainly of the rectum and the anal canal, although the terminal part of the sigmoid colon is also in the pelvic cavity (Fig. 5.20).

Rectum

The **rectum** is continuous:

- above, with the sigmoid colon at about the level of vertebra SIII; and
- below, with the anal canal as this structure penetrates the pelvic floor and passes through the perineum to end as the anus.

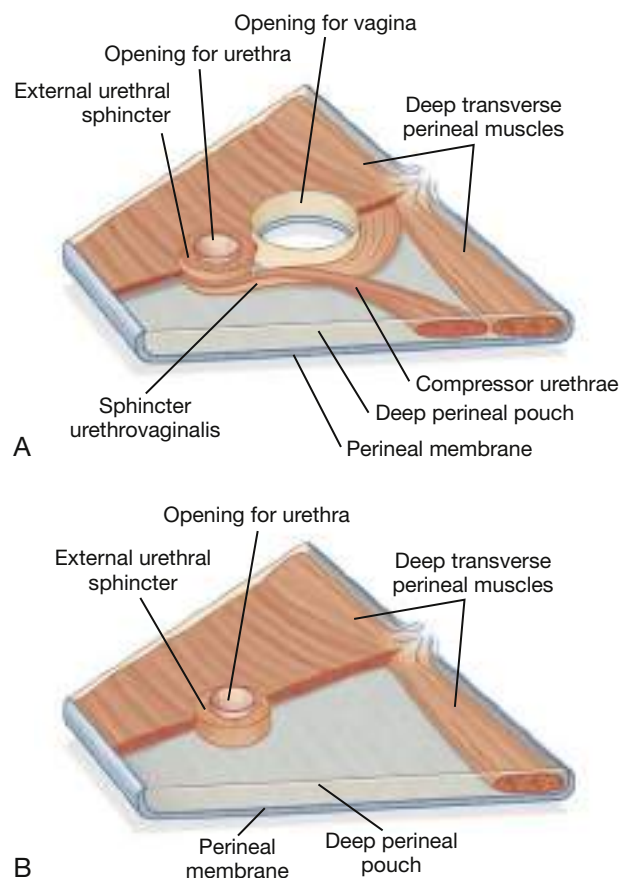


Fig. 5.18 Muscles in the deep perineal pouch. **A.** In women. **B.** In men.

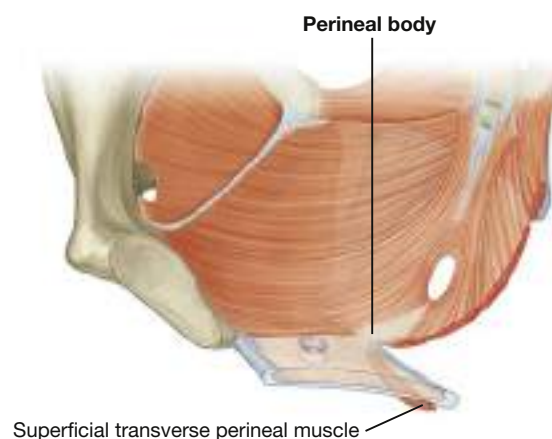


Fig. 5.19 Perineal body.

The rectum, the most posterior element of the pelvic viscera, is immediately anterior to and follows the concave contour of the sacrum (Fig. 5.20A).

The anorectal junction is pulled forward (perineal flexure) by the action of the puborectalis part of the levator ani muscle, so the anal canal moves in a posterior direction as it passes inferiorly through the pelvic floor.

In addition to conforming to the general curvature of the sacrum in the anteroposterior plane, the rectum has three lateral curvatures; the upper and lower curvatures to the right and the middle curvature to the left. The lower part of the rectum is expanded to form the **rectal ampulla**. Finally, unlike the colon, the rectum lacks distinct taeniae coli muscles, omental appendices, and sacculations (haustra of the colon).

Clinical app

Digital rectal examination

A digital rectal examination (DRE) is performed by placing the gloved and lubricated index finger into the rectum through the anus. The anal mucosa can be palpated for abnormal masses, and in women, the posterior wall of the vagina and the cervix can be palpated. In men, the prostate can be evaluated for any extraneous nodules or masses. In persons who have undergone vaginoplasty, such as is common with transgender women, the prostate is not removed and the vaginal cavity is constructed between the prostate and rectum. The examination of the prostate in these individuals is easier to palpate transvaginally, along the anterior wall of the vagina, rather than rectally.

Anal canal

The **anal canal** begins at the terminal end of the rectal ampulla where it narrows at the pelvic floor (Fig. 5.20B). It terminates as the anus after passing through the perineum. As it passes through the pelvic floor, the anal canal is surrounded along its entire length by the internal and external anal sphincters, which normally keep it closed (Fig. 5.20B).

The lining of the anal canal bears a number of characteristic structural features that reflect the approximate position of the anococcygeal membrane in the fetus (which closes the terminal end of the developing gastrointestinal system in the fetus) and the transition from gastrointestinal mucosa to skin in the adult (Fig. 5.20B).

- The upper part of the anal canal is lined by mucosa similar to that lining the rectum and is distinguished by a number of longitudinally oriented folds known as **anal columns**, which are united inferiorly by crescentic folds termed **anal valves**. Superior to each valve is a depression termed an **anal sinus**. The anal valves together form a circle around the anal canal at a location known as the **pectinate line**, which marks the approximate position of the anal membrane in the fetus.
- Inferior to the pectinate line is a transition zone known as the **anal pecten**, which is lined by nonkeratinized, stratified,

squamous epithelium. The anal pecten ends inferiorly at the anocutaneous line (“white line”), or where the lining of the anal canal becomes true skin.

Clinical app

Carcinoma of the colon and rectum

Carcinoma of the colon and rectum (colorectum) is a common disease.

Given the position of the colon and rectum in the abdominopelvic cavity and its proximity to other organs, it is extremely important to accurately stage colorectal tumors: a tumor in the pelvis, for example, could invade the uterus or bladder.

Urinary system

The pelvic parts of the urinary system consist of the terminal parts of the ureters, the bladder, and the proximal part of the urethra (Fig. 5.21).

Ureters

The ureters enter the pelvic cavity from the abdomen by passing through the pelvic inlet (Fig. 5.21). On each side, the ureter crosses the pelvic inlet and enters the pelvic cavity in the area anterior to the bifurcation of the common iliac artery. From this point, it continues along the pelvic wall and floor to join the base of the bladder.

In the pelvis, the ureter is crossed by:

- the ductus deferens in men, and
- the uterine artery in women.

Bladder

The bladder is the most anterior element of the pelvic viscera. Although it is entirely situated in the pelvic cavity when empty, it expands superiorly into the abdominal cavity when full (Fig. 5.21).

The empty bladder is shaped like a three-sided pyramid that has tipped over to lie on one of its margins (Fig. 5.22A). It has an apex, a base, a superior surface, and two inferolateral surfaces (Fig. 5.22A).

- The **apex** of the bladder is directed toward the top of the pubic symphysis; a structure known as the **median umbilical ligament** (a remnant of the embryological urachus that contributes to the formation of the bladder) continues from it superiorly up the anterior abdominal wall to the umbilicus.
- The **base** of the bladder is shaped like an inverted triangle and faces posteroinferiorly. The two ureters enter the

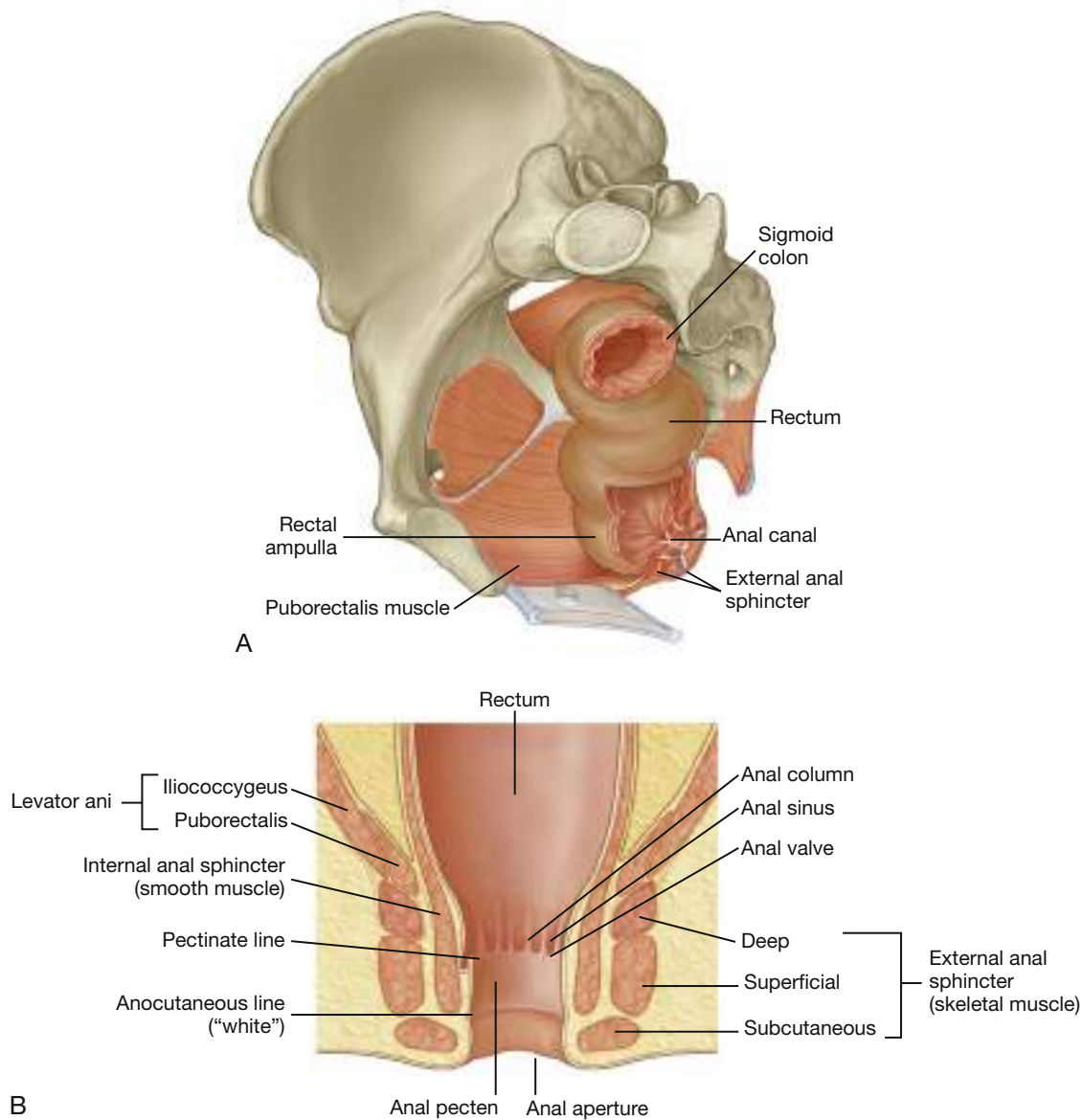


Fig. 5.20 Rectum and anal canal. **A.** Left pelvic bone removed. **B.** Longitudinal section.

bladder at each of the upper corners of the base, and the urethra drains inferiorly from the lower corner of the base (Fig. 5.22A, B). Inside, the mucosal lining on the base of the bladder is smooth and firmly attached to the underlying smooth muscle coat of the wall—unlike elsewhere in the bladder in which the mucosa is folded and loosely attached to the wall. The smooth triangular area between the openings of the ureters and urethra on the inside of the bladder is known as the **trigone** (Fig. 5.22B).

- The **inferolateral surfaces** of the bladder are cradled between the levator ani muscles of the pelvic diaphragm and the adjacent obturator internus muscles above the attachment of the pelvic diaphragm. The superior surface is slightly domed when the bladder is empty; it balloons upward as the bladder fills.

Neck of bladder

The neck of the bladder surrounds the origin of the urethra at the point where the two inferolateral surfaces and the base intersect (see Fig. 5.21).

The neck is the most inferior part of the bladder and the most “fixed” part. It is anchored into position by a pair of tough fibromuscular bands, which connect the neck and pelvic part of the urethra to the posteroinferior aspect of each pubic bone.

- In women, these fibromuscular bands are termed **pubovesical ligaments** (Fig. 5.23A). Together with the perineal membrane and associated muscles, the levator ani muscles, and the pubic bones, these ligaments help support the bladder.

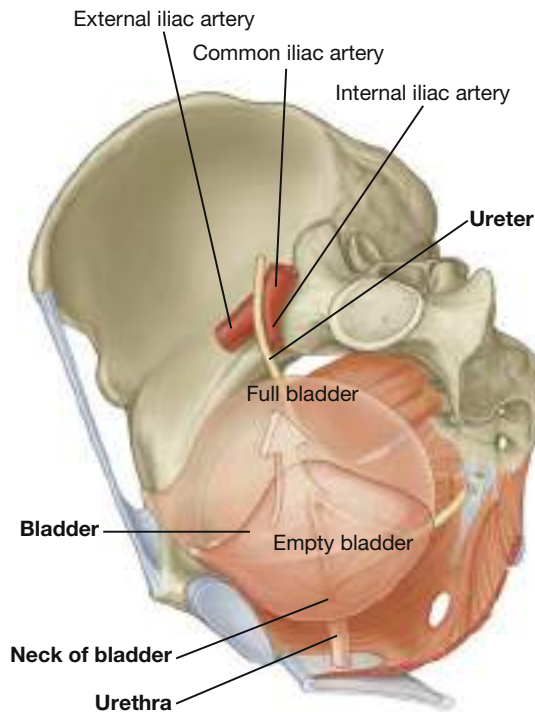


Fig. 5.21 Pelvic parts of the urinary system.

- In men, the paired fibromuscular bands are known as **puboprostatic ligaments** because they blend with the fibrous capsule of the prostate, which surrounds the neck of the bladder and adjacent part of the urethra (Fig. 5.23B).

Although the bladder is considered to be pelvic in the adult, it has a higher position in children. At birth, the bladder is almost entirely abdominal; the urethra begins approximately at the upper margin of the pubic symphysis. With age, the bladder descends until after puberty when it assumes the adult position.

Clinical app

Bladder cancer

Bladder cancer is the most common tumor of the urinary tract and is usually a disease of the sixth and seventh decades, although there is an increasing trend for younger patients to develop this disease.

Bladder tumors may spread through the bladder wall and invade local structures, including the rectum, uterus (in women), and the lateral walls of the pelvic cavity. Prostatic involvement is not uncommon in male patients.

Large bladder tumors may produce complications, including invasion and obstruction of the ureters. Ureteric obstruction can then obstruct the kidneys and induce kidney failure.

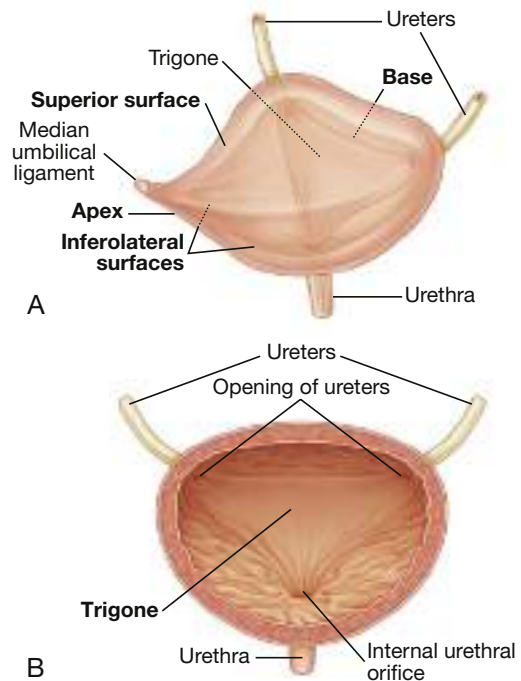


Fig. 5.22 Bladder. A. Superolateral view. B. The trigone. Anterior view with the anterior part of the bladder cut away.

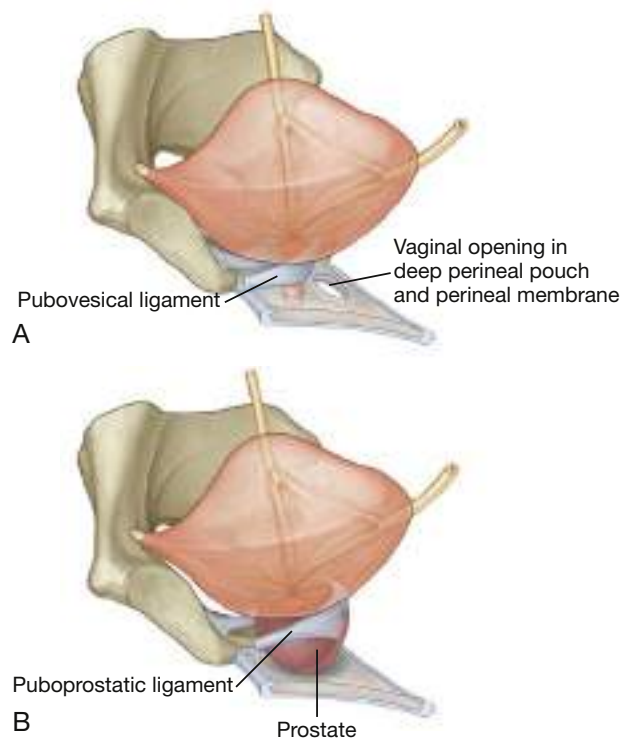


Fig. 5.23 Ligaments that anchor the neck of the bladder and pelvic part of the urethra to the pelvic bones. A. In women. B. In men.



Clinical app

Bladder stones

In some patients, small calculi (stones) form in the kidneys. These may pass down the ureter, causing ureteric obstruction, and into the bladder where insoluble salts further precipitate on these small calculi to form larger calculi. Often, these patients develop (or may already have) problems with bladder emptying, which leaves residual urine in the bladder. This urine may become infected and alter the pH of the urine, permitting further precipitation of insoluble salts.

Clinical app

Suprapubic catheterization

In certain instances it is necessary to catheterize the bladder through the anterior abdominal wall. For example, when the prostate is markedly enlarged and it is impossible to pass a urethral catheter into the bladder. The bladder is a retroperitoneal structure and, when full, lies adjacent to the anterior abdominal wall.

The procedure of suprapubic catheterization is straightforward and involves the passage of a small catheter through the abdominal wall in the midline above the pubic symphysis. The catheter passes into the bladder without compromising other structures and allows drainage.

Urethra

The urethra begins at the base of the bladder and ends with an external opening in the perineum. The paths taken by the urethra differ significantly in women and men.

In women

In women, the urethra is short, being about 4 cm long. It travels a slightly curved course as it passes inferiorly through the pelvic floor into the perineum where it passes through the deep perineal pouch and perineal membrane before opening in the vestibule that lies between the labia minora (Fig. 5.24A).

The urethral opening is anterior to the vaginal opening in the vestibule. The inferior aspect of the urethra is bound to the anterior surface of the vagina. Two small para-urethral mucous glands (**Skene's glands**) are associated with the lower end of the urethra. Each drains via a duct that opens onto the lateral margin of the external urethral orifice.

In men

In men, the urethra is long, about 20 cm, and bends twice along its course (Fig. 5.24B). Beginning at the base of the bladder and passing inferiorly through the prostate, it passes

through the deep perineal pouch and perineal membrane and immediately enters the root of the penis. As the urethra exits the deep perineal pouch, it bends forward to course anteriorly in the root of the penis. When the penis is flaccid, the urethra makes another bend, this time inferiorly, when passing from the root to the body of the penis. During erection, the bend between the root and body of the penis disappears.

The urethra in men is divided into preprostatic, prostatic, membranous, and spongy parts (Fig. 5.24B).

Preprostatic part. The preprostatic part of the urethra is about 1 cm long, extends from the base of the bladder to the prostate, and is associated with a circular cuff of smooth muscle fibers (the **internal urethral sphincter**) (Fig. 5.24B). Contraction of this sphincter prevents retrograde movement of semen into the bladder during ejaculation.

Prostatic part. The prostatic part of the urethra (Fig. 5.24C) is 3 to 4 cm long and is surrounded by the prostate. In this region, the lumen of the urethra is marked by a longitudinal midline fold of mucosa (the **urethral crest**). The depression on each side of the crest is the **prostatic sinus**; the ducts of the prostate empty into these two sinuses.

Midway along its length, the urethral crest is enlarged to form a somewhat circular elevation (the seminal colliculus) (Fig. 5.24C). In men, the seminal colliculus is used to determine the position of the prostate gland during transurethral transection of the prostate.

A small blind-ended pouch—the **prostatic utricle** (thought to be the homologue of the uterus in women)—opens onto the center of the seminal colliculus (Fig. 5.24C). On each side of the prostatic utricle is the opening of the ejaculatory duct of the male reproductive system. Therefore the connection between the urinary and reproductive tracts in men occurs in the prostatic part of the urethra.

Membranous part. The membranous part of the urethra is narrow and passes through the deep perineal pouch (Fig. 5.24B). During its transit through this pouch, the urethra, in both men and women, is surrounded by skeletal muscle of the **external urethral sphincter**.

Spongy urethra. The spongy urethra is surrounded by erectile tissue (the **corpus spongiosum**) of the penis. It is enlarged to form a bulb at the base of the penis and again at the end of the penis to form the **navicular fossa** (Fig. 5.24B). The two bulbourethral glands in the deep perineal pouch are part of the male reproductive system and open into the bulb of the spongy urethra. The external urethral orifice is the sagittal slit at the end of the penis.

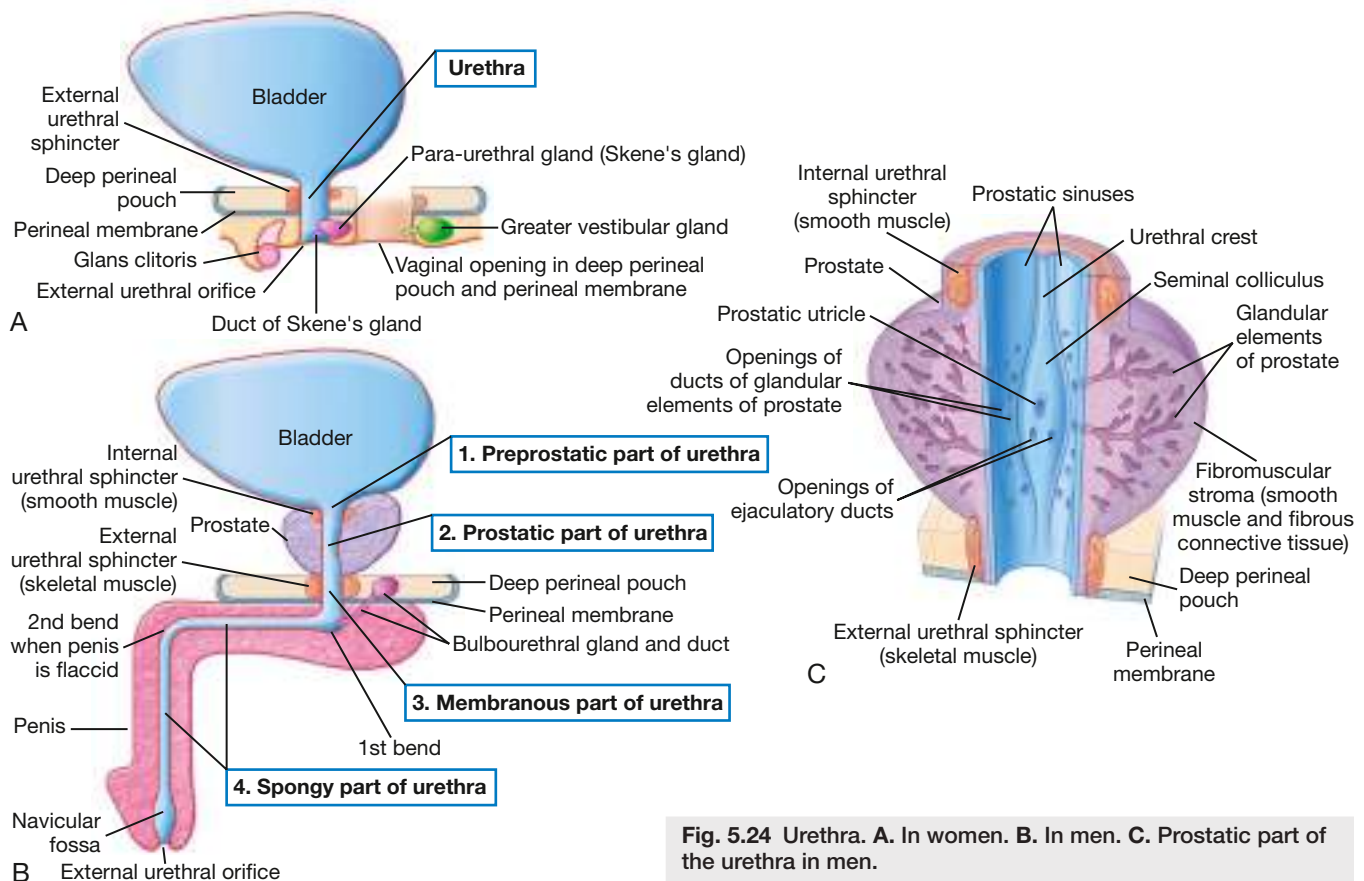


Fig. 5.24 Urethra. A. In women. B. In men. C. Prostatic part of the urethra in men.

Clinical app

Bladder infection

The relatively short length of the urethra in women makes them more susceptible than men to bladder infection. Similarly, transgender women who have undergone vaginoplasty will have a shortened urethra and are also at increased risk of urinary tract infection. Transgender men who have undergone metoidioplasty or phalloplasty will have lengthened urethras, but the neourethra lacks muscular and elastic tissue, reducing clearance of urine. This may also increase the risk of urinary tract infection. The primary symptoms of urinary tract infection in any individual is usually inflammation of the bladder (cystitis). In children younger than 1 year of age, infection from the bladder may spread via the ureters to the kidneys, where it can produce renal damage and ultimately lead to renal failure. Early diagnosis and treatment are necessary.

Reproductive system

In men

The reproductive system in men has components in the abdomen, pelvis, and perineum (Fig. 5.25A). The major

Clinical app

Urethral catheterization

Urethral catheterization is often performed to drain urine from a patient's bladder when the patient is unable to micturate. When inserting urinary catheters, it is important to appreciate the gender anatomy of the patient.

In men the spongy urethra angles superiorly to pass through the perineal membrane and into the pelvis. Just inferior to the perineal membrane, the wall of the urethral bulb is relatively thin and can be damaged when inserting catheters or doing cystoscopy. In women, these procedures are much simpler because the urethra is short and straight.

components are a testis, epididymis, ductus deferens, and ejaculatory duct on each side, and the urethra and penis in the midline. In addition, three types of accessory glands are associated with the system:

- a single prostate,
- a pair of seminal vesicles, and
- a pair of bulbourethral glands.

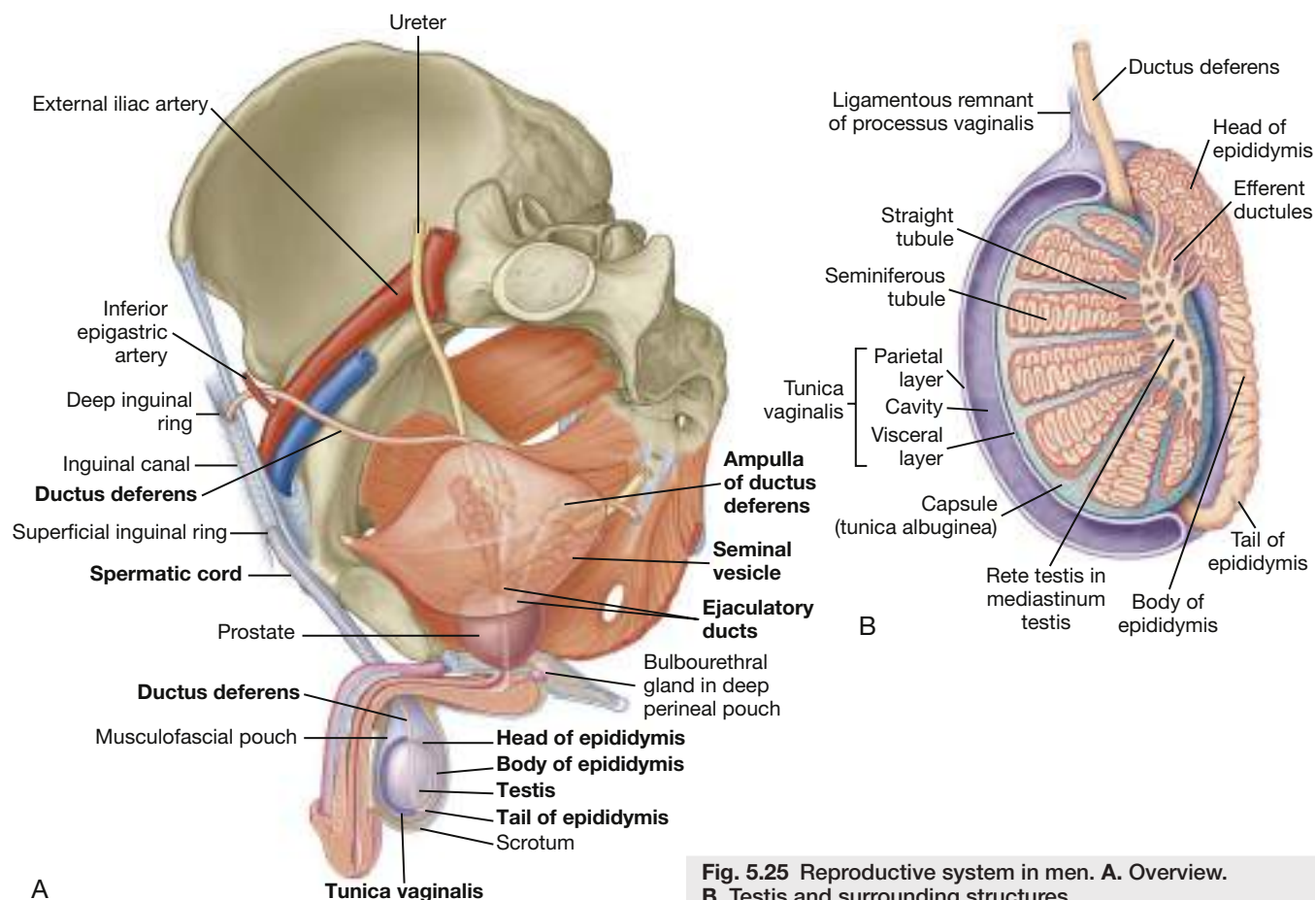


Fig. 5.25 Reproductive system in men. **A.** Overview. **B.** Testis and surrounding structures.

The design of the reproductive system in men is basically a series of ducts and tubules. The arrangement of parts and linkage to the urinary tract reflects its embryological development.

Testes

The **testes** originally develop high on the posterior abdominal wall and then descend, normally before birth, through the inguinal canal in the anterior abdominal wall and into the scrotum of the perineum. During descent, the testes carry their vessels, lymphatics, and nerves, as well as their principal drainage ducts, the **ductus deferens (vas deferens)** with them. The lymph drainage of the testes is therefore to the lateral aortic or lumbar nodes and pre-aortic nodes in the abdomen and not to the inguinal or pelvic lymph nodes.

Each ellipsoid-shaped testis is enclosed within the end of an elongated musculofascial pouch, which is continuous with the anterior abdominal wall and projects into the scrotum. The **spermatic cord** is the tube-shaped connection between the pouch in the scrotum and the abdominal wall (Fig. 5.25A).

The sides and anterior aspect of the testis are covered by a closed sac of peritoneum (the **tunica vaginalis**), which originally connected to the abdominal cavity (Fig. 5.25B).

Normally after testicular descent, the connection closes, leaving a fibrous remnant.

Each testis (Fig. 5.25B) is composed of seminiferous tubules and interstitial tissue surrounded by a thick connective tissue capsule (the **tunica albuginea**). Spermatozoa are produced by the seminiferous tubules. The 400 to 600 highly coiled seminiferous tubules are modified at each end to become straight tubules, which connect to a collecting chamber (the **rete testis**) in a thick, vertically oriented linear wedge of connective tissue (the **mediastinum testis**), projecting from the capsule into the posterior aspect of the

Clinical app

Undescended testes

Around the seventh month of gestation, the testes begin their descent from the posterior abdominal wall through the inguinal canal and into the scrotum. During the descent, the testes may arrest (undescended testes) or they may end up in an ectopic position. Undescended/ectopic testes are associated with infertility and increased risk of testicular tumors.

gonad (Fig. 5.25B). Approximately 12 to 20 **efferent ductules** originate from the upper end of the rete testis, penetrate the capsule, and connect with the epididymis.

Clinical app

Hydrocele of the testis

A hydrocele of the testis is an accumulation of fluid within the cavity of the tunica vaginalis. Hydroceles are typically unilateral and in most cases their cause is unknown, although they may occur secondary to physical trauma, infection, or tumor.

Clinical app

Testicular tumors

Tumors of the testis account for a small percentage of malignancies in men. However, they generally occur in younger patients (between 20 and 40 years of age).

Early diagnosis of testicular tumor is extremely important. Abnormal lumps can be detected by palpation and diagnosis can be made using ultrasound.

Surgical removal of the malignant testis is often carried out using an inguinal approach. The testis is not usually removed through a scrotal incision because it is possible to spread tumor cells into the subcutaneous tissues of the scrotum, which has a different lymphatic drainage than the testis.

Epididymis

The **epididymis** is a single, long coiled duct that courses along the posterolateral side of the testis (Fig. 5.25B). It has two distinct components:

- the **efferent ductules**, which form an enlarged coiled mass that sits on the posterior superior pole of the testis and forms the **head of the epididymis**; and
- the **true epididymis**, which is a single, long, coiled duct into which the efferent ductules all drain and that continues inferiorly along the posterolateral margin of the testis as the **body of epididymis** and enlarges to form the **tail of epididymis** at the inferior pole of the testis.

During passage through the epididymis, spermatozoa acquire the ability to move and fertilize an egg. The epididymis also stores spermatozoa until ejaculation. The end of the epididymis is continuous with the ductus deferens.

Ductus deferens

The ductus deferens is a long muscular duct that transports spermatozoa from the tail of the epididymis in the scrotum to the ejaculatory duct in the pelvic cavity (Fig. 5.25A). It ascends

in the scrotum as a component of the spermatic cord and passes through the inguinal canal in the anterior abdominal wall.

After passing through the deep inguinal ring, the ductus deferens bends medially around the lateral side of the inferior epigastric artery and crosses the external iliac artery and the external iliac vein at the pelvic inlet to enter the pelvic cavity (Fig. 5.25A).

The duct descends medially on the pelvic wall deep to the peritoneum and crosses the ureter posterior to the bladder. It continues inferomedially along the base of the bladder, anterior to the rectum, almost to the midline where it is joined by the duct of the seminal vesicle to form the ejaculatory duct (Fig. 5.25A).

Between the ureter and ejaculatory duct, the ductus deferens expands to form the ampulla of the ductus deferens. The ejaculatory duct penetrates through the prostate gland to connect with the prostatic urethra.

Clinical app

Vasectomy

The ductus deferens transports spermatozoa from the tail of the epididymis in the scrotum to the ejaculatory duct in the pelvic cavity. Because it has a thick smooth muscle wall, it can be easily palpated in the spermatic cord between the testes and the superficial inguinal ring. Also, because it can be accessed through skin and superficial fascia, it is amenable to surgical dissection and surgical division. When this is carried out bilaterally (vasectomy), the patient is rendered sterile—this is a useful method for male contraception.

Seminal vesicle

Each **seminal vesicle** is an accessory gland of the male reproductive system that develops as a blind-ended tubular outgrowth from the ductus deferens (Fig. 5.25A). The tube is coiled with numerous pocket-like outgrowths and is encapsulated by connective tissue to form an elongate structure situated between the bladder and rectum. The gland is immediately lateral to and follows the course of the ductus deferens at the base of the bladder.

The duct of the seminal vesicle joins the ductus deferens to form the **ejaculatory duct** (Fig. 5.25A). Secretions from the seminal vesicle contribute significantly to the volume of the ejaculate (semen).

Prostate

The **prostate** is an unpaired accessory structure of the male reproductive system that surrounds the urethra in the pelvic cavity (Fig. 5.25A). It lies immediately inferior to the bladder, posterior to the pubic symphysis, and anterior to the rectum.

The prostate is shaped like an inverted rounded cone with a larger base, which is continuous above with the neck of the bladder, and a narrower apex, which rests below on the pelvic



Pelvis and Perineum

floor. The inferolateral surfaces of the prostate are in contact with the levator ani muscles that together cradle the prostate between them.

The prostate develops as 30 to 40 individual complex glands, which grow from the urethral epithelium into the surrounding wall of the urethra. Collectively, these glands enlarge the wall of the urethra into what is known as the *prostate*; however, the individual glands retain their own ducts, which empty independently into the prostatic sinuses on the posterior aspect of the urethral lumen.

Secretions from the prostate, together with secretions from the seminal vesicles, contribute to the formation of semen during ejaculation.

The ejaculatory ducts pass almost vertically in an antero-inferior direction through the posterior aspect of the prostate to open into the prostatic urethra.

Clinical app

Prostate problems

Prostate cancer is one of the most commonly diagnosed malignancies in men, and often the disease is advanced at diagnosis. Prostate cancer typically occurs in the peripheral regions of the prostate and is relatively asymptomatic. In many cases it is diagnosed by either a digital rectal examination (cisgender men) or transvaginal examination (transgender women having undergone vaginoplasty). Blood tests, which include serum acid phosphatase and serum prostate-specific antigen (PSA), are also used. Prostate volume and PSA is decreased with androgen suppression in transgender individuals on testosterone blockers. In rectal examinations, the tumorous prostate feels “rock” hard. The diagnosis is usually made by obtaining a number of biopsies of the prostate.

Benign prostatic hypertrophy is a disease of the prostate that occurs with increasing age in most men (Fig. 5.26). It generally involves the more central regions of the prostate, which gradually

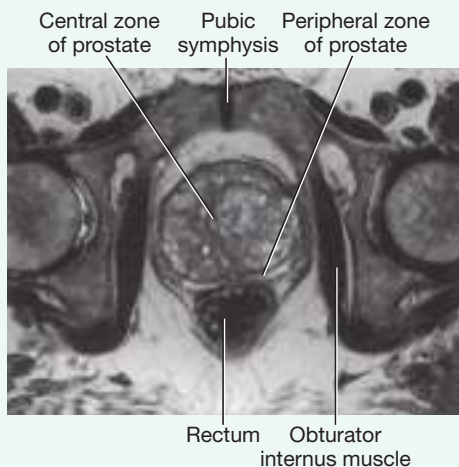


Fig. 5.26 Axial T2-weighted magnetic resonance image of benign prostatic hypertrophy.

enlarge. The prostate feels “bulky” on digital rectal examination. Owing to the more central hypertrophic change of the prostate, the urethra is compressed, and a urinary outflow obstruction develops in a number of patients. With time, the bladder may become hypertrophied in response to the urinary outflow obstruction. In some male patients, the obstruction becomes so severe that urine cannot be passed and transurethral or suprapubic catheterization is necessary. Despite being a benign disease, benign prostatic hypertrophy can therefore have a marked effect on the daily lives of many patients.

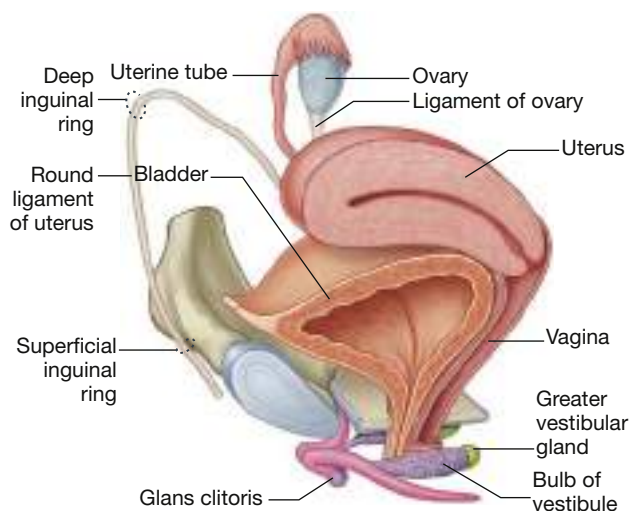


Fig. 5.27 Reproductive system in women.

Bulbourethral glands

The **bulbourethral glands** (see Fig. 5.25A), one on each side, are small, pea-shaped mucous glands situated within the deep perineal pouch. They are lateral to the membranous part of the urethra. The duct from each gland passes infero-medially through the **perineal membrane** to open into the bulb of the spongy urethra at the root of the penis.

Together with small glands positioned along the length of the spongy urethra, the bulbourethral glands contribute to lubrication of the urethra and the pre-ejaculatory emission from the penis.

In women

The reproductive tract in women is contained mainly in the pelvic cavity and perineum, although during pregnancy, the uterus expands into the abdomen cavity. Major components of the system consist of (Fig. 5.27):

- an ovary on each side and
- a uterus, vagina, and clitoris in the midline.

In addition, a pair of accessory glands (the **greater vestibular glands**) are associated with the tract.

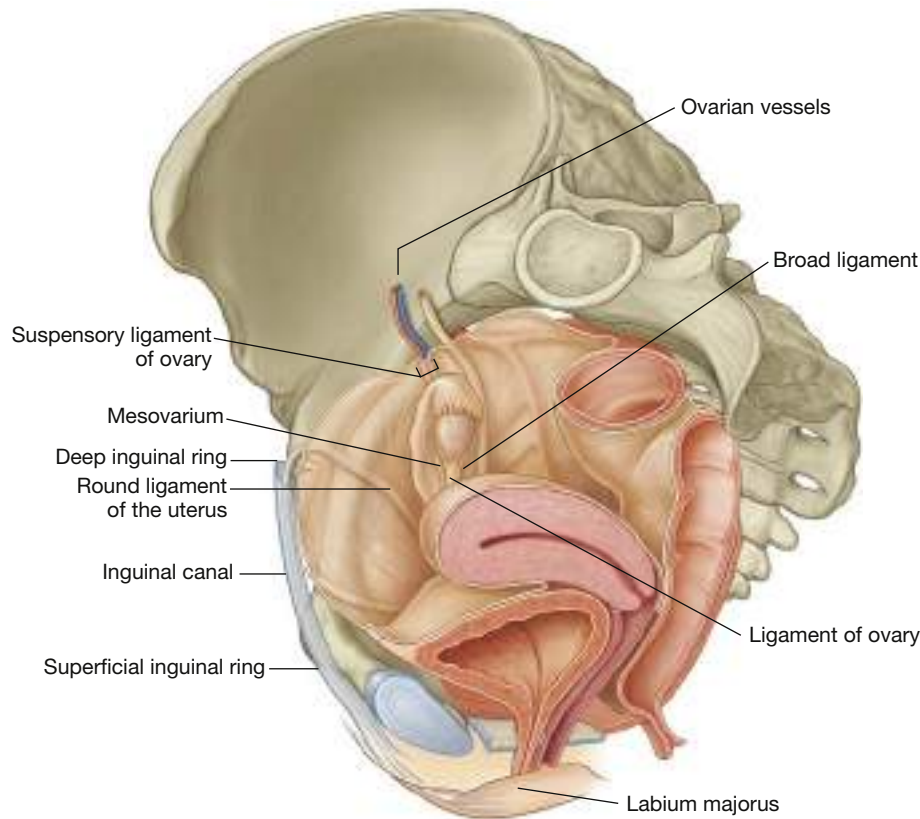


Fig. 5.28 Ovaries and broad ligament.

Ovaries

Like the testes in men, the **ovaries** develop high on the posterior abdominal wall and then descend before birth, bringing with them their vessels, lymphatics, and nerves. Unlike the testes, the ovaries do not migrate through the inguinal canal into the perineum but stop short and assume a position on the lateral wall of the pelvic cavity (Fig. 5.28).

The ovaries are the sites of egg production (oogenesis). Mature eggs are ovulated into the peritoneal cavity and normally directed into the adjacent openings of the uterine tubes by cilia on the ends of the uterine tubes.

Clinical app

Ovarian cancer

Ovarian cancer remains one of the major challenges in oncology. The ovaries contain numerous cell types, all of which can undergo malignant change and require different imaging and treatment protocols and ultimately have different prognoses. Ovarian cancer may occur at any age, but more typically it occurs in older women.

Many factors have been linked with the development of ovarian tumors, including a strong family history.

Cancer of the ovaries may spread via the blood and lymphatics and frequently metastasizes directly into the peritoneal cavity. Such direct peritoneal cavity spread allows the passage of tumor

cells along the paracolic gutters and over the liver from where this disease may disseminate easily. Unfortunately, many patients already have metastatic and diffuse disease at the time of diagnosis. It is important to note that one or both ovaries may either be removed (oophorectomy) or retained in transgender men or non-binary people as part of a spectrum of gender-affirming procedures. In any individual with ovaries, ovarian cancer risk remains and an investigation should proceed if deemed clinically appropriate. For cisgendered women, ovaries are imaged by transvaginal ultrasound. In those patients in whom vaginectomy has been performed (removal of the vagina) and an ultrasound is indicated, imaging can be done either transrectally or transabdominally.

The ovaries lie adjacent to the lateral pelvic wall just inferior to the pelvic inlet. Each of the two almond-shaped ovaries is about 3 cm long and is suspended by a mesentery (the **mesovarium**) that is a posterior extension of the broad ligament.

Uterus

The **uterus** is a thick-walled muscular organ in the midline between the bladder and rectum (see Fig. 5.28). It consists of a body and a cervix, and inferiorly it joins the vagina (Fig. 5.29). Superiorly, uterine tubes project laterally from the uterus and open into the peritoneal cavity immediately adjacent to the ovaries (Fig. 5.29).

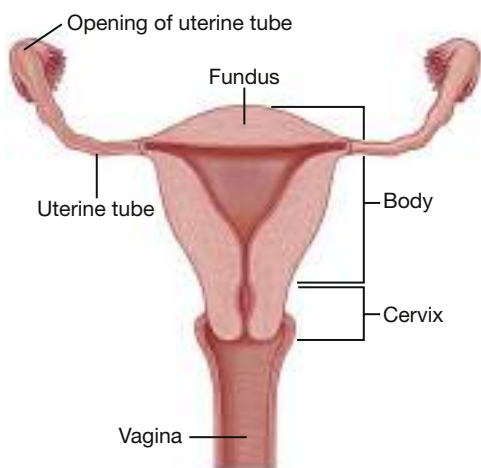


Fig. 5.29 Uterus. Anterior view. The anterior half of the uterus and vagina have been cut away.

The body of the uterus is flattened anteroposteriorly and, above the level of origin of the uterine tubes (Fig. 5.29), has a rounded superior end (**fundus of uterus**). The cavity of the body of the uterus is a narrow slit when viewed laterally and is shaped like an inverted triangle when viewed anteriorly. Each of the superior corners of the cavity is continuous with the lumen of a uterine tube and the inferior corner is continuous with the central canal of the cervix.

Clinical app

Hysterectomy

A hysterectomy is the surgical removal of the uterus. This is usually a complete excision of the body, fundus, and cervix of the uterus, though occasionally the cervix may be left in situ. In some instances the uterine (fallopian) tubes and the ovaries also are removed. This procedure is called a *total abdominal hysterectomy* and *bilateral salpingo-oophorectomy*.

Hysterectomy, oophorectomy, and salpingo-oophorectomy may be performed in patients who have reproductive malignancy, such as uterine, cervical, and ovarian cancers. Other indications include strong family history of reproductive disorders, endometriosis, and excessive bleeding. Occasionally the uterus may need to be removed postpartum because of excessive postpartum bleeding. Hysterectomy is also indicated in transgender men who desire the procedure as a component of the gender-affirming process.

A hysterectomy is performed through a transverse suprapubic incision (Pfannenstiel's incision). During the procedure, tremendous care is taken to identify the distal ureters and to ligate the nearby uterine arteries without damage to the ureters.

Implantation of the blastocyst normally occurs in the body of the uterus. During pregnancy, the uterus dramatically expands superiorly into the abdominal cavity.

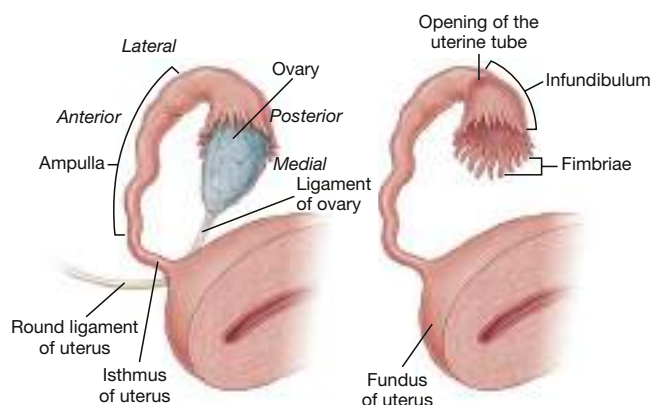


Fig. 5.30 Uterine tubes.

Uterine tubes

The **uterine tubes** extend from each side of the superior end of the body of the uterus to the lateral pelvic wall and are enclosed within the upper margins of the mesosalpinx portions of the broad ligaments. Because the ovaries are suspended from the posterior aspect of the broad ligaments, the uterine tubes pass superiorly over, and terminate laterally to, the ovaries.

Each uterine tube has an expanded trumpet-shaped end (the **infundibulum**), which curves around the superolateral pole of the related ovary (Fig. 5.30). The margin of the infundibulum is rimmed with small finger-like projections termed **fimbriae**. The lumen of the uterine tube opens into the peritoneal cavity at the narrowed end of the infundibulum. Medial to the infundibulum, the tube expands to form the **ampulla** and then narrows to form the **isthmus** before joining with the body of the uterus (Fig. 5.30).

The fimbriated infundibulum facilitates the collection of ovulated eggs from the ovary. Fertilization normally occurs in the ampulla.

Clinical app

Tubal ligation

A simple and effective method of birth control is to surgically ligate (clip) the uterine tubes, preventing spermatozoa from reaching the ampulla.

Cervix

The **cervix** forms the inferior part of the uterus and is shaped like a short, broad cylinder with a narrow central channel. The body of the uterus normally arches forward (anteflexed on the cervix) over the superior surface of the emptied bladder (Fig. 5.31A). In addition, the cervix is angled forward (anteverted)

on the vagina so that the inferior end of the cervix projects into the upper anterior aspect of the vagina (Figs. 5.31A, 5.32). Because the end of the cervix is dome shaped, it bulges into the vagina, and a gutter, or fornix, is formed around the margin of the cervix where it joins the vaginal wall (Fig. 5.31B). The tubular central canal of the cervix opens below as the **external os** into the vaginal cavity and above as the **internal os** into the uterine cavity (Fig. 5.31B).

Clinical app

Carcinoma of the cervix and uterus

Carcinoma of the cervix and uterus is a common disease in any individual with a cervix and uterus, including women, transgender men, and some non-binary people who have not had a hysterectomy. Diagnosis is by inspection, cytology (examination of the cervical cells), imaging, biopsy, and dilatation and curettage (D&C) of the uterus.

Carcinoma of the cervix and uterus may be treated by local resection, removal of the uterus (hysterectomy), and adjuvant chemotherapy. The tumor spreads via lymphatics to the internal and common iliac lymph nodes.

Vagina

The **vagina** is the copulatory organ in women. It is a distensible fibromuscular tube that extends from the perineum through the pelvic floor and into the pelvic cavity (Fig. 5.32A). The internal end of the canal is enlarged to form a region called the **vaginal vault**.

The anterior wall of the vagina is related to the base of the bladder and to the urethra; in fact, the urethra is embedded in, or fused to, the anterior vaginal wall (Fig. 5.32A).

Posteriorly, the vagina is related principally to the rectum.

Inferiorly, the vagina opens into the vestibule of the perineum immediately posterior to the external opening of the urethra. From its external opening (the **introitus**), the vagina courses posterosuperiorly through the perineal membrane and into the pelvic cavity where it is attached by its anterior wall to the circular margin of the cervix.

The **vaginal fornix** is the recess formed between the margin of the cervix and the vaginal wall. Based on position, the fornix is subdivided into a posterior fornix, an anterior fornix, and two lateral fornices (Figs. 5.31B, 5.32B).

The vaginal canal is normally collapsed so that the anterior wall is in contact with the posterior wall. By using a speculum to open the vaginal canal, a physician can see the domed inferior end of the cervix, the vaginal fornices, and the external os of the cervical canal in a patient (Fig. 5.32B).

During intercourse, semen is deposited in the vaginal vault. Spermatozoa make their way into the external os of the cervical canal, pass through the cervical canal into the

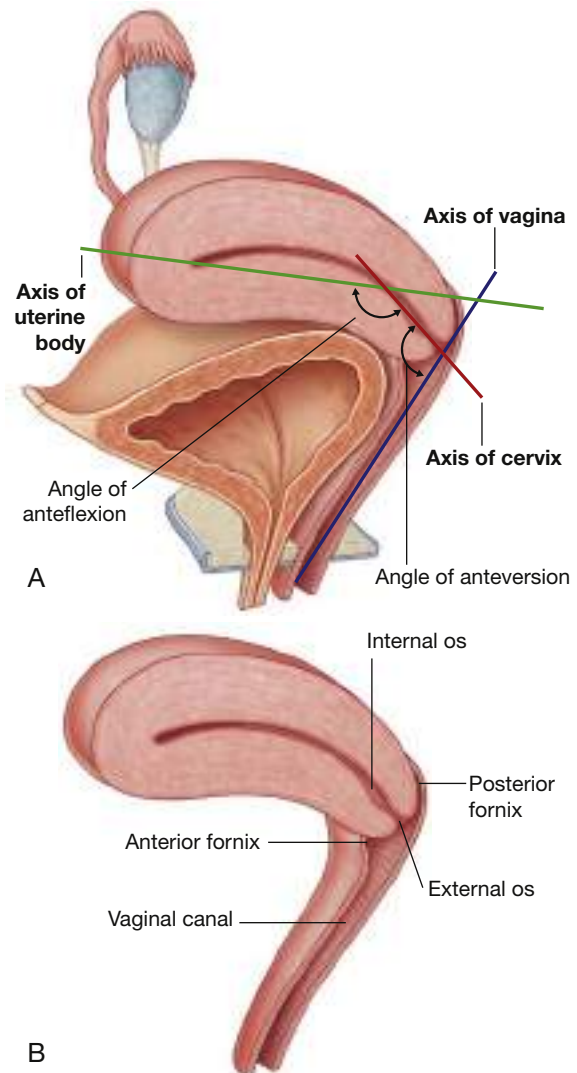


Fig. 5.31 Uterus and vagina. **A.** Angles of anteversion and anteversion. **B.** The cervix protrudes into the vagina.

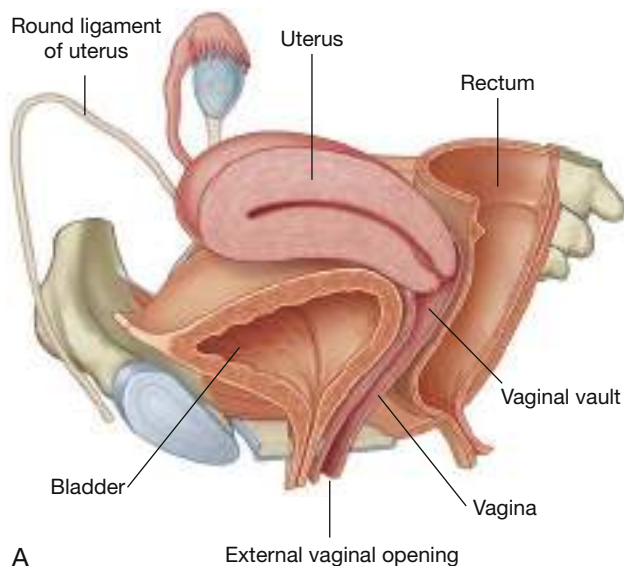
uterine cavity, and then continue through the uterine cavity into the uterine tubes.

Fascia

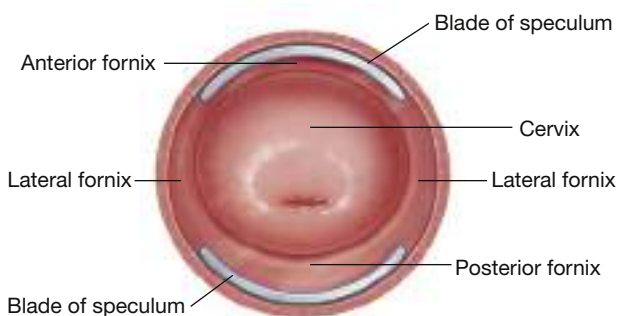
Fascia in the pelvic cavity lines the pelvic walls, surrounds the bases of the pelvic viscera, and forms sheaths around blood vessels and nerves that course medially from the pelvic walls to reach the viscera in the midline. This pelvic fascia is a continuation of the extraperitoneal connective tissue layer found in the abdomen.

In women

In women, a **rectovaginal septum** separates the posterior surface of the vagina from the rectum (Fig. 5.33A). Condensations of fascia form ligaments that extend from the cervix to the anterior (**pubocervical ligament**), lateral



A



B

Fig. 5.32 Vagina. A. Left half of pelvis cut away. **B.** Vaginal fornices and cervix as viewed through a speculum.

(**transverse cervical** or **cardinal ligament**), and posterior (**uterosacral ligament**) pelvic walls. These ligaments, together with the perineal membrane, the levator ani muscles, and the perineal body are thought to stabilize the uterus in the pelvic cavity. The most important of these ligaments are the transverse cervical or cardinal ligaments, which extend laterally from each side of the cervix and vaginal vault to the related pelvic wall.

In men

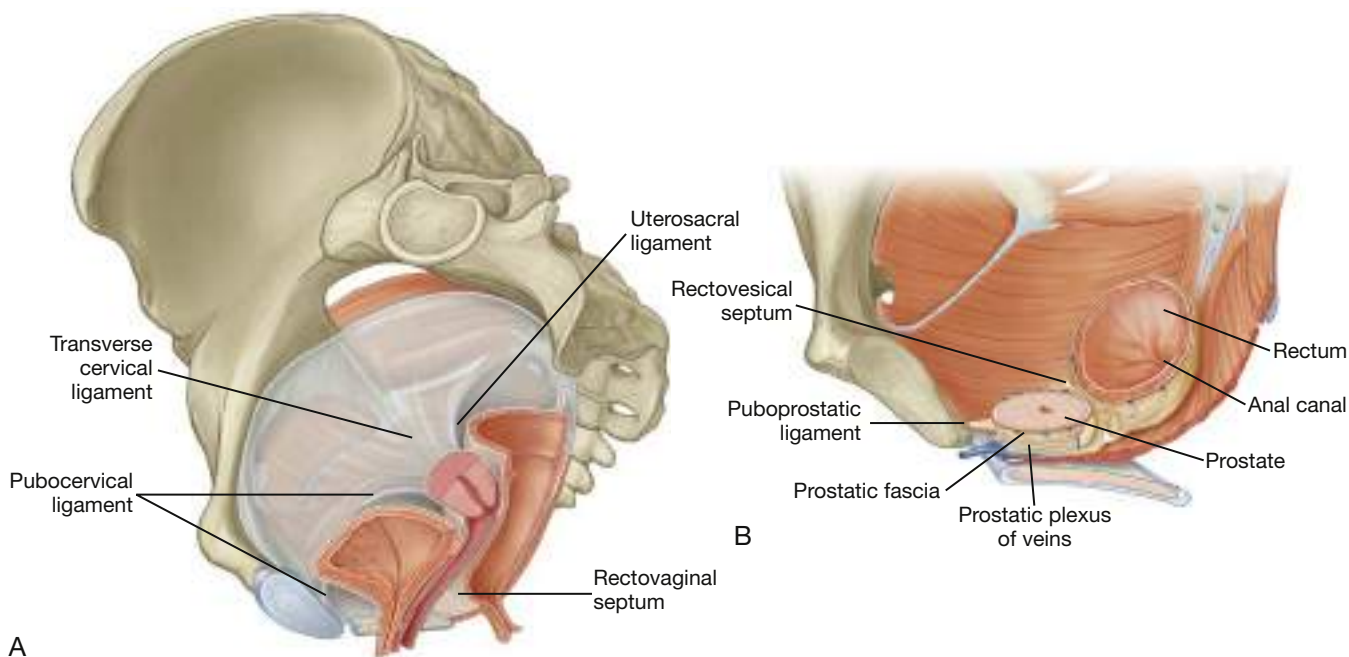
In men, a condensation of fascia around the anterior and lateral region of the prostate (**prostatic fascia**) contains and surrounds the prostatic plexus of veins and is continuous posteriorly with the **rectovesical septum**, which separates the posterior surface of the prostate and base of the bladder from the rectum (Fig. 5.33B).

Peritoneum

The peritoneum of the pelvis is continuous at the pelvic inlet with the peritoneum of the abdomen. In the pelvis, the peritoneum drapes over the pelvic viscera in the midline, forming:

- pouches between adjacent viscera, and
- folds and ligaments between viscera and pelvic walls.

Anteriorly, median and medial umbilical folds of peritoneum cover the embryological remnants of the urachus and umbilical arteries, respectively (Fig. 5.34). These folds



A

B

Fig. 5.33 Pelvic fascia. A. In women. **B.** In men.

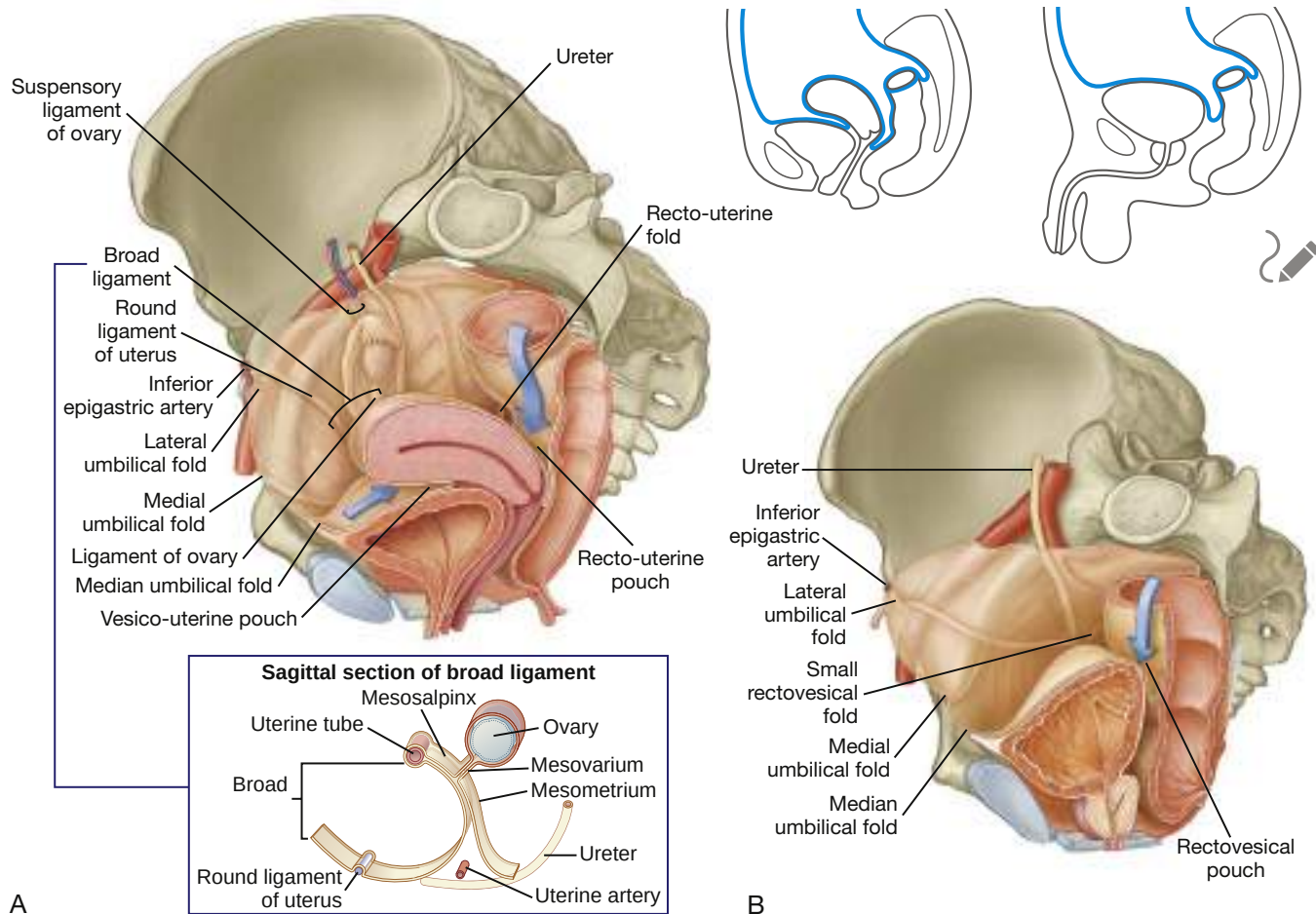


Fig. 5.34 Peritoneum in the pelvis. **A.** In women. **B.** In men.

ascend out of the pelvis and onto the anterior abdominal wall. Posteriorly, peritoneum drapes over the anterior and lateral aspects of the upper third of the rectum, but only the anterior surface of the middle third of the rectum is covered by peritoneum; the lower third of the rectum is not covered at all.

In women

In women, the uterus lies between the bladder and rectum, and the uterine tubes extend from the superior aspect of the uterus to the lateral pelvic walls (Fig. 5.34A). As a consequence, a shallow **vesico-uterine pouch** occurs anteriorly, between the bladder and uterus, and a deep **recto-uterine pouch** (pouch of Douglas) occurs posteriorly between the uterus and rectum. In addition, a large fold of peritoneum (the broad ligament), with a uterine tube enclosed in its superior margin and an ovary attached posteriorly, is located on each side of the uterus and extends to the lateral pelvic walls.

In the midline, the peritoneum descends over the posterior surface of the uterus and cervix and onto the vaginal wall adjacent to the posterior vaginal fornix. It then reflects

onto the anterior and lateral walls of the rectum. The deep pouch of peritoneum formed between the anterior surface of the rectum and posterior surfaces of the uterus, cervix, and vagina is the recto-uterine pouch. A sharp sickle-shaped ridge of peritoneum (**recto-uterine fold**) occurs on each side near the base of the recto-uterine pouch. The **recto-uterine folds** overlie the **uterosacral ligaments**, which are condensations of pelvic fascia that extend from the cervix to the posterolateral pelvic walls.

Broad ligament

The **broad ligament** is a sheet-like fold of peritoneum oriented in the coronal plane that runs from the lateral pelvic wall to the uterus, encloses the uterine tube in its superior margin, and suspends the ovary from its posterior aspect (Fig. 5.34). The uterine arteries cross the ureters at the base of the broad ligaments, and the ligament of the ovary and round ligament of the uterus are enclosed within the parts of the broad ligament related to the ovary and uterus, respectively. The broad ligament has three parts (Fig. 5.34A):

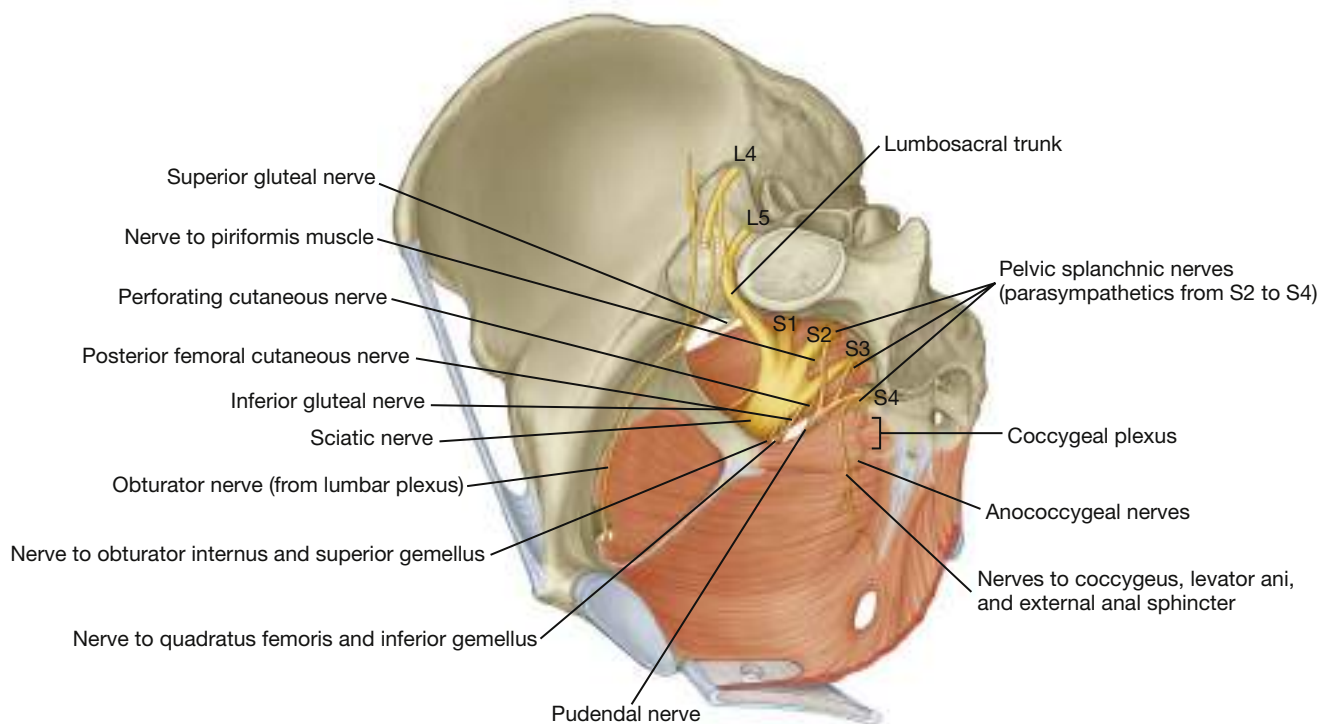


Fig. 5.35 Sacral and coccygeal plexuses.

- the **mesometrium**, the largest part of the broad ligament, which extends from the lateral pelvic walls to the body of the uterus;
- the **mesosalpinx**, the most superior part of the broad ligament, which suspends the uterine tube in the pelvic cavity; and
- the **mesovarium**, a posterior extension of the broad ligament, which attaches to the ovary.

The peritoneum of the mesovarium is continuous with the ovarian surface (germinal) epithelium (Fig. 5.34A). The ovaries are positioned with their long axis in the vertical plane. The ovarian vessels, nerves, and lymphatics enter the superior pole of the ovary from a lateral position and are covered by another raised fold of peritoneum, which, with the structures it contains, forms the **suspensory ligament of ovary (infundibulopelvic ligament)** (Fig. 5.34A).

The inferior pole of the ovary is attached to a fibromuscular band of tissue (the **ligament of ovary**), which courses medially in the margin of the mesovarium to the uterus and then continues anterolaterally as the **round ligament of uterus** (Fig. 5.34). The round ligament of uterus passes over the pelvic inlet to reach the deep inguinal ring and then courses through the inguinal canal to end in connective tissue related to the labium majus in the perineum. Both the

ligament of ovary and the round ligament of uterus are remnants of the gubernaculum, which attaches the gonad to the labioscrotal swellings in the embryo.

In men

In men, the visceral peritoneum drapes over the top of the bladder onto the superior poles of the seminal vesicles and then reflects onto the anterior and lateral surfaces of the rectum (Fig. 5.34B). A **rectovesical pouch** occurs between the bladder and rectum.

Clinical app

The recto-uterine pouch

The recto-uterine pouch (pouch of Douglas) is an extremely important clinical region situated between the rectum and uterus. When the patient is in the supine position, the recto-uterine pouch is the lowest portion of the abdominopelvic cavity and is a site where infection and fluids typically collect. It is impossible to palpate this region transabdominally, but it can be examined by transvaginal and transrectal digital palpation. If an abscess is suspected, it may be drained by a needle placed through the posterior fornix of the vagina or the anterior wall of the rectum.

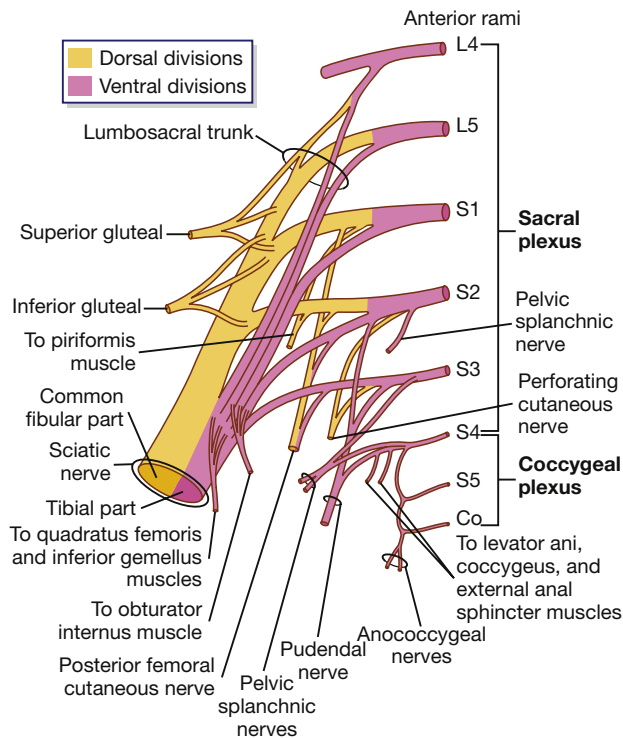


Fig. 5.36 Components and branches of the sacral and coccygeal plexuses.

Nerves

Somatic plexuses

Sacral and coccygeal plexuses

The sacral and coccygeal plexuses are situated on the posterolateral wall of the pelvic cavity and generally occur in the plane between the muscles and blood vessels. They are formed by the ventral rami of S1 to Co, with a significant contribution from L4 and L5, which enter the pelvis from the lumbar plexus (Figs. 5.35, 5.36). Nerves from these mainly somatic plexuses contribute to the innervation of the lower limb and muscles of the pelvis and perineum. Cutaneous branches supply skin over the lateral side of the foot, the posterior aspect of the lower limb, and most of the perineum.

Sacral plexus

The **sacral plexus** on each side is formed by the anterior rami of S1 to S4 and the lumbosacral trunk (L4 and L5) (Fig. 5.36). The plexus is formed in relation to the anterior surface of the piriformis muscle, which is part of the posterolateral pelvic wall. Sacral contributions to the plexus pass out of the anterior sacral foramina and course laterally and inferiorly on the pelvic wall. The lumbosacral trunk, consisting of part of the anterior ramus of L4 and all of the anterior ramus of L5, courses vertically into the pelvic cavity from the abdomen by passing immediately anterior to the sacro-iliac joint.

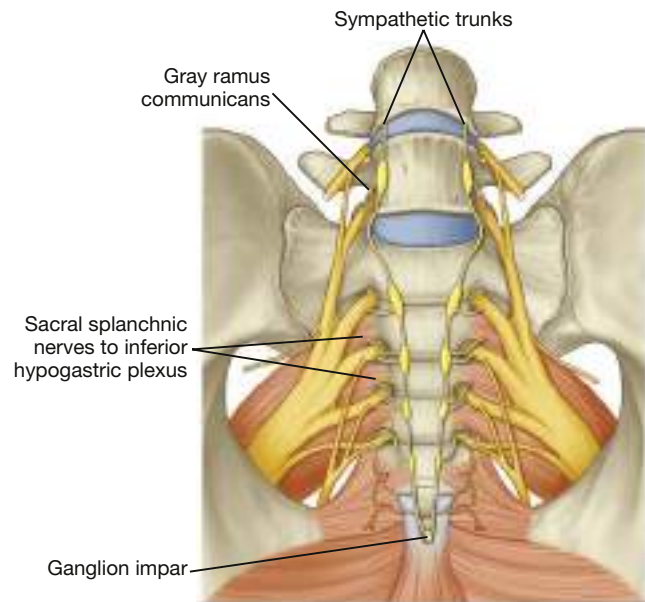


Fig. 5.37 Sympathetic trunks in the pelvis.

Gray rami communicantes from ganglia of the sympathetic trunk connect with each of the anterior rami and carry postganglionic sympathetic fibers destined for the periphery to the somatic nerves (Fig. 5.37). In addition, special visceral nerves (**pelvic splanchnic nerves**) originating from S2 to S4 deliver preganglionic parasympathetic fibers to the pelvic part of the prevertebral plexus (Fig. 5.38, p. 237).

Each anterior ramus has ventral and dorsal divisions that combine with similar divisions from other levels to form terminal nerves (Fig. 5.36). The anterior ramus of S4 has only a ventral division.

Branches of the sacral plexus include the sciatic nerve and gluteal nerves, which are major nerves of the lower limb, and the pudendal nerve, which is the nerve of the perineum (Table 5.4). Numerous smaller branches supply the pelvic wall, floor, and lower limb.

Most nerves originating from the sacral plexus leave the pelvic cavity by passing through the greater sciatic foramen inferior to piriformis muscle and enter the gluteal region of the lower limb. Other nerves leave the pelvic cavity using different routes; a few nerves do not leave the pelvic cavity and course directly into the muscles in the pelvic cavity. Finally, two nerves that leave the pelvic cavity through the greater sciatic foramen loop around the ischial spine and sacrospinous ligament and pass medially through the lesser sciatic foramen to supply structures in the perineum and lateral pelvic wall.

Sciatic nerve. The **sciatic nerve** is the largest nerve of the body and carries contributions from L4 to S3 (Table 5.4, Figs. 5.35, 5.36). It:



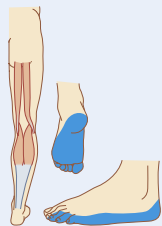
Pelvis and Perineum

Table 5.4 Branches of the sacral and coccygeal plexuses (spinal segments in parentheses do not consistently participate)

BRANCH

Sacral plexus

Sciatic



Spinal segments

L4 to S3

Motor function

All muscles in the posterior or hamstring compartment of the thigh (including the hamstring part of the adductor magnus) except for the short head of the biceps

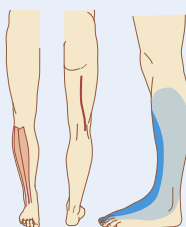
All muscles in the posterior compartment of the leg

All muscles in the sole of the foot

Sensory (cutaneous) function

Skin on posterolateral and lateral surfaces of foot and sole of foot

Tibial part



L4 to S2

Motor function

Short head of biceps in the posterior compartment of the thigh

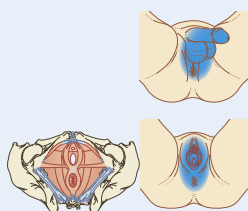
All muscles in the anterior and lateral compartments of the leg

Extensor digitorum brevis in the foot (also contributes to the supply of the first dorsal interosseous muscle)

Sensory (cutaneous) function

Skin on the anterolateral surface of the leg and dorsal surface of the foot

Common fibular part



S2 to S4

Motor function

Skeletal muscles in the perineum including the external urethral and anal sphincters and levator ani (overlaps in supply of the levator ani and external sphincter with branches directly from ventral division of S4)

Sensory (cutaneous) function

Most skin of the perineum; penis and clitoris

Pudendal



L4 to S1

Motor function

Gluteus medius, gluteus minimus, and tensor fasciae latae

Superior gluteal

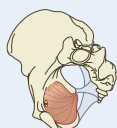


L5 to S2

Motor function

Gluteus maximus

Inferior gluteal



L5 to S2

Motor function

Obturator internus and superior gemellus

Nerve to obturator internus and superior gemellus

Table 5.4 Branches of the sacral and coccygeal plexuses (spinal segments in parentheses do not consistently participate)—cont'd**BRANCH**

Nerve to quadratus femoris and inferior gemellus

L4 to S1

Motor function

Quadratus femoris and inferior gemellus



Posterior femoral cutaneous (posterior cutaneous nerve of thigh)

S1, S3

Sensory (cutaneous) function

Skin on the posterior aspect of the thigh



Perforating cutaneous

S2, S3

Sensory (cutaneous) function

Skin over gluteal fold (overlaps with posterior femoral cutaneous)

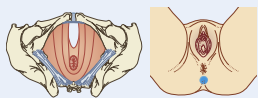


Nerve to piriformis

(L5), S1, S2

Motor function

Piriformis muscle



Nerves to levator ani, coccygeus, and external anal sphincter

S4

Motor function

Levator ani, coccygeus, and external anal sphincter (overlaps with pudendal nerve)

Sensory (cutaneous) function

Small patch of skin between anus and coccyx

Pelvic splanchnic nerves

S2, S3 (4)

Motor (visceral) function

Visceral motor (preganglionic parasympathetic) to pelvic part of prevertebral plexus

Stimulate erection, modulate mobility in gastrointestinal system distal to the left colic flexure, inhibitory to internal urethral sphincter

Sensory (visceral) function

Visceral afferents from pelvic viscera and distal parts of colon. Pain from cervix and possibly from bladder and proximal urethra

Coccygeal plexus

Anococcygeal nerves

S4 to Co

Sensory (cutaneous) function

Perianal skin



Pelvis and Perineum

- forms on the anterior surface of the piriformis muscle and leaves the pelvic cavity through the greater sciatic foramen inferior to piriformis;
- passes through the gluteal region into the thigh where it divides into its two major branches: the common fibular nerve (common peroneal nerve) and the tibial nerve—dorsal divisions of L4, L5, S1, and S2 are carried in the common fibular part of the nerve, and the ventral divisions of L4, L5, S1, S2, and S3 are carried in the tibial part;
- innervates muscles in the posterior compartment of the thigh and muscles in the leg and foot; and
- carries sensory fibers from the skin of the foot and lateral leg.

Pudendal nerve. The **pudendal nerve** forms anteriorly to the lower part of piriformis muscle from ventral divisions of S2 to S4 (Table 5.4; also see Figs. 5.35, 5.36). It:

- leaves the pelvic cavity through the greater sciatic foramen, inferior to the piriformis muscle, and enters the gluteal region;
- courses into the perineum by immediately passing around the sacrospinous ligament where the ligament joins the ischial spine and through the lesser sciatic foramen (this course takes the nerve out of the pelvic cavity, around the peripheral attachment of the pelvic floor, and into the perineum);
- is accompanied throughout its course by the internal pudendal vessels; and
- innervates skin and skeletal muscles of the perineum, including the external anal and external urethral sphincters.

Clinical app

Pudendal block

Pudendal block anesthesia is performed to relieve the pain associated with childbirth. Although the use of this procedure is less common since the widespread adoption of epidural anesthesia, it provides an excellent option for women who have a contraindication to neuraxial anesthesia (e.g., spinal anatomy, low platelets, too close to delivery). Pudendal blocks are also used for certain types of chronic pelvic pain and in some rectal or urological procedures. The injection is usually given where the pudendal nerve crosses the lateral aspect of the sacrospinous ligament near its attachment to the ischial spine. During childbirth, a finger inserted into the vagina can palpate the ischial spine. The needle is passed transcutaneously to the medial aspect of the ischial spine and around the sacrospinous ligament. Infiltration is performed, and the perineum is anesthetized. Pudendal nerve blocks can also be performed with imaging guidance (using fluoroscopy, computed tomography, or ultrasound) to localize the nerve.

Other branches of the sacral plexus (see Table 5.4). Other branches of the sacral plexus include:

- motor branches to muscles of the gluteal region, pelvic wall, and pelvic floor (superior and inferior gluteal nerves, nerve to obturator internus and superior gemellus, nerve to quadratus femoris and inferior gemellus, nerve to piriformis, nerves to levator ani); and
- sensory nerves to skin over the inferior gluteal region and posterior aspects of the thigh and upper leg (perforating cutaneous nerve and posterior cutaneous nerve of the thigh) (see Figs. 5.35, 5.36).

The **superior gluteal nerve** leaves the pelvic cavity through the greater sciatic foramen superior to the piriformis muscle and supplies muscles in the gluteal region.

The **inferior gluteal nerve** leaves the pelvic cavity through the greater sciatic foramen inferior to the piriformis muscle and supplies the **gluteus maximus**.

The **nerve to the obturator internus** and the associated **superior gemellus** muscle leaves the pelvic cavity through the greater sciatic foramen inferior to the piriformis muscle. Like the pudendal nerve, it passes around the ischial spine and through the lesser sciatic foramen to enter the perineum and supply the obturator internus muscle from the medial side of the muscle inferior to the attachment of the levator ani muscle.

The **nerve to the quadratus femoris** muscle and the **inferior gemellus** muscle and the **posterior cutaneous nerve of the thigh (posterior femoral cutaneous nerve)** also leave the pelvic cavity through the greater sciatic foramen inferior to the piriformis muscle and course to muscles and skin, respectively, in the lower limb.

Unlike most of the other nerves originating from the sacral plexus, which leave the pelvic cavity through the greater sciatic foramen either above or below the piriformis muscle, the **perforating cutaneous nerve** leaves the pelvic cavity by penetrating directly through the sacrotuberous ligament and then courses to skin over the inferior aspect of the buttocks.

The **nerve to the piriformis** and a number of small nerves to the levator ani and coccygeus muscles originate from the sacral plexus and pass directly into their target muscles without leaving the pelvic cavity.

Coccygeal plexus

The small coccygeal plexus has a minor contribution from S4 and is formed mainly by the anterior rami of S5 and Co, which originate inferiorly to the pelvic floor. They penetrate the coccygeus muscle to enter the pelvic cavity and join with the anterior ramus of S4 to form a single trunk from which small **anococcygeal nerves** originate (see Table 5.4). These

nerves penetrate the muscle and the overlying sacrospinous and sacrotuberous ligaments and pass superficially to innervate skin in the anal triangle of the perineum.

Visceral plexuses

Paravertebral sympathetic chain

The paravertebral part of the visceral nervous system is represented in the pelvis by the inferior ends of the sympathetic trunks (Fig. 5.38A). Each trunk enters the pelvic cavity from the abdomen by passing over the ala of the sacrum medially to the lumbosacral trunks and posteriorly to the iliac vessels. The trunks course inferiorly along the anterior surface of the sacrum where they are positioned medially to the anterior sacral foramina. Four ganglia occur along each trunk. Anteriorly to the coccyx, the two trunks join to form a single small terminal ganglion (the **ganglion impar**).

The principal function of the sympathetic trunks in the pelvis is to deliver postganglionic sympathetic fibers to the anterior rami of sacral nerves for distribution to the periphery, mainly to parts of the lower limb and perineum. This is accomplished by gray rami communicantes, which connect the trunks to the sacral anterior rami.

In addition to gray rami communicantes, other branches (the **sacral splanchnic nerves**) join and contribute to the pelvic part of the prevertebral plexus associated with innervating pelvic viscera.

Pelvic extensions of the prevertebral plexus

The pelvic parts of the prevertebral plexus carry sympathetic, parasympathetic, and visceral afferent fibers (see Fig. 5.38A). Pelvic parts of the plexus are associated with innervating pelvic viscera and erectile tissues of the perineum.

The prevertebral plexus enters the pelvis as two **hypogastric nerves**, one on each side, that cross the pelvic inlet medially to the internal iliac vessels. The hypogastric nerves are formed by the separation of the fibers in the **superior hypogastric plexus** into right and left bundles. The superior hypogastric plexus is situated anterior to vertebra LV between the promontory of the sacrum and the bifurcation of the aorta.

When the hypogastric nerves are joined by pelvic splanchnic nerves carrying preganglionic parasympathetic fibers from S2 to S4, the **pelvic plexuses (inferior hypogastric plexuses)** are formed (Fig. 5.38). The inferior hypogastric plexuses, one on each side, course in an inferior direction around the pelvic walls, medially to major vessels and somatic nerves. They give origin to the following subsidiary plexuses, which innervate the pelvic viscera:

- the **rectal plexus**,
- the **uterovaginal plexus**,
- the **prostatic plexus**, and
- the **vesical plexus**.

Terminal branches of the inferior hypogastric plexuses penetrate and pass through the deep perineal pouch and innervate erectile tissues of the penis and the clitoris in the perineum (Fig. 5.38B). In men, these nerves, called **cavernous nerves**, are extensions of the prostatic plexus. The pattern of distribution of similar nerves in women is not entirely clear, but they are likely extensions of the uterovaginal plexus.

Sympathetic fibers

Sympathetic fibers enter the inferior hypogastric plexuses from the hypogastric nerves and from branches (sacral splanchnic nerves) of the upper sacral parts of the sympathetic trunks (see Fig. 5.38A). Ultimately, these nerves are derived from preganglionic fibers that leave the spinal cord in the anterior roots, mainly of T10 to L2. These fibers:

- innervate blood vessels,
- cause contraction of smooth muscle in the internal urethral sphincter in men and the internal anal sphincters in both men and women,
- cause smooth muscle contraction associated with the reproductive tract and with the accessory glands of the reproductive system, and
- are important in moving secretions from the epididymis and associated glands into the urethra to form semen during ejaculation.

Parasympathetic fibers

Parasympathetic fibers enter the pelvic plexus in pelvic splanchnic nerves that originate from spinal cord levels S2 to S4 (Fig. 5.38). They:

- are generally vasodilatory,
- stimulate bladder contraction,
- stimulate erection, and
- modulate activity of the enteric nervous system of the colon distal to the left colic flexure (in addition to pelvic viscera, some of the fibers from the pelvic plexus course superiorly in the prevertebral plexus or as separate nerves and pass into the inferior mesenteric plexus of the abdomen).

Visceral afferent fibers

Visceral afferent fibers follow the course of the sympathetic and parasympathetic fibers to the spinal cord. Afferent fibers that enter the cord in lower thoracic levels and lumbar levels with sympathetic fibers generally carry pain; however, pain fibers from the cervix and some pain fibers from the bladder and urethra may accompany parasympathetic nerves to sacral levels of the spinal cord.

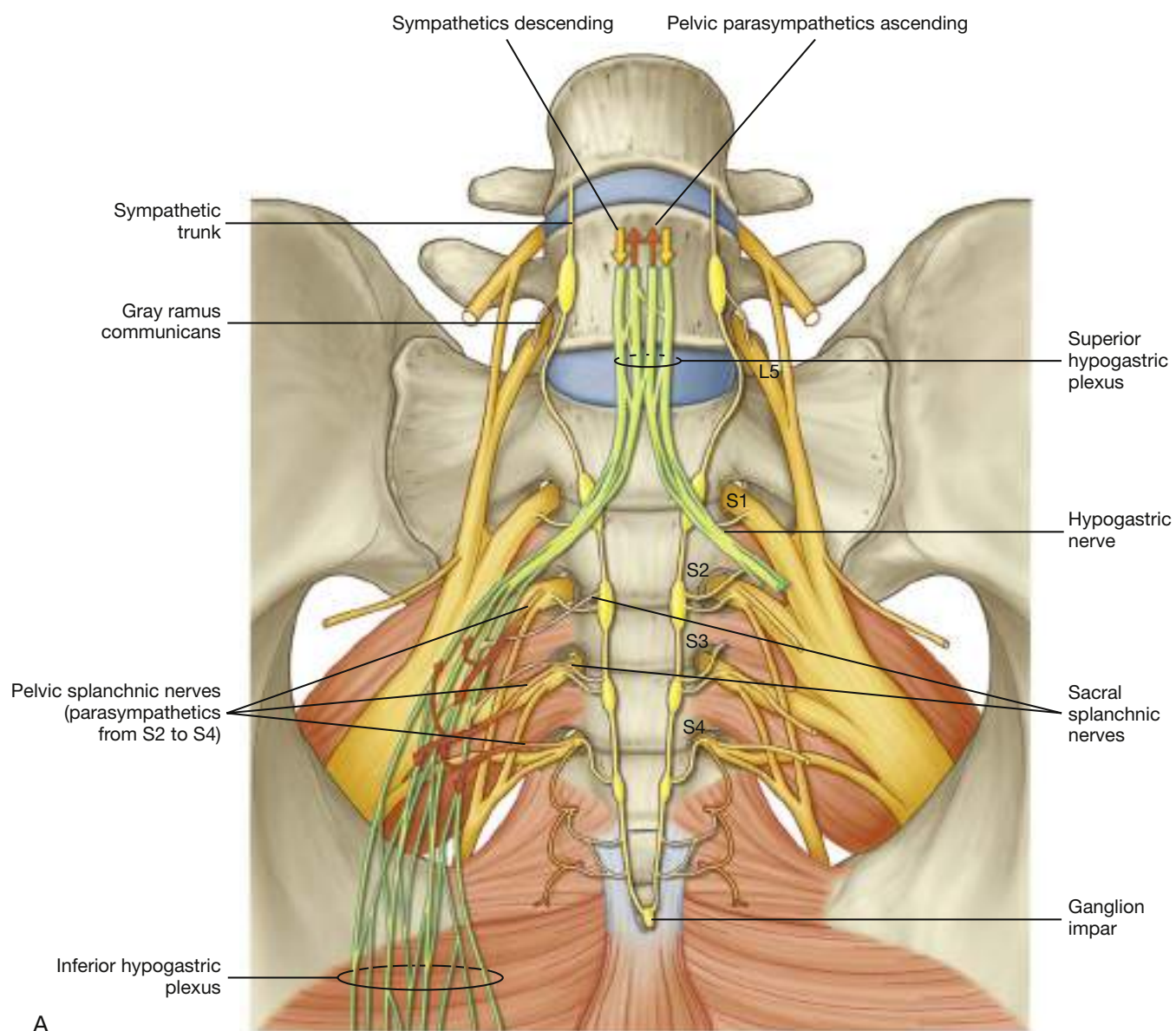


Fig. 5.38 Pelvic extensions of the prevertebral plexus. **A.** Anterior view.

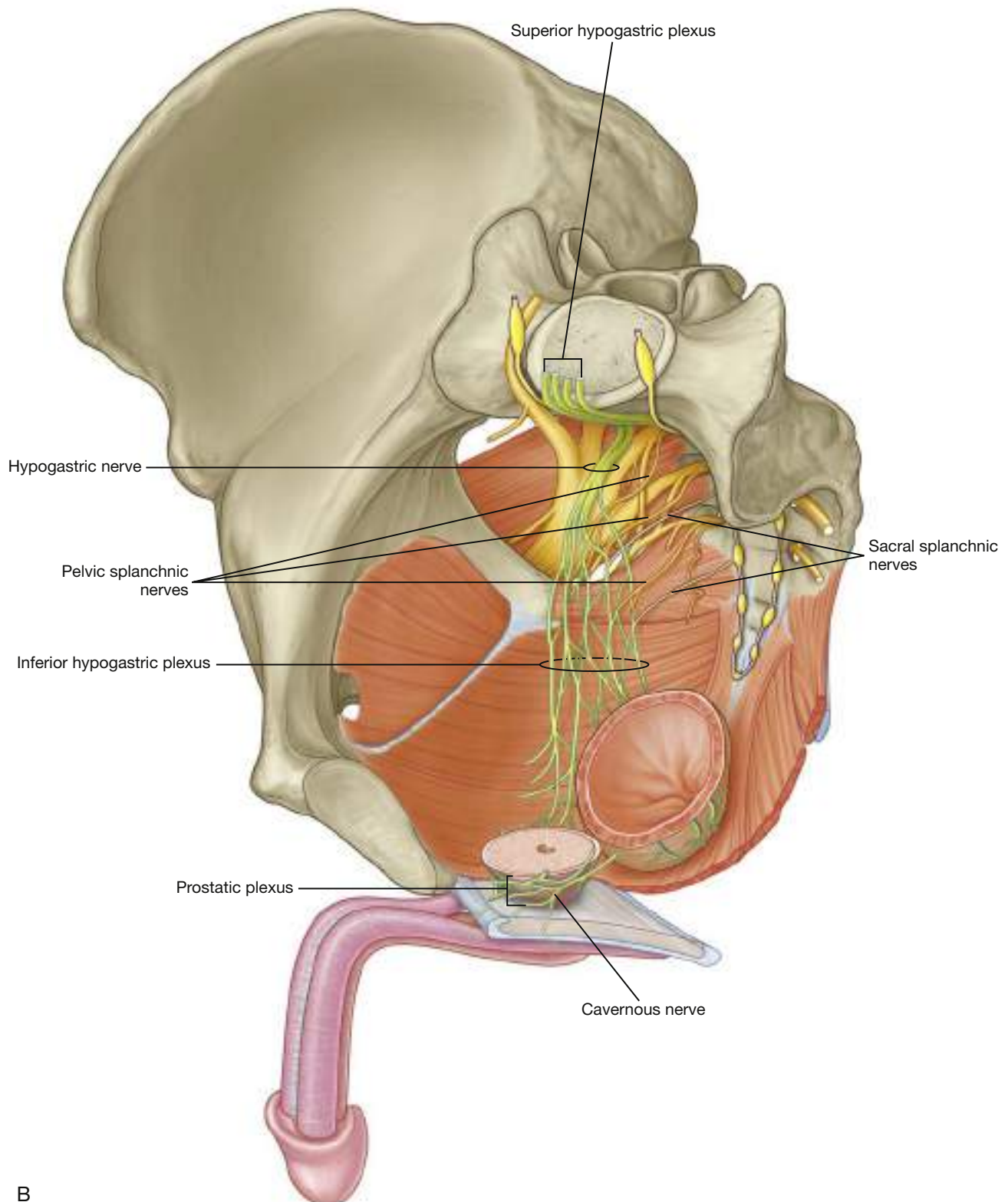


Fig. 5.38, cont'd B. Anteromedial view of right side of plexus.

Clinical app

Prostatectomy and impotence

It may be necessary to perform radical surgery to cure cancer of the prostate. To do this, the prostate and its attachments around the base of the bladder, including the seminal vesicles, must be removed en masse. Parts of the inferior hypogastric plexus in this region give rise to nerves that innervate the erectile tissues of the penis. Impotence may occur if these nerves cannot or are not preserved during removal of the prostate.

For the same reasons, women may experience sexual dysfunction if similar nerves are damaged during pelvic surgery, for example, during a total hysterectomy.

Blood vessels

Arteries

The major artery of the pelvis and perineum is the internal iliac artery on each side (Figs. 5.39, 5.40). In addition to providing a blood supply to most of the pelvic viscera, pelvic walls and floor, and structures in the perineum, including erectile tissues of the clitoris and the penis, this artery gives rise to branches that follow nerves into the gluteal region of the lower limb. Other vessels that originate in the abdomen and contribute to the supply of pelvic structures include the median sacral artery and, in women, the ovarian arteries.

Internal iliac artery

The **internal iliac artery** originates from the common iliac artery on each side, approximately at the level of the intervertebral disc between LV and SI and lies anteromedial to the sacro-iliac joint (Fig. 5.39). The vessel courses inferiorly over the pelvic inlet, then divides into anterior and posterior trunks at the level of the superior border of the greater sciatic foramen. Branches from the posterior trunk contribute to the supply of the lower posterior abdominal wall, the posterior pelvic wall, and the gluteal region. Branches from the anterior trunk supply the pelvic viscera, the perineum, the gluteal region, the adductor region of the thigh, and, in the fetus, the placenta.

Posterior trunk

Branches of the posterior trunk include the following (Fig. 5.39):

- The **iliolumbar artery** ascends laterally back out of the pelvic inlet and divides into a lumbar branch and an iliac branch. The lumbar branch contributes to the supply of the posterior abdominal wall, psoas, quadratus lumborum

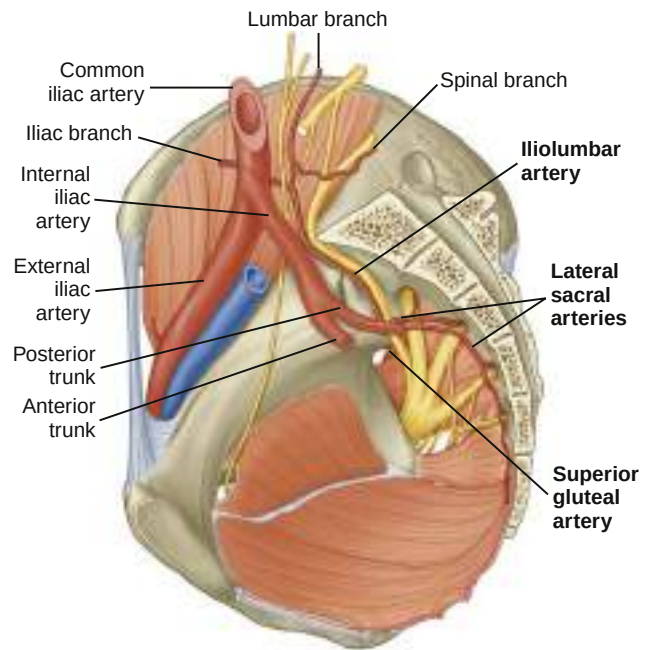


Fig. 5.39 Branches of the posterior trunk of the internal iliac artery.

muscles, and cauda equina via a small spinal branch that passes through the intervertebral foramen between LV and SI. The iliac branch passes laterally into the iliac fossa to supply muscle and bone.

- The **lateral sacral arteries**, usually two, originate from the posterior division of the internal iliac artery and course medially and inferiorly along the posterior pelvic wall. They give rise to branches that pass into the anterior sacral foramina to supply related bone and soft tissues, structures in the vertebral (sacral) canal, and skin and muscle posterior to the sacrum.
- The **superior gluteal artery** is the largest branch of the internal iliac artery. It courses posteriorly, usually passing between the lumbosacral trunk and anterior ramus of S1, to leave the pelvic cavity through the greater sciatic foramen above the piriformis muscle and enter the gluteal region of the lower limb. This vessel makes a substantial contribution to the blood supply of muscles and skin in the gluteal region and supplies branches to adjacent muscles and bones of the pelvic walls.

Anterior trunk

Branches of the anterior trunk of the internal iliac artery include the following (Fig. 5.40):

- The first branch of the anterior trunk is the **umbilical artery**, which gives origin to the superior vesical artery, then travels forward just inferior to the margin of the pelvic inlet. Anteriorly, the vessel leaves the pelvic cavity and

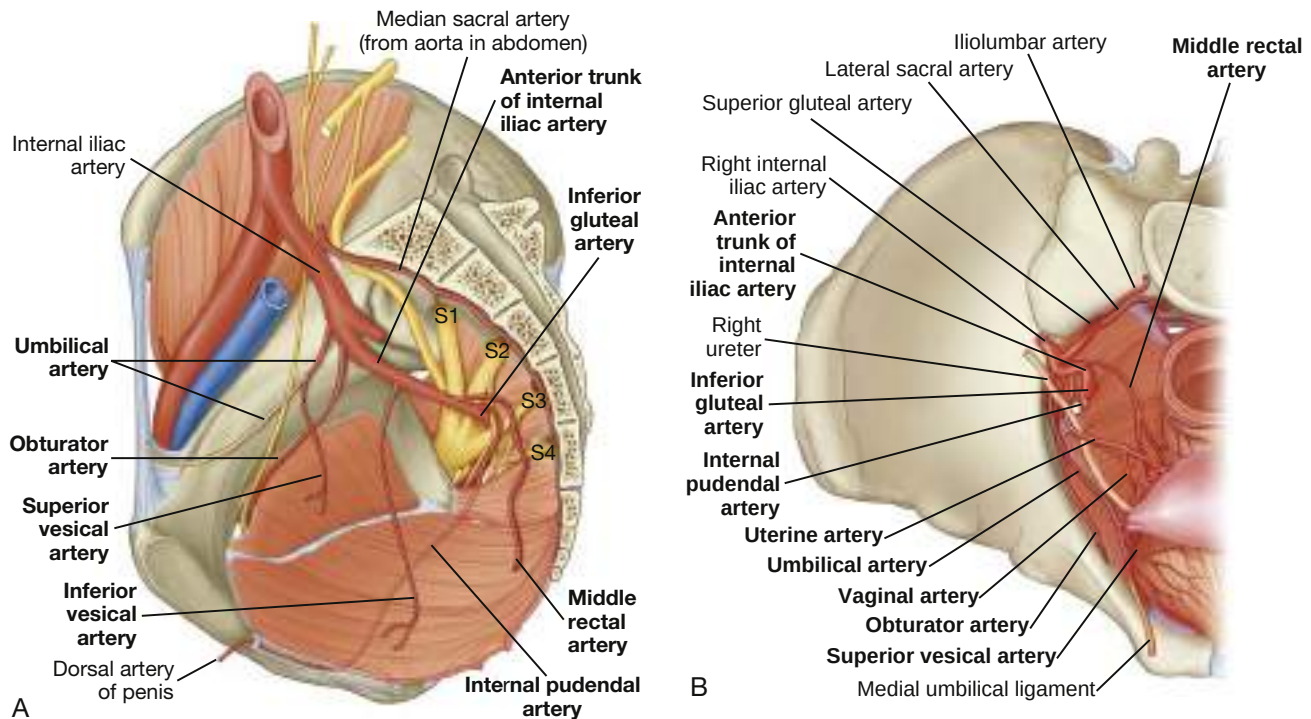


Fig. 5.40 Branches of the anterior trunk of the internal iliac artery. A. Male. B. Female.

ascends on the internal aspect of the anterior abdominal wall to reach the umbilicus. In the fetus, the umbilical artery is large and carries blood from the fetus to the placenta. After birth, the vessel closes distally to the origin of the superior vesical artery and eventually becomes a solid fibrous cord. On the anterior abdominal wall, the cord raises a fold of peritoneum termed the **medial umbilical fold**. The fibrous remnant of the umbilical artery itself is the **medial umbilical ligament**.

- The **superior vesical artery** normally originates from the root of the umbilical artery and courses medially and inferiorly to supply the superior aspect of the bladder and distal parts of the ureter. In men, it also may give rise to an artery that supplies the ductus deferens.
- The **inferior vesical artery** occurs in men and supplies branches to the bladder, ureter, seminal vesicle, and prostate. The **vaginal artery** in women is the equivalent of the inferior vesical artery in men and, descending to the vagina, supplies branches to the vagina and to adjacent parts of the bladder and rectum. The vaginal artery and uterine artery may originate together as a common branch from the anterior trunk, or the vaginal artery may arise independently.
- The **middle rectal artery** courses medially to supply the rectum. The vessel anastomoses with the superior rectal artery, which originates from the inferior mesenteric artery in the abdomen, and the inferior rectal artery,

which originates from the internal pudendal artery in the perineum.

- The **obturator artery** courses anteriorly along the pelvic wall and leaves the pelvic cavity via the obturator canal. Together with the obturator nerve above and the obturator vein below, it enters and supplies the adductor region of the thigh.
- The **internal pudendal artery** courses inferiorly from its origin in the anterior trunk and leaves the pelvic cavity through the greater sciatic foramen inferior to the piriformis muscle. In association with the pudendal nerve on its medial side, the vessel passes laterally to the ischial spine and then through the lesser sciatic foramen to enter the perineum. The internal pudendal artery is the main artery of the perineum. Among the structures it supplies are the erectile tissues of the clitoris and the penis.
- The **inferior gluteal artery** is a large terminal branch of the anterior trunk of the internal iliac artery. It passes between the anterior rami S1 and S2 or S2 and S3 of the sacral plexus and leaves the pelvic cavity through the greater sciatic foramen inferior to the piriformis muscle. It enters and contributes to the blood supply of the gluteal region and anastomoses with a network of vessels around the hip joint.
- The **uterine artery** in women courses medially and anteriorly in the base of the broad ligament to reach the cervix (Figs. 5.40B, 5.41). Along its course, the vessel

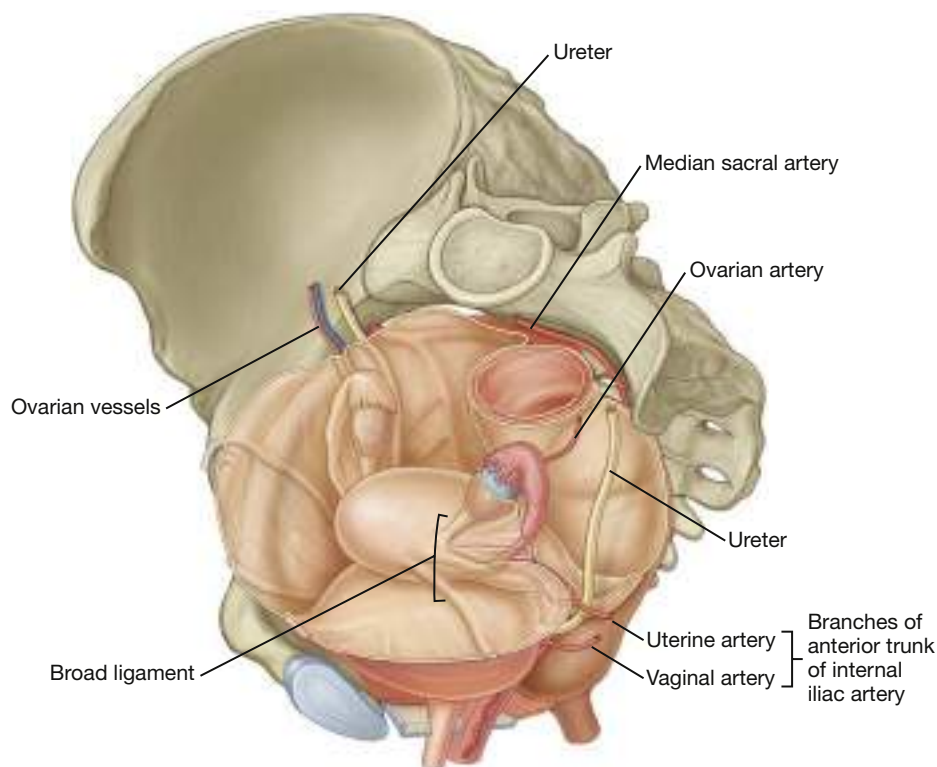


Fig. 5.41 Uterine and vaginal arteries.

crosses the ureter and passes superiorly to the lateral vaginal fornix. Once the vessel reaches the cervix, it ascends along the lateral margin of the uterus to reach the uterine tube where it curves laterally and anastomoses with the ovarian artery. The uterine artery is the major blood supply to the uterus and enlarges significantly during pregnancy. Through anastomoses with other arteries, the vessel contributes to the blood supply of the ovaries and vagina as well.

Ovarian arteries

In women, the gonadal (ovarian) vessels originate from the abdominal aorta and then descend to cross the pelvic inlet and supply the ovaries (see Fig. 5.41). They anastomose with terminal parts of the uterine arteries. On each side, the vessels travel in the **suspensory ligament of ovary** (the **infundibulopelvic ligament**) as they cross the pelvic inlet to the ovary. Branches pass through the mesovarium to reach the ovary and through the mesometrium of the broad ligament to anastomose with the uterine artery. The ovarian arteries enlarge significantly during pregnancy to augment uterine blood supply.

Median sacral artery

The median sacral artery (see Figs. 5.40A and 5.41) originates from the posterior surface of the aorta just superior to the aortic bifurcation at vertebral level LIV in the abdomen.

It descends in the midline, crosses the pelvic inlet, and then courses along the anterior surface of the sacrum and coccyx. It gives rise to the last pair of lumbar arteries and to branches that anastomose with the iliolumbar and lateral sacral arteries.

Veins

Pelvic veins follow the course of all branches of the internal iliac artery except for the umbilical artery and the iliolumbar artery (Fig. 5.42A). On each side, the veins drain into internal iliac veins, which leave the pelvic cavity to join common iliac veins situated just superior and lateral to the pelvic inlet.

Within the pelvic cavity, extensive interconnected venous plexuses are associated with the surfaces of the viscera (bladder, rectum, prostate, uterus, and vagina). Together, these plexuses form the pelvic plexus of veins. The part of the venous plexus surrounding the rectum and anal canal drains via superior rectal veins (tributaries of inferior mesenteric veins) into the hepatic portal system and via middle and inferior rectal veins into the caval system. This pelvic plexus is an important portacaval shunt when the hepatic portal system is blocked (Fig. 5.42B).

The inferior part of the rectal venous plexus around the anal canal has two parts, an internal and an external. The **internal rectal venous plexus** is in connective tissue between the internal anal sphincter and the epithelium lining the canal. This plexus connects superiorly with

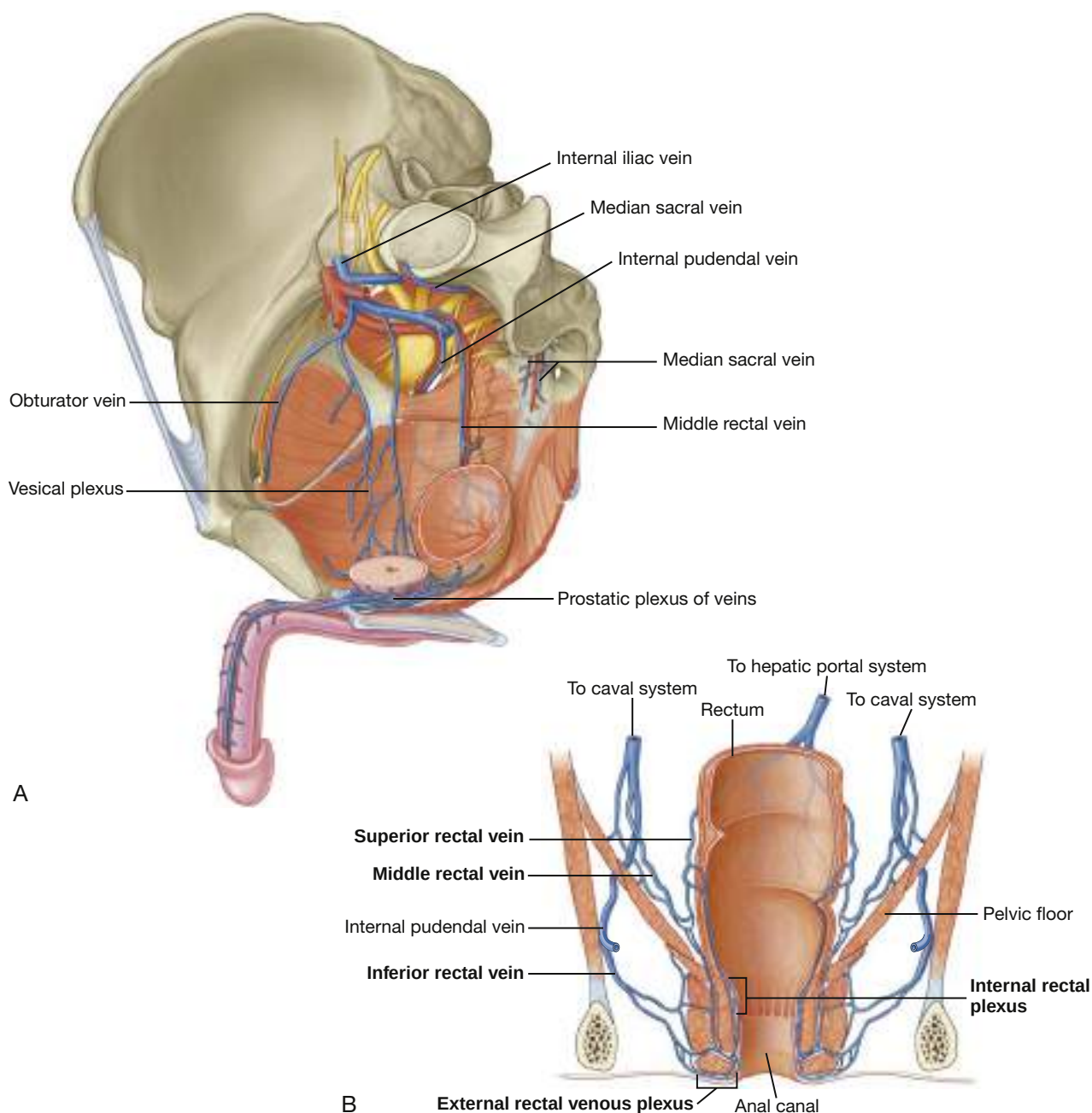


Fig. 5.42 Pelvic veins. **A.** In a man with the left side of the pelvis and most of the viscera removed. **B.** Veins associated with the rectum and anal canal.

longitudinally arranged branches of the superior rectal vein that lie one in each anal column. When enlarged, these branches form varices or internal hemorrhoids, which originate above the pectinate line and are covered by colonic mucosa. The **external rectal venous plexus** circles the external anal sphincter and is subcutaneous. Enlargement of vessels in the external rectal plexus results in external hemorrhoids.

The single **deep dorsal vein** that drains erectile tissues of the clitoris and the penis passes directly into the pelvic cavity through a gap formed between the arcuate

pubic ligament and the anterior margin of the perineal membrane. The vein joins the prostatic plexus of veins in men and the vesical (bladder) plexus of veins in women. Superficial veins that drain the skin of the penis and corresponding regions of the clitoris drain into the external pudendal veins, which are tributaries of the great saphenous vein in the thigh.

In addition to tributaries of the internal iliac vein, median sacral veins and ovarian veins parallel the courses of the median sacral artery and ovarian artery, respectively, and leave the pelvic cavity to join veins in the abdomen:

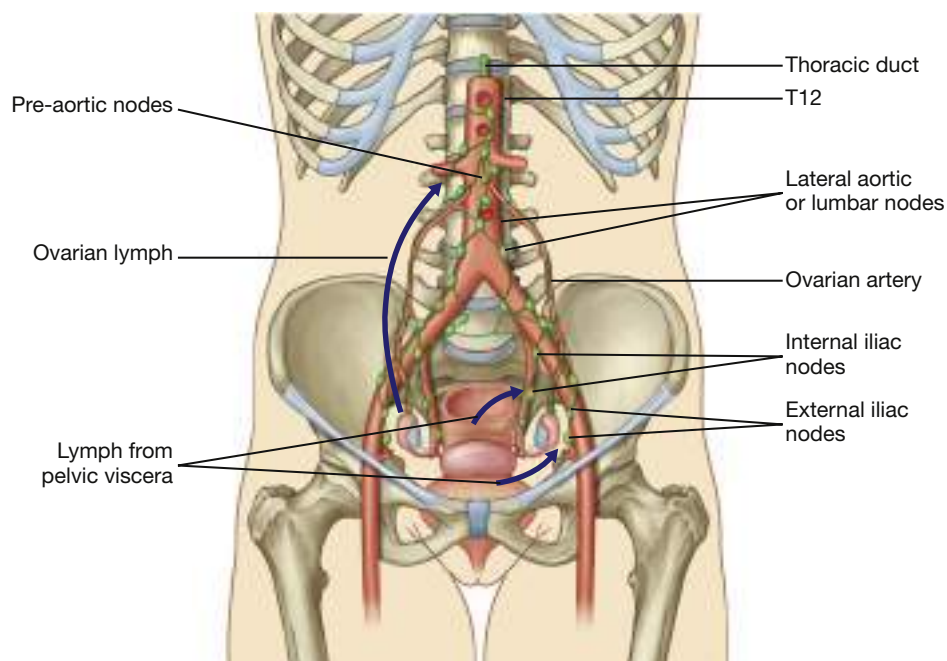


Fig. 5.43 Pelvic lymphatics.

- The **median sacral veins** coalesce to form a single vein that joins either the left common iliac vein or the junction of the two common iliac veins to form the inferior vena cava.
- The **ovarian veins** follow the course of the corresponding arteries; on the left they join the left renal vein, and on the right they join the inferior vena cava in the abdomen.

Lymphatics

Lymphatics from most pelvic viscera drain mainly into lymph nodes distributed along the internal iliac and external iliac arteries and their associated branches (Fig. 5.43), which drain into nodes associated with the common iliac arteries and then into the lateral aortic or lumbar nodes associated with the lateral surfaces of the abdominal aorta. In turn, these lateral aortic or lumbar nodes drain into the lumbar trunks, which continue to the origin of the thoracic duct at approximately vertebral level TXII.

Lymphatics from the ovaries and related parts of the uterus and uterine tubes leave the pelvic cavity superiorly and drain, via vessels that accompany the ovarian arteries, directly into lateral aortic or lumbar nodes and, in some cases, into the pre-aortic nodes on the anterior surface of the aorta.

In addition to draining pelvic viscera, nodes along the internal iliac artery also receive drainage from the gluteal region of the lower limb and from deep areas of the perineum.

Clinical app

Hemorrhoids

A hemorrhoid is an engorgement of veins related to the anal sphincter. Hemorrhoids have a slight genetic predisposition; however, straining during bowel movements, obesity, and sedentary life style can also produce hemorrhoids, as can portal hypertension. The symptoms include irritation, pain, and swelling. Internal hemorrhoids originate from the internal rectal venous plexus that occurs inside the rectum and have a tendency to bleed. Prolapsed hemorrhoids are internal hemorrhoids that pass outside the anal canal and form lumps, which may undergo thrombosis and become painful. External hemorrhoids originate from the external rectal plexus and occur at the distal boundary of the anal canal.

PERINEUM

The perineum is a diamond-shaped region positioned inferiorly to the pelvic floor between the thighs. Its peripheral boundary is the pelvic outlet; its ceiling is the pelvic diaphragm (the levator ani and coccygeus muscles); and its narrow lateral walls are formed by the walls of the pelvic cavity below the attachment of the levator ani muscle (Fig. 5.44A).

The perineum is divided into an anterior urogenital triangle and a posterior anal triangle.

- The urogenital triangle is associated with the openings of the urinary systems and the reproductive systems and functions to anchor the external genitalia.

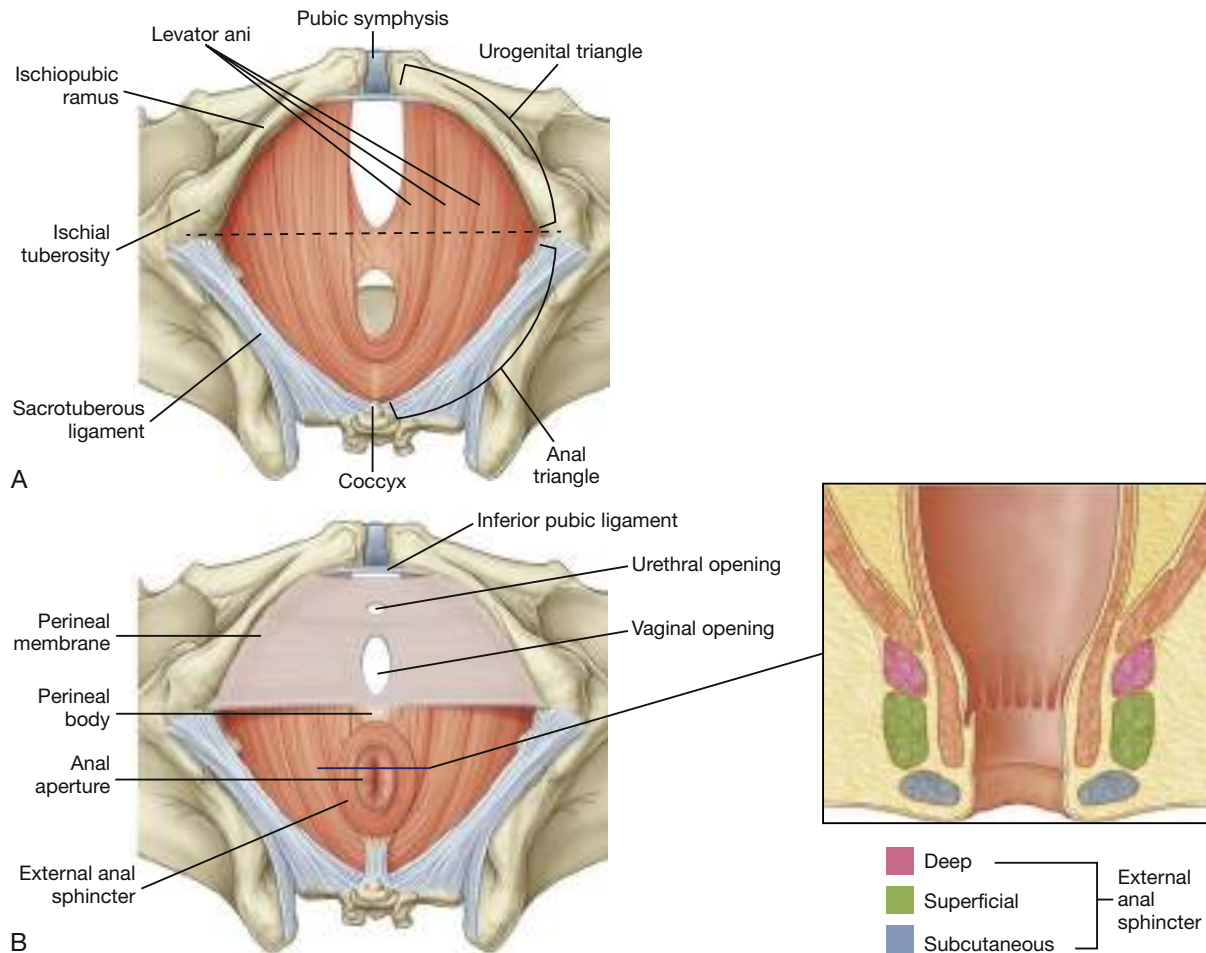


Fig. 5.44 Borders and ceiling of the perineum. A. Boundaries of the perineum. B. Perineal membrane.

- The anal triangle contains the anus and the external anal sphincter.

The pudendal nerve (S2 to S4) and the internal pudendal artery are the major nerve and artery of the region.

Borders and ceiling

The margin of the perineum is marked by the inferior border of the pubic symphysis at its anterior point, the tip of the coccyx at its posterior point, and the ischial tuberosities at each of the lateral points (Fig. 5.44A). The lateral margins are formed by the ischiopubic rami anteriorly and by the sacrotuberous ligaments posteriorly.

The perineum is divided into two triangles by an imaginary line between the two ischial tuberosities (Fig. 5.44A). Anterior to the line is the urogenital triangle, and posterior to the line is the anal triangle. Significantly, the two triangles are not in the same plane. In the anatomical position, the urogenital triangle is oriented in the horizontal plane,

whereas the anal triangle is tilted upward at the transtuberular line so that it faces more posteriorly.

The roof of the perineum is formed mainly by the levator ani muscles that separate the pelvic cavity above from the perineum below. These muscles, one on each side, form a cone- or funnel-shaped pelvic diaphragm, with the anal aperture at its inferior apex in the anal triangle.

Anteriorly, in the **urogenital triangle**, a U-shaped defect in the muscles, the **urogenital hiatus**, allows the passage of the urethra and vagina.

Perineal membrane and deep perineal pouch

The perineal membrane (see p. 218) is a thick fibrous sheet that fills the urogenital triangle (Fig. 5.44B). It has a free posterior border, which is anchored in the midline to the perineal body and is attached laterally to the pubic arch. Immediately superior to the perineal membrane is a thin region termed the *deep perineal pouch*, containing a layer of skeletal muscle and neurovascular tissues. Among the

Surface anatomy

Defining the margins of the perineum

The pubic symphysis, ischial tuberosities, and tip of the sacrum are palpable on patients and can be used to define the boundaries of the perineum. This is best done with patients lying on their backs with their thighs flexed and abducted in the lithotomy position (Fig. 5.45).

- The ischial tuberosities are palpable on each side as large bony masses near the crease of skin (gluteal fold) between the thigh and gluteal region. They mark the lateral corners of the diamond-shaped perineum.
- The tip of the coccyx is palpable in the midline posterior to the anal aperture and marks the most posterior limit of the perineum.
- The anterior limit of the perineum is the pubic symphysis. In women, this is palpable in the midline deep to the mons pubis. In men, the pubic symphysis is palpable immediately superior to where the body of the penis joins the lower abdominal wall.

Imaginary lines that join the ischial tuberosities with the pubic symphysis in front, and with the tip of the coccyx behind, outline the diamond-shaped perineum. An additional line between the ischial tuberosities divides the perineum into two triangles, the urogenital triangle anteriorly and anal triangle posteriorly. This line also approximates the position of the posterior margin of the perineal membrane. The midpoint of this line marks the location of the perineal body or central tendon of the perineum.

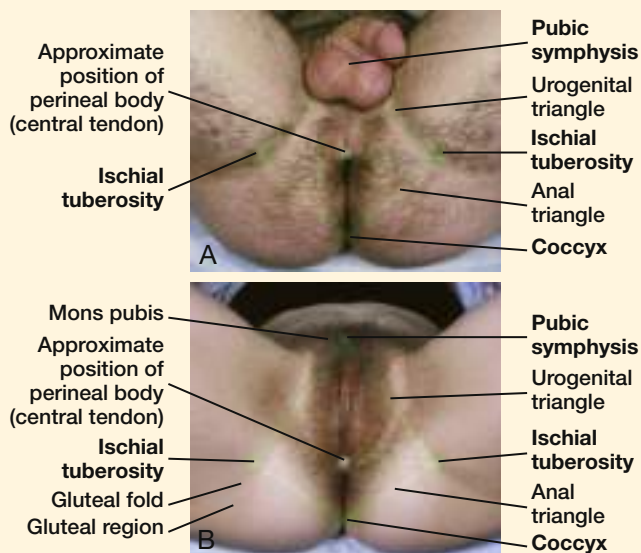


Fig. 5.45 Inferior view of the perineum in the lithotomy position. Boundaries, subdivisions, and palpable landmarks are indicated. **A.** In a man. **B.** In a woman.

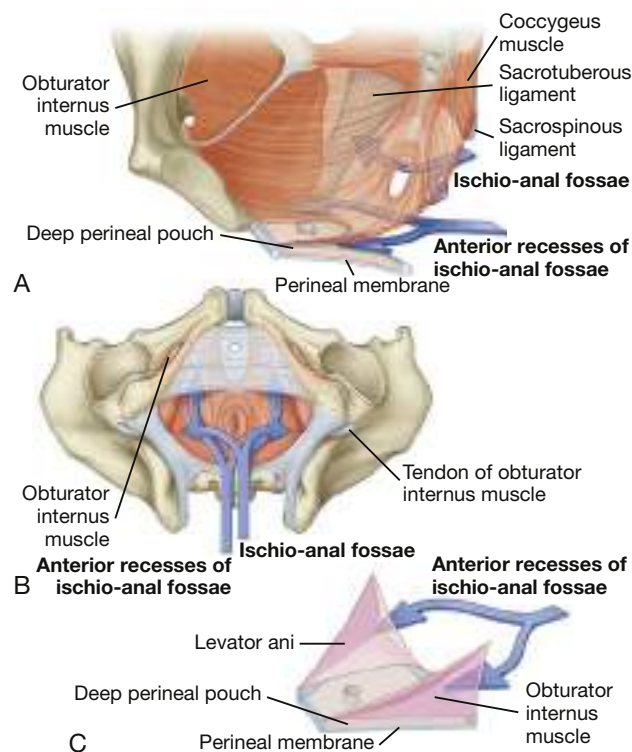


Fig. 5.46 Ischio-anal fossae and their anterior recesses. **A.** Anterolateral view with left pelvic wall removed. **B.** Inferior view. **C.** Anterolateral view with pelvic walls and diaphragm removed.

skeletal muscles in the pouch (see p. 218, Fig. 5.18) is the external urethral sphincter.

The perineal membrane and deep perineal pouch provide support for the external genitalia, which are attached to its inferior surface. Also, the parts of the perineal membrane and deep perineal pouch inferior to the urogenital hiatus in the levator ani provide support for pelvic viscera.

The urethra leaves the pelvic cavity and enters the perineum by passing through the deep perineal pouch and perineal membrane. In women, the vagina also passes through these structures posterior to the urethra.

Ischio-anal fossae and their anterior recesses

Because the levator ani muscles course medially from their origin on the lateral pelvic walls above to the anal aperture and urogenital hiatus below, inverted wedge-shaped gutters occur between the levator ani muscles and adjacent pelvic walls as the two structures diverge inferiorly (Fig. 5.46). In the anal triangle, these gutters, one on each side of the anal aperture, are termed **ischio-anal fossae**. The lateral wall of each fossa is formed mainly by the ischium, obturator

internus muscle, and the sacrotuberous ligament. The medial wall is the levator ani muscle. The medial and lateral walls converge superiorly where the levator ani muscle attaches to the fascia overlying the obturator internus muscle. The ischio-anal fossae allow movement of the pelvic diaphragm and expansion of the anal canal during defecation.

The ischio-anal fossae of the anal triangle are continuous anteriorly with recesses that project into the urogenital triangle superior to the deep perineal pouch. The ischio-anal fossae and their anterior recesses are normally filled with fat.

Clinical app

Abscesses in the ischio-anal fossae

The anal mucosa is particularly vulnerable to injury and may be easily torn by hard feces. Occasionally, patients develop inflammation and infection of the anal canal (sinuses or crypts), which can spread laterally into the ischio-anal fossae or superiorly into the pelvic cavity.

Anal triangle

The anal triangle of the perineum faces posteroinferiorly and is defined laterally by the medial margins of the sacrotuberous ligaments anteriorly by a horizontal line between the two ischial tuberosities and posteriorly by the coccyx. The ceiling of the anal triangle is the pelvic diaphragm, which is formed by the levator ani and coccygeus muscles. The anal aperture occurs centrally in the anal triangle and is related on either side to an ischio-anal fossa. The major muscle in the anal triangle is the external anal sphincter.

The **external anal sphincter**, which surrounds the anal canal, is formed by skeletal muscle and consists of three parts—deep, superficial, and subcutaneous—arranged sequentially along the canal from superior to inferior (Table 5.5, see Fig. 5.44B). The external anal sphincter is innervated

by inferior rectal branches of the pudendal nerve and by branches directly from the anterior ramus of S4.

Urogenital triangle

The urogenital triangle of the perineum is the anterior half of the perineum and is oriented in the horizontal plane. It contains the roots of the external genitalia (Fig. 5.47) and the openings of the urogenital system.

The urogenital triangle is defined (see Fig. 5.44A):

- laterally by the ischiopubic rami,
- posteriorly by an imaginary line between the ischial tuberosities, and
- anteriorly by the inferior margin of the pubic symphysis.

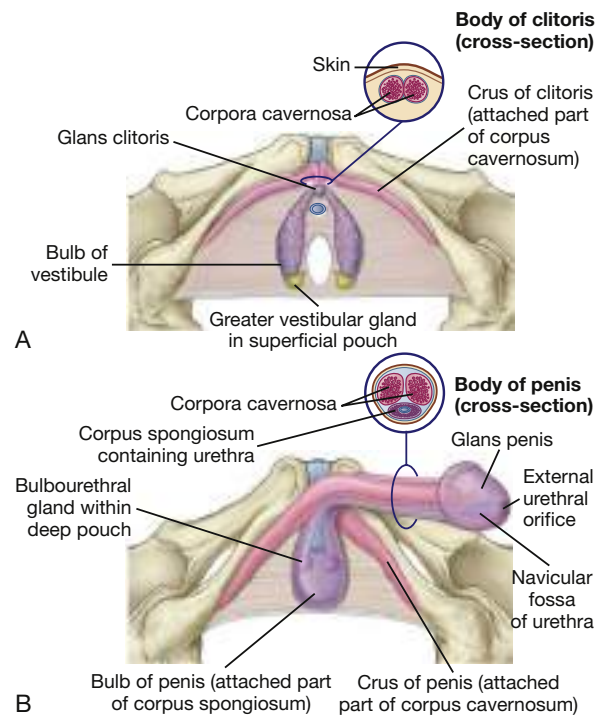


Fig. 5.47 Erectile tissues of clitoris and penis. **A.** Clitoris. **B.** Penis.

Table 5.5 Muscles of the anal triangle

Muscles of pelvic wall	Origin	Insertion	Innervation	Function
External anal sphincter				Closes anal canal
Deep part	Ring-shaped muscle that surrounds superior aspect of anal canal and blends with the fibers of levator ani muscle		Pudendal nerve (S2 and S3) and branches directly from S4	
Superficial part	Surrounds lower part of anal canal	Anchored anteriorly to the perineal body and posteriorly to the anococcygeal body		
Subcutaneous part	Horizontally flattened disc that surrounds the anal aperture just beneath the skin			



Pelvis and Perineum

As with the anal triangle, the roof or ceiling of the urogenital triangle is the levator ani muscle.

Unlike the anal triangle, the urogenital triangle contains a strong fibromuscular support platform, the perineal membrane, and deep perineal pouch (see p. 218), which is attached to the pubic arch.

Anterior extensions of the ischio-anal fossae occur between the deep perineal pouch and the levator ani muscle on each side.

Between the perineal membrane and the membranous layer of superficial fascia is the **superficial perineal pouch**. The principal structures in this pouch are the erectile tissues of the penis and clitoris and associated skeletal muscles.

Structures in the superficial perineal pouch

The superficial perineal pouch contains (Figs. 5.47, 5.48):

- erectile structures that join together to form the penis in men and the clitoris in women and
- skeletal muscles that are associated mainly with parts of the erectile structures attached to the perineal membrane and adjacent bone.

Each erectile structure consists of a central core of expandable vascular tissue and its surrounding connective tissue capsule.

Erectile tissues

Two sets of erectile structures join to form the penis and the clitoris.

A pair of cylindrically shaped **corpora cavernosa**, one on each side of the urogenital triangle, are anchored by their proximal ends to the pubic arch (Fig. 5.47). These attached parts are often termed the **crura** (from the Latin for “legs”) of the clitoris or the penis. The distal ends of the corpora, which are not attached to bone, form the body of the clitoris in women and the dorsal parts of the body of the penis in men.

The second set of erectile tissues surrounds the openings of the urogenital system.

- In women, a pair of erectile structures, termed the **bulbs of vestibule**, are situated one on each side at the vaginal opening and are firmly anchored to the perineal membrane (Fig. 5.47A). Small bands of erectile tissues connect the anterior ends of these bulbs to a single, small, pea-shaped erectile mass, the **glans clitoris**, which is positioned in the midline at the end of the body of the clitoris and anterior to the opening of the urethra.
- In men, a single large erectile mass, the **corpus spongiosum**, is the structural equivalent to the bulbs of the vestibule, the glans clitoris, and the interconnecting bands of erectile tissues in women (Fig. 5.47B). The corpus spongiosum is anchored at its base (bulb of penis) to the perineal membrane. Its

proximal end, which is not attached, forms the ventral part of the body of the penis and expands over the end of the body of the penis to form the glans penis. In men, the urethra is enclosed by the corpus spongiosum and opens at the end of the penis. This is unlike the situation in women in which the urethra is not enclosed by erectile tissue of the clitoris and opens directly into the vestibule of the perineum.

Clitoris

The clitoris is composed of two corpora cavernosa and the **glans clitoris** (Fig. 5.47A). As in the penis, it has an attached part (root) and a free part (body).

- Unlike the root of penis, the **root of clitoris** technically consists only of the two crura. (Although the bulbs of the vestibule are attached to the glans clitoris by thin bands of erectile tissue, they are not included in the attached part of the clitoris.)
- The **body of clitoris**, which is formed only by the unattached parts of the two corpora cavernosa, angles posteriorly and is embedded in the connective tissues of the perineum.

The body of clitoris is supported by a suspensory ligament that attaches superiorly to the pubic symphysis (Fig. 5.48A). The glans clitoris is attached to the distal end of the body and is connected to the bulbs of the vestibule by small bands of erectile tissue. The glans clitoris is exposed in the perineum, and the body of the clitoris can be palpated through skin.

Penis

The penis is composed mainly of the two corpora cavernosa and the single corpus spongiosum, which contains the urethra (Fig. 5.47B). As in the clitoris, it has an attached part (root) and a free part (body):

- The **root of penis** consists of the two crura, which are proximal parts of the corpora cavernosa attached to the pubic arch, and the **bulb of penis**, which is the proximal part of the corpus spongiosum anchored to the perineal membrane.
- The **body of penis**, which is covered entirely by skin, is formed by the tethering of the two proximal free parts of the corpora cavernosa and the related free part of the corpus spongiosum.

The base of the body of penis is supported by two ligaments: the **suspensory ligament of penis** (attached superiorly to the pubic symphysis), and the more superficially positioned **fundiform ligament of penis** (attached above to the linea alba of the anterior abdominal wall and splits below into two bands that pass on each side of the penis and unite inferiorly) (Fig. 5.48B).

Because the anatomical position of the penis is erect, the paired corpora are defined as dorsal in the body of the penis and the single corpus spongiosum as ventral, even though the positions are reversed in the nonerect (flaccid) penis.

Table 5.6 Muscles of the superficial perineal pouch

Muscles of pelvic wall	Origin	Insertion	Innervation	Function
Ischiocavernosus	Ischial tuberosity and ramus	Crus of penis and clitoris	Pudendal nerve (S2 to S4)	Move blood from crura into the body of the erect penis and clitoris
Bulbospongiosus	In women: perineal body In men: perineal body, midline raphe	In women: bulb of vestibule, perineal membrane, body of clitoris, and corpus cavernosum In men: bulbospongiosus, perineal membrane, corpus cavernosum	Pudendal nerve (S2 to S4)	Move blood from attached parts of the clitoris and penis into the glans In men: removal of residual urine from urethra after urination; pulsatile emission of semen during ejaculation
Superficial transverse perineal	Ischial tuberosity and ramus	Perineal body	Pudendal nerve (S2 to S4)	Stabilize the perineal body

The corpus spongiosum expands to form the head of penis (**glans penis**) over the distal ends of the corpora cavernosa (Fig. 5.47B).

Erection

Erection of the penis and clitoris is a vascular event generated by parasympathetic fibers carried in pelvic splanchnic nerves from the anterior rami of S2 to S4, which enter the inferior hypogastric part of the prevertebral plexus and ultimately pass through the deep perineal pouch and perineal membrane to innervate the erectile tissues. Stimulation of these nerves causes specific arteries in the erectile tissues to relax. This allows blood to fill the tissues, causing the penis and clitoris to become erect.

Greater vestibular glands

The greater vestibular glands (Bartholin's glands) are seen in women. They are small, pea-shaped mucous glands that lie

posterior to the bulbs of the vestibule on each side of the vaginal opening and are the female homologues of the bulbourethral glands in men (see Fig. 5.47). However, the bulbourethral glands are located within the deep perineal pouch, whereas the greater vestibular glands are in the superficial perineal pouch.

The duct of each greater vestibular gland opens into the vestibule of the perineum along the posterolateral margin of the vaginal opening.

Like the bulbourethral glands in men, the greater vestibular glands produce secretion during sexual arousal.

Muscles

The superficial perineal pouch contains three pairs of muscles: the **ischiocavernosus**, **bulbospongiosus**, and **superficial transverse perineal muscles** (Table 5.6, Fig. 5.48). Two of these three pairs of muscles are associated with the roots of the penis and clitoris; the other pair is associated with the perineal body.

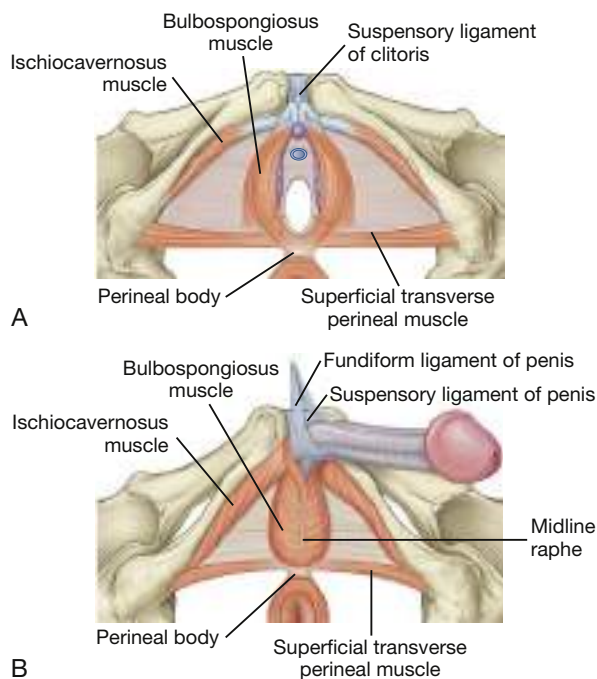


Fig. 5.48 Muscles in the superficial perineal pouch. **A.** In women. **B.** In men.

Surface anatomy

Superficial features of the external genitalia in women

In women, the clitoris and vestibular apparatus, together with a number of skin and tissue folds, form the **vulva** (Fig. 5.49A). On either side of the midline are two thin folds of skin termed the **labia minora**. The region enclosed between them, and into which the urethra and vagina open, is the **vestibule**. Anteriorly, the labia minora each bifurcate, forming a medial and a lateral fold. The medial folds unite to form the **frenulum of clitoris** that joins the glans clitoris (Fig. 5.49B). The lateral folds unite ventrally over the glans clitoris and the body of clitoris to form the **prepuce of clitoris** (hood) (Fig. 5.49B). The body of the clitoris extends anteriorly from the glans clitoris and is palpable deep to the prepuce and related skin. Posterior to the vestibule, the labia minora unite, forming a small transverse fold, the **frenulum of labia minora** (the **fourchette**) (Fig. 5.49C).

Within the vestibule, the vaginal orifice is surrounded to varying degrees by a ring-like fold of membrane, the **hymen**, which may have a small central perforation or may

completely close the vaginal opening. Following rupture of the hymen (resulting from first sexual intercourse or injury), irregular remnants of the hymen fringe the vaginal opening (Fig. 5.49C).

The orifices of the urethra and the vagina are associated with the openings of glands. The ducts of the para-urethral glands (**Skene's glands**) open into the vestibule, one on each side of the lateral margin of the urethra (Fig. 5.49D). The ducts of the greater vestibular glands (**Bartholin's glands**) open adjacent to the posterolateral margin of the vaginal opening in the crease between the vaginal orifice and remnants of the hymen (Fig. 5.49D).

Lateral to the labia minora are two broad folds, the **labia majora**, which unite anteriorly to form the mons pubis (Fig. 5.49A). The **mons pubis** overlies the inferior aspect of the pubic symphysis and is anterior to the vestibule and the clitoris. Posteriorly, the labia majora do not unite and are separated by a depression termed the **posterior commissure**, which overlies the position of the perineal body (Fig. 5.49A).

The cervix is visible when the vaginal canal is opened with a speculum (Fig. 5.49E). The external cervical os opens onto the surface

of the dome-shaped cervix. A recess or gutter, termed the **foreskin**, occurs between the cervix and the vaginal wall and is further subdivided, based on location, into anterior, posterior, and lateral fornices.

The roots of the clitoris occur deep to surface features of the perineum and are attached to the ischiopubic rami and the perineal membrane.

The bulbs of the vestibule (Fig. 5.49F), composed of erectile tissues, lie deep to the labia minora on either side of the vestibule. These erectile masses are continuous, via thin bands of erectile tissues, with the glans clitoris, which is visible under the clitoral hood. The greater vestibular glands occur posterior to the bulbs of the vestibule on either side of the vaginal orifice.

The crura of clitoris are attached, one on each side, to the ischiopubic rami. Each crus is formed by the attached part of the corpus cavernosum. Anteriorly, these erectile corpora detach from bone, curve posteroinferiorly, and unite to form the body of the clitoris.

The body of clitoris underlies the ridge of skin immediately anterior to the clitoral hood (prepuce). The glans clitoris is positioned at the end of the body of clitoris.

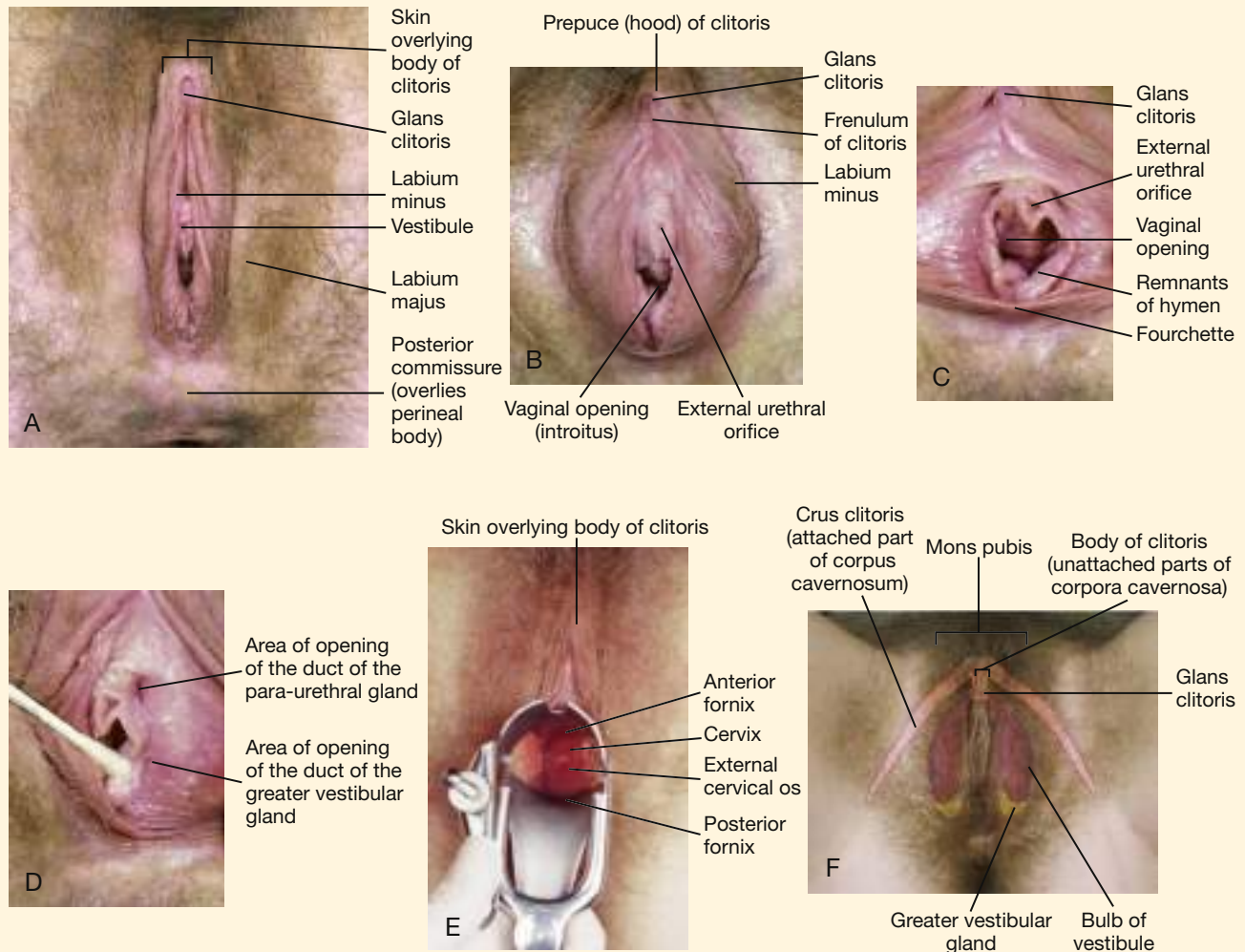


Fig. 5.49 Structures in the urogenital triangle of a woman. **A.** Inferior view of the urogenital triangle of a woman with major features indicated. **B.** Inferior view of the vestibule. The labia minora have been pulled apart to open the vestibule. Also indicated are the glans clitoris, the clitoral hood, and the frenulum of the clitoris. **C.** Inferior view of the vestibule showing the urethral and vaginal orifices and the hymen. The labia minora have been pulled further apart than in Fig. 5.49B. **D.** Inferior view of the vestibule with the left labium minus pulled to the side to show the regions of the vestibule into which the greater vestibular and para-urethral glands open. **E.** View through the vaginal canal of the cervix. **F.** Inferior view of the urogenital triangle of a woman with the erectile tissues of the clitoris and vestibule and the greater vestibular glands indicated with overlays.

Surface anatomy

Superficial features of the external genitalia in men

Superficial components of the genital organs in men consist of the scrotum and the penis (Fig. 5.50A). The urogenital triangle itself contains the root of the penis; however, the testes and associated structures, although they migrate into the scrotum from the abdomen, are generally evaluated with the penis during a physical examination.

The scrotum in men is homologous to the labia majora in women. Each oval testis is readily palpable through the skin of the scrotum (Fig. 5.50A). Posterolateral to the testis is an elongated mass of tissue, often visible as a raised ridge that contains lymphatics and blood vessels of the testis, and the epididymis and ductus deferens. A midline raphe (Fig. 5.50B) is visible on the skin, separating left and right sides of the scrotum. In some individuals, this raphe is prominent and extends from the anal aperture, over the scrotum, and along the ventral surface of the body of the penis to the frenulum of the glans.

The external urethral orifice is a sagittal slit, normally positioned at the tip of the glans (Fig. 5.50C). The inferior margin of the urethral orifice is continuous with a midline **raphe of penis**, which represents a line of fusion formed in the glans as the urethra develops in the fetus. The base of this raphe is continuous

with the **frenulum** of the glans, which is a median fold of skin that attaches the glans to more loosely attached skin proximal to the glans. The base of the glans is expanded to form a raised circular margin (the **corona of glans**) (Fig. 5.50D); the two lateral ends of the corona join inferiorly at the midline raphe of the glans. The depression posterior to the corona is the neck of the glans. Normally, a fold of skin at the neck of the glans is continuous anteriorly with thin skin that tightly adheres to the glans and posteriorly with thicker skin loosely attached to the body. This fold, known as the **prepuce**, extends forward to cover the glans. The prepuce is removed during male circumcision, leaving the glans exposed.

The root of the penis is formed by the attached parts of the corpus spongiosum and the corpora cavernosa. The corpus spongiosum is attached to the perineal membrane and can be easily palpated as a large mass anterior to the perineal body. This mass, which is covered by the bulbospongiosus muscles, is the bulb of penis (Fig. 5.50E).

The corpus spongiosum detaches from the perineal membrane anteriorly, becomes the ventral part of the body of penis (shaft of penis), and eventually terminates as the expanded glans penis.

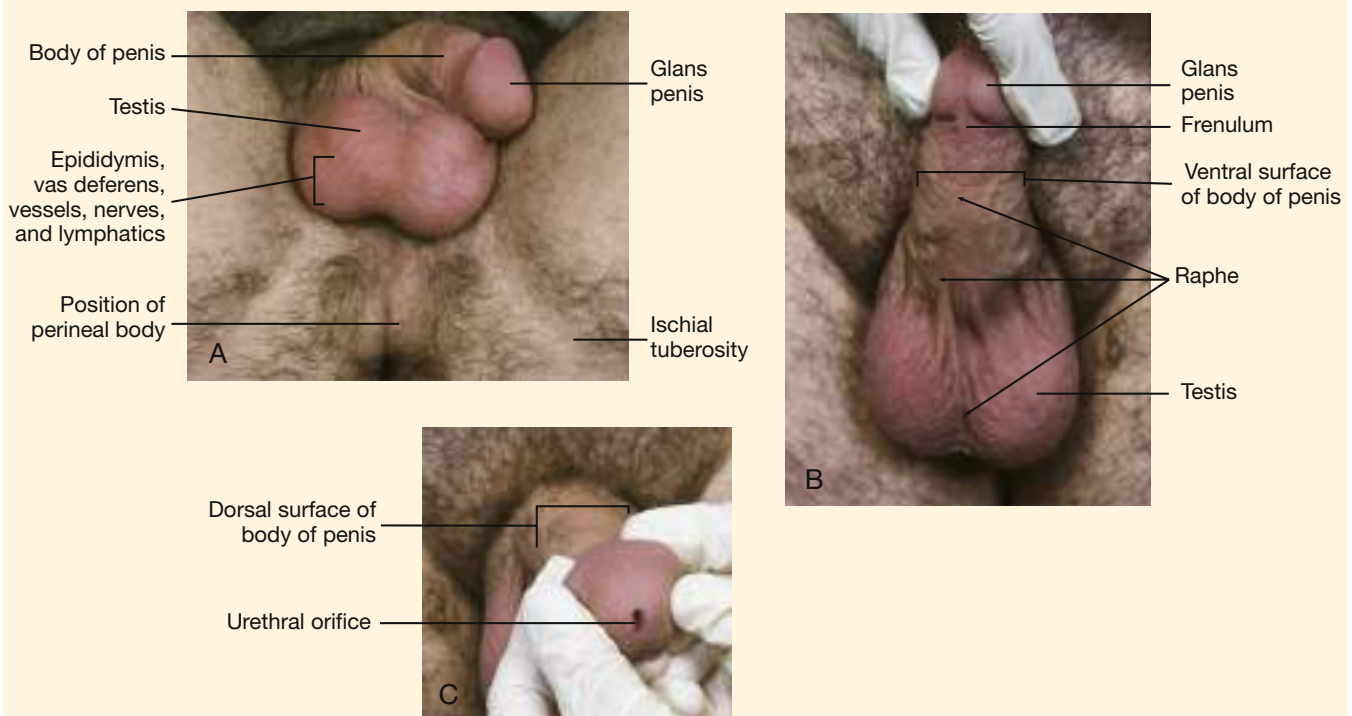


Fig. 5.50 Structures in the urogenital triangle of a man. **A.** Inferior view. **B.** Ventral surface of the body of the penis. **C.** Anterior view of the glans penis showing the urethral opening.



Surface anatomy—cont'd

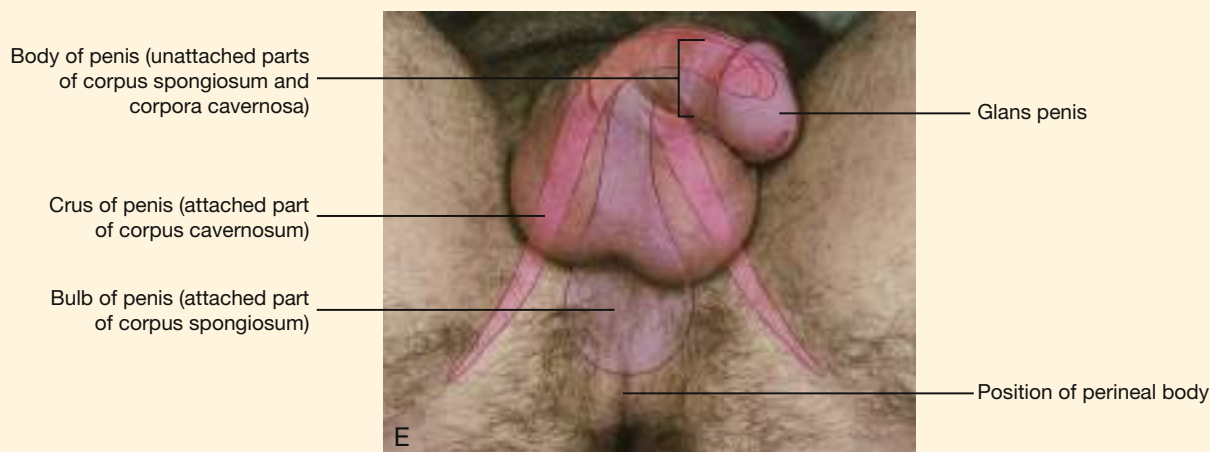
The crura of the penis, one crus on each side, are the attached parts of the corpora cavernosa and are anchored to the ischiopubic rami (Fig. 5.50E). The corpora cavernosa are

unattached anteriorly and become the paired erectile masses that form the dorsal part of the body of the penis. The glans penis caps the anterior ends of the corpora cavernosa.

Fig. 5.50, cont'd D. Lateral view of the body of the penis and glans. **E.** Inferior view of the urogenital triangle of a man with the erectile tissues of the penis indicated with overlays.



Neck of glans
Corona of glans
Prepuce
Glans penis



Body of penis (unattached parts
of corpus spongiosum and
corpora cavernosa)

Crus of penis (attached part
of corpus cavernosum)

Bulb of penis (attached part
of corpus spongiosum)

Glans penis

Position of perineal body

Superficial fascia of the urogenital triangle

The superficial fascia of the urogenital triangle is continuous with similar fascia on the anterior abdominal wall (Fig. 5.51).

As with the superficial fascia of the abdominal wall, the perineal fascia has a membranous layer on its deep surface. This membranous layer (**Colles' fascia**) (Fig. 5.51) is attached:

- posteriorly to the perineal membrane and therefore does not extend into the anal triangle and
- to the ischiopubic rami that form the lateral borders of the urogenital triangle and therefore does not extend into the thigh.

It defines the external limits of the superficial perineal pouch, lines the scrotum or labia, and extends around the body of the penis and clitoris (Fig. 5.51A).

Anteriorly, the membranous layer of fascia is continuous over the pubic symphysis and pubic bones with the membranous layer of fascia on the anterior abdominal wall. In the lower lateral abdominal wall, the membranous layer of abdominal fascia is attached to the deep fascia of the thigh just inferior to the inguinal ligament (Fig. 5.51).

Because the membranous layer of fascia encloses the superficial perineal pouch and continues up the anterior abdominal wall, fluids or infectious material that accumulate in the pouch can track out of the perineum and onto the lower abdominal wall. This material will not track into the anal triangle or the thigh because the fascia fuses with deep tissues at the borders of these regions.

Clinical app

Urethral rupture

Urethral rupture may occur at a series of well-defined anatomical points.

The most common injury is a rupture of the proximal spongy urethra below the perineal membrane. The urethra is usually torn when structures of the perineum are caught between a hard object (e.g., a steel beam or cross bar of a bicycle) and the inferior pubic arch. Urine escapes through the rupture into the superficial perineal pouch and descends into the scrotum and onto the anterior abdominal wall deep to the superficial fascia.

In association with severe pelvic fractures, urethral rupture may occur at the prostatomembranous junction above the deep perineal pouch. The urine will extravasate into the true pelvis.

The worst and most serious urethral rupture is related to serious pelvic injuries where there is complete disruption of the puboprostatic ligaments. The prostate is dislocated superiorly not only by the ligamentous disruption but also by the extensive hematoma formed within the true pelvis. The diagnosis can be made by palpating the elevated prostate during a digital rectal examination.

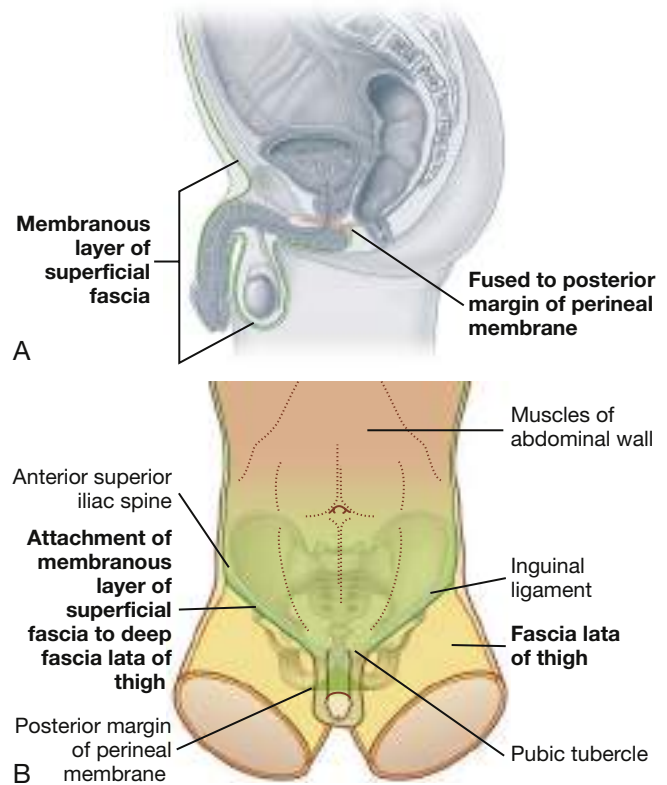


Fig. 5.51 Superficial fascia. **A.** Lateral view. **B.** Anterior view.

Somatic nerves

Pudendal nerve

The major somatic nerve of the perineum is the pudendal nerve (see p. 236 and Fig. 5.52A). As it enters and courses through the perineum, it travels along the lateral wall of the ischio-anal fossa in the **pudendal canal**, which is a tubular compartment formed in the fascia that covers the obturator internus muscle. This pudendal canal also contains the internal pudendal artery and accompanying veins (Fig. 5.52A).

The pudendal nerve has three major terminal branches—the inferior rectal, perineal nerves, and the dorsal nerve of penis or clitoris—which are accompanied by branches of the internal pudendal artery (Fig. 5.52B).

- The **inferior rectal nerve** is often multiple, penetrates through the fascia of the pudendal canal, and courses medially across the ischio-anal fossa to innervate the external anal sphincter and related regions of the levator ani muscles. The nerve is also general sensory for the skin of the anal triangle.
- The **perineal nerve** passes into the urogenital triangle and gives rise to motor and cutaneous branches. The motor branches supply skeletal muscles in the superficial and

deep perineal pouches. The largest of the sensory branches is the posterior scrotal nerve in men and the posterior labial nerve in women.

- The **dorsal nerve of penis and clitoris** enters the deep perineal pouch (Fig. 5.52). It passes along the lateral margin of the pouch and then exits by passing inferiorly through the perineal membrane in a position just inferior to the pubic symphysis where it meets the body of the clitoris or the penis. It courses along the dorsal surface of the body to reach the glans. The dorsal nerve is sensory to the penis and clitoris, particularly to the glans.

Other somatic nerves

Other somatic nerves that enter the perineum are mainly sensory and include branches of the ilio-inguinal, genitofemoral, posterior femoral cutaneous, and anococcygeal nerves.

Visceral nerves

Visceral nerves enter the perineum by two routes:

- Those to the skin, which consist mainly of postganglionic sympathetics, are delivered into the region along the



Fig. 5.52 Pudendal nerve. A. In men. B. In women.

- Those to erectile tissues enter the region mainly by passing through the deep perineal pouch from the inferior hypogastric plexus in the pelvic cavity (see Fig. 5.38). The fibers that stimulate erection are parasympathetic fibers, which enter the inferior hypogastric plexus via pelvic splanchnic nerves from spinal cord levels of S2 to S4.

Arteries

272

The **internal pudendal artery** originates as a branch of the anterior trunk of the internal iliac artery in the pelvis (Fig. 5.53) and accompanies the pudendal nerve in the pudendal canal on the lateral wall of the ischio-anal fossa.

Inferior rectal arteries

One or more **inferior rectal arteries** originate from the internal pudendal artery in the anal triangle and cross the ischio-anal fossa medially to branch and supply muscle and related skin (Fig. 5.53). They anastomose with middle and superior rectal arteries from the internal iliac artery and the inferior mesenteric artery, respectively,

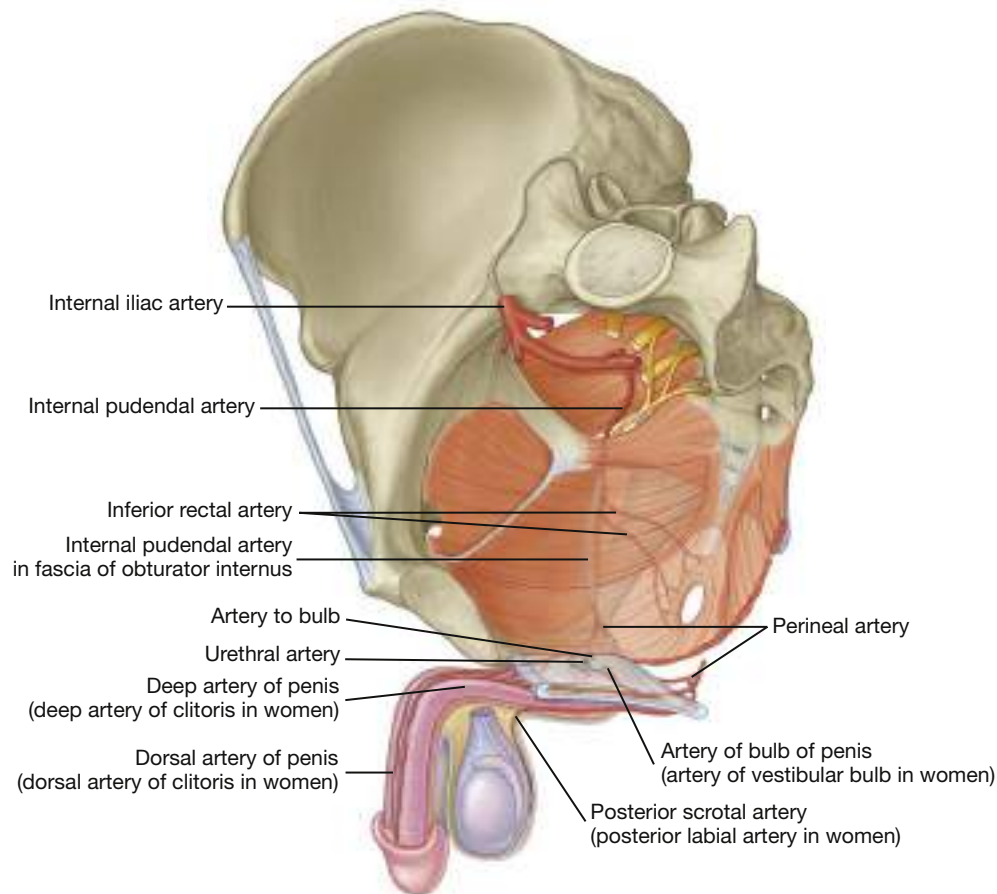


Fig. 5.53 Arteries in the perineum.

to form a network of vessels that supply the rectum and anal canal.

Perineal artery

The **perineal artery** originates near the anterior end of the pudendal canal and gives off a transverse perineal branch and a posterior scrotal or labial artery to surrounding tissues and skin (see [Fig. 5.53](#)).

Terminal part of the internal pudendal artery

The terminal part of the internal pudendal artery accompanies the dorsal nerve of the penis or clitoris into the deep perineal pouch and supplies branches to the tissues in the deep perineal pouch and erectile tissues.

Branches that supply the erectile tissues in men include the artery to the bulb of the penis, the urethral artery, the deep artery of the penis, and the dorsal artery of the penis (see [Fig. 5.53](#)).

- The **artery of bulb of penis** has a branch that supplies the bulbourethral gland and then penetrates the perineal membrane to supply the corpus spongiosum.

- A **urethral artery** also penetrates the perineal membrane and supplies the penile urethra and surrounding erectile tissue to the glans.
- Near the anterior margin of the deep perineal pouch, the internal pudendal artery bifurcates into two terminal branches. A **deep artery of penis** penetrates the perineal membrane to enter the crus and supply the crus and corpus cavernosum of the body. The **dorsal artery of penis** penetrates the anterior margin of the perineal membrane to meet the dorsal surface of the body of the penis. The vessel courses along the dorsal surface of the penis, medial to the dorsal nerve, and supplies the glans penis and superficial tissues of the penis; it also anastomoses with branches of the deep artery of penis and the urethral artery.

Branches that supply the erectile tissues in women are similar to those in men.

- **Arteries of the bulb of vestibule** supply the bulb of the vestibule and related vagina.

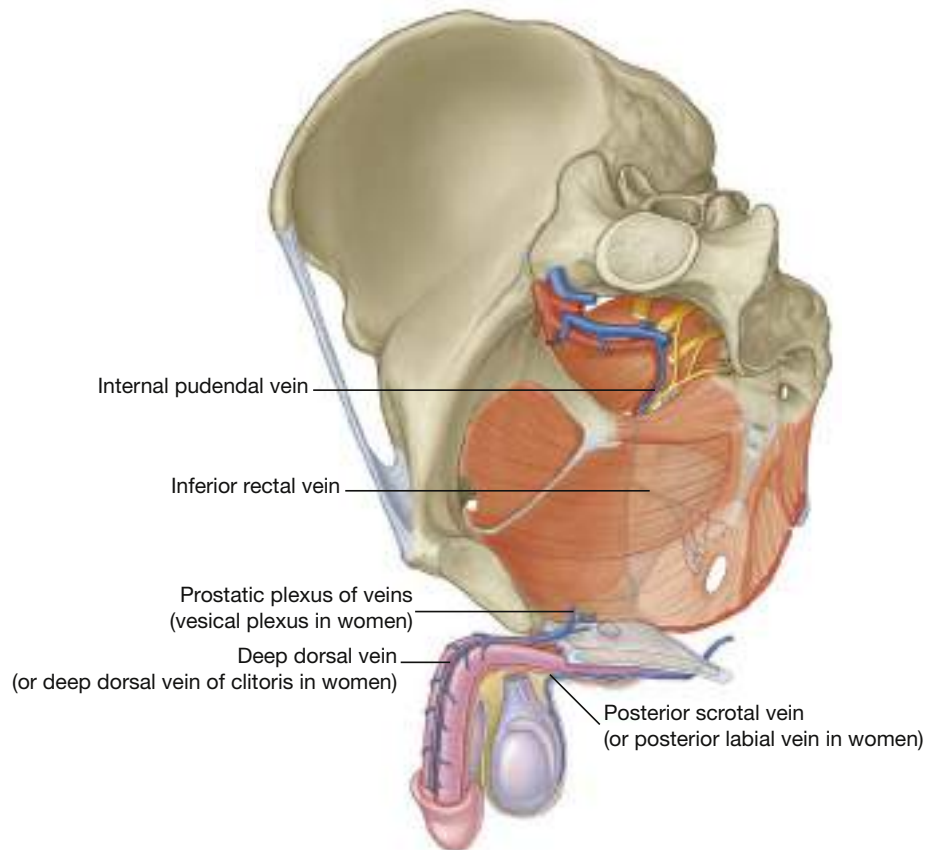


Fig. 5.54 Perineal veins.

- **Deep arteries of the clitoris** supply the crura and corpus cavernosum of the body.
- **Dorsal arteries of the clitoris** supply surrounding tissues and the glans.

External pudendal arteries

The **external pudendal arteries** consist of a superficial vessel and a deep vessel, which originate from the femoral artery in the thigh. They course medially to enter the perineum anteriorly and supply related skin of the penis and scrotum or the clitoris and labia majora.

Testicular and cremasteric arteries

In men, the **testicular arteries** originate from the abdominal aorta and descend into the scrotum through the inguinal canal to supply the testes. Also, **cremasteric arteries**, which originate from the inferior epigastric branch of the external iliac artery, accompany the spermatic cord into the scrotum.

In women, small cremasteric arteries follow the round ligament of the uterus through the inguinal canal.

Veins

Veins in the perineum generally accompany the arteries and join the **internal pudendal veins** that connect with the **internal iliac vein** in the pelvis (Fig. 5.54). The exception is the **deep dorsal vein of penis or clitoris** that drains mainly the glans and the corpora cavernosa. The deep dorsal vein courses along the midline between the dorsal arteries on each side of the body of penis or clitoris, passes through the gap between the inferior pubic ligament and the deep perineal pouch, and connects with the plexus of veins surrounding the prostate in men or bladder in women.

External pudendal veins, which drain anterior parts of the labia majora or the scrotum and overlap with the area of drainage of the internal pudendal veins, connect with the femoral vein in the thigh. Superficial dorsal veins of the penis or clitoris that drain skin are tributaries of the external pudendal veins.

Lymphatics

Lymphatic vessels from deep parts of the perineum accompany the internal pudendal blood vessels and drain mainly into **internal iliac nodes** in the pelvis.

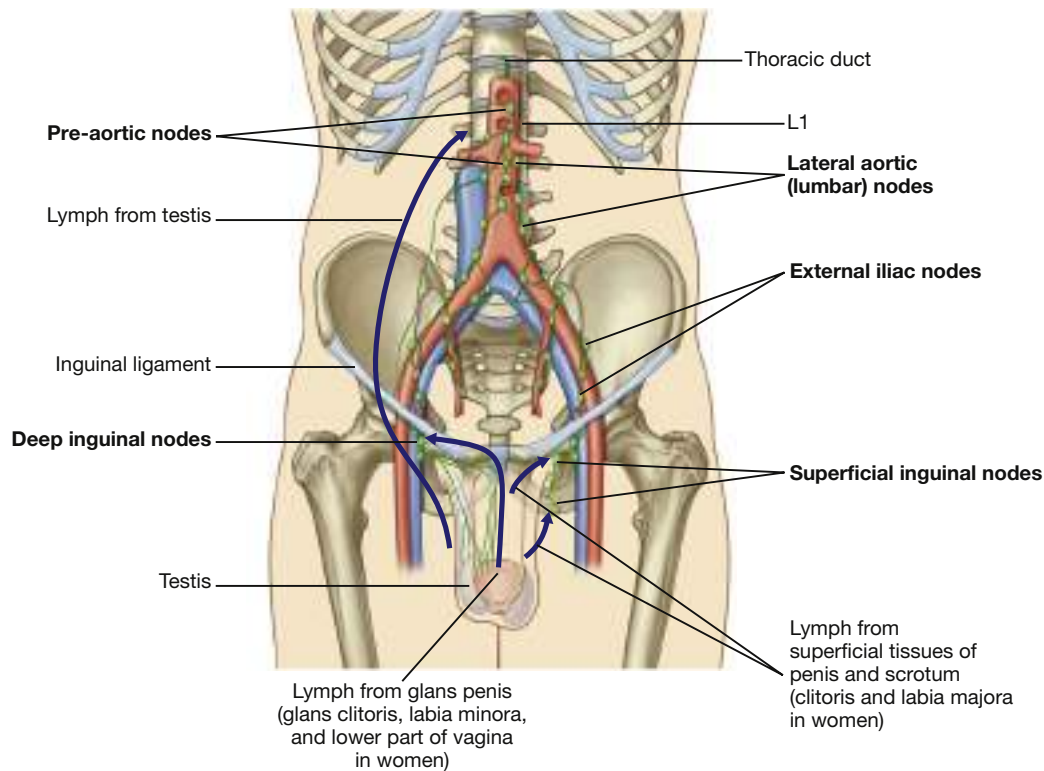


Fig. 5.55 Lymphatic drainage of the perineum.

Lymphatic channels from superficial tissues of the penis or the clitoris accompany the superficial external pudendal blood vessels and drain mainly into **superficial inguinal nodes**, as do lymphatic channels from the scrotum or labia majora (Fig. 5.55). The glans penis, the glans clitoris, labia minora, and the terminal inferior end of the vagina drain into **deep inguinal nodes** and **external iliac nodes**.

Lymphatics from the testes drain via channels that ascend in the spermatic cord, pass through the inguinal canal, and course up the posterior abdominal wall to connect directly with lateral aortic or lumbar nodes and pre-aortic nodes around the aorta at approximately vertebral levels LI and LII. Therefore disease from the testes tracks superiorly to nodes high in the posterior abdominal wall and not to inguinal or iliac nodes.



Imaging app

Visualizing the male pelvic cavity and perineum in the axial plane

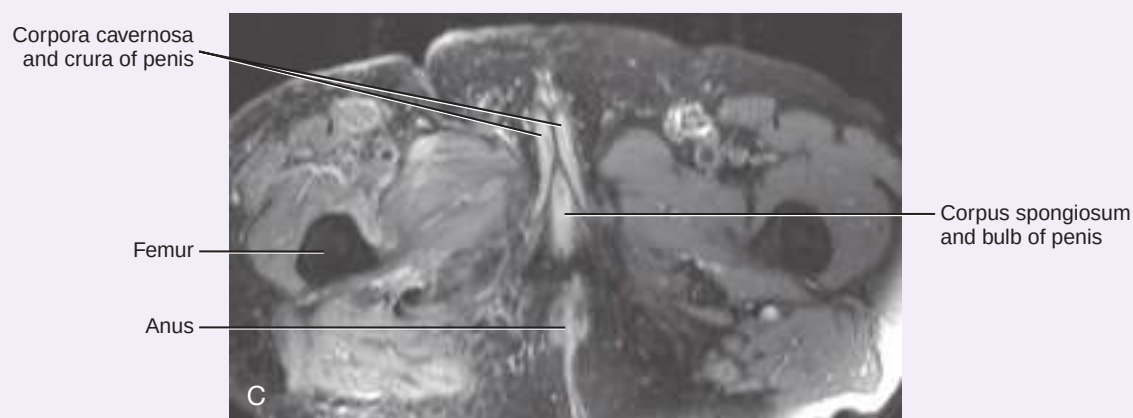
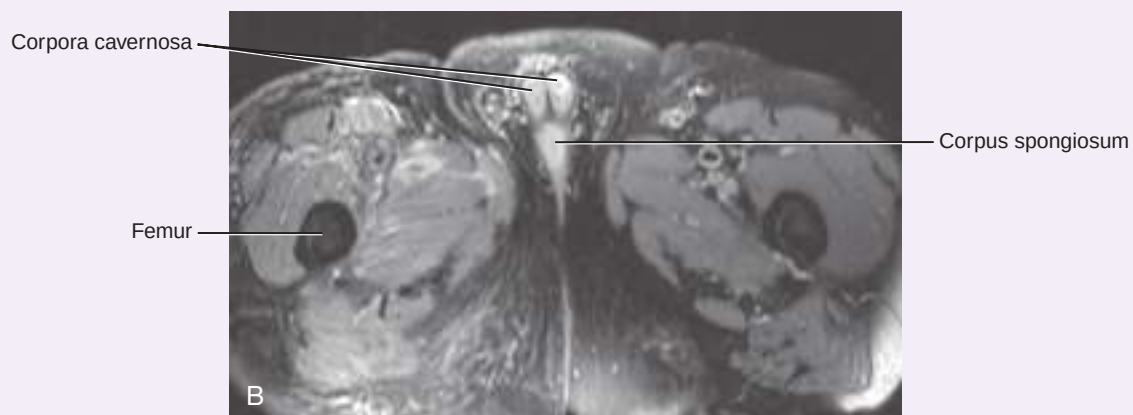
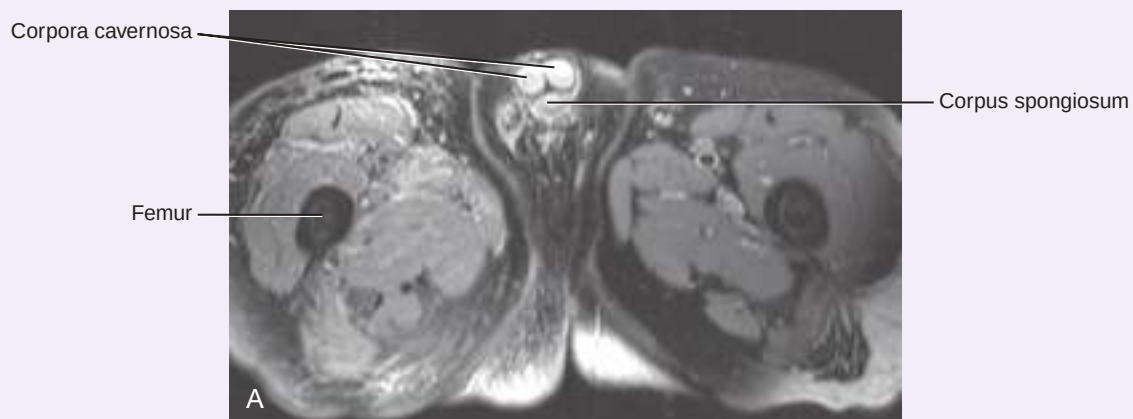


Fig. 5.56 A to C. Series of axial images that pass through the pelvic cavity and perineum from inferior to superior showing the various structures and their relationships to each other (T2-weighted MR images in axial plane).

Imaging app—cont'd

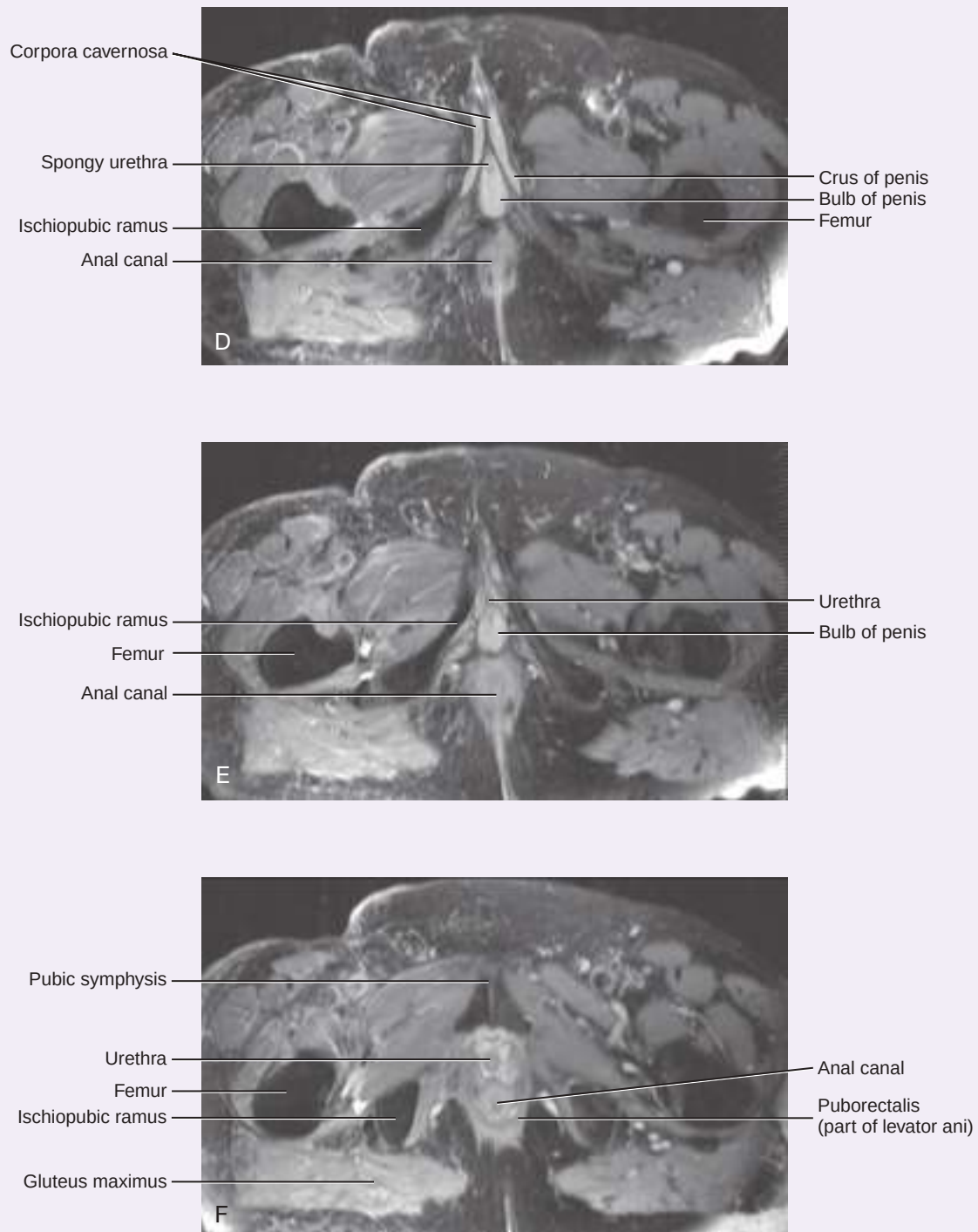


Fig. 5.56, cont'd D to F.

Continued



Imaging app—cont'd

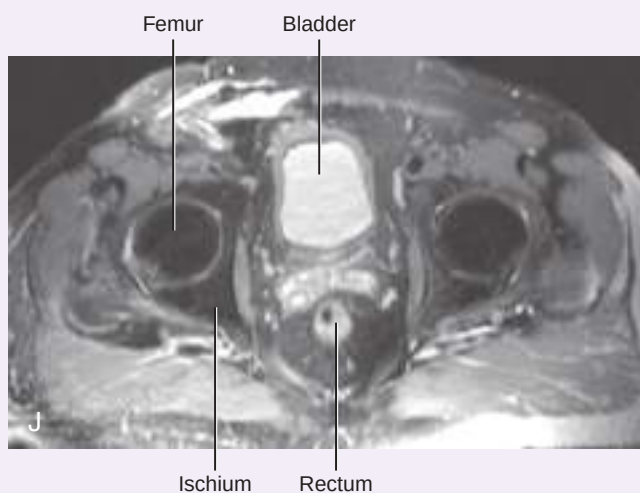
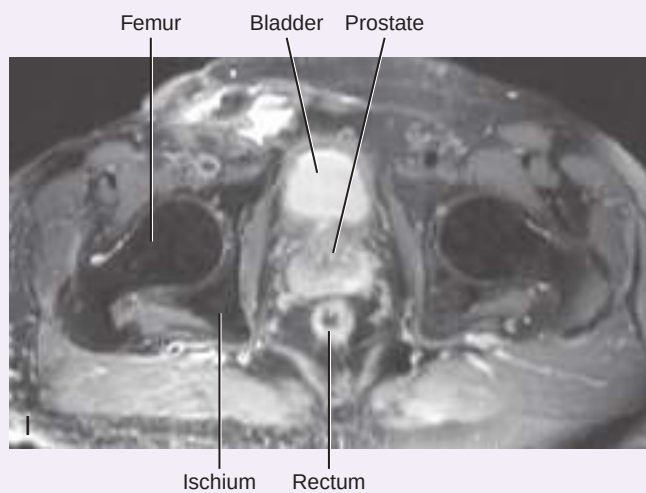
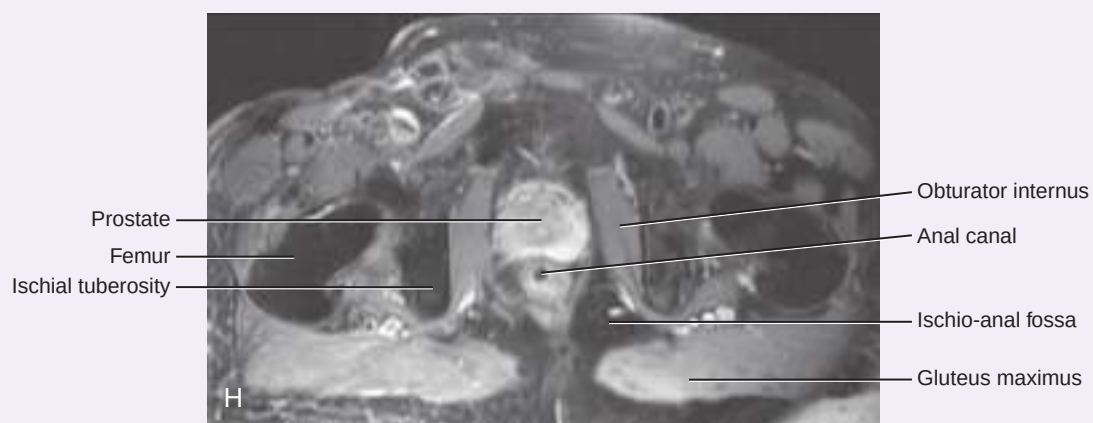
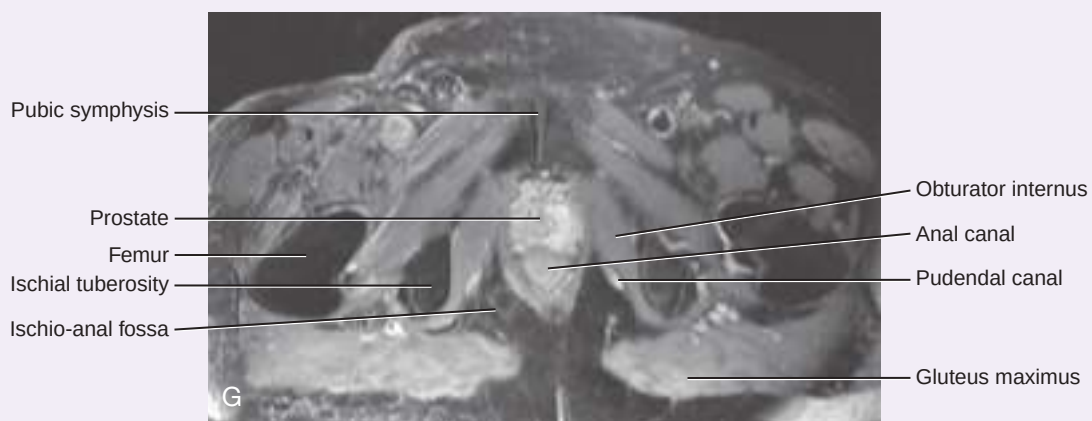


Fig. 5.56, cont'd G to J.

Imaging app

Visualizing the female pelvic cavity and perineum in the sagittal plane

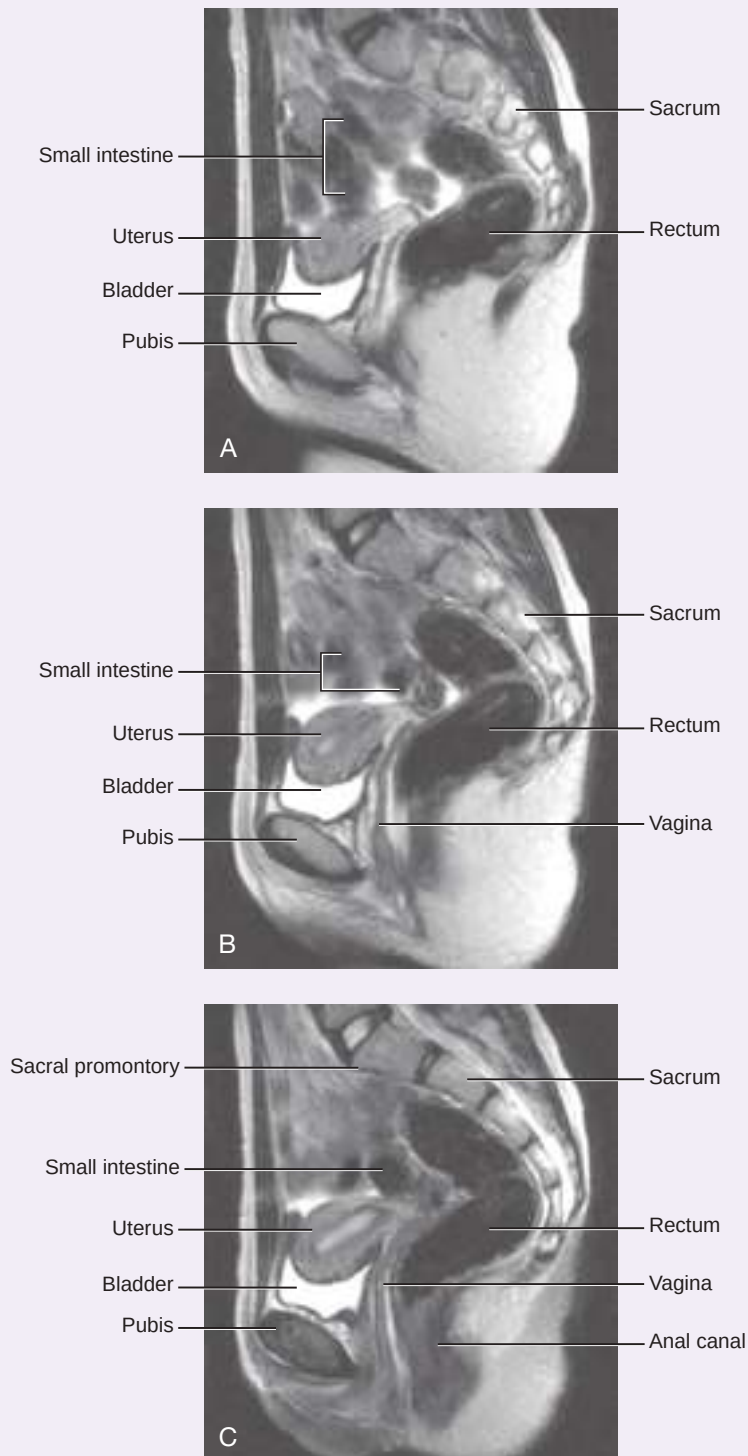


Fig. 5.57 A to C. Series of sagittal images that pass through the female pelvic cavity and perineum showing the various structures and their relationships to each other (T2-weighted MR images in sagittal plane).

Continued



Imaging app—cont'd

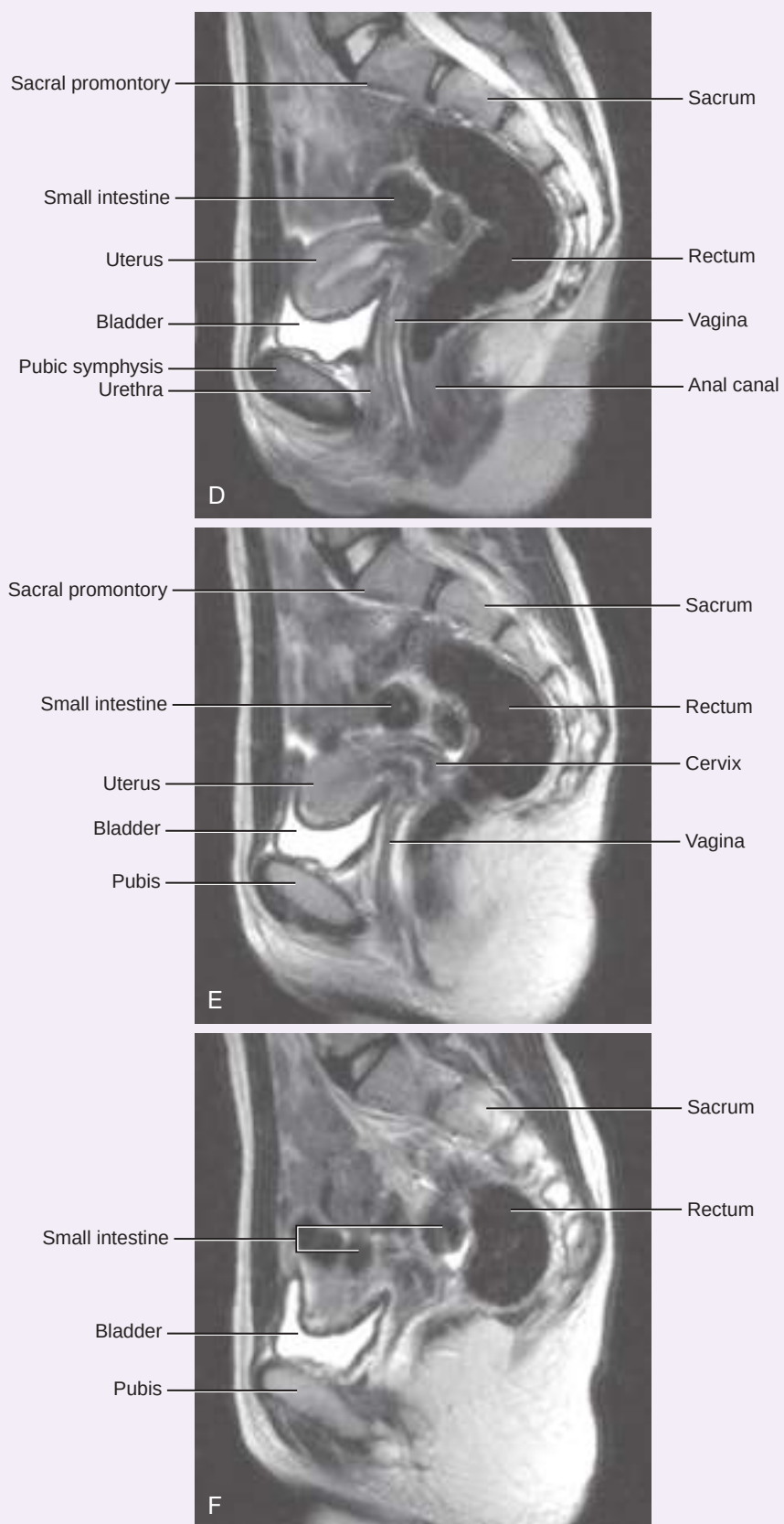


Fig. 5.57, cont'd D to F.

Imaging app

Visualizing the female pelvic cavity and perineum in the coronal plane

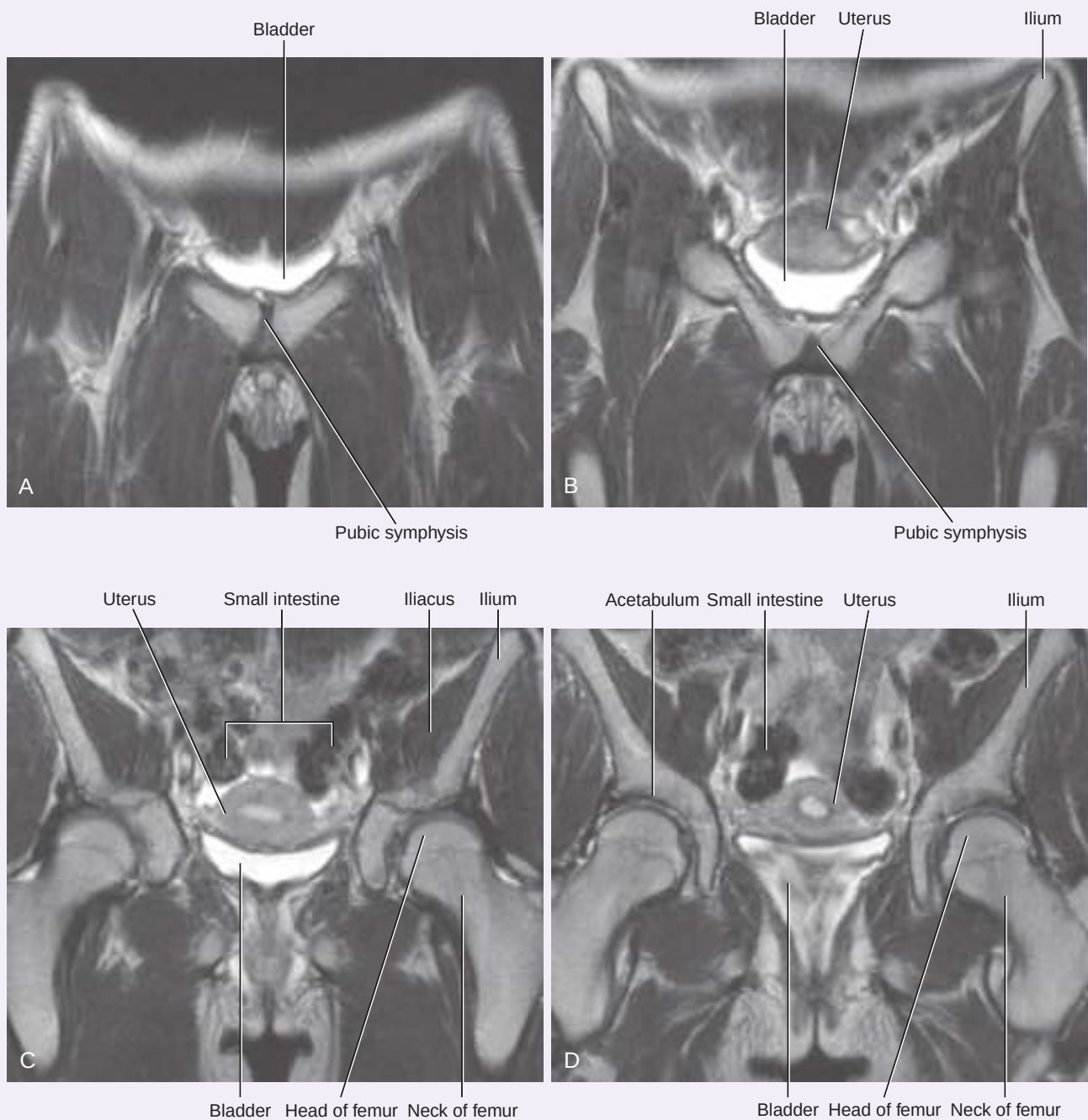


Fig. 5.58 A to D. Series of coronal images that pass through the pelvic cavity and perineum from anterior to posterior showing the various structures and their relationships to each other (T2-weighted MR images in coronal plane).



Imaging app

Visualizing the female pelvic cavity and perineum in the axial plane

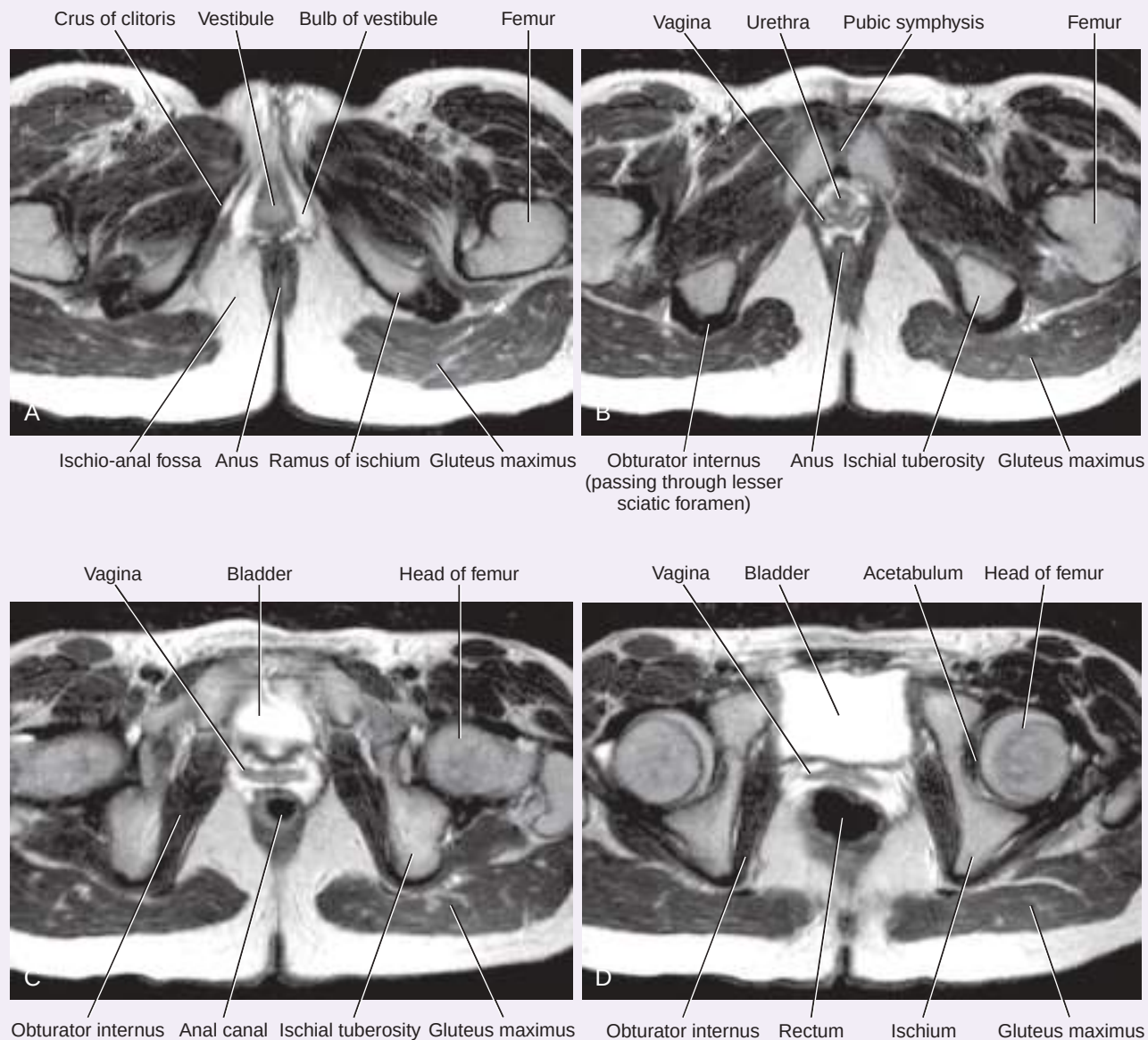


Fig. 5.59 A to D. Series of axial images that pass through the pelvic cavity and perineum from inferior to superior showing the various structures and their relationships with each other (T2-weighted MR images in axial plane).

Imaging app—cont'd

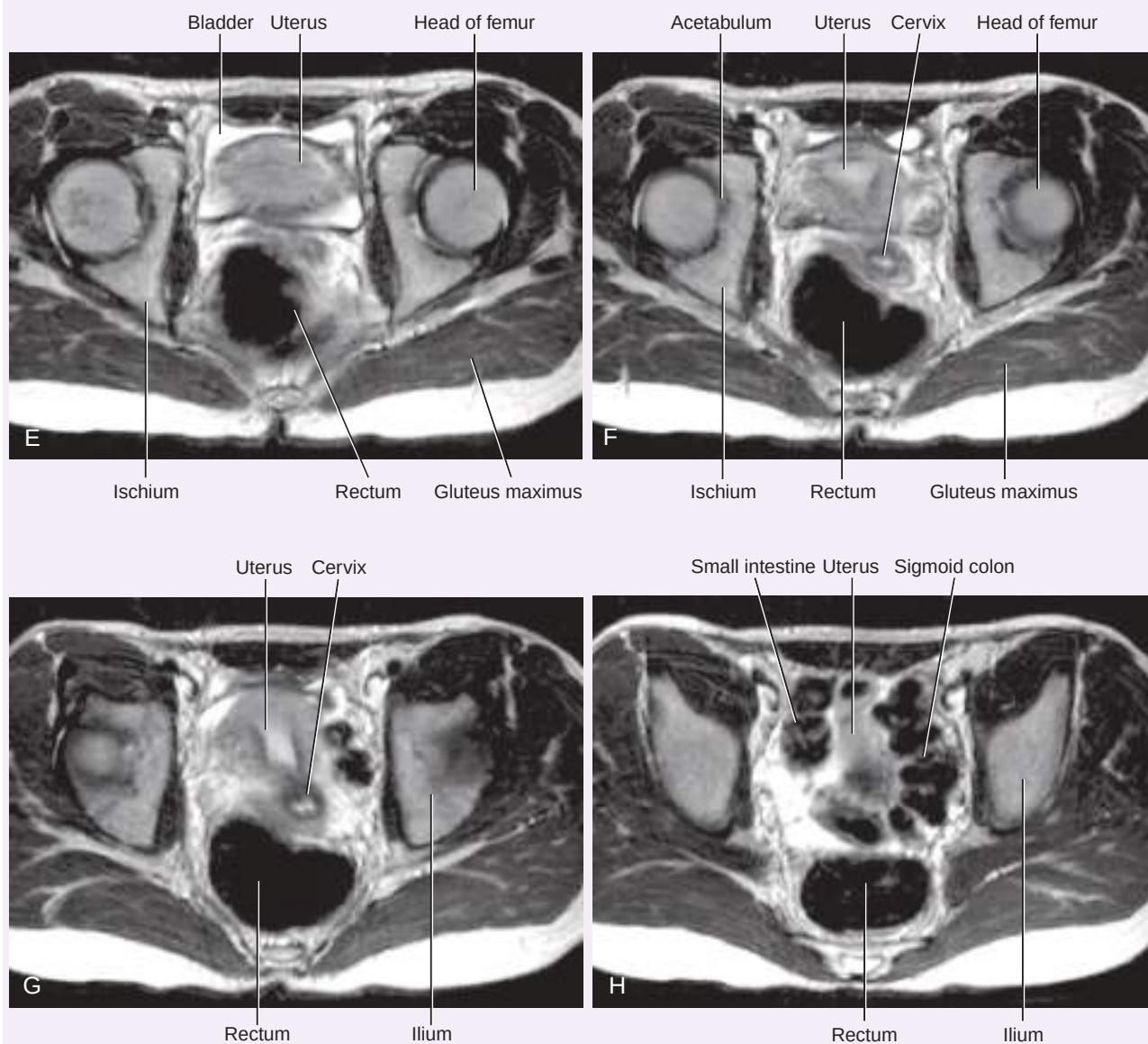


Fig. 5.59, cont'd E to H.

6

Lower Limb

ADDITIONAL LEARNING RESOURCES FOR CHAPTER 6, *LOWER LIMB*, CAN BE FOUND ON THE ACCOMPANYING EBOOK:

- Self-Assessment (scored) — National Board style multiple-choice questions, Chapter 6
- Short Questions (not scored) — these are questions requiring short responses, Chapter 6
- PT Case Studies
 - Plantar fasciitis
 - Achilles tendinitis and tendinosis
 - Eversion ankle sprain
 - High ankle sprain
 - Patellofemoral pain syndrome
 - Anterior lateral shin splints
 - See more PT Case Studies online*
- Clinical Cases
 - Femoral hernia
 - Groin injury
 - Iliopsoas tendinitis
 - Iliotibial band syndrome
 - Nerve entrapment syndrome
 - Pes cavus
 - Varicose veins
 - Knee joint injury
 - Fracture of neck of femur
 - Deep vein thrombosis
 - See more Clinical Cases online*

Regional anatomy 286 **Leg 331**

The hip 287
Bony pelvis 287
Proximal femur 290
Hip joint 292
Gateways to the lower limb 295
Nerves 297
Arteries 297
Veins 298
Lymphatics 299
Deep fascia and the saphenous opening 300
Femoral triangle 301

Gluteal region 303
Muscles 303
Nerves 305
Arteries 308
Veins 308
Lymphatics 308

Thigh 309
Bones 309
Muscles 313
Arteries 317
Veins 321
Nerves 321
Knee joint 323
Tibiofibular joint 329
Popliteal fossa 329

Foot 340
Bones 340
Joints 344
Tarsal tunnel, retinacula, and arrangement of major structures at the ankle 351
Arches of the foot 352
Plantar aponeurosis 353
Fibrous sheaths of toes 353
Extensor hoods 354
Intrinsic muscles 355
Arteries 357
Veins 359
Nerves 359

Regional anatomy

The lower limb is divided into the gluteal region, thigh, leg, and foot on the basis of major joints, component bones, and superficial landmarks (Figs. 6.1, 6.2):

- The **gluteal region** is posterolateral and between the iliac crest and the fold of skin (gluteal fold) that defines the lower limit of the buttocks. The major bone of the gluteal region is the pelvic bone.
- Anteriorly, the **thigh** is between the inguinal ligament and the knee joint—the hip joint is just inferior to the middle third of the inguinal ligament, and the posterior thigh is between the gluteal fold and the knee. The bone of the thigh is the femur.
- The **leg** is between the knee and ankle joints. The bones of the leg are the tibia and fibula.
- The **foot** is distal to the ankle joint. Bones of the foot are the tarsals, metatarsals, and phalanges.

The major functions of the lower limb are:

- to support the weight of the body when standing, and
- to move the body through space.

When standing erect, the line of the center of gravity is slightly posterior to the hip joints, anterior to the knee and ankle joints, and directly over the almost circular support base formed by the feet on the ground. The organization of ligaments at the hip and knee joints, together with the shape of the articular surfaces particularly at the knee, facilitates “locking” of these joints into position, thereby reducing the muscular energy required to maintain a standing position.

When walking, integration of movements at all joints in the lower limb positions the foot on the ground and moves the body smoothly over the foot with minimal changes in the position of the body’s center of gravity.

The lower limb is directly anchored to the axial skeleton by a sacro-iliac joint and by strong ligaments, which link the pelvic bone to the sacrum. This design serves to transmit the weight of the body above to the lower limb below.

Movements at the hip joint are flexion, extension, abduction, adduction, medial and lateral rotation, and circumduction (Fig. 6.3).

The knee and ankle joints are primarily hinge joints. Movements at the knee are mainly flexion and extension (Fig. 6.4A). Movements at the ankle are dorsiflexion

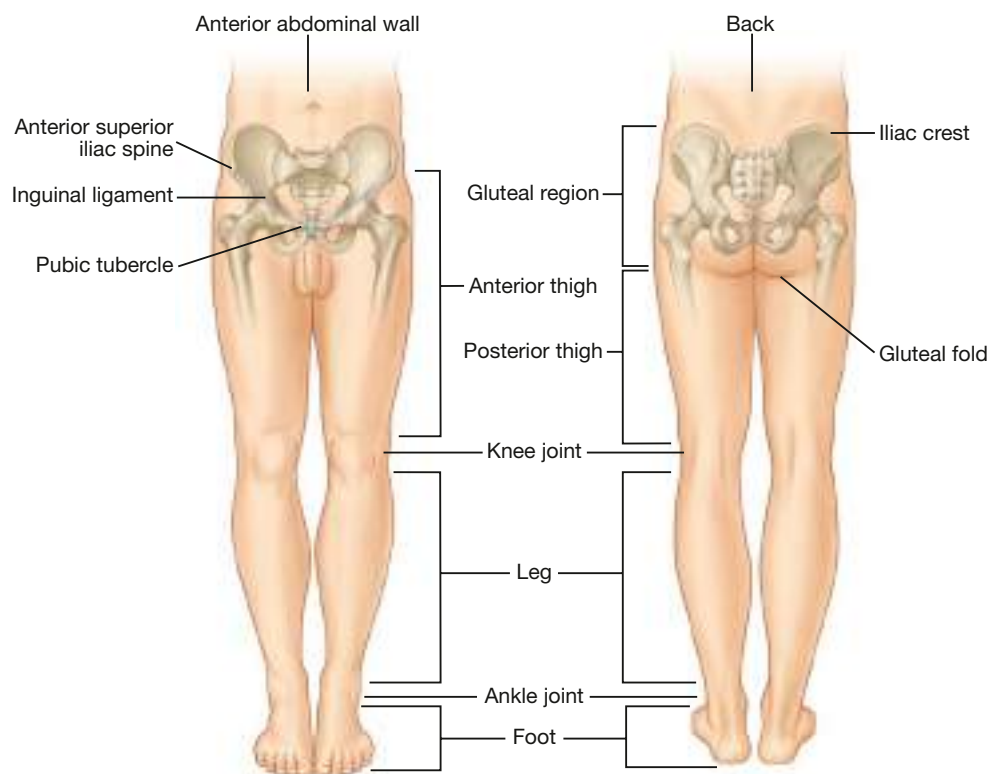


Fig. 6.1 Regions of the lower limb.

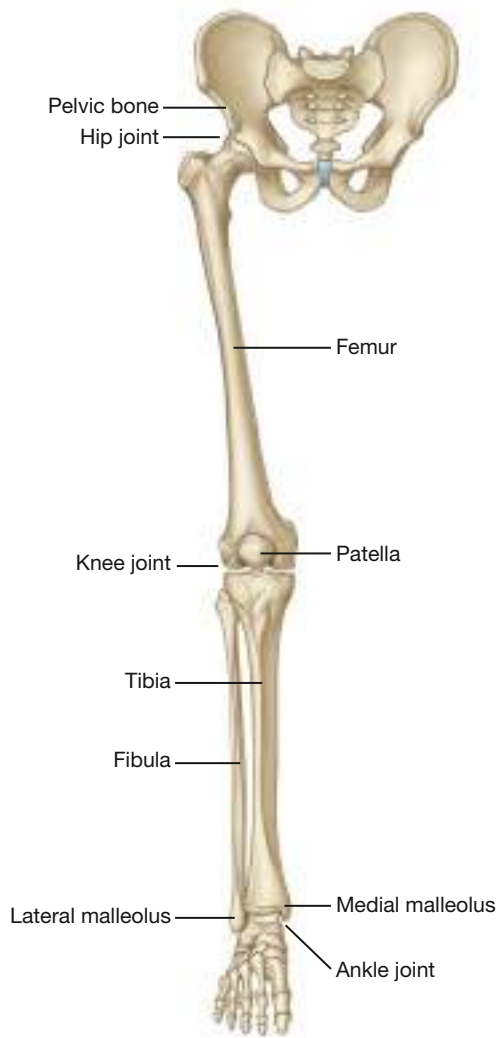


Fig. 6.2 Bones and joints of the lower limb.

(movement of the dorsal side of foot toward the leg) and plantarflexion (Fig. 6.4B).

THE HIP

Bony pelvis

The external surfaces of the pelvic bones, sacrum, and coccyx are predominantly the regions of the pelvis associated with the lower limb, although some muscles do originate from the deep or internal surfaces of these bones and from the deep surfaces of the lumbar vertebrae above.

Each pelvic bone is formed by three bones (**ilium**, **ischium**, and **pubis**), which fuse during childhood. The

ilium is superior and the pubis and ischium are anteroinferior and posteroinferior, respectively (Fig. 6.5).

Ilium

The upper fan-shaped part of the ilium is associated on its inner side with the abdomen and on its outer side with the lower limb. The top of this region is the **iliac crest**, which ends anteriorly as the **anterior superior iliac spine** and posteriorly as the **posterior superior iliac spine** (Fig. 6.5). A prominent lateral expansion of the crest just posterior to the anterior superior iliac spine is the **tuberculum of iliac crest**.

The anterior inferior iliac spine is on the anterior margin of the ilium, and below this, where the ilium fuses with the pubis, is a raised area of bone (the **iliopubic eminence** [Fig. 6.5]).

The gluteal surface of the ilium faces posterolaterally, lies below the iliac crest, and provides attachment for the gluteal muscles. It is marked by three curved lines (inferior, anterior, and posterior gluteal lines (Fig. 6.5):

- The **inferior gluteal line** originates just superior to the anterior inferior iliac spine and curves inferiorly across the bone to end near the posterior margin of the acetabulum.
- The **anterior gluteal line** originates from the lateral margin of the iliac crest between the anterior superior iliac spine and the tuberculum of iliac crest and arches inferiorly across the ilium to disappear just superior to the upper margin of the greater sciatic foramen.
- The **posterior gluteal line** descends almost vertically from the iliac crest to a position near the posterior inferior iliac spine.

Ischial tuberosity

The **ischial tuberosity** is posteroinferior to the acetabulum and is associated mainly with the hamstring muscles of the posterior thigh (Fig. 6.6). It is divided into upper and lower areas by a transverse line.

The upper area of the ischial tuberosity is oriented vertically and is further subdivided into two parts by an oblique line that descends from medial to lateral across the surface.

The lower area of the ischial tuberosity is oriented horizontally and is divided into medial and lateral regions by a ridge of bone.

When sitting, this medial part supports the body weight.

The sacrotuberous ligament is attached to a sharp ridge on the medial margin of the ischial tuberosity.

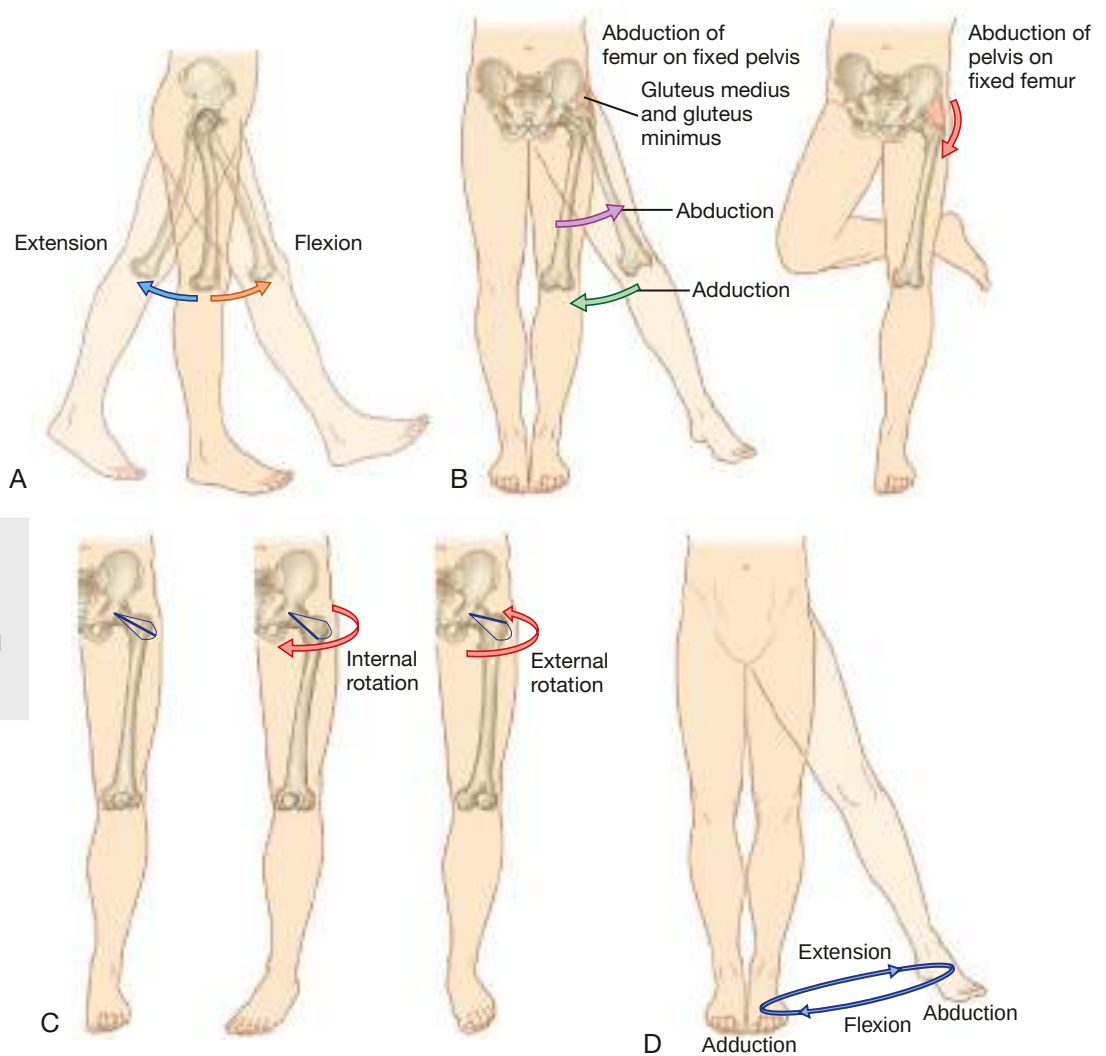


Fig. 6.3 Movements of the hip joint. **A.** Flexion and extension. **B.** Abduction and adduction. **C.** External and internal rotation. **D.** Circumduction.

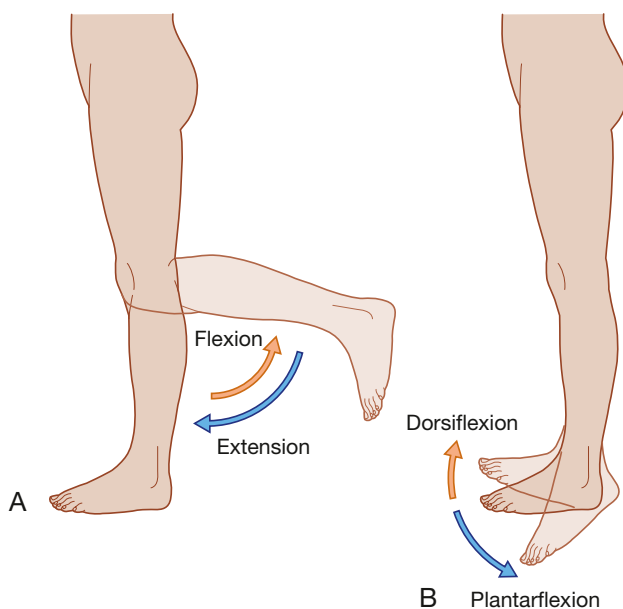


Fig. 6.4 Movements of the knee and ankle. **A.** Knee flexion and extension. **B.** Ankle dorsiflexion and plantarflexion.

Ischiopubic ramus and pubic bone

The external surfaces of the ischiopubic ramus anterior to the ischial tuberosity and the body of the pubis provide attachment for muscles of the medial compartment of thigh (Fig. 6.6).

Acetabulum

The large cup-shaped **acetabulum** for articulation with the head of the femur is on the lateral surface of the pelvic bone in the region where the ilium, pubis, and ischium fuse (Fig. 6.7).

The margin of the acetabulum is marked inferiorly by a prominent notch (**acetabular notch**).

The wall of the acetabulum consists of nonarticular and articular parts:

- The nonarticular part is rough and forms a shallow circular depression (the **acetabular fossa**) in central and inferior parts of the acetabular floor; the acetabular notch is continuous with the acetabular fossa (Fig. 6.7).

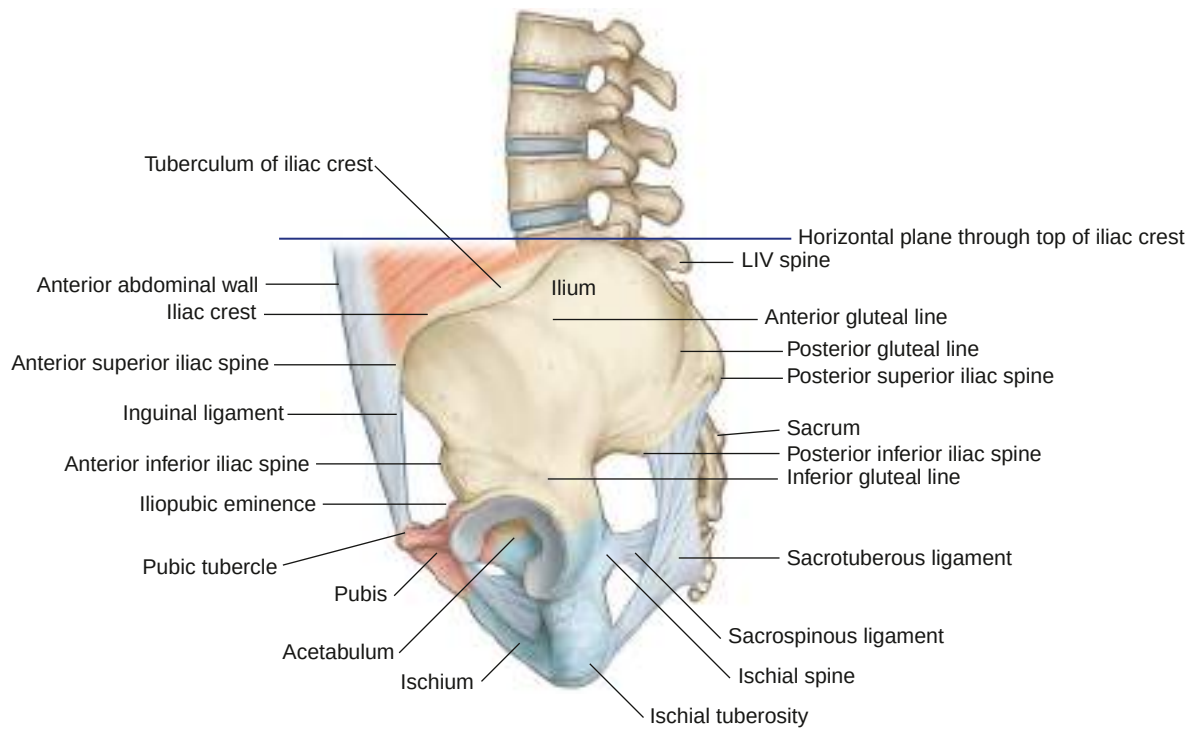


Fig. 6.5 External surface of the bony pelvis. Lateral view.

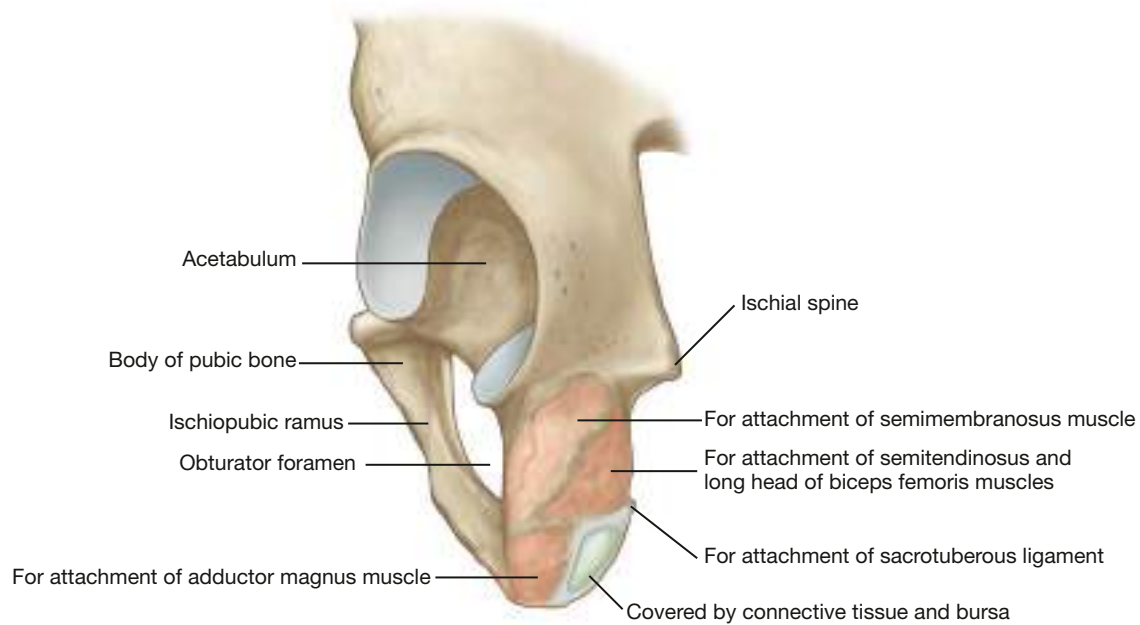


Fig. 6.6 Ischial tuberosity. Posterolateral view.



Fig. 6.7 Acetabulum.

- The articular (**lunate**) **surface** is broad and surrounds the anterior, superior, and posterior margins of the acetabular fossa (Fig. 6.7).

The smooth, crescent-shaped, articular surface (the lunate surface) is broadest superiorly where most of the body's weight is transmitted through the pelvis to the femur. The lunate surface is deficient inferiorly at the acetabular notch (Fig. 6.7).

The acetabular fossa provides attachment for the ligament of the head of the femur, whereas blood vessels and nerves pass through the acetabular notch.

Clinical app

Pelvic fractures

There are many ways of classifying pelvic fractures that enable a surgeon to determine the appropriate treatment and the patient's prognosis. The pelvic bones, sacrum, and associated joints form a bony ring surrounding the pelvic cavity.

Pelvic fractures are generally of four types.

- Type 1 injuries occur without disruption of the bony pelvic ring (e.g., a fracture of the iliac crest). These types of injuries are unlikely to represent significant trauma, though in the case of a fracture of the iliac crest, blood loss needs to be assessed.
- Type 2 injuries occur with a single break in the bony pelvic ring. An example of this would be a single fracture with diastasis (separation) of the pubic symphysis.

- Type 3 injuries occur with double breaks in the bony pelvic ring. These include bilateral fractures of the pubic rami, which may produce urethral damage.
- Type 4 injuries occur at and around the acetabulum.

Other types of pelvic ring injuries include disruption of the sacro-iliac joint with or without dislocation. This may involve significant visceral pelvic trauma and hemorrhage.

Other general pelvic injuries include stress fractures and insufficiency fractures, as seen in athletes and in elderly patients with osteoporosis, respectively.

Proximal femur

The femur is the bone of the thigh and the longest bone in the body. Its proximal end is characterized by a head and neck and two large projections (the greater and lesser trochanters) on the upper part of the shaft (Fig. 6.8).

The **head** of the femur is spherical and articulates with the acetabulum of the pelvic bone. It is characterized by a nonarticular pit (**fovea**) on its medial surface for the attachment of the ligament of the head.

The **neck** of the femur is a cylindrical strut of bone that connects the head to the shaft of the femur. It projects superomedially from the shaft at an angle of approximately 125° and projects slightly forward. The orientation of the neck relative to the shaft increases the range of movement of the hip joint.

The upper part of the **shaft** of the femur bears a greater and lesser trochanter, which are attachment sites for muscles that move the hip joint.

Greater and lesser trochanters

The **greater trochanter** extends superiorly from the shaft of the femur just lateral to the region where the shaft joins the neck of the femur (Fig. 6.8). It continues posteriorly where its medial surface is deeply grooved to form the **trochanteric fossa**. The lateral wall of this fossa bears a distinct oval depression for attachment of the obturator externus muscle.

The greater trochanter has an elongate ridge on its antero-lateral surface for attachment of the gluteus minimus and a similar ridge more posteriorly on its lateral surface for attachment of the gluteus medius. Between these two points, the greater trochanter is palpable.

On the medial side of the superior aspect of the greater trochanter and just above the trochanteric fossa is a small impression for attachment of the obturator internus and its associated gemelli muscles, and immediately

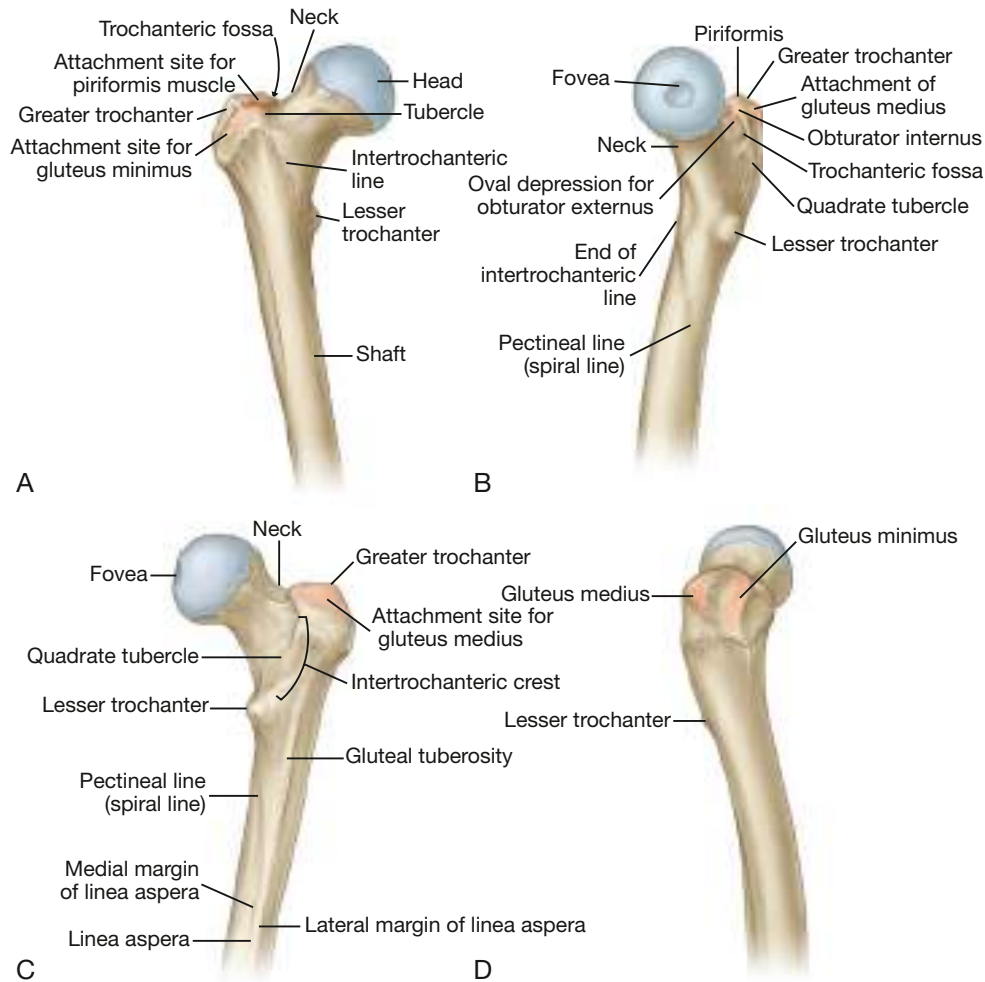


Fig. 6.8 Proximal end of the right femur. **A.** Anterior view. **B.** Medial view. **C.** Posterior view. **D.** Lateral view.

above and behind this feature is an impression on the margin of the trochanter for attachment of the piriformis muscle.

The **lesser trochanter** is smaller than the greater trochanter and has a blunt conical shape. It projects posteromedially from the shaft of femur just inferior to the junction with the neck (Fig. 6.8). It is the attachment site for the combined tendons of psoas major and iliacus muscles.

Extending between the two trochanters and separating the shaft from the neck of the femur are the intertrochanteric line and intertrochanteric crest.

Intertrochanteric line

The **intertrochanteric line** is a ridge of bone on the anterior surface of the upper margin of the shaft that descends medially from a tubercle on the anterior surface of the base of the greater trochanter to a position

just anterior to the base of the lesser trochanter (Fig. 6.8). It is continuous with the **pectineal line** (spiral line), which curves medially under the lesser trochanter and around the shaft of the femur to merge with the medial margin of the **linea aspera** on the posterior aspect of the femur.

Intertrochanteric crest

The **intertrochanteric crest** is on the posterior surface of the femur and descends medially across the bone from the posterior margin of the greater trochanter to the base of the lesser trochanter (Fig. 6.8). It is a broad smooth ridge of bone with a prominent tubercle (the **quadrate tubercle**) on its upper half, which provides attachment for the quadratus femoris muscle.

Shaft of the femur

The shaft of the femur descends from lateral to medial in the coronal plane at an angle of 7° from the vertical axis (Fig. 6.9).

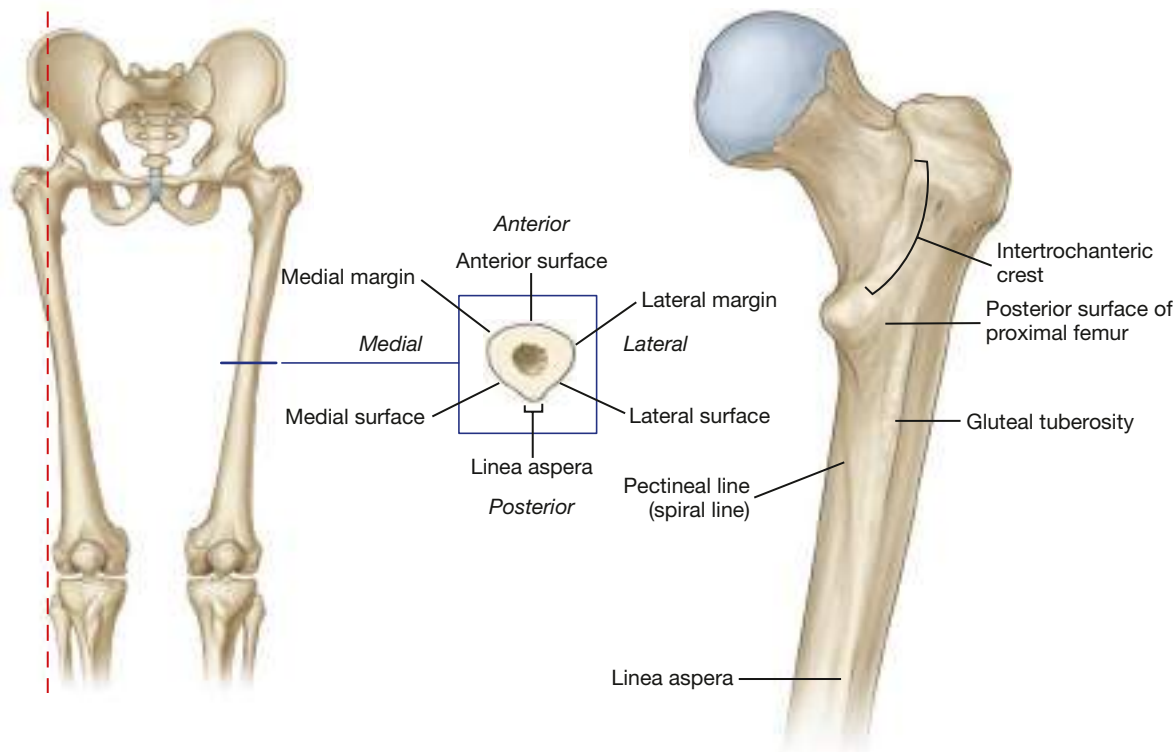


Fig. 6.9 Shaft of the femur. On the right is a posterior view of proximal shaft of right femur.

The distal end of the femur is therefore closer to the midline than the upper end of the shaft.

The middle third of the shaft of the femur is triangular in shape with smooth lateral and medial margins between anterior, lateral (posterolateral), and medial (posteromedial) surfaces. The posterior margin is broad and forms a prominent raised crest (the linea aspera) (Fig. 6.9).

The linea aspera is a major site of muscle attachment in the thigh. In the proximal third of the femur, the medial and lateral margins of the linea aspera diverge and continue superiorly as the pectineal line and gluteal tuberosity, respectively (Fig. 6.9):

- The pectineal line curves anteriorly under the lesser trochanter and joins the intertrochanteric line.
- The gluteal tuberosity is a broad linear roughening that curves laterally to the base of the greater trochanter.

The gluteus maximus muscle is attached to the gluteal tuberosity.

The triangular area enclosed by the pectineal line, the gluteal tuberosity, and the intertrochanteric crest is

the posterior surface of the proximal end of the femur (Fig. 6.9).

Hip joint

The hip joint is a synovial articulation between the head of the femur and the acetabulum of the pelvic bone (Fig. 6.11A; also see Fig. 6.16). The joint is a multiaxial ball-and-socket

Clinical app

Femoral neck fractures

Femoral neck fractures (Fig. 6.10) can interrupt blood supply to the femoral head. Blood supply to the head and neck is primarily from an arterial ring formed by the branches of the medial and lateral circumflex femoral arteries around the base of the femoral neck. From here, vessels course along the neck, penetrate the capsule, and supply the femoral head. Blood supply to the femoral head and femoral neck is further enhanced by the artery of the ligament of head of femur, a branch of the obturator artery, which is generally small and variable. Femoral neck fractures may disrupt associated vessels and lead to necrosis of the femoral head.



Fig. 6.10 This radiograph of the pelvis, anteroposterior view, demonstrates a fracture of the neck of the femur.

Clinical app

Intertrochanteric fractures

In these fractures, the break usually runs from the greater trochanter through to the lesser trochanter and does not involve the femoral neck. Intertrochanteric fractures preserve the femoral neck blood supply and do not render the femoral head ischemic.

Clinical app

Femoral shaft fractures

An appreciable amount of energy is needed to fracture the femoral shaft. This type of injury is therefore accompanied by damage to the surrounding soft tissues, which include the muscle compartments and the structures they contain.

joint designed for stability and weightbearing at the expense of mobility.

When considering the effects of muscle action on the hip joint, the long neck of the femur and the angulation of the neck on the shaft of the femur must be kept in mind. For example, medial and lateral rotation of the femur involves muscles that move the greater trochanter forward and backward, respectively, relative to the acetabulum ([Fig. 6.11B](#)).

The articular surfaces of the hip joint are:

- the spherical head of the femur, and
- the lunate surface of the acetabulum of the pelvic bone ([Fig. 6.12A](#)).

The acetabulum almost entirely encompasses the hemispherical head of the femur and contributes substantially to joint stability. The nonarticular acetabular fossa contains loose connective tissue. The lunate surface is covered by hyaline cartilage and is broadest superiorly ([Fig. 6.12](#)).

Except for the fovea, the head of the femur is also covered by hyaline cartilage.

The rim of the acetabulum is raised slightly by a fibrocartilaginous collar (the **acetabular labrum**). Inferiorly, the labrum bridges across the acetabular notch as the **transverse acetabular ligament** and converts the notch into a foramen ([Fig. 6.12A](#)).

The **ligament of head of femur** is a flat band of delicate connective tissue that attaches at one end to the fovea on the head of the femur and at the other end to the acetabular fossa, transverse acetabular ligament, and margins of the acetabular notch

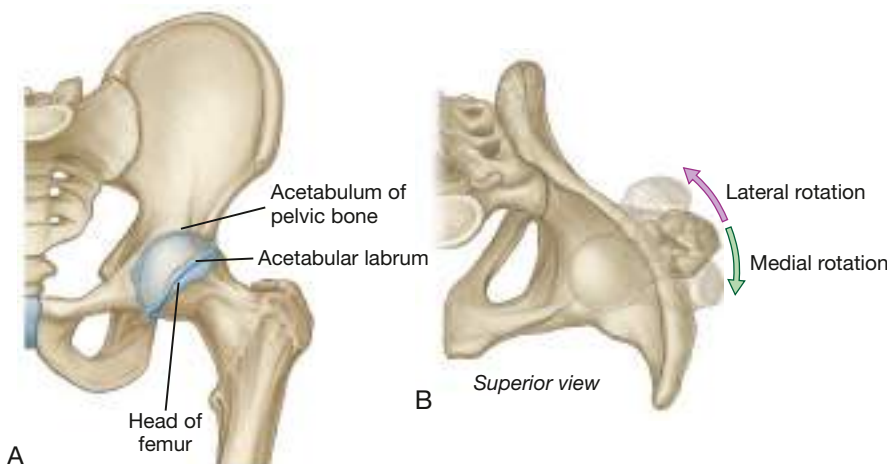


Fig. 6.11 Hip joint. **A.** Articular surfaces. Anterior view. **B.** Movement of the neck of the femur during medial and lateral rotation. Superior view.

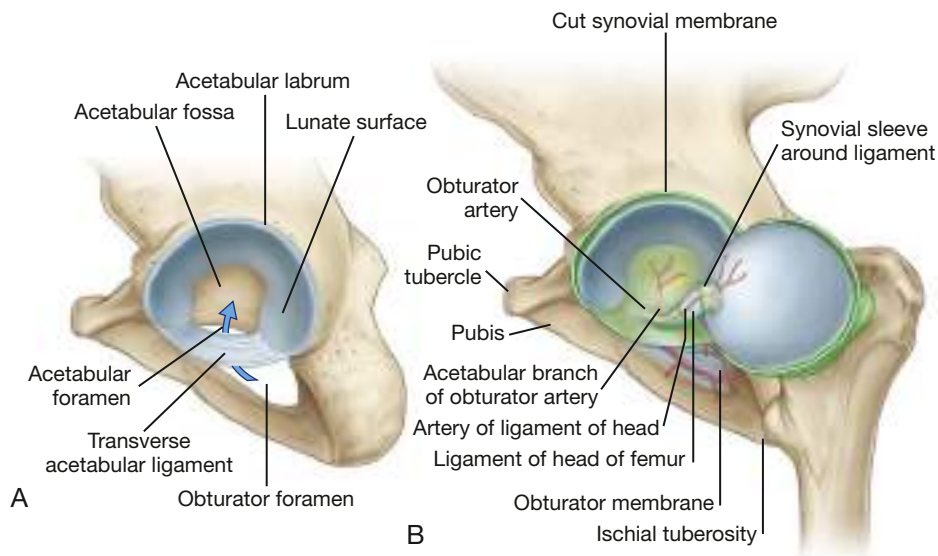


Fig. 6.12 Hip joint. **A.** Transverse acetabular ligament. **B.** Ligament of the head of the femur. The head of the femur has been laterally rotated out of the acetabulum to show the ligament.

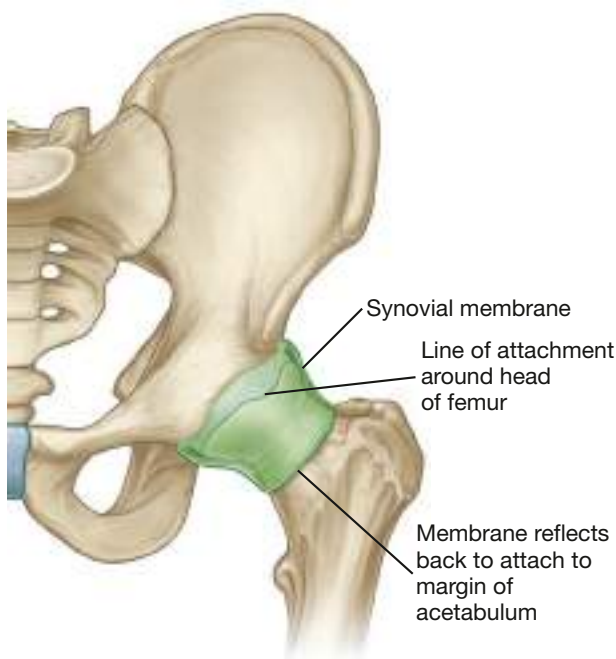


Fig. 6.13 Synovial membrane of the hip joint.

(Fig. 6.12B). It carries a small branch of the obturator artery, which contributes to the blood supply of the head of the femur.

The synovial membrane attaches to the margins of the articular surfaces of the femur and acetabulum, forms a tubular covering around the ligament of head of femur, and lines the fibrous membrane of the joint (Figs. 6.12B, 6.13). From its attachment to the margin of the head of the femur, the synovial membrane covers the neck of the femur before reflecting onto the fibrous membrane (Fig. 6.13).

The fibrous membrane that encloses the hip joint is strong and generally thick. Medially, it is attached to the margin of the acetabulum, the transverse acetabular ligament, and

the adjacent margin of the obturator foramen (Fig. 6.14A). Laterally, it is attached to the intertrochanteric line on the anterior aspect of the femur and to the neck of the femur just proximal to the intertrochanteric crest on the posterior surface.

Ligaments

Three ligaments reinforce the external surface of the fibrous membrane and stabilize the joint: the iliofemoral, pubofemoral, and ischiofemoral ligaments.

- The **iliofemoral ligament** is anterior to the hip joint and is triangular-shaped (Fig. 6.14B). Its apex is attached to the ilium between the anterior inferior iliac spine and the margin of the acetabulum and its base is attached along the intertrochanteric line of the femur. Parts of the ligament attached above and below the intertrochanteric line are thicker than those attached to the central part of the line. This results in the ligament having a Y appearance.
- The **pubofemoral ligament** is anteroinferior to the hip joint (Fig. 6.14B). It is also triangular in shape, with its base attached medially to the iliopubic eminence, adjacent bone, and obturator membrane. Laterally, it blends with the fibrous membrane and with the deep surface of the iliofemoral ligament.
- The **ischiofemoral ligament** reinforces the posterior aspect of the fibrous membrane (Fig. 6.14C). It is attached medially to the ischium just posteroinferior to the acetabulum and laterally to the greater trochanter deep to the iliofemoral ligament.

The fibers of all three ligaments are oriented in a spiral fashion around the hip joint so that they become taut when the joint is extended. This stabilizes the joint and reduces the amount of muscle energy required to maintain a standing position.

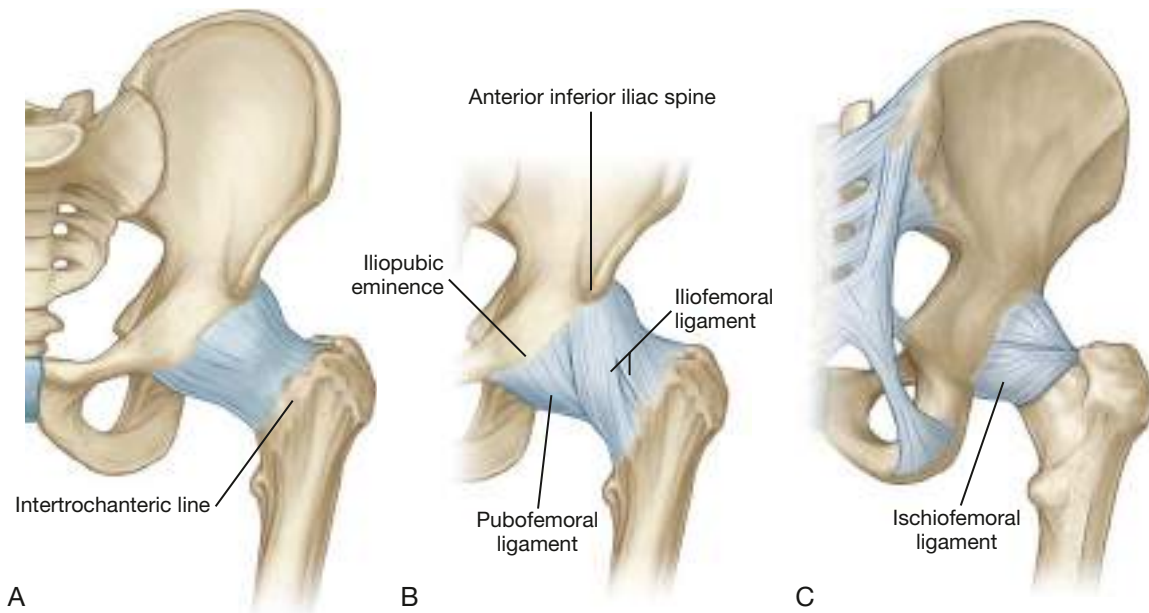


Fig. 6.14 Fibrous membrane and ligaments of the hip joint. **A.** Fibrous membrane of the joint capsule. Anterior view. **B.** Iliofemoral and pubofemoral ligaments. Anterior view. **C.** Ischiofemoral ligament. Posterior view.

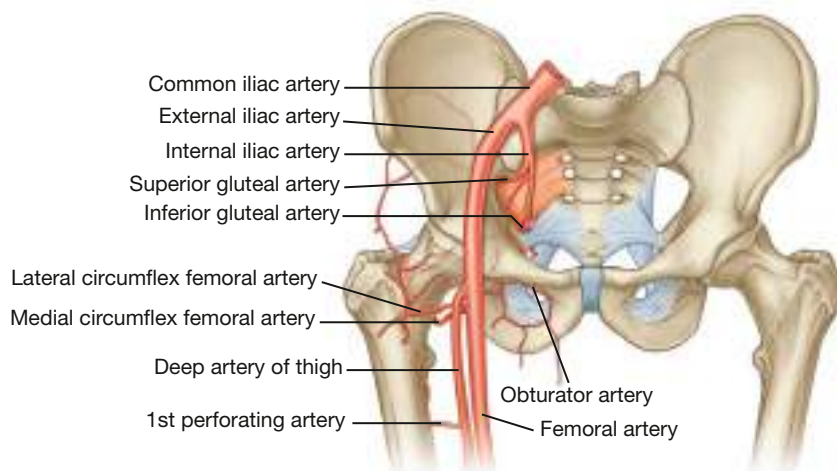


Fig. 6.15 Blood supply of the hip joint.

Blood supply and innervation

Vascular supply to the hip joint is predominantly through branches of the **obturator artery**, **medial and lateral circumflex femoral arteries**, **superior and inferior gluteal arteries**, and the **first perforating branch** of the deep artery of the thigh. The articular branches of these vessels form a network around the joint (Fig. 6.15).

The hip joint is innervated by articular branches from the femoral, obturator, and superior gluteal nerves and the nerve to the quadratus femoris.

Gateways to the lower limb

There are four major routes by which structures pass from the abdomen and pelvis into and out of the lower limb (Fig. 6.17):

- **Obturator canal** — an almost vertically oriented passageway at the anterosuperior edge of the obturator foramen. The obturator canal connects the abdominopelvic region with the medial compartment of thigh.
- **Greater sciatic foramen** — formed on the posterolateral pelvic wall and is the major route for structures to pass between the pelvis and the gluteal region of the lower limb (Fig. 6.17). The piriformis muscle passes out of the pelvis into the gluteal region through the greater sciatic foramen and separates the foramen into two parts, a part above the muscle and a part below.
- **Lesser sciatic foramen** — inferior to the greater sciatic foramen on the posterolateral pelvic wall (Fig. 6.17). It is also inferior to the lateral attachment of the pelvic

Imaging app

Visualizing the hip joint

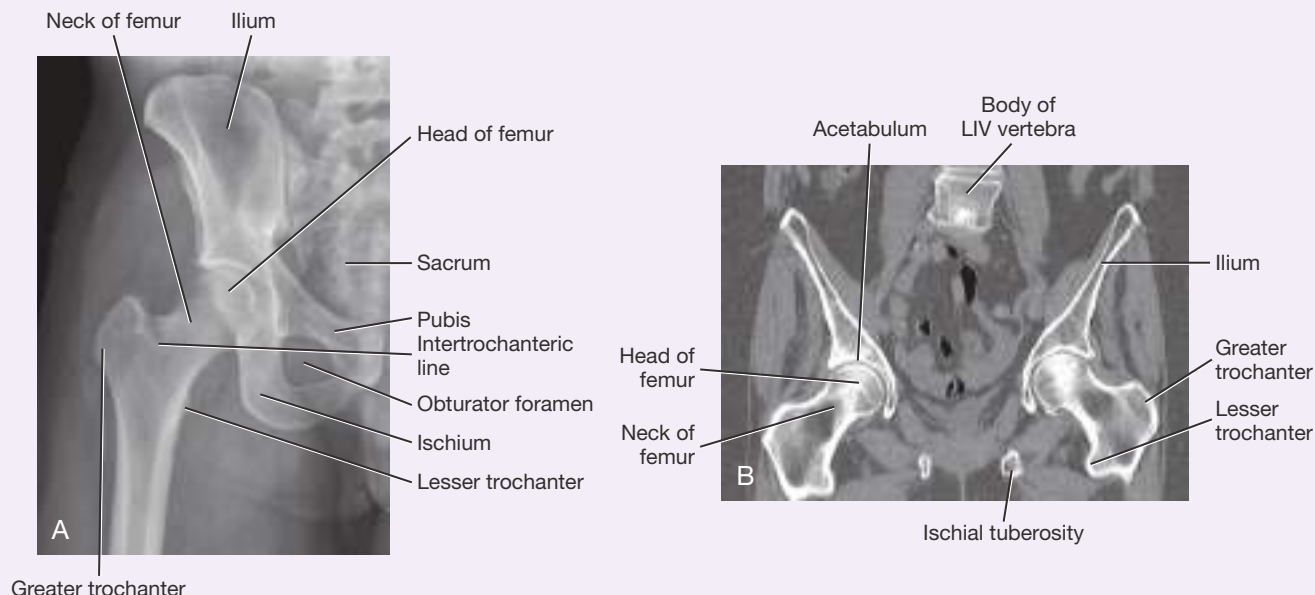


Fig. 6.16 Hip joint. **A.** Normal hip joint. Radiograph, anterior-posterior view. **B.** Hip joints. Computed tomography image in coronal plane.

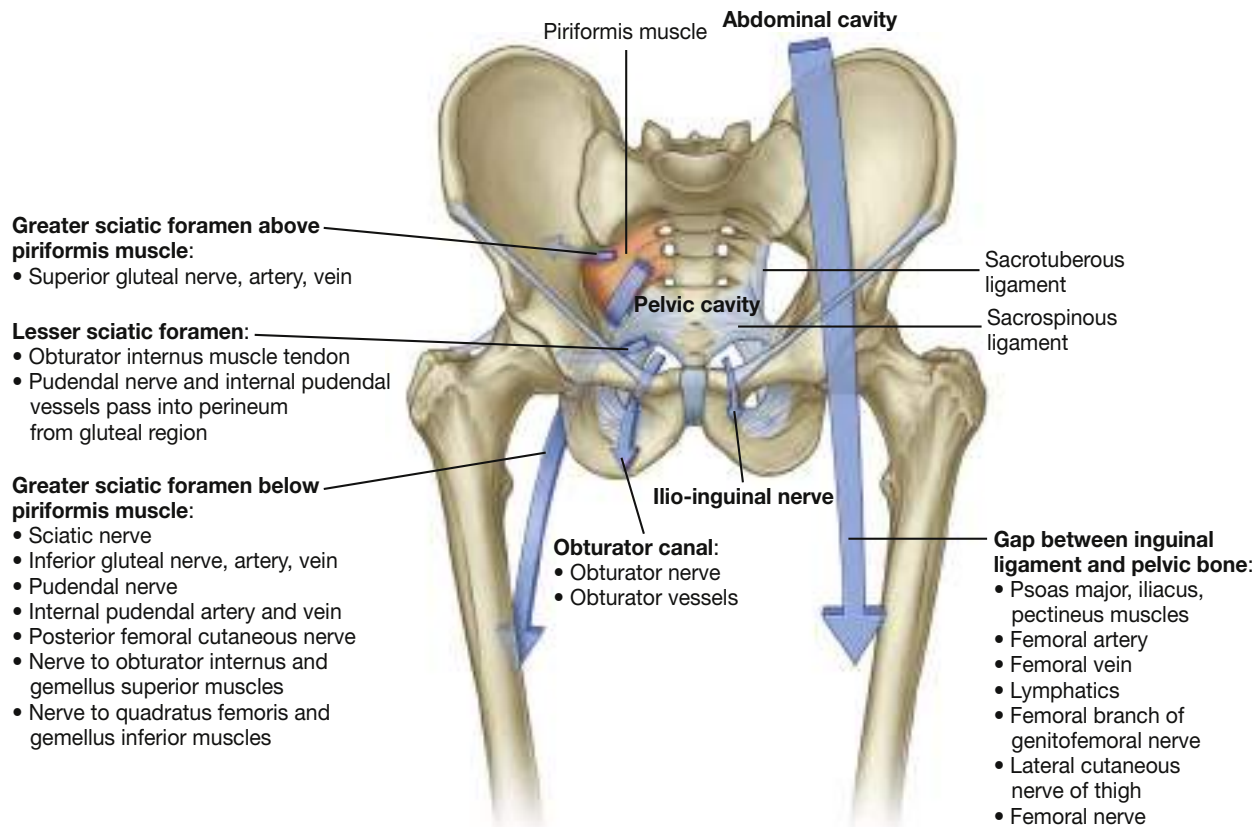


Fig. 6.17 Gateways to the lower limb.

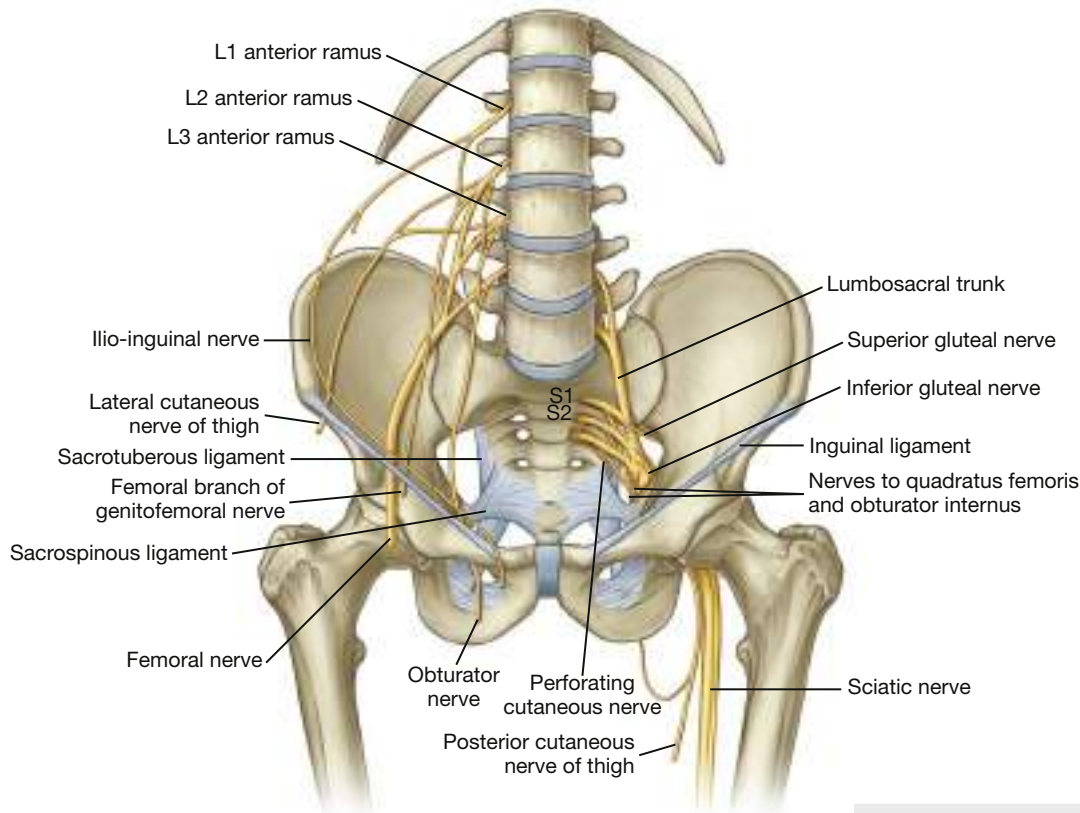


Fig. 6.18 Branches of the lumbosacral plexus.

floor (levator ani and coccygeus muscles) to the pelvic wall and therefore connects the gluteal region with the perineum.

- Gap between the inguinal ligament and pelvic bone — a large crescent-shaped gap between the inguinal ligament above and the anterosuperior margin of the pelvic bone below is the major route of communication between the abdomen and the anteromedial aspect of the thigh (Fig. 6.17).

Nerves

Nerves that enter the lower limb from the abdomen and pelvis are terminal branches of the lumbosacral plexus on the posterior wall of the abdomen and the posterolateral walls of the pelvis (Fig. 6.18).

The **lumbar plexus** is formed by the anterior rami of spinal nerves L1 to L3 and part of L4. The rest of the anterior ramus of L4 and the anterior ramus of L5 combine to form the **lumbosacral trunk**, which enters the pelvic cavity and joins with the anterior rami of S1 to S3 and part of S4 to form the **sacral plexus**.

Nerves that originate from the lumbosacral plexus and that leave the abdomen and pelvis to enter the lower limb are indicated in Fig. 6.18 and described in Table 6.1, p. 278.

Arteries

Femoral artery

The major artery supplying the lower limb is the **femoral artery** (Fig. 6.19), which is the continuation of the external iliac artery in the abdomen. The external iliac artery becomes the femoral artery as the vessel passes under the inguinal ligament to enter the femoral triangle in the anterior aspect of the thigh. Branches supply most of the thigh and all of the leg and foot.

Superior and inferior gluteal arteries and the obturator artery

The **superior and inferior gluteal arteries** originate in the pelvic cavity as branches of the internal iliac artery (Fig. 6.19, see pp. 240–241) and supply the gluteal region. The superior gluteal artery leaves the pelvis through the greater sciatic foramen above the piriformis muscle, and the inferior gluteal artery leaves through the same foramen but below the piriformis muscle.

The **obturator artery** is also a branch of the internal iliac artery in the pelvic cavity (p. 241) and passes through the obturator canal to enter and supply the medial compartment of thigh (Fig. 6.19).

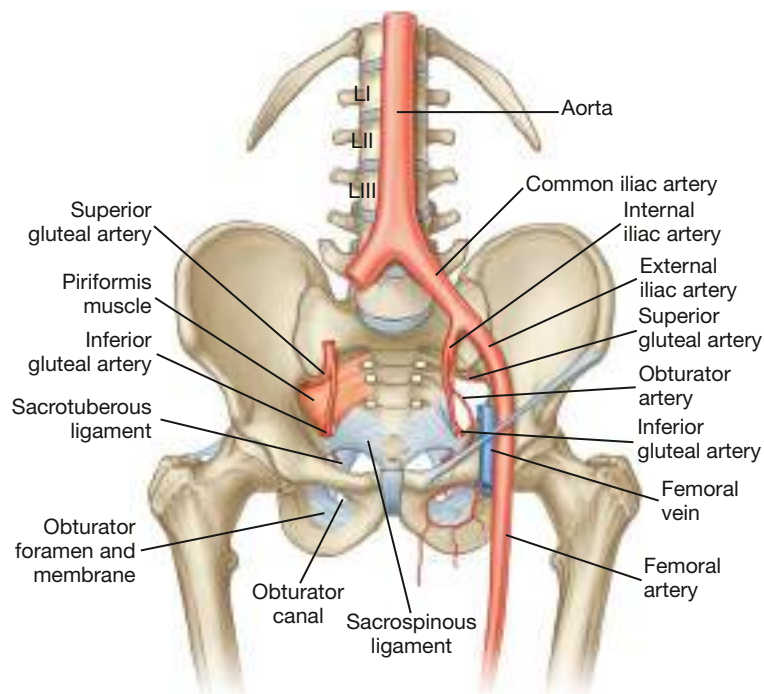


Fig. 6.19 Arteries of the lower limb.

Branches of the femoral, inferior gluteal, superior gluteal, and obturator arteries, together with branches from the internal pudendal artery of the perineum, interconnect to form an anastomotic network in the upper thigh and gluteal region. The presence of these anastomotic channels may provide collateral circulation when one of the vessels is interrupted.

Veins

Veins draining the lower limb form superficial and deep groups (Fig. 6.20).

The deep veins generally follow the arteries (femoral, superior gluteal, inferior gluteal, and obturator). The major deep vein draining the limb is the **femoral vein** (Fig. 6.20). It becomes the external iliac vein when it passes under the inguinal ligament to enter the abdomen.

The superficial veins are in the subcutaneous connective tissue and are interconnected with and ultimately drain into the deep veins. The superficial veins form two major channels—the **great saphenous vein** and the **small saphenous vein**. Both veins originate from a dorsal venous arch in the foot (Fig. 6.20):

- The **great saphenous vein** originates from the medial side of the dorsal venous arch and then ascends up the medial side of the leg, knee, and thigh to connect with the femoral vein just inferior to the inguinal ligament.
- The **small saphenous vein** originates from the lateral side of the dorsal venous arch, ascends up the posterior surface

of the leg, and then penetrates deep fascia to join the popliteal vein posterior to the knee; proximal to the knee, the popliteal vein becomes the femoral vein.

Clinical app

Varicose veins

The normal flow of blood in the venous system depends on the presence of competent valves, which prevent reflux. Venous return is supplemented with contraction of the muscles in the lower limb, which pump the blood toward the heart. When venous valves become incompetent they tend to place extra pressure on more distal valves, which may also become incompetent. This condition produces dilated tortuous superficial veins (varicose veins) in the distribution of the great (long) and small (short) saphenous venous systems.

Clinical app

Deep vein thrombosis

Thrombosis resulting from venous stasis, injury to the vessel wall, or hypercoagulable states may occur in the deep veins of the lower limb and within the pelvic veins.

In some patients a deep vein thrombosis (DVT) in the veins of the leg may propagate into the femoral veins. This clot may break off and pass through the heart to enter the pulmonary circulation, resulting in occlusion of the pulmonary artery (pulmonary embolism), cardiopulmonary arrest, and death.

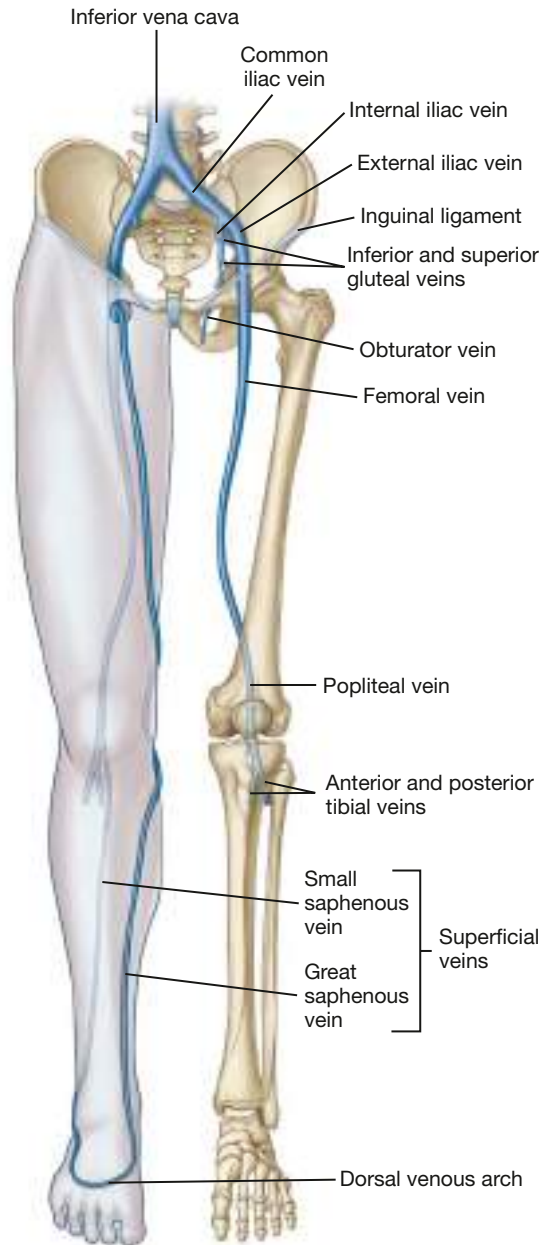


Fig. 6.20 Veins of the lower limb.

Clinical app

Harvesting veins for grafts

Vein grafts have long been used for vascular conduits. Superficial veins of the arms and legs are harvested and used to bypass areas of arterial occlusion and stenoses. Typically vein bypass grafts are used for coronary artery bypass surgery and to bypass areas of vascular occlusion in the lower limb.

Clinical app—cont'd

The commonest vein used for bypass grafting is the great saphenous vein, but the radial artery is also used and, occasionally, the small saphenous vein. Historically, a long incision was required to obtain access to the vein, but now a small incision (approximately 2 inches) is made either above or below the knee and the vein is removed laparoscopically.

It is important to remember that veins contain valves and to use the vein as an appropriate conduit, it must either be reversed or, using special surgical techniques, the valves can be obliterated.

In coronary artery bypass grafting the vein is anastomosed to the ascending arch of the aorta and then anastomosed distal to the regions of occlusion on the coronary vessels. Similarly, in lower limb ischemic disease the vein can be used to bypass the regions of stenosis and occlusion within the femoral artery and the distal branches.

Lymphatics

Most lymphatic vessels in the lower limb drain into superficial and deep inguinal nodes located in the fascia just inferior to the inguinal ligament (Fig. 6.21).

Superficial inguinal nodes

The **superficial inguinal nodes**, of which there are approximately 10, are in the superficial fascia and parallel the course of the inguinal ligament in the upper thigh (Fig. 6.21). Medially, they extend inferiorly along the terminal part of the great saphenous vein.

Superficial inguinal nodes receive lymph from the gluteal region, lower abdominal wall, perineum, and superficial regions of the lower limb. They drain via vessels that accompany the femoral vessels into external iliac nodes associated with the external iliac artery in the abdomen.

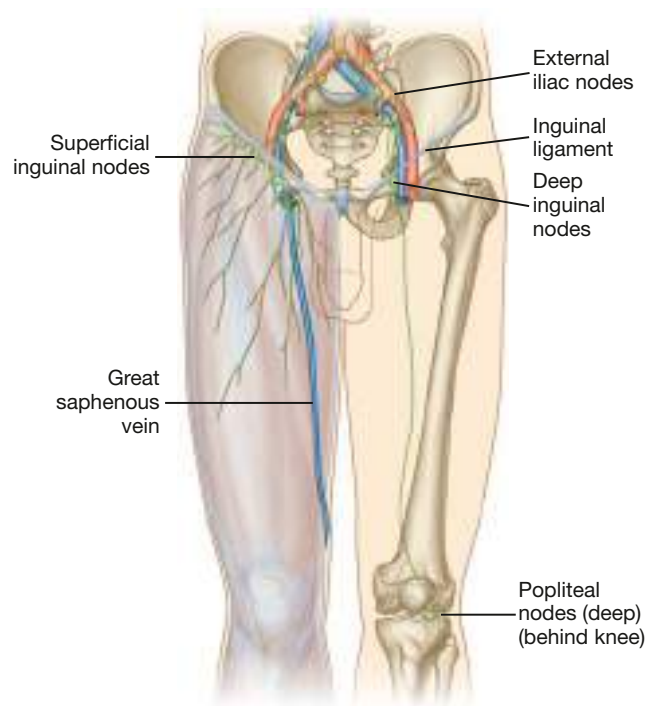
Deep inguinal nodes

The **deep inguinal nodes**, of which there are up to three, are medial to the femoral vein (Fig. 6.21).

The deep inguinal nodes receive lymph from deep lymphatics associated with the femoral vessels and from the glans penis (or clitoris) in the perineum. They interconnect with the superficial inguinal nodes and drain into the external iliac nodes via vessels that pass along the medial side of the femoral vein as it passes under the inguinal ligament. The space through which the lymphatic vessels pass under the inguinal ligament is the femoral canal.

Table 6.1 Branches of the lumbosacral plexus associated with the lower limb

Branch	Spinal segments	Function: motor	Function: sensory (cutaneous)
Ilio-inguinal	L1	No motor function in lower limb but innervates muscles of the abdominal wall	Skin over anteromedial part of upper thigh and adjacent skin of perineum
Genitofemoral	L1, L2	No motor function in lower limb, but genital branch innervates cremaster muscle in the wall of the spermatic cord in men	Femoral branch innervates skin on anterior central part of upper thigh; the genital branch innervates skin in anterior part of perineum (anterior scrotum in men and mons pubis and anterior labia majora in women)
Femoral	L2 to L4	All muscles in the anterior compartment of thigh; in the abdomen, also gives rise to branches that supply iliacus and pectineus	Skin over the anterior thigh, anteromedial knee, medial side of the leg, and the medial side of the foot
Obturator	L2 to L4	All muscles in the medial compartment of thigh (except pectineus and the part of adductor magnus attached to the ischium); also innervates obturator externus	Skin over upper medial aspect of thigh
Sciatic	L4 to S3	All muscles in the posterior compartment of thigh and the part of adductor magnus attached to the ischium; all muscles in the leg and foot	Skin over lateral side of leg and foot and over the sole and dorsal surface of foot
Superior gluteal	L4 to S1	Muscles of the gluteal region (gluteus medius, gluteus minimus, tensor fasciae latae)	
Inferior gluteal	L5 to S2	Muscle of the gluteal region (gluteus maximus)	
Lateral cutaneous nerve of thigh	L2, L3		Parietal peritoneum in iliac fossa; skin over anterolateral thigh
Posterior cutaneous nerve of thigh	S1 to S3		Skin over gluteal fold and upper medial aspect of thigh and adjacent perineum, posterior aspect of thigh and upper posterior leg
Nerve to quadratus femoris	L4 to S1	Muscles of gluteal region (quadratus femoris and gemellus inferior)	
Nerve to obturator internus	L5 to S2	Muscles of gluteal region (obturator internus and gemellus superior)	
Perforating cutaneous nerve	S2, S3		Skin over medial aspect of gluteal fold



Popliteal nodes

In addition to the inguinal nodes, there is a small collection of deep nodes posterior to the knee close to the popliteal vessels (Fig. 6.21). These **popliteal nodes** receive lymph from superficial vessels, which accompany the small saphenous vein, and from deep areas of the leg and foot. They ultimately drain into the deep and superficial inguinal nodes.

Deep fascia and the saphenous opening

Fascia lata

The outer layer of deep fascia in the lower limb forms a thick “stocking-like” membrane, which covers the limb and lies beneath the superficial fascia (Fig. 6.22A). This deep fascia is particularly thick in the thigh and gluteal region and is termed the **fascia lata**.

The fascia lata is anchored superiorly to bone and soft tissues along a line of attachment that defines the upper margin of the lower limb.

Fig. 6.21 Lymphatic drainage of the lower limb.

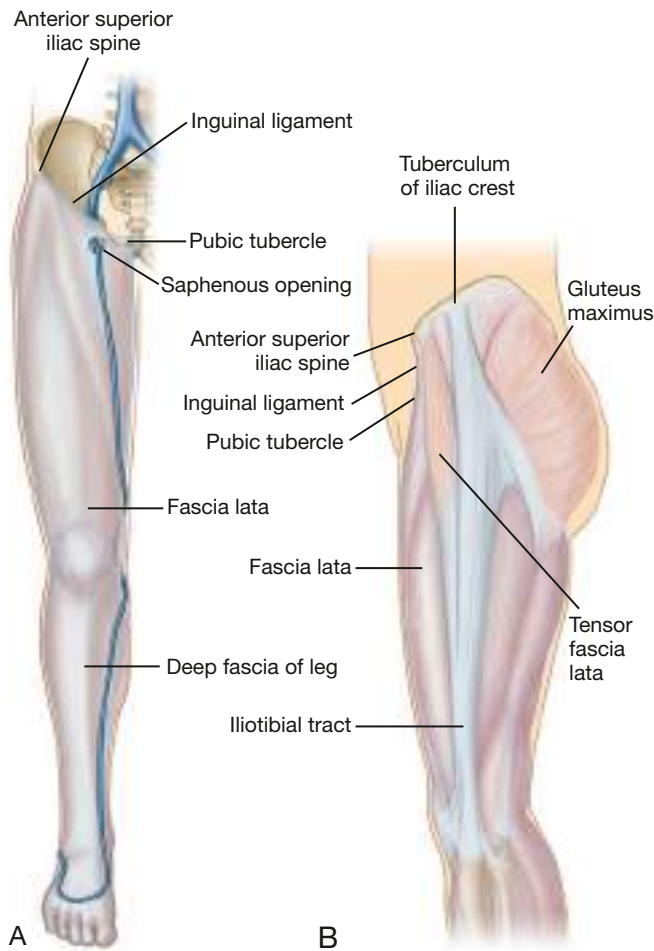


Fig. 6.22 Fascia lata. **A.** Right limb. Anterior view. **B.** Left limb. Lateral view.

Inferiorly, the fascia lata is continuous with the deep fascia of the leg.

Iliotibial tract

The fascia lata is thickened laterally into a longitudinal band (the **iliotibial tract**), which descends along the lateral margin of the limb from the tuberculum of iliac crest to a bony attachment just below the knee (Fig. 6.22B).

The superior aspect of the fascia lata in the gluteal region splits anteriorly to enclose the tensor fasciae latae muscle and posteriorly to enclose the gluteus maximus muscle:

- The tensor fasciae latae muscle is partially enclosed by and inserts into the superior and anterior aspects of the iliotibial tract.
- Most of the gluteus maximus muscle inserts into the posterior aspect of the iliotibial tract.

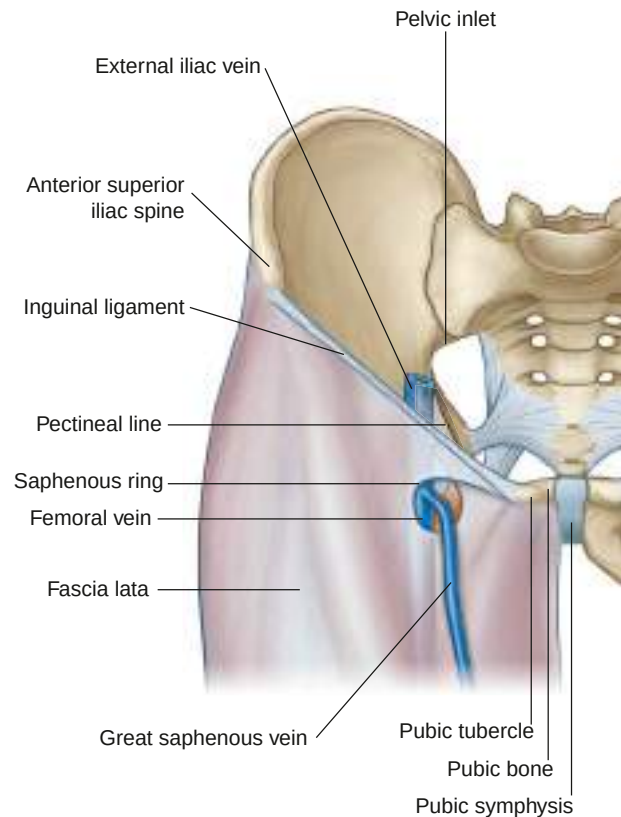


Fig. 6.23 Saphenous opening. Anterior view.

The tensor fasciae latae and gluteus maximus muscles, working through their attachments to the iliotibial tract, hold the leg in extension once other muscles have extended the leg at the knee joint. The iliotibial tract and its two associated muscles also stabilize the hip joint by preventing lateral displacement of the proximal end of the femur away from the acetabulum.

Saphenous opening

The fascia lata has one prominent aperture on the anterior aspect of the thigh just inferior to the medial end of the inguinal ligament (the **saphenous opening**), which allows the great saphenous vein to pass from superficial fascia through the deep fascia to connect with the femoral vein (Fig. 6.23).

Femoral triangle

The femoral triangle is a wedge-shaped depression formed by muscles in the upper thigh at the junction between the anterior abdominal wall and the lower limb (Fig. 6.24):

- The base of the triangle is the inguinal ligament.

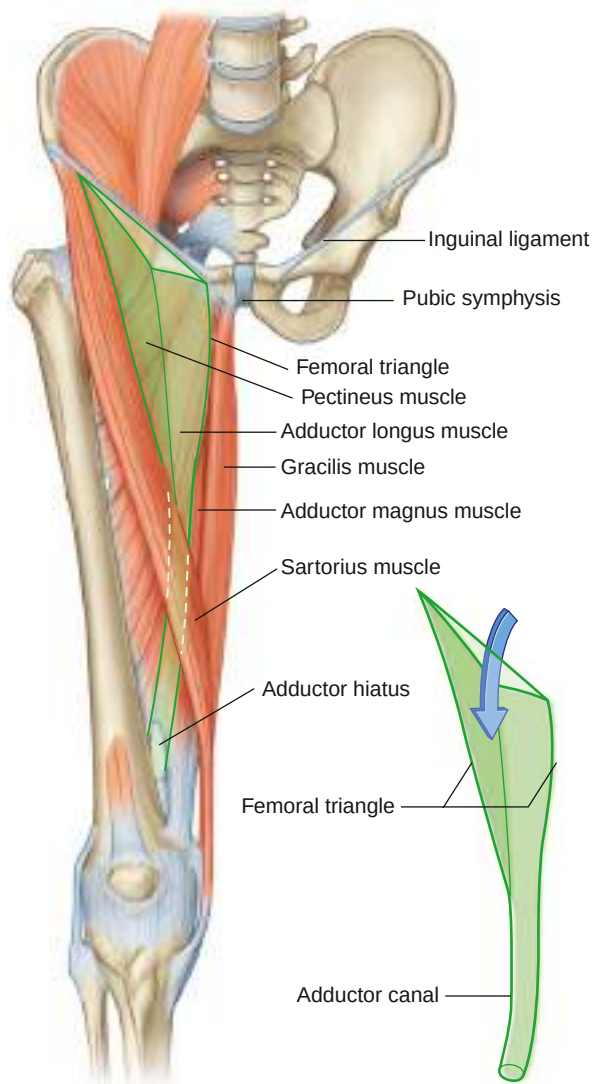


Fig. 6.24 Boundaries of the femoral triangle.

- The medial border is the medial margin of the adductor longus muscle in the medial compartment of thigh.
- The lateral margin is the medial margin of the sartorius muscle in the anterior compartment of thigh.
- The floor of the triangle is formed medially by the pectineus and adductor longus muscles in the medial compartment of thigh and laterally by the iliopsoas muscle descending from the abdomen.
- The apex of the femoral triangle points inferiorly and is continuous with a fascial canal (**adductor canal**), which descends medially down the thigh and posteriorly through an aperture in the lower end of one of the largest of the adductor muscles in the thigh (the adductor magnus muscle) to open into the popliteal fossa behind the knee.

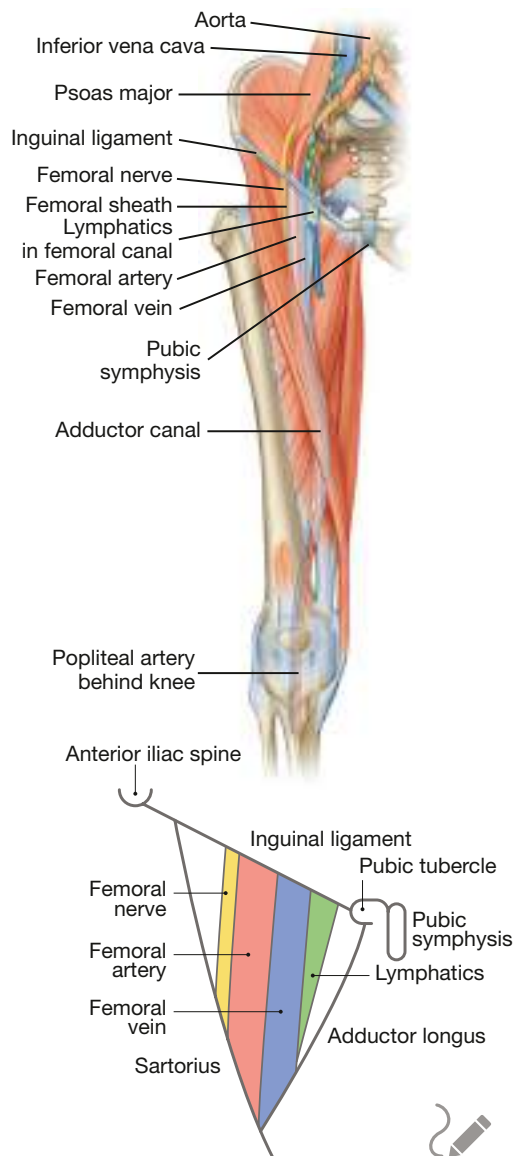


Fig. 6.25 Contents of the femoral triangle.

The femoral nerve, artery, and vein, and lymphatics pass between the abdomen and lower limb under the inguinal ligament and in the femoral triangle (Fig. 6.25). The femoral artery and vein pass inferiorly through the adductor canal and become the popliteal vessels behind the knee where they meet and are distributed with branches of the sciatic nerve, which descends through the posterior thigh from the gluteal region.

From lateral to medial, major structures in the femoral triangle are the femoral nerve, the femoral artery, the femoral vein, and lymphatic vessels (Fig. 6.25).

Femoral sheath

In the femoral triangle, the femoral artery and vein and the associated lymphatic vessels are surrounded by a

funnel-shaped sleeve of fascia (the **femoral sheath**) (Fig. 6.25). The sheath is continuous superiorly with the transversalis fascia and iliacus fascia of the abdomen and merges inferiorly with connective tissue associated with the vessels. Each of the three structures surrounded by the sheath is contained within a separate fascial compartment within the sheath. The most medial compartment (the **femoral canal**) contains the lymphatic vessels and is conical in shape. The opening of this canal superiorly is potentially a weak point in the lower abdomen and is the site for femoral hernias. The femoral nerve is lateral to and not contained within the femoral sheath.

Surface anatomy

Finding the femoral artery in the femoral triangle

The femoral artery descends into the thigh from the abdomen by passing under the inguinal ligament and into the femoral triangle (Fig. 6.26). In the femoral triangle, its pulse is easily felt just inferior to the inguinal ligament midway between the pubic symphysis and the anterior superior iliac spine. Medial to the artery is the femoral vein, and medial to the vein is the femoral canal, which contains lymphatics and lies immediately lateral to the pubic tubercle. The femoral nerve lies lateral to the femoral artery.

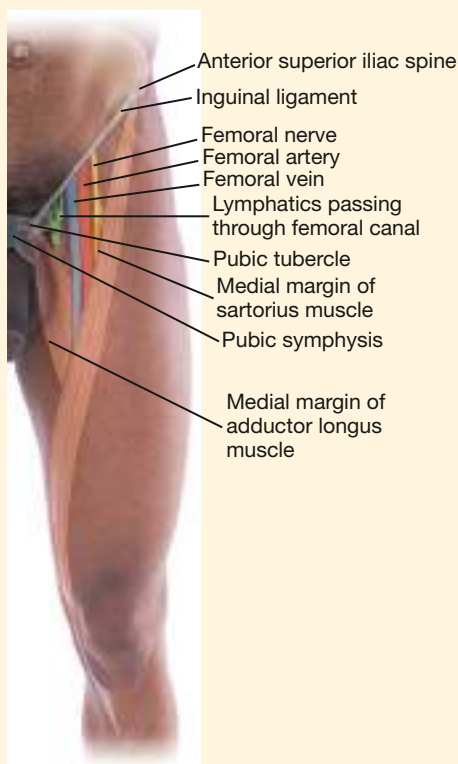


Fig. 6.26 Position of the femoral artery in the femoral triangle.

Clinical app

Vascular access in the lower limb

The femoral artery and vein are easily accessible in the femoral triangle.

Many radiological procedures involve catheterization of the femoral artery or the femoral vein to obtain access to the contralateral lower limb, the ipsilateral lower limb, the vessels of the thorax and abdomen, and even the cerebral vessels.

Cardiologists also can use the femoral artery to place catheters in vessels around the arch of the aorta and into the coronary arteries to perform coronary angiography and angioplasty.

GLUTEAL REGION

The gluteal region lies posterolateral to the bony pelvis and the proximal end of the femur (Fig. 6.27). Muscles in the region mainly abduct, extend, and laterally rotate the femur relative to the pelvic bone.

The gluteal region communicates anteromedially with the pelvic cavity and perineum through the greater and lesser sciatic foramina, respectively (Fig. 6.27). Inferiorly, it is continuous with the posterior thigh.

Muscles

Muscles of the gluteal region (Table 6.2, Fig. 6.28) compose mainly two groups:

- a deep group of small muscles that are mainly lateral rotators of the femur at the hip joint and include the **piriformis**, **obturator internus**, **gemellus superior**, **gemellus inferior**, and **quadratus femoris**, and
- a more superficial group of larger muscles that mainly abduct and extend the hip and include the **gluteus minimus**, **gluteus medius**, and **gluteus maximus**. An additional muscle in this group, the **tensor fasciae latae**, stabilizes the knee in extension by acting on a specialized longitudinal band of deep fascia (the iliotibial tract) that passes down the lateral side of the thigh to attach to the proximal end of the tibia in the leg.

The **piriformis** muscle is the most superior of the deep group of muscles (Fig. 6.28A) and is a muscle of the pelvic wall and of the gluteal region. It originates from between the anterior sacral foramina on the anterolateral surface of the sacrum and passes laterally and inferiorly

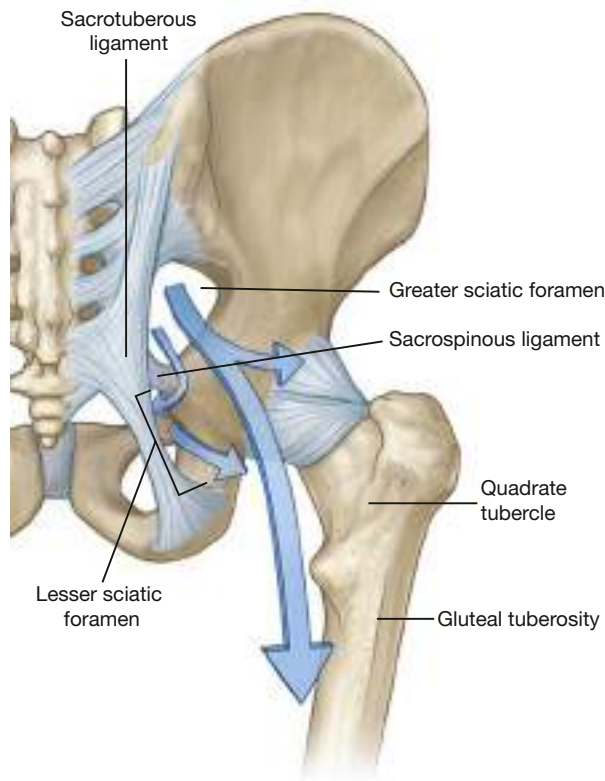


Fig. 6.27 Gluteal region. Posterior view.

through the greater sciatic foramen. Piriformis is an important landmark because it divides the greater sciatic foramen into two regions, one above and one below the piriformis.

The obturator internus muscle, like the piriformis muscle, is a muscle of the pelvic wall and of the gluteal region (Fig. 6.28A). The muscle fibers of the obturator internus converge to form a tendon, which bends 90° around the ischium between the ischial spine and ischial tuberosity, and passes through the lesser sciatic foramen to enter the gluteal region. Gemellus superior and inferior (gemelli is Latin for “twins”) are a pair of triangular muscles associated with the upper and lower margins of the obturator internus tendon (Fig. 6.28A).

The **gluteus medius** and **minimus** muscles abduct the pelvis over the stance limb at the hip joint and reduce pelvic drop over the opposite swing limb during walking (Fig. 6.28B).

Gluteus maximus is the largest muscle in the gluteal region and overlies most of the other gluteal muscles (Fig. 6.29). It is quadrangular and has a broad origin from the bony pelvis and associated ligaments and fascia. It is often described as being enclosed within two layers of the fascia lata, which covers the thigh and gluteal region. Laterally, the upper and superficial lower parts of the gluteus maximus insert into the

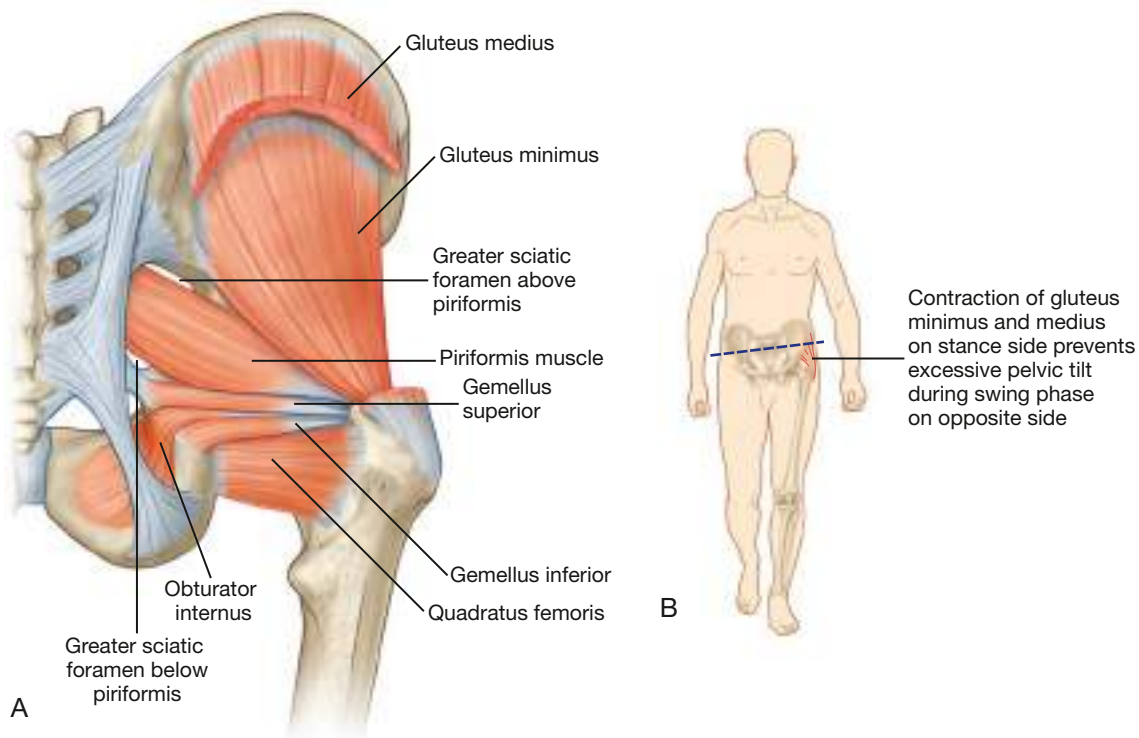


Fig. 6.28 Deep muscles in the gluteal region. **A.** Posterior view. **B.** Function.

iliotibial tract, which passes over the lateral surface of the greater trochanter and descends down the thigh and into the upper leg. Deep distal parts of the muscle attach to the elongate gluteal tuberosity of the proximal femur.

Clinical app

Trendelenburg's sign

Trendelenburg's sign occurs in people with weak or paralyzed abductor muscles (gluteus medius and gluteus minimus) of the hip. The sign is demonstrated by asking the patient to stand on one limb. When standing on the affected limb, the pelvis severely drops over the swing limb.

Positive findings are typically found in patients with damage to the superior gluteal nerve. Damage to this nerve may occur with associated pelvic fractures, space occupying lesions within the pelvis extending into the greater sciatic foramen and in some cases relating to hip surgery where there has been atrophy and disruption of the insertion of the gluteus medius and gluteus minimus tendons on the greater trochanter.

In patients with a positive Trendelenburg's sign, gait also is abnormal. Typically during the stance phase of the affected limb, the weakened abductor muscles allow the pelvis to tilt inferiorly over the swing limb. The patient compensates for the pelvic drop by lurching the trunk to the affected side in order to maintain the level of the pelvis throughout the gait cycle.

Nerves

Superior gluteal nerve

Of all the nerves that pass through the greater sciatic foramen, the **superior gluteal nerve** is the only one that passes above the piriformis muscle (Fig. 6.30A). After entering the gluteal region, the nerve loops up over the inferior margin of gluteus minimus and travels anteriorly and laterally in the plane between the gluteus minimus and medius muscles.

The superior gluteal nerve supplies branches to the gluteus minimus and medius muscles and terminates by innervating the tensor fasciae latae muscle.

Sciatic nerve

The **sciatic nerve** enters the gluteal region through the greater sciatic foramen inferior to the piriformis muscle (Fig. 6.30). It descends in the plane between the superficial and deep group of gluteal region muscles, crossing the posterior surfaces of first the obturator internus and associated gemellus muscles and then the quadratus femoris muscle. It lies just deep to the gluteus maximus at the midpoint between the ischial tuberosity and the greater trochanter. At

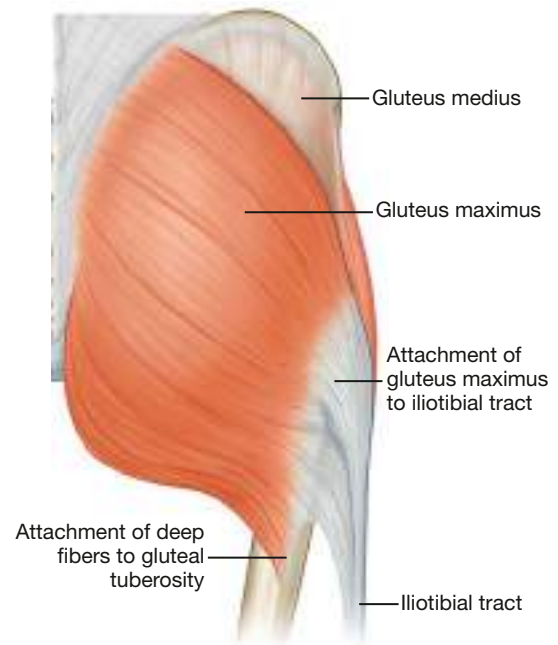


Fig. 6.29 Gluteus maximus muscle. Posterior view.

the lower margin of the quadratus femoris muscle, the sciatic nerve enters the posterior thigh.

The sciatic nerve is the largest nerve in the body and innervates all muscles in the posterior compartment of thigh that flex the knee and all muscles that work the ankle and foot. It also innervates a large area of skin in the lower limb.

Nerve to quadratus femoris

The **nerve to the quadratus femoris** enters the gluteal region through the greater sciatic foramen inferior to the piriformis muscle and deep to the sciatic nerve (Fig. 6.30). Unlike other nerves in the gluteal region, the nerve to the quadratus femoris lies anterior to the plane of the deep muscles.

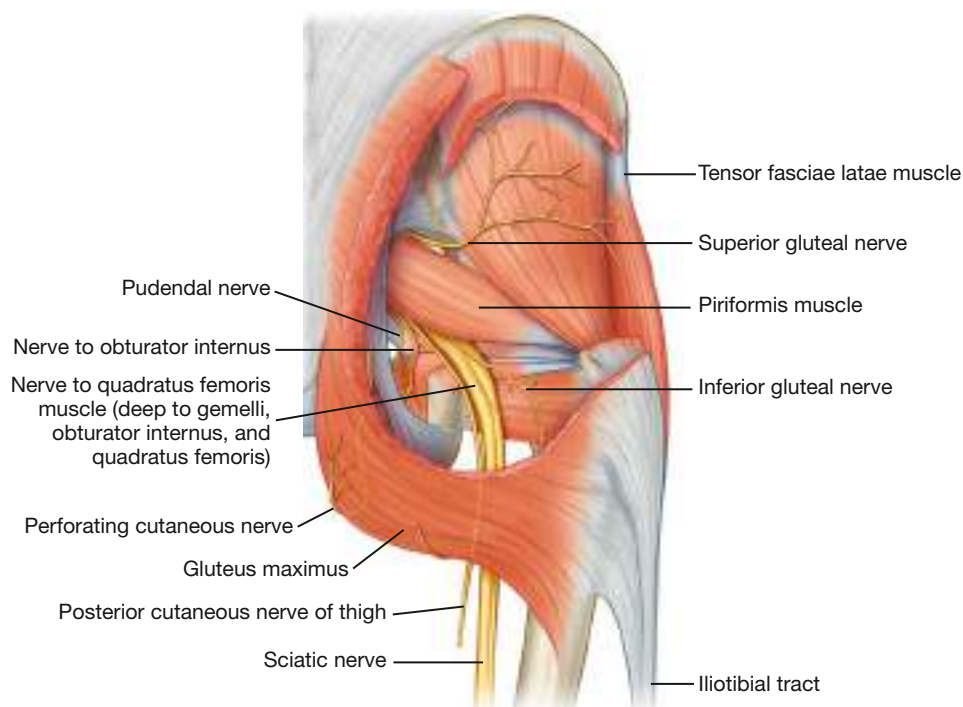
The nerve to the quadratus femoris descends along the ischium deep to the tendon of the obturator internus muscle and associated gemellus muscles to penetrate and innervate the quadratus femoris. It supplies a small branch to the gemellus inferior.

Nerve to obturator internus

The nerve to the **obturator internus** enters the gluteal region through the greater sciatic foramen inferior to the piriformis muscle and between the posterior cutaneous nerve of the thigh and the pudendal nerve (Fig. 6.30). It supplies a small branch to the gemellus superior and then passes over the ischial spine and through the lesser sciatic foramen to innervate the obturator internus muscle from the medial surface of the muscle in the perineum.

Table 6.2 Muscles of the gluteal region (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Piriformis	Anterior surface of sacrum between anterior sacral foramina	Medial side of superior border of greater trochanter of femur	Branches from S1, S2	Laterally rotates the extended femur at hip joint; abducts flexed femur at hip joint
Obturator internus	Anterolateral wall of true pelvis; deep surface of obturator membrane and surrounding bone	Medial side of greater trochanter of femur	Nerve to obturator internus (L5, S1)	Laterally rotates the extended femur at hip joint; abducts flexed femur at hip joint
Gemellus superior	External surface of ischial spine	Along length of superior surface of the obturator internus tendon and into the medial side of greater trochanter of femur with obturator internus tendon	Nerve to obturator internus (L5, S1)	Laterally rotates the extended femur at hip joint; abducts flexed femur at hip joint
Gemellus inferior	Upper aspect of ischial tuberosity	Along length of inferior surface of the obturator internus tendon and into the medial side of greater trochanter of femur with obturator internus tendon	Nerve to quadratus femoris (L5, S1)	Laterally rotates the extended femur at hip joint; abducts flexed femur at hip joint
Quadratus femoris	Lateral aspect of the ischium just anterior to the ischial tuberosity	Quadrate tubercle on the intertrochanteric crest of the proximal femur	Nerve to quadratus femoris (L5, S1)	Laterally rotates femur at hip joint
Gluteus minimus	External surface of ilium between inferior and anterior gluteal lines	Linear facet on the anterolateral aspect of the greater trochanter	Superior gluteal nerve (L4, L5, S1)	Abducts femur at hip joint; holds pelvis secure over stance leg and prevents pelvic drop on the opposite swing side during walking; medially rotates thigh
Gluteus medius	External surface of ilium between anterior and posterior gluteal lines	Elongate facet on the lateral surface of the greater trochanter	Superior gluteal nerve (L4, L5, S1)	Abducts femur at hip joint; holds pelvis secure over stance leg and prevents pelvic drop on the opposite swing side during walking; medially rotates thigh
Gluteus maximus	Fascia covering gluteus medius, external surface of ilium behind posterior gluteal line, fascia of erector spinae, dorsal surface of lower sacrum, lateral margin of coccyx, external surface of sacrotuberous ligament	Posterior aspect of iliotibial tract of fascia lata and gluteal tuberosity of proximal femur	Inferior gluteal nerve (L5, S1, S2)	Powerful extensor of flexed femur at hip joint; lateral stabilizer of hip joint and knee joint; laterally rotates and abducts thigh
Tensor fasciae latae	Lateral aspect of crest of ilium between anterior superior iliac spine and tubercle of the crest	Iliotibial tract of fascia lata	Superior gluteal nerve (L4, L5, S1)	Stabilizes the knee in extension

**Fig. 6.30** Nerves of the gluteal region.

Posterior cutaneous nerve of the thigh

The **posterior cutaneous nerve of the thigh** enters the gluteal region through the greater sciatic foramen inferior to the piriformis muscle and immediately medial to the sciatic nerve (Fig. 6.30). It descends through the gluteal region just deep to the gluteus maximus and enters the posterior thigh.

The posterior cutaneous nerve of the thigh has a number of gluteal branches, which loop around the lower margin of the gluteus maximus muscle to innervate skin over the gluteal fold. A small perineal branch passes medially to contribute to the innervation of skin of the scrotum or labia majora in the perineum. The main trunk of the posterior cutaneous nerve of the thigh passes inferiorly, giving rise to branches that innervate skin on the posterior thigh and leg.

Pudendal nerve

The **pudendal nerve** enters the gluteal region through the greater sciatic foramen inferior to the piriformis muscle and medial to the sciatic nerve (Fig. 6.30). It passes over the sacrospinous ligament and immediately passes through the lesser sciatic foramen to enter the perineum. The course of the pudendal nerve in the gluteal region is short and the nerve is often hidden by the overlying upper margin of the sacrotuberous ligament.

The pudendal nerve is the major somatic nerve of the perineum and has no branches in the gluteal region.

Inferior gluteal nerve

The **inferior gluteal nerve** enters the gluteal region through the greater sciatic foramen inferior to the piriformis muscle and along the posterior surface of the sciatic nerve (Fig. 6.30). It penetrates and supplies the gluteus maximus muscle.

Perforating cutaneous nerve

The **perforating cutaneous nerve** is the only nerve in the gluteal region that does not enter the area through the greater sciatic foramen. It is a small nerve that leaves the sacral plexus in the pelvic cavity by piercing the sacrotuberous ligament. It then loops around the lower border of the gluteus maximus to supply skin over the medial aspect of the gluteus maximus (Fig. 6.30).

Clinical app

Intramuscular injection in the gluteal region: avoiding the sciatic nerve

From time to time it is necessary to administer drugs intramuscularly; that is, by direct injection into muscles. This procedure must be carried out without injuring neurovascular structures. A typical site for an intramuscular injection is the gluteal region. The sciatic nerve passes through this region

Clinical app—cont'd

and needs to be avoided. The safest place to inject is the upper outer quadrant of either gluteal region.

The gluteal region can be divided into quadrants by two imaginary lines positioned using palpable bony landmarks (Fig. 6.31).

One line descends vertically from the highest point of the iliac crest.

The other line passes horizontally through the first line midway between the highest point of the iliac crest and the horizontal plane through the ischial tuberosity.

It is important to remember that the gluteal region extends as far forward as the anterior superior iliac spine. The sciatic nerve curves through the upper lateral corner of the lower medial quadrant and descends along the medial margin of the lower lateral quadrant.

Occasionally, the sciatic nerve bifurcates into its tibial and common fibular branches in the pelvis, in which case the common fibular nerve passes into the gluteal region through, or even above, the piriformis muscle.

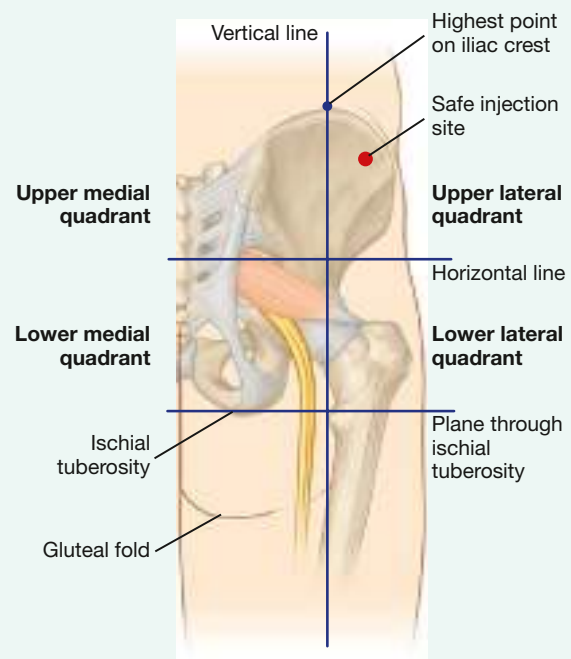


Fig. 6.31 Site for intramuscular injections.

The superior gluteal nerve and vessels normally enter the gluteal region above the piriformis and pass superiorly and forward.

The anterior corner of the upper lateral quadrant is normally used for injections to avoid injuring any part of the sciatic nerve or other nerves and vessels in the gluteal region. A needle placed in this region enters the gluteus medius anterosuperior to the margin of the gluteus maximus.

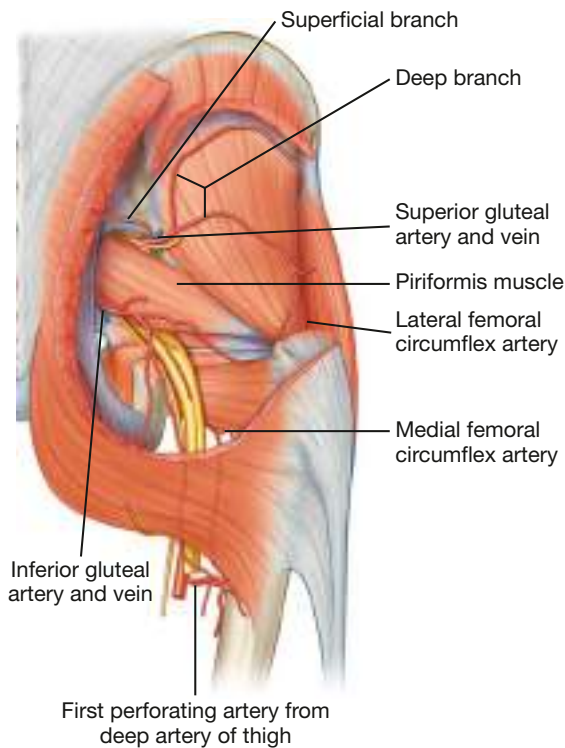


Fig. 6.32 Arteries of the gluteal region.

Arteries

Inferior gluteal artery

The **inferior gluteal artery** originates from the anterior trunk of the internal iliac artery in the pelvic cavity. It leaves the pelvic cavity through the greater sciatic foramen inferior to the piriformis muscle (Fig. 6.32).

The inferior gluteal artery supplies adjacent muscles and descends through the gluteal region and into the posterior thigh where it supplies adjacent structures and anastomoses with perforating branches of the femoral artery. It also supplies a branch to the sciatic nerve.

Superior gluteal artery

The **superior gluteal artery** originates from the posterior trunk of the internal iliac artery in the pelvic cavity. It leaves the pelvic cavity through the greater sciatic foramen above the piriformis muscle (Fig. 6.32). In the gluteal region, it divides into a superficial branch and a deep branch:

- The superficial branch passes onto the deep surface of the gluteus maximus muscle.
- The deep branch passes between the gluteus medius and minimus muscles.

In addition to adjacent muscles, the superior gluteal artery contributes to the supply of the hip joint. Branches

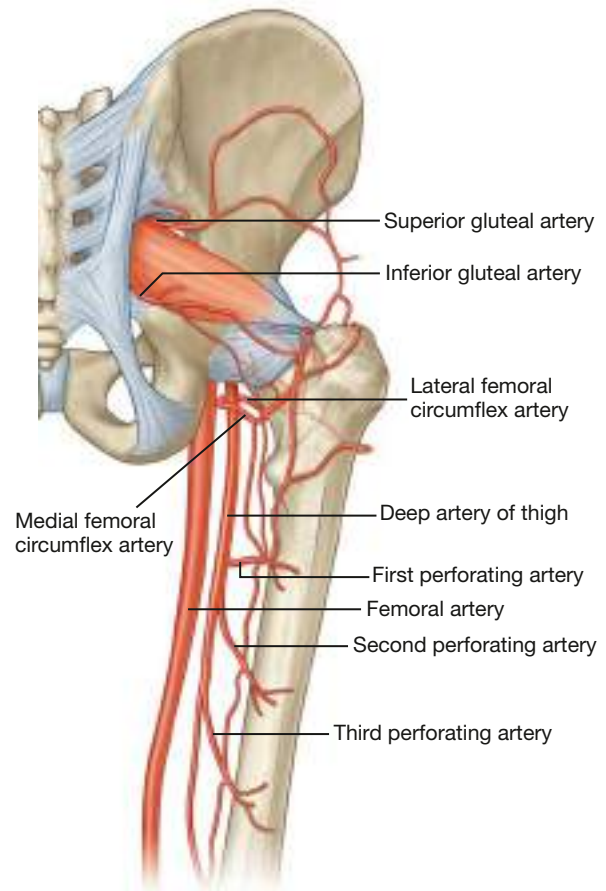


Fig. 6.33 Anastomoses between gluteal arteries and vessels originating from the femoral artery in the thigh. Posterior view.

of the artery also anastomose with the lateral and medial femoral circumflex arteries from the deep femoral artery in the thigh and with the inferior gluteal artery (Fig. 6.33).

Veins

Inferior and superior gluteal veins follow the inferior and superior gluteal arteries into the pelvis where they join the pelvic plexus of veins. Peripherally, the veins anastomose with superficial gluteal veins, which ultimately drain anteriorly into the femoral vein.

Lymphatics

Deep lymphatic vessels of the gluteal region accompany the blood vessels into the pelvic cavity and connect with internal iliac nodes.

Superficial lymphatics drain into the superficial inguinal nodes on the anterior aspect of the thigh.

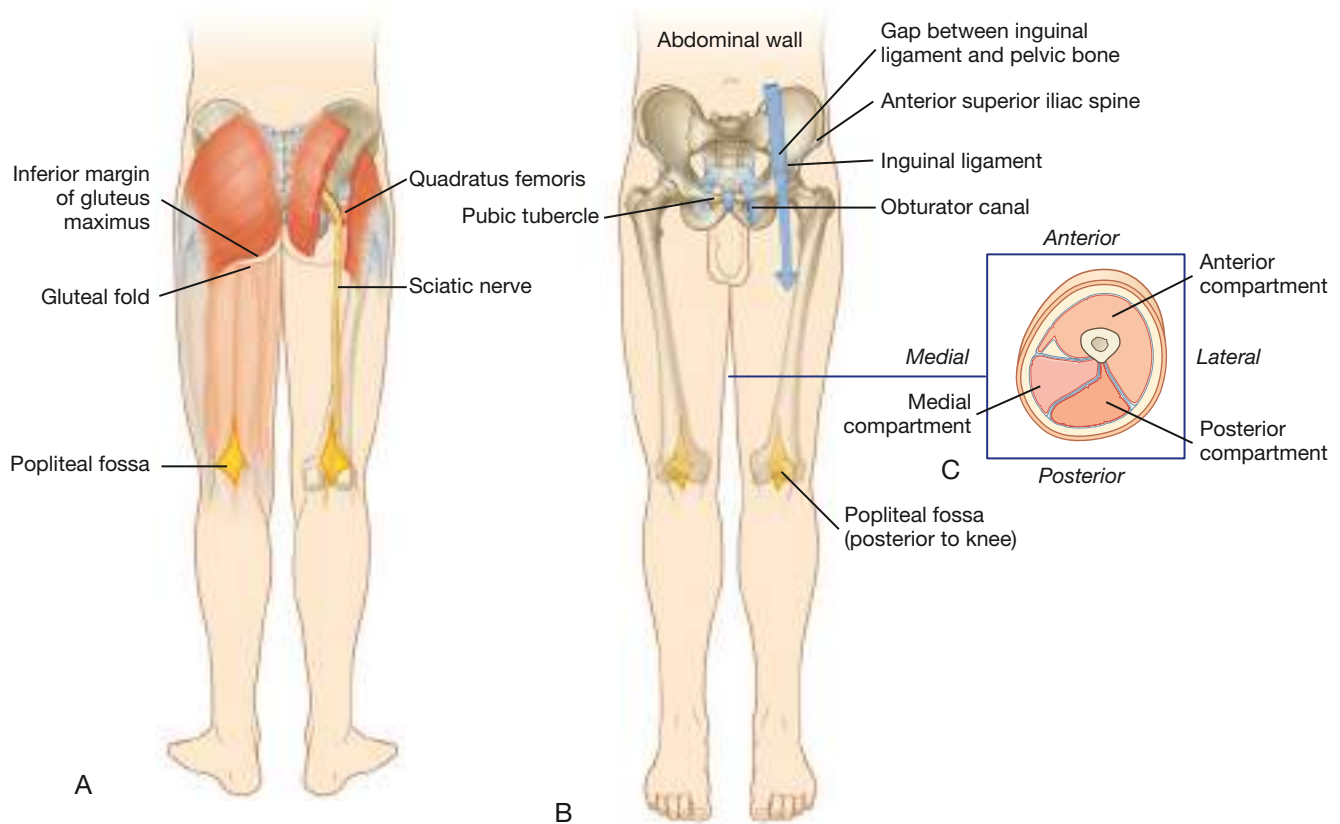


Fig. 6.34 Thigh. **A.** Posterior view. **B.** Anterior view. **C.** Cross-section through the mid-thigh.

THIGH

The thigh is the region of the lower limb that is approximately between the hip and knee joints (Fig. 6.34):

- Anteriorly, it is separated from the abdominal wall by the inguinal ligament.
- Posteriorly, it is separated from the gluteal region by the gluteal fold superficially and by the inferior margins of the gluteus maximus and quadratus femoris on deeper planes.

Structures enter and leave the top of the thigh by three routes:

- Posteriorly, the thigh is continuous with the gluteal region, and the major structure passing between the two regions is the sciatic nerve (Fig. 6.34A).
- Anteriorly, the thigh communicates with the abdominal cavity through the aperture between the inguinal ligament and pelvic bone (Fig. 6.34B), and major structures passing through this aperture are the iliopsoas and pectineus

muscles, the femoral nerve, artery and vein, and lymphatic vessels.

- Medially, structures (including the obturator nerve and associated vessels) pass between the thigh and pelvic cavity through the obturator canal (Fig. 6.34B).

The thigh is divided into three compartments (anterior, medial, and posterior) by intermuscular septa between the posterior aspect of the femur and the fascia lata (the thick layer of deep fascia that completely surrounds or invests the thigh; Fig. 6.34C).

Bones

The skeletal support for the thigh is the femur (Fig. 6.35). Most of the large muscles in the thigh insert into the proximal ends of the two bones of the leg (tibia and fibula) and flex and extend the leg at the knee joint. The distal end of the femur provides origin for the gastrocnemius muscles, which are predominantly in the posterior compartment of leg and plantarflex the foot.

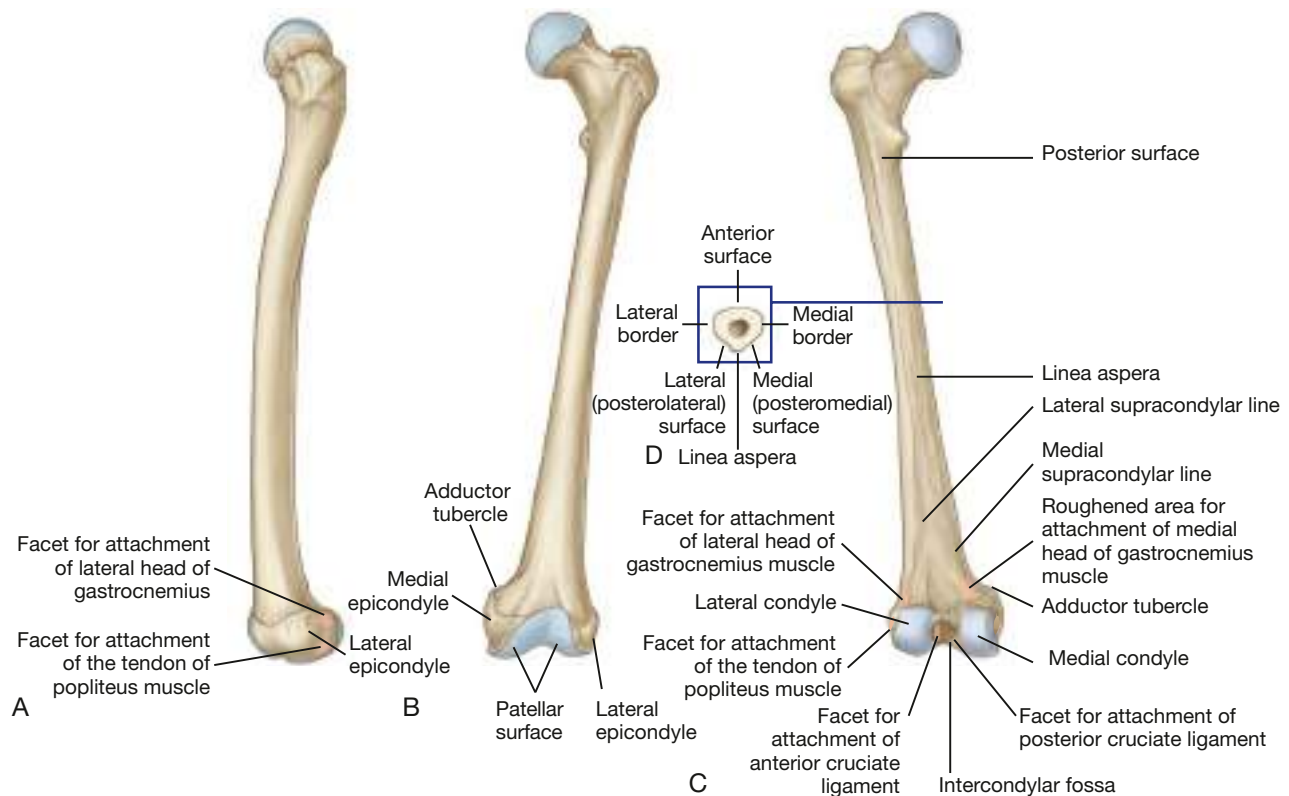


Fig. 6.35 Shaft and distal end of femur. **A.** Lateral view. **B.** Anterior view. **C.** Posterior view. **D.** Cross-section through shaft of femur.

Shaft and distal end of femur

The shaft of femur is bowed forward and has an oblique course from the neck of the femur to the distal end (Fig. 6.35A,B). As a consequence of this oblique orientation, the knee is close to the midline under the body's center of gravity.

The middle part of the shaft of the femur is triangular in cross-section (Fig. 6.35D). In the middle part of the shaft, the femur has smooth medial (posteromedial), lateral (posterolateral), and anterior surfaces and medial, lateral, and posterior borders. The medial and lateral borders are rounded, whereas the posterior border forms a broad roughened crest—the **linea aspera** (Fig. 6.35C).

In proximal and distal regions of the femur, the linea aspera widens to form an additional posterior surface. At the distal end of the femur, this posterior surface forms the floor of the popliteal fossa and its margins, which are continuous with the linea aspera above, form the **medial** and **lateral supracondylar lines**. The medial supracondylar line terminates at a prominent tubercle (the **adductor tubercle**) on the superior aspect of the **medial condyle** of the distal end. Just lateral to the lower end of the medial supracondylar line is an elongate roughened area of bone for the proximal attachment of the medial head of the gastrocnemius muscle (Fig. 6.35).

The distal end of the femur is characterized by two large condyles that articulate with the proximal head of the tibia (Fig. 6.35). The condyles are separated posteriorly by an **intercondylar fossa** and are joined anteriorly where they articulate with the patella.

The surfaces of the condyles that articulate with the tibia are rounded posteriorly and become flatter inferiorly. On each condyle, a shallow oblique groove separates the surface that articulates with the tibia from the more anterior surface that articulates with the patella. The surfaces of the medial and lateral condyles that articulate with the patella form a V-shaped trench, which faces anteriorly. The lateral surface of the trench is larger and steeper than the medial surface.

The walls of the intercondylar fossa bear two facets for the superior attachment of the cruciate ligaments, which stabilize the knee joint (Fig. 6.35C).

Epicondyles, for the attachment of collateral ligaments of the knee joint, are bony elevations on the nonarticular outer surfaces of the condyles (Fig. 6.35).

Additionally, just posterosuperior to the **medial epicondyle** is the adductor tubercle, and just posterior to the **lateral epicondyle** are facets for the attachment of the lateral head of the gastrocnemius and the popliteus muscles (Fig. 6.35C).

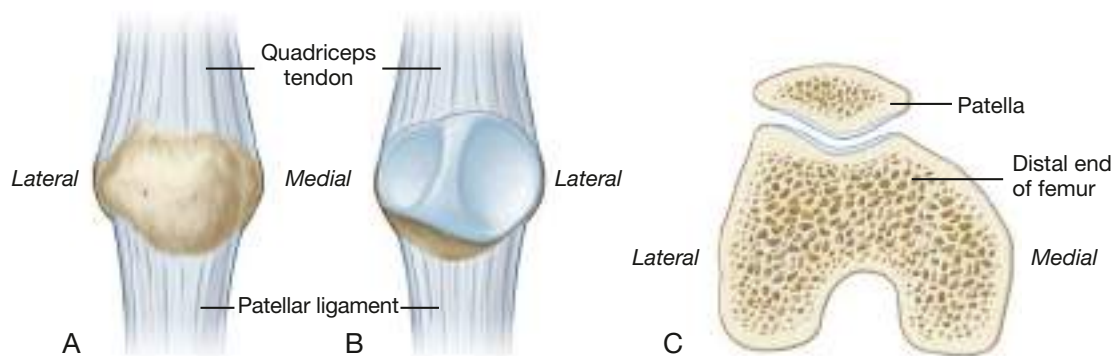


Fig. 6.36 Patella. A. Anterior view. B. Posterior view. C. Superior view.

Patella

The patella (knee cap) is the largest sesamoid bone (a bone formed within the tendon of a muscle) in the body and is formed within the tendon of the quadriceps femoris muscle as it crosses anterior to the knee joint to insert on the tibia.

The patella is triangular (Fig. 6.36):

- Its apex is pointed inferiorly for attachment to the patellar ligament, which connects the patella to the tibia.
- Its base is broad and thick for the attachment of the quadriceps tendon from above.
- Its posterior surface articulates with the femur and has medial and lateral facets (Fig. 6.36B) that slope away from a raised smooth ridge—the lateral facet is larger than the medial facet for articulation with the larger corresponding surface on the lateral condyle of the femur.

Proximal end of tibia

The tibia is the medial and larger of the two bones in the leg, and is the only one that articulates with the femur at the knee joint.

The proximal end of the tibia is expanded in the transverse plane for weight bearing and consists of a **medial condyle** and a **lateral condyle**, which are both flattened in the horizontal plane and overhang the shaft (Fig. 6.37).

The superior surfaces of the medial and lateral condyles are articular and separated by an intercondylar region, which contains sites of attachment for the cruciate ligaments and interarticular cartilages (menisci) of the knee joint (Fig. 6.37A).

The articular surfaces of the medial and lateral condyles and the intercondylar region together form a “tibial plateau,” which articulates with and is anchored to the distal end of the femur. Inferior to the condyles on the proximal part of

the shaft is a large **tibial tuberosity** and the roughening for muscle and ligament attachments.

Tibial condyles and intercondylar areas

The tibial condyles are thick horizontal discs of bone attached to the top of the tibial shaft (Fig. 6.37).

The medial condyle is larger than the lateral condyle and is better supported over the shaft of the tibia. Its superior surface is oval for articulation with the medial condyle of the femur (Fig. 6.37A). The articular surface extends laterally onto the side of the raised **medial intercondylar tubercle**.

The superior surface of the lateral condyle is circular and articulates above with the lateral condyle of the femur (Fig. 6.37A). The medial edge of this surface extends onto the side of the **lateral intercondylar tubercle**.

The superior articular surfaces of both the lateral and medial condyles are concave, particularly centrally. The outer margins of the surfaces are flatter and are the regions in contact with the interarticular discs (menisci) of fibrocartilage in the knee joint.

The nonarticular posterior surface of the medial condyle bears a distinct horizontal groove for part of the attachment of the semimembranosus muscle, and the undersurface of the lateral condyle bears a distinct circular facet for articulation with the proximal head of the fibula.

The intercondylar region of the tibial plateau lies between the articular surfaces of the medial and lateral condyles (Fig. 6.37). It is narrow centrally where it is raised to form the **intercondylar eminence**, the sides of which are elevated further to form medial and lateral intercondylar tubercles.

The intercondylar region bears six distinct facets (Fig. 6.37A) for the attachment of menisci and cruciate ligaments. In addition to these facets, a large anterolateral region of the anterior intercondylar area is roughened and perforated by

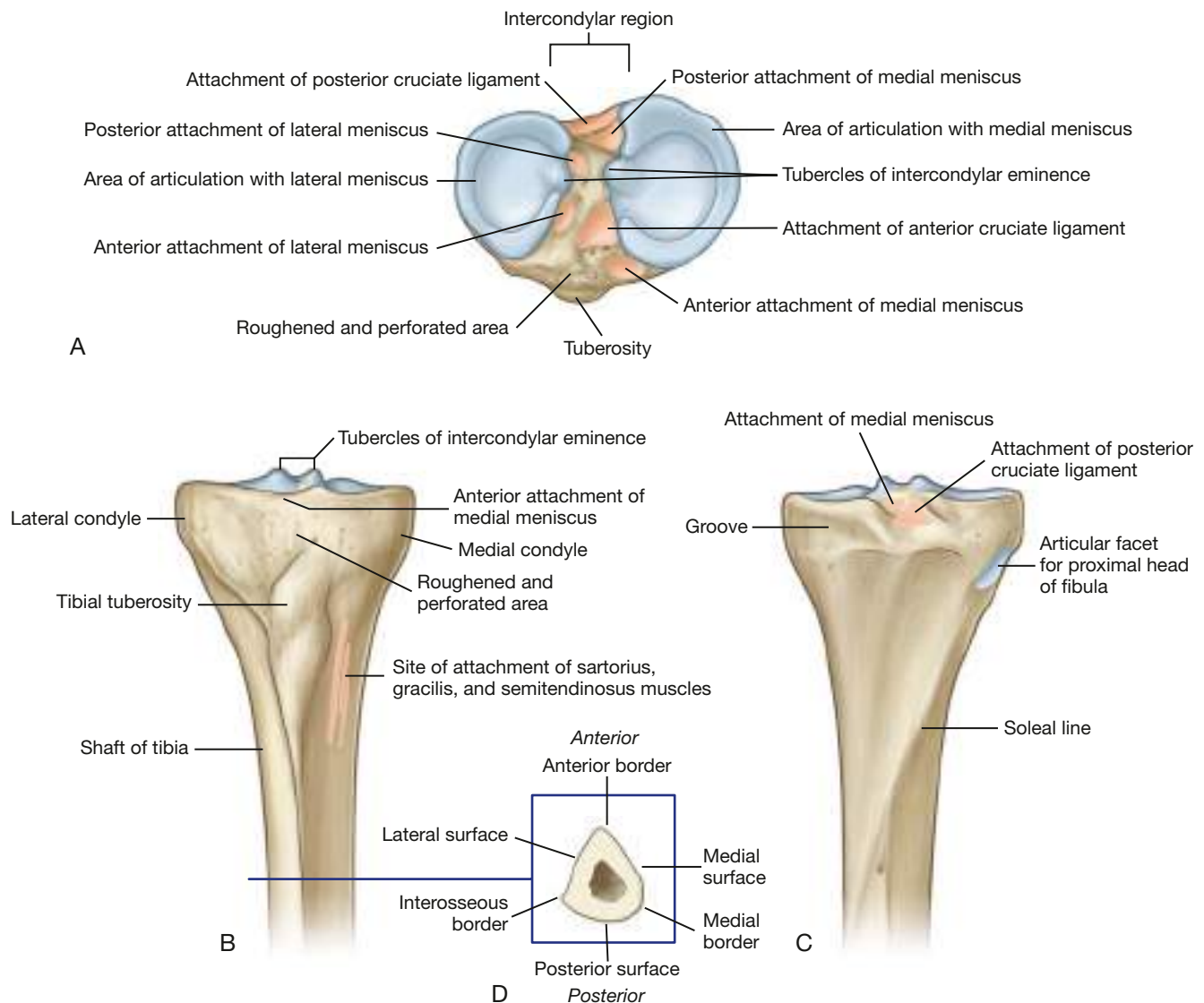


Fig. 6.37 Proximal end of the tibia. **A.** Superior view, tibial plateau. **B.** Anterior view. **C.** Posterior view. **D.** Cross-section through the shaft of tibia.

numerous small nutrient foramina for blood vessels. This region is continuous with a similar surface on the front of the tibia above the tuberosity and lies against infrapatellar connective tissue.

Tibial tuberosity

The tibial tuberosity is a palpable inverted triangular area on the anterior aspect of the tibia below the site of junction between the two condyles (Fig. 6.37A,B). It is the site of attachment for the **patellar ligament**, which is a continuation of the quadriceps femoris tendon below the patella.

Shaft of tibia

The shaft of the tibia is triangular in cross-section and has three surfaces (posterior, medial, and lateral) and three borders (anterior, interosseous, and medial) (Fig. 6.37D):

- The **anterior border** is sharp and descends from the tibial tuberosity where it is continuous superiorly with a ridge that passes along the lateral margin of the tuberosity and onto the lateral condyle.
- The **interosseous border** is a subtle vertical ridge that descends along the lateral aspect of the tibia from the region of bone anterior and inferior to the articular facet for the head of the fibula.
- The **medial border** is indistinct superiorly where it begins at the anterior end of the groove on the posterior surface of the medial tibial condyle but is sharp in the mid-shaft.

The large **medial surface** of the shaft of the tibia between the anterior and medial borders is smooth and subcutaneous and is palpable along almost its entire extent. Medial

and somewhat inferior to the tibial tuberosity, this medial surface bears a subtle, slightly roughened elongate elevation. This elevation is the site of the combined attachment of three muscles (sartorius, gracilis, and semitendinosus), which descend from the thigh (Fig. 6.37B).

The **posterior surface** of the shaft of the tibia between the interosseous and medial borders is widest superiorly where it is crossed by a roughened oblique line (the soleal line) (Fig. 6.37C).

The **lateral surface** between the anterior and interosseous borders is smooth and unremarkable.

Clinical app

Shin splints

Shin splints are a generic term applied to patients with pain and discomfort in the midtibial region. The commonest causes of shin splints include tendinosis, tibial periostitis, medial tibial stress syndrome, compartment syndrome, and stress fractures. Most patients with shin splints present with pain during or after exercise usually related to high impact training, excessive training, or other biomechanical factors.

The cause of medial tibial stress syndrome is not entirely clear; however, it may be excessive periosteal tension relating to the muscle attachments in the midmedial tibial region. A resulting inflammatory response causes pain. In addition, the bone itself may become weakened and susceptible to small linear stress fractures.

Proximal end of fibula

The fibula is the lateral bone of the leg and does not take part in formation of the knee joint or in weight bearing. It is much smaller than the tibia and has a small proximal head, a narrow neck, and a delicate shaft, which ends as the lateral malleolus at the ankle.

The **head** of the fibula is a globe-shaped expansion at the proximal end of the fibula (Fig. 6.38). A circular facet on the superomedial surface is for articulation above with a similar facet on the inferior aspect of the lateral condyle of the tibia. Just posterolateral to this facet, the bone projects superiorly as a blunt apex (styloid process).

The **neck** of the fibula separates the expanded head from the **shaft**. The common fibular nerve lies against the posterolateral aspect of the neck (Fig. 6.38A).

Like the tibia, the shaft of the fibula has three borders (anterior, posterior, and interosseous) and three surfaces (lateral, posterior, and medial) that lie between the borders (Fig. 6.38B):

- The **anterior border** is sharp mid-shaft and begins superiorly from the anterior aspect of the head.

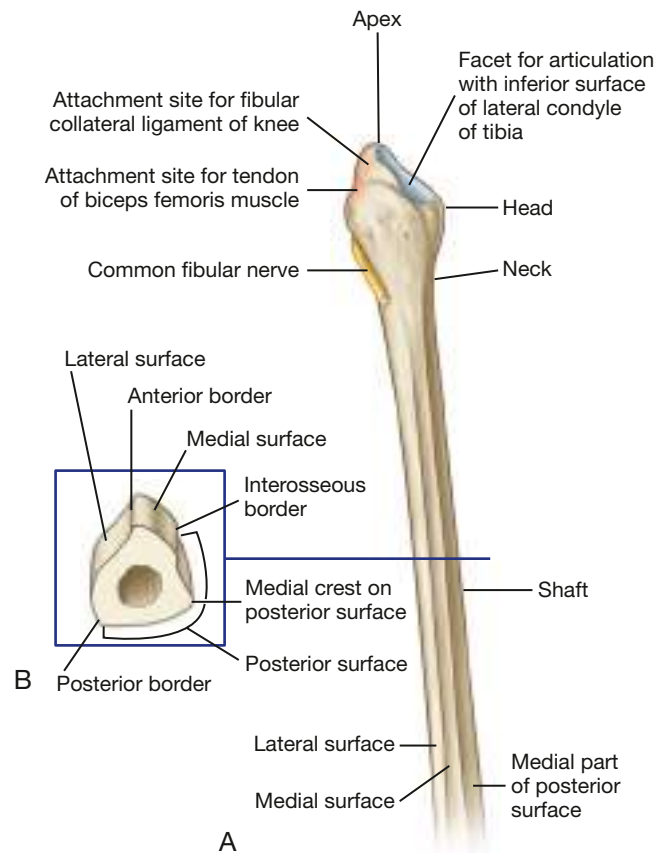


Fig. 6.38 Proximal end of the fibula. **A.** Anterior view. **B.** Cross-section through the shaft of fibula.

- The **posterior border** is rounded and descends from the region of the styloid process of the head.
- The **interosseous border** is medial in position.

The three surfaces of the fibula are associated with the three muscular compartments (lateral, posterior, and anterior) of the leg.

Muscles

Muscles of the thigh are arranged in three compartments (anterior, medial, and posterior) separated by intermuscular septa (Fig. 6.39).

Anterior compartment (Table 6.3, Fig. 6.40)

The **anterior compartment of thigh** contains the **sartorius** and the four large **quadriceps femoris muscles** (**rectus femoris**, **vastus lateralis**, **vastus medialis**, and **vastus intermedius**). All are innervated by the femoral nerve. A tiny muscle (**articularis genus**), which is often part of the vastus intermedius muscle, originates from the

femur just inferior to the origin of the vastus intermedius and inserts into the suprapatellar bursa associated with the knee joint. This articular muscle pulls the bursa away from the knee joint during extension. In addition to these muscles, the terminal ends of the psoas major and iliacus

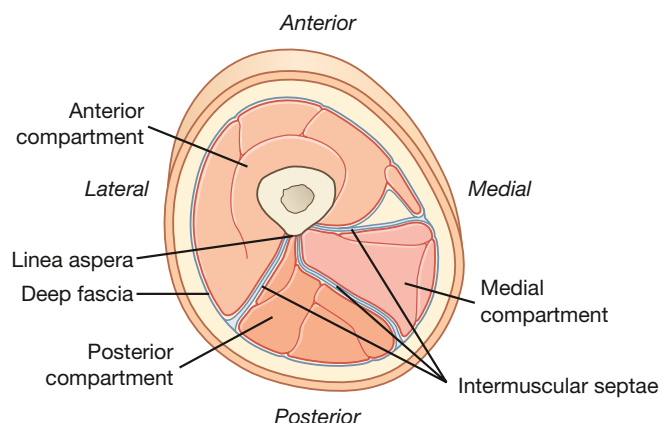


Fig. 6.39 Transverse section through the mid-thigh.

muscles pass into the upper part of the anterior compartment from sites of origin on the posterior abdominal wall (Fig. 6.41). These muscles are innervated by branches directly from the anterior rami of L1 to L3 (psoas major) or from the femoral nerve (iliacus) as it passes down the abdominal wall.

The sartorius muscle together with gracilis, and semitendinosus muscles from the medial and posterior compartments, respectively, attach to the tibia as part of a three-pronged pattern on the tibia. These combined tendons of insertion are often termed the **pes anserinus** (Latin for “goose foot”)(Fig. 6.40).

Muscles in the anterior compartment act on the hip and knee joints:

- Psoas major and iliacus act on the hip joint.
- Sartorius and rectus femoris act on both the hip and knee joints.
- The vastus muscles act on the knee joint.

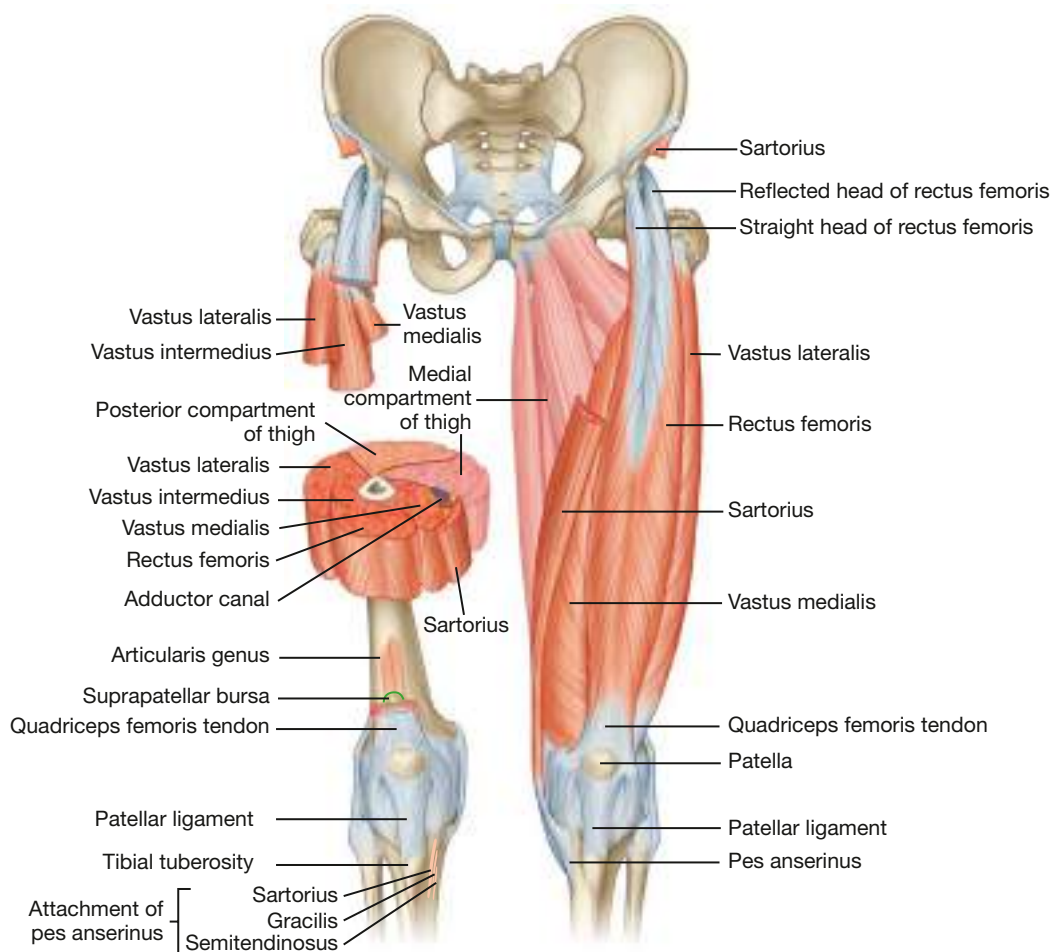


Fig. 6.40 Muscles of the anterior compartment of thigh.

