Anatomy

A REGIONAL ATLAS OF THE HUMAN BODY

Sixth Edition

Includes
online access
to interactive atlas,
images, full text,
and more!

Carmine D. Clemente

Wolters Kluwer | Lippincott Williams & Wilkins

thePoint

CLEMENTE | **ANATOMY**

Anatomy

A REGIONAL ATLAS OF THE HUMAN BODY

Sixth Edition

Carmine D. Clemente, A.B., M.S., Ph.D., Dr.H.L.

Distinguished Professor of Anatomy and Cell Biology and
Professor of Neurobiology, Emeritus (Recalled)
University of California at Los Angeles School of Medicine

Professor of Surgery (Anatomy)
Charles R. Drew University of Medicine and Science
Los Angeles, California

With More Than 150 Plates of Direct Clinical Importance

Wolters Kluwer | Lippincott Williams & Wilkins
Health

Philadelphia • Baltimore • New York • London
Buenos Aires • Hong Kong • Sydney • Tokyo

Acquisitions Editor: Crystal Taylor
Marketing Manager: Brian Moody
Product Manager: Julie Montalbano
Designer: Terry Mallon
Compositor: Aptara, Inc.

351 West Camden Street
Baltimore, MD 21201

530 Walnut Street
Philadelphia, PA 19106

Printed in China.

9 8 7 6 5 4 3 2 1

This 6th edition of *Anatomy*: *A Regional Atlas of the Human Body* is published by arrangement with Elsevier Germany GmbH, publisher and copyright holder of *Sobotta Atlas der Anatomie des Menschen, 22. Auflage, Band 1, Band 2; München: Elsevier/Urban & Fischer* ©2006. The English translation was undertaken by Lippincott Williams & Wilkins.

Most of the illustrations in this atlas have been previously published in the following:
Clemente, Carmine D. *Anatomy*: *A Regional Atlas of the Human Body,* 4th Edition. Baltimore: Williams & Wilkins, 1997.
Sobotta, J. *Atlas of Human Anatomy,* 21st German Edition/13th English Edition, Volumes 1 and 2. Edited by R. Putz and R. Pabst. Munich: Urban & Fischer, 2000; Baltimore: Lippincott Williams & Wilkins, 2001.
Sobotta, J. *Atlas of Human Anatomy,* 11th English Edition, Volume 1. Edited by J. Staubesand. Baltimore, Munich: Urban & Schwarzenberg, 1990.
Sobotta, J. *Atlas der Anatomie des Menschen, 18. Auflage*, Band 2. Edited by H. Ferner. Munich: Urban & Schwarzenberg, 1982.
Wicke, L. *Atlas of Radiologic Anatomy,* 6th English Edition. Edited and translated by A.N. Taylor. Baltimore: Williams & Wilkins, 1998.

Library of Congress Cataloging-in-Publication Data

Clemente, Carmine D.
Anatomy : a regional atlas of the human body / Carmine D. Clemente. – 6th ed.
p. ; cm.
Includes bibliographical references and index.
ISBN 978-1-58255-889-9 (alk. paper)
1. Anatomy, Surgical and topographical–Atlases. I. Title.
[DNLM: 1. Anatomy, Regional–Atlases. QS 17 C626a 2011]
QM531.C57 2011
611–dc22 2009037389

DISCLAIMER

Care has been taken to confirm the accuracy of the information present and to describe generally accepted practices. However, the authors, editors, and publisher are not responsible for errors or omissions or for any consequences from application of the information in this book and make no warranty, expressed or implied, with respect to the currency, completeness, or accuracy of the contents of the publication. Application of this information in a particular situation remains the professional responsibility of the practitioner; the clinical treatments described and recommended may not be considered absolute and universal recommendations.

The authors, editors, and publisher have exerted every effort to ensure that drug selection and dosage set forth in this text are in accordance with the current recommendations and practice at the time of publication. However, in view of ongoing research, changes in government regulations, and the constant flow of information relating to drug therapy and drug reactions, the reader is urged to check the package insert for each drug for any change in indications and dosage and for added warnings and precautions. This is particularly important when the recommended agent is a new or infrequently employed drug.

Some drugs and medical devices presented in this publication have Food and Drug Administration (FDA) clearance for limited use in restricted research settings. It is the responsibility of the health care providers to ascertain the FDA status of each drug or device planned for use in their clinical practice.

To purchase additional copies of this book, call our customer service department at **(800) 638-3030** or fax orders to **(301) 223-2320**. International customers should call **(301) 223-2300**.

Visit Lippincott Williams & Wilkins on the Internet: http://www.lww.com. Lippincott Williams & Wilkins customer service representatives are available from 8:30 am to 6:00 pm, EST.

Preface to the Sixth Edition

It is always reinforcing and rewarding for an author when the publisher of a book requests another edition. I have now had this pleasure five times after the first edition of this atlas was published 34 years ago in 1975. Previous editions, as well as this edition, have benefited greatly by the many suggestions from colleagues and especially students. Students often approach this in a thoughtful subtle manner. First, the student may say how much he or she has learned from the book and give praise to the nature and color of the figures and then point out a mistaken label in one of the figures that may not have caught my eye. Of course, I am always grateful for these suggestions.

In this edition, I have added many new figures—for example, 14 new figures on 5 plates dealing with the brachial plexus. At the same time, a few figures that did not prove to be excellent teaching items have been removed. Perhaps the most important change in the book is the addition of a significant number of X-rays, CT scans, and ultrasound scans. I am most grateful to Edward J. H. Nathanial, M.D., Ph.D., Emeritus Professor at the University of Winnipeg School of Medicine in Canada, for providing at least 15 figures of clinical significance. Several figures also were contributed by Dr. G.L. Colborn, Emeritus Professor from the Medical College of Georgia in Augusta, Georgia. I have also had the pleasure of discussions with Dr. James D. Collins, Professor of Radiologic Sciences here at UCLA. I thank Dr. Constantine Karakousis, Professor of Surgery and Chief of Surgical Oncology at the University of Buffalo in Buffalo, New York, for the use of several of his figures and for comments on the clinical importance of several plates. Certain X-rays from Dr. Lothar Wicke's 6th English edition of *Atlas of Radiologic Anatomy,* edited by Dr. Anna Taylor here at UCLA, were also used.

There are more than 200 plates of clinical importance in this atlas, and I have benefited greatly from my discussions and collaboration with Professor Gerald Buckberg, M.D., Professor of Cardiac Surgery here at UCLA, and the late Dr. F. Torrent Guasp from Madrid, Spain, on the progressive unfolding of cardiac muscle as shown in Plate 186. These studies have given insightful information on the manner by which the heart muscle develops and matures.

Most of the figures in this atlas come from the Sobotta atlases, recent editions of which have been published by Professor R. Putz in Munich, Germany, and Professor R. Pabst in Hanover, Germany. My deepest appreciation to these two brilliant anatomists knows no bounds. Their German editions of Sobotta have been recently reproduced as the 14th English Edition in 2006. A number of drawings, some of which were also used in the 5th edition, were made by a former resident artist here at UCLA, Ms. Jill Penkhus. I am most grateful for her artistic creativity.

I am most indebted to the editors at Lippincott Williams & Wilkins in Baltimore, and especially to Ms. Crystal Taylor, with whom I have interacted for more than 20 years on several earlier editions of this atlas, and Ms. Julie Montalbano, the Product Manager of this edition. Here at UCLA, I am privileged to have worked with outstanding associates who form the gross anatomy faculty for both the medical and dental school at this university. These include **Dr. Shelley Metten,** the Chairperson of the Anatomy Division, and **Drs. Robert Trelease, Richard Braun, Joseph Miller, Elena Stark, Yau Shi Lin, Jonathan Wisco, Quynh Pham, Guido Zampighi, David Hovda, Anna Taylor, Robin Fisher, Charles Olmstead, Francesco Chiappelli, and Jayc Sedlmayr.** Dr. Sedlmayr is now on the faculty of the Louisiana State University School of Medicine in New Orleans. In my 57 years of active teaching here at UCLA, collectively, these anatomists are the finest anatomy colleagues I have ever worked with.

Finally, but by no means least, I must say that my wife, Julie, has been a steadfast inspiration to me and my academic life, and I am eternally grateful to her.

Carmine D. Clemente
Los Angeles, California—October 2009

From the Preface to the Fifth Edition

I continue to observe the use of this atlas in the anatomy classroom and laboratory here at the UCLA Center for the Health Sciences, and many suggestions I have received over the past six years from students and from friends around the world have been incorporated in this edition. Further, students have convinced me that a **special section on the cranial nerves** would be helpful to them. This has now been included and a series of diagrammatic drawings (patterned after Grant and other authors) along with a number of figures relevant to the cranial nerves have been collected in a group of **29 plates** at the end of the Neck and Head section. Most of the new cranial nerve drawings were done by Ms. Jill Penkhus several years ago when she was the resident artist in the Department of Anatomy here. In addition to these, several new pieces of art have been included in this atlas.

Among the new illustrations in this edition are modified replacements of the nine remaining illustrations in the 4th edition that originated from the controversial atlas *Topographical Human Anatomy* by Pernkopf. These new color illustrations were expertly rendered by the medical illustrators at Anatomical Chart Company (ACC) and David Rini. By far, however, my deepest appreciation is extended to **Professors R. Putz** in Munich and **R. Pabst** in Hanover, Germany, for their exceedingly creative contributions for the 21st German and 13th English editions of the *Sobotta Atlas of Human Anatomy.* More than 325 figures in their most recent two-volume set are the principal new drawings on which this edition is based. The other figures are ones that were used in my 4th edition. I am responsible for all the notes that accompany all of the figures, and any mistakes that may be found in these are mine and those of no one else. I would be most grateful to any student or professor who may have suggestions or who may identify errors, if these were transmitted to me here in Los Angeles.

Many new clinically related plates have been added to those in the 4th edition. This atlas now contains more than 150 plates that are of direct clinical importance. These are listed in the front pages of the book and they include surface anatomy, radiographs (many of which come from the outstanding collection of Professor L. Wicke of Vienna), MRIs, CT scans, arteriograms, lymphangiograms, bronchograms, and even a series of arthroscopic images of the knee joint. These have been added because of the increased emphasis on the clinical relevance to the teaching of Anatomy that has become common in medical schools, not only in the United States but in many other countries as well. One plate (#146) is based on the work of Drs. R. Torrent-Guasp of Madrid and Gerald Buckberg of UCLA here in Los Angeles.

There are many who have helped to make this atlas possible. Among them are Ms. Betty Sun, Ms. Crystal Taylor, Ms. Kathleen Scogna, and Ms. Cheryl Stringfellow at Lippincott Williams & Wilkins in Baltimore and, of course, many at the Elsevier Corporation, the publishers that acquired the Sobotta collection from Urban & Fischer. I am especially grateful to Dr. Constantine Karakousis, Professor of Surgery and Chief of Surgical Oncology at the University of Buffalo in Buffalo, New York, for his recommendations and comments on the clinical importance of several of the plates. Perhaps most of all, my continuing gratitude goes to Julie, my wife, who has helped me both at the computer and in being considerate for all the time it has taken me to do this manuscript, time that could have been given to some of her interests.

Carmine D. Clemente
Los Angeles, California—February 2006

From the Preface to the First Edition

Twenty-five years ago, while a student at the University of Pennsylvania, I marvelled at the clarity, completeness, and boldness of the anatomical illustrations of the original German editions of Professor Johannes Sobotta's atlas and their excellent three-volume English counterparts, the recent editions of which were authored by the late Professor Frank H. J. Figge. It is a matter of record that before World War II these atlases were the most popular ones consulted by American medical students. In the United States, with the advent of other anatomical atlases, the shortening of courses of anatomy in the medical schools, and the increase in publishing cost, the excellent but larger editions of the Sobotta atlases have become virtually unknown to a full generation of students. During the past 20 years of teaching Gross Anatomy at the University of California at Los Angeles, I have found only a handful of students who are familiar with the beautiful and still unexcelled Sobotta illustration.

This volume introduces several departures from the former Sobotta atlases. It is the first English edition that represents the Sobotta plates in a regional sequence—the pectoral region and upper extremity, the thorax, the abdomen, the pelvis and perineum, the lower extremity, the back, vertebral column and spinal cord, and finally, the neck and head. This sequence is consistent with that followed in many courses presented in the United States and Canada and one which should be useful to students in other countries.

Many have contributed to bringing this Atlas to fruition. I thank Dr. David S. Maxwell, Professor and Vice Chairman for Gross Anatomy and my colleague at UCLA, for his encouragement and suggestions. I also wish to express my appreciation to Caroline Belz and Louise Campbell, who spent many hours proofreading and typing the original text. I especially wish to thank Mary Mansor for constructing the index—a most laborious task. I am grateful to Barbara Robins for her assistance in typing some of the early parts of the manuscript, and above all, to her sister Julie, who is my wife and who makes all of my efforts worthwhile through her encouragement and devotion.

Carmine D. Clemente
Los Angeles, California—January 1975

Contents

CHAPTER 7: The Neck and Head

CHAPTER 8: Cranial Nerves

Plates of Direct Clinical Importance

Plates 1–3	Male and Female Surface Anatomy
Plates 4, 6, 7–9	Anatomy of the Female Breast and Lymphatic Channels
Plates 10, 12–14	Surface Vessels and Nerves of the Anterior Trunk
Plates 22–24	Arteries, Veins, and Nerves of the Axilla
Plates 28, 29	Arteries and Superficial Veins in the Upper Limb
Plates 30–32, 54, 55	Muscles That Form the Rotator Cuff in the Shoulder
Plate 35	Dermatomes of the Upper Limb
Plates 36, 37	Vessels and Nerves: Anterior and Posterior Brachium
Plates 38, 39	Arteries and Nerves of the Upper Limb; Brachial Arteriogram
Plate 41	Variations in the Superficial Veins of the Upper Limb
Plate 46–53	Brachial Plexus
Plate 67	Course of the Radial Nerve Along the Radial Groove
Plates 68, 69	Superficial Vessels and Nerves of the Forearm; Cubital Fossa
Plates 77–79	Median, Ulnar, and Radial Nerves in the Forearm; Brachial Artery
Plate 86	Dermatomes on Posterior Aspect of Upper Limb
Plates 90, 91	Local Anesthesia of Fingers
Plate 99	Synovial Sheathes of the Fingers
Plate 115	X-Ray of Should Joint Bones
Plates 120, 121	Radiographic Anatomy of the Right Should Joint Bones
Plate 123	X-Rays of Elbow Joint: Adult and Child
Plate 127	Radiograph of the Wrist and Hand
Plate 129	Radiograph of the Right Wrist
Plate 131	Radiograph of the Right Hand (Lateral Projection)
Plates 132, 133, 135, 136	CT Scans of the Arm, Forearm, and Wrist
Plate 139	Surface Anatomy of Anterior Body Wall (Male and Female)
Plate 151	Radiograph of the Chest Showing the Heart and Lungs
Plates 154–156	Surface Projections of the Pleura and Lungs
Plate 163	Surface Projection of the Trachea
Plate 165	Bronchogram of Bronchial Tree; Bronchoscope of Trachea
Plate 168	Radiograph of the Thorax
Plate 171	Anterior Wall Projection of Underlying Heart Valves
Plate 180	Left Coronary Arteriogram
Plate 181	Right Coronary Arteriogram
Plate 191	Heart Valves: Projection on Chest Wall and Their Structure
Plate 196	Frontal Section of the Thorax and Upper Abdomen
Plate 200	Radiograph of Esophagus and View through Esophagoscope
Plate 205	Angiogram of the Aortic Arch and Its Branches
Plates 212, 213, 218	MRIs and CT of the Chest
Plate 219	Surface Anatomy: Regions of the Body; GI System Organs
Plate 229	CT Scans of the Body Wall and Abdomen
Plates 240, 241	Descent of Testis and Congenital and Direct Inguinal Hernias
Plate 244	Surface Projections: Thorax, Abdomen, Male Pelvic Organs
Plate 245	Surface Projections: Thorax, Abdomen, Female Pelvic Organs
Plates 246, 247	Median and Paramedian Sections of Male Abdomen and Pelvis
Plate 256	Celiac Trunk Arteriogram
Plate 257	Variations in Blood Supply to the Liver and Stomach
Plate 261	Surface Projections and Radiographs of the Stomach
Plate 263	X-Ray of the Stomach
Plate 265	X-Ray of the Stomach Showing a Small Ulcer
Plate 267	X-Rays Showing Gastric and Duodenal Ulcers
Plate 270	Surface Projections of the Liver
Plate 273	Ultrasound Scans of the Hepatic and Portal Veins
Plate 275	CT Scan of Upper Abdomen at Level T10-T11
Plate 276	CT Scan of Abdomen at Level L1
Plate 277	Ultrasound Scans: Upper Abdomen and Tumor Mass in Liver
Plate 279	Cholangiogram and X-Ray of Biliary Duct System
Plate 280	Ultrasound Scan: Abdomen Showing Parts of the Gallbladder
Plate 281	Ultrasound Scans of Gallbladder and Gallstones
Plate 282	Surface Projection: Duodenum and Pancreas
Plate 284	CT Scan: Abdomen at Level L2 Showing Pancreas, etc.
Plate 285	CT Scan Showing a Tumor in the Head of the Pancreas
Plate 286	CT Scan: Diffuse Inflammation of the Pancreas (Pancreatitis)

Plate 287	CT Scan Showing a Hemorrhage within the Spleen
Plate 289	Radiograph of the Jejunum, Ileum, Cecum, and Ascending Colon
Plate 291	Radiograph of the Small Intestine
Plate 293	Superior Mesenteric Arteriogram
Plate 295	Inferior Mesenteric Arteriogram
Plate 302	Variations in the Location of the Vermiform Appendix
Plate 305	Radiograph of the Large Intestine
Plate 310	Arteriogram of the Renal Artery
Plate 311	Surface Anatomy of the Back Showing Location of the Kidneys
Plate 313	Retrograde Pyelogram
Plates 318–322	CT Scans of the Abdomen
Plate 325	Radiograph of the Pelvis
Plate 330	Uterosalpingogram
Plate 332	Variations in the Position of the Uterus in the Pelvis
Plate 334	CT Scan of the Female Pelvis
Plate 337	X-Ray of the Pregnant Uterus
Plate 338	Pregnant Uterus: Fetal Sonograms
Plate 339	Variations in the Divisions of the Internal Iliac Artery
Plate 340	Arteriogram of the Iliac Arteries in the Female
Plate 344	Female External Genitalia
Plate 353	Peritoneum over Empty and Full Bladders
Plate 356	Radiographs of Male Pelvic Organs
Plates 363, 364	CT Scans of the Female and Male Pelvis
Plate 371	Surface Anatomy of the Back
Plate 372	Cutaneous Nerves and Dermatomes of the Back
Plate 391	Radiograph of Odontoid Process and Atlantoaxial Joints
Plate 398	Intervertebral Disks
Plates 400, 401	Radiograph of the Vertebral Column
Plates 402–407	Spinal Cord
Plate 408	Lumbar and Sacral Punctures into the Spinal Column
Plates 409–412	Lower Limb: Surface Anatomy, Cutaneous Nerves, Bones
Plates 413–415	Lower Limb: Arteries, Muscles: Anterior and Posterior Aspects
Plate 422	Variations in the Deep Femoral Artery and Circumflex Arteries
Plate 428	Surface Vessels and Nerves: Gluteal Region, Posterior Thigh
Plates 434, 435	Safe Zones for Intramuscular Injections in Gluteal Region
Plates 440, 441	Nerves of the Lower Limb
Plate 444	Variations in Branching of Anterior Tibial Fibular Arteries
Plate 446	Superficial Veins and Nerves of Anterior and Medial Leg, Foot
Plate 453	Ankle and Foot Movements
Plate 454	Vessels and Nerves of the Dorsal Foot
Plate 460	Vessels and Nerves on the Posterior Aspect of the Leg (Calf)
Plates 474, 476	Vessels and Nerves on the Plantar Aspect of the Foot
Plates 483	Blood Supply and Radiograph of the Hip Joint
Plate 484	Radiograph of the Knee Joint
Plate 489	Four MRIs of the Knee Joint
Plate 490	Arthrogram of the Knee Joint
Plate 491	Arthroscopic Images of the Knee Joint
Plate 493	Radiographs of the Knee Joint
Plate 494	Movements at the Knee Joint
Plate 498	X-Ray of the Ankle Joint
Plate 508	Radiograph, MRI of Ankle, Subtalar, and Talonavicular Joints
Plates 511–513	CT Scans of the Mid and Distal Thigh and Mid Leg
Plate 515	MRI through the Metatarsal Bones of the Foot
Plates 517, 518	Surface Anatomy of the Face and Neck
Plate 599	Surgical Entry into the Respiratory System
Plate 525	Drainage of Lymph of Superficial Lateral Scalp and Face
Plate 535	Jugular Veins in the Neck
Plates 536–538	Thyroid Gland
Plates 548, 553, 554	Facial Nerve on the Face
Plates 557, 558	Temporomandibular Joint
Plate 560	Variations in the Maxillary Artery
Plate 571, 572	Newborn Skull
Plates 573, 574	Scalp, Diploic Veins, Internal Carotid Artery
Plate 582	Variations in the Formation of the Circle of Willis
Plates 583, 584	Arteriogram of the Internal Carotid and Vertebral Arteries
Plates 588–590	Base of the Skull and Brain: Cranial Nerves and Vessels
Plate 593	Eye from Anterior
Plates 601–604	Nerve in the Orbit
Plate 609	Horizontal Section of the Eyeball
Plates 611, 612	MRI, Vessels and Nerves within the Orbit and Retina
Plate 616	Vessels and Nerves in the Nasal Cavity
Plates 617, 618	Paranasal Sinuses
Plates 619–622	Oral Cavity
Plates 625, 626	Salivary Glands
Plates 633–640	Anatomy of the Dental Arches and Teeth; Their Innervation
Plates 641–648	Pharynx
Plates 649–656	Larynx
Plates 657–668	External, Middle, and Internal Ear
Plate 669–694	Cranial Nerves I–XII

Plates Containing Muscle Charts

CHAPTER 1

Pectoral Region, Axilla, Shoulder, and Upper Limb

Plates

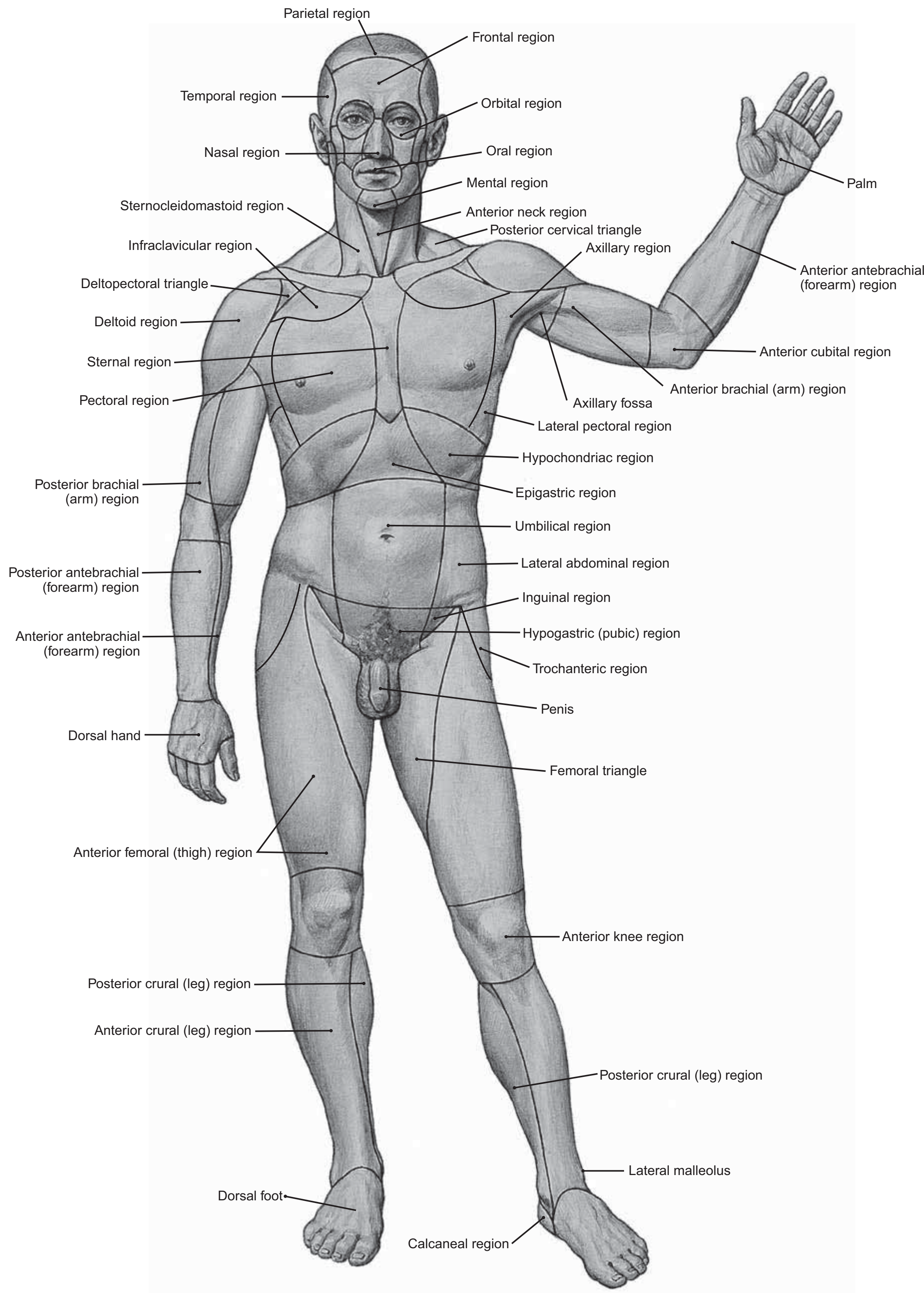


FIGURE 1 Regions of the Body: Anterior View

NOTE: (1) Surface areas are identified by specific names to describe the location of structures and symptoms precisely.

(2) Some regions are named after bones (sternal, parietal, infraclavicular, etc.), others for muscles (deltoid, pectoral, sternocleidomastoid), and still others for specialized anatomical structures (umbilical, oral, nasal, etc.).

(3) The principal regions of the body include the pectoral region and upper extremity, thorax, abdomen, pelvis and perineum, lower extremity, back and spinal column, and neck and head.

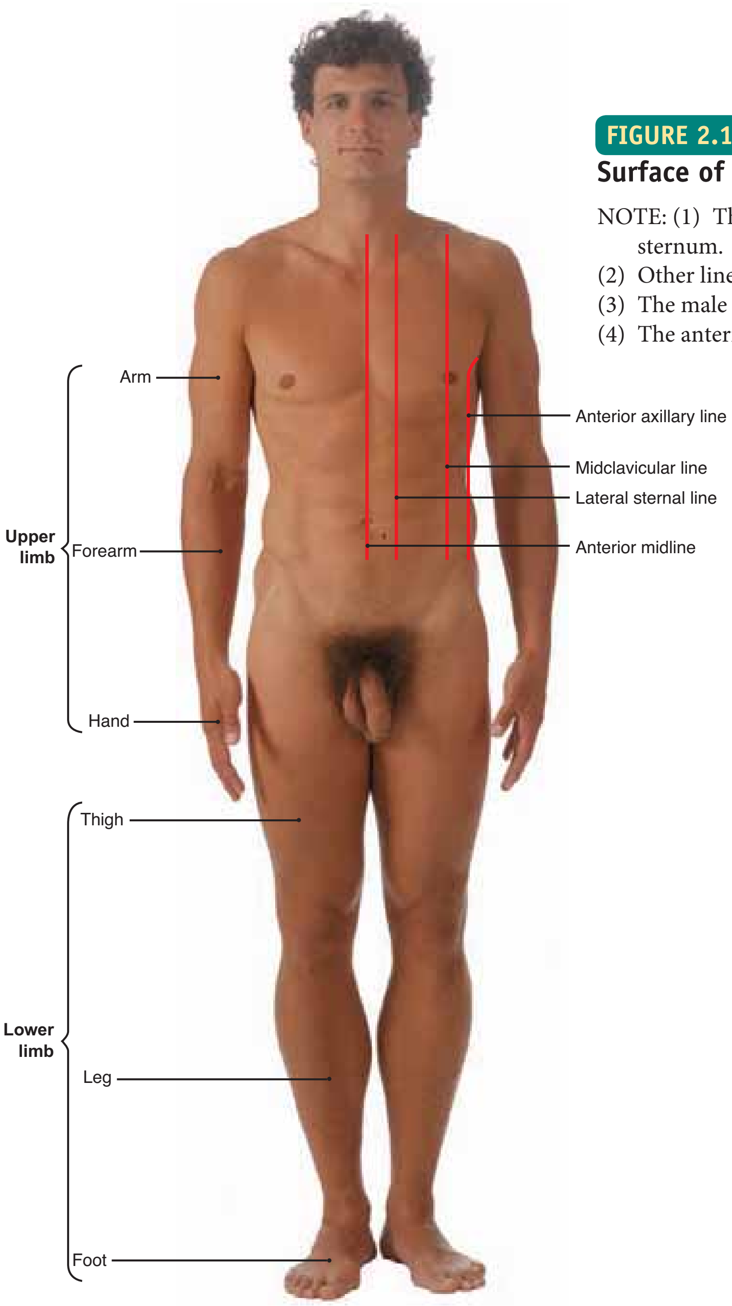


FIGURE 2.1 Regions and Longitudinal Lines on the Anterior Surface of the Male Body

NOTE: (1) The lateral sternal line descends along the lateral border of the sternum.
(2) Other lines parallel to this are called parasternal lines.
(3) The male nipple lies near the midclavicular line.
(4) The anterior axillary line descends from the anterior axillary fold.

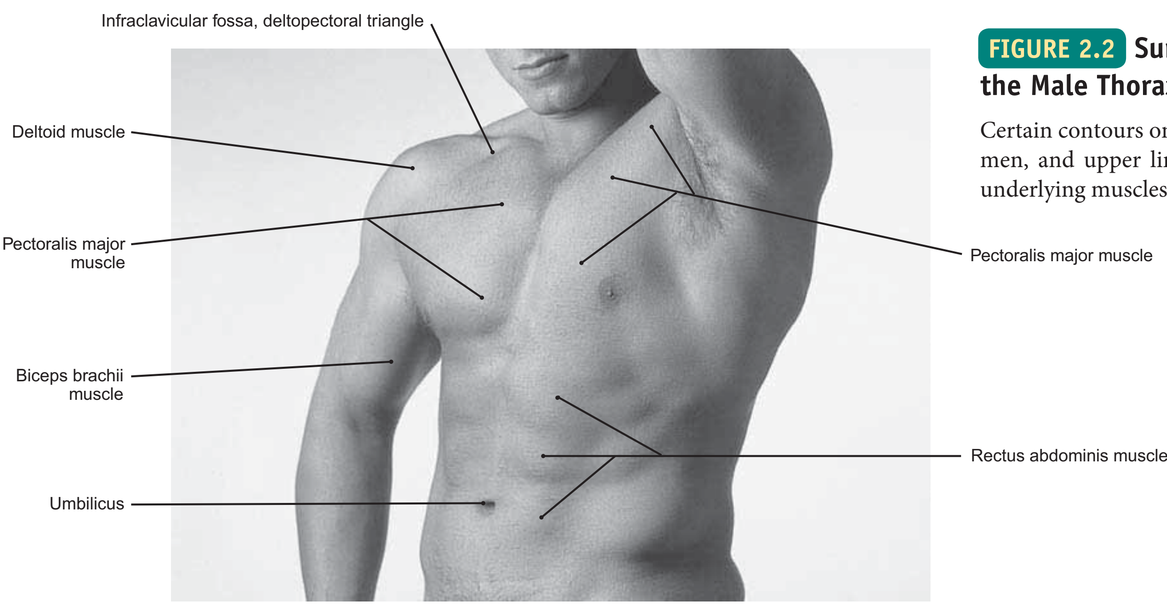


FIGURE 2.2 Surface Contours on the Male Thorax

Certain contours on the chest, upper abdomen, and upper limb reveal the shape of underlying muscles.

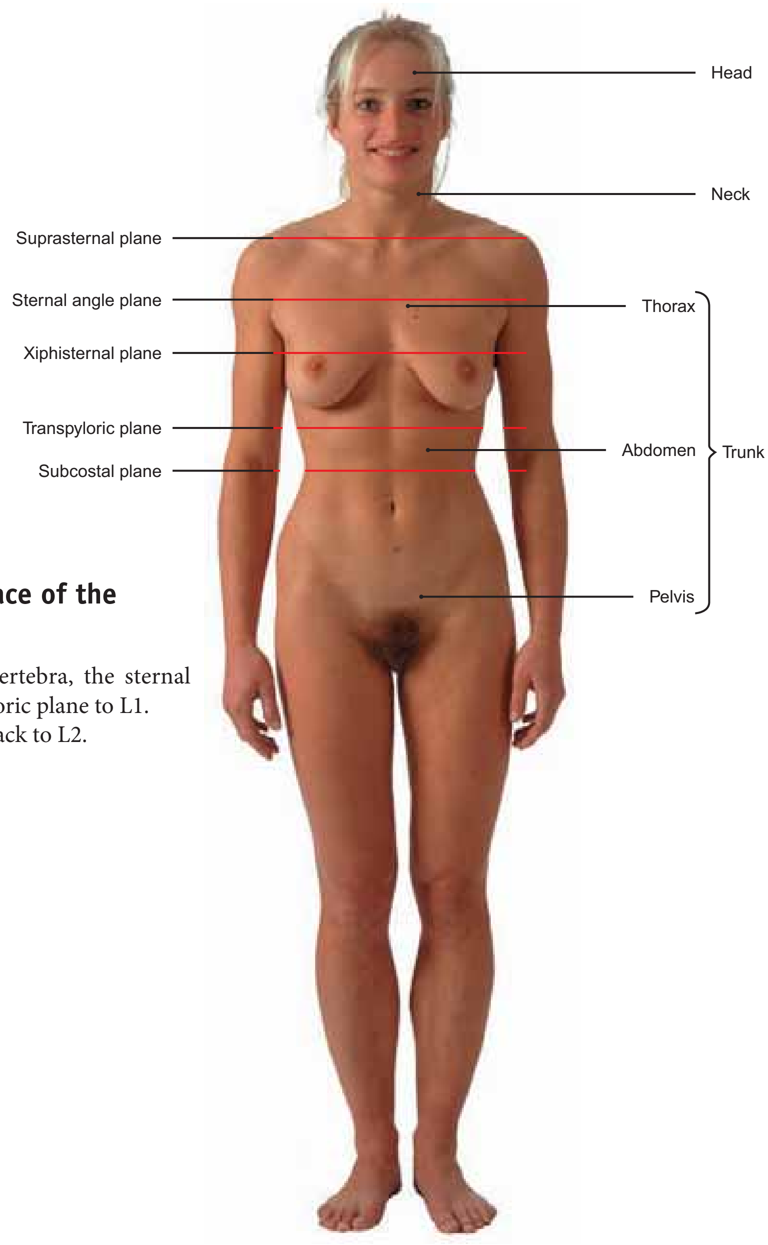


FIGURE 3.1 Transverse Planes Shown on the Surface of the Female Thorax

NOTE: (1) The suprasternal plane projects back to the T2 vertebra, the sternal angle to T4, the xiphisternal junction to T9, and the transpyloric plane to L1.
(2) The subcostal plane, below the 10th rib anteriorly, projects back to L2.

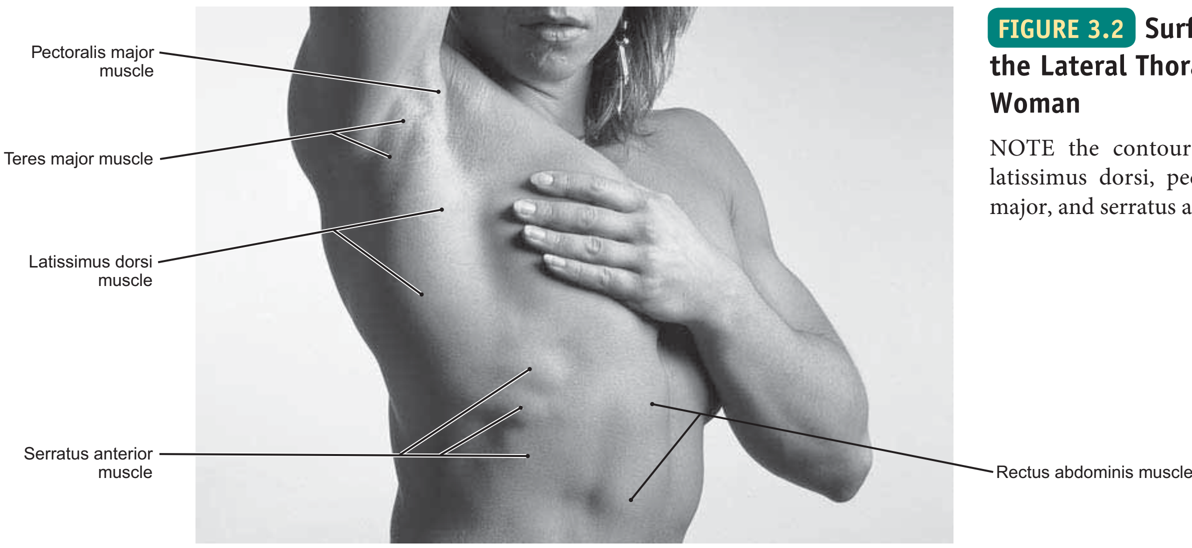


FIGURE 3.2 Surface Contours on the Lateral Thorax of a Young Woman

NOTE the contours of well-developed latissimus dorsi, pectoralis major, teres major, and serratus anterior muscles.

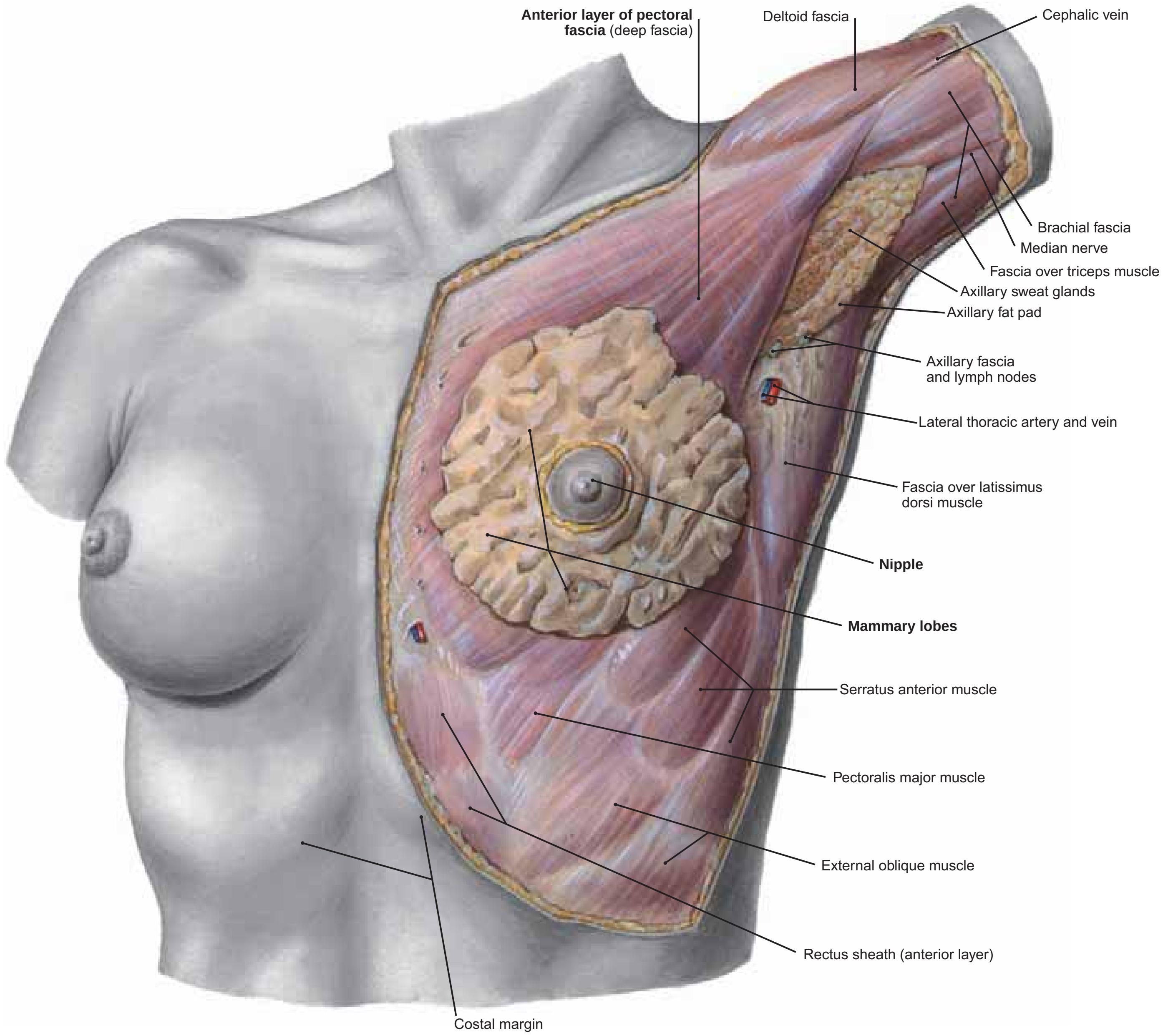


FIGURE 4.1 Anterior Pectoral Region and Female Breast ▲

NOTE: (1) The lobular nature of the breast.
(2) It extends from the lateral sternal line to the midaxillary line and from the second to the sixth rib.
(3) The breast is located in the superficial fascia anterior to the pectoral fascia.
(4) Shown are the superficial axillary lymph nodes and the axillary sweat glands.

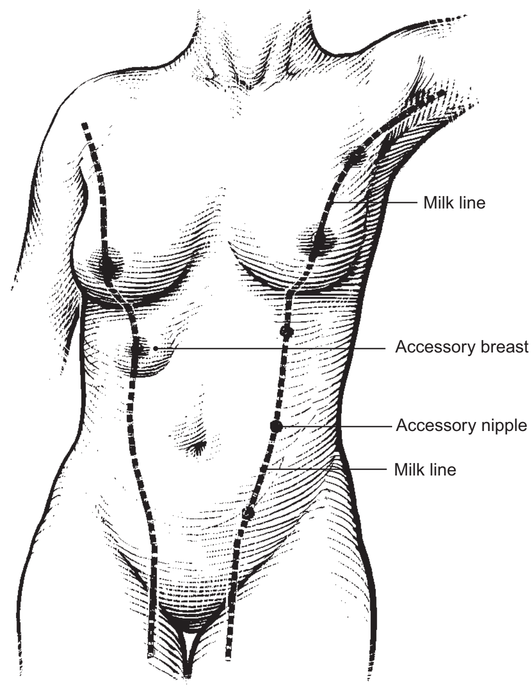


FIGURE 4.2 Milk Line and Accessory Nipples and Breasts ▶

NOTE: (1) Supernumerary nipples (polythelia) and/or multiple breasts on the same side (polymastia) occur in about 1% of people.
(2) These are found along the curved milk line extending from the axillary fossa to the groin.
(3) This condition occurs slightly more frequently in males than in females and may easily be handled surgically.

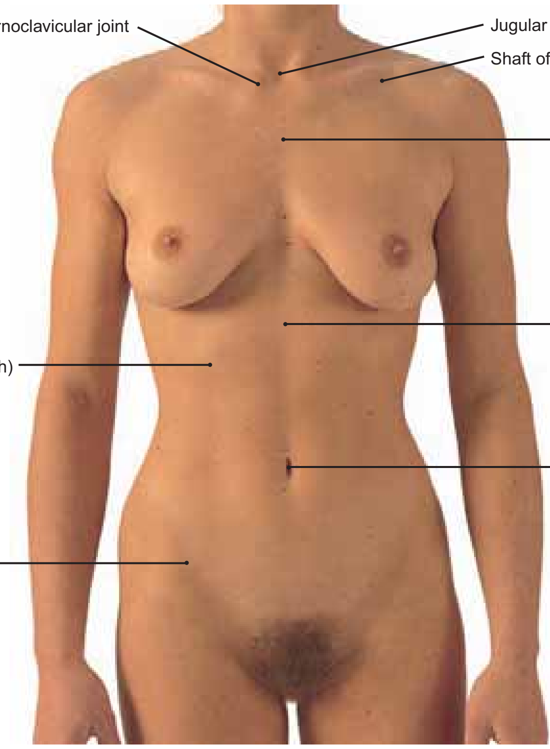
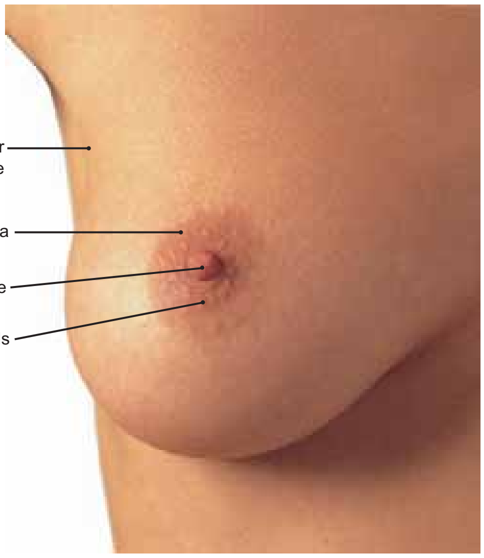


FIGURE 5.1 Surface Anatomy of the Anterior Thoracic and Abdominal Walls of a Young Female

NOTE: Bony structures and the umbilicus are labeled.



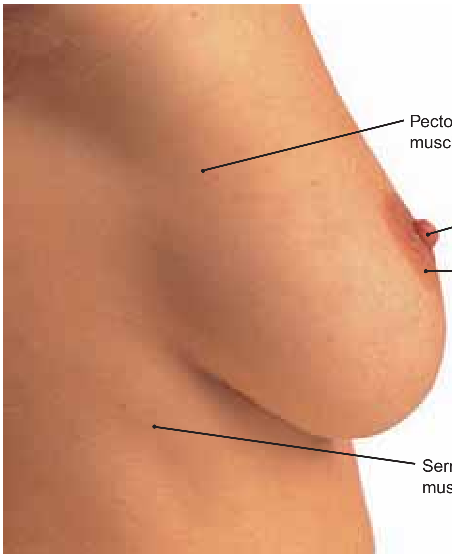


FIGURE 5.2 Female Breast (Anterior View)

FIGURE 5.3 Female Breast (Lateral View)

NOTE: The nipple and areolar glands project from the surface of the pigmented areola. Also observe the muscular contours of the pectoralis major and serratus anterior muscles.

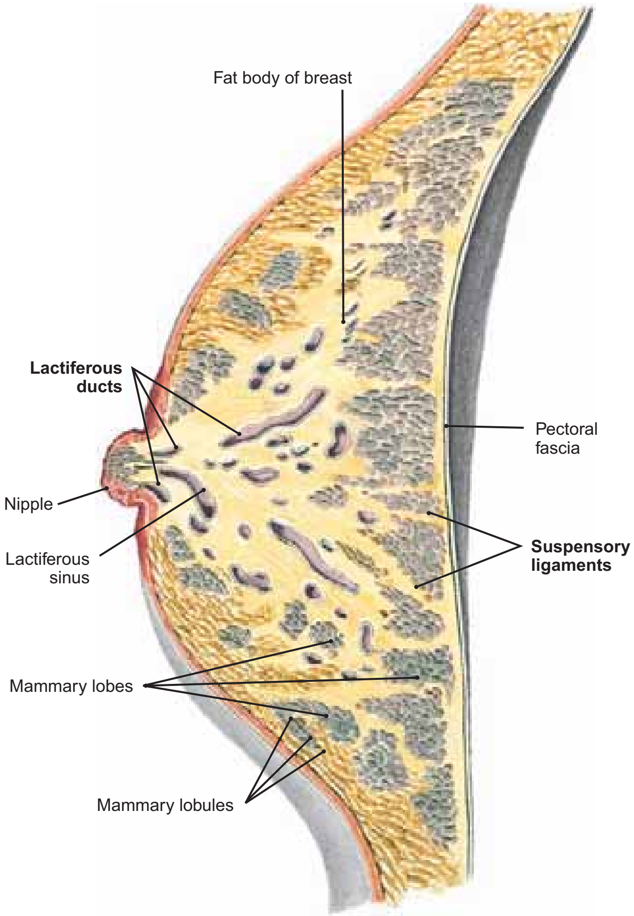


FIGURE 6.1 Sagittal Section through Mammary Gland of Gravid Female

NOTE: (1) The radial arrangement of the lobes, separated by connective tissue and fat.
(2) In the lactiferous duct system, each of the 15 to 20 lobes has its own duct.
(3) The pectoral fascia separates the breast from the pectoralis major muscle.
(4) The connective-tissue suspensory ligaments (of Cooper) extend to the pectoral fascia.

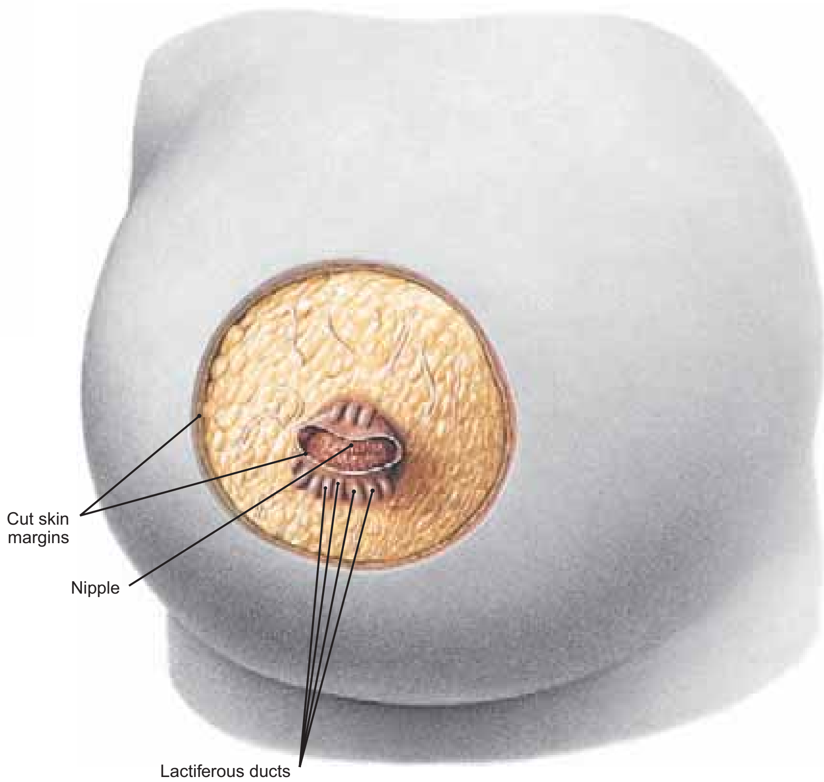


FIGURE 6.2 Right Mammary Gland: Dissection of the Nipple ▶

NOTE: (1) A circular piece of skin has been incised from around the nipple.
(2) The 15 to 20 lactiferous ducts are arranged radially around the nipple and seen just deep to the skin.

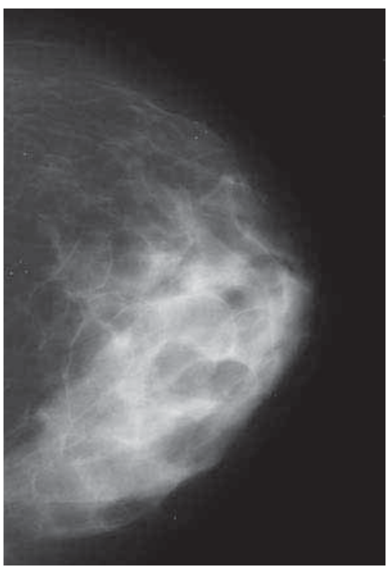


FIGURE 6.3 Radiograph of Normal Female Breast

Lateral mammograph of a 47-year-old woman.

Cancer of the Breast

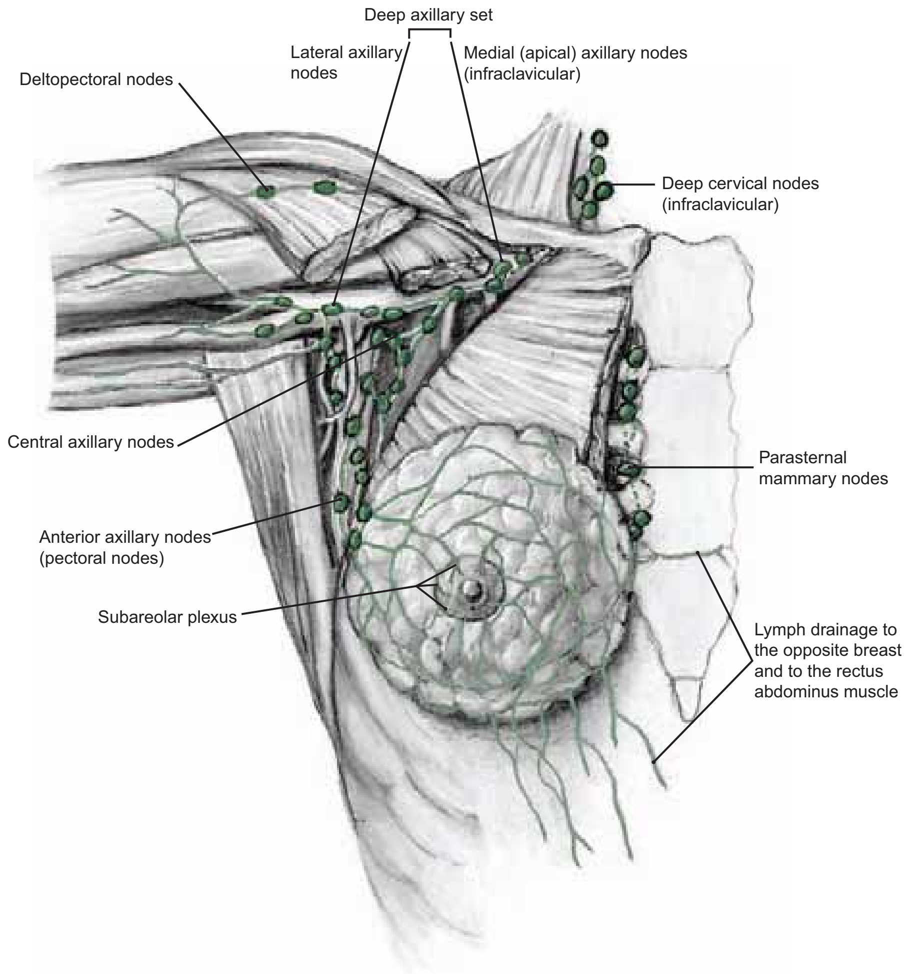
Cancer of the breast usually develops in the epithelial cells that line the ducts of the glandular tissue. Often, the initial clinical sign of breast cancer is a painless lump in the upper lateral quadrant of the organ. This may progress:

(1) to invade the connective tissue between the lobules (suspensory ligaments of Cooper) and cause a **retraction of the nipple;**
(2) to grow more deeply and **fix the breast to the pectoral fascia** overlying the pectoralis major muscle. This causes the breast to be **less movable** and it **tends to elevate** when the underlying pectoralis major contracts;
(3) to cause a **dimpling,** a **thickening,** and a **discoloration of the skin over the tumor.** The skin then assumes an appearance of an orange peel and hence has been called the **peau d'orange sign** of advanced breast carcinoma.

From the local primary tumor site, malignant cells spread by entering lymphatic capillaries and proceed to lymph nodes, where they may multiply to form metastatic secondary tumors. The most frequent routes of early metastatic spread involve the lateral thoracic and axillary lymph nodes as well as nodes that accompany the internal thoracic vessels lateral and parallel to the sternum. Spread of tumor cells also occurs by way of venous capillaries to larger veins and then to more widespread organs.

FIGURE 7.1 Axillary and Parasternal Nodes and Lymph Channels from the Female Breast

NOTE the central and anterior axillary nodes. Also observe the deep lateral and deep medial axillary nodes more superiorly along with the parasternal and deep cervical nodes.



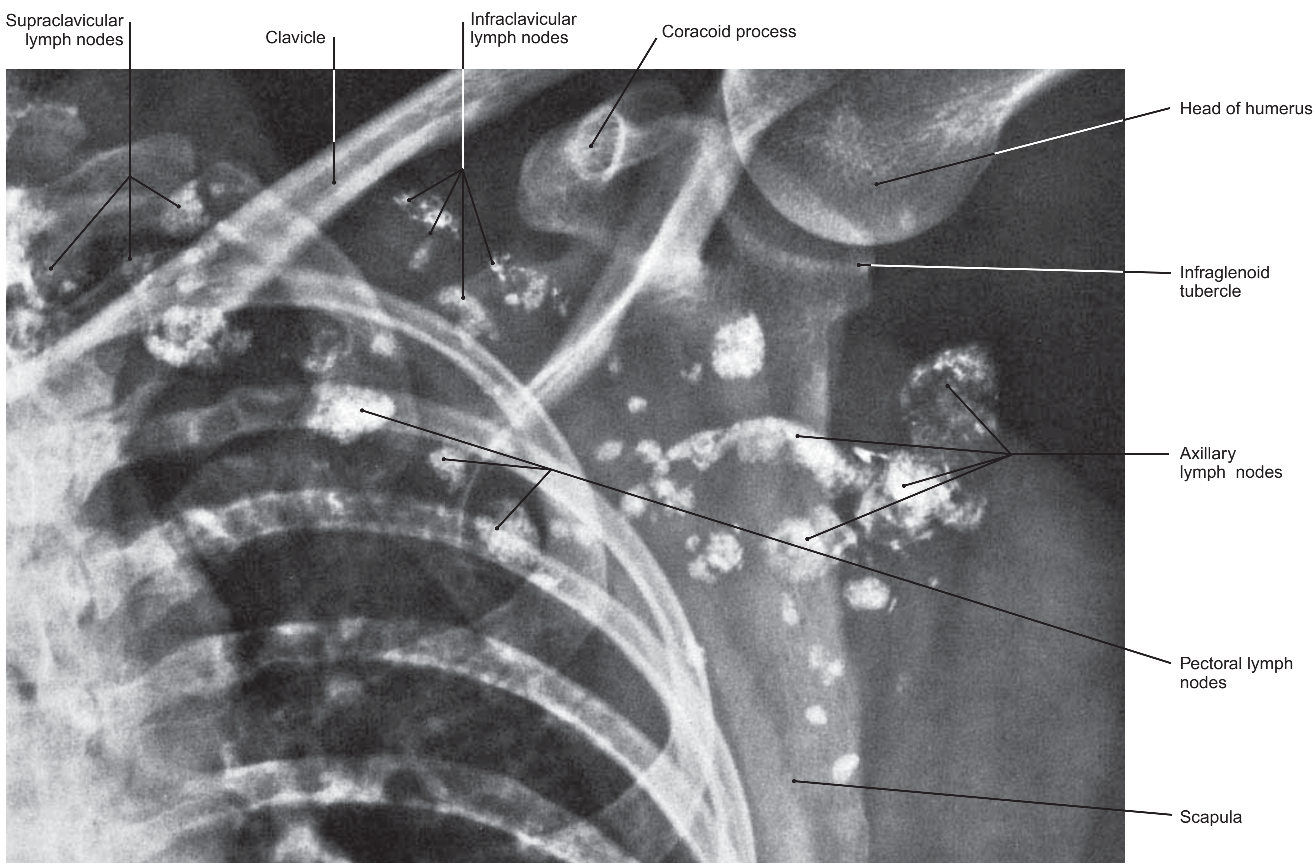


FIGURE 7.2 Lymphangiogram of the Pectoral and Axillary Lymph Nodes

(From Wicke, 6th ed.)

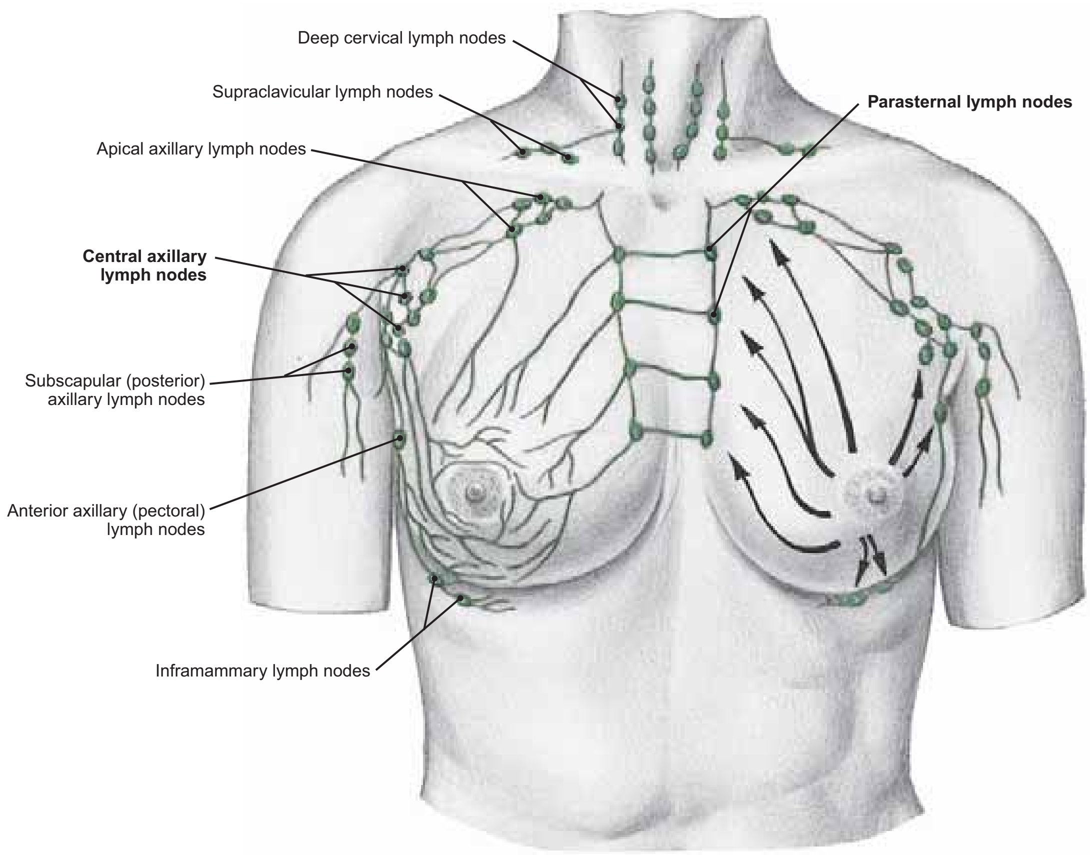


FIGURE 8.1 Lymphatic Drainage from the Adult Female Breast

NOTE: (1) Numerous lymph vessels in the breast communicate in a subareolar plexus deep to and around the nipple.
(2) About 85% of the lymph from the breast courses laterally and upward to axillary and infraclavicular nodes.
(3) Most of the remaining lymph passes medially to parasternal nodes along the internal thoracic vessels.
(4) Some lymph vessels drain downward to upper abdominal nodes and some go to the opposite breast.