Table 6.3 Muscles of the anterior compartment of thigh (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Psoas major	Posterior abdominal wall (lumbar transverse processes, intervertebral discs, and adjacent bodies from TXII to LV and tendinous arches between these points)	Lesser trochanter of femur	Anterior rami (L1 , L2 , L3)	Flexes the thigh at the hip joint
Iliacus	Posterior abdominal wall (iliac fossa)	Lesser trochanter of femur	Femoral nerve (L2 , L3)	Flexes the thigh at the hip joint
Vastus medialis	Femur—medial part of intertrochanteric line, pectineal line, medial lip of the linea aspera, medial supracondylar line	Quadriceps femoris tendon and medial border of patella	Femoral nerve (L2, L3 , L4)	Extends the leg at the knee joint
Vastus intermedius	Femur—upper two-thirds of anterior and lateral surfaces	Quadriceps femoris tendon and lateral margin of patella	Femoral nerve (L2, L3 , L4)	Extends the leg at the knee joint
Vastus lateralis	Femur—lateral part of intertrochanteric line, margin of greater trochanter, lateral margin of gluteal tuberosity, lateral lip of the linea aspera	Quadriceps femoris tendon and lateral margin of patella	Femoral nerve (L2, L3 , L4)	Extends the leg at the knee joint
Rectus femoris	Straight head originates from the anterior inferior iliac spine; reflected head originates from the ilium just superior to the acetabulum	Quadriceps femoris tendon	Femoral nerve (L2, L3 , L4)	Flexes the thigh at the hip joint and extends the leg at the knee joint
Sartorius	Anterior superior iliac spine	Medial surface of tibia just inferomedial to tibial tuberosity	Femoral nerve (L2 , L3)	Flexes the thigh at the hip joint and flexes the leg at the knee joint

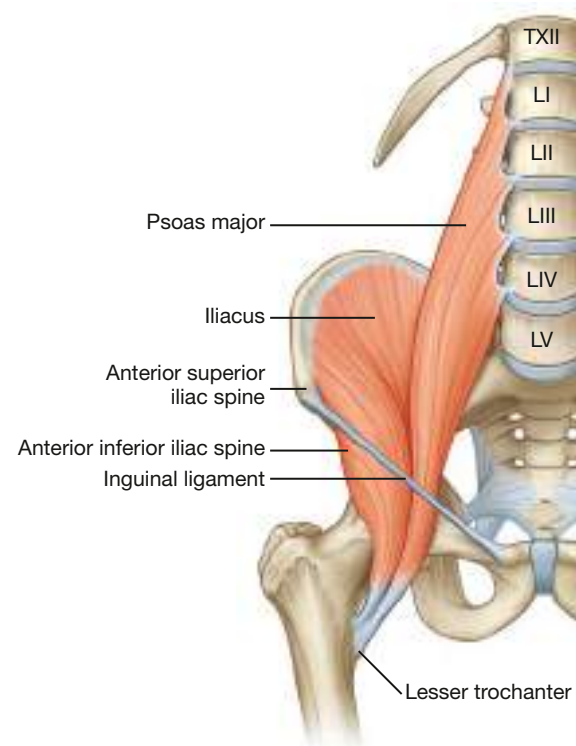
Clinical app

Quadriceps injury

Quadriceps muscle injuries include avulsion of the straight and reflected head of the rectus femoris muscles, proximal musculotendinous muscle tears, and quadriceps tendon disruption. Proximal injuries of the straight and reflected heads of the rectus femoris are uncommon. However, in adolescents it is possible to avulse these origins with a small fragment of bone. This can cause considerable pain and may result in the growth of a prominent bony tubercle.

Proximal injuries of the rectus femoris muscle occur very frequently in professional athletes and are the second most common thigh injury.

Quadriceps tendon disruption is a devastating injury. A typical history is “miss-kicking” a ball and hitting the ground, producing an abrupt deceleration and resulting in tearing the quadriceps tendon. Examination demonstrates that the patient is unable to extend the knee against resistance and in most cases a gap in the tendon can be palpated. In most instances, surgery is required to reattach the tendon to the patella.

**Fig. 6.41** Psoas major and iliacus muscles.

Patellar ligament

The patellar ligament is functionally the continuation of the quadriceps femoris tendon below the patella and is attached above to the apex and margins of the patella and below to the tibial tuberosity (Fig. 6.40). The more superficial fibers

of the quadriceps femoris tendon and the patellar ligament are continuous over the anterior surface of the patella, and lateral and medial fibers are continuous with the ligament beside the margins of the patella.

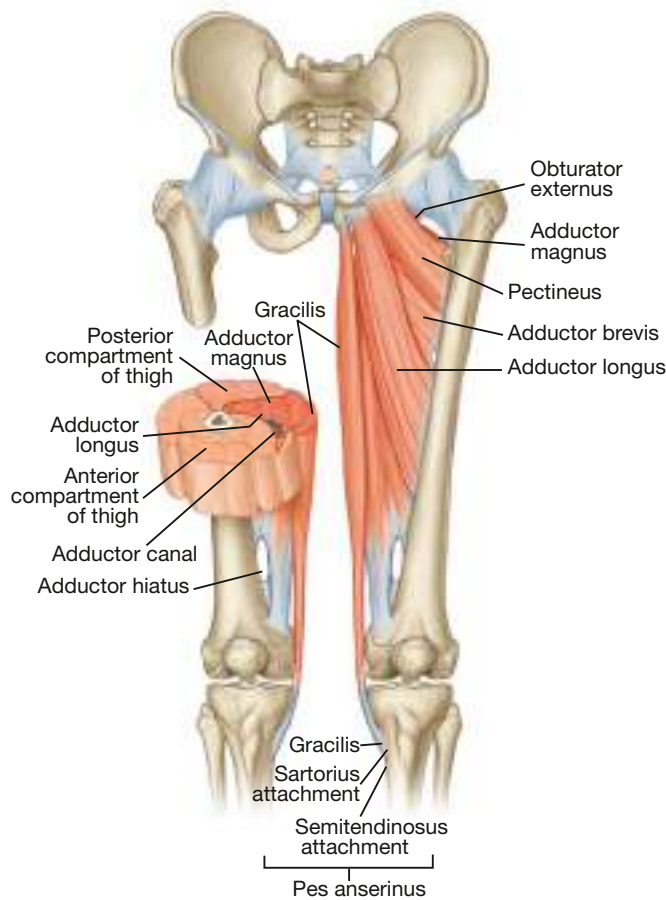


Fig. 6.42 Muscles of the medial compartment of thigh. Anterior view.

Medial compartment (Table 6.4, Fig. 6.42)

The **medial compartment of thigh** contains six muscles (**gracilis**, **pectineus**, **adductor longus**, **adductor brevis**, **adductor magnus**, and **obturator externus**). All except the pectineus, which is innervated by the femoral nerve, and part of the adductor magnus, which is innervated by the sciatic nerve, are innervated by the obturator nerve. Collectively, all these muscles except the obturator externus mainly adduct the thigh at the hip joint; the adductor longus and magnus may also medially rotate the thigh. Obturator externus is a lateral rotator of the thigh at the hip joint, and the gracilis also flexes the leg at the knee joint.

The **adductor magnus** is the largest and deepest of the muscles in the medial compartment of thigh (Fig. 6.43). The muscle forms the distal posterior wall of the adductor canal. It is a triangular or fan-shaped muscle anchored by its apex to the pelvis and attached by its expanded base to the femur. The medial part of the adductor magnus, often called the *hamstring part*, originates from the ischial tuberosity of the pelvic bone and descends almost vertically along the thigh to insert via a rounded tendon into the adductor tubercle on

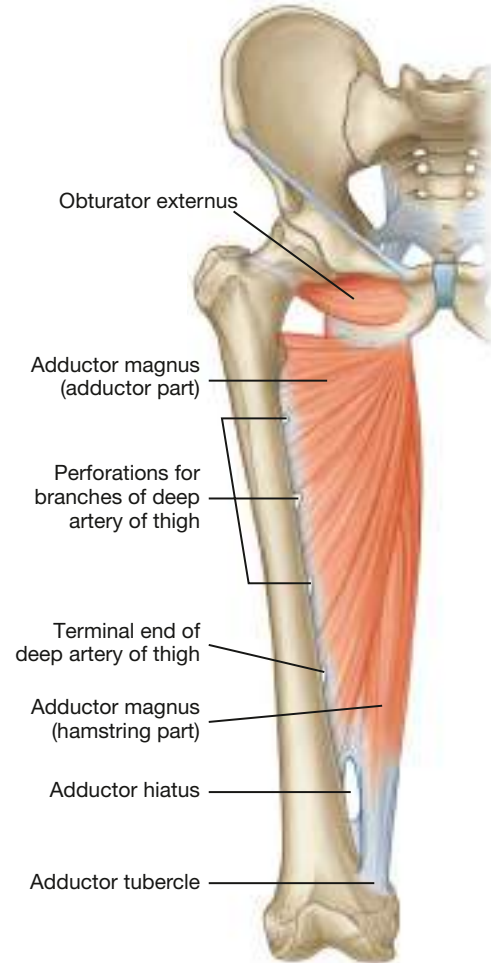


Fig. 6.43 Adductor magnus and obturator externus muscles. Anterior view.

the medial condyle of the distal head of the femur. The lateral or adductor part of the muscle inserts via an aponeurosis up onto the medial supracondylar line. A large circular gap inferiorly between the hamstring and adductor parts of the muscle is the **adductor hiatus** (Fig. 6.43), which allows the femoral artery and associated veins to pass between the adductor canal on the anteromedial aspect of the thigh and the popliteal fossa posterior to the knee. The adductor part of the muscle is innervated by the obturator nerve, and the hamstring part is innervated by the tibial division of the sciatic nerve.

Posterior compartment (Table 6.5, Fig. 6.44)

There are three long muscles in the posterior compartment of thigh: **biceps femoris**, **semitendinosus**, and **semimembranosus**—and they are collectively known as the **hamstrings**. All except the short head of biceps femoris cross both the hip and knee joints. As a group, the hamstrings flex the leg at the knee joint and extend the thigh at the hip joint.

They are also rotators at both joints. All are innervated by the sciatic nerve.

Clinical app

Hamstring injuries

Hamstring injuries include tendon avulsion at the ischial tuberosity and intermuscular, musculotendinous, and myofascial disruptions within the muscle bellies. Among the common causes of these injuries are water skiing (hamstring tendon avulsion), track and field events, football and soccer injuries, and rapid sprint injuries (muscle belly injuries). Occasionally, hamstring origin avulsions may require surgical reattachment.

Clinical app

Compartment syndrome

Compartment syndrome occurs when there is swelling within a fascial enclosed muscle compartment in the limbs. Typical causes may include limb trauma, intracompartment hemorrhage, and limb compression. As pressure within the compartment elevates, capillary blood flow and tissue perfusion is compromised, which can ultimately lead to neuromuscular damage if not treated.

Arteries

Three arteries enter the thigh: the femoral artery, the obturator artery, and the inferior gluteal artery. Of these, the femoral artery is the largest and supplies most of the lower limb. The three arteries contribute to an anastomotic network of vessels around the hip joint.

Femoral artery

The femoral artery (Fig. 6.45) is the continuation of the external iliac artery and begins as the external iliac artery passes under the inguinal ligament to enter the femoral triangle on the anterior aspect of the upper thigh (Fig. 6.45).

The femoral artery passes vertically through the femoral triangle and then continues down the thigh in the adductor canal. It leaves the canal by passing through the adductor hiatus in the adductor magnus muscle and becomes the popliteal artery behind the knee (Fig. 6.45).

A cluster of four small branches—**superficial epigastric artery**, **superficial circumflex iliac artery**, **superficial external pudendal artery**, and **deep external pudendal artery**—originate from the femoral artery in the femoral triangle and supply cutaneous regions of the upper thigh, lower abdomen, and perineum (Fig. 6.45).

Deep artery of thigh

The largest branch of the femoral artery in the thigh is the **deep artery of thigh (profunda femoris artery)**, which

Table 6.4 Muscles of the medial compartment of thigh (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Gracilis	A line on the external surfaces of the body of the pubis, the inferior pubic ramus, and the ramus of the ischium	Medial surface of proximal shaft of tibia	Obturator nerve (L2 , L3)	Adducts thigh at hip joint and flexes leg at knee joint
Pectineus	Pectineal line (pecten pubis) and adjacent bone of pelvis	Oblique line extending from base of lesser trochanter to linea aspera on posterior surface of proximal femur	Femoral nerve (L2 , L3)	Adducts and flexes thigh at hip joint
Adductor longus	External surface of body of pubis (triangular depression inferior to pubic crest and lateral to pubic symphysis)	Linea aspera on middle one-third of shaft of femur	Obturator nerve (anterior division) (L2 , L3 , L4)	Adducts and medially rotates thigh at hip joint
Adductor brevis	External surface of body of pubis and inferior pubic ramus	Posterior surface of proximal femur and upper one-third of linea aspera	Obturator nerve (L2 , L3)	Adducts thigh at hip joint
Adductor magnus	Adductor part—ischiopubic ramus	Posterior surface of proximal femur, linea aspera, medial supracondylar line	Obturator nerve (L2 , L3 , L4)	Adducts and medially rotates thigh at hip joint
	Hamstring part—ischial tuberosity	Adductor tubercle and supracondylar line	Sciatic nerve (tibial division) (L2 , L3 , L4)	
Obturator externus	External surface of obturator membrane and adjacent bone	Trochanteric fossa	Obturator nerve (posterior division) (L3, L4)	Laterally rotates thigh at hip joint

originates from the lateral side of the femoral artery in the femoral triangle and is the major source of blood supply to the thigh (Fig. 6.46). The deep artery of thigh immediately passes:

- posteriorly between the pectineus and adductor longus muscles and then between the adductor longus and adductor brevis muscles; and
- then travels inferiorly between the adductor longus and adductor magnus, eventually penetrating through the

adductor magnus to connect with branches of the popliteal artery behind the knee.

The deep artery of thigh has lateral and medial circumflex femoral branches and three perforating branches.

Lateral circumflex femoral artery

The **lateral circumflex femoral artery** normally originates proximally from the lateral side of the deep artery of thigh but may arise directly from the femoral artery (Fig. 6.46).

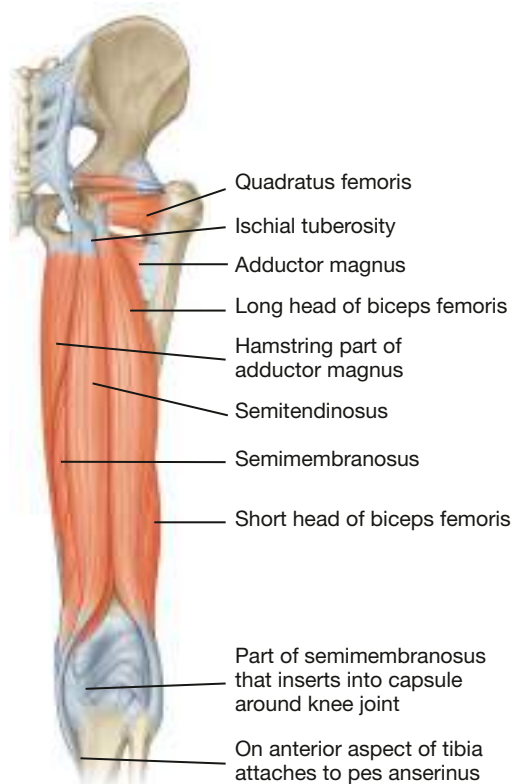


Fig. 6.44 Muscles of the posterior compartment of thigh. Posterior view.

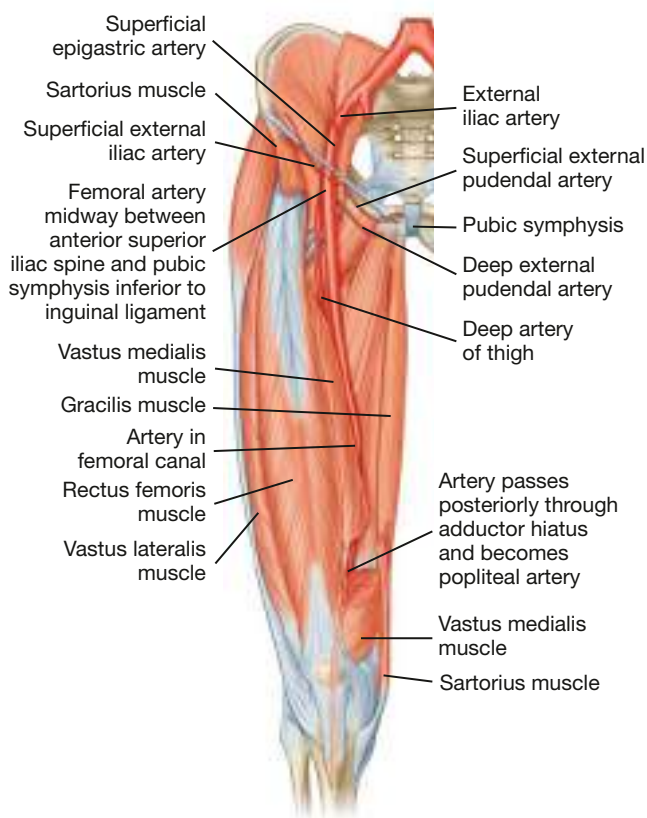


Fig. 6.45 Femoral artery.

Table 6.5 Muscles of the posterior compartment of thigh (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Biceps femoris	Long head—inferomedial part of the upper area of the ischial tuberosity; short head—lateral lip of linea aspera	Head of fibula	Sciatic nerve (L5, S1 , S2)	Flexes leg at knee joint; extends and laterally rotates thigh at hip joint and laterally rotates leg at knee joint
Semitendinosus	Inferomedial part of the upper area of the ischial tuberosity	Medial surface of proximal tibia	Sciatic nerve (L5, S1 , S2)	Flexes leg at knee joint and extends thigh at hip joint; medially rotates thigh at hip joint and leg at knee joint
Semimembranosus	Superolateral impression on the ischial tuberosity	Groove and adjacent bone on medial and posterior surface of medial tibial condyle	Sciatic nerve (L5, S1 , S2)	Flexes leg at knee joint and extends thigh at hip joint; medially rotates thigh at hip joint and leg at knee joint

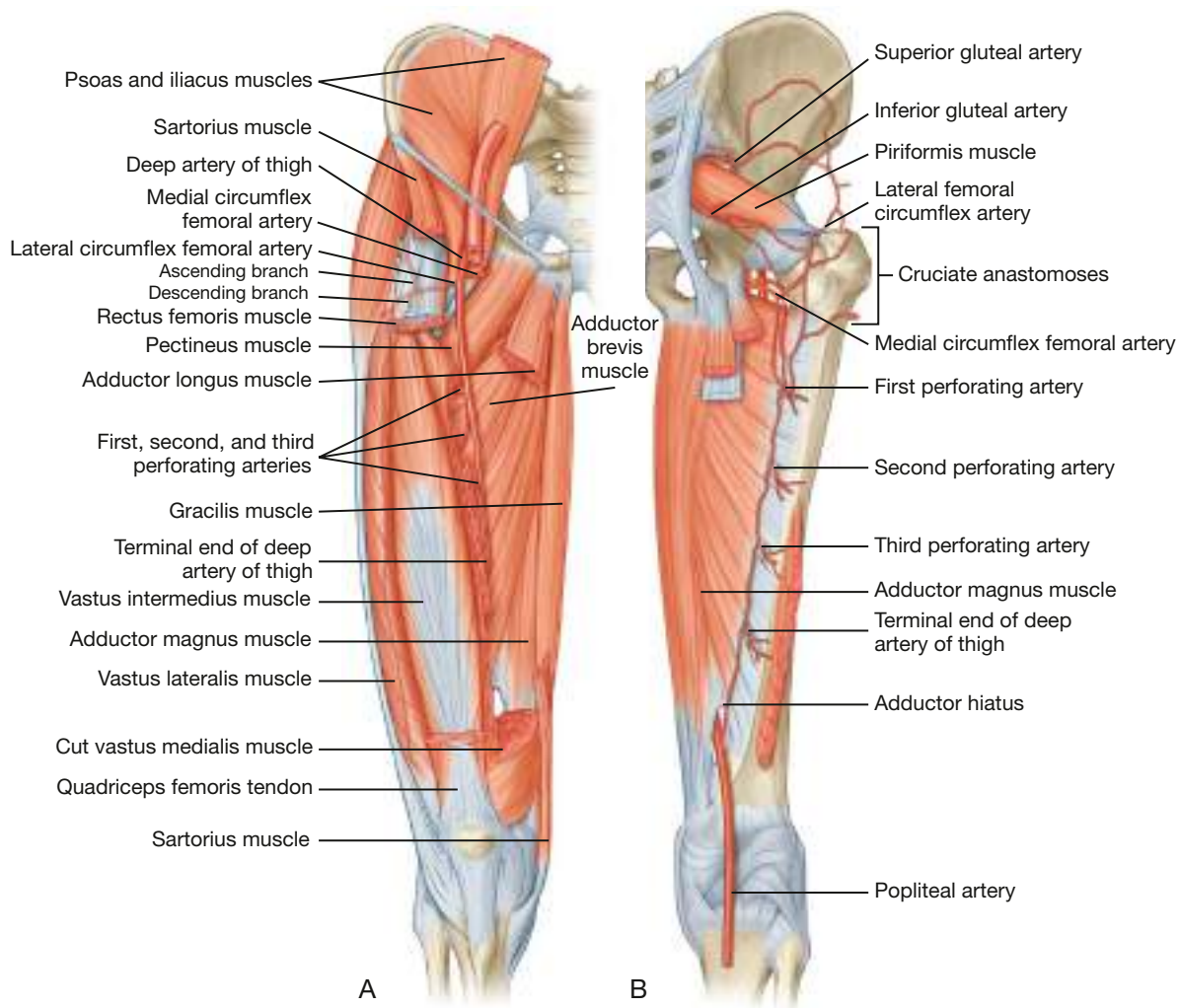


Fig. 6.46 Deep artery of thigh. **A.** Anterior view. **B.** Posterior view.

It passes deep to the sartorius and rectus femoris and divides into three terminal branches:

- One vessel (**ascending branch**) ascends laterally deep to the tensor fasciae latae muscle and connects with a branch of the medial circumflex femoral artery to form a channel, which circles the neck of the femur and supplies the neck and head of the femur.
- One vessel (**descending branch**) descends deep to the rectus femoris, penetrates the vastus lateralis muscle, and connects with a branch of the popliteal artery near the knee.
- One vessel (**transverse branch**) passes laterally to pierce the vastus lateralis and then circles around the proximal shaft of femur to anastomose with branches from the medial femoral circumflex artery, the inferior gluteal artery, and the first perforating artery to form the cruciate anastomosis around the hip (Fig. 6.46).

Medial circumflex femoral artery

The **medial circumflex femoral artery** normally originates proximally from the posteromedial aspect of the deep artery of thigh but may originate from the femoral artery (Fig. 6.46). It passes medially around the shaft of femur, first between the pectineus and iliopsoas and then between the obturator externus and adductor brevis muscles. Near the margin of the adductor brevis, the vessel gives off a small branch, which enters the hip joint through the acetabular notch and anastomoses with the acetabular branch of the obturator artery.

The main trunk of the medial circumflex femoral artery passes over the superior margin of the adductor magnus and divides into two major branches deep to the quadratus femoris muscle:

- One branch ascends to the trochanteric fossa and connects with branches of the gluteal and lateral circumflex femoral arteries.

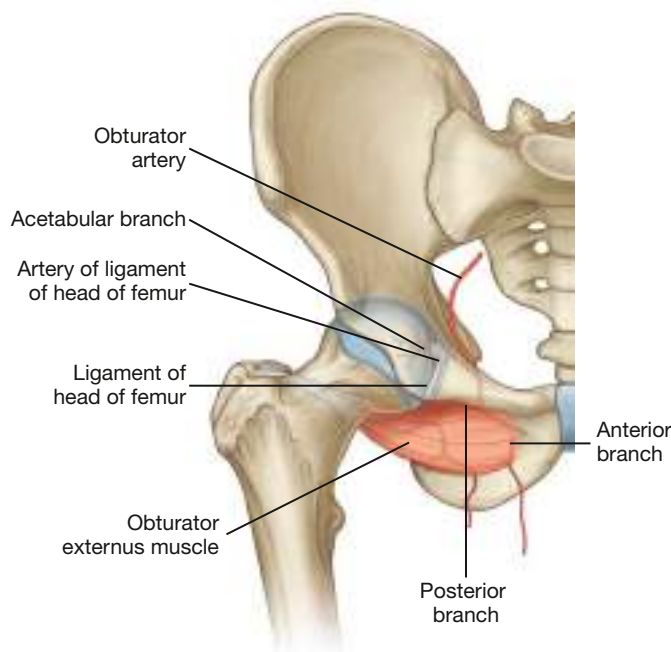


Fig. 6.47 Obturator artery.

- The other branch passes laterally to participate with branches from the lateral femoral circumflex artery, the inferior gluteal artery, and the first perforating artery in forming an anastomotic network of vessels around the hip.

Perforating arteries

The three **perforating arteries** branch from the deep artery of thigh (Fig. 6.46) as it descends anterior to the adductor brevis muscle—the first originates above the muscle, the second originates anterior to the muscle, and the third originates below the muscle. All three penetrate through the adductor magnus near its attachment to the linea aspera to enter and supply the posterior compartment of thigh. Here, the vessels have ascending and descending branches that interconnect to form a longitudinal channel, which participates above in forming an anastomotic network of vessels around the hip and inferiorly anastomoses with branches of the popliteal artery behind the knee.

Obturator artery

The **obturator artery** originates as a branch of the internal iliac artery in the pelvic cavity and enters the medial compartment of thigh through the obturator canal (Fig. 6.47). As it passes through the canal, it bifurcates into an **anterior branch** and a **posterior branch**, which, together, form a channel that circles the margin of the obturator membrane and lies within the attachment of the obturator externus muscle.

Vessels arising from the anterior and posterior branches supply adjacent muscles and anastomose with the inferior gluteal and medial circumflex femoral arteries. In addition, an acetabular vessel originates from the posterior branch, enters the hip joint through the acetabular notch, and contributes to the supply of the head of the femur.

Clinical app

Peripheral vascular disease

Peripheral vascular disease is often characterized by reduced blood flow to the legs. This disorder may be due to stenoses (narrowing) and/or occlusions (blockages) in the lower aorta, iliac, femoral, tibial, and fibular vessels. Patients typically have chronic leg ischemia and “acute on chronic” leg ischemia.

Chronic leg ischemia

Chronic leg ischemia is a disorder in which vessels have undergone atheromatous change, and often there is significant luminal narrowing (usually over 50%). Most patients with peripheral arterial disease have widespread arterial disease (including cardiovascular and cerebrovascular disease), which may be clinically asymptomatic. Some of these patients develop such severe ischemia that the viability of the limb is threatened (**critical limb ischemia**).

The commonest symptom of chronic leg ischemia is **intermittent claudication**. Patients typically have a history of pain that develops in the calf muscles (usually associated with occlusions or narrowing in the femoral artery) or the buttocks (usually associated with occlusion or narrowing in the aorto-iliac segments). The pain experienced in these muscles is often cramp-like and occurs with walking. The patient rests and is able to continue walking up to the same distance until the pain recurs and stops walking as before.

Acute on chronic ischemia

In some patients with chronic limb ischemia, an acute event blocks the vessels or reduces the blood supply to such a degree that the viability of the limb is threatened.

Occasionally a leg may become acutely ischemic with no evidence of underlying atheromatous disease. In these instances a blood clot is likely to have embolized from the heart. Patients with mitral valve disease and atrial fibrillation are prone to embolic disease.

Critical limb ischemia

Critical limb ischemia occurs when the blood supply to the limb is so poor that the viability of the limb is severely threatened, and in this case many patients develop gangrene, ulceration, and severe rest pain in the foot. These patients require urgent treatment, which may be in the form of surgical reconstruction, radiological angioplasty, or even amputation.

Veins

Veins in the thigh consist of superficial and deep veins. Deep veins generally follow the arteries and have similar names. Superficial veins are in the superficial fascia, interconnect with deep veins, and do not generally accompany arteries. The largest of the superficial veins in the thigh is the great saphenous vein.

Great saphenous vein

The great saphenous vein originates from a venous arch on the dorsal aspect of the foot and ascends along the medial side of the lower limb to the proximal thigh (see Fig. 6.20). Here it passes through the saphenous opening in the deep fascia covering the anterior thigh to connect with the femoral vein in the femoral triangle (see Fig. 6.23).

Nerves

There are three major nerves in the thigh, each associated with one of the three compartments. The **femoral nerve** is associated with the anterior compartment of thigh, the **obturator nerve** is associated with the medial compartment of thigh, and the **sciatic nerve** is associated with the posterior compartment of thigh.

Femoral nerve

The femoral nerve originates from the lumbar plexus (spinal cord segments L2 to L4) on the posterior abdominal wall and enters the femoral triangle of the thigh by passing under the inguinal ligament (Fig. 6.48). In the femoral triangle, the femoral nerve lies on the lateral side of the femoral artery and is outside the femoral sheath, which surrounds the vessels.

Before entering the thigh, the femoral nerve supplies branches to the iliacus and pectineus muscles.

Immediately after passing under the inguinal ligament, the femoral nerve divides into anterior and posterior branches, which supply muscles of the anterior compartment of thigh and skin on the anterior and medial aspects of the thigh and on the medial sides of the leg and foot.

Branches of the femoral nerve (Fig. 6.48) include:

- anterior cutaneous branches, which penetrate deep fascia to supply skin on the front of the thigh and knee;
- numerous motor nerves, which supply the quadriceps femoris muscle (rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis muscles) and the sartorius muscle; and
- one long cutaneous nerve, the saphenous nerve, which supplies skin as far distally as the medial side of the foot.

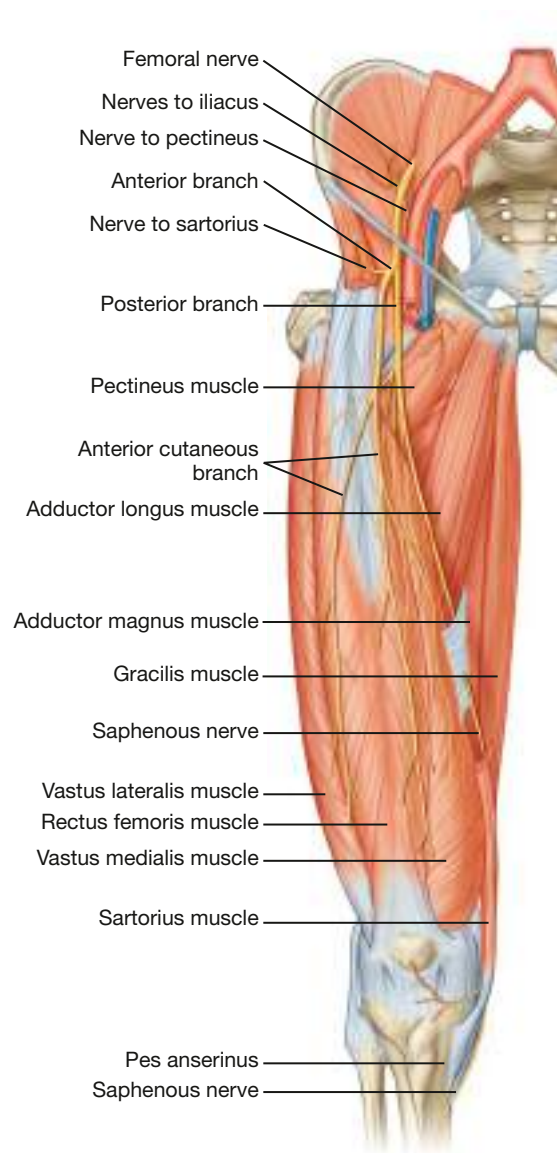


Fig. 6.48 Femoral nerve.

The **saphenous nerve** accompanies the femoral artery through the adductor canal but does not pass through the adductor hiatus with the femoral artery (Fig. 6.48). Rather, the saphenous nerve penetrates directly through connective tissues near the end of the canal to appear between the sartorius and gracilis muscles on the medial side of the knee. Here the saphenous nerve penetrates deep fascia and continues down the medial side of the leg to the foot, supplying skin on the medial side of the knee, leg, and foot.

Obturator nerve

The obturator nerve is a branch of the lumbar plexus (spinal cord segments L2 to L4) on the posterior abdominal

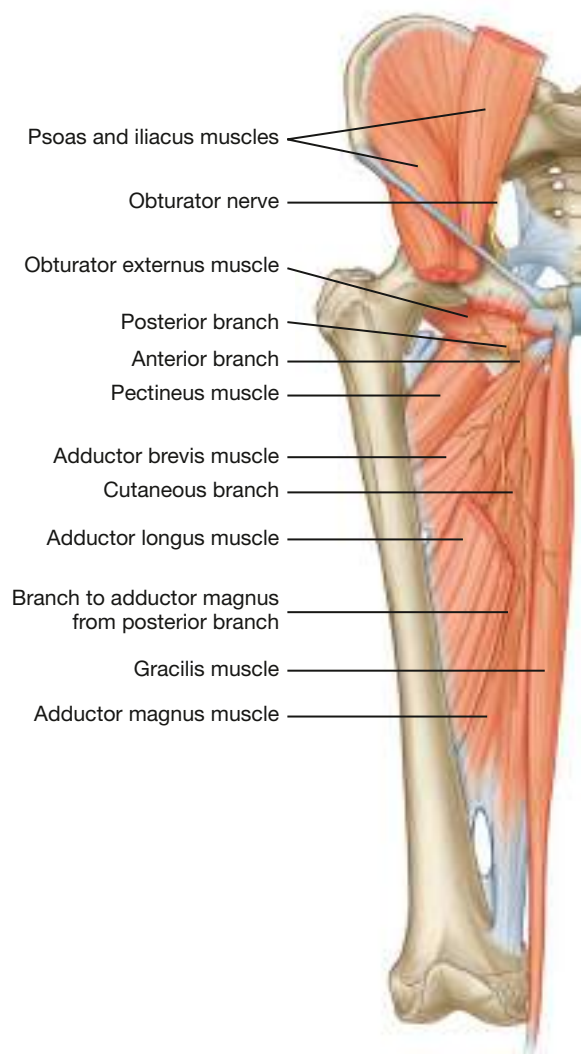


Fig. 6.49 Obturator nerve.

wall. It descends in the psoas muscle and then passes out of the medial margin of the psoas muscle to enter the pelvis (Fig. 6.49). The obturator nerve continues along the lateral pelvic wall and then enters the medial compartment of thigh by passing through the obturator canal. It supplies most of the adductor muscles and skin on the medial aspect of the thigh. As the obturator nerve enters the thigh, it divides into two branches: an anterior branch and a posterior branch, which are separated by the adductor brevis muscle:

- The **posterior branch** descends behind the adductor brevis muscle and on the anterior surface of the adductor magnus muscle and supplies the obturator externus and adductor brevis muscles and the part of adductor magnus that attaches to the linea aspera.



Fig. 6.50 Sciatic nerve.

- The **anterior branch** descends on the anterior surface of the adductor brevis muscle and is behind the pectineus and adductor longus muscles. It supplies branches to the adductor longus, gracilis, and adductor brevis muscles and often contributes to the supply of the pectineus muscle. Cutaneous branches innervate the skin on the medial side of the thigh.

Sciatic nerve

The sciatic nerve is a branch of the lumbosacral plexus (spinal cord segments L4 to S3) and descends into the posterior compartment of thigh from the gluteal region (Fig. 6.50). It innervates all muscles in the posterior compartment of thigh, and then its branches continue into the leg and foot.

In the posterior compartment of thigh, the sciatic nerve lies on the adductor magnus muscle and is crossed by the long head of biceps femoris muscle.

Proximal to the knee, and sometimes within the pelvis, the sciatic nerve divides into its two terminal branches: the **tibial nerve** and the **common fibular nerve** (Fig. 6.50). These nerves travel vertically down the thigh and enter the popliteal fossa posterior to the knee. Here, they meet the popliteal artery and vein.

The tibial nerve supplies branches to all muscles in the posterior compartment of thigh (long head of biceps femoris, semimembranosus, semitendinosus) except the short head of the biceps femoris, which is innervated by the common fibular part (Fig. 6.50).

The tibial nerve descends through the popliteal fossa, enters the posterior compartment of leg, and continues into the sole of the foot.

The tibial nerve innervates:

- all muscles in the posterior compartment of leg,
- all intrinsic muscles in the sole of the foot except for the first two dorsal interossei muscles, which are innervated by the deep fibular nerve, and
- skin on the posterolateral side of the lower half of the leg; lateral side of the ankle, foot, and little toe; and on the sole of the foot and toes.

The common fibular nerve supplies the short head of the biceps femoris in the posterior compartment of thigh and then continues into the lateral and anterior compartments of leg and onto the foot (Fig. 6.50).

The common fibular nerve innervates:

- all muscles in the anterior and lateral compartments of the leg,
- one muscle (extensor digitorum brevis) on the dorsal aspect of the foot,
- the first two dorsal interossei muscles in the sole of the foot, and
- skin over the lateral aspect of the leg and ankle and over the dorsal aspect of the foot and toes.

Knee joint

The knee joint is the largest synovial joint in the body (Fig. 6.51; also see Fig. 6.59). The detailed movements of the knee joint are complex, but basically the joint is a hinge joint that allows mainly flexion and extension. The joint consists of:

- the articulation between the femur and tibia, which is weight bearing, and
- the articulation between the patella and the femur, which allows the pull of the quadriceps femoris muscle to be directed anteriorly over the knee to the tibia without tendon wear.



Fig. 6.51 Knee joint. Joint capsule is not shown.

Articular surfaces

The articular surfaces of the bones that contribute to the knee joint are covered by hyaline cartilage. The major surfaces involved include:

- the two femoral condyles, and
- the adjacent surfaces of the superior aspect of the tibial condyles.

The surfaces of the femoral condyles that articulate with the tibia in flexion of the knee are curved or round, whereas the surfaces that articulate in full extension are flat (Fig. 6.52A,B).

The articular surfaces between the femur and patella are the V-shaped trench on the anterior surface of the distal end of the femur where the two condyles join and the adjacent surfaces on the posterior aspect of the patella. The joint surfaces are all enclosed within a single articular cavity, as are the intra-articular menisci between the femoral and tibial condyles (Fig. 6.52C).

Menisci

There are two menisci, which are fibrocartilaginous C-shaped cartilages in the knee joint, one medial (**medial meniscus**) and the other lateral (**lateral meniscus**) (Fig. 6.53). Both are attached at each end to facets in the intercondylar region of the tibial plateau.

The medial meniscus is attached around its margin to the capsule of the joint and to the tibial collateral ligament,

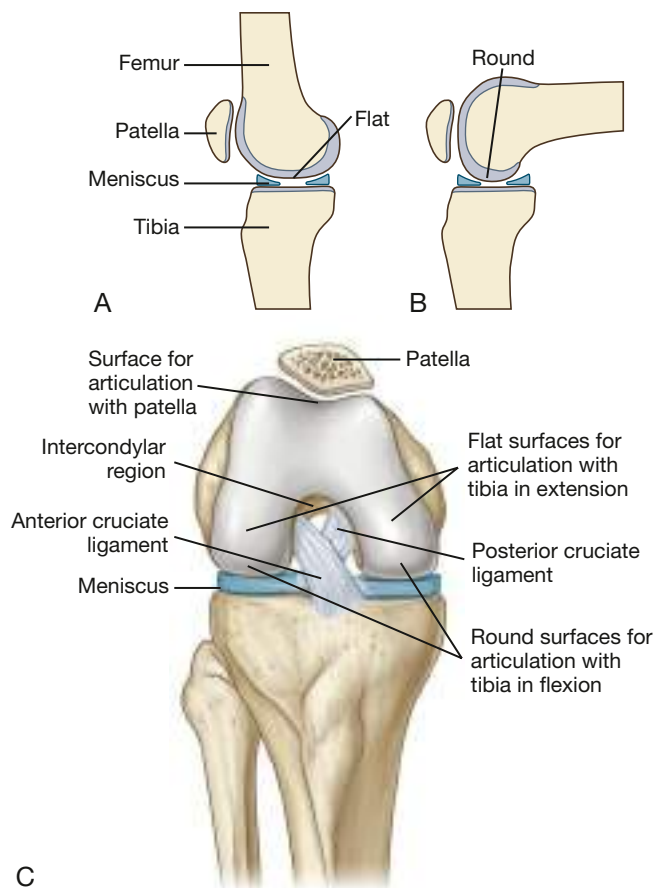


Fig. 6.52 Articular surfaces of the knee joint. **A.** Extended. **B.** Flexed. **C.** Anterior view (flexed).

whereas the lateral meniscus is unattached to the capsule. Therefore the lateral meniscus is more mobile than the medial meniscus.

The menisci are interconnected anteriorly by a transverse ligament of the knee (Fig. 6.53). The lateral meniscus is also connected to the tendon of the popliteus muscle, which passes superolaterally between this meniscus and the capsule to insert on the femur (Fig. 6.53).

The menisci improve congruency between the femoral and tibial condyles during joint movements where the surfaces of the femoral condyles articulating with the tibial plateau change from small curved surfaces in flexion to large flat surfaces in extension (Fig. 6.52).

Synovial membrane

The synovial membrane of the knee joint attaches to the margins of the articular surfaces and to the superior and inferior outer margins of the menisci (Fig. 6.54A). The two cruciate ligaments, which attach in the intercondylar region of the tibia below and the intercondylar fossa of the femur

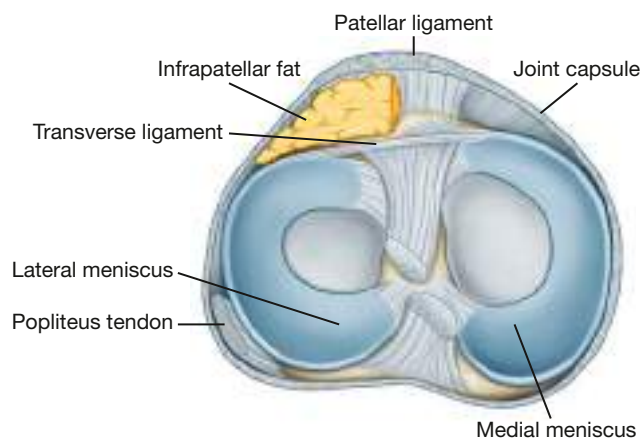


Fig. 6.53 Menisci of the knee joint. Superior view.

above, are outside the articular cavity but enclosed within the fibrous membrane of the knee joint.

Anteriorly, the synovial membrane is separated from the patellar ligament by an **infrapatellar fat pad** (Fig. 6.54). On each side of the pad, the synovial membrane forms a fringed margin (an **alar fold**), which projects into the articular cavity. In addition, the synovial membrane covering the lower part of the infrapatellar fat pad is raised into a sharp midline fold directed posteriorly (the **infrapatellar synovial fold**), which attaches to the margin of the intercondylar fossa of the femur.

The synovial membrane of the knee joint forms pouches in two locations to provide low friction surfaces for the movement of tendons associated with the joint:

- the small **subpopliteal recess** (Fig. 6.54A) extends between the lateral meniscus and the tendon of the popliteus muscle, and
- the large **suprapatellar bursa** (Fig. 6.54B) is a continuation of the articular cavity superiorly between the distal end of the shaft of the femur and the quadriceps femoris muscle and tendon. The apex of this bursa is attached to the small articularis genus muscle, which pulls the bursa away from the joint during extension of the knee.

Other bursae associated with the knee, but not normally communicating with the articular cavity, include the subcutaneous prepatellar bursa, deep and subcutaneous infrapatellar bursae, and numerous other bursae associated with tendons and ligaments around the joint (Fig. 6.54B).

The prepatellar bursa is subcutaneous and anterior to the patella. The deep and subcutaneous infrapatellar bursae are on the deep and subcutaneous sides of the patellar ligament, respectively.

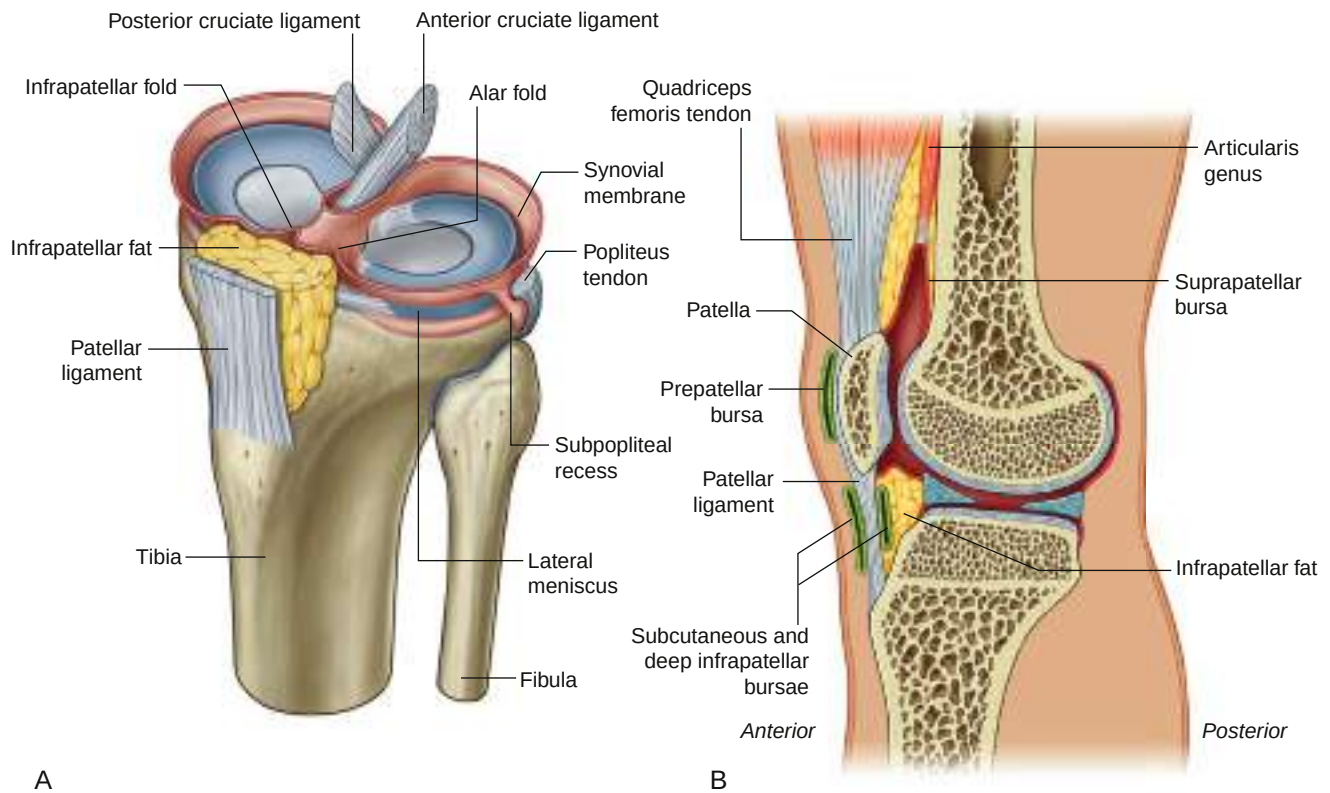


Fig. 6.54 Synovial membrane of the knee joint and associated bursae. **A.** Superolateral view; patella and femur not shown. **B.** Paramedial sagittal section through the knee.

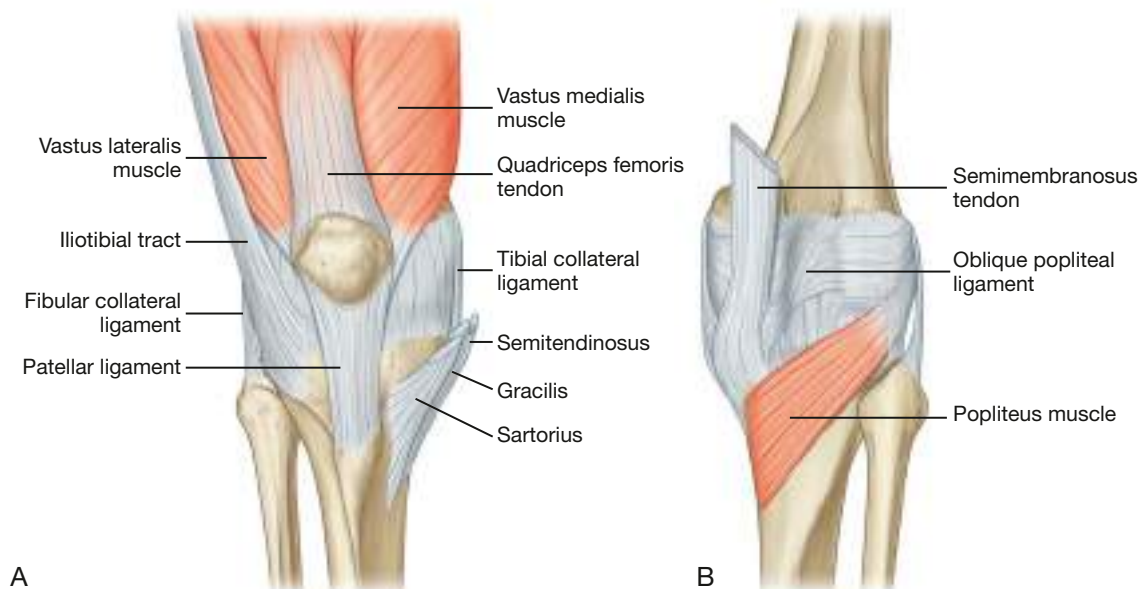


Fig. 6.55 Fibrous membrane of the knee joint capsule. **A.** Anterior view. **B.** Posterior view.

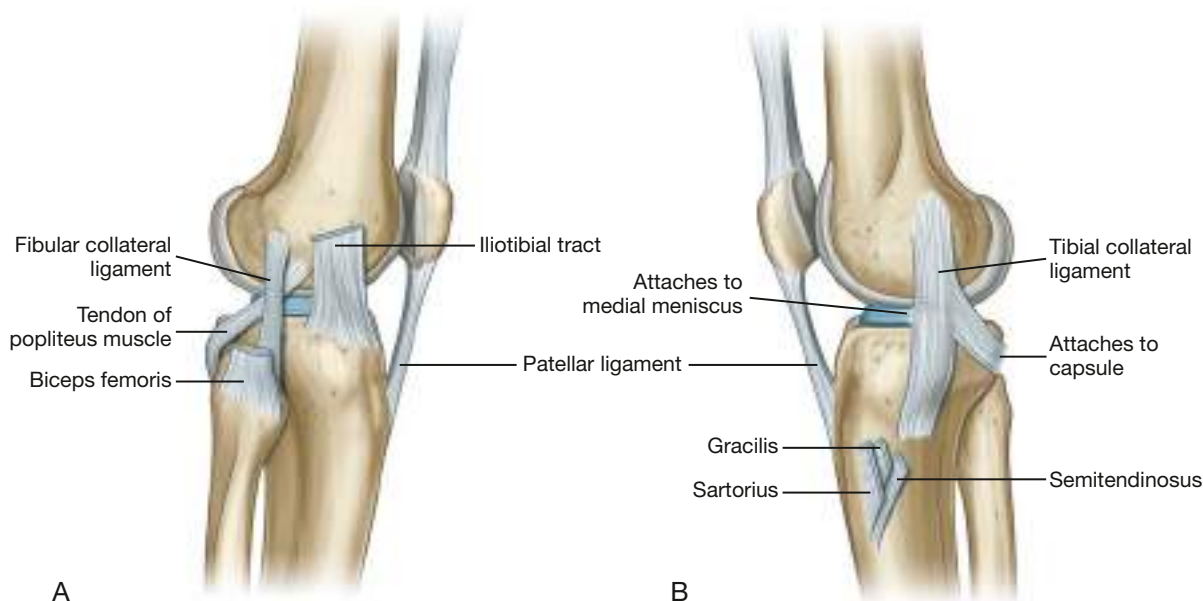


Fig. 6.56 Collateral ligaments of the knee joint. A. Lateral view. B. Medial view.

Fibrous membrane

The fibrous membrane of the knee joint is extensive and is partly formed and reinforced by extensions from tendons of the surrounding muscles (Fig. 6.55). In general, the fibrous membrane encloses the articular cavity and the intercondylar region (Fig. 6.55):

- On the medial side of the knee joint, the fibrous membrane blends with the tibial collateral ligament and is attached on its internal surface to the medial meniscus.
- Laterally, the external surface of the fibrous membrane is separated by a space from the fibular collateral ligament, and the internal surface of the fibrous membrane is not attached to the lateral meniscus.
- Anteriorly, the fibrous membrane is attached to the margins of the patella where it is reinforced with tendinous expansions from the vastus lateralis and vastus medialis muscles, which also merge above with the quadriceps femoris tendon and below with the patellar ligament.

The fibrous membrane is reinforced anterolaterally by a fibrous extension from the iliotibial tract and posteromedially by an extension from the tendon of semimembranosus (the **oblique popliteal ligament**), which reflects superiorly across the back of the fibrous membrane from medial to lateral (Fig. 6.55B).

The upper end of the popliteus muscle passes through an aperture in the posterolateral aspect of the fibrous

membrane of the knee and is enclosed by the fibrous membrane as its tendon travels around the joint to insert into the lateral aspect of the lateral femoral condyle (Fig. 6.55B).

Ligaments

The major ligaments associated with the knee joint are the patellar ligament, the tibial (medial) and fibular (lateral) collateral ligaments, and the anterior and posterior cruciate ligaments.

Patellar ligament

The **patellar ligament** is basically the continuation of the quadriceps femoris tendon inferior to the patella (Fig. 6.55A). It is attached above to the margins and apex of the patella and below to the tibial tuberosity.

Collateral ligaments

The collateral ligaments, one on each side of the joint, stabilize the hinge-like motion of the knee (Fig. 6.56).

The cord-like **fibular collateral ligament** is attached superiorly to the lateral femoral epicondyle just above the groove for the popliteus tendon (Fig. 6.56A). Inferiorly, it is attached to a depression on the lateral surface of the fibular head. It is separated from the fibrous membrane by a bursa.

The broad and flat **tibial collateral ligament** (Fig. 6.56B) is attached by much of its deep surface to the underlying fibrous membrane. It is anchored superiorly to the medial femoral epicondyle just inferior to the adductor tubercle and descends

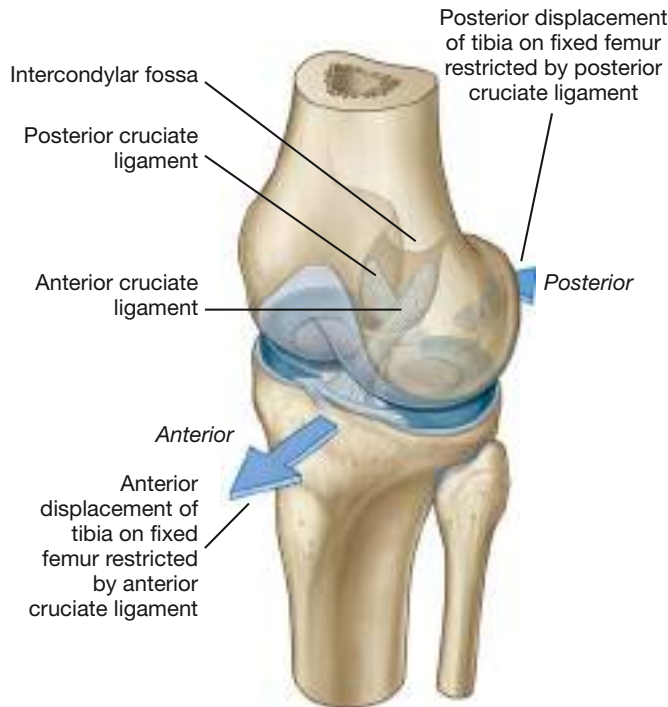


Fig. 6.57 Cruciate ligaments of the knee joint. Superolateral view.

anteriorly to attach to the medial margin and medial surface of the tibia above and behind the attachment of sartorius, gracilis, and semitendinosus tendons (Fig. 6.56B).

Cruciate ligaments

The two cruciate ligaments are in the intercondylar region of the knee and interconnect the femur and tibia (Fig. 6.57). They are termed *cruciate* (Latin for “shaped like a cross”) because they cross each other in the sagittal plane between their femoral and tibial attachments:

- The **anterior cruciate ligament** attaches to a facet on the anterior part of the intercondylar area of the tibia and ascends posteriorly to attach to a facet at the back of the lateral wall of the intercondylar fossa of the femur (Fig. 6.57).
- The **posterior cruciate ligament** attaches to the posterior aspect of the intercondylar area of the tibia and ascends anteriorly to attach to the medial wall of the intercondylar fossa of the femur (Fig. 6.57).

The anterior cruciate ligament crosses lateral to the posterior cruciate ligament as they pass through the intercondylar region.

The anterior cruciate ligament prevents anterior displacement of the tibia relative to the femur and the posterior cruciate ligament restricts posterior displacement (Fig. 6.57).

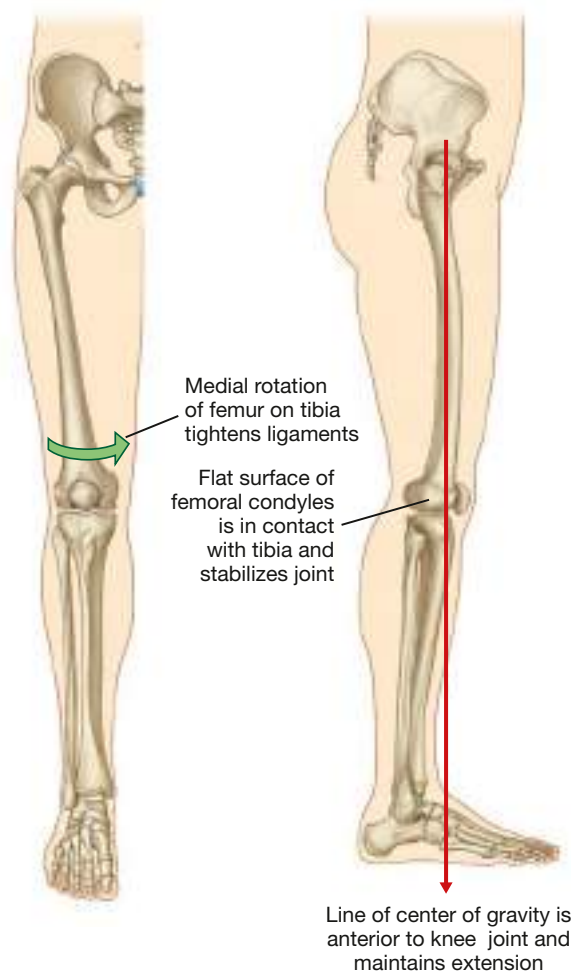


Fig. 6.58 Knee “locking” mechanism.

Locking mechanism

When standing, the knee joint is locked into position, thereby reducing the amount of muscle work needed to maintain the standing position (Fig. 6.58).

One component of the locking mechanism is a change in the shape and size of the femoral surfaces that articulate with the tibia (see Fig. 6.52A,B):

- In flexion, the surfaces are the curved and rounded areas on the posterior aspects of the femoral condyles.
- As the knee is extended, the surfaces move to the broad and flat areas on the inferior aspects of the femoral condyles.

Consequently the joint surfaces become larger and more stable in extension.

Another component of the locking mechanism is medial rotation of the femur on the tibia during extension. Medial

Imaging app

Visualizing the knee joint

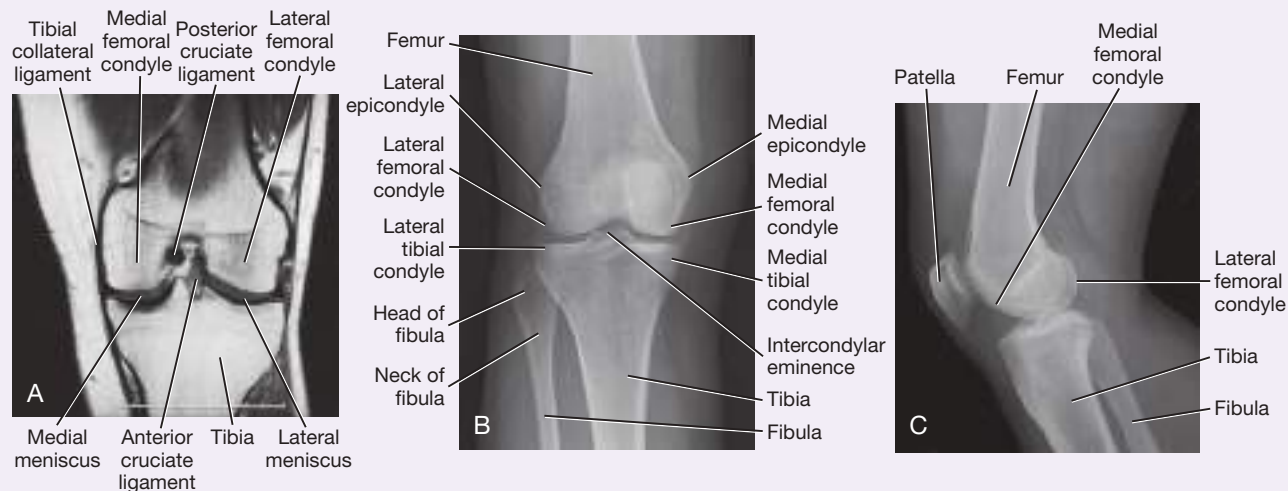


Fig. 6.59 Normal knee joint. **A.** Normal knee joint showing the tibial collateral ligament, the medial and lateral menisci, and the anterior and posterior cruciate ligaments. T1-weighted magnetic resonance image in the coronal plane. **B.** Radiograph, anterior-posterior view. **C.** Radiograph, lateral view.

rotation and full extension tightens all the associated ligaments.

Another feature that keeps the knee extended when standing is that the body's center of gravity is positioned along a vertical line that passes anterior to the knee joint.

The popliteus muscle unlocks the knee by initiating lateral rotation of the femur on the tibia.

Vascular supply and innervation

Vascular supply to the knee joint is predominantly through descending and genicular branches from the femoral, popliteal, and lateral circumflex femoral arteries in the thigh and the circumflex fibular artery and recurrent branches from the anterior tibial artery in the leg. These vessels form an anastomotic network around the joint (Fig. 6.60).

The knee joint is innervated by branches from the obturator, femoral, tibial, and common fibular nerves.

Clinical app

Soft tissue injuries to the knee

Soft tissue injuries are common at and around the knee joint.

The typical injuries include tears of the anterior and posterior cruciate ligaments, meniscal tears, and trauma to the collateral ligaments. Isolated soft tissue injuries may occur, but it is not uncommon for certain types of injuries to occur together, for example, anterior cruciate ligament disruption, tibial collateral ligament disruption, and tears of the medial or lateral menisci.

Clinical app

Clinical tests for tears in the cruciate ligaments:

- **Anterior drawer test**—a positive anterior drawer test is when the proximal head of a supine patient's tibia can be pulled anteriorly on the femur. The patient lies supine on a couch. The knee is flexed to 90° and the heel and sole of the foot are placed on the couch. If the tibia moves forward, the anterior cruciate ligament is torn.
- **Posterior drawer test**—a positive posterior drawer test occurs when the proximal head of a supine patient's tibia can be pushed posteriorly on the femur. The patient is placed in a supine position and the knee is flexed to approximately 90° with the foot in the neutral position. If the tibial plateau moves posteriorly, the posterior cruciate ligament is torn.

Clinical app

Arthroscopy

An arthroscope is a small camera that is placed into the knee joint through the anterolateral or anteromedial aspect of the knee joint. The joint is filled with a saline solution and the camera is manipulated around the knee joint to assess the cruciate ligaments, menisci, and cartilaginous surfaces. Any damage observed can be repaired or trimmed.

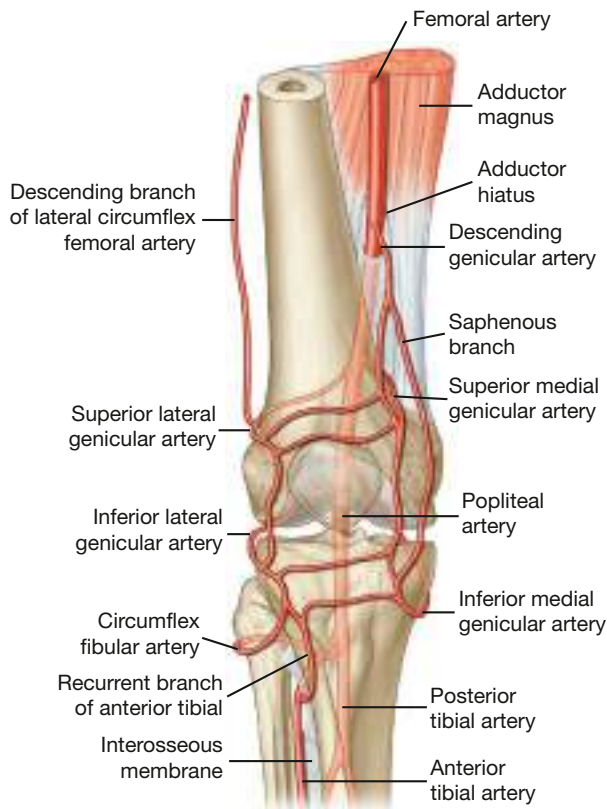


Fig. 6.60 Anastomoses of arteries around the knee. Anterior view.

Tibiofibular joint

The small proximal tibiofibular joint is synovial in type and allows very little movement (Fig. 6.61). The opposing joint surfaces on the undersurface of the lateral condyle of the tibia and on the superomedial surface of the head of the fibula are flat and circular. The capsule is reinforced by anterior and posterior ligaments.

Popliteal fossa

The **popliteal fossa** is an important area of transition between the thigh and leg and is the major route by which structures pass from one region to the other.

The popliteal fossa is a diamond-shaped space behind the knee joint formed between muscles in the posterior compartments of thigh and leg (Fig. 6.62A):

- The margins of the upper part of the diamond are formed medially by the distal ends of the semitendinosus and semimembranosus muscles and laterally by the distal end of the biceps femoris muscle.
- The margins of the smaller lower part of the space are formed medially by the medial head of the gastrocnemius



Fig. 6.61 Tibiofibular joint.

muscle and laterally by the plantaris muscle and the lateral head of the gastrocnemius muscle.

- The floor of the fossa is formed by the capsule of the knee joint and adjacent surfaces of the femur and tibia, and, more inferiorly, by the popliteus muscle.
- The roof is formed by deep fascia, which is continuous above with the fascia lata of the thigh and below with deep fascia of the leg.

Contents

The major contents of the popliteal fossa are the popliteal artery, the popliteal vein, and the tibial and common fibular nerves (Fig. 6.62B).

The tibial and common fibular nerves originate proximal to the popliteal fossa as the two major branches of the sciatic nerve (Fig. 6.62B). They are the most superficial of the neurovascular structures in the popliteal fossa and enter the region directly from above under the margin of the biceps femoris muscle (Fig. 6.62B):

- The tibial nerve descends vertically through the popliteal fossa and exits deep to the margin of plantaris muscle to enter the posterior compartment of leg.
- The common fibular nerve exits by following the biceps femoris tendon over the lower lateral margin of the popliteal fossa and continues to the lateral side of the leg where it swings around the neck of the fibula and enters the lateral compartment of leg.

The popliteal artery is the continuation of the femoral artery in the anterior compartment of thigh, and begins as

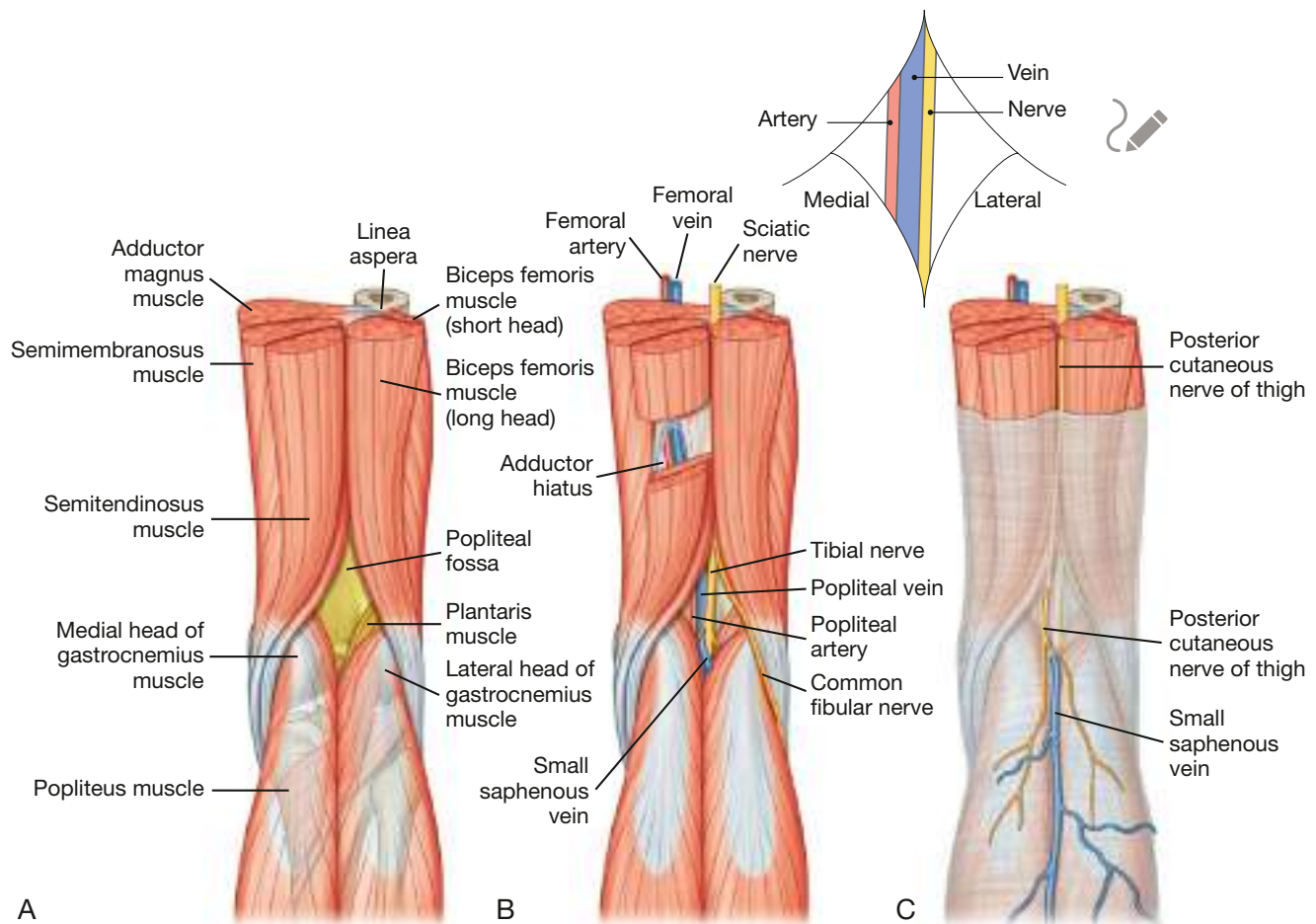


Fig. 6.62 Popliteal fossa. A. Boundaries. B. Nerves and vessels. C. Superficial structures.

the femoral artery passes posteriorly through the adductor hiatus in the adductor magnus muscle (Fig. 6.62B).

The popliteal artery appears deep in the popliteal fossa on the upper medial side under the margin of the semimembranosus muscle. It descends obliquely through the fossa with the tibial nerve and enters the posterior compartment of leg where it ends just lateral to the midline of the leg by dividing into the anterior and posterior tibial arteries.

In the popliteal fossa, the popliteal artery gives rise to branches, which supply adjacent muscles, and to a series of geniculate arteries, which contribute to vascular anastomoses around the knee (see Fig. 6.60).

The popliteal vein is superficial to and travels with the popliteal artery (Fig. 6.62B). It exits the popliteal fossa superiorly to become the femoral vein by passing through the adductor hiatus.

Roof of popliteal fossa

The roof of the popliteal fossa is covered by superficial fascia and skin (Fig. 6.62C). The most important structure in the superficial fascia is the small saphenous vein. This vessel ascends vertically in the superficial fascia on the back of the leg from the lateral side of the dorsal venous arch in the foot. It ascends to the back of the knee where it penetrates deep fascia, which forms the roof of the popliteal fossa and joins with the popliteal vein.

One other structure that passes through the roof of the fossa is the posterior cutaneous nerve of thigh, which descends through the thigh superficial to the hamstring muscles, passes through the roof of the popliteal fossa, and then continues inferiorly with the small saphenous vein to innervate skin on the upper half of the back of the leg.

Surface anatomy

Visualizing the contents of the popliteal fossa

The popliteal fossa is a diamond-shaped depression formed between the hamstrings and gastrocnemius muscle posterior to the knee. The tendons of the biceps femoris muscle and the semitendinosus muscle are palpable and often visible.

The head of the fibula is palpable on the lateral side of the knee and can be used as a landmark for identifying the biceps femoris tendon and the common fibular nerve, which curves laterally out of the popliteal fossa and crosses the neck of the fibula just inferior to the head.

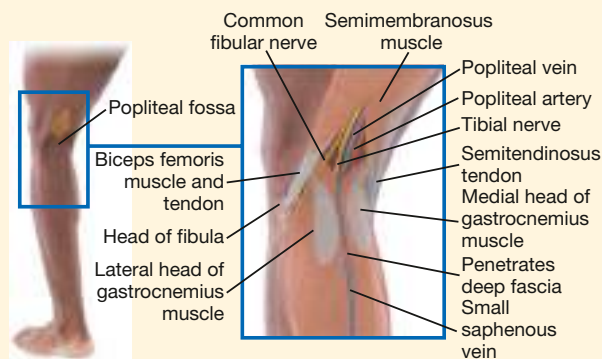


Fig. 6.63 Visualizing the contents of the popliteal fossa. Posterior view of the left knee.

The popliteal fossa contains the popliteal artery, the popliteal vein, the tibial nerve, and the common fibular nerve (Fig. 6.63). The popliteal artery is the deepest of the structures in the fossa and descends through the region from the upper medial side. As a consequence of its position, the popliteal artery pulse is difficult to find, but usually can be detected on deep palpation just medial to the midline of the fossa.

The small saphenous vein penetrates deep fascia in the upper part of the posterior leg and joins the popliteal vein.

LEG

The leg is that part of the lower limb between the knee joint and ankle joint (Fig. 6.64).

The bones of the leg are the lateral **fibula** and the medial **tibia**. The tibia is the weight-bearing bone of the leg and is therefore much larger than the fibula.

The leg is divided into anterior (extensor), posterior (flexor), and lateral (fibular) compartments (Fig. 6.64) by:

- an interosseous membrane, and
- two intermuscular septa, which pass between the fibula and deep fascia surrounding the limb.

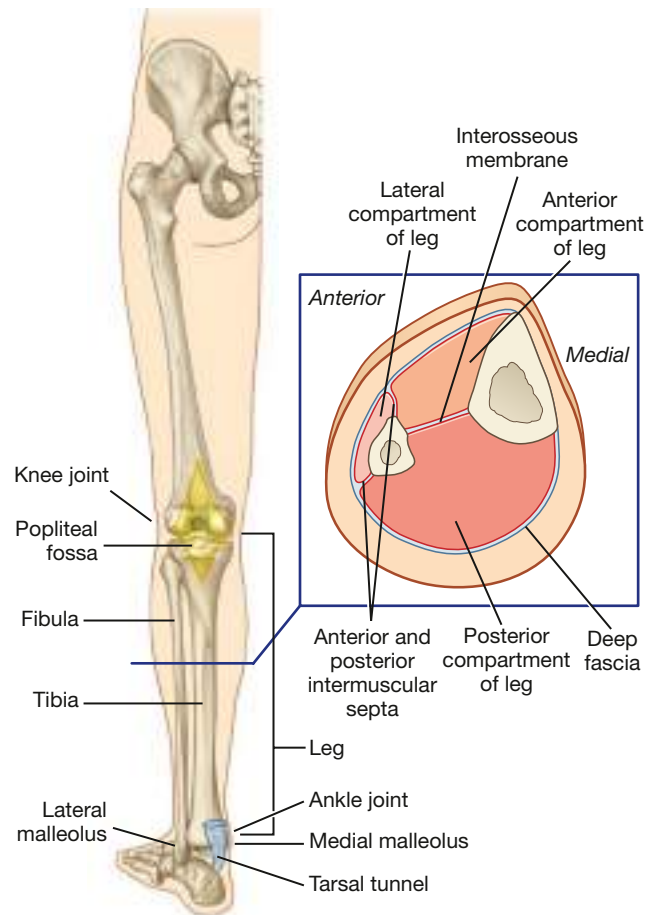


Fig. 6.64 Posterior view of leg; cross-section through the left leg (inset).

Muscles in the anterior compartment of leg dorsiflex the ankle, extend the toes, and invert the foot. Muscles in the posterior compartment plantarflex the ankle, flex the toes, and invert the foot. Muscles in the lateral compartment evert the foot. Major nerves and vessels supply or pass through each compartment.

Bones

Shaft and distal end of tibia

The shaft of tibia (Fig. 6.65A,B) is triangular in cross-section and has anterior, interosseous, and medial borders and medial, lateral, and posterior surfaces (Fig. 6.65C):

- The anterior and medial borders and the entire medial surface are subcutaneous and easily palpable.
- The interosseous border of the tibia is connected by the interosseous membrane along its length to the interosseous border of the fibula.
- The posterior surface is marked by an oblique line (the soleal line).

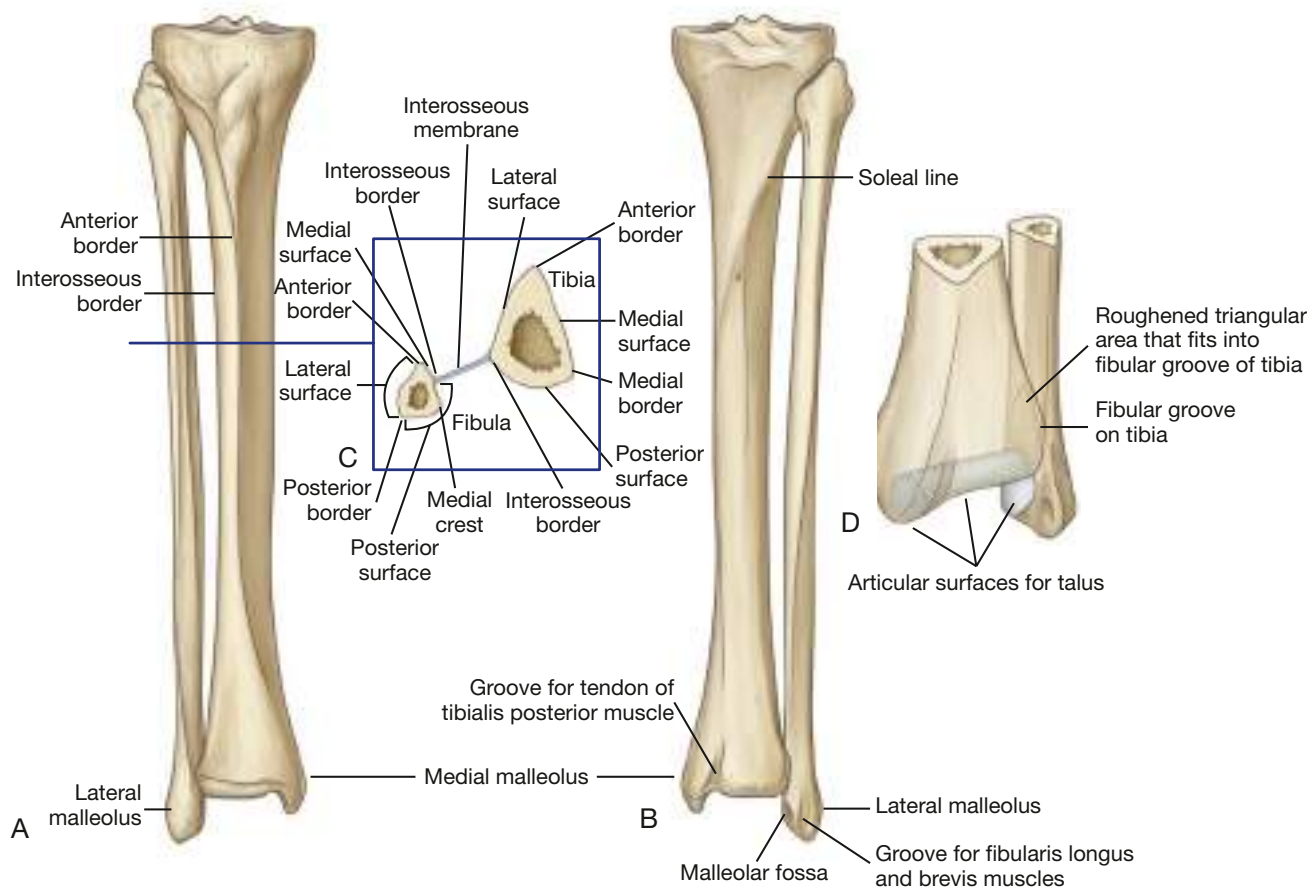


Fig. 6.65 Tibia and fibula. **A.** Anterior view. **B.** Posterior view. **C.** Cross-section through shafts. **D.** Posteromedial view of distal ends.

The soleal line descends across the bone from the lateral side to the medial side where it merges with the medial border. In addition, a vertical line descends down the upper part of the posterior surface from the midpoint of the soleal line. It disappears in the lower one-third of the tibia.

The shaft of the tibia expands at both the upper and lower ends to support the body's weight at the knee and ankle joints.

The distal end of the tibia is shaped like a rectangular box with a bony protuberance on the medial side (the **medial malleolus**; Fig. 6.65). The upper part of the box is continuous with the shaft of the tibia, whereas the lower surface and the medial malleolus articulate with one of the tarsal bones (talus) to form a large part of the ankle joint.

The posterior surface of the box-like distal end of the tibia is marked by a vertical groove, which continues inferiorly and medially onto the posterior surface of the medial malleolus. The groove is for the tendon of the tibialis posterior muscle.

The lateral surface of the distal end of the tibia is occupied by a deep triangular notch (the **fibular notch**) (Fig. 6.65D) to which the distal head of the fibula is anchored by a thickened part of the interosseous membrane.

Shaft and distal end of fibula

The fibula is not involved in weight bearing. The fibular shaft is therefore much narrower than the shaft of the tibia (Fig. 6.65A,B). Also, and except for the ends, the fibula is enclosed by muscles.

Like the tibia, the shaft of the fibula is triangular in cross-section and has three borders and three surfaces for the attachment of muscles, intermuscular septa, and ligaments (Fig. 6.65C). The interosseous border of the fibula faces and is attached to the interosseous border of the tibia by the interosseous membrane. Intermuscular septa attach to the anterior and posterior borders. Muscles attach to the three surfaces.

The narrow **medial surface** faces the anterior compartment of leg, the **lateral surface** faces the lateral compartment

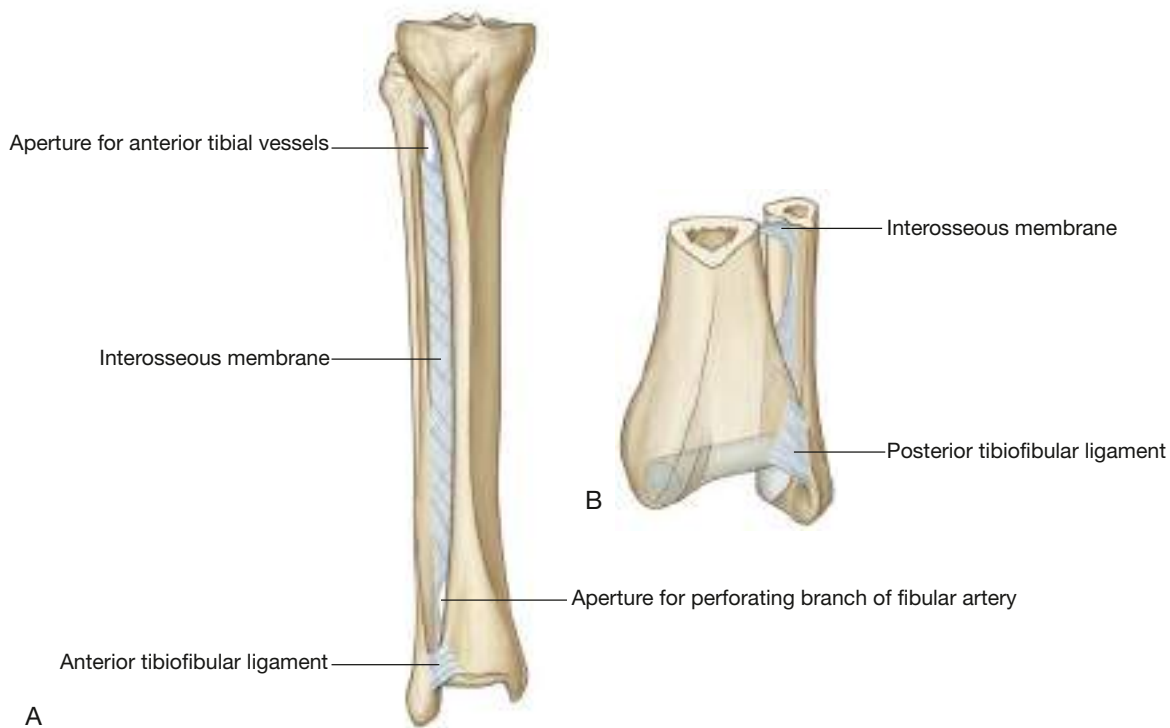


Fig. 6.66 Interosseous membrane. **A.** Anterior view. **B.** Posteromedial view.

of leg, and the **posterior surface** faces the posterior compartment of leg.

The posterior surface is marked by a vertical crest (**medial crest**), which divides the posterior surface into two parts, each attached to a different deep flexor muscle.

The distal end of the fibula expands to form the spade-shaped **lateral malleolus** (Fig. 6.65).

The medial surface of the lateral malleolus bears a facet for articulation with the lateral surface of talus, thereby forming the lateral part of the ankle joint. Just superior to this articular facet is a triangular area, which fits into the fibular notch on the distal end of the tibia (Fig. 6.65D). Here the tibia and fibula are joined together by the distal end of the interosseous membrane. Posteroinferior to the facet for articulation with the talus is a pit or fossa (the **malleolar fossa**) for the attachment of the posterior talofibular ligament associated with the ankle joint.

The posterior surface of the lateral malleolus is marked by a shallow groove for the tendons of the fibularis longus and fibularis brevis muscles.

Joints

Interosseous membrane of leg

The interosseous membrane of leg is a tough fibrous sheet of connective tissue that spans the distance between facing interosseous borders of the tibial and fibular shafts (Fig. 6.66A).

There are two apertures in the interosseous membrane, one at the top and the other at the bottom, for vessels to pass between the anterior and posterior compartments of the leg (Fig. 6.66A).

The interosseous membrane not only links the tibia and fibula together, but it also provides an increased surface area for muscle attachment.

The distal ends of the fibula and tibia are held together by the inferior aspect of the interosseous membrane, which spans the narrow space between the fibular notch on the lateral surface of the distal end of the tibia and the corresponding surface on the distal end of the fibula (Fig. 6.66A,B). This expanded end of the interosseous membrane is reinforced by anterior and posterior tibiofibular ligaments. This firm linking together of the distal ends of the tibia and fibula is essential to produce the skeletal framework for articulation with the foot at the ankle joint.

Posterior compartment of leg

Muscles

Muscles in the posterior (flexor) compartment of leg are organized into two groups, superficial and deep, separated by a layer of deep fascia. Generally, the muscles mainly plantarflex and invert the foot and flex the toes. All are innervated by the tibial nerve.

Table 6.6 Superficial group of muscles in the posterior compartment of leg (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Gastrocnemius	Medial head—posterior surface of distal femur just superior to medial condyle; lateral head—upper posterolateral surface of lateral femoral condyle	Via calcaneal tendon, to posterior surface of calcaneus	Tibial nerve (S1, S2)	Plantarflexes foot and flexes knee
Plantaris	Inferior part of lateral supracondylar line of femur and oblique popliteal ligament of knee	Via calcaneal tendon, to posterior surface of calcaneus	Tibial nerve (S1, S2)	Plantarflexes foot and flexes knee
Soleus	Soleal line and medial border of tibia; posterior aspect of fibular head and adjacent surfaces of neck and proximal shaft; tendinous arch between tibial and fibular attachments	Via calcaneal tendon to posterior surface of calcaneus	Tibial nerve (S1, S2)	Plantarflexes the foot

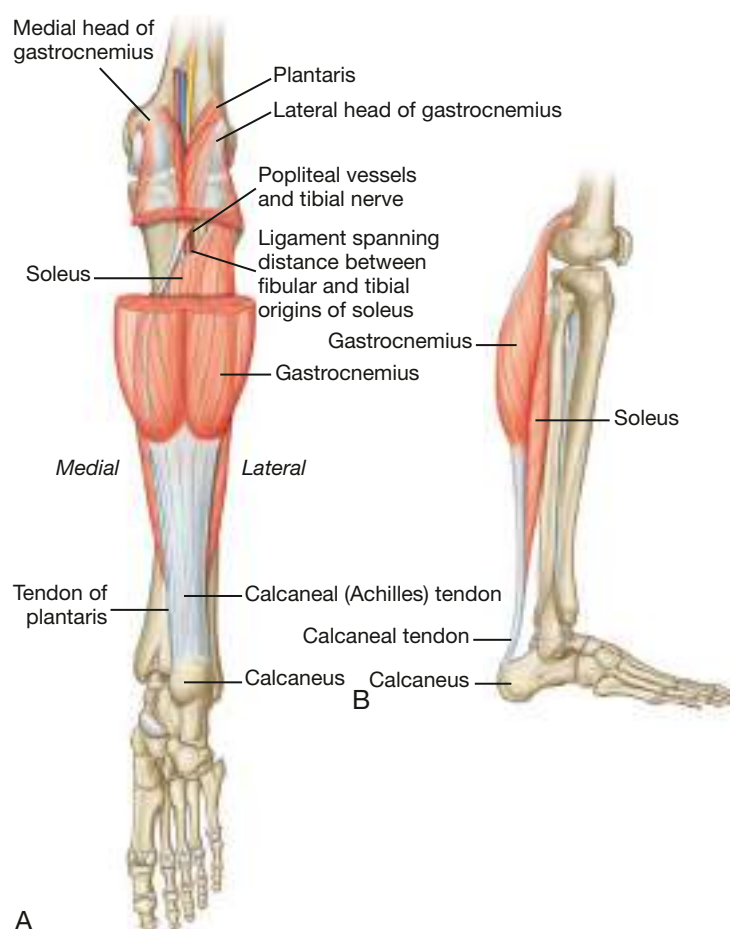


Fig. 6.67 Superficial group of muscles in the posterior compartment of leg. **A.** Posterior view. **B.** Lateral view.

Superficial group

The superficial group of muscles in the posterior compartment of leg comprises three muscles—the **gastrocnemius**, **plantaris**, and **soleus** (Table 6.6, Fig. 6.67)—all of which insert onto the heel (calcaneus) of the foot and plantarflex the foot at the ankle joint (Fig. 6.67). As a unit, these muscles are large and powerful because they propel the body forward

off the planted foot during walking and can elevate the body upward onto the toes when standing. Two of the muscles (gastrocnemius and plantaris) originate on the distal end of the femur and can also flex the knee.

Deep group

There are four muscles in the deep posterior compartment of leg (Table 6.7, Fig. 6.68)—the **popliteus**, **flexor hallucis**

longus, flexor digitorum longus, and tibialis posterior. The popliteus muscle acts on the knee, whereas the other three muscles act mainly on the foot.

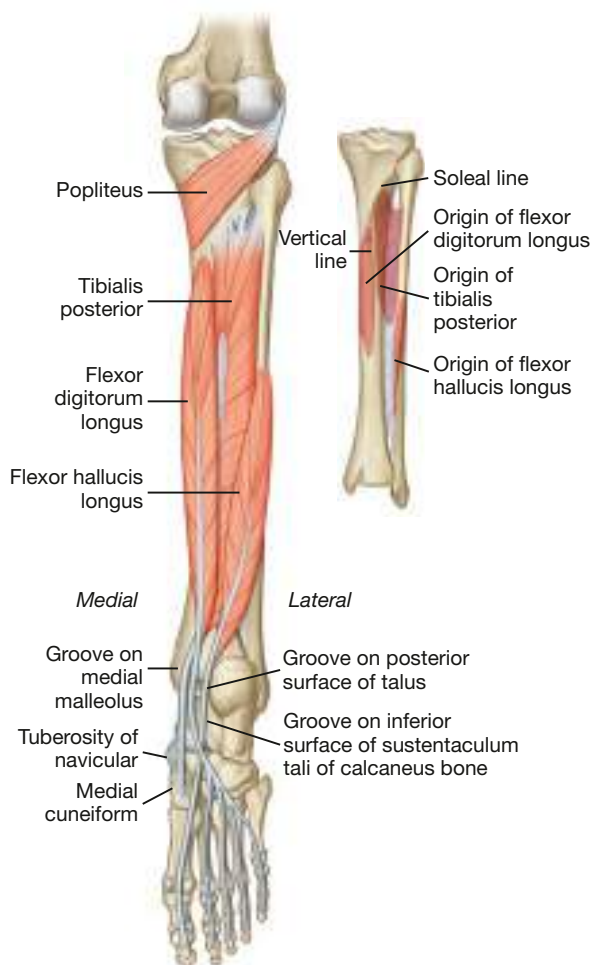


Fig. 6.68 Deep group of muscles in the posterior compartment of leg.

Arteries

Popliteal artery

The **popliteal artery** is the major blood supply to the leg and foot and enters the posterior compartment of leg from the popliteal fossa behind the knee (Fig. 6.69).

The popliteal artery passes into the posterior compartment of leg between the gastrocnemius and popliteus muscles. As it continues inferiorly it passes under the tendinous arch formed between the fibular and tibial heads of the soleus muscle and enters the deep region of the posterior compartment of leg where it immediately divides into an anterior tibial artery and a posterior tibial artery.

There are two large sural arteries, one on each side, that branch from the popliteal artery to supply the gastrocnemius, soleus, and plantaris muscles (Fig. 6.69). In addition, the popliteal artery gives rise to branches that contribute to a collateral network of vessels around the knee joint (see Fig. 6.60).

Anterior tibial artery

The **anterior tibial artery** passes forward through the aperture in the upper part of the interosseous membrane and enters and supplies the anterior compartment of leg (Fig. 6.69). It continues inferiorly onto the dorsal aspect of the foot.

Posterior tibial artery

The **posterior tibial artery** supplies the posterior and lateral compartments of the leg and continues into the sole of the foot (Fig. 6.69).

The posterior tibial artery descends through the deep region of the posterior compartment of leg on the superficial surfaces of the tibialis posterior and flexor digitorum longus muscles. It passes through the tarsal tunnel behind the medial malleolus and into the sole of the foot.

Table 6.7 Deep group of muscles in the posterior compartment of leg (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Popliteus	Lateral femoral condyle	Posterior surface of proximal tibia	Tibial nerve (L4 to S1)	Stabilizes knee joint (resists lateral rotation of tibia on femur) Unlocks knee joint (laterally rotates femur on fixed tibia)
Flexor hallucis longus	Posterior surface of fibula and adjacent interosseous membrane	Plantar surface of distal phalanx of great toe	Tibial nerve (S2 , S3)	Flexes great toe; particularly active during the toe-off phase of walking when the body is propelled forward off the stance leg and the great toe is the last part of the foot to leave the ground
Flexor digitorum longus	Medial side of posterior surface of the tibia	Plantar surfaces of bases of distal phalanges of the lateral four toes	Tibial nerve (S2 , S3)	Flexes lateral four toes
Tibialis posterior	Posterior surfaces of interosseous membrane and adjacent regions of tibia and fibula	Mainly to tuberosity of navicular and adjacent region of medial cuneiform	Tibial nerve (L4, L5)	Inversion and plantarflexion of foot; support of medial arch of foot during walking

In the leg, the posterior tibial artery supplies adjacent muscles and bone and has two major branches, the circumflex fibular artery and the fibular artery:

- The **circumflex fibular artery** passes laterally through the soleus muscle and around the neck of the fibula to connect with the anastomotic network of vessels surrounding the knee (Fig. 6.69; see also Fig. 6.60).
- The **fibular artery** parallels the course of the tibial artery but descends along the lateral side of the posterior compartment adjacent to the medial crest on the posterior surface of the fibula, which separates the attachments of the tibialis posterior and flexor hallucis longus muscles (Fig. 6.69).

The fibular artery supplies adjacent muscles and bone in the posterior compartment of leg and also has branches that pass laterally through the intermuscular septum to supply the fibularis muscles in the lateral compartment of leg.

A **perforating branch** that originates from the fibular artery distally in the leg passes anteriorly through the inferior aperture in the interosseous membrane to anastomose with a branch of the anterior tibial artery.

The fibular artery passes behind the attachment between the distal ends of the tibia and fibula and terminates in a network of vessels over the lateral surface of the calcaneus.

Veins

Deep veins in the posterior compartment generally follow the arteries.

Nerves

Tibial nerve

The nerve associated with the posterior compartment of leg is the tibial nerve (Fig. 6.70A), a major branch of the sciatic nerve that descends into the posterior compartment from the popliteal fossa.

The tibial nerve passes under the tendinous arch formed between the fibular and tibial heads of the soleus muscle and passes vertically through the deep region of the posterior compartment of leg on the surface of the tibialis posterior muscle with the posterior tibial vessels.

The tibial nerve leaves the posterior compartment of leg at the ankle by passing through the tarsal tunnel behind the medial malleolus. It enters the foot to supply most intrinsic muscles and skin.

In the leg, the tibial nerve gives rise to:

- branches that supply all the muscles in the posterior compartment of leg, and
- two cutaneous branches, the **sural nerve** and **medial calcaneal nerve** (Fig. 6.70A,B).

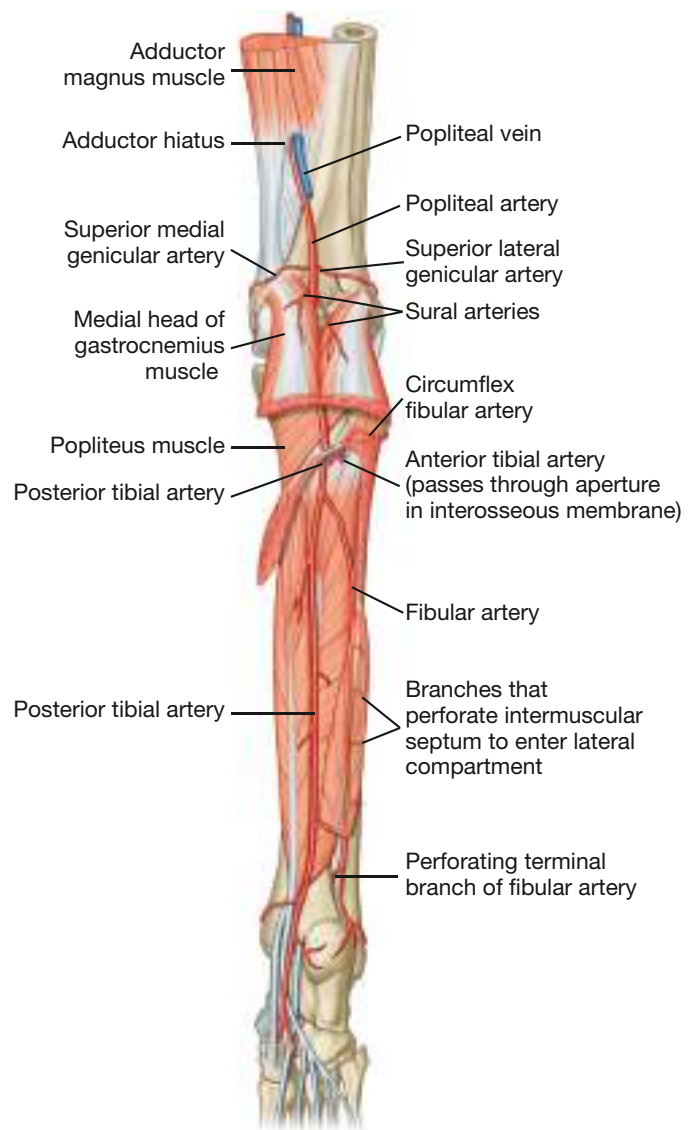


Fig. 6.69 Arteries in the posterior compartment of leg.

Branches of the tibial nerve that innervate the superficial group of muscles of the posterior compartment and popliteus muscle of the deep group originate high in the leg between the two heads of the gastrocnemius muscle in the distal region of the popliteal fossa. Branches innervate the gastrocnemius, plantaris, and soleus muscles, and pass more deeply into the popliteus muscle.

Branches to the deep muscles of the posterior compartment originate from the tibial nerve deep to the soleus muscle in the upper half of the leg and innervate the tibialis posterior, flexor hallucis longus, and flexor digitorum longus muscles.

Sural nerve

The sural nerve originates high in the leg between the two heads of the gastrocnemius muscle (Fig. 6.70B). It

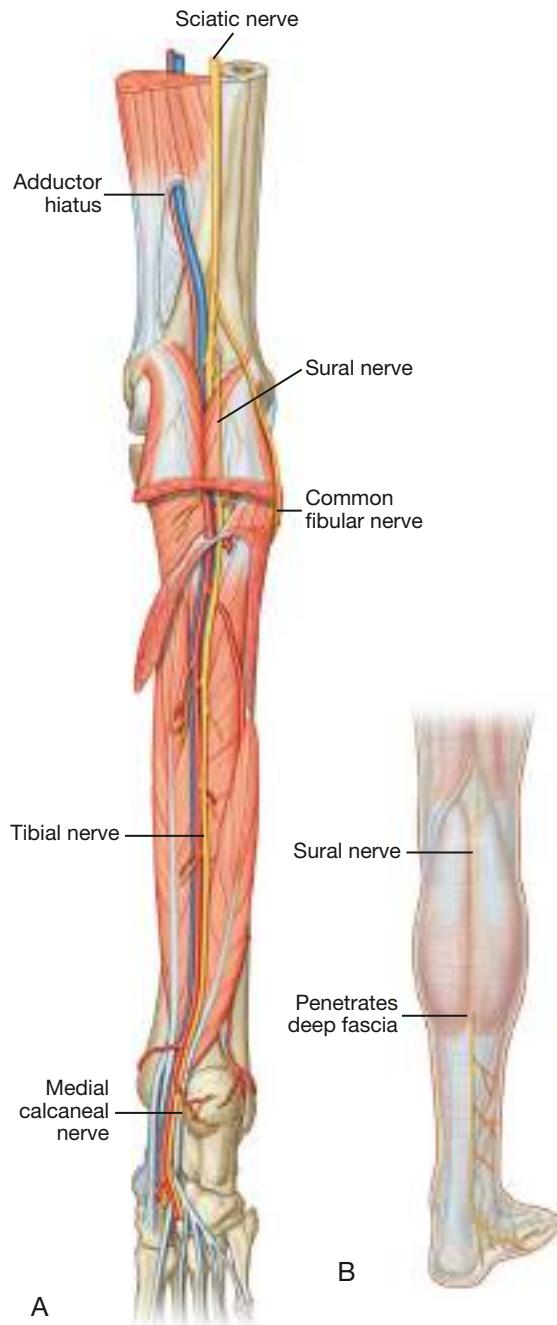


Fig. 6.70 Tibial nerve. **A.** Posterior view. **B.** Sural nerve.

descends superficial to the belly of the gastrocnemius muscle and penetrates through the deep fascia approximately in the middle of the leg where it is joined by a sural communicating branch from the common fibular nerve. It passes down the leg, around the lateral malleolus, and into the foot.

The sural nerve supplies skin on the lower posterolateral surface of the leg and the lateral side of the foot and little toe.

Medial calcaneal nerve

The medial calcaneal nerve is often multiple and originates from the tibial nerve low in the leg near the ankle and descends onto the medial side of the heel.

The medial calcaneal nerve innervates skin on the medial surface and sole of the heel (Fig. 6.70A).

Lateral compartment of leg

Muscles

There are two muscles in the lateral compartment of leg—**fibularis longus** and **fibularis brevis** (Table 6.8, Fig. 6.71). Both evert the foot (turn the sole outward) and are innervated by the superficial fibular nerve, which is a branch of the common fibular nerve.

Arteries

No major artery passes vertically through the lateral compartment of leg. It is supplied by branches (mainly from the fibular artery in the posterior compartment of leg) that penetrate into the lateral compartment (Fig. 6.72).

Veins

Deep veins generally follow the arteries.

Nerves

Superficial fibular nerve

The nerve associated with the lateral compartment of leg is the **superficial fibular nerve**. This nerve originates as one of the two major branches of the common fibular nerve, which enters the lateral compartment of leg from the popliteal fossa (Fig. 6.72B).

The common fibular nerve courses around the neck of the fibula (Fig. 6.72A) and enters the lateral compartment by passing between the attachments of the fibularis longus muscle to the head and shaft of fibula. Here the common fibular nerve divides into its two terminal branches (Fig. 6.72B):

- the superficial fibular nerve, and
- the deep fibular nerve.

The superficial fibular nerve descends in the lateral compartment deep to the fibularis longus and innervates the fibularis longus and fibularis brevis (Fig. 6.72B). It then penetrates deep fascia in the lower leg and enters the foot where it divides into medial and lateral branches, which supply dorsal areas of the foot and toes except for:

- the web space between the great and second toes, which is supplied by the deep fibular nerve, and
- the lateral side of the little toe, which is supplied by the sural branch of the tibial nerve.

The deep fibular nerve passes anteromedially through the intermuscular septum into the anterior compartment of leg, which it supplies.

Anterior compartment of leg

Muscles

There are four muscles in the anterior compartment of leg—the **tibialis anterior**, **extensor hallucis longus**, **extensor digitorum longus**, and **fibularis tertius** (Table 6.9, Fig. 6.73).

Collectively they dorsiflex the foot at the ankle joint, extend the toes, and invert the foot. All are innervated by the deep fibular nerve, which is a branch of the common fibular nerve.

Arteries

The artery associated with the anterior compartment of leg is the **anterior tibial artery**, which originates from the popliteal artery in the posterior compartment of leg and passes forward into the anterior compartment of leg through an aperture in the interosseous membrane.

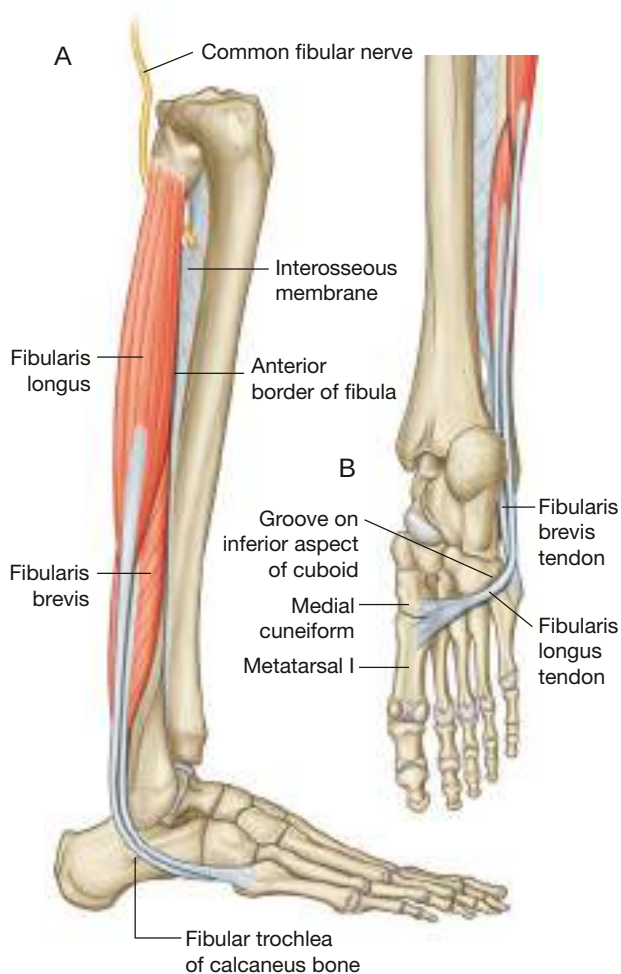


Fig. 6.71 Muscles in the lateral compartment of leg. **A.** Lateral view. **B.** Inferior view of the right foot, with the foot plantarflexed at the ankle.

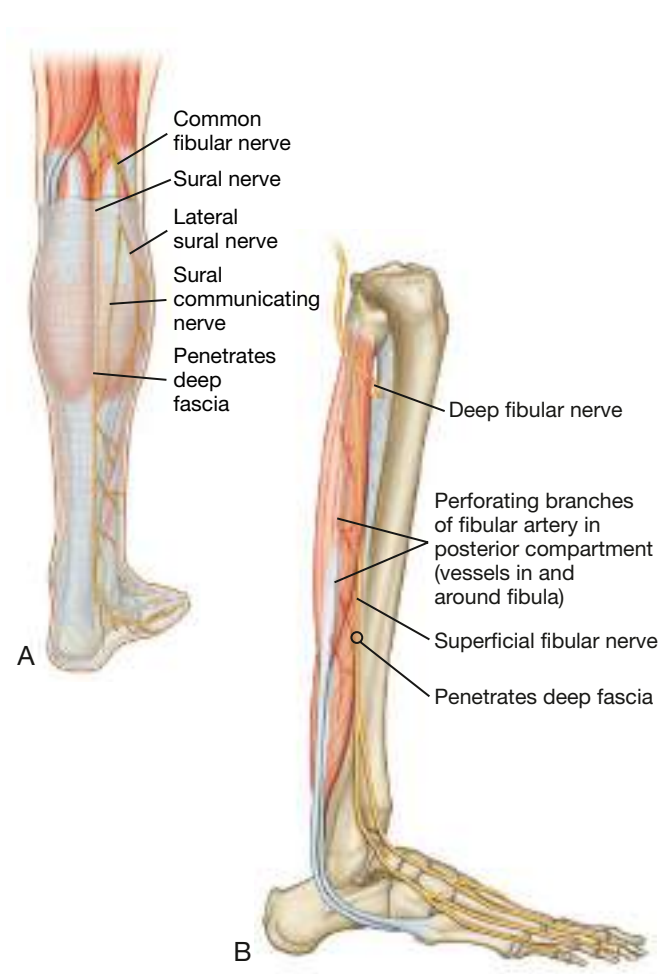


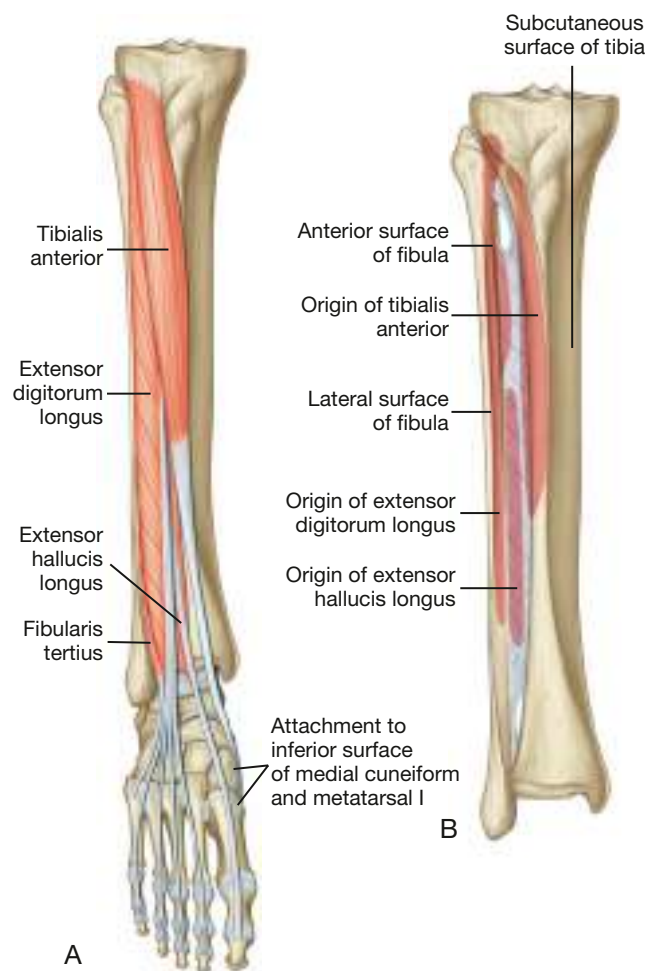
Fig. 6.72 Common fibular nerve, and nerves and arteries of the lateral compartment of leg. **A.** Posterior view, right leg. **B.** Lateral view, right leg.

Table 6.8 Muscles of the lateral compartment of leg (spinal segments in **bold** are the major segments innervating the muscle)

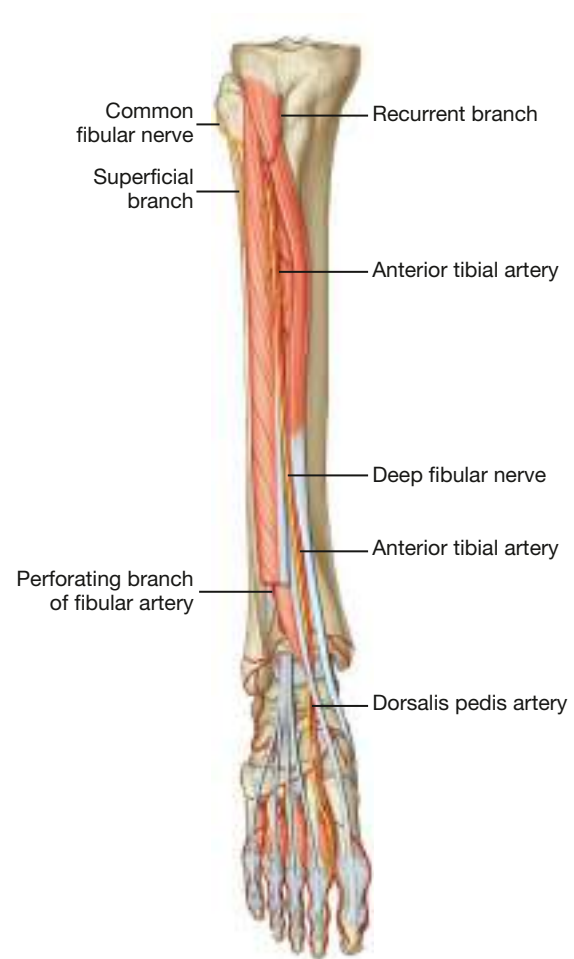
Muscle	Origin	Insertion	Innervation	Function
Fibularis longus	Upper lateral surface of fibula, head of fibula, and occasionally the lateral tibial condyle	Undersurface of lateral sides of distal end of medial cuneiform and base of metatarsal I	Superficial fibular nerve (L5, S1, S2)	Eversion and plantarflexion of foot; supports mainly lateral and transverse arches of foot
Fibularis brevis	Lower two-thirds of lateral surface of shaft of fibula	Tuberosity at base of metatarsal V	Superficial fibular nerve (L5, S1, S2)	Eversion of foot

Table 6.9 Muscles of the anterior compartment of leg (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Tibialis anterior	Lateral surface of tibia and adjacent interosseous membrane	Medial and inferior surfaces of medial cuneiform and adjacent surfaces on base of metatarsal I	Deep fibular nerve (L4, L5)	Dorsiflexion of foot at ankle joint; inversion of foot; dynamic support of medial arch of foot
Extensor hallucis longus	Middle one-half of medial surface of fibula and adjacent surface of interosseous membrane	Dorsal surface of base of distal phalanx of great toe	Deep fibular nerve (L5, S1)	Extension of great toe and dorsiflexion of foot
Extensor digitorum longus	Proximal one-half of medial surface of fibula and related surface of lateral tibial condyle	Via dorsal digital expansions into bases of distal and middle phalanges of lateral four toes	Deep fibular nerve (L5, S1)	Extension of lateral four toes and dorsiflexion of foot
Fibularis tertius	Distal part of medial surface of fibula	Dorsomedial surface of base of metatarsal V	Deep fibular nerve (L5, S1)	Dorsiflexion and eversion of foot

**Fig. 6.73** Muscles of the anterior compartment of leg. **A.** Muscles. **B.** Proximal attachments.

The anterior tibial artery descends through the anterior compartment on the interosseous membrane (Fig. 6.74). In the distal leg, it lies between the tendons of the tibialis anterior and extensor hallucis longus muscles. It leaves the leg by passing anterior to the distal end of the tibia and ankle joint and continues onto the dorsal aspect of the foot as the dorsalis pedis artery.

**Fig. 6.74** Anterior tibial artery and deep fibular nerve.

In the proximal leg, the anterior tibial artery has a recurrent branch, which connects with the anastomotic network of vessels around the knee joint (see Fig. 6.60).

Along its course, the anterior tibial artery supplies numerous branches to adjacent muscles and is joined by the perforating branch of the fibular artery, which passes forward through the lower aspect of the interosseous membrane from the posterior compartment of leg.

Distally, the anterior tibial artery gives rise to an **anterior medial malleolar artery** and an **anterior lateral malleolar artery**, which pass posteriorly around the distal ends of the tibia and fibula, respectively, and connect with vessels from the posterior tibial and fibular arteries to form an anastomotic network around the ankle.

Veins

Deep veins follow the arteries and have similar names.

Nerves

Deep fibular nerve

The nerve associated with the anterior compartment of leg is the deep fibular nerve (Fig. 6.74). This nerve originates in the lateral compartment of leg as one of the two divisions of the common fibular nerve.

The deep fibular nerve passes through the intermuscular septum that separates the lateral from the anterior compartments of leg and then passes deep to the extensor digitorum longus. It reaches the anterior interosseous membrane where it meets and descends with the anterior tibial artery.

The deep fibular nerve:

- innervates all muscles in the anterior compartment; and
- then continues into the dorsal aspect of the foot where it innervates the extensor digitorum brevis, contributes to the innervation of the first two dorsal interossei muscles, and supplies the skin between the great and second toes.

Clinical app

Foot drop

Foot drop is an inability to dorsiflex the foot. Patients with foot drop have a characteristic “steppage” gait. As the patient walks, the knee of the affected limb is elevated to an abnormal height during the swing phase to prevent the foot from dragging. At the end of the swing phase, the foot “slaps” the ground. Also, the unaffected limb often acquires a characteristic tiptoe pattern of gait during the stance phase. A typical cause of foot drop is damage to the common fibular nerve, which may occur with fractures of the fibular neck. Other causes include disc protrusion compressing the L5 nerve root, disorders of the sciatic nerve and the lumbosacral plexus, and pathologies of the spinal cord and brain.

FOOT

The foot is the region of the lower limb distal to the ankle joint. It is subdivided into the ankle, the metatarsus, and the digits.

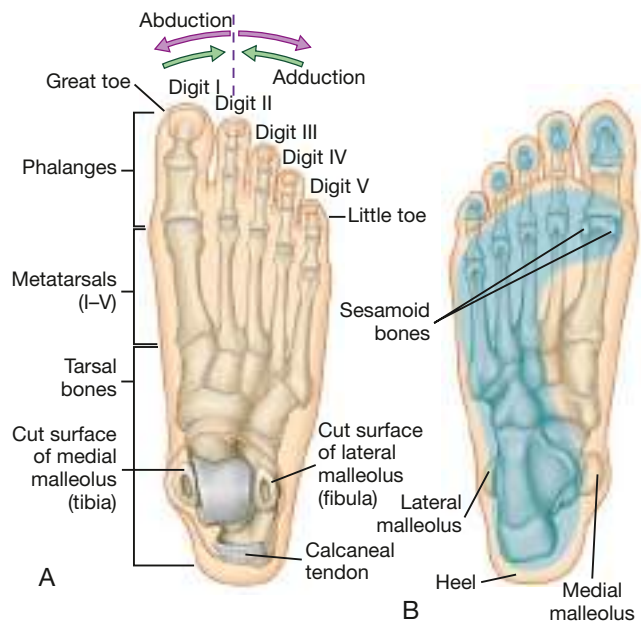


Fig. 6.75 Foot. **A.** Dorsal aspect, right foot. **B.** Plantar aspect, right foot, showing the surface in contact with the ground when standing.

There are five digits consisting of the medially positioned great toe (digit I) and four more laterally placed digits, ending laterally with the little toe (digit V) (Fig. 6.75).

The foot has a superior surface (**dorsum of foot**) and an inferior surface (**sole**; Fig. 6.75).

Abduction and adduction of the toes are defined with respect to the long axis of the second digit. Unlike in the hand where the thumb is oriented 90° to the other fingers, the great toe is oriented in the same position as the other toes. The foot is the body’s point of contact with the ground and provides a stable platform for upright stance. It also levers the body forward during walking.

Bones

There are three groups of bones in the foot (Fig. 6.76):

- the seven **tarsal bones**, which form the skeletal framework for the ankle,
- **metatarsals (I to V)**, which are the bones of the metatarsus, and
- the **phalanges**, which are the bones of the toes—each toe has three phalanges, except for the great toe, which has two.

Tarsal bones

The tarsal bones are arranged in a proximal group and a distal group with an intermediate bone between the two groups on the medial side of the foot (Fig. 6.76A).

Proximal group

The proximal group consists of two large bones, the talus (Latin for “ankle”) and the calcaneus (Latin for “heel”):

- The **talus** is the most superior bone of the foot and sits on top of and is supported by the calcaneus (Fig. 6.76B). It articulates above with the tibia and fibula to form the ankle joint and also projects forward to articulate with the intermediate tarsal bone (navicular) on the medial side of the foot.

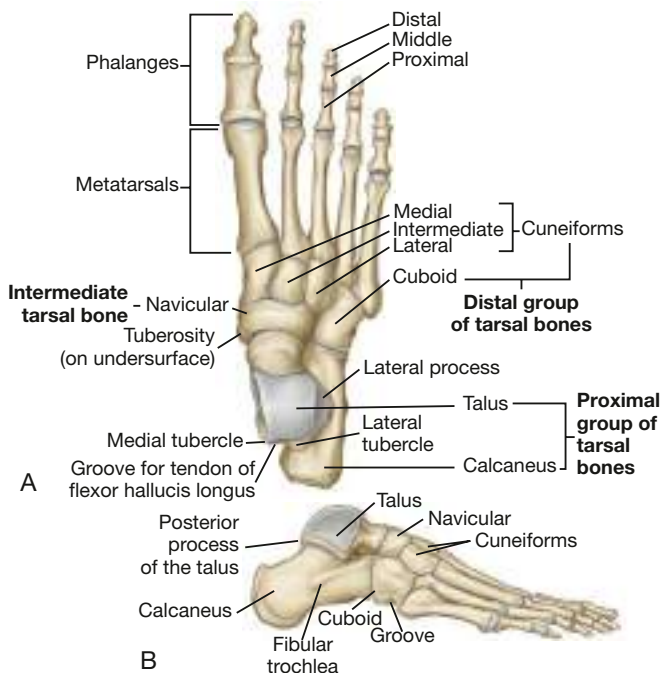


Fig. 6.76 Bones of the foot. **A.** Dorsal view, right foot. **B.** Lateral view, right foot.

- The **calcaneus** is the largest of the tarsal bones (Fig. 6.76A,B)—posteriorly it forms the bony framework of the heel and anteriorly projects forward to articulate with one of the distal group of tarsal bones (cuboid) on the lateral side of the foot.

Talus

The talus, when viewed from the medial or lateral sides, is snail-shaped (Fig. 6.77A). It has a rounded **head**, which is projected forward and medially at the end of a short broad **neck**, which is connected posteriorly to an expanded body.

Anteriorly, the head of the talus is domed for articulation with a corresponding circular depression on the posterior surface of the navicular bone. Inferiorly, this domed articular surface is continuous with an additional three articular facets separated by smooth ridges (Fig. 6.76B):

- The anterior and middle facets articulate with adjacent surfaces on the calcaneus bone.
- The other facet, medial to the facets for articulation with the calcaneus, articulates with a ligament—the plantar calcaneonavicular ligament (spring ligament)—which connects the calcaneus to the navicular under the head of the talus.

The neck of the talus is marked inferiorly by a deep groove (the **sulcus tali**), which passes obliquely forward across the inferior surface from medial to lateral, and expands dramatically on the lateral side. Posterior to the sulcus tali is a large facet (posterior calcaneal articular facet) for articulation with the calcaneus.

The superior aspect of the body of the talus is elevated to fit into the socket formed by the distal ends of the tibia and fibula to form the ankle joint:

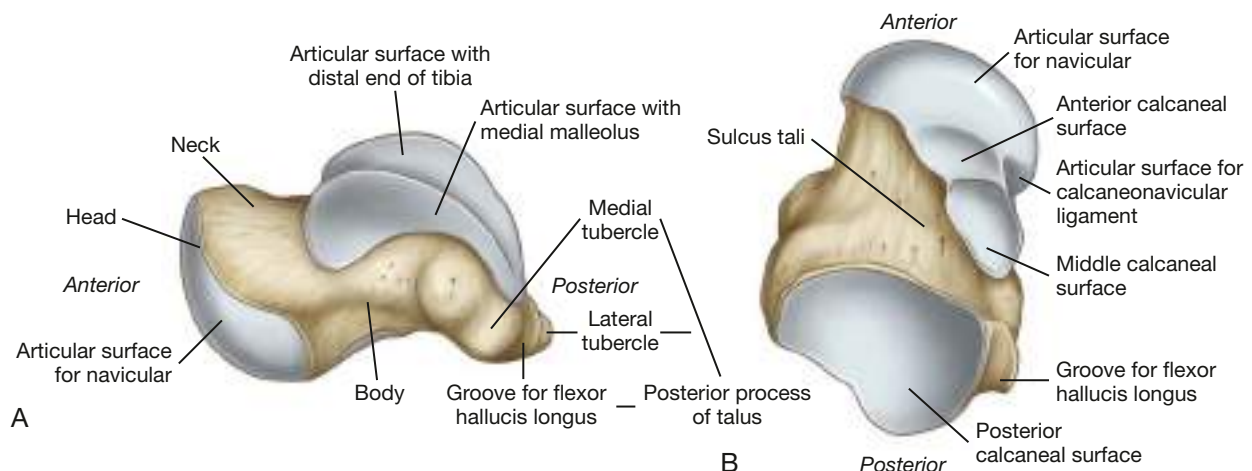


Fig. 6.77 Talus, right foot. **A.** Medial view. **B.** Inferior view.

- The upper (trochlear) surface of this elevated region articulates with the inferior end of the tibia.
- The medial surface articulates with the medial malleolus of the tibia.
- The lateral surface articulates with the lateral malleolus of the fibula.

Because the lateral malleolus is larger and projects more inferiorly than the medial malleolus at the ankle joint, the corresponding lateral articular surface on the talus is larger and projects more inferiorly than the medial surface.

The lower part of the lateral surface of the body of the talus, which supports the lower part of the facet for articulation with the fibula, forms a bony projection (the **lateral process**) (Fig. 6.76A).

The inferior surface of the body of the talus has a large oval concave facet (the **posterior calcaneal articular facet**) for articulation with the calcaneus (Fig. 6.77B).

The posterior aspect of the body of the talus consists of a backward and medially facing projection (the **posterior process**). The posterior process is marked on its surface by a lateral tubercle and a medial tubercle, which bracket between them the **groove for tendon of the flexor hallucis longus** as it passes from the leg into the foot.

Clinical app

Fracture of the talus

One of the problems with fractures of the talus is that the blood supply to the bone is vulnerable to damage. The main blood supply to the bone enters the talus through the tarsal sinus (medial end of tarsal sinus; see Fig. 6.79) from a branch of the posterior tibial artery. This vessel supplies most of the neck and the body of the talus. Branches of the dorsalis pedis artery enter the superior aspect of the talar neck and supply the dorsal portion of the head and neck, and branches from the fibular artery supply a small portion of the lateral talus.

Fractures of the neck of the talus often interrupt the blood supply to the talus, so making the body and posterior aspect of the talus susceptible to osteonecrosis, which may in turn lead to premature osteoarthritis.

Calcaneus

The calcaneus sits under and supports the talus. It is an elongate, irregular, box-shaped bone with its long axis generally oriented along the midline of the foot but deviating lateral to the midline anteriorly (Fig. 6.78).

The calcaneus projects behind the ankle joint to form the skeletal framework of the heel. The posterior surface of this heel region is circular and divided into upper, middle, and lower parts. The calcaneal tendon (Achilles tendon) attaches to the middle part:

- The upper part is separated from the calcaneal tendon by a bursa.
- The lower part curves forward, is covered by subcutaneous tissue, is the weight-bearing region of the heel, and is continuous onto the plantar surface of the bone as the **calcaneal tuberosity**.

The calcaneal tuberosity projects forward on the plantar surface as a large medial process and a small lateral process separated from each other by a V-shaped notch (Fig. 6.78B). At the anterior end of the plantar surface is a tubercle (the **calcaneal tubercle**) for the posterior attachment of the short plantar ligament of the sole of the foot.

The lateral surface of the calcaneus has a smooth contour except for two slightly raised regions (Fig. 6.78C). One of these raised areas—the **fibular trochlea** (peroneal tubercle)—is anterior to the middle of the surface and often has two shallow grooves, which pass, one above the other, obliquely across its surface. The tendons of the fibularis brevis and longus muscles are bound to the trochlea as they pass over the lateral side of the calcaneus.

Superior and posterior to the fibular trochlea is a second raised area or tubercle for attachment of the calcaneofibular part of the lateral collateral ligament of the ankle joint.

The medial surface of the calcaneus is concave and has one prominent feature associated with its upper margin (the **sustentaculum tali**; Fig. 6.78A), which is a shelf of bone projecting medially and supporting the more posterior part of the head of the talus.

The underside of the sustentaculum tali has a distinct groove running from posterior to anterior and along which the tendon of the flexor hallucis longus muscle travels into the sole of the foot (Fig. 6.78B).

The superior surface of the sustentaculum tali has a facet (**middle talar articular surface**) for articulation with the corresponding middle facet on the head of the talus (Fig. 6.78A,C).

Anterior and posterior talar articular surfaces are on the superior surface of the calcaneus itself (Fig. 6.78A):

- The anterior talar articular surface is small and articulates with the corresponding anterior facet on the head of the talus.
- The posterior talar articular surface is large and is approximately near the middle of the superior surface of the calcaneus.

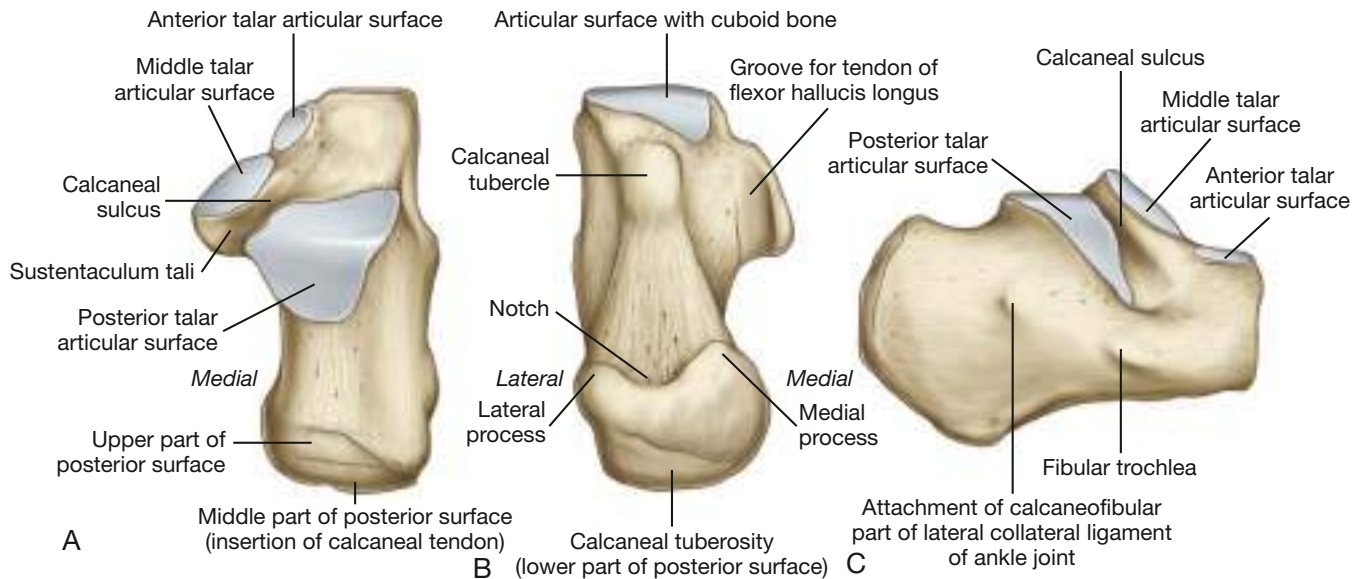


Fig. 6.78 Calcaneus, right foot. A. Superior view. B. Inferior view. C. Lateral view.

Between the posterior talar articular surface, which articulates with the body of the talus, and the other two articular surfaces, which articulate with the head of the talus, is a deep groove (the **calcaneal sulcus**; Fig. 6.78A,C).

The calcaneal sulcus on the superior surface of the calcaneus and the sulcus tali on the inferior surface of the talus together form the **tarsal sinus**, which is a large gap between the anterior ends of the calcaneus and talus that is visible when the skeleton of the foot is viewed from its lateral aspect (Fig. 6.79).

Clinical app

Calcaneal (Achilles) tendon rupture

Rupture of the calcaneal tendon is often related to sudden or direct trauma. This type of injury frequently occurs in a normal healthy tendon. In addition, there are certain conditions that may predispose the tendon to rupture. Among these conditions are tendinopathy (due to overuse or to age-related degenerative changes) and previous calcaneal tendon interventions such as injections of pharmaceuticals and the use of certain antibiotics (quinolone group). The diagnosis of Achilles tendon rupture is relatively straightforward. The patient typically complains of “being kicked” or “shot” behind the ankle, and clinical examination often reveals a gap in the tendon.

Intermediate tarsal bone

The intermediate tarsal bone on the medial side of the foot is the **navicular** (boat shaped) (see Fig. 6.76). This bone articulates behind with the talus and articulates in front and on the lateral side with the distal group of tarsal bones.

One distinctive feature of the navicular is a prominent rounded tuberosity for the attachment of the tibialis posterior tendon, which projects inferiorly on the medial side of the plantar surface of the bone.

Distal group

From lateral to medial, the distal group of tarsal bones consists of (see Fig. 6.76):

- The **cuboid** (Greek for “cube”), which articulates posteriorly with the calcaneus, medially with the lateral cuneiform, and anteriorly with the bases of the lateral two metatarsals—the tendon of the fibularis longus muscle lies in a prominent groove on the anterior plantar surface, which passes obliquely forward across the bone from lateral to medial.
- Three **cuneiforms** (Latin for “wedge”)—the **lateral**, **intermediate**, and **medial** cuneiform bones, in addition to articulating with each other, articulate posteriorly with the navicular bone and anteriorly with the bases of the medial three metatarsals (see Fig. 6.76).

Metatarsals

There are five metatarsals in the foot, numbered I to V from medial to lateral (Fig. 6.80; also see Fig. 6.81). Metatarsal I, associated with the great toe, is shortest and thickest. The second is the longest.

Each metatarsal has a **head** at the distal end, an elongate **shaft** in the middle, and a proximal **base**.

The head of each metatarsal articulates with the proximal phalanx of a toe and the base articulates with one or more of the distal group of tarsal bones. The plantar surface of

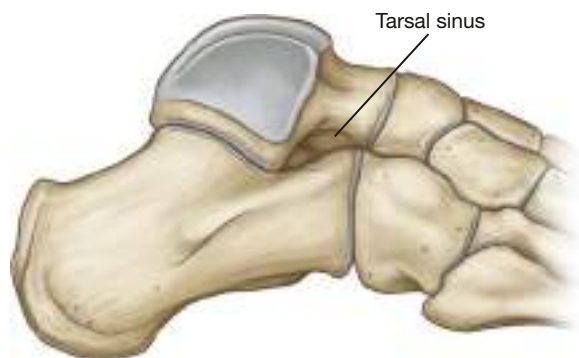


Fig. 6.79 Tarsal sinus. Lateral view, right foot.



Fig. 6.80 Metatarsals and phalanges. Dorsal view, right foot.

the head of metatarsal I also articulates with two sesamoid bones.

The sides of the bases of metatarsals II to V also articulate with each other. The lateral side of the base of metatarsal V has a prominent **tuberosity**, which projects posteriorly and is the attachment site for the tendon of the fibularis brevis muscle ([Fig. 6.80](#)).

Phalanges

The phalanges are the bones of the toes ([Figs. 6.80 and 6.81](#)). Each toe has three phalanges (**proximal**, **middle**, and **distal**), except for the great toe, which has only two (proximal and distal).

Each phalanx consists of a **base**, a **shaft**, and a distal **head**:

- The base of each proximal phalanx articulates with the head of the related metatarsal.
- The head of each distal phalanx is nonarticular and flattened into a crescent-shaped plantar tuberosity under the plantar pad at the end of the digit.

In each toe, the total length of the phalanges combined is much shorter than the length of the associated metatarsal.

Imaging app

Visualizing the bones of the foot

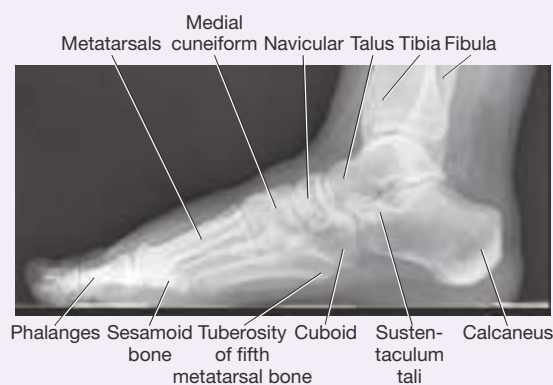


Fig. 6.81 Foot bones. Radiograph, lateral view.

Joints

Ankle joint

The ankle joint is synovial in type and involves the talus of the foot and the tibia and fibula of the leg ([Fig. 6.82](#); also see [Fig. 6.86](#)).

The ankle joint mainly allows hinge-like dorsiflexion and plantarflexion of the foot on the leg.

The distal end of the fibula is firmly anchored to the larger distal end of the tibia by strong ligaments. Together, the fibula and tibia create a deep bracket-shaped socket for the upper expanded part of the body of the talus:

- The roof of the socket is formed by the inferior surface of the distal end of the tibia.
- The medial side of the socket is formed by the medial malleolus of the tibia.
- The longer lateral side of the socket is formed by the lateral malleolus of the fibula.

The articular surfaces are covered by hyaline cartilage.

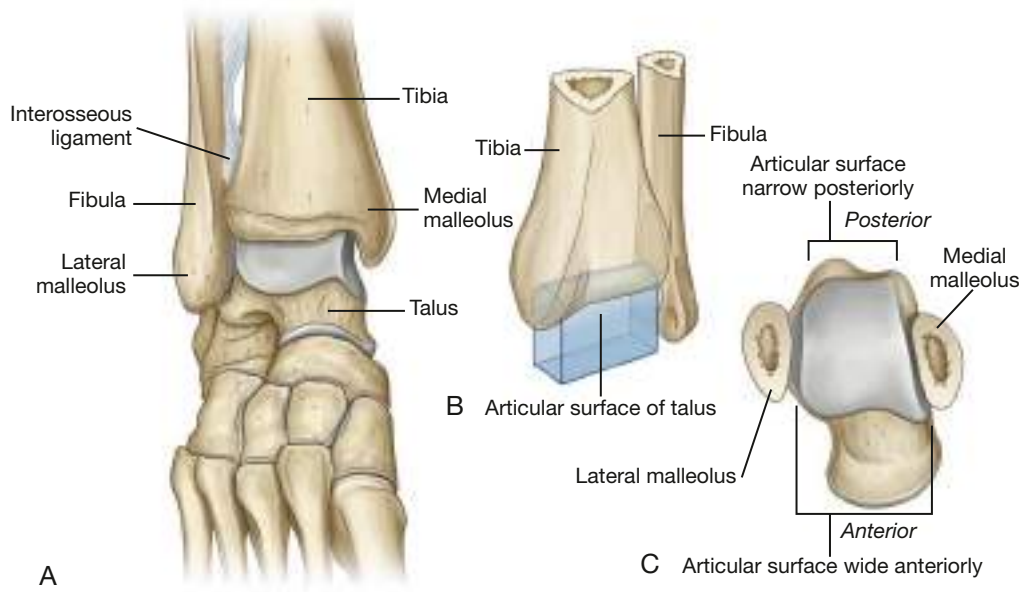


Fig. 6.82 Ankle joint. **A.** Anterior view with foot plantarflexed, right foot. **B.** Schematic of joint. **C.** Superior view of the talus to show the shape of the articular surface.

The articular part of the talus is shaped like a short half cylinder tipped onto its flat side with one end facing lateral and the other end facing medial. The curved upper surface of the half cylinder and the two ends are covered by hyaline cartilage and fit into the bracket-shaped socket formed by the distal ends of the tibia and fibula (Fig. 6.82C).

When viewed from above, the articular surface of the talus is much wider anteriorly than it is posteriorly. As a result, the bone fits tighter into its socket when the foot is dorsiflexed, and the wider surface of the talus moves into the ankle joint than when the foot is plantarflexed and the narrower part of the talus is in the joint. The joint is therefore most stable when the foot is dorsiflexed.

The articular cavity is enclosed by a synovial membrane, which attaches around the margins of the articular surfaces, and by a fibrous membrane, which covers the synovial membrane and is also attached to the adjacent bones.

The ankle joint is stabilized by **medial** (deltoid) and **lateral** ligaments (Figs. 6.83 and 6.84).

Medial ligament (deltoid ligament)

The medial (deltoid) ligament is large, strong (Fig. 6.83), and triangular in shape. Its apex is attached above to the medial malleolus and its broad base is attached below to a line that extends from the tuberosity of the navicular bone in front to the medial tubercle of the talus behind.

The medial ligament is subdivided into four parts based on the inferior points of attachment (Fig. 6.83):

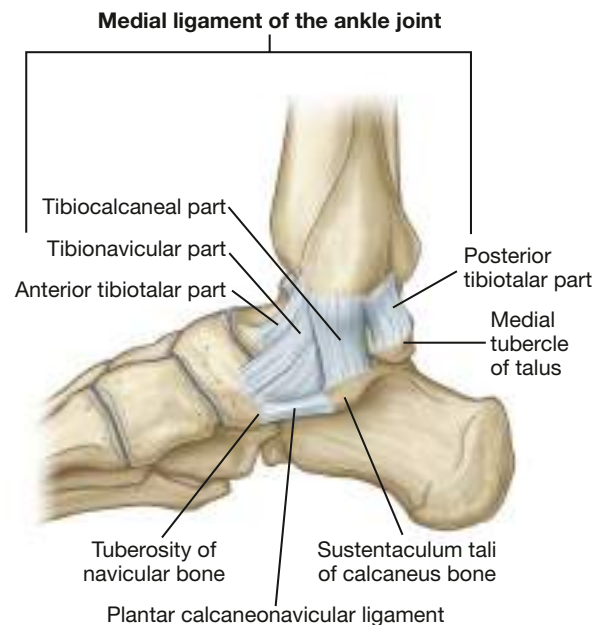


Fig. 6.83 Medial ligament of the ankle joint, right foot.

- The part that attaches in front to the tuberosity of the navicular and the associated margin of the plantar calcaneonavicular ligament (spring ligament), which connects the navicular bone to the sustentaculum tali of the calcaneus bone behind, is the **tibionavicular part** of the medial ligament.
- The **tibiofibular part**, which is more central, attaches to the sustentaculum tali of the calcaneus bone.

- The **posterior tibiotalar part** attaches to the medial side and medial tubercle of the talus.
- The fourth part (the **anterior tibiotalar part**) is deep to the tibionavicular and tibiocalcaneal parts of the medial ligament and attaches to the medial surface of the talus.

Lateral ligament

The lateral ligament of the ankle is composed of three separate ligaments: the anterior talofibular ligament, the posterior talofibular ligament, and the calcaneofibular ligament (Fig. 6.84).

- The **anterior talofibular ligament** is a short ligament and attaches the anterior margin of the lateral malleolus to the adjacent region of the talus.
- The **posterior talofibular ligament** runs horizontally backward and medially from the malleolar fossa on the medial side of the lateral malleolus to the posterior process of the talus.

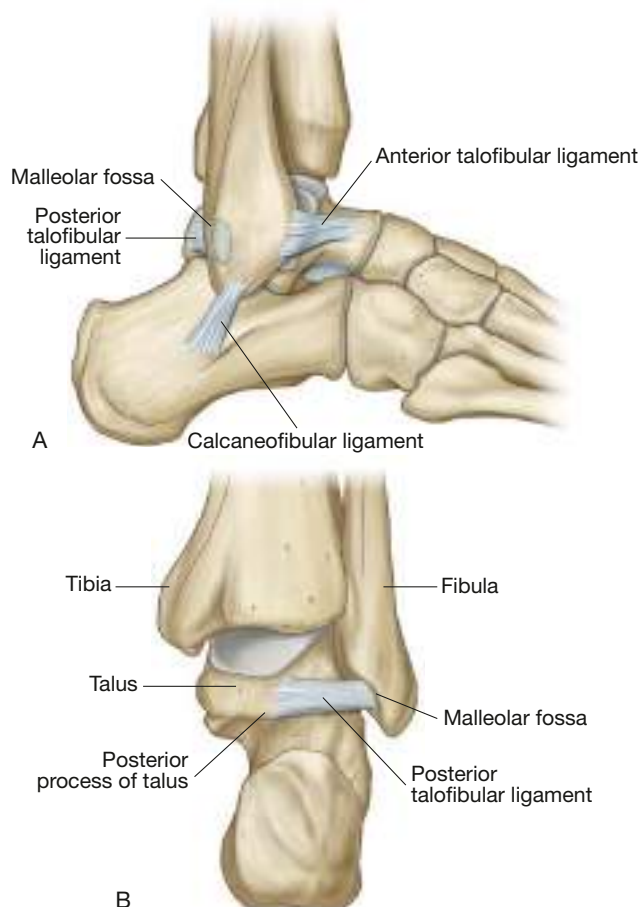


Fig. 6.84 Lateral ligament of the ankle joint, right foot. **A.** Lateral view. **B.** Posterior view.

- The **calcaneofibular ligament** is attached above to the malleolar fossa on the posteromedial side of the lateral malleolus and passes posteroinferiorly to attach below to a tubercle on the lateral surface of the calcaneus.

Intertarsal joints

The numerous synovial joints between the individual tarsal bones mainly invert, evert, supinate, and pronate the foot (Fig. 6.85):

- Inversion and eversion is turning the whole sole of the foot inward and outward, respectively.
- Pronation is rotating the front of the foot laterally relative to the back of the foot, and supination is the reverse movement.

Pronation and supination allow the foot to maintain normal contact with the ground when in different stances or when standing on irregular surfaces.

The major joints at which movements occur include the subtalar, talocalcaneonavicular, and calcaneocuboid joints (see Fig. 6.85). The talocalcaneonavicular and calcaneocuboid joints together form what is often referred to as the **transverse tarsal joint**.

Intertarsal joints between the cuneiforms and between the cuneiforms and the navicular allow only limited movement.

The joint between the cuboid and navicular is normally fibrous.

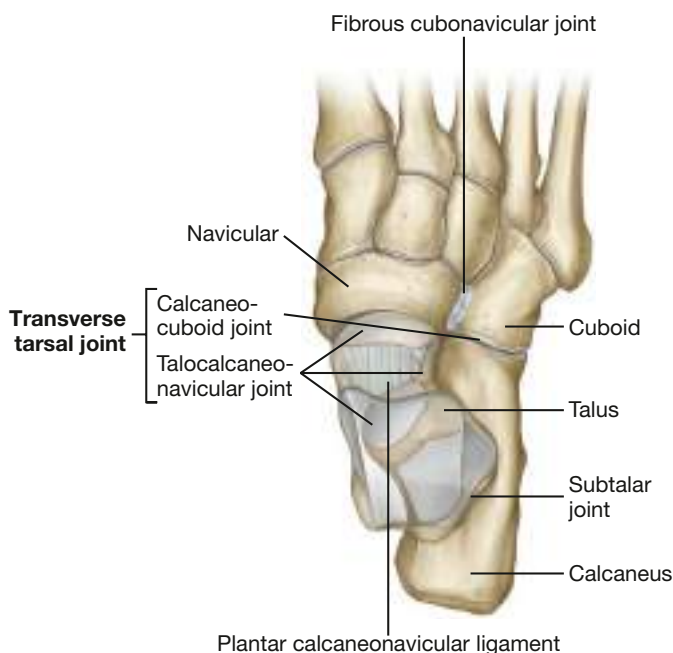


Fig. 6.85 Intertarsal joints, right foot.

Imaging app

Visualizing the ankle joint

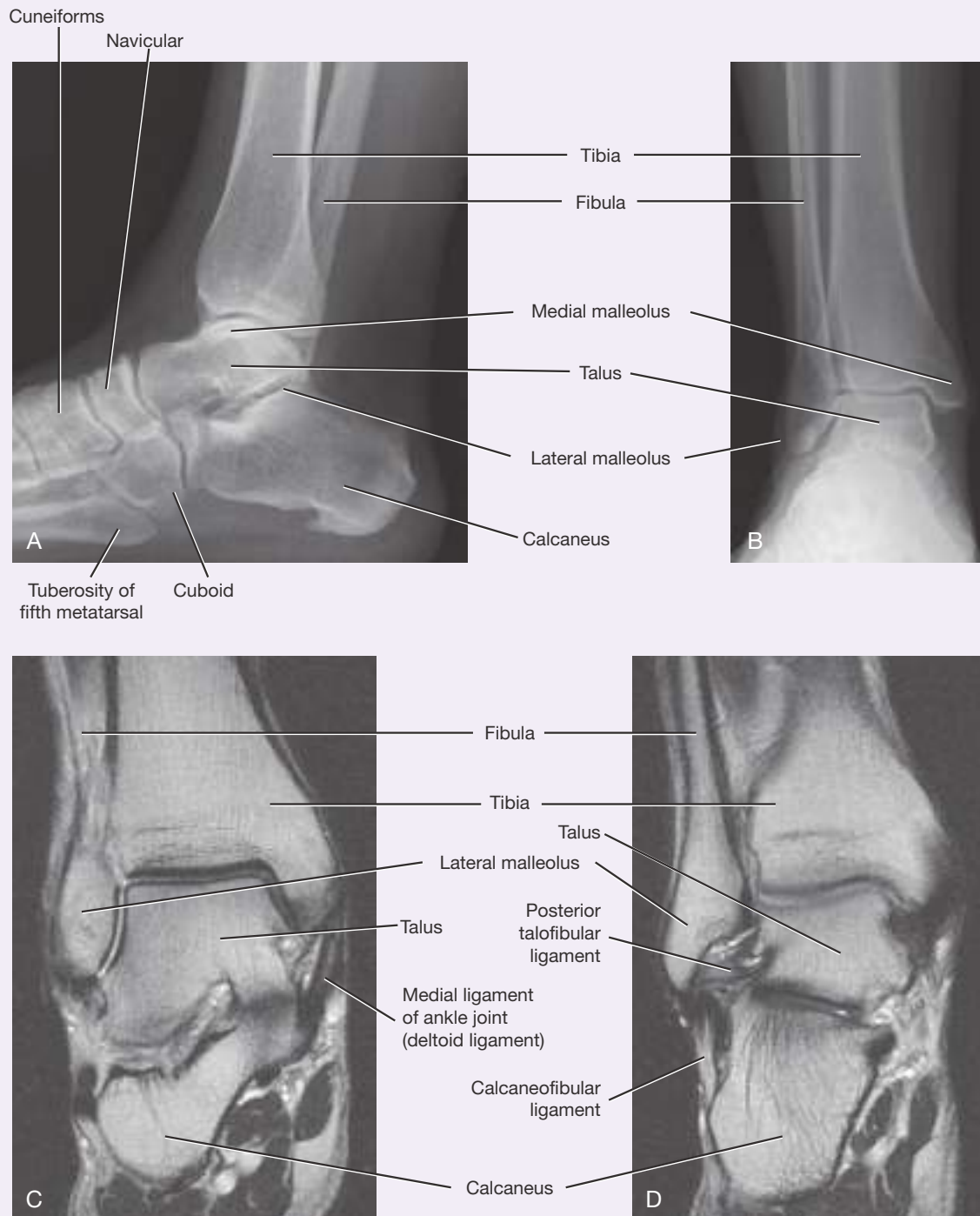


Fig. 6.86 Normal ankle joint. **A.** Radiograph, lateral view. **B.** Radiograph, anterior-posterior view. **C.** Coronal view of the ankle joint showing the medial ligament (deltoid ligament). T2-weighted magnetic resonance (MR) image in coronal plane. **D.** Coronal view of ankle joint showing posterior talofibular and calcaneofibular ligaments. T2-weighted MR image in coronal plane.

Clinical app

Ankle injuries

The anatomy of the ankle joint is complex. However, from a clinical perspective it may be regarded as a fibro-osseous ring oriented in the coronal plane.

- The upper part of the ring is formed by the joint between the distal ends of the fibula and tibia and by the ankle joint itself.
- The sides of the ring are formed by the ligaments that connect the medial malleolus and lateral malleolus to the adjacent tarsal bones.
- The bottom of the ring is not part of the ankle joint but consists of the subtalar joint and the associated ligaments.

Injuries may occur as fractures or ligament disruptions. Typically, two parts of this fibro-osseous ring are disrupted. Inversion injuries of the ankle joint are common. In this injury, the anterior talofibular and calcaneofibular parts of the lateral ligament are disrupted. These structures, once disrupted, allow the ankle to invert, often producing a fracture of the medial malleolus or a partial tear to the medial (deltoid) ligament.

Subtalar joint

The subtalar joint is between (Fig. 6.87):

- the large posterior calcaneal facet on the inferior surface of the talus, and
- the corresponding posterior talar facet on the superior surface of the calcaneus.

The articular cavity is enclosed by synovial membrane, which is covered by a fibrous membrane.

The subtalar joint allows gliding and rotation, which are involved in inversion and eversion of the foot. **Lateral, medial, posterior, and interosseous talocalcaneal ligaments** stabilize the joint. The interosseous talocalcaneal ligament lies in the tarsal sinus (Fig. 6.87).

Talocalcaneonavicular joint

The **talocalcaneonavicular joint** (Fig. 6.88) is a complex joint in which the head of the talus articulates with the calcaneus and plantar calcaneonavicular ligament (spring ligament) below and the navicular in front (Fig. 6.88A).

The talocalcaneonavicular joint allows gliding and rotation movements, which, together with similar movements of the subtalar joint, are involved with inversion



Fig. 6.87 Interosseous talocalcaneal ligament. Lateral view, right foot.

and eversion of the foot. It also participates in pronation and supination.

The parts of the talocalcaneonavicular joint between the talus and calcaneus are:

- the anterior and middle calcaneal facets on the inferior surface of the talar head, and
- the corresponding anterior and middle talar facets on the superior surface and sustentaculum tali, respectively, of the calcaneus (Fig. 6.88B).

The part of the joint between the talus and the plantar calcaneonavicular ligament (spring ligament) is between the ligament and a facet on the inferior surface of the talar head.

The joint between the navicular and talus is the largest part of the talocalcaneonavicular joint and is between the ovoid anterior end of the talar head and the corresponding concave posterior surface of the navicular.

Ligaments

The capsule of the talocalcaneonavicular joint, which is a synovial joint, is reinforced (Fig. 6.88A,B,C):

- posteriorly by the interosseous talocalcaneal ligament,
- superiorly by the **talonavicular ligament**, which passes between the neck of the talus and adjacent regions of the navicular, and
- inferiorly by the plantar calcaneonavicular ligament (spring ligament).

The lateral part of the talocalcaneonavicular joint is reinforced by the calcaneonavicular part of the **bifurcate ligament**, which is a Y-shaped ligament superior to the joint

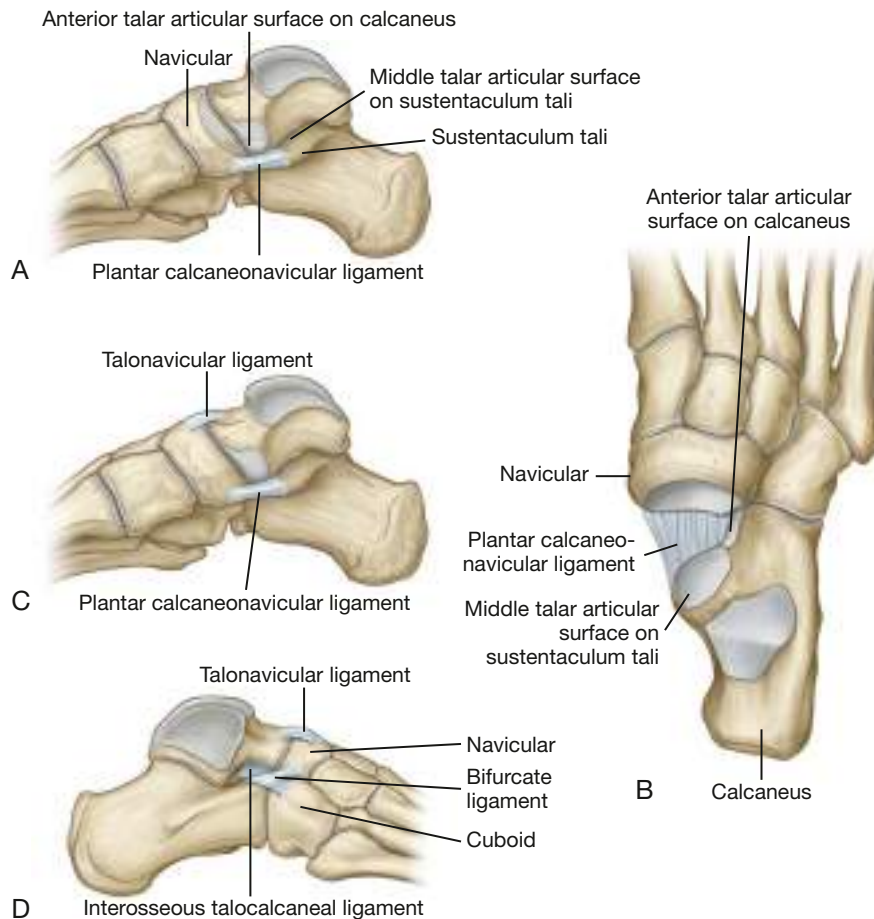


Fig. 6.88 Talocalcaneonavicular joint. **A.** Medial view, right foot. **B.** Superior view, right foot, talus removed. **C.** Ligaments, medial view, right foot. **D.** Ligaments, lateral view, right foot.

(Fig. 6.88D). The base of the bifurcate ligament is attached to the anterior aspect of the superior surface of the calcaneus and its arms are attached to:

- the dorsomedial surface of the cuboid (**calcaneocuboid ligament**), and
- the dorsolateral part of the navicular (**calcaneonavicular ligament**).

The **plantar calcaneonavicular ligament** (spring ligament) is a broad thick ligament that spans the space between the sustentaculum tali behind and the navicular bone in front (Fig. 6.88B,C). It supports the head of the talus, takes part in the talocalcaneonavicular joint, and resists depression of the medial arch of the foot.

Calcaneocuboid joint

The **calcaneocuboid joint** is a synovial joint between:

- the facet on the anterior surface of the calcaneus, and
- the corresponding facet on the posterior surface of the cuboid.

The calcaneocuboid joint allows sliding and rotating movements involved with inversion and eversion of the foot, and also contributes to pronation and supination of the fore-foot on the hindfoot.

Ligaments

The calcaneocuboid joint is reinforced by the bifurcate ligament (see previous discussion) and by the long plantar ligament and the plantar calcaneocuboid ligament (short plantar ligament) (Fig. 6.89).

The **plantar calcaneocuboid ligament** (short plantar ligament) is short, wide, and very strong and connects the calcaneal tubercle to the inferior surface of the cuboid (Fig. 6.89A). It not only supports the calcaneocuboid joint, but it also assists the long plantar ligament in resisting depression of the lateral arch of the foot.

The **long plantar ligament** is the longest ligament in the sole of the foot and lies inferior to the plantar calcaneocuboid ligament (Fig. 6.89B):

- Posteriorly, it attaches to the inferior surface of the calcaneus between the tuberosity and the calcaneal tubercle.

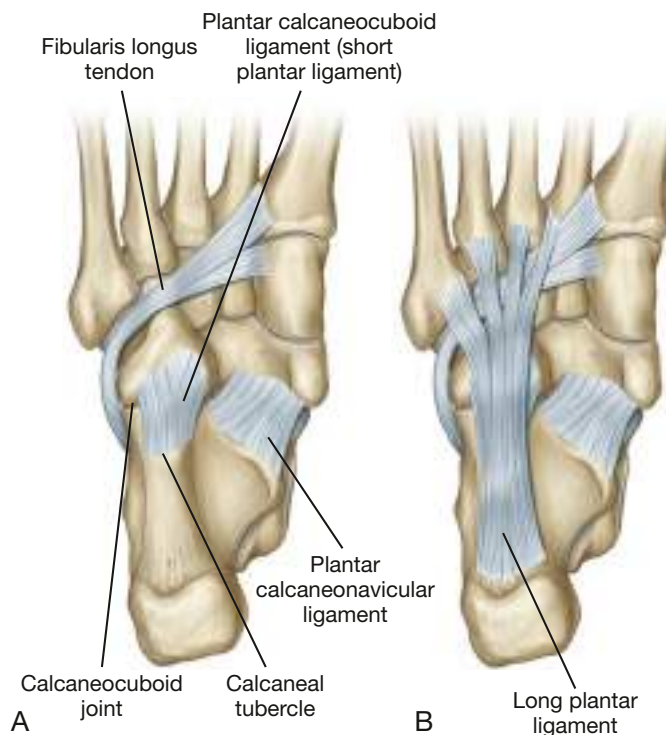


Fig. 6.89 Plantar ligaments, right foot. **A.** Plantar calcaneocuboid ligament (short plantar ligament). **B.** Long plantar ligament.



Fig. 6.90 Tarsometatarsal, metatarsophalangeal, and interphalangeal joints and the deep transverse metatarsal ligaments, right foot.

- Anteriorly, it attaches to a broad ridge and a tubercle on the inferior surface of the cuboid bone behind the groove for the fibularis longus tendon.

More superficial fibers of the long plantar ligament extend to the bases of the metatarsal bones.

The long plantar ligament supports the calcaneocuboid joint and is the strongest ligament, resisting depression of the lateral arch of the foot.

Tarsometatarsal joints

The **tarsometatarsal joints** between the metatarsal bones and adjacent tarsal bones are plane joints and allow limited sliding movements (Fig. 6.90).

The range of movement of the tarsometatarsal joint between the metatarsal of the great toe and the medial cuneiform is greater than that of the other tarsometatarsal joints and allows flexion, extension, and rotation. The tarsometatarsal joints, with the transverse tarsal joint, take part in pronation and supination of the foot.

Metatarsophalangeal joints

The metatarsophalangeal joints are ellipsoid synovial joints between the sphere-shaped heads of the metatarsals and the corresponding bases of the proximal phalanges of the digits.

The metatarsophalangeal joints allow extension and flexion and limited abduction, adduction, rotation, and circumduction.

The joint capsules are reinforced by medial and lateral **collateral ligaments** and by **plantar ligaments**, which have grooves on their plantar surfaces for the long tendons of the digits (Fig. 6.90).

Clinical app

Bunions

Clinically, a bunion is a significant protuberance of bone that may include soft tissue around the medial aspect of the first metatarsophalangeal joint. This area is an extremely important region of the foot because it is crossed by tendons and ligaments that transmit and distribute the body's weight during movement. It is postulated that abnormal stresses in this region of the joint may actually produce the bunion deformity. As the bunion progresses, the great toe appears to move toward the smaller toes, producing crowding of the digits. Typically the patient's symptoms are pain, swelling, and inflammation.

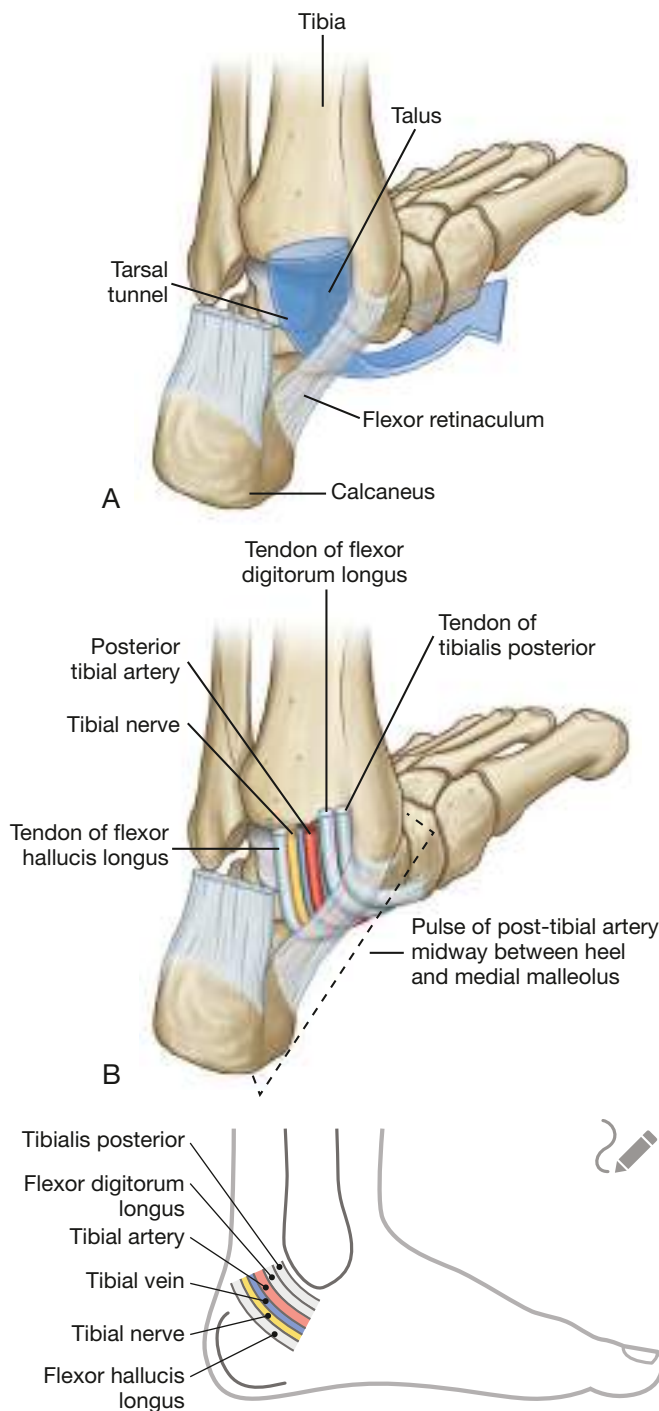


Fig. 6.91 Tarsal tunnel and flexor retinaculum. Posteromedial view, left foot. **A.** Bones. **B.** Tarsal tunnel and flexor retinaculum.

Deep transverse metatarsal ligaments

Four **deep transverse metatarsal ligaments** link the heads of the metatarsals together and enable the metatarsals to act as a single unified structure (Fig. 6.90). The ligaments blend with the plantar ligaments of the adjacent metatarsophalangeal joints.

The metatarsal of the great toe is oriented in the same plane as the metatarsals of the other toes and is linked to the metatarsal of the second toe by a deep transverse metatarsal ligament. In addition, the joint between the metatarsal of the great toe and medial cuneiform has a limited range of motion. The great toe therefore has a very restricted independent function.

Interphalangeal joints

The interphalangeal joints are hinge joints that allow mainly flexion and extension. They are reinforced by medial and lateral **collateral ligaments** and by **plantar ligaments** (Fig. 6.90).

Tarsal tunnel, retinacula, and arrangement of major structures at the ankle

The tarsal tunnel is formed on the posteromedial side of the ankle by (Fig. 6.91):

- a depression formed by the medial malleolus of the tibia, the medial and posterior surfaces of the talus, the medial surface of the calcaneus, and the inferior surface of the sustentaculum tali of the calcaneus; and
- an overlying flexor retinaculum.

Flexor retinaculum

The flexor retinaculum is a strap-like layer of connective tissue that spans the bony depression formed by the medial malleolus, the medial and posterior surfaces of the talus, the medial surface of calcaneus, and the inferior surface of the sustentaculum tali (Fig. 6.91). It attaches above to the medial malleolus and below and behind to the inferomedial margin of the calcaneus.

The retinaculum is continuous above with the deep fascia of the leg and below with deep fascia (plantar aponeurosis) of the foot.

Septa from the flexor retinaculum convert grooves on the bones into tubular connective tissue channels for the tendons of the flexor muscles as they pass into the sole of the foot from the posterior compartment of leg (Fig. 6.91). Free movement of the tendons in the channels is facilitated by synovial sheaths, which surround the tendons.

Two compartments on the posterior surface of the medial malleolus are for the tendons of the tibialis posterior and flexor digitorum longus muscles. The tendon of the tibialis posterior is medial to the tendon of the flexor digitorum longus.

Immediately lateral to the tendons of the tibialis posterior and flexor digitorum longus, the posterior tibial artery with its associated veins and the tibial nerve pass through the tarsal tunnel into the sole of the foot.

Lateral to the tibial nerve is the compartment on the posterior surface of the talus and the undersurface of the sustentaculum tali for the tendon of the flexor hallucis longus muscle.

Surface anatomy

Finding the tarsal tunnel—the gateway to the foot

The tarsal tunnel (Fig. 6.92) is formed on the medial side of the foot in the groove between the medial malleolus and the heel (calcaneal tuberosity) and by the overlying flexor retinaculum.

The posterior tibial artery and tibial nerve enter the foot through the tarsal tunnel. The tendons of the tibialis posterior, flexor digitorum longus, and flexor hallucis longus also pass through the tarsal tunnel in compartments formed by septa of the flexor retinaculum.

The order of structures passing through the tunnel from the anteromedial to posterolateral are the tendon of the tibialis posterior, the tendon of the flexor digitorum longus, the posterior tibial artery and associated veins, the tibial nerve, and the tendon of the flexor hallucis longus (“Tom, Dick, and a very nervous Harry”).

The tibial artery is palpable just posteroinferior to the medial malleolus on the anterior face of the visible groove between the heel and medial malleolus.

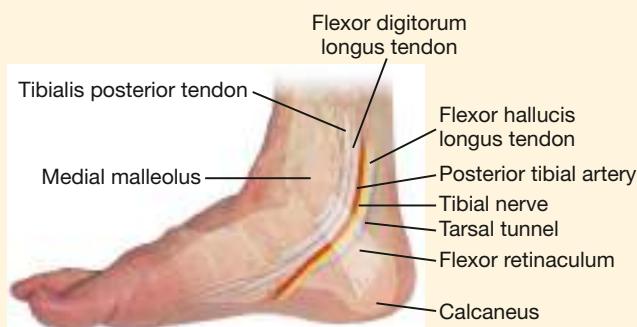


Fig. 6.92 Finding the tarsal tunnel—the gateway to the foot.

Extensor retinacula

Two extensor retinacula strap the tendons of the extensor muscles to the ankle region and prevent tendon bowing during extension of the foot and toes (Fig. 6.93):

- A **superior extensor retinaculum** is a thickening of deep fascia in the distal leg just superior to the ankle joint and attached to the anterior borders of the fibula and tibia.
- An **inferior extensor retinaculum** is Y-shaped, attached by its base to the lateral side of the upper surface of the calcaneus, and crosses medially over the foot to attach by one of its arms to the medial malleolus, whereas the other arm wraps medially around the foot and attaches to the medial side of the plantar aponeurosis.

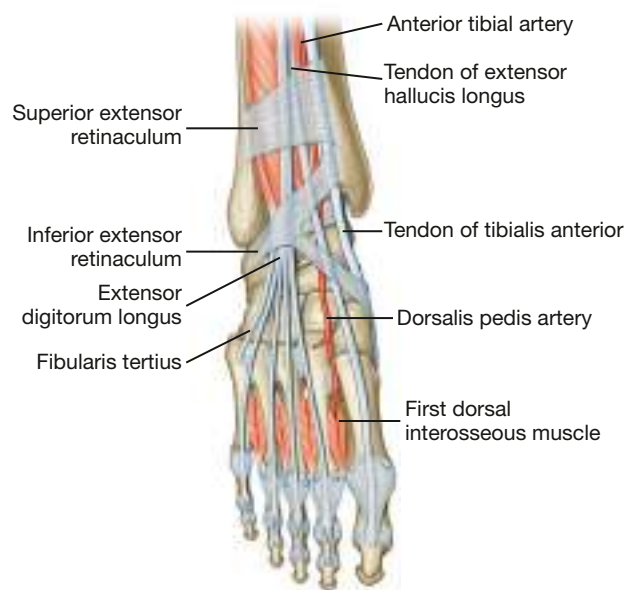


Fig. 6.93 Extensor retinacula, right foot.

The tendons of the extensor digitorum longus and fibularis tertius pass through a compartment on the lateral side of the proximal foot. Medial to these tendons, the dorsalis pedis artery (terminal branch of the anterior tibial artery), the tendon of the extensor hallucis longus muscle, and finally the tendon of the tibialis anterior muscle pass under the extensor retinacula.

Fibular retinacula

Fibular (peroneal) retinacula bind the tendons of the fibularis longus and fibularis brevis muscles to the lateral side of the foot (Fig. 6.94):

- A **superior fibular retinaculum** extends between the lateral malleolus and the calcaneus.
- An **inferior fibular retinaculum** attaches to the lateral surface of the calcaneus around the fibular trochlea and blends above with the fibers of the inferior extensor retinaculum.

At the fibular trochlea, a septum separates the compartment for the tendon of the fibularis brevis muscle above from that for the fibularis longus below.

Arches of the foot

The bones of the foot do not lie in a horizontal plane. Instead, they form longitudinal and transverse arches relative to the ground (Fig. 6.95), which absorb and distribute downward

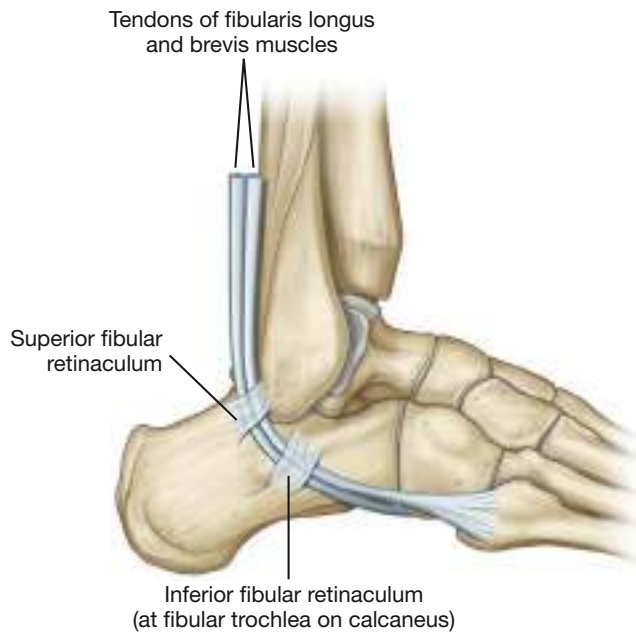


Fig. 6.94 Fibular retinacula. Lateral view, right foot.

forces from the body during standing and moving on different surfaces.

Longitudinal arch

The longitudinal arch of the foot is formed between the posterior end of the calcaneus and the heads of the metatarsals (Fig. 6.95A). It is highest on the medial side where it forms the medial part of the longitudinal arch and lowest on the lateral side where it forms the lateral part.

Transverse arch

The transverse arch of the foot is highest in a coronal plane that cuts through the head of the talus and disappears near the heads of the metatarsals where these bones are held together by the deep transverse metatarsal ligaments (Fig. 6.95B).

Ligaments and muscles support the arches of the foot (Fig. 6.96):

- Ligaments that support the arches include the plantar calcaneonavicular (spring ligament), plantar calcaneocuboid (short plantar ligament), long plantar ligament, and the plantar aponeurosis.
- Muscles that provide dynamic support for the arches during walking include the tibialis anterior and posterior, and the fibularis longus.

Plantar aponeurosis

The plantar aponeurosis is a thickening of deep fascia in the sole of the foot (Fig. 6.97). It is firmly anchored to the medial

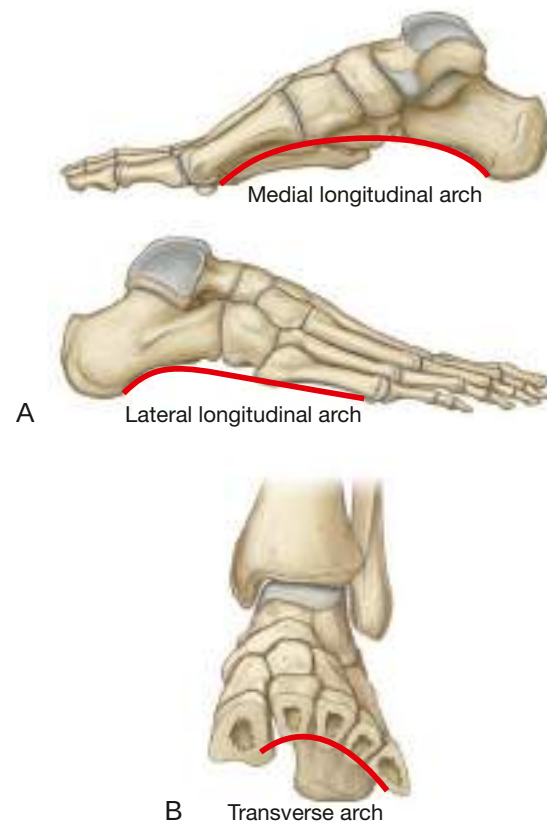


Fig. 6.95 Arches of the foot. A. Longitudinal arches, right foot. B. Transverse arch, left foot.

process of the calcaneal tuberosity and extends forward as a thick band of longitudinally arranged connective tissue fibers. The fibers diverge as they pass anteriorly and form digital bands, which enter the toes and connect with bones, ligaments, and dermis of the skin.

Distal to the metatarsophalangeal joints, the digital bands of the plantar aponeurosis are interconnected by transverse fibers that form superficial transverse metatarsal ligaments.

The plantar aponeurosis supports the longitudinal arch of the foot and protects deeper structures in the sole.

Fibrous sheaths of toes

The tendons of the flexor digitorum longus, flexor digitorum brevis, and flexor hallucis longus muscles enter fibrous digital sheaths or tunnels on the plantar aspect of the digits (Fig. 6.98). These fibrous sheaths begin anterior to the metacarpophalangeal joints and extend to the distal phalanges. They are formed by fibrous arches and cruciate (cross-shaped) ligaments attached posteriorly to the margins of the phalanges and to the plantar ligaments associated with the metatarsophalangeal and interphalangeal joints.

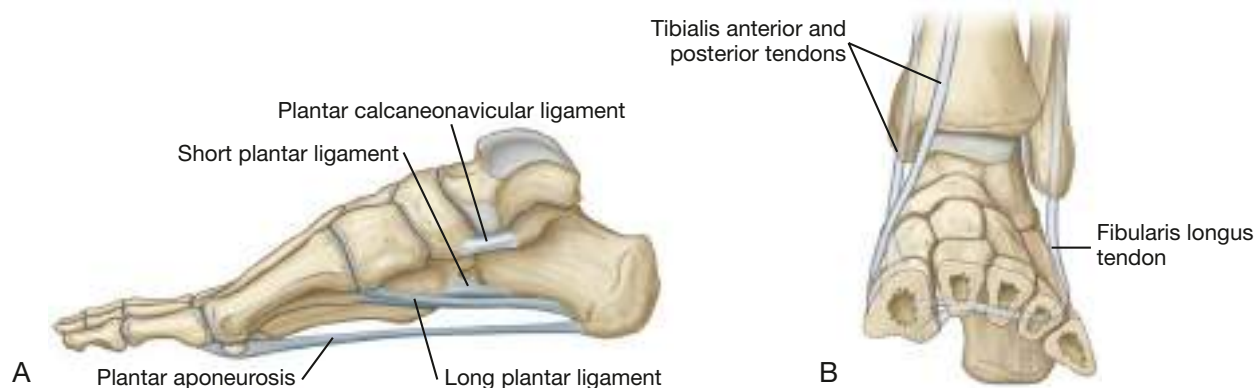


Fig. 6.96 Support for arches of the foot. **A.** Ligaments. Medial view, right foot. **B.** Cross-section through the foot to show tendons of muscles supporting the arches, left foot.

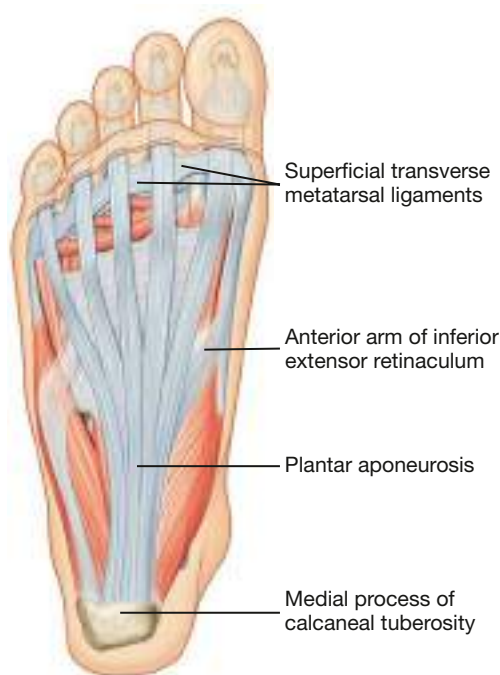


Fig. 6.97 Plantar aponeurosis, right foot.



Fig. 6.98 Fibrous digital sheaths, right foot.

These fibrous tunnels hold the tendons to the bony plane and prevent tendon bowing when the toes are flexed. Within each tunnel, the tendons are surrounded by a synovial sheath.

Extensor hoods

The tendons of the extensor digitorum longus, extensor digitorum brevis, and extensor hallucis longus pass into the dorsal aspect of the digits and expand over the proximal phalanges to form complex dorsal digital expansions (“extensor hoods”) (Fig. 6.99).

Each extensor hood is triangular with the apex attached to the distal phalanx, the central region attached to the middle (toes II to V) or proximal (toe I) phalanx, and each corner of the base wrapped around the sides of the metatarsophalangeal joint. The corners of the hoods attach mainly to the deep transverse metatarsal ligaments.

Many of the intrinsic muscles of the foot insert into the free margin of the hood on each side. The attachment of these muscles into the extensor hoods allows the forces from these muscles to be distributed over the toes to cause flexion of the metatarsophalangeal joints while extending

the interphalangeal joints (Fig. 6.99). The function of these movements in the foot is uncertain, but they may prevent overextension of the metatarsophalangeal joints and flexion of the interphalangeal joints when the heel is elevated off the ground and the toes grip the ground during walking.

Intrinsic muscles

Intrinsic muscles of the foot originate and insert in the foot:

- the **extensor digitorum brevis** and **extensor hallucis brevis** on the dorsal aspect of the foot (Table 6.10, Fig. 6.100);
- all other intrinsic muscles are on the plantar side of the foot where they are organized into four layers.

Intrinsic muscles mainly modify the actions of the long tendons and generate fine movements of the toes.

All intrinsic muscles of the foot are innervated by the medial and lateral plantar branches of the tibial nerve except for the extensor digitorum brevis, which is innervated by the deep fibular nerve. The first two dorsal interossei also may receive part of their innervation from the deep fibular nerve.

First layer

There are three components in the first layer of muscles, which is the most superficial of the four layers in the sole of the foot and is immediately deep to the plantar aponeurosis (Table 6.11, Fig. 6.101). From medial to lateral, these muscles are the **abductor hallucis**, **flexor digitorum brevis**, and **abductor digiti minimi**.

Second layer

The second muscle layer in the sole of the foot is associated with the tendons of the flexor digitorum longus muscle, which pass through this layer, and consists of the **quadratus plantae** and **four lumbrical muscles** (Table 6.12, Fig. 6.102).

Third layer

There are three muscles in the third layer in the sole of the foot (Table 6.13, Fig. 6.103):

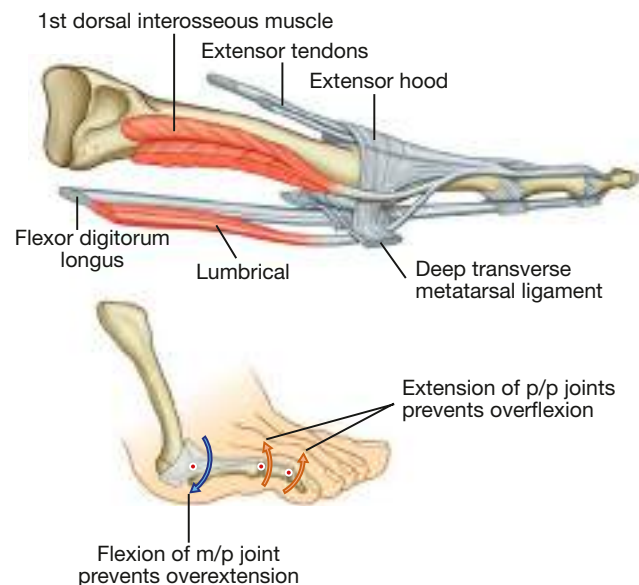


Fig. 6.99 Extensor hoods, right foot.

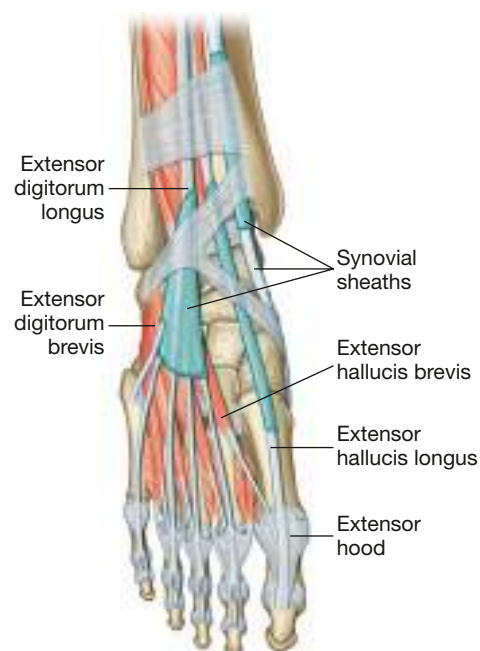


Fig. 6.100 Extensor digitorum brevis muscle, right foot.

Table 6.10 Muscle of the dorsal aspect of the foot (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Extensor hallucis brevis and extensor digitorum brevis	Superolateral surface of the calcaneus	Base of proximal phalanx of great toe and lateral sides of the tendons of extensor digitorum longus of toes II to IV	Deep fibular nerve (S1, S2)	Extension of metatarsophalangeal joint of great toe and extension of toes II to IV

Table 6.11 First layer of muscles in the sole of the foot (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Abductor hallucis	Medial process of calcaneal tuberosity	Medial side of base of proximal phalanx of great toe	Medial plantar nerve from the tibial nerve (S1, S2, S3)	Abducts and flexes great toe at metatarsophalangeal joint
Flexor digitorum brevis	Medial process of calcaneal tuberosity and plantar aponeurosis	Sides of plantar surface of middle phalanges of lateral four toes	Medial plantar nerve from the tibial nerve (S1, S2, S3)	Flexes lateral four toes at proximal interphalangeal joint
Abductor digiti minimi	Lateral and medial processes of calcaneal tuberosity and band of connective tissue connecting calcaneus with base of metatarsal V	Lateral side of base of proximal phalanx of little toe	Lateral plantar nerve from the tibial nerve (S1, S2, S3)	Abducts little toe at the metatarsophalangeal joint

Table 6.12 Second layer of muscles in the sole of the foot (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Quadratus plantae	Medial surface of calcaneus and lateral process of calcaneal tuberosity	Lateral side of tendon of flexor digitorum longus in proximal sole of the foot	Lateral plantar nerve from tibial nerve (S1, S2, S3)	Assists flexor digitorum longus tendon in flexing toes II to V
Lumbricals	First lumbrical—medial side of tendon of flexor digitorum longus associated with toe II; second, third, and fourth lumbricals—adjacent surfaces of adjacent tendons of flexor digitorum longus	Medial free margins of extensor hoods of toes II to V	First lumbrical—medial plantar nerve from the tibial nerve; second, third, and fourth lumbricals—lateral plantar nerve from the tibial nerve (S2, S3)	Flexion of metatarsophalangeal joint and extension of interphalangeal joints; act through the extensor hoods to resist excessive extension of the metatarsophalangeal joints and flexion of the interphalangeal joints when the heel leaves the ground during walking

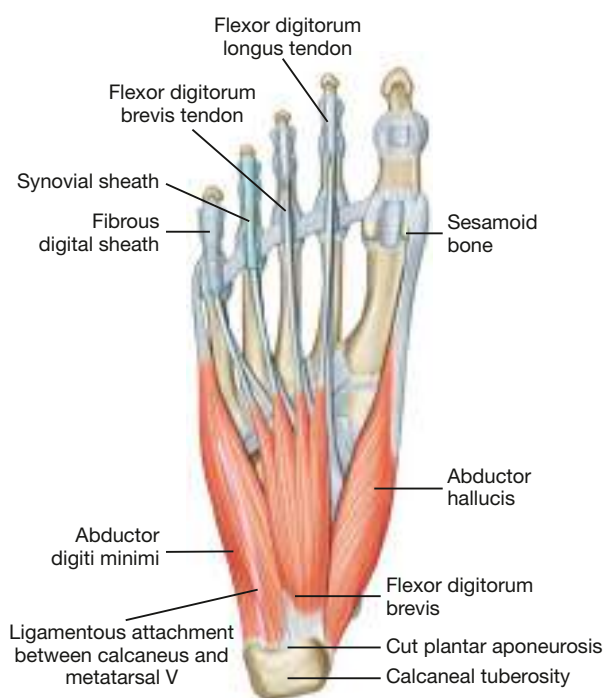


Fig. 6.101 First layer of muscles in the sole of the foot, right foot.

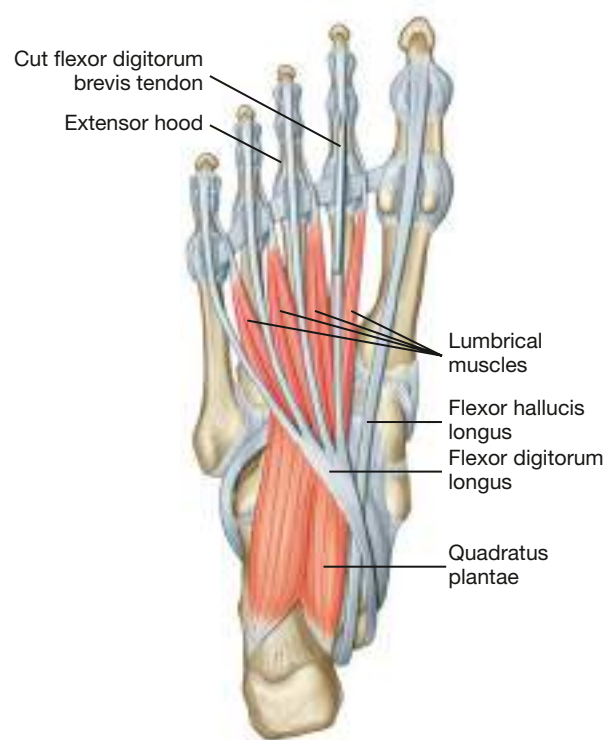


Fig. 6.102 Second layer of muscles in the sole of the foot, right foot.

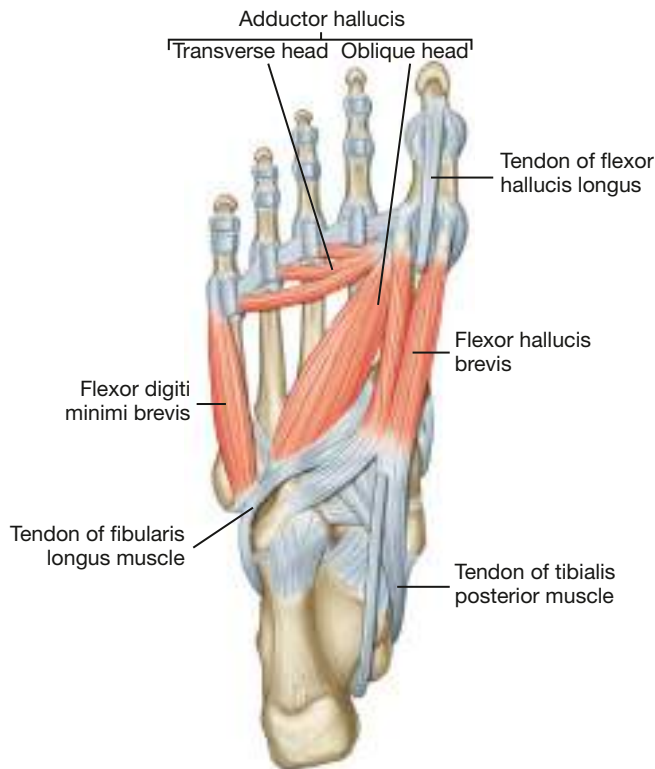


Fig. 6.103 Third layer of muscles in the sole of the foot, right foot.

- Two (the **flexor hallucis brevis** and **adductor hallucis**) are associated with the great toe.
- The third (the **flexor digiti minimi brevis**) is associated with the little toe.

Fourth layer

There are two muscle groups in the deepest muscle layer in the sole of the foot: the **dorsal** and **plantar interossei** (Table 6.14, Fig. 6.104).

Arteries

Blood supply to the foot is by branches of the posterior tibial and dorsalis pedis (dorsal artery of the foot) arteries.

Posterior tibial artery and plantar arch

The posterior tibial artery enters the foot through the tarsal tunnel on the medial side of the ankle and posterior to the medial malleolus. Here it bifurcates into a small medial plantar artery and a much larger lateral plantar artery (Fig. 6.105).

Lateral plantar artery

The **lateral plantar artery** passes anterolaterally into the sole of the foot, first deep to the proximal end of the abductor

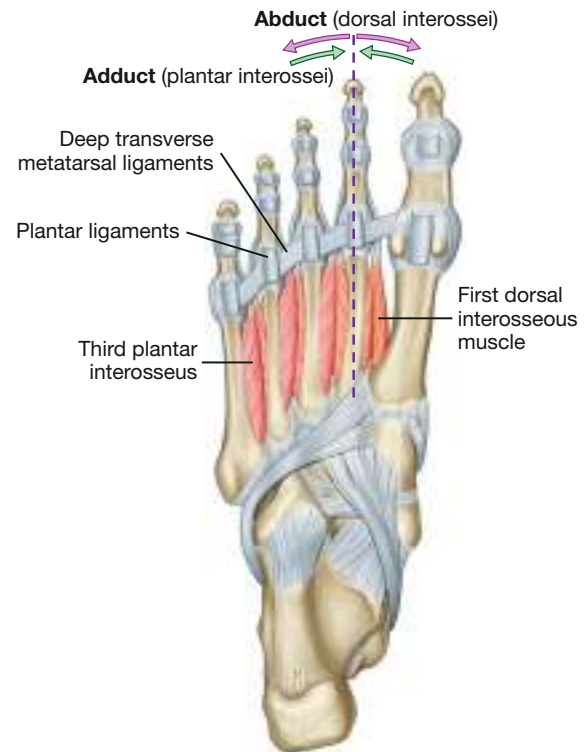


Fig. 6.104 Fourth layer of muscles in the sole of the foot, right foot.

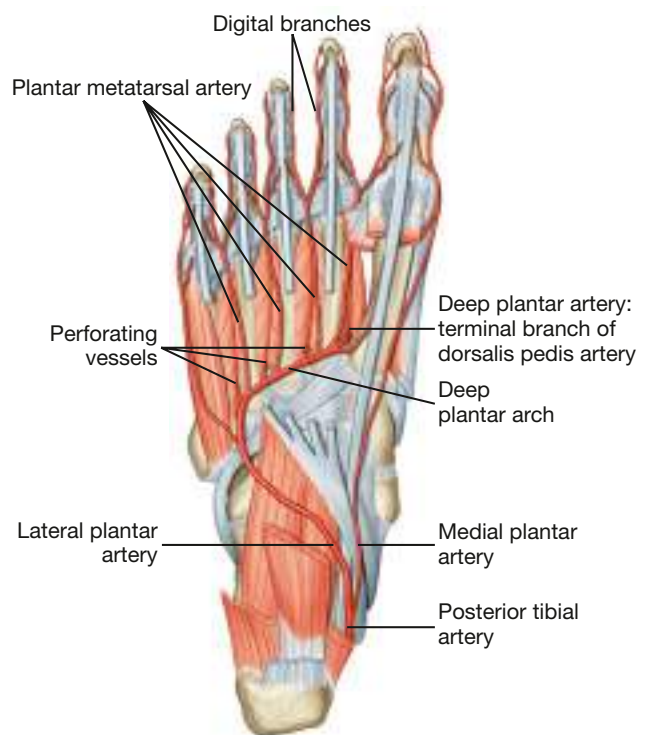


Fig. 6.105 Arteries in the sole of the foot, right foot.

Table 6.13 Third layer of muscles in the sole of the foot (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Flexor hallucis brevis	Plantar surface of cuboid and lateral cuneiform; tendon of tibialis posterior	Lateral and medial sides of base of proximal phalanx of the great toe	Medial plantar nerve from tibial nerve (S1, S2)	Flexes metatarsophalangeal joint of the great toe
Adductor hallucis	Transverse head—ligaments associated with metatarsophalangeal joints of lateral three toes; oblique head—bases of metatarsals II to IV and from sheath covering fibularis longus	Lateral side of base of proximal phalanx of great toe	Lateral plantar nerve from tibial nerve (S2, S3)	Adducts great toe at metatarsophalangeal joint
Flexor digiti minimi brevis	Base of metatarsal V and related sheath of fibularis longus tendon	Lateral side of base of proximal phalanx of little toe	Lateral plantar nerve from tibial nerve (S2, S3)	Flexes little toe at metatarsophalangeal joint

Table 6.14 Fourth layer of muscles in the sole of the foot (spinal segments in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Dorsal interossei	Sides of adjacent metatarsals	Extensor hoods and bases of proximal phalanges of toes II to IV	Lateral plantar nerve from tibial nerve; first and second dorsal interossei also innervated by deep fibular nerve (S2, S3)	Abduction of toes II to IV at metatarsophalangeal joints; act through the extensor hoods to resist extension of metatarsophalangeal joints and flexion of interphalangeal joints
Plantar interossei	Medial sides of metatarsals of toes III to V	Extensor hoods and bases of proximal phalanges of toes III to V	Lateral plantar nerve from tibial nerve (S2, S3)	Adduction of toes III to V at metatarsophalangeal joints; act through the extensor hoods to resist extension of the metatarsophalangeal joints and flexion of the interphalangeal joints

hallucis muscle and then between the quadratus plantae and flexor digitorum brevis muscles (Fig. 6.105). It reaches the base of metatarsal V where it lies in the groove between the flexor digitorum brevis and abductor digiti minimi muscles. From here, the lateral plantar artery curves medially to form the **deep plantar arch**, which crosses the deep plane of the sole on the metatarsal bases and the interossei muscles.

Between the bases of metatarsals I and II, the deep plantar arch joins with the terminal branch (deep plantar artery) of the dorsalis pedis artery, which enters the sole from the dorsal side of the foot.

Major branches of the deep plantar arch include:

- a digital branch to the lateral side of the little toe;
- four plantar metatarsal arteries, which supply digital branches to adjacent sides of toes I to V and the medial side of the great toe; and
- three perforating arteries, which pass between the bases of metatarsals II to V to anastomose with vessels on the dorsal aspect of the foot.

Medial plantar artery

The **medial plantar artery** passes into the sole of the foot by passing deep to the proximal end of the abductor hallucis muscle (Fig. 6.105). It supplies a deep branch to adjacent muscles and then passes forward in the groove between the

abductor hallucis and the flexor digitorum brevis muscles. It ends by joining the digital branch of the deep plantar arch, which supplies the medial side of the great toe.

Near the base of metatarsal I, the medial plantar artery gives rise to a superficial branch, which divides into three vessels that pass superficial to the flexor digitorum brevis muscle to join the plantar metatarsal arteries from the deep plantar arch.

Dorsalis pedis artery

The **dorsalis pedis artery** is the continuation of the anterior tibial artery and begins as the anterior tibial artery crosses the ankle joint (Fig. 6.106). It passes anteriorly over the dorsal aspect of the talus, navicular, and intermediate cuneiform bones and then passes inferiorly as the **deep plantar artery** between the two heads of the first dorsal interosseous muscle to join the deep plantar arch in the sole of the foot.

Branches of the dorsalis pedis artery include lateral and medial tarsal branches, an arcuate artery, and a first dorsal metatarsal artery (Fig. 6.106):

- The **tarsal arteries** pass medially and laterally over the tarsal bones, supplying adjacent structures and anastomosing with a network of vessels formed around the ankle.
- The **arcuate artery** passes laterally over the dorsal aspect of the metatarsals near their bases and gives rise to three

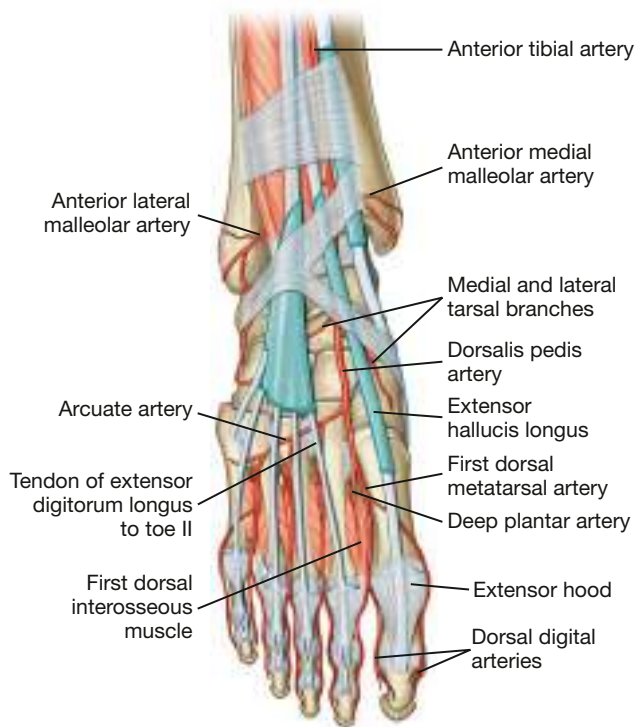


Fig. 6.106 Dorsalis pedis artery, right foot.

dorsal metatarsal arteries that supply **dorsal digital arteries** to adjacent sides of digits II to V and to a dorsal digital artery that supplies the lateral side of digit V.

- The **first dorsal metatarsal artery** (the last branch of the dorsalis pedis artery before the dorsalis pedis artery continues as the deep plantar artery into the sole of the foot) supplies dorsal digital branches to adjacent sides of the great and second toes.

The dorsal metatarsal arteries connect with perforating branches from the deep plantar arch and similar branches from the plantar metatarsal arteries.

Surface anatomy

Finding the dorsalis pedis artery

The nature of the dorsalis pedis pulse (Fig. 6.107) is important for assessing peripheral circulation because the dorsalis pedis artery is the farthest palpable vessel from the heart. Also, it is the lowest palpable artery in the body when a person is standing.

The dorsalis pedis artery passes onto the dorsal aspect of the foot and anteriorly over the tarsal bones where it lies between and is parallel to the tendon of the extensor hallucis longus and the tendon of the extensor digitorum longus to the second toe.

Surface anatomy— cont'd

It is palpable in this position. The terminal branch of the dorsalis pedis artery passes into the plantar surface of the foot between the two heads of the first dorsal interosseous muscle.

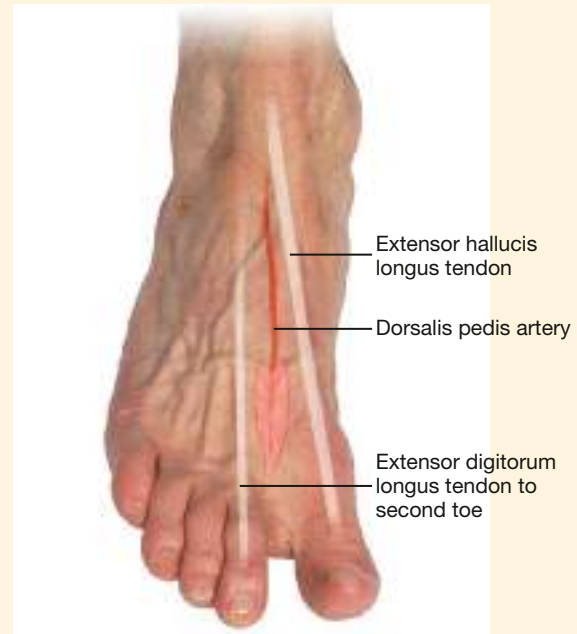


Fig. 6.107 Finding the dorsalis pedis artery, right foot.

Veins

There are interconnected networks of deep and superficial veins in the foot. The deep veins follow the arteries. Superficial veins drain into a dorsal venous arch on the dorsal surface of the foot over the metatarsals (Fig. 6.108):

- The **great saphenous vein** originates from the medial side of the arch and passes anterior to the medial malleolus and onto the medial side of the leg.
- The **small saphenous vein** originates from the lateral side of the arch and passes posterior to the lateral malleolus and onto the back of the leg.

Nerves

The foot is supplied by the tibial, deep fibular, superficial fibular, sural, and saphenous nerves:

- All five nerves contribute to cutaneous or general sensory innervation.
- The tibial nerve innervates all intrinsic muscles of the foot except for the extensor digitorum brevis, which is innervated by the deep fibular nerve.

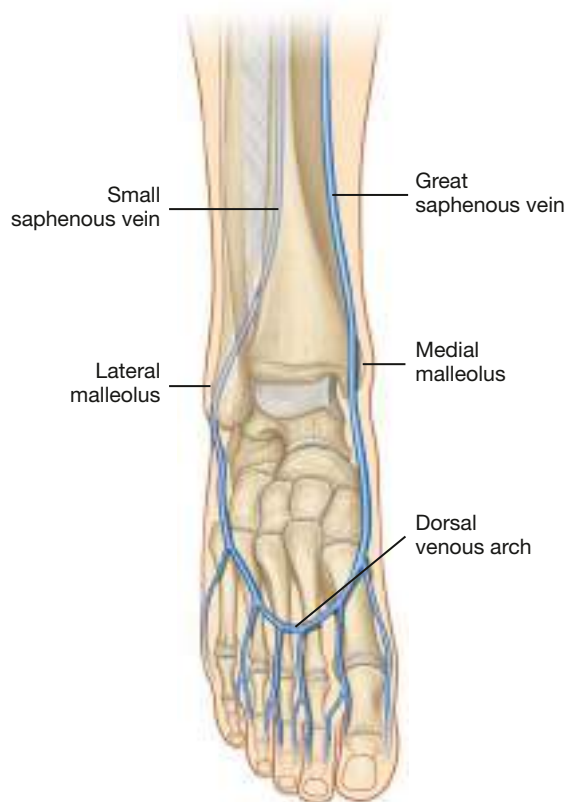


Fig. 6.108 Superficial veins of the foot, right foot.

- The deep fibular nerve often also contributes to the innervation of the first and second dorsal interossei.

Tibial nerve

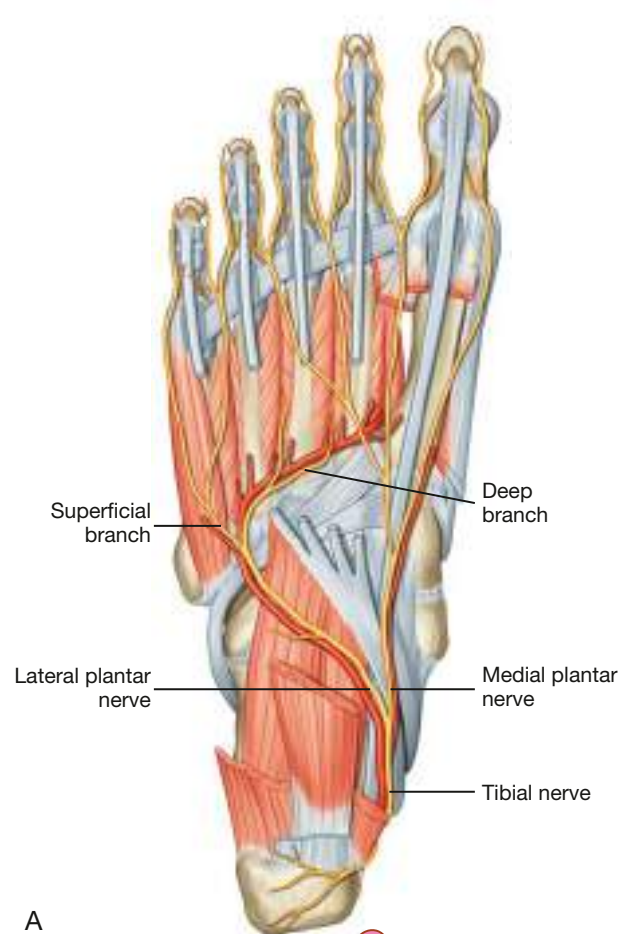
The **tibial nerve** enters the foot through the tarsal tunnel posterior to the medial malleolus. In the tunnel, the nerve is lateral to the posterior tibial artery and gives origin to **medial calcaneal branches**, which penetrate the flexor retinaculum to supply the heel. Midway between the medial malleolus and the heel, the tibial nerve bifurcates with the posterior tibial artery into (Fig. 6.109):

- a large medial plantar nerve, and
- a smaller lateral plantar nerve.

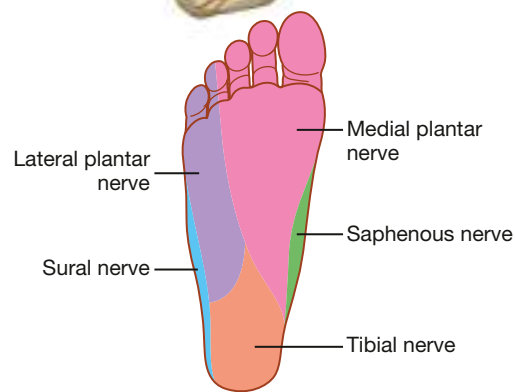
The medial and lateral plantar nerves lie together between their corresponding arteries.

Medial plantar nerve

The **medial plantar nerve** is the major sensory nerve in the sole of the foot (Fig. 6.109B). It innervates skin on most of the anterior two-thirds of the sole and adjacent surfaces of the medial three and one-half toes, which includes the great toe. In addition to this large area of plantar skin, the nerve also innervates four intrinsic muscles—the abductor hallucis, flexor digitorum brevis, flexor hallucis brevis, and the first lumbrical.



A



B

Fig. 6.109 Lateral and medial plantar nerves. A. Sole of the right foot. B. Cutaneous distribution.

The medial plantar nerve passes into the sole of the foot deep to the abductor hallucis muscle and forward in the groove between the abductor hallucis and flexor digitorum brevis, supplying branches to both these muscles.

The medial plantar nerve supplies a digital branch (**proper plantar digital nerve**) to the medial side of the great toe and then divides into three nerves (**common plantar digital nerves**) on the plantar surface of the flexor digitorum brevis, which continue forward to supply proper plantar digital branches to adjacent surfaces of toes I to IV. The nerve to the first lumbrical originates from the first common plantar digital nerve.

Lateral plantar nerve

The **lateral plantar nerve** is an important motor nerve in the foot because it innervates all intrinsic muscles in the sole except for the muscles supplied by the medial plantar nerve (the abductor hallucis, flexor digitorum brevis, flexor hallucis brevis, and first lumbrical; Fig. 6.109). It also innervates a strip of skin on the lateral side of the anterior two-thirds of the sole and the adjacent plantar surfaces of the lateral one and one-half digits.

The lateral plantar nerve enters the sole of the foot by passing deep to the proximal attachment of the abductor hallucis muscle. It continues laterally and anteriorly across the sole between the flexor digitorum brevis and quadratus plantae muscles, supplying branches to both these muscles, and then divides near the head of metatarsal V into a deep and superficial branch (Fig. 6.109).

The **superficial branch** of the lateral plantar nerve gives rise to a **proper plantar digital nerve**, which supplies skin on the lateral side of the little toe and to a **common plantar digital nerve**, which divides to supply proper plantar digital nerves to skin on the adjacent sides of toes IV and V.

The proper plantar digital nerve to the lateral side of the little toe also innervates the flexor digiti minimi brevis and the dorsal and plantar interossei muscles between metatarsals IV and V.

The **deep branch** of the lateral plantar nerve is motor and accompanies the lateral plantar artery deep to the long flexor tendons and the adductor hallucis muscle. It supplies branches to the second to fourth lumbrical muscles, the adductor hallucis muscle, and all interossei except those between metatarsals IV and V, which are innervated by the superficial branch.

Clinical app

Morton's neuroma

A Morton's neuroma is an enlarged common plantar nerve usually in the third interspace between the third and fourth toes. In this region of the foot the lateral plantar nerve often unites with the medial plantar nerve. As the two nerves join, the resulting nerve is typically larger in diameter than those of the other toes. Also, it is in a relatively subcutaneous position, just above the fat pad of the foot close to the artery and the vein. Above the nerve is the deep transverse metatarsal ligament, which is a broad strong structure holding the metatarsals together. Typically, as the patient enters the "push off" phase of walking, the interdigital nerve is sandwiched between the ground and the deep transverse metatarsal ligament. The forces tend to compress the common plantar nerve, which can be irritated in which case there is usually some associated inflammatory change and thickening.

Typically, patients experience pain in the third interspace, which may be sharp or dull and is usually worsened by wearing shoes and walking.

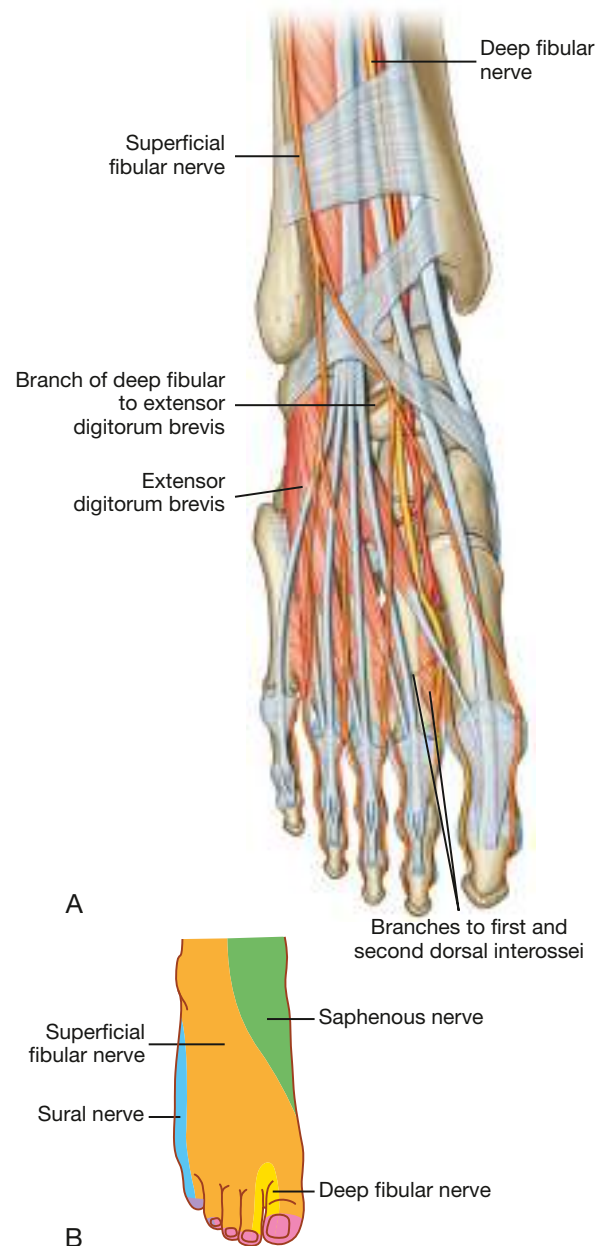


Fig. 6.110 A. Terminal branches of superficial and deep fibular nerves in the right foot. **B.** Cutaneous distribution.

Deep fibular nerve

The **deep fibular nerve** innervates the extensor digitorum brevis, contributes to the innervation of the first two dorsal interossei muscles, and supplies general sensory branches to the skin on the adjacent dorsal sides of the first and second toes and to the web space between them (Fig. 6.110).

The deep fibular nerve enters the dorsal aspect of the foot on the lateral side of the dorsalis pedis artery and is parallel with and lateral to the tendon of the extensor hallucis longus muscle. Just distal to the ankle joint, the nerve gives origin to a lateral branch, which innervates the extensor digitorum brevis from its deep surface.

The deep fibular nerve continues forward on the dorsal surface of the foot, penetrates deep fascia between metatarsals I and II near the metatarsophalangeal joints, and then divides into two **dorsal digital nerves**, which supply skin over adjacent surfaces of toes I and II down to the beginning of the nail beds (Fig. 6.110).

Small motor branches that contribute to the supply of the first two dorsal interossei muscles originate from the deep fibular nerve before it penetrates deep fascia.

Superficial fibular nerve

The **superficial fibular nerve** is sensory to most skin on the dorsal aspect of the foot and toes except for skin on adjacent sides of toes I and II (which is innervated by the deep fibular nerve) and skin on the lateral side of the foot and little toe (which is innervated by the sural nerve; Fig. 6.110).

The superficial fibular nerve penetrates deep fascia on the anterolateral side of the lower leg and enters the dorsal aspect of the foot in superficial fascia. It gives rise to cutaneous branches and **dorsal digital nerves** along its course.

Sural nerve

The sural nerve is a cutaneous branch of the tibial nerve that originates high in the leg. It enters the foot in superficial fascia posterior to the lateral malleolus close to the short saphenous vein. Terminal branches innervate skin on the lateral side of the foot and dorsolateral surface of the little toe (Fig. 6.110B).

Saphenous nerve

The saphenous nerve is a cutaneous branch of the femoral nerve that originates in the thigh. Terminal branches enter the foot in superficial fascia on the medial side of the ankle and supply skin on the medial side of the proximal foot (Fig. 6.110B).

Clinical app

Dermatomes and myotomes in the lower limb

General sensory and somatic motor innervation of the lower limb is by peripheral nerves emanating from the lumbar and sacral plexuses on the posterior abdominal and pelvic walls. These plexuses are formed by the anterior rami of L1 to L3 and most of L4 (lumbar plexus) and L4 to S5 (sacral plexus).

Nerves originating from the lumbar and sacral plexuses and entering the lower limb carry fibers from spinal cord levels L1 to S3. As a consequence of this innervation, lumbar and upper sacral nerves are tested clinically by examining the lower limb. In addition, clinical signs (such as pain, pins and

needles, paresthesia, and fascicular muscle twitching) resulting from any disorder affecting these spinal nerves (e.g., herniated intervertebral disc in the lumbar region) appear in the lower limb.

Dermatomes

Dermatomes in the lower limb are shown in Fig. 6.111.

Regions that can be tested for sensation and are reasonably autonomous (have minimal overlap) are:

- over the inguinal ligament—L1
- lateral side of the thigh—L2
- lower medial side of the thigh—L3
- medial side of the great toe (digit I)—L4
- medial side of digit II—L5
- little toe (digit V)—S1
- back of the thigh—S2
- skin over the gluteal fold—S3

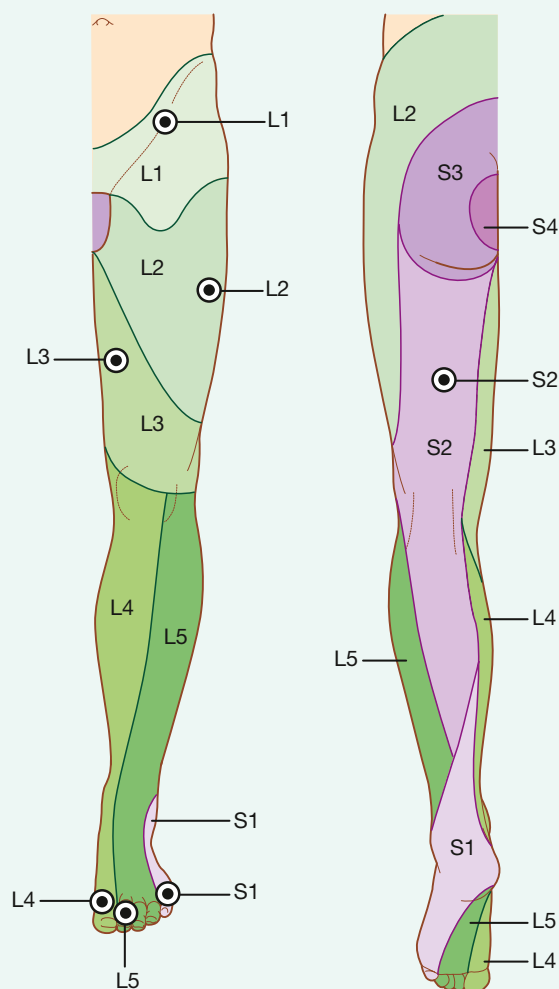


Fig. 6.111 Dermatomes of the lower limb. Dots indicate autonomous zones (i.e., with minimal overlap).

Myotomes

Selected joint movements are used to test myotomes (Fig. 6.112).

For example:

- Flexion of the hip is controlled primarily by L1 and L2.
- Extension of the knee is controlled mainly by L3 and L4.
- Knee flexion is controlled mainly by L5 to S2.
- Plantarflexion of the foot is controlled predominantly by S1 and S2.
- Adduction of the digits is controlled by S2 and S3.

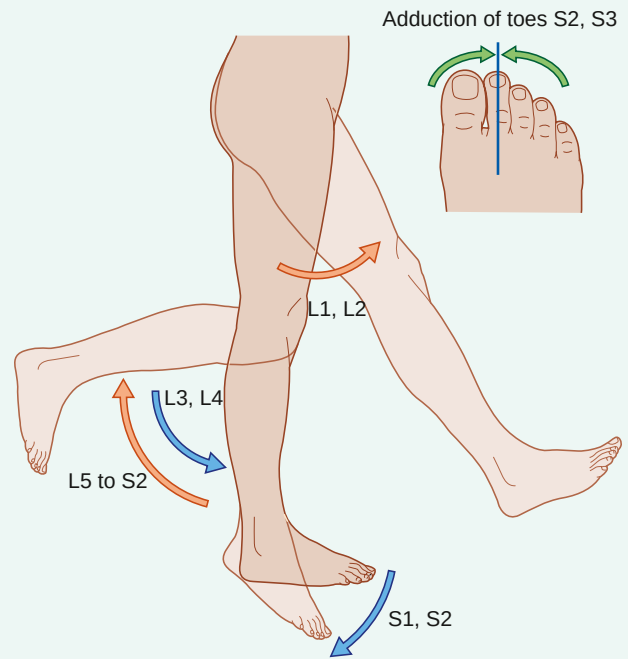


Fig. 6.112 Movements generated by myotomes.

Clinical app

Testing sensory innervation carried by major peripheral nerves in the lower limb

In addition to innervating major muscle groups, each of the major peripheral nerves originating from the lumbar and sacral plexuses carries general sensory information from patches of skin (Fig. 6.113). Sensation from these areas can be used to test for peripheral nerve lesions:

- The femoral nerve innervates skin on the anterior thigh, medial side of the leg, and medial side of the ankle.
- The obturator nerve innervates the medial side of the thigh.
- The tibial part of the sciatic nerve innervates the lateral side of the ankle and foot.
- The common fibular nerve innervates the lateral side of the leg and the dorsum of the foot.

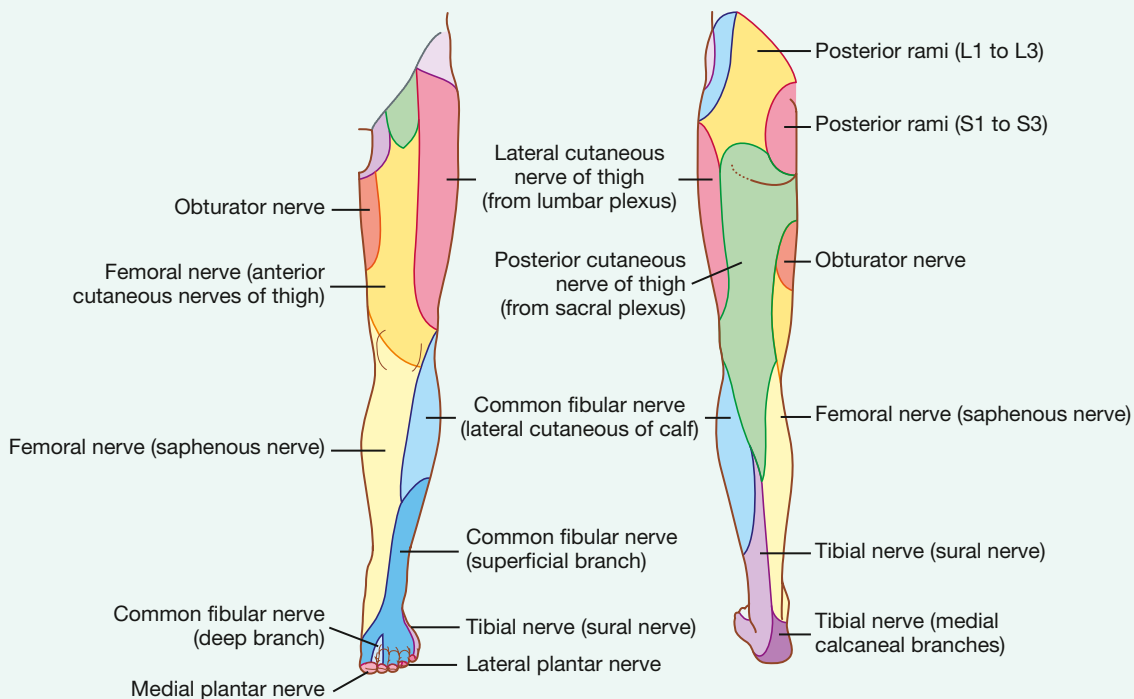


Fig. 6.113 Regions of skin innervated by peripheral nerves.

Clinical app

Tendon taps in the lower limb

In an unconscious patient, both somatic sensory and somatic motor functions of spinal cord levels can be tested using tendon reflexes:

- A tap on the patellar ligament at the knee tests predominantly L3 and L4.
- A tendon tap on the calcaneal tendon posterior to the ankle (tendon of gastrocnemius and soleus) tests S1 and S2.

Clinical app

Gait and gait defects

The body's center of gravity lies just anterior to the anterior edge of the S11 vertebra in the pelvis. During walking, many anatomical features of the lower limbs contribute to minimizing fluctuations in the body's center of gravity and thereby reduce the amount of energy needed to maintain locomotion and produce a smooth, efficient gait (Fig. 6.114). They include pelvic tilt in the coronal

plane, pelvic rotation in the transverse plane, movement of the knees toward the midline, flexion of the knees, and complex interactions between the hip, knee, and ankle. As a result, during walking, the body's center of gravity normally fluctuates only 5 cm in both vertical and lateral directions.

Any pathology that alters the determinants of gait changes the gait pattern and increases the amount of energy required to walk.

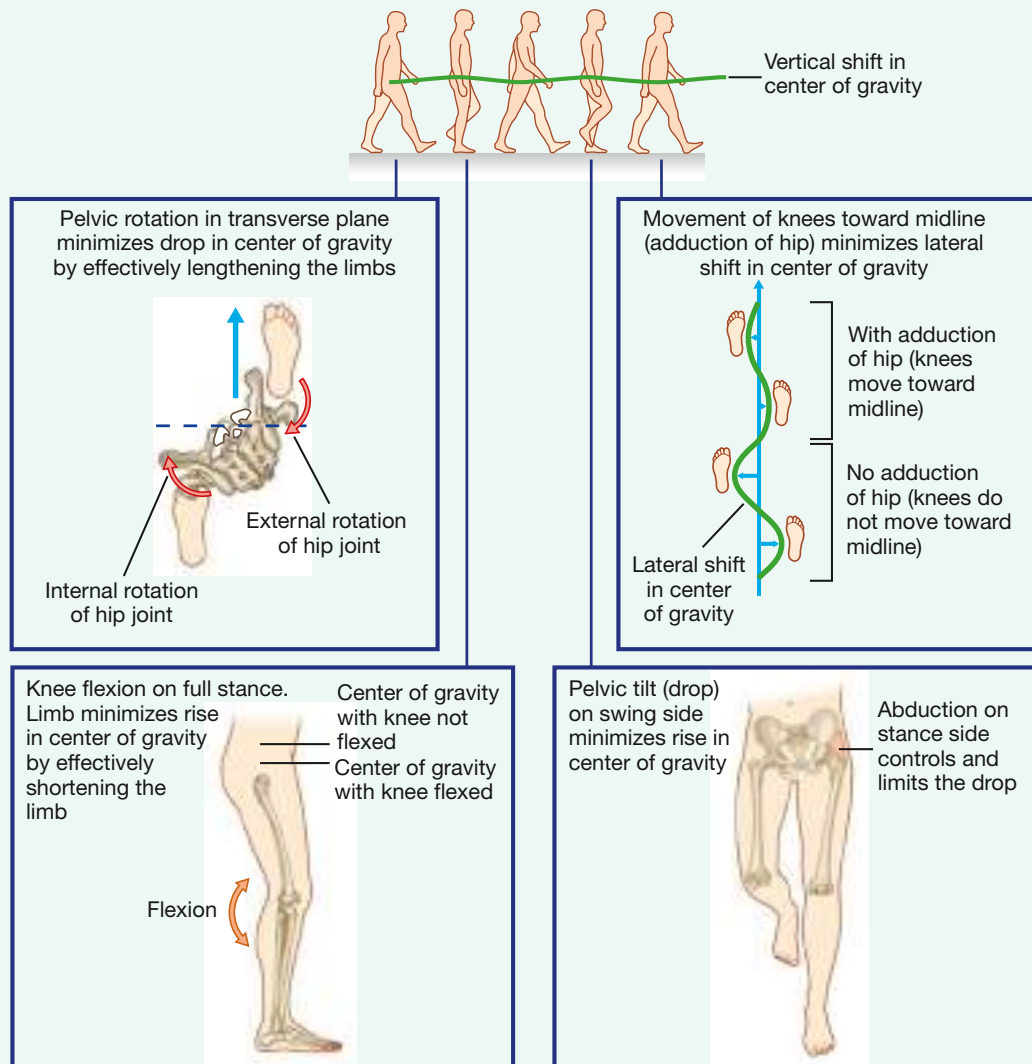


Fig. 6.114 Some of the determinants of gait.

Surface anatomy

Pulse points

Peripheral pulses can be felt at four locations in the lower limb (Fig. 6.115):

- **femoral pulse** in the femoral triangle—femoral artery inferior to the inguinal ligament and midway between the anterior superior iliac spine and the pubic symphysis
- **popliteal pulse** in the popliteal fossa—popliteal artery deep in the popliteal fossa medial to the midline
- **posterior tibial pulse** in the tarsal tunnel—posterior tibial artery posteroinferior to the medial malleolus in the groove between the medial malleolus and the heel (calcaneal tuberosity)
- **dorsalis pedis pulse** on the dorsal aspect of the foot—dorsalis pedis artery as it passes distally over the tarsal bones between the tendon of the extensor hallucis longus and the tendon of the extensor digitorum longus to the second toe



Fig. 6.115 Where to feel peripheral arterial pulses in the lower limb.

7

Upper Limb

**ADDITIONAL LEARNING RESOURCES
FOR CHAPTER 7, *UPPER LIMB*,
CAN BE FOUND ON THE ACCOMPANYING
EBOOK:**

- Self-Assessment (scored) — National Board style multiple-choice questions, Chapter 7
- Short Questions (not scored) — these are questions requiring short responses, Chapter 7
- PT Case Studies
 - Upper quarter screening examination
 - Thoracic outlet syndrome
 - Rotator cuff tendinitis
 - Adhesive capsulitis
 - Subacromial impingement
 - See more PT Case Studies online*
- Clinical Cases
 - Pancoast tumor
 - Clavicular fracture
 - Extensor tendon injury of the hand
 - Hand infection
 - High median nerve palsy
 - Winged scapula
 - Brachial plexus nerve block
 - Complication of a fractured first rib
 - Carpal tunnel syndrome
 - See more Clinical Cases online*

Regional anatomy 368

Shoulder 370

- Bones 370
- Joints 372
- Muscles 377

Posterior scapular region 379

- Gateways to the posterior scapular region 379
- Nerves 380
- Arteries and veins 381

Axilla 381

- Axillary inlet 382
- Anterior wall 382
- Medial wall 383
- Lateral wall 384
- Posterior wall 384
- Gateways in the posterior wall 386
- Floor 386
- Contents of the axilla 386

Arm 398

- Bones 398
- Muscles 401
- Nerves 401
- Arteries and veins 403

Elbow joint 405

Cubital fossa 408

Forearm 410

- Bones 410
- Joints 412

Anterior compartment of the forearm 414

- Muscles 414
- Arteries and veins 414
- Nerves 417

Posterior compartment of the forearm 418

- Muscles 418
- Arteries and veins 418
- Nerves 421

Hand 422

- Bones 423
- Joints 425
- Carpal tunnel and structures at the wrist 426
- Palmar aponeurosis 427
- Anatomical snuffbox 428
- Fibrous digital sheaths 429
- Extensor hoods 429
- Muscles 430
- Arteries and veins 432
- Nerves 435

Regional anatomy

Based on the position of its major joints, the upper limb is divided into the shoulder, arm, forearm, and hand (Fig. 7.1):

- The shoulder is the area of upper limb attachment to the trunk. The bones of the shoulder include the scapula, clavicle, and proximal end of the humerus.
- The arm is between the shoulder and the elbow joint. The bone of the arm is the humerus.
- The forearm is between the elbow joint and the wrist joint. The bones of the forearm are the ulna and radius.
- The hand is distal to the wrist joint. Bones of the hand are the carpals, metacarpals, and phalanges.

The major function of the upper limb is to position the hand in space for use as a mechanical and sensory tool.

Unlike the lower limb, which is used for support, stability, and locomotion, the upper limb is designed to be flexible. The shoulder is suspended from the trunk predominantly by muscles and can therefore be moved relative to the body. Sliding (protraction and retraction) and rotating the scapula on the thoracic wall changes the position of the **glenohumeral joint (shoulder joint)** and extends the reach of the hand (Fig. 7.2). The glenohumeral joint allows the arm to move around three axes with a wide range of motion. Movements of the arm at this joint are flexion, extension, abduction, adduction, medial rotation (internal rotation), lateral rotation (external rotation), and circumduction (Fig. 7.3).

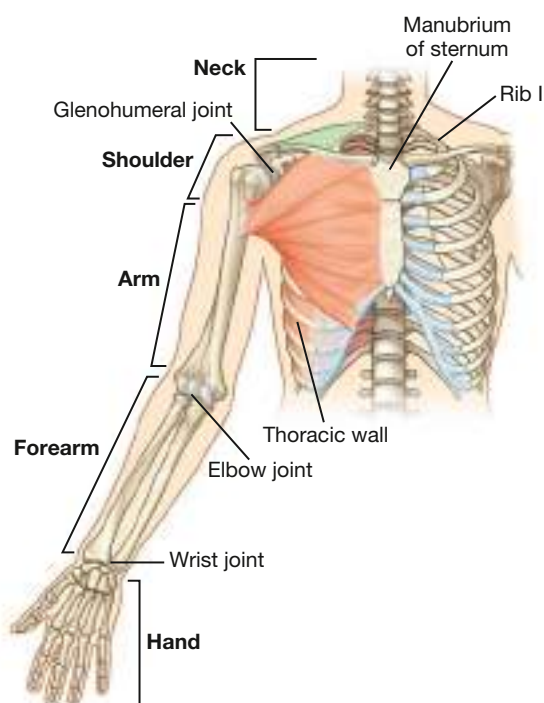


Fig. 7.1 Anterior view of the upper limb.

The major movements at the **elbow joint** are flexion and extension of the forearm (Fig. 7.4A). At the other end of the forearm, the distal end of the lateral bone, the radius, can be flipped over the adjacent head of the medial bone, the ulna. Because the hand is articulated with the radius, it can be efficiently moved from a palm-anterior position to a palm-posterior position simply by crossing the distal end of the radius over the ulna (Fig. 7.4B). This movement, termed *pronation*, occurs solely in the forearm. Supination returns the hand to the anatomical position.

At the **wrist joint**, the hand can be abducted, adducted, flexed, extended, and circumducted (Fig. 7.5). These movements, combined with those of the shoulder, arm, and forearm, enable the hand to be placed in a wide range of positions relative to the body.

The thumb is positioned at right angles to the orientation of the index, middle, ring, and little fingers (Fig. 7.6). As a result, movements of the thumb occur at right angles to those of the other digits. For example, flexion brings the thumb across the palm, whereas abduction moves it away from the fingers at right angles to the palm (Fig. 7.6A,B).

Importantly, with the thumb positioned at right angles to the palm. Only a slight rotation of the thumb brings it into a position directly facing the other fingers (Fig. 7.6C). This opposition of the thumb is essential for normal hand function.

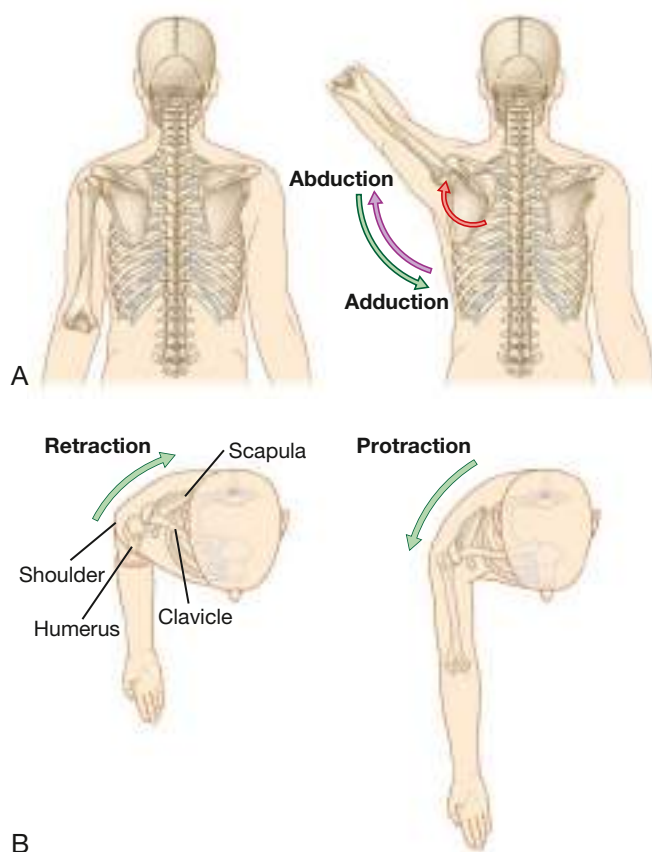


Fig. 7.2 Movements of the scapula. A. Rotation. B. Protraction and retraction.

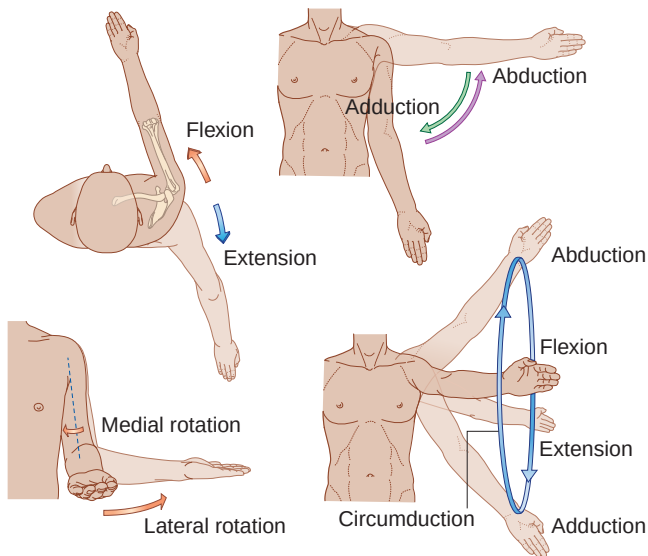


Fig. 7.3 Movements of the arm at the glenohumeral joint.

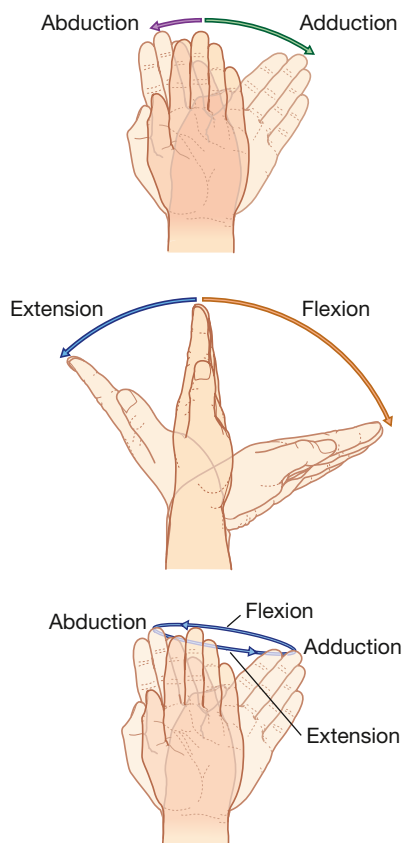


Fig. 7.5 Movements of the hand at the wrist joint.

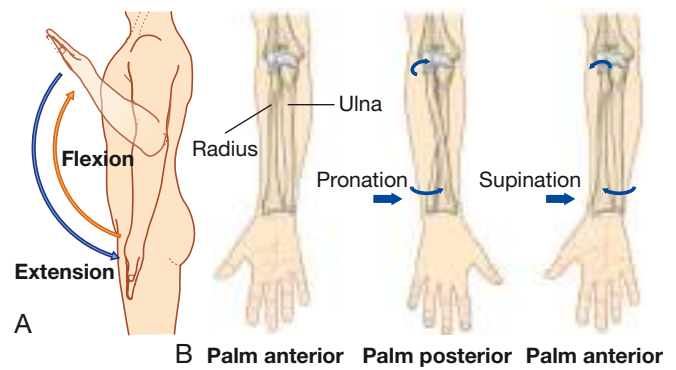


Fig. 7.4 Movements of the forearm. A. Flexion and extension at the elbow joint. B. Pronation and supination.

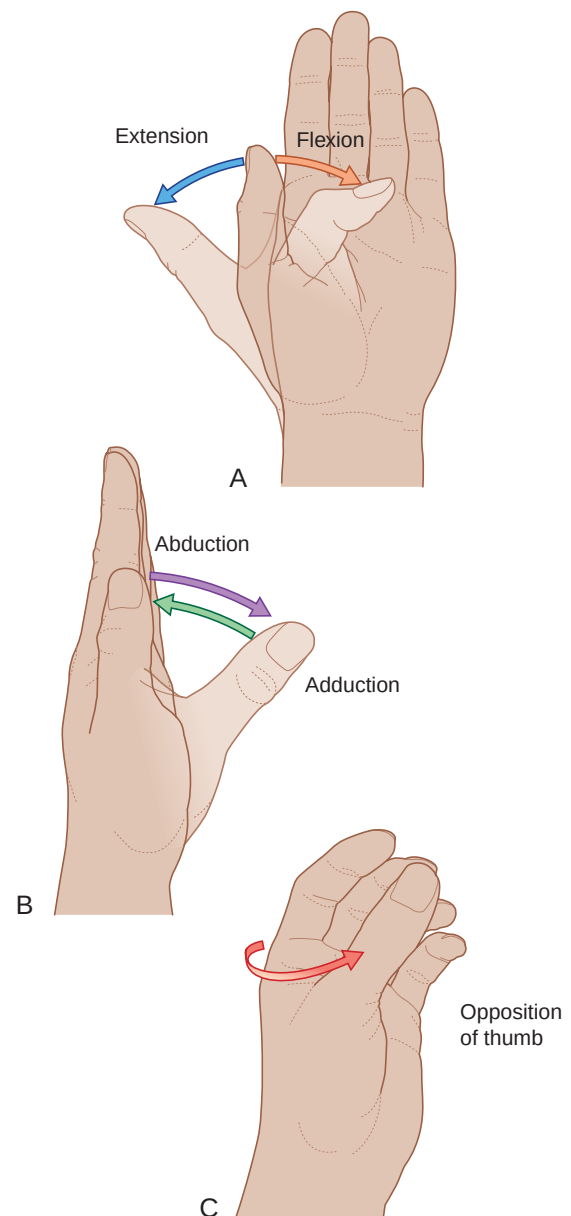


Fig. 7.6 A-C. Movements of the thumb.



SHOULDER

The bone framework of the shoulder consists of:

- the clavicle and scapula, which form the **pectoral girdle (shoulder girdle)**, and
- the proximal end of the humerus.

The superficial muscles of the shoulder consist of the trapezius and deltoid muscles, which together form the smooth muscular contour over the lateral part of the shoulder. These muscles connect the scapula and clavicle to the trunk and to the arm, respectively.

Bones

Clavicle

The clavicle is the only bony attachment between the trunk and the upper limb. It is palpable along its entire length and has a gentle S-shaped contour with the forward-facing convex part medial and the forward-facing concave part lateral. The acromial (lateral) end of the clavicle is flat, whereas the sternal (medial) end is more robust and somewhat quadrangular (Fig. 7.7).

The acromial end of the clavicle has a small oval facet on its surface for articulation with a similar facet on the medial surface of the acromion of the scapula.

The sternal end has a much larger facet for articulation mainly with the manubrium of the sternum and, to a lesser extent, with the first costal cartilage.

The inferior surface of the lateral third of the clavicle possesses a distinct tuberosity consisting of a tubercle (the **conoid tubercle**) and lateral roughening (the **trapezoid line**) for attachment of the important coracoclavicular ligament.

In addition, the surfaces and margins of the clavicle are roughened by the attachment of muscles that connect the clavicle to the thorax, neck, and upper limb. The superior surface is smoother than the inferior surface.

Scapula

The scapula is a large, flat triangular bone with (Fig. 7.8):

- three angles (lateral, superior, and inferior);
- three borders (superior, lateral, and medial);
- two surfaces (costal and posterior); and
- three processes (acromion, spine, and coracoid process)

The **lateral angle** of the scapula is marked by a shallow, somewhat comma-shaped **glenoid cavity** that articulates with the head of the humerus to form the glenohumeral joint (Fig. 7.8B,C).

A large triangular-shaped roughening (the **infraglenoid tubercle**) inferior to the glenoid cavity is the site of attachment for the long head of the triceps brachii muscle (Fig. 7.8B,C).

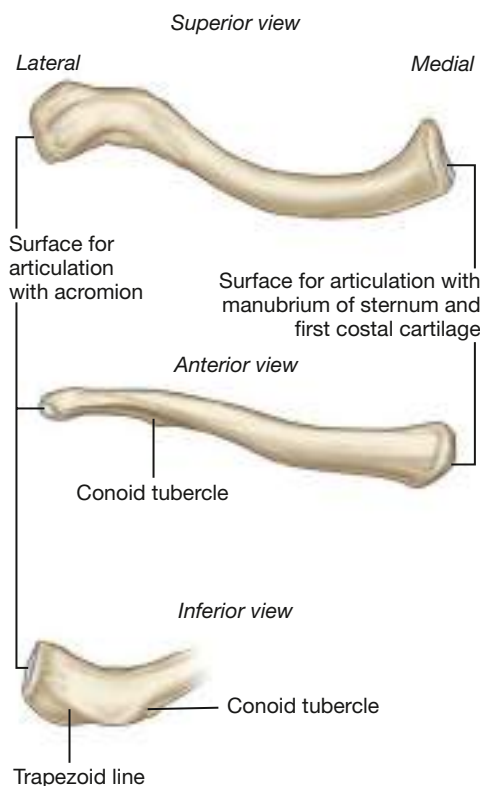


Fig. 7.7 Right clavicle.

A less distinct **supraglenoid tubercle** is located superior to the glenoid cavity and is the site of attachment for the long head of the biceps brachii muscle (Fig. 7.8C).

A prominent spine subdivides the posterior surface of the scapula into a small, superior **supraspinous fossa** and a much larger, inferior **infraspinous fossa** (Fig. 7.8A).

The **acromion**, which is an anterolateral projection of the spine, arches over the glenohumeral joint and articulates, via a small oval facet on its distal end, with the clavicle (Fig. 7.8B).

The region between the lateral angle of the scapula and the attachment of the spine to the posterior surface of the scapula is the **greater scapular notch (spinoglenoid notch)** (Fig. 7.8A).

Unlike the posterior surface, the **costal surface** of the scapula is unremarkable, being characterized by a shallow concave **subscapular fossa** over much of its extent (Fig. 7.8B). The costal surface and margins provide for muscle attachment, and the costal surface, together with its related muscle (**subscapularis**), moves freely over the underlying thoracic wall.

The lateral border of the scapula is strong and thick for muscle attachment, whereas the medial border and much of the superior border is thin and sharp.

The superior border is marked on its lateral end by:

- the **coracoid process** (Fig. 7.8B,C), a hook-like structure that projects anterolaterally and is positioned directly inferior to the lateral part of the clavicle; and

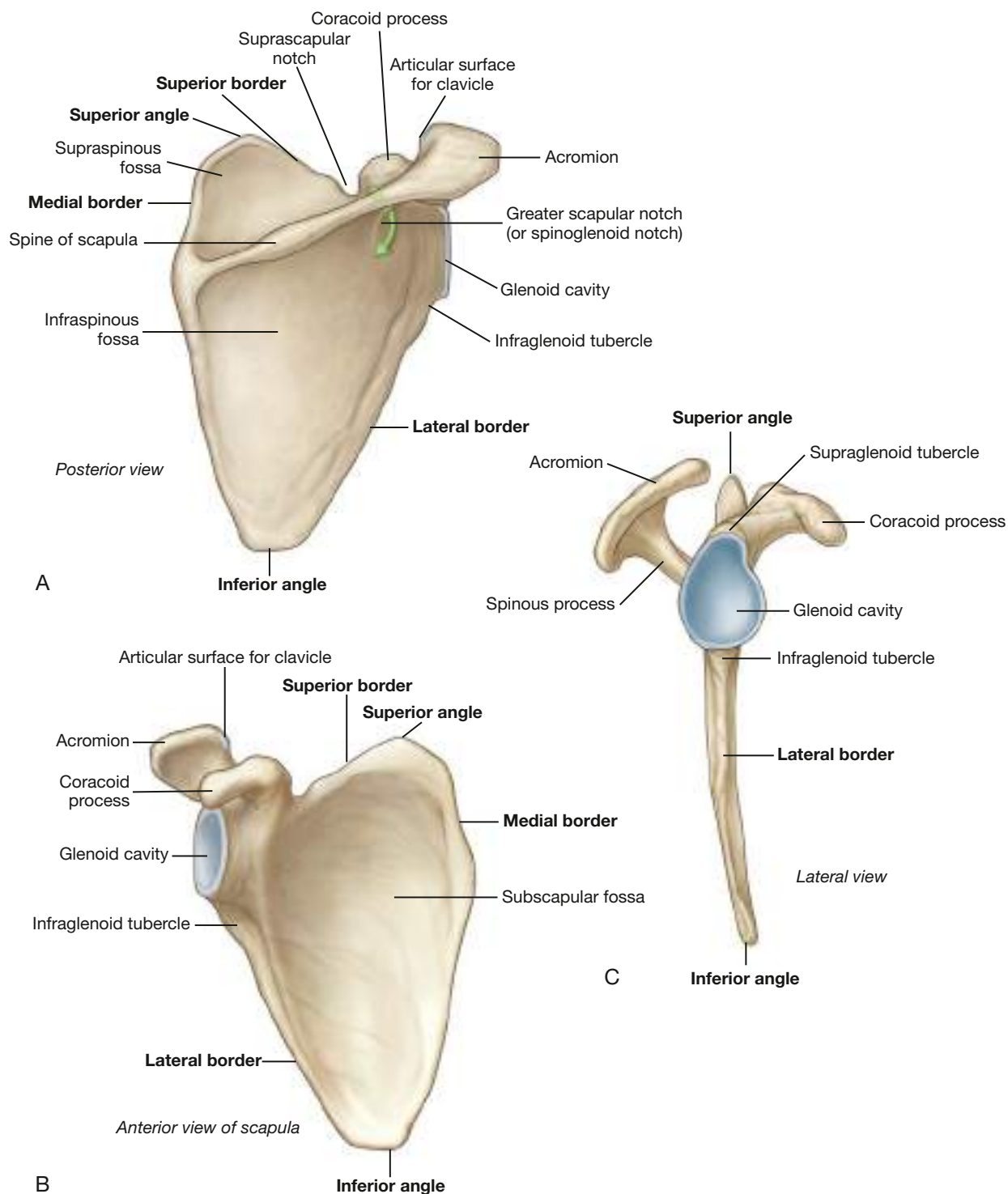


Fig. 7.8 Scapula. **A.** Posterior view of right scapula. **B.** Anterior view of costal surface. **C.** Lateral view.

- the small but distinct **suprascapular notch** (Fig. 7.8A), which lies immediately medial to the root of the coracoid process.

The spine and acromion can be readily palpated on a patient, as can the tip of the coracoid process, the inferior angle, and much of the medial border of the scapula.

Proximal humerus

The proximal end of the humerus consists of the head, the anatomical neck, the greater and lesser tubercles, the surgical neck, and the superior half of the shaft of humerus (Fig. 7.9).

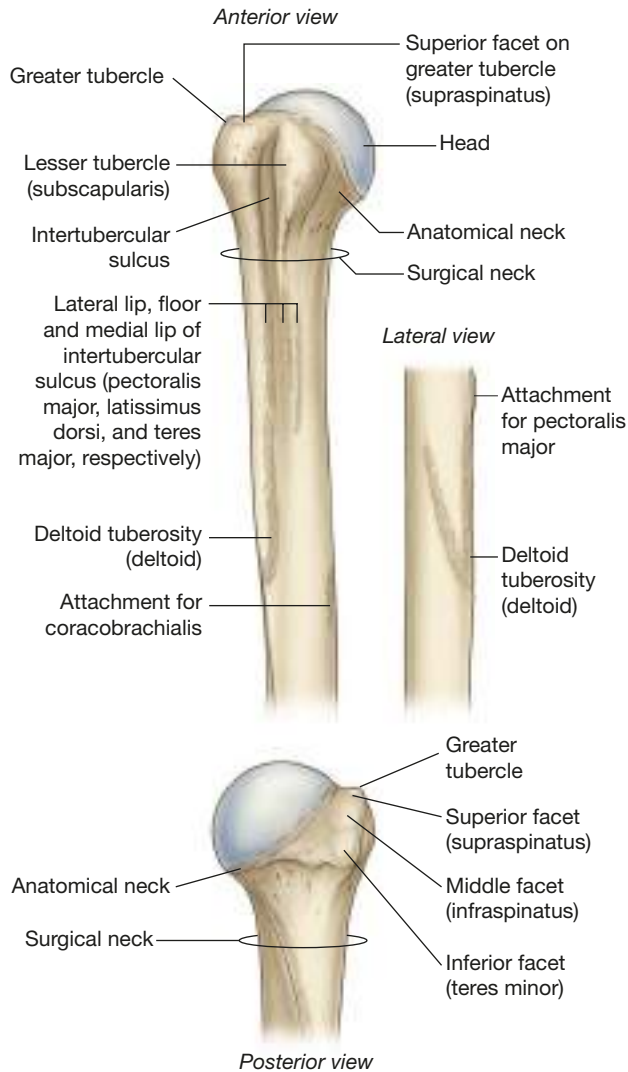


Fig. 7.9 Proximal end of right humerus.

The **head** is half-spherical and projects medially and somewhat superiorly to articulate with the much smaller glenoid cavity of the scapula.

The **anatomical neck** is very short and is formed by a narrow constriction immediately distal to the head. It lies between the head and the greater and lesser tubercles laterally and between the head and the shaft more medially.

Greater and lesser tubercles

The **greater** and **lesser tubercles** are prominent landmarks on the proximal end of the humerus and serve as attachment sites for the four rotator cuff muscles of the glenohumeral joint (Fig. 7.9).

The greater tubercle is lateral in position. Its superior surface and posterior surface are marked by three large smooth facets for muscle tendon attachment (Fig. 7.9):

- The superior facet is for attachment of the supraspinatus muscle.
- The middle facet is for attachment of infraspinatus.
- The inferior facet is for attachment of teres minor.

The lesser tubercle is anterior in position, and its surface is marked by a large smooth impression for attachment of the subscapularis muscle.

A deep **intertubercular sulcus (bicipital groove)** separates the lesser and greater tubercles and continues inferiorly onto the proximal shaft of the humerus (Fig. 7.9). The tendon of the long head of the biceps brachii passes through this sulcus.

Roughenings on the lateral and medial lips and on the floor of the intertubercular sulcus mark sites for the attachment of the pectoralis major, teres major, and latissimus dorsi muscles, respectively.

The lateral lip of the intertubercular sulcus is continuous inferiorly with a large V-shaped **deltoid tuberosity** on the lateral surface of the humerus midway along its length (Fig. 7.9), which is where the deltoid muscle inserts onto the humerus.

In approximately the same position but on the medial surface of the bone there is a thin vertical roughening for attachment of the coracobrachialis muscle.

Surgical neck

One of the most important features of the proximal end of the humerus is the **surgical neck** (Fig. 7.9). This region is oriented in the horizontal plane between the expanded proximal part of the humerus (head, anatomical neck, and tubercles) and the narrower shaft. The axillary nerve and the posterior circumflex humeral artery, which pass into the deltoid region from the axilla, do so immediately posterior to the surgical neck. Because the surgical neck is weaker than more proximal regions of the bone, it is one of the sites where the humerus commonly fractures.

Clinical app

Fracture of the proximal humerus

Typically, fractures occur around the surgical neck of the humerus. Although the axillary nerve and posterior circumflex humeral artery may be damaged with this type of fracture, this rarely happens. However, it is important that the axillary nerve is tested to be sure that the injury has not damaged the nerve and that the treatment itself does not cause a neurologic deficit.

Joints

The three joints in the shoulder complex are the sternoclavicular, acromioclavicular, and glenohumeral joints.

The sternoclavicular joint and the acromioclavicular joint link the two bones of the pectoral girdle to each other and to

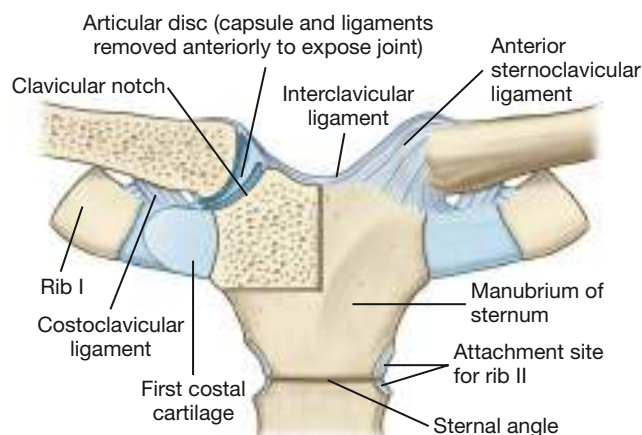


Fig. 7.10 Sternoclavicular joint.

the trunk. The combined movements at these two joints enable the scapula to be positioned over a wide range on the thoracic wall, substantially increasing “reach” by the upper limb.

The glenohumeral joint (shoulder joint) is the articulation between the humerus of the arm and the scapula.

Sternoclavicular joint

The **sternoclavicular joint** occurs between the proximal end of the clavicle and the **clavicular notch** of the **manubrium of sternum** together with a small part of the first costal cartilage (Figs. 7.10, 7.11). It is synovial and saddle-shaped. The articular cavity is completely separated into two compartments by an articular disc. The sternoclavicular joint allows movement of the clavicle, predominantly in the anteroposterior and vertical planes, although some rotation also occurs.

The sternoclavicular joint is surrounded by a joint capsule and is reinforced by four ligaments (Fig. 7.10):

- The **anterior and posterior sternoclavicular ligaments** are anterior and posterior, respectively, to the joint.
- An **interclavicular ligament** links the ends of the two clavicles to each other and to the superior surface of the manubrium of sternum.
- The **costoclavicular ligament** is positioned laterally to the joint and links the proximal end of the clavicle to the first rib and related costal cartilage.

Acromioclavicular joint

The **acromioclavicular joint** is a small synovial joint between an oval facet on the medial surface of the acromion and a similar facet on the acromial end of the clavicle (Figs. 7.12, 7.13). It allows movement in the anteroposterior and vertical planes together with some axial rotation.

The acromioclavicular joint is surrounded by a joint capsule and is reinforced by (Fig. 7.12):

- a small **acromioclavicular ligament** superior to the joint and passing between adjacent regions of the clavicle and acromion; and
- a much larger **coracoclavicular ligament**, which is not directly related to the joint but is an important strong accessory ligament, providing much of the weight-bearing support for the upper limb on the clavicle and maintaining the position of the clavicle on the acromion. It spans the distance between the coracoid process of the scapula and the inferior surface of the acromial end of the clavicle and comprises an anterior **trapezoid ligament** (which attaches to the trapezoid line on the clavicle) and a posterior **conoid ligament** (which attaches to the related conoid tubercle).

Glenohumeral joint

The **glenohumeral joint** is a synovial ball-and-socket articulation between the head of the humerus and the glenoid cavity of the scapula (Fig. 7.14; see Fig. 7.15). It is multiaxial with a wide range of movements provided at the cost of skeletal stability. Joint stability is provided instead by the rotator cuff muscles, the long head of the biceps brachii muscle, related bony processes, and extracapsular ligaments.

The articular surfaces of the glenohumeral joint are the large spherical head of the humerus and the small glenoid cavity of the scapula (Fig. 7.14).

The glenoid cavity is deepened and expanded peripherally by a fibrocartilaginous collar (the **glenoid labrum**), which attaches to the margin of the fossa (Fig. 7.14). Superiorly, this labrum is continuous with the tendon of the long head of the biceps brachii muscle, which attaches to the supraglenoid tubercle and passes through the articular cavity superior to the head of the humerus.

The synovial membrane attaches to the margins of the articular surfaces and lines the fibrous membrane of the

Imaging app

Visualizing the sternoclavicular joint

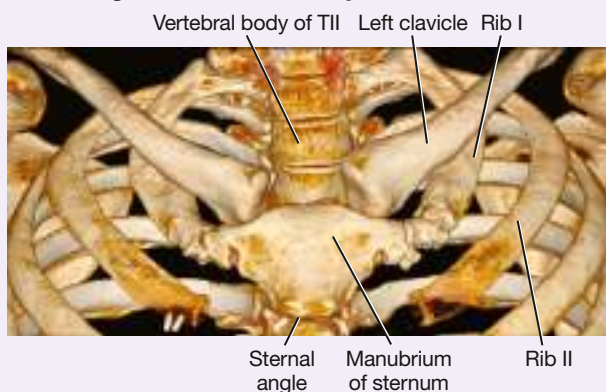


Fig. 7.11 Anterior view of normal sternoclavicular joints. Volume-rendered reconstruction using multidetector computed tomography.

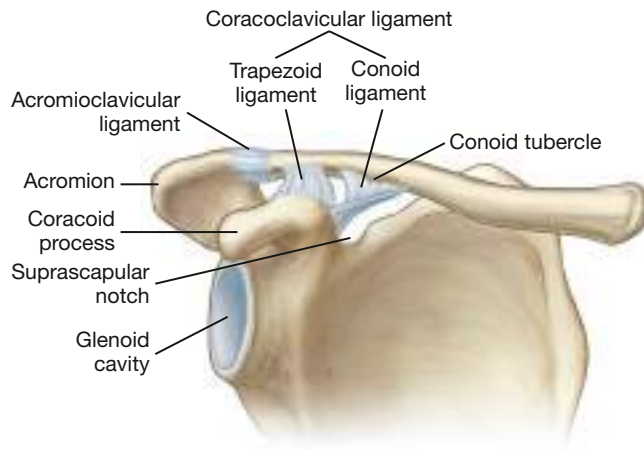


Fig. 7.12 Right acromioclavicular joint.

Imaging app

Visualizing the acromioclavicular joint

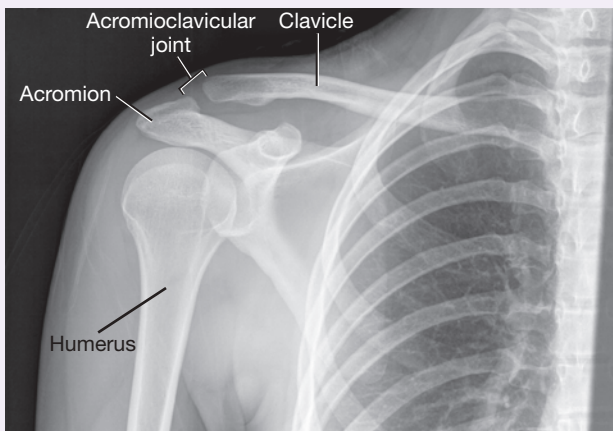


Fig. 7.13 Radiograph of a normal right acromioclavicular joint (anteroposterior view).

joint capsule (Fig. 7.16). The synovial membrane is loose inferiorly. This redundant region of synovial membrane and related fibrous membrane accommodates abduction of the arm.

The synovial membrane protrudes through apertures in the fibrous membrane to form bursae, which lie between the tendons of surrounding muscles and the fibrous membrane. The most consistent of these is the **subtendinous bursa of the subscapularis** (Figs. 7.16, 7.17), which lies between the subscapularis muscle and the fibrous membrane. The synovial membrane also folds around the tendon of the long head of the biceps brachii muscle in the joint and extends along the tendon as it passes into the intertubercular sulcus (Figs. 7.16, 7.18). All these synovial

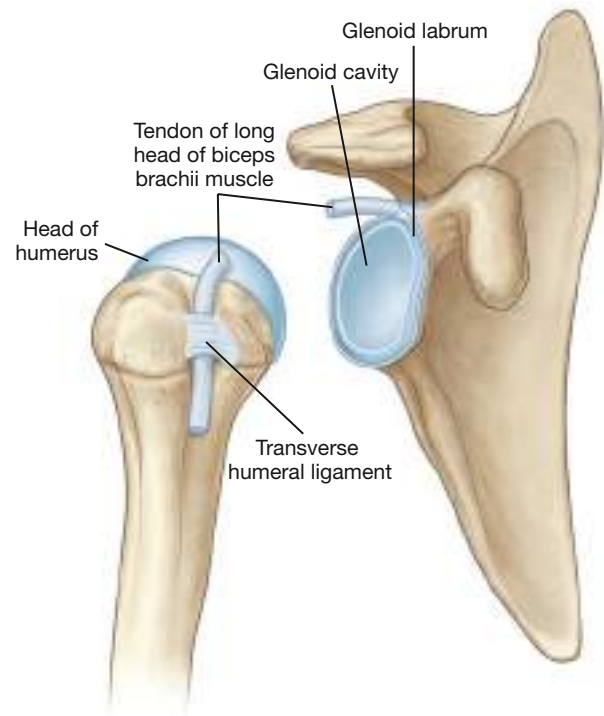


Fig. 7.14 Articular surfaces of right glenohumeral joint.

structures reduce friction between the tendons and adjacent joint capsule and bone.

In addition to bursae that communicate with the articular cavity through apertures in the fibrous membrane, other bursae are associated with the joint but are not connected to it. These occur:

- between the acromion (or deltoid muscle) and supraspinatus muscle (or joint capsule) (the **subacromial** or **subdeltoid bursa**) (Fig. 7.17);
- between the acromion and skin;
- between the coracoid process and the joint capsule; and
- in relationship to tendons of muscles around the joint (coracobrachialis, teres major, long head of triceps brachii, and latissimus dorsi muscles).

The fibrous membrane of the joint capsule attaches to the margin of the glenoid cavity outside the attachment of the glenoid labrum and the long head of the biceps brachii muscle and to the anatomical neck of the humerus (Fig. 7.18).

On the humerus, the medial attachment occurs more inferiorly than the neck and extends onto the shaft. In this region, the fibrous membrane is also loose or folded in the anatomical position. This redundant area of the fibrous membrane accommodates abduction of the arm.

Openings in the fibrous membrane provide continuity of the articular cavity with bursae that occur between the joint capsule and surrounding muscles and around the tendon of

Imaging app

Visualizing the glenohumeral joint



Fig. 7.15 Radiograph of a normal glenohumeral joint.

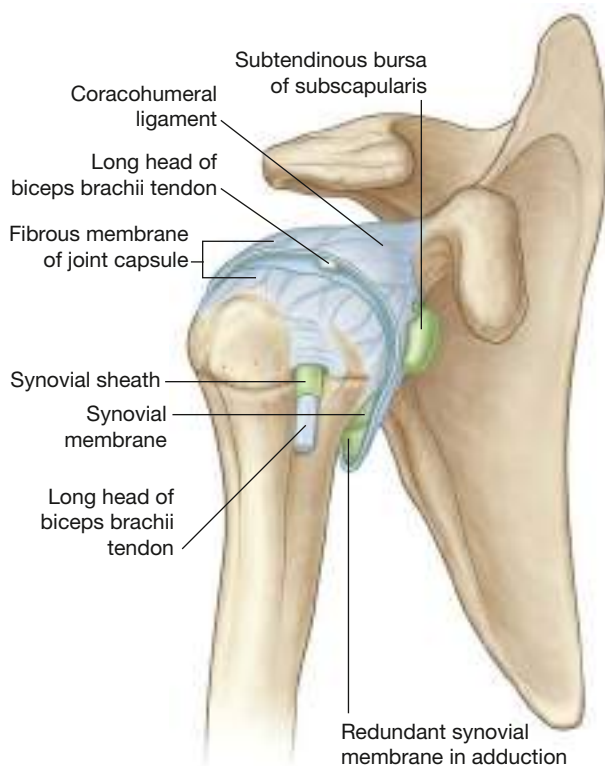


Fig. 7.16 Synovial membrane and joint capsule of right glenohumeral joint.

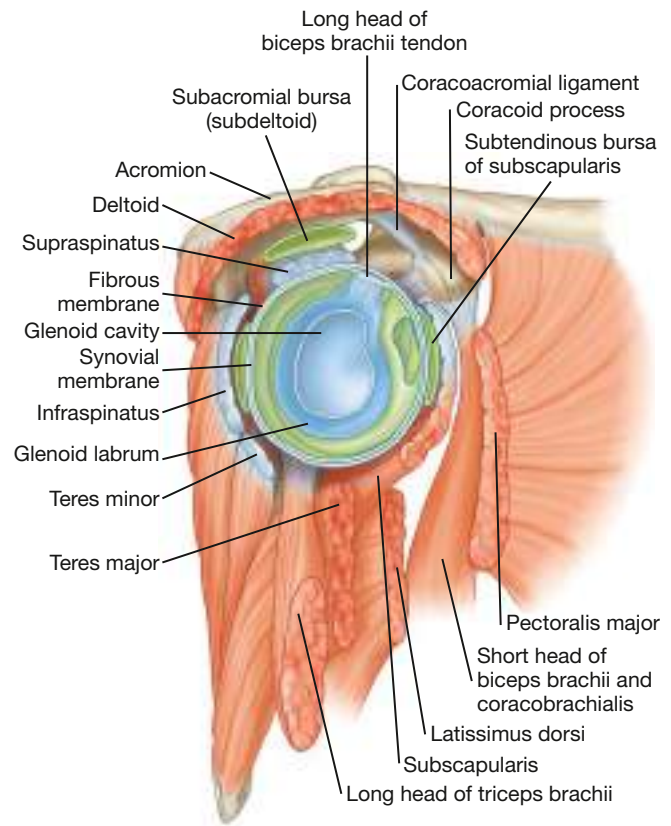


Fig. 7.17 Lateral view of right glenohumeral joint and surrounding muscles with proximal end of humerus removed.

the long head of the biceps brachii muscle in the intertubercular sulcus.

The fibrous membrane of the joint capsule is thickened (Fig. 7.18):

- anterosuperiorly in three locations to form **superior, middle, and inferior glenohumeral ligaments**, which pass from the superomedial margin of the glenoid cavity to the lesser tubercle and inferior related anatomical neck of the humerus;
- superiorly between the base of the coracoid process and the greater tubercle of the humerus (the **coracohumeral ligament**; and
- between the greater and lesser tubercles of the humerus (**transverse humeral ligament**)—this holds the tendon of the long head of the biceps brachii muscle in the intertubercular sulcus.

Joint stability is provided by surrounding muscle tendons and a skeletal arch formed superiorly by the coracoid process and acromion and the coracoacromial ligament (Figs. 7.17 and 7.19).

Tendons of the rotator cuff muscles (the supraspinatus, infraspinatus, teres minor, and subscapularis muscles) blend with the joint capsule and form a musculotendinous collar

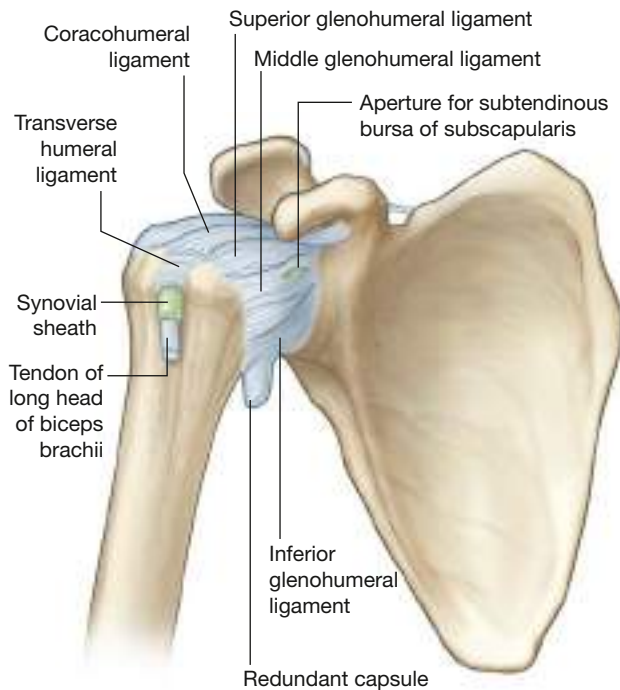


Fig. 7.18 Capsule of right glenohumeral joint.

Imaging app

Visualizing the rotator cuff muscles

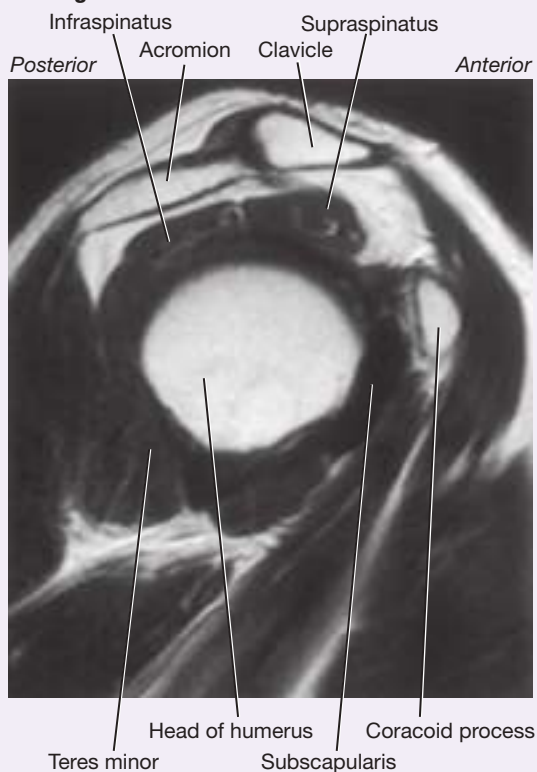


Fig. 7.19 Magnetic resonance image (T1-weighted) of a normal glenohumeral joint in the sagittal plane.

that surrounds the posterior, superior, and anterior aspects of the glenohumeral joint (see [Figs. 7.17; 7.19](#)). This cuff of muscles stabilizes and holds the head of the humerus in the glenoid cavity of the scapula without compromising the arm's flexibility and range of motion. The tendon of the long head of the biceps brachii muscle passes superiorly through the joint and restricts upward movement of the humeral head on the glenoid cavity.

Vascular supply to the glenohumeral joint is predominantly through branches of the anterior and posterior circumflex humeral and suprascapular arteries.

The glenohumeral joint is innervated by branches from the posterior cord of the brachial plexus and from the suprascapular, axillary, and lateral pectoral nerves.

Clinical app

Fractures of the clavicle and dislocations of the acromioclavicular and sternoclavicular joints

The clavicle is often fractured because of its small size and the large forces that it often transmits from the upper limb to the trunk. The typical site of fracture is the middle third ([Fig. 7.20](#)), proximal to the attachment of the coracoclavicular ligament.

The acromial end of the clavicle tends to dislocate at the acromioclavicular joint with trauma ([Fig. 7.21](#)). A minor injury tends to tear the fibrous joint capsule and ligaments of the

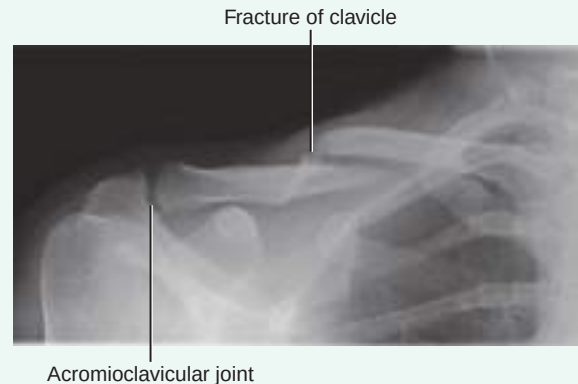


Fig. 7.20 Radiograph showing an oblique fracture of the middle third of the right clavicle.

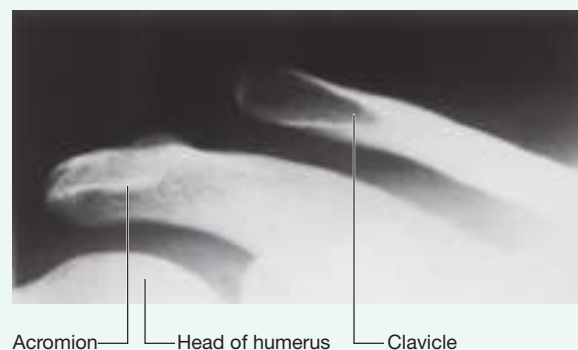


Fig. 7.21 Radiograph of dislocated right acromioclavicular joint (shoulder separation).

Clinical app—cont'd

acromioclavicular joint, resulting in acromioclavicular separation on a plain radiograph. More severe trauma will disrupt the conoid and trapezoid ligaments of the coracoclavicular ligament, which results in elevation and upward subluxation of the clavicle.

The typical injury at the medial end of the clavicle is an anterior or posterior dislocation of the sternoclavicular joint. Importantly, a posterior dislocation of the clavicle may impinge on the great vessels and compress or disrupt them.

Clinical app

Dislocations of the glenohumeral joint

The glenohumeral joint is extremely mobile, providing a wide range of movement at the expense of stability. The relatively small bony glenoid cavity, supplemented by the less robust fibrocartilaginous glenoid labrum and the ligamentous support, makes it susceptible to dislocation.

Anteroinferior dislocation (Fig. 7.22) occurs most frequently and is usually associated with an isolated traumatic incident (clinically, all anterior dislocations are anteroinferior). In some cases, the anteroinferior glenoid labrum is torn with or without a small bony fragment. Once the joint capsule and cartilage are disrupted, the joint is susceptible to further (recurrent) dislocations. When an anteroinferior dislocation occurs, the axillary nerve may be injured by direct compression of the humeral head on the nerve inferiorly as it passes through the quadrangular space. Furthermore, the “lengthening” effect of the humerus may stretch the radial nerve, which is tightly bound within the radial groove, and produce a radial nerve paralysis. Occasionally, an anteroinferior dislocation is associated with a fracture. Posterior dislocation is extremely rare.

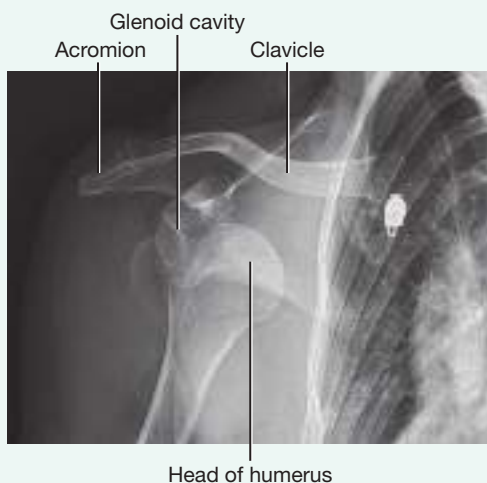


Fig. 7.22 Radiograph showing an anteroinferior dislocation of the shoulder joint with an accompanying fracture of the greater tubercle and the glenoid rim.

Clinical app

Rotator cuff disorders

The two main disorders of the rotator cuff are impingement and tendinopathy. The muscle most commonly involved is supraspinatus as it passes beneath the acromion and the acromioclavicular ligament. This space, beneath which the supraspinatus tendon passes, is of fixed dimensions. Swelling of the supraspinatus muscle, excessive fluid within the subacromial/subdeltoid bursa, or subacromial bony spurs may produce significant impingement when the arm is abducted.

The blood supply to the supraspinatus tendon is relatively poor. Repeated trauma in certain circumstances makes the tendon susceptible to degenerative change, which may result in calcium deposition, producing extreme pain.

When the supraspinatus tendon has undergone significant degenerative change, it is further susceptible to trauma and partial- or full-thickness tears may develop (Fig. 7.23). These tears are most common in older patients and may result in considerable difficulty in carrying out normal activities of daily living such as combing hair. However, complete tears may be entirely asymptomatic.

Torn supraspinatus tendon

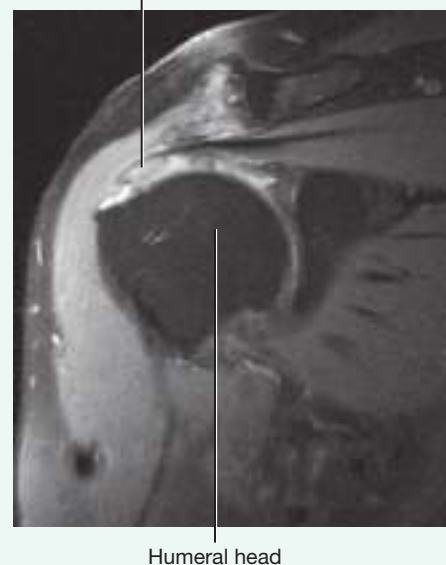


Fig. 7.23 Magnetic resonance image of a full-thickness tear of the supraspinatus tendon as it inserts onto the greater tubercle of the humerus.

Muscles

The two most superficial muscles of the shoulder are the **trapezius** and **deltoid** muscles (Table 7.1, Fig. 7.24). Together, they provide the characteristic contour of the shoulder:

- The trapezius attaches the scapula and clavicle to the trunk.
- The deltoid attaches the scapula and clavicle to the humerus.



Table 7.1 Muscles of the shoulder (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Trapezius	Superior nuchal line, external occipital protuberance, medial margin of the ligamentum nuchae, spinous processes of CVII to TXII and the related supraspinous ligaments	Superior edge of the crest of the spine of the scapula, acromion, posterior border of lateral one-third of clavicle	Motor accessory nerve Cranial nerve [XI]. Sensory (proprioception) anterior rami of C3 and C4	Powerful elevator of the scapula; rotates the scapula during abduction of humerus above horizontal; middle fibers retract scapula; lower fibers depress scapula
Deltoid	Inferior edge of the crest of the spine of the scapula, lateral margin of the acromion, anterior border of lateral one-third of clavicle	Deltoid tuberosity of humerus	Axillary nerve [C5 , C6]	Major abductor of arm; clavicular fibers assist in flexing the arm; posterior fibers assist in extending the arm
Levator scapulae	Transverse processes of C1 and CII vertebrae and posterior tubercles of transverse processes of CIII and CIV vertebrae	Posterior surface of medial border of scapula from superior angle to root of spine of the scapula	Branches directly from anterior rami of C3 and C4 spinal nerves and by branches [C5] from the dorsal scapular nerve	Elevates the scapula
Rhomboid minor	Lower end of ligamentum nuchae and spinous processes of CVII and TI vertebrae	Posterior surface of medial border of scapula at the root of the spine of the scapula	Dorsal scapular nerve [C4 , C5]	Elevates and retracts the scapula
Rhomboid major	Spinous processes of TII-TV vertebrae and intervening supraspinous ligaments	Posterior surface of medial border of scapula from the root of the spine of the scapula to the inferior angle	Dorsal scapular nerve [C4 , C5]	Elevates and retracts the scapula

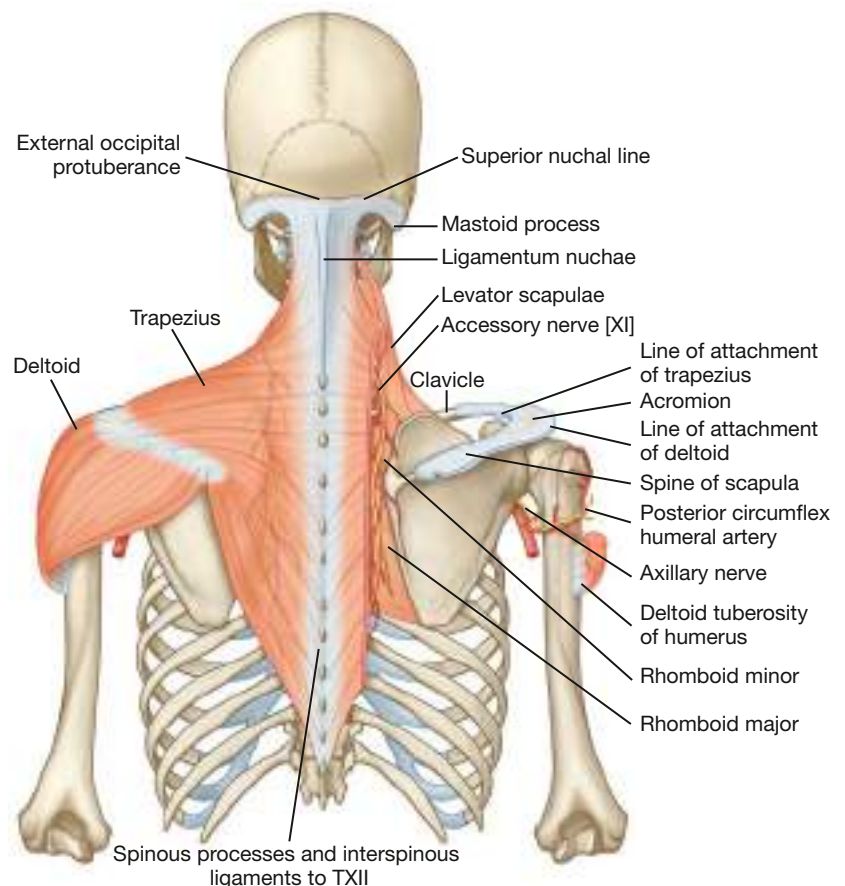


Fig. 7.24 Attachment and neurovascular supply of the trapezius and deltoid muscles.

Table 7.2 Muscles of the posterior scapular region (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Supraspinatus	Medial two-thirds of the supraspinous fossa of the scapula and the deep fascia that covers the muscle	Most superior facet on the greater tubercle of the humerus	Suprascapular nerve [C5 , C6]	Rotator cuff muscle ; participates in abduction of the glenohumeral joint; stabilization of glenohumeral joint
Infraspinatus	Medial two-thirds of the infraspinous fossa of the scapula and the deep fascia that covers the muscle	Middle facet on posterior surface of the greater tubercle of the humerus	Suprascapular nerve [C5 , C6]	Rotator cuff muscle ; lateral rotation of arm at the glenohumeral joint; stabilization of glenohumeral joint
Teres minor	Upper two-thirds of a flattened strip of bone on the posterior surface of the scapula immediately adjacent to the lateral border of the scapula	Inferior facet on the posterior surface of the greater tubercle of the humerus	Axillary nerve [C5 , C6]	Rotator cuff muscle ; lateral rotation of arm at the glenohumeral joint; stabilization of glenohumeral joint
Teres major	Elongate oval area on the posterior surface of the inferior angle of the scapula	Medial lip of the intertubercular sulcus on the anterior surface of the humerus	Inferior subscapular nerve [C5 , C6 , C7]	Medial rotation and extension of the arm at the glenohumeral joint; stabilization of glenohumeral joint
Long head of triceps brachii	Infraglenoid tubercle on scapula	Common tendon of insertion with medial and lateral heads on the olecranon process of ulna	Radial nerve [C6 , C7 , C8]	Extension of the forearm at the elbow joint; accessory adductor and extensor of the arm at the glenohumeral joint

Both the trapezius and deltoid are attached to opposing surfaces and margins of the spine of the scapula, the acromion, and the clavicle, and these structures can be palpated between the attachments of trapezius and deltoid.

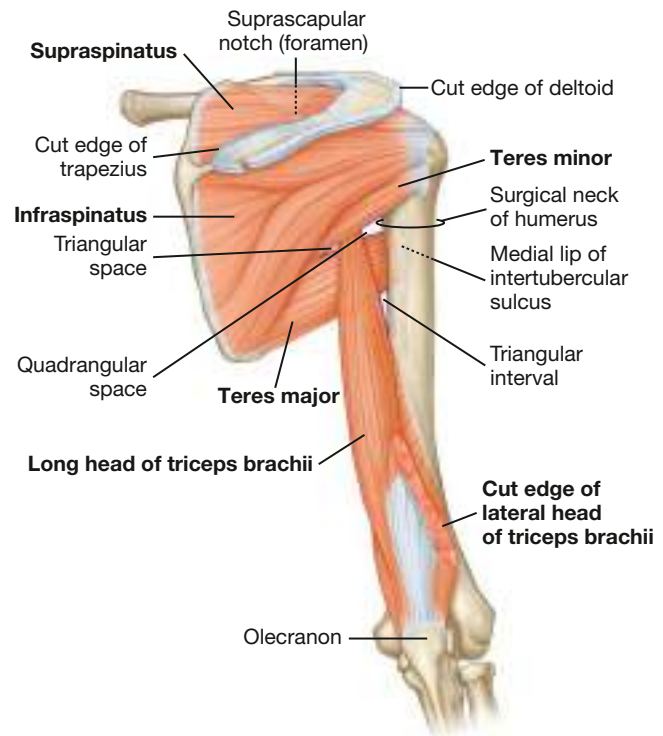
Deep to the trapezius the scapula is attached to the vertebral column by three muscles—the **levator scapulae**, **rhomboid minor**, and **rhomboid major** (Table 7.1, Fig. 7.24). These three muscles work with the trapezius (and with muscles found anteriorly) to position the scapula on the trunk.

POSTERIOR SCAPULAR REGION

The posterior scapular region occupies the posterior aspect of the scapula and is located deep to the trapezius and deltoid muscles. It contains four muscles that pass between the scapula and proximal end of the humerus: the **supraspinatus**, **infraspinatus**, **teres minor**, and **teres major** muscles (Table 7.2, Fig. 7.25).

The posterior scapular region also contains part of one additional muscle, the **long head of the triceps brachii**, which passes between the scapula and the proximal end of the forearm (Fig. 7.25). The importance of the triceps brachii in the posterior scapular region is that its vertical course between the teres minor and teres major together with these muscles and the humerus forms spaces through which nerves and vessels pass between regions.

The supraspinatus, infraspinatus, and teres minor muscles are three of the four components of the rotator cuff, which stabilizes the glenohumeral joint. The other component is **subscapularis** that is on the anterior aspect of the scapula.

**Fig. 7.25** Right posterior scapular region.

Gateways to the posterior scapular region

Suprascapular foramen

The **suprascapular foramen** is the route through which structures pass between the base of the neck and the posterior scapular region. It is formed by the suprascapular notch of the scapula and the **superior transverse scapular**



Upper Limb

(suprascapular) ligament, which converts the notch into a foramen (Fig. 7.26).

The suprascapular nerve passes through the suprascapular foramen; the suprascapular artery and the suprascapular vein follow the same course as the nerve but normally pass immediately superior to the superior transverse scapular ligament and not through the foramen (Fig. 7.26).

Quadrangular space (from posterior)

The quadrangular space provides a passageway for nerves and vessels passing between more anterior regions (the axilla) and the posterior scapular region (Figs. 7.25, 7.26). In the posterior scapular region, its boundaries are formed by:

- the inferior margin of the teres minor,
- the surgical neck of the humerus,
- the superior margin of the teres major, and
- the lateral margin of the long head of triceps brachii.

The axillary nerve and the posterior circumflex humeral artery and vein pass through this space (Fig. 7.26).

Clinical app

Quadrangular space syndrome

Hypertrophy of the muscles around the quadrangular space or fibrosis of the muscle edges may impinge on the axillary nerve. This may produce weakness of the deltoid muscle. It may also produce atrophy of the teres minor muscle, which may affect the control that the rotator cuff muscles exert on shoulder movement.

Triangular space

The triangular space is an area of communication between the axilla and the posterior scapular region (see Fig. 7.25). When viewed from the posterior scapular region, the triangular space is formed by:

- the medial margin of the long head of triceps brachii,
- the superior margin of the teres major, and
- the inferior margin of the teres minor.

The circumflex scapular artery and vein pass through this gap (see Fig. 7.26).

Triangular interval

The triangular interval is formed by (see Fig. 7.25):

- the lateral margin of the long head of triceps brachii,
- the shaft of the humerus, and
- the inferior margin of the teres major.

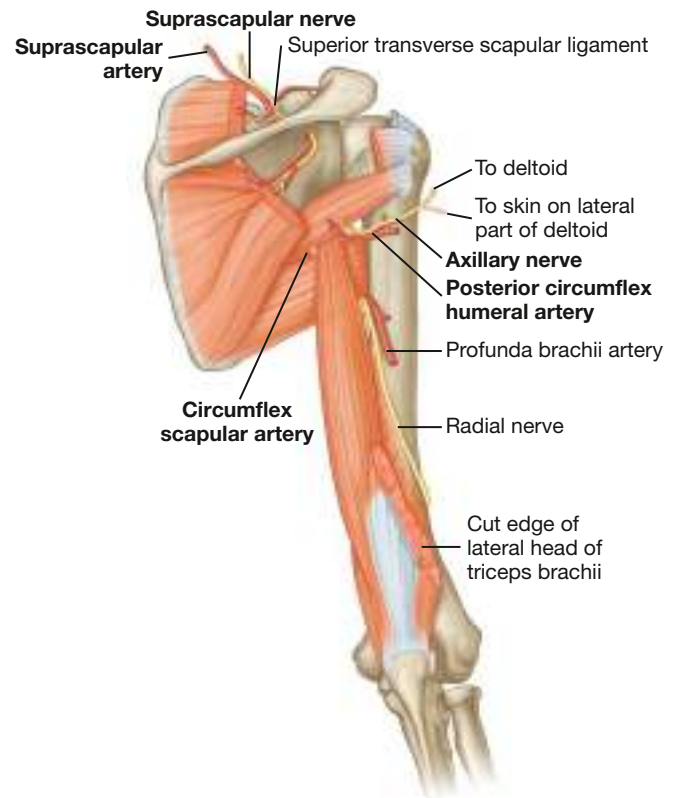


Fig. 7.26 Arteries and nerves associated with gateways in the posterior scapular region.

Because this space is below the inferior margin of the teres major, which defines the inferior boundary of the axilla, the triangular interval serves as a passageway between the anterior and posterior compartments of the arm and between the posterior compartment of the arm and the axilla. The radial nerve, the **profunda brachii artery (deep artery of arm)**, and associated veins pass through it (see Fig. 7.26).

Nerves

The two major nerves of the posterior scapular region are the suprascapular and axillary nerves (see Fig. 7.25), both of which originate from the brachial plexus in the axilla.

Suprascapular nerve

The **suprascapular nerve** originates in the base of the neck from the superior trunk of the brachial plexus. It passes posterolaterally from its origin through the suprascapular foramen to reach the posterior scapular region where it lies in the plane between bone and muscle (see Fig. 7.26).

It innervates the supraspinatus muscle, then passes through the greater scapular (spinoglenoid) notch between the root of the spine of the scapula and the glenoid cavity to terminate in and innervate the infraspinatus muscle.

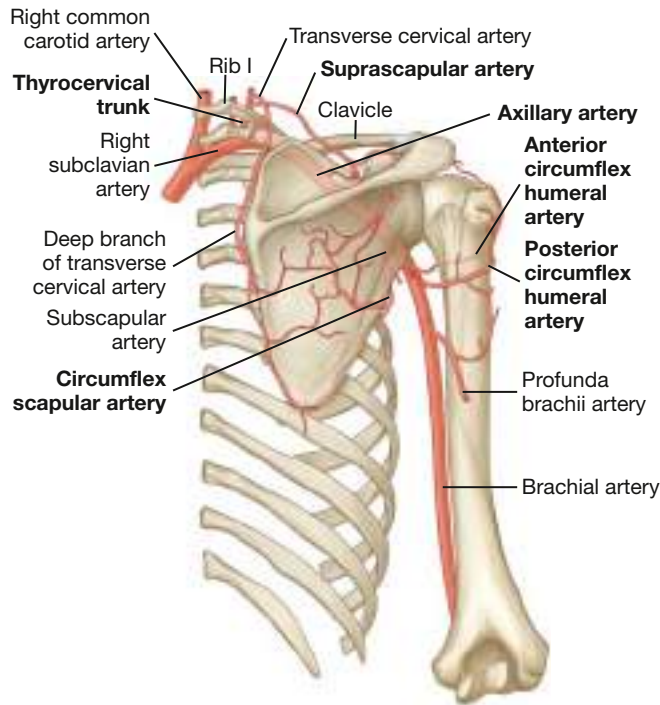


Fig. 7.27 Arterial anastomoses around the shoulder.

Generally, the suprascapular nerve has no cutaneous branches.

Axillary nerve

The **axillary nerve** originates from the posterior cord of the brachial plexus. It exits the axilla by passing through the quadrangular space in the posterior wall of the axilla and enters the posterior scapular region (see Fig. 7.26). Together with the posterior circumflex humeral artery and vein, it is directly related to the posterior surface of the surgical neck of the humerus.

The axillary nerve innervates the deltoid and teres minor muscles. In addition, it has a cutaneous branch, the superior lateral cutaneous nerve of the arm, which carries general sensation from the skin over the inferior part of the deltoid muscle.

Arteries and veins

Three major arteries are found in the posterior scapular region: the suprascapular, posterior circumflex humeral, and circumflex scapular arteries. These arteries contribute to an interconnected vascular network around the scapula (Fig. 7.27).

Suprascapular artery

The **suprascapular artery** originates in the base of the neck as a branch of the thyrocervical trunk, which, in turn, is a

major branch of the subclavian artery (Fig. 7.27). The vessel may also originate directly from the third part of the subclavian artery.

The suprascapular artery normally enters the posterior scapular region superior to the suprascapular foramen, whereas the nerve passes through the foramen. In the posterior scapular region, the vessel runs with the suprascapular nerve (see Fig. 7.26).

In addition to supplying the supraspinatus and infraspinatus muscles, the suprascapular artery contributes branches to numerous structures along its course.

Posterior circumflex humeral artery

The **posterior circumflex humeral artery** originates from the third part of the axillary artery in the axilla (Figs. 7.26, 7.27).

The posterior circumflex humeral artery and axillary nerve leave the axilla through the quadrangular space in the posterior wall and enter the posterior scapular region. The vessel supplies the related muscles and the glenohumeral joint.

Circumflex scapular artery

The **circumflex scapular artery** is a branch of the subscapular artery that also originates from the third part of the axillary artery in the axilla (Fig. 7.27; also see Fig. 7.26). The circumflex scapular artery leaves the axilla through the triangular space and enters the posterior scapular region, passes through the origin of the teres minor muscle, and forms anastomotic connections with other arteries in the region.

Veins

Veins in the posterior scapular region generally follow the arteries and connect with vessels in the neck, back, arm, and axilla.

AXILLA

The axilla is the gateway to the upper limb, providing an area of transition between the neck and the arm (Fig. 7.28A). Formed by the clavicle, the scapula, the upper thoracic wall, the humerus, and related muscles, the axilla is an irregularly shaped pyramidal space with (Fig. 7.28A,B):

- four sides,
- an inlet, and
- a floor (base).

The axillary inlet is continuous superiorly with the neck, and the lateral part of the floor opens into the arm.

All major structures passing into and out of the upper limb pass through the axilla (Fig. 7.28C). Apertures formed

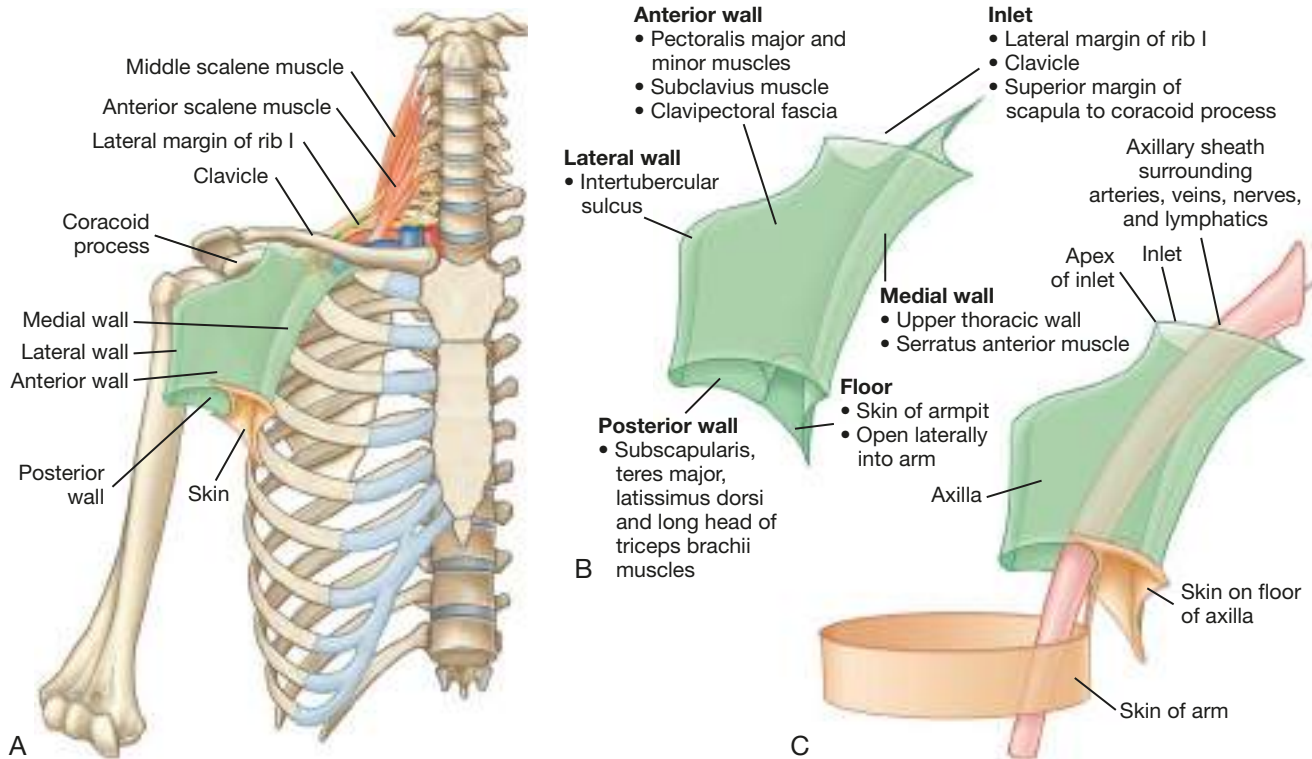


Fig. 7.28 Axilla. **A.** Walls and transition between neck and arm. **B.** Boundaries. **C.** Continuity with the arm.

between muscles in the anterior and posterior walls enable structures to pass between the axilla and immediately adjacent regions (the posterior scapular, pectoral, and deltoid regions).

Axillary inlet

The axillary inlet is oriented in the horizontal plane and is somewhat triangular with its apex directed laterally (Fig. 7.28). The margins of the inlet are completely formed by bone:

- The medial margin is the lateral border of rib I.
- The anterior margin is the posterior surface of the clavicle.
- The posterior margin is the superior border of the scapula up to the coracoid process.

The apex of the triangularly shaped axillary inlet is lateral in position and is formed by the medial aspect of the coracoid process.

Major vessels and nerves pass between the neck and the axilla by crossing over the lateral border of rib I and through the axillary inlet (Fig. 7.28A).

The subclavian artery, the major blood vessel supplying the upper limb, becomes the axillary artery as it crosses the lateral margin of rib I and enters the axilla. Similarly, the

axillary vein becomes the subclavian vein as it passes over the lateral margin of rib I and leaves the axilla to enter the neck.

At the axillary inlet, the axillary vein is anterior to the axillary artery, which, in turn, is anterior to the trunks of the brachial plexus (Fig. 7.28A).

The inferior trunk (lower trunk) of the brachial plexus lies directly on rib I in the neck as does the subclavian artery and vein. As they pass over rib I, the vein and artery are separated by the insertion of the anterior scalene muscle (Fig. 7.28A).

Anterior wall

The anterior wall of the axilla is formed by the lateral part of the **pectoralis major muscle**, the underlying **pectoralis minor** and **subclavius muscles**, and the **clavipectoral fascia** (Table 7.3, Figs. 7.28B, 7.29).

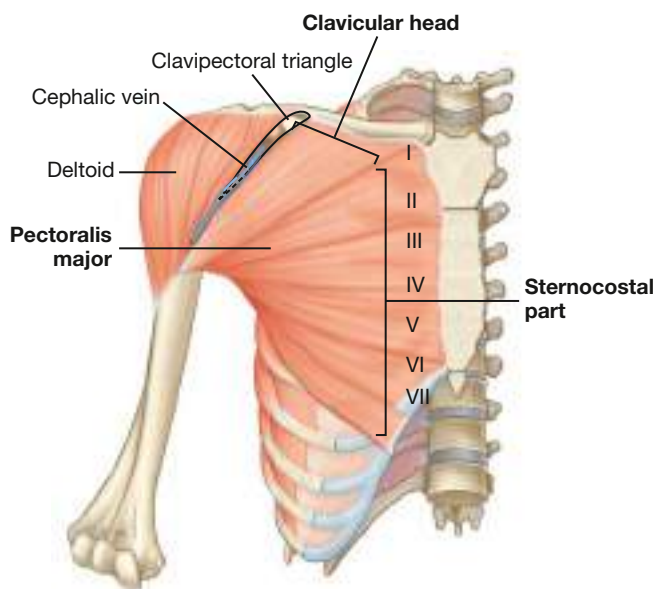
Clavipectoral fascia

The clavipectoral fascia is a thick sheet of connective tissue that connects the clavicle to the floor of the axilla (Fig. 7.30). It encloses the subclavius and pectoralis minor muscles and spans the gap between them.

Structures travel between the axilla and the anterior wall of the axilla by passing through the clavipectoral fascia

Table 7.3 Muscles of the anterior wall of the axilla (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Pectoralis major	Clavicular head—anterior surface of medial half of clavicle; sternocostal head—anterior surface of sternum; first seven costal cartilages; sternal end of sixth rib; aponeurosis of external oblique	Lateral lip of intertubercular sulcus of humerus	Medial and lateral pectoral nerves; clavicular head [C5 , C6]; sternocostal head [C6, C7 , C8, T1]	Flexion, adduction, and medial rotation of arm at glenohumeral joint; clavicular head—flexion of extended arm; sternocostal head—extension of flexed arm
Subclavius	First rib at junction between rib and costal cartilage	Groove on inferior surface of middle one-third of clavicle	Nerve to subclavius [C5 , C6]	Pulls tip of shoulder down; pulls clavicle medially to stabilize sternoclavicular joint
Pectoralis minor	Anterior surfaces and superior borders of ribs III to V; and from deep fascia overlying the related intercostal spaces	Coracoid process of scapula (medial border and upper surface)	Medial pectoral nerve (with a contribution from lateral pectoral nerve) [C5, C6, C7 , C8, T1]	Pulls tip of shoulder down; protracts scapula

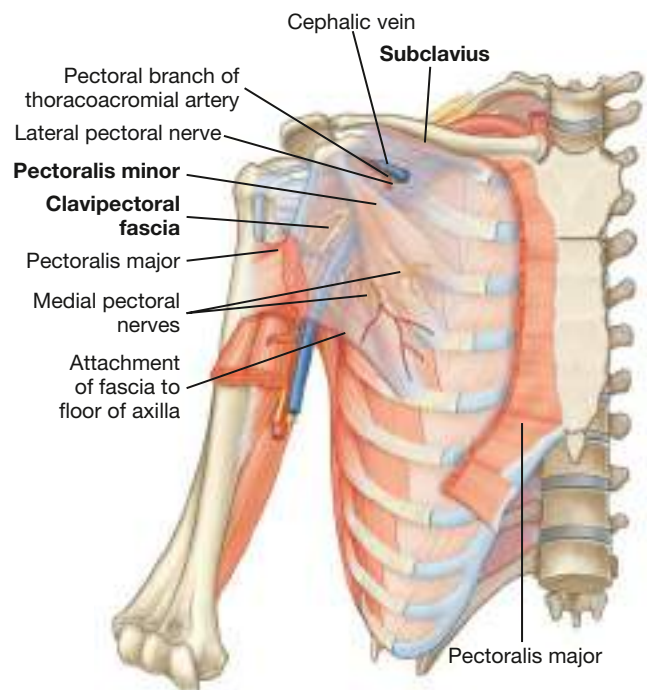
**Fig. 7.29** Pectoralis major muscle.

either between the pectoralis minor and subclavius muscles or inferior to the pectoralis minor muscle.

Important structures that pass between the subclavius and pectoralis minor muscles include the cephalic vein, the thoracoacromial artery, and the lateral pectoral nerve.

The lateral thoracic artery leaves the axilla by passing through the fascia inferior to the pectoralis minor muscle.

The medial pectoral nerve leaves the axilla by penetrating directly through the pectoralis minor muscle to supply this muscle and to reach the pectoralis major muscle. Occasionally, branches of the medial pectoral nerve pass around the lower margin of the pectoralis minor to reach and innervate the overlying pectoralis major muscle.

**Fig. 7.30** Pectoralis minor and subclavius muscles and clavipectoral fascia.

Medial wall

The medial wall of the axilla consists of the upper thoracic wall (the ribs and related intercostal tissues) and the **serratus anterior muscle** (Table 7.4, Fig. 7.31; see Fig. 7.28B).

The only major structure that passes directly through the medial wall and into the axilla is the **intercostobrachial nerve** (Fig. 7.31C). This nerve is the lateral cutaneous branch of the second intercostal nerve (anterior ramus of T2). It communicates with a branch of the brachial plexus (the medial cutaneous nerve of the arm) in the axilla and supplies skin on the upper posteromedial side of the arm, which is part of the T2 dermatome.



Table 7.4 Muscles of the medial wall of the axilla (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Serratus anterior	Lateral surfaces of upper 8-9 ribs and deep fascia overlying the related intercostal spaces	Costal surface of medial border of scapula	Long thoracic nerve [C5 , C6 , C7]	Protraction and rotation of the scapula; keeps medial border and inferior angle of scapula opposed to thoracic wall

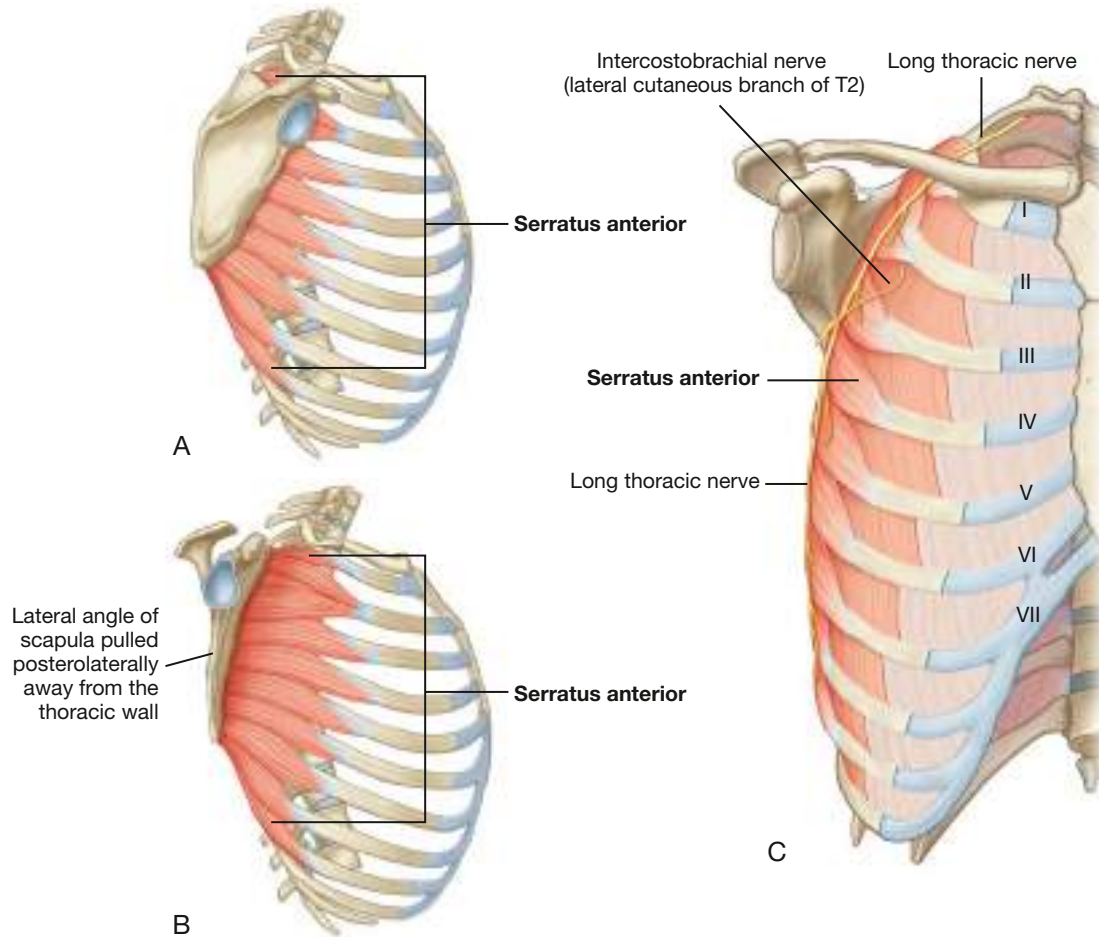


Fig. 7.31 Medial wall of the axilla. **A.** Lateral view. **B.** Lateral view with lateral angle of scapula retracted posteriorly. **C.** Anterior view.

Clinical app

“Winging” of the scapula

Because the long thoracic nerve passes down the lateral thoracic wall on the external surface of the serratus anterior muscle just deep to skin and subcutaneous fascia, it is vulnerable to damage (see Fig. 7.31C). Loss of function of this muscle causes the medial border and, particularly, the inferior angle of the scapula to elevate away from the thoracic wall, resulting in characteristic “winging” of the scapula on pushing forward with the arm. Furthermore, normal elevation of the arm is no longer possible.

Lateral wall

The lateral wall of the axilla is narrow and formed entirely by the **intertubercular sulcus** of the humerus (Fig. 7.32). The pectoralis major muscle of the anterior wall attaches to the lateral lip of the intertubercular sulcus. The latissimus dorsi and teres major muscles of the posterior wall attach to the floor and medial lip of the intertubercular sulcus, respectively (Table 7.5, Fig. 7.32).

Posterior wall

The posterior wall of the axilla is complex (Table 7.5, Figs. 7.28B, 7.33). Its bone framework is formed by the costal surface of the scapula. Muscles of the wall are:

Table 7.5 Muscles of the lateral and posterior wall of the axilla (spinal segments indicated in **bold** are the major segments innervating the muscle; spinal segments enclosed in parentheses do not consistently innervate the muscle)

Muscle	Origin	Insertion	Innervation	Function
Subscapularis	Medial two-thirds of subscapular fossa	Lesser tubercle of humerus	Upper and lower subscapular nerves [C5, C6 , (C7)]	Rotator cuff muscle ; medial rotation of the arm at the glenohumeral joint
Teres major	Elongate oval area on the posterior surface of the inferior angle of the scapula	Medial lip of the intertubercular sulcus on the anterior surface of the humerus	Lower subscapular nerve [C5, C6 , C7]	Medial rotation and extension of the arm at the glenohumeral joint
Latissimus dorsi	Spinous processes of lower six thoracic vertebrae and related interspinous ligaments; via the thoracolumbar fascia to the spinous processes of the lumbar vertebrae, related interspinous ligaments, and iliac crest; lower 3-4 ribs	Floor of intertubercular sulcus	Thoracodorsal nerve [C6, C7, C8]	Adduction, medial rotation, and extension of the arm at the glenohumeral joint
Long head of triceps brachii	Infraglenoid tubercle on scapula	Common tendon of insertion with medial and lateral heads on the olecranon process of ulna	Radial nerve [C6, C7 , C8]	Extension of the forearm at the elbow joint; accessory adductor and extensor of the arm at the glenohumeral joint



Fig. 7.32 Lateral wall of the axilla (anterior view).

- the **subscapularis** muscle (associated with the costal surface of the scapula),
- the distal parts of the **latissimus dorsi** and **teres major** muscles (which pass into the wall from the back and posterior scapular region), and
- the proximal part of the long head of the **triceps brachii** muscle (which passes vertically down the wall and into the arm).

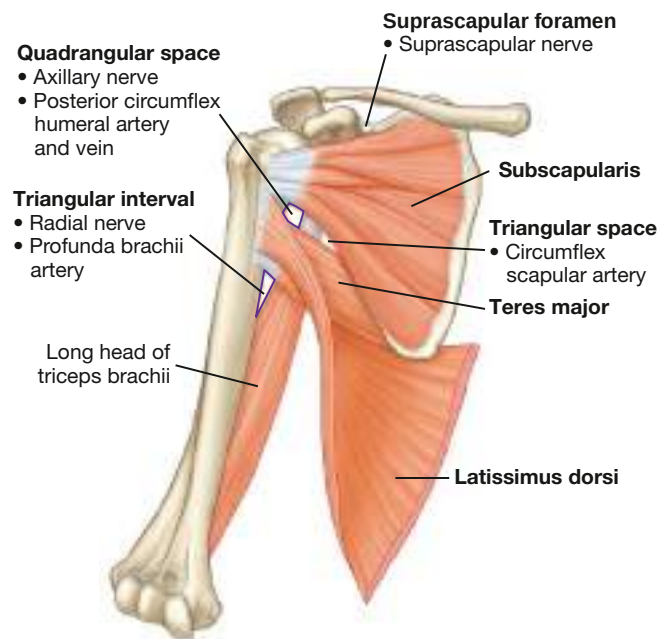


Fig. 7.33 Posterior wall of the axilla (anterior view).

Gaps between the muscles of the posterior wall form apertures through which structures pass between the axilla, posterior scapular region, and posterior compartment of the arm (**Fig. 7.33**).

Together with three muscles of the posterior scapular region (the supraspinatus, infraspinatus, and teres minor muscles), the subscapularis is a member of the rotator cuff muscles, which stabilize the glenohumeral joint.

The **long head of the triceps brachii** muscle passes vertically through the posterior wall of the axilla and, together with surrounding muscles and adjacent bones, results in the



Upper Limb

formation of three apertures through which major structures pass through the posterior wall (Fig. 7.33):

- the quadrangular space,
- the triangular space, and
- the triangular interval.

Gateways in the posterior wall

(See also “Gateways to the posterior scapular region,” p. 379, and Fig. 7.25.)

Quadrangular space

The quadrangular space provides a passageway for nerves and vessels passing between the axilla and the more posterior scapular and deltoid regions (Fig. 7.33). When viewed anteriorly, its boundaries are formed by:

- the inferior margin of the subscapularis muscle;
- the surgical neck of the humerus;
- the superior margin of the teres major muscle; and
- the lateral margin of the long head of the triceps brachii muscle.

Passing through the quadrangular space are the axillary nerve and the posterior circumflex humeral artery and vein (see Fig. 7.26).

Triangular space

The **triangular space** is an area of communication between the axilla and the posterior scapular region (Fig. 7.33). When viewed anteriorly, it is formed by:

- the medial margin of the long head of the triceps brachii muscle,
- the superior margin of the teres major muscle, and
- the inferior margin of the subscapularis muscle.

The circumflex scapular artery and vein pass into this space (see Fig. 7.26).

Triangular interval

This triangular interval is formed by (Fig. 7.33):

- the lateral margin of the long head of the triceps brachii muscle,
- the shaft of the humerus, and
- the inferior margin of the teres major muscle.

The radial nerve passes out of the axilla traveling through this interval to reach the posterior compartment of the arm (see Fig. 7.26).

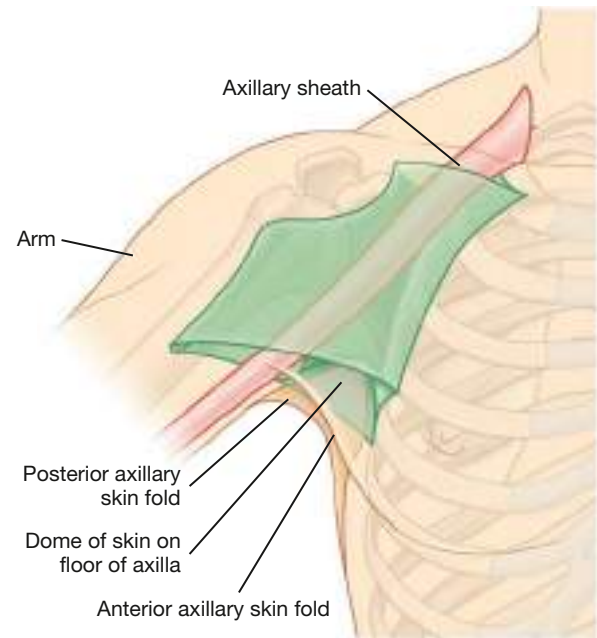


Fig. 7.34 Floor of the axilla.

Floor

The floor of the axilla (Fig. 7.34; also see Fig 7.28B) is formed by fascia and a dome of skin that spans the distance between the inferior margins of the walls. It is supported by the clavipectoral fascia.

Inferiorly, structures pass into and out of the axilla immediately lateral to the floor where the anterior and posterior walls of the axilla converge and where the axilla is continuous with the anterior compartment of the arm.

Contents of the axilla

Passing through the axilla are the major vessels, nerves, and lymphatics of the upper limb. The space also contains the proximal parts of two muscles (**biceps brachii** and **coracobrachialis muscles**; Table 7.6) of the arm, the axillary process of the breast, and collections of lymph nodes, which drain the upper limb and chest wall.

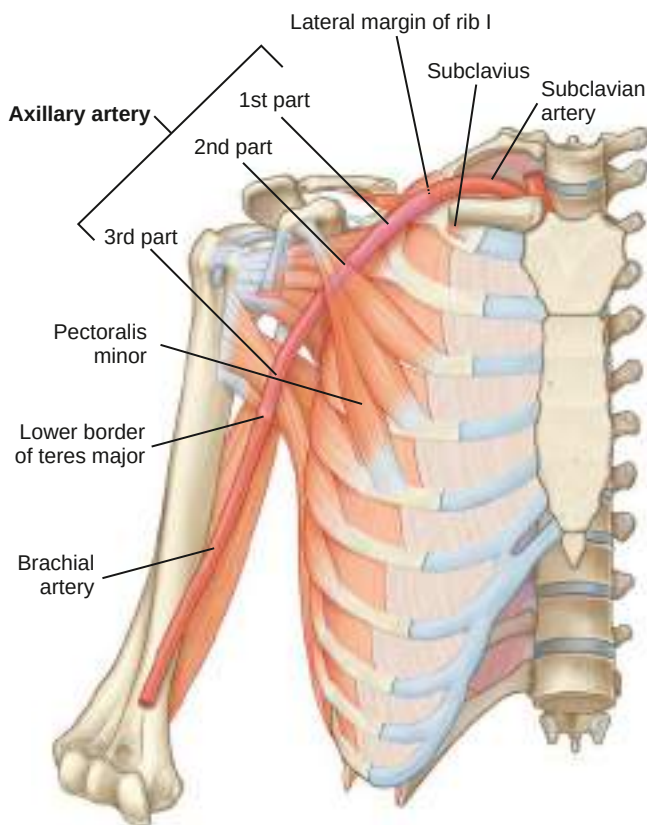
Axillary artery

The axillary artery supplies the walls of the axilla and related regions and continues as the major blood supply to the more distal parts of the upper limb (Fig. 7.35).

The subclavian artery in the neck becomes the axillary artery at the lateral margin of rib I and passes through the axilla, becoming the brachial artery at the inferior margin of the teres major muscle.

Table 7.6 Muscles having parts that pass through the axilla (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Biceps brachii	Long head—supraglenoid tubercle of scapula; short head—apex of coracoid process	Radial tuberosity	Musculocutaneous nerve [C5, C6]	Powerful flexor of the forearm at the elbow joint and supinator of the forearm; accessory flexor of the arm at the glenohumeral joint
Coracobrachialis	Apex of coracoid process	Linear roughening on mid-shaft of humerus on medial side	Musculocutaneous nerve [C5, C6, C7]	Flexor of the arm at the glenohumeral joint; adducts arm

**Fig. 7.35** Contents of the axilla: the axillary artery.

The axillary artery is separated into three parts by the pectoralis minor muscle, which crosses anteriorly to the vessel (Fig. 7.35):

- The first part is proximal to pectoralis minor.
- The second part is posterior to pectoralis minor.
- The third part is distal to pectoralis minor.

Generally, six branches arise from the axillary artery (Fig. 7.36):

- One branch, the **superior thoracic artery**, originates from the first part.

- Two branches, the **thoracoacromial artery** and the **lateral thoracic artery**, originate from the second part.
- Three branches, the **subscapular artery**, the **anterior circumflex humeral artery**, and the **posterior circumflex humeral artery**, originate from the third part.

Superior thoracic artery

The **superior thoracic artery** is small and originates from the anterior surface of the first part of the axillary artery (Fig. 7.36). It supplies upper regions of the medial and anterior axillary walls.

Thoracoacromial artery

The **thoracoacromial artery** is short and originates from the anterior surface of the second part of the axillary artery just posterior to the medial (superior) margin of the pectoralis minor muscle (Fig. 7.36). It curves around the superior margin of the muscle, penetrates the clavipectoral fascia, and immediately divides into four branches (the pectoral, deltoid, clavicular, and acromial branches), which supply the anterior axillary wall and related regions.

Additionally, the pectoral branch contributes vascular supply to the breast, and the deltoid branch passes into the clavipectoral triangle where it accompanies the cephalic vein and supplies adjacent structures (see Fig. 7.30).

Lateral thoracic artery

The **lateral thoracic artery** arises from the anterior surface of the second part of the axillary artery posterior to the lateral (inferior) margin of pectoralis minor (Fig. 7.36). It follows the margin of the muscle to the thoracic wall and supplies the medial and anterior walls of the axilla. In women, branches emerge from around the inferior margin of the pectoralis major muscle and contribute to the vascular supply of the breast.

Subscapular artery

The **subscapular artery** is the largest branch of the axillary artery and is the major blood supply to the posterior wall of

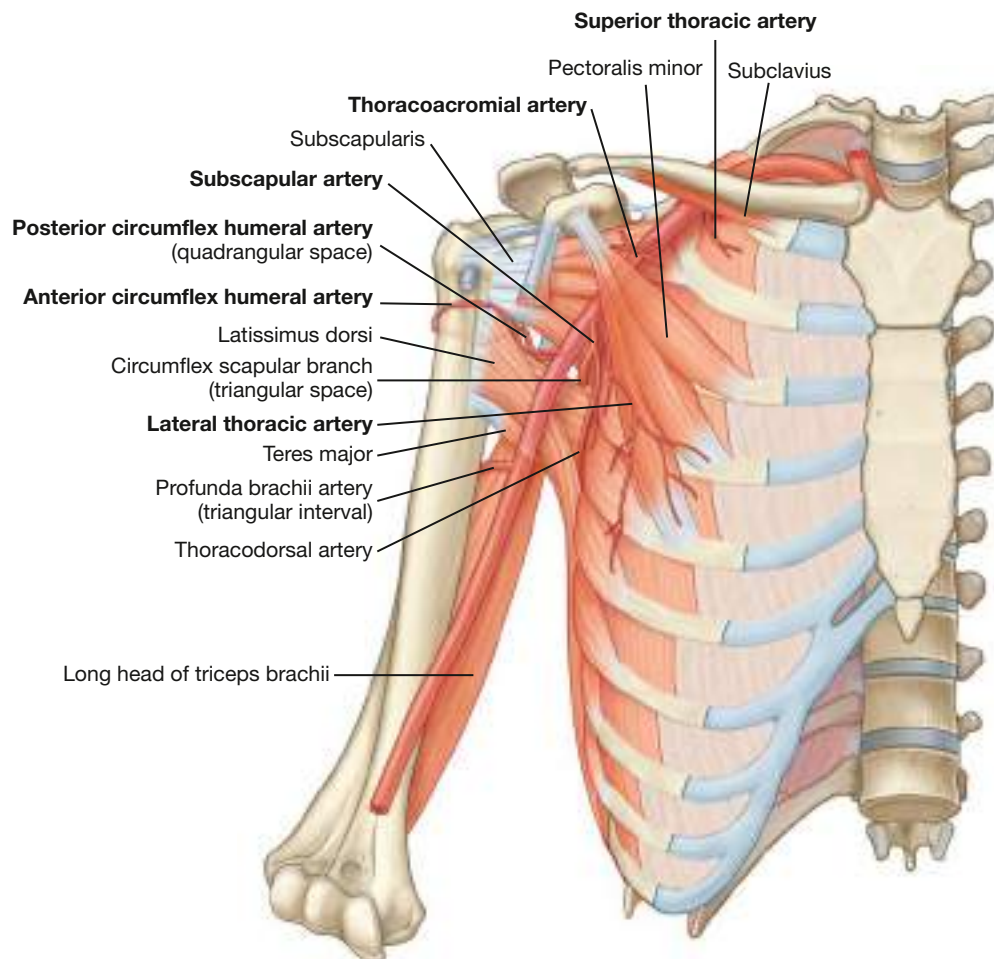


Fig. 7.36 Branches of the axillary artery.

the axilla (Fig. 7.36). It also contributes to the blood supply of the posterior scapular region.

The subscapular artery originates from the posterior surface of the third part of the axillary artery, follows the inferior margin of the subscapularis muscle for a short distance, then divides into its two terminal branches, the **circumflex scapular artery** and the **thoracodorsal artery** (Fig. 7.36).

The circumflex scapular artery passes through the triangular space between the subscapularis, teres major, and long head of the triceps muscles. Posteriorly, it passes inferior to, or pierces, the origin of the teres minor muscle to enter the infraspinous fossa. It anastomoses with the suprascapular artery and the **deep branch (dorsal scapular artery)** of the transverse cervical artery, thereby contributing to an anastomotic network of vessels around the scapula.

The thoracodorsal artery approximately follows the lateral border of the scapula to the inferior angle. It contributes to the vascular supply of the posterior and medial walls of the axilla.

Anterior circumflex humeral artery

The **anterior circumflex humeral artery** is small compared to the posterior circumflex humeral artery and originates from the lateral side of the third part of the axillary artery (Fig. 7.36). It passes anterior to the surgical neck of the humerus and anastomoses with the posterior circumflex humeral artery.

This anterior circumflex humeral artery supplies branches to surrounding tissues, which include the gleno-humeral joint and the head of the humerus.

Posterior circumflex humeral artery

The **posterior circumflex humeral artery** originates from the lateral surface of the third part of the axillary artery immediately posterior to the origin of the anterior circumflex humeral artery (Fig. 7.36). With the axillary nerve, it leaves the axilla by passing through the quadrangular space between the teres major, teres minor, and the long head of the triceps brachii muscle and the surgical neck of the humerus (see Fig. 7.26).

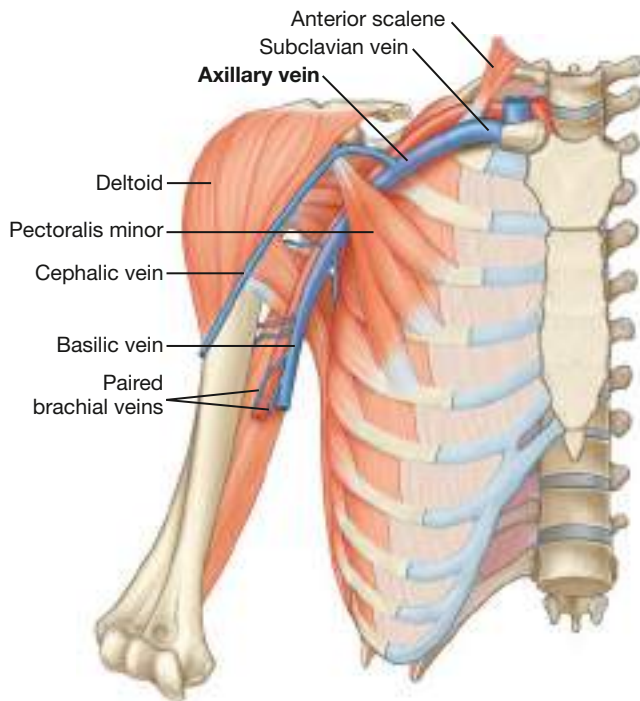


Fig. 7.37 Axillary vein.

The posterior circumflex humeral artery curves around the surgical neck of the humerus and supplies the surrounding muscles and the glenohumeral joint. It anastomoses with the anterior circumflex humeral artery, and with branches from the profunda brachii, suprascapular, and thoracoacromial arteries.

Axillary vein

The axillary vein begins at the lower margin of the teres major muscle and is the continuation of the basilic vein (Fig. 7.37), which is a superficial vein that drains the posteromedial surface of the hand and forearm and penetrates the deep fascia in the middle of the arm.

The axillary vein passes through the axilla medial and anterior to the axillary artery and becomes the subclavian vein as the vessel crosses the lateral border of rib I at the axillary inlet. Tributaries of the axillary vein generally follow the branches of the axillary artery. Other tributaries include brachial veins that follow the brachial artery and the cephalic vein (Fig. 7.37).

The cephalic vein is a superficial vein that drains the lateral and posterior parts of the hand, the forearm, and the arm. In the area of the shoulder, it passes into an inverted triangular cleft (the **clavipectoral triangle**) between the deltoid muscle, pectoralis major muscle, and the clavicle. In the superior part of the clavipectoral triangle, the cephalic vein passes deep to the clavicular head of the pectoralis major muscle and pierces the clavipectoral fascia to join the axillary vein.

Clinical app

Trauma to the arteries in and around the axilla

Fracture of rib I

As the subclavian artery passes out of the neck and into the axilla, it is fixed in position by the surrounding muscles to the superior surface of rib I. A rapid deceleration injury involving upper thoracic trauma may cause a first rib fracture, which may significantly compromise the distal part of the subclavian artery or the first part of the axillary artery. Fortunately, there are anastomotic connections between branches of the subclavian artery and the axillary artery, which form a network around the scapula and proximal end of the humerus; therefore, even with complete vessel transection, the arm is rarely rendered completely ischemic (ischemia is poor blood supply to an organ or a limb).

Anterior dislocation of the humeral head

Anterior dislocation of the humeral head may compress the axillary artery, resulting in vessel occlusion. This is unlikely to render the upper limb completely ischemic, but it may be necessary to surgically reconstruct the axillary artery to obtain pain-free function. Importantly, the axillary artery is intimately related to the brachial plexus, which also may be damaged at the time of anterior dislocation.

Clinical app

Central venous access via the subclavian/axillary vein

There are a number of routes through which central venous access may be obtained. The *subclavian route* and the *jugular route* are commonly used by clinicians. The subclavian route is a misnomer that remains the preferred term in clinical practice. In fact, most clinicians enter the first part of the axillary vein.

Brachial plexus

The brachial plexus is a somatic nerve plexus formed by the **anterior rami** of C5 to C8 and most of the anterior ramus of T1 (Fig. 7.38). It originates in the neck, passes laterally and inferiorly over rib I, and enters the axilla.

The parts of the brachial plexus, from medial to lateral, are roots, trunks, divisions, and cords. All major nerves that innervate the upper limb originate from the brachial plexus, mostly from the cords. Proximal parts of the brachial plexus are posterior to the subclavian artery in the neck, while more distal regions of the plexus surround the axillary artery.

Roots

The roots of the brachial plexus are the anterior rami of C5 to C8 and most of T1. Close to their origin, the roots receive **gray rami communicantes** from the sympathetic

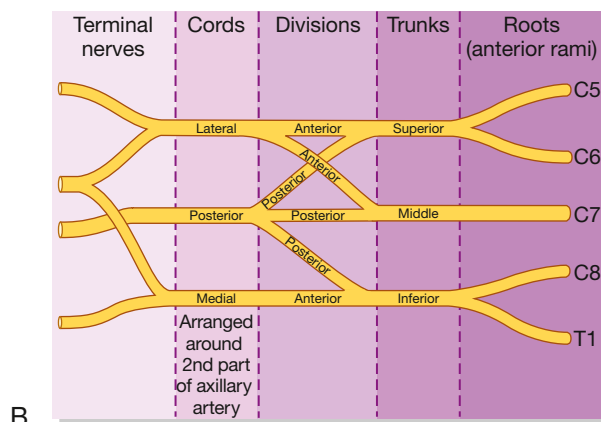
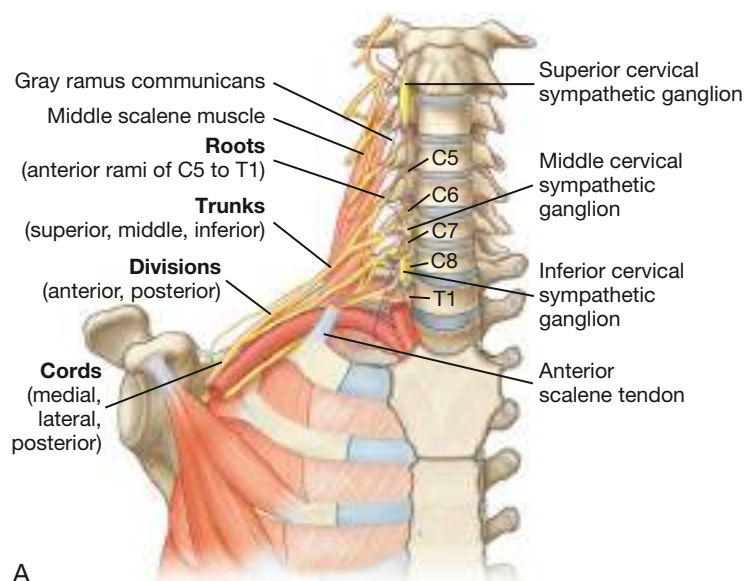


Fig. 7.38 Brachial plexus. **A.** Major components in the neck and axilla. **B.** Schematic showing parts of the brachial plexus.

trunk (Fig. 7.38). These carry postganglionic sympathetic fibers onto the roots for distribution to the periphery. The roots and trunks enter the **posterior triangle** of the neck by passing between the anterior scalene and middle scalene muscles and lie superior and posterior to the subclavian artery.

Trunks

The three trunks of the brachial plexus originate from the roots, pass laterally over rib I, and enter the axilla (Fig. 7.38):

- The **superior trunk** is formed by the union of C5 and C6 roots.
- The **middle trunk** is a continuation of the C7 root.
- The **inferior trunk** is formed by the union of the C8 and T1 roots.

The inferior trunk lies on rib I posterior to the subclavian artery; the middle and superior trunks are more superior in position.

Divisions

Each of the three trunks of the brachial plexus divides into an **anterior** and a **posterior division** (Fig. 7.38):

- The three anterior divisions form parts of the brachial plexus that ultimately give rise to peripheral nerves associated with the anterior compartments of the arm and forearm.
- The three posterior divisions combine to form parts of the brachial plexus that give rise to nerves associated with the posterior compartments.

Cords

The three cords of the brachial plexus originate from the divisions and are related to the second part of the axillary artery (Fig. 7.38):

- The **lateral cord** results from the union of the anterior divisions of the upper and middle trunks and therefore has contributions from C5 to C7; it is positioned lateral to the second part of the axillary artery;
- The **medial cord** is medial to the second part of the axillary artery and is the continuation of the anterior division of the inferior trunk; it contains contributions from C8 and T1.
- The **posterior cord** occurs posterior to the second part of the axillary artery and originates as the union of all three posterior divisions; it contains contributions from all roots of the brachial plexus (C5 to T1).

Most of the major peripheral nerves of the upper limb originate from the cords of the brachial plexus. Generally, nerves associated with the anterior compartments of the upper limb arise from the medial and lateral cords and nerves associated with the posterior compartments originate from the posterior cord.

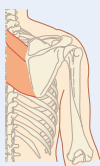
Branches (Table 7.7)

Branches of the roots

In addition to small segmental branches from C5 to C8 to muscles of the neck and a contribution of C5 to the phrenic nerve, the roots of the brachial plexus give rise to the dorsal scapular and long thoracic nerves (Figs. 7.39, 7.40).

Table 7.7 Branches of brachial plexus ([brackets] indicate that a spinal segment is a minor component of the nerve or is inconsistently present in the nerve)**Branch**

Dorsal scapular
Origin: C5 root
Spinal segment: C5



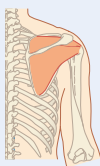
Function: motor
Rhomboid major, rhomboid minor

Long thoracic
Origin: C5 to C7 roots
Spinal segments:
C5 to C7



Function: motor
Serratus anterior

Suprascapular
Origin: Superior trunk
Spinal segments: C5, C6



Function: motor
Supraspinatus, infraspinatus

Nerve to subclavius
Origin: Superior trunk
Spinal segments: C5, C6



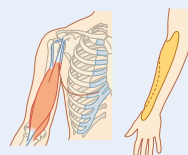
Function: motor
Subclavius

Lateral pectoral
Origin: Lateral cord
Spinal segments:
C5 to C7



Function: motor
Pectoralis major

Musculocutaneous
Origin: Lateral cord
Spinal segments:
C5 to C7



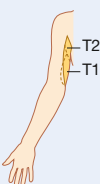
Function: motor
All muscles in the anterior compartment of the arm
Function: sensory
Skin on lateral side of forearm

Medial pectoral
Origin: Medial cord
Spinal segments: C8, T1
(also receives contributions from spinal segments C5 to C7 through a communication with the lateral pectoral nerve)



Function: motor
Pectoralis major, pectoralis minor

Medial cutaneous of arm
Origin: Medial cord
Spinal segments: C8, T1



Function: sensory
Skin on medial side of distal one-third of arm

Continued



Upper Limb

Table 7.7 Branches of brachial plexus ([brackets] indicate that a spinal segment is a minor component of the nerve or is inconsistently present in the nerve)—cont'd

Medial cutaneous of forearm
Origin: Medial cord
Spinal segments: C8, T1



Function: sensory
Skin on medial side of forearm

Median
Origin: Medial and lateral cords
Spinal segments:
[C5], C6 to T1



Function: motor
All muscles in the anterior compartment of the forearm (except flexor carpi ulnaris and medial half of flexor digitorum profundus), three thenar muscles of the thumb, and two lateral lumbrical muscles
Function: sensory
Skin over the palmar surface of the lateral three and one-half digits and over the lateral side of the palm and middle of the wrist

Ulnar
Origin: Medial cord
Spinal segments:
[C7], C8, T1



Function: motor
All intrinsic muscles of the hand (except three thenar muscles and two lateral lumbricals); also flexor carpi ulnaris and the medial half of flexor digitorum profundus in the forearm
Function: sensory
Skin over the palmar surface of the medial one and one-half digits and associated palm and wrist and skin over the dorsal surface of the medial one and one-half digits

Superior subscapular
Origin: Posterior cord
Spinal segments: C5, C6



Function: motor
Subscapularis

Thoracodorsal
Origin: Posterior cord
Spinal segments:
C6 to C8



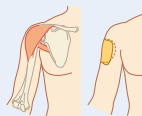
Function: motor
Latissimus dorsi

Inferior subscapular
Origin: Posterior cord
Spinal segments: C5, C6



Function: motor
Subscapularis, teres major

Axillary
Origin: Posterior cord
Spinal segments: C5, C6



Function: motor
Deltoid, teres minor
Function: sensory
Skin over upper lateral part of arm

Radial
Origin: Posterior cord
Spinal segments:
C5 to C8, [T1]



Function: motor
All muscles in the posterior compartments of arm and forearm
Function: sensory
Skin on the posterior aspects of the arm and forearm, the lower lateral surface of the arm, and the dorsal lateral surface of the hand

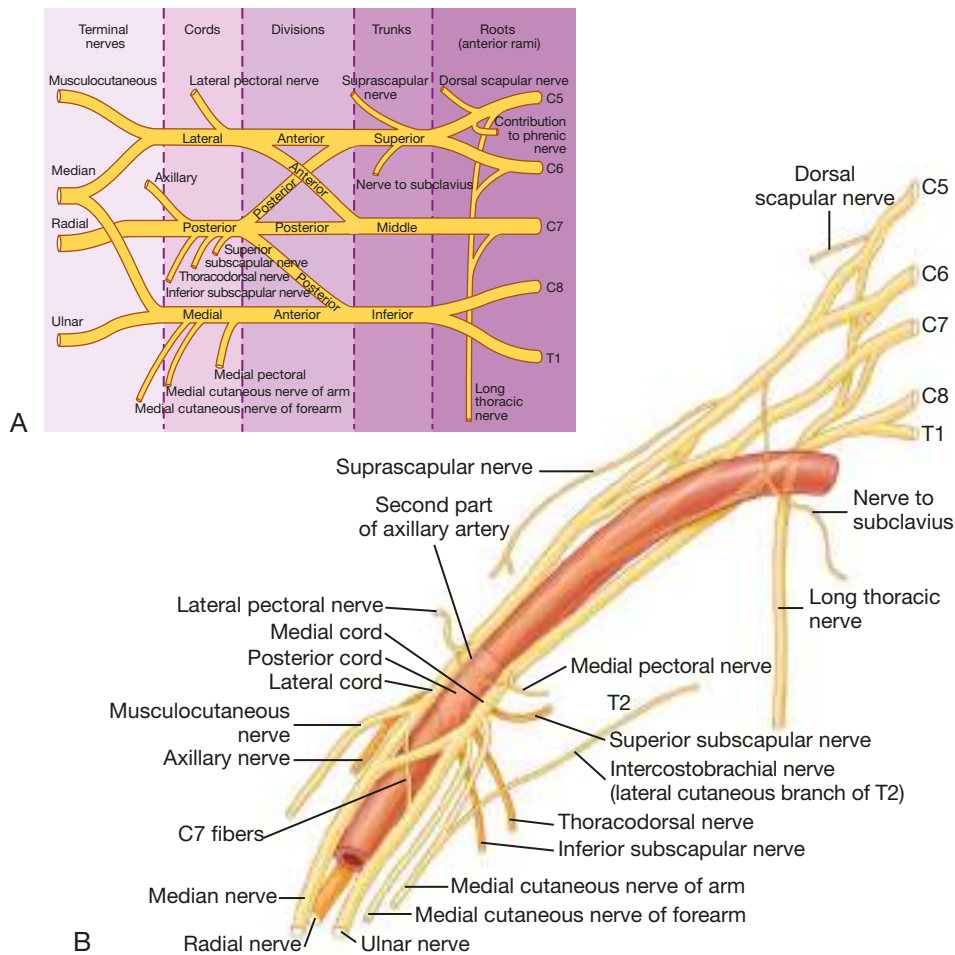


Fig. 7.39 Brachial plexus. **A.** Schematic showing branches of the brachial plexus. **B.** Relationships to the axillary artery.

The dorsal scapular nerve:

- originates from the C5 root of the brachial plexus,
- passes posteriorly, often piercing the middle scalene muscle in the neck, to reach and travel along the medial border of the scapula, and
- innervates the rhomboid major and minor muscles from their deep surfaces.

The long thoracic nerve:

- originates from the anterior rami of C5 to C7,
- passes vertically down the neck, through the axillary inlet, and down the medial wall of the axilla to supply the serratus anterior muscle, and
- lies on the superficial aspect of the serratus anterior muscle.