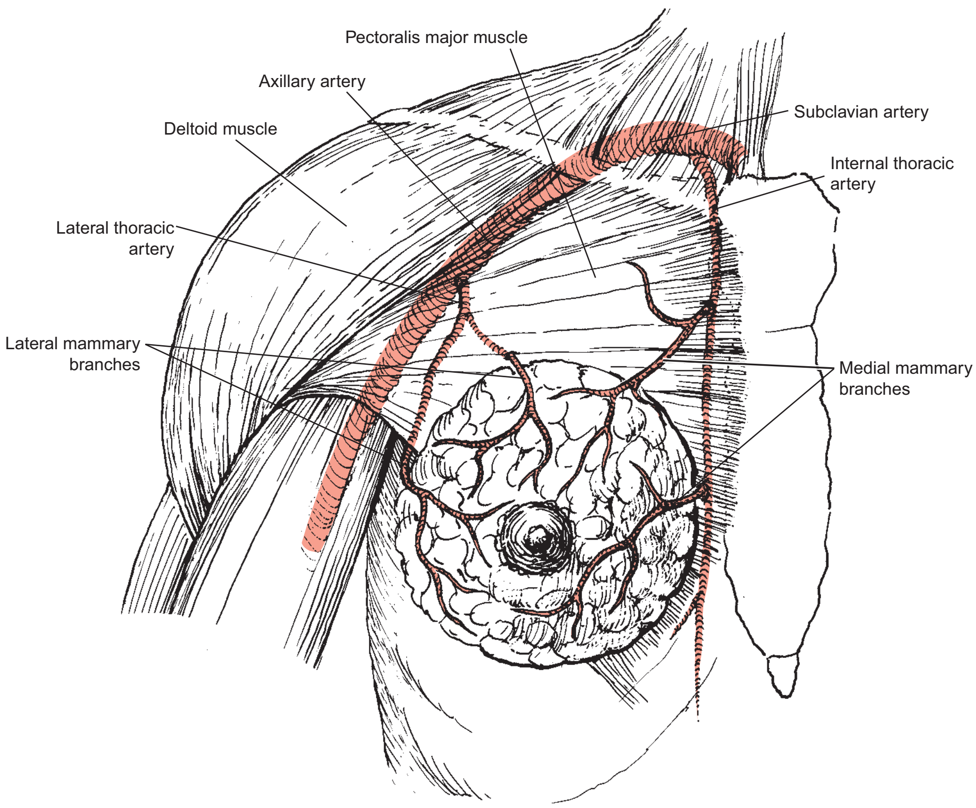


FIGURE 8.2 Medial and Lateral Mammary Arteries

NOTE that lateral branches from the lateral thoracic artery and medial perforating branches from the internal thoracic artery supply the breast anteriorly. (From *Clemente's Anatomy Dissector*, 2nd Edition. Baltimore: Lippincott Williams & Wilkins, 2007.)

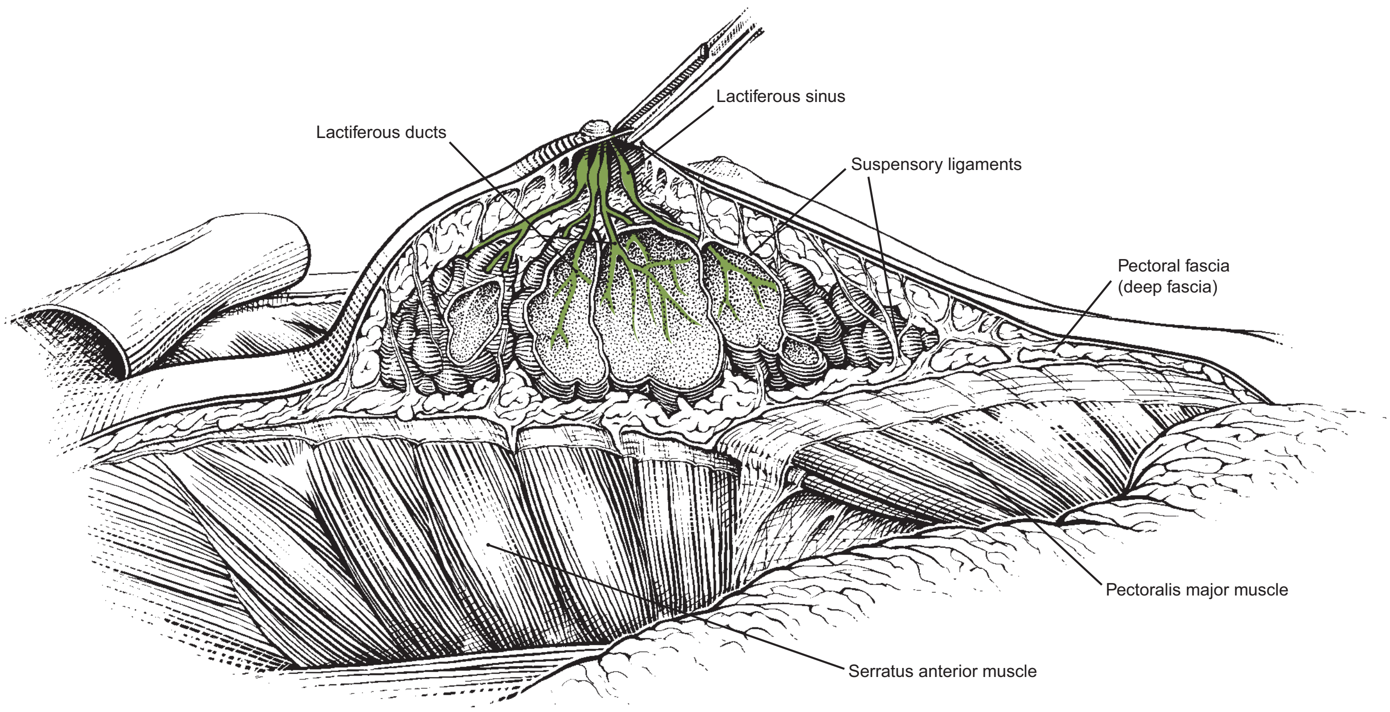


FIGURE 9.1 **Lateral View of the Female Breast in a Reclined Thorax**

NOTE: (1) The duct system originating in the mammary gland lobules. The individual ducts course forward through the superficial fascia of the breast to the nipple.

(2) The **suspensory ligaments** (of Cooper) that separate the mammary lobules. These support the breast by attaching to the deep pectoral fascia. In aging, the ligaments loose strength and result in the characteristic sagging breasts of the elderly.

(From *Clemente's Anatomy Dissector,* 1st Edition. Baltimore: Lippincott Williams & Wilkins, 2002.)

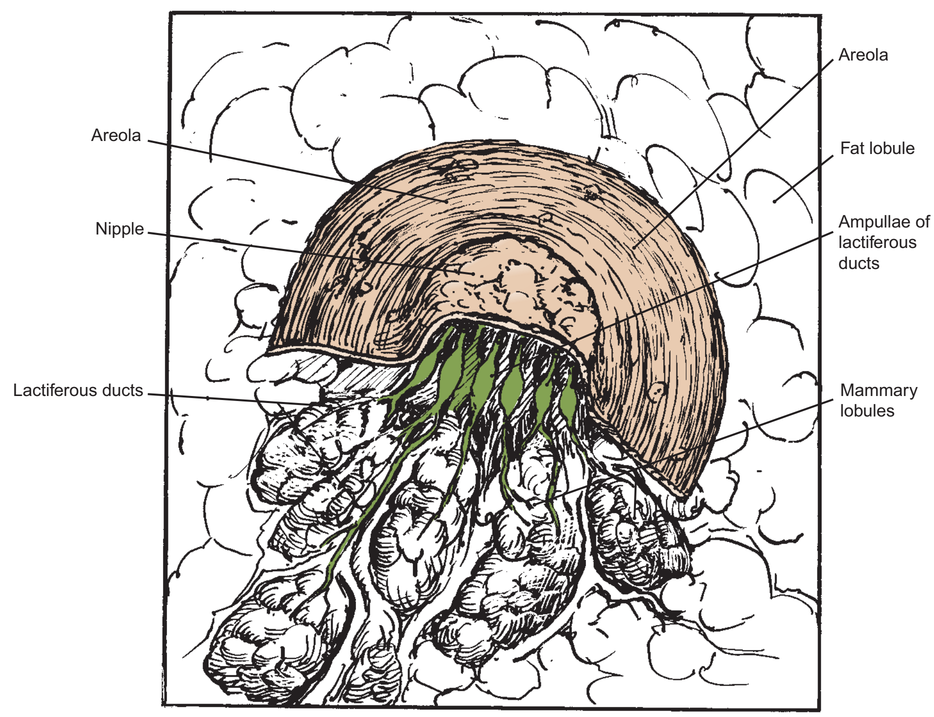


FIGURE 9.2 **The Dissected Nipple and Lactiferous Duct System**

NOTE the lactiferous ducts as they commence in the mammary lobules and course forward to open on the surface of the nipple. Also observe how the ducts enlarge into lactiferous sinuses within which milk collects prior to ejection as the infant suckles.

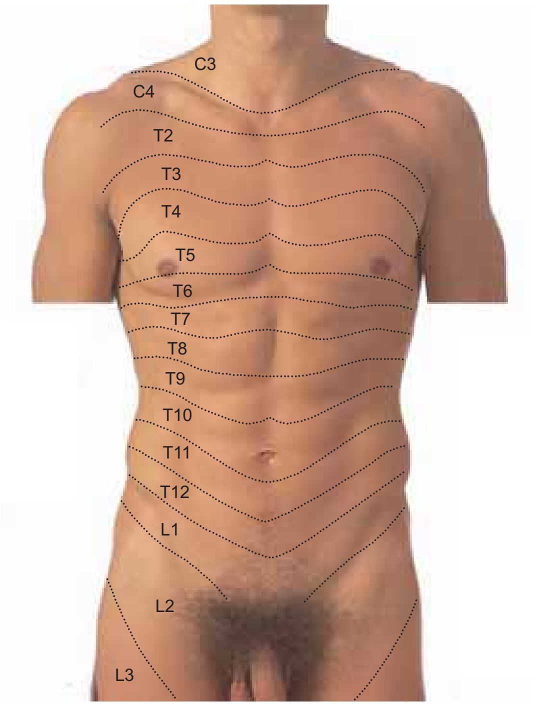
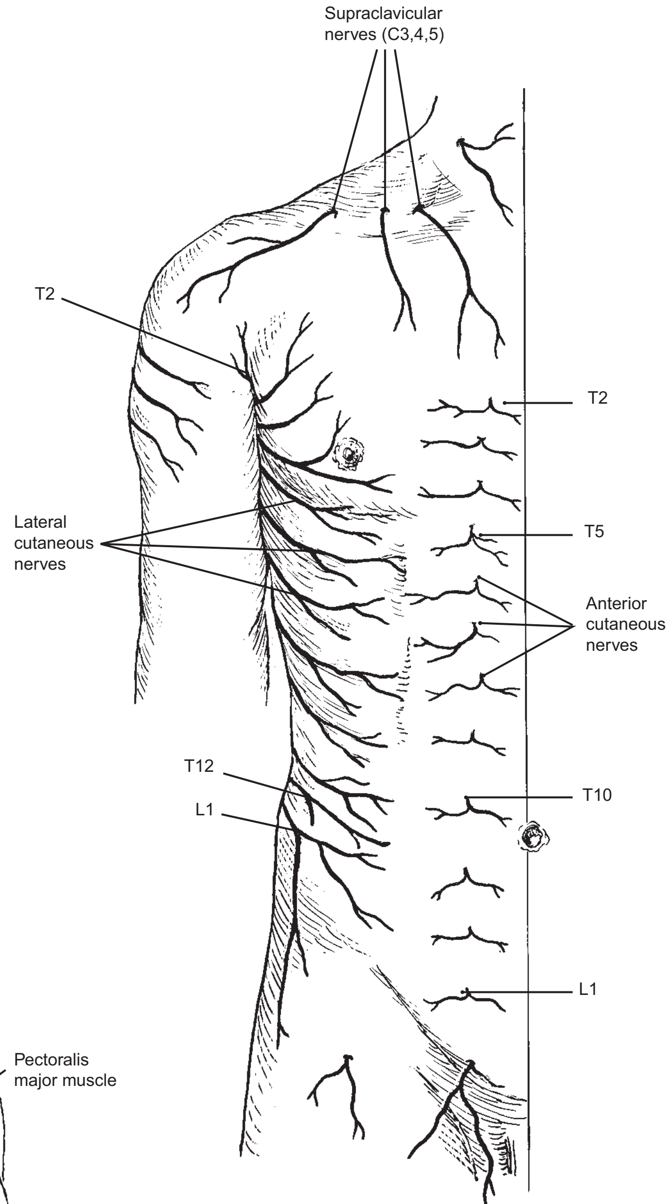


FIGURE 10.1 Segmental Sensory Innervation of Anterior Body Wall (Dermatomes)

NOTE: C5 to C8 and most of T1 do not supply the body wall, since they supply the upper limb.



▲ **FIGURE 10.2 Cutaneous Branches of Spinal Nerves**

NOTE the segmental cutaneous nerves to lateral cutaneous branches in the midaxillary line and anterior cutaneous branches just lateral to the sternum.
(From *Clemente's Anatomy Dissector*, 2nd Edition. Baltimore: Lippincott Williams & Wilkins, 2007.)

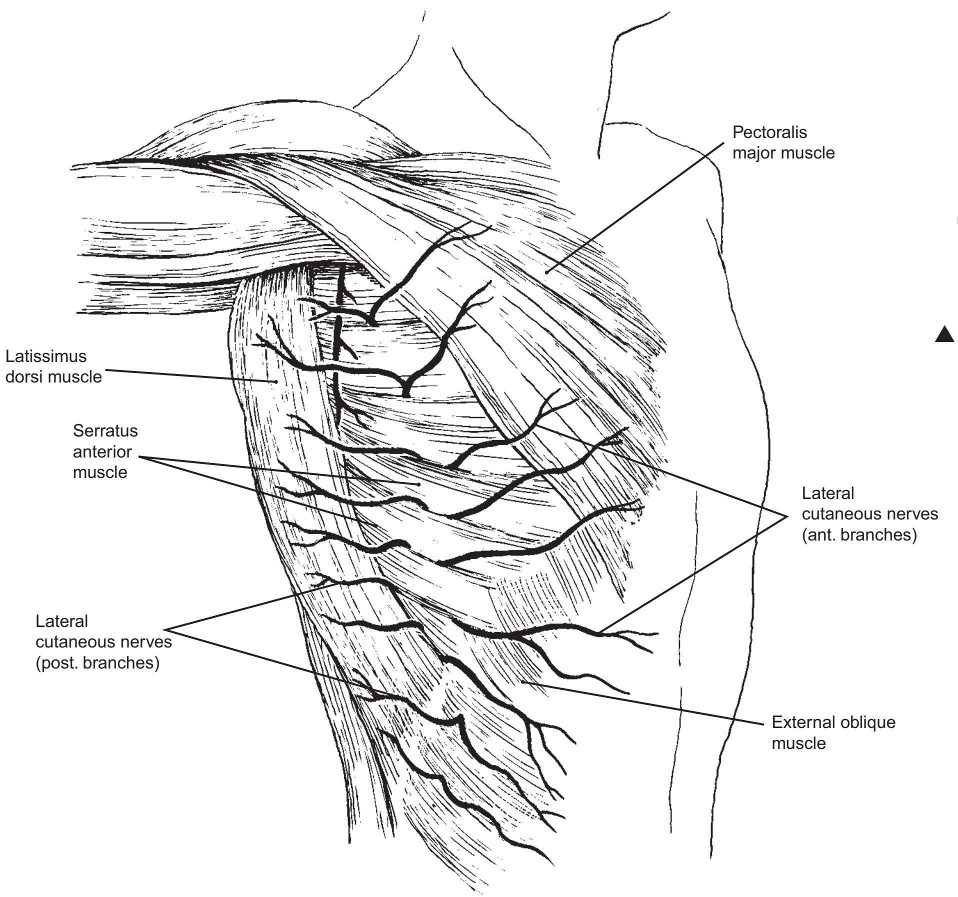


FIGURE 10.3 Lateral Cutaneous Branches of Thoracic Nerves

NOTE that as the lateral cutaneous nerves penetrate the intercostal space, each divides into anterior and posterior cutaneous branches.

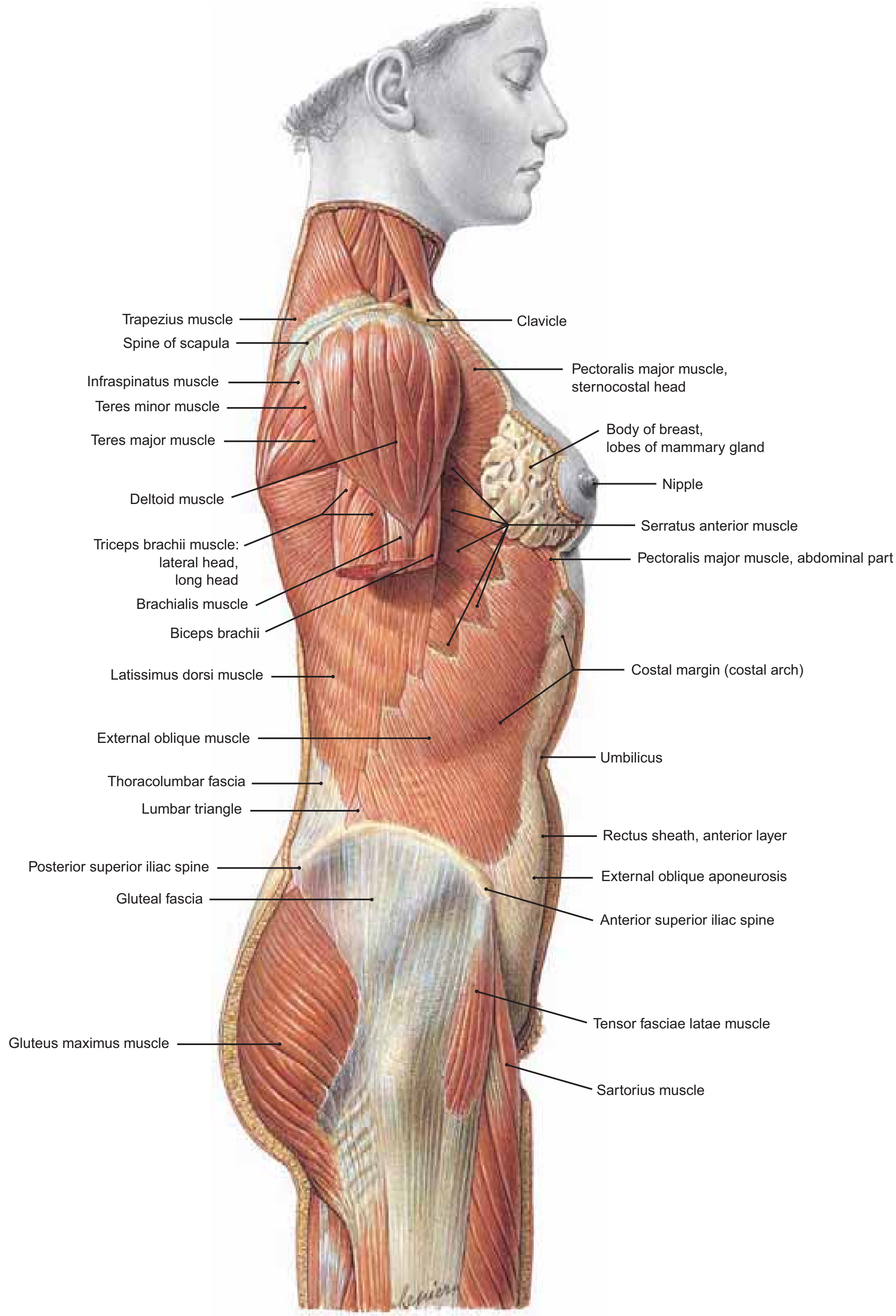


FIGURE 11 Muscles of the Lateral Thoracic and Abdominal Wall

NOTE: (1) The interdigitations of the external oblique muscle with the serratus anterior muscle superiorly and the latissimus dorsal muscle inferiorly.

(2) The lumbar triangle. Its boundaries are the external oblique muscle (anteriorly), the latissimus dorsi muscle (posteriorly), and the crest of the ilium (inferiorly).

(3) The external oblique muscle ends in a broad and strong aponeurosis medially.

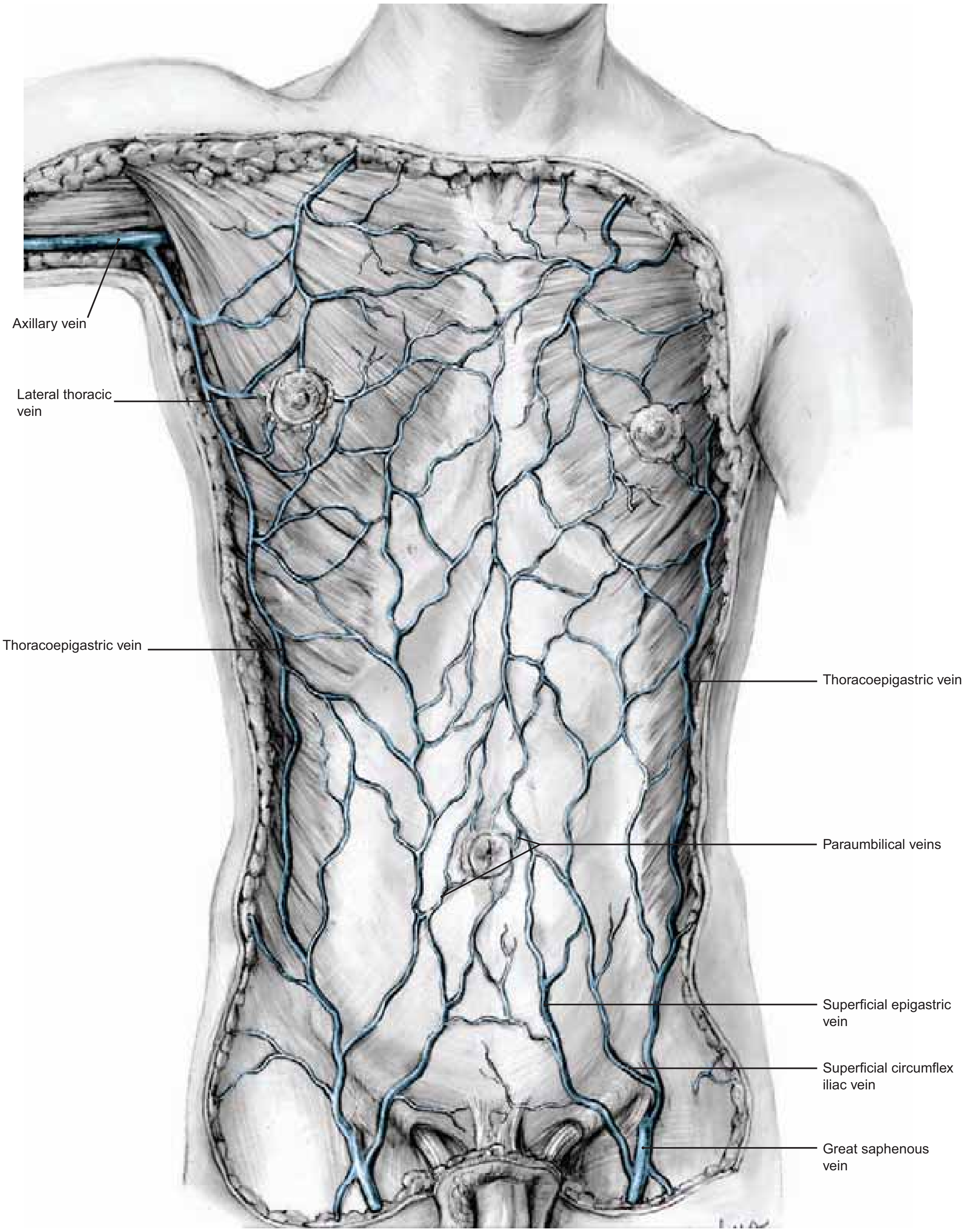


FIGURE 12 Anterior Thoracic Wall; Superficial Dissection in the Male

NOTE: (1) The thoracoepigastric veins along both lateral aspects of the thoracic wall; realize that these veins drain superiorly into the lateral thoracic veins, which flow into the axillary veins.

(2) The paraumbilical veins. Surrounding the umbilicus, these form an anastomosis between the systemic anterior abdominal wall veins and the intra-abdominal portal vein.

(3) Usually surface venous blood flow above the umbilicus drains into vessels that feed into the superior vena cava, while surface veins below the umbilicus drain into the femoral veins and thence into the inferior vena cava.

(4) The surface veins can become greatly enlarged if flow through the inferior vena cava is significantly reduced, as in cirrhosis of the liver

(From C.D. Clemente. *Gray's Anatomy,* 30th American Edition. Philadelphia: Lea & Febiger, 1985.)

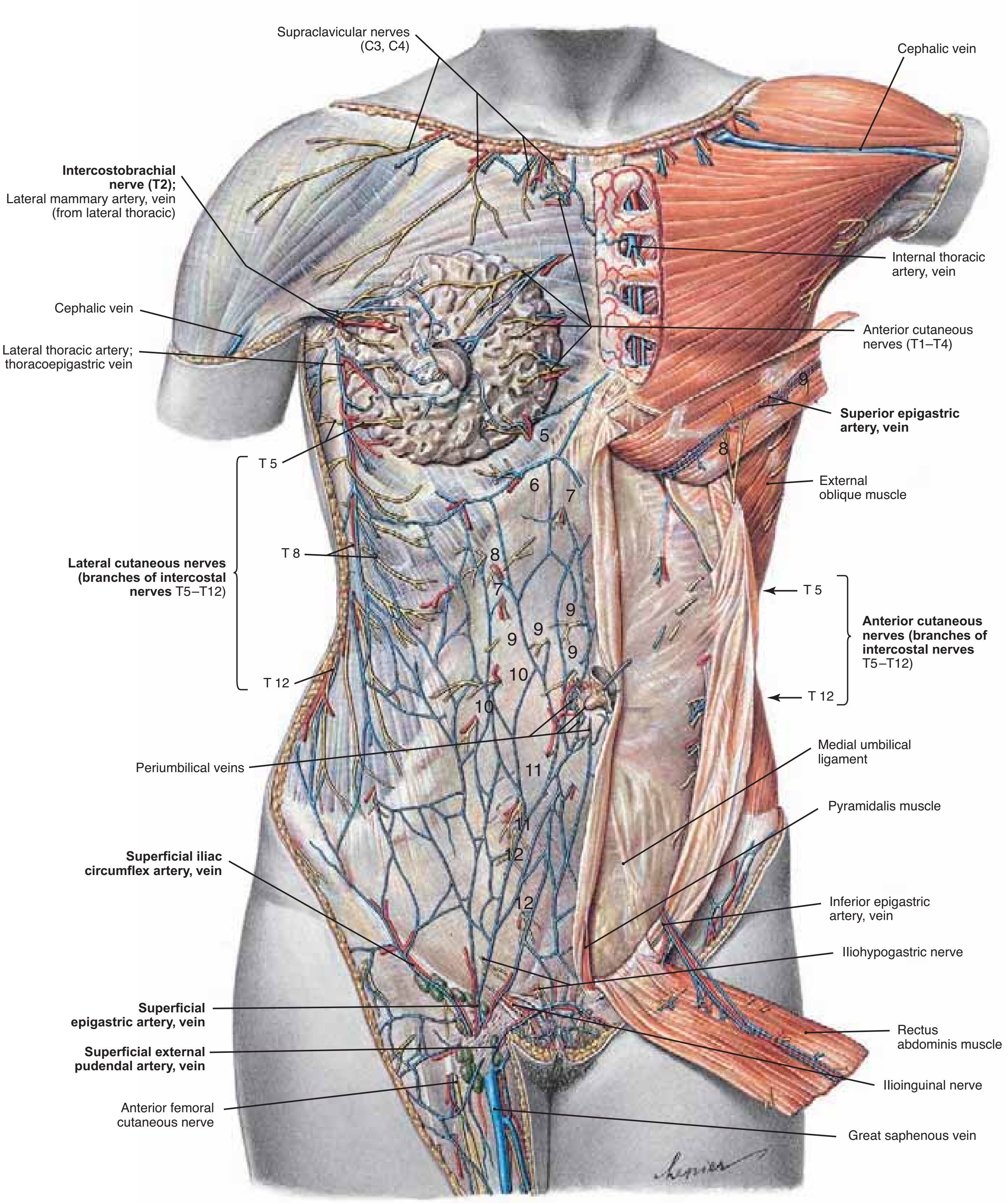


FIGURE 13 Superficial Vessels and Nerves of the Anterior Trunk: Pectoral Region and Anterior Abdominal Wall

NOTE: (1) Cutaneous innervation of the trunk: supraclavicular nerves (C3, C4), intercostal nerves (T1–T12), and the ilioinguinal and iliohypogastric branches of L1.

(2) The intercostal nerves give off lateral and anterior cutaneous branches.

(3) Anastomoses between the thoracoepigastric vein above and the superficial iliac circumflex and inferior epigastric veins below.

(4) The breast, its innervation (T2–T6 intercostal nerves), and its blood supply (internal thoracic artery, lateral thoracic artery, and intercostal arteries).

(5) The nipple at the level of T4 and the umbilicus at the level of T10.

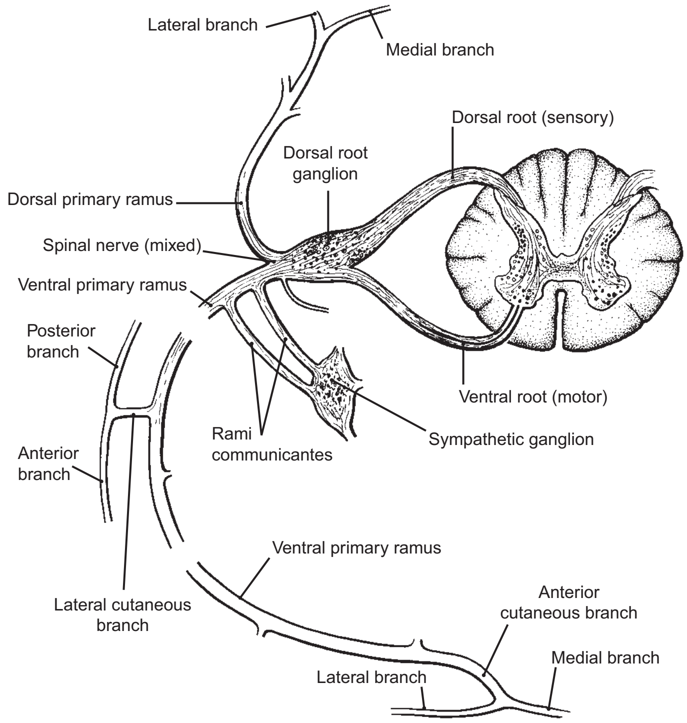


FIGURE 14.1 A Typical Segmental Spinal Nerve and Its Branches

(From *Clemente's Anatomy Dissector*, 2nd Edition. Baltimore: Lippincott Williams & Wilkins, 2007.)

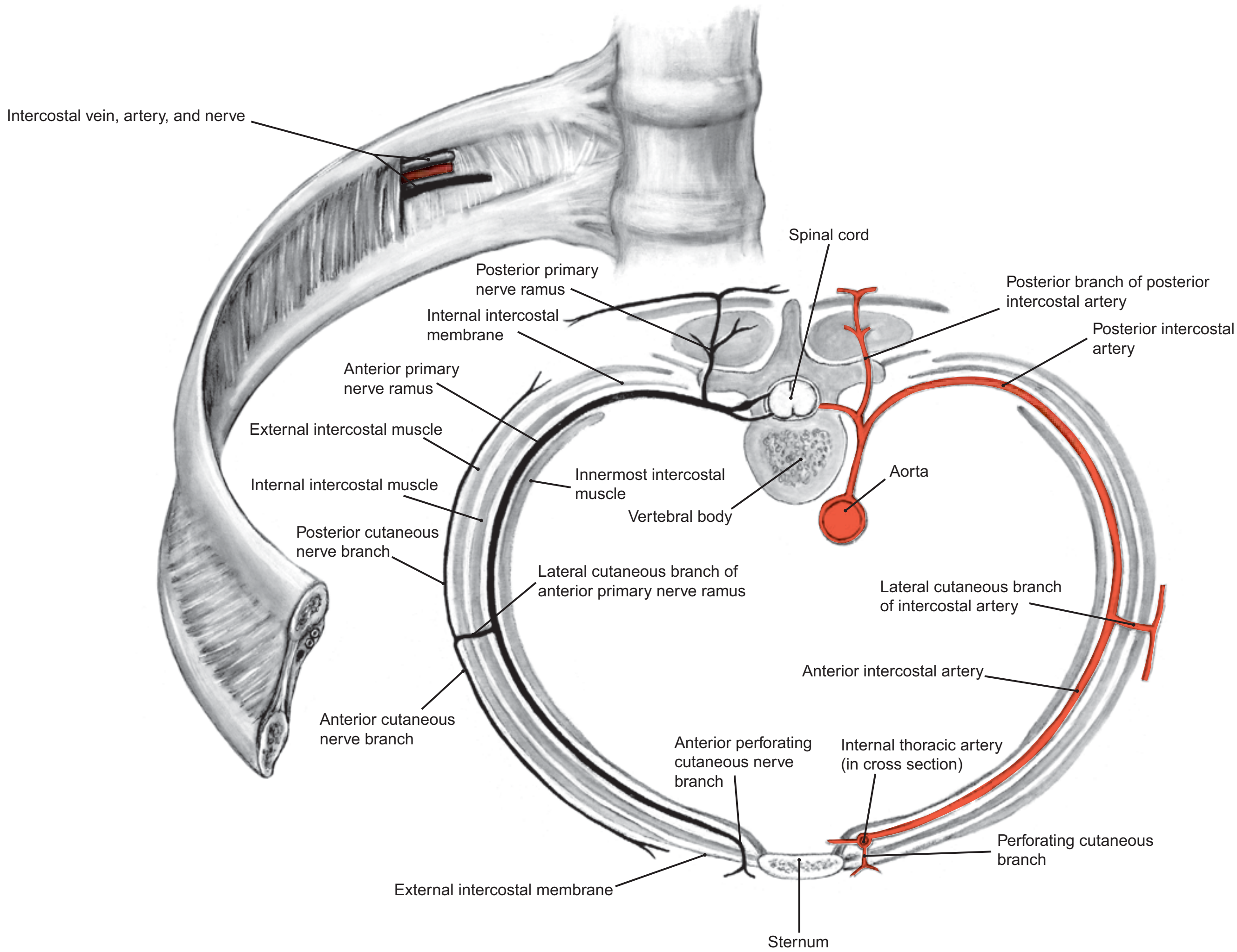


FIGURE 14.2 A Segmental Thoracic Nerve and Intercostal Artery and Their Branches

NOTE: (1) Segmental intercostal nerves are formed by the junction of dorsal and ventral spinal roots. Distal to this junction, the mixed spinal nerve divides into dorsal and ventral primary rami. The posterior primary ramus courses to the back, while the anterior primary ramus courses between adjacent ribs as an intercostal nerve and gives off lateral and anterior cutaneous branches.

(2) Posterior intercostal arteries are derived from the aorta. Each sends a posterior branch to the back. The anterior branch becomes the anterior **intercostal artery,** and it also gives off lateral and anterior cutaneous branches.

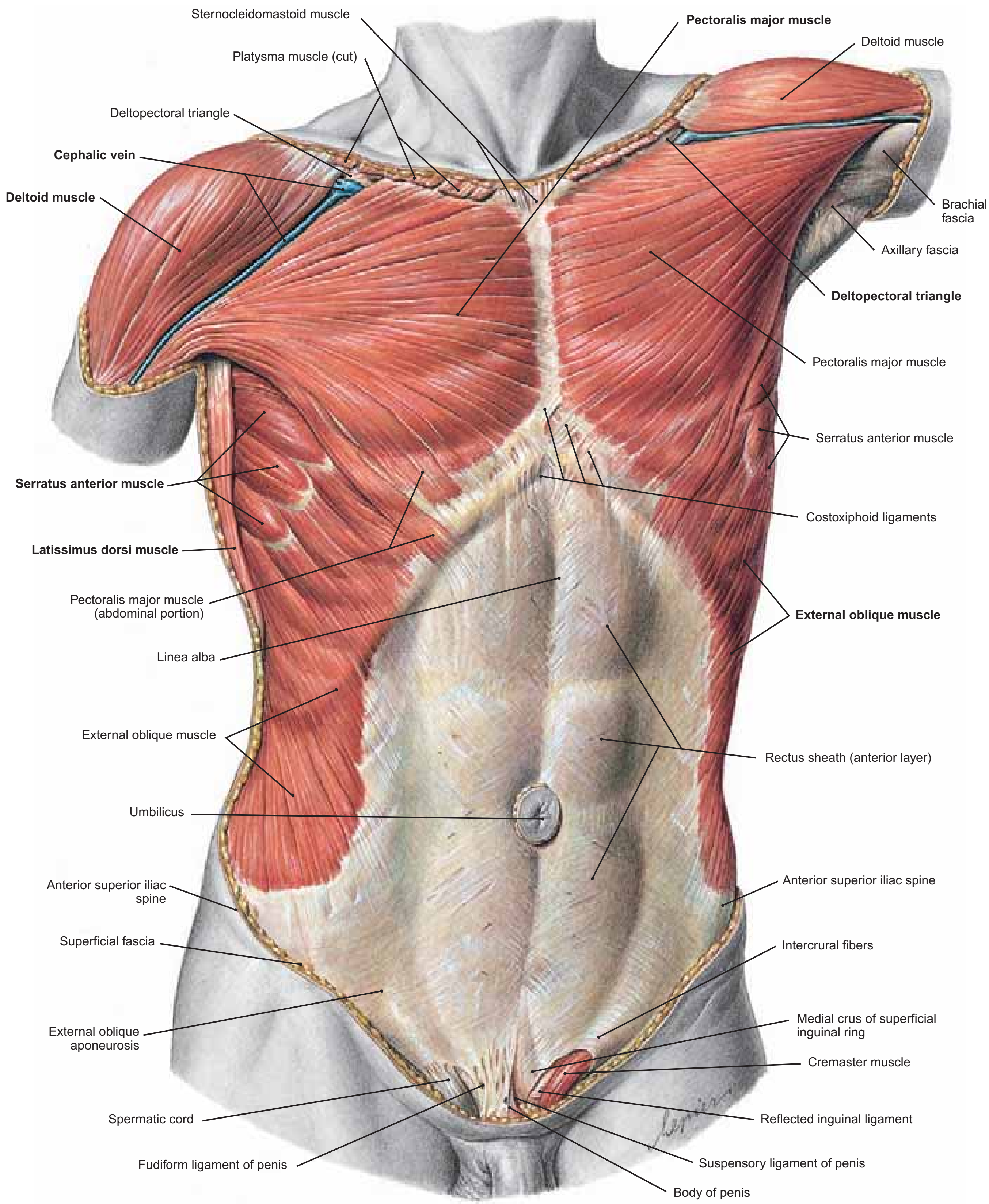


FIGURE 15 Muscles of the Superficial Thoracic and Abdominal Walls

Muscle	Origin	Insertion	Innervation	Action
Pectoralis major	Medial half of clavicle; second to sixth ribs; costal margin of sternum; aponeurosis of external oblique	Humerus, lateral lip of intertubercular sulcus	Lateral (C5, C6, C7) and medial (C8, T1) pectoral nerves	Adducts and rotates arm medially; **sternal part:** helps extend humerus; **clavicular part:** helps flex humerus

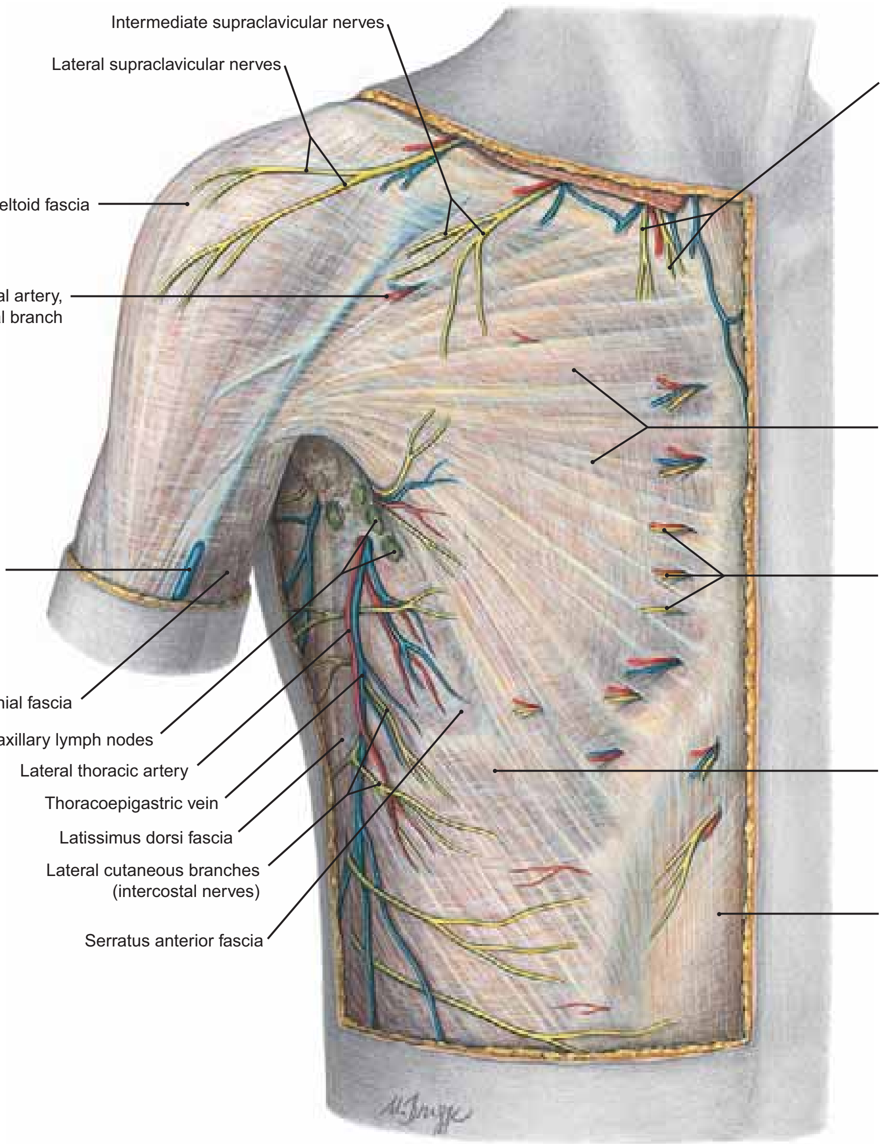


FIGURE 16 Anterior Thoracic Wall; Superficial Dissection in the Male

NOTE: (1) The skin and superficial fascia have been removed, but the cutaneous vessels and nerves have been retained.

(2) The cutaneous neurovascular structures penetrate through the deep fascia (pectoral fascia) to get to the superficial fascia and skin.

(3) Most cutaneous vessels and nerves are anterior and lateral cutaneous branches of the intercostal nerves and vessels.

(4) The deep fascia that covers the pectoralis major muscle and the manner in which it blends inferiorly with the sheath of the rectus abdominus muscle (the rectus sheath) and medially across the sternum with the fascia on the opposite side.

(5) The pectoral fascia also has a deep layer that covers the deep surface of the muscle.

(6) The **supraclavicular nerves** are derived from C3 and C4, but overwhelmingly C4.

(7) The **intercostobrachial nerve (T2)** joins the medial brachial cutaneous nerve to supply the skin of the axillary fossa and upper medial arm.

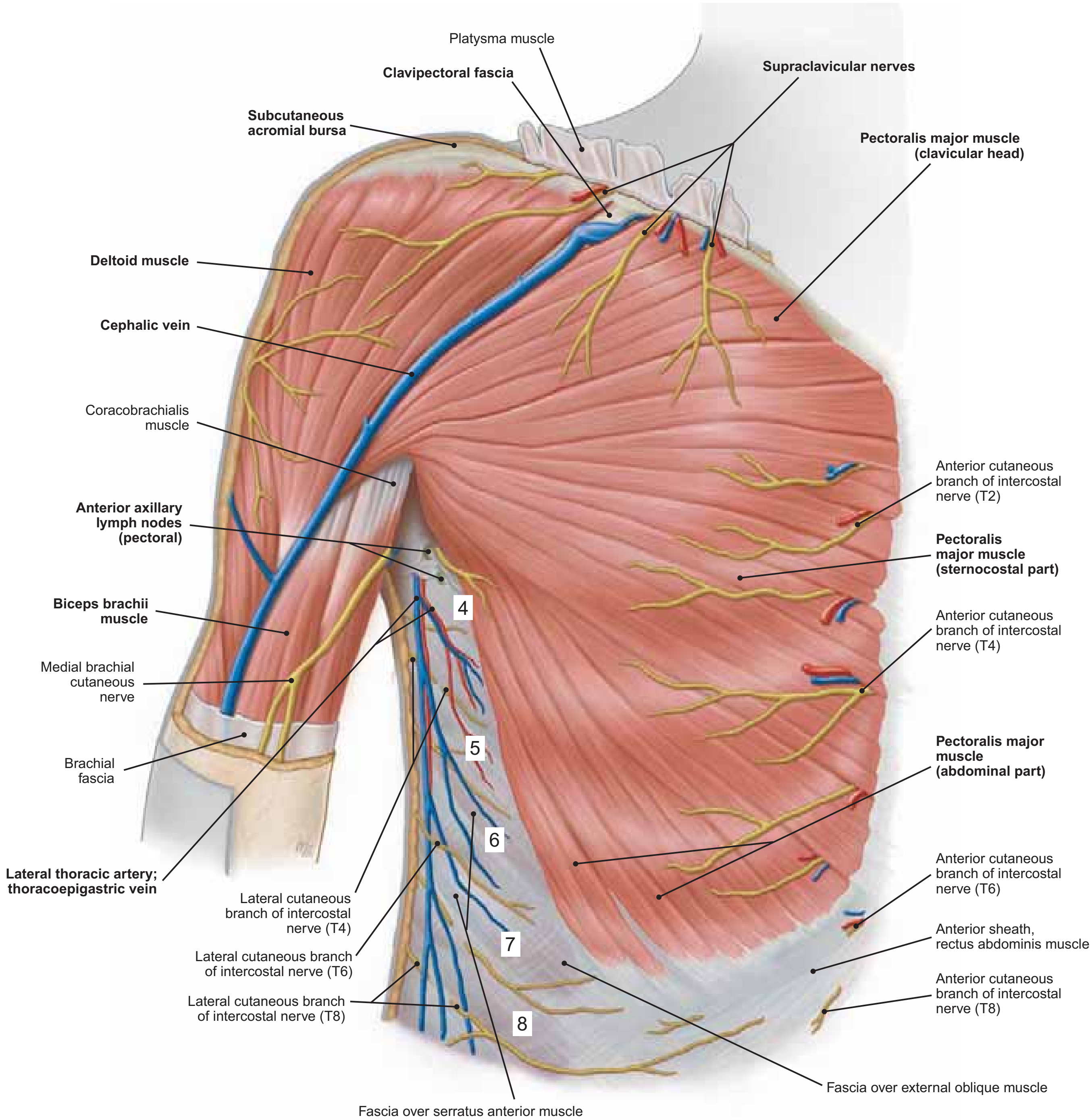


FIGURE 17 Pectoralis Major and Deltoid Muscles (Anterior View)

NOTE: (1) The anterior layer of the pectoral fascia and the deltoid fascia as seen in Figure 16 have been removed.
(2) The lateral cutaneous vessels and nerves penetrating through the intercostal spaces in the midaxillary line.
(3) The anterior cutaneous vessels and nerves piercing the pectoralis major muscle along the lateral border of the sternum.
(4) The clavicular fibers of this muscle course obliquely downward, and laterally, the upper sternocostal fibers are directed nearly horizontally, and the lower sternocostal and abdominal fibers ascend nearly vertically to the humerus.
(5) The natural cleft between the clavicular and sternocostal heads. Detaching the clavicular head uncovers some of the vessels and nerves that supply this muscle (see Fig. 22.1).
(6) The fourth to the eighth ribs are numbered sequentially.

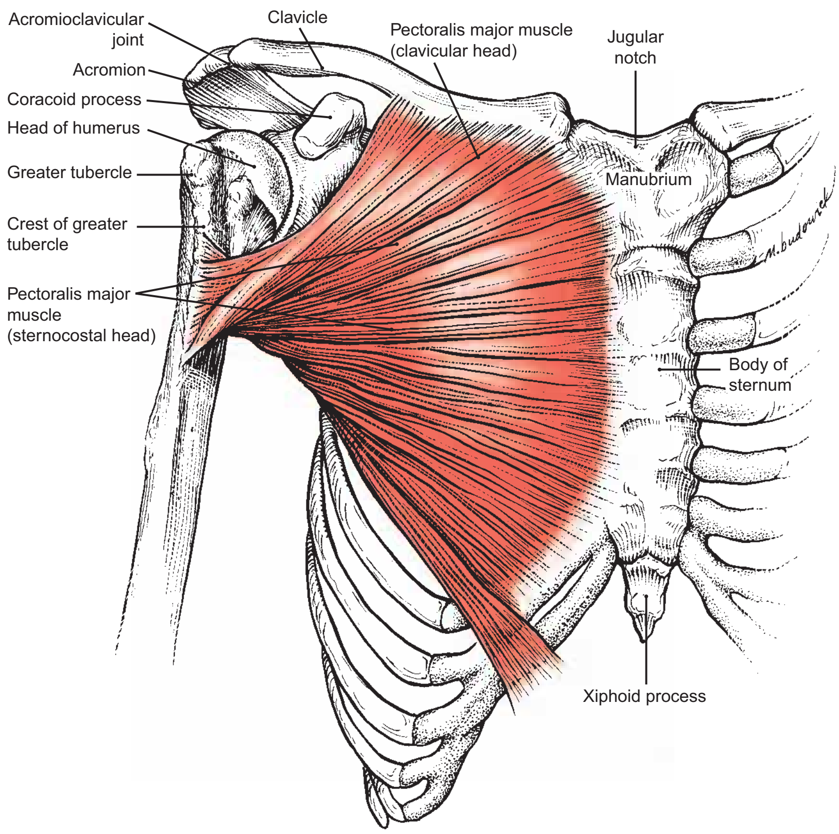


FIGURE 18.1 The Pectoralis Major Muscle

NOTE: (1) The pectoralis major muscle has fibers that descend from the clavicle and fibers that ascend from the lower sternum and the aponeurosis of the external oblique muscle. Between these are the transverse fibers that cross the chest.

(2) This broad mass of muscle fibers inserts onto the lateral lip of the intertubercular sulcus of the humerus.

(3) The ascending and lower transverse fibers form a rounded inferior border that becomes the anterior axillary fold. This muscle and the pectoralis minor overlie the nerves of the brachial plexus and the axillary vessels and their branches.

(4) The pectoralis major medially rotates and adducts the humerus. In addition, the clavicular fibers assist in flexing the humerus, while the inferior sternal fibers and those attaching to the aponeurosis of the external oblique assist in extending the humerus.

(Contributed by Dr. Gene L. Colborn, Medical College of Georgia.)

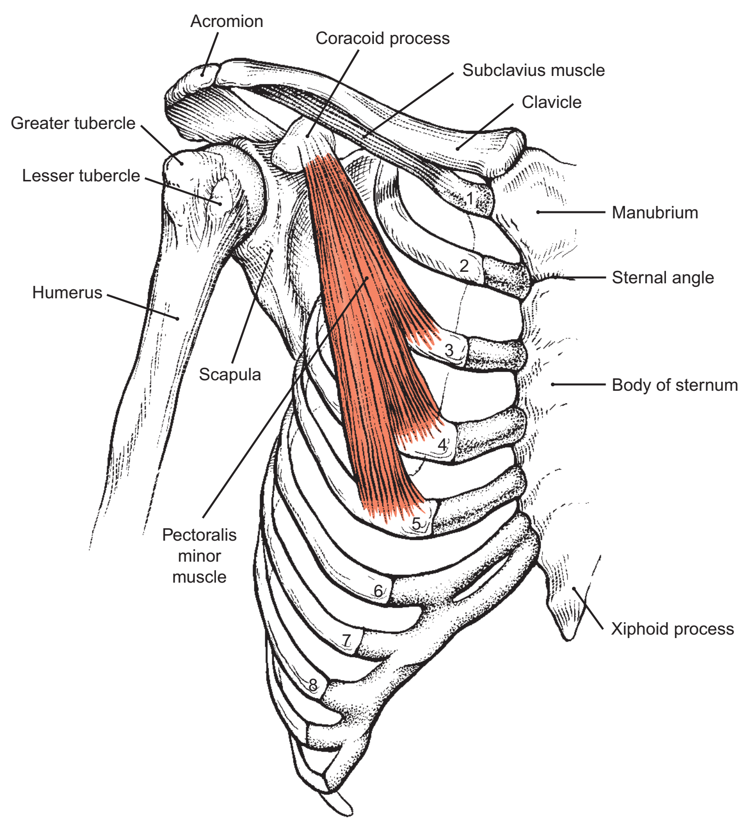


FIGURE 18.2 The Pectoralis Minor Muscle

NOTE: (1) The pectoralis minor muscle is often called **"the key to the axilla"**; this is because it crosses the axillary artery, dividing it into three parts, medial, deep, and lateral to the pectoralis minor muscle. There is one branch off of the first part of the axillary artery, two branches off of the second part, and three branches off of the third part.

(2) Deep to the pectoralis minor muscle, the cords of the brachial plexus are found. These are called the **medial, lateral, and posterior cords,** and they are located medial, lateral, and posterior to the axillary artery.

(3) The pectoralis minor muscle can protract the scapula (i.e., draw it forward) when the insertion on the third, fourth, and fifth ribs is fixed. When the attachment to the coracoid process is fixed, the pectoralis minor can help elevate the ribs, and thus, it becomes an accessory muscle of respiration.

(From *Clemente's Anatomy Dissector,* 2nd Edition. Baltimore: Lippincott Williams & Wilkins, 2007.)

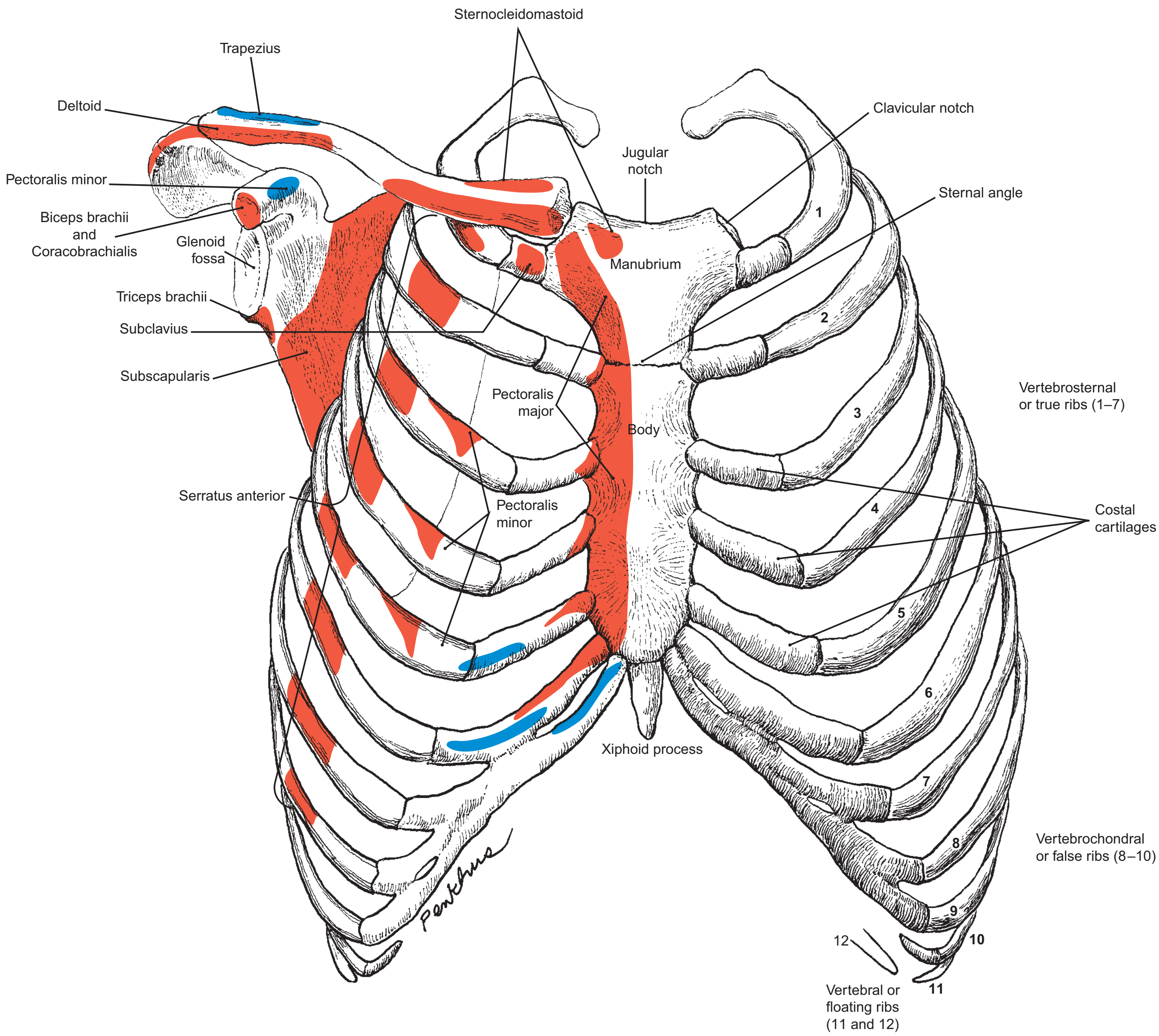


FIGURE 19 The Anterior Surface of the Sternum and Ribs

NOTE: (1) The costal cartilages and the manner in which they articulate with the sternum.

(2) The **jugular notch** (also called the suprasternal notch) along the superior border of the manubrium.

(3) Lateral to the manubrium, the clavicle articulates into the clavicular notch, and just below this, the first rib articulates with the lateral surface of the manubrium.

(4) Rib 2 articulates with the sternum lateral to the sternal angle (i.e., between the manubrium and body of the sternum).

(5) Ribs 4, 5, and 6 articulate on the body of the sternum, and rib 7, joined by the costal margins of ribs 8, 9, and 10, attaches to the junction of the **xiphoid process** and sternal body (the **xiphisternal junction**).

(6) The origin of the **pectoralis major muscle** attaches along the medial half of the clavicle and lateral one-third of the manubrium and body of the sternum.

(7) The **pectoralis minor muscle** inserts on the third, fourth, and fifth ribs, and the **biceps brachii** and **coracobrachialis muscles** attach just above the glenoid fossa (supraglenoid tubercle), while the triceps arises from the infraglenoid tubercle below the glenoid fossa.

(From C.D. Clemente. *Gray's Anatomy,* 30th American Edition. Philadelphia: Lea & Febiger, 1985.)