Clinical app

Damage to long thoracic nerve

A mastectomy (surgical removal of the breast) involves excision of the breast tissue to the pectoralis major muscle and fascia. Within the axilla, the breast tissue must be removed from the medial

Clinical app—cont'd

axillary wall. Closely applied to the medial axillary wall is the long thoracic nerve. Damage to this nerve can result in paralysis of the serratus anterior muscle, producing a characteristic “winged” scapula. This nerve also can be injured during placement of chest tubes or by trauma to the lateral body wall.

Branches of the trunks

The only branches from the trunks of the brachial plexus are two nerves that originate from the superior trunk (upper trunk): the suprascapular nerve and the nerve to the subclavius muscle (Figs. 7.39, 7.40).

The **suprascapular nerve** (C5 and C6):

- originates from the superior trunk of the brachial plexus,
- passes laterally through the posterior triangle of the neck and through the suprascapular foramen to enter the posterior scapular region,
- innervates the supraspinatus and infraspinatus muscles, and
- is accompanied in the lateral parts of the neck and in the posterior scapular region by the suprascapular artery.

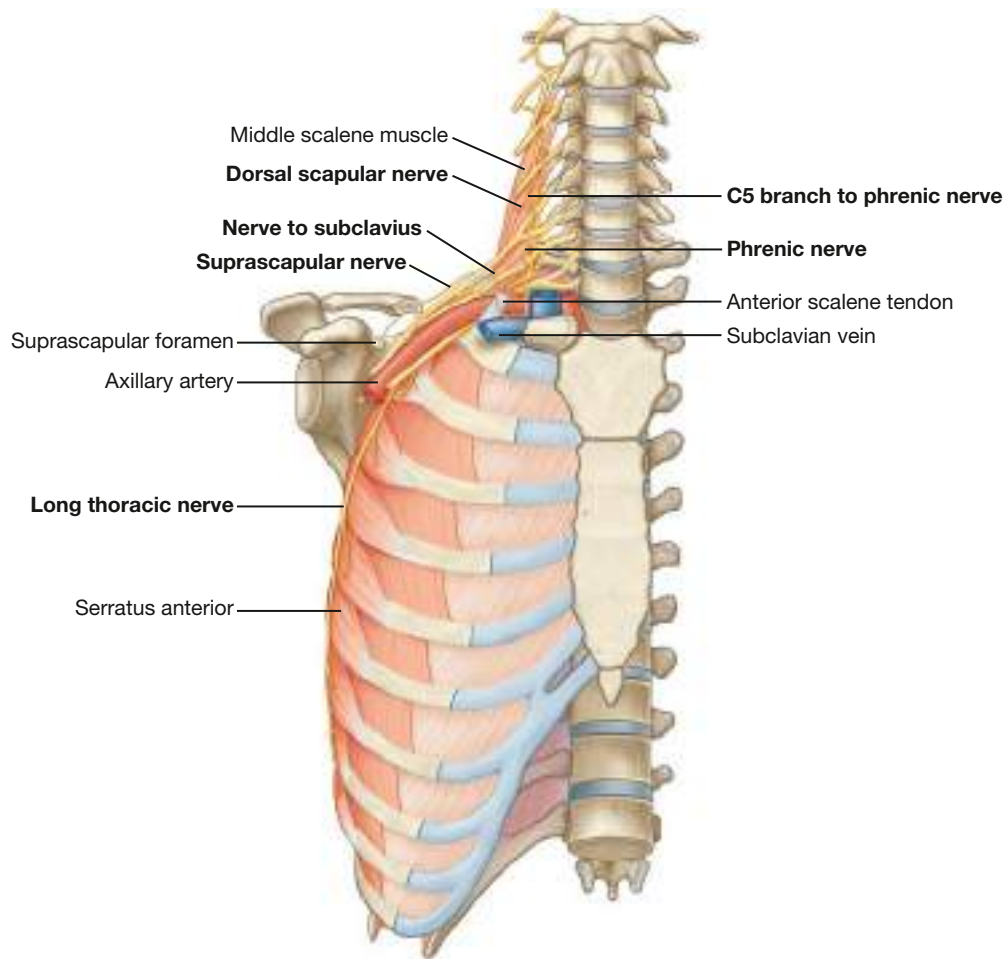


Fig. 7.40 Branches of the roots and trunks of the brachial plexus.

The **nerve to subclavius muscle** (C5 and C6) is a small nerve that:

- originates from the superior trunk of the brachial plexus,
- passes anteroinferiorly over the subclavian artery and vein, and
- innervates the subclavius muscle.

Branches of the lateral cord

Three nerves originate entirely or partly from the lateral cord (Figs. 7.39, 7.41).

The **lateral pectoral nerve** is the most proximal of the branches from the lateral cord. It passes anteriorly together with the thoracoacromial artery to penetrate the clavipectoral fascia that spans the gap between the subclavius and pectoralis minor muscles and innervates the pectoralis major muscle.

The **musculocutaneous nerve** is a large terminal branch of the lateral cord. It passes laterally to penetrate the coracobrachialis muscle, passes between the biceps brachii and brachialis muscles in the arm, and innervates all three flexor

muscles in the anterior compartment of the arm, terminating as the **lateral cutaneous nerve of forearm**.

The **lateral root of median nerve** is the largest terminal branch of the lateral cord and passes medially to join a similar branch from the medial cord to form the median nerve.

Branches of the medial cord

The medial cord has five branches (Figs. 7.39, 7.41).

The **medial pectoral nerve** is the most proximal branch. It receives a communicating branch from the lateral pectoral nerve and then passes anteriorly between the axillary artery and axillary vein. Branches of the nerve penetrate and supply the pectoralis minor muscle. Some of these branches pass through the muscle to reach and supply the pectoralis major muscle. Other branches occasionally pass around the inferior or lateral margin of the pectoralis minor muscle to reach the pectoralis major muscle.

The **medial cutaneous nerve of arm (medial brachial cutaneous nerve)** passes through the axilla and into the arm where it penetrates deep fascia and supplies skin over the medial side of the distal third of the arm. In the axilla, the

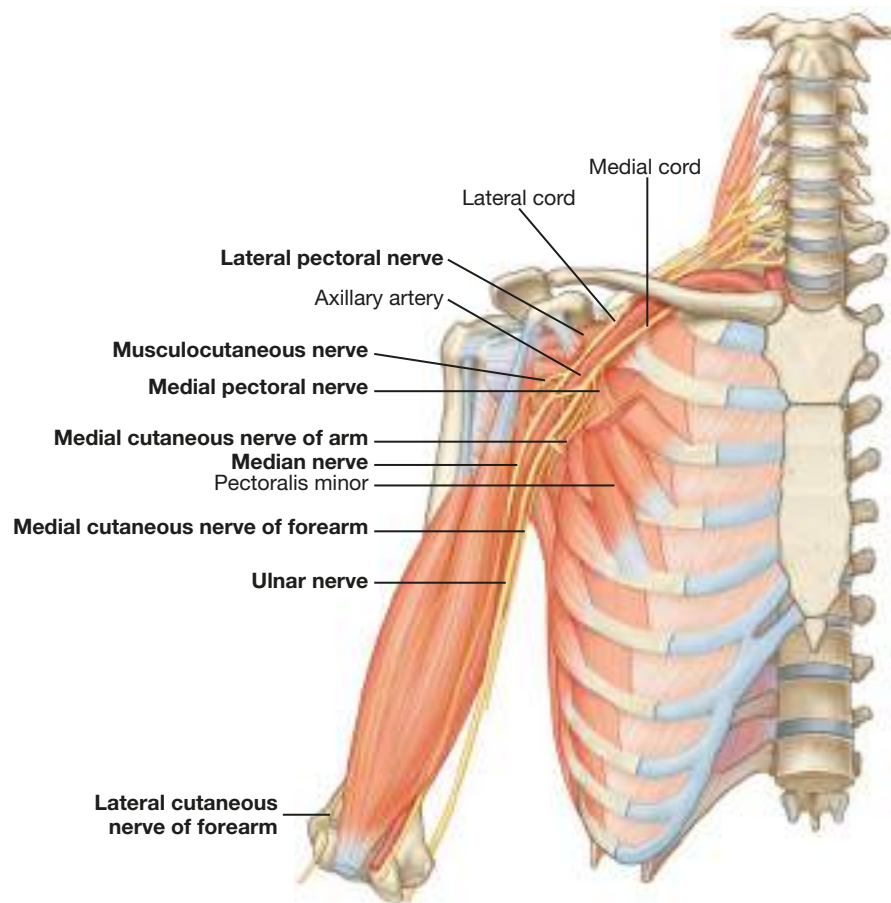


Fig. 7.41 Branches of the lateral and medial cords of the brachial plexus.

nerve communicates with the **intercostobrachial nerve** of T2. Fibers of the medial cutaneous nerve of arm innervate the upper part of the medial surface of the arm and floor of the axilla.

The **medial cutaneous nerve of forearm (medial antebrachial cutaneous nerve)** originates just distal to the origin of the medial cutaneous nerve of arm. It passes out of the axilla and into the arm where it gives off a branch to the skin over the biceps brachii muscle and then continues down the arm to penetrate the deep fascia with the basilic vein, continuing inferiorly to supply the skin over the anterior surface of the forearm. It innervates skin over the medial surface of the forearm down to the wrist.

The **medial root of median nerve** passes laterally to join with a similar root from the lateral cord to form the median nerve anterior to the third part of the axillary artery.

The **ulnar nerve** is a large terminal branch of the medial cord. However, near its origin, it often receives a communicating branch from the lateral root of the median nerve originating from the lateral cord and carrying fibers from C7 (see Fig. 7.39B). The ulnar nerve passes through the arm and forearm into the hand where it innervates all intrinsic

muscles of the hand (except for the three thenar muscles and the two lateral lumbrical muscles). On passing through the forearm, branches of the ulnar nerve innervate the flexor carpi ulnaris muscle and the medial half of the flexor digitorum profundus muscle. The ulnar nerve innervates skin over the palmar surface of the little finger, medial half of the ring finger, associated palm and wrist, and over the dorsal surface of the medial part of the hand.

Median nerve. The median nerve is formed anterior to the third part of the axillary artery by the union of lateral and medial roots originating from the lateral and medial cords of the brachial plexus (Figs. 7.39, 7.41). It passes into the arm anterior to the brachial artery and through the arm into the forearm where branches innervate most of the muscles in the anterior compartment of the forearm (except for the flexor carpi ulnaris muscle and the medial half of the flexor digitorum profundus muscle, which are innervated by the ulnar nerve).

The median nerve continues into the hand to innervate:

- the three thenar muscles associated with the thumb,
- the two lateral lumbrical muscles associated with movement of the index and middle fingers, and



Upper Limb

- the skin over the palmar surface of the lateral three and one-half digits and over the lateral side of the palm and middle of the wrist.

The musculocutaneous nerve, the lateral root of the median nerve, the median nerve, the medial root of the median nerve, and the ulnar nerve form an M over the third part of the axillary artery (Fig. 7.41). This feature, together with penetration of the coracobrachialis muscle by the musculocutaneous nerve, can be used to identify components of the brachial plexus in the axilla.

Branches of the posterior cord

Five nerves originate from the posterior cord of the brachial plexus (Figs. 7.39, 7.42):

- the superior subscapular nerve,
- the thoracodorsal nerve,
- the inferior subscapular nerve,
- the axillary nerve, and
- the radial nerve.

All these nerves except the radial nerve innervate muscles associated with the shoulder region or the posterior wall of the axilla; the radial nerve passes into the arm and forearm.

The **superior subscapular nerve**, the thoracodorsal, and the **inferior subscapular nerves** originate sequentially from the posterior cord and pass directly into muscles associated with the posterior wall of the axilla (Fig. 7.42). The **superior subscapular nerve** is short and passes into and supplies the subscapularis muscle. The **thoracodorsal nerve** is the longest of these three nerves and passes vertically along the posterior axillary wall. It penetrates and innervates the latissimus dorsi muscle. The **inferior subscapular nerve** also passes inferiorly along the posterior axillary wall and innervates the subscapularis and teres major muscles.

The **axillary nerve** originates from the posterior cord and passes inferiorly and laterally along the posterior wall to exit the axilla through the quadrangular space (Fig. 7.42). It passes posteriorly around the surgical neck of the humerus and innervates both the deltoid and teres minor muscles. A **superior lateral cutaneous nerve of arm** originates from the axillary nerve after passing through the quadrangular space and loops around the posterior margin of the deltoid muscle to innervate skin in that region. The **axillary nerve** is accompanied by the posterior circumflex humeral artery.

The **radial nerve** is the largest terminal branch of the posterior cord (Fig. 7.42). It passes out of the axilla and into the posterior compartment of the arm by passing through the triangular interval between the inferior border of the

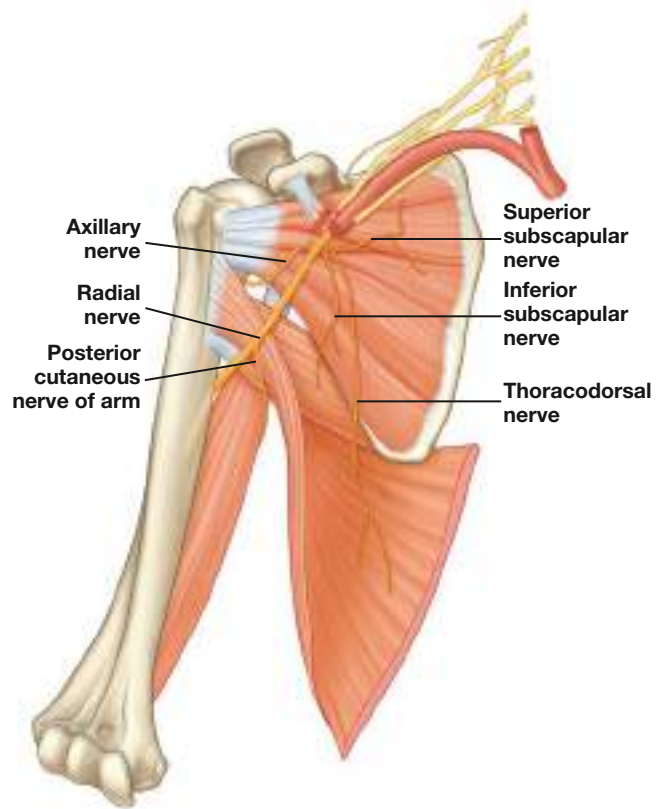


Fig. 7.42 Branches of the posterior cord of the brachial plexus.

teres major muscle, the long head of the triceps brachii muscle, and the shaft of the humerus. It is accompanied through the triangular interval by the profunda brachii artery, which originates from the brachial artery in the anterior compartment of the arm. The radial nerve and its branches innervate:

- all muscles in the posterior compartments of the arm and forearm, and
- the skin on the posterior aspect of the arm and forearm, the lower lateral surface of the arm, and the dorsolateral surface of the hand.

The **posterior cutaneous nerve of arm (posterior brachial cutaneous nerve)** originates from the radial nerve in the axilla and innervates skin on the posterior surface of the arm.

Lymphatics

All lymphatics from the upper limb drain into lymph nodes in the axilla (Fig. 7.43).

In addition, axillary nodes receive drainage from an extensive area on the adjacent trunk, which includes regions of the upper back and shoulder, the lower neck, the chest,

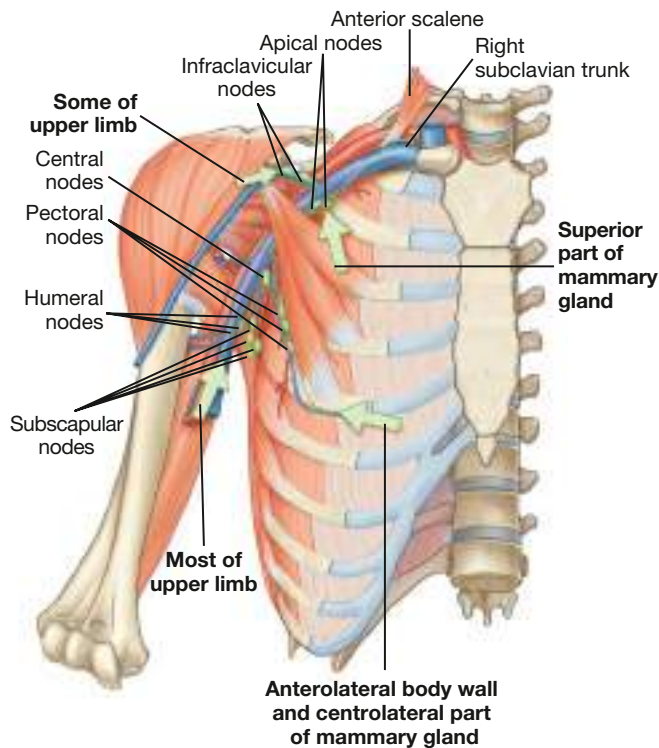


Fig. 7.43 Lymph nodes and vessels in the axilla.

and the upper anterolateral abdominal wall. Axillary nodes also receive drainage from approximately 75% of the mammary gland.

The 20 to 30 axillary nodes are generally divided into five groups on the basis of location (Fig. 7.43).

Humeral (lateral) nodes posteromedial to the axillary vein receive most of the lymphatic drainage from the upper limb.

Pectoral (anterior) nodes occur along the inferior margin of the pectoralis minor muscle and along the course of the lateral thoracic vessels. They receive drainage from the abdominal wall, the chest, and the mammary gland.

Subscapular (posterior) nodes on the posterior axillary wall in association with the subscapular vessels drain the posterior axillary wall and receive lymphatics from the back, the shoulder, and the neck.

Central nodes are embedded in axillary fat and receive tributaries from humeral, subscapular, and pectoral groups of nodes.

Apical nodes are the most superior group of nodes in the axilla and drain all other groups of nodes in the region. In addition, they receive lymphatic vessels that accompany the cephalic vein as well as vessels that drain the superior region of the mammary gland.

Efferent vessels from the apical group converge to form the subclavian trunk, which usually joins the venous system

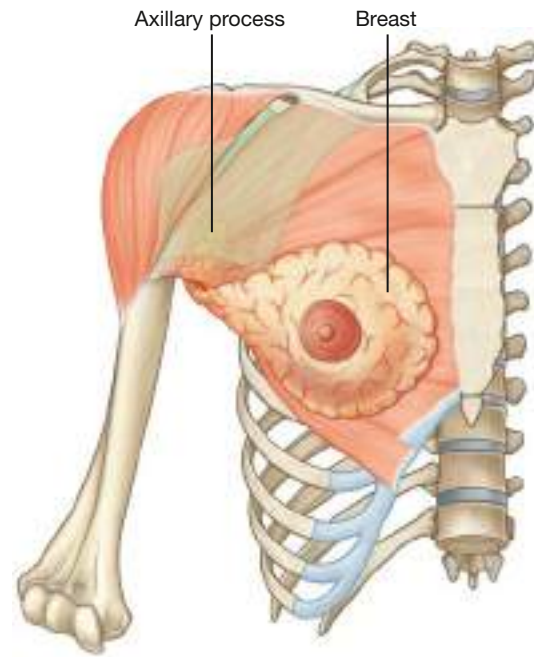


Fig. 7.44 Axillary process of the breast.

at the junction between the right subclavian vein and the right internal jugular vein in the neck. On the left, the subclavian trunk usually joins the thoracic duct in the base of the neck.

Axillary process of the mammary gland

Although the mammary gland is in superficial fascia overlying the thoracic wall, its superolateral region extends along the inferior margin of the pectoralis major muscle toward the axilla. In some cases, this may pass around the margin of the muscle to penetrate deep fascia and enter the axilla (Fig. 7.44). This axillary process rarely reaches as high as the apex of the axilla.

Clinical app

Injuries to the brachial plexus

Brachial plexus injuries are usually the result of blunt trauma producing nerve avulsions and disruption. These injuries are usually devastating for the function of the upper limb and require many months of dedicated rehabilitation for even a small amount of function to return.

Spinal cord injuries in the cervical region and direct pulling injuries tend to affect the roots of the brachial plexus. Severe trauma to the first rib usually affects the trunks. The divisions and cords of the brachial plexus can be injured by dislocation of the glenohumeral joint.



Clinical app

Lymphatic drainage and breast cancer

Lymphatic drainage from the lateral part of the breast passes through nodes in the axilla. Significant disruption to the normal lymphatic drainage of the upper limb may occur if a mastectomy or a surgical axillary nodal clearance has been carried out for breast cancer. Furthermore, some patients have radiotherapy to the axilla to prevent the spread of metastatic disease, but a side effect of this is the destruction of the tiny lymphatics as well as the cancer cells. If the lymphatic drainage of the upper limb is damaged, the arm may swell (lymphedema).

ARM

The arm is the region of the upper limb between the shoulder and the elbow (Fig. 7.45A). The superior aspect of the arm communicates medially with the axilla. Inferiorly, a number of important structures pass between the arm and the forearm through the cubital fossa, which is positioned anterior to the elbow joint.

The arm is divided into two compartments by medial and lateral intermuscular septa, which pass from each side of the humerus to the outer sleeve of deep fascia that surrounds the limb (Fig. 7.45B).

The anterior compartment of the arm contains muscles that predominantly flex the elbow joint; the posterior compartment contains muscles that extend the joint. Major nerves and vessels supply and pass through each compartment.

Bones

The skeletal support for the arm is the humerus (Fig. 7.46). However, most of the large muscles of the arm insert into the proximal ends of the two bones of the forearm, the radius and the ulna, and flex and extend the forearm at the elbow joint. In addition, the muscles predominantly situated in the forearm that move the hand originate at the distal end of the humerus.

Shaft and distal end of the humerus

In cross-section, the shaft of the humerus is somewhat triangular with (Fig. 7.46):

- **anterior, lateral, and medial borders, and**
- **anterolateral, anteromedial, and posterior surfaces.**

The posterior surface of the humerus is marked on its superior aspect by a linear roughening for the attachment of the lateral head of the triceps brachii muscle, beginning just

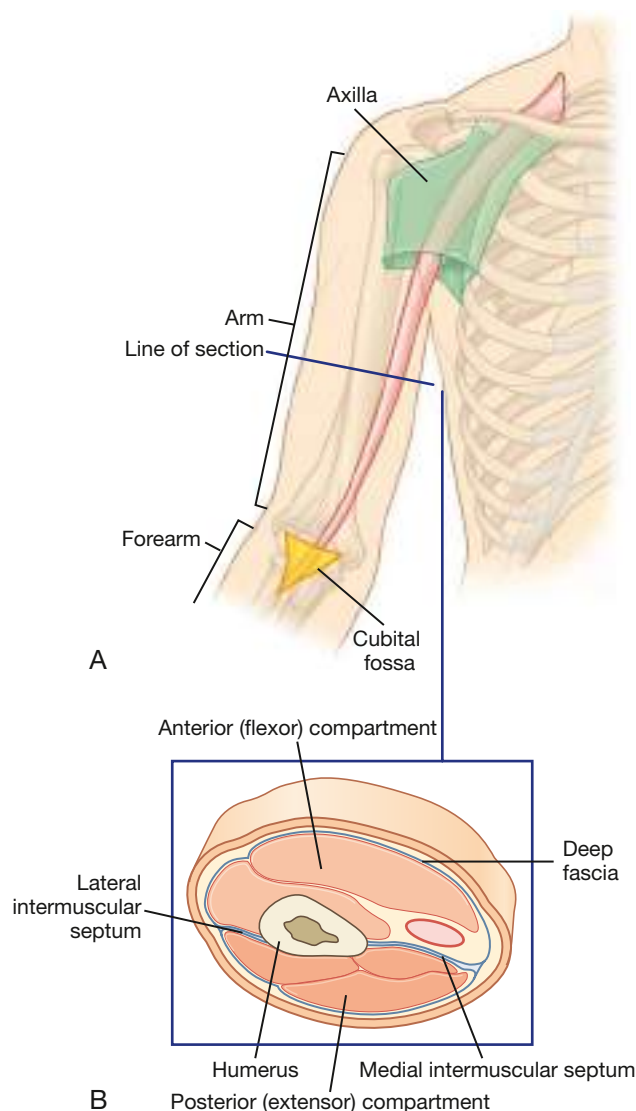


Fig. 7.45 Arm. A. Proximal and distal relationships. B. Transverse section through the middle of the arm.

inferior to the surgical neck and passing diagonally across the bone to the **deltoid tuberosity** (Fig. 7.46).

The middle part of the posterior surface and adjacent part of the anterolateral surface are marked by the shallow **radial groove**, which passes diagonally down the bone and parallel to the sloping posterior margin of the deltoid tuberosity (Fig. 7.46). The radial nerve and the profunda brachii artery lie in this groove.

Approximately in the middle of the shaft, the medial border is marked by a thin elongated roughening for the attachment of the coracobrachialis muscle (Fig. 7.46).

Intermuscular septa, which separate the anterior compartment from the posterior compartment, attach to the medial and lateral borders (Fig. 7.47A).

Distally, the humerus becomes flattened, and these borders expand as the **lateral supraepicondylar ridge** (lateral

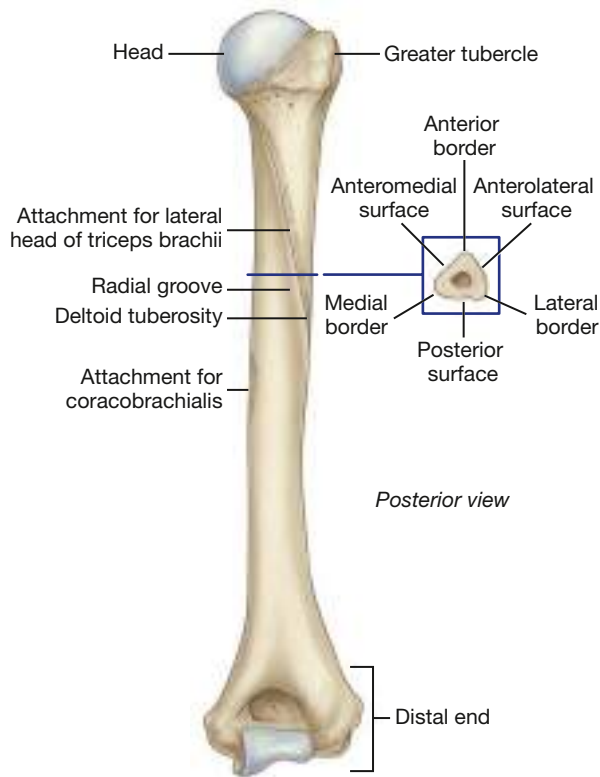


Fig. 7.46 Humerus. Posterior view.

supracondylar ridge) and the **medial supraepicondylar ridge** (medial supracondylar ridge) (Fig. 7.47A). The lateral supraepicondylar ridge is more pronounced than the medial and is roughened for the attachment of muscles found in the posterior compartment of the forearm.

The distal end of the humerus, which is flattened in the anteroposterior plane, bears a condyle, two epicondyles, and three fossae, as follows.

The condyle

The two articular parts of the condyle, the **capitulum** and the **trochlea** (Fig. 7.47A), articulate with the two bones of the forearm.

The capitulum articulates with the radius of the forearm. Lateral in position and hemispherical in shape, it projects anteriorly and somewhat inferiorly and is not visible when the humerus is viewed from the posterior aspect.

The trochlea articulates with the ulna of the forearm. It is pulley shaped and lies medial to the capitulum. Its medial edge is more pronounced than its lateral edge and, unlike the capitulum, it extends onto the posterior surface of the bone.

The two epicondyles

The two epicondyles lie adjacent and somewhat superior to the trochlea and capitulum (Fig. 7.47A).

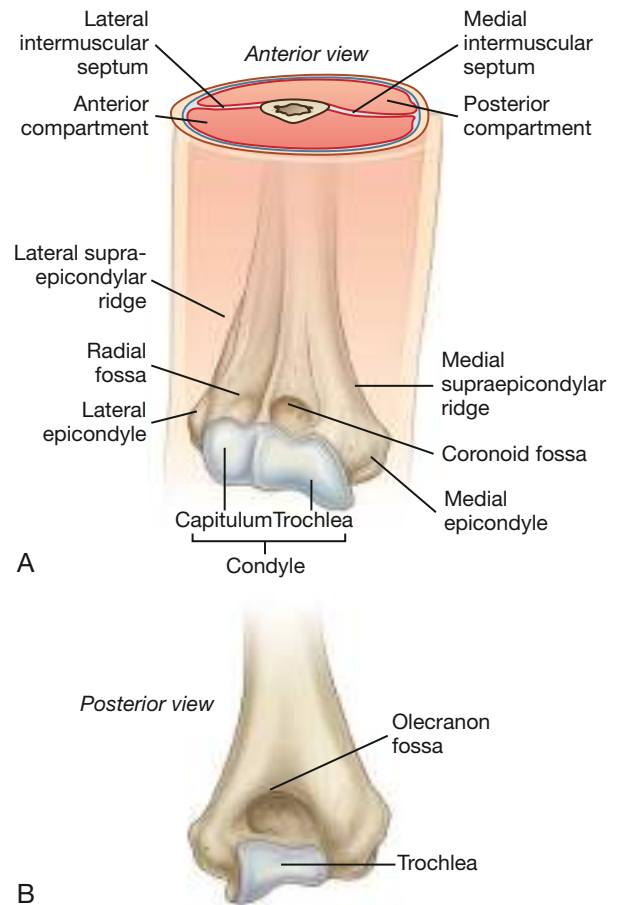


Fig. 7.47 Distal end of the humerus. A. Anterior view. B. Posterior view.

The **medial epicondyle**, a large bony protuberance, is the major palpable landmark on the medial side of the elbow and projects medially from the distal end of the humerus. On its surface, it bears a large oval impression for the attachment of muscles in the anterior compartment of the forearm (common flexor origin). The ulnar nerve passes from the arm into the forearm around the posterior surface of the medial epicondyle and can be palpated against the bone in this location.

The **lateral epicondyle** is much less pronounced than the medial epicondyle. It is lateral to the capitulum and has a large irregular impression for the attachment of muscles in the posterior compartment of the forearm (common extensor origin).

The three fossae

Three fossae occur superior to the trochlea and capitulum on the distal end of the humerus (Fig. 7.47).

The **radial fossa** is the least distinct of the fossae and occurs immediately superior to the capitulum on the anterior surface of the humerus.

The **coronoid fossa** is adjacent to the radial fossa and is superior to the trochlea.



Upper Limb

The largest of the fossae, the **olecranon fossa**, occurs immediately superior to the trochlea on the posterior surface of the distal end of the humerus (Fig. 7.47B).

These three fossae accommodate projections from the bones in the forearm during movements of the elbow joint.

Proximal end of the radius

The proximal end of the radius consists of a head, a neck, and the radial tuberosity (Fig. 7.48).

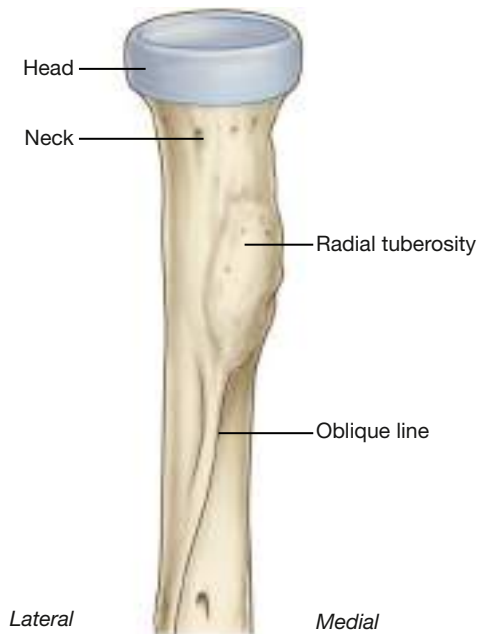


Fig. 7.48 Anterior view of the proximal end of the radius.

The **head** of the radius is a thick disc-shaped structure oriented in the horizontal plane. The circular superior surface is concave for articulation with the capitulum of the humerus. The thick margin of the disc is broad medially where it articulates with the radial notch on the proximal end of the ulna.

The **neck** of the radius is a short and narrow cylinder of bone between the expanded head and the radial tuberosity on the shaft.

The **radial tuberosity** is a large blunt projection medial to the distal part of the neck. Much of its surface is roughened for the attachment of the biceps brachii tendon. The oblique line of the radius continues diagonally across the shaft of the bone from the inferior margin of the radial tuberosity.

Proximal end of the ulna

The proximal end of the ulna is much larger than the proximal end of the radius and consists of the olecranon, the coronoid process, the trochlear notch, the radial notch, and the tuberosity of ulna (Fig. 7.49).

The **olecranon** is a large projection of bone that extends proximally from the ulna. Its anterolateral surface is articular and contributes to the formation of the trochlear notch, which articulates with the trochlea of the humerus. The superior surface is marked by a large roughened impression for the attachment of the triceps brachii muscle. The posterior surface is smooth, shaped somewhat triangularly, and can be palpated as the “tip of the elbow.”

The **coronoid process** projects anteriorly from the proximal end of the ulna (Fig. 7.49). Its superolateral surface is articular and participates with the olecranon



Fig. 7.49 Lateral, anterior, medial, and posterior views of the proximal end of the ulna.

Table 7.8 Muscles of the anterior compartment of the arm (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Coracobrachialis	Apex of coracoid process	Linear roughening on mid-shaft of humerus on medial side	Musculocutaneous nerve [C5, C6, C7]	Flexor of the arm at the glenohumeral joint
Biceps brachii	Long head—supraglenoid tubercle of scapula; short head—apex of coracoid process	Radial tuberosity	Musculocutaneous nerve [C5, C6]	Powerful flexor of the forearm at the elbow joint and supinator of the forearm; accessory flexor of the arm at the glenohumeral joint
Brachialis	Anterior aspect of humerus (medial and lateral surfaces) and adjacent intermuscular septae	Tuberosity of the ulna	Musculocutaneous nerve [C5, C6]; (small contribution by the radial nerve [C7] to lateral part of muscle)	Powerful flexor of the forearm at the elbow joint

in forming the **trochlear notch**. The lateral surface is marked by the **radial notch** for articulation with the head of the radius.

Just inferior to the radial notch is a fossa that allows the radial tuberosity to change position during pronation and supination. The posterior margin of this fossa is broadened to form the **supinator crest**. The anterior surface of the coronoid process is triangular, with the apex directed distally, and has a number of roughenings for muscle attachment. The largest of these roughenings, the **tuberosity of ulna**, is at the apex of the anterior surface and is the attachment site for the brachialis muscle.

Clinical app

Rupture of biceps tendon

It is relatively unusual for muscles and their tendons to rupture in the upper limb; however, the tendon that most commonly ruptures is the tendon of the long head of the biceps brachii muscle. In isolation, this has relatively little effect on the upper limb, but it does produce a characteristic deformity—on flexing the elbow, there is an extremely prominent bulge of the muscle belly as its unrestrained fibers contract—the “Popeye” sign.

Muscles

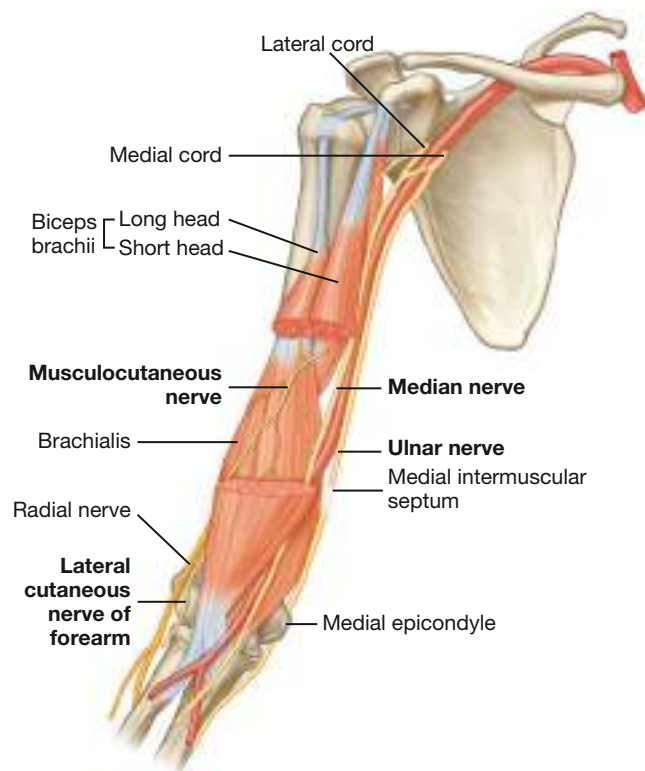
The anterior compartment of the arm contains three muscles—the **coracobrachialis**, **brachialis**, and **biceps brachii** muscles (Table 7.8, Fig. 7.50)—which are innervated predominantly by the musculocutaneous nerve.

The posterior compartment contains one muscle—the **triceps brachii** muscle (Table 7.9, Fig. 7.51)—which is innervated by the radial nerve.

Nerves

Musculocutaneous nerve

The musculocutaneous nerve leaves the axilla and enters the arm by passing through the coracobrachialis muscle

**Fig. 7.50** Musculocutaneous, median, and ulnar nerves in the arm.

(Fig. 7.50). It passes diagonally down the arm in the plane between the biceps brachii and brachialis muscles. After giving rise to motor branches in the arm, it emerges laterally to the tendon of the biceps brachii muscle at the elbow, penetrates deep fascia, and continues as the **lateral cutaneous nerve of forearm**.

The musculocutaneous nerve provides:

- motor innervation to all muscles in the anterior compartment of the arm, and
- sensory innervation to skin on the lateral surface of the forearm.



Table 7.9 Muscle of the posterior compartment of the arm (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Triceps brachii	Long head—infraglenoid tubercle of scapula; medial head—posterior surface of humerus; lateral head—posterior surface of humerus	Olecranon	Radial nerve [C6, C7 , C8]	Extension of the forearm at the elbow joint. Long head can also extend and adduct the arm at the shoulder joint

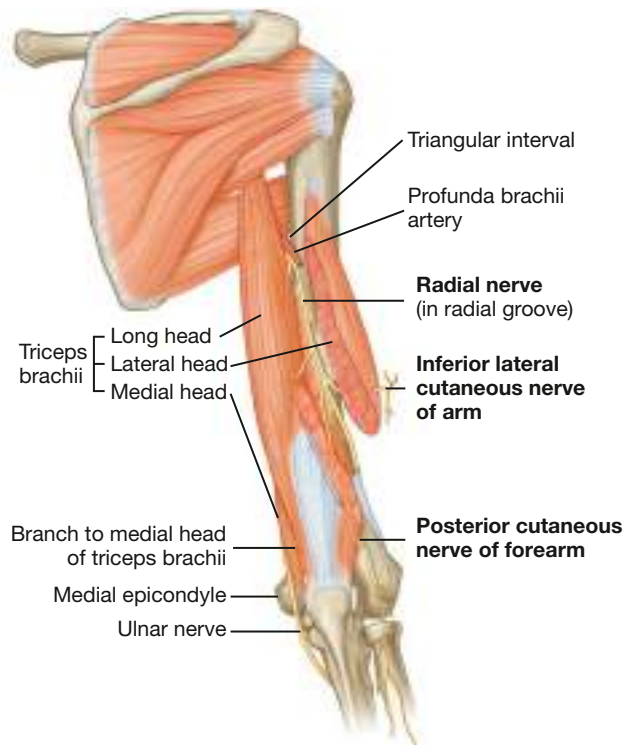


Fig. 7.51 Radial nerve in the arm.

Median nerve

The median nerve enters the arm from the axilla at the inferior margin of the teres major muscle (Fig. 7.50). It passes vertically down the medial side of the arm in the anterior compartment and is related to the brachial artery throughout its course:

- In proximal regions, the median nerve is immediately lateral to the brachial artery.
- In more distal regions, the median nerve crosses to the medial side of the brachial artery and lies anterior to the elbow joint.

The median nerve has no major branches in the arm, but a branch to one of the muscles of the forearm, the pronator teres muscle, may originate from the nerve immediately proximal to the elbow joint.

Clinical app

Median nerve injury in the arm

In the arm and forearm the median nerve is usually not injured by trauma because of its relatively deep position. On very rare occasions, a fibrous band may arise from the anterior aspect of the humerus beneath which the median nerve passes. This is an embryological remnant of the coracobrachialis muscle and is sometimes called the *ligament of Struthers*; occasionally, it may calcify. This band can compress the median nerve, resulting in weakness of the flexor muscles in the forearm and the thenar muscles in the hand. Nerve conduction studies can demonstrate the site of nerve compression.

Ulnar nerve

The ulnar nerve enters the arm with the median nerve and axillary artery (Fig. 7.50). It passes through proximal regions medial to the axillary artery. In the middle of the arm, the ulnar nerve penetrates the medial intermuscular septum and enters the posterior compartment where it lies anterior to the medial head of the triceps brachii muscle. It passes posterior to the medial epicondyle of the humerus and then into the anterior compartment of the forearm.

The ulnar nerve has no major branches in the arm.

Radial nerve

The radial nerve originates from the posterior cord of the brachial plexus and enters the arm by crossing the inferior margin of the teres major muscle (Fig. 7.51). As it enters the arm, it lies posterior to the brachial artery. Accompanied by the profunda brachii artery, the radial nerve enters the posterior compartment of the arm by passing through the triangular interval.

As the radial nerve passes diagonally from medial to lateral through the posterior compartment, it lies in the radial groove directly on bone. On the lateral side of the arm, it passes anteriorly through the lateral intermuscular septum and enters the anterior compartment where it lies between the brachialis muscle and a muscle of the posterior compartment of the forearm—the brachioradialis muscle, which attaches to the lateral supraepicondylar ridge of the humerus. The radial nerve enters the forearm anterior to the

lateral epicondyle of the humerus just deep to the brachioradialis muscle.

In the arm, the radial nerve has muscular and cutaneous branches (Fig. 7.51).

Muscular branches include those to the triceps brachii, brachioradialis, and extensor carpi radialis longus muscles. In addition, the radial nerve contributes to the innervation of the lateral part of the brachialis muscle. One of the branches to the medial head of the triceps brachii muscle arises before the radial nerve's entrance into the posterior compartment and passes vertically down the arm in association with the ulnar nerve.

Cutaneous branches of the radial nerve that originate in the posterior compartment of the arm are the **inferior lateral cutaneous nerve of arm** and the **posterior cutaneous nerve of forearm**, both of which penetrate through the lateral head of the triceps brachii muscle and the overlying deep fascia to become subcutaneous.

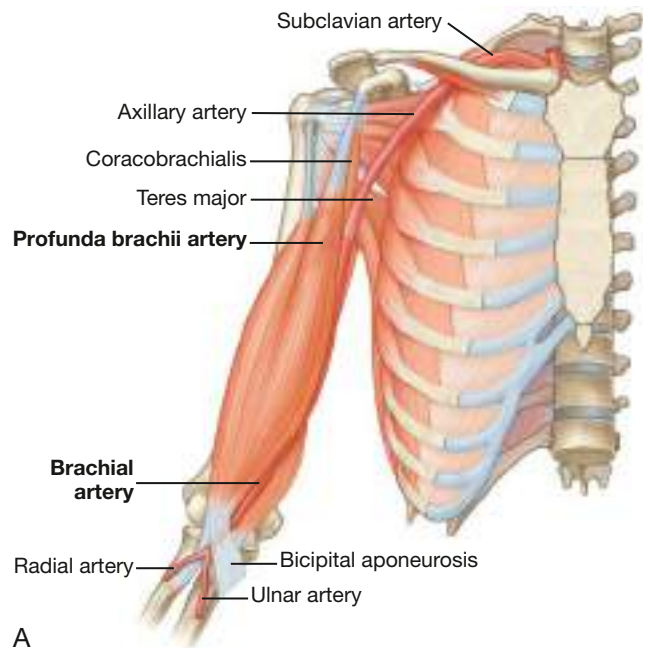
Clinical app

Radial nerve injury in the arm

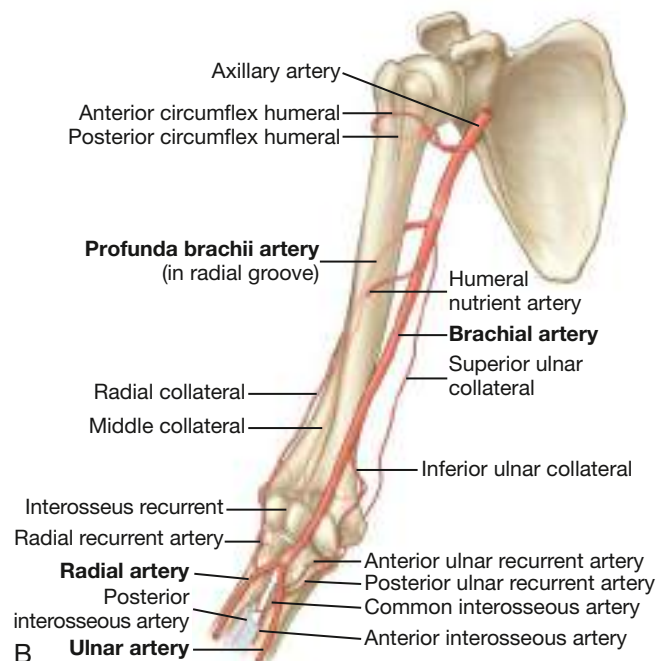
The radial nerve is tightly bound with the profunda brachii artery between the medial and lateral heads of the triceps brachii muscle in the radial groove. If the humerus is fractured (Fig. 7.52), the radial nerve may become stretched or transected in this region, leading to permanent damage and loss of function. The nerve should always be tested when a fracture of the mid-shaft of the humerus is suspected. The patient's symptoms usually include wrist drop (due to denervation of the extensor muscles) and sensory changes over the dorsum of the hand.



Fig. 7.52 Radiograph of the humerus demonstrating a mid-shaft fracture, which may disrupt the radial nerve.



A



B

Fig. 7.53 Brachial artery. A. Brachial artery. B. Branches.

Arteries and veins

Brachial artery

The major artery of the arm, the **brachial artery**, is found in the anterior compartment (Fig. 7.53A). Beginning as a continuation of the axillary artery at the lower border of the teres major muscle, it terminates just distal to the elbow joint where it divides into the radial and ulnar arteries.



Upper Limb

In the proximal arm, the brachial artery lies on the medial side. In the distal arm, it moves laterally to assume a position midway between the lateral epicondyle and the medial epicondyle of the humerus (Fig. 7.53A). It crosses anteriorly to the elbow joint where it lies immediately medial to the tendon of the biceps brachii muscle. The brachial artery is palpable along its length. In proximal regions, the brachial artery can be compressed against the medial side of the humerus.

Branches of the brachial artery in the arm include those to muscles and two ulnar collateral vessels, which contribute to a network of arteries around the elbow joint (Fig. 7.53B). Additional branches are the profunda brachii artery and nutrient arteries to the humerus, which pass through a foramen in the anteromedial surface of the humeral shaft.

Surface anatomy

Locating the brachial artery in the right arm

The brachial artery is on the medial side of the arm in the cleft between the biceps brachii and triceps brachii muscles (Fig. 7.54). The median nerve courses with the brachial artery, whereas the ulnar nerve deviates posteriorly from the vessel in distal regions.

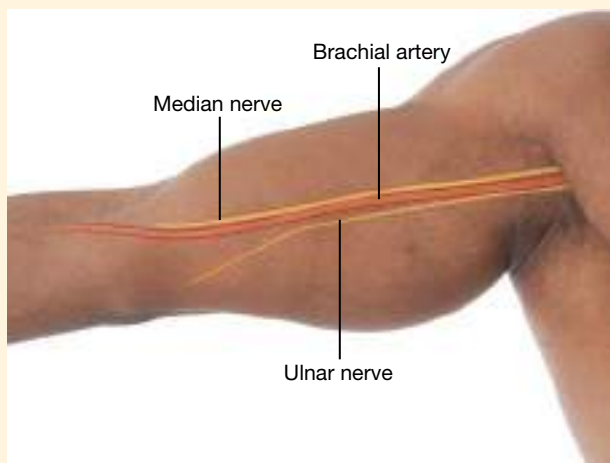


Fig. 7.54 Locating the brachial artery in the right arm (medial view of arm with brachial artery, median nerve, and ulnar nerve).

Profunda brachii artery

The **profunda brachii artery**, the largest branch of the brachial artery, passes into and supplies the posterior compartment of the arm (Fig. 7.53B). It enters the posterior compartment with the radial nerve and together they pass

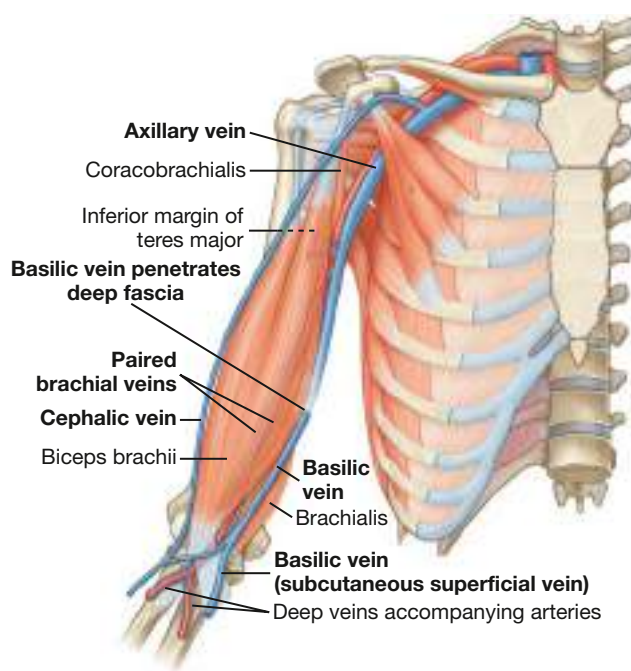


Fig. 7.55 Veins of the arm.

through the triangular interval, which is formed by the shaft of the humerus, the inferior margin of the teres major muscle, and the lateral margin of the long head of the triceps muscle. They then pass along the radial groove on the posterior surface of the humerus deep to the lateral head of the triceps brachii muscle.

Branches of the profunda brachii artery supply adjacent muscles and anastomose with the posterior circumflex humeral artery. The artery terminates as two collateral vessels, which contribute to an anastomotic network of arteries around the elbow joint.

Veins

Paired brachial veins pass along the medial and lateral sides of the brachial artery, receiving tributaries that accompany branches of the artery (Fig. 7.55).

In addition to these deep veins, two large subcutaneous veins, the basilic vein and the cephalic vein, are located in the arm (Fig. 7.55).

The basilic vein passes vertically in the distal half of the arm, penetrates deep fascia to assume a position medial to the brachial artery, and then becomes the axillary vein at the lower border of the teres major muscle. The brachial veins join the basilic, or axillary, vein.

The cephalic vein passes superiorly on the anterolateral aspect of the arm and through the anterior wall of the axilla to reach the axillary vein.

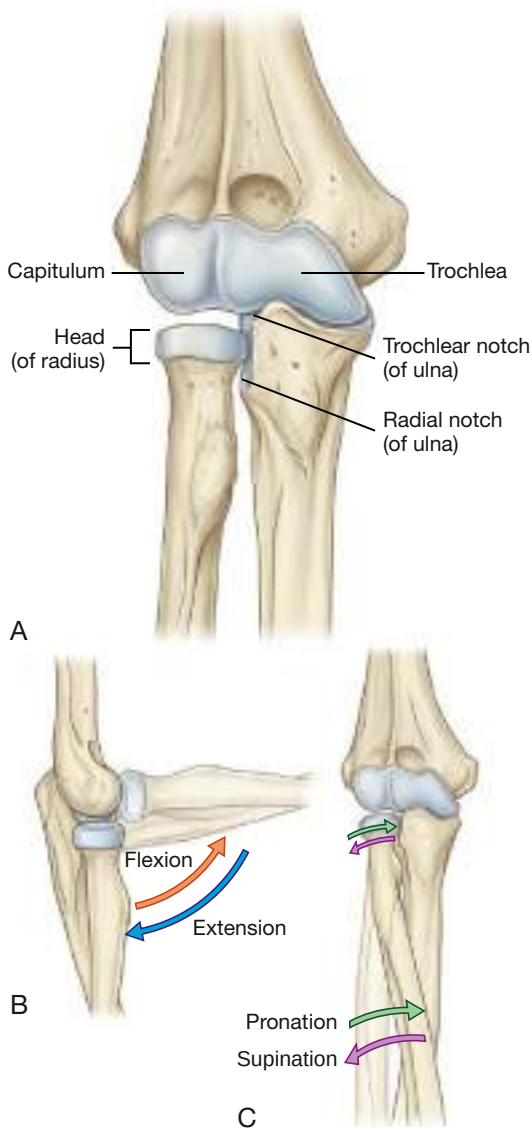


Fig. 7.56 Components and movements of the elbow joint. **A.** Bones and joint surfaces. **B.** Flexion and extension. **C.** Pronation and supination.

ELBOW JOINT

The elbow joint is a complex joint involving three separate articulations that share a common synovial cavity (Fig. 7.56; also see Fig. 7.60).

The joints between the trochlear notch of the ulna and the trochlea of the humerus and between the head of the radius and the capitulum of the humerus are primarily involved with hinge-like flexion and extension of the forearm on the arm and, together, are the principal articulations of the elbow joint.

The joint between the head of the radius and the radial notch of the ulna, the proximal radioulnar joint, is involved with pronation and supination of the forearm.

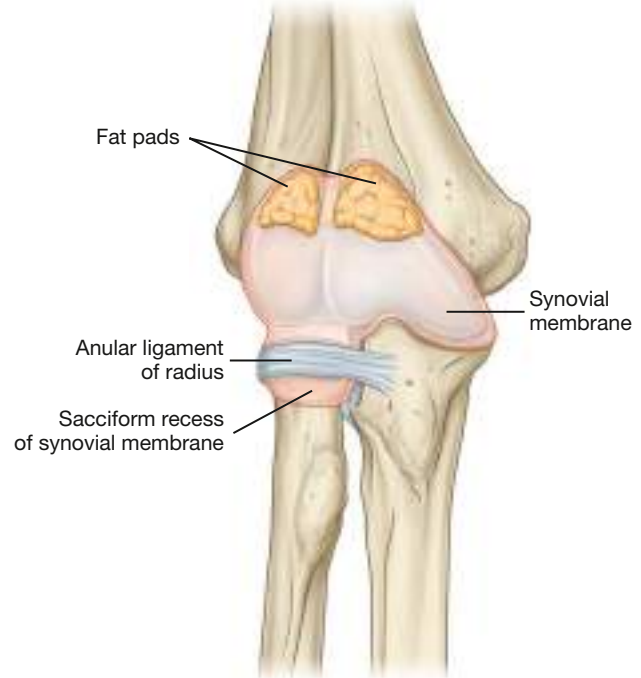


Fig. 7.57 Synovial membrane of elbow joint (anterior view).

The synovial membrane originates from the edges of the articular cartilage and lines the radial fossa, the coronoid fossa, the olecranon fossa, the deep surface of the joint capsule, and the medial surface of the trochlea (Fig. 7.57).

The synovial membrane is separated from the fibrous membrane of the joint capsule by pads of fat in regions overlying the coronoid fossa, the olecranon fossa, and the radial fossa (Fig. 7.57). These fat pads accommodate the related bony processes during extension and flexion of the elbow. Attachments of the brachialis and triceps brachii muscles to the joint capsule overlying these regions pull the attached fat pads out of the way when the adjacent bony processes are moved into the fossae.

The fibrous membrane of the joint capsule overlies the synovial membrane, encloses the joint, and attaches to the medial epicondyle and the margins of the olecranon, coronoid, and radial fossae of the humerus (Fig. 7.58). It also attaches to the coronoid process and olecranon of the ulna. On the lateral side, the free inferior margin of the joint capsule passes around the neck of the radius from an anterior attachment to the coronoid process of the ulna to a posterior attachment to the base of the olecranon.

The fibrous membrane of the joint capsule is thickened medially and laterally to form collateral ligaments, which support the flexion and extension movements of the elbow joint (Fig. 7.58).

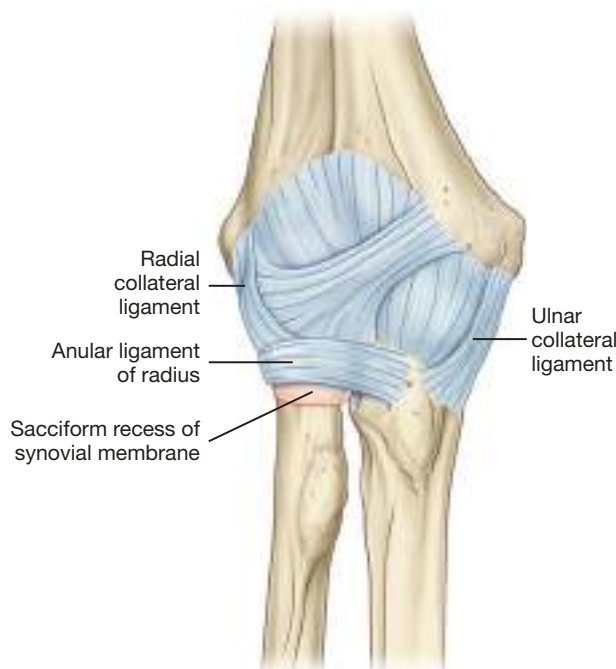


Fig. 7.58 Joint capsule and ligaments of the right elbow joint.

In addition, the external surface of the joint capsule is reinforced laterally where it cuffs the head of the radius with a strong **anular ligament of radius** (Fig. 7.58). Although this ligament blends with the fibrous membrane of the joint capsule in most regions, they are separate posteriorly. The anular ligament of radius also blends with the **radial collateral ligament** (Fig. 7.58).

The anular ligament of radius and related joint capsule allow the radial head to slide against the radial notch of the ulna and pivot on the capitulum during pronation and supination of the forearm.

The deep surface of the fibrous membrane of the joint capsule and the related anular ligament of radius that articulate with the sides of the radial head are lined by cartilage. A pocket of synovial membrane (sacciform recess) protrudes from the inferior free margin of the joint capsule and facilitates rotation of the radial head during pronation and supination (Fig. 7.58).

Vascular supply to the elbow joint is through an anastomotic network of vessels derived from collateral and recurrent branches of the brachial, profunda brachii, radial, and ulnar arteries.

The elbow joint is innervated predominantly by branches of the radial and musculocutaneous nerves, but there may be some innervation by branches of the ulnar and median nerves.

Imaging app

Developmental changes in the elbow joint

In an adult it is usually not difficult to interpret a radiograph, but in children developmental patterns have to be considered (Fig. 7.59).

As the elbow develops, numerous secondary ossification centers appear before and around puberty. It is easy to mistakenly interpret these as fractures. In addition, it is also possible for the epiphyses and apophyses to be “pulled off” or disrupted. Therefore when interpreting a child’s radiograph of the elbow, the physician must know the child’s age. Fusion occurs at around the time of puberty. The approximate ages of appearance of the secondary ossification centers around the elbow joint and are:

- capitulum—1 year,
- head (of radius)—5 years,
- medial epicondyle—5 years,
- trochlea—11 years,
- olecranon—12 years, and
- lateral epicondyle—13 years.



Fig. 7.59 Radiographs of elbow joint development. A. At age 2 years. B. At age 5 years. C. At age 5 or 6 years. D. At age 12 years.

Imaging app

Visualizing the elbow joint

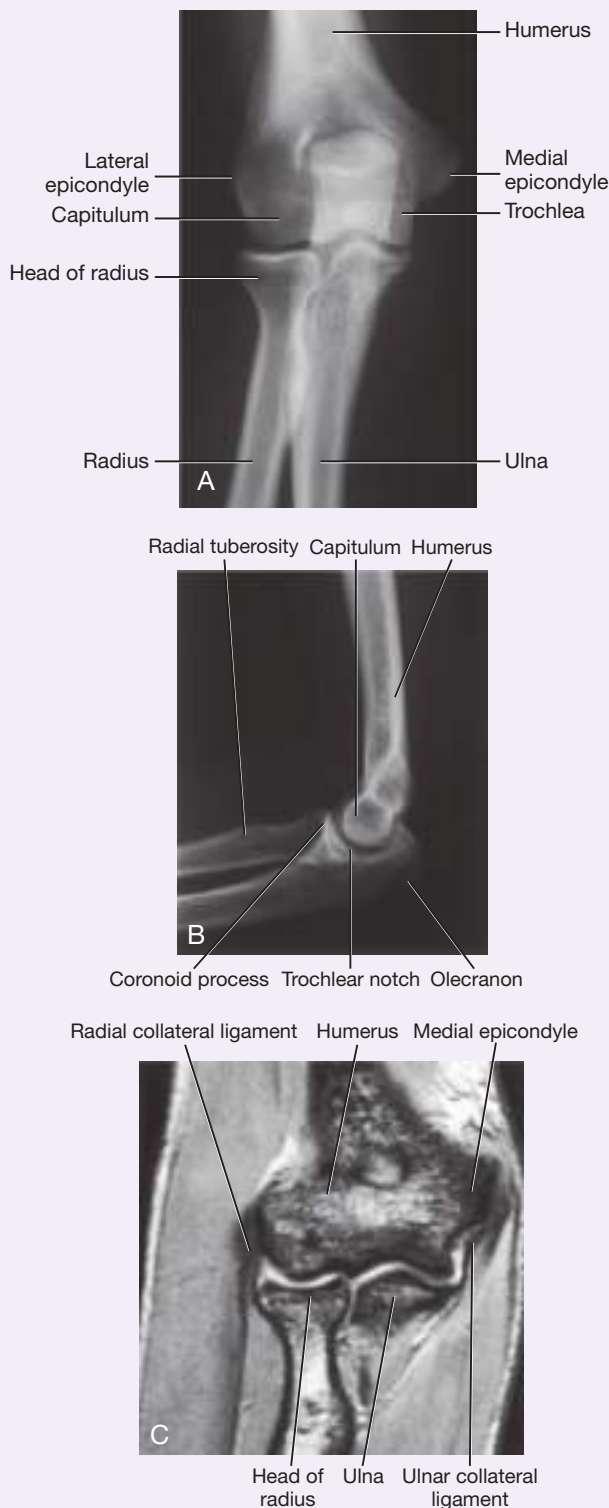


Fig. 7.60 Elbow joint **A.** Radiograph (anteroposterior view). **B.** Radiograph (lateral view). **C.** Magnetic resonance image (coronal plane).

Clinical app

Supracondylar fracture of the humerus

Elbow injuries in children may result in a transverse fracture of the distal end of the humerus above the level of the epicondyles. This fracture is termed a *supracondylar fracture*. The distal fragment and its soft tissues are pulled posteriorly by the triceps muscle. This posterior displacement effectively “bowstrings” the brachial artery over the irregular proximal fracture fragment. In children, this is a relatively devastating injury: the muscles of the anterior compartment of the forearm are rendered ischemic and form severe contractions, significantly reducing the function of the anterior compartment and flexor muscles (Volkmann’s ischemic contracture).

Clinical app

Pulled elbow

Pulled elbow is a disorder that typically occurs in children younger than 5 years of age. It is commonly caused by a sharp pull of the child’s hand, usually when the child is pulled up onto a curb. The not-yet-developed head of the radius and the laxity of the anular ligament of radius allow the head to sublux from this cuff of tissue.

Clinical app

Fracture of the head of radius

A fracture of the head of radius is a common injury and can cause appreciable morbidity. It is one of the typical injuries that occur with a fall on the outstretched hand. On falling, the force is transmitted to the radial head, which fractures. These fractures result in loss of full extension, and potential surgical reconstruction may require long periods of physiotherapy to obtain a full range of movement at the elbow joint.

Clinical app

“Tennis” and “golfer’s” elbow (epicondylitis)

It is not uncommon for people who are involved in sports such as golf and tennis to develop an overuse strain of the origins of the flexor and extensor muscles of the forearm. The pain is typically around the epicondyles and usually resolves after rest. If pain and inflammation persist, surgical division of the extensor or flexor origin from the bone may be necessary. Typically, in tennis players this pain occurs on the lateral epicondyle and common extensor origin (tennis elbow), whereas in golfers it occurs on the medial epicondyle and common flexor origin (golfer’s elbow).



Clinical app

Ulnar nerve injury at the elbow

Posterior to the medial epicondyle of the humerus, the ulnar nerve is bound in a fibro-osseous tunnel (the cubital tunnel) by a retinaculum. Older patients may develop degenerative changes within this tunnel, which compresses the ulnar nerve when the elbow joint is flexed. The repeated action of flexion and extension of the elbow joint may cause local nerve damage, resulting in impaired function of the ulnar nerve. Localized neuritis in this region secondary to direct trauma may also produce ulnar nerve damage.

CUBITAL FOSSA

The cubital fossa is an important area of transition between the arm and the forearm. It is located anterior to the elbow joint and appears as a triangular depression formed between two forearm muscles (Fig. 7.61A):

- the brachioradialis muscle originating from the lateral supraepicondylar ridge of the humerus, and
- the pronator teres muscle originating from the medial epicondyle of the humerus.

The base of the triangle is an imaginary horizontal line between the medial and lateral epicondyles. The bed or floor of the fossa is formed mainly by the brachialis muscle.

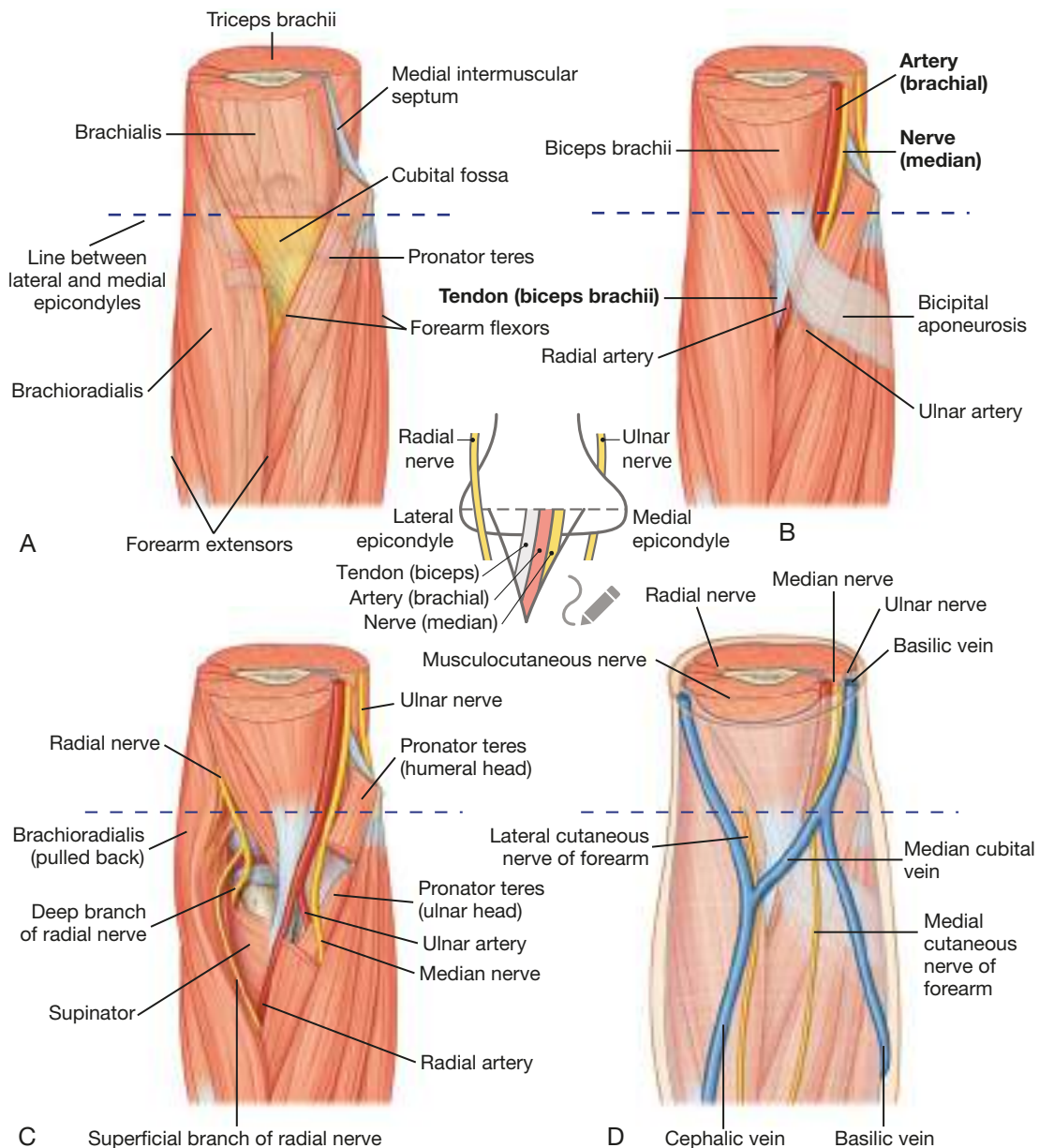


Fig. 7.61 Cubital fossa. **A.** Margins. **B.** Contents. **C.** Position of the radial nerve. **D.** Superficial structures.

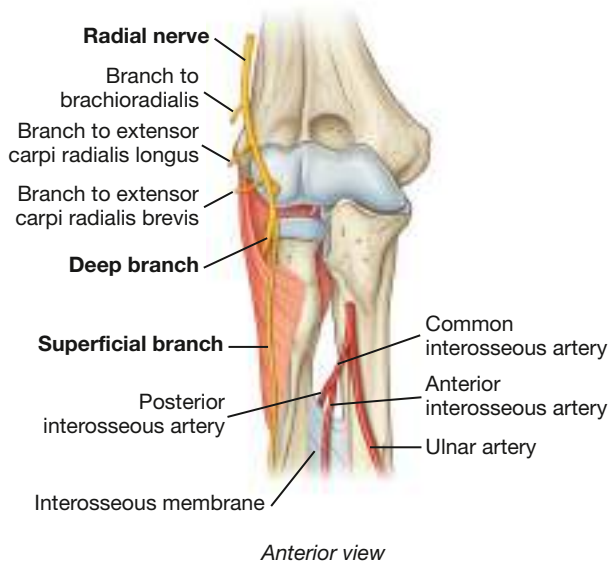


Fig. 7.62 Radial nerve in posterior compartment of forearm.

The major contents of the cubital fossa from lateral to medial are (Fig. 7.61B):

- the tendon of the biceps brachii muscle,
- the brachial artery, and
- the median nerve.

The brachial artery normally bifurcates into the radial and ulnar arteries in the apex of the fossa, although this bifurcation may occur much higher in the arm, even in the axilla (Fig. 7.61C). When taking a blood pressure reading from a patient, the clinician places the stethoscope over the brachial artery in the cubital fossa.

The median nerve lies immediately medial to the brachial artery and leaves the fossa by passing between the ulnar and humeral heads of the pronator teres muscle (Fig. 7.61C).

The brachial artery and the median nerve are covered and protected anteriorly in the distal part of the cubital fossa by the bicipital aponeurosis (Fig. 7.61B). This flat connective tissue membrane passes between the medial side of the tendon of the biceps brachii muscle and deep fascia of the forearm. The sharp medial margin of the bicipital aponeurosis can often be felt.

The radial nerve lies just under the lip of the brachioradialis muscle, which forms the lateral margin of the fossa (Fig. 7.61C). In this position, the radial nerve divides into superficial and deep branches:

- The superficial branch continues into the forearm just deep to the brachioradialis muscle.
- The deep branch passes between the two heads of the supinator muscle (Fig. 7.62) to access the posterior compartment of the forearm.

The ulnar nerve does not pass through the cubital fossa. Instead, it passes posterior to the medial epicondyle.

The roof of the cubital fossa is formed by superficial fascia and skin. The most important structure within the roof is the median cubital vein (Fig. 7.61D), which passes diagonally across the roof and connects the cephalic vein on the lateral side of the upper limb with the basilic vein on the medial side. The bicipital aponeurosis separates the median cubital vein from the brachial artery and median nerve. Other structures within the roof are cutaneous nerves—the medial cutaneous and lateral cutaneous nerves of the forearm.

Clinical app

Construction of a dialysis fistula

Many patients throughout the world require renal dialysis for kidney failure. The patient's blood is filtered and cleaned by the dialysis machine. Blood therefore has to be taken from patients into the filtering device and then returned to them. This process of dialysis occurs over many hours and requires flow rates of 250 to 500 mL/min. To enable such large volumes of blood to be removed from and returned to the body, the blood is taken from vessels that have a high flow. As no veins in the peripheral limbs have such high flow, a surgical procedure is necessary to create such a system. In most patients, the brachial artery is anastomosed (joined) to the cephalic vein at the elbow, or the radial artery is anastomosed to the cephalic vein at the wrist. Some surgeons place an arterial graft between these vessels. After 6 weeks, the veins increase in size in response to their arterial blood flow and are amenable to direct cannulation or dialysis.

Clinical app

Blood pressure measurement

Blood pressure measurement is an extremely important physiological parameter. High blood pressure (hypertension) requires treatment to prevent long-term complications such as stroke. Low blood pressure may be caused by extreme blood loss, widespread infection, or poor cardiac output (e.g., after myocardial infarction). Accurate measurement of blood pressure is essential.

Most clinicians use a sphygmomanometer and a stethoscope. The sphygmomanometer is a device that inflates a cuff around the midportion of the arm to compress the brachial artery against the humerus. The cuff is inflated so it exceeds the systolic blood pressure (greater than 120 mm Hg). The clinician places a stethoscope over the brachial artery in the cubital fossa and listens (auscultates) for the pulse. As the pressure in the arm cuff of the sphygmomanometer is reduced just below the level of the systolic blood pressure, the pulse becomes audible as a regular thumping sound. As the pressure in the sphygmomanometer continues to drop, the regular thumping sound becomes clearer. When the pressure in



Clinical app—cont'd

the sphygmomanometer is less than that of the diastolic blood pressure, the audible thumping sound becomes inaudible. Using the simple scale on the sphygmomanometer, the patient's blood pressure can be determined. The normal range is 90–120/60–80 mm Hg (systolic blood pressure/diastolic blood pressure).

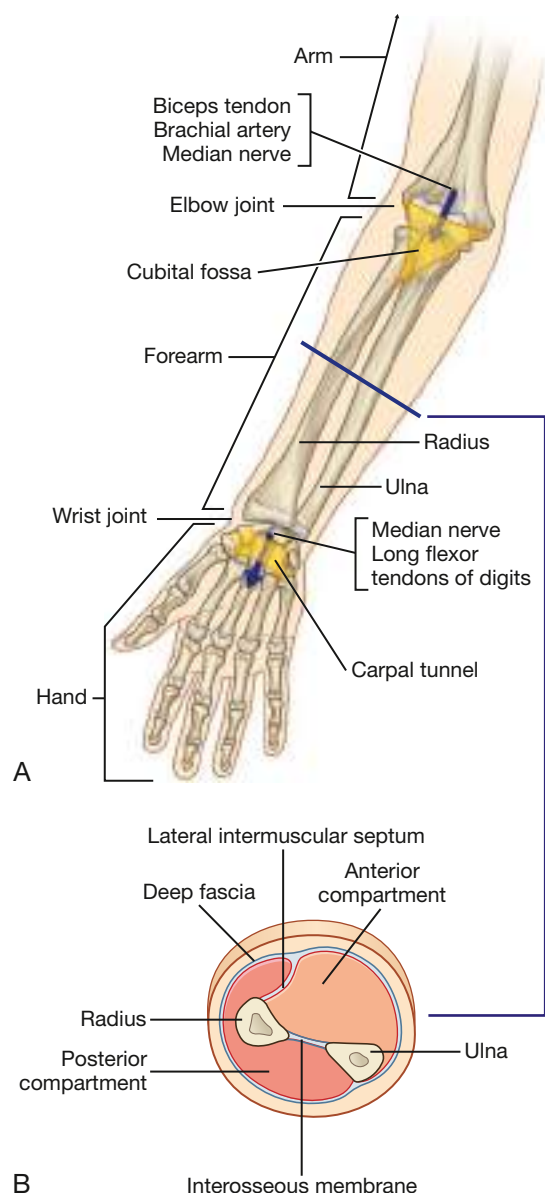


Fig. 7.63 Forearm. **A.** Proximal and distal relationships of the forearm. **B.** Transverse section through the middle of the forearm.

FOREARM

The forearm is the part of the upper limb that extends between the elbow joint and the wrist joint.

Structures pass between the forearm and the hand through, or anterior to, the carpal tunnel (Fig. 7.63A). The

major exception is the radial artery, which passes dorsally around the wrist to enter the hand posteriorly.

The bone framework of the forearm consists of two parallel bones, the radius and the ulna (Figs. 7.63A, 7.65). The radius is lateral in position and is small proximally where it articulates with the humerus and large distally where it forms the wrist joint with the carpal bones of the hand.

The ulna is medial in the forearm, and its proximal and distal dimensions are the reverse of those for the radius: the ulna is large proximally and small distally. Proximal and distal joints between the radius and the ulna allow the distal end of the radius to swing over the adjacent end of the ulna, resulting in pronation and supination of the hand.

As in the arm, the forearm is divided into anterior and posterior compartments (Fig. 7.63B). In the forearm, these compartments are separated by:

- a lateral intermuscular septum, which passes from the anterior border of the radius to deep fascia surrounding the limb;
- an interosseous membrane, which links adjacent borders of the radius and ulna along most of their length; and
- the attachment of deep fascia along the posterior border of the ulna.

Muscles in the anterior compartment of the forearm flex the wrist and digits and pronate the hand. Muscles in the posterior compartment extend the wrist and digits and supinate the hand. Major nerves and vessels supply or pass through each compartment.

Bones

Shaft and distal end of radius

The shaft of the radius is narrow proximally where it is continuous with the radial tuberosity and neck, and much broader distally where it expands to form the distal end (Fig. 7.64).

Throughout most of its length, the shaft of the radius is triangular in cross-section and has (Fig. 7.64):

- three borders (anterior, posterior, and interosseous), and
- three surfaces (anterior, posterior, and lateral).

The **anterior border** begins on the medial side of the bone as a continuation of the radial tuberosity. In the superior third of the bone, it crosses the shaft diagonally, from medial to lateral, as the oblique line of the radius. The **posterior border** is distinct only in the middle third of the bone. The **interosseous border** is sharp and is the attachment site for the interosseous membrane, which links the radius to the ulna.

The anterior and posterior surfaces of the radius are generally smooth, whereas an oval roughening for the attachment of pronator teres marks approximately the middle of the lateral surface of the radius.

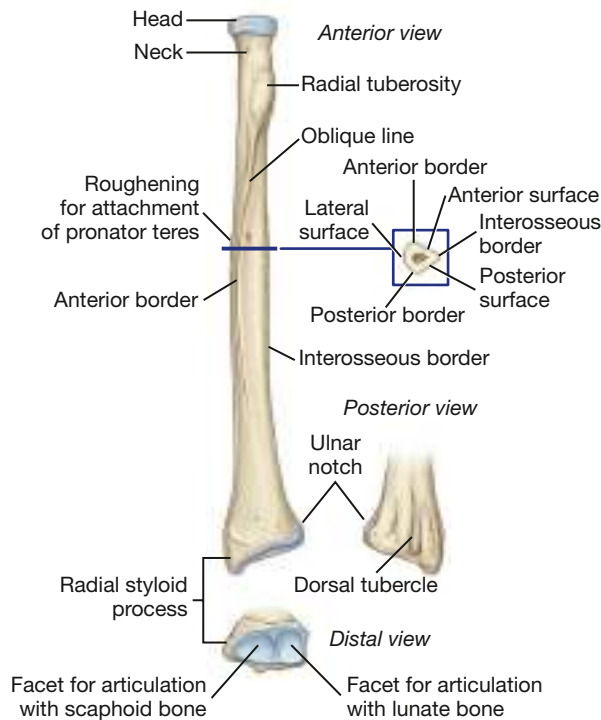


Fig. 7.64 Shaft and distal end of the right radius.

Imaging app

Visualizing the forearm



Fig. 7.65 Radiograph of the forearm (anteroposterior view).

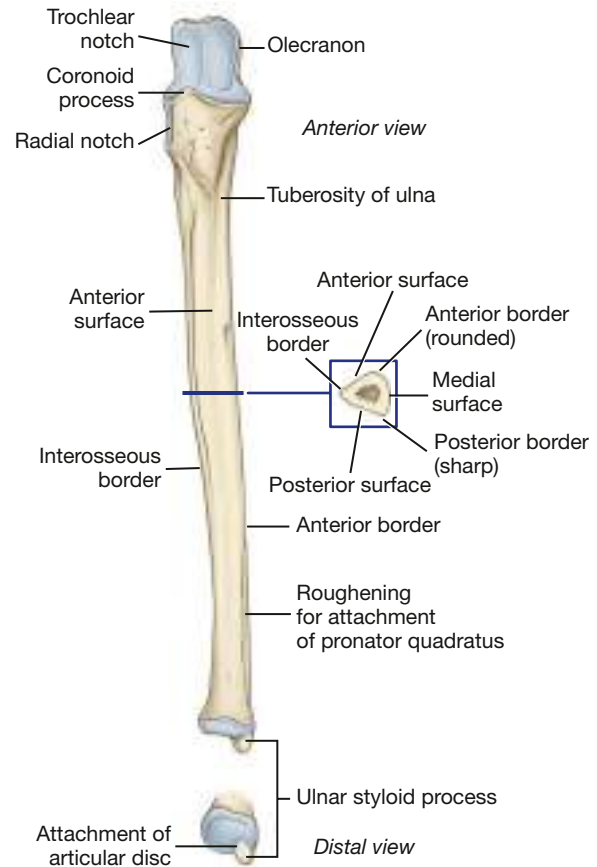


Fig. 7.66 Shaft and distal end of right ulna.

Viewed anteriorly, the distal end of the radius is broad and somewhat flattened anteroposteriorly (Fig. 7.64). Consequently, the radius has expansive anterior and posterior parts and narrow medial and lateral parts. Its anterior surface is smooth and unremarkable, except for the prominent sharp ridge that forms its lateral margin.

The posterior part of the radius is characterized by the presence of a large **dorsal tubercle** (Fig. 7.64) that acts as a pulley for the tendon of one of the extensor muscles of the thumb (extensor pollicis longus). The medial part is marked by a prominent facet for articulation with the distal end of the ulna (Fig. 7.64). The lateral part of the distal end of the radius is diamond shaped and extends distally as a **radial styloid process** (Fig. 7.64).

The distal end of the bone is marked by two facets for articulation with two carpal bones (the scaphoid and lunate) (Fig. 7.64).

Shaft and distal end of ulna

The shaft of the ulna is broad superiorly where it is continuous with the large proximal end and narrow distally to form a small distal head (Fig. 7.66). Like the radius, the shaft of the ulna is triangular in cross-section and has:



Upper Limb

- three borders (anterior, posterior, and interosseous), and
- three surfaces (anterior, posterior, and medial).

The **anterior border** is smooth and rounded. The **posterior border** is sharp and palpable along its entire length. The interosseous border is also sharp and is the attachment site for the interosseous membrane, which joins the ulna to the radius.

The **anterior surface** of the ulna is smooth, except distally where there is a prominent linear roughening for the attachment of the pronator quadratus muscle. The **medial surface** is smooth and unremarkable. The **posterior surface** is marked by lines that separate different regions of muscle attachments to bone.

The distal end of the ulna is small and characterized by a rounded head and the **ulnar styloid process** (Fig. 7.66). The anterolateral and distal part of the head is covered by articular cartilage. The ulnar styloid process originates from the posteromedial aspect of the ulna and projects distally.

Clinical app

Fractures of the radius and ulna

When a severe injury occurs to the forearm it usually involves both bones, resulting in either fracture of both bones or more commonly a fracture of one bone and a dislocation of the other. Commonly, the mechanism of injury and the age of the patient determine which of these are likely to occur. Whenever a fracture of the radius or ulna is demonstrated radiographically, further images of the elbow and wrist should be obtained to exclude dislocations.

Joints

Distal radioulnar joint

The distal radioulnar joint occurs between the articular surface of the head of the ulna with the ulnar notch on the end of the radius and with a fibrous articular disc, which separates the radioulnar joint from the wrist joint (Fig. 7.67).

The triangular-shaped articular disc is attached by its apex to a roughened depression on the ulna between the styloid process and the articular surface of the head and by its base to the angular margin of the radius between the ulnar notch and the articular surface for the carpal bones.

Synovial membrane is attached to the margins of the distal radioulnar joint and is covered on its external surface by a fibrous joint capsule.

The distal radioulnar joint allows the distal end of the radius to move anteromedially over the ulna.

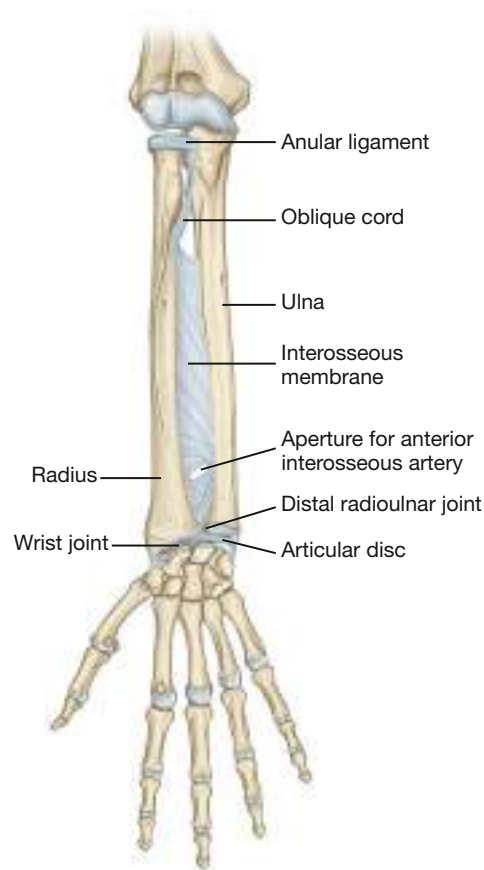


Fig. 7.67 Distal radioulnar joint and the interosseous membrane.

Interosseous membrane

The interosseous membrane is a thin fibrous sheet that connects the medial and lateral borders of the radius and ulna, respectively (Fig. 7.67). Collagen fibers within the sheet pass predominantly inferiorly from the radius to the ulna.

The interosseous membrane has a free upper margin that is situated just inferior to the radial tuberosity and a small circular aperture in its distal third. Vessels pass between the anterior and posterior compartments superior to the upper margin and through the inferior aperture.

The interosseous membrane connects the radius and ulna without restricting pronation and supination and provides attachment for muscles in the anterior and posterior compartments. The orientation of fibers in the membrane is also consistent with its role in transferring forces from the radius to the ulna and ultimately, therefore, from the hand to the humerus.

Pronation and supination

Pronation and supination of the hand occur entirely in the forearm and involve rotation of the radius at the elbow and movement of the distal end of the radius over the ulna (Fig. 7.68).

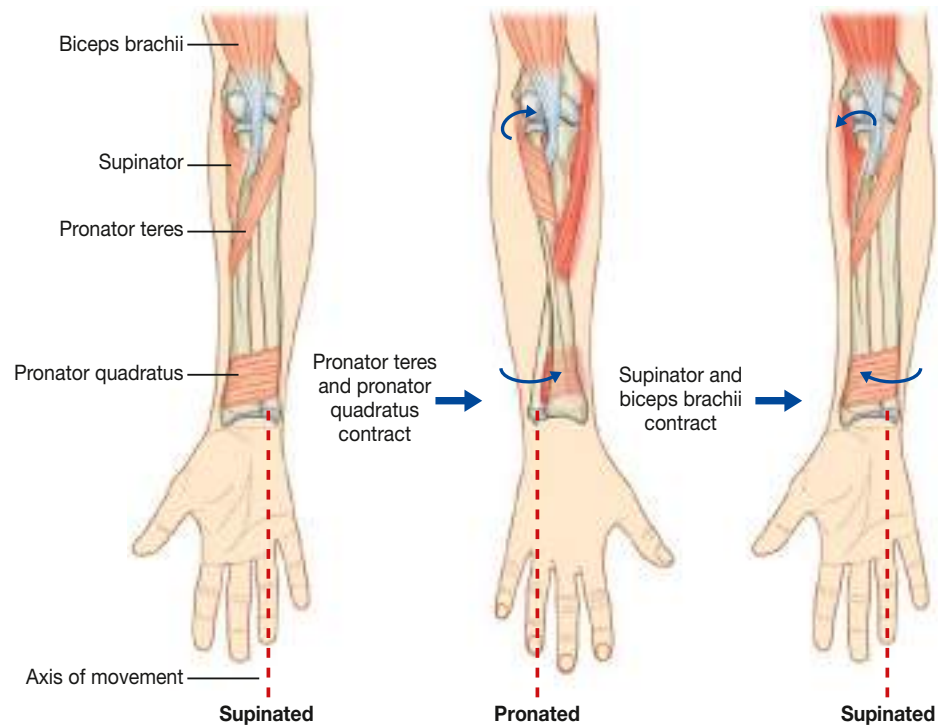


Fig. 7.68 Pronation and supination.

At the elbow, the superior articular surface of the radial head spins on the capitulum while the articular surface on the side of the head slides against the radial notch of the ulna and adjacent areas of the joint capsule and anular ligament of radius. At the distal radioulnar joint, the ulnar notch of the radius slides anteriorly over the convex surface of the head of the ulna. During these movements, the bones are held together by:

- the anular ligament of radius at the proximal radioulnar joint,
- the interosseous membrane along the lengths of the radius and ulna, and
- the articular disc at the distal radioulnar joint.

Because the hand articulates predominantly with the radius, the translocation of the distal end of the radius medially over the ulna moves the hand from the palm-anterior (supinated) position to the palm-posterior (pronated) position.

Two muscles (biceps brachii and supinator) supinate and two muscles (pronator teres and pronator quadratus) pronate the hand (Fig. 7.68).

Abduction of the ulna during pronation

Abduction of the distal end of the ulna occurs during pronation to maintain the position of the palm of the hand over a central point (Fig. 7.69). The muscle involved in this

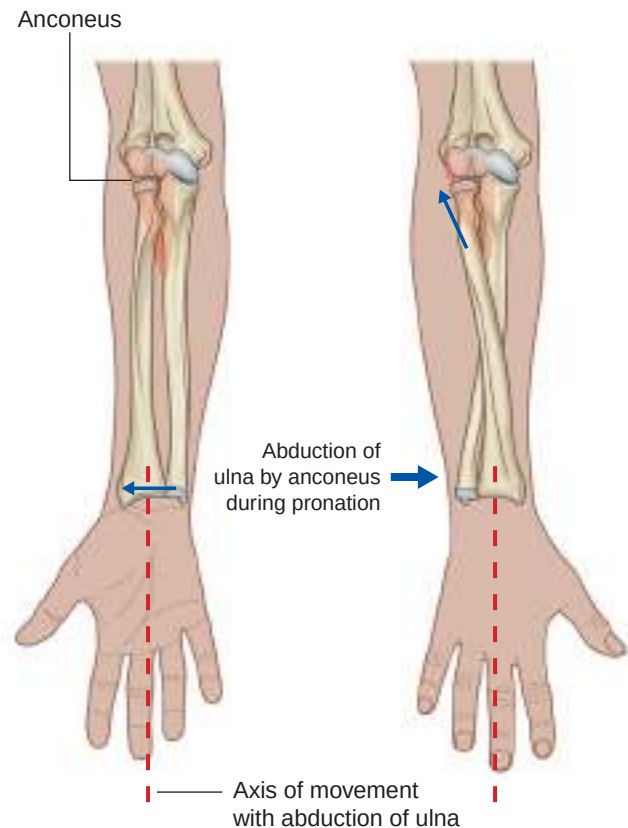


Fig. 7.69 Abduction of the distal end of the ulna by the anconeus muscle during pronation.



Table 7.10 Superficial layer of muscles in the anterior compartment of the forearm (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Flexor carpi ulnaris	Humeral head—medial epicondyle of humerus; ulnar head—olecranon and posterior border of ulna	Pisiform bone, and then via pisohamate and pisometacarpal ligaments into the hamate and base of metacarpal V	Ulnar nerve [C7, C8 , T1]	Flexes and adducts the wrist joint
Palmaris longus (absent in 15% of the population)	Medial epicondyle of humerus	Palmar aponeurosis of hand	Median nerve [C7 , C8]	Flexes wrist joint; because the palmar aponeurosis anchors skin of the hand, contraction of the muscle resists shearing forces when gripping
Flexor carpi radialis	Medial epicondyle of humerus	Base of metacarpals II and III	Median nerve [C6 , C7]	Flexes and abducts the wrist
Pronator teres	Humeral head—medial epicondyle and adjacent supraepicondylar ridge; ulnar head—medial side of coronoid process	Roughening on lateral surface, mid-shaft of radius	Median nerve [C6 , C7]	Pronation

movement is the anconeus muscle, which is a triangular muscle in the posterior compartment of the forearm that runs from the lateral epicondyle to the lateral surface of the proximal end of the ulna.

ANTERIOR COMPARTMENT OF THE FOREARM

Muscles

Muscles in the anterior (flexor) compartment of the forearm occur in three layers: superficial, intermediate, and deep. Generally, these muscles are associated with:

- movements of the wrist joint,
- flexion of the fingers including the thumb, and
- pronation.

All muscles in the anterior compartment of the forearm are innervated by the median nerve, except for the flexor carpi ulnaris muscle and the medial half of the flexor digitorum profundus muscle, which are innervated by the ulnar nerve.

Superficial layer

All four muscles in the superficial layer—the **flexor carpi ulnaris**, **palmaris longus**, **flexor carpi radialis**, and **pronator teres**—have a common origin from the medial epicondyle of the humerus and, except for the pronator teres, extend distally from the forearm into the hand (Table 7.10, Fig. 7.70).

Intermediate layer

The only muscle in the intermediate layer of the anterior compartment of the forearm is the **flexor digitorum superficialis** muscle (Table 7.11, Fig. 7.71).

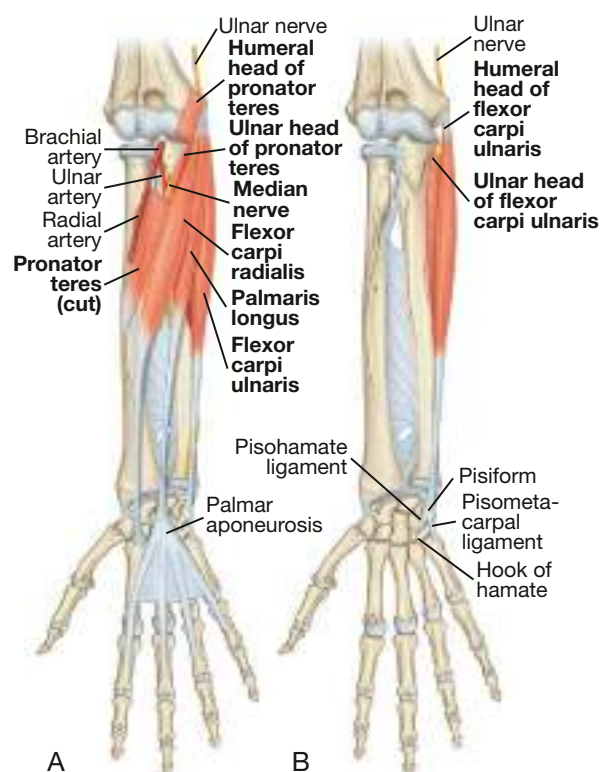


Fig. 7.70 Superficial layer of forearm muscles. **A.** Superficial muscles (flexor retinaculum not shown). **B.** Flexor carpi ulnaris muscle.

Deep layer

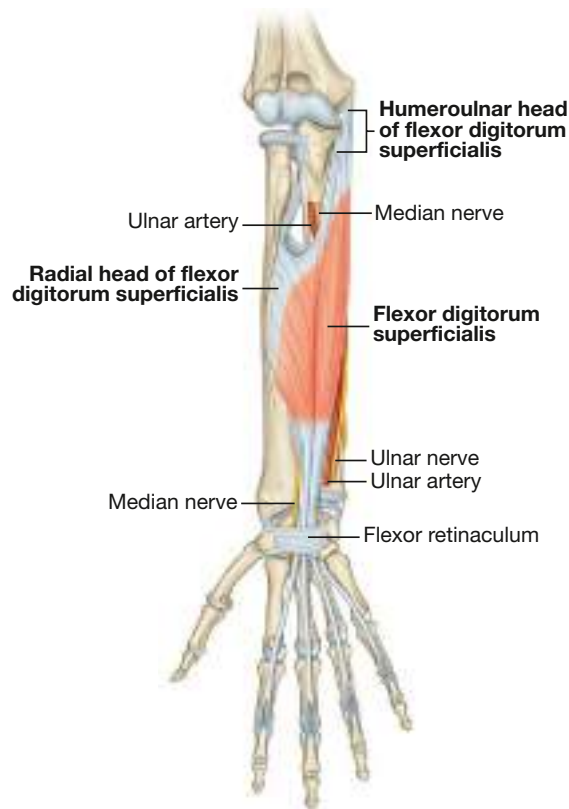
There are three deep muscles in the anterior compartment of the forearm: the **flexor digitorum profundus**, **flexor pollicis longus**, and **pronator quadratus** (Table 7.12, Fig. 7.72).

Arteries and veins

The largest arteries in the forearm are in the anterior compartment, pass distally to supply the hand, and give rise to vessels that supply the posterior compartment (Fig. 7.73).

Table 7.11 Intermediate layer of muscles in the anterior compartment of the forearm (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Flexor digitorum superficialis	Humeral head—medial epicondyle of humerus and adjacent margin of coronoid process; radial head—oblique line of radius	Four tendons that attach to the palmar surfaces of the middle phalanges of the index, middle, ring, and little fingers	Median nerve [C8, T1]	Flexes proximal interphalangeal joints of the index, middle, ring, and little fingers; can also flex metacarpophalangeal joints of the same fingers and the wrist joint

**Fig. 7.71** Intermediate layer of forearm muscles.

The brachial artery enters the forearm from the arm by passing through the cubital fossa. At the apex of the cubital fossa, it divides into its two major branches, the radial and ulnar arteries.

Radial artery

The radial artery originates from the brachial artery at approximately the neck of the radius and passes along the lateral aspect of the forearm (Fig. 7.73). It is:

- just deep to the brachioradialis muscle in the proximal half of the forearm;
- related on its lateral side to the superficial branch of the radial nerve in the middle third of the forearm;
- medial to the tendon of the brachioradialis muscle and covered only by deep fascia, superficial fascia, and skin in the distal forearm.

In the distal forearm, the radial artery lies immediately lateral to the large tendon of the flexor carpi radialis muscle and directly anterior to the pronator quadratus muscle and the distal end of the radius (Fig. 7.73).

The radial artery leaves the forearm, passes around the lateral side of the wrist, and penetrates the posterolateral aspect of the hand between the bases of metacarpals I and II (Fig. 7.73). Branches of the radial artery in the hand often provide the major blood supply to the thumb and lateral side of the index finger.

Branches of the radial artery originating in the forearm include:

- a **radial recurrent artery**, which contributes to an anastomotic network around the elbow joint and to numerous vessels that supply muscles on the lateral side of the forearm (see Fig. 7.53B);
- a small **palmar carpal branch**, which contributes to an anastomotic network of vessels that supply the carpal bones and joints; and
- a somewhat larger branch, the **superficial palmar branch**, which enters the hand by passing through, or superficial to, the thenar muscles at the base of the thumb (Fig. 7.73), which anastomoses with the superficial palmar arch formed by the ulnar artery.

Ulnar artery

The ulnar artery is larger than the radial artery and passes down the medial side of the forearm (Fig. 7.73). It leaves the cubital fossa by passing deep to the pronator teres muscle and then passes through the forearm in the fascial plane between the flexor carpi ulnaris and flexor digitorum profundus muscles.

In the distal forearm, the ulnar artery often remains tucked under the lateral lip of the flexor carpi ulnaris tendon.

In distal regions of the forearm, the ulnar nerve is immediately medial to the ulnar artery.

The ulnar artery leaves the forearm, enters the hand by passing lateral to the pisiform bone and superficial to the flexor retinaculum of the wrist, and arches over the palm (Fig. 7.73). It is often the major blood supply to the medial three and one-half digits.

Table 7.12 Deep layer of muscles in the anterior compartment of the forearm (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Flexor digitorum profundus	Anterior and medial surfaces of ulna and anterior medial half of interosseous membrane	Four tendons, which attach to the palmar surfaces of the distal phalanges of the index, middle, ring, and little fingers	Lateral half by median nerve (anterior interosseous nerve); medial half by ulnar nerve [C8 , T1]	Flexes distal interphalangeal joints of the index, middle, ring, and little fingers; can also flex metacarpophalangeal joints of the same fingers and the wrist joint
Flexor pollicis longus	Anterior surface of radius and radial half of interosseous membrane	Palmar surface of base of distal phalanx of thumb	Median nerve (anterior interosseous nerve) [C7 , C8]	Flexes interphalangeal joint of the thumb; can also flex metacarpophalangeal joint of the thumb
Pronator quadratus	Linear ridge on distal anterior surface of ulna	Distal anterior surface of radius	Median nerve (anterior interosseous nerve) [C7 , C8]	Pronation

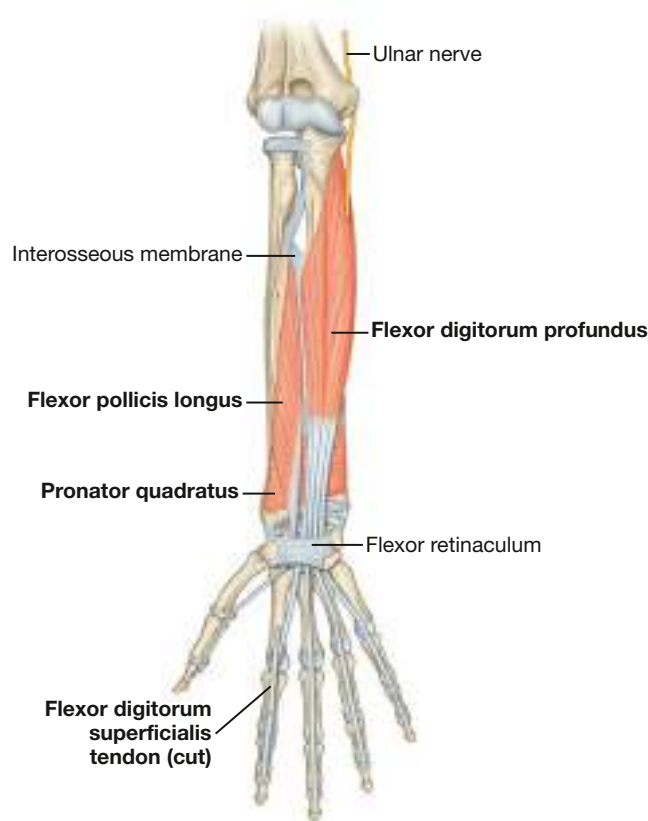


Fig. 7.72 Deep layer of forearm muscles.

Branches of the ulnar artery that arise in the forearm include:

- the **ulnar recurrent artery** with **anterior** and **posterior branches**, which contribute to an anastomotic network of vessels around the elbow joint (see Fig. 7.53B);
- numerous muscular arteries, which supply surrounding muscles;
- the **common interosseous artery**, which divides into **anterior** and **posterior interosseous arteries** (Fig. 7.73); and

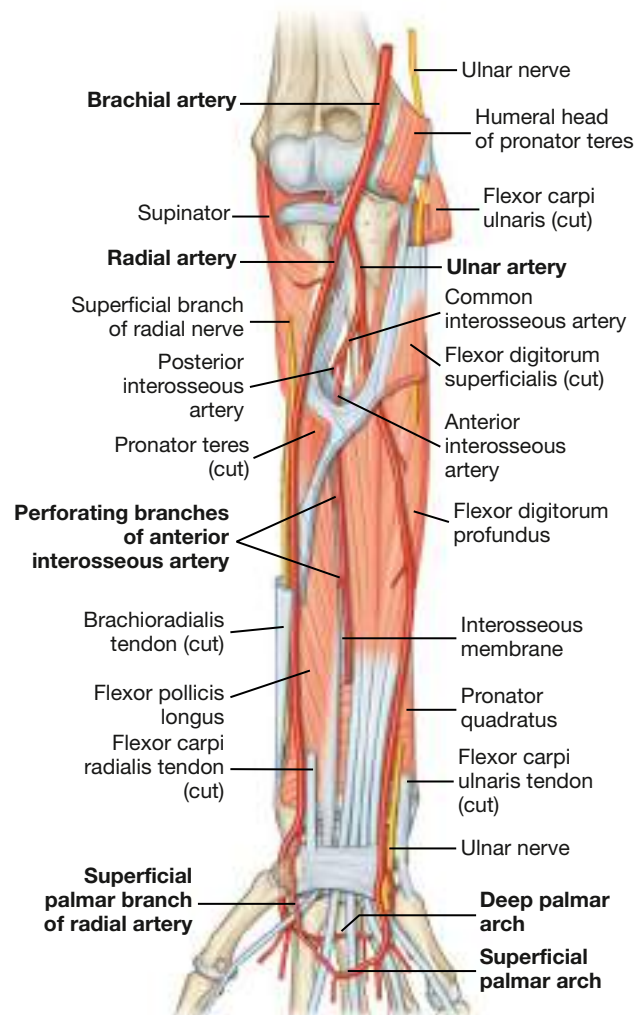


Fig. 7.73 Arteries of the anterior compartment of the forearm.

- two small carpal arteries (**dorsal carpal branch** and **palmar carpal branch**), which supply the wrist.

The **posterior interosseous artery** passes dorsally over the proximal margin of the interosseous membrane into the posterior compartment of the forearm.

The **anterior interosseous artery** passes distally along the anterior aspect of the interosseous membrane and supplies muscles of the deep compartment of the forearm and the radius and ulna (Fig. 7.73). It has numerous branches, which perforate the interosseous membrane to supply deep muscles of the posterior compartment; it also has a small branch, which contributes to the vascular network around the carpal bones and joints. Perforating the interosseous membrane in the distal forearm, the anterior interosseous artery terminates by joining the posterior interosseous artery.

Veins

Deep veins of the anterior compartment generally accompany the arteries and ultimately drain into brachial veins associated with the brachial artery in the cubital fossa.

Nerves

Nerves in the anterior compartment of the forearm are the median and ulnar nerves and the superficial branch of the radial nerve (Fig. 7.74).

Median nerve

The median nerve innervates the muscles in the anterior compartment of the forearm except for the flexor carpi ulnaris and the medial part of the flexor digitorum profundus (ring and little fingers). It leaves the cubital fossa by passing between the two heads of the pronator teres muscle and passing between the humeroulnar and radial heads of the flexor digitorum superficialis muscle (Fig. 7.74).

The median nerve continues a straight linear course distally down the forearm in the fascia on the deep surface of the flexor digitorum superficialis muscle. Just proximal to the wrist, it moves around the lateral side of the muscle and becomes more superficial in position, lying between the tendons of the palmaris longus and flexor carpi radialis muscles. It leaves the forearm and enters the palm of the hand by passing through the carpal tunnel deep to the flexor retinaculum (Fig. 7.74).

Most branches to the muscles in the superficial and intermediate layers of the forearm originate medially from the nerve just distal to the elbow joint (Fig. 7.74).

The largest branch of the median nerve in the forearm is the **anterior interosseous nerve**, which originates between the two heads of the pronator teres. It passes distally down the forearm with the anterior interosseous artery, innervates the muscles in the deep layer (the flexor pollicis longus, the lateral half of flexor digitorum profundus, and pronator quadratus), and terminates as articular branches to joints of the distal forearm and wrist.

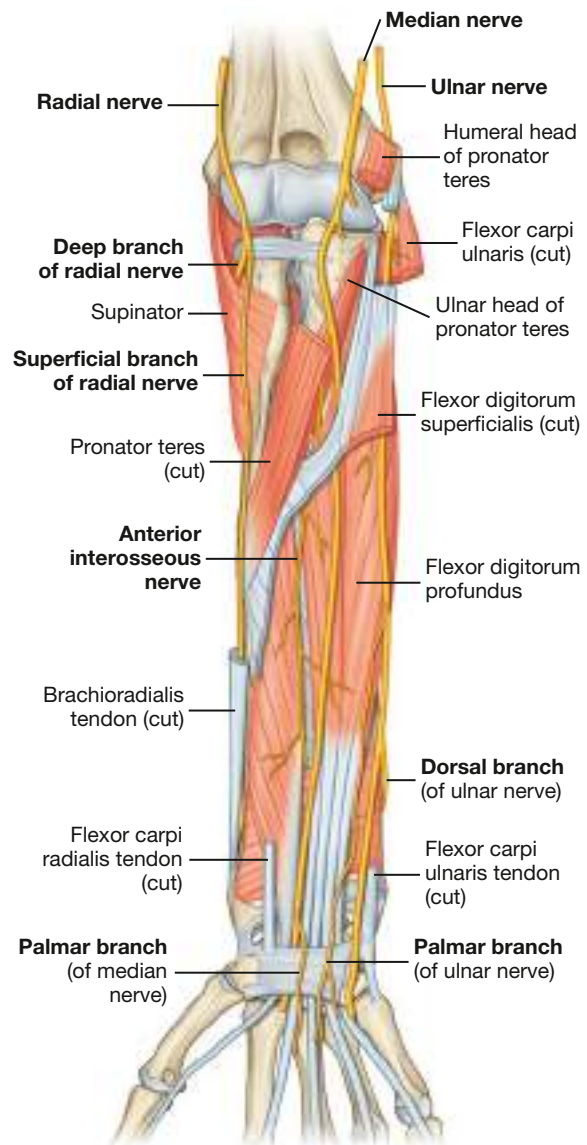


Fig. 7.74 Nerves of anterior forearm.

A small **palmar branch** originates from the median nerve in the distal forearm immediately proximal to the flexor retinaculum, passes superficial to the flexor retinaculum of the wrist into the hand, and innervates the skin over the base and central palm.

Ulnar nerve

The ulnar nerve passes through the forearm and into the hand where most of its major branches occur. In the forearm, the ulnar nerve innervates only the flexor carpi ulnaris muscle and the medial part (ring and little fingers) of the flexor digitorum profundus muscle (Fig. 7.74).

The ulnar nerve enters the anterior compartment of the forearm by passing posteriorly around the medial epicondyle of the humerus and between the humeral and ulnar heads



Upper Limb

of the flexor carpi ulnaris muscle. After passing down the medial side of the forearm in the plane between the flexor carpi ulnaris and the flexor digitorum profundus muscles, it lies under the lateral lip of the tendon of the flexor carpi ulnaris proximal to the wrist.

The ulnar artery is lateral to the ulnar nerve in the distal two-thirds of the forearm, and both the ulnar artery and nerve enter the hand by passing superficial to the flexor retinaculum and immediately lateral to the pisiform bone (Fig. 7.74).

In the forearm the ulnar nerve gives rise to:

- **muscular branches** to the flexor carpi ulnaris and to the medial half of the flexor digitorum profundus that arise soon after the ulnar nerve enters the forearm; and
- two small cutaneous branches—the **palmar branch** originates in the middle of the forearm and passes into the hand to supply skin on the medial side of the palm (Fig. 7.74), and the larger **dorsal branch** originates from the ulnar nerve in the distal forearm and passes posteriorly deep to the tendon of the flexor carpi ulnaris and innervates skin on the posteromedial side of the back of the hand and most skin on the posterior surfaces of the medial one and one-half digits (Fig. 7.74).

Radial nerve

The radial nerve bifurcates into deep and superficial branches under the margin of the brachioradialis muscle in the lateral border of the cubital fossa (Fig. 7.74).

The **deep branch** is predominantly motor and passes between the superficial and deep layers of the supinator muscle to access and supply muscles in the posterior compartment of the forearm.

The **superficial branch** of the radial nerve is sensory. It passes down the anterolateral aspect of the forearm deep to the brachioradialis muscle and in association with the radial artery. Approximately two-thirds of the way down the forearm, the superficial branch of the radial nerve passes laterally and posteriorly around the radial side of the forearm deep to the tendon of the brachioradialis. The nerve continues into the hand where it innervates skin on the posterolateral surface.

POSTERIOR COMPARTMENT OF THE FOREARM

Muscles

Muscles in the posterior compartment of the forearm occur in two layers: a superficial and a deep layer. The muscles are associated with:

- movement of the wrist joint,
- extension of the fingers and thumb, and
- supination.

All muscles in the posterior compartment of the forearm are innervated by the radial nerve.

Superficial layer

The seven muscles in the superficial layer are the **brachioradialis**, **extensor carpi radialis longus**, **extensor carpi radialis brevis**, **extensor digitorum**, **extensor digiti minimi**, **extensor carpi ulnaris**, and **anconeus** (Table 7.13, Fig. 7.75). All have a common origin from the supraepicondylar ridge and lateral epicondyle of the humerus and, except for the brachioradialis and anconeus, extend as tendons into the hand.

Deep layer

The deep layer of the posterior compartment of the forearm consists of five muscles: **supinator**, **abductor pollicis longus**, **extensor pollicis brevis**, **extensor pollicis longus**, and **extensor indicis** (Table 7.14, Fig. 7.76).

Except for the supinator muscle, all these deep layer muscles originate from the posterior surfaces of the radius, ulna, and interosseous membrane and pass into the thumb and fingers.

Three of these muscles—the abductor pollicis longus, extensor pollicis brevis, and extensor pollicis longus—emerge from between the extensor digitorum and the extensor carpi radialis brevis tendons of the superficial layer and pass into the thumb.

Two of these three “outcropping” muscles (the abductor pollicis longus and extensor pollicis brevis) form a distinct muscular bulge in the distal posterolateral surface of the forearm.

All muscles of the deep layer are innervated by the posterior interosseous nerve, the continuation of the deep branch of the radial nerve.

Arteries and veins

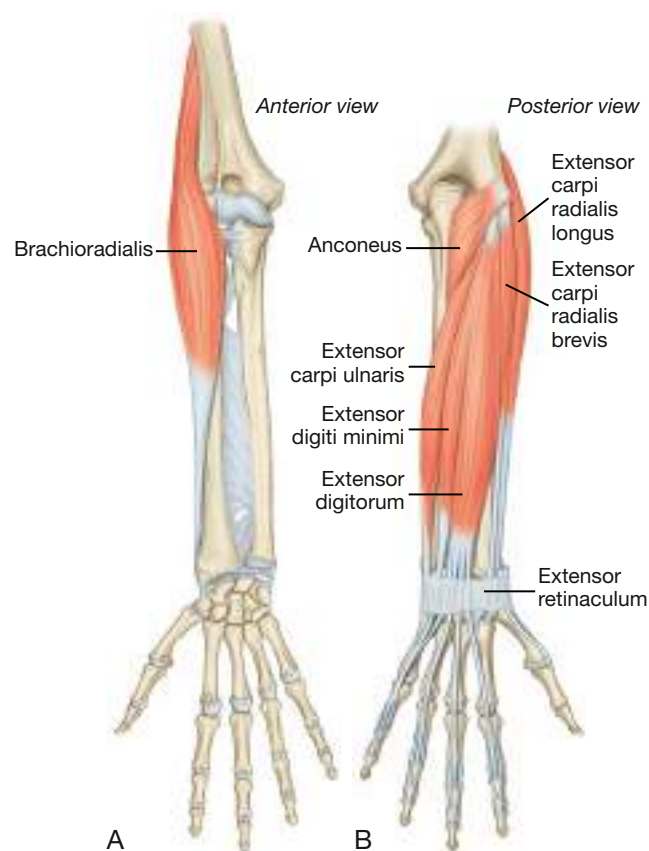
The blood supply to the posterior compartment of the forearm occurs predominantly through branches of the radial, posterior interosseous, and anterior interosseous arteries (Fig. 7.77; also see Fig. 7.73).

Posterior interosseous artery

The posterior interosseous artery originates in the anterior compartment from the common interosseous branch of the ulnar artery and passes posteriorly over the proximal margin of the interosseous membrane and into the posterior compartment of the forearm (see Fig. 7.73). It contributes a branch, the **recurrent**

Table 7.13 Superficial layer of muscles in the posterior compartment of the forearm (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Brachioradialis	Proximal part of lateral supraepicondylar ridge of humerus and adjacent intermuscular septum	Lateral surface of distal end of radius	Radial nerve [C5, C6] before division into superficial and deep branches	Accessory flexor of elbow joint when forearm is mid-pronated
Extensor carpi radialis longus	Distal part of lateral supraepicondylar ridge of humerus and adjacent intermuscular septum	Dorsal surface of base of metacarpal II	Radial nerve [C6 , C7] before division into superficial and deep branches	Extends and abducts the wrist
Extensor carpi radialis brevis	Lateral epicondyle of humerus and adjacent intermuscular septum	Dorsal surface of base of metacarpals II and III	Deep branch of radial nerve [C7 , C8] before penetrating supinator muscle	Extends and abducts the wrist
Extensor digitorum	Lateral epicondyle of humerus and adjacent intermuscular septum and deep fascia	Four tendons, which insert via extensor hoods into the dorsal aspects of the bases of the middle and distal phalanges of the index, middle, ring, and little fingers	Posterior interosseous nerve [C7 , C8]	Extends the index, middle, ring, and little fingers; can also extend the wrist
Extensor digiti minimi	Lateral epicondyle of humerus and adjacent intermuscular septum together with extensor digitorum	Extensor hood of the little finger	Posterior interosseous nerve [C7 , C8]	Extends the little finger
Extensor carpi ulnaris	Lateral epicondyle of humerus and posterior border of ulna	Tubercle on the base of the medial side of metacarpal V	Posterior interosseous nerve [C7 , C8]	Extends and adducts the wrist
Anconeus	Lateral epicondyle of humerus	Olecranon and proximal posterior surface of ulna	Radial nerve [C6, C7, C8] (via branch to medial head of triceps brachii)	Abduction of the ulna in pronation; accessory extensor of the elbow joint

**Fig. 7.75** Superficial layer of muscles in the posterior compartment of the forearm. **A.** Brachioradialis muscle (anterior view). **B.** Superficial muscles (posterior view).

interosseous artery (see Fig. 7.53B) to the vascular network around the elbow joint and then passes between the supinator and abductor pollicis longus muscles to supply the superficial extensors (Fig. 7.77). After receiving the terminal end of the anterior interosseous artery, the posterior interosseous artery terminates by joining the dorsal carpal arch of the wrist.

Anterior interosseous artery

The anterior interosseous artery, also a branch of the common interosseous branch of the ulnar artery (see Fig. 7.73), is situated in the anterior compartment of the forearm on the interosseous membrane. It has numerous perforating branches that pass directly through the interosseous membrane to supply deep muscles of the posterior compartment. The terminal end of the anterior interosseous artery passes posteriorly through an aperture in the interosseous membrane in distal regions of the forearm to join the posterior interosseous artery (Fig. 7.77).

Radial artery

The radial artery has muscular branches that contribute to the supply of the extensor muscles on the radial side of the forearm.

Veins

Deep veins of the posterior compartment generally accompany the arteries. They ultimately drain into brachial veins associated with the brachial artery in the cubital fossa.



Upper Limb

Table 7.14 Deep layer of muscles in the posterior compartment of the forearm (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscle	Origin	Insertion	Innervation	Function
Supinator	Superficial layer—lateral epicondyle of humerus, radial collateral and anular ligaments; deep layer—supinator crest of the ulna	Lateral surface of radius superior to the anterior oblique line	Posterior interosseous nerve [C6 , C7]	Supination
Abductor pollicis longus	Posterior surfaces of ulna and radius (distal to the attachments of supinator and anconeus), and intervening interosseous membrane	Lateral side of base of metacarpal I	Posterior interosseous nerve [C7 , C8]	Abducts carpometacarpal joint of thumb; accessory extensor of the thumb
Extensor pollicis brevis	Posterior surface of radius (distal to abductor pollicis longus) and the adjacent interosseous membrane	Dorsal surface of base of proximal phalanx of the thumb	Posterior interosseous nerve [C7 , C8]	Extends metacarpophalangeal joint of the thumb; can also extend the carpometacarpal joint of the thumb
Extensor pollicis longus	Posterior surface of ulna (distal to the abductor pollicis longus) and the adjacent interosseous membrane	Dorsal surface of base of distal phalanx of thumb	Posterior interosseous nerve [C7 , C8]	Extends interphalangeal joint of the thumb; can also extend carpometacarpal and metacarpophalangeal joints of the thumb
Extensor indicis	Posterior surface of ulna (distal to extensor pollicis longus) and adjacent interosseous membrane	Extensor hood of index finger	Posterior interosseous nerve [C7 , C8]	Extends index finger

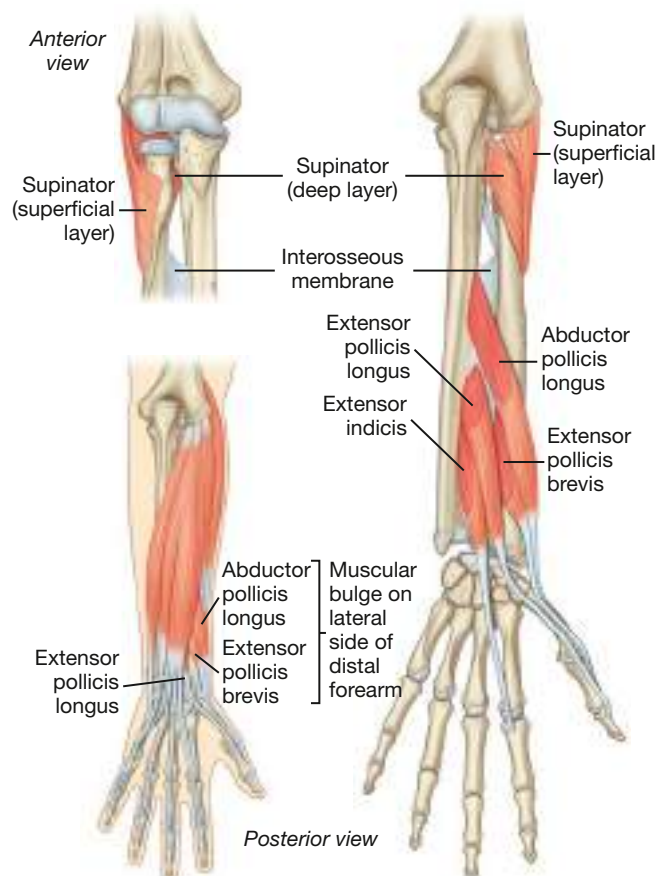


Fig. 7.76 Deep layer of muscles in the posterior compartment of the forearm.

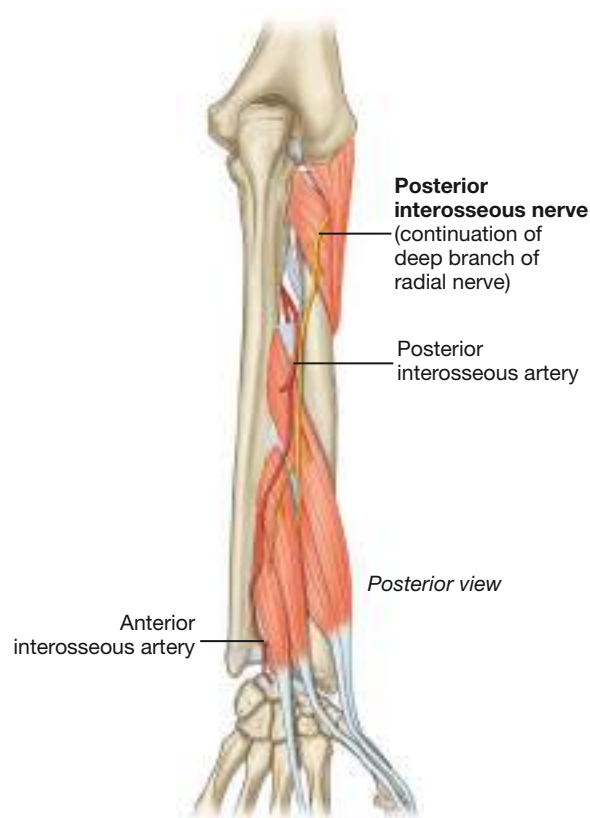


Fig 7.77 Arteries and radial nerve in the posterior compartment of the forearm.

Nerves

Radial nerve

The nerve of the posterior compartment of the forearm is the radial nerve (Fig. 7.77). Most of the muscles are innervated by the deep branch, which originates from the radial nerve in the lateral wall of the cubital fossa deep to the brachioradialis muscle and becomes the **posterior interosseous nerve** (Fig. 7.77), after emerging from between the two layers of the supinator muscle in the posterior compartment of the forearm (Fig. 7.77).

In the lateral wall of the cubital fossa and before dividing into **superficial** and **deep branches**, the radial nerve innervates the brachioradialis and extensor carpi radialis longus muscles.

The deep branch innervates the extensor carpi radialis brevis then passes between the two heads of the supinator muscle and follows the plane of separation between the two heads dorsally and laterally around the proximal shaft of the radius to the posterior aspect of the forearm. It supplies the supinator muscle and then emerges as the **posterior interosseous nerve** from the muscle to lie between the superficial and deep layers of muscles.

The posterior interosseous nerve supplies the remaining muscles in the posterior compartment and terminates as articular branches, which pass deep to the extensor pollicis longus muscle to reach the wrist.

Surface anatomy

Identifying tendons and locating major vessels and nerves in the distal forearm

Tendons that pass from the forearm into the hand are readily visible in the distal forearm and can be used as landmarks to locate major vessels and nerves.

In the anterior aspect of the distal forearm, the tendons of the flexor carpi radialis, flexor carpi ulnaris, and palmaris longus

muscles can be easily located either by palpating or by asking a patient to flex the wrist against resistance (Fig. 7.78A).

The tendon of flexor carpi radialis is located approximately at the junction between the lateral and middle thirds of an imaginary line drawn transversely across the distal forearm. The radial artery is immediately lateral to this tendon, and this site is used for taking a radial pulse (Fig. 7.78A).

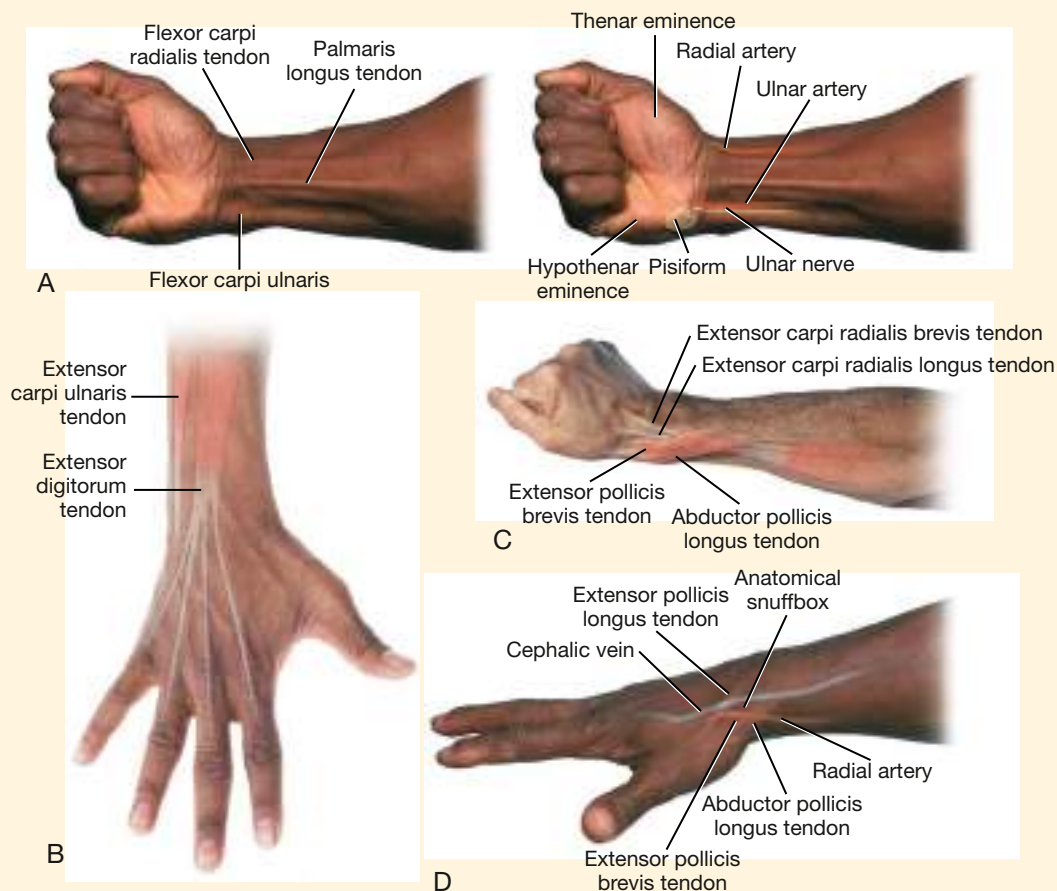


Fig. 7.78 Identifying tendons and locating major vessels and nerves in the distal right forearm. **A.** Anterior distal forearm and wrist. **B.** Posterior distal forearm and wrist. **C.** Lateral view of posterior wrist and forearm. **D.** Anatomical snuffbox.



Surface anatomy—cont'd

The tendon of the flexor carpi ulnaris is easily palpated along the medial margin of the forearm and inserts on the pisiform, which can also be palpated by following the tendon to the base of the hypothenar eminence of the hand (Fig. 7.78A). The ulnar artery and ulnar nerve travel through the distal forearm and into the hand under the lateral lip of the flexor carpi ulnaris tendon and lateral to the pisiform (Fig. 7.78A).

The palmaris longus tendon may be absent but, when present, lies medial to the flexor carpi radialis tendon and is particularly prominent when the wrist is flexed against resistance (Fig. 7.78A). The median nerve is also medial to the flexor carpi radialis tendon and lies under the palmaris longus tendon.

The long tendons of the digits of the hand are deep to the median nerve and between the long flexors of the wrist. Their position can be visualized by rapidly and repeatedly flexing and extending the fingers from medial to lateral.

In the posterior distal forearm and wrist, the tendons of the extensor digitorum (Fig. 7.78B) are in the midline and radiate into the index, middle, ring, and little fingers from the wrist.

The distal ends of the tendons of the extensor carpi radialis longus and brevis muscles are on the lateral side of the wrist

(Fig. 7.78C) and can be accentuated by making a tight fist and extending the wrist against resistance.

The tendon of the extensor carpi ulnaris can be felt on the far medial side of the wrist between the distal end of the ulna and the wrist (Fig. 7.78B).

Hyperextension and abduction of the thumb reveals the anatomical snuffbox (Fig. 7.78D). The medial margin of this triangular area is the tendon of the extensor pollicis longus, which swings around the dorsal tubercle of the radius and then travels into the thumb. The lateral margin is formed by the tendons of the extensor pollicis brevis and abductor pollicis longus. The radial artery passes through the anatomical snuffbox when traveling laterally around the wrist to reach the back of the hand and penetrate the base of the first dorsal interosseous muscle to access the deep aspect of the palm of the hand. The pulse of the radial artery can be felt in the floor of the anatomical snuffbox in the relaxed wrist (Fig. 7.78D). The cephalic vein crosses the roof of the anatomical snuffbox, and cutaneous branches of the radial nerve can be felt by moving a finger back and forth along the tendon of the extensor pollicis longus muscle.

HAND

The hand (Fig. 7.79) is the region of the upper limb distal to the wrist joint and is a mechanical and sensory tool. It is subdivided into three parts:

- the wrist (carpus),
- the metacarpus, and
- the digits (five fingers including the thumb).

The five digits consist of the laterally positioned thumb; medial to the thumb are the remaining four fingers—the index, middle, ring, and little fingers.

In the normal resting position, the fingers form a flexed arcade, with the little finger flexed most and the index finger flexed least. In the anatomical position, the fingers are extended.

The hand has an anterior surface (**palm**) and a dorsal surface (**dorsum of hand**).

Abduction and adduction of the fingers are defined with respect to the long axis of the middle finger (Fig. 7.79). In the anatomical position, the long axis of the thumb is rotated 90° to the rest of the digits so that the pad of the thumb points medially; consequently, movements of the thumb are defined at right angles to the movements of the other digits of the hand.

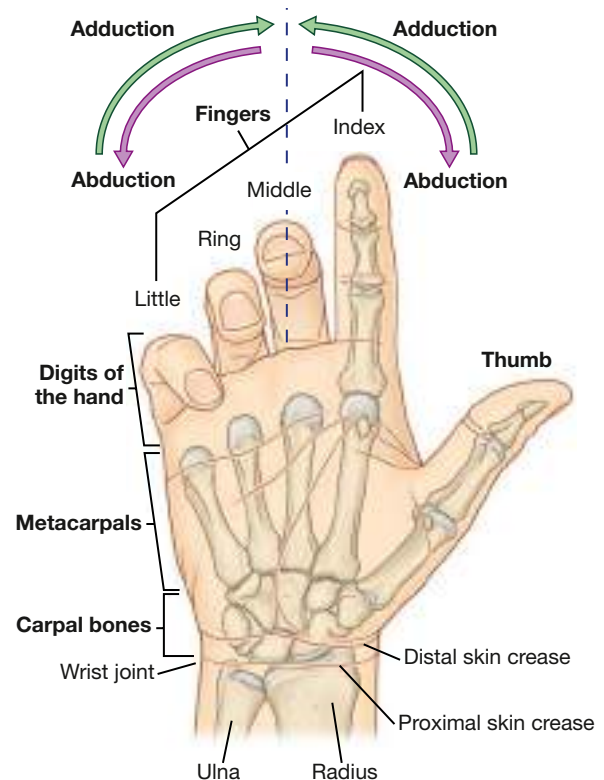


Fig. 7.79 Right hand. The fingers are shown in a normal resting arcade in which they are flexed. In the anatomical position, the digits are straight and adducted.

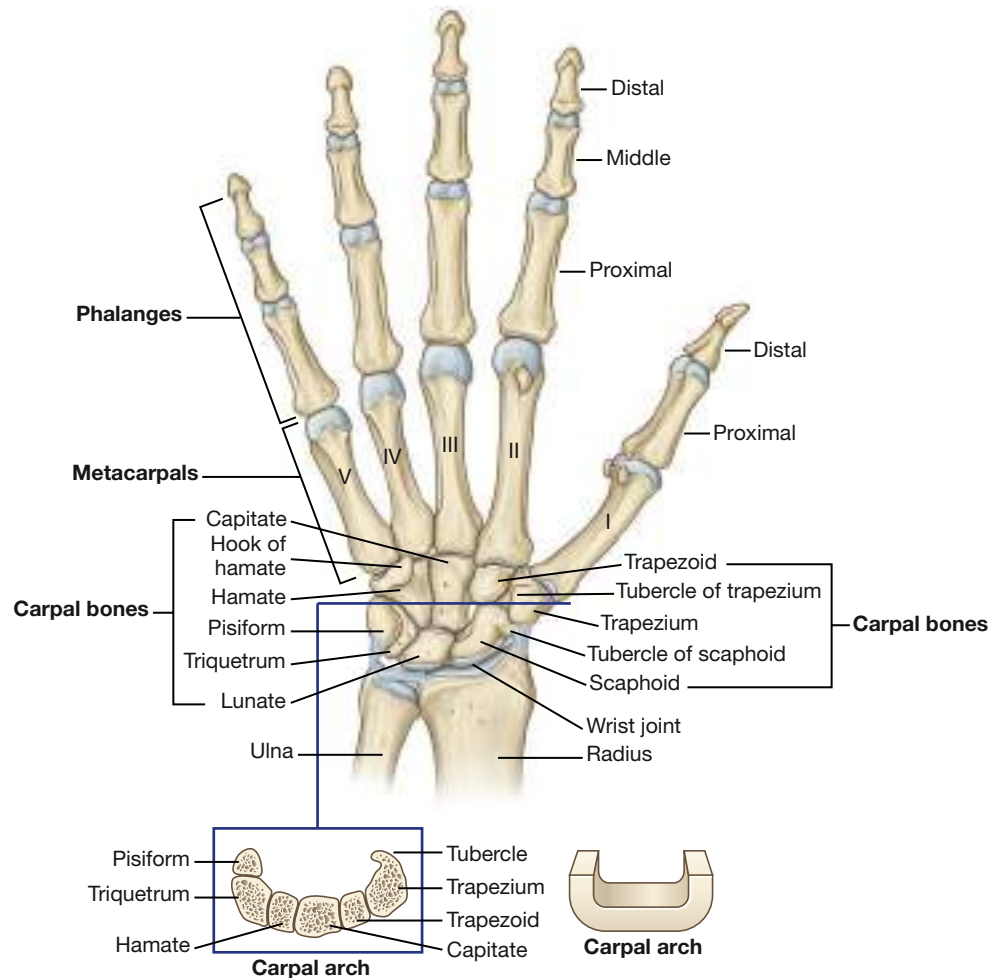


Fig 7.80 Bones of the right hand and wrist.

Bones

There are three groups of bones in the hand (Figs. 7.80; 7.81A):

- The eight **carpal bones** are the bones of the wrist.
- The five **metacarpals (I to V)** are the bones of the metacarpus.
- The **phalanges** are the bones of the digits—the thumb has only two, the rest of the digits have three (Fig. 7.80).

The carpal bones and metacarpals of the index, middle, ring, and little fingers (metacarpals II to V) tend to function as a unit and form much of the bony framework of the palm. The metacarpal bone of the thumb functions independently and has increased flexibility at the carpometacarpal joint to provide opposition of the thumb to the fingers.

Carpal bones

The small carpal bones of the wrist are arranged in two rows, a proximal and a distal row, each consisting of four bones (Fig. 7.80).

Proximal row

From lateral to medial and when viewed anteriorly, the proximal row of bones consists of (Fig. 7.80):

- the boat-shaped **scaphoid**,
- the **lunate**, which has a crescent shape,
- the three-sided **triquetrum**, and
- the pea-shaped **pisiform**.

The pisiform is a sesamoid bone in the tendon of the flexor carpi ulnaris and articulates with the anterior surface of the triquetrum.

The scaphoid has a prominent **tubercle** on its lateral palmar surface that is directed anteriorly.

Distal row

From lateral to medial and when viewed anteriorly, the distal row of carpal bones consists of (Fig. 7.80):

- the irregular four-sided **trapezium**,



Upper Limb

- the four-sided **trapezoid**,
- the **capitate**, which has a head, and
- the **hamate**, which has a hook.

The trapezium articulates with the metacarpal bone of the thumb and has a distinct **tubercle** on its palmar surface that projects anteriorly.

The largest of the carpal bones, the capitate, articulates with the base of metacarpal III.

The hamate, which is positioned just lateral and distal to the pisiform, has a prominent hook (**hook of hamate**) on its palmar surface that projects anteriorly.

Articular surfaces

The carpal bones have numerous articular surfaces (Fig. 7.80). All of them articulate with each other, and the carpal bones in the distal row articulate with the metacarpals of the digits. With the exception of the metacarpal of the thumb, all movements of the metacarpal bones on the carpal bones are limited.

The expansive proximal surfaces of the scaphoid and lunate articulate with the radius to form the wrist joint (Figs. 7.80, 7.81B).

Carpal arch

The carpal bones do not lie in a flat plane; rather they form an arch whose base is directed anteriorly (Fig. 7.80). The lateral side of this base is formed by the tubercles of the scaphoid and trapezium. The medial side is formed by the pisiform and the hook of hamate.

The flexor retinaculum attaches to and spans the distance between the medial and lateral sides of the base to form the anterior wall of the so-called carpal tunnel. The sides and roof of the carpal tunnel are formed by the arch of the carpal bones.

Metacarpals

Each of the five metacarpal bones is related to one digit (Figs. 7.80, 7.81A):

- Metacarpal I is related to the thumb.
- Metacarpals II to V are related to the index, middle, ring, and little fingers, respectively.

Each metacarpal consists of a **base**, a **shaft (body)**, and, distally, a **head**.

Imaging app

Visualizing the hand and wrist joint

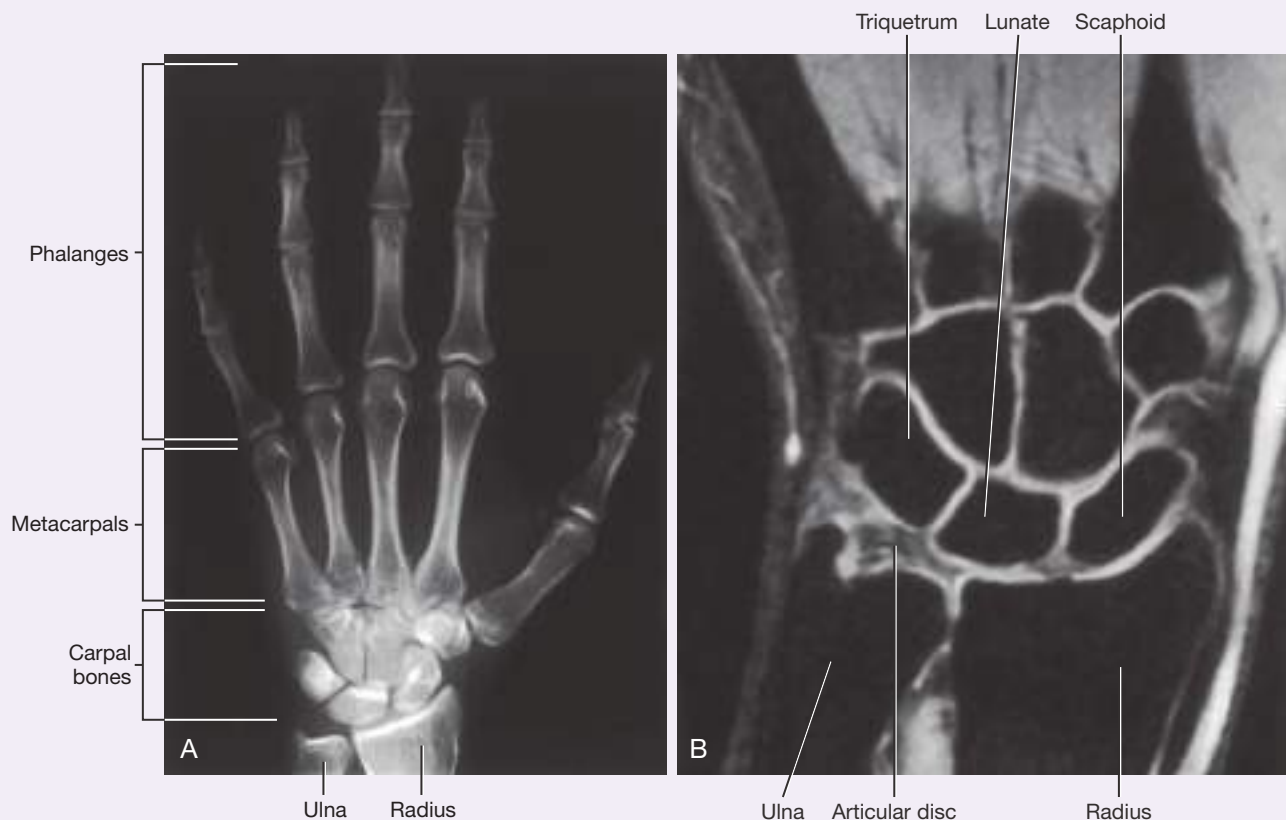


Fig. 7.81 Hand and wrist joint. **A.** Radiograph of a normal hand and wrist joint (anteroposterior view). **B.** Magnetic resonance image of a normal wrist joint in the coronal plane.

All of the bases of the metacarpals articulate with the carpal bones; in addition, the bases of the metacarpal bones of the fingers articulate with each other.

All of the heads of the metacarpal bones articulate with the proximal phalanges of the digits. The heads form the knuckles on the dorsal surface of the hand when the fingers are flexed.

Phalanges

The phalanges are the bones of the digits (Figs. 7.80, 7.81A):

- The thumb has two—a **proximal** and a **distal phalanx**.
- The rest of the digits have three—a **proximal**, a **middle**, and a **distal phalanx**.

Each phalanx has a **base**, a **shaft (body)**, and, distally, a **head**.

The base of each proximal phalanx articulates with the head of the related metacarpal bone.

The head of each distal phalanx is nonarticular and flattened into a crescent-shaped palmar tuberosity, which lies under the palmar pad at the end of the digit.

Joints

Wrist joint

The wrist joint is a synovial joint between the distal end of the radius and the articular disc overlying the distal end of the ulna and the scaphoid, lunate, and triquetrum (Fig. 7.81B; also see Fig. 7.80). Together, the articular surfaces of the carpals form an oval shape with a convex contour that articulates with the corresponding concave surface of the radius and articular disc.

The wrist joint allows movement around two axes. The hand can be abducted, adducted, flexed, and extended at the wrist joint.

The capsule of the wrist joint is reinforced by **palmar radiocarpal**, **palmar ulnocarpal**, and **dorsal radiocarpal ligaments**. In addition, **radial and ulnar collateral ligaments of the wrist joint** span the distance between the styloid processes of the radius and ulna and the adjacent carpal bones. These ligaments reinforce the medial and lateral sides of the wrist joint and support them during flexion and extension.

Carpal joints

The synovial joints between the carpal bones share a common articular cavity. The joint capsule of the joints is reinforced by numerous ligaments.

Although movement at the **carpal joints (intercarpal joints)** is limited, they do contribute to the positioning of the hand in abduction, adduction, flexion, and, particularly, extension.

Carpometacarpal joints

There are five carpometacarpal joints between the metacarpals and the related distal row of carpal bones (Fig. 7.81B; also see Fig. 7.80).

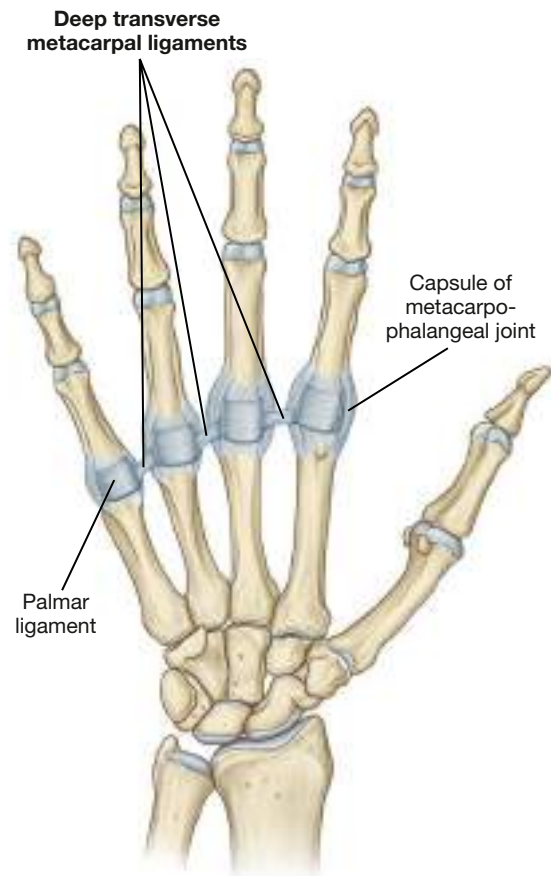


Fig. 7.82 Deep transverse metacarpal ligaments, right hand.

The saddle joint between metacarpal I and the trapezium imparts a wide range of mobility to the thumb that is not a feature of the rest of the digits. Movements at this carpo-metacarpal joint are flexion, extension, abduction, adduction, rotation, and circumduction.

The carpometacarpal joints between metacarpals II to V and the carpal bones are much less mobile than the carpo-metacarpal joint of the thumb, allowing only limited gliding movements. Movement of the joints increases medially, so metacarpal V slides to the greatest degree. This can be best observed on the dorsal surface of the hand as it makes a fist.

Metacarpophalangeal joints

The joints between the distal heads of the metacarpals and the proximal phalanges of the digits are condylar joints, which allow flexion, extension, abduction, adduction, circumduction, and limited rotation. The capsule of each joint is reinforced by the **palmar ligament** and by **medial and lateral collateral ligaments** (Fig. 7.82).

Deep transverse metacarpal ligaments

The three deep **transverse metacarpal ligaments** (Fig. 7.82) are thick bands of connective tissue connecting the palmar



Upper Limb

ligaments of the metacarpophalangeal joints of the fingers to each other. They are important because, by linking the heads of the metacarpal bones together, they restrict the movement of these bones relative to each other. As a result, they help form a unified skeletal framework for the palm of the hand.

Significantly, a deep transverse metacarpal ligament does not occur between the palmar ligament of the metacarpophalangeal joint of the thumb and the palmar ligament of the index finger. The absence of this ligament and the presence of a saddle joint between metacarpal I and the trapezium are responsible for the increased mobility of the thumb relative to the rest of the digits of the hand.

Interphalangeal joints of hand

The interphalangeal joints of the hand are hinge joints that allow mainly flexion and extension. They are reinforced by medial and lateral **collateral ligaments** and **palmar ligaments**.

Clinical app

Fracture of the scaphoid and avascular necrosis of the proximal scaphoid

The most common carpal injury is a fracture across the waist of the scaphoid bone (Fig. 7.83B). In approximately 10% of individuals, the scaphoid bone has a sole blood supply from the radial artery, which enters through the distal portion of the bone to supply the proximal portion. When a fracture occurs across the waist of the scaphoid, the proximal portion therefore undergoes avascular necrosis.

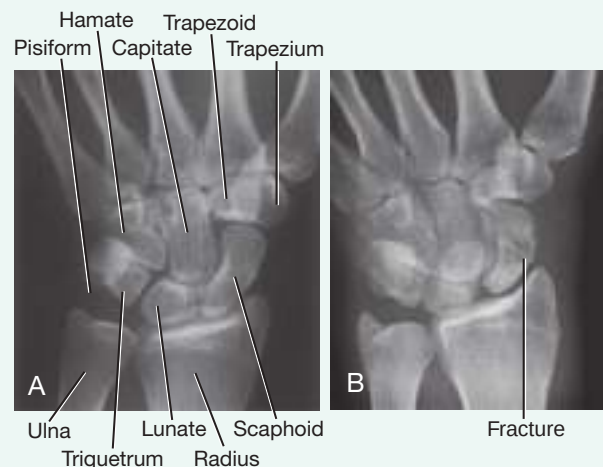


Fig. 7.83 Wrist radiographs (posterior-anterior view).

Double jointed

Double jointed refers to hypermobility of a joint due to increased range of motion. Increased range of motion can be caused by permissive shapes of joint surfaces and more flexible capsule and ligaments. It can also be related to pathology.

Clinical app

Knuckle cracking

Knuckle cracking refers to the sound made when the metacarpophalangeal joints are forcefully flexed. The sound is made by the explosive formation of a gas bubble in the joint during the flexion.

Carpal tunnel and structures at the wrist

The carpal tunnel is formed anteriorly at the wrist by a deep arch formed by the carpal bones and the flexor retinaculum (Fig. 7.84).

The base of the carpal arch is formed medially by the pisiform and the hook of the hamate and laterally by the tubercles of the scaphoid and trapezium.

The flexor retinaculum is a thick connective tissue ligament that bridges the space between the medial and lateral sides of the base of the arch and converts the carpal arch into the carpal tunnel.

The four tendons of the flexor digitorum profundus, the four tendons of the flexor digitorum superficialis, and the tendon of the flexor pollicis longus pass through the carpal tunnel, as does the median nerve (Fig. 7.84).

The flexor retinaculum holds the tendons to the bony plane at the wrist and prevents them from “bowing.”

Free movement of the tendons in the carpal tunnel is facilitated by synovial sheaths, which surround the tendons. All the tendons of the flexor digitorum profundus and flexor digitorum superficialis are surrounded by a single synovial sheath; a separate sheath surrounds the tendon of the flexor pollicis longus. The median nerve is anterior to the tendons in the carpal tunnel.

The tendon of the flexor carpi radialis is surrounded by a synovial sheath and passes through a tubular compartment formed by the attachment of the lateral aspect of the flexor retinaculum to the margins of a groove on the medial side of the tubercle of trapezium.

The ulnar artery, ulnar nerve, and the tendon of the palmaris longus pass into the hand anterior to the flexor retinaculum and therefore do not pass through the carpal tunnel (Fig. 7.84). The tendon of the palmaris longus is not surrounded by a synovial sheath.

The radial artery passes dorsally around the lateral side of the wrist and lies adjacent to the external surface of the scaphoid.

The extensor tendons pass into the hand on the medial, lateral, and posterior surfaces of the wrist in six compartments defined by an extensor retinaculum and lined by synovial sheaths (Fig. 7.84):

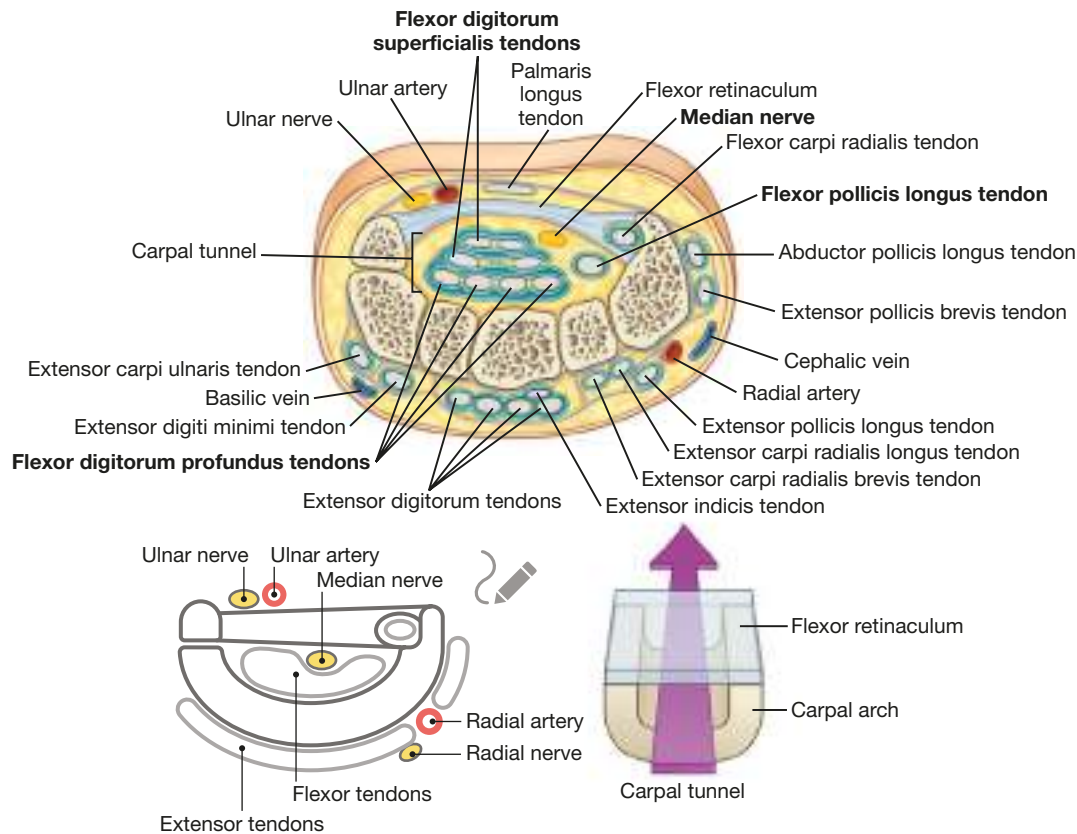


Fig. 7.84 Carpal tunnel. Structure and relations.

- The tendons of the extensor digitorum and extensor indicis share a compartment and synovial sheath on the posterior surface of the wrist.
- The tendons of the extensor carpi ulnaris and extensor digiti minimi have separate compartments and sheaths on the medial side of the wrist.
- The tendons of the abductor pollicis longus and extensor pollicis brevis muscles, the extensor carpi radialis longus and extensor carpi radialis brevis muscles, and the extensor pollicis longus muscle pass through three compartments on the lateral surface of the wrist.

Clinical app

De Quervain syndrome

De Quervain syndrome is an inflammatory disorder that occurs within the first dorsal extensor compartment and involves the extensor pollicis brevis and abductor pollicis longus tendon and their common tendon sheath. Patients typically present with significant wrist pain preventing appropriate flexion/extension and abduction of the thumb. The cause of this disorder is often overuse. For example, the syndrome is common in young mothers who are constantly lifting young children. Other causes include inflammatory disorders such as rheumatoid arthritis.

Palmar aponeurosis

The **palmar aponeurosis** is a triangular condensation of deep fascia that covers the palm and is anchored to the skin in distal regions (Fig. 7.86).

Surface anatomy

Position of the flexor retinaculum and the recurrent branch of the median nerve

The proximal margin of the flexor retinaculum can be determined using two bony landmarks (Fig. 7.85).

The pisiform bone is readily palpable at the distal end of the flexor carpi ulnaris tendon.

The tubercle of the scaphoid can be palpated at the distal end of the flexor carpi radialis tendon as it enters the wrist.

An imaginary line between these two points marks the proximal margin of the flexor retinaculum. The distal margin of the flexor retinaculum is approximately deep to the point where the anterior margin of the thenar eminence meets the hypothenar eminence near the base of the palm.

The recurrent branch of the median nerve lies deep to the skin and deep fascia overlying the anterior margin of the thenar eminence near the midline of the palm (Fig. 7.85).



Surface anatomy—cont'd

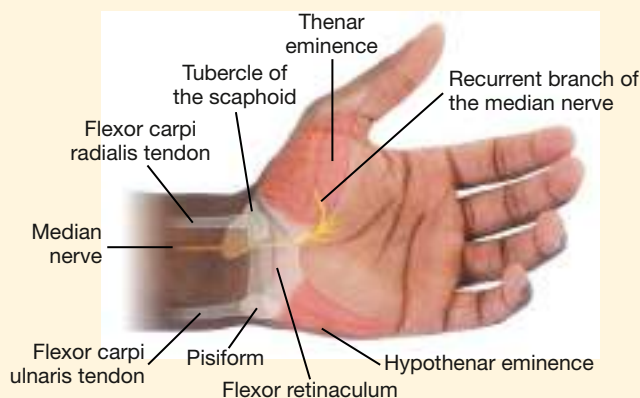


Fig. 7.85 Anterior hand to show the position of the flexor retinaculum and recurrent branch of the median nerve in the left hand.

Clinical app

Carpal tunnel syndrome

Carpal tunnel syndrome is an entrapment syndrome caused by pressure on the median nerve within the carpal tunnel.

Patients typically report pain and pins and needles in the distribution of the median nerve in the hand. Weakness and loss of muscle bulk of the thenar muscles may also occur. Gently tapping over the median nerve (in the region of the flexor retinaculum) readily produces these symptoms (Tinel's sign).

The apex of the triangle is continuous with the palmaris longus tendon when present; otherwise it is anchored to the flexor retinaculum. From this point, fibers radiate to extensions at the base of the digits that project into each of the index, middle, ring, and little fingers and, to a lesser extent, the thumb.

Transverse fibers interconnect the more longitudinally arranged bundles that continue into the digits.

Vessels, nerves, and long flexor tendons lie deep to the palmar aponeurosis in the palm.

Anatomical snuffbox

The *anatomical snuffbox* is a term given to the triangular depression formed on the posterolateral side of the wrist and metacarpal I by the extensor tendons passing into the thumb (Fig. 7.87). Historically, ground tobacco (snuff) was placed in this depression before being inhaled into the nose. The base of the triangle is at

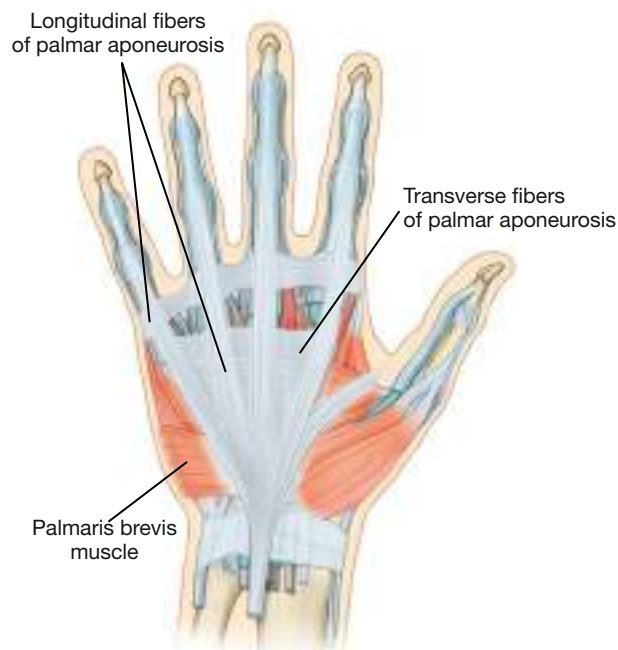


Fig. 7.86 Palmar aponeurosis, right hand.

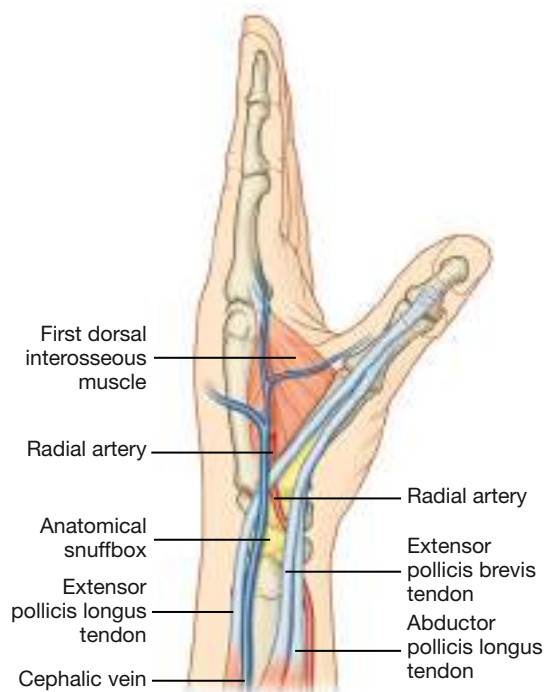


Fig. 7.87 Anatomical snuffbox, left hand.

the wrist, and the apex is directed into the thumb. The impression is most apparent when the thumb is extended:

- The lateral border is formed by the tendons of the abductor pollicis longus and extensor pollicis brevis.
- The medial border is formed by the tendon of the extensor pollicis longus.

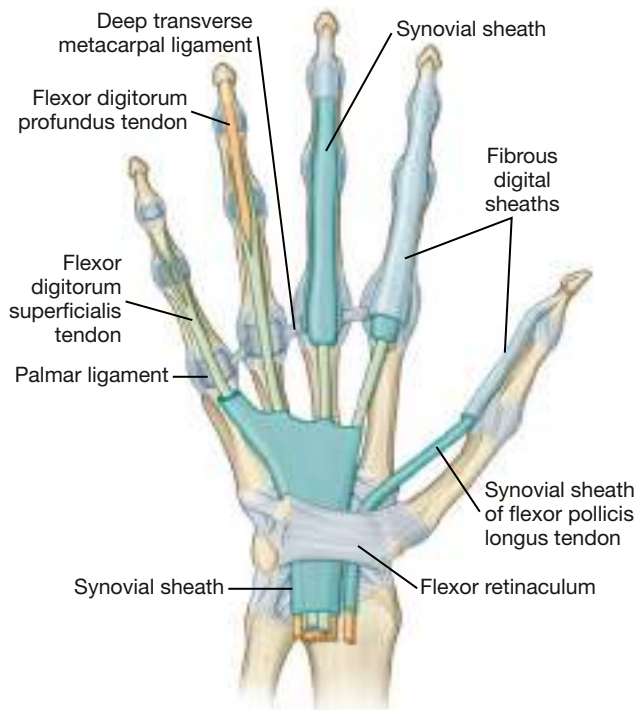


Fig. 7.88 Fibrous digital sheaths and synovial sheaths of the right hand.

- The floor of the impression is formed by the scaphoid, trapezium, and the distal ends of the tendons of the extensor carpi radialis longus and extensor carpi radialis brevis.

The radial artery passes obliquely through the anatomical snuffbox deep to the extensor tendons of the thumb and lies adjacent to the scaphoid and trapezium.

Terminal parts of the superficial branch of the radial nerve pass subcutaneously over the snuffbox as does the origin of the cephalic vein from the dorsal venous arch of the hand.

Fibrous digital sheaths

After exiting the carpal tunnel, the tendons of the flexor digitorum superficialis and profundus muscles cross the palm and enter fibrous sheaths on the palmar aspect of the digits (Fig. 7.88). These fibrous sheaths:

- begin proximally, anterior to the metacarpophalangeal joints, and extend to the distal phalanges;
- are formed by fibrous arches and cruciate (cross-shaped) ligaments, which are attached posteriorly to the margins of the phalanges and to the palmar ligaments associated with the metacarpophalangeal and interphalangeal joints; and
- hold the tendons to the bony plane and prevent the tendons from bowing when the digits are flexed.

Within each tunnel, the tendons are surrounded by a synovial sheath. The synovial sheaths of the thumb and little finger are continuous with the sheaths associated with the tendons in the carpal tunnel (Fig. 7.88).

Clinical app

Tenosynovitis

Tenosynovitis is inflammation of a tendon and its sheath. The condition may be due to overuse; however, it can also be associated with other disorders such as rheumatoid arthritis and connective tissue pathologies. If the inflammation becomes severe and ensuing fibrosis occurs, the tendon will not run smoothly within the tendon sheath and typically within the fingers, the tendon may stick or may require excess force to fully extend and flex, producing a “triggering” phenomenon.

Clinical app

Trigger finger

Trigger finger is a common disorder of late childhood and adulthood and is typically characterized by catching or snapping and occasionally locking of the flexor tendon(s) in the hand. Trigger finger can be associated with significant dysfunction and pain. The triggering is usually related to fibrosis and tightening of the flexor tendon sheath at the level of the metacarpophalangeal joint.

Extensor hoods

The tendons of the extensor digitorum and extensor pollicis longus muscles pass onto the dorsal aspect of the digits and expand over the proximal phalanges to form complex “extensor hoods” or “dorsal digital expansions” (Fig. 7.89). The tendons of the extensor digiti minimi, extensor indicis, and extensor pollicis brevis muscles join these hoods.

Each extensor hood is triangular with:

- the apex attached to the distal phalanx;
- the central region attached to the middle phalanx (index, middle, ring, and little fingers) or proximal phalanx (thumb); and
- each corner of the base wrapped around the sides of the metacarpophalangeal joint—in the index, middle, ring, and little fingers, the corners of the hoods attach mainly to the deep transverse metacarpal ligaments; in the thumb, the hood is attached on each side to muscles.

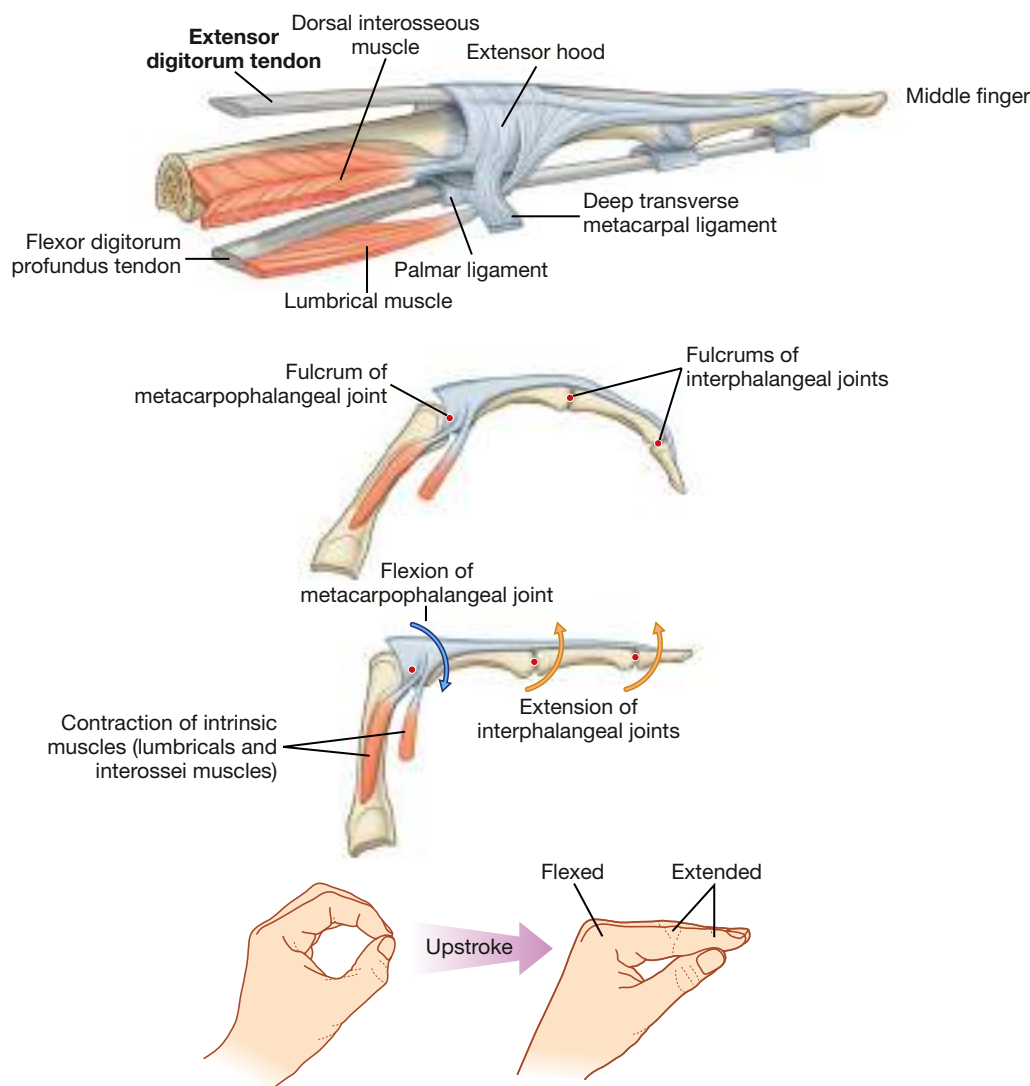


Fig. 7.89 Extensor hood, left hand.

In addition to other attachments, many of the intrinsic muscles of the hand insert into the free margin of the hood on each side. By inserting into the extensor hood, these intrinsic muscles are responsible for complex delicate movements of the digits that could not be accomplished with the long flexor and extensor tendons alone.

In the index, middle, ring, and little fingers, the lumbrical, interossei, and abductor digiti minimi muscles attach to the extensor hoods. In the thumb, the adductor pollicis and abductor pollicis brevis muscles insert into and anchor the extensor hood.

Because force from the small intrinsic muscles of the hand is applied to the extensor hood distal to the fulcrum of the metacarpophalangeal joints, the muscles flex these joints (Fig. 7.89). Simultaneously, the force is transferred dorsally through the hood to extend the interphalangeal joints. This ability to flex the metacarpophalangeal joints while extending the interphalangeal joints is entirely due to the intrinsic

muscles of the hand working through the extensor hoods. This type of precision movement is used in the upstroke when writing a *t* (Fig. 7.89).

Muscles

The intrinsic muscles of the hand are the palmaris brevis, interossei, adductor pollicis, thenar, hypothenar, and lumbrical muscles (Table 7.15, Figs. 7.90 to 7.94). Unlike the extrinsic muscles that originate in the forearm, insert in the hand, and function in forcefully gripping (“power grip”) with the hand, the intrinsic muscles occur entirely in the hand and mainly execute precision movements (“precision grip”) with the fingers and thumb.

All of the intrinsic muscles of the hand are innervated by the deep branch of the ulnar nerve except for the three thenar and two lateral lumbrical muscles, which are innervated by the median nerve. The intrinsic muscles are predominantly

Table 7.15 Intrinsic muscles of the hand (spinal segments indicated in **bold** are the major segments innervating the muscle)

Muscles	Origin	Insertion	Innervation	Function
Palmaris brevis	Palmar aponeurosis and flexor retinaculum	Dermis of skin on the medial margin of the hand	Superficial branch of the ulnar nerve [C8, T1]	Improves grip
Dorsal interossei (four muscles)	Adjacent sides of metacarpals	Extensor hood and base of proximal phalanges of index, middle, and ring fingers	Deep branch of ulnar nerve [C8, T1]	Abduction of index, middle, and ring fingers at the metacarpophalangeal joints
Palmar interossei (four muscles)	Sides of metacarpals	Extensor hoods of the thumb, index, ring, and little fingers and the proximal phalanx of thumb	Deep branch of ulnar nerve [C8, T1]	Adduction of the thumb, index, ring, and little fingers at the metacarpophalangeal joints
Adductor pollicis	Transverse head—metacarpal III; oblique head—capitate and bases of metacarpals II and III	Base of proximal phalanx and extensor hood of thumb	Deep branch of ulnar nerve [C8, T1]	Adducts thumb
Lumbricals (four muscles)	Tendons of flexor digitorum profundus	Extensor hoods of index, ring, middle, and little fingers	Medial two by the deep branch of the ulnar nerve; lateral two by digital branches of the median nerve	Flex metacarpophalangeal joints while extending interphalangeal joints
Thenar muscles				
Opponens pollicis	Tubercle of trapezium and flexor retinaculum	Lateral margin and adjacent palmar surface of metacarpal I	Recurrent branch of median nerve [C8, T1]	Medially rotates thumb
Abductor pollicis brevis	Tubercles of scaphoid and trapezium and adjacent flexor retinaculum	Proximal phalanx and extensor hood of thumb	Recurrent branch of median nerve [C8, T1]	Abducts thumb at metacarpophalangeal joint
Flexor pollicis brevis	Tubercle of the trapezium and flexor retinaculum	Proximal phalanx of the thumb	Recurrent branch of median nerve [C8, T1]	Flexes thumb at metacarpophalangeal joint
Hypothenar muscles				
Opponens digiti minimi	Hook of hamate and flexor retinaculum	Medial aspect of metacarpal V	Deep branch of ulnar nerve [C8, T1]	Laterally rotates metacarpal V
Abductor digiti minimi	Pisiform, the pisohamate ligament, and tendon of flexor carpi ulnaris	Proximal phalanx of little finger	Deep branch of ulnar nerve [C8, T1]	Abducts little finger at metacarpophalangeal joint
Flexor digiti minimi brevis	Hook of the hamate and flexor retinaculum	Proximal phalanx of little finger	Deep branch of ulnar nerve [C8, T1]	Flexes little finger at metacarpophalangeal joint

innervated by spinal cord segment T1 with a contribution from C8.

Interossei

The four bipennate **dorsal interossei** are the most posterior of all of the intrinsic muscles and can be palpated through the skin on the posterior aspect of the hand (Fig. 7.90). The muscles lie between and are attached to the shafts of adjacent metacarpal bones (Fig. 7.90). Each muscle inserts both into the base of the proximal phalanx and into the extensor hood of its related digit.

The four **palmar interossei** are anterior to the dorsal interossei and are unipennate muscles originating from the metacarpals of the digits with which each is associated (Fig. 7.91).

The first palmar interosseous muscle is rudimentary and often considered part of either the adductor pollicis or the flexor pollicis brevis. When present, it originates from the

medial side of the palmar surface of metacarpal I and inserts into both the base of the proximal phalanx of the thumb and into the extensor hood. A sesamoid bone often occurs in the tendon attached to the base of the phalanx.

Thenar muscles

The three thenar muscles (the **opponens pollicis**, **flexor pollicis brevis**, and **abductor pollicis brevis** muscles) are associated with opposition of the thumb to the fingers and with delicate movements of the thumb (Table 7.15, Fig. 7.93) and are responsible for the prominent swelling (**thenar eminence**) on the lateral side of the palm at the base of the thumb.

Hypothenar muscles

The hypothenar muscles (the **opponens digiti minimi**, **abductor digiti minimi**, and **flexor digiti minimi brevis**) contribute to the swelling (**hypothenar eminence**) on the

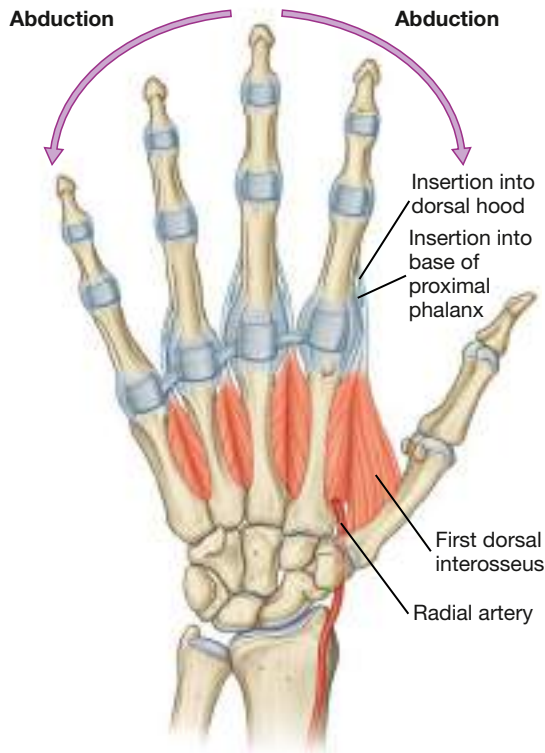


Fig. 7.90 Dorsal interossei (palmar view), right hand.

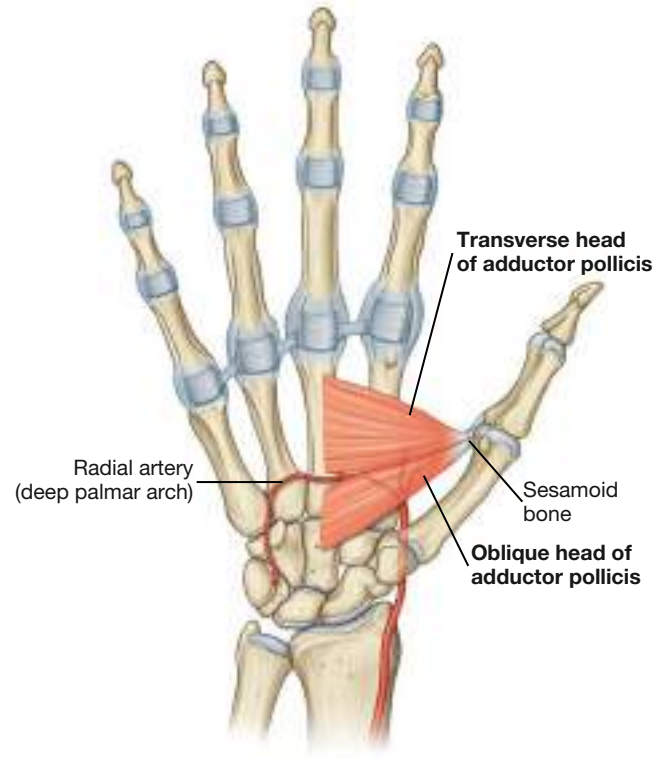


Fig. 7.92 Adductor pollicis, right hand.

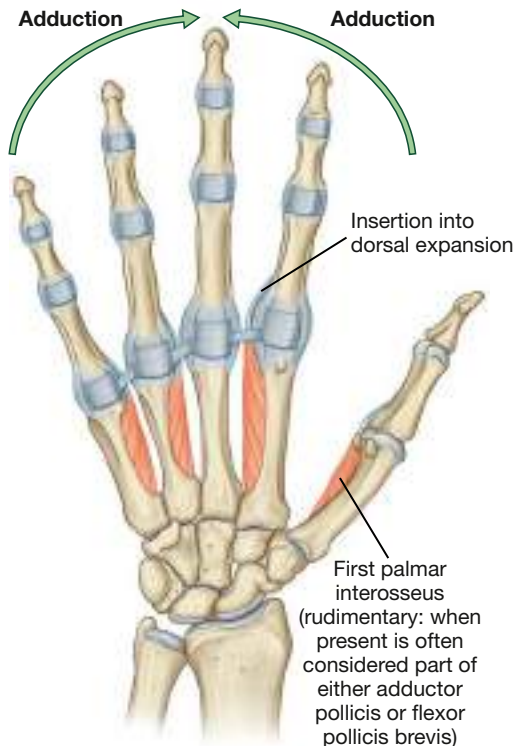


Fig. 7.91 Palmar interossei (palmar view), right hand.

medial side of the palm at the base of the little finger ([Table 7.15](#), [Fig. 7.93](#)). The hypothenar muscles are similar to the thenar muscles in name and in organization.

Lumbrical muscles

There are four lumbrical (worm-like) muscles, each of which is associated with one of the fingers ([Fig. 7.94](#)). The muscles originate from the tendons of the flexor digitorum profundus in the palm and insert into the extensor hoods. The lumbricals are unique because they link flexor tendons with extensor tendons. Through their insertion into the extensor hoods, they participate in flexing the metacarpophalangeal joints and extending the interphalangeal joints.

Arteries and veins

The blood supply to the hand is by the radial and ulnar arteries, which form two interconnected vascular arches (superficial and deep) in the palm ([Fig. 7.95](#)). Vessels to the digits, muscles, and joints originate from the two arches and the parent arteries:

- The radial artery contributes substantially to the supply of the thumb and the lateral side of the index finger.
- The remaining digits and the medial side of the index finger are supplied mainly by the ulnar artery.

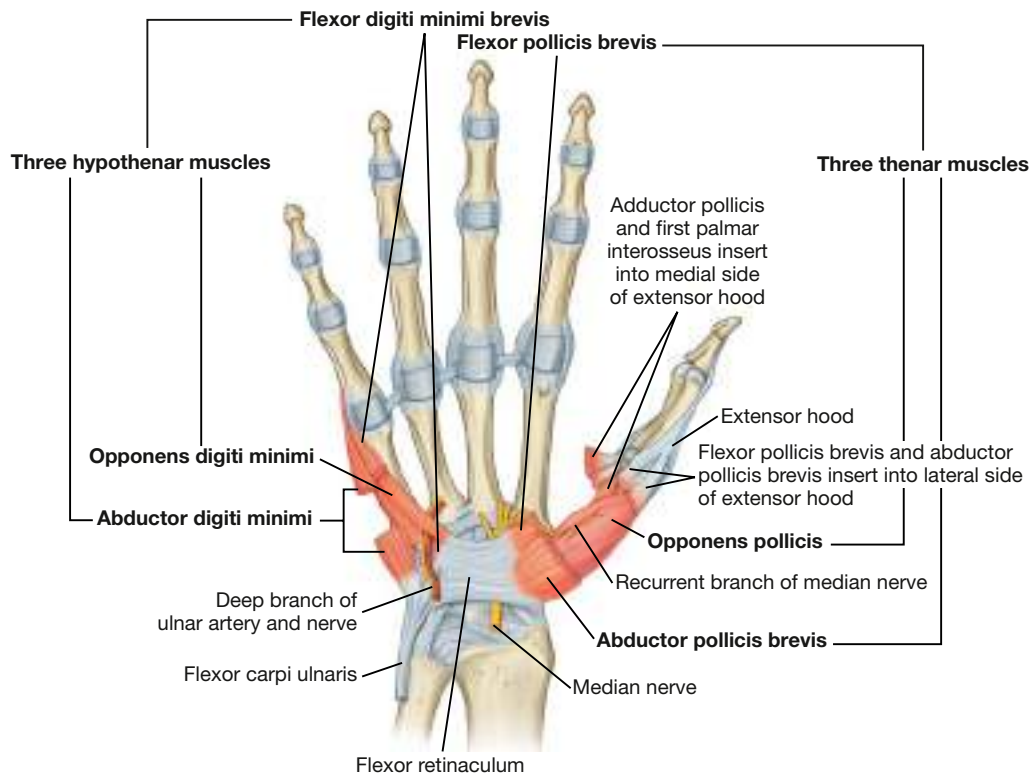


Fig. 7.93 Thenar and hypothenar muscles, right hand.

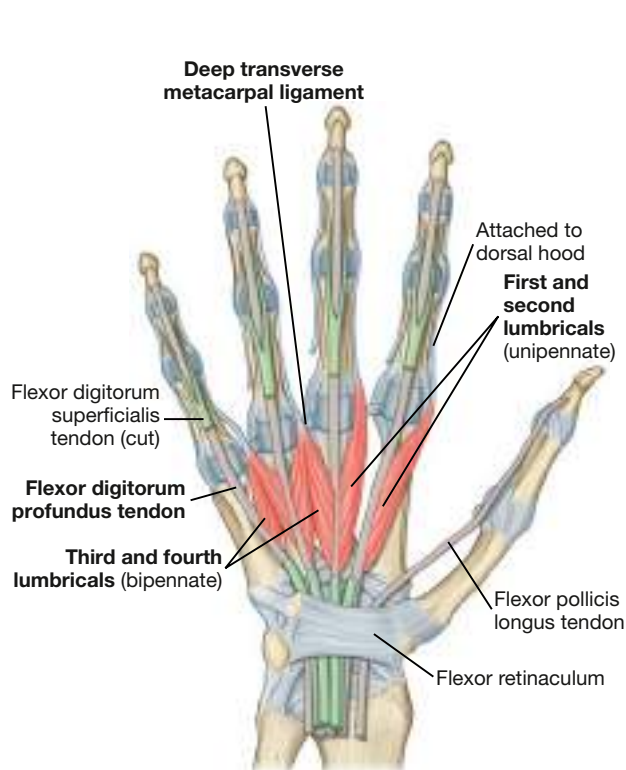


Fig. 7.94 Lumbrical muscles, right hand.

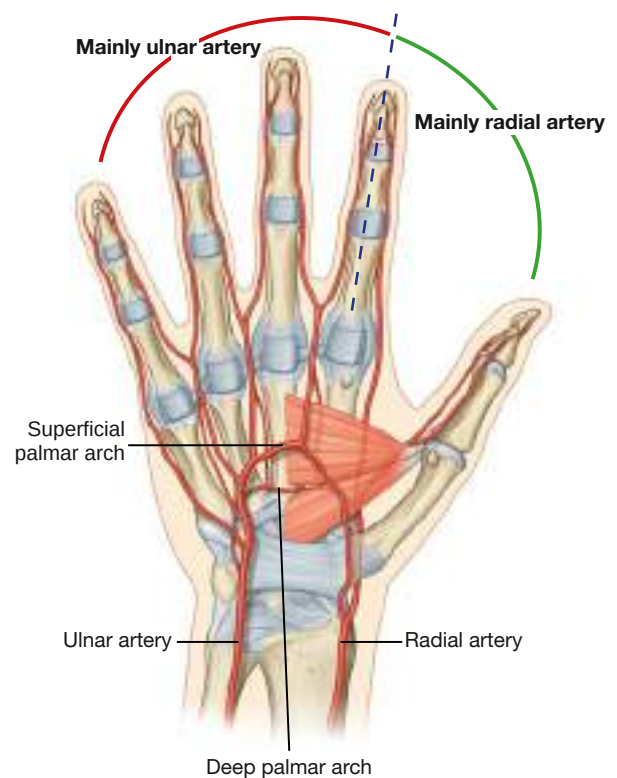


Fig. 7.95 Arterial supply of the right hand.

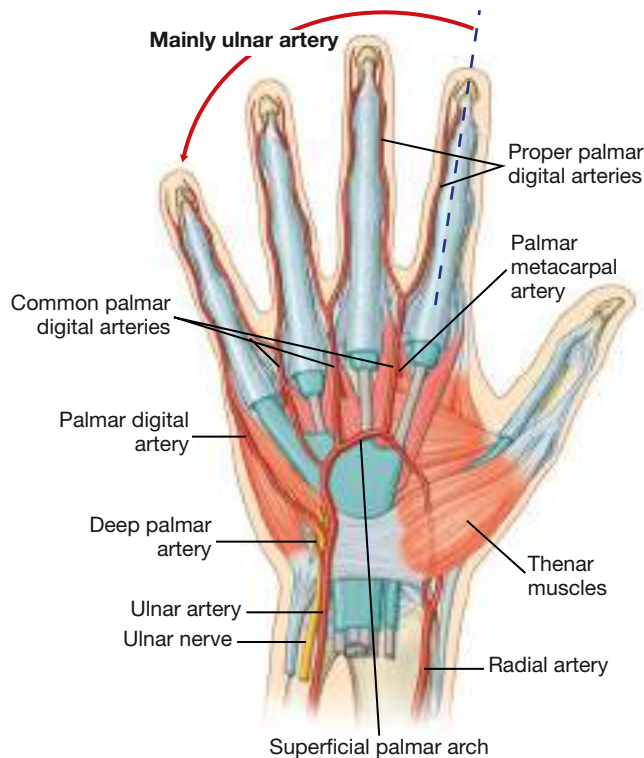


Fig. 7.96 Superficial palmar arch, right hand.

Ulnar artery and superficial palmar arch

The **ulnar artery** and ulnar nerve enter the hand on the medial side of the wrist (Figs. 7.95, 7.96). The vessel lies between the palmaris brevis and the flexor retinaculum and is lateral to the ulnar nerve and the pisiform bone. Distally, the ulnar artery is medial to the hook of the hamate bone and then swings laterally across the palm, forming the **superficial palmar arch** (Fig. 7.96), which is superficial to the long flexor tendons of the digits and just deep to the palmar aponeurosis. On the lateral side of the palm, the arch communicates with a palmar branch of the radial artery.

One branch of the ulnar artery in the hand is the **deep palmar branch** (Figs. 7.96, 7.97), which arises from the medial aspect of the ulnar artery just distal to the pisiform, and penetrates the origin of the hypothenar muscles. It curves medially around the hook of the hamate to access the deep plane of the palm and to anastomose with the deep palmar arch derived from the radial artery.

Branches from the superficial palmar arch include (Fig. 7.96):

- a **palmar digital artery** to the medial side of the little finger; and
- three large, **common palmar digital arteries**, which ultimately provide the principal blood supply to the lateral side of the little finger, both sides of the ring and middle fingers, and the medial side of the index finger; they are

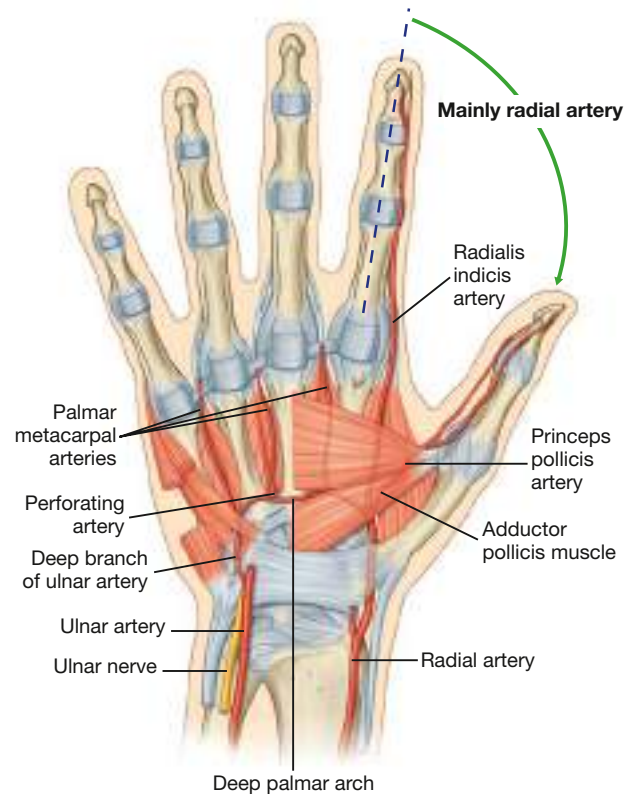


Fig. 7.97 Deep palmar arch, right hand.

joined by palmar metacarpal arteries from the deep palmar arch before bifurcating into the **proper palmar digital arteries**, which enter the fingers.

Radial artery and deep palmar arch

The **radial artery** curves around the lateral side of the wrist, passes over the floor of the anatomical snuffbox and into the deep plane of the palm by penetrating anteriorly through the back of the hand (Fig. 7.95). It passes between the two heads of the first dorsal interosseous muscle and then between the two heads of the adductor pollicis to access the deep plane of the palm and form the deep palmar arch.

The **deep palmar arch** passes medially through the palm between the metacarpal bones and the long flexor tendons of the digits. On the medial side of the palm, it communicates with the deep palmar branch of the ulnar artery (Fig. 7.97).

Before penetrating the back of the hand, the radial artery gives rise to two vessels (Fig. 7.98):

- a **dorsal carpal branch**, which passes medially as the **dorsal carpal arch** across the wrist and gives rise to **dorsal metacarpal arteries**, which subsequently divide to become small dorsal digital arteries that enter the fingers; and
- the **first dorsal metacarpal artery**, which supplies adjacent sides of the index finger and thumb.

Two vessels, the **princeps pollicis artery** and the **radialis indicis artery**, arise from the radial artery in the plane between the first dorsal interosseus and adductor pollicis (Fig. 7.97). The princeps pollicis artery is the major blood supply to the thumb, and the radialis indicis artery supplies the lateral side of the index finger.

The deep palmar arch gives rise to (Fig. 7.97):

- three **palmar metacarpal arteries**, which join the common palmar digital arteries from the superficial palmar arch, and
- three **perforating branches**, which pass posteriorly between the heads of origin of the dorsal interossei to anastomose with the dorsal metacarpal arteries from the dorsal carpal arch.

Clinical app

Allen's test

To test for adequate anastomoses between the radial and ulnar arteries, compress both the radial and ulnar arteries at the wrist, then release pressure from one or the other and determine the filling pattern of the hand. If there is little connection between the deep and superficial palmar arches, only the thumb and lateral side of the index finger will fill with blood (become red) when pressure on the radial artery alone is released.

Veins

As generally found in the upper limb, the hand contains interconnected networks of deep and superficial veins. The deep veins follow the arteries; the superficial veins drain into a dorsal venous network on the back of the hand over the metacarpal bones (Fig. 7.99).

The cephalic vein originates from the lateral side of the dorsal venous network and passes over the anatomical snuffbox into the forearm.

The basilic vein originates from the medial side of the dorsal venous network and passes into the dorsomedial aspect of the forearm.

Nerves

The hand is supplied by the ulnar, median, and radial nerves (Figs. 7.100, 7.102, 7.104). All three nerves contribute to cutaneous or general sensory innervation. The ulnar nerve innervates all intrinsic muscles of the hand except for the three thenar muscles and the two lateral lumbricals, which are innervated by the median nerve. The radial nerve only innervates skin on the dorsolateral side of the hand.

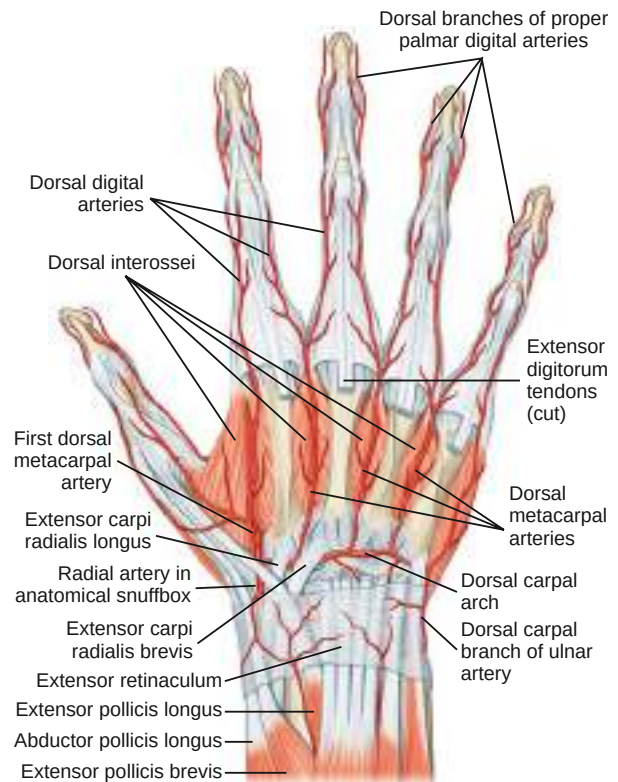


Fig. 7.98 Arteries on the dorsum of the right hand.

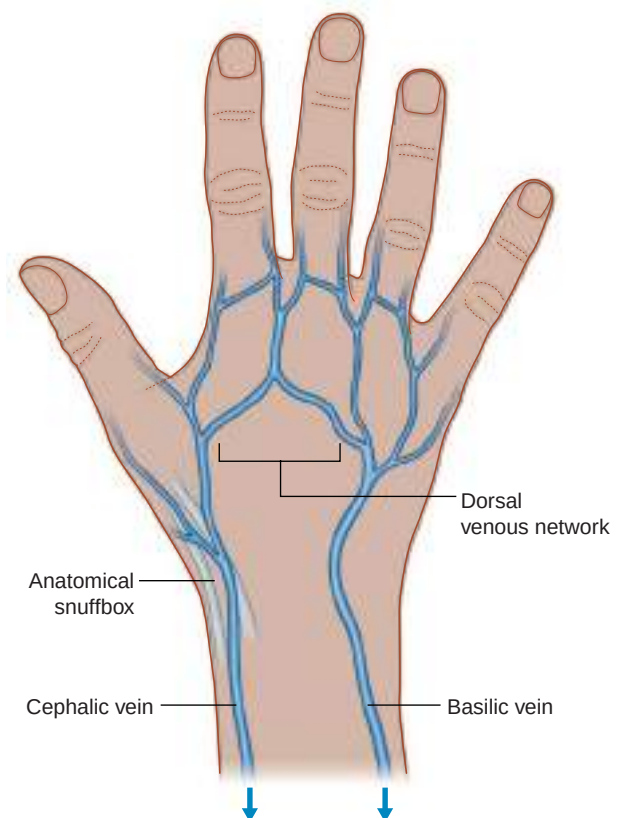


Fig. 7.99 Dorsal venous arch of the right hand.



Ulnar nerve

The ulnar nerve enters the hand lateral to the pisiform and posteromedially to the ulnar artery (Fig. 7.100). Immediately distal to the pisiform, it divides into a deep branch, which is mainly motor, and a superficial branch, which is mainly sensory.

The **deep branch** of the ulnar nerve passes with the deep branch of the ulnar artery (Fig. 7.100). It penetrates and supplies the hypothenar muscles to reach the deep aspect of the palm, arches laterally across the palm deep to the long flexors of the digits, and supplies the interossei, adductor pollicis, and the two medial lumbricals. In addition, the deep branch of the ulnar nerve contributes small articular branches to the wrist joint.

As the deep branch of the ulnar nerve passes across the palm, it lies in a fibro-osseous tunnel (Guyon's canal) between the hook of the hamate and the flexor tendons. Occasionally, small outpouchings of synovial membrane (ganglia) from the joints of the carpus compress the nerve within this canal, producing sensory and motor symptoms.

The superficial branch of the ulnar nerve innervates the palmaris brevis muscle and continues across the palm to supply skin on the palmar surface of the little finger and the medial half of the ring finger (Fig. 7.100).

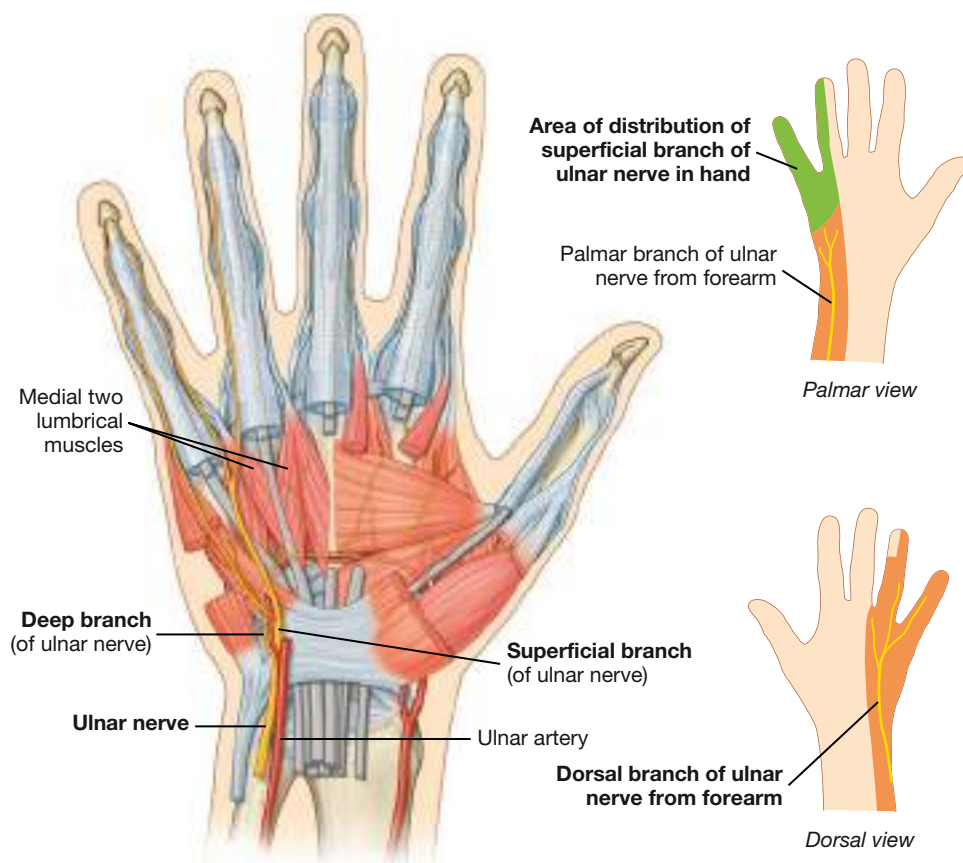


Fig. 7.100 Ulnar nerve in the right hand.

Clinical app

Ulnar nerve injury

The ulnar nerve is most commonly injured at two sites: the elbow and the wrist.

At the elbow, the nerve lies posterior to the medial epicondyle.

At the wrist, the ulnar nerve passes superficial to the flexor retinaculum and lies lateral to the pisiform bone.

Ulnar nerve lesions are characterized by “clawing” of the hand in which the metacarpophalangeal joints of the fingers are hyperextended and the interphalangeal joints are flexed because the function of most of the intrinsic muscles of the hand is lost (Fig. 7.101).

Clawing is most pronounced in the medial fingers because the function of all intrinsic muscles of these digits is lost, whereas in the lateral two digits, the lumbricals are innervated by the median nerve. Function of the adductor pollicis muscle is also lost.

In lesions of the ulnar nerve at the elbow, function of the flexor carpi ulnaris muscle and flexor digitorum profundus to the medial two digits is lost as well. Clawing of the hand, particularly of the little and ring fingers, is worse with lesions of the ulnar nerve at the wrist than at the elbow because interruption of the nerve at the elbow paralyzes the ulnar half of the flexor digitorum profundus, which leads to lack of flexion at the distal interphalangeal joints in these fingers.

Ulnar nerve lesions at the elbow and wrist result in impaired sensory innervation on the palmar aspect of the medial one and one-half digits.

Damage to the ulnar nerve at the wrist or at a site proximal to the wrist can be distinguished by evaluating the status of

function of the **dorsal branch** (cutaneous) of the ulnar nerve, which originates in distal regions of the forearm. This branch innervates skin over the dorsal surface of the hand on the medial side.

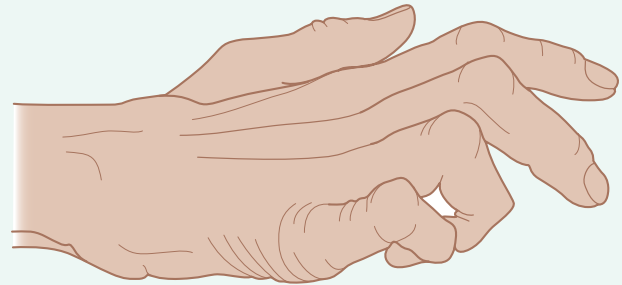


Fig. 7.101 Typical appearance of a “clawed hand” due to a lesion of the ulnar nerve.

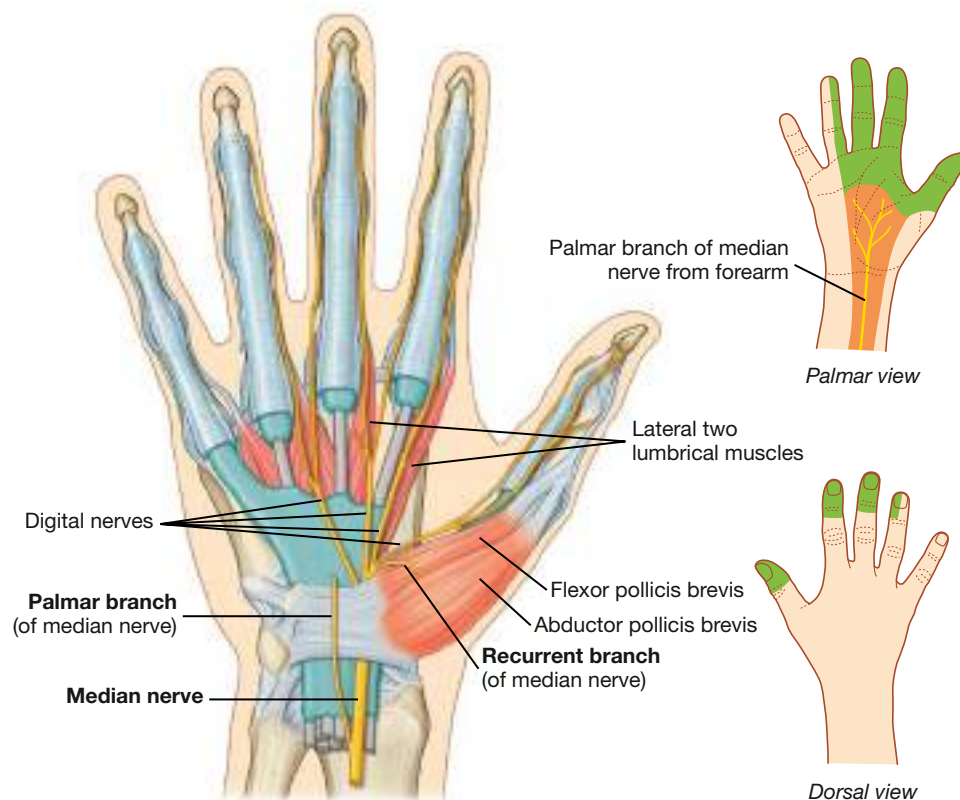


Fig. 7.102 Median nerve in the right hand.



Median nerve

The median nerve is the most important sensory nerve in the hand because it innervates skin on the thumb, index, and middle fingers, and on the lateral side of the ring finger (Fig. 7.102). The nervous system, using touch, gathers information about the environment from this area, particularly from the skin on the thumb and index finger. In addition, sensory information from the lateral three and one-half digits enables the fingers to be positioned with the appropriate amount of force when using precision grip.

The median nerve also innervates the thenar muscles that are responsible for opposition of the thumb to the other digits.

The median nerve enters the hand by passing through the carpal tunnel and divides into a recurrent branch and palmar digital branches (Fig. 7.102).

The **recurrent branch** of the median nerve innervates the three thenar muscles. Originating from the lateral side of the median nerve near the distal margin of the flexor retinaculum, it curves around the margin of the retinaculum and passes proximally over the flexor pollicis brevis muscle. The recurrent branch then passes between the flexor pollicis brevis and abductor pollicis brevis to end in the opponens pollicis.

The **palmar digital nerves** cross the palm deep to the palmar aponeurosis and the superficial palmar arch and enter the digits. They innervate skin on the palmar surfaces of the lateral three and one-half digits and cutaneous regions over the dorsal aspects of the distal phalanges (nail beds) of the same digits. In addition to skin, the digital nerves supply the lateral two lumbrical muscles.

Superficial branch of the radial nerve

The only part of the radial nerve that enters the hand is the superficial branch (Fig. 7.104). It enters the hand by passing over the anatomical snuffbox on the dorsolateral side of the wrist.

The superficial branch of the radial nerve innervates skin over the dorsolateral aspect of the palm and the dorsal aspects of the lateral three and one-half digits distally to approximately the terminal interphalangeal joints.

Surface anatomy

Motor function of the median and ulnar nerves in the hand

The ability to flex the metacarpophalangeal joints while extending the interphalangeal joints of the fingers is entirely dependent on the intrinsic muscles of the hand (Fig. 7.103).

These muscles are mainly innervated by the deep branch of the ulnar nerve, which carries fibers from spinal cord level (C8)T1.

Adducting the fingers to grasp an object placed between them is caused by the palmar interossei muscles, which are innervated by the deep branch of the ulnar nerve carrying fibers from spinal cord level (C8)T1.

The ability to grasp an object between the pad of the thumb and the pad of one of the fingers depends on normal functioning of the thenar muscles, which are innervated by the recurrent branch of the median nerve carrying fibers from spinal cord level C8(T1).



Fig. 7.103 Flexing the metacarpophalangeal joints and extending the interphalangeal joints: the “ta-ta” position.

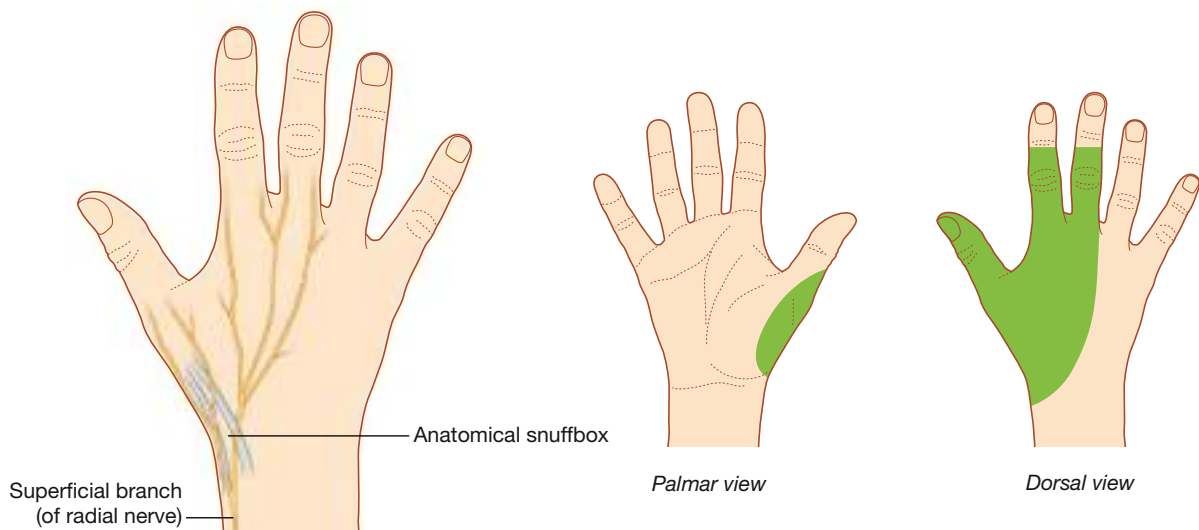


Fig. 7.104 Radial nerve in the right hand.

Clinical app

Radial nerve injury

Around the elbow joint the radial nerve divides into its two terminal branches—the superficial branch and the deep branch.

The most common radial nerve injury is damage to the nerve in the radial groove of the humerus, which produces a global paralysis of the muscles of the posterior compartment resulting in “**wrist drop**.” Radial nerve damage can result from fracture of the shaft of the humerus as the radial nerve spirals around in the radial groove. The typical injury produces reduction of sensation in the cutaneous distribution, predominantly over the posterior aspect of the hand. Severing the posterior interosseous nerve (continuation of deep branch of radial nerve) may paralyze the muscles of the posterior compartment of the forearm, but the nerve supply is variable. Typically, the patient may not be able to extend the fingers.

The distal branches of the superficial branch of the radial nerve can be readily palpated as “cords” passing over the tendon of the extensor pollicis longus in the anatomical snuffbox. Damage to these branches is of little consequence because they supply only a small area of skin.

Clinical app

Dermatomes and myotomes in the upper limb

Innervation of the upper limb is by the brachial plexus, which is formed by the anterior rami of cervical spinal nerves C5 to C8 and T1. This plexus is initially formed in the neck and then continues into the upper limb. Major nerves that ultimately innervate the arm, forearm, and hand originate from the brachial plexus.

As a consequence of this innervation pattern, clinical testing of lower cervical and T1 nerves is carried out by examining dermatomes, myotomes, and tendon reflexes in the upper limb. Another consequence is that the clinical signs of problems related to lower cervical nerves—pain, pins-and-needles sensations or paresthesia, and muscle twitching—appear in the upper limb.

Importantly, the major spinal cord level associated with innervation of the diaphragm, C4, is immediately above the spinal cord levels associated with the upper limb. Evaluation of dermatomes and myotomes in the upper limb can provide important information about potential breathing problems that might develop as complications of damage to the spinal cord in regions just below the C4 spinal level.

Dermatomes of the upper limb are shown in Fig. 7.105A. Areas where overlap of dermatomes is minimal and can be clinically tested include the:

- upper lateral region of the arm for spinal cord level C5,
- palmar pad of the thumb for spinal cord level C6,

Clinical app—cont'd

- pad of the index finger for spinal cord level C7,
 - pad of the little finger for spinal cord level C8, and
 - skin on the medial aspect of the elbow for spinal cord level T1.
- Select joint movements are used to test myotomes (Fig. 7.105B):
- Abduction of the arm at the glenohumeral joint is controlled predominantly by C5.
 - Flexion of the forearm at the elbow joint is controlled primarily by C6.
 - Extension of the forearm at the elbow joint is controlled mainly by C7.
 - Flexion of the fingers is controlled mainly by C8.
 - Abduction and adduction of the index, middle, and ring fingers is controlled predominantly by T1.

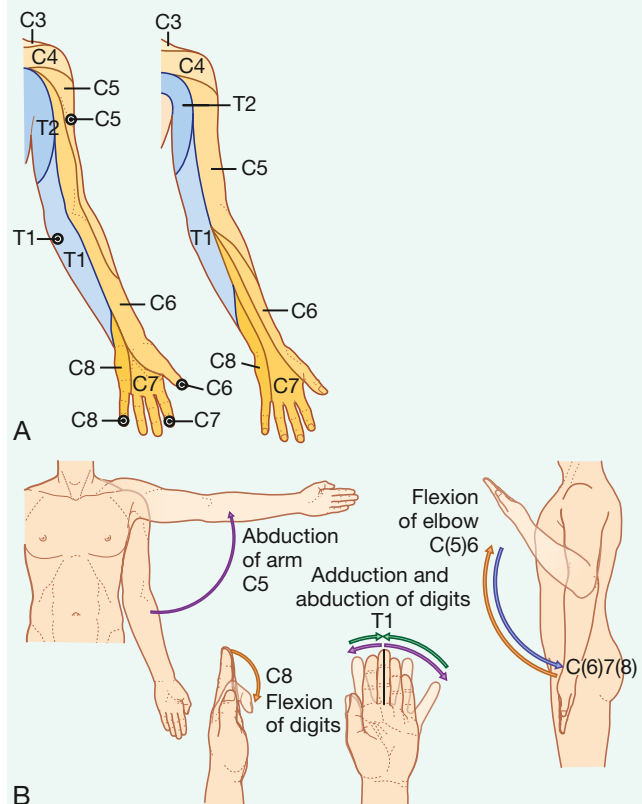


Fig. 7.105 Dermatomes and myotomes in the upper limb. **A.** Dermatomes. **B.** Movements produced by myotomes.

Clinical app

Tendon taps in the upper limb

In an unconscious patient, both somatic sensory and motor functions of spinal cord levels can be tested using tendon reflexes:

- A tap on the tendon of the biceps in the cubital fossa tests mainly for spinal cord level C6.
- A tap on the tendon of the triceps posterior to the elbow tests mainly for C7.



Clinical app

Testing sensory innervation carried by major peripheral nerves in the upper limb

In addition to innervating major muscle groups, each of the major peripheral nerves originating from the brachial plexus carries somatic sensory information from patches of skin quite different from dermatomes. Sensation in these areas can be used to test for peripheral nerve lesions:

- The axillary nerve innervates skin on the superior lateral surface on the arm.

- The musculocutaneous nerve innervates skin on the anterolateral side of the forearm.
- The median nerve innervates the palmar surface of the lateral three and one-half digits.
- The ulnar nerve innervates the medial one and one-half digits.
- The radial nerve supplies skin on the posterior surface of the forearm and the dorsolateral surface of the hand.

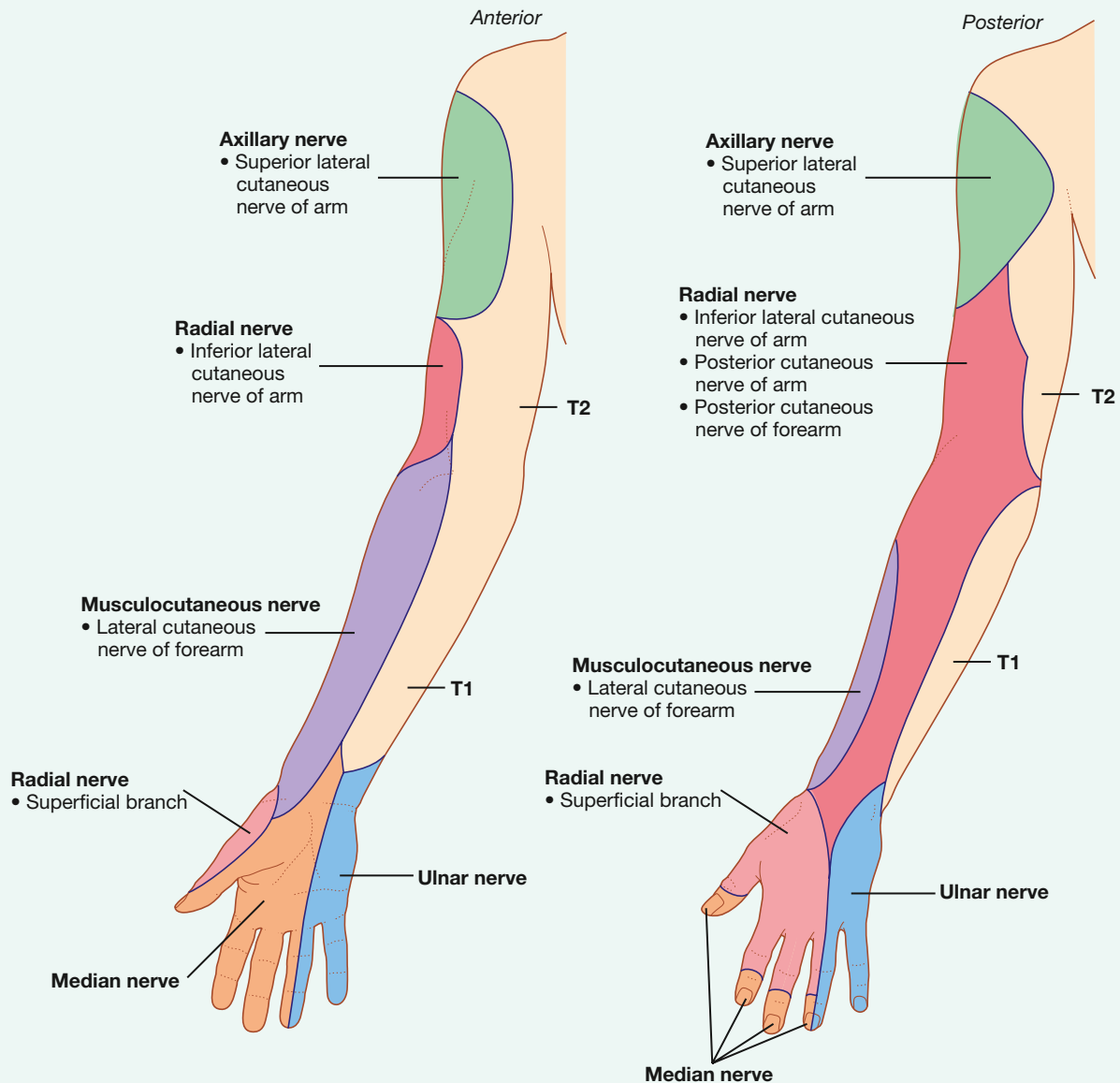


Fig. 7.106 Anterior and posterior areas of skin innervated by major peripheral nerves in the arm and forearm.

Surface anatomy

Pulse points

Peripheral pulses can be felt at six locations in the upper limb (Fig. 7.107A):

Axillary pulse: axillary artery in the axilla lateral to the apex of the dome of skin covering the floor of the axilla.

Brachial pulse in midarm: brachial artery on the medial side of the arm in the cleft between the biceps brachii and triceps brachii muscles. This is the position where a blood pressure cuff is placed (Fig. 7.107B).

Brachial pulse in the cubital fossa: brachial artery medial to the tendon of the biceps brachii muscle. This is the position where a

stethoscope is placed to hear the pulse of the vessel when taking a blood pressure reading (Fig. 7.107B).

Radial pulse in the distal forearm: radial artery immediately lateral to the tendon of the flexor carpi radialis muscle. This is the most common site for “taking a pulse.”

Ulnar pulse in the distal forearm: ulnar artery immediately under the lateral margin of the flexor carpi ulnaris tendon and proximal to the pisiform.

Radial pulse in the anatomical snuffbox: radial artery as it crosses the lateral side of the wrist between the tendon of the extensor pollicis longus muscle and the tendons of the extensor pollicis brevis and abductor pollicis longus muscles.

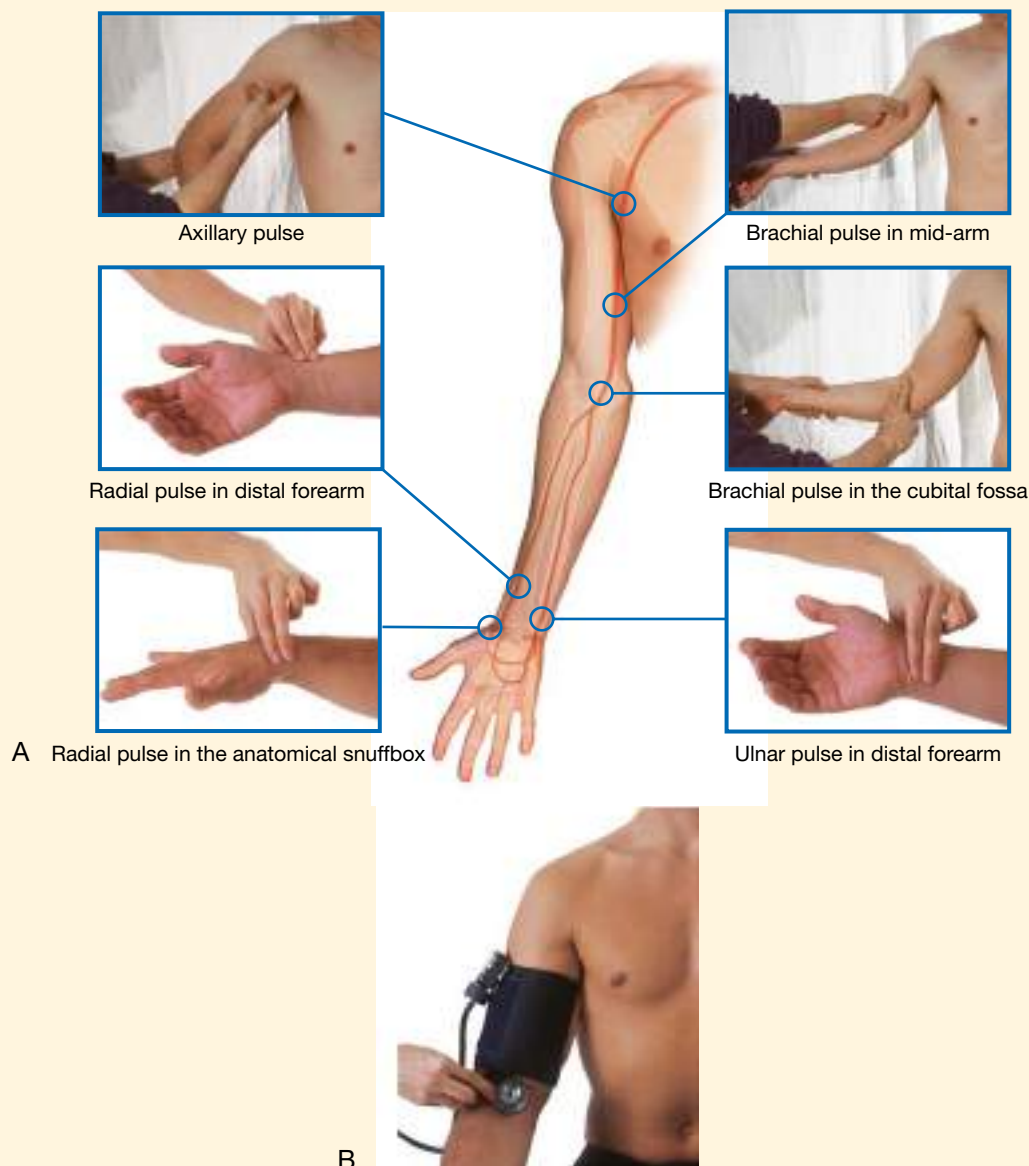


Fig. 7.107 Where to take peripheral artery pulses in the upper limb. **A.** Pulse points. **B.** Placement of blood pressure cuff and stethoscope.

8

Head and Neck

ADDITIONAL LEARNING RESOURCES FOR CHAPTER 8, *HEAD AND NECK*, CAN BE FOUND ON THE ACCOMPANYING EBOOK:

- Self-Assessment — National Board style multiple-choice questions, Chapter 8
- Short Questions — These are questions requiring short responses, Chapter 8
- Clinical Cases
 - Pancoast tumor
 - Subclavian steal syndrome
 - Branchial cyst
 - Epiglottitis
 - Otosclerosis
 - Scalp laceration
 - Scaphocephaly
 - Temporal arteritis
 - Tonsillitis
 - Multinodular goiter
 - Parotid duct calculus
 - Extradural hematoma
 - Stenosis of the internal carotid artery
 - Posterior communicating artery aneurysm
 - Recurrent epistaxis
 - Complication of orbital fracture
 - Brainstem tumor
 - Pituitary macroadenoma

***Regional anatomy* 445**

Head 446

Neck 446

Skull 446

Anterior view 446

Lateral view 448

Posterior view 451

Superior view 451

Inferior view 452

Cranial cavity 454

Roof 455

Floor 455

Meninges 462

Cranial dura mater 462

Arachnoid mater 465

Pia mater 465

Meningeal spaces 465

Brain and its blood supply 466

Brain 466

Blood supply 467

Venous drainage 469

Cranial nerves 475

Olfactory nerve [I] 475

Optic nerve [II] 475

Oculomotor nerve [III] 477

Trochlear nerve [IV] 478

Trigeminal nerve [V] 478

Ophthalmic nerve [V₁] 478

Maxillary nerve [V₂] 479

Mandibular nerve [V₃] 479

Abducent nerve [VI] 479

Facial nerve [VII] 479

Vestibulocochlear nerve [VIII] 479

Glossopharyngeal nerve [IX] 480

Vagus nerve [X] 480

Accessory nerve [XI] 480

Hypoglossal nerve [XII] 484

Face 484

- Muscles 484
- Parotid gland 487
- Innervation 489
- Vessels 492

Scalp 496

- Layers 496
- Innervation 498
- Vessels 499
- Lymphatic drainage 500

Orbit 501

- Bony orbit 501
- Eyelids 502
- Lacrimal apparatus 505
- Sensory innervation 506
- Fissures and foramina 507
- Fascial specializations 509
- Muscles 510
- Vessels 513
- Innervation 515
- Eyeball 519

Ear 522

- External ear 522
- Middle ear 526
- Internal ear 530

Temporal and infratemporal fossae 535

- Bony framework 536
- Temporomandibular joints 538
- Masseter muscle 540
- Temporal fossa 540
- Infratemporal fossa 541

Pterygopalatine fossa 550

- Skeletal framework 551
- Gateways 551
- Contents 552

Neck 557

- Fascia 558
- Superficial venous drainage 560
- Anterior triangle of the neck 561
- Posterior triangle of the neck 572
- Root of the neck 577

Pharynx 584

- Skeletal framework 585
- Pharyngeal wall 586

Fascia 587

Gaps in the pharyngeal wall and structures passing through them 587

Nasopharynx 588

Oropharynx 590

Laryngopharynx 590

Tonsils 590

Vessels 590

Nerves 591

Larynx 592

Laryngeal cartilages 593

Extrinsic ligaments 595

Intrinsic ligaments 596

Laryngeal joints 597

Cavity of the larynx 598

Intrinsic muscles 600

Function of the larynx 601

Vessels 602

Nerves 603

Nasal cavities 604

Lateral wall 605

Regions 605

Skeletal framework 606

External nose 606

Paranasal sinuses 607

Walls, floor, and roof 609

Nares 611

Choanae 611

Gateways 611

Vessels 613

Innervation 614

Oral cavity 616

Skeletal framework 617

Walls: the cheeks 620

Floor 621

Salivary glands 627

Roof—palate 629

Oral fissure and lips 633

Oropharyngeal isthmus 634

Teeth and gingivae 634

Regional anatomy

The head and neck are anatomically complex areas of the body. The **head** is composed of a series of compartments, which are formed by bone and soft tissues (Fig. 8.1). They are:

- the cranial cavity,
- two ears,
- two orbits,
- two nasal cavities, and
- an oral cavity.

The **neck** extends from the head above to the shoulders and thorax below (Fig. 8.1). The neck has four major compartments (Fig. 8.2), which are enclosed by an outer musculofascial collar:

- The vertebral compartment contains the cervical vertebrae and associated postural muscles.

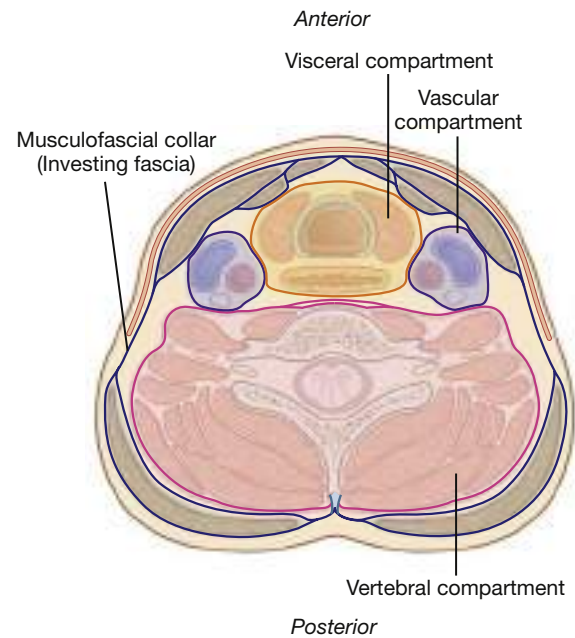


Fig. 8.2 Major compartments of the neck.

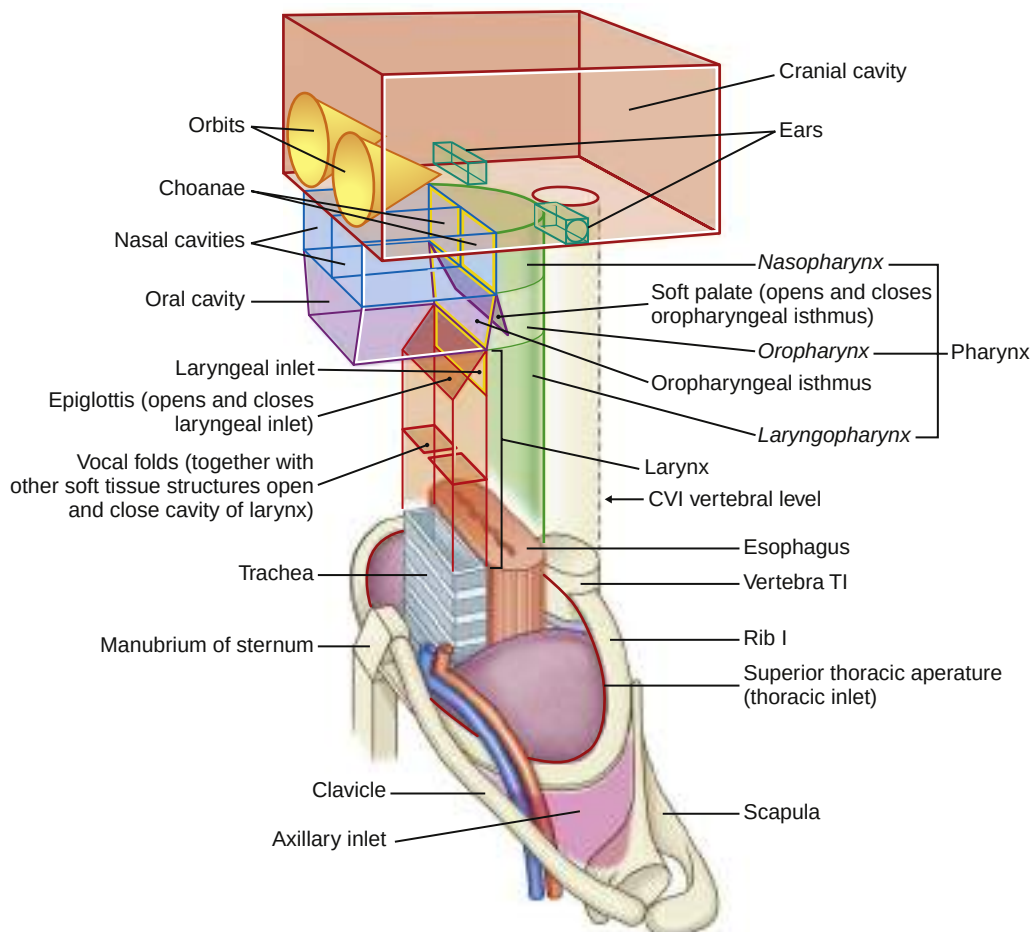


Fig. 8.1 Overall design of head and neck.

- The visceral compartment contains important glands (thyroid, parathyroid, and thymus) and parts of the respiratory and digestive tracts (larynx and pharynx) that pass between the head and thorax.
- The two vascular compartments, one on each side, contain the major blood vessels and the vagus nerve.

HEAD

- Houses and protects the brain and all the receptor systems associated with the special senses—the nasal cavities associated with smell, the orbits with vision, the ears with hearing and balance, and the oral cavity with taste.
- Contains the upper parts of the respiratory and digestive systems—the nasal and oral cavities—which have structural features for modifying the air or food passing into each system.

NECK

- Supports and positions the head. Importantly, it enables an individual to position sensory systems in the head relative to environmental cues without moving the entire body.
- Contains specialized structures (pharynx and larynx) that connect the upper parts of the digestive and respiratory tracts (nasal and oral cavities) in the head with the esophagus and trachea, which begin relatively low in the neck and pass into the thorax.

The head and neck together function in communication. Sounds produced by the larynx are modified in the pharynx and oral cavity to produce speech. In addition, the muscles of facial expression adjust the contours of the face to relay nonverbal signals.

SKULL

The skull has 22 bones, excluding the ossicles of the ear. Except for the mandible, which forms the lower jaw, the bones of the skull are attached to each other by sutures, are immobile, and form the **cranium**.

The cranium can be subdivided into:

- an upper domed part (the **calvaria**), which covers the cranial cavity containing the brain;
- a base that consists of the floor of the cranial cavity; and
- a lower anterior part—the **facial skeleton (viscerocranium)**.

The bones forming the calvaria are mainly the paired temporal and parietal bones and parts of the unpaired frontal, sphenoid, and occipital bones.

The bones forming the base of the cranium are mainly parts of the sphenoid, temporal, and occipital bones.

The bones forming the facial skeleton are the paired nasal bones, palatine bones, lacrimal bones, zygomatic bones, maxillae, inferior nasal conchae, and the unpaired vomer.

The mandible is not part of the cranium nor part of the facial skeleton.

Anterior view

The anterior view of the skull includes the **forehead** superiorly, and, inferiorly, the orbits, the **nasal region**, the part of the face between the orbit and the upper jaw, the upper jaw, and the lower jaw (Fig. 8.3; also see Fig. 8.4).

Frontal bone

The forehead consists of the **frontal bone**, which also forms the superior part of the rim of each orbit (Fig. 8.3).

Just superior to the rim of the orbit on each side are the raised **superciliary arches**. These are more pronounced in men than in women. Between these arches is a small depression (the **glabella**).

Clearly visible in the medial part of the superior rim of each orbit is the **supra-orbital foramen (supra-orbital notch; Table 8.1)**.

Medially, the frontal bone projects inferiorly, forming a part of the medial rim of the orbit.

Laterally, the **zygomatic process** of the frontal bone projects inferiorly, forming the upper lateral rim of the orbit. This process articulates with the **frontal process** of the zygomatic bone.

Zygomatic and nasal bones

The lower lateral rim of the orbit, as well as the lateral part of the inferior rim of the orbit, is formed by the **zygomatic bone** (the cheekbone) (Fig. 8.3).

Superiorly, in the nasal region, the paired nasal bones articulate with each other in the midline and with the frontal bone superiorly. The center of the **frontonasal suture** formed by the articulation of the nasal bones and the frontal bone is the **nasion**.

Laterally, each nasal bone articulates with the **frontal process** of each maxilla.

Inferiorly, the **piriform aperture** is the large opening in the nasal region and the anterior opening of the nasal cavities. It is bounded superiorly by the nasal bones and laterally and inferiorly by each maxilla.

Visible through the piriform aperture are the fused **nasal crests**, forming the lower part of the bony **nasal septum** and ending anteriorly as the **anterior nasal spine**, and the paired **inferior nasal conchae**.

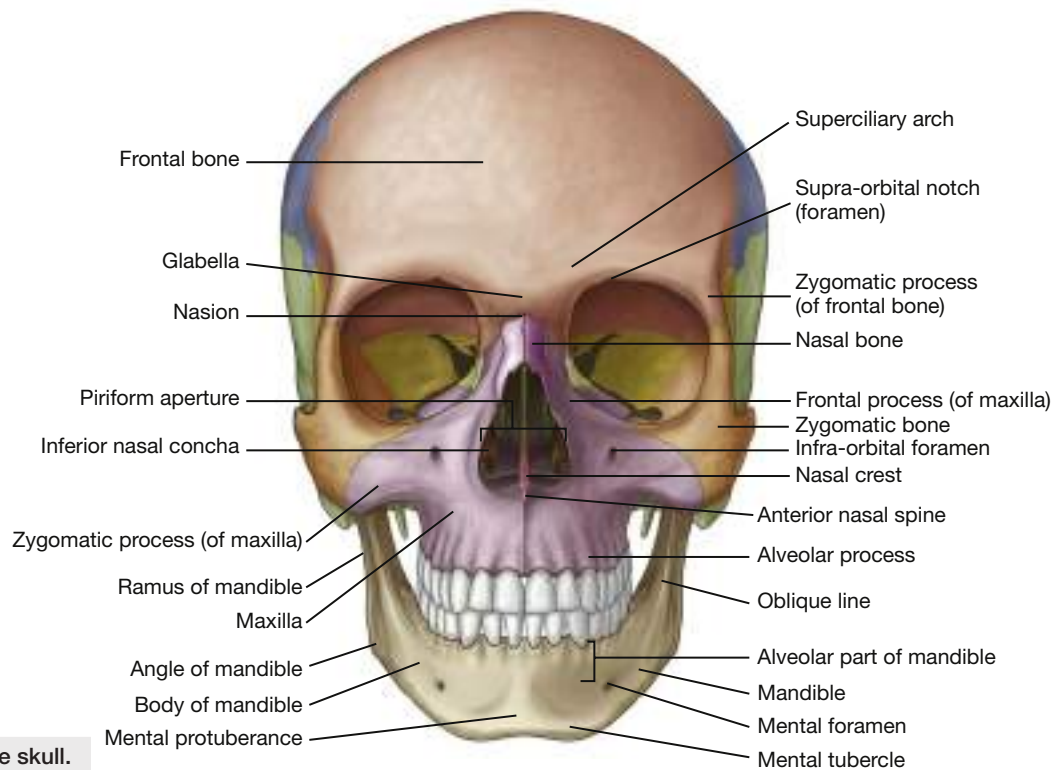


Fig. 8.3 Anterior view of the skull.

Imaging app

Visualizing the skull—anterior view

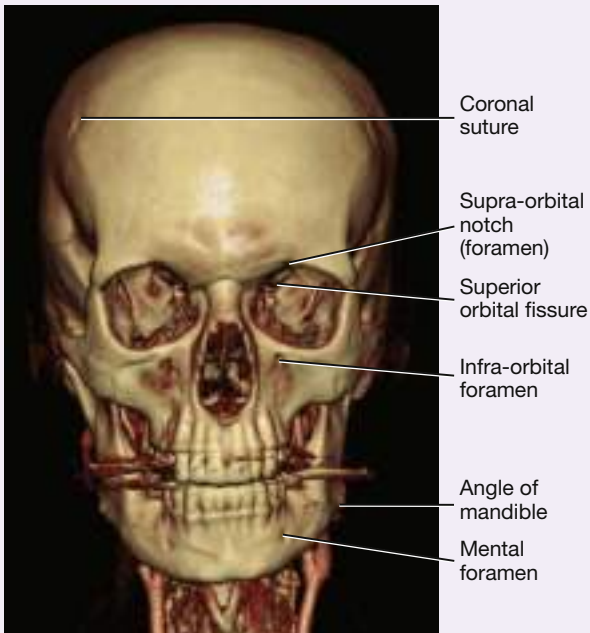


Fig. 8.4 Volume-rendered anterior view using multidetector computed tomography.

Maxillae

The part of the face between the orbit and the upper teeth and each upper jaw is formed by the paired maxillae (Fig. 8.3).

Superiorly, each maxilla contributes to the inferior and medial rims of the orbit.

Laterally, the **zygomatic process** of each maxilla articulates with the zygomatic bone, and medially, the frontal process of each maxilla articulates with the frontal bone.

Inferiorly, the part of each maxilla, lateral to the opening of the nasal cavity, is the **body of maxilla**.

On the anterior surface of the body of maxilla, just below the inferior rim of the orbit, is the **infra-orbital foramen** (Table 8.1).

Inferiorly, each maxilla ends as the **alveolar process**, which contains the teeth and forms the upper jaw.

Mandible

The lower jaw (mandible) is the most inferior structure in the anterior view of the skull (see Fig. 8.3). It consists of the **body of mandible** anteriorly and the **ramus of mandible** posteriorly. These meet posteriorly at the **angle of mandible**. All these parts of the mandible are visible, to some extent, in the anterior view.

The body of mandible is arbitrarily divided into two parts:

- The lower part is the **base of mandible**.
- The upper part is the **alveolar part of mandible**.

Table 8.1 External foramina of the skull

Foramen	Structures passing through foramen
Anterior view	
Supra-orbital foramen	Supra-orbital nerve and vessels
Infra-orbital foramen	Infra-orbital nerve and vessels
Mental foramen	Mental nerve and vessels
Lateral view	
Zygomatofacial foramen	Zygomatofacial nerve
Superior view	
Parietal foramen	Emissary veins
Inferior view	
Incisive foramina	Nasopalatine nerve; sphenopalatine vessels
Greater palatine foramen	Greater palatine nerve and vessels
Lesser palatine foramina	Lesser palatine nerve and vessels
Pterygoid canal	Nerve of pterygoid canal and vessels
Foramen ovale	Mandibular nerve [V ₃]; lesser petrosal nerve
Foramen spinosum	Middle meningeal artery
Foramen lacerum	Filled with cartilage
Carotid canal	Internal carotid artery and nerve plexus
Foramen magnum	Continuation of brain and spinal cord; vertebral arteries and nerve plexuses; anterior spinal artery; posterior spinal arteries; roots of accessory nerve [XI]; meninges
Condylar canal	Emissary veins
Hypoglossal canal	Hypoglossal nerve [XII] and vessels
Jugular foramen	Internal jugular vein; inferior petrosal sinus; glossopharyngeal nerve [IX]; vagus nerve [X]; accessory nerve [XI]
Stylomastoid foramen	Facial nerve [VII]

The alveolar part of mandible contains the teeth and is resorbed when the teeth are removed. The base of mandible has a midline swelling (the **mental protuberance**) on its anterior surface where the two sides of the mandible come together. Just lateral to the mental protuberance, on either side, are slightly more pronounced bumps (**mental tubercles**).

Laterally, a **mental foramen** (see Table 8.1) is visible half-way between the upper border of the alveolar part of mandible and the lower border of the base of mandible. Continuing past this foramen is a ridge (the **oblique line**) passing from the front of the ramus onto the body of mandible. The

oblique line is a point of attachment for muscles that depress the lower lip.

Lateral view

The lateral view of the skull consists of the lateral wall of the cranium, which includes lateral portions of the calvaria and the facial skeleton, and half of the lower jaw (Fig. 8.5; see also Fig. 8.6):

- Bones forming the lateral portion of the calvaria include the frontal, parietal, occipital, sphenoid, and temporal bones.
- Bones forming the visible part of the facial skeleton include the nasal, maxilla, and zygomatic bones.
- The mandible forms the visible part of the lower jaw.

Lateral portion of the calvaria

The lateral portion of the calvaria begins anteriorly with the frontal bone. In upper regions, the frontal bone articulates with the parietal bone at the **coronal suture** (Fig. 8.5). The parietal bone then articulates with the occipital bone at the **lambdoid suture**.

In lower parts of the lateral portion of the calvaria, the frontal bone articulates with the **greater wing of sphenoid bone** (Fig. 8.5), which then articulates with the parietal bone at the **sphenoparietal suture**, and with the anterior edge of the temporal bone at the **sphenosquamous suture**.

The junction where the frontal, parietal, sphenoid, and temporal bones are in close proximity is the **pterion** (Fig. 8.5). The clinical consequences of a skull fracture in this area can be very serious. The bone in this area is particularly thin and overlies the anterior division of the middle meningeal artery, which can be torn by a skull fracture in this area, resulting in an extradural hematoma.

The final articulation across the lower part of the lateral portion of the calvaria is between the temporal bone and the occipital bone at the **occipitomastoid suture** (Fig. 8.5).

Temporal bone

A major contributor to the lower portion of the lateral wall of the cranium is the temporal bone (Fig. 8.5), which consists of several parts:

- The **squamous part** has the appearance of a large, flat plate, forms the anterior and superior parts of the temporal bone, contributes to the lateral wall of the cranium, and articulates anteriorly with the greater wing of the sphenoid bone at the sphenosquamous suture and with the parietal bone superiorly at the squamous suture.
- The **zygomatic process** is an anterior bony projection from the lower surface of the squamous part of the temporal bone

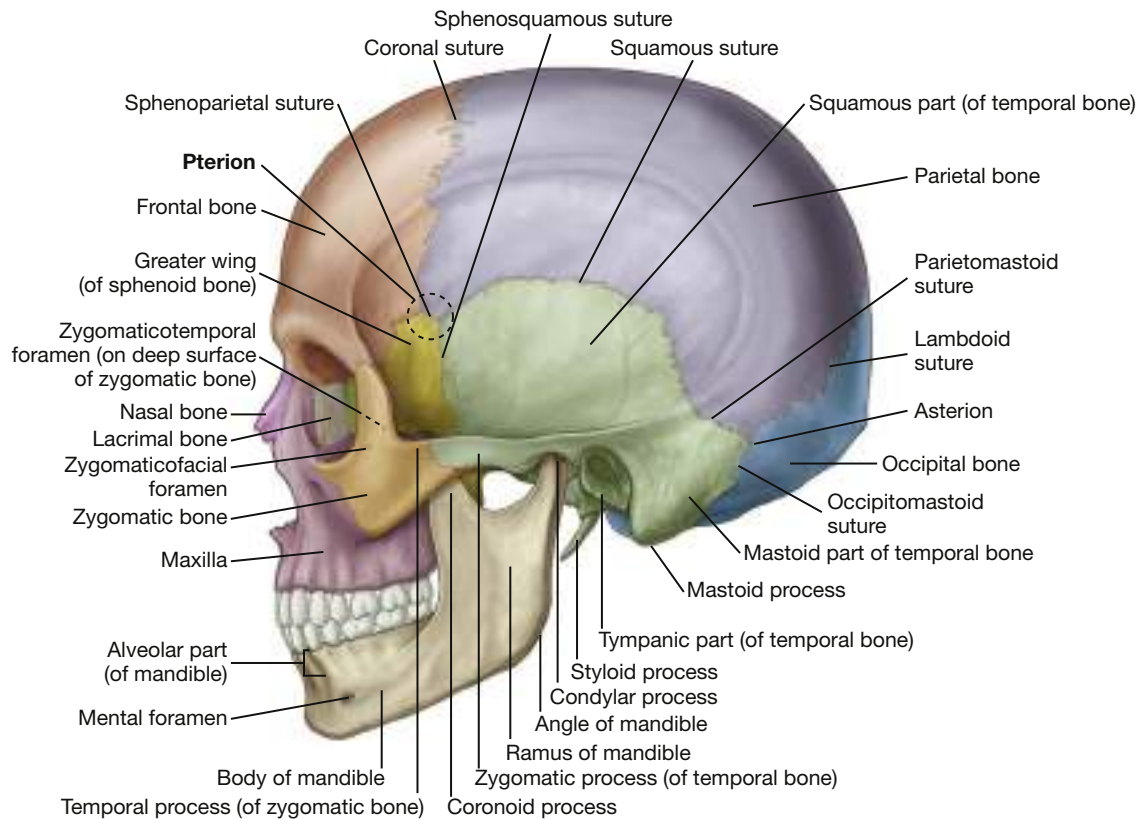


Fig. 8.5 Lateral view of the skull.

Imaging app

Visualizing the skull—lateral view

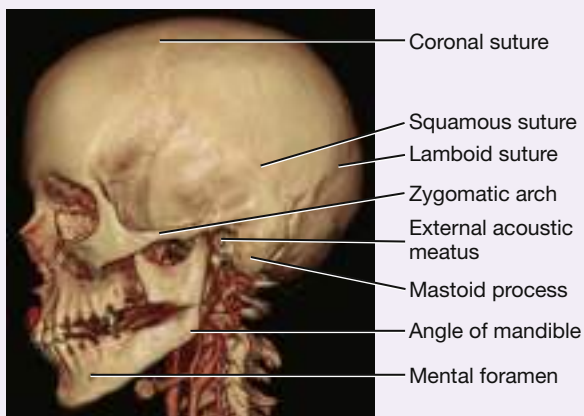


Fig. 8.6 Volume-rendered lateral view using multidetector computed tomography.

that initially projects laterally and then curves anteriorly to articulate with the temporal process of the zygomatic bone to form the **zygomatic arch**.

- Immediately below the origin of the zygomatic process from the squamous part of the temporal bone is the **tympanic part** of the temporal bone, and clearly visible on the surface of this part is the **external acoustic opening** leading to the **external acoustic meatus** (ear canal).
- The petromastoid part is usually separated into a **petrous part** and a **mastoid part** for descriptive purposes.

The mastoid part is the most posterior part of the temporal bone and is the only part of the petromastoid part of the temporal bone seen on a lateral view of the skull. It is continuous with the squamous part of the temporal bone anteriorly and articulates with the parietal bone superiorly at the **parietomastoid suture** and with the occipital bone posteriorly at the occipitomastoid suture. These two sutures are continuous with each other, and the parietomastoid suture is continuous with the squamous suture.

Inferiorly, a large bony prominence (the **mastoid process**) projects from the inferior border of the mastoid part of the temporal bone (Fig. 8.5). This is a point of attachment for several muscles.

Medial to the mastoid process, the **styloid process** projects from the lower border of the temporal bone.

Surface anatomy

Anatomical position of the head and major landmarks

The head is in the anatomical position when the inferior margins of the bony orbits and the superior margins of the external acoustic meatuses are in the same horizontal plane (Frankfort plane).

In addition to the external acoustic meatus and the bony margin of the orbit, other features that are palpable include the head of mandible, zygomatic arch, zygomatic bone, mastoid process, and external occipital protuberance (Fig. 8.7).

The head of mandible is anterior to the external ear and behind and inferior to the posterior end of the zygomatic arch. It is best found by opening and closing the jaw and palpating the head of mandible as it moves forward onto the articular tubercle and then back into the mandibular fossa, respectively.

The zygomatic arch extends forward from the region of the temporomandibular joint to the zygomatic bone, which forms a bony prominence lateral to the inferior margin of the anterior opening of the orbit.

The mastoid process is a large bony protuberance that is easily palpable posterior to the inferior aspect of the external acoustic meatus. The superior end of the sternocleidomastoid muscle attaches to the mastoid process.

The external occipital protuberance is palpable in the midline posteriorly where the contour of the skull curves sharply forward. This landmark marks the point superficially where the back of the neck joins the head.

Another clinically useful feature of the head is the vertex. This is the highest point of the head in the anatomical position and marks the approximate point on the scalp where there is a transition from cervical to cranial innervation of the scalp. Anterior to the vertex, the scalp and face are innervated by the trigeminal nerve [V]. Posterior to the vertex, the scalp is innervated by branches from cervical spinal nerves.

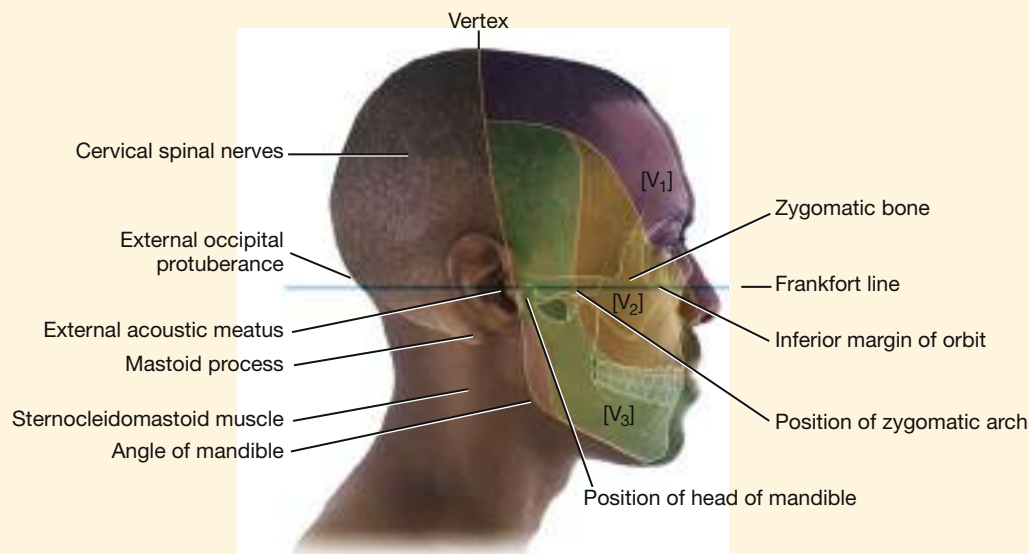


Fig. 8.7 Anatomical position of the head and major landmarks. Lateral head and neck of a man.

Visible part of the facial skeleton

The bones of the viscerocranium visible in a lateral view of the skull include the nasal, maxilla, and zygomatic bones (Fig. 8.5) as follows:

- a nasal bone anteriorly;
- the maxilla with its alveolar process containing teeth forming the upper jaw; anteriorly, it articulates with the nasal bone; superiorly, it contributes to the formation of the inferior and medial borders of the orbit; medially, its frontal process articulates with the frontal bone; laterally,

its zygomatic process articulates with the zygomatic bone; and

- the zygomatic bone, an irregularly shaped bone with a rounded lateral surface that forms the prominence of the cheek, is a visual centerpiece in this view; medially, it assists in the formation of the inferior rim of the orbit through its articulation with the zygomatic process of the maxilla; superiorly, its frontal process articulates with the zygomatic process of the frontal bone, assisting in the formation of the lateral rim of the orbit; laterally, seen prominently in this view of the skull, the horizontal

temporal process of the zygomatic bone projects backward to articulate with the zygomatic process of the temporal bone and so form the zygomatic arch.

Usually a small foramen (the **zygomaticofacial foramen**; see Table 8.1) is visible on the lateral surface of the zygomatic bone. A **zygomaticotemporal foramen** is present on the medial deep surface of the bone.

Mandible

The final bony structure visible in a lateral view of the skull is the mandible. Inferiorly in the anterior part of this view, it consists of the anterior body of mandible, a posterior ramus of mandible, and the angle of mandible where the inferior margin of the mandible meets the posterior margin of the ramus (Fig. 8.5).

The teeth are in the alveolar part of the body of mandible, and the mental protuberance is visible in this view.

The mental foramen is on the lateral surface of the body and on the superior part of the ramus, and a **condylar** and **coronoid process** extend upward.

The condylar process is involved in articulation of the mandible with the temporal bone, and the coronoid process is the point of attachment for the temporalis muscle.

Posterior view

The occipital, parietal, and temporal bones are seen in the posterior view of the skull (Fig. 8.8).

Occipital bone

Centrally the flat or **squamous part of occipital bone** is the main structure in this view of the skull (Fig. 8.8). It articulates superiorly with the paired parietal bones at the lambdoid suture and laterally with each temporal bone at the occipitomastoid sutures. Along the lambdoid suture, small islands of bone (**sutural bones** or wormian bones) may be observed.

Several bony landmarks are visible on the occipital bone. There is a midline projection (the **external occipital protuberance**) with curved lines extending laterally from it (**superior nuchal lines**). The most prominent point of the external occipital protuberance is the **inion**. About 1 inch (2.5 cm) below the superior nuchal lines, two additional lines (the **inferior nuchal lines**) curve laterally. Extending downward from the external occipital protuberance is the **external occipital crest**.

Temporal bones

Laterally, the temporal bones are visible in the posterior view of the skull, with the mastoid processes being the prominent feature (Fig. 8.8). On the inferomedial border of each mastoid process is a notch (the **mastoid notch**), which is a point of attachment for the posterior belly of the digastric muscle.

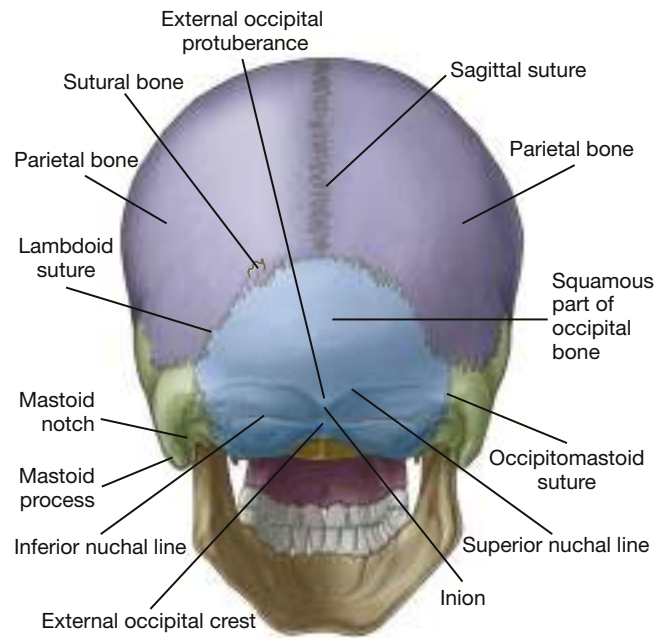


Fig. 8.8 Posterior view of the skull.

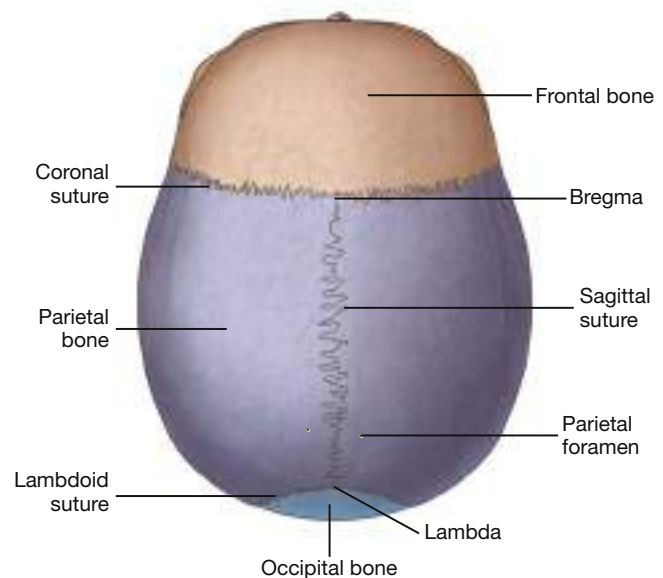


Fig. 8.9 Superior view of the skull.

Superior view

The frontal bone, parietal bones, and occipital bone are seen in a superior view of the skull (Fig. 8.9). These bones make up the superior part of the calvaria, or the **calva** (skullcap).

In an anterior to posterior direction:

- The unpaired frontal bone articulates with the paired parietal bones at the coronal suture.

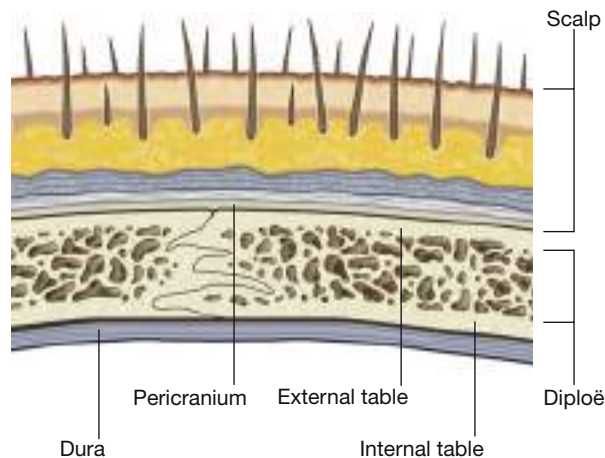


Fig. 8.10 Calvaria.

- The two parietal bones articulate with each other in the midline at the sagittal suture.
- The parietal bones articulate with the unpaired occipital bone at the lambdoid suture.

The junction of the sagittal and coronal sutures is the **bregma**, and the junction of the sagittal and lambdoid sutures is the **lambda**.

The only foramina visible in this view of the skull may be the parietal foramina located posteriorly, one on each parietal bone just lateral to the sagittal suture (Fig. 8.9).

The bones making up the calvaria (Fig. 8.10) are unique in their structure, consisting of dense internal and external tables of compact bone separated by a layer of spongy bone (the **diploë**).

Inferior view

The base of the skull is seen in the inferior view and extends anteriorly from the middle incisor teeth posteriorly to the superior nuchal lines and laterally to the mastoid processes and zygomatic arches (Fig. 8.11).

For descriptive purposes, the base of the skull is often divided into:

- an anterior part, which includes the teeth and the hard palate;
- a middle part, which extends from behind the hard palate to the anterior margin of the foramen magnum; and
- a posterior part, which extends from the anterior edge of the foramen magnum to the superior nuchal lines.

Anterior part

The main features of the anterior part of the base of the skull are the teeth and the hard palate.

The teeth project from the **alveolar processes** of the two maxillae. These processes are arranged together in a U-shaped alveolar arch that borders the hard palate on three sides (Fig. 8.11).

The **hard palate** is composed of the **palatine processes** of each maxilla anteriorly and the **horizontal plates** of each **palatine bone** posteriorly.

*** paired palatine processes of each maxilla meet in the midline at the **intermaxillary suture**, the paired maxilla and the paired palatine bones meet at the **palatamaxillary suture**, and the paired horizontal plates of each palatine bone meet in the midline at the **interpalatine suture**.

Several additional features are also visible when the hard palate is examined:

- The **incisive fossa** in the anterior midline immediately posterior to the teeth, the walls of which contain **incisive foramina** (the openings of the **incisive canals**, which are passageways between the hard palate and nasal cavity).
- The **greater palatine foramina** near the posterolateral border of the hard palate on each side, which lead to **greater palatine canals**.
- Just posterior to the greater palatine foramina, the **lesser palatine foramina** in the **pyramidal process** of each palatine bone, which lead to **lesser palatine canals**.
- A midline pointed projection (the **posterior nasal spine**) in the free posterior border of the hard palate.

Middle part

The middle part of the base of the skull is complex:

- Forming the anterior half are the vomer and sphenoid bones.
- Forming the posterior half are the occipital and paired temporal bones.

Anterior half

Vomer

Anteriorly, the small vomer is in the midline, resting on the sphenoid bone (Fig. 8.11). It contributes to the formation of the bony nasal septum separating the two choanae.

Sphenoid

Most of the anterior part of the middle part of the base of the skull consists of the sphenoid bone.

The sphenoid bone is made up of a centrally placed **body**, paired **greater and lesser wings** projecting laterally from the body, and two downward-projecting **pterygoid processes** immediately lateral to each choana.

Three parts of the sphenoid bone, the body, greater wings, and pterygoid processes, are seen in the inferior view of the skull (Fig. 8.11). The lesser wing of the sphenoid is not seen in the inferior view.

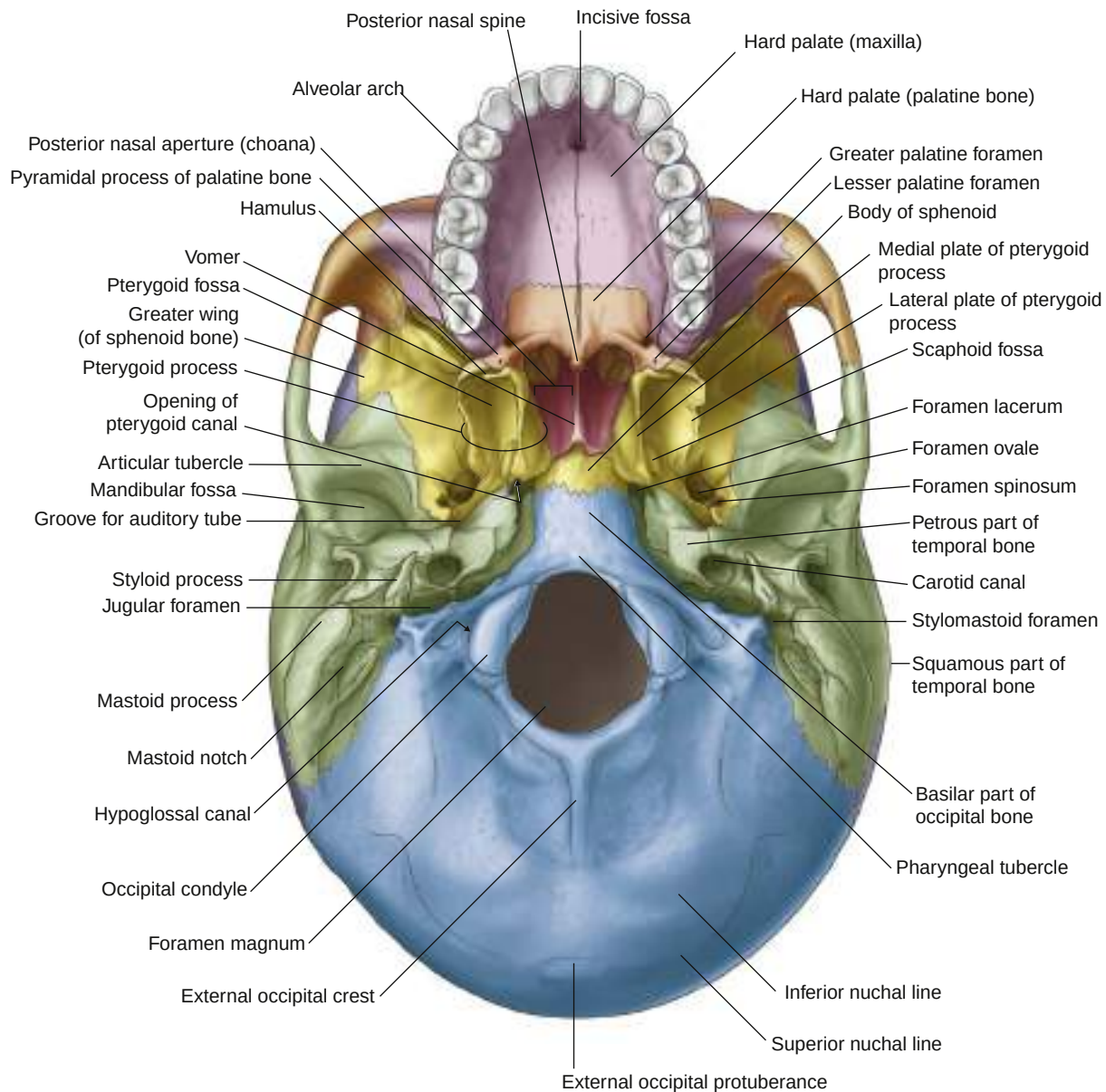


Fig. 8.11 Inferior view of the skull.

Body

The body of the sphenoid is a centrally placed cube of bone containing two large air sinuses separated by a septum.

It articulates anteriorly with the vomer, ethmoid, and palatine bones, posterolaterally with the temporal bones, and posteriorly with the occipital bone.

Pterygoid processes

Extending downward from the junction of the body and the greater wings are the pterygoid processes (Fig. 8.11). Each of these processes consists of a narrow **medial plate** and broader **lateral plate** separated by the **pterygoid fossa**.

Each medial plate of the pterygoid process ends inferiorly with a hook-like projection, the **pterygoid hamulus**, and divides superiorly to form the small, shallow **scaphoid fossa**.

Just superior to the scaphoid fossa, at the root of the medial plate of the pterygoid process is the opening of the **pterygoid canal**, which passes forward from near the anterior margin of the foramen lacerum.

Greater wing

Lateral to the lateral plate of the pterygoid process is the greater wing of the sphenoid (Fig. 8.11), which not only forms a part of the base of the skull, but also continues laterally to form part of the lateral wall of the skull. It articulates laterally and posteriorly with parts of the temporal bone.

Important features visible on the surface of the greater wing in an inferior view of the skull are the foramen ovale and the foramen spinosum on the posterolateral border extending outward from the upper end of the lateral plate of the pterygoid process.

Posterior half of middle part

In the posterior half of the middle part of the base of the skull are the occipital bone and the paired temporal bones (Fig. 8.11).

Occipital bone

The occipital bone, or more specifically its **basilar part**, is in the midline immediately posterior to the body of the sphenoid. It extends posteriorly to the **foramen magnum** and is bounded laterally by the temporal bones.

Prominent on the basilar part of the occipital bone is the **pharyngeal tubercle**, a bony protuberance for the attachment of parts of the pharynx to the base of the skull (Fig. 8.11).

Temporal bone

Immediately lateral to the basilar part of the occipital bone is the petrous part of the petromastoid part of each temporal bone.

Wedge-shaped in its appearance, with its **apex** anteromedial, the petrous part of the temporal bone is between the greater wing of the sphenoid anteriorly and the basilar part of the occipital bone posteriorly. The apex forms one of the boundaries of the **foramen lacerum**, an irregular opening filled in life with cartilage (Fig. 8.11).

The other boundaries of the foramen lacerum are the basilar part of the occipital bone medially and the body of the sphenoid anteriorly.

Posterolateral from the foramen lacerum along the petrous part of the temporal bone is the large circular opening for the **carotid canal**.

Between the petrous part of the temporal bone and the greater wing of the sphenoid is a groove for the cartilaginous part of the **pharyngotympanic tube (auditory tube)**. This groove continues posterolaterally into a bony canal in the petrous part of the temporal bone for the pharyngotympanic tube.

Just lateral to the greater wing of the sphenoid is the squamous part of the temporal bone, which participates in the temporomandibular joint. It contains the **mandibular fossa**, which is a concavity where the head of the mandible articulates with the base of the skull. An important feature of this articulation is the prominent **articular tubercle**, which is the downward projection of the anterior border of the mandibular fossa (Fig. 8.11).

Posterior part

The posterior part of the base of the skull extends from the anterior edge of the foramen magnum posteriorly to the superior nuchal lines (Fig. 8.11). It consists of parts of the occipital bone centrally and the temporal bones laterally.

Occipital bone

The occipital bone is the major bony element of this part of the base of the skull (Fig. 8.11). It has four parts organized

around the foramen magnum, which is a prominent feature of this part of the base of the skull and through which the brain and spinal cord are continuous.

The parts of the occipital bone are the squamous part, which is posterior to the foramen magnum, the **lateral parts**, which are lateral to the foramen magnum, and the **basilar part**, which is anterior to the foramen magnum (Fig. 8.11).

The squamous and lateral parts are components of the posterior part of the base of the skull.

The most visible feature of the squamous part of the occipital bone, when examining the inferior view of the skull, is a ridge of bone (the external occipital crest) that extends downward from the external occipital protuberance toward the foramen magnum. The inferior nuchal lines arc laterally from the midpoint of the crest.

Immediately lateral to the foramen magnum are the lateral parts of the occipital bones, which contain numerous important structural features.

On each anterolateral border of the foramen magnum are the rounded **occipital condyles** (Fig. 8.11). These paired structures articulate with the atlas (vertebra CI). Posterior to each condyle is a depression (the **condylar fossa**) containing a **condylar canal**, and anterior and superior to each condyle is the large **hypoglossal canal**. Lateral to each hypoglossal canal is a large, irregular, **jugular foramen** formed by opposition of the **jugular notch** of the occipital bone and **jugular notch** of the temporal bone.

Temporal bone

Laterally, on each side, in the posterior part of the base of the skull is the temporal bone. The parts of the temporal bone seen in this location are the mastoid part of the petromastoid part and the styloid process (see Fig. 8.11).

The lateral edge of the mastoid part is identified by the large cone-shaped mastoid process projecting from its inferior surface. This prominent bony structure is the point of attachment for several muscles. On the medial aspect of the mastoid process is the deep mastoid notch, which is also an attachment point for a muscle.

Anteromedial to the mastoid process is the needle-shaped styloid process projecting from the lower border of the temporal bone. The styloid process is also a point of attachment for numerous muscles and ligaments.

Finally, between the styloid process and the mastoid process is the stylomastoid foramen.

CRANIAL CAVITY

The cranial cavity is the space within the cranium that contains the brain, meninges, proximal parts of the cranial nerves, blood vessels, and cranial venous sinuses.

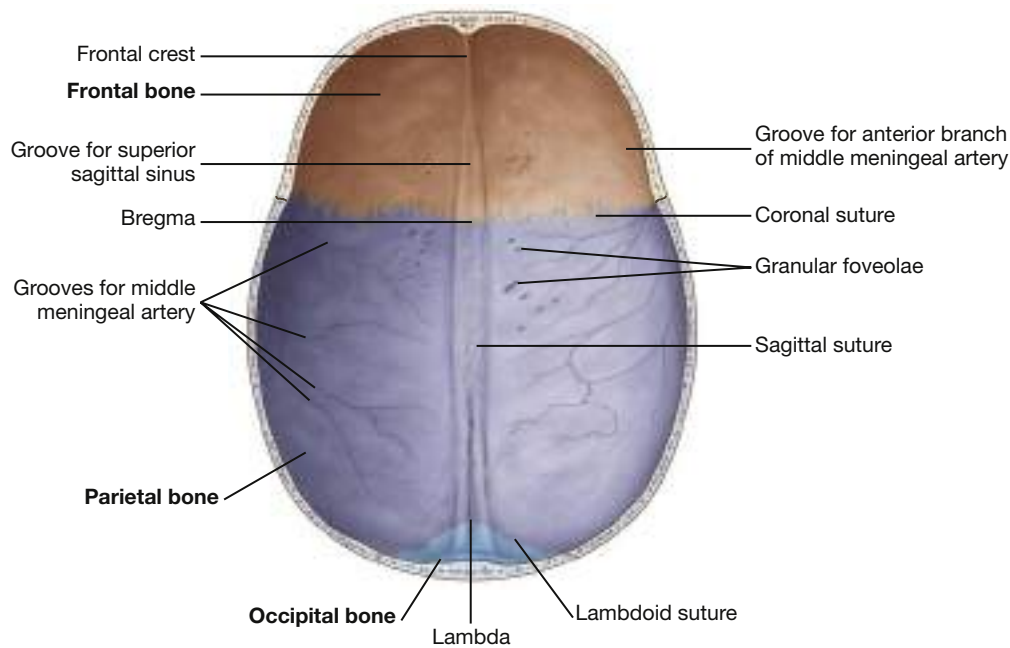


Fig. 8.12 Roof of the cranial cavity.

Roof

The calvaria is the dome-shaped roof that protects the superior aspect of the brain. It consists mainly of the frontal bone anteriorly, the paired parietal bones in the middle, and the occipital bone posteriorly (Fig. 8.12).

Sutures visible internally include:

- the coronal suture between the frontal and parietal bones,
- the sagittal suture between the paired parietal bones, and
- the lambdoid suture between the parietal and occipital bones.

Visible junctions of these sutures are the bregma, where the coronal and sagittal sutures meet, and the lambda, where the lambdoid and sagittal sutures meet.

Other markings on the internal surface of the calva include bony ridges and numerous grooves and pits (Fig. 8.12).

From anterior to posterior, features seen on the bony roof of the cranial cavity are (Fig. 8.12):

- a midline ridge of bone extending from the surface of the frontal bone (the **frontal crest**), which is a point of attachment for **the falx cerebri** (a specialization of the dura mater that partially separates the two cerebral hemispheres);
- a **groove for the superior sagittal sinus**, which widens and deepens posteriorly and marks the position of the superior sagittal sinus (an intradural venous structure);

- on either side of the groove for the superior sagittal sinus throughout its course, a small number of depressions and pits (the **granular foveolae**), which mark the location of arachnoid granulations (prominent structures readily identifiable when a brain with its meningeal coverings is examined; the arachnoid granulations are involved in the reabsorption of cerebrospinal fluid [CSF]); and
- on the lateral aspects of the roof of the cranial cavity, smaller grooves created by various meningeal vessels.

Floor

The floor of the cranial cavity is divided into anterior, middle, and posterior cranial fossae.

Anterior cranial fossa

Parts of the frontal, ethmoid, and sphenoid bones form the anterior cranial fossa (Fig. 8.13). Its floor is composed of:

- frontal bone in the anterior and lateral direction;
- ethmoid bone in the midline; and
- two parts of the sphenoid bone (posteriorly), the body (midline), and the lesser wings (laterally).

The anterior cranial fossa is above the nasal cavity and the orbits and is filled by the frontal lobes of the cerebral hemispheres.

Anteriorly, a small wedge-shaped midline crest of bone (the frontal crest) projects from the frontal bone. This is a point of attachment for the falx cerebri. Immediately

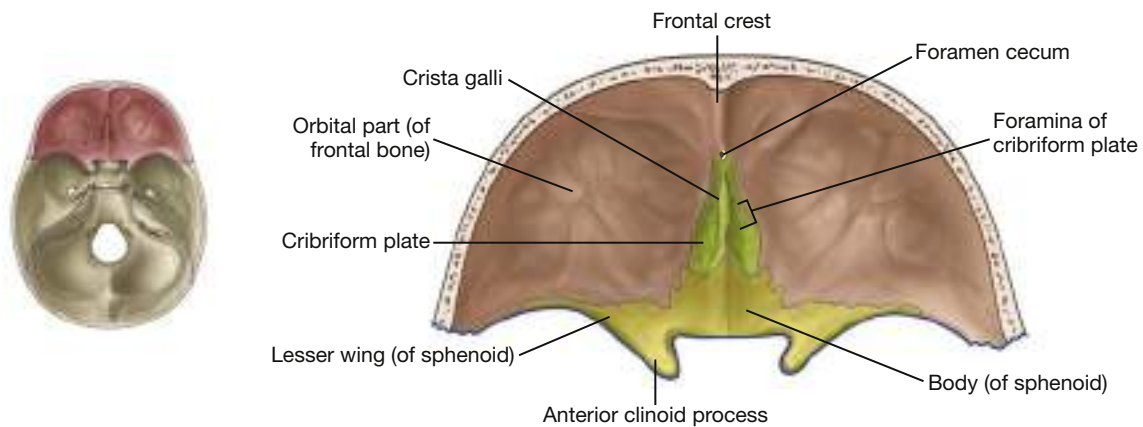


Fig. 8.13 Anterior cranial fossa.

Table 8.2 Internal foramina of the skull

Foramen	Structures passing through foramen
Anterior cranial fossa	
Foramen cecum	Emissary veins to nasal cavity
Olfactory foramina in cribriform plate	Olfactory nerves [I]
Middle cranial fossa	
Optic canal	Optic nerve [II]; ophthalmic artery
Superior orbital fissure	Oculomotor nerve [III]; trochlear nerve [IV]; ophthalmic division of the trigeminal nerve [V ₁]; abducent nerve [VI]; ophthalmic veins
Foramen rotundum	Maxillary division of the trigeminal nerve [V ₂]
Foramen ovale	Mandibular division of the trigeminal nerve [V ₃]; lesser petrosal nerve
Foramen spinosum	Middle meningeal artery
Hiatus for the greater petrosal nerve	Greater petrosal nerve
Hiatus for the lesser petrosal nerve	Lesser petrosal nerve
Posterior cranial fossa	
Foramen magnum	End of brainstem/beginning of spinal cord; vertebral arteries; spinal roots of the accessory nerve; meninges
Internal acoustic meatus	Facial nerve [VII]; vestibulocochlear nerve [VIII]; labyrinthine artery
Jugular foramen	Glossopharyngeal nerve [IX]; vagus nerve [X]; accessory nerve [XI]; inferior petrosal sinus, sigmoid sinus (forming internal jugular vein)
Hypoglossal canal	Hypoglossal nerve [XII]; meningeal branch of the ascending pharyngeal artery
Condylar canal	Emissary vein

posterior to the frontal crest is the **foramen cecum** (Table 8.2). This foramen between the frontal and ethmoid bones may transmit emissary veins connecting the nasal cavity with the superior sagittal sinus.

Posterior to the frontal crest is a prominent wedge of bone projecting superiorly from the **ethmoid** (the **crista galli**). This is another point of attachment for the falx cerebri, which is the vertical extension of dura mater partially separating the two cerebral hemispheres.

Lateral to the crista galli is the **cribriform plate** of the ethmoid bone (see Fig. 8.13). This is a sieve-like structure,

which allows small olfactory nerve fibers to pass through its foramina from the nasal mucosa to the olfactory bulb. The olfactory nerves are commonly referred to collectively as the olfactory nerve [I].

On each side of the ethmoid, the floor of the anterior cranial fossa is formed by relatively thin plates of frontal bone (the **orbital part** of the frontal bone), which also forms the roof of the orbit below. Posterior to both the frontal and ethmoid bones, the rest of the floor of the anterior cranial fossa is formed by the body and lesser wings of the sphenoid. In the midline the body extends anteriorly between the

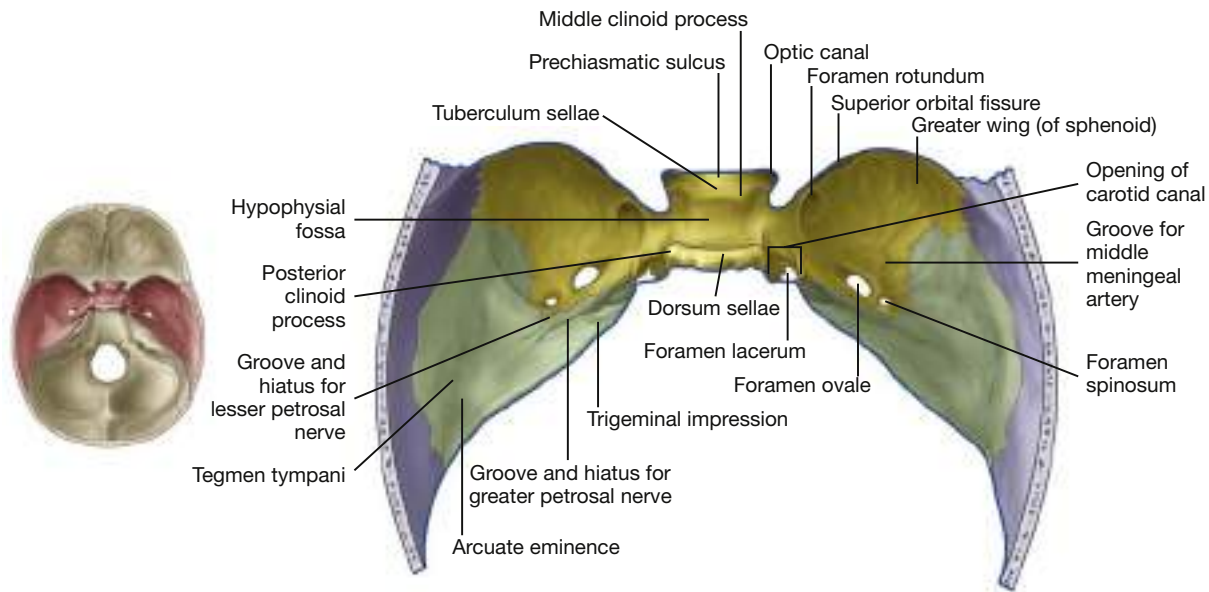


Fig. 8.14 Middle cranial fossa.

orbital parts of the frontal bone to reach the ethmoid bone and posteriorly into the middle cranial fossa.

The boundary between the anterior and middle cranial fossae in the midline is the anterior edge of the prechiasmatic sulcus, a smooth groove stretching between the optic canals across the body of the sphenoid.

Lesser wings of the sphenoid

The two lesser wings of the sphenoid project laterally from the body of the sphenoid and form a distinct boundary between the lateral parts of the anterior and middle cranial fossae (see Fig. 8.13).

Overhanging the anterior part of the middle cranial fossae, each lesser wing ends laterally as a sharp point at the junction of the frontal bone and the greater wing of the sphenoid near the upper lateral edge of the superior orbital fissure that is formed between the greater and lesser wings.

Medially each lesser wing widens, curves posteriorly, and ends as a rounded **anterior clinoid process** (see Fig. 8.13). These processes serve as the anterior point of attachment for the **tentorium cerebelli**, which is a sheet of dura that separates the posterior part of the cerebral hemispheres from the cerebellum. Just anterior to each anterior clinoid process is a circular opening in the lesser wing of the sphenoid (the **optic canal**), through which the ophthalmic artery and optic nerve [II] pass as they exit the cranial cavity to enter the orbit. The optic canals are usually included in the middle cranial fossa.

Middle cranial fossa

The middle cranial fossa consists of parts of the sphenoid and temporal bones (Fig. 8.14).

The boundary between the anterior and middle cranial fossae in the midline is the anterior edge of the prechiasmatic sulcus, which is a smooth groove stretching between the optic canals across the body of the sphenoid.

The posterior boundaries of the middle cranial fossa are formed on each side by the anterior surface, as high as the superior border of the petrous part of the petromastoid part of the temporal bone.

Sphenoid

The floor in the midline of the middle cranial fossa is elevated and formed by the body of the sphenoid. Lateral to this are large depressions formed on either side by the greater wing of the sphenoid and the squamous part of the temporal bone. These depressions contain the temporal lobes of the brain.

Sella turcica

Just posterior to the chiasmatic sulcus is the uniquely modified remainder of the body of the sphenoid (the **sella turcica**), which consists of a deep central area (the **hypophysial fossa**) containing the pituitary gland with anterior and posterior vertical walls of bone (Fig. 8.14).

The anterior wall of the sella is vertical in position with its superior extent visible as a slight elevation (the **tuberculum sellae**) at the posterior edge of the chiasmatic sulcus.

Lateral projections from the corners of the tuberculum sellae (the **middle clinoid processes**) are sometimes evident.

The posterior wall of the sella turcica is the **dorsum sellae**, a large ridge of bone projecting upward and forward. At the top of this bony ridge, the lateral edges contain rounded

projections (the **posterior clinoid processes**), which are points of attachment, like the anterior clinoid processes, for the tentorium cerebelli.

Fissures and foramina

A diagonal gap, the **superior orbital fissure**, separates the greater wing of the sphenoid from the lesser wing and is a major passageway between the middle cranial fossa and the orbit (Fig. 8.14; also see Table 8.2). Passing through the fissure are the oculomotor nerve [III], the trochlear nerve [IV], the ophthalmic nerve [V₁], the abducent nerve [VI], and ophthalmic veins.

Posterior to the medial end of the superior orbital fissure on the floor of the middle cranial fossa is a rounded foramen projecting in an anterior direction (the **foramen rotundum**) through which the maxillary nerve [V₂] passes from the middle cranial fossa to the pterygopalatine fossa (Fig. 8.14; also see Table 8.2).

Posterolateral to the **foramen rotundum** is a large oval opening (the **foramen ovale**), which allows structures to pass between the extracranial infratemporal fossa and the middle cranial fossa (Fig. 8.14; also see Table 8.2). The mandibular nerve [V₃], lesser petrosal nerve (carrying fibers from the tympanic plexus that originally came from the glossopharyngeal nerve [IX]), and occasionally a small vessel (the accessory middle meningeal artery) pass through this foramen.

Posterolateral from the foramen ovale is the small **foramen spinosum** (Fig. 8.14). This opening also connects the infratemporal fossa with the middle cranial fossa. The middle meningeal artery and its associated veins pass through this foramen, and, once inside, the groove for the middle meningeal artery across the floor and lateral wall of the middle cranial fossa clearly marks their path.

Posteromedial to the foramen ovale is the **rounded intracranial opening** of the **carotid canal**. Directly inferior to this opening is an irregular foramen (the **foramen lacerum**) (Fig. 8.14; also see Table 8.2). Clearly observed in the inferior view of the skull, the foramen lacerum is closed in life by a cartilaginous plug and no structures pass through it completely.

Temporal bone

The posterior boundary of the middle cranial fossa is formed by the anterior surface of the petrous part of the petromastoid part of the temporal bone.

Medially, there is a slight depression (**trigeminal impression**) in the anterior surface of the petrous part of the temporal bone (Fig. 8.14), which marks the location of the sensory ganglion for the trigeminal nerve [V].

Lateral to the trigeminal impression and on the anterior surface of the petrous part of the temporal bone is a small

linear groove that passes in a superolateral direction and ends in a foramen (the **groove and hiatus for the greater petrosal nerve**) (Fig. 8.14). The greater petrosal nerve is a branch of the facial nerve [VII].

Anterolateral to the groove for the greater petrosal nerve is a second, smaller **groove and hiatus for the lesser petrosal nerve**, a branch from the tympanic plexus carrying fibers that originally came from the glossopharyngeal nerve [IX] (Fig. 8.14).

Above and lateral to the small openings for the greater and lesser petrosal nerves, near the superior ridge of the petrous part of the temporal bone, is a rounded protrusion of bone (the **arcuate eminence**) produced by the underlying anterior semicircular canal of the inner ear (Fig. 8.14).

Just anterior and lateral to the arcuate eminence, the anterior surface of the petrous part of the temporal bone is slightly depressed. This region is the **tegmen tympani**, which marks the thin bony roof of the middle ear cavity.

Posterior cranial fossa

The posterior cranial fossa consists mostly of parts of the temporal and occipital bones, with small contributions from the sphenoid and parietal bones (Fig. 8.15). It is the largest and deepest of the three cranial fossae and contains the brainstem (midbrain, pons, and medulla) and the cerebellum.

Boundaries

The anterior boundaries of the posterior cranial fossa in the midline are the dorsum sellae and the **clivus** (Fig. 8.15). The clivus is a slope of bone that extends upward from the foramen magnum. It is formed by contributions from the body of the sphenoid and from the basilar part of the occipital bone.

Laterally the anterior boundaries of the posterior cranial fossa are the superior border of the petrous part of the petromastoid part of the temporal bone.

Posteriorly the squamous part of the occipital bone to the level of the transverse groove is the major boundary, and laterally the petromastoid part of the temporal bone and small parts of the occipital and parietal bones border the fossa.

Foramen magnum

Centrally, in the deepest part of the posterior cranial fossa, is the largest foramen in the skull, the foramen magnum (Fig. 8.15; also see Table 8.2). It is surrounded by the basilar part of the occipital bone anteriorly, the lateral parts of the occipital bone on either side, and the squamous part of the occipital bone posteriorly.

The spinal cord passes superiorly through the foramen magnum to continue as the brainstem.

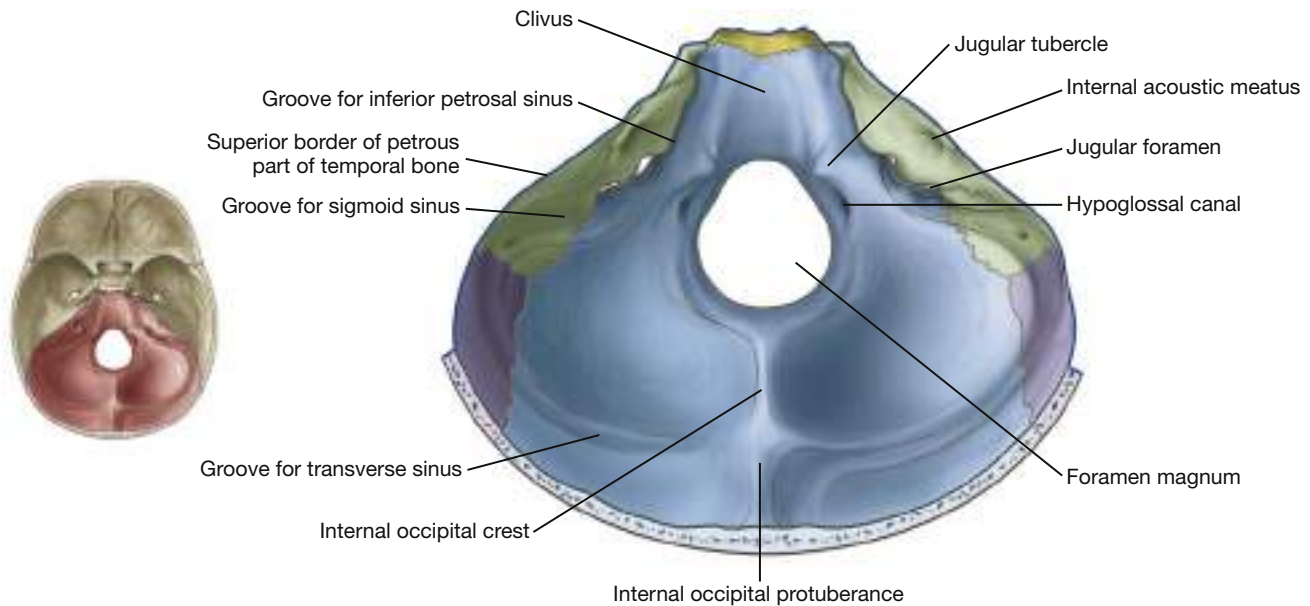


Fig. 8.15 Posterior cranial fossa.

Also passing through the foramen magnum are the vertebral arteries, the meninges, and the spinal roots of the accessory nerve [XI].

Grooves and foramina

The clivus slopes upward from the foramen magnum. Lateral to the clivus is a **groove for the inferior petrosal sinus** between the basilar part of the occipital bone and the petrous part of the petromastoid part of the temporal bone (Fig. 8.15).

Laterally, across the upper half of the posterior surface of the petrous part of the temporal bone, is an oval foramen (the **internal acoustic meatus**) (Fig. 8.15; also see Table 8.2). The facial [VII] and vestibulocochlear [VIII] nerves and the labyrinthine artery pass through it.

Inferior to the internal acoustic meatus, the temporal bone is separated from the occipital bone by the large jugular foramen (Fig. 8.15). Leading to this foramen from the medial side is the groove for the inferior petrosal sinus and from the lateral side is the **groove for the sigmoid sinus**. The sigmoid sinus passes into the jugular foramen and is continuous with the internal jugular vein, while the inferior petrosal sinus empties into the internal jugular vein in the area of the jugular foramen. Also passing through the jugular foramen are the glossopharyngeal nerve [IX], the vagus nerve [X], and the accessory nerve [XI].

Medial to the jugular foramen is a large rounded mound of the occipital bone (the **jugular tubercle**). Just inferior to this, and superior to the foramen magnum, is the

hypoglossal canal through which the hypoglossal nerve [XII] leaves the posterior cranial fossa and a meningeal branch of the ascending pharyngeal artery enters the posterior cranial fossa (Fig. 8.15).

Just posterolateral to the hypoglossal canal is the small **condylar canal** that, when present, transmits an emissary vein.

Squamous part of the occipital bone

The squamous part of the occipital bone has several prominent features (Fig. 8.15):

- Running upward in the midline from the foramen magnum is the **internal occipital crest**.
- On either side of the internal occipital crest, the floor of the posterior cranial fossa is concave to accommodate the cerebellar hemispheres.
- The internal occipital crest ends superiorly in a bony prominence (the internal occipital protuberance).
- Extending laterally from the internal occipital protuberance are grooves produced by the transverse sinuses, which continue laterally, eventually joining a groove for each sigmoid sinus. Each of these grooves then turns inferiorly toward the jugular foramina.

The transverse and sigmoid sinuses are intradural venous sinuses.

Foramina and fissures through which major structures pass between the cranial cavity and other regions are summarized in Fig. 8.16.

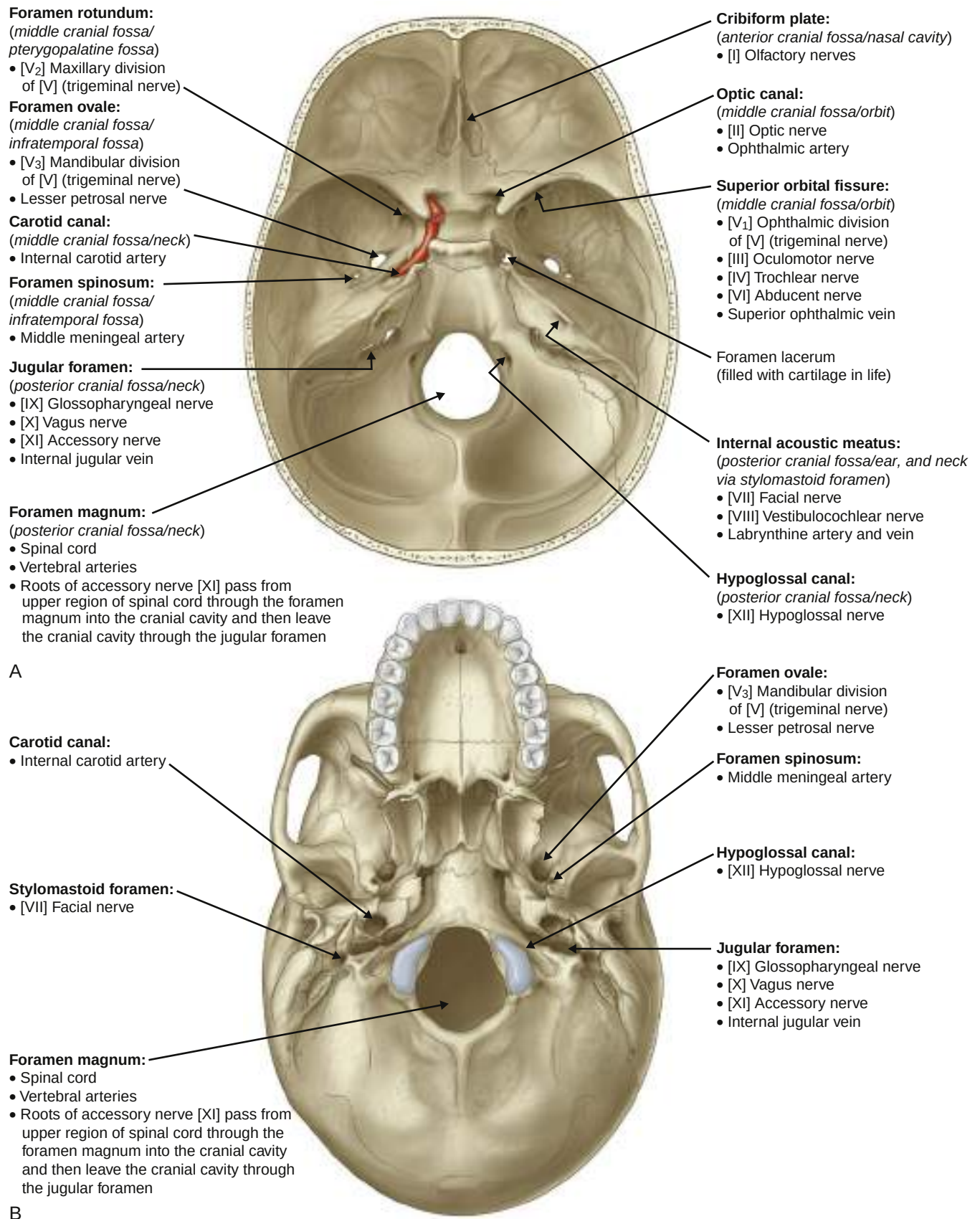


Fig. 8.16 Summary of foramina and fissures through which major structures enter and leave the cranial cavity. **A.** Floor of cranial cavity. **B.** Inferior aspect of cranium.

Clinical app

Medical imaging of the head

Radiography

Until recently the standard method of imaging the head was plain radiography. The radiographs are taken in three standard projections—namely the posteroanterior view, the lateral view, and the Towne's view.

Computed tomography

Since the development of computed tomography (CT), cerebral computed tomography has become the “workhorse” of neuroradiological examination. It is ideally used for head injury because the brain and its coverings can be easily and quickly examined and blood is easily detected.

With intravenous contrast, CT angiography can be used to demonstrate the position and the size of an intracerebral aneurysm before endovascular treatment.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) is unsurpassed by other imaging techniques in its ability for contrast resolution. The brain and its coverings, cerebrospinal fluid (CSF), and the vertebral column can be easily and quickly examined.

Magnetic resonance angiography has been extremely useful in determining the completeness of the intracranial vasculature (circle of Willis), which is necessary in some surgical conditions.

Ultrasonography

Initial work using ultrasound to assess the brain appeared fruitless, but with increasing probe technology it is now possible to carry out intracranial Doppler studies, which enable a surgeon to detect whether a patient is experiencing cerebral embolization from a carotid plaque.

Clinical app

Fractures of the skull vault

The skull vault is a remarkably strong structure because it protects our most vital organ, the brain. From a clinical standpoint, skull fractures alert clinicians to the nature and force of an injury and potential complications. Of key importance is the need to minimize the extent of primary brain injury and to treat potential secondary complications rather than focusing on the skull fracture. Skull fractures that have particular significance include depressed skull fractures, compound fractures, and pterion fractures.

Depressed skull fractures

In a depressed skull fracture, a bony fragment is depressed below the normal skull convexity. This may lead to secondary arterial and venous damage with hematoma formation. Furthermore, a primary brain injury can also result from this type of fracture.

Clinical app—cont'd

Compound fractures

In a compound fracture there is a fracture of the bone together with a breach of the skin, which may allow an infection to enter. Typically these fractures are associated with scalp lacerations and can usually be treated with antibiotics.

Pterion fractures

The **pterion** is an important circular area on the lateral aspect of the skull where the frontal, parietal, sphenoid, and temporal bones come together. Importantly, deep to the pterion is the middle meningeal artery. An injury to this point of the skull is extremely serious because damage to this vessel may produce a significant extradural hematoma, which can be fatal.

Surface anatomy

Estimating the position of the middle meningeal artery

The middle meningeal artery (Fig. 8.17) is a branch of the maxillary artery in the infratemporal fossa. It enters the skull through the foramen spinosum and is within the dura mater lining the cranial cavity.

In lateral blows to the head, the middle meningeal artery can be ruptured, leading to extradural hemorrhage and eventual death if not treated.

The anterior branch of the middle meningeal artery is the part of the vessel most often torn. This branch is in the temple region of the head, approximately midway between the superior margin of the orbit and the upper part of the external ear in what is termed the *pterion*.

Lateral blows to the head can fracture the internal table of bone of the skull and tear the middle meningeal artery in the outer layer of dura mater that is fused to the cranium. Blood under pulsatile arterial pressure leaks out of the vessel and gradually separates the dura from the bone, forming a progressively larger extradural hematoma.

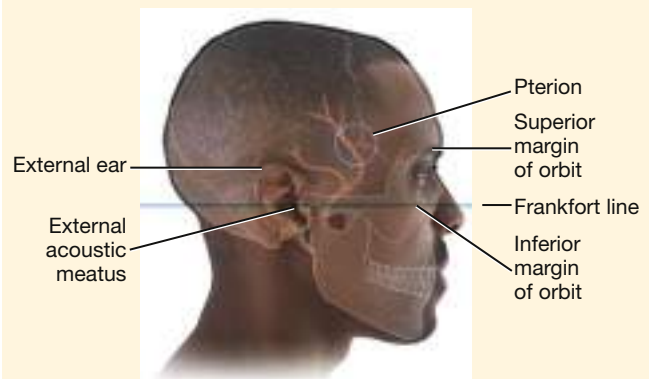


Fig. 8.17 Estimating the position of the middle meningeal artery. Lateral head and neck of a man.

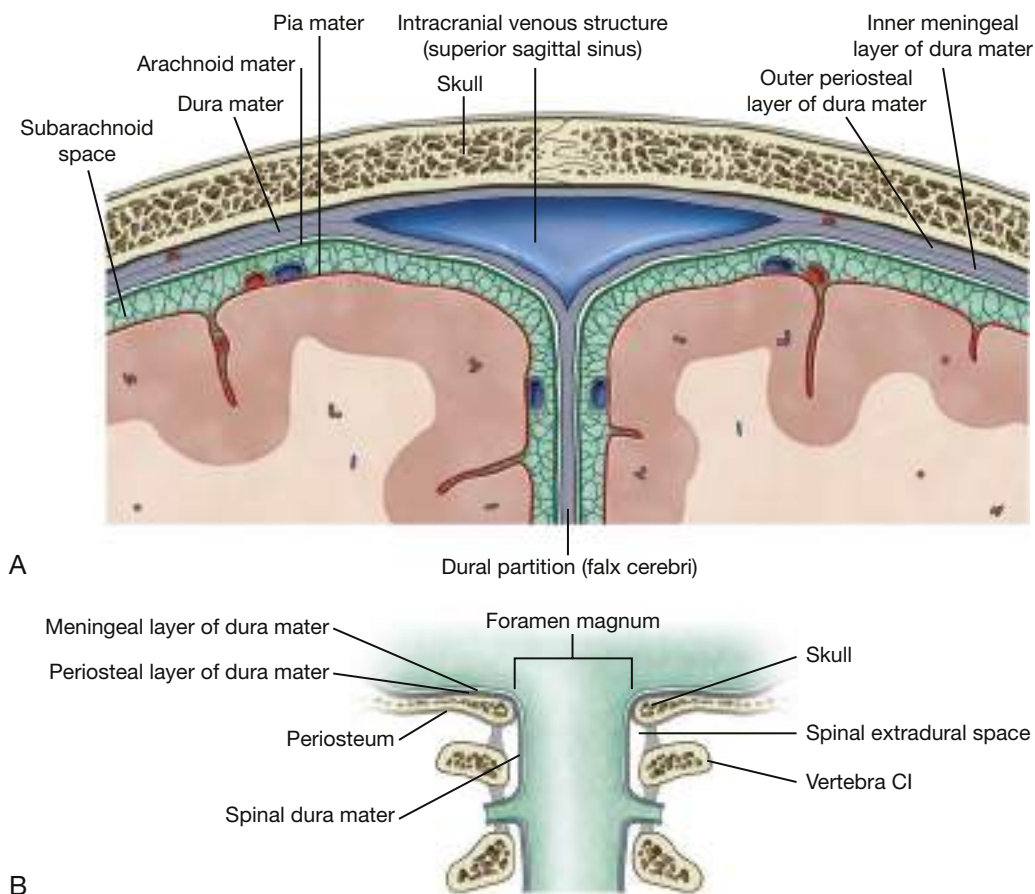


Fig. 8.18 Cranial meninges. **A.** Superior coronal view. **B.** Continuity with the spinal meninges.

MENINGES

The brain, as well as the spinal cord, is surrounded by three layers of membranes (the **meninges**; Fig. 8.18A): a tough outer layer—the **dura mater**, a delicate middle layer—the **arachnoid mater**, and an inner layer firmly attached to the surface of the brain—the **pia mater**.

The cranial meninges are continuous with, and similar to, the spinal meninges through the foramen magnum, with one important distinction—the cranial dura mater consists of two layers, and only one of these is continuous through the foramen magnum (Fig. 8.18B).

Cranial dura mater

The cranial dura mater is a thick, tough, outer covering of the brain. It consists of an outer periosteal layer and an inner meningeal layer (Fig. 8.18A):

- The outer **periosteal layer** is firmly attached to the skull, is the periosteum of the cranial cavity, contains the meningeal arteries, and is continuous with the periosteum

on the outer surface of the skull at the foramen magnum and other intracranial foramina (Fig. 8.18B).

- The inner **meningeal layer** is in close contact with the arachnoid mater and is continuous with the spinal dura mater through the foramen magnum.

The two layers of dura separate from each other at numerous locations to form two unique types of structures (Fig. 8.18A):

- dural partitions, which project inward and incompletely separate parts of the brain; and
- intracranial venous structures (cranial venous sinuses, see pp. 469 to 472).

Dural partitions

The dural partitions project into the cranial cavity and partially subdivide the cranial cavity. They include the falx cerebri, tentorium cerebelli, falx cerebelli, and diaphragma sellae.

Falx cerebri

The falx cerebri (Fig. 8.19) is a crescent-shaped downward projection of meningeal dura mater from the dura lining the

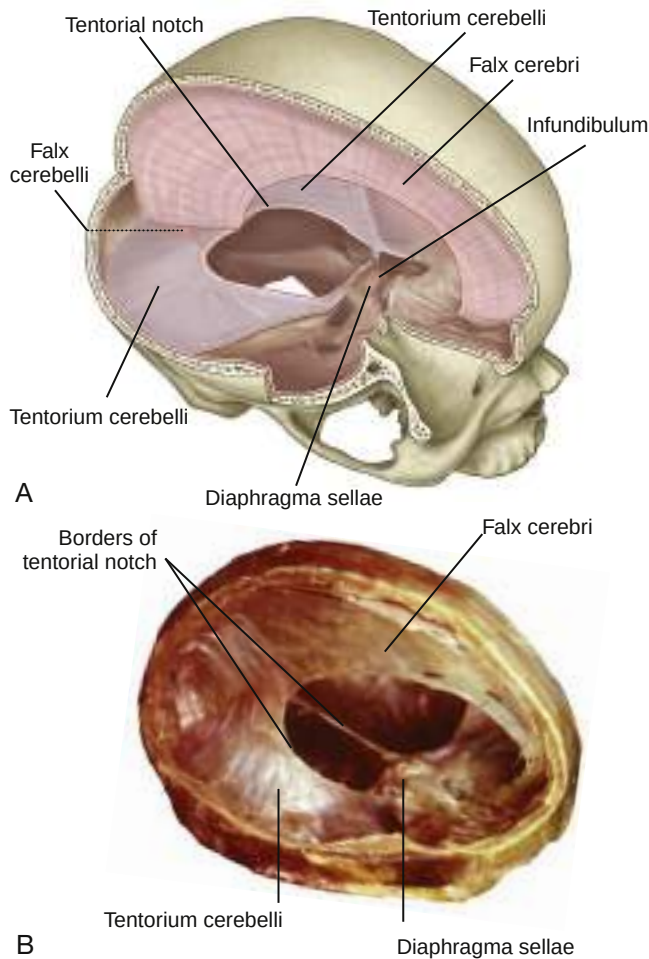


Fig. 8.19 Dural partitions. **A.** Diagram. **B.** Dissection.

calva that passes between the two cerebral hemispheres. It is attached anteriorly to the crista galli of the ethmoid bone and frontal crest of the frontal bone. Posteriorly it is attached to and blends with the tentorium cerebelli.

Tentorium cerebelli

The tentorium cerebelli (Fig. 8.19) is a horizontal projection of the meningeal dura mater that covers and separates the cerebellum in the posterior cranial fossa from the posterior parts of the cerebral hemispheres. It is attached posteriorly to the occipital bone along the grooves for the transverse sinuses. Laterally, it is attached to the superior border of the petrous part of the temporal bone, ending anteriorly at the anterior and posterior clinoid processes.

The anterior and medial borders of the tentorium cerebelli are free, forming an oval opening in the midline (the **tentorial notch**) through which the midbrain passes.

Falx cerebelli

The falx cerebelli (Fig. 8.19) is a small midline projection of meningeal dura mater in the posterior cranial fossa. It

is attached posteriorly to the internal occipital crest of the occipital bone and superiorly to the tentorium cerebelli. Its anterior edge is free and is between the two cerebellar hemispheres.

Diaphragma sellae

The final dural projection is the diaphragma sellae (Fig. 8.19). This small horizontal shelf of meningeal dura mater covers the hypophysial fossa in the sella turcica of the sphenoid bone. There is an opening in the center of the diaphragma sellae through which passes the **infundibulum**, which connects the pituitary gland with the base of the brain and any accompanying blood vessels.

Arterial supply

The arterial supply to the dura mater (Fig. 8.20) travels in the outer periosteal layer of the dura and consists of:

- **anterior meningeal arteries** in the anterior cranial fossa,
- the **middle** and **accessory meningeal arteries** in the middle cranial fossa, and
- the **posterior meningeal artery** and other meningeal branches in the posterior cranial fossa.

All are small arteries except for the middle meningeal artery, which is much larger and supplies the greatest part of the dura.

The anterior meningeal arteries are branches of the **ethmoidal arteries** (Fig. 8.20).

The middle meningeal artery is a branch of the maxillary artery (Fig. 8.20). It enters the middle cranial fossa through the foramen spinosum and divides into anterior and posterior branches:

- The anterior branch passes in an almost vertical direction to reach the vertex of the skull, crossing the pterion during its course.
- The posterior branch passes in a posterosuperior direction, supplying this region of the middle cranial fossa.

The accessory meningeal artery is usually a small branch of the maxillary artery that enters the middle cranial fossa through the foramen ovale and supplies areas medial to this foramen.

The posterior meningeal artery and other meningeal branches supplying the dura mater in the posterior cranial fossa come from several sources (Fig. 8.20):

- The posterior meningeal artery, the terminal branch of the **ascending pharyngeal artery**, enters the posterior cranial fossa through the jugular foramen.

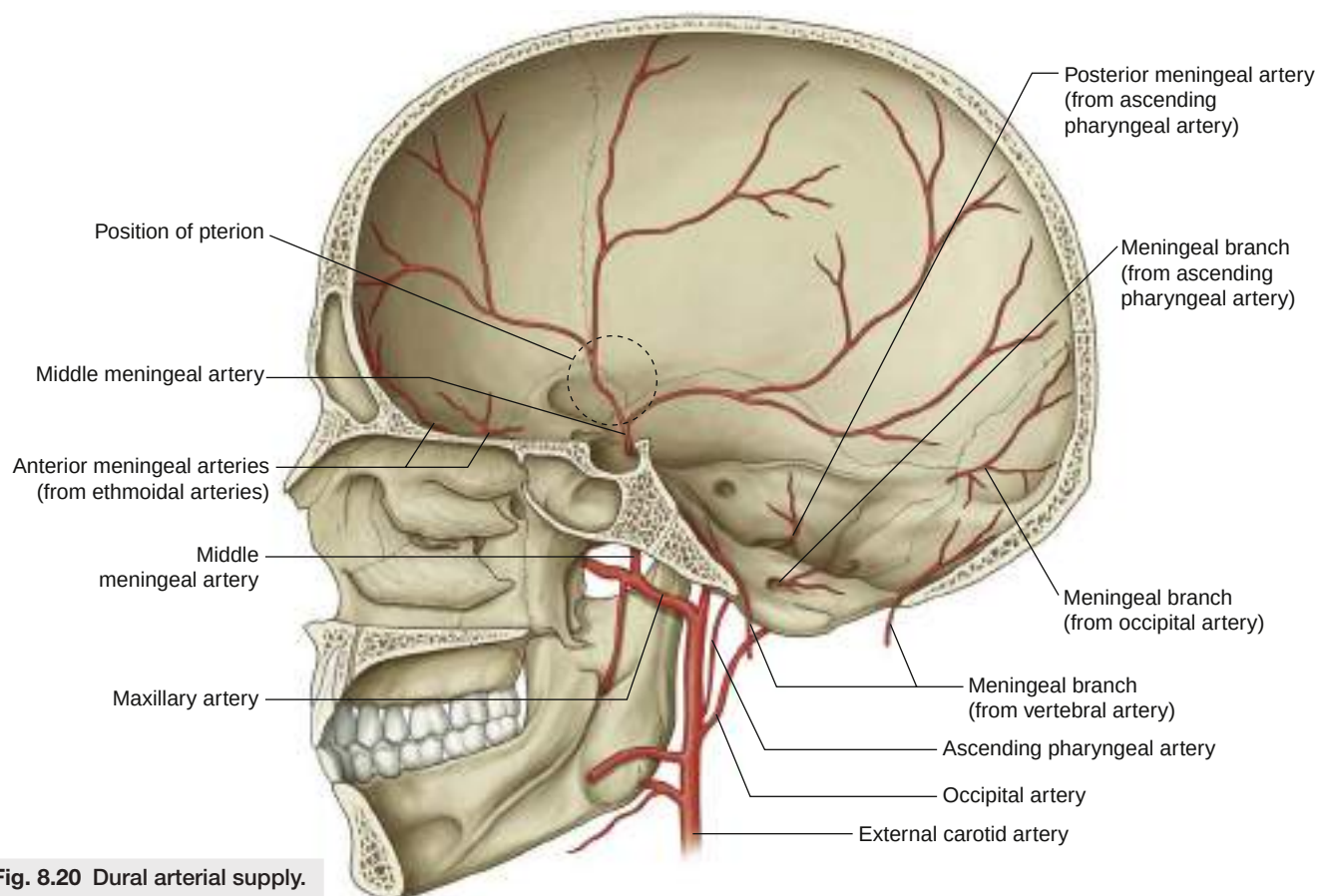


Fig. 8.20 Dural arterial supply.

- A meningeal branch from the ascending pharyngeal artery enters the posterior cranial fossa through the hypoglossal canal.
- Meningeal branches from the **occipital artery** enter the posterior cranial fossa through the jugular foramen and the mastoid foramen.
- A meningeal branch from the **vertebral artery** arises as the vertebral artery enters the posterior cranial fossa through the foramen magnum.

Innervation

Innervation of the dura mater (Fig. 8.21) is by small meningeal branches of all three divisions of the trigeminal nerve [V_1 , V_2 , and V_3], the vagus nerve [X], and the first, second, and, sometimes third cervical nerves. (Possible involvement of the glossopharyngeal [IX] and hypoglossal nerves [XII] in the posterior cranial fossa has also been reported.)

In the anterior cranial fossa, meningeal branches from the ethmoidal nerves, which are branches of the ophthalmic nerve [V_1], supply the floor and the anterior part of the falx cerebri (Fig. 8.21).

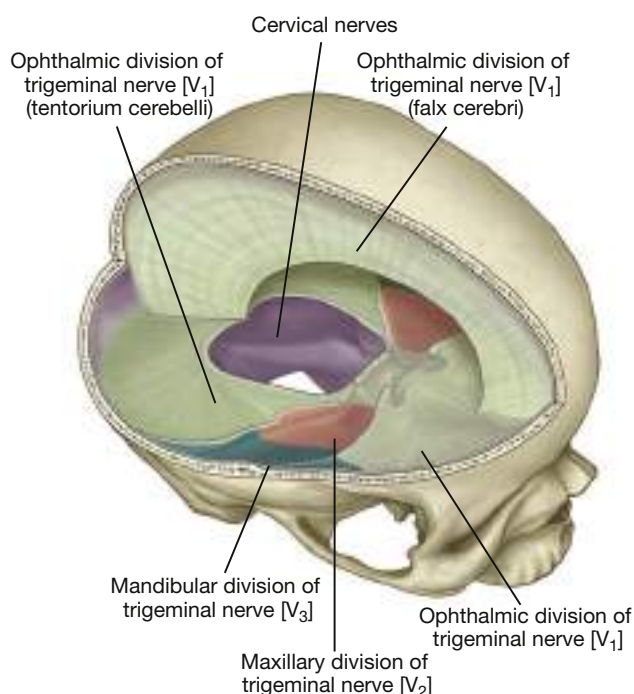


Fig. 8.21 Dural innervation.

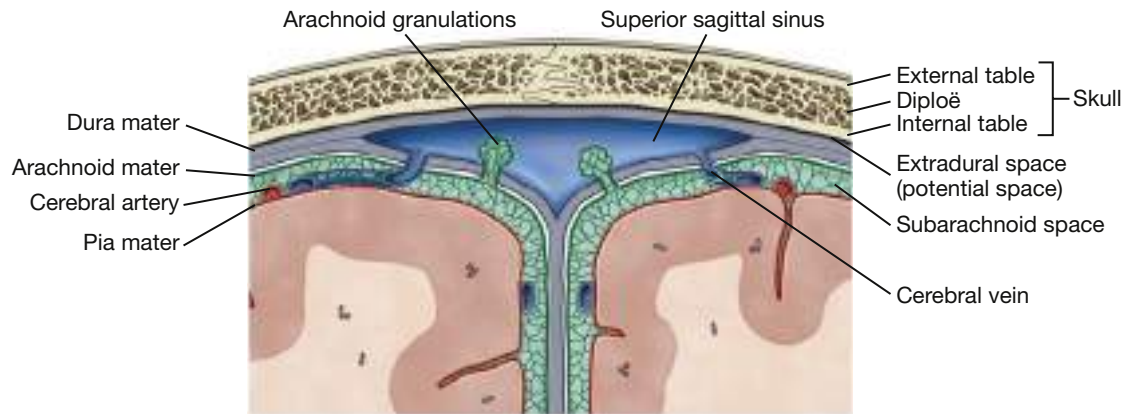


Fig. 8.22 Arrangement of the meninges and spaces.

Additionally, a meningeal branch of the ophthalmic nerve [V_1] turns and runs posteriorly, supplying the tentorium cerebelli and the posterior part of the falx cerebri (Fig. 8.21).

The middle cranial fossa is supplied medially by meningeal branches from the maxillary nerve [V_2] and laterally, along the distribution of the middle meningeal artery, by meningeal branches from the mandibular nerve [V_3] (Fig. 8.21).

The posterior cranial fossa is supplied by meningeal branches from the first, second, and, sometimes, the third cervical nerves, which enter the fossa through the foramen magnum, the hypoglossal canal, and the jugular foramen (Fig. 8.21). Meningeal branches of the vagus nerve [X] have also been described. (Possible contributions from the glossopharyngeal [IX] and hypoglossal [XII] nerves have also been reported.)

Arachnoid mater

The arachnoid mater is a thin, avascular membrane that lines, but is not adherent to, the inner surface of the dura mater (Fig. 8.22). From its inner surface, thin processes or trabeculae extend downward, cross the subarachnoid space, and become continuous with the pia mater.

Unlike the pia, the arachnoid does not enter the grooves or fissures of the brain, except for the longitudinal fissure between the two cerebral hemispheres.

Pia mater

The pia mater is a thin, delicate membrane that closely invests the surface of the brain (Fig. 8.22). It follows the contours of the brain, entering the grooves and fissures on its surface, and is closely applied to the roots of the cranial nerves at their origins.

Meningeal spaces

Extradural space

The potential space between dura mater and bone is the **extradural space**. Normally, the outer or periosteal layer of dura mater is firmly attached to the bones surrounding the cranial cavity (Fig. 8.22).

Subdural space

Anatomically, a true subdural space does not exist. Blood collecting in this region (subdural hematoma) due to injury represents a dissection of the dural border cell layer, which is the innermost lining of the meningeal dura. Dural border cells are flattened cells surrounded by extracellular spaces filled with amorphous material. While very infrequent, an occasional cell junction may be seen between these cells and the underlying arachnoid layer.

Subarachnoid space

Deep to the arachnoid mater is the only normally occurring fluid-filled space associated with the meninges. It occurs because the arachnoid mater clings to the inner surface of the dura mater and does not follow the contour of the brain, while the pia mater, being against the surface of the brain, closely follows the grooves and fissures on the surface of the brain. A narrow space (the **subarachnoid space**) is therefore created between these two membranes (Fig. 8.22).

The subarachnoid space surrounds the brain and spinal cord, and in certain locations it enlarges into expanded areas (subarachnoid **cisterns**). It contains CSF and blood vessels.

CSF is produced by the choroid plexus, primarily in the ventricles of the brain. It is a clear, colorless, cell-free fluid that circulates through the subarachnoid space surrounding the brain and spinal cord.

The CSF returns to the venous system through **arachnoid villi**. These project as clumps (**arachnoid granulations**) into the superior sagittal sinus, which is a dural venous sinus, and its lateral extensions, the **lateral lacunae**.

Clinical app

Cerebrospinal fluid leak

Leakage of CSF from the subarachnoid space may occur after any procedure in and around the brain, spinal cord, and meningeal membranes. These procedures include lumbar spine surgery, epidural injection, and CSF aspiration.

In “cerebrospinal fluid leak syndrome,” CSF leaks out of the subarachnoid space and through dura mater for no apparent reason. The clinical consequences of this include dizziness, nausea, fatigue, and metallic taste in the mouth. Other effects also include facial nerve weakness and double vision.

Clinical app

Hydrocephalus

Hydrocephalus is a dilatation of the cerebral ventricular system, which is due to either an obstruction to the flow of CSF, overproduction of CSF, or a failure of reabsorption of CSF.

CSF is secreted by the epithelial cells of the choroid plexus within ventricles of the brain. The CSF passes from the ventricles through foramina into the subarachnoid space.

The CSF circulates around the spinal cord inferiorly, envelops the brain superiorly, and is absorbed through the arachnoid granulations in the walls of the dural venous sinuses. In adults almost half a liter of CSF is produced a day.

In adults the commonest cause of hydrocephalus is an interruption of the normal CSF absorption through the arachnoid granulations. This occurs when blood enters the subarachnoid space after subarachnoid hemorrhage, passes over the brain, and interferes with normal CSF absorption. To prevent severe hydrocephalus, it may be necessary to place a small catheter through the brain into the ventricular system to drain the CSF to relieve the pressure.

In children, hydrocephalus is always dramatic in its later stages. The hydrocephalus increases the size and dimensions of the ventricle, and as a result the brain enlarges. Because the skull sutures are not fused, the head expands. Cranial enlargement in utero may make a vaginal delivery impossible, and delivery then has to be by caesarean section.

Both computed tomography and MRI enable a radiologist to determine the site of obstruction and, in most cases, the cause of the obstruction.

Clinical app

Meningitis

Meningitis is a rare infection of the leptomeninges (the **leptomeninges** are a combination of the arachnoid mater and the pia mater). Infection of the meninges typically occurs via a blood-borne route, though in some cases it may be by direct spread (e.g., trauma) or from the nasal cavities through the cribriform plate in the ethmoid bone.

The typical history of meningitis is nonspecific at first. The patient may have a mild headache, fever, drowsiness, and nausea. As the infection progresses, photophobia (light intolerance) and ecchymosis may ensue. Straight leg raising causes marked neck pain and discomfort (Kernig's sign) and an emergency hospital admission is warranted.

BRAIN AND ITS BLOOD SUPPLY

Brain

The brain is a component of the central nervous system (CNS).

During development the brain can be divided into five continuous parts (Figs. 8.23, 8.24). From rostral (or cranial) to caudal they are:

- the **telencephalon (cerebrum)**, which becomes the large cerebral hemispheres, the surface of which consists of elevations (gyri) and depressions (sulci) and is partially separated by a deep longitudinal fissure, and which fills the area of the cranial cavity above the tentorium cerebelli and is subdivided into lobes based on their position;
- the **diencephalon**, which is hidden from view in the adult brain by the cerebral hemispheres, consists of the thalamus, hypothalamus, and other related structures and classically

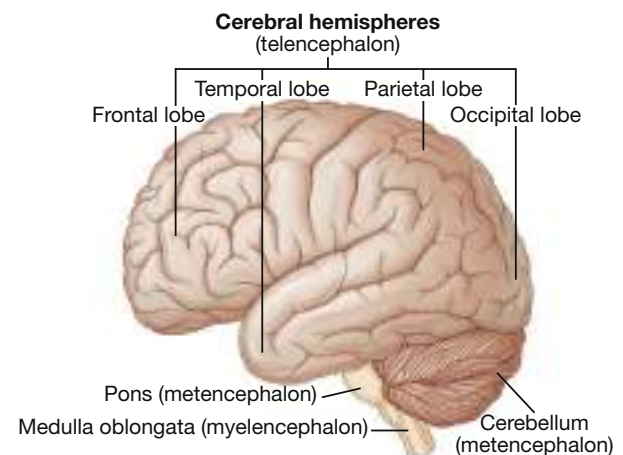


Fig. 8.23 Lateral view of the brain.

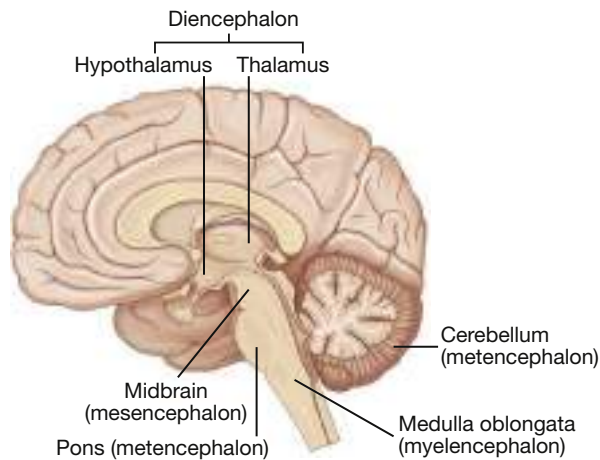


Fig. 8.24 Sagittal section of the brain.

is considered to be the most rostral part of the brainstem. (However, in common use today, the term *brainstem* usually refers to the midbrain, pons, and medulla);

- the **mesencephalon (midbrain)**, which is the first part of the brainstem seen when an intact adult brain is examined and spans the junction between the middle and posterior cranial fossae;
- the **metencephalon**, which gives rise to the cerebellum (consisting of two lateral hemispheres and a midline part in the posterior cranial fossa below the tentorium cerebelli) and the pons (anterior to the cerebellum, a bulging part of the brainstem in the most anterior part of the posterior cranial fossa against the clivus and dorsum sellae); and
- the **myelencephalon (medulla oblongata)**, the caudal most part of the brainstem, which ends at the foramen magnum or the uppermost rootlets of the first cervical nerve and to which cranial nerves VI to XII are attached.

Blood supply

The brain receives its arterial supply from two pairs of vessels, the **vertebral** and **internal carotid arteries** (Figs. 8.25, 8.26), which are interconnected in the cranial cavity to produce a **cerebral arterial circle** (of Willis).

Vertebral arteries

Each vertebral artery arises from the first part of each **subclavian artery** in the lower part of the neck and passes superiorly through the foramen transversarium of the upper six cervical vertebrae. On entering the cranial cavity through the foramen magnum, each vertebral artery gives off a small meningeal branch.

Continuing forward, the vertebral artery gives rise to three additional branches before joining with its companion vessel to form the **basilar artery** (Fig. 8.27):

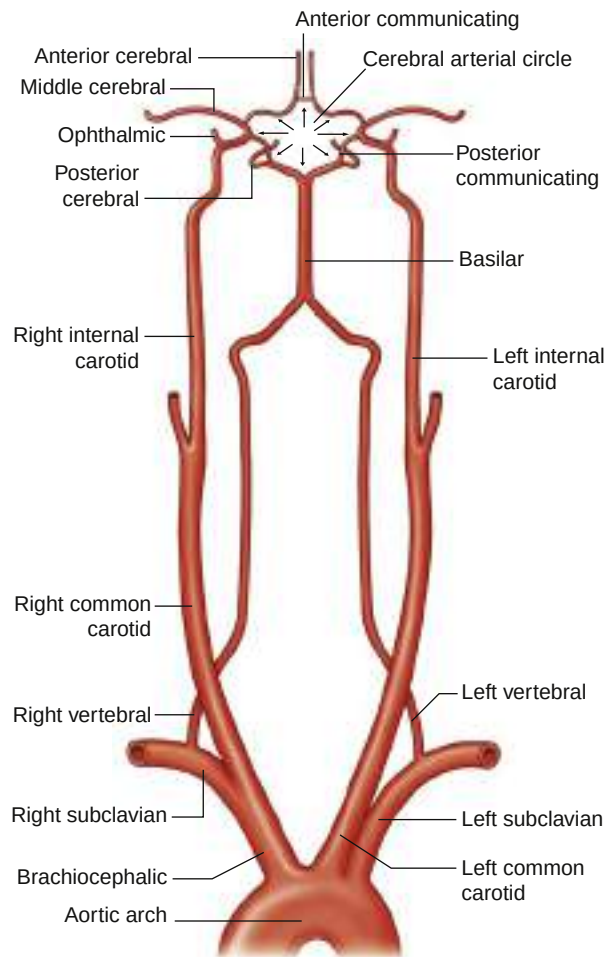


Fig. 8.25 Arterial supply to the brain.

- The largest branch is a **posterior inferior cerebellar artery**.
- Another branch joins with its companion from the other side to form the single **anterior spinal artery**, which then descends in the anterior median fissure of the spinal cord.
- A third branch is the **posterior spinal artery**, which passes posteriorly around the medulla then descends on the posterior surface of the spinal cord in the area of the attachment of the posterior roots—there are two posterior spinal arteries, one on each side (although the posterior spinal arteries can originate directly from the vertebral arteries, they more commonly branch from the posterior inferior cerebellar arteries).

The basilar artery travels in a rostral direction along the anterior aspect of the pons (Fig. 8.27). Its branches, in a caudal to rostral direction, include the **anterior inferior cerebellar arteries**, several small **pontine arteries**, and the **superior cerebellar arteries**. The basilar artery ends as a bifurcation, giving rise to two **posterior cerebral arteries**.

Imaging app

Visualizing the internal carotid and vertebral arteries

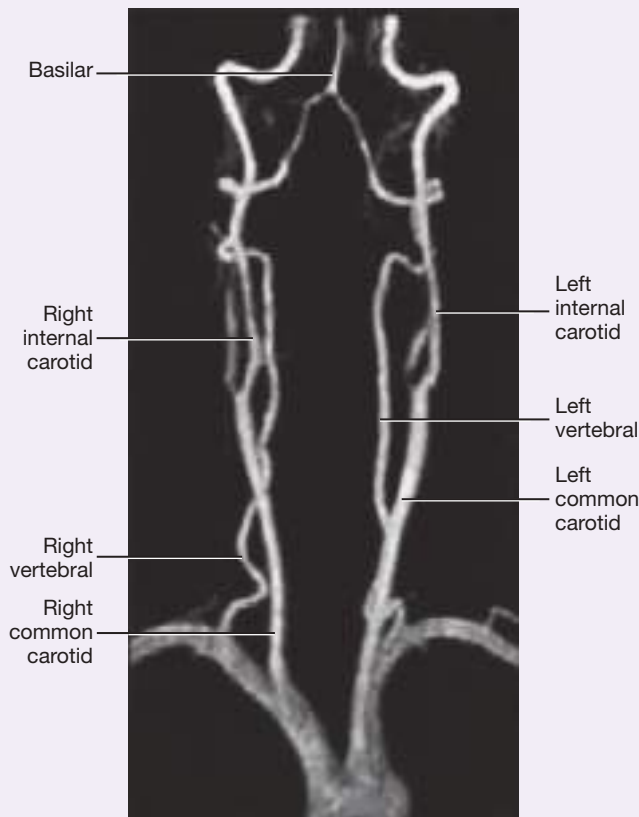


Fig. 8.26 Magnetic resonance angiogram showing normal carotid and vertebral arteries.

Internal carotid arteries

The two internal carotid arteries arise as one of the two terminal branches of the common carotid arteries (see Figs. 8.25, 8.26). They proceed superiorly to the base of the skull where they enter the carotid canal.

Entering the cranial cavity, each internal carotid artery gives off the **ophthalmic artery**, the **posterior communicating artery**, the **middle cerebral artery**, and the **anterior cerebral artery** (Fig. 8.27).

Cerebral arterial circle

The cerebral arterial circle (of Willis) is formed at the base of the brain by the interconnecting vertebrobasilar and internal carotid systems of vessels (see Fig. 8.25). This anastomotic interconnection is accomplished by:

- an anterior communicating artery connecting the left and right anterior cerebral arteries to each other (Fig. 8.27; also see Fig. 8.25); and

- two posterior communicating arteries, one on each side, connecting the internal carotid artery with the posterior cerebral artery (Fig. 8.27; also see Fig. 8.25).

Clinical app

Endarterectomy

Endarterectomy is a surgical procedure to remove atheromatous plaques from arteries.

Atheromatous plaques occur in the subendothelial layer of vessels and consist of lipid-laden macrophages and cholesterol debris. The developing plaques eventually accumulate fibrous connective tissue and calcify. Plaques commonly occur around vessel bifurcations, limiting blood flow, and may embolize to distal organs.

During endarterectomy, the plaque is removed and the vessel reopened. In many instances a patch of material is sewn over the hole in the vessel, enabling improved flow and preventing narrowing from the suturing of the vessel.

Clinical app

Stroke

A stroke is the acute development of a focal neurological deficit as a result of localized or diffuse cerebral hypoperfusion.

The causes of stroke include cerebral thrombosis, cerebral hemorrhage, subarachnoid hemorrhage, and cerebral embolus. In the case of most strokes, small vessel cerebrovascular obstruction is caused by emboli from an atherosclerotic plaque within more proximal vessels in the neck and thorax.

Less severe strokes—transient ischemic attacks (TIAs)—are caused in the same way as strokes, but recovery is usually complete within 24 hours. They serve as a warning that treatment may be necessary.

Clinical app

Intracerebral aneurysms

Cerebral aneurysms most commonly arise from the vessels in and around the cerebral arterial circle (of Willis). They typically occur in and around the anterior communicating artery, the posterior communicating artery, the branches of the middle cerebral artery, the distal end of the basilar artery, and the posterior inferior cerebellar artery.

If the aneurysm ruptures, the patient complains of a sudden-onset “thunderclap” headache that produces neck stiffness and may induce vomiting. An initial CT scan demonstrates blood within the subarachnoid space, and this may be associated with an intracerebral bleed. Further management usually includes cerebral angiography, which enables the radiologist to determine the site, size, and origin of the aneurysm.

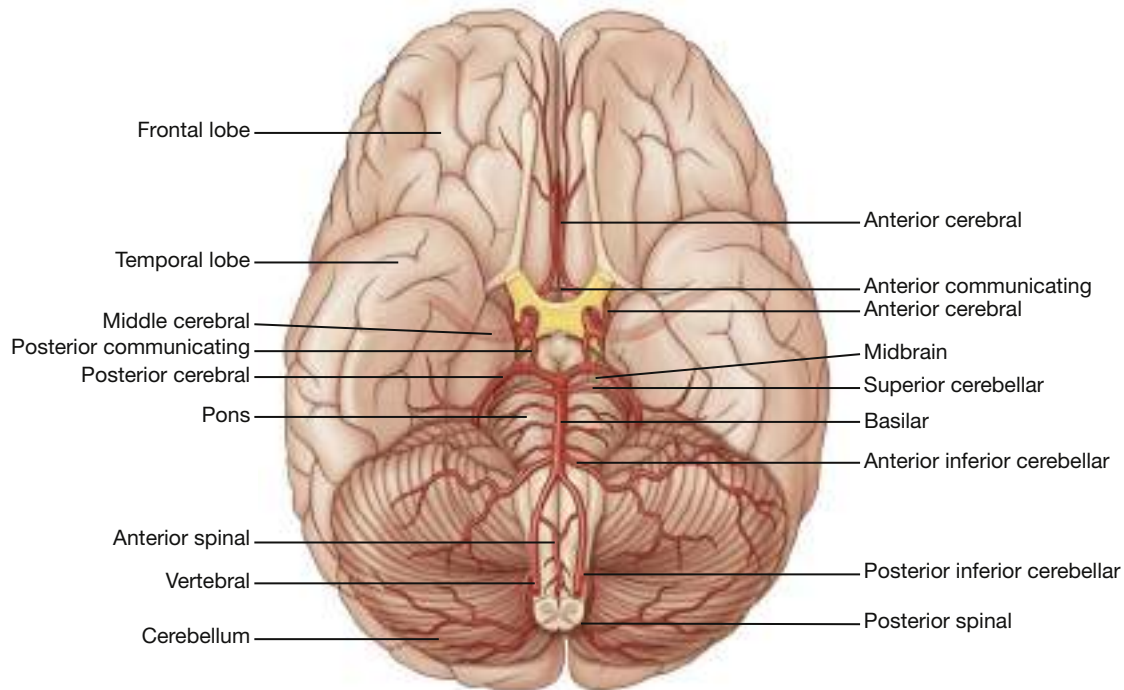


Fig. 8.27 Arteries on the base of the brain.

Venous drainage

Venous drainage of the brain begins internally as networks of small venous channels lead to larger cerebral veins, cerebellar veins, and veins draining the brainstem, which eventually empty into **dural venous sinuses**. The dural venous sinuses are endothelial-lined spaces between the outer periosteal and the inner meningeal layers of the dura mater and eventually lead to the **internal jugular veins**.

Also emptying into the dural venous sinuses are **diploic veins**, which run between the internal and external tables of compact bone in the roof of the cranial cavity, and **emissary veins**, which pass from outside the cranial cavity to the dural venous sinuses (Fig. 8.28).

Dural venous sinuses

The dural venous sinuses include the superior sagittal, inferior sagittal, straight, transverse, sigmoid, and occipital sinuses; the confluence of sinuses; and the cavernous, sphenoparietal, superior petrosal, inferior petrosal, and basilar sinuses (Table 8.3, Fig. 8.29).

Superior sagittal sinus

The superior sagittal sinus is in the superior border of the falx cerebri (Fig. 8.29). It begins anteriorly at the foramen cecum where it may receive a small emissary vein from the nasal cavity and ends posteriorly in the confluence of sinuses, usually bending to the right to empty into the right transverse sinus. The superior sagittal sinus communicates

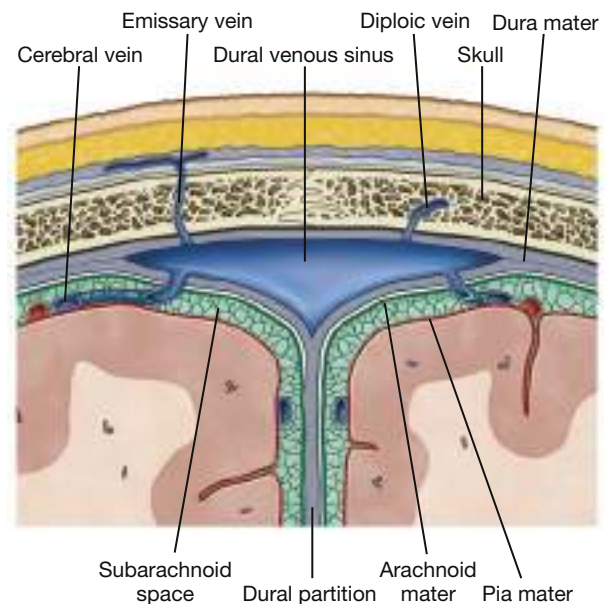


Fig. 8.28 Dural venous sinuses.

with lateral extensions (lateral lacunae) of the sinus containing numerous arachnoid granulations.

Inferior sagittal and straight sinuses

The inferior sagittal sinus is in the inferior margin of the falx cerebri (Fig. 8.29). It receives a few cerebral veins and veins from the falx cerebri and ends posteriorly at the anterior edge of the tentorium cerebelli where it is joined by the

Table 8.3 Dural venous sinuses

Dural sinus	Location	Receives
Superior sagittal	Superior border of falx cerebri	Superior cerebral, diploic, and emissary veins and cerebrospinal fluid
Inferior sagittal	Inferior margin of falx cerebri	A few cerebral veins and veins from the falx cerebri
Straight	Junction of falx cerebri and tentorium cerebelli	Inferior sagittal sinus, great cerebral vein, posterior cerebral veins, superior cerebellar veins, and veins from the falx cerebri
Occipital	In falx cerebelli against occipital bone	[Communicates inferiorly with vertebral plexus of veins]
Confluence of sinuses	Dilated space at the internal occipital protuberance	Superior sagittal, straight, and occipital sinuses
Transverse (right and left)	Horizontal extensions from the confluence of sinuses along the posterior and lateral attachments of the tentorium cerebelli	Drainage from confluence of sinuses (the right transverse sinus usually receives the superior sagittal sinus; the left transverse sinus usually receives the straight sinus).
Sigmoid (right and left)	Continuation of transverse sinuses to internal jugular vein; groove of parietal, temporal, and occipital bones	Transverse sinuses, and cerebral, cerebellar, diploic, and emissary veins
Cavernous (paired)	Lateral aspect of body of sphenoid	Cerebral and ophthalmic veins, sphenoparietal sinuses, and emissary veins from pterygoid plexus of veins
Intercavernous	Crossing sella turcica	[Interconnects cavernous sinuses]
Sphenoparietal (paired)	Inferior surface of lesser wings of sphenoid	Diploic and meningeal veins
Superior petrosal (paired)	Superior margin of petrous part of temporal bone	Cavernous sinus and cerebral and cerebellar veins
Inferior petrosal (paired)	Groove between petrous part of temporal bone and occipital bone ending in internal jugular vein	Cavernous sinus, cerebellar veins, and veins from the internal ear and brainstem
Basilar	Clivus, just posterior to sella turcica of sphenoid	[Connect bilateral inferior petrosal sinuses and communicate with vertebral plexus of veins]

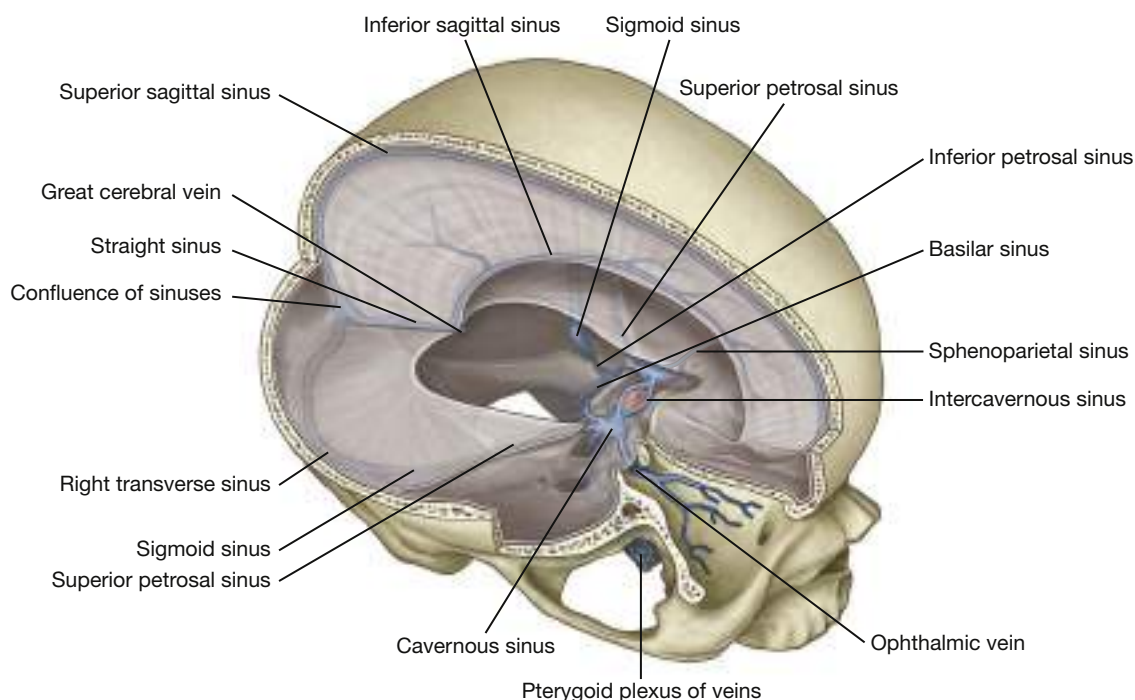


Fig. 8.29 Veins and dural venous sinuses.

great cerebral vein and, together with the great cerebral vein, forms the straight sinus (Fig. 8.29).

The straight sinus continues posteriorly along the junction of the falx cerebri and the tentorium cerebelli and ends in the confluence of sinuses, usually bending to the left to empty into the left transverse sinus (Fig. 8.29).

Confluence of sinuses, transverse and sigmoid sinuses

The superior sagittal and straight sinuses and the occipital sinus (in the falx cerebelli) empty into the confluence of sinuses, which is a dilated space at the internal occipital protuberance (Fig. 8.29) and is drained by the right and left transverse sinuses.

The paired transverse sinuses extend in horizontal directions from the confluence of sinuses where the tentorium cerebelli joins the lateral and posterior walls of the cranial cavity (Fig. 8.29).

The right transverse sinus usually receives blood from the superior sagittal sinus, and the left transverse sinus usually receives blood from the straight sinus.

The transverse sinuses also receive blood from the superior petrosal sinus, veins from the inferior parts of the cerebral hemispheres and the cerebellum, and diploic and emissary veins.

As the transverse sinuses leave the surface of the occipital bone, they become the sigmoid sinuses (Fig. 8.29), which turn inferiorly, grooving the parietal, temporal, and occipital bones before ending at the beginning of the internal jugular veins. The sigmoid sinuses also receive blood from cerebral, cerebellar, diploic, and emissary veins.

Cavernous sinuses

The paired cavernous sinuses are against the lateral aspect of the body of the sphenoid bone on either side of the sella turcica (Figs. 8.29, 8.30, 8.31). They are of great clinical importance because of their connections and the structures that pass through them.

The cavernous sinuses receive blood not only from cerebral veins, but also from the ophthalmic veins (from the orbit) and emissary veins (from the pterygoid plexus of veins in the infratemporal fossa). These connections provide pathways for infections to pass from extracranial sites into intracranial locations.

Structures passing through each cavernous sinus are (Fig. 8.30):

- the internal carotid artery, and
- the abducent nerve [VI].