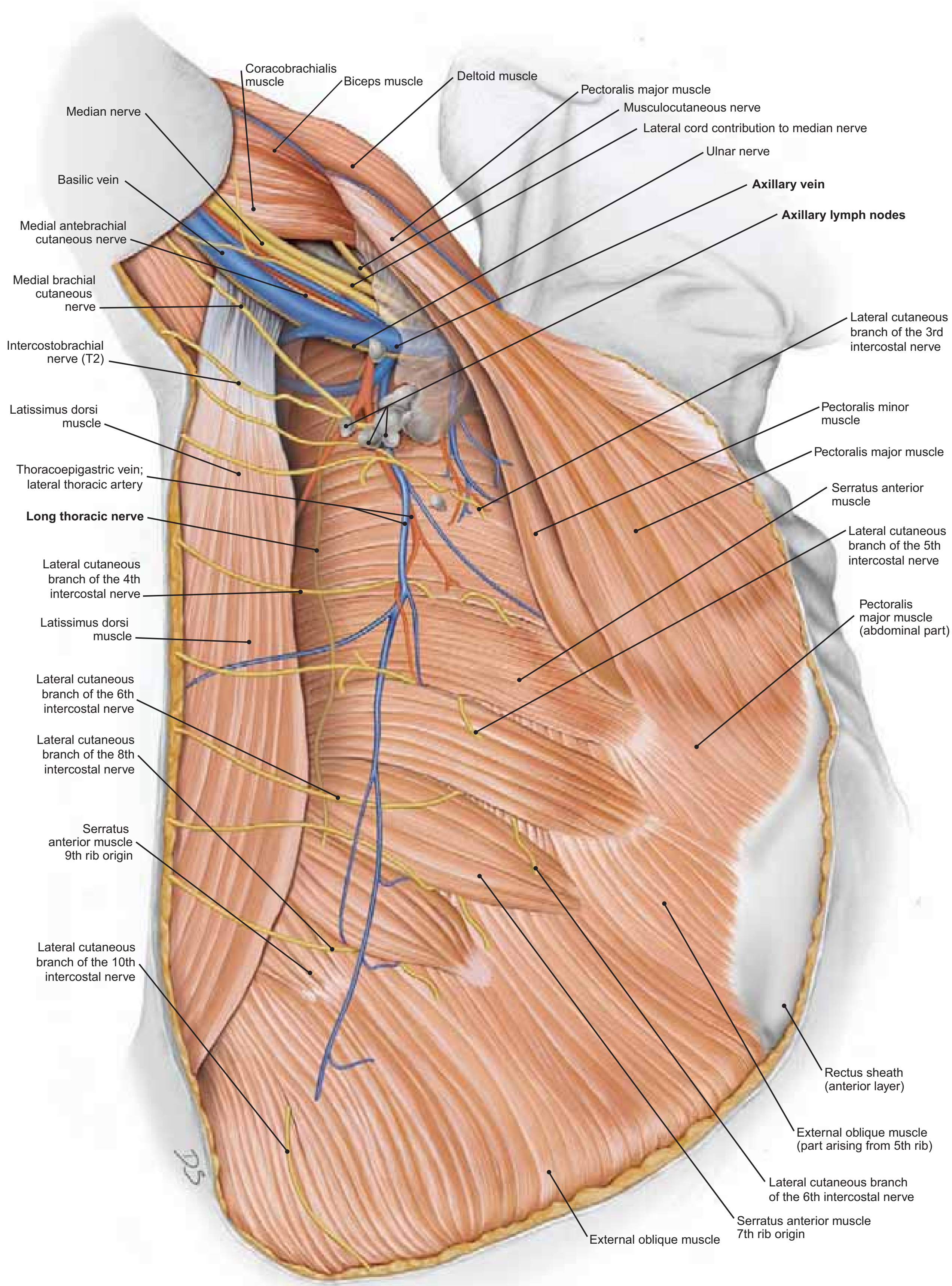


FIGURE 20 Lateral Aspect of the Upper Right Thoracic Wall and the Superficial Axillary Structures

Muscle	Origin	Insertion	Innervation	Action
Pectoralis minor	Coracoid process of scapula	Ribs 2 to 5	Medial pectoral nerve (C8, T1)	Protracts scapula; elevates ribs
Serratus anterior	Fleshy slips from upper nine ribs	Medial border of scapula	Long thoracic nerve (C5, C6, C7)	Protracts and rotates scapula; holds scapula close to thoracic wall

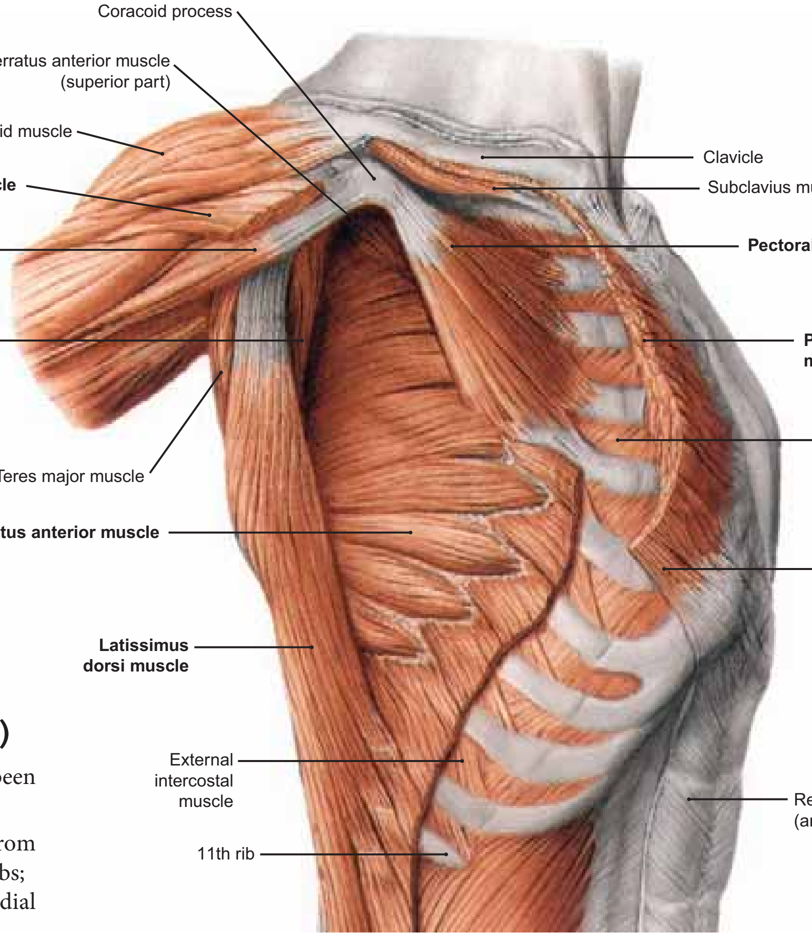


FIGURE 21.1 Pectoralis Minor, Serratus Anterior, and Latissimus Dorsi Muscles, Lateral View (Right)

NOTE that the pectoralis major muscle has been reflected, revealing:

(1) the pectoralis minor muscle extending from coracoid process to the second to sixth ribs;
(2) the serratus anterior, forming the medial wall of the axilla.

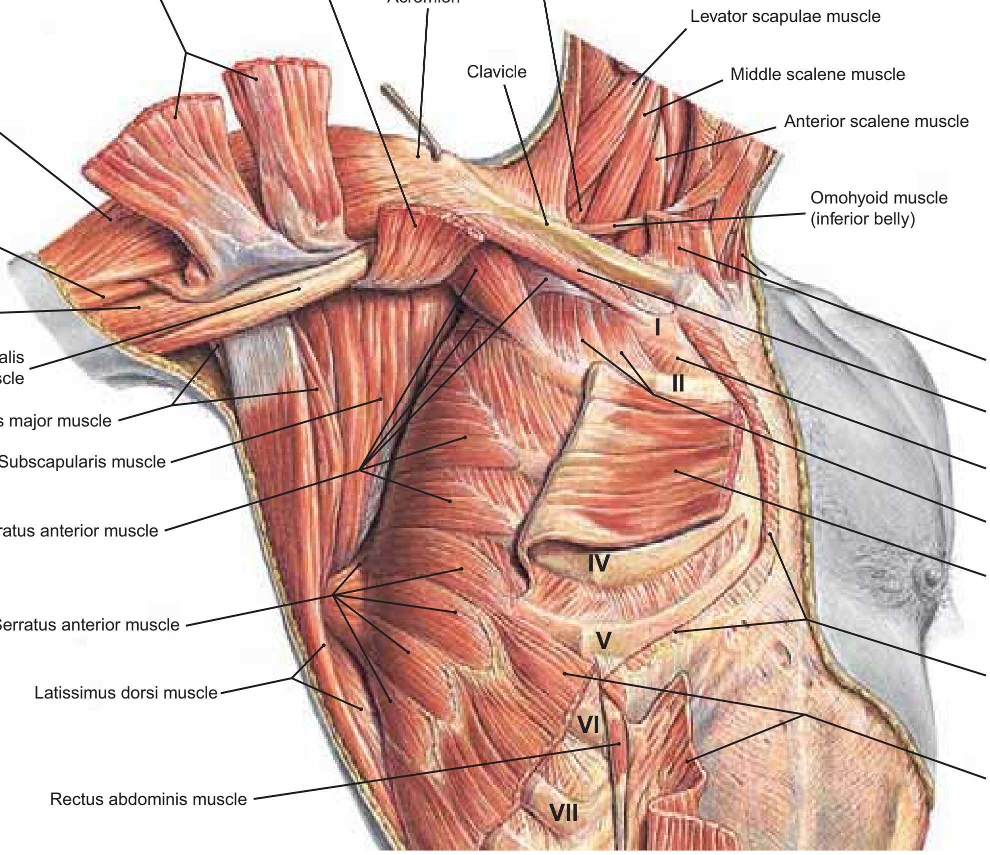


FIGURE 21.2 The Subscapularis and Serratus Anterior Muscles (Right Lateral View)

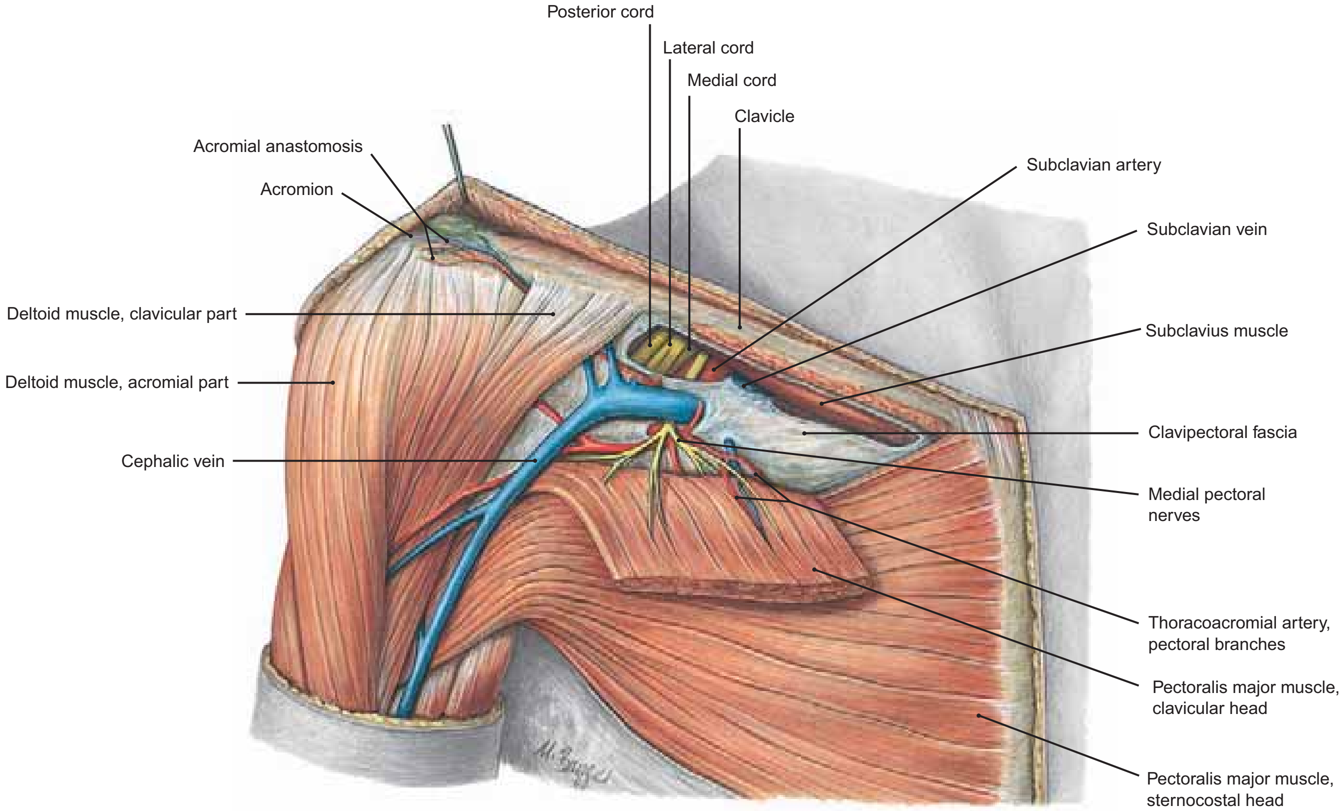


FIGURE 22.1 Deltopectoral Triangle (Right)

NOTE: (1) The clavicular head of the pectoralis major muscle has been severed and reflected downward.
(2) The investing layer of deep fascia covering the deep surface of the pectoralis major muscle and the clavipectoral fascia, which extends between the clavicle and the medial border of the pectoralis minor muscle, are exposed.
(3) The cephalic vein pierces the clavipectoral fascia to join the axillary vein.
(4) The thoracoacromial artery (from the axillary artery) and the lateral pectoral nerve (from the lateral cord of the brachial plexus) pierce the fascia from below to supply blood to the region and to innervate the pectoralis major muscle.

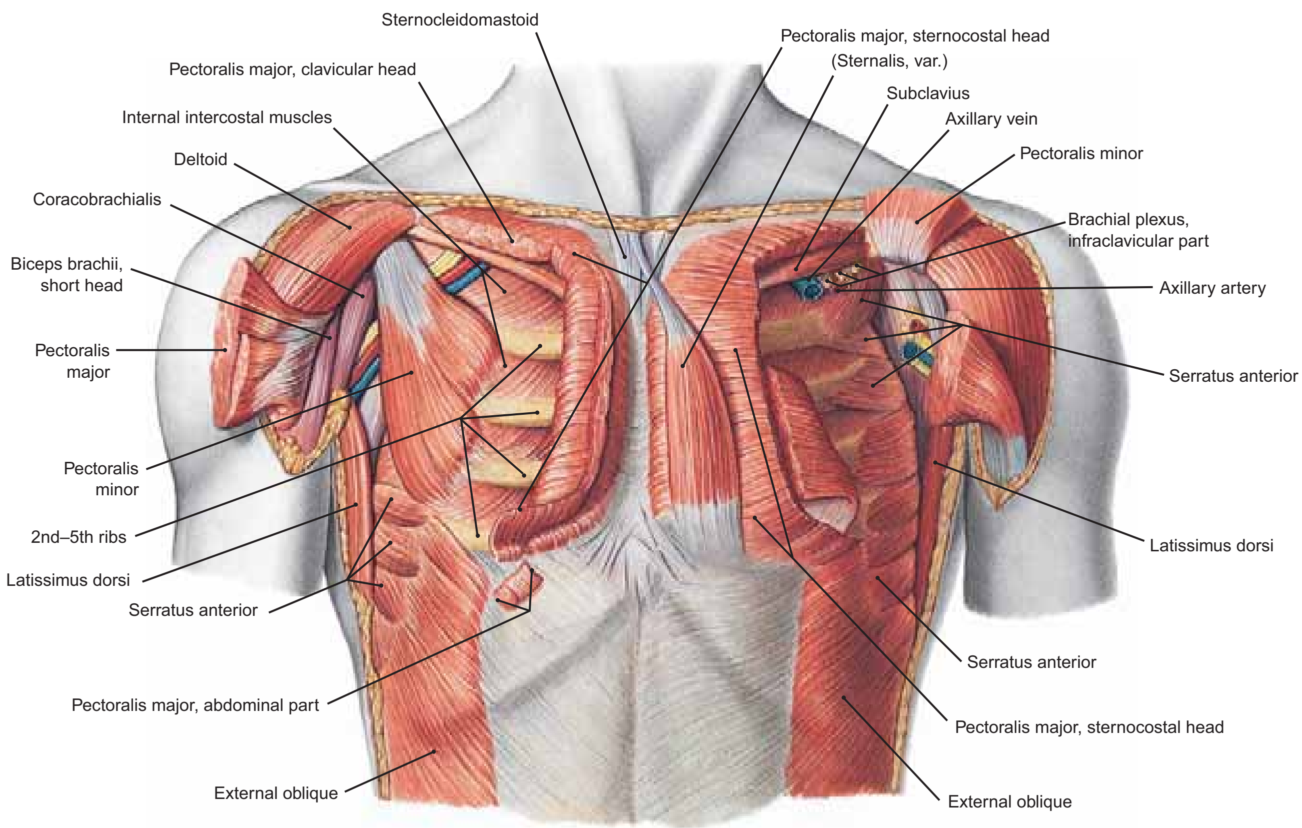


FIGURE 22.2 Pectoralis Minor, Serratus Anterior, and Latissimus Dorsi Muscles (Right Lateral View)

NOTE that the pectoralis major muscle has been reflected, revealing the pectoralis minor muscle extending from the second to fifth ribs to the coracoid process. Also note that the serratus anterior muscle forms the medial wall of the axilla.

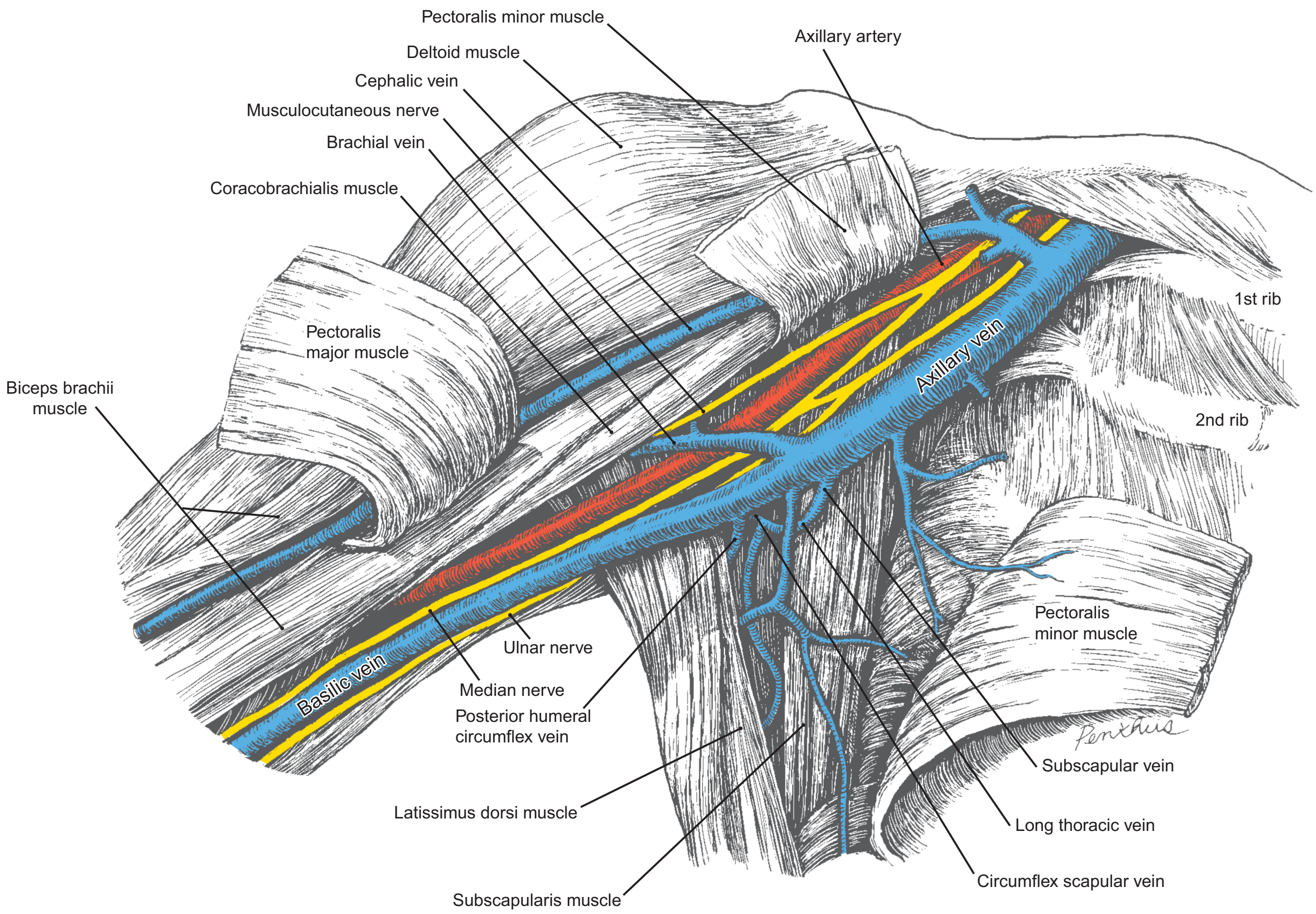


FIGURE 23.1 The Veins of the Right Axilla

NOTE the relationship of the axillary vein to the axillary artery and the nerves in the axilla.
(From C.D. Clemente. *Gray's Anatomy*, 30th American Edition. Philadelphia: Lea & Febiger, 1985.)

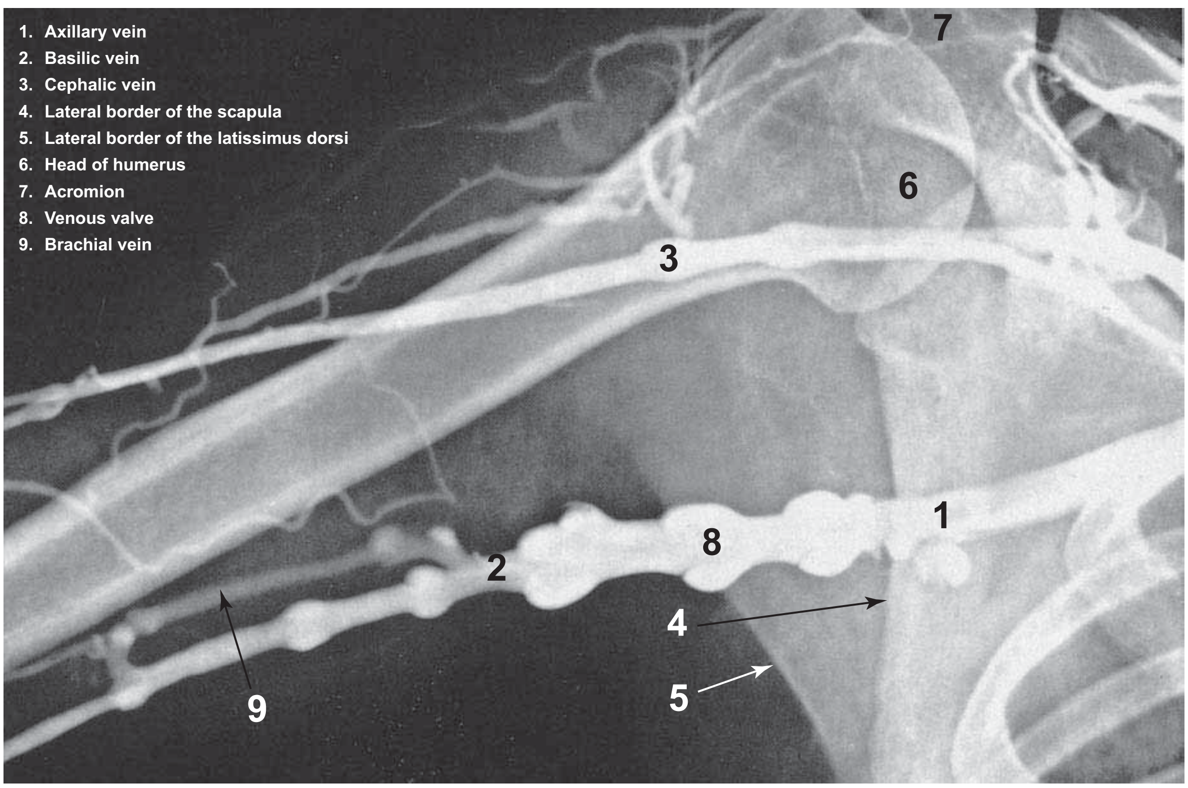


FIGURE 23.2 Radiograph of Veins in the Axillary Region

NOTE: (1) The basilic vein [2] becomes the axillary vein [1].
(2) One of the brachial veins [9] also flows into the axillary vein, as does the cephalic vein [3], the junction of which is medial to the field shown here.
(3) The venous valves [8] along the course of the axillary vein.

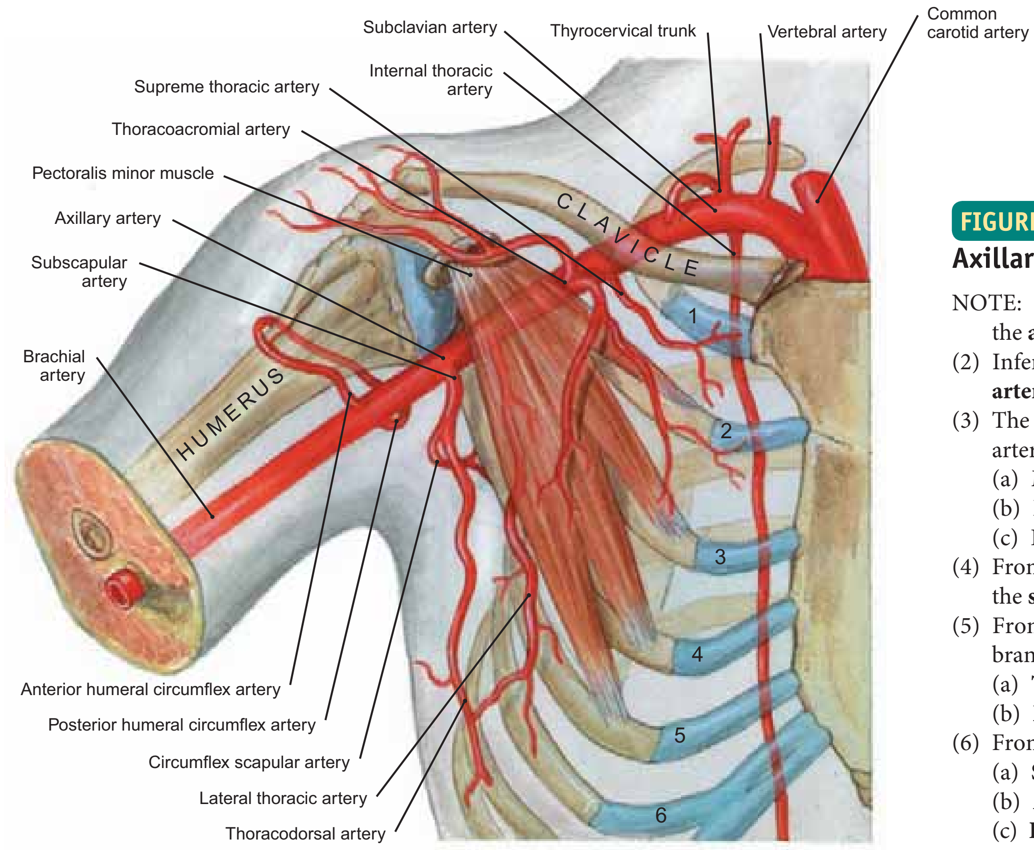


FIGURE 24.1 Branches of the Axillary Artery

NOTE: (1) The **subclavian artery** becomes the **axillary artery** distal to the clavicle.

(2) Inferior to the teres major, the **axillary artery** becomes the **brachial artery**.

(3) The pectoralis minor crosses the axillary artery, dividing it into three parts:
- (a) Medial to the muscle
- (b) Beneath the muscle
- (c) Lateral to the muscle

(4) From the first part, there is one branch, the **supreme thoracic artery**.

(5) From the second part are derived two branches:
- (a) **Thoracoacromial artery**
- (b) **Lateral thoracic artery**

(6) From the third part come three branches:
- (a) **Subscapular artery**
- (b) **Anterior humeral circumflex artery**
- (c) **Posterior humeral circumflex artery**

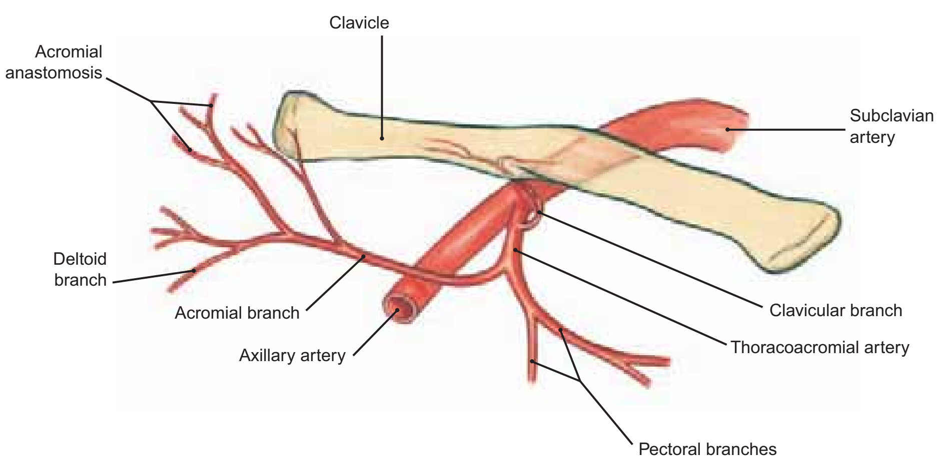


FIGURE 24.2 Thoracoacromial Artery and Its Branches

NOTE that the four branches of the thoracoacromial artery usually are the clavicular, pectoral, acromial, and deltoid.

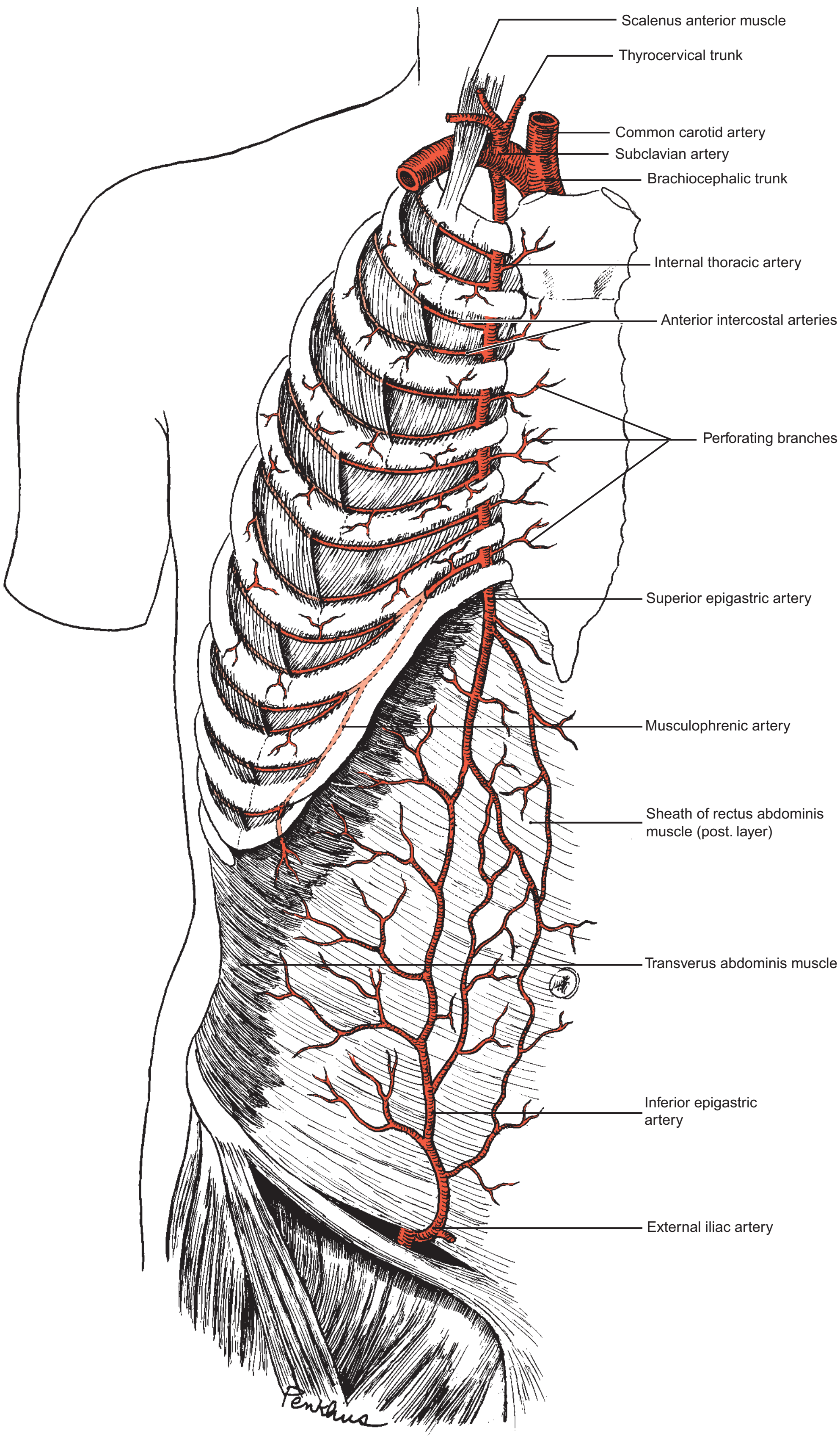


FIGURE 25 **The Internal Thoracic and Epigastric Arterial Anastomosis**

NOTE: (1) The **internal thoracic artery** arises from the axillary artery, and in its descent in the chest, it gives off perforating branches segmentally. At the costal margin, the internal thoracic artery terminates by dividing into the **musculophrenic** and **superior epigastric arteries**.

(2) The **inferior epigastric artery** arises from the external iliac artery just superior to the inguinal ligament, and it anastomoses with the superior epigastric branch of the internal thoracic artery.

(3) This arterial anastomosis forms a major interconnection between the subclavian and external iliac systems and, in effect, between the inferior vena cava and the superior vena cava.

(From C.D. Clemente. *Gray's Anatomy,* 30th American Edition. Philadelphia: Lea & Febiger, 1985.)

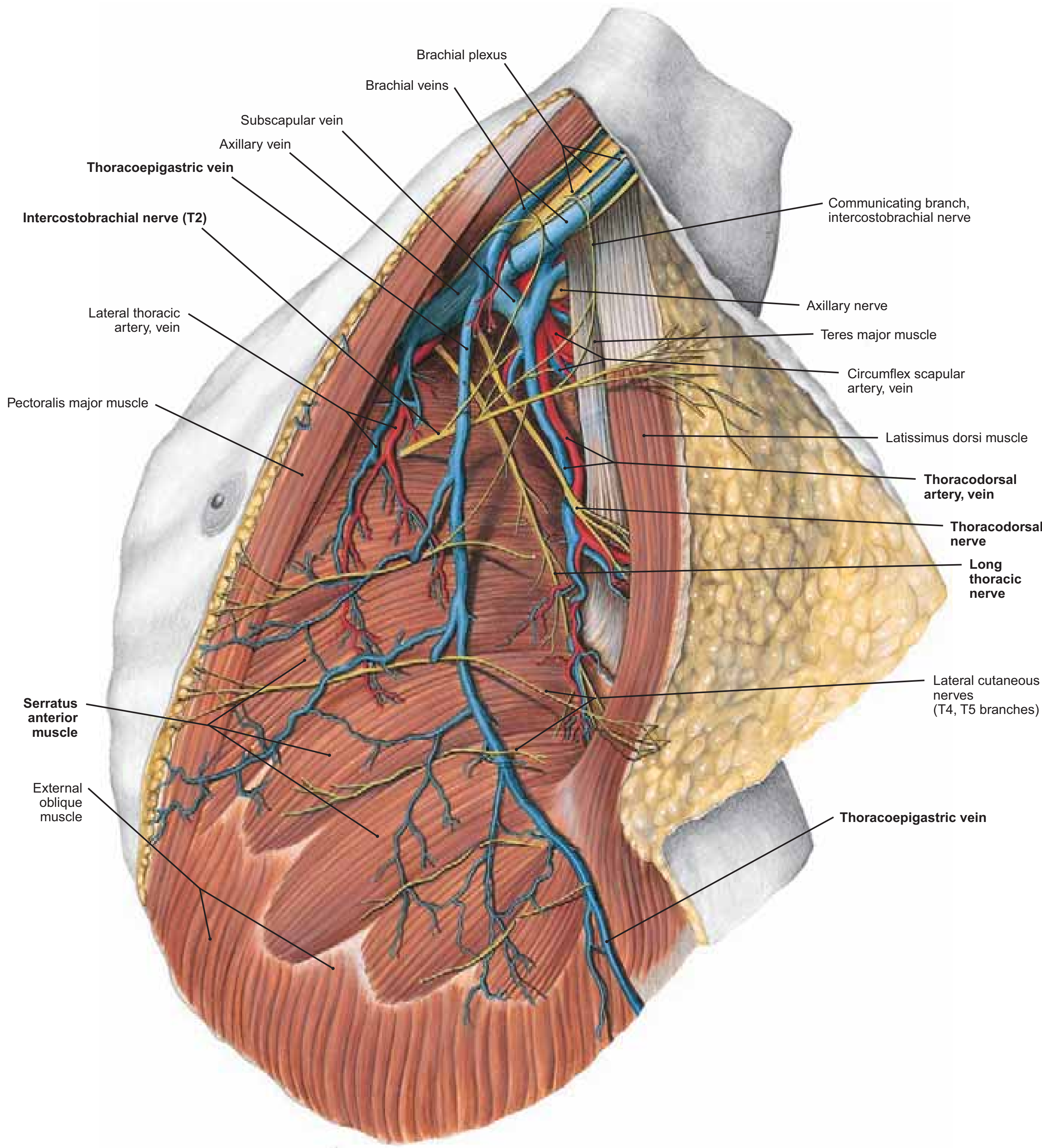


FIGURE 26 **Axilla: Superficial Vessels and Nerves (Left)**

NOTE: (1) The boundaries of the axilla are:

(a) **Anteriorly**, the pectoralis major muscle
(b) **Posteriorly**, the subscapularis, teres major, and latissimus dorsi muscles
(c) **Medially**, the serratus anterior muscle covering the second to the sixth ribs
(d) **Laterally**, the bicipital groove of the humerus.

(2) The lower part of the serratus anterior muscle arises from the lower ribs as fleshy interdigitations with the external oblique muscle.
(3) The serratus anterior is innervated by the long thoracic nerve, and the latissimus dorsi by the thoracodorsal nerve.
(4) The axillary vein lies medial to the axillary artery and the brachial plexus.
(5) The ascending course of the thoracoepigastric vein and the lateral thoracic vessels.

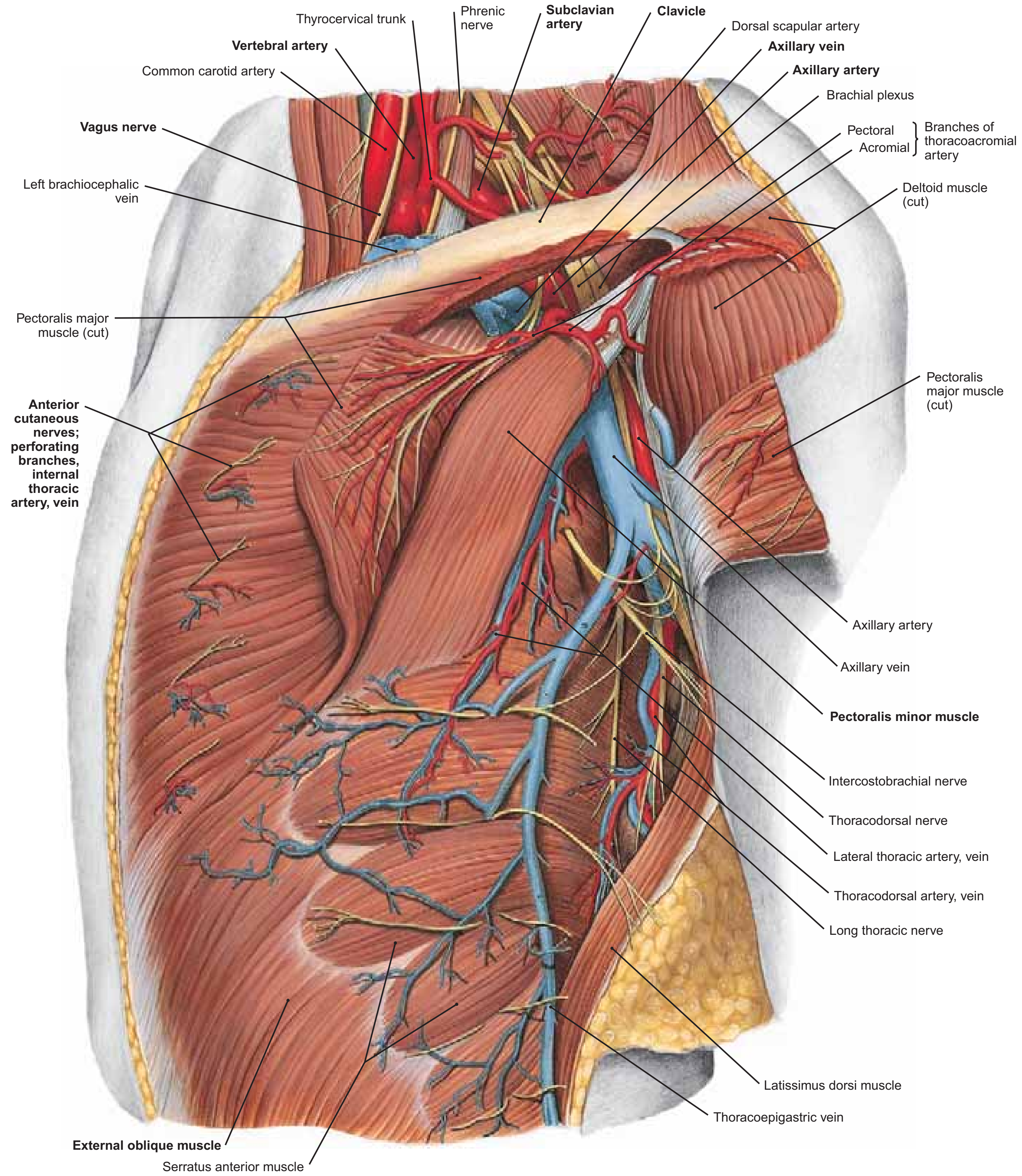


FIGURE 27 **Axilla (Left): Deep Vessels and Nerves**

NOTE: (1) The subclavian artery becomes the axillary artery distal to the clavicle.

(2) The pectoralis minor muscle is capable of elevating the ribs if the coracoid attachment is fixed or of protracting the scapula if the costal attachment is fixed.

(3) The axillary artery is surrounded by the three cords of the brachial plexus.

(4) The thoracoacromial artery divides into **pectoral, acromial, deltoid,** and small **clavicular** branches.

(5) The intercostobrachial nerve (T2) pierces the second intercostal space in its course toward the axilla and arm, and it communicates with the medial brachial cutaneous nerve.

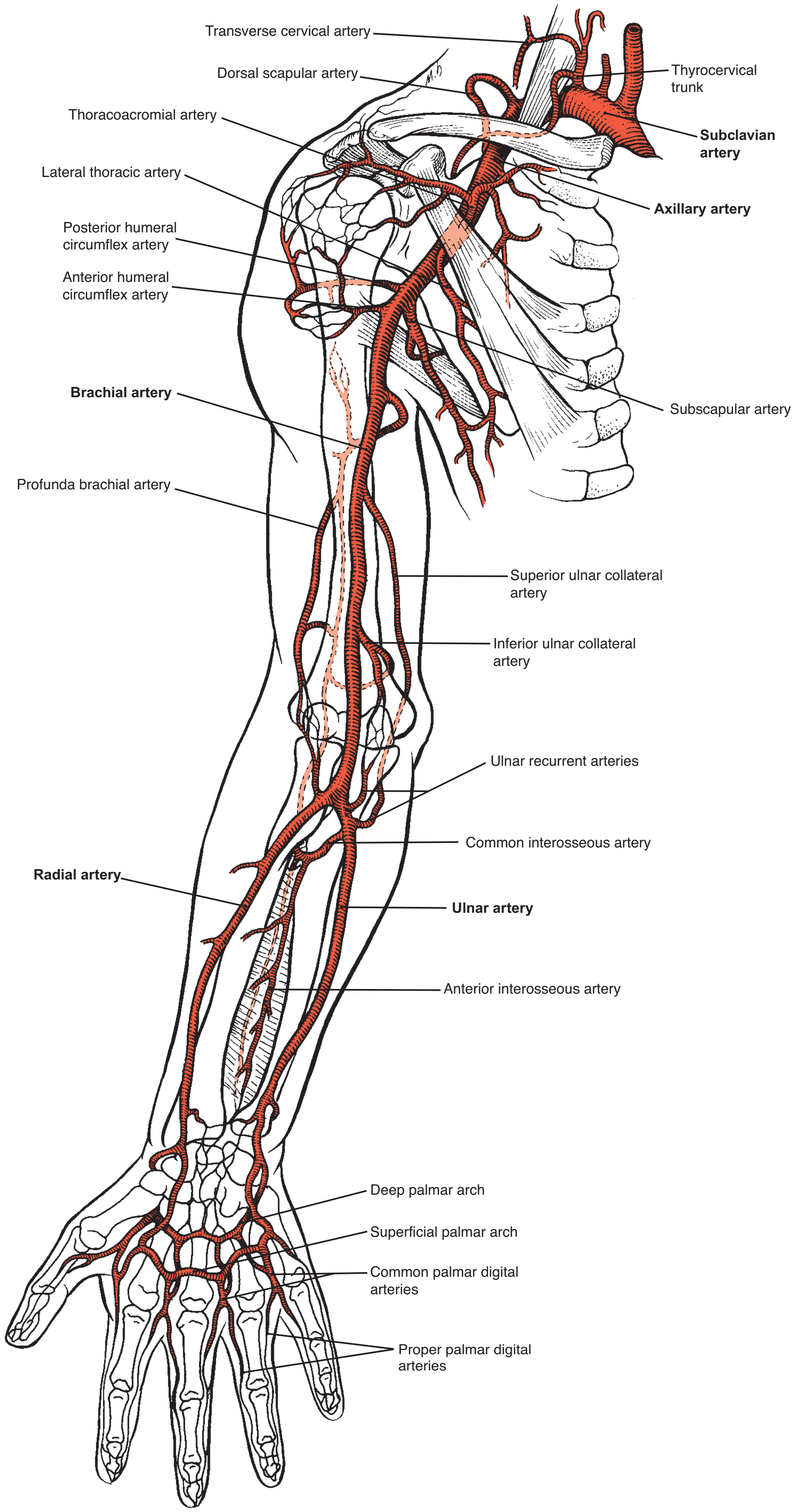


FIGURE 28 Arteries of the Upper Limb

(Contributed by Dr. Gene L. Colborn, Medical College of Georgia.)

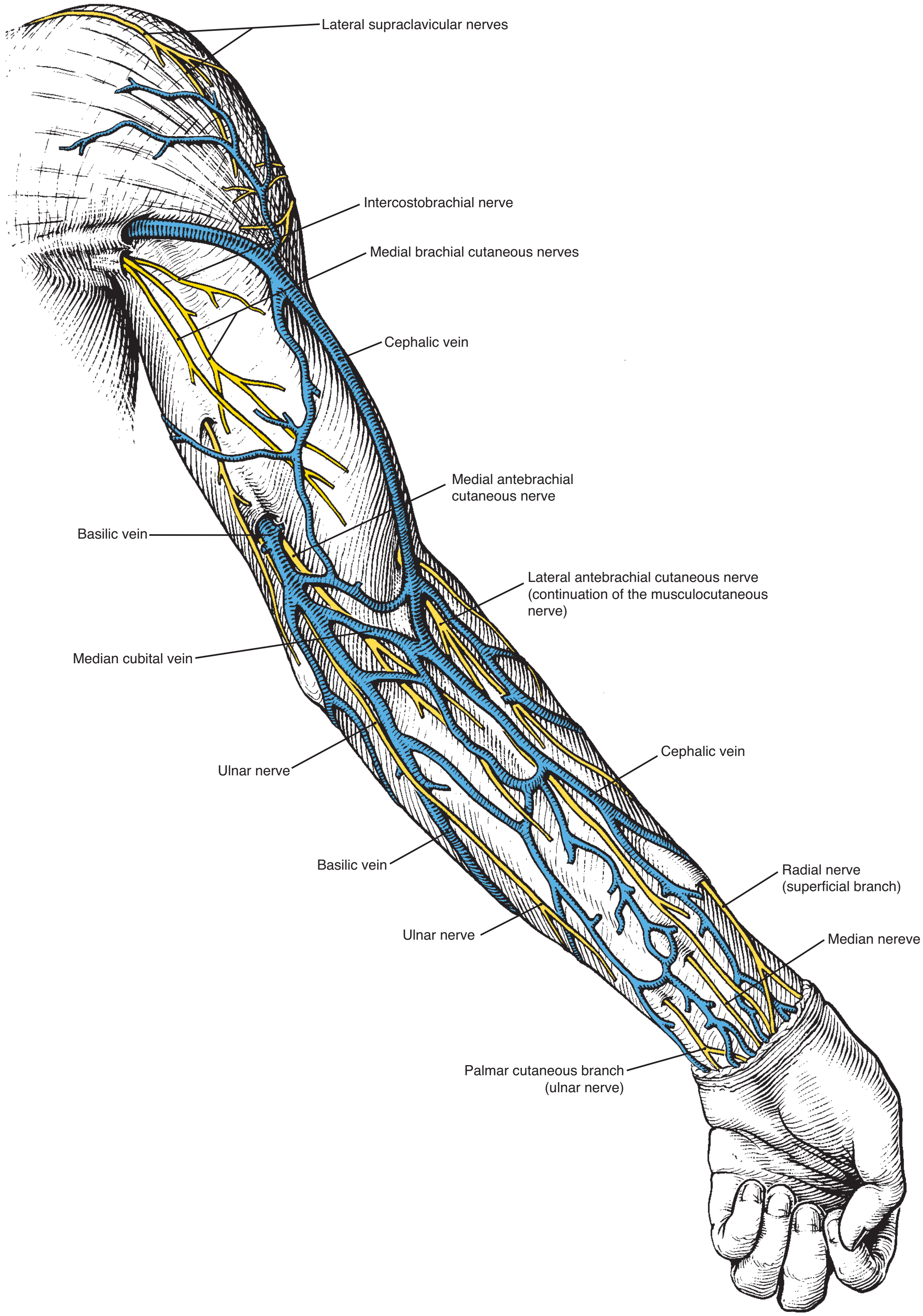


FIGURE 29 **The Superficial Veins of the Upper Extremity**

NOTE: The **cephalic vein laterally** commencing on the radial (or thumb) side of the hand and the **basilic vein** commencing on the ulnar (or little finger) side of the hand. These channels communicate in the antecubital fossa by the **median cubital vein**.
(Contributed by Dr. Gene L. Colborn, Medical College of Georgia.)

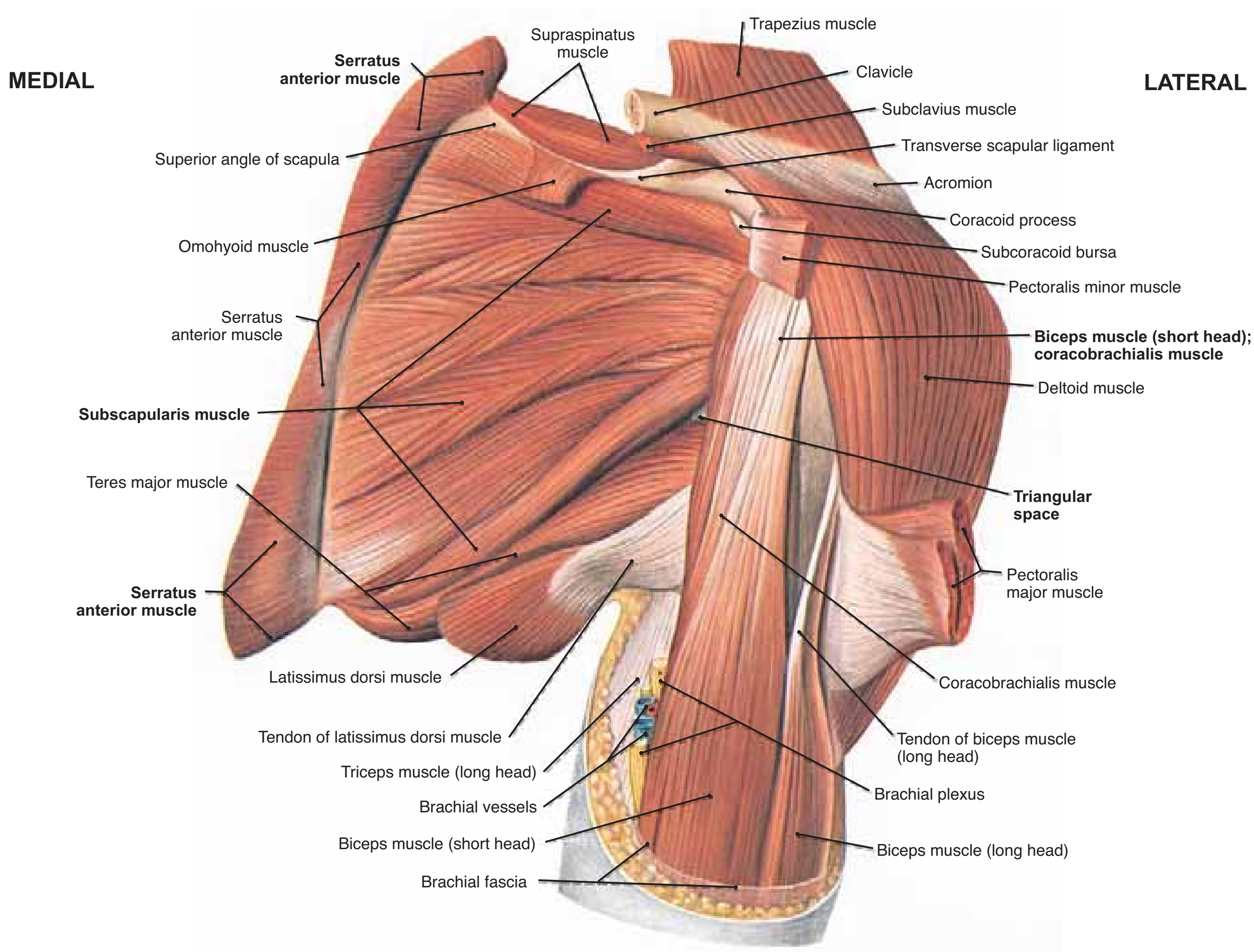


FIGURE 30 Muscles of Anterior Aspect of the Shoulder (Left)

NOTE: (1) The large triangular mass of the subscapularis muscle occupying the concave subscapular fossa. From this broad origin, its fibers converge toward the humerus, where it inserts on the lesser tubercle.

(2) The subscapularis along with the other muscles that constitute the "rotator cuff" (supraspinatus, infraspinatus, and teres minor) help stabilize the shoulder joint by keeping the head of the humerus in the glenoid fossa.

(3) Both the short head of the biceps and the coracobrachialis have a common origin from the coracoid process.

Muscle	Origin	Insertion	Innervation	Action
Subscapularis	Subscapular fossa of the scapula	Lesser tubercle of humerus	Upper and lower subscapular nerves (C5, C6) from posterior cord of brachial plexus	Medial rotation of humerus
Latissimus dorsi	Thoracolumbar fascia; spinous processes of lower six thoracic and lumbar vertebrae, and the sacrum	Bottom of the intertubercular sulcus of humerus	Thoracodorsal nerve (C6, C7, C8) from posterior cord of brachial plexus	Extends, adducts, and medially rotates the humerus
Deltoid	Lateral third of clavicle; the acromion; spine of the scapula	Deltoid tubercle on lateral surface of humerus	Axillary nerve (C5, C6) from posterior cord of brachial plexus	Abduction of the humerus; anterior fibers assist in flexion and posterior fibers in extension of humerus

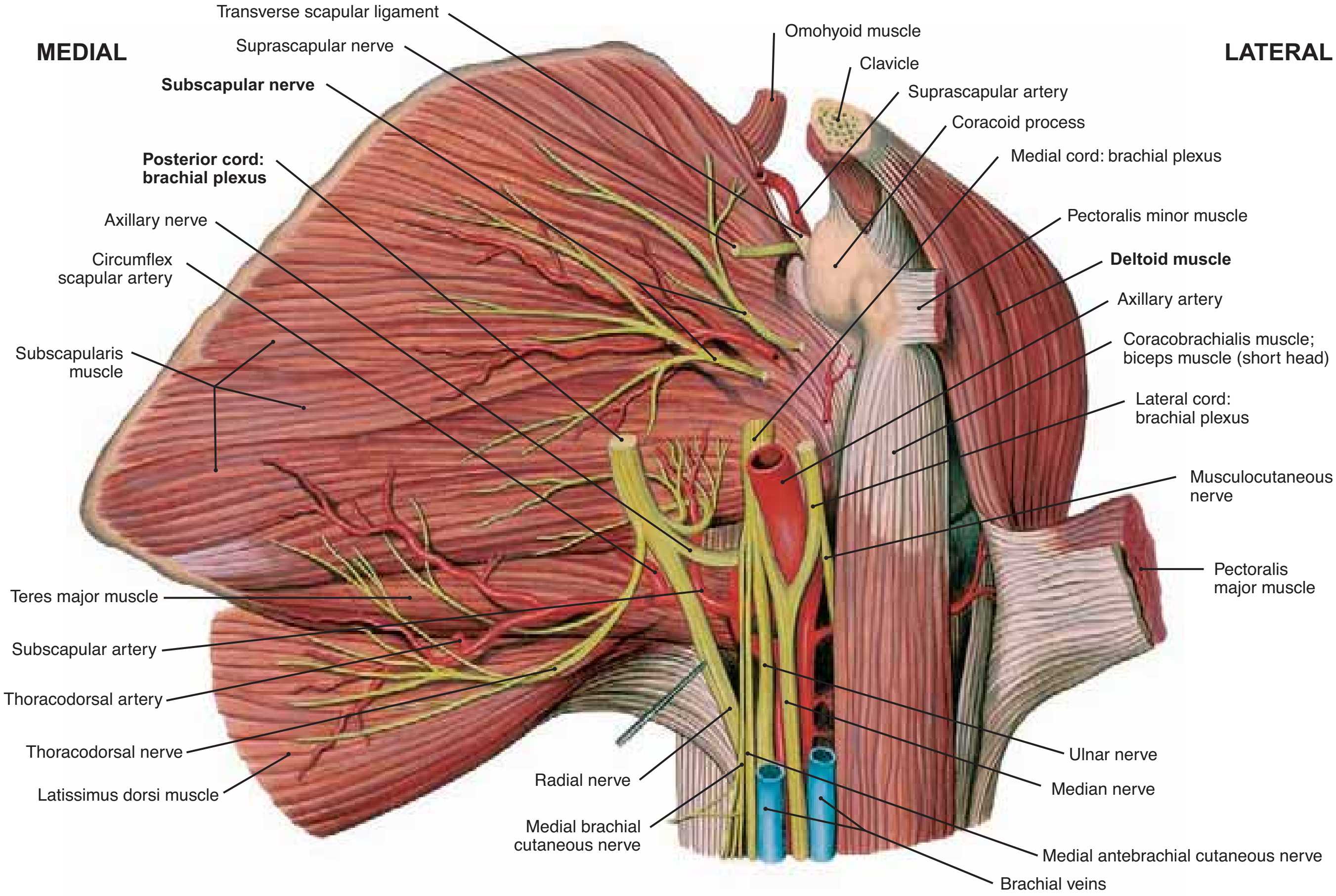


FIGURE 31.1 Nerves and Vessels of Anterior Aspect of the Shoulder (Left)

NOTE: (1) The relationships of the medial, lateral, and posterior cords of the brachial plexus to the axillary artery.
(2) The posterior cord and its axillary and radial terminal nerves have been pulled medially from behind the axillary artery in this dissection.
(3) The median nerve formed by contributions from the lateral and medial cords. Observe that the median nerve, its two roots of origin and the ulnar and musculocutaneous nerves outline an **M** formation on the anterior aspect of the axillary artery.

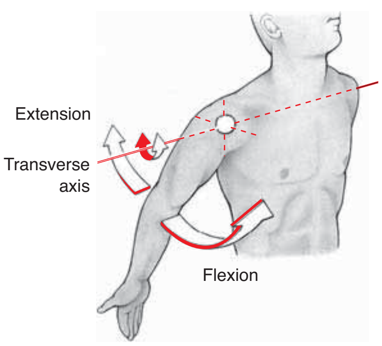


FIGURE 31.2 Shoulder Joint: Flexion and Extension

In **flexion** the upper limb is moved anteriorly (forward), while in **extension** the limb moves posteriorly (backward) in reference to the transverse axis.

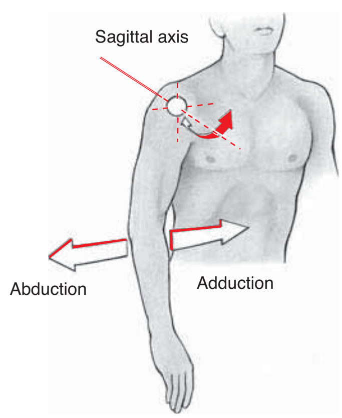


FIGURE 31.3 Shoulder Joint: Abduction and Adduction

In **abduction**, the upper limb is moved laterally, or away from the midline of the body, with reference to the sagittal axis. In **adduction**, the upper limb is moved medially, or toward the midline of the body.

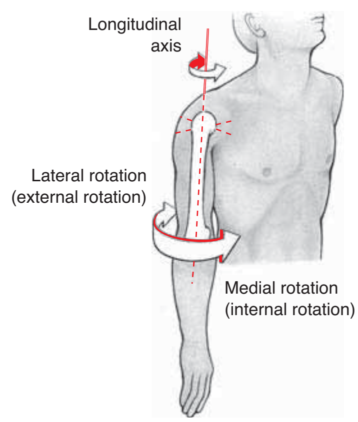


FIGURE 31.4 Shoulder Joint: Medial and Lateral Rotation

Medial rotation at the shoulder joint occurs when the humerus is rotated internally (medially) with reference to the long or longitudinal axis of the bone. In contrast, **lateral rotation** of the upper limb moves the humerus (arm) externally or laterally.

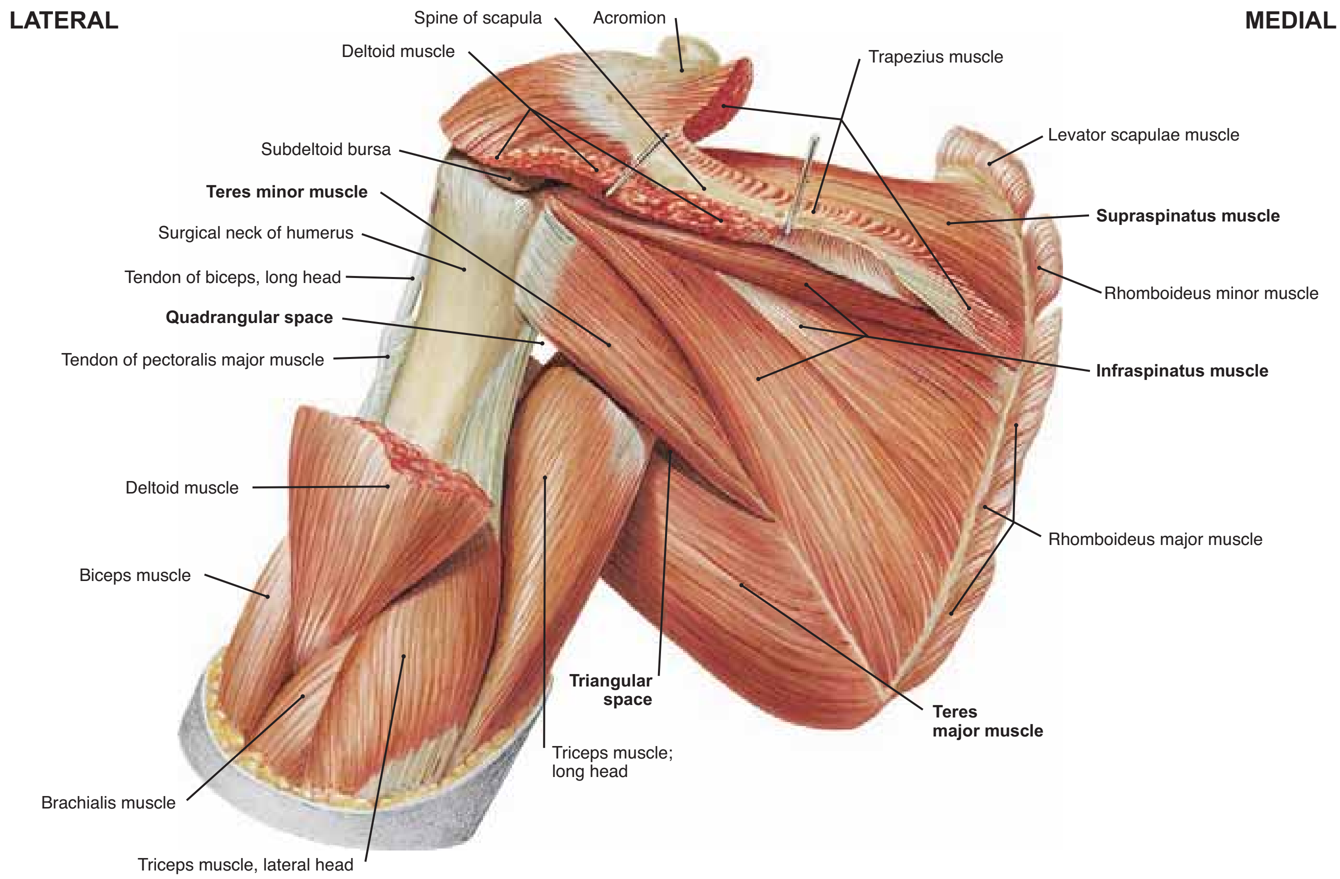


FIGURE 32 Posterior Scapular Muscles (Left)

NOTE: (1) The supraspinatus, infraspinatus, and teres minor muscles all course laterally from the dorsal scapula, and all are considered "rotator cuff" muscles.
(2) These three muscles insert in sequence from above downward on the greater tubercle of the humerus.
(3) The long head of the triceps intersects a space between the teres major and teres minor muscles, forming a **quadrangular space** laterally and a **triangular space** medially.
(4) The posterior humeral circumflex artery and the axillary nerve pass through the quadrangular space.
(5) The circumflex scapular branch of the subscapular artery passes through the triangular space.
(6) Since the lateral border of the quadrangular space is the surgical neck of the humerus, the axillary nerve and posterior humeral circumflex artery are in danger if the bone is fractured at this site.

Muscle	Origin	Insertion	Innervation	Action
Supraspinatus	Supraspinatus fossa of the scapula	Highest facet of the greater tubercle of humerus	Suprascapular nerve (C5)	Initiates abduction of the arm; rotates the humerus laterally
Infraspinatus	Infraspinatus fossa of the scapula	Middle part of greater tubercle of humerus	Suprascapular nerve (C5, C6)	Rotates the humerus laterally
Teres major	Lower lateral border and inferior angle of the scapula	Crest of lesser tubercle and medial lip of intertubercular sulcus of humerus	Lower subscapular nerve (C5, C6)	Adducts and medially rotates the humerus; assists in extension of the arm
Teres minor	Upper part of the lateral border of the scapula	Lower part of the greater tubercle of humerus	Axillary nerve (C5)	Rotates humerus laterally; weakly adducts humerus

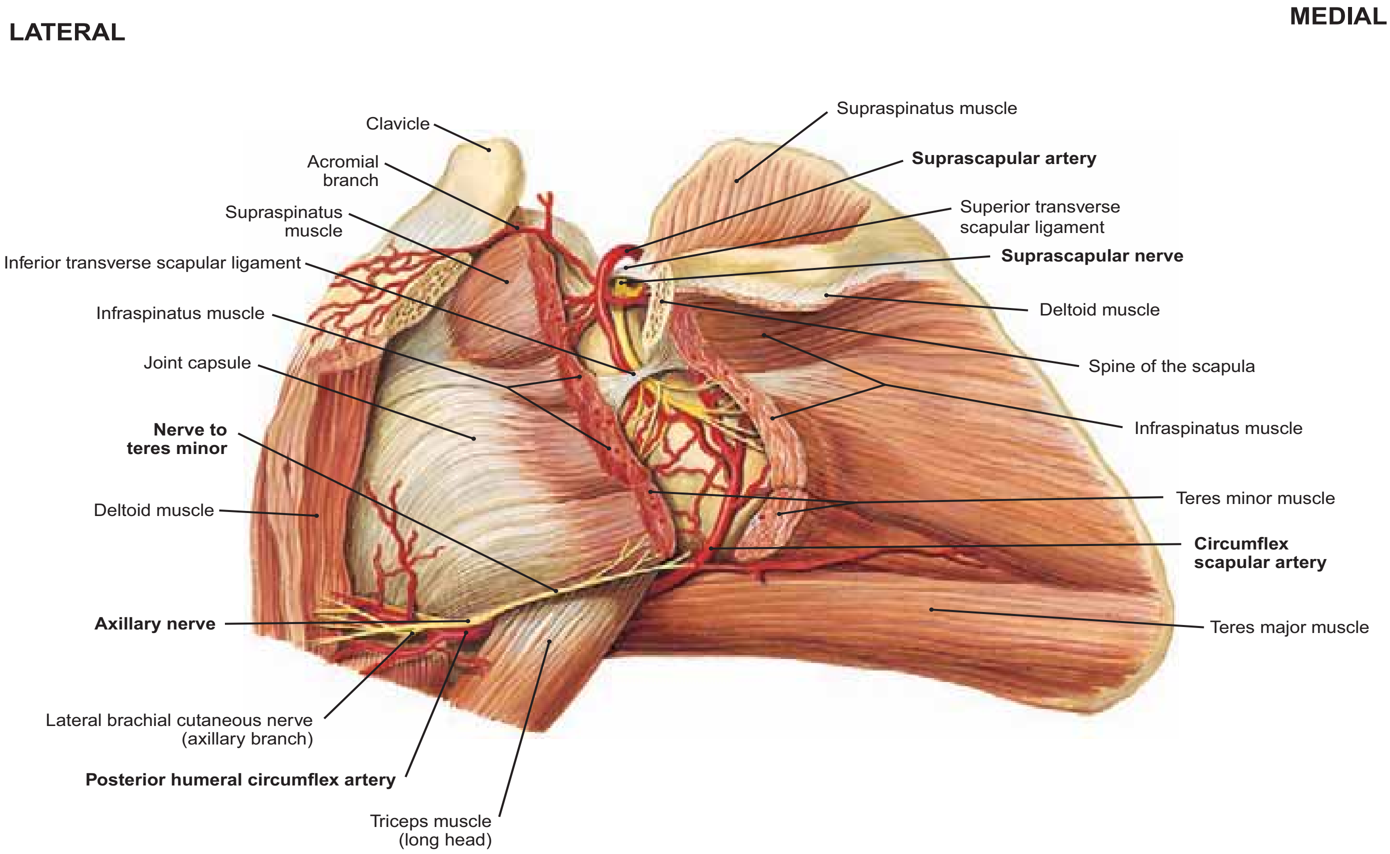
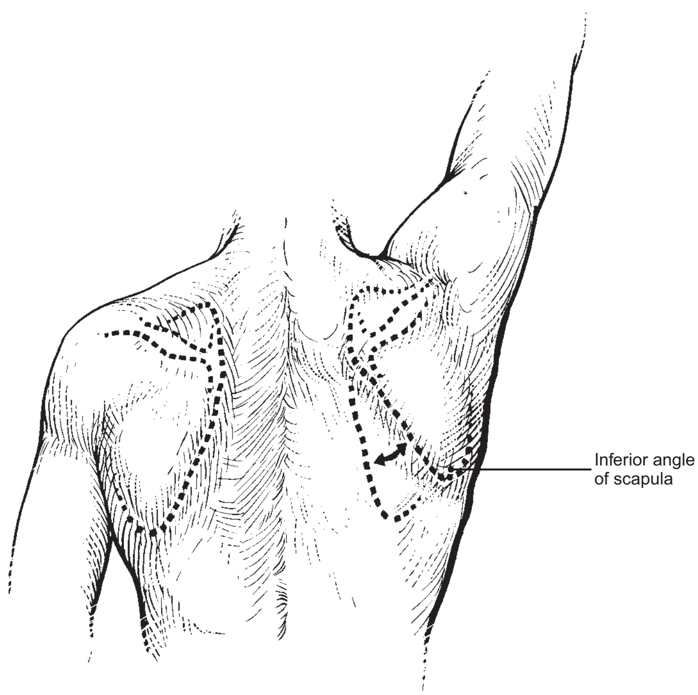


FIGURE 33.1 Nerves and Vessels of Posterior Scapular Region (Left)

NOTE: (1) The **superior** transverse scapular ligament bridges the scapular notch, and the suprascapular nerve passes beneath the ligament while the suprascapular artery usually passes above it to reach the supraspinatus fossa.
(2) Both the suprascapular nerve and the artery pass beneath the **inferior** transverse scapular ligament to reach the infraspinatus fossa.
(3) The axillary nerve supplies four structures: (a) the teres minor muscle, (b) the deltoid muscle, (c) the capsule of the shoulder joint, and (d) the skin over the shoulder joint.
(4) The axillary nerve and posterior humeral circumflex artery from the dorsal view. These two structures have passed through the quadrangular space, whereas the circumflex scapular artery reaches the infraspinatus fossa through the triangular space.

FIGURE 33.2 Abduction of the Upper Limb

NOTE: (1) The first 20 degrees of abduction is performed by the supraspinatus muscle.
(2) From 20 to 90 degrees, abduction is almost exclusively the action of the deltoid muscle.
(3) Continuing beyond 90 degrees to 180 degrees (as shown in this figure), the vertebral border and inferior angle of the scapula must rotate laterally as the upper limb is elevated.



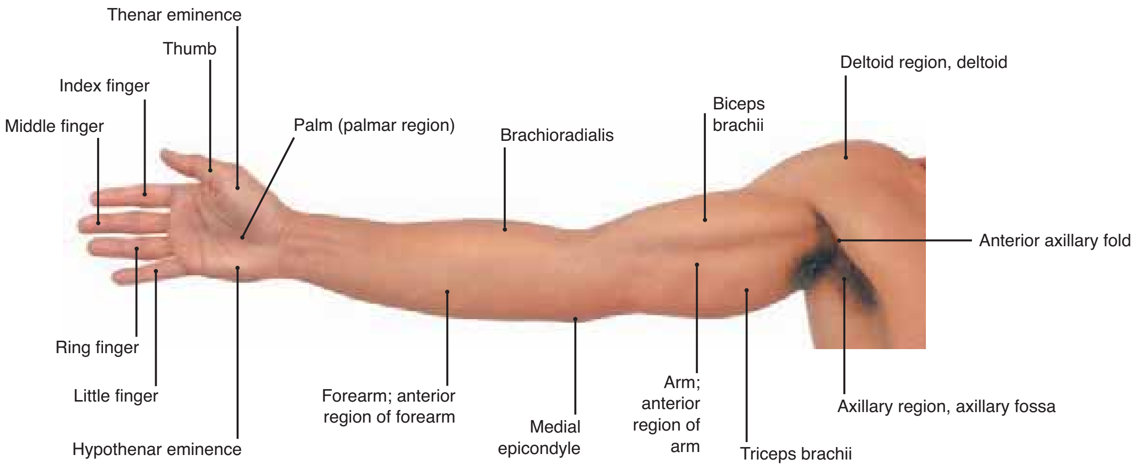


FIGURE 34.1 **Surface Anatomy of the Right Upper Limb (Anterior Aspect)**

NOTE: (1) The vertically oriented **medial bicipital furrow** along the arm. The **basilic vein** and the **medial antebrachial cutaneous nerve** course beneath the skin along this furrow. More deeply are found the brachial artery and vein and the **median** and **ulnar nerves**;
(2) The **cubital fossa** in front of the elbow joint, between the bellies of the flexor and extensor muscles in the upper forearm.

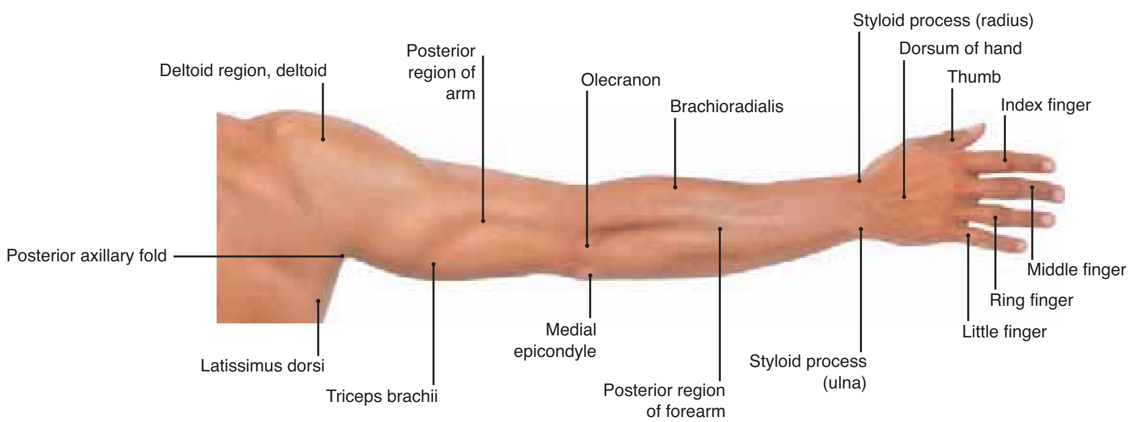


FIGURE 34.2 **Surface Anatomy of the Right Upper Limb (Posterior Aspect)**

NOTE: (1) The surface contours of the **biceps brachii** and **brachioradialis** muscles and the surface projections of the olecranon and the medial epicondyle in the elbow region.
(2) The distal sharp ends of both the radius and the ulna end in a **styloid process**. They are frequently fractured by severe trauma at the wrist.

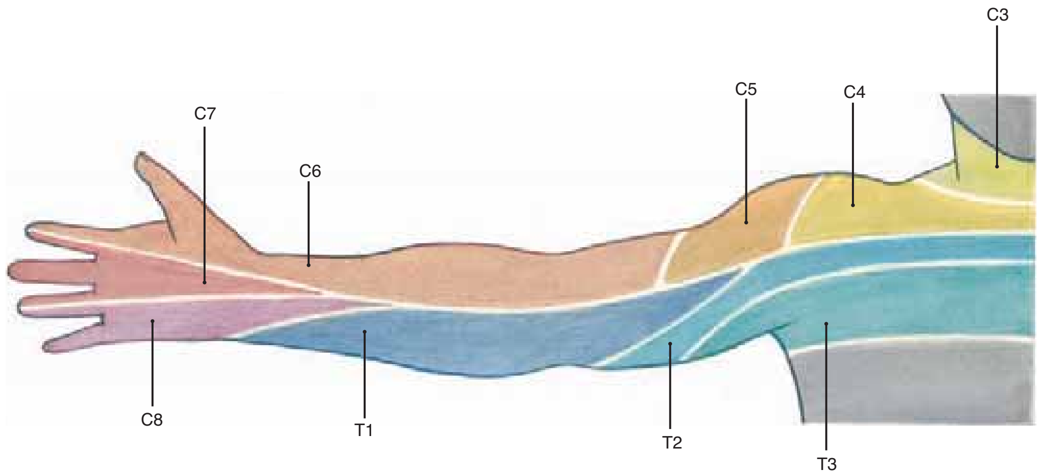


FIGURE 35.1 Cutaneous Innervation and Dermatomes of the Upper Limb (Anterior Aspect)

NOTE: (1) An area of skin surface that receives innervation from any single spinal nerve is called a **dermatome**.
(2) The solid lines on this figure and on Figure 35.2 are the boundaries between dermatomes. The boundary between C5 and C6 laterally and T1 and T2 medially is called the **anterior axial line**.
(3) The dermatomes on the anterior aspect of the limb commence over the anterior lateral surface of the brachium with the C5 dermatome.
(4) Continuing down laterally in the forearm is the C6 dermatome, the palmar and radial hand is C7, the ulnar aspect of the hand is C8, and then sequentially up the medial surface of the forearm and arm are the T1 and T2 dermatomes.
(5) Although there is overlap between adjacent dermatomes (such as between C5 and C6), **there is no overlap across the axial** line (such as between C6 and T1). This has important clinical significance, because differences in sensation across the axial line might help localize a problem in the spinal cord.

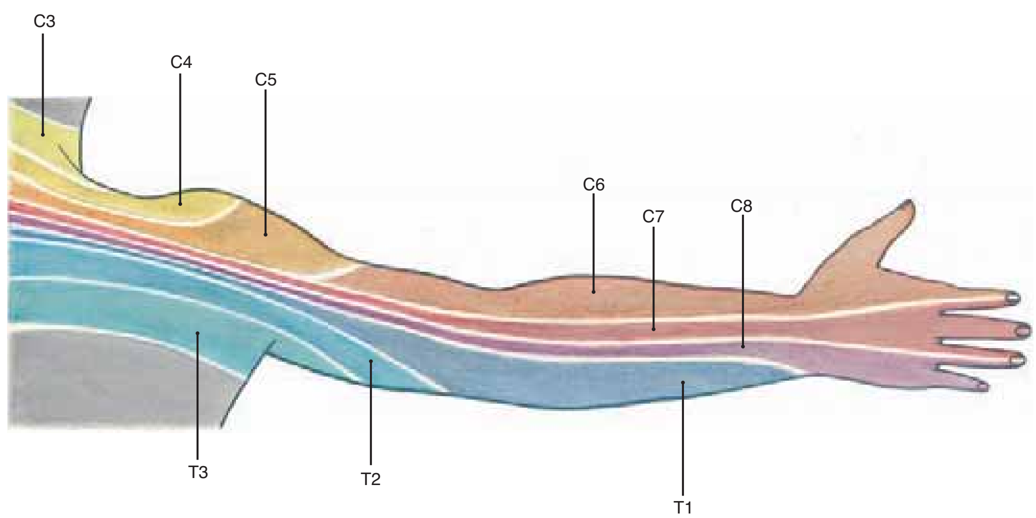


FIGURE 35.2 Cutaneous Innervation and Dermatomes of the Upper Limb (Posterior Aspect)

NOTE: (1) Dermatomes on the posterior surface of the upper limb start at the proximal lateral region of the arm with the C5 dermatome.
(2) The C6 dermatome continues down the radial aspect of the forearm and hand; it includes the dorsal thumb and the radial part of the index finger.
(3) The C7 dermatome includes the posterior aspect of the middle finger and the adjacent halves of the index and ring fingers as well as a strip of skin over the intermediate parts of the posterior hand and forearm.
(4) The C8 dermatome includes the little finger and the adjacent part of the ring finger and the ulnar part of the hand, along with a thin region of forearm skin.
(5) Continuing sequentially up the posterior aspect of the medial (ulnar) side of the forearm and arm are the T1 and T2 dermatomes.

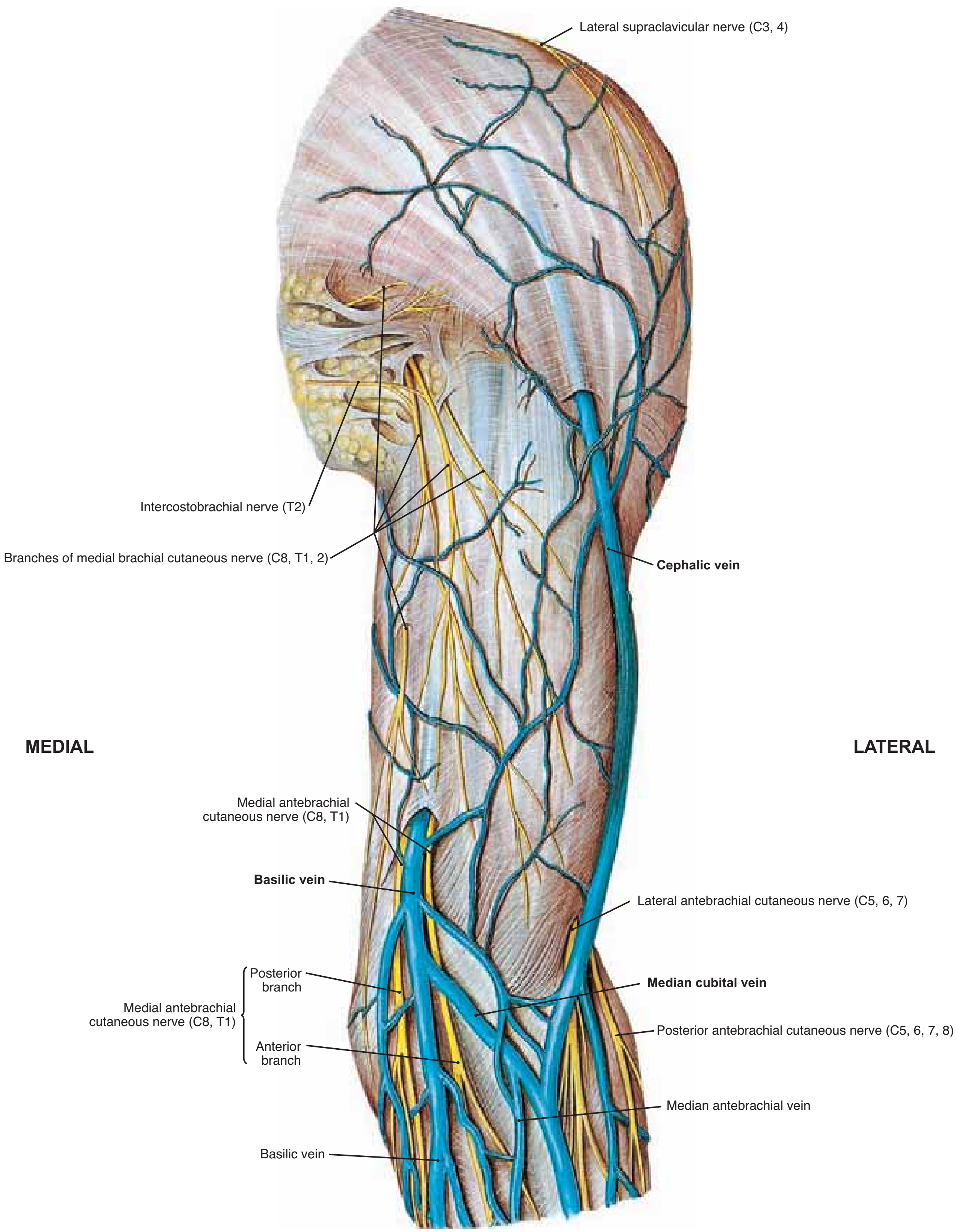


FIGURE 36 Superficial Veins and Cutaneous Nerves of the Left Upper Arm (Anterior View)

NOTE: (1) The **basilic vein** ascends on the medial (ulnar) aspect of the arm, pierces the deep fascia, and at the lower border of the teres major, joins the brachial veins to form the axillary vein.

(2) In contrast, the **cephalic vein** ascends along the lateral aspect of the arm toward the axillary vein, which it joins deep to the deltopectoral triangle.

(3) The principal sensory nerves of the anterior arm region are the **medial brachial cutaneous** and **intercostobrachial nerves.**

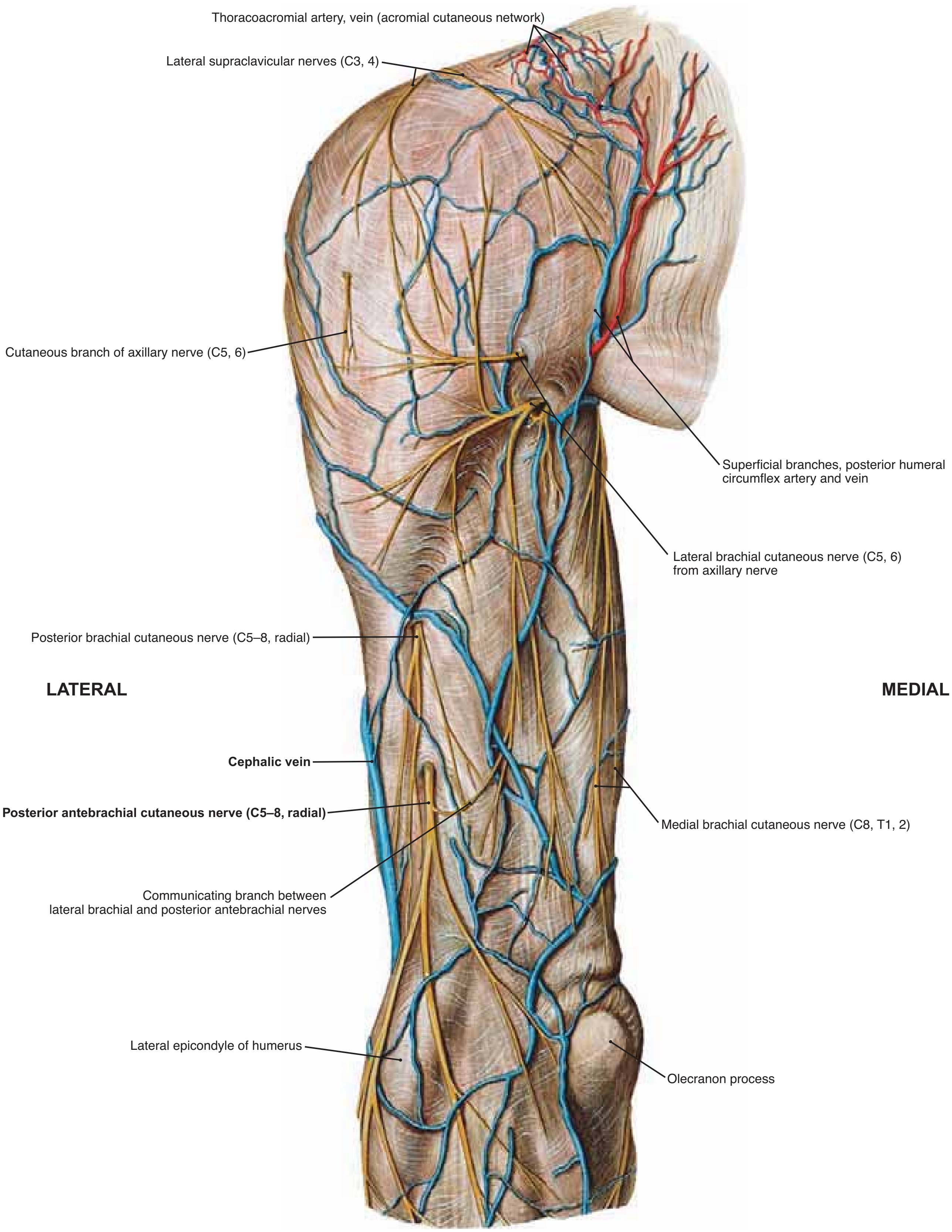
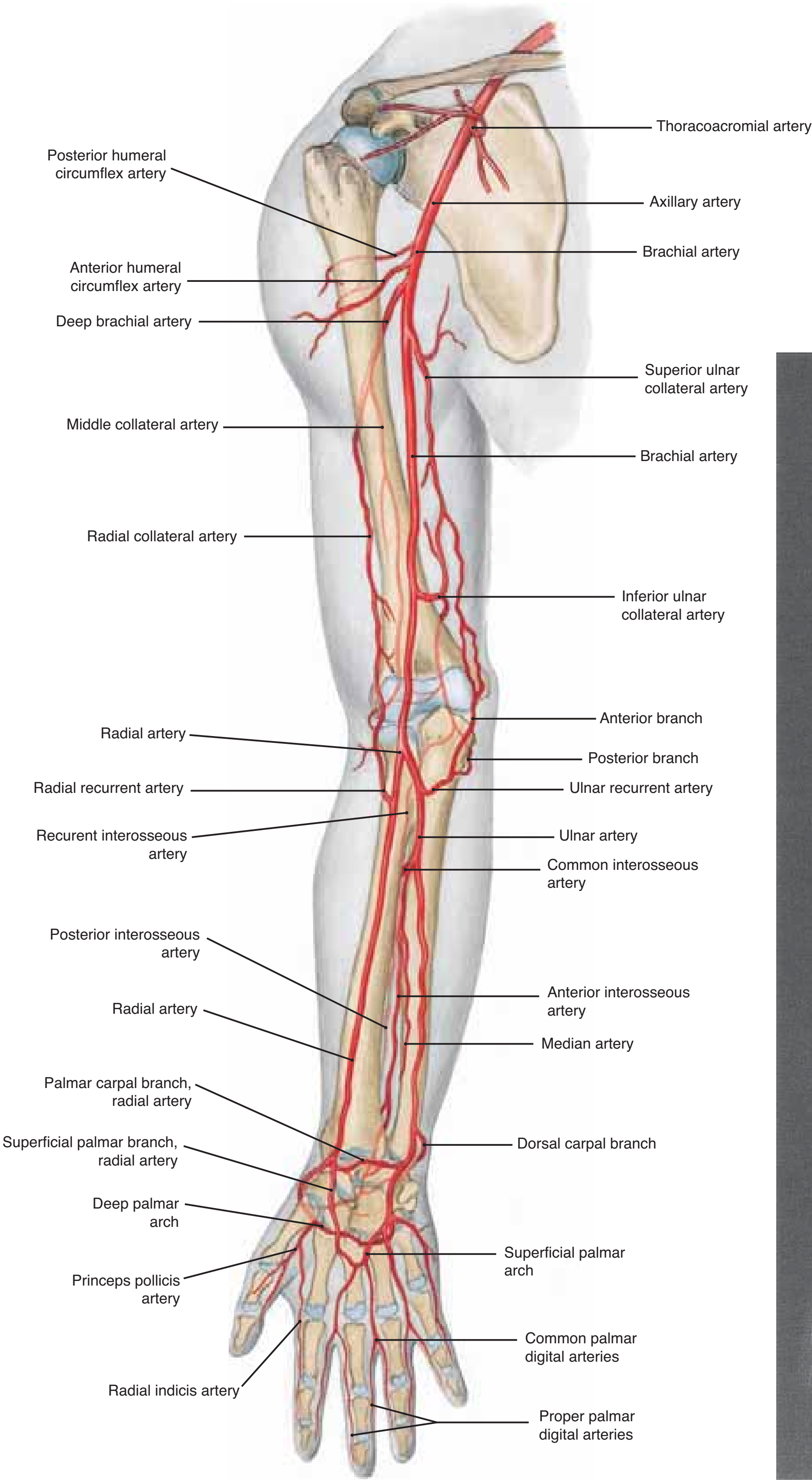


FIGURE 37 Superficial Veins and Cutaneous Nerves of Left Upper Arm (Posterior View)

NOTE: (1) The posterior arm region receives cutaneous innervation from the **radial** (posterior brachial cutaneous nerve) and **axillary** (lateral brachial cutaneous nerve) nerves. Both are derived from the posterior cord of the brachial plexus.

(2) The **posterior antebrachial cutaneous nerve** (from the radial nerve) perforates the lateral head of the triceps about 5 cm above the elbow. Upon piercing the superficial fascia, it sends cutaneous branches to the posterior surface of the forearm as well as a communicating branch to the cutaneous rami of the axillary nerve.



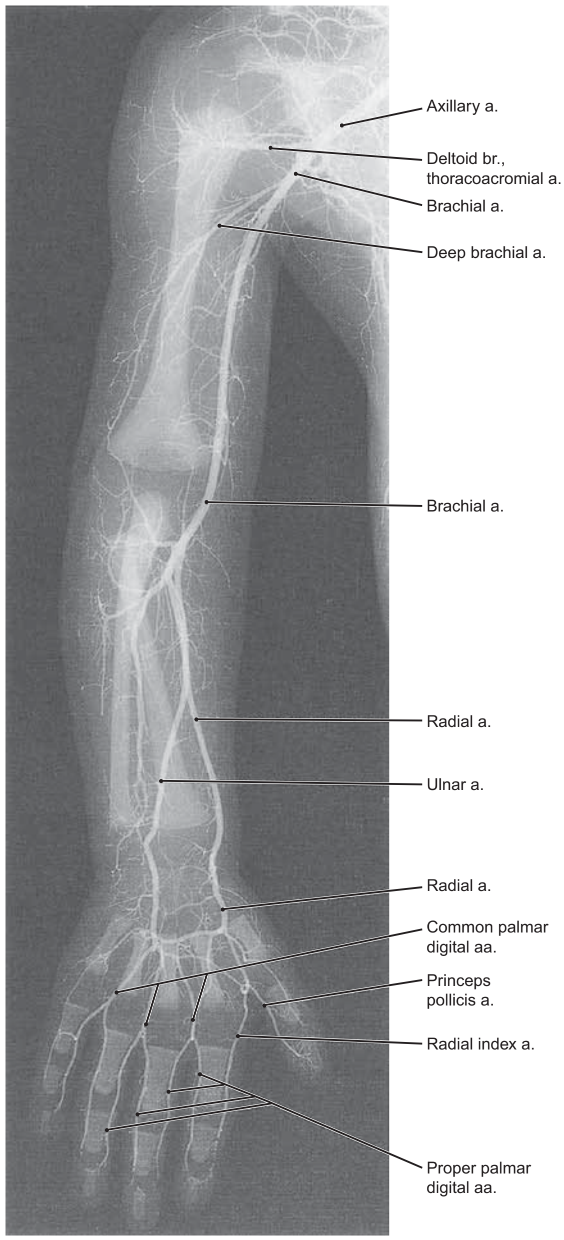


FIGURE 38.1 Schematic View of the Arteries of the Upper Limb (Anterior View)

NOTE that the arteries of the upper limb derive from the brachial artery and the axillary artery.

FIGURE 38.2 Arteriogram of the Upper Limb in a Stillborn Infant

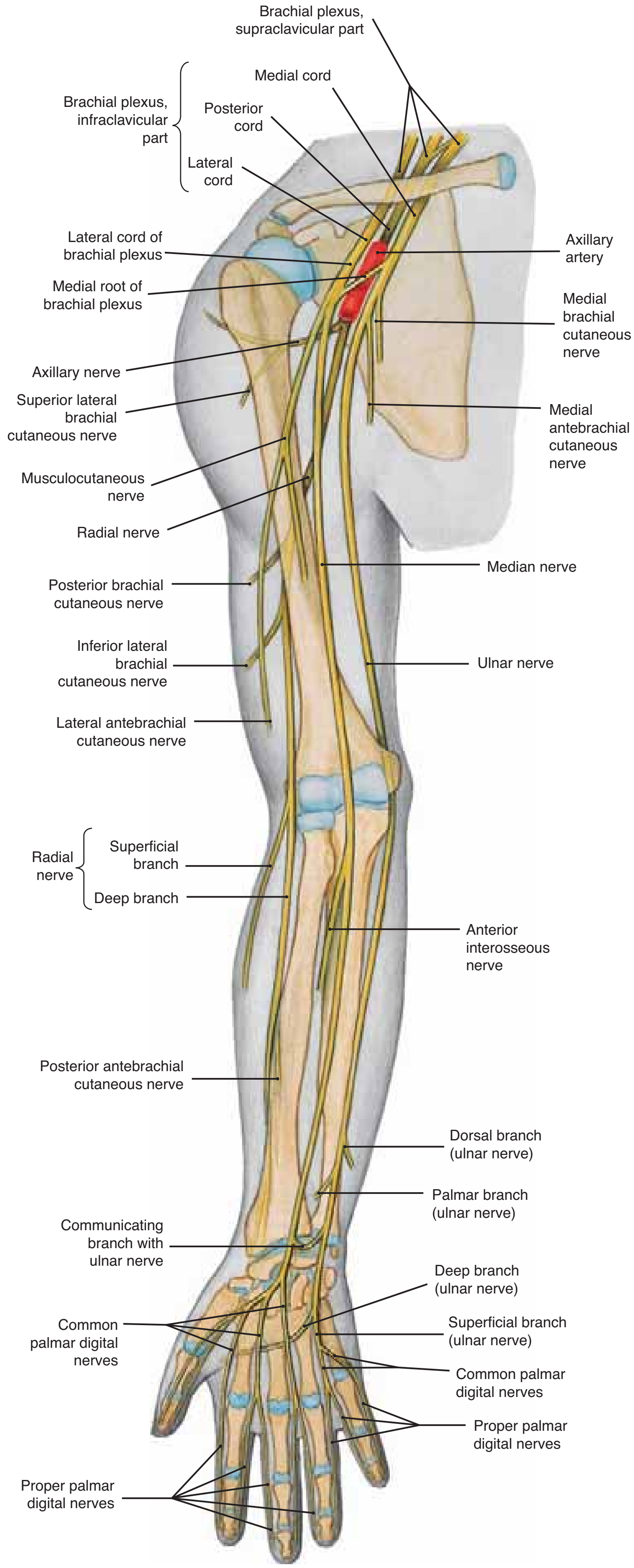


FIGURE 39 Nerves of the Upper Limb

NOTE that all of the nerves of the upper limb derive from the brachial plexus in the axilla.

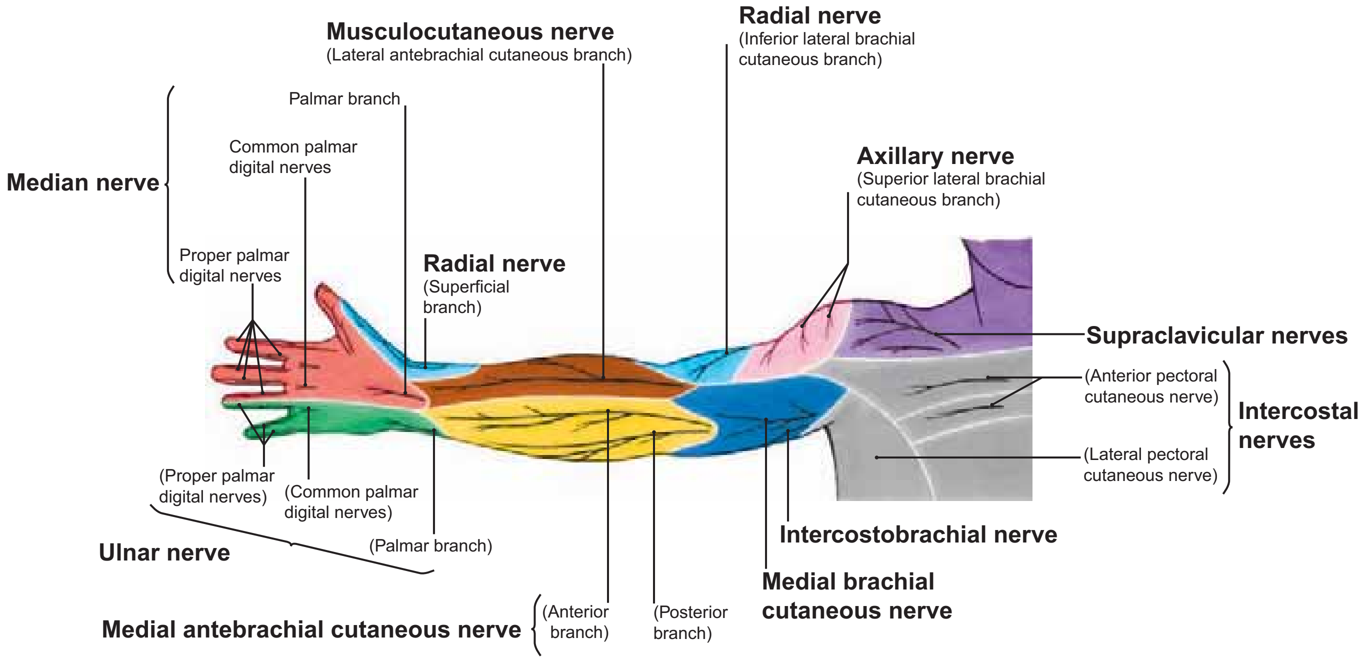


FIGURE 40.1 Cutaneous Fields and Courses of Cutaneous Nerves in the Upper Limb (Anterior Aspect)

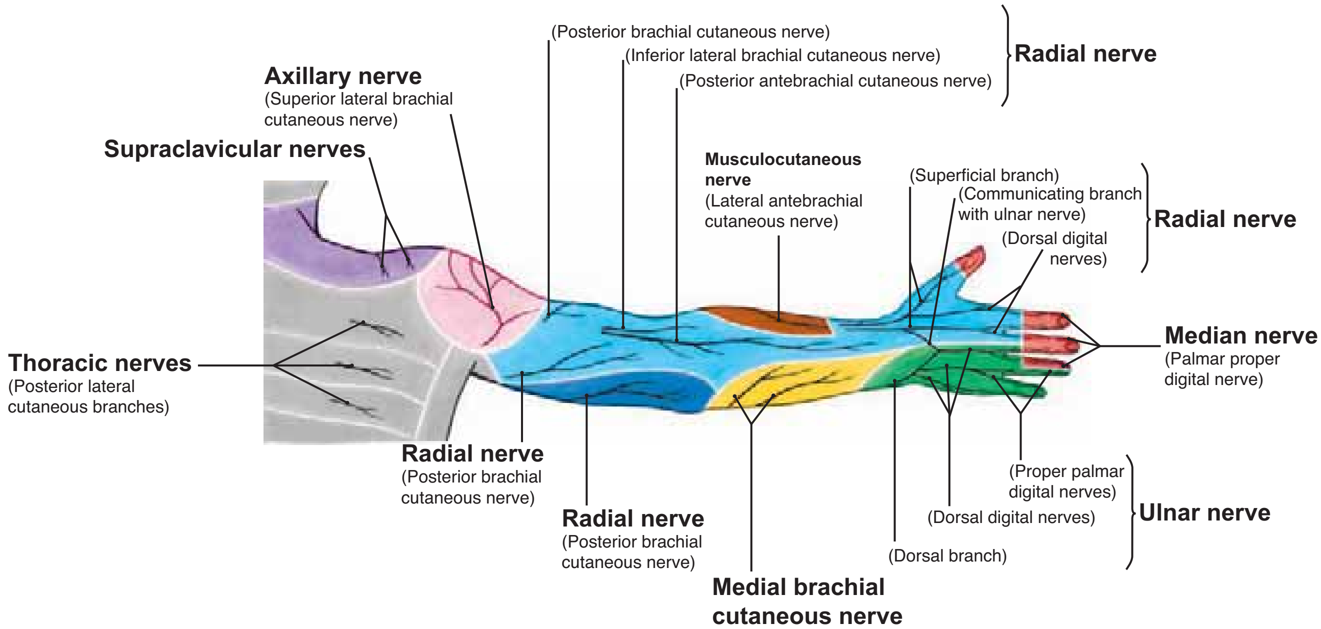


FIGURE 40.2 Cutaneous Fields and Courses of Cutaneous Nerves in the Upper Limb (Posterior Aspect)

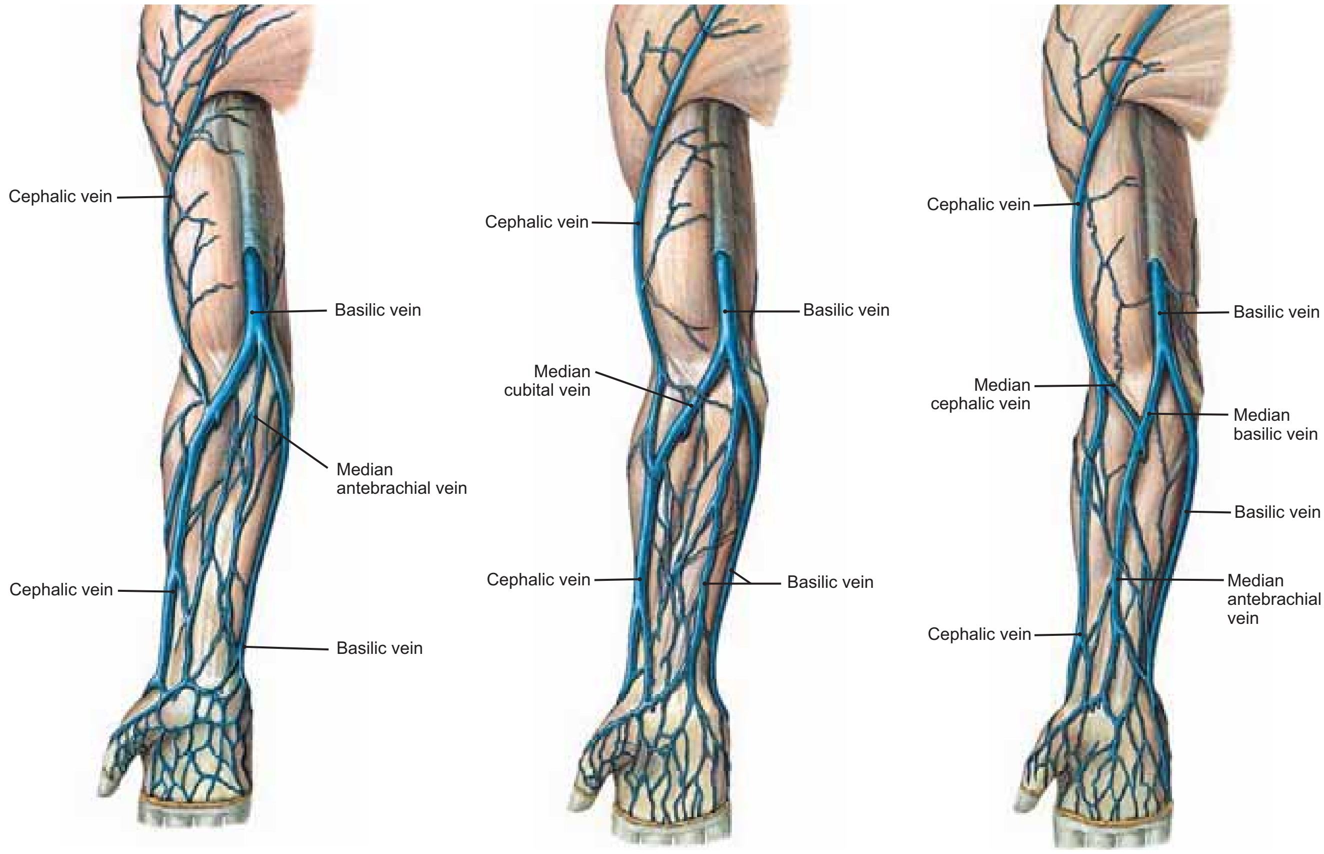


FIGURE 41.1 **Variations in the Venous Pattern of the Upper Extremity**

NOTE: Superficial veins are variable and are of significance clinically. The median cubital vein is often used for the withdrawal of blood and the injection of fluids into the vascular system. Care must be taken not to injure the median nerve or puncture the brachial artery, which lie deep to the median cubital vein and the underlying bicipital aponeurosis.

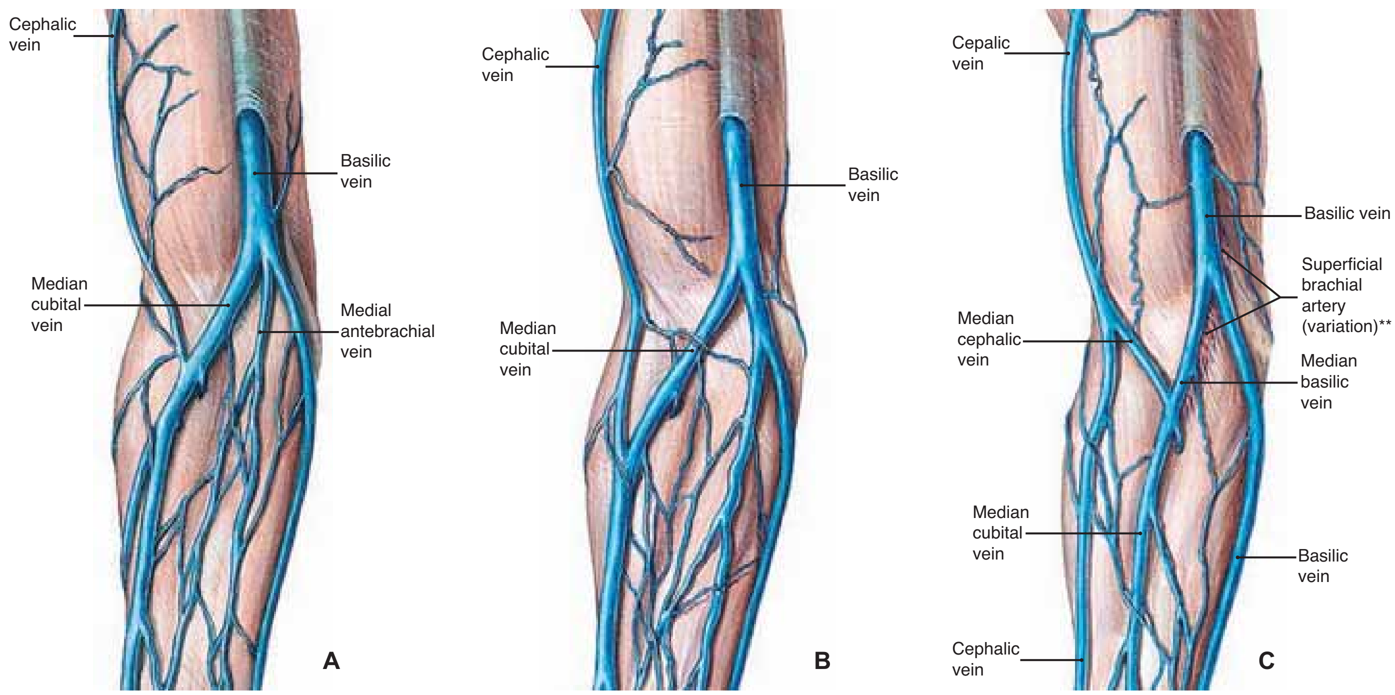


FIGURE 41.2A–C **Variations of the Superficial Veins in the Antecubital Fossa**

NOTE: Each of these three variations is an enlargement of the antecubital region shown in the figure above. **This variation (rare) of a superficial branch of the brachial artery is important to understand. Intended intravenous injections can mistakenly be made into this superficial brachial artery if this variation occurs in a patient.

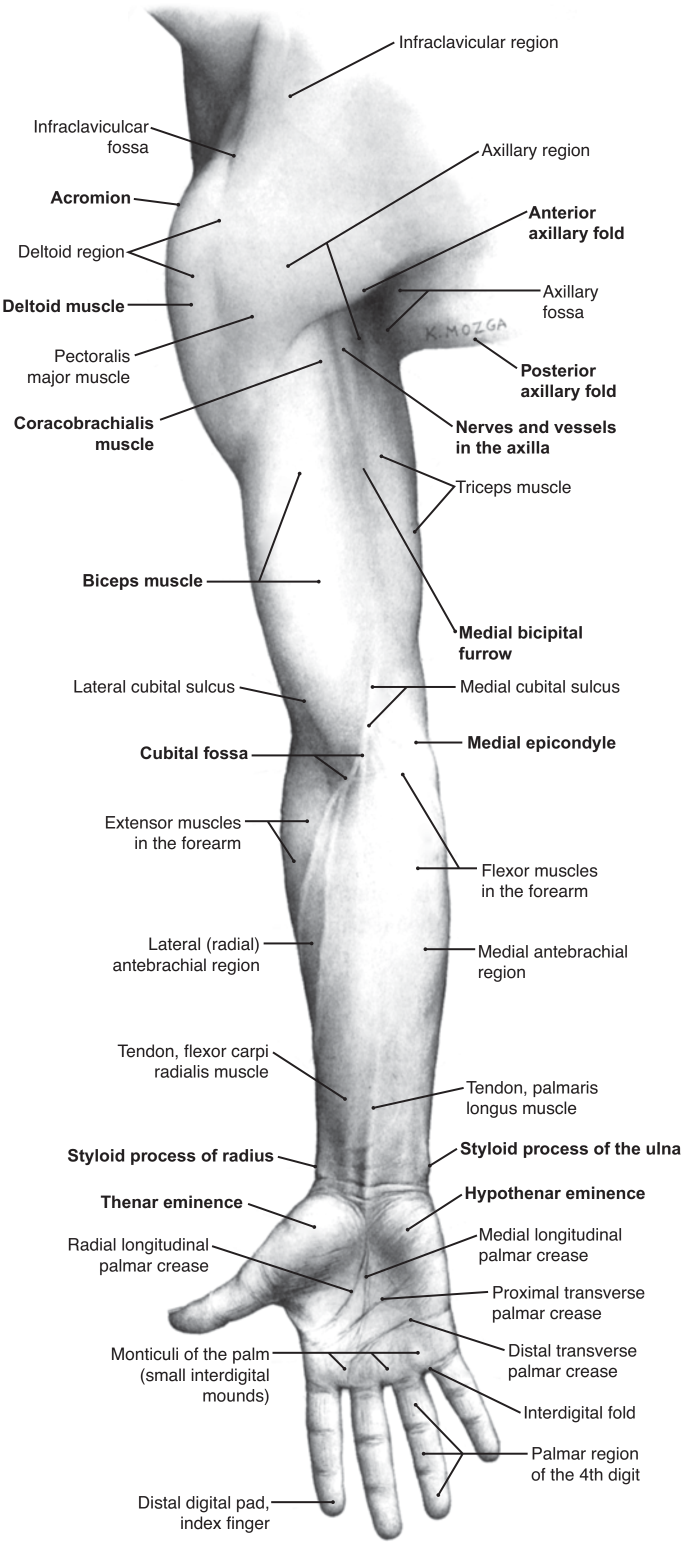


FIGURE 42.1 **Surface Anatomy of the Right Upper Limb, Anterior Aspect**

NOTE: (1) The vertically oriented medial bicipital furrow along the arm. The basilic vein and the medial antebrachial cutaneous nerve course beneath the skin along this furrow. More deeply are found the brachial artery and vein and the median and ulnar nerves;

(2) The cubital fossa in front of the elbow joint, between the bellies of the flexor and extensor muscles in the upper forearm.

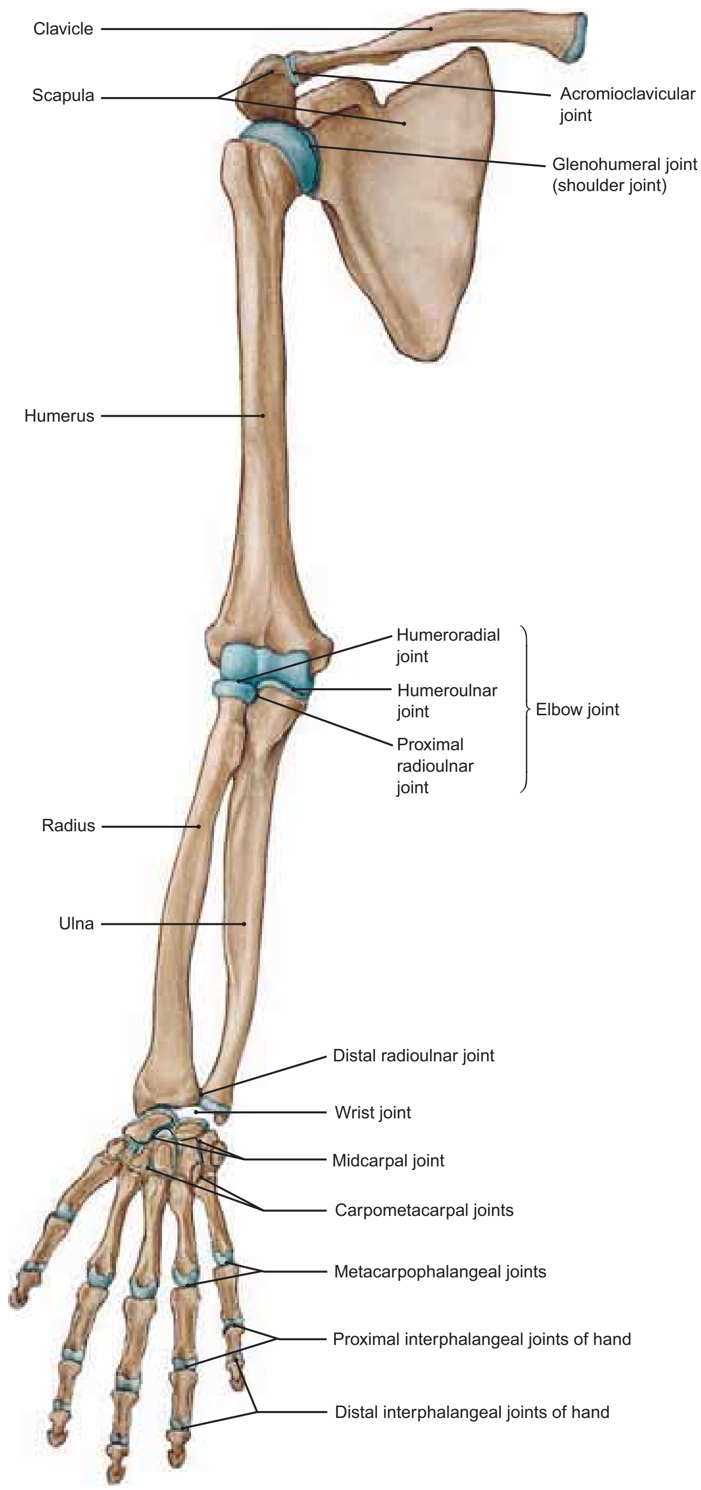


FIGURE 42.2 **Bones of the Upper Limb and Pectoral Girdle**

NOTE: The pectoral girdle includes the clavicle and the bones to which it is attached; these are the manubrium of the sternum and the scapula.

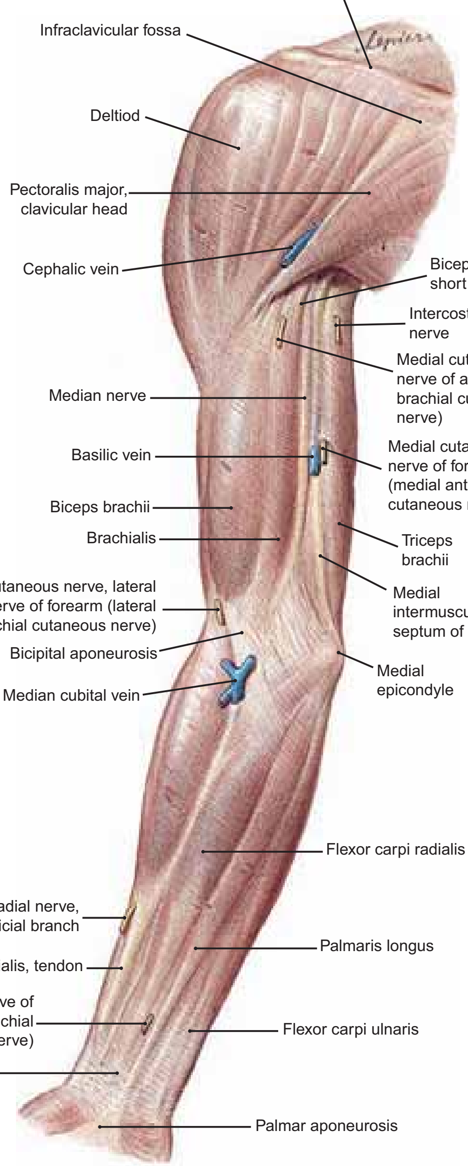


FIGURE 43.1 Fascia Over the Flexor Compartments of the Right Upper Limb (Anterior View)

NOTE: (1) The medial neurovascular compartment in the arm showing the median nerve, basilic vein, and medial antebrachial cutaneous nerve.
(2) Observe the flexor muscles of the arm and the flexor muscles of the forearm on the anterior aspect of the upper limb.