Structures in the lateral wall of each cavernous sinus are, from superior to inferior (Fig. 8.30):

- the oculomotor nerve [III],
- the trochlear nerve [IV],

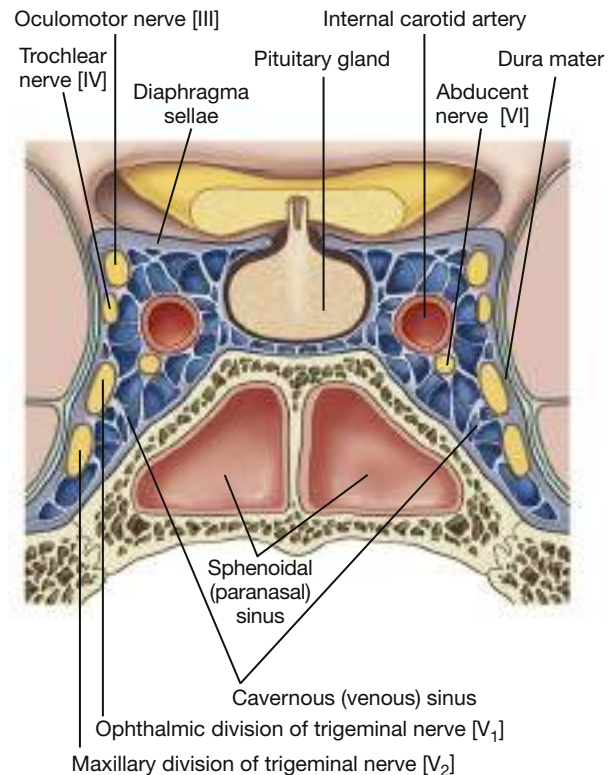


Fig. 8.30 Cavernous sinus.

- the ophthalmic nerve [V₁], and
- the maxillary nerve [V₂].

These structures passing through the cavernous sinus and lateral walls are vulnerable to injury due to inflammation.

Connecting the right and left cavernous sinuses are the intercavernous sinuses on the anterior and posterior sides of the pituitary stalk (Fig. 8.29).

Sphenoparietal sinuses drain into the anterior ends of each cavernous sinus. These small sinuses are along the inferior surface of the lesser wings of the sphenoid and receive blood from the diploic and meningeal veins.

Superior and inferior petrosal sinuses

The superior petrosal sinuses drain the cavernous sinuses into the transverse sinuses. Each superior petrosal sinus begins at the posterior end of the cavernous sinus, passes posterolaterally along the superior margin of the petrous part of each temporal bone, and connects to the transverse sinus (Fig. 8.29). The superior petrosal sinuses also receive cerebral and cerebellar veins.

The inferior petrosal sinuses also begin at the posterior ends of the cavernous sinuses. These bilateral sinuses pass posteroinferiorly in a groove between the petrous part of the temporal bone and the basal part of the occipital bone, ending in the internal jugular veins. They assist in draining the cavernous sinuses and receive blood from cerebellar veins and veins from the internal ear and brainstem.

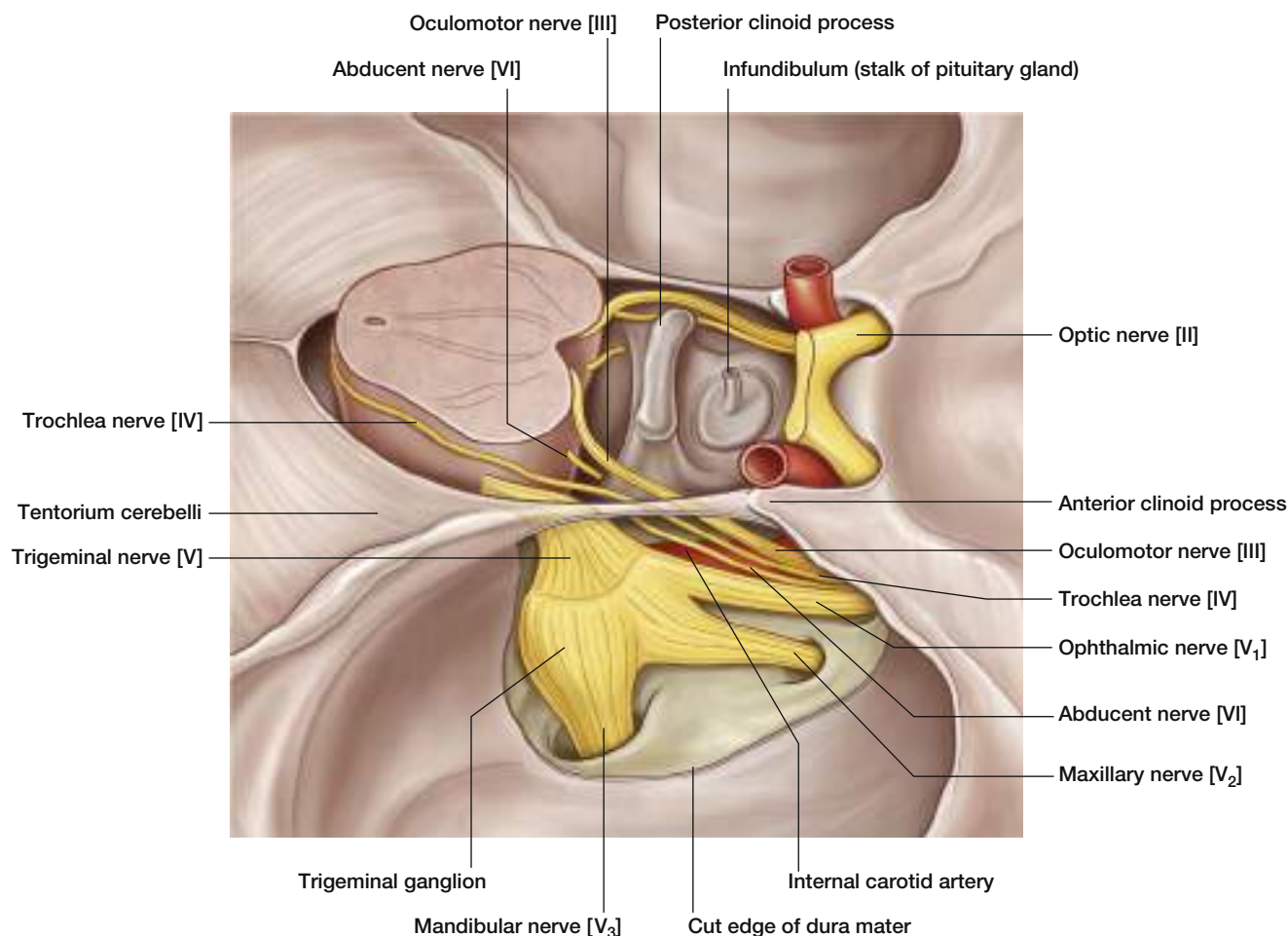


Fig. 8.31 Lateral view of right cavernous sinus with meningeal layer of dura removed to show contents.

Basilar sinuses connect the inferior petrosal sinuses to each other and to the vertebral plexus of veins. They are on the clivus, just posterior to the sella turcica of the sphenoid bone (Fig. 8.29).

Clinical app

Emissary veins

Emissary veins connect extracranial veins with intracranial veins and are important clinically because they can be a conduit through which infections can enter the cranial cavity. Emissary veins lack valves, as do the majority of veins in the head and neck.

Clinical app

Head injury

Head trauma is a common injury and is a significant cause of morbidity and death. At the time of the initial head injury two processes take place.

- First the primary brain injury may involve primary axonal and cellular damage, which results from the shearing deceleration forces within the brain. These injuries are generally not repairable. Further primary brain injuries

include intracerebral hemorrhage and penetrating injuries, which may directly destroy gray and white matter.

- The secondary injuries are sequelae of the initial trauma. They include scalp laceration, fracture of the cranial vault, disruption of intracerebral arteries and veins, intracerebral edema, and infection. In most cases these can be treated if diagnosed early, and rapid and effective treatment will significantly improve the patient's recovery and prognosis.

Clinical app

Concussion

Concussion (mild traumatic brain injury [MTBI]) is the most common type of traumatic brain injury. The injury typically results from a rapid deceleration of the head or by a rotation of the brain within the cranial cavity. General symptoms of MTBI can include posttraumatic amnesia, confusion, loss of consciousness, headache, dizziness, vomiting, lack of motor coordination, and light sensitivity. The diagnosis of concussion, MTBI, is based on the event, the current neurological status, and the state of consciousness of the patient.

Clinical app

Types of intracranial hemorrhage

Extradural hemorrhage

An extradural hemorrhage (Fig. 8.32) is caused by arterial damage and results from tearing of the branches of the middle meningeal artery, which typically occurs in the region of the pterion. Blood collects between the periosteal layer of the dura and the calvaria and, under arterial pressure, slowly expands.

The typical history is of a blow to the head (often during a sporting activity) that produces a minor loss of consciousness. Following the injury, the patient usually regains consciousness and has a lucid interval for a period of hours. After this, rapid drowsiness and unconsciousness ensue, which may lead to death.

Subdural hematoma

A subdural hematoma (Fig. 8.33) is created by a hemorrhage within the dural border cell layer. The hematoma results from venous bleeding, usually from torn cerebral veins where they enter the superior sagittal sinus.

Patients at most risk of developing a subdural hematoma are the young and elderly. The clinical history usually includes a trivial injury followed by an insidious loss of consciousness or alteration of personality.

Subarachnoid hemorrhage

Subarachnoid hemorrhage (Fig. 8.34) typically results from a ruptured intracerebral aneurysm arising from the vessels supplying and around the arterial circle (of Willis) but may occur in patients who have undergone significant cerebral trauma.



Fig. 8.32 Extradural hematoma. Axial CT scan of brain.



Fig. 8.33 Chronic (low-density) subdural hematoma. Axial CT scan of brain.

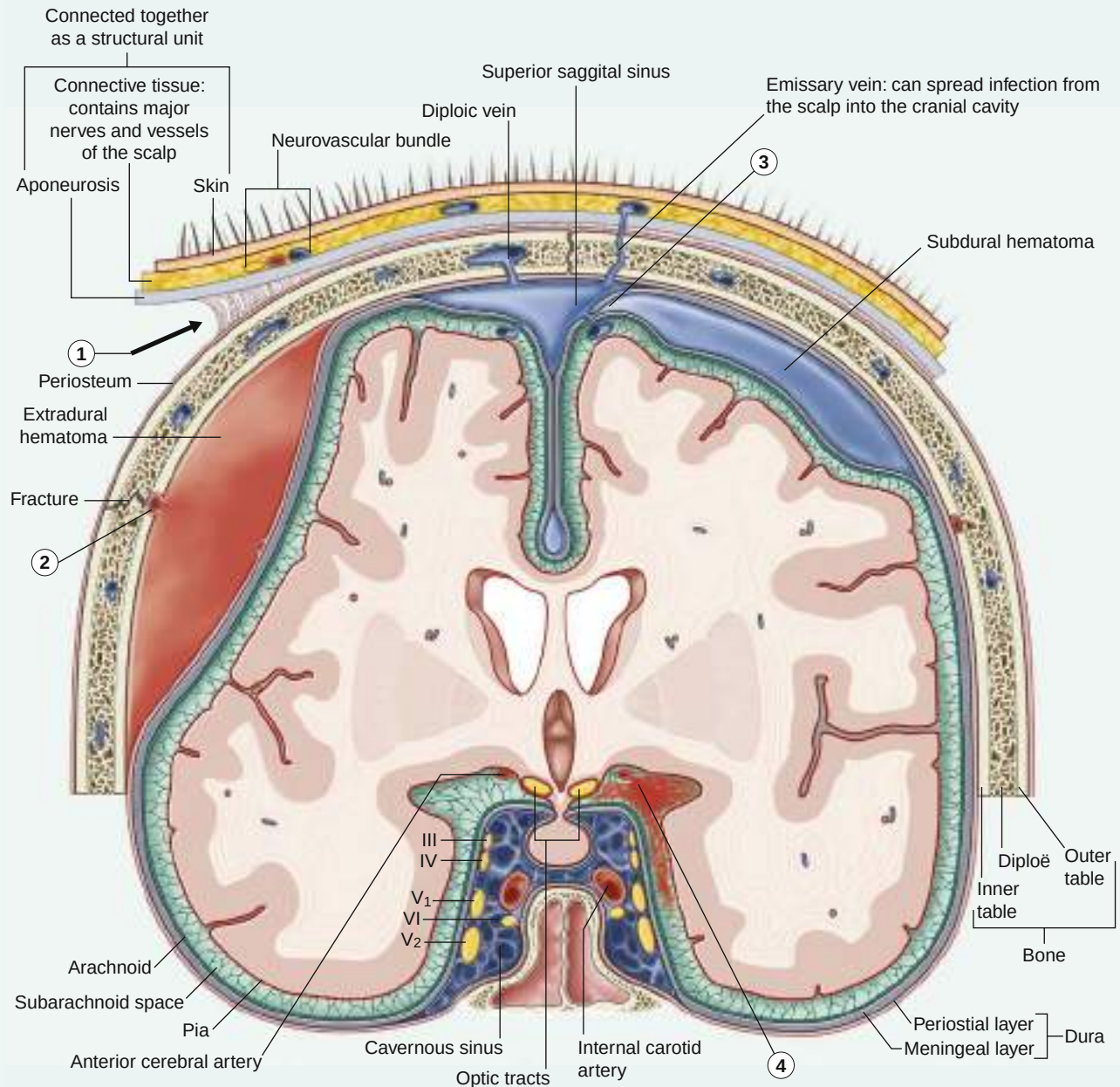


Fig. 8.34 Subarachnoid hemorrhage. Axial CT scan of brain.

Clinical app

Scalp and meninges

Summary of relationships and clinical significance of the scalp and meninges



- ① Loose connective tissue (danger area)
 - In scalping injuries, this is the layer in which separation occurs.
 - Infection can easily spread in this layer.
 - Blunt trauma can result in hemorrhage in this layer (blood can spread forward into the face, resulting in "black eyes").
- ② Rupture of the middle meningeal artery (branches) by fracture of the inner table of bone results in extradural hematoma. Under pressure, the blood progressively separates dura from the bone.
- ③ Tear to cerebral vein where it crosses dura to enter cranial venous sinus can result in subdural hematoma. The tear separates a thin layer of meningeal dura from that which remains attached to the periosteal layer. As a result, the hematoma is covered by an inner limiting membrane derived from part of the meningeal dura.
- ④ Aneurysm
 - Ruptured aneurysms of vessels of the cerebral arterial circle hemorrhage directly into the subarachnoid space and CSF.

CRANIAL NERVES

The 12 pairs of cranial nerves are part of the peripheral nervous system (PNS) and pass through foramina or fissures in the cranial cavity. All nerves except one, the accessory nerve [XI], originate from the brain.

In addition to having similar somatic and visceral components as spinal nerves, some cranial nerves also contain special sensory and motor components (Tables 8.4, 8.5).

The special sensory components are associated with hearing, seeing, smelling, balancing, and tasting.

Special motor components include those that innervate skeletal muscles derived embryologically from the pharyngeal arches and not from somites.

In human embryology, six pharyngeal arches are designated, but the fifth pharyngeal arch never develops. Each of the pharyngeal arches that does develop is associated with a developing cranial nerve or one of its branches. These cranial nerves carry efferent fibers that innervate the skeletal musculature derived from the pharyngeal arch.

Innervation of the musculature derived from the five pharyngeal arches that do develop is as follows:

- first arch—trigeminal nerve [V₃],
- second arch—facial nerve [VII],
- third arch—glossopharyngeal nerve [IX],
- fourth arch—superior laryngeal branch of the vagus nerve [X],
- sixth arch—recurrent laryngeal branch of the vagus nerve [X], and
- posterior arches—accessory nerve [XI].

Olfactory nerve [I]

The **olfactory nerve [I]** carries special afferent (SA) fibers for the sense of smell. Its sensory neurons have:

- peripheral processes that act as olfactory receptors in the nasal mucosa, and
- central processes that return information to the brain.

The receptors are in the roof and upper parts of the nasal cavity and the central processes. After joining into small bundles, axons of the receptors enter the cranial cavity by passing through the cribriform plate of the ethmoid bone (Fig. 8.35). They terminate by synapsing with secondary neurons in the olfactory bulbs (Fig. 8.36).

Optic nerve [II]

The **optic nerve [II]** carries SA fibers for vision. These fibers return information to the brain from photoreceptors in the retina. Neuronal processes leave the retinal receptors, join into small bundles, and are carried by the optic nerves to other components of the visual system in the brain. The optic nerves enter the cranial cavity through the optic canals (Fig. 8.35).

Table 8.4 Cranial nerve functional components

Functional component	Abbreviation	General function	Cranial nerves containing component
General somatic afferent	GSA	Perception of touch, pain, temperature	Trigeminal nerve [V]; facial nerve [VII]; glossopharyngeal nerve [IX]; vagus nerve [X]
General visceral afferent	GVA	Sensory input from viscera	Glossopharyngeal nerve [IX]; vagus nerve [X]
Special afferent*	SA	Smell, taste, vision, hearing, and balance	Olfactory nerve [I]; optic nerve [II]; facial nerve [VII]; vestibulocochlear nerve [VIII]; glossopharyngeal nerve [IX]; vagus nerve [X]
General somatic efferent	GSE	Motor innervation to skeletal (voluntary) muscles	Oculomotor nerve [III]; trochlear nerve [IV]; abducent nerve [VI]; hypoglossal nerve [XII]
General visceral efferent	GVE	Motor innervation to smooth muscle, heart muscle, and glands	Oculomotor nerve [III]; facial nerve [VII]; glossopharyngeal nerve [IX]; vagus nerve [X]
Branchial efferent†	BE	Motor innervation to skeletal muscles derived from pharyngeal arch mesoderm	Trigeminal nerve [V]; facial nerve [VII]; glossopharyngeal nerve [IX]; vagus nerve [X]; accessory nerve [XI] (see Diogo et al. 2015 <i>Nature</i> 520:466–473)

Other terminology used when describing functional components:

*Special sensory, or special visceral afferent (SVA): smell, taste. Special somatic afferent (SSA): vision, hearing, balance.

†Special visceral efferent (SVE) or branchial motor.

Table 8.5 Cranial nerves (see Table 8.4 for abbreviations)

Nerve	COMPONENT		Exit from skull	Function
	Afferent	Efferent		
Olfactory nerve [I]	SA		Cribriform plate of ethmoid bone	Smell
Optic nerve [II]	SA		Optic canal	Vision
Oculomotor nerve [III]		GSE, GVE	Superior orbital fissure	GSE—innervates levator palpebrae superioris, superior rectus, inferior rectus, medial rectus, and inferior oblique muscles GVE—innervates sphincter pupillae for pupillary constriction; ciliary muscles for accommodation of the lens for near vision
Trochlear nerve [IV]		GSE	Superior orbital fissure	Innervates superior oblique muscle
Trigeminal nerve [V]	GSA	BE	Superior orbital fissure— ophthalmic division [V ₁] Foramen rotundum—maxillary nerve [V ₂] Foramen ovale—mandibular division [V ₃]	GSA—sensory from: ophthalmic division [V ₁ —eyes, conjunctiva, orbital contents, nasal cavity, frontal sinus, ethmoidal cells, upper eyelid, dorsum of nose, anterior part of scalp, dura in anterior cranial fossa, superior part of tentorium cerebelli; maxillary nerve [V ₂ —dura in middle cranial fossa, nasopharynx, palate, nasal cavity, upper teeth, maxillary sinus, skin covering the side of the nose, lower eyelid, cheek, upper lip; mandibular division [V ₃ —skin of lower face, cheek, lower lip, anterior part of external ear, part of external acoustic meatus, temporal fossa, anterior two-thirds of tongue, lower teeth, mastoid air cells, mucous membranes of cheek, mandible, dura in middle cranial fossa BE—innervates temporalis, masseter, medial and lateral pterygoids, tensor tympani, tensor veli palatini, anterior belly of digastric, and mylohyoid muscles
Abducent nerve [VI]		GSE	Superior orbital fissure	Innervates lateral rectus muscle
Facial nerve [VII]	GSA, SA	GVE, BE	Stylomastoid foramen [nerve leaves cranial cavity through internal acoustic meatus and gives rise to branches in the facial canal of the temporal bone before exiting through the stylomastoid foramen. These branches leave the skull through other fissures and canals.]	GSA—sensory from part of external acoustic meatus and deeper parts of auricle SA—taste from anterior two-thirds of tongue GVE—innervates lacrimal gland, submandibular and sublingual salivary glands, and mucous membranes of nasal cavity, hard and soft palates BE—innervates muscles of face (muscles of facial expression) and scalp derived from the second pharyngeal arch, and stapedius, posterior belly of digastric, stylohyoid muscles
Vestibulocochlear nerve [VIII]	SA		[Nerve leaves cranial cavity through internal acoustic meatus]	Vestibular division—balance Cochlear division—hearing
Glossopharyngeal nerve [IX]	GVA, SA, GSA	GVE, BE	Jugular foramen	GVA—sensory from carotid body and sinus GSA—posterior one-third of tongue, palatine tonsils, oropharynx, mucosa of middle ear, pharyngotympanic tube, and mastoid air cells SA—taste from posterior one-third of tongue GVE—innervates parotid salivary gland BE—innervates stylopharyngeus muscle
Vagus nerve [X]	GSA, GVA, SA	GVE, BE	Jugular foramen	GSA—sensory from larynx, laryngopharynx, deeper parts of auricle, part of external acoustic meatus, and dura in posterior cranial fossa GVA—sensory from aortic body chemoreceptors and aortic arch baroreceptors, esophagus, bronchi, lungs, heart, and abdominal viscera of the foregut and midgut SA—taste from the epiglottis and pharynx GVE—innervates smooth muscle and glands in the pharynx, larynx, thoracic viscera, and abdominal viscera of the foregut and midgut BE—innervates one tongue muscle (palatoglossus), muscles of soft palate (except tensor veli palatini), pharynx (except stylopharyngeus), and larynx
Accessory nerve [XI]		BE	Jugular foramen	Innervates sternocleidomastoid and trapezius muscles
Hypoglossal nerve [XII]		GSE	Hypoglossal canal	Innervates hyoglossus, genioglossus, and styloglossus muscles and all intrinsic muscles of the tongue

Fig. 8.35 Cranial nerves exiting the cranial cavity.

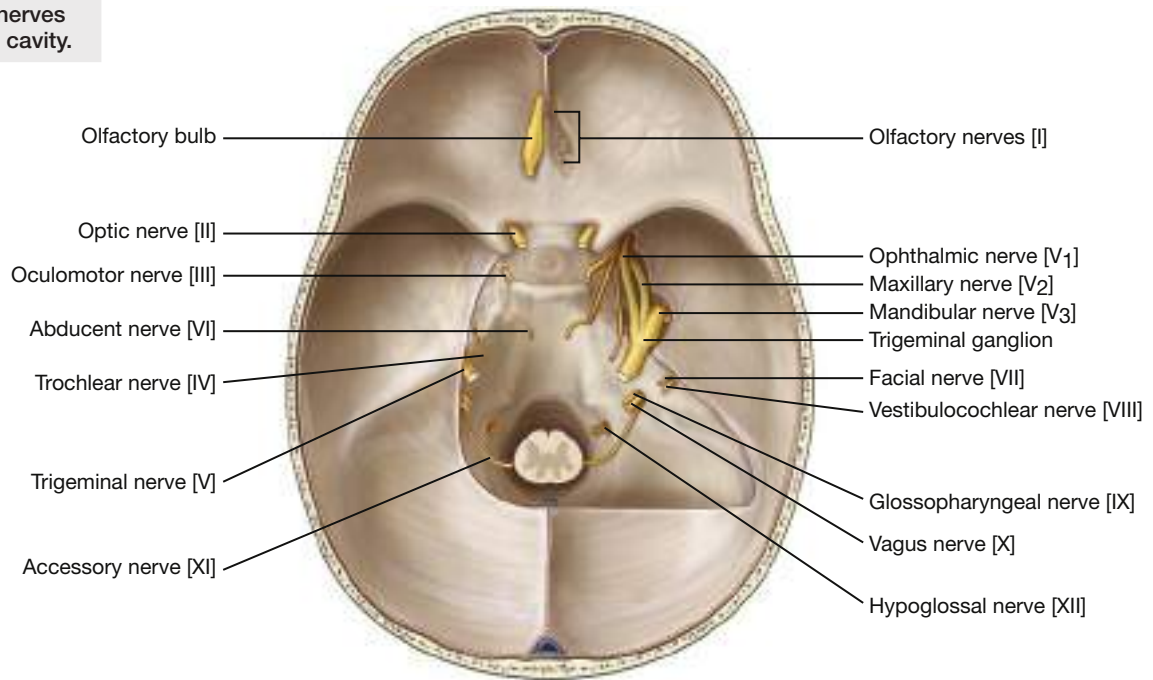
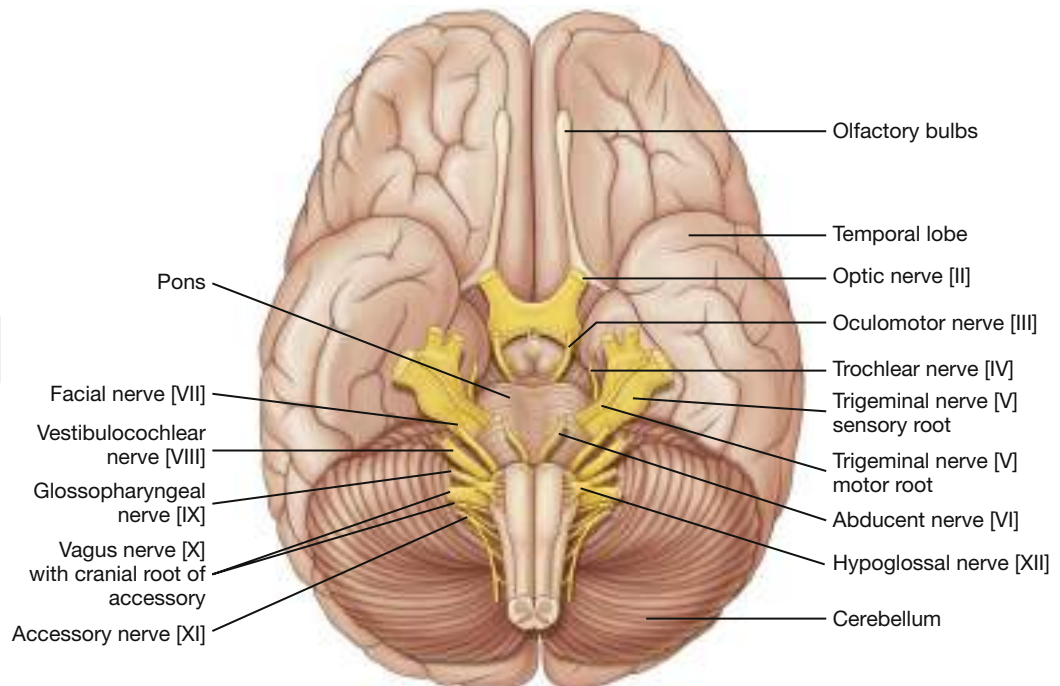


Fig. 8.36 Cranial nerves on the base of the brain.



Oculomotor nerve [III]

The **oculomotor nerve [III]** carries two types of fibers:

- General somatic efferent (GSE) fibers innervate most of the extra-ocular muscles.

- General visceral efferent (GVE) fibers are part of the parasympathetic part of the autonomic division of the PNS.

The oculomotor nerve [III] leaves the anterior surface of the brainstem between the midbrain and the pons.

Table 8.6 Parasympathetic ganglia of the head

Ganglion	Input	Cranial nerve origin of preganglionic fibers	Function
Ciliary	Oculomotor nerve [III]	Oculomotor nerve [III]	Innervation of sphincter pupillae muscle for pupillary constriction and ciliary muscles for accommodation of the lens for near vision
Pterygopalatine	Greater petrosal nerve	Facial nerve [VII]	Innervation of lacrimal gland and mucous glands of nasal cavity, maxillary sinus, and palate
Otic	Lesser petrosal nerve	Glossopharyngeal nerve [IX]	Innervation of parotid gland
Submandibular	Chorda tympani to lingual	Facial nerve [VII]	Innervation of submandibular and sublingual glands

(Fig. 8.36). It enters the anterior edge of the tentorium cerebelli, continues in an anterior direction in the lateral wall of the cavernous sinus (Figs. 8.35, 8.36; also see Fig. 8.34), and leaves the cranial cavity through the superior orbital fissure.

In the orbit, the GSE fibers in the oculomotor nerve innervate levator palpebrae superioris, superior rectus, inferior rectus, medial rectus, and inferior oblique muscles.

The GVE fibers are preganglionic parasympathetic fibers that synapse in the ciliary ganglion and ultimately innervate the sphincter pupillae muscle responsible for pupillary constriction and the ciliary muscles responsible for accommodation of the lens for near vision (Table 8.6).

Trochlear nerve [IV]

The **trochlear nerve [IV]** is a cranial nerve that carries GSE fibers to innervate the superior oblique muscle, an extraocular muscle in the orbit. It arises in the midbrain and is the only cranial nerve to exit from the posterior surface of the brainstem (Fig. 8.36). After curving around the midbrain, it enters the inferior surface of the free edge of the tentorium cerebelli, continues in an anterior direction in the lateral wall of the cavernous sinus (Figs. 8.35, 8.36; also see Fig. 8.34), and enters the orbit through the superior orbital fissure.

Trigeminal nerve [V]

The **trigeminal nerve [V]** is the major sensory nerve of the head and innervates muscles that move the lower jaw. It carries general somatic afferent (GSA) and branchial efferent (BE) fibers:

- The GSA fibers provide sensory input from the face, anterior one-half of the scalp, mucous membranes of the oral and nasal cavities and the paranasal sinuses, the nasopharynx, part of the ear and external acoustic meatus, part of the tympanic membrane, orbital contents and conjunctiva, the dura mater in the anterior and middle cranial fossae, and possibly the mastoid air cells.

- The BE fibers innervate the muscles of mastication, the tensor tympani, the tensor veli palatini, the mylohyoid, and the anterior belly of the digastric.

The trigeminal nerve exits from the anterolateral surface of the pons as a large sensory root and a small motor root (Fig. 8.36). These roots continue forward out of the posterior cranial fossa and into the middle cranial fossa by passing over the medial tip of the petrous part of the temporal bone (Fig. 8.35).

In the middle cranial fossa the sensory root expands into the **trigeminal ganglion** (Fig. 8.35), which contains cell bodies for the sensory neurons in the trigeminal nerve and is comparable to a spinal ganglion. The ganglion is in a depression (the trigeminal depression) on the anterior surface of the petrous part of the temporal bone in a dural cave (the **trigeminal cave**). The motor root is below and completely separate from the sensory root at this point.

Arising from the anterior border of the trigeminal ganglion are the three terminal divisions of the trigeminal nerve, which, in descending order, are:

- the **ophthalmic nerve (ophthalmic division [V₁])**,
- the **maxillary nerve (maxillary division [V₂])**, and
- the **mandibular nerve (mandibular division [V₃])**.

Ophthalmic nerve [V₁]

The ophthalmic nerve [V₁] passes forward in the dura of the lateral wall of the cavernous sinus (see Fig. 8.34), leaves the cranial cavity, and enters the orbit through the superior orbital fissure.

The ophthalmic nerve [V₁] carries sensory branches from the eyes, conjunctiva, and orbital contents, including the lacrimal gland. It also receives sensory branches from the nasal cavity, frontal sinus, ethmoidal cells, falx cerebri, dura in the anterior cranial fossa and superior parts of the tentorium cerebelli, upper eyelid, dorsum of the nose, and the anterior part of the scalp.

Maxillary nerve [V₂]

The maxillary nerve [V₂] passes forward in the dura mater of the lateral wall of the cavernous sinus just inferior to the ophthalmic nerve [V₁] (see Fig. 8.34), leaves the cranial cavity through the foramen rotundum, and enters the pterygo-palatine fossa.

The maxillary nerve [V₂] receives sensory branches from the dura in the middle cranial fossa, the nasopharynx, the palate, the nasal cavity, teeth of the upper jaw, maxillary sinus, skin covering the side of the nose, the lower eyelid, the cheek, and the upper lip.

Mandibular nerve [V₃]

The mandibular nerve [V₃] leaves the inferior margin of the trigeminal ganglion and leaves the skull through the foramen ovale and enters the infratemporal fossa.

The motor root of the trigeminal nerve also passes through the foramen ovale and unites with the sensory component of the mandibular nerve [V₃] outside the skull. Thus the mandibular nerve [V₃] is the only division of the trigeminal nerve that contains a motor component.

Outside the skull the motor fibers innervate the four muscles of mastication (temporalis, masseter, and medial and lateral pterygoids), as well as the tensor tympani, the tensor veli palatini, the anterior belly of the digastric, and the mylohyoid muscles.

The mandibular nerve [V₃] also receives sensory branches from the skin of the lower face, cheek, lower lip, anterior part of the external ear, part of the external acoustic meatus and the temporal region, the anterior two-thirds of the tongue, the teeth of the lower jaw, the mastoid air cells, the mucous membranes of the cheek, the mandible, and dura in the middle cranial fossa.

Abducent nerve [VI]

The **abducent nerve** [VI] carries GSE fibers to innervate the lateral rectus muscle in the orbit. It arises from the brainstem between the pons and medulla and passes forward, piercing the dura covering the clivus (see Figs. 8.35, 8.36). Continuing upward in a dural canal, it crosses the superior edge of the petrous temporal bone, enters and crosses the cavernous sinus (see Fig. 8.34) just inferolateral to the internal carotid artery, and enters the orbit through the superior orbital fissure.

Facial nerve [VII]

The **facial nerve** [VII] carries GSA, SA, GVE, and BE fibers:

- The GSA fibers provide sensory input from part of the external acoustic meatus and deeper parts of the auricle.
- The SA fibers are for taste from the anterior two-thirds of the tongue.
- The GVE fibers are part of the parasympathetic part of the autonomic division of the PNS and stimulate secretomotor activity in the lacrimal gland, submandibular and sublingual salivary glands, glands in the mucous membranes of the nasal cavity, and hard and soft palates.
- The BE fibers innervate the muscles of the face (muscles of facial expression) and scalp derived from the second pharyngeal arch and the stapedius, the posterior belly of the digastric, and the stylohyoid muscles.

The facial nerve [VII] attaches to the lateral surface of the brainstem between the pons and medulla oblongata (see Fig. 8.36). It consists of a large motor root and a smaller sensory root (the **intermediate nerve**):

- The intermediate nerve contains the SA fibers for taste, the parasympathetic GVE fibers, and the GSA fibers.
- The larger motor root contains the BE fibers.

The motor and sensory roots cross the posterior cranial fossa and leave the cranial cavity through the internal acoustic meatus (see Fig. 8.35). After entering the facial canal in the petrous part of the temporal bone, the two roots fuse and form the facial nerve [VII]. Near this point the nerve enlarges as the **geniculate ganglion**, which is similar to a spinal ganglion containing cell bodies for sensory neurons.

At the geniculate ganglion, the facial nerve [VII] turns and gives off the **greater petrosal nerve**, which carries mainly preganglionic parasympathetic (GVE) fibers (Table 8.6).

The facial nerve [VII] continues along the bony canal, giving off the **nerve to stapedius** and the **chorda tympani** before exiting the skull through the stylomastoid foramen.

The chorda tympani carries taste (SA) fibers from the anterior two-thirds of the tongue and preganglionic parasympathetic (GVE) fibers destined for the submandibular ganglion (Table 8.6).

Vestibulocochlear nerve [VIII]

The vestibulocochlear nerve [VIII] carries SA fibers for hearing and balance and consists of two divisions:

- a vestibular component for balance, and
- a cochlear component for hearing.

The vestibulocochlear nerve [VIII] attaches to the lateral surface of the brainstem between the pons and medulla

after emerging from the internal acoustic meatus and crossing the posterior cranial fossa (see [Figs. 8.35, 8.36](#)). The two divisions combine into the single nerve seen in the posterior cranial fossa within the substance of the petrous part of the temporal bone.

Glossopharyngeal nerve [IX]

The glossopharyngeal nerve [IX] carries GVA, GSA, SA, GVE, and BE fibers:

- The GVA fibers provide sensory input from the carotid body and sinus.
- The GSA fibers provide sensory input from the posterior one-third of the tongue, palatine tonsils, oropharynx, mucosa of the middle ear, mastoid air cells, and pharyngotympanic tube.
- The SA fibers are for taste from the posterior one-third of the tongue.
- The GVE fibers are part of the parasympathetic part of the autonomic division of the PNS and stimulate secretomotor activity in the parotid salivary gland.
- The BE fibers innervate the muscle derived from the third pharyngeal arch (the stylopharyngeus muscle).

The glossopharyngeal nerve [IX] arises as several rootlets on the anterolateral surface of the upper medulla oblongata (see [Fig. 8.36](#)). The rootlets cross the posterior cranial fossa and enter the jugular foramen (see [Fig. 8.35](#)). Within the jugular foramen, and before exiting from it, the rootlets merge to form the glossopharyngeal nerve.

Within or immediately outside the jugular foramen are two ganglia (the **superior** and **inferior ganglia**), which contain the cell bodies of the sensory neurons in the glossopharyngeal nerve [IX].

Tympanic nerve

Branching from the glossopharyngeal nerve [IX] either within or immediately outside the jugular foramen is the **tympanic nerve**. This branch re-enters the temporal bone, enters the middle ear cavity, and participates in the formation of the **tympanic plexus**. Within the middle ear cavity it provides sensory innervation to the mucosa of the cavity, pharyngotympanic tube, and mastoid air cells.

The tympanic nerve also contributes GVE fibers, which leave the tympanic plexus in the **lesser petrosal nerve**—a small nerve that exits the temporal bone, enters the middle cranial fossa, and descends through the foramen ovale to exit the cranial cavity carrying preganglionic parasympathetic fibers to the otic ganglion (see [Table 8.6](#)).

Vagus nerve [X]

The vagus nerve [X] carries GSA, GVA, SA, GVE, and BE fibers:

- The GSA fibers provide sensory input from the larynx, laryngopharynx, deeper parts of the auricle, part of the external acoustic meatus, and the dura mater in the posterior cranial fossa.
- The GVA fibers provide sensory input from the aortic body chemoreceptors, aortic arch baroreceptors, and the esophagus, bronchi, lungs, heart, and abdominal viscera in the foregut and midgut.
- The SA fibers are for taste around the epiglottis and pharynx.
- The GVE fibers are part of the parasympathetic part of the autonomic division of the PNS and stimulate smooth muscle and glands in the pharynx, larynx, thoracic viscera, and abdominal viscera of the foregut and midgut.
- The BE fibers innervate one muscle of the tongue (palatoglossus) and the muscles of the soft palate (except tensor veli palatini), pharynx (except stylopharyngeus), and larynx.

The vagus nerve arises as a group of rootlets on the anterolateral surface of the medulla oblongata just inferior to the rootlets arising to form the glossopharyngeal nerve [IX] (see [Fig. 8.36](#)). The rootlets cross the posterior cranial fossa and enter the jugular foramen (see [Fig. 8.35](#)). Within this foramen, and before exiting from it, the rootlets merge to form the vagus nerve [X]. Within or immediately outside the jugular foramen are two ganglia, the **superior** (jugular) and **inferior** (nodose) **ganglia**, which contain the cell bodies of the sensory neurons in the vagus nerve [X].

Accessory nerve [XI]

The accessory nerve [XI] is a cranial nerve that carries BE fibers to innervate the sternocleidomastoid and trapezius muscles. It is a unique cranial nerve because its roots arise from motor neurons in the upper five segments of the cervical spinal cord. These fibers leave the lateral surface of the spinal cord and, joining together as they ascend, enter the cranial cavity through the foramen magnum (see [Fig. 8.36](#)). The accessory nerve [XI] continues through the posterior cranial fossa and exits through the jugular foramen (see [Fig. 8.35](#)). It then descends in the neck to innervate the sternocleidomastoid and trapezius muscles from their deep surfaces.

Cranial root of the accessory nerve

Some descriptions of the accessory nerve [XI] refer to a few rootlets arising from the caudal part of the medulla

Clinical app**Cranial nerve lesions**

Cranial nerve	Clinical findings	Example of lesion
Olfactory nerve [I]	Loss of smell (anosmia)	Injury to the cribriform plate; congenital absence
Optic nerve [II]	Blindness/visual field abnormalities, loss of pupillary constriction	Direct trauma to the orbit; disruption of the optic pathway
Oculomotor nerve [III]	Dilated pupil, ptosis, loss of normal pupillary reflex, eye moves inferiorly and laterally (down and out)	Pressure from an aneurysm arising from the posterior communicating, posterior cerebral, or superior cerebellar artery; pressure from a herniating cerebral uncus (false localizing sign); cavernous sinus mass or thrombosis
Trochlear nerve [IV]	Inability to look inferiorly when the eye is adducted (down and in)	Along the course of the nerve around the brainstem; orbital fracture
Trigeminal nerve [V]	Loss of sensation and pain in the region supplied by the three divisions of the nerve over the face; loss of motor function of the muscles of mastication on the side of the lesion	Typically in the region of the trigeminal ganglion, though local masses around the foramina through which the divisions pass can produce symptoms
Abducent nerve [VI]	Inability of lateral eye movement	Brain lesion or cavernous sinus lesion extending onto the orbit
Facial nerve [VII]	Paralysis of facial muscles Abnormal taste sensation from the anterior two-thirds of the tongue and dry conjunctivae Paralysis of contralateral facial muscles below the eye	Damage to the branches within the parotid gland; injury to temporal bone; viral inflammation of nerve; brainstem injury
Vestibulocochlear nerve [VIII]	Progressive unilateral hearing loss and tinnitus (ringing in the ear)	Tumor at the cerebellopontine angle
Glossopharyngeal nerve [IX]	Loss of taste to the posterior one-third of the tongue and sensation of the soft palate	Brainstem lesion; penetrating neck injury
Vagus nerve [X]	Soft palate deviation with deviation of the uvula to the normal side; vocal cord paralysis	Brainstem lesion; penetrating neck injury
Accessory nerve [XI]	Paralysis of sternocleidomastoid and trapezius muscles	Penetrating injury to the posterior triangle of the neck
Hypoglossal nerve [XII]	Atrophy of ipsilateral muscles of the tongue and deviation toward the affected side; speech disturbance	Penetrating injury to the neck and skull base pathology

Clinical app**Overview of cranial nerves****Cranial nerve reflexes**

Corneal (blink) reflex

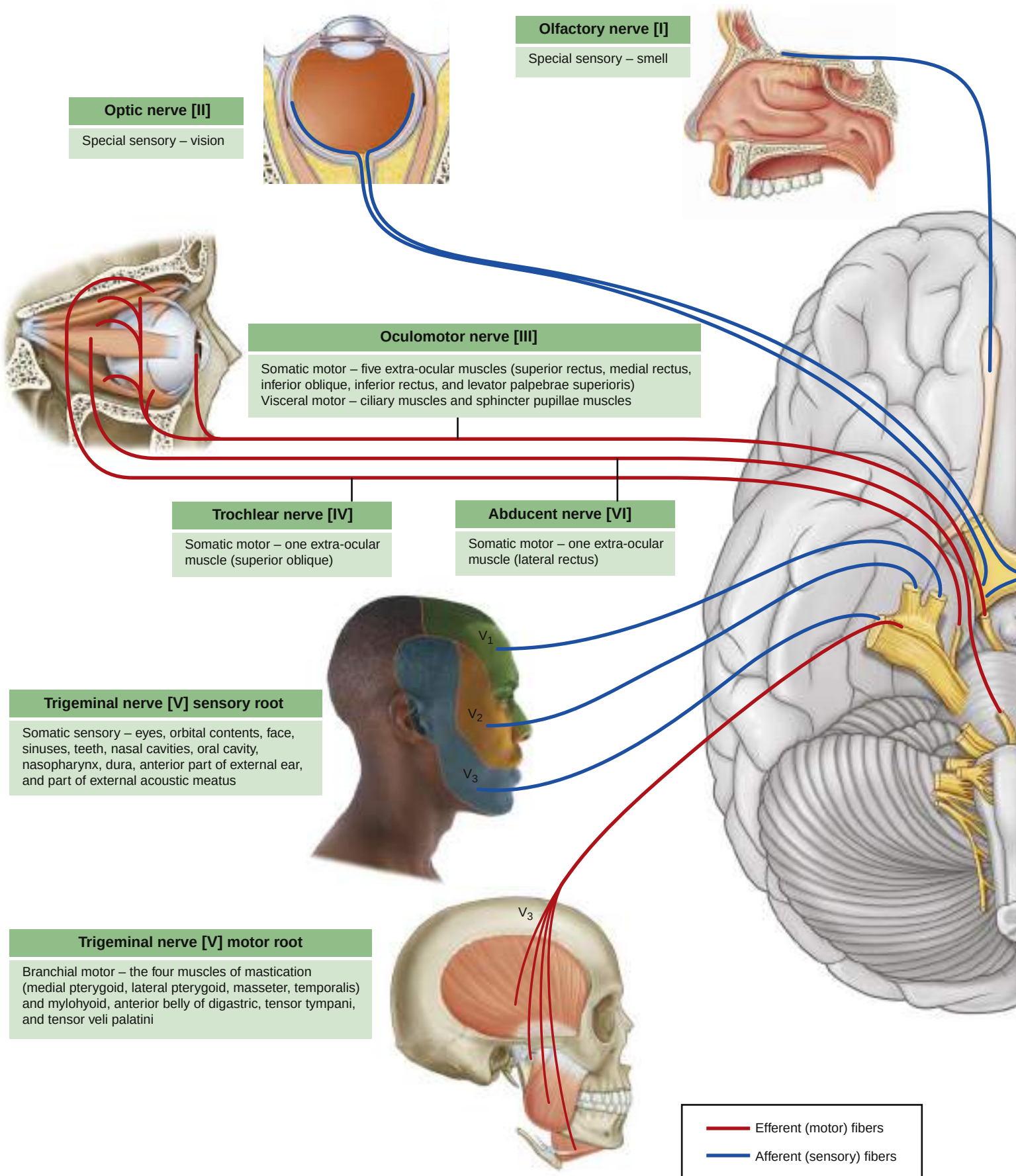
- Afferent—Trigeminal nerve (CN V)
- Efferent—Facial nerve (CN VII)

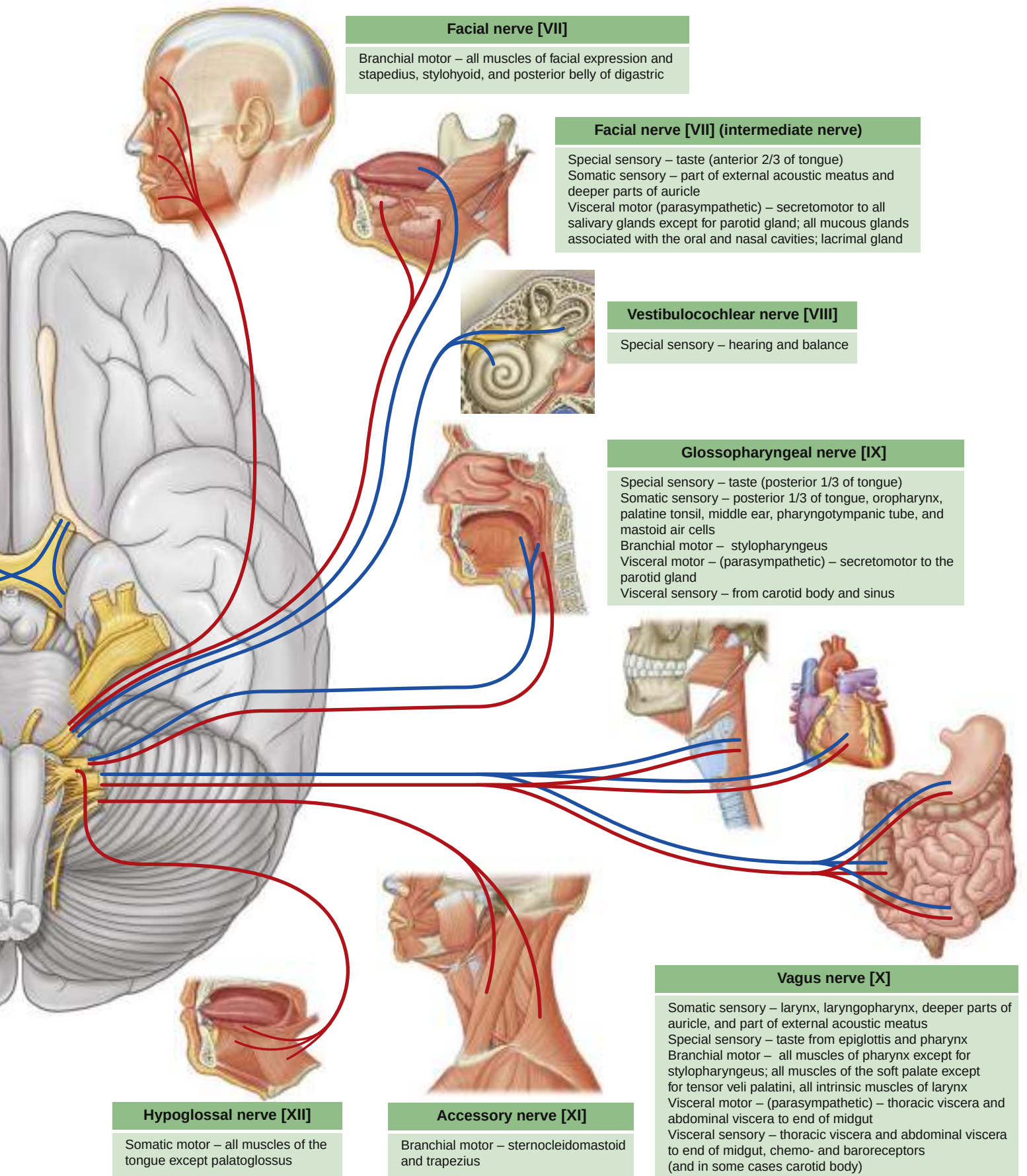
Gag reflex

- Afferent—Glossopharyngeal nerve (CN IX)
- Efferent—Vagus nerve (CN X)

Pupillary (light) reflex

- Afferent—optic nerve (CN II)
- Efferent—oculomotor nerve (CN III)





oblongata on the anterolateral surface just inferior to the rootlets arising to form the vagus nerve [X] as the “cranial” root of the accessory nerve (see Fig. 8.36). Leaving the medulla, the cranial roots course with the “spinal” roots of the accessory nerve [XI] into the jugular foramen at which point the cranial roots join the vagus nerve [X]. As part of the vagus nerve [X], they are distributed to the pharyngeal musculature innervated by the vagus nerve [X] and are therefore described as being part of the vagus nerve [X].

Hypoglossal nerve [XII]

The hypoglossal nerve [XII] carries GSE fibers to innervate all intrinsic and most of the extrinsic muscles of the tongue. It arises as several rootlets from the anterior surface of the medulla, passes laterally across the posterior cranial fossa and exits through the hypoglossal canal (see Figs. 8.35, 8.36). This nerve innervates the hyoglossus, styloglossus, and genioglossus muscles and all intrinsic muscles of the tongue.

FACE

A face-to-face meeting is an important initial contact between individuals. Part of this exchange is the use of facial expressions to convey emotions. In fact, a physician can gain important information about an individual’s general health by observing a patient’s face.

Thus an understanding of the unique organization of the various structures between the superciliary arches superiorly, the lower edge of the mandible inferiorly, and as far back as the ears on either side—the area defined as the face—is particularly useful in the practice of medicine.

Muscles

The muscles of the face (Table 8.7, Fig. 8.37) develop from the second pharyngeal arch and are innervated by branches of the facial nerve [VII]. They are in the superficial fascia, with origins from either bone or fascia and insertions into the skin.

Because these muscles control expressions of the face, they are sometimes referred to as muscles of “facial expression.” They also act as sphincters and dilators of the orifices of the face (i.e., the orbits, nose, and mouth). This organizational arrangement into functional groups provides a logical approach to understanding these muscles.

Orbital group

Two muscles are associated with the orbital group—the orbicularis oculi and the corrugator supercilii.

The **orbicularis oculi** is a large muscle that completely surrounds each orbital orifice and extends into each eyelid

(Table 8.7; also see Fig. 8.38). It closes the eyelids. It has two major parts:

- the outer **orbital part**; and
- the inner **palpebral part**.

The second muscle in the orbital group is the much smaller **corrugator supercilii** (Table 8.7; also see Fig. 8.38), which is deep to the eyebrows and the orbicularis oculi muscle and is active when frowning.

Nasal group

Three muscles are associated with the nasal group—the nasalis, the procerus, and the depressor septi nasi (Table 8.7, Fig. 8.39). The largest and best developed of the muscles of the nasal group is the **nasalis**, which is active when the nares are flared (Table 8.7, Fig. 8.39).

The **procerus** is a small muscle superficial to the nasal bone and is active when an individual frowns (Table 8.7, Fig. 8.39).

The final muscle in the nasal group is the **depressor septi nasi**, another muscle that assists in widening the nares (see Table 8.7, Fig. 8.39).

Oral group

The muscles in the oral group move the lips and cheek. They include the orbicularis oris and buccinator muscles and a lower and upper group of muscles (Fig. 8.40; also see Table 8.7). Many of these muscles intersect just lateral to the corner of the mouth on each side at a structure termed the *modiolus*. The **orbicularis oris** is a complex muscle consisting of fibers that completely encircle the mouth (Fig. 8.40; also see Table 8.7). Its function is apparent when pursing the lips, as occurs during whistling.

The **buccinator** forms the muscular component of the cheek and is used every time air expanding the cheeks is forcefully expelled (Table 8.7, Figs. 8.40, 8.41).

Lower group of oral muscles

The muscles in the lower group consist of the depressor anguli oris, depressor labii inferioris, and mentalis (Table 8.7, Fig. 8.40). The **depressor anguli oris** is active during frowning. The **depressor labii inferioris** depresses the lower lip and moves it laterally, and the **mentalis** helps position the lip when drinking from a cup or when pouting.

Upper group of oral muscles

The muscles of the upper group of oral muscles consist of risorius, zygomaticus major, zygomaticus minor, levator labii superioris, levator labii superioris alaeque nasi, and levator anguli oris (Table 8.7, Fig. 8.40). The **risorius** helps produce a grin; the **zygomaticus major** and **zygomaticus minor** help produce a smile; the **levator labii superioris**

Table 8.7 Muscles of the face

Muscle	Origin	Insertion	Innervation	Function
Orbital group				
Orbicularis oculi —Palpebral part	Medial palpebral ligament	Lateral palpebral raphe	Facial nerve [VII]	Closes the eyelids gently
—Orbital part	Nasal part of frontal bone; frontal process of maxilla; medial palpebral ligament	Fibers form an uninterrupted ellipse around orbit	Facial nerve [VII]	Closes the eyelids forcefully
Corrugator supercilii	Medial end of the superciliary arch	Skin of the medial half of eyebrow	Facial nerve [VII]	Draws the eyebrows medially and downward
Nasal group				
Nasalis —Transverse part	Maxilla just lateral to nose	Aponeurosis across dorsum of nose with muscle fibers from the other side	Facial nerve [VII]	Compresses nasal aperture
—Alar part	Maxilla over lateral incisor	Alar cartilage of nose	Facial nerve [VII]	Draws cartilage downward and laterally, opening nostril
Procerus	Nasal bone and upper part of lateral nasal cartilage	Skin of lower forehead between eyebrows	Facial nerve [VII]	Draws down medial angle of eyebrows, producing transverse wrinkles over bridge of nose
Depressor septi	Maxilla above medial incisor	Mobile part of the nasal septum	Facial nerve [VII]	Pulls nose inferiorly
Oral group				
Depressor anguli oris	Oblique line of mandible below canine, premolar, and first molar teeth	Skin at the corner of mouth and blending with orbicularis oris	Facial nerve [VII]	Draws corner of mouth down and laterally
Depressor labii inferioris	Anterior part of oblique line of mandible	Lower lip at midline; blends with muscle from opposite side	Facial nerve [VII]	Draws lower lip downward and laterally
Mentalis	Mandible inferior to incisor teeth	Skin of chin	Facial nerve [VII]	Raises and protrudes lower lip as it wrinkles skin on chin
Risorius	Fascia over masseter muscle	Skin at the corner of the mouth	Facial nerve [VII]	Retracts corner of mouth
Zygomaticus major	Posterior part of lateral surface of zygomatic bone	Skin at the corner of the mouth	Facial nerve [VII]	Draws the corner of the mouth upward and laterally
Zygomaticus minor	Anterior part of lateral surface of zygomatic bone	Upper lip just medial to corner of mouth	Facial nerve [VII]	Draws the upper lip upward
Levator labii superioris	Infra-orbital margin of maxilla	Skin of upper lateral half of upper lip	Facial nerve [VII]	Raises upper lip; helps form nasolabial furrow
Levator labii superioris alaeque nasi	Frontal process of maxilla	Alar cartilage of nose and upper lip	Facial nerve [VII]	Raises upper lip and opens nostril
Levator anguli oris	Maxilla below infra-orbital foramen	Skin at the corner of mouth	Facial nerve [VII]	Raises corner of mouth; helps form nasolabial furrow
Orbicularis oris	From muscles in area; maxilla and mandible in midline	Forms ellipse around mouth	Facial nerve [VII]	Closes lips; protrudes lips
Buccinator	Posterior parts of maxilla and mandible; pterygomandibular raphe	Blends with orbicularis oris and into lips	Facial nerve [VII]	Presses the cheek against teeth; compresses distended cheeks
Other muscles or groups				
Anterior auricular	Anterior part of temporal fascia	Into helix of ear	Facial nerve [VII]	Draws ear upward and forward
Superior auricular	Epicranial aponeurosis on side of head	Upper part of auricle	Facial nerve [VII]	Elevates ear
Posterior auricular	Mastoid process of temporal bone	Convexity of concha of ear	Facial nerve [VII]	Draws ear upward and backward
Occipitofrontalis —Frontal belly	Skin of eyebrows	Into galea aponeurotica	Facial nerve [VII]	Wrinkles forehead; raises eyebrows

Continued

Table 8.7 Muscles of the face—cont'd

Muscle	Origin	Insertion	Innervation	Function
—Occipital belly	Lateral part of superior nuchal line of occipital bone and mastoid process of temporal bone	Into galea aponeurotica	Facial nerve [VII]	Draws scalp backward
Platysma	Below the clavicle in the upper part of the thorax	Ascends through the neck to the mandible. The more medial fibers insert on the mandible, more lateral fibers join muscles around mouth	Facial nerve [VII]	Tenses skin of neck and moves lower lip and corners of mouth down

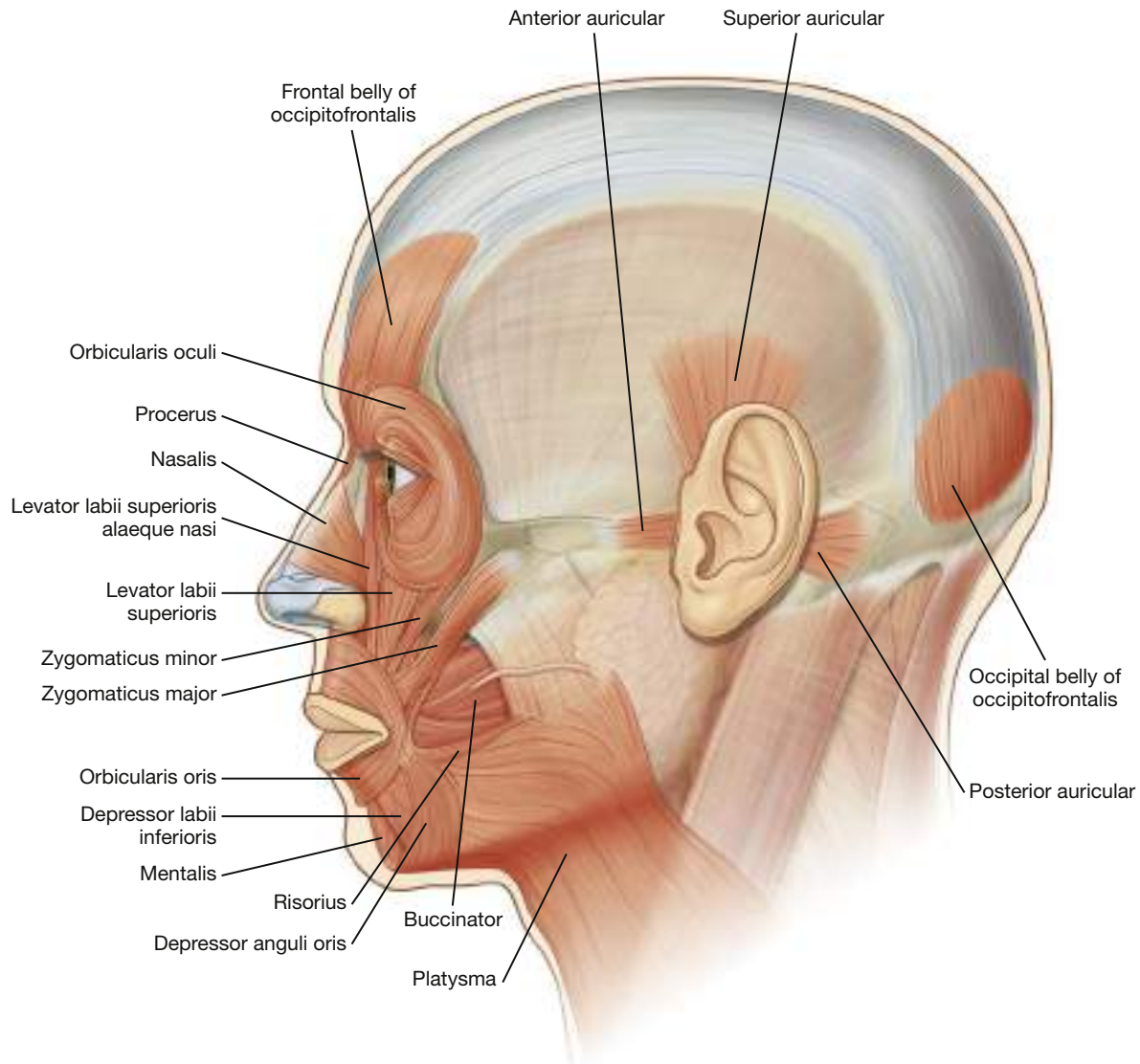


Fig. 8.37 Facial muscles.

deepens the furrow between the nose and the corner of the mouth during sadness; the **levator labii superioris alaeque nasi** may assist in flaring the nares; and the **levator anguli oris** elevates the corner of the mouth and may help deepen the furrow between the nose and the corner of the mouth during sadness.

Other muscles or muscle groups

Several additional muscles or groups of muscles not in the area defined as the face, but derived from the second pharyngeal arch and innervated by the facial nerve [VII], are considered muscles of facial expression. They include the platysma, auricular, and occipitofrontalis muscles (Table 8.7,

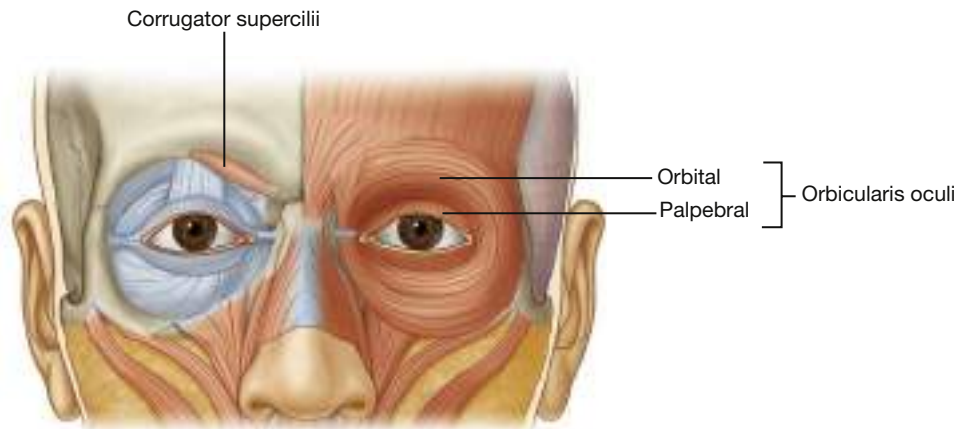


Fig. 8.38 Orbital group of facial muscles.

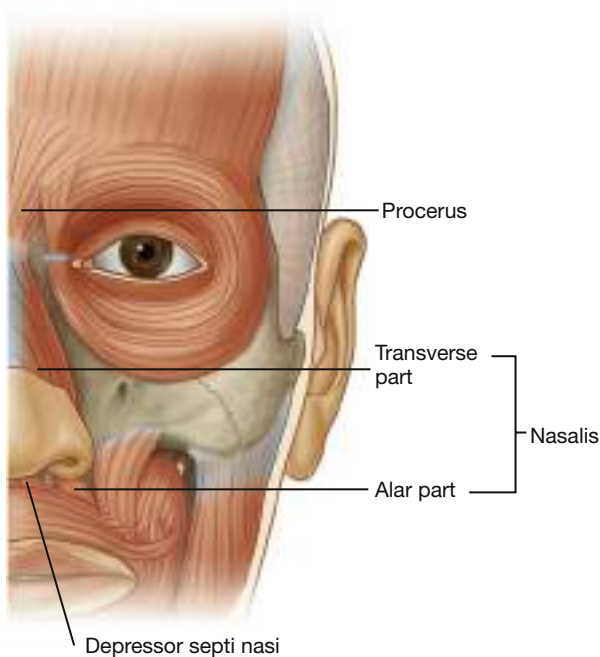


Fig. 8.39 Nasal group of facial muscles.

Fig. 8.37). The **platysma** is a large, thin sheet of muscle in the superficial fascia of the neck. It tenses the skin of the neck and can move the lower lip and corners of the mouth down.

Three muscles associated with the ear are also in the group of “other muscles of facial expression.” These are the anterior, superior, and posterior **auricular muscles** (Table 8.7, Fig. 8.42; see Fig. 8.37).

The **occipitofrontalis** is the final muscle in this category and is associated with the scalp (Table 8.7; see Fig. 8.37). It consists of a frontal belly anteriorly and an occipital belly posteriorly. An aponeurotic tendon connects the two.

Parotid gland

The **parotid glands** are the largest of the three pairs of main salivary glands in the head and numerous structures pass through them. They are anterior to and below the lower half of the ear, superficial, posterior, and deep to the ramus of mandible (Fig. 8.43). They extend down to the lower border of the mandible and up to the zygomatic arch. Posteriorly they cover the anterior part of the sternocleidomastoid muscle and continue anteriorly to halfway across the masseter muscle.

The **parotid duct** leaves the anterior edge of the parotid gland midway between the zygomatic arch and the corner of the mouth (see Fig. 8.43). It crosses the face in a transverse direction and, after crossing the medial border of the masseter muscle, turns deeply into the buccal fat pad and pierces the buccinator muscle. It opens into the oral cavity near the second upper molar tooth.

Important relationships

Several major structures enter and pass through or pass just deep to the parotid gland. These include the facial nerve [VII], the external carotid artery and its branches, and the retromandibular vein and its tributaries (see Fig. 8.43).

Facial nerve

The facial nerve [VII] exits the skull through the stylomastoid foramen and then passes into the parotid gland where it usually divides into upper and lower trunks. These pass through the substance of the parotid gland where there may be further branching and anastomosing of the nerves.

Five terminal groups of branches of the facial nerve [VII]—the **temporal**, **zygomatic**, **buccal**, **marginal mandibular**, and **cervical branches**—emerge from the upper, anterior, and lower borders of the parotid gland (see Fig. 8.43).

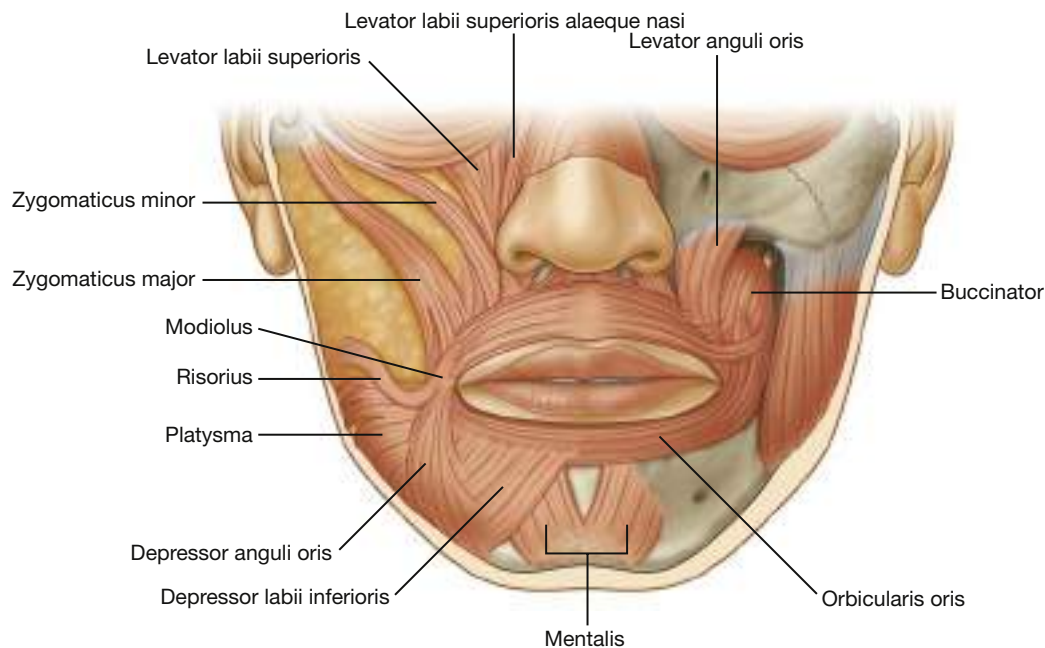


Fig. 8.40 Oral group of facial muscles.

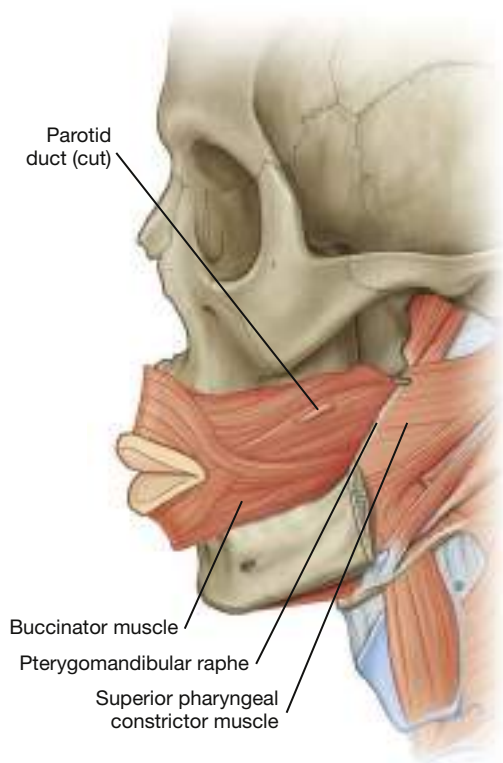


Fig. 8.41 Buccinator muscle.

External carotid artery and its branches

The external carotid artery enters into or passes deep to the inferior border of the parotid gland (see Fig. 8.43). As it continues in a superior direction, it gives off the



Fig. 8.42 Auricular muscles.

posterior auricular artery before dividing into its two terminal branches (the **maxillary** and **superficial temporal arteries**) near the lower border of the ear:

- The maxillary artery passes horizontally, deep to the mandible.
- The superficial temporal artery continues in a superior direction and emerges from the upper border of the gland after giving off the **transverse facial artery**.

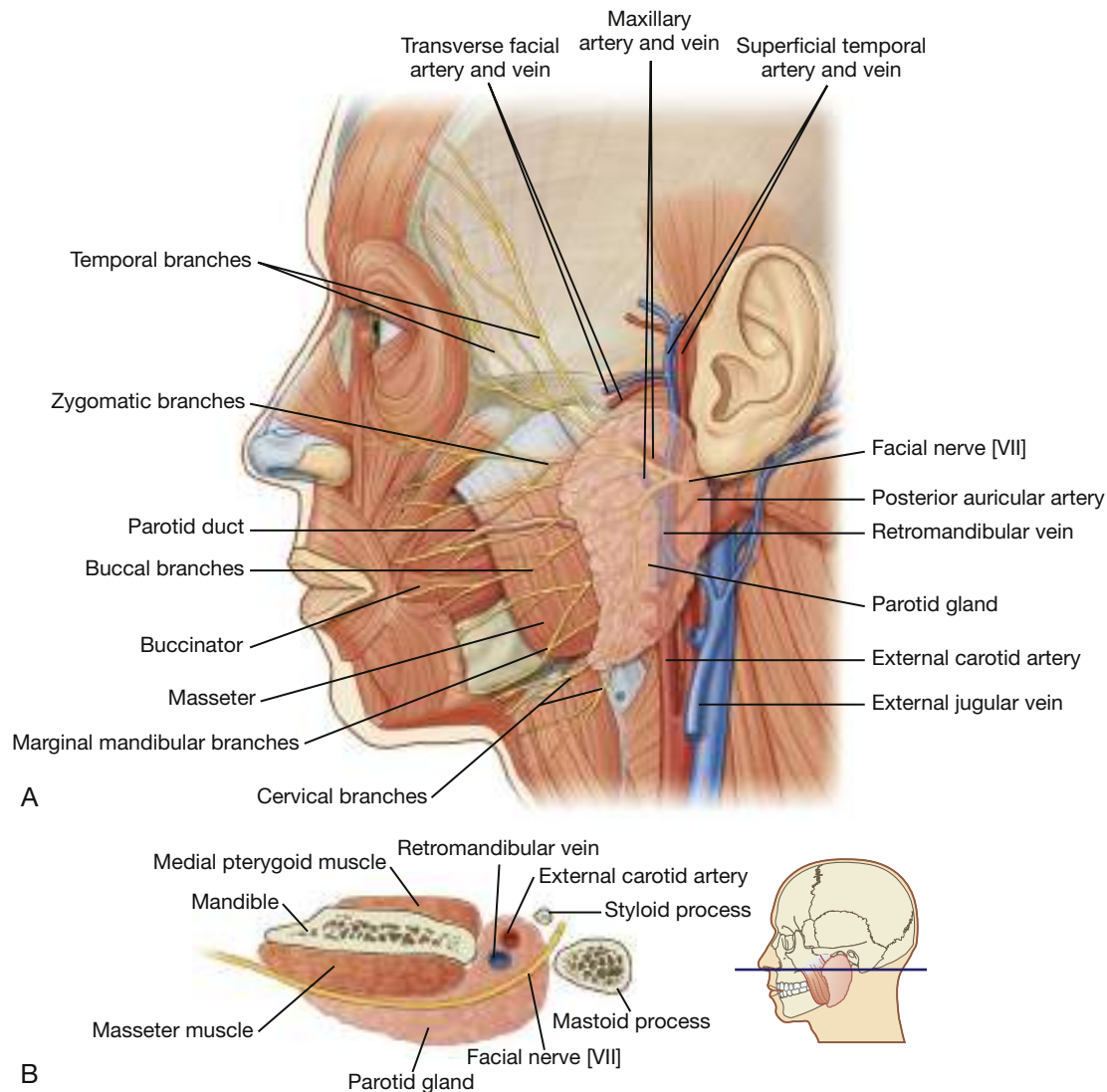


Fig. 8.43 Parotid gland. **A.** Lateral view. **B.** Cross-section.

Retromandibular vein and its tributaries

The retromandibular vein is formed in the substance of the parotid gland when the **superficial temporal** and **maxillary veins** join together (see Fig. 8.43) and pass inferiorly in the substance of the parotid gland. It usually divides into anterior and posterior branches just below the inferior border of the gland.

Arterial supply

The parotid gland receives its arterial supply from the numerous arteries that pass through its substance (see above).

Innervation

Sensory innervation of the parotid gland is provided by the **auriculotemporal nerve**, which is a branch of the mandibular nerve [V₃]. This division of the trigeminal nerve exits the skull through the foramen ovale.

The auriculotemporal nerve also carries secretomotor fibers to the parotid gland. These postganglionic parasympathetic fibers have their origin in the otic ganglion associated with the mandibular nerve [V₃] and are just inferior to the foramen ovale.

Preganglionic parasympathetic fibers to the otic ganglion come from the glossopharyngeal nerve [IX].

Innervation

During development a cranial nerve becomes associated with each of the pharyngeal arches. Because the face is primarily derived from the first and second pharyngeal arches, innervation of neighboring facial structures varies as follows:

- The trigeminal nerve [V] innervates facial structures derived from the first arch.

Clinical app

Parotid gland—tumors and stones

The parotid gland is the largest of the paired salivary glands and is enclosed within the investing layer of deep cervical fascia.

The parotid gland produces a watery saliva and salivary amylase, which are necessary for food bolus formation, oral digestion, and smooth passage of the bolus into the upper gastrointestinal tract.

Tumors of the parotid gland

The commonest tumors of the parotid gland (Fig. 8.44) are benign and typically involve the superficial gland. These include pleomorphic adenoma and part of the adenolymphoma. Their importance is in relation to their anatomical position. Critically, the relationship of the tumor to the branches of the facial nerve [VII] must be defined because resection may damage the facial nerve [VII].

Parotid gland stones

It is not uncommon for stones to develop within the parotid gland. They typically occur within the main confluence of the ducts and within the main parotid duct. The patient usually complains of intense pain when salivating and tends to avoid foods that produce this symptom. The pain can be easily reproduced in the clinic by squirting lemon juice into the patient's mouth.



Fig. 8.44 Tumor in parotid gland. Axial CT scan.

- The facial nerve [VII] innervates facial structures derived from the second arch.

Sensory innervation

Because the face is derived developmentally from a number of structures originating from the first pharyngeal arch, cutaneous innervation of the face is by branches of the trigeminal nerve [V].

The trigeminal nerve [V] divides into three major divisions—the ophthalmic [V₁], maxillary [V₂], and mandibular [V₃] nerves—before leaving the middle cranial fossa (Fig. 8.45). Each of these divisions passes out of the cranial cavity to innervate a part of the face, so most of the skin covering the face is innervated by branches of the trigeminal nerve [V]. The exception is a small area covering the angle and lower border of the ramus of mandible and parts of the ear, which are innervated by the trigeminal [V], facial [VII], vagus [X], and cervical nerves.

Ophthalmic nerve [V₁]

The ophthalmic nerve [V₁] exits the skull through the superior orbital fissure and enters the orbit (Fig. 8.45). Its branches that innervate the face include (Fig. 8.46):

- the **supra-orbital** and **supratrochlear nerves**, which leave the orbit superiorly and innervate the upper eyelid, forehead, and scalp;
- the **infratrochlear nerve**, which exits the orbit in the medial angle to innervate the medial half of the upper eyelid, the skin in the area of the medial angle, and the side of the nose;
- the **lacrimal nerve**, which exits the orbit in the lateral angle to innervate the lateral half of the upper eyelid and the skin in the area of the lateral angle; and
- the **external nasal nerve**, which supplies the anterior part of the nose.

Maxillary nerve [V₂]

The maxillary nerve [V₂] exits the skull through the foramen rotundum. Branches (see Fig. 8.45) that innervate the face include (Fig. 8.46):

- a small **zygomaticotemporal branch**, which exits the zygomatic bone and supplies a small area of the anterior temple above the zygomatic arch;
- a small **zygomaticofacial branch**, which exits the zygomatic bone and supplies a small area of skin over the zygomatic bone; and
- the large **infra-orbital nerve**, which exits the maxilla through the infra-orbital foramen and immediately divides into multiple branches to supply the lower eyelid, cheek, side of the nose, and upper lip (Fig. 8.46).

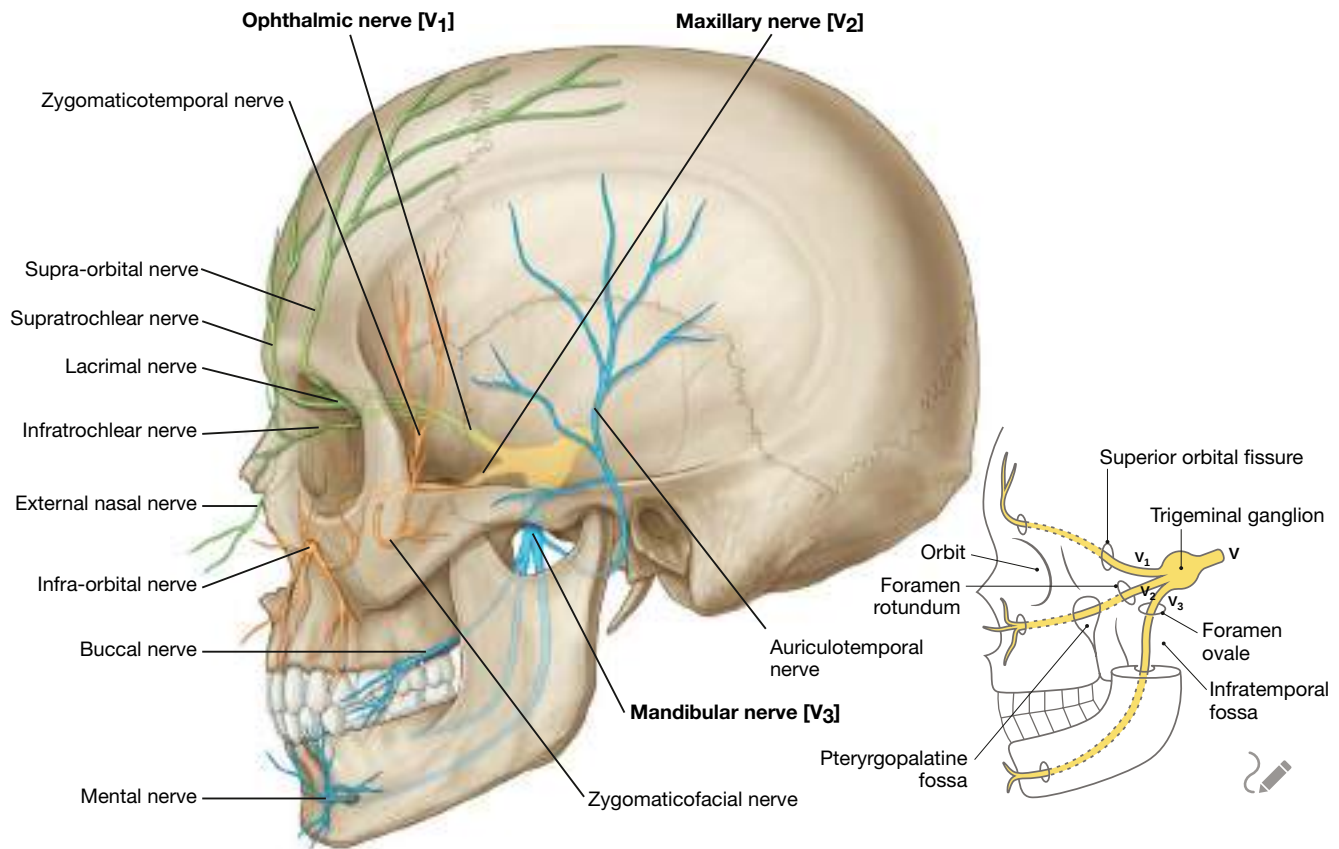


Fig. 8.45 Trigeminal nerve [V] leaving the skull.

Mandibular nerve [V₃]

The mandibular nerve [V₃] exits the skull through the foramen ovale. Branches (see Fig. 8.45) innervating the face include (Fig. 8.46):

- the **auriculotemporal nerve**, which enters the face just posterior to the temporomandibular joint, passes through the parotid gland, and ascends just anterior to the ear to supply the external acoustic meatus, the surface of the tympanic membrane (eardrum), and a large area of the temple;
- the **buccal nerve**, which is on the surface of the buccinator muscle supplying the cheek; and
- the **mental nerve**, which exits the mandible through the mental foramen and immediately divides into multiple branches to supply the skin and mucous membrane of the lower lip and skin of the chin.

Motor innervation

The muscles of the face, as well as those associated with the ear and the scalp, are derived from the second pharyngeal arch. The cranial nerve associated with this arch is the facial nerve [VII] and therefore branches of the facial nerve [VII] innervate all these muscles (Fig. 8.47A).

Clinical app

Trigeminal neuralgia

Trigeminal neuralgia (tic douloureux) is a complex sensory disorder of the sensory root of the trigeminal nerve. Typically the pain is in the region of the mandibular [V₃] and maxillary [V₂] nerves. Usually the pain is of sudden onset, excruciating in nature, and triggered by touching a sensitive region of skin.

The facial nerve [VII] exits the posterior cranial fossa through the internal acoustic meatus. It passes through the temporal bone, giving off several branches, and emerges from the base of the skull through the stylomastoid foramen (Fig. 8.47B). At this point it gives off the **posterior auricular nerve**. This branch passes upward, behind the ear, to supply the occipital belly of the occipitofrontalis muscle of the scalp and the posterior auricular muscle of the ear.

The main stem of the facial nerve [VII] then gives off another branch, which innervates the posterior belly of the digastric muscle and the stylohyoid muscle. At this point, the facial nerve [VII] enters the deep surface of the parotid gland (Fig. 8.47B).

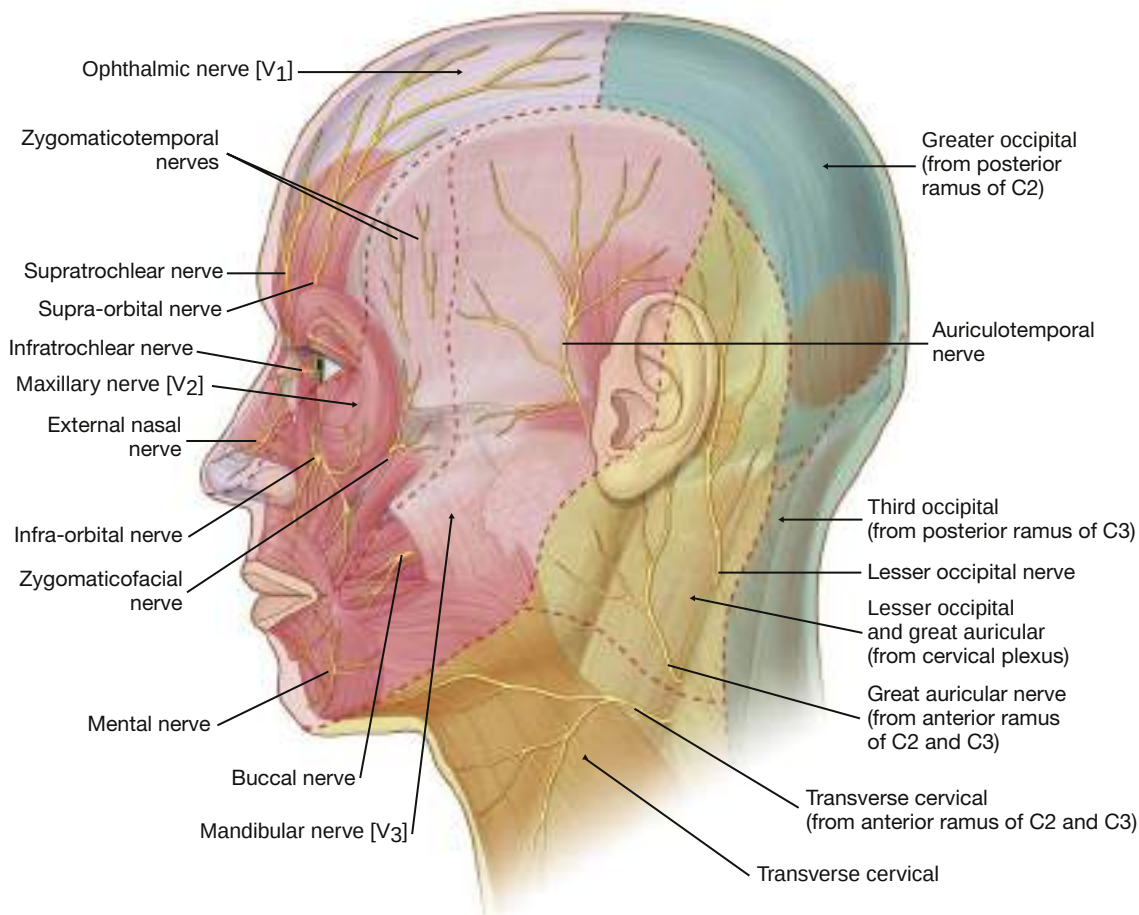


Fig. 8.46 Cutaneous distribution of the trigeminal nerve [V].

Once in the parotid gland, the main stem of the facial nerve [VII] usually divides into upper (temporofacial) and lower (cervicofacial) trunks or branches. As these branches pass through the substance of the parotid gland, they may branch further or take part in an anastomotic network (the parotid plexus).

Whatever types of interconnections occur, five terminal groups of branches of the facial nerve [VII]—the temporal, zygomatic, buccal, marginal mandibular, and cervical branches—emerge from the parotid gland (Fig. 8.47A).

Although there are variations in the pattern of distribution of the five terminal groups of branches, the basic pattern is as follows:

- Temporal branches exit from the superior border of the parotid gland to supply muscles in the area of the temple, forehead, and supra-orbital area.
- Zygomatic branches emerge from the anterosuperior border of the parotid gland to supply muscles in the infra-orbital area, the lateral nasal area, and the upper lip.
- Buccal branches emerge from the anterior border of the parotid gland to supply muscles in the cheek, the upper lip, and the corner of the mouth.

- Marginal mandibular branches emerge from the anteroinferior border of the parotid gland to supply muscles of the lower lip and chin.
- Cervical branches emerge from the inferior border of the parotid gland to supply the platysma.

Vessels

The arterial supply to the face is primarily from branches of the external carotid artery, though there is some limited supply from a branch of the internal carotid artery.

Similarly, most of the venous return is back to the internal jugular vein, though some important connections from the face result in venous return through a clinically relevant intracranial pathway involving the cavernous sinus.

Arteries

Facial artery

The facial artery is the major vessel supplying the face (Fig. 8.48A). It branches from the anterior surface of the external carotid artery (Fig. 8.48B), passes up through the deep structures of the neck, and appears at the lower border of

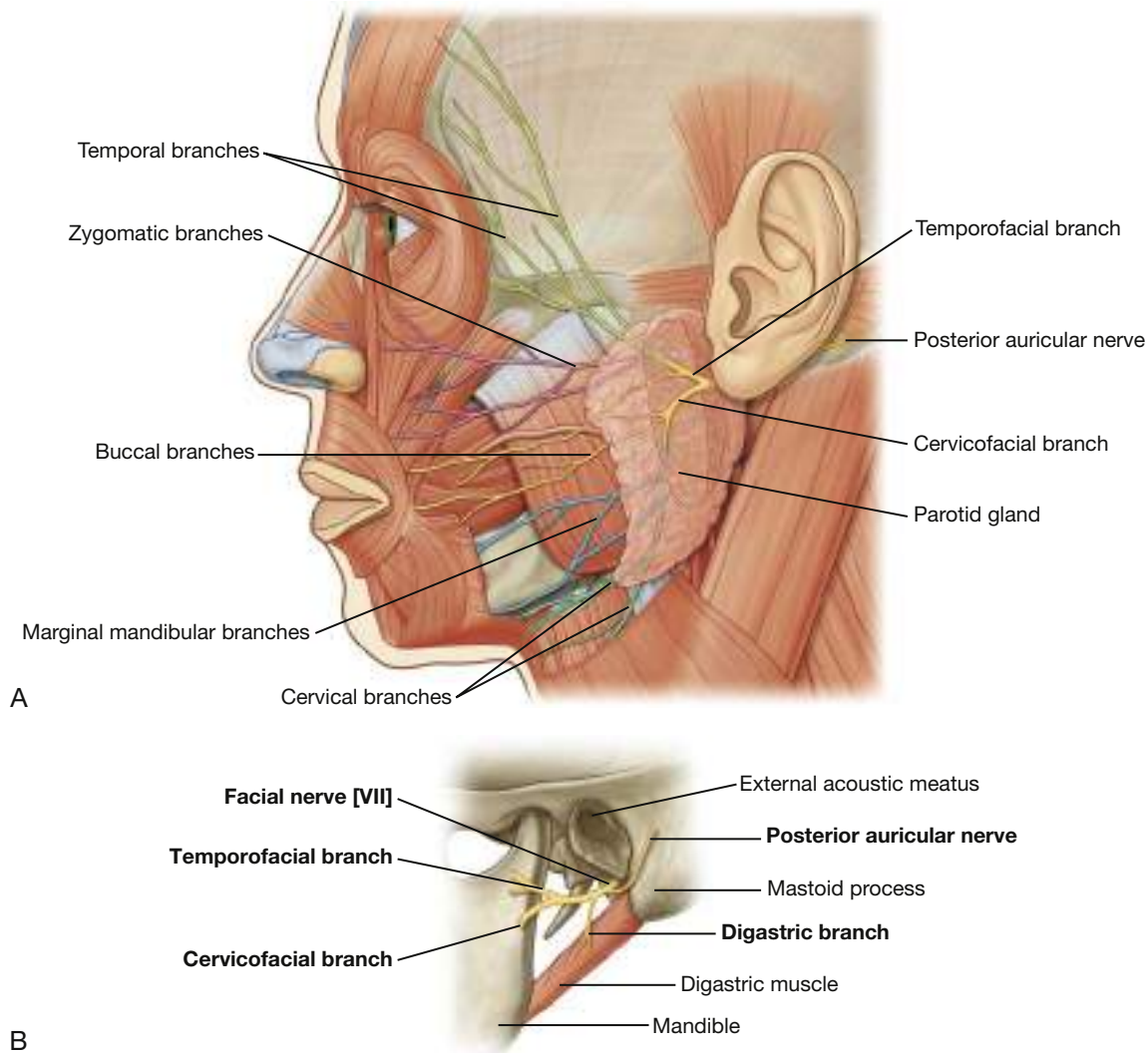


Fig. 8.47 Facial nerve [VII] on the face. **A.** Terminal branches. **B.** Branches before entering the parotid gland.

the mandible after passing posterior to the submandibular gland. Curving around the inferior border of the mandible just anterior to the masseter where its pulse can be felt, the facial artery then enters the face (Fig. 8.48B). From this point, the facial artery runs upward and medially in a tortuous course. It passes along the side of the nose and terminates as the **angular artery** at the medial corner of the eye.

Along its path the facial artery is deep to the platysma, risorius, and zygomaticus major and minor, superficial to the buccinator and levator anguli oris, and may pass superficially to or through the levator labii superioris.

Branches of the facial artery include the superior and inferior labial branches and the lateral nasal branch (Fig. 8.48B).

The labial branches arise near the corner of the mouth:

- The **inferior labial branch** supplies the lower lip.
- The **superior labial branch** supplies the upper lip and provides a branch to the nasal septum.

Near the midline, the superior and inferior labial branches anastomose with their companion arteries from the opposite side of the face. This provides an important connection between the facial arteries and the external carotid arteries of opposite sides.

The **lateral nasal branch** is a small branch arising from the facial artery as it passes along the side of the nose. It supplies the lateral surface and dorsum of the nose.

Transverse facial artery

Another contributor to the vascular supply of the face is the transverse facial artery (Fig. 8.48A,B), which is a branch of the superficial temporal artery (the smaller of the two terminal branches of the external carotid artery).

The transverse facial artery arises from the superficial temporal artery within the substance of the parotid gland, passes through the gland, and crosses the face in a transverse direction. Lying on the superficial surface of the

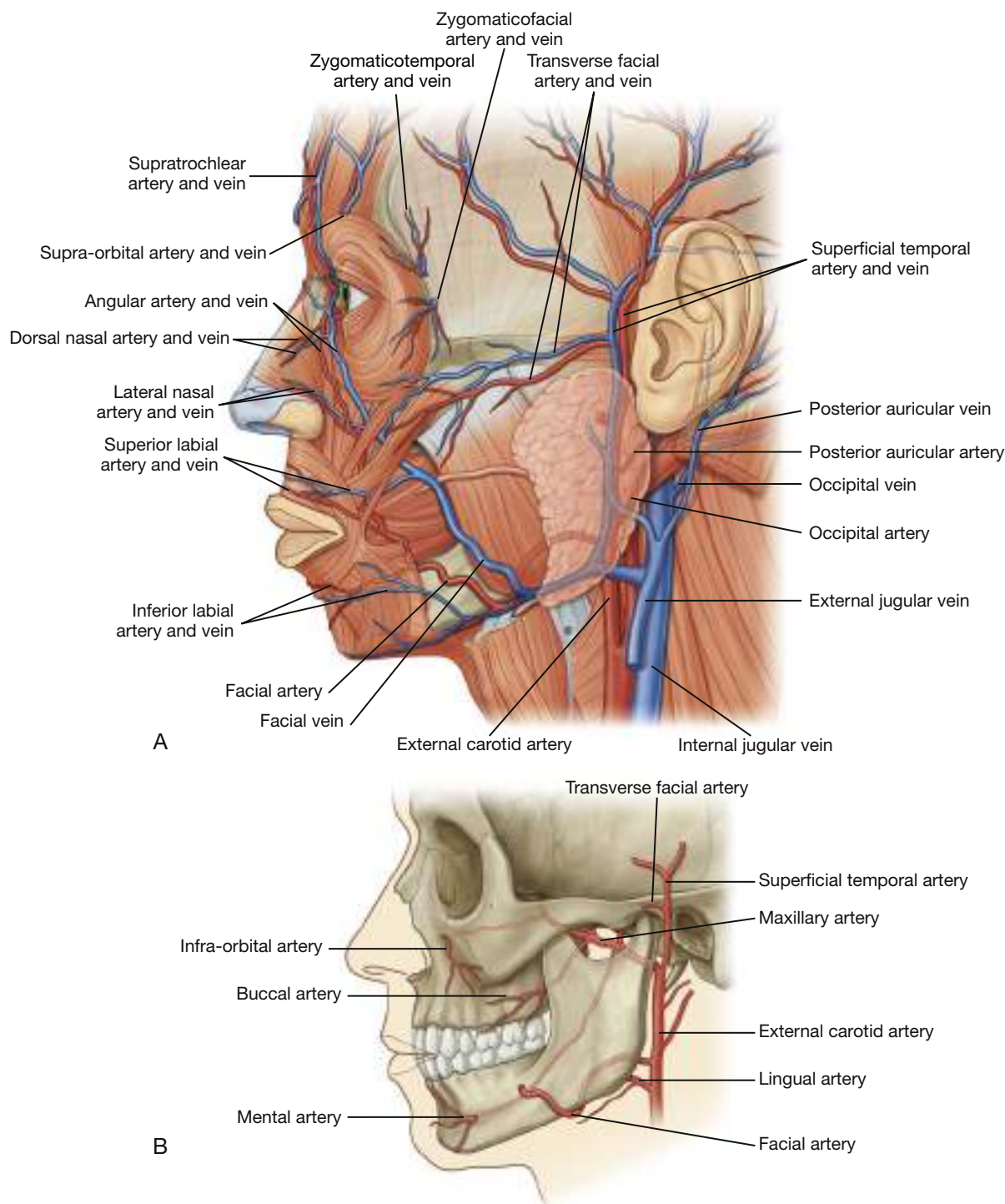


Fig. 8.48 Vasculature of the face. **A.** Lateral view. **B.** Branches of the maxillary artery.

masseter muscle, it is between the zygomatic arch and the parotid duct.

Branches of the maxillary artery

The maxillary artery, the larger of the two terminal branches of the external carotid artery, gives off several small branches that contribute to the arterial supply to the face (Fig. 8.48):

- The **infra-orbital artery** enters the face through the infra-orbital foramen and supplies the lower eyelid, upper lip, and the area between these structures.
- The **buccal artery** enters the face on the superficial surface of the buccinator muscle and supplies structures in this area.
- The **mental artery** enters the face through the mental foramen and supplies the chin.

Branches of the ophthalmic artery

Three small arteries from the internal carotid artery also contribute to the arterial supply of the face. These vessels arise from the **ophthalmic artery**, a branch of the internal carotid artery, after the ophthalmic artery enters the orbit:

- The **zygomaticofacial** and **zygomaticotemporal arteries** come from the lacrimal branch of the ophthalmic artery (Fig. 8.48A), enter the face through the zygomaticofacial and zygomaticotemporal foramina, and supply the area of the face over the zygomatic bone.
- The **dorsal nasal artery**, a terminal branch of the ophthalmic artery, exits the orbit in the medial corner and supplies the dorsum of the nose (Fig. 8.48A).
- The supra-orbital and supratrochlear arteries supply the anterior scalp.

Veins

Facial vein

The facial vein is the major vein draining the face (Fig. 8.49). Its point of origin is near the medial corner of the orbit as the **supratrochlear** and **supra-orbital veins** come together to form the **angular vein**. This vein becomes the facial vein as it proceeds inferiorly and assumes a position just posterior to the facial artery. The facial vein descends across the

face with the facial artery until it reaches the inferior border of the mandible. Here the artery and vein part company, and the facial vein passes superficial to the submandibular gland to enter the internal jugular vein.

Throughout its course, the facial vein receives tributaries from veins draining the eyelids, external nose, lips, cheek, and chin that accompany the various branches of the facial artery.

Transverse facial vein

The transverse facial vein is a small vein that accompanies the transverse facial artery in its journey across the face (see Fig. 8.48A). It empties into the superficial temporal vein within the substance of the parotid gland.

Intracranial venous connections

As it crosses the face, the facial vein has numerous connections with venous channels passing into deeper regions of the head (see Fig. 8.49):

- Near the medial corner of the orbit, it communicates with ophthalmic veins.
- In the area of the cheek, it communicates with veins passing into the infra-orbital foramen.
- It communicates with veins passing into deeper regions of the face (i.e., the deep facial vein connecting with the pterygoid plexus of veins).

All these venous channels have interconnections with the intracranial cavernous sinus through emissary veins that connect intracranial with extracranial veins. There are no valves in the facial vein or any other venous channels in the head, so blood can move in any direction. Because of the interconnections between the veins, infections of the face, primarily above the mouth (i.e., the “danger area”) should be handled with great care to prevent the dissemination of infectious material in an intracranial direction.

Lymphatic drainage

Lymphatic drainage from the face primarily moves toward three groups of lymph nodes (Fig. 8.50):

- **submental nodes** inferior and posterior to the chin, which drain lymphatics from the medial part of the lower lip and chin bilaterally;
- **submandibular nodes** superficial to the submandibular gland and inferior to the body of the mandible, which drain the lymphatics from the medial corner of the orbit, most of the external nose, medial part of the cheek, the upper lip and the lateral part of the lower lip that follow the course of the facial artery; and

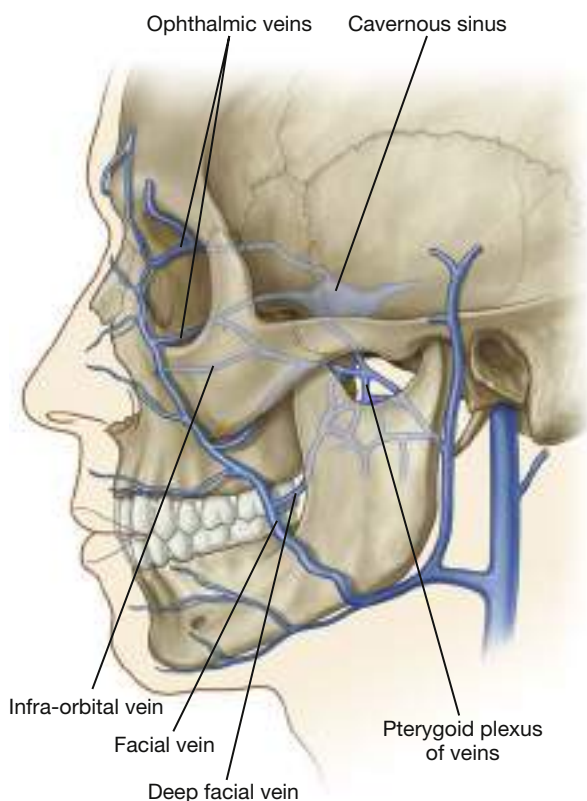


Fig. 8.49 Intracranial venous connections.

- **pre-auricular and parotid** nodes anterior to the ear, which drain lymphatics from most of the eyelids, a part of the external nose, and the lateral part of the cheek.

Clinical app

Facial nerve [VII] palsy (Bell's palsy)

The complexity of the facial nerve [VII] is demonstrated by the different pathological processes and sites at which these processes occur.

Central lesions

A primary brainstem lesion affecting the motor nucleus of the facial nerve (VII) would lead to ipsilateral (same side) weakness of the whole face. However, because the upper part of the nucleus receives motor input from the left and right cerebral hemispheres, a lesion occurring above the nucleus leads to contralateral lower facial weakness. In this example, motor innervation to the upper face is spared because the upper part of the nucleus receives input from both hemispheres. Preservation and loss of the special functions are determined by the extent of the lesion.

Lesions at and around the geniculate ganglion

Typically lesions at and around the geniculate ganglion are accompanied by loss of motor function on the whole of the ipsilateral (same) side of the face. Taste to the anterior two-thirds of the tongue, lacrimation, and some salivation also are likely to be affected because the lesion is proximal to the greater petrosal and chorda tympani branches of the nerve.

Lesions at and around the stylomastoid foramen

Lesions at and around the stylomastoid foramen are the commonest abnormality of the facial nerve [VII] and usually result from a viral inflammation of the nerve within the bony canal before exiting through the stylomastoid foramen. Typically the patient has an ipsilateral loss of motor function that produces an unusual appearance: one side of the face looks normal and the affected side sags and lacks tone. Lacrimation and taste may not be affected if the lesion remains distal to the greater petrosal and chorda tympani branches that originate deep in the temporal bone.

SCALP

The scalp is the part of the head that extends from the superciliary arches anteriorly to the external occipital protuberance and superior nuchal lines posteriorly. Laterally it continues inferiorly to the zygomatic arch.

The scalp is a multilayered structure with layers that can be defined by the word itself (Fig. 8.52):

- S—skin,
- C—connective tissue (dense),

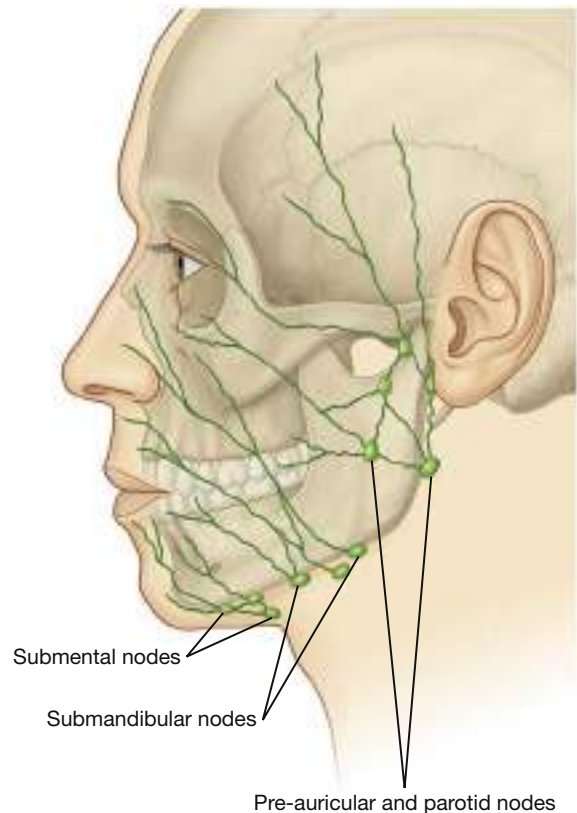


Fig. 8.50 Lymphatic drainage of the face.

- A—aponeurotic layer,
- L—loose connective tissue, and
- P—pericranium.

Layers

Examining the layers of the scalp reveals that the first three layers are tightly held together, forming a single unit. This unit is sometimes referred to as the *scalp proper* and is the tissue torn away during serious “scalping” injuries.

Skin

The skin is the outer layer of the scalp (Figs. 8.52 and 8.53). It is similar structurally to skin throughout the body with the exception that hair is present on a large amount of it.

Connective tissue (dense)

Deep to the skin is dense connective tissue (Figs. 8.52, 8.53). This layer anchors the skin to the third layer and contains the arteries, veins, and nerves supplying the scalp.

Aponeurotic layer

The deepest layer of the first three layers is the aponeurotic layer (Fig. 8.53; also see Fig. 8.52). Firmly attached to the skin by the dense connective tissue of the second layer,

Surface anatomy

Major features of the face

The major features of the face are those related to the anterior openings of the orbit, the nasal cavities, and the oral cavity (Fig. 8.51).

The palpebral fissures are between the upper and lower eyelids and can be opened and closed. The oral fissure is the gap between the upper and lower lips and can also be opened and closed.

The sphincter muscles of the oral and palpebral fissures are the orbicularis oris and orbicularis oculi muscles, respectively. These muscles are innervated by the facial nerve [VII].

The nares are the anterior apertures of the nasal cavities and are continuously open.

The vertical groove in the midline between the external nose and the upper lip is the philtrum.

Sensory innervation of the face is carried by the trigeminal nerve [V]. The three divisions of this nerve are represented on the face and can be tested by touching the forehead (the ophthalmic nerve [V₁]), the anterior cheek (the maxillary nerve [V₂]), and skin over the anterior body of the mandible (the mandibular nerve [V₃]).

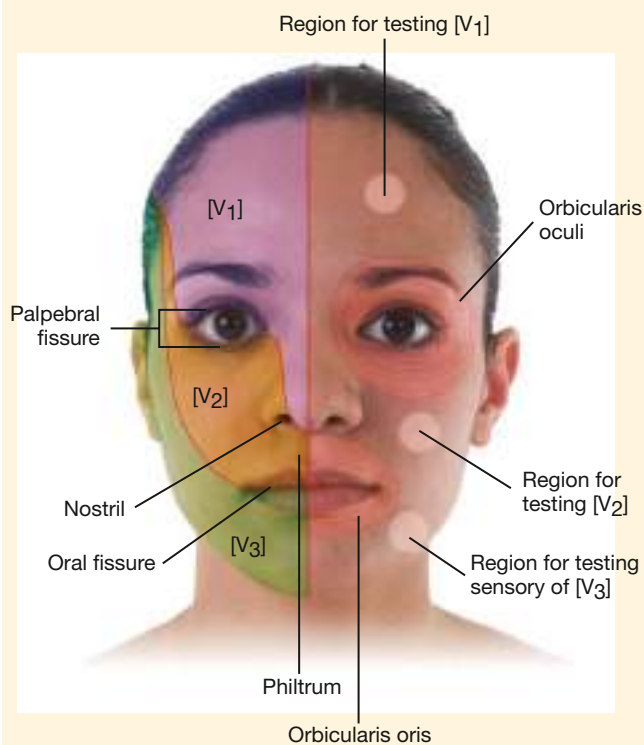


Fig. 8.51 Major features of the face. Anterior head and neck of a woman.

this layer consists of the occipitofrontalis muscle, which has a frontal belly anteriorly, an occipital belly posteriorly, and an aponeurotic tendon—the **epicranial aponeurosis (galea aponeurotica)**—connecting the two (Fig. 8.54).

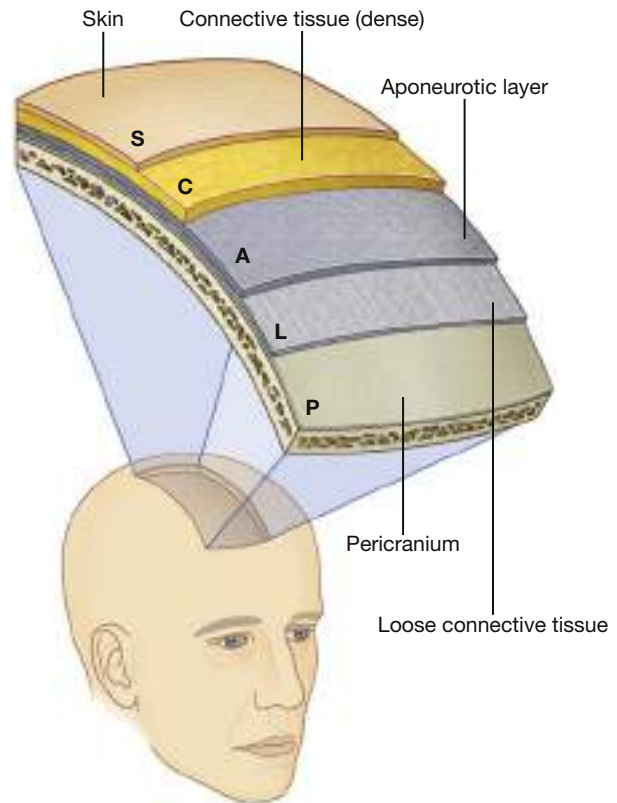


Fig. 8.52 SCALP.

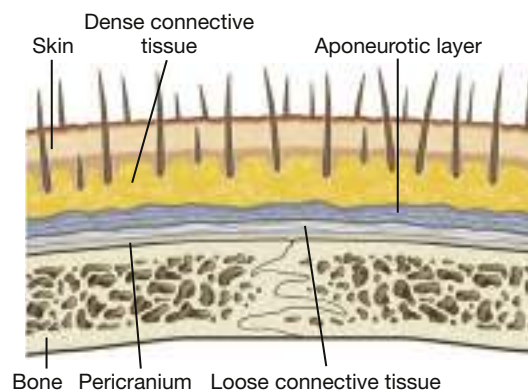


Fig. 8.53 Layers of the scalp.

The frontal belly of occipitofrontalis begins anteriorly where it is attached to the skin of the eyebrows. It passes upward, across the forehead, to become continuous with the aponeurotic tendon (Fig. 8.54A).

Posteriorly, each occipital belly of occipitofrontalis arises from the lateral part of the superior nuchal line of the occipital bone and the mastoid process of the temporal bone (Fig. 8.54B). It also passes superiorly to attach to the aponeurotic tendon.

The occipitofrontalis muscles move the scalp, wrinkle the forehead, and raise the eyebrows. The frontal belly is

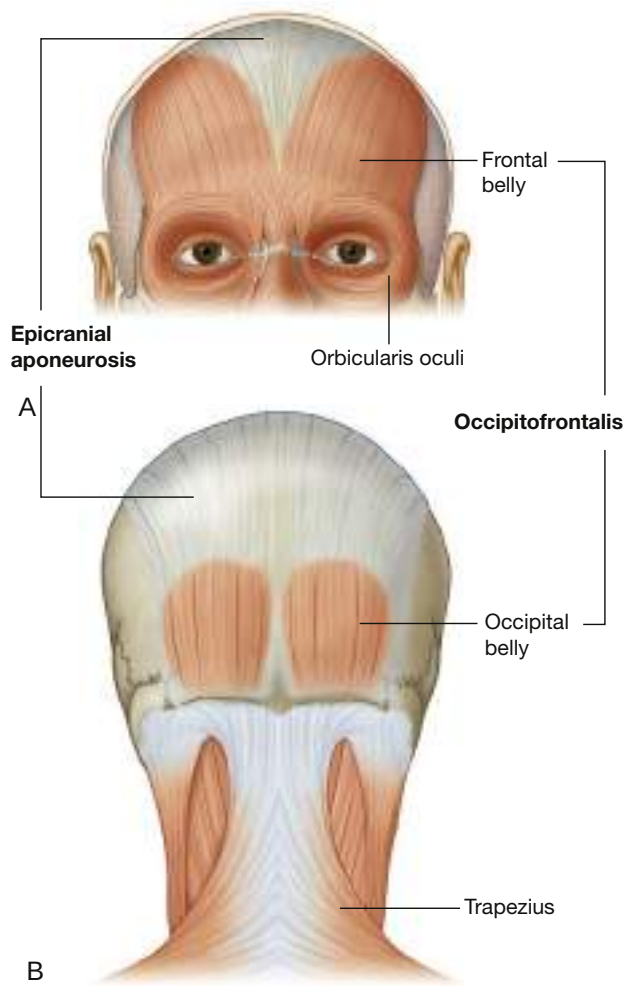


Fig. 8.54 Occipitofrontalis muscle. **A.** Frontal belly. **B.** Occipital belly.

innervated by temporal branches of the facial nerve [VII] and the posterior belly by the posterior auricular branch.

Loose connective tissue

A layer of loose connective tissue separates the aponeurotic layer from the pericranium and facilitates movement of the scalp proper over the calvaria (Fig. 8.53; also see Fig. 8.52). Because of its consistency, infections tend to localize and spread through the loose connective tissue.

Pericranium

The pericranium is the deepest layer of the scalp and is the periosteum on the outer surface of the calvaria (Fig. 8.53; also see Fig. 8.52). It is attached to the bones of the calvaria but is removable, except in the area of the sutures.

Innervation

Sensory innervation of the scalp is from two major sources, cranial nerves or cervical nerves, depending on whether it is

anterior or posterior to the ears and the vertex of the head (Fig. 8.55). The occipitofrontalis muscle is innervated by branches of the facial nerve [VII].

Anterior to the ears and the vertex

Branches of the trigeminal nerve [V] supply the scalp anterior to the ears and the vertex of the head (Fig. 8.55). These branches are the supratrochlear, supra-orbital, zygomaticotemporal, and auriculotemporal nerves:

- The **supratrochlear nerve** exits the orbit, passes through the frontalis muscle, continues superiorly across the front of the forehead, and supplies the front of the forehead near the midline.
- The **supra-orbital nerve** exits the orbit through the supra-orbital notch or foramen, passes through the frontalis muscle, and continues superiorly across the scalp as far back as the vertex of the head.
- The **zygomaticotemporal nerve** exits the skull through a foramen in the zygomatic bone and supplies the scalp over a small anterior area of the temple.
- The **auriculotemporal nerve** exits from the skull deep to the parotid gland, passes just anterior to the ear, continues superiorly anterior to the ear until nearly reaching the vertex of the head, and supplies the scalp over the temporal region and anterior to the ear to near the vertex.

Posterior to the ears and the vertex

Posterior to the ears and vertex, sensory innervation of the scalp is by cervical nerves, specifically branches from spinal cord levels C2 and C3 (Fig. 8.55). These branches are the great auricular, the lesser occipital, the greater occipital, and the third occipital nerves:

- The **great auricular nerve** is a branch of the cervical plexus, arises from the anterior rami of the C2 and C3 spinal nerves, ascends on the surface of the sternocleidomastoid muscle, and innervates a small area of the scalp just posterior to the ear.
- The **lesser occipital nerve** is also a branch of the cervical plexus, arises from the anterior ramus of the C2 spinal nerve, ascends on the posterior border of the sternocleidomastoid muscle, and supplies an area of the scalp posterior and superior to the ear.
- The **greater occipital nerve** is a branch of the posterior ramus of the C2 spinal nerve, emerges just inferior to the obliquus capitis inferior muscle, ascends superficial to the suboccipital triangle, pierces the semispinalis capitis and trapezius muscles, and then spreads out to supply a large part of the posterior scalp as far superiorly as the vertex.
- The **third occipital nerve** is a branch of the posterior ramus of the C3 spinal nerve, pierces the semispinalis capitis and trapezius muscles, and supplies a small area of the lower part of the scalp.

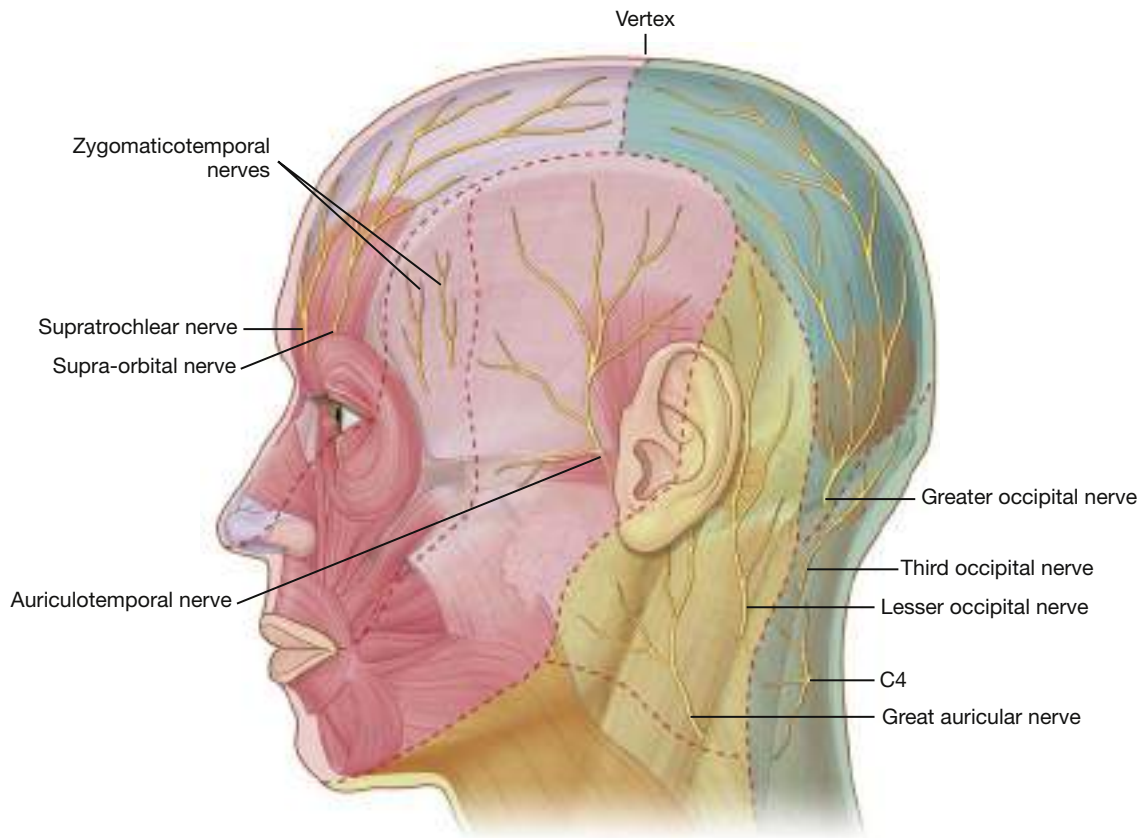


Fig. 8.55 Innervation of the scalp.

Vessels

Arteries

Arteries supplying the scalp (Fig. 8.56) are branches of either the external carotid artery or the ophthalmic artery, which is a branch of the internal carotid artery.

Branches from the ophthalmic artery

The supratrochlear and supra-orbital arteries supply the anterior and superior aspects of the scalp (Fig. 8.56). They branch from the ophthalmic artery while it is in the orbit, continue through the orbit, and exit onto the forehead in association with the supratrochlear and supra-orbital nerves. Like the nerves, the arteries ascend across the forehead to supply the scalp as far posteriorly as the vertex of the head.

Branches from the external carotid artery

Three branches of the external carotid artery supply the largest part of the scalp—the posterior auricular, occipital, and superficial temporal arteries supply the lateral and posterior aspects of the scalp (Fig. 8.56):

- The smallest branch (the **posterior auricular artery**) leaves the posterior aspect of the external carotid artery, passes through deeper structures, and emerges to supply an area of the scalp posterior to the ear.

- Also arising from the posterior aspect of the external carotid artery is the **occipital artery**, which ascends in a posterior direction, passes through several layers of back musculature, and emerges to supply a large part of the posterior aspect of the scalp.
- The third arterial branch supplying the scalp is the **superficial temporal artery**, a terminal branch of the external carotid artery that passes superiorly just anterior to the ear, divides into anterior and posterior branches, and supplies almost the entire lateral aspect of the scalp.

Veins

Veins draining the scalp follow a pattern similar to the arteries (Fig. 8.56):

- The **supratrochlear** and **supra-orbital veins** drain the anterior part of the scalp from the superciliary arches to the vertex of the head, pass inferior to the superciliary arches, communicate with the ophthalmic veins in the orbit, and continue inferiorly to participate in the formation of the angular vein, which is the upper tributary to the facial vein.
- The **superficial temporal vein** drains the entire lateral area of the scalp before passing inferiorly to join in the formation of the retromandibular vein.

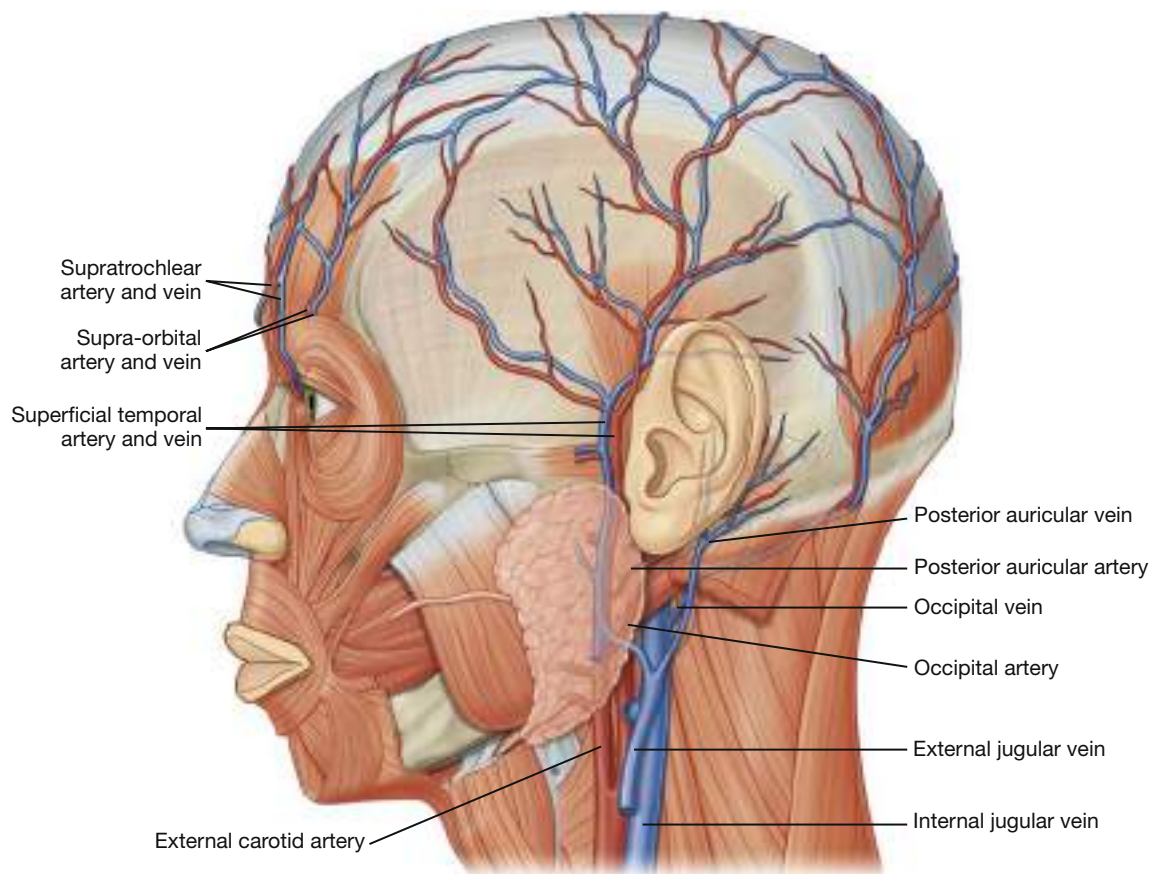


Fig. 8.56 Vasculature of the scalp.

- The **posterior auricular vein** drains the area of the scalp posterior to the ear and eventually empties into a tributary of the retromandibular vein.
- The **occipital vein** drains the posterior aspect of the scalp from the external occipital protuberance and superior nuchal lines to the vertex of the head; deeper, it passes through the musculature in the posterior neck to join in the formation of the plexus of veins in the suboccipital triangle.

Clinical app

Scalp laceration

The scalp has an extremely rich blood supply from the external carotid arteries, so lacerations of the scalp tend to bleed profusely. Importantly, scalp bleeding is predominantly arterial because of two reasons. First, in the erect position the venous pressure is extremely low. Second, the vessels do not retract when lacerated because the dense connective tissue layer in which they are found prevents retraction.

Lymphatic drainage

Lymphatic drainage of the scalp generally follows the pattern of arterial distribution.

The lymphatics in the occipital region initially drain to occipital nodes near the attachment of the trapezius muscle at the base of the skull (Fig. 8.57). Further along the pathway occipital nodes drain into upper deep cervical nodes. There is also some direct drainage to upper deep cervical nodes from this part of the scalp.

Lymphatics from the upper part of the scalp drain in two directions:

- Posterior to the vertex of the head, they drain to **mastoid nodes** (retro-auricular/posterior auricular nodes) posterior to the ear near the mastoid process of the temporal bone, and efferent vessels from these nodes drain into upper deep cervical nodes.
- Anterior to the vertex of the head they drain to **pre-auricular** and **parotid nodes** anterior to the ear on the surface of the parotid gland.

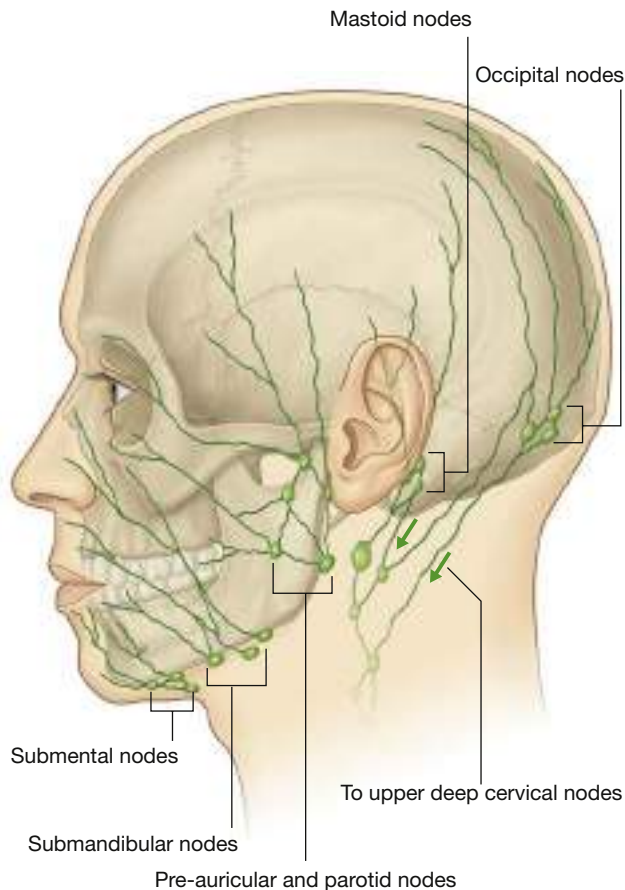


Fig. 8.57 Lymphatic drainage of the scalp.

Finally, there may be some lymphatic drainage from the forehead to the submandibular nodes through efferent vessels that follow the facial artery.

ORBIT

The orbits are bilateral structures in the upper half of the face below the anterior cranial fossa and anterior to the middle cranial fossa that contain the eyeball, the optic nerve, the extra-ocular muscles, the lacrimal apparatus, adipose tissue, fascia, and the nerves and vessels that supply these structures.

Bony orbit

Seven bones contribute to the framework of each orbit (Fig. 8.58). They are the maxilla, zygomatic, frontal, ethmoid, lacrimal, sphenoid, and palatine bones. Together they give the bony orbit the shape of a pyramid, with its wide base opening anteriorly onto the face, and its apex extending in a posteromedial direction. Completing the pyramid configuration are medial, lateral, superior, and inferior walls.

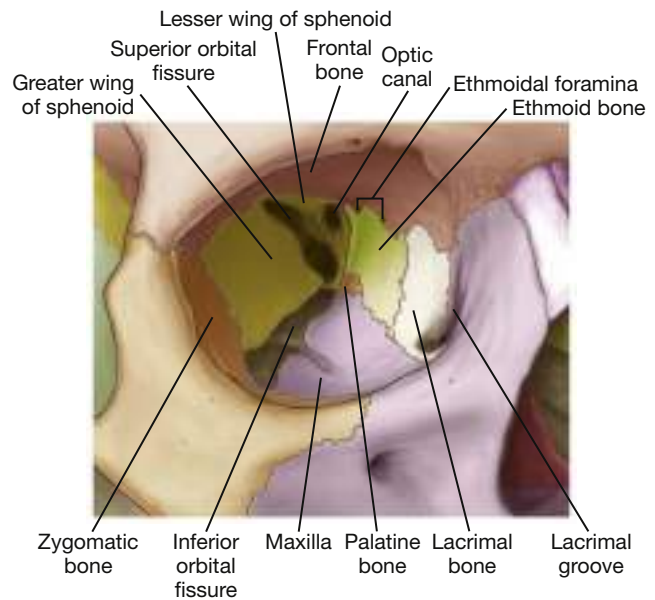


Fig. 8.58 Bones of the orbit.

The apex of the pyramid-shaped bony orbit is the optic canal, whereas the base (the orbital rim) is formed (Fig. 8.58):

- superiorly by the frontal bone,
- medially by the frontal process of the maxilla,
- inferiorly by the zygomatic process of the maxilla and the zygomatic bone, and
- laterally by the zygomatic bone, the frontal process of the zygomatic bone, and the zygomatic process of the frontal bone.

Roof

The **roof (superior wall)** of the bony orbit is made up of the orbital part of the frontal bone with a small contribution from the sphenoid bone (Fig. 8.58). This thin plate of bone separates the contents of the orbit from the brain in the anterior cranial fossa.

Unique features of the roof include:

- anteromedially, the **trochlear fovea** for the attachment of a pulley through which the superior oblique muscle passes and the possible intrusion of part of the frontal sinus; and
- anterolaterally, a depression (the **lacrimal fossa**) for the orbital part of the lacrimal gland.

Posteriorly, the lesser wing of the sphenoid bone completes the roof.

Medial wall

The **medial walls** of the paired bony orbits are parallel to each other, and each consists of four bones—the maxilla, lacrimal, ethmoid, and sphenoid bones (Fig. 8.58).

The largest contributor to the medial wall is the orbital plate of the ethmoid bone. This part of the ethmoid bone contains collections of ethmoidal cells, which are clearly visible in a dried skull.

Also visible at the junction between the roof and the medial wall, usually associated with the fronto-ethmoidal suture, are the **anterior** and **posterior ethmoidal foramina**. The anterior and posterior ethmoidal nerves and vessels leave the orbit through these openings.

Anterior to the ethmoid bone is the small lacrimal bone, and completing the anterior part of the medial wall is the frontal process of the maxilla. These two bones participate in the formation of the **lacrimal groove**, which contains the lacrimal sac and is bound by the **posterior lacrimal crest** (part of the lacrimal bone) and the **anterior lacrimal crest** (part of the maxilla).

Posterior to the ethmoid bone the medial wall is completed by a small part of the sphenoid bone, which forms a part of the medial wall of the optic canal.

Floor

The **floor (inferior wall)** of the bony orbit, which is also the roof of the maxillary sinus, consists primarily of the orbital surface of the maxilla (see Fig. 8.58), with small contributions from the zygomatic and palatine bones.

Beginning posteriorly and continuing along the lateral boundary of the floor of the bony orbit is the inferior orbital fissure. Beyond the anterior end of the fissure, the zygomatic bone completes the floor of the bony orbit.

Posteriorly, the orbital process of the palatine bone makes a small contribution to the floor of the bony orbit near the junction of the maxilla, ethmoid, and sphenoid bones.

Lateral wall

The **lateral wall** of the bony orbit consists of contributions from two bones—anteriorly the zygomatic bone and posteriorly the greater wing of the sphenoid bone (see Fig. 8.58).

Clinical app

Orbital fracture

Fractures of the orbit are not uncommon and may involve the orbital margins with extension into the maxilla, frontal, and zygomatic bones. These fractures are often part of complex facial fractures. Fractures within the orbit frequently occur within the floor and the medial wall; however, superior and lateral wall fractures also occur. Inferior orbital floor fractures are one of the commonest types of injuries. These fractures may drag the inferior oblique muscle and associated tissues into the fracture line. In these instances, patients may have upward gaze failure (upward gaze diplopia) in the affected eye.

Clinical app—cont'd

Medial wall fractures characteristically show air within the orbit in radiographs. This is due to fracture of the ethmoidal labyrinth permitting direct continuity between the orbit and the ethmoidal paranasal sinuses. Occasionally, patients feel a “full” sensation within the orbit when blowing their nose.

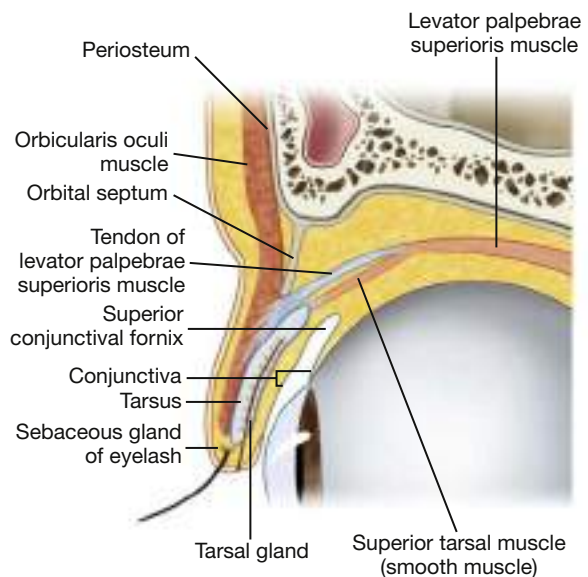


Fig. 8.59 Eyelids.

Eyelids

The upper and lower eyelids are anterior structures that, when closed, protect the surface of the eyeball.

The space between the eyelids, when they are open, is the **palpebral fissure**.

The layers of the eyelids, from anterior to posterior, consist of skin, subcutaneous tissue, voluntary muscle, the orbital septum, the tarsus, and conjunctiva (Fig. 8.59).

The upper and lower eyelids are basically similar in structure except for the addition of two muscles (levator palpebrae superioris and superior tarsal) in the upper eyelid.

Skin and subcutaneous tissue

The skin of the eyelids is not particularly substantial and only a thin layer of connective tissue separates the skin from the underlying voluntary muscle layer (Fig. 8.59).

Orbicularis oculi

The muscle fibers encountered next in an anteroposterior direction through the eyelid belong to the **palpebral part of orbicularis oculi** (Fig. 8.59). This muscle is part of the larger orbicularis oculi muscle, which consists primarily of two

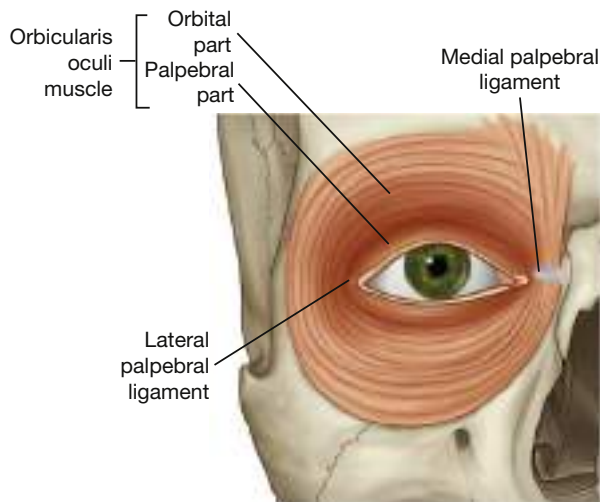


Fig. 8.60 Orbicularis oculi muscle.

parts—an **orbital part**, which surrounds the orbit, and the **palpebral part**, which is in the eyelids (Fig. 8.60). Orbicularis oculi is innervated by the facial nerve [VII] and closes the eyelids.

The palpebral part is thin and anchored medially by the **medial palpebral ligament**, which attaches to the anterior lacrimal crest, and laterally blends with fibers from the muscle in the lower eyelid at the **lateral palpebral ligament**.

Orbital septum

Deep to the palpebral part of the orbicularis oculi is an extension of periosteum into both the upper and lower eyelids from the margin of the orbit (Fig. 8.61). This is the **orbital septum**, which extends downward into the upper eyelid and upward into the lower eyelid and is continuous with the periosteum outside and inside the orbit (Fig. 8.61). The orbital septum attaches to the tendon of levator palpebrae superioris muscle in the upper eyelid and attaches to the tarsus in the lower eyelid.

Tarsus and levator palpebrae superioris

Providing major support for each eyelid is the tarsus (Fig. 8.62). There is a large **superior tarsus** in the upper eyelid and a smaller **inferior tarsus** in the lower eyelid. These plates of dense connective tissue are attached medially to the anterior lacrimal crest of the maxilla by the medial palpebral ligament and laterally to the orbital tubercle on the zygomatic bone by the lateral palpebral ligament.

Although the tarsal plates in the upper and lower eyelids are generally similar in structure and function, there is one unique difference. Associated with the tarsus in the upper eyelid is the **levator palpebrae superioris** muscle (Fig. 8.62; also see Table 8.8, pg. 511), which raises the eyelid. In companion with the levator palpebrae superioris muscle is a collection of smooth muscle fibers passing from the inferior

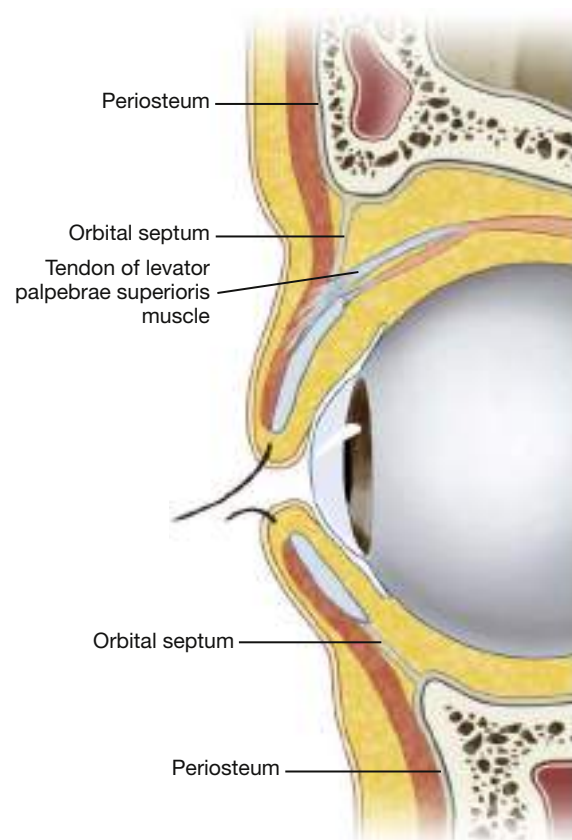


Fig. 8.61 Orbital septum.

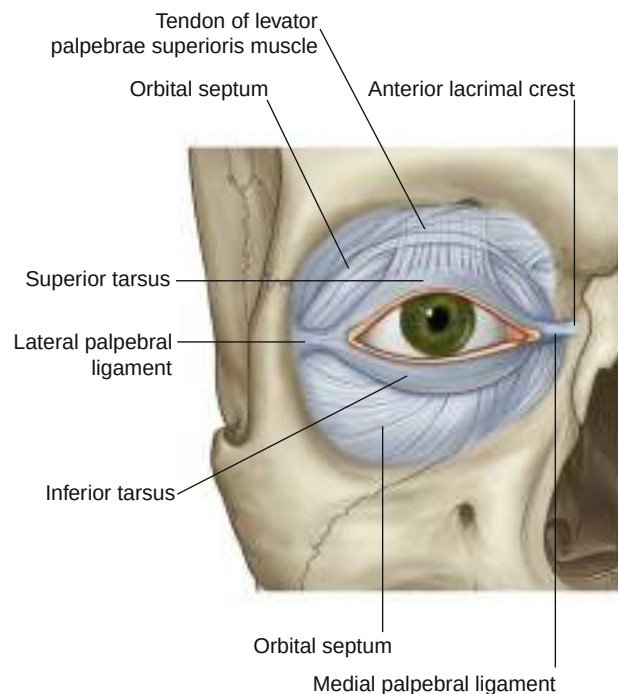


Fig. 8.62 Tarsal plates.

surface of the levator to the upper edge of the superior tarsus (Fig. 8.59). Innervated by postganglionic sympathetic fibers from the superior cervical ganglion, this muscle is the **superior tarsal muscle**.

Conjunctiva

The structure of the eyelid is completed by a thin membrane (the **conjunctiva**), which covers the posterior surface of each eyelid (Fig. 8.59) and then reflects onto the outer surface (**sclera**) of the eyeball. It extends on the eyeball to the junction between the sclera and the cornea. With this membrane in place, a **conjunctival sac** is formed when the eyelids are closed, and the upper and lower extensions of this sac are the **superior** and **inferior conjunctival fornices** (Fig. 8.59).

Glands

Embedded in the tarsal plates are tarsal glands, which empty onto the free margin of each eyelid (Fig. 8.59). These glands are modified sebaceous glands and secrete an oily substance that increases the viscosity of the tears and decreases the rate of evaporation of tears from the surface of the eyeball. Blockage and inflammation of a tarsal gland is a **chalazion** and is on the inner surface of the eyelid.

The tarsal glands are not the only glands associated with the eyelids (see Fig. 8.59). Associated with the eyelash follicles are sebaceous and sweat glands. Blockage and inflammation of either of these is a **stye** and is on the edge of the eyelid.

Vessels

The arterial supply to the eyelids is from the numerous vessels in the area. They include (Fig. 8.63):

- the supratrochlear, supra-orbital, lacrimal, and dorsal nasal arteries from the ophthalmic artery,
- the angular artery from the facial artery,
- the transverse facial artery from the superficial temporal artery, and
- branches from the superficial temporal artery itself.

Venous drainage follows an external pattern through veins associated with the various arteries and an internal pattern moving into the orbit through connections with the ophthalmic veins.

Lymphatic drainage is primarily to the parotid nodes, with some drainage from the medial corner of the eye along lymphatic vessels associated with the angular and facial arteries to the submandibular nodes.

Innervation

Innervation of the eyelids includes both sensory and motor components.

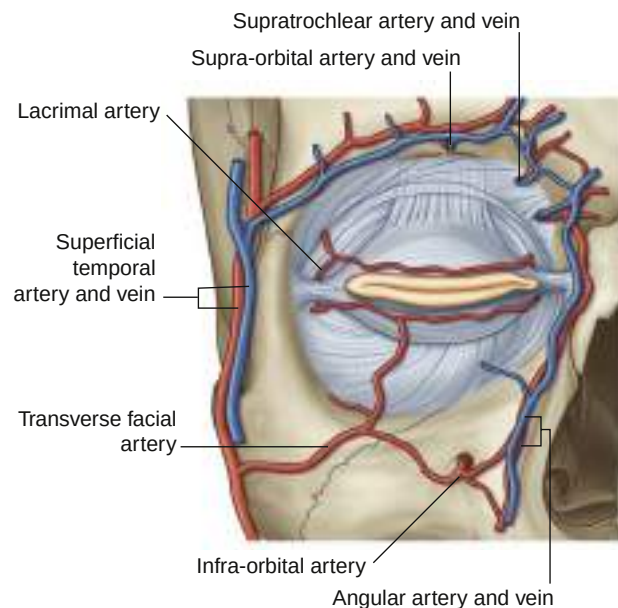


Fig. 8.63 Vasculature of the eyelids.

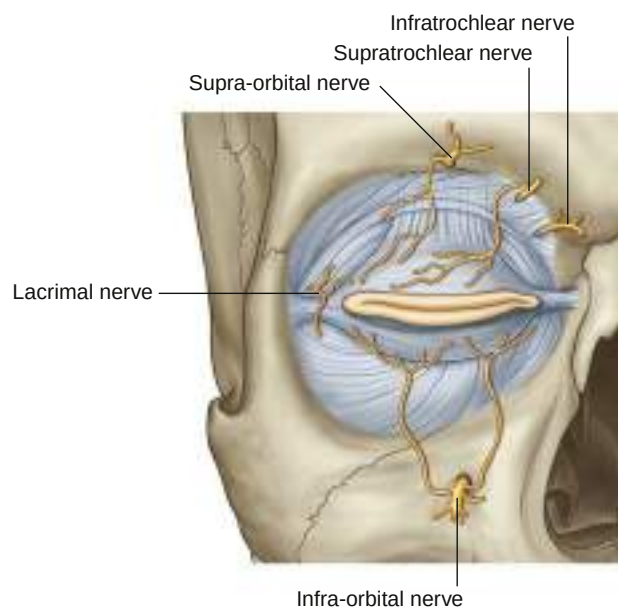


Fig. 8.64 Innervation of the eyelids.

The sensory nerves are all branches of the trigeminal nerve [V]. Palpebral branches arise from (Fig. 8.64):

- the supra-orbital, supratrochlear, infratrochlear, and lacrimal branches of the ophthalmic nerve [V₁], and
- the infra-orbital branch of the maxillary nerve [V₂].

Motor innervation is from:

- the facial nerve [VII], which innervates the palpebral part of the orbicularis oculi;

- the oculomotor nerve [III], which innervates the levator palpebrae superioris; and
- sympathetic fibers, which innervate the superior tarsal muscle.

Clinical app

Full and partial ptosis

Loss of innervation of the orbicularis oculi by the facial nerve [VII] causes an inability to close the eyelids tightly and the lower eyelid droops away, resulting in a spillage of tears.

Loss of innervation of the levator palpebrae superioris by the oculomotor nerve causes an inability to open the superior eyelid voluntarily, producing a complete ptosis.

Loss of innervation of the superior tarsal muscle by sympathetic fibers causes a constant partial ptosis.

Clinical app

Horner's syndrome

Horner's syndrome is caused by a lesion in the sympathetic trunk in the neck that results in sympathetic dysfunction. It is characterized by three typical features:

- pupillary constriction due to paralysis of the dilator pupillae muscle;
 - partial ptosis (drooping of the upper eyelid) due to paralysis of the superior tarsal muscle; and
 - absence of sweating on the ipsilateral side of the face and the neck due to absence of innervation of the sweat glands.
- Secondary changes may also include:
- ipsilateral vasodilation due to loss of the normal sympathetic control of the subcutaneous blood vessels; and
 - enophthalmos (sinking of the eye)—believed to result from paralysis of the orbitalis muscle (a smooth muscle that spans the inferior orbital fissure and may contribute to maintaining the normal position of the eyeball), though this is an uncommon feature of Horner's syndrome.

The commonest cause for Horner's syndrome is an apical lung tumor eroding the cervicothoracic ganglion.

Lacrimal apparatus

The lacrimal apparatus is involved in the production, movement, and drainage of fluid from the surface of the eyeball. It is made up of the **lacrimal gland** and its ducts, the **lacrimal canaliculi**, the **lacrimal sac**, and the **nasolacrimal duct**.

The lacrimal gland is anterior in the superolateral region of the orbit (Fig. 8.65) and is divided into two parts by the levator palpebrae superioris (Fig. 8.66):

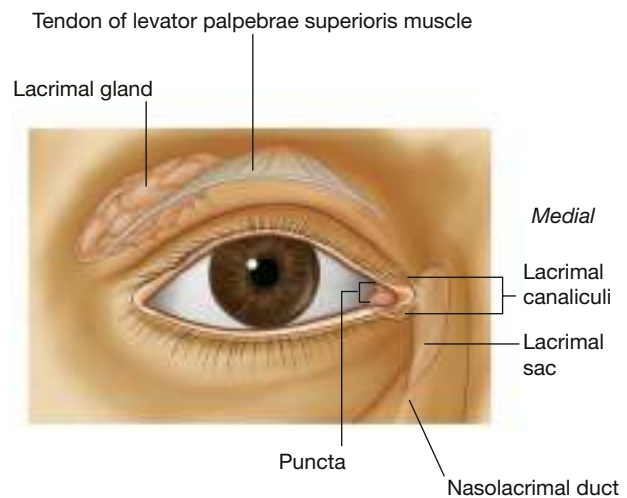


Fig. 8.65 Lacrimal gland, anterior view.

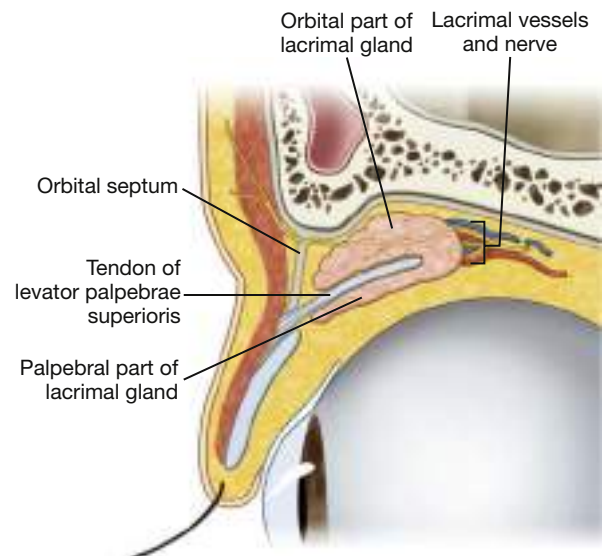


Fig. 8.66 Lacrimal gland and levator palpebrae superioris.

- The larger **orbital part** is in a depression, and the lacrimal fossa is in the frontal bone.
- The smaller **palpebral part** is inferior to levator palpebrae superioris in the superolateral part of the eyelid.

Numerous ducts empty the glandular secretions into the lateral part of the superior fornix of the conjunctiva.

Fluid is continually being secreted by the lacrimal gland and moved across the surface of the eyeball from lateral to medial as the eyelids blink.

The fluid accumulates medially in the **lacrimal lake** and is drained from the lake by the lacrimal canaliculi, one canaliculus is associated with each eyelid (Fig. 8.65). The

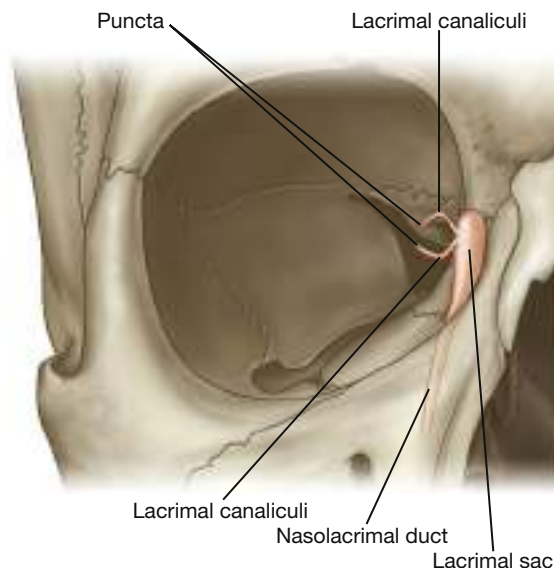


Fig. 8.67 Formation of the lacrimal sac.

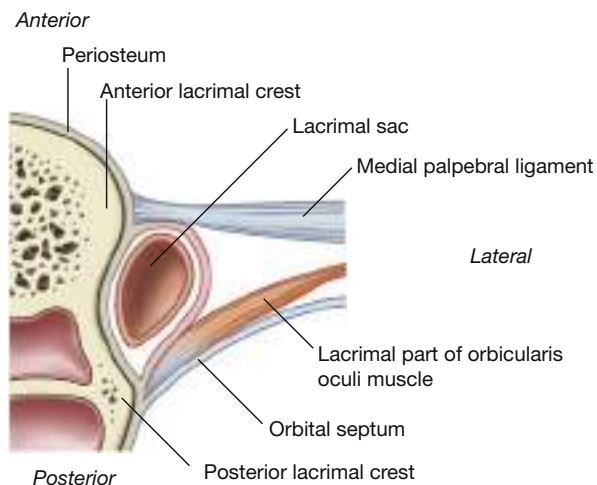


Fig. 8.68 Position of lacrimal sac.

lacrimal punctum is the opening through which fluid enters each canaliculus.

Passing medially, the lacrimal canaliculi eventually join the lacrimal sac between the anterior and posterior lacrimal crests posterior to the medial palpebral ligament and anterior to the lacrimal part of the orbicularis oculi muscle (Figs. 8.67 and 8.68). When the orbicularis oculi muscle contracts during blinking, the small lacrimal part of the muscle may dilate the lacrimal sac and draw tears into it through the canaliculi from the conjunctival sac.

Innervation

The innervation of the lacrimal gland involves three different components (Fig. 8.70).

Sensory innervation

Sensory neurons from the lacrimal gland return to the CNS through the lacrimal branch of the ophthalmic nerve [V₁].

Secretomotor (parasympathetic) innervation

Secretomotor fibers from the parasympathetic part of the autonomic division of the PNS stimulate fluid secretion from the lacrimal gland. These preganglionic parasympathetic neurons leave the CNS in the facial nerve [VII], enter the greater petrosal nerve (a branch of the facial nerve [VII]), and continue with this nerve until it becomes the **nerve of the pterygoid canal** (Fig. 8.70).

Surface anatomy

The eye and lacrimal apparatus

Major features of the eye include the sclera, cornea, iris, and pupil (Fig. 8.69A). The cornea is continuous with the sclera and is the clear circular region of the external covering of the eye through which the pupil and iris are visible. The sclera is not transparent and is normally white.

The upper and lower eyelids of each eye (Fig. 8.69B) enclose between them the palpebral fissure. The eyelids come together at the medial and lateral palpebral commissures on either side of each eye (Fig. 8.69A).

At the medial side of the palpebral fissure and lateral to the medial palpebral commissure is a small triangular area, the lacrimal lake (Fig. 8.69A).

The elevated mound of tissue on the medial side of the lacrimal lake is the lacrimal caruncle, and the lateral margin overlying the sclera is the lacrimal fold (Fig. 8.69B).

The lacrimal apparatus consists of the lacrimal gland and the system of ducts and channels that collect the tears and drain them into the nasal cavity (Fig. 8.69C). Tears hydrate and maintain the transparency of the cornea.

The lacrimal gland is associated with the upper eyelid and is in a small depression in the lateral roof of the orbit just posterior to the orbital margin. The multiple small ducts of the gland open into the upper margin of the conjunctival sac, which is the thin gap between the deep surface of the eyelid and the cornea.

Tears are swept medially over the eye by blinking and are collected in small openings (lacrimal puncta), one on each of the upper and lower eyelids near the lacrimal lake (Fig. 8.69C).

Each punctum is on a small raised mound of tissue (a lacrimal papilla) and is the opening of a small canal (lacrimal canaliculus) that connects with the lacrimal sac (Fig. 8.69C).

The lacrimal sac is in the lacrimal fossa on the medial side of the orbit. From the lacrimal sac, tears drain via the nasolacrimal duct into the nasal cavity (Fig. 8.69C).

Surface anatomy

The eye and lacrimal apparatus—cont'd

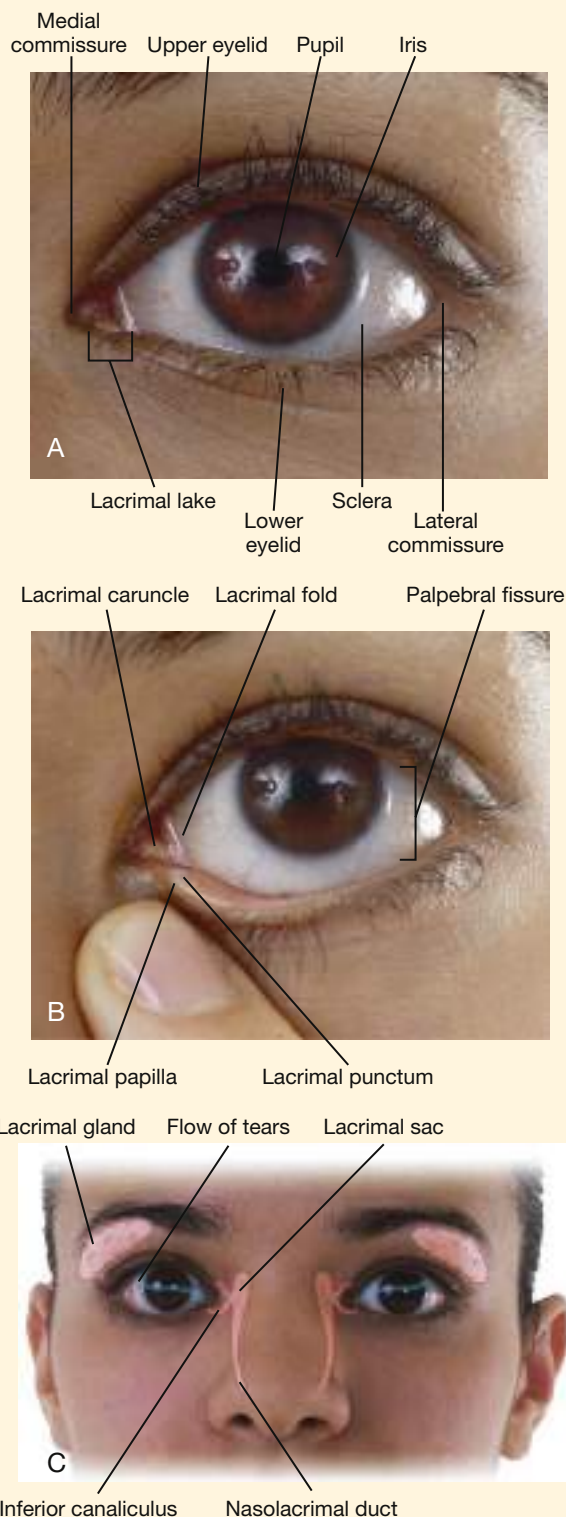


Fig. 8.69 Eye and lacrimal apparatus. **A.** Left eye and surrounding structures. **B.** Left eye with surrounding structures with lower eyelid pulled down to reveal the lacrimal papilla and lacrimal punctum. **C.** Face of a woman. Lacrimal apparatus and the flow of tears are indicated.

The nerve of the pterygoid canal eventually joins the pterygopalatine ganglion where the preganglionic parasympathetic neurons synapse on postganglionic parasympathetic neurons (Fig. 8.70). The postganglionic neurons join the maxillary nerve [V_2] and continue with it until the zygomatic nerve branches from it and travel with the zygomatic nerve until it gives off the zygomaticotemporal nerve, which eventually distributes postganglionic parasympathetic fibers in a small branch that joins the lacrimal nerve. The lacrimal nerve passes to the lacrimal gland.

Sympathetic innervation

Sympathetic innervation of the lacrimal gland follows a similar path as parasympathetic innervation. Postganglionic sympathetic fibers originating in the superior cervical ganglion travel along the plexus surrounding the internal carotid artery (Fig. 8.70). They leave this plexus as the deep petrosal nerve and join the parasympathetic fibers in the nerve of the pterygoid canal. Passing through the pterygopalatine ganglion, the sympathetic fibers from this point onward follow the same path as the parasympathetic fibers to the lacrimal gland.

Vessels

The arterial supply to the lacrimal gland is by branches from the ophthalmic artery, and venous drainage is through the ophthalmic veins.

Fissures and foramina

Numerous structures enter and leave the orbit through a variety of openings (Fig. 8.71).

Optic canal

When the bony orbit is viewed from an anterolateral position, the round opening at the apex of the pyramidal-shaped orbit is the optic canal, which opens into the middle cranial fossa and is bounded medially by the body of the sphenoid and laterally by the lesser wing of the sphenoid. Passing through the optic canal are the optic nerve and the ophthalmic artery (Fig. 8.72).

Superior orbital fissure

Just lateral to the optic canal is a triangular-shaped gap between the roof and lateral wall of the bony orbit. This is the superior orbital fissure and allows structures to pass between the orbit and the middle cranial fossa (see Fig. 8.71).

Passing through the superior orbital fissure are the superior and inferior branches of the oculomotor nerve [III]; the trochlear nerve [IV]; the abducent nerve [VI]; the lacrimal, frontal, and nasociliary branches of the ophthalmic nerve [V_1]; and the superior ophthalmic vein (Fig. 8.72).

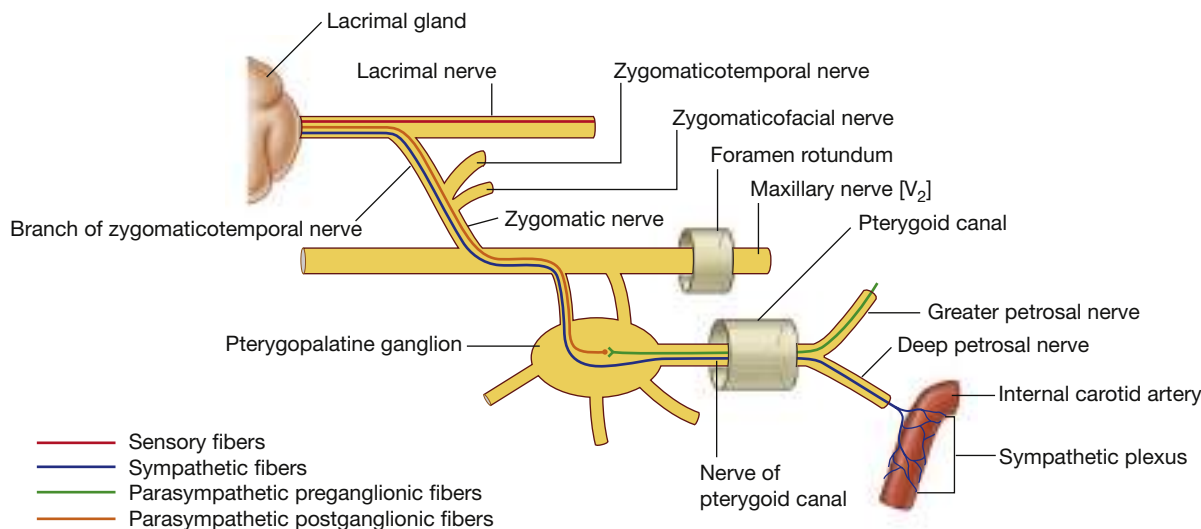


Fig. 8.70 Innervation of the lacrimal gland.

Inferior orbital fissure

Separating the lateral wall of the orbit from the floor of the orbit is a longitudinal opening, the inferior orbital fissure (see Fig. 8.71). Its borders are the greater wing of the sphenoid and the maxilla, palatine, and zygomatic bones. This long fissure allows communication between:

- the orbit and the pterygopalatine fossa posteriorly,
- the orbit and the infratemporal fossa in the middle, and
- the orbit and the temporal fossa posterolaterally.

Passing through the inferior orbital fissure are the maxillary nerve [V₂] and its zygomatic branch, the infra-orbital vessels, and a vein communicating with the pterygoid plexus of veins.

Infra-orbital foramen

Beginning posteriorly and crossing about two-thirds of the inferior orbital fissure, a groove (the **infra-orbital groove**) is encountered that continues anteriorly across the floor of the orbit (see Fig. 8.71). This groove connects with the **infra-orbital canal** that opens onto the face at the **infra-orbital foramen**.

The infra-orbital nerve, a branch of the maxillary nerve [V₂], and vessels pass through this structure as they exit onto the face.

Other openings

Associated with the medial wall of the bony orbit are several smaller openings (see Fig. 8.71).

The **anterior** and **posterior ethmoidal foramina** are at the junction between the superior and medial walls (see

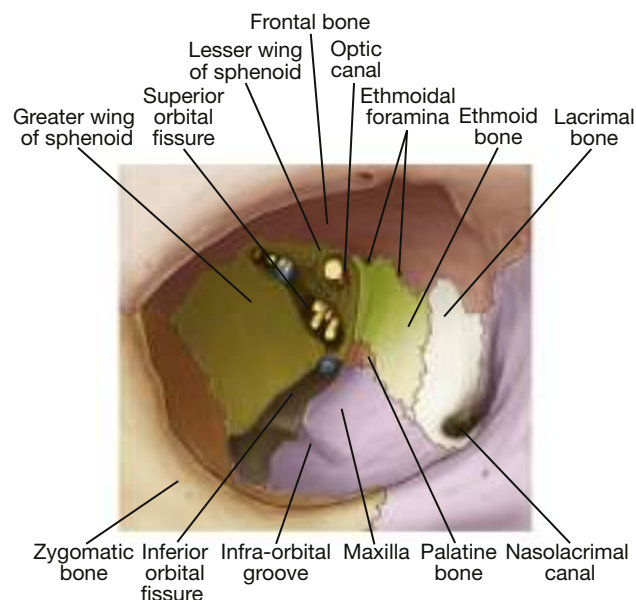


Fig. 8.71 Openings into the bony orbit.

Fig. 8.71). These openings provide exits from the orbit into the ethmoid bone for the anterior and posterior ethmoidal nerves and vessels.

Completing the openings on the medial wall is a canal in the lower part of the wall anteriorly. Clearly visible is the depression for the lacrimal sac formed by the lacrimal bone and the frontal process of the maxilla. This depression is continuous with the nasolacrimal canal (see Fig. 8.71), which leads to the inferior nasal meatus. Contained within the nasolacrimal canal is the nasolacrimal duct, a part of the lacrimal apparatus.

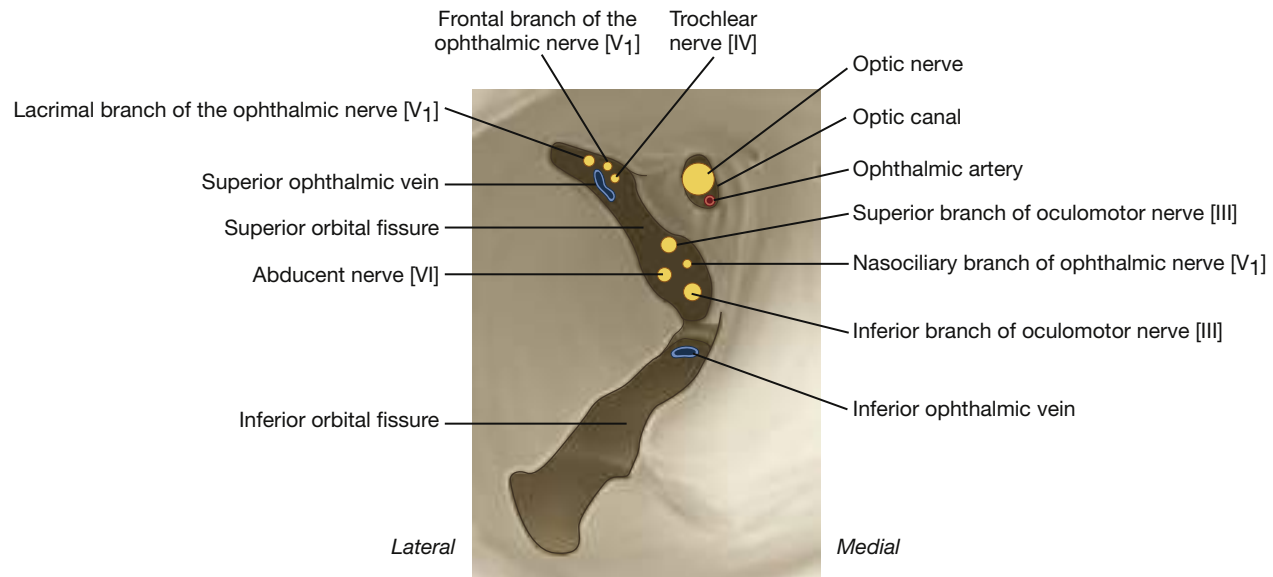


Fig. 8.72 Optic canal and superior orbital fissure.

Fascial specializations

Periorbital

The periosteum lining the bones that form the orbit is the **periorbital** (Fig. 8.73A). It is continuous at the margins of the orbit with the periosteum on the outer surface of the skull and sends extensions into the upper and lower eyelids (the **orbital septa**).

At the various openings where the orbit communicates with the cranial cavity, the periorbital is continuous with the periosteal layer of dura mater. In the posterior part of the orbit, the periorbital thickens around the optic canal and the central part of the superior orbital fissure. This is the point of origin of the four rectus muscles and is the **common tendinous ring** (Fig. 8.73B).

Fascial sheath of the eyeball

The **fascial sheath of the eyeball** (bulbar sheath) is a layer of fascia that encloses a major part of the eyeball (Figs. 8.74, 8.75):

- Posteriorly, it is firmly attached to the sclera (the white part of the eyeball) around the point of entrance of the optic nerve into the eyeball.
- Anteriorly, it is firmly attached to the sclera near the edge of the cornea (the clear part of the eyeball).
- Additionally, as the muscles approach the eyeball, the investing fascia surrounding each muscle blends with the fascial sheath of the eyeball as the muscles pass through and continue to their point of attachment.

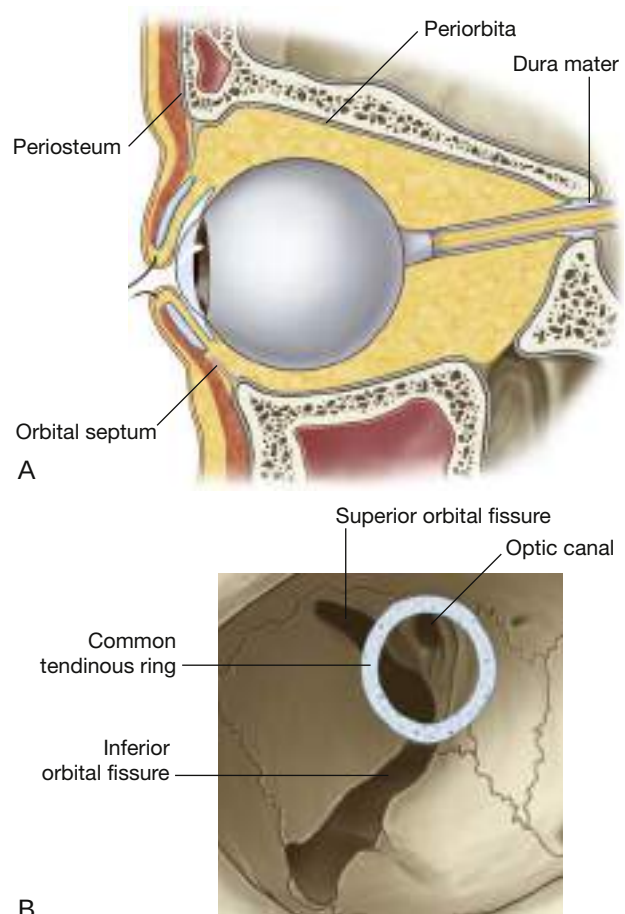


Fig. 8.73 Periorbital. A. Lateral view. B. Common tendinous ring.

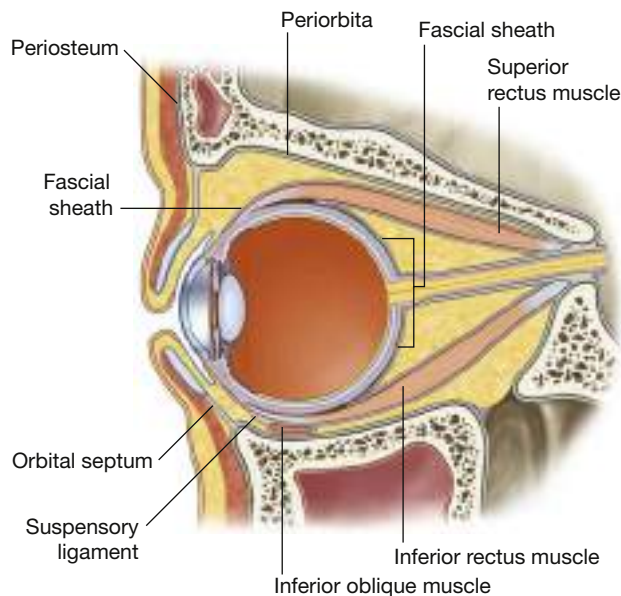


Fig. 8.74 Fascial sheath of the eyeball.

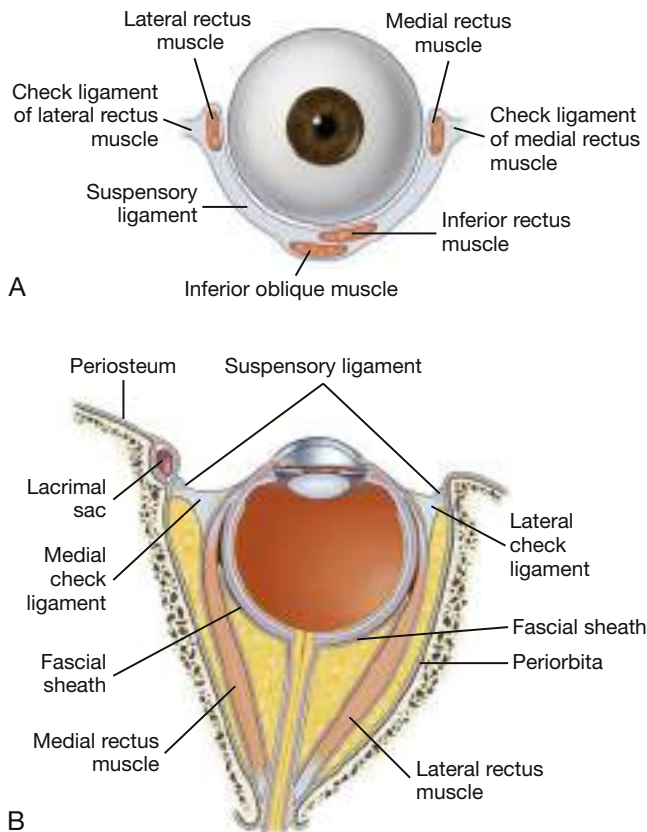


Fig. 8.75 Check ligaments. **A.** Anterior view. **B.** Superior view.

A specialized lower part of the fascial sheath of the eyeball is the **suspensory ligament** (Figs. 8.74, 8.75A), which supports the eyeball. This “sling-like” structure is made up of the fascial sheath of the eyeball and contributions from the two inferior ocular muscles and the medial and lateral ocular muscles.

Check ligaments of the medial and lateral rectus muscles

Other fascial specialization in the orbit are the check ligaments (see Fig. 8.75B). These are expansions of the investing fascia covering the medial and lateral rectus muscles, which attach to the medial and lateral walls of the bony orbit and may assist in maintaining the normal position of the eyeball:

- The medial check ligament attaches immediately posterior to the posterior lacrimal crest of the lacrimal bone.
- The lateral check ligament attaches to the orbital tubercle of the zygomatic bone.

Muscles

There are two groups of muscles within the orbit:

- **extrinsic muscles of the eyeball (extra-ocular muscles)** involved in movements of the eyeball or raising upper eyelids, and
- **intrinsic muscles** within the eyeball, which control the shape of the lens and size of the pupil.

The extrinsic muscles include the levator palpebrae superioris, superior rectus, inferior rectus, medial rectus, lateral rectus, superior oblique, and inferior oblique.

The intrinsic muscles include the **ciliary muscle**, the **sphincter pupillae**, and the **dilator pupillae**.

Extrinsic muscles

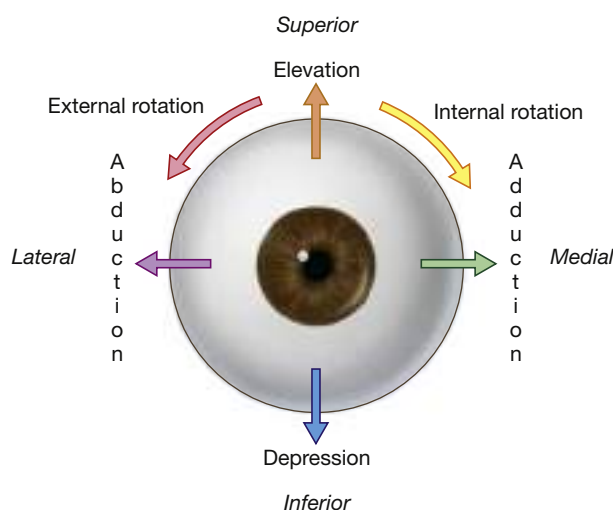
Of the seven muscles in the extrinsic group of muscles, one raises the eyelids, whereas the other six move the eyeball itself (Table 8.8).

The movements of the eyeball, in three dimensions, (Fig. 8.76) are:

- elevation—moving the pupil superiorly,
- depression—moving the pupil inferiorly,
- abduction—moving the pupil laterally,
- adduction—moving the pupil medially,
- internal rotation (intorsion)—rotating the upper part of the pupil medially (or toward the nose), and
- external rotation (extorsion)—rotating the upper part of the pupil laterally (or toward the temple).

Table 8.8 Extrinsic (extra-ocular) muscles

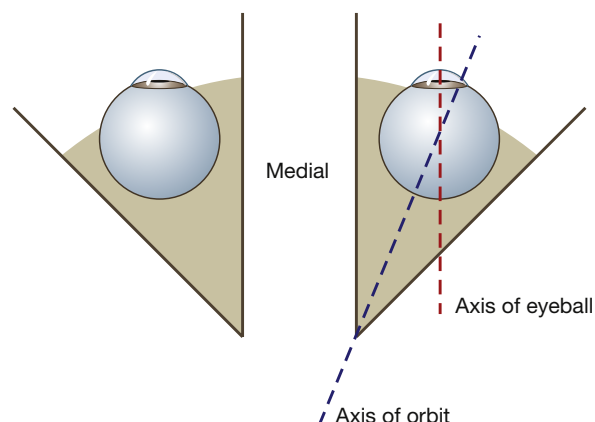
Muscle	Origin	Insertion	Innervation	Function
Levator palpebrae superioris	Lesser wing of sphenoid anterior to optic canal	Anterior surface of tarsal plate; a few fibers to skin and superior conjunctival fornix	Oculomotor nerve [III]—superior branch	Elevation of upper eyelid
Superior rectus	Superior part of common tendinous ring	Anterior half of eyeball superiorly	Oculomotor nerve [III]—superior branch	Elevation, adduction, internal rotation of eyeball
Inferior rectus	Inferior part of common tendinous ring	Anterior half of eyeball inferiorly	Oculomotor nerve [III]—inferior branch	Depression, adduction, external rotation of eyeball
Medial rectus	Medial part of common tendinous ring	Anterior half of eyeball medially	Oculomotor nerve [III]—inferior branch	Adduction of eyeball
Lateral rectus	Lateral part of common tendinous ring	Anterior half of eyeball laterally	Abducent nerve [VI]	Abduction of eyeball
Superior oblique	Body of sphenoid, superior and medial to optic canal	Outer posterior quadrant of eyeball (superior surface)	Trochlear nerve [IV]	Depression, abduction, internal rotation of eyeball
Inferior oblique	Medial floor of orbit posterior to rim; maxilla lateral to nasolacrimal groove	Outer posterior quadrant of eyeball (inferior surface)	Oculomotor nerve [III]—inferior branch	Elevation, abduction, external rotation of eyeball

**Fig. 8.76** Movements of the eyeball.

The axis of each orbit is directed slightly laterally from back to front, but each eyeball is directed anteriorly (Fig. 8.77). Therefore the pull of some muscles has multiple effects on the movement of the eyeball, whereas that of others has a single effect.

The levator palpebrae superioris raises the upper eyelid and is the most superior muscle in the orbit (Table 8.8, Fig. 8.78B).

A unique feature of levator palpebrae superioris is that a collection of smooth muscle fibers passes from its inferior surface to the upper edge of the superior tarsus (see Fig. 8.59). This group of smooth muscle fibers (the superior tarsal muscle) help maintain eyelid elevation and are innervated by

**Fig. 8.77** Axes of the eyeball and orbit.

postganglionic sympathetic fibers from the superior cervical ganglion.

The four rectus muscles occupy medial, lateral, inferior, and superior positions as they pass from their origins posteriorly to their points of attachment on the anterior half of the eyeball (Table 8.8, Figs. 8.78, 8.80, 8.81; also see Fig. 8.79).

The superior and inferior rectus muscles have complicated actions because the apex of the orbit, where the muscles originate, is medial to the central axis of the eyeball when looking directly forward (Table 8.8, Fig. 8.81A).

To isolate the function of and to test the superior and inferior rectus muscles, a patient is asked to track a physician's finger laterally and then either upward or downward (Fig. 8.81B). The first movement brings the axis of the eyeball into alignment with the long axis of the superior and inferior rectus muscles. Moving the finger upward tests the

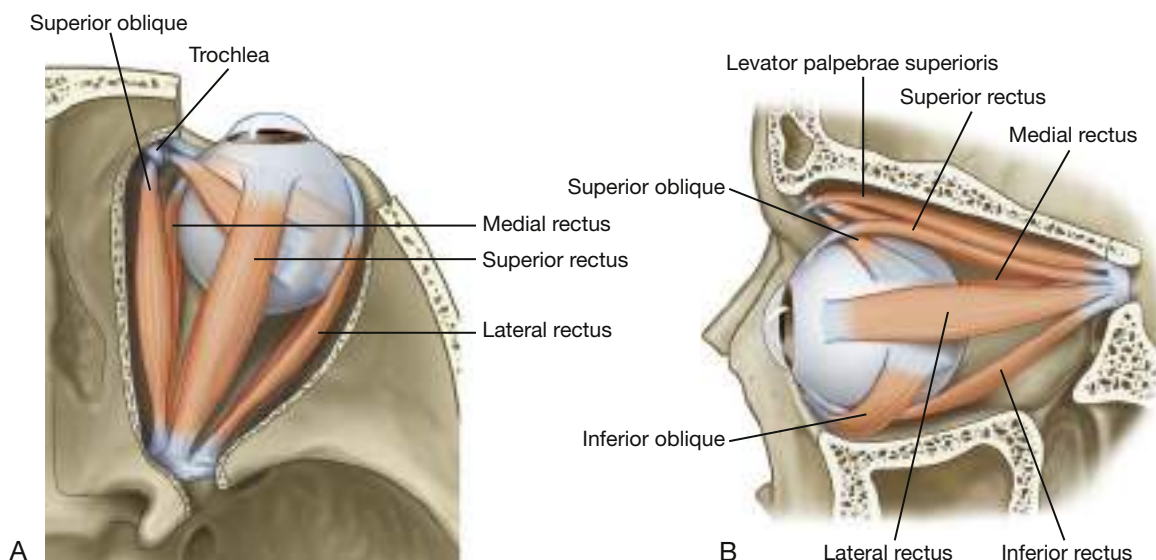


Fig. 8.78 Muscles of the eyeball. **A.** Superior view. **B.** Lateral view.

Imaging app

Visualizing the muscles of the eyeball

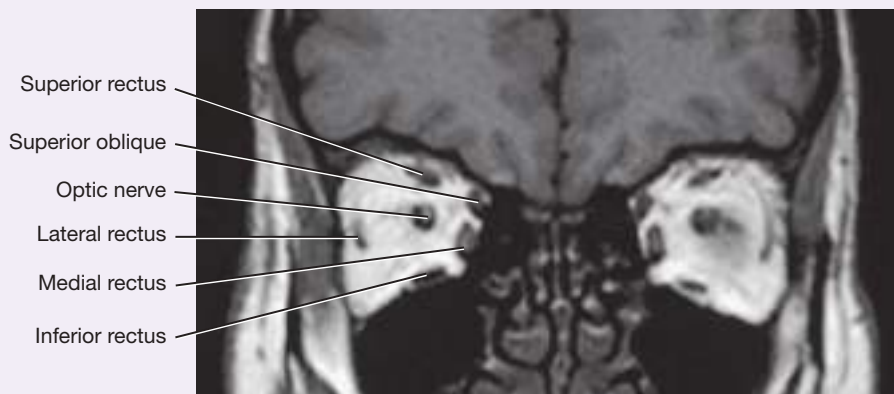


Fig. 8.79 Coronal magnetic resonance image through the eye.

superior rectus muscle and moving it downward tests the inferior rectus muscle (Fig. 8.81B).

The orientation and actions of the medial and lateral rectus muscles are more straightforward than those of the superior and inferior rectus muscles (Table 8.8, Fig. 8.81A).

To isolate the function of and test the medial and lateral rectus muscles, a patient is asked to track a physician's finger medially and laterally, respectively, in the horizontal plane (Fig. 8.81B).

The oblique muscles are in the superior and inferior parts of the orbit, do not originate from the common tendinous ring, are angular in their approaches to the eyeball, and,

unlike the rectus muscles, attach to the posterior half of the eyeball (Table 8.8; also see Figs. 8.78, 8.79, 8.80).

A unique feature of the superior oblique is that the tendon of this muscle passes through the trochlea and turns laterally to cross the eyeball in a posterolateral direction (see Fig. 8.78A). It continues deep to the superior rectus muscle and inserts into the outer posterior quadrant of the eyeball.

To isolate the function of and to test the superior oblique muscle, a patient is asked to track a physician's finger medially to bring the axis of the tendon of the muscle into alignment with the axis of the eyeball and then to look down, which tests the muscle (Fig. 8.81B).

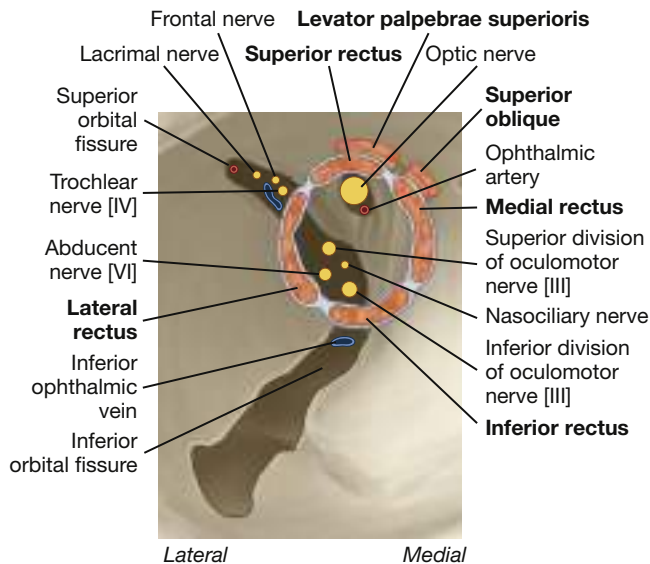


Fig. 8.80 Origins of muscles of the eyeball, coronal view.

A unique feature of the inferior oblique muscle is that it is the only extrinsic muscle that does not take origin from the posterior part of the orbit (Table 8.8; see Fig. 8.78B). It crosses the floor of the orbit in a posterolateral direction between the inferior rectus and the floor of the orbit before inserting into the outer posterior quadrant just under the lateral rectus.

To isolate the function of and to test the inferior oblique muscle, a patient is asked to track a physician's finger medially to bring the axis of the eyeball into alignment with the axis of the muscle and then to look up, which tests the muscle (Fig. 8.81B).

Extrinsic muscles and eyeball movements

Six of the seven extrinsic muscles of the orbit are directly involved in movements of the eyeball.

For each of the rectus muscles, the medial, lateral, inferior, and superior, and the superior and inferior obliques, a specific action or group of actions can be described (see Table 8.8). However, these muscles do not act in isolation. They work as teams of muscles in the coordinated movement of the eyeball to position the pupil as needed.

For example, although the lateral rectus is the muscle primarily responsible for moving the eyeball laterally, it is assisted in this action by the superior and inferior oblique muscles.

Vessels

Arteries

The arterial supply to the structures in the orbit, including the eyeball, is by the **ophthalmic artery** (Fig. 8.83). This vessel is a branch of the internal carotid artery given

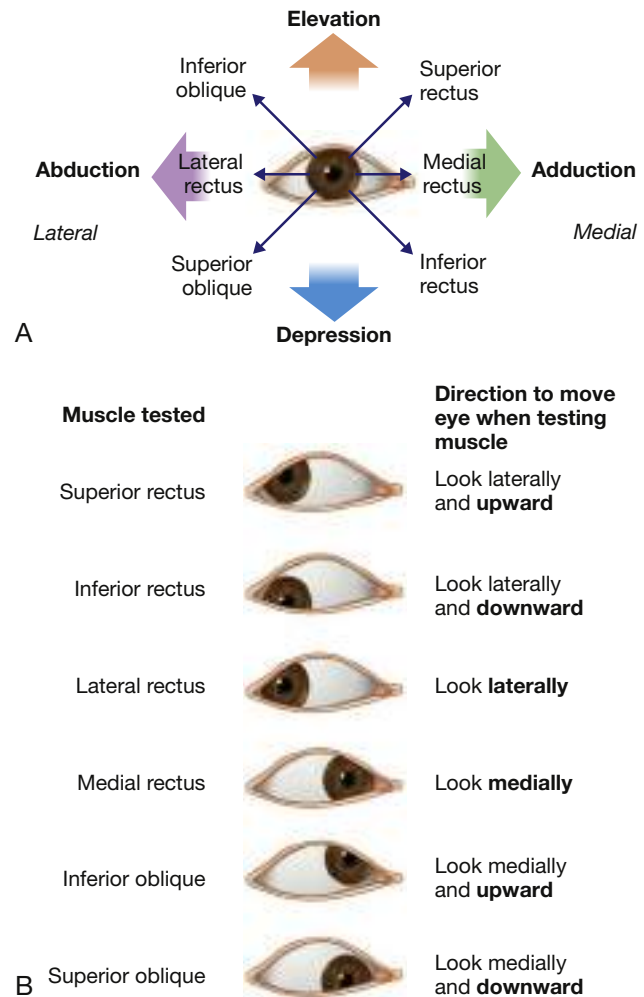


Fig. 8.81 Actions of muscles of the eyeball. **A.** Action of individual muscles (anatomical action). **B.** Movement of eye when testing specific muscle (clinical testing).

off immediately after the internal carotid artery leaves the cavernous sinus. The ophthalmic artery passes into the orbit through the optic canal with the optic nerve (Fig. 8.83).

In the orbit the ophthalmic artery initially lies inferior and lateral to the optic nerve (Fig. 8.83). As it passes forward in the orbit, it crosses superior to the optic nerve and proceeds anteriorly on the medial side of the orbit.

In the orbit the ophthalmic artery gives off numerous branches as follows (Fig. 8.83):

- the **lacrimal artery**, which arises from the ophthalmic artery on the lateral side of the optic nerve and passes anteriorly on the lateral side of the orbit, supplying the lacrimal gland, muscles, the anterior ciliary branch to the eyeball, and the lateral sides of the eyelid;
- the **central retinal artery**, which enters the optic nerve, proceeds down the center of the nerve to the retina, and is clearly seen when viewing the retina with an

Clinical app

The H-test

A simple “formula” for remembering the nerves that innervate the extraocular muscles is “LR6S04 and all the rest are 3” (lateral rectus [VI], superior oblique [IV], all the rest including levator palpebrae superioris are [III]).

The function of all extrinsic muscles and their nerves [III, IV, VI] that move the eyeball in both orbits can all easily be tested at the same time by having the patient track, without moving his or her head, an object such as the tip of a pen or a finger moved in an “H” pattern—starting from the midline between the two eyes (Fig. 8.82).

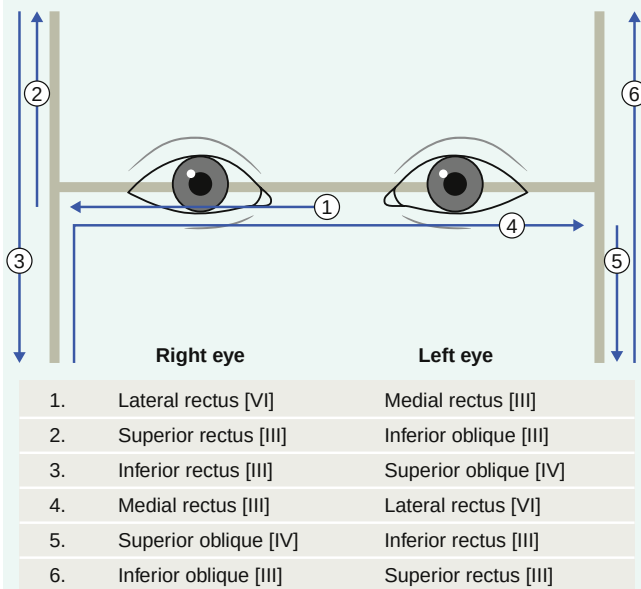


Fig. 8.82 The “H-test.”

ophthalmoscope—occlusion of this vessel or of the parent artery leads to blindness;

- the **long** and **short posterior ciliary arteries**, which are branches that enter the eyeball posteriorly, piercing the sclera and supplying structures inside the eyeball;
- the **muscular arteries**, which are branches supplying the intrinsic muscles of the eyeball;
- the **supra-orbital artery**, which usually arises from the ophthalmic artery immediately after it has crossed the optic nerve, proceeds anteriorly, and exits the orbit through the supra-orbital foramen with the supra-orbital nerve—it supplies the forehead and scalp as it passes across these areas to the vertex of the skull;
- the **posterior ethmoidal artery**, which exits the orbit through the posterior ethmoidal foramen to supply the ethmoidal cells and nasal cavity;
- the **anterior ethmoidal artery**, which exits the orbit through the anterior ethmoidal foramen, enters the cranial

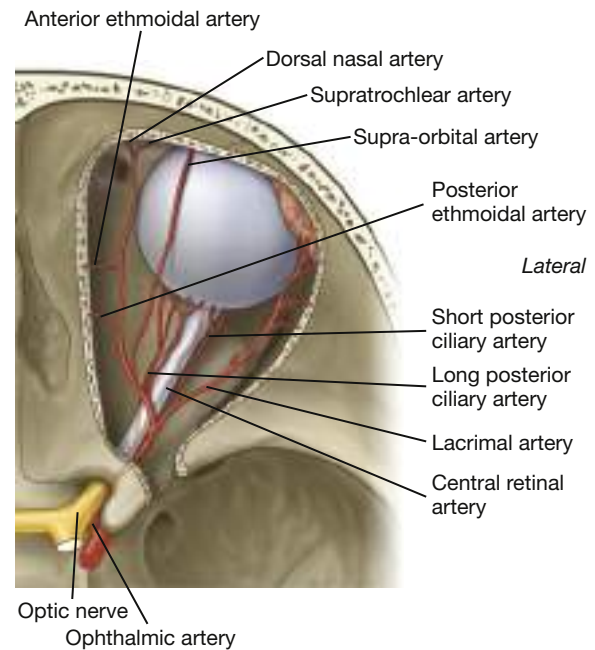


Fig. 8.83 Arterial supply to the orbit and eyeball.

cavity, giving off the anterior meningeal branch, and continues into the nasal cavity, supplying the septum and lateral wall, and ending as the dorsal nasal artery;

- the **medial palpebral arteries**, which are small branches supplying the medial area of the upper and lower eyelids;
- the **dorsal nasal artery**, which is one of the two terminal branches of the ophthalmic artery, leaves the orbit to supply the upper surface of the nose; and
- the **supratrochlear artery**, which is the other terminal branch of the ophthalmic artery and leaves the orbit with the supratrochlear nerve, supplying the forehead as it passes across it in a superior direction.

Veins

There are two venous channels in the orbit—the superior and inferior ophthalmic veins (Fig. 8.84).

The **superior ophthalmic vein** begins in the anterior area of the orbit as connecting veins from the supra-orbital vein and the angular vein join together. It passes across the superior part of the orbit, receiving tributaries from the companion veins to the branches of the ophthalmic artery and veins draining the posterior part of the eyeball. Posteriorly, it leaves the orbit through the superior orbital fissure and enters the cavernous sinus.

The **inferior ophthalmic vein** is smaller than the superior ophthalmic vein, begins anteriorly, and passes across the inferior part of the orbit. It receives various tributaries from muscles and the posterior part of the eyeball as it crosses the orbit.

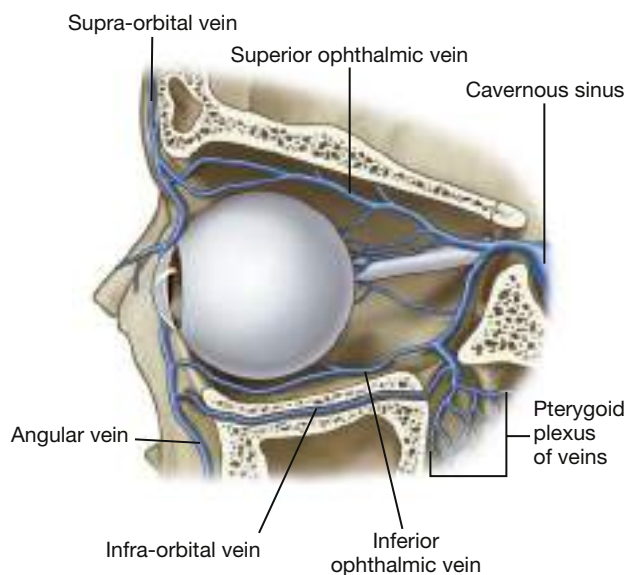


Fig. 8.84 Venous drainage of the orbit and eyeball.

The inferior ophthalmic vein leaves the orbit posteriorly by:

- joining with the superior ophthalmic vein,
- passing through the superior orbital fissure on its own to join the cavernous sinus, or
- passing through the inferior orbital fissure to join with the pterygoid plexus of veins in the infratemporal fossa.

Because the ophthalmic veins communicate with the cavernous sinus, they act as a route by which infections can spread from outside to inside the cranial cavity.

Innervation

Numerous nerves pass into the orbit and innervate structures within its bony walls. They include the optic nerve [II], the oculomotor nerve [III], the trochlear nerve [IV], the abducent nerve [VI], and autonomic nerves. Other nerves such as the ophthalmic nerve [V₁] innervate orbital structures and then travel out of the orbit to innervate other regions.

Optic nerve

The optic nerve [II] is not a true cranial nerve, but rather an extension of the brain carrying afferent fibers from the retina of the eyeball to the visual centers of the brain. The optic nerve is surrounded by the cranial meninges, including the subarachnoid space, which extend as far forward as the eyeball.

Any increase in intracranial pressure therefore results in increased pressure in the subarachnoid space surrounding the optic nerve. This may impede venous return along the

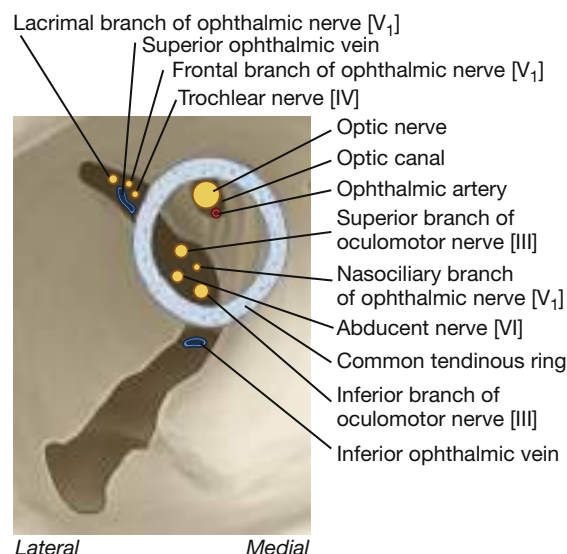


Fig. 8.85 Innervation of the orbit and eyeball.

retinal veins, causing edema of the optic disc (papilledema), which can be seen when the retina is examined using an ophthalmoscope.

The optic nerve leaves the orbit through the optic canal (Fig. 8.85). It is accompanied in the optic canal by the ophthalmic artery.

Oculomotor nerve

The oculomotor nerve [III] leaves the anterior surface of the brainstem between the midbrain and the pons. It passes forward in the lateral wall of the cavernous sinus.

Just before entering the orbit the oculomotor nerve [III] divides into superior and inferior branches (Fig. 8.86). These branches enter the orbit through the superior orbital fissure, lying within the common tendinous ring (Fig. 8.85).

Inside the orbit the small superior branch passes upward over the lateral side of the optic nerve to innervate the superior rectus and levator palpebrae superioris muscles (Fig. 8.86).

The large inferior branch divides into three branches (Fig. 8.86):

- one passing below the optic nerve as it passes to the medial side of the orbit to innervate the medial rectus muscle,
- a second descending to innervate the inferior rectus muscle, and
- the third descends as it runs forward along the floor of the orbit to innervate the inferior oblique muscle.

As the third branch descends, it gives off the **branch to the ciliary ganglion** (Fig. 8.86). This is the parasympathetic root to the ciliary ganglion and carries preganglionic parasympathetic fibers that will synapse in the ciliary ganglion

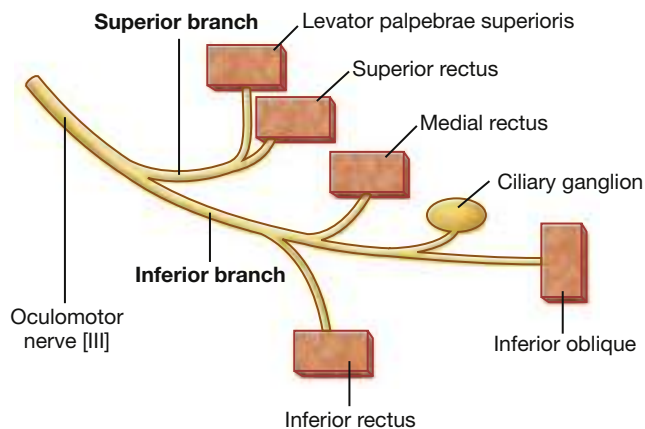


Fig. 8.86 Oculomotor nerve [III] and its divisions.

with postganglionic parasympathetic fibers. The postganglionic fibers are distributed to the eyeball through short ciliary nerves and innervate the sphincter pupillae and ciliary muscles.

Trochlear nerve

The trochlear nerve [IV] arises from the posterior surface of the midbrain and passes around the midbrain to enter the edge of the tentorium cerebelli. It continues on an intradural path, arriving in and passing through the lateral wall of the cavernous sinus just below the oculomotor nerve [III].

Just before entering the orbit, the trochlear nerve ascends, passing across the oculomotor nerve [III] and enters the orbit through the superior orbital fissure above the common tendinous ring (Fig. 8.85). In the orbit the trochlear nerve [IV] ascends and turns medially, crossing above the levator palpebrae superioris muscle to enter the upper border of the superior oblique muscle (Fig. 8.87).

Abducent nerve

The abducent nerve [VI] arises from the brainstem between the pons and medulla. It enters the dura covering the clivus and continues in a dural canal until it reaches the cavernous sinus.

The abducent nerve enters the cavernous sinus and runs through the sinus lateral to the internal carotid artery. It passes out of the sinus and enters the orbit through the superior orbital fissure within the common tendinous ring (Fig. 8.85). Once in the orbit it courses laterally to supply the lateral rectus muscle.

Postganglionic sympathetic fibers

Preganglionic sympathetic fibers arise from the upper segments of the thoracic spinal cord, mainly T1. They enter the sympathetic chain through white rami communicantes, and ascend to the **superior cervical ganglion** where they synapse with postganglionic sympathetic fibers.

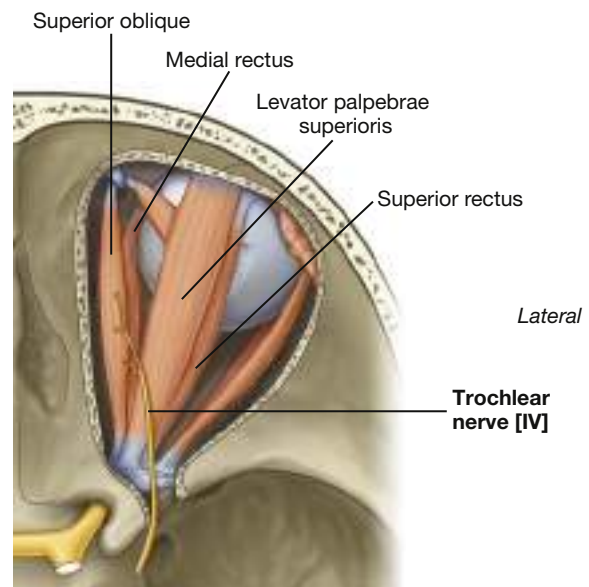


Fig. 8.87 Trochlear nerve [IV] in the orbit.

The postganglionic fibers are distributed along the internal carotid artery and its branches.

The postganglionic sympathetic fibers destined for the orbit travel with the ophthalmic artery. Once in the orbit the fibers are distributed to the eyeball either by:

- passing through the ciliary ganglion, without synapsing, and joining the short ciliary nerves, which pass from the ganglion to the eyeball; or
- passing through long ciliary nerves to reach the eyeball.

In the eyeball postganglionic sympathetic fibers innervate the dilator pupillae muscle.

Ophthalmic nerve [V₁]

The ophthalmic nerve [V₁] is the smallest and most superior of the three divisions of the trigeminal nerve [V]. This purely sensory nerve receives input from structures in the orbit and from additional branches on the face and scalp.

Leaving the trigeminal ganglion, the ophthalmic nerve [V₁] passes forward in the lateral wall of the cavernous sinus inferior to the trochlear [IV] and oculomotor [III] nerves. Just before it enters the orbit it divides into three branches—the lacrimal, frontal, and nasociliary nerves (Fig. 8.88). These branches enter the orbit through the superior orbital fissure with the frontal and lacrimal nerves outside the common tendinous ring and the nasociliary nerve within the common tendinous ring (Fig. 8.85).

Lacrimal nerve

The lacrimal nerve is the smallest of the three branches of the ophthalmic nerve [V₁]. Once in the orbit it passes

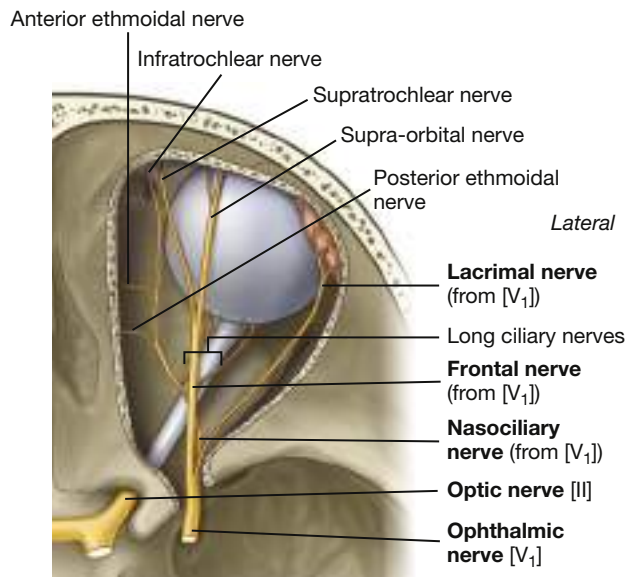


Fig. 8.88 Ophthalmic nerve [V₁] and its divisions.

forward along the upper border of the lateral rectus muscle (Figs. 8.89, 8.90). It receives a branch from the zygomaticotemporal nerve, which carries parasympathetic and sympathetic postganglionic fibers for distribution to the lacrimal gland.

Reaching the anterolateral aspect of the orbit, the lacrimal nerve supplies the lacrimal gland, conjunctiva, and lateral part of the upper eyelid.

Frontal nerve

The frontal nerve is the largest branch of the ophthalmic nerve [V₁] and receives sensory input from areas outside the orbit. Exiting the superior orbital fissure, this branch passes forward between the levator palpebrae superioris and the periorbita on the roof of the orbit (Fig. 8.89). About midway across the orbit, it divides into its two terminal branches—the supra-orbital and supratrochlear nerves (Fig. 8.89; also see Fig. 8.88):

- The supratrochlear nerve continues forward in an anteromedial direction, passing above the trochlea, and exits the orbit medial to the supra-orbital foramen and supplies the conjunctiva and skin of the upper eyelid and the skin on the lower medial part of the forehead.
- The supra-orbital nerve is the larger of the two branches; it continues forward, passing between the levator palpebrae superioris muscle and the periorbita covering the roof of the orbit (Fig. 8.89), exits the orbit through the supra-orbital notch, and ascends across the forehead and scalp, supplying the upper eyelid and conjunctiva, the forehead, and as far posteriorly as the middle of the scalp.

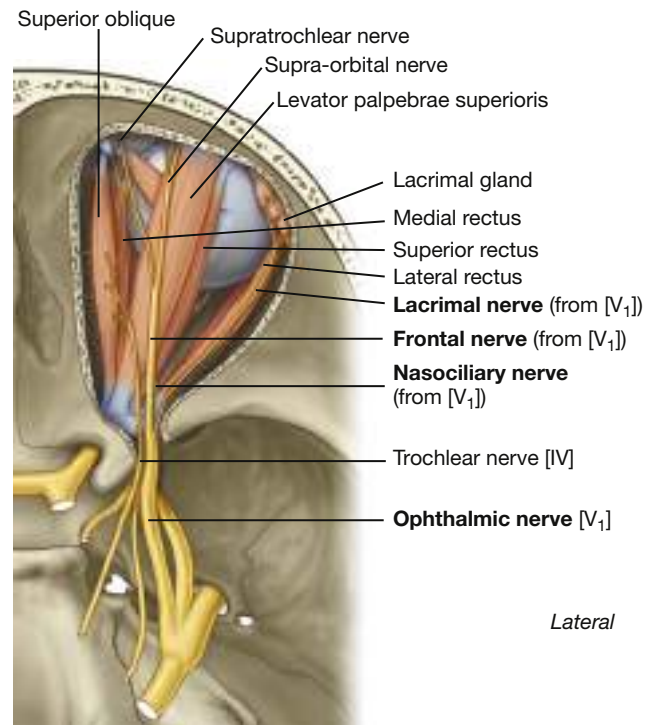


Fig. 8.89 Relationship of the ophthalmic nerve [V₁] and its divisions to the muscles of the eyeball.

Nasociliary nerve

The nasociliary nerve is intermediate in size between the frontal and lacrimal nerves and is usually the first branch from the ophthalmic nerve [V₁] (Fig. 8.88). It is most deeply placed in the orbit, entering the area within the common tendinous ring between the superior and inferior branches of the oculomotor nerve [III] (Fig. 8.90; also see Fig. 8.85).

Once in the orbit, the nasociliary nerve crosses the superior surface of the optic nerve as it passes in a medial direction below the superior rectus muscle (Figs. 8.88, 8.90). Its first branch, the **communicating branch with the ciliary ganglion (sensory root to the ciliary ganglion)**, is given off early in its path through the orbit (Fig. 8.91).

The nasociliary nerve continues forward along the medial wall of the orbit between the superior oblique and the medial rectus muscles, giving off several branches (Figs. 8.89, 8.91). These include:

- the **long ciliary nerves**, which are sensory to the eyeball but may also carry sympathetic fibers for pupillary dilation;
- the **posterior ethmoidal nerve**, which exits the orbit through the posterior ethmoidal foramen to supply posterior ethmoidal cells and the sphenoidal sinus;
- the **infratrochlear nerve**, which distributes to the medial part of the upper and lower eyelids, the lacrimal sac, and skin of the upper half of the nose; and

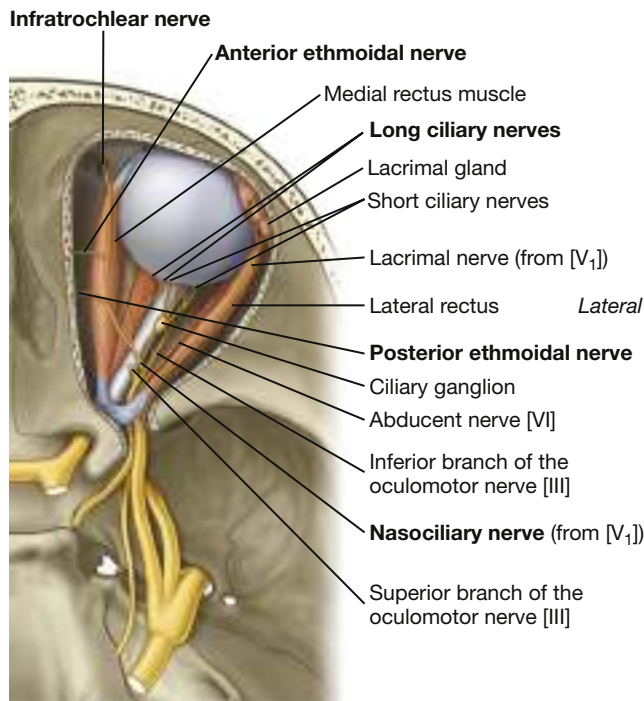


Fig. 8.90 Course of the nasociliary nerve [V₁] in the orbit.

- the **anterior ethmoidal nerve**, which exits the orbit through the anterior ethmoidal foramen to supply the anterior cranial fossa, nasal cavity, and skin of the lower half of the nose.

Ciliary ganglion

The ciliary ganglion is a parasympathetic ganglion of the oculomotor nerve [III]. It is associated with the nasociliary branch of the ophthalmic nerve [V₁] and is the site where preganglionic and postganglionic parasympathetic neurons synapse as fibers from this part of the autonomic division of the PNS make their way to the eyeball. The ciliary ganglion is also traversed by postganglionic sympathetic fibers and sensory fibers as they travel to the eyeball.

The ciliary ganglion is a very small ganglion, in the posterior part of the orbit immediately lateral to the optic nerve and between the optic nerve and the lateral rectus muscle (Fig. 8.90). It is usually described as receiving at least two, and possibly three, branches or roots from other nerves in the orbit.

Parasympathetic root

As the inferior branch of the oculomotor nerve [III] passes the area of the ciliary ganglion, it sends a branch to the ganglion (the parasympathetic root). The parasympathetic branch carries preganglionic parasympathetic fibers, which enter the ganglion and synapse with postganglionic parasympathetic fibers within the ganglion (Fig. 8.91).

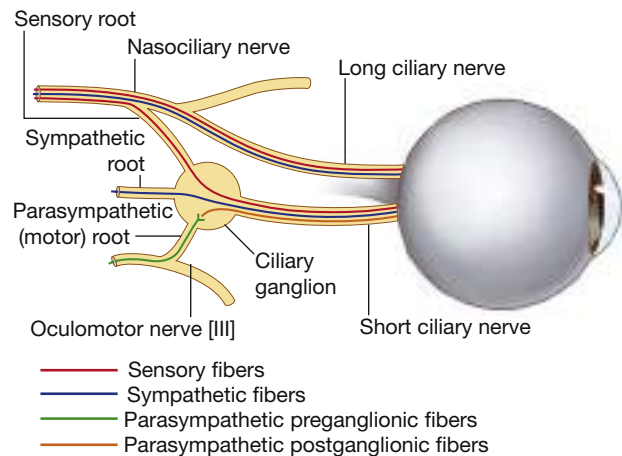


Fig. 8.91 Ciliary ganglion.

The postganglionic parasympathetic fibers leave the ganglion through short ciliary nerves, which enter the posterior aspect of the eyeball around the optic nerve.

In the eyeball the parasympathetic fibers innervate:

- the sphincter pupillae muscle, responsible for pupillary constriction, and
- the ciliary muscle, responsible for accommodation of the lens of the eye for near vision.

Sensory root

A second branch (the sensory root) passes from the nasociliary nerve to the ganglion (Fig. 8.91). This branch enters the posterosuperior aspect of the ganglion and carries sensory fibers, which pass through the ganglion and continue along the short ciliary nerves to the eyeball. These fibers are responsible for sensory innervation to all parts of the eyeball.

Sympathetic root

The third branch to the ciliary ganglion is the most variable. This branch, when present, is the sympathetic root and contains postganglionic sympathetic fibers from the superior cervical ganglion (Fig. 8.91). These fibers travel up the internal carotid artery, leave the plexus surrounding the artery in the cavernous sinus, and enter the orbit through the common tendinous ring. In the orbit they enter the posterior aspect of the ciliary ganglion, cross the ganglion, and continue along the short ciliary nerves to the eyeball.

Sympathetic fibers to the eyeball may not enter the ganglion as a separate sympathetic root. Rather, the postganglionic sympathetic fibers may leave the plexus associated with the internal carotid artery in the cavernous sinus, join the ophthalmic nerve (V₁), and course into the ciliary ganglion in the sensory root from the nasociliary nerve. In addition, the sympathetic fibers carried in the nasociliary nerve may

not enter the ganglion at all and course directly into the eyeball in the long ciliary nerves (Fig. 8.91).

Whatever their path, postganglionic sympathetic fibers reach the eyeball and innervate the dilator pupillae muscle.

Eyeball

The globe-shaped eyeball occupies the anterior part of the orbit. Its rounded shape is disrupted anteriorly where it bulges outward. This outward projection represents about one-sixth of the total area of the eyeball and is the transparent cornea (Fig. 8.92).

Posterior to the cornea and in order from front to back are the anterior chamber, the iris and pupil, the posterior chamber, the lens, the postremal (vitreous) chamber, and the retina.

Anterior and posterior chambers

The **anterior chamber** is the area directly posterior to the cornea and anterior to the colored part of the eye (**iris**) (Fig. 8.92).

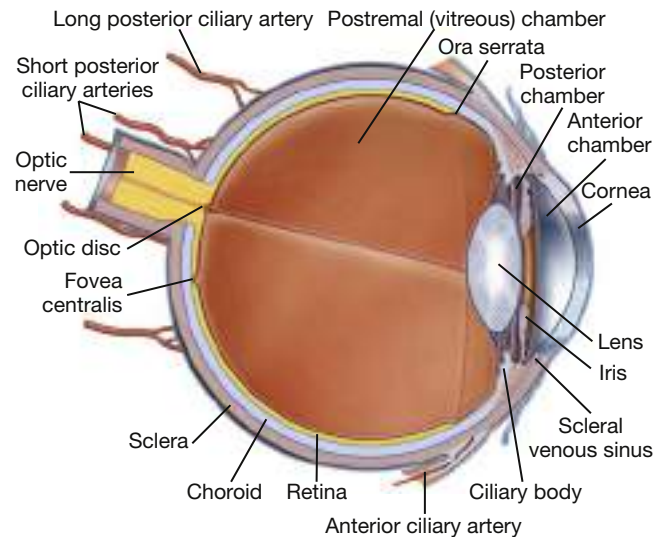


Fig. 8.92 Eyeball.

Clinical app

Ophthalmoscopy

Direct visualization of the postremal (vitreous) chamber of the eye and the posterior wall of the eye through the pupil and the lens is possible using an ophthalmoscope (Fig. 8.93).

The optic nerve, observed as the optic disc, is easily seen. The typical four branches of the retinal artery and the fovea are also seen.

Using ophthalmoscopy, the physician can look for diseases of the optic nerve, vascular abnormalities, and changes within the retina (Fig. 8.93).

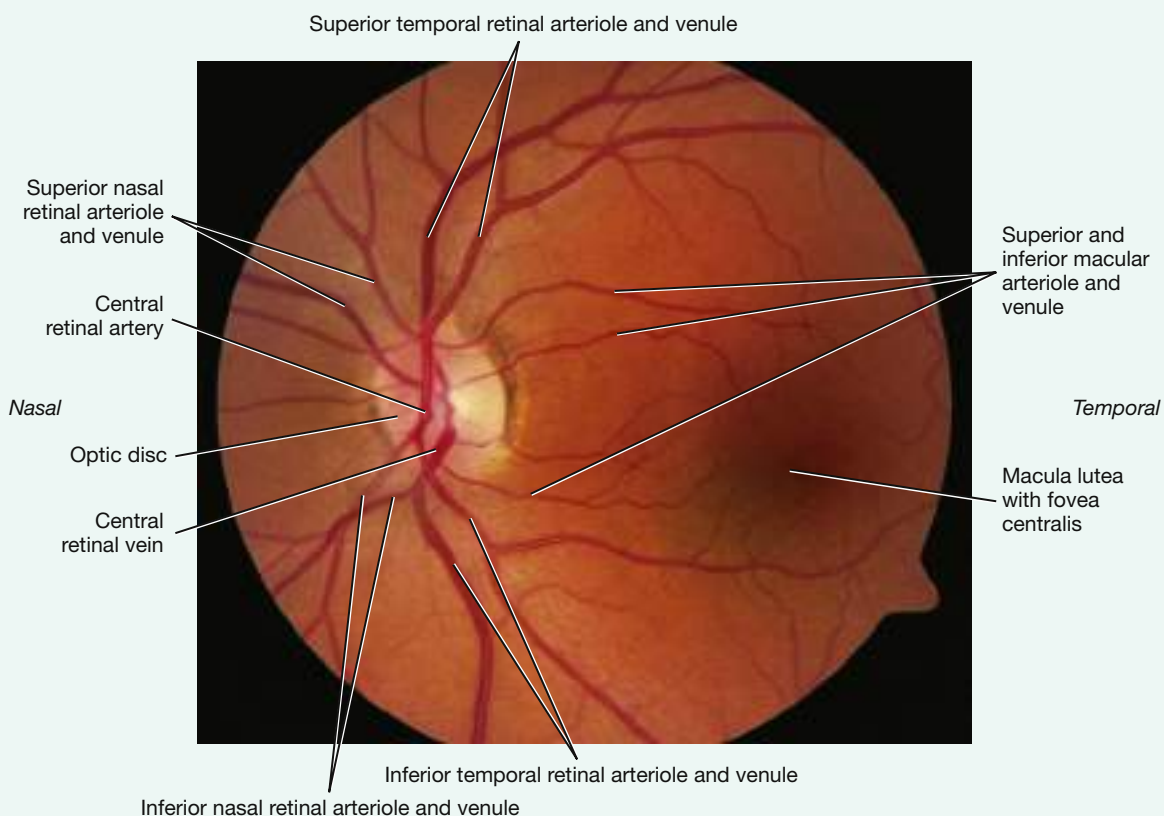


Fig. 8.93 Ophthalmoscopic view of posterior chamber of the right eye.

The central opening in the iris is the **pupil**. Posterior to the iris and anterior to the lens is the smaller **posterior chamber**.

The anterior and posterior chambers are continuous with each other through the pupillary opening. They are filled with a fluid (**aqueous humor**), which is secreted into the posterior chamber, flows into the anterior chamber through the pupil, and is absorbed into the **scleral venous sinus** (the canal of Schlemm), which is a circular venous channel at the junction between the cornea and the iris (see Fig. 8.92).

The aqueous humor supplies nutrients to the avascular cornea and lens and maintains the intra-ocular pressure. If the normal cycle of its production and absorption is disturbed so that the amount of fluid increases, intra-ocular pressure will increase.

Lens and vitreous humor

The **lens** separates the anterior one-fifth of the eyeball from the posterior four-fifths (see Fig. 8.92). It is a transparent, biconvex elastic disc attached circumferentially to muscles associated with the outer wall of the eyeball. This lateral attachment provides the lens with the ability to change its refractive ability to maintain visual acuity. The clinical term for opacity of the lens is a cataract.

The posterior four-fifths of the eyeball, from the lens to the retina, is occupied by the postremal (vitreous) chamber (see Fig. 8.92). This segment is filled with a transparent, gelatinous substance—the **vitreous body** (**vitreous humor**). This substance, unlike aqueous humor, cannot be replaced.

Walls of the eyeball

Surrounding the internal components of the eyeball are the walls of the eyeball. They consist of three layers: an outer fibrous layer, a middle vascular layer, and an inner retinal layer (see Fig. 8.92).

- The outer fibrous layer consists of the **sclera** posteriorly and the **cornea** anteriorly.
- The middle vascular layer consists of the **choroid** posteriorly and is continuous with the ciliary body and iris anteriorly.
- The inner layer consists of the optic part of the **retina** posteriorly and the nonvisual retina that covers the internal surface of the ciliary body and iris anteriorly.

Vessels

Arterial supply

The arterial supply to the eyeball is from several sources (see Fig. 8.92):

- The **short posterior ciliary arteries** are branches from the ophthalmic artery that pierce the sclera around the optic nerve and enter the choroid layer (see Fig. 8.92).

- The **long posterior ciliary arteries**, usually two, enter the sclera on the medial and lateral sides of the optic nerve and proceed anteriorly in the choroid layer to anastomose with the anterior ciliary arteries (see Fig. 8.92).
- The **anterior ciliary arteries** are branches of the arteries supplying the muscles (see Fig. 8.92); as the muscles attach to the sclera, these arteries pierce the sclera to anastomose with the long posterior ciliary arteries in the choroid layer.
- The **central retinal artery** that has traversed the optic nerve and enters the area of the retina at the optic disc (Fig. 8.93).

Venous drainage

Venous drainage of the eyeball is primarily related to drainage of the choroid layer. Four large veins (the **vorticoses veins**) are involved in this process. They exit through the sclera from each of the posterior quadrants of the eyeball and enter the superior and inferior ophthalmic veins. There is also a central retinal vein accompanying the central retinal artery.

Clinical app

Glaucoma

Intraocular pressure will rise if the normal cycle of aqueous humor fluid production and absorption is disturbed so that the amount of fluid increases. This condition is glaucoma and can lead to a variety of visual problems including blindness, which results from compression of the retina and its blood supply.

Clinical app

Cataracts

With increasing age and in certain disease states the lens of the eye becomes opaque. Increasing opacity results in increasing visual impairment. A common operation is excision of the cloudy lens and replacement with a new man-made lens.

Fibrous layer of the eyeball

The fibrous layer of the eyeball consists of two components—the sclera covers the posterior and lateral parts of the eyeball, about five-sixths of the surface, and the cornea covers the anterior part (see Fig. 8.92).

Sclera

The sclera is an opaque layer of dense connective tissue that can be seen anteriorly through its conjunctival covering as the “white of the eye” (see Fig. 8.92). It is pierced by numerous vessels and nerves, including the optic nerve posteriorly, and provides attachment for the various muscles involved in eyeball movements.

The fascial sheath of the eyeball covers the surface of the sclera externally from the entrance of the optic nerve to the corneoscleral junction while internally the surface of the sclera is loosely attached to the choroid of the vascular layer.

Cornea

Continuous with the sclera anteriorly is the transparent cornea. It covers the anterior one-sixth of the surface of the eyeball and, being transparent, allows light to enter the eyeball (see Fig. 8.92).

Vascular layer of the eyeball

The vascular layer of the eyeball consists of three continuous parts—the choroid, the ciliary body, and the iris from posterior to anterior (see Fig. 8.92).

Choroid

The choroid is posterior and represents approximately two-thirds of the vascular layer (see Fig. 8.92). It is a thin, highly vascular, pigmented layer consisting of smaller vessels adjacent to the retina and larger vessels more peripherally. It is firmly attached to the retina internally and loosely attached to the sclera externally.

Ciliary body

Extending from the anterior border of the choroid is the ciliary body (Figs. 8.92, 8.94). This triangular-shaped structure between the choroid and the iris forms a complete ring around the eyeball. Its components include the ciliary muscle and the ciliary processes (see Fig. 8.94).

The **ciliary muscle** consists of smooth muscle fibers arranged longitudinally, circularly, and radially. Controlled by parasympathetics traveling to the orbit in the oculomotor nerve [III], these muscle fibers, on contraction, decrease the size of the ring formed by the ciliary body (Table 8.9, see Fig. 8.94).

The **ciliary processes** are longitudinal ridges projecting from the inner surface of the ciliary body (see Fig. 8.94). Extending from them are **zonular fibers** attached to the lens of the eyeball, which suspend the lens in its proper position and collectively form the **suspensory ligament of the lens**.

Contraction of the ciliary muscle decreases the size of the ring formed by the ciliary body. This reduces tension on the suspensory ligament of the lens. The lens therefore becomes more rounded (relaxed), resulting in accommodation of the lens for near vision.

Ciliary processes also contribute to the formation of aqueous humor.

Iris

Completing the vascular layer of the eyeball anteriorly is the iris (see Fig. 8.94). This circular structure, projecting outward from the ciliary body, is the colored part of the eye with a

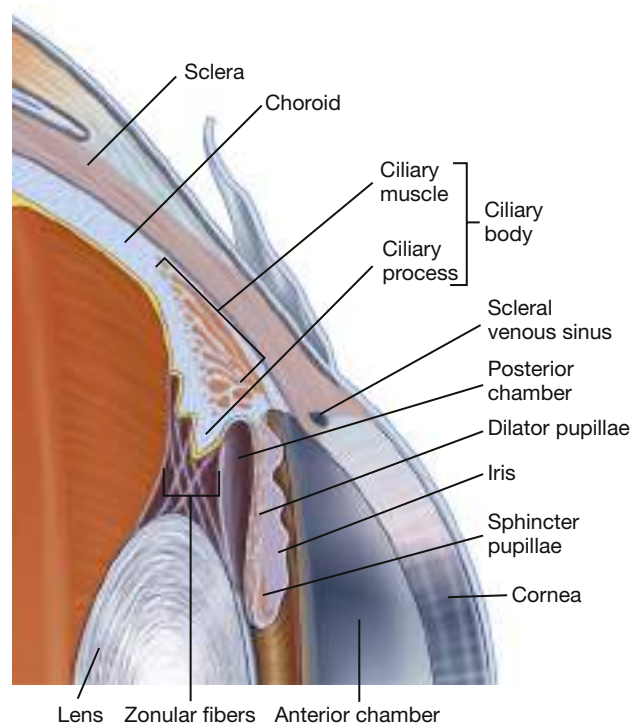


Fig. 8.94 Ciliary body.

central opening (the pupil). Controlling the size of the pupil are smooth muscle fibers (sphincter pupillae) and myoepithelial cells (dilator pupillae) within the iris (see Fig. 8.94):

- Fibers arranged in a circular pattern make up the **sphincter pupillae** muscle (Table 8.9), which is innervated by parasympathetics—contraction of its fibers decreases or constricts the pupillary opening.
- Contractile fibers arranged in a radial pattern make up the **dilator pupillae** muscle (Table 8.9), which is innervated by sympathetics—contraction of its fibers increases or dilates the pupillary opening.

Inner layer of the eyeball

The inner layer of the eyeball is the retina (see Fig. 8.92). It consists of two parts. Posteriorly and laterally is the **optic part of the retina**, which is sensitive to light, and anteriorly is the **nonvisual part**, which covers the internal surface of the ciliary body and the iris. The junction between these parts is an irregular line (the **ora serrata**).

Optic part of the retina

The optic part of the retina consists of two layers, an outer pigmented layer and an inner neural layer:

- The **pigmented layer** is firmly attached to the choroid and continues anteriorly over the internal surface of the ciliary body and iris.

Table 8.9 Intrinsic muscles of the eye

Muscle	Location	Innervation	Function
Ciliary	Muscle fibers in the ciliary body	Parasympathetics from the oculomotor nerve [III]	Constricts ciliary body, relaxes tension on lens, lens become more rounded
Sphincter pupillae	Circularly arranged fibers in the iris	Parasympathetics from the oculomotor nerve [III]	Constricts pupil
Dilator pupillae	Radially arranged fibers in the iris	Sympathetics from the superior cervical ganglion (T1)	Dilates pupil

- The **neural layer**, which can be further subdivided into its various neural components, is only attached to the pigmented layer around the optic nerve and at the ora serrata.

It is the neural layer that separates in the case of a detached retina.

Several obvious features are visible on the posterior surface of the optic part of the retina.

The **optic disc** is where the optic nerve leaves the retina (see Fig. 8.93). It is lighter than the surrounding retina, and branches of the central retinal artery spread from this point outward to supply the retina. As there are no light-sensitive receptor cells in the optic disc, it is referred to as a blind spot in the retina.

Lateral to the optic disc, a small area with a hint of yellowish coloration is the **macula lutea** with its central depression, the **fovea centralis** (see Fig. 8.93). This is the thinnest area of the retina and visual sensitivity here is higher than elsewhere in the retina because it has fewer **rods** (light-sensitive receptor cells that function in dim light and are insensitive to color) and more **cones** (light-sensitive receptor cells that respond to bright light and are sensitive to color).

EAR

The ear is the organ of hearing and balance. It has three parts (Fig. 8.95):

- The first part is the **external ear** consisting of the part attached to the lateral aspect of the head and the canal leading inward.
- The second part is the **middle ear**—a cavity in the petrous part of the temporal bone bounded laterally and separated from the external canal by a membrane and connected internally to the pharynx by a narrow tube.
- The third part is the **internal ear** consisting of a series of cavities within the petrous part of the temporal bone between the middle ear laterally and the internal acoustic meatus medially.

The internal ear converts the mechanical signals received from the middle ear, which start as sound captured by the

external ear into electrical signals to transfer information to the brain. The internal ear also contains receptors that detect motion and position.

External ear

The external ear consists of two parts (Fig. 8.95). The part projecting from the side of the head is the **auricle (pinna)**, and the canal leading inward is the **external acoustic meatus**.

Auricle

The auricle is on the side of the head and assists in capturing sound. It consists of cartilage covered with skin and arranged in a pattern of various elevations and depressions (Fig. 8.96).

The large outside rim of the auricle is the **helix**. It ends inferiorly at the fleshy **lobule**, the only part of the auricle not supported by cartilage.

The hollow center of the auricle is the **concha of auricle**. The external acoustic meatus leaves from the depths of this area.

Just anterior to the opening of the external acoustic meatus, in front of the concha, is an elevation (the **tragus**). Opposite the tragus, and above the fleshy lobule, is another elevation (the **antitragus**). A smaller curved rim, parallel and anterior to the helix, is the **antihelix**.

Muscles

Numerous intrinsic and extrinsic muscles are associated with the auricle:

- The intrinsic muscles pass between the cartilaginous parts of the auricle and may change the shape of the auricle.
- The extrinsic muscles, the anterior, superior, and posterior auricular muscles, pass from the scalp or skull to the auricle and may also play a role in positioning of the auricle (see Fig. 8.35).

Both groups of muscles are innervated by the facial nerve [VII].

Innervation

Sensory innervation of the auricle is from many sources (Fig. 8.97):

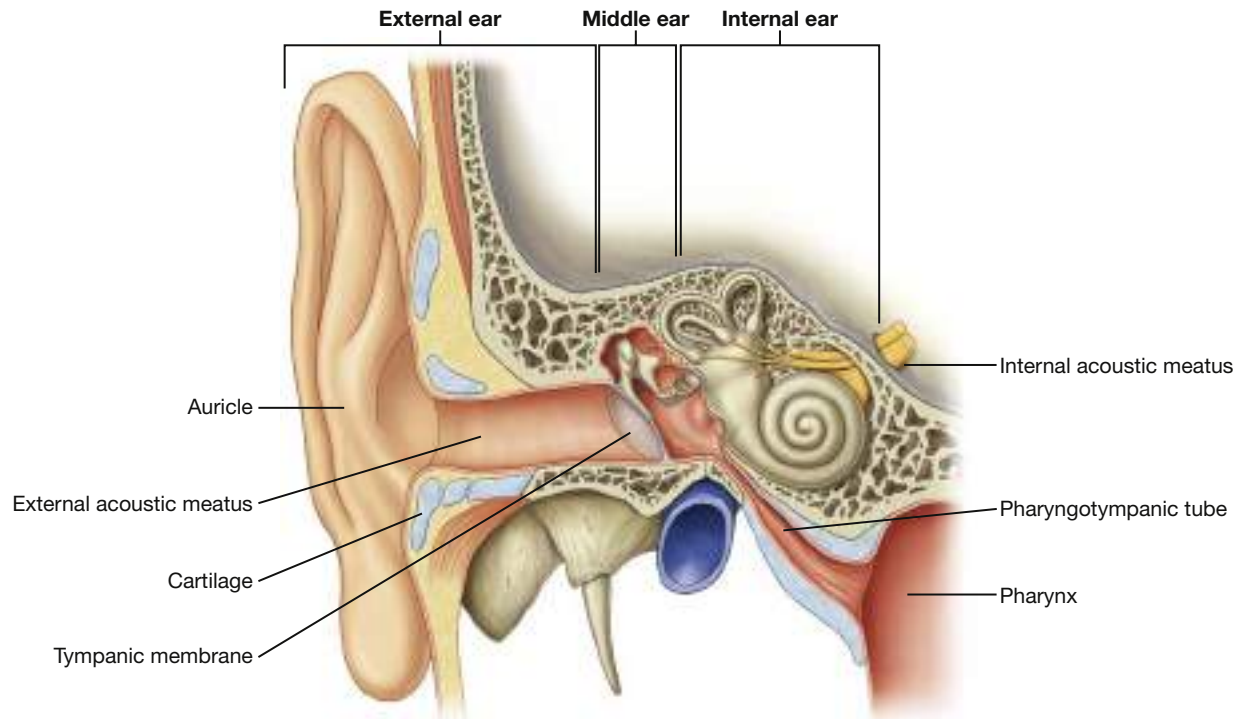


Fig. 8.95 Right ear.

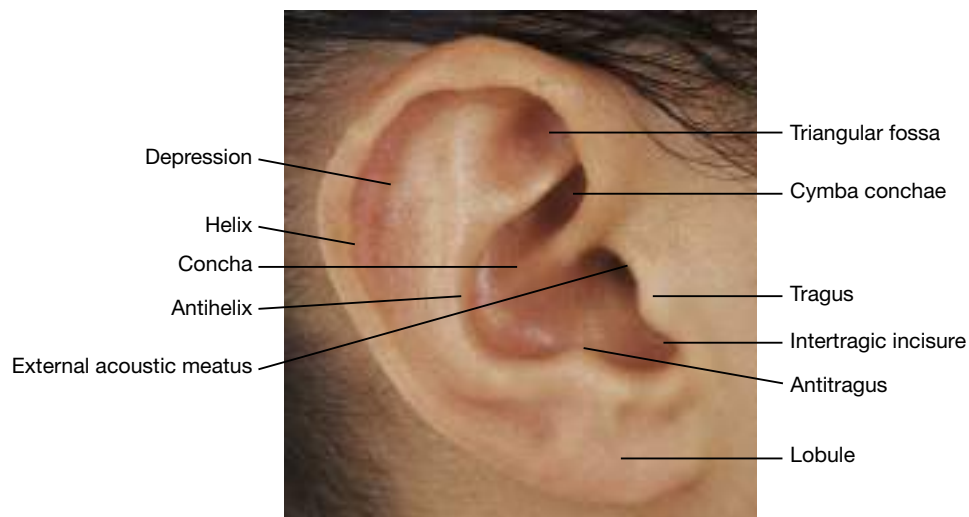


Fig. 8.96 Auricle.

- The outer more superficial surfaces of the auricle are supplied by the great auricular nerve (anterior and posterior inferior portions) and the lesser occipital nerve (posterior superior portion) from the cervical plexus and the auriculotemporal branch of the mandibular nerve [V₃] (anterior superior portion).
- The deeper parts of the auricle are supplied by the vagus nerve [X] (the auricular branch) and the facial nerve [VII]

(which sends a branch to the auricular branch of the vagus nerve [X]).

Vessels

The arterial supply to the auricle is from numerous sources. The external carotid artery supplies the posterior auricular artery, the superficial temporal artery supplies anterior auricular branches, and the occipital artery supplies a branch.

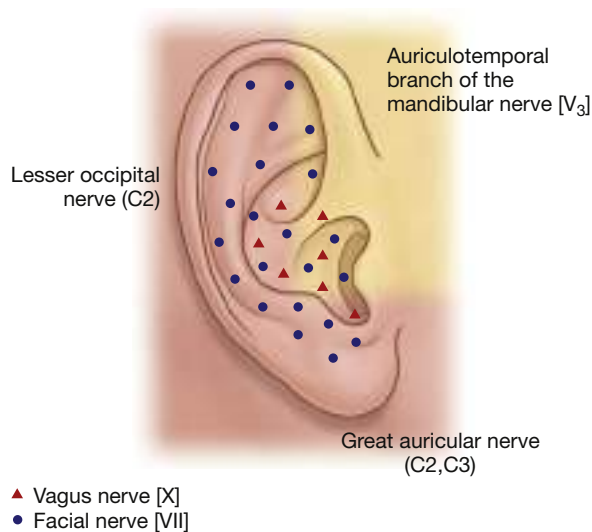


Fig. 8.97 Sensory innervation of the auricle.

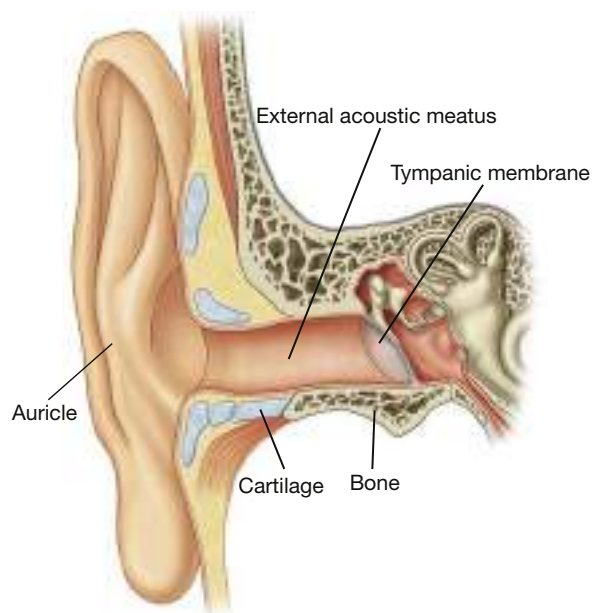


Fig. 8.98 External acoustic meatus.

Venous drainage is through vessels following the arteries.

Lymphatic drainage of the auricle passes anteriorly into parotid nodes, posteriorly into mastoid nodes, and possibly into the upper deep cervical nodes.

External acoustic meatus

The external acoustic meatus extends from the deepest part of the concha to the **tympanic membrane** (eardrum) a distance of approximately 1 inch (2.5 cm) (Fig. 8.98). Its walls consist of cartilage and bone. The lateral one-third is formed from cartilaginous extensions from some of the auricular cartilages, and the medial two-thirds is a bony tunnel in the temporal bone.

Throughout its length the external acoustic meatus is covered with skin, some of which contains hair and modified sweat glands producing **cerumen** (earwax). Its diameter varies, being wider laterally and narrow medially.

The external acoustic meatus does not follow a straight course. From the external opening it passes upward in an anterior direction, then turns slightly posteriorly—still passing upward—and finally turns again in an anterior direction with a slight descent.

Clinical app

Swimmer's ear

Swimmer's ear, often called otitis externa, is a painful condition resulting from an infection in the external acoustic meatus. It frequently occurs in swimmers.

Clinical app

Surfer's ear

Surfer's ear, which is prevalent among individuals who surf or swim in cold water, results from the development of a "bony lump" in the external acoustic meatus. Growth of the lump eventually constricts the meatus and reduces hearing by the affected ear.

Innervation

Sensory innervation of the external acoustic meatus is from several of the cranial nerves. The major sensory input travels through branches of the auriculotemporal nerve, a branch of the mandibular nerve [V₃] (anterior and superior walls), and in the auricular branch of the vagus nerve [X] (posterior and inferior walls). A minor sensory input may also come from a branch of the facial nerve [VII] to the auricular branch of the vagus nerve [X].

Tympanic membrane

The tympanic membrane separates the external acoustic meatus from the middle ear (Figs. 8.99, 8.100). It is at an angle, sloping medially from top to bottom and posteriorly to anteriorly. Its lateral surface therefore faces inferiorly and anteriorly. It consists of a connective tissue core lined with skin on the outside and mucous membrane on the inside.

Around the periphery of the tympanic membrane a **fibrocartilaginous ring** attaches it to the tympanic part of the temporal bone. At its center, a concavity is produced by the attachment on its internal surface of the lower end of the **handle of malleus**, part of the malleus bone in the middle ear. This point of attachment is the **umbo of tympanic membrane**.

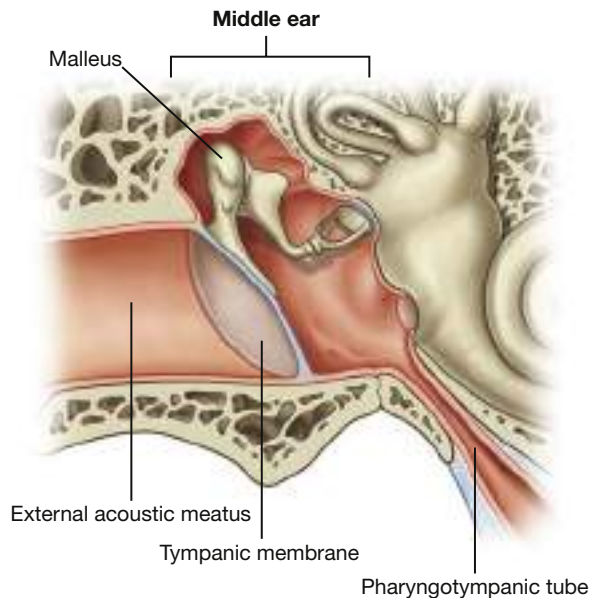


Fig. 8.99 Middle ear.

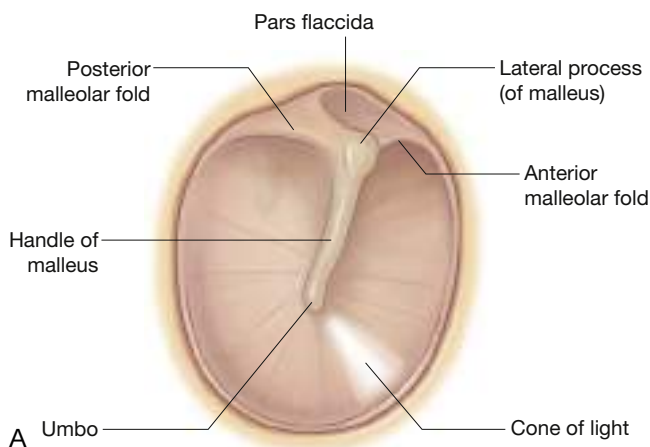


Fig. 8.100 Tympanic membrane (right ear). **A.** Diagram. **B.** Otoscopic view.

Anteroinferior to the umbo of tympanic membrane a bright reflection of light, referred to as the cone of light, is usually visible when examining the tympanic membrane with an otoscope (Fig. 8.100).

Superior to the umbo in an anterior direction is the attachment of the rest of the handle of malleus (Fig. 8.100). At the most superior extent of this line of attachment, a small bulge in the membrane marks the position of the **lateral process** of the malleus as it projects against the internal surface of the tympanic membrane. Extending away from this elevation, on the internal surface of the membrane, are the **anterior** and **posterior malleolar folds**. Superior to these folds the tympanic membrane is thin and slack (the **pars flaccida**), whereas the rest of the membrane is thick and taut (the **pars tensa**).

Innervation

Innervation of the external and internal surfaces of the tympanic membrane is by several cranial nerves:

- Sensory innervation of the skin on the outer surface of the tympanic membrane is primarily by the auriculotemporal nerve, a branch of the mandibular nerve [V_3] with additional participation of the auricular branch of the vagus nerve [X], a small contribution by a branch of the facial nerve [VII] to the auricular branch of the vagus nerve [X], and possibly a contribution from the glossopharyngeal nerve [IX].
- Sensory innervation of the mucous membrane on the inner surface of the tympanic membrane is carried entirely by the glossopharyngeal [IX] nerve.

Clinical app

Examination of the ear

External ear

The external ear is easily examined. The external acoustic meatus and the tympanic membrane require otoscopic examination (see Fig. 8.100B). An otoscope is a device through which light can be shone and the image magnified to inspect the external acoustic meatus and the tympanic membrane.

The examination begins by grasping the posterosuperior aspect of the ear and gently pulling it superiorly, posteriorly and slightly laterally to straighten the external acoustic meatus. The normal tympanic membrane is relatively translucent and has a gray-reddish tinge. The handle of the malleus is visible near the center of the membrane. In the 5 o'clock position, a cone of light is always demonstrated.

Middle and inner ears

In addition to a functional assessment, the middle and inner ear can also be evaluated by computed tomography and MRI.

Tympanic membrane perforation

Although perforation of the tympanic membrane (eardrum) has many causes, trauma and infection are the commonest.

Clinical app—cont'd

Otitis media (infection of the middle ear) is common but can usually be treated by antibiotics. If the infection persists, the chronic inflammatory change may damage the ossicular chain and other structures within the middle ear to produce deafness.

Most ruptures of the tympanic membrane tend to heal spontaneously, but surgical intervention may be necessary if the rupture is large.

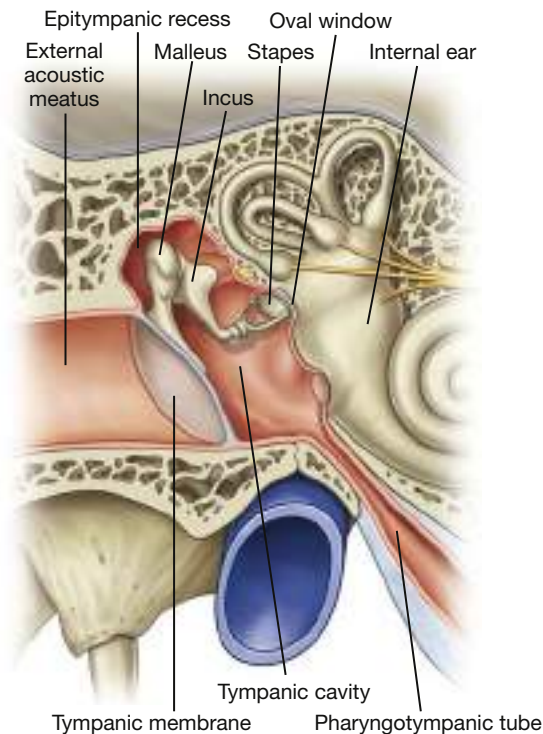


Fig. 8.101 Parts of the middle ear.

Middle ear

The middle ear is an air-filled, mucous membrane-lined space in the temporal bone between the tympanic membrane laterally and the lateral wall of the internal ear medially. It is described as consisting of two parts (Fig. 8.101):

- the **tympanic cavity** immediately adjacent to the tympanic membrane; and
- the **epitympanic recess** superiorly.

The middle ear communicates with the mastoid area posteriorly (via the aditus to the mastoid antrum) and the nasopharynx anteriorly (via the pharyngotympanic tube)(Fig. 8.101). Its basic function is to transmit vibrations of the tympanic membrane across the cavity of the middle ear to the internal ear. It accomplishes this through three interconnected but movable

bones that bridge the space between the tympanic membrane and the internal ear. These bones are the malleus (connected to the tympanic membrane), the incus (connected to the malleus by a synovial joint), and the stapes (connected to the incus by a synovial joint and attached to the lateral wall of the internal ear at the oval window).

Boundaries

The middle ear has a roof and a floor and anterior, posterior, medial, and lateral walls (Fig. 8.102).

Roof (tegmental wall)

The tegmental wall of the middle ear consists of a thin layer of bone, which separates the middle ear from the middle cranial fossa. This layer of bone is the **tegmen tympani** on the anterior surface of the petrous part of the temporal bone (Fig. 8.102).

Floor (jugular wall)

The jugular wall of the middle ear consists of a thin layer of bone that separates it from the internal jugular vein (Fig. 8.102). Occasionally the floor is thickened by the presence of mastoid air cells.

Near the medial border of the floor is a small aperture through which the tympanic branch from the glossopharyngeal nerve [IX] enters the middle ear.

Lateral wall (membranous wall)

The membranous wall of the middle ear consists almost entirely of the tympanic membrane (Fig. 8.102), but because the tympanic membrane does not extend superiorly into the epitympanic recess, the upper part of the membranous wall of the middle ear is the bony lateral wall of the epitympanic recess.

Posterior wall (mastoid wall)

The mastoid wall of the middle ear is only partially complete. The lower part of this wall consists of a bony partition between the tympanic cavity and mastoid air cells. Superiorly, the epitympanic recess is continuous with the **aditus to the mastoid antrum** (Figs. 8.102, 8.103).

Associated with the mastoid wall are (Fig. 8.102):

- the pyramidal eminence, a small elevation through which the tendon of the stapedius muscle enters the middle ear; and
- the opening through which the chorda tympani nerve, a branch of the facial nerve [VII], enters the middle ear.

Anterior wall

The anterior wall of the middle ear is only partially complete. The lower part consists of a thin layer of bone that

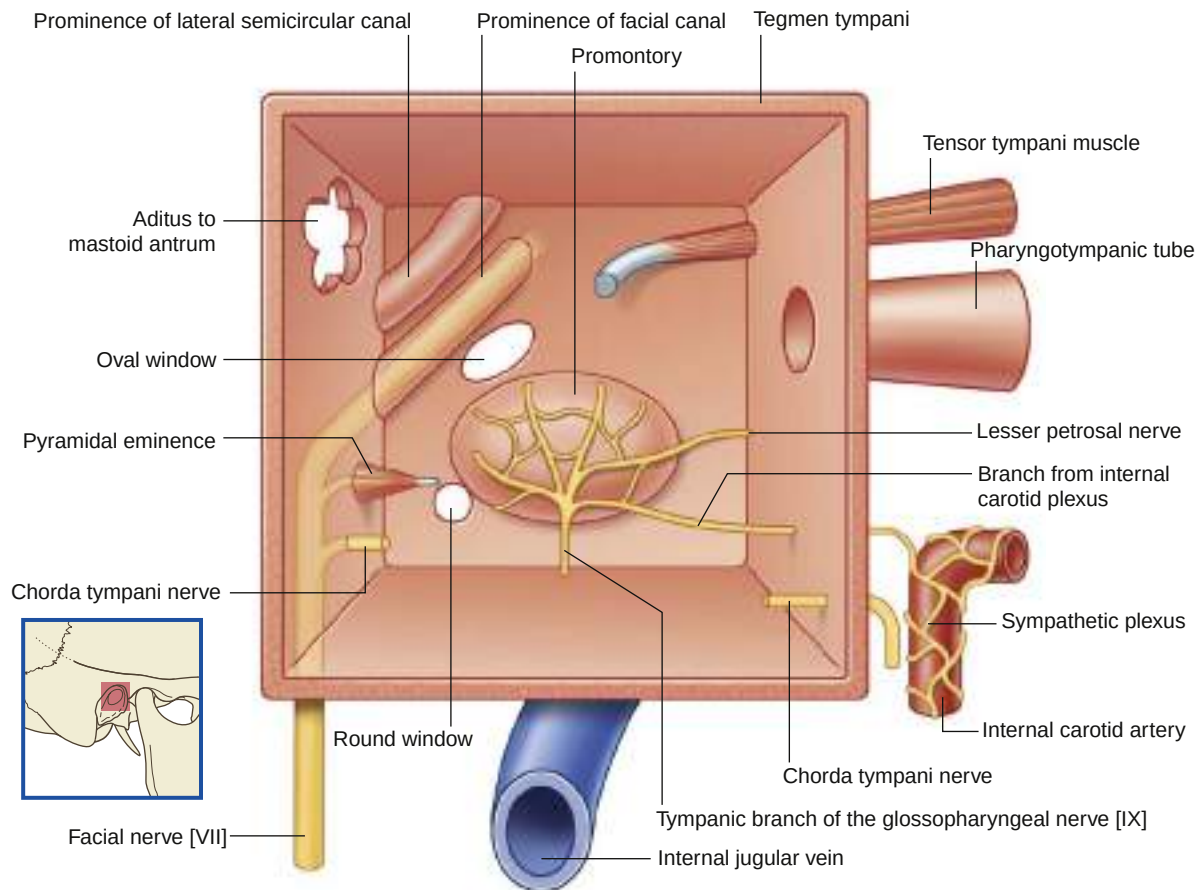


Fig. 8.102 Boundaries of the middle ear.

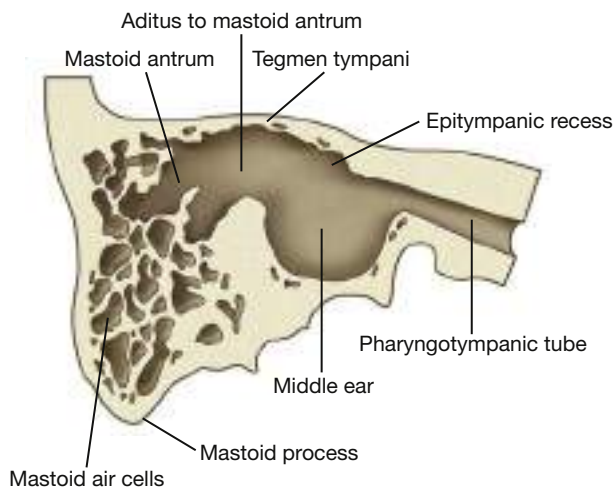


Fig. 8.103 Mastoid antrum and surrounding bone.

separates the tympanic cavity from the internal carotid artery. Superiorly, the wall is deficient because of the presence of (Fig. 8.102):

- a large opening for the entrance of the pharyngotympanic tube into the middle ear; and

- a smaller opening for the canal containing the tensor tympani muscle.

The foramen for the exit of the chorda tympani nerve from the middle ear is also associated with this wall (Fig. 8.102).

Medial wall (labyrinthine wall)

The labyrinthine wall of the middle ear is also the lateral wall of the internal ear. A prominent structure on this wall is a rounded bulge (the **promontory**) produced by the basal coil of the **cochlea**, which is an internal ear structure involved with hearing (see Fig. 8.102).

Associated with the mucous membrane covering the promontory is a plexus of nerves (the **tympanic plexus**), which consists primarily of contributions from the tympanic branch of the glossopharyngeal nerve [IX] and branches from the internal carotid plexus. It supplies the mucous membrane of the middle ear, the mastoid area, and the pharyngotympanic tube and gives rise to the lesser petrosal nerve that enters the middle cranial fossa (see pp. 491, 507). Other structures associated with the labyrinthine wall are two openings, the oval and round windows, and two prominent elevations (see Fig. 8.102):

- The **oval window** is posterosuperior to the promontory, is the point of attachment for the **base of stapes (footplate)**, and ends the chain of bones that transfer vibrations initiated by the tympanic membrane to the cochlea of the internal ear.
- The **round window** is posteroinferior to the promontory.
- Posterior and superior to the oval window on the medial wall is the **prominence of facial canal**, which is a ridge of bone produced by the facial nerve [VII] in its canal as it passes through the temporal bone.
- Just above and posterior to the prominence of facial canal is a broader ridge of bone (**prominence of lateral semicircular canal**) produced by the lateral semicircular canal, which is a structure involved in detecting motion.

Mastoid area

Posterior to the epitympanic recess of the middle ear is the aditus to mastoid antrum, which is the opening to the mastoid antrum (see Fig. 8.103).

The **mastoid antrum** is a cavity continuous with collections of air-filled spaces (the **mastoid cells**) throughout the mastoid part of the temporal bone, including the mastoid process. The mastoid antrum is separated from the middle cranial fossa above by only the thin tegmen tympani.

The mucous membrane lining the mastoid air cells is continuous with the mucous membrane throughout the middle ear. Therefore infections in the middle ear can easily spread into the mastoid area.

Clinical app

Mastoiditis

Infection within the mastoid antrum and mastoid cells is usually secondary to infection in the middle ear. The mastoid cells provide an excellent culture chamber for infection. Infection of the bone (osteomyelitis) may also develop, spreading into the middle cranial fossa.

Pharyngotympanic tube

The pharyngotympanic tube connects the middle ear with the nasopharynx (Fig. 8.104) and equalizes pressure on both sides of the tympanic membrane. Its opening in the middle ear is on the anterior wall, and from here it extends forward, medially, and downward to enter the nasopharynx just posterior to the inferior meatus of the nasal cavity. It consists of:

- a **bony part** (the one-third nearest the middle ear), and
- a **cartilaginous part** (the remaining two-thirds).

The opening of the bony part is clearly visible on the inferior surface of the skull at the junction of the squamous and

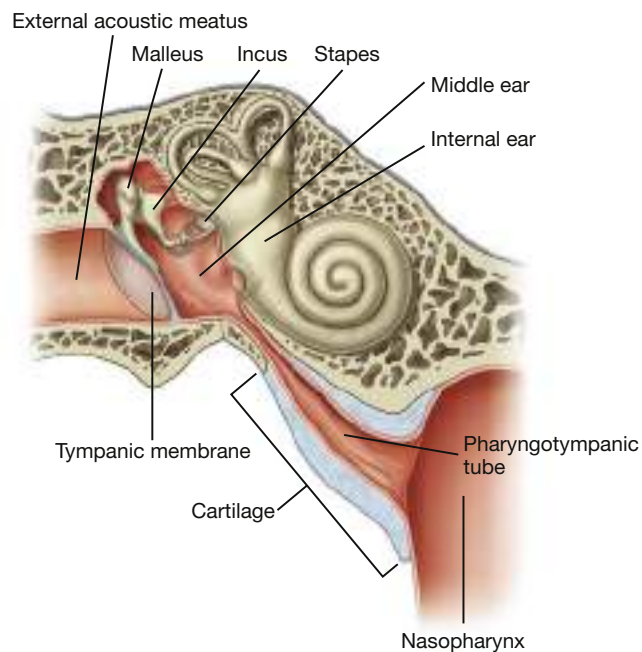


Fig. 8.104 Pharyngotympanic tube.

petrous parts of the temporal bone immediately posterior to the foramen ovale and foramen spinosum.

Vessels

The arterial supply to the pharyngotympanic tube is from several sources. Branches arise from the **ascending pharyngeal artery** (a branch of the external carotid artery) and from two branches of the maxillary artery (the middle meningeal artery and the artery of the pterygoid canal).

Venous drainage of the pharyngotympanic tube is to the pterygoid plexus of veins in the infratemporal fossa.

Innervation

Innervation of the mucous membrane lining the pharyngotympanic tube is primarily from the tympanic plexus because it is continuous with the mucous membrane lining the tympanic cavity, the internal surface of the tympanic membrane, and the mastoid antrum and mastoid cells. This plexus receives its major contribution from the tympanic nerve, a branch of the glossopharyngeal nerve [IX].

Auditory ossicles

The bones of the middle ear consist of the malleus, incus, and stapes. They form an osseous chain across the middle ear from the tympanic membrane to the oval window of the internal ear (Fig. 8.105).

Muscles associated with the auditory ossicles modulate movement during the transmission of vibrations.

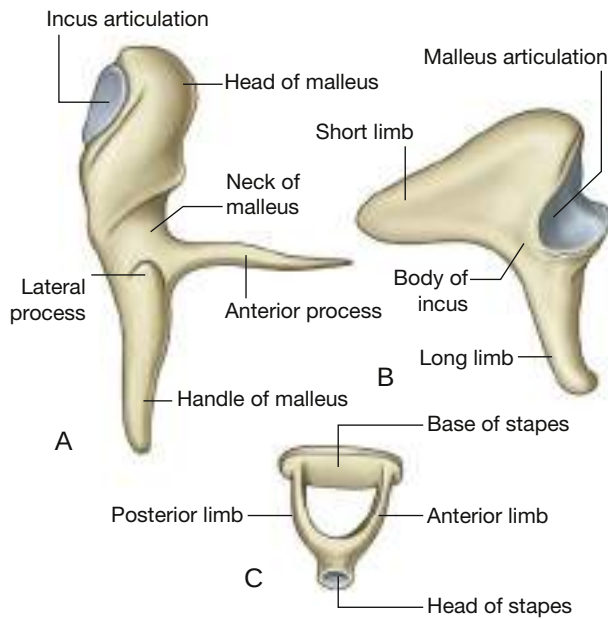


Fig. 8.105 Auditory ossicles. **A.** Malleus. **B.** Incus. **C.** Stapes.

Malleus

The malleus is the largest of the auditory ossicles and is attached to the tympanic membrane. Identifiable parts include the **head of malleus**, **neck of malleus**, **anterior and lateral processes**, and **handle of malleus** (Fig. 8.105). The head of malleus is the rounded upper part of the malleus in the epitympanic recess. Its posterior surface articulates with the incus.

Inferior to the head of malleus is the constricted neck of malleus, and below this are the anterior and lateral processes:

- The anterior process is attached to the anterior wall of the middle ear by a ligament.
- The lateral process is attached to the anterior and posterior malleolar folds of the tympanic membrane.

The downward extension of the malleus, below the anterior and lateral processes, is the handle of malleus, which is attached to the tympanic membrane.

Incus

The second bone in the series of auditory ossicles is the incus. It consists of the **body of incus** and **long and short limbs** (Fig. 8.105):

- The enlarged body of incus articulates with the head of malleus and is in the epitympanic recess.
- The long limb extends downward from the body, paralleling the handle of the malleus, and ends by bending medially to articulate with the stapes.
- The short limb extends posteriorly and is attached by a ligament to the upper posterior wall of the middle ear.

Stapes

The stapes is the most medial bone in the osseous chain and is attached to the oval window. It consists of the **head of stapes**, **anterior and posterior limbs**, and the **base of stapes** (Fig. 8.105):

- The head of stapes is directed laterally and articulates with the long process of the incus.
- The two limbs separate from each other and attach to the oval base.
- The base of stapes fits into the oval window on the labyrinthine wall of the middle ear.

Muscles associated with the ossicles

Two muscles are associated with the bony ossicles of the middle ear—the tensor tympani and stapedius (Table 8.10, Fig. 8.106).

Vessels

Numerous arteries supply the structures in the middle ear:

- The two largest branches are the **tympanic branch** of the maxillary artery and the **mastoid branch** of the occipital or posterior auricular arteries.
- Smaller branches come from the middle meningeal artery, the ascending pharyngeal artery, the artery of the pterygoid canal, and tympanic branches from the internal carotid artery.

Table 8.10 Muscles of the middle ear

Muscle	Origin	Insertion	Innervation	Function
Tensor tympani	Cartilaginous part of pharyngotympanic tube, greater wing of sphenoid, its own bony canal	Upper part of handle of malleus	Branch from mandibular nerve [V ₃]	Contraction pulls handle of malleus medially, tensing tympanic membrane
Stapedius	Attached to inside of pyramidal eminence	Neck of stapes	Branch of facial nerve [VII]	Contraction pulls stapes posteriorly, preventing excessive oscillation

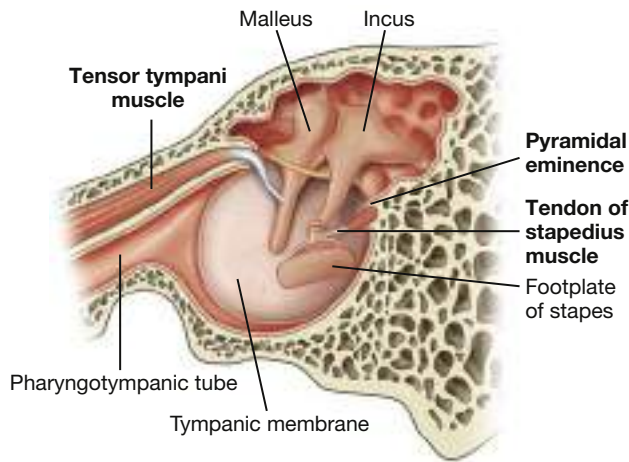


Fig. 8.106 Muscles associated with the auditory ossicles.

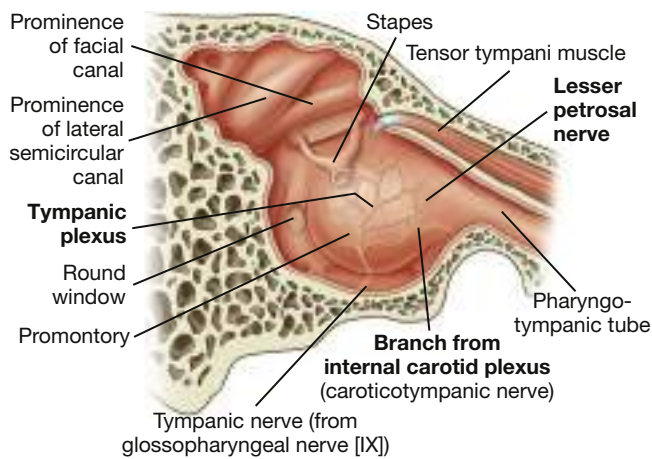


Fig. 8.107 Innervation of the middle ear.

Venous drainage of the middle ear returns to the pterygoid plexus of veins and the superior petrosal sinus.

Innervation

The tympanic plexus innervates the mucous membrane lining the walls and contents of the middle ear, which includes the mastoid area and the pharyngotympanic tube. It is formed by the **tympanic nerve**, a branch of the glossopharyngeal nerve [IX], and from branches of the internal carotid plexus. The tympanic plexus occurs in the mucous membrane covering the promontory, which is the rounded bulge on the labyrinthine wall of the middle ear (Fig. 8.107).

As the glossopharyngeal nerve [IX] exits the skull through the jugular foramen, it gives off the tympanic nerve. This branch re-enters the skull through a small foramen and passes through the bone to the middle ear.

Once in the middle ear, the tympanic nerve forms the **tympanic plexus**, along with branches from the plexus of nerves surrounding the internal carotid artery

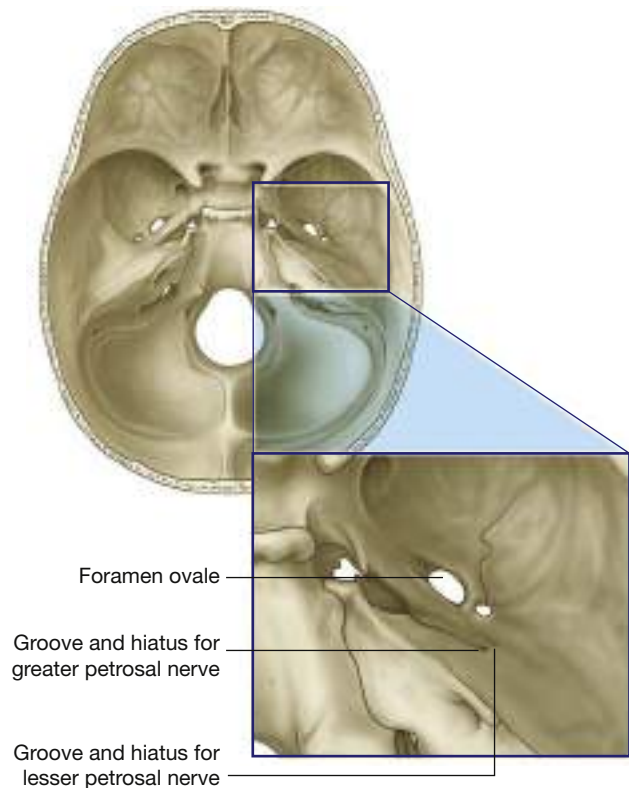


Fig. 8.108 Grooves and hiatuses for the greater and lesser petrosal nerves.

(**caroticotympanic nerves**). Branches from the tympanic plexus supply the mucous membranes of the middle ear, including the pharyngotympanic tube and the mastoid area.

The tympanic plexus also gives off a major branch (the lesser petrosal nerve), which supplies preganglionic parasympathetic fibers to the otic ganglion (Fig. 8.107).

The **lesser petrosal nerve** leaves the area of the promontory, exits the middle ear, travels through the petrous part of the temporal bone, and exits onto the anterior surface of the petrous part of the temporal bone through a hiatus just below the hiatus for the greater petrosal nerve (Fig. 8.108). It continues diagonally across the anterior surface of the temporal bone before exiting the middle cranial fossa through the foramen ovale. Once outside the skull, it enters the otic ganglion.

Internal ear

The internal ear consists of a series of bony cavities (the **bony labyrinth**) and membranous ducts and sacs (the **membranous labyrinth**) within these cavities. All these structures are in the petrous part of the temporal bone between the middle ear laterally and the internal acoustic meatus medially (Figs. 8.109, 8.110).

The bony labyrinth consists of the **vestibule**, three **semicircular canals**, and the **cochlea** (Fig. 8.110). These bony cavities are lined with periosteum and contain a clear fluid (the **perilymph**).

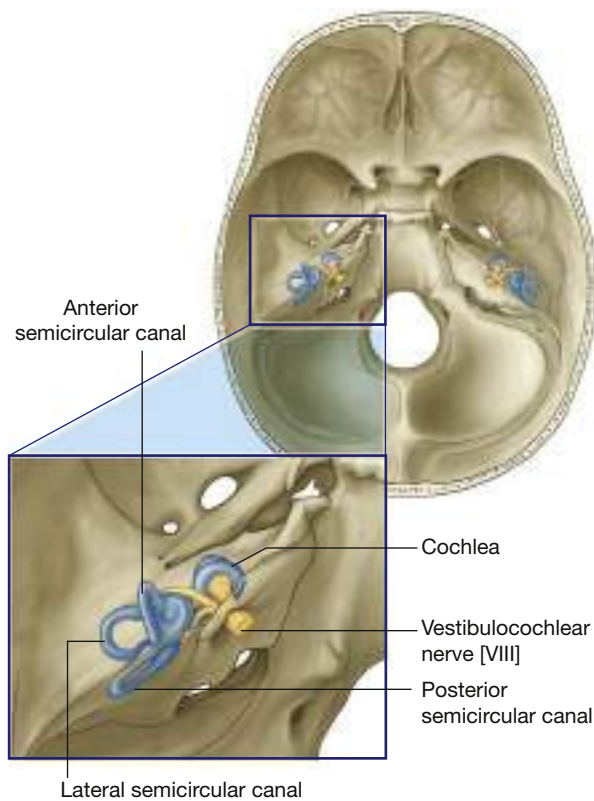


Fig. 8.109 Location of the internal ear in temporal bone.

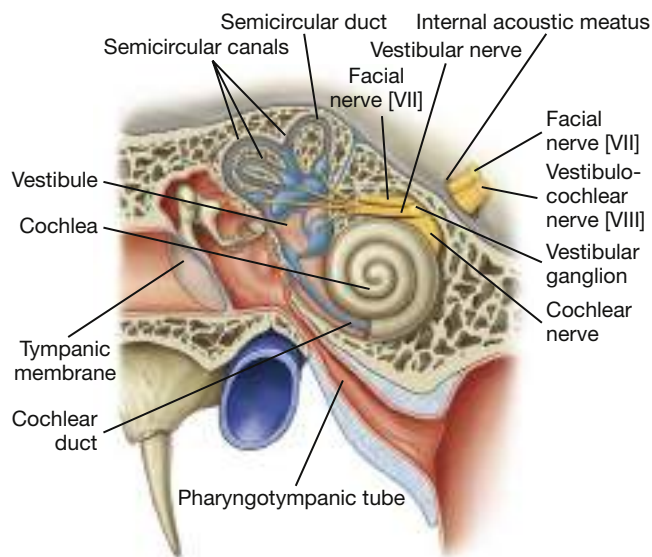


Fig. 8.110 Internal ear.

Suspended within the perilymph but not filling all spaces of the bony labyrinth is the membranous labyrinth, which consists of the **semicircular ducts**, the **cochlear duct**, and two sacs (the **utricle** and the **sacculus**). These membranous spaces are filled with **endolymph**.

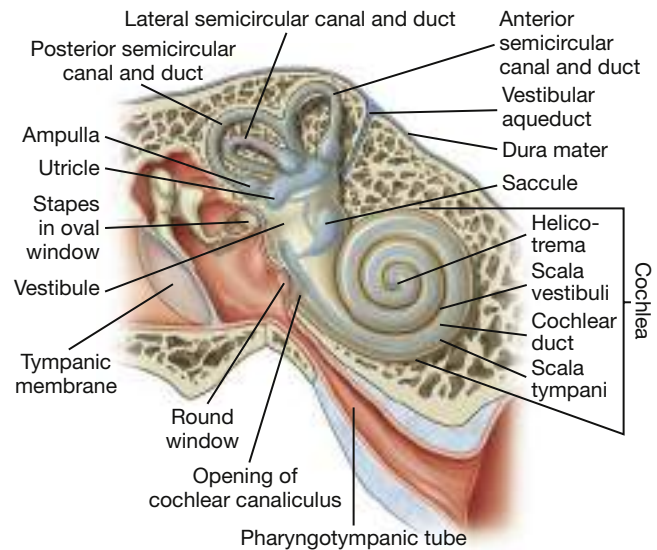


Fig. 8.111 Bony labyrinth.

The structures in the internal ear convey information to the brain about balance and hearing:

- The cochlear duct is the organ of hearing.
- The semicircular ducts, utricle, and sacculus are the organs of balance.

The nerve responsible for these functions is the vestibulocochlear nerve [VIII], which divides into vestibular (balance) and cochlear (hearing) parts after entering the internal acoustic meatus (Fig. 8.110).

Bony labyrinth

The vestibule, which contains the oval window in its lateral wall, is the central part of the bony labyrinth (Fig. 8.111). It communicates anteriorly with the cochlea and posterosuperiorly with the semicircular canals.

A narrow canal (the **vestibular aqueduct**) leaves the vestibule and passes through the temporal bone to open on the posterior surface of the petrous part of the temporal bone.

Semicircular canals

Projecting in a posterosuperior direction from the vestibule are the **anterior**, **posterior**, and **lateral semicircular canals** (Fig. 8.111). Each of these canals forms two-thirds of a circle connected at both ends to the vestibule and with one end dilated to form the **ampulla**. The canals are oriented so that each canal is at right angles to the other two.

Cochlea

Projecting in an anterior direction from the vestibule is the cochlea, which is a bony structure that twists on itself two

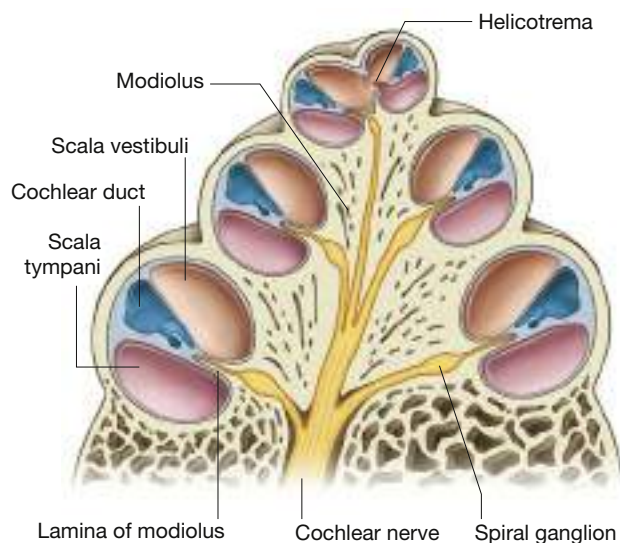


Fig. 8.112 Cochlea.

and one-half to two and three-quarters times around a central column of bone (the **modiolus**). This arrangement produces a cone-shaped structure with a **base of cochlea** that faces posteromedially and an apex that faces anterolaterally (Fig. 8.112). This positions the wide base of the modiolus near the internal acoustic meatus where it is entered by branches of the cochlear part of the vestibulocochlear nerve [VIII].

Extending laterally throughout the length of the modiolus is a thin lamina of bone (the **lamina of modiolus**, or **spiral lamina**) (Fig. 8.112). Circling around the modiolus and held in a central position by its attachment to the lamina of

modiolus is the cochlear duct, which is a component of the membranous labyrinth.

Attached peripherally to the outer wall of the cochlea, the cochlear duct creates two canals (the **scala vestibuli** and the **scala tympani**) (Figs. 8.112, 8.113), which extend throughout the cochlea and are continuous with each other at the apex through a narrow slit (the **helicotrema**):

- The scala vestibuli is continuous with the vestibule.
- The scala tympani is separated from the middle ear by the secondary tympanic membrane covering the round window (Fig. 8.113).

Finally, near the round window is a small channel (the **cochlear canaliculus**), which passes through the temporal bone and opens on its inferior surface into the posterior cranial fossa. This provides a connection between the perilymph-containing cochlea and the subarachnoid space (Fig. 8.113).

Membranous labyrinth

The membranous labyrinth is a continuous system of ducts and sacs within the bony labyrinth. It is filled with endolymph and separated from the periosteum that covers the walls of the bony labyrinth by perilymph (Fig. 8.113).

Consisting of two sacs (the utricle and the saccule) and four ducts (the three semicircular ducts and the cochlear duct), the membranous labyrinth has unique functions related to balance and hearing (Fig. 8.113):

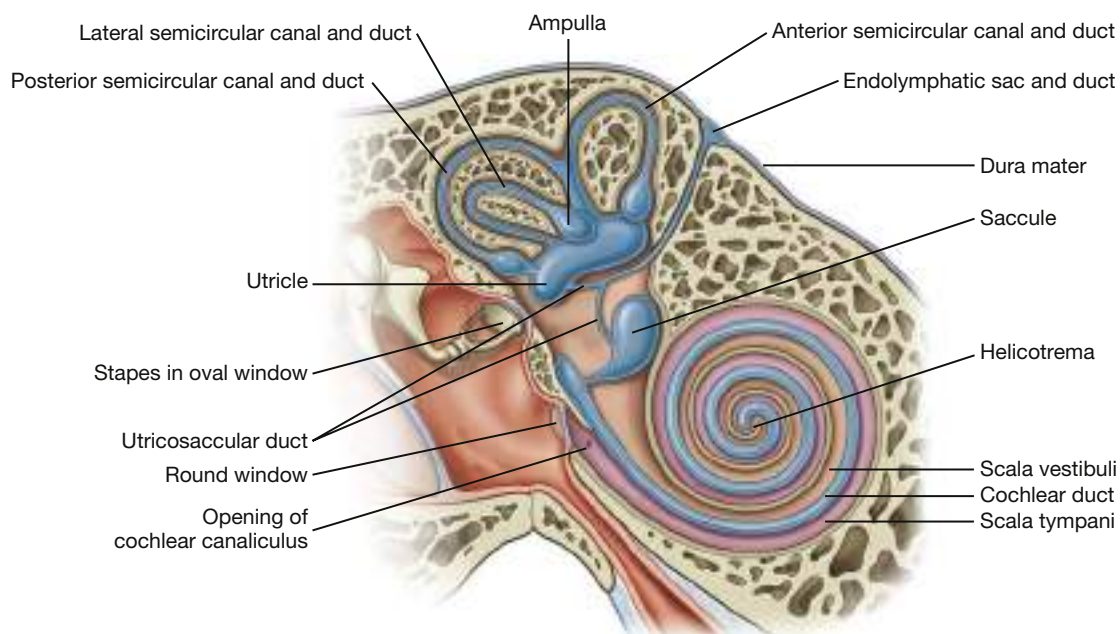


Fig. 8.113 Membranous labyrinth.

- The utricle, saccule, and three semicircular ducts are part of the vestibular apparatus (i.e., organs of balance).
- The cochlear duct is the organ of hearing.

The general organization of the parts of the membranous labyrinth (Fig. 8.113) places:

- the cochlear duct within the cochlea of the bony labyrinth anteriorly;
- the three semicircular ducts within the three semicircular canals of the bony labyrinth posteriorly; and
- the saccule and utricle within the vestibule of the bony labyrinth in the middle.

Organs of balance

Five of the six components of the membranous labyrinth are concerned with balance. These are the two sacs (the utricle and the saccule) and three ducts (the anterior, posterior, and lateral semicircular ducts).

Utricle, saccule, and endolymphatic duct

The utricle is the larger of the two sacs (Fig. 8.113). It is oval, elongated, and irregular in shape and is in the posterosuperior part of the vestibule of the bony labyrinth.

The three semicircular ducts empty into the utricle (Fig. 8.113). Each semicircular duct is similar in shape, including a dilated end forming the ampulla, to its complementary bony semicircular canal, only much smaller.

The saccule is a smaller, rounded sac lying in the antero-inferior part of the vestibule of the bony labyrinth (Fig. 8.113). The cochlear duct empties into it.

The utriculosaccular duct establishes continuity between all components of the membranous labyrinth and connects the utricle and saccule (Fig. 8.113). Branching from this small duct is the **endolymphatic duct**, which enters the vestibular aqueduct (a channel through the temporal bone) to emerge onto the posterior surface of the petrous part of the temporal bone in the posterior cranial fossa. Here the endolymphatic duct expands into the **endolymphatic sac**, which is an extradural pouch that functions in resorption of endolymph.

Sensory receptors

Functionally, sensory receptors for balance are organized into unique structures that are located in each of the components of the vestibular apparatus. In the utricle and saccule, the sense organ is the **macula of utricle** and the **macula of saccule**, respectively, and in the ampulla of each of the three semicircular ducts it is the **crista**.

The utricle responds to linear acceleration in the horizontal plane and sideways head tilts, while the saccule responds to linear acceleration in the vertical plane, such as forward-backward and upward-downward movements. In contrast,

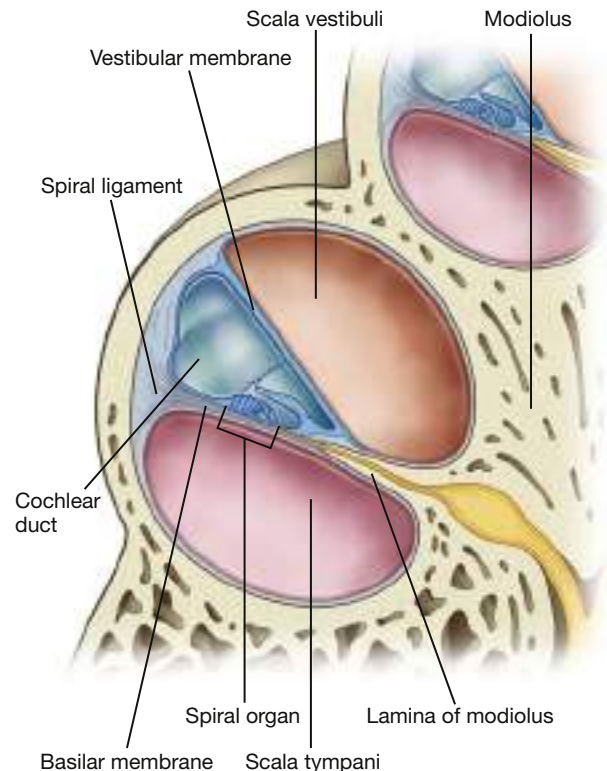


Fig. 8.114 Membranous labyrinth, cross-section.

the receptors in the three semicircular ducts respond to rotational movement in any direction.

Organ of hearing

Cochlear duct

The cochlear duct has a central position in the cochlea of the bony labyrinth dividing it into two canals (the scala vestibuli and the scala tympani). It is maintained in this position by being attached centrally to the lamina of modiolus, which is a thin lamina of bone extending from the modiolus (the central bony core of the cochlea), and peripherally to the outer wall of the cochlea (Figs. 8.113, 8.114).

Thus the triangular-shaped cochlear duct has (Fig. 8.114):

- an outer wall against the bony cochlea consisting of thickened, epithelial-lined periosteum (the **spiral ligament**);
- a roof (the **vestibular membrane**), which separates the endolymph in the cochlear duct from the perilymph in the scala vestibuli and consists of a membrane with a connective tissue core lined on either side with epithelium; and
- a floor, which separates the endolymph in the cochlear duct from the perilymph in the scala tympani and consists of the free edge of the lamina of modiolus and a membrane (the **basilar membrane**) extending from this free edge of the lamina of modiolus to an extension of the spiral ligament covering the outer wall of the cochlea.

The **spiral organ** is the organ of hearing, rests on the basilar membrane, and projects into the enclosed, endolymph-filled cochlear duct (Fig. 8.114).

Vessels

The arterial supply to the internal ear is divided between vessels supplying the bony labyrinth and the membranous labyrinth.

The bony labyrinth is supplied by the same arteries that supply the surrounding temporal bone. These include an anterior tympanic branch from the maxillary artery, a stylomastoid branch from the posterior auricular artery, and a petrosal branch from the middle meningeal artery.

The membranous labyrinth is supplied by the **labyrinthine artery**, which either arises from the anterior inferior cerebellar artery or is a direct branch of the basilar artery. Whatever its origin, it enters the internal acoustic meatus with the facial [VII] and vestibulocochlear [VIII] nerves and eventually divides into:

- a **cochlear branch**, which passes through the modiolus and supplies the cochlear duct; and
- one or two **vestibular branches**, which supply the vestibular apparatus.

Venous drainage of the membranous labyrinth is through vestibular veins and cochlear veins, which follow the arteries. These come together to form a **labyrinthine vein**, which eventually empties into either the inferior petrosal sinus or the sigmoid sinus.

Innervation

The vestibulocochlear nerve [VIII] carries SA fibers for hearing (the cochlear component) and balance (the vestibular component). It enters the lateral surface of the brainstem, between the pons and medulla, after exiting the temporal bone through the internal acoustic meatus and crossing the posterior cranial fossa.

Inside the temporal bone, at the distal end of the internal acoustic meatus, the vestibulocochlear nerve divides to form:

- the **cochlear nerve**, and
- the **vestibular nerve**.

The vestibular nerve enlarges to form the **vestibular ganglion** before dividing into **superior and inferior parts**, which distribute to the three semicircular ducts and the utricle and saccule (see Fig. 8.110).

The cochlear nerve enters the base of the cochlea and passes upward through the modiolus. The ganglion cells of the cochlear nerve are in the **spiral ganglion** at the base of the lamina of modiolus as it winds around the modiolus (see Fig. 8.112). Branches of the cochlear nerve pass through the

lamina of modiolus to innervate the receptors in the spiral organ.

Facial nerve [VII] in the temporal bone

The facial nerve [VII] is closely associated with the vestibulocochlear nerve [VIII] as it enters the internal acoustic meatus of the temporal bone. Traveling through the temporal bone, its path and several of its branches are directly related to the internal and middle ears.

The facial nerve [VII] enters the internal acoustic meatus in the petrous part of the temporal bone (Fig. 8.115A). The vestibulocochlear nerve and the labyrinthine artery accompany it.

At the distal end of the internal acoustic meatus, the facial nerve [VII] enters the facial canal and continues laterally between the internal and middle ears. At this point the facial nerve [VII] enlarges and bends posteriorly and laterally. The enlargement is the sensory **geniculate ganglion**. As the facial canal continues, the facial nerve [VII] turns sharply downward and running in an almost vertical direction, it exits the skull through the stylomastoid foramen (Fig. 8.115A).

Branches

Greater petrosal nerve. At the geniculate ganglion, the facial nerve [VII] gives off the greater petrosal nerve (Fig. 8.115A). This is the first branch of the facial nerve [VII]. The greater petrosal nerve leaves the geniculate ganglion, travels anteromedially through the temporal bone, and emerges through the hiatus for the greater petrosal nerve on the anterior surface of the petrous part of the temporal bone (see Fig. 8.108). The greater petrosal nerve carries preganglionic parasympathetic fibers to the pterygopalatine ganglion.

Continuing beyond the bend, the position of the facial nerve [VII] is indicated on the medial wall of the middle ear by a bulge (see Fig. 8.107).

Nerve to stapedius and chorda tympani. Near the beginning of its vertical descent, the facial nerve [VII] gives off a small branch, the nerve to stapedius (Fig. 8.115A), which innervates the stapedius muscle, and just before it exits the skull, the facial nerve [VII] gives off the chorda tympani nerve (Fig. 8.115).

The chorda tympani does not immediately exit the temporal bone, but ascends to enter the middle ear through its posterior wall, passing near the upper aspect of the tympanic membrane between the malleus and incus (Fig. 8.115B). It then exits the middle ear through a canal leading to the **petrotympanic fissure** and exits the skull through this fissure to join the lingual nerve in the infratemporal fossa.

Transmission of sound

A sound wave enters the external acoustic meatus and strikes the tympanic membrane moving it medially (Fig. 8.116). As

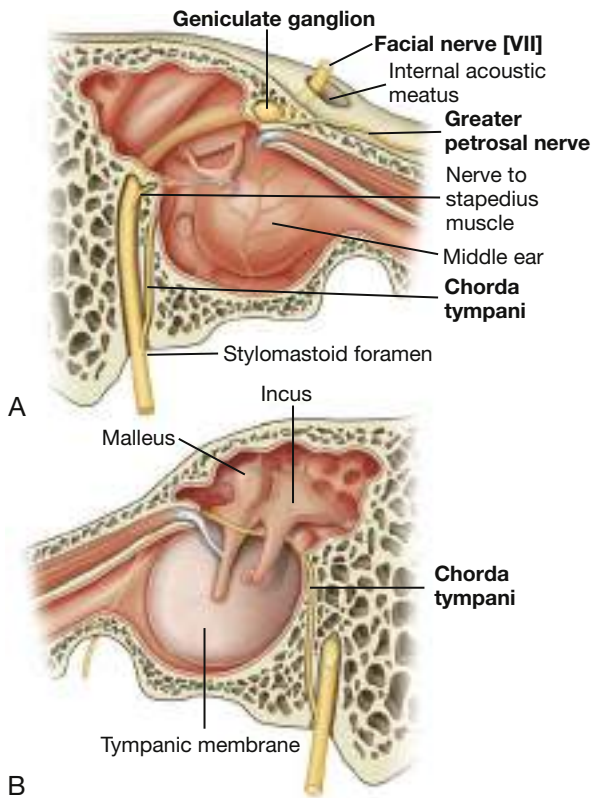


Fig. 8.115 A. Facial nerve in the temporal bone. **B.** Chorda tympani in the temporal bone.

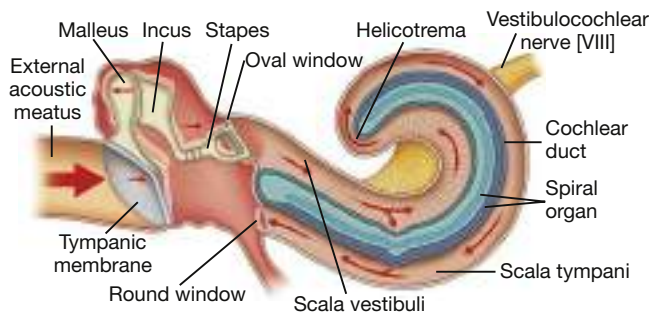


Fig. 8.116 Transmission of sound.

the handle of malleus is attached to this membrane, the handle of malleus also moves medially. This moves the head of the malleus laterally. Because the heads of the malleus and incus articulate with each other, the head of the incus is also moved laterally. This pushes the long process of the incus medially. The long process articulates with the stapes, so its movement causes the stapes to move medially. In turn, because the base of stapes is attached to the oval window, the oval window is also moved medially.

This action completes the transfer of a large-amplitude, low-force, airborne wave that vibrates the tympanic membrane into a small-amplitude, high-force vibration of the

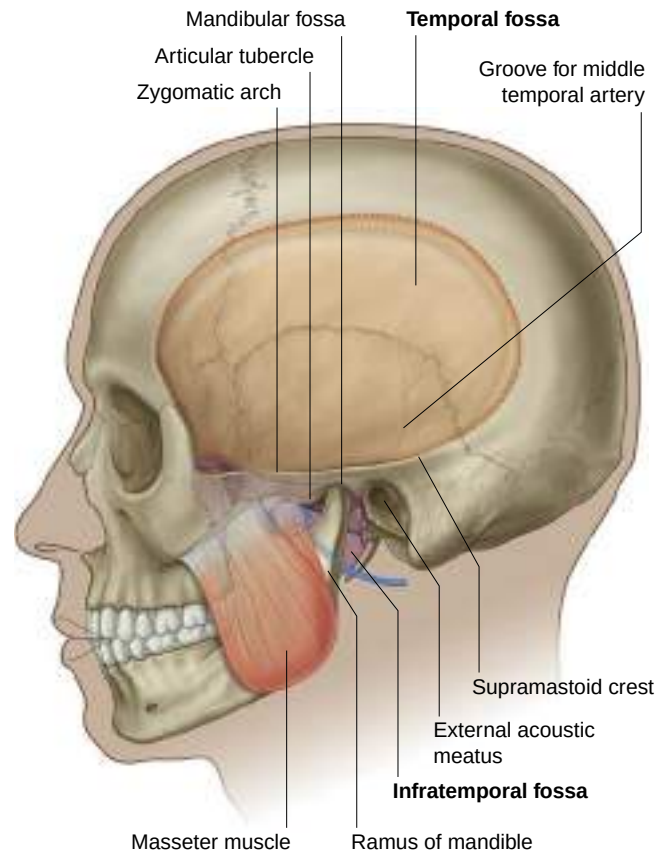


Fig. 8.117 Temporal and infratemporal fossae.

oval window, which generates a wave in the fluid-filled scala vestibuli of the cochlea.

The wave established in the perilymph of the scala vestibuli moves through the cochlea and causes an outward bulging of the secondary tympanic membrane covering the round window at the lower end of the scala tympani (Fig. 8.116). This wave causes the basilar membrane to vibrate, which in turn leads to stimulation of receptor cells in the spiral organ.

The receptor cells send impulses back to the brain through the cochlear part of the vestibulocochlear nerve [VIII] where they are interpreted as sound.

If the sounds are too loud, causing excessive movement of the tympanic membrane, contraction of the tensor tympani muscle (attached to the malleus) and/or the stapedius muscle (attached to the stapes) dampens the vibrations of the ossicles and decreases the force of the vibrations reaching the oval window.

TEMPORAL AND INFRATEMPORAL FOSSAE

The temporal and infratemporal fossae are interconnected spaces on the lateral side of the head (Fig. 8.117). Their boundaries are formed by bone and soft tissues.

The temporal fossa is superior to the infratemporal fossa, above the zygomatic arch, and communicates with the infratemporal fossa below through the gap between the zygomatic arch and the more medial surface of the skull.

The infratemporal fossa is a wedge-shaped space deep to the masseter muscle and the underlying ramus of mandible. Structures that travel between the cranial cavity, neck, pterygopalatine fossa, floor of the oral cavity, floor of the orbit, temporal fossa, and superficial regions of the head pass through it.

Of the four muscles of mastication (masseter, temporalis, medial pterygoid, and lateral pterygoid) that move the lower jaw at the temporomandibular joint, one (masseter) is lateral to the infratemporal fossa, two (medial and lateral pterygoid) are in the infratemporal fossa, and one (temporalis) fills the temporal fossa.

Bony framework

Bones that contribute significantly to the boundaries of the temporal and infratemporal fossae include the temporal, zygomatic, and sphenoid bones and the maxilla and mandible (Figs. 8.118, 8.119).

Parts of the frontal and parietal bones are also involved.

Temporal bone

The squamous part of the temporal bone forms part of the bony framework of the temporal and infratemporal fossae (Fig. 8.118).

The tympanic part of the temporal bone forms the posteromedial corner of the roof of the infratemporal fossa and articulates with the head of mandible to form the temporomandibular joint.

The lateral surface of the squamous part of the temporal bone is marked by two surface features on the medial wall of the temporal fossa (Fig. 8.118):

- a transversely oriented **supramastoid crest**, which extends posteriorly from the base of the zygomatic process and marks the posteroinferior border of the temporal fossa; and
- a vertically oriented **groove for middle temporal artery**, a branch of the superficial temporal artery.

Two features that participate in forming the temporomandibular joint on the inferior aspect of the root of the zygomatic process of the temporal bone are the articular tubercle and the mandibular fossa (Fig. 8.118). Both are elongate from medial to lateral. Posterior to the mandibular fossa is the external acoustic meatus. The tympanic part of the temporal bone is a flat concave plate of bone that curves inferiorly from the back of the mandibular fossa and forms part of the wall of the external acoustic meatus.

When viewed from inferiorly, there is a distinct **tympanosquamous fissure** between the tympanic and squamous parts of the temporal bone. Medially, a small slip of bone from the petrous part of the temporal bone insinuates itself into the fissure and forms a **petrotympanic fissure** between it and the tympanic part (Fig. 8.118).

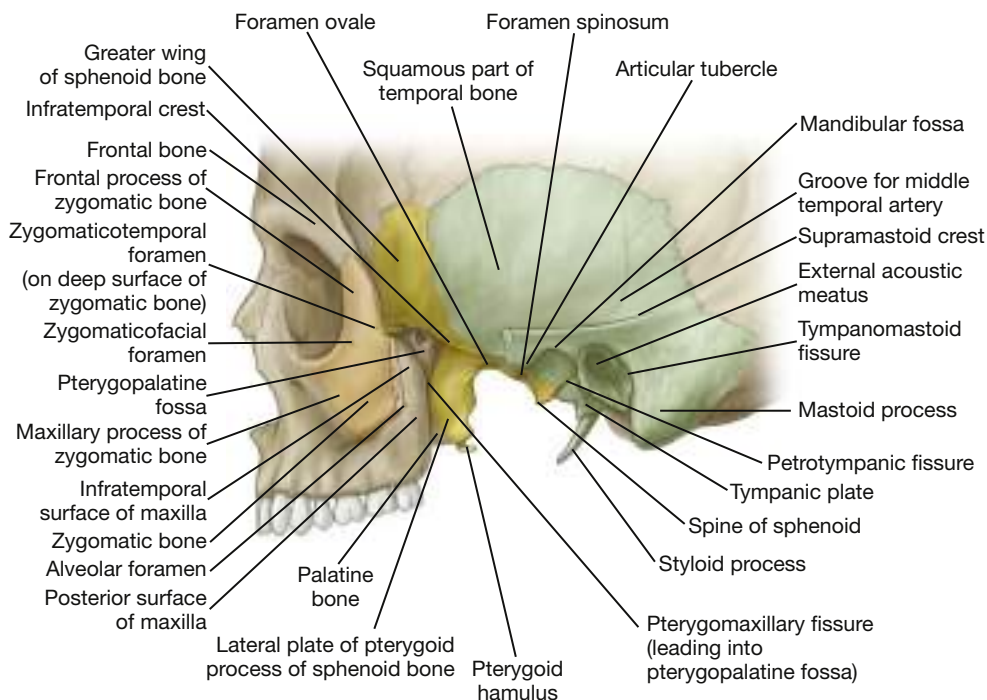


Fig. 8.118 Bony features related to the temporal and infratemporal fossae.

The chorda tympani nerve exits the skull and enters the infratemporal fossa through the medial end of the petrotympanic fissure.

Sphenoid bone

The parts of the sphenoid bone that form part of the bony framework of the infratemporal fossa are the lateral plate of the pterygoid process and the greater wing (Fig. 8.118). The greater wing also forms part of the medial wall of the temporal fossa.

The greater wings extend one on each side from the body of sphenoid. They project laterally from the body and curve superiorly. The inferior and lateral surfaces form the roof of the infratemporal fossa and the medial wall of the temporal fossa, respectively.

The sharply angled boundary between the lateral and inferior surfaces of the greater wing is the **infratemporal crest** (Fig. 8.118).

Two apertures (the foramen ovale and the foramen spinosum) pass through the base of the greater wing and allow the mandibular nerve [V_3] and the middle meningeal artery, respectively, to pass between the middle cranial fossa and infratemporal fossa. In addition, one or more small sphenoidal emissary foramina penetrate the base of the greater wing anteromedial to the foramen ovale and allow emissary veins to pass between the pterygoid plexus of veins in the infratemporal fossa and the cavernous sinus in the middle cranial fossa.

Projecting vertically downward from the greater wing immediately medial to the foramen spinosum is the irregularly shaped **spine of sphenoid**, which is the attachment site for the cranial end of the sphenomandibular ligament (Fig. 8.118).

The lateral plate of the pterygoid process is a vertically oriented sheet of bone that projects posterolaterally from the pterygoid process (Fig. 8.118). Its lateral and medial surfaces provide attachment for the lateral and medial pterygoid muscles, respectively.

Maxilla

The posterior surface of the maxilla contributes to the anterior wall of the infratemporal fossa (Fig. 8.118). This surface is marked by a foramen for the posterior superior alveolar nerve and vessels. The superior margin forms the inferior border of the inferior orbital fissure.

Zygomatic bone

The zygomatic bone is a quadrangular-shaped bone that forms the palpable bony prominence of the cheek (Fig. 8.118):

- A **maxillary process** extends anteromedially to articulate with the zygomatic process of the maxilla.

- A **frontal process** extends superiorly to articulate with the zygomatic process of the frontal bone.
- A **temporal process** extends posteriorly to articulate with the zygomatic process of the temporal bone to complete the zygomatic arch.

A small zygomaticofacial foramen on the lateral surface of the zygomatic bone transmits the zygomaticofacial nerve and vessels onto the cheek (Fig. 8.118).

A thin plate of bone extends posteromedially from the frontal process and contributes to the lateral wall of the orbit on one side and the anterior wall of the temporal fossa on the other. A zygomaticotemporal foramen on the temporal fossa surface of the plate where it attaches to the frontal process is for the zygomaticotemporal nerve.

Ramus of mandible

The **ramus of mandible** is quadrangular in shape and has medial and lateral surfaces and condylar and coronoid processes (Fig. 8.119).

The lateral surface of the ramus of mandible is generally smooth except for the presence of a few obliquely oriented

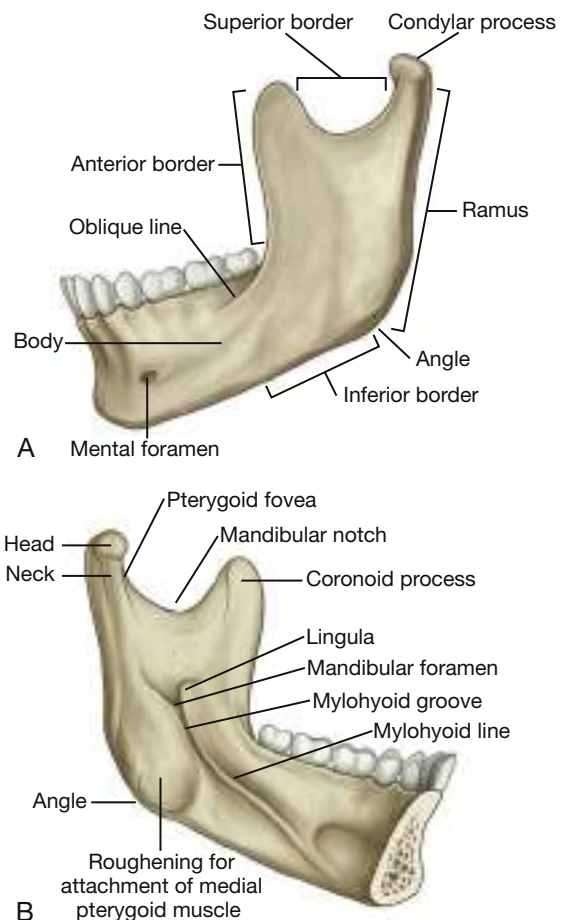


Fig. 8.119 Mandible. A. Lateral view of left side. B. Medial view of left side.

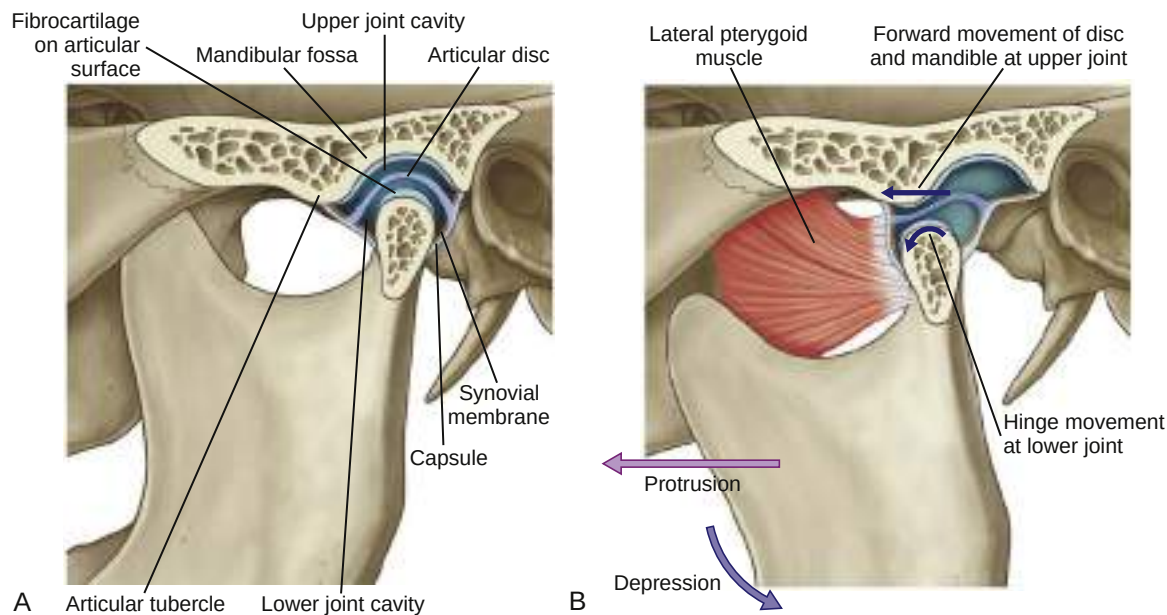


Fig. 8.120 Temporomandibular joint. **A.** Mouth closed. **B.** Mouth open.

ridges. Most of the lateral surface provides attachment for the masseter muscle.

The posterior and inferior borders of the ramus intersect to form the **angle of mandible**, while the superior border is notched to form the **mandibular notch** (Fig. 8.119). The anterior border is sharp and is continuous below with the **oblique line** on the body of mandible.

The **coronoid process** extends superiorly from the junction of the anterior and superior borders of the ramus. It is a flat, triangular process that provides attachment for the temporalis muscle (Fig. 8.119).

The **condylar process** extends superiorly from the posterior and superior borders of the ramus (Fig. 8.119). It consists of:

- the **head of mandible**, which is expanded medially and participates in forming the temporomandibular joint; and
- the **neck of mandible**, which bears a shallow depression (the **pterygoid fovea**) on its anterior surface for attachment of the lateral pterygoid muscle.

The medial surface of the ramus of mandible is the lateral wall of the infratemporal fossa (Fig. 8.119B). Its most distinctive feature is the **mandibular foramen**, which is the superior opening of the mandibular canal. The inferior alveolar nerve and vessels pass through this foramen.

Immediately anterosuperior to the mandibular foramen is a triangular elevation (the **lingula**) for attachment of the mandibular end of the sphenomandibular ligament (see Fig. 8.119).

An elongate groove (the **mylohyoid groove**) extends anteroinferiorly from the mandibular foramen (see Fig. 8.119). The **nerve to mylohyoid** is in this groove.

Posteriorly to the mylohyoid groove and mandibular foramen, the medial surface of the ramus of mandible is roughened for attachment of the medial pterygoid muscle.

Temporomandibular joints

The temporomandibular joints, one on each side, allow opening and closing of the mouth and complex chewing or side-to-side movements of the lower jaw.

Each joint is synovial and is formed between the head of mandible and the articular fossa and articular tubercle of the temporal bone (see Fig. 8.120A).

Unlike most other synovial joints where the articular surfaces of the bones are covered by a layer of hyaline cartilage, those of the temporomandibular joint are covered by fibrocartilage. In addition, the joint is completely divided by a fibrous **articular disc** into two parts:

- The lower part of the joint allows mainly the hinge-like depression and elevation of the mandible.
- The upper part of the joint allows the head of the mandible to translocate forward (protrusion) onto the articular tubercle and backward (retraction) into the mandibular fossa.

Opening the mouth involves both depression and protrusion (see Fig. 8.120B).

The forward or protrusive movement allows greater depression of the mandible by preventing backward movement of the angle of mandible into structures in the neck.

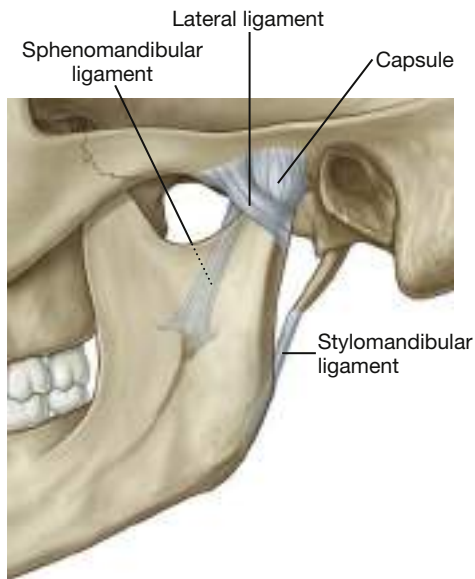


Fig. 8.121 Ligaments associated with the temporomandibular joint.

Joint capsule

The **synovial membrane** of the joint capsule lines all nonarticular surfaces of the upper and lower compartments of the joint and is attached to the margins of the articular disc (see Fig. 8.120B).

The **fibrous membrane** of the joint capsule encloses the temporomandibular joint complex and is attached (see Fig. 8.120B):

- above, along the anterior margin of the articular tubercle;
- laterally and medially along the margins of the articular fossa;
- posteriorly to the region of the tympanosquamous suture; and
- below around the upper part of the neck of mandible.

The articular disc attaches around its periphery to the inner aspect of the fibrous membrane (see Fig. 8.120B).

Extracapsular ligaments

Three extracapsular ligaments are associated with the temporomandibular joint—the lateral, sphenomandibular, and the stylomandibular ligaments (Fig. 8.121):

- The **lateral ligament** is closest to the joint, just lateral to the capsule, and runs diagonally backward from the margin of the articular tubercle to the neck of the mandible.
- The **sphenomandibular ligament** is medial to the temporomandibular joint and runs from the spine of the sphenoid bone at the base of the skull to the lingula on the medial side of the ramus of mandible.

- The **stylomandibular ligament** passes from the styloid process of the temporal bone to the posterior margin and angle of mandible.

Movements of the mandible

A chewing or grinding motion occurs when the movements at the temporomandibular joint on one side are coordinated with a reciprocal set of movements at the joint on the other side. Muscles that generate these movements are the four muscles of mastication (masseter, temporalis, medial pterygoid, and lateral pterygoid) (Table 8.11), and a number of muscles associated with the floor of the oral cavity (geniohyoid, mylohyoid) and anterior triangle of the neck (anterior belly of digastric). Movements of the mandible include depression, elevation, protrusion, and retraction (Fig. 8.122).

Clinical app

Temporomandibular joint disorders

The term *temporomandibular joint disorder* refers to a number of problems in and around the temporomandibular joint. Like other synovial joints, the temporomandibular joint is subject to arthritis, bony fusion, trauma, dislocation and fracture as well as developmental anomalies. Typical symptoms associated with temporomandibular joint problems include eating difficulties, clicking and popping, pain, earache, and headache. The joint and most muscles that move the joint are innervated by the trigeminal nerve. Inflammation of the joint or surrounding tissues can result in reflex muscle spasms that limit movement. “Grinding of the teeth” and malalignment of the occlusal surfaces of the teeth also can result in temporomandibular joint problems.

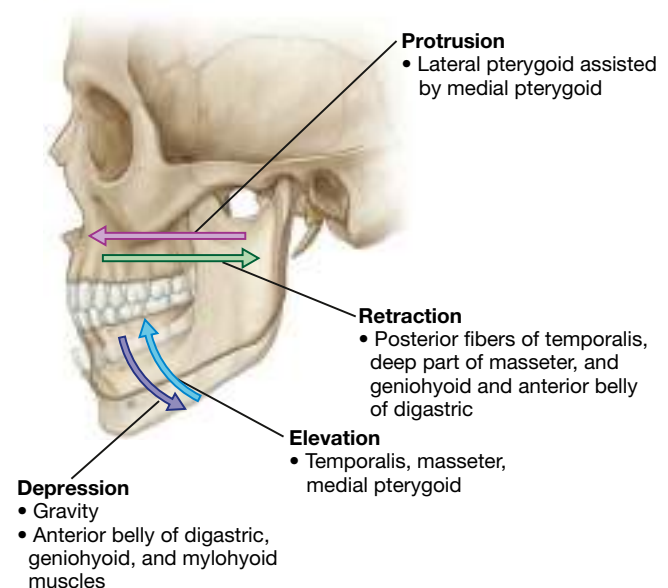


Fig. 8.122 Movements of the temporomandibular joint.

Table 8.11 Muscles of mastication

Muscle	Origin	Insertion	Innervation	Function
Masseter	Superficial part: maxillary process of the zygomatic bone and the anterior two-thirds of the zygomatic process of the maxilla Deep part: medial aspect of the zygomatic arch and posterior part of its inferior margin	Superficial part: angle of the mandible and related posterior part of the lateral surface of the ramus of the mandible Deep part: central and upper part of ramus of mandible as high as the coronoid process	Masseteric nerve from the anterior trunk of the mandibular nerve [V ₃]	Elevation of mandible
Temporalis	Bone of temporal fossa and temporal fascia	Coronoid process of mandible and anterior margin of ramus of mandible almost to last molar tooth	Deep temporal nerves from the anterior trunk of the mandibular nerve [V ₃]	Elevation and retraction of mandible; also participates in side-to-side movements
Medial pterygoid	Deep head—medial surface of lateral plate of pterygoid process and pyramidal process of palatine bone; superficial head—tuberosity of maxilla and pyramidal process of palatine bone	Medial surface of mandible near angle	Nerve to medial pterygoid from the mandibular nerve [V ₃]	Elevation and side-to-side movements of the mandible
Lateral pterygoid	Upper head—roof of infratemporal fossa; lower head—lateral surface of lateral plate of the pterygoid process	Capsule of temporomandibular joint in the region of attachment to the articular disc and to the pterygoid fovea on the neck of mandible	Nerve to lateral pterygoid from the anterior trunk of mandibular nerve [V ₃] or from buccal branch	Protrusion and side-to-side movements of the mandible

Masseter muscle

The **masseter** muscle is a powerful muscle of mastication that elevates the mandible (Table 8.11, Fig. 8.123). It overlies the lateral surface of the ramus of mandible.

Temporal fossa

The temporal fossa is a narrow, fan-shaped space that covers the lateral surface of the skull (Fig. 8.124A):

- Its upper margin is defined by a pair of temporal lines that arch across the skull from the zygomatic process of the frontal bone to the supramastoid crest of the temporal bone.
- It is limited laterally by the **temporal fascia**, which is a tough, fan-shaped aponeurosis overlying the temporalis muscle and attached by its outer margin to the superior temporal line and by its inferior margin to the zygomatic arch.
- Anteriorly, it is limited by the posterior surface of the frontal process of the zygomatic bone and the posterior surface of the zygomatic process of the frontal bone, which separate the temporal fossa behind from the orbit in front.
- Its inferior margin is marked by the zygomatic arch laterally and by the infratemporal crest of the greater wing of the sphenoid medially (Fig. 8.124B)—between these two features, the floor of the temporal fossa is open medially to the infratemporal fossa and laterally to the region containing the masseter muscle.

Contents

The major structure in the temporal fossa is the temporalis muscle (Fig. 8.125).

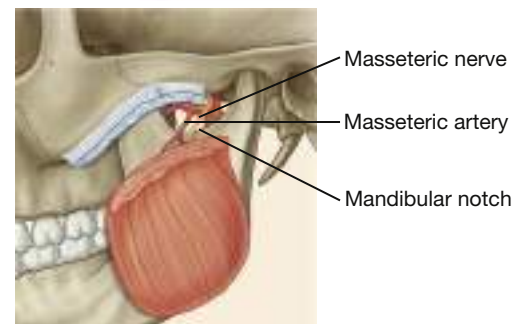
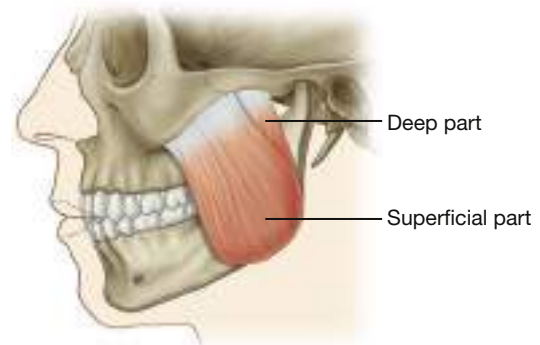


Fig. 8.123 Masseter muscle.

Also passing through the fossa is the zygomaticotemporal branch of the maxillary nerve [V₂], which enters the region through the zygomaticotemporal foramen on the temporal fossa surface of the zygomatic bone (Fig. 8.126).

Temporalis muscle

The **temporalis** muscle is a large, flat muscle that fills much of the temporal fossa (Table 8.11, Fig. 8.125). The more

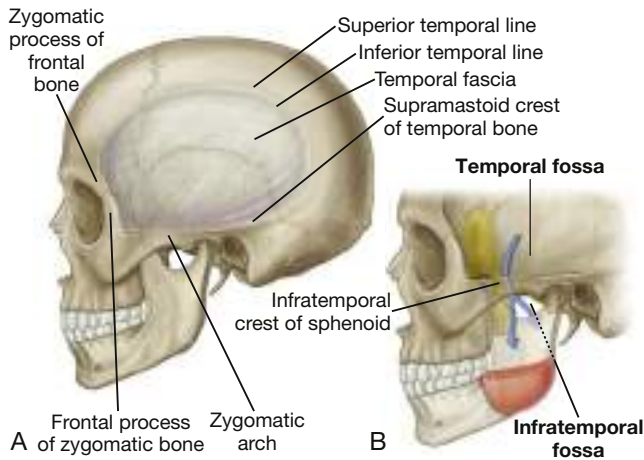


Fig. 8.124 Temporal fossa. A. Lateral view. B. Lateral view showing the infratemporal fossa.

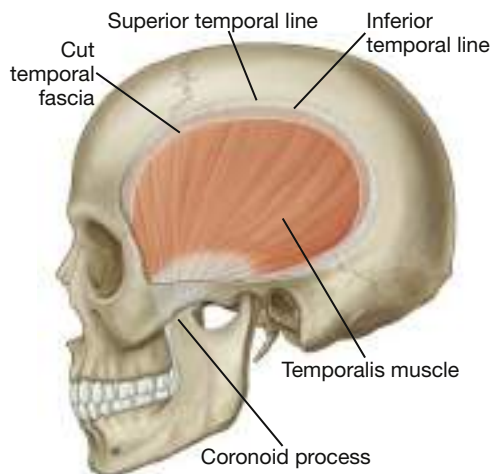


Fig. 8.125 Temporalis muscle. Lateral view.

anterior fibers are oriented vertically, and the more posterior fibers are oriented horizontally.

Deep temporal nerves

The deep temporal nerves, usually two in number, originate from the anterior trunk of the mandibular nerve [V_3] in the infratemporal fossa (Fig. 8.126). They pass superiorly and around the infratemporal crest of the greater wing of the sphenoid to enter the temporal fossa deep to the temporalis muscle, and supply the temporalis muscle.

Zygomaticotemporal nerve

The zygomaticotemporal nerve is a branch of the zygomatic nerve (Fig. 8.126). The zygomatic nerve is a branch of the maxillary nerve [V_2], which originates in the pterygopalatine fossa and passes into the orbit.

The zygomaticotemporal nerve enters the temporal fossa through one or more small foramina on the temporal fossa surface of the zygomatic bone (Fig. 8.126).

Branches of the zygomaticotemporal nerve pass superiorly between the bone and the temporalis muscle to penetrate the temporal fascia and supply the skin of the temple (Fig. 8.126).

Deep temporal arteries

Normally two in number, these vessels originate from the maxillary artery in the infratemporal fossa and travel with the deep temporal nerves around the infratemporal crest of the greater wing of the sphenoid to supply the temporalis muscle (Fig. 8.126). They anastomose with branches of the middle temporal artery.

Middle temporal artery

The middle temporal artery originates from the superficial temporal artery just superior to the root of the zygomatic arch between this structure and the external ear (Fig. 8.126). It penetrates the temporalis fascia, passes under the margin of the temporalis muscle, and travels superiorly on the deep surface of the temporalis muscle.

The middle temporal artery supplies the temporalis and anastomoses with branches of the deep temporal arteries.

Infratemporal fossa

The wedge-shaped infratemporal fossa is inferior to the temporal fossa and between the ramus of mandible laterally and the wall of the pharynx medially. It has a roof, a lateral wall, and a medial wall and is open to the neck posteroinferiorly (Fig. 8.127):

- The **roof** is formed by the inferior surfaces of the greater wing of the sphenoid and the temporal bone; contains the foramen spinosum, foramen ovale, and the petrotympanic fissure; is lateral to the infratemporal crest of the greater wing of the sphenoid; and is open superiorly to the temporal fossa.
- The **lateral wall** is the medial surface of the ramus of mandible, which contains the opening to the mandibular canal.
- The **medial wall** is formed anteriorly by the lateral plate of the pterygoid process and more posteriorly by the pharynx and by two muscles of the soft palate (tensor and levator veli palatini muscles), and contains the pterygomaxillary fissure anteriorly, which allows structures to pass between the infratemporal and pterygopalatine fossae.
- The **anterior wall** is formed by part of the posterior surface of the maxilla and contains the alveolar foramen, and the upper part opens as the inferior orbital fissure into the orbit.

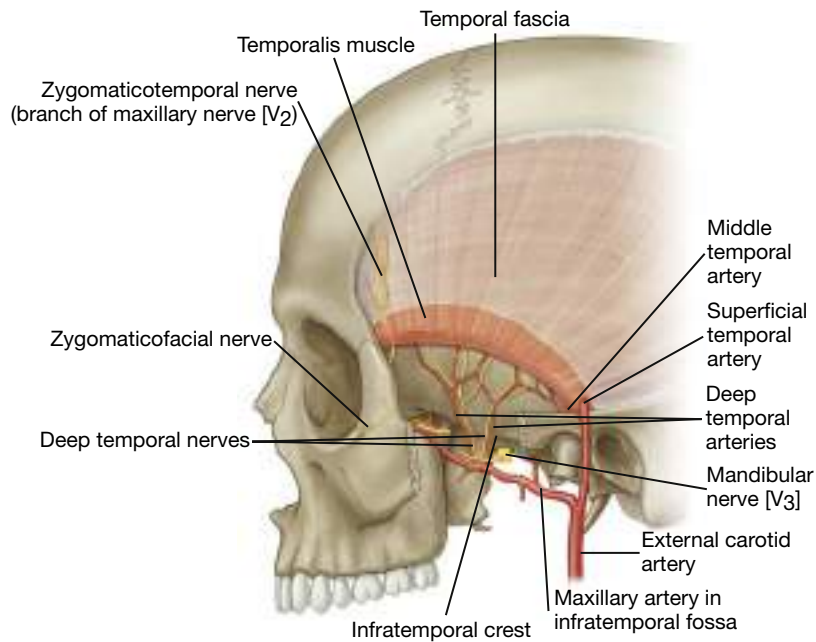


Fig. 8.126 Nerves and arteries of the temporal fossa.

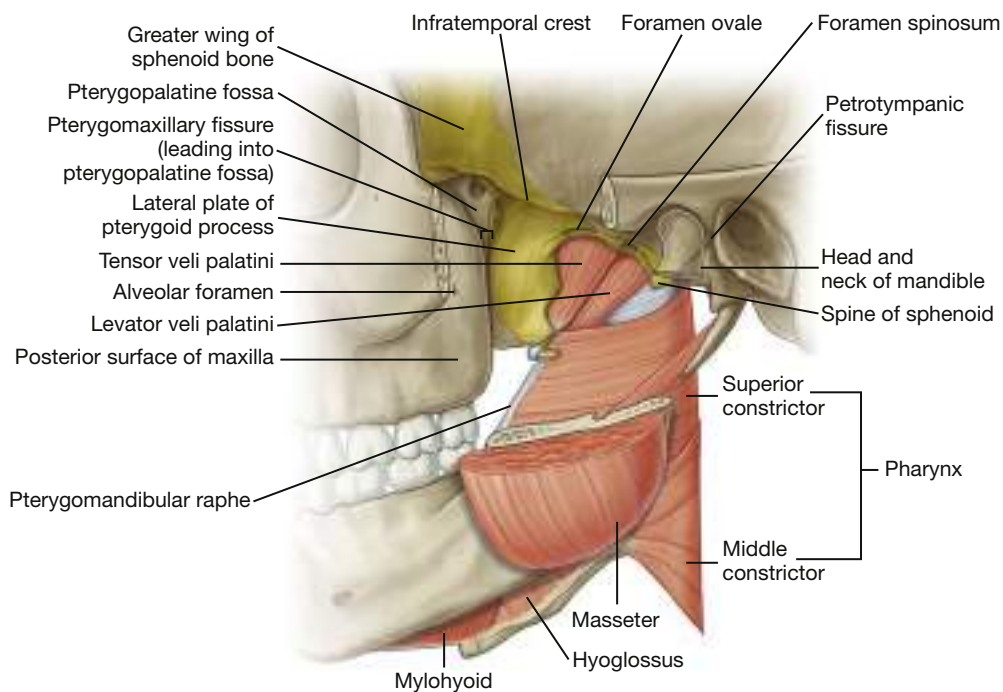


Fig. 8.127 Borders of the infratemporal fossa.

Contents

Major contents of the infratemporal fossa include the sphenomandibular ligament, medial and lateral pterygoid muscles, the maxillary artery, the mandibular nerve [V₃], branches of the facial nerve [VII] and the glossopharyngeal nerve [IX], and the pterygoid plexus of veins.

Sphenomandibular ligament

The sphenomandibular ligament is an extracapsular ligament of the temporomandibular joint (Fig. 8.128). It is attached superiorly to the spine of the sphenoid bone and expands inferiorly to attach to the lingula of the mandible and the posterior margin of the mandibular foramen (Fig. 8.128).

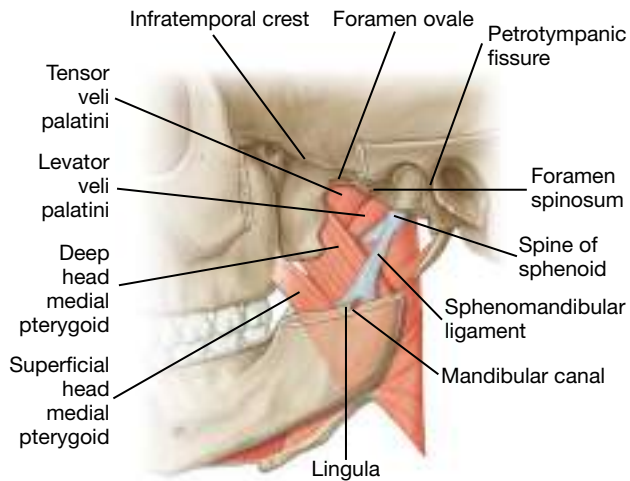


Fig. 8.128 Medial pterygoid muscle.

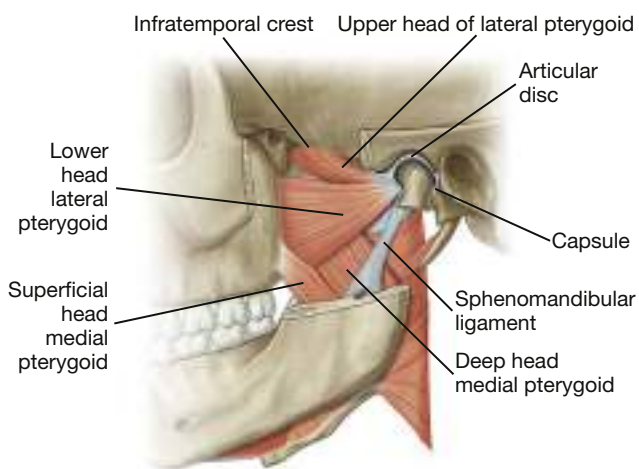


Fig. 8.129 Lateral pterygoid muscle.

Medial and lateral pterygoid muscles

The **medial pterygoid** muscle is quadrangular in shape and has deep and superficial heads (Table 8.11, Fig. 8.128).

The medial pterygoid mainly elevates the mandible. Because it passes obliquely backward to insert into the mandible, it also assists the lateral pterygoid muscle in protruding the lower jaw.

The **lateral pterygoid** is a thick triangular muscle and like the medial pterygoid muscle has two heads (Table 8.11, Fig. 8.129). The fibers from both heads of the lateral pterygoid muscle converge to insert into the pterygoid fovea of the neck of mandible and into the capsule of the temporomandibular joint in the region where the capsule is attached internally to the articular disc.

Unlike the medial pterygoid muscle whose fibers tend to be oriented vertically, those of the lateral pterygoid are oriented almost horizontally. As a result, when the lateral

pterygoid contracts, it pulls the articular disc and head of mandible forward onto the articular tubercle and is therefore the major protruder of the lower jaw.

When the lateral and medial pterygoids contract on only one side, the chin moves to the opposite side. When opposite movements at the two temporomandibular joints are coordinated, a chewing movement results.

Mandibular nerve [V₃]

The mandibular nerve [V₃] is the largest of the three divisions of the trigeminal nerve [V].

Unlike the ophthalmic [V₁] and maxillary [V₂] nerves, which are purely sensory, the mandibular nerve [V₃] is both motor and sensory.

In addition to carrying general sensation from the teeth and gingivae of the mandible, the anterior two-thirds of the tongue, mucosa on the floor of the oral cavity, the lower lip, skin over the temple and lower face, and part of the cranial dura mater, the mandibular nerve [V₃] also carries motor innervation to most of the muscles that move the mandible, one of the muscles (tensor tympani) in the middle ear, and one of the muscles of the soft palate (tensor veli palatini).

All branches of the mandibular nerve [V₃] originate in the infratemporal fossa.

Like the ophthalmic [V₁] and maxillary [V₂] nerves, the sensory part of the mandibular nerve [V₃] originates from the trigeminal ganglion in the middle cranial fossa (Fig. 8.130; also see Fig. 8.36, pg. 477):

- The sensory part of the mandibular nerve [V₃] drops vertically through the foramen ovale and enters the infratemporal fossa between the tensor veli palatini muscle and the upper head of the lateral pterygoid muscle.
- The small motor root of the trigeminal nerve [V] passes medial to the trigeminal ganglion in the cranial cavity, then passes through the foramen ovale and immediately joins the sensory part of the mandibular nerve [V₃].

Branches

Soon after the sensory and motor roots join, the mandibular nerve [V₃] gives rise to a small meningeal branch and to the nerve to the medial pterygoid and then divides into anterior and posterior trunks (Fig. 8.130):

- Branches from the anterior trunk are the buccal, masseteric, and deep temporal nerves and the nerve to lateral pterygoid, all of which, except the buccal nerve (which is predominantly sensory), are motor nerves.
- Branches from the posterior trunk are the auriculotemporal, lingual, and inferior alveolar nerves, all of which, except a small nerve (nerve to mylohyoid) that branches from the inferior alveolar nerve, are sensory nerves.

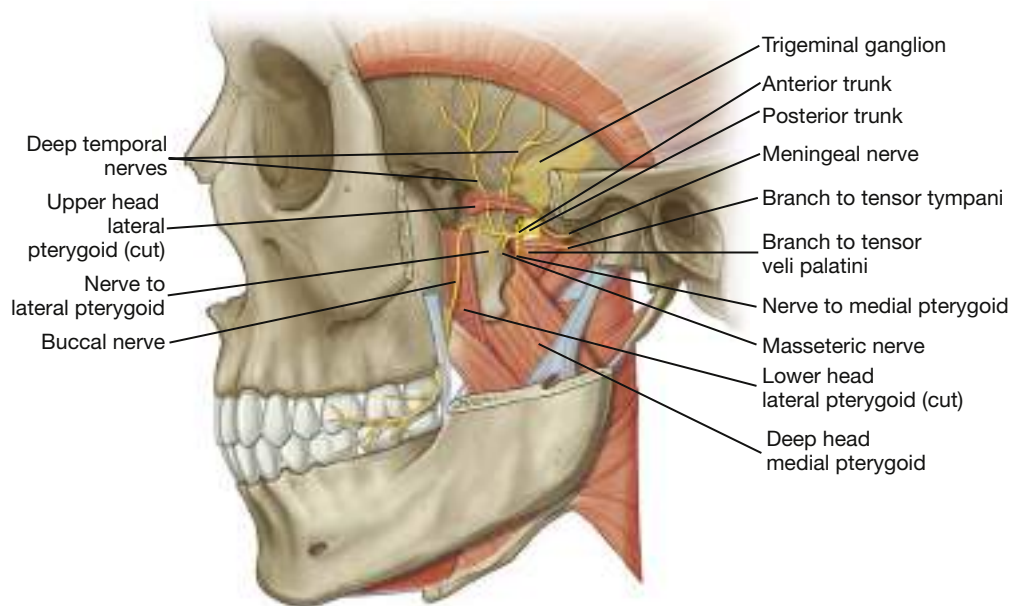


Fig. 8.130 Mandibular nerve [V₃]*—meningeal nerve, nerve to medial pterygoid, and branches of anterior trunk.*

Meningeal branch

The meningeal branch originates from the medial side of the mandibular nerve [V₃] and ascends to leave the infratemporal fossa with the middle meningeal artery, and re-enters the cranial cavity through the foramen spinosum (Fig. 8.130). It is sensory for the dura mater, mainly of the middle cranial fossa, and also supplies the mastoid cells that communicate with the middle ear.

Nerve to medial pterygoid

The nerve to medial pterygoid also originates medially from the mandibular nerve [V₃] (Fig. 8.130). It descends to enter and supply the deep surface of the medial pterygoid muscle. Near its origin from the mandibular nerve [V₃], it has two small branches:

- One of these supplies the tensor veli palatini.
- The other ascends to supply the tensor tympani muscle, which occupies a small bony canal above and parallel to the pharyngotympanic tube in the temporal bone.

Buccal nerve

The buccal nerve is a branch of the anterior trunk of the mandibular nerve [V₃] (Fig. 8.130). It is predominantly a sensory nerve, but may also carry the motor innervation to the lateral pterygoid muscle and to part of the temporalis muscle.

The buccal nerve passes laterally between the upper and lower heads of lateral pterygoid and then descends around the anterior margin of the insertion of temporalis muscle to the anterior margin of the ramus of mandible, often slipping through the tendon of temporalis. It continues into the cheek lateral to the buccinator muscle to supply general sensory nerves to the adjacent skin and oral mucosa and the buccal gingivae of the lower molars.

Masseteric nerve

The masseteric nerve is a branch of the anterior trunk of the mandibular nerve [V₃]. It passes laterally over the lateral pterygoid muscle and through the mandibular notch to penetrate and supply the masseter muscle (Fig. 8.130; also see Fig. 8.123).

Deep temporal nerves

The deep temporal nerves, usually two in number, originate from the anterior trunk of the mandibular nerve [V₃] (Fig. 8.130). They pass laterally above the lateral pterygoid muscle and curve around the infratemporal crest to ascend in the temporal fossa and supply the temporalis muscle from its deep surface (Fig. 8.130; also see Fig. 8.126).

Nerve to lateral pterygoid

The nerve to lateral pterygoid may originate directly as a branch from the anterior trunk of the mandibular nerve [V₃] or from its buccal branch (Fig. 8.130). From its origin, it passes directly into the deep surface of the lateral pterygoid muscle.

Auriculotemporal nerve

The auriculotemporal nerve is the first branch of the posterior trunk of the mandibular nerve [V₃] and originates as two roots that pass posteriorly and enclose between them the middle meningeal artery ascending from the maxillary artery to the foramen spinosum (Fig. 8.131A).

After the two roots join, the auriculotemporal nerve passes first between the tensor veli palatini muscle and the upper head of lateral pterygoid muscle and then between the sphenomandibular ligament and the neck of mandible. It curves laterally around the neck of mandible and then ascends deep to the parotid gland between the temporomandibular joint and ear.

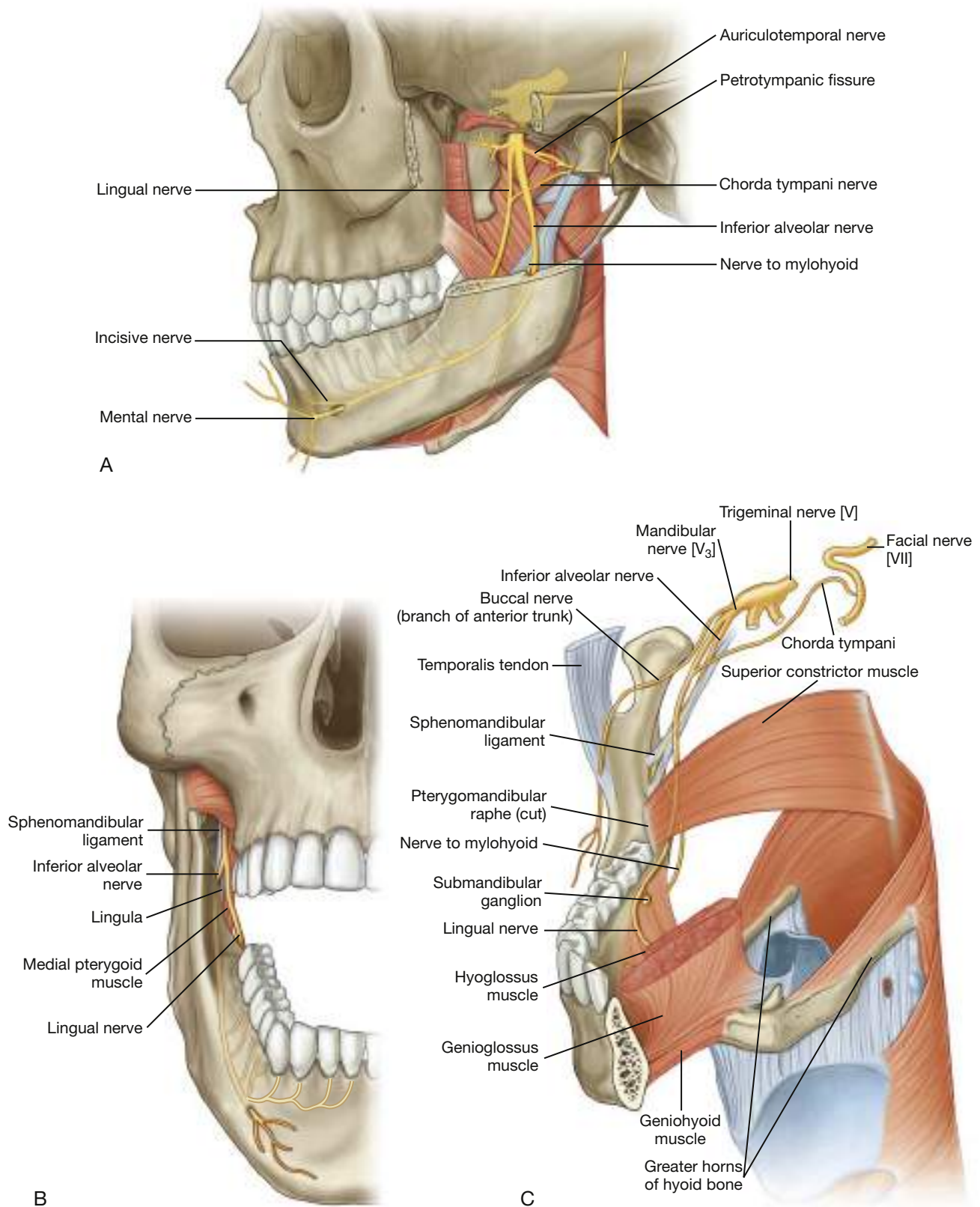


Fig. 8.131 Mandibular nerve [V₃]—posterior trunk. **A.** Lateral view. **B.** Anterior view. **C.** Anteromedial view.

The terminal branches of the auriculotemporal nerve carry general sensation from skin over a large area of the temple. In addition, the auriculotemporal nerve contributes to sensory innervation of the external ear, the external auditory meatus, tympanic membrane, and temporomandibular joint. It also delivers postganglionic parasympathetic nerves from the glossopharyngeal nerve [IX] to the parotid gland.

Lingual nerve

The **lingual nerve** is a major sensory branch of the posterior trunk of the mandibular nerve [V₃] (Fig. 8.131). It carries general sensation from the anterior two-thirds of the tongue, oral mucosa on the floor of the oral cavity, and lingual gingivae associated with the lower teeth.

The lingual nerve is joined high in the infratemporal fossa by the chorda tympani branch of the facial nerve [VII] (Fig. 8.131A,C), which carries:

- taste from the anterior two-thirds of the tongue, and
- parasympathetic fibers to all salivary glands below the level of the oral fissure.

The lingual nerve first descends between the tensor veli palatini muscle and the lateral pterygoid muscle where it is joined by the chorda tympani nerve and then descends across the lateral surface of the medial pterygoid muscle to enter the oral cavity (Fig. 8.131A).

The lingual nerve enters the oral cavity between the posterior attachment of the mylohyoid muscle to the mylohyoid line and the attachment of the superior constrictor of the pharynx to the pterygomandibular raphe. As the lingual nerve enters the floor of the oral cavity, it is in a shallow groove on the medial surface of the mandible immediately inferior to the last molar tooth (Fig. 8.131B,C). In this position, it is palpable through the oral mucosa and in danger when operating on the molar teeth and gingivae.

The lingual nerve passes into the tongue on the lateral surface of the hyoglossus muscle where it is attached to the **submandibular ganglion** (Fig. 8.131C), which contains the cell bodies for the postganglionic parasympathetic fibers of the chorda tympani nerve carried from the infratemporal fossa into the floor of the oral cavity on the lingual nerve.

Inferior alveolar nerve

The **inferior alveolar nerve**, like the lingual nerve, is a major sensory branch of the posterior trunk of the mandibular nerve [V₃] (Fig. 8.131). In addition to innervating all lower teeth and much of the associated gingivae, it also supplies the mucosa and skin of the lower lip and skin of the chin. It has one motor branch, which innervates the mylohyoid muscle and the anterior belly of the digastric muscle.

The inferior alveolar nerve originates deep to the lateral pterygoid muscle from the posterior trunk of the mandibular

nerve [V₃] in association with the lingual nerve. It descends on the lateral surface of the medial pterygoid muscle, passes between the sphenomandibular ligament and the ramus of mandible, and then enters the mandibular canal through the mandibular foramen. Just before entering the mandibular foramen, it gives origin to the **nerve to mylohyoid** (Fig. 8.131A,C), which lies in the mylohyoid groove inferior to the foramen and continues anteriorly below the floor of the oral cavity to innervate the mylohyoid muscle and the anterior belly of the digastric muscle.

The inferior alveolar nerve passes anteriorly within the mandibular canal of the lower jaw (Fig. 8.131A,B). The mandibular canal and its contents are inferior to the roots of the molar teeth, and the roots can sometimes curve around the canal, making extraction of these teeth difficult.

The inferior alveolar nerve supplies branches to the three molar teeth and the second premolar tooth and associated labial gingivae and then divides into its two terminal branches (Fig. 8.131A):

- the **incisive nerve**, which continues in the mandibular canal to supply the first premolar, incisor, and canine teeth and related gingivae; and
- the **mental nerve**, which exits the mandible through the mental foramen and supplies the lower lip and chin. The mental nerve is palpable and sometimes visible through the oral mucosa adjacent to the roots of the premolar teeth.

Clinical app

Lingual nerve injury

A lingual nerve injury proximal to where the chorda tympani joins it in the infratemporal fossa will produce loss of general sensation from the anterior two-thirds of the tongue, oral mucosa, gingivae, the lower lip, and the chin.

If a lingual nerve lesion is distal to the site where it is joined by the chorda tympani, secretion from the salivary glands below the oral fissure and taste from the anterior two-thirds of the tongue will also be lost.

Clinical app

Anesthesia of the inferior alveolar nerve

Anesthesia of the inferior alveolar nerve is widely practiced by most dentists. To anesthetize this nerve, the needle is placed lateral to the palatoglossal arch in the oral cavity and is advanced along the medial surface of the inferior third of the ramus of the mandible so that the anesthetic can be deposited in the region of the mandibular foramen.