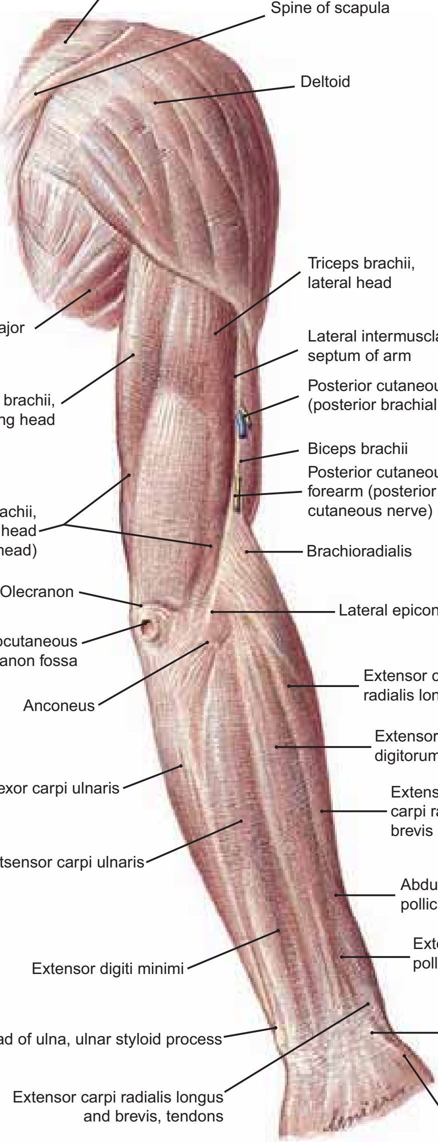


FIGURE 43.2 Fascia Over the Extensor Muscles of the Right Upper Limb (Posterior View)

NOTE: (1) The triceps muscle in the posterior compartment of the arm and the extensor muscles of the wrist and fingers on the dorsal aspect of the forearm.
(2) Observe the brachioradialis muscle, which flexes the forearm at the elbow joint when the forearm is pronated. Also note the extensor carpi radialis longus and brevis adjacent to the brachioradialis.

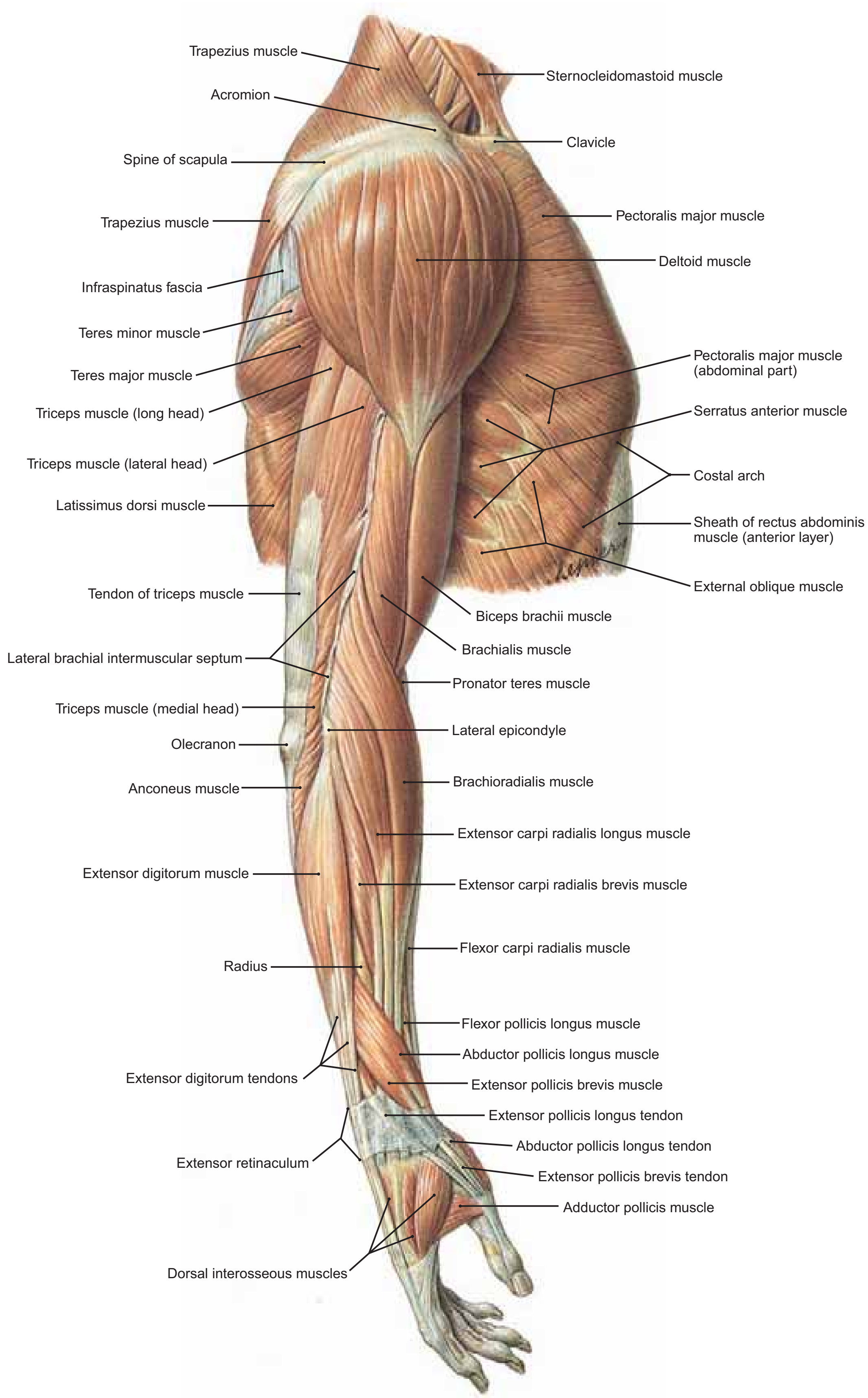
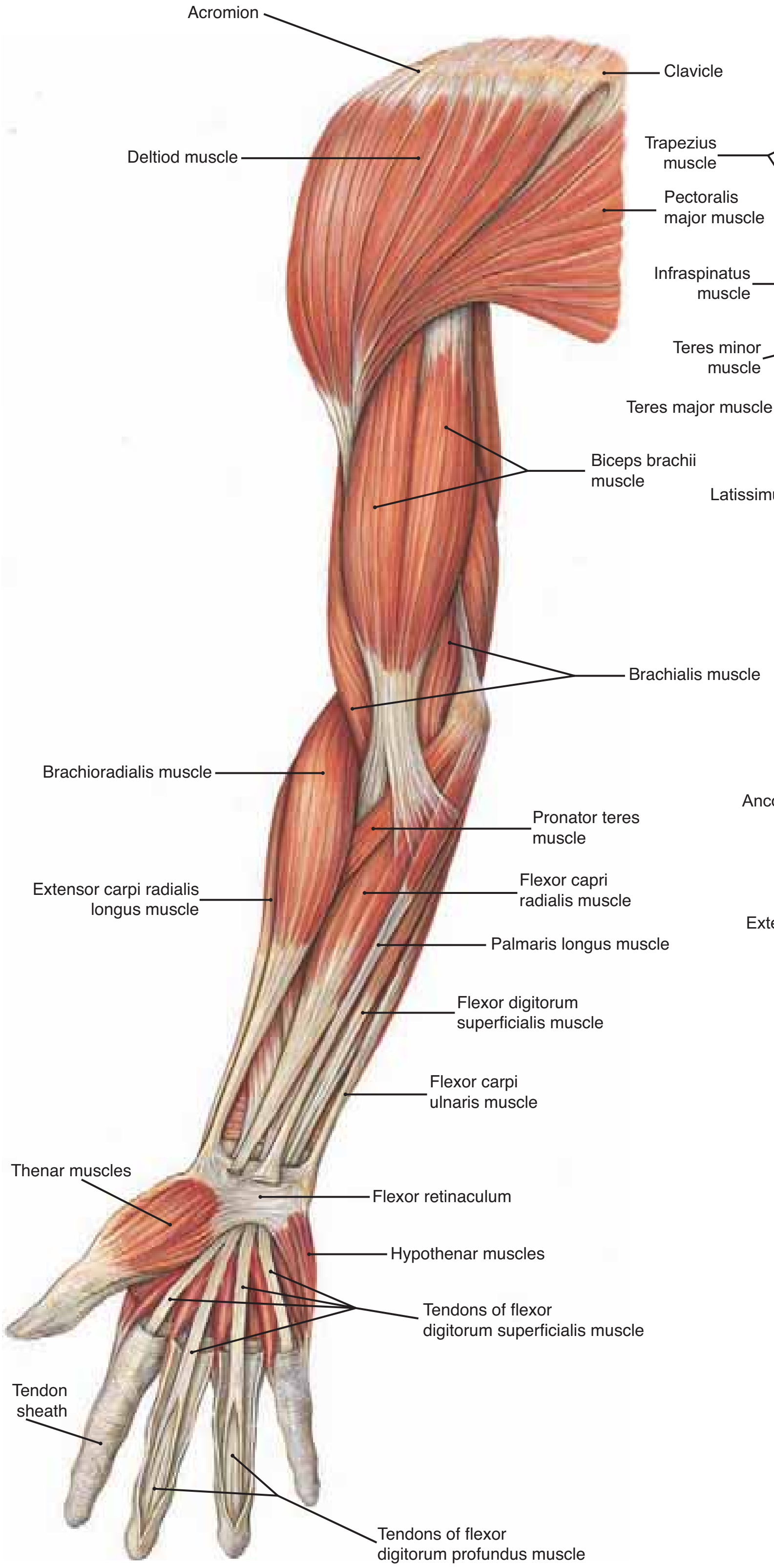


FIGURE 44 **Lateral View of the Muscles of the Upper Extremity and Lateral Thorax**

NOTE the lateral view of the **deltoid, triceps brachii, biceps brachii,** and **brachialis** in the arm; the **brachioradialis, extensor carpi radialis longus** and **brevis, extensor digitorum,** and **abductor** and **extensors pollicis longus** and **brevis** in the forearm. Also note the **adductor pollicis** and the **dorsal interosseous muscles** in the hand.



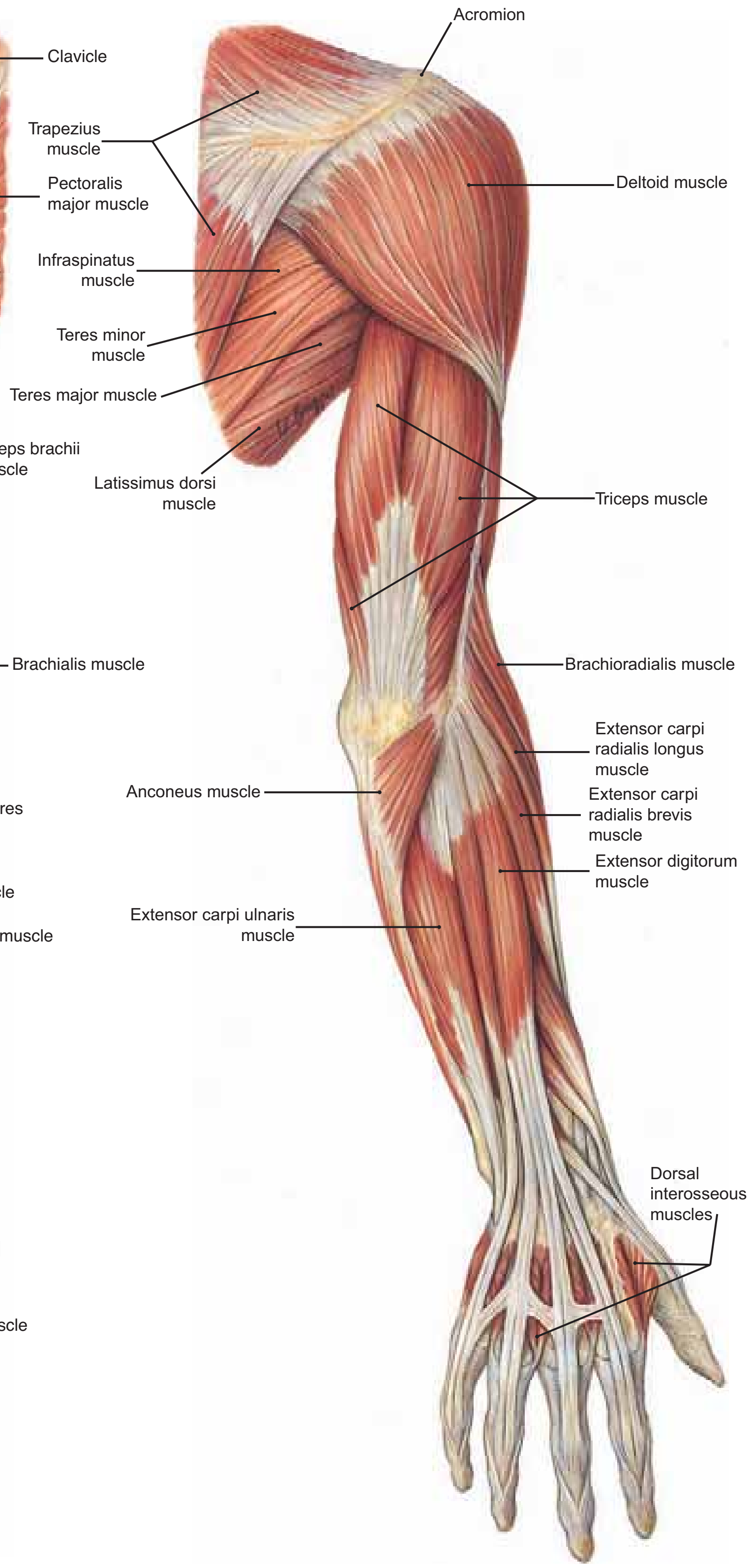


FIGURE 45.1 Muscles of the Upper Extremity (Anterior View)

NOTE the **biceps** and **brachialis** muscles in the arm; **pronator teres**, **flexor carpi radialis**, **palmaris longus**, **flexor digitorum**, and **flexor carpi ulnaris** in the forearm; and the **thenar** and **hypothenar** muscles in the hand along with the **flexor tendons**.

FIGURE 45.2 Muscles of the Upper Extremity (Posterior View)

NOTE the **triceps** and **brachialis** in the arm; the **brachioradialis**, **extensor carpi radialis longus** and **brevis**, **extensor digitorum**, and **extensor carpi ulnaris** muscles in the forearm; and the **dorsal interosseous** muscles in the hand.

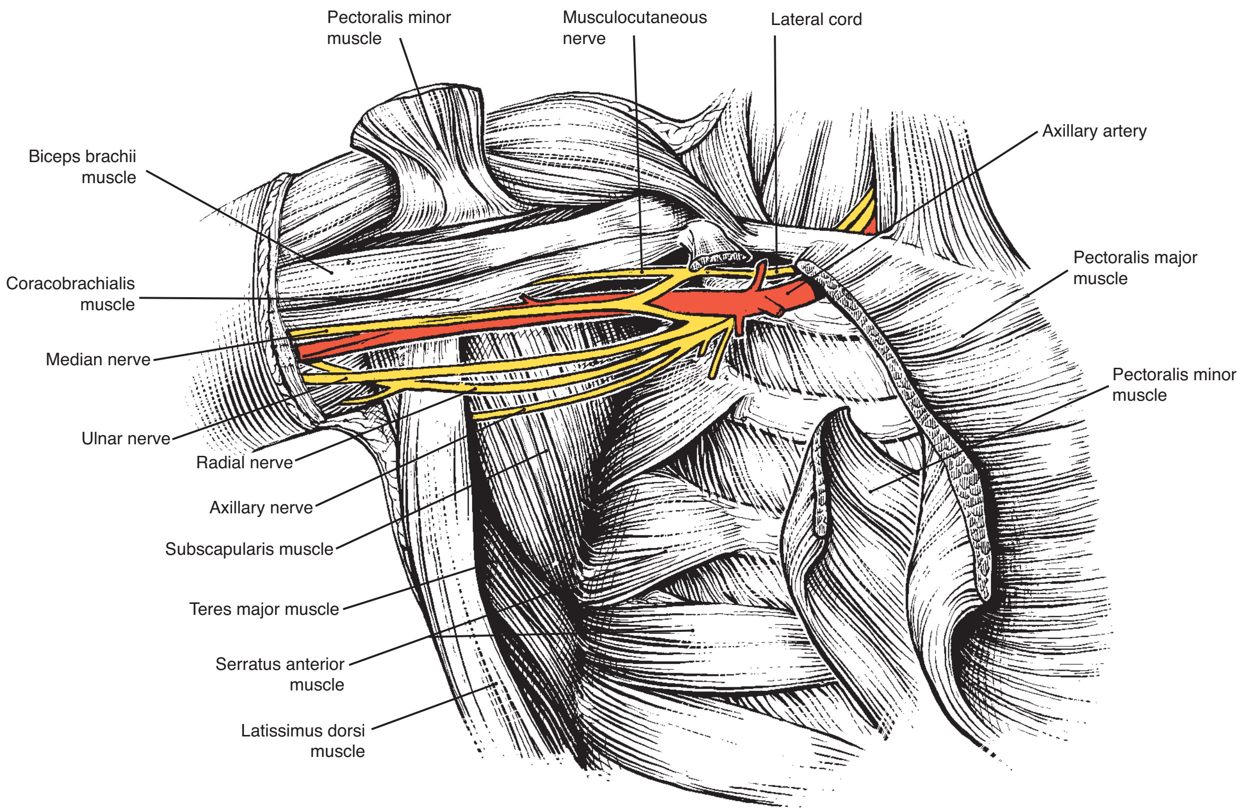


FIGURE 46.1 The Axillary Artery and the Cords of the Brachial Plexus

NOTE that the median nerve is formed by contributions from the lateral and medial cords (the **M** of the brachial plexus).
(Contributed by Dr. Gene L. Colborn, Medical College of Georgia.)

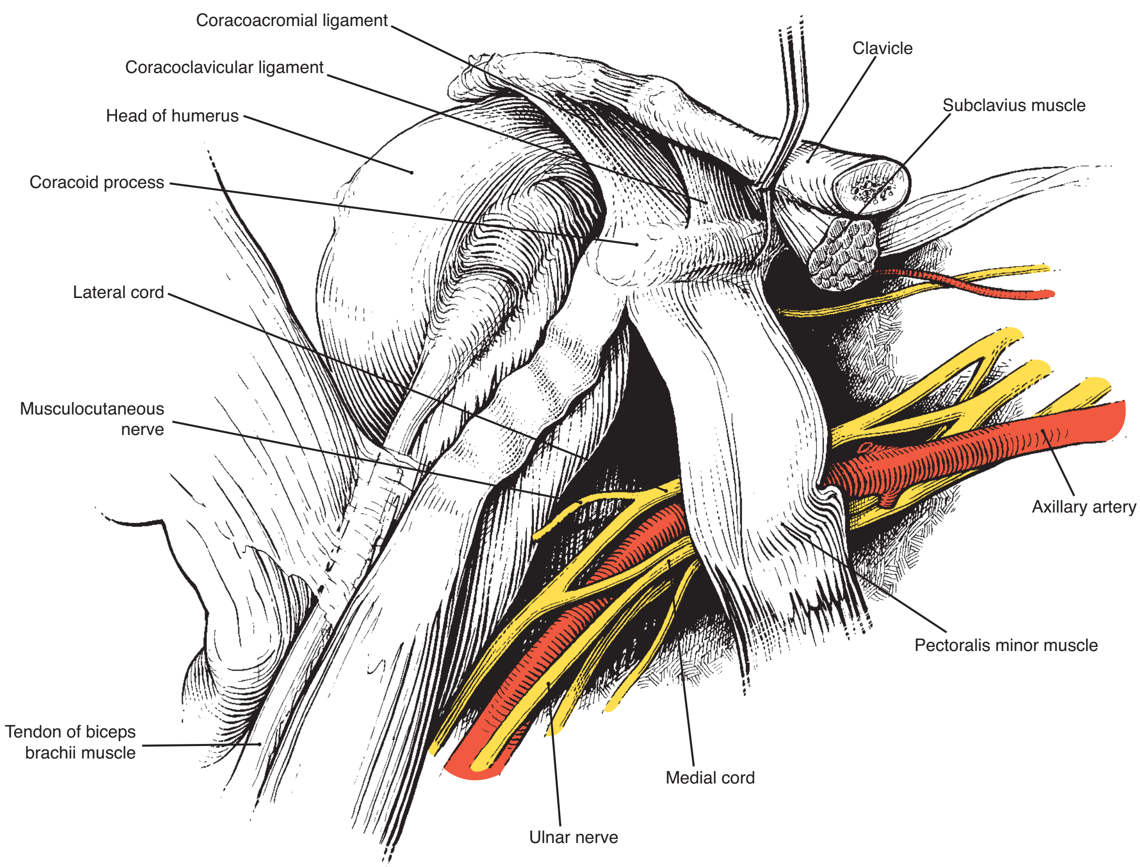


FIGURE 46.2 The Cords of the Brachial Plexus in the Axilla

NOTE the musculocutaneous, median, and ulnar nerves.
(Contributed by Dr. Gene L. Colborn, Medical College of Georgia.)

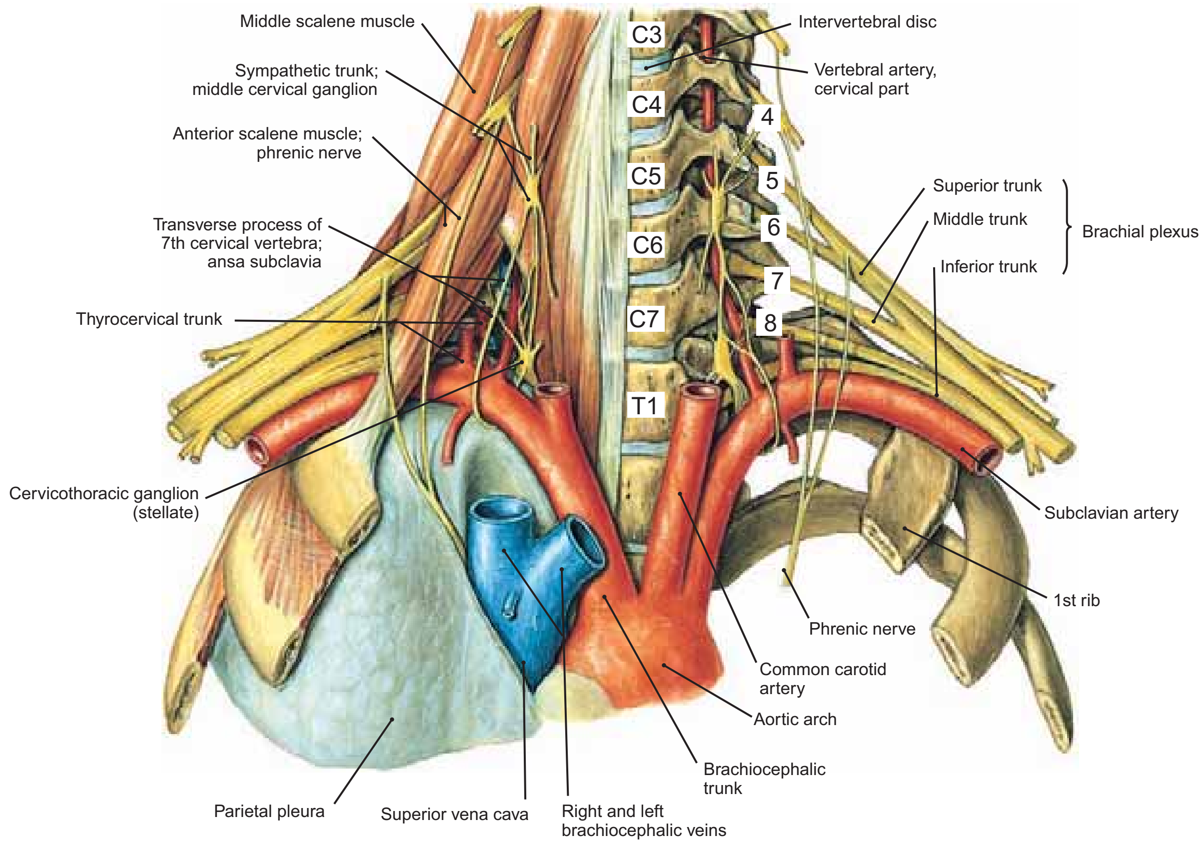


FIGURE 47.1 Roots of Origin of the Brachial Plexus in the Posterior Lateral Neck Region

NOTE: (1) The roots of C5, C6, C7, C8, and T1 emerge from the vertebral column and form the upper, middle, and lower trunks of the brachial plexus.
(2) C5 and C6 join to form the upper trunk, C7 forms the middle trunk, and C8 and T1 join to form the lower trunk.
(3) Crossing the first rib under the clavicle with the subclavian artery, each trunk splits into anterior and posterior divisions. The divisions then reassemble to form three cords: **lateral**, **medial**, and **posterior**. Now study Figure 47.2 and read its NOTE.

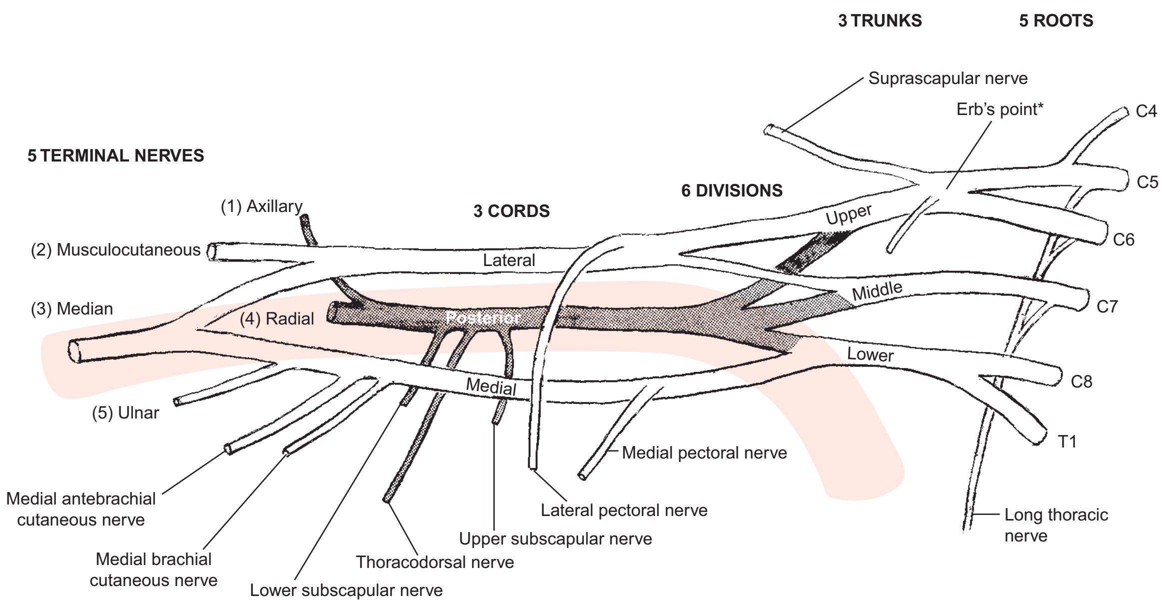


FIGURE 47.2 Diagrammatic View of the Brachial Plexus with Axillary Artery

NOTE the **5 roots** (C5, C6, C7, C8, T1), **3 trunks** (upper, middle, and lower), **6 divisions** (3 anterior, 3 posterior), **3 cords** (lateral, medial, and posterior), and **5 terminal nerves** (axillary, musculocutaneous, median, radial, and ulnar). ***Erb's point** is a point 2 to 3 cm above the clavicle and lateral to the posterior border of the sternocleidomastoid muscle at which the upper cord of the brachial plexus (C5–C6) can be stimulated electrically to cause certain muscles of the upper limb to contract.
(From *Clemente's Anatomy Dissector*, 2nd Edition. Baltimore: Lippincott Williams & Wilkins, 2007.)

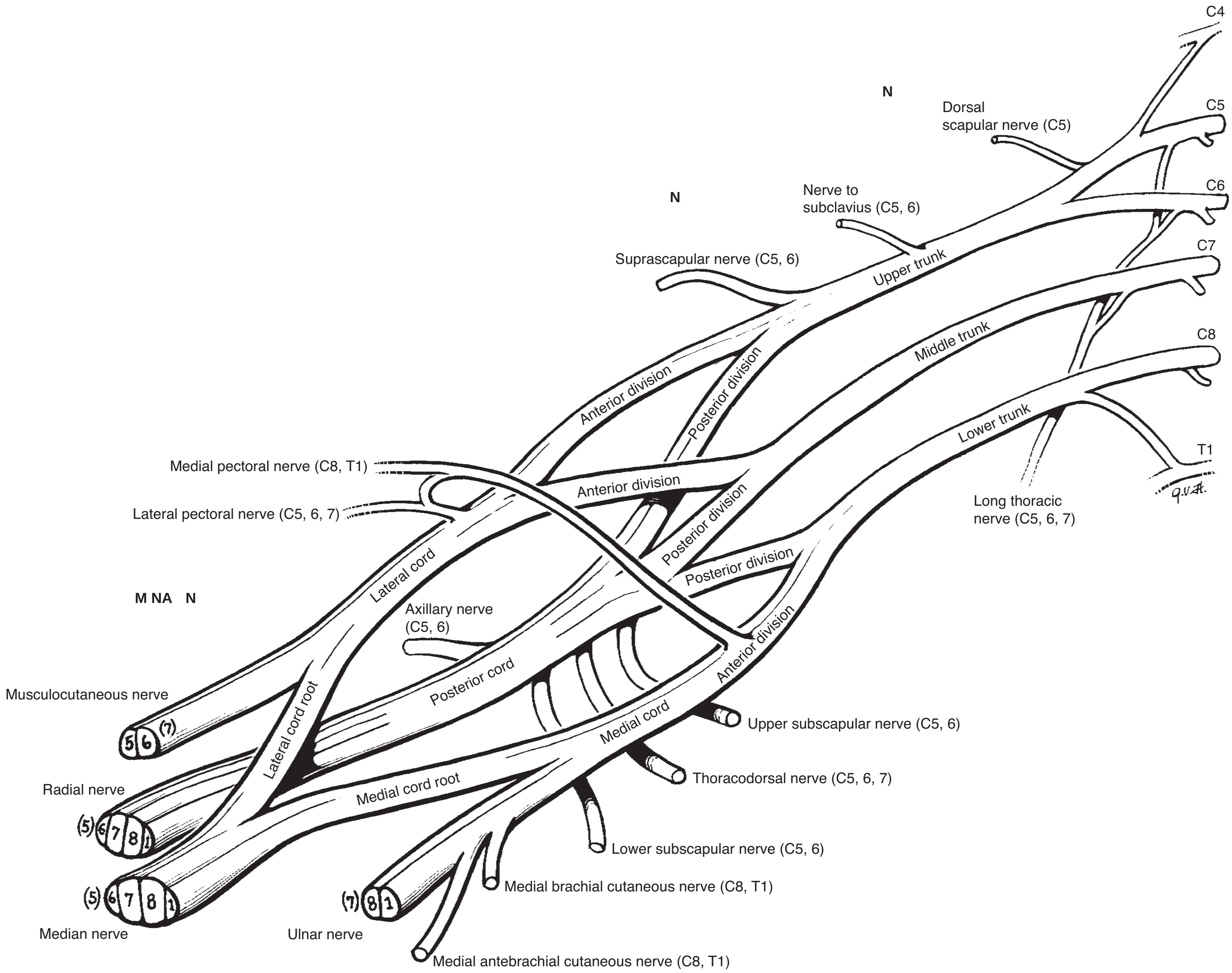


FIGURE 48 Formation of the Brachial Plexus

NOTE: (1) The brachial plexus commences with 5 spinal roots (**C5, C6, C7, C8, and T1**).

(2) The 5 roots join to form 3 trunks: **C5** and **C6** form the **upper** trunk, **C7** continues alone as the **middle** trunk, and **C8** and **T1** join to form the **lower** trunk.

(3) Deep to the clavicle, each trunk divides into an **anterior** and a **posterior division**.

(4) These 6 divisions form 3 cords in the axilla: the 3 posterior divisions form the **posterior cord**; the anterior divisions of the upper and middle trunks form the **lateral cord**; and the anterior division of the lower trunk continues as the **medial cord**.

(5) The posterior cord divides into a relatively small branch, the **axillary nerve**, and the large **radial nerve**.

(6) The lateral cord and the medial cord each sends a branch to form the **median nerve**.

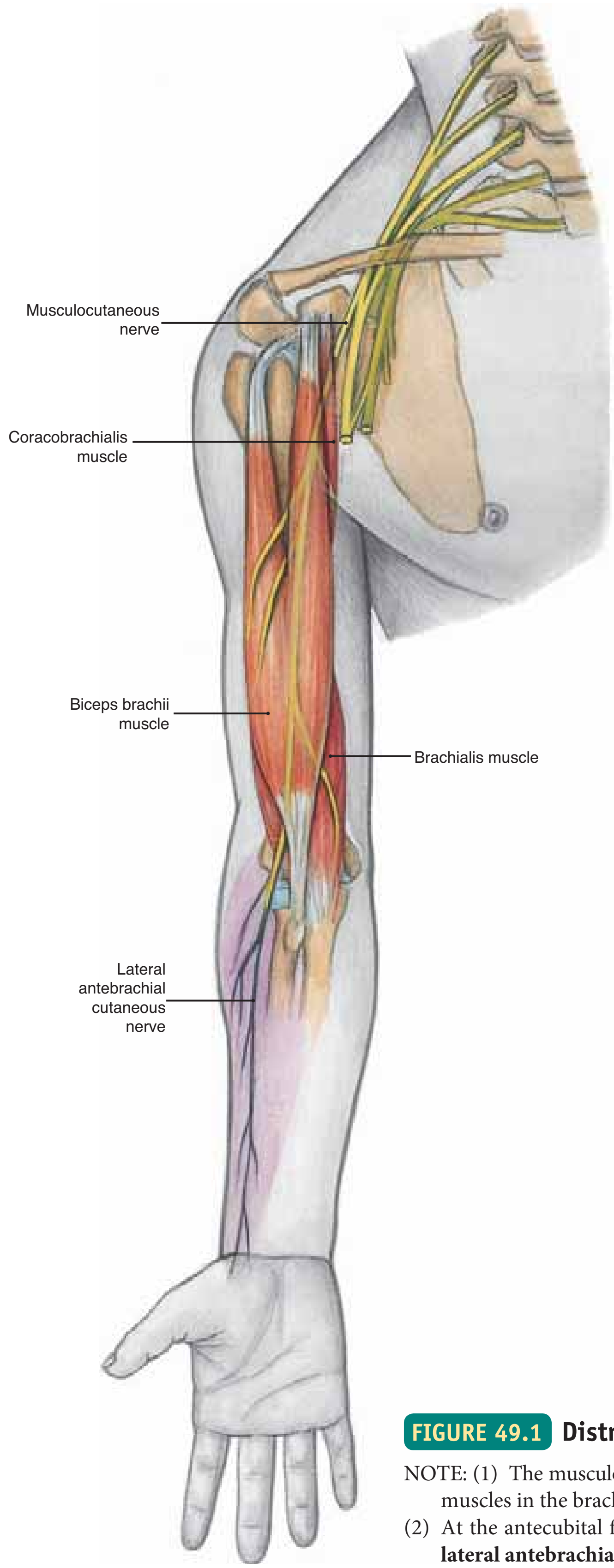
(7) The **musculocutaneous nerve** comes off of the lateral cord and the **ulnar nerve** continues from the medial cord down the upper limb.

(8) Eleven other nerves are given off, and they are listed to the right.

Complete brachial plexus:

NOTE: In addition to the 5 terminal nerves discussed to the left, the brachial plexus gives rise to 11 other nerves. These are the:

1. Long thoracic nerve (roots C6, C6, C7)
2. Dorsal scapular nerve (C5 root)
3. Nerve to subclavius muscle (upper trunk)
4. Subscapular nerve (upper trunk)
5. Lateral pectoral nerve (lateral cord)
6. Medial pectoral nerve (medial cord)
7. Medial brachial cutaneous nerve (medial cord)
8. Medial antebrachial cutaneous nerve (medial cord)
9. Upper subscapular nerve (posterior cord)
10. Thoracodorsal nerve (posterior cord)
11. Lower subscapular nerve (posterior cord)



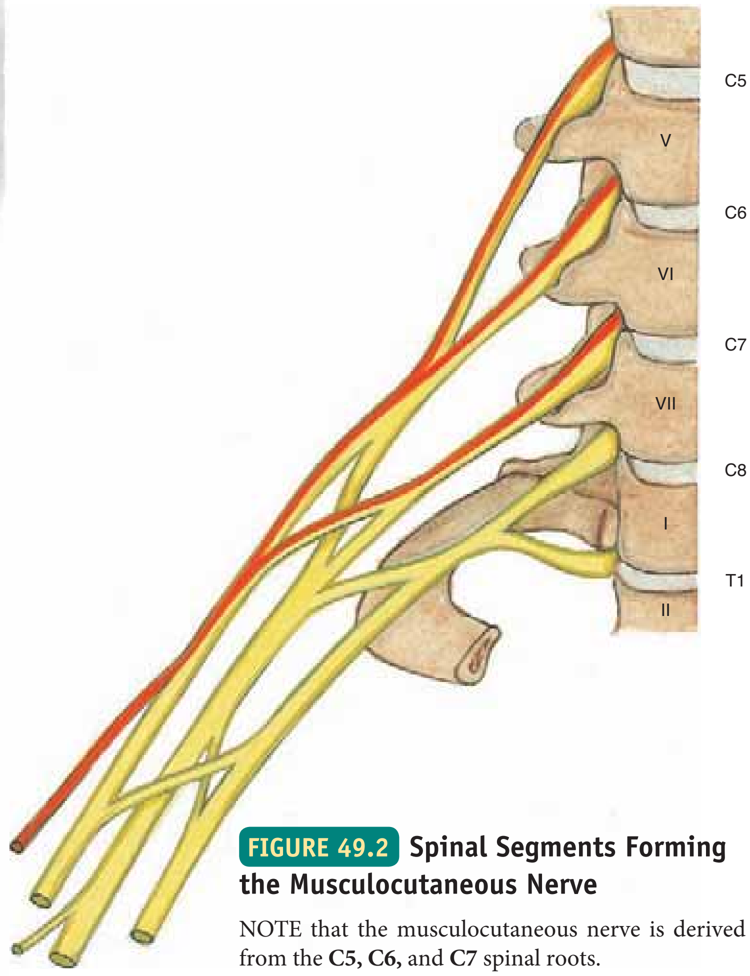


FIGURE 49.2 Spinal Segments Forming the Musculocutaneous Nerve

NOTE that the musculocutaneous nerve is derived from the **C5, C6,** and **C7** spinal roots.

FIGURE 49.1 Distribution of the Musculocutaneous Nerve

NOTE: (1) The musculocutaneous nerve supplies the **biceps brachii**, **brachialis**, and coracobrachialis muscles in the brachium.

(2) At the antecubital fossa, the nerve becomes superficial and continues down the forearm as the **lateral antebrachial cutaneous nerve** (also called the lateral cutaneous nerve of the forearm).

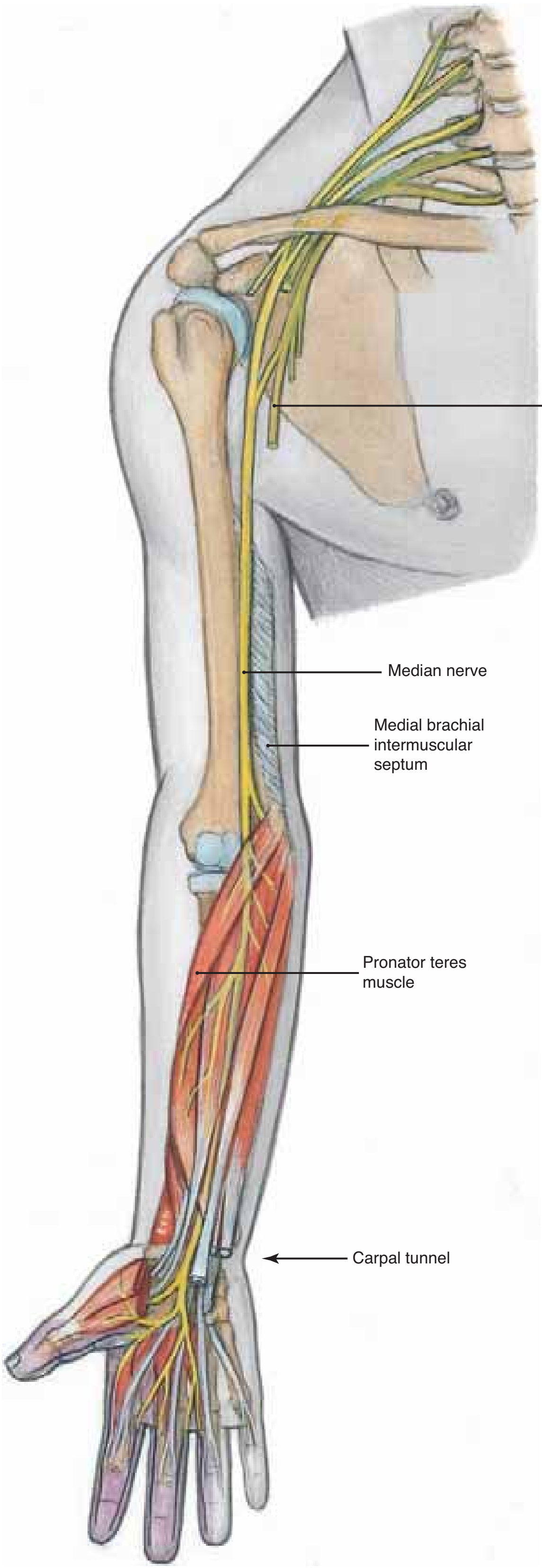


FIGURE 50.1 Median Nerve Distribution in the Forearm and Hand

NOTE that the median nerve supplies muscles in the anterior forearm, the three thenar muscles to the thumb, and the first two lumbrical muscles in the hand.

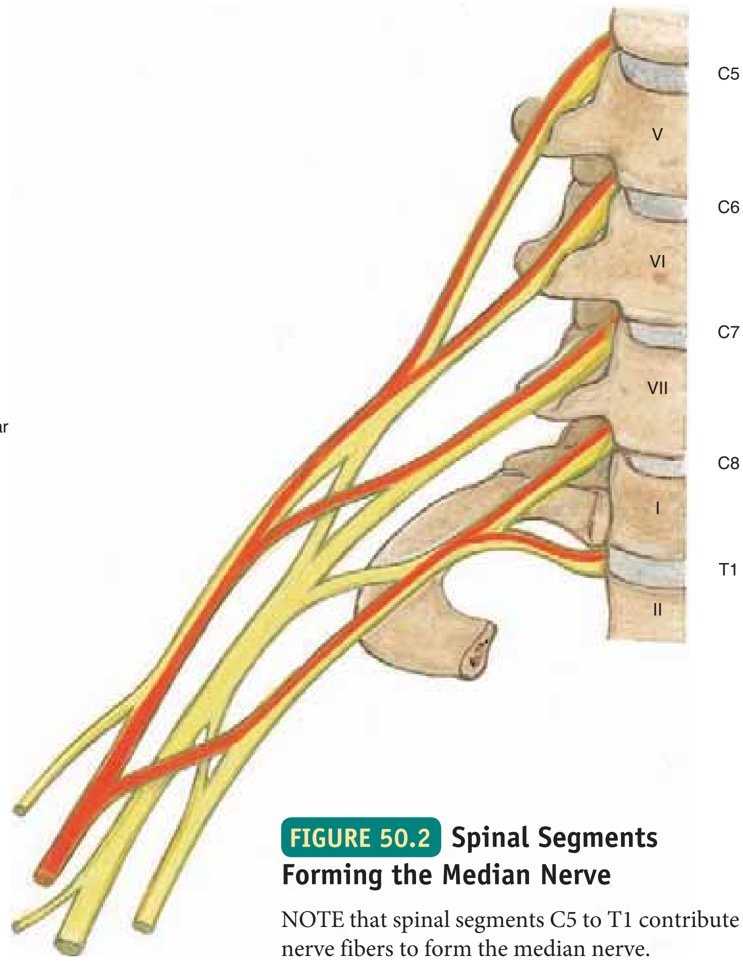
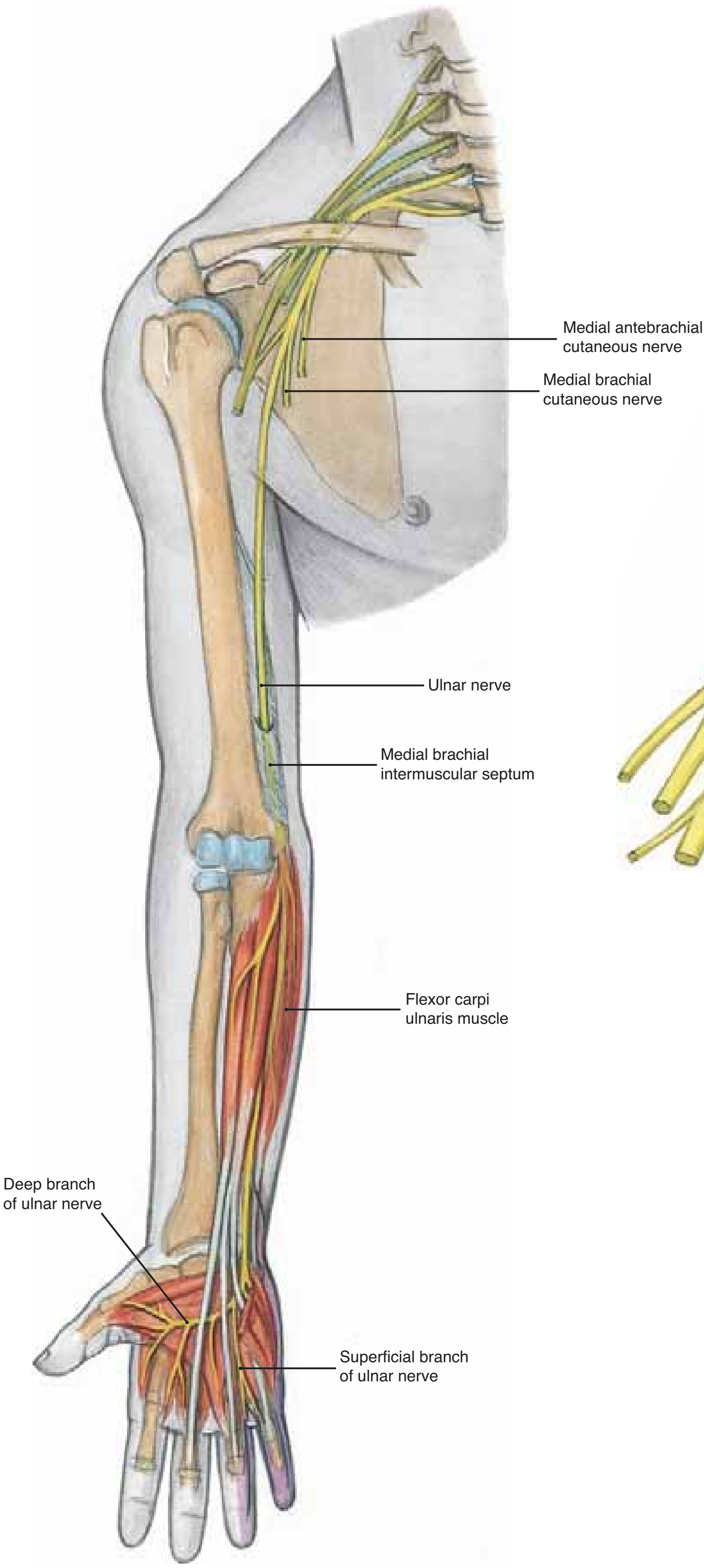


FIGURE 50.2 Spinal Segments Forming the Median Nerve

NOTE that spinal segments C5 to T1 contribute nerve fibers to form the median nerve.

FIGURE 50.3 Median Nerve Palsy

NOTE that lesions of the median nerve result in an inability to flex the thumb, the index finger, and the middle finger at the metacarpophalangeal joint. The ring and little fingers can still be flexed because the ulnar nerve is intact.



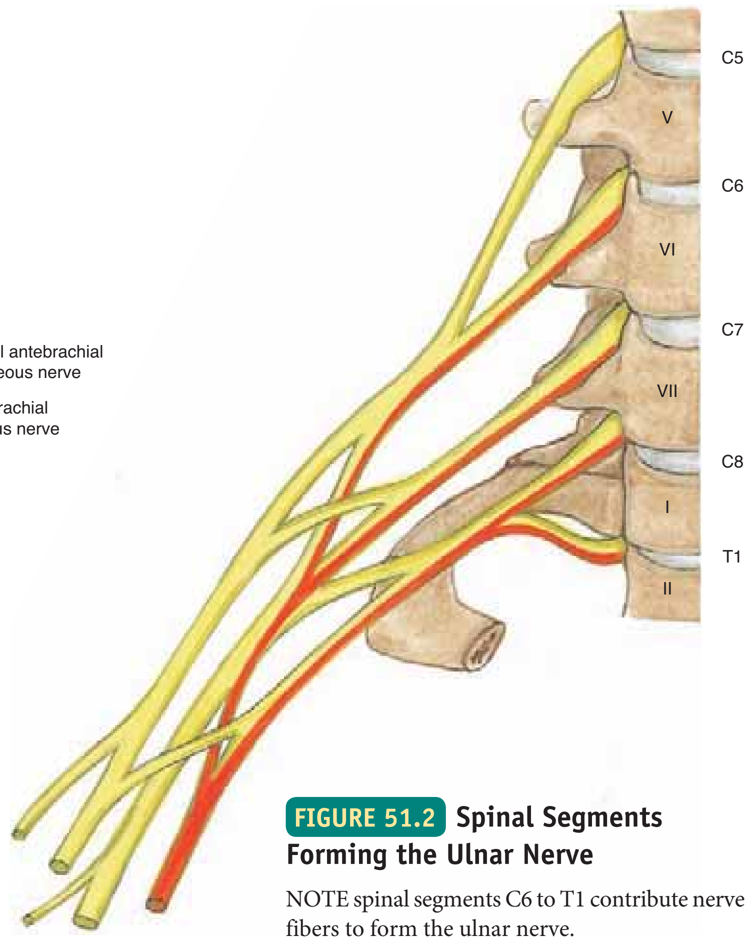


FIGURE 51.2 Spinal Segments Forming the Ulnar Nerve

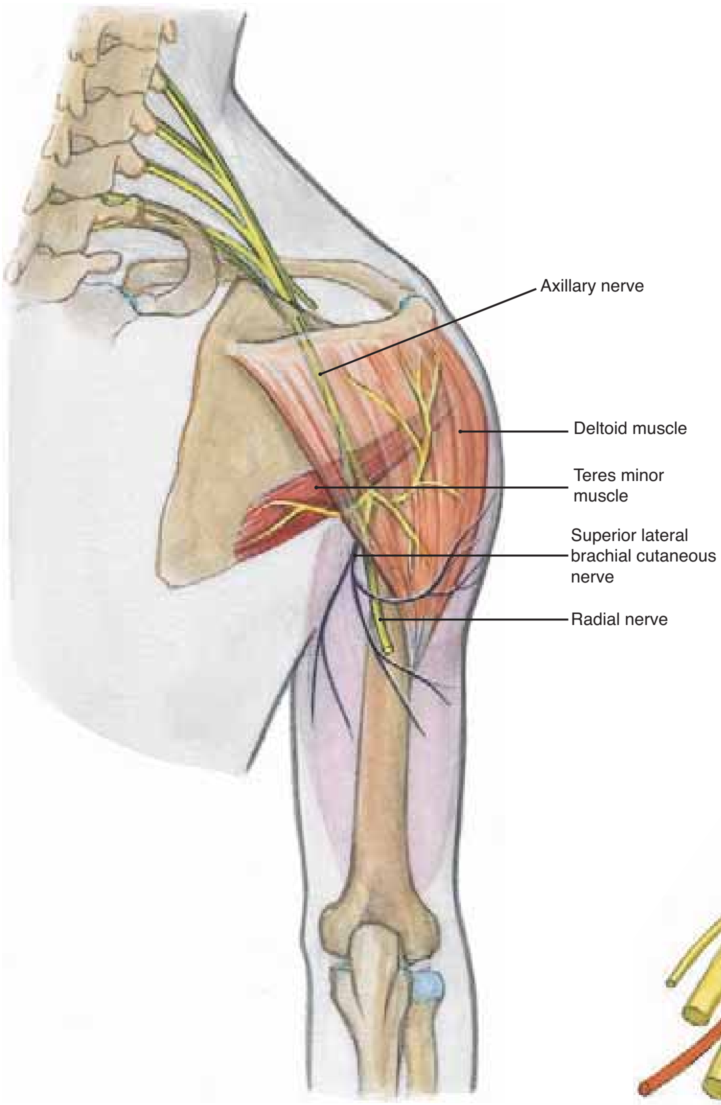
NOTE spinal segments C6 to T1 contribute nerve fibers to form the ulnar nerve.

FIGURE 51.1 Ulnar Nerve Distribution in the Forearm and Hand

NOTE: (1) The ulnar nerve supplies the flexor carpi ulnaris and the medial half of the flexor digitorum profundus in the forearm.
(2) In the hand, the ulnar nerve supplies the three hypothenar muscles, the third and fourth lumbricals, all of the interossei, and sensory innervation to the skin of the ulnar 1½ digits on the palmar and dorsal sides.

FIGURE 51.3 Ulnar Nerve Palsy

NOTE: (1) Lesions of the ulnar nerve result in an inability to flex the distal interphalangeal joint of the fourth and fifth digits. Patients cannot make a complete fist. This results in a hand that has a characteristic deformity known as "**claw hand**."
(2) Also, there is loss of sensory innervation to the ulnar aspect of the hand and the medial 1½ digits.



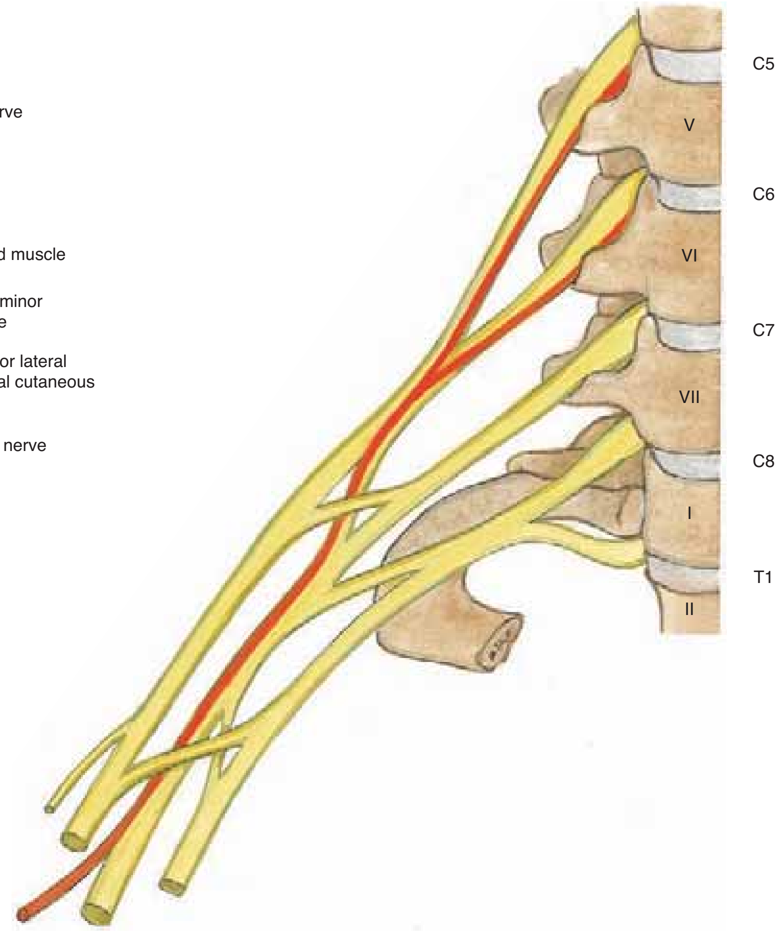


FIGURE 52.1 Axillary Nerve Distribution in the Arm and Shoulder

NOTE that the axillary nerve supplies the deltoid and teres minor muscles. It also gives sensory fibers to the shoulder joint and to the skin over the inferior part of the shoulder joint.

FIGURE 52.2 Spinal Segments Forming the Axillary Nerve

NOTE that spinal segments C5 and C6 contribute nerve fibers to form the axillary nerve.

FIGURE 52.3 Ulnar Nerve Palsy

NOTE that lesions of the axillary nerve result in atrophy of the deltoid muscle that overlies the shoulder region. The teres minor muscle is also denervated. Loss of the deltoid results in a protrusion of the bony structures on the lateral aspect of the shoulder, as seen in this figure.

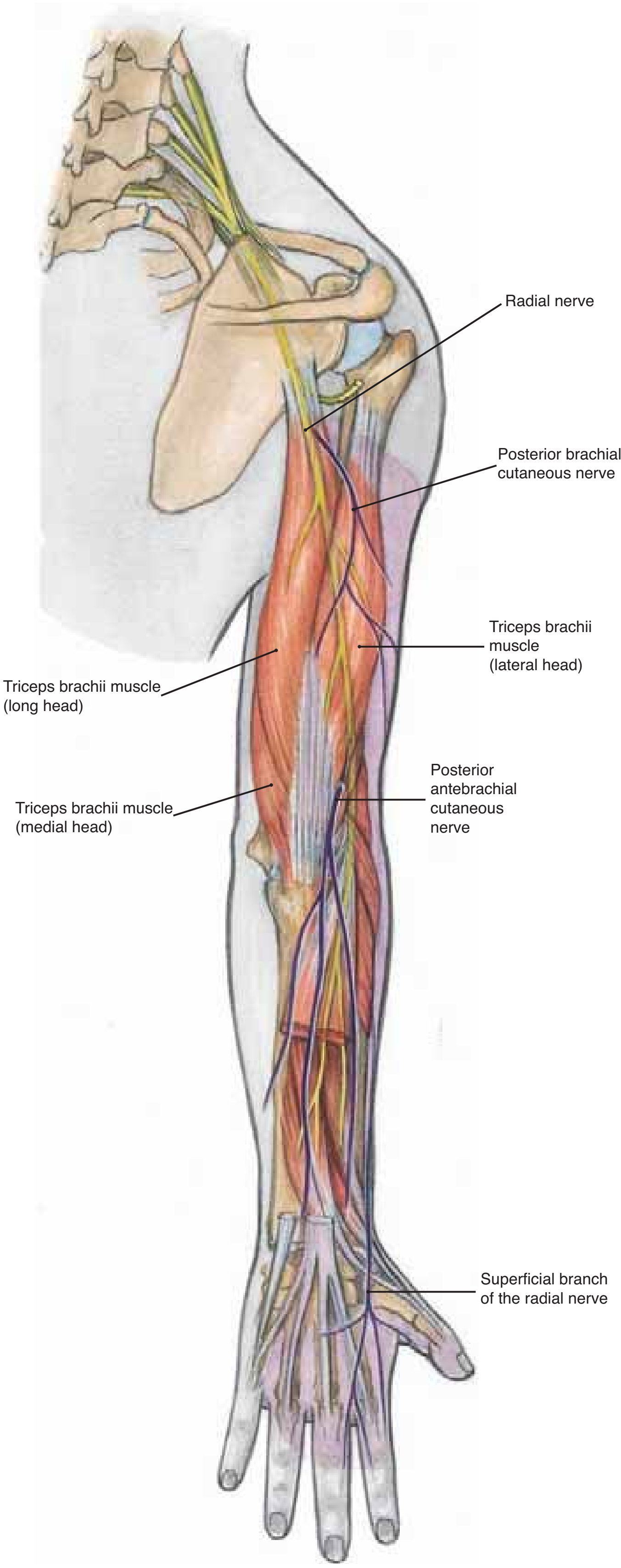


FIGURE 53.1 **Radial Nerve Distribution to the Upper Limb**

NOTE: (1) The radial nerve descends from the posterior cord of the brachial plexus to supply the triceps brachii muscle and the extensor muscles in the posterior forearm.
(2) Its sensory branches supply the posterior arm and forearm to the dorsum of the hand. It supplies the thumb, the index and middle fingers, and half of the ring finger down to the distal interphalangeal joint.

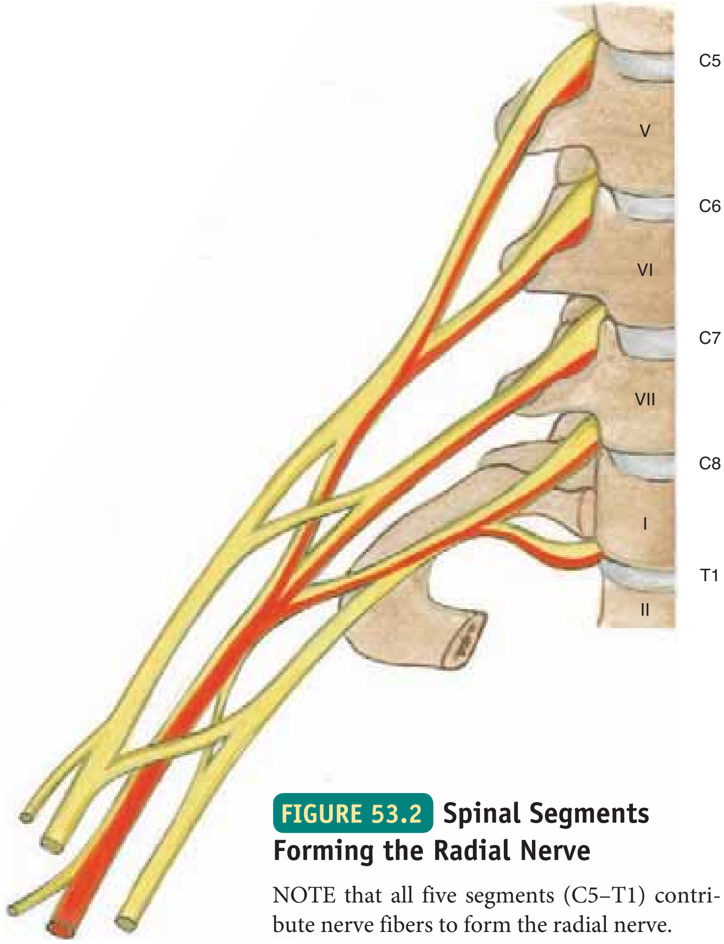


FIGURE 53.2 **Spinal Segments Forming the Radial Nerve**

NOTE that all five segments (C5–T1) contribute nerve fibers to form the radial nerve.

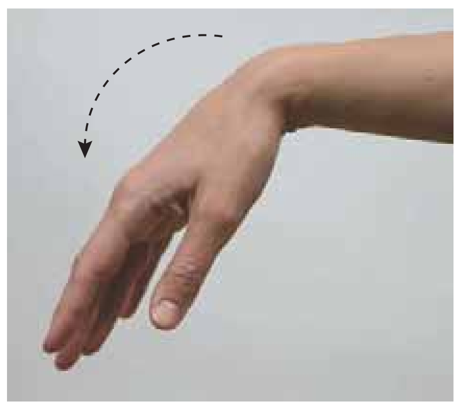


FIGURE 53.3 **Radial Nerve Palsy**

NOTE that a lesion of the radial nerve in the arm results in denervation of the extensor muscles in the forearm. Because the forearm flexor muscles are no longer opposed, a condition called "**wrist drop**" occurs.

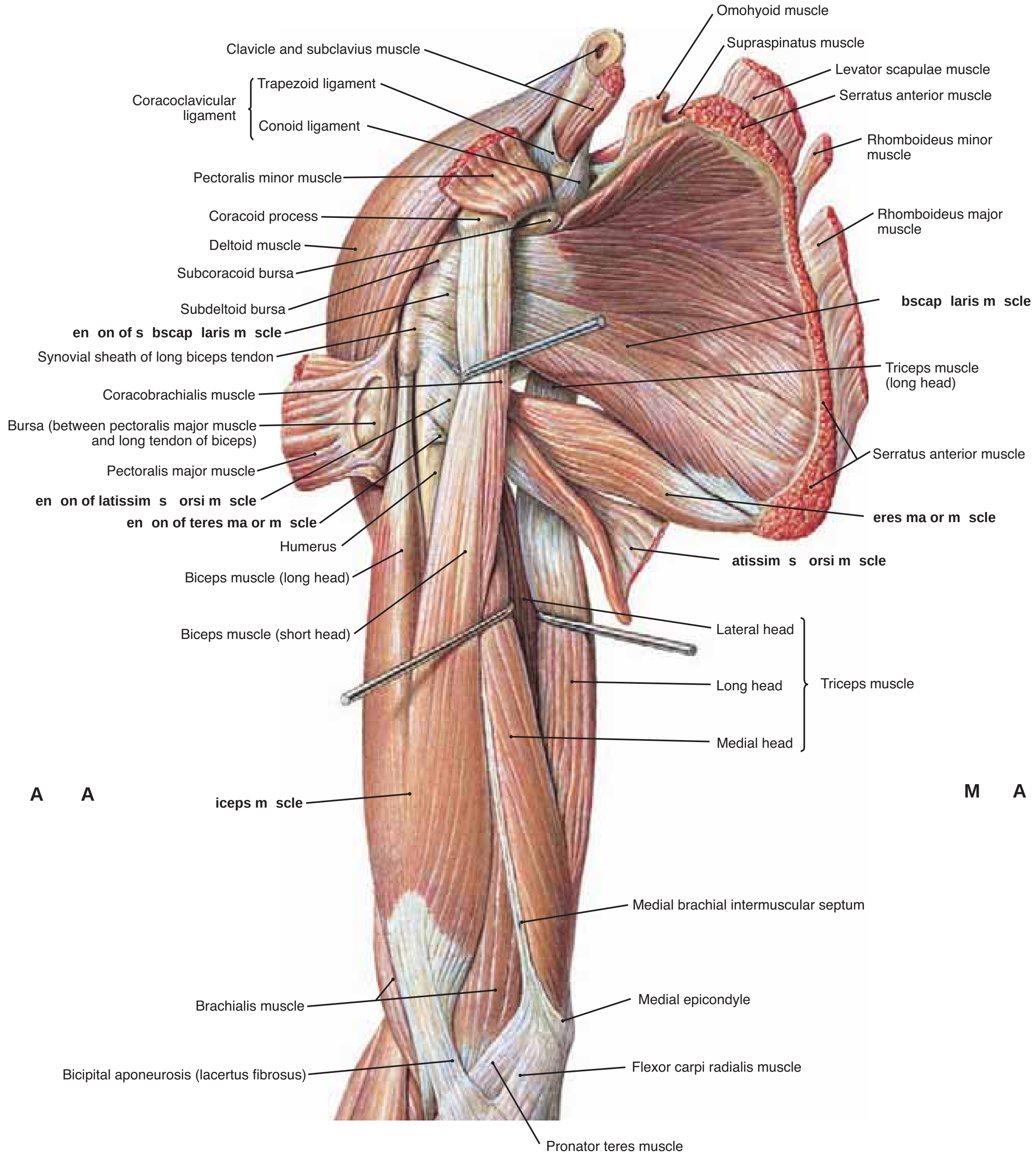


FIGURE 54 Muscles of the Right Shoulder and Arm (Anterior View)

NOTE: (1) The insertion of the subscapularis muscle on the lesser tubercle of the humerus. Distal to this, from medial to lateral, insert the teres major, latissimus dorsi, and pectoralis major muscles.

(2) The pectoralis minor, coracobrachialis, and short head of the biceps all attach to the coracoid process.

(3) The tendon of insertion of the pectoralis major muscle and the long tendon of the biceps muscle are usually separated by a bursa.

(4) From its origin on the coracoid process, the short head of the biceps courses inferiorly and laterally across the tendons of the subscapularis and latissimus dorsi to join the belly of the long head.

(5) The biceps is a very powerful supinator of the forearm and it is an efficient flexor of the forearm, especially when the forearm is supinated.

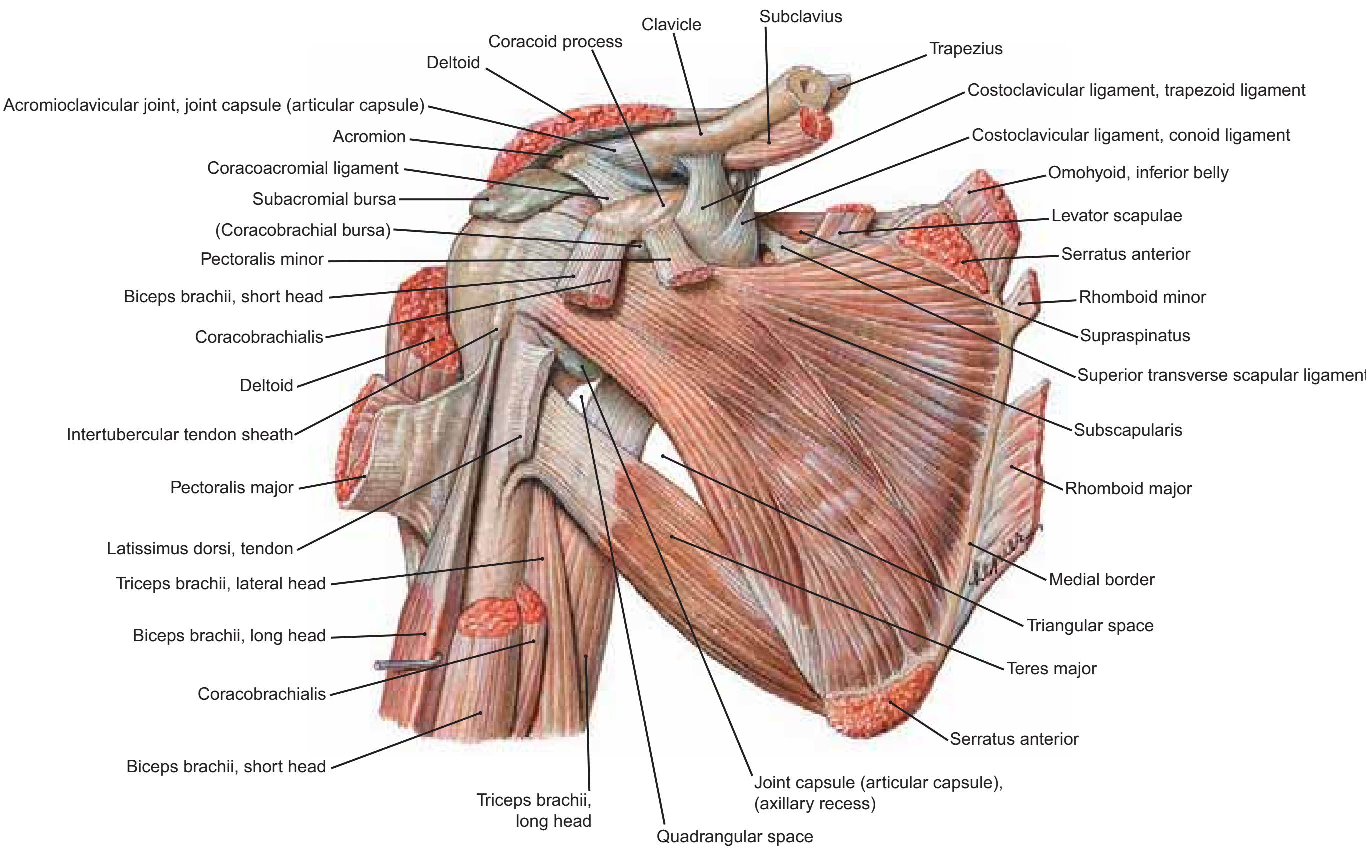


FIGURE 55.1 Anterior View of the Shoulder Muscles

NOTE the subcapularis muscle on the anterior surface of the scapula. It is one of the four muscles that make up the **rotator cuff**. It is a medial rotator of the humerus.

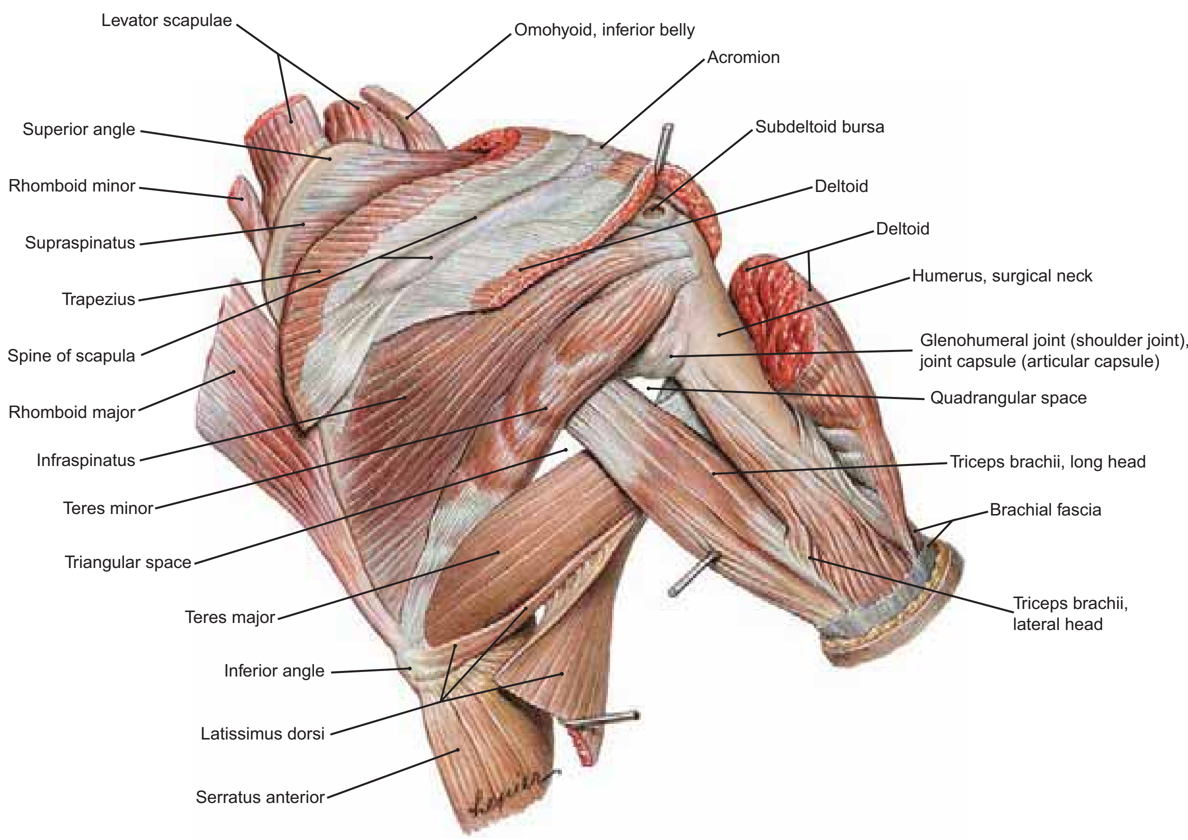


FIGURE 55.2 Posterior View of the Shoulder Muscles

NOTE the **quadrangular space**; through it course the axillary nerve and posterior humeral circumflex artery from the anterior axilla to the posterior surface of the shoulder. Also note the **triangular space** that transmits the circumflex scapular branch of the subscapular artery.

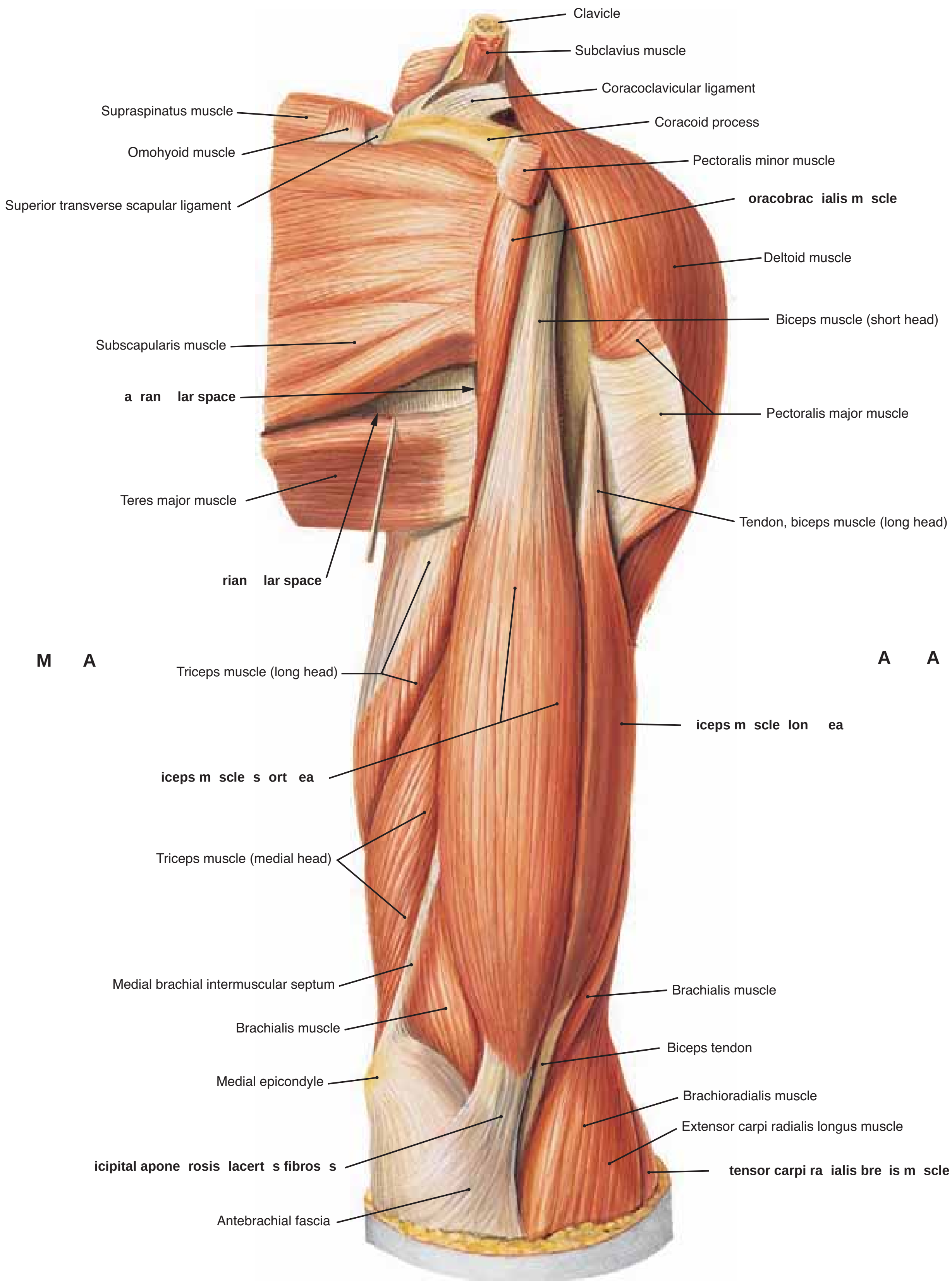


FIGURE 56 Superficial View of Muscles on the Anterior Aspect of the Left Arm

Muscle	Origin	Insertion	Innervation	Action
Biceps brachii	Long head: Supraglenoid tubercle of the scapula. Short head: Coracoid process of the scapula	Tuberosity of the radius and the bicipital aponeurosis	Musculocutaneous nerve (C5, C6)	Flexes and supinates the forearm; long head can also assist in flexing the humerus

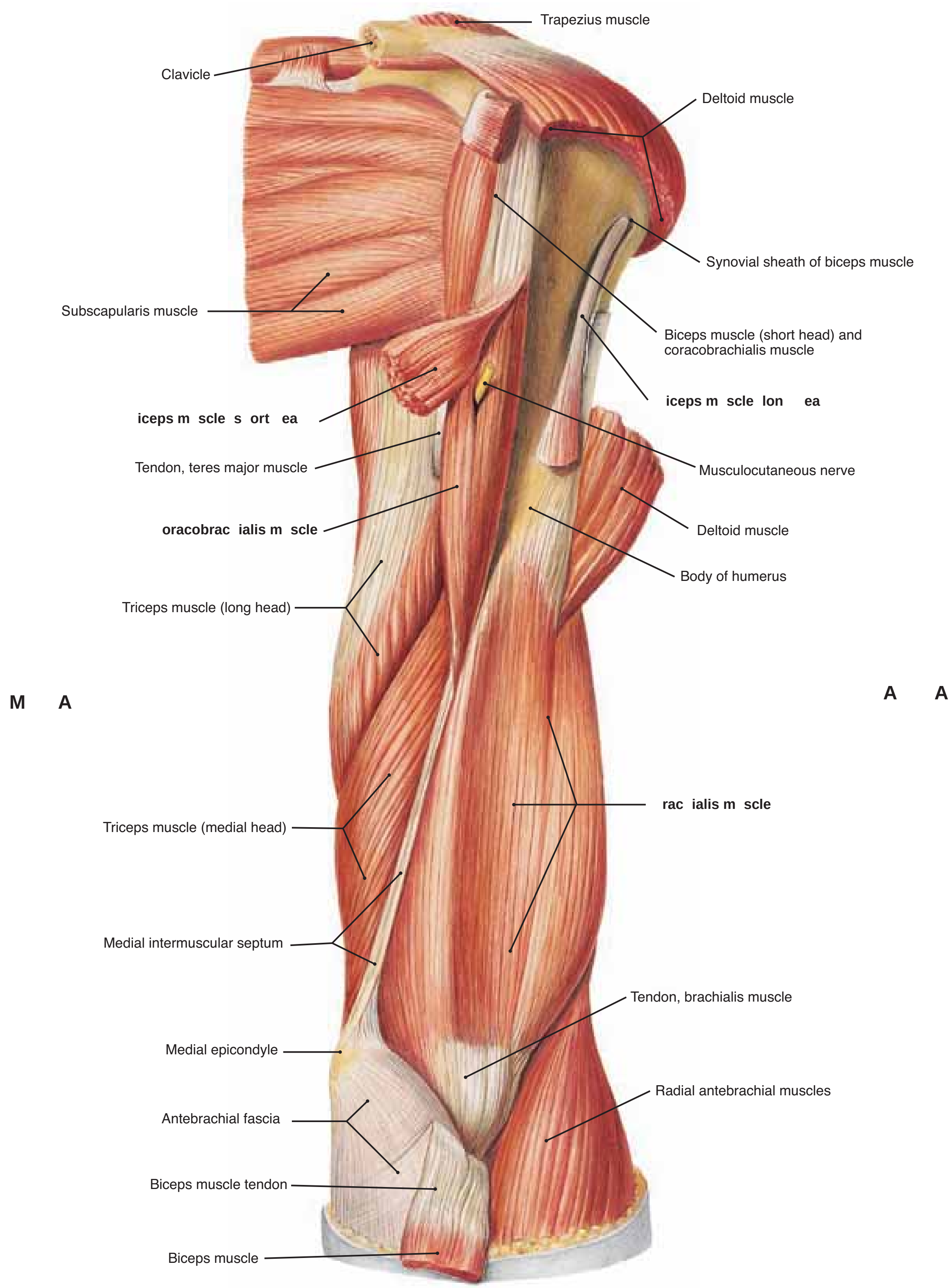


FIGURE 57 Deep View of the Muscles on the Anterior Aspect of the Left Arm

Muscle	Origin	Insertion	Innervation	Action
Brachialis	Distal half of anterior surface of the humerus	Tuberosity of the ulna and anterior surface of the coronoid process	Musculocutaneous nerve and often a small branch of the radial nerve (C5, C6)	Powerful flexor of the forearm
Coracobrachialis	Coracoid process of the scapula	Along the medial surface of the humerus near its middle	Musculocutaneous nerve (C6, C7)	Flexes and adducts the arm

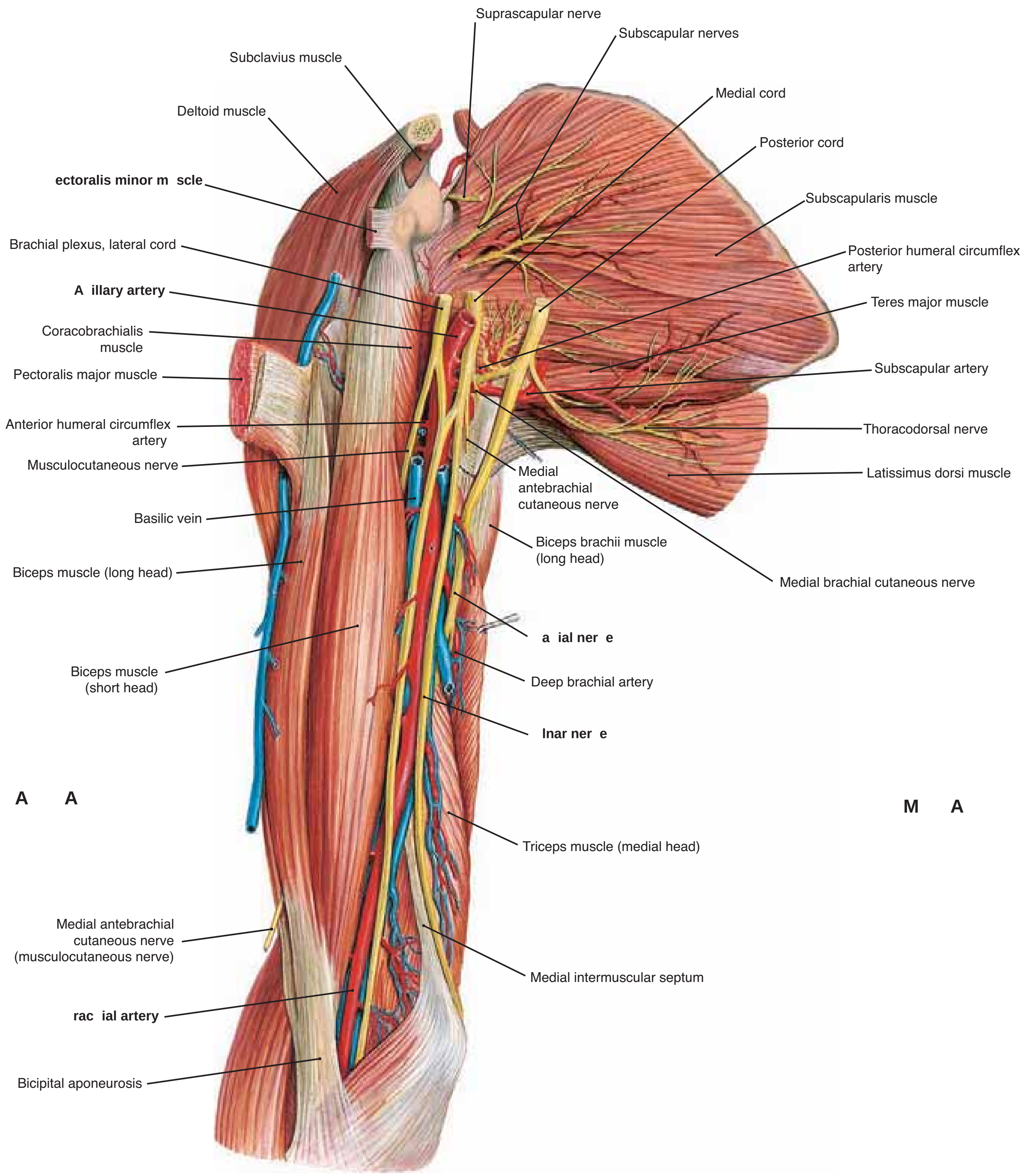


FIGURE 58 Vessels and Nerves of the Anterior Arm (Right Arm, Superficial Dissection)

NOTE: (1) The **median nerve** crosses the brachial artery anteriorly from lateral to medial just above the cubital fossa.

(2) The median nerve arises by two roots, one each from the medial and lateral cords of the brachial plexus. The lateral cord then continues downward as the **musculocutaneous nerve**, whereas the medial cord becomes the **ulnar nerve** distal to the axilla.

(3) At the origin of the median nerve, its two roots and the musculocutaneous and ulnar nerves combine to form an outline that resembles the letter M.

(4) Neither the ulnar nor the median nerve gives off branches in the arm region.

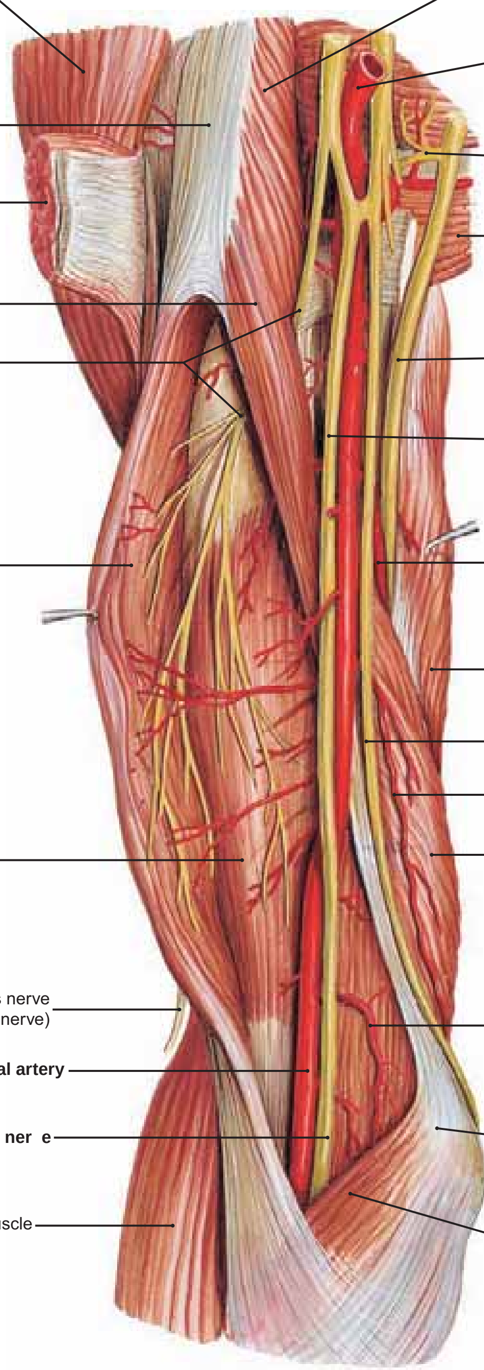


FIGURE 59 **Nerves and Arteries of the Anterior Right Arm (Deep Dissection)**

NOTE: (1) The musculocutaneous nerve descends from the lateral cord and perforates the coracobrachialis muscle, which it supplies.

(2) The short head of the biceps muscle has been pulled aside to reveal the musculocutaneous nerve more deeply between the biceps and brachialis muscles, both of which it supplies. This nerve continues into the forearm as the **lateral antebrachial cutaneous nerve**.

(3) The superficial course of the brachial artery in the arm. Its branches include the profunda (deep) brachial artery and the superior and inferior ulnar collateral arteries, in addition to its muscular branches.

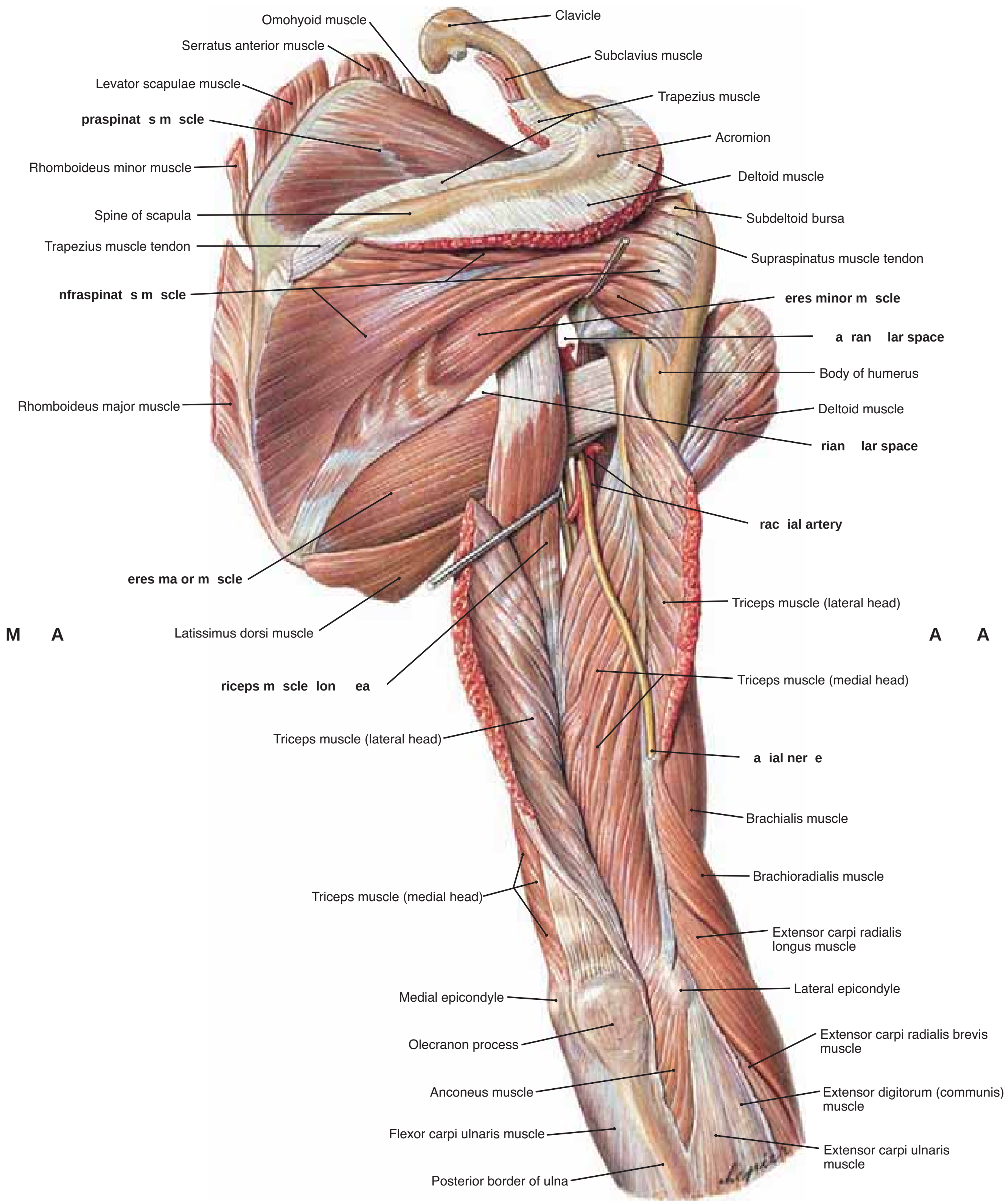


FIGURE 60 Muscles of the Right Shoulder and Deep Arm (Posterior View)

NOTE: (1) The deltoid muscle and the lateral head of the triceps have been severed, thereby exposing the course of the radial nerve in the upper arm.
(2) The sequential insertions of the supraspinatus, infraspinatus, and teres minor on the greater tubercle of the humerus.
(3) The boundaries of the quadrangular space: **medial**, long head of triceps; **lateral**, the humerus; **superior**, teres minor; and **inferior**, teres major. The axillary nerve and posterior humeral circumflex vessels course through the space.
(4) The boundaries of the triangular space: **superior**, teres minor; **inferior**, teres major; and **lateral**, long head of triceps. The circumflex scapular vessels course through the space.

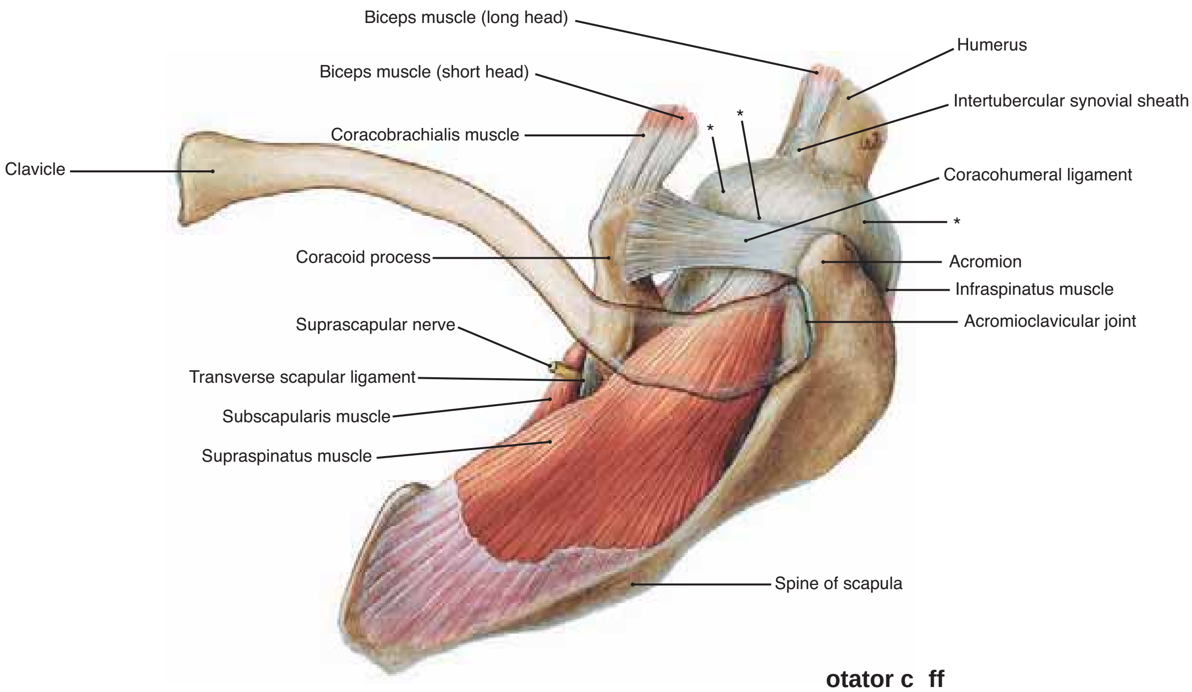


FIGURE 61.1 **The Supraspinatus Muscle Inserting into the Rotator Cuff Tendinous Capsule**

NOTE: (1) The supraspinatus muscle located in the supraspinatus fossa (above the scapular spine) coursing laterally to the head of the humerus.

(2) The tendon of the supraspinatus muscle participates in the formation of the **rotator cuff** (indicated by the asterisks [*]). This is the musculotendinous capsule surrounding the head of the humerus.

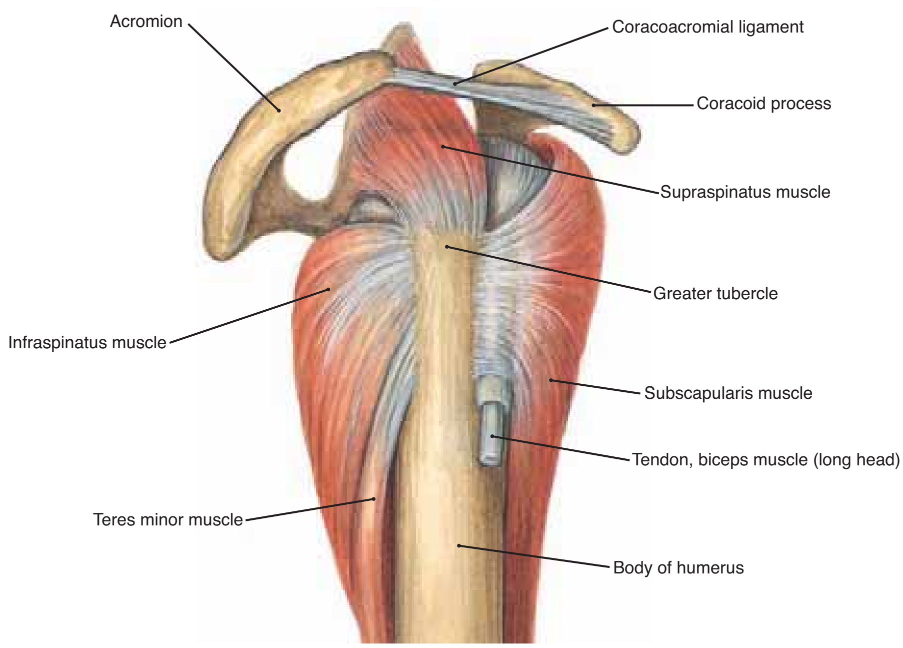


FIGURE 61.2 **Rotator Cuff Muscles (Lateral View of the Humeral Head)**

NOTE: (1) The four muscles—**supraspinatus**, **infraspinatus**, **teres minor**, and **subscapularis**—have tendons of insertion on the head of the humerus. These form a musculotendinous capsule called the **rotator cuff**.

(2) The supraspinatus approaches the humerus superiorly, the infraspinatus and teres minor anteriorly, and the subscapularis posteriorly.

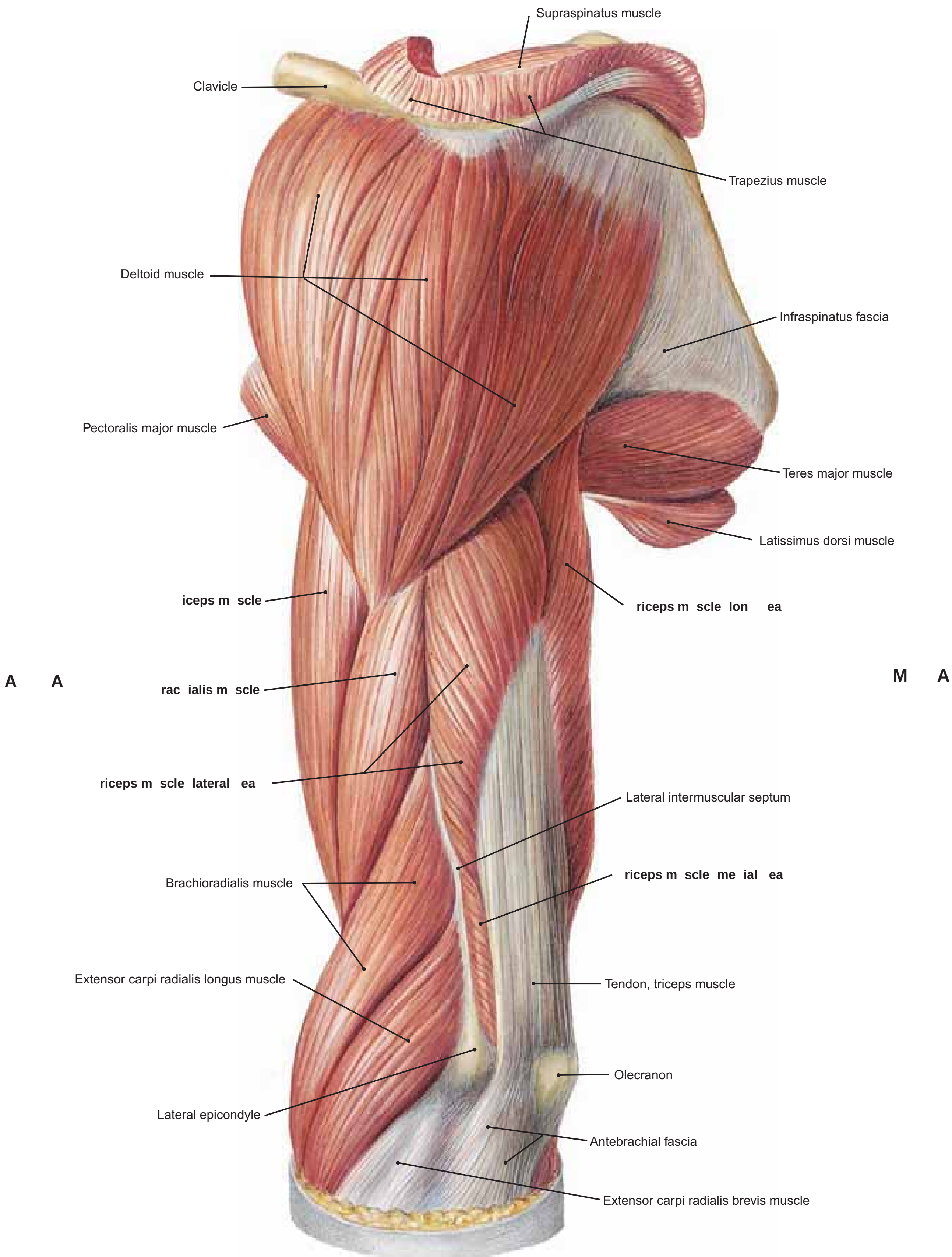


FIGURE 62 Muscles of the Arm (Lateral View)

NOTE: (1) The deltoid muscle acting as a whole abducts the arm. The clavicular portion flexes and medially rotates the arm, whereas the scapular part extends and laterally rotates the arm.

(2) The lateral intermuscular septum separates the anterior muscular compartment from the posterior muscular compartment.

(3) The sequential origin of the brachioradialis and extensor carpi radialis longus from the humerus above the lateral epicondyle; the extensor carpi radialis brevis arises directly from the lateral epicondyle.

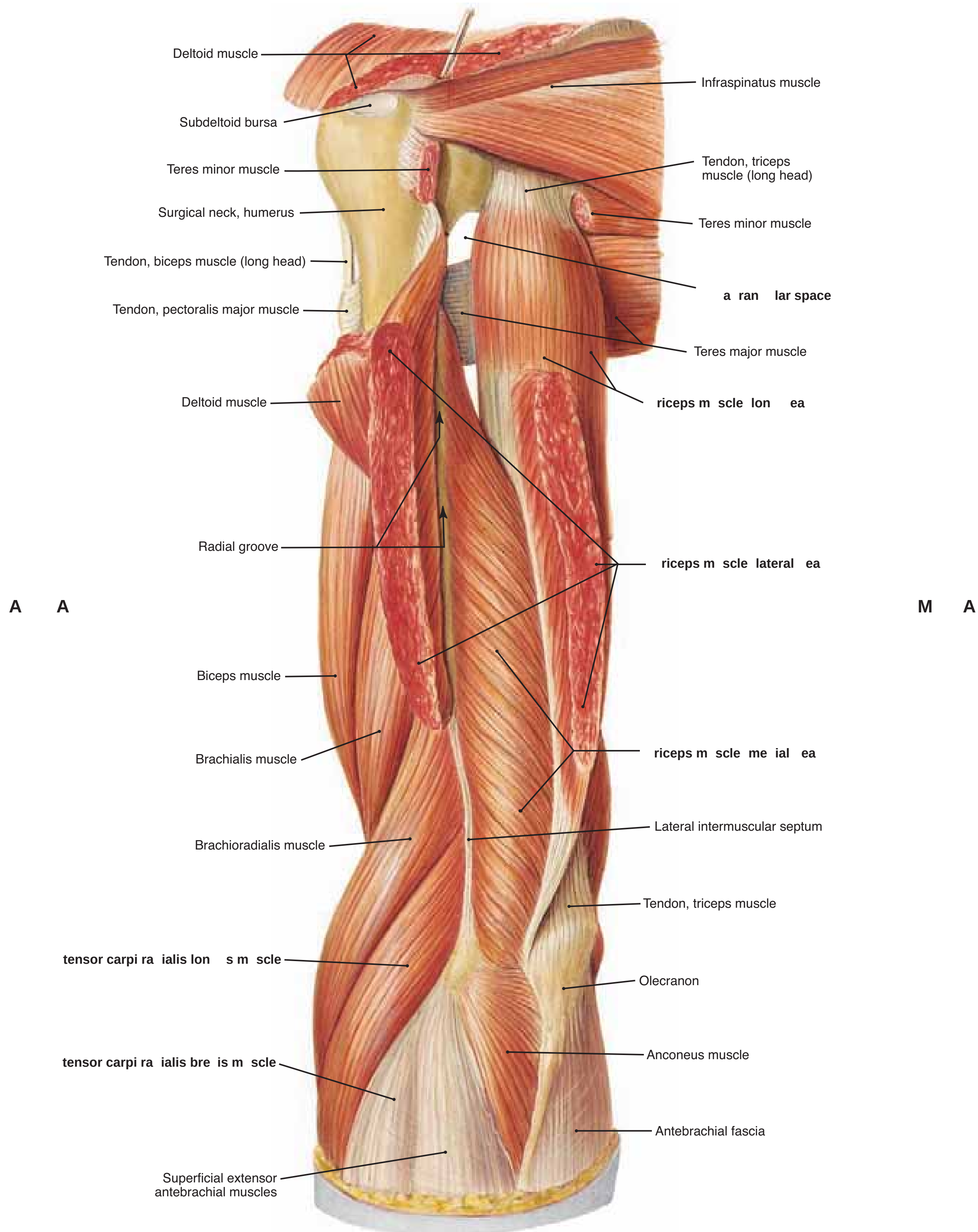


FIGURE 63 **Deep Muscles of the Arm and Shoulder (Posterior View)**

NOTE: (1) Much of the deltoid and teres minor muscles has been removed in this dissection, and the lateral head of the triceps muscle was transected and reflected. Observe the radial groove between the medial and lateral heads of the triceps.

(2) The broad origin of the medial and lateral heads of the triceps from the posterior surface of the humerus (see Fig. 65).

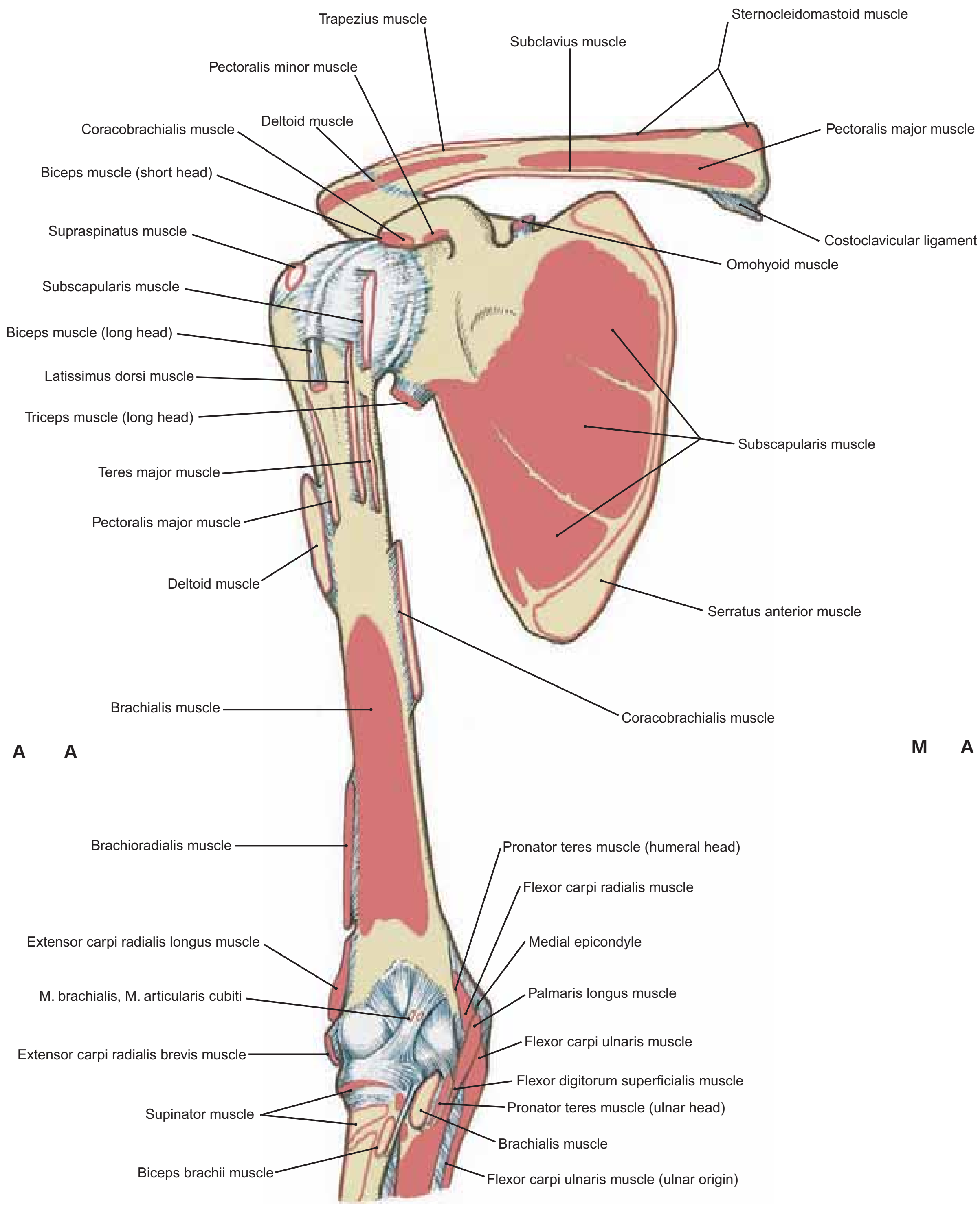


FIGURE 64 Anterior View of Bones of the Upper Limb (Including the Proximal End of the Radius and Ulna) Showing Attachments of Muscles

NOTE: (1) The broad **origin** of the subscapularis muscle in the subscapular fossa of the scapula. Its **insertion** on the lesser tubercle of the humerus is proximal to the insertions of the latissimus dorsi and teres major muscles.

(2) The biceps muscle extends across both the shoulder and elbow joints, but the coracobrachialis muscle crosses only the shoulder joint.

(3) The tendon of the long head of the biceps commences within the capsule of the shoulder joint and immediately becomes enclosed within a sheath formed by the synovial membrane of the joint.

(4) Upon emerging from the joint capsule, the tendon of the long head of the biceps descends in the intertubercular sulcus (bicipital groove). Inflammation of the synovial sheath of this tendon within the sulcus can be exceedingly painful because the tendon is closely bound to bone in this region.

(5) The latissimus dorsi and teres major insert on the humerus medial to the tendon of the long head of the biceps, whereas the pectoralis major inserts lateral to it.

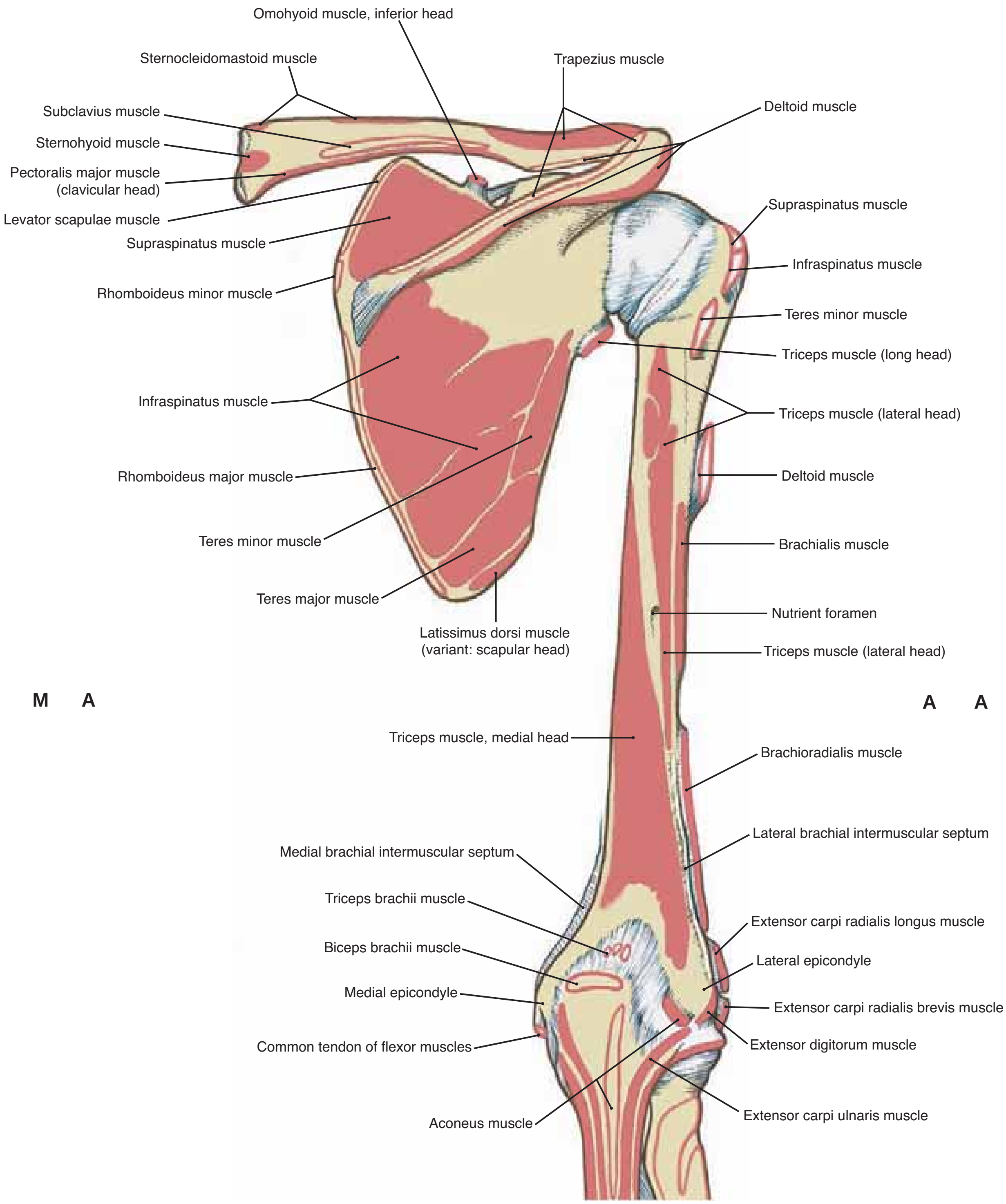


FIGURE 65 **Posterior View of the Bones of the Upper Limb Showing Attachments of Muscles**

NOTE the attachments of the supraspinatus, infraspinatus, teres minor, teres major, and the three heads of the triceps muscle. For the triceps, see below.

Muscle	Origin	Insertion	Innervation	Action
Triceps brachii	**Long head:** Infraglenoid tubercle of the scapula. **Lateral head:** Posterior surface and lateral border of the humerus and the lateral intermuscular septum. **Medial head:** Posterior surface and medial border of the humerus and the medial intermuscular septum.	Posterior part of the olecranon process of the ulna and the deep fascia of the dorsal forearm	Radial nerve (C7, C8)	All three heads extend the forearm at the elbow joint; the long head also extends the humerus at the shoulder joint

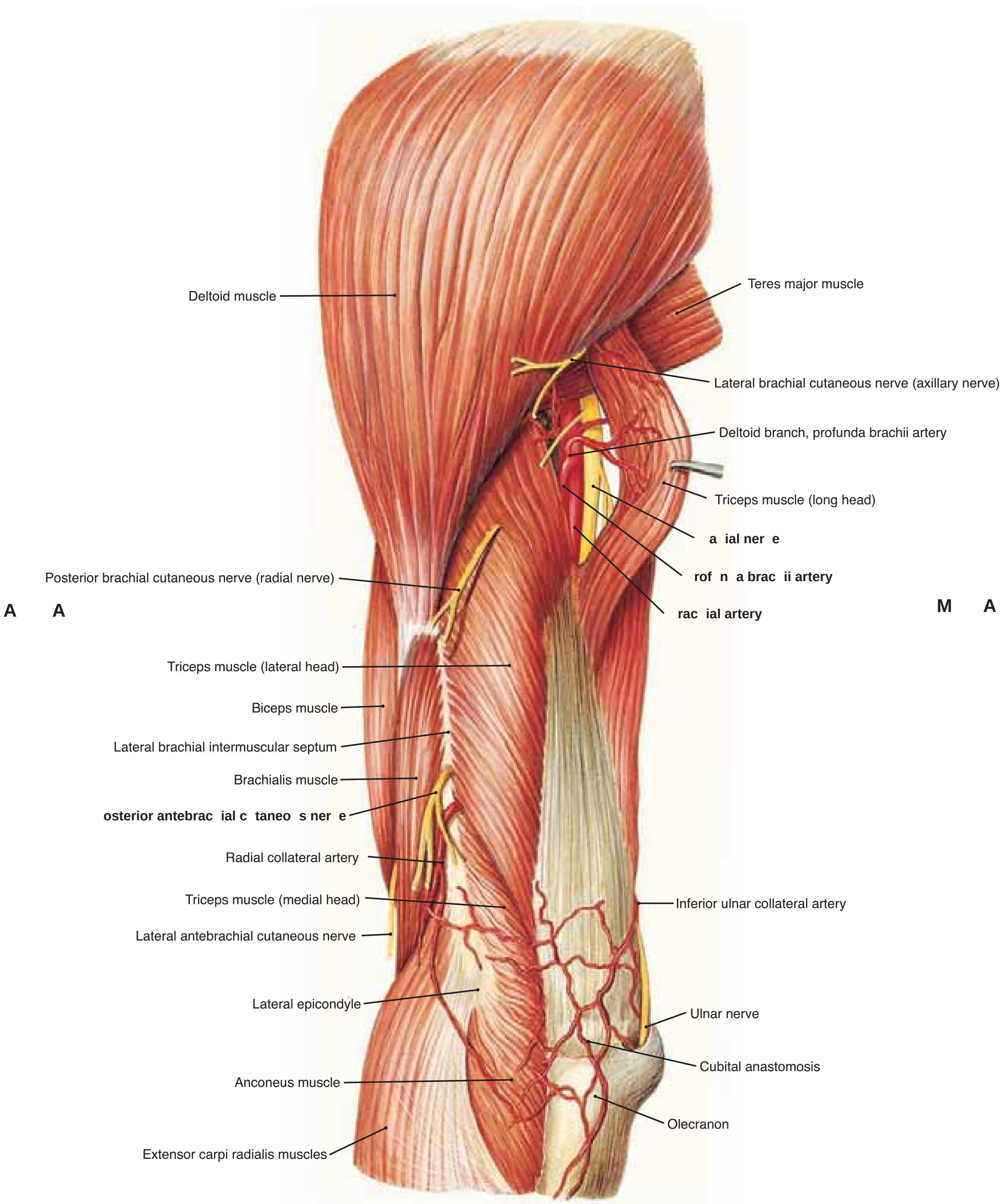


FIGURE 66 Nerves and Arteries of the Left Posterior Arm (Superficial Branches)

NOTE: (1) The origin of the profunda brachii artery from the brachial artery and its relationship to the radial nerve. The long head of the triceps has been pulled medially.
(2) The relationship of the ulnar nerve to the olecranon process and the vascular anastomosis around the elbow.
(3) Both the posterior brachial and posterior antebrachial nerves of the radial nerve perforate the lateral head of the triceps muscle to reach the superficial fascia and skin.
(4) The site of attachment of the deltoid muscle on the humerus, and the relationship of this attachment to the uppermost fibers of the brachialis muscle, the lateral intermuscular septum, and the lateral head of the triceps muscle (see Fig. 63).