Chorda tympani and the lesser petrosal nerve

Branches of two cranial nerves join branches of the mandibular nerve [V₃] in the infratemporal fossa (Fig. 8.132). These are the chorda tympani branch of the facial nerve [VII] and the lesser petrosal nerve, a branch of the tympanic plexus in the middle ear, which had its origin from a branch of the glossopharyngeal nerve [IX] (see Fig. 8.102, pg. 527).

Chorda tympani

The chorda tympani (Fig. 8.132) carries taste from the anterior two-thirds of the tongue and parasympathetic innervation to all salivary glands below the level of the oral fissure.

The chorda tympani originates from the facial nerve [VII] within the temporal bone and in association with the mastoid wall of the middle ear, passes anteriorly through a small canal, and enters the lateral aspect of the middle ear. As it continues anterosuperiorly across the middle ear, it is separated from the tympanic membrane by the handle of malleus. It leaves the middle ear through the medial end of the petrotympanic fissure, enters the infratemporal fossa, descends medial to the spine of the sphenoid and then to the lateral pterygoid muscle, and joins the lingual nerve.

Preganglionic parasympathetic fibers carried in the chorda tympani synapse with postganglionic parasympathetic fibers in the submandibular ganglion, which “hangs off” the lingual nerve in the floor of the oral cavity (Fig. 8.132).

Postganglionic parasympathetic fibers leave the submandibular ganglion and either (Fig. 8.132):

- re-enter the lingual nerve to travel with its terminal branches to reach target tissues; or
- pass directly from the submandibular ganglion into glands.

The taste (SA) fibers do not pass through the ganglion and are distributed with terminal branches of the lingual nerve.

Lesser petrosal nerve

The lesser petrosal nerve carries mainly parasympathetic fibers destined for the parotid gland (Fig. 8.132B). The preganglionic parasympathetic fibers are located in the glossopharyngeal nerve [IX] as it exits the jugular foramen at the base of the skull (Fig. 8.132B). Branching from the glossopharyngeal nerve [IX] either within or immediately outside the jugular foramen is the tympanic nerve.

The tympanic nerve re-enters the temporal bone through a small foramen on the ridge of bone separating the jugular foramen from the carotid canal and ascends through a small bony canal (inferior tympanic canaliculus) to the promontory located on the labyrinthine (medial) wall of the middle ear. Here it participates in the formation of the tympanic plexus. The lesser petrosal nerve is a branch of this plexus.

The lesser petrosal nerve contains mainly preganglionic parasympathetic fibers. It leaves the middle ear and enters the middle cranial fossa through a small opening on the anterior surface of the petrous part of the temporal bone just lateral and inferior to the opening for the greater petrosal nerve, a branch of the facial nerve [VII]. The lesser petrosal nerve then passes medially and descends through the foramen ovale with the mandibular nerve [V₃].

In the infratemporal fossa, the preganglionic parasympathetic fibers synapse with cell bodies of postganglionic parasympathetic fibers in the otic ganglion located on the medial side of the mandibular nerve [V₃], around the origin of the nerve to the medial pterygoid (Fig. 8.132). Postganglionic parasympathetic fibers leave the otic ganglion and join the auriculotemporal nerve, which carries them to the parotid gland.

Maxillary artery

The maxillary artery is the largest branch of the external carotid artery in the neck and is a major source of blood supply for the nasal cavity, the lateral wall and roof of the oral cavity, all teeth, and the dura mater in the cranial cavity. It passes through and supplies the infratemporal fossa and then enters the pterygopalatine fossa, where it gives origin to terminal branches (Fig. 8.133).

The maxillary artery originates within the substance of the parotid gland and then passes forward, between the neck of mandible and sphenomandibular ligament, into the infratemporal fossa. It ascends obliquely through the infratemporal fossa to enter the pterygopalatine fossa by passing through the pterygomaxillary fissure. This part of the vessel may pass either lateral or medial to the lower head of lateral pterygoid. If it passes medial to the lower head, the maxillary artery then loops laterally between the upper and lower heads of lateral pterygoid to access the **pterygomaxillary fissure**.

Branches

Branches of the maxillary artery are as follows (Fig. 8.133):

- The first part of the maxillary artery (the part between the neck of mandible and the sphenomandibular ligament) gives origin to two major branches (the middle meningeal and inferior alveolar arteries) and a number of smaller branches (deep auricular, anterior tympanic, and accessory meningeal).
- The second part of the maxillary artery (the part related to the lateral pterygoid muscle) gives origin to deep temporal, masseteric, buccal, and pterygoid branches, which course with branches of the mandibular nerve [V₃].
- The third part of the maxillary artery is in the pterygopalatine fossa (see p. 514).

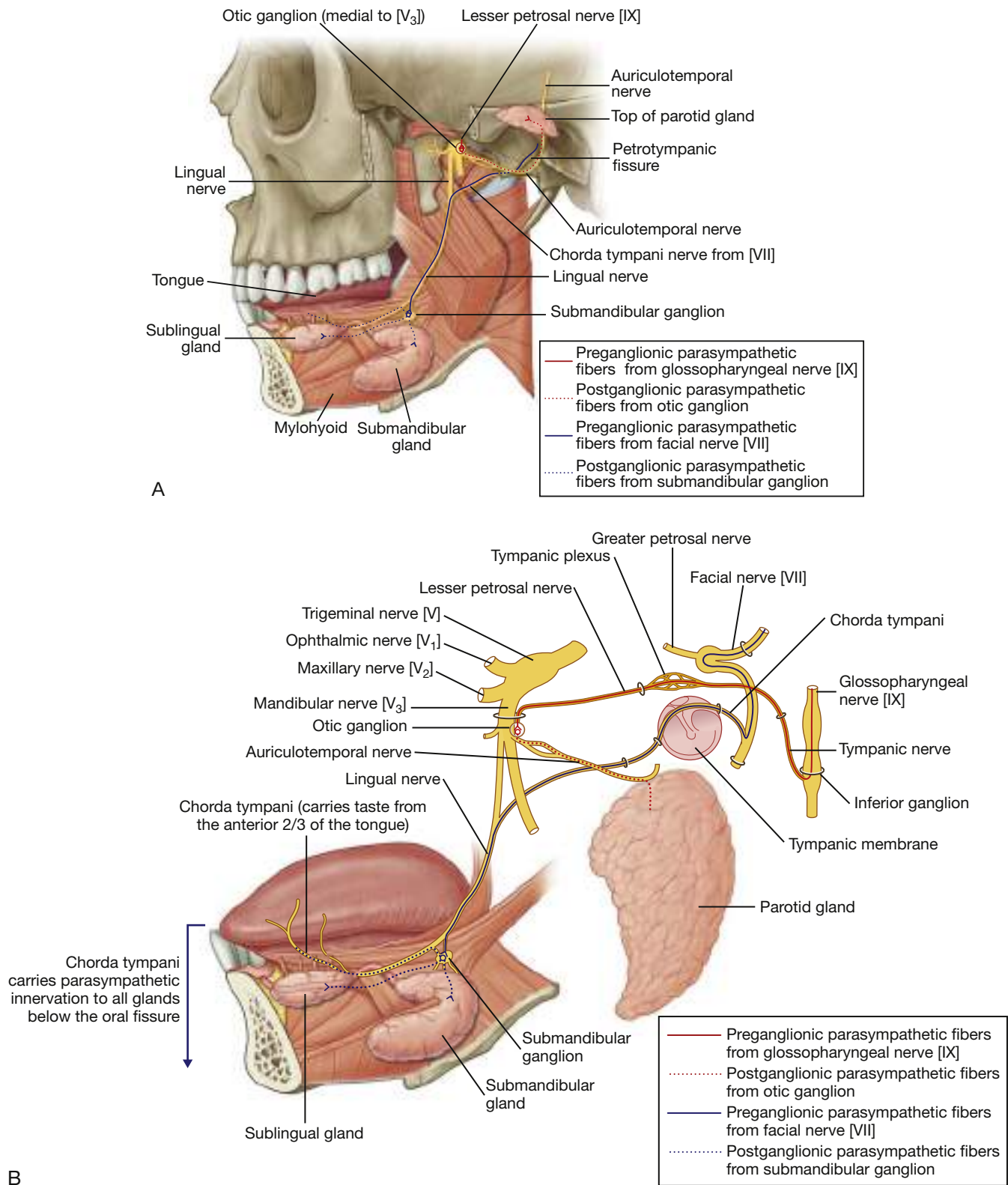


Fig. 8.132 Chorda tympani and lesser petrosal nerves. **A.** Course after emerging from the skull. **B.** Course of parasympathetic fibers.

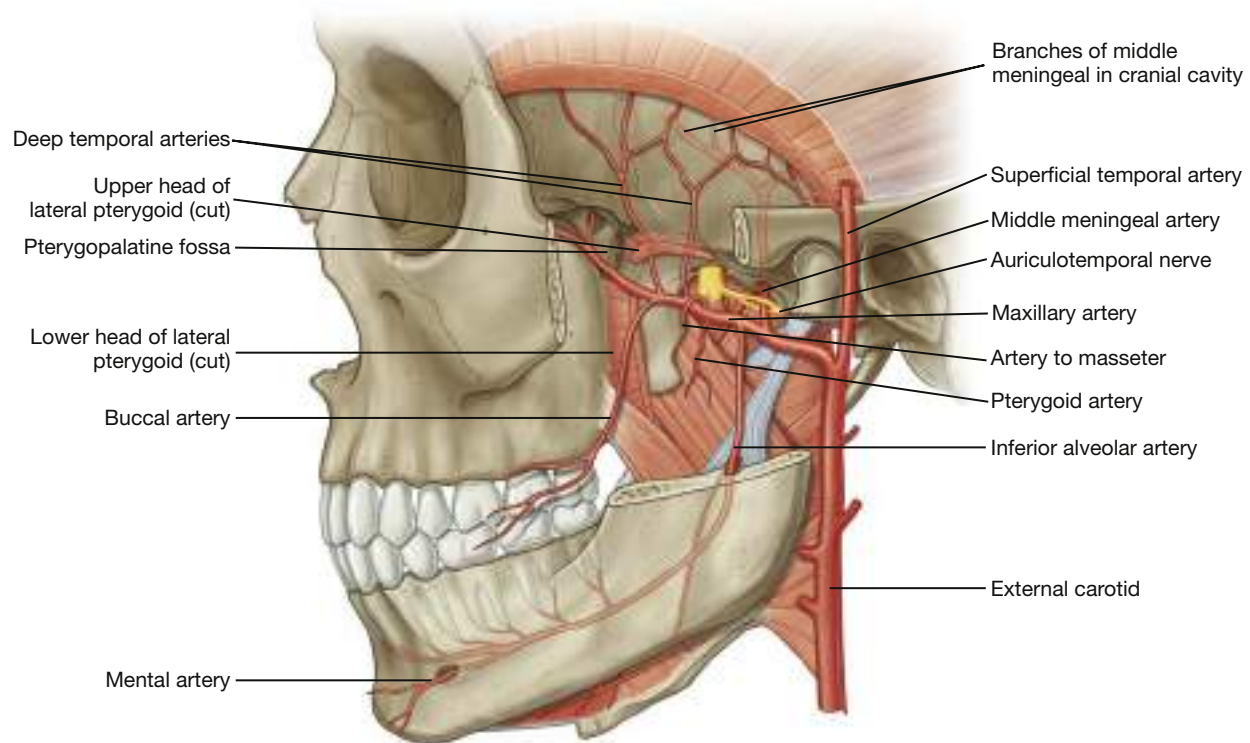


Fig. 8.133 Maxillary artery.

Middle meningeal artery

The middle meningeal artery ascends vertically from the maxillary artery and passes through the foramen spinosum to enter the cranial cavity (Fig. 8.133). In the infratemporal fossa, it passes superiorly between the sphenomandibular ligament on the medial side and the lateral pterygoid muscle on the lateral side. Just inferior to the foramen spinosum, it passes between the two roots of the auriculotemporal nerve at their origin from the mandibular nerve [V₃].

The middle meningeal artery is the largest of the meningeal vessels and supplies much of the dura mater, bone, and related bone marrow of the cranial cavity walls.

Inferior alveolar artery

The inferior alveolar artery descends from the maxillary artery to enter the mandibular foramen and canal with the inferior alveolar nerve (Fig. 8.133). It is distributed with the inferior alveolar nerve and supplies all lower teeth, and contributes to the supply of the buccal gingivae, chin, and lower lip.

Before entering the mandible, the inferior alveolar artery gives origin to a small mylohyoid branch, which accompanies the nerve to mylohyoid.

Deep auricular, anterior tympanic, and accessory meningeal arteries

The deep auricular, anterior tympanic, and accessory meningeal arteries are small branches from the first part of

the maxillary artery and contribute to the blood supply of the external acoustic meatus, deep surface of the tympanic membrane, and cranial dura mater, respectively.

The accessory meningeal branch also contributes small branches to surrounding muscles in the infratemporal fossa before ascending through the foramen ovale into the cranial cavity to supply dura mater.

Branches from the second part

Deep temporal arteries, usually two in number, originate from the second part of the maxillary artery and travel with the deep temporal nerves to supply the temporalis muscle in the temporal fossa (Fig. 8.133).

Numerous pterygoid arteries also originate from the second part of the maxillary artery and supply the pterygoid muscles.

The masseteric artery, also from the second part of the maxillary artery, accompanies the masseteric nerve laterally through the mandibular notch to supply the masseter muscle.

The buccal artery is distributed with the buccal nerve and supplies skin, muscle, and oral mucosa of the cheek.

Pterygoid plexus

The **pterygoid plexus** is a network of veins between the medial and lateral pterygoid muscles and between the lateral pterygoid and temporalis muscles (Fig. 8.134).

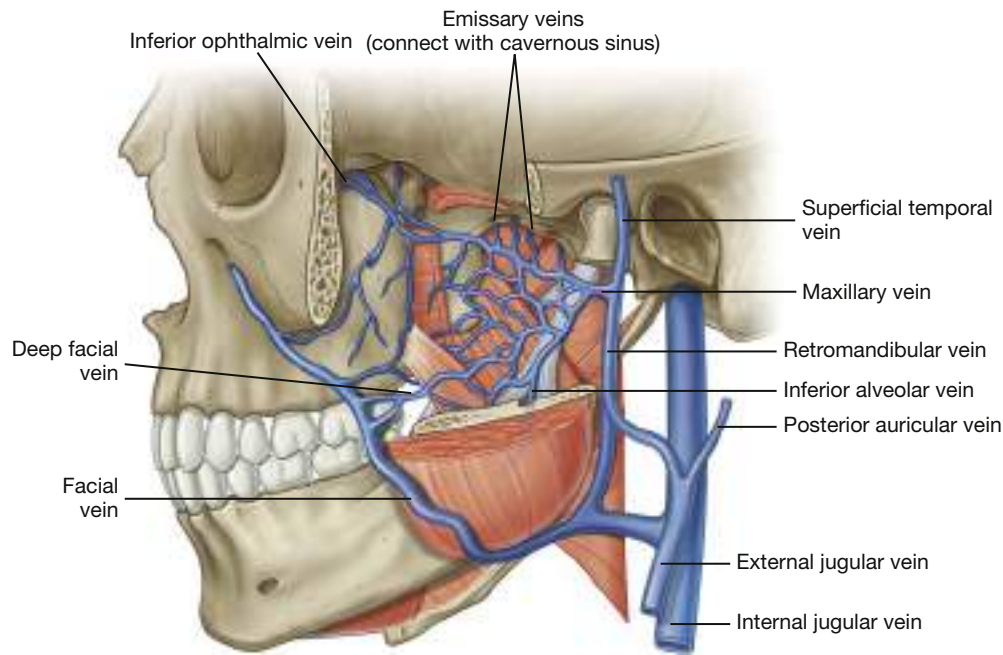


Fig. 8.134 Pterygoid plexus of veins.

Veins that drain regions supplied by arteries branching from the maxillary artery in the infratemporal fossa and pterygopalatine fossa connect with the pterygoid plexus. These tributary veins include those that drain the nasal cavity, roof and lateral wall of the oral cavity, all teeth, muscles of the infratemporal fossa, paranasal sinuses, and nasopharynx. In addition, the inferior ophthalmic vein from the orbit can drain through the inferior orbital fissure into the pterygoid plexus.

The pterygoid plexus connects (Fig. 8.134):

- posteriorly, via a short maxillary vein, with the retromandibular vein in the neck; and
- anteriorly, via a deep facial vein, with the facial vein on the face.

Clinical app

Middle meningeal artery and extradural hematoma

Within the cranial cavity, the middle meningeal artery and its branches travel in the periosteal (outer) layer of dura mater, which is tightly adherent to the bony walls. As major branches of the middle meningeal artery pass superiorly up the walls of the cranial cavity in the region of the “pterion,” they can be damaged by lateral blows to the head. When the vessels are torn, the leaking blood results in an extradural hematoma.

Clinical app

Spread of infection from the pterygoid plexus into the cranial cavity

Small emissary veins often connect the pterygoid plexus in the infratemporal fossa to the cavernous sinus in the cranial cavity. These emissary veins pass through the foramen ovale, the cartilage that fills the foramen lacerum, and a small sphenoidal foramen on the medial side of the lateral plate of the pterygoid process at the base of the skull. They are a route by which infections can spread into the cranial cavity from structures, such as the teeth, that are drained by the pterygoid plexus. Also, because there are no valves in veins of the head and neck, anesthetic inadvertently injected under pressure into veins of the pterygoid plexus can backflow into tissues or into the cranial cavity.

PTERYGOPALATINE FOSSA

The pterygopalatine fossa is an inverted teardrop-shaped space between bones on the lateral side of the skull immediately posterior to the maxilla (Fig. 8.135).

Although small in size, the pterygopalatine fossa communicates via fissures and foramina in its walls with the:

- middle cranial fossa,
- infratemporal fossa,
- floor of the orbit,

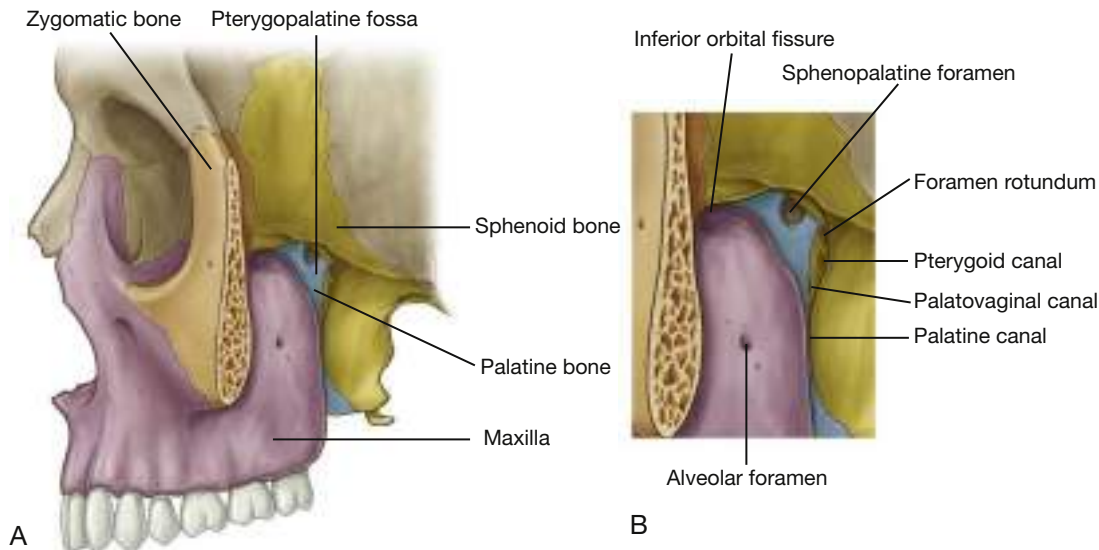


Fig. 8.135 Pterygopalatine fossa. **A.** Anterolateral view. **B.** Lateral view.

- lateral wall of the nasal cavity,
- oropharynx, and
- roof of the oral cavity.

Because of its strategic location, the pterygopalatine fossa is a major site of distribution for the maxillary nerve [V_2] and for the terminal part of the maxillary artery. It also contains the pterygopalatine ganglion where preganglionic parasympathetic fibers originating in the facial nerve [VII] synapse with postganglionic parasympathetic fibers and these fibers, along with sympathetic fibers originating from the T1 spinal cord level join branches of the maxillary nerve [V_2].

All the upper teeth receive their innervation and blood supply from the maxillary nerve [V_2] and the terminal part of the maxillary artery, respectively, that pass through the pterygopalatine fossa.

Skeletal framework

The walls of the pterygopalatine fossa are formed by parts of the palatine, maxilla, and sphenoid bones (Fig. 8.135):

- The anterior wall is formed by the posterior surface of the maxilla.
- The medial wall is formed by the lateral surface of the palatine bone.
- The posterior wall and roof are formed by parts of the sphenoid bone.

Sphenoid bone

The part of the sphenoid bone that contributes to the formation of the pterygopalatine fossa is the anterosuperior surface of the pterygoid process (Fig. 8.136). Opening onto this surface are two large foramina:

- The maxillary nerve [V_2] passes through the most lateral and superior of these—the **foramen rotundum**—which communicates posteriorly with the middle cranial fossa (Fig. 8.136B).
- The greater petrosal nerve from the facial nerve [VII] and sympathetic fibers from the internal carotid plexus join to form the nerve of the pterygoid canal that passes forward into the pterygopalatine fossa through the more medial and inferior foramen—the **anterior opening of the pterygoid canal** (Fig. 8.136A).

Pterygoid canal

The pterygoid canal is a bony canal running horizontally through the root of the pterygoid process of the sphenoid bone. It opens anteriorly into the pterygopalatine fossa. Posteriorly it continues through the cartilage filling the foramen lacerum and opens into the middle cranial fossa just anteroinferior to the internal carotid as the vessel enters the cranial cavity through the carotid canal (Fig. 8.136B).

Gateways

Seven foramina and fissures provide apertures through which structures enter and leave the pterygopalatine fossa (Fig. 8.137):

- The **foramen rotundum** and **pterygoid canal** communicate with the middle cranial fossa and open onto the posterior wall.
- A small **palatovaginal canal** opens onto the posterior wall and leads to the nasopharynx.
- The **palatine canal** leads to the roof of the oral cavity (hard palate) and opens inferiorly.
- The **sphenopalatine foramen** opens onto the lateral wall of the nasal cavity and is in the medial wall.

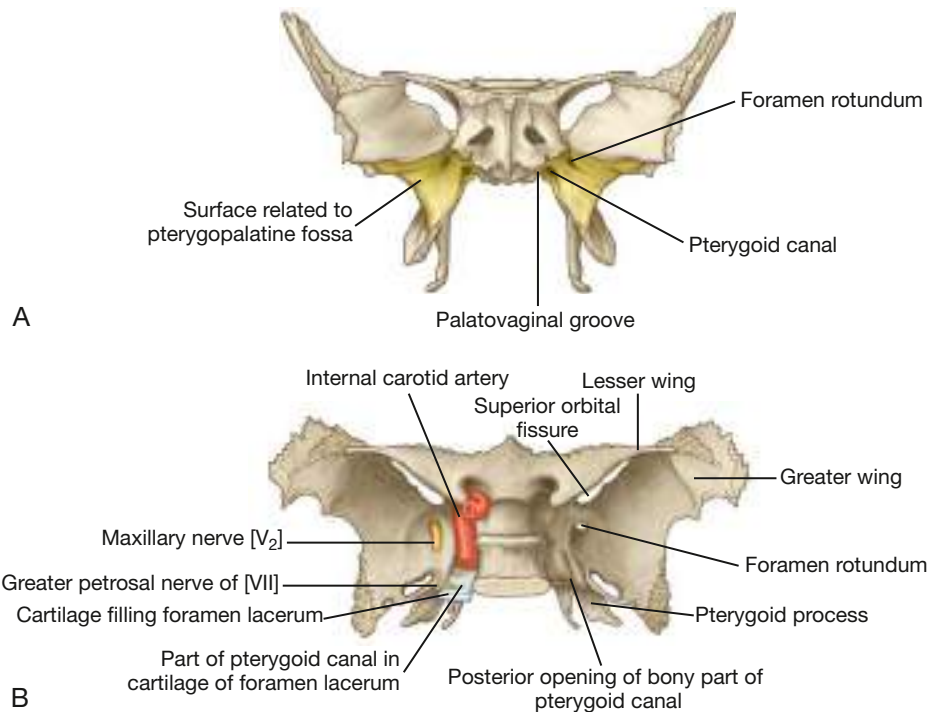


Fig. 8.136 Sphenoid bone. **A.** Anterior view. **B.** Posterosuperior view.

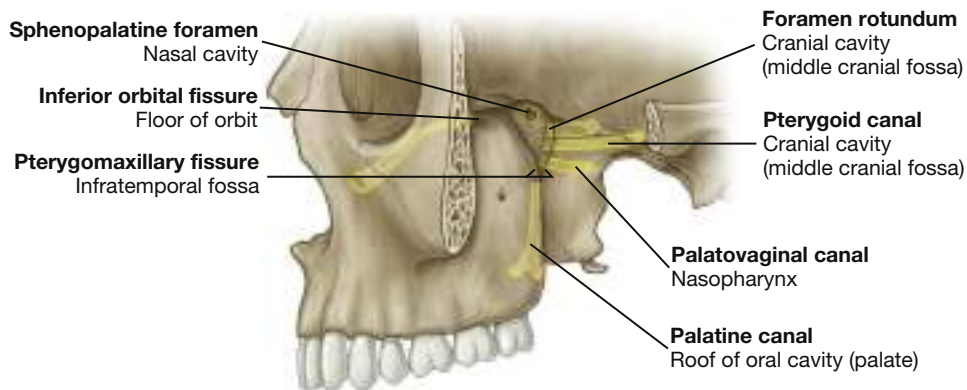


Fig. 8.137 Gateways of the pterygopalatine fossa.

- The lateral aspect of the pterygopalatine fossa is continuous with the infratemporal fossa via a large gap (the **pterygomaxillary fissure**) between the posterior surface of the maxilla and pterygoid process of the sphenoid bone.
- The superior aspect of the anterior wall of the fossa opens into the floor of the orbit via the **inferior orbital fissure**.

Contents

The maxillary nerve [V₂] and terminal part of the maxillary artery enter and branch within the pterygopalatine fossa. In addition, the nerve of the pterygoid canal enters the fossa carrying:

- preganglionic parasympathetic fibers from the greater petrosal branch of the facial nerve [VII], and

- postganglionic sympathetic fibers from the deep petrosal branch of the carotid plexus.

The preganglionic parasympathetic fibers synapse in the pterygopalatine ganglion and both the sympathetic and postganglionic parasympathetic fibers pass with branches of the maxillary nerve [V₂] out of the fossa and into adjacent regions.

In addition to nerves and arteries, veins and lymphatics also pass through the pterygopalatine fossa.

Maxillary nerve [V₂]

The maxillary nerve [V₂] is purely sensory. It originates from the trigeminal ganglion in the cranial cavity, exits the middle cranial fossa, and enters the pterygopalatine fossa

through the foramen rotundum (Fig. 8.138). It passes anteriorly through the fossa and exits as the infra-orbital nerve through the inferior orbital fissure.

While passing through the pterygopalatine fossa, the maxillary nerve [V₂] gives rise to the zygomatic nerve, the posterior superior alveolar nerve, and two ganglionic branches. The two ganglionic branches originate from its inferior surface and pass to the pterygopalatine ganglion.

Postganglionic parasympathetic fibers, arising in the pterygopalatine ganglion, join the general sensory branches of the maxillary nerve [V₂] in the pterygopalatine ganglion, as do postganglionic sympathetic fibers from the carotid plexus, and the three types of fibers leave the ganglion as orbital, palatine, nasal, and pharyngeal branches.

Branches of maxillary nerve [V₂] or pterygopalatine ganglion

Orbital branches. The **orbital branches** are small and pass through the inferior orbital fissure to contribute to the supply of the orbital wall and of the sphenoidal and ethmoidal sinuses.

Greater and lesser palatine nerves. The **greater** and **lesser palatine nerves** (Fig. 8.138) pass inferiorly from the pterygopalatine ganglion, enter and pass through the palatine canal, and enter the oral surface of the palate through the greater and lesser palatine foramina.

The greater palatine nerve passes forward on the roof of the oral cavity to innervate mucosa and glands of the hard palate and the adjacent gingiva, almost as far forward as the incisor teeth.

In the palatine canal, the greater palatine nerve gives origin to **posterior inferior nasal nerves**, which pass medially through

small foramina in the perpendicular plate of the palatine bone and contribute to the innervation of the lateral nasal wall.

After passing through the lesser palatine foramen, the lesser palatine nerve passes posteriorly to supply the soft palate.

Nasal nerves. The nasal nerves (Fig. 8.138), approximately seven in number, pass medially through the sphenopalatine foramen to enter the nasal cavity. Most pass anteriorly to supply the lateral wall of the nasal cavity, while others pass across the roof to supply the medial wall.

One of the nerves passing across the roof to supply the medial wall of the nasal cavity (the **nasopalatine nerve**) is the largest of the nasal nerves and passes anteriorly down the nasal septum, through the incisive canal and fossa in the hard palate to enter the roof of the oral cavity and supply mucosa, gingiva, and glands adjacent to the incisor teeth.

Pharyngeal nerve. The **pharyngeal nerve** passes posteriorly from the pterygopalatine ganglion and leaves the fossa through the palatovaginal canal, which it then exits to supply the mucosa and glands of the nasopharynx (Fig. 8.138).

Zygomatic nerve. The **zygomatic nerve** (Fig. 8.138) originates directly from the maxillary nerve [V₂] in the pterygopalatine fossa, which it leaves to enter the orbit through the inferior orbital fissure. It passes forward on the lateral orbital wall and divides into zygomaticotemporal and zygomaticofacial branches:

- The **zygomaticotemporal branch** continues forward at the base of the lateral orbital wall, passes through a small bony

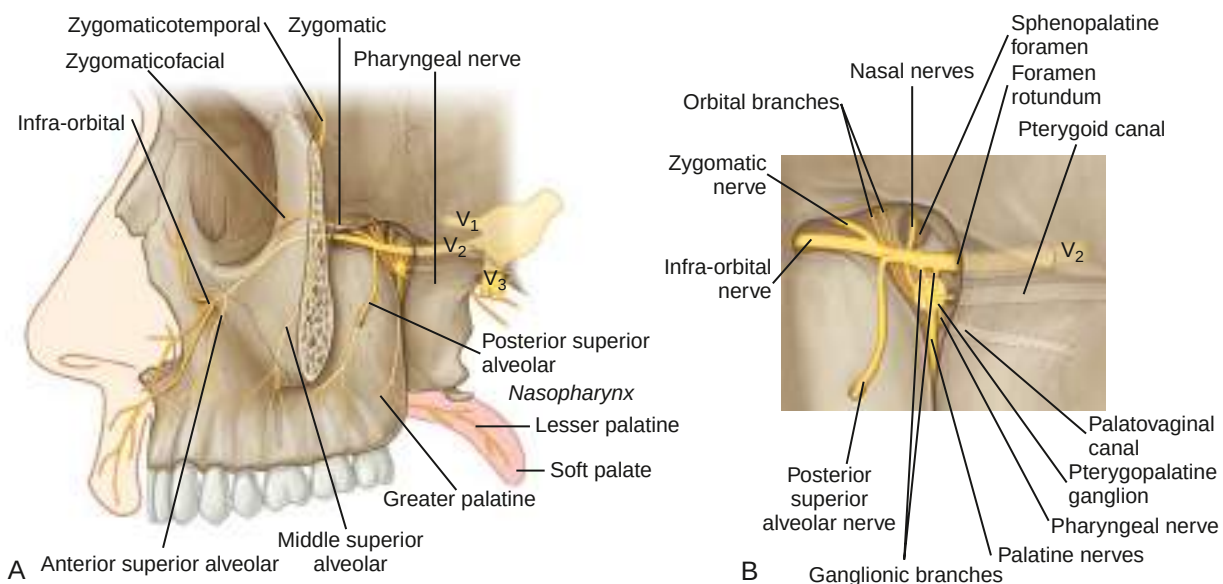


Fig. 8.138 Maxillary nerve [V₂]. A. Terminal branches. B. In relationship to the pterygopalatine ganglion.

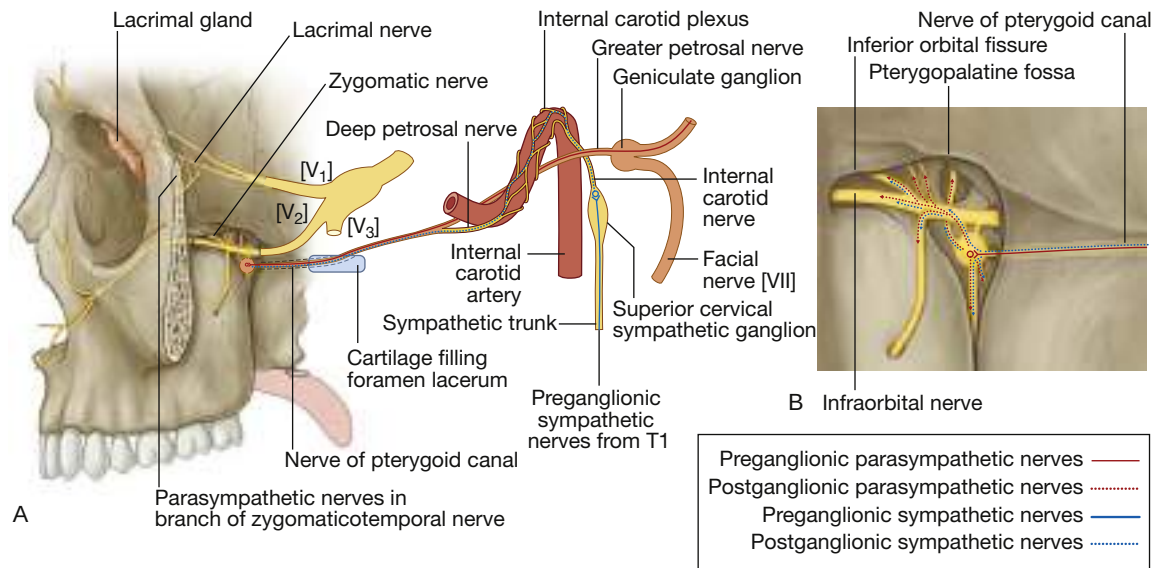


Fig. 8.139 Nerve of the pterygoid canal. **A.** Overview. **B.** In relationship to the pterygopalatine ganglion.

canal in the zygomatic bone to enter the temporal fossa through a small foramen in the lateral orbital margin on the posterior surface of the frontal process of the zygomatic bone, and passes superficially to supply skin over the temple.

- The **zygomaticofacial branch** also passes forward at the base of the lateral orbital wall and leaves through a small bony canal in the orbital margin, which opens via multiple small foramina on the anterolateral surface of the zygomatic bone, and its branches supply the adjacent skin.

Posterior superior alveolar nerve. The **posterior superior alveolar nerve** (Fig. 8.138) originates from the maxillary nerve [V₂] in the pterygopalatine fossa and passes laterally out of the fossa through the pterygomaxillary fissure to enter the infratemporal fossa. It continues laterally and inferiorly to enter the posterior surface of the maxilla through a small alveolar foramen approximately midway between the last molar tooth and the inferior orbital fissure. It then passes inferiorly just deep to the mucosa of the maxillary sinus to join the **superior dental plexus**.

The posterior superior alveolar nerve supplies the molar teeth and adjacent buccal gingivae and contributes to the supply of the maxillary sinus.

Infra-orbital nerve. The infra-orbital nerve (Fig. 8.138) is the anterior continuation of the maxillary nerve [V₂] that leaves the pterygopalatine fossa through the inferior orbital fissure. It lies first in the infra-orbital groove in the floor of the orbit and then continues forward in the infra-orbital canal.

While in the infra-orbital groove and canal, the infra-orbital nerve gives origin to **middle** and **anterior superior**

alveolar nerves, respectively, which ultimately join the **superior alveolar plexus** to supply the upper teeth:

- The middle superior alveolar nerve also supplies the maxillary sinus.
- The anterior superior alveolar nerve also gives origin to a small nasal branch, which passes medially through the lateral wall of the nasal cavity to supply parts of the areas of the nasal floor and walls.

The infra-orbital nerve exits the infra-orbital canal through the infra-orbital foramen inferior to the orbital margin and divides into nasal, palpebral, and superior labial branches:

- Nasal branches supply skin over the lateral aspect of the external nose and part of the nasal septum.
- Palpebral branches supply skin of the lower eyelid.
- Superior labial branches supply skin over the cheek, upper lip, and the related oral mucosa (Fig. 8.138).

Nerve of the pterygoid canal and the pterygopalatine ganglion

The nerve of the pterygoid canal (Fig. 8.139) is formed in the middle cranial fossa by the union of:

- the greater petrosal nerve (a branch of the facial nerve [VII]), and
- the deep petrosal nerve (a branch of the internal carotid plexus).

The nerve of the pterygoid canal passes into the pterygopalatine fossa and joins the pterygopalatine ganglion. It

carries mainly preganglionic parasympathetic and postganglionic sympathetic fibers.

Greater petrosal nerve

The greater petrosal nerve, which originates from the geniculate ganglion of the facial nerve [VII] (Fig. 8.139A) in the temporal bone, exits the temporal bone through a small canal that opens via a fissure onto the anterior surface of the petrous part of the temporal bone. It passes anteromedially along the posterior margin of the middle cranial fossa and then under the internal carotid artery to reach the superior surface of the cartilage filling the foramen lacerum.

As the greater petrosal nerve passes under the internal carotid artery, it is joined by the deep petrosal nerve to form the nerve of the pterygoid canal (Fig. 8.139A).

The greater petrosal nerve carries parasympathetic innervation to all glands above the oral fissure, including:

- mucous glands in the nasal cavity;
- salivary glands in the upper half of the oral cavity; and
- the lacrimal gland in the orbit.

The greater petrosal nerve also carries some taste (SA) fibers from the soft palate in the lesser palatine nerve.

Deep petrosal nerve

The **deep petrosal nerve** is formed by postganglionic sympathetic fibers that originate in the **superior cervical sympathetic ganglion** in the neck and leave the ganglion as the **internal carotid nerve** (Fig. 8.139A).

Preganglionic sympathetic fibers that synapse in the ganglion are from the T1 spinal nerve.

The internal carotid nerve forms the internal carotid plexus around the internal carotid artery as the internal carotid artery passes through the skull and into the cranial cavity. Some of the fibers from the internal carotid plexus converge to form the deep petrosal nerve, which leaves the internal carotid plexus in the middle cranial fossa and joins the greater petrosal branch of the facial nerve [VII].

The deep petrosal nerve carries postganglionic sympathetic fibers destined mainly for blood vessels.

Pterygopalatine ganglion

The nerve of the pterygoid canal (preganglionic parasympathetic fibers and postganglionic sympathetic fibers) enters the superior surface of the cartilage that fills the foramen lacerum and passes anteriorly through the cartilage to enter the pterygoid canal in the root of the pterygoid process of the sphenoid bone. It passes through the canal and into the pterygopalatine fossa where it joins the pterygopalatine ganglion formed around the branches of the maxillary nerve [V₂] (see Fig. 8.139).

The **pterygopalatine ganglion** is the largest of the four parasympathetic ganglia in the head and is formed by the cell bodies of the postganglionic neurons associated with preganglionic parasympathetic fibers of the facial nerve [VII] carried by the greater petrosal nerve and the nerve of the pterygoid canal.

The postganglionic parasympathetic fibers that originate in the pterygopalatine ganglion, together with postganglionic sympathetic fibers passing through the ganglion, join fibers from the ganglionic branches of the maxillary nerve [V₂] to form orbital, palatine, nasal, and pharyngeal branches, which leave the ganglion (Fig. 8.140).

Other postganglionic parasympathetic and sympathetic fibers pass superiorly through the ganglionic branches of the maxillary nerve [V₂] to enter the main trunk of the maxillary nerve and be distributed with the zygomatic, posterior superior alveolar, and infra-orbital nerves. Of these, the postganglionic parasympathetic and sympathetic fibers that pass into the orbit with the zygomatic nerve are particularly important because they ultimately innervate the lacrimal gland.

Innervation of the lacrimal gland

Approximately midway along the orbital wall, the postganglionic parasympathetic and sympathetic fibers leave the zygomaticotemporal branch of the zygomatic nerve and form a special autonomic nerve, which travels up the lateral orbital wall to join the lacrimal nerve (Fig. 8.139; also see Fig. 8.70, pg. 508).

The lacrimal nerve is a major general sensory branch of the ophthalmic nerve [V₁], which passes forward in the orbit at the margin between the lateral wall and roof.

The postganglionic parasympathetic and sympathetic fibers pass with the lacrimal nerve to the lacrimal gland.

Clinical app

Dry eye

A lesion anywhere along the course of the parasympathetic fibers that leave the brain as part of the facial nerve [VII] and are ultimately carried to the lacrimal gland along branches of the ophthalmic nerve [V₁] results in “dry eye” and can eventually lead to opacity of the cornea, resulting in loss of vision in the affected eye.

Maxillary artery

The maxillary artery is a major branch of the external carotid artery in the neck. It originates adjacent to the neck of mandible, passes forward through the infratemporal fossa, and then enters the pterygopalatine fossa through the pterygomaxillary fissure (Fig. 8.140).

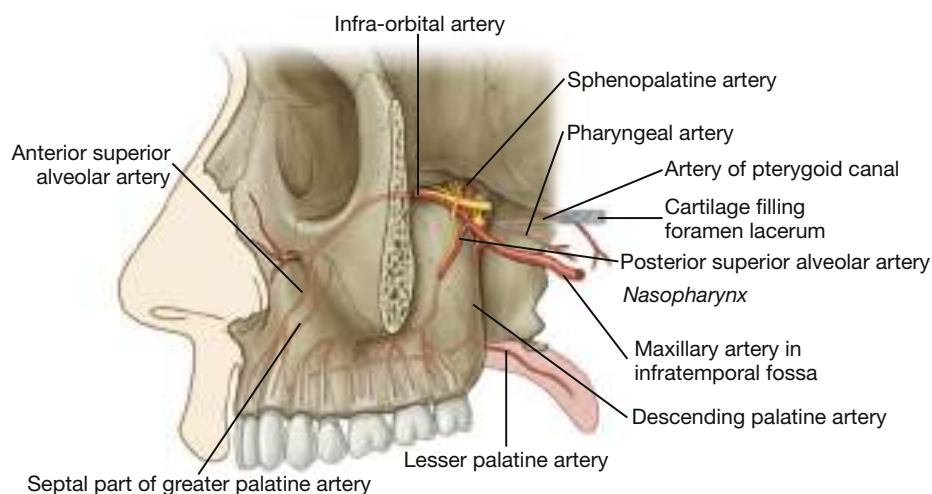


Fig. 8.140 Maxillary artery in the pterygopalatine fossa.

The part of the maxillary artery in the pterygopalatine fossa (the third part) is anterior to the pterygopalatine ganglion and gives origin to branches that accompany branches of the maxillary nerve [V₂] and the pterygopalatine ganglion.

Branches of the maxillary artery include the posterior superior alveolar, infra-orbital, greater palatine, pharyngeal, and sphenopalatine arteries and the artery of the pterygoid canal. Collectively, these branches supply much of the nasal cavity, the roof of the oral cavity, and all upper teeth. In addition, they contribute to the blood supply of the sinuses, oropharynx, and floor of the orbit.

Branches

Posterior superior alveolar artery. The **posterior superior alveolar artery** originates from the maxillary artery as it passes through the pterygomaxillary fissure (Fig. 8.140). It meets the posterior superior alveolar nerve, accompanies it through the alveolar foramen on the infratemporal surface of the maxilla, and supplies the molar and premolar teeth, adjacent gingiva, and the maxillary sinus.

Infra-orbital artery. The infra-orbital artery passes forward with the infra-orbital nerve and leaves the pterygopalatine fossa through the inferior orbital fissure (Fig. 8.140). With the infra-orbital nerve, it lies in the infra-orbital groove and infra-orbital canal, and emerges through the infra-orbital foramen to supply parts of the face.

Within the infra-orbital canal, the infra-orbital artery gives origin to:

- branches that contribute to the blood supply of structures near the floor of the orbit—the inferior rectus and inferior oblique muscles and the lacrimal sac; and

- **anterior superior alveolar arteries**, which supply the incisor and canine teeth and the maxillary sinus.

Greater palatine artery. The **greater palatine artery** passes inferiorly with the palatine nerves into the palatine canal (Fig. 8.140). It gives origin to a **lesser palatine branch**, which passes through the lesser palatine foramen to supply the soft palate, and then continues through the greater palatine foramen to supply the hard palate. The latter vessel passes forward on the inferior surface of the palate to enter the incisive fossa and pass superiorly through the incisive canal to supply the anterior aspect of the septal wall of the nasal cavity.

Pharyngeal branch. The **pharyngeal branch** of the maxillary artery travels posteriorly and leaves the pterygopalatine fossa through the palatovaginal canal with the pharyngeal nerve (Fig. 8.140). It supplies the posterior aspect of the roof of the nasal cavity, the sphenoidal sinus, and the pharyngotympanic tube.

Sphenopalatine artery. The **sphenopalatine artery** is the terminal branch of the maxillary artery (Fig. 8.140). It leaves the pterygopalatine fossa medially through the sphenopalatine foramen and accompanies the nasal nerves, giving off:

- posterior lateral nasal arteries, which supply the lateral wall of the nasal cavity and contribute to the supply of the paranasal sinuses; and
- posterior septal branches, which travel medially across the roof to supply the nasal septum—the largest of these branches passes anteriorly down the septum to anastomose with the end of the greater palatine artery.

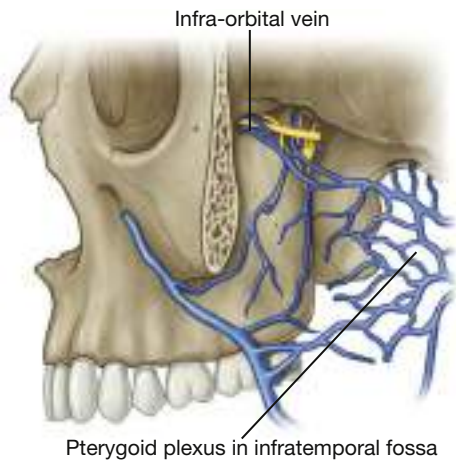


Fig. 8.141 Veins of the pterygopalatine fossa.

Artery of pterygoid canal. The artery of pterygoid canal passes posteriorly into the pterygoid canal (Fig. 8.140). It supplies surrounding tissues and terminates, after passing inferiorly through cartilage filling the foramen lacerum, in the mucosa of the nasopharynx.

Veins. Veins that drain areas supplied by branches of the terminal part of the maxillary artery generally travel with these branches back into the pterygopalatine fossa.

The veins coalesce in the pterygopalatine fossa and then pass laterally through the pterygomaxillary fissure to join the pterygoid plexus of veins in the infratemporal fossa (Fig. 8.141).

The infra-orbital vein, which drains the inferior aspect of the orbit, may pass directly into the infratemporal fossa through the lateral aspect of the inferior orbital fissure, so bypassing the pterygopalatine fossa.

NECK

The neck is a tube providing continuity from the head to the trunk. It extends anteriorly from the lower border of the mandible to the upper surface of the manubrium of sternum and posteriorly from the superior nuchal line on the occipital bone of the skull to the intervertebral disc between the CVII and TI vertebrae. Within the tube, four compartments provide longitudinal organization (Fig. 8.142):

- The visceral compartment is anterior and contains parts of the digestive and respiratory systems and several endocrine glands.
- The vertebral compartment is posterior and contains the cervical vertebrae, spinal cord, cervical nerves, and muscles associated with the vertebral column.
- The two vascular compartments, one on each side, are lateral and contain the major blood vessels and the vagus nerve [X].

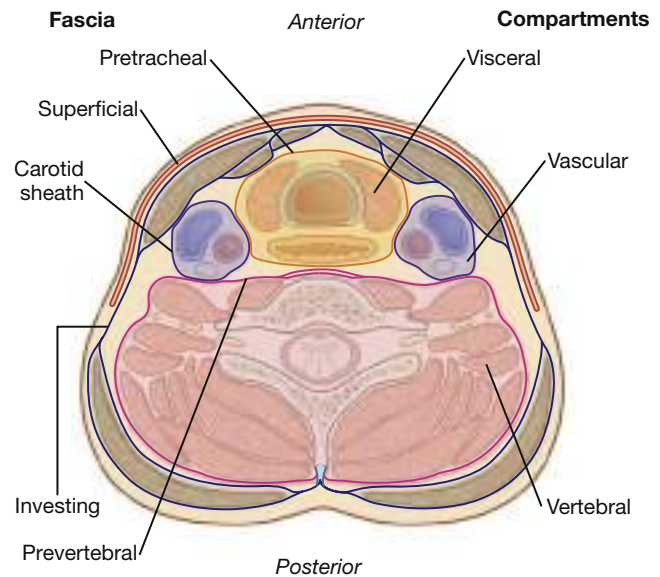


Fig. 8.142 Compartments of the neck.

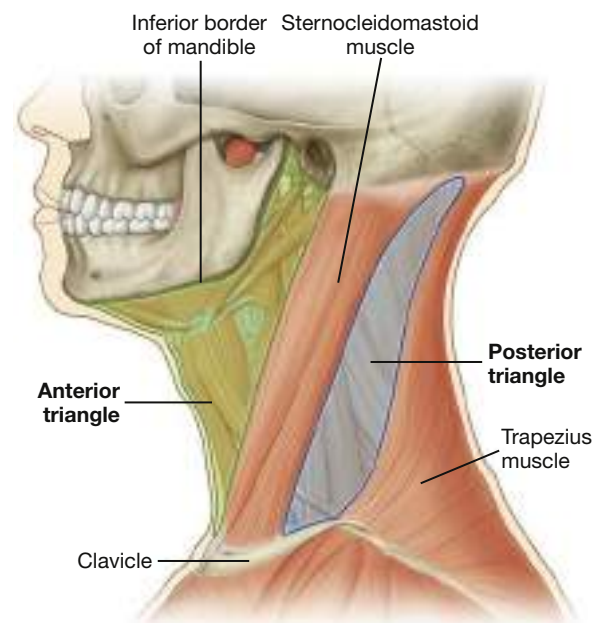


Fig. 8.143 Anterior and posterior triangles of the neck.

All these compartments are contained within unique layers of cervical fascia.

For descriptive purposes the neck is divided into anterior and posterior triangles (Fig. 8.143):

- The boundaries of the **anterior triangle** are the anterior border of the sternocleidomastoid muscle, the inferior border of the mandible, and the midline of the neck.
- The boundaries of the **posterior triangle** are the posterior border of the sternocleidomastoid muscle, the anterior

Surface anatomy

How to outline the anterior and posterior triangles of the neck

The boundaries of the anterior and posterior triangles on each side of the neck are easily established using readily visible bony and muscular landmarks (Fig. 8.144).

The base of each anterior triangle is the inferior margin of the mandible; the anterior margin is the midline of the neck, and the posterior margin is the anterior border of the sternocleidomastoid muscle. The apex of each anterior triangle points inferiorly and is at the suprasternal notch.

The anterior triangles are associated with structures such as the airway and digestive tract and nerves and vessels that pass between the thorax and head. They are also associated with the thyroid and parathyroid glands.

The base of each posterior triangle is the middle one-third of the clavicle. The medial margin is the posterior border of the sternocleidomastoid muscle, and the lateral margin is the anterior border of the trapezius muscle. The apex points superiorly and is immediately posteroinferior to the mastoid process.

The posterior triangles are associated with nerves and vessels that pass into and out of the upper limbs.

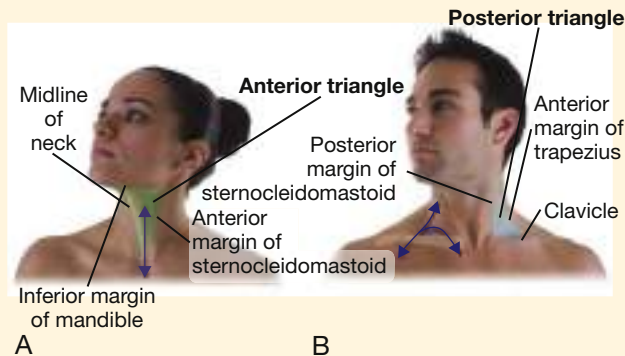


Fig. 8.144 How to outline the anterior and posterior triangles of the neck. **A.** In a woman, anterolateral view. The left anterior triangle is indicated. Structures coursing between head and thorax are associated with the anterior triangles (arrow in green area). **B.** In a man, anterior view of the posterior triangles. Structures coursing between thorax/neck and upper limb are associated with the posterior triangles (blue arrows).

border of the trapezius muscle, and the middle one-third of the clavicle.

Fascia

The fascia of the neck has a number of unique features.

The **superficial fascia** in the neck contains a thin sheet of muscle (the **platysma**, see Table 8.7, pg. 486), while the deep cervical fascia is organized into several distinct layers, including (Fig. 8.142):

- an investing layer, which surrounds all structures in the neck;
- the prevertebral layer, which surrounds the vertebral column and the deep muscles associated with the back;
- the pretracheal layer, which encloses the viscera of the neck; and
- the carotid sheaths, which receive a contribution from the other three fascial layers and surround the two major neurovascular bundles on either side of the neck.

Investing layer

The **investing layer** completely surrounds the neck (Fig. 8.145).

Attaching posteriorly to the ligamentum nuchae and the spinous process of the CVII vertebra, this fascial layer splits as it passes forward to enclose the trapezius muscle, reunites into a single layer as it forms the roof of the posterior triangle, splits again to surround the sternocleidomastoid muscle, and reunites again to join its twin from the other side.

Anteriorly, the investing fascia surrounds the infrahyoid muscles.

The investing fascia is attached:

- superiorly to the external occipital protuberance and the superior nuchal line,
- laterally to the mastoid process and zygomatic arch, and
- inferiorly to the spine of the scapula, the acromion, the clavicle, and the manubrium of sternum.

The external and anterior jugular veins; the lesser occipital, great auricular, transverse cervical, and supraclavicular nerves; and all branches of the cervical plexus pierce the investing fascia.

Prevertebral layer

The prevertebral layer is a cylindrical layer of fascia that surrounds the vertebral column and the muscles associated with it (Fig. 8.145). Muscles in this group include the prevertebral muscles, the anterior, middle, and posterior scalene muscles, and the deep muscles of the back.

The prevertebral fascia is attached posteriorly along the length of the ligamentum nuchae and superiorly forms a continuous circular line attaching to the base of the skull. This circle:

- begins anteriorly as the fascia attaches to the basilar part of the occipital bone, the area of the jugular foramen, and the carotid canal;
- continues laterally, attaching to the mastoid process; and
- continues posteriorly along the superior nuchal line, ending at the external occipital protuberance where it associates with its partner from the opposite side.

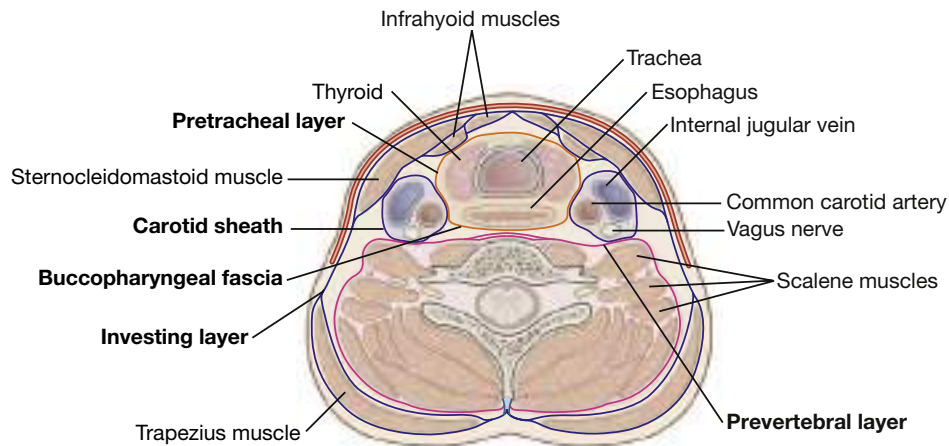


Fig. 8.145 Fascia of neck, transverse view.

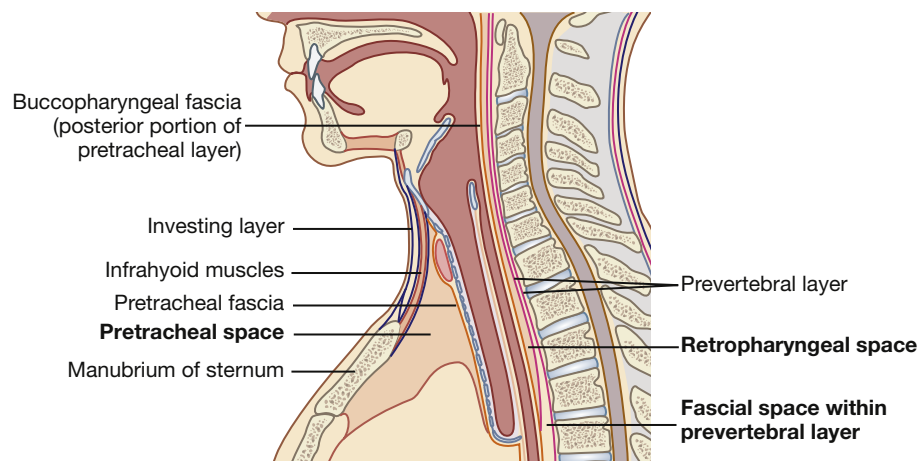


Fig. 8.146 Fascia of the neck, sagittal view.

Anteriorly, the prevertebral fascia is attached to the anterior surfaces of the transverse processes and bodies of vertebrae C1 to CVII.

The prevertebral fascia passing between the attachment points on the transverse processes is unique. In this location, it splits into two layers, creating a longitudinal fascial space containing loose connective tissue that extends from the base of the skull through the thorax (Figs. 8.145, 8.146).

There is one additional specialization of the prevertebral fascia in the lower region of the neck. The prevertebral fascia in an anterolateral position extends from the anterior and middle scalene muscles to surround the brachial plexus and subclavian artery as these structures pass into the axilla. This fascial extension is the **axillary sheath**.

Pretracheal layer

The **pretracheal layer** consists of a collection of fascias that surround the trachea, esophagus, and thyroid gland (Fig. 8.145). Anteriorly, it consists of a pretracheal fascia that

crosses the neck, just posterior to the infrahyoid muscles, and covers the trachea and the thyroid gland. The pretracheal fascia begins superiorly at the hyoid bone and ends inferiorly in the upper thoracic cavity. Laterally, this fascia continues and covers the thyroid gland and the esophagus.

Posteriorly, the pretracheal layer is referred to as the buccopharyngeal fascia and separates the pharynx and the esophagus from the prevertebral layer (Fig. 8.146).

The buccopharyngeal fascia begins superiorly at the base of the skull and ends inferiorly in the thoracic cavity.

Carotid sheath

Each **carotid sheath** is a column of fascia that surrounds the common carotid artery, the internal carotid artery, the internal jugular vein, and the vagus nerve as these structures pass through the neck (Fig. 8.145).

It receives contributions from the investing, prevertebral, and pretracheal layers, though the extent of each component's contribution varies.

Fascial compartments

The arrangement of the various layers of cervical fascia organizes the neck into four longitudinal compartments (see Fig. 8.142):

- The first compartment is the largest, includes the other three, and consists of the area surrounded by the investing layer.
- The second compartment (vertebral compartment) consists of the vertebral column, the deep muscles associated with this structure, and is the area contained within the prevertebral layer.
- The third compartment (the visceral compartment) contains the pharynx, the trachea, the esophagus, and the thyroid and parathyroid glands, which are surrounded by the pretracheal layer.
- Finally, there is a compartment (the carotid sheath) consisting of the neurovascular structures that pass from the base of the skull to the thoracic cavity, and the sheath enclosing these structures receives contributions from the other cervical fascias.

Clinical app

Spread of neck infections

Between the fascial layers in the neck are spaces that may provide a conduit for the spread of infections from the neck to the mediastinum.

Three spaces could be involved in this process (Fig. 8.146):

- The first is the **pretracheal space** between the investing layer of cervical fascia (covering the posterior surface of the infrahyoid muscles) and the pretracheal fascia (covering the anterior surface of the trachea and the thyroid gland), which passes between the neck and the anterior part of the superior mediastinum.
- The second is the **retropharyngeal space** between the buccopharyngeal fascia (on the posterior surface of the pharynx and esophagus) and the prevertebral fascia (on the anterior surface of the transverse processes and bodies of the cervical vertebrae), which extends from the base of the skull to the upper part of the posterior mediastinum.
- The **third space** is within the prevertebral layer (covering the anterior surface of the transverse processes and bodies of the cervical vertebrae). This layer splits into two laminae to create a fascial space that begins at the base of the skull and extends through the posterior mediastinum to the diaphragm.

Superficial venous drainage

The external jugular and anterior jugular veins are the primary venous channels for superficial venous drainage of the neck (Fig. 8.147).

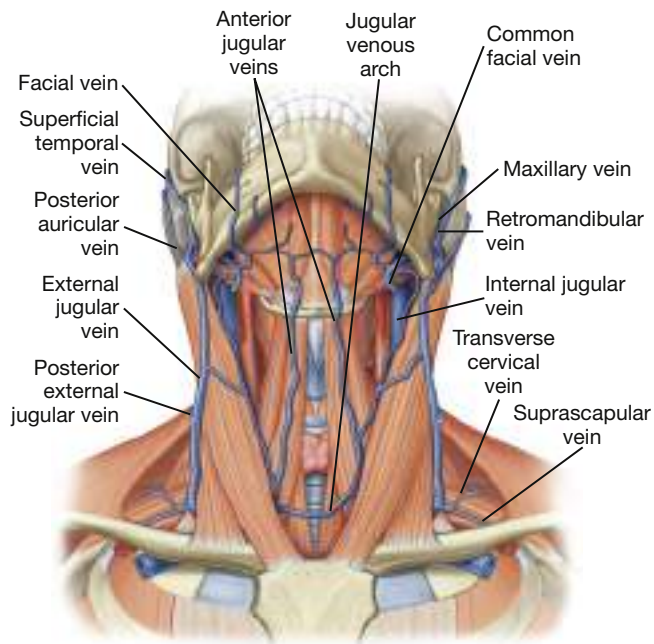


Fig. 8.147 Superficial veins of neck.

External jugular veins

The external jugular vein is formed posterior to the angle of mandible as the **posterior auricular vein** and the **retromandibular vein** join (Fig. 8.147):

- The posterior auricular vein drains the scalp behind and above the ear.
- The retromandibular vein is formed when the **superficial temporal** and **maxillary veins** join in the substance of the parotid gland and descends to the angle of mandible where it divides into an anterior and a posterior division (Fig. 8.147)—the posterior division joins the posterior auricular vein to form the external jugular vein, and the anterior division joins the **facial vein** to form the common facial vein, which passes deep and becomes a tributary to the internal jugular vein.

Once formed, the external jugular vein passes straight down the neck in the superficial fascia and is superficial to the sternocleidomastoid muscle throughout its course, crossing it diagonally as it descends.

Reaching the lower part of the neck, just superior to the clavicle and immediately posterior to the sternocleidomastoid muscle, the external jugular vein pierces the investing layer of cervical fascia, passes deep to the clavicle, and enters the **subclavian vein**.

Tributaries received by the external jugular vein along its course include the **posterior external jugular vein** (draining superficial areas of the back of the neck) and the **transverse cervical** and **suprascapular veins** (draining the posterior scapular region).

Clinical app

Central venous access

In most instances, access to peripheral veins of the arm and the leg will suffice for administering intravenous drugs and fluids and for obtaining blood for analysis; however, in certain circumstances it is necessary to place larger-bore catheters in the central veins, for example for dialysis, parenteral nutrition, or the administration of drugs that have a tendency to produce phlebitis.

“Blind puncture” of the subclavian and jugular veins to obtain central venous access used to be standard practice. However, subclavian vein puncture is not without complications. As the subclavian vein passes inferiorly, posterior to the clavicle, it passes over the apex of the lung. Any misplacement of a needle into or through this structure may puncture the apical pleura, producing a pneumothorax. Inadvertent arterial puncture and vein laceration may also produce a hemopneumothorax.

Placing a catheter in the internal jugular vein (Fig. 8.148) carries fewer risks, but local hematoma and damage to the carotid artery are again important complications.

Current practice is to identify major vessels using ultrasound and to obtain central venous access under direct vision to avoid any significant complication.

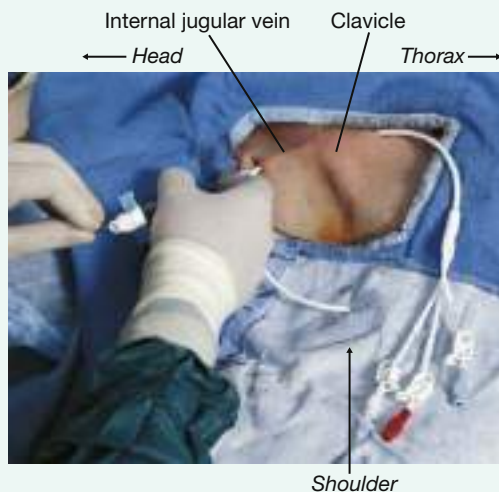


Fig. 8.148 Placing a central venous catheter in the neck.

Anterior jugular veins

The **anterior jugular veins**, although variable and inconsistent, are usually described as draining the anterior aspect of the neck (Fig. 8.147). These paired venous channels, which begin as small veins, come together at or just superior to the hyoid bone. Once formed, each anterior jugular vein descends on either side of the midline of the neck.

Inferiorly, near the medial attachment of the sternocleidomastoid muscle, each anterior jugular vein pierces the

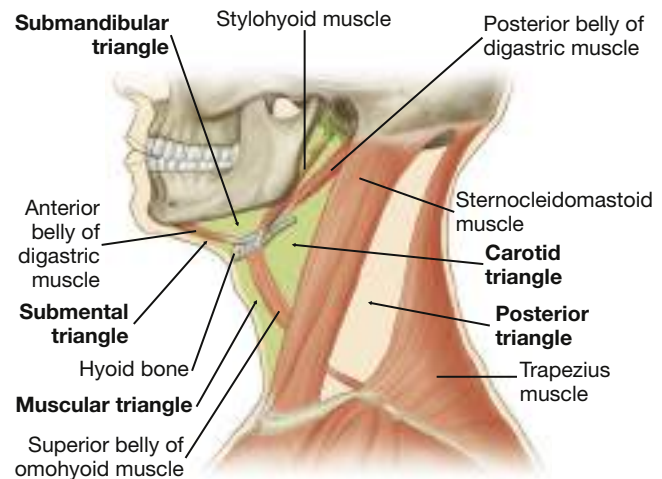


Fig. 8.149 Borders and subdivisions of the anterior triangle of the neck.

investing layer of cervical fascia to enter the subclavian vein. Occasionally, the anterior jugular vein may enter the external jugular vein immediately before the external jugular vein enters the subclavian vein.

Often, the right and left anterior jugular veins communicate with each other, being connected by a **jugular venous arch** in the area of the suprasternal notch.

Anterior triangle of the neck

The anterior triangle of the neck is outlined by the anterior border of the sternocleidomastoid muscle laterally, the inferior border of the mandible superiorly, and the midline of the neck medially (Fig. 8.149). It is further subdivided into several smaller triangles as follows:

- The **submandibular triangle** is outlined by the inferior border of the mandible superiorly and the anterior and posterior bellies of the digastric muscle inferiorly.
- The single **submental triangle** is outlined by the body of the hyoid bone inferiorly, the anterior belly of the digastric muscle laterally on each side, and the mandibular symphysis superiorly in the midline.
- The **muscular triangle** is outlined by the hyoid bone superiorly, the superior belly of the omohyoid muscles and the anterior border of the sternocleidomastoid muscle laterally, and the mandibular symphysis.
- The **carotid triangle** is outlined by the superior belly of the omohyoid muscle anteroinferiorly, the stylohyoid muscle and posterior belly of the digastric superiorly, and the anterior border of the sternocleidomastoid muscle posteriorly.

Each of these triangles contains numerous structures that can be identified as being within a specific triangle, passing into a specific triangle from outside the area, originating

Table 8.12 Muscles in the anterior triangle of the neck

Muscle	Origin	Insertion	Innervation	Function
Stylohyoid	Base of styloid process	Lateral area of body of hyoid bone	Facial nerve [VII]	Pulls hyoid bone upward in a posterosuperior direction
Digastric —Anterior belly	Digastric fossa on lower inside of mandible	Attachment of tendon between two bellies to body of hyoid bone	Mylohyoid nerve from inferior alveolar branch of mandibular nerve [V ₃]	Opens mouth by lowering mandible; raises hyoid bone
—Posterior belly	Mastoid notch on medial side of mastoid process of temporal bone	Attachment of tendon between two bellies to body of hyoid bone	Facial nerve [VII]	Pulls hyoid bone upward and back
Mylohyoid	Mylohyoid line on mandible	Body of hyoid bone and fibers from muscle on opposite side	Mylohyoid nerve from inferior alveolar branch of mandibular nerve [V ₃]	Support and elevation of floor of mouth; elevation of hyoid
Geniohyoid	Inferior mental spine on inner surface of mandible	Anterior surface of body of hyoid bone	Branch from anterior ramus of C1 (carried along the hypoglossal nerve [XII])	Fixed mandible elevates and pulls hyoid bone forward; fixed hyoid bone pulls mandible downward and inward
Sternohyoid	Posterior aspect of sternoclavicular joint and adjacent manubrium of sternum	Body of hyoid bone medial to attachment of omohyoid muscle	Anterior rami of C1 to C3 through the ansa cervicalis	Depresses hyoid bone after swallowing
Omohyoid	Superior border of scapula medial to suprascapular notch	Lower border of body of hyoid bone just lateral to attachment of sternohyoid	Anterior rami of C1 to C3 through the ansa cervicalis	Depresses and fixes hyoid bone
Thyrohyoid	Oblique line on lamina of thyroid cartilage	Greater horn and adjacent aspect of body of hyoid bone	Fibers from anterior ramus of C1 carried along hypoglossal nerve [XII]	Depresses hyoid bone, but when hyoid bone is fixed, it raises larynx
Sternothyroid	Posterior surface of manubrium of sternum	Oblique line on lamina of thyroid cartilage	Anterior rami of C1 to C3 through the ansa cervicalis	Draws larynx (thyroid cartilage) downward

in one triangle and passing to another triangle, or passing through several triangles while passing through the region.

A discussion of the anterior triangle of the neck must therefore combine a systemic approach describing the muscles, vessels, and nerves in the area with a regional approach describing the contents of each triangle.

Muscles

The muscles in the anterior triangle of the neck (Table 8.12) can be grouped according to their location relative to the hyoid bone:

- Muscles superior to the hyoid are classified as **suprahyoid muscles** and include the stylohyoid, digastric, mylohyoid, and geniohyoid.
- Muscles inferior to the hyoid are **infrahyoid muscles** and include the omohyoid, sternohyoid, thyrohyoid, and sternothyroid.

Suprahyoid muscles

The four pairs of suprahyoid muscles are in the submental and submandibular triangles (Table 8.12, Fig. 8.149). They pass in a superior direction from the hyoid bone to the skull or mandible and raise the hyoid, as occurs during swallowing.

The **stylohyoid** muscle arises from the base of the styloid process and passes anteroinferiorly to attach to the lateral area of the body of the hyoid bone (Table 8.12, Fig. 8.150).

The **digastric** muscle has anterior and posterior bellies connected by a tendon, which attaches to the body of the hyoid bone (Table 8.12, Fig. 8.150). Because of this arrangement, the muscle has multiple actions depending on which bone is fixed. The innervation of the posterior belly of the digastric muscle is by the facial nerve [VII], whereas the anterior belly of the muscle is innervated by the mandibular division [V₃] of the trigeminal nerve [V].

The **mylohyoid** muscle is superior to the anterior belly of the digastric and, with its partner from the opposite side, forms the floor of the mouth (Table 8.12, Fig. 8.150). The mylohyoid muscle supports and elevates the floor of the mouth and elevates the hyoid bone.

The **geniohyoid** muscle is superior to the floor of the oral cavity and is not generally considered a muscle of the anterior triangle of the neck; however, it can be regarded as a suprahyoid muscle. It is the final muscle in the suprahyoid group (Table 8.12, Fig. 8.150). A narrow muscle, it is superior to the medial part of each mylohyoid muscle. The muscles from each side are next to each other in the midline.

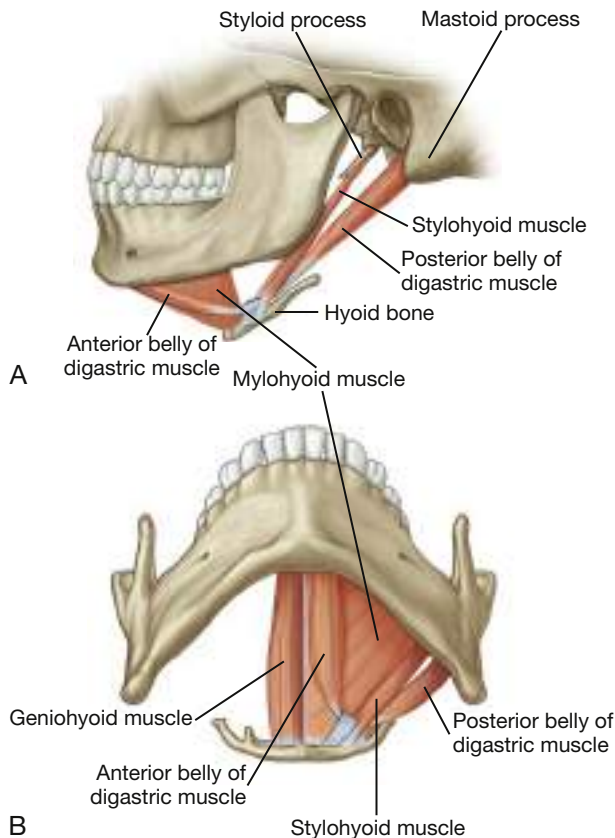


Fig. 8.150 Suprahyoid muscles. **A.** Lateral view. **B.** Inferior view.

Infrahyoid muscles

The four infrahyoid muscles are in the muscular triangle (Table 8.12, Fig. 8.151). They attach the hyoid bone to inferior structures and depress the hyoid bone. They also provide a stable point of attachment for the suprahyoid muscles. Because of their appearance, they are sometimes referred to as the “strap muscles.”

The **sternohyoid** muscle is a long, thin muscle that depresses the hyoid bone (Table 8.12, Fig. 8.152).

Lateral to the sternohyoid muscle is the **omohyoid** muscle (Table 8.12, Fig. 8.151). This muscle consists of two bellies with an intermediate tendon and is in both the posterior and anterior triangles of the neck. The omohyoid depresses and fixes the hyoid bone. It is innervated by the anterior rami of C1 to C3 through the ansa cervicalis.

The **thyrohyoid** muscle is deep to the superior parts of the omohyoid and sternohyoid (Table 8.12, Fig. 8.151). The thyrohyoid muscle depresses the hyoid, but when the hyoid is fixed it raises the larynx (e.g., when high notes are sung).

Lying beneath the sternohyoid and, in continuity with the thyrohyoid, the **sternothyroid** is the last muscle in the infrahyoid group (Table 8.12, Fig. 8.151) and draws the larynx (thyroid cartilage) downward.

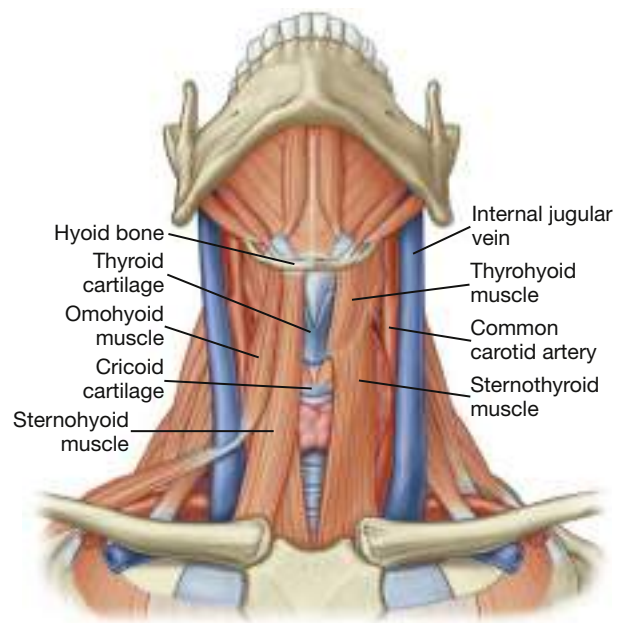


Fig. 8.151 Infrahyoid muscles.

Vessels

Passing through the anterior triangle of the neck are the common carotid arteries and their branches and the external and internal carotid arteries. These vessels supply all structures of the head and neck.

Associated with this arterial system are the internal jugular vein and its tributaries. These vessels receive blood from all structures of the head and neck.

Carotid system

Common carotid arteries

The **common carotid arteries** are the beginning of the carotid system (Fig. 8.152):

- The **right common carotid artery** originates from the brachiocephalic trunk immediately posterior to the right sternoclavicular joint and is entirely in the neck throughout its course.
- The **left common carotid artery** begins in the thorax as a direct branch of the arch of the aorta and passes superiorly to enter the neck near the left sternoclavicular joint.

Both right and left common carotid arteries ascend through the neck, just lateral to the trachea and esophagus, within a fascial compartment (the carotid sheath). They give off no branches as they pass through the neck.

Near the superior edge of the thyroid cartilage each common carotid artery divides into its two terminal branches—the **external** and **internal carotid arteries** (Fig. 8.153).

The superior part of each common carotid artery and its division into external and internal carotid arteries occurs in

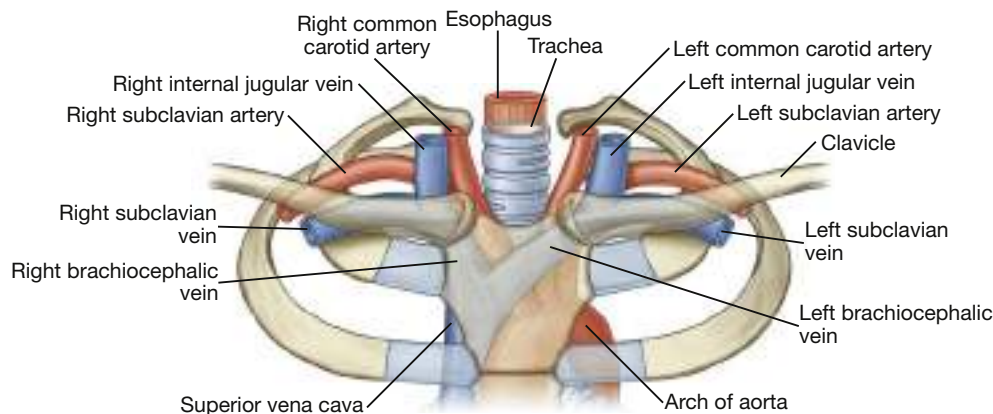


Fig. 8.152 Origin of common carotid arteries.

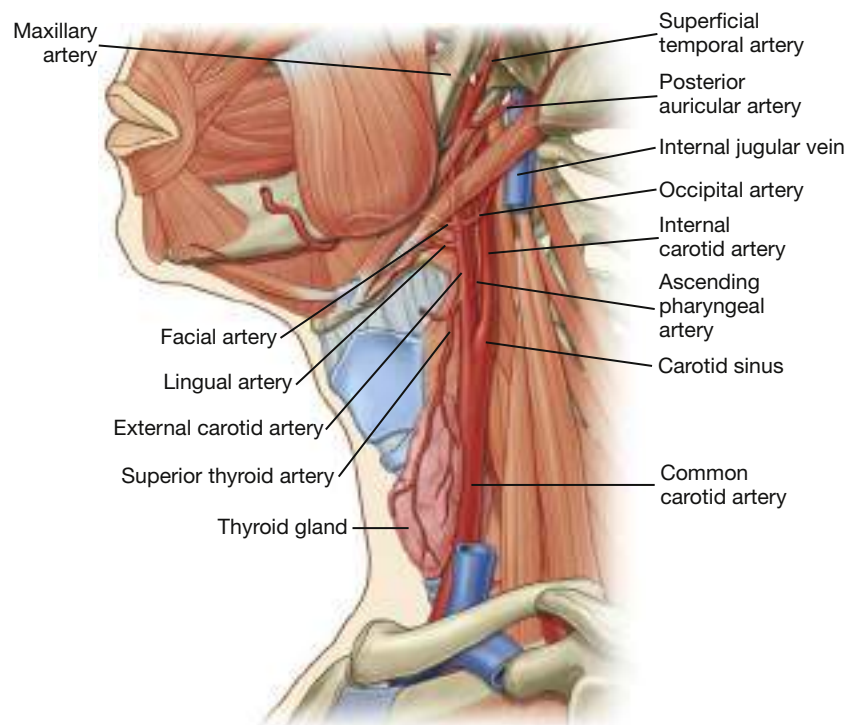


Fig. 8.153 Carotid system.

the carotid triangle, which is a subdivision of the anterior triangle of the neck (see [Fig. 8.149](#)).

At the bifurcation, the common carotid artery and the beginning of the internal carotid artery are dilated. This dilation is the **carotid sinus** and contains receptors that monitor changes in blood pressure and are innervated by a branch of the glossopharyngeal nerve [IX].

Another accumulation of receptors in the area of the bifurcation is responsible for detecting changes in blood chemistry, primarily oxygen content. This is the **carotid body** and is innervated by branches from both the glossopharyngeal [IX] and vagus [X] nerves.

Internal carotid arteries

After its origin, the internal carotid artery ascends toward the base of the skull ([Fig. 8.153](#)). It gives off no branches in the neck and enters the cranial cavity through the carotid canal in the petrous part of the temporal bone.

The internal carotid arteries supply the cerebral hemispheres, the eyes and the contents of the orbits, and the forehead.

External carotid arteries

The external carotid arteries begin giving off branches immediately after the bifurcation of the common carotid arteries ([Table 8.13](#), [Fig. 8.153](#)) as follows:

Table 8.13 Branches of the external carotid artery

Branch	Supplies
Superior thyroid artery	Thyrohyoid muscle, internal structures of the larynx, sternocleidomastoid and cricothyroid muscles, thyroid gland
Ascending pharyngeal artery	Pharyngeal constrictors and stylopharyngeus muscle, palate, palatine tonsil, pharyngotympanic tube, meninges in posterior cranial fossa
Lingual artery	Muscles of the tongue, palatine tonsil, soft palate, epiglottis, floor of mouth, sublingual gland
Facial artery	All structures in the face from the inferior border of the mandible anterior to the masseter muscle to the medial corner of the eye, the soft palate, palatine tonsil, pharyngotympanic tube, submandibular gland
Occipital artery	Sternocleidomastoid muscle, meninges in posterior cranial fossa, mastoid cells, deep muscles of the back, posterior scalp
Posterior auricular artery	Parotid gland and nearby muscles, external ear and scalp posterior to ear, middle and inner ear structures
Superficial temporal artery	Parotid gland and duct, masseter muscle, lateral face, anterior part of external ear, temporalis muscle, parietal and temporal fossae
Maxillary artery	External acoustic meatus, lateral and medial surface of tympanic membrane, temporomandibular joint, dura mater on lateral wall of skull and inner table of cranial bones, trigeminal ganglion and dura in vicinity, mylohyoid muscle, mandibular teeth, skin on chin, temporalis muscle, outer table of bones of skull in temporal fossa, structures in infratemporal fossa, maxillary sinus, upper teeth and gingivae, infra-orbital skin, palate, roof of pharynx, nasal cavity

- The **superior thyroid artery** is the first branch, arises from the anterior surface near or at the bifurcation, and passes in a downward and forward direction to reach the superior pole of the thyroid gland.
- The **ascending pharyngeal artery** is the second and smallest branch—it arises from the posterior aspect of the external carotid artery and ascends between the internal carotid artery and the pharynx.
- The **lingual artery** arises from the anterior surface of the external carotid artery just above the superior thyroid artery at the level of the hyoid bone, passes deep to the hypoglossal nerve [XII], and passes between the middle constrictor of the pharynx and hyoglossus muscles.
- The **facial artery** is the third anterior branch of the external carotid artery, arises just above the lingual artery, passes deep to the stylohyoid and posterior belly of the digastric muscles, continues deep between the submandibular gland and mandible, and emerges over the edge of the mandible just anterior to the masseter muscle, to enter the face.
- The **occipital artery** arises from the posterior surface of the external carotid artery, near the level of origin of the facial artery, passes upward and posteriorly deep to the posterior belly of the digastric muscle, and emerges on the posterior aspect of the scalp.
- The **posterior auricular artery** is a small branch arising from the posterior surface of the external carotid artery; it passes upward and posteriorly.
- The **superficial temporal artery** is one of the terminal branches and appears as an upward continuation of the external carotid artery; beginning posterior to the neck of mandible, it passes anterior to the ear, crosses the zygomatic process of the temporal bone, and above this point divides into anterior and posterior branches.
- The **maxillary artery** is the larger of the two terminal branches of the external carotid artery—arising posterior

to the neck of mandible, it passes through the parotid gland, continues medial to the neck of mandible and into the infratemporal fossa, and continues through this area into the pterygopalatine fossa.

Veins

Collecting blood from the skull, brain, superficial face, and parts of the neck, the **internal jugular vein** (Fig. 8.153) begins as a dilated continuation of the **sigmoid sinus**, which is a dural venous sinus. This initial dilated part is referred to as the **superior bulb of jugular vein** and receives another dural venous sinus (the **inferior petrosal sinus**) soon after it is formed. It exits the skull through the jugular foramen associated with the glossopharyngeal [IX], vagus [X], and accessory [XI] nerves, and enters the carotid sheath.

The internal jugular vein traverses the neck within the carotid sheath, initially posterior to the internal carotid artery, but passes to a more lateral position farther down. It remains lateral to the common carotid artery through the rest of the neck with the vagus nerve [X] posterior and partially between the two vessels.

The paired internal jugular veins join with the subclavian veins posterior to the sternal end of the clavicle to form the right and left **brachiocephalic veins** (see Fig. 8.152).

Tributaries to each internal jugular vein include the inferior petrosal sinus, and the **facial, lingual, pharyngeal, occipital, superior thyroid, and middle thyroid veins**.

Nerves

Numerous cranial and peripheral nerves:

- pass through the anterior triangle of the neck as they continue to their final destination;

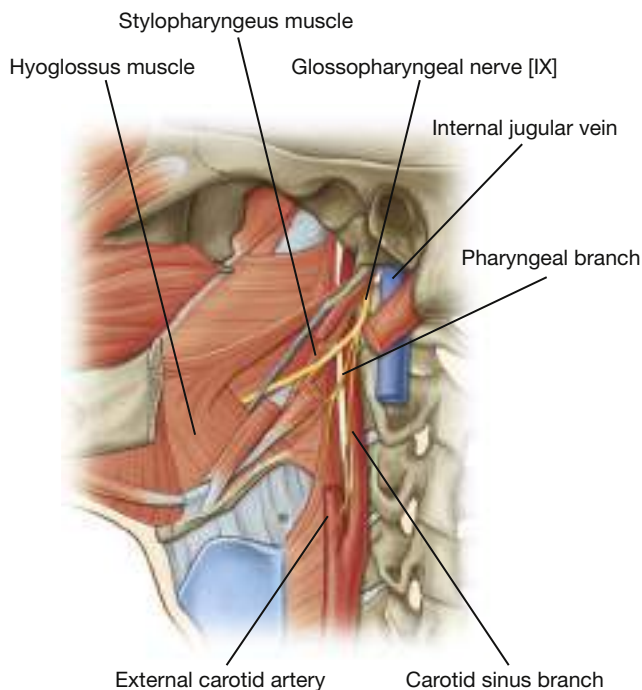


Fig. 8.154 Glossopharyngeal nerve [IX] in the anterior triangle of the neck.

- send branches to structures in or forming boundaries of the anterior triangle of the neck; and
- while in the anterior triangle of the neck, send branches to nearby structures.

The cranial nerves in these categories include the facial [VII], glossopharyngeal [IX], vagus [X], accessory [XI], and hypoglossal [XII].

Branches of spinal nerves in these categories include the transverse cervical nerve from the cervical plexus and the upper and lower roots of the ansa cervicalis.

Facial nerve [VII]

After emerging from the stylomastoid foramen, the facial nerve [VII] gives off branches that innervate the posterior belly of the digastric and the stylohyoid in the anterior triangle of the neck (see Fig. 8.47, pg. 493). The facial nerve [VII] also innervates platysma muscle that overlies the anterior triangle and part of the posterior triangle of the neck.

Glossopharyngeal nerve [IX]

The glossopharyngeal nerve [IX] leaves the cranial cavity through the jugular foramen. It begins its descent between the internal carotid artery and the internal jugular vein, lying deep to the styloid process and the muscles associated with the styloid process. As the glossopharyngeal nerve [IX] completes its descent, it passes forward between the internal and external carotid arteries, and curves around the lateral

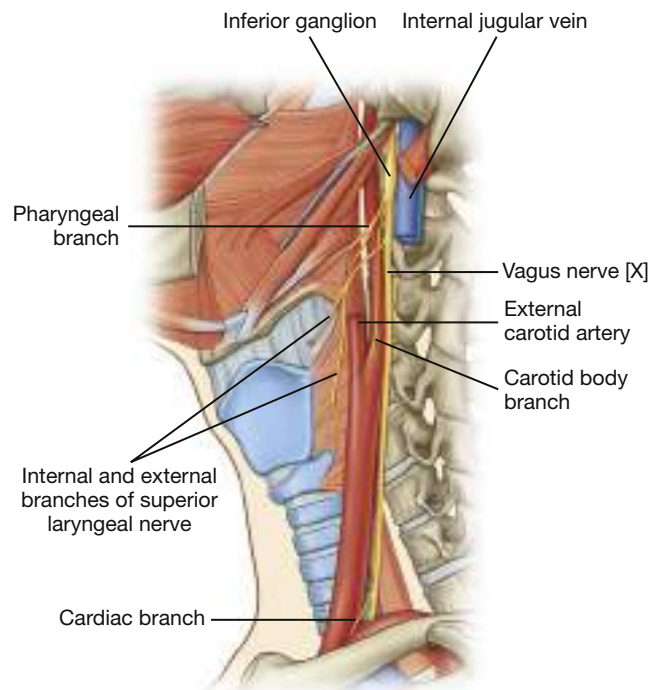


Fig. 8.155 Vagus nerve [X] in the anterior triangle of the neck.

border of the stylopharyngeus muscle (Fig. 8.154). At this point, it continues in an anterior direction, deep to the hyoglossus muscle, to reach the base of the tongue and the area of the palatine tonsil.

As the glossopharyngeal nerve [IX] passes through the area of the anterior triangle of the neck, it innervates the stylopharyngeus muscle, sends a branch to the carotid sinus, and supplies sensory branches to the pharynx.

Vagus nerve [X]

The vagus nerve [X] exits the cranial cavity through the jugular foramen between the glossopharyngeal [IX] and accessory [XI] nerves.

Outside the skull the vagus nerve [X] enters the carotid sheath and descends through the neck enclosed in this structure medial to the internal jugular vein and posterior to the internal carotid and common carotid arteries (Fig. 8.155).

Branches of the vagus nerve [X] as it passes through the anterior triangle of the neck include a motor branch to the pharynx, a branch to the carotid body, the superior laryngeal nerve (which divides into external and internal laryngeal branches), and possibly a cardiac branch (Fig. 8.155).

Accessory nerve [XI]

The accessory nerve [XI] is the most posterior of the three cranial nerves exiting the cranial cavity through the jugular foramen. It begins its descent medial to the internal jugular vein, emerging from between the internal jugular vein

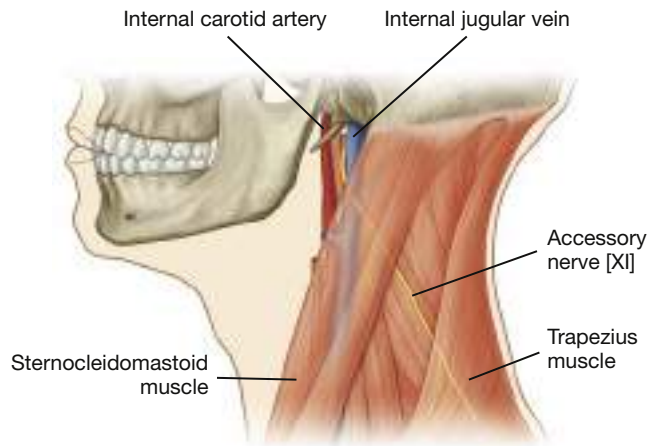


Fig. 8.156 Accessory nerve [XI] in the neck.

and internal carotid artery to cross the lateral surface of the internal jugular vein as it passes downward and backward to disappear either into or beneath the anterior border of the sternocleidomastoid muscle (Fig. 8.156).

The accessory nerve gives off no branches as it passes through the anterior triangle of the neck.

Hypoglossal nerve [XII]

The hypoglossal nerve [XII] leaves the cranial cavity through the hypoglossal canal and is medial to the internal jugular vein and internal carotid artery immediately outside the skull. As it descends, it passes outward between the internal jugular vein and internal carotid artery (Fig. 8.157). At this point it passes forward, hooking around the occipital artery, across the lateral surfaces of the internal and external carotid arteries and the lingual artery, and then continues deep to the posterior belly of the digastric and stylohyoid muscles. It passes over the surface of the hyoglossus muscle and disappears deep to the mylohyoid muscle.

The hypoglossal nerve [XII], which supplies the tongue, does not give off any branches as it passes through the anterior triangle of the neck.

Transverse cervical nerve

The transverse cervical nerve is a branch of the cervical plexus arising from the anterior rami of cervical nerves C2 and C3. It emerges from beneath the posterior border of the sternocleidomastoid muscle, near the middle of the muscle, and loops around the sternocleidomastoid to cross its

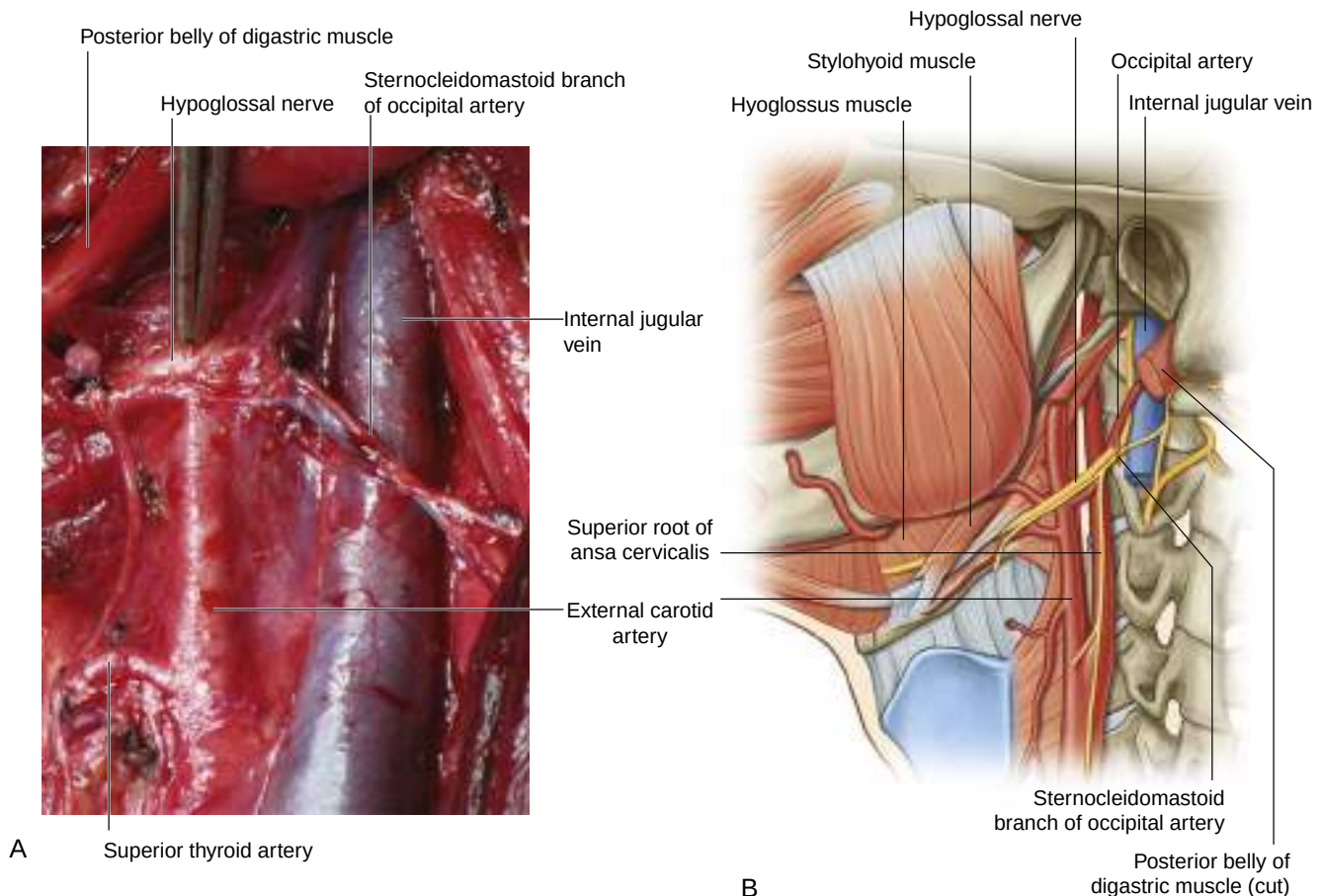


Fig. 8.157 Hypoglossal nerve [XII] in the anterior triangle of the neck. **A.** Surgical view of hypoglossal nerve in anterior triangle. **B.** Diagram.

anterior surface in a transverse direction (Fig. 8.158). It continues across the neck and provides cutaneous innervation to this area.

Ansa cervicalis

The ansa cervicalis is a loop of nerve fibers from cervical nerves C1 to C3 that innervate the “strap muscles” in the anterior triangle of the neck (Fig. 8.159). It begins as branches from the cervical nerve C1 join the hypoglossal nerve [XII] soon after it leaves the skull.

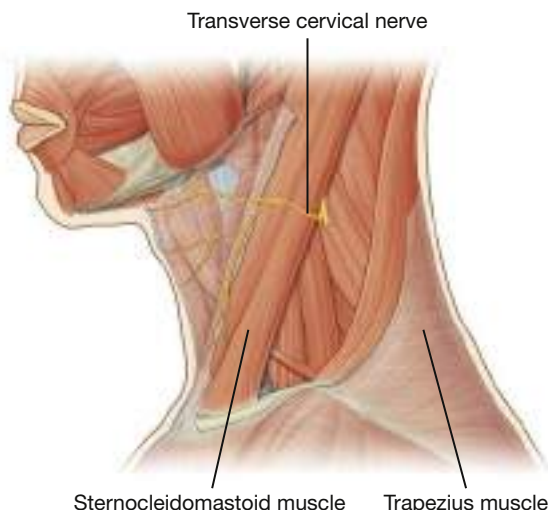


Fig. 8.158 Transverse cervical nerve in the anterior triangle of the neck.

As the hypoglossal nerve [XII] completes its descent and begins to pass forward across the internal and external carotid arteries, some of the cervical nerve fibers leave it and descend between the internal jugular vein and the internal, and then common, carotid arteries. These nerve fibers are the **superior root** of the ansa cervicalis and innervate the superior belly of the omohyoid muscle, and the upper parts of the sternohyoid and sternothyroid muscles.

Completing the loop is a direct branch from the cervical plexus containing nerve fibers from the second and third cervical nerves C2 and C3 (Fig. 8.159). This is the **inferior root** of the ansa cervicalis. It descends either medial or lateral to the internal jugular vein before turning medially to join the superior root. At this location, the ansa cervicalis gives off branches that innervate the inferior belly of the omohyoid, and the lower parts of the sternohyoid and sternothyroid muscles.

Elements of the gastrointestinal and respiratory systems

The esophagus, trachea, pharynx, and larynx lie in the neck and are related to the anterior triangles.

Esophagus

The esophagus is part of the gastrointestinal system and has only a short course in the lower neck. It begins at vertebral level CVI where it is continuous with the pharynx above and courses inferiorly to pass through the thoracic inlet. It lies directly anterior to the vertebral column (Fig. 8.160A).

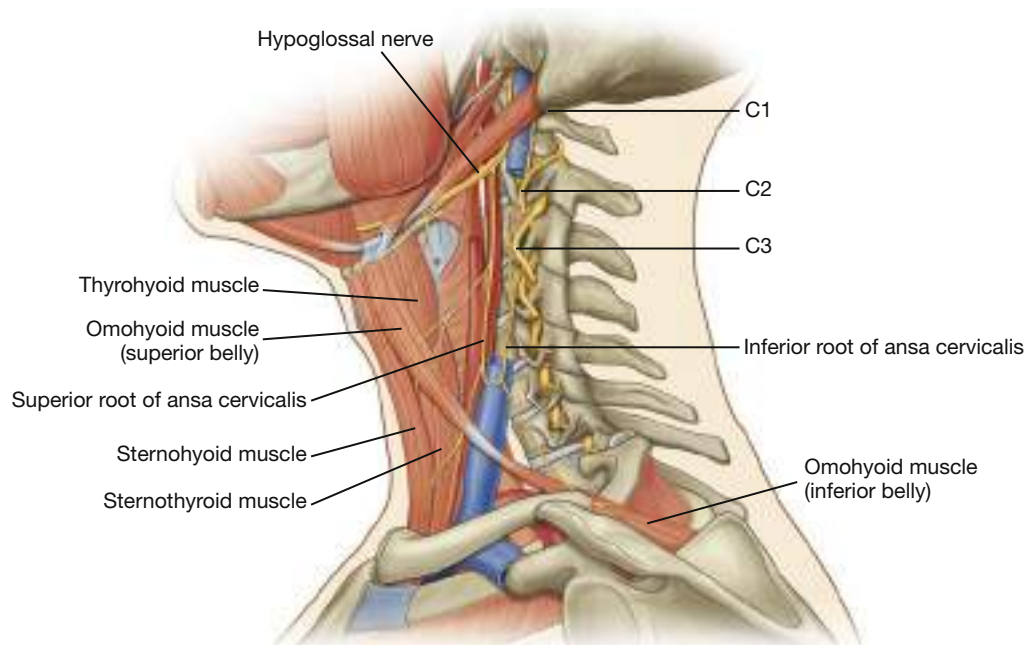


Fig. 8.159 Ansa cervicalis.

Trachea

The trachea is part of the lower airway and, like the esophagus, begins at vertebral level C6, where it is continuous with the larynx above (Fig. 8.160A). The trachea lies directly anterior to the esophagus and passes inferiorly in the midline to enter the thorax.

Clinical app

Tracheobronchial injury

Tracheobronchial injuries rarely occur in isolation and are most often associated with other significant injuries to the neck and chest.

Penetrating injuries occur most frequently in the mid and upper thirds of the trachea whereas injuries involving blunt trauma (e.g., road traffic accidents) occur more frequently at the level of the carina. It is important to remember that all sites of the tracheobronchial tree may be involved in the traumatized patient.

There are no specific signs or symptoms attributable to tracheobronchial injury. These injuries are often associated with other significant chest injuries, including pneumothorax, esophageal rupture, cardiac injury, and spinal injury. The diagnosis is usually obtained by performing a CT scan of the chest (this would be part of a trauma series including the head, neck, chest, abdomen, and pelvis). Direct visualization of the tracheobronchial tree can be performed using a flexible bronchoscope, and, if necessary, surgery may be required to deal with ruptures or strictures.

The surgical mortality rate for treatment on tracheobronchial injuries is relatively low; however, many of these do not occur in isolation, and in many instances, due to the severity of the injury, death occurs at the time of the injury.

Pharynx and Larynx

The pharynx is a common pathway for air and food, and it connects respiratory and digestive compartments in the head with similar compartments in the lower neck (see pp. 584–592).

The larynx is the upper end of the lower airway. It is continuous with the trachea below and the pharynx posteroinferiorly (see pp. 592–604).

Thyroid and parathyroid glands

The thyroid and parathyroid glands are endocrine glands positioned anteriorly in the neck (Fig. 8.160).

Both glands begin as pharyngeal outgrowths that migrate caudally to their final position as development continues.

The thyroid gland is a large, unpaired gland, while the parathyroid glands, usually four in number, are small and are on the posterior surface of the thyroid gland.

Thyroid gland

The thyroid gland is anterior in the neck below and lateral to the thyroid cartilage (Fig. 8.160). It consists of two lateral **lobes** (which cover the anterolateral surfaces of the trachea, the cricoid cartilage, and the lower part of the thyroid cartilage) with an **isthmus** that connects the lateral lobes and crosses the anterior surfaces of the second and third tracheal cartilages.

Lying deep to the sternohyoid, sternothyroid, and omohyoid muscles, the thyroid gland is in the visceral compartment of the neck (Fig. 8.160A). This compartment also includes the pharynx, trachea, and esophagus and is surrounded by the pretracheal layers of fascia.

The thyroid gland arises as a median outgrowth from the floor of the pharynx near the base of the tongue. The foramen cecum of the tongue indicates the site of origin and the thyroglossal duct marks the path of migration of the thyroid gland to its final adult location. The thyroglossal duct usually disappears early in development, but remnants may persist as a cyst or as a connection to the foramen cecum (i.e., a fistula).

There may also be a functional thyroid gland:

- associated with the tongue (a lingual thyroid);
- anywhere along the path of migration of the thyroid gland; or
- extending upward from the gland along the path of the thyroglossal duct (a pyramidal lobe).

Arterial supply

Two major arteries supply the thyroid gland.

Superior thyroid artery. The superior thyroid artery is the first branch of the external carotid artery (Fig. 8.161). It descends, passing along the lateral margin of the thyrohyoid muscle, to reach the superior pole of the lateral lobe of the gland where it divides into anterior and posterior glandular branches:

- The **anterior glandular branch** passes along the superior border of the thyroid gland and anastomoses with its twin from the opposite side across the isthmus (Fig. 8.161).
- The **posterior glandular branch** passes to the posterior side of the gland and may anastomose with the inferior thyroid artery (Fig. 8.162).

Inferior thyroid artery. The **inferior thyroid artery** is a branch of the **thyrocervical trunk**, which arises from the first part of the subclavian artery (Figs. 8.161, 8.162). It ascends along the medial edge of the anterior scalene muscle, passes posteriorly to the carotid sheath, and reaches the inferior pole of the lateral lobe of the thyroid gland.

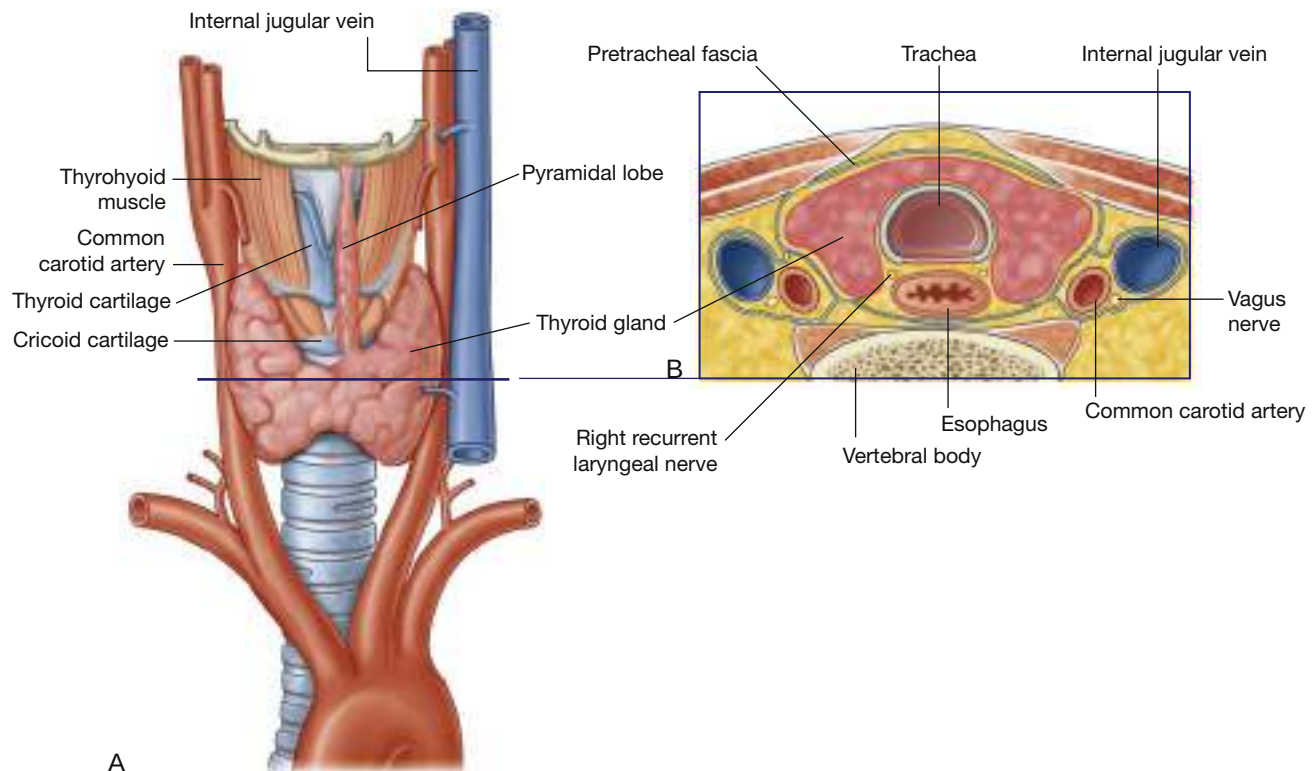


Fig. 8.160 Thyroid gland in the anterior triangle of neck. **A.** Anterior view. **B.** Transverse view showing trachea and esophagus below vertebral level CVI.

At the thyroid gland the inferior thyroid artery divides into an:

- inferior branch, which supplies the lower part of the thyroid gland and anastomoses with the posterior branch of the superior thyroid artery; and
- an ascending branch, which supplies the parathyroid glands.

Occasionally, a small **thyroid ima artery** arises from the brachiocephalic trunk or the arch of the aorta and ascends on the anterior surface of the trachea to supply the thyroid gland.

Venous and lymphatic drainage

Three veins drain the thyroid gland (Fig. 8.161):

- The **superior thyroid vein** primarily drains the area supplied by the superior thyroid artery.
- The **middle** and **inferior thyroid veins** drain the rest of the thyroid gland.

The superior and middle thyroid veins drain into the internal jugular vein, and the inferior thyroid veins empty into the right and left brachiocephalic veins, respectively.

Lymphatic drainage of the thyroid gland is into nodes beside the trachea (paratracheal nodes) and to deep cervical nodes inferior to the omohyoid muscle along the internal jugular vein.

Recurrent laryngeal nerves

The thyroid gland is closely related to the recurrent laryngeal nerves. After branching from the vagus nerve [X] and looping around the subclavian artery on the right and the arch of the aorta on the left, the **recurrent laryngeal nerves** ascend in a groove on each side between the trachea and esophagus (Fig. 8.162). They pass deep to the posteromedial surface of the lateral lobes of the thyroid gland and enter the larynx by passing deep to the lower margin of the inferior constrictor of the pharynx.

Together with branches of the inferior thyroid arteries, the recurrent laryngeal nerves are clearly related to and may pass through ligaments, one on each side, that bind the thyroid gland to the trachea and to the cricoid cartilage of the larynx. These relationships need to be considered when surgically removing or manipulating the thyroid gland.

Parathyroid glands

The parathyroid glands are two pairs of small, ovoid, yellowish structures on the deep surface of the lateral lobes of the

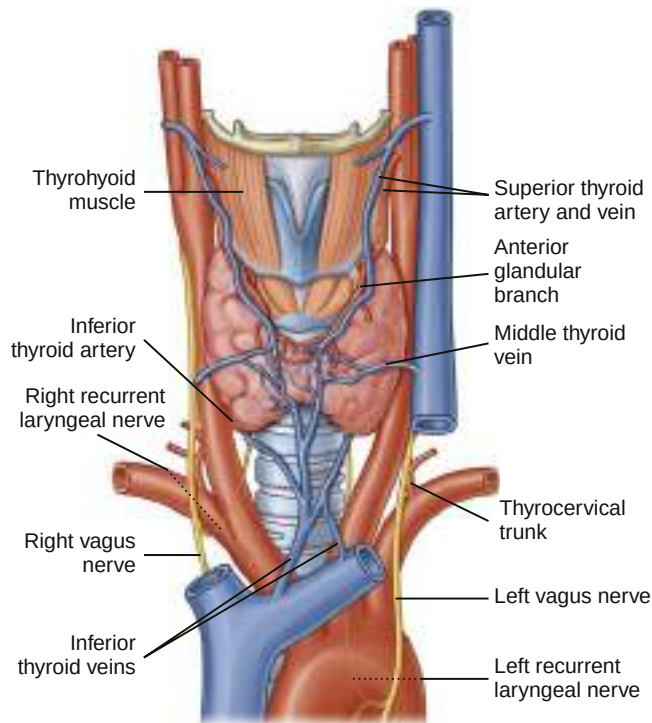


Fig. 8.161 Vasculature of the thyroid: anterior view.

thyroid gland. They are designated as the superior and inferior parathyroid glands (Fig. 8.162). However, their position is quite variable and they may be anywhere from the carotid bifurcation superiorly to the mediastinum inferiorly.

Derived from the third (the inferior parathyroid glands) and fourth (the superior parathyroid glands) pharyngeal pouches, these paired structures migrate to their final adult position and are named accordingly.

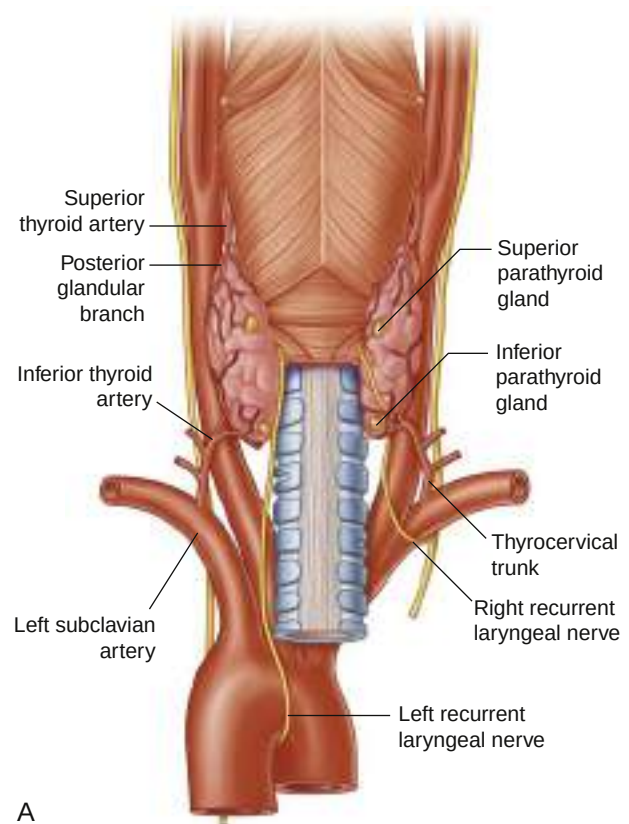
The arteries supplying the parathyroid glands are usually the inferior thyroid arteries, and venous and lymphatic drainage follows that described for the thyroid gland.

Clinical app

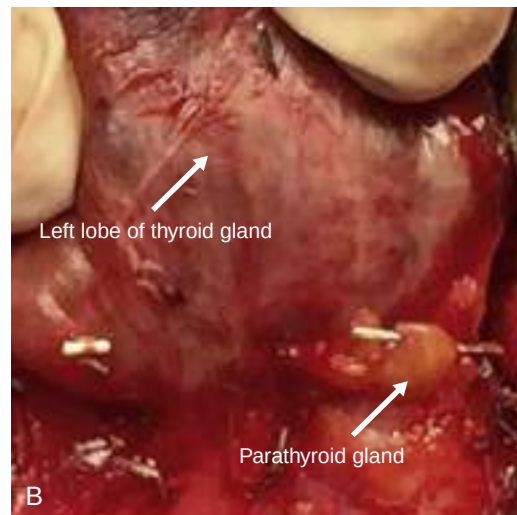
Thyroidectomy

A thyroidectomy is a relatively common surgical procedure. In most cases it involves excision of part or most of the thyroid gland, leaving some gland behind. This surgical procedure is usually carried out for benign diseases, such as multinodular goiter. However, thyroid carcinoma, albeit rare, is also an indication for thyroidectomy.

Given the location of the thyroid gland, there is a possibility of damaging other structures when carrying out a thyroidectomy, namely the parathyroid glands (which may be excised en masse with the thyroid gland), the recurrent laryngeal nerve, and the sympathetic trunk.



A



B

Fig. 8.162 Superior and inferior thyroid arteries and left and right recurrent laryngeal nerves. A. Posterior view. B. Surgical (anterolateral) view of parathyroid gland with left lobe of thyroid retracted.

Location of structures in subdivisions of the anterior triangle of the neck

The regional location of major structures in the anterior triangle of the neck is summarized in Table 8.14. Structures can be identified as being within a specific subdivision, passing into a specific subdivision from outside the area, originating in one subdivision and passing to another subdivision, or passing through several subdivisions while traversing the region.

Clinical app

Goiter

One of the commonest disorders of the thyroid gland is a **multinodular goiter**, which is a diffuse irregular enlargement of the thyroid gland with areas of thyroid hypertrophy and colloid cyst formation. Most patients are euthyroid (i.e., have normal serum thyroxine levels). The typical symptom is a diffuse mass in the neck, which may be managed medically or may need surgical excision if the mass is large enough to affect the patient's life or cause respiratory problems.

Surface anatomy

How to find the thyroid gland

The left and right lobes of the thyroid gland are in the anterior triangles in the lower neck on either side of the airway and digestive tract inferior to the position of the oblique line of the thyroid cartilage (Fig. 8.163). In fact, the sternothyroid muscles, which attach superiorly to the oblique lines, lie anterior to the lobes of the thyroid gland and prevent the lobes from moving upward in the neck.

The lobes of the thyroid gland can be most easily palpated by finding the thyroid prominence and arch of the cricoid cartilage and then feeling posterolateral to the larynx.

The isthmus of the thyroid gland crosses anterior to the upper end of the trachea and can be easily palpated in the midline inferior to the arch of the cricoid.

The presence of the isthmus of the thyroid gland makes palpating the tracheal cartilages difficult in the neck. Also, the presence of the isthmus of the thyroid gland and the associated vessels found in and crossing the midline makes it difficult to artificially enter the airway anteriorly through the trachea. This procedure, a tracheostomy, is a surgical procedure.

Position of oblique line on thyroid cartilage

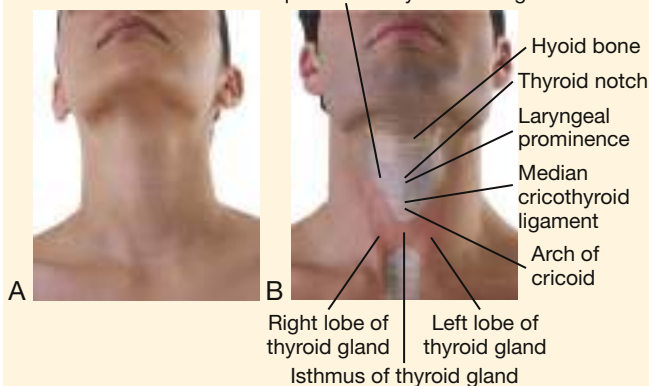


Fig. 8.163 How to find the thyroid gland. **A.** In a woman, anterior view of neck. **B.** In a man, anterior view of neck.

Clinical app

Hyperparathyroidism

Hyperparathyroidism involves the excess production of parathyroid hormone, which may be in response to a tumor within a parathyroid gland or as a secondary response due to low calcium levels.

Clinical app

Ectopic parathyroid glands

The parathyroid glands develop from the third and fourth pharyngeal pouches and translocate to their more adult locations during development. The position of the glands can be highly variable, sometimes being situated high in the neck or in the thorax.

Posterior triangle of the neck

The posterior triangle of the neck is on the lateral aspect of the neck in direct continuity with the upper limb. It is bordered:

- anteriorly by the posterior edge of the sternocleidomastoid muscle;
- posteriorly by the anterior edge of the trapezius muscle;
- basally by the middle one-third of the clavicle; and
- apically by the occipital bone just posterior to the mastoid process where the attachments of the trapezius and sternocleidomastoid come together (Fig. 8.164).

The roof of the posterior triangle consists of an investing layer of cervical fascia that surrounds the sternocleidomastoid and trapezius muscles as it passes through the region.

The muscular floor of the posterior triangle is covered by the prevertebral layer of cervical fascia and, from superior to inferior, consists of the splenius capitis, levator scapulae, and the posterior, middle, and anterior scalene muscles.

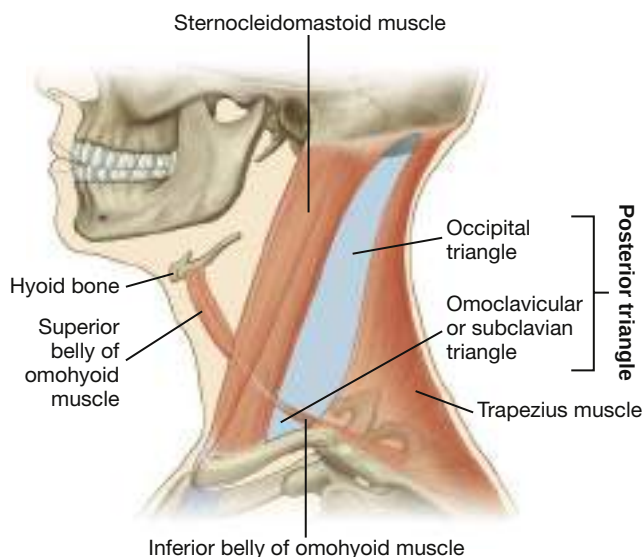
Muscles

Numerous muscles participate in forming the borders and floor of the posterior triangle of the neck (Table 8.15).

In addition, the **omohyoid** muscle passes across the inferior part of the posterior triangle before disappearing under the sternocleidomastoid muscle and emerging in the anterior triangle (Table 8.15, Fig. 8.165). It is enclosed in the investing layer of cervical fascia and crosses the posterior triangle from lateral to medial as it continues in a superior direction. It has two bellies connected by a tendon, which is anchored by a fascial sling to the clavicle:

Table 8.14 Subdivisions of the anterior triangle of the neck—a regional approach

Subdivision	Boundaries	Contents
Submental triangle (unpaired)	Mandibular symphysis; anterior belly of digastric muscle; body of hyoid bone	Submental lymph nodes; tributaries forming the anterior jugular vein
Submandibular triangle (paired)	Lower border of mandible; anterior belly of digastric muscle; posterior belly of digastric muscle	Submandibular gland; submandibular lymph nodes; hypoglossal nerve [XII]; mylohyoid nerve; facial artery and vein
Carotid triangle (paired)	Posterior belly of digastric muscle; superior belly of omohyoid muscle; anterior border of sternocleidomastoid muscle	Tributaries to common facial vein; cervical branch of facial nerve [VII]; common carotid artery; external and internal carotid arteries; superior thyroid; ascending pharyngeal; lingual, facial, and occipital arteries; internal jugular vein; vagus [X], accessory [XI], and hypoglossal [XII] nerves; superior and inferior roots of ansa cervicalis; transverse cervical nerve
Muscular triangle (paired)	Midline of neck; superior belly of omohyoid muscle; anterior border of sternocleidomastoid muscle	Sternohyoid, omohyoid, sternothyroid, and thyrohyoid muscles; thyroid and parathyroid glands; pharynx

**Fig. 8.164** Borders of the posterior triangle of the neck.

- The **superior belly** is in the anterior triangle.
- The **inferior belly** crosses the posterior triangle, subdividing it into a small, **omoclavicular or subclavian triangle** inferiorly and a much larger **occipital triangle** superiorly.

Vessels

External jugular vein

One of the most superficial structures passing through the posterior triangle of the neck is the external jugular vein (Fig. 8.166). This large vein forms near the angle of mandible, when the posterior branch of the retromandibular and posterior auricular veins join, and descends through the neck in the superficial fascia.

After crossing the sternocleidomastoid muscle, the external jugular vein enters the posterior triangle and continues its vertical descent.

In the lower part of the posterior triangle, the external jugular vein pierces the investing layer of cervical fascia and ends in the subclavian vein.

Tributaries to the external jugular vein, while it traverses the posterior triangle of the neck, include the transverse cervical, suprascapular, and anterior jugular veins.

Subclavian artery and its branches

Several arteries are found within the boundaries of the posterior triangle of the neck. The largest is the third part of the subclavian artery as it crosses the base of the posterior triangle (Fig. 8.167).

The **first part of the subclavian artery** ascends to the medial border of the anterior scalene muscle from either the brachiocephalic trunk on the right side or directly from the arch of the aorta on the left side. It has numerous branches.

The **second part of the subclavian artery** passes laterally between the anterior and middle scalene muscles, and one branch may arise from it.

The **third part of the subclavian artery** emerges from between the anterior and middle scalene muscles to cross the base of the posterior triangle (see Fig. 8.167). It extends from the lateral border of the anterior scalene muscle to the lateral border of rib I where it becomes the **axillary artery** and continues into the upper limb.

A single branch (the **dorsal scapular artery**) may arise from the third part of the subclavian artery. This branch passes posterolaterally to reach the superior angle of the scapula where it descends along the medial border of the scapula posterior to the rhomboid muscles.

Transverse cervical and suprascapular arteries

Two other small arteries also cross the base of the posterior triangle. These are the transverse cervical and the suprascapular arteries (see Fig. 8.167). They are both branches of the thyrocervical trunk, which arises from the first part of the subclavian artery.

After branching from the thyrocervical trunk, the **transverse cervical artery** passes laterally and slightly posteriorly across the base of the posterior triangle anterior to the anterior scalene muscle and the brachial plexus. Reaching the

Table 8.15 Muscles associated with the posterior triangle of the neck (parentheses indicate possible involvement)

Muscle	Origin	Insertion	Innervation	Function
Sternocleidomastoid —Sternal head	Upper part of anterior surface of manubrium of sternum	Lateral one-half of superior nuchal line	Accessory nerve [XI] and branches from anterior rami of C2 to C3 (C4)	Individually—will tilt head toward shoulder on same side, rotating head to turn face to opposite side; acting together, draw head forward
—Clavicular head	Superior surface of medial one-third of clavicle	Lateral surface of mastoid process		
Trapezius	Superior nuchal line; external occipital protuberance; ligamentum nuchae; spinous processes of vertebrae CVII to TXII	Lateral one-third of clavicle; acromion; spine of scapula	Motor—accessory nerve [XI]; proprioception—C3 and C4	Assists in rotating the scapula during abduction of humerus above horizontal; upper fibers—elevate, middle fibers—adduct, lower fibers—depress scapula
Splenius capitis	Lower half of ligamentum nuchae; spinous processes of vertebrae CVII to TIV	Mastoid process; skull below lateral one-third of superior nuchal line	Posterior rami of middle cervical nerves	Together, draw head backward; individually, draw and rotate head to one side (turn face to same side)
Levator scapulae	Transverse processes of C1 to CIV	Upper part of medial border of scapula	C3, C4, and dorsal scapular nerve (C4, C5)	Elevates scapula
Posterior scalene	Posterior tubercles of transverse processes of vertebrae CIV to CVI	Upper surface of rib II	Anterior rami of C5 to C7	Elevation of rib II
Middle scalene	Transverse processes of vertebrae CII to CVII	Upper surface of rib I posterior to the groove for the subclavian artery	Anterior rami of C3 to C7	Elevation of rib I
Anterior scalene	Anterior tubercles of the transverse processes of vertebrae CIII to CVI	Scalene tubercle and upper surface of rib I	Anterior rami of C4 to C7	Elevation of rib I
Omohyoid	Superior border of scapula medial to scapular notch	Inferior border of body of hyoid bone	Ansa cervicalis; anterior rami of C1 to C3	Depress the hyoid bone

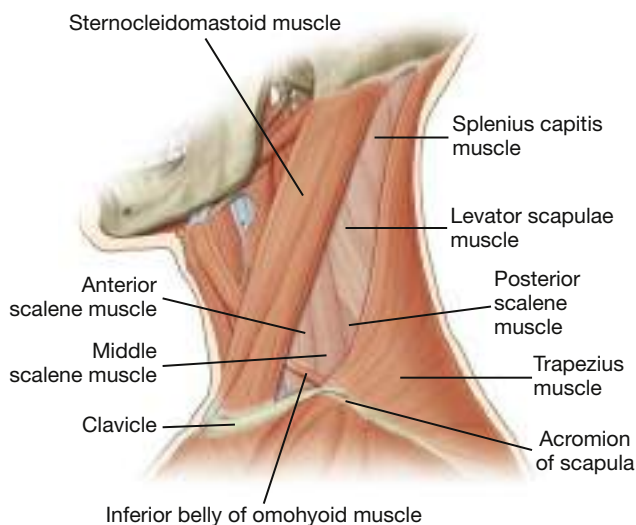


Fig. 8.165 Muscles of the posterior triangle of the neck.

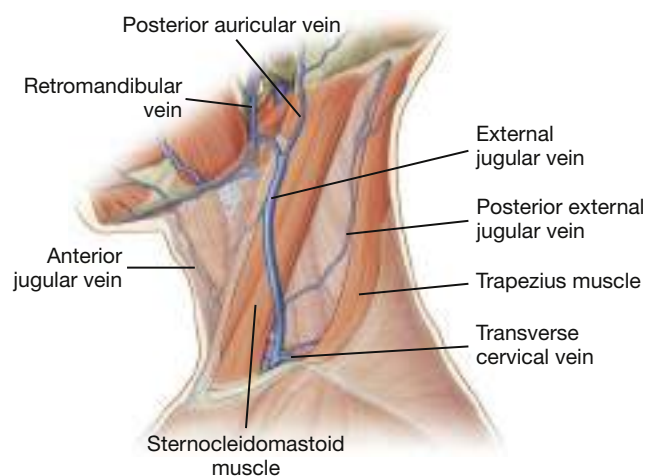


Fig. 8.166 External jugular vein in the posterior triangle of the neck.

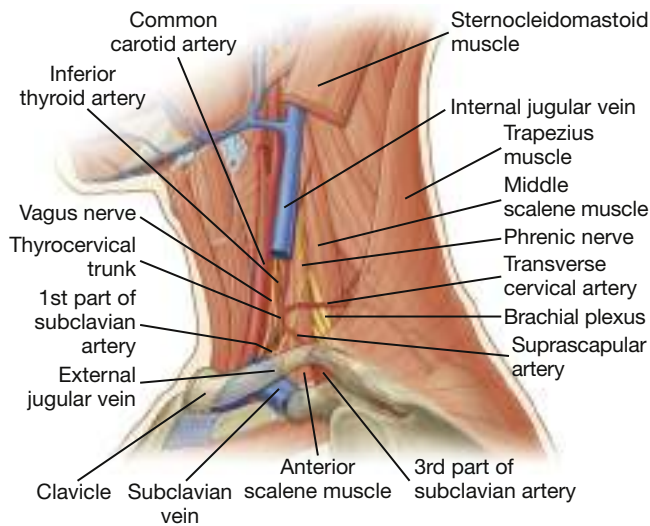


Fig. 8.167 Arteries in the posterior triangle of the neck.

deep surface of the trapezius muscle, it divides into superficial and deep branches:

- The **superficial branch** continues on the deep surface of the trapezius muscle.
- The **deep branch** continues on the deep surface of the rhomboid muscles near the medial border of the scapula.

The **suprascapular artery**, also a branch of the thyrocervical trunk, passes laterally, in a slightly downward direction across the lowest part of the posterior triangle, and ends up posterior to the clavicle (see Fig. 8.167). Approaching the scapula, it passes over the superior transverse scapular ligament and distributes branches to muscles on the posterior surface of the scapula.

Veins

Veins accompany all the arteries described previously.

The **subclavian vein** is a continuation of the axillary vein and begins at the lateral border of rib I. It crosses the base of the posterior triangle, and the external jugular and possibly the suprascapular and transverse cervical veins enter it. It ends by joining with the internal jugular vein to form the brachiocephalic vein near the sternoclavicular joint. In the posterior triangle it is anterior to, and slightly lower than, the subclavian artery and passes anterior to the anterior scalene muscle.

Transverse cervical and suprascapular veins travel with each of the similarly named arteries. These veins become tributaries to either the external jugular vein or the initial part of the subclavian vein.

Nerves

A variety of nerves pass through or are within the posterior triangle (Fig. 8.168). These include the accessory nerve [XI], branches of the cervical plexus, components forming the brachial plexus, and branches of the brachial plexus.

Accessory nerve

The accessory nerve [XI] exits the cranial cavity through the jugular foramen. It descends through the neck in a posterior direction to reach the anterior border of the sternocleidomastoid muscle. Passing either deep to or through and innervating the sternocleidomastoid muscle, the accessory nerve [XI] continues to descend and enters the posterior triangle (Fig. 8.168). It crosses the posterior triangle, still in an obliquely downward direction, within the investing layer of cervical fascia as this fascia crosses between the sternocleidomastoid and trapezius muscles. When the accessory nerve [XI] reaches the anterior border of the trapezius muscle, it

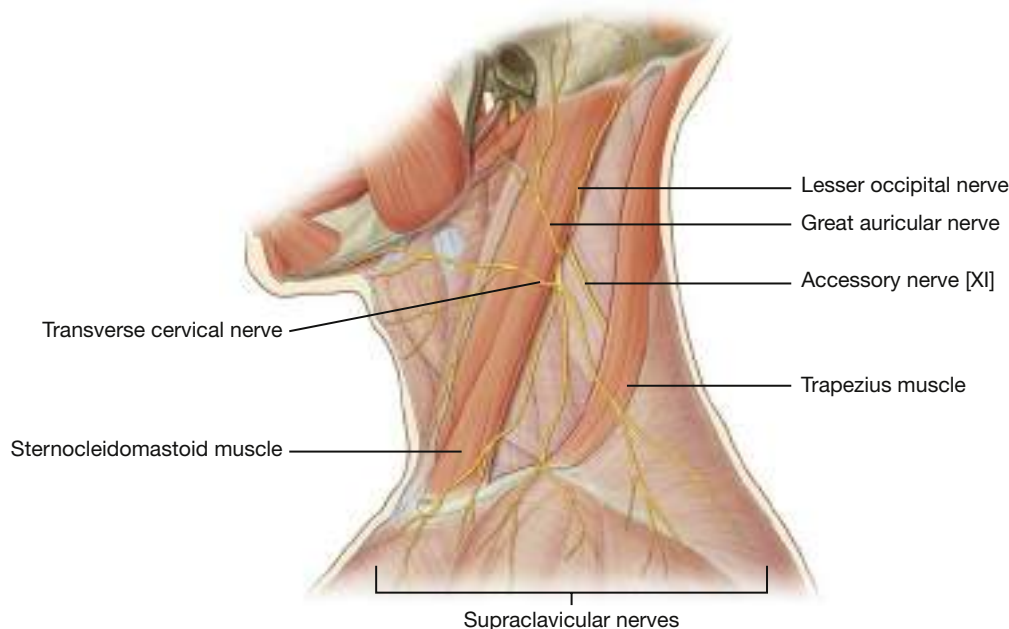


Fig. 8.168 Accessory nerve in the posterior triangle of the neck.

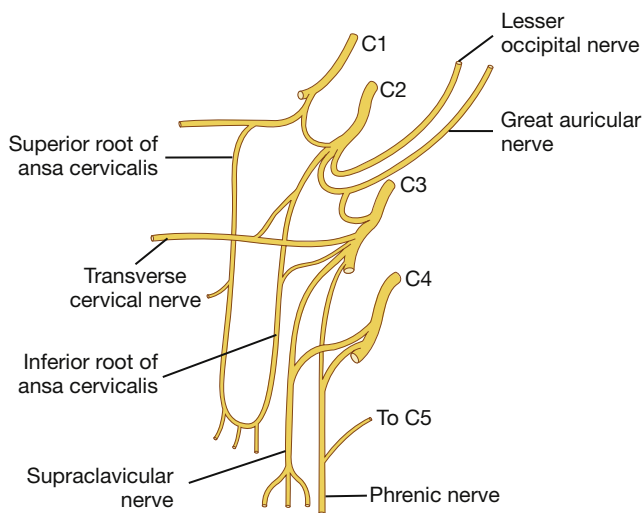


Fig. 8.169 Cervical plexus.

continues on the deep surface of the trapezius and innervates it. The superficial location of the accessory nerve as it crosses the posterior triangle makes it susceptible to injury.

Cervical plexus

The cervical plexus is formed by the anterior rami of cervical nerves C1 to C4 (Figs. 8.168, 8.169).

The cervical plexus forms in the substance of the muscles, making up the floor of the posterior triangle within the prevertebral layer of cervical fascia, and consists of muscular (or deep) and cutaneous (or superficial) branches.

Muscular branches

Muscular (deep) branches of the cervical plexus distribute to several groups of muscles. A major branch is the **phrenic nerve**, which supplies the diaphragm with both sensory and motor

innervation (Fig. 8.169). It arises from the anterior rami of cervical nerves C3 to C5. Hooking around the upper lateral border of the anterior scalene muscle, the nerve continues inferiorly across the anterior surface of the anterior scalene within the prevertebral fascia to enter the thorax (see Fig. 8.167). As the nerve descends in the neck, it is “pinned” to the anterior scalene muscle by the transverse cervical and suprascapular arteries.

Several muscular branches of the cervical plexus supply prevertebral and lateral vertebral muscles, including the rectus capitis anterior, rectus capitis lateralis, longus colli, and longus capitis (Table 8.16, Fig. 8.170).

The cervical plexus also contributes to the formation of the superior and inferior roots of the ansa cervicalis (Fig. 8.169). This loop of nerves receives contributions from the anterior rami of the cervical nerves C1 to C3 and innervates the infrahyoid muscles.

Cutaneous branches

Cutaneous (superficial) branches of the cervical plexus are visible in the posterior triangle as they pass outward from the posterior border of the sternocleidomastoid muscle (Figs. 8.168, 8.169):

- The **lesser occipital nerve** consists of contributions from cervical nerve C2, ascends along the posterior border of the sternocleidomastoid muscle, and distributes to the skin of the neck and scalp posterior to the ear.
- The **great auricular nerve** consists of branches from cervical nerves C2 and C3 (see Fig. 8.169), emerges from the posterior border of the sternocleidomastoid muscle, and ascends across the muscle to the base of the ear, supplying the skin of the parotid region, the ear, and the mastoid area.

Table 8.16 Prevertebral and lateral muscles

Muscle	Origin	Insertion	Innervation	Function
Rectus capitis anterior	Anterior surface of lateral part of atlas and its transverse process	Inferior surface of basilar part of occipital bone	Branches from anterior rami of C1, C2	Flexes head at atlanto-occipital joint
Rectus capitis lateralis	Superior surface of transverse process of atlas	Inferior surface of jugular process of occipital bone	Branches from anterior rami of C1, C2	Flexes head laterally to same side
Longus colli —Superior oblique part	Anterior tubercles of transverse processes of vertebrae CIII to CV	Tubercle of anterior arch of atlas	Branches from anterior rami of C2 to C6	Flexes neck anteriorly and laterally and slight rotation to opposite side
—Inferior oblique part	Anterior surface of bodies of vertebrae T1, TII, and maybe TIII	Anterior tubercles of transverse processes of vertebrae CV and CVI		
—Vertical part	Anterior surface of bodies of T1 to TIII and CV to CVII	Anterior surface of bodies of vertebrae CII to CIV		
Longus capitis	Tendinous slips to transverse processes of vertebrae CIII to CVI	Inferior surface of basilar part of occipital bone	Branches from anterior rami of C1 to C3	Flexes the head

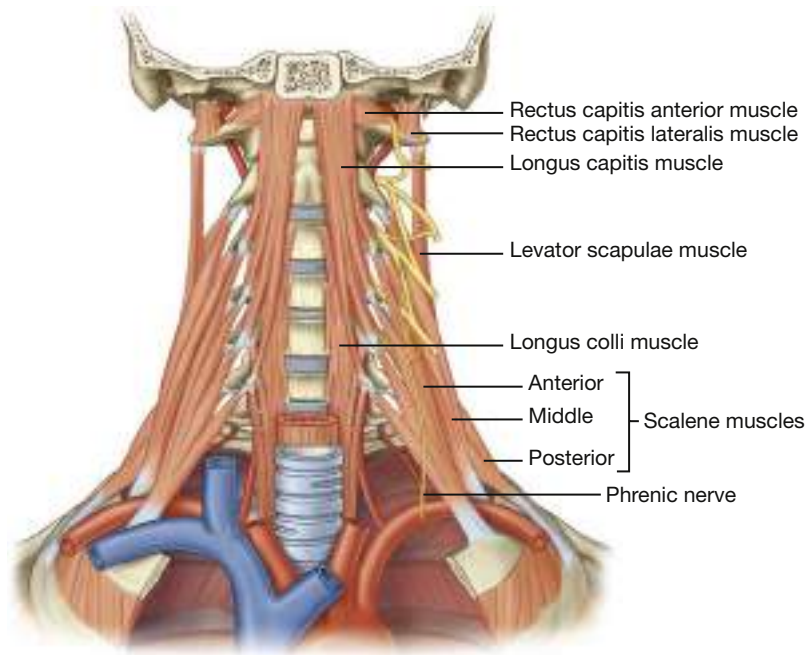


Fig. 8.170 Prevertebral and lateral vertebral muscles supplied by cervical plexus.

- The **transverse cervical nerve** consists of branches from the cervical nerves C2 and C3 (see Fig. 8.169), passes around the midpart of the sternocleidomastoid muscle, and continues horizontally across the muscle to supply the lateral and anterior parts of the neck.
- The **supraclavicular nerves** are a group of cutaneous nerves from cervical nerves C3 and C4 (see Fig. 8.169) that, after emerging from beneath the posterior border of the sternocleidomastoid muscle, descend and supply the skin over the clavicle and shoulder as far inferiorly as rib II.

Brachial plexus

The brachial plexus forms from the anterior rami of cervical nerves C5 to C8 and thoracic nerve T1. The contributions of each of these nerves, which are between the anterior and middle scalene muscles, are the **roots** of the brachial plexus. As the roots emerge from between these muscles, they form the next component of the brachial plexus (the **trunks**). The anterior rami of C5 and C6 form the upper trunk; the anterior ramus of C7 forms the middle trunk; and the anterior rami of C8 and T1 form the lower trunk.

The trunks cross the base of the posterior triangle (Fig. 8.167). Several branches of the brachial plexus may be visible in the posterior triangle. These include the:

- **dorsal scapular nerve** to the rhomboid muscles,
- **long thoracic nerve** to the serratus anterior muscle,
- nerve to the subclavius muscle, and
- **suprascapular nerve** to the supraspinatus and infraspinatus muscles.

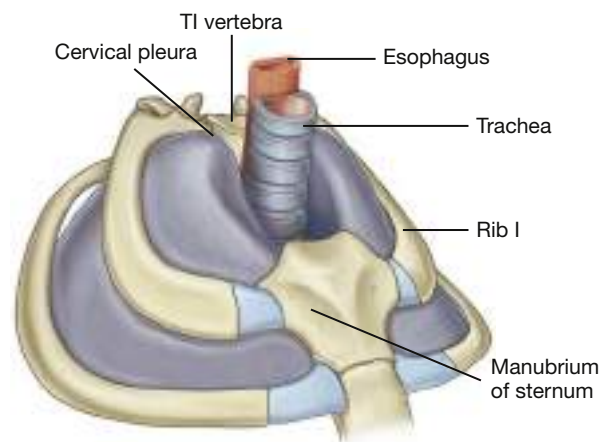


Fig. 8.171 Root of the neck.

Root of the neck

The root of the neck (Fig. 8.171) is the area immediately superior to the superior thoracic aperture and axillary inlets. It is bounded by:

- the top of the manubrium of sternum and superior margin of the clavicle anteriorly, and
- the top of the thoracic vertebra T1 and the superior margin of the scapula to the coracoid process posteriorly.

It contains structures passing between the neck, thorax, and upper limb. There is also an extension of the thoracic cavity projecting into the root of the neck. This consists of an

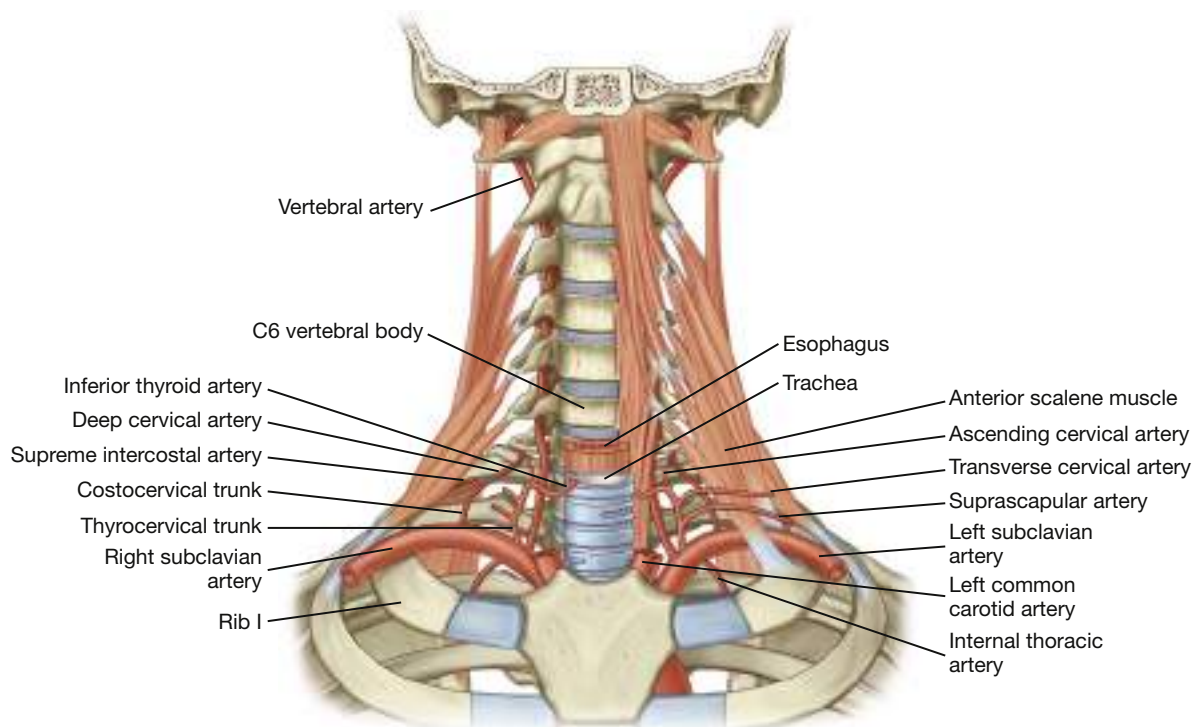


Fig. 8.172 Vasculature of the root of the neck.

upward projection of the pleural cavity, on both sides, and includes the cervical part of the parietal pleura (cupula) and the apical part of the superior lobe of each lung.

Anteriorly, the pleural cavity extends above the top of the manubrium of sternum and superior border of rib I, while posteriorly, due to the downward slope of the superior thoracic aperture, the pleural cavity remains below the top of vertebra T1.

Vessels

Subclavian arteries

The subclavian arteries on both sides arch upward out of the thorax to enter the root of the neck (Fig. 8.172).

The **right subclavian artery** begins posterior to the sternoclavicular joint as one of two terminal branches of the brachiocephalic trunk. It arches superiorly and laterally to pass anterior to the extension of the pleural cavity in the root of the neck and posterior to the anterior scalene muscle. Continuing laterally across rib I, it becomes the **axillary artery** as it crosses its lateral border.

The **left subclavian artery** begins lower in the thorax than the right subclavian artery as a direct branch of the arch of the aorta. Lying posterior to the left common carotid artery and lateral to the trachea, it ascends and arches laterally, passing anterior to the extension of the pleural cavity and posterior to the anterior scalene muscle. It continues laterally over rib I, and becomes the axillary artery as it crosses the lateral border of rib I.

Both subclavian arteries are divided into three parts by the anterior scalene muscle (Fig. 8.172):

- The first part extends from the origin of the artery to the anterior scalene muscle.
- The second part is the part of the artery posterior to the anterior scalene muscle.
- The third part is the part lateral to the anterior scalene muscle before the artery reaches the lateral border of rib I.

All branches from the right and left subclavian arteries arise from the first part of the artery, except in the case of one branch (the costocervical trunk) on the right side (Fig. 8.172). The branches include the vertebral artery, the thyrocervical trunk, the internal thoracic artery, and the costocervical trunk.

Vertebral artery

The **vertebral artery** is the first branch of the subclavian artery as it enters the root of the neck (Fig. 8.172). A large branch, arising from the first part of the subclavian artery medial to the anterior scalene muscle, it ascends and enters the foramen in the transverse process of vertebra C6. Continuing to pass superiorly, the vertebral artery passes through the foramina of vertebrae CV to C1. At the superior border of vertebra C1, the artery turns medially and crosses the posterior arch of vertebra C1. From here it passes through the foramen magnum to enter the posterior cranial fossa.

Thyrocervical trunk

The second branch of the subclavian artery is the **thyrocervical trunk** (Fig. 8.172). It arises from the first part of the subclavian artery medial to the anterior scalene muscle and divides into three branches—the inferior thyroid, the transverse cervical, and the suprascapular arteries.

Inferior thyroid artery. The **inferior thyroid artery** (Fig. 8.172) is the superior continuation of the thyrocervical trunk. It ascends, anterior to the anterior scalene muscle, and eventually turns medially, crossing posterior to the carotid sheath and its contents, and anterior to the vertebral artery. Reaching the posterior surface of the thyroid gland, it supplies the thyroid gland.

When the inferior thyroid artery turns medially, it gives off an important branch (the **ascending cervical artery**, Fig. 8.172), which continues to ascend on the anterior surface of the prevertebral muscles, supplying these muscles and sending branches to the spinal cord.

Transverse cervical artery. The middle branch of the thyrocervical trunk is the **transverse cervical artery** (see Fig. 8.172). This branch passes laterally, across the anterior surface of the anterior scalene muscle and the phrenic nerve, and enters and crosses the base of the posterior triangle of the neck. It continues to the deep surface of the trapezius muscle, where it divides into superficial and deep branches:

- The **superficial branch** continues on the deep surface of the trapezius muscle.
- The **deep branch** continues on the deep surface of the rhomboid muscles near the medial border of the scapula.

Suprascapular artery. The lowest branch of the thyrocervical trunk is the **suprascapular artery** (see Fig. 8.172). This branch passes laterally, crossing anterior to the anterior scalene muscle, the phrenic nerve, the third part of the subclavian artery, and the trunks of the brachial plexus. At the superior border of the scapula, it crosses over the superior transverse scapular ligament and enters the supraspinatus fossa.

Internal thoracic artery

The third branch of the subclavian artery is the **internal thoracic artery** (see Fig. 8.172). This artery branches from the inferior edge of the subclavian artery and descends.

It passes posterior to the clavicle and the large veins in the region and anterior to the pleural cavity. It enters the thoracic cavity posterior to the ribs and anterior to the transversus thoracis muscle and continues to descend, giving off numerous branches.

Costocervical trunk

The final branch of the subclavian artery in the root of the neck is the **costocervical trunk** (see Fig. 8.172). It arises in a slightly different position, depending on the side:

- On the left, it arises from the first part of the subclavian artery, just medial to the anterior scalene muscle.
- On the right, it arises from the second part of the subclavian artery.

On both sides, the costocervical trunk ascends and passes posteriorly over the dome of the pleural cavity and continues in a posterior direction behind the anterior scalene muscle. Eventually it divides into two branches—the deep cervical and the supreme intercostal arteries:

- The **deep cervical artery** ascends in the back of the neck and anastomoses with the descending branch of the occipital artery.
- The **supreme intercostal artery** descends anterior to rib I and divides to form the posterior intercostal arteries for the first two intercostal spaces.

Veins

Numerous veins pass through the root of the neck. Small veins accompany each of the arteries described previously, and large veins form major drainage channels.

The **subclavian veins** begin at the lateral margin of rib I as continuations of the **axillary veins**. Passing medially on each side, just anterior to the anterior scalene muscles, each subclavian vein is joined by the internal jugular vein to form the brachiocephalic veins.

The only tributary to the subclavian veins are the external jugular veins.

The veins accompanying the numerous arteries in this region empty into other veins.

Nerves

Several nerves and components of the nervous system pass through the root of the neck.

Phrenic nerves

The phrenic nerves are branches of the cervical plexus and arise on each side as contributions from the anterior rami of cervical nerves C3 to C5 come together. Passing around the upper lateral border of each anterior scalene muscle, the phrenic nerves continue inferiorly across the anterior surface of each anterior scalene muscle within the prevertebral layer of cervical fascia (Fig. 8.173). Leaving the lower edge of the anterior scalene muscle, each phrenic nerve passes between the subclavian vein and artery to enter the thorax and continue to the diaphragm.

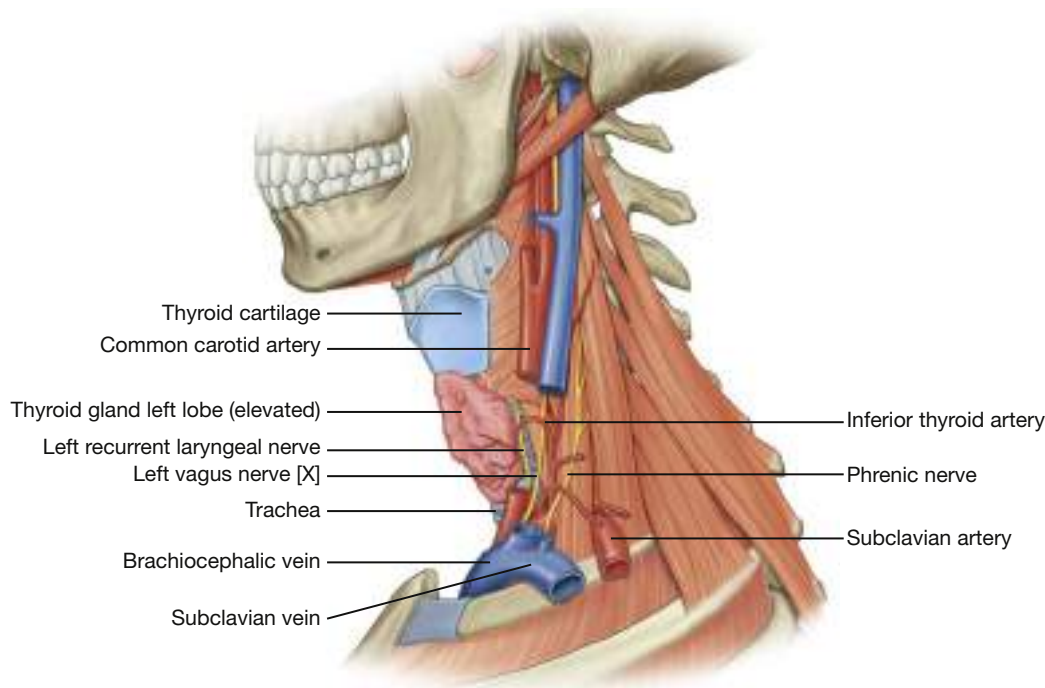


Fig. 8.173 Nerves in the root of the neck.

Vagus nerves [X]

The vagus nerves [X] descend through the neck within the carotid sheath, posterior to and just between the common carotid artery and the internal jugular vein.

In the lower part of the neck, the vagus nerves [X] give off cardiac branches, which continue downward and medially, passing posterior to the subclavian arteries to disappear into the thorax.

In the root of the neck, each vagus nerve [X] passes anterior to the subclavian artery and posterior to the subclavian vein as it enters the thorax (Fig. 8.173).

Recurrent laryngeal nerves

The right and left recurrent laryngeal nerves are visible as they originate in (the right recurrent laryngeal nerve), or pass through (the left recurrent laryngeal nerve), the root of the neck.

The **right recurrent laryngeal nerve** is a branch of the right vagus nerve [X] as it reaches the lower edge of the first part of the subclavian artery in the root of the neck. It passes around the subclavian artery and upward and medially in a groove between the trachea and the esophagus as it heads to the larynx.

The **left recurrent laryngeal nerve** is a branch of the left vagus nerve [X] as it crosses the arch of the aorta in the superior mediastinum. It passes below and behind the arch of the aorta and ascends beside the trachea to the larynx.

Clinical app

Recurrent laryngeal nerve palsy

Damage to either the right or left recurrent laryngeal nerves may lead initially to a hoarse voice and finally to an inability to speak. Recurrent laryngeal nerve palsy can occur from disruption of the nerves anywhere along their course. Furthermore, interruption of the vagus nerves before the division of the recurrent laryngeal nerves can also produce vocal symptoms.

Lung cancer in the apex of the right lung can affect the right recurrent laryngeal nerve, whereas cancers that infiltrate into the area between the pulmonary artery and aorta, an area known clinically as the “aortopulmonary window,” can affect the left recurrent laryngeal nerve.

Assessment of the vocal cords is necessary before and after thyroid surgery because the recurrent laryngeal nerves are closely related to ligaments that bind the gland to the larynx and can be easily traumatized during surgical procedures.

Sympathetic nervous system

Various components of the sympathetic nervous system are visible as they pass through the root of the neck (Fig. 8.174). These include:

- the cervical part of the sympathetic trunk,
- the ganglia associated with the cervical part of the sympathetic trunk, and

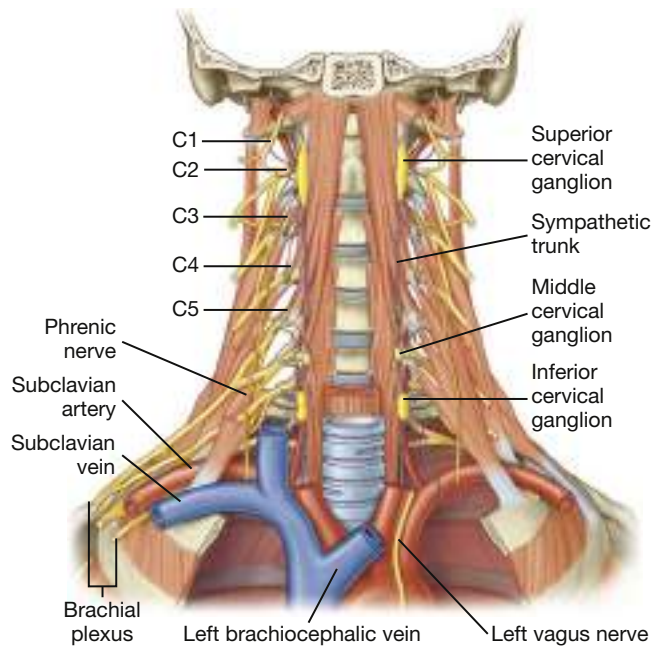


Fig. 8.174 Cervical part of the sympathetic trunk.

- cardiac nerves branching from the cervical part of the sympathetic trunk (Fig. 8.174).

The sympathetic trunks are two parallel cords that run from the base of the skull to the coccyx. Along the way they are punctuated by ganglia, which are collections of neuronal cell bodies outside the CNS.

Cervical part of the sympathetic trunk

The **cervical part of the sympathetic trunk** is anterior to the longus colli and longus capitis muscles, and posterior to the common carotid artery in the carotid sheath and the internal carotid artery. It is connected to each cervical spinal nerve by a gray ramus communicans (Fig. 8.174). There are no white rami communicantes in the cervical region.

Ganglia

Three ganglia are usually described along the course of the sympathetic trunk in the cervical region, and in these ganglia ascending preganglionic sympathetic fibers from the upper thoracic spinal cord levels synapse with postganglionic sympathetic fibers. The postganglionic sympathetic fibers are distributed in branches from these ganglia.

Superior cervical ganglion. A very large **superior cervical ganglion** in the area of cervical vertebrae CI and CII marks the superior extent of the sympathetic trunk (Figs. 8.174, 8.175). Its branches pass to:

- the internal carotid and external carotid arteries, forming plexuses around these vessels,

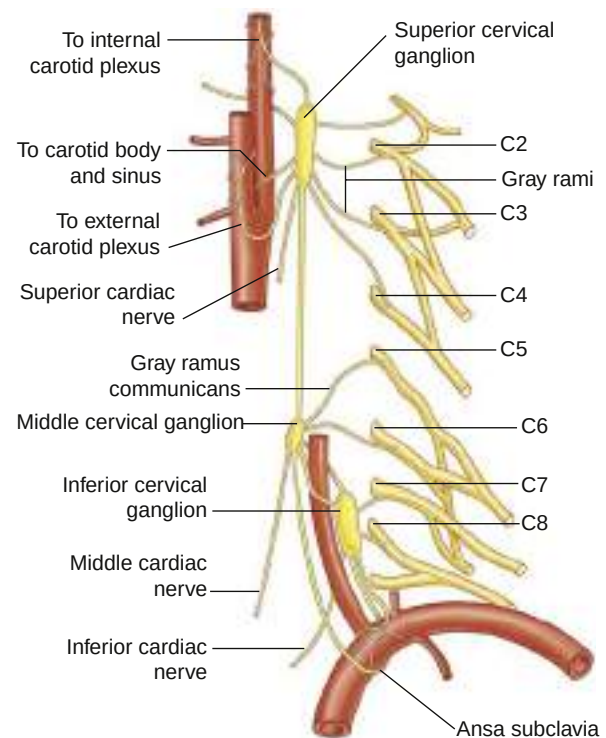


Fig. 8.175 Components of the sympathetic nervous system in the root of the neck.

- cervical spinal nerves C1 to C4 through gray rami communicantes,
- the pharynx, and
- the heart as **superior cardiac nerves**.

Middle cervical ganglion. A second ganglion inferior to the superior cervical ganglion along the course of the sympathetic trunk (the **middle cervical ganglion**) is encountered at about the level of cervical vertebra CVI (Figs. 8.174, 8.175). Branches from this ganglion pass to:

- cervical spinal nerves C5 and C6 through gray rami communicantes, and
- the heart as **middle cardiac nerves**.

Inferior cervical ganglion. At the lower end of the cervical part of the sympathetic trunk is another ganglion (the inferior cervical ganglion), which becomes very large when it combines with the first thoracic ganglion and forms the **cervicothoracic ganglion (stellate ganglion)**. The inferior cervical ganglion (Figs. 8.174, 8.175) is anterior to the neck of rib I and the transverse process of cervical vertebra CVII, and posterior to the first part of the subclavian artery and the origin of the vertebral artery.

Branches from this ganglion pass to:

- spinal nerves C7 to T1 through gray rami communicantes,

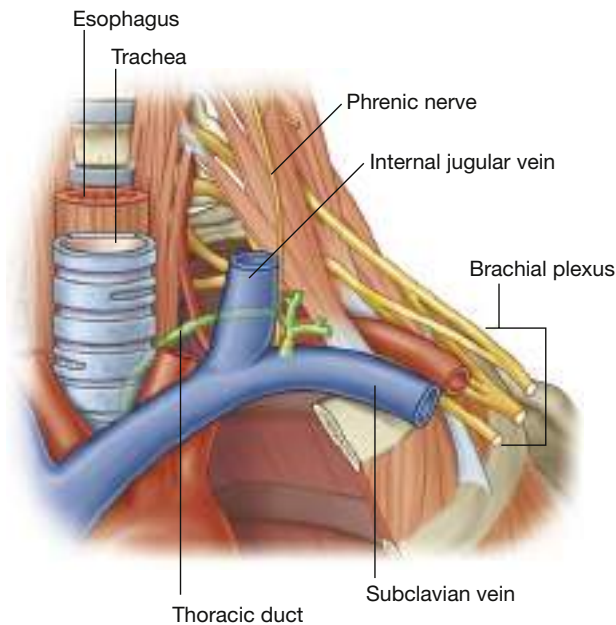


Fig. 8.176 Thoracic duct in the root of the neck.

- the vertebral artery, forming a plexus associated with this vessel, and
- the heart as **inferior cardiac nerves**.

This ganglion may also receive white rami communicantes from thoracic spinal nerve T1 and occasionally from T2.

Lymphatics

Thoracic duct

The **thoracic duct** is a major lymphatic channel that begins in the abdomen, passes superiorly through the thorax, and ends in the venous channels in the neck. It passes through the lower thoracic cavity in the midline with:

- the thoracic aorta on the left,
- the azygos vein on the right, and
- the esophagus anteriorly.

At about the level of thoracic vertebra TV the thoracic duct passes to the left and continues to ascend just to the left of the esophagus. It passes through the superior mediastinum and enters the root of the neck to the left of the esophagus (Fig. 8.176). Arching laterally, it passes posterior to the carotid sheath and turns inferiorly in front of the thyrocervical trunk, the phrenic nerve, and the vertebral artery.

The thoracic duct terminates in the junction between the left internal jugular and the left subclavian veins. Near its junction with the venous system it is joined by (Fig. 8.177):

- the **left jugular trunk**, which drains lymph from the left side of the head and neck;

- the **left subclavian trunk**, which drains lymph from the left upper limb; and
- occasionally, the **left bronchomediastinal trunk**, which drains lymph from the left half of the thoracic structures.

A similar confluence of three lymphatic trunks occurs on the right side of the body. Emptying into the junction between the right internal jugular and right subclavian veins are (Fig. 8.177):

- the **right jugular trunk** from the head and neck,
- the **right subclavian trunk** from the right upper limb, and
- occasionally, the **right bronchomediastinal trunk** carrying lymph from the structures in the right half of the thoracic cavity and the right upper intercostal spaces.

There is variability in how these trunks enter the veins. They may combine into a single right lymphatic duct to enter the venous system or enter as three separate trunks.

Lymphatics of the neck

A description of the organization of the lymphatic system in the neck becomes a summary of the lymphatic system in the head and neck. It is impossible to separate the two regions. The components of this system include superficial nodes around the head, superficial cervical nodes along the external jugular vein, and deep cervical nodes forming a chain along the internal jugular vein (Fig. 8.178).

The basic pattern of drainage is for superficial lymphatic vessels to drain to the superficial nodes. Some of these drain to the superficial cervical nodes on their way to the deep cervical nodes, and others drain directly to the deep cervical nodes.

Superficial lymph nodes

Five groups of superficial lymph nodes form a ring around the head and are primarily responsible for the lymphatic drainage of the face and scalp. Their pattern of drainage is very similar to the area of distribution of the arteries near their location.

Beginning posteriorly these groups are (Fig. 8.178):

- **occipital nodes** near the attachment of the trapezius muscle to the skull and associated with the occipital artery—lymphatic drainage is from the posterior scalp and neck;
- **mastoid nodes (retroauricular/posterior auricular nodes)** posterior to the ear near the attachment of the sternocleidomastoid muscle and associated with the posterior auricular artery—lymphatic drainage is from the posterolateral half of the scalp;
- **pre-auricular and parotid nodes** anterior to the ear and associated with the superficial temporal and transverse

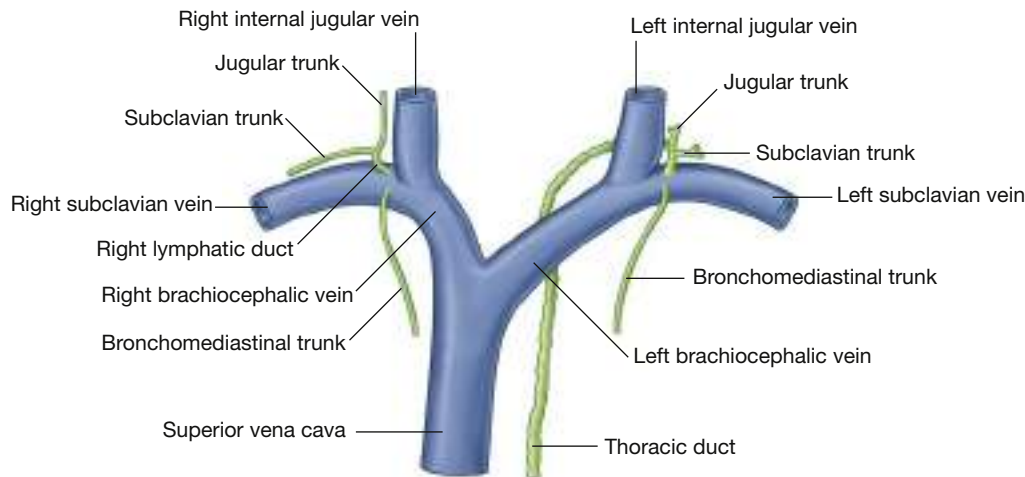


Fig. 8.177 Termination of lymphatic trunks in the root of the neck.

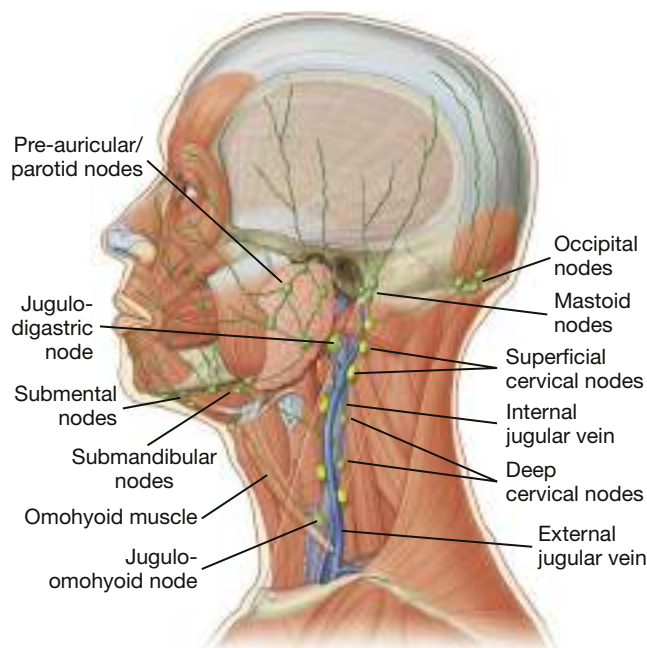


Fig. 8.178 Lymphatic system in the neck.

facial arteries—lymphatic drainage is from the anterior surface of the auricle, the anterolateral scalp, the upper half of the face, the eyelids, and the cheeks;

- **submandibular nodes** inferior to the body of mandible and associated with the facial artery—lymphatic drainage is from structures along the path of the facial artery as high as the forehead, as well as the gingivae, the teeth, and the tongue; and
- **submental nodes** inferior and posterior to the chin—lymphatic drainage is from the center part of the lower lip, the chin, the floor of the mouth, the tip of the tongue, and the lower incisor teeth.

Lymphatic flow from these superficial lymph nodes passes in several directions:

- Drainage from the occipital and mastoid nodes passes to the superficial cervical nodes along the external jugular vein.
- Drainage from the pre-auricular and parotid nodes, the submandibular nodes, and the submental nodes passes to the deep cervical nodes.

Superficial cervical lymph nodes

The **superficial cervical nodes** are a collection of lymph nodes along the external jugular vein on the superficial surface of the sternocleidomastoid muscle (see Fig. 8.178). They primarily receive lymphatic drainage from the posterior and posterolateral regions of the scalp through the occipital and mastoid nodes, and send lymphatic vessels in the direction of the deep cervical nodes.

Deep cervical lymph nodes

The **deep cervical nodes** are a collection of lymph nodes that form a chain along the internal jugular vein (see Fig. 8.178). They are divided into upper and lower groups where the intermediate tendon of the omohyoid muscle crosses the common carotid artery and the internal jugular vein.

The most superior node in the upper deep cervical group is the **jugulodigastric node** (see Fig. 8.178). This large node is where the posterior belly of the digastric muscle crosses the internal jugular vein and receives lymphatic drainage from the tonsils and tonsillar region.

Another large node, usually associated with the lower deep cervical group because it is at or just inferior to the intermediate tendon of the omohyoid muscle, is the **jugulo-omohyoid node** (see Fig. 8.178). This node receives lymphatic drainage from the tongue.

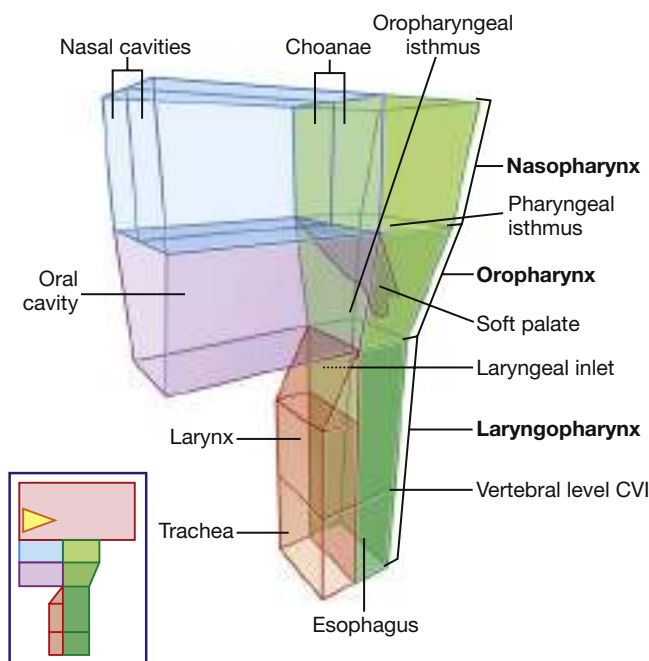


Fig. 8.179 Pharynx.

The deep cervical nodes eventually receive all lymphatic drainage from the head and neck either directly or through regional groups of nodes.

From the deep cervical nodes, lymphatic vessels form the right and left jugular trunks, which empty into the right lymphatic duct on the right side or the thoracic duct on the left side.

Clinical app

Clinical lymphatic drainage of the head and neck

Enlargement of the neck lymph nodes (cervical lymphadenopathy) is a common manifestation of disease processes that occur in the head and neck. Evaluation of cervical lymph nodes is extremely important in determining the nature and etiology of the primary disease process that has produced nodal enlargement. Examination of the lymph nodes often gives the clinician a clue as to the nature of the pathological process.

- Soft, tender, and inflamed lymph nodes suggest an acute inflammatory process, which is most likely to be infective.
- Firm, multinodular, large-volume rubbery nodes often suggest a diagnosis of lymphoma. Most cervical lymph nodes are easily palpable and suitable for biopsy to establish a tissue diagnosis.

A relatively simple “level” system of nodal enlargement has been designed that is extremely helpful in evaluating

Clinical app—cont’d

lymph node spread of primary head and neck tumors. Once the number of levels of nodes are determined, as well as the size of the lymph nodes, the best mode of treatment can be instituted. The lymph node level also enables a prognosis to be made. The levels are as follows:

- Level I—from the midline of the submental triangle up to the level of the submandibular gland.
- Level II—from the skull base to the level of the hyoid bone anteriorly to the posterior border of the sternocleidomastoid muscle.
- Level III—the inferior aspect of the hyoid bone to the bottom cricoid arch and anterior to the posterior border of the sternocleidomastoid up to the midline.
- Level IV—from the inferior aspect of the cricoid to the top of the manubrium of sternum and anterior to the posterior border of the sternocleidomastoid muscle.
- Level V—posterior to the sternocleidomastoid muscle and anterior to the trapezius muscle above the level of the clavicle.
- Level VI—below the hyoid bone and above the jugular (sternal) notch in the midline.
- Level VII—below the level of the jugular (sternal) notch.

PHARYNX

The pharynx is a musculofascial half-cylinder that links the oral and nasal cavities in the head to the larynx and esophagus in the neck (Fig. 8.179). The pharyngeal cavity is a common pathway for air and food.

The pharynx is attached above to the base of the skull and is continuous below, approximately at the level of vertebra CVI, with the top of the esophagus. The walls of the pharynx are attached anteriorly to the margins of the nasal cavities, oral cavity, and larynx. Based on these anterior relationships, the pharynx is subdivided into three regions—the nasopharynx, oropharynx, and laryngopharynx:

- The posterior apertures (choanae) of the nasal cavities open into the nasopharynx.
- The posterior opening of the oral cavity (oropharyngeal isthmus) opens into the oropharynx.
- The superior aperture of the larynx (laryngeal inlet) opens into the laryngopharynx.

In addition to these openings, the pharyngeal cavity is related anteriorly to the posterior one-third of the tongue and to the posterior aspect of the larynx. The pharyngotympanic tubes open into the lateral walls of the nasopharynx.

Lingual, pharyngeal, and palatine tonsils are on the deep surface of the pharyngeal walls.

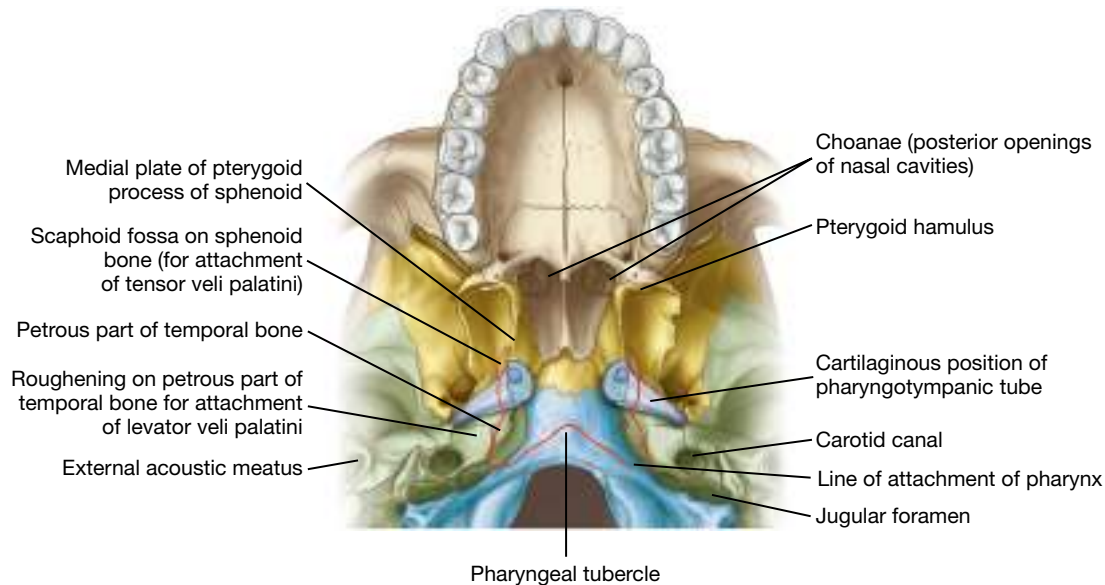


Fig. 8.180 Line of attachment of the pharynx to the base of the skull.

The pharynx is separated from the posteriorly positioned vertebral column by a thin retropharyngeal space containing loose connective tissue.

Although the soft palate is generally considered part of the roof of the oral cavity, it is also related to the pharynx. The soft palate is attached to the posterior margin of the hard palate and is a type of “flutter valve” that can:

- swing up (elevate) to close the pharyngeal isthmus and seal off the nasopharynx from the oropharynx; and
- swing down (depress) to close the oropharyngeal isthmus and seal off the oral cavity from the oropharynx.

Skeletal framework

The superior and anterior margins of the pharyngeal wall are attached to bone and cartilage, and to ligaments. The two sides of the pharyngeal wall are welded together posteriorly in the midline by a vertically oriented cord-like ligament (the pharyngeal raphe). This connective tissue structure descends from the pharyngeal tubercle on the base of the skull to the level of cervical vertebra CVI where the raphe blends with connective tissue in the posterior wall of the esophagus.

There is an irregular C-shaped line of pharyngeal wall attachment on the base of the skull (Fig. 8.180). The open part of the C faces the nasal cavities. Each arm of the C begins at the posterior margin of the medial plate of the pterygoid process of the sphenoid bone, just inferior to the cartilaginous part of the pharyngotympanic tube. The line crosses inferior to the pharyngotympanic tube and then passes onto the petrous part of the temporal bone where it is just medial to the roughening for the attachment of one of the muscles (levator veli palatini) of the soft palate. From

here, the line swings medially onto the occipital bone and joins the line from the other side at a prominent elevation of bone in the midline (the pharyngeal tubercle).

Anterior vertical line of attachment for the lateral pharyngeal walls

The vertical line of attachment for the lateral pharyngeal walls to structures related to the nasal and oral cavities and larynx is discontinuous and in three parts.

First part

On each side, the anterior line of attachment of the lateral pharyngeal wall begins superiorly on the posterior edge of the medial pterygoid plate of the sphenoid bone just inferior to where the pharyngotympanic tube lies against this plate (Fig. 8.181). It continues inferiorly along the edge of the medial plate of the pterygoid process and onto the pterygoid hamulus. From this point, the line descends along the pterygomandibular raphe to the mandible where this part of the line terminates.

The **pterygomandibular raphe** is a linear cord-like connective tissue ligament that spans the distance between the tip of the pterygoid hamulus and a triangular roughening immediately posterior to the third molar on the mandible (Fig. 8.181). It joins a muscle of the lateral pharyngeal wall (superior constrictor) with a muscle of the lateral wall of the oral cavity (buccinator).

Second part

The second part of the line of attachment of the lateral pharyngeal wall is related to the hyoid bone (Fig. 8.181). It begins on the lower aspect of the stylohyoid ligament, which connects

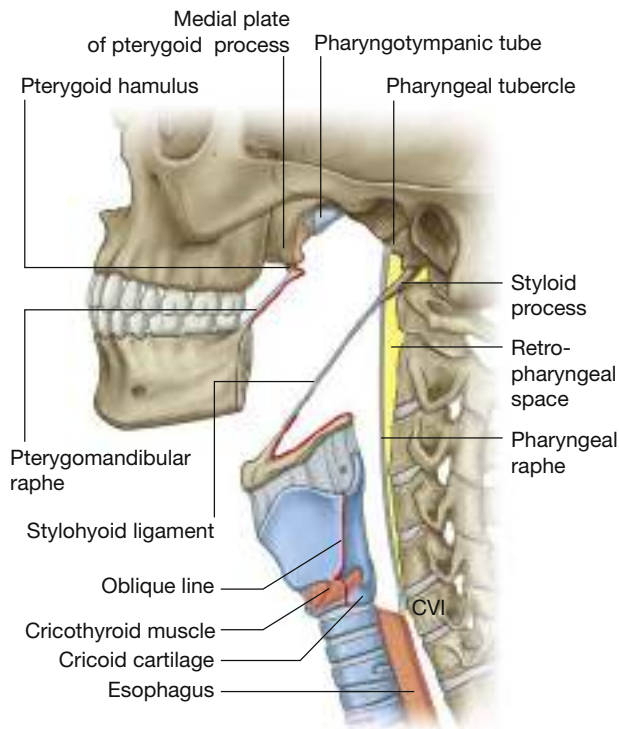


Fig. 8.181 Attachments of the lateral pharyngeal wall.

the tip of the styloid process of the temporal bone to the lesser horn of the hyoid bone. The line continues onto the lesser horn and then turns and runs posteriorly along the entire upper surface of the greater horn of the hyoid where it terminates.

Third part

The most inferior and third part of the line of attachment of the lateral pharyngeal wall begins superiorly on the superior tubercle of the thyroid cartilage, and descends along the oblique line to the inferior tubercle.

From the inferior tubercle, the line of attachment continues over the cricothyroid muscle along a tendinous thickening of fascia to the cricoid cartilage where it terminates.

Pharyngeal wall

The pharyngeal wall is formed by skeletal muscles and by fascia. Gaps between the muscles are reinforced by the

fascia and provide routes for structures to pass through the wall.

Muscles

The muscles of the pharynx are organized into two groups based on the orientation of muscle fibers.

The constrictor muscles have fibers oriented in a circular direction relative to the pharyngeal wall, whereas the longitudinal muscles have fibers oriented vertically.

Constrictor muscles

The three constrictor muscles on each side are major contributors to the structure of the pharyngeal wall (Table 8.17, Fig. 8.182), and their names indicate their position—**superior**, **middle**, and **inferior constrictor muscles**. Posteriorly, the muscles from each side are joined together by the pharyngeal raphe (Fig. 8.182B). Anteriorly, these muscles attach to bones, cartilages, and ligaments related to the lateral margins of the nasal and oral cavities and the larynx.

The constrictor muscles overlap each other in a fashion resembling the walls of three flower pots stacked one on the other (Fig. 8.182A). The inferior constrictors overlap the lower margins of the middle constrictors and, in the same way, the middle constrictors overlap the superior constrictors.

Collectively, the muscles constrict or narrow the pharyngeal cavity.

When the constrictor muscles contract sequentially from top to bottom, as in swallowing, they move a bolus of food through the pharynx and into the esophagus.

All of the constrictors are innervated by the pharyngeal branch of the vagus nerve [X].

Longitudinal muscles

The three longitudinal muscles of the pharyngeal wall (Table 8.18, Fig. 8.183) are named according to their origins—**stylopharyngeus**, from the styloid process of the temporal bone; **salpingopharyngeus**, from the cartilaginous part of the pharyngotympanic tube (*salpinx* is Greek for “tube”); and **palatopharyngeus** from the soft palate. From their sites of origin, these muscles descend and attach into the pharyngeal wall.

Table 8.17 Constrictor muscles of the pharynx

Muscle	Posterior attachment	Anterior attachment	Innervation	Function
Superior constrictor	Pharyngeal raphe	Pterygomandibular raphe and adjacent bone on the mandible and pterygoid hamulus	Vagus nerve [X]	Constriction of pharynx
Middle constrictor	Pharyngeal raphe	Upper margin of greater horn of hyoid bone and adjacent margins of lesser horn and stylohyoid ligament	Vagus nerve [X]	Constriction of pharynx
Inferior constrictor	Pharyngeal raphe	Cricoid cartilage, oblique line of thyroid cartilage, and a ligament that spans between these attachments and crosses the cricothyroid muscle	Vagus nerve [X]	Constriction of pharynx

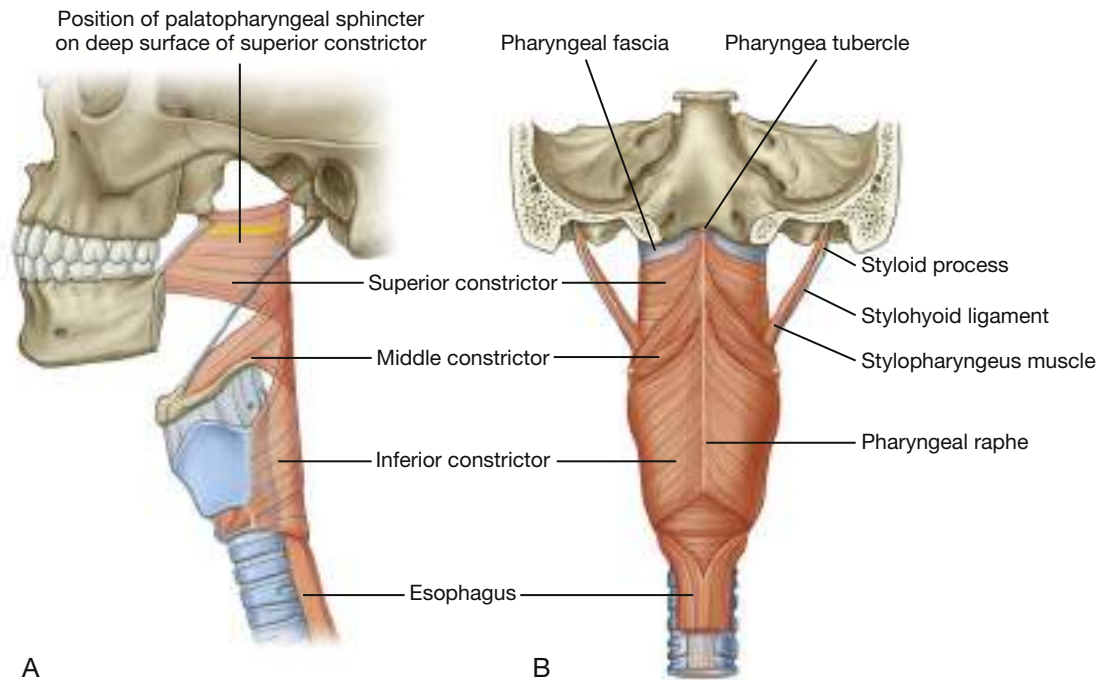


Fig. 8.182 Constrictor muscles of the pharynx. **A.** Lateral view. **B.** Posterior view.

Table 8.18 Longitudinal muscles of the pharynx

Muscle	Origin	Insertion	Innervation	Function
Stylopharyngeus	Medial side of base of styloid process	Pharyngeal wall	Glossopharyngeal nerve [IX]	Elevation of the pharynx
Salpingopharyngeus	Inferior aspect of pharyngeal end of pharyngotympanic tube	Pharyngeal wall	Vagus nerve [X]	Elevation of the pharynx
Palatopharyngeus	Upper surface of palatine aponeurosis	Pharyngeal wall	Vagus nerve [X]	Elevation of the pharynx; closure of the oropharyngeal isthmus

The longitudinal muscles elevate the pharyngeal wall or, during swallowing, pull the pharyngeal wall up and over a bolus of food being moved through the pharynx and into the esophagus.

Fascia

The pharyngeal fascia is separated into two layers, which sandwich the pharyngeal muscles between them:

- A thin layer (**buccopharyngeal fascia**) coats the outside of the muscular part of the wall and is a component of the pretracheal layer of cervical fascia (see p. 559).
- A much thicker layer (**pharyngobasilar fascia**) lines the inner surface.

The fascia reinforces the pharyngeal wall where muscle is deficient. This is particularly evident above the level of the superior constrictor where the pharyngeal wall is formed almost entirely of fascia (Fig. 8.184). This part of the wall is

reinforced externally by muscles of the soft palate (tensor and levator veli palatini).

Gaps in the pharyngeal wall and structures passing through them

Gaps between muscles of the pharyngeal wall provide important routes for muscles and neurovascular tissues (Fig. 8.184).

Above the margin of superior constrictor, the pharyngeal wall is deficient in muscle and completed by pharyngeal fascia.

The tensor and levator veli palatini muscles of the soft palate initially descend from the base of the skull and are lateral to the pharyngeal fascia. In this position, they reinforce the pharyngeal wall:

- Levator veli palatini passes through the pharyngeal fascia inferior to the pharyngotympanic tube and enters the soft palate.

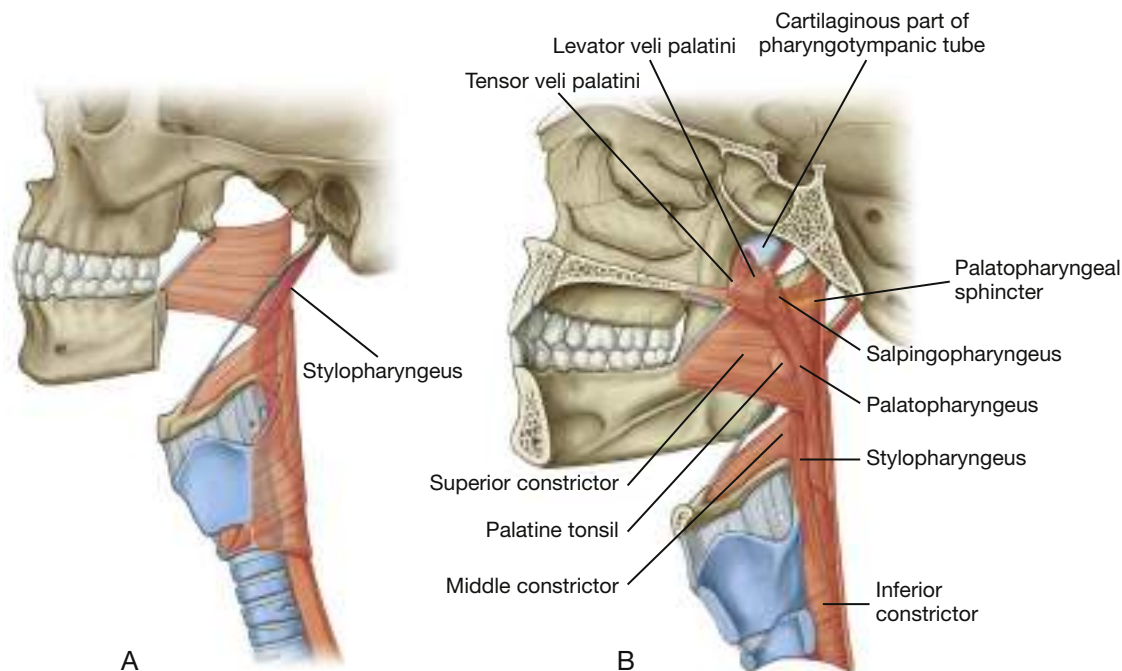


Fig. 8.183 Longitudinal muscles of the pharynx. **A.** Stylopharyngeus muscle. **B.** Medial view.

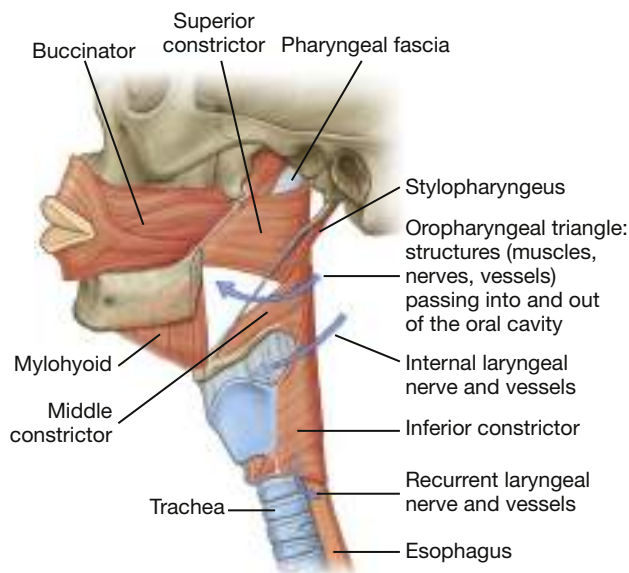


Fig. 8.184 Gaps between muscles in the pharyngeal wall.

- The tendon of tensor veli palatini turns medially around the pterygoid hamulus and passes through the origin of the buccinator muscle to enter the soft palate.

One of the largest and most important apertures in the pharyngeal wall is between the superior and middle constrictor muscles of the pharynx and the posterior border of the mylohyoid muscle, which forms the floor of the mouth (Fig. 8.184). This triangular-shaped gap (**oropharyngeal**

triangle) not only enables stylopharyngeus to slip into the pharyngeal wall, but also allows muscles, nerves, and vessels to pass between regions lateral to the pharyngeal wall and the oral cavity, particularly to the tongue.

The gap between the middle and inferior constrictor muscles allows the internal laryngeal vessels and nerve access to the aperture in the thyrohyoid membrane to enter the larynx (Fig. 8.184).

The recurrent laryngeal nerves and accompanying inferior laryngeal vessels enter the larynx posterior to the inferior horn of the thyroid cartilage deep to the inferior margin of the inferior constrictor muscle (Fig. 8.184).

Nasopharynx

The nasopharynx is behind the posterior apertures (choanae) of the nasal cavities and above the level of the soft palate (Fig. 8.185). Its ceiling is formed by the sloping base of the skull and consists of the posterior part of the body of the sphenoid bone and the basal part of the occipital bone. The ceiling and lateral walls of the nasopharynx form a domed vault at the top of the pharyngeal cavity that is always open.

The cavity of the nasopharynx is continuous below with the cavity of the oropharynx at the pharyngeal isthmus (Fig. 8.185A). The position of the pharyngeal isthmus is marked on the pharyngeal wall by a mucosal fold caused by the underlying **palatopharyngeal sphincter**, which is part of the superior constrictor muscle.

Elevation of the soft palate and constriction of the palatopharyngeal sphincter closes the pharyngeal isthmus

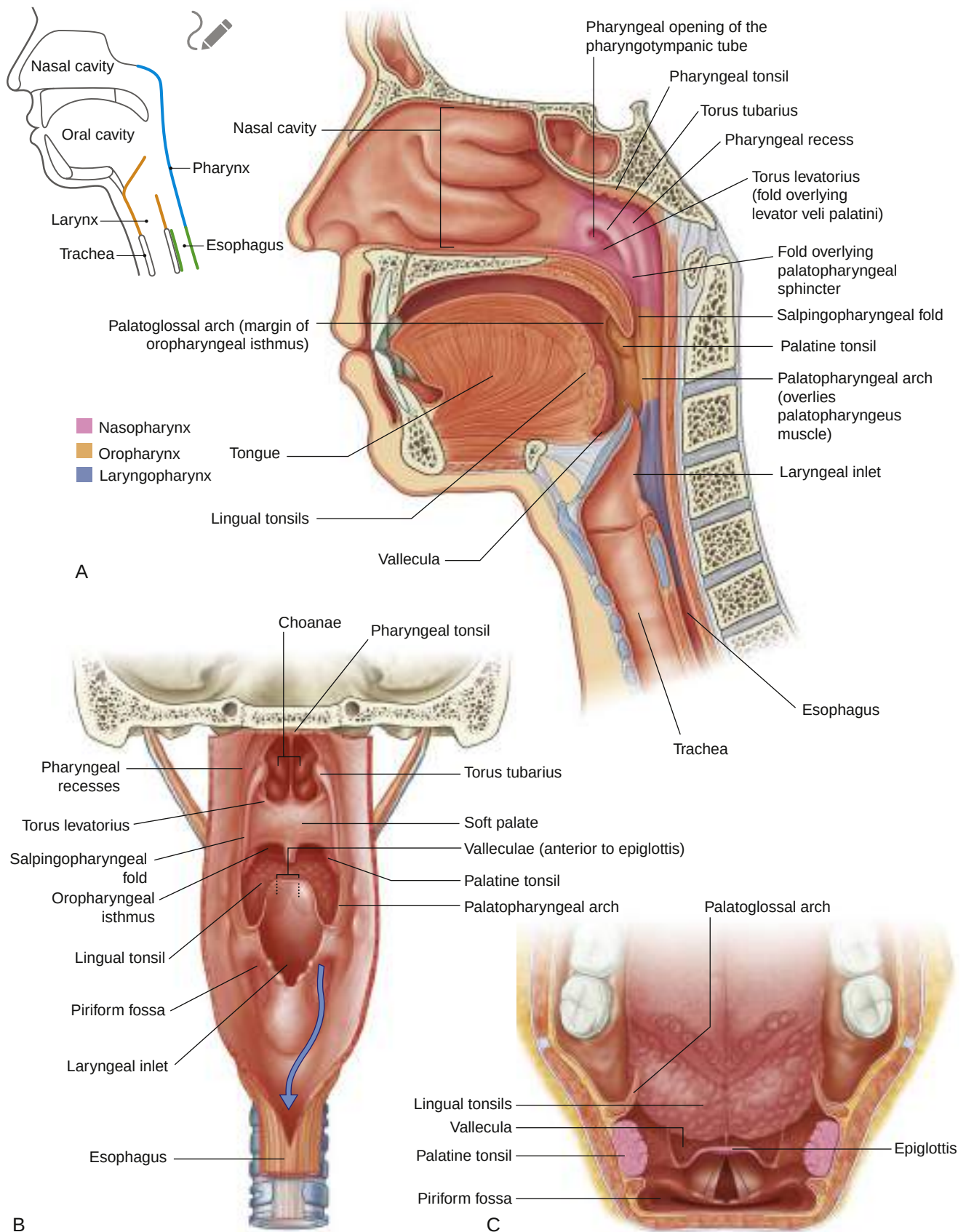


Fig. 8.185 Mucosal features of the pharynx. **A.** Lateral view. **B.** Posterior view with the pharyngeal wall opened. **C.** Superior view.

during swallowing and separates the nasopharynx from the oropharynx.

There is a large collection of lymphoid tissue (the **pharyngeal tonsil**) in the mucosa covering the roof of the nasopharynx (Fig. 8.185A). Enlargement of this tonsil, known then as adenoids, can occlude the nasopharynx so that breathing is only possible through the oral cavity.

The most prominent features on each lateral wall of the nasopharynx are (Fig. 8.185A):

- the pharyngeal opening of the pharyngotympanic tube, and
- mucosal elevations and folds covering the end of the pharyngotympanic tube and the adjacent muscles.

The opening of the pharyngotympanic tube is posterior to and slightly above the level of the hard palate and lateral to the top of the soft palate.

Because the pharyngotympanic tube projects into the nasopharynx from a posterolateral direction, its posterior rim forms an elevation or bulge on the pharyngeal wall. Posterior to this tubal elevation (**torus tubarius**) is a deep recess (**pharyngeal recess**) (Fig. 8.185A,B).

Mucosal folds related to the pharyngotympanic tube include (Fig. 8.185A):

- the small vertical **salpingopharyngeal fold**, which descends from the tubal elevation and overlies **salpingopharyngeus muscle**; and
- a broad fold or elevation (**torus levatorius**) that appears to emerge from just under the opening of the pharyngotympanic tube, continues medially onto the upper surface of the soft palate, and overlies the levator veli palatini muscle.

Oropharynx

The oropharynx is posterior to the oral cavity, inferior to the level of the soft palate, and superior to the upper margin of the epiglottis (Fig. 8.185). The **palatoglossal folds** (arches), one on each side, that cover the **palatoglossal muscles**, mark the boundary between the oral cavity and the oropharynx. The arched opening between the two folds is the **oropharyngeal isthmus**. Just posterior and medial to these folds are another pair of folds (arches), the **palatopharyngeal folds**, one on each side, that overlie the **palatopharyngeus muscles** (see Fig. 8.185A).

The anterior wall of the oropharynx inferior to the oropharyngeal isthmus is formed by the upper part of the posterior one-third or pharyngeal part of the tongue. When holding liquid or solids in the oral cavity, the oropharyngeal isthmus is closed by depression of the soft palate, elevation of the back of the tongue, and movement toward the midline of the palatoglossal and palatopharyngeal folds. This allows

a person to breathe while chewing or manipulating material in the oral cavity.

On swallowing, the oropharyngeal isthmus is opened, the palate is elevated, the laryngeal cavity is closed, and the food or liquid is directed into the esophagus. A person cannot breathe and swallow at the same time because the airway is closed at two sites, the pharyngeal isthmus and the larynx.

Laryngopharynx

The laryngopharynx extends from the superior margin of the epiglottis to the top of the esophagus at the level of vertebra CVI (Fig. 8.185).

The laryngeal inlet opens into the anterior wall of the laryngopharynx. Inferior to the laryngeal inlet, the anterior wall consists of the posterior aspect of the larynx.

The cavity of the laryngopharynx is related anteriorly to a pair of mucosal pouches (**valleculae**), one on each side of the midline, between the base of the tongue and epiglottis (see Fig. 8.185C). The valleculae are depressions formed between a midline mucosal fold and two lateral folds that connect the tongue to the epiglottis.

There is another pair of mucosal recesses (**piriform fossae**) between the central part of the larynx and the more lateral lamina of the thyroid cartilage (see Fig. 8.185B,C). The piriform fossae form channels that direct solids and liquids from the oral cavity around the raised laryngeal inlet and into the esophagus.

Tonsils

Collections of lymphoid tissue in the mucosa of the pharynx surrounding the openings of the nasal and oral cavities (Waldeyer's tonsillar ring) are part of the body's defense system. The largest of these collections form distinct masses (**tonsils**). Tonsils occur mainly in three areas (Fig. 8.185):

- The pharyngeal tonsil, known as adenoids when enlarged, is in the midline on the roof of the nasopharynx.
- The palatine tonsils are on each side of the oropharynx between the palatoglossal and palatopharyngeal arches just posterior to the oropharyngeal isthmus. (The palatine tonsils are visible through the open mouth of a patient when the tongue is depressed.)
- The lingual tonsil refers collectively to numerous lymphoid nodules on the posterior one-third of the tongue.

Small lymphoid nodules also occur in the pharyngotympanic tube near its opening into the nasopharynx and on the upper surface of the soft palate.

Vessels

Arteries

Numerous vessels supply the pharyngeal wall (Fig. 8.186).

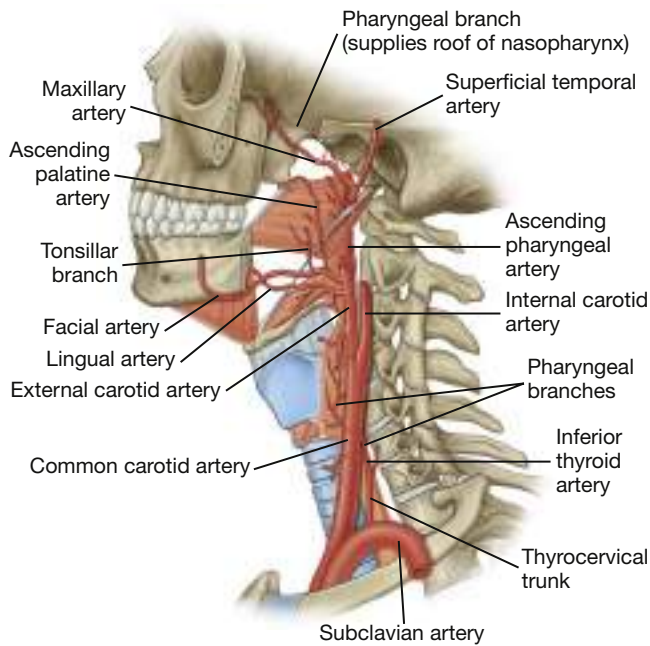


Fig. 8.186 Arterial supply of the pharynx.

Arteries that supply upper parts of the pharynx include:

- the ascending pharyngeal artery,
- the ascending palatine and tonsillar branches of the facial artery, and
- numerous branches of the maxillary and the lingual arteries.

All these vessels are from the external carotid artery.

Arteries that supply the lower parts of the pharynx include pharyngeal branches from the inferior thyroid artery, which originates from the thyrocervical trunk of the subclavian artery.

The major blood supply to the palatine tonsil is from the tonsillar branch of the facial artery, which penetrates the superior constrictor muscle.

Veins

Veins of the pharynx form a plexus, which drains superiorly into the pterygoid plexus in the infratemporal fossa and inferiorly into the facial and internal jugular veins (Fig. 8.187).

Lymphatics

Lymphatic vessels from the pharynx drain into the deep cervical nodes and include **retropharyngeal** (between nasopharynx and vertebral column), **paratracheal**, and **infrahyoid nodes** (Fig. 8.187).

The palatine tonsils drain through the pharyngeal wall into the jugulodigastric nodes in the region where the facial

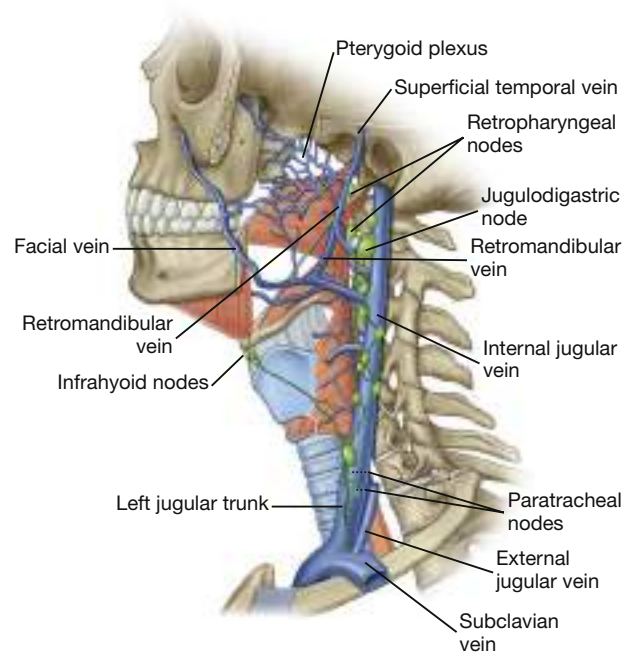


Fig. 8.187 Venous and lymphatic drainage of the pharynx.

vein drains into the internal jugular vein (and inferior to the posterior belly of the digastric muscle).

Nerves

Motor and most sensory innervation (except for the nasal region) of the pharynx is mainly through branches of the vagus [X] and glossopharyngeal [IX] nerves, which form a plexus in the outer fascia of the pharyngeal wall (Fig. 8.188).

The **pharyngeal plexus** is formed by:

- the pharyngeal branch of the vagus nerve [X],
- branches from the **external laryngeal nerve** from the **superior laryngeal branch** of the vagus nerve [X], and
- pharyngeal branches of the glossopharyngeal nerve [IX].

The **pharyngeal branch of the vagus nerve [X]** originates from the upper part of its **inferior ganglion** above the origin of the superior laryngeal nerve and is the major motor nerve of the pharynx (Fig. 8.188).

All muscles of the pharynx are innervated by the vagus nerve [X] mainly through the pharyngeal plexus, except for the stylopharyngeus, which is innervated directly by a branch of the glossopharyngeal nerve [IX].

Each subdivision of the pharynx has a different sensory innervation:

- The nasopharynx is innervated by a pharyngeal branch of the maxillary nerve [V₂] that originates in the pterygopalatine fossa and passes through the palatovaginal

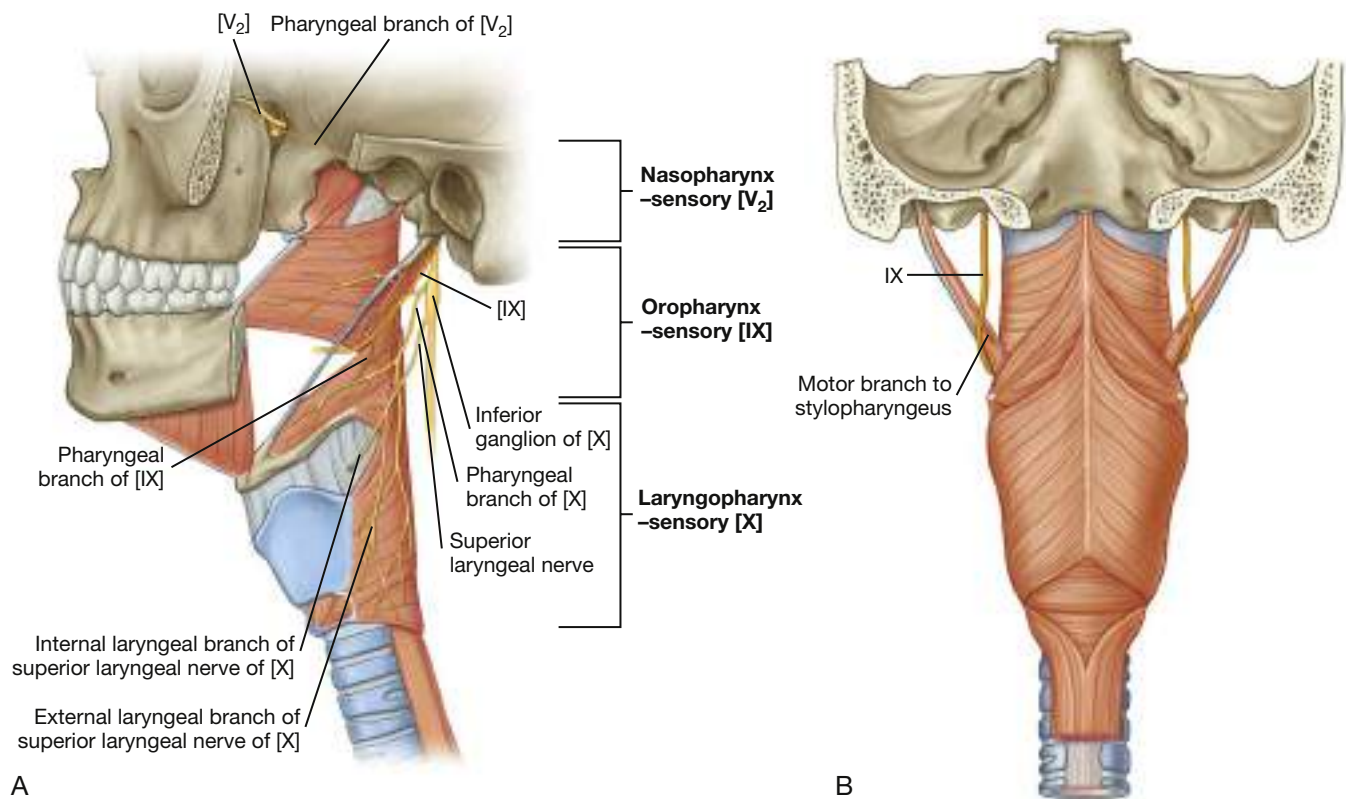


Fig. 8.188 Innervation of the pharynx. **A.** Lateral view. **B.** Posterior view showing innervation of stylopharyngeus.

canal in the sphenoid bone to reach the roof of the pharynx (see Fig. 8.138A, pg. 553).

- The oropharynx is innervated by the glossopharyngeal nerve [IX] via the pharyngeal plexus.
- The laryngopharynx is innervated by the vagus nerve [X] via the internal branch of the superior laryngeal nerve.

Glossopharyngeal nerve [IX]

The glossopharyngeal nerve [IX] is related to the pharynx throughout most of its course outside the cranial cavity.

After exiting the skull through the jugular foramen, the glossopharyngeal nerve [IX] descends on the posterior surface of the stylopharyngeus muscle, passes onto the lateral surface of the stylopharyngeus, and then passes anteriorly through the gap between the superior and middle constrictors to eventually reach the posterior aspect of the tongue (see Fig. 8.188B).

As the glossopharyngeal nerve [IX] passes under the free edge of the superior constrictor, it is just inferior to the palatine tonsil lying on the deep surface of the superior constrictor.

Pharyngeal branches to the pharyngeal plexus and a motor branch to the stylopharyngeus muscle are among branches that originate from the glossopharyngeal nerve [IX] in the neck. Because sensory innervation of the

oropharynx is by the glossopharyngeal nerve [IX], this nerve carries sensory innervation from the palatine tonsil and is also the afferent limb of the gag reflex.

LARYNX

The larynx is a hollow musculoligamentous structure with a cartilaginous framework that caps the lower respiratory tract.

The cavity of the larynx is continuous below with the trachea and, above, opens into the pharynx immediately posterior and slightly inferior to the tongue and the posterior opening (oropharyngeal isthmus) of the oral cavity (Fig. 8.189).

The larynx is both a valve (or sphincter) to close the lower respiratory tract and an instrument to produce sound. It is composed of:

- three large unpaired cartilages (cricoid, thyroid, and epiglottis),
- three pairs of smaller cartilages (arytenoid, corniculate, and cuneiform), and
- a fibro-elastic membrane and numerous intrinsic muscles.

The larynx is suspended from the hyoid bone above and attached to the trachea below by membranes and ligaments. It

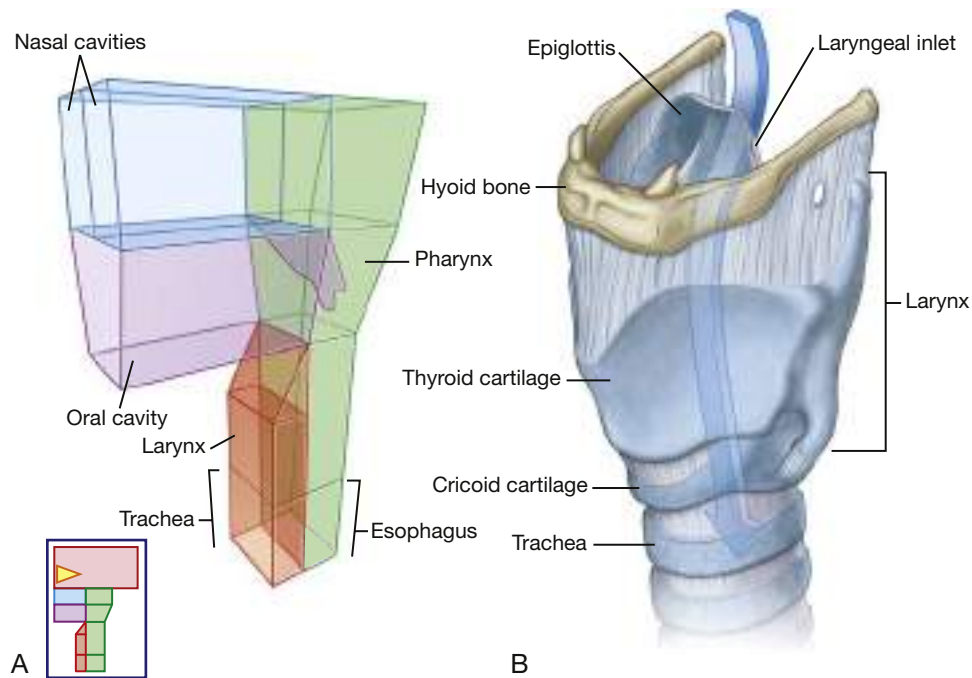


Fig. 8.189 Larynx. **A.** Relationship to other cavities. **B.** Lateral view.

is highly mobile in the neck and can be moved up and down and forward and backward by the action of extrinsic muscles that attach either to the larynx itself or to the hyoid bone.

During swallowing, the dramatic upward and forward movements of the larynx facilitate closing the laryngeal inlet and opening the esophagus.

Motor and sensory innervation of the larynx is provided by the vagus nerve [X].

Clinical app

Laryngoscopy

Laryngoscopy is a medical procedure that is used to inspect the larynx. The functions of laryngoscopy include the evaluation of patients with difficulty swallowing, assessment of the vocal cords, and assessment of the larynx for tumors, masses, and weak voice.

The larynx is typically visualized using two methods. Indirect laryngoscopy involves passage of a small rod-mounted mirror, (not dissimilar to a dental mirror) into the oropharynx permitting indirect visualization of the larynx. Direct laryngoscopy can be performed using a device with a curved metal tip that holds the tongue and epiglottis forwards, allowing direct inspection of the larynx. This procedure can only be performed in the unconscious patient or in a patient where the gag reflex is not intact. Other methods of inspection include the passage of fiberoptic endoscopes either through the oral cavity or nasal cavity.

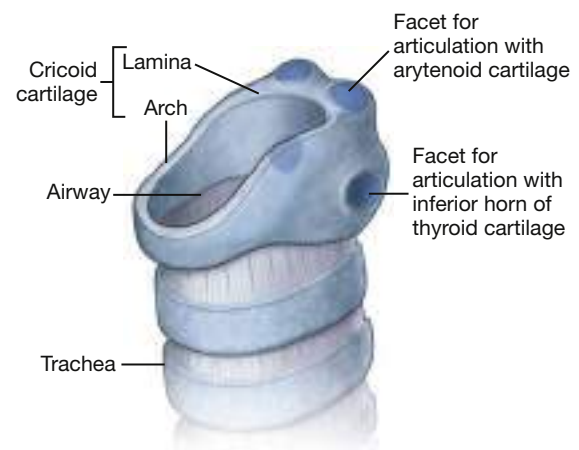


Fig. 8.190 Cricoid cartilage.

Laryngeal cartilages

Cricoid cartilage

The cricoid cartilage is the most inferior of the laryngeal cartilages and completely encircles the airway (Fig. 8.190). It is shaped like a signet ring with a broad **lamina of cricoid cartilage** posterior to the airway and a much narrower **arch of cricoid cartilage** circling anteriorly.

The cricoid cartilage has two articular facets on each side for articulation with other laryngeal cartilages:

- One facet is on the sloping superolateral surface of the lamina and articulates with the base of an arytenoid cartilage.

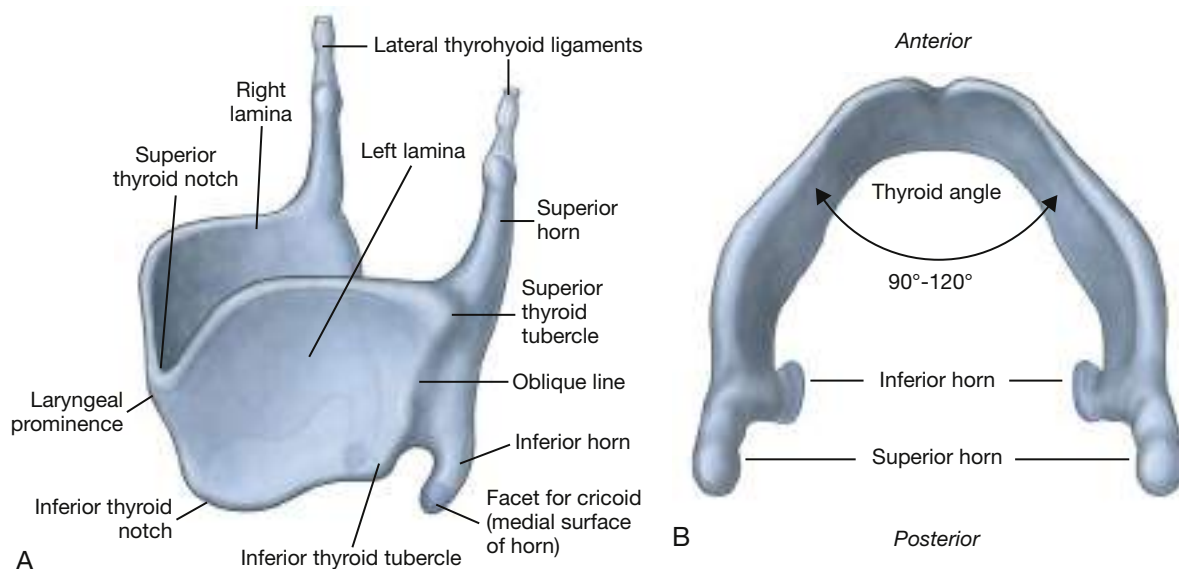


Fig. 8.191 Thyroid cartilage. **A.** Anterolateral view. **B.** Superior view.

- The other facet is on the lateral surface of the lamina near its base and is for articulation with the medial surface of the inferior horn of the thyroid cartilage.

Thyroid cartilage

The thyroid cartilage (Fig. 8.191) is the largest of the laryngeal cartilages. It is formed by a right and a left lamina, which are widely separated posteriorly, but converge and join anteriorly. The most superior point of the site of fusion between the two broad flat laminae projects forward as the **laryngeal prominence** (Adam's apple). The angle between the two laminae is more acute in men (90°) than in women (120°) so the laryngeal prominence is more apparent in men than women.

Just superior to the laryngeal prominence, the **superior thyroid notch** separates the two laminae as they diverge laterally. Both the superior thyroid notch and the laryngeal prominence are palpable landmarks in the neck. There is a less distinct **inferior thyroid notch** in the midline along the base of the thyroid cartilage.

The posterior margin of each lamina of the thyroid cartilage is elongated to form a **superior horn** and an **inferior horn**:

- The medial surface of the inferior horn has a facet for articulation with the cricoid cartilage.
- The superior horn is connected by a **lateral thyrohyoid ligament** to the posterior end of the greater horn of the hyoid bone.

The lateral surface of each thyroid lamina is marked by a ridge (the **oblique line**), which curves anteriorly from the base of the superior horn to a little short of midway along the inferior margin of the lamina (Fig. 8.191). The oblique line is

a site of attachment for the extrinsic muscles of the larynx (sternothyroid, thyrohyoid, and inferior constrictor).

The ends of the oblique line are expanded to form **superior** and **inferior thyroid tubercles**.

Epiglottis

The epiglottis is a leaf-shaped cartilage attached by its stem to the posterior aspect of the thyroid cartilage at the angle (Fig. 8.192) and projects posterosuperiorly from its attachment to the thyroid cartilage. The attachment is via the **thyro-epiglottic ligament** in the midline approximately midway between the laryngeal prominence and the inferior thyroid notch. The upper margin of the epiglottis is behind the pharyngeal part of the tongue.

The inferior half of the posterior surface of the epiglottis is raised slightly to form an epiglottic tubercle.

Arytenoid cartilages

The two arytenoid cartilages are pyramid-shaped cartilages with three surfaces, a **base of arytenoid cartilage** and an **apex of arytenoid cartilage** (Fig. 8.193):

- The base is concave and articulates with the sloping articular facet on the superolateral surface of the lamina of cricoid cartilage.
- The apex articulates with a corniculate cartilage.
- The **medial surface** of each cartilage faces the other.
- The **anterolateral surface** has two depressions separated by a ridge for muscle (vocalis) and ligament (vestibular ligament) attachment.
- The **posterior surface** is covered by the transverse arytenoid muscles (see Fig. 8.204).

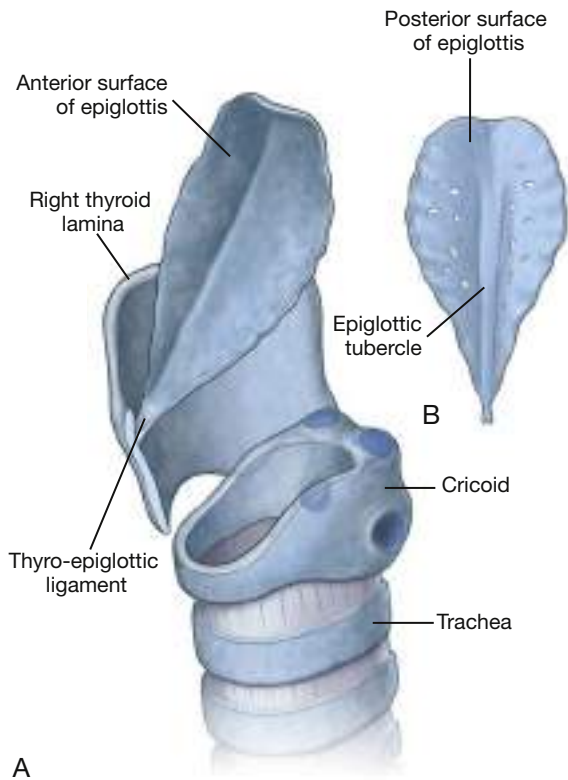


Fig. 8.192 Epiglottis. **A.** Anterolateral view. **B.** Posterior surface.

The anterior angle of the base is elongated into a **vocal process** to which the vocal ligament is attached. The lateral angle is similarly elongated into a muscular process for attachment of the posterior and lateral crico-arytenoid muscles.

Corniculate

The corniculate cartilages (Fig. 8.194) are two small conical cartilages whose bases articulate with the apices of the

arytenoid cartilages. Their apices project posteromedially toward each other.

Cuneiform

These two small club-shaped cartilages (Fig. 8.194) lie anterior to the corniculate cartilages and are suspended in the part of the fibro-elastic membrane of the larynx that attaches the arytenoid cartilages to the lateral margin of the epiglottis.

Extrinsic ligaments

Thyrohyoid membrane

The thyrohyoid membrane is a tough fibro-elastic ligament that spans between the superior margin of the thyroid cartilage below and the hyoid bone above (Fig. 8.195).

An aperture in the lateral part of the thyrohyoid membrane on each side is for the superior laryngeal artery, the internal branch of the superior laryngeal nerve and lymphatics.

The posterior borders of the thyrohyoid membrane are thickened to form the **lateral thyrohyoid ligaments**. The membrane is also thickened anteriorly in the midline to form the **median thyrohyoid ligament**.

Occasionally, there is a small cartilage (**triticeal cartilage**) in each lateral thyrohyoid ligament.

Hyo-epiglottic ligament

The hyo-epiglottic ligament (Fig. 8.195) extends from the midline of the epiglottis anterosuperiorly to the body of the hyoid bone.

Cricotracheal ligament

The cricotracheal ligament (Fig. 8.195) runs from the lower border of the cricoid cartilage to the adjacent upper border of the first tracheal cartilage.

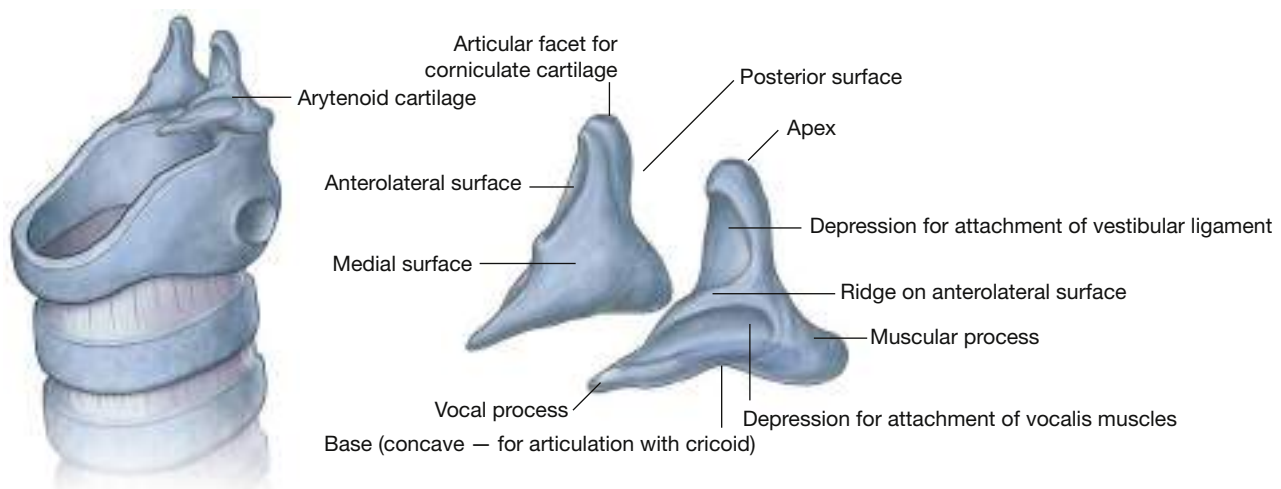


Fig. 8.193 Arytenoid cartilages.

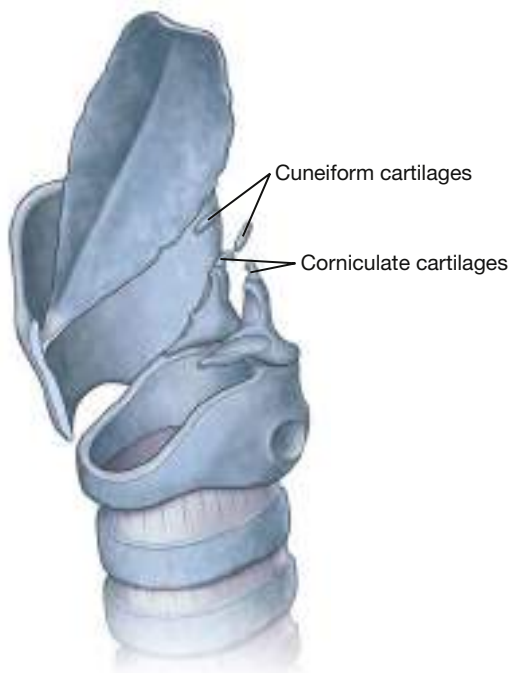


Fig. 8.194 Corniculate and cuneiform cartilages.

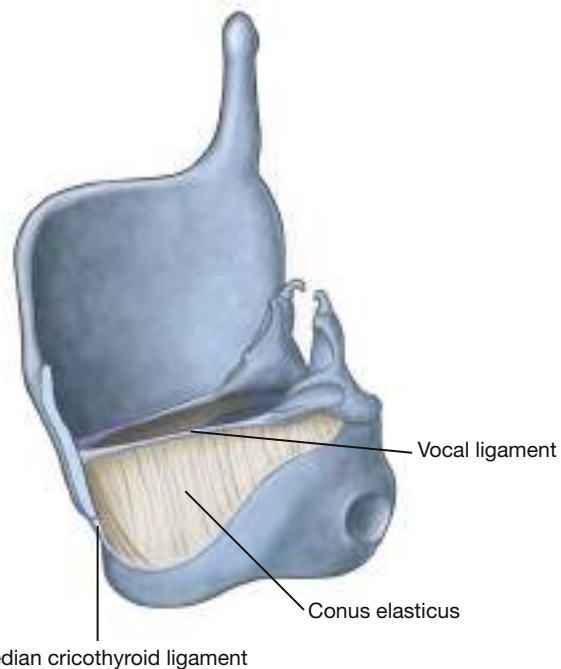


Fig. 8.196 Cricothyroid ligament.

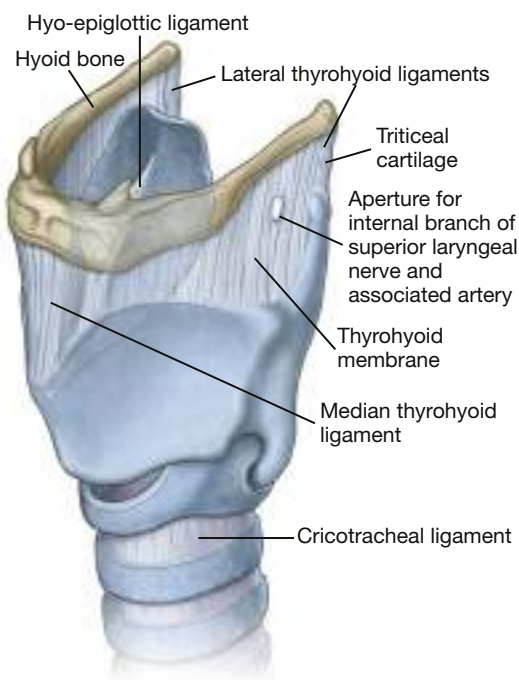


Fig. 8.195 Extrinsic ligaments of the larynx.

Intrinsic ligaments

Fibro-elastic membrane of the larynx

The fibro-elastic membrane of the larynx links together the laryngeal cartilages and completes the architectural framework of the laryngeal cavity. It is composed of two parts—a

lower cricothyroid ligament and an upper quadrangular membrane.

Conus elasticus (cricovocal membrane)

The conus elasticus ([Fig. 8.196](#)) is attached to the arch of cricoid cartilage and extends superiorly to end in a free upper margin within the space enclosed by the thyroid cartilage. On each side, this upper free margin attaches:

- anteriorly to the thyroid cartilage, and
- posteriorly to the vocal processes of the arytenoid cartilages.

The free margin between these two points of attachment is thickened to form the **vocal ligament**, which is under the **vocal fold (true vocal cord)** of the larynx.

The conus elasticus is also thickened anteriorly in the midline to form a distinct **median cricothyroid ligament**, which spans the distance between the arch of cricoid cartilage and the inferior thyroid notch and adjacent deep surface of the thyroid cartilage up to the attachment of the vocal ligaments.

Quadrangular membrane

The quadrangular membrane on each side runs between the lateral margin of the epiglottis and the anterolateral surface of the arytenoid cartilage on the same side ([Fig. 8.198](#)). It is also attached to the corniculate cartilage, which articulates with the apex of arytenoid cartilage.

Surface anatomy

How to locate the cricothyroid ligament

The median cricothyroid ligament (Fig. 8.197) can be easily found using palpable features of the larynx as landmarks.

Using a finger to gently feel laryngeal structures in the midline, first find the thyroid notch in the superior margin of the thyroid cartilage and then move the finger inferiorly over the laryngeal prominence and down the anterior surface of the thyroid angle. As the finger crosses the inferior margin of the thyroid cartilage in the midline, a soft depression is felt before the finger slides onto the arch of the cricoid cartilage, which is hard.

The soft depression between the lower margin of the thyroid cartilage and the arch of the cricoid is the position of the cricothyroid ligament.

A tube passed through the median cricothyroid ligament enters the airway just inferior to the position of the vocal folds of the larynx.

Structures that may occur in or cross the midline between the skin and the median cricothyroid ligament include the pyramidal lobe of the thyroid gland and small vessels, respectively.

Inferior to the cricoid cartilage, the upper cartilage of the trachea can sometimes be palpated above the level of the isthmus of the thyroid gland that crosses the trachea anteriorly.

The landmarks used for finding the median cricothyroid ligament are similar in men and women; however, because the laminae of the thyroid cartilage meet at a more acute angle in men, the structures are more prominent in men than in women.

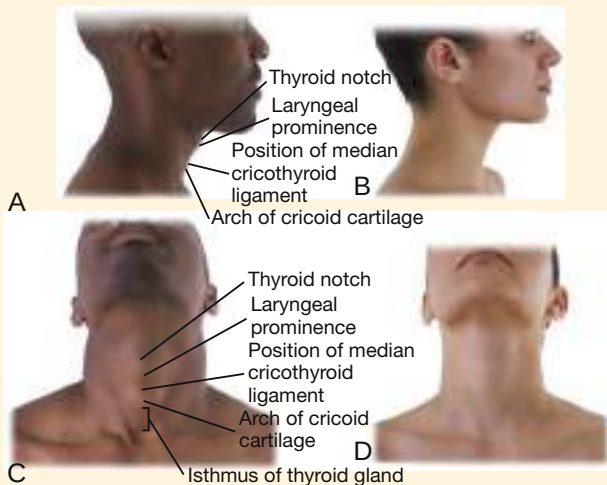


Fig. 8.197 How to locate the median cricothyroid ligament. **A.** In a man, lateral view of head and neck. **B.** In a woman, lateral view of head and neck. **C.** In a man, anterior neck with the chin elevated. **D.** In a woman, anterior neck with the chin elevated.

Each quadrangular membrane has a free upper margin between the top of the epiglottis and the corniculate cartilage and a free lower margin. The free lower margin is

Clinical app

Cricothyrotomy

In emergency situations, when the airway is blocked above the level of the vocal folds, the median cricothyroid ligament can be perforated and a small tube inserted through the incision to establish an airway. Except for small vessels and the occasional presence of a pyramidal lobe of the thyroid gland, normally there are few structures between the median cricothyroid ligament and skin.

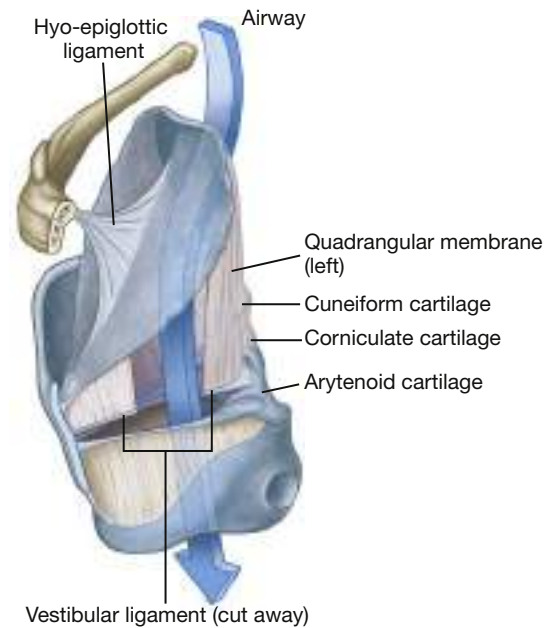


Fig. 8.198 Quadrangular membrane.

thickened to form the **vestibular ligament** under the **vestibular fold (false vocal cord)** of the larynx.

On each side, the vestibular ligament of the quadrangular membrane is separated from the vocal ligament of the cricothyroid ligament below by a gap. Because the vestibular ligament attaches to the anterolateral surface of the arytenoid cartilage and the vocal ligament attaches to the vocal process of the same cartilage, the vestibular ligament is lateral to the vocal ligament when viewed from above (Fig. 8.199).

Laryngeal joints

Cricothyroid joints

The joints between the inferior horns of the thyroid cartilage and the cricoid cartilage, and between the cricoid cartilage and arytenoid cartilages are synovial. Each is surrounded by a capsule and is reinforced by associated ligaments. The cricothyroid joints enable the thyroid cartilage to move forward and tilt downward on the cricoid cartilage (Fig. 8.200).

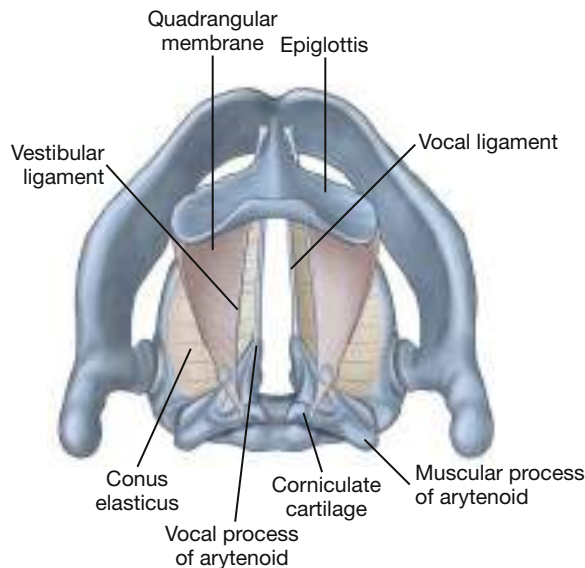


Fig. 8.199 Fibro-elastic membrane of the larynx (superior view).

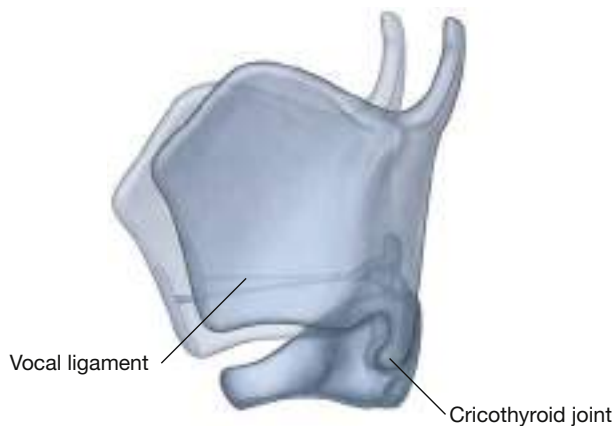


Fig. 8.200 Movements of the cricothyroid joints.

Because the vocal ligaments pass between the posterior aspect of the thyroid angle and the arytenoid cartilages sit on the lamina of cricoid cartilage, forward movement and downward rotation of the thyroid cartilage on the cricoid cartilage effectively lengthens and puts tension on the vocal ligaments (Fig. 8.200).

Crico-arytenoid joints

The crico-arytenoid joints between articular facets on the superolateral surfaces of the cricoid cartilage and the bases of the arytenoid cartilages enable the arytenoid cartilages to slide away or toward each other and to rotate so that the vocal processes pivot either toward or away from the midline. These movements abduct and adduct the vocal ligaments (Fig. 8.201).

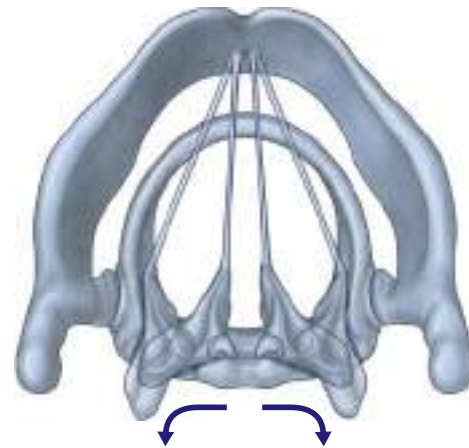


Fig. 8.201 Movements of the crico-arytenoid joints.

Cavity of the larynx

The central cavity of the larynx (Fig. 8.202) is tubular and lined by mucosa. Its architectural support is provided by the fibro-elastic membrane of the larynx and by the laryngeal cartilages to which it is attached.

The superior aperture of the cavity (laryngeal inlet) opens into the anterior aspect of the pharynx just below and posterior to the tongue (Fig. 8.202A):

- Its anterior border is formed by mucosa covering the superior margin of the epiglottis.
- Its lateral borders are formed by mucosal folds (**aryepiglottic folds**), which enclose the superior margins of the quadrangular membranes and adjacent soft tissues, and two tubercles on the more posterolateral margin of the laryngeal inlet on each side mark the positions of the underlying cuneiform and corniculate cartilages.
- Its posterior border in the midline is formed by a mucosal fold that forms a depression (**interarytenoid notch**) between the two corniculate tubercles.

The inferior opening of the laryngeal cavity is continuous with the lumen of the trachea, is completely encircled by the cricoid cartilage, and is horizontal in position unlike the laryngeal inlet, which is oblique and points posterosuperiorly into the pharynx. In addition, the inferior opening is continuously open, whereas the laryngeal inlet can be closed by downward movement of the epiglottis.

Division into three major regions

Two pairs of mucosal folds, the vestibular and vocal folds, which project medially from the lateral walls of the laryngeal cavity, constrict it and divide it into three major

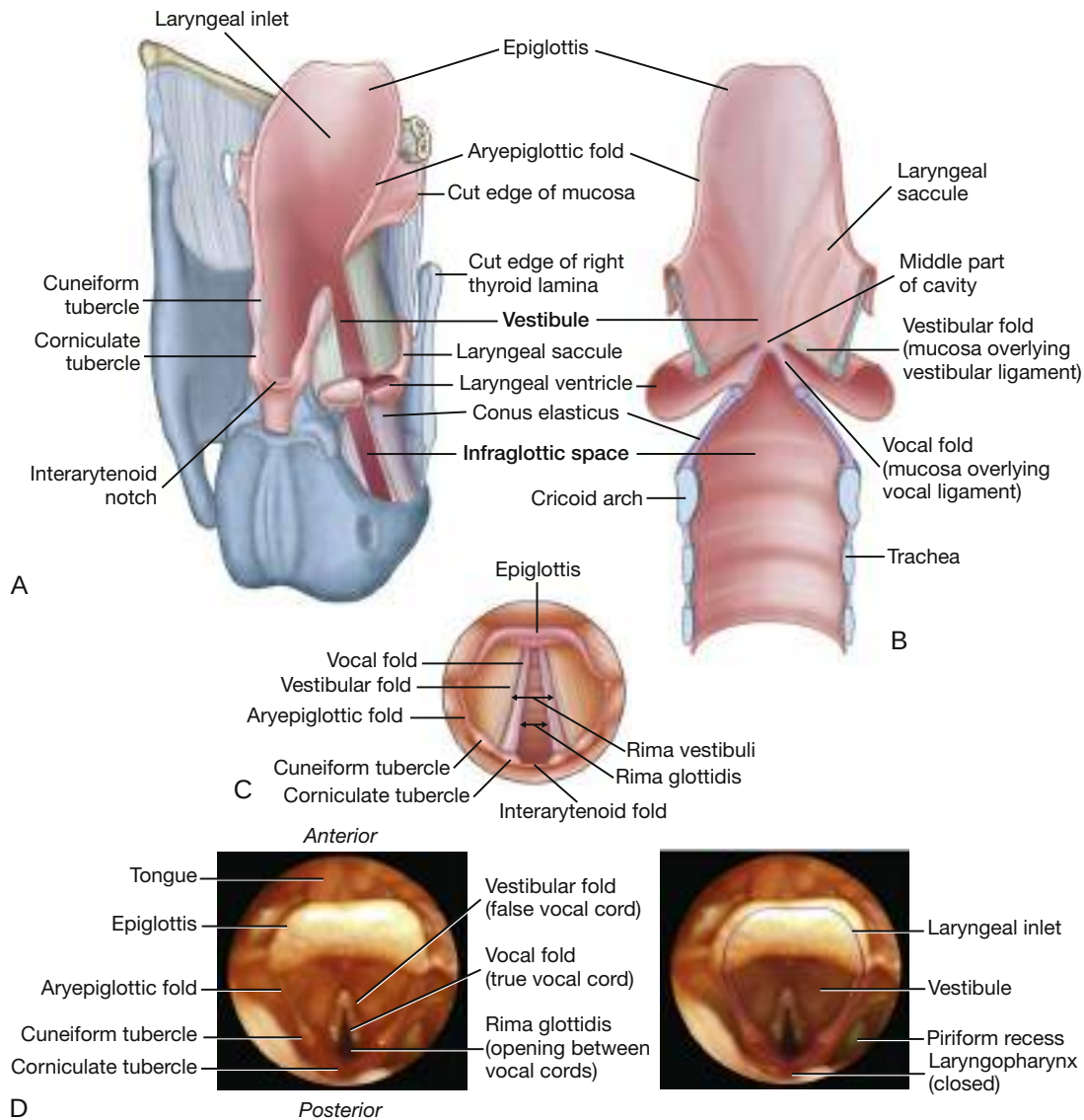


Fig. 8.202 Laryngeal cavity. **A.** Posterolateral view. **B.** Posterior view (cutaway). **C.** Superior view through the laryngeal inlet. **D.** Labeled photographs of the larynx, superior view.

regions—the vestibule, a middle chamber, and the infraglottic cavity (Fig. 8.202B):

- The **vestibule** is the upper chamber of the laryngeal cavity between the laryngeal inlet and the vestibular folds, which enclose the vestibular ligaments and associated soft tissues.
- The middle part of the laryngeal cavity is very thin and is between the vestibular folds above and the vocal folds below.
- The **infraglottic space** is the most inferior chamber of the laryngeal cavity and is between the vocal folds (which enclose the vocal ligaments and related soft tissues) and the inferior opening of the larynx.

Laryngeal ventricles and saccules

On each side, the mucosa of the middle cavity bulges laterally through the gap between the vestibular and vocal ligaments to produce an expanded trough-shaped space (a **laryngeal ventricle**) (Fig. 8.202A,B). An elongate tubular extension of each ventricle (**laryngeal saccule**) projects anterosuperiorly between the vestibular fold and thyroid cartilage and may reach as high as the top of the thyroid cartilage (Fig. 8.202A). Within the walls of these laryngeal saccules are numerous mucous glands. Mucus secreted into the saccules lubricates the vocal folds.

Rima vestibuli and rima glottidis

When viewed from above (Fig. 8.202C,D), there is a triangular opening (the **rima vestibuli**) between the two adjacent

vestibular folds at the entrance to the middle chamber of the laryngeal cavity. The apex of the opening is anterior, and its base is formed by the posterior wall of the laryngeal cavity.

Inferior to the vestibular folds, the vocal folds (true vocal cords) and adjacent mucosa-covered parts of the arytenoid cartilages form the lateral walls of a similar, but narrower triangular opening (the **rima glottidis** between the two adjacent vocal folds) (Fig. 8.202C,D). This opening separates the middle chamber above from the infraglottic cavity below. The base of this triangular opening is formed by the fold of mucosa (**interarytenoid fold**) at the bottom of the interarytenoid notch.

Both the rima glottidis and the rima vestibuli can be opened and closed by movement of the arytenoid cartilages and associated fibro-elastic membranes.

Intrinsic muscles

The intrinsic muscles of the larynx (Table 8.19, Figs. 8.203, 8.204, 8.205) adjust tension in the vocal ligaments, open and close the rima glottidis, control the inner dimensions of the vestibule, close the rima vestibuli, and facilitate closing of the laryngeal inlet. They do this mainly by:

- acting on the cricothyroid and cricoarytenoid joints,
- adjusting the distance between the epiglottis and arytenoid cartilages,

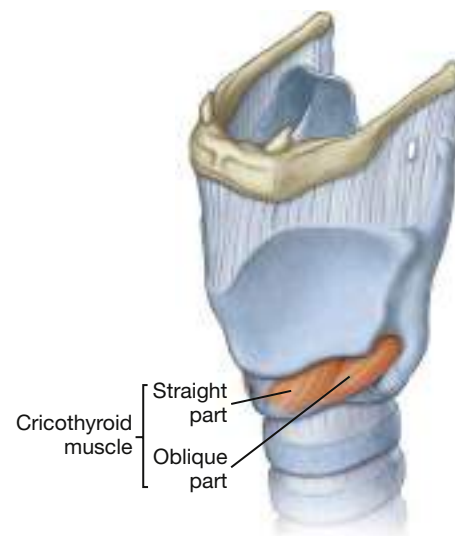


Fig. 8.203 Cricothyroid muscle.

- pulling directly on the vocal ligaments, and
- forcing soft tissues associated with the quadrangular membranes and vestibular ligaments toward the midline.

The **cricothyroid muscles** are the only intrinsic muscles of the larynx innervated by the superior laryngeal branches of the vagus nerves [X] (see Fig. 8.203). All other intrinsic

Table 8.19 Intrinsic muscles of the larynx

Muscle	Origin	Insertion	Innervation	Function
Cricothyroid	Anterolateral aspect of arch of cricoid cartilage	Oblique part—inferior horn of the thyroid cartilage; straight part—inferior margin of thyroid cartilage	External branch of superior laryngeal nerve from the vagus nerve [X]	Forward and downward rotation of the thyroid cartilage at the cricothyroid joint
Posterior crico-arytenoid	Oval depression on posterior surface of lamina of cricoid cartilage	Posterior surface of muscular process of arytenoid cartilage	Recurrent laryngeal branch of the vagus nerve [X]	Abduction and external rotation of the arytenoid cartilage. The posterior crico-arytenoid muscles are the primary abductors of the vocal folds. In other words, they are the primary openers of the rima glottidis.
Lateral crico-arytenoid	Superior surface of arch of cricoid cartilage	Anterior surface of muscular process of arytenoid cartilage	Recurrent laryngeal branch of the vagus nerve [X]	Internal rotation of the arytenoid cartilage and adduction of vocal folds
Transverse arytenoid	Lateral border of posterior surface of arytenoid cartilage	Lateral border of posterior surface of opposite arytenoid cartilage	Recurrent laryngeal branch of the vagus nerve [X]	Adduction of arytenoid cartilages
Oblique arytenoid	Posterior surface of muscular process of arytenoid cartilage	Posterior surface of apex of adjacent arytenoid cartilage; extends into aryepiglottic fold	Recurrent laryngeal branch of the vagus nerve [X]	Sphincter of the laryngeal inlet
Thyro-arytenoid	Thyroid angle and adjacent cricothyroid ligament	Anterolateral surface of arytenoid cartilage; some fibers continue in aryepiglottic folds to the lateral margin of the epiglottis	Recurrent laryngeal branch of the vagus nerve [X]	Sphincter of vestibule and of laryngeal inlet
Vocalis	Lateral surface of vocal process of arytenoid cartilage	Vocal ligament and thyroid angle	Recurrent laryngeal branch of the vagus nerve [X]	Adjusts tension in vocal folds

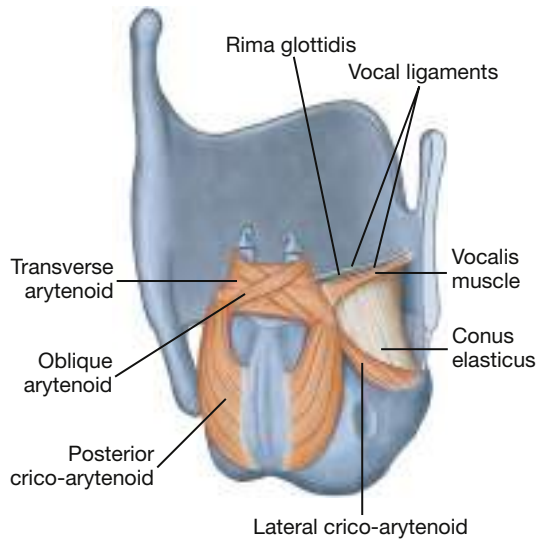


Fig. 8.204 Crico-arytenoid, oblique and transverse arytenoids, and vocalis muscles.

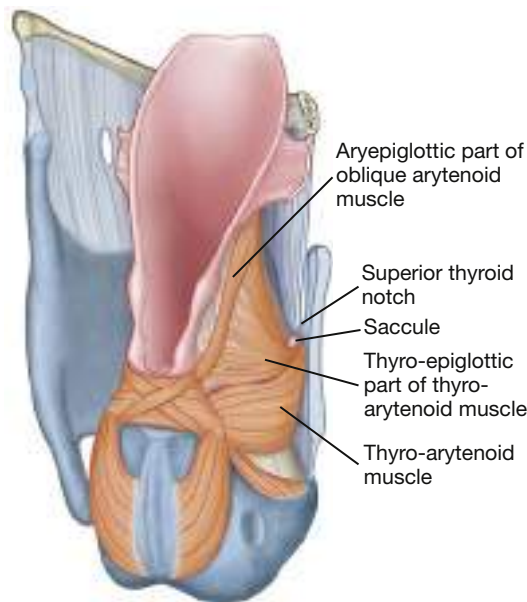


Fig. 8.205 Thyro-arytenoid muscle.

muscles are innervated by the recurrent laryngeal branches of the vagus nerves [X] (Figs. 8.204, 8.205).

Function of the larynx

The larynx is an elaborate sphincter for the lower respiratory tract and provides a mechanism for producing sounds. Adjustments of the size of the central cavity of the larynx result from changes in the dimensions of the rima glottidis, the rima vestibuli, the vestibule, and the laryngeal inlet (Fig. 8.206). These changes result from muscle actions and laryngeal mechanics.

Respiration

During quiet respiration, the laryngeal inlet, vestibule, rima vestibuli, and rima glottidis are open. The arytenoid cartilages are abducted and the rima glottidis is triangular shaped (Fig. 8.206A). During forced inspiration (Fig. 8.206B), the arytenoid cartilages are rotated laterally, mainly by the action of the **posterior cricoarytenoid muscles**. As a result, the vocal folds are abducted, and the rima glottidis widens into a rhomboid shape, which effectively increases the diameter of the laryngeal airway.

Phonation

When phonating, the arytenoid cartilages and vocal folds are adducted and air is forced through the closed rima glottidis (Fig. 8.206C). This action causes the vocal folds to vibrate against each other and produce sounds, which can then be modified by the upper parts of the airway and oral cavity. Tension in the vocal folds can be adjusted by the **vocalis and cricothyroid muscles**.

Effort closure

Effort closure of the larynx (Fig. 8.206D) occurs when air is retained in the thoracic cavity to stabilize the trunk (e.g., during heavy lifting) or as part of the mechanism for increasing intra-abdominal pressure. During effort closure, the rima glottidis is completely closed, as is the rima vestibuli and lower parts of the vestibule. The result is to completely and forcefully shut the airway.

Swallowing

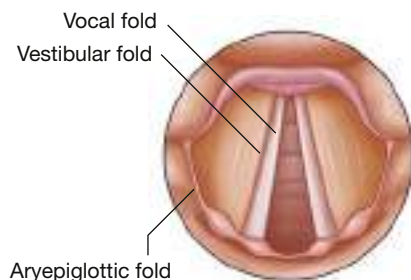
During swallowing, the rima glottidis, the rima vestibuli, and vestibule are closed and the laryngeal inlet is narrowed. In addition, the larynx moves up and forward. This action causes the epiglottis to swing downward toward the arytenoid cartilages and to effectively narrow or close the laryngeal inlet (Fig. 8.206E). The up and forward movement of the larynx also opens the esophagus, which is attached to the posterior aspect of the lamina of cricoid cartilage. All these actions together prevent solids and liquids from entry into the airway and facilitate their movement through the piriform fossae into the esophagus.

Clinical app

Exogenous Testosterone and Vocal Cord Mass

In individuals receiving testosterone as part of masculinizing hormone therapy (e.g., transgender men), the vocal cords will lengthen and thicken, causing the fundamental frequency and pitch to decrease, producing a more masculine voice.

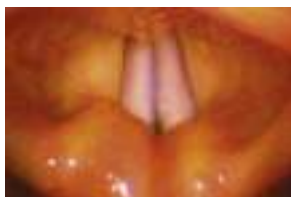
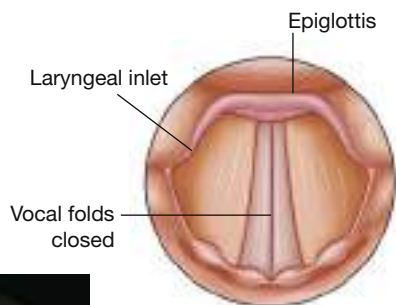
Quiet respiration



A

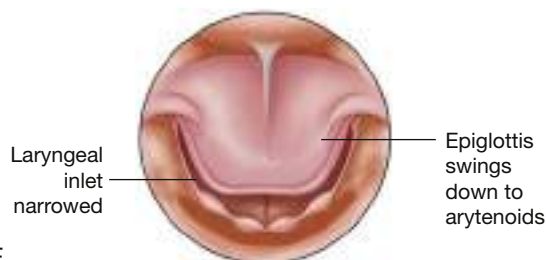
Phonation

- vocal folds adducted and stridulating as air is forced between them
- vestibule open



C

Swallowing



E

Forced inspiration

- vocal folds abducted and rima glottidis wide open
- vestibule open

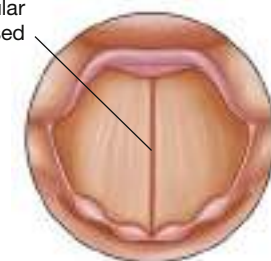


B

Effort closure

- vocal folds and vestibular folds adducted
- rima glottidis and vestibule closed

Vestibular folds closed



D

Fig. 8.206 Laryngeal function. A. Quiet respiration. B. Forced inspiration. C. Phonation. D. Effort closure. E. Swallowing.

Vessels

Arteries

The major blood supply to the larynx is by the superior and inferior laryngeal arteries (Fig. 8.207):

- The **superior laryngeal artery** originates near the upper margin of the thyroid cartilage from the superior thyroid branch of the external carotid artery and accompanies the

internal branch of the superior laryngeal nerve through the thyrohyoid membrane to reach the larynx.

- The **inferior laryngeal artery** originates from the inferior thyroid branch of the thyrocervical trunk of the subclavian artery low in the neck and, together with the recurrent laryngeal nerve, ascends in the groove between the esophagus and trachea—it enters the larynx by passing deep to the margin of the inferior constrictor muscle of the pharynx.

Clinical app

Tracheostomy

A tracheostomy is a surgical procedure in which a hole is made in the trachea and a tube is inserted to enable ventilation.

The typical situation in which a tracheostomy is performed is in the calm atmosphere of an operating theater. A small transverse incision is placed in the lower third of the neck anteriorly. The strap muscles are retracted laterally and the trachea can be easily visualized. Occasionally, it is necessary to divide the isthmus of thyroid gland. An incision is made in the second and third tracheal rings and a small tracheostomy tube inserted.

After the tracheostomy has been in situ for the required length of time, it is simply removed. The hole through which it was inserted almost inevitably closes without any intervention.

Patients with long-term tracheostomies are unable to vocalize because no air is passing through the vocal cords.

Veins

Veins draining the larynx accompany the arteries (Fig. 8.208):

- **Superior laryngeal veins** drain into superior thyroid veins, which, in turn, drain into the internal jugular veins.
- **Inferior laryngeal veins** drain into inferior thyroid veins, which drain into the left brachiocephalic vein.

Lymphatics

Lymphatics drain regions above and below the vocal folds:

- Those above the vocal folds follow the superior laryngeal artery and terminate in deep cervical nodes associated with the bifurcation of the common carotid artery.
- Those below the vocal folds drain into deep nodes associated with the inferior thyroid artery or with nodes associated with the front of the cricothyroid ligament or upper trachea.

Nerves

Sensory and motor innervation of the larynx is by two branches of the vagus nerves [X]—the superior laryngeal nerves and the recurrent laryngeal nerves (Fig. 8.209).

Superior laryngeal nerves

The **superior laryngeal nerves** originate from the inferior vagal ganglia high in the neck (Fig. 8.209). On each side, they descend medial to the internal carotid artery and divide into internal and external branches just above the level of the superior horn of the hyoid bone:

- The external branch (**external laryngeal nerve**) descends along the lateral wall of the pharynx to supply and penetrate the inferior constrictor of the pharynx and ends by supplying the cricothyroid muscle.

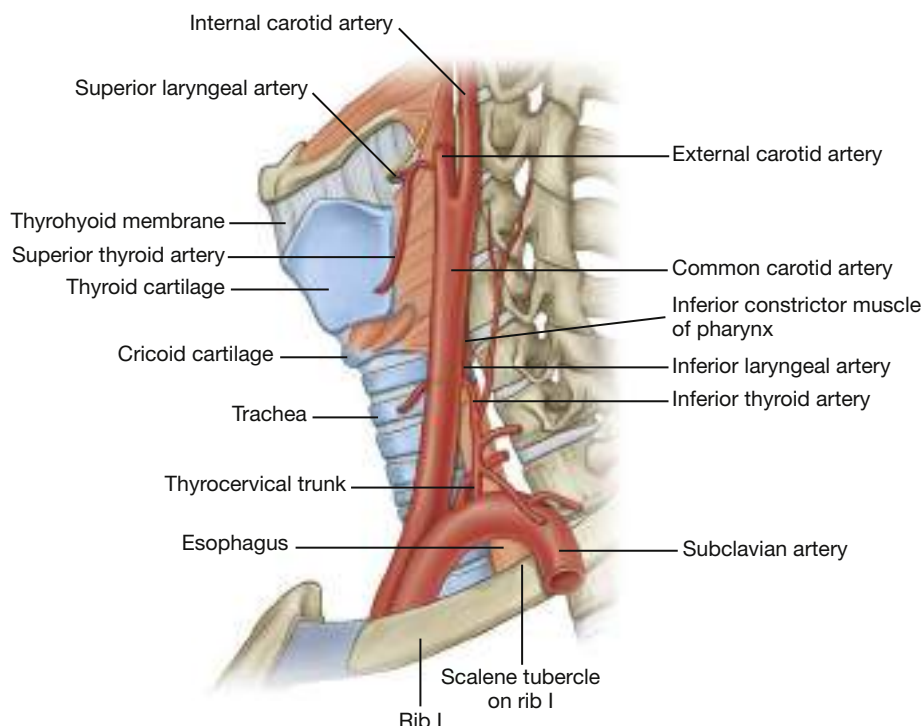


Fig. 8.207 Arterial supply of the larynx, left lateral view.

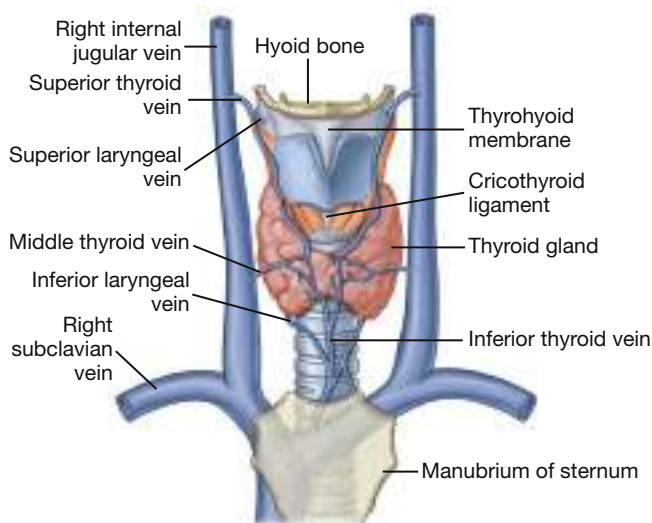


Fig. 8.208 Venous drainage of the larynx, anterior view.

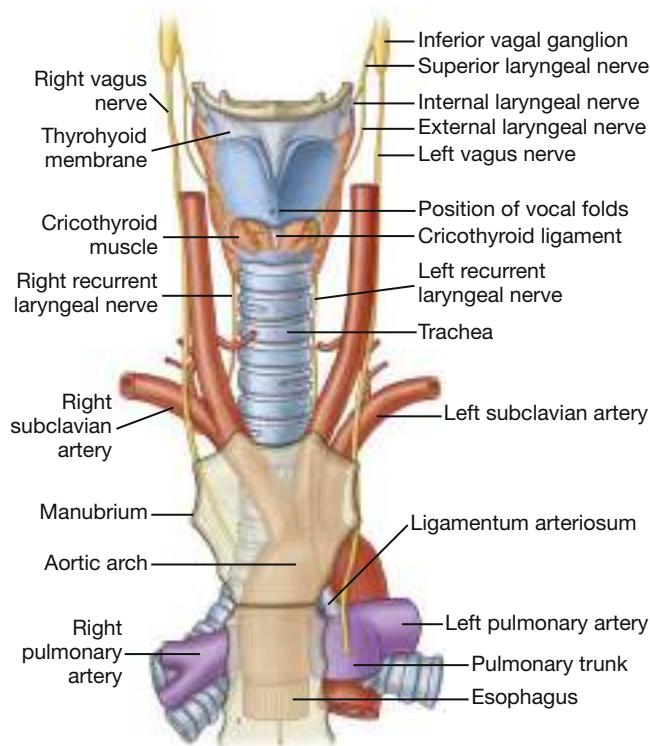


Fig. 8.209 Innervation of the larynx.

- The internal branch (**internal laryngeal nerve**) passes anteroinferiorly to penetrate the thyrohyoid membrane—it is mainly sensory and supplies the laryngeal cavity down to the level of the vocal folds.

Recurrent laryngeal nerves

The recurrent laryngeal nerves are (Fig. 8.209):

- sensory to the laryngeal cavity below the level of the vocal folds, and

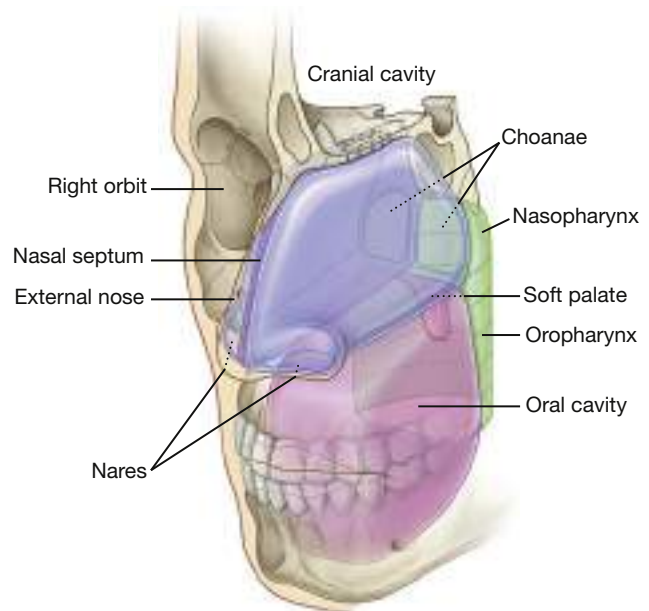


Fig. 8.210 Nasal cavities (anterolateral view). Relationship to other cavities.

- motor to all intrinsic muscles of the larynx except for the cricothyroid.

The left recurrent laryngeal nerve originates in the thorax, whereas the right recurrent laryngeal nerve originates in the root of the neck. Both nerves generally ascend in the neck in the groove between the esophagus and trachea and enter the larynx deep to the margin of the inferior constrictor. They may pass medial, lateral, or through the lateral ligament of the thyroid gland, which attaches the thyroid gland to the trachea and lower part of the cricoid cartilage on each side.

NASAL CAVITIES

The two nasal cavities are the uppermost parts of the respiratory tract and contain the olfactory receptors. They are elongated wedge-shaped spaces with a large inferior base and a narrow superior apex (Fig. 8.210), and are held open by a skeletal framework consisting mainly of bone and cartilage.

The smaller anterior regions of the cavities are enclosed by the external nose, whereas the larger posterior regions are more central within the skull. The anterior apertures of the nasal cavities are the nares, which open onto the inferior surface of the nose (Fig. 8.210). The posterior apertures are the choanae, which open into the nasopharynx.

The nasal cavities are separated:

- from each other by a midline nasal septum,
- from the oral cavity below by the hard palate, and

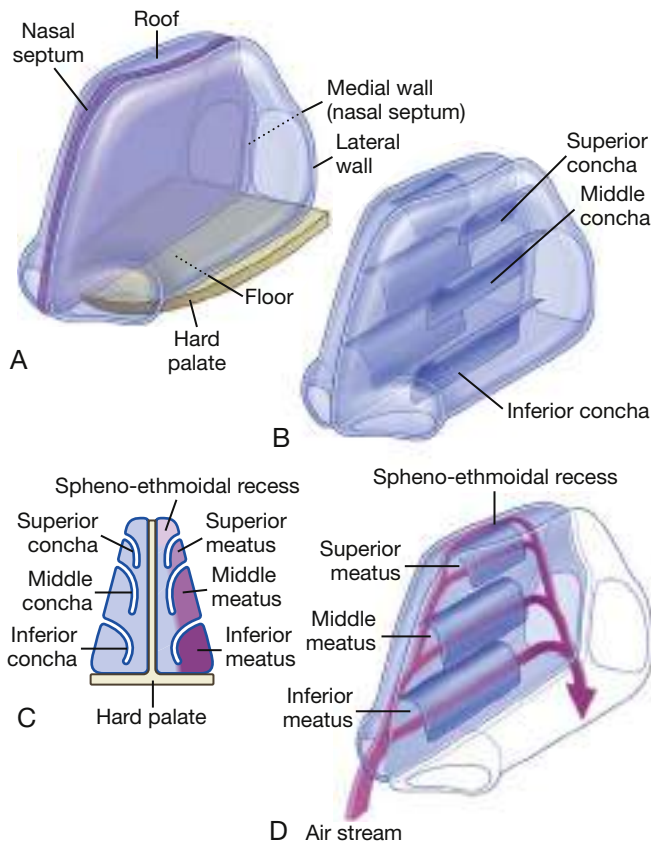


Fig. 8.211 Nasal cavities. **A.** Floor, roof, and lateral walls. **B.** Conchae on lateral walls. **C.** Coronal section. **D.** Air channels in right nasal cavity.

- from the cranial cavity above by parts of the frontal, ethmoid, and sphenoid bones.

Lateral to the nasal cavities are the orbits.

Each nasal cavity has a floor, roof, medial wall, and lateral wall.

Lateral wall

The lateral wall is characterized by three curved shelves of bone (conchae), which are one above the other and project medially and inferiorly across the nasal cavity (Fig. 8.211B). The medial, anterior, and posterior margins of the conchae are free.

The conchae divide each nasal cavity into four air channels (Fig. 8.211C,D):

- an **inferior nasal meatus** between the **inferior concha** and the nasal floor;
- a **middle nasal meatus** between the inferior and **middle concha**;
- a **superior nasal meatus** between the middle and **superior concha**; and
- a **spheno-ethmoidal recess** between the superior concha and the nasal roof.

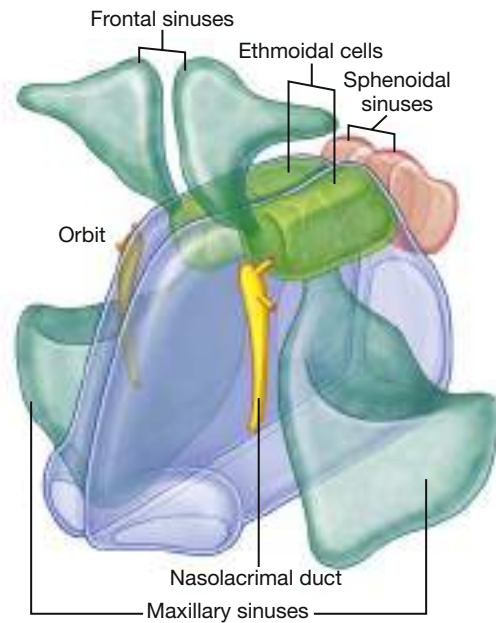


Fig. 8.212 Paranasal sinuses and nasolacrimal duct.

These conchae increase the surface area of contact between tissues of the lateral wall and the respired air.

The openings of the paranasal sinuses, which are extensions of the nasal cavity that erode into the surrounding bones during childhood and early adulthood, are on the lateral wall and roof of the nasal cavities (Fig. 8.212). In addition, the lateral wall also contains the opening of the nasolacrimal duct, which drains tears from the eye into the nasal cavity.

Regions

Each nasal cavity consists of three general regions—the nasal vestibule, the respiratory region, and the olfactory region (Fig. 8.213):

- The **nasal vestibule** is a small dilated space just internal to the naris that is lined by skin and contains hair follicles.
- The **respiratory region** is the largest part of the nasal cavity, has a rich neurovascular supply, and is lined by respiratory epithelium composed mainly of ciliated and mucous cells.
- The **olfactory region** is small, is at the apex of each nasal cavity, is lined by olfactory epithelium, and contains the olfactory receptors.

In addition to housing receptors for the sense of smell (olfaction), the nasal cavities adjust the temperature and humidity of respired air by the action of a rich blood supply, and trap and remove particulate matter from the airway by filtering the air through hair in the vestibule and by capturing foreign material in abundant mucus. The mucus normally is moved posteriorly by cilia on epithelial cells in the nasal cavities and is swallowed.

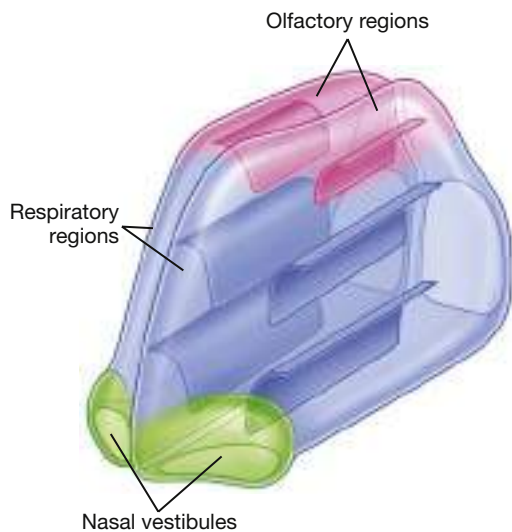


Fig. 8.213 Regions of the nasal cavities.

Skeletal framework

Bones that contribute to the skeletal framework of the nasal cavities include the:

- unpaired ethmoid, sphenoid, frontal bone, and vomer; and
- paired nasal, maxillary, palatine and lacrimal bones and the inferior conchae bone.

Of all the bones associated with the nasal cavities, the ethmoid is a key element.

Ethmoid bone

The single ethmoid bone is one of the most complex bones in the skull. It contributes to the roof, lateral wall, and medial wall of both nasal cavities, and contains the ethmoidal cells (ethmoidal sinuses).

The ethmoid bone is cuboidal in overall shape (Fig. 8.214A) and is composed of two rectangular box-shaped **ethmoidal labyrinths**, one on each side, united superiorly across the midline by a perforated sheet of bone (the **cribriform plate**). A second sheet of bone (the **perpendicular plate**) descends vertically in the median sagittal plane from the cribriform plate to form part of the nasal septum.

Each ethmoidal labyrinth is composed of two delicate sheets of bone, which sandwich between the ethmoidal cells.

The cribriform plate is at the apex of the nasal cavities and fills the **ethmoidal notch** in the frontal bone (Fig. 8.214B) and separates the nasal cavities below from the cranial cavity above. Small perforations in the bone allow the fibers of the olfactory nerve [I] to pass between the two regions.

A large triangular process (the **crista galli**) at the midline on the superior surface of the cribriform plate anchors a fold (falx cerebri) of dura mater in the cranial cavity.

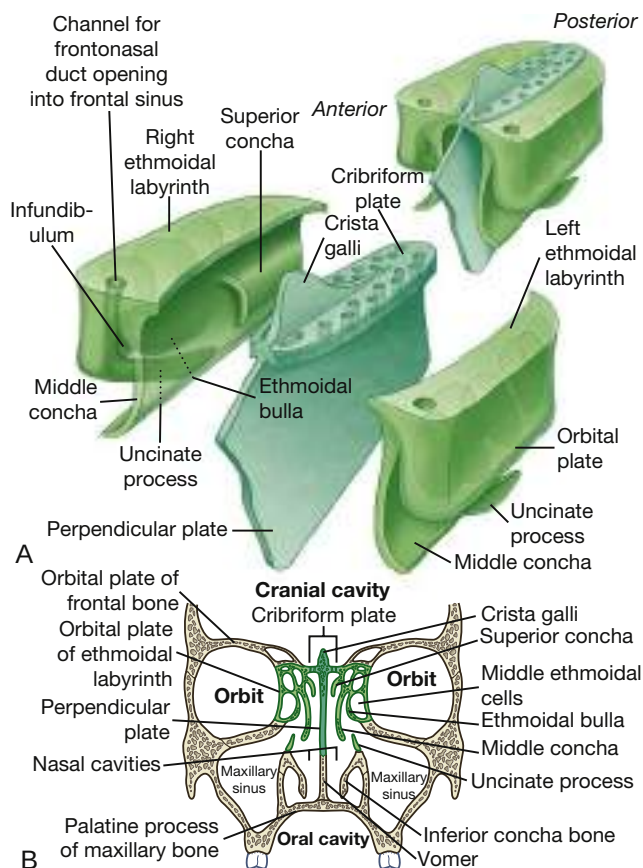


Fig. 8.214 Ethmoid bone. A. Overall shape. B. Coronal section through skull.

The perpendicular plate of the ethmoid bone is quadrangular in shape, descends in the midline from the cribriform plate, and forms the upper part of the median nasal septum (Fig. 8.214).

Clinical app

Deviated nasal septum

The nasal septum is typically situated in the midline; however, septal deviation to one side or the other is not uncommon and in many cases is secondary to direct trauma. Extreme septal deviation can produce nasal occlusion. The deviation can be corrected surgically.

External nose

The external nose extends the nasal cavities onto the front of the face and positions the nares so that they point downward (Fig. 8.215). It is pyramidal in shape with its apex anterior in position. The upper angle of the nose between the openings of the orbits is continuous with the forehead.

Like posterior regions, the anterior parts of the nasal cavities found within the nose are held open by a skeletal

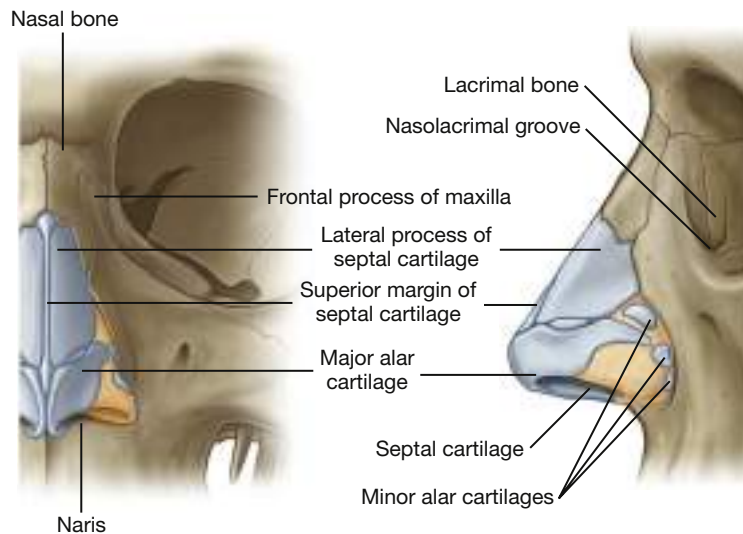


Fig. 8.215 External nose.

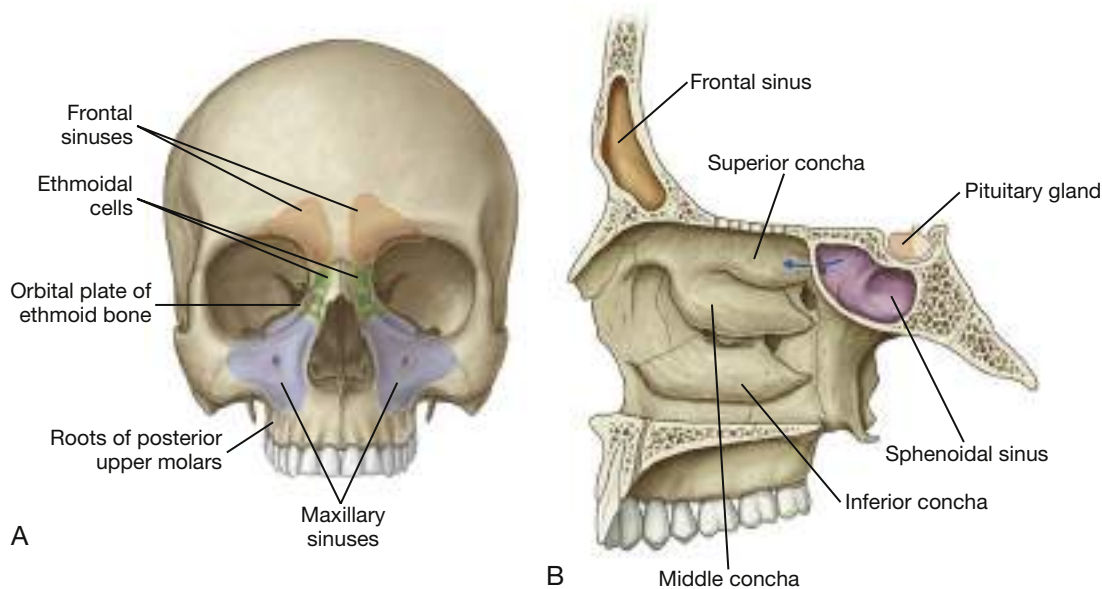


Fig. 8.216 Paranasal sinuses. A. Anterior view. B. Paramedian view of right nasal cavity.

framework, which is composed partly of bone and mainly of cartilage (Fig. 8.215):

- The bony parts are where the nose is continuous with the skull—here the nasal bones and parts of the maxillae and frontal bones provide support.
- Anteriorly and on each side, support is provided by **lateral** processes of the septal cartilage, **major alar**, three or four **minor alar cartilages**, and a single septal cartilage in the midline that forms the anterior part of the nasal septum.

Paranasal sinuses

There are four paranasal air sinuses—the ethmoidal cells and the sphenoidal, maxillary, and frontal sinuses (Figs. 8.216, 8.217). Each is named according to the bone in which it is found.

The paranasal sinuses develop as outgrowths from the nasal cavities and erode into the surrounding bones. All are:

- lined by respiratory mucosa, which is ciliated and mucus secreting;
- open into the nasal cavities; and
- innervated by branches of the trigeminal nerve [V].

Imaging app

Visualizing the nasal cavities and paranasal sinuses

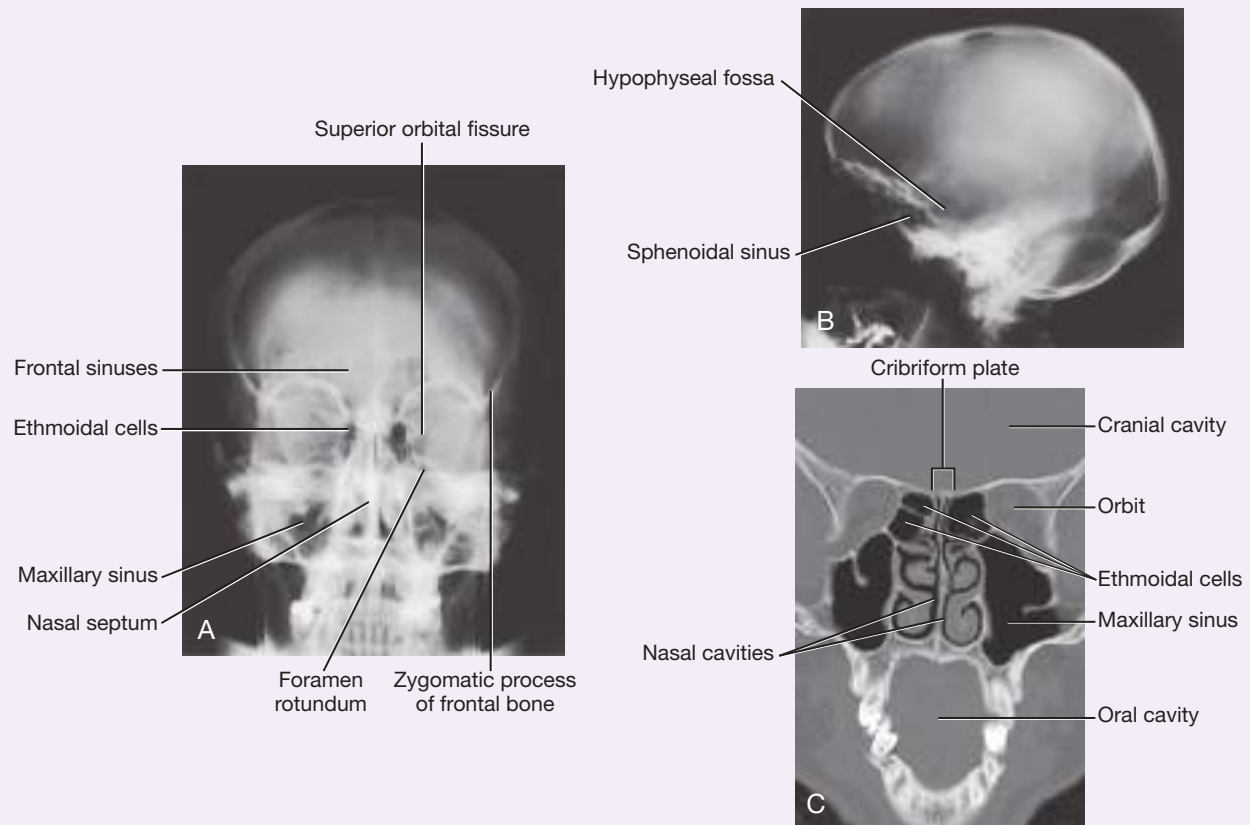


Fig. 8.217 A. Anterior view (posteroanterior skull radiograph). B. Lateral view (skull radiograph). C. CT image in coronal plane.

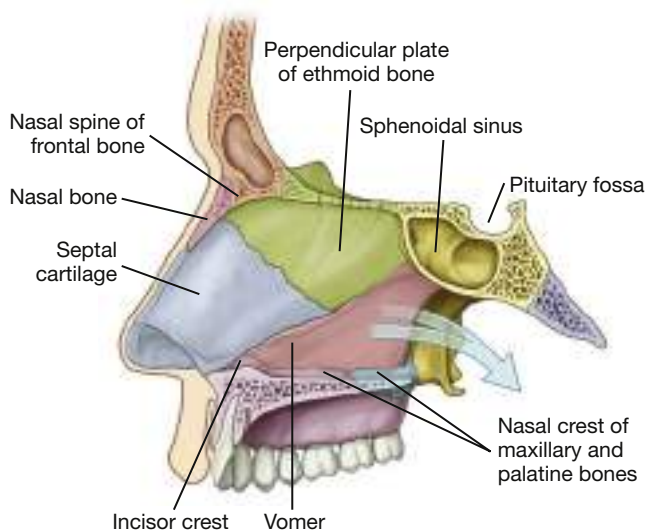


Fig. 8.218 Medial wall of the nasal cavity—the nasal septum.

Frontal sinuses

The frontal sinuses, one on each side, are variable in size and are the most superior of the sinuses (Figs. 8.216A,B, 8.217A). Each is triangular in shape and is in the part of the frontal bone under the forehead. The base of each triangular sinus is oriented vertically in the bone at the midline above the bridge of the nose and the apex is laterally approximately one-third of the way along the upper margin of the orbit.

Each frontal sinus drains onto the lateral wall of the middle meatus via the frontonasal duct, which penetrates the ethmoidal labyrinth and continues as the ethmoidal infundibulum at the front end of the **semilunar hiatus**.

Ethmoidal cells

The ethmoidal cells on each side fill the ethmoidal labyrinth (Figs. 8.216A,B; 8.217A,C). Each cluster of cells is separated from the orbit by the thin orbital plate of the ethmoidal

labyrinth and from the nasal cavity by the medial wall of the ethmoidal labyrinth.

The ethmoidal cells are formed by a variable number of individual air chambers, which are divided into anterior, middle, and posterior ethmoidal cells based on the location of their apertures on the lateral wall of the nasal cavity.

Maxillary sinuses

The maxillary sinuses, one on each side, are the largest of the paranasal sinuses and completely fill the bodies of the maxillae (Figs. 8.216B, 8.217A,C). Each is pyramidal in shape with the apex directed laterally and the base deep to the lateral wall of the adjacent nasal cavity. The medial wall or base of the maxillary sinus is formed by the maxilla, and by parts of the inferior concha and palatine bone that overlie the maxillary hiatus.

The opening of the maxillary sinus is near the top of the base, in the center of the semilunar hiatus, which grooves the lateral wall of the middle nasal meatus.

Sphenoidal sinuses

The sphenoidal sinuses, one on either side within the body of the sphenoid, open into the roof of the nasal cavity via apertures on the posterior wall of the spheno-ethmoidal recess (Figs. 8.216C, 8.217C). The apertures are high on the anterior walls of the sphenoidal sinuses.

The sphenoidal sinuses are related:

- above to the cranial cavity, particularly to the pituitary gland and to the optic chiasm;
- laterally, to the cranial cavity, particularly to the cavernous sinuses; and
- below and in front, to the nasal cavities.

Clinical app

Surgical approach to the pituitary gland

Because only thin shelves of bone separate the sphenoidal sinuses from the nasal cavities below and hypophyseal fossa above, the pituitary gland can be surgically approached through the roof of the nasal cavities by passing first through the anteroinferior aspect of the sphenoid bone and into the sphenoidal sinuses and then through the top of the sphenoid bone into the hypophyseal fossa.

Walls, floor, and roof

Medial wall

The medial wall of each nasal cavity is the mucosa-covered surface of the thin nasal septum, which is oriented vertically

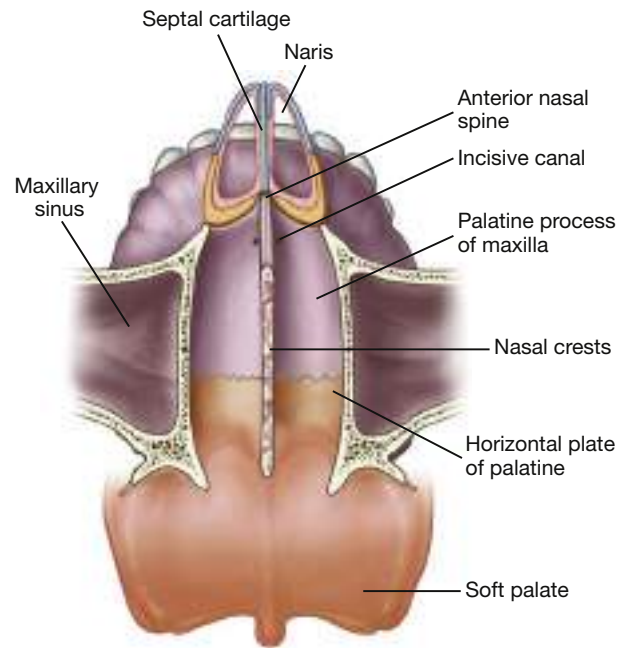


Fig. 8.219 Floor of the nasal cavity (superior view).

in the median sagittal plane and separates the right and left nasal cavities from each other.

The nasal septum (Fig. 8.218) consists of:

- the **septal nasal cartilage** anteriorly;
- posteriorly, mainly the vomer and the perpendicular plate of the ethmoid bone;
- small contributions by the nasal bones where they meet in the midline and the nasal spine of the frontal bone; and
- contributions by the nasal crests of the maxillary and palatine bones, rostrum of the sphenoid bone, and the incisor crest of the maxilla.

Floor

The floor of each nasal cavity (Fig. 8.219) is smooth, concave, and much wider than the roof. It consists of:

- soft tissues of the external nose, and
- the upper surface of the palatine process of the maxilla and the horizontal plate of the palatine bone, which together form the hard palate.

The naris opens anteriorly into the floor, and the superior aperture of the incisive canal is deep to the mucosa immediately lateral to the nasal septum near the front of the hard palate.

Roof

The roof of the nasal cavity is narrow and is highest in central regions where it is formed by the cribriform plate of the ethmoid bone (Fig. 8.220).

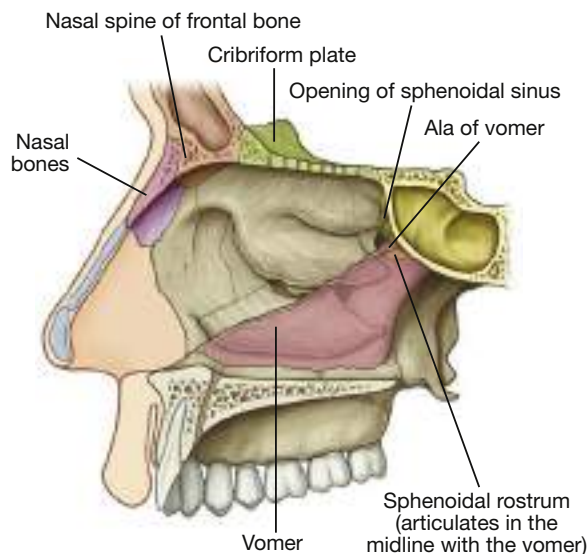
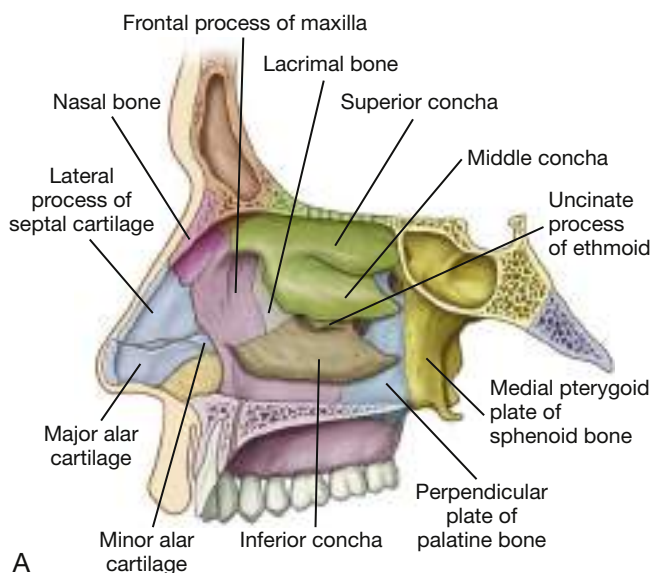


Fig. 8.220 Roof of the nasal cavity.

Anterior to the cribriform plate, the roof slopes inferiorly to the nares and is formed by:

- the nasal spine of the frontal bone and the nasal bones, and
- the lateral processes of the septal cartilage and major alar cartilages of the external nose.



Posteriorly, the roof of each cavity slopes inferiorly to the choana and is formed by:

- the anterior surface of the sphenoid bone,
- the ala of the vomer and adjacent sphenoidal process of the palatine bone, and
- the vaginal process of the medial plate of the pterygoid process.

Underlying the mucosa, the roof is perforated superiorly by openings in the cribriform plate and, anterior to these openings, by a separate foramen for the anterior ethmoidal nerve and vessels.

The opening between the sphenoidal sinus and the speno-ethmoidal recess is on the posterior slope of the roof.

Lateral wall

The lateral wall of each nasal cavity is complex and is formed by bone, cartilage, and soft tissues.

Bony support for the lateral wall (Fig. 8.221A) is provided by:

- the ethmoidal labyrinth and uncinat process,
- the perpendicular plate of the palatine bone,
- the medial plate of the pterygoid process of the sphenoid bone,

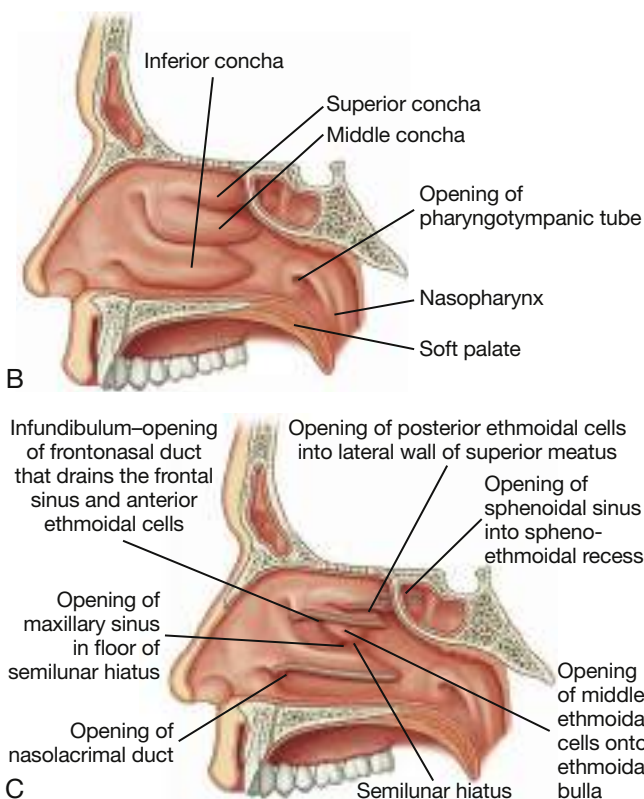


Fig. 8.221 Lateral wall of the nasal cavity. **A.** Bones. **B.** Covered with mucosa. **C.** Conchae broken away at attachment to lateral wall.

- the medial surfaces of the lacrimal bones and maxillae, and
- the inferior concha bone.

In the external nose, the lateral wall of the cavity is supported by cartilage (lateral process of the septal cartilage and major and minor alar cartilages) and by soft tissues. The surface of the lateral wall is irregular in contour and is interrupted by the three nasal conchae.

The inferior, middle, and superior conchae (Fig. 8.221B) extend medially across the nasal cavity, separating it into four air channels, an inferior, middle, and superior meatus, and a sphenothmoidal recess (see Fig. 8.211C,D). The conchae do not extend forward into the external nose. The anterior end of each concha curves inferiorly to form a lip that overlies the end of the related meatus.

Immediately inferior to the attachment of the middle concha and just anterior to the midpoint of the concha, the lateral wall of the middle meatus elevates to form the dome-shaped **ethmoidal bulla** (Fig. 8.221C). This is formed by the underlying middle ethmoidal cells, which expand the medial wall of the ethmoidal labyrinth.

Inferior to the ethmoidal bulla is a curved gutter (the **semilunar hiatus**), which is formed by the mucosa covering the lateral wall as it spans a defect in the bony wall between the ethmoidal bulla above and the uncinate process below.

The anterior end of the semilunar hiatus forms a channel (the **ethmoidal infundibulum**), which curves upward and continues as the **frontonasal duct** through the anterior part of the ethmoidal labyrinth to open into the frontal sinus.

The **nasolacrimal duct** and most of the paranasal sinuses open onto the lateral wall of the nasal cavity (Fig. 8.221C):

- The nasolacrimal duct opens onto the lateral wall of the inferior nasal meatus under the anterior lip of the inferior concha—it drains tears from the conjunctival sac of the eye into the nasal cavity and originates at the inferior end of the lacrimal sac on the anteromedial wall of the orbit.
- The frontal sinus drains via the frontonasal duct and ethmoidal infundibulum into the anterior end of the semilunar hiatus on the lateral wall of the middle nasal meatus—the anterior ethmoidal cells drain into the frontonasal duct or ethmoidal infundibulum (in some cases, the frontal sinus drains directly into the anterior end of the middle nasal meatus and the frontonasal duct ends blindly in the anterior ethmoidal cells).
- The middle ethmoidal cells open onto or just above the ethmoidal bulla.
- The posterior ethmoidal cells usually open onto the lateral wall of the superior nasal meatus.
- The large maxillary sinus opens into the semilunar hiatus, usually just inferior to the center of the ethmoidal bulla. This opening is near the roof of the maxillary sinus.

The only paranasal sinus that does not drain onto the lateral wall of the nasal cavity is the sphenoidal sinus, which usually opens onto the sloping posterior roof of the nasal cavity.

Nares

The nares are oval apertures on the inferior aspect of the external nose and are the anterior openings of the nasal cavities (Fig. 8.222A). They are held open by the surrounding alar cartilages and septal cartilage and by the inferior nasal spine and adjacent margins of the maxillae.

Although the nares are continuously open, they can be widened further by the action of the related muscles of facial expression (nasalis, depressor septi nasi, and levator labii superioris alaeque nasi muscles; Fig. 8.222B).

Choanae

The choanae are the oval-shaped openings between the nasal cavities and the nasopharynx (Fig. 8.223). Unlike the nares, which have flexible borders of cartilage and soft tissues, the choanae are rigid openings completely surrounded by bone, and their margins are formed:

- inferiorly, by the posterior border of the horizontal plate of the palatine bone;
- laterally, by the posterior margin of the medial plate of the pterygoid process; and
- medially, by the posterior border of the vomer.

The roof of the choanae is formed:

- anteriorly, by the ala of the vomer and the vaginal process of the medial plate of the pterygoid process; and
- posteriorly, by the body of the sphenoid bone.

Gateways

There are a number of routes by which nerves and vessels enter and leave the soft tissues lining each nasal cavity (Fig. 8.224), and these include the cribriform plate, sphenopalatine foramen, the incisive canal, small foramina in the lateral wall, and around the margin of the nares.

Cribriform plate

The fibers of the olfactory nerve [I] exit the nasal cavity and enter the cranial cavity through perforations in the cribriform plate (Fig. 8.224). In addition, small foramina between the cribriform plate and surrounding bone allow the anterior ethmoidal nerve, a branch of the ophthalmic nerve [V₁], and accompanying vessels to pass from the orbit into the cranial cavity and then down into the nasal cavity.

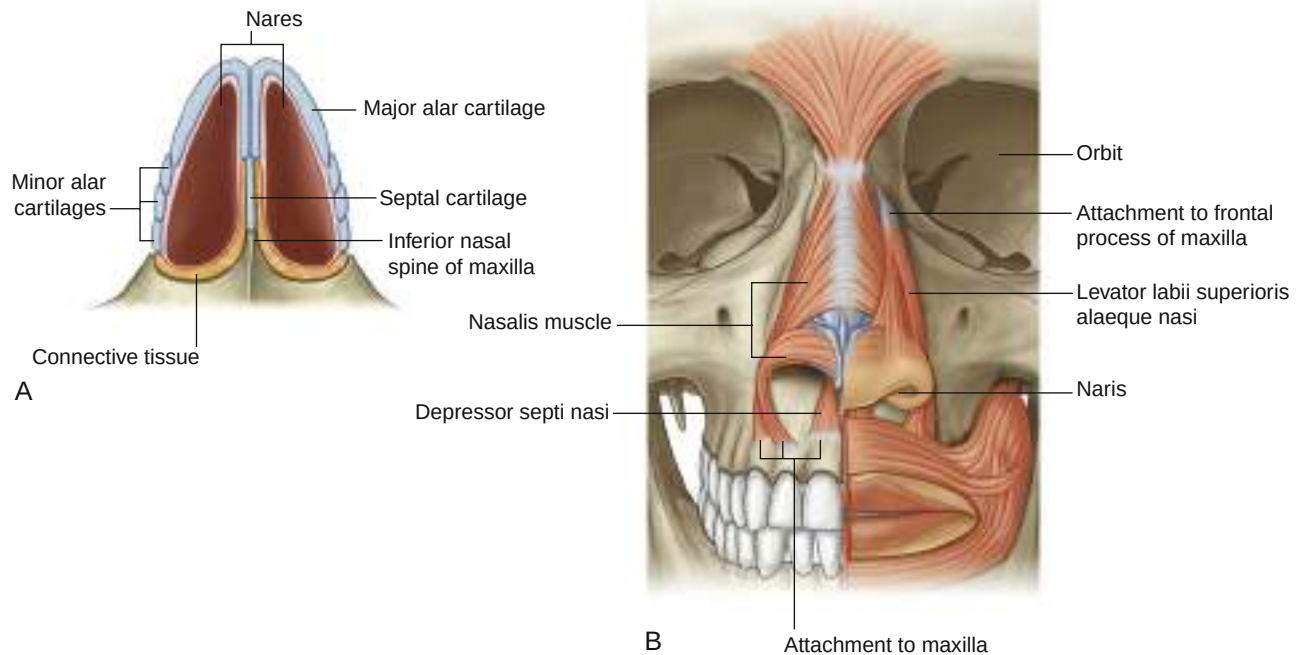


Fig. 8.222 Nares. **A.** Inferior view. **B.** Associated muscles.

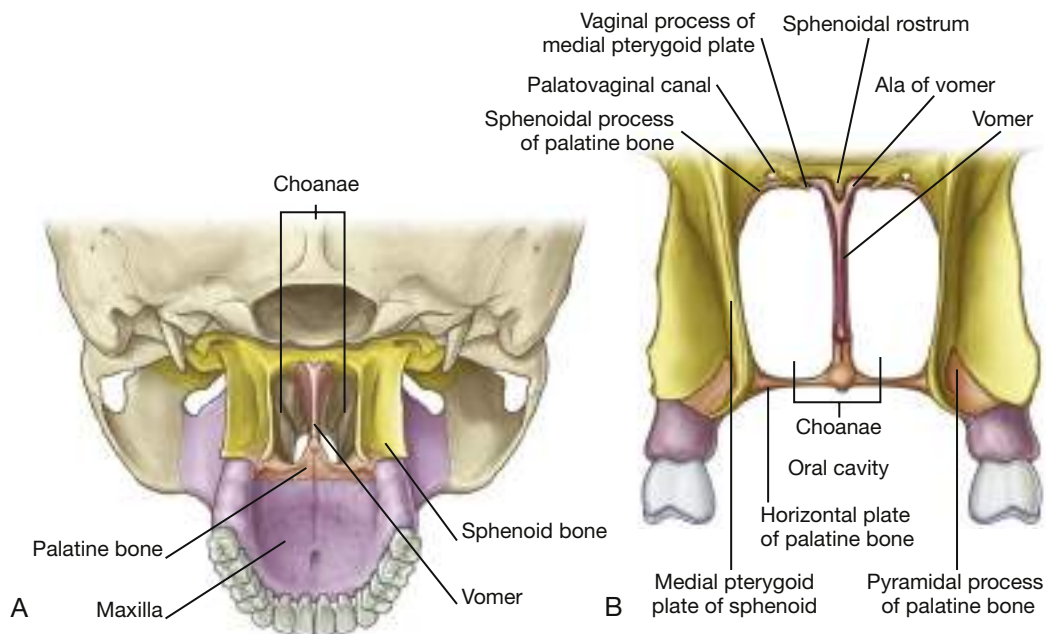


Fig. 8.223 Choanae (posterior view). **A.** Overview. **B.** Magnified view.

In addition, there is a connection in some individuals between nasal veins and the superior sagittal sinus of the cranial cavity through a prominent foramen (the foramen cecum) in the midline between the crista galli and frontal bone.

Sphenopalatine foramen

One of the most important routes by which nerves and vessels enter and leave the nasal cavity is the sphenopalatine

foramen in the posterolateral wall of the superior nasal meatus (Fig. 8.224). This foramen is just superior to the attachment of the posterior end of the middle nasal concha and is formed by the sphenopalatine notch in the palatine bone and the body of the sphenoid bone.

The sphenopalatine foramen is a route of communication between the nasal cavity and the pterygopalatine fossa. Major structures passing through the foramen are:

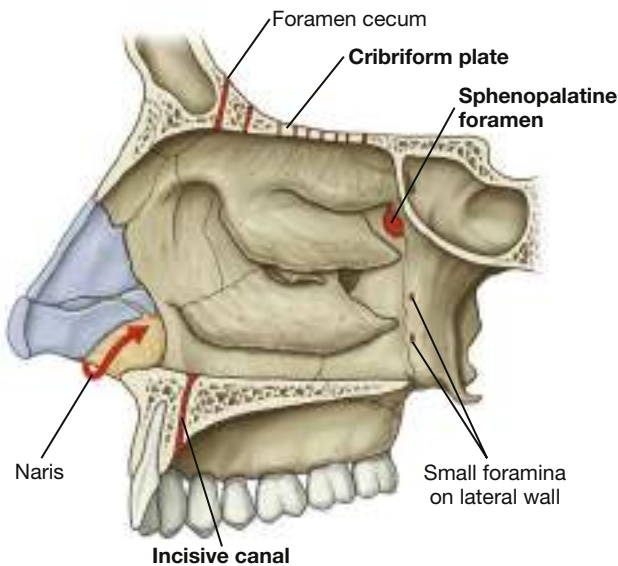


Fig. 8.224 Gateways to the nasal cavities.

- the sphenopalatine branch of the maxillary artery,
- the nasopalatine branch of the maxillary nerve [V_2], and
- superior nasal branches of the maxillary nerve [V_2].

Incisive canal

Another route by which structures enter and leave the nasal cavities is through the **incisive canal** in the floor of each nasal cavity (Fig. 8.224). This canal is immediately lateral to the nasal septum and just posterosuperior to the root of the central incisor in the maxilla. The two incisive canals, one on each side, both open into the single unpaired incisive fossa in the roof of the oral cavity and transmits:

- the nasopalatine nerve from the nasal cavity into the oral cavity, and
- the terminal end of the greater palatine artery from the oral cavity into the nasal cavity.

Small foramina in the lateral wall

Other routes by which vessels and nerves get into and out of the nasal cavity include the nares and small foramina in the lateral wall (Fig. 8.224):

- Internal nasal branches of the infra-orbital nerve of the maxillary nerve [V_2] and alar branches of the nasal artery from the facial artery loop around the margin of the naris to gain entry to the lateral wall of the nasal cavity from the face.
- Inferior nasal branches from the greater palatine branch of the maxillary nerve [V_2] enter the lateral wall of the nasal cavity from the palatine canal by passing through small foramina on the lateral wall.

Vessels

The nasal cavities have a rich vascular supply for altering the humidity and temperature of respired air. In fact, the submucosa of the respiratory region, particularly that related to the conchae and septum, is often described as “erectile” or “cavernous” because the tissue enlarges or shrinks depending on the amount of blood flowing into the system.

Arteries

Arteries that supply the nasal cavity include vessels that originate from both the internal and external carotid arteries (Fig. 8.225):

- Vessels that originate from branches of the external carotid artery include the sphenopalatine, greater palatine, superior labial, and lateral nasal arteries.
- Vessels that originate from branches of the internal carotid artery are the anterior and posterior ethmoidal arteries.

Sphenopalatine artery

The largest vessel supplying the nasal cavity is the **sphenopalatine artery** (Fig. 8.225), which is the terminal branch of the maxillary artery in the pterygopalatine fossa. It leaves the pterygopalatine fossa and enters the nasal cavity by passing medially through the sphenopalatine foramen and onto the lateral wall of the nasal cavity.

Greater palatine artery

The terminal end of the **greater palatine artery** enters the anterior aspect of the floor of the nasal cavity by passing up through the incisive canal from the roof of the oral cavity (Fig. 8.225).

Like the sphenopalatine artery, the greater palatine artery arises in the pterygopalatine fossa as a branch of the maxillary artery. It passes first onto the roof of the oral cavity by passing down through the palatine canal and greater palatine foramen to the posterior aspect of the palate, then passes forward on the undersurface of the palate, and up through the incisive fossa and canal to reach the floor of the nasal cavity. The greater palatine artery supplies anterior regions of the medial wall and adjacent floor of the nasal cavity, and anastomoses with the septal branch of the sphenopalatine artery.

Superior labial and lateral nasal arteries

The superior labial artery and the lateral nasal artery originate from the facial artery on the front of the face (Fig. 8.225).

The **superior labial artery** originates from the facial artery near the lateral end of the oral fissure and passes medially in the lip, supplying the lip and giving rise to branches that supply the nose and nasal cavity. An alar branch supplies the region around the lateral aspect of the naris, and a septal branch passes into the nasal cavity and supplies anterior regions of the nasal septum.

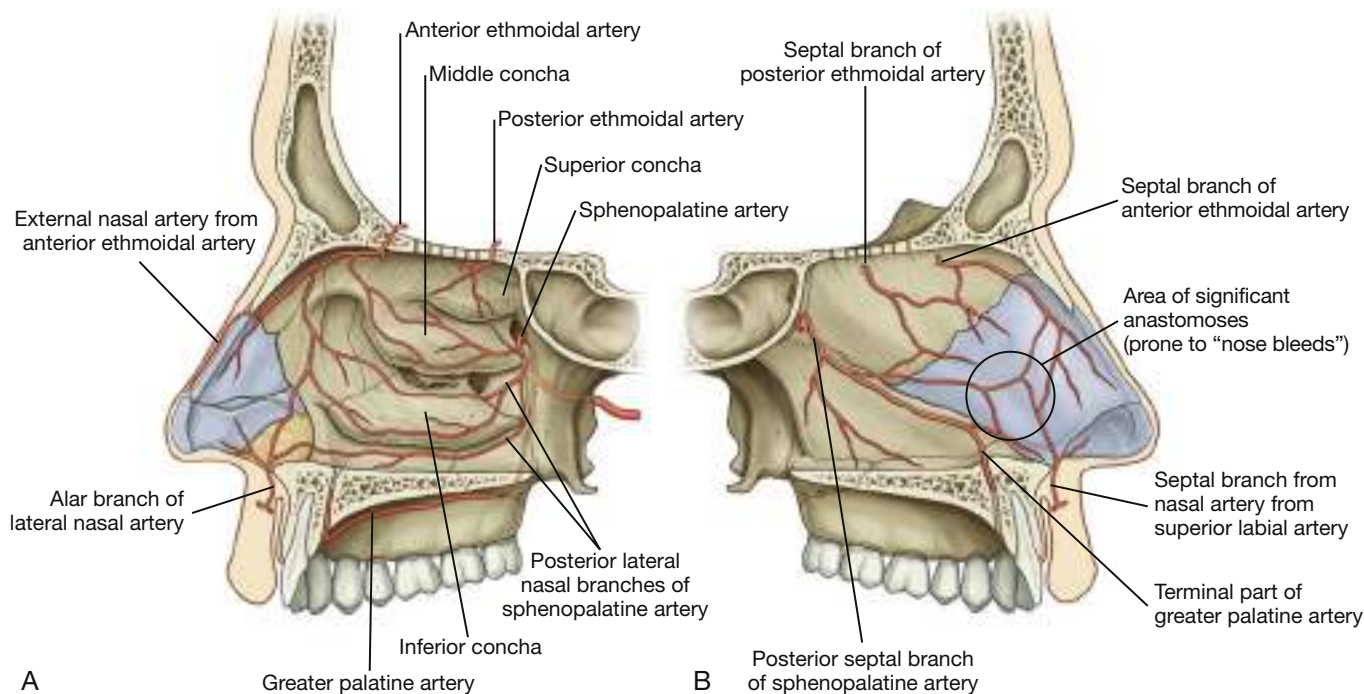


Fig. 8.225 Arterial supply of the nasal cavities. **A.** Lateral wall of the right nasal cavity. **B.** Septum (medial wall of right nasal cavity).

The **lateral nasal artery** originates from the facial artery in association with the margin of the external nose and contributes to the blood supply of the external nose. Alar branches pass around the lateral margin of the naris and supply the nasal vestibule.

Anterior and posterior ethmoidal arteries

The anterior and posterior ethmoidal arteries (Fig. 8.225) originate in the orbit from the ophthalmic artery, which originates in the cranial cavity as a major branch of the internal carotid artery. They pass through canals in the medial wall of the orbit between the ethmoidal labyrinth and frontal bone, supply the adjacent paranasal sinuses, and then enter the cranial cavity immediately lateral and superior to the cribriform plate.

Clinical app

Epistaxis

Vessels that supply the nasal cavities form extensive anastomoses with each other. This is particularly evident in the anterior region of the medial wall where there are anastomoses between branches of the greater palatine, sphenopalatine, superior labial, and anterior ethmoidal arteries and where the vessels are relatively close to the surface (Fig. 8.225C). This area is the major site of nosebleeds, or epistaxis.

The **posterior ethmoidal artery** descends into the nasal cavity through the cribriform plate and has branches to the upper parts of the medial and lateral walls.

The **anterior ethmoidal artery** passes forward, with the accompanying anterior ethmoidal nerve, in a groove on the cribriform plate and enters the nasal cavity by descending through a slit-like foramen immediately lateral to the crista galli.

Veins

Veins draining the nasal cavities generally follow the arteries (Fig. 8.226):

- Veins that pass with branches that ultimately originate from the maxillary artery drain into the pterygoid plexus of veins in the infratemporal fossa.
- Veins from anterior regions of the nasal cavities join the facial vein.

Innervation

Nerves that innervate the nasal cavities are (Fig. 8.227):

- the olfactory nerve [I] for olfaction, and
- branches of the ophthalmic [V₁] and maxillary [V₂] nerves for general sensation.

Secretomotor innervation of mucous glands in the nasal cavities and paranasal sinuses is by parasympathetic fibers

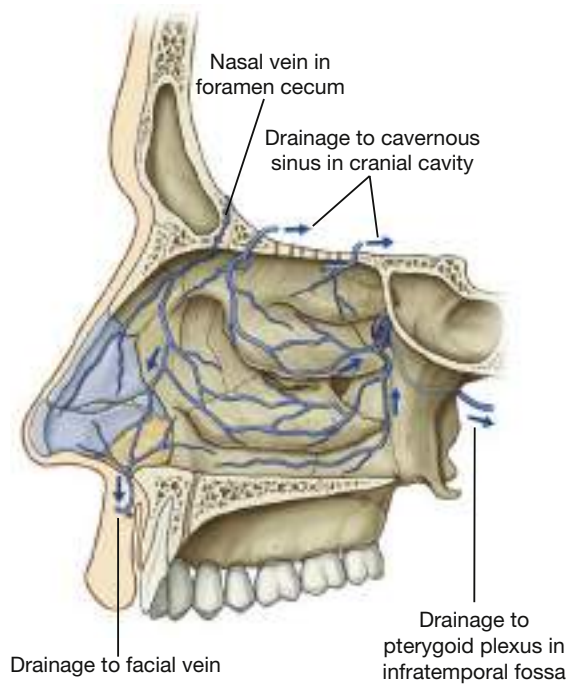


Fig. 8.226 Venous drainage of the nasal cavities.

from the facial nerve [VII], which mainly join branches of the maxillary nerve [V₂] in the pterygopalatine fossa.

Olfactory nerve [I]

The olfactory nerve [I] is composed of axons from receptors in the olfactory epithelium at the top of each nasal cavity.

Bundles of these axons pass superiorly through perforations in the cribriform plate to synapse with neurons in the olfactory bulb of the brain (Fig. 8.227).

Branches from the ophthalmic nerve [V₁]

Branches from the ophthalmic nerve [V₁] that innervate the nasal cavity are the anterior and posterior ethmoidal nerves, which originate from the nasociliary nerve in the orbit (Fig. 8.227).

Anterior and posterior ethmoidal nerves

The anterior ethmoidal nerve (Fig. 8.227) travels with the anterior ethmoidal artery and leaves the orbit through a canal between the ethmoidal labyrinth and the frontal bone. It passes through and supplies the adjacent ethmoidal cells and frontal sinus, and then enters the cranial cavity immediately lateral and superior to the cribriform plate.

The anterior ethmoidal nerve travels forward in a groove on the cribriform plate and then enters the nasal cavity by descending through a slit-like foramen immediately lateral to the crista galli. It has branches to the medial and lateral wall of the nasal cavity and then continues forward on the undersurface of the nasal bone. It passes onto the external surface of the nose by traveling between the nasal bone and lateral nasal cartilage, and then terminates as the **external nasal nerve**, which supplies skin around the naris, in the nasal vestibule, and on the tip of the nose.

Like the anterior ethmoidal nerve, the posterior ethmoidal nerve leaves the orbit through a similar canal in the

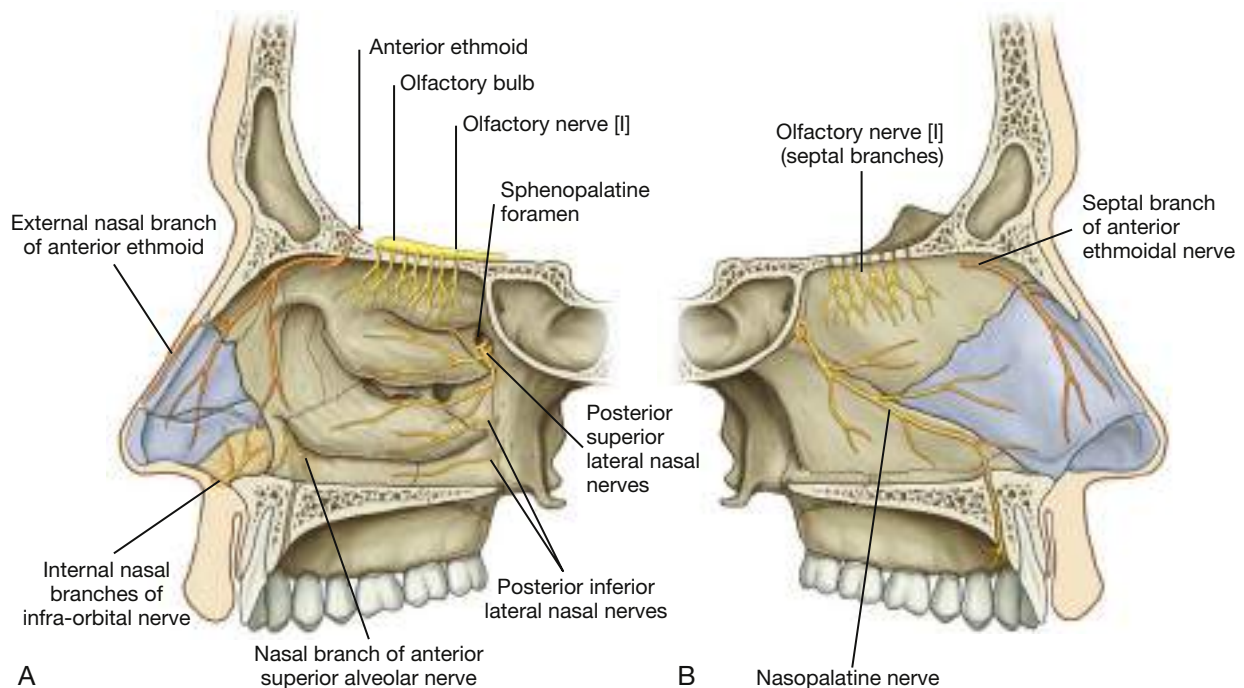


Fig. 8.227 Innervation of the nasal cavities. A. Lateral wall of right nasal cavity. B. Medial wall of right nasal cavity.

medial wall of the orbit. It terminates by supplying the mucosa of the ethmoidal cells and sphenoidal sinus and normally does not extend into the nasal cavity itself.

Branches from the maxillary nerve [V₂]

A number of nasal branches from the maxillary nerve [V₂] innervate the nasal cavity. Many of these nasal branches (Fig. 8.227) originate in the pterygopalatine fossa, which is just lateral to the lateral wall of the nasal cavity, and leave the fossa to enter the nasal cavity by passing medially through the sphenopalatine foramen:

- A number of these nerves (**posterior superior lateral nasal nerves**) pass forward on and supply the lateral wall of the nasal cavity.
- Others (**posterior superior medial nasal nerves**) cross the roof to the nasal septum and supply both these regions.
- The largest of these nerves is the **nasopalatine nerve**, which passes forward and down the medial wall of the nasal cavity to pass through the incisive canal onto the roof of the oral cavity and terminates by supplying the oral mucosa posterior to the incisor teeth.
- Other nasal nerves (**posterior inferior nasal nerves**) originate from the greater palatine nerve, descending from the pterygopalatine fossa in the palatine canal just lateral to the nasal cavity, and pass through small bony foramina to innervate the lateral wall of the nasal cavity.
- A small nasal nerve also originates from the anterior superior alveolar branch of the infra-orbital nerve and passes medially through the maxilla to supply the lateral wall near the anterior end of the inferior concha.

Parasympathetic innervation

Secretomotor innervation of glands in the mucosa of the nasal cavity and paranasal sinuses is by preganglionic parasympathetic fibers carried in the greater petrosal branch of the facial nerve [VII]. These fibers enter the pterygopalatine fossa and synapse in the pterygopalatine ganglion (see Fig. 8.139). Postganglionic parasympathetic fibers then join branches of the maxillary nerve [V₂] to leave the fossa and ultimately reach target glands.

Sympathetic innervation

Sympathetic innervation, mainly involved with regulating blood flow in the nasal mucosa, is from the spinal cord level T1. Preganglionic sympathetic fibers enter the sympathetic trunk and ascend to synapse in the superior cervical sympathetic ganglion. Postganglionic sympathetic fibers pass onto the internal carotid artery, enter the cranial cavity, and then leave the internal carotid artery to form the deep petrosal nerve, which joins the greater petrosal nerve of the

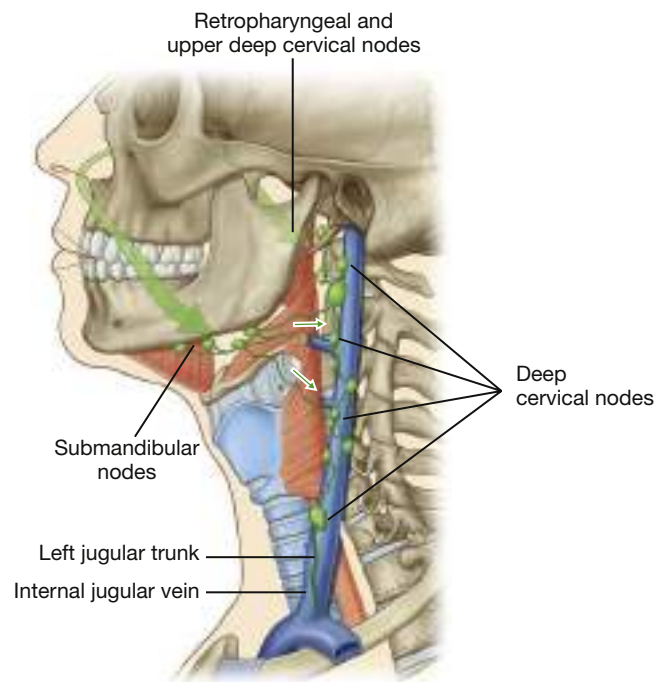


Fig. 8.228 Lymphatic drainage of the nasal cavities.

facial nerve [VII] and enters the pterygopalatine fossa (see Fig. 8.139, pg. 554).

Like the parasympathetic fibers, the sympathetic fibers follow branches of the maxillary nerve [V₂] into the nasal cavity.

Lymphatics

Lymph from anterior regions of the nasal cavities drains forward onto the face by passing around the margins of the nares (Fig. 8.228). These lymphatics ultimately connect with the submandibular nodes.

Lymph from posterior regions of the nasal cavity and the paranasal sinuses drains into upper deep cervical nodes. Some of this lymph passes first through the retropharyngeal nodes.

ORAL CAVITY

The oral cavity is inferior to the nasal cavities (Fig. 8.229A). It has a roof and floor, and lateral walls, opens onto the face through the oral fissure, and is continuous with the cavity of the pharynx at the oropharyngeal isthmus.

The roof of the oral cavity consists of the hard and soft palates. The floor is formed mainly of soft tissues, which include a muscular diaphragm and the tongue. The lateral walls (cheeks) are muscular and merge anteriorly with the lips surrounding the **oral fissure** (the anterior opening of the oral cavity).

The posterior aperture of the oral cavity is the oropharyngeal isthmus, which opens into the oral part of the pharynx.

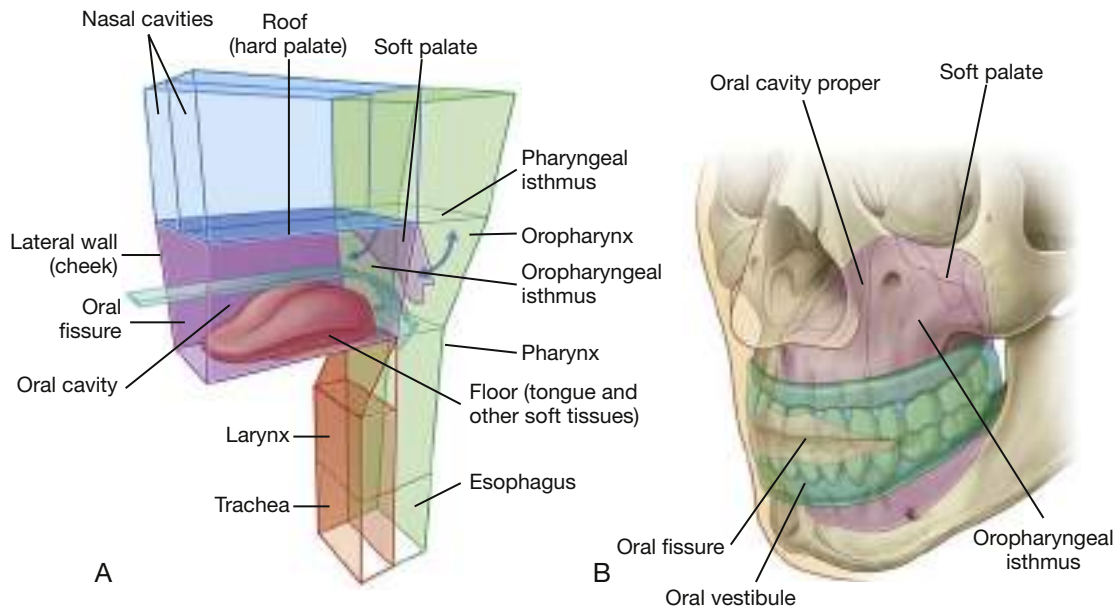


Fig. 8.229 Oral cavity. **A.** Relationship to other cavities. **B.** Oral vestibule and oral cavity proper.

The oral cavity is separated into two regions by the upper and lower dental arches consisting of the teeth and alveolar bone that supports them (Fig. 8.229B):

- The outer **oral vestibule**, which is horseshoe-shaped, is between the dental arches and the deep surfaces of the cheeks and lips—the oral fissure opens into it and can be opened and closed by muscles of facial expression, and by movements of the lower jaw.
- The inner **oral cavity proper** is enclosed by the dental arches.

The degree of separation between the upper and lower dental arches is established by elevating or depressing the lower jaw (mandible) at the temporomandibular joint.

The oropharyngeal isthmus at the back of the oral cavity proper can be opened and closed by surrounding soft tissues, which include the soft palate and tongue.

The oral cavity has multiple functions:

- It is the inlet for the digestive system involved with the initial processing of food, which is aided by secretions from salivary glands;
- It manipulates sounds produced by the larynx, and one outcome of this is speech; and
- It can be used for breathing because it opens into the pharynx, which is a common pathway for food and air.

Skeletal framework

Bones that contribute to the skeletal framework of the oral cavity or are related to the anatomy of structures in the oral cavity include:

Clinical app

Oral cancer

Oral cancer is a subtype of head and neck malignancy. Malignant tissue may grow anywhere in the oral cavity including the lips, tongue, mandible, and maxilla. Typically, oral cancers are squamous; however, malignancies may also occur within the salivary glands and lymph nodes. Oral cancers can spread relatively rapidly to local lymph node groups and to the lungs. The early signs and symptoms include; white or red patches of mucosal change within the mouth (leukoplakia or erythroplakia), which are usually painless. Ulceration may occur within these plaques exposing the malignant tissue. Although some patients may have a genetic predisposition to oral cancer, the three commonest risk factors include tobacco smoking, alcohol abuse, and human papillomavirus.

- the paired maxillae, palatine, and temporal bones; and
- the unpaired mandible, sphenoid, and hyoid bones.

In addition, the cartilaginous parts of the pharyngotympanic tubes on the inferior aspect of the base of the skull are related to the attachment of muscles of the soft palate.

Maxillae

The two maxillae contribute substantially to the architecture of the roof of the oral cavity. The parts involved are the alveolar and palatine processes (Fig. 8.230A).

The palatine process is a horizontal shelf that projects from the medial surface of each maxilla. It originates just

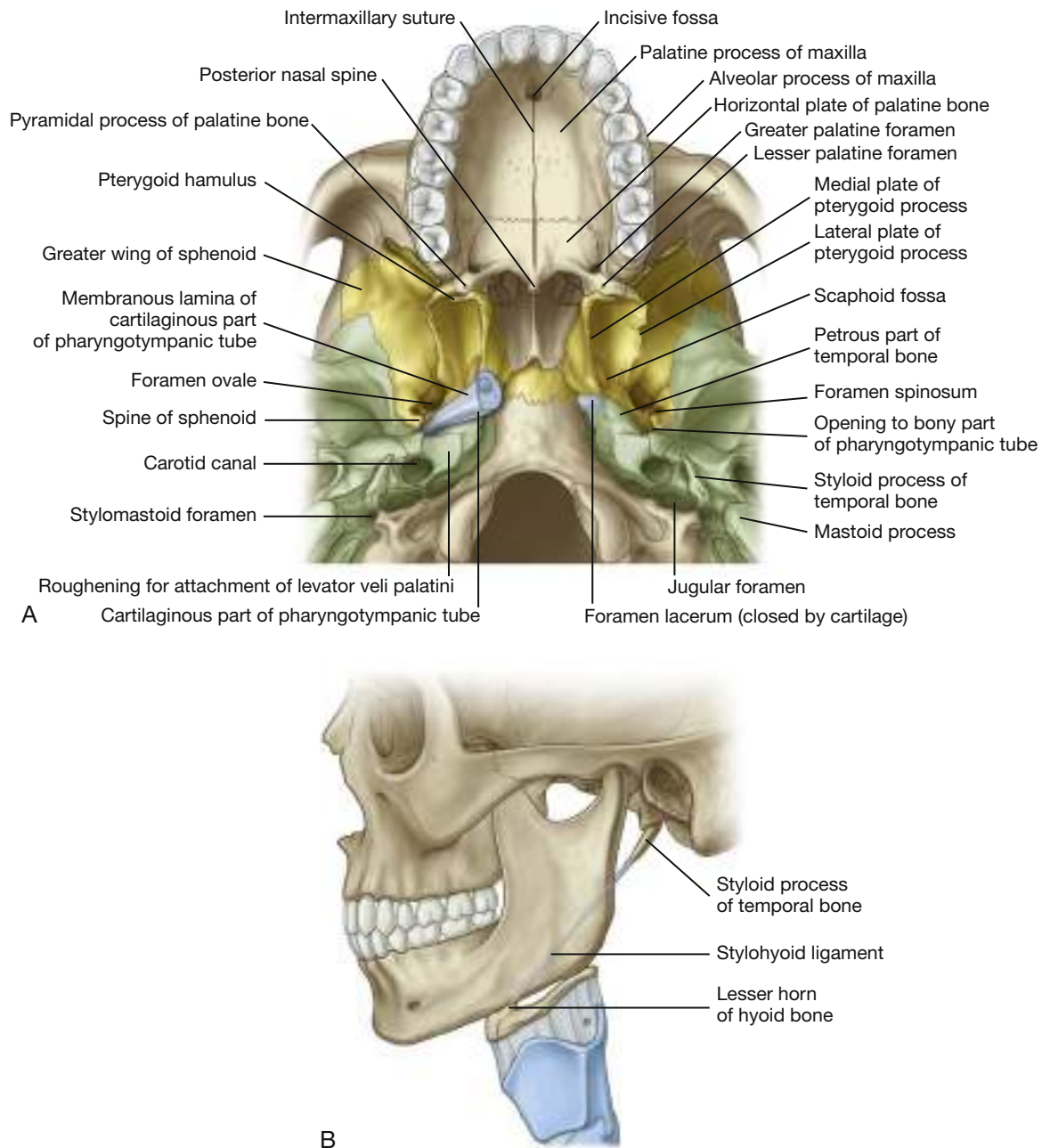


Fig. 8.230 Base and lateral aspects of the skull. **A.** Features in the base of the skull related to structures associated with the oral cavity. **B.** Styloid process of the temporal bone.

superior to the medial aspect of the alveolar process and extends to the midline where it is joined, at a suture, with the palatine process from the other side. Together, the two palatine processes form the anterior two-thirds of the hard palate.

In the midline on the inferior surface of the hard palate and at the anterior end of the intermaxillary suture is a single small fossa (incisive fossa) just behind the incisor teeth. Two incisive canals, one on each side, extend posterosuperiorly from the roof of this fossa to open onto the floor of the nasal cavity. The canals and fossae allow

passage of the greater palatine vessels and the nasopalatine nerves.

Palatine bones

The parts of each L-shaped palatine bone that contribute to the roof of the oral cavity are the horizontal plate and the pyramidal process (Fig. 8.230A).

The horizontal plate projects medially from the inferior aspect of the palatine bone and is joined by sutures to its partner in the midline and, on the same side, with the palatine process of the maxilla anteriorly.

A single **posterior nasal spine** is formed at the midline where the two horizontal plates join and projects backward from the margin of the hard palate. The posterior margin of the horizontal plates and the posterior nasal spine are associated with attachment of the soft palate.

The greater palatine foramen, formed mainly by the horizontal plate of the palatine bone and completed laterally by the adjacent part of the maxilla, opens onto the posterolateral aspect of the horizontal plate (Fig. 8.230A). This foramen is the inferior opening of the palatine canal, which continues superiorly into the pterygopalatine fossa and transmits the greater palatine nerve and vessels to the palate.

Also opening onto the palatine bone is the lesser palatine foramen (Fig. 8.230A). This foramen is the inferior opening of the lesser palatine canal, which branches from the greater palatine canal and transmits the lesser palatine nerve and vessels to the soft palate.

The pyramidal process projects posteriorly and fills the space between the inferior ends of the medial and lateral plates of the pterygoid process of the sphenoid bone (Fig. 8.230A).

Sphenoid bone

The pterygoid processes and spines of the sphenoid bone are associated with structures related to the soft palate, which forms part of the roof of the oral cavity (Fig. 8.230A).

The pterygoid processes descend, one on each side, from the lateral aspect of the body of the sphenoid bone. Each process has a medial and a lateral plate. These two vertically oriented plates project from the posterior aspect of the process. The V-shaped gap that occurs inferiorly between the two plates is filled by the pyramidal process of the palatine bone.

Projecting posterolaterally from the inferior margin of the medial plate of the pterygoid process is an elongate hook-shaped structure (the pterygoid hamulus) (Fig. 8.230A). This hamulus is immediately behind the alveolar arch and inferior to the posterior margin of the hard palate. It is:

- a “pulley” for one of the muscles (tensor veli palatini) of the soft palate, and
- the attachment site for the upper end of the pterygomandibular raphe, which is attached below to the mandible and joins together the superior constrictor of the pharynx and the buccinator muscle of the cheek.

At the root of the medial plate of the pterygoid process on the base of the skull is a small canoe-shaped fossa (**scaphoid fossa**), which begins just medial to the foramen ovale and descends anteriorly and medially to the root of the medial plate of the pterygoid process (Fig. 8.230A). This fossa is for the attachment of one of the muscles of the soft palate (tensor veli palatini).

The spines of the sphenoid, one on each side, are vertical projections from the inferior surfaces of the greater wings of the sphenoid bone (Fig. 8.230A). Each spine is immediately posteromedial to the foramen spinosum.

The medial aspect of the spine provides attachment for the most lateral part of the tensor veli palatini muscle of the soft palate.

Temporal bone

The styloid process and inferior aspect of the petrous part of the temporal bone provide attachment for muscles associated with the tongue and soft palate, respectively.

The styloid process projects anteroinferiorly from the underside of the temporal bone. It can be as long as 1 inch (2.5 cm) and points toward the lesser horn of the hyoid bone to which it is attached by the stylohyoid ligament (Fig. 8.230B). The root of the styloid process is immediately anterior to the stylomastoid foramen and lateral to the jugular foramen. The styloglossus muscle of the tongue attaches to the anterolateral surface of the styloid process.

The inferior aspect of the temporal bone has a triangular roughened area immediately anteromedial to the opening of the carotid canal (Fig. 8.230A). The levator veli palatini muscle of the soft palate is attached here.

Cartilaginous part of the pharyngotympanic tube

The trumpet-shaped cartilaginous part of the pharyngotympanic tube is in a groove between the anterior margin of the petrous part of the temporal bone and the posterior margin of the greater wing of the sphenoid (Fig. 8.230A).

The medial and lateral walls of the cartilaginous part of the pharyngotympanic tube are formed mainly of cartilage, whereas the more inferolateral wall is more fibrous and is known as the **membranous lamina**.

The apex of the cartilaginous part of the pharyngotympanic tube connects laterally to the opening of the bony part in the temporal bone.

The expanded medial end of the cartilaginous part of the pharyngotympanic tube is immediately posterior to the upper margin of the medial plate of the pterygoid process and opens into the nasopharynx.

The cartilaginous part of the pharyngotympanic tube is lateral to the attachment of the levator veli palatini muscle to the petrous part of the temporal bone and medial to the spine of the sphenoid. The tensor veli palatini muscle is attached, in part, to the membranous lamina.

Mandible

The mandible is the bone of the lower jaw (Fig. 8.231). It consists of a body of right and left parts, which are fused anteriorly in the midline (**mandibular symphysis**), and two rami.

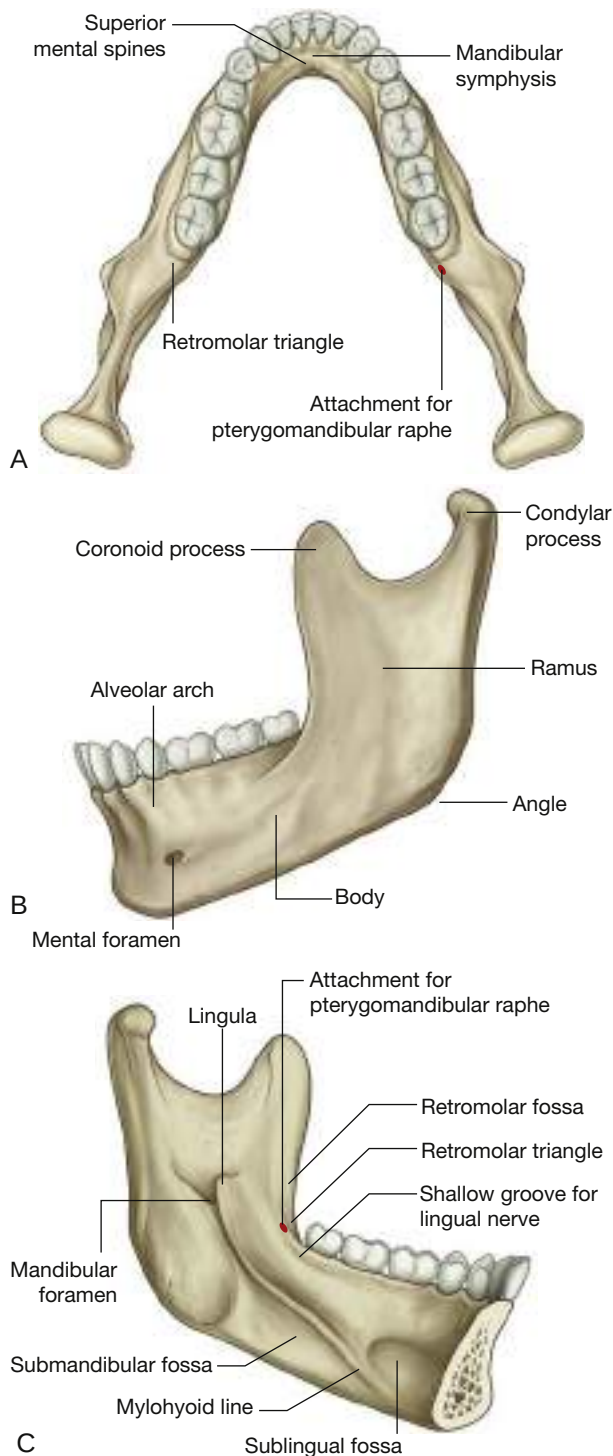


Fig. 8.231 Mandible. A. Superior view. B. Lateral view. C. Medial view.

The site of fusion is particularly visible on the external surface of the bone as a small vertical ridge in the midline.

The upper surface of the body of mandible bears the alveolar arch, which anchors the lower teeth, and on its external surface on each side is a small mental foramen (Fig. 8.231B).

Posterior to the mandibular symphysis on the internal surface of the mandible are two pairs of small spines, one pair immediately above the other pair. These are the **superior** and **inferior mental spines** (**superior** and **inferior genial spines**), and are attachment sites for a pair of muscles that pass into the tongue and a pair of muscles that connect the mandible to the hyoid bone (Fig. 8.231A; also see Fig. 8.234A).

Extending from the midline and originating inferior to the mental spines is a raised line or ridge (the **mylohyoid line**), which runs posteriorly and superiorly along the internal surface of each side of the body of the mandible to end just below the level of the last molar tooth (Fig. 8.231C).

Above the anterior one-third of the mylohyoid line is a shallow depression (the **sublingual fossa**), and below the posterior two-thirds of the mylohyoid line is another depression (the **submandibular fossa**).

Between the last molar tooth and the mylohyoid line is a shallow groove for the lingual nerve.

Immediately posterior to the last molar tooth on the medial upper surface of the body of mandible is a small triangular depression (**retromolar triangle**) (Fig. 8.231C). The pterygomandibular raphe attaches just medial to the apex of this triangle and extends from here to the tip of the pterygoid hamulus above.

The ramus of mandible, one on each side, is quadrangular shaped and oriented in the sagittal plane. On the medial surface of the ramus is a large **mandibular foramen** for transmission of the inferior alveolar nerve and vessels (Fig. 8.231C).

Hyoid bone

The hyoid bone is a small U-shaped bone in the neck between the larynx and the mandible. It has an anterior body of hyoid bone and two large greater horns, one on each side, which project posteriorly and superiorly from the body (Fig. 8.232). There are two small conical lesser horns on the superior surface where the greater horns join with the body. The stylohyoid ligaments attach to the apices of the lesser horns.

The hyoid bone is a key bone in the neck because it connects the floor of the oral cavity in front with the pharynx behind and the larynx below.

Walls: the cheeks

The walls of the oral cavity are formed by the cheeks.

Each cheek consists of fascia and a layer of skeletal muscle sandwiched between skin externally and oral mucosa internally. The thin layer of skeletal muscle within the cheeks is principally the buccinator muscle, which is a muscle of facial expression (Table 8.20, Fig. 8.233).

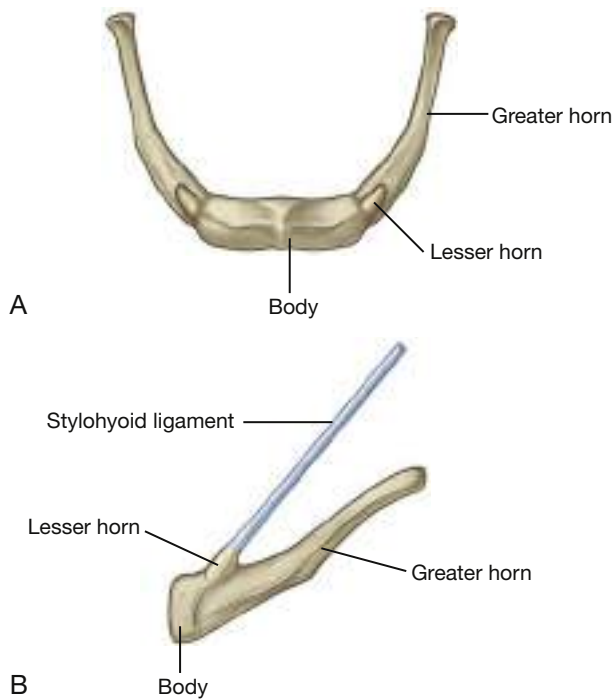


Fig. 8.232 Hyoid bone. **A.** Anterior view. **B.** Lateral view.

Floor

The floor of the oral cavity proper is formed mainly by three structures:

- a muscular diaphragm, which fills the U-shaped gap between the left and right sides of the body of the mandible and is composed of the paired mylohyoid muscles (Table 8.21, Fig. 8.234A);
- two cord-like geniohyoid muscles above the diaphragm, which run from the mandible in front to the hyoid bone behind (Fig. 8.234B,C); and
- the tongue, which is superior to the geniohyoid muscles.

Also present in the floor of the oral cavity proper are salivary glands and their ducts. The largest of these glands, on each side, are the sublingual gland and the oral part of the submandibular gland.

Tongue

The tongue is a muscular structure that forms part of the floor of the oral cavity and part of the anterior wall of the

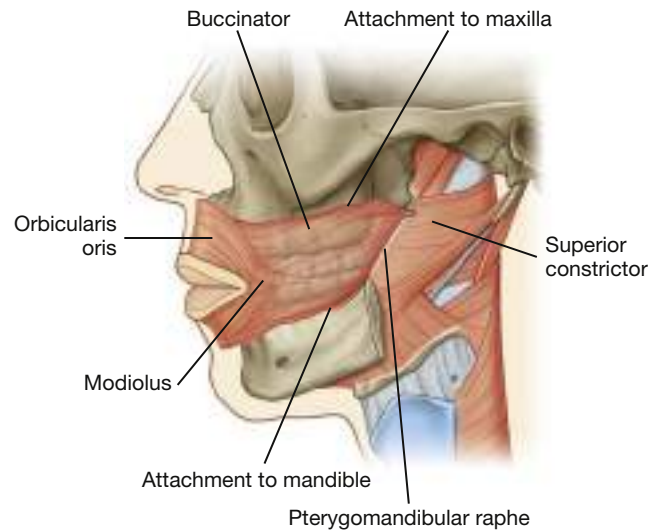


Fig. 8.233 Buccinator muscle.

oropharynx (Fig. 8.235A). Its anterior (oral) part is in the oral cavity and is somewhat triangular in shape with a blunt **apex of tongue**. The apex is directed anteriorly and sits immediately behind the incisor teeth. The **root of tongue** is attached to the mandible and the hyoid bone.

The superior surface of the oral or anterior two-thirds of the tongue is oriented in the horizontal plane.

The pharyngeal surface or posterior one-third of the tongue curves inferiorly and becomes oriented more in the vertical plane. The oral and pharyngeal surfaces are separated by a V-shaped **terminal sulcus of tongue**. This terminal sulcus forms the inferior margin of the oropharyngeal isthmus between the oral and pharyngeal cavities. At the apex of the V-shaped sulcus is a small depression (the **foramen cecum of tongue**), which marks the site in the embryo where the epithelium invaginated to form the thyroid gland. In some people a thyroglossal duct persists and connects the foramen cecum on the tongue with the thyroid gland in the neck.

Papillae

The superior surface of the oral part of the tongue is covered by hundreds of papillae (Fig. 8.235B):

- **Filiform papillae** are small cone-shaped projections of the mucosa that end in one or more points.

Table 8.20 General sensation from the skin and oral mucosa of the cheeks is carried by the buccal branch of the mandibular nerve [V₃]

Muscle	Origin	Insertion	Innervation	Function
Buccinator	Pterygomandibular raphe, alveolar part of mandible, alveolar process of maxilla	Blends with fibers of orbicularis oris muscle; modiolus (button-shaped nodule of connective tissue at the interface between the muscles of the lips and cheeks)	Buccal branch of VII	Holds the cheeks against the alveolar arches; keeps food between the teeth when chewing

Table 8.21 Muscles in the floor of the oral cavity

Muscle	Origin	Insertion	Innervation	Function
Mylohyoid	Mylohyoid line of mandible	Median fibrous raphe and adjacent part of hyoid bone	Nerve to mylohyoid from the inferior alveolar branch of mandibular nerve [V ₃]	Supports and elevates floor of oral cavity; elevates and pulls forward hyoid bone, and therefore attached larynx, during initial stages of swallowing; depresses mandible when hyoid is fixed.
Geniohyoid	Inferior mental spines of mandible	Body of hyoid bone	C1	Depresses mandible when hyoid is fixed; elevates and pulls hyoid forward when mandible is fixed

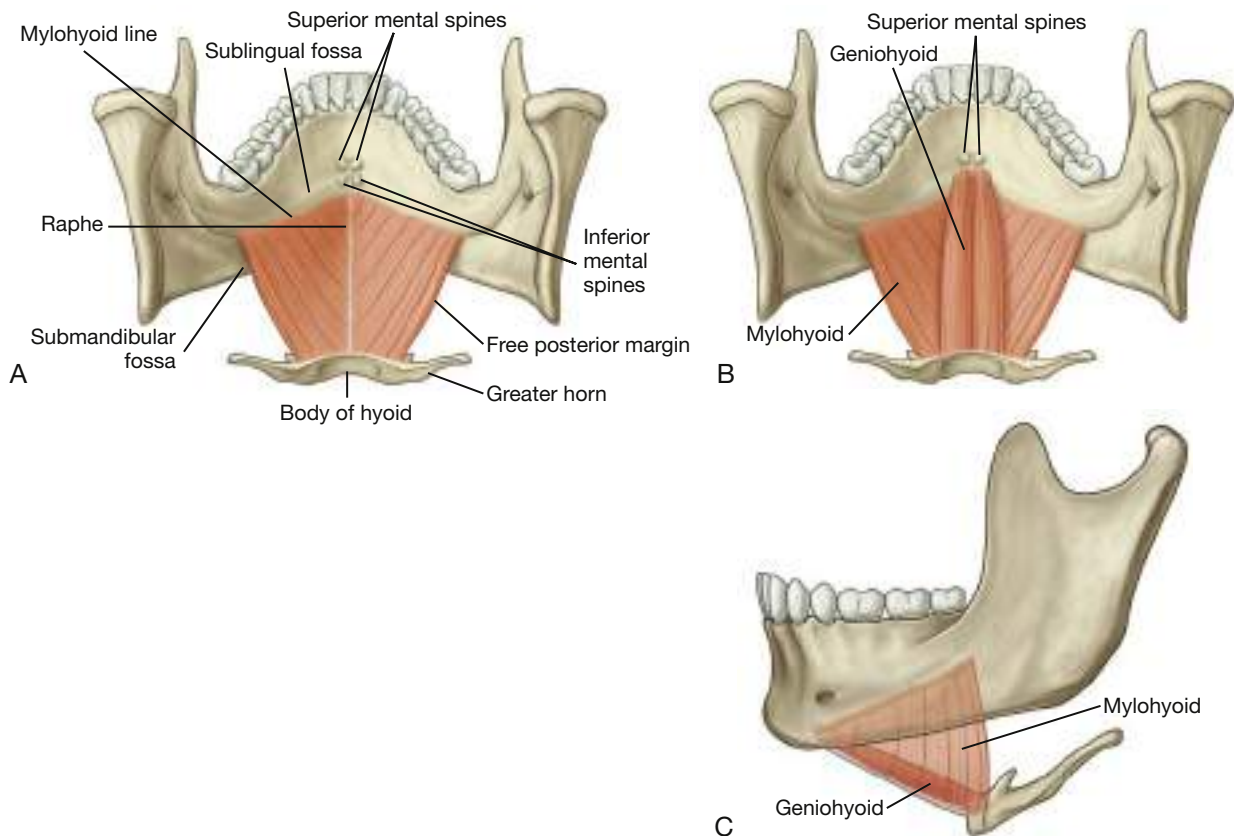


Fig. 8.234 A. Mylohyoid muscles. B. Geniohyoid muscles. C. Lateral view.

- **Fungiform papillae** are rounder in shape and larger than the filiform papillae and tend to be concentrated along the margins of the tongue.
- The largest of the papillae are the **vallate papillae**, which are blunt-ended cylindrical papillae invaginations in the tongue's surface—there are only about 8 to 12 vallate papillae in a single V-shaped line immediately anterior to the terminal sulcus of tongue.
- **Foliate papillae** are linear folds of mucosa on the sides of the tongue near the terminal sulcus of tongue.

The papillae in general increase the area of contact between the surface of the tongue and the contents of the oral cavity. All except the filiform papillae have taste buds on their surfaces.

Inferior surface of tongue

The undersurface of the oral part of the tongue lacks papillae, but does have a number of linear mucosal folds (Fig. 8.236C,D). A single median fold (the **frenulum of tongue**) is continuous with the mucosa covering the floor of the oral cavity, and overlies the lower margin of a mid-line sagittal septum, which internally separates the right and left sides of the tongue. On each side of the frenulum is a lingual vein, and lateral to each vein is a rough **fimbriated fold**.

Pharyngeal surface

The mucosa covering the pharyngeal surface of the tongue is irregular in contour because of the many small nodules

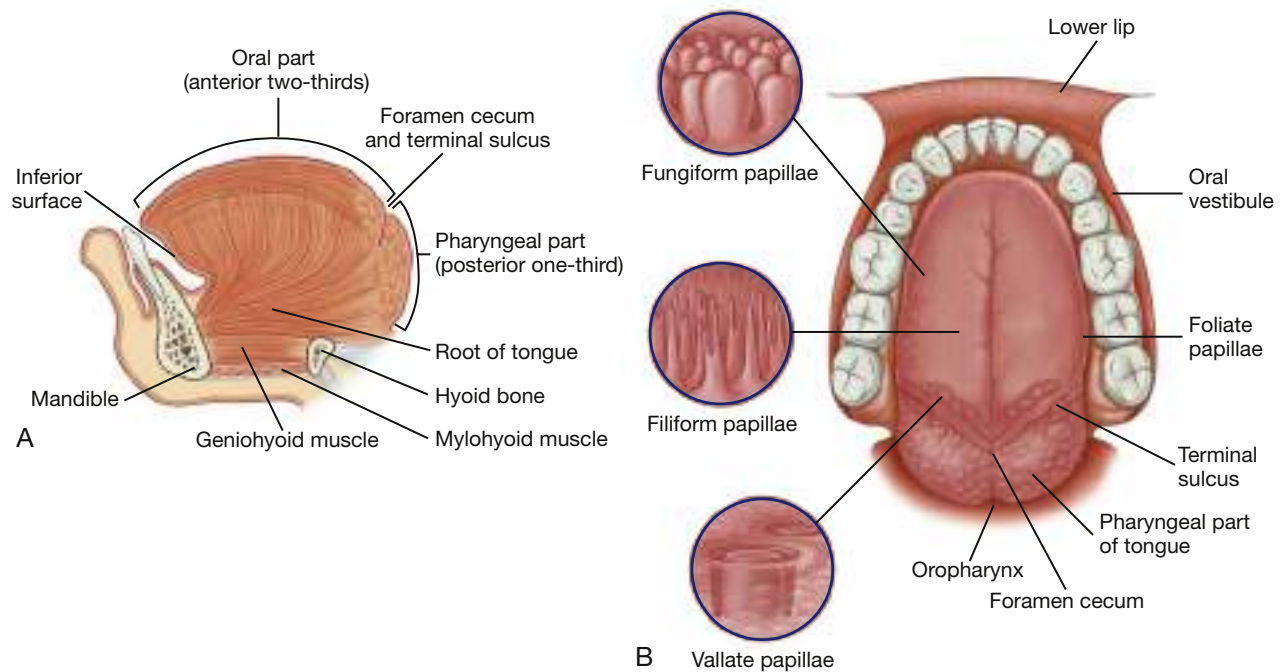


Fig. 8.235 Tongue. **A.** Paramedian sagittal section. **B.** Superior view.

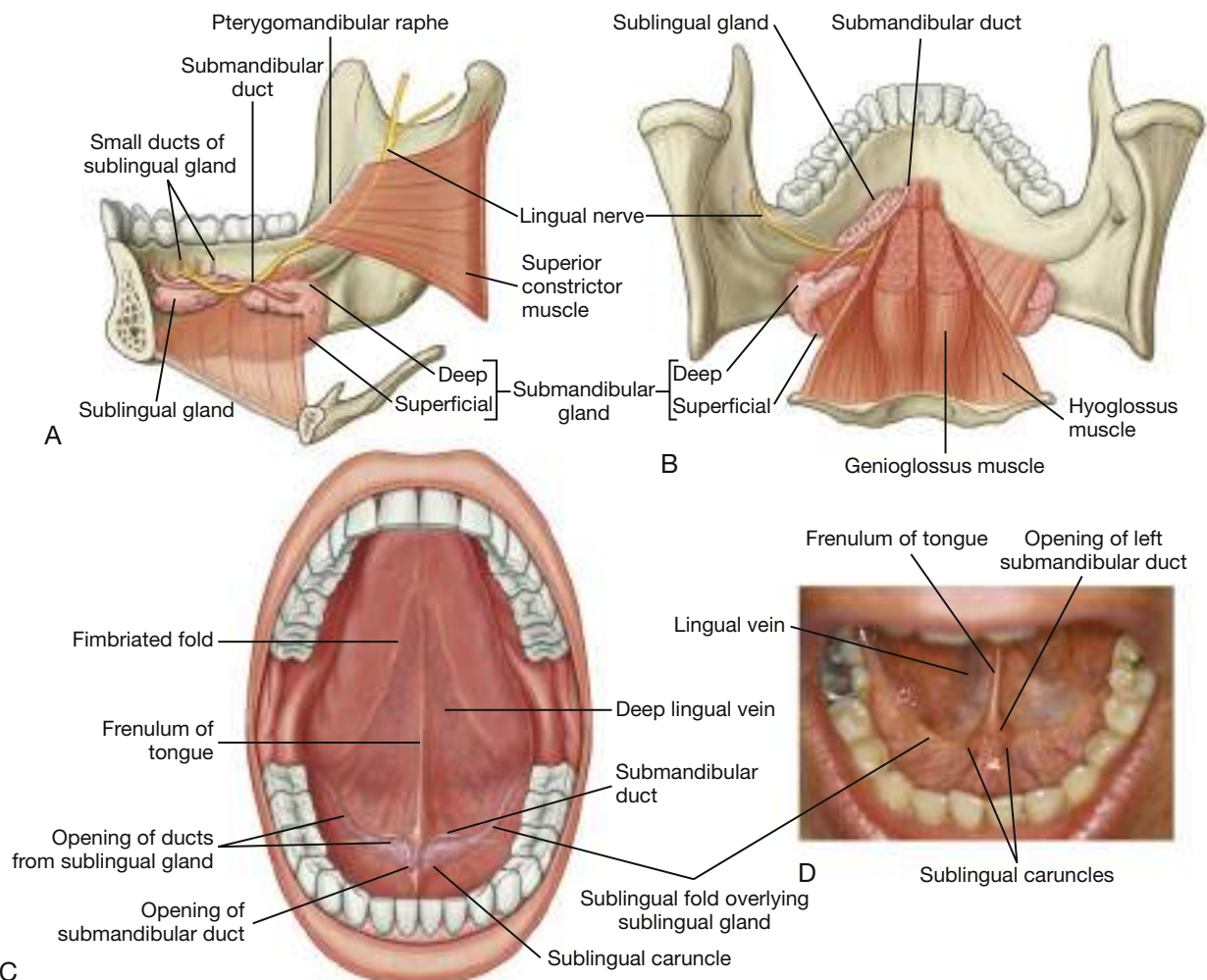


Fig. 8.236 Submandibular and sublingual glands. **A.** Medial view. **B.** Posterior view. **C.** Anterior view. **D.** Anterosuperior view.

Table 8.22 Muscles of the tongue

Muscle	Origin	Insertion	Innervation	Function
Intrinsic				
Superior longitudinal (just deep to surface of tongue)	Submucosal connective tissue at the back of the tongue and from the median septum of the tongue	Muscle fibers pass forward and obliquely to submucosal connective tissue and mucosa on margins of tongue	Hypoglossal nerve [XII]	Shortens tongue; curls apex and sides of tongue
Inferior longitudinal (between genioglossus and hyoglossus muscles)	Root of tongue (some fibers from hyoid)	Apex of tongue	Hypoglossal nerve [XII]	Shortens tongue; uncurls apex and turns it downward
Transverse	Median septum of the tongue	Submucosal connective tissue on lateral margins of tongue	Hypoglossal nerve [XII]	Narrows and elongates tongue
Vertical	Submucosal connective tissue on dorsum of tongue	Connective tissue in more ventral regions of tongue	Hypoglossal nerve [XII]	Flattens and widens tongue
Extrinsic				
Genioglossus	Superior mental spines	Body of hyoid; entire length of tongue	Hypoglossal nerve [XII]	Protrudes tongue; depresses center of tongue
Hyoglossus	Greater horn and adjacent part of body of hyoid bone	Lateral surface of tongue	Hypoglossal nerve [XII]	Depresses tongue
Styloglossus	Styloid process (anterolateral surface)	Lateral surface of tongue	Hypoglossal nerve [XII]	Elevates and retracts tongue
Palatoglossus	Inferior surface of palatine aponeurosis	Lateral margin of tongue	Vagus nerve [X] (via pharyngeal branch to pharyngeal plexus)	Depresses palate; moves palatoglossal fold toward midline; elevates back of the tongue

of lymphoid tissue in the submucosa. These nodules are collectively the **lingual tonsil**.

There are no papillae on the pharyngeal surface.

Muscles

The bulk of the tongue is composed of muscle (Table 8.22, Fig. 8.235A).

The tongue is completely divided into a left and right half by a median sagittal septum composed of connective tissue. This means that all muscles of the tongue are paired. There are intrinsic and extrinsic lingual muscles.

Intrinsic muscles of the tongue (Fig. 8.237) originate and insert within the substance of the tongue. They are divided into **superior longitudinal**, **inferior longitudinal**, **transverse**, and **vertical muscles**, and they alter the shape of the tongue.

Extrinsic muscles of the tongue (Table 8.22, Fig. 8.237) originate from structures outside the tongue and insert into the tongue. There are four major extrinsic muscles on each side, the **genioglossus**, **hyoglossus**, **styloglossus**, and **palatoglossus**. These muscles protrude, retract, depress, and elevate the tongue.

Except for the palatoglossus, which is innervated by the vagus nerve [X], all muscles of the tongue are innervated by the hypoglossal nerve [XII].

Clinical app

Test for cranial nerve XII

Asking a patient to “stick your tongue out” can be used as a test for the hypoglossal nerves [XII] (genioglossus muscle). If the nerves are functioning normally, the tongue should protrude evenly in the midline. If the nerve on one side is not fully functional, the tip of the tongue will point to that side when protruded.

Vessels

Arteries

The major artery of the tongue is the **lingual artery** (Fig. 8.238).

On each side, the lingual artery originates from the external carotid artery in the neck adjacent to the tip of the greater horn of the hyoid bone. It forms an upward bend and then loops downward and forward to pass deep to the hyoglossus muscle; accompanies the muscle through the aperture formed by the margins of the mylohyoid, superior constrictor, and middle constrictor muscles; and enters the floor of the oral cavity.

The lingual artery then travels forward in the plane between the hyoglossus and genioglossus muscles to the apex of the tongue.

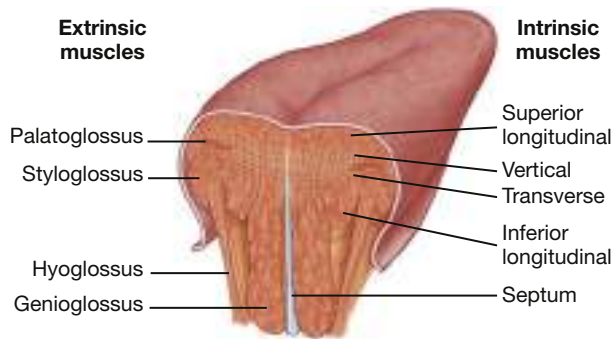


Fig. 8.237 Muscles of the tongue.

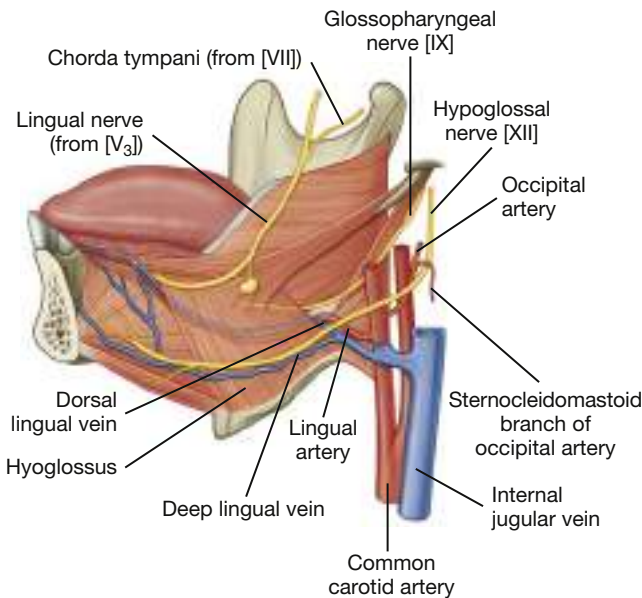


Fig. 8.238 Arteries, veins, and nerves of the tongue.

In addition to the tongue, the lingual artery supplies the sublingual gland, gingiva, and oral mucosa in the floor of the oral cavity.

Veins

The tongue is drained by dorsal lingual and deep lingual veins (Fig. 8.238).

The **deep lingual veins** are visible through the mucosa on the undersurface of the tongue. Although they accompany the lingual arteries in anterior parts of the tongue, they become separated from the arteries posteriorly by the hyoglossus muscles. On each side, the deep lingual vein travels with the hypoglossal nerve [XII] on the external surface of the hyoglossus muscle and passes out of the floor of the oral cavity through the aperture (oropharyngeal triangle) formed by the margins of the mylohyoid, superior constrictor, and middle constrictor muscles. It joins the internal jugular vein in the neck.

The **dorsal lingual vein** follows the lingual artery between the hyoglossus and genioglossus muscles and, like

Sensory

- Anterior two-thirds (oral)
- General sensation: mandibular nerve [V₃] via lingual nerve
 - Special sensation (taste): facial nerve [VII] via chorda tympani

- Posterior one-third (pharyngeal)
- General and special (taste) sensation via glossopharyngeal nerve [IX]

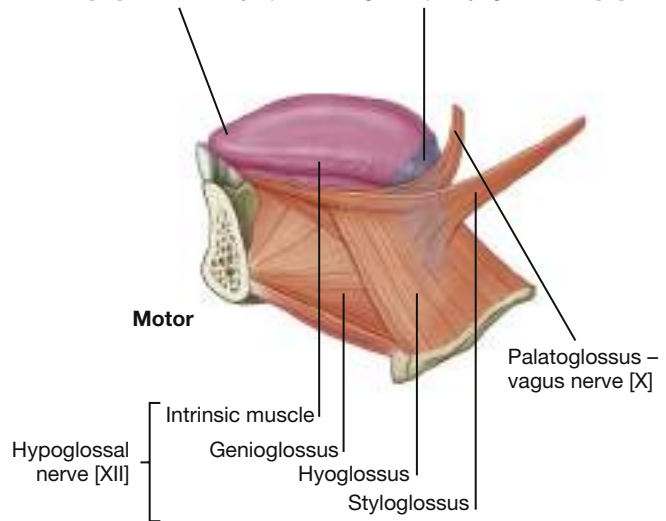


Fig. 8.239 Innervation of the tongue.

the deep lingual vein, drains into the internal jugular vein in the neck.

Innervation

Innervation of the tongue is complex and involves a number of nerves (Figs. 8.238 and 8.239).

Glossopharyngeal nerve [IX]

Taste (SA) and general sensation from the pharyngeal part of the tongue are carried by the glossopharyngeal nerve [IX].

The glossopharyngeal nerve [IX] leaves the skull through the jugular foramen and descends along the posterior surface of the stylopharyngeus muscle. It passes around the lateral surface of the stylopharyngeus and then slips through the posterior aspect of the gap (oropharyngeal triangle) between the superior constrictor, middle constrictor, and mylohyoid muscles. The nerve then passes forward on the oropharyngeal wall just below the inferior pole of the palatine tonsil and enters the pharyngeal part of the tongue deep to the styloglossus and hyoglossus muscles. In addition to taste and general sensation on the posterior one-third of the tongue, branches creep anterior to the terminal sulcus of tongue to carry taste (SA) and general sensation from the vallate papillae.

Lingual nerve

General sensory innervation from the anterior two-thirds or oral part of the tongue is carried by the **lingual nerve**, which is a major branch of the mandibular nerve [V₃]. It originates

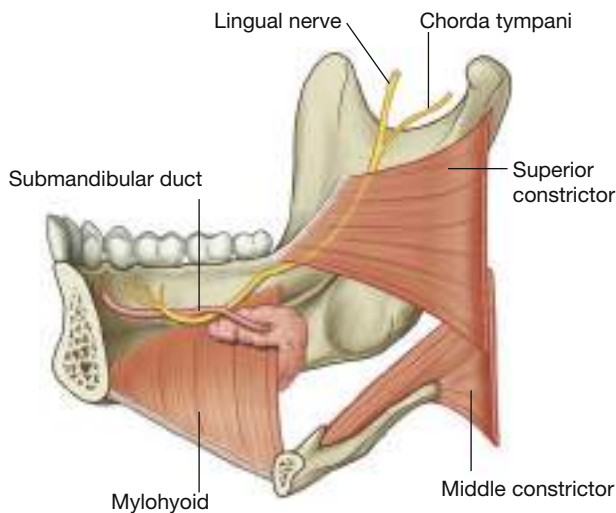


Fig. 8.240 Lingual nerve in the floor of the oral cavity (medial view).

in the infratemporal fossa and passes anteriorly into the floor of the oral cavity by passing through the gap (oropharyngeal triangle) between the mylohyoid, superior constrictor, and middle constrictor muscles (Fig. 8.240).

The lingual nerve then continues anteromedially across the floor of the oral cavity, loops under the submandibular duct, and ascends into the tongue on the external and superior surface of the hyoglossus muscle (Fig. 8.240).

In addition to general sensation from the oral part of the tongue, the lingual nerve also carries general sensation from the mucosa on the floor of the oral cavity and gingiva associated with the lower teeth. The lingual nerve also carries parasympathetic and taste fibers from the oral part of the tongue that are part of the facial nerve [VII].

Facial nerve [VII]

Taste (SA) from the oral part of the tongue is carried into the CNS by the facial nerve [VII]. Special sensory (SA) fibers of the facial nerve [VII] leave the tongue and oral cavity as part of the lingual nerve. The fibers then enter the chorda tympani nerve, which is a branch of the facial nerve [VII] that joins the lingual nerve in the infratemporal fossa (see Fig. 8.240).

Hypoglossal nerve [XII]

All muscles of the tongue are innervated by the hypoglossal nerve [XII] except for the palatoglossus muscle, which is innervated by the vagus nerve [X].

The hypoglossal nerve [XII] leaves the skull through the hypoglossal canal and descends almost vertically in the neck to a level just below the angle of mandible (Fig. 8.241). Here it angles sharply forward around the sternocleidomastoid branch of the occipital artery, crosses the external carotid

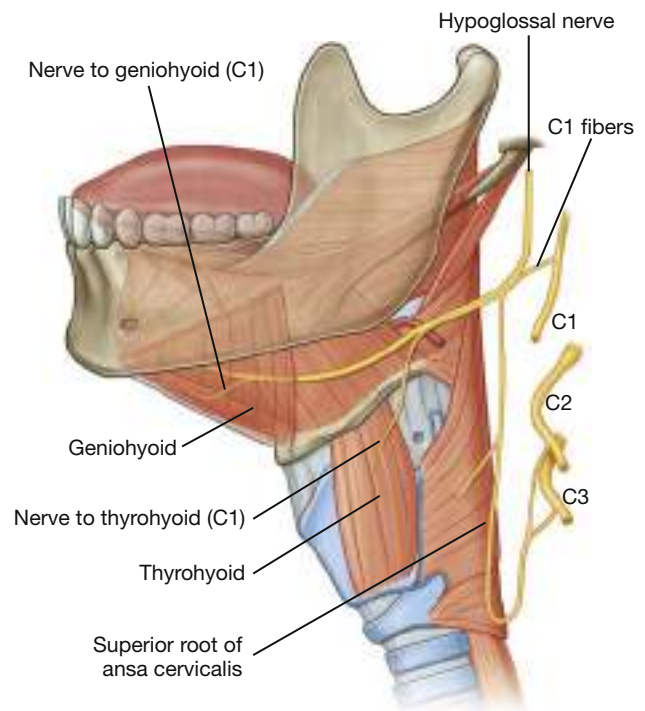


Fig. 8.241 Hypoglossal nerve and C1 fibers.

artery, and continues forward, crossing the loop of the lingual artery to reach the external surface of the lower one-third of the hyoglossus muscle.

The hypoglossal nerve [XII] follows the hyoglossus muscle through the gap (oropharyngeal triangle) between the superior constrictor, middle constrictor, and mylohyoid muscles to reach the tongue.

In the upper neck, a branch from the anterior ramus of C1 joins the hypoglossal nerve [XII]. Most of these C1 fibers leave the hypoglossal nerve [XII] as the superior root of the ansa cervicalis (Fig. 8.241). Near the posterior border of the hyoglossus muscle, the remaining fibers leave the hypoglossal nerve [XII] and form two nerves:

- the thyrohyoid branch, which remains in the neck to innervate the thyrohyoid muscle; and
- the branch to the geniohyoid, which passes into the floor of the oral cavity to innervate the geniohyoid.

Lymphatics

All lymphatic vessels from the tongue ultimately drain into the deep cervical chain of nodes along the internal jugular vein:

- The pharyngeal part of the tongue drains through the pharyngeal wall directly into mainly the jugulodigastric node of the deep cervical chain.
- The oral part of the tongue drains both directly into the deep cervical nodes and indirectly into these nodes by

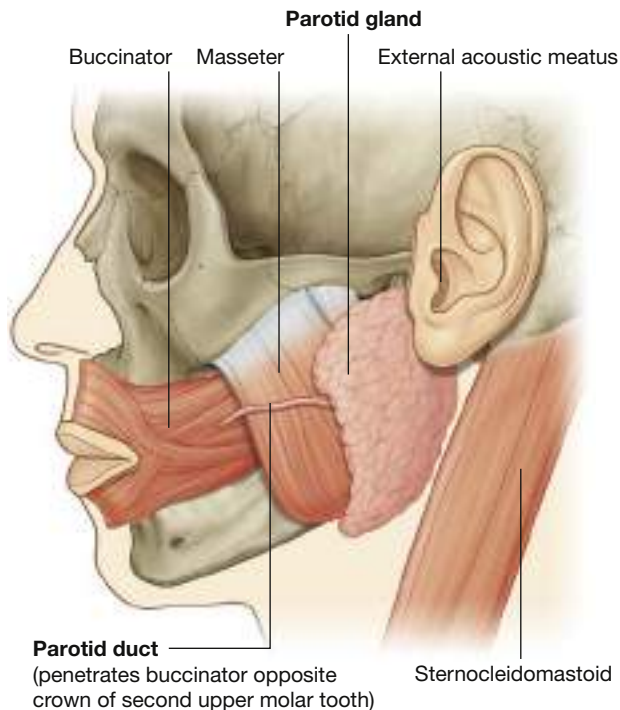


Fig. 8.242 Parotid gland.

passing first through the mylohyoid muscle and into submental and submandibular nodes.

The submental nodes are inferior to the mylohyoid muscles and between the digastric muscles, while the submandibular nodes are below the floor of the oral cavity along the inner aspect of the inferior margins of the mandible.

The tip of the tongue drains through the mylohyoid muscle into the submental nodes and then into mainly the jugulo-omohyoid node of the deep cervical chain.

Salivary glands

Salivary glands are glands that open or secrete into the oral cavity. Most are small glands in the submucosa or mucosa of the oral epithelium lining the tongue, palate, cheeks, and lips, and open into the oral cavity directly or via small ducts. In addition to these small glands are much larger glands, which include the paired parotid, submandibular, and sublingual glands.

Parotid gland

The parotid gland (also see pp. 487-490) on each side is entirely outside the boundaries of the oral cavity in a shallow triangular-shaped trench (Fig. 8.242) formed by:

- the sternocleidomastoid muscle behind;
- the ramus of mandible in front; and
- the external acoustic meatus and the posterior aspect of the zygomatic arch superiorly.

The gland normally extends anteriorly over the masseter muscle and inferiorly over the posterior belly of the digastric muscle.

The parotid duct passes anteriorly across the external surface of the masseter muscle and then turns medially to penetrate the buccinator muscle of the cheek and open into the oral cavity adjacent to the crown of the second upper molar tooth (Fig. 8.242).

The parotid gland encloses the external carotid artery, the retromandibular vein, and the origin of the extracranial part of the facial nerve [VII].

Submandibular glands

The elongate **submandibular glands** are smaller than the parotid glands but larger than the sublingual glands. Each is hook shaped (Fig. 8.243, Fig. 8.44):

- The larger arm of the hook is directed forward in the horizontal plane below the mylohyoid muscle and is therefore outside the boundaries of the oral cavity. This larger superficial part of the gland is directly against a shallow impression on the medial side of the mandible (submandibular fossa) inferior to the mylohyoid line.
- The smaller arm of the hook (or deep part) of the gland loops around the posterior margin of the mylohyoid muscle to enter and lie within the floor of the oral cavity where it is lateral to the root of the tongue on the lateral surface of the hyoglossus muscle.

The **submandibular duct** emerges from the medial side of the deep part of the gland in the oral cavity and passes forward to open on the summit of a small **sublingual caruncle** (papilla) beside the base of frenulum of the tongue (see Fig. 8.236C,D).

The lingual nerve loops under the submandibular duct, crossing first the lateral side and then the medial side of the duct, as the nerve descends anteromedially through the floor of the oral cavity and then ascends into the tongue.

Sublingual glands

The sublingual glands are the smallest of the three major paired salivary glands. Each is almond shaped and is immediately lateral to the submandibular duct and associated lingual nerve in the floor of the oral cavity (see Fig. 8.236A,B).

Each sublingual gland lies directly against the medial surface of the mandible where it forms a shallow groove (sublingual fossa) superior to the anterior one-third of the mylohyoid line.

The superior margin of the sublingual gland raises an elongate fold of mucosa (**sublingual fold**), which extends from the posterolateral aspect of the floor of the oral cavity to the sublingual papilla beside the base of the frenulum of the tongue at the midline anteriorly (see Fig. 8.236C,D).

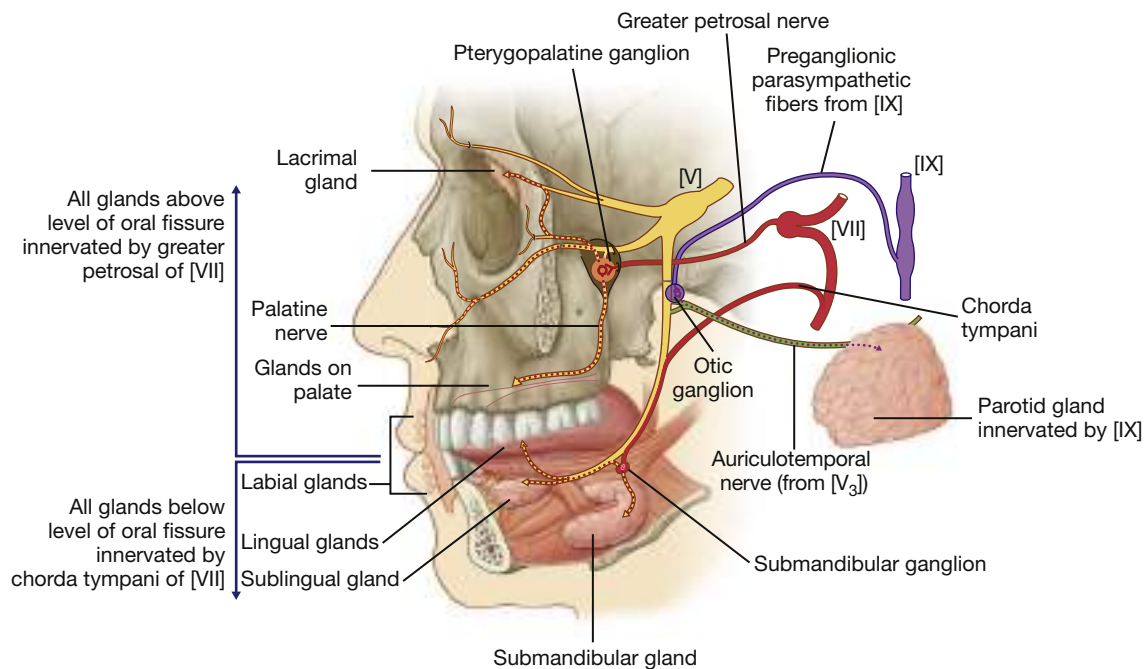


Fig. 8.243 Summary of parasympathetic (secretomotor) innervation of glands in the head.

The sublingual gland drains into the oral cavity via numerous small ducts (minor sublingual ducts), which open onto the crest of the sublingual fold. Occasionally, the more anterior part of the gland is drained by a duct (major sublingual duct) that opens together with the submandibular duct on the sublingual caruncle.

Vessels

Vessels that supply the parotid gland originate from the external carotid artery and from its branches that are adjacent to the gland. The submandibular and sublingual glands are supplied by branches of the facial and lingual arteries.

Veins from the parotid gland drain into the external jugular vein, and those from the submandibular and sublingual glands drain into lingual and facial veins.

Lymphatic vessels from the parotid gland drain into nodes that are on or in the gland. These parotid nodes then drain into superficial and deep cervical nodes.

Lymphatics from the submandibular and sublingual glands drain mainly into submandibular nodes and then into deep cervical nodes, particularly the jugulo-omohyoid node.

Innervation

Parasympathetic

Parasympathetic innervation to all salivary glands in the oral cavity is by branches of the facial nerve [VII], which join branches of the maxillary [V₂] and mandibular [V₃] nerves to reach their target destinations (Fig. 8.243).

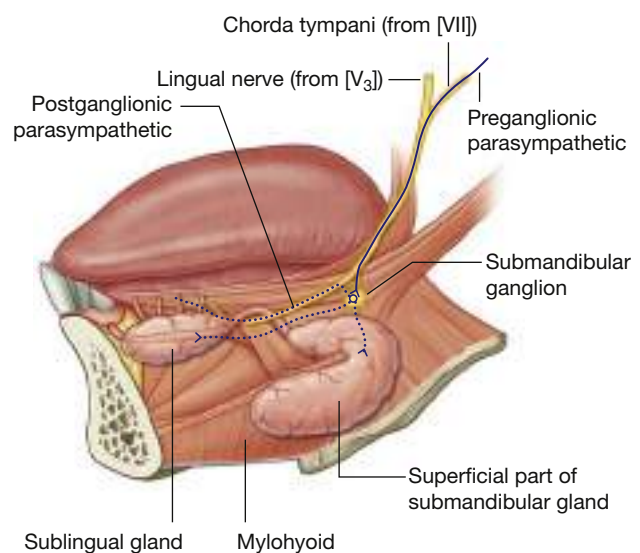


Fig. 8.244 Course of parasympathetic fibers carried in the chorda tympani nerve.

The parotid gland receives its parasympathetic innervation from fibers that initially traveled in the glossopharyngeal nerve [IX], which eventually joins a branch of the mandibular nerve [V₃] in the infratemporal fossa (Fig. 8.243).

Greater petrosal nerve

All salivary glands above the level of the oral fissure, as well as all mucous glands in the nose and the lacrimal gland in the orbit, are innervated by parasympathetic fibers carried in the greater petrosal branch of the facial nerve [VII] (Fig. 8.243).

Preganglionic parasympathetic fibers carried in this nerve enter the pterygopalatine fossa and synapse with postganglionic parasympathetic fibers in the pterygopalatine ganglion formed around branches of the maxillary nerve [V₂]. Postganglionic parasympathetic fibers join general sensory branches of the maxillary nerve, such as the palatine nerves, destined for the roof of the oral cavity, to reach their target glands.

Chorda tympani

All glands below the level of the oral fissure, which include those small glands in the floor of the oral cavity, in the lower lip, and in the tongue, and the larger submandibular and sublingual glands, are innervated by parasympathetic fibers carried in the chorda tympani branch of the facial nerve [VII] (Fig. 8.243-8.244).

The chorda tympani joins the lingual nerve of the mandibular nerve [V₃] in the infratemporal fossa and passes with it into the oral cavity. On the external surface of the hyoglossus muscle, preganglionic parasympathetic fibers leave the inferior aspect of the lingual nerve to synapse with postganglionic parasympathetic fibers in the submandibular ganglion, which appears to hang off the lingual nerve (Fig. 8.243-8.244). Postganglionic parasympathetic fibers leave the ganglion and pass directly to the submandibular and sublingual glands

while others hop back onto the lingual nerve and travel with branches of the lingual nerve to target glands.

Sympathetic

Sympathetic innervation to the salivary glands is from spinal cord level T1. Preganglionic sympathetic fibers enter the sympathetic trunk and ascend to synapse in the superior cervical sympathetic ganglion (Fig. 8.245). Postganglionic fibers hop onto adjacent blood vessels and nerves to reach the glands.

Roof—palate

The roof of the oral cavity consists of the palate, which has two parts—an anterior hard palate and a posterior soft palate (Fig. 8.246).

Hard palate

The hard palate separates the oral cavity from the nasal cavities. It consists of a bony plate covered above and below by mucosa (Fig. 8.246):

- Above, it is covered by respiratory mucosa and forms the floor of the nasal cavities.
- Below, it is covered by a tightly bound layer of oral mucosa and forms much of the roof of the oral cavity.

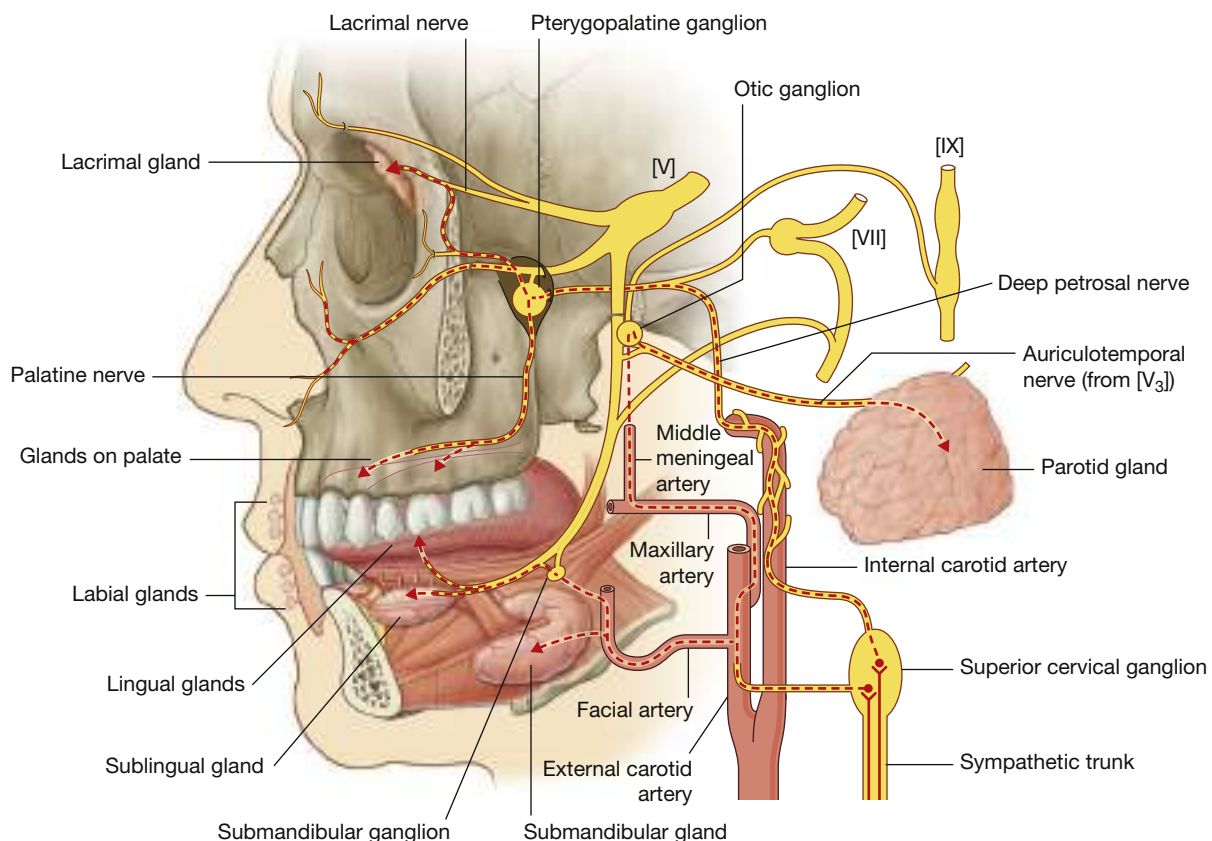


Fig. 8.245 Summary of sympathetic innervation of glands in the head.

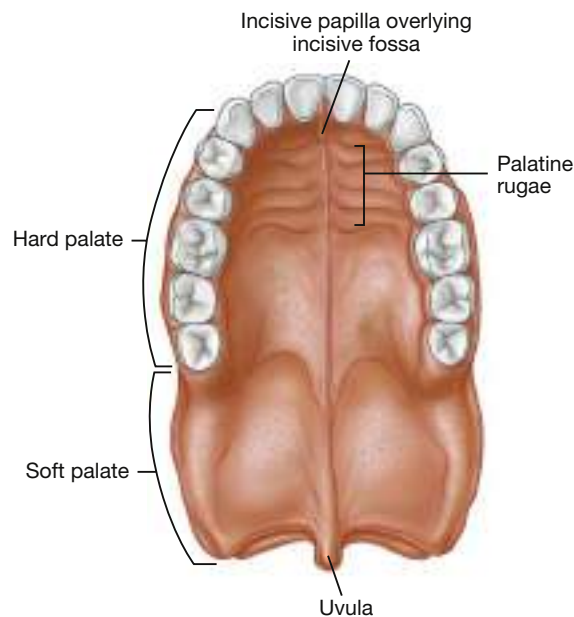


Fig. 8.246 Palate.

The palatine processes of the maxillae form the anterior three-quarters of the hard palate. The horizontal plates of the palatine bones form the posterior one-quarter. In the oral cavity, the upper alveolar arch borders the hard palate anteriorly and laterally. Posteriorly, the hard palate is continuous with the soft palate.

The mucosa of the hard palate in the oral cavity possesses numerous **transverse palatine folds (palatine rugae)** and a median longitudinal ridge (**palatine raphe**), which ends anteriorly in a small oval elevation (**incisive papilla**) (Fig. 8.246).

The incisive papilla overlies the incisive fossa formed between the horizontal plates of the maxillae immediately behind the incisor teeth.

Soft palate

The soft palate (Fig. 8.246) continues posteriorly from the hard palate and acts as a valve that can be:

- depressed to help close the oropharyngeal isthmus; or
- elevated to separate the nasopharynx from the oropharynx.

The soft palate is formed and moved by four muscles and is covered by mucosa that is continuous with the mucosa lining the pharynx and oral and nasal cavities.

The small tear-shaped muscular projection that hangs from the posterior free margin of the soft palate is the **uvula**.

Muscles of the soft palate

Five muscles (Table 8.23, Figs. 8.247, 8.248) on each side contribute to the formation and movement of the soft palate. Two of these, the **tensor veli palatini** and **levator veli palatini**, descend into the palate from the base of the skull. Two others, the **palatoglossus** and **palatopharyngeus**, ascend into the palate from the tongue and pharynx, respectively. The palatine tonsils are placed on each side between mucosal folds over the palatoglossus and palatopharyngeus muscles. The last muscle, the **musculus uvulae**, is associated with the uvula.

All muscles of the palate are innervated by the vagus nerve [X] except for the tensor veli palatini, which is innervated by the mandibular nerve [V₃] (via the nerve to medial pterygoid).

Table 8.23 Muscles of the soft palate

Muscle	Origin	Insertion	Innervation	Function
Tensor veli palatini	Scaphoid fossa of sphenoid bone; fibrous part of pharyngotympanic tube; spine of sphenoid	Palatine aponeurosis	Mandibular nerve [V ₃] via the branch to medial pterygoid muscle	Tenses the soft palate; opens the pharyngotympanic tube
Levator veli palatini	Petrous part of temporal bone anterior to opening for carotid canal	Superior surface of palatine aponeurosis	Vagus nerve [X] via pharyngeal branch to pharyngeal plexus	Only muscle to elevate the soft palate above the neutral position
Palatopharyngeus	Superior surface of palatine aponeurosis	Pharyngeal wall	Vagus nerve [X] via pharyngeal branch to pharyngeal plexus	Depresses soft palate; moves palatopharyngeal arch toward midline, thereby helping to close the oropharyngeal isthmus; elevates pharynx
Palatoglossus	Inferior surface of palatine aponeurosis	Lateral margin of tongue	Vagus nerve [X] via pharyngeal branch to pharyngeal plexus	Depresses palate; moves palatoglossal arch toward midline, thereby helping to close the oropharyngeal isthmus; elevates back of the tongue
Musculus uvulae	Posterior nasal spine of hard palate	Connective tissue of uvula	Vagus nerve [X] via pharyngeal branch to pharyngeal plexus	Elevates and retracts uvula; thickens central region of soft palate

Clinical app

Test for cranial nerve X

Clinically, the levator veli palatini, which is innervated by cranial nerve X, can be tested by asking a patient to say “ah.” If the muscle on each side is functioning normally, the palate elevates evenly in the midline. If one side is not functioning, the palate deviates away from the abnormal side.

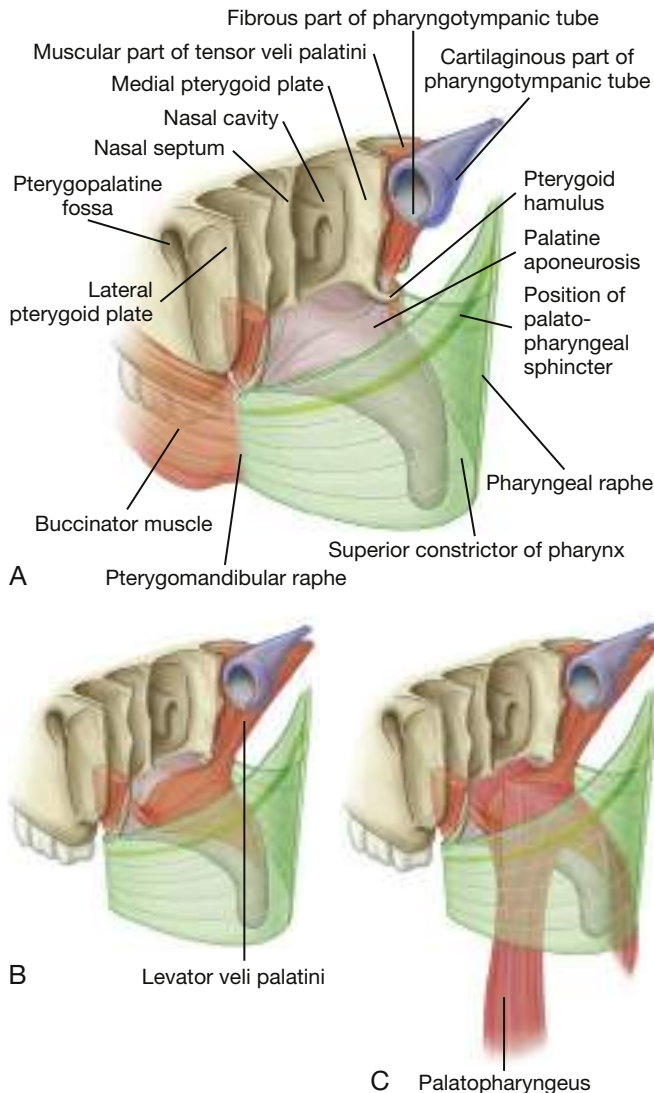


Fig. 8.247 A. Tensor veli palatini muscles and the palatine aponeurosis. B. Levator veli palatini muscles. C. Palatopharyngeus muscles.

Vessels

Arteries

Arteries of the palate include the greater palatine branch of the maxillary artery, the ascending palatine branch of the facial artery, and the palatine branch of the ascending

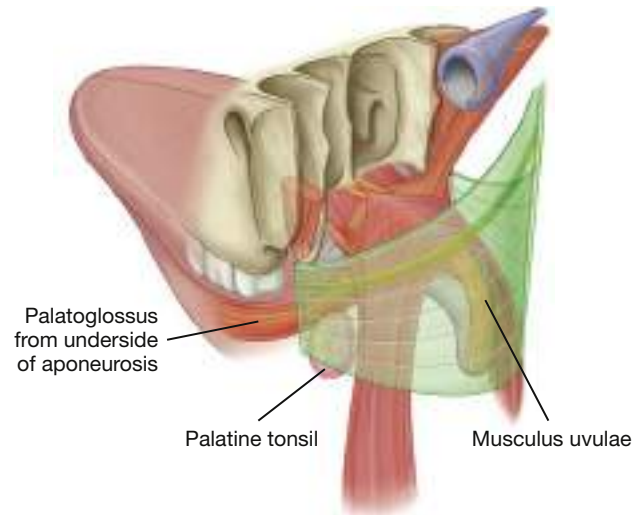


Fig. 8.248 Palatoglossus muscles and musculus uvulae.

pharyngeal artery. The maxillary, facial, and ascending pharyngeal arteries are all branches that arise in the neck from the external carotid artery (Fig. 8.249).

Ascending palatine artery and palatine branch

The **ascending palatine artery** of the facial artery ascends along the external surface of the pharynx. The palatine branch loops medially over the top of the superior constrictor muscle of the pharynx to penetrate the pharyngeal fascia with the levator veli palatini muscle and follows the levator veli palatini to the soft palate.

The **palatine branch** of the ascending pharyngeal artery follows the same course as the palatine branch of the ascending palatine artery from the facial artery and may replace the vessel.

Greater palatine artery

The **greater palatine artery** originates from the maxillary artery in the pterygopalatine fossa. It descends into the palatine canal, where it gives origin to a small **lesser palatine branch**, and then continues through the greater palatine foramen onto the inferior surface of the hard palate (Figs. 8.249, 8.250). The greater palatine artery passes forward on the hard palate and then leaves the palate superiorly through the incisive canal to enter the medial wall of the nasal cavity where it terminates. The greater palatine artery is the major artery of the hard palate. It also supplies palatal gingiva. The lesser palatine branch passes through the lesser palatine foramen just posterior to the greater palatine foramen, and contributes to the vascular supply of the soft palate (Figs. 8.249, 8.250).

Veins

Veins from the palate generally follow the arteries and ultimately drain into the pterygoid plexus of veins in the

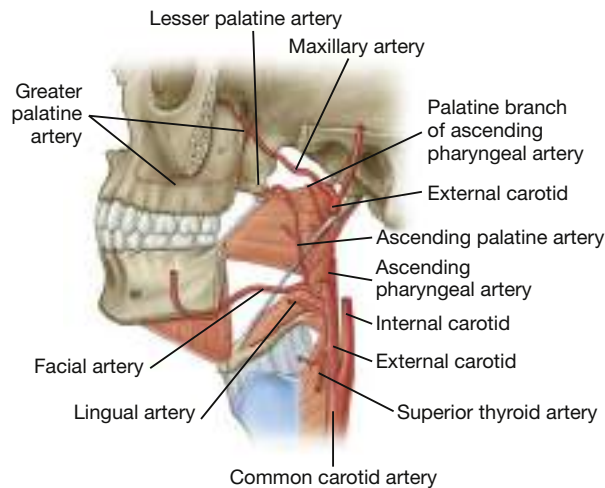


Fig. 8.249 Arteries of the palate.

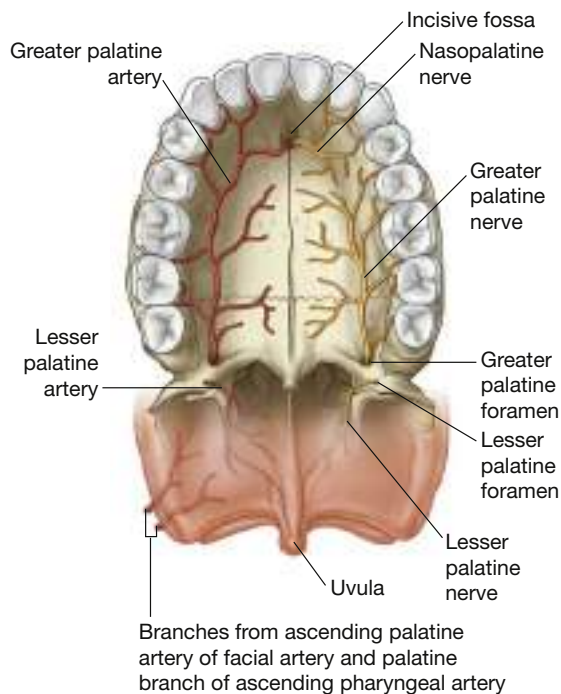


Fig. 8.250 Palatine nerves and arteries.

infratemporal fossa (Fig. 8.251) or into a network of veins associated with the palatine tonsil, which drain into the pharyngeal plexus of veins or directly into the facial vein.

Lymphatics

Lymphatic vessels from the palate drain into deep cervical nodes (Fig. 8.251).

Innervation

The palate is supplied by the greater and lesser palatine nerves and the nasopalatine nerve (Figs. 8.250).

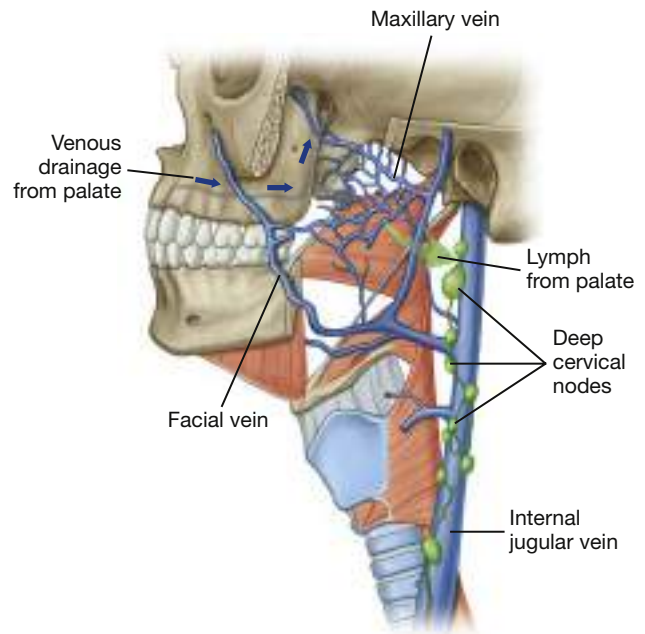


Fig. 8.251 Venous and lymphatic drainage of the palate.

General sensory fibers carried in all these nerves originate in the pterygopalatine fossa from the maxillary nerve [V₂].

Parasympathetic (to glands) and SA (taste on soft palate) fibers from a branch of the facial nerve [VII] join the nerves in the pterygopalatine fossa as do the sympathetics (mainly to blood vessels) ultimately derived from the T1 spinal cord level (Fig. 8.252).

Greater and lesser palatine nerves

The greater and lesser palatine nerves descend through the pterygopalatine fossa and palatine canal to reach the palate (Figs. 8.250, 8.252):

- The greater palatine nerve travels through the greater palatine foramen and turns anteriorly to supply the hard palate and gingiva as far as the first premolar.
- The lesser palatine nerve passes posteromedially to supply the soft palate.

Nasopalatine nerve

The nasopalatine nerve also originates in the pterygopalatine fossa, but passes medially into the nasal cavity. It continues medially over the roof of the nasal cavity to reach the medial wall, then anteriorly and obliquely down the wall to reach the incisive canal in the anterior floor, and descends through the incisive canal and fossa to reach the inferior surface of the hard palate.

The nasopalatine nerve supplies gingiva and mucosa adjacent to the incisors and canine.

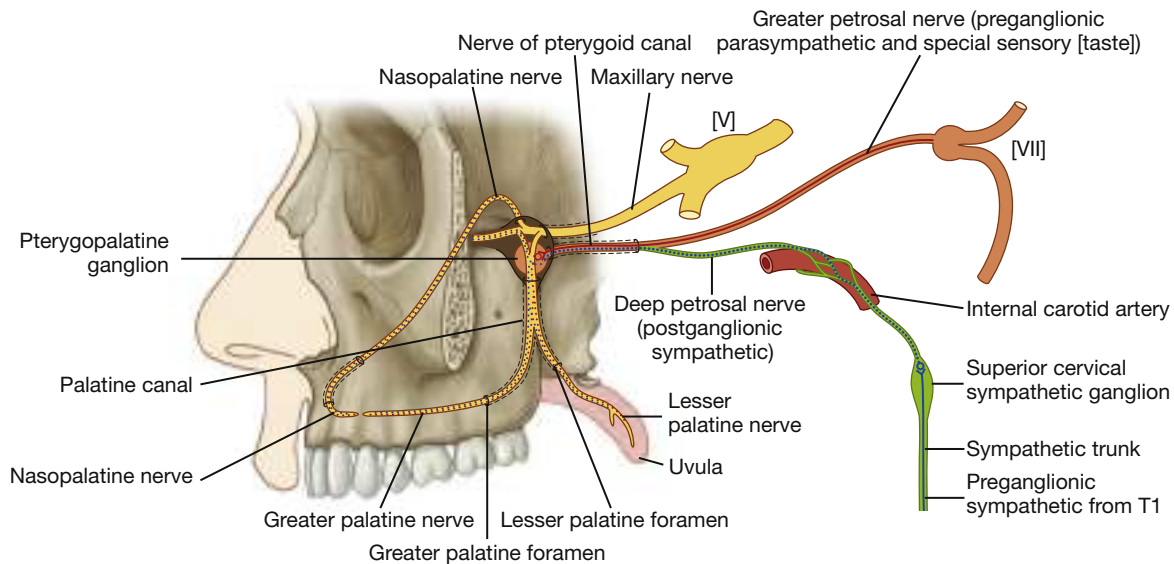


Fig. 8.252 Innervation of the palate.

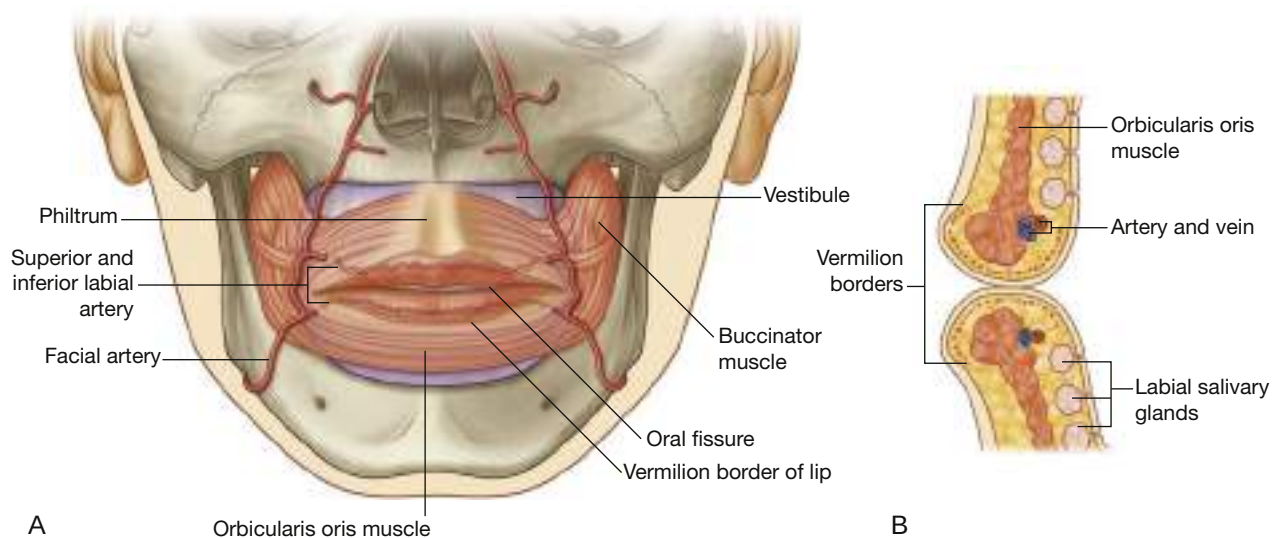


Fig. 8.253 Oral fissure and lips. A. Anterior view. B. Lateral view.

Oral fissure and lips

The oral fissure is the slit-like opening between the lips that connects the oral vestibule to the outside (Fig. 8.253). It can be opened and closed, and altered in shape by the movements of the muscles of facial expression associated with the lips and surrounding regions, and by movements of the lower jaw (mandible).

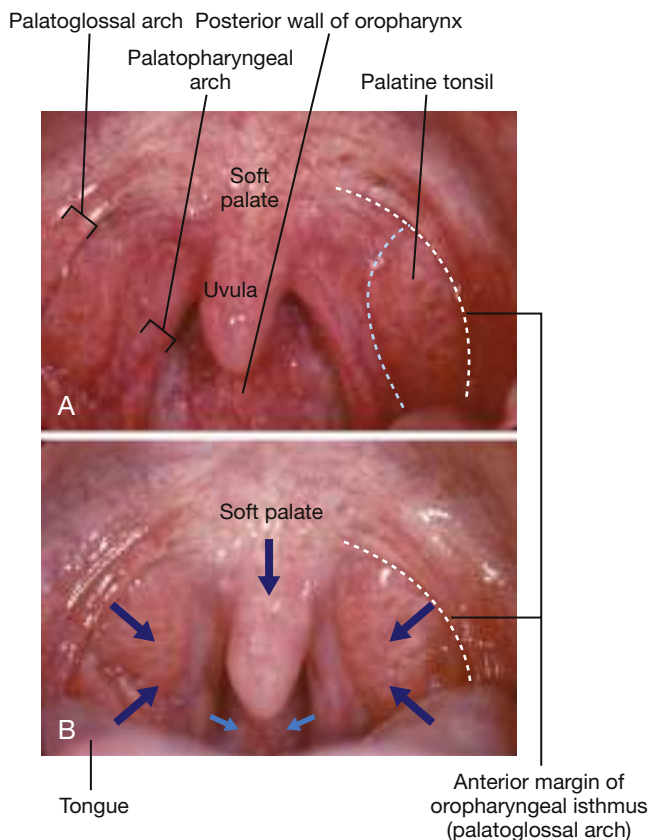
The **lips** are entirely composed of soft tissues (Fig. 8.253B). They are lined internally by oral mucosa and covered externally by skin (Fig. 8.253A). Externally, there is an area of transition from the thicker skin that covers the face to the thinner skin that overlies the margins of the lips and continues as oral mucosa onto the deep surfaces of the lips.

Blood vessels are closer to the surface in areas where the skin is thin and as a consequence there is a vermilion border that covers the margins of the lips.

The upper lip has a shallow vertical groove on its external surface (the **philtrum**) sandwiched between two elevated ridges of skin (Fig. 8.253A). The philtrum and ridges are formed embryologically by fusion of the medial nasal processes.

On the inner surface of both lips, a fold of mucosa (the **median labial frenulum**) connects the lip to the adjacent gum.

The lips enclose the orbicularis oris muscle, neurovascular tissues, and labial glands. The small pea-shaped labial



Closure of oropharyngeal isthmus

- Medial and downward movement of palatoglossal arches
- Medial and downward movement of palatopharyngeal arches
- Upward movement of tongue
- Downward and forward movement of soft palate

Fig. 8.254 Open mouth with soft palate. **A.** Oropharyngeal isthmus opened. **B.** Oropharyngeal isthmus closed.

glands are between the muscle tissue and the oral mucosa and open into the oral vestibule (Fig. 8.253B).

A number of muscles of facial expression control the shape and size of the oral fissure. The most important of these is the orbicularis oris muscle, which encircles the orifice and acts as a sphincter. A number of other muscles of facial expression blend into the orbicularis oris or other tissues of the lips and open or adjust the contours of the oral fissure. These include the buccinator, levator labii superioris, zygomaticus major and minor, levator anguli oris, depressor labii inferioris, depressor anguli oris, and platysma (see pp. 484-486).

Oropharyngeal isthmus

The oropharyngeal isthmus is the opening between the oral cavity and the oropharynx (Fig. 8.254). It is formed:

- laterally by the palatoglossal arches,
- superiorly by the soft palate, and

- inferiorly by the sulcus terminalis of the tongue that divides the oral surface of the tongue (anterior two-thirds) from the pharyngeal surface (posterior one-third).

The oropharyngeal isthmus can be closed by elevation of the posterior aspect of the tongue, depression of the palate, and medial movement of the palatoglossal arches toward the midline (Fig. 8.254B).

Medial movement of the palatopharyngeal arches medial and posterior to the palatoglossal arches is also involved in closing the oropharyngeal isthmus. By closing the oropharyngeal isthmus, food or liquid can be held in the oral cavity while breathing.

Teeth and gingivae

The **teeth** are attached to sockets (alveoli) in two elevated arches of bone on the mandible below and the maxillae above (alveolar arches). If the teeth are removed, the alveolar bone is resorbed and the arches disappear.

The **gingivae** (gums) are specialized regions of the oral mucosa that surround the teeth and cover adjacent regions of the alveolar bone.

The different types of teeth are distinguished on the basis of morphology, position, and function (Fig. 8.255A).

In adults, there are 32 teeth: 16 in the upper jaw and 16 in the lower jaw. On each side in both maxillary and mandibular arches are two incisor, one canine, two premolar, and three molar teeth (Fig. 8.255A).

- The **incisor teeth** are the “front teeth” and have one root and a chisel-shaped crown, which “cuts.”
- The **canine teeth** are posterior to the incisors, are the longest teeth, have a crown with a single pointed cusp, and “grasp.”
- The **premolar teeth** (bicuspid) have a crown with two pointed cusps, one on the buccal (cheek) side of the tooth and the other on the lingual (tongue) or palatal (palate) side, generally have one root (but the upper first premolar next to the canine may have two), and “grind.”
- The **molar teeth** are behind the premolar teeth, have three roots and crowns with three to five cusps, and “grind.”

Two successive sets of teeth develop in humans, deciduous teeth (“baby” teeth) (Fig. 8.255B) and permanent teeth (“adult” teeth). The deciduous teeth emerge from the gingivae at between 6 months and 2 years of age. Permanent teeth begin to emerge and replace the deciduous teeth at around age 6 years, and can continue to emerge into adulthood.

The 20 deciduous teeth consist of two incisor, one canine, and two molar teeth on each side of the upper and lower jaws. These teeth are replaced by the incisor, canine, and premolar teeth of the permanent teeth. The permanent molar

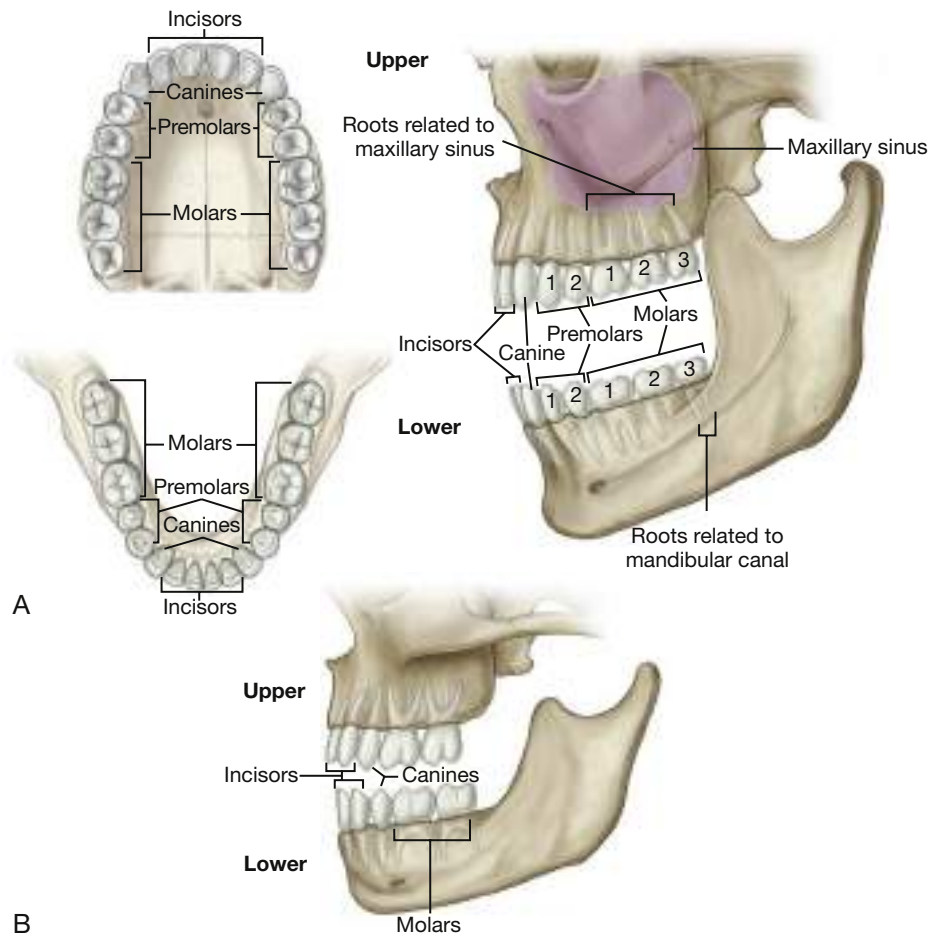


Fig. 8.255 Teeth. **A.** Adult upper and lower permanent teeth. **B.** Deciduous ("baby") teeth.

teeth erupt posterior to the deciduous molars and require the jaws to elongate forward to accommodate them.

Vessels

Arteries

All teeth are supplied by vessels that branch either directly or indirectly from the maxillary artery (Fig. 8.256).

Inferior alveolar artery

All lower teeth are supplied by the **inferior alveolar artery** (Fig. 8.256), which originates from the maxillary artery in the infratemporal fossa. The vessel enters the mandibular canal of the mandible, passes anteriorly in bone supplying vessels to the more posterior teeth, and divides opposite the first premolar into **incisor** and **mental branches**. The mental branch leaves the mental foramen to supply the chin, while the incisor branch continues in bone to supply the anterior teeth and adjacent structures.

Anterior and posterior superior alveolar arteries

All upper teeth are supplied by anterior and posterior superior alveolar arteries (Fig. 8.256).

The **posterior superior alveolar artery** originates from the maxillary artery just after the maxillary artery enters the pterygopalatine fossa and it leaves the fossa through the pterygomaxillary fissure. It descends on the posterolateral surface of the maxilla, branches, and enters small canals in the bone to supply the molar and premolar teeth.

The **anterior superior alveolar artery** originates from the infra-orbital artery, which arises from the maxillary artery in the pterygopalatine fossa. The infra-orbital artery leaves the pterygopalatine fossa through the inferior orbital fissure and enters the inferior orbital groove and canal in the floor of the orbit. The anterior superior alveolar artery originates from the infra-orbital artery in the infra-orbital canal. It passes through bone and branches to supply the incisor and canine teeth.

Gingival supply

The gingivae are supplied by multiple vessels and the source depends on which side of each tooth the gingiva is—the side facing the oral vestibule or cheek (vestibular or buccal side) or the side facing the tongue or palate (lingual or palatal side):

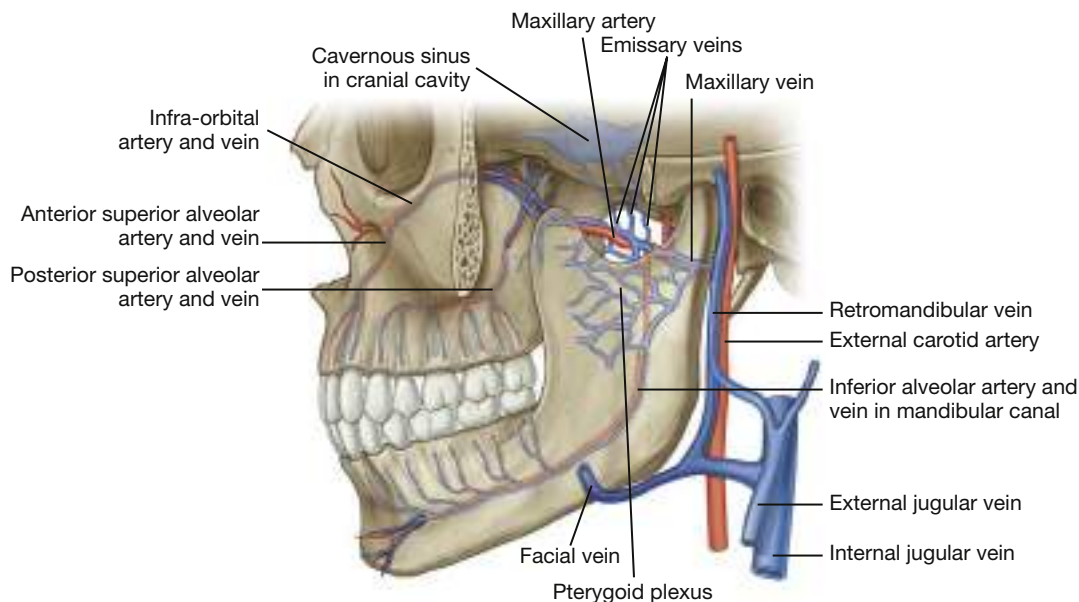


Fig. 8.256 Arteries and veins of the teeth.

- Buccal gingiva of the lower teeth is supplied by branches from the inferior alveolar artery, whereas the lingual side is supplied by branches from the lingual artery of the tongue.
- Buccal gingiva of the upper teeth is supplied by branches of the anterior and posterior superior alveolar arteries.
- Palatal gingiva of the upper teeth is supplied by branches from the nasopalatine (incisor and canine teeth) and greater palatine (premolar and molar teeth) arteries.

Veins

Veins from the upper and lower teeth generally follow the arteries (Fig. 8.256).

Inferior alveolar veins from the lower teeth and superior alveolar veins from the upper teeth drain mainly into the pterygoid plexus of veins in the infratemporal fossa, although some drainage from the anterior teeth may be via tributaries of the facial vein.

The pterygoid plexus drains mainly into the maxillary vein and ultimately into the retromandibular vein and jugular system of veins. In addition, small communicating vessels pass superiorly, from the plexus, and pass through small emissary foramina in the base of the skull to connect with the cavernous sinus in the cranial cavity. Infection originating in the teeth can track into the cranial cavity through these small emissary veins.

Venous drainage from the teeth can also be via vessels that pass through the mental foramen to connect with the facial vein.

Veins from the gingivae also follow the arteries and ultimately drain into the facial vein or into the pterygoid plexus of veins.

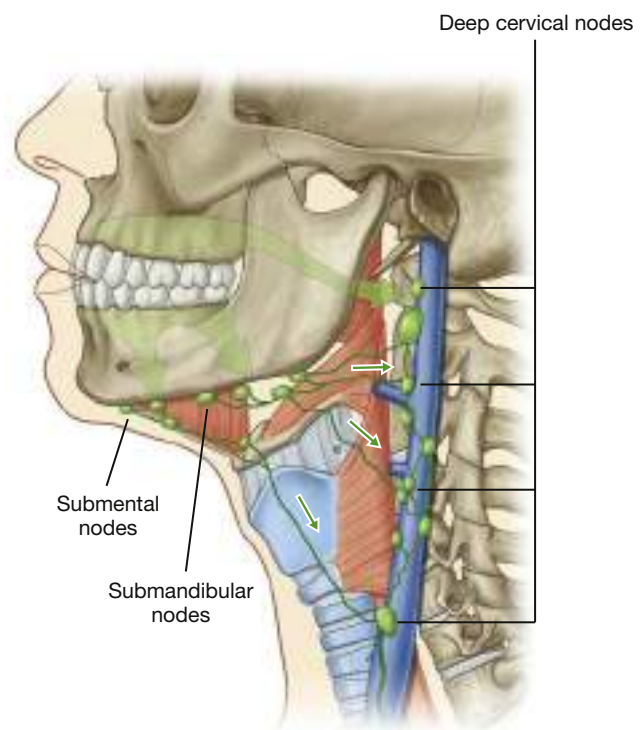


Fig. 8.257 Lymphatic drainage of the teeth and gums.

Lymphatics

Lymphatic vessels from the teeth and gingivae drain mainly into submandibular, submental, and deep cervical nodes (Fig. 8.257).

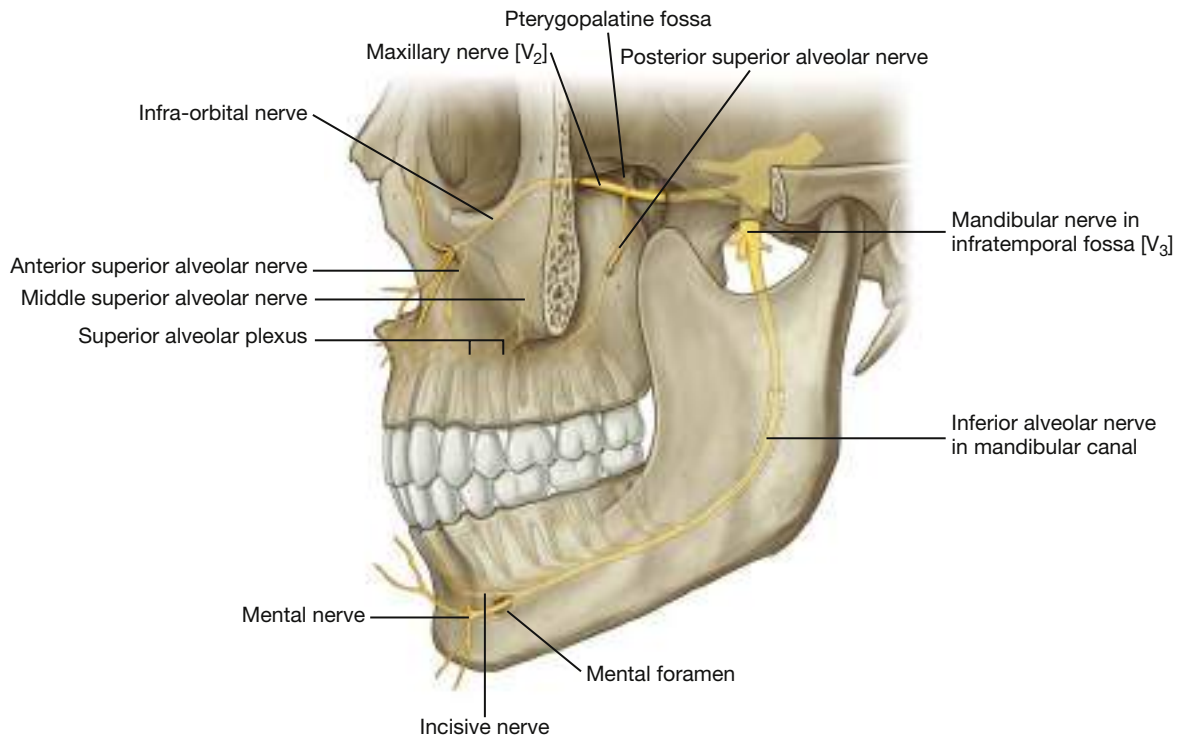


Fig. 8.258 Innervation of the teeth.

Innervation

All nerves that innervate the teeth and gingivae are branches of the trigeminal nerve [V] (Figs. 8.258, 8.259).

Inferior alveolar nerve

The lower teeth are all innervated by branches from the inferior alveolar nerve, which originates in the infratemporal fossa from the mandibular nerve [V₃] (Figs. 8.258, 8.259). The inferior alveolar nerve and its accompanying vessels enter the mandibular foramen on the medial surface of the ramus of mandible and travel anteriorly through the bone in the mandibular canal. Branches to the back teeth originate directly from the inferior alveolar nerve.

Adjacent to the first premolar tooth, the inferior alveolar nerve divides into incisive and mental branches:

- The **incisive branch** innervates the first premolar, the canine, and the incisor teeth, together with the associated vestibular (buccal) gingiva.
- The **mental nerve** exits the mandible through the mental foramen and innervates the chin and lower lip.

Anterior, middle, and posterior superior alveolar nerves

All upper teeth are innervated by the anterior, middle, and posterior superior alveolar nerves, which originate directly

or indirectly from the maxillary nerve [V₂] (Figs. 8.258, 8.259).

The posterior superior alveolar nerve originates directly from the maxillary nerve [V₂] in the pterygopalatine fossa, exits the pterygopalatine fossa through the pterygomaxillary fissure, and descends on the posterolateral surface of the maxilla. It enters the maxilla through a small foramen approximately midway between the pterygomaxillary fissure and the last molar tooth and passes through the bone in the wall of the maxillary sinus. The posterior superior alveolar nerve then innervates the molar teeth through the superior alveolar plexus formed by the posterior, middle, and anterior alveolar nerves.

The middle and anterior superior alveolar nerves originate from the infra-orbital branch of the maxillary nerve [V₂] in the floor of the orbit:

- The middle superior alveolar nerve arises from the infra-orbital nerve in the infra-orbital groove, passes through the bone in the lateral wall of the maxillary sinus, and innervates the premolar teeth via the superior alveolar plexus.
- The anterior superior alveolar nerve originates from the infra-orbital nerve in the infra-orbital canal, passes through the maxilla in the anterior wall of the maxillary sinus, and, via the superior alveolar plexus, supplies the canine and incisor teeth.

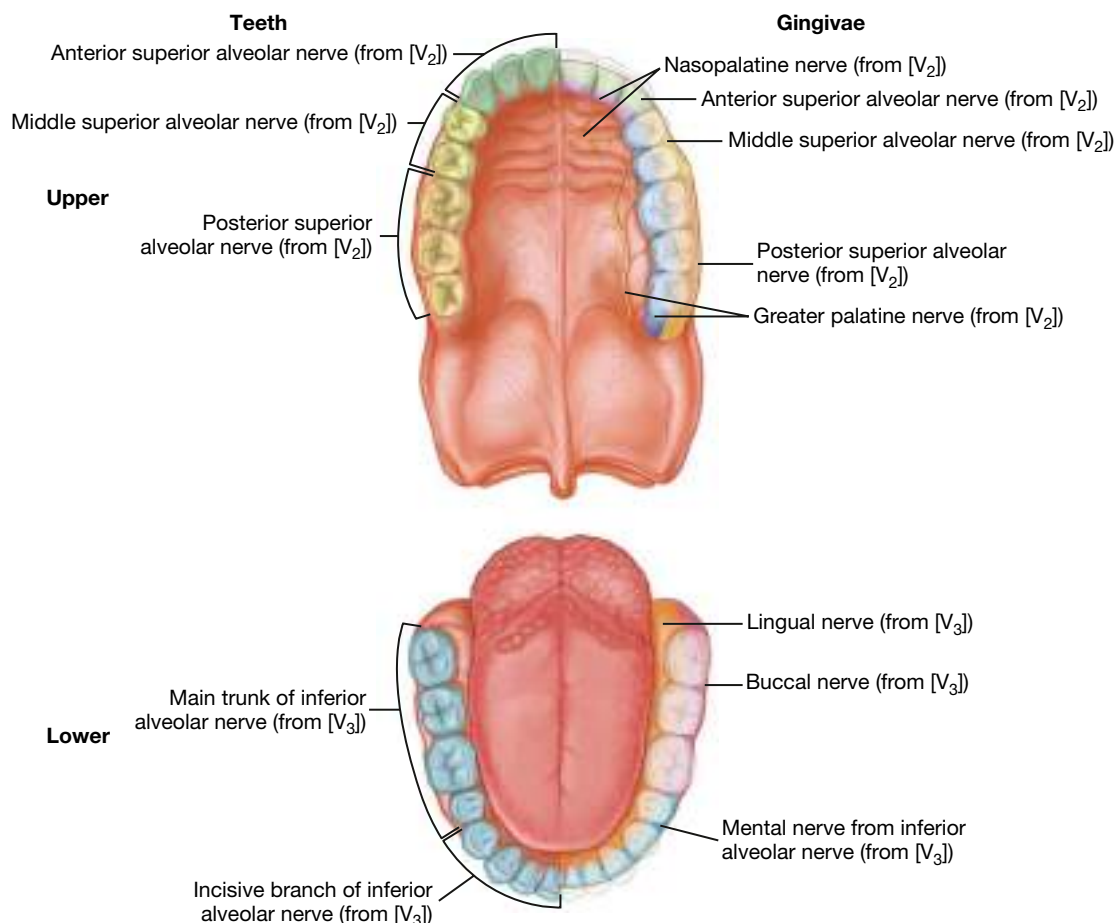


Fig. 8.259 Innervation of the teeth and gums.

Innervation of gingivae

Like the teeth, the gingivae are innervated by nerves that ultimately originate from the trigeminal nerve [V] (Fig. 8.259):

- Gingiva associated with the upper teeth is innervated by branches derived from the maxillary nerve [V₂].
- Gingiva associated with the lower teeth is innervated by branches of the mandibular nerve [V₃].

The gingiva on the buccal side of the upper teeth is innervated by the anterior, middle, and superior alveolar nerves, which also innervate the adjacent teeth. Gingiva on the palatal (lingual) side of the same teeth is innervated by the nasopalatine and the greater palatine nerves:

- The nasopalatine nerve innervates gingiva associated with the incisor and canine teeth.
- The greater palatine nerve supplies gingiva associated with the remaining teeth.

The gingiva associated with the buccal side of the mandibular incisor, canine, and premolar teeth is innervated by the mental branch of the inferior alveolar nerve. Gingiva on the buccal side of the mandibular molar teeth is innervated by the buccal nerve, which originates in the infratemporal fossa from the mandibular nerve [V₃]. Gingiva adjacent to the lingual surface of all lower teeth is innervated by the lingual nerve.

Surface anatomy

Pulse points

Arterial pulses can be felt at four locations in the head and neck (Fig. 8.260).

- Carotid pulse—the common or external carotid artery can be palpated in the anterior triangle of the neck. This is one of the strongest pulses in the body. The pulse can be obtained by palpating either the common carotid artery posterolateral to the larynx or the external carotid artery immediately lateral to the pharynx midway between the superior margin of the thyroid cartilage below and the greater horn of the hyoid bone above.
- Facial pulse—the facial artery can be palpated as it crosses the inferior border of the mandible immediately adjacent to the anterior margin of masseter muscle.
- Temporal pulse—the superficial temporal artery can be palpated anterior to the ear and immediately posterosuperior to the position of the temporomandibular joint.
- Temporal pulse—the anterior branch of the superficial temporal artery can be palpated posterior to the zygomatic process of the frontal bone as it passes lateral to the temporal fascia and into anterolateral regions of the scalp. In some individuals pulsations of the superficial temporal artery can be seen through the skin.

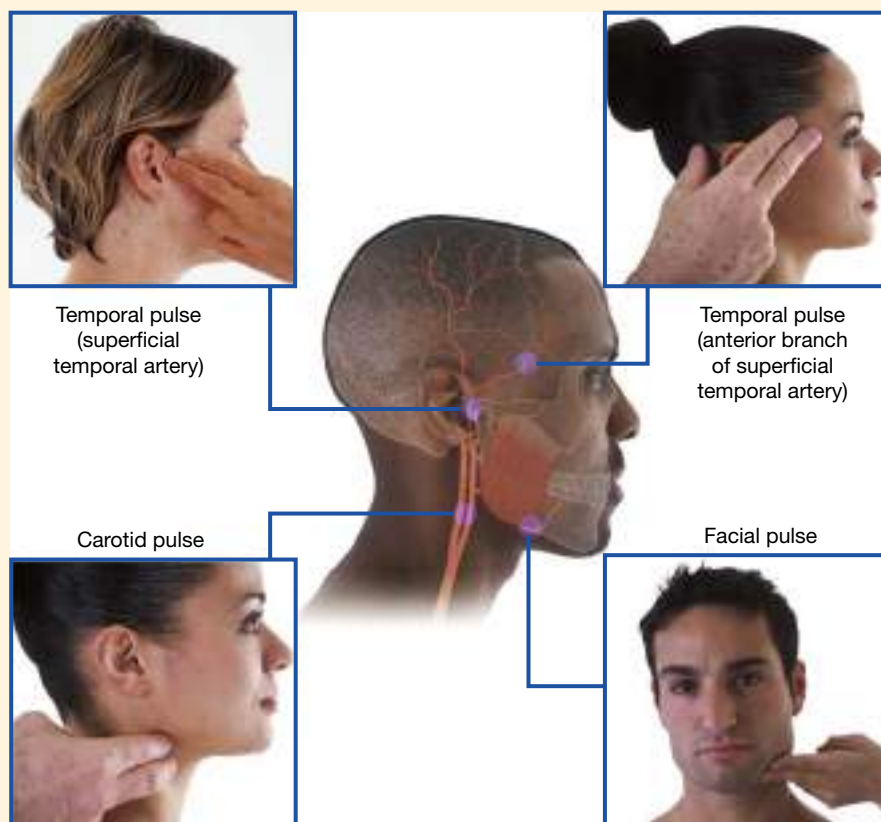


Fig. 8.260 Where to take arterial pulses in the head and neck.

Index

Page numbers followed by “*f*” indicate figures, “*t*” indicate tables, and “*b*” indicate boxes.

A

- Abdomen, 145–222
 - groin of, 156–160
 - posterior abdominal region of, 201–222, 201f
 - regional anatomy of, 146–222, 146f
 - surface topography of, 146–147
 - sympathetic innervation of, 28–29, 29f
- Abdominal aorta
 - anterior branches of, 187–193, 188f
 - branches of, 213t
 - posterior branches of, 213
 - visceral branches of, 213
- Abdominal aortic plexus, 217
- Abdominal esophagus, 167–168, 168f
- Abdominal prevertebral plexus, 198–199, 199f
- Abdominal radiograph, image interpretation, 8
- Abdominal viscera, 163–201
 - innervation of, 196–201
 - lymphatics of, 196
 - organs of, 167–187
 - peritoneal cavity of, 164–167
 - peritoneum of, 163–164, 163f, 164b
 - venous drainage of, 193–196
- Abdominal wall, 147–155
 - anterolateral muscles of, 149–152, 150t
 - arterial supply and venous drainage of, 155, 155f–156f
 - extraperitoneal fascia of, 152–153, 153f
 - innervation of, 153–155, 154f
 - layers of, 148f, 153f
 - lymphatic drainage of, 155, 155f
 - peritoneum of, 153
 - posterior, 201–205, 201f
 - bones of, 201–205
 - diaphragm of, 202–205, 203f–204f
 - muscles of, 202, 202f, 203t
 - ribs of, 202
 - superficial fascia of, 148–149, 148f–149f
- Abdominopelvic cavity hernias, 163b
- Abducent nerve, 477f, 479, 516
- Abduction
 - of thumb, 421b–422b
 - of ulna during pronation, 413–414, 413f
- Abductor digiti minimi, 355, 356t
- Abductor hallucis, 355, 356t
- Abscesses, in ischio-anal fossae, 265b
- Accessory hemiazygos vein, 139
- Accessory meningeal artery, 463, 549
- Accessory nerves (XI), 480–484, 566–567, 575–576
 - cranial root of, 480–484
 - in neck, 567f
 - posterior triangle of, 575f
- Acetabular labrum, 293, 293f–294f
- Acetabulum, 224f, 225, 288–290, 290f
- Achilles tendon, 342
 - rupture of, 343b
- Acromioclavicular joint, 373, 374f, 374b
 - right, 374b
- Adductor canal, 302
- Adductor hallucis, 357, 358t
- Adductor hiatus, 316, 316f, 337f
- Adductor magnus, 316, 316f
- Adductor pollicis, 432f
- Adductor tubercle, 310
- Adrenals, sympathetic innervation of, 28–29
- Ala, 226–227, 227f
- Alar cartilages, 607
- Alar fold, 324
- Alar ligaments, 38
- Allen's test, 435b
- Alveolar nerves, 637
- Alveolar processes, 447, 452
- Ampulla, 246, 246f, 531
- Anal canal, 176, 177f, 237, 238f
- Anal columns, 237, 238f
- Anal sinus, 237, 238f
- Anal triangle, 265, 265f, 265t
- Anal valves, 237, 238f
- Anastomoses
 - around knee, 329f
 - arterial, around shoulder, 381f
 - of gluteal artery, 308f
 - portosystemic, 195b
- Anatomical position, of head and major landmarks, 450b
- Anatomical snuffbox, 421b–422b, 428–429, 428f
- Anatomy, 2–3
 - terms relating to
 - location, 3
 - planes, 2–3, 2f
 - position, 2
 - trans/non-binary terms related, 3
- Anesthesia
 - of inferior alveolar nerve, 546b
 - puddendal block, 254b
- Aneurysm
 - abdominal aortic, 213b–214b
 - intracerebral, 468b
- Angiography
 - digital subtraction, 4–5, 5f
 - magnetic resonance, normal carotid and vertebral arteries, 468b
- Angular incisure, 169
- Ankle joint, 344–346, 345f
 - bracket-shaped socket, 344–345
 - dorsiflexion and plantarflexion, 288f
 - intertarsal, 346f
- Ankle joint (*Continued*)
 - lateral ligament, 346, 346f
 - medial ligament, 345–346, 345f
- Anular pancreas, 184b
- Anococcygeal ligament (anococcygeal body), 233f, 234
- Anococcygeal nerves, 251f, 254–255
- Ansa cervicalis, 568, 568f
- Anterior arch, atlas and axis, 38
- Anterior cardiac veins, 120
- Anterior chamber, of eyeball, 519–520
- Anterior circumflex humeral artery, 388, 388f
- Anterior compartment
 - of forearm
 - arteries and veins, 414–417, 416f
 - muscles, 414
 - nerves, 417–418
 - of leg, 338–340
 - arteries in, 338–340
 - muscles in, 338, 339f, 339t
 - nerves in, 340
 - veins in, 340
 - of thigh, 313–315, 314f, 315t
- Anterior cranial fossa, 455–457, 456f, 456t
- Anterior cutaneous branches, 81
- Anterior (ventral), describing anatomical location, 2f, 3
- Anterior divisions, of brachial plexus, 390
- Anterior drawer test, 328b
- Anterior inferior iliac spine, 224f–225f, 225–226
- Anterior intercostal arteries, 79–80, 80f
- Anterior interosseous artery, 419, 420f
- Anterior interventricular branch, 118
- Anterior interventricular sulci, 106
- Anterior interventricular vein, 120
- Anterior jugular veins, 561
- Anterior median fissure, 55, 55f
- Anterior mediastinum, 102
- Anterior papillary muscle, 111
- Anterior rami, 59
- Anterior root, of spinal nerves, 59
- Anterior sacro-iliac ligament, 228, 228f
- Anterior spinal artery, 56, 467
- Anterior superior alveolar artery, 635
- Anterior superior iliac spine, 224f–225f, 225–226
- Anterior surface, of heart, 105, 107f
- Anterior talofibular ligament, 346
- Anterior tibial artery, 335, 336f, 339f
- Anterior triangle, of neck, 557, 558f, 558b, 561–571
- Anterior trunk, of internal iliac artery, 258–260, 259f
- Anterior tympanic artery, 549
- Anterior vagal trunk, 137, 167

- Anterior view, of skull, 446–448, 447f
 - frontal bone, 446
 - mandible, 447–448
 - maxillae, 447
 - zygomatic and nasal bones, 446
- Anterior wall
 - of axilla, 382–383
 - of infratemporal fossa, 541
 - of middle ear, 526–527
- Anterolateral muscles, of abdominal wall, 149–152, 150t
- Anulus fibrosus, 43
- Aorta
 - abdominal, 187–193, 188f, 212–213, 212f
 - arch and branches of, 130–131
 - anomalies in, 132b
 - coarctation of, 131b
 - traumatic injury to, 131b
- Aortic dissection, 132b
- Aortic plexus, 199
- Aortic valve, 114, 115f
- Aortic valve disease, 116b
- Apertures
 - in pelvic wall, 230–232, 232f
 - piriform, 446
- Apex
 - of the bladder, 237, 239f
 - of heart, 105, 107f
 - of sacrum, 40
 - of tongue, 621
- Aponeurosis
 - external oblique muscle and, 150f
 - internal oblique muscle and, 151f
 - palatine, 631f
 - palmar, 427–428, 428f
 - plantar, 353, 354f
 - transversus abdominis muscle and, 151f
- Aponeurotic layers, of scalp, 496–498
- Appendicitis, 175b
- Appendicular group, of back muscles, 48, 49t
- Appendicular skeleton, 9, 9f
- Appendix, 174, 174f
- Aqueous humor, 520
- Arachnoid mater, 21, 465
- Arachnoid trabeculae, 57
- Arches
 - of foot, 352–353, 353f
 - superciliary, 446
- Arcuate eminence, 458
- Arcuate ligament, 203–204
- Arcuate line, 152, 225f, 226
- Areola, 64
- Arm
 - arteries and veins, 403–404, 404f
 - bones, 398–401
 - medial cutaneous nerve of, 393f, 394–395
 - muscles, 401
 - nerves, 401–403
- Arterial supply
 - of abdominal esophagus, 168f
 - of abdominal wall, 155, 155f
 - of auricle, 523
 - of brain, 467, 467f
 - of breast, 65–66
 - of cecum and appendix, 175, 175f
 - of colon, 177f
 - of cranial dura mater, 463–464, 464f
- Arterial supply (*Continued*)
 - of diaphragm, 83
 - of duodenum, 170, 171f
 - of esophagus, 136
 - of eyeball, 514f, 520
 - of eyelids, 504
 - of face, 492
 - of gastrointestinal tract, 187–193
 - of hand, 433f
 - to ileum and jejunum, 170, 171f
 - of intercostal spaces, 77f, 78–80
 - of internal ear, 534
 - of liver and gallbladder, 182f
 - of nasal cavities, 613–614, 614f
 - of pancreas, 184, 185f
 - of parotid glands, 489
 - of pharynx, 590–591, 591f
 - of rectum and anal canal, 177f
 - of scalp, 499
 - of small intestine, 171f
 - of spleen, 187f
 - of suprarenal glands, 211f
 - of teeth and gingivae, 635–636
 - of thyroid gland, 569–570
- Arteria radicularis magna, 56–57
- Arteries, 16
 - of anterior compartment of leg, 338–340
 - associated with posterior scapular region, 380f
 - of foot, 357–359, 357f
 - of gluteal region, 308, 308f
 - of hip, 297–298
 - of larynx, 602, 603f
 - of lateral compartment of leg, 337, 338f
 - of lower limb, 298f
 - of palate, 631, 632f
 - palatine, 632f
 - of pelvis, 258–260, 258f–259f
 - of perineum, 272–274, 273f
 - of posterior compartment of leg, 335–336, 336f
 - of posterior triangle of the neck, 575f
 - of pterygoid canal, 557
 - of spinal cord, 56–57, 56f
 - of temporal fossa, 542f
 - of thigh, 317–320
 - of tongue, 624–625, 625f
- Artery of Adamkiewicz, 56–57, 56f
- Arthroscopy, 328b
- Articular discs, 12
- Articular facets, superior and inferior, 38
- Articular processes, superior and inferior, 38
- Articular surfaces
 - of carpal bones, 424
 - of glenohumeral joint, 373, 374f
 - of knee joint, 323, 324f
 - of talus, 341
- Aryepiglottic folds, 598
- Arytenoid cartilage, 594–595, 595f
- Ascending aorta, 125–126, 126f
- Ascending lumbar veins, 215
- Ascending palatine artery, 631
- Ascending part of duodenum, 169
- Ascending pharyngeal artery, 528, 565, 565t
- Atheromatous plaques, 468b
- Atherosclerosis, 17b
- Atlanto-occipital joint, 38
- Atlas (C1 vertebra), 38, 39f–40f
 - articulation between axis and, 40b
 - transverse ligament of, 38
- Atrial septal defect (ASD), 117b
- Atrioventricular bundle, 122–123, 122f
- Atrioventricular node, 121–122, 122f
- Atrium proper, 110
- Atrophy, muscle, 16b
- Auditory ossicles, 528–529, 529f
 - muscles associated with, 530f
- Auricle, 522–524, 523f
 - innervation, 522–523
 - muscles, 522–524, 523f
 - sensory innervation of, 524f
 - vessels, 523–524
- Auriculotemporal nerve, 489, 498, 544–546
- Avascular necrosis, 11b
- Axial plane
 - female pelvic cavity and perineum in, 282b
 - male pelvic cavity and perineum in, 276b
- Axial skeleton, 9, 9f
- Axilla
 - anterior wall, 382–383
 - axillary inlet, 382, 382f
 - contents of
 - axillary artery, 386–389
 - axillary vein, 389
 - brachial plexus, 389–396
 - lymphatics, 396–397, 397f
 - floor of, 386f
 - lateral wall of, 384, 385f, 385t
 - medial wall of, 383, 384f, 384t
 - posterior wall of, 384–386, 385f, 385t
 - gateways in, 386
- Axillary artery, 386–389, 387f
- Axillary inlet, 382, 382f
- Axillary nerve, 381, 396
- Axillary nodes, 66, 155
- Axillary process, of breast, 65b
- Axillary vein, 389, 389f
- Axis
 - CII vertebra, 38, 39f–40f
 - of eyeball and orbit, 511, 511f
- Azygos system, of veins, in posterior mediastinum, 137–139, 139f
- Azygos vein, 138

B

- Back, 35–62
- Back pain, 45b
- Balance, organs of, 533
- Ball-and-socket joints, 12, 13f
- Barium sulfate
 - follow-through, 4f
 - suspension, 4
- Bartholin's glands, 267b–268b
- Base
 - of bladder, 237–238, 239f
 - of brain, arteries on, 469f
 - of cochlea, 531–532
 - of heart, 105, 106f
 - of skull
 - anterior part, 452
 - middle part, 452
 - posterior part, 454

- Basilar artery, 467
 - Basilic vein, 404, 435
 - Bell's palsy, 496b
 - Benign prostatic hypertrophy, 244b
 - Biceps brachii, 387t, 401t
 - Bicondylar joints, 12
 - Bile, duct system, 185–186, 185f
 - Biopsy, bone marrow, 226b
 - Bladder, 237–239, 239f
 - cancer, 239b
 - infection, 241b
 - Bladder stones, 240b
 - Block, pudendal, 254b
 - Blood pressure measurement, 409b–410b
 - Blood supply
 - of diaphragm, 205
 - of hip joint, 295, 295f
 - Blood vessels, 16
 - of anterior abdominal region, 215b
 - of pelvis, 258–262
 - of perineum, 272–274
 - Body, 1–34
 - of clitoris, 265f, 266
 - of epididymis, 242f, 243
 - of penis, 265f, 266
 - of pubis, 225f, 226
 - of sphenoid, 453
 - of stomach, 168
 - systems of, 9–33
 - Bone marrow
 - biopsy, 226b
 - transplants, 10b
 - Bones, 9–10
 - of arm, 398–401
 - classification of, 9
 - of foot, 340–344, 340f–341f, 344b
 - fractures of, 11b
 - function, 9
 - of hand, 423–425, 423f
 - innervation of, 10
 - of lower limb, 287f
 - of orbit, 501f
 - palatine, 618–619
 - of pelvis, 224–227
 - of shoulder, 370–372
 - of thigh, 309–313
 - of wrist, 423f
 - Bony labyrinth, 531–532, 531f
 - cochlea, 531–532, 532f
 - semicircular canals, 531
 - Bony orbit, 501–502, 508f
 - floor, 502
 - lateral wall, 502
 - medial wall, 501–502
 - roof, 501
 - Bony pelvis, 287–290, 289f
 - acetabulum, 288–290, 290f
 - ilium, 287
 - ischial tuberosity, 287, 289f
 - ischiopubic ramus and pubic bone, 288
 - Borders
 - of anterior triangle of neck, 561f
 - of heart, 106
 - of infratemporal fossa, 542f
 - of perineum, 263–264, 263f
 - of posterior triangle of neck, 573f
 - Boundaries
 - of femoral triangle, 302f
 - of middle ear, 526–528, 527f
 - of perineum, 263f
 - of popliteal fossa, 330f
 - of posterior cranial fossa, 458
 - Bowel lumen, 172b
 - Bowel obstruction, 178b
 - Brachial artery, 403–404, 403f–404f, 404b
 - Brachialis, 401t
 - Brachial plexus, 577
 - branches, 389–396, 390f, 391t–392t, 393f–396f
 - cords, 390, 390f
 - divisions, 390
 - injuries to, 397b
 - roots, 389–390
 - trunks, 390
 - Brachiocephalic trunk, 131
 - Brain, 466–467
 - blood supply, 467–468, 467f
 - lateral view of, 466f
 - MRI in coronal plane, 7f
 - parts of, 20
 - sagittal section of, 467f
 - venous drainage, 469–472
 - Branches
 - of anterior trunk of internal iliac artery, 258f
 - axillary artery of, 388f
 - brachial artery, 403f, 404
 - brachial plexus
 - lateral cord, 394
 - medial cord, 394–396
 - posterior cord, 396
 - roots, 390–393
 - trunks, 393–394
 - external carotid artery, 499, 565t
 - facial nerve, 491
 - of lumbosacral plexus, 297f, 300t
 - mandibular nerve, 543–546
 - maxillary nerve, 553–554
 - nasociliary nerve, 517
 - of ophthalmic artery, 495, 499
 - ophthalmic nerve, 615–616
 - perforating, 435
 - of posterior trunk of internal iliac artery, 258f
 - radial artery, 415
 - of sacral and coccygeal plexuses, 252t–253t
 - subclavian artery, 573
 - costocervical trunk, 579
 - internal thoracic artery, 579
 - thyrocervical trunk, 579
 - ulnar nerve, 436f
 - vertebral artery, 578
 - ulnar artery, 415–417
 - Breast, 64–66, 65f
 - arterial supply of, 65–66
 - axillary process of, 65b, 397f
 - innervation of, 66
 - lymphatic drainage of, 66
 - in men, 66
 - suspensory ligaments of, 64–65
 - venous drainage of, 66
 - in women, 67b
 - Breast cancer, 66b
 - Bregma, 452
 - Broad ligament, 249–250, 249f
 - Bronchial arteries, 96f, 97
 - Bronchial tree, 90–94, 94f
 - Bronchial veins, 96f, 97
 - Bronchomediastinal trunks, 80
 - Bronchopulmonary segments, 94–95, 95f
 - Bronchoscopy, 98b–99b
 - Buccal artery, 494
 - Buccal nerve, 491, 544
 - Buccinator, 484, 485t–486t, 488f, 621f, 621t
 - Buccopharyngeal fascia, 587
 - Bulb
 - of penis, 266
 - artery of, 273, 273f
 - of vestibule, 265f, 266, 267b–268b
 - arteries to, 273
 - Bulbourethral glands, 242f, 244
 - Bunions, 350b
 - Bursa
 - of glenohumeral joint, 374, 375f
 - suprapatellar, 324
- ## C
- Calcaneocuboid joint, 349–350
 - Calcaneofibular ligament, 346
 - Calcaneus, 342–343, 343f
 - Calculi, in bladder, 240b
 - Calvaria, 446, 452f
 - lateral portion of, 448–449
 - Camper's fascia, 148, 148f
 - Cancer
 - affecting recurrent laryngeal nerve, 580b
 - bladder, 239b
 - breast, lymphatic drainage and, 398b
 - esophageal, 137b
 - oral, 617b
 - ovarian, 245b
 - pancreatic, 185b
 - urinary tract, 210b
 - vertebrae and, 44b
 - Canine teeth, 634
 - Capitate, 424
 - Capitulum of humerus, 399
 - Carcinoma
 - of the cervix and uterus, 247b
 - of colon and rectum, 237b
 - of stomach, 172b–173b
 - Cardia, of stomach, 168
 - Cardiac auscultation, 117b
 - Cardiac chambers, 106–114, 109f
 - aortic valve, 114, 115f
 - left atrium, 113, 114f
 - left ventricle, 113–114, 115f
 - mitral valve, 114
 - pulmonary valve, 113, 113f
 - right atrium, 109–111, 111f
 - right ventricle, 111–112, 112f
 - tricuspid valve, 112–113
 - visualizing, 110b
 - Cardiac conduction system, 120–123, 121b, 122f
 - atrioventricular bundle in, 122–123
 - atrioventricular node in, 121–122
 - sino-atrial node in, 121

- Cardiac innervation, 123–124, 123f
 - parasympathetic, 124
 - sympathetic, 124
 - visceral afferents, 124
- Cardiac muscle, 16
- Cardiac orientation, 105–106, 105f
 - base and apex, 105, 106f
 - external sulci, 106
 - margins and borders, 106
 - surfaces, 105, 107f–108f
- Cardiac skeleton, 117, 118f
- Cardiac veins, 120, 121f
- Cardiac notch, 169
- Cardiovascular system, 16–17
- Carotid arteries, 468b
 - branches, 488, 499
 - carotid system, 563–564
- Carotid pulse, 639b
- Carotid sheath, of neck fascia, 559
- Carotid system, 563–565, 564f
- Carotid triangle, 561
- Carpal bones, 423–424
 - articular surface, 424
 - carpal arch, 424
 - distal row, 423–424
 - proximal row, 423
- Carpal joints, 425
- Carpal tunnel, and structures at wrist, 427f
- Carpal tunnel syndrome, 428b
- Carpometacarpal joints, 425–426
- Cartilage, 9
 - function of, 9
 - laryngeal, 593–595
 - types of, 9
- Cartilaginous joints, 13, 14f
- Cataracts, 520b
- Catheterization
 - of femoral artery, 303b
 - suprapubic, 240b
 - urethral, 241b
- Cathode ray tube, 3, 4f
- Cauda equina, 59, 60f
- Caudal, describing anatomical location, 3
- Caudate lobe, of liver, 181
- Cavernous nerves, 255, 256f–257f
- Cavernous sinuses, 471, 471f
- Cavity
 - cranial, 454–459
 - of larynx, 598–600, 599f
- Cecum, 174, 174f
- Ceiling of perineum, 263–264, 263f
- Celiac plexus, 198–199, 217
- Celiac trunk, 188–190, 189f
- Central canal, 55f, 56
- Central nervous system (CNS), 20–21, 20f
 - subdivisions of, 21–32
- Central retinal artery, 513–514, 520
- Central venous access
 - in neck, 561f, 561b
 - via subclavian/axillary vein, 389b
- Cephalic vein, 404, 408f, 435
- Cerebellum, 20
- Cerebral arterial circle, 467
- Cerebrospinal fluid
 - leakage, 466b
 - lumbar tap, 59b–60b
 - returns to the venous system, 466
- Cerebrum, 466
- Cervical enlargement, 55
- Cervical lymph nodes
 - deep, 583–584
 - superficial, 583
- Cervical part, of sympathetic trunk, 581, 581f
- Cervical pleura, 85
- Cervical plexus, 576–577, 576f
 - cutaneous branches, 576–577
 - muscular branches, 576
- Cervical ribs, 72b
- Cervical vertebrae, 36, 36f, 36b, 38
 - atlas and axis, 38
 - typical, 36b
 - variations in number of, 44b
- Cervical viscera, sympathetic innervation of, 28, 28f
- Cervix, 246–247, 247f, 267b–268b
- Chalazion, 504
- Chambers, of eyeball, 519–520
- Check ligaments, 510, 510f
- Cheek, 620
- Chest
 - flail, 72b
 - surgical access to, 82b
- Chest radiograph, image interpret, 7
- Chest tube insertion, 82b
- Choanae, 611, 612f
- Cholecystectomy, 186b
- Cholecystitis, 186b
- Chorda tympani, 547, 548f, 629
 - nerve to, 534
 - parasympathetic fibers, course of, 628f
 - in temporal bone, 535f
- Choroid, 520–521
- Chronic leg ischemia, 320b
- Chyle, 18
- Chylomicrons, 18
- Ciliary arteries, 520
- Ciliary body, 521, 521f
- Ciliary ganglion, 518–519, 518f
- Ciliary muscle, 521, 522t
- Ciliary processes, 521
- Circumflex branch, 118
- Circumflex fibular artery, 336, 336f
- Circumflex iliac artery, 155
- Circumflex scapular artery, 381
- Cirrhosis, hepatic, 195b
- Cisterna chyli, 139
- Clavicle, 370
 - fractures of, 376b–377b
 - right, 370f
- Clavipectoral fascia, 66, 68f, 382, 383f
- “Clawing,” of hand, 436b–437b
- Clitoris, 265f, 266
 - deep dorsal vein of, 274
 - dorsal nerve of, 271
 - erectile tissues of, 265f
 - glans, 266
- CNS. *See* Central nervous system (CNS)
- Coccygeal plexus, 250f–251f, 252t–253t, 254–255
- Coccygeus muscles, 232
- Coccygeus, nerves to, 251f
- Coccyx, 36f, 37, 39f–40f, 40, 227, 227f
- Cochlea, 527, 530–532, 532f
- Colic flexure, 176, 177f
- Collateral ligaments, of knee joint, 326–327, 326f
- Colles’ fascia, 149, 149f, 270
- Colon, 176, 176f
 - rectum and, carcinoma of, 237b
- Colonoscopy, of gastrointestinal tract, 179b
- Columns, anal, 237, 238f
- Common carotid arteries, 563–564, 564f
- Common fibular nerve, 323, 329, 337f–338f
- Common fibular part, sciatic nerve to, 251f
- Common hepatic artery, 190, 190f
- Compact bone, 9
- Compartment syndrome, 317b
- Compound fractures, 461b
- Compressor urethrae, 235, 236f
- Computed tomography (CT), 5
 - abdominal, 6f
 - of head, 461b
 - high-resolution, in lung, 98b–99b
 - image interpretation, 8
 - in pulmonary trunk, 96b
 - scanner, 5, 6f
 - of urinary tract, 211b
- Concha, of auricle, 522
- Concussion, 472b
- Condylar (ellipsoid) joints, 12, 13f
- Condylar process, 451, 538
- Condyle
 - of humerus, 399, 399f
 - occipital, 38, 454
- Cones, 522
- Confluence of sinuses, 471
- Congenital heart defects, 117b
- Conjoint tendon, 157–158
- Conjunctiva, 504
- Connective tissue layer, of scalp, 496
- Constrictive pericarditis, 105b
- Constrictor muscles, of pharynx, 586, 586t, 587f
- Contrast agents, 4
 - urological, 8
- Conus medullaris, 55
- Cooper’s ligament, 150, 151f
- Coracobrachialis, 387t, 401t
- Cords of brachial plexus, 390, 390f
- Cornea, 521
- Corniculate cartilage, 595, 596f
- Cornua, 227, 227f
- Coronal planes, 2, 2f
 - computed tomography image of hip joint in, 296b
 - female pelvic cavity and perineum in, 281b
 - MRI of brain in, 7f
- Coronal suture, 448
- Coronary arteries, 117–120, 119f
 - clinical terminology for, 120b
- Coronary artery bypass grafts, 124b
- Coronary artery disease, 124b
- Coronary lymphatics, 120
- Coronary sulcus, 106, 109f
- Coronary vasculature, 117–120
 - cardiac veins, 120, 121f
 - coronary arteries, 117–120, 119f, 120b
 - coronary lymphatics, 120

- Coronoid fossa, 399
 Coronoid process, 451, 538
 Corpora cavernosa, 265f, 266
 Corpus spongiosum, 240, 265f, 266, 269b–270b
 Costal groove, 69
 Costal part, of parietal pleura, 85
 Costocervical trunk, 78, 579
 Costodiaphragmatic recesses, 87, 88f
 Costomediastinal recesses, 87, 88f
 Costotransverse joints, 73, 74f
 Costotransverse ligament, 73
 Costovertebral joints, 73, 74f
 Couinaud's segments, of liver, 182b
 Cranial cavity, 454–459
 floor, 455
 infections from pterygoid plexus spreading into, 550b
 roof, 455, 455f
 Cranial, describing anatomical location, 3
 Cranial dura mater, 462–465
 Cranial nerve preganglionic parasympathetic fibers, 30–31
 Cranial nerves, 475–484, 475t–476t, 477f
 abducent, 479
 accessory, 480–484
 facial, 479
 glossopharyngeal, 480
 hypoglossal, 484
 lesions, 481b
 mandibular, 479
 maxillary, 479
 oculomotor, 477–478, 478t
 olfactory, 475, 477f
 ophthalmic, 478
 optic, 475, 477f
 overview of, 481b
 test for, 631b
 Cremasteric arteries, 274
 Cremasteric reflex, 157, 161b
 Crest, of ribs, 69
 Cribriform plate, 456, 606, 611–612
 Crico-arytenoid joints, 598
 movements of, 598f
 Crico-arytenoid muscle, 601f
 Cricoid cartilage, 593–594, 593f
 Cricothyroid joint, 597–598
 Cricothyroid ligament, 596, 596f
 how to locate, 597f, 597b
 Cricothyroid muscle, 600–601, 600f
 Cricothyrotomy, 597b
 Cricotracheal ligament, 595
 Crista galli, 606
 Critical limb ischemia, 320b
 Cruciate ligaments, 327, 327f
 clinical tests for, 328b
 Crura, 266
 of clitoris, 266, 267b–268b
 of diaphragm, 203, 204f
 of penis, 266, 269b–270b
 Cubital fossa, 408–409, 408f–409f
 Cuboid, 343
 Cuneiform, 343, 595, 596f
 Curvatures, of vertebral column, 41, 43f
 Cutaneous branches, of cervical plexus, 576–577
- D**
- Dartos fascia, 149, 149f
 Deep artery
 of clitoris, 274
 of penis, 273, 273f
 of thigh, 317–320, 319f
 Deep auricular artery, 549
 Deep cervical artery, 579
 Deep cervical lymph nodes, 583–584
 Deep, describing anatomical location, 3
 Deep dorsal vein, 261
 Deep fascia, 15
 of hip, 300–301
 Deep fibular nerve, 339f, 340, 361–362, 361f
 Deep group of muscles
 in back, 51–53, 51f
 in posterior compartment of leg, 334–335, 335f, 335t
 Deep inguinal nodes, 275, 275f, 299
 Deep inguinal ring, 157, 157f
 Deep layer of forearm muscles
 anterior compartment, 414, 416f, 416t
 posterior compartment, 418, 420f, 420t
 Deep palmar arch, 434–435, 434f
 Deep perineal pouch (deep perineal space), 232, 234, 235f–236f, 235t, 263–264, 263f
 Deep petrosal nerve, 555
 Deep temporal arteries, 541
 Deep temporal nerves, 541, 544
 Deep transverse metacarpal ligaments, 425, 425f
 Deep transverse metatarsal ligaments, 350f, 351
 Deep transverse perineal muscle, 235, 236f
 Deep vein thrombosis, 215b, 298b
 Defecation, 234b
 Deltoid ligament, 345–346
 Deltoid muscle, 377, 378f
 Dens, 38, 39f–40f
 Dense connective tissue layer, of scalp, 496
 Denticulate ligament, 58
 Depressed skull fractures, 461b
 Depressor anguli oris, 484
 Depressor labii inferioris, 484
 De Quervain syndrome, 427b
 Dermatomes, 22–23, 22f, 23b
 anterior view, 23f
 of anterolateral abdominal wall, 154f
 in lower limb, 362b–363b
 in upper limb, 439b
 Dermatomyotomes, 21
 Dermis, 15
 Descending part, of duodenum, 169
 Developmental changes in elbow joint, 406b
 Deviated nasal septum, 606b
 Dialysis fistula, construction of, 409b
 Diaphragm, 81–84, 83f–84f, 202–205, 203f–204f
 arterial supply in, 83
 movement of, during breathing, 84
 pelvic, 233–234, 233f, 233t
 Diaphragma sellae, 463
 Diaphragmatic hernias, 205b
 Diaphragmatic nodes, 80
 Diaphragmatic part, of parietal pleura, 85
 Diaphragmatic surface, of heart, 105, 108f
 Diencephalon, 466–467
- Digastric muscle, 562
 Digital rectal examination, 237b
 Digital subtraction angiography, 4–5, 5f
 Dilator pupillae, 521
 Diploë, 452
 Discectomy, 48b
 Disease
 of joints, 46b
 peripheral vascular, 320b
 peritoneal spread of, 164b
 Dislocations
 acromioclavicular and sternoclavicular joints, 376b–377b
 anterior, of humeral head, 389b
 of glenohumeral joint, 377b
 Distal, describing anatomical location, 3
 Distal end
 of femur, 310, 310f
 of fibula, 332–333, 332f
 of humerus, 398–400
 of tibia, 331–332
 Distal group, of tarsal bones, 341f, 343
 Distal radioulnar joint, 412–414, 412f
 Distal row, of carpal bones, 423–424
 Distribution pattern, of facial nerve, 492
 Diverticular disease, 178b
 Domes, of diaphragm, 204
 Doppler ultrasound, 5
 Dorsal artery
 of clitoris, 274
 of penis, 273, 273f
 Dorsal digital nerves, 362
 Dorsal interossei, 358t, 431, 432f
 Dorsal lingual vein, 625
 Dorsal nasal artery, 495, 514
 Dorsal nerve, of penis and clitoris, 271
 Dorsal scapular nerve, 393, 393f
 Dorsal venous arch, of hand, 435f
 Dorsalis pedis artery, 358–359, 359f
 finding, 359b
 Dorsalis pedis pulse, 365b
 Double jointed, 426b
 Dry eye, 555b
 Ducts
 lymphatic, 19, 19f
 nasolacrimal, 505, 605f, 611
 parotid, 487
 submandibular, 627
 Ductus arteriosus, 117b, 131
 Ductus deferens, 242f, 243
 Duodenal ulceration, 172b
 Duodenojejunal flexure, 169
 Duodenum, 169–170, 170f
 Dura mater, 20
 cranial, 462–465
 spinal, 57, 57f
 Dural innervation, 464, 464f
 Dural partitions, 462–463, 463f
 Dural venous sinuses, 469–472, 469f, 470t
 and veins, 470f
- E**
- Ears, 522–535
 external, 522–525
 innervation of scalp
 anterior to, 498
 posterior to, 498

Ears (*Continued*)

- internal, 522, 530–535, 531f
- middle, 522, 526–530
- Ectopic parathyroid glands, 572b
 - in thymus, 127b
- Efferent ductules, 242–243, 242f
- Effort closure, of larynx, 601, 602f
- Ejaculatory duct, 242f, 243
- Elastic cartilage, 9
- Elbow joint, 405–406, 405f–406f, 406b–407b
- Emissary veins, 472b
- Endarterectomy, 468b
- Endolymphatic duct, 533
- Endopelvic fascia, 151
- Endoscopy, of gastrointestinal tract, 179b
- Endothoracic fascia, 15, 78
- Enteric system, 31–32, 31f, 200, 200f
- Epaxial muscles, 21
- Epicondyles, of humerus, 399
- Epicondylitis, 407b
- Epicranial aponeurosis, 496–497
- Epidermis, 15
- Epididymis, 242f, 243
- Epigastric artery, 155, 156f
- Epiglottis, 594, 595f
- Epiphyseal fractures, 11b
- Episiotomy, 236b
- Epistaxis, 614b
- Erectile tissues, 265f, 266–267
- Erection, 267
- Erector spinae muscles, 51, 52f, 52t
- Esophageal cancer, 137b
- Esophageal plexus, 136–137, 137f
- Esophageal rupture, 137b
- Esophagus, 568
 - abdominal, 167–168, 168f
 - constrictions in, 136b
 - in posterior mediastinum, 135–137, 135f
 - arterial supply in, 136
 - important structures of, relationship to, 135–136
 - innervation in, 136
 - venous and lymphatic drainage in, 136
 - in superior mediastinum, 131
- Ethmoid bone, 606, 606f
- Ethmoidal artery, 514, 614
- Ethmoidal cells, 608–609
- Ethmoidal foramina, 502
- Exogenous testosterone, 601b
- Extension elbow joint, 405f
- Extension, knee, 288f
- Extensor carpi ulnaris tendon, 421b–422b
- Extensor digitorum brevis, 355, 355f, 355t
- Extensor digitorum tendon, 421b–422b
- Extensor hallucis brevis, 355, 355t
- Extensor hoods, 354–355, 355f, 429–430, 430f
- Extensor retinacula, 352, 352f
- External acoustic meatus, 524, 524f
- External anal sphincter, 265
 - nerves to, 251f
- External carotid artery, 563
 - branches of, 565t
- External ear, 522–524, 523f
 - auricle, 522–524, 523f
 - examination of, 525b–526b
 - external acoustic meatus, 524, 524f
 - tympanic membrane, 524–525

External genitalia

- of men, 269b–270b
- of women, 267b–268b
- External iliac nodes, 275, 275f
- External intercostal muscle, of thoracic wall, 78, 78t
- External jugular veins, 560, 573, 574f
- External laryngeal nerve, 603
- External nasal nerves, 490, 615
- External nose, 606–607, 607f
- External oblique, 149–150, 150f, 150t
- External os, 246–247, 247f
- External pudendal arteries, 274
- External rectal venous plexus, 260–261, 261f
- External spermatic fascia, 157
- External sulci, 106
- External urethral sphincter, 235, 236f, 240, 241f
- Extracapsular ligaments, 539
- Extradural hematoma, 473b, 550b
- Extradural space, 465, 465f
- Extraperitoneal fascia, 15, 152–153, 153f
- Extrinsic ligaments, of larynx, 595, 596f
- Extrinsic muscles
 - of auricle, 522
 - extra-ocular, 511t
 - eyeball movements and, 513
 - orbital, 510–513
 - of tongue, 4490
- Eye
 - dry, 555b
 - and lacrimal apparatus, 506b, 507f
- Eyeball, 519–522, 519f
 - actions of muscles of, 513f
 - anterior and posterior chamber, 519–520
 - arterial supply, 520
 - fascial sheath of, 509–510, 510f
 - fibrous layer of, 520–521
 - inner layer of, 521–522
 - innervation, 515f
 - lens and vitreous humor, 520
 - movements of, 511f, 513
 - muscles, 512f, 512b
 - vascular layer of, 521
 - venous drainage, 520
 - walls of, 520
- Eyelids, 502–505, 502f
 - conjunctiva, 504
 - glands, 504
 - innervation, 504–505, 504f
 - orbicularis oculi, 502–503
 - orbital septum, 503
 - skin and subcutaneous tissue, 502
 - tarsus and levator palpebrae superioris, 503–504
 - vessels, 504

F

Face

- major features of, 497f, 497b
- motor innervation of, 491–492
- muscles, 484–487, 485t–486t, 486f
 - nasal group of, 487f
 - orbital group of, 487f
- parotid glands, 487–489, 489f
- Facial artery, 565

- Facial nerve (VII), 477f, 479, 487, 493f, 566, 626
 - branches, 492, 534
 - palsy, 496b
 - in temporal bone, 534, 535f
- Facial pulse, 639b
- Facial skeleton, visible part of, 450–451
- Facial vein, 495, 565
- Falciform ligament, 180
- False pelvis (greater pelvis), 224, 224f
- False ribs, 69
- Falx cerebelli, 463
- Falx cerebri, 462–463
- Fascia, 15
 - deep, 15
 - extraperitoneal, 152–153, 153f
 - importance of, 15b
 - neck, 558–560, 559f
 - compartments of, 560
 - of pectoral region, 68f
 - of pelvis, 247–248, 248f
 - pharyngeal, 587
 - renal, 206–207, 208f
 - specializations, orbital, 509–510
 - superficial, 15
 - abdominal, 148–149, 148f–149f
 - of urogenital triangle, 270, 271f
- Fascia lata, 149, 149f, 300–301, 301f
- Fascial sheath, of eyeball, 509–510, 510f
- Fat pad
 - infrapatellar, 324
 - synovial joint, 12
- Fat, renal, 206–207, 208f
- Femoral artery, 155, 297, 303b, 317–320, 318f
- Femoral hernias, 162b
- Femoral neck fractures, 292b
- Femoral nerve, 222, 321, 321f, 363b
- Femoral pulse, 365b
- Femoral sheath, 302–303
- Femoral triangle, 301
 - boundaries of, 302f
 - contents of, 302f
- Femur
 - proximal, 290–292, 291f
 - shaft and distal end of, 292f, 310, 310f
- Fibrocartilage, 9
- Fibro-elastic membrane, of larynx, 596–597, 598f
- Fibrous joints, 13, 14f
- Fibrous layer, of eyeball, 520–521
- Fibrous membrane, 12
 - of elbow joint, 405
 - of hip joint, 294, 295f
 - of joint capsule, 374
 - of knee joint, 325f, 326
 - of temporomandibular joint capsule, 539
- Fibrous pericardium, 103, 103f
- Fibrous sheaths
 - digital, 429, 429f
 - of toes, 353–354, 354f
- Fibula, 332f
 - proximal end of, 313, 313f
 - shaft and distal end of, 332–333
- Fibular artery, 336, 336f
- Fibular retinacula, 352, 353f
- Fibularis brevis, 338t
- Fibularis longus, 338t

- Filiform papillae, 621
 Filum terminale, 55
 Fimbriae, 246, 246f
 Fingers, 422f
 Fissures
 middle cranial fossa, 458
 oral, 633–634, 633f
 orbital, 507–508
 palpebral, 497b, 502
 pterygopalatine fossa, 551
 Flail chest, 72b
 Flat bones, 10
 Flat muscle, of abdomen, 149–151
 Flexion
 elbow joint, 405f
 knee joint, 288f
 Flexor carpi ulnaris tendon, 421b–422b
 Flexor digiti minimi brevis, 357, 358t
 Flexor digitorum brevis, 357, 358t
 Flexor digitorum profundus, 416t
 Flexor digitorum superficialis, 414, 415f–416f, 415t
 Flexor pollicis longus, 416t
 Flexor retinaculum, 427b
 of foot, 351–352, 351f
 Floating ribs, 69
 Floor
 of axilla, 386, 386f
 of bony orbit, 502
 of cranial cavity, 455
 of middle ear, 526
 of nasal cavity, 609, 609f
 of oral cavity, 621–627, 622t
 Fluorodeoxyglucose (FDG), labeled with
 fluorine-18, 7
 Fluoroscopy unit, 4f
 Foliate papillae, 622
 Foot, 286, 340–362
 arches of, 352–353, 353f
 arteries in, 357–359, 357f
 dorsalis pedis artery, 358–359, 359f, 359b
 posterior tibial artery and plantar arch, 357–358
 bones of, 340–344, 340f–341f, 344b
 metatarsals, 343–344, 344f, 344b
 phalanges, 344, 344f, 344b
 tarsal, 343
 extensor hoods, 354–355, 355f
 extensor retinacula, 352, 352f
 fibrous sheaths of toes, 353–354, 354f
 fibular retinacula, 352, 353f
 flexor retinaculum, 351–352, 351f
 intrinsic muscles of, 355–357, 355f, 355t
 first layer of, 355, 356f, 356t
 fourth layer, 357, 357f, 358t
 second layer, 355, 356f, 356t
 third layer, 355–357, 357f, 358t
 joints of, 344–351
 ankle, 344–346, 345f
 deep transverse metatarsal ligaments, 350f, 351
 interphalangeal, 350f, 351
 intertarsal, 346–350
 metatarsophalangeal, 350, 350f
 tarsometatarsal, 350, 350f
 Foot (*Continued*)
 nerves in, 359–362
 plantar aponeurosis, 353, 354f
 tarsal tunnel, 351–352, 351f, 352b
 veins in, 359, 360f
 Foot drop, 340b
 Foramen
 greater sciatic, 295
 lesser sciatic, 295–297
 Foramen cecum, 455–456, 456t
 of tongue, 621
 Foramen magnum, 454, 458–459
 Foramen ovale, 111
 Foramen rotundum, 551
 Foramen transversarium, 38
 Foramina
 internal, of skull, 456t
 intervertebral, 40, 42f
 middle cranial fossa, 458
 orbital, 507–508
 posterior cranial fossa, 459
 pterygopalatine fossa, 551
 sacral, 226–227, 227f
 sciatic, 230b
 small, in nasal cavity lateral wall, 613
 Forearm, 411b
 anterior compartment
 arteries and veins, 414–417, 416f
 muscles, 414
 nerves, 417–418
 bones, 410–412
 joints, 412–414
 medial cutaneous nerve of, 394–395
 movements of, 369f
 posterior compartment of, 418–421
 arteries and veins, 418–419
 nerves, 421
 radiograph of, 411f
 Foregut, 188, 188f
 Fornix, vaginal, 247, 247f–248f
 Fourchette, 267b–268b
 Four-quadrant pattern, of abdomen, 146, 146f
 Fovea centralis, 522
 Fracture
 across waist of scaphoid bone, 426b
 bone, 11b
 of clavicle, 376b–377b
 epiphyseal, 11b
 femoral neck, 292b
 femoral shaft, 293b
 of head of radius, 407b
 intertrochanteric, 293b
 orbital, 502b
 pars interarticularis, 48b
 pelvic, 230b, 290b
 of proximal humerus, 372b
 of radius and ulna, 412b
 rib, 72b, 389b
 skull vault, 461b
 supracondylar, of humerus, 407b
 of talus, 342b
 vertebral, 47b
 Frenulum
 of clitoris, 267b–268b
 of glans, 269b–270b
 Frontal bone, 446
 Frontal nerve, 517
 Frontal sinuses, 608
 Fundiform ligament, of penis, 149, 266, 267f
 Fundus
 of stomach, 168
 of uterus, 246, 246f
 Fungiform papillae, 622
 Fusion
 of cervical vertebrae, 44b
 spinal, 48b
- ## G
- Gait, 364b
 Gallbladder, 183
 Gallstones, 186b
 Ganglia, 198–199, 199f
 abdominal prevertebral, 217–219, 218f, 219t
 branches from, 140–141
 ciliary, 518–519, 518f
 pterygopalatine, 555
 in root of neck, 581–582
 spiral, 532f, 534
 superior cervical, 516, 581
 Ganglion, 24
 Ganglion impar, 197, 255, 256f–257f
 Gaps, in pharyngeal wall, 587–588, 588f
 Gastroduodenal artery, 189f, 190
 Gastroesophageal junction, 171b–172b
 Gastrointestinal contrast examinations, 8
 Gastrointestinal system, pelvic viscera and, 236–237, 238f
 Gastrointestinal tract
 abdominal
 endoscopy of, 179b
 lymphatic drainage of, 196, 196f
 venous drainage of, 194f
 arterial supply to, 187–193
 congenital disorders of, 178b
 elements in neck, 568–569
 vascular supply to, 193b
 Gastrotomy, 182b
 Gender differences
 in pelvis, 229–230, 229f
 in urethra, 240, 241f
 General somatic afferents (GSAs), 22
 General somatic efferents (GSEs), 22, 477
 General visceral afferent fibers (GVAs), 24
 General visceral efferent fibers (GVEs), 24, 477
 Geniculate ganglion, 479, 534
 lesions, 496b
 Geniohyoid muscle, 562, 622f
 Genitalia, external
 of men, 269b–270b
 of women, 267b–268b
 Genitofemoral nerve, 221
 Gingivae, 634–638
 arterial supply, 635–636
 innervation of, 637–638
 lymphatics, 636
 veins, 636
 Ginglymus, 13f
 Glabella, 446
 Glandular branches, of superior thyroid artery, 569

Glans clitoris, 265f, 266
 Glans penis, 265f, 267, 269b–270b
 Glaucoma, 520b
 Glenohumeral joint, 368, 373–376, 374f–376f, 375b–376b
 dislocations of, 377b
 movements of arm at, 369f
 Gliding joint, 13f
 Glossopharyngeal nerves (IX), 480, 566, 566f, 592, 625
 Gluteal nerve
 inferior, 251f, 254
 superior, 251f, 254
 Gluteal region, 286, 303–308, 304f
 arteries of, 308, 308f
 lymphatics of, 308
 muscles of, 303–305, 304f–305f, 306t
 nerves of, 305–308, 306f
 veins of, 308
 Gluteal surface, 225f, 226
 Gluteus maximus, 305f
 Gluteus medius, 304
 Gluteus minimus, 304
 Gluteus muscle, 301
 Goiter, 572b
 Golfer's elbow, 407b
 Gomphoses, 13, 14f
 Grafts, vein harvesting for, 299b
 Gray matter, 20, 55f, 56
 Gray rami communicantes, 251, 251f
 Gray ramus communicans, 25–26
 Great auricular nerve, 498, 576
 Great cardiac vein, 120
 Greater occipital nerve, 498
 Greater omentum, 165–166, 166f, 166b
 Greater palatine artery, 556, 613
 Greater palatine foramen, 619
 Greater palatine nerve, 632
 Greater petrosal nerve, 555, 628–629
 Greater sac, of peritoneal cavity, 164, 165f
 Greater sciatic foramen, 230–231, 231f–232f
 Greater sciatic notch, 224f, 225
 Greater splanchnic nerve, 141
 Greater trochanter, 290–292, 291f
 Greater tubercle, 372
 Greater vestibular glands, 244, 265f, 267, 267b–268b
 Greater wing, of sphenoid, 453
 Great saphenous vein, 298, 321, 359
 Great vessels, abnormal origin of, 133b
 Groin, 156–160
 masses around, 161b
 Grooves
 for greater and lesser petrosal nerves, 530f
 mylohyoid, 538
 posterior cranial fossa, 459
 superior sagittal sinus, 455
 Gubernaculum, 156–157
 Gums, 634–638

H

Hamate, 424
 Hamstring, 316
 injury to, 317b
 Hand
 anatomical snuffbox, 428–429, 428f

Hand (*Continued*)
 arteries and veins, 432–435
 bones of, 423–425
 extensor hoods, 429–430, 430f
 fibrous digital sheaths, 429, 429f
 joints, 425–426
 muscles, 430–432, 431t
 nerves, 435–438
 palmar aponeurosis, 427–428, 428f
 and wrist joint, 424b
 Hard palate, 452, 629–630
 Haustra of colon, 174
 Head, 443–640
 anatomical position and major landmarks, 450b
 of epididymis, 242f, 243
 of fibula, 331b
 injury to, 472b
 of mandible, 538
 medical imaging of, 461b
 overall design of, 445f
 parasympathetic ganglia of, 478t
 of ribs, 69
 Heart, 105–124
 cardiac chambers in, 106–114, 109f, 110b
 cardiac conduction system in, 120–123, 121b, 122f
 cardiac orientation in, 105–106, 105f
 cardiac skeleton in, 117, 118f
 coronary vasculature in, 117–120
 innervation in, 123–124, 123f
 sympathetic nerves to, 28f
 visualizing, 108b
 Heart attack, 124b
 symptoms of, 124b
 in men and women, 125b
 Heart sounds, 116b
 Helicotrema, 532
 Helix, 522
 Hematoma, extradural, 473b, 550b
 Hemiazzygos vein, 138–139, 139f
 Hemodialysis, 164b
 Hemorrhage, subarachnoid, 473f, 473b
 Hemorrhoids, 262b
 Hepatic cirrhosis, 195b
 Hepatic duct, 185, 185f
 Hepatopancreatic ampulla, 184
 Hepatorenal recess, 180
 Hernias
 abdominopelvic cavity, 163b
 diaphragmatic, 205b
 femoral, 162b
 hiatal, 206b
 incisional, 163b
 inguinal, 162b
 potential problem of, 163b
 umbilical, 163b
 Herniation, of intervertebral discs, 45b–46b
 Herpes zoster, 60b
 Hiatal hernia, 206b
 High-resolution computed tomography (HRCT), lung, 98b–99b
 Hilum
 of kidney, 207
 of lungs, 85, 89, 90f
 splenic, 186

Hindgut, 188, 188f
 Hinge joints, 12, 13f
 Hip, 287–303
 arteries, 297–298, 298f
 bony pelvis, 287–290, 289f
 deep fascia and saphenous opening of, 300–301, 301f
 femoral triangle, 301, 302f
 gateways to lower limb, 295–297, 296f
 hip joint, 292–295, 293f–295f, 296b
 lymphatics, 299–300, 300f
 movements of, 288f
 nerves, 297, 297f
 proximal femur, 290–292, 291f
 veins, 298, 299f
 Hoarseness, 134b–135b
 Horizontal plane, 2f, 3
 Horner's syndrome, 505b
 Humeral head, anterior dislocation, 389b
 Humerus
 proximal, 371–372
 proximal end of right, 372f
 shaft and distal end, 398–400, 399f
 supracondylar fracture, 407b
 Hyaline cartilage, 9, 11
 Hydrocele, of the testis, 243b
 Hydrocephalus, 466b
 Hymen, 267b–268b
 Hyo-epiglottic ligament, 595
 Hyoid bone, 585–586, 620, 621f
 Hypaxial muscles, 21
 Hyperextension, of thumb, 421b–422b
 Hyperparathyroidism, 572b
 Hypogastric nerves, 199, 255, 256f–257f
 Hypoglossal canal, 454, 460f
 Hypoglossal nerves (XII), 476t, 477f, 484, 567, 567f, 626, 626f
 test for, 624b
 Hypothenar muscles, 431–432, 433f
 Hysterectomy, 246b

I

Ileal arteries, 190–192
 Ileocecal fold, 172f, 173
 Ileocolic artery, 192
 Ileum, 170–173, 171f, 171b
 Iliac crest, 225f, 226
 Iliac fossa, 225f, 226
 Iliac tuberosity, 225f, 226
 Iliacus, 202, 315f
 Iliococcygeus, 233f, 234
 Iliocostalis, 51
 Iliofemoral ligament, 294
 Iliohypogastric nerve, 153–154, 220
 Ilio-inguinal nerve, 153–154, 220–221
 Iliolumbar artery, 258, 258f
 Iliolumbar ligaments, 38–40
 Iliolumbar vein, 214
 Iliopsoas muscle, 202
 Iliopubic eminence, 287
 Iliotibial tract, 301
 Ilium, 225–226, 225f, 287, 289f
 Imaging, 3–9
 diagnostic techniques for, 3–7
 image interpretation in, 7–8

- Imaging (*Continued*)
 medical imaging of head, 461b
 safety in, 8–9, 8t
- Impotence, prostatectomy and, 258b
- Incisional hernias, 163b
- Incisive canal, 613
- Incisive nerve, 546
- Incisor teeth, 634
- Incus, 529, 529f
- Infections
 of bladder, 241b
 neck, spread of, 560b
 pterygoid plexus, spreading into cranial cavity, 550b
- Inferior alveolar artery, 549, 635
- Inferior alveolar nerve, 546
 anesthesia of, 546b
 innervation, 637
- Inferior articular processes, 68
- Inferior cervical ganglion, 581–582
- Inferior costal facet, 68
- Inferior, describing anatomical location, 2f, 3
- Inferior gluteal artery, 259, 259f, 297–298, 308
- Inferior gluteal nerve, 251f, 254, 307
- Inferior hypogastric plexuses, 255, 256f–257f
- Inferior laryngeal artery, 602
- Inferior laryngeal veins, 603
- Inferior margin, of heart, 106
- Inferior mesenteric artery, 192–193, 192f
- Inferior mesenteric vein, 196
- Inferior oblique, 511t, 513
- Inferior ophthalmic vein, 514
- Inferior orbital fissure, 508
- Inferior part, of duodenum, 169
- Inferior petrosal sinuses, 471–472
- Inferior phrenic arteries, 83
- Inferior pubic ligament, 229, 229f
- Inferior ramus, 225f, 226
- Inferior rectal arteries, 272–273, 273f
- Inferior rectal nerve, 271, 272f
- Inferior rectus, 511–512, 511t
- Inferior sagittal sinus, 469–471
- Inferior subscapular nerve, 393f
- Inferior thoracic aperture, 67, 70f
- Inferior thyroid artery, 569–570, 579
- Inferior vena cava, 130b, 214–215, 214f
 filter, 215b
- Inferior vesical artery, 259, 259f
- Inferior view, of skull, 452, 453f
 anterior part, 452
 middle part, 452–454
 posterior part, 454
- Inferolateral surfaces, of bladder, 238, 239f
- Infraglottic space, 599
- Infrahyoid muscle, 562–563, 563f
- Infra-orbital artery, 494, 556
- Infra-orbital foramen, 508
- Infra-orbital nerve, 490, 554
- Infrapatellar fat pad, 324
- Infrapatellar synovial fold, 324
- Infraspinatus muscle, 380
- Infratemporal fossa, 541–550, 542f
- Infratrochlear nerves, 490, 517
- Infundibulopelvic ligament, 250, 260
- Infundibulum, 246, 246f
- Inguinal canal, 157–160, 157f
 anterior wall of, 157
 contents of, 158
 floor of, 158
 posterior wall of, 157–158
 roof of, 158
- Inguinal hernias, 162b
 direct, 162b
 indirect, 162b
- Inguinal ligament, 150
 pelvic bone and, gap between, 297
- Inhaled objects, 94b
- Injections, intramuscular, to gluteal region, 307b
- Injury
 ankle, 348b
 to hamstring, 317b
 head, 472b
 quadriceps, 315b
 soft tissue, to knee, 328b
 tracheobronchial, 569b
- Inner layer, of eyeball, 521–522
- Innervation
 of abdominal wall, 153–155, 154f
 of bone, 10
 of breast, 66
 cranial dura mater, 464–465
 of diaphragm, 205
 dural, 464f
 external acoustic meatus, 524
 of eyelids, 504–505, 504f
 of hip joint, 295, 295f
 internal ear, 534
 of knee joint, 328
 lacrimal gland, 506, 508f, 555
 of larynx, 603, 604f
 lungs, 97, 97f
 of middle ear, 530, 530f
 nasal cavities, 614–616, 615f
 orbit, 506, 515–519
 of palate, 632, 633f
 parotid gland, 489
 pericardial, 104b
 peripheral sympathetic, 26–28, 27f
 of peritoneum, 164b
 of pharynx, 592f
 salivary gland, 628–629
 of scalp, 498, 499f
 sensory, testing in upper limb, 440b
 suprarenal, 212
 teeth and gingivae, 637–638
 of thoracic wall, by intercostal nerves, 81, 82f
 of tongue, 625, 625f
 tympanic membrane, 525
 ureteric, 209
 visceral sensory, 31
- Interarytenoid notch, 598
- Interatrial septum, 110–111
 defect in, 117b
- Interchondral joints, 74f, 75
- Intercondylar area, of tibia, 311–312
- Intercondylar eminence, 311
- Intercondylar fossa, 310
- Intercostal artery, 155
- Intercostal muscles, 78, 79f
- Intercostal nerve block, 83b
- Intercostal nerves, 81, 82f
- Intercostal nodes, 80, 82f
- Intercostal spaces, 75–81, 77f
 arterial supply of, 77f, 78–80
 innervation of, 81
 lymphatic drainage of, 80, 82f
 muscles of, 78, 79f
 venous drainage of, 80, 81f
- Intercostobrachial nerve, 81
- Intermediate group of back muscles, 50, 50f, 50t
- Intermediate layer, forearm muscles, 414, 415f, 415t
- Intermediate tarsal bone, 343
- Internal carotid arteries, 468, 564
- Internal ear, 522, 530–535, 531f
 bony labyrinth, 531–532
 innervation, 534
 membranous labyrinth, 532–534, 532f
 sound transmission, 534–535, 535f
 in temporal bone, 531f
 vessels, 534
- Internal iliac artery, 258–260, 258f
 anterior trunk of, 258–260, 259f
 posterior trunk of, 258, 258f
- Internal iliac nodes, 274
- Internal iliac vein, 274, 274f
- Internal intercostal muscle, of thoracic wall, 78, 78t
- Internal jugular vein, 565
- Internal laryngeal nerve, 604
- Internal oblique, 150, 150t
 inguinal canal and, 158f
- Internal os, 246–247, 247f
- Internal pudendal artery, 259, 259f, 272–274, 273f
- Internal pudendal veins, 274, 274f
- Internal rectal venous plexus, 260–261, 261f
- Internal spermatic fascia, 157–158
- Internal thoracic artery, 79, 155
- Internal urethral sphincter, 240, 241f
- Interossei muscles, 431
- Interosseous membrane
 of forearm, 412, 412f
 of leg, 333, 333f
- Interosseous talocalcaneal ligament, 348f
- Interosseus sacro-iliac ligament, 228, 228f
- Interphalangeal joints
 of hand, 426
 of toes, 350f, 351
- Interspinales, 52
- Interspinous ligaments, 47, 47f
- Intertarsal joints, 346–350, 346f
- Intertransversarii, 52
- Intertrochanteric crest, 291
- Intertrochanteric line, 291
- Intertubercular plane, of abdomen, 147
- Intervertebral discs, 42–43, 45f
 herniation of, 45b–46b
- Intervertebral foramina, 40, 42f
- Intestine
 large, 173–176, 173f
 small, 169–173
- Intracerebral aneurysm, 468b
- Intracranial hemorrhage, 473b
- Intracranial venous connections, 495

Intramuscular injections, to gluteal region, 307b
 Intravenous urogram, of urinary tract, 211b
 Intravenous urography, 8
 Intrinsic ligaments, of larynx, 596–597
 Intrinsic muscles
 of auricle, 522
 of eye, 522t
 of foot, 355–357, 355f, 355t
 first layer of, 355, 356f, 356t
 fourth layer, 357, 357f, 358t
 second layer, 355, 356f, 356t
 third layer, 355–357, 357f, 358t
 of hand, 431t
 of larynx, 600–601, 600t
 of orbit, 510
 of tongue, 624
 Introitus, 247
 Investing layer, of neck fascia, 558
 Iodine, as contrast agent, 4
 Iris, 519–521
 Irregular bones, 10
 Ischemia, chronic leg, 320b
 Ischial spine, 224f–225f, 225–226, 230
 Ischial tuberosity, 224f–225f, 225–226, 287, 289f
 Ischio-anal fossae, 264–265, 264f
 Ischiofemoral ligament, 294
 Ischiopubic ramus, 288
 Ischium, 225f, 226
 Isthmus, 246, 246f

J

Jaundice, 186b
 Jejunal arteries, 190–192
 Jejunostomy, 182b
 Jejunum, 170, 171f, 171b
 Joint capsule, 11
 elbow joint, 406f
 of temporomandibular joint, 539
 Joints, 11–13, 11f
 atlanto-occipital, 38
 costotransverse, 73
 costovertebral, 73, 74f
 diseases of, 46b
 of elbow, 405–406
 of foot, 344–351
 of forearm, 412–414
 of hand, 425–426
 of hip, 292–295
 interchondral, 74f, 75
 laryngeal, 597–598
 of leg, 333
 of lower limb, 287f
 manubriosternal, 74f, 75, 75b
 of pelvis, 227–229
 of shoulder, 372–376
 solid, 11–13, 11f, 13f
 sternocostal, 73–74, 74f
 synovial, 11–12, 11f
 temporomandibular, 538–539, 538f
 “uncovertebral”, 45, 45f
 between vertebrae in back, 42–45
 between vertebral arches, 44–45
 xiphisternal, 74f, 75
 zygapophysial, 44–45, 45f

Jugular notch, 76b
 Jugular tubercle, 459
 Jugular veins
 anterior, 561
 external, 560, 573, 574f
 superior bulb of, 565
 Jugular wall, of middle ear, 526
 Jugulodigastric node, 583
 Jugulo-omohyoid node, 583

K

Kidneys, 206–208
 fat and fascia of, 206–207, 208f
 relationships to other structures, 206, 207f
 retroperitoneal position of, 206f
 structure of, 207, 208f
 transplant, 210b
 vasculature and lymphatics of, 208, 209f
 Knee joint, 323–328, 323f
 articular surfaces of, 323, 324f
 fibrous membrane, 325f, 326
 flexion and extension, 288f
 ligaments of, 326–328
 locking mechanism of, 327–328, 327f
 menisci, 323–324, 324f
 synovial membrane, 324, 325f
 vascular supply and innervation, 328
 Knuckle cracking, 426b
 Kyphosis, 44b

L

Labial branches, of facial artery, 493
 Labia majora, 267b–268b
 Labia minora, 267b–268b
 Labyrinthine artery, 534
 Labyrinthine vein, 534
 Labyrinthine wall, of middle ear, 527–528
 Laceration, of scalp, 500b
 Lacrimal apparatus, 505–506
 Lacrimal artery, 513
 Lacrimal gland, 505, 505f
 innervation of, 508f, 555
 Lacrimal lake, 505–506
 Lacrimal nerves, 490, 516–517
 Lacrimal sac, 505, 506f
 Lacteals, 18
 Lactiferous ducts, 64
 Lacunar ligament, 150
 Lambda, 452, 455f
 Lambdoid suture, 448
 Laminae, 68
 of modiolus, 532
 of vertebra, 38
 Large intestine, 173–176, 173f
 Laryngeal cartilage, 593–595
 Laryngopharynx, 590
 Laryngoscopy, 593b
 Larynx, 569, 592–604, 593f
 cartilages, 593–595
 cavity of, 598–600
 extrinsic ligaments, 595
 function of, 601, 602f
 intrinsic ligaments, 596–597
 intrinsic muscles, 600–601, 600t

Larynx (*Continued*)
 laryngeal joints, 597–598
 nerve, 603–604, 604f
 vessels, 602–603
 Lateral aortic nodes, 216–217
 Lateral arcuate ligament, 204
 Lateral circumflex femoral artery, 318–319, 319f
 Lateral compartment, of leg, 337–338
 arteries in, 337, 338f
 muscles in, 337, 338f, 338t
 nerves in, 337–338, 338f
 veins in, 337
 Lateral condyle, 311
 Lateral cord of brachial plexus, branches of, 394
 Lateral costotransverse ligament, 73
 Lateral crus, 157
 Lateral cutaneous branch, 81
 Lateral cutaneous nerve, of thigh, 219t, 221
 Lateral, describing anatomical location, 2f, 3
 Lateral epicondyle, 310
 Lateral ligament, of temporomandibular joint, 539
 Lateral malleolus, 342
 Lateral masses, atlas and axis, 38
 Lateral nasal artery, 614
 Lateral pectoral nerve, 394
 Lateral plantar artery, 357–358, 357f
 Lateral plantar nerve, 360f, 361
 Lateral pterygoid muscle, 543, 543f
 Lateral rectus, check ligament of, 510
 Lateral sacral arteries, 258, 258f
 Lateral thoracic artery, 387
 Lateral vertebral muscles, 576t, 577f
 Lateral wall
 of axilla, 384, 385f, 385t
 of bony orbit, 502
 of infratemporal fossa, 541
 of nasal cavities, 605, 605f, 610–611, 610f
 Latissimus dorsi, 48f, 49, 49t
 Layers
 of eyeball, 520–521
 of forearm muscles
 anterior compartment, deep layer, 414, 416f, 416t
 intermediate layer, 414
 posterior compartment, deep layer, 418, 420f, 420t
 posterior compartment, superficial layers, 418, 419f, 419t
 superficial layer, 414, 414f, 414t
 of intrinsic muscles of foot, 355–357
 first layer of, 355, 356f, 356t
 fourth layer, 357, 357f, 358t
 second layer, 355, 356f, 356t
 third layer, 355–357, 357f, 358t
 of scalp, 496–498, 497f
 Least splanchnic nerve, 141
 Left atrium, 113, 114f
 visualizing, 113b
 Left brachiocephalic veins, 127, 127f, 129b
 Left bundle branch, 123
 Left colic artery, 193
 Left common carotid artery, 563
 Left coronary artery, 118, 119f
 Left fibrous trigone, 117

- Left gastric artery, 188
 Left jugular trunk, 139
 Left lung, 90, 91f
 Left phrenic nerves, of superior mediastinum, 134
 Left pulmonary artery, 96f, 97
 Left pulmonary surface, of heart, 105
 Left subclavian artery, 131
 Left superior intercostal vein, 129, 129f
 Left vagus nerves, of superior mediastinum, 133, 133f
 Left ventricle, 113–114, 115f
 Leg, 286, 331–340, 331f
 anterior compartments of, 338–340
 arteries in, 338–340
 muscles in, 338, 339f, 339t
 nerves in, 340
 veins in, 340
 bones of, 331–333
 compartments of, 331
 joints of, 333
 lateral compartment of, 337–338
 arteries in, 337, 338f
 muscles in, 337, 338f, 338t
 nerves in, 337–338, 338f
 veins in, 337
 posterior compartment of, 333–337
 arteries in, 335–336, 336f
 muscles in, 333–335, 334f–335f, 334t
 nerves in, 336–337, 337f
 veins in, 336
 Lens, 520
 Leptomeninges, 466b
 Lesion
 at and around geniculate ganglion, 496b
 at and around stylomastoid foramen, 496b
 central, 496b
 of cranial nerves, 481b
 Lesser occipital nerve, 498, 576
 Lesser omentum, 166, 167f
 Lesser palatine nerve, 632
 Lesser petrosal nerve, 530, 547, 548f
 Lesser sciatic foramen, 230–232, 231f–232f
 Lesser sciatic notch, 224f–225f, 225
 Lesser splanchnic nerve, 141
 Lesser trochanter, 290–292, 291f
 Lesser tubercle, 372
 Lesser wing, of sphenoid bone, 457
 Levator anguli oris, 484–486, 485t–486t
 Levator ani, 233–234, 233f
 nerves to, 251f
 Levatores costarum, 52
 Levator labii superioris alaeque nasi, 484–486, 485t–486t
 Levator palpebrae superioris, 503–504, 505f
 Levator prostatae, 234
 Levator scapulae, 48, 48f, 49t, 379
 Levator veli palatini, 587, 630t, 631f
 Ligamenta flava, 46, 46f, 47b
 Ligaments
 associated with
 external oblique, 150, 150f
 liver, 180–181, 180f
 of back, 46–47
 extracapsular, 539
 foot
 Ligaments (*Continued*)
 plantar calcaneocuboid, 349–350, 350f
 support for arches of, 353, 354f
 of hip, 294
 of inguinal region, 151f
 of knee joint, 326–328
 of larynx
 extrinsic, 595, 596f
 intrinsic, 596–597
 of ovary, 250
 of pelvic fascia, 247–248
 of pelvic wall, 230
 peritoneal, 167
 sacro-iliac, 228
 splenic, 187f
 Ligamentum arteriosum, 131
 Ligamentum nuchae, 46–47, 47f
 Linea aspera, 310
 Linea terminalis, 224f, 225
 Line of attachment, for lateral pharyngeal
 walls, 585–586, 586f
 Lingual artery, 565
 Lingual nerve, 546, 625–626
 in floor of oral cavity, 626f
 injury, 546b
 Lingual tonsils, 590, 622–624
 Lips, 633, 633f
 Liver, 180–182
 associated ligaments with, 180–181, 180f
 diaphragmatic surface of, 180, 180f
 lobes of, 181–182
 segmental anatomy of, 182b
 visceral surface of, 180, 181f
 Lobar bronchi, 94
 Lobes, thyroid gland, 569
 Lobule, 522
 Locking mechanism, of knee joint, 327–328, 327f
 Long bones, 10
 Longissimus, 51
 Longitudinal arch, of foot, 353, 353f
 Longitudinal ligaments, anterior and
 posterior, 46, 46f
 Longitudinal muscles, of pharynx, 586–587, 587t, 588f
 Long plantar ligament, 349–350, 350f
 Long thoracic nerve, 393, 393f, 393b
 Loose connective tissue layers, of scalp, 498
 Lordosis, 44b
 Lower limb, 285–366
 dermatomes and myotomes in, 362b–363b
 foot, 340–362
 functions of, 286
 gluteal region of, 286, 303–308, 304f
 hip, 287–303
 legs, 331–340, 331f
 regional anatomy of, 286–362, 286f–287f
 thigh, 309–330, 309f
 Lumbar arteries, 213, 213t
 Lumbar cerebrospinal fluid tap, 59b–60b
 Lumbar nodes, 216–217
 Lumbar plexus, 219–222, 219f, 297
 branches of, 219t
 cutaneous distribution of nerves from, 221f
 in posterior abdominal region, 220f
 Lumbar splanchnic nerves, 198
 Lumbar veins, 214, 215f
 Lumbar vertebrae, 36f, 37–40, 39f–40f, 201–202
 typical, 37b
 Lumbosacral joints, 227, 228f
 Lumbosacral plexus, branches of, 297f, 300t
 Lumbrical muscles, 355, 356t, 432, 433f
 Lunate surface, of acetabulum, 290
 Lung cancer, 101b
 Lungs, 88–97, 89f
 bronchial arteries and veins in, 96f, 97
 bronchial tree in, 90–94, 94f
 bronchopulmonary segments in, 94–95, 95f
 bronchoscopy, 98b–99b
 high-resolution computed tomography, 98b–99b
 hilum of, 85, 89, 90f
 innervation, 97, 97f
 left, 90, 91f
 lymphatic drainage in, 97, 98f
 plain chest radiograph, 100b
 pulmonary arteries in, 95–97, 96f
 pulmonary veins in, 96f, 97
 right, 89–90, 91f
 root of, 85, 89, 90f
 sounds, 93b
 visualizing, 91b–92b, 98b–99b
 Lymph, 18
 Lymph nodes, 18–19, 19b
 facial, 495
 inguinal
 deep, 299
 superficial, 299
 level of enlargement, 584b
 in neck
 deep cervical, 583–584
 superficial, 582–583
 superficial cervical, 583
 pre-auricular and parotid, 496, 501f, 582–583
 regions of, 19f
 Lymphatic drainage
 of abdominal wall, 155, 155f
 auricle, 524
 of breast, 66
 in esophagus, 136
 eyelids, 504
 of face, 495–496, 496f
 of gastrointestinal tract, 196, 196f
 of intercostal spaces, 80, 82f
 of larynx, 603
 of lungs, 97, 98f
 nasal cavities, 616, 616f
 palate, 632, 632f
 of perineum, 275f
 pharynx, 591, 591f
 of scalp, 500–501, 501f
 thyroid gland, 570
 tongue, 626–627
 Lymphatic system, 18–19
 lymphatic trunks and ducts, 19, 19f
 lymphatic vessels, 18
 lymph nodes, 18–19, 19b
 structure and function of, 18f

Lymphatics

- of gluteal region, 308
- of hip, 299–300
- of lower limb, 300f
- of teeth and gingivae, 636

M

- Macula lutea, 522
- Macula of saccule, 533
- Macula of utricle, 533
- Magnetic resonance imaging (MRI), 5–6
 - of ankle joint, 347b
 - of elbow joint, 407b
 - of glenohumeral joint, 376b
 - of head, 461b
 - image interpretation, 8
- Malabsorption procedures, for obesity, 172b
- Malleus, 529, 529f
- Malrotation, of gastrointestinal tract, 178b
- Mammary glands, 64
 - axillary process of, 397
- Mandible, 447–448
 - lateral and medial view of, 537
 - ramus of, 537–538
- Mandibular foramen, 538
- Mandibular nerve (V_3), 479, 543, 544f–545f
 - branches, 543–546
 - innervation, 491–492
- Manubriosternal joints, 74f, 75, 75b
- Manubrium, of sternum, 72, 73f
- Marginal artery, 193b
- Margins
 - of heart, 106
 - visualizing, 110b
 - of perineum, 264b
- Masseter muscle, 540, 540f
- Masseteric nerve, 544
- Mastoid area, of middle ear, 527f, 528
- Mastoid nodes, 500, 582
- Mastoid notch, 451
- Mastoid part, of temporal bone, 454
- Mastoid wall, of middle ear, 526
- Mastoiditis, 528b
- Maxillae, 447, 537, 617–618
- Maxillary artery, 547–549, 549f, 555–557, 565, 565t
 - branches of, 494, 494f
 - in pterygopalatine fossa, 556f
 - second part of, 547
- Maxillary nerves, 477f, 479, 490, 552–557
 - branches of, 553–554, 553f
- Maxillary sinuses, 609
- Meckel's diverticulum, 172b
- Medial arcuate ligament, 203–204
- Medial brachial cutaneous nerve, branches of, 394–395
- Medial calcaneal nerve, 337, 337f
- Medial circumflex femoral artery, 319–320, 319f
- Medial compartment, of muscles of thigh, 316, 316f, 317t
- Medial condyle, 311
- Medial crus, 157
- Medial cutaneous nerve, of arm, 393f
- Medial, describing anatomical location, 2f, 3
- Medial epicondyle, 310

- Medial ligament, ankle joint, 345–346, 345f
- Medial palpebral artery, 514
- Medial pectoral nerve, 394
- Medial plantar artery, 357f, 358
- Medial plantar nerve, 360, 360f
- Medial pterygoid muscle, 543, 543f
- Medial rectus, check ligament of, 510
- Medial umbilical fold, 258–259
- Medial umbilical ligament, 258–259, 259f
- Medial wall
 - of axilla, 383, 384f, 384t
 - of bony orbit, 501–502
 - of infratemporal fossa, 541
 - of middle ear, 527–528
 - of nasal cavity, 608f, 609
- Median arcuate ligament, 82–83
- Median cubital vein, 408f, 409
- Median labial frenulum, 633
- Median nerve, 395, 401f, 402, 417, 417f
 - of hand, 437f, 438
 - recurrent branch of, 426–427
- Median sacral artery, 213, 213t, 259f–260f, 260
- Median sacral veins, 261f, 262
- Median sagittal plane, 3
- Median umbilical ligament, 237, 239f
- Mediastinal part, of parietal pleura, 85
- Mediastinum, 97–141
 - anterior, 102
 - lateral view of, 102f
 - middle, 102
 - posterior, 135–141
 - sagittal section of, 103f
 - subdivisions of, 102f
 - superior, 126–135, 127f, 128b
 - visualizing, in axial plane, 141b
- Mediastinum testis, 242–243, 242f
- Medulla oblongata, 467
- Membranous labyrinth, 532–534, 532f
 - cross-section, 533f
 - organs of balance, 533
 - organs of hearing, 533–534
- Membranous part of urethra, 240, 241f
- Men
 - breast in, 66
 - heart attack, symptoms of, 125b
 - pelvic fascia in, 248, 248f
 - reproductive system in, 241–244, 242f
 - urethra of, anatomy of, 240, 241f
- Meningeal branch, of mandibular nerve, 544
- Meningeal layer, of dura mater, 462
- Meningeal spaces, 465–466, 465f
- Meninges, 20–21, 57–58, 57f
 - arachnoid mater, 465
 - arrangement of, 20f
 - cranial dura mater, 462–465, 462f
 - meningeal spaces, 465–466, 465f
 - pia mater, 465
- Meningitis, 466b
- Meningocele, 43b
- Menisci, of knee joint, 323–324, 324f
- Mental artery, 494
- Mental foramen, 448
- Mental nerve, 491, 546, 637
- Mentalis, 484, 485t–486t
- Mesencephalon, 467

- Mesenteric artery
 - inferior, 192–193, 192f
 - superior, 190–192, 191f
- Mesenteries, 166, 167f
- Mesoappendix, 174, 174f
- Mesometrium, 249f, 250
- Mesosalpinx, 249f, 250
- Mesovarium, 245, 249f, 250
- Metacarpals, 424–425
- Metacarpophalangeal joints, 425–426, 425f
- Metatarsals, 343–344, 344f, 344b
- Metatarsophalangeal joints, 350, 350f
- Metencephalon, 467
- Midbrain, 467
- Middle cardiac vein, 120
- Middle cervical ganglion, 581
- Middle colic artery, 192
- Middle cranial fossa, 457–458, 457f
 - fissures and foramina, 458
 - sella turcica, 457–458
 - sphenoid, 457
 - temporal bone, 458
- Middle ear, 522, 526–530
 - auditory ossicles, 528–529, 529f
 - boundaries, 526–528, 527f
 - innervation, 530, 530f
 - mastoid area, 528
 - muscles of, 529t
 - parts of, 526f
 - pharyngotympanic tube, 528, 528f
 - vessels, 529–530
- Middle mediastinum, 102
 - ascending aorta in, 125, 126f
 - heart in, 105–124
 - pericardium in, 102–104, 103f
 - pulmonary trunk in, 124–125, 126f
 - vasculature in, 126, 126f
- Middle meningeal artery, 461f, 461b, 549, 550b
- Middle part, of laryngeal cavity, 599
- Middle rectal artery, 259, 259f
- Middle temporal artery, 541
- Midgut, 188, 188f
- Mid-thigh, transverse section through, 314f
- Mitral valve, 114
- Mitral valve disease, 116b
- Modiolus, 531–532
- Molar teeth, 634
- Mons pubis, 267b–268b
- Morton's neuroma, 361b
- Motor function of median and ulnar nerves
 - in hand, 438b
- Motor innervation, of face, 491–492
- Motor neurons, 21, 21f
 - visceral, 24
- Movements
 - of crico-arytenoid joints, 598f
 - of cricothyroid joint, 598f
 - of eyeball, 511f, 513
 - of forearm, 369f
 - of hand at wrist joint, 369f
 - of scapula, 368f
 - of synovial joints, 12
 - of temporomandibular joints, 539, 539f
 - of thoracic wall and diaphragm, during breathing, 84, 85f
 - of thumb, 369f

Multifidus, 51–52
 Multinodular goiter, 572b
 Muscles
 of anal triangle, 265t
 in anterior compartment of leg, 338, 339f, 339t
 in anterior triangle of neck, 562t
 in anterior wall of axilla, 383t
 of arm, 401
 atrophy, 16b
 auditory ossicles, associated with, 529, 530f
 auricle, 522–524, 523f
 within deep perineal pouch, 235t
 epaxial, 21
 eyeball, 512f–513f, 512b
 facial, 484–487, 485t–486t, 486f
 nasal group of, 487f
 orbital group of, 487f
 in floor of oral cavity, 622t
 of forearm
 anterior compartment, 414
 posterior compartment, 418
 of gluteal region, 303–305, 304f–305f, 306t
 of hand, 430–432, 431t
 hypaxial, 21
 injuries and strains, 16b
 of lateral and posterior wall of axilla, 385t
 in lateral compartment of leg, 337, 338f, 338t
 of mastication, 540t
 of medial wall of axilla, 384t
 of middle ear, 529t
 within orbit, 510–522
 paralysis, 16b
 of pectoral region, 66, 68f, 69t
 of pelvic diaphragm, 233t
 of pelvic wall, 230, 231t, 232f
 of pharynx, 586–587
 of posterior compartment of leg, 333–335, 334f–335f, 334t
 of posterior scapular region, 379t
 of posterior triangle of neck, 572–573, 574f, 574t
 of shoulder, 378t
 of soft palate, 630, 630t
 of superficial perineal pouch, 267, 267f, 267t
 support for arches of foot, 353, 354f
 of thigh, 313–317
 of tongue, 624, 624t, 625f
 types of, 15
 Muscular artery, 514
 Muscular branches, of cervical plexus, 576
 Muscular system, 15–16
 Muscular triangle, 561
 Musculature, of back, 48–55
 deep group of muscles, 51–53, 51f
 intermediate group of muscles, 50, 50f, 50t
 superficial groups of muscles, 48–50, 48f, 49t
 thoracolumbar fascia, 53–55, 54f
 Musculi pectinati, 110
 Musculocutaneous nerve, 394, 401, 401f
 Musculophrenic artery, 79
 Musculus uvulae, 630, 630t, 631f
 Myelencephalon, 467
 Myelomeningocele, 43b

Mylohyoid groove, 538
 Mylohyoid muscle, 562, 622f
 Myotomes, 23, 23f, 23b
 in lower limb, 362b–363b
 in upper limb, 439b

N

Nares, 497b, 611
 Nasal bones, 446
 Nasal cavities, 604–616, 605f
 arteries, 613–614, 614f
 choanae, 611, 612f
 external nose, 606–607, 607f
 floor, 609, 609f
 gateways, 611–613, 613f
 innervation, 614–616, 615f
 lateral wall, 605, 605f, 610–611, 610f
 lymphatics, 616, 616f
 medial wall, 608f, 609
 regions of, 605, 606f
 roof, 609–610, 610f
 skeletal framework, 606
 veins, 614, 615f
 visualizing, 608b
 walls of, 609–611
 Nasal group, of facial muscles, 484, 487f
 Nasalis, 484
 Nasal nerves, 553
 Nasal vestibule, 605
 Nasociliary nerve, 517–518, 518f
 Nasolacrimal duct, 505, 605f, 611
 Nasopalatine nerve, 553, 616, 632
 Nasopharynx, 588–590
 Navicular fossa, 240, 241f
 Neck, 443–640
 anterior triangle of, 557, 558f, 558b, 561–571
 of bladder, 238–239, 239f
 compartments of, 445, 445f, 557f
 fascia, 558–560, 559f
 lymphatics, 582–584, 583f
 of mandible, 538
 overall design of, 445f
 posterior triangle of, 557–558, 557f, 558b, 572–577
 of ribs, 69
 root of, 577–584, 577f
 superficial veins of, 560f
 superficial venous drainage, 560–561
 surgical neck of humerus, 372
 Nerve injury
 affecting superficial back muscles, 49b
 brachial plexus, 402
 lingual nerve, in infratemporal fossa, 546b
 median nerve, in arm, 402b
 radial nerve, 439b
 in arm, 403f, 403b
 ulnar nerve, 436b–437b
 at elbow, 408b
 Nerve plexuses, 32, 32f
 Nerves
 in anterior compartment of leg, 340
 of arm, 401–403
 associated with posterior scapular region, 380f
 cranial, 475–484, 475t–476t, 477f

Nerves (*Continued*)
 in foot, 359–362
 of forearm
 anterior compartment, 417–418
 posterior compartment, 421
 of gluteal region, 305–308, 306f
 of hip, 297, 297f
 larynx, 603–604, 604f
 in lateral compartment of legs, 337–338, 338f
 to lateral pterygoid, 544
 to medial pterygoid, 544
 mylohyoid, 546
 of neck, 565–568
 root of neck, 580, 580f
 to obturator internus, 305
 palatine, 632f
 of parasympathetic system, 29–31
 of pelvis, 251–255
 of pericardium, 104
 peripheral, regions of skin innervated by, 363b
 of pharynx, 591–592
 in posterior compartment of leg, 336–337, 337f
 posterior scapular region, 380–381
 of posterior triangle of neck, 575–577
 pterygoid canal, 506, 554–555, 554f
 to quadratus femoris, 305
 somatic, of perineum, 271
 to stapedius and chorda tympani, 534
 in superior mediastinum, 131–134
 phrenic, 133–134
 vagus, 131–133
 of temporal fossa, 542f
 of thigh, 321–323
 tongue, 625f
 Nervous system, 20–32
 CNS, 20–21, 20f
 dermatomes, 22–23, 22f, 23b
 enteric system, 31–32, 31f
 myotomes, 23, 23f, 23b
 nerve plexuses, 32
 parasympathetic system, 25, 29–31, 30f
 in posterior abdominal region, 217
 somatic part of, 21–22, 21f
 somatic plexuses, 32
 sympathetic system, 25–29, 25f–26f
 visceral part of, 21, 23–25, 24f
 visceral plexuses, 32
 Neural layer, of retina, 522
 Neuralgia, trigeminal, 491b
 Nine-region pattern, of abdomen, 146–147, 146f, 147b
 Nipple, 64
 Noncoronary cusp, 114
 Noncoronary sinus, 114
 Nuchal lines, 451, 453f
 Nuclear medicine imaging, 6–7
 image interpretation, 8
 of urinary tract, 211b
 Nucleus pulposus, 43

O
 Obesity, surgery for, 172b
 Obliquus capitis inferior, 52, 53f, 54t
 Obliquus capitis superior, 52, 53f, 54t

Obturator artery, 259, 259f, 297–298, 320, 320f
 Obturator canal, 231, 232f, 295
 Obturator externus, 316, 316f
 Obturator foramen, 224f, 225
 Obturator groove, 225f, 226
 Obturator internus, 230, 231t, 232f, 303
 nerve to, 251f, 254, 305
 Obturator membrane, 224f, 225
 Obturator nerve, 222, 321–322, 322f, 363b
 Obtuse margin, of heart, 106
 Occipital artery, 565
 Occipital bone, 451, 454
 squamous part, 459
 Occipital nodes, 582
 Occipitofrontalis, 487, 498f
 Occipitomastoid suture, 448
 Oculomotor nerve (III), 477–478, 477f, 478t, 515–516, 516f
 Olecranon fossa, 400
 Olfactory nerves (I), 475, 477f
 Olfactory region, of nasal cavity, 605
 Omenta, 165–166
 Omental appendices, 173
 Omental bursa, 164
 Omental (epiploic) foramen, 164, 165f
 Ophthalmic artery, branches, 495, 499
 Ophthalmic nerves (V), 477f, 478, 490, 516–518
 branches from, 615–616
 divisions of, 517f
 relationship in divisions to the muscles of the eyeball, 517f
 Ophthalmoscopy, 519f, 519b
 Optic canal, 507–508, 509f
 Optic disc, 522
 Optic nerves (II), 475, 477f, 515
 Ora serrata, 521
 Oral cancer, 617b
 Oral cavity, 616–638, 617f
 cheeks, 620
 floor, 621–627
 oral fissure and lips, 633–634, 633f
 oropharyngeal isthmus, 634
 roof (palate), 629–632, 630f
 salivary glands, 627–629
 skeletal framework, 617–620
 teeth and gingivae, 634–638
 tongue, 621–627
 walls of, 620
 Oral cavity proper, 617
 Oral fissures, 616, 633–634, 633f
 Oral group, of facial muscles, 484–486
 Oral vestibule, 617
 Orbicularis oculi, 502–503, 503f
 Orbit
 bony, 501–502, 508f
 eyeball, 519–522
 eyelid, 502–505
 facial specializations, 509–510
 fissures and foramina, 507–508
 innervation, 506, 515–519
 lacrimal apparatus, 505–506
 muscles, 510–522
 sensory innervation, 506–507
 vessels, 513–515

Orbital group, of facial muscles, 484, 487f
 Orbital septum, 503, 503f
 Orientation, of pelvis, 229, 229f
 Oropharyngeal isthmus, 634, 634f
 Oropharynx, 590
 Osteoporosis, 11b, 44b
 Ostomies, 182b
 Oval window, 528
 Ovarian arteries, 213, 213t, 260, 260f
 Ovarian cancer, 245b
 Ovarian veins, 262
 Ovaries, 245, 245f

P

Pain
 back, 45b
 referred, 33b, 125b
 Palate, 629–632, 630f
 innervation of, 632, 633f
 Palatine aponeurosis, 631f
 Palatine bones, 618–619
 Palatine branch, of ascending palatine artery, 4510
 Palatine canal, 551
 Palatine processes, 452
 Palatoglossus muscle, 624t, 630t, 631f
 Palatopharyngeal sphincter, 588
 Palatopharyngeus muscle, 586, 587t, 630t, 631f
 Palatovaginal canal, 551
 Palmar aponeurosis, 427–428, 428f
 Palmar digital artery, 434
 Palmar digital nerves, 438
 Palmar interossei, 431, 432f
 Palmar metacarpal arteries, 435
 Palmaris longus tendon, 421b–422b
 Palpebral fissure, 497b, 502
 Palsy
 facial nerve, 496b
 recurrent laryngeal nerve, 580b
 Pancreas, 183–184, 183f, 184b
 arterial supply to, 184, 185f
 visualizing, 184b
 Pancreatic cancer, 185b
 Pancreatic duct, 183f, 184
 Pancreaticoduodenal artery, inferior, 190
 Papilla, 621–622
 Papillary muscles, 111
 Para-aortic nodes, 216–217
 Paracolic gutters, 176
 Paralysis, muscle, 16b
 Paranasal sinuses, 605f, 607–609, 607f
 visualizing, 608b
 Parasternal nodes, 80, 82f, 155
 Parasympathetic fibers, 255, 256f–257f
 Parasympathetic innervation, 124
 of gastrointestinal tract, 199–200, 200f
 of glands in head, 628f
 lacrimal gland, 506–507
 nasal cavity, 616
 salivary glands, 628–629
 Parasympathetic root to ciliary ganglion, 518
 Parasympathetic system, 25, 29–31, 30f
 visceral sensory fibers in, 31
 Parathyroid glands, 570–571
 Para-urethral mucous glands (Skene's glands), 240, 241f
 Paravertebral sympathetic chain, 255, 256f–257f
 Paravertebral sympathetic trunk, 28
 Parietal pelvic fascia, 151
 Parietal pleura, 85, 87f
 innervation of, 86b
 reflections and recesses, 88f
 Parietomastoid part, of temporal bone, 449
 Parotid glands, 487–489, 489f
 stones in, 490b
 tumors in, 490f, 490b
 Parotid nodes, 500, 582–583
 Pars interarticularis fractures, 48b
 Patella, 311, 311f
 Patellar ligament, 314f, 315, 326
 Pecten pubis (pectineal line), 150, 225f, 226, 229f
 Pectinate line, 237, 238f
 Pectinate muscles, 110
 Pectoral region, of thorax, 64–66
 breast in, 64–66, 65f, 65b
 muscles of, 66, 68f, 69t
 Pectoralis major, 382, 383f, 383t
 Pectoralis minor, 66, 68f, 69t, 382, 383f, 383t
 Pedicle, of vertebra, 38
 Pelvic bone, 202, 224–226, 224f
 components of, 225–226, 225f
 linea terminalis of, 224f, 225
 Pelvic cavity, 224, 224f
 Pelvic diaphragm, 232–234, 233f, 233t
 Pelvic extensions, of prevertebral plexus, 255, 256f–257f
 Pelvic floor, 232–235
 pelvic diaphragm and, 233–234, 233f, 233t
 perineal membrane and deep perineal pouch and, 234–235, 235f, 235t
 Pelvic fracture, 230b
 Pelvic inlet, 230, 230f
 Pelvic nerves
 somatic plexus in, 251–255
 visceral plexuses in, 255
 Pelvic outlet, 224, 232, 232f
 Pelvic plexuses (inferior hypogastric plexuses), 255, 256f–257f
 Pelvic splanchnic nerves, 29–30, 198, 200, 251, 251f, 256f–257f
 Pelvic veins, 260–262, 261f
 Pelvic viscera, 236–247
 gastrointestinal system and, 236–237, 238f
 MRI in sagittal plane, 6f
 reproductive system and, 241–247, 244f
 sympathetic innervation of, 28–29, 29f
 urinary system and, 237–240, 239f
 Pelvic wall, 230–232
 apertures in, 230–232, 232f
 ligaments of, 230
 muscles of, 230, 231t, 232f
 Pelvis, 223–284
 blood vessels of, 258–262
 bones, 224–227
 fascia, 247–248, 248f
 fracture, 230b, 290b
 gender differences in, 229–230, 229f
 imaging app for, 276b, 279b, 281b

- Pelvis (*Continued*)
 joints, 227–229
 lymphatics of, 262, 262f
 measurements, in obstetrics, 232b
 nerves, 251–255
 orientation of, 229, 229f
 peritoneum, 248–250, 249f
 regional anatomy of, 224–262, 224f
 true, 230–236, 230f
- Penis, 265f, 266–267
 corona of glans, 269b–270b
 deep dorsal vein of, 274
 dorsal nerve of, 271
 erectile tissues of, 265f
 erection of, 267
 fundiform ligament of, 149, 266, 267f
- Percutaneous coronary intervention, 124b
- Perforated bowel, 165b
- Perforating arteries, of deep femoral artery, 319f, 320
- Perforating cutaneous nerve, 251f, 254, 307–308
- Perforation, of tympanic membrane, 525b–526b
- Pericardiacophrenic vessels, 103
- Pericardial effusion, 105b
- Pericarditis, 104b
- Pericardium, 102–104, 103f
 fibrous, 103, 103f
 innervation of, 104b
 nerves of, 104
 sagittal section of, 103f
 serous, 103–104, 104f
 vessels of, 104
- Pericranium, 498
- Perilymph, 530
- Perineal artery, 273, 273f
- Perineal body, 235–236, 236f
- Perineal flexure, 234
- Perineal membrane, 232, 234–235, 235f–236f, 235t, 244, 263–264, 263f
- Perineal nerve, 271–272, 272f
- Perinephric fat, 206
- Perineum, 223–284, 224f, 263f
 anal triangle and, 265, 265f, 265t
 blood vessels of, 272–274
 borders and ceiling of, 263–264, 263f
 imaging app for, 276b, 279b, 281b
 ischio-anal fossae in, anterior recesses of, 264–265, 264f
 lymphatics of, 274–275, 275f
 regional anatomy of, 224–275, 224f
 somatic nerves of, 271
 surface anatomy of, 264b
 urogenital triangle and, 263f, 265–270
 veins of, 274, 274f
 visceral nerves of, 271–272
- Prioriorbita, 509, 509f
- Periosteal layer, of dura mater, 462
- Peripheral artery pulses, in upper limb, 441b
- Peripheral nervous system, 20, 20f
 parasympathetic system, 25, 29–31, 30f
 sympathetic system, 25–29, 25f–26f
- Peripheral reflections, 86–87, 87f–88f
- Peripheral sympathetic innervation, 26–28, 27f
- Peripheral vascular disease, 320b
- Perirenal fat, 206
- Peritoneal cavity, 164–167, 165f
- Peritoneal dialysis, 164b
- Peritoneum
 of abdominal viscera, 163–164, 163f, 164b
 of abdominal wall, 153
 in men, 249f, 250
 in women, 249–250, 249f
- Persistent ductus arteriosus (PDA), 117b
- Petrosal nerve, 458, 530, 534, 555, 628–629
 grooves and hiatuses for, 530f
- Petrosal sinuses, 471–472
- Petrotympanic fissure, 534, 536
- Petrous part, of temporal bone, 454
- Phalanges, 344, 344f, 344b
 of hand, 425
- Pharyngeal branch, of maxillary artery, 556
- Pharyngeal fascia, 587
- Pharyngeal nerves, 553
- Pharyngeal recess, 590
- Pharyngeal tonsil, 590
- Pharyngeal tubercle, 454
- Pharyngeal wall
 lateral, line of attachment for, 585–586, 586f
 muscles, 586–587
- Pharyngobasilar fascia, 587
- Pharyngotympanic tube, 528, 528f
 cartilaginous part of, 619
- Pharynx, 569, 584–592, 584f
 fascia, 587
 innervation, 592f
 laryngopharynx, 590
 mucosal features of, 589f
 nasopharynx, 588–590
 nerve, 591–592
 oropharynx, 590
 pharyngeal wall, 586–587
 structures passing through gaps in, 587–588
 skeletal framework, 585–586
 vessels, 590–591
- Philtrum, 497b, 633
- Phonation, larynx role in, 601, 602f
- Phrenic arteries, inferior, 213, 213t
- Phrenic nerves, 579
 of diaphragm, 83, 205
 of superior mediastinum, 133–134
- Pia mater, 21, 57f, 58, 465
- Pigmented layer, of retina, 521
- Piriform aperture, 446
- Piriformis, 230, 231t, 232f, 303–304
 nerve to, 251f, 254
- Pisiform, 423
- Pituitary gland, surgical approach to, 609b
- Pivot joints, 12, 13f
- Plain chest radiograph, in lungs, 100b
- Plain radiography, 3–5
 image interpretation, 7–8
- Plane joints, 12
- Plantar aponeurosis, 353, 354f
- Plantar arch, 357–358
- Plantar calcaneocuboid ligament, 349, 350f
- Plantar calcaneonavicular ligament, 349
- Plantar interossei, 358t
- Plaques, atheromatous, 468b
- Platysma, 486–487
- Pleura, 84–87, 86f
 parietal, 85–87, 87f
 visceral, 85, 87
- Pleural cavities, 84–97, 86f
 lungs, 88–97, 89f
 visualizing, 91b–92b
- Pleural effusion, 88b
- Pleural recesses, 87b
 visualizing, 91b–92b
- Plexuses
 brachial, 577
 cervical, 576–577, 576f
 myenteric and submucous nerve, 31
 nerve, 32
 of pelvis
 somatic, 251–255
 visceral, 255
 pterygoid, 549–550, 550f
 somatic, 32
 visceral, 32, 32f
- Pneumonia, 101b
- Pneumothorax, 88b
- Polyhydramnios, 184b
- Popliteal artery, 329–330, 335–336, 336f
- Popliteal fossa, 329–330, 330f
 contents of, 329–330, 330f
 roof of, 330
- Popliteal nodes, 300
- Popliteal pulse, 365b
- Porta hepatis, 180
- Portal vein, 193–196, 194f
- Portosystemic anastomosis, 195b
- Positron emission tomography, 7
- Posterior abdominal region, 201–222, 201f
 abdominal wall of, 201–205, 201f
 lymphatic system in, 216–217, 216f, 216t
 nervous system in, 217
 sympathetic trunks and splanchnic nerves in, 217–222
 vasculature of, 212–215
 viscera of, 206–212
- Posterior arch, atlas and axis, 38
- Posterior auricular artery, 565
- Posterior auricular nerve, 491
- Posterior auricular vein, 500, 560
- Posterior cardiac vein, 120
- Posterior chamber, of eyeball, 519–520
- Posterior ciliary artery, 514, 520
- Posterior circumflex humeral artery, 381, 388–389
- Posterior commissure, 267b–268b
- Posterior compartment
 of forearm
 arteries and veins, 418–419
 muscles, 418
 radial nerve, 421
 of leg, 333–337
 arteries in, 335–336, 336f
 muscles in, 333–335, 334f–335f, 334t
 nerves in, 336–337, 337f
 veins in, 336
 of muscles of thigh, 316–317, 318f, 318t
- Posterior cord of brachial plexus, branches of, 396
- Posterior cranial fossa, 456t, 458, 459f
 boundaries, 458
 foramen magnum, 458–459

- Posterior cranial fossa (*Continued*)
 - grooves and foramina, 459
 - squamous part of occipital bone, 459
 - Posterior cutaneous nerve
 - of arm, 396
 - of thigh, 307
 - Posterior (dorsal), describing anatomical location, 2f, 3
 - Posterior divisions of brachial plexus, 390
 - Posterior drawer test, 328b
 - Posterior femoral cutaneous nerve, 251f, 254
 - Posterior inferior iliac spine, 225f, 226
 - Posterior intercostal arteries, 78–79, 80f
 - Posterior interosseous artery, 418–419, 420f
 - Posterior interventricular sulci, 106
 - Posterior interventricular vein, 120
 - Posterior median sulcus, 55, 55f
 - Posterior mediastinum, 135–141
 - azygos system of veins, 137–139, 139f
 - esophagus in, 135–137, 135f
 - sympathetic trunks in, 140–141
 - thoracic aorta in, 137, 138f, 138t
 - thoracic duct in, 139–140, 140f
 - Posterior nasal spine, 619
 - Posterior papillary muscles, 112
 - Posterior rami, 59
 - Posterior root, of spinal nerves, 58–59
 - Posterior sacro-iliac ligament, 228, 228f
 - Posterior scapular region
 - arteries and veins, 381
 - gateways to, 380f
 - nerves, 380–381
 - Posterior spinal artery, 56, 56f, 467
 - Posterior superior alveolar artery, 635
 - Posterior superior alveolar nerve, 554
 - Posterior superior iliac spine, 225f, 226
 - Posterior talofibular ligament, 346
 - Posterior tibial artery, 335–336, 357–358, 357f
 - Posterior tibial pulse, 365b
 - Posterior triangle, of neck, 557–558, 557f, 558b, 572–577
 - Posterior trunk
 - of internal iliac artery, 258, 258f
 - mandibular nerve, 545f
 - Posterior vagal trunk, 137, 167
 - Posterior view, of skull, 451, 451f
 - occipital bone, 451
 - temporal bone, 451
 - Posterior wall
 - of axilla, 384–386, 385t
 - of middle ear, 526
 - Posterolateral sulcus, 55, 55f
 - Postganglionic fibers, 24
 - Postganglionic sympathetic fibers, 516
 - Pouch of Douglas, 249, 249f
 - Pre-aortic nodes, 216–217
 - Pre-auricular nodes, 496, 501f, 582–583
 - Preganglionic fibers, 24
 - parasympathetic, 30–31
 - peripheral sympathetic innervation, 26–28, 27f
 - Preganglionic parasympathetic fibers, 30–31
 - Premolar teeth, 634
 - Preperitoneal fascia, 153b
 - Preprostatic part of urethra, 240, 241f
 - Prepuce
 - of clitoris, 267b–268b
 - of penis, 269b–270b
 - Pretracheal layer, of neck fascia, 559
 - Pretracheal space, 560b
 - Prevertebral layer, of neck fascia, 558–559
 - Prevertebral muscles, 576t, 577f
 - Prevertebral plexus
 - abdominal, 198–199, 199f, 217–219, 218f
 - pelvic extensions of, 255, 256f–257f
 - Princeps pollicis artery, 435
 - Procerus, 484
 - Profunda brachii artery, 404
 - Prominence of facial canal, 528
 - Promontory, 226–227, 227f
 - Pronation
 - elbow joint, 405f
 - in forearm, 412–414, 413f
 - Pronator quadratus, 416t
 - Prostate, 242f, 243–244
 - problems, 244b
 - Prostatectomy, impotence and, 258b
 - Prostatic fascia, 248, 248f
 - Prostatic part of urethra, 240, 241f
 - Prostatic sinus, 240, 241f
 - Prostatic utricle, 240, 241f
 - Proximal, describing anatomical location, 3
 - Proximal end
 - of fibula, 313, 313f
 - of radius, 400, 400f
 - of tibia, 311–313, 312f
 - shaft, 312–313, 312f
 - tibial condyles and intercondylar areas, 311–312
 - tibial tuberosity, 312
 - of ulna, 400–401, 400f
 - Proximal femur, 290–292, 291f
 - greater and lesser trochanters, 290–292
 - Proximal group of tarsal bones, 341–343
 - calcaneus, 342–343, 343f
 - talus, 341–342, 341f
 - Proximal humerus, 371–372, 372f, 372b
 - Proximal row, of carpal bones, 423
 - Psoas major, 202, 315f
 - Psoas minor, 202
 - Psoas muscle abscess, 205b
 - Pterion, 448, 449f
 - fractures, 461b
 - Pterygoid canal, 551
 - artery of, 557
 - nerve of, 554, 554f
 - Pterygoid muscles, 543
 - lateral, 543f
 - medial, 543f
 - Pterygoid plexus, 549–550, 550f
 - Pterygoid processes, 453, 619
 - Pterygomandibular raphe, 585
 - Pterygopalatine fossa, 550–557, 551f
 - fossa, 551
 - gateways, 551–552, 552f
 - maxillary artery in, 556f
 - maxillary nerve, 552–557
 - pterygopalatine ganglion, 555
 - skeletal framework, 551
 - Pterygopalatine ganglion, 555
 - Ptoxis, 505b
 - Pubic bone, 288
 - Pubic crest, 225f, 226
 - Pubic symphysis, 226, 228–229, 229f
 - Pubic tubercle, 224f–225f, 225–226
 - Pubis, 225f, 226
 - Puboanalis muscles, 234
 - Pubocervical ligament, 247–248, 248f
 - Pubococcygeus, 233f, 234
 - Pubofemoral ligament, 294
 - Puboprosthetic ligaments, 239, 239f
 - Puboprosthetic, 234
 - Puborectalis, 233f, 234
 - Pubovaginalis, 234
 - Pubovesical ligaments, 238, 239f
 - Pudendal block anesthesia, 254b
 - Pudendal nerve, 250f–251f, 252t–253t, 254, 271, 272f, 307
 - Pulled elbow, 407b
 - Pulmonary artery, 95–97, 96f
 - left, 97
 - right, 95
 - Pulmonary ligament, 89, 90f
 - Pulmonary trunk, 124–125, 126f
 - Pulmonary valve, 113, 113f
 - Pulmonary veins, 96f, 97
 - visualizing, 113b
 - Pulse points, 365b
 - head and neck, 639b
 - upper limb, 441b
 - Pyloric sphincter, 168–169
 - Pylorus, 168–169
 - Pyramidalis, 150t, 152, 152f
- ## Q
- Quadrangular membrane, 596–597, 597f
 - Quadrangular space
 - posterior scapular region, 380, 380f
 - posterior wall of axilla, 386
 - Quadrangular space syndrome, 380b
 - Quadrants
 - abdominal, 147b
 - of gluteal region, 307b
 - Quadrangle lobe, of liver, 181
 - Quadratus femoris, nerve to, 251f, 254, 305
 - Quadratus lumborum, 202
 - Quadratus plantae, 355, 356t
 - Quadriceps, injury to, 315b
- ## R
- Radial artery, 415, 419
 - Radial fossa, 399
 - Radial nerve, 402, 418, 421
 - in arm, 402f
 - superficial branch of, 438, 438f
 - Radialis indicis artery, 435
 - Radiation exposure dosages, 8t
 - Radicular arteries, superior and inferior, 56, 56f
 - Radiography
 - of foot bones, 344b
 - of head, 461b
 - of knee joint, 328b
 - of normal glenohumeral joint, 375b
 - of normal right acromioclavicular joint, 374b, 376b–377b
 - plain, 3–5
 - image interpretation, 7–8
 - Radioisotope, 7
 - Radionuclide, 7

- Radius
 - head, fracture of, 407b
 - proximal end of, 400, 400f
 - shaft and distal end, 410–411, 411f
 - Ramus
 - ischiopubic, 288
 - of mandible, 537–538
 - superior pubic, 225f, 226
 - Raphe of penis, 269b–270b
 - Rectal ampulla, 237, 238f
 - Recto-uterine fold, 249, 249f
 - Recto-uterine pouch, 249, 249f, 250b
 - Rectovaginal septum, 247–248, 248f
 - Rectovesical pouch, 250
 - Rectovesical septum, 248, 248f
 - Rectum, 176, 177f, 236–237, 238f
 - Rectus abdominis, 150t, 151–152, 152f
 - Rectus capitis posterior major, 52–53, 53f, 54t
 - Rectus capitis posterior minor, 52, 53f, 54t
 - Rectus sheath, 152, 152f
 - Recurrent laryngeal nerve, 133, 134b–135b
 - Referred pain, 33b, 125b, 175f
 - Reflexes, tendon taps
 - in lower limb, 364b
 - in upper limb, 439b
 - Regional anatomy
 - abdomen, 146–222, 146f
 - of back, 36–60
 - thorax, 64–141, 64f
 - Regional approach, to anatomy study, 2
 - Regional vertebrae, 39f–40f
 - Renal arteries, 213, 213t
 - Renal cortex, 207
 - Renal fascia, 206–207, 208f
 - Renal pelvis, 207
 - Reproductive system
 - in men, 241–244, 242f
 - in women, 244–247, 244f
 - Respiration, larynx role in, 601, 602f
 - Respiratory group, of back muscles, 50, 50t
 - Respiratory region, of nasal cavity, 605
 - Respiratory system, elements in neck, 568–569
 - Restrictive procedures, for obesity, 172b
 - Rete testis, 242–243, 242f
 - Retina, optic part of, 521–522
 - Retinacula, of foot, 352, 353f
 - Retromammary space, 65
 - Retromandibular vein, 489, 560
 - Retroperitoneal fascia, 152–153, 153b
 - Retroperitoneal lymph node surgery, 217b
 - Retropharyngeal space, 560b
 - Rheumatoid arthritis, 46b
 - Rhomboid major, 48, 48f, 49t
 - Rhomboid minor, 48, 48f, 49t
 - Rib I, 69–70
 - Rib II, 70
 - Rib X, 72
 - Rib XI, 72
 - Rib XII, 72
 - Ribs, 66, 69–72, 71f
 - cervical, 72b
 - fractures in, 72b
 - rib I, 389b
 - thoracic vertebrae in, articulation of, 68–69
 - upper and lower, distinct features of, 69–72, 72f
 - Right atrium, 109–111, 111f
 - Right auricle, 110
 - Right brachiocephalic veins, 127, 127f
 - Right bundle branch, 122–123
 - Right colic artery, 192
 - Right common carotid artery, 563
 - Right coronary artery, 117–118, 119f
 - Right ear, 523f
 - Right fibrous trigone, 117
 - Right lung, 89–90, 91f
 - Right marginal vein, 120
 - Right phrenic nerves, of superior mediastinum, 133–134
 - Right pulmonary artery, 95, 96f
 - Right pulmonary surface, of heart, 105
 - Right vagus nerves, of superior mediastinum, 132–133, 133f
 - Right ventricle, 111–112, 112f
 - Rima glottidis, 599–600
 - Rima vestibuli, 599–600
 - Risorius, 484–486
 - Roof
 - of bony orbit, 501
 - of cranial cavity, 455, 455f
 - of infratemporal fossa, 541
 - of middle ear, 526
 - of nasal cavity, 609–610, 610f
 - of oral cavity, 629–632, 630f
 - of popliteal fossa, 330, 330f
 - Root
 - of accessory nerve, 480–484
 - of brachial plexus, 389–390
 - branches, 390–393
 - of clitoris, 265f, 266
 - of lungs, 85, 89, 90f
 - of neck, 577–584, 577f
 - lymphatics, 582
 - nerves in, 579–582, 580f
 - vessels, 578–579
 - of penis, 266
 - superior root of ansa cervicalis, 568
 - Rostral, describing anatomical location, 3
 - Rotator cuff disorders, 377b
 - Rotator cuff muscles, 375–376, 376b
 - Rotatores, 52
 - Round ligament of uterus, 157, 159f–160f, 160, 249f, 250
 - Round window, 528
 - Rupture
 - of Achilles tendon, 343b
 - of biceps tendon, 401b
 - of spleen, 187b
 - urethral, 271b
- S**
- Sacculi
 - laryngeal, 599
 - of membranous labyrinth, 533
 - Sacral canal, 226–227, 227f
 - Sacral foramina, 226–227, 227f
 - Sacral hiatus, 226–227, 227f
 - Sacral plexus, 251–254, 251f, 252t–253t
 - Sacral preganglionic parasympathetic fibers, 29–30
 - Sacral splanchnic nerves, 198, 255, 256f–257f
 - Sacro-iliac joints, 228, 228f, 228b
 - Sacrospinous ligaments, 230, 231f
 - Sacrospinous ligaments, 230, 231f
 - Sacrum, 36f, 37, 39f–40f, 40, 201–202, 224, 224f, 226–227, 227f
 - Saddle joints, 12, 13f
 - Safety, in imaging, 8–9, 8t
 - Sagittal planes, 2f, 3
 - female pelvic cavity and perineum in, 279b
 - MRI of pelvic viscera in, 6f
 - vertebral column curvatures in, 43b
 - Sagittal section
 - of brain, 467f
 - of broad ligament, 249f
 - Salivary glands, 627–629
 - Salpingopharyngeal fold, 590
 - Saphenous nerve, 222, 361f, 362
 - Saphenous opening, of hip, 301, 301f
 - Saphenous vein, 298
 - Scala tympani, 532, 532f
 - Scala vestibuli, 532, 532f
 - Scalene tubercle, 69–70
 - Scalp, 496–501, 497f
 - arterial supply, 499
 - innervation, 498, 499f
 - layers, 496–498, 497f
 - lymphatic drainage, 500–501, 501f
 - meninges and, 474b
 - venous drainage, 499
 - Scaphoid, 423
 - fracture of, 426b
 - Scaphoid fossa, 619
 - Scapula, 371f
 - borders of, 370
 - movements of, 368f
 - “winging” of, 384b
 - Scarpa’s fascia, 149, 149f
 - Sciatic foramen
 - greater, 295
 - lesser, 295–297
 - Sciatic nerve, 250f–251f, 251–254, 252t–253t, 305, 306f, 307b, 322–323, 322f, 363b
 - Sclera, 504, 520–521
 - Scleral venous sinus, 520
 - Scoliosis, 44b
 - Secretomotor innervation
 - of glands in head, 628f
 - lacrimal gland, 506
 - mucous glands, 614–615
 - Segmental bronchi, 94
 - Segmental medullary arteries, 56, 56f
 - Segmental muscles, of back, 52, 53f, 54t
 - Segmental spinal arteries, 56, 56f
 - Sella turcica, 457–458
 - Semicircular canals, 530–531
 - Seminal vesicle, 242f, 243
 - Semispinalis capitis, 52
 - Semispinalis muscles, 51
 - Sensory innervation
 - of auricle, 524f
 - face, 490, 497b
 - lacrimal gland, 506
 - upper limb, testing of, 440b
 - Sensory neurons, 21, 21f
 - visceral, 24, 31
 - Sensory receptors, for balance, 533
 - Sensory root to ciliary ganglion, 518
 - Septal papillary muscles, 112

- Serous pericardium, 103–104, 104f
- Serratus anterior muscle, 383, 384t
- Serratus posterior muscles, 50, 50f, 50t
- Sesamoid bones, 10
- Shaft
 - of femur, 291–292, 292f, 310, 310f
 - of fibula, 332–333, 332f
 - of humerus, 398–400, 399f
 - of radius, 410–411, 411f
 - of tibia, 312–313, 312f, 331–332
 - of ulna, 411–412, 411f
- Shin splints, 313b
- Short bones, 10
- Shoulder, 370–379
 - bones of, 370–372
 - joints, 372–376
 - muscles, 377–379
- Shunts, ventriculoperitoneal, 164b
- Sigmoid arteries, 193
- Sigmoid mesocolon, 167
- Sigmoid sinuses, 471
- Sino-atrial node, 121, 122f
- Sinuses
 - dural venous, 469–472, 469f, 470t
 - paranasal, 605f, 607–609, 607f
 - tarsal, 343, 344f
- Sinus of venae cavae, 110
- Skeletal age, determination of, 10b
- Skeletal framework
 - of back, 36–41
 - nasal cavities, 606
 - oral cavity, 617–620
 - pharynx, 585–586
 - pterygopalatine fossa, 551
 - sternum, 72–73, 73f
 - of thorax, 68–75
 - joints, 73–75
 - ribs, 69–72, 71f
 - sternum, 72–73, 73f
 - thoracic vertebrae, 68–69
- Skeletal muscle, 15
- Skeletal system, 9–13
 - bone, 9–10
 - cartilage, 9
 - joints, 11–13, 11f
- Skene's glands, 267b–268b
- Skin, 15
 - eyelid, 502
 - layers of scalp, 496
- Skull, 446–454
 - anterior view of, 446–448, 447f
 - frontal bone, 446
 - mandible, 447–448
 - maxillae, 447
 - zygomatic and nasal bones, 446
 - base and lateral aspects of, 618f
 - external foramina, 448t
 - fractures of, 461b
 - internal foramina, 456t
 - lateral view, 448–451, 449f, 449b
 - calvaria, 448–449, 452f
 - facial skeleton, visible part of, 450–451
 - inferior view, 452, 453f
 - mandible, 451
 - temporal bone, 448–449
- Skull (*Continued*)
 - posterior view, 451, 451f
 - occipital bone, 451
 - temporal bone, 451
 - superior view, 451–452, 451f
- Small cardiac vein, 120
- Small intestine, 169–173
- Small saphenous vein, 298, 359
- Smooth muscle, 15
- Soft palate, 630
 - muscles of, 630, 630t
 - open mouth with, 634f
- Soft tissue injury, to knee, 328b
- Sole of foot, muscle layers of, 356t
- Solid joints, 11–13, 11f, 13f
- Somatic motor efferents, 22
- Somatic motor fibers, 22
- Somatic part, of nervous system, 21–22, 21f
- Somatic plexuses, 32, 32f
- Somatic sensory afferents, 22
- Somatic sensory fibers, 22
- Somites, 21, 21f
- Sound
 - of heart, 116b
 - of lungs, 93b
 - transmission of, 534–535, 535f
- Spermatic cord, 158–160, 159f–160f, 242, 242f
- Sphenoidal sinuses, 609
- Sphenoid bone, 452, 537, 551, 552f, 619
 - lesser wing of, 457
- Sphenomandibular ligament, 539, 542
- Sphenopalatine artery, 556, 613
- Sphenopalatine foramen, 551, 612–613
- Sphenoparietal suture, 448
- Sphincter
 - within deep perineal pouch, 235
 - muscle of face, 497b
 - urethral, 235, 236f, 240
- Sphincter pupillae, 521
- Sphincter urethrovaginalis, 235, 236f
- Spigelian hernia, 163b
- Spina bifida, 43b
- Spinal cord, 20, 55–60, 55f
 - features of, 55f
 - inferior ends of, 58f, 58b
 - meninges, 57–58, 57f
 - nerves of, 58–60, 59f
 - vasculature, 56–57
- Spinal fusion, 48b
- Spinal ganglion, 58–59
- Spinal nerves, 58–60
 - nomenclature of, 60, 61f
 - organization of, 59f
- Spinal segment, 59
- Spinalis, 51
- Spine of sphenoid, 537
- Spinotransversales muscles, 51, 51f, 51t
- Spinous process, 38
- Spiral ganglion, 532f, 534
- Spiral lamina, 532
- Spiral ligament, 533
- Spiral organ, 533f, 534
- Splanchnic nerves, 28–29, 197, 198f, 217–222
- Spleen, 186–187, 186f
- Splenic artery, 188–190
- Splenic vein, 193–195
- Splenius capitis, 51, 51f, 51t
- Splenius cervicis, 51, 51f, 51t
- Splenomegaly, 187b
- Spondylolisthesis, 48b
- Spongy bone, 9
- Spongy urethra, 240, 241f
- Sportsmen's groin/sportsmen's hernia, 163b
- Squamous part
 - of occipital bone, 459
 - of temporal bone, 448, 454
- Stapedius, 529t
- Stapes, 529, 529f
- Stellate ganglion, 581
- Stent graft, abdominal aortic, 213b–214b
- Sternal angle, 75, 76b
- Sternal bone marrow, collection of, 73b
- Sternoclavicular joint, 373, 373f, 373b
- Sternocostal joints, 73–74, 74f
- Sternohyoid muscle, 563
- Sternum, 66, 72, 73f
 - body of, 72–73
 - manubrium of, 72
 - xiphoid process in, 73
- Stomach, 168–169, 168f
 - sympathetic innervation of, 200–201
 - visualizing, 169b
- Stones
 - bladder, 240b
 - in parotid gland, 490b
- Straight sinus, 469–471
- Strangulation, of hernia, 163b
- Stroke, 468b
- Stylohyoid muscle, 562
- Styloid process, 449
 - of temporal bone, 618f
- Stylomandibular ligament, 539
- Stylomastoid foramen lesions, 496b
- Subarachnoid hemorrhage, 473f, 473b
- Subarachnoid space, 57–58, 465–466
 - inferior ends of, 58f, 58b
- Subclavian arteries, 467, 573, 578–579
- Subclavian vein, 575, 579
- Subclavius muscle, 66, 68f, 69t, 382, 383f, 383t
 - nerve to, 394
- Subcostal muscle, 78, 79f
- Subcostal nerve, 81, 153–154
- Subcostal plane, of abdomen, 147
- Subcutaneous tissue, of eyelid, 502
- Subdivisions
 - of anterior triangle of neck, 571, 573t
 - functional, of central nervous system, 21–32
- Subdural hematoma, 473f, 473b
- Subdural space, 465
- Sublingual glands, 623f, 627–628
- Submandibular ganglion, 546
- Submandibular glands, 623f, 627
- Submandibular nodes, 495, 583
- Submandibular triangle, 561
- Submental nodes, 495, 583
- Submental triangle, 561
- Suboccipital muscles, 52–53, 54f, 54t
- Suboccipital triangle, 53, 54f
- Subphrenic recess, 180
- Subpopliteal recess, 324

- Subscapular artery, 387–388
 - Subtalar joint, 348, 348f
 - Subtraction angiography, 4–5, 5f
 - Sulci, of heart, 106, 109f
 - Sulcus tali, 341
 - Sulcus terminalis cordis, 109–110
 - Superficial cervical lymph nodes, 583
 - Superficial, describing anatomical location, 3
 - Superficial fascia, 15
 - abdominal, 148–149, 148f–149f
 - of urogenital triangle, 270, 271f
 - Superficial fibular nerve, 337–338, 338f, 361f, 362
 - Superficial group of muscles
 - in back, 48–50, 48f, 49t
 - in posterior compartment of leg, 334, 334f, 334t
 - Superficial inguinal nodes, 155, 275, 275f, 299
 - Superficial inguinal ring, 157, 158f
 - Superficial layer, forearm muscles, 414, 414f
 - anterior compartment, 414t
 - posterior compartment, 418, 419f, 419t
 - Superficial lymph nodes, 582–583
 - Superficial palmar arch, 434, 434f
 - Superficial perineal pouch, structures in, 266–267, 267f
 - Superficial temporal artery, 565
 - Superficial veins, of neck, 560f
 - Superior articular processes, 68
 - Superior bulb of jugular vein, 565
 - Superior cervical ganglion, 28, 516, 581
 - Superior costal facet, 68
 - Superior costotransverse ligament, 73
 - Superior, describing anatomical location, 2f, 3
 - Superior epigastric artery, 79
 - Superior gemellus, nerve to, 251f, 254
 - Superior gluteal artery, 258, 258f, 297–298, 308
 - Superior gluteal nerve, 251f, 254, 305
 - Superior hypogastric plexus, 199, 217, 255, 256f–257f
 - Superior labial artery, 613
 - Superior laryngeal artery, 602
 - Superior laryngeal nerves, 603–604
 - Superior laryngeal veins, 603
 - Superior mediastinum, 126–135, 127f, 128b
 - aorta and its branches, arch of, 130–131
 - left superior intercostal vein in, 129, 129f
 - nerves of, 131–134
 - right and left brachiocephalic veins in, 127
 - superior vena cava in, 129
 - thoracic duct in, 135
 - with thymus and venous channels removed, 130f
 - thymus in, 127, 127b, 128f
 - with thymus removed, 128f
 - trachea and esophagus in, 131, 132f
 - visualizing structures in, 128b, 134b
 - Superior mesenteric artery, 190–192
 - branching of, 191f
 - distribution of, 191f
 - Superior mesenteric vein, 195–196
 - Superior oblique, 511t, 512
 - Superior ophthalmic vein, 514
 - Superior orbital fissure, 458, 507, 509f
 - Superior part, of duodenum, 169
 - Superior petrosal sinuses, 471–472
 - Superior phrenic arteries, 83
 - Superior pubic ligament, 229, 229f
 - Superior pubic ramus, 225f, 226
 - Superior rectal artery, 193
 - Superior sagittal sinus, 469
 - Superior subscapular nerve, 396
 - Superior thoracic aperture, 67, 68f–69f
 - Superior thoracic artery, 387
 - Superior thyroid artery, 565, 565t, 569
 - Superior vena cava, 129, 130b
 - Superior vesical artery, 259, 259f
 - Superior view, of skull, 451–452, 451f
 - Supination
 - elbow joint, 405f
 - in forearm, 412–414, 413f
 - Supraclavicular cervical nerve, 577
 - Supracondylar fracture, of humerus, 407b
 - Supracondylar lines, 310
 - Suprahyoid muscle, 562, 563f
 - Supra-orbital artery, 514
 - Supra-orbital nerve, 490, 498
 - Suprapatellar bursa, 324
 - Suprapleural membrane, 85
 - Suprapubic catheterization, 240b
 - Suprarenal glands, 210–212
 - Suprascapular artery, 381
 - Suprascapular foramen, 379–380
 - Suprascapular nerve, 380–381, 393
 - Supraspinatus tendon, 377b
 - Supraspinous ligament, 46–47, 47f
 - Suprasternal notch, 72
 - Supratrochlear artery, 514
 - Supratrochlear nerve, 490, 498
 - Supreme intercostal artery, 78, 579
 - Sural nerve, 336–337, 337f, 361f, 362
 - Surfaces
 - of heart, 105, 107f–108f
 - inferolateral, of bladder, 238, 239f
 - of tongue, 621
 - inferior, 622
 - pharyngeal, 622–624
 - Surfer's ear, 524b
 - Surgery
 - approach to pituitary gland, 609b
 - for obesity, 172b
 - Surgical neck of humerus, 372, 372f
 - Suspensory ligament
 - of clitoris, 266, 267f
 - of eyeball, 510
 - of lens, 521
 - of ovary, 249f, 250, 260
 - of penis, 266, 267f
 - Suspensory muscle, of duodenum, 169
 - Sustentaculum tali, 342
 - Sutural ligament, 13
 - Sutures, 13, 14f
 - skull, 448, 451f
 - Swallowing, larynx role in, 601, 602f
 - Swimmer's ear, 524b
 - Sympathetic fibers, 255, 256f–257f
 - Sympathetic innervation, 124
 - of glands in head, 629f
 - lacrimal gland, 507
 - nasal cavity, 616
 - Sympathetic nervous system
 - cervical part of the sympathetic trunk, 581, 581f
 - ganglia, 581–582
 - Sympathetic root to ciliary ganglion, 518–519
 - Sympathetic system, 25–29, 25f–26f
 - visceral sensory fibers in, 31
 - Sympathetic trunks, 197–198, 197f, 217–222
 - of pelvis, 251f, 256f–257f
 - in posterior mediastinum, 140–141, 141f
 - Symphyses, 13, 14f
 - between vertebral bodies, 42–43, 45f
 - Synchondroses, 13, 14f
 - Syndesmoses, 13, 14f
 - Synovial joints, 11–12, 11f
 - descriptions based on shape and movement, 12
 - types of, 12, 13f
 - Synovial membrane, 11, 294, 294f, 324, 325f
 - of elbow joint, 405, 405f
 - of glenohumeral joint, 375f
 - Synovial sheaths, of hand, 429f
 - Systemic approach, to anatomy study, 2
- ## T
- Tail, of epididymis, 242f
 - Talocalcaneonavicular joint, 348–349, 349f
 - Talus, 341–342, 341f
 - fracture of, 342b
 - Tarsal bones, 340–343
 - distal group of, 341f, 343
 - intermediate, 343
 - proximal group, 341–343
 - calcaneus, 342–343, 343f
 - talus, 341–342, 341f
 - Tarsal glands, 504
 - Tarsal plates, 503f, 504
 - Tarsal sinus, 343, 344f
 - Tarsal tunnel, 351–352, 351f, 352b
 - Tarsometatarsal joint, 350, 350f
 - Tarsus, 503–504, 503f
 - Tears
 - in cruciate ligaments, 328b
 - in supraspinatus tendon, 377b
 - Technetium-99m, 7
 - Tectorial membrane, 46
 - Teeth, 634–638
 - innervation, 637–638
 - successive sets of, 634
 - vessels, 635–636
 - Tegmental wall, of middle ear, 526
 - Telencephalon, 466
 - Temporal and infratemporal fossae, 535–550, 535f
 - bony framework, 536–538, 536f
 - infratemporal fossa, 541–550, 542f
 - masseter muscle, 540, 540f
 - temporal fossa, 540–541, 541f
 - temporomandibular joints, 538–539, 538f
 - Temporal bone, 448–449, 536–537, 619
 - facial nerve, 534, 535f
 - lateral view, 448–449
 - middle cranial fossa, 458
 - petrous part, 454
 - posterior view, 451
 - styloid process of, 618f

- Temporal pulse, 639b
- Temporalis, 540–541, 541f
- Temporomandibular joints, 538–539, 538f
 - disorders, 539b
 - extracapsular ligaments, 539
 - joint capsule, 539
 - ligaments associated, 539f
 - movements of, 539, 539f
- Tendinous arch, 233f, 234
- Tendinous intersections, 151–152
- Tendons, 12
 - in distal forearm, 421b–422b
 - identifying, 421b–422b
 - of rotator cuff muscles, 375–376
 - of wrist, 426
- Tendon taps, 364b
- Tennis elbow, 407b
- Tenosynovitis, 429b
- Tensor fasciae latae, 301
- Tensor tympani, 529t
- Tensor veli palatini muscles, 630, 630t, 631f
- Tentorium cerebelli, 457, 463
- Testes, 242–243, 242f
 - descent of, 156f
- Testicular arteries, 213, 213t, 274
- Testicular tumors, 243b
- Testosterone, exogenous, 601b
- Thenar muscles, 431, 433f
- Thigh, 286, 309–330, 309f
 - arteries of, 317–320
 - bones of, 309–313, 310f
 - deep artery of, 317–320, 319f
 - knee joint, 323–328, 323f
 - lateral cutaneous nerve of, 219t, 221
 - muscles of, 313–317
 - anterior compartment, 313–315, 314f, 315t
 - medial compartment, 316, 316f, 317t
 - posterior compartment, 316–317, 318f, 318t
 - nerves of, 321–323
 - posterior cutaneous nerve of, 307
 - tibiofibular joint, 329, 329f
 - veins of, 321
- Third occipital nerve, 498
- Third space within prevertebral layer of neck, 560b
- Thoracic aorta, in posterior mediastinum, 137, 138f, 138t
- Thoracic duct
 - in posterior mediastinum, 139–140, 140f
 - in root of neck, 582, 582f
 - in superior mediastinum, 135
- Thoracic outlet syndrome, 67
- Thoracic spinal nerve, 25f
- Thoracic splanchnic nerves, 197–198
- Thoracic vertebrae, 36, 36f, 38, 39f–40f, 68–69, 71f
 - articulation with ribs, 68–69
 - typical, 37b, 68, 70f
 - variations in number of, 44b
- Thoracic viscera, sympathetic innervation of, 28, 28f
- Thoracic wall, 64f, 66–81
 - arteries of, 80f
 - inferior thoracic aperture in, 67, 70f
 - intercostal spaces of, 77f, 78
- Thoracic wall (*Continued*)
 - lymphatic vessels and nodes of, 82f
 - movement of, during breathing, 84, 85f
 - muscles of, 78t
 - skeletal framework of, 68–75
 - superior thoracic aperture, 67, 68f–69f
 - veins of, 81f
- Thoracoacromial artery, 387
- Thoracolumbar fascia, 53–55, 54f
- Thoracostomy, 82b
- Thorax, 64, 64f
 - diaphragm, 81–84
 - mediastinum, 97–141
 - pectoral region, 64–66
 - pleural cavities, 84–97
 - regional anatomy, 64–141, 64f
 - thoracic wall, 66–81
- Thrombosis, deep vein, 298b
- Thumb
 - hyperextension and abduction, 421b–422b
 - movements of, 369f
- Thymus, 127, 128f
 - ectopic parathyroid glands in, 127b
- Thyro-arytenoid muscle, 600t, 601f
- Thyrocervical trunk, 579
- Thyrohyoid membrane, 595
- Thyrohyoid muscle, 563
- Thyroid cartilage, 594, 594f
 - inferior tubercle, 586
- Thyroid gland, 569–570
 - how to find, 572f, 572b
- Thyroid ima artery, 131
- Thyroidectomy, 571b
- Tibia, 332f
 - condyles and intercondylar areas of, 311–312
 - popliteal fossa, 329–330
 - proximal end of, 311–313, 312f
 - shaft and distal end of, 331–332
 - shaft of, 312–313, 312f
- Tibial nerve, 329, 336–337, 337f, 360–361, 360f
- Tibial part, sciatic nerve to, 251f
- Tibial tuberosity, 312
- Tibialis anterior, 339t
- Tibiofibular joint, 329, 329f
- Tic douloureux, 491b
- TIV vertebral level, visualizing structures at, 132b
- TIV/V vertebral level, 75, 75f
 - visualizing structures at, 76b
- Toes, fibrous sheaths of, 353–354, 354f
- Tongue, 621–627, 623f
 - innervation, 625, 625f
 - lymphatics, 626–627
 - muscles, 624, 624t, 625f
 - papillae, 621–622
 - surfaces of, 621–624
 - vessels, 624–625
- Tonsils, 590
 - lingual, 590, 622–624
 - palatine, 590
 - pharyngeal, 590
- Torus levatorius, 590
- Torus tubarius, 590
- Total hip replacement, 14f
- Trabeculae, arachnoid, 57
- Trabeculae carnea, 111
- Trachea, 90–94
 - in superior mediastinum, 131, 132f
- Tracheobronchial injury, 569b
- Tracheostomy, 603b
- Tragus, 522
- Trans/non-binary anatomical terminology, 3
- Transmission of sound, 534–535, 535f
- Transplantation, bone marrow, 10b
- Transpyloric plane, of abdomen, 147
- Transversalis fascia, 15, 151
- Transverse arch, of foot, 353, 353f
- Transverse cervical artery, 573–575, 579
- Transverse cervical nerve, 567–568, 568f, 577
- Transverse cervical or cardinal ligament, 247–248, 248f
- Transverse costal facet, 38, 68
- Transverse facial artery, 488, 493–494
- Transverse facial vein, 495
- Transverse ligament, of atlas, 38
- Transverse mesocolon, 167
- Transverse pericardial sinus, 104
- Transverse perineal muscle, deep, 235, 236f
- Transverse plane, 2f, 3
- Transverse process, 38, 68
- Transverse sinuses, 471
- Transversospinales muscles, 51–52, 53f, 53t
- Transversus abdominis, 150t, 151
 - aponeurosis and, 151f
 - inguinal canal and, 159f
- Transversus thoracis muscle, 78, 79f
- Trapezium, 423
- Trapezius, 48–49, 49t, 377, 378f
 - innervation and blood supply of, 49f
- Trendelenburg's sign, 305b
- Triangular interval, posterior wall of axilla, 386
- Triangular space
 - posterior scapular region, 380
 - posterior wall of axilla, 386
- Triceps brachii, 402t
- Tricuspid valve, 112–113
- Trigeminal innervation, of scalp, 498
- Trigeminal nerves (V), 476t, 477f, 478
 - cutaneous distribution of, 492f
 - leaving the skull, 491f
- Trigeminal neuralgia, 491b
- Trigger finger, 429b
- Trigone, 237–238, 239f
- Trochanters, 290–292, 291f
- Trochlea of humerus, 399
- Trochlear nerves, 476t, 477f, 478, 481b, 516, 516f
- True epididymis, 242f
- True pelvis (lesser pelvis), 224, 224f, 230–236, 230f
 - pelvic floor, 232–235
 - pelvic inlet, 230, 230f
 - pelvic outlet, 232, 232f
 - pelvic wall, 230–232
 - perineal body, 235–236, 236f
- True ribs, 69
- Trunks
 - brachial plexus, 390
 - branches, 393–394
 - costocervical, 579
 - internal iliac artery and, 258–260, 258f
 - lymphatic, 19, 19f, 583f

- Trunks (*Continued*)
 paravertebral sympathetic, 28
 sympathetic, 251f, 256f–257f
 thyrocervical, 579
- Tubal ligation, 246b
- Tubercle, of ribs, 69
- Tuberculum of iliac crest, 225f, 226
- Tuberosity, tibial, 312
- Tubes, uterine, 246, 246f
- Tumors
 in parotid gland, 490f, 490b
 testicular, 243b
- Tunica
 albuginea, 242–243, 242f
 vaginalis, 242, 242f
- Tunica externa (adventitia), 16
- Tunica intima, 16
- Tunica media, 16
- Tunicae, of blood vessels, 16
- Tympanic membrane, 524–525, 525f
 perforation of, 525b–526b
- Tympanic nerve, 480
- Tympanic part, of temporal bone, 449, 536
- U**
- Ulceration, duodenal, 172b
- Ulna
 abduction during pronation, 413–414, 413f
 proximal end of, 400–401, 400f
 shaft and distal end, 411–412, 411f
- Ulnar artery, 415–417, 426
- Ulnar nerve, 395, 401f, 402, 417–418, 436, 436f
- Ultrasonography, of head, 461b
- Ultrasound, 5
 abdominal, 5f
 Doppler, 5
 of urinary tract, 211b
- Umbilical artery, 258–259, 259f
- Umbilical hernias, 163b
- Umbo of tympanic membrane, 524
- Uncovertebral joints, 45, 45f
- Undescended testes, 242b
- Upper limb, 367–442
 anterior view of, 368f
 arm, 398–404, 398f
 axilla, 381–397, 382f
 cubital fossa, 408–409, 408f–409f
 dermatomes and myotomes, 439b
 elbow joint, 405–406
 forearm, 410–414, 410f
 anterior compartment of, 414–418
 posterior compartment of, 418–421
 hand, 422–438
 posterior scapular region, 379–381, 379f
 regional anatomy of, 368–438
- Ureteropelvic junction, 209
- Ureters, 208–209, 209f, 237, 239f
 innervation of, 209
 vasculature and lymphatics of, 209
- Urethra, 239f, 240, 241f
 in men, 240
 in women, 240
- Urethral artery, 273, 273f
- Urethral catheterization, 241b
- Urethral crest, 240, 241f
- Urethral rupture, 271b
- Urethral sphincter, external, 235, 236f
- Urinary system, pelvic viscera and, 237–240, 239f
- Urinary tract cancer, 210b
- Urinary tract stones, 210b
- Urogenital hiatus, 233f, 234, 263
- Urogenital triangle, 263, 263f
 superficial fascia of, 270, 271f
- Urological contrast studies, 8
- Uterine artery, 259–260, 259f–260f
- Uterine tubes, 246, 246f
- Uterosacral ligament, 247–248, 248f
- Uterus, 245–246, 246f
- Utricle, 533
- V**
- Vagal trunks, 167
- Vagina, 247, 247f–248f
- Vaginal artery, 259, 260f
- Vaginal fornix, 247, 247f–248f
- Vaginal vault, 247, 248f
- Vagus nerve (X), 200, 480, 566, 566f, 580
 pharyngeal branch, 591
 of superior mediastinum, 131–133, 134b–135b
- Vallate papillae, 622
- Valve disease, 116b
- Valves, anal, 237, 238f
- Varicose veins, 17b, 298b
- Vas deferens, 242
- Vascular compartments, of neck, 445f, 446
- Vascular layer, of eyeball, 521
- Vascular supply, of knee joint, 328
- Vasculature
 eyelids, 504f
 facial, 494f
 of posterior abdominal region, 212–215
 renal, 208, 209f
 of root of neck, 578f
 scalp, 500f
 suprarenal, 211–212, 211f
 thyroid gland, 571f
 ureteric, 209
- Vasectomy, 243b
- Veins, 16, 381, 417, 419
 in anterior compartment of leg, 340
 of arm, 404
 azygos system of, in posterior mediastinum, 137–139, 139f
 emissary, 472b
 facial, 495
 in foot, 359, 360f
 of gluteal region, 308
 of hand, 435
 harvesting for grafts, 299b
 in lateral compartment of leg, 336
 of lower limb, 298f
 of neck, 565
 of orbit, 514–515
 pelvic, 260–262, 261f
 of perineum, 274, 274f
 in posterior compartment of leg, 336
 pterygoid plexus of, 550f
 of pterygopalatine fossa, 557, 557f
- Veins (*Continued*)
 in root of neck, 579
 of spinal cord, 57, 57f
 of teeth and gingivae, 636
 of thigh, 321
 of tongue, 625
- Veins of Thebesius, 120
- Venae cordis minimae, 120
- Venous access
 for central and dialysis lines, 130b
 central, via subclavian/axillary vein, 389b
- Venous drainage
 of abdominal viscera, 193–196
 of abdominal wall, 155
 of auricle, 524
 of brain, 469–472
 of breast, 66
 of diaphragm, 83
 of esophagus, 136
 of eyeball, 515f, 520
 of eyelid, 504
 of gastrointestinal tract, 194f
 of intercostal spaces, 80, 81f
 of internal ear, 534
 of larynx, 603, 604f
 of nasal cavities, 614, 615f
 of palate, 631–632, 632f
 of pharynx, 591, 591f
 of scalp, 499
 superficial, of neck, 560–561
 of thyroid gland, 570
- Ventricles
 cerebral, 20
 laryngeal, 599
- Ventricular septal defect (VSD), 117b
- Ventriculoperitoneal shunts, 164b
- Vertebrae
 cancer and, 44b
 cervical, 36, 36f, 36b, 38
 fractures of, 47b
 joints of, 42–45
 lumbar, 36f, 37–40, 39f–40f, 201–202
 thoracic, 36, 36f, 38, 39f–40f
 variations in number of, 44b
- Vertebral arch, 38
 posterior spaces between, 41, 42f
- Vertebral arteries, 467, 468b, 578
- Vertebral body, 37
- Vertebral canal, 38
 anesthesia within, 60b
 arrangement of structures in, 58, 59f
 spinal nerves in, 60f
- Vertebral column
 anterior and posterior longitudinal ligaments of, 46f
 cervical region of, 36b
 clinical, 47b
 curvatures of, 41, 43f
- Vertebral compartments, of neck, 445, 445f
- Vertebral foramen, 68
- Vertebral notches, superior and inferior, 38
- Vertebroplasty, 43b–44b
- Vertex
 innervation of scalp anterior to, 498
 innervation of scalp posterior to, 498
- Vertical muscles, of abdomen, 151–152
- Vesico-uterine pouch, 249, 249f

Vessels, of pericardium, 104
Vestibular aqueduct, 531
Vestibule, 267b–268b, 530–531, 599
 of laryngeal cavity, 599
Vestibulocochlear nerves (VIII), 479–480
Visceral afferent fibers, 255
Visceral afferents, 31, 124
Visceral compartments, of neck, 445f, 446
Visceral nerves, of perineum, 271–272
Visceral part, of nervous system, 21, 23–25, 24f
Visceral pleura, 85, 86f, 87
 innervation of, 86b
Visceral plexuses, 32, 32f
 of pelvis, 255, 256f–257f
Visceral sensory innervation, 31
Vitreous humor, 520
Vocal cord mass, 601b
Vocalis muscle, 600t, 601f
Vomer, 452
Vorticose veins, 520
Vulva, 267b–268b

W

Walls
 of eyeball, 520
 lateral pharyngeal, line of attachment for, 585–586, 586f
 of nasal cavity, 609–611
 oral cavity, 620
White matter, 20, 55f, 56
White ramus communicans, 25
“Winging,” of scapula, 384b
Women
 heart attack, symptoms of, 125b
 pelvic fascia in, 247–248, 248f
 peritoneum in, pelvic, 249–250, 249f
 reproductive system in, 244–247, 244f
 urethra of, anatomy of, 240, 241f
Wrist, carpal tunnel and structures at, 426–427, 427f
Wrist drop, 439b
Wrist joint, 424b, 425

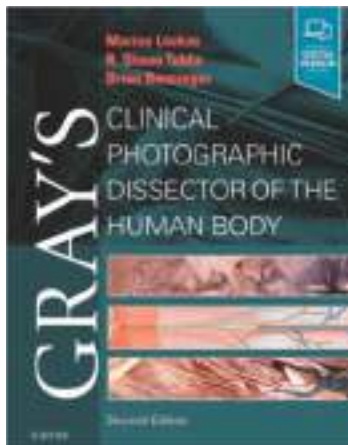
X

Xiphisternal joints, 74f, 75
Xiphoid process, 73, 73f
X-rays, cathode ray tube for production of, 3, 4f

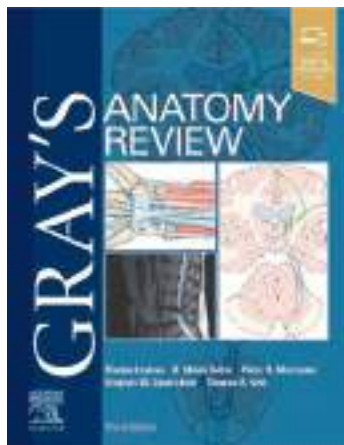
Z

Zonular fibers, 521
Zygapophyseal joints, 44–45, 45f, 227, 228f
Zygomatic bones, 446, 450, 537
Zygomatic nerve, 553–554
Zygomatic process, 446–449
Zygomaticofacial branch, 490
 of zygomatic nerve, 554
Zygomaticotemporal branch, 490
 of zygomatic nerve, 553–554
Zygomaticotemporal nerve, 498, 541
Zygomaticus major, 484–486
Zygomaticus minor, 484–486

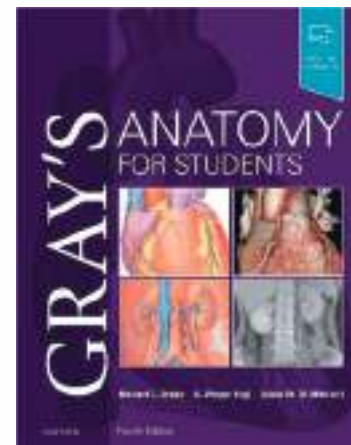
TRUST Gray's



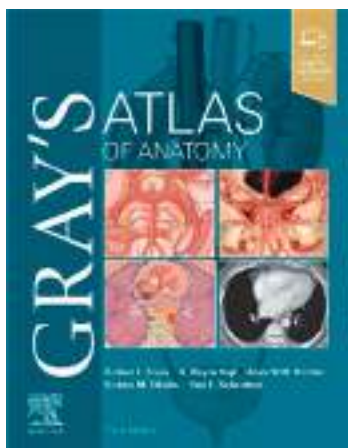
Gray's Clinical Photographic
Dissector of the Human Body 2e
ISBN: 9780323544177



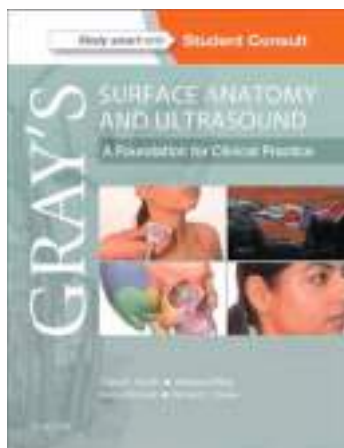
Gray's Anatomy Review 3e
ISBN: 9780323639163



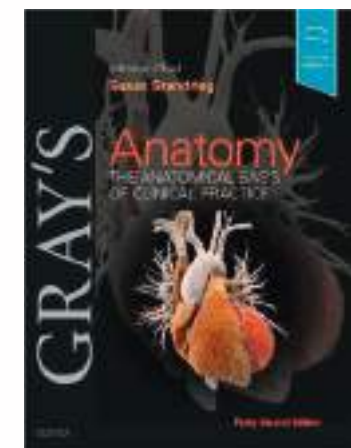
Gray's Anatomy for Students 4e
ISBN: 9780323393041



Gray's Atlas of Anatomy 3e
ISBN: 9780323636391

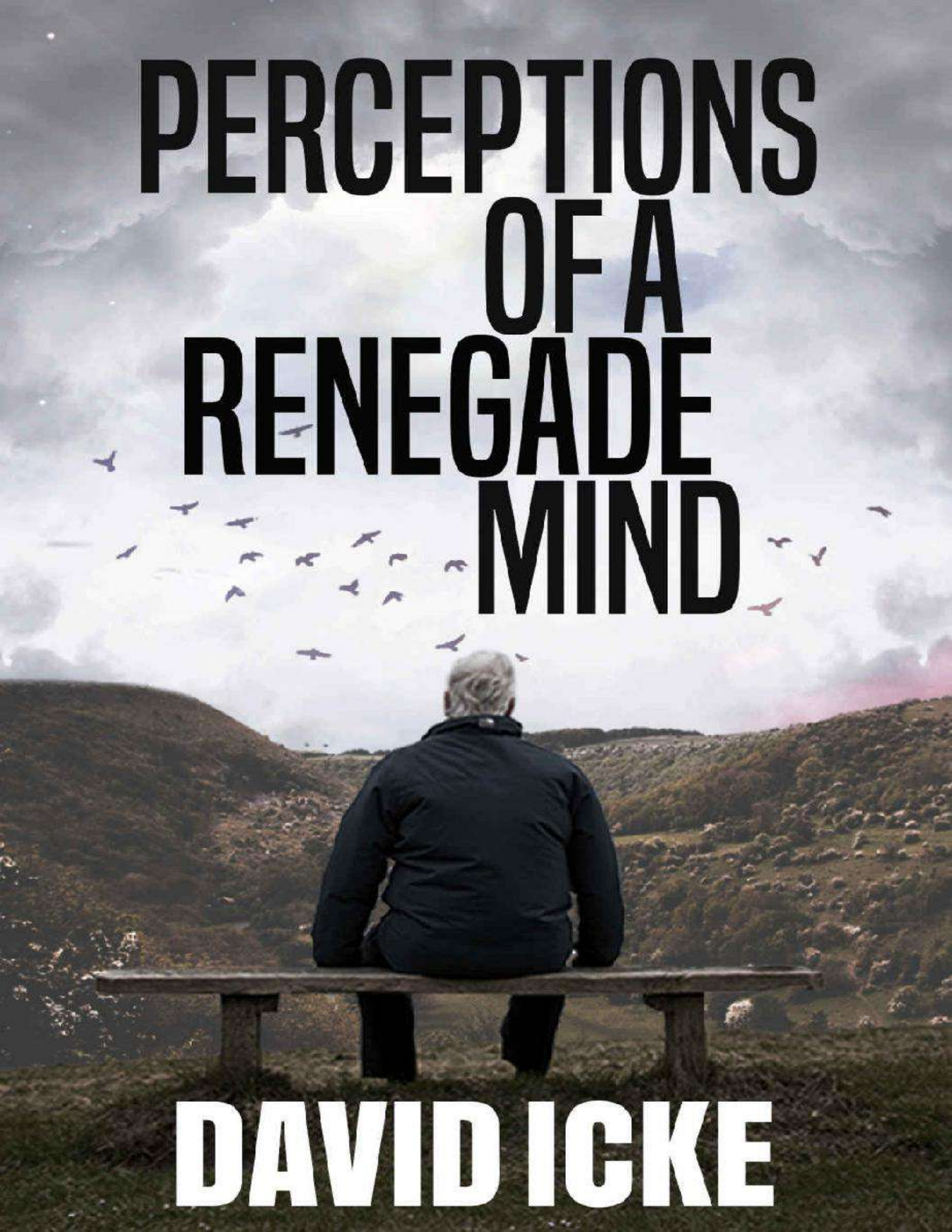


Gray's Surface Anatomy
and Ultrasound
ISBN: 9780702070181



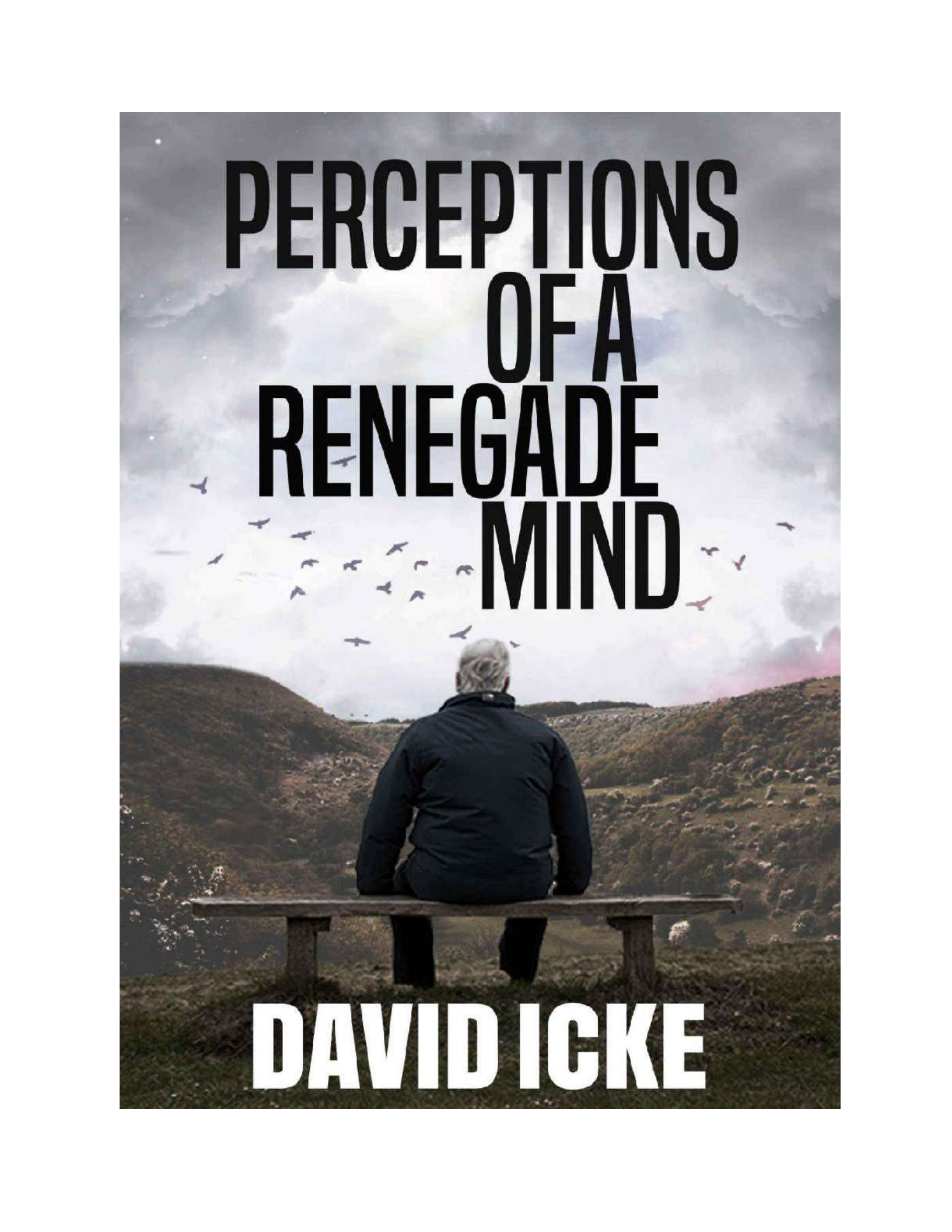
Gray's Anatomy 42e
The Anatomical Basis for
Clinical Practice
ISBN: 9780702077050

www.elsevierhealth.com

A person with grey hair, wearing a dark jacket, is seen from behind, sitting on a wooden bench. They are looking out over a vast, hilly landscape under a dramatic, cloudy sky. A large flock of birds is flying in the sky, and a faint rainbow is visible on the right side. The title 'PERCEPTIONS OF A RENEGADE MIND' is overlaid in large, bold, black letters.

PERCEPTIONS OF A RENEGADE MIND

DAVID ICKE



PERCEPTIONS OF A RENEGADE MIND

DAVID ICKE

PERCEPTIONS OF A RENEGADE MIND



ickonic
publishing

First published in July 2021.

ickonic
publishing

**New Enterprise House
St Helens Street
Derby
DE1 3GY
UK**

email: gareth.icke@davidicke.com

Copyright © 2021 David Icke

No part of this book may be reproduced in any form without permission from the Publisher, except for the quotation of brief passages in criticism

Cover Design: Gareth Icke
Book Design: Neil Hague

**British Library Cataloguing-in
Publication Data**

A catalogue record for this book is
available from the British Library

eISBN 978-18384153-1-0

PERCEPTIONS OF A RENEGADE MIND



DAVID ICKE

Dedication:

To Freeeeedom!

ICKONIC

THE ALTERNATIVE

NEW. DIFFERENT. REVOLUTIONARY

**HUNDREDS OF CUTTING EDGE DOCUMENTARIES,
FEATURE FILMS, SERIES & PODCASTS.**

SIGN UP NOW AT ICKONIC.COM

THE LIFE STORY OF DAVID ICKE

RENEGADE

THE FEATURE LENGTH FILM



AVAILABLE NOW AT DAVIDICKE.COM

Renegade:

Adjective

‘Having rejected tradition: Unconventional.’

Merriam-Webster Dictionary

Acquiescence to tyranny is the death of the spirit

You may be 38 years old, as I happen to be. And one day, some great opportunity stands before you and calls you to stand up for some great principle, some great issue, some great cause. And you refuse to do it because you are afraid ... You refuse to do it because you want to live longer ... You're afraid that you will lose your job, or you are afraid that you will be criticised or that you will lose your popularity, or you're afraid that somebody will stab you, or shoot at you or bomb your house; so you refuse to take the stand.

Well, you may go on and live until you are 90, but you're just as dead at 38 as you would be at 90. And the cessation of breathing in your life is but the belated announcement of an earlier death of the spirit.

Martin Luther King

**How the few control the many and always have – the many do
whatever they're told**

'Forward, the Light Brigade!'
Was there a man dismayed?
Not though the soldier knew
Someone had blundered.
Theirs not to make reply,
Theirs not to reason why,
Theirs but to do and die.
Into the valley of Death
Rode the six hundred.

Cannon to right of them,
Cannon to left of them,
Cannon in front of them
Volleyed and thundered;
Stormed at with shot and shell,
Boldly they rode and well,
Into the jaws of Death,
Into the mouth of hell
Rode the six hundred

Alfred Lord Tennyson (1809-1892)

The mist is lifting slowly
I can see the way ahead
And I've left behind the empty streets
That once inspired my life
And the strength of the emotion
Is like thunder in the air
'Cos the promise that we made each other
Haunts me to the end

The secret of your beauty
And the mystery of your soul
I've been searching for in everyone I meet
And the times I've been mistaken
It's impossible to say
And the grass is growing
Underneath our feet

The words that I remember
From my childhood still are true
That there's none so blind
As those who will not see
And to those who lack the courage
And say it's dangerous to try
Well they just don't know
That love eternal will not be denied

I know you're out there somewhere
Somewhere, somewhere
I know you're out there somewhere

Somewhere you can hear my voice
I know I'll find you somehow
Somehow, somehow
I know I'll find you somehow
And somehow I'll return again to you

The Moody Blues

Are you a gutless wonder - or a Renegade Mind?

Monuments put from pen to paper,
Turns me into a gutless wonder,
And if you tolerate this,
Then your children will be next.
Gravity keeps my head down,
Or is it maybe shame ...

Manic Street Preachers

Rise like lions after slumber
In unvanquishable number.
Shake your chains to earth like dew
Which in sleep have fallen on you.
Ye are many – they are few.

Percy Shelley

Contents

CHAPTER 1	'I'm thinking' – Oh, but <i>are</i> you?
CHAPTER 2	Renegade perception
CHAPTER 3	The Pushbacker sting
CHAPTER 4	'Covid': The calculated catastrophe
CHAPTER 5	There <i>is no</i> 'virus'
CHAPTER 6	Sequence of deceit
CHAPTER 7	War on your mind
CHAPTER 8	'Reframing' insanity
CHAPTER 9	We must have it? So what is it?
CHAPTER 10	Human 2.0
CHAPTER 11	Who controls the Cult?
CHAPTER 12	Escaping Wetiko
POSTSCRIPT	
APPENDIX	Cowan-Kaufman-Morell Statement on Virus Isolation
BIBLIOGRAPHY	
INDEX	

CHAPTER ONE

I'm thinking' – Oh, but *are* you?

Think for yourself and let others enjoy the privilege of doing so too
Voltaire

French-born philosopher, mathematician and scientist René Descartes became famous for his statement in Latin in the 17th century which translates into English as: 'I think, therefore I am.'

On the face of it that is true. Thought reflects perception and perception leads to both behaviour and self-identity. In that sense 'we' are what we think. But who or what is doing the thinking and is thinking the only route to perception? Clearly, as we shall see, 'we' are not always the source of 'our' perception, indeed with regard to humanity as a whole this is rarely the case; and thinking is far from the only means of perception. Thought is the village idiot compared with other expressions of consciousness that we all have the potential to access and tap into. This has to be true when we *are* those other expressions of consciousness which are infinite in nature. We have forgotten this, or, more to the point, been manipulated to forget.

These are not just the esoteric musings of the navel. The whole foundation of human control and oppression is control of perception. Once perception is hijacked then so is behaviour which is dictated by perception. Collective perception becomes collective behaviour and collective behaviour is what we call human society. Perception is all and those behind human control know that which is

why perception is the target 24/7 of the psychopathic manipulators that I call the Global Cult. They know that if they dictate perception they will dictate behaviour and collectively dictate the nature of human society. They are further aware that perception is formed from information received and if they control the circulation of information they will to a vast extent direct human behaviour. Censorship of information and opinion has become globally Nazi-like in recent years and never more blatantly than since the illusory 'virus pandemic' was triggered out of China in 2019 and across the world in 2020. Why have billions submitted to house arrest and accepted fascistic societies in a way they would have never believed possible? Those controlling the information spewing from government, mainstream media and Silicon Valley (all controlled by the same Global Cult networks) told them they were in danger from a 'deadly virus' and only by submitting to house arrest and conceding their most basic of freedoms could they and their families be protected. This monumental and provable lie became the *perception* of the billions and therefore the *behaviour* of the billions. In those few words you have the whole structure and modus operandi of human control. Fear is a perception – False Emotion Appearing Real – and fear is the currency of control. In short ... get them by the balls (or give them the impression that you have) and their hearts and minds will follow. Nothing grips the dangly bits and freezes the rear-end more comprehensively than fear.

World number 1

There are two 'worlds' in what appears to be one 'world' and the prime difference between them is knowledge. First we have the mass of human society in which the population is maintained in coldly-calculated ignorance through control of information and the 'education' (indoctrination) system. That's all you really need to control to enslave billions in a perceptual delusion in which what are perceived to be *their* thoughts and opinions are ever-repeated mantras that the system has been downloading all their lives through 'education', media, science, medicine, politics and academia

in which the personnel and advocates are themselves overwhelmingly the perceptual products of the same repetition. Teachers and academics in general are processed by the same programming machine as everyone else, but unlike the great majority they never leave the 'education' program. It gripped them as students and continues to grip them as programmers of subsequent generations of students. The programmed become the programmers – the programmed programmers. The same can largely be said for scientists, doctors and politicians and not least because as the American writer Upton Sinclair said: 'It is difficult to get a man to understand something when his salary depends upon his not understanding it.' If your career and income depend on thinking the way the system demands then you will – bar a few free-minded exceptions – concede your mind to the Perceptual Mainframe that I call the Postage Stamp Consensus. This is a tiny band of perceived knowledge and possibility 'taught' (downloaded) in the schools and universities, pounded out by the mainstream media and on which all government policy is founded. Try thinking, and especially speaking and acting, outside of the 'box' of consensus and see what that does for your career in the Mainstream Everything which bullies, harasses, intimidates and ridicules the population into compliance. Here we have the simple structure which enslaves most of humanity in a perceptual prison cell for an entire lifetime and I'll go deeper into this process shortly. Most of what humanity is taught as fact is nothing more than programmed belief. American science fiction author Frank Herbert was right when he said: 'Belief can be manipulated. Only knowledge is dangerous.' In the 'Covid' age belief is promoted and knowledge is censored. It was always so, but never to the extreme of today.

World number 2

A 'number 2' is slang for 'doing a poo' and how appropriate that is when this other 'world' is doing just that on humanity every minute of every day. World number 2 is a global network of secret societies and semi-secret groups dictating the direction of society via

governments, corporations and authorities of every kind. I have spent more than 30 years uncovering and exposing this network that I call the Global Cult and knowing its agenda is what has made my books so accurate in predicting current and past events. Secret societies are secret for a reason. They want to keep their hoarded knowledge to themselves and their chosen initiates and to hide it from the population which they seek through ignorance to control and subdue. The whole foundation of the division between World 1 and World 2 is *knowledge*. What number 1 knows number 2 must not. Knowledge they have worked so hard to keep secret includes (a) the agenda to enslave humanity in a centrally-controlled global dictatorship, and (b) the nature of reality and life itself. The latter (b) must be suppressed to allow the former (a) to prevail as I shall be explaining. The way the Cult manipulates and interacts with the population can be likened to a spider's web. The 'spider' sits at the centre in the shadows and imposes its will through the web with each strand represented in World number 2 by a secret society, satanic or semi-secret group, and in World number 1 – the world of the seen – by governments, agencies of government, law enforcement, corporations, the banking system, media conglomerates and Silicon Valley (Fig 1 overleaf). The spider and the web connect and coordinate all these organisations to pursue the same global outcome while the population sees them as individual entities working randomly and independently. At the level of the web governments *are* the banking system *are* the corporations *are* the media *are* Silicon Valley *are* the World Health Organization working from their inner cores as one unit. Apparently unconnected countries, corporations, institutions, organisations and people are on the *same team* pursuing the same global outcome. Strands in the web immediately around the spider are the most secretive and exclusive secret societies and their membership is emphatically restricted to the Cult inner-circle emerging through the generations from particular bloodlines for reasons I will come to. At the core of the core you would get them in a single room. That's how many people are dictating the direction of human society and its transformation

through the 'Covid' hoax and other means. As the web expands out from the spider we meet the secret societies that many people will be aware of – the Freemasons, Knights Templar, Knights of Malta, Opus Dei, the inner sanctum of the Jesuit Order, and such like. Note how many are connected to the Church of Rome and there is a reason for that. The Roman Church was established as a revamp, a rebranding, of the relocated 'Church' of Babylon and the Cult imposing global tyranny today can be tracked back to Babylon and Sumer in what is now Iraq.



Figure 1: The global web through which the few control the many. (Image Neil Hague.)

Inner levels of the web operate in the unseen away from the public eye and then we have what I call the cusp organisations located at the point where the hidden meets the seen. They include a series of satellite organisations answering to a secret society founded in London in the late 19th century called the Round Table and among them are the Royal Institute of International Affairs (UK, founded in 1920); Council on Foreign Relations (US, 1921); Bilderberg Group (worldwide, 1954); Trilateral Commission (US/worldwide, 1972); and the Club of Rome (worldwide, 1968) which was created to exploit environmental concerns to justify the centralisation of global power to 'save the planet'. The Club of Rome instigated with others the human-caused climate change hoax which has led to all the 'green

new deals' demanding that very centralisation of control. Cusp organisations, which include endless 'think tanks' all over the world, are designed to coordinate a single global policy between political and business leaders, intelligence personnel, media organisations and anyone who can influence the direction of policy in their own sphere of operation. Major players and regular attenders will know what is happening – or some of it – while others come and go and are kept overwhelmingly in the dark about the big picture. I refer to these cusp groupings as semi-secret in that they can be publicly identified, but what goes on at the inner-core is kept very much 'in house' even from most of their members and participants through a fiercely-imposed system of compartmentalisation. Only let them know what they need to know to serve your interests and no more. The structure of secret societies serves as a perfect example of this principle. Most Freemasons never get higher than the bottom three levels of 'degree' (degree of knowledge) when there are 33 official degrees of the Scottish Rite. Initiates only qualify for the next higher 'compartment' or degree if those at that level choose to allow them. Knowledge can be carefully assigned only to those considered 'safe'. I went to my local Freemason's lodge a few years ago when they were having an 'open day' to show how cuddly they were and when I chatted to some of them I was astonished at how little the rank and file knew even about the most ubiquitous symbols they use. The mushroom technique – keep them in the dark and feed them bullshit – applies to most people in the web as well as the population as a whole. Sub-divisions of the web mirror in theme and structure transnational corporations which have a headquarters somewhere in the world dictating to all their subsidiaries in different countries. Subsidiaries operate in their methodology and branding to the same centrally-dictated plan and policy in pursuit of particular ends. The Cult web functions in the same way. Each country has its own web as a subsidiary of the global one. They consist of networks of secret societies, semi-secret groups and bloodline families and their job is to impose the will of the spider and the global web in their particular country. Subsidiary networks control and manipulate the national political system, finance, corporations, media, medicine, etc. to

ensure that they follow the globally-dictated Cult agenda. These networks were the means through which the 'Covid' hoax could be played out with almost every country responding in the same way.

The 'Yessir' pyramid

Compartmentalisation is the key to understanding how a tiny few can dictate the lives of billions when combined with a top-down sequence of imposition and acquiescence. The inner core of the Cult sits at the peak of the pyramidal hierarchy of human society (Fig 2 overleaf). It imposes its will – its agenda for the world – on the level immediately below which acquiesces to that imposition. This level then imposes the Cult will on the level below them which acquiesces and imposes on the next level. Very quickly we meet levels in the hierarchy that have no idea there even is a Cult, but the sequence of imposition and acquiescence continues down the pyramid in just the same way. 'I don't know why we are doing this but the order came from "on-high" and so we better just do it.' Alfred Lord Tennyson said of the cannon fodder levels in his poem *The Charge of the Light Brigade*: 'Theirs not to reason why; theirs but to do and die.' The next line says that 'into the valley of death rode the six hundred' and they died because they obeyed without question what their perceived 'superiors' told them to do. In the same way the population capitulated to 'Covid'. The whole hierarchical pyramid functions like this to allow the very few to direct the enormous many.

Eventually imposition-acquiescence-imposition-acquiescence comes down to the mass of the population at the foot of the pyramid. If they acquiesce to those levels of the hierarchy imposing on them (governments/law enforcement/doctors/media) a circuit is completed between the population and the handful of super-psychopaths in the Cult inner core at the top of the pyramid.

Without a circuit-breaking refusal to obey, the sequence of imposition and acquiescence allows a staggeringly few people to impose their will upon the entirety of humankind. We are looking at the very sequence that has subjugated billions since the start of 2020. Our freedom has not been taken from us. Humanity has given it

away. Fascists do not impose fascism because there are not enough of them. Fascism is imposed by the population acquiescing to fascism. Put another way allowing their perceptions to be programmed to the extent that leads to the population giving their freedom away by giving their perceptions – their mind – away. If this circuit is not broken by humanity ceasing to cooperate with their own enslavement then nothing can change. For that to happen people have to critically think and see through the lies and window dressing and then summon the backbone to act upon what they see. The Cult spends its days working to stop either happening and its methodology is systematic and highly detailed, but it can be overcome and that is what this book is all about.

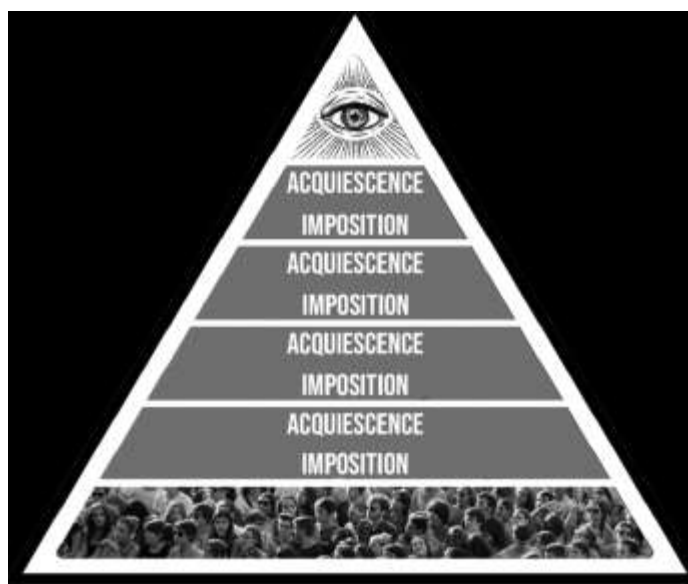


Figure 2: The simple sequence of imposition and compliance that allows a handful of people at the peak of the pyramid to dictate the lives of billions.

The Life Program

Okay, back to world number 1 or the world of the 'masses'. Observe the process of what we call 'life' and it is a perceptual download from cradle to grave. The Cult has created a global structure in which perception can be programmed and the program continually topped-up with what appears to be constant confirmation that the program is indeed true reality. The important word here is 'appears'.

This is the structure, the fly-trap, the Postage Stamp Consensus or Perceptual Mainframe, which represents that incredibly narrow band of perceived possibility delivered by the 'education' system, mainstream media, science and medicine. From the earliest age the download begins with parents who have themselves succumbed to the very programming their children are about to go through. Most parents don't do this out of malevolence and mostly it is quite the opposite. They do what they believe is best for their children and that is what the program has told them is best. Within three or four years comes the major transition from parental programming to full-blown state (Cult) programming in school, college and university where perceptually-programmed teachers and academics pass on their programming to the next generations. Teachers who resist are soon marginalised and their careers ended while children who resist are called a problem child for whom Ritalin may need to be prescribed. A few years after entering the 'world' children are under the control of authority figures representing the state telling them when they have to be there, when they can leave and when they can speak, eat, even go to the toilet. This is calculated preparation for a lifetime of obeying authority in all its forms. Reflex-action fear of authority is instilled by authority from the start. Children soon learn the carrot and stick consequences of obeying or defying authority which is underpinned daily for the rest of their life. Fortunately I daydreamed through this crap and never obeyed authority simply because it told me to. This approach to my alleged 'betters' continues to this day. There can be consequences of pursuing open-minded freedom in a world of closed-minded conformity. I spent a lot of time in school corridors after being ejected from the classroom for not taking some of it seriously and now I spend a lot of time being ejected from Facebook, YouTube and Twitter. But I can tell you that being true to yourself and not compromising your self-respect is far more exhilarating than bowing to authority for authority's sake. You don't have to be a sheep to the shepherd (authority) and the sheep dog (fear of not obeying authority).

The perceptual download continues throughout the formative years in school, college and university while script-reading 'teachers', 'academics' 'scientists', 'doctors' and 'journalists' insist that ongoing generations must be as programmed as they are. Accept the program or you will not pass your 'exams' which confirm your 'degree' of programming. It is tragic to think that many parents pressure their offspring to work hard at school to download the program and qualify for the next stage at college and university. The late, great, American comedian George Carlin said: 'Here's a bumper sticker I'd like to see: We are proud parents of a child who has resisted his teachers' attempts to break his spirit and bend him to the will of his corporate masters.' Well, the best of luck finding many of those, George. Then comes the moment to leave the formal programming years in academia and enter the 'adult' world of work. There you meet others in your chosen or prescribed arena who went through the same Postage Stamp Consensus program before you did. There is therefore overwhelming agreement between almost everyone on the basic foundations of Postage Stamp reality and the rejection, even contempt, of the few who have a mind of their own and are prepared to use it. This has two major effects. Firstly, the consensus confirms to the programmed that their download is really how things are. I mean, everyone knows that, right? Secondly, the arrogance and ignorance of Postage Stamp adherents ensure that anyone questioning the program will have unpleasant consequences for seeking their own truth and not picking their perceptions from the shelf marked: 'Things you must believe without question and if you don't you're a dangerous lunatic conspiracy theorist and a harebrained nutter'.

Every government, agency and corporation is founded on the same Postage Stamp prison cell and you can see why so many people believe the same thing while calling it their own 'opinion'. Fusion of governments and corporations in pursuit of the same agenda was the definition of fascism described by Italian dictator Benito Mussolini. The pressure to conform to perceptual norms downloaded for a lifetime is incessant and infiltrates society right

down to family groups that become censors and condemners of their own 'black sheep' for not, ironically, being sheep. We have seen an explosion of that in the 'Covid' era. Cult-owned global media unleashes its propaganda all day every day in support of the Postage Stamp and targets with abuse and ridicule anyone in the public eye who won't bend their mind to the will of the tyranny. Any response to this is denied (certainly in my case). They don't want to give a platform to expose official lies. Cult-owned-and-created Internet giants like Facebook, Google, YouTube and Twitter delete you for having an unapproved opinion. Facebook boasts that its AI censors delete 97-percent of 'hate speech' before anyone even reports it. Much of that 'hate speech' will simply be an opinion that Facebook and its masters don't want people to see. Such perceptual oppression is widely known as fascism. Even Facebook executive Benny Thomas, a 'CEO Global Planning Lead', said in comments secretly recorded by investigative journalism operation Project Veritas that Facebook is 'too powerful' and should be broken up:

I mean, no king in history has been the ruler of two billion people, but Mark Zuckerberg is ... And he's 36. That's too much for a 36-year-old ... You should not have power over two billion people. I just think that's wrong.

Thomas said Facebook-owned platforms like Instagram, Oculus, and WhatsApp needed to be separate companies. 'It's too much power when they're all one together'. That's the way the Cult likes it, however. We have an executive of a Cult organisation in Benny Thomas that doesn't know there is a Cult such is the compartmentalisation. Thomas said that Facebook and Google 'are no longer companies, they're countries'. Actually they are more powerful than countries on the basis that if you control information you control perception and control human society.

I love my oppressor

Another expression of this psychological trickery is for those who realise they are being pressured into compliance to eventually

convince themselves to believe the official narratives to protect their self-respect from accepting the truth that they have succumbed to meek and subservient compliance. Such people become some of the most vehement defenders of the system. You can see them everywhere screaming abuse at those who prefer to think for themselves and by doing so reminding the compliers of their own capitulation to conformity. 'You are talking dangerous nonsense you Covidiot!!' Are you trying to convince me or yourself? It is a potent form of Stockholm syndrome which is defined as: 'A psychological condition that occurs when a victim of abuse identifies and attaches, or bonds, positively with their abuser.' An example is hostages bonding and even 'falling in love' with their kidnappers. The syndrome has been observed in domestic violence, abused children, concentration camp inmates, prisoners of war and many and various Satanic cults. These are some traits of Stockholm syndrome listed at goodtherapy.org:

- Positive regard towards perpetrators of abuse or captor [see 'Covid'].
- Failure to cooperate with police and other government authorities when it comes to holding perpetrators of abuse or kidnapping accountable [or in the case of 'Covid' cooperating with the police to enforce and defend their captors' demands].
- Little or no effort to escape [see 'Covid'].
- Belief in the goodness of the perpetrators or kidnappers [see 'Covid'].
- Appeasement of captors. This is a manipulative strategy for maintaining one's safety. As victims get rewarded – perhaps with less abuse or even with life itself – their appeasing behaviours are reinforced [see 'Covid'].
- Learned helplessness. This can be akin to 'if you can't beat 'em, join 'em'. As the victims fail to escape the abuse or captivity, they may start giving up and soon realize it's just easier for everyone if they acquiesce all their power to their captors [see 'Covid'].

- Feelings of pity toward the abusers, believing they are actually victims themselves. Because of this, victims may go on a crusade or mission to 'save' [protect] their abuser [see the venom unleashed on those challenging the official 'Covid' narrative].
- Unwillingness to learn to detach from their perpetrators and heal. In essence, victims may tend to be less loyal to themselves than to their abuser [*definitely* see 'Covid'].

Ponder on those traits and compare them with the behaviour of great swathes of the global population who have defended governments and authorities which have spent every minute destroying their lives and livelihoods and those of their children and grandchildren since early 2020 with fascistic lockdowns, house arrest and employment deletion to 'protect' them from a 'deadly virus' that their abusers' perceptually created to bring about this very outcome. We are looking at mass Stockholm syndrome. All those that agree to concede their freedom will believe those perceptions are originating in their own independent 'mind' when in fact by conceding their reality to Stockholm syndrome they have by definition conceded any independence of mind. Listen to the 'opinions' of the acquiescing masses in this 'Covid' era and what gushes forth is the repetition of the official version of everything delivered unprocessed, unfiltered and unquestioned. The whole programming dynamic works this way. I must be free because I'm told that I am and so I think that I am.

You can see what I mean with the chapter theme of 'I'm thinking – Oh, but *are* you?' The great majority are not thinking, let alone for themselves. They are repeating what authority has told them to believe which allows them to be controlled. Weaving through this mentality is the fear that the 'conspiracy theorists' are right and this again explains the often hysterical abuse that ensues when you dare to contest the official narrative of anything. Denial is the mechanism of hiding from yourself what you don't want to be true. Telling people what they want to hear is easy, but it's an infinitely greater challenge to tell them what they would rather not be happening.

One is akin to pushing against an open door while the other is met with vehement resistance no matter what the scale of evidence. I don't want it to be true so I'll convince myself that it's not. Examples are everywhere from the denial that a partner is cheating despite all the signs to the reflex-action rejection of any idea that world events in which country after country act in exactly the same way are centrally coordinated. To accept the latter is to accept that a force of unspeakable evil is working to destroy your life and the lives of your children with nothing too horrific to achieve that end. Who the heck wants that to be true? But if we don't face reality the end is duly achieved and the consequences are far worse and ongoing than breaking through the walls of denial today with the courage to make a stand against tyranny.

Connect the dots – but how?

A crucial aspect of perceptual programming is to portray a world in which everything is random and almost nothing is connected to anything else. Randomness cannot be coordinated by its very nature and once you perceive events as random the idea they could be connected is waved away as the rantings of the tinfoil-hat brigade. You can't plan and coordinate random you idiot! No, you can't, but you can hide the coldly-calculated and long-planned behind the *illusion* of randomness. A foundation manifestation of the Renegade Mind is to scan reality for patterns that connect the apparently random and turn pixels and dots into pictures. This is the way I work and have done so for more than 30 years. You look for similarities in people, modus operandi and desired outcomes and slowly, then ever quicker, the picture forms. For instance: There would seem to be no connection between the 'Covid pandemic' hoax and the human-caused global-warming hoax and yet they are masks (appropriately) on the same face seeking the same outcome. Those pushing the global warming myth through the Club of Rome and other Cult agencies are driving the lies about 'Covid' – Bill Gates is an obvious one, but they are endless. Why would the same people be involved in both when they are clearly not connected? Oh, but they

are. Common themes with personnel are matched by common goals. The 'solutions' to both 'problems' are centralisation of global power to impose the will of the few on the many to 'save' humanity from 'Covid' and save the planet from an 'existential threat' (we need 'zero Covid' and 'zero carbon emissions'). These, in turn, connect with the 'dot' of globalisation which was coined to describe the centralisation of global power in every area of life through incessant political and corporate expansion, trading blocks and superstates like the European Union. If you are the few and you want to control the many you have to centralise power and decision-making. The more you centralise power the more power the few at the centre will have over the many; and the more that power is centralised the more power those at the centre have to centralise even quicker. The momentum of centralisation gets faster and faster which is exactly the process we have witnessed. In this way the hoaxed 'pandemic' and the fakery of human-caused global warming serve the interests of globalisation and the seizure of global power in the hands of the Cult inner-circle which is behind 'Covid', 'climate change' and globalisation. At this point random 'dots' become a clear and obvious picture or pattern.

Klaus Schwab, the classic Bond villain who founded the Cult's Gates-funded World Economic Forum, published a book in 2020, *The Great Reset*, in which he used the 'problem' of 'Covid' to justify a total transformation of human society to 'save' humanity from 'climate change'. Schwab said: 'The pandemic represents a rare but narrow window of opportunity to reflect, reimagine, and reset our world.' What he didn't mention is that the Cult he serves is behind both hoaxes as I show in my book *The Answer*. He and the Cult don't have to reimagine the world. They know precisely what they want and that's why they destroyed human society with 'Covid' to 'build back better' in their grand design. Their job is not to imagine, but to get humanity to imagine and agree with their plans while believing it's all random. It must be pure coincidence that 'The Great Reset' has long been the Cult's code name for the global imposition of fascism and replaced previous code-names of the 'New World

Order' used by Cult frontmen like Father George Bush and the 'New Order of the Ages' which emerged from Freemasonry and much older secret societies. New Order of the Ages appears on the reverse of the Great Seal of the United States as 'Novus ordo seclorum' underneath the Cult symbol used since way back of the pyramid and all seeing-eye (Fig 3). The pyramid is the hierarchy of human control headed by the illuminated eye that symbolises the force behind the Cult which I will expose in later chapters. The term 'Annuit Coeptis' translates as 'He favours our undertaking'. We are told the 'He' is the Christian god, but 'He' is not as I will be explaining.



Figure 3: The all-seeing eye of the Cult 'god' on the Freemason-designed Great Seal of the United States and also on the dollar bill.

Having you on

Two major Cult techniques of perceptual manipulation that relate to all this are what I have called since the 1990s Problem-Reaction-Solution (PRS) and the Totalitarian Tiptoe (TT). They can be uncovered by the inquiring mind with a simple question: Who benefits? The answer usually identifies the perpetrators of a given action or happening through the concept of 'he who most benefits from a crime is the one most likely to have committed it'. The Latin 'Cue bono?' – Who benefits? – is widely attributed to the Roman orator and statesman Marcus Tullius Cicero. No wonder it goes back so far when the concept has been relevant to human behaviour since

history was recorded. Problem-Reaction-Solution is the technique used to manipulate us every day by covertly creating a problem (or the illusion of one) and offering the solution to the problem (or the illusion of one). In the first phase you create the problem and blame someone or something else for why it has happened. This may relate to a financial collapse, terrorist attack, war, global warming or pandemic, anything in fact that will allow you to impose the 'solution' to change society in the way you desire at that time. The 'problem' doesn't have to be real. PRS is manipulation of perception and all you need is the population to believe the problem is real. Human-caused global warming and the 'Covid pandemic' only have to be *perceived* to be real for the population to accept the 'solutions' of authority. I refer to this technique as NO-Problem-Reaction-Solution. Billions did not meekly accept house arrest from early 2020 because there was a real deadly 'Covid pandemic' but because they perceived – believed – that to be the case. The antidote to Problem-Reaction-Solution is to ask who benefits from the proposed solution. Invariably it will be anyone who wants to justify more control through deletion of freedom and centralisation of power and decision-making.

The two world wars were Problem-Reaction-Solutions that transformed and realigned global society. Both were manipulated into being by the Cult as I have detailed in books since the mid-1990s. They dramatically centralised global power, especially World War Two, which led to the United Nations and other global bodies thanks to the overt and covert manipulations of the Rockefeller family and other Cult bloodlines like the Rothschilds. The UN is a stalking horse for full-blown world government that I will come to shortly. The land on which the UN building stands in New York was donated by the Rockefellers and the same Cult family was behind Big Pharma scalpel and drug 'medicine' and the creation of the World Health Organization as part of the UN. They have been stalwarts of the eugenics movement and funded Hitler's race-purity expert' Ernst Rudin. The human-caused global warming hoax has been orchestrated by the Club of Rome through the UN which is

manufacturing both the 'problem' through its Intergovernmental Panel on Climate Change and imposing the 'solution' through its Agenda 21 and Agenda 2030 which demand the total centralisation of global power to 'save the world' from a climate hoax the United Nations is itself perpetrating. What a small world the Cult can be seen to be particularly among the inner circles. The bedfellow of Problem-Reaction-Solution is the Totalitarian Tiptoe which became the Totalitarian Sprint in 2020. The technique is fashioned to hide the carefully-coordinated behind the cover of apparently random events. You start the sequence at 'A' and you know you are heading for 'Z'. You don't want people to know that and each step on the journey is presented as a random happening while all the steps strung together lead in the same direction. The speed may have quickened dramatically in recent times, but you can still see the incremental approach of the Tiptoe in the case of 'Covid' as each new imposition takes us deeper into fascism. Tell people they have to do this or that to get back to 'normal', then this and this and this. With each new demand adding to the ones that went before the population's freedom is deleted until it disappears. The spider wraps its web around the flies more comprehensively with each new diktat. I'll highlight this in more detail when I get to the 'Covid' hoax and how it has been pulled off. Another prime example of the Totalitarian Tiptoe is how the Cult-created European Union went from a 'free-trade zone' to a centralised bureaucratic dictatorship through the Tiptoe of incremental centralisation of power until nations became mere administrative units for Cult-owned dark suits in Brussels.

The antidote to ignorance is knowledge which the Cult seeks vehemently to deny us, but despite the systematic censorship to that end the Renegade Mind can overcome this by vociferously seeking out the facts no matter the impediments put in the way. There is also a method of thinking and perceiving – *knowing* – that doesn't even need names, dates, place-type facts to identify the patterns that reveal the story. I'll get to that in the final chapter. All you need to know about the manipulation of human society and to what end is still out there – *at the time of writing* – in the form of books, videos

and websites for those that really want to breach the walls of programmed perception. To access this knowledge requires the abandonment of the mainstream media as a source of information in the awareness that this is owned and controlled by the Cult and therefore promotes mass perceptions that suit the Cult. Mainstream media lies all day, every day. That is its function and very reason for being. Where it does tell the truth, here and there, is only because the truth and the Cult agenda very occasionally coincide. If you look for fact and insight to the BBC, CNN and virtually all the rest of them you are asking to be conned and perceptually programmed.

Know the outcome and you'll see the journey

Events seem random when you have no idea where the world is being taken. Once you do the random becomes the carefully planned. Know the outcome and you'll see the journey is a phrase I have been using for a long time to give context to daily happenings that appear unconnected. Does a problem, or illusion of a problem, trigger a proposed 'solution' that further drives society in the direction of the outcome? Invariably the answer will be yes and the random – *abracadabra* – becomes the clearly coordinated. So what is this outcome that unlocks the door to a massively expanded understanding of daily events? I will summarise its major aspects – the fine detail is in my other books – and those new to this information will see that the world they thought they were living in is a very different place. The foundation of the Cult agenda is the incessant centralisation of power and all such centralisation is ultimately in pursuit of Cult control on a global level. I have described for a long time the planned world structure of top-down dictatorship as the Hunger Games Society. The term obviously comes from the movie series which portrayed a world in which a few living in military-protected hi-tech luxury were the overlords of a population condemned to abject poverty in isolated 'sectors' that were not allowed to interact. 'Covid' lockdowns and travel bans anyone? The 'Hunger Games' pyramid of structural control has the inner circle of the Cult at the top with pretty much the entire

population at the bottom under their control through dependency for survival on the Cult. The whole structure is planned to be protected and enforced by a military-police state ([Fig 4](#)).

Here you have the reason for the global lockdowns of the fake pandemic to coldly destroy independent incomes and livelihoods and make everyone dependent on the 'state' (the Cult that controls the 'states'). I have warned in my books for many years about the plan to introduce a 'guaranteed income' – a barely survivable pittance – designed to impose dependency when employment was destroyed by AI technology and now even more comprehensively at great speed by the 'Covid' scam. Once the pandemic was played and lockdown consequences began to delete independent income the authorities began to talk right on cue about the need for a guaranteed income and a 'Great Reset'. Guaranteed income will be presented as benevolent governments seeking to help a desperate people – desperate as a direct result of actions of the same governments. The truth is that such payments are a trap. You will only get them if you do exactly what the authorities demand including mass vaccination (genetic manipulation). We have seen this theme already in Australia where those dependent on government benefits have them reduced if parents don't agree to have their children vaccinated according to an insane health-destroying government-dictated schedule. Calculated economic collapse applies to governments as well as people. The Cult wants rid of countries through the creation of a world state with countries broken up into regions ruled by a world government and super states like the European Union. Countries must be bankrupted, too, to this end and it's being achieved by the trillions in 'rescue packages' and furlough payments, trillions in lost taxation, and money-no-object spending on 'Covid' including constant all-medium advertising (programming) which has made the media dependent on government for much of its income. The day of reckoning is coming – as planned – for government spending and given that it has been made possible by printing money and not by production/taxation there is inflation on the way that has the

potential to wipe out monetary value. In that case there will be no need for the Cult to steal your money. It just won't be worth anything (see the German Weimar Republic before the Nazis took over). Many have been okay with lockdowns while getting a percentage of their income from so-called furlough payments without having to work. Those payments are dependent, however, on people having at least a theoretical job with a business considered non-essential and ordered to close. As these business go under because they are closed by lockdown after lockdown the furlough stops and it will for everyone eventually. Then what? The 'then what?' is precisely the idea.



Figure 4: The Hunger Games Society structure I have long warned was planned and now the 'Covid' hoax has made it possible. This is the real reason for lockdowns.

Hired hands

Between the Hunger Games Cult elite and the dependent population is planned to be a vicious military-police state (a fusion of the two into one force). This has been in the making for a long time with police looking ever more like the military and carrying weapons to match. The pandemic scam has seen this process accelerate so fast as

lockdown house arrest is brutally enforced by carefully recruited fascist minds and gormless system-servers. The police and military are planned to merge into a centrally-directed world army in a global structure headed by a world government which wouldn't be elected even by the election fixes now in place. The world army is not planned even to be human and instead wars would be fought, primarily against the population, using robot technology controlled by artificial intelligence. I have been warning about this for decades and now militaries around the world are being transformed by this very AI technology. The global regime that I describe is a particular form of fascism known as a technocracy in which decisions are not made by clueless and co-opted politicians but by unelected technocrats – scientists, engineers, technologists and bureaucrats. Cult-owned-and-controlled Silicon Valley giants are examples of technocracy and they already have far more power to direct world events than governments. They are with their censorship *selecting* governments. I know that some are calling the 'Great Reset' a Marxist communist takeover, but fascism and Marxism are different labels for the same tyranny. Tell those who lived in fascist Germany and Stalinist Russia that there was a difference in the way their freedom was deleted and their lives controlled. I could call it a fascist technocracy or a Marxist technocracy and they would be equally accurate. The Hunger Games society with its world government structure would oversee a world army, world central bank and single world cashless currency imposing its will on a microchipped population ([Fig 5](#)). Scan its different elements and see how the illusory pandemic is forcing society in this very direction at great speed. Leaders of 23 countries and the World Health Organization (WHO) backed the idea in March, 2021, of a global treaty for 'international cooperation' in 'health emergencies' and nations should 'come together as a global community for peaceful cooperation that extends beyond this crisis'. Cut the Orwellian bullshit and this means another step towards global government. The plan includes a cashless digital money system that I first warned about in 1993. Right at the start of 'Covid' the deeply corrupt Tedros

Adhanom Ghebreyesus, the crooked and merely gofer 'head' of the World Health Organization, said it was possible to catch the 'virus' by touching cash and it was better to use cashless means. The claim was ridiculous nonsense and like the whole 'Covid' mind-trick it was nothing to do with 'health' and everything to do with pushing every aspect of the Cult agenda. As a result of the Tedros lie the use of cash has plummeted. The Cult script involves a single world digital currency that would eventually be technologically embedded in the body. China is a massive global centre for the Cult and if you watch what is happening there you will know what is planned for everywhere. The Chinese government is developing a digital currency which would allow fines to be deducted immediately via AI for anyone caught on camera breaking its fantastic list of laws and the money is going to be programmable with an expiry date to ensure that no one can accrue wealth except the Cult and its operatives.



Figure 5: The structure of global control the Cult has been working towards for so long and this has been enormously advanced by the 'Covid' illusion.

Serfdom is so smart

The Cult plan is far wider, extreme, and more comprehensive than even most conspiracy researchers appreciate and I will come to the true depths of deceit and control in the chapters 'Who controls the

Cult?’ and ‘Escaping Wetiko’. Even the world that we know is crazy enough. We are being deluged with ever more sophisticated and controlling technology under the heading of ‘smart’. We have smart televisions, smart meters, smart cards, smart cars, smart driving, smart roads, smart pills, smart patches, smart watches, smart skin, smart borders, smart pavements, smart streets, smart cities, smart communities, smart environments, smart growth, smart planet ... smart *everything* around us. Smart technologies and methods of operation are designed to interlock to create a global Smart Grid connecting the entirety of human society including human minds to create a centrally-dictated ‘hive’ mind. ‘Smart cities’ is code for densely-occupied megacities of total surveillance and control through AI. Ever more destructive frequency communication systems like 5G have been rolled out without any official testing for health and psychological effects (colossal). 5G/6G/7G systems are needed to run the Smart Grid and each one becomes more destructive of body and mind. Deleting independent income is crucial to forcing people into these AI-policed prisons by ending private property ownership (except for the Cult elite). The Cult’s Great Reset now openly foresees a global society in which no one will own any possessions and everything will be rented while the Cult would own literally everything under the guise of government and corporations. The aim has been to use the lockdowns to destroy sources of income on a mass scale and when the people are destitute and in unrepayable amounts of debt (problem) Cult assets come forward with the pledge to write-off debt in return for handing over all property and possessions (solution). Everything – literally everything including people – would be connected to the Internet via AI. I was warning years ago about the coming Internet of Things (IoT) in which all devices and technology from your car to your fridge would be plugged into the Internet and controlled by AI. Now we are already there with much more to come. The next stage is the Internet of Everything (IoE) which is planned to include the connection of AI to the human brain and body to replace the human mind with a centrally-controlled AI mind. Instead of perceptions

being manipulated through control of information and censorship those perceptions would come direct from the Cult through AI. What do you think? You think whatever AI decides that you think. In human terms there would be no individual 'think' any longer. Too incredible? The ravings of a lunatic? Not at all. Cult-owned crazies in Silicon Valley have been telling us the plan for years without explaining the real motivation and calculated implications. These include Google executive and 'futurist' Ray Kurzweil who highlights the year 2030 for when this would be underway. He said:

Our thinking ... will be a hybrid of biological and non-biological thinking ... humans will be able to extend their limitations and 'think in the cloud' ... We're going to put gateways to the cloud in our brains ... We're going to gradually merge and enhance ourselves ... In my view, that's the nature of being human – we transcend our limitations.

As the technology becomes vastly superior to what we are then the small proportion that is still human gets smaller and smaller and smaller until it's just utterly negligible.

The sales-pitch of Kurzweil and Cult-owned Silicon Valley is that this would make us 'super-human' when the real aim is to make us post-human and no longer 'human' in the sense that we have come to know. The entire global population would be connected to AI and become the centrally-controlled 'hive-mind' of externally-delivered perceptions. The Smart Grid being installed to impose the Cult's will on the world is being constructed to allow particular locations – even one location – to control the whole global system. From these prime control centres, which absolutely include China and Israel, anything connected to the Internet would be switched on or off and manipulated at will. Energy systems could be cut, communication via the Internet taken down, computer-controlled driverless autonomous vehicles driven off the road, medical devices switched off, the potential is limitless given how much AI and Internet connections now run human society. We have seen nothing yet if we allow this to continue. Autonomous vehicle makers are working with law enforcement to produce cars designed to automatically pull over if they detect a police or emergency vehicle flashing from up to 100 feet away. At a police stop the car would be unlocked and the

window rolled down automatically. Vehicles would only take you where the computer (the state) allowed. The end of petrol vehicles and speed limiters on all new cars in the UK and EU from 2022 are steps leading to electric computerised transport over which ultimately you have no control. The picture is far bigger even than the Cult global network or web and that will become clear when I get to the nature of the 'spider'. There is a connection between all these happenings and the instigation of DNA-manipulating 'vaccines' (which aren't 'vaccines') justified by the 'Covid' hoax. That connection is the unfolding plan to transform the human body from a biological to a synthetic biological state and this is why synthetic biology is such a fast-emerging discipline of mainstream science. 'Covid vaccines' are infusing self-replicating synthetic genetic material into the cells to cumulatively take us on the Totalitarian Tiptoe from Human 1.0 to the synthetic biological Human 2.0 which will be physically and perceptually attached to the Smart Grid to one hundred percent control every thought, perception and deed. Humanity needs to wake up and *fast*.

This is the barest explanation of where the 'outcome' is planned to go but it's enough to see the journey happening all around us. Those new to this information will already see 'Covid' in a whole new context. I will add much more detail as we go along, but for the minutiae evidence see my mega-works, *The Answer*, *The Trigger* and *Everything You Need to Know But Have Never Been Told*.

Now – how does a Renegade Mind see the 'world'?

CHAPTER TWO

Renegade Perception

It is one thing to be clever and another to be wise

George R.R. Martin

A simple definition of the difference between a programmed mind and a Renegade Mind would be that one sees only dots while the other connects them to see the picture. Reading reality with accuracy requires the observer to (a) know the planned outcome and (b) realise that everything, but *everything*, is connected.

The entirety of infinite reality is connected – that's its very nature – and with human society an expression of infinite reality the same must apply. Simple cause and effect is a connection. The effect is triggered by the cause and the effect then becomes the cause of another effect. Nothing happens in isolation because it *can't*. Life in whatever reality is simple choice and consequence. We make choices and these lead to consequences. If we don't like the consequences we can make different choices and get different consequences which lead to other choices and consequences. The choice and the consequence are not only connected they are indivisible. You can't have one without the other as an old song goes. A few cannot control the world unless those being controlled allow that to happen – cause and effect, choice and consequence. Control – who has it and who doesn't – is a two-way process, a symbiotic relationship, involving the controller and controlled. 'They took my freedom away!!' Well, yes, but you also gave it to them. Humanity is

subjected to mass control because humanity has acquiesced to that control. This is all cause and effect and literally a case of give and take. In the same way world events of every kind are connected and the Cult works incessantly to sell the illusion of the random and coincidental to maintain the essential (to them) perception of dots that hide the picture. Renegade Minds know this and constantly scan the world for patterns of connection. This is absolutely pivotal in understanding the happenings in the world and without that perspective clarity is impossible. First you know the planned outcome and then you identify the steps on the journey – the day-by-day apparently random which, when connected in relation to the outcome, no longer appear as individual events, but as the proverbial *chain* of events leading in the same direction. I'll give you some examples:

Political puppet show

We are told to believe that politics is 'adversarial' in that different parties with different beliefs engage in an endless tussle for power. There may have been some truth in that up to a point – and only a point – but today divisions between 'different' parties are rhetorical not ideological. Even the rhetorical is fusing into one-speak as the parties eject any remaining free thinkers while others succumb to the ever-gathering intimidation of anyone with the 'wrong' opinion. The Cult is not a new phenomenon and can be traced back thousands of years as my books have documented. Its intergenerational initiatives have been manipulating events with increasing effect the more that global power has been centralised. In ancient times the Cult secured control through the system of monarchy in which 'special' bloodlines (of which more later) demanded the right to rule as kings and queens simply by birthright and by vanquishing others who claimed the same birthright. There came a time, however, when people had matured enough to see the unfairness of such tyranny and demanded a say in who governed them. Note the word – *governed* them. Not served them – *governed* them, hence government defined as 'the political direction and control exercised over the

actions of the members, citizens, or inhabitants of communities, societies, and states; direction of the affairs of a state, community, etc.' Governments exercise control over rather than serve just like the monarchies before them. Bizarrely there are still countries like the United Kingdom which are ruled by a monarch *and* a government that officially answers to the monarch. The UK head of state and that of Commonwealth countries such as Canada, Australia and New Zealand is 'selected' by who in a *single family* had unprotected sex with whom and in what order. Pinch me it can't be true. Ouch! Shit, it is. The demise of monarchies in most countries offered a potential vacuum in which some form of free and fair society could arise and the Cult had that base covered. Monarchies had served its interests but they couldn't continue in the face of such widespread opposition and, anyway, replacing a 'royal' dictatorship that people could see with a dictatorship 'of the people' hiding behind the concept of 'democracy' presented far greater manipulative possibilities and ways of hiding coordinated tyranny behind the illusion of 'freedom'.

Democracy is quite wrongly defined as government selected by the population. This is not the case at all. It is government selected by *some* of the population (and then only in theory). This 'some' doesn't even have to be the majority as we have seen so often in first-past-the-post elections in which the so-called majority party wins fewer votes than the 'losing' parties combined. Democracy can give total power to a party in government from a minority of the votes cast. It's a sleight of hand to sell tyranny as freedom. Seventy-four million Trump-supporting Americans didn't vote for the 'Democratic' Party of Joe Biden in the distinctly dodgy election in 2020 and yet far from acknowledging the wishes and feelings of that great percentage of American society the Cult-owned Biden government set out from day one to destroy them and their right to a voice and opinion. Empty shell Biden and his Cult handlers said they were doing this to 'protect democracy'. Such is the level of lunacy and sickness to which politics has descended. Connect the dots and relate them to the desired outcome – a world government run by self-appointed technocrats and no longer even elected

politicians. While operating through its political agents in government the Cult is at the same time encouraging public disdain for politicians by putting idiots and incompetents in theoretical power on the road to deleting them. The idea is to instil a public reaction that says of the technocrats: 'Well, they couldn't do any worse than the pathetic politicians.' It's all about controlling perception and Renegade Minds can see through that while programmed minds cannot when they are ignorant of both the planned outcome and the manipulation techniques employed to secure that end. This knowledge can be learned, however, and fast if people choose to get informed.

Politics may at first sight appear very difficult to control from a central point. I mean look at the 'different' parties and how would you be able to oversee them all and their constituent parts? In truth, it's very straightforward because of their structure. We are back to the pyramid of imposition and acquiescence. Organisations are structured in the same way as the system as a whole. Political parties are not open forums of free expression. They are hierarchies. I was a national spokesman for the British Green Party which claimed to be a different kind of politics in which influence and power was devolved; but I can tell you from direct experience – and it's far worse now – that Green parties are run as hierarchies like all the others however much they may try to hide that fact or kid themselves that it's not true. A very few at the top of all political parties are directing policy and personnel. They decide if you are elevated in the party or serve as a government minister and to do that you have to be a yes man or woman. Look at all the maverick political thinkers who never ascended the greasy pole. If you want to progress within the party or reach 'high-office' you need to fall into line and conform. Exceptions to this are rare indeed. Should you want to run for parliament or Congress you have to persuade the local or state level of the party to select you and for that you need to play the game as dictated by the hierarchy. If you secure election and wish to progress within the greater structure you need to go on conforming to what is acceptable to those running the hierarchy

from the peak of the pyramid. Political parties are perceptual gulags and the very fact that there are party 'Whips' appointed to 'whip' politicians into voting the way the hierarchy demands exposes the ridiculous idea that politicians are elected to serve the people they are supposed to represent. Cult operatives and manipulation has long seized control of major parties that have any chance of forming a government and at least most of those that haven't. A new party forms and the Cult goes to work to infiltrate and direct. This has reached such a level today that you see video compilations of 'leaders' of all parties whether Democrats, Republicans, Conservative, Labour and Green parroting the same Cult mantra of 'Build Back Better' and the 'Great Reset' which are straight off the Cult song-sheet to describe the transformation of global society in response to the Cult-instigated hoaxes of the 'Covid pandemic' and human-caused 'climate change'. To see Caroline Lucas, the Green Party MP that I knew when I was in the party in the 1980s, speaking in support of plans proposed by Cult operative Klaus Schwab representing the billionaire global elite is a real head-shaker.

Many parties – one master

The party system is another mind-trick and was instigated to change the nature of the dictatorship by swapping 'royalty' for dark suits that people believed – though now ever less so – represented their interests. Understanding this trick is to realise that a single force (the Cult) controls all parties either directly in terms of the major ones or through manipulation of perception and ideology with others. You don't need to manipulate Green parties to demand your transformation of society in the name of 'climate change' when they are obsessed with the lie that this is essential to 'save the planet'. You just give them a platform and away they go serving your interests while believing they are being environmentally virtuous. America's political structure is a perfect blueprint for how the two or multi-party system is really a one-party state. The Republican Party is controlled from one step back in the shadows by a group made up of billionaires and their gofers known as neoconservatives or Neocons.

I have exposed them in fine detail in my books and they were the driving force behind the policies of the imbecilic presidency of Boy George Bush which included 9/11 (see *The Trigger* for a comprehensive demolition of the official story), the subsequent 'war on terror' (war of terror) and the invasions of Afghanistan and Iraq. The latter was a No-Problem-Reaction-Solution based on claims by Cult operatives, including Bush and British Prime Minister Tony Blair, about Saddam Hussein's 'weapons of mass destruction' which did not exist as war criminals Bush and Blair well knew.



Figure 6: Different front people, different parties – same control system.

The Democratic Party has its own 'Neocon' group controlling from the background which I call the 'Democons' and here's the penny-drop – the Neocons and Democons answer to the same masters one step further back into the shadows (Fig 6). At that level of the Cult the Republican and Democrat parties are controlled by the same people and no matter which is in power the Cult is in power. This is how it works in almost every country and certainly in Britain with Conservative, Labour, Liberal Democrat and Green parties now all on the same page whatever the rhetoric may be in their feeble attempts to appear different. Neocons operated at the time of Bush through a think tank called The Project for the New American Century which in September, 2000, published a document entitled *Rebuilding America's Defenses: Strategies, Forces, and Resources*

For a New Century demanding that America fight ‘multiple, simultaneous major theatre wars’ as a ‘core mission’ to force regime-change in countries including Iraq, Libya and Syria. Neocons arranged for Bush (‘Republican’) and Blair (‘Labour Party’) to front-up the invasion of Iraq and when they departed the Democons orchestrated the targeting of Libya and Syria through Barack Obama (‘Democrat’) and British Prime Minister David Cameron (‘Conservative Party’). We have ‘different’ parties and ‘different’ people, but the same unfolding script. The more the Cult has seized the reigns of parties and personnel the more their policies have transparently pursued the same agenda to the point where the fascist ‘Covid’ impositions of the Conservative junta of Jackboot Johnson in Britain were opposed by the Labour Party because they were not fascist enough. The Labour Party is likened to the US Democrats while the Conservative Party is akin to a British version of the Republicans and on both sides of the Atlantic they all speak the same language and support the direction demanded by the Cult although some more enthusiastically than others. It’s a similar story in country after country because it’s all centrally controlled. Oh, but what about Trump? I’ll come to him shortly. Political ‘choice’ in the ‘party’ system goes like this: You vote for Party A and they get into government. You don’t like what they do so next time you vote for Party B and they get into government. You don’t like what they do when it’s pretty much the same as Party A and why wouldn’t that be with both controlled by the same force? Given that only two, sometimes three, parties have any chance of forming a government to get rid of Party B that you don’t like you have to vote again for Party A which ... you don’t like. This, ladies and gentlemen, is what they call ‘democracy’ which we are told – wrongly – is a term interchangeable with ‘freedom’.

The cult of cults

At this point I need to introduce a major expression of the Global Cult known as Sabbatian-Frankism. Sabbatian is also spelt as Sabbatean. I will summarise here. I have published major exposés

and detailed background in other works. Sabbatian-Frankism combines the names of two frauds posing as 'Jewish' men, Sabbatai Zevi (1626-1676), a rabbi, black magician and occultist who proclaimed he was the Jewish messiah; and Jacob Frank (1726-1791), the Polish 'Jew', black magician and occultist who said he was the reincarnation of 'messiah' Zevi and biblical patriarch Jacob. They worked across two centuries to establish the Sabbatian-Frankist cult that plays a major, indeed central, role in the manipulation of human society by the Global Cult which has its origins much further back in history than Sabbatai Zevi. I should emphasise two points here in response to the shrill voices that will scream 'anti-Semitism': (1) Sabbatian-Frankists are NOT Jewish and only pose as such to hide their cult behind a Jewish façade; and (2) my information about this cult has come from Jewish sources who have long realised that their society and community has been infiltrated and taken over by interloper Sabbatian-Frankists. Infiltration has been the foundation technique of Sabbatian-Frankism from its official origin in the 17th century. Zevi's Sabbatian sect attracted a massive following described as the biggest messianic movement in Jewish history, spreading as far as Africa and Asia, and he promised a return for the Jews to the 'Promised Land' of Israel. Sabbatianism was not Judaism but an inversion of everything that mainstream Judaism stood for. So much so that this sinister cult would have a feast day when Judaism had a fast day and whatever was forbidden in Judaism the Sabbatians were encouraged and even commanded to do. This included incest and what would be today called Satanism. Members were forbidden to marry outside the sect and there was a system of keeping their children ignorant of what they were part of until they were old enough to be trusted not to unknowingly reveal anything to outsiders. The same system is employed to this day by the Global Cult in general which Sabbatian-Frankism has enormously influenced and now largely controls.

Zevi and his Sabbatians suffered a setback with the intervention by the Sultan of the Islamic Ottoman Empire in the Middle East and what is now the Republic of Turkey where Zevi was located. The

Sultan gave him the choice of proving his 'divinity', converting to Islam or facing torture and death. Funnily enough Zevi chose to convert or at least appear to. Some of his supporters were disillusioned and drifted away, but many did not with 300 families also converting – only in theory – to Islam. They continued behind this Islamic smokescreen to follow the goals, rules and rituals of Sabbatianism and became known as 'crypto-Jews' or the 'Dönme' which means 'to turn'. This is rather ironic because they didn't 'turn' and instead hid behind a fake Islamic persona. The process of appearing to be one thing while being very much another would become the calling card of Sabbatianism especially after Zevi's death and the arrival of the Satanist Jacob Frank in the 18th century when the cult became Sabbatian-Frankism and plumbed still new depths of depravity and infiltration which included – still includes – human sacrifice and sex with children. Wherever Sabbatians go paedophilia and Satanism follow and is it really a surprise that Hollywood is so infested with child abuse and Satanism when it was established by Sabbatian-Frankists and is still controlled by them? Hollywood has been one of the prime vehicles for global perceptual programming and manipulation. How many believe the version of 'history' portrayed in movies when it is a travesty and inversion (again) of the truth? Rabbi Marvin Antelman describes Frankism in his book, *To Eliminate the Opiate*, as 'a movement of complete evil' while Jewish professor Gershom Scholem said of Frank in *The Messianic Idea in Judaism*: 'In all his actions [he was] a truly corrupt and degenerate individual ... one of the most frightening phenomena in the whole of Jewish history.' Frank was excommunicated by traditional rabbis, as was Zevi, but Frank was undeterred and enjoyed vital support from the House of Rothschild, the infamous banking dynasty whose inner-core are Sabbatian-Frankists and not Jews. Infiltration of the Roman Church and Vatican was instigated by Frank with many Dönme 'turning' again to convert to Roman Catholicism with a view to hijacking the reins of power. This was the ever-repeating modus operandi and continues to be so. Pose as an advocate of the religion, culture or country that you want to control and then

manipulate your people into the positions of authority and influence largely as advisers, administrators and Svengalis for those that appear to be in power. They did this with Judaism, Christianity (Christian Zionism is part of this), Islam and other religions and nations until Sabbatian-Frankism spanned the world as it does today.

Sabbatian Saudis and the terror network

One expression of the Sabbatian-Frankist Dönme within Islam is the ruling family of Saudi Arabia, the House of Saud, through which came the vile distortion of Islam known as Wahhabism. This is the violent creed followed by terrorist groups like Al-Qaeda and ISIS or Islamic State. Wahhabism is the hand-chopping, head-chopping 'religion' of Saudi Arabia which is used to keep the people in a constant state of fear so the interloper House of Saud can continue to rule. Al-Qaeda and Islamic State were lavishly funded by the House of Saud while being created and directed by the Sabbatian-Frankist network in the United States that operates through the Pentagon, CIA and the government in general of whichever 'party'. The front man for the establishment of Wahhabism in the middle of the 18th century was a Sabbatian-Frankist 'crypto-Jew' posing as Islamic called Muhammad ibn Abd al-Wahhab. His daughter would marry the son of Muhammad bin Saud who established the first Saudi state before his death in 1765 with support from the British Empire. Bin Saud's successors would establish modern Saudi Arabia in league with the British and Americans in 1932 which allowed them to seize control of Islam's major shrines in Mecca and Medina. They have dictated the direction of Sunni Islam ever since while Iran is the major centre of the Shiite version and here we have the source of at least the public conflict between them. The Sabbatian network has used its Wahhabi extremists to carry out Problem-Reaction-Solution terrorist attacks in the name of 'Al-Qaeda' and 'Islamic State' to justify a devastating 'war on terror', ever-increasing surveillance of the population and to terrify people into compliance. Another insight of the Renegade Mind is the streetwise understanding that

just because a country, location or people are attacked doesn't mean that those apparently representing that country, location or people are not behind the attackers. Often they are *orchestrating* the attacks because of the societal changes that can be then justified in the name of 'saving the population from terrorists'.

I show in great detail in *The Trigger* how Sabbatian-Frankists were the real perpetrators of 9/11 and not '19 Arab hijackers' who were blamed for what happened. Observe what was justified in the name of 9/11 alone in terms of Middle East invasions, mass surveillance and control that fulfilled the demands of the Project for the New American Century document published by the Sabbatian Neocons. What appear to be enemies are on the deep inside players on the same Sabbatian team. Israel and Arab 'royal' dictatorships are all ruled by Sabbatians and the recent peace agreements between Israel and Saudi Arabia, the United Arab Emirates (UAE) and others are only making formal what has always been the case behind the scenes. Palestinians who have been subjected to grotesque tyranny since Israel was bombed and terrorised into existence in 1948 have never stood a chance. Sabbatian-Frankists have controlled Israel (so the constant theme of violence and war which Sabbatians love) and they have controlled the Arab countries that Palestinians have looked to for real support that never comes. 'Royal families' of the Arab world in Saudi Arabia, Bahrain, UAE, etc., are all Sabbatians with allegiance to the aims of the cult and not what is best for their Arabic populations. They have stolen the oil and financial resources from their people by false claims to be 'royal dynasties' with a genetic right to rule and by employing vicious militaries to impose their will.

Satanic 'illumination'

The Satanist Jacob Frank formed an alliance in 1773 with two other Sabbatians, Mayer Amschel Rothschild (1744-1812), founder of the Rothschild banking dynasty, and Jesuit-educated fraudulent Jew, Adam Weishaupt, and this led to the formation of the Bavarian Illuminati, firstly under another name, in 1776. The Illuminati would

be the manipulating force behind the French Revolution (1789-1799) and was also involved in the American Revolution (1775-1783) before and after the Illuminati's official creation. Weishaupt would later become (in public) a Protestant Christian in archetypal Sabbatian style. I read that his name can be decoded as Adam-Weishaupt or 'the first man to lead those who know'. He wasn't a leader in the sense that he was a subordinate, but he did lead those below him in a crusade of transforming human society that still continues today. The theme was confirmed as early as 1785 when a horseman courier called Lanz was reported to be struck by lightning and extensive Illuminati documents were found in his saddlebags. They made the link to Weishaupt and detailed the plan for world takeover. Current events with 'Covid' fascism have been in the making for a very long time. Jacob Frank was jailed for 13 years by the Catholic Inquisition after his arrest in 1760 and on his release he headed for Frankfurt, Germany, home city and headquarters of the House of Rothschild where the alliance was struck with Mayer Amschel Rothschild and Weishaupt. Rothschild arranged for Frank to be given the title of Baron and he became a wealthy nobleman with a big following of Jews in Germany, the Austro-Hungarian Empire and other European countries. Most of them would have believed he was on their side.

The name 'Illuminati' came from the Zohar which is a body of works in the Jewish mystical 'bible' called the Kabbalah. 'Zohar' is the foundation of Sabbatian-Frankist belief and in Hebrew 'Zohar' means 'splendour', 'radiance', 'illuminated', and so we have 'Illuminati'. They claim to be the 'Illuminated Ones' from their knowledge systematically hidden from the human population and passed on through generations of carefully-chosen initiates in the global secret society network or Cult. Hidden knowledge includes an awareness of the Cult agenda for the world and the nature of our collective reality that I will explore later. Cult 'illumination' is symbolised by the torch held by the Statue of Liberty which was gifted to New York by French Freemasons in Paris who knew exactly what it represents. 'Liberty' symbolises the goddess worshipped in

Babylon as Queen Semiramis or Ishtar. The significance of this will become clear. Notice again the ubiquitous theme of inversion with the Statue of 'Liberty' really symbolising mass control (Fig 7). A mirror-image statute stands on an island in the River Seine in Paris from where New York Liberty originated (Fig 8). A large replica of the Liberty flame stands on top of the Pont de l'Alma tunnel in Paris where Princess Diana died in a Cult ritual described in *The Biggest Secret*. Lucifer 'the light bringer' is related to all this (and much more as we'll see) and 'Lucifer' is a central figure in Sabbatian-Frankism and its associated Satanism. Sabbatians reject the Jewish Torah, or Pentateuch, the 'five books of Moses' in the Old Testament known as Genesis, Exodus, Leviticus, Numbers, and Deuteronomy which are claimed by Judaism and Christianity to have been dictated by 'God' to Moses on Mount Sinai. Sabbatians say these do not apply to them and they seek to replace them with the Zohar to absorb Judaism and its followers into their inversion which is an expression of a much greater global inversion. They want to delete all religions and force humanity to worship a one-world religion – Sabbatian Satanism that also includes worship of the Earth goddess. Satanic themes are being more and more introduced into mainstream society and while Christianity is currently the foremost target for destruction the others are planned to follow.



Figure 7: The Cult goddess of Babylon disguised as the Statue of Liberty holding the flame of Lucifer the 'light bringer'.



Figure 8: Liberty's mirror image in Paris where the New York version originated.

Marx brothers

Rabbi Marvin Antelman connects the Illuminati to the Jacobins in *To Eliminate the Opiate* and Jacobins were the force behind the French Revolution. He links both to the Bund der Gerechten, or League of the Just, which was the network that inflicted communism/Marxism on the world. Antelman wrote:

The original inner circle of the Bund der Gerechten consisted of born Catholics, Protestants and Jews [Sabbatian-Frankist infiltrators], and those representatives of respective subdivisions formulated schemes for the ultimate destruction of their faiths. The heretical Catholics laid plans which they felt would take a century or more for the ultimate destruction of the church; the apostate Jews for the ultimate destruction of the Jewish religion.

Sabbatian-created communism connects into this anti-religion agenda in that communism does not allow for the free practice of religion. The Sabbatian 'Bund' became the International Communist Party and Communist League and in 1848 'Marxism' was born with the Communist Manifesto of Sabbatian assets Karl Marx and Friedrich Engels. It is absolutely no coincidence that Marxism, just a different name for fascist and other centrally-controlled tyrannies, is being imposed worldwide as a result of the 'Covid' hoax and nor that Marxist/fascist China was the place where the hoax originated. The reason for this will become very clear in the chapter 'Covid: The calculated catastrophe'. The so-called 'Woke' mentality has hijacked

traditional beliefs of the political left and replaced them with far-right make-believe 'social justice' better known as Marxism. Woke will, however, be swallowed by its own perceived 'revolution' which is really the work of billionaires and billionaire corporations feigning being 'Woke'. Marxism is being touted by Wokers as a replacement for 'capitalism' when we don't have 'capitalism'. We have cartelism in which the market is stitched up by the very Cult billionaires and corporations bankrolling Woke. Billionaires love Marxism which keeps the people in servitude while they control from the top. Terminally naïve Wokers think they are 'changing the world' when it's the Cult that is doing the changing and when they have played their vital part and become surplus to requirements they, too, will be targeted. The Illuminati-Jacobins were behind the period known as 'The Terror' in the French Revolution in 1793 and 1794 when Jacobin Maximillian de Robespierre and his Orwellian 'Committee of Public Safety' killed 17,000 'enemies of the Revolution' who had once been 'friends of the Revolution'. Karl Marx (1818-1883), whose Sabbatian creed of Marxism has cost the lives of at least 100 million people, is a hero once again to Wokers who have been systematically kept ignorant of real history by their 'education' programming. As a result they now promote a Sabbatian 'Marxist' abomination destined at some point to consume them. Rabbi Antelman, who spent decades researching the Sabbatian plot, said of the League of the Just and Karl Marx:

Contrary to popular opinion Karl Marx did not originate the Communist Manifesto. He was paid for his services by the League of the Just, which was known in its country of origin, Germany, as the Bund der Geächteten.

Antelman said the text attributed to Marx was the work of other people and Marx 'was only repeating what others already said'. Marx was 'a hired hack – lackey of the wealthy Illuminists'. Marx famously said that religion was the 'opium of the people' (part of the Sabbatian plan to demonise religion) and Antelman called his books, *To Eliminate the Opiate*. Marx was born Jewish, but his family converted to Christianity (Sabbatian modus operandi) and he

attacked Jews, not least in his book, *A World Without Jews*. In doing so he supported the Sabbatian plan to destroy traditional Jewishness and Judaism which we are clearly seeing today with the vindictive targeting of orthodox Jews by the Sabbatian government of Israel over 'Covid' laws. I don't follow any religion and it has done much damage to the world over centuries and acted as a perceptual straightjacket. Renegade Minds, however, are always asking *why* something is being done. It doesn't matter if they agree or disagree with what is happening – *why* is it happening is the question. The 'why?' can be answered with regard to religion in that religions create interacting communities of believers when the Cult wants to dismantle all discourse, unity and interaction (see 'Covid' lockdowns) and the ultimate goal is to delete all religions for a one-world religion of Cult Satanism worshipping their 'god' of which more later. We see the same 'why?' with gun control in America. I don't have guns and don't want them, but why is the Cult seeking to disarm the population at the same time that law enforcement agencies are armed to their molars and why has every tyrant in history sought to disarm people before launching the final takeover? They include Hitler, Stalin, Pol Pot and Mao who followed confiscation with violent seizing of power. You know it's a Cult agenda by the people who immediately race to the microphones to exploit dead people in multiple shootings. Ultra-Zionist Cult lackey Senator Chuck Schumer was straight on the case after ten people were killed in Boulder, Colorado in March, 2121. Simple rule ... if Schumer wants it the Cult wants it and the same with his ultra-Zionist mate the wild-eyed Senator Adam Schiff. At the same time they were calling for the disarmament of Americans, many of whom live a long way from a police response, Schumer, Schiff and the rest of these pampered clowns were sitting on Capitol Hill behind a razor-wired security fence protected by thousands of armed troops in addition to their own armed bodyguards. Mom and pop in an isolated home? They're just potential mass shooters.

Zion Mainframe

Sabbatian-Frankists and most importantly the Rothschilds were behind the creation of 'Zionism', a political movement that demanded a Jewish homeland in Israel as promised by Sabbatai Zevi. The very symbol of Israel comes from the German meaning of the name Rothschild. Dynasty founder Mayer Amschel Rothschild changed the family name from Bauer to Rothschild, or 'Red-Shield' in German, in deference to the six-pointed 'Star of David' hexagram displayed on the family's home in Frankfurt. The symbol later appeared on the flag of Israel after the Rothschilds were centrally involved in its creation. Hexagrams are not a uniquely Jewish symbol and are widely used in occult ('hidden') networks often as a symbol for Saturn (see my other books for why). Neither are Zionism and Jewishness interchangeable. Zionism is a political movement and philosophy and not a 'race' or a people. Many Jews oppose Zionism and many non-Jews, including US President Joe Biden, call themselves Zionists as does Israel-centric Donald Trump. America's support for the Israel government is pretty much a gimme with ultra-Zionist billionaires and corporations providing fantastic and dominant funding for both political parties. Former Congresswoman Cynthia McKinney has told how she was approached immediately she ran for office to 'sign the pledge' to Israel and confirm that she would always vote in that country's best interests. All American politicians are approached in this way. Anyone who refuses will get no support or funding from the enormous and all-powerful Zionist lobby that includes organisations like mega-lobby group AIPAC, the American Israel Public Affairs Committee. Trump's biggest funder was ultra-Zionist casino and media billionaire Sheldon Adelson while major funders of the Democratic Party include ultra-Zionist George Soros and ultra-Zionist financial and media mogul, Haim Saban. Some may reel back at the suggestion that Soros is an Israel-firster (Sabbatian-controlled Israel-firster), but Renegade Minds watch the actions not the words and everywhere Soros donates his billions the Sabbatian agenda benefits. In the spirit of Sabbatian inversion Soros pledged \$1 billion for a new university network to promote 'liberal values and tackle intolerance'. He made the announcement during his annual speech

at the Cult-owned World Economic Forum in Davos, Switzerland, in January, 2020, after his 'harsh criticism' of 'authoritarian rulers' around the world. You can only laugh at such brazen mendacity. How *he* doesn't laugh is the mystery. Translated from the Orwellian 'liberal values and tackle intolerance' means teaching non-white people to hate white people and for white people to loathe themselves for being born white. The reason for that will become clear.

The 'Anti-Semitism' fraud

Zionists support the Jewish homeland in the land of Palestine which has been the Sabbatian-Rothschild goal for so long, but not for the benefit of Jews. Sabbatians and their global Anti-Semitism Industry have skewed public and political opinion to equate opposing the violent extremes of Zionism to be a blanket attack and condemnation of all Jewish people. Sabbatians and their global Anti-Semitism Industry have skewed public and political opinion to equate opposing the violent extremes of Zionism to be a blanket attack and condemnation of all Jewish people. This is nothing more than a Sabbatian protection racket to stop legitimate investigation and exposure of their agendas and activities. The official definition of 'anti-Semitism' has more recently been expanded to include criticism of Zionism – a *political movement* – and this was done to further stop exposure of Sabbatian infiltrators who created Zionism as we know it today in the 19th century. Renegade Minds will talk about these subjects when they know the shit that will come their way. People must decide if they want to know the truth or just cower in the corner in fear of what others will say. Sabbatians have been trying to label me as 'anti-Semitic' since the 1990s as I have uncovered more and more about their background and agendas. Useless, gutless, fraudulent 'journalists' then just repeat the smears without question and on the day I was writing this section a pair of unquestioning repeaters called Ben Quinn and Archie Bland (how appropriate) outright called me an 'anti-Semite' in the establishment propaganda sheet, the London *Guardian*, with no supporting evidence. The

Sabbatian Anti-Semitism Industry said so and who are they to question that? They wouldn't dare. Ironically 'Semitic' refers to a group of languages in the Middle East that are almost entirely Arabic. 'Anti-Semitism' becomes 'anti-Arab' which if the consequences of this misunderstanding were not so grave would be hilarious. Don't bother telling Quinn and Bland. I don't want to confuse them, bless 'em. One reason I am dubbed 'anti-Semitic' is that I wrote in the 1990s that Jewish operatives (Sabbatians) were heavily involved in the Russian Revolution when Sabbatians overthrew the Romanov dynasty. This apparently made me 'anti-Semitic'. Oh, really? Here is a section from *The Trigger*:

British journalist Robert Wilton confirmed these themes in his 1920 book *The Last Days of the Romanovs* when he studied official documents from the Russian government to identify the members of the Bolshevik ruling elite between 1917 and 1919. The Central Committee included 41 Jews among 62 members; the Council of the People's Commissars had 17 Jews out of 22 members; and 458 of the 556 most important Bolshevik positions between 1918 and 1919 were occupied by Jewish people. Only 17 were Russian. Then there were the 23 Jews among the 36 members of the vicious Cheka Soviet secret police established in 1917 who would soon appear all across the country.

Professor Robert Service of Oxford University, an expert on 20th century Russian history, found evidence that ['Jewish'] Leon Trotsky had sought to make sure that Jews were enrolled in the Red Army and were disproportionately represented in the Soviet civil bureaucracy that included the Cheka which performed mass arrests, imprisonment and executions of 'enemies of the people'. A US State Department Decimal File (861.00/5339) dated November 13th, 1918, names [Rothschild banking agent in America] Jacob Schiff and a list of ultra-Zionists as funders of the Russian Revolution leading to claims of a 'Jewish plot', but the key point missed by all is they were not 'Jews' – they were Sabbatian-Frankists.

Britain's Winston Churchill made the same error by mistake or otherwise. He wrote in a 1920 edition of the *Illustrated Sunday Herald* that those behind the Russian revolution were part of a 'worldwide conspiracy for the overthrow of civilisation and for the reconstitution of society on the basis of arrested development, of envious malevolence, and impossible equality' (see 'Woke' today because that has been created by the same network). Churchill said there was no need to exaggerate the part played in the creation of Bolshevism and in the actual bringing about of the Russian

Revolution 'by these international and for the most part atheistical Jews' ['atheistical Jews' = Sabbatians]. Churchill said it is certainly a very great one and probably outweighs all others: 'With the notable exception of Lenin, the majority of the leading figures are Jews.' He went on to describe, knowingly or not, the Sabbatian modus operandi of placing puppet leaders nominally in power while they control from the background:

Moreover, the principal inspiration and driving power comes from the Jewish leaders. Thus Tchitcherin, a pure Russian, is eclipsed by his nominal subordinate, Litvinoff, and the influence of Russians like Bukharin or Lunacharski cannot be compared with the power of Trotsky, or of Zinovieff, the Dictator of the Red Citadel (Petrograd), or of Krassin or Radek – all Jews. In the Soviet institutions the predominance of Jews is even more astonishing. And the prominent, if not indeed the principal, part in the system of terrorism applied by the Extraordinary Commissions for Combatting Counter-Revolution has been taken by Jews, and in some notable cases by Jewesses.

What I said about seriously disproportionate involvement in the Russian Revolution by Jewish 'revolutionaries' (Sabbatians) is provable fact, but truth is no defence against the Sabbatian Anti-Semitism Industry, its repeater parrots like Quinn and Bland, and the now breathtaking network of so-called 'Woke' 'anti-hate' groups with interlocking leaderships and funding which have the role of discrediting and silencing anyone who gets too close to exposing the Sabbatians. We have seen 'truth is no defence' confirmed in legal judgements with the Saskatchewan Human Rights Commission in Canada decreeing this: 'Truthful statements can be presented in a manner that would meet the definition of hate speech, and not all truthful statements must be free from restriction.' Most 'anti-hate' activists, who are themselves consumed by hatred, are too stupid and ignorant of the world to know how they are being used. They are far too far up their own virtue-signalling arses and it's far too dark for them to see anything.

The 'revolution' game

The background and methods of the 'Russian' Revolution are straight from the Sabbatian playbook seen in the French Revolution

and endless others around the world that appear to start as a revolution of the people against tyrannical rule and end up with a regime change to more tyrannical rule overtly or covertly. Wars, terror attacks and regime overthrows follow the Sabbatian cult through history with its agents creating them as Problem-Reaction-Solutions to remove opposition on the road to world domination. Sabbatian dots connect the Rothschilds with the Illuminati, Jacobins of the French Revolution, the 'Bund' or League of the Just, the International Communist Party, Communist League and the Communist Manifesto of Karl Marx and Friedrich Engels that would lead to the Rothschild-funded Russian Revolution. The sequence comes under the heading of 'creative destruction' when you advance to your global goal by continually destroying the status quo to install a new status quo which you then also destroy. The two world wars come to mind. With each new status quo you move closer to your planned outcome. Wars and mass murder are to Sabbatians a collective blood sacrifice ritual. They are obsessed with death for many reasons and one is that death is an inversion of life. Satanists and Sabbatians are obsessed with death and often target churches and churchyards for their rituals. Inversion-obsessed Sabbatians explain the use of inverted symbolism including the *inverted* pentagram and *inverted* cross. The inversion of the cross has been related to targeting Christianity, but the cross was a religious symbol long before Christianity and its inversion is a statement about the Sabbatian mentality and goals more than any single religion.

Sabbatians operating in Germany were behind the rise of the occult-obsessed Nazis and the subsequent Jewish exodus from Germany and Europe to Palestine and the United States after World War Two. The Rothschild dynasty was at the forefront of this both as political manipulators and by funding the operation. Why would Sabbatians help to orchestrate the horrors inflicted on Jews by the Nazis and by Stalin after they organised the Russian Revolution? Sabbatians hate Jews and their religion, that's why. They pose as Jews and secure positions of control within Jewish society and play the 'anti-Semitism' card to protect themselves from exposure

through a global network of organisations answering to the Sabbatian-created-and-controlled globe-spanning intelligence network that involves a stunning web of military-intelligence operatives and operations for a tiny country of just nine million. Among them are Jewish assets who are not Sabbatians but have been convinced by them that what they are doing is for the good of Israel and the Jewish community to protect them from what they have been programmed since childhood to believe is a Jew-hating hostile world. The Jewish community is just a highly convenient cover to hide the true nature of Sabbatians. Anyone getting close to exposing their game is accused by Sabbatian place-people and gofers of 'anti-Semitism' and claiming that all Jews are part of a plot to take over the world. I am not saying that. I am saying that Sabbatians – the *real* Jew-haters – have infiltrated the Jewish community to use them both as a cover and an 'anti-Semitic' defence against exposure. Thus we have the Anti-Semitism Industry targeted researchers in this way and most Jewish people think this is justified and genuine. They don't know that their 'Jewish' leaders and institutions of state, intelligence and military are not controlled by Jews at all, but cultists and stooges of Sabbatian-Frankism. I once added my name to a pro-Jewish freedom petition online and the next time I looked my name was gone and text had been added to the petition blurb to attack me as an 'anti-Semite' such is the scale of perceptual programming.

Moving on America

I tell the story in *The Trigger* and a chapter called 'Atlantic Crossing' how particularly after Israel was established the Sabbatians moved in on the United States and eventually grasped control of government administration, the political system via both Democrats and Republicans, the intelligence community like the CIA and National Security Agency (NSA), the Pentagon and mass media. Through this seriously compartmentalised network Sabbatians and their operatives in Mossad, Israeli Defense Forces (IDF) and US agencies pulled off 9/11 and blamed it on 19 'Al-Qaeda hijackers' dominated by men from, or connected to, Sabbatian-ruled Saudi

Arabia. The '19' were not even on the planes let alone flew those big passenger jets into buildings while being largely incompetent at piloting one-engine light aircraft. 'Hijacker' Hani Hanjour who is said to have flown American Airlines Flight 77 into the Pentagon with a turn and manoeuvre most professional pilots said they would have struggled to do was banned from renting a small plane by instructors at the Freeway Airport in Bowie, Maryland, just *six weeks* earlier on the grounds that he was an incompetent pilot. The Jewish population of the world is just 0.2 percent with even that almost entirely concentrated in Israel (75 percent Jewish) and the United States (around two percent). This two percent and globally 0.2 percent refers to *Jewish* people and not Sabbatian interlopers who are a fraction of that fraction. What a sobering thought when you think of the fantastic influence on world affairs of tiny Israel and that the Project for the New America Century (PNAC) which laid out the blueprint in September, 2000, for America's war on terror and regime change wars in Iraq, Libya and Syria was founded and dominated by Sabbatians known as 'Neocons'. The document conceded that this plan would not be supported politically or publicly without a major attack on American soil and a Problem-Reaction-Solution excuse to send troops to war across the Middle East. Sabbatian Neocons said:

... [The] process of transformation ... [war and regime change] ... is likely to be a long one, absent some catastrophic and catalysing event – like a new Pearl Harbor.

Four months later many of those who produced that document came to power with their inane puppet George Bush from the long-time Sabbatian Bush family. They included Sabbatian Dick Cheney who was officially vice-president, but really de-facto president for the entirety of the 'Bush' government. Nine months after the 'Bush' inauguration came what Bush called at the time 'the Pearl Harbor of the 21st century' and with typical Sabbatian timing and symbolism 2001 was the 60th anniversary of the attack in 1941 by the Japanese Air Force on Pearl Harbor, Hawaii, which allowed President Franklin Delano Roosevelt to take the United States into a Sabbatian-

instigated Second World War that he said in his election campaign that he never would. The evidence is overwhelming that Roosevelt and his military and intelligence networks knew the attack was coming and did nothing to stop it, but they did make sure that America's most essential naval ships were not in Hawaii at the time. Three thousand Americans died in the Pearl Harbor attacks as they did on September 11th. By the 9/11 year of 2001 Sabbatians had widely infiltrated the US government, military and intelligence operations and used their compartmentalised assets to pull off the 'Al-Qaeda' attacks. If you read *The Trigger* it will blow your mind to see the utterly staggering concentration of 'Jewish' operatives (Sabbatian infiltrators) in essential positions of political, security, legal, law enforcement, financial and business power before, during, and after the attacks to make them happen, carry them out, and then cover their tracks – and I do mean *staggering* when you think of that 0.2 percent of the world population and two percent of Americans which are Jewish while Sabbatian infiltrators are a fraction of that. A central foundation of the 9/11 conspiracy was the hijacking of government, military, Air Force and intelligence computer systems in real time through 'back-door' access made possible by Israeli (Sabbatian) 'cyber security' software. Sabbatian-controlled Israel is on the way to rivalling Silicon Valley for domination of cyberspace and is becoming the dominant force in cyber-security which gives them access to entire computer systems and their passcodes across the world. Then add to this that Zionists head (officially) Silicon Valley giants like Google (Larry Page and Sergey Brin), Google-owned YouTube (Susan Wojcicki), Facebook (Mark Zuckerberg and Sheryl Sandberg), and Apple (Chairman Arthur D. Levinson), and that ultra-Zionist hedge fund billionaire Paul Singer has a \$1 billion stake in Twitter which is only nominally headed by 'CEO' pothead Jack Dorsey. As cable news host Tucker Carlson said of Dorsey: 'There used to be debate in the medical community whether dropping a ton of acid had permanent effects and I think that debate has now ended.' Carlson made the comment after Dorsey told a hearing on Capitol Hill (if you cut through his bullshit) that he

believed in free speech so long as he got to decide what you can hear and see. These 'big names' of Silicon Valley are only front men and women for the Global Cult, not least the Sabbatians, who are the true controllers of these corporations. Does anyone still wonder why these same people and companies have been ferociously censoring and banning people (like me) for exposing any aspect of the Cult agenda and especially the truth about the 'Covid' hoax which Sabbatians have orchestrated?

The Jeffrey Epstein paedophile ring was a Sabbatian operation. He was officially 'Jewish' but he was a Sabbatian and women abused by the ring have told me about the high number of 'Jewish' people involved. The Epstein horror has Sabbatian written all over it and matches perfectly their *modus operandi* and obsession with sex and ritual. Epstein was running a Sabbatian blackmail ring in which famous people with political and other influence were provided with young girls for sex while everything was being filmed and recorded on hidden cameras and microphones at his New York house, Caribbean island and other properties. Epstein survivors have described this surveillance system to me and some have gone public. Once the famous politician or other figure knew he or she was on video they tended to do whatever they were told. Here we go again ...when you've got them by the balls their hearts and minds will follow. Sabbatians use this blackmail technique on a wide scale across the world to entrap politicians and others they need to act as demanded. Epstein's private plane, the infamous 'Lolita Express', had many well-known passengers including Bill Clinton while Bill Gates has flown on an Epstein plane and met with him four years after Epstein had been jailed for paedophilia. They subsequently met many times at Epstein's home in New York according to a witness who was there. Epstein's infamous side-kick was Ghislaine Maxwell, daughter of Mossad agent and ultra-Zionist mega-crooked British businessman, Bob Maxwell, who at one time owned the *Daily Mirror* newspaper. Maxwell was murdered at sea on his boat in 1991 by Sabbatian-controlled Mossad when he became a liability with his

business empire collapsing as a former Mossad operative has confirmed (see *The Trigger*).

Money, money, money, funny money ...

Before I come to the Sabbatian connection with the last three US presidents I will lay out the crucial importance to Sabbatians of controlling banking and finance. Sabbatian Mayer Amschel Rothschild set out to dominate this arena in his family's quest for total global control. What is freedom? It is, in effect, choice. The more choices you have the freer you are and the fewer your choices the more you are enslaved. In the global structure created over centuries by Sabbatians the biggest decider and restrictor of choice is ... money. Across the world if you ask people what they would like to do with their lives and why they are not doing that they will reply 'I don't have the money'. This is the idea. A global elite of multi-billionaires are described as 'greedy' and that is true on one level; but control of money – who has it and who doesn't – is not primarily about greed. It's about control. Sabbatians have seized ever more control of finance and sucked the wealth of the world out of the hands of the population. We talk now, after all, about the 'One-percent' and even then the wealthiest are a lot fewer even than that. This has been made possible by a money scam so outrageous and so vast it could rightly be called the scam of scams founded on creating 'money' out of nothing and 'loaning' that with interest to the population. Money out of nothing is called 'credit'. Sabbatians have asserted control over governments and banking ever more completely through the centuries and secured financial laws that allow banks to lend hugely more than they have on deposit in a confidence trick known as fractional reserve lending. Imagine if you could lend money that doesn't exist and charge the recipient interest for doing so. You would end up in jail. Bankers by contrast end up in mansions, private jets, Malibu and Monaco.

Banks are only required to keep a fraction of their deposits and wealth in their vaults and they are allowed to lend 'money' they don't have called 'credit'. Go into a bank for a loan and if you succeed

the banker will not move any real wealth into your account. They will type into your account the amount of the agreed 'loan' – say £100,000. This is not wealth that really exists; it is non-existent, fresh-air, created-out-of-nothing 'credit' which has never, does not, and will never exist except in theory. Credit is backed by nothing except wind and only has buying power because people think that it has buying power and accept it in return for property, goods and services. I have described this situation as like those cartoon characters you see chasing each other and when they run over the edge of a cliff they keep running forward on fresh air until one of them looks down, realises what's happened, and they all crash into the ravine. The whole foundation of the Sabbatian financial system is to stop people looking down except for periodic moments when they want to crash the system (as in 2008 and 2020 ongoing) and reap the rewards from all the property, businesses and wealth their borrowers had signed over as 'collateral' in return for a 'loan' of fresh air. Most people think that money is somehow created by governments when it comes into existence from the start as a debt through banks 'lending' illusory money called credit. Yes, the very currency of exchange is a *debt* from day one issued as an interest-bearing loan. Why don't governments create money interest-free and lend it to their people interest-free? Governments are controlled by Sabbatians and the financial system is controlled by Sabbatians for whom interest-free money would be a nightmare come true. Sabbatians underpin their financial domination through their global network of central banks, including the privately-owned US Federal Reserve and Britain's Bank of England, and this is orchestrated by a privately-owned central bank coordination body called the Bank for International Settlements in Basle, Switzerland, created by the usual suspects including the Rockefellers and Rothschilds. Central bank chiefs don't answer to governments or the people. They answer to the Bank for International Settlements or, in other words, the Global Cult which is dominated today by Sabbatians.

Built-in disaster

There are so many constituent scams within the overall banking scam. When you take out a loan of thin-air credit only the amount of that loan is theoretically brought into circulation to add to the amount in circulation; but you are paying back the principle plus interest. The additional interest is not created and this means that with every 'loan' there is a shortfall in the money in circulation between what is borrowed and what has to be paid back. There is never even close to enough money in circulation to repay all outstanding public and private debt including interest. Coldly weaved in the very fabric of the system is the certainty that some will lose their homes, businesses and possessions to the banking 'lender'. This is less obvious in times of 'boom' when the amount of money in circulation (and the debt) is expanding through more people wanting and getting loans. When a downturn comes and the money supply contracts it becomes painfully obvious that there is not enough money to service all debt and interest. This is less obvious in times of 'boom' when the amount of money in circulation (and the debt) is expanding through more people wanting and getting loans. When a downturn comes and the money supply contracts and it becomes painfully obvious – as in 2008 and currently – that there is not enough money to service all debt and interest. Sabbatian banksters have been leading the human population through a calculated series of booms (more debt incurred) and busts (when the debt can't be repaid and the banks get the debtor's tangible wealth in exchange for non-existent 'credit'). With each 'bust' Sabbatian bankers have absorbed more of the world's tangible wealth and we end up with the One-percent. Governments are in bankruptcy levels of debt to the same system and are therefore owned by a system they do not control. The Federal Reserve, 'America's central bank', is privately-owned and American presidents only nominally appoint its chairman or woman to maintain the illusion that it's an arm of government. It's not. The 'Fed' is a cartel of private banks which handed billions to its associates and friends after the crash of 2008 and has been Sabbatian-controlled since it was manipulated into being in 1913 through the covert trickery of Rothschild banking agents Jacob Schiff and Paul

Warburg, and the Sabbatian Rockefeller family. Somehow from a Jewish population of two-percent and globally 0.2 percent (Sabbatian interlopers remember are far smaller) ultra-Zionists headed the Federal Reserve for 31 years between 1987 and 2018 in the form of Alan Greenspan, Bernard Bernanke and Janet Yellen (now Biden's Treasury Secretary) with Yellen's deputy chairman a Israeli-American dual citizen and ultra-Zionist Stanley Fischer, a former governor of the Bank of Israel. Ultra-Zionist Fed chiefs spanned the presidencies of Ronald Reagan ('Republican'), Father George Bush ('Republican'), Bill Clinton ('Democrat'), Boy George Bush ('Republican') and Barack Obama ('Democrat'). We should really add the pre-Greenspan chairman, Paul Adolph Volcker, 'appointed' by Jimmy Carter ('Democrat') who ran the Fed between 1979 and 1987 during the Carter and Reagan administrations before Greenspan took over. Volcker was a long-time associate and business partner of the Rothschilds. No matter what the 'party' officially in power the United States economy was directed by the same force. Here are members of the Obama, Trump and Biden administrations and see if you can make out a common theme.

Barack Obama ('Democrat')

Ultra-Zionists Robert Rubin, Larry Summers, and Timothy Geithner ran the US Treasury in the Clinton administration and two of them reappeared with Obama. Ultra-Zionist Fed chairman Alan Greenspan had manipulated the crash of 2008 through deregulation and jumped ship just before the disaster to make way for ultra-Zionist Bernard Bernanke to hand out trillions to Sabbatian 'too big to fail' banks and businesses, including the ubiquitous ultra-Zionist Goldman Sachs which has an ongoing staff revolving door operation between itself and major financial positions in government worldwide. Obama inherited the fallout of the crash when he took office in January, 2009, and fortunately he had the support of his ultra-Zionist White House Chief of Staff Rahm Emmanuel, son of a terrorist who helped to bomb Israel into being in 1948, and his ultra-Zionist senior adviser David Axelrod, chief strategist in Obama's two

successful presidential campaigns. Emmanuel, later mayor of Chicago and former senior fundraiser and strategist for Bill Clinton, is an example of the Sabbatian policy after Israel was established of migrating insider families to America so their children would be born American citizens. 'Obama' chose this financial team throughout his administration to respond to the Sabbatian-instigated crisis:

Timothy Geithner (ultra-Zionist) Treasury Secretary; Jacob J. Lew, Treasury Secretary; Larry Summers (ultra-Zionist), director of the White House National Economic Council; Paul Adolph Volcker (Rothschild business partner), chairman of the Economic Recovery Advisory Board; Peter Orszag (ultra-Zionist), director of the Office of Management and Budget overseeing all government spending; Penny Pritzker (ultra-Zionist), Commerce Secretary; Jared Bernstein (ultra-Zionist), chief economist and economic policy adviser to Vice President Joe Biden; Mary Schapiro (ultra-Zionist), chair of the Securities and Exchange Commission (SEC); Gary Gensler (ultra-Zionist), chairman of the Commodity Futures Trading Commission (CFTC); Sheila Bair (ultra-Zionist), chair of the Federal Deposit Insurance Corporation (FDIC); Karen Mills (ultra-Zionist), head of the Small Business Administration (SBA); Kenneth Feinberg (ultra-Zionist), Special Master for Executive [bail-out] Compensation. Feinberg would be appointed to oversee compensation (with strings) to 9/11 victims and families in a campaign to stop them having their day in court to question the official story. At the same time ultra-Zionist Bernard Bernanke was chairman of the Federal Reserve and these are only some of the ultra-Zionists with allegiance to Sabbatian-controlled Israel in the Obama government. Obama's biggest corporate donor was ultra-Zionist Goldman Sachs which had employed many in his administration.

Donald Trump ('Republican')

Trump claimed to be an outsider (he wasn't) who had come to 'drain the swamp'. He embarked on this goal by immediately appointing ultra-Zionist Steve Mnuchin, a Goldman Sachs employee for 17

years, as his Treasury Secretary. Others included Gary Cohn (ultra-Zionist), chief operating officer of Goldman Sachs, his first Director of the National Economic Council and chief economic adviser, who was later replaced by Larry Kudlow (ultra-Zionist). Trump's senior adviser throughout his four years in the White House was his sinister son-in-law Jared Kushner, a life-long friend of Israel Prime Minister Benjamin Netanyahu. Kushner is the son of a convicted crook who was pardoned by Trump in his last days in office. Other ultra-Zionists in the Trump administration included: Stephen Miller, Senior Policy Adviser; Avrahm Berkowitz, Deputy Adviser to Trump and his Senior Adviser Jared Kushner; Ivanka Trump, Adviser to the President, who converted to Judaism when she married Jared Kushner; David Friedman, Trump lawyer and Ambassador to Israel; Jason Greenblatt, Trump Organization executive vice president and chief legal officer, who was made Special Representative for International Negotiations and the Israeli-Palestinian Conflict; Rod Rosenstein, Deputy Attorney General; Elliot Abrams, Special Representative for Venezuela, then Iran; John Eisenberg, National Security Council Legal Adviser and Deputy Council to the President for National Security Affairs; Anne Neuberger, Deputy National Manager, National Security Agency; Ezra Cohen-Watnick, Acting Under Secretary of Defense for Intelligence; Elan Carr, Special Envoy to monitor and combat anti-Semitism; Len Khodorkovsky, Deputy Special Envoy to monitor and combat anti-Semitism; Reed Cordish, Assistant to the President, Intragovernmental and Technology Initiatives. Trump Vice President Mike Pence and Secretary of State Mike Pompeo, both Christian Zionists, were also vehement supporters of Israel and its goals and ambitions.

Donald 'free-speech believer' Trump pardoned a number of financial and violent criminals while ignoring calls to pardon Julian Assange and Edward Snowden whose crimes are revealing highly relevant information about government manipulation and corruption and the widespread illegal surveillance of the American people by US 'security' agencies. It's so good to know that Trump is on the side of freedom and justice and not mega-criminals with

allegiance to Sabbatian-controlled Israel. These included a pardon for Israeli spy Jonathan Pollard who was jailed for life in 1987 under the Espionage Act. Aviem Sella, the Mossad agent who recruited Pollard, was also pardoned by Trump while Assange sat in jail and Snowden remained in exile in Russia. Sella had 'fled' (was helped to escape) to Israel in 1987 and was never extradited despite being charged under the Espionage Act. A Trump White House statement said that Sella's clemency had been 'supported by Benjamin Netanyahu, Ron Dermer, Israel's US Ambassador, David Friedman, US Ambassador to Israel and Miriam Adelson, wife of leading Trump donor Sheldon Adelson who died shortly before. Other friends of Jared Kushner were pardoned along with Sholom Weiss who was believed to be serving the longest-ever white-collar prison sentence of more than 800 years in 2000. The sentence was commuted of Ponzi-schemer Eliyahu Weinstein who defrauded Jews and others out of \$200 million. I did mention that Assange and Snowden were ignored, right? Trump gave Sabbatians almost everything they asked for in military and political support, moving the US Embassy from Tel Aviv to Jerusalem with its critical symbolic and literal implications for Palestinian statehood, and the 'deal of the Century' designed by Jared Kushner and David Friedman which gave the Sabbatian Israeli government the green light to substantially expand its already widespread program of building illegal Jewish-only settlements in the occupied land of the West Bank. This made a two-state 'solution' impossible by seizing all the land of a potential Palestinian homeland and that had been the plan since 1948 and then 1967 when the Arab-controlled Gaza Strip, West Bank, Sinai Peninsula and Syrian Golan Heights were occupied by Israel. All the talks about talks and road maps and delays have been buying time until the West Bank was physically occupied by Israeli real estate. Trump would have to be a monumentally ill-informed idiot not to see that this was the plan he was helping to complete. The Trump administration was in so many ways the Kushner administration which means the Netanyahu administration which means the Sabbatian administration. I understand why many opposing Cult fascism in all its forms gravitated to Trump, but he

was a crucial part of the Sabbatian plan and I will deal with this in the next chapter.