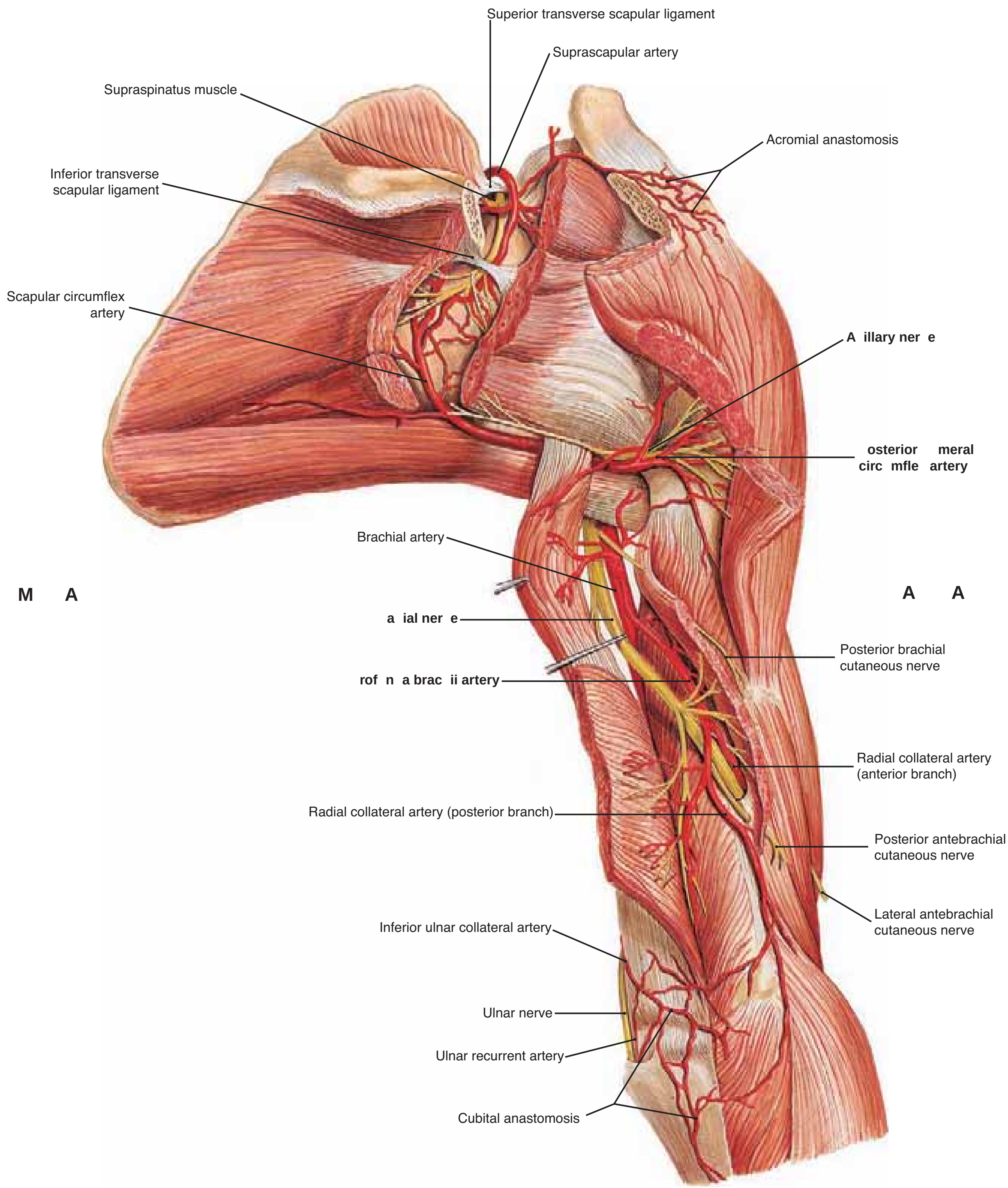


FIGURE 67 Deep Nerves and Arteries of the Shoulder and Posterior Brachial Regions

NOTE: (1) The course of the axillary nerve and posterior humeral circumflex artery through the quadrangular space to reach the deltoid and dorsal shoulder region.

(2) The course of the radial nerve and profunda brachii artery along the radial (spiral) groove to the posterior brachial region. This groove lies along the body of the humerus between the origins of the lateral and medial heads of the triceps muscle.

(3) The common insertion of the three heads of the triceps muscle onto the olecranon process of the ulna.

(4) In addition to a **deltoid branch**, which anastomoses with the posterior humeral circumflex artery and helps supply the long head of the triceps along with the deltoid muscle, the profunda brachii artery gives off the **middle and radial collateral arteries**.

(5) The latter two vessels and the **superior and inferior ulnar collateral** branches of the brachial artery are the four descending vessels that participate in the anastomosis around the elbow joint (see Fig. 66).

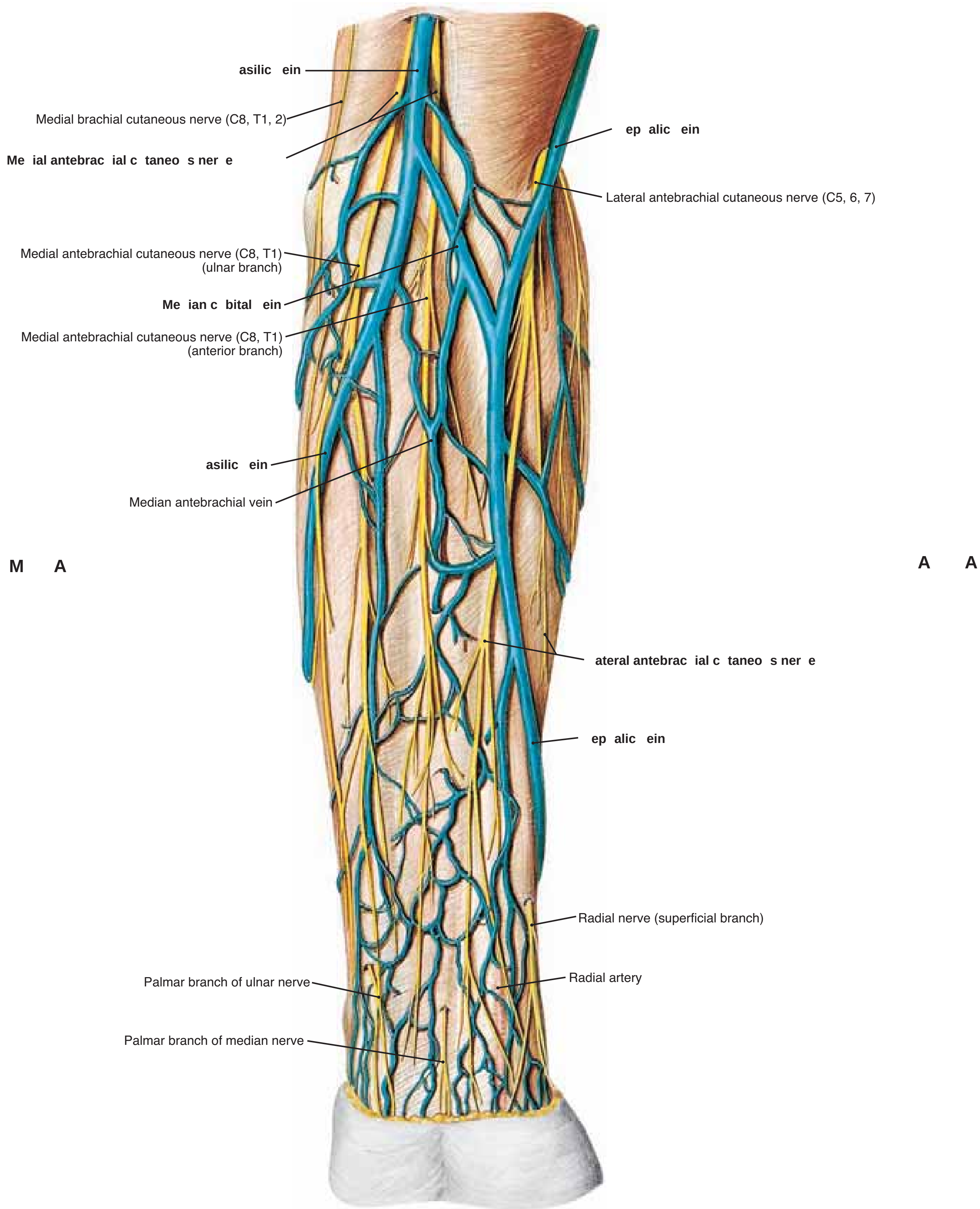


FIGURE 68 Forearm; Superficial Veins and Cutaneous Nerves of Left Upper Limb (Anterior Surface)

NOTE: (1) The median cubital vein joins the cephalic and basilic veins in the cubital fossa.

(2) The main sensory nerves of the anterior forearm are the medial antebrachial cutaneous nerve (derived from the medial cord of the brachial plexus) and the lateral antebrachial cutaneous nerve, which is a continuation of the musculocutaneous nerve.

(3) The medial antebrachial cutaneous nerve courses with the basilic vein, while the lateral antebrachial cutaneous nerve lies next to the cephalic vein at the elbow.

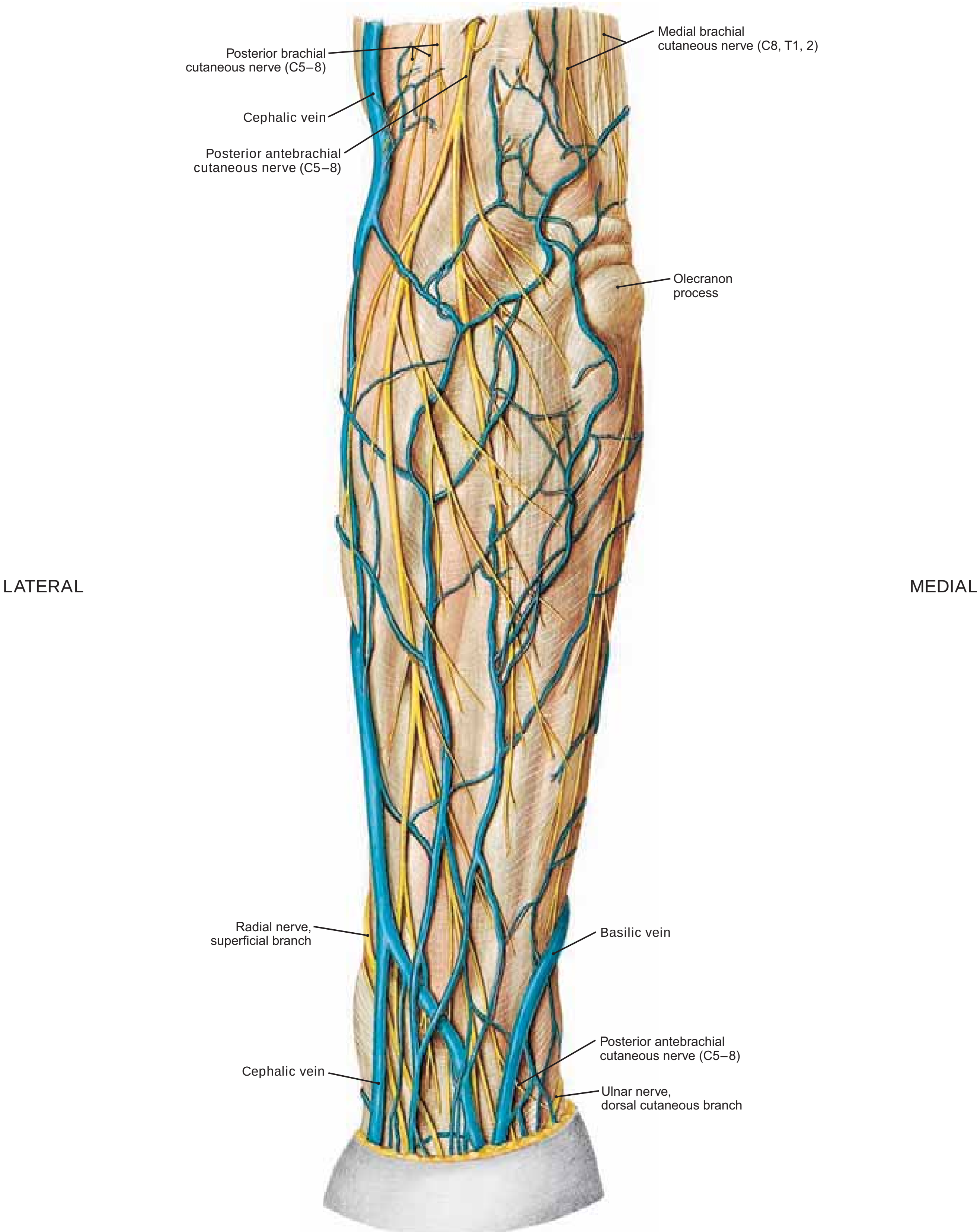


FIGURE 69 Forearm; Superficial Veins and Cutaneous Nerves of the Left Upper Limb (Posterior Surface)

NOTE: (1) Branches of the radial nerve (posterior antebrachial cutaneous and superficial radial) contribute the principal innervation to the skin on the posterior aspect of the forearm.

(2) At the wrist, the dorsal branch of the ulnar nerve passes backward onto the dorsal surfaces of the wrist and hand.

(3) The basilic vein arises on the ulnar (or medial) side of the dorsum of the hand and wrist, while the cephalic vein arises on the radial (lateral) side.

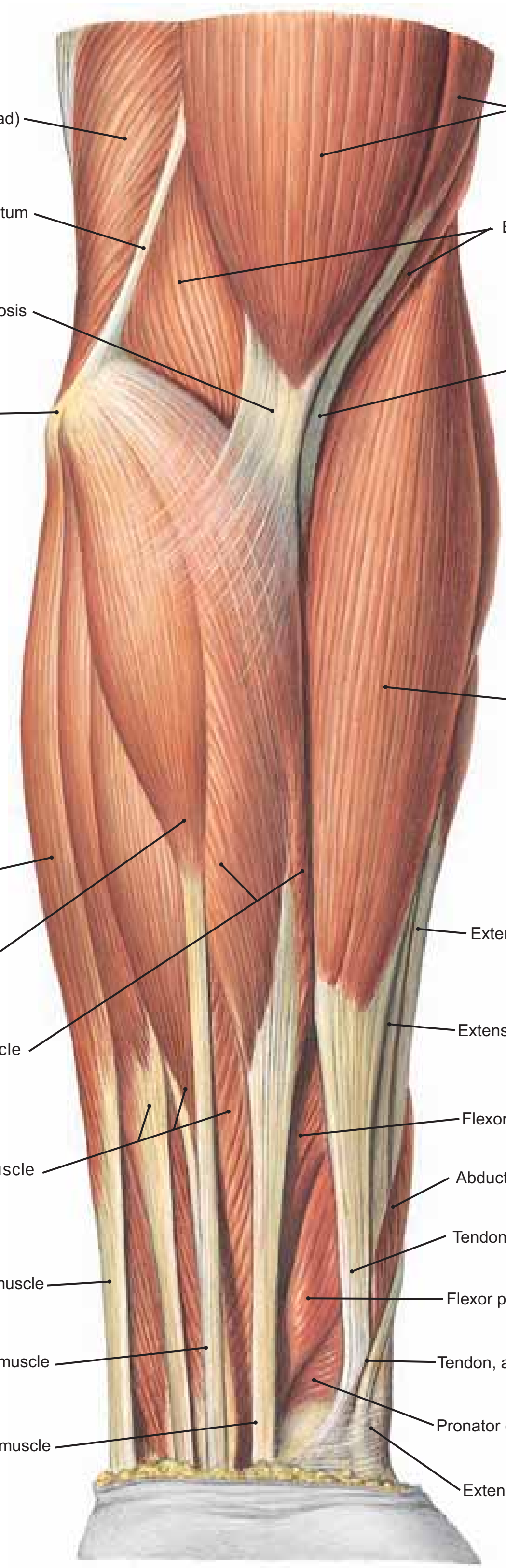


FIGURE 70 Left Anterior Forearm Muscles, Superficial Group

NOTE: (1) The brachioradialis muscle is studied with the posterior forearm muscles and is not included with the flexor muscles of the anterior forearm.

(2) The anterior forearm muscles arise from the medial epicondyle of the humerus and include the pronator teres (not labeled, see Fig. 76), **flexor carpi radialis**, **palmaris longus**, and **flexor carpi ulnaris**. Beneath these is the **flexor digitorum superficialis**.

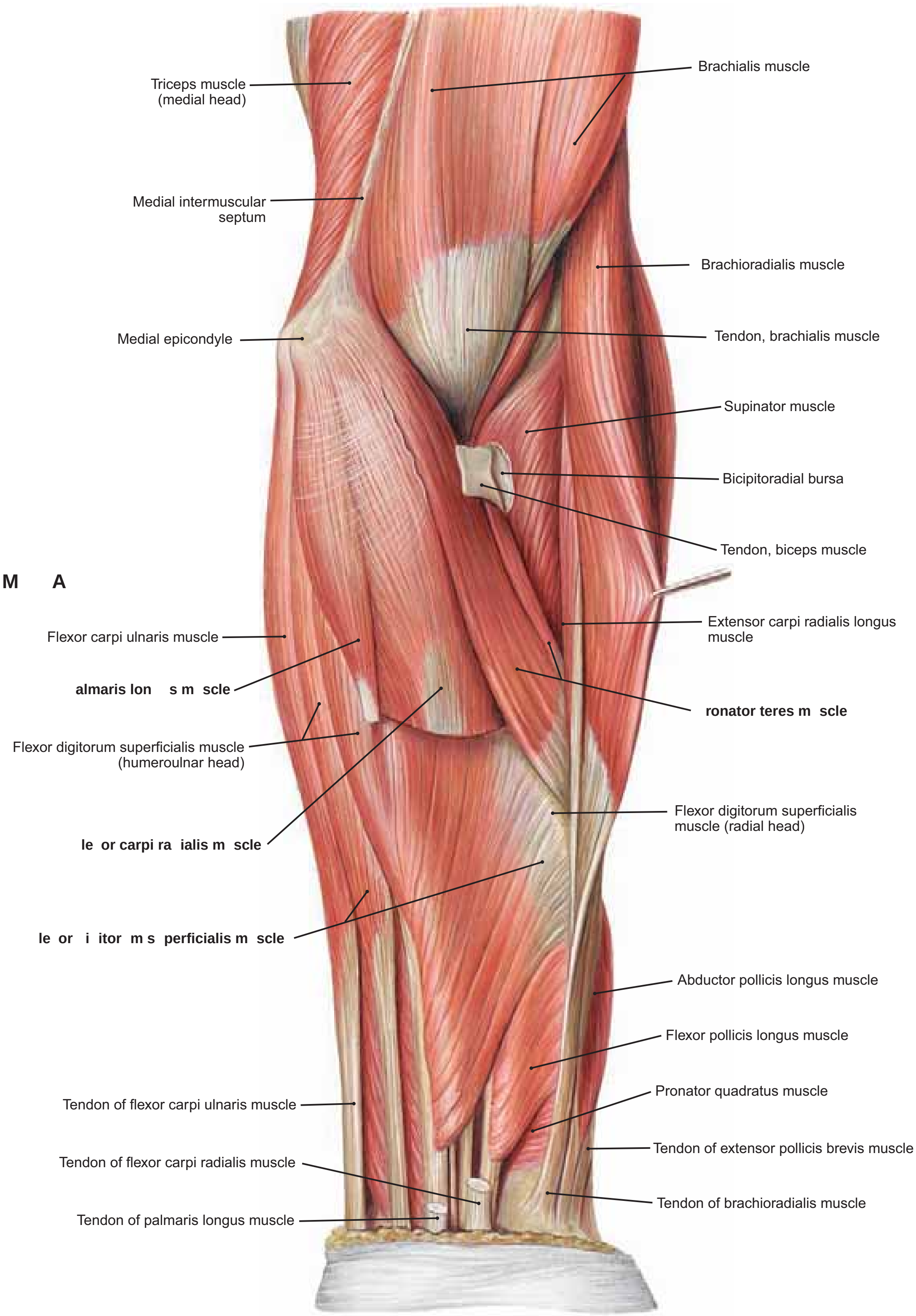


FIGURE 71 Flexor Digitorum Superficialis Muscle and Related Muscles (Left)

NOTE: (1) The palmaris longus, flexor carpi radialis, and insertion of the biceps have been cut to reveal the flexor digitorum superficialis and pronator teres.

(2) The triangular cubital fossa is bounded medially by the superficial flexors and laterally by the extensors. Its floor is the brachialis muscle.

(3) The pronator teres arises by two heads: a larger **humeral head** from the medial epicondyle and a much smaller **ulnar head** from the coronoid process. It crosses the forearm obliquely to insert on the shaft of the radius.

(4) The flexor digitorum superficialis arises broadly from the humerus and ulna medially (humeral–ulnar head) and from the anterior border of the radius laterally (radial head).

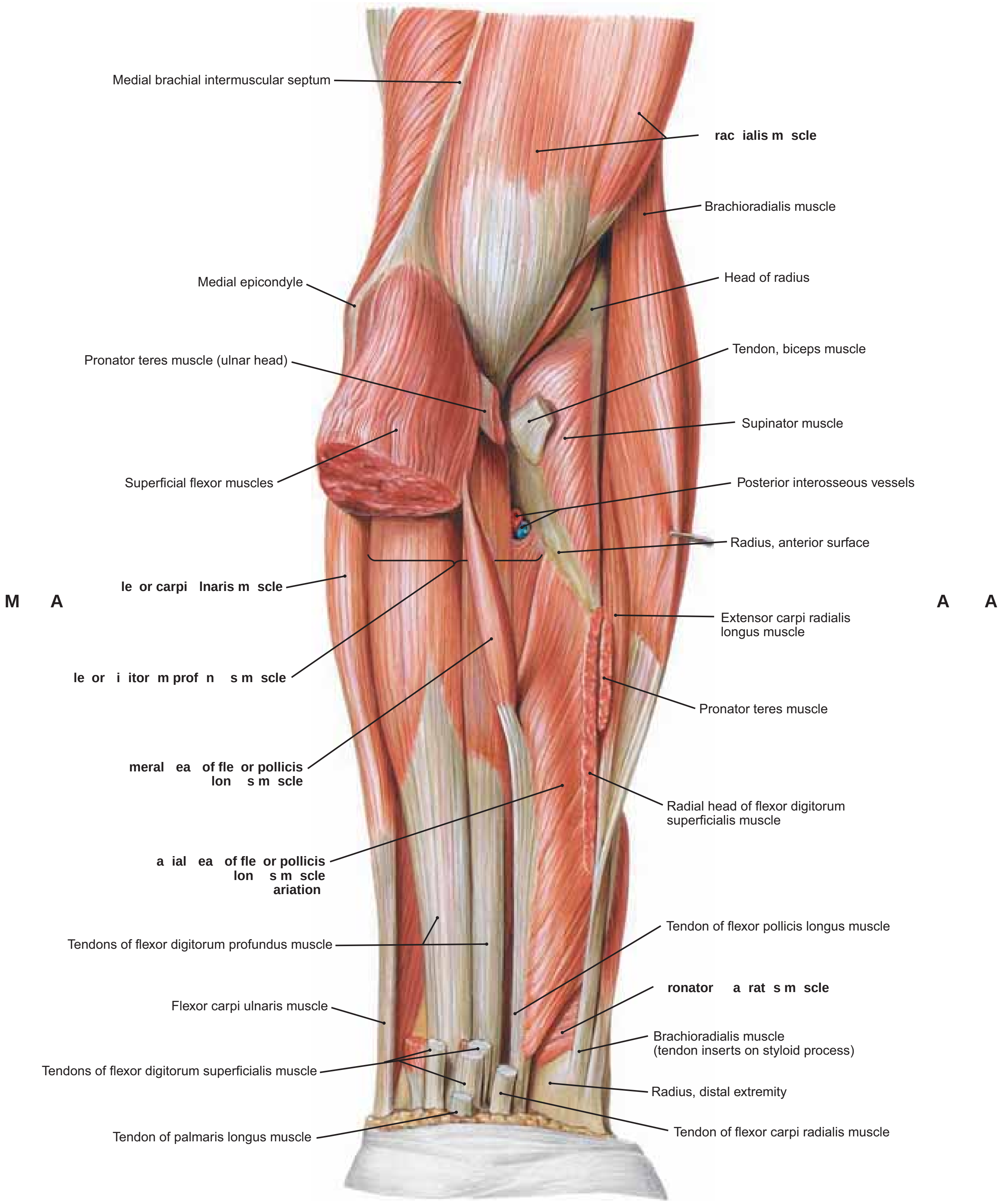


FIGURE 72 Left Anterior Forearm Muscles, Deep Group

NOTE: (1) The superficial anterior forearm muscles have been removed to reveal the three muscles of the deep group: the flexor digitorum profundus, the flexor pollicis longus, and the pronator quadratus.

(2) The pronator quadratus is a small quadrangular muscle situated at the distal end of the forearm beneath the tendons of the flexor digitorum profundus and flexor pollicis longus. It is partially shown in this dissection and can be seen better in Figs. 84.1 and 99.1.

(3) In this drawing, the tendons of the flexor digitorum profundus to the ring and little fingers and those to the middle and index fingers appear fused at the wrist, as if they were two structures rather than four.

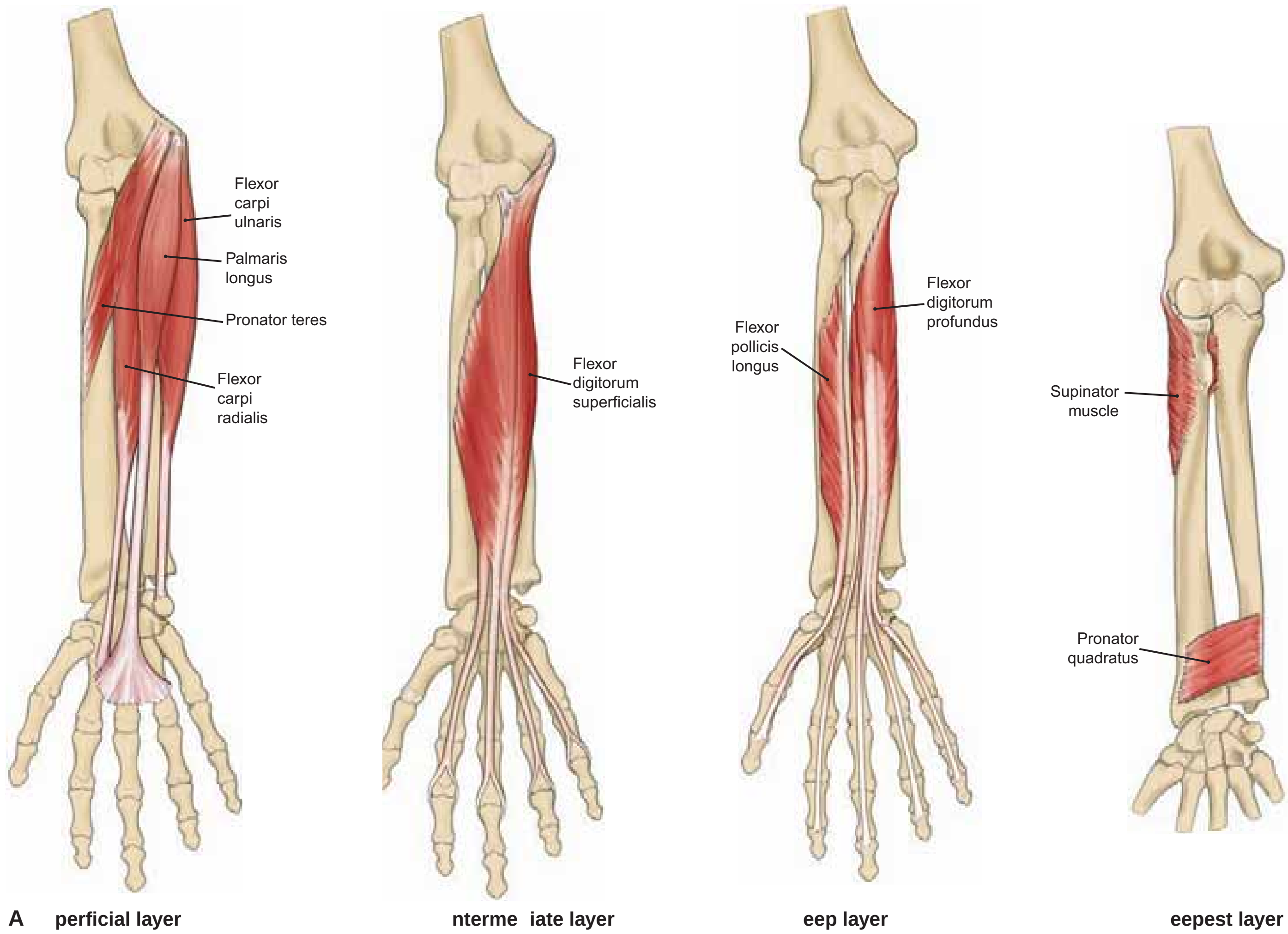


FIGURE 73A–D **Anterior Muscles of the Forearm**

NOTE that the supinator muscle shown in **D** is usually classified with the dorsal forearm muscles.

FLEXOR MUSCLES OF FOREARM: SUPERFICIAL GROUP

Muscle	Origin	Insertion	Innervation	Action
Pronator teres	**Humeral head:** Medial epicondyle of humerus. **Ulnar head:** Coronoid process of ulna	Midway along the lateral surface of the radius	Median nerve (C6, C7) (enters the forearm by passing between the two heads)	Pronates and flexes the forearm
Flexor carpi radialis	Medial epicondyle of humerus	Base of the second metacarpal bone	Median nerve (C6, C7)	Flexes the hand at the wrist joint; abducts the hand (radially deviates the hand)
Palmaris longus	Medial epicondyle of humerus	Anterior flexor retinaculum and the palmar aponeurosis	Median nerve (C6, C7)	Flexes the hand at the wrist and tenses the palmar aponeurosis
Flexor digitorum superficialis	**Humeroulnar head:** Medial epicondyle of humerus and the coronoid process of ulna **Radial head:** Anterior surface of the radius below the radial tuberosity	By four long tendons onto the sides of the middle phalanx of the four medial fingers	Median nerve (C7, C8, T1)	Flexes the middle and proximal phalanges of the four medial fingers; also flexes the wrist
Flexor carpi ulnaris	**Humeral head:** Medial epicondyle of humerus **Ulnar head:** Medial margin of olecranon, and upper posterior border of ulna	Pisiform bone and by ligaments to the hamate and fifth metacarpal bone	Ulnar nerve (C7, C8)	Flexes the hand at the wrist joint; adducts the hand (ulnar deviates the hand) **(see also Fig. 72)**

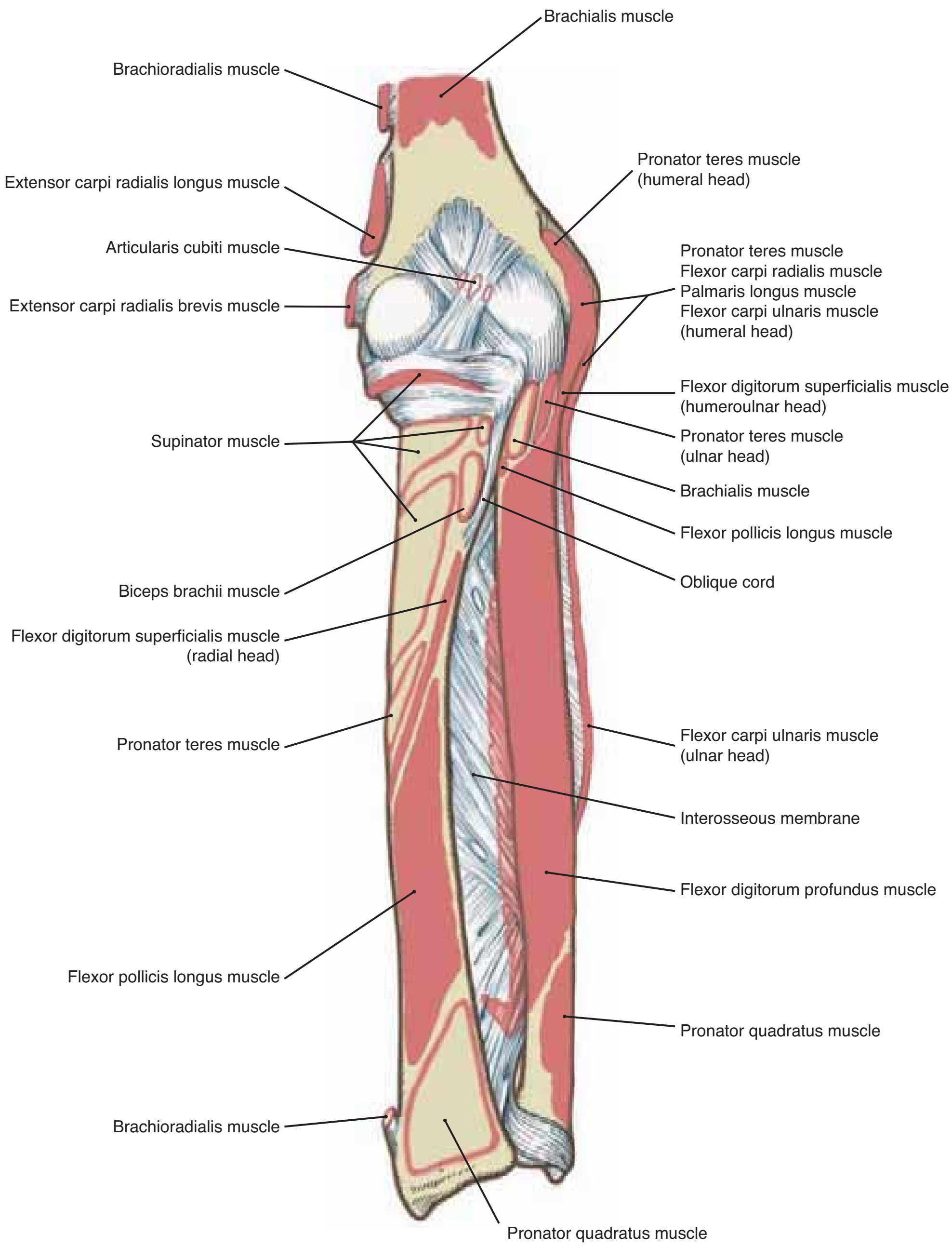
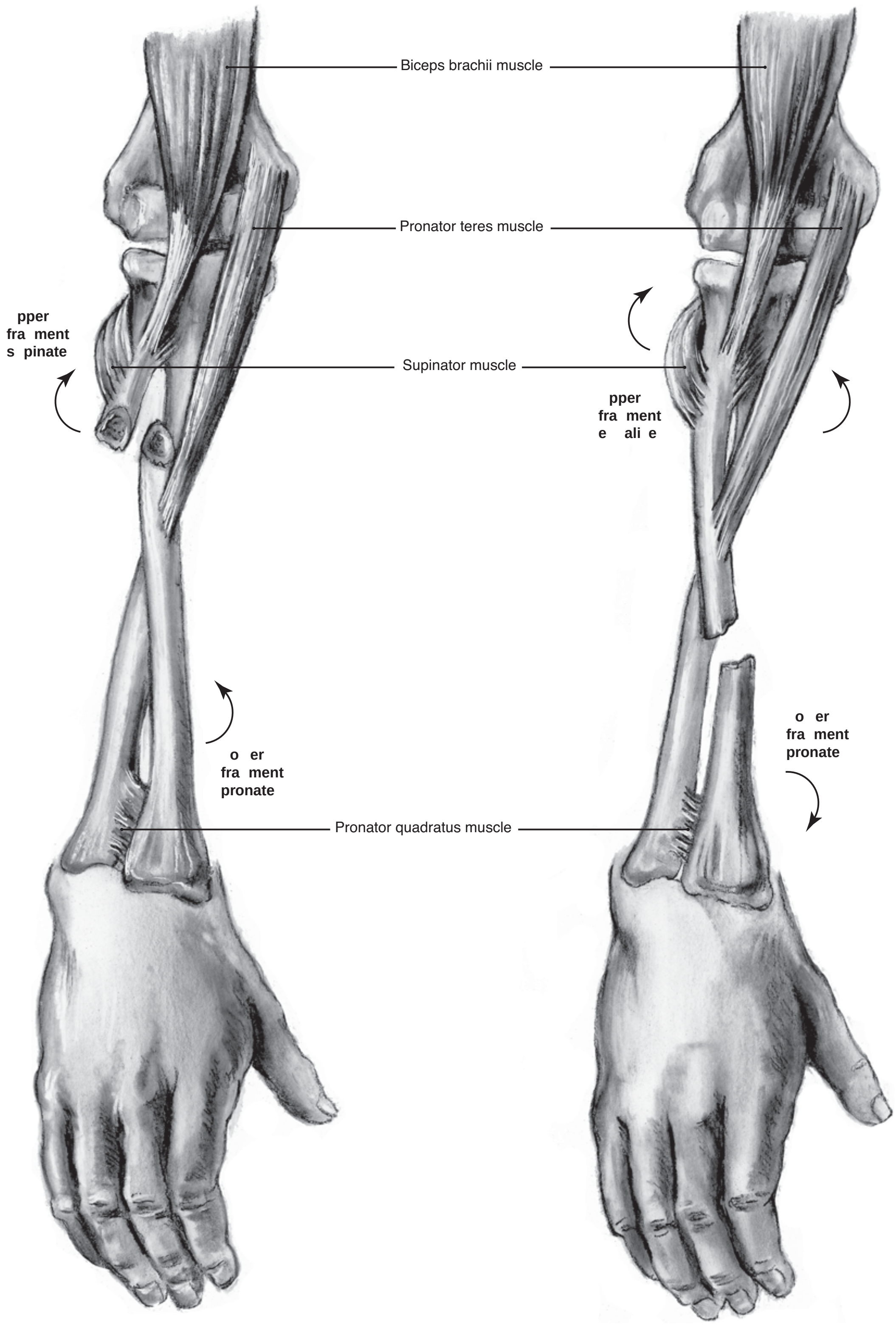


FIGURE 74 Muscle Attachments on the Anterior Surface of the Radius and Ulna

NOTE that muscle **origins** are **solid color areas**, while muscle **insertions** are the **open areas** surrounded by red lines.

FLEXOR MUSCLES OF THE FOREARM: DEEP GROUP

Muscle	Origin	Insertion	Innervation	Action
Flexor digitorum profundus	Upper three-fourths of the anterior and medial aspects of the ulna and the ulnar half of the interosseous membrane	Anterior surface of the base of the distal phalanx of the four medial fingers	Median nerve by its interosseous branch; and the ulnar nerve (C8, T1)	Flexes the distal phalanx of the four medial fingers and also flexes the hand at the wrist
Flexor pollicis longus	**Radial head:** Anterior surface of radius and the adjacent part of the interosseous membrane. **Humeral head:** Medial epicondyle of humerus or the coronoid process of the ulna	Base of the distal phalanx of the thumb	Median nerve by its interosseous branch (C8, T1)	Flexes the distal phalanx and helps in flexing the proximal phalanx of the thumb
Pronator quadratus	Distal fourth of anterior surface of the ulna	Distal fourth of anterior surface of the radius	Median nerve by its interosseous branch (C8, T1)	Pronates the hand



A

FIGURE 75A, B Fracture Site of the Radius Relative to the Pronator Teres Muscle

NOTE: The pronator teres muscle is important with respect to fractures of the radius.

(1) In **A:** When the fracture is superior to the insertion of the pronator teres, the upper fragment of the radius is pulled into supination by the supinator muscle and the biceps brachii muscle. The inferior fragment is strongly pronated.

(2) In **B:** When the fracture is inferior to the insertion of the pronator teres, the upper fragment's position is equalized between the supinator muscle and the pronator teres muscle, while the lower fragment is fully pronated by the pronator quadratus muscle.

(From P. Thorek. *Anatomy in Surgery*. Philadelphia: J.B. Lippincott, 1958.)

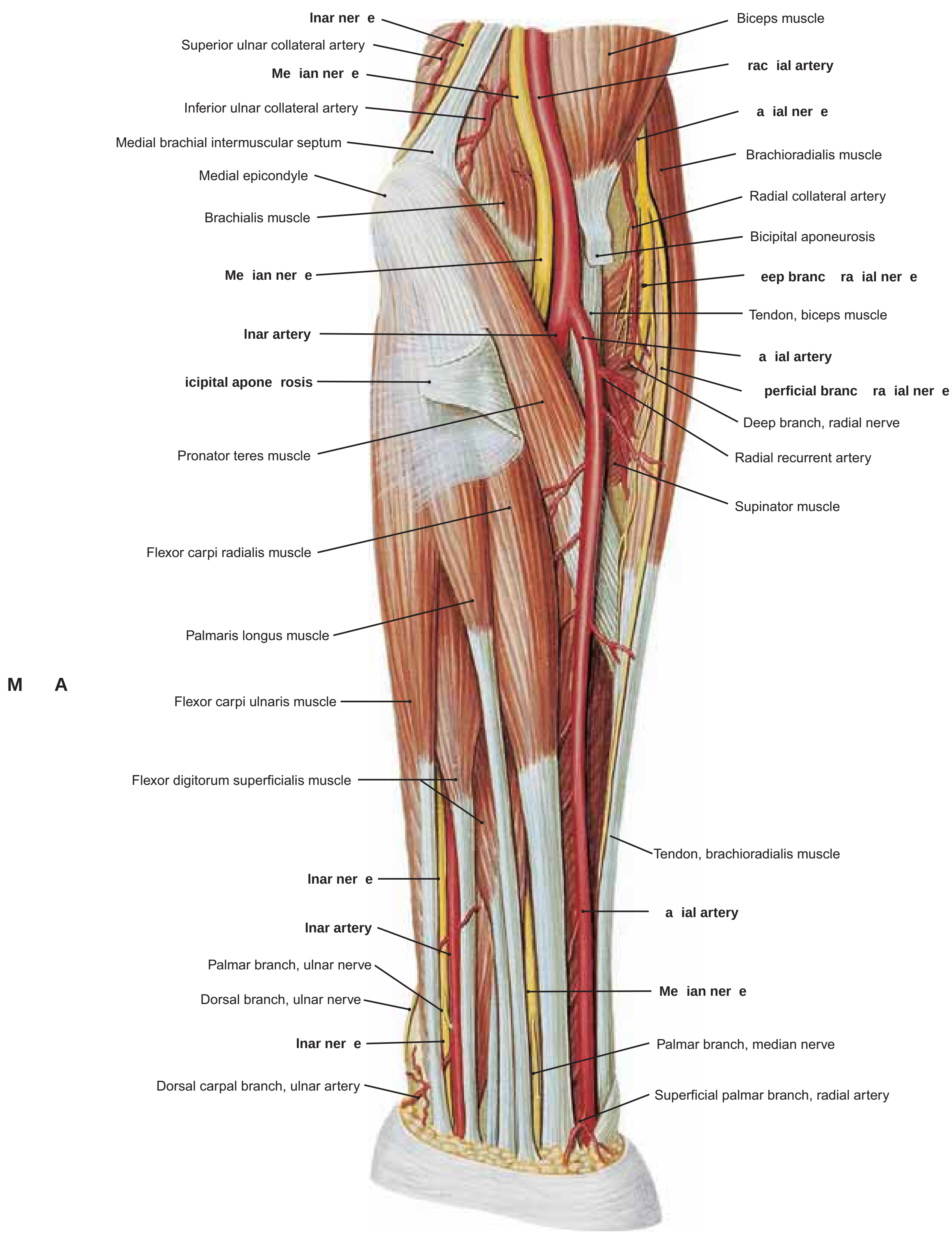


FIGURE 76 Anterior Dissection of the Left Forearm Vessels and Nerves, Stage 1

NOTE: (1) The bicipital aponeurosis has been reflected to reveal the underlying median nerve, brachial artery, and tendon of insertion of the biceps brachii muscle.

(2) The brachioradialis muscle has been pulled laterally (toward the radial side) to expose the course of the radial artery and the division of the radial nerve into its superficial and deep branches.

(3) The radial artery, as it descends in the forearm, courses anterior to the biceps brachii muscle, the supinator muscle, the tendon of insertion of the pronator teres, and the belly of the flexor pollicis longus (the latter is not labeled in this figure, but can be seen in Figs. 72 and 73).

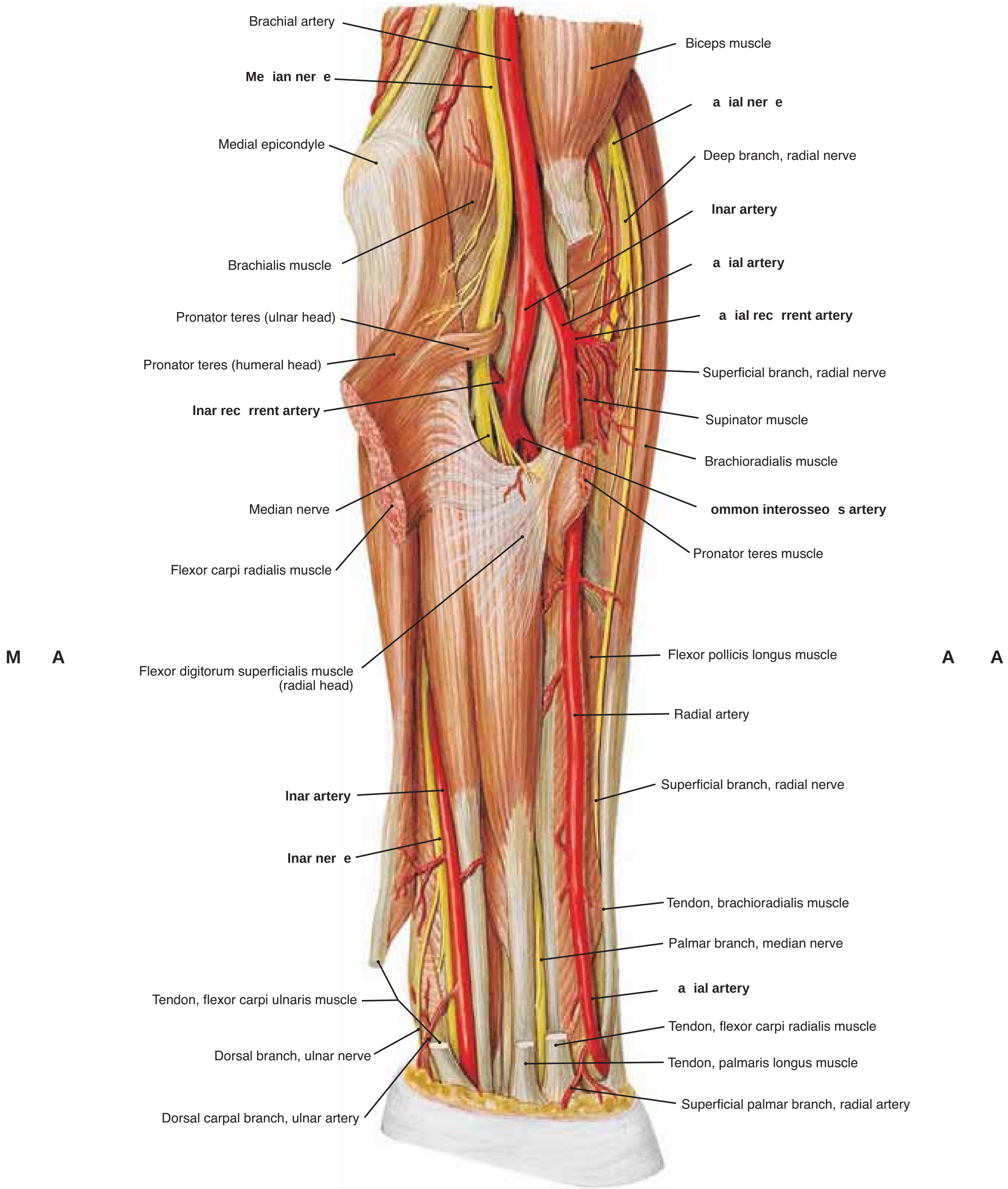


FIGURE 77 **Anterior Dissection of the Left Forearm Vessels and Nerves, Stage 2**

NOTE: (1) The pronator teres and flexor carpi radialis muscles are reflected just below the cubital fossa to show the bifurcation of the brachial artery into the ulnar and radial arteries.

(2) At the wrist, the tendon of the flexor carpi ulnaris muscle is severed and pulled aside to expose the ulnar nerve and artery.

(3) The median nerve lies deep to the flexor digitorum superficialis muscle along much of its course in the forearm, but just above the wrist it usually becomes visible between the tendons. Observe that the tendons of the flexor pollicis longus and flexor carpi radialis are on its **radial side** and the tendons of the palmaris longus and flexor digitorum superficialis are on its **ulnar side.**

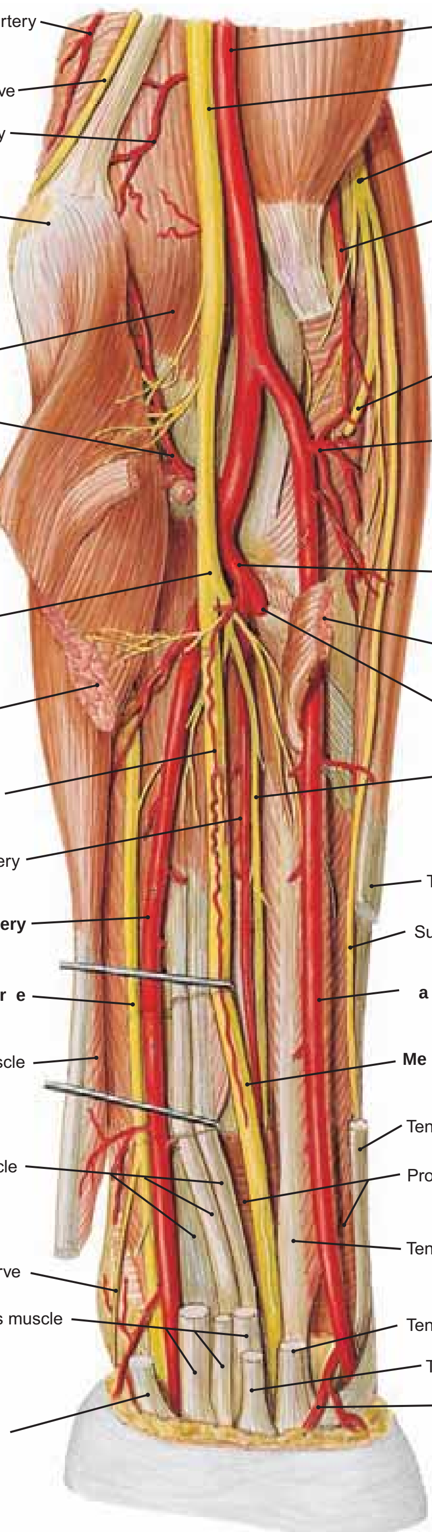


FIGURE 78 Anterior Dissection of the Left Forearm Vessels and Nerves, Stage 3

NOTE: (1) The division of the **brachial artery** into the **radial** and **ulnar arteries** at the lower end of the cubital fossa.

(2) The **common interosseous artery** branches from the **ulnar artery** and divides almost immediately into the **anterior and posterior interosseous arteries.**

(3) The courses of the ulnar and median nerves. In the lower half of the forearm, the **ulnar nerve** descends with the ulnar artery, whereas the median nerve descends in front of the anterior interosseous nerve and artery.

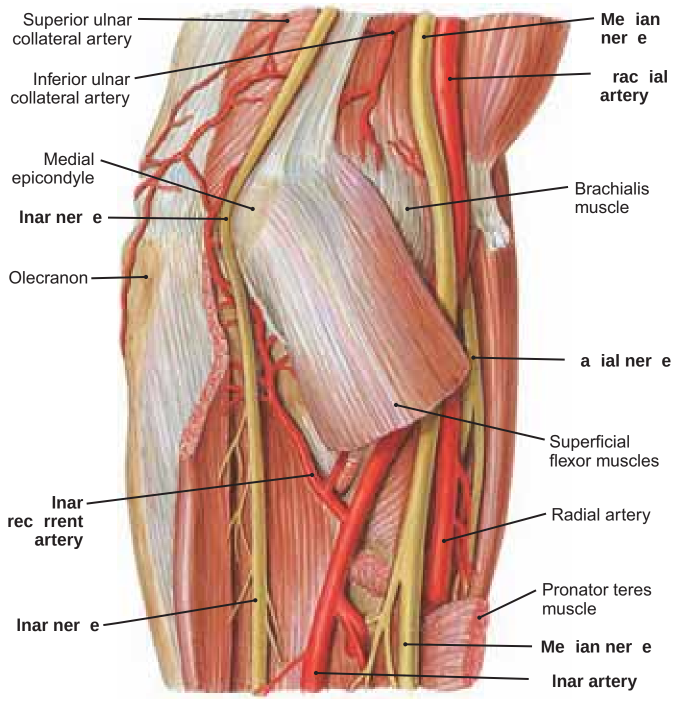


FIGURE 79.1 **Nerves and Arteries at the Elbow (Medial View)**

NOTE: The **ulnar nerve** enters the forearm directly behind the medial epicondyle, and at this site it is closely related to the **ulnar recurrent artery**.

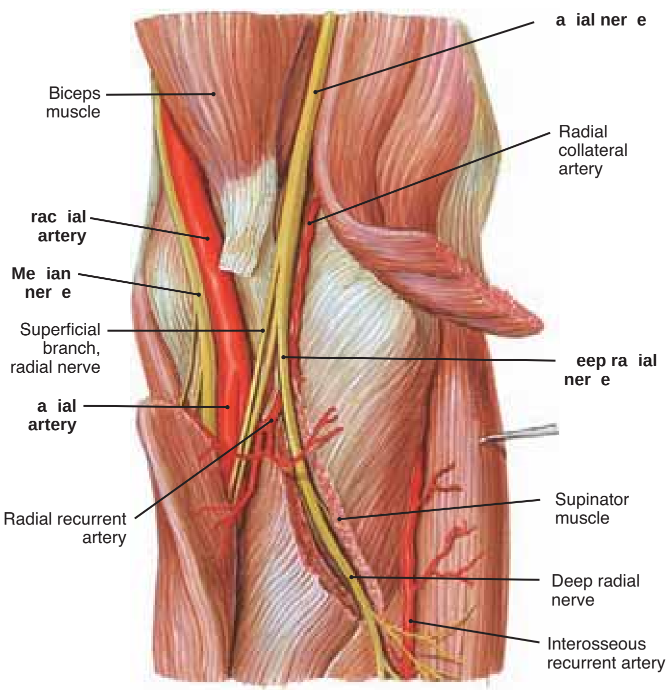


FIGURE 79.2 **Nerves and Arteries at the Elbow (Lateral View)**

NOTE: The **deep radial nerve** passes into the forearm in front of the lateral part of the elbow joint. It then courses dorsally through the supinator muscle to supply the posterior forearm muscles.

FIGURE 79.3 **Brachial Arteriogram Showing the Origins of the Vessels That Supply the Elbow and Forearm**

1. Profunda brachii artery
2. Brachial artery
3. Superior ulnar collateral artery
4. Radial collateral artery
5. Inferior ulnar collateral artery
6. Radial recurrent artery
7. Radial artery
8. Ulnar artery
9. Ulnar recurrent artery
10. Interosseous recurrent artery
11. Common interosseous artery
12. Posterior interosseous artery
13. Anterior interosseous artery

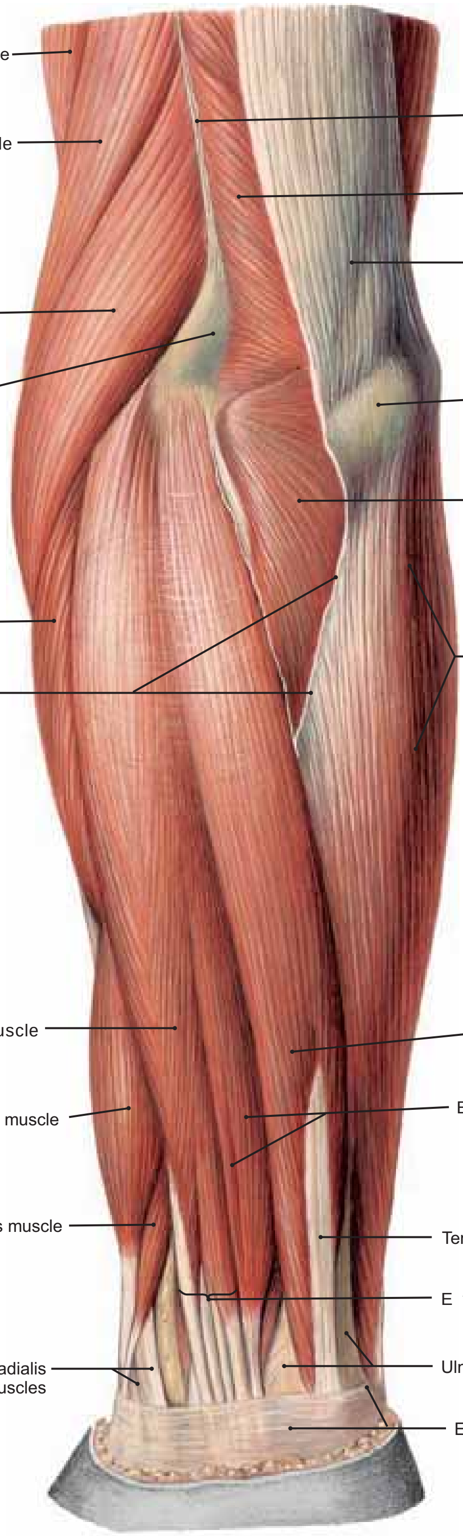


FIGURE 80 Posterior Muscles of the Left Forearm, Superficial Group (Posterior View)

NOTE: The superficial radial group of extensor muscles of the forearm includes the **brachioradialis muscle** and the **extensors carpi radialis longus and brevis**.

Muscle	Origin	Insertion	Innervation	Action
Brachioradialis	Upper two-thirds of lateral supracondylar ridge of humerus	Lateral aspect of the base of the styloid process of the radius	Radial nerve (C5, C6)	Flexes the forearm when the forearm is semipronated

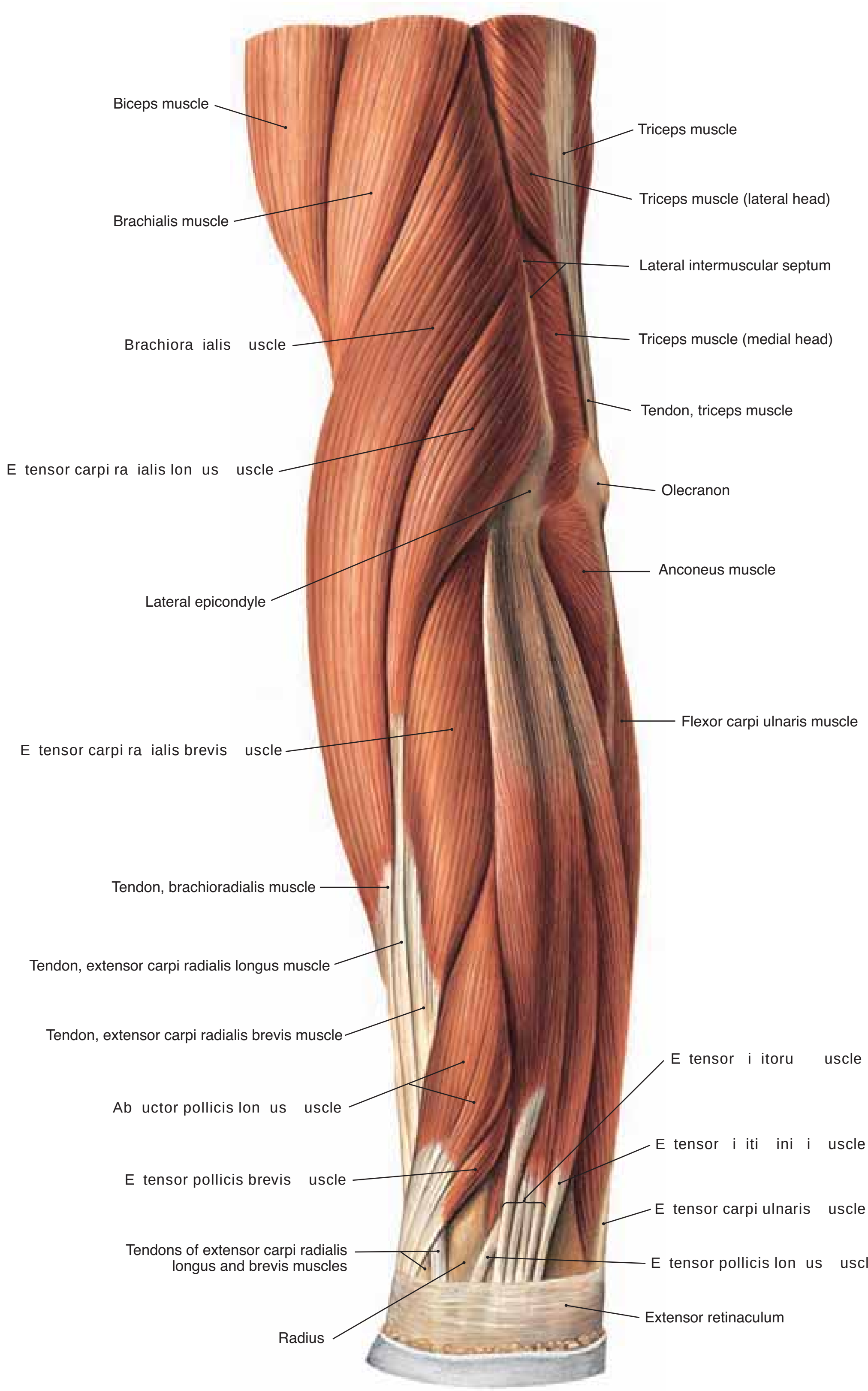


FIGURE 81 **Posterior Muscles of the Left Forearm, Superficial Group (Lateral View)**

Muscle	Origin	Insertion	Innervation	Action
Extensor carpi radialis longus	Lower third of lateral supracondylar ridge of humerus	Dorsal surface of the base of the second metacarpal bone	Radial nerve (C6, C7)	Extends the hand; abducts the hand at the wrist (radial deviation)
Extensor carpi radialis brevis	Lateral epicondyle of humerus	Dorsal surface of the base of the third metacarpal bone	Radial nerve (C6, C7)	Extends the hand; abducts the hand at the wrist (radial deviation)

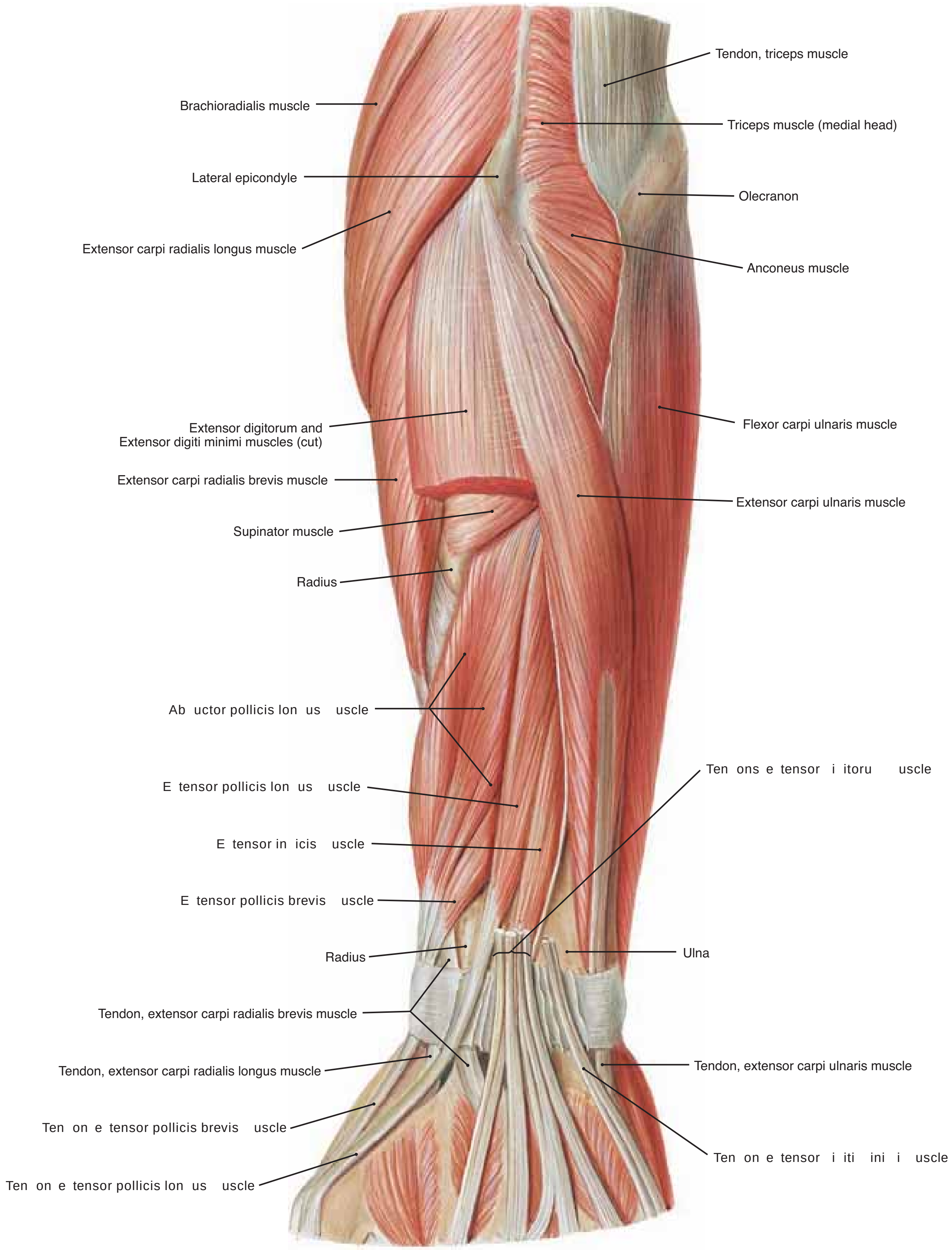


FIGURE 82 Deep Extensor Muscles of the Left Posterior Forearm

NOTE: Four other muscles complete the **superficial** extensor muscles on the posterior aspect of the forearm. These are the **extensor digitorum**, **extensor digiti minimi, extensor carpi ulnaris,** and the **anconeus.** There are also five **deep** extensor muscles: the **abductor pollicis longus, extensor pollicis longus** and **brevis, extensor indicis,** and the **supinator** muscle.