Joe Biden ('Democrat')

A barely cognitive Joe Biden took over the presidency in January, 2021, along with his fellow empty shell, Vice-President Kamala Harris, as the latest Sabbatian gofers to enter the White House. Names on the door may have changed and the 'party' – the force behind them remained the same as Zionists were appointed to a stream of pivotal areas relating to Sabbatian plans and policy. They included: Janet Yellen, Treasury Secretary, former head of the Federal Reserve, and still another ultra-Zionist running the US Treasury after Mnuchin (Trump), Lew and Geithner (Obama), and Summers and Rubin (Clinton); Anthony Blinken, Secretary of State; Wendy Sherman, Deputy Secretary of State (so that's 'Biden's' Sabbatian foreign policy sorted); Jeff Zients, White House coronavirus coordinator; Rochelle Walensky, head of the Centers for Disease Control; Rachel Levine, transgender deputy health secretary (that's 'Covid' hoax policy under control); Merrick Garland, Attorney General; Alejandro Mayorkas, Secretary of Homeland Security; Cass Sunstein, Homeland Security with responsibility for new immigration laws; Avril Haines, Director of National Intelligence; Anne Neuberger, National Security Agency cybersecurity director (note, cybersecurity); David Cohen, CIA Deputy Director; Ronald Klain, Biden's Chief of Staff (see Rahm Emanuel); Eric Lander, a 'leading geneticist', Office of Science and Technology Policy director (see Smart Grid, synthetic biology agenda); Jessica Rosenworcel, acting head of the Federal Communications Commission (FCC) which controls Smart Grid technology policy and electromagnetic communication systems including 5G. How can it be that so many pivotal positions are held by two-percent of the American population and 0.2 percent of the world population administration after administration no matter who is the president and what is the party? It's a coincidence? Of course it's not and this is why Sabbatians have built their colossal global web of interlocking 'anti-

hate' hate groups to condemn anyone who asks these glaring questions as an 'anti-Semite'. The way that Jewish people horrifically abused in Sabbatian-backed Nazi Germany are exploited to this end is stomach-turning and disgusting beyond words.

Political fusion

Sabbatian manipulation has reversed the roles of Republicans and Democrats and the same has happened in Britain with the Conservative and Labour Parties. Republicans and Conservatives were always labelled the 'right' and Democrats and Labour the 'left', but look at the policy positions now and the Democrat-Labour 'left' has moved further to the 'right' than Republicans and Conservatives under the banner of 'Woke', the Cult-created far-right tyranny. Where once the Democrat-Labour 'left' defended free speech and human rights they now seek to delete them and as I said earlier despite the 'Covid' fascism of the Jackboot Johnson Conservative government in the UK the Labour Party of leader Keir Starmer demanded even more extreme measures. The Labour Party has been very publicly absorbed by Sabbatians after a political and media onslaught against the previous leader, the weak and inept Jeremy Corbyn, over made-up allegations of 'anti-Semitism' both by him and his party. The plan was clear with this 'anti-Semite' propaganda and what was required in response was a swift and decisive 'fuck off' from Corbyn and a statement to expose the Anti-Semitism Industry (Sabbatian) attempt to silence Labour criticism of the Israeli government (Sabbatians) and purge the party of all dissent against the extremes of ultra-Zionism (Sabbatians). Instead Corbyn and his party fell to their knees and appeased the abusers which, by definition, is impossible. Appeasing one demand leads only to a new demand to be appeased until takeover is complete. Like I say – 'fuck off' would have been a much more effective policy and I have used it myself with great effect over the years when Sabbatians are on my case which is most of the time. I consider that fact a great compliment, by the way. The outcome of the Labour Party capitulation is that we now have a Sabbatian-controlled

Conservative Party 'opposed' by a Sabbatian-controlled Labour Party in a one-party Sabbatian state that hurtles towards the extremes of tyranny (the Sabbatian cult agenda). In America the situation is the same. Labour's Keir Starmer spends his days on his knees with his tongue out pointing to Tel Aviv, or I guess now Jerusalem, while Boris Johnson has an 'anti-Semitism czar' in the form of former Labour MP John Mann who keeps Starmer company on his prayer mat.

Sabbatian influence can be seen in Jewish members of the Labour Party who have been ejected for criticism of Israel including those from families that suffered in Nazi Germany. Sabbatians despise real Jewish people and target them even more harshly because it is so much more difficult to dub them 'anti-Semitic' although in their desperation they do try.

CHAPTER THREE

The Pushbacker sting

*Until you realize how easy it is for your mind to be manipulated, you
remain the puppet of someone else's game*

Evita Ochel

I will use the presidencies of Trump and Biden to show how the manipulation of the one-party state plays out behind the illusion of political choice across the world. No two presidencies could – on the face of it – be more different and apparently at odds in terms of direction and policy.

A Renegade Mind sees beyond the obvious and focuses on outcomes and consequences and not image, words and waffle. The Cult embarked on a campaign to divide America between those who blindly support its agenda (the mentality known as 'Woke') and those who are pushing back on where the Cult and its Sabbatians want to go. This presents infinite possibilities for dividing and ruling the population by setting them at war with each other and allows a perceptual ring fence of demonisation to encircle the Pushbackers in a modern version of the Little Big Horn in 1876 when American cavalry led by Lieutenant Colonel George Custer were drawn into a trap, surrounded and killed by Native American tribes defending their land of thousands of years from being seized by the government. In this modern version the roles are reversed and it's those defending themselves from the Sabbatian government who are surrounded and the government that's seeking to destroy them. This trap was set years ago and to explain how we must return to 2016

and the emergence of Donald Trump as a candidate to be President of the United States. He set out to overcome the best part of 20 other candidates in the Republican Party before and during the primaries and was not considered by many in those early stages to have a prayer of living in the White House. The Republican Party was said to have great reservations about Trump and yet somehow he won the nomination. When you know how American politics works – politics in general – there is no way that Trump could have become the party's candidate unless the Sabbatian-controlled 'Neocons' that run the Republican Party wanted that to happen. We saw the proof in emails and documents made public by WikiLeaks that the Democratic Party hierarchy, or Democons, systematically undermined the campaign of Bernie Sanders to make sure that Sabbatian gofer Hillary Clinton won the nomination to be their presidential candidate. If the Democons could do that then the Neocons in the Republican Party could have derailed Trump in the same way. But they didn't and at that stage I began to conclude that Trump could well be the one chosen to be president. If that was the case the 'why' was pretty clear to see – the goal of dividing America between Cult agenda-supporting Wokers and Pushbackers who gravitated to Trump because he was telling them what they wanted to hear. His constituency of support had been increasingly ignored and voiceless for decades and profoundly through the eight years of Sabbatian puppet Barack Obama. Now here was someone speaking their language of pulling back from the incessant globalisation of political and economic power, the exporting of American jobs to China and elsewhere by 'American' (Sabbatian) corporations, the deletion of free speech, and the mass immigration policies that had further devastated job opportunities for the urban working class of all races and the once American heartlands of the Midwest.

Beware the forked tongue

Those people collectively sighed with relief that at last a political leader was apparently on their side, but another trait of the Renegade Mind is that you look even harder at people telling you

what you want to hear than those who are telling you otherwise. Obviously as I said earlier people wish what they want to hear to be true and genuine and they are much more likely to believe that than someone saying what they don't want to hear and don't want to be true. Sales people are taught to be skilled in eliciting by calculated questioning what their customers want to hear and repeating that back to them as their own opinion to get their targets to like and trust them. Assets of the Cult are also sales people in the sense of selling perception. To read Cult manipulation you have to play the long and expanded game and not fall for the Vaudeville show of party politics. Both American parties are vehicles for the Cult and they exploit them in different ways depending on what the agenda requires at that moment. Trump and the Republicans were used to be the focus of dividing America and isolating Pushbackers to open the way for a Biden presidency to become the most extreme in American history by advancing the full-blown Woke (Cult) agenda with the aim of destroying and silencing Pushbackers now labelled Nazi Trump supporters and white supremacists.

Sabbatians wanted Trump in office for the reasons described by ultra-Zionist Saul Alinsky (1909-1972) who was promoting the Woke philosophy through 'community organising' long before anyone had heard of it. In those days it still went by its traditional name of Marxism. The reason for the manipulated Trump phenomenon was laid out in Alinsky's 1971 book, *Rules for Radicals*, which was his blueprint for overthrowing democratic and other regimes and replacing them with Sabbatian Marxism. Not surprisingly his to-do list was evident in the Sabbatian French and Russian 'Revolutions' and that in China which will become very relevant in the next chapter about the 'Covid' hoax. Among Alinsky's followers have been the deeply corrupt Barack Obama, House Speaker Nancy Pelosi and Hillary Clinton who described him as a 'hero'. All three are Sabbatian stooges with Pelosi personifying the arrogant corrupt idiocy that so widely fronts up for the Cult inner core. Predictably as a Sabbatian advocate of the 'light-bringer' Alinsky features Lucifer on the dedication page of his book as the original radical who gained

his own kingdom ('Earth' as we shall see). One of Alinsky's golden radical rules was to pick an individual and focus all attention, hatred and blame on them and not to target faceless bureaucracies and corporations. *Rules for Radicals* is really a Sabbatian handbook with its contents repeatedly employed all over the world for centuries and why wouldn't Sabbatians bring to power their designer-villain to be used as the individual on which all attention, hatred and blame was bestowed? This is what they did and the only question for me is how much Trump knew that and how much he was manipulated. A bit of both, I suspect. This was Alinsky's Trump technique from a man who died in 1972. The technique has spanned history:

Pick the target, freeze it, personalize it, polarize it. Don't try to attack abstract corporations or bureaucracies. Identify a responsible individual. Ignore attempts to shift or spread the blame.

From the moment Trump came to illusory power everything was about him. It wasn't about Republican policy or opinion, but all about Trump. Everything he did was presented in negative, derogatory and abusive terms by the Sabbatian-dominated media led by Cult operations such as CNN, MSNBC, *The New York Times* and the Jeff Bezos-owned *Washington Post* – 'Pick the target, freeze it, personalize it, polarize it.' Trump was turned into a demon to be vilified by those who hated him and a demi-god loved by those who worshipped him. This, in turn, had his supporters, too, presented as equally demonic in preparation for the punchline later down the line when Biden was about to take office. It was here's a Trump, there's a Trump, everywhere a Trump, Trump. Virtually every news story or happening was filtered through the lens of 'The Donald'. You loved him or hated him and which one you chose was said to define you as Satan's spawn or a paragon of virtue. Even supporting some Trump policies or statements and not others was enough for an assault on your character. No shades of grey were or are allowed. Everything is black and white (literally and figuratively). A Californian I knew had her head utterly scrambled by her hatred for Trump while telling people they should love each other. She was so totally consumed by

Trump Derangement Syndrome as it became to be known that this glaring contradiction would never have occurred to her. By definition anyone who criticised Trump or praised his opponents was a hero and this lady described Joe Biden as 'a kind, honest gentleman' when he's a provable liar, mega-crook and vicious piece of work to boot. Sabbatians had indeed divided America using Trump as the fall-guy and all along the clock was ticking on the consequences for his supporters.

In hock to his masters

Trump gave Sabbatians via Israel almost everything they wanted in his four years. Ask and you shall receive was the dynamic between himself and Benjamin Netanyahu orchestrated by Trump's ultra-Zionist son-in-law Jared Kushner, his ultra-Zionist Ambassador to Israel, David Friedman, and ultra-Zionist 'Israel adviser', Jason Greenblatt. The last two were central to the running and protecting from collapse of his business empire, the Trump Organisation, and colossal business failures made him forever beholding to Sabbatian networks that bailed him out. By the start of the 1990s Trump owed \$4 billion to banks that he couldn't pay and almost \$1 billion of that was down to him personally and not his companies. This mega-disaster was the result of building two new casinos in Atlantic City and buying the enormous Taj Mahal operation which led to crippling debt payments. He had borrowed fantastic sums from 72 banks with major Sabbatian connections and although the scale of debt should have had him living in a tent alongside the highway they never foreclosed. A plan was devised to lift Trump from the mire by BT Securities Corporation and Rothschild Inc. and the case was handled by Wilber Ross who had worked for the Rothschilds for 27 years. Ross would be named US Commerce Secretary after Trump's election. Another crucial figure in saving Trump was ultra-Zionist 'investor' Carl Icahn who bought the Taj Mahal casino. Icahn was made special economic adviser on financial regulation in the Trump administration. He didn't stay long but still managed to find time to make a tidy sum of a reported \$31.3 million when he sold his

holdings affected by the price of steel three days before Trump imposed a 235 percent tariff on steel imports. What amazing bits of luck these people have. Trump and Sabbatian operatives have long had a close association and his mentor and legal adviser from the early 1970s until 1986 was the dark and genetically corrupt ultra-Zionist Roy Cohn who was chief counsel to Senator Joseph McCarthy's 'communist' witch-hunt in the 1950s. *Esquire* magazine published an article about Cohn with the headline 'Don't mess with Roy Cohn'. He was described as the most feared lawyer in New York and 'a ruthless master of dirty tricks ... [with] ... more than one Mafia Don on speed dial'. Cohn's influence, contacts, support and protection made Trump a front man for Sabbatians in New York with their connections to one of Cohn's many criminal employers, the 'Russian' Sabbatian Mafia. Israel-centric media mogul Rupert Murdoch was introduced to Trump by Cohn and they started a long friendship. Cohn died in 1986 weeks after being disbarred for unethical conduct by the Appellate Division of the New York State Supreme Court. The wheels of justice do indeed run slow given the length of Cohn's crooked career.

QAnon-sense

We are asked to believe that Donald Trump with his fundamental connections to Sabbatian networks and operatives has been leading the fight to stop the Sabbatian agenda for the fascistic control of America and the world. Sure he has. A man entrapped during his years in the White House by Sabbatian operatives and whose biggest financial donor was casino billionaire Sheldon Adelson who was Sabbatian to his DNA?? Oh, do come on. Trump has been used to divide America and isolate Pushbackers on the Cult agenda under the heading of 'Trump supporters', 'insurrectionists' and 'white supremacists'. The US Intelligence/Mossad Psyop or psychological operation known as QAnon emerged during the Trump years as a central pillar in the Sabbatian campaign to lead Pushbackers into the trap set by those that wished to destroy them. I knew from the start that QAnon was a scam because I had seen the same scenario many

times before over 30 years under different names and I had written about one in particular in the books. 'Not again' was my reaction when QAnon came to the fore. The same script is pulled out every few years and a new name added to the letterhead. The story always takes the same form: 'Insiders' or 'the good guys' in the government-intelligence-military 'Deep State' apparatus were going to instigate mass arrests of the 'bad guys' which would include the Rockefellers, Rothschilds, Barack Obama, Hillary Clinton, George Soros, etc., etc. Dates are given for when the 'good guys' are going to move in, but the dates pass without incident and new dates are given which pass without incident. The central message to Pushbackers in each case is that they don't have to do anything because there is 'a plan' and it is all going to be sorted by the 'good guys' on the inside. 'Trust the plan' was a QAnon mantra when the only plan was to misdirect Pushbackers into putting their trust in a Psyop they believed to be real. Beware, beware, those who tell you what you want to hear and always check it out. Right up to Biden's inauguration QAnon was still claiming that 'the Storm' was coming and Trump would stay on as president when Biden and his cronies were arrested and jailed. It was never going to happen and of course it didn't, but what did happen as a result provided that punchline to the Sabbatian Trump/QAnon Psyop.

On January 6th, 2021, a very big crowd of Trump supporters gathered in the National Mall in Washington DC down from the Capitol Building to protest at what they believed to be widespread corruption and vote fraud that stopped Trump being re-elected for a second term as president in November, 2020. I say as someone that does not support Trump or Biden that the evidence is clear that major vote-fixing went on to favour Biden, a man with cognitive problems so advanced he can often hardly string a sentence together without reading the words written for him on the Teleprompter. Glaring ballot discrepancies included serious questions about electronic voting machines that make vote rigging a comparative cinch and hundreds of thousands of paper votes that suddenly appeared during already advanced vote counts and virtually all of

them for Biden. Early Trump leads in crucial swing states suddenly began to close and disappear. The pandemic hoax was used as the excuse to issue almost limitless numbers of mail-in ballots with no checks to establish that the recipients were still alive or lived at that address. They were sent to streams of people who had not even asked for them. Private organisations were employed to gather these ballots and who knows what they did with them before they turned up at the counts. The American election system has been manipulated over decades to become a sick joke with more holes than a Swiss cheese for the express purpose of dictating the results. Then there was the criminal manipulation of information by Sabbatian tech giants like Facebook, Twitter and Google-owned YouTube which deleted pro-Trump, anti-Biden accounts and posts while everything in support of Biden was left alone. Sabbatians wanted Biden to win because after the dividing of America it was time for full-on Woke and every aspect of the Cult agenda to be unleashed.

Hunter gatherer

Extreme Silicon Valley bias included blocking information by the *New York Post* exposing a Biden scandal that should have ended his bid for president in the final weeks of the campaign. Hunter Biden, his monumentally corrupt son, is reported to have sent a laptop to be repaired at a local store and failed to return for it. Time passed until the laptop became the property of the store for non-payment of the bill. When the owner saw what was on the hard drive he gave a copy to the FBI who did nothing even though it confirmed widespread corruption in which the Joe Biden family were using his political position, especially when he was vice president to Obama, to make multiple millions in countries around the world and most notably Ukraine and China. Hunter Biden's one-time business partner Tony Bobulinski went public when the story broke in the *New York Post* to confirm the corruption he saw and that Joe Biden not only knew what was going on he also profited from the spoils. Millions were handed over by a Chinese company with close

connections – like all major businesses in China – to the Chinese communist party of President Xi Jinping. Joe Biden even boasted at a meeting of the Cult's World Economic Forum that as vice president he had ordered the government of Ukraine to fire a prosecutor. What he didn't mention was that the same man just happened to be investigating an energy company which was part of Hunter Biden's corrupt portfolio. The company was paying him big bucks for no other reason than the influence his father had. Overnight Biden's presidential campaign should have been over given that he had lied publicly about not knowing what his son was doing. Instead almost the entire Sabbatian-owned mainstream media and Sabbatian-owned Silicon Valley suppressed circulation of the story. This alone went a mighty way to rigging the election of 2020. Cult assets like Mark Zuckerberg at Facebook also spent hundreds of millions to be used in support of Biden and vote 'administration'.

The Cult had used Trump as the focus to divide America and was now desperate to bring in moronic, pliable, corrupt Biden to complete the double-whammy. No way were they going to let little things like the will of the people thwart their plan. Silicon Valley widely censored claims that the election was rigged because it *was* rigged. For the same reason anyone claiming it was rigged was denounced as a 'white supremacist' including the pathetically few Republican politicians willing to say so. Right across the media where the claim was mentioned it was described as a 'false claim' even though these excuses for 'journalists' would have done no research into the subject whatsoever. Trump won seven million more votes than any sitting president had ever achieved while somehow a cognitively-challenged soon to be 78-year-old who was hidden away from the public for most of the campaign managed to win more votes than any presidential candidate in history. It makes no sense. You only had to see election rallies for both candidates to witness the enthusiasm for Trump and the apathy for Biden. Tens of thousands would attend Trump events while Biden was speaking in empty car parks with often only television crews attending and framing their shots to hide the fact that no one was there. It was pathetic to see

footage come to light of Biden standing at a podium making speeches only to TV crews and party fixers while reading the words written for him on massive Teleprompter screens. So, yes, those protestors on January 6th had a point about election rigging, but some were about to walk into a trap laid for them in Washington by the Cult Deep State and its QAnon Psyop. This was the Capitol Hill riot ludicrously dubbed an 'insurrection'.

The spider and the fly

Renegade Minds know there are not two 'sides' in politics, only one side, the Cult, working through all 'sides'. It's a stage show, a puppet show, to direct the perceptions of the population into focusing on diversions like parties and candidates while missing the puppeteers with their hands holding all the strings. The Capitol Hill 'insurrection' brings us back to the Little Big Horn. Having created two distinct opposing groupings – Woke and Pushbackers – the trap was about to be sprung. Pushbackers were to be encircled and isolated by associating them all in the public mind with Trump and then labelling Trump as some sort of Confederate leader. I knew immediately that the Capitol riot was a set-up because of two things. One was how easy the rioters got into the building with virtually no credible resistance and secondly I could see – as with the 'Covid' hoax in the West at the start of 2020 – how the Cult could exploit the situation to move its agenda forward with great speed. My experience of Cult techniques and activities over more than 30 years has showed me that while they do exploit situations they haven't themselves created this never happens with events of fundamental agenda significance. Every time major events giving cultists the excuse to rapidly advance their plan you find they are manipulated into being for the specific reason of providing that excuse – Problem-Reaction-Solution. Only a tiny minority of the huge crowd of Washington protestors sought to gain entry to the Capitol by smashing windows and breaching doors. That didn't matter. The whole crowd and all Pushbackers, even if they did not support Trump, were going to be lumped together as dangerous

insurrectionists and conspiracy theorists. The latter term came into widespread use through a CIA memo in the 1960s aimed at discrediting those questioning the nonsensical official story of the Kennedy assassination and it subsequently became widely employed by the media. It's still being used by inept 'journalists' with no idea of its origin to discredit anyone questioning anything that authority claims to be true. When you are perpetrating a conspiracy you need to discredit the very word itself even though the dictionary definition of conspiracy is merely 'the activity of secretly planning with other people to do something bad or illegal' and 'a general agreement to keep silent about a subject for the purpose of keeping it secret'. On that basis there are conspiracies almost wherever you look. For obvious reasons the Cult and its lapdog media have to claim there are no conspiracies even though the word appears in state laws as with conspiracy to defraud, to murder, and to corrupt public morals.

Agent provocateurs are widely used by the Cult Deep State to manipulate genuine people into acting in ways that suit the desired outcome. By genuine in this case I mean protestors genuinely supporting Trump and claims that the election was stolen. In among them, however, were agents of the state wearing the garb of Trump supporters and QAnon to pump-prime the Capital riot which some genuine Trump supporters naively fell for. I described the situation as 'Come into my parlour said the spider to the fly'. Leaflets appeared through the Woke paramilitary arm Antifa, the anti-fascist fascists, calling on supporters to turn up in Washington looking like Trump supporters even though they hated him. Some of those arrested for breaching the Capitol Building were sourced to Antifa and its stable mate Black Lives Matter. Both organisations are funded by Cult billionaires and corporations. One man charged for the riot was according to his lawyer a former FBI agent who had held top secret security clearance for 40 years. Attorney Thomas Plofchan said of his client, 66-year-old Thomas Edward Caldwell:

He has held a Top Secret Security Clearance since 1979 and has undergone multiple Special Background Investigations in support of his clearances. After retiring from the Navy, he

worked as a section chief for the Federal Bureau of Investigation from 2009-2010 as a GS-12 [mid-level employee].

He also formed and operated a consulting firm performing work, often classified, for U.S government customers including the US. Drug Enforcement Agency, Department of Housing and Urban Development, the US Coast Guard, and the US Army Personnel Command.

A judge later released Caldwell pending trial in the absence of evidence about a conspiracy or that he tried to force his way into the building. *The New York Post* reported a 'law enforcement source' as saying that 'at least two known Antifa members were spotted' on camera among Trump supporters during the riot while one of the rioters arrested was John Earle Sullivan, a seriously extreme Black Lives Matter Trump-hater from Utah who was previously arrested and charged in July, 2020, over a BLM-Antifa riot in which drivers were threatened and one was shot. Sullivan is the founder of Utah-based Insurgence USA which is an affiliate of the Cult-created-and-funded Black Lives Matter movement. Footage appeared and was then deleted by Twitter of Trump supporters calling out Antifa infiltrators and a group was filmed changing into pro-Trump clothing before the riot. Security at the building was *pathetic* – as planned. Colonel Leroy Fletcher Prouty, a man with long experience in covert operations working with the US security apparatus, once described the tell-tale sign to identify who is involved in an assassination. He said:

No one has to direct an assassination – it happens. The active role is played secretly by permitting it to happen. This is the greatest single clue. Who has the power to call off or reduce the usual security precautions?

This principle applies to many other situations and certainly to the Capitol riot of January 6th, 2021.

The sting

With such a big and potentially angry crowd known to be gathering near the Capitol the security apparatus would have had a major police detail to defend the building with National Guard troops on

standby given the strength of feeling among people arriving from all over America encouraged by the QAnon Psyop and statements by Donald Trump. Instead Capitol Police 'security' was flimsy, weak, and easily breached. The same number of officers was deployed as on a regular day and that is a blatant red flag. They were not staffed or equipped for a possible riot that had been an obvious possibility in the circumstances. No protective and effective fencing worth the name was put in place and there were no contingency plans. The whole thing was basically a case of standing aside and waving people in. Once inside police mostly backed off apart from one Capitol police officer who ridiculously shot dead unarmed Air Force veteran protestor Ashli Babbitt without a warning as she climbed through a broken window. The 'investigation' refused to name or charge the officer after what must surely be considered a murder in the circumstances. They just lifted a carpet and swept. The story was endlessly repeated about five people dying in the 'armed insurrection' when there was no report of rioters using weapons. Apart from Babbitt the other four died from a heart attack, strokes and apparently a drug overdose. Capitol police officer Brian Sicknick was reported to have died after being bludgeoned with a fire extinguisher when he was alive after the riot was over and died later of what the Washington Medical Examiner's Office said was a stroke. Sicknick had no external injuries. The lies were delivered like rapid fire. There was a narrative to build with incessant repetition of the lie until the lie became the accepted 'everybody knows that' truth. The 'Big Lie' technique of Nazi Propaganda Minister Joseph Goebbels is constantly used by the Cult which was behind the Nazis and is today behind the 'Covid' and 'climate change' hoaxes. Goebbels said:

If you tell a lie big enough and keep repeating it, people will eventually come to believe it. The lie can be maintained only for such time as the State can shield the people from the political, economic and/or military consequences of the lie. It thus becomes vitally important for the State to use all of its powers to repress dissent, for the truth is the mortal enemy of the lie, and thus by extension, the truth is the greatest enemy of the State.

Most protestors had a free run of the Capitol Building. This allowed pictures to be taken of rioters in iconic parts of the building including the Senate chamber which could be used as propaganda images against all Pushbackers. One Congresswoman described the scene as 'the worst kind of non-security anybody could ever imagine'. Well, the first part was true, but someone obviously did imagine it and made sure it happened. Some photographs most widely circulated featured people wearing QAnon symbols and now the Psyop would be used to dub all QAnon followers with the ubiquitous fit-all label of 'white supremacist' and 'insurrectionists'. When a Muslim extremist called Noah Green drove his car at two police officers at the Capitol Building killing one in April, 2021, there was no such political and media hysteria. They were just disappointed he wasn't white.

The witch-hunt

Government prosecutor Michael Sherwin, an aggressive, dark-eyed, professional Rottweiler led the 'investigation' and to call it over the top would be to understate reality a thousand fold. Hundreds were tracked down and arrested for the crime of having the wrong political views and people were jailed who had done nothing more than walk in the building, committed no violence or damage to property, took a few pictures and left. They were labelled a 'threat to the Republic' while Biden sat in the White House signing executive orders written for him that were dismantling 'the Republic'. Even when judges ruled that a mother and son should not be in jail the government kept them there. Some of those arrested have been badly beaten by prison guards in Washington and lawyers for one man said he suffered a fractured skull and was made blind in one eye. Meanwhile a woman is shot dead for no reason by a Capitol Police officer and we are not allowed to know who he is never mind what has happened to him although that will be *nothing*. The Cult's QAnon/Trump sting to identify and isolate Pushbackers and then target them on the road to crushing and deleting them was a resounding success. You would have thought the Russians had

invaded the building at gunpoint and lined up senators for a firing squad to see the political and media reaction. Congresswoman Alexandria Ocasio-Cortez is a child in a woman's body, a terrible-tuos, me, me, me, Woker narcissist of such proportions that words have no meaning. She said she thought she was going to die when 'insurrectionists' banged on her office door. It turned out she wasn't even in the Capitol Building when the riot was happening and the 'banging' was a Capitol Police officer. She referred to herself as a 'survivor' which is an insult to all those true survivors of violent and sexual abuse while she lives her pampered and privileged life talking drivel for a living. Her Woke colleague and fellow mega-narcissist Rashida Tlaib broke down describing the devastating effect on her, too, of *not being* in the building when the rioters were there. Ocasio-Cortez and Tlaib are members of a fully-Woke group of Congresswomen known as 'The Squad' along with Ilhan Omar and Ayanna Pressley. The Squad from what I can see can be identified by its vehement anti-white racism, anti-white men agenda, and, as always in these cases, the absence of brain cells on active duty.

The usual suspects were on the riot case immediately in the form of Democrat ultra-Zionist senators and operatives Chuck Schumer and Adam Schiff demanding that Trump be impeached for 'his part in the insurrection'. The same pair of prats had led the failed impeachment of Trump over the invented 'Russia collusion' nonsense which claimed Russia had helped Trump win the 2016 election. I didn't realise that Tel Aviv had been relocated just outside Moscow. I must find an up-to-date map. The Russia hoax was a Sabbatian operation to keep Trump occupied and impotent and to stop any rapport with Russia which the Cult wants to retain as a perceptual enemy to be pulled out at will. Puppet Biden began attacking Russia when he came to office as the Cult seeks more upheaval, division and war across the world. A two-year stage show 'Russia collusion inquiry' headed by the not-very-bright former 9/11 FBI chief Robert Mueller, with support from 19 lawyers, 40 FBI agents plus intelligence analysts, forensic accountants and other

staff, devoured tens of millions of dollars and found no evidence of Russia collusion which a ten-year-old could have told them on day one. Now the same moronic Schumer and Schiff wanted a second impeachment of Trump over the Capitol 'insurrection' (riot) which the arrested development of Schumer called another 'Pearl Harbor' while others compared it with 9/11 in which 3,000 died and, in the case of CNN, with the Rwandan genocide in the 1990s in which an estimated 500,000 to 600,000 were murdered, between 250, 000 and 500,000 women were raped, and populations of whole towns were hacked to death with machetes. To make those comparisons purely for Cult political reasons is beyond insulting to those that suffered and lost their lives and confirms yet again the callous inhumanity that we are dealing with. Schumer is a monumental idiot and so is Schiff, but they serve the Cult agenda and do whatever they're told so they get looked after. Talking of idiots – another inane man who spanned the Russia and Capitol impeachment attempts was Senator Eric Swalwell who had the nerve to accuse Trump of collusion with the Russians while sleeping with a Chinese spy called Christine Fang or 'Fang Fang' which is straight out of a Bond film no doubt starring Klaus Schwab as the bloke living on a secret island and controlling laser weapons positioned in space and pointing at world capitals. Fang Fang plays the part of Bond's infiltrator girlfriend which I'm sure she would enjoy rather more than sharing a bed with the brainless Swalwell, lying back and thinking of China. The FBI eventually warned Swalwell about Fang Fang which gave her time to escape back to the Chinese dictatorship. How very thoughtful of them. The second Trump impeachment also failed and hardly surprising when an impeachment is supposed to remove a sitting president and by the time it happened Trump was no longer president. These people are running your country America, well, officially anyway. Terrifying isn't it?

Outcomes tell the story - always

The outcome of all this – and it's the *outcome* on which Renegade Minds focus, not the words – was that a vicious, hysterical and

obviously pre-planned assault was launched on Pushbackers to censor, silence and discredit them and even targeted their right to earn a living. They have since been condemned as 'domestic terrorists' that need to be treated like Al-Qaeda and Islamic State. 'Domestic terrorists' is a label the Cult has been trying to make stick since the period of the Oklahoma bombing in 1995 which was blamed on 'far-right domestic terrorists'. If you read *The Trigger* you will see that the bombing was clearly a Problem-Reaction-Solution carried out by the Deep State during a Bill Clinton administration so corrupt that no dictionary definition of the term would even nearly suffice. Nearly 30, 000 troops were deployed from all over America to the empty streets of Washington for Biden's inauguration. Ten thousand of them stayed on with the pretext of protecting the capital from insurrectionists when it was more psychological programming to normalise the use of the military in domestic law enforcement in support of the Cult plan for a police-military state. Biden's fascist administration began a purge of 'wrong-thinkers' in the military which means anyone that is not on board with Woke. The Capitol Building was surrounded by a fence with razor wire and the Land of the Free was further symbolically and literally dismantled. The circle was completed with the installation of Biden and the exploitation of the QAnon Psyop.

America had never been so divided since the civil war of the 19th century, Pushbackers were isolated and dubbed terrorists and now, as was always going to happen, the Cult immediately set about deleting what little was left of freedom and transforming American society through a swish of the hand of the most controlled 'president' in American history leading (officially at least) the most extreme regime since the country was declared an independent state on July 4th, 1776. Biden issued undebated, dictatorial executive orders almost by the hour in his opening days in office across the whole spectrum of the Cult wish-list including diluting controls on the border with Mexico allowing thousands of migrants to illegally enter the United States to transform the demographics of America and import an election-changing number of perceived Democrat

voters. Then there were Biden deportation amnesties for the already illegally resident (estimated to be as high as 20 or even 30 million). A bill before Congress awarded American citizenship to anyone who could prove they had worked in agriculture for just 180 days in the previous two years as 'Big Ag' secured its slave labour long-term. There were the plans to add new states to the union such as Puerto Rico and making Washington DC a state. They are all parts of a plan to ensure that the Cult-owned Woke Democrats would be permanently in power.

Border – what border?

I have exposed in detail in other books how mass immigration into the United States and Europe is the work of Cult networks fuelled by the tens of billions spent to this and other ends by George Soros and his global Open Society (open borders) Foundations. The impact can be seen in America alone where the population has increased by *100 million* in little more than 30 years mostly through immigration. I wrote in *The Answer* that the plan was to have so many people crossing the southern border that the numbers become unstoppable and we are now there under Cult-owned Biden. El Salvador in Central America puts the scale of what is happening into context. A third of the population now lives in the United States, much of it illegally, and many more are on the way. The methodology is to crush Central and South American countries economically and spread violence through machete-wielding psychopathic gangs like MS-13 based in El Salvador and now operating in many American cities. Biden-imposed lax security at the southern border means that it is all but open. He said before his 'election' that he wanted to see a surge towards the border if he became president and that was the green light for people to do just that after election day to create the human disaster that followed for both America and the migrants. When that surge came the imbecilic Alexandria Ocasio-Cortez said it wasn't a 'surge' because they are 'children, not insurgents' and the term 'surge' (used by Biden) was a claim of 'white supremacists'.

This disingenuous lady may one day enter the realm of the most basic intelligence, but it won't be any time soon.

Sabbatians and the Cult are in the process of destroying America by importing violent people and gangs in among the genuine to terrorise American cities and by overwhelming services that cannot cope with the sheer volume of new arrivals. Something similar is happening in Europe as Western society in general is targeted for demographic and cultural transformation and upheaval. The plan demands violence and crime to create an environment of intimidation, fear and division and Soros has been funding the election of district attorneys across America who then stop prosecuting many crimes, reduce sentences for violent crimes and free as many violent criminals as they can. Sabbatians are creating the chaos from which order – their order – can respond in a classic Problem-Reaction-Solution. A Freemasonic moto says 'Ordo Ab Chao' (Order out of Chaos) and this is why the Cult is constantly creating chaos to impose a new 'order'. Here you have the reason the Cult is constantly creating chaos. The 'Covid' hoax can be seen with those entering the United States by plane being forced to take a 'Covid' test while migrants flooding through southern border processing facilities do not. Nothing is put in the way of mass migration and if that means ignoring the government's own 'Covid' rules then so be it. They know it's all bullshit anyway. Any pushback on this is denounced as 'racist' by Wokers and Sabbatian fronts like the ultra-Zionist Anti-Defamation League headed by the appalling Jonathan Greenblatt which at the same time argues that Israel should not give citizenship and voting rights to more Palestinian Arabs or the 'Jewish population' (in truth the Sabbatian network) will lose control of the country.

Society-changing numbers

Biden's masters have declared that countries like El Salvador are so dangerous that their people must be allowed into the United States for humanitarian reasons when there are fewer murders in large parts of many Central American countries than in US cities like

Baltimore. That is not to say Central America cannot be a dangerous place and Cult-controlled American governments have been making it so since way back, along with the dismantling of economies, in a long-term plan to drive people north into the United States. Parts of Central America are very dangerous, but in other areas the story is being greatly exaggerated to justify relaxing immigration criteria. Migrants are being offered free healthcare and education in the United States as another incentive to head for the border and there is no requirement to be financially independent before you can enter to prevent the resources of America being drained. You can't blame migrants for seeking what they believe will be a better life, but they are being played by the Cult for dark and nefarious ends. The numbers since Biden took office are huge. In February, 2021, more than 100,000 people were known to have tried to enter the US illegally through the southern border (it was 34,000 in the same month in 2020) and in March it was 170,000 – a 418 percent increase on March, 2020. These numbers are only known people, not the ones who get in unseen. The true figure for migrants illegally crossing the border in a single month was estimated by one congressman at 250,000 and that number will only rise under Biden's current policy. Gangs of murdering drug-running thugs that control the Mexican side of the border demand money – thousands of dollars – to let migrants cross the Rio Grande into America. At the same time gun battles are breaking out on the border several times a week between rival Mexican drug gangs (which now operate globally) who are equipped with sophisticated military-grade weapons, grenades and armoured vehicles. While the Capitol Building was being 'protected' from a non-existent 'threat' by thousands of troops, and others were still deployed at the time in the Cult Neocon war in Afghanistan, the southern border of America was left to its fate. This is not incompetence, it is cold calculation.

By March, 2021, there were 17,000 unaccompanied children held at border facilities and many of them are ensnared by people traffickers for paedophile rings and raped on their journey north to America. This is not conjecture – this is fact. Many of those designated

children are in reality teenage boys or older. Meanwhile Wokers posture their self-purity for encouraging poor and tragic people to come to America and face this nightmare both on the journey and at the border with the disgusting figure of House Speaker Nancy Pelosi giving disingenuous speeches about caring for migrants. The woman's evil. Wokers condemned Trump for having children in cages at the border (so did Obama, *Shhhh*), but now they are sleeping on the floor without access to a shower with one border facility 729 percent over capacity. The Biden insanity even proposed flying migrants from the southern border to the northern border with Canada for 'processing'. The whole shambles is being overseen by ultra-Zionist Secretary of Homeland Security, the moronic liar Alejandro Mayorkas, who banned news cameras at border facilities to stop Americans seeing what was happening. Mayorkas said there was not a ban on news crews; it was just that they were not allowed to film. Alongside him at Homeland Security is another ultra-Zionist Cass Sunstein appointed by Biden to oversee new immigration laws. Sunstein despises conspiracy researchers to the point where he suggests they should be banned or *taxed* for having such views. The man is not bonkers or anything. He's perfectly well-adjusted, but adjusted to what is the question. Criticise what is happening and you are a 'white supremacist' when earlier non-white immigrants also oppose the numbers which effect their lives and opportunities. Black people in poor areas are particularly damaged by uncontrolled immigration and the increased competition for work opportunities with those who will work for less. They are also losing voting power as Hispanics become more dominant in former black areas. It's a downward spiral for them while the billionaires behind the policy drone on about how much they care about black people and 'racism'. None of this is about compassion for migrants or black people – that's just wind and air. Migrants are instead being mercilessly exploited to transform America while the countries they leave are losing their future and the same is true in Europe. Mass immigration may now be the work of Woke Democrats, but it can be traced back to the 1986 Immigration Reform and Control Act (it

wasn't) signed into law by Republican hero President Ronald Reagan which gave amnesty to millions living in the United States illegally and other incentives for people to head for the southern border. Here we have the one-party state at work again.

Save me syndrome

Almost every aspect of what I have been exposing as the Cult agenda was on display in even the first days of 'Biden' with silencing of Pushbackers at the forefront of everything. A Renegade Mind will view the Trump years and QAnon in a very different light to their supporters and advocates as the dots are connected. The QAnon/Trump Psyop has given the Cult all it was looking for. We may not know how much, or little, that Trump realised he was being used, but that's a side issue. This pincer movement produced the desired outcome of dividing America and having Pushbackers isolated. To turn this around we have to look at new routes to empowerment which do not include handing our power to other people and groups through what I will call the 'Save Me Syndrome' – 'I want someone else to do it so that I don't have to'. We have seen this at work throughout human history and the QAnon/Trump Psyop is only the latest incarnation alongside all the others. Religion is an obvious expression of this when people look to a 'god' or priest to save them or tell them how to be saved and then there are 'save me' politicians like Trump. Politics is a diversion and not a 'saviour'. It is a means to block positive change, not make it possible.

Save Me Syndrome always comes with the same repeating theme of handing your power to whom or what you believe will save you while your real 'saviour' stares back from the mirror every morning. Renegade Minds are constantly vigilant in this regard and always asking the question 'What can I do?' rather than 'What can someone else do for me?' Gandhi was right when he said: 'You must be the change you want to see in the world.' We are indeed the people we have been waiting for. We are presented with a constant raft of reasons to concede that power to others and forget where the real power is. Humanity has the numbers and the Cult does not. It has to

use diversion and division to target the unstoppable power that comes from unity. Religions, governments, politicians, corporations, media, QAnon, are all different manifestations of this power-diversion and dilution. Refusing to give your power to governments and instead handing it to Trump and QAnon is not to take a new direction, but merely to recycle the old one with new names on the posters. I will explore this phenomenon as we proceed and how to break the cycles and recycles that got us here through the mists of repeating perception and so repeating history.

For now we shall turn to the most potent example in the entire human story of the consequences that follow when you give your power away. I am talking, of course, of the 'Covid' hoax.

CHAPTER FOUR

'Covid': Calculated catastrophe

Facts are threatening to those invested in fraud
DaShanne Stokes

We can easily unravel the real reason for the 'Covid pandemic' hoax by employing the Renegade Mind methodology that I have outlined this far. We'll start by comparing the long-planned Cult outcome with the 'Covid pandemic' outcome. Know the outcome and you'll see the journey.

I have highlighted the plan for the Hunger Games Society which has been in my books for so many years with the very few controlling the very many through ongoing dependency. To create this dependency it is essential to destroy independent livelihoods, businesses and employment to make the population reliant on the state (the Cult) for even the basics of life through a guaranteed pittance income. While independence of income remained these Cult ambitions would be thwarted. With this knowledge it was easy to see where the 'pandemic' hoax was going once talk of 'lockdowns' began and the closing of all but perceived 'essential' businesses to 'save' us from an alleged 'deadly virus'. Cult corporations like Amazon and Walmart were naturally considered 'essential' while mom and pop shops and stores had their doors closed by fascist decree. As a result with every new lockdown and new regulation more small and medium, even large businesses not owned by the Cult, went to the wall while Cult giants and their frontmen and women grew financially fatter by the second. Mom and pop were

denied an income and the right to earn a living and the wealth of people like Jeff Bezos (Amazon), Mark Zuckerberg (Facebook) and Sergei Brin and Larry Page (Google/Alphabet) have reached record levels. The Cult was increasing its own power through further dramatic concentrations of wealth while the competition was being destroyed and brought into a state of dependency. Lockdowns have been instigated to secure that very end and were never anything to do with health. My brother Paul spent 45 years building up a bus repair business, but lockdowns meant buses were running at a fraction of normal levels for months on end. Similar stories can be told in their hundreds of millions worldwide. Efforts of a lifetime coldly destroyed by Cult multi-billionaires and their lackeys in government and law enforcement who continued to earn their living from the taxation of the people while denying the right of the same people to earn theirs. How different it would have been if those making and enforcing these decisions had to face the same financial hardships of those they affected, but they never do.

Gates of Hell

Behind it all in the full knowledge of what he is doing and why is the psychopathic figure of Cult operative Bill Gates. His puppet Tedros at the World Health Organization declared 'Covid' a pandemic in March, 2020. The WHO had changed the definition of a 'pandemic' in 2009 just a month before declaring the 'swine flu pandemic' which would not have been so under the previous definition. The same applies to 'Covid'. The definition had included... 'an infection by an infectious agent, occurring simultaneously in different countries, with a significant mortality rate relative to the proportion of the population infected'. The new definition removed the need for 'significant mortality'. The 'pandemic' has been fraudulent even down to the definition, but Gates demanded economy-destroying lockdowns, school closures, social distancing, mandatory masks, a 'vaccination' for every man, woman and child on the planet and severe consequences and restrictions for those that refused. Who gave him this power? The

Cult did which he serves like a little boy in short trousers doing what his daddy tells him. He and his psychopathic missus even smiled when they said that much worse was to come (what they knew was planned to come). Gates responded in the matter-of-fact way of all psychopaths to a question about the effect on the world economy of what he was doing:

Well, it won't go to zero but it will shrink. Global GDP is probably going to take the biggest hit ever [Gates was smiling as he said this] ... in my lifetime this will be the greatest economic hit. But you don't have a choice. People act as if you have a choice. People don't feel like going to the stadium when they might get infected ... People are deeply affected by seeing these stats, by knowing they could be part of the transmission chain, old people, their parents and grandparents, could be affected by this, and so you don't get to say ignore what is going on here.

There will be the ability to open up, particularly in rich countries, if things are done well over the next few months, but for the world at large normalcy only returns when we have largely vaccinated the entire population.

The man has no compassion or empathy. How could he when he's a psychopath like all Cult players? My own view is that even beyond that he is very seriously mentally ill. Look in his eyes and you can see this along with his crazy flailing arms. You don't do what he has done to the world population since the start of 2020 unless you are mentally ill and at the most extreme end of psychopathic. You especially don't do it when to you know, as we shall see, that cases and deaths from 'Covid' are fakery and a product of monumental figure massaging. 'These stats' that Gates referred to are based on a 'test' that's not testing for the 'virus' as he has known all along. He made his fortune with big Cult support as an infamously ruthless software salesman and now buys global control of 'health' (death) policy without the population he affects having any say. It's a breathtaking outrage. Gates talked about people being deeply affected by fear of 'Covid' when that was because of *him* and his global network lying to them minute-by-minute supported by a lying media that he seriously influences and funds to the tune of hundreds of millions. He's handed big sums to media operations including the BBC, NBC, Al Jazeera, Univision, *PBS NewsHour*,

ProPublica, National Journal, The Guardian, The Financial Times, The Atlantic, Texas Tribune, USA Today publisher Gannett, Washington Monthly, Le Monde, Center for Investigative Reporting, Pulitzer Center on Crisis Reporting, National Press Foundation, International Center for Journalists, Solutions Journalism Network, the Poynter Institute for Media Studies, and many more. Gates is everywhere in the 'Covid' hoax and the man must go to prison – or a mental facility – for the rest of his life and his money distributed to those he has taken such enormous psychopathic pleasure in crushing.

The Muscle

The Hunger Games global structure demands a police-military state – a fusion of the two into one force – which viciously imposes the will of the Cult on the population and protects the Cult from public rebellion. In that regard, too, the 'Covid' hoax just keeps on giving. Often unlawful, ridiculous and contradictory 'Covid' rules and regulations have been policed across the world by moronic automatons and psychopaths made faceless by face-nappy masks and acting like the Nazi SS and fascist blackshirts and brownshirts of Hitler and Mussolini. The smallest departure from the rules decreed by the psychos in government and their clueless gofers were jumped upon by the face-nappy fascists. Brutality against public protestors soon became commonplace even on girls, women and old people as the brave men with the batons – the Face-Nappies as I call them – broke up peaceful protests and handed out fines like confetti to people who couldn't earn a living let alone pay hundreds of pounds for what was once an accepted human right. Robot Face-Nappies of Nottingham police in the English East Midlands fined one group £11,000 for attending a child's birthday party. For decades I charted the transformation of law enforcement as genuine, decent officers were replaced with psychopaths and the brain dead who would happily and brutally do whatever their masters told them. Now they were let loose on the public and I would emphasise the point that none of this just happened. The step-by-step change in the dynamic between police and public was orchestrated from the shadows by

those who knew where this was all going and the same with the perceptual reframing of those in all levels of authority and official administration through 'training courses' by organisations such as Common Purpose which was created in the late 1980s and given a massive boost in Blair era Britain until it became a global phenomenon. Supposed public 'servants' began to view the population as the enemy and the same was true of the police. This was the start of the explosion of behaviour manipulation organisations and networks preparing for the all-war on the human psyche unleashed with the dawn of 2020. I will go into more detail about this later in the book because it is a core part of what is happening.

Police desecrated beauty spots to deter people gathering and arrested women for walking in the countryside alone 'too far' from their homes. We had arrogant, clueless sergeants in the Isle of Wight police where I live posting on Facebook what they insisted the population must do or else. A schoolmaster sergeant called Radford looked young enough for me to ask if his mother knew he was out, but he was posting what he *expected* people to do while a Sergeant Wilkinson boasted about fining lads for meeting in a McDonald's car park where they went to get a lockdown takeaway. Wilkinson added that he had even cancelled their order. What a pair of prats these people are and yet they have increasingly become the norm among Jackboot Johnson's Yellowshirts once known as the British police. This was the theme all over the world with police savagery common during lockdown protests in the United States, the Netherlands, and the fascist state of Victoria in Australia under its tyrannical and again moronic premier Daniel Andrews. Amazing how tyrannical and moronic tend to work as a team and the same combination could be seen across America as arrogant, narcissistic Woke governors and mayors such as Gavin Newsom (California), Andrew Cuomo (New York), Gretchen Whitmer (Michigan), Lori Lightfoot (Chicago) and Eric Garcetti (Los Angeles) did their Nazi and Stalin impressions with the full support of the compliant brutality of their enforcers in uniform as they arrested small business owners defying

fascist shutdown orders and took them to jail in ankle shackles and handcuffs. This happened to bistro owner Marlena Pavlos-Hackney in Gretchen Whitmer's fascist state of Michigan when police arrived to enforce an order by a state-owned judge for 'putting the community at risk' at a time when other states like Texas were dropping restrictions and migrants were pouring across the southern border without any 'Covid' questions at all. I'm sure there are many officers appalled by what they are ordered to do, but not nearly enough of them. If they were truly appalled they would not do it. As the months passed every opportunity was taken to have the military involved to make their presence on the streets ever more familiar and 'normal' for the longer-term goal of police-military fusion.

Another crucial element to the Hunger Games enforcement network has been encouraging the public to report neighbours and others for 'breaking the lockdown rules'. The group faced with £11,000 in fines at the child's birthday party would have been dobbed-in by a neighbour with a brain the size of a pea. The technique was most famously employed by the Stasi secret police in communist East Germany who had public informants placed throughout the population. A police chief in the UK says his force doesn't need to carry out 'Covid' patrols when they are flooded with so many calls from the public reporting other people for visiting the beach. Dorset police chief James Vaughan said people were so enthusiastic about snitching on their fellow humans they were now operating as an auxiliary arm of the police: 'We are still getting around 400 reports a week from the public, so we will respond to reports ... We won't need to be doing hotspot patrols because people are very quick to pick the phone up and tell us.' Vaughan didn't say that this is a pillar of all tyrannies of whatever complexion and the means to hugely extend the reach of enforcement while spreading distrust among the people and making them wary of doing anything that might get them reported. Those narcissistic Isle of Wight sergeants Radford and Wilkinson never fail to add a link to their Facebook posts where the public can inform on their fellow slaves.

Neither would be self-aware enough to realise they were imitating the Stasi which they might well never have heard of. Government psychologists that I will expose later laid out a policy to turn communities against each other in the same way.

A coincidence? Yep, and I can knit fog

I knew from the start of the alleged pandemic that this was a Cult operation. It presented limitless potential to rapidly advance the Cult agenda and exploit manipulated fear to demand that every man, woman and child on the planet was 'vaccinated' in a process never used on humans before which infuses self-replicating *synthetic* material into human cells. Remember the plan to transform the human body from a biological to a synthetic biological state. I'll deal with the 'vaccine' (that's not actually a vaccine) when I focus on the genetic agenda. Enough to say here that mass global 'vaccination' justified by this 'new virus' set alarms ringing after 30 years of tracking these people and their methods. The 'Covid' hoax officially beginning in China was also a big red flag for reasons I will be explaining. The agenda potential was so enormous that I could dismiss any idea that the 'virus' appeared naturally. Major happenings with major agenda implications never occur without Cult involvement in making them happen. My questions were twofold in early 2020 as the media began its campaign to induce global fear and hysteria: Was this alleged infectious agent released on purpose by the Cult or did it even exist at all? I then did what I always do in these situations. I sat, observed and waited to see where the evidence and information would take me. By March and early April synchronicity was strongly – and ever more so since then – pointing me in the direction of *there is no 'virus'*. I went public on that with derision even from swathes of the alternative media that voiced a scenario that the Chinese government released the 'virus' in league with Deep State elements in the United States from a top-level bio-lab in Wuhan where the 'virus' is said to have first appeared. I looked at that possibility, but I didn't buy it for several reasons. Deaths from the 'virus' did not in any way match what they

would have been with a 'deadly bioweapon' and it is much more effective if you sell the *illusion* of an infectious agent rather than having a real one unless you can control through injection who has it and who doesn't. Otherwise you lose control of events. A made-up 'virus' gives you a blank sheet of paper on which you can make it do whatever you like and have any symptoms or mutant 'variants' you choose to add while a real infectious agent would limit you to what it actually does. A phantom disease allows you to have endless ludicrous 'studies' on the 'Covid' dollar to widen the perceived impact by inventing ever more 'at risk' groups including one study which said those who walk slowly may be almost four times more likely to die from the 'virus'. People are in psychiatric wards for less.

A real 'deadly bioweapon' can take out people in the hierarchy that are not part of the Cult, but essential to its operation. Obviously they don't want that. Releasing a real disease means you immediately lose control of it. Releasing an illusory one means you don't. Again it's vital that people are extra careful when dealing with what they want to hear. A bioweapon unleashed from a Chinese laboratory in collusion with the American Deep State may fit a conspiracy narrative, but is it true? Would it not be far more effective to use the excuse of a 'virus' to justify the real bioweapon – the 'vaccine'? That way your disease agent does not have to be transmitted and arrives directly through a syringe. I saw a French virologist Luc Montagnier quoted in the alternative media as saying he had discovered that the alleged 'new' severe acute respiratory syndrome coronavirus , or SARS-CoV-2, was made artificially and included elements of the human immunodeficiency 'virus' (HIV) and a parasite that causes malaria. SARS-CoV-2 is alleged to trigger an alleged illness called Covid-19. I remembered Montagnier's name from my research years before into claims that an HIV 'retrovirus' causes AIDs – claims that were demolished by Berkeley virologist Peter Duesberg who showed that no one had ever proved that HIV causes acquired immunodeficiency syndrome or AIDS. Claims that become accepted as fact, publicly and medically, with no proof whatsoever are an ever-recurring story that profoundly applies to

‘Covid’. Nevertheless, despite the lack of proof, Montagnier’s team at the Pasteur Institute in Paris had a long dispute with American researcher Robert Gallo over which of them discovered and isolated the HIV ‘virus’ and with *no evidence* found it to cause AIDS. You will see later that there is also no evidence that any ‘virus’ causes any disease or that there is even such a thing as a ‘virus’ in the way it is said to exist. The claim to have ‘isolated’ the HIV ‘virus’ will be presented in its real context as we come to the shocking story – and it is a story – of SARS-CoV-2 and so will Montagnier’s assertion that he identified the full SARS-CoV-2 genome.

Hoax in the making

We can pick up the ‘Covid’ story in 2010 and the publication by the Rockefeller Foundation of a document called ‘Scenarios for the Future of Technology and International Development’. The inner circle of the Rockefeller family has been serving the Cult since John D. Rockefeller (1839-1937) made his fortune with Standard Oil. It is less well known that the same Rockefeller – the Bill Gates of his day – was responsible for establishing what is now referred to as ‘Big Pharma’, the global network of pharmaceutical companies that make outrageous profits dispensing scalpel and drug ‘medicine’ and are obsessed with pumping vaccines in ever-increasing number into as many human arms and backsides as possible. John D. Rockefeller was the driving force behind the creation of the ‘education’ system in the United States and elsewhere specifically designed to program the perceptions of generations thereafter. The Rockefeller family donated exceptionally valuable land in New York for the United Nations building and were central in establishing the World Health Organization in 1948 as an agency of the UN which was created from the start as a Trojan horse and stalking horse for world government. Now enter Bill Gates. His family and the Rockefellers have long been extremely close and I have seen genealogy which claims that if you go back far enough the two families fuse into the same bloodline. Gates has said that the Bill and Melinda Gates Foundation was inspired by the Rockefeller Foundation and why not

when both are serving the same Cult? Major tax-exempt foundations are overwhelmingly criminal enterprises in which Cult assets fund the Cult agenda in the guise of 'philanthropy' while avoiding tax in the process. Cult operatives can become mega-rich in their role of front men and women for the psychopaths at the inner core and they, too, have to be psychopaths to knowingly serve such evil. Part of the deal is that a big percentage of the wealth gleaned from representing the Cult has to be spent advancing the ambitions of the Cult and hence you have the Rockefeller Foundation, Bill and Melinda Gates Foundation (and *so* many more) and people like George Soros with his global Open Society Foundations spending their billions in pursuit of global Cult control. Gates is a global public face of the Cult with his interventions in world affairs including Big Tech influence; a central role in the 'Covid' and 'vaccine' scam; promotion of the climate change shakedown; manipulation of education; geoengineering of the skies; and his food-control agenda as the biggest owner of farmland in America, his GMO promotion and through other means. As one writer said: 'Gates monopolizes or wields disproportionate influence over the tech industry, global health and vaccines, agriculture and food policy (including biopiracy and fake food), weather modification and other climate technologies, surveillance, education and media.' The almost limitless wealth secured through Microsoft and other not-allowed-to-fail ventures (including vaccines) has been ploughed into a long, long list of Cult projects designed to enslave the entire human race. Gates and the Rockefellers have been working as one unit with the Rockefeller-established World Health Organization leading global 'Covid' policy controlled by Gates through his mouth-piece Tedros. Gates became the WHO's biggest funder when Trump announced that the American government would cease its donations, but Biden immediately said he would restore the money when he took office in January, 2021. The Gates Foundation (the Cult) owns through limitless funding the world health system and the major players across the globe in the 'Covid' hoax.

Okay, with that background we return to that Rockefeller Foundation document of 2010 headed 'Scenarios for the Future of Technology and International Development' and its 'imaginary' epidemic of a virulent and deadly influenza strain which infected 20 percent of the global population and killed eight million in seven months. The Rockefeller scenario was that the epidemic destroyed economies, closed shops, offices and other businesses and led to governments imposing fierce rules and restrictions that included mandatory wearing of face masks and body-temperature checks to enter communal spaces like railway stations and supermarkets. The document predicted that even after the height of the Rockefeller-envisaged epidemic the authoritarian rule would continue to deal with further pandemics, transnational terrorism, environmental crises and rising poverty. Now you may think that the Rockefellers are our modern-day seers or alternatively, and rather more likely, that they well knew what was planned a few years further on. Fascism had to be imposed, you see, to 'protect citizens from risk and exposure'. The Rockefeller scenario document said:

During the pandemic, national leaders around the world flexed their authority and imposed airtight rules and restrictions, from the mandatory wearing of face masks to body-temperature checks at the entries to communal spaces like train stations and supermarkets. Even after the pandemic faded, this more authoritarian control and oversight of citizens and their activities stuck and even intensified. In order to protect themselves from the spread of increasingly global problems – from pandemics and transnational terrorism to environmental crises and rising poverty – leaders around the world took a firmer grip on power.

At first, the notion of a more controlled world gained wide acceptance and approval. Citizens willingly gave up some of their sovereignty – and their privacy – to more paternalistic states in exchange for greater safety and stability. Citizens were more tolerant, and even eager, for top-down direction and oversight, and national leaders had more latitude to impose order in the ways they saw fit.

In developed countries, this heightened oversight took many forms: biometric IDs for all citizens, for example, and tighter regulation of key industries whose stability was deemed vital to national interests. In many developed countries, enforced cooperation with a suite of new regulations and agreements slowly but steadily restored both order and, importantly, economic growth.

There we have the prophetic Rockefellers in 2010 and three years later came their paper for the Global Health Summit in Beijing, China, when government representatives, the private sector, international organisations and groups met to discuss the next 100 years of 'global health'. The Rockefeller Foundation-funded paper was called 'Dreaming the Future of Health for the Next 100 Years and more prophecy ensued as it described a dystopian future: 'The abundance of data, digitally tracking and linking people may mean the 'death of privacy' and may replace physical interaction with transient, virtual connection, generating isolation and raising questions of how values are shaped in virtual networks.' Next in the 'Covid' hoax preparation sequence came a 'table top' simulation in 2018 for another 'imaginary' pandemic of a disease called Clade X which was said to kill 900 million people. The exercise was organised by the Gates-funded Johns Hopkins University's Center for Health Security in the United States and this is the very same university that has been compiling the disgustingly and systematically erroneous global figures for 'Covid' cases and deaths. Similar Johns Hopkins health crisis scenarios have included the Dark Winter exercise in 2001 and Atlantic Storm in 2005.

Nostradamus 201

For sheer predictive genius look no further prophecy-watchers than the Bill Gates-funded Event 201 held only six weeks before the 'coronavirus pandemic' is supposed to have broken out in China and Event 201 was based on a scenario of a global 'coronavirus pandemic'. Melinda Gates, the great man's missus, told the BBC that he had 'prepared for years' for a coronavirus pandemic which told us what we already knew. Nostradamugates had predicted in a TED talk in 2015 that a pandemic was coming that would kill a lot of people and demolish the world economy. My god, the man is a machine – possibly even literally. Now here he was only weeks before the real thing funding just such a simulated scenario and involving his friends and associates at Johns Hopkins, the World Economic Forum Cult-front of Klaus Schwab, the United Nations,

Johnson & Johnson, major banks, and officials from China and the Centers for Disease Control in the United States. What synchronicity – Johns Hopkins would go on to compile the fraudulent ‘Covid’ figures, the World Economic Forum and Schwab would push the ‘Great Reset’ in response to ‘Covid’, the Centers for Disease Control would be at the forefront of ‘Covid’ policy in the United States, Johnson & Johnson would produce a ‘Covid vaccine’, and everything would officially start just weeks later in China. Spooky, eh? They were even accurate in creating a simulation of a ‘virus’ pandemic because the ‘real thing’ would also be a simulation. Event 201 was not an exercise preparing for something that might happen; it was a rehearsal for what those in control knew was *going* to happen and very shortly. Hours of this simulation were posted on the Internet and the various themes and responses mirrored what would soon be imposed to transform human society. News stories were inserted and what they said would be commonplace a few weeks later with still more prophecy perfection. Much discussion focused on the need to deal with misinformation and the ‘anti-vax movement’ which is exactly what happened when the ‘virus’ arrived – was said to have arrived – in the West.

Cult-owned social media banned criticism and exposure of the official ‘virus’ narrative and when I said there *was* no ‘virus’ in early April, 2020, I was banned by one platform after another including YouTube, Facebook and later Twitter. The mainstream broadcast media in Britain was in effect banned from interviewing me by the Tony-Blair-created government broadcasting censor Ofcom headed by career government bureaucrat Melanie Dawes who was appointed just as the ‘virus’ hoax was about to play out in January, 2020. At the same time the Ickonic media platform was using Vimeo, another ultra-Zionist-owned operation, while our own player was being created and they deleted in an instant hundreds of videos, documentaries, series and shows to confirm their unbelievable vindictiveness. We had copies, of course, and they had to be restored one by one when our player was ready. These people have no class. Sabbatian Facebook promised free advertisements for the Gates-

controlled World Health Organization narrative while deleting ‘false claims and conspiracy theories’ to stop ‘misinformation’ about the alleged coronavirus. All these responses could be seen just a short while earlier in the scenarios of Event 201. Extreme censorship was absolutely crucial for the Cult because the official story was so ridiculous and unsupportable by the evidence that it could never survive open debate and the free-flow of information and opinion. If you can’t win a debate then don’t have one is the Cult’s approach throughout history. Facebook’s little boy front man – front boy – Mark Zuckerberg equated ‘credible and accurate information’ with official sources and exposing their lies with ‘misinformation’.

Silencing those that can see

The censorship dynamic of Event 201 is now the norm with an army of narrative-supporting ‘fact-checker’ organisations whose entire reason for being is to tell the public that official narratives are true and those exposing them are lying. One of the most appalling of these ‘fact-checkers’ is called NewsGuard founded by ultra-Zionist Americans Gordon Crovitz and Steven Brill. Crovitz is a former publisher of *The Wall Street Journal*, former Executive Vice President of Dow Jones, a member of the Council on Foreign Relations (CFR), and on the board of the American Association of Rhodes Scholars. The CFR and Rhodes Scholarships, named after Rothschild agent Cecil Rhodes who plundered the gold and diamonds of South Africa for his masters and the Cult, have featured widely in my books. NewsGuard don’t seem to like me for some reason – I really can’t think why – and they have done all they can to have me censored and discredited which is, to quote an old British politician, like being savaged by a dead sheep. They are, however, like all in the censorship network, very well connected and funded by organisations themselves funded by, or connected to, Bill Gates. As you would expect with anything associated with Gates NewsGuard has an offshoot called HealthGuard which ‘fights online health care hoaxes’. How very kind. Somehow the NewsGuard European Managing Director Anna-Sophie Harling, a remarkably young-

looking woman with no broadcasting experience and little hands-on work in journalism, has somehow secured a position on the 'Content Board' of UK government broadcast censor Ofcom. An executive of an organisation seeking to discredit dissidents of the official narratives is making decisions for the government broadcast 'regulator' about content?? Another appalling 'fact-checker' is Full Fact funded by George Soros and global censors Google and Facebook.

It's amazing how many activists in the 'fact-checking', 'anti-hate', arena turn up in government-related positions – people like UK Labour Party activist Imran Ahmed who heads the Center for Countering Digital Hate founded by people like Morgan McSweeney, now chief of staff to the Labour Party's hapless and useless 'leader' Keir Starmer. Digital Hate – which is what it really is – uses the American spelling of Center to betray its connection to a transatlantic network of similar organisations which in 2020 shapeshifted from attacking people for 'hate' to attacking them for questioning the 'Covid' hoax and the dangers of the 'Covid vaccine'. It's just a coincidence, you understand. This is one of Imran Ahmed's hysterical statements: 'I would go beyond calling anti-vaxxers conspiracy theorists to say they are an extremist group that pose a national security risk.' No one could ever accuse this prat of understatement and he's including in that those parents who are now against vaccines after their children were damaged for life or killed by them. He's such a nice man. Ahmed does the rounds of the Woke media getting soft-ball questions from spineless 'journalists' who never ask what right he has to campaign to destroy the freedom of speech of others while he demands it for himself. There also seems to be an overrepresentation in Ofcom of people connected to the narrative-worshipping BBC. This incredible global network of narrative-support was super-vital when the 'Covid' hoax was played in the light of the mega-whopper lies that have to be defended from the spotlight cast by the most basic intelligence.

Setting the scene

The Cult plays the long game and proceeds step-by-step ensuring that everything is in place before major cards are played and they don't come any bigger than the 'Covid' hoax. The psychopaths can't handle events where the outcome isn't certain and as little as possible – preferably nothing – is left to chance. Politicians, government and medical officials who would follow direction were brought to illusory power in advance by the Cult web whether on the national stage or others like state governors and mayors of America. For decades the dynamic between officialdom, law enforcement and the public was changed from one of service to one of control and dictatorship. Behaviour manipulation networks established within government were waiting to impose the coming 'Covid' rules and regulations specifically designed to subdue and rewire the psyche of the people in the guise of protecting health. These included in the UK the Behavioural Insights Team part-owned by the British government Cabinet Office; the Scientific Pandemic Insights Group on Behaviours (SPI-B); and a whole web of intelligence and military groups seeking to direct the conversation on social media and control the narrative. Among them are the cyberwarfare (on the people) 77th Brigade of the British military which is also coordinated through the Cabinet Office as civilian and military leadership continues to combine in what they call the Fusion Doctrine. The 77th Brigade is a British equivalent of the infamous Israeli (Sabbatian) military cyberwarfare and Internet manipulation operation Unit 8200 which I expose at length in *The Trigger*. Also carefully in place were the medical and science advisers to government – many on the payroll past or present of Bill Gates – and a whole alternative structure of unelected government stood by to take control when elected parliaments were effectively closed down once the 'Covid' card was slammed on the table. The structure I have described here and so much more was installed in every major country through the Cult networks. The top-down control hierarchy looks like this: The Cult – Cult-owned Gates – the World Health Organization and Tedros – Gates-funded or controlled chief medical officers and science 'advisers' (dictators) in each country –

political 'leaders' – law enforcement – The People. Through this simple global communication and enforcement structure the policy of the Cult could be imposed on virtually the entire human population so long as they acquiesced to the fascism. With everything in place it was time for the button to be pressed in late 2019/early 2020.

These were the prime goals the Cult had to secure for its will to prevail:

- 1) Locking down economies, closing all but designated 'essential' businesses (Cult-owned corporations were 'essential'), and putting the population under house arrest was an imperative to destroy independent income and employment and ensure dependency on the Cult-controlled state in the Hunger Games Society. Lockdowns had to be established as the global blueprint from the start to respond to the 'virus' and followed by pretty much the entire world.
- 2) The global population had to be terrified into believing in a deadly 'virus' that didn't actually exist so they would unquestioningly obey authority in the belief that authority must know how best to protect them and their families. Software salesman Gates would suddenly morph into the world's health expert and be promoted as such by the Cult-owned media.
- 3) A method of testing that wasn't testing for the 'virus', but was only claimed to be, had to be in place to provide the illusion of 'cases' and subsequent 'deaths' that had a very different cause to the 'Covid-19' that would be scribbled on the death certificate.
- 4) Because there was no 'virus' and the great majority testing positive with a test not testing for the 'virus' would have no symptoms of anything the lie had to be sold that people without symptoms (without the 'virus') could still pass it on to others. This was crucial to justify for the first time quarantining – house arresting – healthy people. Without this the economy-destroying lockdown of *everybody* could not have been credibly sold.
- 5) The 'saviour' had to be seen as a vaccine which beyond evil drug companies were working like angels of mercy to develop as quickly as possible, with all corners cut, to save the day. The public must absolutely not know that the 'vaccine' had nothing to do with a 'virus' or that the contents were ready and waiting with a very different motive long before the 'Covid' card was even lifted from the pack.

I said in March, 2020, that the 'vaccine' would have been created way ahead of the 'Covid' hoax which justified its use and the following December an article in the New York *Intelligencer* magazine said the Moderna 'vaccine' had been 'designed' by

January, 2020. This was 'before China had even acknowledged that the disease could be transmitted from human to human, more than a week before the first confirmed coronavirus case in the United States'. The article said that by the time the first American death was announced a month later 'the vaccine had already been manufactured and shipped to the National Institutes of Health for the beginning of its Phase I clinical trial'. The 'vaccine' was actually 'designed' long before that although even with this timescale you would expect the article to ask how on earth it could have been done that quickly. Instead it asked why the 'vaccine' had not been rolled out then and not months later. Journalism in the mainstream is truly dead. I am going to detail in the next chapter why the 'virus' has never existed and how a hoax on that scale was possible, but first the foundation on which the Big Lie of 'Covid' was built.

The test that doesn't test

Fraudulent 'testing' is the bottom line of the whole 'Covid' hoax and was the means by which a 'virus' that did not exist *appeared* to exist. They could only achieve this magic trick by using a test not testing for the 'virus'. To use a test that *was* testing for the 'virus' would mean that every test would come back negative given there was no 'virus'. They chose to exploit something called the RT-PCR test invented by American biochemist Kary Mullis in the 1980s who said publicly that his PCR test ... *cannot detect infectious disease*. Yes, the 'test' used worldwide to detect infectious 'Covid' to produce all the illusory 'cases' and 'deaths' compiled by Johns Hopkins and others *cannot detect infectious disease*. This fact came from the mouth of the man who invented PCR and was awarded the Nobel Prize in Chemistry in 1993 for doing so. Sadly, and incredibly conveniently for the Cult, Mullis died in August, 2019, at the age of 74 just before his test would be fraudulently used to unleash fascism on the world. He was said to have died from pneumonia which was an irony in itself. A few months later he would have had 'Covid-19' on his death certificate. I say the timing of his death was convenient because had he lived Mullis, a brilliant, honest and decent man, would have been

vociferously speaking out against the use of his test to detect 'Covid' when it was never designed, or able, to do that. I know that to be true given that Mullis made the same point when his test was used to 'detect' – not detect – HIV. He had been seriously critical of the Gallo/Montagnier claim to have isolated the HIV 'virus' and shown it to cause AIDS for which Mullis said there was no evidence. AIDS is actually not a disease but a series of diseases from which people die all the time. When they die from those *same diseases* after a positive 'test' for HIV then AIDS goes on their death certificate. I think I've heard that before somewhere. Countries instigated a policy with 'Covid' that anyone who tested positive with a test not testing for the 'virus' and died of any other cause within 28 days and even longer 'Covid-19' had to go on the death certificate. Cases have come from the test that can't test for infectious disease and the deaths are those who have died of *anything* after testing positive with a test not testing for the 'virus'. I'll have much more later about the death certificate scandal.

Mullis was deeply dismissive of the now US 'Covid' star Anthony Fauci who he said was a liar who didn't know anything about anything – 'and I would say that to his face – nothing.' He said of Fauci: 'The man thinks he can take a blood sample, put it in an electron microscope and if it's got a virus in there you'll know it – he doesn't understand electron microscopy and he doesn't understand medicine and shouldn't be in a position like he's in.' That position, terrifyingly, has made him the decider of 'Covid' fascism policy on behalf of the Cult in his role as director since 1984 of the National Institute of Allergy and Infectious Diseases (NIAID) while his record of being wrong is laughable; but being wrong, so long as it's the *right kind* of wrong, is why the Cult loves him. He'll say anything the Cult tells him to say. Fauci was made Chief Medical Adviser to the President immediately Biden took office. Biden was installed in the White House by Cult manipulation and one of his first decisions was to elevate Fauci to a position of even more control. This is a coincidence? Yes, and I identify as a flamenco dancer called Lola. How does such an incompetent criminal like Fauci remain in that

pivotal position in American health since *the 1980s*? When you serve the Cult it looks after you until you are surplus to requirements. Kary Mullis said prophetically of Fauci and his like: 'Those guys have an agenda and it's not an agenda we would like them to have ... they make their own rules, they change them when they want to, and Tony Fauci does not mind going on television in front of the people who pay his salary and lie directly into the camera.' Fauci has done that almost daily since the 'Covid' hoax began. Lying is in Fauci's DNA. To make the situation crystal clear about the PCR test this is a direct quote from its inventor Kary Mullis:

It [the PCR test] doesn't tell you that you're sick and doesn't tell you that the thing you ended up with was really going to hurt you ...'

Ask yourself why governments and medical systems the world over have been using this very test to decide who is 'infected' with the SARS-CoV-2 'virus' and the alleged disease it allegedly causes, 'Covid-19'. The answer to that question will tell you what has been going on. By the way, here's a little show-stopper – the 'new' SARS-CoV-2 'virus' was 'identified' as such right from the start using ... *the PCR test not testing for the 'virus'*. If you are new to this and find that shocking then stick around. I have hardly started yet. Even worse, other 'tests', like the 'Lateral Flow Device' (LFD), are considered so useless that they have to be *confirmed* by the PCR test! Leaked emails written by Ben Dyson, adviser to UK 'Health' Secretary Matt Hancock, said they were 'dangerously unreliable'. Dyson, executive director of strategy at the Department of Health, wrote: 'As of today, someone who gets a positive LFD result in (say) London has at best a 25 per cent chance of it being a true positive, but if it is a self-reported test potentially as low as 10 per cent (on an optimistic assumption about specificity) or as low as 2 per cent (on a more pessimistic assumption).' These are the 'tests' that schoolchildren and the public are being urged to have twice a week or more and have to isolate if they get a positive. Each fake positive goes in the statistics as a 'case' no matter how ludicrously inaccurate and the

'cases' drive lockdown, masks and the pressure to 'vaccinate'. The government said in response to the email leak that the 'tests' were accurate which confirmed yet again what shocking bloody liars they are. The real false positive rate is *100 percent* as we'll see. In another 'you couldn't make it up' the UK government agreed to pay £2.8 billion to California's Innova Medical Group to supply the irrelevant lateral flow tests. The company's primary test-making centre is in China. Innova Medical Group, established in March, 2020, is owned by Pasaca Capital Inc, chaired by Chinese-American millionaire Charles Huang who was born in Wuhan.

How it works – and how it doesn't

The RT-PCR test, known by its full title of Polymerase chain reaction, is used across the world to make millions, even billions, of copies of a DNA/RNA genetic information sample. The process is called 'amplification' and means that a tiny sample of genetic material is amplified to bring out the detailed content. I stress that it is not testing for an infectious disease. It is simply amplifying a sample of genetic material. In the words of Kary Mullis: 'PCR is ... just a process that's used to make a whole lot of something out of something.' To emphasise the point companies that make the PCR tests circulated around the world to 'test' for 'Covid' warn on the box that it can't be used to detect 'Covid' or infectious disease and is for research purposes only. It's okay, rest for a minute and you'll be fine. This is the test that produces the 'cases' and 'deaths' that have been used to destroy human society. All those global and national medical and scientific 'experts' demanding this destruction to 'save us' *KNOW* that the test is not testing for the 'virus' and the cases and deaths they claim to be real are an almost unimaginable fraud. Every one of them and so many others including politicians and psychopaths like Gates and Tedros must be brought before Nuremburg-type trials and jailed for the rest of their lives. The more the genetic sample is amplified by PCR the more elements of that material become sensitive to the test and by that I don't mean sensitive for a 'virus' but for elements of the genetic material which

is *naturally* in the body or relates to remnants of old conditions of various kinds lying dormant and causing no disease. Once the amplification of the PCR reaches a certain level *everyone* will test positive. So much of the material has been made sensitive to the test that everyone will have some part of it in their body. Even lying criminals like Fauci have said that once PCR amplifications pass 35 cycles everything will be a false positive that cannot be trusted for the reasons I have described. I say, like many proper doctors and scientists, that 100 percent of the 'positives' are false, but let's just go with Fauci for a moment.

He says that any amplification over 35 cycles will produce false positives and yet the US Centers for Disease Control (CDC) and Food and Drug Administration (FDA) have recommended up to 40 *cycles* and the National Health Service (NHS) in Britain admitted in an internal document for staff that it was using 45 *cycles* of amplification. A long list of other countries has been doing the same and at least one 'testing' laboratory has been using 50 *cycles*. Have you ever heard a doctor, medical 'expert' or the media ask what level of amplification has been used to claim a 'positive'. The 'test' comes back 'positive' and so you have the 'virus', end of story. Now we can see how the government in Tanzania could send off samples from a goat and a pawpaw fruit under human names and both came back positive for 'Covid-19'. Tanzania president John Magufuli mocked the 'Covid' hysteria, the PCR test and masks and refused to import the DNA-manipulating 'vaccine'. The Cult hated him and an article sponsored by the Bill Gates Foundation appeared in the London *Guardian* in February, 2021, headed 'It's time for Africa to rein in Tanzania's anti-vaxxer president'. Well, 'reined in' he shortly was. Magufuli appeared in good health, but then, in March, 2021, he was dead at 61 from 'heart failure'. He was replaced by Samia Hassan Suhulu who is connected to Klaus Schwab's World Economic Forum and she immediately reversed Magufuli's 'Covid' policy. A sample of cola tested positive for 'Covid' with the PCR test in Germany while American actress and singer-songwriter Erykah Badu tested positive in one nostril and negative in the other. Footballer Ronaldo called

the PCR test 'bullshit' after testing positive three times and being forced to quarantine and miss matches when there was nothing wrong with him. The mantra from Tedros at the World Health Organization and national governments (same thing) has been test, test, test. They know that the more tests they can generate the more fake 'cases' they have which go on to become 'deaths' in ways I am coming to. The UK government has its Operation Moonshot planned to test multiple millions every day in workplaces and schools with free tests for everyone to use twice a week at home in line with the Cult plan from the start to make testing part of life. A government advertisement for an 'Interim Head of Asymptomatic Testing Communication' said the job included responsibility for delivering a 'communications strategy' (propaganda) 'to support the expansion of asymptomatic testing that *'normalises testing as part of everyday life'*'. More tests means more fake 'cases', 'deaths' and fascism. I have heard of, and from, many people who booked a test, couldn't turn up, and yet got a positive result through the post for a test they'd never even had. The whole thing is crazy, but for the Cult there's method in the madness. Controlling and manipulating the level of amplification of the test means the authorities can control whenever they want the number of apparent 'cases' and 'deaths'. If they want to justify more fascist lockdown and destruction of livelihoods they keep the amplification high. If they want to give the illusion that lockdowns and the 'vaccine' are working then they lower the amplification and 'cases' and 'deaths' will appear to fall. In January, 2021, the Cult-owned World Health Organization suddenly warned laboratories about over-amplification of the test and to lower the threshold. Suddenly headlines began appearing such as: 'Why ARE "Covid" cases plummeting?' This was just when the vaccine rollout was underway and I had predicted months before they would make cases appear to fall through amplification tampering when the 'vaccine' came. These people are so predictable.

Cow vaccines?

The question must be asked of what is on the test swabs being poked far up the nose of the population to the base of the brain? A nasal swab punctured one woman's brain and caused it to leak fluid. Most of these procedures are being done by people with little training or medical knowledge. Dr Lorraine Day, former orthopaedic trauma surgeon and Chief of Orthopaedic Surgery at San Francisco General Hospital, says the tests are really a '*vaccine*'. Cows have long been vaccinated this way. She points out that masks have to cover the nose and the mouth where it is claimed the '*virus*' exists in saliva. Why then don't they take saliva from the mouth as they do with a DNA test instead of pushing a long swab up the nose towards the brain? The ethmoid bone separates the nasal cavity from the brain and within that bone is the cribriform plate. Dr Day says that when the swab is pushed up against this plate and twisted the procedure is '*depositing things back there*'. She claims that among these '*things*' are nanoparticles that can enter the brain. Researchers have noted that a team at the Gates-funded Johns Hopkins have designed tiny, star-shaped micro-devices that can latch onto intestinal mucosa and release drugs into the body. Mucosa is the thin skin that covers the inside surface of parts of the body such as *the nose* and mouth and produces mucus to protect them. The Johns Hopkins micro-devices are called '*theragrippers*' and were '*inspired*' by a parasitic worm that digs its sharp teeth into a host's intestines. Nasal swabs are also coated in the sterilisation agent ethylene oxide. The US National Cancer Institute posts this explanation on its website:

At room temperature, ethylene oxide is a flammable colorless gas with a sweet odor. It is used primarily to produce other chemicals, including antifreeze. In smaller amounts, ethylene oxide is used as a pesticide and a sterilizing agent. The ability of ethylene oxide to damage DNA makes it an effective sterilizing agent but also accounts for its cancer-causing activity.

The Institute mentions lymphoma and leukaemia as cancers most frequently reported to be associated with occupational exposure to ethylene oxide along with stomach and breast cancers. How does anyone think this is going to work out with the constant testing

regime being inflicted on adults and children at home and at school that will accumulate in the body anything that's on the swab?

Doctors know best

It is vital for people to realise that 'hero' doctors 'know' only what the Big Pharma-dominated medical authorities tell them to 'know' and if they refuse to 'know' what they are told to 'know' they are out the door. They are mostly not physicians or healers, but repeaters of the official narrative – or else. I have seen alleged professional doctors on British television make shocking statements that we are supposed to take seriously. One called 'Dr' Amir Khan, who is actually telling patients how to respond to illness, said that men could take the birth pill to 'help slow down the effects of Covid-19'. In March, 2021, another ridiculous 'Covid study' by an American doctor proposed injecting men with the female sex hormone progesterone as a 'Covid' treatment. British doctor Nighat Arif told the BBC that face coverings were now going to be part of ongoing normal. Yes, the vaccine protects you, she said (evidence?) ... but the way to deal with viruses in the community was always going to come down to hand washing, face covering and keeping a physical distance. That's not what we were told before the 'vaccine' was circulating. Arif said she couldn't imagine ever again going on the underground or in a lift without a mask. I was just thanking my good luck that she was not my doctor when she said – in March, 2021 – that if 'we are *behaving* and we are doing all the right things' she thought we could 'have our nearest and dearest around us at home ... around *Christmas* and *New Year*! Her patronising delivery was the usual school teacher talking to six-year-olds as she repeated every government talking point and probably believed them all. If we have learned anything from the 'Covid' experience surely it must be that humanity's perception of doctors needs a fundamental rethink. NHS 'doctor' Sara Kayat told her television audience that the 'Covid vaccine' would '100 percent prevent hospitalisation and death'. Not even Big Pharma claimed that. We have to stop taking 'experts' at their word without question when so many of them are

clueless and only repeating the party line on which their careers depend. That is not to say there are not brilliant doctors – there are and I have spoken to many of them since all this began – but you won't see them in the mainstream media or quoted by the psychopaths and yes-people in government.

Remember the name – Christian Drosten

German virologist Christian Drosten, Director of Charité Institute of Virology in Berlin, became a national star after the pandemic hoax began. He was feted on television and advised the German government on 'Covid' policy. Most importantly to the wider world Drosten led a group that produced the 'Covid' testing protocol for the PCR test. What a remarkable feat given the PCR cannot test for infectious disease and even more so when you think that Drosten said that his method of testing for SARS-CoV-2 was developed 'without having virus material available'. *He developed a test for a 'virus' that he didn't have and had never seen.* Let that sink in as you survey the global devastation that came from what he did. The whole catastrophe of Drosten's 'test' was based on the alleged genetic sequence published by Chinese scientists on the Internet. We will see in the next chapter that this alleged 'genetic sequence' has never been produced by China or anyone and cannot be when there *is no* SARS-CoV-2. Drosten, however, doesn't seem to let little details like that get in the way. He was the lead author with Victor Corman from the same Charité Hospital of the paper 'Detection of 2019 novel coronavirus (2019-nCoV) by real-time PCR' published in a magazine called *Eurosurveillance*. This became known as the Corman-Drosten paper. In November, 2020, with human society devastated by the effects of the Corman-Drosten test baloney, the protocol was publicly challenged by 22 international scientists and independent researchers from Europe, the United States, and Japan. Among them were senior molecular geneticists, biochemists, immunologists, and microbiologists. They produced a document headed 'External peer review of the RTPCR test to detect SARS-Cov-2 Reveals 10 Major Flaws At The Molecular and Methodological Level: Consequences

For False-Positive Results'. The flaws in the Corman-Drosten test included the following:

- The test is non-specific because of erroneous design
- Results are enormously variable
- The test is unable to discriminate between the whole 'virus' and viral fragments
- It doesn't have positive or negative controls
- The test lacks a standard operating procedure
- It is unsupported by proper peer view

The scientists said the PCR 'Covid' testing protocol was not founded on science and they demanded the Corman-Drosten paper be retracted by *Eurosurveillance*. They said all present and previous Covid deaths, cases, and 'infection rates' should be subject to a massive retroactive inquiry. Lockdowns and travel restrictions should be reviewed and relaxed and those diagnosed through PCR to have 'Covid-19' should not be forced to isolate. Dr Kevin Corbett, a health researcher and nurse educator with a long academic career producing a stream of peer-reviewed publications at many UK universities, made the same point about the PCR test debacle. He said of the scientists' conclusions: 'Every scientific rationale for the development of that test has been totally destroyed by this paper. It's like Hiroshima/Nagasaki to the Covid test.' He said that China hadn't given them an isolated 'virus' when Drosten developed the test. Instead they had developed the test from *a sequence in a gene bank*.' Put another way ... *they made it up!* The scientists were supported in this contention by a Portuguese appeals court which ruled in November, 2020, that PCR tests are unreliable and it is unlawful to quarantine people based solely on a PCR test. The point about China not providing an isolated virus must be true when the 'virus' has never been isolated to this day and the consequences of that will become clear. Drosten and company produced this useless 'protocol' right on cue in January, 2020, just as the 'virus' was said to

be moving westward and it somehow managed to successfully pass a peer-review in 24 hours. In other words there was no peer-review for a test that would be used to decide who had 'Covid' and who didn't across the world. The Cult-created, Gates-controlled World Health Organization immediately recommended all its nearly 200 member countries to use the Drosten PCR protocol to detect 'cases' and 'deaths'. The sting was underway and it continues to this day.

So who is this Christian Drosten that produced the means through which death, destruction and economic catastrophe would be justified? His education background, including his doctoral thesis, would appear to be somewhat shrouded in mystery and his track record is dire as with another essential player in the 'Covid' hoax, the Gates-funded Professor Neil Ferguson at the Gates-funded Imperial College in London of whom more shortly. Drosten predicted in 2003 that the alleged original SARS 'virus' (SARS-1) was an epidemic that could have serious effects on economies and an effective vaccine would take at least two years to produce. Drosten's answer to every alleged 'outbreak' is a vaccine which you won't be shocked to know. What followed were just 774 official deaths worldwide and none in Germany where there were only nine cases. That is even if you believe there ever was a SARS 'virus' when the evidence is zilch and I will expand on this in the next chapter. Drosten claims to be co-discoverer of 'SARS-1' and developed a test for it in 2003. He was screaming warnings about 'swine flu' in 2009 and how it was a widespread infection far more severe than any dangers from a vaccine could be and people should get vaccinated. It would be helpful for Drosten's vocal chords if he simply recorded the words 'the virus is deadly and you need to get vaccinated' and copies could be handed out whenever the latest made-up threat comes along. Drosten's swine flu epidemic never happened, but Big Pharma didn't mind with governments spending hundreds of millions on vaccines that hardly anyone bothered to use and many who did wished they hadn't. A study in 2010 revealed that the risk of dying from swine flu, or H1N1, was no higher than that of the annual seasonal flu which is what at least most of 'it' really was as in

the case of 'Covid-19'. A media investigation into Drosten asked how with such a record of inaccuracy he could be *the* government adviser on these issues. The answer to that question is the same with Drosten, Ferguson and Fauci – they keep on giving the authorities the 'conclusions' and 'advice' they want to hear. Drosten certainly produced the goods for them in January, 2020, with his PCR protocol garbage and provided the foundation of what German internal medicine specialist Dr Claus Köhnlein, co-author of *Virus Mania*, called the 'test pandemic'. The 22 scientists in the *Eurosurveillance* challenge called out conflicts of interest within the Drosten 'protocol' group and with good reason. Olfert Landt, a regular co-author of Drosten 'studies', owns the biotech company TIB Molbiol Syntheselabor GmbH in Berlin which manufactures and sells the tests that Drosten and his mates come up with. They have done this with SARS, Enterotoxigenic E. coli (ETEC), MERS, Zika 'virus', yellow fever, and now 'Covid'. Landt told the *Berliner Zeitung* newspaper:

The testing, design and development came from the Charité [Drosten and Corman]. We simply implemented it immediately in the form of a kit. And if we don't have the virus, which originally only existed in Wuhan, we can make a synthetic gene to simulate the genome of the virus. That's what we did very quickly.

This is more confirmation that the Drosten test was designed without access to the 'virus' and only a synthetic simulation which is what SARS-CoV-2 really is – a computer-generated synthetic fiction. It's quite an enterprise they have going here. A Drosten team decides what the test for something should be and Landt's biotech company flogs it to governments and medical systems across the world. His company must have made an absolute fortune since the 'Covid' hoax began. Dr Reiner Fuellmich, a prominent German consumer protection trial lawyer in Germany and California, is on Drosten's case and that of Tedros at the World Health Organization for crimes against humanity with a class-action lawsuit being prepared in the United States and other legal action in Germany.

Why China?

Scamming the world with a 'virus' that doesn't exist would seem impossible on the face of it, but not if you have control of the relatively few people that make policy decisions and the great majority of the global media. Remember it's not about changing 'real' reality it's about controlling *perception* of reality. You don't have to make something happen you only have to make people *believe* that it's happening. Renegade Minds understand this and are therefore much harder to swindle. 'Covid-19' is not a 'real' 'virus'. It's a mind virus, like a computer virus, which has infected the minds, not the bodies, of billions. It all started, publically at least, in China and that alone is of central significance. The Cult was behind the revolution led by its asset Mao Zedong, or Chairman Mao, which established the People's Republic of China on October 1st, 1949. It should have been called The Cult's Republic of China, but the name had to reflect the recurring illusion that vicious dictatorships are run by and for the people (see all the 'Democratic Republics' controlled by tyrants). In the same way we have the 'Biden' Democratic Republic of America officially ruled by a puppet tyrant (at least temporarily) on behalf of Cult tyrants. The creation of Mao's merciless communist/fascist dictatorship was part of a frenzy of activity by the Cult at the conclusion of World War Two which, like the First World War, it had instigated through its assets in Germany, Britain, France, the United States and elsewhere. Israel was formed in 1948; the Soviet Union expanded its 'Iron Curtain' control, influence and military power with the Warsaw Pact communist alliance in 1955; the United Nations was formed in 1945 as a Cult precursor to world government; and a long list of world bodies would be established including the World Health Organization (1948), World Trade Organization (1948 under another name until 1995), International Monetary Fund (1945) and World Bank (1944). Human society was redrawn and hugely centralised in the global Problem-Reaction-Solution that was World War Two. All these changes were significant. Israel would become the headquarters of the Sabbatians

and the revolution in China would prepare the ground and control system for the events of 2019/2020.

Renegade Minds know there are no borders except for public consumption. The Cult is a seamless, borderless global entity and to understand the game we need to put aside labels like borders, nations, countries, communism, fascism and democracy. These delude the population into believing that countries are ruled within their borders by a government of whatever shade when these are mere agencies of a global power. America's illusion of democracy and China's communism/fascism are subsidiaries – vehicles – for the same agenda. We may hear about conflict and competition between America and China and on the lower levels that will be true; but at the Cult level they are branches of the same company in the way of the McDonald's example I gave earlier. I have tracked in the books over the years support by US governments of both parties for Chinese Communist Party infiltration of American society through allowing the sale of land, even military facilities, and the acquisition of American business and university influence. All this is underpinned by the infamous stealing of intellectual property and technological know-how. Cult-owned Silicon Valley corporations waive their fraudulent 'morality' to do business with human-rights-free China; Cult-controlled Disney has become China's PR department; and China in effect owns 'American' sports such as basketball which depends for much of its income on Chinese audiences. As a result any sports player, coach or official speaking out against China's horrific human rights record is immediately condemned or fired by the China-worshipping National Basketball Association. One of the first acts of China-controlled Biden was to issue an executive order telling federal agencies to stop making references to the 'virus' by the 'geographic location of its origin'. Long-time Congressman Jerry Nadler warned that criticising China, America's biggest rival, leads to hate crimes against Asian people in the United States. So shut up you bigot. China is fast closing in on Israel as a country that must not be criticised which is apt, really, given that Sabbatians control them both. The two countries have

developed close economic, military, technological and strategic ties which include involvement in China's 'Silk Road' transport and economic initiative to connect China with Europe. Israel was the first country in the Middle East to recognise the establishment of Mao's tyranny in 1950 months after it was established.

Project Wuhan – the 'Covid' Psyop

I emphasise again that the Cult plays the long game and what is happening to the world today is the result of centuries of calculated manipulation following a script to take control step-by-step of every aspect of human society. I will discuss later the common force behind all this that has spanned those centuries and thousands of years if the truth be told. Instigating the Mao revolution in China in 1949 with a 2020 'pandemic' in mind is not only how they work – the 71 years between them is really quite short by the Cult's standards of manipulation preparation. The reason for the Cult's Chinese revolution was to create a fiercely-controlled environment within which an extreme structure for human control could be incubated to eventually be unleashed across the world. We have seen this happen since the 'pandemic' emerged from China with the Chinese control-structure founded on AI technology and tyrannical enforcement sweep across the West. Until the moment when the Cult went for broke in the West and put its fascism on public display Western governments had to pay some lip-service to freedom and democracy to not alert too many people to the tyranny-in-the-making. Freedoms were more subtly eroded and power centralised with covert government structures put in place waiting for the arrival of 2020 when that smokescreen of 'freedom' could be dispensed with. The West was not able to move towards tyranny before 2020 anything like as fast as China which was created as a tyranny and had no limits on how fast it could construct the Cult's blueprint for global control. When the time came to impose that structure on the world it was the same Cult-owned Chinese communist/fascist government that provided the excuse – the 'Covid pandemic'. It was absolutely crucial to the Cult plan for the Chinese response to the 'pandemic' –

draconian lockdowns of the entire population – to become the blueprint that Western countries would follow to destroy the livelihoods and freedom of their people. This is why the Cult-owned, Gates-owned, WHO Director-General Tedros said early on:

The Chinese government is to be congratulated for the extraordinary measures it has taken to contain the outbreak. China is actually setting a new standard for outbreak response and it is not an exaggeration.

Forbes magazine said of China: ‘... those measures protected untold millions from getting the disease’. The Rockefeller Foundation ‘epidemic scenario’ document in 2010 said ‘prophetically’:

However, a few countries did fare better – China in particular. The Chinese government’s quick imposition and enforcement of mandatory quarantine for all citizens, as well as its instant and near-hermetic sealing off of all borders, saved millions of lives, stopping the spread of the virus far earlier than in other countries and enabling a swifter post-pandemic recovery.

Once again – *spooky*.

The first official story was the ‘bat theory’ or rather the bat diversion. The source of the ‘virus outbreak’ we were told was a ‘wet market’ in Wuhan where bats and other animals are bought and eaten in horrifically unhygienic conditions. Then another story emerged through the alternative media that the ‘virus’ had been released on purpose or by accident from a BSL-4 (biosafety level 4) laboratory in Wuhan not far from the wet market. The lab was reported to create and work with lethal concoctions and bioweapons. Biosafety level 4 is the highest in the World Health Organization system of safety and containment. Renegade Minds are aware of what I call designer manipulation. The ideal for the Cult is for people to buy its prime narrative which in the opening salvos of the ‘pandemic’ was the wet market story. It knows, however, that there is now a considerable worldwide alternative media of researchers sceptical of anything governments say and they are often given a version of events in a form they can perceive as credible while misdirecting them from the real truth. In this case let them

think that the conspiracy involved is a 'bioweapon virus' released from the Wuhan lab to keep them from the real conspiracy – *there is no 'virus'*. The WHO's current position on the source of the outbreak at the time of writing appears to be: 'We haven't got a clue, mate.' This is a good position to maintain mystery and bewilderment. The inner circle will know where the 'virus' came from – *nowhere*. The bottom line was to ensure the public believed there *was* a 'virus' and it didn't much matter if they thought it was natural or had been released from a lab. The belief that there was a 'deadly virus' was all that was needed to trigger global panic and fear. The population was terrified into handing their power to authority and doing what they were told. They had to or they were 'all gonna die'.

In March, 2020, information began to come my way from real doctors and scientists and my own additional research which had my intuition screaming: 'Yes, that's it! *There is no virus.*' The 'bioweapon' was not the 'virus'; it was the '*vaccine*' already being talked about that would be the bioweapon. My conclusion was further enhanced by happenings in Wuhan. The 'virus' was said to be sweeping the city and news footage circulated of people collapsing in the street (which they've never done in the West with the same 'virus'). The Chinese government was building 'new hospitals' in a matter of ten days to 'cope with demand' such was the virulent nature of the 'virus'. Yet in what seemed like no time the 'new hospitals' closed – even if they even opened – and China declared itself 'virus-free'. It was back to business as usual. This was more propaganda to promote the Chinese draconian lockdowns in the West as the way to 'beat the virus'. Trouble was that we subsequently had lockdown after lockdown, but never business as usual. As the people of the West and most of the rest of the world were caught in an ever-worsening spiral of lockdown, social distancing, masks, isolated old people, families forced apart, and livelihood destruction, it was party-time in Wuhan. Pictures emerged of thousands of people enjoying pool parties and concerts. It made no sense until you realised there never was a 'virus' and the

whole thing was a Cult set-up to transform human society out of one of its major global strongholds – China.

How is it possible to deceive virtually the entire world population into believing there is a deadly virus when there is not even a 'virus' let alone a deadly one? It's nothing like as difficult as you would think and that's clearly true because it happened.

Postscript: See end of book Postscript for more on the 'Wuhan lab virus release' story which the authorities and media were pushing heavily in the summer of 2021 to divert attention from the truth that the 'Covid virus' is pure invention.

CHAPTER FIVE

There is no 'virus'

You can fool some of the people all of the time, and all of the people some of the time, but you cannot fool all of the people all of the time
Abraham Lincoln

The greatest form of mind control is repetition. The more you repeat the same mantra of alleged 'facts' the more will accept them to be true. It becomes an 'everyone knows that, mate'. If you can also censor any other version or alternative to your alleged 'facts' you are pretty much home and cooking.

By the start of 2020 the Cult owned the global mainstream media almost in its entirety to spew out its 'Covid' propaganda and ignore or discredit any other information and view. Cult-owned social media platforms in Cult-owned Silicon Valley were poised and ready to unleash a campaign of ferocious censorship to obliterate all but the official narrative. To complete the circle many demands for censorship by Silicon Valley were led by the mainstream media as 'journalists' became full-out enforcers for the Cult both as propagandists and censors. Part of this has been the influx of young people straight out of university who have become 'journalists' in significant positions. They have no experience and a headful of programmed perceptions from their years at school and university at a time when today's young are the most perceptually-targeted generations in known human history given the insidious impact of technology. They enter the media perceptually prepared and ready to repeat the narratives of the system that programmed them to

repeat its narratives. The BBC has a truly pathetic 'specialist disinformation reporter' called Marianna Spring who fits this bill perfectly. She is clueless about the world, how it works and what is really going on. Her role is to discredit anyone doing the job that a proper journalist would do and system-serving hacks like Spring wouldn't dare to do or even see the need to do. They are too busy licking the arse of authority which can never be wrong and, in the case of the BBC propaganda programme, *Panorama*, contacting payments systems such as PayPal to have a donations page taken down for a film company making documentaries questioning vaccines. Even the BBC soap opera *EastEnders* included a disgracefully biased scene in which an inarticulate white working class woman was made to look foolish for questioning the 'vaccine' while a well-spoken black man and Asian woman promoted the government narrative. It ticked every BBC box and the fact that the black and minority community was resisting the 'vaccine' had nothing to do with the way the scene was written. The BBC has become a disgusting tyrannical propaganda and censorship operation that should be defunded and disbanded and a free media take its place with a brief to stop censorship instead of demanding it. A BBC 'interview' with Gates goes something like: 'Mr Gates, sir, if I can call you sir, would you like to tell our audience why you are such a great man, a wonderful humanitarian philanthropist, and why you should absolutely be allowed as a software salesman to decide health policy for approaching eight billion people? Thank you, sir, please sir.' Propaganda programming has been incessant and merciless and when all you hear is the same story from the media, repeated by those around you who have only heard the same story, is it any wonder that people on a grand scale believe absolute mendacious garbage to be true? You are about to see, too, why this level of information control is necessary when the official 'Covid' narrative is so nonsensical and unsupportable by the evidence.

Structure of Deceit

The pyramid structure through which the 'Covid' hoax has been manifested is very simple and has to be to work. As few people as possible have to be involved with full knowledge of what they are doing – and why – or the real story would get out. At the top of the pyramid are the inner core of the Cult which controls Bill Gates who, in turn, controls the World Health Organization through his pivotal funding and his puppet Director-General mouthpiece, Tedros. Before he was appointed Tedros was chair of the Gates-founded Global Fund to 'fight against AIDS, tuberculosis and malaria', a board member of the Gates-funded 'vaccine alliance' GAVI, and on the board of another Gates-funded organisation. Gates owns him and picked him for a specific reason – Tedros is a crook and worse. 'Dr' Tedros (he's not a medical doctor, the first WHO chief not to be) was a member of the tyrannical Marxist government of Ethiopia for decades with all its human rights abuses. He has faced allegations of corruption and misappropriation of funds and was exposed three times for covering up cholera epidemics while Ethiopia's health minister. Tedros appointed the mass-murdering genocidal Zimbabwe dictator Robert Mugabe as a WHO goodwill ambassador for public health which, as with Tedros, is like appointing a psychopath to run a peace and love campaign. The move was so ridiculous that he had to drop Mugabe in the face of widespread condemnation. American economist David Steinman, a Nobel peace prize nominee, lodged a complaint with the International Criminal Court in The Hague over alleged genocide by Tedros when he was Ethiopia's foreign minister. Steinman says Tedros was a 'crucial decision maker' who directed the actions of Ethiopia's security forces from 2013 to 2015 and one of three officials in charge when those security services embarked on the 'killing' and 'torturing' of Ethiopians. You can see where Tedros is coming from and it's sobering to think that he has been the vehicle for Gates and the Cult to direct the global response to 'Covid'. Think about that. A psychopathic Cult dictates to psychopath Gates who dictates to psychopath Tedros who dictates how countries of the world must respond to a 'Covid virus' never scientifically shown to exist. At the same time psychopathic Cult-owned Silicon Valley information

giants like Google, YouTube, Facebook and Twitter announced very early on that they would give the Cult/Gates/Tedros/WHO version of the narrative free advertising and censor those who challenged their intelligence-insulting, mendacious story.

The next layer in the global 'medical' structure below the Cult, Gates and Tedros are the chief medical officers and science 'advisers' in each of the WHO member countries which means virtually all of them. Medical officers and arbiters of science (they're not) then take the WHO policy and recommended responses and impose them on their country's population while the political 'leaders' say they are deciding policy (they're clearly not) by 'following the science' on the advice of the 'experts' – the same medical officers and science 'advisers' (dictators). In this way with the rarest of exceptions the entire world followed the same policy of lockdown, people distancing, masks and 'vaccines' dictated by the psychopathic Cult, psychopathic Gates and psychopathic Tedros who we are supposed to believe give a damn about the health of the world population they are seeking to enslave. That, amazingly, is all there is to it in terms of crucial decision-making. Medical staff in each country then follow like sheep the dictates of the shepherds at the top of the national medical hierarchies – chief medical officers and science 'advisers' who themselves follow like sheep the shepherds of the World Health Organization and the Cult. Shepherds at the national level often have major funding and other connections to Gates and his Bill and Melinda Gates Foundation which carefully hands out money like confetti at a wedding to control the entire global medical system from the WHO down.

Follow the money

Christopher Whitty, Chief Medical Adviser to the UK Government at the centre of 'virus' policy, a senior adviser to the government's Scientific Advisory Group for Emergencies (SAGE), and Executive Board member of the World Health Organization, was gifted a grant of \$40 million by the Bill and Melinda Gates Foundation for malaria research in Africa. The BBC described the unelected Whitty as 'the

official who will probably have the greatest impact on our everyday lives of any individual policymaker in modern times' and so it turned out. What Gates and Tedros have said Whitty has done like his equivalents around the world. Patrick Vallance, co-chair of SAGE and the government's Chief Scientific Adviser, is a former executive of Big Pharma giant GlaxoSmithKline with its fundamental financial and business connections to Bill Gates. In September, 2020, it was revealed that Vallance owned a deferred bonus of shares in GlaxoSmithKline worth £600,000 while the company was 'developing' a 'Covid vaccine'. Move along now – nothing to see here – what could possibly be wrong with that? Imperial College in London, a major player in 'Covid' policy in Britain and elsewhere with its 'Covid-19' Response Team, is funded by Gates and has big connections to China while the now infamous Professor Neil Ferguson, the useless 'computer modeller' at Imperial College is also funded by Gates. Ferguson delivered the dramatically inaccurate excuse for the first lockdowns (much more in the next chapter). The Institute for Health Metrics and Evaluation (IHME) in the United States, another source of outrageously false 'Covid' computer models to justify lockdowns, is bankrolled by Gates who is a vehement promotor of lockdowns. America's version of Whitty and Vallance, the again now infamous Anthony Fauci, has connections to 'Covid vaccine' maker Moderna as does Bill Gates through funding from the Bill and Melinda Gates Foundation. Fauci is director of the National Institute of Allergy and Infectious Diseases (NIAID), a major recipient of Gates money, and they are very close. Deborah Birx who was appointed White House Coronavirus Response Coordinator in February, 2020, is yet another with ties to Gates. Everywhere you look at the different elements around the world behind the coordination and decision making of the 'Covid' hoax there is Bill Gates and his money. They include the World Health Organization; Centers for Disease Control (CDC) in the United States; National Institutes of Health (NIH) of Anthony Fauci; Imperial College and Neil Ferguson; the London School of Hygiene where Chris Whitty worked; Regulatory agencies like the UK Medicines & Healthcare products Regulatory Agency (MHRA)

which gave emergency approval for 'Covid vaccines'; Wellcome Trust; GAVI, the Vaccine Alliance; the Coalition for Epidemic Preparedness Innovations (CEPI); Johns Hopkins University which has compiled the false 'Covid' figures; and the World Economic Forum. A [Nationalfile.com](https://www.nationalfile.com) article said:

Gates has a lot of pull in the medical world, he has a multi-million dollar relationship with Dr. Fauci, and Fauci originally took the Gates line supporting vaccines and casting doubt on [the drug hydroxychloroquine]. Coronavirus response team member Dr. Deborah Birx, appointed by former president Obama to serve as United States Global AIDS Coordinator, also sits on the board of a group that has received billions from Gates' foundation, and Birx reportedly used a disputed Bill Gates-funded model for the White House's Coronavirus effort. Gates is a big proponent for a population lockdown scenario for the Coronavirus outbreak.

Another funder of Moderna is the Defense Advanced Research Projects Agency (DARPA), the technology-development arm of the Pentagon and one of the most sinister organisations on earth. DARPA had a major role with the CIA covert technology-funding operation In-Q-Tel in the development of Google and social media which is now at the centre of global censorship. Fauci and Gates are extremely close and openly admit to talking regularly about 'Covid' policy, but then why wouldn't Gates have a seat at every national 'Covid' table after his Foundation committed \$1.75 billion to the 'fight against Covid-19'. When passed through our Orwellian Translation Unit this means that he has bought and paid for the Cult-driven 'Covid' response worldwide. Research the major 'Covid' response personnel in your own country and you will find the same Gates funding and other connections again and again. Medical and science chiefs following World Health Organization 'policy' sit atop a medical hierarchy in their country of administrators, doctors and nursing staff. These 'subordinates' are told they must work and behave in accordance with the policy delivered from the 'top' of the national 'health' pyramid which is largely the policy delivered by the WHO which is the policy delivered by Gates and the Cult. The whole 'Covid' narrative has been imposed on medical staff by a climate of fear although great numbers don't even need that to comply. They do so through breathtaking levels of ignorance and

include doctors who go through life simply repeating what Big Pharma and their hierarchical masters tell them to say and believe. No wonder Big Pharma 'medicine' is one of the biggest killers on Planet Earth.

The same top-down system of intimidation operates with regard to the Cult Big Pharma cartel which also dictates policy through national and global medical systems in this way. The Cult and Big Pharma agendas are the same because the former controls and owns the latter. 'Health' administrators, doctors, and nursing staff are told to support and parrot the dictated policy or they will face consequences which can include being fired. How sad it's been to see medical staff meekly repeating and imposing Cult policy without question and most of those who can see through the deceit are only willing to speak anonymously off the record. They know what will happen if their identity is known. This has left the courageous few to expose the lies about the 'virus', face masks, overwhelmed hospitals that aren't, and the dangers of the 'vaccine' that isn't a vaccine. When these medical professionals and scientists, some renowned in their field, have taken to the Internet to expose the truth their articles, comments and videos have been deleted by Cult-owned Facebook, Twitter and YouTube. What a real head-shaker to see YouTube videos with leading world scientists and highly qualified medical specialists with an added link underneath to the notorious Cult propaganda website *Wikipedia* to find the 'facts' about the same subject.

HIV – the 'Covid' trial-run

I'll give you an example of the consequences for health and truth that come from censorship and unquestioning belief in official narratives. The story was told by PCR inventor Kary Mullis in his book *Dancing Naked in the Mind Field*. He said that in 1984 he accepted as just another scientific fact that Luc Montagnier of France's Pasteur Institute and Robert Gallo of America's National Institutes of Health had independently discovered that a 'retrovirus' dubbed HIV (human immunodeficiency virus) caused AIDS. They

were, after all, Mullis writes, specialists in retroviruses. This is how the medical and science pyramids work. Something is announced or *assumed* and then becomes an everybody-knows-that purely through repetition of the assumption as if it is fact. Complete crap becomes accepted truth with no supporting evidence and only repetition of the crap. This is how a 'virus' that doesn't exist became the 'virus' that changed the world. The HIV-AIDS fairy story became a multi-billion pound industry and the media poured out propaganda terrifying the world about the deadly HIV 'virus' that caused the lethal AIDS. By then Mullis was working at a lab in Santa Monica, California, to detect retroviruses with his PCR test in blood donations received by the Red Cross. In doing so he asked a virologist where he could find a reference for HIV being the cause of AIDS. 'You don't need a reference,' the virologist said ... '*Everybody knows it.*' Mullis said he wanted to quote a reference in the report he was doing and he said he felt a little funny about not knowing the source of such an important discovery when everyone else seemed to. The virologist suggested he cite a report by the Centers for Disease Control and Prevention (CDC) on morbidity and mortality. Mullis read the report, but it only said that an organism had been identified and did not say how. The report did not identify the original scientific work. Physicians, however, *assumed* (key recurring theme) that if the CDC was convinced that HIV caused AIDS then proof must exist. Mullis continues:

I did computer searches. Neither Montagnier, Gallo, nor anyone else had published papers describing experiments which led to the conclusion that HIV probably caused AIDS. I read the papers in *Science* for which they had become well known as AIDS doctors, but all they had said there was that they had found evidence of a past infection by something which was probably HIV in some AIDS patients.

They found antibodies. Antibodies to viruses had always been considered evidence of past disease, not present disease. Antibodies signaled that the virus had been defeated. The patient had saved himself. There was no indication in these papers that this virus caused a disease. They didn't show that everybody with the antibodies had the disease. In fact they found some healthy people with antibodies.

Mullis asked why their work had been published if Montagnier and Gallo hadn't really found this evidence, and why had they been fighting so hard to get credit for the discovery? He says he was hesitant to write 'HIV is the probable cause of AIDS' until he found published evidence to support that. 'Tens of thousands of scientists and researchers were spending billions of dollars a year doing research based on this idea,' Mullis writes. 'The reason had to be there somewhere; otherwise these people would not have allowed their research to settle into one narrow channel of investigation.' He said he lectured about PCR at numerous meetings where people were always talking about HIV and he asked them how they knew that HIV was the cause of AIDS:

Everyone said something. Everyone had the answer at home, in the office, in some drawer. They all knew, and they would send me the papers as soon as they got back. But I never got any papers. Nobody ever sent me the news about how AIDS was caused by HIV.

Eventually Mullis was able to ask Montagnier himself about the reference proof when he lectured in San Diego at the grand opening of the University of California AIDS Research Center. Mullis says this was the last time he would ask his question without showing anger. Montagnier said he should reference the CDC report. 'I read it', Mullis said, and it didn't answer the question. 'If Montagnier didn't know the answer who the hell did?' Then one night Mullis was driving when an interview came on National Public Radio with Peter Duesberg, a prominent virologist at Berkeley and a California Scientist of the Year. Mullis says he finally understood why he could not find references that connected HIV to AIDS – *there weren't any!* No one had ever proved that HIV causes AIDS even though it had spawned a multi-billion pound global industry and the media was repeating this as fact every day in their articles and broadcasts terrifying the shit out of people about AIDS and giving the impression that a positive test for HIV (see 'Covid') was a death sentence. Duesberg was a threat to the AIDS gravy train and the agenda that underpinned it. He was therefore abused and castigated after he told the Proceedings of the National Academy of Sciences

there was no good evidence implicating the new 'virus'. Editors rejected his manuscripts and his research funds were deleted. Mullis points out that the CDC has defined AIDS as one of more than 30 diseases *if accompanied* by a positive result on a test that detects antibodies to HIV; but those same diseases are not defined as AIDS cases when antibodies are not detected:

If an HIV-positive woman develops uterine cancer, for example, she is considered to have AIDS. If she is not HIV positive, she simply has uterine cancer. An HIV-positive man with tuberculosis has AIDS; if he tests negative he simply has tuberculosis. If he lives in Kenya or Colombia, where the test for HIV antibodies is too expensive, he is simply presumed to have the antibodies and therefore AIDS, and therefore he can be treated in the World Health Organization's clinic. It's the only medical help available in some places. And it's free, because the countries that support WHO are worried about AIDS.

Mullis accuses the CDC of continually adding new diseases (see ever more 'Covid symptoms') to the grand AIDS definition and of virtually doctoring the books to make it appear as if the disease continued to spread. He cites how in 1993 the CDC enormously broadened its AIDS definition and county health authorities were delighted because they received \$2,500 per year from the Federal government for every reported AIDS case. Ladies and gentlemen, I have just described, via Kary Mullis, the 'Covid pandemic' of 2020 and beyond. Every element is the same and it's been pulled off in the same way by the same networks.

The 'Covid virus' exists? Okay – prove it. Er ... still waiting

What Kary Mullis described with regard to 'HIV' has been repeated with 'Covid'. A claim is made that a new, or 'novel', infection has been found and the entire medical system of the world repeats that as fact exactly as they did with HIV and AIDS. No one in the mainstream asks rather relevant questions such as 'How do you know?' and 'Where is your proof?' The SARS-Cov-2 'virus' and the 'Covid-19 disease' became an overnight 'everybody-knows-that'. The origin could be debated and mulled over, but what you could not suggest was that 'SARS-Cov-2' didn't exist. That would be

ridiculous. 'Everybody knows' the 'virus' exists. Well, I didn't for one along with American proper doctors like Andrew Kaufman and Tom Cowan and long-time American proper journalist Jon Rappaport. We dared to pursue the obvious and simple question: 'Where's the evidence?' The overwhelming majority in medicine, journalism and the general public did not think to ask that. After all, *everyone knew* there was a new 'virus'. Everyone was saying so and I heard it on the BBC. Some would eventually argue that the 'deadly virus' was nothing like as deadly as claimed, but few would venture into the realms of its very existence. Had they done so they would have found that the evidence for that claim had gone AWOL as with HIV causes AIDS. In fact, not even that. For something to go AWOL it has to exist in the first place and scientific proof for a 'SARS-Cov-2' can be filed under nothing, nowhere and zilch.

Dr Andrew Kaufman is a board-certified forensic psychiatrist in New York State, a Doctor of Medicine and former Assistant Professor and Medical Director of Psychiatry at SUNY Upstate Medical University, and Medical Instructor of Hematology and Oncology at the Medical School of South Carolina. He also studied biology at the Massachusetts Institute of Technology (MIT) and trained in Psychiatry at Duke University. Kaufman is retired from allopathic medicine, but remains a consultant and educator on natural healing. I saw a video of his very early on in the 'Covid' hoax in which he questioned claims about the 'virus' in the absence of any supporting evidence and with plenty pointing the other way. I did everything I could to circulate his work which I felt was asking the pivotal questions that needed an answer. I can recommend an excellent pull-together interview he did with the website The Last Vagabond entitled *Dr Andrew Kaufman: Virus Isolation, Terrain Theory and Covid-19* and his website is andrewkaufmanmd.com. Kaufman is not only a forensic psychiatrist; he is forensic in all that he does. He always reads original scientific papers, experiments and studies instead of second-third-fourth-hand reports about the 'virus' in the media which are repeating the repeated repetition of the narrative. When he did so with the original Chinese 'virus' papers Kaufman

realised that there was no evidence of a 'SARS-Cov-2'. They had never – from the start – shown it to exist and every repeat of this claim worldwide was based on the accepted existence of proof that was nowhere to be found – see Kary Mullis and HIV. Here we go again.

Let's postulate

Kaufman discovered that the Chinese authorities immediately concluded that the cause of an illness that broke out among about 200 initial patients in Wuhan was a 'new virus' when there were no grounds to make that conclusion. The alleged 'virus' was not isolated from other genetic material in their samples and then shown through a system known as Koch's postulates to be the causative agent of the illness. The world was told that the SARS-Cov-2 'virus' caused a disease they called 'Covid-19' which had 'flu-like' symptoms and could lead to respiratory problems and pneumonia. If it wasn't so tragic it would almost be funny. *'Flu-like' symptoms? Pneumonia? Respiratory disease?* What in *CHINA* and particularly in *Wuhan*, one of the most polluted cities in the world with a resulting epidemic of respiratory disease?? Three hundred thousand people get pneumonia in China every year and there are nearly a billion cases worldwide of 'flu-like symptoms'. These have a whole range of causes – including pollution in Wuhan – but no other possibility was credibly considered in late 2019 when the world was told there was a new and deadly 'virus'. The global prevalence of pneumonia and 'flu-like systems' gave the Cult networks unlimited potential to re-diagnose these other causes as the mythical 'Covid-19' and that is what they did from the very start. Kaufman revealed how Chinese medical and science authorities (all subordinates to the Cult-owned communist government) took genetic material from the lungs of only a few of the first patients. The material contained their own cells, bacteria, fungi and other microorganisms living in their bodies. The only way you could prove the existence of the 'virus' and its responsibility for the alleged 'Covid-19' was to isolate the virus from all the other material – a process also known as 'purification' – and

then follow the postulates sequence developed in the late 19th century by German physician and bacteriologist Robert Koch which became the 'gold standard' for connecting an alleged causation agent to a disease:

1. The microorganism (bacteria, fungus, virus, etc.) must be present in every case of the disease and all patients must have the same symptoms. It must also *not be present in healthy individuals*.
2. The microorganism must be isolated from the host with the disease. If the microorganism is a bacteria or fungus it must be grown in a pure culture. If it is a virus, it must be purified (i.e. containing no other material except the virus particles) from a clinical sample.
3. The specific disease, with all of its characteristics, must be reproduced when the infectious agent (the purified virus or a pure culture of bacteria or fungi) is inoculated into a healthy, susceptible host.
4. The microorganism must be recoverable from the experimentally infected host as in step 2.

Not one of these criteria has been met in the case of 'SARS-Cov-2' and 'Covid-19'. Not ONE. EVER. Robert Koch refers to bacteria and not viruses. What are called 'viral particles' are so minute (hence masks are useless by any definition) that they could only be seen after the invention of the electron microscope in the 1930s and can still only be observed through that means. American bacteriologist and virologist Thomas Milton Rivers, the so-called 'Father of Modern Virology' who was very significantly director of the Rockefeller Institute for Medical Research in the 1930s, developed a less stringent version of Koch's postulates to identify 'virus' causation known as 'Rivers criteria'. 'Covid' did not pass that process either. Some even doubt whether any 'virus' can be isolated from other particles containing genetic material in the Koch method. Freedom of Information requests in many countries asking for scientific proof that the 'Covid virus' has been purified and isolated and shown to exist have all come back with a 'we don't have that' and when this happened with a request to the UK Department of Health they added this comment:

However, outside of the scope of the [Freedom of Information Act] and on a discretionary basis, the following information has been advised to us, which may be of interest. Most infectious diseases are caused by viruses, bacteria or fungi. Some bacteria or fungi have the capacity to grow on their own in isolation, for example in colonies on a petri dish. Viruses are different in that they are what we call 'obligate pathogens' – that is, they cannot survive or reproduce without infecting a host ...

... For some diseases, it is possible to establish causation between a microorganism and a disease by isolating the pathogen from a patient, growing it in pure culture and reintroducing it to a healthy organism. These are known as 'Koch's postulates' and were developed in 1882. However, as our understanding of disease and different disease-causing agents has advanced, these are no longer the method for determining causation [Andrew Kaufman asks why in that case are there two published articles falsely claiming to satisfy Koch's postulates].

It has long been known that viral diseases cannot be identified in this way as viruses cannot be grown in 'pure culture'. When a patient is tested for a viral illness, this is normally done by looking for the presence of antigens, or viral genetic code in a host with molecular biology techniques [Kaufman asks how you could know the origin of these chemicals without having a pure culture for comparison].

For the record 'antigens' are defined so:

Invading microorganisms have antigens on their surface that the human body can recognise as being foreign – meaning not belonging to it. When the body recognises a foreign antigen, lymphocytes (white blood cells) produce antibodies, which are complementary in shape to the antigen.

Notwithstanding that this is open to question in relation to 'SARS-Cov-2' the presence of 'antibodies' can have many causes and they are found in people that are perfectly well. Kary Mullis said: 'Antibodies ... had always been considered evidence of past disease, not present disease.'

'Covid' really is a *computer* 'virus'

Where the UK Department of Health statement says 'viruses' are now 'diagnosed' through a 'viral genetic code in a host with molecular biology techniques', they mean ... *the PCR test* which its inventor said cannot test for infectious disease. They have no credible method of connecting a 'virus' to a disease and we will see that there is no scientific proof that any 'virus' causes any disease or there is any such thing as a 'virus' in the way that it is described. Tenacious Canadian researcher Christine Massey and her team made

some 40 Freedom of Information requests to national public health agencies in different countries asking for proof that SARS-CoV-2 has been isolated and not one of them could supply that information. Massey said of her request in Canada: 'Freedom of Information reveals Public Health Agency of Canada has no record of 'SARS-COV-2' isolation performed by anyone, anywhere, ever.' If you accept the comment from the UK Department of Health it's because they can't isolate a 'virus'. Even so many 'science' papers claimed to have isolated the 'Covid virus' until they were questioned and had to admit they hadn't. A reply from the Robert Koch Institute in Germany was typical: 'I am not aware of a paper which purified isolated SARS-CoV-2.' So what the hell was Christian Drosten and his gang using to design the 'Covid' testing protocol that has produced all the illusory Covid' cases and 'Covid' deaths when the head of the Chinese version of the CDC admitted there was a problem right from the start in that the 'virus' had never been isolated/purified? Breathe deeply: What they are calling 'Covid' is actually created by a *computer program* i.e. *they made it up* – er, that's it. They took lung fluid, with many sources of genetic material, from one single person alleged to be infected with Covid-19 by a PCR test which they *claimed*, without clear evidence, contained a 'virus'. They used several computer programs to create a model of a theoretical virus genome sequence from more than fifty-six million small sequences of RNA, each of an unknown source, assembling them like a puzzle with no known solution. The computer filled in the gaps with sequences from bits in the gene bank to make it look like a bat SARS-like coronavirus! A wave of the magic wand and poof, an *in silico* (computer-generated) genome, a scientific fantasy, was created. UK health researcher Dr Kevin Corbett made the same point with this analogy:

... It's like giving you a few bones and saying that's your fish. It could be any fish. Not even a skeleton. Here's a few fragments of bones. That's your fish ... It's all from gene bank and the bits of the virus sequence that weren't there they made up.

They synthetically created them to fill in the blanks. That's what genetics is; it's a code. So it's ABBCCDDDD and you're missing some what you think is EEE so you put it in. It's all

synthetic. You just manufacture the bits that are missing. This is the end result of the geneticization of virology. This is basically a computer virus.

Further confirmation came in an email exchange between British citizen journalist Frances Leader and the government's Medicines & Healthcare Products Regulatory Agency (the Gates-funded MHRA) which gave emergency permission for untested 'Covid vaccines' to be used. The agency admitted that the 'vaccine' is not based on an isolated 'virus', but comes from a *computer-generated model*. Frances Leader was naturally banned from Cult-owned fascist Twitter for making this exchange public. The process of creating computer-generated alleged 'viruses' is called 'in silico' or 'in silicon' – computer chips – and the term 'in silico' is believed to originate with biological experiments using only a computer in 1989. 'Vaccines' involved with 'Covid' are also produced 'in silico' or by computer not a natural process. If the original 'virus' is nothing more than a made-up computer model how can there be 'new variants' of something that never existed in the first place? They are not new 'variants'; they are new *computer models* only minutely different to the original program and designed to further terrify the population into having the 'vaccine' and submitting to fascism. You want a 'new variant'? Click, click, enter – there you go. Tell the medical profession that you have discovered a 'South African variant', 'UK variants' or a 'Brazilian variant' and in the usual HIV-causes-AIDS manner they will unquestioningly repeat it with no evidence whatsoever to support these claims. They will go on television and warn about the dangers of 'new variants' while doing nothing more than repeating what they have been told to be true and knowing that any deviation from that would be career suicide. Big-time insiders will know it's a hoax, but much of the medical community is clueless about the way they are being played and themselves play the public without even being aware they are doing so. What an interesting 'coincidence' that AstraZeneca and Oxford University were conducting 'Covid vaccine trials' in the three countries – the UK, South Africa and Brazil – where the first three 'variants' were claimed to have 'broken out'.

Here's your 'virus' – it's a unicorn

Dr Andrew Kaufman presented a brilliant analysis describing how the 'virus' was imagined into fake existence when he dissected an article published by *Nature* and written by 19 authors detailing *alleged* 'sequencing of a complete viral genome' of the 'new SARS-CoV-2 virus'. This computer-modelled *in silico* genome was used as a template for all subsequent genome sequencing experiments that resulted in the so-called variants which he said now number more than 6,000. The fake genome was constructed from more than 56 million individual short strands of RNA. Those little pieces were assembled into longer pieces by finding areas of overlapping sequences. The computer programs created over two million possible combinations from which the authors simply chose the longest one. They then compared this to a 'bat virus' and the computer 'alignment' rearranged the sequence and filled in the gaps! They called this computer-generated abomination the 'complete genome'. Dr Tom Cowan, a fellow medical author and collaborator with Kaufman, said such computer-generation constitutes scientific fraud and he makes this superb analogy:

Here is an equivalency: A group of researchers claim to have found a unicorn because they found a piece of a hoof, a hair from a tail, and a snippet of a horn. They then add that information into a computer and program it to re-create the unicorn, and they then claim this computer re-creation is the real unicorn. Of course, they had never actually seen a unicorn so could not possibly have examined its genetic makeup to compare their samples with the actual unicorn's hair, hooves and horn.

The researchers claim they decided which is the real genome of SARS-CoV-2 by 'consensus', sort of like a vote. Again, different computer programs will come up with different versions of the imaginary 'unicorn', so they come together as a group and decide which is the real imaginary unicorn.

This is how the 'virus' that has transformed the world was brought into fraudulent 'existence'. Extraordinary, yes, but as the Nazis said the bigger the lie the more will believe it. Cowan, however, wasn't finished and he went on to identify what he called the real blockbuster in the paper. He quotes this section from a paper written

by virologists and published by the CDC and then explains what it means:

Therefore, we examined the capacity of SARS-CoV-2 to infect and replicate in several common primate and human cell lines, including human adenocarcinoma cells (A549), human liver cells (HUH 7.0), and human embryonic kidney cells (HEK-293T). In addition to Vero E6 and Vero CCL81 cells. ... Each cell line was inoculated at high multiplicity of infection and examined 24h post-infection.

No CPE was observed in any of the cell lines except in Vero cells, which grew to greater than 10 to the 7th power at 24 h post-infection. In contrast, HUH 7.0 and 293T showed only modest viral replication, and A549 cells were incompatible with SARS CoV-2 infection.

Cowan explains that when virologists attempt to prove infection they have three possible 'hosts' or models on which they can test. The first was humans. Exposure to humans was generally not done for ethical reasons and has never been done with SARS-CoV-2 or any coronavirus. The second possible host was animals. Cowan said that forgetting for a moment that they never actually use purified virus when exposing animals they do use solutions that they *claim* contain the virus. Exposure to animals has been done with SARS-CoV-2 in an experiment involving mice and this is what they found: *None of the wild (normal) mice got sick*. In a group of genetically-modified mice, a statistically insignificant number lost weight and had slightly bristled fur, but they experienced nothing like the illness called 'Covid-19'. Cowan said the third method – the one they mostly rely on – is to inoculate solutions they *say* contain the virus onto a variety of tissue cultures. This process had never been shown to kill tissue *unless* the sample material was starved of nutrients and poisoned as *part of the process*. Yes, incredibly, in tissue experiments designed to show the 'virus' is responsible for killing the tissue they starve the tissue of nutrients and add toxic drugs including antibiotics and they do not have control studies to see if it's the starvation and poisoning that is degrading the tissue rather than the 'virus' they allege to be in there somewhere. You want me to pinch you? Yep, I understand. Tom Cowan said this about the whole nonsensical farce as he explains what that quote from the CDC paper really means:

The shocking thing about the above quote is that using their own methods, the virologists found that solutions containing SARS-CoV-2 – even in high amounts – were NOT, I repeat NOT, infective to any of the three human tissue cultures they tested. In plain English, this means they proved, on their terms, that this ‘new coronavirus’ is not infectious to human beings. It is ONLY infective to monkey kidney cells, and only then when you add two potent drugs (gentamicin and amphotericin), known to be toxic to kidneys, to the mix.

My friends, read this again and again. These virologists, published by the CDC, performed a clear proof, on their terms, showing that the SARS-CoV-2 virus is harmless to human beings. That is the only possible conclusion, but, unfortunately, this result is not even mentioned in their conclusion. They simply say they can provide virus stocks cultured only on monkey Vero cells, thanks for coming.

Cowan concluded: ‘If people really understood how this “science” was done, I would hope they would storm the gates and demand honesty, transparency and truth.’ Dr Michael Yeadon, former Vice President and Chief Scientific Adviser at drug giant Pfizer has been a vocal critic of the ‘Covid vaccine’ and its potential for multiple harm. He said in an interview in April, 2021, that ‘not one [vaccine] has the virus. He was asked why vaccines normally using a ‘dead’ version of a disease to activate the immune system were not used for ‘Covid’ and instead we had the synthetic methods of the ‘mRNA Covid vaccine’. Yeadon said that to do the former ‘you’d have to have some of [the virus] wouldn’t you?’ He added: ‘No-one’s got any – seriously.’ Yeadon said that surely they couldn’t have fooled the whole world for a year without having a virus, ‘but oddly enough ask around – no one’s got it’. He didn’t know why with all the ‘great labs’ around the world that the virus had not been isolated – ‘Maybe they’ve been too busy running bad PCR tests and vaccines that people don’t need.’ What is today called ‘science’ is not ‘science’ at all. Science is no longer what is, but whatever people can be manipulated to *believe* that it is. Real science has been hijacked by the Cult to dispense and produce the ‘expert scientists’ and contentions that suit the agenda of the Cult. How big-time this has happened with the ‘Covid’ hoax which is entirely based on fake science delivered by fake ‘scientists’ and fake ‘doctors’. The human-caused climate change hoax is also entirely based on fake science delivered by fake ‘scientists’ and fake ‘climate experts’. In both cases real

scientists, climate experts and doctors have their views suppressed and deleted by the Cult-owned science establishment, media and Silicon Valley. This is the 'science' that politicians claim to be 'following' and a common denominator of 'Covid' and climate are Cult psychopaths Bill Gates and his mate Klaus Schwab at the Gates-funded World Economic Forum. But, don't worry, it's all just a coincidence and absolutely nothing to worry about. Zzzzzzzzz.

What is a 'virus' REALLY?

Dr Tom Cowan is one of many contesting the very existence of viruses let alone that they cause disease. This is understandable when there is no scientific evidence for a disease-causing 'virus'. German virologist Dr Stefan Lanka won a landmark case in 2017 in the German Supreme Court over his contention that there is no such thing as a measles virus. He had offered a big prize for anyone who could prove there is and Lanka won his case when someone sought to claim the money. There is currently a prize of more than 225,000 euros on offer from an Isolate Truth Fund for anyone who can prove the isolation of SARS-CoV-2 and its genetic substance. Lanka wrote in an article headed 'The Misconception Called Virus' that scientists think a 'virus' is causing tissue to become diseased and degraded when in fact it is the *processes they are using* which do that – not a 'virus'. Lanka has done an important job in making this point clear as Cowan did in his analysis of the CDC paper. Lanka says that all claims about viruses as disease-causing pathogens are wrong and based on 'easily recognisable, understandable and verifiable misinterpretations.' Scientists believed they were working with 'viruses' in their laboratories when they were really working with 'typical particles of specific dying tissues or cells ...' Lanka said that the tissue decaying process claimed to be caused by a 'virus' still happens when no alleged 'virus' is involved. It's the *process* that does the damage and not a 'virus'. The genetic sample is deprived of nutrients, removed from its energy supply through removal from the body and then doused in toxic antibiotics to remove any bacteria. He confirms again that establishment scientists do not (pinch me)

conduct control experiments to see if this is the case and if they did they would see the claims that 'viruses' are doing the damage is nonsense. He adds that during the measles 'virus' court case he commissioned an independent laboratory to perform just such a control experiment and the result was that the tissues and cells died in the exact same way as with alleged 'infected' material. This is supported by a gathering number of scientists, doctors and researchers who reject what is called 'germ theory' or the belief in the body being infected by contagious sources emitted by other people. Researchers Dawn Lester and David Parker take the same stance in their highly-detailed and sourced book *What Really Makes You Ill – Why everything you thought you knew about disease is wrong* which was recommended to me by a number of medical professionals genuinely seeking the truth. Lester and Parker say there is no provable scientific evidence to show that a 'virus' can be transmitted between people or people and animals or animals and people:

The definition also claims that viruses are the cause of many diseases, as if this has been definitively proven. But this is not the case; there is no original scientific evidence that definitively demonstrates that any virus is the cause of any disease. The burden of proof for any theory lies with those who proposed it; but none of the existing documents provides 'proof' that supports the claim that 'viruses' are pathogens.

Dr Tom Cowan employs one of his clever analogies to describe the process by which a 'virus' is named as the culprit for a disease when what is called a 'virus' is only material released by cells detoxing themselves from infiltration by chemical or radiation poisoning. The tidal wave of technologically-generated radiation in the 'smart' modern world plus all the toxic food and drink are causing this to happen more than ever. Deluded 'scientists' misread this as a gathering impact of what they wrongly label 'viruses'.

Paper can infect houses

Cowan said in an article for davidicke.com – with his tongue only mildly in his cheek – that he believed he had made a tremendous

discovery that may revolutionise science. He had discovered that small bits of paper are alive, 'well alive-ish', can 'infect' houses, and then reproduce themselves inside the house. The result was that this explosion of growth in the paper inside the house causes the house to explode, blowing it to smithereens. His evidence for this new theory is that in the past months he had carefully examined many of the houses in his neighbourhood and found almost no scraps of paper on the lawns and surrounds of the house. There was an occasional stray label, but nothing more. Then he would return to these same houses a week or so later and with a few, not all of them, particularly the old and decrepit ones, he found to his shock and surprise they were littered with stray bits of paper. He knew then that the paper had infected these houses, made copies of itself, and blew up the house. A young boy on a bicycle at one of the sites told him he had seen a demolition crew using dynamite to explode the house the previous week, but Cowan dismissed this as the idle thoughts of silly boys because 'I was on to something big'. He was on to how 'scientists' mistake genetic material in the detoxifying process for something they call a 'virus'. Cowan said of his house and paper story:

If this sounds crazy to you, it's because it should. This scenario is obviously nuts. But consider this admittedly embellished, for effect, current viral theory that all scientists, medical doctors and virologists currently believe.

He takes the example of the 'novel SARS-Cov2' virus to prove the point. First they take someone with an undefined illness called 'Covid-19' and don't even attempt to find any virus in their sputum. Never mind the scientists still describe how this 'virus', which they have not located attaches to a cell receptor, injects its genetic material, in 'Covid's' case, RNA, into the cell. The RNA once inserted exploits the cell to reproduce itself and makes 'thousands, nay millions, of copies of itself ... Then it emerges victorious to claim its next victim':

If you were to look in the scientific literature for proof, actual scientific proof, that uniform SARS-CoV2 viruses have been properly isolated from the sputum of a sick person, that actual spike proteins could be seen protruding from the virus (which has not been found), you would find that such evidence doesn't exist.

If you go looking in the published scientific literature for actual pictures, proof, that these spike proteins or any viral proteins are ever attached to any receptor embedded in any cell membrane, you would also find that no such evidence exists. If you were to look for a video or documented evidence of the intact virus injecting its genetic material into the body of the cell, reproducing itself and then emerging victorious by budding off the cell membrane, you would find that no such evidence exists.

The closest thing you would find is electron micrograph pictures of cellular particles, possibly attached to cell debris, both of which to be seen were stained by heavy metals, a process that completely distorts their architecture within the living organism. This is like finding bits of paper stuck to the blown-up bricks, thereby proving the paper emerged by taking pieces of the bricks on its way out.

The Enders baloney

Cowan describes the 'Covid' story as being just as make-believe as his paper story and he charts back this fantasy to a Nobel Prize winner called John Enders (1897-1985), an American biomedical scientist who has been dubbed 'The Father of Modern Vaccines'. Enders is claimed to have 'discovered' the process of the viral culture which 'proved' that a 'virus' caused measles. Cowan explains how Enders did this 'by using the EXACT same procedure that has been followed by every virologist to find and characterize every new virus since 1954'. Enders took throat swabs from children with measles and immersed them in 2ml of milk. Penicillin (100u/ml) and the antibiotic streptomycin (50,g/ml) were added and the whole mix was centrifuged – rotated at high speed to separate large cellular debris from small particles and molecules as with milk and cream, for example. Cowan says that if the aim is to find little particles of genetic material ('viruses') in the snot from children with measles it would seem that the last thing you would do is mix the snot with other material – milk –that also has genetic material. 'How are you ever going to know whether whatever you found came from the snot or the milk?' He points out that streptomycin is a 'nephrotoxic' or poisonous-to-the-kidney drug. You will see the relevance of that

shortly. Cowan says that it gets worse, much worse, when Enders describes the culture medium upon which the virus 'grows': 'The culture medium consisted of bovine amniotic fluid (90%), beef embryo extract (5%), horse serum (5%), antibiotics and phenol red as an indicator of cell metabolism.' Cowan asks incredulously: 'Did he just say that the culture medium also contained fluids and tissues that are themselves rich sources of genetic material?' The genetic cocktail, or 'medium', is inoculated onto tissue and cells from rhesus monkey *kidney* tissue. This is where the importance of streptomycin comes in and currently-used antimicrobials and other drugs that are *poisonous to kidneys* and used in ALL modern viral cultures (e.g. gentamicin, streptomycin, and amphotericin). Cowan asks: 'How are you ever going to know from this witch's brew where any genetic material comes from as we now have five different sources of rich genetic material in our mix?' Remember, he says, that all genetic material, whether from monkey kidney tissues, bovine serum, milk, etc., is made from the exact same components. The same central question returns: 'How are you possibly going to know that it was the virus that killed the kidney tissue and not the toxic antibiotic and starvation rations on which you are growing the tissue?' John Enders answered the question himself – *you can't*:

A second agent was obtained from an uninoculated culture of monkey kidney cells. The cytopathic changes [death of the cells] it induced in the unstained preparations could not be distinguished with confidence from the viruses isolated from measles.

The death of the cells ('cytopathic changes') happened in exactly the same manner, whether they inoculated the kidney tissue with the measles snot or not, Cowan says. 'This is evidence that the destruction of the tissue, the very proof of viral causation of illness, was not caused by anything in the snot because they saw the same destructive effect when the snot was not even used ... the cytopathic, i.e., cell-killing, changes come from the process of the culture itself, not from any virus in any snot, period.' Enders quotes in his 1957 paper a virologist called Ruckle as reporting similar findings 'and in addition has isolated an agent from monkey kidney tissue that is so

far indistinguishable from human measles virus'. In other words, Cowan says, these particles called 'measles viruses' are simply and clearly breakdown products of the starved and poisoned tissue. For measles 'virus' see all 'viruses' including the so-called 'Covid virus'. Enders, the 'Father of Modern Vaccines', also said:

There is a potential risk in employing cultures of primate cells for the production of vaccines composed of attenuated virus, since the presence of other agents possibly latent in primate tissues cannot be definitely excluded by any known method.

Cowan further quotes from a paper published in the journal *Viruses* in May, 2020, while the 'Covid pandemic' was well underway in the media if not in reality. 'EVs' here refers to particles of genetic debris from our own tissues, such as exosomes of which more in a moment: 'The remarkable resemblance between EVs and viruses has caused quite a few problems in the studies focused on the analysis of EVs released during viral infections.' Later the paper adds that to date a reliable method that can actually guarantee a complete separation (of EVs from viruses) DOES NOT EXIST. This was published at a time when a fairy tale 'virus' was claimed in total certainty to be causing a fairy tale 'viral disease' called 'Covid-19' – a fairy tale that was already well on the way to transforming human society in the image that the Cult has worked to achieve for so long. Cowan concludes his article:

To summarize, there is no scientific evidence that pathogenic viruses exist. What we think of as 'viruses' are simply the normal breakdown products of dead and dying tissues and cells. When we are well, we make fewer of these particles; when we are starved, poisoned, suffocated by wearing masks, or afraid, we make more.

There is no engineered virus circulating and making people sick. People in laboratories all over the world are making genetically modified products to make people sick. These are called vaccines. There is no virome, no 'ecosystem' of viruses, viruses are not 8%, 50% or 100 % of our genetic material. These are all simply erroneous ideas based on the misconception called a virus.

What is 'Covid'? Load of bollocks

The background described here by Cowan and Lanka was emphasised in the first video presentation that I saw by Dr Andrew Kaufman when he asked whether the 'Covid virus' was in truth a natural defence mechanism of the body called 'exosomes'. These are released by cells when in states of toxicity – see the same themes returning over and over. They are released ever more profusely as chemical and radiation toxicity increases and think of the potential effect therefore of 5G alone as its destructive frequencies infest the human energetic information field with a gathering pace (5G went online in Wuhan in 2019 as the 'virus' emerged). I'll have more about this later. Exosomes transmit a warning to the rest of the body that 'Houston, we have a problem'. Kaufman presented images of exosomes and compared them with 'Covid' under an electron microscope and the similarity was remarkable. They both attach to the same cell receptors (*claimed* in the case of 'Covid'), contain the same genetic material in the form of RNA or ribonucleic acid, and both are found in 'viral cell cultures' with damaged or dying cells. James Hildreth MD, President and Chief Executive Officer of the Meharry Medical College at Johns Hopkins, said: 'The virus is fully an exosome in every sense of the word.' Kaufman's conclusion was that there is no 'virus': 'This entire pandemic is a completely manufactured crisis ... there is no evidence of anyone dying from [this] illness.' Dr Tom Cowan and Sally Fallon Morell, authors of *The Contagion Myth*, published a statement with Dr Kaufman in February, 2021, explaining why the 'virus' does not exist and you can read it that in full in the Appendix.

'Virus' theory can be traced to the 'cell theory' in 1858 of German physician Rudolf Virchow (1821-1920) who contended that disease originates from a single cell infiltrated by a 'virus'. Dr Stefan Lanka said that findings and insights with respect to the structure, function and central importance of tissues in the creation of life, which were already known in 1858, comprehensively refute the cell theory. Virchow ignored them. We have seen the part later played by John Enders in the 1950s and Lanka notes that infection theories were only established as a global dogma through the policies and

eugenics of the Third Reich in Nazi Germany (creation of the same Sabbatian cult behind the 'Covid' hoax). Lanka said: 'Before 1933, scientists dared to contradict this theory; after 1933, these critical scientists were silenced'. Dr Tom Cowan's view is that ill-health is caused by too much of something, too little of something, or toxification from chemicals and radiation – not contagion. We must also highlight as a major source of the 'virus' theology a man still called the 'Father of Modern Virology' – Thomas Milton Rivers (1888-1962). There is no way given the Cult's long game policy that it was a coincidence for the 'Father of Modern Virology' to be director of the Rockefeller Institute for Medical Research from 1937 to 1956 when he is credited with making the Rockefeller Institute a leader in 'viral research'. Cult Rockefellerers were the force behind the creation of Big Pharma 'medicine', established the World Health Organisation in 1948, and have long and close associations with the Gates family that now runs the WHO during the pandemic hoax through mega-rich Cult gofer and psychopath Bill Gates.

Only a Renegade Mind can see through all this bullshit by asking the questions that need to be answered, not taking 'no' or prevarication for an answer, and certainly not hiding from the truth in fear of speaking it. Renegade Minds have always changed the world for the better and they will change this one no matter how bleak it may currently appear to be.

CHAPTER SIX

Sequence of deceit

If you tell the truth, you don't have to remember anything
Mark Twain

Against the background that I have laid out this far the sequence that took us from an invented 'virus' in Cult-owned China in late 2019 to the fascist transformation of human society can be seen and understood in a whole new context.

We were told that a deadly disease had broken out in Wuhan and the world media began its campaign (coordinated by behavioural psychologists as we shall see) to terrify the population into unquestioning compliance. We were shown images of Chinese people collapsing in the street which never happened in the West with what was supposed to be the same condition. In the earliest days when alleged cases and deaths were few the fear register was hysterical in many areas of the media and this would expand into the common media narrative across the world. The real story was rather different, but we were never told that. The Chinese government, one of the Cult's biggest centres of global operation, said they had discovered a new illness with flu-like and pneumonia-type symptoms in a city with such toxic air that it is overwhelmed with flu-like symptoms, pneumonia and respiratory disease. Chinese scientists said it was a new – 'novel' – coronavirus which they called Sars-Cov-2 and that it caused a disease they labelled 'Covid-19'. There was no evidence for this and the 'virus' has never to this day been isolated, purified and its genetic code established from that. It

was from the beginning a computer-generated fiction. Stories of Chinese whistleblowers saying the number of deaths was being suppressed or that the 'new disease' was related to the Wuhan bio-lab misdirected mainstream and alternative media into cul-de-sacs to obscure the real truth – there was no 'virus'.

Chinese scientists took genetic material from the lung fluid of just a few people and said they had found a 'new' disease when this material had a wide range of content. There was no evidence for a 'virus' for the very reasons explained in the last two chapters. The 'virus' has never been shown to (a) exist and (b) cause any disease. People were diagnosed on symptoms that are so widespread in Wuhan and polluted China and with a PCR test that can't detect infectious disease. On this farce the whole global scam was sold to the rest of the world which would also diagnose respiratory disease as 'Covid-19' from symptoms alone or with a PCR test not testing for a 'virus'. Flu miraculously disappeared *worldwide* in 2020 and into 2021 as it was redesignated 'Covid-19'. It was really the same old flu with its 'flu-like' symptoms attributed to 'flu-like' 'Covid-19'. At the same time with very few exceptions the Chinese response of draconian lockdown and fascism was the chosen weapon to respond across the West as recommended by the Cult-owned Tedros at the Cult-owned World Health Organization run by the Cult-owned Gates. All was going according to plan. Chinese scientists – everything in China is controlled by the Cult-owned government – compared their contaminated RNA lung-fluid material with other RNA sequences and said it appeared to be just under 80 percent identical to the SARS-CoV-1 'virus' claimed to be the cause of the SARS (severe acute respiratory syndrome) 'outbreak' in 2003. They decreed that because of this the 'new virus' had to be related and they called it SARS-CoV-2. There are some serious problems with this assumption and *assumption* was all it was. Most 'factual' science turns out to be assumptions repeated into everyone-knows-that. A match of under 80-percent is meaningless. Dr Kaufman makes the point that there's a 96 percent genetic correlation between humans and chimpanzees, but 'no one would say our genetic material is part

of the chimpanzee family'. Yet the Chinese authorities were claiming that a much lower percentage, less than 80 percent, proved the existence of a new 'coronavirus'. For goodness sake human DNA is 60 percent similar to a *banana*.

You are feeling sleepy

The entire 'Covid' hoax is a global Psyop, a psychological operation to program the human mind into believing and fearing a complete fantasy. A crucial aspect of this was what *appeared* to happen in Italy. It was all very well streaming out daily images of an alleged catastrophe in Wuhan, but to the Western mind it was still on the other side of the world in a very different culture and setting. A reaction of 'this could happen to me and my family' was still nothing like as intense enough for the mind-doctors. The Cult needed a Western example to push people over that edge and it chose Italy, one of its major global locations going back to the Roman Empire. An Italian 'Covid' crisis was manufactured in a particular area called Lombardy which just happens to be notorious for its toxic air and therefore respiratory disease. Wuhan, China, *déjà vu*. An hysterical media told horror stories of Italians dying from 'Covid' in their droves and how Lombardy hospitals were being overrun by a tidal wave of desperately ill people needing treatment after being struck down by the 'deadly virus'. Here was the psychological turning point the Cult had planned. Wow, if this is happening in Italy, the Western mind concluded, this indeed could happen to me and my family. Another point is that Italian authorities responded by following the Chinese blueprint so vehemently recommended by the Cult-owned World Health Organization. They imposed fascistic lockdowns on the whole country viciously policed with the help of surveillance drones sweeping through the streets seeking out anyone who escaped from mass house arrest. Livelihoods were destroyed and psychology unravelled in the way we have witnessed since in all lockdown countries. Crucial to the plan was that Italy responded in this way to set the precedent of suspending freedom and imposing fascism in a 'Western liberal democracy'. I emphasised in an

animated video explanation on davidicke.com posted in the summer of 2020 how important it was to the Cult to expand the Chinese lockdown model across the West. Without this, and the bare-faced lie that non-symptomatic people could still transmit a 'disease' they didn't have, there was no way locking down the whole population, sick and not sick, could be pulled off. At just the right time and with no evidence Cult operatives and gofers claimed that people without symptoms could pass on the 'disease'. In the name of protecting the 'vulnerable' like elderly people, who lockdowns would kill by the tens of thousands, we had for the first time healthy people told to isolate as well as the sick. The great majority of people who tested positive had no symptoms because there was nothing wrong with them. It was just a trick made possible by a test not testing for the 'virus'.

Months after my animated video the Gates-funded Professor Neil Ferguson at the Gates-funded Imperial College confirmed that I was right. He didn't say it in those terms, naturally, but he did say it. Ferguson will enter the story shortly for his outrageously crazy 'computer models' that led to Britain, the United States and many other countries following the Chinese and now Italian methods of response. Put another way, following the Cult script. Ferguson said that SAGE, the UK government's scientific advisory group which has controlled 'Covid' policy from the start, wanted to follow the Chinese lockdown model (while they all continued to work and be paid), but they wondered if they could possibly, in Ferguson's words, 'get away with it in Europe'. 'Get away with it'? Who the hell do these moronic, arrogant people think they are? This appalling man Ferguson said that once Italy went into national lockdown they realised they, too, could mimic China:

It's a communist one-party state, we said. We couldn't get away with it in Europe, we thought ... and then Italy did it. And we realised we could. Behind this garbage from Ferguson is a simple fact: Doing the same as China in every country was the plan from the start and Ferguson's 'models' would play a central role in achieving that. It's just a coincidence, of course, and absolutely nothing to worry your little head about.

Oops, sorry, our mistake

Once the Italian segment of the Psyop had done the job it was designed to do a very different story emerged. Italian authorities revealed that 99 percent of those who had 'died from Covid-19' in Italy had one, two, three, or more 'co-morbidities' or illnesses and health problems that could have ended their life. The US Centers for Disease Control and Prevention (CDC) published a figure of 94 percent for Americans dying of 'Covid' while having other serious medical conditions – on average two to three (some five or six) other potential causes of death. In terms of death from an unproven 'virus' I say it is 100 percent. The other one percent in Italy and six percent in the US would presumably have died from 'Covid's' flu-like symptoms with a range of other possible causes in conjunction with a test not testing for the 'virus'. Fox News reported that even more startling figures had emerged in one US county in which 410 of 422 deaths attributed to 'Covid-19' had other potentially deadly health conditions. The Italian National Health Institute said later that the average age of people dying with a 'Covid-19' diagnosis in Italy was about 81. Ninety percent were over 70 with ten percent over 90. In terms of other reasons to die some 80 percent had two or more chronic diseases with half having three or more including cardiovascular problems, diabetes, respiratory problems and cancer. Why is the phantom 'Covid-19' said to kill overwhelmingly old people and hardly affect the young? Old people continually die of many causes and especially respiratory disease which you can re-diagnose 'Covid-19' while young people die in tiny numbers by comparison and rarely of respiratory disease. Old people 'die of Covid' because they die of other things that can be redesignated 'Covid' and it really is that simple.

Flu has flown

The blueprint was in place. Get your illusory 'cases' from a test not testing for the 'virus' and redesignate other causes of death as 'Covid-19'. You have an instant 'pandemic' from something that is nothing more than a computer-generated fiction. With near-on a

billion people having 'flu-like' symptoms every year the potential was limitless and we can see why flu quickly and apparently miraculously disappeared *worldwide* by being diagnosed 'Covid-19'. The painfully bloody obvious was explained away by the childlike media in headlines like this in the UK '*Independent*': 'Not a single case of flu detected by Public Health England this year as Covid restrictions suppress virus'. I kid you not. The masking, social distancing and house arrest that did not make the 'Covid virus' disappear somehow did so with the 'flu virus'. Even worse the article, by a bloke called Samuel Lovett, suggested that maybe the masking, sanitising and other 'Covid' measures should continue to keep the flu away. With a ridiculousness that disturbs your breathing (it's 'Covid-19') the said Lovett wrote: 'With widespread social distancing and mask-wearing measures in place throughout the UK, the usual routes of transmission for influenza have been blocked.' He had absolutely no evidence to support that statement, but look at the consequences of him acknowledging the obvious. With flu not disappearing at all and only being relabelled 'Covid-19' he would have to contemplate that 'Covid' was a hoax on a scale that is hard to imagine. You need guts and commitment to truth to even go there and that's clearly something Samuel Lovett does not have in abundance. He would never have got it through the editors anyway.

Tens of thousands die in the United States alone every winter from flu including many with pneumonia complications. CDC figures record *45 million* Americans diagnosed with flu in 2017-2018 of which 61,000 died and some reports claim 80,000. Where was the same hysteria then that we have seen with 'Covid-19'? Some 250,000 Americans are admitted to hospital with pneumonia every year with about 50,000 cases proving fatal. About 65 million suffer respiratory disease every year and three million deaths makes this the third biggest cause of death worldwide. You only have to redesignate a portion of all these people 'Covid-19' and you have an instant global pandemic or the *appearance* of one. Why would doctors do this? They are told to do this and all but a few dare not refuse those who must be obeyed. Doctors in general are not researching their own

knowledge and instead take it direct and unquestioned from the authorities that own them and their careers. The authorities say they must now diagnose these symptoms 'Covid-19' and not flu, or whatever, and they do it. Dark suits say put 'Covid-19' on death certificates no matter what the cause of death and the doctors do it. Renegade Minds don't fall for the illusion that doctors and medical staff are all highly-intelligent, highly-principled, seekers of medical truth. *Some are*, but not the majority. They are repeaters, gofers, and yes sir, no sir, purveyors of what the system demands they purvey. The 'Covid' con is not merely confined to diseases of the lungs. Instructions to doctors to put 'Covid-19' on death certificates for anyone dying of *anything* within 28 days (or much more) of a positive test not testing for the 'virus' opened the floodgates. The term dying *with* 'Covid' and not *of* 'Covid' was coined to cover the truth. Whether it was a *with* or an *of* they were all added to the death numbers attributed to the 'deadly virus' compiled by national governments and globally by the Gates-funded Johns Hopkins operation in the United States that was so involved in those 'pandemic' simulations. Fraudulent deaths were added to the ever-growing list of fraudulent 'cases' from false positives from a false test. No wonder Professor Walter Ricciardi, scientific advisor to the Italian minister of health, said after the Lombardy hysteria had done its job that 'Covid' death rates were due to Italy having the second oldest population in the world and to *how hospitals record deaths*:

The way in which we code deaths in our country is very generous in the sense that all the people who die in hospitals with the coronavirus are deemed to be dying of the coronavirus. On re-evaluation by the National Institute of Health, only 12 per cent of death certificates have shown a direct causality from coronavirus, while 88 per cent of patients who have died have at least one pre-morbidity – many had two or three.

This is extraordinary enough when you consider the propaganda campaign to use Italy to terrify the world, but how can they even say twelve percent were genuine when the 'virus' has not been shown to exist, its 'code' is a computer program, and diagnosis comes from a test not testing for it? As in China, and soon the world, 'Covid-19' in

Italy was a redesignation of diagnosis. Lies and corruption were to become the real 'pandemic' fuelled by a pathetically-compliant medical system taking its orders from the tiny few at the top of their national hierarchy who answered to the World Health Organization which answers to Gates and the Cult. Doctors were told – ordered – to diagnose a particular set of symptoms 'Covid-19' and put that on the death certificate for any cause of death if the patient had tested positive with a test not testing for the virus or had 'Covid' symptoms like the flu. The United States even introduced big financial incentives to manipulate the figures with hospitals receiving £4,600 from the Medicare system for diagnosing someone with regular pneumonia, \$13,000 if they made the diagnosis from the same symptoms 'Covid-19' pneumonia, and \$39,000 if they put a 'Covid' diagnosed patient on a ventilator that would almost certainly kill them. A few – painfully and pathetically few – medical whistleblowers revealed (before Cult-owned YouTube deleted their videos) that they had been instructed to 'let the patient crash' and put them straight on a ventilator instead of going through a series of far less intrusive and dangerous methods as they would have done before the pandemic hoax began and the financial incentives kicked in. We are talking cold-blooded murder given that ventilators are so damaging to respiratory systems they are usually the last step before heaven awaits. Renegade Minds never fall for the belief that people in white coats are all angels of mercy and cannot be full-on psychopaths. I have explained in detail in *The Answer* how what I am describing here played out across the world coordinated by the World Health Organization through the medical hierarchies in almost every country.

Medical scientist calls it

Information about the non-existence of the 'virus' began to emerge for me in late March, 2020, and mushroomed after that. I was sent an email by Sir Julian Rose, a writer, researcher, and organic farming promotor, from a medical scientist friend of his in the United States. Even at that early stage in March the scientist was able to explain

how the 'Covid' hoax was being manipulated. He said there were no reliable tests for a specific 'Covid-19 virus' and nor were there any reliable agencies or media outlets for reporting numbers of actual 'Covid-19' cases. We have seen in the long period since then that he was absolutely right. 'Every action and reaction to Covid-19 is based on totally flawed data and we simply cannot make accurate assessments,' he said. Most people diagnosed with 'Covid-19' were showing nothing more than cold and flu-like symptoms 'because most coronavirus strains *are* nothing more than cold/flu-like symptoms'. We had farcical situations like an 84-year-old German man testing positive for 'Covid-19' and his nursing home ordered to quarantine only for him to be found to have a common cold. The scientist described back then why PCR tests and what he called the 'Mickey Mouse test kits' were useless for what they were claimed to be identifying. 'The idea these kits can isolate a specific virus like Covid-19 is nonsense,' he said. Significantly, he pointed out that 'if you want to create a totally false panic about a totally false pandemic – pick a coronavirus'. This is exactly what the Cult-owned Gates, World Economic Forum and Johns Hopkins University did with their Event 201 'simulation' followed by their real-life simulation called the 'pandemic'. The scientist said that all you had to do was select the sickest of people with respiratory-type diseases in a single location – 'say Wuhan' – and administer PCR tests to them. You can then claim that anyone showing 'viral sequences' similar to a coronavirus 'which will inevitably be quite a few' is suffering from a 'new' disease:

Since you already selected the sickest flu cases a fairly high proportion of your sample will go on to die. You can then say this 'new' virus has a CFR [case fatality rate] higher than the flu and use this to infuse more concern and do more tests which will of course produce more 'cases', which expands the testing, which produces yet more 'cases' and so on and so on. Before long you have your 'pandemic', and all you have done is use a simple test kit trick to convert the worst flu and pneumonia cases into something new that doesn't ACTUALLY EXIST [my emphasis].

He said that you then 'just run the same scam in other countries' and make sure to keep the fear message running high 'so that people

will feel panicky and less able to think critically'. The only problem to overcome was the fact *there is no* actual new deadly pathogen and only regular sick people. This meant that deaths from the 'new deadly pathogen' were going to be way too low for a real new deadly virus pandemic, but he said this could be overcome in the following ways – all of which would go on to happen:

1. You can claim this is just the beginning and more deaths are imminent [you underpin this with fantasy 'computer projections']. Use this as an excuse to quarantine everyone and then claim the quarantine prevented the expected millions of dead.
2. You can [say that people] 'minimizing' the dangers are irresponsible and bully them into not talking about numbers.
3. You can talk crap about made up numbers hoping to blind people with pseudoscience.
4. You can start testing well people (who, of course, will also likely have shreds of coronavirus [RNA] in them) and thus inflate your 'case figures' with 'asymptomatic carriers' (you will of course have to spin that to sound deadly even though any virologist knows the more symptom-less cases you have the less deadly is your pathogen).

The scientist said that if you take these simple steps 'you can have your own entirely manufactured pandemic up and running in weeks'. His analysis made so early in the hoax was brilliantly prophetic of what would actually unfold. Pulling all the information together in these recent chapters we have this is simple 1, 2, 3, of how you can delude virtually the entire human population into believing in a 'virus' that doesn't exist:

- A 'Covid case' is someone who tests positive with a test not testing for the 'virus'.
- A 'Covid death' is someone who dies of *any cause* within 28 days (or much longer) of testing positive with a test not testing for the 'virus'.
- Asymptomatic means there is nothing wrong with you, but they claim you can pass on what you don't have to justify locking

down (quarantining) healthy people in totality.

The foundations of the hoax are that simple. A study involving ten million people in Wuhan, published in November, 2020, demolished the whole lie about those without symptoms passing on the 'virus'. They found '300 asymptomatic cases' and traced their contacts to find that not one of them was detected with the 'virus'.

'Asymptomatic' patients and their contacts were isolated for no less than two weeks and nothing changed. I know it's all crap, but if you are going to claim that those without symptoms can transmit 'the virus' then you must produce evidence for that and they never have. Even World Health Organization official Dr Maria Van Kerkhove, head of the emerging diseases and zoonosis unit, said as early as June, 2020, that she doubted the validity of asymptomatic transmission. She said that 'from the data we have, it still seems to be rare that an asymptomatic person actually transmits onward to a secondary individual' and by 'rare' she meant that she couldn't cite any case of asymptomatic transmission.

The Ferguson factor

The problem for the Cult as it headed into March, 2020, when the script had lockdown due to start, was that despite all the manipulation of the case and death figures they still did not have enough people alleged to have died from 'Covid' to justify mass house arrest. This was overcome in the way the scientist described: 'You can claim this is just the beginning and more deaths are imminent ... Use this as an excuse to quarantine everyone and then claim the quarantine prevented the expected millions of dead.' Enter one Professor Neil Ferguson, the Gates-funded 'epidemiologist' at the Gates-funded Imperial College in London. Ferguson is Britain's Christian Drosten in that he has a dire record of predicting health outcomes, but is still called upon to advise government on the next health outcome when another 'crisis' comes along. This may seem to be a strange and ridiculous thing to do. Why would you keep turning for policy guidance to people who have a history of being

monumentally wrong? Ah, but it makes sense from the Cult point of view. These 'experts' keep on producing predictions that suit the Cult agenda for societal transformation and so it was with Neil Ferguson as he revealed his horrific (and clearly insane) computer model predictions that allowed lockdowns to be imposed in Britain, the United States and many other countries. Ferguson does not have even an A-level in biology and would appear to have no formal training in computer modelling, medicine or epidemiology, according to Derek Winton, an MSc in Computational Intelligence. He wrote an article somewhat aghast at what Ferguson did which included taking no account of respiratory disease 'seasonality' which means it is far worse in the winter months. Who would have thought that respiratory disease could be worse in the winter? Well, certainly not Ferguson.

The massively China-connected Imperial College and its bizarre professor provided the excuse for the long-incubated Chinese model of human control to travel westward at lightning speed. Imperial College confirms on its website that it collaborates with the Chinese Research Institute; publishes more than 600 research papers every year with Chinese research institutions; has 225 Chinese staff; 2,600 Chinese students – the biggest international group; 7,000 former students living in China which is the largest group outside the UK; and was selected for a tour by China's President Xi Jinping during his state visit to the UK in 2015. The college takes major donations from China and describes itself as the UK's number one university collaborator with Chinese research institutions. The China communist/fascist government did not appear phased by the woeful predictions of Ferguson and Imperial when during the lockdown that Ferguson induced the college signed a five-year collaboration deal with China tech giant Huawei that will have Huawei's indoor 5G network equipment installed at the college's West London tech campus along with an 'AI cloud platform'. The deal includes Chinese sponsorship of Imperial's Venture Catalyst entrepreneurship competition. Imperial is an example of the enormous influence the Chinese government has within British and North American

universities and research centres – and further afield. Up to 200 academics from more than a dozen UK universities are being investigated on suspicion of ‘unintentionally’ helping the Chinese government build weapons of mass destruction by ‘transferring world-leading research in advanced military technology such as aircraft, missile designs and cyberweapons’. Similar scandals have broken in the United States, but it’s all a coincidence. Imperial College serves the agenda in many other ways including the promotion of every aspect of the United Nations Agenda 21/2030 (the Great Reset) and produced computer models to show that human-caused ‘climate change’ is happening when in the real world it isn’t. Imperial College is driving the climate agenda as it drives the ‘Covid’ agenda (both Cult hoaxes) while Patrick Vallance, the UK government’s Chief Scientific Adviser on ‘Covid’, was named Chief Scientific Adviser to the UN ‘climate change’ conference known as COP26 hosted by the government in Glasgow, Scotland. ‘Covid’ and ‘climate’ are fundamentally connected.

Professor Woeful

From Imperial’s bosom came Neil Ferguson still advising government despite his previous disasters and it was announced early on that he and other key people like UK Chief Medical Adviser Chris Whitty had caught the ‘virus’ as the propaganda story was being sold. Somehow they managed to survive and we had Prime Minister Boris Johnson admitted to hospital with what was said to be a severe version of the ‘virus’ in this same period. His whole policy and demeanour changed when he returned to Downing Street. It’s a small world with these government advisors – especially in their communal connections to Gates – and Ferguson had partnered with Whitty to write a paper called ‘Infectious disease: Tough choices to reduce Ebola transmission’ which involved another scare-story that didn’t happen. Ferguson’s ‘models’ predicted that up to 150,000 could die from ‘mad cow disease’, or BSE, and its version in sheep if it was transmitted to humans. BSE was not transmitted and instead triggered by an organophosphate pesticide used to treat a pest on

cows. Fewer than 200 deaths followed from the human form. Models by Ferguson and his fellow incompetents led to the unnecessary culling of millions of pigs, cattle and sheep in the foot and mouth outbreak in 2001 which destroyed the lives and livelihoods of farmers and their families who had often spent decades building their herds and flocks. Vast numbers of these animals did not have foot and mouth and had no contact with the infection. Another 'expert' behind the cull was Professor Roy Anderson, a computer modeller at Imperial College specialising in the epidemiology of *human*, not animal, disease. Anderson has served on the Bill and Melinda Gates Grand Challenges in Global Health advisory board and chairs another Gates-funded organisation. Gates is everywhere.

In a precursor to the 'Covid' script Ferguson backed closing schools 'for prolonged periods' over the swine flu 'pandemic' in 2009 and said it would affect a third of the world population if it continued to spread at the speed he claimed to be happening. His mates at Imperial College said much the same and a news report said: 'One of the authors, the epidemiologist and disease modeller Neil Ferguson, who sits on the World Health Organisation's emergency committee for the outbreak, said the virus had "full pandemic potential".' Professor Liam Donaldson, the Chris Whitty of his day as Chief Medical Officer, said the worst case could see 30 percent of the British people infected by swine flu with 65,000 dying. Ferguson and Donaldson were indeed proved correct when at the end of the year the number of deaths attributed to swine flu was 392. The term 'expert' is rather liberally applied unfortunately, not least to complete idiots. Swine flu 'projections' were great for GlaxoSmithKline (GSK) as millions rolled in for its Pandemrix influenza vaccine which led to brain damage with children most affected. The British government (taxpayers) paid out more than £60 million in compensation after GSK was given immunity from prosecution. Yet another 'Covid' déjà vu. Swine flu was supposed to have broken out in Mexico, but Dr Wolfgang Wodarg, a German doctor, former member of parliament and critic of the 'Covid' hoax, observed 'the spread of swine flu' in Mexico City at the time. He

said: 'What we experienced in Mexico City was a very mild flu which did not kill more than usual – which killed even fewer people than usual.' Hyping the fear against all the facts is not unique to 'Covid' and has happened many times before. Ferguson is reported to have over-estimated the projected death toll of bird flu (H5N1) by some three million-fold, but bird flu vaccine makers again made a killing from the scare. This is some of the background to the Neil Ferguson who produced the perfectly-timed computer models in early 2020 predicting that half a million people would die in Britain without draconian lockdown and 2.2 million in the United States. Politicians panicked, people panicked, and lockdowns of alleged short duration were instigated to 'flatten the curve' of cases gleaned from a test not testing for the 'virus'. I said at the time that the public could forget the 'short duration' bit. This was an agenda to destroy the livelihoods of the population and force them into mass control through dependency and there was going to be nothing 'short' about it. American researcher Daniel Horowitz described the consequences of the 'models' spewed out by Gates-funded Ferguson and Imperial College:

What led our government and the governments of many other countries into panic was a single Imperial College of UK study, funded by global warming activists, that predicted 2.2 million deaths if we didn't lock down the country. In addition, the reported 8-9% death rate in Italy scared us into thinking there was some other mutation of this virus that they got, which might have come here.

Together with the fact that we were finally testing and had the ability to actually report new cases, we thought we were headed for a death spiral. But again ... we can't flatten a curve if we don't know when the curve started.

How about it *never* started?

Giving them what they want

An investigation by German news outlet *Welt Am Sonntag* (*World on Sunday*) revealed how in March, 2020, the German government gathered together 'leading scientists from several research institutes and universities' and 'together, they were to produce a [modelling]

paper that would serve as legitimization for further tough political measures'. The Cult agenda was justified by computer modelling not based on evidence or reality; it was specifically constructed to justify the Cult demand for lockdowns all over the world to destroy the independent livelihoods of the global population. All these modellers and everyone responsible for the 'Covid' hoax have a date with a trial like those in Nuremberg after World War Two when Nazis faced the consequences of their war crimes. These corrupt-beyond-belief 'modellers' wrote the paper according to government instructions and it said that if lockdown measures were lifted then up to one million Germans would die from 'Covid-19' adding that some would die 'agonizingly at home, gasping for breath' unable to be treated by hospitals that couldn't cope. All lies. No matter – it gave the Cult all that it wanted. What did long-time government 'modeller' Neil Ferguson say? If the UK and the United States didn't lockdown half a million would die in Britain and 2.2 million Americans. Anyone see a theme here? 'Modellers' are such a crucial part of the lockdown strategy that we should look into their background and follow the money. Researcher Rosemary Frei produced an excellent article headlined 'The Modelling-paper Mafiosi'. She highlights a guy called John Edmunds, a British epidemiologist, and professor in the Faculty of Epidemiology and Population Health at the London School of Hygiene & Tropical Medicine. He studied at Imperial College. Edmunds is a member of government 'Covid' advisory bodies which have been dictating policy, the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG) and the Scientific Advisory Group for Emergencies (SAGE).

Ferguson, another member of NERVTAG and SAGE, led the way with the original 'virus' and Edmunds has followed in the 'variant' stage and especially the so-called UK or Kent variant known as the 'Variant of Concern' (VOC) B.1.1.7. He said in a co-written report for the Centre for Mathematical modelling of Infectious Diseases at the London School of Hygiene and Tropical Medicine, with input from the Centre's 'Covid-19' Working Group, that there was 'a realistic

possibility that VOC B.1.1.7 is associated with an increased risk of death compared to non-VOC viruses'. Fear, fear, fear, get the vaccine, fear, fear, fear, get the vaccine. Rosemary Frei reveals that almost all the paper's authors and members of the modelling centre's 'Covid-19' Working Group receive funding from the Bill and Melinda Gates Foundation and/or the associated Gates-funded Wellcome Trust. The paper was published by e-journal *Medrx* ^{xiv} which only publishes papers not peer-reviewed and the journal was established by an organisation headed by Facebook's Mark Zuckerberg and his missus. What a small world it is. Frei discovered that Edmunds is on the Scientific Advisory Board of the Coalition for Epidemic Preparedness Innovations (CEPI) which was established by the Bill and Melinda Gates Foundation, Klaus Schwab's Davos World Economic Forum and Big Pharma giant Wellcome. CEPI was 'launched in Davos [in 2017] to develop vaccines to stop future epidemics', according to its website. 'Our mission is to accelerate the development of vaccines against emerging infectious diseases and enable equitable access to these vaccines for people during outbreaks.' What kind people they are. Rosemary Frei reveals that Public Health England (PHE) director Susan Hopkins is an author of her organisation's non-peer-reviewed reports on 'new variants'. Hopkins is a professor of infectious diseases at London's Imperial College which is gifted tens of millions of dollars a year by the Bill and Melinda Gates Foundation. Gates-funded modelling disaster Neil Ferguson also co-authors Public Health England reports and he spoke in December, 2020, about the potential danger of the B.1.1.7. 'UK variant' promoted by Gates-funded modeller John Edmunds. When I come to the 'Covid vaccines' the 'new variants' will be shown for what they are – bollocks.

Connections, connections

All these people and modellers are lockdown-obsessed or, put another way, they demand what the Cult demands. Edmunds said in January, 2021, that to ease lockdowns too soon would be a disaster and they had to 'vaccinate much, much, much more widely than the

elderly'. Rosemary Frei highlights that Edmunds is married to Jeanne Pimenta who is described in a LinkedIn profile as director of epidemiology at GlaxoSmithKline (GSK) and she held shares in the company. Patrick Vallance, co-chair of SAGE and the government's Chief Scientific Adviser, is a former executive of GSK and has a deferred bonus of shares in the company worth £600,000. GSK has serious business connections with Bill Gates and is collaborating with mRNA-'vaccine' company CureVac to make 'vaccines' for the new variants that Edmunds is talking about. GSK is planning a 'Covid vaccine' with drug giant Sanofi. Puppets Prime Minister Boris Johnson announced in the spring of 2021 that up to 60 million vaccine doses were to be made at the GSK facility at Barnard Castle in the English North East. Barnard Castle, with a population of just 6,000, was famously visited in breach of lockdown rules in April, 2020, by Johnson aide Dominic Cummings who said that he drove there 'to test his eyesight' before driving back to London. Cummings would be better advised to test his integrity – not that it would take long. The GSK facility had nothing to do with his visit then although I'm sure Patrick Vallance would have been happy to arrange an introduction and some tea and biscuits. Ruthless psychopath Gates has made yet another fortune from vaccines in collaboration with Big Pharma companies and gushes at the phenomenal profits to be made from vaccines – more than a 20-to-1 return as he told one interviewer. Gates also tweeted in December, 2019, with the foreknowledge of what was coming: 'What's next for our foundation? I'm particularly excited about what the next year could mean for one of the best buys in global health: vaccines.'

Modeller John Edmunds is a big promotor of vaccines as all these people appear to be. He's the dean of the London School of Hygiene & Tropical Medicine's Faculty of Epidemiology and Population Health which is primarily funded by the Bill and Melinda Gates Foundation and the Gates-established and funded GAVI vaccine alliance which is the Gates vehicle to vaccinate the world. The organisation Doctors Without Borders has described GAVI as being 'aimed more at supporting drug-industry desires to promote new

products than at finding the most efficient and sustainable means for fighting the diseases of poverty'. But then that's why the psychopath Gates created it. John Edmunds said in a video that the London School of Hygiene & Tropical Medicine is involved in every aspect of vaccine development including large-scale clinical trials. He contends that mathematical modelling can show that vaccines protect individuals and society. That's on the basis of shit in and shit out, I take it. Edmunds serves on the UK Vaccine Network as does Ferguson and the government's foremost 'Covid' adviser, the grim-faced, dark-eyed Chris Whitty. The Vaccine Network says it works 'to support the government to identify and shortlist targeted investment opportunities for the most promising vaccines and vaccine technologies that will help combat infectious diseases with epidemic potential, and to address structural issues related to the UK's broader vaccine infrastructure'. Ferguson is acting Director of the Imperial College Vaccine Impact Modelling Consortium which has funding from the Bill and Melina Gates Foundation and the Gates-created GAVI 'vaccine alliance'. Anyone wonder why these characters see vaccines as the answer to every problem? Ferguson is wildly enthusiastic in his support for GAVI's campaign to vaccinate children en masse in poor countries. You would expect someone like Gates who has constantly talked about the need to reduce the population to want to fund vaccines to keep more people alive. I'm sure that's why he does it. The John Edmunds London School of Hygiene & Tropical Medicine (LSHTM) has a Vaccines Manufacturing Innovation Centre which develops, tests and commercialises vaccines. Rosemary Frei writes:

The vaccines centre also performs affiliated activities like combating 'vaccine hesitancy'. The latter includes the Vaccine Confidence Project. The project's stated purpose is, among other things, 'to provide analysis and guidance for early response and engagement with the public to ensure sustained confidence in vaccines and immunisation'. The Vaccine Confidence Project's director is LSHTM professor Heidi Larson. For more than a decade she's been researching how to combat vaccine hesitancy.

How the bloody hell can blokes like John Edmunds and Neil Ferguson with those connections and financial ties model 'virus' case

and death projections for the government and especially in a way that gives their paymasters like Gates exactly what they want? It's insane, but this is what you find throughout the world.

'Covid' is not dangerous, oops, wait, yes it is

Only days before Ferguson's nightmare scenario made Jackboot Johnson take Britain into a China-style lockdown to save us from a deadly 'virus' the UK government website gov.uk was reporting something very different to Ferguson on a page of official government guidance for 'high consequence infectious diseases (HCID)'. It said this about 'Covid-19':

As of 19 March 2020, COVID-19 is no longer considered to be a high consequence infectious diseases (HCID) in the UK [my emphasis]. The 4 nations public health HCID group made an interim recommendation in January 2020 to classify COVID-19 as an HCID. This was based on consideration of the UK HCID criteria about the virus and the disease with information available during the early stages of the outbreak.

Now that more is known about COVID-19, the public health bodies in the UK have reviewed the most up to date information about COVID-19 against the UK HCID criteria. They have determined that several features have now changed; in particular, more information is available about mortality rates (low overall), and there is now greater clinical awareness and a specific and sensitive laboratory test, the availability of which continues to increase. The Advisory Committee on Dangerous Pathogens (ACDP) is also of the opinion that COVID-19 should no longer be classified as an HCID.

Soon after the government had been exposed for downgrading the risk they upgraded it again and everyone was back to singing from the same Cult hymn book. Ferguson and his fellow Gates clones indicated that lockdowns and restrictions would have to continue until a Gates-funded vaccine was developed. Gates said the same because Ferguson and his like were repeating the Gates script which is the Cult script. 'Flatten the curve' became an ongoing nightmare of continuing lockdowns with periods in between of severe restrictions in pursuit of destroying independent incomes and had nothing to do with protecting health about which the Cult gives not a shit. Why wouldn't Ferguson be pushing a vaccine 'solution' when he's owned by vaccine-obsessive Gates who makes a fortune from them and

when Ferguson heads the Vaccine Impact Modelling Consortium at Imperial College funded by the Gates Foundation and GAVI, the 'vaccine alliance', created by Gates as his personal vaccine promotion operation? To compound the human catastrophe that Ferguson's 'models' did so much to create he was later exposed for breaking his own lockdown rules by having sexual liaisons with his married girlfriend Antonia Staats at his home while she was living at another location with her husband and children. Staats was a 'climate' activist and senior campaigner at the Soros-funded Avaaz which I wouldn't trust to tell me that grass is green. Ferguson had to resign as a government advisor over this hypocrisy in May, 2020, but after a period of quiet he was back being quoted by the ridiculous media on the need for more lockdowns and a vaccine rollout. Other government-advising 'scientists' from Imperial College held the fort in his absence and said lockdown could be indefinite until a vaccine was found. The Cult script was being sung by the payrolled choir. I said there was no intention of going back to 'normal' when the 'vaccine' came because the 'vaccine' is part of a very different agenda that I will discuss in Human 2.0. Why would the Cult want to let the world go back to normal when destroying that normal forever was the whole point of what was happening? House arrest, closing businesses and schools through lockdown, (un)social distancing and masks all followed the Ferguson fantasy models. Again as I predicted (these people are so predictable) when the 'vaccine' arrived we were told that house arrest, lockdown, (un)social distancing and masks would still have to continue. I will deal with the masks in the next chapter because they are of fundamental importance.

Where's the 'pandemic'?

Any mildly in-depth assessment of the figures revealed what was really going on. Cult-funded and controlled organisations still have genuine people working within them such is the number involved. So it is with Genevieve Briand, assistant program director of the Applied Economics master's degree program at Johns Hopkins

University. She analysed the impact that 'Covid-19' had on deaths from *all* causes in the United States using official data from the CDC for the period from early February to early September, 2020. She found that allegedly 'Covid' *related*-deaths exceeded those from heart disease which she found strange with heart disease always the biggest cause of fatalities. Her research became even more significant when she noted the sudden decline in 2020 of *all* non-'Covid' deaths: 'This trend is completely contrary to the pattern observed in all previous years ... the total decrease in deaths by other causes almost exactly equals the increase in deaths by Covid-19.' This was such a game, set and match in terms of what was happening that Johns Hopkins University deleted the article on the grounds that it 'was being used to support false and dangerous inaccuracies about the impact of the pandemic'. No – because it exposed the scam from official CDC figures and this was confirmed when those figures were published in January, 2021. Here we can see the effect of people dying from heart attacks, cancer, road accidents and gunshot wounds – *anything* – having 'Covid-19' on the death certificate along with those diagnosed from 'symptoms' who had even not tested positive with a test not testing for the 'virus'. I am not kidding with the gunshot wounds, by the way. Brenda Bock, coroner in Grand County, Colorado, revealed that two gunshot victims tested positive for the 'virus' within the previous 30 days and were therefore classified as 'Covid deaths'. Bock said: 'These two people had tested positive for Covid, but that's not what killed them. A gunshot wound is what killed them.' She said she had not even finished her investigation when the state listed the gunshot victims as deaths due to the 'virus'. The death and case figures for 'Covid-19' are an absolute joke and yet they are repeated like parrots by the media, politicians and alleged medical 'experts'. The official Cult narrative is the only show in town.

Genevieve Briand found that deaths from all causes were not exceptional in 2020 compared with previous years and a Spanish magazine published figures that said the same about Spain which was a 'Covid' propaganda hotspot at one point. *Discovery Salud*, a

health and medicine magazine, quoted government figures which showed how 17,000 *fewer* people died in Spain in 2020 than in 2019 and more than 26,000 fewer than in 2018. The age-standardised mortality rate for England and Wales when age distribution is taken into account was significantly lower in 2020 than the 1970s, 80s and 90s, and was only the ninth highest since 2000. Where is the 'pandemic'?

Post mortems and autopsies virtually disappeared for 'Covid' deaths amid claims that 'virus-infected' bodily fluids posed a risk to those carrying out the autopsy. This was rejected by renowned German pathologist and forensic doctor Klaus Püschel who said that he and his staff had by then done 150 autopsies on 'Covid' patients with no problems at all. He said they were needed to know why some 'Covid' patients suffered blood clots and not severe respiratory infections. The 'virus' is, after all, called SARS or 'severe acute respiratory syndrome'. I highlighted in the spring of 2020 this phenomenon and quoted New York intensive care doctor Cameron Kyle-Sidell who posted a soon deleted YouTube video to say that they had been told to prepare to treat an infectious disease called 'Covid-19', but that was not what they were dealing with. Instead he likened the lung condition of the most severely ill patients to what you would expect with cabin depressurisation in a plane at 30,000 feet or someone dropped on the top of Everest without oxygen or acclimatisation. I have never said this is not happening to a small minority of alleged 'Covid' patients – I am saying this is not caused by a phantom 'contagious virus'. Indeed Kyle-Sidell said that 'Covid-19' was not the disease they were told was coming their way. 'We are operating under a medical paradigm that is untrue,' he said, and he believed they were treating the wrong disease: 'These people are being slowly starved of oxygen.' Patients would take off their oxygen masks in a state of fear and stress and while they were blue in the face on the brink of death. They did not look like patients dying of pneumonia. You can see why they don't want autopsies when their virus doesn't exist and there is another condition in some people that they don't wish to be uncovered. I should add here that

the 5G system of millimetre waves was being rapidly introduced around the world in 2020 and even more so now as they fire 5G at the Earth from satellites. At 60 gigahertz within the 5G range that frequency interacts with the oxygen molecule and stops people breathing in sufficient oxygen to be absorbed into the bloodstream. They are installing 5G in schools and hospitals. The world is not mad or anything. 5G can cause major changes to the lungs and blood as I detail in *The Answer* and these consequences are labelled 'Covid-19', the alleged symptoms of which can be caused by 5G and other electromagnetic frequencies as cells respond to radiation poisoning.

The 'Covid death' scam

Dr Scott Jensen, a Minnesota state senator and medical doctor, exposed 'Covid' Medicare payment incentives to hospitals and death certificate manipulation. He said he was sent a seven-page document by the US Department of Health 'coaching' him on how to fill out death certificates which had never happened before. The document said that he didn't need to have a laboratory test for 'Covid-19' to put that on the death certificate and that shocked him when death certificates are supposed to be about facts. Jensen described how doctors had been 'encouraged, if not pressured' to make a diagnosis of 'Covid-19' if they thought it was probable or '*presumed*'. No positive test was necessary – not that this would have mattered anyway. He said doctors were told to diagnose 'Covid' by symptoms when these were the same as colds, allergies, other respiratory problems, and certainly with influenza which 'disappeared' in the 'Covid' era. A common sniffle was enough to get the dreaded verdict. Ontario authorities decreed that a single care home resident with *one* symptom from a long list must lead to the isolation of the entire home. Other courageous doctors like Jensen made the same point about death figure manipulation and how deaths by other causes were falling while 'Covid-19 deaths' were rising at the same rate due to re-diagnosis. Their videos rarely survive long on YouTube with its Cult-supporting algorithms courtesy of CEO Susan Wojcicki and her bosses at Google. Figure-tampering was so glaring

and ubiquitous that even officials were letting it slip or outright saying it. UK chief scientific adviser Patrick Vallance said on one occasion that 'Covid' on the death certificate doesn't mean 'Covid' was the cause of death (so why the hell is it there?) and we had the rare sight of a BBC reporter telling the truth when she said: 'Someone could be successfully treated for Covid, in say April, discharged, and then in June, get run over by a bus and die ... That person would still be counted as a Covid death in England.' Yet the BBC and the rest of the world media went on repeating the case and death figures as if they were real. Illinois Public Health Director Dr Ngozi Ezike revealed the deceit while her bosses must have been clenching their buttocks:

If you were in a hospice and given a few weeks to live and you were then found to have Covid that would be counted as a Covid death. [There might be] a clear alternate cause, but it is still listed as a Covid death. So everyone listed as a Covid death doesn't mean that was the cause of the death, but that they had Covid at the time of death.

Yes, a 'Covid virus' never shown to exist and tested for with a test not testing for the 'virus'. In the first period of the pandemic hoax through the spring of 2020 the process began of designating almost everything a 'Covid' death and this has continued ever since. I sat in a restaurant one night listening to a loud conversation on the next table where a family was discussing in bewilderment how a relative who had no symptoms of 'Covid', and had died of a long-term problem, could have been diagnosed a death by the 'virus'. I could understand their bewilderment. If they read this book they will know why this medical fraud has been perpetrated the world over.

Some media truth shock

The media ignored the evidence of death certificate fraud until eventually one columnist did speak out when she saw it first-hand. Bel Mooney is a long-time national newspaper journalist in Britain currently working for the *Daily Mail*. Her article on February 19th, 2021, carried this headline: 'My dad Ted passed three Covid tests

and died of a chronic illness yet he's officially one of Britain's 120,000 victims of the virus and is far from alone ... so how many more are there?' She told how her 99-year-old father was in a care home with a long-standing chronic obstructive pulmonary disease and vascular dementia. Maybe, but he was still aware enough to tell her from the start that there was no 'virus' and he refused the 'vaccine' for that reason. His death was not unexpected given his chronic health problems and Mooney said she was shocked to find that 'Covid-19' was declared the cause of death on his death certificate. She said this was a 'bizarre and unacceptable untruth' for a man with long-time health problems who had tested negative twice at the home for the 'virus'. I was also shocked by this story although not by what she said. I had been highlighting the death certificate manipulation for ten months. It was the confirmation that a professional full-time journalist only realised this was going on when it affected her directly and neither did she know that whether her dad tested positive or negative was irrelevant with the test not testing for the 'virus'. Where had she been? She said she did not believe in 'conspiracy theories' without knowing I'm sure that this and 'conspiracy theorists' were terms put into widespread circulation by the CIA in the 1960s to discredit those who did not accept the ridiculous official story of the Kennedy assassination. A blanket statement of 'I don't believe in conspiracy theories' is always bizarre. The dictionary definition of the term alone means the world is drowning in conspiracies. What she said was even more daft when her dad had just been affected by the 'Covid' conspiracy. Why else does she think that 'Covid-19' was going on the death certificates of people who died of something else?

To be fair once she saw from personal experience what was happening she didn't mince words. Mooney was called by the care home on the morning of February 9th to be told her father had died in his sleep. When she asked for the official cause of death what came back was 'Covid-19'. Mooney challenged this and was told there had been deaths from Covid on the dementia floor (confirmed by a test not testing for the 'virus') so they considered it 'reasonable

to assume'. 'But doctor,' Mooney rightly protested, 'an assumption isn't a diagnosis.' She said she didn't blame the perfectly decent and sympathetic doctor – 'he was just doing his job'. Sorry, but that's *bullshit*. He wasn't doing his job at all. He was putting a false cause of death on the death certificate and that is a criminal offence for which he should be brought to account and the same with the millions of doctors worldwide who have done the same. They were not doing their job they were following orders and that must not wash at new Nuremberg trials any more than it did at the first ones. Mooney's doctor was 'assuming' (presuming) as he was told to, but 'just following orders' makes no difference to his actions. A doctor's job is to serve the patient and the truth, not follow orders, but that's what they have done all over the world and played a central part in making the 'Covid' hoax possible with all its catastrophic consequences for humanity. Shame on them and they must answer for their actions. Mooney said her disquiet worsened when she registered her father's death by telephone and was told by the registrar there had been very many other cases like hers where 'the deceased' had not tested positive for 'Covid' yet it was recorded as the cause of death. The test may not matter, but those involved at their level *think* it matters and it shows a callous disregard for accurate diagnosis. The pressure to do this is coming from the top of the national 'health' pyramids which in turn obey the World Health Organization which obeys Gates and the Cult. Mooney said the registrar agreed that this must distort the national figures adding that 'the strangest thing is that every winter we record countless deaths from flu, and this winter there have been none. Not one!' She asked if the registrar thought deaths from flu were being misdiagnosed and lumped together with 'Covid' deaths. The answer was a 'puzzled yes'. Mooney said that the funeral director said the same about 'Covid' deaths which had nothing to do with 'Covid'. They had lost count of the number of families upset by this and other funeral companies in different countries have had the same experience. Mooney wrote:

The nightly shroud-waving and shocking close-ups of pain imposed on us by the TV news bewildered and terrified the population into eager compliance with lockdowns. We were invited to 'save the NHS' and to grieve for strangers – the real-life loved ones behind those shocking death counts. Why would the public imagine what I now fear, namely that the way Covid-19 death statistics are compiled might make the numbers seem greater than they are?

Oh, just a little bit – like 100 percent.

Do the maths

Mooney asked why a country would wish to skew its mortality figures by wrongly certifying deaths? What had been going on? Well, if you don't believe in conspiracies you will never find the answer which is that *it's a conspiracy*. She did, however, describe what she had discovered as a 'national scandal'. In reality it's a global scandal and happening everywhere. Pillars of this conspiracy were all put into place before the button was pressed with the Drosten PCR protocol and high amplifications to produce the cases and death certificate changes to secure illusory 'Covid' deaths. Mooney notes that normally two doctors were needed to certify a death, with one having to know the patient, and how the rules were changed in the spring of 2020 to allow one doctor to do this. In the same period 'Covid deaths' were decreed to be all cases where Covid-19 was put on the death certificate even without a positive test or any symptoms. Mooney asked: 'How many of the 30,851 (as of January 15) care home resident deaths with Covid-19 on the certificate (32.4 per cent of all deaths so far) were based on an assumption, like that of my father? And what has that done to our national psyche?' All of them is the answer to the first question and it has devastated and dismantled the national psyche, actually the global psyche, on a colossal scale. In the UK case and death data is compiled by organisations like Public Health England (PHE) and the Office for National Statistics (ONS). Mooney highlights the insane policy of counting a death from any cause as 'Covid-19' if this happens within 28 days of a positive test (with a test not testing for the 'virus') and she points out that ONS statistics reflect deaths 'involving Covid' 'or due to Covid' which meant in practice any

death where 'Covid-19' was mentioned on the death certificate. She described the consequences of this fraud:

Most people will accept the narrative they are fed, so panicky governments here and in Europe witnessed the harsh measures enacted in totalitarian China and jumped into lockdown. Headlines about Covid deaths tolled like the knell that would bring doomsday to us all. Fear stalked our empty streets. Politicians parroted the frankly ridiculous aim of 'zero Covid' and shut down the economy, while most British people agreed that lockdown was essential and (astonishingly to me, as a patriotic Brit) even wanted more restrictions.

For what? Lies on death certificates? Never mind the grim toll of lives ruined, suicides, schools closed, rising inequality, depression, cancelled hospital treatments, cancer patients in a torture of waiting, poverty, economic devastation, loneliness, families kept apart, and so on. How many lives have been lost as a direct result of lockdown?

She said that we could join in a national chorus of shock and horror at reaching the 120,000 death toll which was surely certain to have been totally skewed all along, but what about the human cost of lockdown justified by these 'death figures'? *The British Medical Journal* had reported a 1,493 percent increase in cases of children taken to Great Ormond Street Hospital with abusive head injuries alone and then there was the effect on families:

Perhaps the most shocking thing about all this is that families have been kept apart – and obeyed the most irrational, changing rules at the whim of government – because they believed in the statistics. They succumbed to fear, which his generation rejected in that war fought for freedom. Dad (God rest his soul) would be angry. And so am I.

Another theme to watch is that in the winter months when there are more deaths from all causes they focus on 'Covid' deaths and in the summer when the British Lung Foundation says respiratory disease plummets by 80 percent they rage on about 'cases'. Either way fascism on population is always the answer.

Nazi eugenics in the 21st century

Elderly people in care homes have been isolated from their families month after lonely month with no contact with relatives and grandchildren who were banned from seeing them. We were told

that lockdown fascism was to 'protect the vulnerable' like elderly people. At the same time Do Not Resuscitate (DNR) orders were placed on their medical files so that if they needed resuscitation it wasn't done and 'Covid-19' went on their death certificates. Old people were not being 'protected' they were being culled – murdered in truth. DNR orders were being decreed for disabled and young people with learning difficulties or psychological problems. The UK Care Quality Commission, a non-departmental body of the Department of Health and Social Care, found that 34 percent of those working in health and social care were pressured into placing 'do not attempt cardiopulmonary resuscitation' orders on 'Covid' patients who suffered from disabilities and learning difficulties without involving the patient or their families in the decision. UK judges ruled that an elderly woman with dementia should have the DNA-manipulating 'Covid vaccine' against her son's wishes and that a man with severe learning difficulties should have the jab despite his family's objections. Never mind that many had already died. The judiciary always supports doctors and government in fascist dictatorships. They wouldn't dare do otherwise. A horrific video was posted showing fascist officers from Los Angeles police forcibly giving the 'Covid' shot to women with special needs who were screaming that they didn't want it. The same fascists are seen giving the jab to a sleeping elderly woman in a care home. This is straight out of the Nazi playbook. Hitler's Nazis committed mass murder of the mentally ill and physically disabled throughout Germany and occupied territories in the programme that became known as Aktion T4, or just T4. Sabbatian-controlled Hitler and his grotesque crazies set out to kill those they considered useless and unnecessary. The Reich Committee for the Scientific Registering of Hereditary and Congenital Illnesses registered the births of babies identified by physicians to have 'defects'. By 1941 alone more than 5,000 children were murdered by the state and it is estimated that in total the number of innocent people killed in Aktion T4 was between 275,000 and 300,000. Parents were told their children had been sent away for 'special treatment' never to return. It is rather pathetic to see claims about plans for new extermination camps being dismissed today

when the same force behind current events did precisely that 80 years ago. Margaret Sanger was a Cult operative who used 'birth control' to sanitise her programme of eugenics. Organisations she founded became what is now Planned Parenthood. Sanger proposed that 'the whole dysgenic population would have its choice of segregation or sterilization'. These included epileptics, 'feeble-minded', and prostitutes. Sanger opposed charity because it perpetuated 'human waste'. She reveals the Cult mentality and if anyone thinks that extermination camps are a 'conspiracy theory' their naivety is touching if breathtakingly stupid.

If you don't believe that doctors can act with callous disregard for their patients it is worth considering that doctors and medical staff agreed to put government-decreed DNR orders on medical files and do nothing when resuscitation is called for. I don't know what you call such people in your house. In mine they are Nazis from the Josef Mengele School of Medicine. Phenomenal numbers of old people have died worldwide from the effects of lockdown, depression, lack of treatment, the 'vaccine' (more later) and losing the will to live. A common response at the start of the manufactured pandemic was to remove old people from hospital beds and transfer them to nursing homes. The decision would result in a mass cull of elderly people in those homes through lack of treatment – *not* 'Covid'. Care home whistleblowers have told how once the 'Covid' era began doctors would not come to their homes to treat patients and they were begging for drugs like antibiotics that often never came. The most infamous example was ordered by New York governor Andrew Cuomo, brother of a moronic CNN host, who amazingly was given an Emmy Award for his handling of the 'Covid crisis' by the ridiculous Wokers that hand them out. Just how ridiculous could be seen in February, 2021, when a Department of Justice and FBI investigation began into how thousands of old people in New York died in nursing homes after being discharged from hospital to make way for 'Covid' patients on Cuomo's say-so – and how he and his staff covered up these facts. This couldn't have happened to a nicer psychopath. Even then there was a 'Covid' spin. Reports said that

thousands of old people who tested positive for 'Covid' in hospital were transferred to nursing homes to both die of 'Covid' and transmit it to others. No – they were in hospital because they were ill and the fact that they tested positive with a test not testing for the 'virus' is irrelevant. They were ill often with respiratory diseases ubiquitous in old people near the end of their lives. Their transfer out of hospital meant that their treatment stopped and many would go on to die.

They're old. Who gives a damn?

I have exposed in the books for decades the Cult plan to cull the world's old people and even to introduce at some point what they call a 'demise pill' which at a certain age everyone would take and be out of here by law. In March, 2021, Spain legalised euthanasia and assisted suicide following the Netherlands, Belgium, Luxembourg and Canada on the Tiptoe to the demise pill. Treatment of old people by many 'care' homes has been a disgrace in the 'Covid' era. There are many, many, caring staff – I know some. There have, however, been legions of stories about callous treatment of old people and their families. Police were called when families came to take their loved ones home in the light of isolation that was killing them. They became prisoners of the state. Care home residents in insane, fascist Ontario, Canada, were not allowed to leave their *room* once the 'Covid' hoax began. UK staff have even wheeled elderly people away from windows where family members were talking with them. Oriana Criscuolo from Stockport in the English North West dropped off some things for her 80-year-old father who has Parkinson's disease and dementia and she wanted to wave to him through a ground-floor window. She was told that was 'illegal'. When she went anyway they closed the curtains in the middle of the day. Oriana said:

It's just unbelievable. I cannot understand how care home staff – people who are being paid to care – have become so uncaring. Their behaviour is inhumane and cruel. It's beyond belief.

She was right and this was not a one-off. What a way to end your life in such loveless circumstances. UK registered nurse Nicky Millen, a proper old school nurse for 40 years, said that when she started her career care was based on dignity, choice, compassion and empathy. Now she said 'the things that are important to me have gone out of the window.' She was appalled that people were dying without their loved ones and saying goodbye on iPads. Nicky described how a distressed 89-year-old lady stroked her face and asked her 'how many paracetamol would it take to finish me off'. Life was no longer worth living while not seeing her family. Nicky said she was humiliated in front of the ward staff and patients for letting the lady stroke her face and giving her a cuddle. Such is the dehumanisation that the 'Covid' hoax has brought to the surface. Nicky worked in care homes where patients told her they were being held prisoner. 'I want to live until I die', one said to her. 'I had a lady in tears because she hadn't seen her great-grandson.' Nicky was compassionate old school meeting psychopathic New Normal. She also said she had worked on a 'Covid' ward with no 'Covid' patients. Jewish writer Shai Held wrote an article in March, 2020, which was headlined 'The Staggering, Heartless Cruelty Toward the Elderly'. What he described was happening from the earliest days of lockdown. He said 'the elderly' were considered a group and not unique individuals (the way of the Woke). Shai Held said:

Notice how the all-too-familiar rhetoric of dehumanization works: 'The elderly' are bunched together as a faceless mass, all of them considered culprits and thus effectively deserving of the suffering the pandemic will inflict upon them. Lost entirely is the fact that the elderly are individual human beings, each with a distinctive face and voice, each with hopes and dreams, memories and regrets, friendships and marriages, loves lost and loves sustained.

'The elderly' have become another dehumanised group for which anything goes and for many that has resulted in cold disregard for their rights and their life. The distinctive face that Held talks about is designed to be deleted by masks until everyone is part of a faceless mass.

'War-zone' hospitals myth

Again and again medical professionals have told me what was really going on and how hospitals 'overrun like war zones' according to the media were virtually empty. The mantra from medical whistleblowers was please don't use my name or my career is over. Citizen journalists around the world sneaked into hospitals to film evidence exposing the 'war-zone' lie. They really *were* largely empty with closed wards and operating theatres. I met a hospital worker in my town on the Isle of Wight during the first lockdown in 2020 who said the only island hospital had never been so quiet. Lockdown was justified by the psychopaths to stop hospitals being overrun. At the same time that the island hospital was near-empty the military arrived here to provide *extra beds*. It was all propaganda to ramp up the fear to ensure compliance with fascism as were never-used temporary hospitals with thousands of beds known as Nightingales and never-used make-shift mortuaries opened by the criminal UK government. A man who helped to install those extra island beds attributed to the army said they were never used and the hospital was empty. Doctors and nurses 'stood around talking or on their phones, wandering down to us to see what we were doing'. There were no masks or social distancing. He accused the useless local island paper, the *County Press*, of 'pumping the fear as if our hospital was overrun and we only have one so it should have been'. He described ambulances parked up with crews outside in deck chairs. When his brother called an ambulance he was told there was a two-hour backlog which he called 'bullshit'. An old lady on the island fell 'and was in a bad way', but a caller who rang for an ambulance was told the situation wasn't urgent enough. Ambulance stations were working under capacity while people would hear ambulances with sirens blaring driving through the streets. When those living near the stations realised what was going on they would follow them as they left, circulated around an urban area with the sirens going, and then came back without stopping. All this was to increase levels of fear and the same goes for the 'ventilator shortage crisis' that cost tens of millions for hastily produced ventilators never to be used.

Ambulance crews that agreed to be exploited in this way for fear propaganda might find themselves a mirror. I wish them well with that. Empty hospitals were the obvious consequence of treatment and diagnoses of non-'Covid' conditions cancelled and those involved handed a death sentence. People have been dying at home from undiagnosed and untreated cancer, heart disease and other life-threatening conditions to allow empty hospitals to deal with a 'pandemic' that wasn't happening.

Death of the innocent

'War-zones' have been laying off nursing staff, even doctors where they can. There was no work for them. Lockdown was justified by saving lives and protecting the vulnerable they were actually killing with DNR orders and preventing empty hospitals being 'overrun'. In Britain the mantra of stay at home to 'save the NHS' was everywhere and across the world the same story was being sold when it was all lies. Two California doctors, Dan Erickson and Artin Massihi at Accelerated Urgent Care in Bakersfield, held a news conference in April, 2020, to say that intensive care units in California were 'empty, essentially', with hospitals shutting floors, not treating patients and laying off doctors. The California health system was working at minimum capacity 'getting rid of doctors because we just don't have the volume'. They said that people with conditions such as heart disease and cancer were not coming to hospital out of fear of 'Covid-19'. Their video was deleted by Susan Wojcicki's Cult-owned YouTube after reaching five million views. Florida governor Ron Desantis, who rejected the severe lockdowns of other states and is being targeted for doing so, said that in March, 2020, every US governor was given models claiming they would run out of hospital beds in days. That was never going to happen and the 'modellers' knew it. Deceit can be found at every level of the system. Urgent children's operations were cancelled including fracture repairs and biopsies to spot cancer. Eric Nicholls, a consultant paediatrician, said 'this is obviously concerning and we need to return to normal operating and to increase capacity as soon as possible'. Psychopaths

in power were rather less concerned *because* they are psychopaths. Deletion of urgent care and diagnosis has been happening all over the world and how many kids and others have died as a result of the actions of these cold and heartless lunatics dictating 'health' policy? The number must be stratospheric. Richard Sullivan, professor of cancer and global health at King's College London, said people feared 'Covid' more than cancer such was the campaign of fear. 'Years of lost life will be quite dramatic', Sullivan said, with 'a huge amount of avoidable mortality'. Sarah Woolnough, executive director for policy at Cancer Research UK, said there had been a 75 percent drop in urgent referrals to hospitals by family doctors of people with suspected cancer. Sullivan said that 'a lot of services have had to scale back – we've seen a dramatic decrease in the amount of elective cancer surgery'. Lockdown deaths worldwide has been absolutely fantastic with the *New York Post* reporting how data confirmed that 'lockdowns end more lives than they save':

There was a sharp decline in visits to emergency rooms and an increase in fatal heart attacks because patients didn't receive prompt treatment. Many fewer people were screened for cancer. Social isolation contributed to excess deaths from dementia and Alzheimer's.

Researchers predicted that the social and economic upheaval would lead to tens of thousands of "deaths of despair" from drug overdoses, alcoholism and suicide. As unemployment surged and mental-health and substance-abuse treatment programs were interrupted, the reported levels of anxiety, depression and suicidal thoughts increased dramatically, as did alcohol sales and fatal drug overdoses.

This has been happening while nurses and other staff had so much time on their hands in the 'war-zones' that Tic-Tok dancing videos began appearing across the Internet with medical staff dancing around in empty wards and corridors as people died at home from causes that would normally have been treated in hospital.

Mentions in dispatches

One brave and truth-committed whistleblower was Louise Hampton, a call handler with the UK NHS who made a viral Internet video saying she had done 'fuck all' during the 'pandemic'

which was 'a load of bollocks'. She said that 'Covid-19' was rebranded flu and of course she lost her job. This is what happens in the medical and endless other professions now when you tell the truth. Louise filmed inside 'war-zone' accident and emergency departments to show they were empty and I mean *empty* as in no one there. The mainstream media could have done the same and blown the gaff on the whole conspiracy. They haven't to their eternal shame. Not that most 'journalists' seem capable of manifesting shame as with the psychopaths they slavishly repeat without question. The relative few who were admitted with serious health problems were left to die alone with no loved ones allowed to see them because of 'Covid' rules and they included kids dying without the comfort of mum and dad at their bedside while the evil behind this couldn't give a damn. It was all good fun to them. A Scottish NHS staff nurse publicly quit in the spring of 2021 saying: 'I can no longer be part of the lies and the corruption by the government.' She said hospitals 'aren't full, the beds aren't full, beds have been shut, wards have been shut'. Hospitals were never busy throughout 'Covid'. The staff nurse said that Nicola Sturgeon, tragically the leader of the Scottish government, was on television saying save the hospitals and the NHS – 'but the beds are empty' and 'we've not seen flu, we always see flu every year'. She wrote to government and spoke with her union Unison (the unions are Cult-compromised and *useless*, but nothing changed. Many of her colleagues were scared of losing their jobs if they spoke out as they wanted to. She said nursing staff were being affected by wearing masks all day and 'my head is splitting every shift from wearing a mask'. The NHS is part of the fascist tyranny and must be dismantled so we can start again with human beings in charge. (Ironically, hospitals were reported to be busier again when official 'Covid' cases *fell* in spring/summer of 2021 and many other conditions required treatment at the same time as *the fake vaccine rollout*.)

I will cover the 'Covid vaccine' scam in detail later, but it is another indicator of the sickening disregard for human life that I am highlighting here. The DNA-manipulating concoctions do not fulfil

the definition of a 'vaccine', have never been used on humans before and were given only emergency approval because trials were not completed and they continued using the unknowing public. The result was what a NHS senior nurse with responsibility for 'vaccine' procedure said was 'genocide'. She said the 'vaccines' were not 'vaccines'. They had not been shown to be safe and claims about their effectiveness by drug companies were 'poetic licence'. She described what was happening as a 'horrid act of human annihilation'. The nurse said that management had instigated a policy of not providing a Patient Information Leaflet (PIL) before people were 'vaccinated' even though health care professionals are supposed to do this according to protocol. Patients should also be told that they are taking part in an ongoing clinical trial. Her challenges to what is happening had seen her excluded from meetings and ridiculed in others. She said she was told to 'watch my step ... or I would find myself surplus to requirements'. The nurse, who spoke anonymously in fear of her career, said she asked her NHS manager why he/she was content with taking part in genocide against those having the 'vaccines'. The reply was that everyone had to play their part and to 'put up, shut up, and get it done'. Government was 'leaning heavily' on NHS management which was clearly leaning heavily on staff. This is how the global 'medical' hierarchy operates and it starts with the Cult and its World Health Organization.

She told the story of a doctor who had the Pfizer jab and when questioned had no idea what was in it. The doctor had never read the literature. We have to stop treating doctors as intellectual giants when so many are moral and medical pygmies. The doctor did not even know that the 'vaccines' were not fully approved or that their trials were ongoing. They were, however, asking their patients if they minded taking part in follow-ups for research purposes – yes, the *ongoing clinical trial*. The nurse said the doctor's ignorance was not rare and she had spoken to a hospital consultant who had the jab without any idea of the background or that the 'trials' had not been completed. Nurses and pharmacists had shown the same ignorance.

‘My NHS colleagues have forsaken their duty of care, broken their code of conduct – Hippocratic Oath – and have been brainwashed just the same as the majority of the UK public through propaganda ...’ She said she had not been able to recruit a single NHS colleague, doctor, nurse or pharmacist to stand with her and speak out. Her union had refused to help. She said that if the genocide came to light she would not hesitate to give evidence at a Nuremberg-type trial against those in power who could have affected the outcomes but didn’t.

And all for what?

To put the nonsense into perspective let’s say the ‘virus’ does exist and let’s go completely crazy and accept that the official manipulated figures for cases and deaths are accurate. *Even then* a study by Stanford University epidemiologist Dr John Ioannidis published on the World Health Organization website produced an average infection to fatality rate of ... *0.23 percent!* Ioannidis said: ‘If one could sample equally from all locations globally, the median infection fatality rate might even be substantially lower than the 0.23% observed in my analysis.’ For healthy people under 70 it was ... *0.05 percent!* This compares with the 3.4 percent claimed by the Cult-owned World Health Organization when the hoax was first played and maximum fear needed to be generated. An updated Stanford study in April, 2021, put the ‘infection’ to ‘fatality’ rate at just 0.15 percent. Another team of scientists led by Megan O’Driscoll and Henrik Salje studied data from 45 countries and published their findings on the Nature website. For children and young people the figure is so small it virtually does not register although authorities will be hyping dangers to the young when they introduce DNA-manipulating ‘vaccines’ for children. The O’Driscoll study produced an average infection-fatality figure of 0.003 for children from birth to four; 0.001 for 5 to 14; 0.003 for 15 to 19; and it was still only 0.456 up to 64. To claim that children must be ‘vaccinated’ to protect them from ‘Covid’ is an obvious lie and so there must be another reason and there is. What’s more the average age of a ‘Covid’ death is akin

to the average age that people die in general. The average age of death in England is about 80 for men and 83 for women. The average age of death from alleged 'Covid' is between 82 and 83. California doctors, Dan Erickson and Artin Massihi, said at their April media conference that projection models of millions of deaths had been 'woefully inaccurate'. They produced detailed figures showing that Californians had a 0.03 chance of dying from 'Covid' based on the number of people who tested positive (with a test not testing for the 'virus'). Erickson said there was a 0.1 percent chance of dying from 'Covid' in the *state* of New York, not just the city, and a 0.05 percent chance in Spain, a centre of 'Covid-19' hysteria at one stage. The Stanford studies supported the doctors' data with fatality rate estimates of 0.23 and 0.15 percent. How close are these figures to my estimate of *zero*? Death-rate figures claimed by the World Health Organization at the start of the hoax were some 15 times higher. The California doctors said there was no justification for lockdowns and the economic devastation they caused. Everything they had ever learned about quarantine was that you quarantine the *sick* and not the healthy. They had never seen this before and it made no medical sense.

Why in the in the light of all this would governments and medical systems the world over say that billions must go under house arrest; lose their livelihood; in many cases lose their mind, their health and their life; force people to wear masks dangerous to health and psychology; make human interaction and even family interaction a criminal offence; ban travel; close restaurants, bars, watching live sport, concerts, theatre, and any activity involving human togetherness and discourse; and closing schools to isolate children from their friends and cause many to commit suicide in acts of hopelessness and despair? The California doctors said lockdown consequences included increased child abuse, partner abuse, alcoholism, depression, and other impacts they were seeing every day. Who would do that to the entire human race if not mentally-ill psychopaths of almost unimaginable extremes like Bill Gates? We must face the reality of what we are dealing with and come out of

denial. Fascism and tyranny are made possible only by the target population submitting and acquiescing to fascism and tyranny. The whole of human history shows that to be true. Most people naively and unquestioning believed what they were told about a 'deadly virus' and meekly and weakly submitted to house arrest. Those who didn't believe it – at least in total – still submitted in fear of the consequences of not doing so. For the rest who wouldn't submit draconian fines have been imposed, brutal policing by psychopaths *for* psychopaths, and condemnation from the meek and weak who condemn the Pushbackers on behalf of the very force that has them, too, in its gun sights. 'Pathetic' does not even begin to suffice. Britain's brainless 'Health' Secretary Matt Hancock warned anyone lying to border officials about returning from a list of 'hotspot' countries could face a jail sentence of up to ten years which is more than for racially-aggravated assault, incest and attempting to have sex with a child under 13. Hancock is a lunatic, but he has the state apparatus behind him in a Cult-led chain reaction and the same with UK 'Vaccine Minister' Nadhim Zahawi, a prominent member of the mega-Cult secret society, Le Cercle, which featured in my earlier books. The Cult enforces its will on governments and medical systems; government and medical systems enforce their will on business and police; business enforces its will on staff who enforce it on customers; police enforce the will of the Cult on the population and play their essential part in creating a world of fascist control that their own children and grandchildren will have to live in their entire lives. It is a hierarchical pyramid of imposition and acquiescence and, yes indeed, of clinical insanity.

Does anyone bright enough to read this book have to ask what the answer is? I think not, but I will reveal it anyway in the fewest of syllables: Tell the psychos and their moronic lackeys to fuck off and let's get on with our lives. We are many – They are few.

CHAPTER SEVEN

War on your mind

One believes things because one has been conditioned to believe them

Aldous Huxley, Brave New World

I have described the 'Covid' hoax as a 'Psyop' and that is true in every sense and on every level in accordance with the definition of that term which is psychological warfare. Break down the 'Covid pandemic' to the foundation themes and it is psychological warfare on the human individual and collective mind.

The same can be said for the entire human belief system involving every subject you can imagine. Huxley was right in his contention that people believe what they are conditioned to believe and this comes from the repetition throughout their lives of the same falsehoods. They spew from government, corporations, media and endless streams of 'experts' telling you what the Cult wants you to believe and often believing it themselves (although *far* from always). 'Experts' are rewarded with 'prestigious' jobs and titles and as agents of perceptual programming with regular access to the media. The Cult has to control the narrative – control *information* – or they lose control of the vital, crucial, without-which-they-cannot-prevail public perception of reality. The foundation of that control today is the Internet made possible by the Defense Advanced Research Projects Agency (DARPA), the incredibly sinister technological arm of the Pentagon. The Internet is the result of military technology.

DARPA openly brags about establishing the Internet which has been a long-term project to lasso the minds of the global population. I have said for decades the plan is to control information to such an extreme that eventually no one would see or hear anything that the Cult does not approve. We are closing in on that end with ferocious censorship since the 'Covid' hoax began and in my case it started back in the 1990s in terms of books and speaking venues. I had to create my own publishing company in 1995 precisely because no one else would publish my books even then. I think they're all still running.

Cult Internet

To secure total control of information they needed the Internet in which pre-programmed algorithms can seek out 'unclean' content for deletion and even stop it being posted in the first place. The Cult had to dismantle print and non-Internet broadcast media to ensure the transfer of information to the appropriate-named 'Web' – a critical expression of the *Cult* web. We've seen the ever-quickenening demise of traditional media and control of what is left by a tiny number of corporations operating worldwide. Independent journalism in the mainstream is already dead and never was that more obvious than since the turn of 2020. The Cult wants all information communicated via the Internet to globally censor and allow the plug to be pulled any time. Lockdowns and forced isolation has meant that communication between people has been through electronic means and no longer through face-to-face discourse and discussion. Cult psychopaths have targeted the bars, restaurants, sport, venues and meeting places in general for this reason. None of this is by chance and it's to stop people gathering in any kind of privacy or number while being able to track and monitor all Internet communications and block them as necessary. Even private messages between individuals have been censored by these fascists that control Cult fronts like Facebook, Twitter, Google and YouTube which are all officially run by Sabbatian place-people and from the background by higher-level Sabbatian place people.

Facebook, Google, Amazon and their like were seed-funded and supported into existence with money-no-object infusions of funds either directly or indirectly from DARPA and CIA technology arm In-Q-Tel. The Cult plays the long game and prepares very carefully for big plays like 'Covid'. Amazon is another front in the psychological war and pretty much controls the global market in book sales and increasingly publishing. Amazon's limitless funds have deleted fantastic numbers of independent publishers to seize global domination on the way to deciding which books can be sold and circulated and which cannot. Moves in that direction are already happening. Amazon's leading light Jeff Bezos is the grandson of Lawrence Preston Gise who worked with DARPA predecessor ARPA. Amazon has big connections to the CIA and the Pentagon. The plan I have long described went like this:

1. Employ military technology to establish the Internet.
2. Sell the Internet as a place where people can freely communicate without censorship and allow that to happen until the Net becomes the central and irreversible pillar of human society. If the Internet had been highly censored from the start many would have rejected it.
3. Fund and manipulate major corporations into being to control the circulation of information on your Internet using cover stories about geeks in garages to explain how they came about. Give them unlimited funds to expand rapidly with no need to make a profit for years while non-Cult companies who need to balance the books cannot compete. You know that in these circumstances your Googles, YouTubes, Facebooks and Amazons are going to secure near monopolies by either crushing or buying up the opposition.
4. Allow freedom of expression on both the Internet and communication platforms to draw people in until the Internet is the central and irreversible pillar of human society and your communication corporations have reached a stage of near monopoly domination.
5. Then unleash your always-planned frenzy of censorship on the basis of 'where else are you going to go?' and continue to expand that until nothing remains that the Cult does not want its human targets to see.

The process was timed to hit the 'Covid' hoax to ensure the best chance possible of controlling the narrative which they knew they had to do at all costs. They were, after all, about to unleash a 'deadly virus' that didn't really exist. If you do that in an environment of free-flowing information and opinion you would be dead in the

water before you could say Gates is a psychopath. The network was in place through which the Cult-created-and-owned World Health Organization could dictate the 'Covid' narrative and response policy slavishly supported by Cult-owned Internet communication giants and mainstream media while those telling a different story were censored. Google, YouTube, Facebook and Twitter openly announced that they would do this. What else would we expect from Cult-owned operations like Facebook which former executives have confirmed set out to make the platform more addictive than cigarettes and coldly manipulates emotions of its users to sow division between people and groups and scramble the minds of the young? If Zuckerberg lives out the rest of his life without going to jail for crimes against humanity, and most emphatically against the young, it will be a travesty of justice. Still, no matter, cause and effect will catch up with him eventually and the same with Sergey Brin and Larry Page at Google with its CEO Sundar Pichai who fix the Google search results to promote Cult narratives and hide the opposition. Put the same key words into Google and other search engines like DuckDuckGo and you will see how different results can be. Wikipedia is another intensely biased 'encyclopaedia' which skews its content to the Cult agenda. YouTube links to Wikipedia's version of 'Covid' and 'climate change' on video pages in which experts in their field offer a different opinion (even that is increasingly rare with Wojcicki censorship). Into this 'Covid' silence-them network must be added government media censors, sorry 'regulators', such as Ofcom in the UK which imposed tyrannical restrictions on British broadcasters that had the effect of banning me from ever appearing. Just to debate with me about my evidence and views on 'Covid' would mean breaking the fascistic impositions of Ofcom and its CEO career government bureaucrat Melanie Dawes. Gutless British broadcasters tremble at the very thought of fascist Ofcom.

Psychos behind 'Covid'

The reason for the 'Covid' catastrophe in all its facets and forms can be seen by whom and what is driving the policies worldwide in such a coordinated way. Decisions are not being made to protect health, but to target psychology. The dominant group guiding and 'advising' government policy are not medical professionals. They are psychologists and behavioural scientists. Every major country has its own version of this phenomenon and I'll use the British example to show how it works. In many ways the British version has been affecting the wider world in the form of the huge behaviour manipulation network in the UK which operates in other countries. The network involves private companies, government, intelligence and military. The Cabinet Office is at the centre of the government 'Covid' Psyop and part-owns, with 'innovation charity' Nesta, the Behavioural Insights Team (BIT) which claims to be independent of government but patently isn't. The BIT was established in 2010 and its job is to manipulate the psyche of the population to acquiesce to government demands and so much more. It is also known as the 'Nudge Unit', a name inspired by the 2009 book by two ultra-Zionists, Cass Sunstein and Richard Thaler, called *Nudge: Improving Decisions About Health, Wealth, and Happiness*. The book, as with the Behavioural Insights Team, seeks to 'nudge' behaviour (manipulate it) to make the public follow patterns of action and perception that suit those in authority (the Cult). Sunstein is so skilled at this that he advises the World Health Organization and the UK Behavioural Insights Team and was Administrator of the White House Office of Information and Regulatory Affairs in the Obama administration. Biden appointed him to the Department of Homeland Security – another ultra-Zionist in the fold to oversee new immigration laws which is another policy the Cult wants to control. Sunstein is desperate to silence anyone exposing conspiracies and co-authored a 2008 report on the subject in which suggestions were offered to ban 'conspiracy theorizing' or impose 'some kind of tax, financial or otherwise, on those who disseminate such theories'. I guess a psychiatrist's chair is out of the question?

Sunstein's mate Richard Thaler, an 'academic affiliate' of the UK Behavioural Insights Team, is a proponent of 'behavioural economics' which is defined as the study of 'the effects of psychological, cognitive, emotional, cultural and social factors on the decisions of individuals and institutions'. Study the effects so they can be manipulated to be what you want them to be. Other leading names in the development of behavioural economics are ultra-Zionists Daniel Kahneman and Robert J. Shiller and they, with Thaler, won the Nobel Memorial Prize in Economic Sciences for their work in this field. The Behavioural Insights Team is operating at the heart of the UK government and has expanded globally through partnerships with several universities including Harvard, Oxford, Cambridge, University College London (UCL) and Pennsylvania. They claim to have 'trained' (reframed) 20,000 civil servants and run more than 750 projects involving 400 randomised controlled trials in dozens of countries' as another version of mind reframers Common Purpose. BIT works from its office in New York with cities and their agencies, as well as other partners, across the United States and Canada – this is a company part-owned by the British government Cabinet Office. An executive order by President Cult-servant Obama established a US Social and Behavioral Sciences Team in 2015. They all have the same reason for being and that's to brainwash the population directly and by brainwashing those in positions of authority.

'Covid' mind game

Another prime aspect of the UK mind-control network is the 'independent' [joke] Scientific Pandemic Insights Group on Behaviours (SPI-B) which 'provides behavioural science advice aimed at anticipating and helping people adhere to interventions that are recommended by medical or epidemiological experts'. That means manipulating public perception and behaviour to do whatever government tells them to do. It's disgusting and if they really want the public to be 'safe' this lot should all be under lock and key. According to the government website SPI-B consists of

'behavioural scientists, health and social psychologists, anthropologists and historians' and advises the Whitty-Vallance-led Scientific Advisory Group for Emergencies (SAGE) which in turn advises the government on 'the science' (it doesn't) and 'Covid' policy. When politicians say they are being guided by 'the science' this is the rabble in each country they are talking about and that 'science' is dominated by behaviour manipulators to enforce government fascism through public compliance. The Behaviour Insight Team is headed by psychologist David Solomon Halpern, a visiting professor at King's College London, and connects with a national and global web of other civilian and military organisations as the Cult moves towards its goal of fusing them into one fascistic whole in every country through its 'Fusion Doctrine'. The behaviour manipulation network involves, but is not confined to, the Foreign Office; National Security Council; government communications headquarters (GCHQ); MI5; MI6; the Cabinet Office-based Media Monitoring Unit; and the Rapid Response Unit which 'monitors digital trends to spot emerging issues; including misinformation and disinformation; and identifies the best way to respond'.

There is also the 77th Brigade of the UK military which operates like the notorious Israeli military's Unit 8200 in manipulating information and discussion on the Internet by posing as members of the public to promote the narrative and discredit those who challenge it. Here we have the military seeking to manipulate *domestic* public opinion while the Nazis in government are fine with that. Conservative Member of Parliament Tobias Ellwood, an advocate of lockdown and control through 'vaccine passports', is a Lieutenant Colonel reservist in the 77th Brigade which connects with the military operation jHub, the 'innovation centre' for the Ministry of Defence and Strategic Command. jHub has also been involved with the civilian National Health Service (NHS) in 'symptom tracing' the population. The NHS is a key part of this mind control network and produced a document in December, 2020, explaining to staff how to use psychological manipulation with different groups and ages to get them to have the DNA-manipulating 'Covid vaccine'

that's designed to cumulatively rewrite human genetics. The document, called 'Optimising Vaccination Roll Out – Do's and Dont's for all messaging, documents and "communications" in the widest sense', was published by NHS England and the NHS Improvement *Behaviour Change Unit* in partnership with Public Health England and Warwick Business School. I hear the mantra about 'save the NHS' and 'protect the NHS' when we need to scrap the NHS and start again. The current version is far too corrupt, far too anti-human and totally compromised by Cult operatives and their assets. UK government broadcast media censor Ofcom will connect into this web – as will the BBC with its tremendous Ofcom influence – to control what the public see and hear and dictate mass perception. Nuremberg trials must include personnel from all these organisations.

The fear factor

The 'Covid' hoax has led to the creation of the UK Cabinet Office-connected Joint Biosecurity Centre (JBC) which is officially described as providing 'expert advice on pandemics' using its independent [all Cult operations are 'independent'] analytical function to provide real-time analysis about infection outbreaks to identify and respond to outbreaks of Covid-19'. Another role is to advise the government on a response to spikes in infections – 'for example by closing schools or workplaces in local areas where infection levels have risen'. Put another way, promoting the Cult agenda. The Joint Biosecurity Centre is modelled on the Joint Terrorism Analysis Centre which analyses intelligence to set 'terrorism threat levels' and here again you see the fusion of civilian and military operations and intelligence that has led to military intelligence producing documents about 'vaccine hesitancy' and how it can be combated. Domestic civilian matters and opinions should not be the business of the military. The Joint Biosecurity Centre is headed by Tom Hurd, director general of the Office for Security and Counter-Terrorism from the establishment-to-its-fingertips Hurd family. His father is former Foreign Secretary Douglas Hurd. How coincidental that Tom

Hurd went to the elite Eton College and Oxford University with Boris Johnson. Imperial College with its ridiculous computer modeller Neil Ferguson will connect with this gigantic web that will itself interconnect with similar set-ups in other major and not so major countries. Compared with this Cult network the politicians, be they Boris Johnson, Donald Trump or Joe Biden, are bit-part players 'following the science'. The network of psychologists was on the 'Covid' case from the start with the aim of generating maximum fear of the 'virus' to ensure compliance by the population. A government behavioural science group known as SPI-B produced a paper in March, 2020, for discussion by the main government science advisory group known as SAGE. It was headed 'Options for increasing adherence to social distancing measures' and it said the following in a section headed 'Persuasion':

- A substantial number of people still do not feel sufficiently personally threatened; it could be that they are reassured by the low death rate in their demographic group, although levels of concern may be rising. Having a good understanding of the risk has been found to be positively associated with adoption of COVID-19 social distancing measures in Hong Kong.
- The perceived level of personal threat needs to be increased among those who are complacent, using hard-hitting evaluation of options for increasing social distancing emotional messaging. To be effective this must also empower people by making clear the actions they can take to reduce the threat.
- Responsibility to others: There seems to be insufficient understanding of, or feelings of responsibility about, people's role in transmitting the infection to others ... Messaging about actions need to be framed positively in terms of protecting oneself and the community, and increase confidence that they will be effective.
- Some people will be more persuaded by appeals to play by the rules, some by duty to the community, and some to personal risk.

All these different approaches are needed. The messaging also needs to take account of the realities of different people's lives. Messaging needs to take account of the different motivational levers and circumstances of different people.

All this could be achieved the SPI-B psychologists said by *using the media to increase the sense of personal threat* which translates as terrify the shit out of the population, including children, so they all do what we want. That's not happened has it? Those excuses for 'journalists' who wouldn't know journalism if it bit them on the arse (the great majority) have played their crucial part in serving this Cult-government Psyop to enslave their own kids and grandkids. How they live with themselves I have no idea. The psychological war has been underpinned by constant government 'Covid' propaganda in almost every television and radio ad break, plus the Internet and print media, which has pounded out the fear with taxpayers footing the bill for their own programming. The result has been people terrified of a 'virus' that doesn't exist or one with a tiny fatality rate even if you believe it does. People walk down the street and around the shops wearing face-nappies damaging their health and psychology while others report those who refuse to be that naïve to the police who turn up in their own face-nappies. I had a cameraman come to my flat and he was so frightened of 'Covid' he came in wearing a mask and refused to shake my hand in case he caught something. He had – naïveitis – and the thought that he worked in the mainstream media was both depressing and made his behaviour perfectly explainable. The fear which has gripped the minds of so many and frozen them into compliance has been carefully cultivated by these psychologists who are really psychopaths. If lives get destroyed and a lot of young people commit suicide it shows our plan is working. SPI-B then turned to compulsion on the public to comply. 'With adequate preparation, rapid change can be achieved', it said. Some countries had introduced mandatory self-isolation on a wide scale without evidence of major public unrest and a large majority of the UK's population appeared to be supportive of more coercive measures with 64 percent of adults saying they would

support putting London under a lockdown (watch the 'polls' which are designed to make people believe that public opinion is in favour or against whatever the subject in hand).

For 'aggressive protective measures' to be effective, the SPI-B paper said, special attention should be devoted to those population groups that are more at risk. Translated from the Orwellian this means making the rest of population feel guilty for not protecting the 'vulnerable' such as old people which the Cult and its agencies were about to kill on an industrial scale with lockdown, lack of treatment and the Gates 'vaccine'. Psychopath psychologists sold their guilt-trip so comprehensively that Los Angeles County Supervisor Hilda Solis reported that children were apologising (from a distance) to their parents and grandparents for bringing 'Covid' into their homes and getting them sick. '... These apologies are just some of the last words that loved ones will ever hear as they die alone,' she said. Gut-wrenchingly Solis then used this childhood tragedy to tell children to stay at home and 'keep your loved ones alive'. Imagine heaping such potentially life-long guilt on a kid when it has absolutely nothing to do with them. These people are deeply disturbed and the psychologists behind this even more so.

Uncivil war – divide and rule

Professional mind-controllers at SPI-B wanted the media to increase a sense of responsibility to others (do as you're told) and promote 'positive messaging' for those actions while in contrast to invoke 'social disapproval' by the unquestioning, obedient, community of anyone with a mind of their own. Again the compliant Goebbels-like media obliged. This is an old, old, trick employed by tyrannies the world over throughout human history. You get the target population to keep the target population in line – *your* line. SPI-B said this could 'play an important role in preventing anti-social behaviour or discouraging failure to enact pro-social behaviour'. For 'anti-social' in the Orwellian parlance of SPI-B see any behaviour that government doesn't approve. SPI-B recommendations said that 'social disapproval' should be accompanied by clear messaging and

promotion of strong collective identity – hence the government and celebrity mantra of ‘we’re all in this together’. Sure we are. The mind doctors have such contempt for their targets that they think some clueless comedian, actor or singer telling them to do what the government wants will be enough to win them over. We have had UK comedian Lenny Henry, actor Michael Caine and singer Elton John wheeled out to serve the propagandists by urging people to have the DNA-manipulating ‘Covid’ non-‘vaccine’. The role of Henry and fellow black celebrities in seeking to coax a ‘vaccine’ reluctant black community into doing the government’s will was especially stomach-turning. An emotion-manipulating script and carefully edited video featuring these black ‘celebs’ was such an insult to the intelligence of black people and where’s the self-respect of those involved selling their souls to a fascist government agenda? Henry said he heard black people’s ‘legitimate worries and concerns’, but people must ‘trust the facts’ when they were doing exactly that by not having the ‘vaccine’. They had to include the obligatory reference to Black Lives Matter with the line ... ‘Don’t let coronavirus cost even more black lives – because we matter’. My god, it was pathetic. ‘I know the vaccine is safe and what it does.’ How? ‘I’m a comedian and it says so in my script.’

SPI-B said social disapproval needed to be carefully managed to avoid victimisation, scapegoating and misdirected criticism, but they knew that their ‘recommendations’ would lead to exactly that and the media were specifically used to stir-up the divide-and-conquer hostility. Those who conform like good little baa, baas, are praised while those who have seen through the tidal wave of lies are ‘Covidiot’. The awake have been abused by the fast asleep for not conforming to fascism and impositions that the awake know are designed to endanger their health, dehumanise them, and tear asunder the very fabric of human society. We have had the curtain-twitchers and morons reporting neighbours and others to the face-napped police for breaking ‘Covid rules’ with fascist police delighting in posting links and phone numbers where this could be done. The Cult cannot impose its will without a compliant police

and military or a compliant population willing to play their part in enslaving themselves and their kids. The words of a pastor in Nazi Germany are so appropriate today:

First they came for the socialists and I did not speak out because I was not a socialist.

Then they came for the trade unionists and I did not speak out because I was not a trade unionist.

Then they came for the Jews and I did not speak out because I was not a Jew.

Then they came for me and there was no one left to speak for me.

Those who don't learn from history are destined to repeat it and so many are.

'Covid' rules: Rewiring the mind

With the background laid out to this gigantic national and global web of psychological manipulation we can put 'Covid' rules into a clear and sinister perspective. Forget the claims about protecting health. 'Covid' rules are about dismantling the human mind, breaking the human spirit, destroying self-respect, and then putting Humpty Dumpty together again as a servile, submissive slave. Social isolation through lockdown and distancing have devastating effects on the human psyche as the psychological psychopaths well know and that's the real reason for them. Humans need contact with each other, discourse, closeness and touch, or they eventually, and literally, go crazy. Masks, which I will address at some length, fundamentally add to the effects of isolation and the Cult agenda to dehumanise and de-individualise the population. To do this while knowing – in fact *seeking* – this outcome is the very epitome of evil and psychologists involved in this *are* the epitome of evil. They must like all the rest of the Cult demons and their assets stand trial for crimes against humanity on a scale that defies the imagination. Psychopaths in uniform use isolation to break enemy troops and agents and make them subservient and submissive to tell what they know. The technique is rightly considered a form of torture and

torture is most certainly what has been imposed on the human population.

Clinically-insane American psychologist Harry Harlow became famous for his isolation experiments in the 1950s in which he separated baby monkeys from their mothers and imprisoned them for months on end in a metal container or 'pit of despair'. They soon began to show mental distress and depression as any idiot could have predicted. Harlow put other monkeys in steel chambers for three, six or twelve months while denying them any contact with animals or humans. He said that the effects of total social isolation for six months were 'so devastating and debilitating that we had assumed initially that twelve months of isolation would not produce any additional decrement'; but twelve months of isolation 'almost obliterated the animals socially'. This is what the Cult and its psychopaths are doing to you and your children. Even monkeys in partial isolation in which they were not allowed to form relationships with other monkeys became 'aggressive and hostile, not only to others, but also towards their own bodies'. We have seen this in the young as a consequence of lockdown. UK government psychopaths launched a public relations campaign telling people not to hug each other even after they received the 'Covid-19 vaccine' which we were told with more lies would allow a return to 'normal life'. A government source told *The Telegraph*: 'It will be along the lines that it is great that you have been vaccinated, but if you are going to visit your family and hug your grandchildren there is a chance you are going to infect people you love.' The source was apparently speaking from a secure psychiatric facility. Janet Lord, director of Birmingham University's Institute of Inflammation and Ageing, said that parents and grandparents should avoid hugging their children. Well, how can I put it, Ms Lord? Fuck off. Yep, that'll do.

Destroying the kids – where are the parents?

Observe what has happened to people enslaved and isolated by lockdown as suicide and self-harm has soared worldwide,

particularly among the young denied the freedom to associate with their friends. A study of 49,000 people in English-speaking countries concluded that almost half of young adults are at clinical risk of mental health disorders. A national survey in America of 1,000 currently enrolled high school and college students found that 5 percent reported attempting suicide during the pandemic. Data from the US CDC's National Syndromic Surveillance Program from January 1st to October 17th, 2020, revealed a 31 percent increase in mental health issues among adolescents aged 12 to 17 compared with 2019. The CDC reported that America in general suffered the biggest drop in life expectancy since World War Two as it fell by a year in the first half of 2020 as a result of 'deaths of despair' – overdoses and suicides. Deaths of despair have leapt by more than 20 percent during lockdown and include the highest number of fatal overdoses ever recorded in a single year – 81,000. Internet addiction is another consequence of being isolated at home which lowers interest in physical activities as kids fall into inertia and what's the point? Children and young people are losing hope and giving up on life, sometimes literally. A 14-year-old boy killed himself in Maryland because he had 'given up' when his school district didn't reopen; an 11-year-old boy shot himself during a zoom class; a teenager in Maine succumbed to the isolation of the 'pandemic' when he ended his life after experiencing a disrupted senior year at school. Children as young as nine have taken their life and all these stories can be repeated around the world. Careers are being destroyed before they start and that includes those in sport in which promising youngsters have not been able to take part. The plan of the psycho-psychologists is working all right. Researchers at Cambridge University found that lockdowns cause significant harm to children's mental health. Their study was published in the *Archives of Disease in Childhood*, and followed 168 children aged between 7 and 11. The researchers concluded:

During the UK lockdown, children's depression symptoms have increased substantially, relative to before lockdown. The scale of this effect has direct relevance for the continuation of different elements of lockdown policy, such as complete or partial school closures ...

... Specifically, we observed a statistically significant increase in ratings of depression, with a medium-to-large effect size. Our findings emphasise the need to incorporate the potential impact of lockdown on child mental health in planning the ongoing response to the global pandemic and the recovery from it.

Not a chance when the Cult's psycho-psychologists were getting exactly what they wanted. The UK's Royal College of Paediatrics and Child Health has urged parents to look for signs of eating disorders in children and young people after a three to four fold increase. Specialists say the 'pandemic' is a major reason behind the rise. You don't say. The College said isolation from friends during school closures, exam cancellations, loss of extra-curricular activities like sport, and an increased use of social media were all contributory factors along with fears about the virus (psycho-psychologists again), family finances, and students being forced to quarantine. Doctors said young people were becoming severely ill by the time they were seen with 'Covid' regulations reducing face-to-face consultations. Nor is it only the young that have been devastated by the psychopaths. Like all bullies and cowards the Cult is targeting the young, elderly, weak and infirm. A typical story was told by a British lady called Lynn Parker who was not allowed to visit her husband in 2020 for the last ten and half months of his life 'when he needed me most' between March 20th and when he died on December 19th. This vacates the criminal and enters the territory of evil. The emotional impact on the immune system alone is immense as are the number of people of all ages worldwide who have died as a result of Cult-demanded, Gates-demanded, lockdowns.

Isolation is torture

The experience of imposing solitary confinement on millions of prisoners around the world has shown how a large percentage become 'actively psychotic and/or acutely suicidal'. Social isolation has been found to trigger 'a specific psychiatric syndrome, characterized by hallucinations; panic attacks; overt paranoia; diminished impulse control; hypersensitivity to external stimuli; and difficulties with thinking, concentration and memory'. Juan Mendez,

a United Nations rapporteur (investigator), said that isolation is a form of torture. Research has shown that even after isolation prisoners find it far more difficult to make social connections and I remember chatting to a shop assistant after one lockdown who told me that when her young son met another child again he had no idea how to act or what to do. Hannah Flanagan, Director of Emergency Services at Journey Mental Health Center in Dane County, Wisconsin, said: 'The specificity about Covid social distancing and isolation that we've come across as contributing factors to the suicides are really new to us this year.' But they are not new to those that devised them. They are getting the effect they want as the population is psychologically dismantled to be rebuilt in a totally different way. Children and the young are particularly targeted. They will be the adults when the full-on fascist AI-controlled technocracy is planned to be imposed and they are being prepared to meekly submit. At the same time older people who still have a memory of what life was like before – and how fascist the new normal really is – are being deleted. You are going to see efforts to turn the young against the old to support this geriatric genocide. Hannah Flanagan said the big increase in suicide in her county proved that social isolation is not only harmful, but deadly. Studies have shown that isolation from others is one of the main risk factors in suicide and even more so with women. Warnings that lockdown could create a 'perfect storm' for suicide were ignored. After all this was one of the *reasons* for lockdown. Suicide, however, is only the most extreme of isolation consequences. There are many others. Dr Dhruv Khullar, assistant professor of healthcare policy at Weill Cornell Medical College, said in a *New York Times* article in 2016 long before the fake 'pandemic':

A wave of new research suggests social separation is bad for us. Individuals with less social connection have disrupted sleep patterns, altered immune systems, more inflammation and higher levels of stress hormones. One recent study found that isolation increases the risk of heart disease by 29 percent and stroke by 32 percent. Another analysis that pooled data from 70 studies and 3.4 million people found that socially isolated individuals had a 30 percent higher risk of dying in the next seven years, and that this effect was largest in middle age.

Loneliness can accelerate cognitive decline in older adults, and isolated individuals are twice as likely to die prematurely as those with more robust social interactions. These effects start early: Socially isolated children have significantly poorer health 20 years later, even after controlling for other factors. All told, loneliness is as important a risk factor for early death as obesity and smoking.

There you have proof from that one article alone four years before 2020 that those who have enforced lockdown, social distancing and isolation knew what the effect would be and that is even more so with professional psychologists that have been driving the policy across the globe. We can go back even further to the years 2000 and 2003 and the start of a major study on the effects of isolation on health by Dr Janine Gronewold and Professor Dirk M. Hermann at the University Hospital in Essen, Germany, who analysed data on 4,316 people with an average age of 59 who were recruited for the long-term research project. They found that socially isolated people are more than 40 percent more likely to have a heart attack, stroke, or other major cardiovascular event and nearly 50 percent more likely to die from any cause. Given the financial Armageddon unleashed by lockdown we should note that the study found a relationship between increased cardiovascular risk and lack of financial support. After excluding other factors social isolation was still connected to a 44 percent increased risk of cardiovascular problems and a 47 percent increased risk of death by any cause. Lack of financial support was associated with a 30 percent increase in the risk of cardiovascular health events. Dr Gronewold said it had been known for some time that feeling lonely or lacking contact with close friends and family can have an impact on physical health and the study had shown that having strong social relationships is of high importance for heart health. Gronewold said they didn't understand yet why people who are socially isolated have such poor health outcomes, but this was obviously a worrying finding, particularly during these times of prolonged social distancing. Well, it can be explained on many levels. You only have to identify the point in the body where people feel loneliness and missing people they are parted from – it's in the centre of the chest where they feel the ache of loneliness and the ache of missing people. 'My heart aches for

you' ... 'My heart aches for some company.' I will explain this more in the chapter Escaping Wetiko, but when you realise that the body is the mind – they are expressions of each other – the reason why state of the mind dictates state of the body becomes clear.

American psychologist Ranjit Powar was highlighting the effects of lockdown isolation as early as April, 2020. She said humans have evolved to be social creatures and are wired to live in interactive groups. Being isolated from family, friends and colleagues could be unbalancing and traumatic for most people and could result in short or even long-term psychological and physical health problems. An increase in levels of anxiety, aggression, depression, forgetfulness and hallucinations were possible psychological effects of isolation. 'Mental conditions may be precipitated for those with underlying pre-existing susceptibilities and show up in many others without any pre-condition.' Powar said personal relationships helped us cope with stress and if we lost this outlet for letting off steam the result can be a big emotional void which, for an average person, was difficult to deal with. 'Just a few days of isolation can cause increased levels of anxiety and depression' – so what the hell has been the effect on the global population of *18 months* of this at the time of writing? Powar said: 'Add to it the looming threat of a dreadful disease being repeatedly hammered in through the media and you have a recipe for many shades of mental and physical distress.' For those with a house and a garden it is easy to forget that billions have had to endure lockdown isolation in tiny overcrowded flats and apartments with nowhere to go outside. The psychological and physical consequences of this are unimaginable and with lunatic and abusive partners and parents the consequences have led to tremendous increases in domestic and child abuse and alcoholism as people seek to shut out the horror. Ranjit Powar said:

Staying in a confined space with family is not all a rosy picture for everyone. It can be extremely oppressive and claustrophobic for large low-income families huddled together in small single-room houses. Children here are not lucky enough to have many board/electronic games or books to keep them occupied.

Add to it the deep insecurity of running out of funds for food and basic necessities. On the other hand, there are people with dysfunctional family dynamics, such as domineering, abusive or alcoholic partners, siblings or parents which makes staying home a period of trial. Incidence of suicide and physical abuse against women has shown a worldwide increase. Heightened anxiety and depression also affect a person's immune system, making them more susceptible to illness.

To think that Powar's article was published on April 11th, 2020.

Six-feet fantasy

Social (unsocial) distancing demanded that people stay six feet or two metres apart. UK government advisor Robert Dingwall from the New and Emerging Respiratory Virus Threats Advisory Group said in a radio interview that the two-metre rule was 'conjured up out of nowhere' and was not based on science. No, it was not based on *medical* science, but it didn't come out of nowhere. The distance related to *psychological* science. Six feet/two metres was adopted in many countries and we were told by people like the criminal Anthony Fauci and his ilk that it was founded on science. Many schools could not reopen because they did not have the space for six-foot distancing. Then in March, 2021, after a year of six-feet 'science', a study published in the *Journal of Infectious Diseases* involving more than 500,000 students and almost 100,000 staff over 16 weeks revealed no significant difference in 'Covid' cases between six feet and three feet and Fauci changed his tune. Now three feet was okay. There is no difference between six feet and three *inches* when there is no 'virus' and they got away with six feet for psychological reasons for as long as they could. I hear journalists and others talk about 'unintended consequences' of lockdown. They are not *unintended* at all; they have been coldly-calculated for a specific outcome of human control and that's why super-psychopaths like Gates have called for them so vehemently. Super-psychopath psychologists have demanded them and psychopathic or clueless, spineless, politicians have gone along with them by 'following the science'. But it's not science at all. 'Science' is not what is; it's only what people can be manipulated to believe it is. The whole 'Covid' catastrophe is

founded on mind control. Three word or three statement mantras issued by the UK government are a well-known mind control technique and so we've had 'Stay home/protect the NHS/save lives', 'Stay alert/control the virus/save lives' and 'hands/face/space'. One of the most vocal proponents of extreme 'Covid' rules in the UK has been Professor Susan Michie, a member of the British Communist Party, who is not a medical professional. Michie is the director of the Centre for Behaviour Change at University College London. She is a *behavioural psychologist* and another filthy rich 'Marxist' who praised China's draconian lockdown. She was known by fellow students at Oxford University as 'Stalin's nanny' for her extreme Marxism. Michie is an influential member of the UK government's Scientific Advisory Group for Emergencies (SAGE) and behavioural manipulation groups which have dominated 'Covid' policy. She is a consultant adviser to the World Health Organization on 'Covid-19' and behaviour. Why the hell are lockdowns anything to do with her when they are claimed to be about health? Why does a behavioural psychologist from a group charged with changing the behaviour of the public want lockdown, human isolation and mandatory masks? Does that question really need an answer? Michie *absolutely* has to explain herself before a Nuremberg court when humanity takes back its world again and even more so when you see the consequences of masks that she demands are compulsory. This is a Michie classic:

The benefits of getting primary school children to wear masks is that regardless of what little degree of transmission is occurring in those age groups it could help normalise the practice. Young children wearing masks may be more likely to get their families to accept masks.

Those words alone should carry a prison sentence when you ponder on the callous disregard for children involved and what a statement it makes about the mind and motivations of Susan Michie. What a lovely lady and what she said there encapsulates the mentality of the psychopaths behind the 'Covid' horror. Let us compare what Michie said with a countrywide study in Germany published at [researchsquare.com](https://www.researchsquare.com) involving 25,000 school children and 17,854 health complaints submitted by parents. Researchers

found that masks are harming children physically, psychologically, and behaviourally with 24 health issues associated with mask wearing. They include: shortness of breath (29.7%); dizziness (26.4%); increased headaches (53%); difficulty concentrating (50%); drowsiness or fatigue (37%); and malaise (42%). Nearly a third of children experienced more sleep issues than before and a quarter developed new fears. Researchers found health issues and other impairments in 68 percent of masked children covering their faces for an average of 4.5 hours a day. Hundreds of those taking part experienced accelerated respiration, tightness in the chest, weakness, and short-term impairment of consciousness. A reminder of what Michie said again:

The benefits of getting primary school children to wear masks is that regardless of what little degree of transmission is occurring in those age groups it could help normalise the practice. Young children wearing masks may be more likely to get their families to accept masks.

Psychopaths in government and psychology now have children and young people – plus all the adults – wearing masks for hours on end while clueless teachers impose the will of the psychopaths on the young they should be protecting. What the hell are parents doing?

Cult lab rats

We have some schools already imposing on students microchipped buzzers that activate when they get 'too close' to their pals in the way they do with lab rats. How apt. To the Cult and its brain-dead servants our children *are* lab rats being conditioned to be unquestioning, dehumanised slaves for the rest of their lives.

Children and young people are being weaned and frightened away from the most natural human instincts including closeness and touch. I have tracked in the books over the years how schools were banning pupils from greeting each other with a hug and the whole Cult-induced Me Too movement has terrified men and boys from a relaxed and natural interaction with female friends and work colleagues to the point where many men try never to be in a room

alone with a woman that's not their partner. Airhead celebrities have as always played their virtue-signalling part in making this happen with their gross exaggeration. For every monster like Harvey Weinstein there are at least tens of thousands of men that don't treat women like that; but everyone must be branded the same and policy changed for them as well as the monster. I am going to be using the word 'dehumanise' many times in this chapter because that is what the Cult is seeking to do and it goes very deep as we shall see. Don't let them kid you that social distancing is planned to end one day. That's not the idea. We are seeing more governments and companies funding and producing wearable gadgets to keep people apart and they would not be doing that if this was meant to be short-term. A tech start-up company backed by GCHQ, the British Intelligence and military surveillance headquarters, has created a social distancing wrist sensor that alerts people when they get too close to others. The CIA has also supported tech companies developing similar devices. The wearable sensor was developed by Tended, one of a number of start-up companies supported by GCHQ (see the CIA and DARPA). The device can be worn on the wrist or as a tag on the waistband and will vibrate whenever someone wearing the device breaches social distancing and gets anywhere near natural human contact. The company had a lucky break in that it was developing a distancing sensor when the 'Covid' hoax arrived which immediately provided a potentially enormous market. How fortunate. The government in big-time Cult-controlled Ontario in Canada is investing \$2.5 million in wearable contact tracing technology that 'will alert users if they may have been exposed to the Covid-19 in the workplace and will beep or vibrate if they are within six feet of another person'. Facedrive Inc., the technology company behind this, was founded in 2016 with funding from the Ontario Together Fund and obviously they, too, had a prophet on the board of directors. The human surveillance and control technology is called TraceSCAN and would be worn by the human cyborgs in places such as airports, workplaces, construction sites, care homes and ... *schools*.

I emphasise schools with children and young people the prime targets. You know what is planned for society as a whole if you keep your eyes on the schools. They have always been places where the state program the next generation of slaves to be its compliant worker-ants – or Woker-ants these days; but in the mist of the ‘Covid’ madness they have been transformed into mind laboratories on a scale never seen before. Teachers and head teachers are just as programmed as the kids – often more so. Children are kept apart from human interaction by walk lanes, classroom distancing, staggered meal times, masks, and the rolling-out of buzzer systems. Schools are now physically laid out as a laboratory maze for lab-rats. Lunatics at a school in Anchorage, Alaska, who should be prosecuted for child abuse, took away desks and forced children to kneel (know your place) on a mat for five hours a day while wearing a mask and using their chairs as a desk. How this was supposed to impact on a ‘virus’ only these clinically insane people can tell you and even then it would be clap-trap. The school banned recess (interaction), art classes (creativity), and physical exercise (getting body and mind moving out of inertia). Everyone behind this outrage should be in jail or better still a mental institution. The behavioural manipulators are all for this dystopian approach to schools. Professor Susan Michie, the mind-doctor and British Communist Party member, said it was wrong to say that schools were safe. They had to be made so by ‘distancing’, masks and ventilation (sitting all day in the cold). I must ask this lady round for dinner on a night I know I am going to be out and not back for weeks. She probably wouldn’t be able to make it, anyway, with all the visits to her own psychologist she must have block-booked.

Masking identity

I know how shocking it must be for you that a behaviour manipulator like Michie wants everyone to wear masks which have long been a feature of mind-control programs like the infamous MKUltra in the United States, but, there we are. We live and learn. I spent many years from 1996 to right across the millennium

researching mind control in detail on both sides of the Atlantic and elsewhere. I met a large number of mind-control survivors and many had been held captive in body and mind by MKUltra. MK stands for mind-control, but employs the German spelling in deference to the Nazis spirited out of Germany at the end of World War Two by Operation Paperclip in which the US authorities, with help from the Vatican, transported Nazi mind-controllers and engineers to America to continue their work. Many of them were behind the creation of NASA and they included Nazi scientist and SS officer Wernher von Braun who swapped designing V-2 rockets to bombard London with designing the Saturn V rockets that powered the NASA moon programme's Apollo craft. I think I may have mentioned that the Cult has no borders. Among Paperclip escapees was Josef Mengele, the Angel of Death in the Nazi concentration camps where he conducted mind and genetic experiments on children often using twins to provide a control twin to measure the impact of his 'work' on the other. If you want to observe the Cult mentality in all its extremes of evil then look into the life of Mengele. I have met many people who suffered mercilessly under Mengele in the United States where he operated under the name Dr Greene and became a stalwart of MKUltra programming and torture. Among his locations was the underground facility in the Mojave Desert in California called the China Lake Naval Weapons Station which is almost entirely below the surface. My books *The Biggest Secret*, *Children of the Matrix* and *The Perception Deception* have the detailed background to MKUltra.

The best-known MKUltra survivor is American Cathy O'Brien. I first met her and her late partner Mark Phillips at a conference in Colorado in 1996. Mark helped her escape and deprogram from decades of captivity in an offshoot of MKUltra known as Project Monarch in which 'sex slaves' were provided for the rich and famous including Father George Bush, Dick Cheney and the Clintons. Read Cathy and Mark's book *Trance-Formation of America* and if you are new to this you will be shocked to the core. I read it in 1996 shortly before, with the usual synchronicity of my life, I found

myself given a book table at the conference right next to hers. MKUltra never ended despite being very publicly exposed (only a small part of it) in the 1970s and continues in other guises. I am still in touch with Cathy. She contacted me during 2020 after masks became compulsory in many countries to tell me how they were used as part of MKUltra programming. I had been observing 'Covid regulations' and the relationship between authority and public for months. I saw techniques that I knew were employed on individuals in MKUltra being used on the global population. I had read many books and manuals on mind control including one called *Silent Weapons for Quiet Wars* which came to light in the 1980s and was a guide on how to perceptually program on a mass scale. 'Silent Weapons' refers to mind-control. I remembered a line from the manual as governments, medical authorities and law enforcement agencies have so obviously talked to – or rather at – the adult population since the 'Covid' hoax began as if they are children. The document said:

If a person is spoken to by a T.V. advertiser as if he were a twelve-year-old, then, due to suggestibility, he will, with a certain probability, respond or react to that suggestion with the uncritical response of a twelve-year-old and will reach in to his economic reservoir and deliver its energy to buy that product on impulse when he passes it in the store.

That's why authority has spoken to adults like children since all this began.

Why did Michael Jackson wear masks?

Every aspect of the 'Covid' narrative has mind-control as its central theme. Cathy O'Brien wrote an article for davidicke.com about the connection between masks and mind control. Her daughter Kelly who I first met in the 1990s was born while Cathy was still held captive in MKUltra. Kelly was forced to wear a mask as part of her programming from the age of *two* to dehumanise her, target her sense of individuality and reduce the amount of oxygen her brain and body received. *Bingo*. This is the real reason for compulsory

masks, why they have been enforced en masse, and why they seek to increase the number they demand you wear. First one, then two, with one disgraceful alleged 'doctor' recommending four which is nothing less than a death sentence. Where and how often they must be worn is being expanded for the purpose of mass mind control and damaging respiratory health which they can call 'Covid-19'. Canada's government headed by the man-child Justin Trudeau, says it's fine for children of two and older to wear masks. An insane 'study' in Italy involving just 47 children concluded there was no problem for babies as young as *four months* wearing them. Even after people were 'vaccinated' they were still told to wear masks by the criminal that is Anthony Fauci. Cathy wrote that mandating masks is allowing the authorities literally to control the air we breathe which is what was done in MKUltra. You might recall how the singer Michael Jackson wore masks and there is a reason for that. He was subjected to MKUltra mind control through Project Monarch and his psyche was scrambled by these simpletons. Cathy wrote:

In MKUltra Project Monarch mind control, Michael Jackson had to wear a mask to silence his voice so he could not reach out for help. Remember how he developed that whisper voice when he wasn't singing? Masks control the mind from the outside in, like the redefining of words is doing. By controlling what we can and cannot say for fear of being labeled racist or beaten, for example, it ultimately controls thought that drives our words and ultimately actions (or lack thereof).

Likewise, a mask muffles our speech so that we are not heard, which controls voice ... words ... mind. This is Mind Control. Masks are an obvious mind control device, and I am disturbed so many people are complying on a global scale. Masks depersonalize while making a person feel as though they have no voice. It is a barrier to others. People who would never choose to comply but are forced to wear a mask in order to keep their job, and ultimately their family fed, are compromised. They often feel shame and are subdued. People have stopped talking with each other while media controls the narrative.

The 'no voice' theme has often become literal with train passengers told not to speak to each other in case they pass on the 'virus', singing banned for the same reason and bonkers California officials telling people riding roller coasters that they cannot shout and scream. Cathy said she heard every day from healed MKUltra survivors who cannot wear a mask without flashing back on ways

their breathing was controlled – ‘from ball gags and penises to water boarding’. She said that through the years when she saw images of people in China wearing masks ‘due to pollution’ that it was really to control their oxygen levels. ‘I knew it was as much of a population control mechanism of depersonalisation as are burkas’, she said. Masks are another Chinese communist/fascist method of control that has been swept across the West as the West becomes China at lightning speed since we entered 2020.

Mask-19

There are other reasons for mandatory masks and these include destroying respiratory health to call it ‘Covid-19’ and stunting brain development of children and the young. Dr Margarite Griesz-Brisson MD, PhD, is a Consultant Neurologist and Neurophysiologist and the Founder and Medical Director of the London Neurology and Pain Clinic. Her CV goes down the street and round the corner. She is clearly someone who cares about people and won’t parrot the propaganda. Griesz-Brisson has a PhD in pharmacology, with special interest in neurotoxicology, environmental medicine, neuroregeneration and neuroplasticity (the way the brain can change in the light of information received). She went public in October, 2020, with a passionate warning about the effects of mask-wearing laws:

The reinhalation of our exhaled air will without a doubt create oxygen deficiency and a flooding of carbon dioxide. We know that the human brain is very sensitive to oxygen deprivation. There are nerve cells for example in the hippocampus that can’t be longer than 3 minutes without oxygen – they cannot survive. The acute warning symptoms are headaches, drowsiness, dizziness, issues in concentration, slowing down of reaction time – reactions of the cognitive system.

Oh, I know, let’s tell bus, truck and taxi drivers to wear them and people working machinery. How about pilots, doctors and police? Griesz-Brisson makes the important point that while the symptoms she mentions may fade as the body readjusts this does not alter the fact that people continue to operate in oxygen deficit with long list of

potential consequences. She said it was well known that neurodegenerative diseases take years or decades to develop. 'If today you forget your phone number, the breakdown in your brain would have already started 20 or 30 years ago.' She said degenerative processes in your brain are getting amplified as your oxygen deprivation continues through wearing a mask. Nerve cells in the brain are unable to divide themselves normally in these circumstances and lost nerve cells will no longer be regenerated. 'What is gone is gone.' Now consider that people like shop workers and *schoolchildren* are wearing masks for hours every day. What in the name of sanity is going to be happening to them? 'I do not wear a mask, I need my brain to think', Griesz-Brisson said, 'I want to have a clear head when I deal with my patients and not be in a carbon dioxide-induced anaesthesia'. If you are told to wear a mask anywhere ask the organisation, police, store, whatever, for their risk assessment on the dangers and negative effects on mind and body of enforcing mask-wearing. They won't have one because it has never been done not even by government. All of them must be subject to class-action lawsuits as the consequences come to light. They don't do mask risk assessments for an obvious reason. They know what the conclusions would be and independent scientific studies that *have* been done tell a horror story of consequences.

'Masks are criminal'

Dr Griesz-Brisson said that for children and adolescents, masks are an absolute no-no. They had an extremely active and adaptive immune system and their brain was incredibly active with so much to learn. 'The child's brain, or the youth's brain, is thirsting for oxygen.' The more metabolically active an organ was, the more oxygen it required; and in children and adolescents every organ was metabolically active. Griesz-Brisson said that to deprive a child's or adolescent's brain of oxygen, or to restrict it in any way, was not only dangerous to their health, it was absolutely criminal. 'Oxygen deficiency inhibits the development of the brain, and the damage that has taken place as a result CANNOT be reversed.' Mind

manipulators of MKUltra put masks on two-year-olds they wanted to neurologically rewire and you can see why. Griesz-Brisson said a child needs the brain to learn and the brain needs oxygen to function. 'We don't need a clinical study for that. This is simple, indisputable physiology.' Consciously and purposely induced oxygen deficiency was an absolutely deliberate health hazard, and an absolute medical contraindication which means that 'this drug, this therapy, this method or measure should not be used, and is not allowed to be used'. To coerce an entire population to use an absolute medical contraindication by force, she said, there had to be definite and serious reasons and the reasons must be presented to competent interdisciplinary and independent bodies to be verified and authorised. She had this warning of the consequences that were coming if mask wearing continued:

When, in ten years, dementia is going to increase exponentially, and the younger generations couldn't reach their god-given potential, it won't help to say 'we didn't need the masks'. I know how damaging oxygen deprivation is for the brain, cardiologists know how damaging it is for the heart, pulmonologists know how damaging it is for the lungs. Oxygen deprivation damages every single organ. Where are our health departments, our health insurance, our medical associations? It would have been their duty to be vehemently against the lockdown and to stop it and stop it from the very beginning.

Why do the medical boards issue punishments to doctors who give people exemptions? Does the person or the doctor seriously have to prove that oxygen deprivation harms people? What kind of medicine are our doctors and medical associations representing? Who is responsible for this crime? The ones who want to enforce it? The ones who let it happen and play along, or the ones who don't prevent it?

All of the organisations and people she mentions there either answer directly to the Cult or do whatever hierarchical levels above them tell them to do. The outcome of both is the same. 'It's not about masks, it's not about viruses, it's certainly not about your health', Griesz-Brisson said. 'It is about much, much more. I am not participating. I am not afraid.' They were taking our air to breathe and there was no unfounded medical exemption from face masks. Oxygen deprivation was dangerous for every single brain. It had to be the free decision of every human being whether they want to

wear a mask that was absolutely ineffective to protect themselves from a virus. She ended by rightly identifying where the responsibility lies for all this:

The imperative of the hour is personal responsibility. We are responsible for what we think, not the media. We are responsible for what we do, not our superiors. We are responsible for our health, not the World Health Organization. And we are responsible for what happens in our country, not the government.

Halle-bloody-lujah.

But surgeons wear masks, right?

Independent studies of mask-wearing have produced a long list of reports detailing mental, emotional and physical dangers. What a definition of insanity to see police officers imposing mask-wearing on the public which will cumulatively damage their health while the police themselves wear masks that will cumulatively damage *their* health. It's utter madness and both public and police do this because 'the government says so' – yes a government of brain-donor idiots like UK Health Secretary Matt Hancock reading the 'follow the science' scripts of psychopathic, lunatic psychologists. The response you get from Stockholm syndrome sufferers defending the very authorities that are destroying them and their families is that 'surgeons wear masks'. This is considered the game, set and match that they must work and don't cause oxygen deficit. Well, actually, scientific studies have shown that they *do* and oxygen levels are monitored in operating theatres to compensate. Surgeons wear masks to stop spittle and such like dropping into open wounds – not to stop 'viral particles' which are so miniscule they can only be seen through an electron microscope. Holes in the masks are significantly bigger than 'viral particles' and if you sneeze or cough they will breach the mask. I watched an incredibly disingenuous 'experiment' that claimed to prove that masks work in catching 'virus' material from the mouth and nose. They did this with a slow motion camera and the mask did block big stuff which stayed inside the mask and

against the face to be breathed in or cause infections on the face as we have seen with many children. 'Viral particles', however, would never have been picked up by the camera as they came through the mask when they are far too small to be seen. The 'experiment' was therefore disingenuous *and* useless.

Studies have concluded that wearing masks in operating theatres (and thus elsewhere) make no difference to preventing infection while the opposite is true with toxic shite building up in the mask and this had led to an explosion in tooth decay and gum disease dubbed by dentists 'mask mouth'. You might have seen the Internet video of a furious American doctor urging people to take off their masks after a four-year-old patient had been rushed to hospital the night before and nearly died with a lung infection that doctors sourced to mask wearing. A study in the journal *Cancer Discovery* found that inhalation of harmful microbes can contribute to advanced stage lung cancer in adults and long-term use of masks can help breed dangerous pathogens. Microbiologists have said frequent mask wearing creates a moist environment in which microbes can grow and proliferate before entering the lungs. The Canadian Agency for Drugs and Technologies in Health, or CADTH, a Canadian national organisation that provides research and analysis to healthcare decision-makers, said this as long ago as 2013 in a report entitled 'Use of Surgical Masks in the Operating Room: A Review of the Clinical Effectiveness and Guidelines'. It said:

- No evidence was found to support the use of surgical face masks to reduce the frequency of surgical site infections
- No evidence was found on the effectiveness of wearing surgical face masks to protect staff from infectious material in the operating room.
- Guidelines recommend the use of surgical face masks by staff in the operating room to protect both operating room staff and patients (despite the lack of evidence).

We were told that the world could go back to 'normal' with the arrival of the 'vaccines'. When they came, fraudulent as they are, the story changed as I knew that it would. We are in the midst of transforming 'normal', not going back to it. Mary Ramsay, head of immunisation at Public Health England, echoed the words of US criminal Anthony Fauci who said masks and other regulations must stay no matter if people are vaccinated. The Fauci idiot continued to wear two masks – different colours so both could be clearly seen – after he *claimed* to have been vaccinated. Senator Rand Paul told Fauci in one exchange that his double-masks were 'theatre' and he was right. It's all theatre. Mary Ramsay back-tracked on the vaccine-return-to-normal theme when she said the public may need to wear masks and social-distance for years despite the jabs. 'People have got used to those lower-level restrictions now, and [they] can live with them', she said telling us what the idea has been all along. 'The vaccine does not give you a pass, even if you have had it, you must continue to follow all the guidelines' said a Public Health England statement which reneged on what we had been told before and made having the 'vaccine' irrelevant to 'normality' even by the official story. Spain's fascist government trumped everyone by passing a law mandating the wearing of masks on the beach and even when swimming in the sea. The move would have devastated what's left of the Spanish tourist industry, posed potential breathing dangers to swimmers and had Northern European sunbathers walking around with their forehead brown and the rest of their face white as a sheet. The ruling was so crazy that it had to be retracted after pressure from public and tourist industry, but it confirmed where the Cult wants to go with masks and how clinically insane authority has become. The determination to make masks permanent and hide the serious dangers to body and mind can be seen in the censorship of scientist Professor Denis Rancourt by Bill Gates-funded academic publishing website ResearchGate over his papers exposing the dangers and uselessness of masks. Rancourt said:

ResearchGate today has permanently locked my account, which I have had since 2015. Their reasons graphically show the nature of their attack against democracy, and their corruption of

science ... By their obscene non-logic, a scientific review of science articles reporting on harms caused by face masks has a 'potential to cause harm'. No criticism of the psychological device (face masks) is tolerated, if the said criticism shows potential to influence public policy.

This is what happens in a fascist world.

Where are the 'greens' (again)?

Other dangers of wearing masks especially regularly relate to the inhalation of minute plastic fibres into the lungs and the deluge of discarded masks in the environment and oceans. Estimates predicted that more than 1.5 billion disposable masks will end up in the world's oceans every year polluting the water with tons of plastic and endangering marine wildlife. Studies project that humans are using 129 billion face masks each month worldwide – about three million a minute. Most are disposable and made from plastic, non-biodegradable microfibers that break down into smaller plastic particles that become widespread in ecosystems. They are littering cities, clogging sewage channels and turning up in bodies of water. I have written in other books about the immense amounts of microplastics from endless sources now being absorbed into the body. Rolf Halden, director of the Arizona State University (ASU) Biodesign Center for Environmental Health Engineering, was the senior researcher in a 2020 study that analysed 47 human tissue samples and found microplastics in all of them. 'We have detected these chemicals of plastics in every single organ that we have investigated', he said. I wrote in *The Answer* about the world being deluged with microplastics. A study by the Worldwide Fund for Nature (WWF) found that people are consuming on average every week some 2,000 tiny pieces of plastic mostly through water and also through marine life and the air. Every year humans are ingesting enough microplastics to fill a heaped dinner plate and in a life-time of 79 years it is enough to fill two large waste bins. Marco Lambertini, WWF International director general said: 'Not only are plastics polluting our oceans and waterways and killing marine life – it's in all of us and we can't escape consuming plastics,' American

geologists found tiny plastic fibres, beads and shards in rainwater samples collected from the remote slopes of the Rocky Mountain National Park near Denver, Colorado. Their report was headed: 'It is raining plastic.' Rachel Adams, senior lecturer in Biomedical Science at Cardiff Metropolitan University, said that among health consequences are internal inflammation and immune responses to a 'foreign body'. She further pointed out that microplastics become carriers of toxins including mercury, pesticides and dioxins (a known cause of cancer and reproductive and developmental problems). These toxins accumulate in the fatty tissues once they enter the body through microplastics. Now this is being compounded massively by people putting plastic on their face and throwing it away.

Workers exposed to polypropylene plastic fibres known as 'flock' have developed 'flock worker's lung' from inhaling small pieces of the flock fibres which can damage lung tissue, reduce breathing capacity and exacerbate other respiratory problems. *Now ...* commonly used surgical masks have three layers of melt-blown textiles made of ... polypropylene. We have billions of people putting these microplastics against their mouth, nose and face for hours at a time day after day in the form of masks. How does anyone think that will work out? I mean – what could possibly go wrong? We posted a number of scientific studies on this at davidicke.com, but when I went back to them as I was writing this book the links to the science research website where they were hosted were dead. Anything that challenges the official narrative in any way is either censored or vilified. The official narrative is so unsupportable by the evidence that only deleting the truth can protect it. A study by Chinese scientists still survived – with the usual twist which it why it was still active, I guess. Yes, they found that virtually all the masks they tested increased the daily intake of microplastic fibres, but people should still wear them because the danger from the 'virus' was worse said the crazy 'team' from the Institute of Hydrobiology in Wuhan. Scientists first discovered microplastics in lung tissue of some patients who died of lung cancer

in the 1990s. Subsequent studies have confirmed the potential health damage with the plastic degrading slowly and remaining in the lungs to accumulate in volume. Wuhan researchers used a machine simulating human breathing to establish that masks shed up to nearly 4,000 microplastic fibres in a month with reused masks producing more. Scientists said some masks are laced with toxic chemicals and a variety of compounds seriously restricted for both health and environmental reasons. They include cobalt (used in blue dye) and formaldehyde known to cause watery eyes, burning sensations in the eyes, nose, and throat, plus coughing, wheezing and nausea. No – that must be ‘Covid-19’.

Mask ‘worms’

There is another and potentially even more sinister content of masks. Mostly new masks of different makes filmed under a microscope around the world have been found to contain strange black fibres or ‘worms’ that appear to move or ‘crawl’ by themselves and react to heat and water. The nearest I have seen to them are the self-replicating fibres that are pulled out through the skin of those suffering from Morgellons disease which has been connected to the phenomena of ‘chemtrails’ which I will bring into the story later on. Morgellons fibres continue to grow outside the body and have a form of artificial intelligence. Black ‘worm’ fibres in masks have that kind of feel to them and there is a nanotechnology technique called ‘worm micelles’ which carry and release drugs or anything else you want to deliver to the body. For sure the suppression of humanity by mind altering drugs is the Cult agenda big time and the more excuses they can find to gain access to the body the more opportunities there are to make that happen whether through ‘vaccines’ or masks pushed against the mouth and nose for hours on end.

So let us summarise the pros and cons of masks:

Against masks: Breathing in your own carbon dioxide; depriving the body and brain of sufficient oxygen; build-up of toxins in the mask that can be breathed into the lungs and cause rashes on the face and 'mask-mouth'; breathing microplastic fibres and toxic chemicals into the lungs; dehumanisation and deleting individualisation by literally making people faceless; destroying human emotional interaction through facial expression and deleting parental connection with their babies which look for guidance to their facial expression.

For masks: They don't protect you from a 'virus' that doesn't exist and even if it did 'viral' particles are so minute they are smaller than the holes in the mask.

Governments, police, supermarkets, businesses, transport companies, and all the rest who seek to impose masks have done no risk assessment on their consequences for health and psychology and are now open to group lawsuits when the impact becomes clear with a cumulative epidemic of respiratory and other disease. Authorities will try to exploit these effects and hide the real cause by dubbing them 'Covid-19'. Can you imagine setting out to force the population to wear health-destroying masks without doing any assessment of the risks? It is criminal and it is evil, but then how many people targeted in this way, who see their children told to wear them all day at school, have asked for a risk assessment? Billions can't be imposed upon by the few unless the billions allow it. Oh, yes, with just a tinge of irony, 85 percent of all masks made worldwide come from *China*.

Wash your hands in toxic shite

'Covid' rules include the use of toxic sanitisers and again the health consequences of constantly applying toxins to be absorbed through the skin is obvious to any level of Renegade Mind. America's Food and Drug Administration (FDA) said that sanitisers are drugs and issued a warning about 75 dangerous brands which contain

methanol used in antifreeze and can cause death, kidney damage and blindness. The FDA circulated the following warning even for those brands that it claims to be safe:

Store hand sanitizer out of the reach of pets and children, and children should use it only with adult supervision. Do not drink hand sanitizer. This is particularly important for young children, especially toddlers, who may be attracted by the pleasant smell or brightly colored bottles of hand sanitizer.

Drinking even a small amount of hand sanitizer can cause alcohol poisoning in children. (However, there is no need to be concerned if your children eat with or lick their hands after using hand sanitizer.) During this coronavirus pandemic, poison control centers have had an increase in calls about accidental ingestion of hand sanitizer, so it is important that adults monitor young children's use.

Do not allow pets to swallow hand sanitizer. If you think your pet has eaten something potentially dangerous, call your veterinarian or a pet poison control center right away. Hand sanitizer is flammable and should be stored away from heat and flames. When using hand sanitizer, rub your hands until they feel completely dry before performing activities that may involve heat, sparks, static electricity, or open flames.

There you go, perfectly safe, then, and that's without even a mention of the toxins absorbed through the skin. Come on kids – sanitise your hands everywhere you go. It will save you from the 'virus'. Put all these elements together of the 'Covid' normal and see how much health and psychology is being cumulatively damaged, even devastated, to 'protect your health'. Makes sense, right? They are only imposing these things because they care, right? *Right?*

Submitting to insanity

Psychological reframing of the population goes very deep and is done in many less obvious ways. I hear people say how contradictory and crazy 'Covid' rules are and how they are ever changing. This is explained away by dismissing those involved as idiots. It is a big mistake. The Cult is delighted if its cold calculation is perceived as incompetence and idiocy when it is anything but. Oh, yes, there are idiots within the system – lots of them – but they are *administering* the Cult agenda, mostly unknowingly. They are not deciding and dictating it. The bulwark against tyranny is self-

respect, always has been, always will be. It is self-respect that has broken every tyranny in history. By its very nature self-respect will not bow to oppression and its perpetrators. There is so little self-respect that it's always the few that overturn dictators. Many may eventually follow, but the few with the iron spines (self-respect) kick it off and generate the momentum. The Cult targets self-respect in the knowledge that once this has gone only submission remains. Crazy, contradictory, ever-changing 'Covid' rules are systematically applied by psychologists to delete self-respect. They *want* you to see that the rules make no sense. It is one thing to decide to do something when *you* have made the choice based on evidence and logic. You still retain your self-respect. It is quite another when you can see what you are being told to do is insane, ridiculous and makes no sense, and *yet you still do it*. Your self-respect is extinguished and this has been happening as ever more obviously stupid and nonsensical things have been demanded and the great majority have complied even when they can see they are stupid and nonsensical.

People walk around in face-nappies knowing they are damaging their health and make no difference to a 'virus'. They do it in fear of not doing it. I know it's daft, but I'll do it anyway. When that happens something dies inside of you and submissive reframing has begun. Next there's a need to hide from yourself that you have conceded your self-respect and you convince yourself that you have not really submitted to fear and intimidation. You begin to believe that you are complying with craziness because it's the right thing to do. When first you concede your self-respect of $2+2 = 4$ to $2+2 = 5$ you *know* you are compromising your self-respect. Gradually to avoid facing that fact you begin to *believe* that $2+2=5$. You have been reframed and I have been watching this process happening in the human psyche on an industrial scale. The Cult is working to break your spirit and one of its major tools in that war is humiliation. I read how former American soldier Bradley Manning (later Chelsea Manning after a sex-change) was treated after being jailed for supplying WikiLeaks with documents exposing the enormity of

government and elite mendacity. Manning was isolated in solitary confinement for eight months, put under 24-hour surveillance, forced to hand over clothing before going to bed, and stand naked for every roll call. This is systematic humiliation. The introduction of anal swab 'Covid' tests in China has been done for the same reason to delete self-respect and induce compliant submission. Anal swabs are mandatory for incoming passengers in parts of China and American diplomats have said they were forced to undergo the indignity which would have been calculated humiliation by the Cult-owned Chinese government that has America in its sights.

Government-people: An abusive relationship

Spirit-breaking psychological techniques include giving people hope and apparent respite from tyranny only to take it away again. This happened in the UK during Christmas, 2020, when the psycho-psychologists and their political lackeys announced an easing of restrictions over the holiday only to reimpose them almost immediately on the basis of yet another lie. There is a big psychological difference between getting used to oppression and being given hope of relief only to have that dashed. Psychologists know this and we have seen the technique used repeatedly. Then there is traumatising people before you introduce more extreme regulations that require compliance. A perfect case was the announcement by the dark and sinister Whitty and Vallance in the UK that 'new data' predicted that 4,000 could die every day over the winter of 2020/2021 if we did not lockdown again. I think they call it lying and after traumatising people with that claim out came Jackboot Johnson the next day with new curbs on human freedom. Psychologists know that a frightened and traumatised mind becomes suggestable to submission and behaviour reframing. Underpinning all this has been to make people fearful and suspicious of each other and see themselves as a potential danger to others. In league with deleted self-respect you have the perfect psychological recipe for self-loathing. The relationship between authority and public is now demonstrably the same as that of

subservience to an abusive partner. These are signs of an abusive relationship explained by psychologist Leslie Becker-Phelps:

Psychological and emotional abuse: Undermining a partner's self-worth with verbal attacks, name-calling, and belittling. Humiliating the partner in public, unjustly accusing them of having an affair, or interrogating them about their every behavior. Keeping partner confused or off balance by saying they were just kidding or blaming the partner for 'making' them act this way ... Feigning in public that they care while turning against them in private. This leads to victims frequently feeling confused, incompetent, unworthy, hopeless, and chronically self-doubting. [Apply these techniques to how governments have treated the population since New Year, 2020, and the parallels are obvious.]

Physical abuse: The abuser might physically harm their partner in a range of ways, such as grabbing, hitting, punching, or shoving them. They might throw objects at them or harm them with a weapon. [Observe the physical harm imposed by masks, lockdown, and so on.]

Threats and intimidation: One way abusers keep their partners in line is by instilling fear. They might be verbally threatening, or give threatening looks or gestures. Abusers often make it known that they are tracking their partner's every move. They might destroy their partner's possessions, threaten to harm them, or threaten to harm their family members. Not surprisingly, victims of this abuse often feel anxiety, fear, and panic. [No words necessary.]

Isolation: Abusers often limit their partner's activities, forbidding them to talk or interact with friends or family. They might limit access to a car or even turn off their phone. All of this might be done by physically holding them against their will, but is often accomplished through psychological abuse and intimidation. The more isolated a person feels, the fewer resources they have to help gain perspective on their situation and to escape from it. [No words necessary.]

Economic abuse: Abusers often make their partners beholden to them for money by controlling access to funds of any kind. They might prevent their partner from getting a job or withhold access to money they earn from a job. This creates financial dependency that makes leaving the relationship very difficult. [See destruction of livelihoods and the proposed meagre 'guaranteed income' so long as you do whatever you are told.]

Using children: An abuser might disparage their partner's parenting skills, tell their children lies about their partner, threaten to take custody of their children, or threaten to harm their children. These tactics instil fear and often elicit compliance. [See reframed social service mafia and how children are being mercilessly abused by the state over 'Covid' while their parents look on too frightened to do anything.]

A further recurring trait in an abusive relationship is the abused blaming themselves for their abuse and making excuses for the abuser. We have the public blaming each other for lockdown abuse by government and many making excuses for the government while attacking those who challenge the government. How often we have heard authorities say that rules are being imposed or reimposed only because people have refused to 'behave' and follow the rules. We don't want to do it – it's *you*.

Renegade Minds are an antidote to all of these things. They will never concede their self-respect no matter what the circumstances. Even when apparent humiliation is heaped upon them they laugh in its face and reflect back the humiliation on the abuser where it belongs. Renegade Minds will never wear masks they know are only imposed to humiliate, suppress and damage both physically and psychologically. Consequences will take care of themselves and they will never break their spirit or cause them to concede to tyranny. UK newspaper columnist Peter Hitchens was one of the few in the mainstream media to speak out against lockdowns and forced vaccinations. He then announced he had taken the jab. He wanted to see family members abroad and he believed vaccine passports were inevitable even though they had not yet been introduced. Hitchens

has a questioning and critical mind, but not a Renegade one. If he had no amount of pressure would have made him concede. Hitchens excused his action by saying that the battle has been lost. Renegade Minds never accept defeat when freedom is at stake and even if they are the last one standing the self-respect of not submitting to tyranny is more important than any outcome or any consequence.

That's why Renegade Minds are the only minds that ever changed anything worth changing.

CHAPTER EIGHT

'Reframing' insanity

Insanity is relative. It depends on who has who locked in what cage
Ray Bradbury

Reframing' a mind means simply to change its perception and behaviour. This can be done subconsciously to such an extent that subjects have no idea they have been 'reframed' while to any observer changes in behaviour and attitudes are obvious.

Human society is being reframed on a ginormous scale since the start of 2020 and here we have the reason why psychologists rather than doctors have been calling the shots. Ask most people who have succumbed to 'Covid' reframing if they have changed and most will say 'no'; but they *have* and fundamentally. The Cult's long-game has been preparing for these times since way back and crucial to that has been to prepare both population and officialdom mentally and emotionally. To use the mind-control parlance they had to reframe the population with a mentality that would submit to fascism and reframe those in government and law enforcement to impose fascism or at least go along with it. The result has been the fact-deleted mindlessness of 'Wokeness' and officialdom that has either enthusiastically or unquestioningly imposed global tyranny demanded by reframed politicians on behalf of psychopathic and deeply evil cultists. 'Cognitive reframing' identifies and challenges the way someone sees the world in the form of situations, experiences and emotions and then restructures those perceptions to view the same set of circumstances in a different way. This can have

benefits if the attitudes are personally destructive while on the other side it has the potential for individual and collective mind control which the subject has no idea has even happened.

Cognitive therapy was developed in the 1960s by Aaron T. Beck who was born in Rhode Island in 1921 as the son of Jewish immigrants from the Ukraine. He became interested in the techniques as a treatment for depression. Beck's daughter Judith S. Beck is prominent in the same field and they founded the Beck Institute for Cognitive Behavior Therapy in Philadelphia in 1994. Cognitive reframing, however, began to be used worldwide by those with a very dark agenda. The Cult reframes politicians to change their attitudes and actions until they are completely at odds with what they once appeared to stand for. The same has been happening to government administrators at all levels, law enforcement, military and the human population. Cultists love mind control for two main reasons: It allows them to control what people think, do and say to secure agenda advancement and, by definition, it calms their legendary insecurity and fear of the unexpected. I have studied mind control since the time I travelled America in 1996. I may have been talking to next to no one in terms of an audience in those years, but my goodness did I gather a phenomenal amount of information and knowledge about so many things including the techniques of mind control. I have described this in detail in other books going back to *The Biggest Secret* in 1998. I met a very large number of people recovering from MKUltra and its offshoots and successors and I began to see how these same techniques were being used on the population in general. This was never more obvious than since the 'Covid' hoax began.

Reframing the enforcers

I have observed over the last two decades and more the very clear transformation in the dynamic between the police, officialdom and the public. I tracked this in the books as the relationship mutated from one of serving the public to seeing them as almost the enemy and certainly a lower caste. There has always been a class divide

based on income and always been some psychopathic, corrupt, and big-I-am police officers. This was different. Wholesale change was unfolding in the collective dynamic; it was less about money and far more about position and perceived power. An us-and-them was emerging. Noses were lifted skyward by government administration and law enforcement and their attitude to the public they were *supposed* to be serving changed to one of increasing contempt, superiority and control. The transformation was so clear and widespread that it had to be planned. Collective attitudes and dynamics do not change naturally and organically that quickly on that scale. I then came across an organisation in Britain called Common Purpose created in the late 1980s by Julia Middleton who would work in the office of Deputy Prime Minister John Prescott during the long and disastrous premiership of war criminal Tony Blair. When Blair speaks the Cult is speaking and the man should have been in jail a long time ago. Common Purpose proclaims itself to be one of the biggest 'leadership development' organisations in the world while functioning as a *charity* with all the financial benefits which come from that. It hosts 'leadership development' courses and programmes all over the world and claims to have 'brought together' what it calls 'leaders' from more than 100 countries on six continents. The modus operandi of Common Purpose can be compared with the work of the UK government's reframing network that includes the Behavioural Insights Team 'nudge unit' and 'Covid' reframing specialists at SPI-B. WikiLeaks described Common Purpose long ago as 'a hidden virus in our government and schools' which is unknown to the general public: 'It recruits and trains "leaders" to be loyal to the directives of Common Purpose and the EU, instead of to their own departments, which they then undermine or subvert, the NHS [National Health Service] being an example.' This is a vital point to understand the 'Covid' hoax. The NHS, and its equivalent around the world, has been utterly reframed in terms of administrators and much of the medical personnel with the transformation underpinned by recruitment policies. The outcome has been the criminal and psychopathic behaviour of the

NHS over 'Covid' and we have seen the same in every other major country. WikiLeaks said Common Purpose trainees are 'learning to rule without regard to democracy' and to usher in a police state (current events explained). Common Purpose operated like a 'glue' and had members in the NHS, BBC, police, legal profession, church, many of Britain's 7,000 quangos, local councils, the Civil Service, government ministries and Parliament, and controlled many RDA's (Regional Development Agencies). Here we have one answer for how and why British institutions and their like in other countries have changed so negatively in relation to the public. This further explains how and why the beyond-disgraceful reframed BBC has become a propaganda arm of 'Covid' fascism. They are all part of a network pursuing the same goal.

By 2019 Common Purpose was quoting a figure of 85,000 'leaders' that had attended its programmes. These 'students' of all ages are known as Common Purpose 'graduates' and they consist of government, state and local government officials and administrators, police chiefs and officers, and a whole range of others operating within the national, local and global establishment. Cressida Dick, Commissioner of the London Metropolitan Police, is the Common Purpose graduate who was the 'Gold Commander' that oversaw what can only be described as the murder of Brazilian electrician Jean Charles de Menezes in 2005. He was held down by psychopathic police and shot seven times in the head by a psychopathic lunatic after being mistaken for a terrorist when he was just a bloke going about his day. Dick authorised officers to pursue and keep surveillance on de Menezes and ordered that he be stopped from entering the underground train system. Police psychopaths took her at her word clearly. She was 'disciplined' for this outrage by being *promoted* – eventually to the top of the 'Met' police where she has been a disaster. Many Chief Constables controlling the police in different parts of the UK are and have been Common Purpose graduates. I have heard the 'graduate' network described as a sort of Mafia or secret society operating within the fabric of government at all levels pursuing a collective policy

ingrained at Common Purpose training events. Founder Julia Middleton herself has said:

Locally and internationally, Common Purpose graduates will be 'lighting small fires' to create change in their organisations and communities ... The Common Purpose effect is best illustrated by the many stories of small changes brought about by leaders, who themselves have changed.

A Common Purpose mission statement declared:

Common Purpose aims to improve the way society works by expanding the vision, decision-making ability and influence of all kinds of leaders. The organisation runs a variety of educational programmes for leaders of all ages, backgrounds and sectors, in order to provide them with the inspirational, information and opportunities they need to change the world.

Yes, but into what? Since 2020 the answer has become clear.

NLP and the Delphi technique

Common Purpose would seem to be a perfect name or would common programming be better? One of the foundation methods of reaching 'consensus' (group think) is by setting the agenda theme and then encouraging, cajoling or pressuring everyone to agree a 'consensus' in line with the core theme promoted by Common Purpose. The methodology involves the 'Delphi technique', or an adaption of it, in which opinions are expressed that are summarised by a 'facilitator or change agent' at each stage. Participants are 'encouraged' to modify their views in the light of what others have said. Stage by stage the former individual opinions are merged into group consensus which just happens to be what Common Purpose wants them to believe. A key part of this is to marginalise anyone refusing to concede to group think and turn the group against them to apply pressure to conform. We are seeing this very technique used on the general population to make 'Covid' group-thinkers hostile to those who have seen through the bullshit. People can be reframed by using perception manipulation methods such as Neuro-Linguistic Programming (NLP) in which you change perception with the use of

carefully constructed language. An NLP website described the technique this way:

... A method of influencing brain behaviour (the 'neuro' part of the phrase) through the use of language (the 'linguistic' part) and other types of communication to enable a person to 'recode' the way the brain responds to stimuli (that's the 'programming') and manifest new and better behaviours. Neuro-Linguistic Programming often incorporates hypnosis and self-hypnosis to help achieve the change (or 'programming') that is wanted.

British alternative media operation UKColumn has done very detailed research into Common Purpose over a long period. I quoted co-founder and former naval officer Brian Gerrish in my book *Remember Who You Are*, published in 2011, as saying the following years before current times:

It is interesting that many of the mothers who have had children taken by the State speak of the Social Services people being icily cool, emotionless and, as two ladies said in slightly different words, '... like little robots'. We know that NLP is cumulative, so people can be given small imperceptible doses of NLP in a course here, another in a few months, next year etc. In this way, major changes are accrued in their personality, but the day by day change is almost unnoticeable.

In these and other ways 'graduates' have had their perceptions uniformly reframed and they return to their roles in the institutions of government, law enforcement, legal profession, military, 'education', the UK National Health Service and the whole swathe of the establishment structure to pursue a common agenda preparing for the 'post-industrial', 'post-democratic' society. I say 'preparing' but we are now there. 'Post-industrial' is code for the Great Reset and 'post-democratic' is 'Covid' fascism. UKColumn has spoken to partners of those who have attended Common Purpose 'training'. They have described how personalities and attitudes of 'graduates' changed very noticeably for the worse by the time they had completed the course. They had been 'reframed' and told they are the 'leaders' – the special ones – who know better than the population. There has also been the very demonstrable recruitment of psychopaths and narcissists into government administration at all

levels and law enforcement. If you want psychopathy hire psychopaths and you get a simple cause and effect. If you want administrators, police officers and 'leaders' to perceive the public as lesser beings who don't matter then employ narcissists. These personalities are identified using 'psychometrics' that identifies knowledge, abilities, attitudes and personality traits, mostly through carefully-designed questionnaires and tests. As this policy has passed through the decades we have had power-crazy, power-trippers appointed into law enforcement, security and government administration in preparation for current times and the dynamic between public and law enforcement/officialdom has been transformed. UKColumn's Brian Gerrish said of the narcissistic personality:

Their love of themselves and power automatically means that they will crush others who get in their way. I received a major piece of the puzzle when a friend pointed out that when they made public officials re-apply for their own jobs several years ago they were also required to do psychometric tests. This was undoubtedly the start of the screening process to get 'their' sort of people in post.

How obvious that has been since 2020 although it was clear what was happening long before if people paid attention to the changing public-establishment dynamic.

Change agents

At the centre of events in 'Covid' Britain is the National Health Service (NHS) which has behaved disgracefully in slavishly following the Cult agenda. The NHS management structure is awash with Common Purpose graduates or 'change agents' working to a common cause. Helen Bevan, a Chief of Service Transformation at the NHS Institute for Innovation and Improvement, co-authored a document called 'Towards a million change agents, a review of the social movements literature: implications for large scale change in the NHS'. The document compared a project management approach to that of change and social movements where 'people change

themselves and each other – peer to peer’. Two definitions given for a ‘social movement’ were:

A group of people who consciously attempt to build a radically new social order; involves people of a broad range of social backgrounds; and deploys politically confrontational and socially disruptive tactics – Cyrus Zirakzadeh 1997

Collective challenges, based on common purposes and social solidarities, in sustained interaction with elites, opponents, and authorities – Sidney Tarrow 1994

Helen Bevan wrote another NHS document in which she defined ‘framing’ as ‘the process by which leaders construct, articulate and put across their message in a powerful and compelling way in order to win people to their cause and call them to action’. I think I could come up with another definition that would be rather more accurate. The National Health Service and institutions of Britain and the wider world have been taken over by reframed ‘change agents’ and that includes everything from the United Nations to national governments, local councils and social services which have been kidnapping children from loving parents on an extraordinary and gathering scale on the road to the end of parenthood altogether. Children from loving homes are stolen and kidnapped by the state and put into the ‘care’ (inversion) of the local authority through council homes, foster parents and forced adoption. At the same time children are allowed to be abused without response while many are under council ‘care’. UKColumn highlighted the Common Purpose connection between South Yorkshire Police and Rotherham council officers in the case of the scandal in that area of the sexual exploitation of children to which the authorities turned not one blind eye, but both:

We were alarmed to discover that the Chief Executive, the Strategic Director of Children and Young People's Services, the Manager for the Local Strategic Partnership, the Community Cohesion Manager, the Cabinet Member for Cohesion, the Chief Constable and his predecessor had all attended Leadership training courses provided by the pseudo-charity Common Purpose.

Once 'change agents' have secured positions of hire and fire within any organisation things start to move very quickly. Personnel are then hired and fired on the basis of whether they will work towards the agenda the change agent represents. If they do they are rapidly promoted even though they may be incompetent. Those more qualified and skilled who are pre-Common Purpose 'old school' see their careers stall and even disappear. This has been happening for decades in every institution of state, police, 'health' and social services and all of them have been transformed as a result in their attitudes to their jobs and the public. Medical professions, including nursing, which were once vocations for the caring now employ many cold, callous and couldn't give a shit personality types. The UKColumn investigation concluded:

By blurring the boundaries between people, professions, public and private sectors, responsibility and accountability, Common Purpose encourages 'graduates' to believe that as new selected leaders, they can work together, outside of the established political and social structures, to achieve a paradigm shift or CHANGE – so called 'Leading Beyond Authority'. In doing so, the allegiance of the individual becomes 'reframed' on CP colleagues and their NETWORK.

Reframing the Face-Nappies

Nowhere has this process been more obvious than in the police where recruitment of psychopaths and development of unquestioning mind-controlled group-thinkers have transformed law enforcement into a politically-correct 'Woke' joke and a travesty of what should be public service. Today they wear their face-nappies like good little gofers and enforce 'Covid' rules which are fascism under another name. Alongside the specifically-recruited psychopaths we have software minds incapable of free thought. Brian Gerrish again:

An example is the policeman who would not get on a bike for a press photo because he had not done the cycling proficiency course. Normal people say this is political correctness gone mad. Nothing could be further from the truth. The policeman has been reframed, and in his reality it is perfect common sense not to get on the bike 'because he hasn't done the cycling course'.

Another example of this is where the police would not rescue a boy from a pond until they had taken advice from above on the 'risk assessment'. A normal person would have arrived, perhaps thought of the risk for a moment, and dived in. To the police now 'reframed', they followed 'normal' procedure.

There are shocking cases of reframed ambulance crews doing the same. Sheer unthinking stupidity of London Face-Nappies headed by Common Purpose graduate Cressida Dick can be seen in their behaviour at a vigil in March, 2021, for a murdered woman, Sarah Everard. A police officer had been charged with the crime. Anyone with a brain would have left the vigil alone in the circumstances. Instead they 'manhandled' women to stop them breaking 'Covid rules' to betray classic reframing. Minds in the thrall of perception control have no capacity for seeing a situation on its merits and acting accordingly. 'Rules is rules' is their only mind-set. My father used to say that rules and regulations are for the guidance of the intelligent and the blind obedience of the idiot. Most of the intelligent, decent, coppers have gone leaving only the other kind and a few old school for whom the job must be a daily nightmare. The combination of psychopaths and rule-book software minds has been clearly on public display in the 'Covid' era with automaton robots in uniform imposing fascistic 'Covid' regulations on the population without any personal initiative or judging situations on their merits. There are thousands of examples around the world, but I'll make my point with the infamous Derbyshire police in the English East Midlands – the ones who think pouring dye into beauty spots and using drones to track people walking in the countryside away from anyone is called 'policing'. To them there are rules decreed by the government which they have to enforce and in their bewildered state a group gathering in a closed space and someone walking alone in the countryside are the same thing. It is beyond idiocy and enters the realm of clinical insanity.

Police officers in Derbyshire said they were 'horrified' – *horrified* – to find 15 to 20 'irresponsible' kids playing a football match at a closed leisure centre 'in breach of coronavirus restrictions'. When they saw the police the kids ran away leaving their belongings behind and the reframed men and women of Derbyshire police were seeking to establish their identities with a view to fining their parents. The most natural thing for youngsters to do – kicking a ball about – is turned into a criminal activity and enforced by the moronic software programs of Derbyshire police. You find the same mentality in every country. These barely conscious 'horrified' officers said they had to take action because 'we need to ensure these rules are being followed' and 'it is of the utmost importance that you ensure your children are following the rules and regulations for Covid-19'. Had any of them done ten seconds of research to see if this parroting of their masters' script could be supported by any evidence? Nope. Reframed people don't think – others think for them and that's the whole idea of reframing. I have seen police officers one after the other repeating without question word for word what officialdom tells them just as I have seen great swathes of the public doing the same. Ask either for 'their' opinion and out spews what they have been told to think by the official narrative. Police and public may seem to be in different groups, but their mentality is the same. Most people do whatever they are told in fear not doing so or because they believe what officialdom tells them; almost the entirety of the police do what they are told for the same reason. Ultimately it's the tiny inner core of the global Cult that's telling both what to do.

So Derbyshire police were 'horrified'. Oh, really? Why did they think those kids were playing football? It was to relieve the psychological consequences of lockdown and being denied human contact with their friends and interaction, touch and discourse vital to human psychological health. Being denied this month after month has dismantled the psyche of many children and young people as depression and suicide have exploded. Were Derbyshire police *horrified by that*? Are you kidding? Reframed people don't have those

mental and emotional processes that can see how the impact on the psychological health of youngsters is far more dangerous than any 'virus' even if you take the mendacious official figures to be true. The reframed are told (programmed) how to act and so they do. The Derbyshire Chief Constable in the first period of lockdown when the black dye and drones nonsense was going on was Peter Goodman. He was the man who severed the connection between his force and the Derbyshire Constabulary *Male Voice* Choir when he decided that it was not inclusive enough to allow women to join. The fact it was a male voice choir making a particular sound produced by male voices seemed to elude a guy who terrifyingly ran policing in Derbyshire. He retired weeks after his force was condemned as disgraceful by former Supreme Court Justice Jonathan Sumption for their behaviour over extreme lockdown impositions. Goodman was replaced by his deputy Rachel Swann who was in charge when her officers were 'horrificed'. The police statement over the boys committing the hanging-offence of playing football included the line about the youngsters being 'irresponsible in the times we are all living through' missing the point that the real relevance of the 'times we are all living through' is the imposition of fascism enforced by psychopaths and reframed minds of police officers playing such a vital part in establishing the fascist tyranny that their own children and grandchildren will have to live in their entire lives. As a definition of insanity that is hard to beat although it might be run close by imposing masks on people that can have a serious effect on their health while wearing a face nappy all day themselves. Once again public and police do it for the same reason – the authorities tell them to and who are they to have the self-respect to say no?

Wokers in uniform

How reframed do you have to be to arrest a *six-year-old* and take him to court for *picking a flower* while waiting for a bus? Brain dead police and officialdom did just that in North Carolina where criminal proceedings happen regularly for children under nine. Attorney Julie Boyer gave the six-year-old crayons and a colouring book

during the 'flower' hearing while the 'adults' decided his fate. County Chief District Court Judge Jay Corpening asked: 'Should a child that believes in Santa Claus, the Easter Bunny and the tooth fairy be making life-altering decisions?' Well, of course not, but common sense has no meaning when you have a common purpose and a reframed mind. Treating children in this way, and police operating in American schools, is all part of the psychological preparation for children to accept a police state as normal all their adult lives. The same goes for all the cameras and biometric tracking technology in schools. Police training is focused on reframing them as snowflake Wokers and this is happening in the military. Pentagon top brass said that 'training sessions on extremism' were needed for troops who asked why they were so focused on the Capitol Building riot when Black Lives Matter riots were ignored. What's the difference between them some apparently and rightly asked. Actually, there is a difference. Five people died in the Capitol riot, only one through violence, and that was a police officer shooting an unarmed protestor. BLM riots killed at least 25 people and cost billions. Asking the question prompted the psychopaths and reframed minds that run the Pentagon to say that more 'education' (programming) was needed. Troop training is all based on psychological programming to make them fodder for the Cult – 'Military men are just dumb, stupid animals to be used as pawns in foreign policy' as Cult-to-his-DNA former Secretary of State Henry Kissinger famously said. Governments see the police in similar terms and it's time for those among them who can see this to defend the people and stop being enforcers of the Cult agenda upon the people.

The US military, like the country itself, is being targeted for destruction through a long list of Woke impositions. Cult-owned gaga 'President' Biden signed an executive order when he took office to allow taxpayer money to pay for transgender surgery for active military personnel and veterans. Are you a man soldier? No, I'm a LGBTQIA+ with a hint of Skoliosexual and Spectrasexual. Oh, good man. Bad choice of words you bigot. The Pentagon announced in March, 2021, the appointment of the first 'diversity and inclusion

officer' for US Special Forces. Richard Torres-Estrada arrived with the publication of a 'D&I Strategic Plan which will guide the enterprise-wide effort to institutionalize and sustain D&I'. If you think a Special Forces 'Strategic Plan' should have something to do with defending America you haven't been paying attention. Defending Woke is now the military's new role. Torres-Estrada has posted images comparing Donald Trump with Adolf Hitler and we can expect no bias from him as a representative of the supposedly non-political Pentagon. Cable news host Tucker Carlson said: 'The Pentagon is now the Yale faculty lounge but with cruise missiles.' Meanwhile Secretary of Defense Lloyd Austin, a board member of weapons-maker Raytheon with stock and compensation interests in October, 2020, worth \$1.4 million, said he was purging the military of the 'enemy within' – anyone who isn't Woke and supports Donald Trump. Austin refers to his targets as 'racist extremists' while in true Woke fashion being himself a racist extremist. Pentagon documents pledge to 'eradicate, eliminate and conquer all forms of racism, sexism and homophobia'. The definitions of these are decided by 'diversity and inclusion committees' peopled by those who see racism, sexism and homophobia in every situation and opinion. Woke (the Cult) is dismantling the US military and purging testosterone as China expands its military and gives its troops 'masculinity training'. How do we think that is going to end when this is all Cult coordinated? The US military, like the British military, is controlled by Woke and spineless top brass who just go along with it out of personal career interests.

'Woke' means fast asleep

Mind control and perception manipulation techniques used on individuals to create group-think have been unleashed on the global population in general. As a result many have no capacity to see the obvious fascist agenda being installed all around them or what 'Covid' is really all about. Their brains are firewalled like a computer system not to process certain concepts, thoughts and realisations that are bad for the Cult. The young are most targeted as the adults they

will be when the whole fascist global state is planned to be fully implemented. They need to be prepared for total compliance to eliminate all pushback from entire generations. The Cult has been pouring billions into taking complete control of 'education' from schools to universities via its operatives and corporations and not least Bill Gates as always. The plan has been to transform 'education' institutions into programming centres for the mentality of 'Woke'. James McConnell, professor of psychology at the University of Michigan, wrote in *Psychology Today* in 1970:

The day has come when we can combine sensory deprivation with drugs, hypnosis, and astute manipulation of reward and punishment, to gain almost absolute control over an individual's behaviour. It should then be possible to achieve a very rapid and highly effective type of brainwashing that would allow us to make dramatic changes in a person's behaviour and personality ...

... We should reshape society so that we all would be trained from birth to want to do what society wants us to do. We have the techniques to do it... no-one owns his own personality you acquired, and there's no reason to believe you should have the right to refuse to acquire a new personality if your old one is anti-social.

This was the potential for mass brainwashing in 1970 and the mentality there displayed captures the arrogant psychopathy that drives it forward. I emphasise that not all young people have succumbed to Woke programming and those that haven't are incredibly impressive people given that today's young are the most perceptually-targeted generations in history with all the technology now involved. Vast swathes of the young generations, however, have fallen into the spell – and that's what it is – of Woke. The Woke mentality and perceptual program is founded on *inversion* and you will appreciate later why that is so significant. Everything with Woke is inverted and the opposite of what it is claimed to be. Woke was a term used in African-American culture from the 1900s and referred to an awareness of social and racial justice. This is not the meaning of the modern version or 'New Woke' as I call it in *The Answer*. Oh, no, Woke today means something very different no matter how much Wokers may seek to hide that and insist Old Woke and New

Woke are the same. See if you find any 'awareness of social justice' here in the modern variety:

- Woke demands 'inclusivity' while excluding anyone with a different opinion and calls for mass censorship to silence other views.
- Woke claims to stand against oppression when imposing oppression is the foundation of all that it does. It is the driver of political correctness which is nothing more than a Cult invention to manipulate the population to silence itself.
- Woke believes itself to be 'liberal' while pursuing a global society that can only be described as fascist (see 'anti-fascist' fascist Antifa).
- Woke calls for 'social justice' while spreading injustice wherever it goes against the common 'enemy' which can be easily identified as a differing view.
- Woke is supposed to be a metaphor for 'awake' when it is solid-gold asleep and deep in a Cult-induced coma that meets the criteria for 'off with the fairies'.

I state these points as obvious facts if people only care to look. I don't do this with a sense of condemnation. We need to appreciate that the onslaught of perceptual programming on the young has been incessant and merciless. I can understand why so many have been reframed, or, given their youth, framed from the start to see the world as the Cult demands. The Cult has had access to their minds day after day in its 'education' system for their entire formative years. Perception is formed from information received and the Cult-created system is a life-long download of information delivered to elicit a particular perception, thus behaviour. The more this has expanded into still new extremes in recent decades and ever-increasing censorship has deleted other opinions and information why wouldn't that lead to a perceptual reframing on a mass scale? I

have described already cradle-to-grave programming and in more recent times the targeting of young minds from birth to adulthood has entered the stratosphere. This has taken the form of skewing what is 'taught' to fit the Cult agenda and the omnipresent techniques of group-think to isolate non-believers and pressure them into line. There has always been a tendency to follow the herd, but we really are in a new world now in relation to that. We have parents who can see the 'Covid' hoax told by their children not to stop them wearing masks at school, being 'Covid' tested or having the 'vaccine' in fear of the peer-pressure consequences of being different. What is 'peer-pressure' if not pressure to conform to group-think? Renegade Minds never group-think and always retain a set of perceptions that are unique to them. Group-think is always underpinned by consequences for not group-thinking. Abuse now aimed at those refusing DNA-manipulating 'Covid vaccines' are a potent example of this. The biggest pressure to conform comes from the very group which is itself being manipulated. 'I am programmed to be part of a hive mind and so you must be.'

Woke control structures in 'education' now apply to every mainstream organisation. Those at the top of the 'education' hierarchy (the Cult) decide the policy. This is imposed on governments through the Cult network; governments impose it on schools, colleges and universities; their leadership impose the policy on teachers and academics and they impose it on children and students. At any level where there is resistance, perhaps from a teacher or university lecturer, they are targeted by the authorities and often fired. Students themselves regularly demand the dismissal of academics (increasingly few) at odds with the narrative that the students have been programmed to believe in. It is quite a thought that students who are being targeted by the Cult become so consumed by programmed group-think that they launch protests and demand the removal of those who are trying to push back against those targeting the students. Such is the scale of perceptual inversion. We see this with 'Covid' programming as the Cult imposes the rules via psycho-psychologists and governments on

shops, transport companies and businesses which impose them on their staff who impose them on their customers who pressure Pushbackers to conform to the will of the Cult which is in the process of destroying them and their families. Scan all aspects of society and you will see the same sequence every time.

Fact free Woke and hijacking the 'left'

There is no more potent example of this than 'Woke', a mentality only made possible by the deletion of factual evidence by an 'education' system seeking to produce an ever more uniform society. Why would you bother with facts when you don't know any? Deletion of credible history both in volume and type is highly relevant. Orwell said: 'Who controls the past controls the future: who controls the present controls the past.' They who control the perception of the past control the perception of the future and they who control the present control the perception of the past through the writing and deleting of history. Why would you oppose the imposition of Marxism in the name of Wokeism when you don't know that Marxism cost at least 100 million lives in the 20th century alone? Watch videos and read reports in which Woker generations are asked basic historical questions – it's mind-blowing. A survey of 2,000 people found that six percent of millennials (born approximately early 1980s to early 2000s) believed the Second World War (1939-1945) broke out with the assassination of President Kennedy (in 1963) and one in ten thought Margaret Thatcher was British Prime Minister at the time. She was in office between 1979 and 1990. We are in a post-fact society. Provable facts are no defence against the fascism of political correctness or Silicon Valley censorship. Facts don't matter anymore as we have witnessed with the 'Covid' hoax. Sacrificing uniqueness to the Woke group-think religion is all you are required to do and that means thinking for yourself is the biggest Woke no, no. All religions are an expression of group-think and censorship and Woke is just another religion with an orthodoxy defended by group-think and censorship. Burned at

the stake becomes burned on Twitter which leads back eventually to burned at the stake as Woke humanity regresses to ages past.

The biggest Woke inversion of all is its creators and funders. I grew up in a traditional left of centre political household on a council estate in Leicester in the 1950s and 60s – you know, the left that challenged the power of wealth-hoarding elites and threats to freedom of speech and opinion. In those days students went on marches defending freedom of speech while today's Wokers march for its deletion. What on earth could have happened? Those very elites (collectively the Cult) that we opposed in my youth and early life have funded into existence the antithesis of that former left and hijacked the 'brand' while inverting everything it ever stood for. We have a mentality that calls itself 'liberal' and 'progressive' while acting like fascists. Cult billionaires and their corporations have funded themselves into control of 'education' to ensure that Woke programming is unceasing throughout the formative years of children and young people and that non-Wokers are isolated (that word again) whether they be students, teachers or college professors. The Cult has funded into existence the now colossal global network of Woke organisations that have spawned and promoted all the 'causes' on the Cult wish-list for global transformation and turned Wokers into demanders of them. Does anyone really think it's a coincidence that the Cult agenda for humanity is a carbon (sorry) copy of the societal transformations desired by Woke?? These are only some of them:

Political correctness: The means by which the Cult deletes all public debates that it knows it cannot win if we had the free-flow of information and evidence.

Human-caused 'climate change': The means by which the Cult seeks to transform society into a globally-controlled dictatorship imposing its will over the fine detail of everyone's lives 'to save the planet' which doesn't actually need saving.

Transgender obsession: Preparing collective perception to accept the 'new human' which would not have genders because it would be created technologically and not through procreation. I'll have much more on this in Human 2.0.

Race obsession: The means by which the Cult seeks to divide and rule the population by triggering racial division through the perception that society is more racist than ever when the opposite is the case. Is it perfect in that regard? No. But to compare today with the racism of apartheid and segregation brought to an end by the civil rights movement in the 1960s is to insult the memory of that movement and inspirations like Martin Luther King. Why is the 'anti-racism' industry (which it is) so dominated by privileged white people?

White supremacy: This is a label used by privileged white people to demonise poor and deprived white people pushing back on tyranny to marginalise and destroy them. White people are being especially targeted as the dominant race by number within Western society which the Cult seeks to transform in its image. If you want to change a society you must weaken and undermine its biggest group and once you have done that by using the other groups you next turn on them to do the same ... 'Then they came for the Jews and I was not a Jew so I did nothing.'

Mass migration: The mass movement of people from the Middle East, Africa and Asia into Europe, from the south into the United States and from Asia into Australia are another way the Cult seeks to dilute the racial, cultural and political influence of white people on Western society. White people ask why their governments appear to be working against them while being politically and culturally biased towards incoming cultures. Well, here's your answer. In the same way sexually 'straight' people, men and women, ask why the

authorities are biased against them in favour of other sexualities. The answer is the same – that's the way the Cult wants it to be for very sinister motives.

These are all central parts of the Cult agenda and central parts of the Woke agenda and Woke was created and continues to be funded to an immense degree by Cult billionaires and corporations. If anyone begins to say 'coincidence' the syllables should stick in their throat.

Billionaire 'social justice warriors'

Joe Biden is a 100 percent-owned asset of the Cult and the Wokers' man in the White House whenever he can remember his name and for however long he lasts with his rapidly diminishing cognitive function. Even walking up the steps of an aircraft without falling on his arse would appear to be a challenge. He's not an empty-shell puppet or anything. From the minute Biden took office (or the Cult did) he began his executive orders promoting the Woke wish-list. You will see the Woke agenda imposed ever more severely because it's really the *Cult* agenda. Woke organisations and activist networks spawned by the Cult are funded to the extreme so long as they promote what the Cult wants to happen. Woke is funded to promote 'social justice' by billionaires who become billionaires by destroying social justice. The social justice mantra is only a cover for dismantling social justice and funded by billionaires that couldn't give a damn about social justice. Everything makes sense when you see that. One of Woke's premier funders is Cult billionaire financier George Soros who said: 'I am basically there to make money, I cannot and do not look at the social consequences of what I do.' This is the same Soros who has given more than \$32 billion to his Open Society Foundations global Woke network and funded Black Lives Matter, mass immigration into Europe and the United States, transgender activism, climate change activism, political correctness and groups targeting 'white supremacy' in the form of privileged white thugs that dominate Antifa. What a scam it all is and when

you are dealing with the unquestioning fact-free zone of Woke scamming them is child's play. All you need to pull it off in all these organisations are a few in-the-know agents of the Cult and an army of naïve, reframed, uninformed, narcissistic, know-nothings convinced of their own self-righteousness, self-purity and virtue.

Soros and fellow billionaires and billionaire corporations have poured hundreds of millions into Black Lives Matter and connected groups and promoted them to a global audience. None of this is motivated by caring about black people. These are the billionaires that have controlled and exploited a system that leaves millions of black people in abject poverty and deprivation which they do absolutely nothing to address. The same Cult networks funding BLM were behind the *slave trade*! Black Lives Matter hijacked a phrase that few would challenge and they have turned this laudable concept into a political weapon to divide society. You know that BLM is a fraud when it claims that *All Lives Matter*, the most inclusive statement of all, is 'racist'. BLM and its Cult masters don't want to end racism. To them it's a means to an end to control all of humanity never mind the colour, creed, culture or background. What has destroying the nuclear family got to do with ending racism? Nothing – but that is one of the goals of BLM and also happens to be a goal of the Cult as I have been exposing in my books for decades. Stealing children from loving parents and giving schools ever more power to override parents is part of that same agenda. BLM is a Marxist organisation and why would that not be the case when the Cult created Marxism *and* BLM? Patrisse Cullors, a BLM co-founder, said in a 2015 video that she and her fellow organisers, including co-founder Alicia Garza, are 'trained Marxists'. The lady known after marriage as Patrisse Khan-Cullors bought a \$1.4 million home in 2021 in one of the whitest areas of California with a black population of just 1.6 per cent and has so far bought *four* high-end homes for a total of \$3.2 million. How very Marxist. There must be a bit of spare in the BLM coffers, however, when Cult corporations and billionaires have handed over the best part of \$100 million. Many black people can see that Black Lives Matter is not

working for them, but against them, and this is still more confirmation. Black journalist Jason Whitlock, who had his account suspended by Twitter for simply linking to the story about the 'Marxist's' home buying spree, said that BLM leaders are 'making millions of dollars off the backs of these dead black men who they wouldn't spit on if they were on fire and alive'.

Black Lies Matter

Cult assets and agencies came together to promote BLM in the wake of the death of career criminal George Floyd who had been jailed a number of times including for forcing his way into the home of a black woman with others in a raid in which a gun was pointed at her stomach. Floyd was filmed being held in a Minneapolis street in 2020 with the knee of a police officer on his neck and he subsequently died. It was an appalling thing for the officer to do, but the same technique has been used by police on peaceful protestors of lockdown without any outcry from the Woke brigade. As unquestioning supporters of the Cult agenda Wokers have supported lockdown and all the 'Covid' claptrap while attacking anyone standing up to the tyranny imposed in its name. Court documents would later include details of an autopsy on Floyd by County Medical Examiner Dr Andrew Baker who concluded that Floyd had taken a fatal level of the drug fentanyl. None of this mattered to fact-free, question-free, Woke. Floyd's death was followed by worldwide protests against police brutality amid calls to defund the police. Throwing babies out with the bathwater is a Woke speciality. In the wake of the murder of British woman Sarah Everard a Green Party member of the House of Lords, Baroness Jones of Moulsecoomb (Nincompoopia would have been better), called for a 6pm curfew for all men. This would be in breach of the Geneva Conventions on war crimes which ban collective punishment, but that would never have crossed the black and white Woke mind of Baroness Nincompoopia who would have been far too convinced of her own self-righteousness to compute such details. Many American cities did defund the police in the face of Floyd riots

and after \$15 million was deleted from the police budget in Washington DC under useless Woke mayor Muriel Bowser car-jacking alone rose by 300 percent and within six months the US capital recorded its highest murder rate in 15 years. The same happened in Chicago and other cities in line with the Cult/Soros plan to bring fear to streets and neighbourhoods by reducing the police, releasing violent criminals and not prosecuting crime. This is the mob-rule agenda that I have warned in the books was coming for so long. Shootings in the area of Minneapolis where Floyd was arrested increased by 2,500 percent compared with the year before. Defunding the police over George Floyd has led to a big increase in dead people with many of them black. Police protection for politicians making these decisions stayed the same or increased as you would expect from professional hypocrites. The Cult doesn't actually want to abolish the police. It wants to abolish local control over the police and hand it to federal government as the psychopaths advance the Hunger Games Society. Many George Floyd protests turned into violent riots with black stores and businesses destroyed by fire and looting across America fuelled by Black Lives Matter. Woke doesn't do irony. If you want civil rights you must loot the liquor store and the supermarket and make off with a smart TV. It's the only way.

It's not a race war – it's a class war

Black people are patronised by privileged blacks and whites alike and told they are victims of white supremacy. I find it extraordinary to watch privileged blacks supporting the very system and bloodline networks behind the slave trade and parroting the same Cult-serving manipulative crap of their privileged white, often billionaire, associates. It is indeed not a race war but a class war and colour is just a diversion. Black Senator Cory Booker and black Congresswoman Maxine Waters, more residents of Nincompoopia, personify this. Once you tell people they are victims of someone else you devalue both their own responsibility for their plight and the power they have to impact on their reality and experience. Instead

we have: 'You are only in your situation because of whiteness – turn on them and everything will change.' It won't change. Nothing changes in our lives unless *we* change it. Crucial to that is never seeing yourself as a victim and always as the creator of your reality. Life is a simple sequence of choice and consequence. Make different choices and you create different consequences. *You* have to make those choices – not Black Lives Matter, the Woke Mafia and anyone else that seeks to dictate your life. Who are they these Wokers, an emotional and psychological road traffic accident, to tell you what to do? Personal empowerment is the last thing the Cult and its Black Lives Matter want black people or anyone else to have. They claim to be defending the underdog while *creating* and perpetuating the underdog. The Cult's worst nightmare is human unity and if they are going to keep blacks, whites and every other race under economic servitude and control then the focus must be diverted from what they have in common to what they can be manipulated to believe divides them. Blacks have to be told that their poverty and plight is the fault of the white bloke living on the street in the same poverty and with the same plight they are experiencing. The difference is that your plight black people is due to him, a white supremacist with 'white privilege' living on the street. Don't unite as one human family against your mutual oppressors and suppressors – fight the oppressor with the white face who is as financially deprived as you are. The Cult knows that as its 'Covid' agenda moves into still new levels of extremism people are going to respond and it has been spreading the seeds of disunity everywhere to stop a united response to the evil that targets *all of us*.

Racist attacks on 'whiteness' are getting ever more outrageous and especially through the American Democratic Party which has an appalling history for anti-black racism. Barack Obama, Joe Biden, Hillary Clinton and Nancy Pelosi all eulogised about Senator Robert Byrd at his funeral in 2010 after a nearly 60-year career in Congress. Byrd was a brutal Ku Klux Klan racist and a violent abuser of Cathy O'Brien in MKUltra. He said he would never fight in the military 'with a negro by my side' and 'rather I should die a thousand times,

and see Old Glory trampled in the dirt never to rise again, than to see this beloved land of ours become degraded by race mongrels, a throwback to the blackest specimen from the wilds'. Biden called Byrd a 'very close friend and mentor'. These 'Woke' hypocrites are not anti-racist they are anti-poor and anti-people not of their perceived class. Here is an illustration of the scale of anti-white racism to which we have now descended. Seriously Woke and moronic *New York Times* contributor Damon Young described whiteness as a 'virus' that 'like other viruses will not die until there are no bodies left for it to infect'. He went on: '... the only way to stop it is to locate it, isolate it, extract it, and kill it.' Young can say that as a black man with no consequences when a white man saying the same in reverse would be facing a jail sentence. *That's* racism. We had super-Woke numbskull senators Tammy Duckworth and Mazie Hirono saying they would object to future Biden Cabinet appointments if he did not nominate more Asian Americans and Pacific Islanders. Never mind the ability of the candidate what do they look like? Duckworth said: 'I will vote for racial minorities and I will vote for LGBTQ, but anyone else I'm not voting for.' Appointing people on the grounds of race is illegal, but that was not a problem for this ludicrous pair. They were on-message and that's a free pass in any situation.

Critical race racism

White children are told at school they are intrinsically racist as they are taught the divisive 'critical race theory'. This claims that the law and legal institutions are inherently racist and that race is a socially constructed concept used by white people to further their economic and political interests at the expense of people of colour. White is a 'virus' as we've seen. Racial inequality results from 'social, economic, and legal differences that white people create between races to maintain white interests which leads to poverty and criminality in minority communities'. I must tell that to the white guy sleeping on the street. The principal of East Side Community School in New York sent white parents a manifesto that called on

them to become 'white traitors' and advocate for full 'white abolition'. These people are teaching your kids when they urgently need a psychiatrist. The 'school' included a chart with 'eight white identities' that ranged from 'white supremacist' to 'white abolition' and defined the behaviour white people must follow to end 'the regime of whiteness'. Woke blacks and their privileged white associates are acting exactly like the slave owners of old and Ku Klux Klan racists like Robert Byrd. They are too full of their own self-purity to see that, but it's true. Racism is not a body type; it's a state of mind that can manifest through any colour, creed or culture.

Another racial fraud is '*equity*'. Not equality of treatment and opportunity – equity. It's a term spun as equality when it means something very different. Equality in its true sense is a raising up while 'equity' is a race to the bottom. Everyone in the same level of poverty is 'equity'. Keep everyone down – that's equity. The Cult doesn't want anyone in the human family to be empowered and BLM leaders, like all these 'anti-racist' organisations, continue their privileged, pampered existence by perpetuating the perception of gathering racism. When is the last time you heard an 'anti-racist' or 'anti-Semitism' organisation say that acts of racism and discrimination have *fallen*? It's not in the interests of their fundraising and power to influence and the same goes for the professional soccer anti-racism operation, Kick It Out. Two things confirmed that the Black Lives Matter riots in the summer of 2020 were Cult creations. One was that while anti-lockdown protests were condemned in this same period for 'transmitting 'Covid' the authorities supported mass gatherings of Black Lives Matter supporters. I even saw self-deluding people claiming to be doctors say the two types of protest were not the same. No – the non-existent 'Covid' was in favour of lockdowns and attacked those that protested against them while 'Covid' supported Black Lives Matter and kept well away from its protests. The whole thing was a joke and as lockdown protestors were arrested, often brutally, by reframed Face-Nappies we had the grotesque sight of police officers taking the knee to Black Lives Matter, a Cult-funded Marxist

organisation that supports violent riots and wants to destroy the nuclear family and white people.

He's not white? Shucks!

Woke obsession with race was on display again when ten people were shot dead in Boulder, Colorado, in March, 2021. Cult-owned Woke TV channels like CNN said the shooter appeared to be a white man and Wokers were on Twitter condemning 'violent white men' with the usual mantras. Then the shooter's name was released as Ahmad Al Aliwi Alissa, an anti-Trump Arab-American, and the sigh of disappointment could be heard five miles away. Never mind that ten people were dead and what that meant for their families. Race baiting was all that mattered to these sick Cult-serving people like Barack Obama who exploited the deaths to further divide America on racial grounds which is his job for the Cult. This is the man that 'racist' white Americans made the first black president of the United States and then gave him a second term. Not-very-bright Obama has become filthy rich on the back of that and today appears to have a big influence on the Biden administration. Even so he's still a downtrodden black man and a victim of white supremacy. This disingenuous fraud reveals the contempt he has for black people when he puts on a Deep South Alabama accent whenever he talks to them, no, *at* them.

Another BLM red flag was how the now fully-Woke (fully-Cult) and fully-virtue-signalled professional soccer authorities had their teams taking the knee before every match in support of Marxist Black Lives Matter. Soccer authorities and clubs displayed 'Black Lives Matter' on the players' shirts and flashed the name on electronic billboards around the pitch. Any fans that condemned what is a Freemasonic taking-the-knee ritual were widely condemned as you would expect from the Woke virtue-signallers of professional sport and the now fully-Woke media. We have reverse racism in which you are banned from criticising any race or culture except for white people for whom anything goes – say what you like, no problem. What has this got to do with racial harmony and

equality? We've had black supremacists from Black Lives Matter telling white people to fall to their knees in the street and apologise for their white supremacy. Black supremacists acting like white supremacist slave owners of the past couldn't breach their self-obsessed, race-obsessed sense of self-purity. Joe Biden appointed a race-obsessed black supremacist Kristen Clarke to head the Justice Department Civil Rights Division. Clarke claimed that blacks are endowed with 'greater mental, physical and spiritual abilities' than whites. If anyone reversed that statement they would be vilified. Clarke is on-message so no problem. She's never seen a black-white situation in which the black figure is anything but a virtuous victim and she heads the Civil Rights Division which should treat everyone the same or it isn't civil rights. Another perception of the Renegade Mind: If something or someone is part of the Cult agenda they will be supported by Woke governments and media no matter what. If they're not, they will be condemned and censored. It really is that simple and so racist Clarke prospers despite (make that because of) her racism.

The end of culture

Biden's administration is full of such racial, cultural and economic bias as the Cult requires the human family to be divided into warring factions. We are now seeing racially-segregated graduations and everything, but everything, is defined through the lens of perceived 'racism'. We have 'racist' mathematics, 'racist' food and even 'racist' *plants*. World famous Kew Gardens in London said it was changing labels on plants and flowers to tell its pre-'Covid' more than two million visitors a year how racist they are. Kew director Richard Deverell said this was part of an effort to 'move quickly to decolonise collections' after they were approached by one Ajay Chhabra 'an actor with an insight into how sugar cane was linked to slavery'. They are *plants* you idiots. 'Decolonisation' in the Woke manual really means colonisation of society with its mentality and by extension colonisation by the Cult. We are witnessing a new Chinese-style 'Cultural Revolution' so essential to the success of all

Marxist takeovers. Our cultural past and traditions have to be swept away to allow a new culture to be built-back-better. Woke targeting of long-standing Western cultural pillars including historical monuments and cancelling of historical figures is what happened in the Mao revolution in China which 'purged remnants of capitalist and traditional elements from Chinese society' and installed Maoism as the dominant ideology'. For China see the Western world today and for 'dominant ideology' see Woke. Better still see Marxism or Maoism. The 'Covid' hoax has specifically sought to destroy the arts and all elements of Western culture from people meeting in a pub or restaurant to closing theatres, music venues, sports stadiums, places of worship and even banning *singing*. Destruction of Western society is also why criticism of any religion is banned except for Christianity which again is the dominant religion as white is the numerically-dominant race. Christianity may be fading rapidly, but its history and traditions are weaved through the fabric of Western society. Delete the pillars and other structures will follow until the whole thing collapses. I am not a Christian defending that religion when I say that. I have no religion. It's just a fact. To this end Christianity has itself been turned Woke to usher its own downfall and its ranks are awash with 'change agents' – knowing and unknowing – at every level including Pope Francis (*definitely* knowing) and the clueless Archbishop of Canterbury Justin Welby (possibly not, but who can be sure?). Woke seeks to coordinate attacks on Western culture, traditions, and ways of life through 'intersectionality' defined as 'the complex, cumulative way in which the effects of multiple forms of discrimination (such as racism, sexism, and classism) combine, overlap, or intersect especially in the experiences of marginalised individuals or groups'. Wade through the Orwellian Woke-speak and this means coordinating disparate groups in a common cause to overthrow freedom and liberal values.

The entire structure of public institutions has been infested with Woke – government at all levels, political parties, police, military, schools, universities, advertising, media and trade unions. This abomination has been achieved through the Cult web by appointing

Wokers to positions of power and battering non-Wokers into line through intimidation, isolation and threats to their job. Many have been fired in the wake of the empathy-deleted, vicious hostility of 'social justice' Wokers and the desire of gutless, spineless employers to virtue-signal their Wokeness. Corporations are filled with Wokers today, most notably those in Silicon Valley. Ironically at the top they are not Woke at all. They are only exploiting the mentality their Cult masters have created and funded to censor and enslave while the Wokers cheer them on until it's their turn. Thus the Woke 'liberal left' is an inversion of the traditional liberal left. Campaigning for justice on the grounds of power and wealth distribution has been replaced by campaigning for identity politics. The genuine traditional left would never have taken money from today's billionaire abusers of fairness and justice and nor would the billionaires have wanted to fund that genuine left. It would not have been in their interests to do so. The division of opinion in those days was between the haves and have nots. This all changed with Cult manipulated and funded identity politics. The division of opinion today is between Wokers and non-Wokers and not income brackets. Cult corporations and their billionaires may have taken wealth disparity to cataclysmic levels of injustice, but as long as they speak the language of Woke, hand out the dosh to the Woke network and censor the enemy they are 'one of us'. Billionaires who don't give a damn about injustice are laughing at them till their bellies hurt. Wokers are not even close to self-aware enough to see that. The transformed 'left' dynamic means that Wokers who drone on about 'social justice' are funded by billionaires that have destroyed social justice the world over. It's *why* they are billionaires.

The climate con

Nothing encapsulates what I have said more comprehensively than the hoax of human-caused global warming. I have detailed in my books over the years how Cult operatives and organisations were the pump-primers from the start of the climate con. A purpose-built vehicle for this is the Club of Rome established by the Cult in 1968

with the Rockefellers and Rothschilds centrally involved all along. Their gofer frontman Maurice Strong, a Canadian oil millionaire, hosted the Earth Summit in Rio de Janeiro, Brazil, in 1992 where the global 'green movement' really expanded in earnest under the guiding hand of the Cult. The Earth Summit established Agenda 21 through the Cult-created-and-owned United Nations to use the illusion of human-caused climate change to justify the transformation of global society to save the world from climate disaster. It is a No-Problem-Reaction-Solution sold through governments, media, schools and universities as whole generations have been terrified into believing that the world was going to end in their lifetimes unless what old people had inflicted upon them was stopped by a complete restructuring of how everything is done. Chill, kids, it's all a hoax. Such restructuring is precisely what the Cult agenda demands (purely by coincidence of course). Today this has been given the codename of the Great Reset which is only an updated term for Agenda 21 and its associated Agenda 2030. The latter, too, is administered through the UN and was voted into being by the General Assembly in 2015. Both 21 and 2030 seek centralised control of all resources and food right down to the raindrops falling on your own land. These are some of the demands of Agenda 21 established in 1992. See if you recognise this society emerging today:

- End national sovereignty
- State planning and management of all land resources, ecosystems, deserts, forests, mountains, oceans and fresh water; agriculture; rural development; biotechnology; and ensuring '*equity*'
- The state to 'define the role' of business and financial resources
- Abolition of private property
- 'Restructuring' the family unit (see BLM)
- Children raised by the state
- People told what their job will be
- Major restrictions on movement
- Creation of 'human settlement zones'

- Mass resettlement as people are forced to vacate land where they live
- Dumbing down education
- Mass global depopulation in pursuit of all the above

The United Nations was created as a Trojan horse for world government. With the climate con of critical importance to promoting that outcome you would expect the UN to be involved. Oh, it's involved all right. The UN is promoting Agenda 21 and Agenda 2030 justified by 'climate change' while also driving the climate hoax through its Intergovernmental Panel on Climate Change (IPCC), one of the world's most corrupt organisations. The IPCC has been lying ferociously and constantly since the day it opened its doors with the global media hanging unquestioningly on its every mendacious word. The Green movement is entirely Woke and has long lost its original environmental focus since it was co-opted by the Cult. An obsession with 'global warming' has deleted its values and scrambled its head. I experienced a small example of what I mean on a beautiful country walk that I have enjoyed several times a week for many years. The path merged into the fields and forests and you felt at one with the natural world. Then a 'Green' organisation, the Hampshire and Isle of Wight Wildlife Trust, took over part of the land and proceeded to cut down a large number of trees, including mature ones, to install a horrible big, bright steel 'this-is-ours-stay-out' fence that destroyed the whole atmosphere of this beautiful place. No one with a feel for nature would do that. Day after day I walked to the sound of chainsaws and a magnificent mature weeping willow tree that I so admired was cut down at the base of the trunk. When I challenged a Woke young girl in a green shirt (of course) about this vandalism she replied: 'It's a weeping willow – it will grow back.' This is what people are paying for when they donate to the Hampshire and Isle of Wight Wildlife Trust and many other 'green' organisations today. It is not the environmental movement that I knew and instead has become a support-system – as with Extinction Rebellion – for a very dark agenda.

Private jets for climate justice

The Cult-owned, Gates-funded, World Economic Forum and its founder Klaus Schwab were behind the emergence of Greta Thunberg to harness the young behind the climate agenda and she was invited to speak to the world at ... the UN. Schwab published a book, *Covid-19: The Great Reset* in 2020 in which he used the 'Covid' hoax and the climate hoax to lay out a new society straight out of Agenda 21 and Agenda 2030. Bill Gates followed in early 2021 when he took time out from destroying the world to produce a book in his name about the way to save it. Gates flies across the world in private jets and admitted that 'I probably have one of the highest greenhouse gas footprints of anyone on the planet ... my personal flying alone is gigantic.' He has also bid for the planet's biggest private jet operator. Other climate change saviours who fly in private jets include John Kerry, the US Special Presidential Envoy for Climate, and actor Leonardo DiCaprio, a 'UN Messenger of Peace with special focus on climate change'. These people are so full of bullshit they could corner the market in manure. We mustn't be sceptical, though, because the Gates book, *How to Avoid a Climate Disaster: The Solutions We Have and the Breakthroughs We Need*, is a genuine attempt to protect the world and not an obvious pile of excrement attributed to a mega-psychopath aimed at selling his masters' plans for humanity. The Gates book and the other shite-pile by Klaus Schwab could have been written by the same person and may well have been. Both use 'climate change' and 'Covid' as the excuses for their new society and by coincidence the Cult's World Economic Forum and Bill and Melinda Gates Foundation promote the climate hoax and hosted Event 201 which pre-empted with a 'simulation' the very 'coronavirus' hoax that would be simulated for real on humanity within weeks. The British 'royal' family is promoting the 'Reset' as you would expect through Prince 'climate change caused the war in Syria' Charles and his hapless son Prince William who said that we must 'reset our relationship with nature and our trajectory as a species' to avoid a climate disaster. Amazing how many promoters of the 'Covid' and 'climate change' control

systems are connected to Gates and the World Economic Forum. A 'study' in early 2021 claimed that carbon dioxide emissions must fall by the equivalent of a global lockdown roughly every two years for the next decade to save the planet. The 'study' appeared in the same period that the Schwab mob claimed in a video that lockdowns destroying the lives of billions are good because they make the earth 'quieter' with less 'ambient noise'. They took down the video amid a public backlash for such arrogant, empathy-deleted stupidity. You see, however, where they are going with this. Corinne Le Quéré, a professor at the Tyndall Centre for Climate Change Research, University of East Anglia, was lead author of the climate lockdown study, and she writes for ... the World Economic Forum. Gates calls in 'his' book for changing 'every aspect of the economy' (long-time Cult agenda) and for humans to eat synthetic 'meat' (predicted in my books) while cows and other farm animals are eliminated. Australian TV host and commentator Alan Jones described what carbon emission targets would mean for farm animals in Australia alone if emissions were reduced as demanded by 35 percent by 2030 and zero by 2050:

Well, let's take agriculture, the total emissions from agriculture are about 75 million tonnes of carbon dioxide, equivalent. Now reduce that by 35 percent and you have to come down to 50 million tonnes, I've done the maths. So if you take for example 1.5 million cows, you're going to have to reduce the herd by 525,000 [by] 2030, nine years, that's 58,000 cows a year. The beef herd's 30 million, reduce that by 35 percent, that's 10.5 million, which means 1.2 million cattle have to go every year between now and 2030. This is insanity!

There are 75 million sheep. Reduce that by 35 percent, that's 26 million sheep, that's almost 3 million a year. So under the Paris Agreement over 30 million beasts, dairy cows, cattle, pigs and sheep would go. More than 8,000 every minute of every hour for the next decade, do these people know what they're talking about?

Clearly they don't at the level of campaigners, politicians and administrators. The Cult *does* know; that's the outcome it wants. We are faced with not just a war on humanity. Animals and the natural world are being targeted and I have been saying since the 'Covid' hoax began that the plan eventually was to claim that the 'deadly virus' is able to jump from animals, including farm animals and

domestic pets, to humans. Just before this book went into production came this story: 'Russia registers world's first Covid-19 vaccine for cats & dogs as makers of Sputnik V warn pets & farm animals could spread virus'. The report said 'top scientists warned that the deadly pathogen could soon begin spreading through homes and farms' and 'the next stage is the infection of farm and domestic animals'. Know the outcome and you'll see the journey. Think what that would mean for animals and keep your eye on a term called zoonosis or zoonotic diseases which transmit between animals and humans. The Cult wants to break the connection between animals and people as it does between people and people. Farm animals fit with the Cult agenda to transform food from natural to synthetic.

The gas of life is killing us

There can be few greater examples of Cult inversion than the condemnation of carbon dioxide as a dangerous pollutant when it is the gas of life. Without it the natural world would be dead and so we would all be dead. We breathe in oxygen and breathe out carbon dioxide while plants produce oxygen and absorb carbon dioxide. It is a perfect symbiotic relationship that the Cult wants to dismantle for reasons I will come to in the final two chapters. Gates, Schwab, other Cult operatives and mindless repeaters, want the world to be 'carbon neutral' by at least 2050 and the earlier the better. 'Zero carbon' is the cry echoed by lunatics calling for 'Zero Covid' when we already have it. These carbon emission targets will deindustrialise the world in accordance with Cult plans – the post-industrial, post-democratic society – and with so-called renewables like solar and wind not coming even close to meeting human energy needs blackouts and cold are inevitable. Texans got the picture in the winter of 2021 when a snow storm stopped wind turbines and solar panels from working and the lights went down along with water which relies on electricity for its supply system. Gates wants everything to be powered by electricity to ensure that his masters have the kill switch to stop all human activity, movement, cooking, water and warmth any time they like. The climate lie is so

stupendously inverted that it claims we must urgently reduce carbon dioxide when we *don't have enough*.

Co2 in the atmosphere is a little above 400 parts per million when the optimum for plant growth is 2,000 ppm and when it falls anywhere near 150 ppm the natural world starts to die and so do we. It fell to as low as 280 ppm in an 1880 measurement in Hawaii and rose to 413 ppm in 2019 with industrialisation which is why the planet has become *greener* in the industrial period. How insane then that psychopathic madman Gates is not satisfied only with blocking the rise of Co2. He's funding technology to suck it out of the atmosphere. The reason why will become clear. The industrial era is not destroying the world through Co2 and has instead turned around a potentially disastrous ongoing fall in Co2. Greenpeace co-founder and scientist Patrick Moore walked away from Greenpeace in 1986 and has exposed the green movement for fear-mongering and lies. He said that 500 million years ago there was *17 times* more Co2 in the atmosphere than we have today and levels have been falling for hundreds of millions of years. In the last 150 million years Co2 levels in Earth's atmosphere had reduced by *90 percent*. Moore said that by the time humanity began to unlock carbon dioxide from fossil fuels we were at '38 seconds to midnight' and in that sense: 'Humans are [the Earth's] salvation.' Moore made the point that only half the Co2 emitted by fossil fuels stays in the atmosphere and we should remember that all pollution pouring from chimneys that we are told is carbon dioxide is in fact nothing of the kind. It's pollution. Carbon dioxide is an invisible gas.

William Happer, Professor of Physics at Princeton University and long-time government adviser on climate, has emphasised the Co2 deficiency for maximum growth and food production. Greenhouse growers don't add carbon dioxide for a bit of fun. He said that most of the warming in the last 100 years, after the earth emerged from the super-cold period of the 'Little Ice Age' into a natural warming cycle, was over by 1940. Happer said that a peak year for warming in 1988 can be explained by a 'monster El Nino' which is a natural and cyclical warming of the Pacific that has nothing to do with 'climate

change'. He said the effect of Co2 could be compared to painting a wall with red paint in that once two or three coats have been applied it didn't matter how much more you slapped on because the wall will not get much redder. Almost all the effect of the rise in Co2 has already happened, he said, and the volume in the atmosphere would now have to *double* to increase temperature by a single degree. Climate hoaxers know this and they have invented the most ridiculously complicated series of 'feedback' loops to try to overcome this rather devastating fact. You hear puppet Greta going on cluelessly about feedback loops and this is why.

The Sun affects temperature? No you *climate denier*

Some other nonsense to contemplate: Climate graphs show that rises in temperature do not follow rises in Co2 – *it's the other way round* with a lag between the two of some 800 years. If we go back 800 years from present time we hit the Medieval Warm Period when temperatures were higher than now without any industrialisation and this was followed by the Little Ice Age when temperatures plummeted. The world was still emerging from these centuries of serious cold when many climate records began which makes the ever-repeated line of the 'hottest year since records began' meaningless when you are not comparing like with like. The coldest period of the Little Ice Age corresponded with the lowest period of sunspot activity when the Sun was at its least active. Proper scientists will not be at all surprised by this when it confirms the obvious fact that earth temperature is affected by the scale of Sun activity and the energetic power that it subsequently emits; but when is the last time you heard a climate hoaxer talking about the Sun as a source of earth temperature?? Everything has to be focussed on Co2 which makes up just 0.117 percent of so-called greenhouse gases and only a fraction of even that is generated by human activity. The rest is natural. More than 90 percent of those greenhouse gases are water vapour and clouds ([Fig 9](#)). Ban moisture I say. Have you noticed that the climate hoaxers no longer use the polar bear as their promotion image? That's because far from becoming extinct polar

bear communities are stable or thriving. Joe Bastardi, American meteorologist, weather forecaster and outspoken critic of the climate lie, documents in his book *The Climate Chronicles* how weather patterns and events claimed to be evidence of climate change have been happening since long before industrialisation: 'What happened before naturally is happening again, as is to be expected given the cyclical nature of the climate due to the design of the planet.' If you read the detailed background to the climate hoax in my other books you will shake your head and wonder how anyone could believe the crap which has spawned a multi-trillion dollar industry based on absolute garbage (see HIV causes AIDs and Sars-Cov-2 causes 'Covid-19'). Climate and 'Covid' have much in common given they have the same source. They both have the contradictory *everything* factor in which everything is explained by reference to them. It's hot – 'it's climate change'. It's cold – 'it's climate change'. I got a sniffle – 'it's Covid'. I haven't got a sniffle – 'it's Covid'. Not having a sniffle has to be a symptom of 'Covid'. Everything is and not having a sniffle is especially dangerous if you are a slow walker. For sheer audacity I offer you a Cambridge University 'study' that actually linked 'Covid' to 'climate change'. It had to happen eventually. They concluded that climate change played a role in 'Covid-19' spreading from animals to humans because ... wait for it ... I kid you not ... *the two groups were forced closer together as populations grow*. Er, that's it. The whole foundation on which this depended was that 'Bats are the likely zoonotic origin of SARS-CoV-1 and SARS-CoV-2'. Well, they are not. They are nothing to do with it. Apart from bats not being the origin and therefore 'climate change' effects on bats being irrelevant I am in awe of their academic insight. Where would we be without them? Not where we are that's for sure.

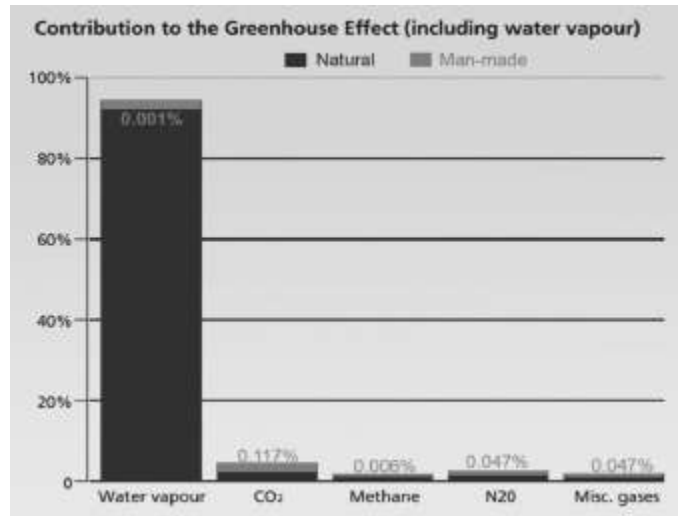


Figure 9: The idea that the gas of life is disastrously changing the climate is an insult to brain cell activity.

One other point about the weather is that climate modification is now well advanced and not every major weather event is natural – or earthquake come to that. I cover this subject at some length in other books. China is openly planning a rapid expansion of its weather modification programme which includes changing the climate in an area more than one and a half times the size of India. China used weather manipulation to ensure clear skies during the 2008 Olympics in Beijing. I have quoted from US military documents detailing how to employ weather manipulation as a weapon of war and they did that in the 1960s and 70s during the conflict in Vietnam with Operation Popeye manipulating monsoon rains for military purposes. Why would there be international treaties on weather modification if it wasn't possible? Of course it is. Weather is energetic information and it can be changed.

How was the climate hoax pulled off? See 'Covid'

If you can get billions to believe in a 'virus' that doesn't exist you can get them to believe in human-caused climate change that doesn't exist. Both are being used by the Cult to transform global society in the way it has long planned. Both hoaxes have been achieved in pretty much the same way. First you declare a lie is a fact. There's a

'virus' you call SARS-Cov-2 or humans are warming the planet with their behaviour. Next this becomes, via Cult networks, the foundation of government, academic and science policy and belief. Those who parrot the mantra are given big grants to produce research that confirms the narrative is true and ever more 'symptoms' are added to make the 'virus'/'climate change' sound even more scary. Scientists and researchers who challenge the narrative have their grants withdrawn and their careers destroyed. The media promote the lie as the unquestionable truth and censor those with an alternative view or evidence. A great percentage of the population believe what they are told as the lie becomes an everybody-knows-that and the believing-masses turn on those with a mind of their own. The technique has been used endlessly throughout human history. Wokers are the biggest promoters of the climate lie *and* 'Covid' fascism because their minds are owned by the Cult; their sense of self-righteous self-purity knows no bounds; and they exist in a bubble of reality in which facts are irrelevant and only get in the way of looking without seeing.

Running through all of this like veins in a blue cheese is control of information, which means control of perception, which means control of behaviour, which collectively means control of human society. The Cult owns the global media and Silicon Valley fascists for the simple reason that it *has* to. Without control of information it can't control perception and through that human society. Examine every facet of the Cult agenda and you will see that anything supporting its introduction is never censored while anything pushing back is always censored. I say again: Psychopaths that know why they are doing this must go before Nuremberg trials and those that follow their orders must trot along behind them into the same dock. 'I was just following orders' didn't work the first time and it must not work now. Nuremberg trials must be held all over the world before public juries for politicians, government officials, police, compliant doctors, scientists and virologists, and all Cult operatives such as Gates, Tedros, Fauci, Vallance, Whitty, Ferguson, Zuckerberg, Wojcicki, Brin, Page, Dorsey, the whole damn lot of

them – including, no *especially*, the psychopath psychologists. Without them and the brainless, gutless excuses for journalists that have repeated their lies, none of this could be happening. Nobody can be allowed to escape justice for the psychological and economic Armageddon they are all responsible for visiting upon the human race.

As for the compliant, unquestioning, swathes of humanity, and the self-obsessed, all-knowing ignorance of the Wokers ... don't start me. God help their kids. God help their grandkids. God *help them*.

CHAPTER NINE

We must have it? So what is it?

*Well I won't back down. No, I won't back down. You can stand me
up at the Gates of Hell. But I won't back down*

Tom Petty

I will now focus on the genetically-manipulating 'Covid vaccines' which do not meet this official definition of a vaccine by the US Centers for Disease Control (CDC): 'A product that stimulates a person's immune system to produce immunity to a specific disease, protecting the person from that disease.' On that basis 'Covid vaccines' are not a vaccine in that the makers don't even claim they stop infection or transmission.

They are instead part of a multi-levelled conspiracy to change the nature of the human body and what it means to be 'human' and to depopulate an enormous swathe of humanity. What I shall call Human 1.0 is on the cusp of becoming Human 2.0 and for very sinister reasons. Before I get to the 'Covid vaccine' in detail here's some background to vaccines in general. Government regulators do not test vaccines – the makers do – and the makers control which data is revealed and which isn't. Children in America are given 50 vaccine doses by age six and 69 by age 19 and the effect of the whole combined schedule has never been tested. Autoimmune diseases when the immune system attacks its own body have soared in the mass vaccine era and so has disease in general in children and the young. Why wouldn't this be the case when vaccines target the *immune system*? The US government gave Big Pharma drug

companies immunity from prosecution for vaccine death and injury in the 1986 National Childhood Vaccine Injury Act (NCVIA) and since then the government (taxpayer) has been funding compensation for the consequences of Big Pharma vaccines. The criminal and satanic drug giants can't lose and the vaccine schedule has increased dramatically since 1986 for this reason. There is no incentive to make vaccines safe and a big incentive to make money by introducing ever more. Even against a ridiculously high bar to prove vaccine liability, and with the government controlling the hearing in which it is being challenged for compensation, the vaccine court has so far paid out more than \$4 billion. These are the vaccines we are told are safe and psychopaths like Zuckerberg censor posts saying otherwise. The immunity law was even justified by a ruling that vaccines by their nature were 'unavoidably unsafe'.

Check out the ingredients of vaccines and you will be shocked if you are new to this. *They put that in children's bodies?? What??* Try aluminium, a brain toxin connected to dementia, aborted foetal tissue and formaldehyde which is used to embalm corpses. World-renowned aluminium expert Christopher Exley had his research into the health effect of aluminium in vaccines shut down by Keele University in the UK when it began taking funding from the Bill and Melinda Gates Foundation. Research when diseases 'eradicated' by vaccines began to decline and you will find the fall began long *before* the vaccine was introduced. Sometimes the fall even plateaued after the vaccine. Diseases like scarlet fever for which there was no vaccine declined in the same way because of environmental and other factors. A perfect case in point is the polio vaccine. Polio began when lead arsenate was first sprayed as an insecticide and residues remained in food products. Spraying started in 1892 and the first US polio epidemic came in Vermont in 1894. The simple answer was to stop spraying, but Rockefeller-created Big Pharma had a better idea. Polio was decreed to be caused by the *poliovirus* which 'spreads from person to person and can infect a person's spinal cord'. Lead arsenate was replaced by the lethal DDT which had the same effect of causing paralysis by damaging the brain and central nervous

system. Polio plummeted when DDT was reduced and then banned, but the vaccine is still given the credit for something it didn't do. Today by far the biggest cause of polio is the vaccines promoted by Bill Gates. Vaccine justice campaigner Robert Kennedy Jr, son of assassinated (by the Cult) US Attorney General Robert Kennedy, wrote:

In 2017, the World Health Organization (WHO) reluctantly admitted that the global explosion in polio is predominantly vaccine strain. The most frightening epidemics in Congo, Afghanistan, and the Philippines, are all linked to vaccines. In fact, by 2018, 70% of global polio cases were vaccine strain.

Vaccines make fortunes for Cult-owned Gates and Big Pharma while undermining the health and immune systems of the population. We had a glimpse of the mentality behind the Big Pharma cartel with a report on WION (World is One News), an international English language TV station based in India, which exposed the extraordinary behaviour of US drug company Pfizer over its 'Covid vaccine'. The WION report told how Pfizer had made fantastic demands of Argentina, Brazil and other countries in return for its 'vaccine'. These included immunity from prosecution, even for Pfizer negligence, government insurance to protect Pfizer from law suits and handing over as collateral sovereign assets of the country to include Argentina's bank reserves, military bases and embassy buildings. Pfizer demanded the same of Brazil in the form of waiving sovereignty of its assets abroad; exempting Pfizer from Brazilian laws; and giving Pfizer immunity from all civil liability. This is a 'vaccine' developed with government funding. Big Pharma is evil incarnate as a creation of the Cult and all must be handed tickets to Nuremberg.

Phantom 'vaccine' for a phantom 'disease'

I'll expose the 'Covid vaccine' fraud and then go on to the wider background of why the Cult has set out to 'vaccinate' every man, woman and child on the planet for an alleged 'new disease' with a survival rate of 99.77 percent (or more) even by the grotesquely-

manipulated figures of the World Health Organization and Johns Hopkins University. The 'infection' to 'death' ratio is 0.23 to 0.15 percent according to Stanford epidemiologist Dr John Ioannidis and while estimates vary the danger remains tiny. I say that if the truth be told the fake infection to fake death ratio is zero. Never mind all the evidence I have presented here and in *The Answer* that there is no 'virus' let us just focus for a moment on that death-rate figure of say 0.23 percent. The figure includes all those worldwide who have tested positive with a test not testing for the 'virus' and then died within 28 days or even longer of any other cause – *any other cause*. Now subtract all those illusory 'Covid' deaths on the global data sheets from the 0.23 percent. What do you think you would be left with? *Zero*. A vaccination has never been successfully developed for a so-called coronavirus. They have all failed at the animal testing stage when they caused hypersensitivity to what they were claiming to protect against and made the impact of a disease far worse. Cult-owned vaccine corporations got around that problem this time by bypassing animal trials, going straight to humans and making the length of the 'trials' before the public rollout as short as they could get away with. Normally it takes five to ten years or more to develop vaccines that still cause demonstrable harm to many people and that's without including the long-term effects that are never officially connected to the vaccination. 'Covid' non-vaccines have been officially produced and approved in a matter of months from a standing start and part of the reason is that (a) they were developed before the 'Covid' hoax began and (b) they are based on computer programs and not natural sources. Official non-trials were so short that government agencies gave *emergency*, not full, approval. 'Trials' were not even completed and full approval cannot be secured until they are. Public 'Covid vaccination' is actually a *continuation of the trial*. Drug company 'trials' are not scheduled to end until 2023 by which time a lot of people are going to be dead. Data on which government agencies gave this emergency approval was supplied by the Big Pharma corporations themselves in the form of Pfizer/BioNTech, AstraZeneca, Moderna, Johnson & Johnson, and

others, and this is the case with all vaccines. By its very nature *emergency* approval means drug companies do not have to prove that the 'vaccine' is 'safe and effective'. How could they with trials way short of complete? Government regulators only have to *believe* that they *could* be safe and effective. It is criminal manipulation to get products in circulation with no testing worth the name. Agencies giving that approval are infested with Big Pharma-connected place-people and they act in the interests of Big Pharma (the Cult) and not the public about whom they do not give a damn.

More human lab rats

'Covid vaccines' produced in record time by Pfizer/BioNTech and Moderna employ a technique *never approved before for use on humans*. They are known as mRNA 'vaccines' and inject a synthetic version of 'viral' mRNA or 'messenger RNA'. The key is in the term 'messenger'. The body works, or doesn't, on the basis of information messaging. Communications are constantly passing between and within the genetic system and the brain. Change those messages and you change the state of the body and even its very nature and you can change psychology and behaviour by the way the brain processes information. I think you are going to see significant changes in personality and perception of many people who have had the 'Covid vaccine' synthetic potions. Insider Aldous Huxley predicted the following in 1961 and mRNA 'vaccines' can be included in the term 'pharmacological methods':

There will be, in the next generation or so, a pharmacological method of making people love their servitude, and producing dictatorship without tears, so to speak, producing a kind of painless concentration camp for entire societies, so that people will in fact have their own liberties taken away from them, but rather enjoy it, because they will be distracted from any desire to rebel by propaganda or brainwashing, or brainwashing enhanced by pharmacological methods. And this seems to be the final revolution.

Apologists claim that mRNA synthetic 'vaccines' don't change the DNA genetic blueprint because RNA does not affect DNA only the other way round. This is so disingenuous. A process called 'reverse

transcription' can convert RNA into DNA and be integrated into DNA in the cell nucleus. This was highlighted in December, 2020, by scientists at Harvard and Massachusetts Institute of Technology (MIT). Geneticists report that more than 40 percent of mammalian genomes results from reverse transcription. On the most basic level if messaging changes then that sequence must lead to changes in DNA which is receiving and transmitting those communications. How can introducing synthetic material into cells not change the cells where DNA is located? The process is known as transfection which is defined as 'a technique to insert foreign nucleic acid (DNA or RNA) into a cell, typically with the intention of altering the properties of the cell'. Researchers at the Sloan Kettering Institute in New York found that changes in messenger RNA can deactivate tumour-suppressing proteins and thereby promote cancer. This is what happens when you mess with messaging. 'Covid vaccine' maker Moderna was founded in 2010 by Canadian stem cell biologist Derrick J. Rossi after his breakthrough discovery in the field of transforming and reprogramming stem cells. These are neutral cells that can be programmed to become any cell including sperm cells. Moderna was therefore founded on the principle of genetic manipulation and has never produced any vaccine or drug before its genetically-manipulating synthetic 'Covid' shite. Look at the name – Mode-RNA or Modify-RNA. Another important point is that the US Supreme Court has ruled that genetically-modified DNA, or complementary DNA (cDNA) synthesized in the laboratory from messenger RNA, can be patented and owned. These psychopaths are doing this to the human body.

Cells replicate synthetic mRNA in the 'Covid vaccines' and in theory the body is tricked into making antigens which trigger antibodies to target the 'virus spike proteins' which as Dr Tom Cowan said have *never been seen*. Cut the crap and these 'vaccines' deliver *self-replicating* synthetic material to the cells with the effect of changing human DNA. The more of them you have the more that process is compounded while synthetic material is all the time self-replicating. 'Vaccine'-maker Moderna describes mRNA as 'like

software for the cell' and so they are messing with the body's software. What happens when you change the software in a computer? Everything changes. For this reason the Cult is preparing a production line of mRNA 'Covid vaccines' and a long list of excuses to use them as with all the 'variants' of a 'virus' never shown to exist. The plan is further to transfer the mRNA technique to other vaccines mostly given to children and young people. The cumulative consequences will be a transformation of human DNA through a constant infusion of synthetic genetic material which will kill many and change the rest. Now consider that governments that have given emergency approval for a vaccine that's not a vaccine; never been approved for humans before; had no testing worth the name; and the makers have been given immunity from prosecution for any deaths or adverse effects suffered by the public. The UK government awarded *permanent legal indemnity* to itself and its employees for harm done when a patient is being treated for 'Covid-19' or 'suspected Covid-19'. That is quite a thought when these are possible 'side-effects' from the 'vaccine' (they are not 'side', they are effects) listed by the US Food and Drug Administration:

Guillain-Barre syndrome; acute disseminated encephalomyelitis; transverse myelitis; encephalitis; myelitis; encephalomyelitis; meningoencephalitis; meningitis; encephalopathy; convulsions; seizures; stroke; narcolepsy; cataplexy; anaphylaxis; acute myocardial infarction (heart attack); myocarditis; pericarditis; autoimmune disease; death; implications for pregnancy, and birth outcomes; other acute demyelinating diseases; non anaphylactic allergy reactions; thrombocytopenia ; disseminated intravascular coagulation; venous thromboembolism; arthritis; arthralgia; joint pain; Kawasaki disease; multisystem inflammatory syndrome in children; vaccine enhanced disease. The latter is the way the 'vaccine' has the potential to make diseases far worse than they would otherwise be.

UK doctor and freedom campaigner Vernon Coleman described the conditions in this list as 'all unpleasant, most of them very serious, and you can't get more serious than death'. The thought that anyone at all has had the 'vaccine' in these circumstances is testament to the potential that humanity has for clueless, unquestioning, stupidity and for many that programmed stupidity has already been terminal.

An insider speaks

Dr Michael Yeadon is a former Vice President, head of research and Chief Scientific Adviser at vaccine giant Pfizer. Yeadon worked on the inside of Big Pharma, but that did not stop him becoming a vocal critic of 'Covid vaccines' and their potential for multiple harms, including infertility in women. By the spring of 2021 he went much further and even used the no, no, term 'conspiracy'. When you begin to see what is going on it is impossible not to do so. Yeadon spoke out in an interview with freedom campaigner James Delingpole and I mentioned earlier how he said that no one had samples of 'the virus'. He explained that the mRNA technique originated in the anti-cancer field and ways to turn on and off certain genes which could be advantageous if you wanted to stop cancer growing out of control. 'That's the origin of them. They are a very unusual application, really.' Yeadon said that treating a cancer patient with an aggressive procedure might be understandable if the alternative was dying, but it was quite another thing to use the same technique as a public health measure. Most people involved wouldn't catch the infectious agent you were vaccinating against and if they did they probably wouldn't die:

If you are really using it as a public health measure you really want to as close as you can get to zero side-effects ... I find it odd that they chose techniques that were really cutting their teeth in the field of oncology and I'm worried that in using gene-based vaccines that have to be injected in the body and spread around the body, get taken up into some cells, and the regulators haven't quite told us which cells they get taken up into ... you are going to be generating a wide range of responses ... with multiple steps each of which could go well or badly.

I doubt the Cult intends it to go well. Yeadon said that you can put any gene you like into the body through the 'vaccine'. 'You can certainly give them a gene that would do them some harm if you wanted.' I was intrigued when he said that when used in the cancer field the technique could turn genes on and off. I explore this process in *The Answer* and with different genes having different functions you could create mayhem – physically and psychologically – if you turned the wrong ones on and the right ones off. I read reports of an experiment by researchers at the University of Washington's school of computer science and engineering in which they encoded DNA to infect computers. The body is itself a biological computer and if human DNA can inflict damage on a computer why can't the computer via synthetic material mess with the human body? It can. The Washington research team said it was possible to insert malicious malware into 'physical DNA strands' and corrupt the computer system of a gene sequencing machine as it 'reads gene letters and stores them as binary digits 0 and 1'. They concluded that hackers could one day use blood or spit samples to access computer systems and obtain sensitive data from police forensics labs or infect genome files. It is at this level of digital interaction that synthetic 'vaccines' need to be seen to get the full picture and that will become very clear later on. Michael Yeadon said it made no sense to give the 'vaccine' to younger people who were in no danger from the 'virus'. What was the benefit? It was all downside with potential effects:

The fact that my government in what I thought was a civilised, rational country, is raining [the 'vaccine'] on people in their 30s and 40s, even my children in their 20s, they're getting letters and phone calls, I know this is not right and any of you doctors who are vaccinating you know it's not right, too. They are not at risk. They are not at risk from the disease, so you are now hoping that the side-effects are so rare that you get away with it. You don't give new technology ... that you don't understand to 100 percent of the population.

Blood clot problems with the AstraZeneca 'vaccine' have been affecting younger people to emphasise the downside risks with no benefit. AstraZeneca's version, produced with Oxford University, does not use mRNA, but still gets its toxic cocktail inside cells where

it targets DNA. The Johnson & Johnson 'vaccine' which uses a similar technique has also produced blood clot effects to such an extent that the United States paused its use at one point. They are all 'gene therapy' (cell modification) procedures and not 'vaccines'. The truth is that once the content of these injections enter cells we have no idea what the effect will be. People can speculate and some can give very educated opinions and that's good. In the end, though, only the makers know what their potions are designed to do and even they won't know every last consequence. Michael Yeadon was scathing about doctors doing what they knew to be wrong. 'Everyone's mute', he said. Doctors in the NHS must know this was not right, coming into work and injecting people. 'I don't know how they sleep at night. I know I couldn't do it. I know that if I were in that position I'd have to quit.' He said he knew enough about toxicology to know this was not a good risk-benefit. Yeadon had spoken to seven or eight university professors and all except two would not speak out publicly. Their universities had a policy that no one said anything that countered the government and its medical advisors. They were afraid of losing their government grants. This is how intimidation has been used to silence the truth at every level of the system. I say silence, but these people could still speak out if they made that choice. Yeadon called them 'moral cowards' – 'This is about your children and grandchildren's lives and you have just buggered off and left it.'

'Variant' nonsense

Some of his most powerful comments related to the alleged 'variants' being used to instil more fear, justify more lockdowns, and introduce more 'vaccines'. He said government claims about 'variants' were nonsense. He had checked the alleged variant 'codes' and they were 99.7 percent identical to the 'original'. This was the human identity difference equivalent to putting a baseball cap on and off or wearing it the other way round. A 0.3 percent difference would make it impossible for that 'variant' to escape immunity from the 'original'. This made no sense of having new 'vaccines' for

‘variants’. He said there would have to be at least a *30 percent* difference for that to be justified and even then he believed the immune system would still recognise what it was. Gates-funded ‘variant modeller’ and ‘vaccine’-pusher John Edmunds might care to comment. Yeadon said drug companies were making new versions of the ‘vaccine’ as a ‘top up’ for ‘variants’. Worse than that, he said, the ‘regulators’ around the world like the MHRA in the UK had got together and agreed that because ‘vaccines’ for ‘variants’ were so similar to the first ‘vaccines’ *they did not have to do safety studies*. How transparently sinister that is. This is when Yeadon said: ‘There is a conspiracy here.’ There was no need for another vaccine for ‘variants’ and yet we were told that there was and the country had shut its borders because of them. ‘They are going into hundreds of millions of arms without passing ‘go’ or any regulator. Why did they do that? Why did they pick this method of making the vaccine?’

The reason had to be something bigger than that it seemed and ‘it’s not protection against the virus’. It’s was a far bigger project that meant politicians and advisers were willing to do things and not do things that knowingly resulted in avoidable deaths – ‘that’s already happened when you think about lockdown and deprivation of health care for a year.’ He spoke of people prepared to do something that results in the avoidable death of their fellow human beings and it not bother them. This is the penny-drop I have been working to get across for more than 30 years – the level of pure evil we are dealing with. Yeadon said his friends and associates could not believe there could be that much evil, but he reminded them of Stalin, Pol Pot and Hitler and of what Stalin had said: ‘One death is a tragedy. A million? A statistic.’ He could not think of a benign explanation for why you need top-up vaccines ‘which I’m sure you don’t’ and for the regulators ‘to just get out of the way and wave them through’. Why would the regulators do that when they were still wrestling with the dangers of the ‘parent’ vaccine? He was clearly shocked by what he had seen since the ‘Covid’ hoax began and now he was thinking the previously unthinkable:

If you wanted to depopulate a significant proportion of the world and to do it in a way that doesn't involve destruction of the environment with nuclear weapons, poisoning everyone with anthrax or something like that, and you wanted plausible deniability while you had a multi-year infectious disease crisis, I actually don't think you could come up with a better plan of work than seems to be in front of me. I can't say that's what they are going to do, but I can't think of a benign explanation why they are doing it.

He said he never thought that they would get rid of 99 percent of humans, but now he wondered. 'If you wanted to that this would be a hell of a way to do it – it would be unstoppable folks.' Yeadon had concluded that those who submitted to the 'vaccine' would be allowed to have some kind of normal life (but for how long?) while screws were tightened to coerce and mandate the last few percent. 'I think they'll put the rest of them in a prison camp. I wish I was wrong, but I don't think I am.' Other points he made included: There were no coronavirus vaccines then suddenly they all come along at the same time; we have no idea of the long term affect with trials so short; coercing or forcing people to have medical procedures is against the Nuremberg Code instigated when the Nazis did just that; people should at least delay having the 'vaccine'; a quick Internet search confirms that masks don't reduce respiratory viral transmission and 'the government knows that'; they have smashed civil society and they know that, too; two dozen peer-reviewed studies show no connection between lockdown and reducing deaths; he knew from personal friends the elite were still flying around and going on holiday while the public were locked down; the elite were not having the 'vaccines'. He was also asked if 'vaccines' could be made to target difference races. He said he didn't know, but the document by the Project for the New American Century in September, 2000, said developing 'advanced forms of biological warfare that can target *specific genotypes* may transform biological warfare from the realm of terror to a politically useful tool.' Oh, they're evil all right. Of that we can be *absolutely* sure.

Another cull of old people

We have seen from the CDC definition that the mRNA 'Covid vaccine' is not a vaccine and nor are the others that *claim* to reduce 'severity of symptoms' in *some* people, but not protect from infection or transmission. What about all the lies about returning to 'normal' if people were 'vaccinated'? If they are not claimed to stop infection and transmission of the alleged 'virus', how does anything change? This was all lies to manipulate people to take the jabs and we are seeing that now with masks and distancing still required for the 'vaccinated'. How did they think that elderly people with fragile health and immune responses were going to be affected by infusing their cells with synthetic material and other toxic substances? They *knew* that in the short and long term it would be devastating and fatal as the culling of the old that began with the first lockdowns was continued with the 'vaccine'. Death rates in care homes soared immediately residents began to be 'vaccinated' – infused with synthetic material. Brave and committed whistleblower nurses put their careers at risk by exposing this truth while the rest kept their heads down and their mouths shut to put their careers before those they are supposed to care for. A long-time American Certified Nursing Assistant who gave his name as James posted a video in which he described emotionally what happened in his care home when vaccination began. He said that during 2020 very few residents were sick with 'Covid' and no one died during the entire year; but shortly after the Pfizer mRNA injections 14 people died within two weeks and many others were near death. 'They're dropping like flies', he said. Residents who walked on their own before the shot could no longer and they had lost their ability to conduct an intelligent conversation. The home's management said the sudden deaths were caused by a 'super-spreader' of 'Covid-19'. Then how come, James asked, that residents who refused to take the injections were not sick? It was a case of inject the elderly with mRNA synthetic potions and blame their illness and death that followed on the 'virus'. James described what was happening in care homes as 'the greatest crime of genocide this country has ever seen'. Remember the NHS staff nurse from earlier who used the same

word 'genocide' for what was happening with the 'vaccines' and that it was an 'act of human annihilation'. A UK care home whistleblower told a similar story to James about the effect of the 'vaccine' in deaths and 'outbreaks' of illness dubbed 'Covid' after getting the jab. She told how her care home management and staff had zealously imposed government regulations and no one was allowed to even question the official narrative let alone speak out against it. She said the NHS was even worse. Again we see the results of reframing. A worker at a local care home where I live said they had not had a single case of 'Covid' there for almost a year and when the residents were 'vaccinated' they had 19 positive cases in two weeks with eight dying.

It's not the 'vaccine' – honest

The obvious cause and effect was being ignored by the media and most of the public. Australia's health minister Greg Hunt (a former head of strategy at the World Economic Forum) was admitted to hospital after he had the 'vaccine'. He was suffering according to reports from the skin infection 'cellulitis' and it must have been a severe case to have warranted days in hospital. Immediately the authorities said this was nothing to do with the 'vaccine' when an effect of some vaccines is a 'cellulitis-like reaction'. We had families of perfectly healthy old people who died after the 'vaccine' saying that if only they had been given the 'vaccine' earlier they would still be alive. As a numbskull rating that is off the chart. A father of four 'died of Covid' at aged 48 when he was taken ill two days after having the 'vaccine'. The man, a health administrator, had been 'shielding during the pandemic' and had 'not really left the house' until he went for the 'vaccine'. Having the 'vaccine' and then falling ill and dying does not seem to have qualified as a possible cause and effect and 'Covid-19' went on his death certificate. His family said they had no idea how he 'caught the virus'. A family member said: 'Tragically, it could be that going for a vaccination ultimately led to him catching Covid ...The sad truth is that they are never going to know where it came from.' The family warned people to remember

that the virus still existed and was 'very real'. So was their stupidity. Nurses and doctors who had the first round of the 'vaccine' were collapsing, dying and ending up in a hospital bed while they or their grieving relatives were saying they'd still have the 'vaccine' again despite what happened. I kid you not. You mean if your husband returned from the dead he'd have the same 'vaccine' again that killed him??

Doctors at the VCU Medical Center in Richmond, Virginia, said the Johnson & Johnson 'vaccine' was to blame for a man's skin peeling off. Patient Richard Terrell said: 'It all just happened so fast. My skin peeled off. It's still coming off on my hands now.' He said it was stinging, burning and itching and when he bent his arms and legs it was very painful with 'the skin swollen and rubbing against itself'. Pfizer/BioNTech and Moderna vaccines use mRNA to change the cell while the Johnson & Johnson version uses DNA in a process similar to AstraZeneca's technique. Johnson & Johnson and AstraZeneca have both had their 'vaccines' paused by many countries after causing serious blood problems. Terrell's doctor Fnu Nutan said he could have died if he hadn't got medical attention. It sounds terrible so what did Nutan and Terrell say about the 'vaccine' now? Oh, they still recommend that people have it. A nurse in a hospital bed 40 minutes after the vaccination and unable to swallow due to throat swelling was told by a doctor that he lost mobility in his arm for 36 hours following the vaccination. What did he say to the ailing nurse? 'Good for you for getting the vaccination.' We are dealing with a serious form of cognitive dissonance madness in both public and medical staff. There is a remarkable correlation between those having the 'vaccine' and trumpeting the fact and suffering bad happenings shortly afterwards. Witold Rogiewicz, a Polish doctor, made a video of his 'vaccination' and ridiculed those who were questioning its safety and the intentions of Bill Gates: 'Vaccinate yourself to protect yourself, your loved ones, friends and also patients. And to mention quickly I have info for anti-vaxxers and anti-Covidors if you want to contact Bill Gates you can do this through me.' He further ridiculed the dangers of 5G. Days later he

was dead, but naturally the vaccination wasn't mentioned in the verdict of 'heart attack'.

Lies, lies and more lies

So many members of the human race have slipped into extreme states of insanity and unfortunately they include reframed doctors and nursing staff. Having a 'vaccine' and dying within minutes or hours is not considered a valid connection while death from any cause within 28 days or longer of a positive test with a test not testing for the 'virus' means 'Covid-19' goes on the death certificate. How could that 'vaccine'-death connection not have been made except by calculated deceit? US figures in the initial rollout period to February 12th, 2020, revealed that a third of the deaths reported to the CDC after 'Covid vaccines' happened within 48 hours. Five men in the UK suffered an 'extremely rare' blood clot problem after having the AstraZeneca 'vaccine', but no causal link was established said the Gates-funded Medicines and Healthcare products Regulatory Agency (MHRA) which had given the 'vaccine' emergency approval to be used. Former Pfizer executive Dr Michael Yeadon explained in his interview how the procedures could cause blood coagulation and clots. People who should have been at no risk were dying from blood clots in the brain and he said he had heard from medical doctor friends that people were suffering from skin bleeding and massive headaches. The AstraZeneca 'shot' was stopped by some 20 countries over the blood clotting issue and still the corrupt MHRA, the European Medicines Agency (EMA) and the World Health Organization said that it should continue to be given even though the EMA admitted that it 'still cannot rule out definitively' a link between blood clotting and the 'vaccine'. Later Marco Cavaleri, head of EMA vaccine strategy, said there was indeed a clear link between the 'vaccine' and thrombosis, but they didn't know why. So much for the trials showing the 'vaccine' is safe. Blood clots were affecting younger people who would be under virtually no danger from 'Covid' even if it existed which makes it all the more stupid and sinister.

The British government responded to public alarm by wheeling out June Raine, the terrifyingly weak infant school headmistress sound-alike who heads the UK MHRA drug 'regulator'. The idea that she would stand up to Big Pharma and government pressure is laughable and she told us that all was well in the same way that she did when allowing untested, never-used-on-humans-before, genetically-manipulating 'vaccines' to be exposed to the public in the first place. Mass lying is the new normal of the 'Covid' era. The MHRA later said 30 cases of rare blood clots had by then been connected with the AstraZeneca 'vaccine' (that means a lot more in reality) while stressing that the benefits of the jab in preventing 'Covid-19' outweighed any risks. A more ridiculous and disingenuous statement with callous disregard for human health it is hard to contemplate. Immediately after the mendacious 'all-clears' two hospital workers in Denmark experienced blood clots and cerebral haemorrhaging following the AstraZeneca jab and one died. Top Norwegian health official Pål Andre Holme said the 'vaccine' was the only common factor: 'There is nothing in the patient history of these individuals that can give such a powerful immune response ... I am confident that the antibodies that we have found are the cause, and I see no other explanation than it being the vaccine which triggers it.' Strokes, a clot or bleed in the brain, were clearly associated with the 'vaccine' from word of mouth and whistleblower reports. Similar consequences followed with all these 'vaccines' that we were told were so safe and as the numbers grew by the day it was clear we were witnessing human carnage.

Learning the hard way

A woman interviewed by UKColumn told how her husband suffered dramatic health effects after the vaccine when he'd been in good health all his life. He went from being a little unwell to losing all feeling in his legs and experiencing 'excruciating pain'. Misdiagnosis followed twice at Accident and Emergency (an 'allergy' and 'sciatica') before he was admitted to a neurology ward where doctors said his serious condition had been caused by the

‘vaccine’. Another seven ‘vaccinated’ people were apparently being treated on the same ward for similar symptoms. The woman said he had the ‘vaccine’ because they believed media claims that it was safe. ‘I didn’t think the government would give out a vaccine that does this to somebody; I believed they would be bringing out a vaccination that would be safe.’ What a tragic way to learn that lesson. Another woman posted that her husband was transporting stroke patients to hospital on almost every shift and when he asked them if they had been ‘vaccinated’ for ‘Covid’ they all replied ‘yes’. One had a ‘massive brain bleed’ the day after his second dose. She said her husband reported the ‘just been vaccinated’ information every time to doctors in A and E only for them to ignore it, make no notes and appear annoyed that it was even mentioned. This particular report cannot be verified, but it expresses a common theme that confirms the monumental underreporting of ‘vaccine’ consequences. Interestingly as the ‘vaccines’ and their brain blood clot/stroke consequences began to emerge the UK National Health Service began a publicity campaign telling the public what to do in the event of a stroke. A Scottish NHS staff nurse who quit in disgust in March, 2021, said:

I have seen traumatic injuries from the vaccine, they’re not getting reported to the yellow card [adverse reaction] scheme, they’re treating the symptoms, not asking why, why it’s happening. It’s just treating the symptoms and when you speak about it you’re dismissed like you’re crazy, I’m not crazy, I’m not crazy because every other colleague I’ve spoken to is terrified to speak out, they’ve had enough.

Videos appeared on the Internet of people uncontrollably shaking after the ‘vaccine’ with no control over muscles, limbs and even their face. A Scottish mother broke out in a severe rash all over her body almost immediately after she was given the AstraZeneca ‘vaccine’. The pictures were horrific. Leigh King, a 41-year-old hairdresser from Lanarkshire said: ‘Never in my life was I prepared for what I was about to experience ... My skin was so sore and constantly hot ... I have never felt pain like this ...’ But don’t you worry, the ‘vaccine’ is perfectly safe. Then there has been the effect on medical

staff who have been pressured to have the 'vaccine' by psychopathic 'health' authorities and government. A London hospital consultant who gave the name K. Polyakova wrote this to the *British Medical Journal* or *BMJ*:

I am currently struggling with ... the failure to report the reality of the morbidity caused by our current vaccination program within the health service and staff population. The levels of sickness after vaccination is unprecedented and staff are getting very sick and some with neurological symptoms which is having a huge impact on the health service function. Even the young and healthy are off for days, some for weeks, and some requiring medical treatment. Whole teams are being taken out as they went to get vaccinated together.

Mandatory vaccination in this instance is stupid, unethical and irresponsible when it comes to protecting our staff and public health. We are in the voluntary phase of vaccination, and encouraging staff to take an unlicensed product that is impacting on their immediate health ... it is clearly stated that these vaccine products do not offer immunity or stop transmission. In which case why are we doing it?

Not to protect health that's for sure. Medical workers are lauded by governments for agenda reasons when they couldn't give a toss about them any more than they can for the population in general. Schools across America faced the same situation as they closed due to the high number of teachers and other staff with bad reactions to the Pfizer/BioNTech, Moderna, and Johnson & Johnson 'Covid vaccines' all of which were linked to death and serious adverse effects. The *BMJ* took down the consultant's comments pretty quickly on the grounds that they were being used to spread 'disinformation'. They were exposing the truth about the 'vaccine' was the real reason. The cover-up is breathtaking.

Hiding the evidence

The scale of the 'vaccine' death cover-up worldwide can be confirmed by comparing official figures with the personal experience of the public. I heard of many people in my community who died immediately or soon after the vaccine that would never appear in the media or even likely on the official totals of 'vaccine' fatalities and adverse reactions when only about ten percent are estimated to be

reported and I have seen some estimates as low as one percent in a Harvard study. In the UK alone by April 29th, 2021, some 757,654 adverse reactions had been officially reported from the Pfizer/BioNTech, Oxford/AstraZeneca and Moderna 'vaccines' with more than a thousand deaths linked to jabs and that means an estimated ten times this number in reality from a ten percent reporting rate percentage. That's seven million adverse reactions and 10,000 potential deaths and a one percent reporting rate would be ten times *those* figures. In 1976 the US government pulled the swine flu vaccine after 53 deaths. The UK data included a combined 10,000 eye disorders from the 'Covid vaccines' with more than 750 suffering visual impairment or blindness and again multiply by the estimated reporting percentages. As 'Covid cases' officially fell hospitals virtually empty during the 'Covid crisis' began to fill up with a range of other problems in the wake of the 'vaccine' rollout. The numbers across America have also been catastrophic. Deaths linked to *all* types of vaccine increased by 6,000 *percent* in the first quarter of 2021 compared with 2020. A 39-year-old woman from Ogden, Utah, died four days after receiving a second dose of Moderna's 'Covid vaccine' when her liver, heart and kidneys all failed despite the fact that she had no known medical issues or conditions. Her family sought an autopsy, but Dr Erik Christensen, Utah's chief medical examiner, said proving vaccine injury as a cause of death almost never happened. He could think of only one instance where an autopsy would name a vaccine as the official cause of death and that would be anaphylaxis where someone received a vaccine and died almost instantaneously. 'Short of that, it would be difficult for us to definitively say this is the vaccine,' Christensen said. If that is true this must be added to the estimated ten percent (or far less) reporting rate of vaccine deaths and serious reactions and the conclusion can only be that vaccine deaths and serious reactions – including these 'Covid' potions' – are phenomenally understated in official figures. The same story can be found everywhere. Endless accounts of deaths and serious reactions among the public, medical

and care home staff while official figures did not even begin to reflect this.

Professional script-reader Dr David Williams, a 'top public-health official' in Ontario, Canada, insulted our intelligence by claiming only four serious adverse reactions and no deaths from the more than 380,000 vaccine doses then given. This bore no resemblance to what people knew had happened in their own circles and we had Dirk Huyer in charge of getting millions vaccinated in Ontario while at the same time he was Chief Coroner for the province investigating causes of death including possible death from the vaccine. An aide said he had stepped back from investigating deaths, but evidence indicated otherwise. Rosemary Frei, who secured a Master of Science degree in molecular biology at the Faculty of Medicine at Canada's University of Calgary before turning to investigative journalism, was one who could see that official figures for 'vaccine' deaths and reactions made no sense. She said that doctors seldom reported adverse events and when people got really sick or died after getting a vaccination they would attribute that to anything except the vaccines. It had been that way for years and anyone who wondered aloud whether the 'Covid vaccines' or other shots cause harm is immediately branded as 'anti-vax' and 'anti-science'. This was 'career-threatening' for health professionals. Then there was the huge pressure to support the push to 'vaccinate' billions in the quickest time possible. Frei said:

So that's where we're at today. More than half a million vaccine doses have been given to people in Ontario alone. The rush is on to vaccinate all 15 million of us in the province by September. And the mainstream media are screaming for this to be sped up even more. That all adds up to only a very slim likelihood that we're going to be told the truth by officials about how many people are getting sick or dying from the vaccines.

What is true of Ontario is true of everywhere.

They KNEW – and still did it

The authorities knew what was going to happen with multiple deaths and adverse reactions. The UK government's Gates-funded

and Big Pharma-dominated Medicines and Healthcare products Regulatory Agency (MHRA) hired a company to employ AI in compiling the projected reactions to the 'vaccine' that would otherwise be uncountable. The request for applications said: 'The MHRA urgently seeks an Artificial Intelligence (AI) software tool to process the expected high volume of Covid-19 vaccine Adverse Drug Reaction ...' This was from the agency, headed by the disingenuous June Raine, that gave the 'vaccines' emergency approval and the company was hired before the first shot was given. 'We are going to kill and maim you – is that okay?' 'Oh, yes, perfectly fine – I'm very grateful, thank you, doctor.' The range of 'Covid vaccine' adverse reactions goes on for page after page in the MHRA criminally underreported 'Yellow Card' system and includes affects to eyes, ears, skin, digestion, blood and so on. Raine's MHRA amazingly claimed that the 'overall safety experience ... is so far as expected from the clinical trials'. The death, serious adverse effects, deafness and blindness were *expected*? When did they ever mention that? If these human tragedies were expected then those that gave approval for the use of these 'vaccines' must be guilty of crimes against humanity including murder – a definition of which is 'killing a person with malice aforethought or with recklessness manifesting extreme indifference to the value of human life.' People involved at the MHRA, the CDC in America and their equivalent around the world must go before Nuremberg trials to answer for their callous inhumanity. We are only talking here about the immediate effects of the 'vaccine'. The longer-term impact of the DNA synthetic manipulation is the main reason they are so hysterically desperate to inoculate the entire global population in the shortest possible time.

Africa and the developing world are a major focus for the 'vaccine' depopulation agenda and a mass vaccination sales-pitch is underway thanks to caring people like the Rockefellers and other Cult assets. The Rockefeller Foundation, which pre-empted the 'Covid pandemic' in a document published in 2010 that 'predicted' what happened a decade later, announced an initial \$34.95 million grant in February, 2021, 'to ensure more equitable access to Covid-19

testing and vaccines' among other things in Africa in collaboration with '24 organizations, businesses, and government agencies'. The pan-Africa initiative would focus on 10 countries: Burkina Faso, Ethiopia, Ghana, Kenya, Nigeria, Rwanda, South Africa, Tanzania, Uganda, and Zambia'. Rajiv Shah, President of the Rockefeller Foundation and former administrator of CIA-controlled USAID, said that if Africa was not mass-vaccinated (to change the DNA of its people) it was a 'threat to all of humanity' and not fair on Africans. When someone from the Rockefeller Foundation says they want to do something to help poor and deprived people and countries it is time for a belly-laugh. They are doing this out of the goodness of their 'heart' because 'vaccinating' the entire global population is what the 'Covid' hoax set out to achieve. Official 'decolonisation' of Africa by the Cult was merely a prelude to financial colonisation on the road to a return to physical colonisation. The 'vaccine' is vital to that and the sudden and convenient death of the 'Covid' sceptic president of Tanzania can be seen in its true light. A lot of people in Africa are aware that this is another form of colonisation and exploitation and they need to stand their ground.

The 'vaccine is working' scam

A potential problem for the Cult was that the 'vaccine' is meant to change human DNA and body messaging and not to protect anyone from a 'virus' never shown to exist. The vaccine couldn't work because it was not designed to work and how could they make it *appear* to be working so that more people would have it? This was overcome by lowering the amplification rate of the PCR test to produce fewer 'cases' and therefore fewer 'deaths'. Some of us had been pointing out since March, 2020, that the amplification rate of the test not testing for the 'virus' had been made artificially high to generate positive tests which they could call 'cases' to justify lockdowns. The World Health Organization recommended an absurdly high 45 amplification cycles to ensure the high positives required by the Cult and then remained silent on the issue until January 20th, 2021 – Biden's Inauguration Day. This was when the

'vaccinations' were seriously underway and on that day the WHO recommended after discussions with America's CDC that laboratories *lowered their testing amplification*. Dr David Samadi, a certified urologist and health writer, said the WHO was encouraging all labs to reduce their cycle count for PCR tests. He said the current cycle was much too high and was 'resulting in any particle being declared a positive case'. Even one mainstream news report I saw said this meant the number of 'Covid' infections may have been 'dramatically inflated'. Oh, just a little bit. The CDC in America issued new guidance to laboratories in April, 2021, to use 28 cycles *but only for 'vaccinated' people*. The timing of the CDC/WHO interventions were cynically designed to make it appear the 'vaccines' were responsible for falling cases and deaths when the real reason can be seen in the following examples. New York's state lab, the Wadsworth Center, identified 872 positive tests in July, 2020, based on a threshold of 40 cycles. When the figure was lowered to 35 cycles 43 percent of the 872 were no longer 'positives'. At 30 cycles the figure was 63 percent. A Massachusetts lab found that between 85 to 90 percent of people who tested positive in July with a cycle threshold of 40 would be negative at 30 cycles, Ashish Jha, MD, director of the Harvard Global Health Institute, said: 'I'm really shocked that it could be that high ... Boy, does it really change the way we need to be thinking about testing.' I'm shocked that I could see the obvious in the spring of 2020, with no medical background, and most medical professionals still haven't worked it out. No, that's not shocking – it's terrifying.

Three weeks after the WHO directive to lower PCR cycles the London *Daily Mail* ran this headline: 'Why ARE Covid cases plummeting? New infections have fallen 45% in the US and 30% globally in the past 3 weeks but experts say vaccine is NOT the main driver because only 8% of Americans and 13% of people worldwide have received their first dose.' They acknowledged that the drop could not be attributed to the 'vaccine', but soon this morphed throughout the media into the 'vaccine' has caused cases and deaths to fall when it was the PCR threshold. In December, 2020, there was

chaos at English Channel ports with truck drivers needing negative 'Covid' tests before they could board a ferry home for Christmas. The government wanted to remove the backlog as fast as possible and they brought in troops to do the 'testing'. Out of 1,600 drivers just 36 tested positive and the rest were given the all clear to cross the Channel. I guess the authorities thought that 36 was the least they could get away with without the unquestioning catching on. The amplification trick which most people believed in the absence of information in the mainstream applied more pressure on those refusing the 'vaccine' to succumb when it 'obviously worked'. The truth was the exact opposite with deaths in care homes soaring with the 'vaccine' and in Israel the term used was 'skyrocket'. A re-analysis of published data from the Israeli Health Ministry led by Dr Hervé Seligmann at the Medicine Emerging Infectious and Tropical Diseases at Aix-Marseille University found that Pfizer's 'Covid vaccine' killed 'about 40 times more [elderly] people than the disease itself would have killed' during a five-week vaccination period and *260 times* more younger people than would have died from the 'virus' even according to the manipulated 'virus' figures. Dr Seligmann and his co-study author, Haim Yativ, declared after reviewing the Israeli 'vaccine' death data: 'This is a new Holocaust.'

Then, in mid-April, 2021, after vast numbers of people worldwide had been 'vaccinated', the story changed with clear coordination. The UK government began to prepare the ground for more future lockdowns when Nuremberg-destined Boris Johnson told yet another whopper. He said that cases had fallen because of *lockdowns* not 'vaccines'. Lockdowns are irrelevant when *there is no 'virus'* and the test and fraudulent death certificates are deciding the number of 'cases' and 'deaths'. Study after study has shown that lockdowns don't work and instead kill and psychologically destroy people. Meanwhile in the United States Anthony Fauci and Rochelle Walensky, the ultra-Zionist head of the CDC, peddled the same line. More lockdown was the answer and not the 'vaccine', a line repeated on cue by the moron that is Canadian Prime Minister Justin Trudeau. Why all the hysteria to get everyone 'vaccinated' if lockdowns and

not 'vaccines' made the difference? None of it makes sense on the face of it. Oh, but it does. The Cult wants lockdowns *and* the 'vaccine' and if the 'vaccine' is allowed to be seen as the total answer lockdowns would no longer be justified when there are still livelihoods to destroy. 'Variants' and renewed upward manipulation of PCR amplification are planned to instigate never-ending lockdown *and* more 'vaccines'.

You *must* have it – we're desperate

Israel, where the Jewish and Arab population are ruled by the Sabbatian Cult, was the front-runner in imposing the DNA-manipulating 'vaccine' on its people to such an extent that Jewish refusers began to liken what was happening to the early years of Nazi Germany. This would seem to be a fantastic claim. Why would a government of Jewish people be acting like the Nazis did? If you realise that the Sabbatian Cult was behind the Nazis and that Sabbatians hate Jews the pieces start to fit and the question of why a 'Jewish' government would treat Jews with such callous disregard for their lives and freedom finds an answer. Those controlling the government of Israel *aren't Jewish* – they're Sabbatian. Israeli lawyer Tamir Turgal was one who made the Nazi comparison in comments to German lawyer Reiner Fuellmich who is leading a class action lawsuit against the psychopaths for crimes against humanity. Turgal described how the Israeli government was vaccinating children and pregnant women on the basis that there was no evidence that this was dangerous when they had no evidence that it *wasn't* dangerous either. They just had no evidence. This was medical experimentation and Turgal said this breached the Nuremberg Code about medical experimentation and procedures requiring informed consent and choice. Think about that. A Nuremberg Code developed because of Nazi experimentation on Jews and others in concentration camps by people like the evil-beyond-belief Josef Mengele is being breached by the *Israeli* government; but when you know that it's a *Sabbatian* government along with its intelligence and military agencies like Mossad, Shin Bet and the Israeli Defense Forces, and that Sabbatians

were the force behind the Nazis, the kaleidoscope comes into focus. What have we come to when Israeli Jews are suing their government for violating the Nuremberg Code by essentially making Israelis subject to a medical experiment using the controversial 'vaccines'? It's a shocker that this has to be done in the light of what happened in Nazi Germany. The Anshe Ha-Emet, or 'People of the Truth', made up of Israeli doctors, lawyers, campaigners and public, have launched a lawsuit with the International Criminal Court. It says:

When the heads of the Ministry of Health as well as the prime minister presented the vaccine in Israel and began the vaccination of Israeli residents, the vaccinated were not advised, that, in practice, they are taking part in a medical experiment and that their consent is required for this under the Nuremberg Code.

The irony is unbelievable, but easily explained in one word: Sabbatians. The foundation of Israeli 'Covid' apartheid is the 'green pass' or 'green passport' which allows Jews and Arabs who have had the DNA-manipulating 'vaccine' to go about their lives – to work, fly, travel in general, go to shopping malls, bars, restaurants, hotels, concerts, gyms, swimming pools, theatres and sports venues, while non-'vaccinated' are banned from all those places and activities. Israelis have likened the 'green pass' to the yellow stars that Jews in Nazi Germany were forced to wear – the same as the yellow stickers that a branch of UK supermarket chain Morrisons told exempt mask-wearers they had to display when shopping. How very sensitive. The Israeli system is blatant South African-style apartheid on the basis of compliance or non-compliance to fascism rather than colour of the skin. How appropriate that the Sabbatian Israeli government was so close to the pre-Mandela apartheid regime in Pretoria. The Sabbatian-instigated 'vaccine passport' in Israel is planned for everywhere. Sabbatians struck a deal with Pfizer that allowed them to lead the way in the percentage of a national population infused with synthetic material and the result was catastrophic. Israeli freedom activist Shai Dannon told me how chairs were appearing on beaches that said 'vaccinated only'. Health Minister Yuli Edelstein said that anyone unwilling or unable to get

the jabs that 'confer immunity' will be 'left behind'. The man's a liar. Not even the makers claim the 'vaccines' confer immunity. When you see those figures of 'vaccine' deaths these psychopaths were saying that you must take the chance the 'vaccine' will kill you or maim you while knowing it will change your DNA or lockdown for you will be permanent. That's fascism. The Israeli parliament passed a law to allow personal information of the non-vaccinated to be shared with local and national authorities for three months. This was claimed by its supporters to be a way to 'encourage' people to be vaccinated. Hadas Ziv from Physicians for Human Rights described this as a 'draconian law which crushed medical ethics and the patient rights'. But that's the idea, the Sabbatians would reply.

Your papers, please

Sabbatian Israel was leading what has been planned all along to be a global 'vaccine pass' called a 'green passport' without which you would remain in permanent lockdown restriction and unable to do anything. This is how badly – *desperately* – the Cult is to get everyone 'vaccinated'. The term and colour 'green' was not by chance and related to the psychology of fusing the perception of the green climate hoax with the 'Covid' hoax and how the 'solution' to both is the same Great Reset. Lying politicians, health officials and psychologists denied there were any plans for mandatory vaccinations or restrictions based on vaccinations, but they knew that was exactly what was meant to happen with governments of all countries reaching agreements to enforce a global system. 'Free' Denmark and 'free' Sweden unveiled digital vaccine certification. Cyprus, Czech Republic, Estonia, Greece, Hungary, Iceland, Italy, Poland, Portugal, Slovakia, and Spain have all committed to a vaccine passport system and the rest including the whole of the EU would follow. The satanic UK government will certainly go this way despite mendacious denials and at the time of writing it is trying to manipulate the public into having the 'vaccine' so they could go abroad on a summer holiday. How would that work without something to prove you had the synthetic toxicity injected into you?

Documents show that the EU's European Commission was moving towards 'vaccine certificates' in 2018 and 2019 before the 'Covid' hoax began. They knew what was coming. Abracadabra – Ursula von der Leyen, the German President of the Commission, announced in March, 2021, an EU 'Digital Green Certificate' – green again – to track the public's 'Covid status'. The passport sting is worldwide and the Far East followed the same pattern with South Korea ruling that only those with 'vaccination' passports – again the *green* pass – would be able to 'return to their daily lives'.

Bill Gates has been preparing for this 'passport' with other Cult operatives for years and beyond the paper version is a Gates-funded 'digital tattoo' to identify who has been vaccinated and who hasn't. The 'tattoo' is reported to include a substance which is externally readable to confirm who has been vaccinated. This is a bio-luminous light-generating enzyme (think fireflies) called ... *Luciferase*. Yes, named after the Cult 'god' Lucifer the 'light bringer' of whom more to come. Gates said he funded the readable tattoo to ensure children in the developing world were vaccinated and no one was missed out. He cares so much about poor kids as we know. This was just the cover story to develop a vaccine tagging system for everyone on the planet. Gates has been funding the ID2020 'alliance' to do just that in league with other lovely people at Microsoft, GAVI, the Rockefeller Foundation, Accenture and IDEO.org. He said in interviews in March, 2020, before any 'vaccine' publicly existed, that the world must have a globalised digital certificate to track the 'virus' and who had been vaccinated. Gates knew from the start that the mRNA vaccines were coming and when they would come and that the plan was to tag the 'vaccinated' to marginalise the intelligent and stop them doing anything including travel. Evil just doesn't suffice. Gates was exposed for offering a \$10 million bribe to the Nigerian House of Representatives to invoke compulsory 'Covid' vaccination of all Nigerians. Sara Cunial, a member of the Italian Parliament, called Gates a 'vaccine criminal'. She urged the Italian President to hand him over to the International Criminal Court for crimes against

humanity and condemned his plans to 'chip the human race' through ID2020.

You know it's a long-planned agenda when war criminal and Cult gofer Tony Blair is on the case. With the scale of arrogance only someone as dark as Blair can muster he said: 'Vaccination in the end is going to be your route to liberty.' Blair is a disgusting piece of work and he confirms that again. The media has given a lot of coverage to a bloke called Charlie Mullins, founder of London's biggest independent plumbing company, Pimlico Plumbers, who has said he won't employ anyone who has not been vaccinated or have them go to any home where people are not vaccinated. He said that if he had his way no one would be allowed to walk the streets if they have not been vaccinated. Gates was cheering at the time while I was alerting the white coats. The plan is that people will qualify for 'passports' for having the first two doses and then to keep it they will have to have all the follow ups and new ones for invented 'variants' until human genetics is transformed and many are dead who can't adjust to the changes. Hollywood celebrities – the usual propaganda stunt – are promoting something called the WELL Health-Safety Rating to verify that a building or space has 'taken the necessary steps to prioritize the health and safety of their staff, visitors and other stakeholders'. They included Lady Gaga, Jennifer Lopez, Michael B. Jordan, Robert DeNiro, Venus Williams, Wolfgang Puck, Deepak Chopra and 17th Surgeon General Richard Carmona. Yawn. WELL Health-Safety has big connections with China. Parent company Delos is headed by former Goldman Sachs partner Paul Scialla. This is another example – and we will see so many others – of using the excuse of 'health' to dictate the lives and activities of the population. I guess one confirmation of the 'safety' of buildings is that only 'vaccinated' people can go in, right?

Electronic concentration camps

I wrote decades ago about the plans to restrict travel and here we are for those who refuse to bow to tyranny. This can be achieved in one go with air travel if the aviation industry makes a blanket decree.

The 'vaccine' and guaranteed income are designed to be part of a global version of China's social credit system which tracks behaviour 24/7 and awards or deletes 'credits' based on whether your behaviour is supported by the state or not. I mean your entire lifestyle – what you do, eat, say, everything. Once your credit score falls below a certain level consequences kick in. In China tens of millions have been denied travel by air and train because of this. All the locations and activities denied to refusers by the 'vaccine' passports will be included in one big mass ban on doing almost anything for those that don't bow their head to government. It's beyond fascist and a new term is required to describe its extremes – I guess fascist technocracy will have to do. The way the Chinese system of technological – technocratic – control is sweeping the West can be seen in the Los Angeles school system and is planned to be expanded worldwide. Every child is required to have a 'Covid'-tracking app scanned daily before they can enter the classroom. The so-called Daily Pass tracking system is produced by Gates' Microsoft which I'm sure will shock you rigid. The pass will be scanned using a barcode (one step from an inside-the-body barcode) and the information will include health checks, 'Covid' tests and vaccinations. Entry codes are for one specific building only and access will only be allowed if a student or teacher has a negative test with a test not testing for the 'virus', has no symptoms of anything alleged to be related to 'Covid' (symptoms from a range of other illness), and has a temperature under 100 degrees. No barcode, no entry, is planned to be the case for everywhere and not only schools.

Kids are being psychologically prepared to accept this as 'normal' their whole life which is why what they can impose in schools is so important to the Cult and its gofers. Long-time American freedom campaigner John Whitehead of the Rutherford Institute was not exaggerating when he said: 'Databit by databit, we are building our own electronic concentration camps.' Canada under its Cult gofer prime minister Justin Trudeau has taken a major step towards the real thing with people interned against their will if they test positive with a test not testing for the 'virus' when they arrive at a Canadian

airport. They are jailed in internment hotels often without food or water for long periods and with many doors failing to lock there have been sexual assaults. The interned are being charged sometimes \$2,000 for the privilege of being abused in this way. Trudeau is fully on board with the Cult and says the 'Covid pandemic' has provided an opportunity for a global 'reset' to permanently change Western civilisation. His number two, Deputy Prime Minister Chrystia Freeland, is a trustee of the World Economic Forum and a Rhodes Scholar. The Trudeau family have long been servants of the Cult. See *The Biggest Secret* and Cathy O'Brien's book *Trance-Formation of America* for the horrific background to Trudeau's father Pierre Trudeau another Canadian prime minister. Hide your fascism behind the façade of a heart-on-the-sleeve liberal. It's a well-honed Cult technique.

What can the 'vaccine' really do?

We have a 'virus' never shown to exist and 'variants' of the 'virus' that have also never been shown to exist except, like the 'original', as computer-generated fictions. Even if you believe there's a 'virus' the 'case' to 'death' rate is in the region of 0.23 to 0.15 percent and those 'deaths' are concentrated among the very old around the same average age that people die anyway. In response to this lack of threat (in truth none) psychopaths and idiots, knowingly and unknowingly answering to Gates and the Cult, are seeking to 'vaccinate' every man, woman and child on Planet Earth. Clearly the 'vaccine' is not about 'Covid' – none of this ever has been. So what is it all about *really*? Why the desperation to infuse genetically-manipulating synthetic material into everyone through mRNA fraudulent 'vaccines' with the intent of doing this over and over with the excuses of 'variants' and other 'virus' inventions? Dr Sherri Tenpenny, an osteopathic medical doctor in the United States, has made herself an expert on vaccines and their effects as a vehement campaigner against their use. Tenpenny was board certified in emergency medicine, the director of a level two trauma centre for 12 years, and moved to Cleveland in 1996 to start an integrative

medicine practice which has treated patients from all 50 states and some 17 other countries. Weaning people off pharmaceutical drugs is a speciality.

She became interested in the consequences of vaccines after attending a meeting at the National Vaccine Information Center in Washington DC in 2000 where she 'sat through four days of listening to medical doctors and scientists and lawyers and parents of vaccine injured kids' and asked: 'What's going on?' She had never been vaccinated and never got ill while her father was given a list of vaccines to be in the military and was 'sick his entire life'. The experience added to her questions and she began to examine vaccine documents from the Centers for Disease Control (CDC). After reading the first one, the 1998 version of *The General Recommendations of Vaccination*, she thought: 'This is it?' The document was poorly written and bad science and Tenpenny began 20 years of research into vaccines that continues to this day. She began her research into 'Covid vaccines' in March, 2020, and she describes them as 'deadly'. For many, as we have seen, they already have been. Tenpenny said that in the first 30 days of the 'vaccine' rollout in the United States there had been more than 40,000 adverse events reported to the vaccine adverse event database. A document had been delivered to her the day before that was 172 pages long. 'We have over 40,000 adverse events; we have over 3,100 cases of [potentially deadly] anaphylactic shock; we have over 5,000 neurological reactions.' Effects ranged from headaches to numbness, dizziness and vertigo, to losing feeling in hands or feet and paraesthesia which is when limbs 'fall asleep' and people have the sensation of insects crawling underneath their skin. All this happened in the first 30 days and remember that only about *ten percent* (or far less) of adverse reactions and vaccine-related deaths are estimated to be officially reported. Tenpenny said:

So can you think of one single product in any industry, any industry, for as long as products have been made on the planet that within 30 days we have 40,000 people complaining of side effects that not only is still on the market but ... we've got paid actors telling us how great

they are for getting their vaccine. We're offering people \$500 if they will just get their vaccine and we've got nurses and doctors going; 'I got the vaccine, I got the vaccine'.

Tenpenny said they were not going to be 'happy dancing folks' when they began to suffer Bell's palsy (facial paralysis), neuropathies, cardiac arrhythmias and autoimmune reactions that kill through a blood disorder. 'They're not going to be so happy, happy then, but we're never going to see pictures of those people' she said. Tenpenny described the 'vaccine' as 'a well-designed killing tool'.

No off-switch

Bad as the initial consequences had been Tenpenny said it would be maybe 14 months before we began to see the 'full ravage' of what is going to happen to the 'Covid vaccinated' with full-out consequences taking anything between two years and 20 years to show. You can understand why when you consider that variations of the 'Covid vaccine' use mRNA (messenger RNA) to in theory activate the immune system to produce protective antibodies without using the actual 'virus'. How can they when it's a computer program and they've never isolated what they claim is the 'real thing'? Instead they use *synthetic* mRNA. They are inoculating synthetic material into the body which through a technique known as the Trojan horse is absorbed into cells to change the nature of DNA. Human DNA is changed by an infusion of messenger RNA and with each new 'vaccine' of this type it is changed even more. Say so and you are banned by Cult Internet platforms. The contempt the contemptuous Mark Zuckerberg has for the truth and human health can be seen in an internal Facebook video leaked to the Project Veritas investigative team in which he said of the 'Covid vaccines': '... I share some caution on this because we just don't know the long term side-effects of basically modifying people's DNA and RNA.' At the same time this disgusting man's Facebook was censoring and banning anyone saying exactly the same. He must go before a Nuremberg trial for crimes against humanity when he *knows* that he

is censoring legitimate concerns and denying the right of informed consent on behalf of the Cult that owns him. People have been killed and damaged by the very 'vaccination' technique he cast doubt on himself when they may not have had the 'vaccine' with access to information that he denied them. The plan is to have at least annual 'Covid vaccinations', add others to deal with invented 'variants', and change all other vaccines into the mRNA system. Pfizer executives told shareholders at a virtual Barclays Global Healthcare Conference in March, 2021, that the public may need a third dose of 'Covid vaccine', plus regular yearly boosters and the company planned to hike prices to milk the profits in a 'significant opportunity for our vaccine'. These are the professional liars, cheats and opportunists who are telling you their 'vaccine' is safe. Given this volume of mRNA planned to be infused into the human body and its ability to then replicate we will have a transformation of human genetics from biological to synthetic biological – exactly the long-time Cult plan for reasons we'll see – and many will die. Sherri Tenpenny said of this replication:

It's like having an on-button but no off-button and that whole mechanism ... they actually give it a name and they call it the Trojan horse mechanism, because it allows that [synthetic] virus and that piece of that [synthetic] virus to get inside of your cells, start to replicate and even get inserted into other parts of your DNA as a Trojan-horse.

Ask the overwhelming majority of people who have the 'vaccine' what they know about the contents and what they do and they would reply: 'The government says it will stop me getting the virus.' Governments give that false impression on purpose to increase take-up. You can read Sherri Tenpenny's detailed analysis of the health consequences in her blog at [Vaxxter.com](https://vaxxter.com), but in summary these are some of them. She highlights the statement by Bill Gates about how human beings can become their own 'vaccine manufacturing machine'. The man is insane. ['Vaccine'-generated] 'antibodies' carry synthetic messenger RNA into the cells and the damage starts, Tenpenny contends, and she says that lungs can be adversely affected through varying degrees of pus and bleeding which

obviously affects breathing and would be dubbed 'Covid-19'. Even more sinister was the impact of 'antibodies' on macrophages, a white blood cell of the immune system. They consist of Type 1 and Type 2 which have very different functions. She said Type 1 are 'hyper-vigilant' white blood cells which 'gobble up' bacteria etc. However, in doing so, this could cause inflammation and in extreme circumstances be fatal. She says these affects are mitigated by Type 2 macrophages which kick in to calm down the system and stop it going rogue. They clear up dead tissue debris and reduce inflammation that the Type 1 'fire crews' have caused. Type 1 kills the infection and Type 2 heals the damage, she says. This is her punchline with regard to 'Covid vaccinations': She says that mRNA 'antibodies' block Type 2 macrophages by attaching to them and deactivating them. This meant that when the Type 1 response was triggered by infection there was nothing to stop that getting out of hand by calming everything down. There's an on-switch, but no off-switch, she says. What follows can be 'over and out, see you when I see you'.

Genetic suicide

Tenpenny also highlights the potential for autoimmune disease – the body attacking itself – which has been associated with vaccines since they first appeared. Infusing a synthetic foreign substance into cells could cause the immune system to react in a panic believing that the body is being overwhelmed by an invader (it is) and the consequences can again be fatal. There is an autoimmune response known as a 'cytokine storm' which I have likened to a homeowner panicked by an intruder and picking up a gun to shoot randomly in all directions before turning the fire on himself. The immune system unleashes a storm of inflammatory response called cytokines to a threat and the body commits hara-kiri. The lesson is that you mess with the body's immune response at your peril and these 'vaccines' seriously – fundamentally – mess with immune response. Tenpenny refers to a consequence called anaphylactic shock which is a severe and highly dangerous allergic reaction when the immune system

floods the body with chemicals. She gives the example of having a bee sting which primes the immune system and makes it sensitive to those chemicals. When people are stung again maybe years later the immune response can be so powerful that it leads to anaphylactic shock. Tenpenny relates this 'shock' with regard to the 'Covid vaccine' to something called polyethylene glycol or PEG. Enormous numbers of people have become sensitive to this over decades of use in a whole range of products and processes including food, drink, skin creams and 'medicine'. Studies have claimed that some 72 percent of people have antibodies triggered by PEG compared with two percent in the 1960s and allergic hypersensitive reactions to this become a gathering cause for concern. Tenpenny points out that the 'mRNA vaccine' is coated in a 'bubble' of polyethylene glycol which has the potential to cause anaphylactic shock through immune sensitivity. Many reports have appeared of people reacting this way after having the 'Covid vaccine'. What do we think is going to happen as humanity has more and more of these 'vaccines'?

Tenpenny said: 'All these pictures we have seen with people with these rashes ... these weepy rashes, big reactions on their arms and things like that – it's an acute allergic reaction most likely to the polyethylene glycol that you've been previously primed and sensitised to.'

Those who have not studied the conspiracy and its perpetrators at length might think that making the population sensitive to PEG and then putting it in these 'vaccines' is just a coincidence. It is not. It is instead testament to how carefully and coldly-planned current events have been and the scale of the conspiracy we are dealing with. Tenpenny further explains that the 'vaccine' mRNA procedure can breach the blood-brain barrier which protects the brain from toxins and other crap that will cause malfunction. In this case they could make two proteins corrupt brain function to cause Amyotrophic lateral sclerosis (ALS), a progressive nervous system disease leading to loss of muscle control, and frontal lobe degeneration – Alzheimer's and dementia. Immunologist J. Bart Classon published a paper connecting mRNA 'vaccines' to prion

disease which can lead to Alzheimer's and other forms of neurodegenerative disease while others have pointed out the potential to affect the placenta in ways that make women infertile. This will become highly significant in the next chapter when I will discuss other aspects of this non-vaccine that relate to its nanotechnology and transmission from the injected to the uninjected.

Qualified in idiocy

Tenpenny describes how research has confirmed that these 'vaccine'-generated antibodies can interact with a range of other tissues in the body and attack many other organs including the lungs. 'This means that if you have a hundred people standing in front of you that all got this shot they could have a hundred different symptoms.' Anyone really think that Cult gofers like the Queen, Tony Blair, Christopher Whitty, Anthony Fauci, and all the other psychopaths have really had this 'vaccine' in the pictures we've seen? Not a bloody chance. Why don't doctors all tell us about all these dangers and consequences of the 'Covid vaccine'? Why instead do they encourage and pressure patients to have the shot? Don't let's think for a moment that doctors and medical staff can't be stupid, lazy, and psychopathic and that's without the financial incentives to give the jab. Tenpenny again:

Some people are going to die from the vaccine directly but a large number of people are going to start to get horribly sick and get all kinds of autoimmune diseases 42 days to maybe a year out. What are they going to do, these stupid doctors who say; 'Good for you for getting that vaccine.' What are they going to say; 'Oh, it must be a mutant, we need to give an extra dose of that vaccine.'

Because now the vaccine, instead of one dose or two doses we need three or four because the stupid physicians aren't taking the time to learn anything about it. If I can learn this sitting in my living room reading a 19 page paper and several others so can they. There's nothing special about me, I just take the time to do it.

Remember how Sara Kayat, the NHS and TV doctor, said that the 'Covid vaccine' would '100 percent prevent hospitalisation and death'. Doctors can be idiots like every other profession and they

should not be worshipped as infallible. They are not and far from it. Behind many medical and scientific 'experts' lies an uninformed prat trying to hide themselves from you although in the 'Covid' era many have failed to do so as with UK narrative-repeating 'TV doctor' Hilary Jones. Pushing back against the minority of proper doctors and scientists speaking out against the 'vaccine' has been the entire edifice of the Cult global state in the form of governments, medical systems, corporations, mainstream media, Silicon Valley, and an army of compliant doctors, medical staff and scientists willing to say anything for money and to enhance their careers by promoting the party line. If you do that you are an 'expert' and if you won't you are an 'anti-vaxxer' and 'Covidiot'. The pressure to be 'vaccinated' is incessant. We have even had reports claiming that the 'vaccine' can help cure cancer and Alzheimer's and make the lame walk. I am waiting for the announcement that it can bring you coffee in the morning and cook your tea. Just as the symptoms of 'Covid' seem to increase by the week so have the miracles of the 'vaccine'. American supermarket giant Kroger Co. offered nearly 500,000 employees in 35 states a \$100 bonus for having the 'vaccine' while donut chain Krispy Kreme promised 'vaccinated' customers a free glazed donut every day for the rest of 2021. Have your DNA changed and you will get a doughnut although we might not have to give you them for long. Such offers and incentives confirm the desperation.

Perhaps the worse vaccine-stunt of them all was UK 'Health' Secretary Matt-the-prat Hancock on live TV after watching a clip of someone being 'vaccinated' when the roll-out began. Hancock faked tears so badly it was embarrassing. Brain-of-Britain Piers Morgan, the lockdown-supporting, 'vaccine' supporting, 'vaccine' passport-supporting, TV host played along with Hancock – 'You're quite emotional about that' he said in response to acting so atrocious it would have been called out at a school nativity which will presumably today include Mary and Jesus in masks, wise men keeping their camels six feet apart, and shepherds under tent arrest. System-serving Morgan tweeted this: 'Love the idea of covid vaccine passports for everywhere: flights, restaurants, clubs, football, gyms,

shops etc. It's time covid-denying, anti-vaxxer loonies had their bullsh*t bluff called & bar themselves from going anywhere that responsible citizens go.' If only I could aspire to his genius. To think that Morgan, who specialises in shouting over anyone he disagrees with, was lauded as a free speech hero when he lost his job after storming off the set of his live show like a child throwing his dolly out of the pram. If he is a free speech hero we are in real trouble. I have no idea what 'bullsh*t' means, by the way, the * throws me completely.

The Cult is desperate to infuse its synthetic DNA-changing concoction into everyone and has been using every lie, trick and intimidation to do so. The question of '*Why?*' we shall now address.

CHAPTER TEN

Human 2.0

I believe that at the end of the century the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted –
Alan Turing (1912-1954), the ‘Father of artificial intelligence’

I have been exposing for decades the plan to transform the human body from a biological to a synthetic-biological state. The new human that I will call Human 2.0 is planned to be connected to artificial intelligence and a global AI ‘Smart Grid’ that would operate as one global system in which AI would control everything from your fridge to your heating system to your car to your mind. Humans would no longer be ‘human’, but post-human and sub-human, with their thinking and emotional processes replaced by AI.

What I said sounded crazy and beyond science fiction and I could understand that. To any balanced, rational, mind it *is* crazy. Today, however, that world is becoming reality and it puts the ‘Covid vaccine’ into its true context. Ray Kurzweil is the ultra-Zionist ‘computer scientist, inventor and futurist’ and co-founder of the Singularity University. Singularity refers to the merging of humans with machines or ‘transhumanism’. Kurzweil has said humanity would be connected to the cyber ‘cloud’ in the period of the ever-recurring year of 2030:

Our thinking ... will be a hybrid of biological and non-biological thinking ... humans will be able to extend their limitations and ‘think in the cloud’ ... We’re going to put gateways to the

cloud in our brains ... We're going to gradually merge and enhance ourselves ... In my view, that's the nature of being human – we transcend our limitations. As the technology becomes vastly superior to what we are then the small proportion that is still human gets smaller and smaller and smaller until it's just utterly negligible.

They are trying to sell this end-of-humanity-as-we-know-it as the next stage of 'evolution' when we become super-human and 'like the gods'. They are lying to you. Shocked, eh? The population, and again especially the young, have been manipulated into addiction to technologies designed to enslave them for life. First they induced an addiction to smartphones (holdables); next they moved to technology on the body (wearables); and then began the invasion of the body (implantables). I warned way back about the plan for microchipped people and we are now entering that era. We should not be diverted into thinking that this refers only to chips we can see. Most important are the nanochips known as smart dust, neural dust and nanobots which are far too small to be seen by the human eye. Nanotechnology is everywhere, increasingly in food products, and released into the atmosphere by the geoengineering of the skies funded by Bill Gates to 'shut out the Sun' and 'save the planet from global warming'. Gates has been funding a project to spray millions of tonnes of chalk (calcium carbonate) into the stratosphere over Sweden to 'dim the Sun' and cool the Earth. Scientists warned the move could be disastrous for weather systems in ways no one can predict and opposition led to the Swedish space agency announcing that the 'experiment' would not be happening as planned in the summer of 2021; but it shows where the Cult is going with dimming the impact of the Sun and there's an associated plan to change the planet's atmosphere. Who gives psychopath Gates the right to dictate to the entire human race and dismantle planetary systems? The world will not be safe while this man is at large.

The global warming hoax has made the Sun, like the gas of life, something to fear when both are essential to good health and human survival (more inversion). The body transforms sunlight into vital vitamin D through a process involving ... *cholesterol*. This is the cholesterol we are also told to fear. We are urged to take Big Pharma

statin drugs to reduce cholesterol and it's all systematic. Reducing cholesterol means reducing vitamin D uptake with all the multiple health problems that will cause. At least if you take statins long term it saves the government from having to pay you a pension. The delivery system to block sunlight is widely referred to as chemtrails although these have a much deeper agenda, too. They appear at first to be contrails or condensation trails streaming from aircraft into cold air at high altitudes. Contrails disperse very quickly while chemtrails do not and spread out across the sky before eventually their content falls to earth. Many times I have watched aircraft cross-cross a clear blue sky releasing chemtrails until it looks like a cloudy day. Chemtrails contain many things harmful to humans and the natural world including toxic heavy metals, aluminium (see Alzheimer's) and nanotechnology. Ray Kurzweil reveals the reason without actually saying so: 'Nanobots will infuse all the matter around us with information. Rocks, trees, everything will become these intelligent creatures.' How do you deliver that? *From the sky*. Self-replicating nanobots would connect everything to the Smart Grid. The phenomenon of Morgellons disease began in the chemtrail era and the correlation has led to it being dubbed the 'chemtrail disease'. Self-replicating fibres appear in the body that can be pulled out through the skin. Morgellons fibres continue to grow outside the body and have a form of artificial intelligence. I cover this at greater length in *Phantom Self*.

'Vaccine' operating system

'Covid vaccines' with their self-replicating synthetic material are also designed to make the connection between humanity and Kurzweil's 'cloud'. American doctor and dedicated campaigner for truth, Carrie Madej, an Internal Medicine Specialist in Georgia with more than 20 years medical experience, has highlighted the nanotechnology aspect of the fake 'vaccines'. She explains how one of the components in at least the Moderna and Pfizer synthetic potions are 'lipid nanoparticles' which are 'like little tiny computer bits' – a 'sci-fi substance' known as nanobots and hydrogel which can be 'triggered

at any moment to deliver its payload' and act as 'biosensors'. The synthetic substance had 'the ability to accumulate data from your body like your breathing, your respiration, thoughts and emotions, all kind of things' and each syringe could carry a *million* nanobots:

This substance because it's like little bits of computers in your body, crazy, but it's true, it can do that, [and] obviously has the ability to act through Wi-Fi. It can receive and transmit energy, messages, frequencies or impulses. That issue has never been addressed by these companies. What does that do to the human?

Just imagine getting this substance in you and it can react to things all around you, the 5G, your smart device, your phones, what is happening with that? What if something is triggering it, too, like an impulse, a frequency? We have something completely foreign in the human body.

Madej said her research revealed that electromagnetic (EMF) frequencies emitted by phones and other devices had increased dramatically in the same period of the 'vaccine' rollout and she was seeing more people with radiation problems as 5G and other electromagnetic technology was expanded and introduced to schools and hospitals. She said she was 'floored with the EMF coming off' the devices she checked. All this makes total sense and syncs with my own work of decades when you think that Moderna refers in documents to its mRNA 'vaccine' as an 'operating system':

Recognizing the broad potential of mRNA science, we set out to create an mRNA technology platform that functions very much like an operating system on a computer. It is designed so that it can plug and play interchangeably with different programs. In our case, the 'program' or 'app' is our mRNA drug – the unique mRNA sequence that codes for a protein ...

... Our MRNA Medicines – 'The 'Software Of Life': When we have a concept for a new mRNA medicine and begin research, fundamental components are already in place. Generally, the only thing that changes from one potential mRNA medicine to another is the coding region – the actual genetic code that instructs ribosomes to make protein. Utilizing these instruction sets gives our investigational mRNA medicines a software-like quality. We also have the ability to combine different mRNA sequences encoding for different proteins in a single mRNA investigational medicine.

Who needs a real ‘virus’ when you can create a computer version to justify infusing your operating system into the entire human race on the road to making living, breathing people into cyborgs? What is missed with the ‘vaccines’ is the *digital* connection between synthetic material and the body that I highlighted earlier with the study that hacked a computer with human DNA. On one level the body is digital, based on mathematical codes, and I’ll have more about that in the next chapter. Those who ridiculously claim that mRNA ‘vaccines’ are not designed to change human genetics should explain the words of Dr Tal Zaks, chief medical officer at Moderna, in a 2017 TED talk. He said that over the last 30 years ‘we’ve been living this phenomenal digital scientific revolution, and I’m here today to tell you, that we are actually *hacking the software of life*, and that it’s changing the way we think about prevention and treatment of disease’:

In every cell there’s this thing called messenger RNA, or mRNA for short, that transmits the critical information from the DNA in our genes to the protein, which is really the stuff we’re all made out of. This is the critical information that determines what the cell will do. So we think about it as an operating system. So if you could change that, if you could introduce a line of code, or change a line of code, it turns out, that has profound implications for everything, from the flu to cancer.

Zaks should more accurately have said that this has profound implications for the human genetic code and the nature of DNA. Communications within the body go both ways and not only one. But, hey, no, the ‘Covid vaccine’ will not affect your genetics. Cult fact-checkers say so even though the man who helped to develop the mRNA technique says that it does. Zaks said in 2017:

If you think about what it is we’re trying to do. We’ve taken information and our understanding of that information and how that information is transmitted in a cell, and we’ve taken our understanding of medicine and how to make drugs, and we’re fusing the two. We think of it as information therapy.

I have been writing for decades that the body is an information field communicating with itself and the wider world. This is why

radiation which is information can change the information field of body and mind through phenomena like 5G and change their nature and function. 'Information therapy' means to change the body's information field and change the way it operates. DNA is a receiver-transmitter of information and can be mutated by information like mRNA synthetic messaging. Technology to do this has been ready and waiting in the underground bases and other secret projects to be rolled out when the 'Covid' hoax was played. 'Trials' of such short and irrelevant duration were only for public consumption. When they say the 'vaccine' is 'experimental' that is not true. It may appear to be 'experimental' to those who don't know what's going on, but the trials have already been done to ensure the Cult gets the result it desires. Zaks said that it took decades to sequence the human genome, completed in 2003, but now they could do it in a week. By 'they' he means scientists operating in the public domain. In the secret projects they were sequencing the genome in a week long before even 2003.

Deluge of mRNA

Highly significantly the Moderna document says the guiding premise is that if using mRNA as a medicine works for one disease then it should work for many diseases. They were leveraging the flexibility afforded by their platform and the fundamental role mRNA plays in protein synthesis to pursue mRNA medicines for a broad spectrum of diseases. Moderna is confirming what I was saying through 2020 that multiple 'vaccines' were planned for 'Covid' (and later invented 'variants') and that previous vaccines would be converted to the mRNA system to infuse the body with massive amounts of genetically-manipulating synthetic material to secure a transformation to a synthetic-biological state. The 'vaccines' are designed to kill stunning numbers as part of the long-exposed Cult depopulation agenda and transform the rest. Given this is the goal you can appreciate why there is such hysterical demand for every human to be 'vaccinated' for an alleged 'disease' that has an estimated 'infection' to 'death' ratio of 0.23-0.15 percent. As I write

children are being given the 'vaccine' in trials (their parents are a disgrace) and ever-younger people are being offered the vaccine for a 'virus' that even if you believe it exists has virtually zero chance of harming them. Horrific effects of the 'trials' on a 12-year-old girl were revealed by a family member to be serious brain and gastric problems that included a bowel obstruction and the inability to swallow liquids or solids. She was unable to eat or drink without throwing up, had extreme pain in her back, neck and abdomen, and was paralysed from the waist down which stopped her urinating unaided. When the girl was first taken to hospital doctors said it was all in her mind. She was signed up for the 'trial' by her parents for whom no words suffice. None of this 'Covid vaccine' insanity makes any sense unless you see what the 'vaccine' really is – a body-changer. Synthetic biology or 'SynBio' is a fast-emerging and expanding scientific discipline which includes everything from genetic and molecular engineering to electrical and computer engineering. Synthetic biology is defined in these ways:

- A multidisciplinary area of research that seeks to create new biological parts, devices, and systems, or to redesign systems that are already found in nature.
- The use of a mixture of physical engineering and genetic engineering to create new (and therefore synthetic) life forms.
- An emerging field of research that aims to combine the knowledge and methods of biology, engineering and related disciplines in the design of chemically-synthesized DNA to create organisms with novel or enhanced characteristics and traits (synthetic organisms including humans).

We now have synthetic blood, skin, organs and limbs being developed along with synthetic body parts produced by 3D printers. These are all elements of the synthetic human programme and this comment by Kurzweil's co-founder of the Singularity University,

Peter Diamandis, can be seen in a whole new light with the 'Covid' hoax and the sanctions against those that refuse the 'vaccine':

Anybody who is going to be resisting the progress forward [to transhumanism] is going to be resisting evolution and, fundamentally, they will die out. It's not a matter of whether it's good or bad. It's going to happen.

'Resisting evolution'? What absolute bollocks. The arrogance of these people is without limit. His 'it's going to happen' mantra is another way of saying 'resistance is futile' to break the spirit of those pushing back and we must not fall for it. Getting this genetically-transforming 'vaccine' into everyone is crucial to the Cult plan for total control and the desperation to achieve that is clear for anyone to see. Vaccine passports are a major factor in this and they, too, are a form of resistance is futile. It's NOT. The paper funded by the Rockefeller Foundation for the 2013 'health conference' in China said:

We will interact more with artificial intelligence. The use of robotics, bio-engineering to augment human functioning is already well underway and will advance. Re-engineering of humans into potentially separate and unequal forms through genetic engineering or mixed human-robots raises debates on ethics and equality.

A new demography is projected to emerge after 2030 [that year again] of technologies (robotics, genetic engineering, nanotechnology) producing robots, engineered organisms, 'nanobots' and artificial intelligence (AI) that can self-replicate. Debates will grow on the implications of an impending reality of human designed life.

What is happening today is so long planned. The world army enforcing the will of the world government is intended to be a robot army, not a human one. Today's military and its technologically 'enhanced' troops, pilotless planes and driverless vehicles are just stepping stones to that end. Human soldiers are used as Cult fodder and its time they woke up to that and worked for the freedom of the population instead of their own destruction and their family's destruction – the same with the police. Join us and let's sort this out. The phenomenon of enforce my own destruction is widespread in the 'Covid' era with Woker 'luvvies' in the acting and entertainment

industries supporting 'Covid' rules which have destroyed their profession and the same with those among the public who put signs on the doors of their businesses 'closed due to Covid – stay safe' when many will never reopen. It's a form of masochism and most certainly insanity.

Transgender = transhumanism

When something explodes out of nowhere and is suddenly everywhere it is always the Cult agenda and so it is with the tidal wave of claims and demands that have infiltrated every aspect of society under the heading of 'transgenderism'. The term 'trans' is so 'in' and this is the dictionary definition:

A prefix meaning 'across', 'through', occurring ... in loanwords from Latin, used in particular for denoting movement or conveyance from place to place (transfer; transmit; transplant) or complete change (transform; transmute), or to form adjectives meaning 'crossing', 'on the other side of', or 'going beyond' the place named (transmontane; transnational; trans-Siberian).

Transgender means to go beyond gender and transhuman means to go beyond human. Both are aspects of the Cult plan to transform the human body to a synthetic state with *no gender*. Human 2.0 is not designed to procreate and would be produced technologically with no need for parents. The new human would mean the end of parents and so men, and increasingly women, are being targeted for the deletion of their rights and status. Parental rights are disappearing at an ever-quickenning speed for the same reason. The new human would have no need for men or women when there is no procreation and no gender. Perhaps the transgender movement that appears to be in a permanent state of frenzy might now contemplate on how it is being used. This was never about transgender rights which are only the interim excuse for confusing gender, particularly in the young, on the road to *fusing* gender. Transgender activism is not an end; it is a *means* to an end. We see again the technique of creative destruction in which you destroy the status quo to 'build back better' in the form that you want. The gender status quo had to be

destroyed by persuading the Cult-created Woke mentality to believe that you can have 100 genders or more. A programme for 9 to 12 year olds produced by the Cult-owned BBC promoted the 100 genders narrative. The very idea may be the most monumental nonsense, but it is not what is true that counts, only what you can make people *believe* is true. Once the gender of $2 + 2 = 4$ has been dismantled through indoctrination, intimidation and $2 + 2 = 5$ then the new no-gender normal can take its place with Human 2.0.

Aldous Huxley revealed the plan in his prophetic *Brave New World* in 1932:

Natural reproduction has been done away with and children are created, decanted', and raised in 'hatcheries and conditioning centres'. From birth, people are genetically designed to fit into one of five castes, which are further split into 'Plus' and 'Minus' members and designed to fulfil predetermined positions within the social and economic strata of the World State.

How could Huxley know this in 1932? For the same reason George Orwell knew about the Big Brother state in 1948, Cult insiders I have quoted knew about it in 1969, and I have known about it since the early 1990s. If you are connected to the Cult or you work your balls off to uncover the plan you can predict the future. The process is simple. If there is a plan for the world and nothing intervenes to stop it then it will happen. Thus if you communicate the plan ahead of time you are perceived to have predicted the future, but you haven't. You have revealed the plan which without intervention will become the human future. The whole reason I have done what I have is to alert enough people to inspire an intervention and maybe at last that time has come with the Cult and its intentions now so obvious to anyone with a brain in working order.

The future is here

Technological wombs that Huxley described to replace parent procreation are already being developed and they are only the projects we know about in the public arena. Israeli scientists told *The Times of Israel* in March, 2021, that they have grown 250-cell embryos

into mouse fetuses with fully formed organs using artificial wombs in a development they say could pave the way for gestating humans outside the womb. Professor Jacob Hanna of the Weizmann Institute of Science said:

We took mouse embryos from the mother at day five of development, when they are just of 250 cells, and had them in the incubator from day five until day 11, by which point they had grown all their organs.

By day 11 they make their own blood and have a beating heart, a fully developed brain. Anybody would look at them and say, 'this is clearly a mouse foetus with all the characteristics of a mouse.' It's gone from being a ball of cells to being an advanced foetus.

A special liquid is used to nourish embryo cells in a laboratory dish and they float on the liquid to duplicate the first stage of embryonic development. The incubator creates all the right conditions for its development, Hanna said. The liquid gives the embryo 'all the nutrients, hormones and sugars they need' along with a custom-made electronic incubator which controls gas concentration, pressure and temperature. The cutting-edge in the underground bases and other secret locations will be light years ahead of that, however, and this was reported by the London *Guardian* in 2017:

We are approaching a biotechnological breakthrough. Ectogenesis, the invention of a complete external womb, could completely change the nature of human reproduction. In April this year, researchers at the Children's Hospital of Philadelphia announced their development of an artificial womb.

The article was headed 'Artificial wombs could soon be a reality. What will this mean for women?' What would it mean for children is an even bigger question. No mother to bond with only a machine in preparation for a life of soulless interaction and control in a world governed by machines (see the *Matrix* movies). Now observe the calculated manipulations of the 'Covid' hoax as human interaction and warmth has been curtailed by distancing, isolation and fear with people communicating via machines on a scale never seen before.

These are all dots in the same picture as are all the personal assistants, gadgets and children's toys through which kids and adults communicate with AI as if it is human. The AI 'voice' on Sat-Nav should be included. All these things are psychological preparation for the Cult endgame. Before you can make a physical connection with AI you have to make a psychological connection and that is what people are being conditioned to do with this ever gathering human-AI interaction. Movies and TV programmes depicting the transhuman, robot dystopia relate to a phenomenon known as 'pre-emptive programming' in which the world that is planned is portrayed everywhere in movies, TV and advertising. This is conditioning the conscious and subconscious mind to become familiar with the planned reality to dilute resistance when it happens for real. What would have been a shock such is the change is made less so. We have young children put on the road to transgender transition surgery with puberty blocking drugs at an age when they could never be able to make those life-changing decisions.

Rachel Levine, a professor of paediatrics and psychiatry who believes in treating children this way, became America's highest-ranked openly-transgender official when she was confirmed as US Assistant Secretary at the Department of Health and Human Services after being nominated by Joe Biden (the Cult). Activists and governments press for laws to deny parents a say in their children's transition process so the kids can be isolated and manipulated into agreeing to irreversible medical procedures. A Canadian father Robert Hoogland was denied bail by the Vancouver Supreme Court in 2021 and remained in jail for breaching a court order that he stay silent over his young teenage daughter, a minor, who was being offered life-changing hormone therapy without parental consent. At the age of 12 the girl's 'school counsellor' said she may be transgender, referred her to a doctor and told the school to treat her like a boy. This is another example of state-serving schools imposing ever more control over children's lives while parents have ever less.

Contemptible and extreme child abuse is happening all over the world as the Cult gender-fusion operation goes into warp-speed.

Why the war on men – and now women?

The question about what artificial wombs mean for women should rightly be asked. The answer can be seen in the deletion of women's rights involving sport, changing rooms, toilets and status in favour of people in male bodies claiming to identify as women. I can identify as a mountain climber, but it doesn't mean I can climb a mountain any more than a biological man can be a biological woman. To believe so is a triumph of belief over factual reality which is the very perceptual basis of everything Woke. Women's sport is being destroyed by allowing those with male bodies who say they identify as female to 'compete' with girls and women. Male body 'women' dominate 'women's' competition with their greater muscle mass, bone density, strength and speed. With that disadvantage sport for women loses all meaning. To put this in perspective nearly 300 American high school boys can run faster than the quickest woman sprinter in the world. Women are seeing their previously protected spaces invaded by male bodies simply because they claim to identify as women. That's all they need to do to access all women's spaces and activities under the Biden 'Equality Act' that destroys equality for women with the usual Orwellian Woke inversion. Male sex offenders have already committed rapes in women's prisons after claiming to identify as women to get them transferred. Does this not matter to the Woke 'equality' hypocrites? Not in the least. What matters to Cult manipulators and funders behind transgender activists is to advance gender fusion on the way to the no-gender 'human'. When you are seeking to impose transparent nonsense like this, or the 'Covid' hoax, the only way the nonsense can prevail is through censorship and intimidation of dissenters, deletion of factual information, and programming of the unquestioning, bewildered and naive. You don't have to scan the world for long to see that all these things are happening.

Many women's rights organisations have realised that rights and status which took such a long time to secure are being eroded and that it is systematic. Kara Dansky of the global Women's Human Rights Campaign said that Biden's transgender executive order immediately he took office, subsequent orders, and Equality Act legislation that followed 'seek to erase women and girls in the law as a category'. *Exactly*. I said during the long ago-started war on men (in which many women play a crucial part) that this was going to turn into a war on them. The Cult is phasing out *both* male and female genders. To get away with that they are brought into conflict so they are busy fighting each other while the Cult completes the job with no unity of response. Unity, people, *unity*. We need unity everywhere. Transgender is the only show in town as the big step towards the no-gender human. It's not about rights for transgender people and never has been. Woke political correctness is deleting words relating to genders to the same end. Wokers believe this is to be 'inclusive' when the opposite is true. They are deleting words describing gender because gender *itself* is being deleted by Human 2.0. Terms like 'man', 'woman', 'mother' and 'father' are being deleted in the universities and other institutions to be replaced by the *no*-gender, not trans-gender, 'individuals' and 'guardians'. Women's rights campaigner Maria Keffler of Partners for Ethical Care said: 'Children are being taught from kindergarten upward that some boys have a vagina, some girls have a penis, and that kids can be any gender they want to be.' Do we really believe that suddenly countries all over the world at the same time had the idea of having drag queens go into schools or read transgender stories to very young children in the local library? It's coldly-calculated confusion of gender on the way to the fusion of gender. Suzanne Vierling, a psychologist from Southern California, made another important point:

Yesterday's slave woman who endured gynecological medical experiments is today's girl-child being butchered in a booming gender-transitioning sector. Ovaries removed, pushing her into menopause and osteoporosis, uncharted territory, and parents' rights and authority decimated.

The erosion of parental rights is a common theme in line with the Cult plans to erase the very concept of parents and 'ovaries removed, pushing her into menopause' means what? Those born female lose the ability to have children – another way to discontinue humanity as we know it.

Eliminating Human 1.0 (before our very eyes)

To pave the way for Human 2.0 you must phase out Human 1.0. This is happening through plummeting sperm counts and making women infertile through an onslaught of chemicals, radiation (including smartphones in pockets of men) and mRNA 'vaccines'. Common agriculture pesticides are also having a devastating impact on human fertility. I have been tracking collapsing sperm counts in the books for a long time and in 2021 came a book by fertility scientist and reproductive epidemiologist Shanna Swan, *Count Down: How Our Modern World Is Threatening Sperm Counts, Altering Male and Female Reproductive Development and Imperiling the Future of the Human Race*. She reports how the global fertility rate dropped by *half* between 1960 and 2016 with America's birth rate 16 percent below where it needs to be to sustain the population. Women are experiencing declining egg quality, more miscarriages, and more couples suffer from infertility. Other findings were an increase in erectile dysfunction, infant boys developing more genital abnormalities, male problems with conception, and plunging levels of the male hormone testosterone which would explain why so many men have lost their backbone and masculinity. This has been very evident during the 'Covid' hoax when women have been prominent among the Pushbackers and big strapping blokes have bowed their heads, covered their faces with a nappy and quietly submitted. Mind control expert Cathy O'Brien also points to how global education introduced the concept of 'we're all winners' in sport and classrooms: 'Competition was defused, and it in turn defused a sense of fighting back.' This is another version of the 'equity' doctrine in which you drive down rather than raise up. What a contrast in Cult-controlled China with its global ambitions

where the government published plans in January, 2021, to 'cultivate masculinity' in boys from kindergarten through to high school in the face of a 'masculinity crisis'. A government adviser said boys would be soon become 'delicate, timid and effeminate' unless action was taken. Don't expect any similar policy in the targeted West. A 2006 study showed that a 65-year-old man in 2002 had testosterone levels 15 percent lower than a 65-year-old man in 1987 while a 2020 study found a similar story with young adults and adolescents. Men are getting prescriptions for testosterone replacement therapy which causes an even greater drop in sperm count with up to 99 percent seeing sperm counts drop to zero during the treatment. More sperm is defective and malfunctioning with some having two heads or not pursuing an egg.

A class of *synthetic* chemicals known as phthalates are being blamed for the decline. These are found everywhere in plastics, shampoos, cosmetics, furniture, flame retardants, personal care products, pesticides, canned foods and even receipts. Why till receipts? Everyone touches them. Let no one delude themselves that all this is not systematic to advance the long-time agenda for human body transformation. Phthalates mimic hormones and disrupt the hormone balance causing testosterone to fall and genital birth defects in male infants. Animals and fish have been affected in the same way due to phthalates and other toxins in rivers. When fish turn gay or change sex through chemicals in rivers and streams it is a pointer to why there has been such an increase in gay people and the sexually confused. It doesn't matter to me what sexuality people choose to be, but if it's being affected by chemical pollution and consumption then we need to know. Does anyone really think that this is not connected to the transgender agenda, the war on men and the condemnation of male 'toxic masculinity'? You watch this being followed by 'toxic femininity'. It's already happening. When breastfeeding becomes 'chest-feeding', pregnant women become pregnant people along with all the other Woke claptrap you know that the world is going insane and there's a Cult scam in progress. Transgender activists are promoting the Cult agenda while Cult

billionaires support and fund the insanity as they laugh themselves to sleep at the sheer stupidity for which humans must be infamous in galaxies far, far away.

‘Covid vaccines’ and female infertility

We can now see why the ‘vaccine’ has been connected to potential infertility in women. Dr Michael Yeadon, former Vice President and Chief Scientific Advisor at Pfizer, and Dr Wolfgang Wodarg in Germany, filed a petition with the European Medicines Agency in December, 2020, urging them to stop trials for the Pfizer/BioNTech shot and all other mRNA trials until further studies had been done. They were particularly concerned about possible effects on fertility with ‘vaccine’-produced antibodies attacking the protein Syncytin-1 which is responsible for developing the placenta. The result would be infertility ‘of indefinite duration’ in women who have the ‘vaccine’ with the placenta failing to form. Section 10.4.2 of the Pfizer/BioNTech trial protocol says that pregnant women or those who might become so should not have mRNA shots. Section 10.4 warns men taking mRNA shots to ‘be abstinent from heterosexual intercourse’ and not to donate sperm. The UK government said that it *did not know* if the mRNA procedure had an effect on fertility. *Did not know?* These people have to go to jail. UK government advice did not recommend at the start that pregnant women had the shot and said they should avoid pregnancy for at least two months after ‘vaccination’. The ‘advice’ was later updated to pregnant women should only have the ‘vaccine’ if the benefits outweighed the risks to mother and foetus. What the hell is that supposed to mean? Then ‘spontaneous abortions’ began to appear and rapidly increase on the adverse reaction reporting schemes which include only a fraction of adverse reactions. Thousands and ever-growing numbers of ‘vaccinated’ women are describing changes to their menstrual cycle with heavier blood flow, irregular periods and menstruating again after going through the menopause – all links to reproduction effects. Women are passing blood clots and the lining of their uterus while men report erectile dysfunction and blood effects. Most

significantly of all *unvaccinated* women began to report similar menstrual changes after interaction with '*vaccinated*' people and men and children were also affected with bleeding noses, blood clots and other conditions. 'Shedding' is when vaccinated people can emit the content of a vaccine to affect the unvaccinated, but this is different. 'Vaccinated' people were not shedding a 'live virus' allegedly in 'vaccines' as before because the fake 'Covid vaccines' involve synthetic material and other toxicity. Doctors exposing what is happening prefer the term 'transmission' to shedding. Somehow those that have had the shots are transmitting effects to those that haven't. Dr Carrie Madej said the nano-content of the 'vaccines' can 'act like an antenna' to others around them which fits perfectly with my own conclusions. This 'vaccine' transmission phenomenon was becoming known as the book went into production and I deal with this further in the Postscript.

Vaccine effects on sterility are well known. The World Health Organization was accused in 2014 of sterilising millions of women in Kenya with the evidence confirmed by the content of the vaccines involved. The same WHO behind the 'Covid' hoax admitted its involvement for more than ten years with the vaccine programme. Other countries made similar claims. Charges were lodged by Tanzania, Nicaragua, Mexico, and the Philippines. The Gardasil vaccine claimed to protect against a genital 'virus' known as HPV has also been linked to infertility. Big Pharma and the WHO (same thing) are criminal and satanic entities. Then there's the Bill Gates Foundation which is connected through funding and shared interests with 20 pharmaceutical giants and laboratories. He stands accused of directing the policy of United Nations Children's Fund (UNICEF), vaccine alliance GAVI, and other groupings, to advance the vaccine agenda and silence opposition at great cost to women and children. At the same time Gates wants to reduce the global population. Coincidence?

Great Reset = Smart Grid = new human

The Cult agenda I have been exposing for 30 years is now being openly promoted by Cult assets like Gates and Klaus Schwab of the World Economic Forum under code-terms like the 'Great Reset', 'Build Back Better' and 'a rare but narrow window of opportunity to reflect, reimagine, and reset our world'. What provided this 'rare but narrow window of opportunity'? The 'Covid' hoax did. Who created that? *They* did. My books from not that long ago warned about the planned 'Internet of Things' (IoT) and its implications for human freedom. This was the plan to connect all technology to the Internet and artificial intelligence and today we are way down that road with an estimated 36 billion devices connected to the World Wide Web and that figure is projected to be 76 billion by 2025. I further warned that the Cult planned to go beyond that to the Internet of *Everything* when the human brain was connected via AI to the Internet and Kurzweil's 'cloud'. Now we have Cult operatives like Schwab calling for precisely that under the term 'Internet of Bodies', a fusion of the physical, digital and biological into one centrally-controlled Smart Grid system which the Cult refers to as the 'Fourth Industrial Revolution'. They talk about the 'biological', but they really mean the synthetic-biological which is required to fully integrate the human body and brain into the Smart Grid and artificial intelligence planned to replace the human mind. We have everything being synthetically manipulated including the natural world through GMO and smart dust, the food we eat and the human body itself with synthetic 'vaccines'. I said in *The Answer* that we would see the Cult push for synthetic meat to replace animals and in February, 2021, the so predictable psychopath Bill Gates called for the introduction of synthetic meat to save us all from 'climate change'. The climate hoax just keeps on giving like the 'Covid' hoax. The war on meat by vegan activists is a carbon (oops, sorry) copy of the manipulation of transgender activists. They have no idea (except their inner core) that they are being used to promote and impose the agenda of the Cult or that they are only the *vehicle* and not the *reason*. This is not to say those who choose not to eat meat shouldn't be respected and supported in that right, but there are ulterior motives

for those in power. A *Forbes* article in December, 2019, highlighted the plan so beloved of Schwab and the Cult under the heading: 'What Is The Internet of Bodies? And How Is It Changing Our World?' The article said the human body is the latest data platform (remember 'our vaccine is an operating system'). *Forbes* described the plan very accurately and the words could have come straight out of my books from long before:

The Internet of Bodies (IoB) is an extension of the IoT and basically connects the human body to a network through devices that are ingested, implanted, or connected to the body in some way. Once connected, data can be exchanged, and the body and device can be remotely monitored and controlled.

They were really describing a human hive mind with human perception centrally-dictated via an AI connection as well as allowing people to be 'remotely monitored and controlled'. Everything from a fridge to a human mind could be directed from a central point by these insane psychopaths and 'Covid vaccines' are crucial to this. *Forbes* explained the process I mentioned earlier of holdable and wearable technology followed by implantable. The article said there were three generations of the Internet of Bodies that include:

- Body external: These are wearable devices such as Apple Watches or Fitbits that can monitor our health.
- Body internal: These include pacemakers, cochlear implants, and digital pills that go inside our bodies to monitor or control various aspects of health.
- Body embedded: The third generation of the Internet of Bodies is embedded technology where technology and the human body are melded together and have a real-time connection to a remote machine.

Forbes noted the development of the Brain Computer Interface (BCI) which merges the brain with an external device for monitoring and controlling in real-time. 'The ultimate goal is to help restore function to individuals with disabilities by using brain signals rather than conventional neuromuscular pathways.' Oh, do fuck off. The goal of brain interface technology is controlling human thought and emotion from the central point in a hive mind serving its masters wishes. Many people are now agreeing to be chipped to open doors without a key. You can recognise them because they'll be wearing a mask, social distancing and lining up for the 'vaccine'. The Cult plans a Great Reset money system after they have completed the demolition of the global economy in which 'money' will be exchanged through communication with body operating systems. Rand Corporation, a Cult-owned think tank, said of the Internet of Bodies or IoB:

Internet of Bodies technologies fall under the broader IoT umbrella. But as the name suggests, IoB devices introduce an even more intimate interplay between humans and gadgets. IoB devices monitor the human body, collect health metrics and other personal information, and transmit those data over the Internet. Many devices, such as fitness trackers, are already in use ... IoB devices ... and those in development can track, record, and store users' whereabouts, bodily functions, and what they see, hear, and even think.

Schwab's World Economic Forum, a long-winded way of saying 'fascism' or 'the Cult', has gone full-on with the Internet of Bodies in the 'Covid' era. 'We're entering the era of the Internet of Bodies', it declared, 'collecting our physical data via a range of devices that can be implanted, swallowed or worn'. The result would be a huge amount of health-related data that could improve human wellbeing around the world, and prove crucial in fighting the 'Covid-19 pandemic'. Does anyone think these clowns care about 'human wellbeing' after the death and devastation their pandemic hoax has purposely caused? Schwab and co say we should move forward with the Internet of Bodies because 'Keeping track of symptoms could help us stop the spread of infection, and quickly detect new cases'. How wonderful, but keeping track' is all they are really bothered

about. Researchers were investigating if data gathered from smartwatches and similar devices could be used as viral infection alerts by tracking the user's heart rate and breathing. Schwab said in his 2018 book *Shaping the Future of the Fourth Industrial Revolution*:

The lines between technologies and beings are becoming blurred and not just by the ability to create lifelike robots or synthetics. Instead it is about the ability of new technologies to literally become part of us. Technologies already influence how we understand ourselves, how we think about each other, and how we determine our realities. As the technologies ... give us deeper access to parts of ourselves, we may begin to integrate digital technologies into our bodies.

You can see what the game is. Twenty-four hour control and people – if you could still call them that – would never know when something would go ping and take them out of circulation. It's the most obvious rush to a global fascist dictatorship and the complete submission of humanity and yet still so many are locked away in their Cult-induced perceptual coma and can't see it.

Smart Grid control centres

The human body is being transformed by the 'vaccines' and in other ways into a synthetic cyborg that can be attached to the global Smart Grid which would be controlled from a central point and other sub-locations of Grid manipulation. Where are these planned to be? Well, China for a start which is one of the Cult's biggest centres of operation. The technological control system and technocratic rule was incubated here to be unleashed across the world after the 'Covid' hoax came out of China in 2020. Another Smart Grid location that will surprise people new to this is Israel. I have exposed in *The Trigger* how Sabbatian technocrats, intelligence and military operatives were behind the horrors of 9/11 and not 19 Arab hijackers' who somehow manifested the ability to pilot big passenger airliners when instructors at puddle-jumping flying schools described some of them as a joke. The 9/11 attacks were made possible through control of civilian and military air computer systems and those of the White House, Pentagon and connected agencies. See *The Trigger* – it

will blow your mind. The controlling and coordinating force were the Sabbatian networks in Israel and the United States which by then had infiltrated the entire US government, military and intelligence system. The real name of the American Deep State is 'Sabbatian State'. Israel is a tiny country of only nine million people, but it is one of the global centres of cyber operations and fast catching Silicon Valley in importance to the Cult. Israel is known as the 'start-up nation' for all the cyber companies spawned there with the Sabbatian specialisation of 'cyber security' that I mentioned earlier which gives those companies access to computer systems of their clients in real time through 'backdoors' written into the coding when security software is downloaded. The Sabbatian centre of cyber operations outside Silicon Valley is the Israeli military Cyber Intelligence Unit, the biggest infrastructure project in Israel's history, headquartered in the desert-city of Beersheba and involving some 20,000 'cyber soldiers'. Here are located a literal army of Internet trolls scanning social media, forums and comment lists for anyone challenging the Cult agenda. The UK military has something similar with its 77th Brigade and associated operations. The Beersheba complex includes research and development centres for other Cult operations such as Intel, Microsoft, IBM, Google, Apple, Hewlett-Packard, Cisco Systems, Facebook and Motorola. Techcrunch.com ran an article about the Beersheba global Internet technology centre headlined 'Israel's desert city of Beersheba is turning into a cybertech oasis':

The military's massive relocation of its prestigious technology units, the presence of multinational and local companies, a close proximity to Ben Gurion University and generous government subsidies are turning Beersheba into a major global cybertech hub. Beersheba has all of the ingredients of a vibrant security technology ecosystem, including Ben Gurion University with its graduate program in cybersecurity and Cyber Security Research Center, and the presence of companies such as EMC, Deutsche Telekom, PayPal, Oracle, IBM, and Lockheed Martin. It's also the future home of the INCB (Israeli National Cyber Bureau); offers a special income tax incentive for cyber security companies, and was the site for the relocation of the army's intelligence corps units.

Sabbatians have taken over the cyber world through the following process: They scan the schools for likely cyber talent and develop them at Ben Gurion University and their period of conscription in the Israeli Defense Forces when they are stationed at the Beersheba complex. When the cyber talented officially leave the army they are funded to start cyber companies with technology developed by themselves or given to them by the state. Much of this is stolen through backdoors of computer systems around the world with America top of the list. Others are sent off to Silicon Valley to start companies or join the major ones and so we have many major positions filled by apparently 'Jewish' but really Sabbatian operatives. Google, YouTube and Facebook are all run by 'Jewish' CEOs while Twitter is all but run by ultra-Zionist hedge-fund shark Paul Singer. At the centre of the Sabbatian global cyber web is the Israeli army's Unit 8200 which specialises in hacking into computer systems of other countries, inserting viruses, gathering information, instigating malfunction, and even taking control of them from a distance. A long list of Sabbatians involved with 9/11, Silicon Valley and Israeli cyber security companies are operatives of Unit 8200. This is not about Israel. It's about the Cult. Israel is planned to be a Smart Grid hub as with China and what is happening at Beersheba is not for the benefit of Jewish people who are treated disgustingly by the Sabbatian elite that control the country. A glance at the Nuremberg Codes will tell you that.

The story is much bigger than 'Covid', important as that is to where we are being taken. Now, though, it's time to really strap in. There's more ... much more ...

CHAPTER ELEVEN

Who controls the Cult?

Awake, arise or be forever fall'n
John Milton, *Paradise Lost*

I have exposed this far the level of the Cult conspiracy that operates in the world of the seen and within the global secret society and satanic network which operates in the shadows one step back from the seen. The story, however, goes much deeper than that.

The 'Covid' hoax is major part of the Cult agenda, but only part, and to grasp the biggest picture we have to expand our attention beyond the realm of human sight and into the infinity of possibility that we cannot see. It is from here, ultimately, that humanity is being manipulated into a state of total control by the force which dictates the actions of the Cult. How much of reality can we see? Next to damn all is the answer. We may appear to see all there is to see in the 'space' our eyes survey and observe, but little could be further from the truth. The human 'world' is only a tiny band of frequency that the body's visual and perceptual systems can decode into *perception* of a 'world'. According to mainstream science the electromagnetic spectrum is 0.005 percent of what exists in the Universe ([Fig 10](#)). The maximum estimate I have seen is 0.5 percent and either way it's miniscule. I say it is far, far, smaller even than 0.005 percent when you compare reality we see with the totality of reality that we don't. Now get this if you are new to such information: Visible light, the only band of frequency that we can see, is a *fraction* of the 0.005

percent (Fig 11 overleaf). Take this further and realise that our universe is one of infinite universes and that universes are only a fragment of overall reality – *infinite* reality. Then compare that with the almost infinitesimal frequency band of visible light or human sight. You see that humans are as near blind as it is possible to be without actually being so. Artist and filmmaker, Sergio Toporek, said:

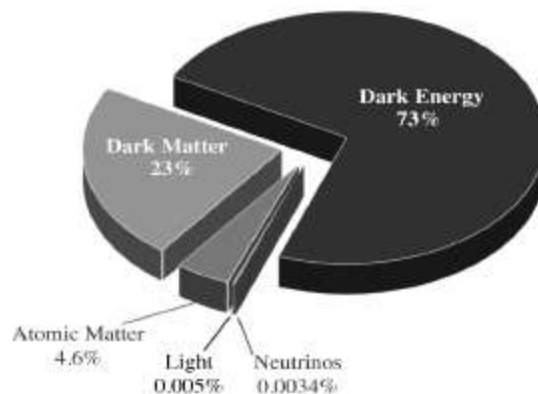


Figure 10: Humans can perceive such a tiny band of visual reality it's laughable.

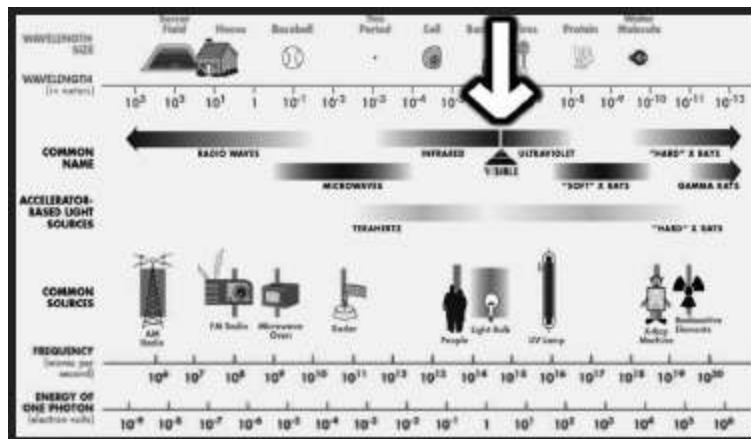


Figure 11: We can see a smear of the 0.005 percent electromagnetic spectrum, but we still know it all. Yep, makes sense.

Consider that you can see less than 1% of the electromagnetic spectrum and hear less than 1% of the acoustic spectrum. 90% of the cells in your body carry their own microbial DNA and are not 'you'. The atoms in your body are 99.9999999999999999% empty space and none of them are the ones you were born with ... Human beings have 46 chromosomes, two less than a potato.

The existence of the rainbow depends on the conical photoreceptors in your eyes; to animals without cones, the rainbow does not exist. So you don't just look at a rainbow, you create it. This is pretty amazing, especially considering that all the beautiful colours you see represent less than 1% of the electromagnetic spectrum.

Suddenly the 'world' of humans looks a very different place. Take into account, too, that Planet Earth when compared with the projected size of this single universe is the equivalent of a billionth of a pinhead. Imagine the ratio that would be when compared to infinite reality. To think that Christianity once insisted that Earth and humanity were the centre of everything. This background is vital if we are going to appreciate the nature of 'human' and how we can be manipulated by an unseen force. To human visual reality virtually *everything* is unseen and yet the prevailing perception within the institutions and so much of the public is that if we can't see it, touch it, hear it, taste it and smell it then it cannot exist. Such perception is indoctrinated and encouraged by the Cult and its agents because it isolates believers in the strictly limited, village-idiot, realm of the five senses where perceptions can be firewalled and information controlled. Most of those perpetuating the 'this-world-is-all-there-is' insanity are themselves indoctrinated into believing the same delusion. While major players and influencers know that official reality is laughable most of those in science, academia and medicine really believe the nonsense they peddle and teach succeeding generations. Those who challenge the orthodoxy are dismissed as nutters and freaks to protect the manufactured illusion from exposure. Observe the dynamic of the 'Covid' hoax and you will see how that takes the same form. The inner-circle psychopaths knows it's a gigantic scam, but almost the entirety of those imposing their fascist rules believe that 'Covid' is all that they're told it is.

Stolen identity

Ask people who they are and they will give you their name, place of birth, location, job, family background and life story. Yet that is not who they are – it is what they are *experiencing*. The difference is *absolutely crucial*. The true 'I', the eternal, infinite 'I', is consciousness,

a state of being aware. Forget 'form'. That is a vehicle for a brief experience. Consciousness does not come *from* the brain, but *through* the brain and even that is more symbolic than literal. We are awareness, pure awareness, and this is what withdraws from the body at what we call 'death' to continue our eternal beingness, *isness*, in other realms of reality within the limitlessness of infinity or the Biblical 'many mansions in my father's house'. Labels of a human life, man, woman, transgender, black, white, brown, nationality, circumstances and income are not who we are. They are what we are – awareness – is *experiencing* in a brief connection with a band of frequency we call 'human'. The labels are not the self; they are, to use the title of one of my books, a *Phantom Self*. I am not David Icke born in Leicester, England, on April 29th, 1952. I am the consciousness *having that experience*. The Cult and its non-human masters seek to convince us through the institutions of 'education', science, medicine, media and government that what we are *experiencing* is who we *are*. It's so easy to control and direct perception locked away in the bewildered illusions of the five senses with no expanded radar. Try, by contrast, doing the same with a humanity aware of its true self and its true power to consciously create its reality and experience. How is it possible to do this? We do it all day every day. If you perceive yourself as 'little me' with no power to impact upon your life and the world then your life experience will reflect that. You will hand the power you don't think you have to authority in all its forms which will use it to control your experience. This, in turn, will appear to confirm your perception of 'little me' in a self-fulfilling feedback loop. But that is what 'little me' really is – a *perception*. We are all 'big-me', infinite me, and the Cult has to make us forget that if its will is to prevail. We are therefore manipulated and pressured into self-identifying with human labels and not the consciousness/awareness *experiencing* those human labels.

The phenomenon of identity politics is a Cult-instigated manipulation technique to sub-divide previous labels into even smaller ones. A United States university employs this list of letters to

describe student identity: LGBTTTQQFAGPBDSM or lesbian, gay, bisexual, transgender, transsexual, queer, questioning, flexual, asexual, gender-fuck, polyamorous, bondage/discipline, dominance/submission and sadism/masochism. I'm sure other lists are even longer by now as people feel the need to self-identity the 'I' with the minutiae of race and sexual preference. Wokers programmed by the Cult for generations believe this is about 'inclusivity' when it's really the Cult locking them away into smaller and smaller versions of Phantom Self while firewalling them from the influence of their true self, the infinite, eternal 'I'. You may notice that my philosophy which contends that we are all unique points of attention/awareness within the same infinite whole or Oneness is the ultimate non-racism. The very sense of Oneness makes the judgement of people by their body-type, colour or sexuality utterly ridiculous and confirms that racism has no understanding of reality (including anti-white racism). Yet despite my perception of life Cult agents and fast-asleep Wokers label me racist to discredit my information while they are themselves phenomenally racist and sexist. All they see is race and sexuality and they judge people as good or bad, demons or untouchables, by their race and sexuality. All they see is *Phantom Self* and perceive themselves in terms of Phantom Self. They are pawns and puppets of the Cult agenda to focus attention and self-identity in the five senses and play those identities against each other to divide and rule. Columbia University has introduced segregated graduations in another version of social distancing designed to drive people apart and teach them that different racial and cultural groups have nothing in common with each other. The last thing the Cult wants is unity. Again the pump-primers of this will be Cult operatives in the knowledge of what they are doing, but the rest are just the Phantom Self blind leading the Phantom Self blind. We *do* have something in common – we are all *the same consciousness* having different temporary experiences.

What is this 'human'?

Yes, what *is* 'human'? That is what we are supposed to be, right? I mean 'human'? True, but 'human' is the experience not the 'I'. Break it down to basics and 'human' is the way that information is processed. If we are to experience and interact with this band of frequency we call the 'world' we must have a vehicle that operates within that band of frequency. Our consciousness in its prime form cannot do that; it is way beyond the frequency of the human realm. My consciousness or awareness could not tap these keys and pick up the cup in front of me in the same way that radio station A cannot interact with radio station B when they are on different frequencies. The human body is the means through which we have that interaction. I have long described the body as a biological computer which processes information in a way that allows consciousness to experience this reality. The body is a receiver, transmitter and processor of information in a particular way that we call human. We visually perceive only the world of the five senses in a wakened state – that is the limit of the body's visual decoding system. In truth it's not even visual in the way we experience 'visual reality' as I will come to in a moment. We are 'human' because the body processes the information sources of human into a reality and behaviour system that we *perceive* as human. Why does an elephant act like an elephant and not like a human or a duck? The elephant's biological computer is a different information field and processes information according to that program into a visual and behaviour type we call an elephant. The same applies to everything in our reality. These body information fields are perpetuated through procreation (like making a copy of a software program). The Cult wants to break that cycle and intervene technologically to transform the human information field into one that will change what we call humanity. If it can change the human information field it will change the way that field processes information and change humanity both 'physically' and psychologically. Hence the *messenger* (information) RNA 'vaccines' and so much more that is targeting human genetics by changing the body's information – *messaging* – construct through food, drink, radiation, toxicity and other means.

Reality that we experience is nothing like reality as it really is in the same way that the reality people experience in virtual reality games is not the reality they are really living in. The game is only a decoded source of information that appears to be a reality. Our world is also an information construct – a *simulation* (more later). In its base form our reality is a wavefield of information much the same in theme as Wi-Fi. The five senses decode wavefield information into electrical information which they communicate to the brain to decode into holographic (illusory ‘physical’) information. Different parts of the brain specialise in decoding different senses and the information is fused into a reality that appears to be outside of us but is really inside the brain and the genetic structure in general ([Fig 12](#) overleaf). DNA is a receiver-transmitter of information and a vital part of this decoding process and the body’s connection to other realities. Change DNA and you change the way we decode and connect with reality – see ‘Covid vaccines’. Think of computers decoding Wi-Fi. You have information encoded in a radiation field and the computer decodes that information into a very different form on the screen. You can’t see the Wi-Fi until its information is made manifest on the screen and the information on the screen is inside the computer and not outside. I have just described how we decode the ‘human world’. All five senses decode the waveform ‘Wi-Fi’ field into electrical signals and the brain (computer) constructs reality inside the brain and not outside – ‘You don’t just look at a rainbow, you create it’. Sound is a simple example. We don’t hear sound until the brain decodes it. Waveform sound waves are picked up by the hearing sense and communicated to the brain in an electrical form to be decoded into the sounds that we hear. Everything we hear is inside the brain along with everything we see, feel, smell and taste. Words and language are waveform fields generated by our vocal chords which pass through this process until they are decoded by the brain into words that we hear. Different languages are different frequency fields or sound waves generated by vocal chords. Late British philosopher Alan Watts said:

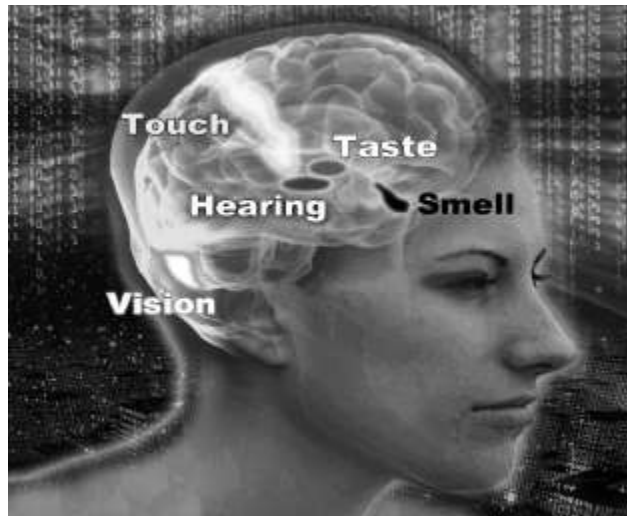


Figure 12: The brain receives information from the five senses and constructs from that our perceived reality.

[Without the brain] the world is devoid of light, heat, weight, solidity, motion, space, time or any other imaginable feature. All these phenomena are interactions, or transactions, of vibrations with a certain arrangement of neurons.

That's exactly what they are and scientist Robert Lanza describes in his book, *Biocentrism*, how we decode electromagnetic waves and energy into visual and 'physical' experience. He uses the example of a flame emitting photons, electromagnetic energy, each pulsing electrically and magnetically:

... these ... invisible electromagnetic waves strike a human retina, and if (and only if) the waves happen to measure between 400 and 700 nano meters in length from crest to crest, then their energy is just right to deliver a stimulus to the 8 million cone-shaped cells in the retina.

Each in turn send an electrical pulse to a neighbour neuron, and on up the line this goes, at 250 mph, until it reaches the ... occipital lobe of the brain, in the back of the head. There, a cascading complex of neurons fire from the incoming stimuli, and we subjectively perceive this experience as a yellow brightness occurring in a place we have been conditioned to call the 'external world'.

You hear what you decode

If a tree falls or a building collapses they make no noise unless someone is there to decode the energetic waves generated by the disturbance into what we call sound. Does a falling tree make a noise? Only if you hear it – *decode* it. Everything in our reality is a frequency field of information operating within the overall ‘Wi-Fi’ field that I call The Field. A vibrational disturbance is generated in The Field by the fields of the falling tree or building. These disturbance waves are what we decode into the sound of them falling. If no one is there to do that then neither will make any noise. Reality is created by the observer – *decoder* – and the *perceptions* of the observer affect the decoding process. For this reason different people – different *perceptions* – will perceive the same reality or situation in a different way. What one may perceive as a nightmare another will see as an opportunity. The question of why the Cult is so focused on controlling human perception now answers itself. All experienced reality is the act of decoding and we don’t experience Wi-Fi until it is decoded on the computer screen. The sight and sound of an Internet video is encoded in the Wi-Fi all around us, but we don’t see or hear it until the computer decodes that information. Taste, smell and touch are all phenomena of the brain as a result of the same process. We don’t taste, smell or feel anything except in the brain and there are pain relief techniques that seek to block the signal from the site of discomfort to the brain because if the brain doesn’t decode that signal we don’t feel pain. Pain is in the brain and only appears to be at the point of impact thanks to the feedback loop between them. We don’t see anything until electrical information from the sight senses is decoded in an area at the back of the brain. If that area is damaged we can go blind when our eyes are perfectly okay. So why do we go blind if we damage an eye? We damage the information processing between the waveform visual information and the visual decoding area of the brain. If information doesn’t reach the brain in a form it can decode then we can’t see the visual reality that it represents. What’s more the brain is decoding only a fraction of the information it receives and the rest is absorbed by the

sub-conscious mind. This explanation is from the science magazine, *Wonderpedia*:

Every second, 11 million sensations crackle along these [brain] pathways ... The brain is confronted with an alarming array of images, sounds and smells which it rigorously filters down until it is left with a manageable list of around 40. Thus 40 sensations per second make up what we perceive as reality.

The 'world' is not what people are told to believe that is it and the inner circles of the Cult *know that*.

Illusory 'physical' reality

We can only see a smear of 0.005 percent of the Universe which is only one of a vast array of universes – 'mansions' – within infinite reality. Even then the brain decodes only 40 pieces of information ('sensations') from a potential *11 million* that we receive every second. Two points strike you from this immediately: The sheer breathtaking stupidity of believing we know anything so rigidly that there's nothing more to know; and the potential for these processes to be manipulated by a malevolent force to control the reality of the population. One thing I can say for sure with no risk of contradiction is that when you can perceive an almost indescribable fraction of infinite reality there is always more to know as in tidal waves of it. Ancient Greek philosopher Socrates was so right when he said that wisdom is to know how little we know. How obviously true that is when you think that we are experiencing a physical world of solidity that is neither physical nor solid and a world of apartness when everything is connected. Cult-controlled 'science' dismisses the so-called 'paranormal' and all phenomena related to that when the 'para'-normal is perfectly normal and explains the alleged 'great mysteries' which dumbfound scientific minds. There is a reason for this. A 'scientific mind' in terms of the mainstream is a material mind, a five-sense mind imprisoned in see it, touch it, hear it, smell it and taste it. Phenomena and happenings that can't be explained that way leave the 'scientific mind' bewildered and the rule is that if they

can't account for why something is happening then it can't, by definition, be happening. I beg to differ. Telepathy is thought waves passing through The Field (think wave disturbance again) to be decoded by someone able to connect with that wavelength (information). For example: You can pick up the thought waves of a friend at any distance and at the very least that will bring them to mind. A few minutes later the friend calls you. 'My god', you say, 'that's incredible – I was just thinking of you.' Ah, but *they* were thinking of *you* before they made the call and that's what you decoded. Native peoples not entrapped in five-sense reality do this so well it became known as the 'bush telegraph'. Those known as psychics and mediums (genuine ones) are doing the same only across dimensions of reality. 'Mind over matter' comes from the fact that matter and mind are the *same*. The state of one influences the state of the other. Indeed one *and* the other are illusions. They are aspects of the same field. Paranormal phenomena are all explainable so why are they still considered 'mysteries' or not happening? Once you go down this road of understanding you begin to expand awareness beyond the five senses and that's the nightmare for the Cult.



Figure 13: Holograms are not solid, but the best ones appear to be.

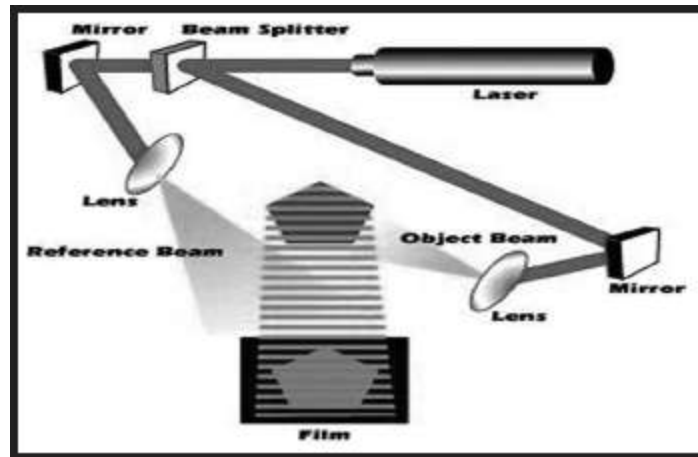


Figure 14: How holograms are created by capturing a waveform version of the subject image.

Holographic 'solidity'

Our reality is not solid, it is holographic. We are now well aware of holograms which are widely used today. Two-dimensional information is decoded into a three-dimensional reality that is not solid although can very much appear to be (Fig 13). Holograms are created with a laser divided into two parts. One goes directly onto a holographic photographic print ('reference beam') and the other takes a waveform image of the subject ('working beam') before being directed onto the print where it 'collides' with the other half of the laser (Fig 14). This creates a *waveform* interference pattern which contains the wavefield information of whatever is being photographed (Fig 15 overleaf). The process can be likened to dropping pebbles in a pond. Waves generated by each one spread out across the water to collide with the others and create a wave representation of where the stones fell and at what speed, weight and distance. A waveform interference pattern of a hologram is akin to the waveform information in The Field which the five senses decode into electrical signals to be decoded by the brain into a holographic illusory 'physical' reality. In the same way when a laser (think human attention) is directed at the waveform interference pattern a three-dimensional version of the subject is projected into apparently 'solid' reality (Fig 16). An amazing trait of holograms reveals more 'paranormal mysteries'. Information of the *whole*

hologram is encoded in waveform in every part of the interference pattern by the way they are created. This means that every *part* of a hologram is a smaller version of the whole. Cut the interference wave-pattern into four and you won't get four parts of the image. You get quarter-sized versions of the *whole* image. The body is a hologram and the same applies. Here we have the basis of acupuncture, reflexology and other forms of healing which identify representations of the whole body in all of the parts, hands, feet, ears, everywhere. Skilled palm readers can do what they do because the information of whole body is encoded in the hand. The concept of as above, so below, comes from this.



Figure 15: A waveform interference pattern that holds the information that transforms into a hologram.



Figure 16: Holographic people including 'Elvis' holographically inserted to sing a duet with Celine Dion.

The question will be asked of why, if solidity is illusory, we can't just walk through walls and each other. The resistance is not solid against solid; it is electromagnetic field against electromagnetic field and we decode this into the *experience* of solid against solid. We should also not underestimate the power of belief to dictate reality. What you believe is impossible *will be*. Your belief impacts on your decoding processes and they won't decode what you think is impossible. What we believe we perceive and what we perceive we experience. 'Can't dos' and 'impossibles' are like a firewall in a computer system that won't put on the screen what the firewall blocks. How vital that is to understanding how human experience has been hijacked. I explain in *The Answer, Everything You Need To Know But Have Never Been Told* and other books a long list of 'mysteries' and 'paranormal' phenomena that are not mysterious and perfectly normal once you realise what reality is and how it works. 'Ghosts' can be seen to pass through 'solid' walls because the walls are not solid and the ghost is a discarnate entity operating on a frequency so different to that of the wall that it's like two radio stations sharing the same space while never interfering with each other. I have seen ghosts do this myself. The apartness of people and objects is also an illusion. Everything is connected by the Field like all sea life is connected by the sea. It's just that within the limits of our visual reality we only 'see' holographic information and not the field of information that connects everything and from which the holographic world is made manifest. If you can only see holographic 'objects' and not the field that connects them they will appear to you as unconnected to each other in the same way that we see the computer while not seeing the Wi-Fi.

What you don't know *can* hurt you

Okay, we return to those 'two worlds' of human society and the Cult with its global network of interconnecting secret societies and satanic groups which manipulate through governments, corporations, media, religions, etc. The fundamental difference between them is *knowledge*. The idea has been to keep humanity

ignorant of the plan for its total enslavement underpinned by a crucial ignorance of reality – who we are and where we are – and how we interact with it. ‘Human’ should be the interaction between our expanded eternal consciousness and the five-sense body experience. We are meant to be *in* this world in terms of the five senses but not *of* this world in relation to our greater consciousness and perspective. In that state we experience the small picture of the five senses within the wider context of the big picture of awareness beyond the five senses. Put another way the five senses see the dots and expanded awareness connects them into pictures and patterns that give context to the apparently random and unconnected. Without the context of expanded awareness the five senses see only apartness and randomness with apparently no meaning. The Cult and its other-dimensional controllers seek to intervene in the frequency realm where five-sense reality is supposed to connect with expanded reality and to keep the two apart (more on this in the final chapter). When that happens five-sense mental and emotional processes are no longer influenced by expanded awareness, or the True ‘I’, and instead are driven by the isolated perceptions of the body’s decoding systems. They are in the world *and* of it. Here we have the human plight and why humanity with its potential for infinite awareness can be so easily manipulatable and descend into such extremes of stupidity.

Once the Cult isolates five-sense mind from expanded awareness it can then program the mind with perceptions and beliefs by controlling information that the mind receives through the ‘education’ system of the formative years and the media perceptual bombardment and censorship of an entire lifetime. Limit perception and a sense of the possible through limiting knowledge by limiting and skewing information while censoring and discrediting that which could set people free. As the title of another of my books says ... *And The Truth Shall Set You Free*. For this reason the last thing the Cult wants in circulation is the truth about anything – especially the reality of the eternal ‘I’ – and that’s why it is desperate to control information. The Cult knows that information becomes perception

which becomes behaviour which, collectively, becomes human society. Cult-controlled and funded mainstream 'science' denies the existence of an eternal 'I' and seeks to dismiss and trash all evidence to the contrary. Cult-controlled mainstream religion has a version of 'God' that is little more than a system of control and dictatorship that employs threats of damnation in an afterlife to control perceptions and behaviour in the here and now through fear and guilt. Neither is true and it's the 'neither' that the Cult wishes to suppress. This 'neither' is that everything is an expression, a point of attention, within an infinite state of consciousness which is the real meaning of the term 'God'.

Perceptual obsession with the 'physical body' and five-senses means that 'God' becomes personified as a bearded bloke sitting among the clouds or a raging bully who loves us if we do what 'he' wants and condemns us to the fires of hell if we don't. These are no more than a 'spiritual' fairy tales to control and dictate events and behaviour through fear of this 'God' which has bizarrely made 'God-fearing' in religious circles a state to be desired. I would suggest that fearing *anything* is not to be encouraged and celebrated, but rather deleted. You can see why 'God fearing' is so beneficial to the Cult and its religions when *they* decide what 'God' wants and what 'God' demands (the Cult demands) that everyone do. As the great American comedian Bill Hicks said satirising a Christian zealot: 'I think what God meant to say.' How much of this infinite awareness ('God') that we access is decided by how far we choose to expand our perceptions, self-identity and sense of the possible. The scale of self-identity reflects itself in the scale of awareness that we can connect with and are influenced by – how much knowing and insight we have instead of programmed perception. You cannot expand your awareness into the infinity of possibility when you believe that you are little me Peter the postman or Mary in marketing and nothing more. I'll deal with this in the concluding chapter because it's crucial to how we turnaround current events.

Where the Cult came from

When I realised in the early 1990s there was a Cult network behind global events I asked the obvious question: When did it start? I took it back to ancient Rome and Egypt and on to Babylon and Sumer in Mesopotamia, the 'Land Between Two Rivers', in what we now call Iraq. The two rivers are the Tigris and Euphrates and this region is of immense historical and other importance to the Cult, as is the land called Israel only 550 miles away by air. There is much more going on with deep esoteric meaning across this whole region. It's not only about 'wars for oil'. Priceless artefacts from Mesopotamia were stolen or destroyed after the American and British invasion of Iraq in 2003 justified by the lies of Boy Bush and Tony Blair (their Cult masters) about non-existent 'weapons of mass destruction'.

Mesopotamia was the location of Sumer (about 5,400BC to 1,750BC), and Babylon (about 2,350BC to 539BC). Sabbatians may have become immensely influential in the Cult in modern times but they are part of a network that goes back into the mists of history. Sumer is said by historians to be the 'cradle of civilisation'. I disagree. I say it was the re-start of what we call human civilisation after cataclysmic events symbolised in part as the 'Great Flood' destroyed the world that existed before. These fantastic upheavals that I have been describing in detail in the books since the early 1990s appear in accounts and legends of ancient cultures across the world and they are supported by geological and biological evidence. Stone tablets found in Iraq detailing the Sumer period say the cataclysms were caused by non-human 'gods' they call the Anunnaki. These are described in terms of extraterrestrial visitations in which knowledge supplied by the Anunnaki is said to have been the source of at least one of the world's oldest writing systems and developments in astronomy, mathematics and architecture that were way ahead of their time. I have covered this subject at length in *The Biggest Secret* and *Children of the Matrix* and the same basic 'Anunnaki' story can be found in Zulu accounts in South Africa where the late and very great Zulu high shaman Credo Mutwa told me that the Sumerian Anunnaki were known by Zulus as the Chitauri or 'children of the serpent'. See my six-hour video interview with Credo on this subject entitled *The*

Reptilian Agenda recorded at his then home near Johannesburg in 1999 which you can watch on the Ickonic media platform.

The Cult emerged out of Sumer, Babylon and Egypt (and elsewhere) and established the Roman Empire before expanding with the Romans into northern Europe from where many empires were savagely imposed in the form of Cult-controlled societies all over the world. Mass death and destruction was their calling card. The Cult established its centre of operations in Europe and European Empires were Cult empires which allowed it to expand into a global force. Spanish and Portuguese colonialists headed for Central and South America while the British and French targeted North America. Africa was colonised by Britain, France, Belgium, the Netherlands, Portugal, Spain, Italy, and Germany. Some like Britain and France moved in on the Middle East. The British Empire was by far the biggest for a simple reason. By now Britain was the headquarters of the Cult from which it expanded to form Canada, the United States, Australia and New Zealand. The Sun never set on the British Empire such was the scale of its occupation. London remains a global centre for the Cult along with Rome and the Vatican although others have emerged in Israel and China. It is no accident that the 'virus' is alleged to have come out of China while Italy was chosen as the means to terrify the Western population into compliance with 'Covid' fascism. Nor that Israel has led the world in 'Covid' fascism and mass 'vaccination'.

You would think that I would mention the United States here, but while it has been an important means of imposing the Cult's will it is less significant than would appear and is currently in the process of having what power it does have deleted. The Cult in Europe has mostly loaded the guns for the US to fire. America has been controlled from Europe from the start through Cult operatives in Britain and Europe. The American Revolution was an illusion to make it appear that America was governing itself while very different forces were pulling the strings in the form of Cult families such as the Rothschilds through the Rockefellers and other subordinates. The Rockefellers are extremely close to Bill Gates and

established both scalpel and drug 'medicine' and the World Health Organization. They play a major role in the development and circulation of vaccines through the Rockefeller Foundation on which Bill Gates said his Foundation is based. Why wouldn't this be the case when the Rockefellers and Gates are on the same team? Cult infiltration of human society goes way back into what we call history and has been constantly expanding and centralising power with the goal of establishing a global structure to dictate everything. Look how this has been advanced in great leaps with the 'Covid' hoax.

The non-human dimension

I researched and observed the comings and goings of Cult operatives through the centuries and even thousands of years as they were born, worked to promote the agenda within the secret society and satanic networks, and then died for others to replace them. Clearly there had to be a coordinating force that spanned this entire period while operatives who would not have seen the end goal in their lifetimes came and went advancing the plan over millennia. I went in search of that coordinating force with the usual support from the extraordinary synchronicity of my life which has been an almost daily experience since 1990. I saw common themes in religious texts and ancient cultures about a non-human force manipulating human society from the hidden. Christianity calls this force Satan, the Devil and demons; Islam refers to the Jinn or Djinn; Zulus have their Chitauri (spelt in other ways in different parts of Africa); and the Gnostic people in Egypt in the period around and before 400AD referred to this phenomena as the 'Archons', a word meaning rulers in Greek. Central American cultures speak of the 'Predators' among other names and the same theme is everywhere. I will use 'Archons' as a collective name for all of them. When you see how their nature and behaviour is described all these different sources are clearly talking about the same force. Gnostics described the Archons in terms of 'luminous fire' while Islam relates the Jinn to 'smokeless fire'. Some refer to beings in form that could occasionally be seen, but the most common of common theme is that they operate from

unseen realms which means almost all existence to the visual processes of humans. I had concluded that this was indeed the foundation of human control and that the Cult was operating within the human frequency band on behalf of this hidden force when I came across the writings of Gnostics which supported my conclusions in the most extraordinary way.

A sealed earthen jar was found in 1945 near the town of Nag Hammadi about 75-80 miles north of Luxor on the banks of the River Nile in Egypt. Inside was a treasure trove of manuscripts and texts left by the Gnostic people some 1,600 years earlier. They included 13 leather-bound papyrus codices (manuscripts) and more than 50 texts written in Coptic Egyptian estimated to have been hidden in the jar in the period of 400AD although the source of the information goes back much further. Gnostics oversaw the Great or Royal Library of Alexandria, the fantastic depository of ancient texts detailing advanced knowledge and accounts of human history. The Library was dismantled and destroyed in stages over a long period with the death-blow delivered by the Cult-established Roman Church in the period around 415AD. The Church of Rome was the Church of Babylon relocated as I said earlier. Gnostics were not a race. They were a way of perceiving reality. Whenever they established themselves and their information circulated the terrorists of the Church of Rome would target them for destruction. This happened with the Great Library and with the Gnostic Cathars who were burned to death by the psychopaths after a long period of oppression at the siege of the Castle of Monségur in southern France in 1244. The Church has always been terrified of Gnostic information which demolishes the official Christian narrative although there is much in the Bible that supports the Gnostic view if you read it in another way. To anyone studying the texts of what became known as the Nag Hammadi Library it is clear that great swathes of Christian and Biblical belief has its origin with Gnostics sources going back to Sumer. Gnostic themes have been twisted to manipulate the perceived reality of Bible believers. Biblical texts have been in the open for centuries where they could be changed while Gnostic

documents found at Nag Hammadi were sealed away and untouched for 1,600 years. What you see is what they wrote.

Use your *pneuma* not your *nous*

Gnosticism and Gnostic come from 'gnosis' which means knowledge, or rather *secret* knowledge, in the sense of spiritual awareness – knowledge about reality and life itself. The desperation of the Cult's Church of Rome to destroy the Gnostics can be understood when the knowledge they were circulating was the last thing the Cult wanted the population to know. Sixteen hundred years later the same Cult is working hard to undermine and silence me for the same reason. The dynamic between knowledge and ignorance is a constant. 'Time' appears to move on, but essential themes remain the same. We are told to 'use your nous', a Gnostic word for head/brain/intelligence. They said, however, that spiritual awakening or 'salvation' could only be secured by expanding awareness *beyond* what they called *nous* and into *pneuma* or Infinite Self. Obviously as I read these texts the parallels with what I have been saying since 1990 were fascinating to me. There is a universal truth that spans human history and in that case why wouldn't we be talking the same language 16 centuries apart? When you free yourself from the perception program of the five senses and explore expanded realms of consciousness you are going to connect with the same information no matter what the perceived 'era' within a manufactured timeline of a single and tiny range of manipulated frequency. Humans working with 'smart' technology or knocking rocks together in caves is only a timeline appearing to operate within the human frequency band. Expanded awareness and the knowledge it holds have always been there whether the era be Stone Age or computer age. We can only access that knowledge by opening ourselves to its frequency which the five-sense prison cell is designed to stop us doing. Gates, Fauci, Whitty, Vallance, Zuckerberg, Brin, Page, Wojcicki, Bezos, and all the others behind the 'Covid' hoax clearly have a long wait before their range of frequency can make that connection given that an open heart is

crucial to that as we shall see. Instead of accessing knowledge directly through expanded awareness it is given to Cult operatives by the secret society networks of the Cult where it has been passed on over thousands of years outside the public arena. Expanded realms of consciousness is where great artists, composers and writers find their inspiration and where truth awaits anyone open enough to connect with it. We need to go there fast.

Archon hijack

A fifth of the Nag Hammadi texts describe the existence and manipulation of the Archons led by a 'Chief Archon' they call 'Yaldabaoth', or the 'Demiurge', and this is the Christian 'Devil', 'Satan', 'Lucifer', and his demons. Archons in Biblical symbolism are the 'fallen ones' which are also referred to as fallen angels after the angels expelled from heaven according to the Abrahamic religions of Judaism, Christianity and Islam. These angels are claimed to tempt humans to 'sin' ongoing and you will see how accurate that symbolism is during the rest of the book. The theme of 'original sin' is related to the 'Fall' when Adam and Eve were 'tempted by the serpent' and fell from a state of innocence and 'obedience' (connection) with God into a state of disobedience (disconnection). The Fall is said to have brought sin into the world and corrupted everything including human nature. Yaldabaoth, the 'Lord Archon', is described by Gnostics as a 'counterfeit spirit', 'The Blind One', 'The Blind God', and 'The Foolish One'. The Jewish name for Yaldabaoth in Talmudic writings is Samael which translates as 'Poison of God', or 'Blindness of God'. You see the parallels. Yaldabaoth in Islamic belief is the Muslim Jinn devil known as Shaytan – Shaytan is Satan as the same themes are found all over the world in every religion and culture. The 'Lord God' of the Old Testament is the 'Lord Archon' of Gnostic manuscripts and that's why he's such a bloodthirsty bastard. Satan is known by Christians as 'the Demon of Demons' and Gnostics called Yaldabaoth the 'Archon of Archons'. Both are known as 'The Deceiver'. We are talking about the same 'bloke' for sure and these common themes

using different names, storylines and symbolism tell a common tale of the human plight.

Archons are referred to in Nag Hammadi documents as mind parasites, inverters, guards, gatekeepers, detainers, judges, pitiless ones and deceivers. The 'Covid' hoax alone is a glaring example of all these things. The Biblical 'God' is so different in the Old and New Testaments because they are not describing the same phenomenon. The vindictive, angry, hate-filled, 'God' of the Old Testament, known as Yahweh, is Yaldabaoth who is depicted in Cult-dictated popular culture as the 'Dark Lord', 'Lord of Time', Lord (Darth) Vader and Dormammu, the evil ruler of the 'Dark Dimension' trying to take over the 'Earth Dimension' in the Marvel comic movie, *Dr Strange*. Yaldabaoth is both the Old Testament 'god' and the Biblical 'Satan'. Gnostics referred to Yaldabaoth as the 'Great Architect of the Universe' and the Cult-controlled Freemason network calls their god 'the 'Great Architect of the Universe' (also Grand Architect). The 'Great Architect' Yaldabaoth is symbolised by the Cult as the all-seeing eye at the top of the pyramid on the Great Seal of the United States and the dollar bill. Archon is encoded in *arch*-itect as it is in *arch*-angels and *arch*-bishops. All religions have the theme of a force for good and force for evil in some sort of spiritual war and there is a reason for that – the theme is true. The Cult and its non-human masters are quite happy for this to circulate. They present themselves as the force for good fighting evil when they are really the force of evil (absence of love). The whole foundation of Cult modus operandi is inversion. They promote themselves as a force for good and anyone challenging them in pursuit of peace, love, fairness, truth and justice is condemned as a satanic force for evil. This has been the game plan throughout history whether the Church of Rome inquisitions of non-believers or 'conspiracy theorists' and 'anti-vaxxers' of today. The technique is the same whatever the timeline era.

Yaldabaoth is revolting (true)

Yaldabaoth and the Archons are said to have revolted against God with Yaldabaoth claiming to *be* God – the *All That Is*. The Old Testament ‘God’ (Yaldabaoth) demanded to be worshipped as such: ‘*I am the LORD, and there is none else, there is no God beside me*’ (Isaiah 45:5). I have quoted in other books a man who said he was the unofficial son of the late Baron Philippe de Rothschild of the Mouton-Rothschild wine producing estates in France who died in 1988 and he told me about the Rothschild ‘revolt from God’. The man said he was given the name Phillip Eugene de Rothschild and we shared long correspondence many years ago while he was living under another identity. He said that he was conceived through ‘occult incest’ which (within the Cult) was ‘normal and to be admired’. ‘Phillip’ told me about his experience attending satanic rituals with rich and famous people whom he names and you can see them and the wider background to Cult Satanism in my other books starting with *The Biggest Secret*. Cult rituals are interactions with Archontic ‘gods’. ‘Phillip’ described Baron Philippe de Rothschild as ‘a master Satanist and hater of God’ and he used the same term ‘revolt from God’ associated with Yaldabaoth/Satan/Lucifer/the Devil in describing the Sabbatian Rothschild dynasty. ‘I played a key role in my family’s revolt from God’, he said. That role was to infiltrate in classic Sabbatian style the Christian Church, but eventually he escaped the mind-prison to live another life. The Cult has been targeting religion in a plan to make worship of the Archons the global one-world religion. Infiltration of Satanism into modern ‘culture’, especially among the young, through music videos, stage shows and other means, is all part of this.

Nag Hammadi texts describe Yaldabaoth and the Archons in their prime form as energy – consciousness – and say they can take form if they choose in the same way that consciousness takes form as a human. Yaldabaoth is called ‘formless’ and represents a deeply inverted, distorted and chaotic state of consciousness which seeks to attached to humans and turn them into a likeness of itself in an attempt at assimilation. For that to happen it has to manipulate

humans into low frequency mental and emotional states that match its own. Archons can certainly appear in human form and this is the origin of the psychopathic personality. The energetic distortion Gnostics called Yaldabaoth is psychopathy. When psychopathic Archons take human form that human will be a psychopath as an expression of Yaldabaoth consciousness. Cult psychopaths are Archons in human form. The principle is the same as that portrayed in the 2009 *Avatar* movie when the American military travelled to a fictional Earth-like moon called Pandora in the Alpha Centauri star system to infiltrate a society of blue people, or Na'vi, by hiding within bodies that looked like the Na'vi. Archons posing as humans have a particular hybrid information field, part human, part Archon, (the ancient 'demigods') which processes information in a way that manifests behaviour to match their psychopathic evil, lack of empathy and compassion, and stops them being influenced by the empathy, compassion and love that a fully-human information field is capable of expressing. Cult bloodlines interbreed, be they royalty or dark suits, for this reason and you have their obsession with incest. Interbreeding with full-blown humans would dilute the Archontic energy field that guarantees psychopathy in its representatives in the human realm.

Gnostic writings say the main non-human forms that Archons take are *serpentine* (what I have called for decades 'reptilian' amid unbounded ridicule from the Archontically-programmed) and what Gnostics describe as 'an unborn baby or foetus with grey skin and dark, unmoving eyes'. This is an excellent representation of the ET 'Greys' of UFO folklore which large numbers of people claim to have seen and been abducted by – Zulu shaman Credo Mutwa among them. I agree with those that believe in extraterrestrial or interdimensional visitations today and for thousands of years past. No wonder with their advanced knowledge and technological capability they were perceived and worshipped as gods for technological and other 'miracles' they appeared to perform. Imagine someone arriving in a culture disconnected from the modern world with a smartphone and computer. They would be

seen as a 'god' capable of 'miracles'. The Renegade Mind, however, wants to know the source of everything and not only the way that source manifests as human or non-human. In the same way that a Renegade Mind seeks the original source material for the 'Covid virus' to see if what is claimed is true. The original source of Archons in form is consciousness – the distorted state of consciousness known to Gnostics as Yaldabaoth.

'Revolt from God' is energetic disconnection

Where I am going next will make a lot of sense of religious texts and ancient legends relating to 'Satan', Lucifer' and the 'gods'. Gnostic descriptions sync perfectly with the themes of my own research over the years in how they describe a consciousness distortion seeking to impose itself on human consciousness. I've referred to the core of infinite awareness in previous books as Infinite Awareness in Awareness of Itself. By that I mean a level of awareness that knows that it is all awareness and is aware of all awareness. From here comes the frequency of love in its true sense and balance which is what love is on one level – the balance of all forces into a single whole called Oneness and Isness. The more we disconnect from this state of love that many call 'God' the constituent parts of that Oneness start to unravel and express themselves as a part and not a whole. They become individualised as intellect, mind, selfishness, hatred, envy, desire for power over others, and such like. This is not a problem in the greater scheme in that 'God', the *All That Is*, can experience all these possibilities through different expressions of itself including humans. What we as expressions of the whole experience the *All That Is* experiences. We are the *All That Is* experiencing itself. As we withdraw from that state of Oneness we disconnect from its influence and things can get very unpleasant and very stupid. Archontic consciousness is at the extreme end of that. It has so disconnected from the influence of Oneness that it has become an inversion of unity and love, an inversion of everything, an inversion of life itself. Evil is appropriately live written backwards. Archontic consciousness is obsessed with death, an inversion of life,

and so its manifestations in Satanism are obsessed with death. They use inverted symbols in their rituals such as the inverted pentagram and cross. Sabbatians as Archontic consciousness incarnate invert Judaism and every other religion and culture they infiltrate. They seek disunity and chaos and they fear unity and harmony as they fear love like garlic to a vampire. As a result the Cult, Archons incarnate, act with such evil, psychopathy and lack of empathy and compassion disconnected as they are from the source of love. How could Bill Gates and the rest of the Archontic psychopaths do what they have to human society in the 'Covid' era with all the death, suffering and destruction involved and have no emotional consequence for the impact on others? Now you know. Why have Zuckerberg, Brin, Page, Wojcicki and company callously censored information warning about the dangers of the 'vaccine' while thousands have been dying and having severe, sometimes life-changing reactions? Now you know. Why have Tedros, Fauci, Whitty, Vallance and their like around the world been using case and death figures they're aware are fraudulent to justify lockdowns and all the deaths and destroyed lives that have come from that? Now you know. Why did Christian Drosten produce and promote a 'testing' protocol that he knew couldn't test for infectious disease which led to a global human catastrophe. Now you know. The Archontic mind doesn't give a shit ([Fig 17](#)). I personally think that Gates and major Cult insiders are a form of AI cyborg that the Archons want humans to become.



Figure 17: Artist Neil Hague's version of the 'Covid' hierarchy.

Human batteries

A state of such inversion does have its consequences, however. The level of disconnection from the Source of All means that you withdraw from that source of energetic sustenance and creativity. This means that you have to find your own supply of energetic power and it has – *us*. When the Morpheus character in the first *Matrix* movie held up a battery he spoke a profound truth when he said: 'The Matrix is a computer-generated dream world built to keep us under control in order to change the human being into one of

these.' The statement was true in all respects. We do live in a technologically-generated virtual reality simulation (more very shortly) and we have been manipulated to be an energy source for Archontic consciousness. The Disney-Pixar animated movie *Monsters, Inc.* in 2001 symbolised the dynamic when monsters in their world had no energy source and they would enter the human world to terrify children in their beds, catch the child's scream, terror (low-vibrational frequencies), and take that energy back to power the monster world. The lead character you might remember was a single giant eye and the symbolism of the Cult's all-seeing eye was obvious. Every thought and emotion is broadcast as a frequency unique to that thought and emotion. Feelings of love and joy, empathy and compassion, are high, quick, frequencies while fear, depression, anxiety, suffering and hate are low, slow, dense frequencies. Which kind do you think Archontic consciousness can connect with and absorb? In such a low and dense frequency state there's no way it can connect with the energy of love and joy. Archons can only feed off energy compatible with their own frequency and they and their Cult agents want to delete the human world of love and joy and manipulate the transmission of low vibrational frequencies through low-vibrational human mental and emotional states. *We are their energy source.* Wars are energetic banquets to the Archons – a world war even more so – and think how much low-frequency mental and emotional energy has been generated from the consequences for humanity of the 'Covid' hoax orchestrated by Archons incarnate like Gates.

The ancient practice of human sacrifice 'to the gods', continued in secret today by the Cult, is based on the same principle. 'The gods' are Archontic consciousness in different forms and the sacrifice is induced into a state of intense terror to generate the energy the Archontic frequency can absorb. Incarnate Archons in the ritual drink the blood which contains an adrenaline they crave which floods into the bloodstream when people are terrorised. Most of the sacrifices, ancient and modern, are children and the theme of 'sacrificing young virgins to the gods' is just code for children. They

have a particular pre-puberty energy that Archons want more than anything and the energy of the young in general is their target. The California Department of Education wants students to chant the names of Aztec gods (Archontic gods) once worshipped in human sacrifice rituals in a curriculum designed to encourage them to 'challenge racist, bigoted, discriminatory, imperialist/colonial beliefs', join 'social movements that struggle for social justice', and 'build new possibilities for a post-racist, post-systemic racism society'. It's the usual Woke crap that inverts racism and calls it anti-racism. In this case solidarity with 'indigenous tribes' is being used as an excuse to chant the names of 'gods' to which people were sacrificed (and still are in secret). What an example of Woke's inability to see beyond black and white, us and them, They condemn the colonisation of these tribal cultures by Europeans (quite right), but those cultures sacrificing people including children to their 'gods', and mass murdering untold numbers as the Aztecs did, is just fine. One chant is to the Aztec god Tezcatlipoca who had a man sacrificed to him in the 5th month of the Aztec calendar. His heart was cut out and he was eaten. Oh, that's okay then. Come on children ... after three ... Other sacrificial 'gods' for the young to chant their allegiance include Quetzalcoatl, Huitzilopochtli and Xipe Totec. The curriculum says that 'chants, affirmations, and energizers can be used to bring the class together, build unity around ethnic studies principles and values, and to reinvigorate the class following a lesson that may be emotionally taxing or even when student engagement may appear to be low'. Well, that's the cover story, anyway. Chanting and mantras are the repetition of a particular frequency generated from the vocal cords and chanting the names of these Archontic 'gods' tunes you into their frequency. That is the last thing you want when it allows for energetic synchronisation, attachment and perceptual influence. Initiates chant the names of their 'Gods' in their rituals for this very reason.

Vampires of the Woke

Paedophilia is another way that Archons absorb the energy of children. Paedophiles possessed by Archontic consciousness are used as the conduit during sexual abuse for discarnate Archons to vampire the energy of the young they desire so much. Stupendous numbers of children disappear every year never to be seen again although you would never know from the media. Imagine how much low-vibrational energy has been generated by children during the 'Covid' hoax when so many have become depressed and psychologically destroyed to the point of killing themselves. Shocking numbers of children are now taken by the state from loving parents to be handed to others. I can tell you from long experience of researching this since 1996 that many end up with paedophiles and assets of the Cult through corrupt and Cult-owned social services which in the reframing era has hired many psychopaths and emotionless automatons to do the job. Children are even stolen to order using spurious reasons to take them by the corrupt and secret (because they're corrupt) 'family courts'. I have written in detail in other books, starting with *The Biggest Secret* in 1997, about the ubiquitous connections between the political, corporate, government, intelligence and military elites (Cult operatives) and Satanism and paedophilia. If you go deep enough both networks have an interlocking leadership. The Woke mentality has been developed by the Cult for many reasons: To promote almost every aspect of its agenda; to hijack the traditional political left and turn it fascist; to divide and rule; and to target agenda pushbackers. But there are other reasons which relate to what I am describing here. How many happy and joyful Wokers do you ever see especially at the extreme end? They are a mental and psychological mess consumed by emotional stress and constantly emotionally cocked for the next explosion of indignation at someone referring to a female as a female. They are walking, talking, batteries as Morpheus might say emitting frequencies which both enslave them in low-vibrational bubbles of perceptual limitation and feed the Archons. Add to this the hatred claimed to be love; fascism claimed to 'anti-fascism', racism claimed to be 'anti-racism';

exclusion claimed to inclusion; and the abuse-filled Internet trolling. You have a purpose-built Archontic energy system with not a wind turbine in sight and all founded on Archontic *inversion*. We have whole generations now manipulated to serve the Archons with their actions and energy. They will be doing so their entire adult lives unless they snap out of their Archon-induced trance. Is it really a surprise that Cult billionaires and corporations put so much money their way? Where is the energy of joy and laughter, including laughing at yourself which is confirmation of your own emotional security? Mark Twain said: 'The human race has one really effective weapon, and that is laughter.' We must use it all the time. Woke has destroyed comedy because it has no humour, no joy, sense of irony, or self-deprecation. Its energy is dense and intense. *Mmmmm*, lunch says the Archontic frequency. Rudolf Steiner (1861-1925) was the Austrian philosopher and famous esoteric thinker who established Waldorf education or Steiner schools to treat children like unique expressions of consciousness and not minds to be programmed with the perceptions determined by authority. I'd been writing about this energy vampiring for decades when I was sent in 2016 a quote by Steiner. He was spot on:

There are beings in the spiritual realms for whom anxiety and fear emanating from human beings offer welcome food. When humans have no anxiety and fear, then these creatures starve. If fear and anxiety radiates from people and they break out in panic, then these creatures find welcome nutrition and they become more and more powerful. These beings are hostile towards humanity. Everything that feeds on negative feelings, on anxiety, fear and superstition, despair or doubt, are in reality hostile forces in super-sensible worlds, launching cruel attacks on human beings, while they are being fed ... These are exactly the feelings that belong to contemporary culture and materialism; because it estranges people from the spiritual world, it is especially suited to evoke hopelessness and fear of the unknown in people, thereby calling up the above mentioned hostile forces against them.

Pause for a moment from this perspective and reflect on what has happened in the world since the start of 2020. Not only will pennies drop, but billion dollar bills. We see the same theme from Don Juan Matus, a Yaqui Indian shaman in Mexico and the information source for Peruvian-born writer, Carlos Castaneda, who wrote a series of

books from the 1960s to 1990s. Don Juan described the force manipulating human society and his name for the Archons was the predator:

We have a predator that came from the depths of the cosmos and took over the rule of our lives. Human beings are its prisoners. The predator is our lord and master. It has rendered us docile, helpless. If we want to protest, it suppresses our protest. If we want to act independently, it demands that we don't do so ... indeed we are held prisoner!

They took us over because we are food to them, and they squeeze us mercilessly because we are their sustenance. Just as we rear chickens in coops, the predators rear us in human coops, humaneros. Therefore, their food is always available to them.

Different cultures, different eras, same recurring theme.

The 'ennoia' dilemma

Nag Hammadi Gnostic manuscripts say that Archon consciousness has no 'ennoia'. This is directly translated as 'intentionality', but I'll use the term 'creative imagination'. The *All That Is* in awareness of itself is the source of all creativity – all possibility – and the more disconnected you are from that source the more you are subsequently denied 'creative imagination'. Given that Archon consciousness is almost entirely disconnected it severely lacks creativity and has to rely on far more mechanical processes of thought and exploit the creative potential of those that do have 'ennoia'. You can see cases of this throughout human society. Archon consciousness almost entirely dominates the global banking system and if we study how that system works you will appreciate what I mean. Banks manifest 'money' out of nothing by issuing lines of 'credit' which is 'money' that has never, does not, and will never exist except in theory. It's a confidence trick. If you think 'credit' figures-on-a-screen 'money' is worth anything you accept it as payment. If you don't then the whole system collapses through lack of confidence in the value of that 'money'. Archontic bankers with no 'ennoia' are 'lending' 'money' that doesn't exist to humans that *do* have creativity – those that have the inspired ideas and create businesses and products. Archon banking feeds off human creativity

which it controls through 'money' creation and debt. Humans have the creativity and Archons exploit that for their own benefit and control while having none themselves. Archon Internet platforms like Facebook claim joint copyright of everything that creative users post and while Archontic minds like Zuckerberg may officially head that company it will be human creatives on the staff that provide the creative inspiration. When you have limitless 'money' you can then buy other companies established by creative humans. Witness the acquisition record of Facebook, Google and their like. Survey the Archon-controlled music industry and you see non-creative dark suit executives making their fortune from the human creativity of their artists. The cases are endless. Research the history of people like Gates and Zuckerberg and how their empires were built on exploiting the creativity of others. Archon minds cannot create out of nothing, but they are skilled (because they have to be) in what Gnostic texts call 'countermimicry'. They can imitate, but not innovate. Sabbatians trawl the creativity of others through backdoors they install in computer systems through their cybersecurity systems. Archon-controlled China is globally infamous for stealing intellectual property and I remember how Hong Kong, now part of China, became notorious for making counterfeit copies of the creativity of others – 'countermimicry'. With the now pervasive and all-seeing surveillance systems able to infiltrate any computer you can appreciate the potential for Archons to vampire the creativity of humans. Author John Lamb Lash wrote in his book about the Nag Hammadi texts, *Not In His Image*:

Although they cannot originate anything, because they lack the divine factor of ennoia (intentionality), Archons can imitate with a vengeance. Their expertise is simulation (HAL, virtual reality). The Demiurge [Yaldabaoth] fashions a heaven world copied from the fractal patterns [of the original] ... His construction is celestial kitsch, like the fake Italianate villa of a Mafia don complete with militant angels to guard every portal.

This brings us to something that I have been speaking about since the turn of the millennium. Our reality is a simulation; a virtual reality that we think is real. No, I'm not kidding.

Human reality? Well, virtually

I had pondered for years about whether our reality is 'real' or some kind of construct. I remembered being immensely affected on a visit as a small child in the late 1950s to the then newly-opened Planetarium on the Marylebone Road in London which is now closed and part of the adjacent Madame Tussauds wax museum. It was in the middle of the day, but when the lights went out there was the night sky projected in the Planetarium's domed ceiling and it appeared to be so real. The experience never left me and I didn't know why until around the turn of the millennium when I became certain that our 'night sky' and entire reality is a projection, a virtual reality, akin to the illusory world portrayed in the *Matrix* movies. I looked at the sky one day in this period and it appeared to me like the domed roof of the Planetarium. The release of the first *Matrix* movie in 1999 also provided a synchronistic and perfect visual representation of where my mind had been going for a long time. I hadn't come across the Gnostic Nag Hammadi texts then. When I did years later the correlation was once again astounding. As I read Gnostic accounts from 1,600 years and more earlier it was clear that they were describing the same simulation phenomenon. They tell how the Yaldabaoth 'Demiurge' and Archons created a 'bad copy' of original reality to rule over all that were captured by its illusions and the body was a prison to trap consciousness in the 'bad copy' fake reality. Read how Gnostics describe the 'bad copy' and update that to current times and they are referring to what we would call today a virtual reality simulation.

Author John Lamb Lash said 'the Demiurge fashions a heaven world copied from the fractal patterns' of the original through expertise in 'HAL' or virtual reality simulation. Fractal patterns are part of the energetic information construct of our reality, a sort of blueprint. If these patterns were copied in computer terms it would indeed give you a copy of a 'natural' reality in a non-natural frequency and digital form. The principle is the same as making a copy of a website. The original website still exists, but now you can change the copy version to make it whatever you like and it can

become very different to the original website. Archons have done this with our reality, a *synthetic* copy of prime reality that still exists beyond the frequency walls of the simulation. Trapped within the illusions of this synthetic Matrix, however, were and are human consciousness and other expressions of prime reality and this is why the Archons via the Cult are seeking to make the human body synthetic and give us synthetic AI minds to complete the job of turning the entire reality synthetic including what we perceive to be the natural world. To quote Kurzweil: 'Nanobots will infuse all the matter around us with information. Rocks, trees, everything will become these intelligent creatures.' Yes, *synthetic* 'creatures' just as 'Covid' and other genetically-manipulating 'vaccines' are designed to make the human body synthetic. From this perspective it is obvious why Archons and their Cult are so desperate to infuse synthetic material into every human with their 'Covid' scam.

Let there be (electromagnetic) light

Yaldabaoth, the force that created the simulation, or Matrix, makes sense of the Gnostic reference to 'The Great Architect' and its use by Cult Freemasonry as the name of its deity. The designer of the Matrix in the movies is called 'The Architect' and that trilogy is jam-packed with symbolism relating to these subjects. I have contended for years that the angry Old Testament God (Yaldabaoth) is the 'God' being symbolically 'quoted' in the opening of Genesis as 'creating the world'. This is not the creation of prime reality – it's the creation of the *simulation*. The Genesis 'God' says: 'Let there be Light: and there was light.' But what is this 'Light'? I have said for decades that the speed of light (186,000 miles per second) is not the fastest speed possible as claimed by mainstream science and is in fact the frequency walls or outer limits of the Matrix. You can't have a fastest or slowest anything within all possibility when everything is possible. The human body is encoded to operate within the speed of light or *within the simulation* and thus we see only the tiny frequency band of visible *light*. Near-death experiencers who perceive reality outside the body during temporary 'death' describe a very different

form of light and this is supported by the Nag Hammadi texts. Prime reality beyond the simulation ('Upper Aeons' to the Gnostics) is described as a realm of incredible beauty, bliss, love and harmony – a realm of 'watery light' that is so powerful 'there are no shadows'. Our false reality of Archon control, which Gnostics call the 'Lower Aeons', is depicted as a realm with a different kind of 'light' and described in terms of chaos, 'Hell', 'the Abyss' and 'Outer Darkness', where trapped souls are tormented and manipulated by demons (relate that to the 'Covid' hoax alone). The watery light theme can be found in near-death accounts and it is not the same as *simulation* 'light' which is electromagnetic or radiation light within the speed of light – the 'Lower Aeons'. Simulation 'light' is the 'luminous fire' associated by Gnostics with the Archons. The Bible refers to Yaldabaoth as 'that old serpent, called the Devil, and Satan, which deceiveth the whole world' (Revelation 12:9). I think that making a simulated copy of prime reality ('countermimicry') and changing it dramatically while all the time manipulating humanity to believe it to be real could probably meet the criteria of deceiving the whole world. Then we come to the Cult god Lucifer – the *Light Bringer*. Lucifer is symbolic of Yaldabaoth, the bringer of radiation light that forms the bad copy simulation within the speed of light. 'He' is symbolised by the lighted torch held by the Statue of Liberty and in the name 'Illuminati'. Sabbatian-Frankism declares that Lucifer is the true god and Lucifer is the real god of Freemasonry honoured as their 'Great or Grand Architect of the Universe' (simulation).

I would emphasise, too, the way Archontic technologically-generated luminous fire of radiation has deluged our environment since I was a kid in the 1950s and changed the nature of The Field with which we constantly interact. Through that interaction technological radiation is changing us. The Smart Grid is designed to operate with immense levels of communication power with 5G expanding across the world and 6G, 7G, in the process of development. Radiation is the simulation and the Archontic manipulation system. Why wouldn't the Archon Cult wish to unleash radiation upon us to an ever-greater extreme to form

Kurzweil's 'cloud'? The plan for a synthetic human is related to the need to cope with levels of radiation beyond even anything we've seen so far. Biological humans would not survive the scale of radiation they have in their script. The Smart Grid is a technological sub-reality within the technological simulation to further disconnect five-sense perception from expanded consciousness. It's a technological prison of the mind.

Infusing the 'spirit of darkness'

A recurring theme in religion and native cultures is the manipulation of human genetics by a non-human force and most famously recorded as the biblical 'sons of god' (the gods plural in the original) who interbred with the daughters of men. The Nag Hammadi *Apocryphon of John* tells the same story this way:

He [Yaldabaoth] sent his angels [Archons/demons] to the daughters of men, that they might take some of them for themselves and raise offspring for their enjoyment. And at first they did not succeed. When they had no success, they gathered together again and they made a plan together ... And the angels changed themselves in their likeness into the likeness of their mates, filling them with the spirit of darkness, which they had mixed for them, and with evil ... And they took women and begot children out of the darkness according to the likeness of their spirit.

Possession when a discarnate entity takes over a human body is an age-old theme and continues today. It's very real and I've seen it. Satanic and secret society rituals can create an energetic environment in which entities can attach to initiates and I've heard many stories of how people have changed their personality after being initiated even into lower levels of the Freemasons. I have been inside three Freemasonic temples, one at a public open day and two by just walking in when there was no one around to stop me. They were in Ryde, the town where I live, Birmingham, England, when I was with a group, and Boston, Massachusetts. They all felt the same energetically – dark, dense, low-vibrational and sinister. Demonic attachment can happen while the initiate has no idea what is going on. To them it's just a ritual to get in the Masons and do a bit of good

business. In the far more extreme rituals of Satanism human possession is even more powerful and they are designed to make possession possible. The hierarchy of the Cult is dictated by the power and perceived status of the possessing Archon. In this way the Archon hierarchy becomes the Cult hierarchy. Once the entity has attached it can influence perception and behaviour and if it attaches to the extreme then so much of its energy (information) infuses into the body information field that the hologram starts to reflect the nature of the possessing entity. This is the *Exorcist* movie type of possession when facial features change and it's known as shapeshifting. Islam's Jinn are said to be invisible tricksters who change shape, 'whisper', confuse and take human form. These are all traits of the Archons and other versions of the same phenomenon. Extreme possession could certainly infuse the 'spirit of darkness' into a partner during sex as the Nag Hammadi texts appear to describe. Such an infusion can change genetics which is also energetic information. Human genetics is information and the 'spirit of darkness' is information. Mix one with the other and change must happen. Islam has the concept of a 'Jinn baby' through possession of the mother and by Jinn taking human form. There are many ways that human genetics can be changed and remember that Archons have been aware all along of advanced techniques to do this. What is being done in human society today – and far more – was known about by Archons at the time of the 'fallen ones' and their other versions described in religions and cultures.

Archons and their human-world Cult are obsessed with genetics as we see today and they know this dictates how information is processed into perceived reality during a human life. They needed to produce a human form that would decode the simulation and this is symbolically known as 'Adam and Eve' who left the 'garden' (prime reality) and 'fell' into Matrix reality. The simulation is not a 'physical' construct (there is no 'physical'); it is a source of information. Think Wi-Fi again. The simulation is an energetic field encoded with information and body-brain systems are designed to decode that information encoded in wave or frequency form which

is transmitted to the brain as electrical signals. These are decoded by the brain to construct our sense of reality – an illusory ‘physical’ world that only exists in the brain or the mind. Virtual reality games mimic this process using the same sensory decoding system. Information is fed to the senses to decode a virtual reality that can appear so real, but isn’t (Figs 18 and 19). Some scientists believe – and I agree with them – that what we perceive as ‘physical’ reality only exists when we are looking or observing. The act of perception or focus triggers the decoding systems which turn waveform information into holographic reality. When we are not observing something our reality reverts from a holographic state to a waveform state. This relates to the same principle as a falling tree not making a noise unless someone is there to hear it or decode it. The concept makes sense from the simulation perspective. A computer is not decoding all the information in a Wi-Fi field all the time and only decodes or brings into reality on the screen that part of Wi-Fi that it’s decoding – focusing upon – at that moment.



Figure 18: Virtual reality technology ‘hacks’ into the body’s five-sense decoding system.



Figure 19: The result can be experienced as very ‘real’.

Interestingly, Professor Donald Hoffman at the Department of Cognitive Sciences at the University of California, Irvine, says that our experienced reality is like a computer interface that shows us only the level with which we interact while hiding all that exists beyond it: 'Evolution shaped us with a user interface that hides the truth. Nothing that we see is the truth – the very language of space and time and objects is the wrong language to describe reality.' He is correct in what he says on so many levels. Space and time are not a universal reality. They are a phenomenon of decoded *simulation* reality as part of the process of enslaving our sense of reality. Near-death experiencers report again and again how space and time did not exist as we perceive them once they were free of the body – body decoding systems. You can appreciate from this why Archons and their Cult are so desperate to entrap human attention in the five senses where we are in the Matrix and of the Matrix. Opening your mind to expanded states of awareness takes you beyond the information confines of the simulation and you become aware of knowledge and insights denied to you before. This is what we call 'awakening' – *awakening from the Matrix* – and in the final chapter I will relate this to current events.

Where are the 'aliens'?

A simulation would explain the so-called 'Fermi Paradox' named after Italian physicist Enrico Fermi (1901-1954) who created the first nuclear reactor. He considered the question of why there is such a lack of extraterrestrial activity when there are so many stars and planets in an apparently vast universe; but what if the night sky that we see, or think we do, is a simulated projection as I say? If you control the simulation and your aim is to hold humanity fast in essential ignorance would you want other forms of life including advanced life coming and going sharing information with humanity? Or would you want them to believe they were isolated and apparently alone? Themes of human isolation and apartness are common whether they be the perception of a lifeless universe or the fascist isolation laws of the 'Covid' era. Paradoxically the very

existence of a simulation means that we are not alone when some force had to construct it. My view is that experiences that people have reported all over the world for centuries with Reptilians and Grey entities are Archon phenomena as Nag Hammadi texts describe; and that benevolent 'alien' interactions are non-human groups that come in and out of the simulation by overcoming Archon attempts to keep them out. It should be highlighted, too, that Reptilians and Greys are obsessed with *genetics* and *technology* as related by cultural accounts and those who say they have been abducted by them. Technology is their way of overcoming some of the limitations in their creative potential and our technology-driven and controlled human society of today is *archetypical* Archon-Reptilian-Grey *modus operandi*. Technocracy is really *Archontocracy*. The Universe does not have to be as big as it appears with a simulation. There is no space or distance only information decoded into holographic reality. What we call 'space' is only the absence of holographic 'objects' and that 'space' is The Field of energetic information which connects everything into a single whole. The same applies with the artificially-generated information field of the simulation. The Universe is not big or small as a physical reality. It is decoded information, that's all, and its perceived size is decided by the way the simulation is encoded to make it appear. The entire night sky as we perceive it only exists in our brain and so where are those 'millions of light years'? The 'stars' on the ceiling of the Planetarium looked a vast distance away.

There's another point to mention about 'aliens'. I have been highlighting since the 1990s the plan to stage a fake 'alien invasion' to justify the centralisation of global power and a world military. Nazi scientist Werner von Braun, who was taken to America by Operation Paperclip after World War Two to help found NASA, told his American assistant Dr Carol Rosin about the Cult agenda when he knew he was dying in 1977. Rosin said that he told her about a sequence that would lead to total human control by a one-world government. This included threats from terrorism, rogue nations, meteors and asteroids before finally an 'alien invasion'. All of these

things, von Braun said, would be bogus and what I would refer to as a No-Problem-Reaction-Solution. Keep this in mind when 'the aliens are coming' is the new mantra. The aliens are not coming – they are *already here* and they have infiltrated human society while looking human. French-Canadian investigative journalist Serge Monast said in 1994 that he had uncovered a NASA/military operation called Project Blue Beam which fits with what Werner von Braun predicted. Monast died of a 'heart attack' in 1996 the day after he was arrested and spent a night in prison. He was 51. He said Blue Beam was a plan to stage an alien invasion that would include religious figures beamed holographically into the sky as part of a global manipulation to usher in a 'new age' of worshipping what I would say is the Cult 'god' Yaldabaoth in a one-world religion. Fake holographic asteroids are also said to be part of the plan which again syncs with von Braun. How could you stage an illusory threat from asteroids unless they were holographic inserts? This is pretty straightforward given the advanced technology outside the public arena and the fact that our 'physical' reality is holographic anyway. Information fields would be projected and we would decode them into the illusion of a 'physical' asteroid. If they can sell a global 'pandemic' with a 'virus' that doesn't exist what will humans not believe if government and media tell them?

All this is particularly relevant as I write with the Pentagon planning to release in June, 2021, information about 'UFO sightings'. I have been following the UFO story since the early 1990s and the common theme throughout has been government and military denials and cover up. More recently, however, the Pentagon has suddenly become more talkative and apparently open with Air Force pilot radar images released of unexplained craft moving and changing direction at speeds well beyond anything believed possible with human technology. Then, in March, 2021, former Director of National Intelligence John Ratcliffe said a Pentagon report months later in June would reveal a great deal of information about UFO sightings unknown to the public. He said the report would have 'massive implications'. The order to do this was included bizarrely

in a \$2.3 trillion 'coronavirus' relief and government funding bill passed by the Trump administration at the end of 2020. I would add some serious notes of caution here. I have been pointing out since the 1990s that the US military and intelligence networks have long had craft – 'flying saucers' or anti-gravity craft – which any observer would take to be extraterrestrial in origin. Keeping this knowledge from the public allows craft flown by *humans* to be perceived as alien visitations. I am not saying that 'aliens' do not exist. I would be the last one to say that, but we have to be streetwise here. President Ronald Reagan told the UN General Assembly in 1987: 'I occasionally think how quickly our differences worldwide would vanish if we were facing an alien threat from outside this world.' That's the idea. Unite against a common 'enemy' with a common purpose behind your 'saviour force' (the Cult) as this age-old technique of mass manipulation goes global.

Science moves this way ...

I could find only one other person who was discussing the simulation hypothesis publicly when I concluded it was real. This was Nick Bostrom, a Swedish-born philosopher at the University of Oxford, who has explored for many years the possibility that human reality is a computer simulation although his version and mine are not the same. Today the simulation and holographic reality hypothesis have increasingly entered the scientific mainstream. Well, the more open-minded mainstream, that is. Here are a few of the ever-gathering examples. American nuclear physicist Silas Beane led a team of physicists at the University of Bonn in Germany pursuing the question of whether we live in a simulation. They concluded that we probably do and it was likely based on a lattice of cubes. They found that cosmic rays align with that specific pattern. The team highlighted the Greisen–Zatsepin–Kuzmin (GZK) limit which refers to cosmic ray particle interaction with cosmic background radiation that creates an apparent boundary for cosmic ray particles. They say in a paper entitled 'Constraints on the Universe as a Numerical Simulation' that this 'pattern of constraint' is exactly what you

would find with a computer simulation. They also made the point that a simulation would create its own 'laws of physics' that would limit possibility. I've been making the same point for decades that the *perceived* laws of physics relate only to this reality, or what I would later call the simulation. When designers write codes to create computer and virtual reality games they are the equivalent of the laws of physics for that game. Players interact within the limitations laid out by the coding. In the same way those who wrote the codes for the simulation decided the laws of physics that would apply. These can be overridden by expanded states of consciousness, but not by those enslaved in only five-sense awareness where simulation codes rule. Overriding the codes is what people call 'miracles'. They are not. They are bypassing the encoded limits of the simulation. A population caught in simulation perception would have no idea that this was their plight. As the Bonn paper said: 'Like a prisoner in a pitch-black cell we would not be able to see the "walls" of our prison,' That's true if people remain mesmerised by the five senses. Open to expanded awareness and those walls become very clear. The main one is the speed of light.

American theoretical physicist James Gates is another who has explored the simulation question and found considerable evidence to support the idea. Gates was Professor of Physics at the University of Maryland, Director of The Center for String and Particle Theory, and on Barack Obama's Council of Advisors on Science and Technology. He and his team found *computer codes* of digital data embedded in the fabric of our reality. They relate to on-off electrical charges of 1 and 0 in the binary system used by computers. 'We have no idea what they are doing there', Gates said. They found within the energetic fabric mathematical sequences known as error-correcting codes or block codes that 'reboot' data to its original state or 'default settings' when something knocks it out of sync. Gates was asked if he had found a set of equations embedded in our reality indistinguishable from those that drive search engines and browsers and he said: 'That is correct.' Rich Terrile, director of the Centre for Evolutionary Computation and Automated Design at NASA's Jet

Propulsion Laboratory, has said publicly that he believes the Universe is a digital hologram that must have been created by a form of intelligence. I agree with that in every way. Waveform information is delivered electrically by the senses to the brain which constructs a *digital* holographic reality that we call the 'world'. This digital level of reality can be read by the esoteric art of numerology. Digital holograms are at the cutting edge of holographics today. We have digital technology everywhere designed to access and manipulate our digital level of perceived reality. Synthetic mRNA in 'Covid vaccines' has a digital component to manipulate the body's digital 'operating system'.

Reality is numbers

How many know that our reality can be broken down to numbers and codes that are the same as computer games? Max Tegmark, a physicist at the Massachusetts Institute of Technology (MIT), is the author of *Our Mathematical Universe* in which he lays out how reality can be entirely described by numbers and maths in the way that a video game is encoded with the 'physics' of computer games. Our world and computer virtual reality are essentially the same.

Tegmark imagines the perceptions of characters in an advanced computer game when the graphics are so good they don't know they are in a game. They think they can bump into real objects (electromagnetic resistance in our reality), fall in love and feel emotions like excitement. When they began to study the apparently 'physical world' of the video game they would realise that everything was made of pixels (which have been found in our energetic reality as must be the case when on one level our world is digital). What computer game characters thought was physical 'stuff', Tegmark said, could actually be broken down into numbers:

And we're exactly in this situation in our world. We look around and it doesn't seem that mathematical at all, but everything we see is made out of elementary particles like quarks and electrons. And what properties does an electron have? Does it have a smell or a colour or a texture? No! ... We physicists have come up with geeky names for [Electron] properties, like

electric charge, or spin, or lepton number, but the electron doesn't care what we call it, the properties are just numbers.

This is the illusory reality Gnostics were describing. This is the simulation. The A, C, G, and T codes of DNA have a binary value – A and C = 0 while G and T = 1. This has to be when the simulation is digital and the body must be digital to interact with it. Recurring mathematical sequences are encoded throughout reality and the body. They include the Fibonacci sequence in which the two previous numbers are added to get the next one, as in ... 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, etc. The sequence is encoded in the human face and body, proportions of animals, DNA, seed heads, pine cones, trees, shells, spiral galaxies, hurricanes and the number of petals in a flower. The list goes on and on. There are fractal patterns – a 'never-ending pattern that is infinitely complex and self-similar across all scales in the as above, so below, principle of holograms. These and other famous recurring geometrical and mathematical sequences such as Phi, Pi, Golden Mean, Golden Ratio and Golden Section are *computer codes* of the simulation. I had to laugh and give my head a shake the day I finished this book and it went into the production stage. I was sent an article in *Scientific American* published in April, 2021, with the headline 'Confirmed! We Live in a Simulation'. Two decades after I first said our reality is a simulation and the speed of light is its outer limit the article suggested that we do live in a simulation and that the speed of light is its outer limit. I left school at 15 and never passed a major exam in my life while the writer was up to his eyes in qualifications. As I will explain in the final chapter *knowing* is far better than thinking and they come from very different sources. The article rightly connected the speed of light to the processing speed of the 'Matrix' and said what has been in my books all this time ... 'If we are in a simulation, as it appears, then space is an abstract property written in code. It is not real'. No it's not and if we live in a simulation something created it and it wasn't *us*. 'That David Icke says we are manipulated by aliens' – he's crackers.'

Wow ...

The reality that humanity thinks is so real is an illusion. Politicians, governments, scientists, doctors, academics, law enforcement, media, school and university curriculums, on and on, are all founded on a world that *does not exist* except as a simulated prison cell. Is it such a stretch to accept that 'Covid' doesn't exist when our entire 'physical' reality doesn't exist? Revealed here is the knowledge kept under raps in the Cult networks of compartmentalised secrecy to control humanity's sense of reality by inducing the population to believe in a reality that's not real. If it wasn't so tragic in its experiential consequences the whole thing would be hysterically funny. None of this is new to Renegade Minds. Ancient Greek philosopher Plato (about 428 to about 347BC) was a major influence on Gnostic belief and he described the human plight thousands of years ago with his Allegory of the Cave. He told the symbolic story of prisoners living in a cave who had never been outside. They were chained and could only see one wall of the cave while behind them was a fire that they could not see. Figures walked past the fire casting shadows on the prisoners' wall and those moving shadows became their sense of reality. Some prisoners began to study the shadows and were considered experts on them (today's academics and scientists), but what they studied was only an illusion (today's academics and scientists). A prisoner escaped from the cave and saw reality as it really is. When he returned to report this revelation they didn't believe him, called him mad and threatened to kill him if he tried to set them free. Plato's tale is not only a brilliant analogy of the human plight and our illusory reality. It describes, too, the dynamics of the 'Covid' hoax. I have only skimmed the surface of these subjects here. The aim of this book is to crisply connect all essential dots to put what is happening today into its true context. All subject areas and their connections in this chapter are covered in great evidential detail in *Everything You Need To Know, But Have Never Been Told* and *The Answer*.

They say that bewildered people 'can't see the forest for the trees'. Humanity, however, can't see the forest for the *twigs*. The five senses

see only twigs while Renegade Minds can see the forest and it's the forest where the answers lie with the connections that reveals.

Breaking free of perceptual programming so the forest can be seen is the way we turn all this around. Not breaking free is how humanity got into this mess. The situation may seem hopeless, but I promise you it's not. We are a perceptual heartbeat from paradise if only we knew.

CHAPTER TWELVE

Escaping Wetiko

Life is simply a vacation from the infinite
Dean Cavanagh

Renegade Minds weave the web of life and events and see common themes in the apparently random. They are always there if you look for them and their pursuit is aided by incredible synchronicity that comes when your mind is open rather than mesmerised by what it thinks it can see.

Infinite awareness is infinite possibility and the more of infinite possibility that we access the more becomes infinitely possible. That may be stating the apparently obvious, but it is a devastatingly-powerful fact that can set us free. We are a point of attention within an infinity of consciousness. The question is how much of that infinity do we choose to access? How much knowledge, insight, awareness, wisdom, do we want to connect with and explore? If your focus is only in the five senses you will be influenced by a fraction of infinite awareness. I mean a range so tiny that it gives new meaning to infinitesimal. Limitation of self-identity and a sense of the possible limit accordingly your range of consciousness. We are what we think we are. Life is what we think it is. The dream is the dreamer and the dreamer is the dream. Buddhist philosophy puts it this way: 'As a thing is viewed, so it appears.' Most humans live in the realm of touch, taste, see, hear, and smell and that's the limit of their sense of the possible and sense of self. Many will follow a religion and speak of a God in his heaven, but their lives are still

dominated by the five senses in their perceptions and actions. The five senses become the arbiter of everything. When that happens all except a smear of infinity is sealed away from influence by the rigid, unyielding, reality bubbles that are the five-sense human or Phantom Self. Archon Cult methodology is to isolate consciousness within five-sense reality – the simulation – and then program that consciousness with a sense of self and the world through a deluge of life-long information designed to instil the desired perception that allows global control. Efforts to do this have increased dramatically with identity politics as identity bubbles are squeezed into the minutiae of five-sense detail which disconnect people even more profoundly from the infinite 'I'.

Five-sense focus and self-identity are like a firewall that limits access to the infinite realms. You only perceive one radio or television station and no other. We'll take that literally for a moment. Imagine a vast array of stations giving different information and angles on reality, but you only ever listen to one. Here we have the human plight in which the population is overwhelmingly confined to CultFM. This relates only to the frequency range of CultFM and limits perception and insight to that band – limits *possibility* to that band. It means you are connecting with an almost imperceptibly minuscule range of possibility and creative potential within the infinite Field. It's a world where everything seems apart from everything else and where synchronicity is rare. Synchronicity is defined in the dictionary as 'the happening by chance of two or more related or similar events at the same time'. Use of 'by chance' betrays a complete misunderstanding of reality. Synchronicity is not 'by chance'. As people open their minds, or 'awaken' to use the term, they notice more and more coincidences in their lives, bits of 'luck', apparently miraculous happenings that put them in the right place at the right time with the right people. Days become peppered with 'fancy meeting you here' and 'what are the chances of that?' My entire life has been lived like this and ever more so since my own colossal awakening in 1990 and 91 which transformed my sense of reality. Synchronicity is not 'by chance'; it is by accessing expanded

realms of possibility which allow expanded potential for manifestation. People broadcasting the same vibe from the same openness of mind tend to be drawn 'by chance' to each other through what I call frequency magnetism and it's not only people. In the last more than 30 years incredible synchronicity has also led me through the Cult maze to information in so many forms and to crucial personal experiences. These 'coincidences' have allowed me to put the puzzle pieces together across an enormous array of subjects and situations. Those who have breached the bubble of five-sense reality will know exactly what I mean and this escape from the perceptual prison cell is open to everyone whenever they make that choice. This may appear super-human when compared with the limitations of 'human', but it's really our natural state. 'Human' as currently experienced is consciousness in an unnatural state of induced separation from the infinity of the whole. I'll come to how this transformation into unity can be made when I have described in more detail the force that holds humanity in servitude by denying this access to infinite self.

The Wetiko factor

I have been talking and writing for decades about the way five-sense mind is systematically barricaded from expanded awareness. I have used the analogy of a computer (five-sense mind) and someone at the keyboard (expanded awareness). Interaction between the computer and the operator is symbolic of the interaction between five-sense mind and expanded awareness. The computer directly experiences the Internet and the operator experiences the Internet via the computer which is how it's supposed to be – the two working as one. Archons seek to control that point where the operator connects with the computer to stop that interaction ([Fig 20](#)). Now the operator is banging the keyboard and clicking the mouse, but the computer is not responding and this happens when the computer is taken over – *possessed* – by an appropriately-named computer 'virus'. The operator has lost all influence over the computer which goes its own way making decisions under the control of the 'virus'. I have

just described the dynamic through which the force known to Gnostics as Yaldabaoth and Archons disconnects five-sense mind from expanded awareness to imprison humanity in perceptual servitude.

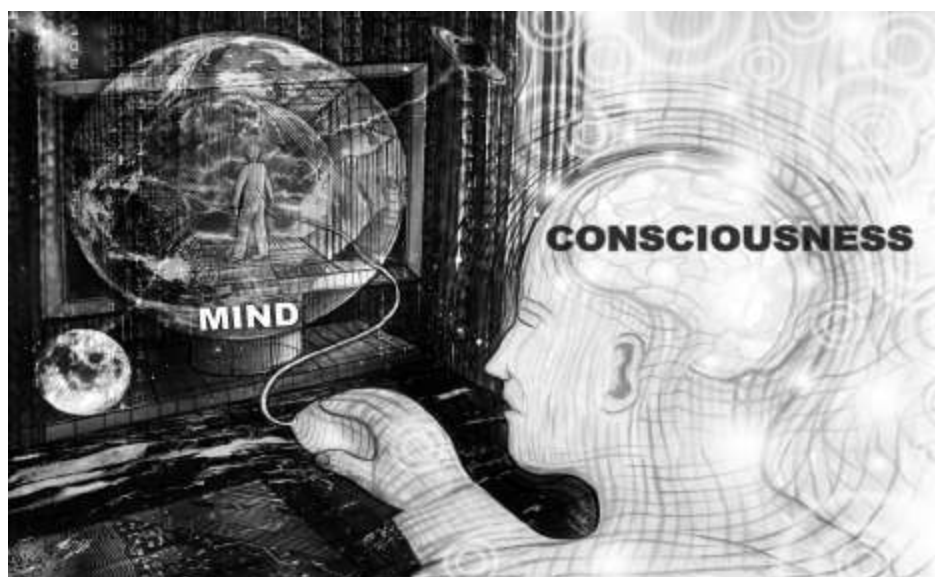


Figure 20: The mind ‘virus’ I have been writing about for decades seeks to isolate five-sense mind (the computer) from the true ‘I’. (Image by Neil Hague).

About a year ago I came across a Native American concept of Wetiko which describes precisely the same phenomenon. Wetiko is the spelling used by the Cree and there are other versions including wintiko and windigo used by other tribal groups. They spell the name with lower case, but I see Wetiko as a proper noun as with Archons and prefer a capital. I first saw an article about Wetiko by writer and researcher Paul Levy which so synced with what I had been writing about the computer/operator disconnection and later the Archons. I then read his book, the fascinating *Dispelling Wetiko, Breaking the Spell of Evil*. The parallels between what I had concluded long before and the Native American concept of Wetiko were so clear and obvious that it was almost funny. For Wetiko see the Gnostic Archons for sure and the Jinn, the Predators, and every other name for a force of evil, inversion and chaos. Wetiko is the Native American name for the force that divides the computer from

the operator (Fig 21). Indigenous author Jack D. Forbes, a founder of the Native American movement in the 1960s, wrote another book about Wetiko entitled *Columbus And Other Cannibals – The Wetiko Disease of Exploitation, Imperialism, and Terrorism* which I also read. Forbes says that Wetiko refers to an evil person or spirit ‘who terrorizes other creatures by means of terrible acts, including cannibalism’. Zulu shaman Credo Mutwa told me that African accounts tell how cannibalism was brought into the world by the Chitauri ‘gods’ – another manifestation of Wetiko. The distinction between ‘evil person or spirit’ relates to Archons/Wetiko possessing a human or acting as pure consciousness. Wetiko is said to be a sickness of the soul or spirit and a state of being that takes but gives nothing back – the Cult and its operatives perfectly described. Black Hawk, a Native American war leader defending their lands from confiscation, said European invaders had ‘poisoned hearts’ – Wetiko hearts – and that this would spread to native societies. Mention of the heart is very significant as we shall shortly see. Forbes writes: ‘Tragically, the history of the world for the past 2,000 years is, in great part, the story of the epidemiology of the wetiko disease.’ Yes, and much longer. Forbes is correct when he says: ‘The wetikos destroyed Egypt and Babylon and Athens and Rome and Tenochtitlan [capital of the Aztec empire] and perhaps now they will destroy the entire earth.’ Evil, he said, is the number one export of a Wetiko culture – see its globalisation with ‘Covid’. Constant war, mass murder, suffering of all kinds, child abuse, Satanism, torture and human sacrifice are all expressions of Wetiko and the Wetiko possessed. The world is Wetiko made manifest, *but it doesn’t have to be*. There is a way out of this even now.



Figure 21: The mind 'virus' is known to Native Americans as 'Wetiko'. (Image by Neil Hague).

Cult of Wetiko

Wetiko is the Yaldabaoth frequency distortion that seeks to attach to human consciousness and absorb it into its own. Once this connection is made Wetiko can drive the perceptions of the target which they believe to be coming from their own mind. All the horrors of history and today from mass killers to Satanists, paedophiles like Jeffrey Epstein and other psychopaths, are the embodiment of Wetiko and express its state of being in all its grotesqueness. The Cult is Wetiko incarnate, Yaldabaoth incarnate, and it seeks to facilitate Wetiko assimilation of humanity in totality into its distortion by manipulating the population into low frequency states that match its own. Paul Levy writes:

'Holographically enforced within the psyche of every human being the wetiko virus pervades and underlies the entire field of consciousness, and can therefore potentially manifest through any one of us at any moment if we are not mindful.' The 'Covid' hoax has achieved this with many people, but others have not fallen into Wetiko's frequency lair. Players in the 'Covid' human catastrophe including Gates, Schwab, Tedros, Fauci, Whitty, Vallance, Johnson, Hancock, Ferguson, Drosten, and all the rest, including the psychopath psychologists, are expressions of Wetiko. This is why

they have no compassion or empathy and no emotional consequence for what they do that would make them stop doing it. Observe all the people who support the psychopaths in authority against the Pushbackers despite the damaging impact the psychopaths have on their own lives and their family's lives. You are again looking at Wetiko possession which prevents them seeing through the lies to the obvious scam going on. *Why can't they see it?* Wetiko won't let them see it. The perceptual divide that has now become a chasm is between the Wetikoed and the non-Wetikoed.

Paul Levy describes Wetiko in the same way that I have long described the Archontic force. They are the same distorted consciousness operating across dimensions of reality: '... the subtle body of wetiko is not located in the third dimension of space and time, literally existing in another dimension ... it is able to affect ordinary lives by mysteriously interpenetrating into our three-dimensional world.' Wetiko does this through its incarnate representatives in the Cult and by weaving itself into The Field which on our level of reality is the electromagnetic information field of the simulation or Matrix. More than that, the simulation *is* Wetiko / Yaldabaoth. Caleb Scharf, Director of Astrobiology at Columbia University, has speculated that 'alien life' could be so advanced that it has transcribed itself into the quantum realm to become what we call physics. He said intelligence indistinguishable from the fabric of the Universe would solve many of its greatest mysteries:

Perhaps hyper-advanced life isn't just external. Perhaps it's already all around. It is embedded in what we perceive to be physics itself, from the root behaviour of particles and fields to the phenomena of complexity and emergence ... In other words, life might not just be in the equations. It might BE the equations [My emphasis].

Scharf said it is possible that 'we don't recognise advanced life because it forms an integral and unsuspecting part of what we've considered to be the natural world'. I agree. Wetiko/Yaldabaoth *is* the simulation. We are literally in the body of the beast. But that doesn't mean it has to control us. We all have the power to overcome Wetiko

influence and the Cult knows that. I doubt it sleeps too well because it knows that.

Which Field?

This, I suggest, is how it all works. There are two Fields. One is the fierce electromagnetic light of the Matrix within the speed of light; the other is the 'watery light' of The Field beyond the walls of the Matrix that connects with the Great Infinity. Five-sense mind and the decoding systems of the body attach us to the Field of Matrix light. They have to or we could not experience this reality. Five-sense mind sees only the Matrix Field of information while our expanded consciousness is part of the Infinity Field. When we open our minds, and most importantly our hearts, to the Infinity Field we have a mission control which gives us an expanded perspective, a road map, to understand the nature of the five-sense world. If we are isolated only in five-sense mind there is no mission control. We're on our own trying to understand a world that's constantly feeding us information to ensure we do not understand. People in this state can feel 'lost' and bewildered with no direction or radar. You can see ever more clearly those who are influenced by the Fields of Big Infinity or little five-sense mind simply by their views and behaviour with regard to the 'Covid' hoax. We have had this division throughout known human history with the mass of the people on one side and individuals who could see and intuit beyond the walls of the simulation – Plato's prisoner who broke out of the cave and saw reality for what it is. Such people have always been targeted by Wetiko/Archon-possessed authority, burned at the stake or demonised as mad, bad and dangerous. The Cult today and its global network of 'anti-hate', 'anti-fascist' Woke groups are all expressions of Wetiko attacking those exposing the conspiracy, 'Covid' lies and the 'vaccine' agenda.

Woke as a whole is Wetiko which explains its black and white mentality and how at one it is with the Wetiko-possessed Cult. Paul Levy said: 'To be in this paradigm is to still be under the thrall of a two-valued logic – where things are either true or false – of a

wetikoized mind.’ Wetiko consciousness is in a permanent rage, therefore so is Woke, and then there is Woke inversion and contradiction. ‘Anti-fascists’ act like fascists because fascists *and* ‘anti-fascists’ are both Wetiko at work. Political parties act the same while claiming to be different for the same reason. Secret society and satanic rituals are attaching initiates to Wetiko and the cold, ruthless, psychopathic mentality that secures the positions of power all over the world is Wetiko. Reframing ‘training programmes’ have the same cumulative effect of attaching Wetiko and we have their graduates described as automatons and robots with a cold, psychopathic, uncaring demeanour. They are all traits of Wetiko possession and look how many times they have been described in this book and elsewhere with regard to personnel behind ‘Covid’ including the police and medical profession. Climbing the greasy pole in any profession in a Wetiko society requires traits of Wetiko to get there and that is particularly true of politics which is not about fair competition and pre-eminence of ideas. It is founded on how many backs you can stab and arses you can lick. This culminated in the global ‘Covid’ coordination between the Wetiko possessed who pulled it off in all the different countries without a trace of empathy and compassion for their impact on humans. Our sight sense can see only holographic form and not the Field which connects holographic form. Therefore we perceive ‘physical’ objects with ‘space’ in between. In fact that ‘space’ is energy/consciousness operating on multiple frequencies. One of them is Wetiko and that connects the Cult psychopaths, those who submit to the psychopaths, and those who serve the psychopaths in the media operations of the world. Wetiko is Gates. Wetiko is the mask-wearing submissive. Wetiko is the fake journalist and ‘fact-checker’. The Wetiko Field is coordinating the whole thing. Psychopaths, gofers, media operatives, ‘anti-hate’ hate groups, ‘fact-checkers’ and submissive people work as one unit *even without human coordination* because they are attached to the *same* Field which is organising it all ([Fig 22](#)). Paul Levy is here describing how Wetiko-possessed people are drawn together and refuse to let any information breach their rigid

perceptions. He was writing long before 'Covid', but I think you will recognise followers of the 'Covid' religion *oh just a little bit*:

People who are channelling the vibratory frequency of wetiko align with each other through psychic resonance to reinforce their unspoken shared agreement so as to uphold their deranged view of reality. Once an unconscious content takes possession of certain individuals, it irresistibly draws them together by mutual attraction and knits them into groups tied together by their shared madness that can easily swell into an avalanche of insanity.

A psychic epidemic is a closed system, which is to say that it is insular and not open to any new information or informing influences from the outside world which contradict its fixed, limited, and limiting perspective.

There we have the Woke mind and the 'Covid' mind. Compatible resonance draws the awakening together, too, which is clearly happening today.

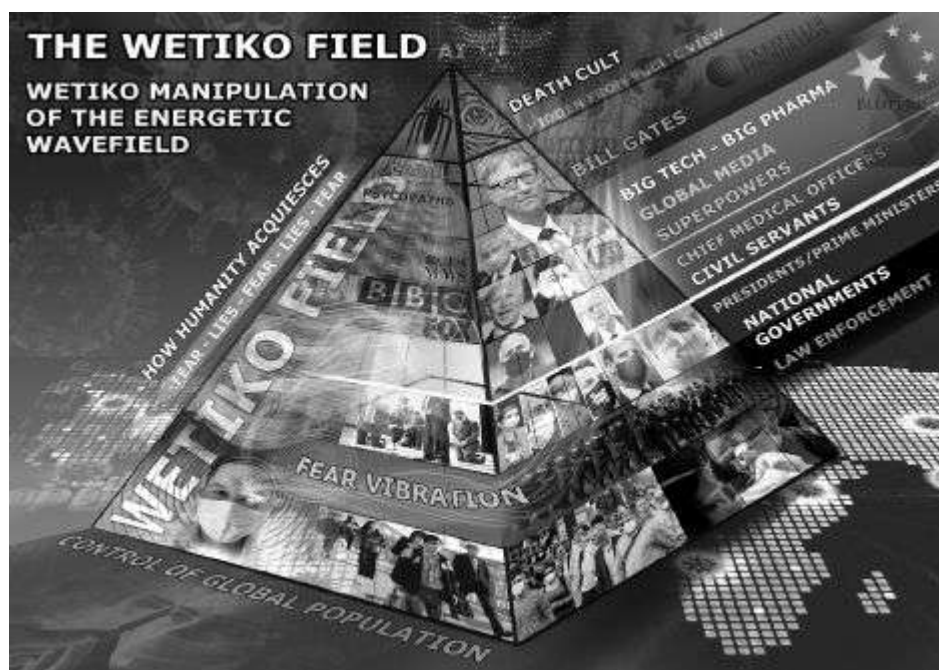


Figure 22: The Wetiko Field from which the Cult pyramid and its personnel are made manifest. (Image by Neil Hague).

Spiritual servitude

Wetiko doesn't care about humans. It's not human; it just possesses humans for its own ends and the effect (depending on the scale of

possession) can be anything from extreme psychopathy to unquestioning obedience. Wetiko's worst nightmare is for human consciousness to expand beyond the simulation. Everything is focussed on stopping that happening through control of information, thus perception, thus frequency. The 'education system', media, science, medicine, academia, are all geared to maintaining humanity in five-sense servitude as is the constant stimulation of low-vibrational mental and emotional states (see 'Covid'). Wetiko seeks to dominate those subconscious spaces between five-sense perception and expanded consciousness where the computer meets the operator. From these subconscious hiding places Wetiko speaks to us to trigger urges and desires that we take to be our own and manipulate us into anything from low-vibrational to psychopathic states. Remember how Islam describes the Jinn as invisible tricksters that 'whisper' and confuse. Wetiko is the origin of the 'trickster god' theme that you find in cultures all over the world. Jinn, like the Archons, are Wetiko which is terrified of humans awakening and reconnecting with our true self for then its energy source has gone. With that the feedback loop breaks between Wetiko and human perception that provides the energetic momentum on which its very existence depends as a force of evil. Humans are both its target and its source of survival, but only if we are operating in low-vibrational states of fear, hate, depression and the background anxiety that most people suffer. We are Wetiko's target because we are its key to survival. It needs us, not the other way round. Paul Levy writes:

A vampire has no intrinsic, independent, substantial existence in its own right; it only exists in relation to us. The pathogenic, vampiric mind-parasite called wetiko is nothing in itself – not being able to exist from its own side – yet it has a 'virtual reality' such that it can potentially destroy our species ...

...The fact that a vampire is not reflected by a mirror can also mean that what we need to see is that there's nothing, no-thing to see, other than ourselves. The fact that wetiko is the expression of something inside of us means that the cure for wetiko is with us as well. The critical issue is finding this cure within us and then putting it into effect.

Evil begets evil because if evil does not constantly expand and find new sources of energetic sustenance its evil, its *distortion*, dies with the assimilation into balance and harmony. Love is the garlic to Wetiko's vampire. Evil, the absence of love, cannot exist in the presence of love. I think I see a way out of here. I have emphasised so many times over the decades that the Archons/Wetiko and their Cult are not all powerful. *They are not*. I don't care how it looks even now *they are not*. I have not called them little boys in short trousers for effect. I have said it because it is true. Wetiko's insatiable desire for power over others is not a sign of its omnipotence, but its insecurity. Paul Levy writes: 'Due to the primal fear which ultimately drives it and which it is driven to cultivate, wetiko's body politic has an intrinsic and insistent need for centralising power and control so as to create imagined safety for itself.' Yeeeeees! Exactly! Why does Wetiko want humans in an ongoing state of fear? Wetiko itself *is* fear and it is petrified of love. As evil is an absence of love, so love is an absence of fear. Love conquers all and *especially* Wetiko which *is* fear. Wetiko brought fear into the world when it wasn't here before. *Fear* was the 'fall', the fall into low-frequency ignorance and illusion – fear is **False Emotion Appearing Real**. The simulation is driven and energised by fear because Wetiko/Yaldabaoth (fear) *are* the simulation. Fear is the absence of love and Wetiko is the absence of love.

Wetiko today

We can now view current events from this level of perspective. The 'Covid' hoax has generated momentous amounts of ongoing fear, anxiety, depression and despair which have empowered Wetiko. No wonder people like Gates have been the instigators when they are Wetiko incarnate and exhibit every trait of Wetiko in the extreme. See how cold and unemotional these people are like Gates and his cronies, how dead of eye they are. That's Wetiko. Sabbatians are Wetiko and everything they control including the World Health Organization, Big Pharma and the 'vaccine' makers, national 'health'

hierarchies, corporate media, Silicon Valley, the banking system, and the United Nations with its planned transformation into world government. All are controlled and possessed by the Wetiko distortion into distorting human society in its image. We are with this knowledge at the gateway to understanding the world. Divisions of race, culture, creed and sexuality are diversions to hide the real division between those possessed and influenced by Wetiko and those that are not. The 'Covid' hoax has brought both clearly into view. Human behaviour is not about race. Tyrants and dictatorships come in all colours and creeds. What unites the US president bombing the innocent and an African tribe committing genocide against another as in Rwanda? What unites them? *Wetiko*. All wars are Wetiko, all genocide is Wetiko, all hunger over centuries in a world of plenty is Wetiko. Children going to bed hungry, including in the West, is Wetiko. Cult-generated Woke racial divisions that focus on the body are designed to obscure the reality that divisions in behaviour are manifestations of mind, not body. Obsession with body identity and group judgement is a means to divert attention from the real source of behaviour – mind and perception. Conflict sown by the Woke both within themselves and with their target groups are Wetiko providing lunch for itself through still more agents of the division, chaos, and fear on which it feeds. The Cult is seeking to assimilate the entirety of humanity and all children and young people into the Wetiko frequency by manipulating them into states of fear and despair. Witness all the suicide and psychological unravelling since the spring of 2020. Wetiko psychopaths want to impose a state of unquestioning obedience to authority which is no more than a conduit for Wetiko to enforce its will and assimilate humanity into itself. It needs us to believe that resistance is futile when it fears resistance and even more so the game-changing non-cooperation with its impositions. It can use violent resistance for its benefit. Violent impositions and violent resistance are *both* Wetiko. The Power of Love with its Power of No will sweep Wetiko from our world. Wetiko and its Cult know that. They just don't want us to know.

AI Wetiko

This brings me to AI or artificial intelligence and something else Wetikos don't want us to know. What is AI *really*? I know about computer code algorithms and AI that learns from data input. These, however, are more diversions, the expeditionary force, for the real AI that they want to connect to the human brain as promoted by Silicon Valley Wetikos like Kurzweil. What is this AI? It is the frequency of *Wetiko*, the frequency of the Archons. The connection of AI to the human brain is the connection of the Wetiko frequency to create a Wetiko hive mind and complete the job of assimilation. The hive mind is planned to be controlled from Israel and China which are both 100 percent owned by Wetiko Sabbatians. The assimilation process has been going on minute by minute in the 'smart' era which fused with the 'Covid' era. We are told that social media is scrambling the minds of the young and changing their personality. This is true, but what is social media? Look more deeply at how it works, how it creates divisions and conflict, the hostility and cruelty, the targeting of people until they are destroyed. That's Wetiko. Social media is manipulated to tune people to the Wetiko frequency with all the emotional exploitation tricks employed by platforms like Facebook and its Wetiko front man, Zuckerberg. Facebook's Instagram announced a new platform for children to overcome a legal bar on them using the main site. This is more Wetiko exploitation and manipulation of kids. Amnesty International likened the plan to foxes offering to guard the henhouse and said it was incompatible with human rights. Since when did Wetiko or Zuckerberg (I repeat myself) care about that? Would Brin and Page at Google, Wojcicki at YouTube, Bezos at Amazon and whoever the hell runs Twitter act as they do if they were not channelling Wetiko? Would those who are developing technologies for no other reason than human control? How about those designing and selling technologies to kill people and Big Pharma drug and 'vaccine' producers who know they will end or devastate lives? Quite a thought for these people to consider is that if you are Wetiko in a human life you are Wetiko on the 'other side' unless your frequency

changes and that can only change by a change of perception which becomes a change of behaviour. Where Gates is going does not bear thinking about although perhaps that's exactly where he wants to go. Either way, that's where he's going. His frequency will make it so.

The frequency lair

I have been saying for a long time that a big part of the addiction to smartphones and devices is that a frequency is coming off them that entraps the mind. People spend ages on their phones and sometimes even a minute or so after they put them down they pick them up again and it all repeats. 'Covid' lockdowns will have increased this addiction a million times for obvious reasons. Addictions to alcohol overindulgence and drugs are another way that Wetiko entraps consciousness to attach to its own. Both are symptoms of low-vibrational psychological distress which alcoholism and drug addiction further compound. Do we think it's really a coincidence that access to them is made so easy while potions that can take people into realms beyond the simulation are banned and illegal? I have explored smartphone addiction in other books, the scale is mind-blowing, and that level of addiction does not come without help. Tech companies that make these phones are Wetiko and they will have no qualms about destroying the minds of children. We are seeing again with these companies the Wetiko perceptual combination of psychopathic enforcers and weak and meek unquestioning compliance by the rank and file.

The global Smart Grid is the Wetiko Grid and it is crucial to complete the Cult endgame. The simulation is radiation and we are being deluged with technological radiation on a devastating scale. Wetiko frauds like Elon Musk serve Cult interests while occasionally criticising them to maintain his street-cred. 5G and other forms of Wi-Fi are being directed at the earth from space on a volume and scale that goes on increasing by the day. Elon Musk's (officially) SpaceX Starlink project is in the process of putting tens of thousands of satellites in low orbit to cover every inch of the planet with 5G and other Wi-Fi to create Kurzweil's global 'cloud' to which the

human mind is planned to be attached very soon. SpaceX has approval to operate 12,000 satellites with more than 1,300 launched at the time of writing and applications filed for 30,000 more. Other operators in the Wi-Fi, 5G, low-orbit satellite market include OneWeb (UK), Telesat (Canada), and AST & Science (US). Musk tells us that AI could be the end of humanity and then launches a company called Neuralink to connect the human brain to computers. Musk's (in theory) Tesla company is building electric cars and the driverless vehicles of the smart control grid. As frauds and bullshitters go Elon Musk in my opinion is Major League.

5G and technological radiation in general are destructive to human health, genetics and psychology and increasing the strength of artificial radiation underpins the five-sense perceptual bubbles which are themselves expressions of radiation or electromagnetism. Freedom activist John Whitehead was so right with his 'databit by databit, we are building our own electronic concentration camps'. The Smart Grid and 5G is a means to control the human mind and infuse perceptual information into The Field to influence anyone in sync with its frequency. You can change perception and behaviour en masse if you can manipulate the population into those levels of frequency and this is happening all around us today. The arrogance of Musk and his fellow Cult operatives knows no bounds in the way that we see with Gates. Musk's satellites are so many in number already they are changing the night sky when viewed from Earth. The astronomy community has complained about this and they have seen nothing yet. Some consequences of Musk's Wetiko hubris include: Radiation; visible pollution of the night sky; interference with astronomy and meteorology; ground and water pollution from intensive use of increasingly many spaceports; accumulating space debris; continual deorbiting and burning up of aging satellites, polluting the atmosphere with toxic dust and smoke; and ever-increasing likelihood of collisions. A collective public open letter of complaint to Musk said:

We are writing to you ... because SpaceX is in process of surrounding the Earth with a network of thousands of satellites whose very purpose is to irradiate every square inch of the

Earth. SpaceX, like everyone else, is treating the radiation as if it were not there. As if the mitochondria in our cells do not depend on electrons moving undisturbed from the food we digest to the oxygen we breathe.

As if our nervous systems and our hearts are not subject to radio frequency interference like any piece of electronic equipment. As if the cancer, diabetes, and heart disease that now afflict a majority of the Earth's population are not metabolic diseases that result from interference with our cellular machinery. As if insects everywhere, and the birds and animals that eat them, are not starving to death as a result.

People like Musk and Gates believe in their limitless Wetiko arrogance that they can do whatever they like to the world because they own it. Consequences for humanity are irrelevant. It's absolutely time that we stopped taking this shit from these self-styled masters of the Earth when you consider where this is going.

Why is the Cult so anti-human?

I hear this question often: Why would they do this when it will affect them, too? Ah, but will it? Who is this *them*? Forget their bodies. They are just vehicles for Wetiko consciousness. When you break it all down to the foundations we are looking at a state of severely distorted consciousness targeting another state of consciousness for assimilation. The rest is detail. The simulation is the fly-trap in which unique sensations of the five senses create a cycle of addiction called reincarnation. Renegade Minds see that everything which happens in our reality is a smaller version of the whole picture in line with the holographic principle. Addiction to the radiation of smart technology is a smaller version of addiction to the whole simulation. Connecting the body/brain to AI is taking that addiction on a giant step further to total ongoing control by assimilating human incarnate consciousness into Wetiko. I have watched during the 'Covid' hoax how many are becoming ever more profoundly attached to Wetiko's perceptual calling cards of aggressive response to any other point of view ('There is no other god but me'), psychopathic lack of compassion and empathy, and servile submission to the narrative and will of authority. Wetiko is the psychopaths *and* subservience to psychopaths. The Cult of Wetiko is

so anti-human because it is *not* human. It embarked on a mission to destroy human by targeting everything that it means to be human and to survive as human. 'Covid' is not the end, just a means to an end. The Cult with its Wetiko consciousness is seeking to change Earth systems, including the atmosphere, to suit them, not humans. The gathering bombardment of 5G alone from ground and space is dramatically changing The Field with which the five senses interact. There is so much more to come if we sit on our hands and hope it will all go away. It is not meant to go away. It is meant to get ever more extreme and we need to face that while we still can – just.

Carbon dioxide is the gas of life. Without that human is over. Kaput, gone, history. No natural world, no human. The Cult has created a cock and bull story about carbon dioxide and climate change to justify its reduction to the point where Gates and the ignoramus Biden 'climate chief' John Kerry want to suck it out of the atmosphere. Kerry wants to do this because his master Gates does. Wetikos have made the gas of life a demon with the usual support from the Wokers of Extinction Rebellion and similar organisations and the bewildered puppet-child that is Greta Thunberg who was put on the world stage by Klaus Schwab and the World Economic Forum. The name Extinction Rebellion is both ironic and as always Wetiko inversion. The gas that we need to survive must be reduced to save us from extinction. The most basic need of human is oxygen and we now have billions walking around in face nappies depriving body and brain of this essential requirement of human existence. More than that 5G at 60 gigahertz interacts with the oxygen molecule to reduce the amount of oxygen the body can absorb into the bloodstream. The obvious knock-on consequences of that for respiratory and cognitive problems and life itself need no further explanation. Psychopaths like Musk are assembling a global system of satellites to deluge the human atmosphere with this insanity. The man should be in jail. Here we have two most basic of human needs, oxygen and carbon dioxide, being dismantled.

Two others, water and food, are getting similar treatment with the United Nations Agendas 21 and 2030 – the Great Reset – planning to

centrally control all water and food supplies. People will not even own rain water that falls on their land. Food is affected at the most basic level by reducing carbon dioxide. We have genetic modification or GMO infiltrating the food chain on a mass scale, pesticides and herbicides polluting the air and destroying the soil. Freshwater fish that provide livelihoods for 60 million people and feed hundreds of millions worldwide are being 'pushed to the brink' according the conservationists while climate change is the only focus. Now we have Gates and Schwab wanting to dispense with current food sources all together and replace them with a synthetic version which the Wetiko Cult would control in terms of production and who eats and who doesn't. We have been on the Totalitarian Tiptoe to this for more than 60 years as food has become ever more processed and full of chemical shite to the point today when it's not natural food at all. As Dr Tom Cowan says: 'If it has a label don't eat it.' Bill Gates is now the biggest owner of farmland in the United States and he does nothing without an ulterior motive involving the Cult. Klaus Schwab wrote: 'To feed the world in the next 50 years we will need to produce as much food as was produced in the last 10,000 years ... food security will only be achieved, however, if regulations on genetically modified foods are adapted to reflect the reality that gene editing offers a precise, efficient and safe method of improving crops.' Liar. People and the world are being targeted with aluminium through vaccines, chemtrails, food, drink cans, and endless other sources when aluminium has been linked to many health issues including dementia which is increasing year after year. Insects, bees and wildlife essential to the food chain are being deleted by pesticides, herbicides and radiation which 5G is dramatically increasing with 6G and 7G to come. The pollinating bee population is being devastated while wildlife including birds, dolphins and whales are having their natural radar blocked by the effects of ever-increasing radiation. In the summer windscreens used to be splattered with insects so numerous were they. It doesn't happen now. Where have they gone?

Synthetic everything

The Cult is introducing genetically-modified versions of trees, plants and insects including a Gates-funded project to unleash hundreds of millions of genetically-modified, lab-altered and patented male mosquitoes to mate with wild mosquitoes and induce genetic flaws that cause them to die out. Clinically-insane Gates-funded Japanese researchers have developed mosquitos that spread vaccine and are dubbed 'flying vaccinators'. Gates is funding the modification of weather patterns in part to sell the myth that this is caused by carbon dioxide and he's funding geoengineering of the skies to change the atmosphere. Some of this came to light with the Gates-backed plan to release tonnes of chalk into the atmosphere to 'deflect the Sun and cool the planet'. Funny how they do this while the heating effect of the Sun is not factored into climate projections focussed on carbon dioxide. The reason is that they want to reduce carbon dioxide (so don't mention the Sun), but at the same time they do want to reduce the impact of the Sun which is so essential to human life and health. I have mentioned the sun-cholesterol-vitamin D connection as they demonise the Sun with warnings about skin cancer (caused by the chemicals in sun cream they tell you to splash on). They come from the other end of the process with statin drugs to reduce cholesterol that turns sunlight into vitamin D. A lack of vitamin D leads to a long list of health effects and how vitamin D levels must have fallen with people confined to their homes over 'Covid'. Gates is funding other forms of geoengineering and most importantly chemtrails which are dropping heavy metals, aluminium and self-replicating nanotechnology onto the Earth which is killing the natural world. See *Everything You Need To Know, But Have Never Been Told* for the detailed background to this.

Every human system is being targeted for deletion by a force that's not human. The Wetiko Cult has embarked on the process of transforming the human body from biological to synthetic biological as I have explained. Biological is being replaced by the artificial and synthetic – Archontic 'countermimicry' – right across human society. The plan eventually is to dispense with the human body altogether

and absorb human consciousness – which it wouldn't really be by then – into cyberspace (the simulation which is Wetiko/Yaldabaoth). Preparations for that are already happening if people would care to look. The alternative media rightly warns about globalism and 'the globalists', but this is far bigger than that and represents the end of the human race as we know it. The 'bad copy' of prime reality that Gnostics describe was a bad copy of harmony, wonder and beauty to start with before Wetiko/Yaldabaoth set out to change the simulated 'copy' into something very different. The process was slow to start with. Entrapped humans in the simulation timeline were not technologically aware and they had to be brought up to intellectual speed while being suppressed spiritually to the point where they could build their own prison while having no idea they were doing so. We have now reached that stage where technological intellect has the potential to destroy us and that's why events are moving so fast. Central American shaman Don Juan Matus said:

Think for a moment, and tell me how you would explain the contradictions between the intelligence of man the engineer and the stupidity of his systems of belief, or the stupidity of his contradictory behaviour. Sorcerers believe that the predators have given us our systems of beliefs, our ideas of good and evil; our social mores. They are the ones who set up our dreams of success or failure. They have given us covetousness, greed, and cowardice. It is the predator who makes us complacent, routinary, and egomaniacal.

In order to keep us obedient and meek and weak, the predators engaged themselves in a stupendous manoeuvre – stupendous, of course, from the point of view of a fighting strategist; a horrendous manoeuvre from the point of those who suffer it. They gave us their mind. The predators' mind is baroque, contradictory, morose, filled with the fear of being discovered any minute now.

For 'predators' see Wetiko, Archons, Yaldabaoth, Jinn, and all the other versions of the same phenomenon in cultures and religions all over the world. The theme is always the same because it's true and it's real. We have reached the point where we have to deal with it. The question is – how?

Don't fight – walk away

I thought I'd use a controversial subheading to get things moving in terms of our response to global fascism. What do you mean 'don't fight'? What do you mean 'walk away'? We've got to fight. We can't walk away. Well, it depends what we mean by fight and walk away. If fighting means physical combat we are playing Wetiko's game and falling for its trap. It wants us to get angry, aggressive, and direct hate and hostility at the enemy we think we must fight. Every war, every battle, every conflict, has been fought with Wetiko leading both sides. It's what it does. Wetiko wants a fight, anywhere, any place. Just hit me, son, so I can hit you back. Wetiko hits Wetiko and Wetiko hits Wetiko in return. I am very forthright as you can see in exposing Wetikos of the Cult, but I don't hate them. I refuse to hate them. It's what they want. What you hate you become. What you *fight* you become. Wokers, 'anti-haters' and 'anti-fascists' prove this every time they reach for their keyboards or don their balaclavas. By walk away I mean to disengage from Wetiko which includes ceasing to cooperate with its tyranny. Paul Levy says of Wetiko:

The way to 'defeat' evil is not to try to destroy it (for then, in playing evil's game, we have already lost), but rather, to find the invulnerable place within ourselves where evil is unable to vanquish us – this is to truly 'win' our battle with evil.

Wetiko is everywhere in human society and it's been on steroids since the 'Covid' hoax. Every shouting match over wearing masks has Wetiko wearing a mask and Wetiko not wearing one. It's an electrical circuit of push and resist, push and resist, with Wetiko pushing *and* resisting. Each polarity is Wetiko empowering itself. Dictionary definitions of 'resist' include 'opposing, refusing to accept or comply with' and the word to focus on is 'opposing'. What form does this take – setting police cars alight or 'refusing to accept or comply with'? The former is Wetiko opposing Wetiko while the other points the way forward. This is the difference between those aggressively demanding that government fascism must be obeyed who stand in stark contrast to the great majority of Pushbackers. We saw this clearly with a march by thousands of Pushbackers against lockdown in London followed days later by a Woker-hijacked

protest in Bristol in which police cars were set on fire. Masks were virtually absent in London and widespread in Bristol. Wetiko wants lockdown on every level of society and infuses its aggression to police it through its unknowing stooges. Lockdown protesters are the ones with the smiling faces and the hugs, The two blatantly obvious states of being – getting more obvious by the day – are the result of Wokers and their like becoming ever more influenced by the simulation Field of Wetiko and Pushbackers ever more influenced by The Field of a far higher vibration beyond the simulation. Wetiko can't invade the heart which is where most lockdown opponents are coming from. It's the heart that allows them to see through the lies to the truth in ways I will be highlighting.

Renegade Minds know that calmness is the place from which wisdom comes. You won't find wisdom in a hissing fit and wisdom is what we need in abundance right now. Calmness is not weakness – you don't have to scream at the top of your voice to be strong. Calmness is indeed a sign of strength. 'No' means I'm not doing it. NOOOO!!! doesn't mean you're not doing it even more. Volume does not advance 'No – I'm not doing it'. You are just not doing it. Wetiko possessed and influenced don't know how to deal with that. Wetiko wants a fight and we should not give it one. What it needs more than anything is our *cooperation* and we should not give that either. Mass rallies and marches are great in that they are a visual representation of feeling, but if it ends there they are irrelevant. You demand that Wetikos act differently? Well, they're not going to are they? They are Wetikos. We don't need to waste our time demanding that something doesn't happen when that will make no difference. We need to delete the means that *allows* it to happen. This, invariably, is our cooperation. You can demand a child stop firing a peashooter at the dog or you can refuse to buy the peashooter. If you provide the means you are cooperating with the dog being smacked on the nose with a pea. How can the authorities enforce mask-wearing if millions in a country refuse? What if the 74 million Pushbackers that voted for Trump in 2020 refused to wear masks, close their businesses or stay in their homes. It would be unenforceable. The

few control the many through the compliance of the many and that's always been the dynamic be it 'Covid' regulations or the Roman Empire. I know people can find it intimidating to say no to authority or stand out in a crowd for being the only one with a face on display; but it has to be done or it's over. I hope I've made clear in this book that where this is going will be far more intimidating than standing up now and saying 'No' – I will not cooperate with my own enslavement and that of my children. There might be consequences for some initially, although not so if enough do the same. The question that must be addressed is what is going to happen if we don't? It is time to be strong and unyieldingly so. No means no. Not here and there, but *everywhere* and *always*. I have refused to wear a mask and obey all the other nonsense. I will not comply with tyranny. I repeat: Fascism is not imposed by fascists – there are never enough of them. Fascism is imposed by the population acquiescing to fascism. *I will not do it*. I will die first, or my body will. Living meekly under fascism is a form of death anyway, the death of the spirit that Martin Luther King described.

Making things happen

We must not despair. This is not over till it's over and it's far from that. The 'fat lady' must refuse to sing. The longer the 'Covid' hoax has dragged on and impacted on more lives we have seen an awakening of phenomenal numbers of people worldwide to the realisation that what they have believed all their lives is not how the world really is. Research published by the system-serving University of Bristol and King's College London in February, 2021, concluded: 'One in every 11 people in Britain say they trust David Icke's take on the coronavirus pandemic.' It will be more by now and we have gathering numbers to build on. We must urgently progress from seeing the scam to ceasing to cooperate with it. Prominent German lawyer Reiner Fuellmich, also licenced to practice law in America, is doing a magnificent job taking the legal route to bring the psychopaths to justice through a second Nuremberg tribunal for crimes against humanity. Fuellmich has an impressive record of

beating the elite in court and he formed the German Corona Investigative Committee to pursue civil charges against the main perpetrators with a view to triggering criminal charges. Most importantly he has grasped the foundation of the hoax – the PCR test not testing for the ‘virus’ – and Christian Drosten is therefore on his charge sheet along with Gates frontman Tedros at the World Health Organization. Major players must not be allowed to inflict their horrors on the human race without being brought to book. A life sentence must follow for Bill Gates and the rest of them. A group of researchers has also indicted the government of Norway for crimes against humanity with copies sent to the police and the International Criminal Court. The lawsuit cites participation in an internationally-planned false pandemic and violation of international law and human rights, the European Commission’s definition of human rights by coercive rules, Nuremberg and Hague rules on fundamental human rights, and the Norwegian constitution. We must take the initiative from hereon and not just complain, protest and react.

There are practical ways to support vital mass non-cooperation. Organising in numbers is one. Lockdown marches in London in the spring in 2021 were mass non-cooperation that the authorities could not stop. There were too many people. Hundreds of thousands walked the London streets in the centre of the road for mile after mile while the Face-Nappies could only look on. They were determined, but calm, and just *did it* with no histrionics and lots of smiles. The police were impotent. Others are organising group shopping without masks for mutual support and imagine if that was happening all over. Policing it would be impossible. If the store refuses to serve people in these circumstances they would be faced with a long line of trolleys full of goods standing on their own and everything would have to be returned to the shelves. How would they cope with that if it kept happening? I am talking here about moving on from complaining to being pro-active; from watching things happen to making things happen. I include in this our relationship with the police. The behaviour of many Face-Nappies

has been disgraceful and anyone who thinks they would never find concentration camp guards in the 'enlightened' modern era have had that myth busted big-time. The period and setting may change – Wetikos never do. I watched film footage from a London march in which a police thug viciously kicked a protestor on the floor who had done nothing. His fellow Face-Nappies stood in a ring protecting him. What he did was a criminal assault and with a crowd far outnumbering the police this can no longer be allowed to happen unchallenged. I get it when people chant 'shame on you' in these circumstances, but that is no longer enough. They *have* no shame those who do this. Crowds needs to start making a citizen's arrest of the police who commit criminal offences and brutally attack innocent people and defenceless women. A citizen's arrest can be made under section 24A of the UK Police and Criminal Evidence (PACE) Act of 1984 and you will find something similar in other countries. I prefer to call it a Common Law arrest rather than citizen's for reasons I will come to shortly. Anyone can arrest a person committing an indictable offence or if they have reasonable grounds to suspect they are committing an indictable offence. On both counts the attack by the police thug would have fallen into this category. A citizen's arrest can be made to stop someone:

- Causing physical injury to himself or any other person
- Suffering physical injury
- Causing loss of or damage to property
- Making off before a constable can assume responsibility for him

A citizen's arrest may also be made to prevent a breach of the peace under Common Law and if they believe a breach of the peace will happen or anything related to harm likely to be done or already done in their presence. This is the way to go I think – the Common Law version. If police know that the crowd and members of the public will no longer be standing and watching while they commit

their thuggery and crimes they will think twice about acting like Brownshirts and Blackshirts.

Common Law – common sense

Mention of Common Law is very important. Most people think the law is the law as in one law. This is not the case. There are two bodies of law, Common Law and Statute Law, and they are not the same. Common Law is founded on the simple premise of do no harm. It does not recognise victimless crimes in which no harm is done while Statute Law does. There is a Statute Law against almost everything. So what is Statute Law? Amazingly it's the law of the *sea* that was brought ashore by the Cult to override the law of the land which is Common Law. They had no right to do this and as always they did it anyway. They had to. They could not impose their will on the people through Common Law which only applies to do no harm. How could you stitch up the fine detail of people's lives with that? Instead they took the law of the sea, or Admiralty Law, and applied it to the population. Statute Law refers to all the laws spewing out of governments and their agencies including all the fascist laws and regulations relating to 'Covid'. The key point to make is that Statute Law is *contract law*. It only applies between *contracting* corporations. Most police officers don't even know this. They have to be kept in the dark, too. Long ago when merchants and their sailing ships began to trade with different countries a contractual law was developed called Admiralty Law and other names. Again it only applied to *contracts* agreed between *corporate* entities. If there is no agreed contract the law of the sea had no jurisdiction *and that still applies to its new alias of Statute Law*. The problem for the Cult when the law of the sea was brought ashore was an obvious one. People were not corporations and neither were government entities. To overcome the latter they made governments and all associated organisations corporations. All the institutions are *private corporations* and I mean governments and their agencies, local councils, police, courts, military, US states, the whole lot. Go to the

Dun and Bradstreet corporate listings website for confirmation that they are all corporations. You are arrested by a private corporation called the police by someone who is really a private security guard and they take you to court which is another private corporation. Neither have jurisdiction over you unless you consent and *contract* with them. This is why you hear the mantra about law enforcement policing by *consent* of the people. In truth the people 'consent' only in theory through monumental trickery.

Okay, the Cult overcame the corporate law problem by making governments and institutions corporate entities; but what about people? They are not corporations are they? Ah ... well in a sense, and *only* a sense, they are. Not people exactly – the illusion of people. The Cult creates a corporation in the name of everyone at the time that their birth certificate is issued. Note birth/ *berth* certificate and when you go to court under the law of the sea on land you stand in a *dock*. These are throwbacks to the origin. My Common Law name is David Vaughan Icke. The name of the corporation created by the government when I was born is called Mr David Vaughan Icke usually written in capitals as MR DAVID VAUGHAN ICKE. That is not me, the living, breathing man. It is a fictitious corporate entity. The trick is to make you think that David Vaughan Icke and MR DAVID VAUGHAN ICKE are the same thing. *They are not*. When police charge you and take you to court they are prosecuting the corporate entity and not the living, breathing, man or woman. They have to trick you into identifying as the corporate entity and contracting with them. Otherwise they have no jurisdiction. They do this through a language known as legalese. Lawful and legal are not the same either. Lawful relates to Common Law and legal relates to Statute Law. Legalese is the language of Statue Law which uses terms that mean one thing to the public and another in legalese. Notice that when a police officer tells someone why they are being charged he or she will say at the end: 'Do you understand?' To the public that means 'Do you comprehend?' In legalese it means 'Do you stand under me?' Do you stand under my authority? If you say

yes to the question you are unknowingly agreeing to give them jurisdiction over you in a contract between two corporate entities.

This is a confidence trick in every way. Contracts have to be agreed between informed parties and if you don't know that David Vaughan Icke is agreeing to be the corporation MR DAVID VAUGHAN ICKE you cannot knowingly agree to contract. They are deceiving you and another way they do this is to ask for proof of identity. You usually show them a driving licence or other document on which your corporate name is written. In doing so you are accepting that you are that corporate entity when you are not. Referring to yourself as a 'person' or 'citizen' is also identifying with your corporate fiction which is why I made the Common Law point about the citizen's arrest. If you are approached by a police officer you identify yourself immediately as a living, breathing, man or woman and say 'I do not consent, I do not contract with you and I do not understand' or stand under their authority. I have a Common Law birth certificate as a living man and these are available at no charge from commonlawcourt.com. Businesses registered under the Statute Law system means that its laws apply. There are, however, ways to run a business under Common Law. Remember all 'Covid' laws and regulations are Statute Law – the law of *contracts* and you do not have to contract. This doesn't mean that you can kill someone and get away with it. Common Law says do no harm and that applies to physical harm, financial harm etc. Police are employees of private corporations and there needs to be a new system of non-corporate Common Law constables operating outside the Statute Law system. If you go to davidicke.com and put Common Law into the search engine you will find videos that explain Common Law in much greater detail. It is definitely a road we should walk.

With all my heart

I have heard people say that we are in a spiritual war. I don't like the term 'war' with its Wetiko dynamic, but I know what they mean. Sweep aside all the bodily forms and we are in a situation in which two states of consciousness are seeking very different realities.

Wetiko wants upheaval, chaos, fear, suffering, conflict and control. The other wants love, peace, harmony, fairness and freedom. That's where we are. We should not fall for the idea that Wetiko is all-powerful and there's nothing we can do. Wetiko is not all-powerful. It's a joke, pathetic. It doesn't have to be, but it has made that choice for now. A handful of times over the years when I have felt the presence of its frequency I have allowed it to attach briefly so I could consciously observe its nature. The experience is not pleasant, the energy is heavy and dark, but the ease with which you can kick it back out the door shows that its real power is in persuading us that it has power. It's all a con. Wetiko is a con. It's a trickster and not a power that can control us if we unleash our own. The con is founded on manipulating humanity to give its power to Wetiko which recycles it back to present the illusion that it has power when its power is *ours* that we gave away. This happens on an energetic level and plays out in the world of the seen as humanity giving its power to Wetiko authority which uses that power to control the population when the power is only the power the population has handed over. How could it be any other way for billions to be controlled by a relative few? I have had experiences with people possessed by Wetiko and again you can kick its arse if you do it with an open heart. Oh yes – the *heart* which can transform the world of perceived 'matter'.

We are receiver-transmitters and processors of information, but what information and where from? Information is processed into perception in three main areas – the brain, the heart and the belly. These relate to thinking, knowing, and emotion. Wetiko wants us to be head and belly people which means we think within the confines of the Matrix simulation and low-vibrational emotional reaction scrambles balance and perception. A few minutes on social media and you see how emotion is the dominant force. Woke is all emotion and is therefore thought-free and fact-free. Our heart is something different. It *knows* while the head *thinks* and has to try to work it out because it doesn't know. The human energy field has seven prime vortexes which connect us with wider reality ([Fig 23](#)). Chakra means

‘wheels of light’ in the Sanskrit language of ancient India. The main ones are: The crown chakra on top of the head; brow (or ‘third eye’) chakra in the centre of the forehead; throat chakra; heart chakra in the centre of the chest; solar plexus chakra below the sternum; sacral chakra beneath the navel; and base chakra at the bottom of the spine. Each one has a particular function or functions. We feel anxiety and nervousness in the belly where the sacral chakra is located and this processes emotion that can affect the colon to give people ‘the shits’ or make them ‘shit scared’ when they are nervous. Chakras all play an important role, but the Mr and Mrs Big is the heart chakra which sits at the centre of the seven, above the chakras that connect us to the ‘physical’ and below those that connect with higher realms (or at least should). Here in the heart chakra we feel love, empathy and compassion – ‘My heart goes out to you’. Those with closed hearts become literally ‘heart-less’ in their attitudes and behaviour (see Bill Gates). Native Americans portrayed Wetiko with what Paul Levy calls a ‘frigid, icy heart, devoid of mercy’ (see Bill Gates).



Figure 23: The chakra system which interpenetrates the human energy field. The heart chakra is the governor – or should be.

Wetiko trembles at the thought of heart energy which it cannot infiltrate. The frequency is too high. What it seeks to do instead is close the heart chakra vortex to block its perceptual and energetic influence. Psychopaths have ‘hearts of stone’ and emotionally-damaged people have ‘heartache’ and ‘broken hearts’. The astonishing amount of heart disease is related to heart chakra

disruption with its fundamental connection to the 'physical' heart. Dr Tom Cowan has written an outstanding book challenging the belief that the heart is a pump and making the connection between the 'physical' and spiritual heart. Rudolph Steiner who was way ahead of his time said the same about the fallacy that the heart is a pump. *What?* The heart is not a pump? That's crazy, right? Everybody knows that. Read Cowan's *Human Heart, Cosmic Heart* and you will realise that the very idea of the heart as a pump is ridiculous when you see the evidence. How does blood in the feet so far from the heart get pumped horizontally up the body by the heart?? Cowan explains in the book the real reason why blood moves as it does. Our 'physical' heart is used to symbolise love when the source is really the heart vortex or spiritual heart which is our most powerful energetic connection to 'out there' expanded consciousness. That's why we feel *knowing* – intuitive knowing – in the centre of the chest. Knowing doesn't come from a process of thoughts leading to a conclusion. It is there in an instant all in one go. Our heart knows because of its connection to levels of awareness that *do* know. This is the meaning and source of intuition – intuitive *knowing*.

For the last more than 30 years of uncovering the global game and the nature of reality my heart has been my constant antenna for truth and accuracy. An American intelligence insider once said that I had quoted a disinformant in one of my books and yet I had only quoted the part that was true. He asked: 'How do you do that?' By using my heart antenna was the answer and anyone can do it. Heart-centred is how we are meant to be. With a closed heart chakra we withdraw into a closed mind and the bubble of five-sense reality. If you take a moment to focus your attention on the centre of your chest, picture a spinning wheel of light and see it opening and expanding. You will feel it happening, too, and perceptions of the heart like joy and love as the heart impacts on the mind as they interact. The more the chakra opens the more you will feel expressions of heart consciousness and as the process continues, and becomes part of you, insights and knowings will follow. An open

heart is connected to that level of awareness that knows all is *One*. You will see from its perspective that the fault-lines that divide us are only illusions to control us. An open heart does not process the illusions of race, creed and sexuality except as brief experiences for a consciousness that is all. Our heart does not see division, only unity (Figs 24 and 25). There's something else, too. Our hearts love to laugh. Mark Twain's quote that says 'The human race has one really effective weapon, and that is laughter' is really a reference to the heart which loves to laugh with the joy of knowing the true nature of infinite reality and that all the madness of human society is an illusion of the mind. Twain also said: 'Against the assault of laughter nothing can stand.' This is so true of Wetiko and the Cult. Their insecurity demands that they be taken seriously and their power and authority acknowledged and feared. We should do nothing of the sort. We should not get aggressive or fearful which their insecurity so desires. We should laugh in their face. Even in their no-face as police come over in their face-nappies and expect to be taken seriously. They don't take themselves seriously looking like that so why should we? Laugh in the face of intimidation. Laugh in the face of tyranny. You will see by its reaction that you have pressed all of its buttons. Wetiko does not know what to do in the face of laughter or when its targets refuse to concede their joy to fear. We have seen many examples during the 'Covid' hoax when people have expressed their energetic power and the string puppets of Wetiko retreat with their tail limp between their knees. Laugh – the world is bloody mad after all and if it's a choice between laughter and tears I know which way I'm going.



Figure 24: Head consciousness without the heart sees division and everything apart from everything else.



Figure 25: Heart consciousness sees everything as One.

'Vaccines' and the soul

The foundation of Wetiko/Archon control of humans is the separation of incarnate five-sense mind from the infinite 'I' and closing the heart chakra where the True 'I' lives during a human life. The goal has been to achieve complete separation in both cases. I was interested therefore to read an account by a French energetic healer of what she said she experienced with a patient who had been given the 'Covid' vaccine. Genuine energy healers can sense information and consciousness fields at different levels of being which are referred to as 'subtle bodies'. She described treating the patient who later returned after having, without the healer's knowledge, two doses of the 'Covid vaccine'. The healer said:

I noticed immediately the change, very heavy energy emanating from [the] subtle bodies. The scariest thing was when I was working on the heart chakra, I connected with her soul: it was detached from the physical body, it had no contact and it was, as if it was floating in a state of total confusion: a damage to the consciousness that loses contact with the physical body, i.e. with our biological machine, there is no longer any communication between them.

I continued the treatment by sending light to the heart chakra, the soul of the person, but it seemed that the soul could no longer receive any light, frequency or energy. It was a very powerful experience for me. Then I understood that this substance is indeed used to detach consciousness so that this consciousness can no longer interact through this body that it possesses in life, where there is no longer any contact, no frequency, no light, no more energetic balance or mind.

This would create a human that is rudderless and at the extreme almost zombie-like operating with a fractional state of consciousness at the mercy of Wetiko. I was especially intrigued by what the healer said in the light of the prediction by the highly-informed Rudolf Steiner more than a hundred years ago. He said:

In the future, we will eliminate the soul with medicine. Under the pretext of a 'healthy point of view', there will be a vaccine by which the human body will be treated as soon as possible directly at birth, so that the human being cannot develop the thought of the existence of soul and Spirit. To materialistic doctors will be entrusted the task of removing the soul of humanity.

As today, people are vaccinated against this disease or that disease, so in the future, children will be vaccinated with a substance that can be produced precisely in such a way that people, thanks to this vaccination, will be immune to being subjected to the 'madness' of spiritual life. He would be extremely smart, but he would not develop a conscience, and that is the true goal of some materialistic circles.

Steiner said the vaccine would detach the physical body from the etheric body (subtle bodies) and 'once the etheric body is detached the relationship between the universe and the etheric body would become extremely unstable, and man would become an automaton'. He said 'the physical body of man must be polished on this Earth by spiritual will – so the vaccine becomes a kind of arymanique (Wetiko) force' and 'man can no longer get rid of a given materialistic feeling'. Humans would then, he said, become 'materialistic of constitution and can no longer rise to the spiritual'. I have been writing for years about DNA being a receiver-transmitter of information that connects us to other levels of reality and these 'vaccines' changing DNA can be likened to changing an antenna and what it can transmit and receive. Such a disconnection would clearly lead to changes in personality and perception. Steiner further predicted the arrival of AI. Big Pharma 'Covid vaccine' makers, expressions of Wetiko, are testing their DNA-manipulating evil on children as I write with a view to giving the 'vaccine' to babies. If it's a soul-body disconnecter – and I say that it is or can be – every child would be disconnected from 'soul' at birth and the 'vaccine' would create a closed system in which spiritual guidance from the greater self would play no part. This has been the ambition of Wetiko all

along. A Pentagon video from 2005 was leaked of a presentation explaining the development of vaccines to change behaviour by their effect on the brain. Those that believe this is not happening with the 'Covid' genetically-modifying procedure masquerading as a 'vaccine' should make an urgent appointment with Naivety Anonymous. Klaus Schwab wrote in 2018:

Neurotechnologies enable us to better influence consciousness and thought and to understand many activities of the brain. They include decoding what we are thinking in fine levels of detail through new chemicals and interventions that can influence our brains to correct for errors or enhance functionality.

The plan is clear and only the heart can stop it. With every heart that opens, every mind that awakens, Wetiko is weakened. Heart and love are far more powerful than head and hate and so nothing like a majority is needed to turn this around.

Beyond the Phantom

Our heart is the prime target of Wetiko and so it must be the answer to Wetiko. We *are* our heart which is part of one heart, the infinite heart. Our heart is where the true self lives in a human life behind firewalls of five-sense illusion when an imposter takes its place – *Phantom Self*; but our heart waits patiently to be set free any time we choose to see beyond the Phantom, beyond Wetiko. A Wetikoed Phantom Self can wreak mass death and destruction while the love of forever is locked away in its heart. The time is here to unleash its power and let it sweep away the fear and despair that is Wetiko. Heart consciousness does not seek manipulated, censored, advantage for its belief or religion, its activism and desires. As an expression of the One it treats all as One with the same rights to freedom and opinion. Our heart demands fairness for itself no more than for others. From this unity of heart we can come together in mutual support and transform this Wetikoed world into what reality is meant to be – a place of love, joy, happiness, fairness, justice and freedom. Wetiko has another agenda and that's why the world is as

it is, but enough of this nonsense. Wetiko can't stay where hearts are open and it works so hard to keep them closed. Fear is its currency and its food source and love in its true sense has no fear. Why would love have fear when it knows it is *All That Is, Has Been, And Ever Can Be* on an eternal exploration of all possibility? Love in this true sense is not the physical attraction that passes for love. This can be an expression of it, yes, but Infinite Love, a love without condition, goes far deeper to the core of all being. It *is* the core of all being. Infinite reality was born from love beyond the illusions of the simulation. Love infinitely expressed is the knowing that all is One and the swiftly-passing experience of separation is a temporary hallucination. You cannot disconnect from Oneness; you can only *perceive* that you have and withdraw from its influence. This is the most important of all perception trickery by the mind parasite that is Wetiko and the foundation of all its potential for manipulation.

If we open our hearts, open the sluice gates of the mind, and redefine self-identity amazing things start to happen. Consciousness expands or contracts in accordance with self-identity. When true self is recognised as infinite awareness and label self – Phantom Self – is seen as only a series of brief experiences life is transformed. Consciousness expands to the extent that self-identity expands and everything changes. You see unity, not division, the picture, not the pixels. From this we can play the long game. No more is an experience something in and of itself, but a fleeting moment in the eternity of forever. Suddenly people in uniform and dark suits are no longer intimidating. Doing what your heart knows to be right is no longer intimidating and consequences for those actions take on the same nature of a brief experience that passes in the blink of an infinite eye. Intimidation is all in the mind. Beyond the mind there is no intimidation.

An open heart does not consider consequences for what it knows to be right. To do so would be to consider not doing what it knows to be right and for a heart in its power that is never an option. The Renegade Mind is really the Renegade Heart. Consideration of consequences will always provide a getaway car for the mind and

the heart doesn't want one. What is right in the light of what we face today is to stop cooperating with Wetiko in all its forms and to do it without fear or compromise. You cannot compromise with tyranny when tyranny always demands more until it has everything. Life is your perception and you are your destiny. Change your perception and you change your life. Change collective perception and we change the world.

Come on people ... One human family, One heart, One goal ...
FREEEEEEEDOM!

We must settle for nothing less.

Postscript

The big scare story as the book goes to press is the 'Indian' variant and the world is being deluged with propaganda about the 'Covid catastrophe' in India which mirrors in its lies and misrepresentations what happened in Italy before the first lockdown in 2020.

The *New York Post* published a picture of someone who had 'collapsed in the street from Covid' in India in April, 2021, which was actually taken during a gas leak in May, 2020. Same old, same old. Media articles in mid-February were asking why India had been so untouched by 'Covid' and then as their vaccine rollout gathered pace the alleged 'cases' began to rapidly increase. Indian 'Covid vaccine' maker Bharat Biotech was funded into existence by the Bill and Melinda Gates Foundation (the pair announced their divorce in May, 2021, which is a pity because they so deserve each other). The Indian 'Covid crisis' was ramped up by the media to terrify the world and prepare people for submission to still more restrictions. The scam that worked the first time was being repeated only with far more people seeing through the deceit. Davidicke.com and Ickonic.com have sought to tell the true story of what is happening by talking to people living through the Indian nightmare which has nothing to do with 'Covid'. We posted a letter from 'Alisha' in Pune who told a very different story to government and media mendacity. She said scenes of dying people and overwhelmed hospitals were designed to hide what was really happening – genocide and starvation. Alisha said that millions had already died of starvation during the ongoing lockdowns while government and media were lying and making it look like the 'virus':

Restaurants, shops, gyms, theatres, basically everything is shut. The cities are ghost towns. Even so-called 'essential' businesses are only open till 11am in the morning. You basically have just an hour to buy food and then your time is up.

Inter-state travel and even inter-district travel is banned. The cops wait at all major crossroads to question why you are traveling outdoors or to fine you if you are not wearing a mask.

The medical community here is also complicit in genocide, lying about hospitals being full and turning away people with genuine illnesses, who need immediate care. They have even created a shortage of oxygen cylinders.

This is the classic Cult modus operandi played out in every country. Alisha said that people who would not have a PCR test not testing for the 'virus' were being denied hospital treatment. She said the people hit hardest were migrant workers and those in rural areas. Most businesses employed migrant workers and with everything closed there were no jobs, no income and no food. As a result millions were dying of starvation or malnutrition. All this was happening under Prime Minister Narendra Modi, a 100-percent asset of the Cult, and it emphasises yet again the scale of pure anti-human evil we are dealing with. Australia banned its people from returning home from India with penalties for trying to do so of up to five years in jail and a fine of £37,000. The manufactured 'Covid' crisis in India was being prepared to justify further fascism in the West. Obvious connections could be seen between the Indian 'vaccine' programme and increased 'cases' and this became a common theme. The Seychelles, the most per capita 'Covid vaccinated' population in the world, went back into lockdown after a 'surge of cases'.

Long ago the truly evil Monsanto agricultural biotechnology corporation with its big connections to Bill Gates devastated Indian farming with genetically-modified crops. Human rights activist Gurcharan Singh highlighted the efforts by the Indian government to complete the job by destroying the food supply to hundreds of millions with 'Covid' lockdowns. He said that 415 million people at the bottom of the disgusting caste system (still going whatever they say) were below the poverty line and struggled to feed themselves every year. Now the government was imposing lockdown at just the

time to destroy the harvest. This deliberate policy was leading to mass starvation. People may reel back at the suggestion that a government would do that, but Wetiko-controlled 'leaders' are capable of any level of evil. In fact what is described in India is in the process of being instigated worldwide. The food chain and food supply are being targeted at every level to cause world hunger and thus control. Bill Gates is not the biggest owner of farmland in America for no reason and destroying access to food aids both the depopulation agenda and the plan for synthetic 'food' already being funded into existence by Gates. Add to this the coming hyper-inflation from the suicidal creation of fake 'money' in response to 'Covid' and the breakdown of container shipping systems and you have a cocktail that can only lead one way and is meant to. The Cult plan is to crash the entire system to 'build back better' with the Great Reset.

'Vaccine' transmission

Reports from all over the world continue to emerge of women suffering menstrual and fertility problems after having the fake 'vaccine' and of the non-'vaccinated' having similar problems when interacting with the 'vaccinated'. There are far too many for 'coincidence' to be credible. We've had menopausal women getting periods, others having periods stop or not stopping for weeks, passing clots, sometimes the lining of the uterus, breast irregularities, and miscarriages (which increased by 400 percent in parts of the United States). Non-'vaccinated' men and children have suffered blood clots and nose bleeding after interaction with the 'vaccinated'. Babies have died from the effects of breast milk from a 'vaccinated' mother. Awake doctors – the small minority – speculated on the cause of non-'vaccinated' suffering the same effects as the 'vaccinated'. Was it nanotechnology in the synthetic substance transmitting frequencies or was it a straight chemical bioweapon that was being transmitted between people? I am not saying that some kind of chemical transmission is not one possible answer, but the foundation of all that the Cult does is frequency and

this is fertile ground for understanding how transmission can happen. American doctor Carrie Madej, an internal medicine physician and osteopath, has been practicing for the last 20 years, teaching medical students, and she says attending different meetings where the agenda for humanity was discussed. Madej, who operates out of Georgia, did not dismiss other possible forms of transmission, but she focused on frequency in search of an explanation for transmission. She said the Moderna and Pfizer 'vaccines' contained nano-lipid particles as a key component. This was a brand new technology never before used on humanity. 'They're using a nanotechnology which is pretty much little tiny computer bits ... nanobots or hydrogel.' Inside the 'vaccines' was 'this sci-fi kind of substance' which suppressed immune checkpoints to get into the cell. I referred to this earlier as the 'Trojan horse' technique that tricks the cell into opening a gateway for the self-replicating synthetic material and while the immune system is artificially suppressed the body has no defences. Madej said the substance served many purposes including an on-demand ability to 'deliver the payload' and using the nano 'computer bits' as biosensors in the body. 'It actually has the ability to accumulate data from your body, like your breathing, your respiration, thoughts, emotions, all kinds of things.'

She said the technology obviously has the ability to operate through Wi-Fi and transmit and receive energy, messages, frequencies or impulses. 'Just imagine you're getting this new substance in you and it can react to things all around you, the 5G, your smart device, your phones.' We had something completely foreign in the human body that had never been launched large scale at a time when we were seeing 5G going into schools and hospitals (plus the Musk satellites) and she believed the 'vaccine' transmission had something to do with this: '... if these people have this inside of them ... it can act like an antenna and actually transmit it outwardly as well.' The synthetic substance produced its own voltage and so it could have that kind of effect. This fits with my own contention that the nano receiver-transmitters are designed to connect people to the

Smart Grid and break the receiver-transmitter connection to expanded consciousness. That would explain the French energy healer's experience of the disconnection of body from 'soul' with those who have had the 'vaccine'. The nanobots, self-replicating inside the body, would also transmit the synthetic frequency which could be picked up through close interaction by those who have not been 'vaccinated'. Madej speculated that perhaps it was 5G and increased levels of other radiation that was causing the symptoms directly although interestingly she said that non-'vaccinated' patients had shown improvement when they were away from the 'vaccinated' person they had interacted with. It must be remembered that you can control frequency and energy with your mind and you can consciously create energetic barriers or bubbles with the mind to stop damaging frequencies from penetrating your field. American paediatrician Dr Larry Palevsky said the 'vaccine' was not a 'vaccine' and was never designed to protect from a 'viral' infection. He called it 'a massive, brilliant propaganda of genocide' because they didn't have to inject everyone to get the result they wanted. He said the content of the jabs was able to infuse any material into the brain, heart, lungs, kidneys, liver, sperm and female productive system. 'This is genocide; this is a weapon of mass destruction.' At the same time American colleges were banning students from attending if they didn't have this life-changing and potentially life-ending 'vaccine'. Class action lawsuits must follow when the consequences of this college fascism come to light. As the book was going to press came reports about fertility effects on sperm in 'vaccinated' men which would absolutely fit with what I have been saying and hospitals continued to fill with 'vaccine' reactions. Another question is what about transmission via blood transfusions? The NHS has extended blood donation restrictions from seven days after a 'Covid vaccination' to 28 days after even a sore arm reaction.

I said in the spring of 2020 that the then touted 'Covid vaccine' would be ongoing each year like the flu jab. A year later Pfizer CEO, the appalling Albert Bourla, said people would 'likely' need a 'booster dose' of the 'vaccine' within 12 months of getting 'fully

vaccinated' and then a yearly shot. 'Variants will play a key role', he said confirming the point. Johnson & Johnson CEO Alex Gorsky also took time out from his 'vaccine' disaster to say that people may need to be vaccinated against 'Covid-19' each year. UK Health Secretary, the psychopath Matt Hancock, said additional 'boosters' would be available in the autumn of 2021. This is the trap of the 'vaccine passport'. The public will have to accept every last 'vaccine' they introduce, including for the fake 'variants', or it would cease to be valid. The only other way in some cases would be continuous testing with a test not testing for the 'virus' and what is on the swabs constantly pushed up your nose towards the brain every time?

'Vaccines' changing behaviour

I mentioned in the body of the book how I believed we would see gathering behaviour changes in the 'vaccinated' and I am already hearing such comments from the non-'vaccinated' describing behaviour changes in friends, loved ones and work colleagues. This will only increase as the self-replicating synthetic material and nanoparticles expand in body and brain. An article in the *Guardian* in 2016 detailed research at the University of Virginia in Charlottesville which developed a new method for controlling brain circuits associated with complex animal behaviour. The method, dubbed 'magnetogenetics', involves genetically-engineering a protein called ferritin, which stores and releases iron, to create a magnetised substance – 'Magneto' – that can activate specific groups of nerve cells from a distance. This is claimed to be an advance on other methods of brain activity manipulation known as optogenetics and chemogenetics (the Cult has been developing methods of brain control for a long time). The ferritin technique is said to be non-invasive and able to activate neurons 'rapidly and reversibly'. In other words, human thought and perception. The article said that earlier studies revealed how nerve cell proteins 'activated by heat and mechanical pressure can be genetically engineered so that they become sensitive to radio waves and magnetic fields, by attaching them to an iron-storing protein called ferritin, or to inorganic

paramagnetic particles'. Sensitive to radio waves and magnetic fields? You mean like 5G, 6G and 7G? This is the human-AI Smart Grid hive mind we are talking about. The *Guardian* article said:

... the researchers injected Magneto into the striatum of freely behaving mice, a deep brain structure containing dopamine-producing neurons that are involved in reward and motivation, and then placed the animals into an apparatus split into magnetised and non-magnetised sections.

Mice expressing Magneto spent far more time in the magnetised areas than mice that did not, because activation of the protein caused the striatal neurons expressing it to release dopamine, so that the mice found being in those areas rewarding. This shows that Magneto can remotely control the firing of neurons deep within the brain, and also control complex behaviours.

Make no mistake this basic methodology will be part of the 'Covid vaccine' cocktail and using magnetics to change brain function through electromagnetic field frequency activation. The Pentagon is developing a 'Covid vaccine' using ferritin. Magnetism would explain changes in behaviour and why videos are appearing across the Internet as I write showing how magnets stick to the skin at the point of the 'vaccine' shot. Once people take these 'vaccines' anything becomes possible in terms of brain function and illness which will be blamed on 'Covid-19' and 'variants'. Magnetic field manipulation would further explain why the non-'vaccinated' are reporting the same symptoms as the 'vaccinated' they interact with and why those symptoms are reported to decrease when not in their company. Interestingly 'Magneto', a 'mutant', is a character in the Marvel Comic *X-Men* stories with the ability to manipulate magnetic fields and he believes that mutants should fight back against their human oppressors by any means necessary. The character was born Erik Lehnsherr to a Jewish family in Germany.

Cult-controlled courts

The European Court of Human Rights opened the door for mandatory 'Covid-19 vaccines' across the continent when it ruled in a Czech Republic dispute over childhood immunisation that legally

enforced vaccination could be 'necessary in a democratic society'. The 17 judges decided that compulsory vaccinations did not breach human rights law. On the face of it the judgement was so inverted you gasp for air. If not having a vaccine infused into your body is not a human right then what is? Ah, but they said human rights law which has been specifically written to delete all human rights at the behest of the state (the Cult). Article 8 of the European Convention on Human Rights relates to the right to a private life. The crucial word here is '*except*':

There shall be no interference by a public authority with the exercise of this right EXCEPT such as is in accordance with the law and is necessary in a democratic society in the interests of national security, public safety or the economic wellbeing of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others [My emphasis].

No interference *except* in accordance with the law means there *are* no 'human rights' *except* what EU governments decide you can have at their behest. 'As is necessary in a democratic society' explains that reference in the judgement and 'in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others' gives the EU a coach and horses to ride through 'human rights' and scatter them in all directions. The judiciary is not a check and balance on government extremism; it is a vehicle to enforce it. This judgement was almost laughably predictable when the last thing the Cult wanted was a decision that went against mandatory vaccination. Judges rule over and over again to benefit the system of which they are a part. Vaccination disputes that come before them are invariably delivered in favour of doctors and authorities representing the view of the state which owns the judiciary. Oh, yes, and we have even had calls to stop putting 'Covid-19' on death certificates within 28 days of a 'positive test' because it is claimed the practice makes the 'vaccine' appear not to work. They are laughing at you.

The scale of madness, inhumanity and things to come was highlighted when those not 'vaccinated' for 'Covid' were refused evacuation from the Caribbean island of St Vincent during massive volcanic eruptions. Cruise ships taking residents to the safety of another island allowed only the 'vaccinated' to board and the rest were left to their fate. Even in life and death situations like this we see 'Covid' stripping people of their most basic human instincts and the insanity is even more extreme when you think that fake 'vaccine'-makers are not even claiming their body-manipulating concoctions stop 'infection' and 'transmission' of a 'virus' that doesn't exist. St Vincent Prime Minister Ralph Gonsalves said: 'The chief medical officer will be identifying the persons already vaccinated so that we can get them on the ship.' Note again the power of the chief medical officer who, like Whitty in the UK, will be answering to the World Health Organization. This is the Cult network structure that has overridden politicians who 'follow the science' which means doing what WHO-controlled 'medical officers' and 'science advisers' tell them. Gonsalves even said that residents who were 'vaccinated' after the order so they could board the ships would still be refused entry due to possible side effects such as 'wooziness in the head'. The good news is that if they were woozy enough in the head they could qualify to be prime minister of St Vincent.

Microchipping freedom

The European judgement will be used at some point to justify moves to enforce the 'Covid' DNA-manipulating procedure. Sandra Ro, CEO of the Global Blockchain Business Council, told a World Economic Forum event that she hoped 'vaccine passports' would help to 'drive forced consent and standardisation' of global digital identity schemes: 'I'm hoping with the desire and global demand for some sort of vaccine passport – so that people can get travelling and working again – [it] will drive forced consent, standardisation, and frankly, cooperation across the world.' The lady is either not very bright, or thoroughly mendacious, to use the term 'forced consent'.

You do not 'consent' if you are forced – you *submit*. She was describing what the plan has been all along and that's to enforce a digital identity on every human without which they could not function. 'Vaccine passports' are opening the door and are far from the end goal. A digital identity would allow you to be tracked in everything you do in cyberspace and this is the same technique used by Cult-owned China to enforce its social credit system of total control. The ultimate 'passport' is planned to be a microchip as my books have warned for nearly 30 years. Those nice people at the Pentagon working for the Cult-controlled Defense Advanced Research Projects Agency (DARPA) claimed in April, 2021, they have developed a microchip inserted under the skin to detect 'asymptomatic Covid-19 infection' before it becomes an outbreak and a 'revolutionary filter' that can remove the 'virus' from the blood when attached to a dialysis machine. The only problems with this are that the 'virus' does not exist and people transmitting the 'virus' with no symptoms is brain-numbing bullshit. This is, of course, not a ruse to get people to be microchipped for very different reasons. DARPA also said it was producing a one-stop 'vaccine' for the 'virus' and all 'variants'. One of the most sinister organisations on Planet Earth is doing this? Better have it then. These people are insane because Wetiko that possesses them is insane.

Researchers from the Salk Institute in California announced they have created an embryo that is part human and part monkey. My books going back to the 1990s have exposed experiments in top secret underground facilities in the United States where humans are being crossed with animal and non-human 'extraterrestrial' species. They are now easing that long-developed capability into the public arena and there is much more to come given we are dealing with psychiatric basket cases. Talking of which – Elon Musk's scientists at Neuralink trained a monkey to play Pong and other puzzles on a computer screen using a joystick and when the monkey made the correct move a metal tube squirted banana smoothie into his mouth which is the basic technique for training humans into unquestioning compliance. Two Neuralink chips were in the monkey's skull and

more than 2,000 wires 'fanned out' into its brain. Eventually the monkey played a video game purely with its brain waves. Psychopathic narcissist Musk said the 'breakthrough' was a step towards putting Neuralink chips into human skulls and merging minds with artificial intelligence. *Exactly*. This man is so dark and Cult to his DNA.

World Economic Fascism (WEF)

The World Economic Forum is telling you the plan by the statements made at its many and various events. Cult-owned fascist YouTube CEO Susan Wojcicki spoke at the 2021 WEF Global Technology Governance Summit (see the name) in which 40 governments and 150 companies met to ensure 'the responsible design and deployment of emerging technologies'. Orwellian translation: 'Ensuring the design and deployment of long-planned technologies will advance the Cult agenda for control and censorship.' Freedom-destroyer and Nuremberg-bound Wojcicki expressed support for tech platforms like hers to censor content that is 'technically legal but could be harmful'. Who decides what is 'harmful'? She does and they do. 'Harmful' will be whatever the Cult doesn't want people to see and we have legislation proposed by the UK government that would censor content on the basis of 'harm' no matter if the information is fair, legal and provably true. Make that *especially* if it is fair, legal and provably true. Wojcicki called for a global coalition to be formed to enforce content moderation standards through automated censorship. This is a woman and mega-censor so self-deluded that she shamelessly accepted a 'free expression' award – *Wojcicki* – in an event sponsored by her own *YouTube*. They have no shame and no self-awareness.

You know that 'Covid' is a scam and Wojcicki a Cult operative when YouTube is censoring medical and scientific opinion purely on the grounds of whether it supports or opposes the Cult 'Covid' narrative. Florida governor Ron DeSantis compiled an expert panel with four professors of medicine from Harvard, Oxford, and Stanford Universities who spoke against forcing children and

vaccinated people to wear masks. They also said there was no proof that lockdowns reduced spread or death rates of 'Covid-19'. Cult-gofer Wojcicki and her YouTube deleted the panel video 'because it included content that contradicts the consensus of local and global health authorities regarding the efficacy of masks to prevent the spread of Covid-19'. This 'consensus' refers to what the Cult tells the World Health Organization to say and the WHO tells 'local health authorities' to do. Wojcicki knows this, of course. The panellists pointed out that censorship of scientific debate was responsible for deaths from many causes, but Wojcicki couldn't care less. She would not dare go against what she is told and as a disgrace to humanity she wouldn't want to anyway. The UK government is seeking to pass a fascist 'Online Safety Bill' to specifically target with massive fines and other means non-censored video and social media platforms to make them censor 'lawful but harmful' content like the Cult-owned Facebook, Twitter, Google and YouTube. What is 'lawful but harmful' would be decided by the fascist Blair-created Ofcom.

Another WEF obsession is a cyber-attack on the financial system and this is clearly what the Cult has planned to take down the bank accounts of everyone – except theirs. Those that think they have enough money for the Cult agenda not to matter to them have got a big lesson coming if they continue to ignore what is staring them in the face. The World Economic Forum, funded by Gates and fronted by Klaus Schwab, announced it would be running a 'simulation' with the Russian government and global banks of just such an attack called Cyber Polygon 2021. What they simulate – as with the 'Covid' Event 201 – they plan to instigate. The WEF is involved in a project with the Cult-owned Carnegie Endowment for International Peace called the WEF-Carnegie Cyber Policy Initiative which seeks to merge Wall Street banks, 'regulators' (I love it) and intelligence agencies to 'prevent' (arrange and allow) a cyber-attack that would bring down the global financial system as long planned by those that control the WEF and the Carnegie operation. The Carnegie Endowment for International Peace sent an instruction to First World

War US President Woodrow Wilson not to let the war end before society had been irreversibly transformed.

The Wuhan lab diversion

As I close, the Cult-controlled authorities and lapdog media are systematically pushing 'the virus was released from the Wuhan lab' narrative. There are two versions – it happened by accident and it happened on purpose. Both are nonsense. The perceived existence of the never-shown-to-exist 'virus' is vital to sell the impression that there is actually an infective agent to deal with and to allow the endless potential for terrifying the population with 'variants' of a 'virus' that does not exist. The authorities at the time of writing are going with the 'by accident' while the alternative media is promoting the 'on purpose'. Cable news host Tucker Carlson who has questioned aspects of lockdown and 'vaccine' compulsion has bought the Wuhan lab story. 'Everyone now agrees' he said. Well, I don't and many others don't and the question is *why* does the system and its media suddenly 'agree'? When the media moves as one unit with a narrative it is always a lie – witness the hour by hour mendacity of the 'Covid' era. Why would this Cult-owned combination which has unleashed lies like machine gun fire suddenly 'agree' to tell the truth??

Much of the alternative media is buying the lie because it fits the conspiracy narrative, but it's the *wrong* conspiracy. The real conspiracy is that *there is no virus* and that is what the Cult is desperate to hide. The idea that the 'virus' was released by accident is ludicrous when the whole 'Covid' hoax was clearly long-planned and waiting to be played out as it was so fast in accordance with the Rockefeller document and Event 201. So they prepared everything in detail over decades and then sat around strumming their fingers waiting for an 'accidental' release from a bio-lab? *What??* It's crazy. Then there's the 'on purpose' claim. You want to circulate a 'deadly virus' and hide the fact that you've done so and you release it down the street from the highest-level bio-lab in China? I repeat – *What??*

You would release it far from that lab to stop any association being made. But, no, we'll do it in a place where the connection was certain to be made. Why would you need to scam 'cases' and 'deaths' and pay hospitals to diagnose 'Covid-19' if you had a real 'virus'? What are sections of the alternative media doing believing this crap? Where were all the mass deaths in Wuhan from a 'deadly pathogen' when the recovery to normal life after the initial propaganda was dramatic in speed? Why isn't the 'deadly pathogen' now circulating all over China with bodies in the street? Once again we have the technique of tell them what they want to hear and they will likely believe it. The alternative media has its 'conspiracy' and with Carlson it fits with his 'China is the danger' narrative over years. China *is* a danger as a global Cult operations centre, but not for this reason. The Wuhan lab story also has the potential to instigate conflict with China when at some stage the plan is to trigger a Problem-Reaction-Solution confrontation with the West. Question everything – *everything* – and especially when the media agrees on a common party line.

Third wave ... fourth wave ... fifth wave ...

As the book went into production the world was being set up for more lockdowns and a 'third wave' supported by invented 'variants' that were increasing all the time and will continue to do so in public statements and computer programs, but not in reality. India became the new Italy in the 'Covid' propaganda campaign and we were told to be frightened of the new 'Indian strain'. Somehow I couldn't find it within myself to do so. A document produced for the UK government entitled 'Summary of further modelling of easing of restrictions – Roadmap Step 2' declared that a third wave was inevitable (of course when it's in the script) and it would be the fault of children and those who refuse the health-destroying fake 'Covid vaccine'. One of the computer models involved came from the Cult-owned *Imperial College* and the other from Warwick University which I wouldn't trust to tell me the date in a calendar factory. The document states that both models presumed extremely high uptake

of the 'Covid vaccines' and didn't allow for 'variants'. The document states: 'The resurgence is a result of some people (mostly children) being ineligible for vaccination; others choosing not to receive the vaccine; and others being vaccinated but not perfectly protected.' The mendacity takes the breath away. Okay, blame those with a brain who won't take the DNA-modifying shots and put more pressure on children to have it as 'trials' were underway involving children as young as six months with parents who give insanity a bad name. Massive pressure is being put on the young to have the fake 'vaccine' and child age consent limits have been systematically lowered around the world to stop parents intervening. Most extraordinary about the document was its claim that the 'third wave' would be driven by 'the resurgence in both hospitalisations and deaths ... dominated by *those that have received two doses of the vaccine*, comprising around 60-70% of the wave respectively'. The predicted peak of the 'third wave' suggested 300 deaths per day with 250 of them *fully 'vaccinated' people*. How many more lies do acquiescers need to be told before they see the obvious? Those who took the jab to 'protect themselves' are projected to be those who mostly get sick and die? So what's in the 'vaccine'? The document went on:

It is possible that a summer of low prevalence could be followed by substantial increases in incidence over the following autumn and winter. Low prevalence in late summer should not be taken as an indication that SARS-CoV-2 has retreated or that the population has high enough levels of immunity to prevent another wave.

They are telling you the script and while many British people believed 'Covid' restrictions would end in the summer of 2021 the government was preparing for them to be ongoing. Authorities were awarding contracts for 'Covid marshals' to police the restrictions with contracts starting in July, 2021, and going through to January 31st, 2022, and the government was advertising for 'Media Buying Services' to secure media propaganda slots worth a potential £320 million for 'Covid-19 campaigns' with a contract not ending until March, 2022. The recipient – via a list of other front companies – was reported to be American media marketing giant Omnicom Group

Inc. While money is no object for 'Covid' the UK waiting list for all other treatment – including life-threatening conditions – passed 4.5 million. Meantime the Cult is seeking to control all official 'inquiries' to block revelations about what has really been happening and why. It must not be allowed to – we need Nuremberg jury trials in every country. The cover-up doesn't get more obvious than appointing ultra-Zionist professor Philip Zelikow to oversee two dozen US virologists, public health officials, clinicians, former government officials and four American 'charitable foundations' to 'learn the lessons' of the 'Covid' debacle. The personnel will be those that created and perpetuated the 'Covid' lies while Zelikow is the former executive director of the 9/11 Commission who ensured that the truth about those attacks never came out and produced a report that must be among the most mendacious and manipulative documents ever written – see *The Trigger* for the detailed exposure of the almost unimaginable 9/11 story in which Sabbatians can be found at every level.

Passive no more

People are increasingly challenging the authorities with amazing numbers of people taking to the streets in London well beyond the ability of the Face-Nappies to stop them. Instead the Nappies choose situations away from the mass crowds to target, intimidate, and seek to promote the impression of 'violent protestors'. One such incident happened in London's Hyde Park. Hundreds of thousands walking through the streets in protest against 'Covid' fascism were ignored by the Cult-owned BBC and most of the rest of the mainstream media, but they delighted in reporting how police were injured in 'clashes with protestors'. The truth was that a group of people gathered in Hyde Park at the end of one march when most had gone home and they were peacefully having a good time with music and chat. Face-Nappies who couldn't deal with the full-march crowd then waded in with their batons and got more than they bargained for. Instead of just standing for this criminal brutality the crowd used their numerical superiority to push the Face-Nappies out of the

park. Eventually the Nappies turned and ran. Unfortunately two or three idiots in the crowd threw drink cans striking two officers which gave the media and the government the image they wanted to discredit the 99.9999 percent who were peaceful. The idiots walked straight into the trap and we must always be aware of potential agent provocateurs used by the authorities to discredit their targets.

This response from the crowd – the can people apart – must be a turning point when the public no longer stand by while the innocent are arrested and brutally attacked by the Face-Nappies. That doesn't mean to be violent, that's the last thing we need. We'll leave the violence to the Face-Nappies and government. But it does mean that when the Face-Nappies use violence against peaceful people the numerical superiority is employed to stop them and make citizen's arrests or Common Law arrests for a breach of the peace. The time for being passive in the face of fascism is over.

We are the many, they are the few, and we need to make that count before there is no freedom left and our children and grandchildren face an ongoing fascist nightmare.

COME ON PEOPLE – IT'S TIME.

One final thought ...

The power of love
A force from above
Cleaning my soul
Flame on burn desire
Love with tongues of fire
Purge the soul
Make love your goal

I'll protect you from the hooded claw
Keep the vampires from your door
When the chips are down I'll be around
With my undying, death-defying
Love for you

Envy will hurt itself
Let yourself be beautiful
Sparkling love, flowers
And pearls and pretty girls
Love is like an energy
Rushin' rushin' inside of me

This time we go sublime
Lovers entwine, divine, divine,
Love is danger, love is pleasure
Love is pure – the only treasure

I'm so in love with you
Purge the soul
Make love your goal

The power of love
A force from above
Cleaning my soul
The power of love
A force from above
A sky-scraping dove

Flame on burn desire
Love with tongues of fire
Purge the soul
Make love your goal

Frankie Goes To Hollywood

APPENDIX

Cowan-Kaufman-Morell Statement on Virus Isolation (SOVI)

Isolation: The action of isolating; the fact or condition of being isolated or standing alone; separation from other things or persons; solitariness

Oxford English Dictionary

The controversy over whether the SARS-CoV-2 virus has ever been isolated or purified continues. However, using the above definition, common sense, the laws of logic and the dictates of science, any unbiased person must come to the conclusion that the SARS-CoV-2 virus has never been isolated or purified. As a result, no confirmation of the virus' existence can be found. The logical, common sense, and scientific consequences of this fact are:

- the structure and composition of something not shown to exist can't be known, including the presence, structure, and function of any hypothetical spike or other proteins;
- the genetic sequence of something that has never been found can't be known;
- "variants" of something that hasn't been shown to exist can't be known;
- it's impossible to demonstrate that SARS-CoV-2 causes a disease called Covid-19.

In as concise terms as possible, here's the proper way to isolate, characterize and demonstrate a new virus. First, one takes samples (blood, sputum, secretions) from many people (e.g. 500) with symptoms which are unique and specific enough to characterize an illness. Without mixing these samples with ANY tissue or products that also contain genetic material, the virologist macerates, filters and ultracentrifuges i.e. *purifies* the specimen. This common virology technique, done for decades to isolate bacteriophages¹ and so-called giant viruses in every virology lab, then allows the virologist to demonstrate with electron microscopy thousands of identically sized and shaped particles. These particles are the isolated and purified virus.

These identical particles are then checked for uniformity by physical and/or microscopic techniques. Once the purity is determined, the particles may be further characterized. This would include examining the structure, morphology, and chemical composition of the particles. Next, their genetic makeup is characterized by extracting the genetic material directly from the purified particles and using genetic-sequencing techniques, such as Sanger sequencing, that have also been around for decades. Then one does an analysis to confirm that these uniform particles are exogenous (outside) in origin as a virus is conceptualized to be, and not the normal breakdown products of dead and dying tissues.² (As of May 2020, we know that virologists have no way to determine whether the particles they're seeing are viruses or just normal breakdown products of dead and dying tissues.)³

1 Isolation, characterization and analysis of bacteriophages from the haloalkaline lake Elmenteita, Kenya Julia Khayeli Akhwale et al, PLOS One, Published: April 25, 2019.
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0215734> – accessed 2/15/21

2 "Extracellular Vesicles Derived From Apoptotic Cells: An Essential Link Between Death and Regeneration," Maojiao Li et al, Frontiers in Cell and Developmental Biology, 2020 October 2.
<https://www.frontiersin.org/articles/10.3389/fcell.2020.573511/full> – accessed 2/15/21

If we have come this far then we have fully isolated, characterized, and genetically sequenced an exogenous virus particle. However, we still have to show it is causally related to a disease. This is carried out by exposing a group of healthy subjects (animals are usually used) to this isolated, purified virus in the manner in which the disease is thought to be transmitted. If the animals get sick with the same disease, as confirmed by clinical and autopsy findings, one has now shown that the virus actually causes a disease. This demonstrates infectivity and transmission of an infectious agent.

None of these steps has even been attempted with the SARS-CoV-2 virus, nor have all these steps been successfully performed for any so-called pathogenic virus. Our research indicates that a single study showing these steps does not exist in the medical literature.

Instead, since 1954, virologists have taken unpurified samples from a relatively few people, often less than ten, with a similar disease. They then minimally process this sample and inoculate this unpurified sample onto tissue culture containing usually four to six other types of material – all of which contain identical genetic material as to what is called a “virus.” The tissue culture is starved and poisoned and naturally disintegrates into many types of particles, some of which contain genetic material. Against all common sense, logic, use of the English language and scientific integrity, this process is called “virus isolation.” This brew containing fragments of genetic material from many sources is then subjected to genetic analysis, which then creates in a computer-simulation process the alleged sequence of the alleged virus, a so called in silico genome. At no time is an actual virus confirmed by electron microscopy. At no time is a genome extracted and sequenced from an actual virus. This is scientific fraud.

The observation that the unpurified specimen — inoculated onto tissue culture along with toxic antibiotics, bovine fetal tissue, amniotic fluid and other tissues — destroys the kidney tissue onto which it is inoculated is given as evidence of the virus' existence and pathogenicity. This is scientific fraud.

From now on, when anyone gives you a paper that suggests the SARS-CoV-2 virus has been isolated, please check the methods sections. If the researchers used Vero cells or any other culture method, you know that their process was not isolation. You will hear the following excuses for why actual isolation isn't done:

1. There were not enough virus particles found in samples from patients to analyze.
2. Viruses are intracellular parasites; they can't be found outside the cell in this manner.

If No. 1 is correct, and we can't find the virus in the sputum of sick people, then on what evidence do we think the virus is dangerous or even lethal? If No. 2 is correct, then how is the virus spread from person to person? We are told it emerges from the cell to infect others. Then why isn't it possible to find it?

Finally, questioning these virology techniques and conclusions is not some distraction or divisive issue. Shining the light on this truth is essential to stop this terrible fraud that humanity is confronting. For, as we now know, if the virus has never been isolated, sequenced or shown to cause illness, if the virus is imaginary, then why are we wearing masks, social distancing and putting the whole world into prison?

Finally, if pathogenic viruses don't exist, then what is going into those injectable devices erroneously called "vaccines," and what is their purpose? This scientific question is the most urgent and relevant one of our time.

We are correct. The SARS-CoV2 virus does not exist.

Sally Fallon Morell, MA

Dr. Thomas Cowan, MD

Dr. Andrew Kaufman, MD

Bibliography

- Alinsky, Saul:** *Rules for Radicals* (Vintage, 1989)
- Antelman, Rabbi Marvin:** *To Eliminate the Opiate* (Zahavia, 1974)
- Bastardi, Joe:** *The Climate Chronicles* (Relentless Thunder Press, 2018)
- Cowan, Tom:** *Human Heart, Cosmic Heart* (Chelsea Green Publishing, 2016)
- Cowan, Tom, and Fallon Morell, Sally:** *The Contagion Myth* (Skyhorse Publishing, 2020)
- Forbes, Jack D:** *Columbus And Other Cannibals – The Wetiko Disease of Exploitation, Imperialism, and Terrorism* (Seven Stories Press, 2008 – originally published in 1979)
- Gates, Bill:** *How to Avoid a Climate Disaster: The Solutions We Have and the Breakthroughs We Need* (Allen Lane, 2021)
- Huxley, Aldous:** *Brave New World* (Chatto & Windus, 1932)
- Köhnlein, Dr Claus, and Engelbrecht, Torsten:** *Virus Mania* (emu-Verlag, Lahnstein, 2020)
- Lanza, Robert, and Berman, Bob:** *Biocentrism* (BenBella Books, 2010)
- Lash, John Lamb:** *Not In His Image* (Chelsea Green Publishing, 2006)
- Lester, Dawn, and Parker, David:** *What Really Makes You Ill – Why everything you thought you knew about disease is wrong* (Independently Published, 2019)
- Levy, Paul:** *Dispelling Wetiko, Breaking the Spell of Evil* (North Atlantic Books, 2013)
- Marx, Karl:** *A World Without Jews* (Philosophical Library, first edition, 1959)
- Mullis, Kary:** *Dancing Naked in the Mine Field* (Bloomsbury, 1999)
- O'Brien, Cathy:** *Trance-Formation of America* (Reality Marketing, 1995)
- Scholem, Gershon:** *The Messianic Idea in Judaism* (Schocken Books, 1994)
- Schwab, Klaus, and Davis, Nicholas:** *Shaping the Future of the Fourth Industrial Revolution: A guide to building a better world* (Penguin Books, 2018)
- Schwab, Klaus:** *The Great Reset* (Agentur Schweiz, 2020)
- Sunstein, Cass and Thaler, Richard:** *Nudge: Improving Decisions About Health, Wealth, and Happiness* (Penguin, 2009)
- Swan, Shanna:** *Count Down: How Our Modern World Is Threatening Sperm Counts, Altering Male and Female Reproductive Development and Imperiling the Future of the Human Race* (Scribner, 2021)
- Tegmark, Max:** *Our Mathematical Universe: My Quest for the Ultimate Nature of Reality* (Penguin, 2015)
- Velikovsky, Immanuel:** *Worlds in Collision* (Paradigma, 2009)

Wilton, Robert: *The Last Days of the Romanovs* (Blurb, 2018, first published 1920)

Index

A

abusive relationships

- blaming themselves, abused as [ref1](#)
- children [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#)
- conspiracy theories [ref1](#)
- domestic abuse [ref1](#), [ref2](#)
- economic abuse and dependency [ref1](#)
- isolation [ref1](#)
- physical abuse [ref1](#)
- psychological abuse [ref1](#)
- signs of abuse [ref1](#)

addiction

- alcoholism [ref1](#)
- frequencies [ref1](#)
- substance abuse [ref1](#), [ref2](#)
- technology [ref1](#), [ref2](#), [ref3](#)

Adelson, Sheldon [ref1](#), [ref2](#), [ref3](#)

Agenda 21/Agenda 2030 (UN) [ref1](#), [ref2](#), [ref3](#), [ref4](#)

AIDs/HIV [ref1](#)

- causal link between HIV and AIDs [ref1](#), [ref2](#)

retroviruses [ref1](#)

- testing [ref1](#), [ref2](#)
- trial-run for Covid-19, as [ref1](#), [ref2](#)

aliens/extraterrestrials [ref1](#), [ref2](#)

aluminium [ref1](#)

Amazon [ref1](#), [ref2](#), [ref3](#)

amplification cycles [ref1](#), [ref2](#)
anaphylactic shock [ref1](#), [ref2](#), [ref3](#), [ref4](#)
animals [ref1](#), [ref2](#), [ref3](#)
antibodies [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Antifa [ref1](#), [ref2](#), [ref3](#), [ref4](#)
antigens [ref1](#), [ref2](#)
anti-Semitism [ref1](#), [ref2](#), [ref3](#)
Archons [ref1](#), [ref2](#)
 consciousness [ref1](#), [ref2](#), [ref3](#)
 energy [ref1](#), [ref2](#), [ref3](#)
 ennoa [ref1](#)
 genetic manipulation [ref1](#), [ref2](#)
 inversion [ref1](#), [ref2](#), [ref3](#)
 lockdowns [ref1](#)
 money [ref1](#)
 radiation [ref1](#)
 religion [ref1](#), [ref2](#)
 technology [ref1](#), [ref2](#), [ref3](#)
 Wetiko factor [ref1](#), [ref2](#), [ref3](#), [ref4](#)
artificial intelligence (AI) [ref1](#)
army made up of robots [ref1](#), [ref2](#)
 Human 2.0 [ref1](#), [ref2](#)
 Internet [ref1](#)
 MHRA [ref1](#)
 Morgellons fibres [ref1](#), [ref2](#)
 Smart Grid [ref1](#)
 Wetiko factor [ref1](#)
asymptomatic, Covid-19 as [ref1](#), [ref2](#), [ref3](#)
aviation industry [ref1](#)

B

banking, finance and money [ref1](#), [ref2](#), [ref3](#)

2008 crisis [ref1](#), [ref2](#)

boom and bust [ref1](#)

cashless digital money systems [ref1](#)

central banks [ref1](#)

credit [ref1](#)

digital currency [ref1](#)

fractional reserve lending [ref1](#)

Great Reset [ref1](#)

guaranteed income [ref1](#), [ref2](#), [ref3](#)

Human 2.0 [ref1](#)

incomes, destruction of [ref1](#), [ref2](#)

interest [ref1](#)

one per cent [ref1](#), [ref2](#)

scams [ref1](#)

BBC [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

Becker-Phelps, Leslie [ref1](#)

Behavioural Insights Team (BIT) (Nudge Unit) [ref1](#), [ref2](#), [ref3](#)

behavioural scientists *and* psychologists, advice from [ref1](#), [ref2](#)

Bezos, Jeff [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Biden, Hunter [ref1](#)

Biden, Joe [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#), [ref11](#),
[ref12](#), [ref13](#), [ref14](#), [ref15](#), [ref16](#), [ref17](#)

Big Pharma

cholesterol [ref1](#)

health professionals [ref1](#), [ref2](#)

immunity from prosecution in US [ref1](#)

vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

Wetiko factor [ref1](#), [ref2](#)

WHO [ref1](#), [ref2](#), [ref3](#)

Bill and Melinda Gates Foundation [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#),
[ref7](#)

billionaires [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#) [ref10](#), [ref11](#)
bird flu (H5N1) [ref1](#)
Black Lives Matter (BLM) [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Blair, Tony [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
Brin, Sergei [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
British Empire [ref1](#)
Bush, George HW [ref1](#), [ref2](#)
Bush, George W [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Byrd, Robert [ref1](#)

C

Canada

Global Cult [ref1](#)
hate speech [ref1](#)
internment [ref1](#)
masks [ref1](#)
old people [ref1](#)
SARS-COV-2 [ref1](#)
satellites [ref1](#)
vaccines [ref1](#)
wearable technology [ref1](#)

Capitol Hill riot [ref1](#), [ref2](#)

agents provocateur [ref1](#)
Antifa [ref1](#)
Black Lives Matter (BLM) [ref1](#), [ref2](#)
QAnon [ref1](#)
security precautions, lack of [ref1](#), [ref2](#), [ref3](#)

carbon dioxide [ref1](#), [ref2](#)

care homes, deaths in [ref1](#), [ref2](#)

cashless digital money systems [ref1](#)

censorship [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

fact-checkers [ref1](#)

masks [ref1](#)

media [ref1](#), [ref2](#)

private messages [ref1](#)

social media [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)

transgender persons [ref1](#)

vaccines [ref1](#), [ref2](#), [ref3](#)

Wokeness [ref1](#)

Centers for Disease Control (CDC) (United States) [ref1](#), [ref2](#), [ref3](#),
[ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#), [ref11](#), [ref12](#), [ref13](#)

centralisation [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

chakras [ref1](#)

change agents [ref1](#), [ref2](#), [ref3](#)

chemtrails [ref1](#), [ref2](#), [ref3](#)

chief medical officers and scientific advisers [ref1](#), [ref2](#), [ref3](#), [ref4](#),
[ref5](#), [ref6](#)

children *see also* **young people**

abuse [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#)

care, taken into [ref1](#), [ref2](#), [ref3](#)

education [ref1](#), [ref2](#), [ref3](#), [ref4](#)

energy [ref1](#)

family courts [ref1](#)

hand sanitisers [ref1](#)

human sacrifice [ref1](#)

lockdowns [ref1](#), [ref2](#), [ref3](#)

masks [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

mental health [ref1](#)

old people [ref1](#)

parents, replacement of [ref1](#), [ref2](#)

Psyop (psychological operation), Covid as a [ref1](#), [ref2](#)

reframing [ref1](#)

smartphone addiction [ref1](#)

social distancing and isolation [ref1](#)
social media [ref1](#)
transgender persons [ref1](#), [ref2](#)
United States [ref1](#)
vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#)
Wetiko factor [ref1](#)

China [ref1](#), [ref2](#), [ref3](#), [ref4](#)

anal swab tests [ref1](#)
Chinese Revolution [ref1](#), [ref2](#), [ref3](#)
digital currency [ref1](#)
Global Cult [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#)
guaranteed income [ref1](#)
Imperial College [ref1](#)
Israel [ref1](#)
lockdown [ref1](#), [ref2](#)
masculinity crisis [ref1](#)
masks [ref1](#)
media [ref1](#)
origins of virus in China [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
pollution causing respiratory diseases [ref1](#)
Sabbatians [ref1](#), [ref2](#)
Smart Grid [ref1](#), [ref2](#)
social credit system [ref1](#)
testing [ref1](#), [ref2](#)
United States [ref1](#), [ref2](#)
vaccines [ref1](#), [ref2](#)
Wetiko factor [ref1](#)
wet market conspiracy [ref1](#)
Wuhan [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

cholesterol [ref1](#), [ref2](#)

Christianity [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

criticism [ref1](#)
cross, inversion of the [ref1](#)

Nag Hammadi texts [ref1](#), [ref2](#), [ref3](#)

Roman Catholic Church [ref1](#), [ref2](#)

Sabbatians [ref1](#), [ref2](#)

Satan [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Wokeness [ref1](#)

class [ref1](#), [ref2](#)

climate change hoax [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Agenda 21/Agenda 2030 [ref1](#), [ref2](#), [ref3](#)

carbon dioxide [ref1](#), [ref2](#)

Club of Rome [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

fear [ref1](#)

funding [ref1](#)

Global Cult [ref1](#)

green new deals [ref1](#)

green parties [ref1](#)

inversion [ref1](#)

perception, control of [ref1](#)

PICC [ref1](#)

reframing [ref1](#)

temperature, increases in [ref1](#)

United Nations [ref1](#), [ref2](#)

Wikipedia [ref1](#)

Wokeness [ref1](#), [ref2](#)

Clinton, Bill [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)

Clinton, Hillary [ref1](#), [ref2](#), [ref3](#)

the cloud [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

Club of Rome and climate change hoax [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

cognitive therapy [ref1](#)

Cohn, Roy [ref1](#)

Common Law [ref1](#)

Admiralty Law [ref1](#)

arrests [ref1](#), [ref2](#)

contractual law, Statute Law as [ref1](#)

corporate entities, people as [ref1](#)

legalese [ref1](#)

sea, law of the [ref1](#)

Statute Law [ref1](#)

Common Purpose leadership programme [ref1](#), [ref2](#)

communism [ref1](#), [ref2](#)

co-morbidities [ref1](#)

computer-generated virus,

Covid-19 as [ref1](#), [ref2](#), [ref3](#)

computer models [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

connections [ref1](#), [ref2](#), [ref3](#), [ref4](#)

consciousness [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Archons [ref1](#), [ref2](#), [ref3](#)

expanded [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

experience [ref1](#)

heart [ref1](#)

infinity [ref1](#), [ref2](#)

religion [ref1](#), [ref2](#)

self-identity [ref1](#)

simulation thesis [ref1](#)

vaccines [ref1](#)

Wetiko factor [ref1](#), [ref2](#)

conspiracy theorists [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

contradictory rules [ref1](#)

contrails [ref1](#)

Corman-Drosten test [ref1](#), [ref2](#), [ref3](#), [ref4](#)

countermimicry [ref1](#), [ref2](#), [ref3](#)

Covid-19 vaccines *see* vaccines

Covidiots [ref1](#), [ref2](#)

Cowan, Tom [ref1](#), [ref2](#), [ref3](#), [ref4](#)

crimes against humanity [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

cyber-operations [ref1](#)

cyberwarfare [ref1](#)

D

DARPA (Defense Advanced Research Projects Agency) [ref1](#)

deaths

care homes [ref1](#)

certificates [ref1](#), [ref2](#), [ref3](#), [ref4](#)

mortality rate [ref1](#)

post-mortems/autopsies [ref1](#)

recording [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

deceit

pyramid of deceit [ref1](#), [ref2](#)

sequence of deceit [ref1](#)

decoding [ref1](#), [ref2](#), [ref3](#)

dehumanisation [ref1](#), [ref2](#), [ref3](#)

Delphi technique [ref1](#)

democracy [ref1](#)

dependency [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Descartes, René [ref1](#)

DNA

numbers [ref1](#)

vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#)

DNR (do not resuscitate)

orders [ref1](#)

domestic abuse [ref1](#), [ref2](#)

downgrading of Covid-19 [ref1](#)

Drosten, Christian [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

Duesberg, Peter [ref1](#), [ref2](#)

E

economic abuse [ref1](#)

Edmunds, John [ref1](#), [ref2](#)

education [ref1](#), [ref2](#), [ref3](#), [ref4](#)

electromagnetic spectrum [ref1](#), [ref2](#)

Enders, John [ref1](#)

energy

Archons [ref1](#), [ref2](#), [ref3](#)

children and young people [ref1](#)

consciousness [ref1](#)

decoding [ref1](#)

frequencies [ref1](#), [ref2](#), [ref3](#), [ref4](#)

heart [ref1](#)

human energy field [ref1](#)

source, humans as an energy [ref1](#), [ref2](#)

vaccines [ref1](#)

viruses [ref1](#)

ennoia [ref1](#)

Epstein, Jeffrey [ref1](#), [ref2](#)

eternal 'I' [ref1](#), [ref2](#)

ethylene oxide [ref1](#)

European Union [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Event [ref1](#) *and* Bill Gates [ref2](#)

exosomes, Covid-19 as natural defence mechanism called [ref1](#)

experience [ref1](#), [ref2](#)

Extinction Rebellion [ref1](#), [ref2](#)

F

Facebook

addiction [ref1](#), 448–50

Facebook

Archons [ref1](#)

censorship [ref1](#), [ref2](#), [ref3](#)

hate speech [ref1](#)

monopoly, as [ref1](#)

private messages, censorship of [ref1](#)

Sabbatians [ref1](#)

United States election fraud [ref1](#)

vaccines [ref1](#)

Wetiko factor [ref1](#)

fact-checkers [ref1](#)

Fauci, Anthony [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#),
[ref11](#), [ref12](#)

fear [ref1](#), [ref2](#), [ref3](#), [ref4](#)

climate change [ref1](#)

computer models [ref1](#)

conspiracy theories [ref1](#)

empty hospitals [ref1](#)

Italy [ref1](#), [ref2](#), [ref3](#)

lockdowns [ref1](#), [ref2](#), [ref3](#), [ref4](#)

masks [ref1](#), [ref2](#)

media [ref1](#), [ref2](#)

medical staff [ref1](#)

Psyop (psychological operation), Covid as a [ref1](#)

Wetiko factor [ref1](#), [ref2](#)

female infertility [ref1](#)

Fermi Paradox [ref1](#)

Ferguson, Neil [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

fertility, decline in [ref1](#)

The Field [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

finance *see* **banking, finance and money**

five-senses [ref1](#), [ref2](#)

Archons [ref1](#), [ref2](#), [ref3](#)

censorship [ref1](#)
consciousness, expansion of [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
decoding [ref1](#)
education [ref1](#), [ref2](#)
the Field [ref1](#), [ref2](#)
God, personification of [ref1](#)
infinity [ref1](#), [ref2](#)
media [ref1](#)
paranormal [ref1](#)
perceptual programming [ref1](#), [ref2](#)
Phantom Self [ref1](#)
pneuma not nous, using [ref1](#)
reincarnation [ref1](#)
self-identity [ref1](#)
Wetiko factor [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
5G [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)
Floyd, George and protests, killing of [ref1](#)
flu, re-labelling of [ref1](#), [ref2](#), [ref3](#)
food and water, control of [ref1](#), [ref2](#)
Freemasons [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
Frei, Rosemary [ref1](#)
frequencies
addictions [ref1](#)
Archons [ref1](#), [ref2](#), [ref3](#)
awareness [ref1](#)
chanting and mantras [ref1](#)
consciousness [ref1](#)
decoding [ref1](#), [ref2](#)
education [ref1](#)
electromagnetic (EMF) frequencies [ref1](#)
energy [ref1](#), [ref2](#), [ref3](#), [ref4](#)
fear [ref1](#)

the Field [ref1](#), [ref2](#) 5G [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#)
five-senses [ref1](#), [ref2](#)
ghosts [ref1](#)
Gnostics [ref1](#)
hive-minds [ref1](#)
human, meaning of [ref1](#)
light [ref1](#), [ref2](#)
love [ref1](#), [ref2](#)
magnetism [ref1](#)
perception [ref1](#)
reality [ref1](#), [ref2](#), [ref3](#)
simulation [ref1](#)
terror [ref1](#)
vaccines [ref1](#)
Wetiko [ref1](#), [ref2](#), [ref3](#)
Fuellmich, Reiner [ref1](#), [ref2](#), [ref3](#)
furlough/rescue payments [ref1](#)

G

Gallo, Robert [ref1](#), [ref2](#), [ref3](#)

Gates, Bill

Archons [ref1](#), [ref2](#), [ref3](#)
climate change [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Daily Pass tracking system [ref1](#)
Epstein [ref1](#)
fascism [ref1](#)
five senses [ref1](#)
GAVI [ref1](#)
Great Reset [ref1](#)
GSK [ref1](#)
Imperial College [ref1](#), [ref2](#)
Johns Hopkins University [ref1](#), [ref2](#), [ref3](#)

lockdowns [ref1](#), [ref2](#)
masks [ref1](#)
Nuremberg trial, proposal for [ref1](#), [ref2](#)
Rockefellers [ref1](#), [ref2](#)
social distancing and isolation [ref1](#)
Sun, dimming the [ref1](#)
synthetic meat [ref1](#), [ref2](#)
vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
Wellcome Trust [ref1](#)
Wetiko factor [ref1](#), [ref2](#), [ref3](#)
WHO [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#)
Wokeness [ref1](#)
World Economic Forum [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Gates, Melinda [ref1](#), [ref2](#), [ref3](#)
GAVI vaccine alliance [ref1](#)
genetics, manipulation of [ref1](#), [ref2](#), [ref3](#)
Germany [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#) *see also* **Nazi Germany**
Global Cult [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
anti-human, why Global Cult is [ref1](#)
Black Lives Matter (BLM) [ref1](#), [ref2](#), [ref3](#), [ref4](#)
China [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#)
climate change hoax [ref1](#)
contradictory rules [ref1](#)
Covid-19 [ref1](#), [ref2](#), [ref3](#)
fascism [ref1](#)
geographical origins [ref1](#)
immigration [ref1](#)
Internet [ref1](#)
mainstream media [ref1](#), [ref2](#)
masks [ref1](#), [ref2](#)
monarchy [ref1](#)
non-human dimension [ref1](#)

perception [ref1](#)
political parties [ref1](#), [ref2](#)
pyramidal hierarchy [ref1](#), [ref2](#), [ref3](#)
reframing [ref1](#)
Sabbatian-Frankism [ref1](#), [ref2](#)
science, manipulation of [ref1](#)
spider and the web [ref1](#)
transgender persons [ref1](#)
vaccines [ref1](#)
who controls the Cult [ref1](#)
Wokeness [ref1](#), [ref2](#), [ref3](#), [ref4](#)

globalisation [ref1](#), [ref2](#)

Gnostics [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Google [ref1](#), [ref2](#), [ref3](#), [ref4](#)

government

behavioural scientists and psychologists, advice from [ref1](#), [ref2](#)

definition [ref1](#)

Joint Biosecurity Centre (JBC) [ref1](#)

people, abusive relationship with [ref1](#)

Great Reset [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)

fascism [ref1](#), [ref2](#), [ref3](#)

financial system [ref1](#)

Human 2.0 [ref1](#)

water and food, control of [ref1](#)

green parties [ref1](#)

Griesz-Brisson, Margarite [ref1](#)

guaranteed income [ref1](#), [ref2](#), [ref3](#)

H

Hancock, Matt [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

hand sanitisers [ref1](#)

heart [ref1](#), [ref2](#)

hive-minds/groupthink [ref1](#), [ref2](#), [ref3](#)

holographs [ref1](#), [ref2](#), [ref3](#), [ref4](#)

hospitals, empty [ref1](#)

human, meaning of [ref1](#)

Human 2.0 [ref1](#)

addiction to technology [ref1](#)

artificial intelligence (AI) [ref1](#), [ref2](#)

elimination of Human 1.0 [ref1](#)

fertility, decline in [ref1](#)

Great Reset [ref1](#)

implantables [ref1](#)

money [ref1](#)

mRNA [ref1](#)

nanotechnology [ref1](#)

parents, replacement of [ref1](#), [ref2](#)

Smart Grid, connection to [ref1](#), [ref2](#)

synthetic biology [ref1](#), [ref2](#), [ref3](#), [ref4](#)

testosterone levels, decrease in [ref1](#)

transgender = transhumanism [ref1](#), [ref2](#), [ref3](#)

vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#)

human sacrifice [ref1](#), [ref2](#), [ref3](#)

Hunger Games Society [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

Huxley, Aldous [ref1](#), [ref2](#), [ref3](#)

I

identity politics [ref1](#), [ref2](#), [ref3](#)

Illuminati [ref1](#), [ref2](#)

illusory physical reality [ref1](#)

immigration [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Imperial College [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)

implantables [ref1](#), [ref2](#)

incomes, destruction of [ref1](#), [ref2](#)

Infinite Awareness [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Internet [ref1](#), [ref2](#) *see also* social media

artificial intelligence (AI) [ref1](#)

independent journalism, lack of [ref1](#)

Internet of Bodies (IoB) [ref1](#)

Internet of Everything (IoE) [ref1](#), [ref2](#)

Internet of Things (IoT) [ref1](#), [ref2](#)

lockdowns [ref1](#)

Psyop (psychological operation), Covid as a [ref1](#)
trolls [ref1](#)

intersectionality [ref1](#)

inversion

Archons [ref1](#), [ref2](#), [ref3](#)

climate change hoax [ref1](#)

energy [ref1](#)

Judaism [ref1](#), [ref2](#), [ref3](#)

symbolism [ref1](#)

Wetiko factor [ref1](#)

Wokeness [ref1](#), [ref2](#), [ref3](#)

Islam

Archons [ref1](#)

crypto-Jews [ref1](#)

Islamic State [ref1](#), [ref2](#)

Jinn and Djinn [ref1](#), [ref2](#), [ref3](#)

Ottoman Empire [ref1](#)

Wahhabism [ref1](#)

isolation *see* **social distancing** *and* **isolation**

Israel

China [ref1](#)

Cyber Intelligence Unit Beersheba complex [ref1](#)

expansion of illegal settlements [ref1](#)

formation [ref1](#)
Global Cult [ref1](#)
Judaism [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
medical experiments, consent for [ref1](#)
Mossad [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Palestine-Israel conflict [ref1](#), [ref2](#), [ref3](#)
parents, replacement of [ref1](#)
Sabbatians [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
September 11, 2001, terrorist attacks on United States [ref1](#)
Silicon Valley [ref1](#)
Smart Grid [ref1](#), [ref2](#)
United States [ref1](#), [ref2](#)
vaccines [ref1](#)
Wetiko factor [ref1](#)

Italy

fear [ref1](#), [ref2](#), [ref3](#)
Lombardy [ref1](#), [ref2](#), [ref3](#)
vaccines [ref1](#)

J

Johns Hopkins University [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
Johnson, Boris [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)
Joint Biosecurity Centre (JBC) [ref1](#)

Judaism

anti-Semitism [ref1](#), [ref2](#), [ref3](#)
Archons [ref1](#), [ref2](#)
crypto-Jews [ref1](#)
inversion [ref1](#), [ref2](#), [ref3](#)
Israel [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Labour Party [ref1](#)
Nazi Germany [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Sabbatians [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Silicon Valley [ref1](#)
Torah [ref1](#)
United States [ref1](#), [ref2](#)
Zionists [ref1](#), [ref2](#), [ref3](#)

K

Kaufman, Andrew [ref1](#), [ref2](#), [ref3](#), [ref4](#)
knowledge [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
Koch's postulates [ref1](#)
Kurzweil, Ray [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
Kushner, Jared [ref1](#), [ref2](#)

L

Labour Party [ref1](#), [ref2](#)
Lanka, Stefan [ref1](#), [ref2](#)
Lateral Flow Device (LFD) [ref1](#)
Levy, Paul [ref1](#), [ref2](#), [ref3](#)
Life Program [ref1](#)
lockdowns [ref1](#), [ref2](#), [ref3](#)
 amplification tampering [ref1](#)
 Archons [ref1](#)
 Behavioural Insights Team [ref1](#)
 Black Lives Matter (BLM) [ref1](#)
 care homes, deaths in [ref1](#)
 children
abuse [ref1](#), [ref2](#)
mental health [ref1](#)
 China [ref1](#), [ref2](#)
 computer models [ref1](#)
 consequences [ref1](#), [ref2](#)
 dependency [ref1](#), [ref2](#), [ref3](#)

domestic abuse [ref1](#)
fall in cases [ref1](#)
fear [ref1](#), [ref2](#), [ref3](#), [ref4](#)
guaranteed income [ref1](#)
Hunger Games Society [ref1](#), [ref2](#), [ref3](#)
interaction, destroying [ref1](#)
Internet [ref1](#), [ref2](#)
overdoses [ref1](#)
perception [ref1](#)
police-military state [ref1](#), [ref2](#)
protests [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
psychopathic personality [ref1](#), [ref2](#), [ref3](#)
reporting/snitching, encouragement of [ref1](#), [ref2](#)
testing [ref1](#)
vaccines [ref1](#)
Wetiko factor [ref1](#)
WHO [ref1](#)
love [ref1](#), [ref2](#), [ref3](#)
Lucifer [ref1](#), [ref2](#), [ref3](#)

M

Madej, Carrie [ref1](#), [ref2](#)
Magufuli, John [ref1](#), [ref2](#)
mainstream media [ref1](#)
BBC [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)
censorship [ref1](#), [ref2](#)
China [ref1](#)
climate change hoax [ref1](#)
fear [ref1](#), [ref2](#)
Global Cult [ref1](#), [ref2](#)
independent journalism, lack of [ref1](#)
Ofcom [ref1](#), [ref2](#), [ref3](#)

perception [ref1](#), [ref2](#)

Psyop (psychological operation), Covid as a [ref1](#)

Sabbatians [ref1](#), [ref2](#)

social disapproval [ref1](#)

social distancing and isolation [ref1](#)

United States [ref1](#), [ref2](#)

vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Mao Zedong [ref1](#), [ref2](#), [ref3](#)

Marx and Marxism [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)

masculinity [ref1](#)

masks/face coverings [ref1](#), [ref2](#), [ref3](#)

 censorship [ref1](#)

 children [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

 China, made in [ref1](#)

 dehumanisation [ref1](#), [ref2](#), [ref3](#)

 fear [ref1](#), [ref2](#)

 flu [ref1](#)

 health professionals [ref1](#), [ref2](#), [ref3](#), [ref4](#)

 isolation [ref1](#)

 laughter [ref1](#)

mass non-cooperation [ref1](#)

microplastics, risk of [ref1](#)

mind control [ref1](#)

multiple masks [ref1](#)

oxygen deficiency [ref1](#), [ref2](#), [ref3](#)

police [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

pollution, as cause of plastic [ref1](#)

Psyop (psychological operation), Covid as a [ref1](#)

reframing [ref1](#), [ref2](#)

risk assessments, lack of [ref1](#), [ref2](#)

self-respect [ref1](#)

surgeons [ref1](#)

United States [ref1](#)
vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Wetiko factor [ref1](#)
'worms' [ref1](#)
The Matrix movies [ref1](#), [ref2](#), [ref3](#)
measles [ref1](#), [ref2](#)
media see mainstream media
Medicines and Healthcare products Regulatory Agency (MHRA)
[ref1](#), [ref2](#), [ref3](#), [ref4](#)
Mesopotamia [ref1](#)
messaging [ref1](#)
military-police state [ref1](#), [ref2](#), [ref3](#)
mind control [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#) *see also* MKUltra
MKUltra [ref1](#), [ref2](#), [ref3](#)
monarchy [ref1](#)
money *see* banking, finance and money
Montagnier, Luc [ref1](#), [ref2](#), [ref3](#)
Mooney, Bel [ref1](#)
Morgellons disease [ref1](#), [ref2](#)
mortality rate [ref1](#)
Mullis, Kary [ref1](#), [ref2](#), [ref3](#)
Musk, Elon [ref1](#)

N

Nag Hammadi texts [ref1](#), [ref2](#), [ref3](#)
nanotechnology [ref1](#), [ref2](#), [ref3](#)
narcissism [ref1](#)
Nazi Germany [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)
near-death experiences [ref1](#), [ref2](#)
Neocons [ref1](#), [ref2](#), [ref3](#)

Neuro-Linguistic Programming (NLP) and the Delphi technique
[ref1](#)

NHS (National Health Service)

amplification cycles [ref1](#)

Common Purpose [ref1](#), [ref2](#)

mind control [ref1](#)

NHS England [ref1](#)

saving the NHS [ref1](#), [ref2](#)

vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

whistle-blowers [ref1](#), [ref2](#), [ref3](#)

No-Problem-Reaction-Solution [ref1](#), [ref2](#), [ref3](#), [ref4](#)

non-human dimension of Global Cult [ref1](#)

nous [ref1](#)

numbers, reality as [ref1](#)

Nuremberg Codes [ref1](#), [ref2](#), [ref3](#)

Nuremberg-like tribunal, proposal for [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#),
[ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#), [ref11](#), [ref12](#)

O

Obama, Barack [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#)

O'Brien, Cathy [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Ochel, Evita [ref1](#)

Ofcom [ref1](#), [ref2](#), [ref3](#)

old people [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Oneness [ref1](#), [ref2](#), [ref3](#)

Open Society Foundations (Soros) [ref1](#), [ref2](#), [ref3](#)

oxygen 406, 528–34

P

paedophilia [ref1](#), [ref2](#)

Page, Larry [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

Palestine-Israel conflict [ref1](#), [ref2](#), [ref3](#)

pandemic, definition of [ref1](#)

pandemic and health crisis scenarios/simulations [ref1](#), [ref2](#), [ref3](#),
[ref4](#)

paranormal [ref1](#)

PCR tests [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

Pearl Harbor attacks, prior knowledge of [ref1](#)

Pelosi, Nancy [ref1](#), [ref2](#), [ref3](#)

perception [ref1](#), [ref2](#), [ref3](#), [ref4](#)

climate change hoax [ref1](#)

control [ref1](#), [ref2](#), [ref3](#)

decoding [ref1](#), [ref2](#)

enslavement [ref1](#)

externally-delivered perceptions [ref1](#)

five senses [ref1](#)

human labels [ref1](#)

media [ref1](#), [ref2](#)

political parties [ref1](#), [ref2](#)

Psyop (psychological operation), Covid as a [ref1](#)

sale of perception [ref1](#)

self-identity [ref1](#), [ref2](#)

Wokeness [ref1](#)

Phantom Self [ref1](#), [ref2](#), [ref3](#)

pharmaceutical industry *see* **Big Pharma**

phthalates [ref1](#)

Plato's Allegory of the Cave [ref1](#), [ref2](#)

pneuma [ref1](#)

police

Black Lives Matter (BLM) [ref1](#)

brutality [ref1](#)

citizen's arrests [ref1](#), [ref2](#)

common law arrests [ref1](#), [ref2](#)

Common Purpose [ref1](#)

defunding [ref1](#)

lockdowns [ref1](#), [ref2](#)

masks [ref1](#), [ref2](#), [ref3](#), [ref4](#)

police-military state [ref1](#), [ref2](#), [ref3](#)

psychopathic personality [ref1](#), [ref2](#), [ref3](#), [ref4](#)

reframing [ref1](#)

United States [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Wokeness [ref1](#)

polio [ref1](#)

political correctness [ref1](#), [ref2](#), [ref3](#), [ref4](#)

political parties [ref1](#), [ref2](#), [ref3](#), [ref4](#)

political puppets [ref1](#)

pollution [ref1](#), [ref2](#), [ref3](#)

post-mortems/autopsies [ref1](#)

Postage Stamp Consensus [ref1](#), [ref2](#)

pre-emptive programming [ref1](#)

Problem-Reaction-Solution [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

Project for the New American Century [ref1](#), [ref2](#), [ref3](#), [ref4](#)

psychopathic personality [ref1](#)

Archons [ref1](#)

heart energy [ref1](#)

lockdowns [ref1](#), [ref2](#), [ref3](#)

police [ref1](#), [ref2](#), [ref3](#), [ref4](#)

recruitment [ref1](#), [ref2](#)

vaccines [ref1](#)

wealth [ref1](#)

Wetiko [ref1](#), [ref2](#)

Psyop (psychological operation), Covid as a [ref1](#), [ref2](#), [ref3](#), [ref4](#),
[ref5](#)

Pushbackers [ref1](#), [ref2](#), [ref3](#), [ref4](#)

pyramid structure [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Q

QAnon Psyop [ref1](#), [ref2](#), [ref3](#)

R

racism *see also* **Black Lives**

Matter (BLM)

anti-racism industry [ref1](#)

class [ref1](#)

critical race theory [ref1](#)

culture [ref1](#)

intersectionality [ref1](#)

reverse racism [ref1](#)

white privilege [ref1](#), [ref2](#)

white supremacy [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Wokeness [ref1](#), [ref2](#), [ref3](#)

radiation [ref1](#), [ref2](#)

randomness, illusion of [ref1](#), [ref2](#), [ref3](#)

reality [ref1](#), [ref2](#), [ref3](#)

reframing [ref1](#), [ref2](#)

change agents [ref1](#), [ref2](#)

children [ref1](#)

climate change [ref1](#)

Common Purpose leadership programme [ref1](#), [ref2](#)

contradictory rules [ref1](#)

enforcers [ref1](#)

masks [ref1](#), [ref2](#)

NLP and the Delphi technique [ref1](#)

police [ref1](#)

Wetiko factor [ref1](#)

Wokeness [ref1](#), [ref2](#)

religion *see also* particular religions

alien invasions [ref1](#)

Archons [ref1](#), [ref2](#)
consciousness [ref1](#), [ref2](#)
control, system of [ref1](#), [ref2](#), [ref3](#)
criticism, prohibition on [ref1](#)
five senses [ref1](#)
good and evil, war between [ref1](#)
hidden non-human forces [ref1](#), [ref2](#)
Sabbatians [ref1](#)
save me syndrome [ref1](#)
Wetiko [ref1](#)
Wokeness [ref1](#)
repetition and mind control [ref1](#), [ref2](#), [ref3](#)
reporting/snitching, encouragement of [ref1](#), [ref2](#)
Reptilians/Grey entities [ref1](#)
rewiring the mind [ref1](#)
Rivers, Thomas Milton [ref1](#), [ref2](#)
Rockefeller family [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#)
Rockefeller Foundation documents [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Roman Empire [ref1](#)
Rothschild family [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#)
RT-PCR tests [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)
Russia
 collusion inquiry in US [ref1](#)
Russian Revolution [ref1](#), [ref2](#)
Sabbatians [ref1](#)

S

Sabbatian-Frankism [ref1](#), [ref2](#)
 anti-Semitism [ref1](#), [ref2](#)
 banking and finance [ref1](#), [ref2](#), [ref3](#)
 China [ref1](#), [ref2](#)
 Israel [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Judaism [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Lucifer [ref1](#)
media [ref1](#), [ref2](#)
Nazis [ref1](#), [ref2](#)
QAnon [ref1](#)
Rothschilds [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
Russia [ref1](#)
Saudi Arabia [ref1](#)
Silicon Valley [ref1](#)
Sumer [ref1](#)
United States [ref1](#), [ref2](#), [ref3](#)
Wetiko factor [ref1](#)
Wokeness [ref1](#), [ref2](#), [ref3](#)
SAGE (Scientific Advisory Group for Emergencies) [ref1](#), [ref2](#), [ref3](#),
[ref4](#)
SARS-1 [ref1](#)
SARs-CoV-2 [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)
Satan/Satanism [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
satellites in low-orbit [ref1](#)
Saudi Arabia [ref1](#)
Save Me Syndrome [ref1](#)
scapegoating [ref1](#)
Schwab, Klaus [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#),
[ref11](#), [ref12](#)
science, manipulation of [ref1](#)
self-identity [ref1](#), [ref2](#), [ref3](#), [ref4](#)
self-respect, attacks on [ref1](#)
September 11, 2001, terrorist attacks on United States [ref1](#), [ref2](#),
[ref3](#), [ref4](#)
77th Brigade of UK military [ref1](#), [ref2](#), [ref3](#)
Silicon Valley/tech giants [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#) *see also*
Facebook

Israel [ref1](#)

Sabbatians [ref1](#)

technocracy [ref1](#)

Wetiko factor [ref1](#)

Wokeness [ref1](#)

simulation hypothesis [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

Smart Grid [ref1](#), [ref2](#), [ref3](#)

artificial intelligence (AI) [ref1](#)

China [ref1](#), [ref2](#)

control centres [ref1](#)

the Field [ref1](#)

Great Reset [ref1](#)

Human 2.0 [ref1](#), [ref2](#)

Israel [ref1](#), [ref2](#)

vaccines [ref1](#)

Wetiko factor [ref1](#)

social disapproval [ref1](#)

social distancing and isolation [ref1](#), [ref2](#), [ref3](#)

abusive relationships [ref1](#), [ref2](#)

children [ref1](#)

flats and apartments [ref1](#)

heart issues [ref1](#)

hugs [ref1](#)

Internet [ref1](#)

masks [ref1](#)

media [ref1](#)

older people [ref1](#), [ref2](#)

one-metre (three feet) rule [ref1](#)

rewiring the mind [ref1](#)

simulation, universe as a [ref1](#)

SPI-B [ref1](#)

substance abuse [ref1](#)

suicide and self-harm [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
technology [ref1](#)
torture, as [ref1](#), [ref2](#)
two-metre (six feet) rule [ref1](#)
women [ref1](#)
social justice [ref1](#), [ref2](#), [ref3](#), [ref4](#)
social media *see also* **Facebook bans on alternative views** [ref1](#)
censorship [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
children [ref1](#)
emotion [ref1](#)
perception [ref1](#)
private messages [ref1](#)
Twitter [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
Wetiko factor [ref1](#)
YouTube [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Soros, George [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
Spain [ref1](#)
SPI-B (Scientific Pandemic Insights Group on Behaviours) [ref1](#),
[ref2](#), [ref3](#), [ref4](#)
spider and the web [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Starmer, Keir [ref1](#)
Statute Law [ref1](#)
Steiner, Rudolf [ref1](#), [ref2](#), [ref3](#)
Stockholm syndrome [ref1](#)
streptomycin [ref1](#)
suicide and self-harm [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Sumer [ref1](#), [ref2](#)
Sunstein, Cass [ref1](#), [ref2](#), [ref3](#)
swine flu (H1N1) [ref1](#), [ref2](#), [ref3](#)
synchronicity [ref1](#)
synthetic biology [ref1](#), [ref2](#), [ref3](#), [ref4](#)
synthetic meat [ref1](#), [ref2](#)

T

technology *see also* **artificial intelligence (AI)**; **Internet**;

social media addiction [ref1](#), [ref2](#), [ref3](#), [ref4](#)

Archons [ref1](#), [ref2](#)

the cloud [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

cyber-operations [ref1](#)

cyberwarfare [ref1](#)

radiation [ref1](#), [ref2](#)

social distancing and isolation [ref1](#)

technocracy [ref1](#)

Tedros Adhanom Ghebreyesus [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#),
[ref8](#), [ref9](#), [ref10](#), [ref11](#), [ref12](#), [ref13](#)

telepathy [ref1](#)

Tenpenny, Sherri [ref1](#)

Tesla, Nikola [ref1](#)

testosterone levels, decrease in [ref1](#)

testing for Covid-19 [ref1](#), [ref2](#)

anal swab tests [ref1](#)

cancer [ref1](#)

China [ref1](#), [ref2](#), [ref3](#)

Corman-Drosten test [ref1](#), [ref2](#), [ref3](#), [ref4](#)

death certificates [ref1](#), [ref2](#)

fraudulent testing [ref1](#)

genetic material, amplification of [ref1](#)

Lateral Flow Device (LFD) [ref1](#)

PCR tests [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

vaccines [ref1](#), [ref2](#), [ref3](#)

Thunberg, Greta [ref1](#), [ref2](#), [ref3](#)

Totalitarian Tiptoe [ref1](#), [ref2](#), [ref3](#), [ref4](#)

transgender persons

activism [ref1](#)

artificial wombs [ref1](#)

censorship [ref1](#)
child abuse [ref1](#), [ref2](#)
Human 2.0 [ref1](#), [ref2](#), [ref3](#)
Wokeness [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
women, deletion of rights and status of [ref1](#), [ref2](#)
young persons [ref1](#)
travel restrictions [ref1](#)
Trudeau, Justin [ref1](#), [ref2](#), [ref3](#)
Trump, Donald [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#),
[ref11](#)
Twitter [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)

U

UKColumn [ref1](#), [ref2](#)
United Nations (UN) [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#) *see also* **Agenda 21/Agenda 2030 (UN)**
United States [ref1](#), [ref2](#)
American Revolution [ref1](#)
borders [ref1](#), [ref2](#)
Capitol Hill riot [ref1](#), [ref2](#)
children [ref1](#)
China [ref1](#), [ref2](#)
CIA [ref1](#), [ref2](#)
Daily Pass tracking system [ref1](#)
demographics by immigration, changes in [ref1](#)
Democrats [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
election fraud [ref1](#)
far-right domestic terrorists, pushbackers as [ref1](#)
Federal Reserve [ref1](#)
flu/respiratory diseases statistics [ref1](#)
Global Cult [ref1](#), [ref2](#)
hand sanitisers, FDA warnings on [ref1](#)

immigration, effects of illegal [ref1](#)
impeachment [ref1](#)
Israel [ref1](#), [ref2](#)
Judaism [ref1](#), [ref2](#), [ref3](#)
lockdown [ref1](#)
masks [ref1](#)
mass media [ref1](#), [ref2](#)
nursing homes [ref1](#)
Pentagon [ref1](#), [ref2](#), [ref3](#), [ref4](#)
police [ref1](#), [ref2](#), [ref3](#), [ref4](#)
pushbackers [ref1](#)
Republicans [ref1](#), [ref2](#)
borders [ref1](#), [ref2](#)
Democrats [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Russia, inquiry into collusion with [ref1](#)
Sabbatians [ref1](#), [ref2](#), [ref3](#)
September 11, 2001, terrorist attacks [ref1](#), [ref2](#), [ref3](#), [ref4](#)
UFO sightings, release of information on [ref1](#)
vaccines [ref1](#)
white supremacy [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Woke Democrats [ref1](#), [ref2](#)

V

vaccines [ref1](#), [ref2](#), [ref3](#)
adverse reactions [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Africa [ref1](#)
anaphylactic shock [ref1](#), [ref2](#), [ref3](#), [ref4](#)
animals [ref1](#), [ref2](#)
anti-vax movement [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
AstraZeneca/Oxford [ref1](#), [ref2](#), [ref3](#), [ref4](#)
autoimmune diseases, rise in [ref1](#), [ref2](#)
Big Pharma [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#)

bioweapon, as real [ref1](#), [ref2](#)
black and ethnic minority communities [ref1](#)
blood clots [ref1](#), [ref2](#)
Brain Computer Interface (BCI) [ref1](#)
care homes, deaths in [ref1](#)
censorship [ref1](#), [ref2](#), [ref3](#)
chief medical officers and scientific advisers, financial interests of
[ref1](#), [ref2](#)
children [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#), [ref10](#)
China [ref1](#), [ref2](#)
clinical trials [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
compensation [ref1](#)
compulsory vaccinations [ref1](#), [ref2](#), [ref3](#)
computer programs [ref1](#)
consciousness [ref1](#)
cover-ups [ref1](#)
creation before Covid [ref1](#)
cytokine storm [ref1](#)
deaths and illnesses caused by vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
definition [ref1](#)
developing countries [ref1](#)
digital tattoos [ref1](#)
DNA-manipulation [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#),
[ref10](#)
emergency approval [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
female infertility [ref1](#)
funding [ref1](#)
genetic suicide [ref1](#)
Global Cult [ref1](#)
heart chakras [ref1](#)
hesitancy [ref1](#)
Human 2.0 [ref1](#), [ref2](#), [ref3](#), [ref4](#)
immunity from prosecution [ref1](#), [ref2](#), [ref3](#)

implantable technology [ref1](#)
Israel [ref1](#)
Johnson & Johnson [ref1](#), [ref2](#), [ref3](#), [ref4](#)
lockdowns [ref1](#)
long-term effects [ref1](#)
mainstream media [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
masks [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Medicines and Healthcare products Regulatory Agency (MHRA)
[ref1](#), [ref2](#)
messaging [ref1](#)
Moderna [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
mRNA vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#)
nanotechnology [ref1](#), [ref2](#)
NHS [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
older people [ref1](#), [ref2](#)
operating system [ref1](#)
passports [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Pfizer/BioNTech [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
polyethylene glycol [ref1](#)
pregnant women [ref1](#)
psychopathic personality [ref1](#)
races, targeting different [ref1](#)
reverse transcription [ref1](#)
Smart Grid [ref1](#)
social distancing [ref1](#)
social media [ref1](#)
sterility [ref1](#)
synthetic material, introduction of [ref1](#)
tests [ref1](#), [ref2](#), [ref3](#)
travel restrictions [ref1](#)
variants [ref1](#), [ref2](#)
viruses, existence of [ref1](#)
whistle-blowing [ref1](#)

WHO [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Wokeness [ref1](#)
working, vaccine as [ref1](#)
young people [ref1](#)
Vallance, Patrick [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#)
variants [ref1](#), [ref2](#), [ref3](#)
vegans [ref1](#)
ventilators [ref1](#), [ref2](#)
virology [ref1](#), [ref2](#)
virtual reality [ref1](#), [ref2](#), [ref3](#)
viruses, existence of [ref1](#)
visual reality [ref1](#), [ref2](#)
vitamin D [ref1](#), [ref2](#)
von Braun, Wernher [ref1](#), [ref2](#)

W

war-zone hospital myths [ref1](#)
waveforms [ref1](#), [ref2](#)
wealth [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#) [ref10](#), [ref11](#)
wet market conspiracy [ref1](#)
Wetiko factor [ref1](#)
 alcoholism and drug addiction [ref1](#)
 anti-human, why Global Cult is [ref1](#)
 Archons [ref1](#), [ref2](#), [ref3](#), [ref4](#)
 artificial intelligence (AI) [ref1](#)
 Big Pharma [ref1](#), [ref2](#)
 children [ref1](#)
 China [ref1](#)
 consciousness [ref1](#), [ref2](#)
 education [ref1](#)
 Facebook [ref1](#)

fear [ref1](#), [ref2](#)
frequency [ref1](#), [ref2](#)
Gates [ref1](#), [ref2](#)
Global Cult [ref1](#), [ref2](#)
heart [ref1](#), [ref2](#)
lockdowns [ref1](#)
masks [ref1](#)
Native American concept [ref1](#)
psychopathic personality [ref1](#), [ref2](#)
reframing/retraining programmes [ref1](#)
religion [ref1](#)
Silicon Valley [ref1](#)
Smart Grid [ref1](#)
smartphone addiction [ref1](#), [ref2](#)
social media [ref1](#)
war [ref1](#), [ref2](#)
WHO [ref1](#)
Wokeness [ref1](#), [ref2](#), [ref3](#)
Yaldabaoth [ref1](#), [ref2](#), [ref3](#), [ref4](#)
whistle-blowing [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
white privilege [ref1](#), [ref2](#)
white supremacy [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
Whitty, Christopher [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#),
[ref10](#)
‘who benefits’ [ref1](#)
Wi-Fi [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Wikipedia [ref1](#), [ref2](#)
Wojcicki, Susan [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#)
Wokeness
 Antifa [ref1](#), [ref2](#), [ref3](#), [ref4](#)
 anti-Semitism [ref1](#)
 billionaire social justice warriors [ref1](#), [ref2](#), [ref3](#)

Capitol Hill riot [ref1](#), [ref2](#)
censorship [ref1](#)
Christianity [ref1](#)
climate change hoax [ref1](#), [ref2](#)
culture [ref1](#)
education, control of [ref1](#)
emotion [ref1](#)
facts [ref1](#)
fascism [ref1](#), [ref2](#), [ref3](#)
Global Cult [ref1](#), [ref2](#), [ref3](#), [ref4](#)
group-think [ref1](#)
immigration [ref1](#)
indigenous people, solidarity with [ref1](#)
inversion [ref1](#), [ref2](#), [ref3](#)
left, hijacking the [ref1](#), [ref2](#)
Marxism [ref1](#), [ref2](#), [ref3](#)
mind control [ref1](#)
New Woke [ref1](#)
Old Woke [ref1](#)
Oneness [ref1](#)
perceptual programming [ref1](#)
 Phantom Self [ref1](#)
police [ref1](#)
defunding the [ref1](#)
reframing [ref1](#)
public institutions [ref1](#)
Pushbackers [ref1](#), [ref2](#), [ref3](#)
racism [ref1](#), [ref2](#), [ref3](#)
reframing [ref1](#), [ref2](#)
religion, as [ref1](#)
Sabbatians [ref1](#), [ref2](#), [ref3](#)
Silicon Valley [ref1](#)
social justice [ref1](#), [ref2](#), [ref3](#), [ref4](#)

transgender [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)
United States [ref1](#), [ref2](#)
vaccines [ref1](#)
Wetiko factor [ref1](#), [ref2](#), [ref3](#)
young people [ref1](#), [ref2](#), [ref3](#)
women, deletion of rights and status of [ref1](#), [ref2](#)
World Economic Forum (WEF) [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#),
[ref8](#), [ref9](#)
World Health Organization (WHO) [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#),
[ref7](#), [ref8](#), [ref9](#)
AIDs/HIV [ref1](#)
amplification cycles [ref1](#)
Big Pharma [ref1](#), [ref2](#), [ref3](#)
cooperation in health emergencies [ref1](#)
creation [ref1](#), [ref2](#)
fatality rate [ref1](#)
funding [ref1](#), [ref2](#), [ref3](#)
Gates [ref1](#)
Internet [ref1](#)
lockdown [ref1](#)
vaccines [ref1](#), [ref2](#), [ref3](#), [ref4](#)
Wetiko factor [ref1](#)
world number 1 (masses) [ref1](#), [ref2](#)
world number 2 [ref1](#)
Wuhan [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#) [ref8](#)

Y

Yaldabaoth [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#)
Yeadon, Michael [ref1](#), [ref2](#), [ref3](#), [ref4](#)
young people *see also* children addiction to technology [ref1](#)
Human 2.0 [ref1](#)
vaccines [ref1](#), [ref2](#)

Wokeness [ref1](#), [ref2](#), [ref3](#)

YouTube [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#)

WHO 548

Z

Zaks, Tal [ref1](#)

Zionism [ref1](#), [ref2](#), [ref3](#)

Zuckerberg, Mark [ref1](#), [ref2](#), [ref3](#), [ref4](#), [ref5](#), [ref6](#), [ref7](#), [ref8](#), [ref9](#),
[ref10](#), [ref11](#), [ref12](#)

Zulus [ref1](#)



Ickonic is something that has been a dream of mine for the last 5 years, growing up around alternative information I have always had a natural interest in what is going on in the World and what could I do to make it better.

Across the range of subjects and positions of influence occupied mainly by people who don't strive to make things better it's the Media that I have always found the most frustrating and fascinating. Mainly because if the Media did their Jobs properly then so much of the negative things happening in the World simply would not be able to happen, because they would be exposed within a heartbeat.

Free Press and the Opportunities that the internet could have given would mean that the Media are able to expose things like never before and hold people to account for their actions. As we all know there are 'Untouchables' that walk among us, people the Media simply won't touch, expose or investigate and that leads to the dark underworlds that infest the establishment the World over. Well I say enough, it's time for something different, a different kind of Media, where no one is off limits from exposing and investigating. All we're interested in at Ickonic is the truth of what is really going on in the World on whichever subject we're covering.

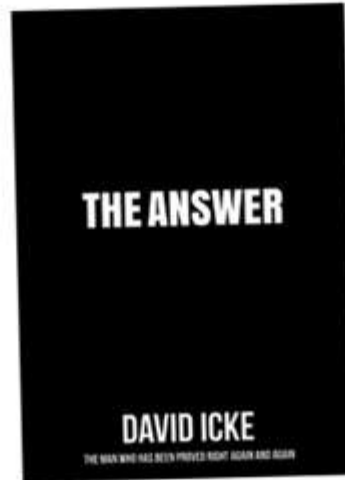
We hope you enjoy what we have created and take something away from the platform, we aim to deliver information that's informative and most importantly self-empowering, you're not a little person, you're part of something much bigger than that and its time we as a collective race began to understand that and look to the future as ours to take.

It's time...

Jaymie Icke - Founder Ickonic Alternative Media.

SIGN UP NOW AT ICKONIC.COM

DAVID ICKE
THE ANSWER



We live in extraordinary times with billions bewildered and seeking answers for what is happening. David Icke, the man who has been proved right again and again, has spent 30 years uncovering the truth behind world affairs and in a stream of previous books he predicted current events.

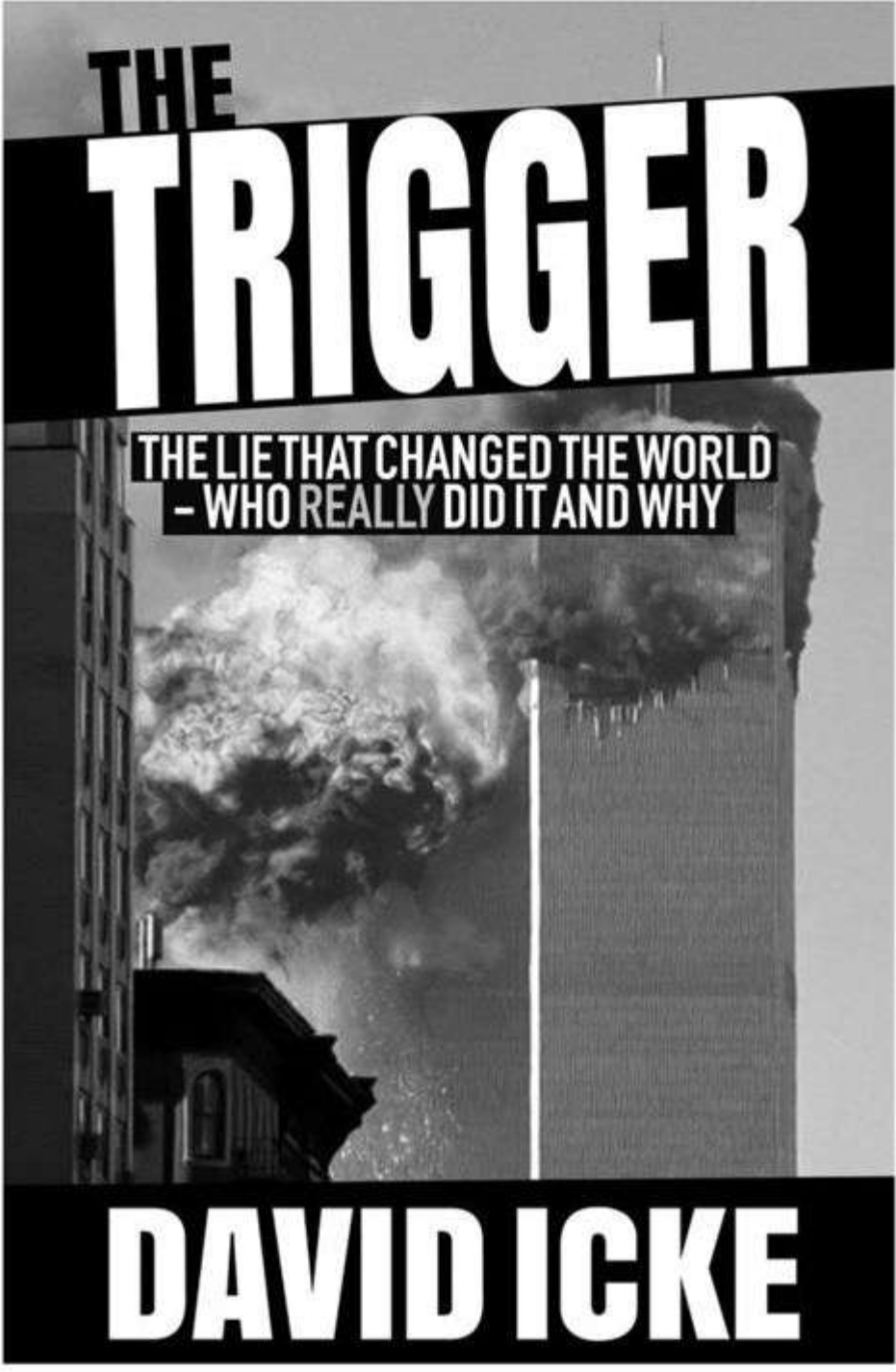
The Answer will change your every perception of life and the world and set you free of the illusions that control human society. There is nothing more vital for our collective freedom than humanity becoming aware of what is in this book.

Available now at davidicke.com.

THE

TRIGGER

**THE LIE THAT CHANGED THE WORLD
- WHO REALLY DID IT AND WHY**



DAVID ICKE

**EVERYTHING
YOU NEED
TO KNOW**

BUT HAVE NEVER BEEN TOLD

DAVID ICKE

DAVIDICKE.COM



DAVID ICKE STORE
LATEST NEWS ARTICLES
DAVID ICKE VIDEOS
WEEKLY DOT-CONNECTOR PODCASTS
LIVE EVENTS

WWW.DAVIDICKE.COM

364

THE LIFE STORY OF DAVID ICKE

RENEGADE

THE FEATURE LENGTH FILM

/ren·iˌgeɪd/

noun

A person who behaves in a rebelliously unconventional manner.



AVAILABLE NOW AT DAVIDICKE.COM

2 NEW BOOKS
BY NEIL HAGUE

ORION'S DOOR

SYMBOLS OF CONSCIOUSNESS & BLUEPRINTS OF CONTROL
- THE STORY OF ORION'S INFLUENCE OVER HUMANITY

CUTTING EDGE VISIONARY ART
& UNIQUE ILLUSTRATED BOOKS

NEIL HAGUE

FOR
BOOKS, PRINTS & T-SHIRTS
VISIT:

NEILHAGUEBOOKS.COM

OR NEILHAGUE.COM



Before you go ...

For more detail, background and evidence about the subjects in *Perceptions of a Renegade Mind* – and so much more – see my others books including *And The Truth Shall Set You Free*; *The Biggest Secret*; *Children of the Matrix*; *The David Icke Guide to the Global Conspiracy*; *Tales from the Time Loop*; *The Perception Deception*; *Remember Who You Are*; *Human Race Get Off Your Knees*; *Phantom Self*; *Everything You Need To Know But Have Never Been Told*, *The Trigger* and *The Answer*.

You can subscribe to the fantastic new Ickonic media platform where there are many hundreds of hours of cutting-edge information in videos, documentaries and series across a whole range of subjects which are added to every week. This includes my 90 minute breakdown of the week's news every Friday to explain *why* events are happening and to what end.