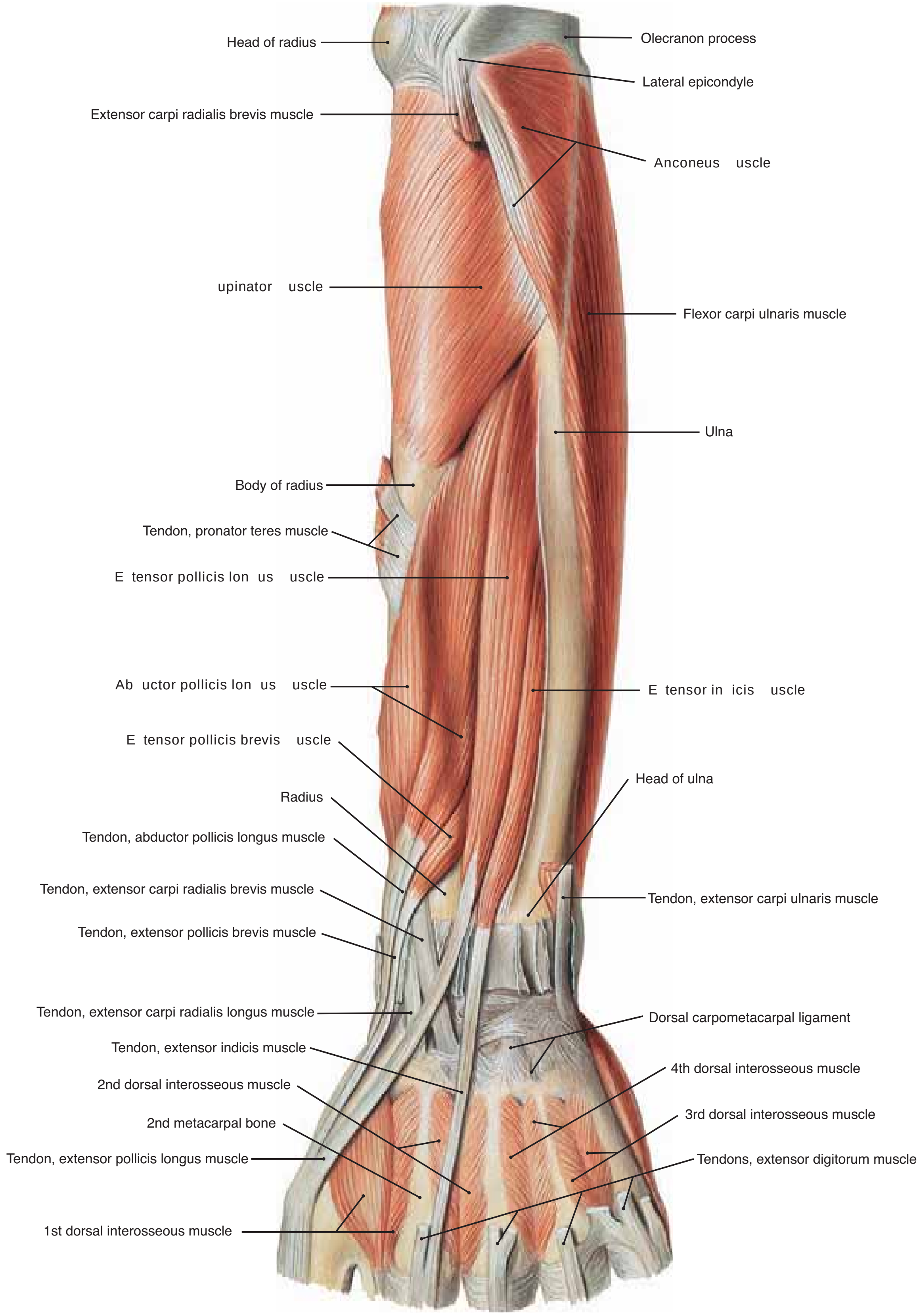


FIGURE 83 Left Posterior Forearm Muscles, Deep Group

NOTE: (1) The three thumb muscles (abductor pollicis longus and extensors pollicis brevis and longus) are exposed when the extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris are removed.

(2) The extensor indicis courses to the index finger, and the supinator is a broad muscle that stretches across the upper forearm from the humerus and ulna to the upper third of the radius.

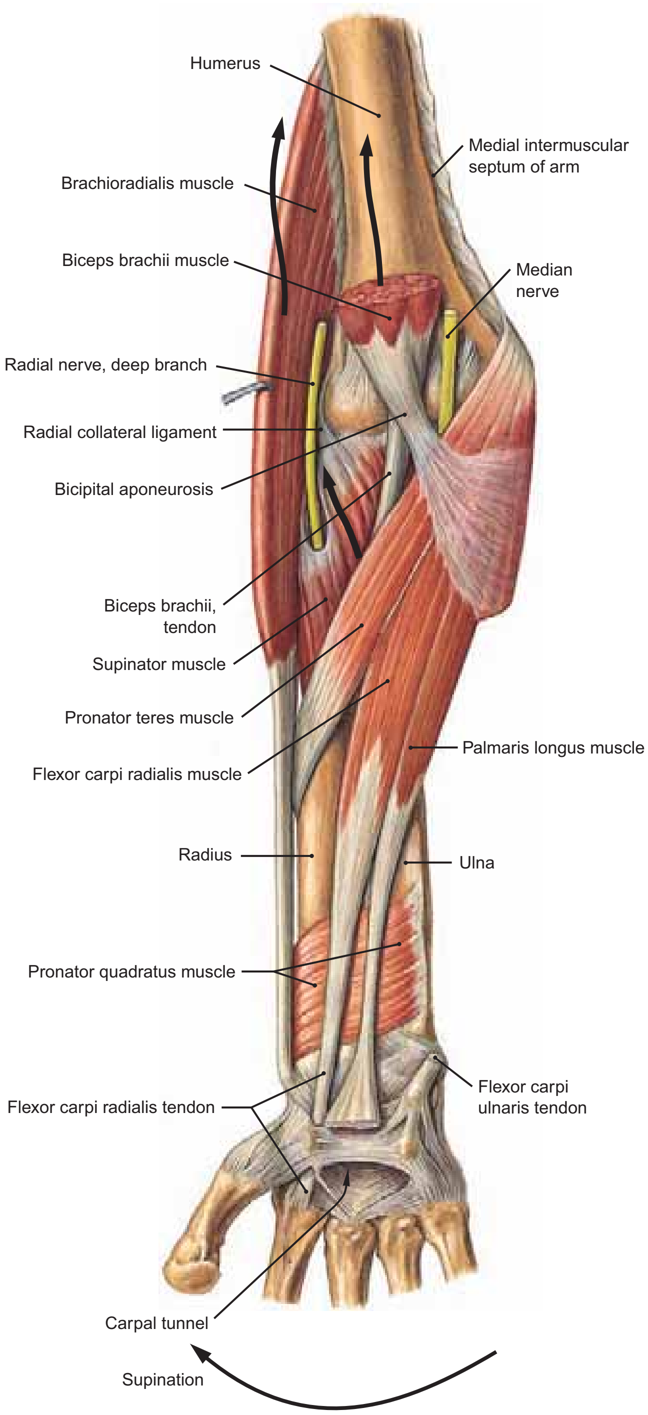


FIGURE 84.1 Supinated Right Forearm (Anterior Aspect)

NOTE: (1) Supination involves turning the pronated forearm and hand over, resulting in the palm being oriented anteriorly and the thumb directed laterally.
(2) In supination, the head of the radius rotates within the annular ligament at the proximal radioulnar joint. The radius then assumes a position lateral to and parallel with the ulna.
(3) The principal muscles that supinate the forearm are the supinator and biceps brachii muscles. In addition, it is thought that the brachioradialis muscle assists in this action, but this has been questioned.

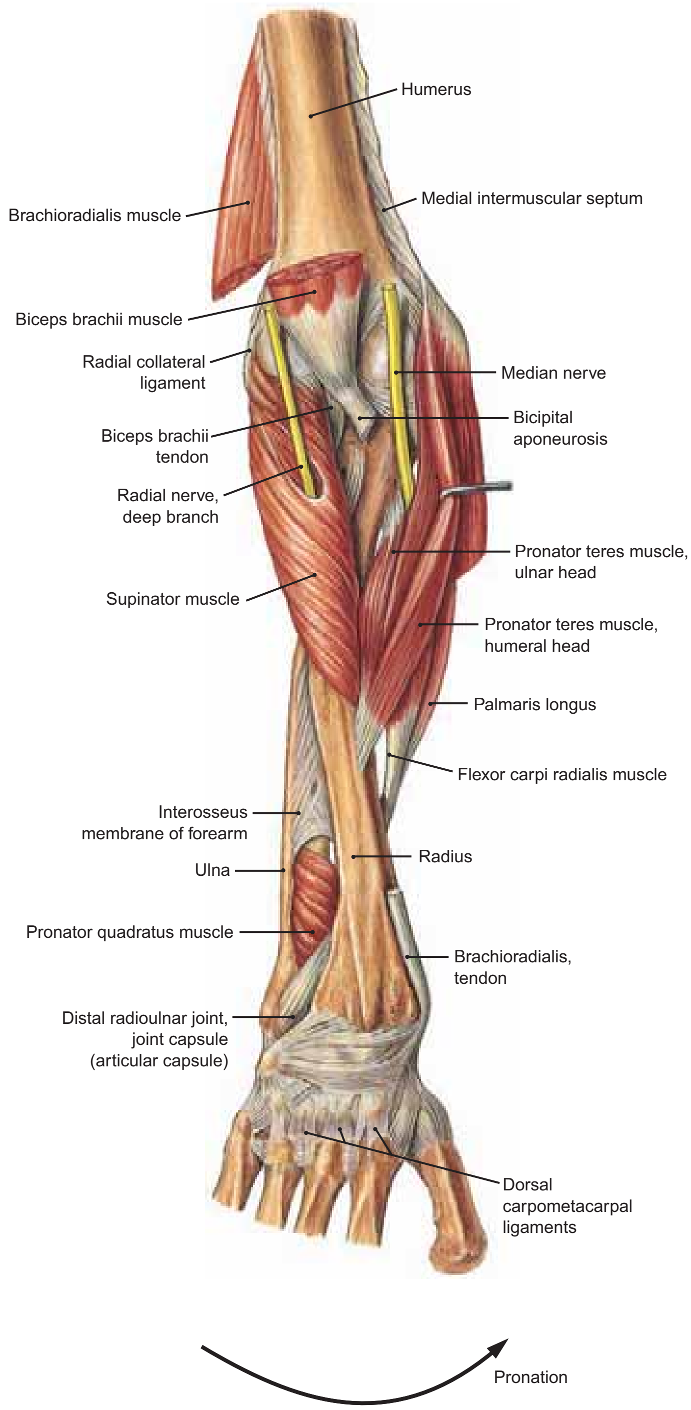


FIGURE 84.2 Pronated Right Forearm (Anterior Aspect)

NOTE: (1) Pronation is the act of turning the supinated forearm and hand over, after which the palm becomes oriented posteriorly and the thumb directed medially.
(2) In pronation of the forearm and hand, the radius turns obliquely across the anterior aspect of the ulna. The proximal end of the radius is still lateral to the ulna, but the distal end is medial to it.
(3) The muscles producing pronation are the **pronator teres** and the **pronator quadratus**. In addition, the **flexor carpi radialis** and the **palmaris longus** may assist.

FIGURE 85A Radial Extensor Muscles of the Forearm

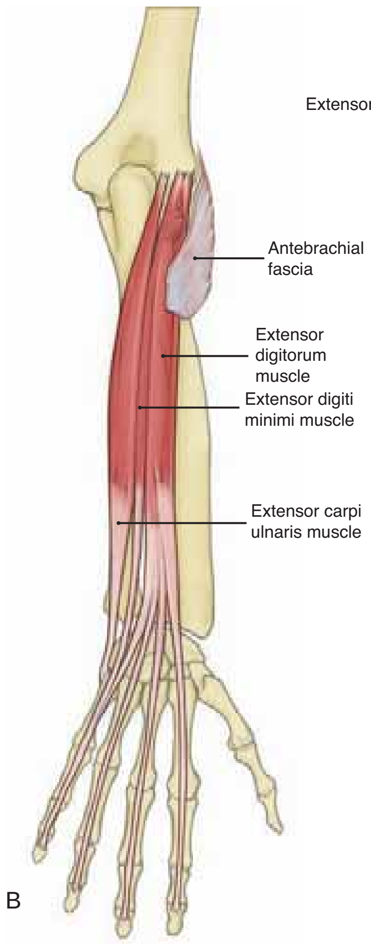


FIGURE 85B Superficial Dorsal Muscles of the Forearm

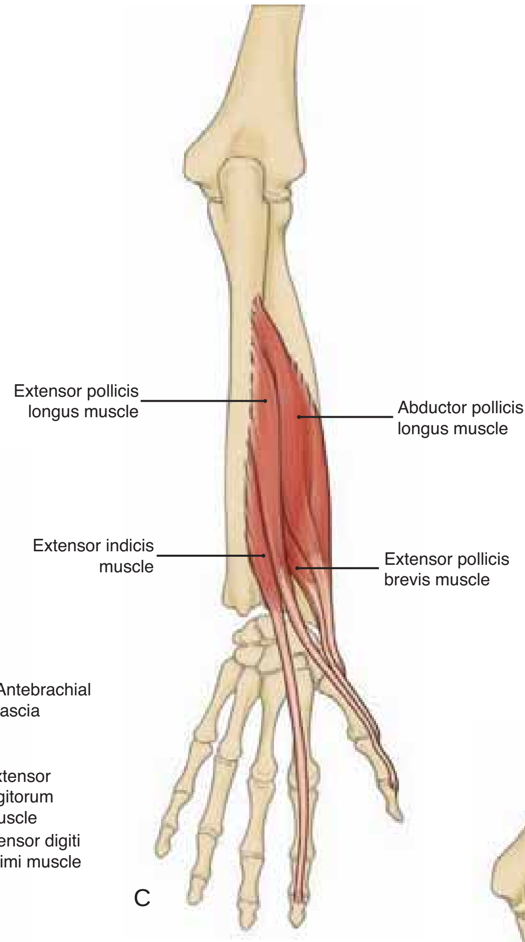


FIGURE 85C Dorsal Muscles of the Forearm: Intermediate and Deep Layers

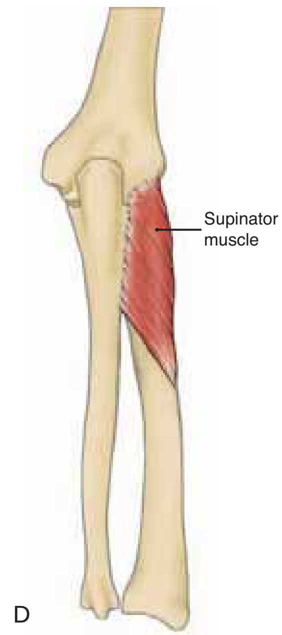


FIGURE 85D Supinator Muscle (One of the Deep Forearm Muscles)

SUPERFICIAL EXTENSOR FOREARM MUSCLES

Muscle	Origin	Insertion	Innervation	Action
Extensor digitorum	Lateral epicondyle of humerus	Dorsum of middle and distal phalanges of the four fingers	Posterior interosseous branch of the radial nerve (C7, C8)	Extends the fingers and the hand
Extensor digiti minimi	Lateral epicondyle of humerus	Dorsal digital expansion of little finger	Posterior interosseous branch of the radial nerve (C7, C8)	Extends the little finger and the hand
Extensor carpi ulnaris	Lateral epicondyle of humerus	Medial side of the base of the fifth metacarpal bone	Posterior interosseous branch of the radial nerve (C7, C8)	Extends and adducts the hand (ulnar deviation)
Anconeus	Lateral epicondyle of humerus	Lateral side of olecranon and shaft of ulna	Radial nerve (C7, C8, T1)	Helps extend the forearm at the elbow joint

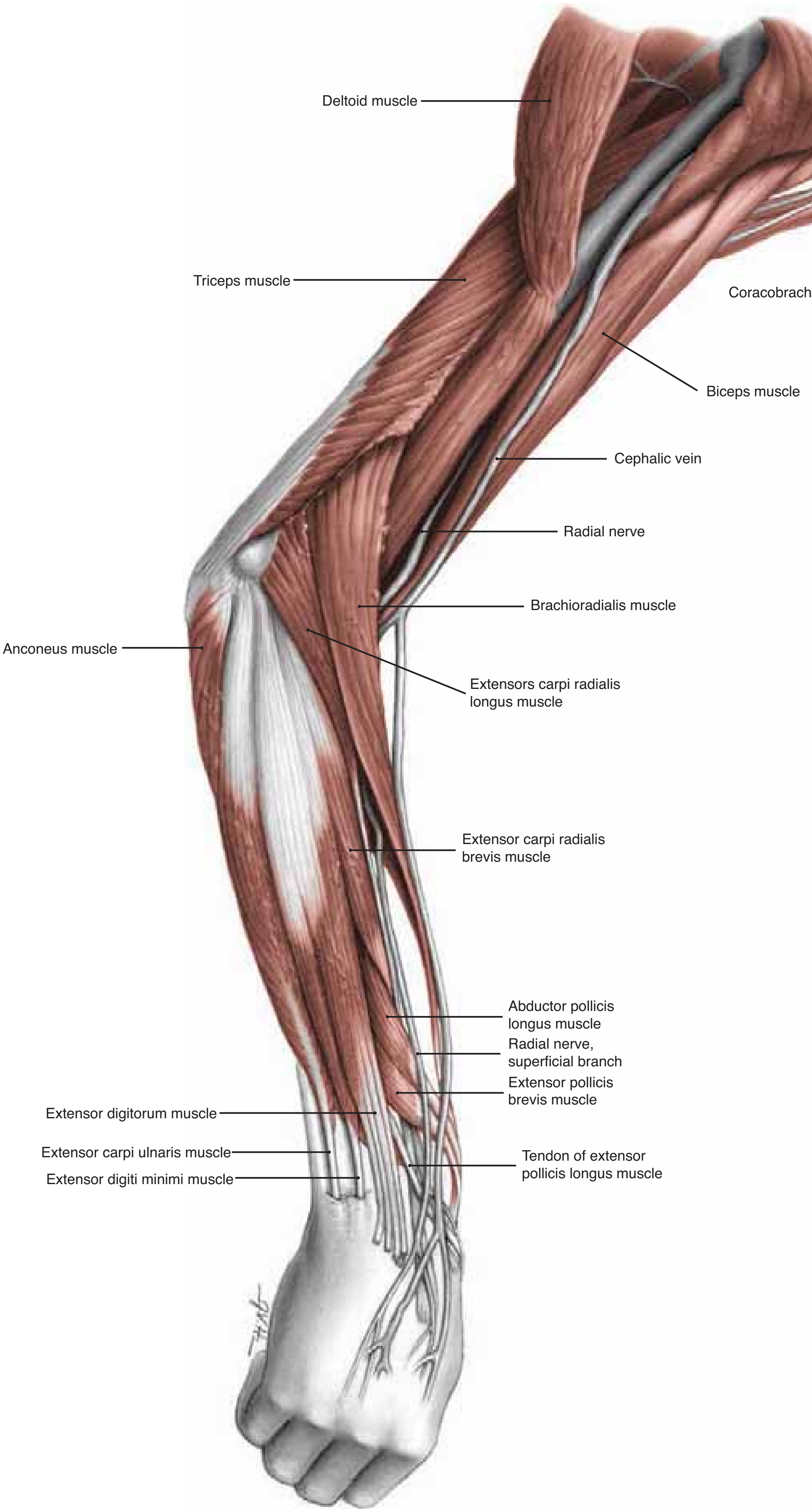


FIGURE 86.1 Posterior Muscles on the Dorsal Arm and Forearm

(Contributed by Dr. Gene L. Colborn, Medical College of Georgia.)

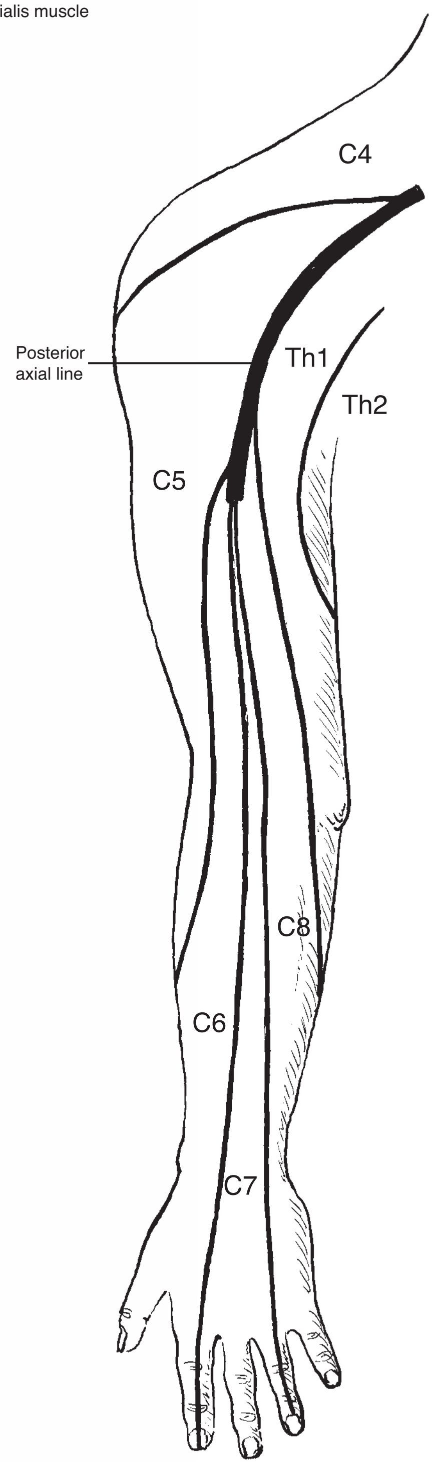


FIGURE 86.2 Dermatomes as Shown on the Posterior Aspect of the Upper Limb

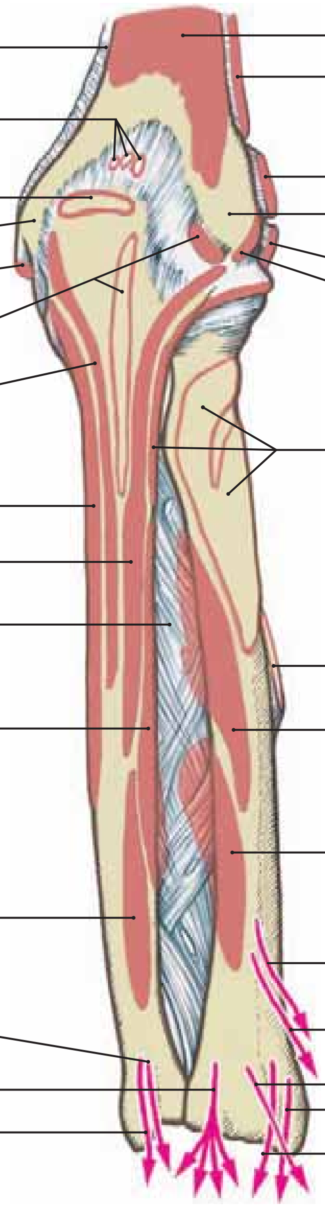


FIGURE 87 Attachments of the Extensor Muscles on the Posterior Ulna and Radius

NOTE that the red arrows (shown inferiorly) indicate the courses of the tendons across the posterior aspect of the wrist joint.

DEEP EXTENSOR FOREARM MUSCLES

Muscle	Origin	Insertion	Innervation	Action
Extensor pollicis longus	Posterior shaft of ulna and interosseous membrane	Base of the distal phalanx of the thumb	Posterior interosseous branch of the radial nerve (C7, C8)	Extends the thumb, and to a minor extent, the hand
Extensor pollicis brevis	Posterior surface of radius and interosseous membrane	Base of the proximal phalanx of the thumb	Posterior interosseous branch of the radial nerve (C7, C8)	Extends the proximal phalanx and metacarpal bone of thumb
Abductor pollicis longus	Posterior surfaces of both radius and ulna and interosseous membrane	Radial side of base of the first metacarpal bone, and on the trapezoid bone	Posterior interosseous branch of the radial nerve (C7, C8)	Abducts and assists in extending the thumb
Extensor indicis	Posterior surface of ulna and interosseous membrane	Into the extensor hood of the index finger	Posterior interosseous branch of the radial nerve (C7, C8)	Extends the index finger and helps extend the hand
Supinator	Lateral epicondyle of humerus; radial collateral ligament; supinator crest of ulna	Lateral surface of the proximal third of the radius	Posterior interosseous branch of the radial nerve (C6)	Rotates the radius to supinate the hand and forearm

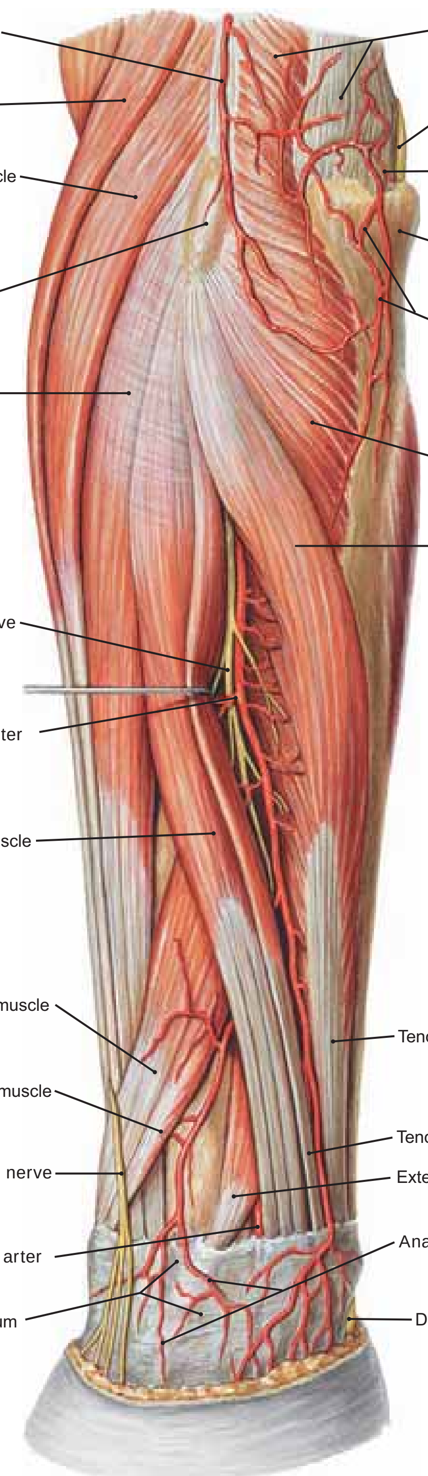


FIGURE 88 Nerves and Arteries of the Left Posterior Forearm

NOTE: (1) The extensor digiti minimi and extensor digitorum have been separated from the extensor carpi ulnaris to expose the **posterior interosseous artery** and the **deep radial nerve**.

(2) The posterior interosseous artery is derived in the anterior compartment of the forearm from the common interosseous artery, a branch of the ulnar artery, which divides into anterior and posterior interosseous branches (see Fig. 38.1).

(3) The posterior interosseous branch passes over the proximal border of the interosseous membrane to achieve the posterior compartment, and it descends with the deep radial nerve between the superficial and deep extensor forearm muscles.

(4) In the distal forearm, the posterior interosseous artery anastomoses with terminal branches of the anterior interosseous artery to help form the carpal anastomosis at the wrist.

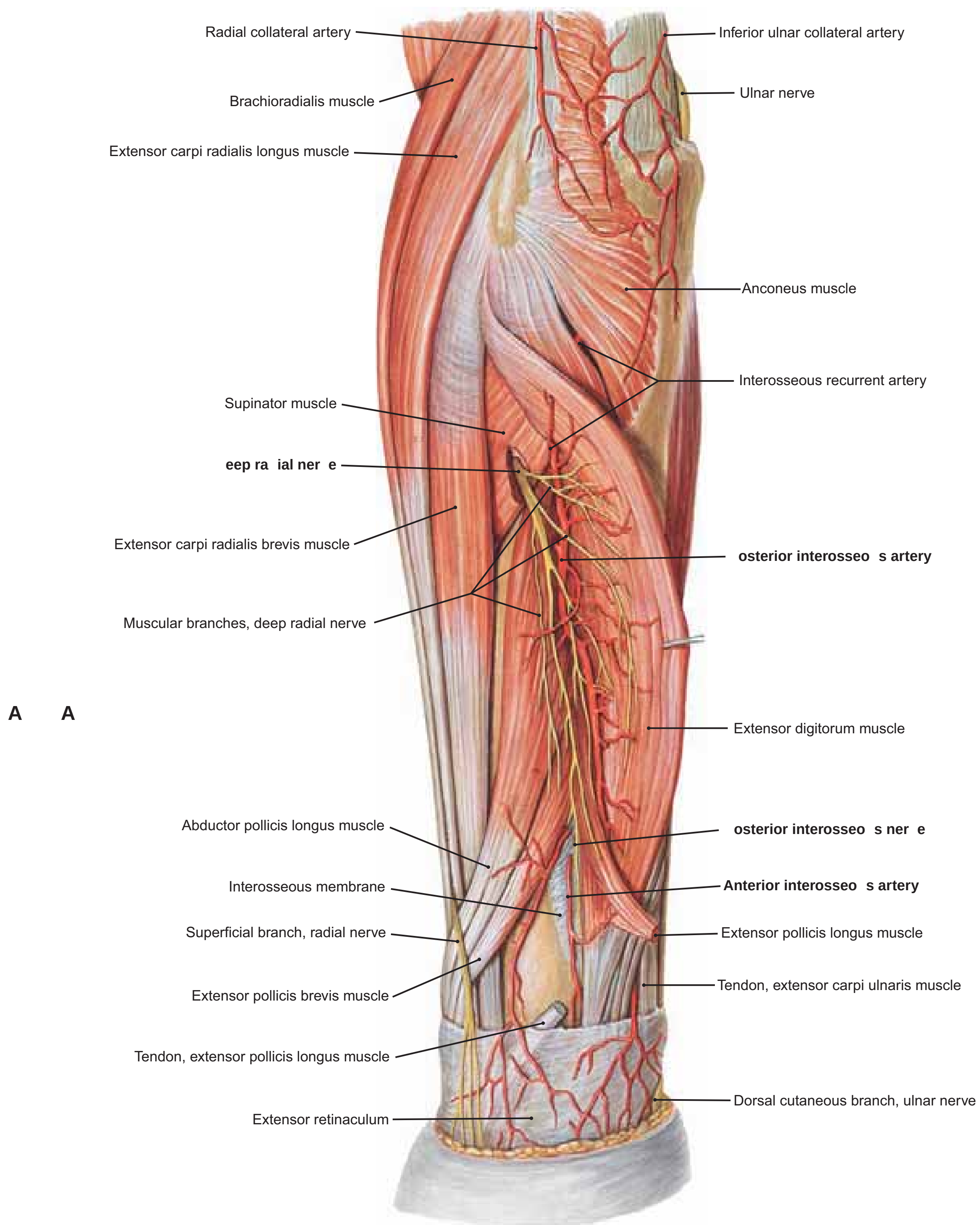


FIGURE 89 Nerves and Arteries of the Left Posterior Forearm (Deep Dissection)

NOTE: (1) The extensor digitorum muscle is separated from the extensor carpi radialis brevis and pulled medially to reveal the **posterior interosseous artery** and **deep radial nerve**.

(2) After the radial nerve leaves the radial groove of the humerus in the lower brachium, it divides into superficial and deep branches.

(3) The **superficial branch** descends along the lateral side of the forearm under cover of the brachioradialis muscle and becomes a sensory nerve to the dorsum of the hand.

(4) The **deep branch** enters the posterior forearm by piercing through the supinator muscle and, coursing along the dorsum of the interosseous membrane, is called the **posterior interosseous nerve**. It supplies all the deep posterior forearm muscles and descends deep to the extensor pollicis longus muscle, which has been cut in this dissection.

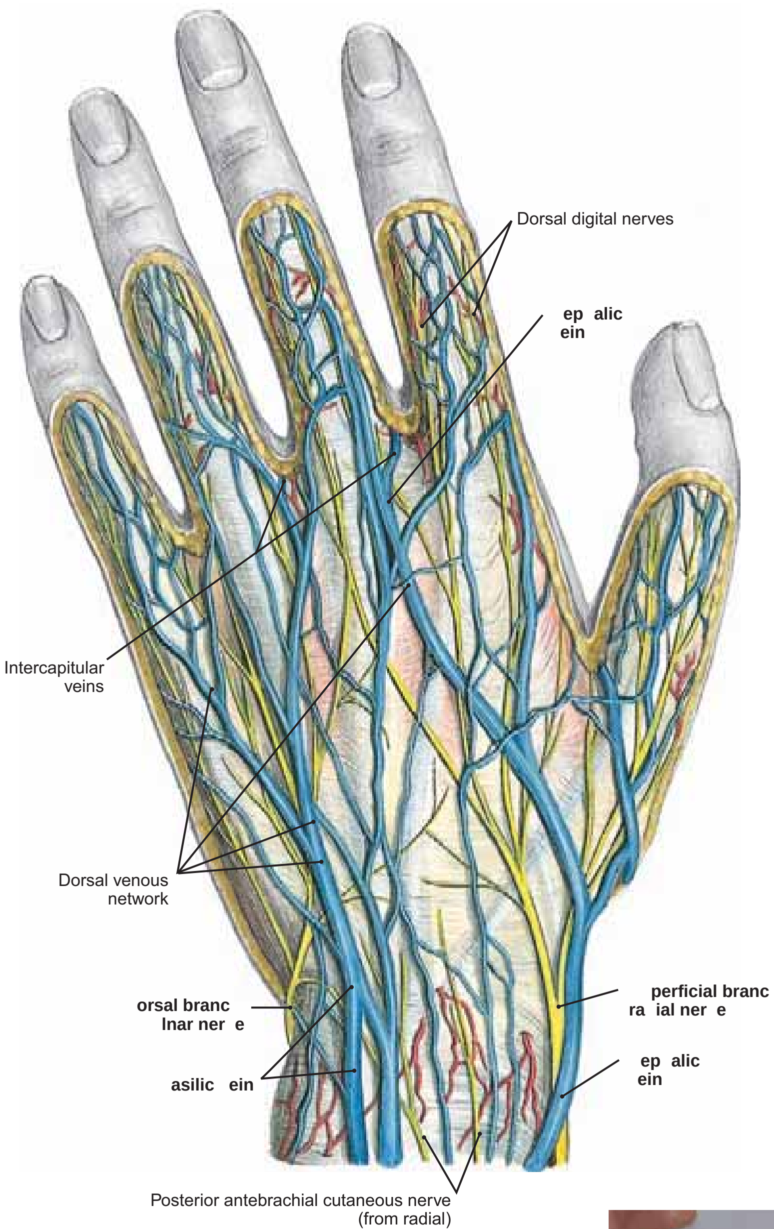


FIGURE 90.1 Superficial Veins and Nerves of the Dorsum of the Left Hand

NOTE: (1) The **cephalic vein** originates on the radial side of the dorsum of the hand, whereas the **basilic vein** arises on the ulnar side.

(2) The **superficial radial** nerve supplies the dorsum of the radial 3½ digits, whereas the **dorsal branch of the ulnar nerve** supplies the dorsum of the ulnar 1½ digits.

(3) The dorsum of the distal phalanx (not dissected) of the radial 3½ digits is supplied by the **median nerve**, but the same region on the ulnar 1½ digits is supplied by the **ulnar nerve**.

(4) There is a profuse venous plexus on the dorsal surface of the hand but very few small superficial veins on the palmar surface. This is beneficial because the frequent mechanical pressures to which the palmar surface is subjected could injure surface vessels.

(5) Adjacent branches of the radial and ulnar nerve frequently communicate. Observe that the posterior antebrachial cutaneous branches usually terminate at the wrist.

FIGURE 90.2 Location of Injection Site (X) to Induce Local Sensory Anesthesia of the Middle Finger

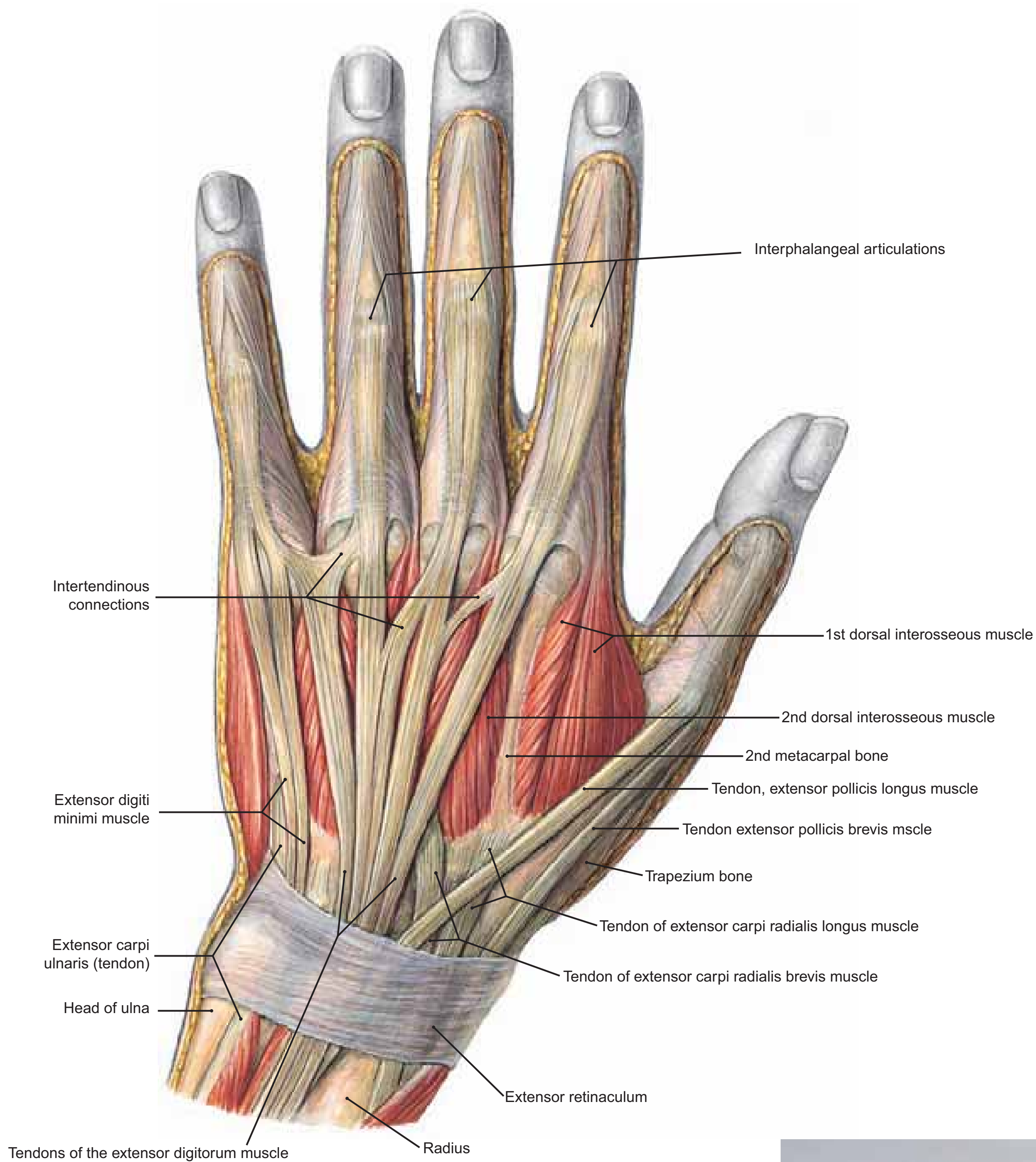


FIGURE 91.1 The Extensor Tendons on the Dorsum of the Left Wrist and Hand

NOTE: (1) The tendons of the extensor digitorum muscle pass deep to the extensor retinaculum (along with the tendons of the extensors pollicis longus and brevis and extensor digiti minimi).

(2) The extensor digitorum tendons then separate and become inserted onto the middle and distal phalanges of the medial four fingers.

(3) Distal to the metacarpophalangeal joints, the tendons spread into aponeuroses covering the dorsal surfaces of the fingers, thereby helping form the **extensor hood**.

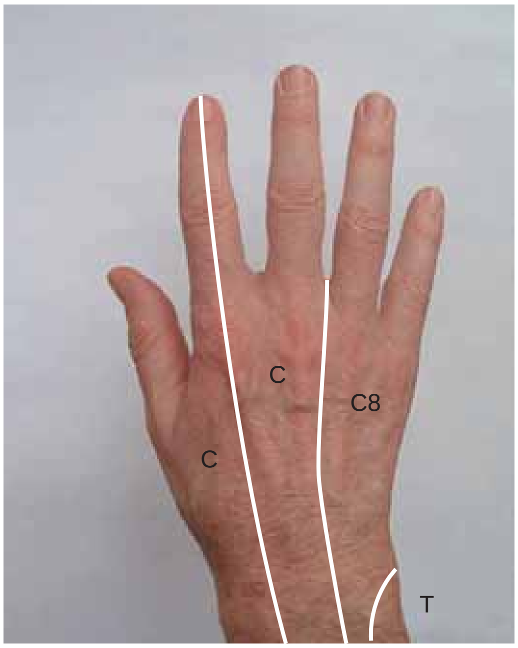


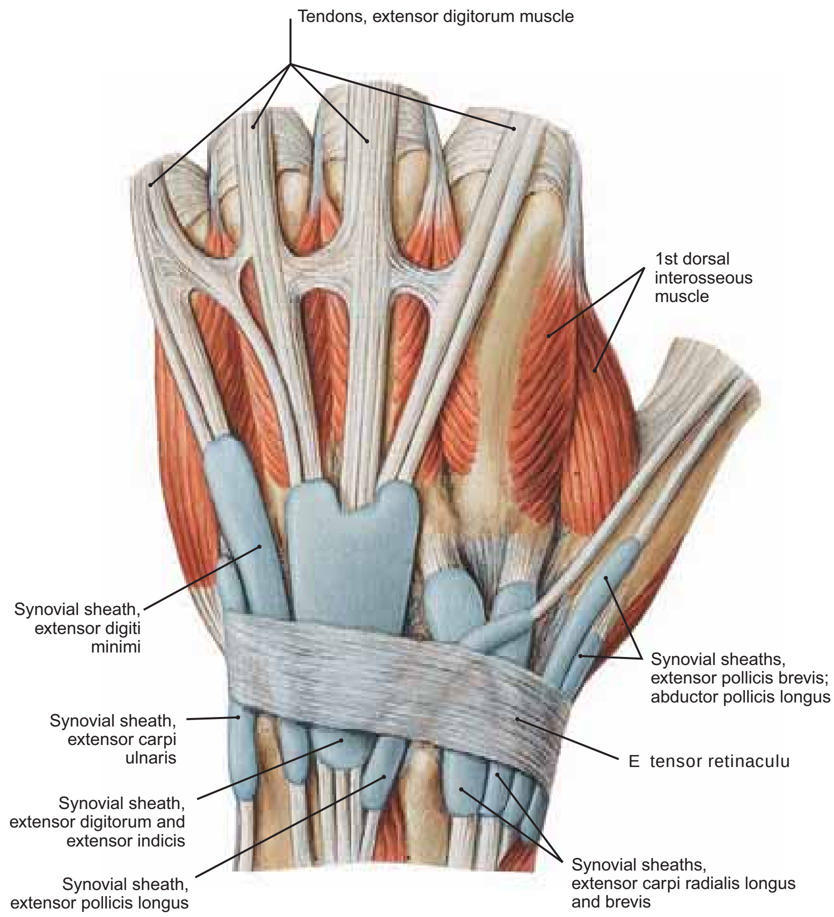
FIGURE 91.2 Dermatomes on the Dorsal Surface of the Left Hand

FIGURE 92.1 Extensor Tendons and Their Synovial Sheaths of the Left Dorsal Wrist

NOTE: (1) A synovial sheath is a double mesothelial-lined envelope that surrounds a tendon, allowing it to move more freely beneath the retinaculum.

(2) There are six synovial compartments on the dorsum of the wrist. From radial to ulnar these contain the tendons of:

(a) Extensor pollicis brevis and abductor pollicis longus
(b) Extensor carpi radialis longus and brevis
(c) Extensor pollicis longus
(d) Extensor digitorum and extensor indicis
(e) Extensor digiti minimi
(f) Extensor carpi ulnaris.



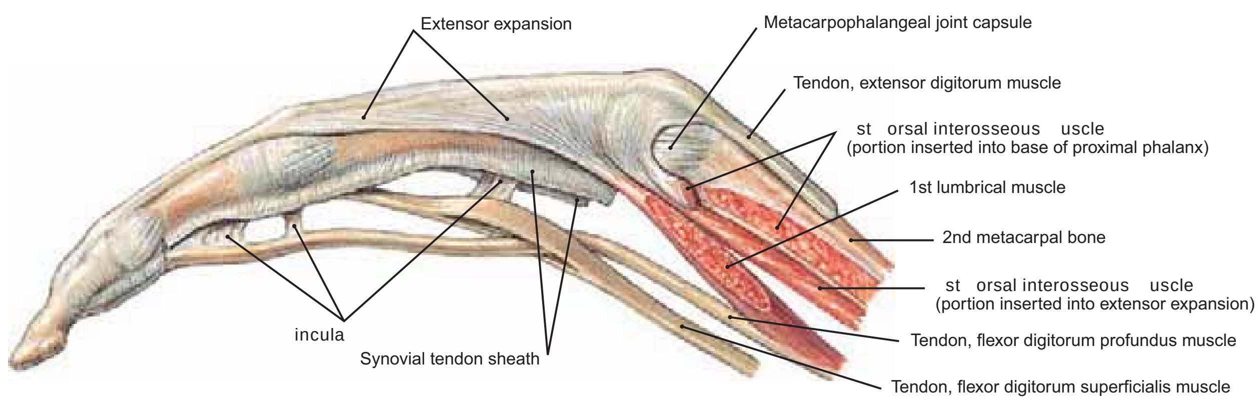


FIGURE 92.2 Tendon Insertions, Index Finger of Right Hand (Radial Side)

NOTE: (1) The dorsal interosseous and lumbrical muscles join fibers from the extensor tendon in the formation of the dorsal extensor expansion.

(2) The vincula are remnants of mesotendons and attach both superficial and deep tendons to the digital sheath.

(3) The tendon of the flexor digitorum superficialis splits to allow the tendon of the flexor digitorum profundus to reach the distal phalanx of the finger.

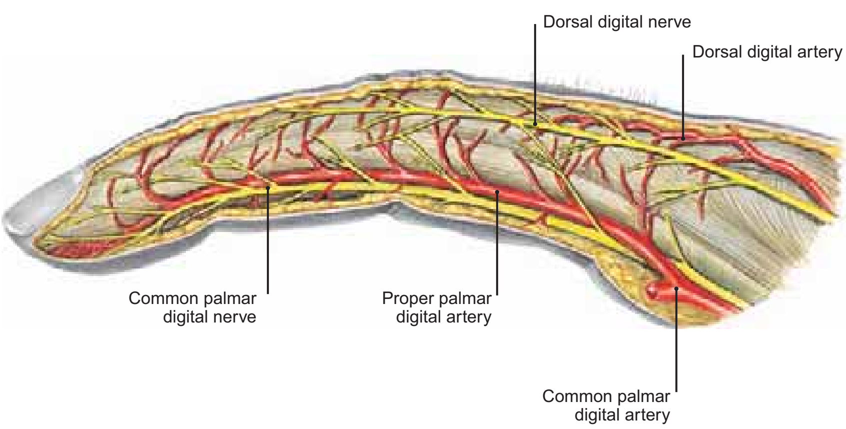
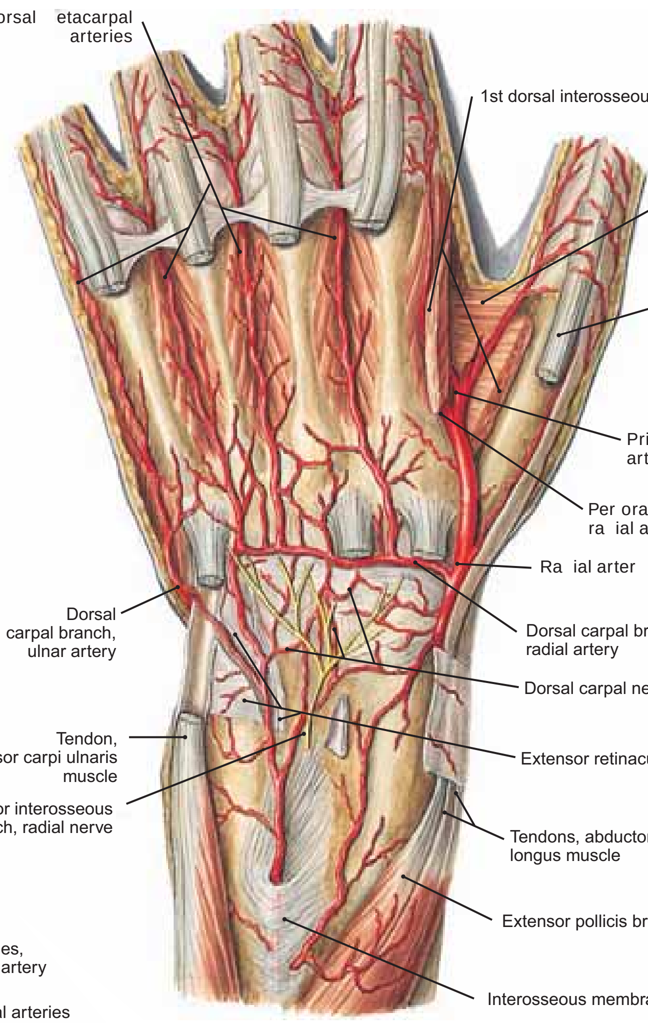


FIGURE 92.3 Nerves and Arteries of the Index Finger

NOTE: The **dorsal digital nerve** and **artery** extend only two-thirds the length of the finger. The distal third is supplied by the **palmar digital nerve and artery,** which also supplies the entire palmar surface of the finger.

FIGURE 93.1 Arteries of the Left Dorsal Wrist and Hand (Deep View)

NOTE: (1) The transverse course of the dorsal carpal branch of the radial artery.
(2) The princeps pollicis branch of the radial artery coursing deep to the first dorsal interosseous muscle.



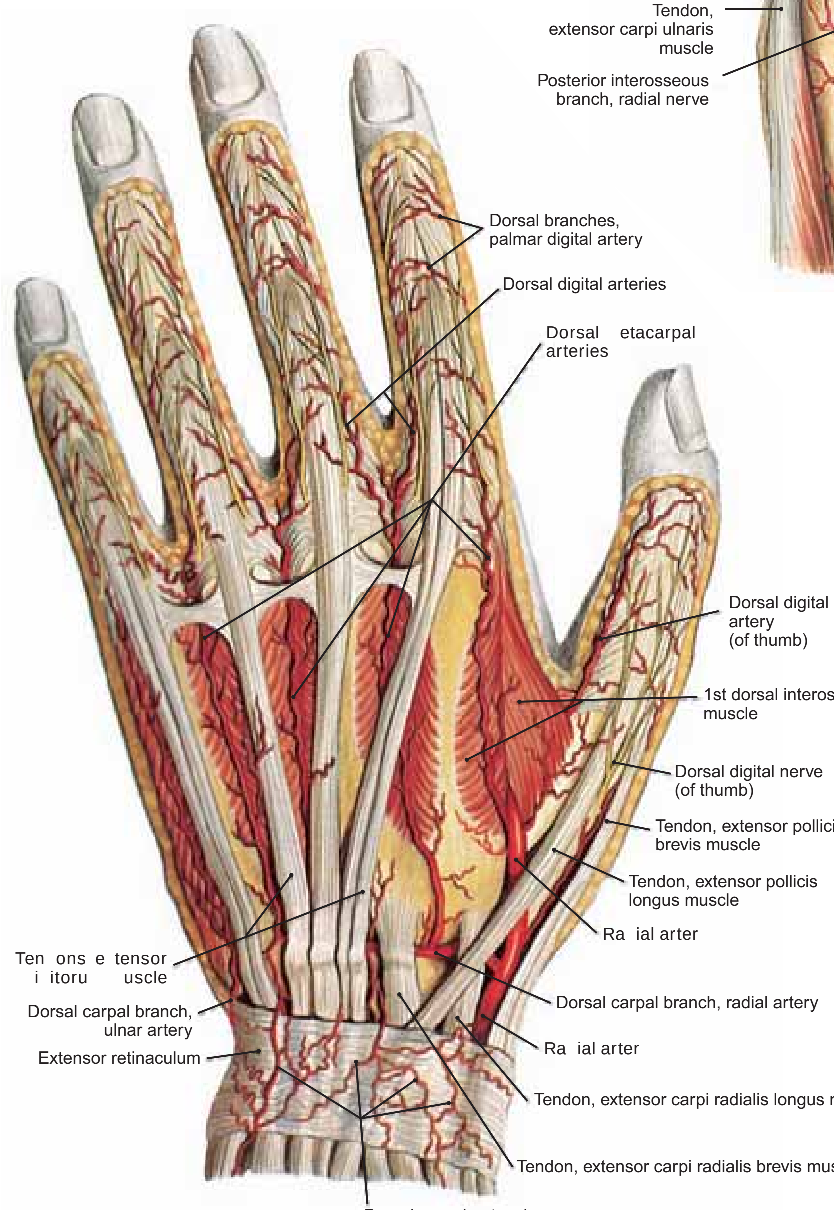


FIGURE 93.2 Tendons, Arteries, and Digital Nerves of Dorsum of the Left Hand

NOTE: (1) The radial artery is the principal source of blood to the dorsum of the hand.
(2) From the dorsal carpal branch stem the dorsal metacarpal arteries, which divide into digital branches.
(3) The dorsal digital artery of the thumb comes directly from the radial.
(4) The distal portions of the dorsal aspect of the digits receive both arterial and nerve branches, which curve to the dorsum from the palmar aspect of the fingers.

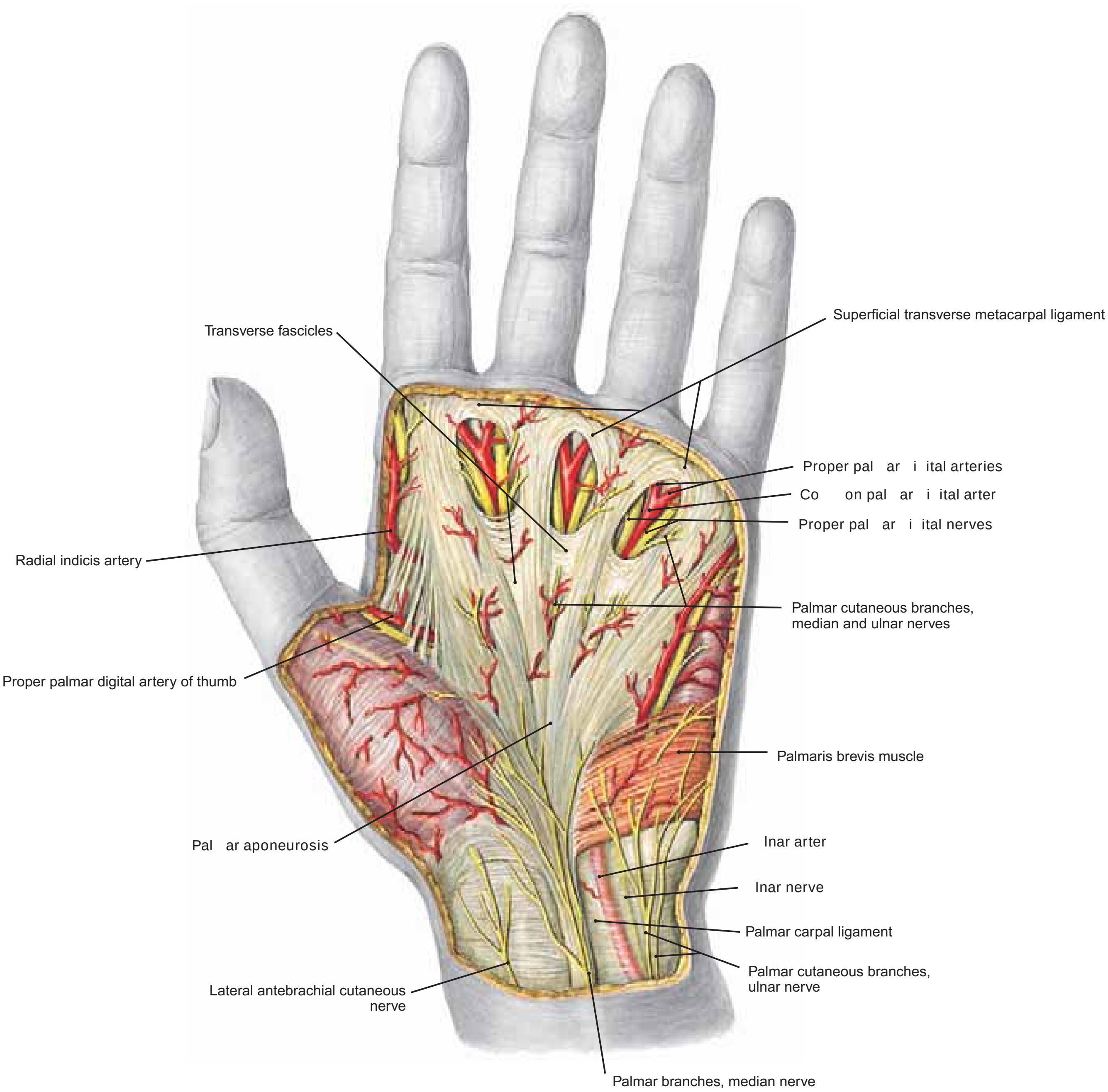


FIGURE 94 Superficial Nerves and Arteries of the Palm of the Left Hand

NOTE: (1) The thick and tough fibrous palmar aponeurosis protects the palmar vessels and nerves and strengthens the midportion of the palm. This is of special benefit when the hands are used to push heavy structures or to manually resist an oncoming forceful object (e.g., a fast moving ball in a sport such as baseball).

(2) The radial two-thirds of the surface of the palm is innervated by the median nerve, whereas the ulnar one-third is supplied by the ulnar nerve.

(3) In the distal palm where the palmar aponeurosis is deficient, the vessels and nerves coursing to the fingers are exposed just deep to the skin. This makes them vulnerable to relatively superficial cuts and abrasions.

(4) The three common palmar digital arteries each divides into two proper digital arteries, and their bifurcations occur at the level of the metacarpophalangeal joints.

(5) As each common palmar digital artery divides, the two proper palmar digital arteries course distally on the fingers and supply the adjacent halves of two fingers.

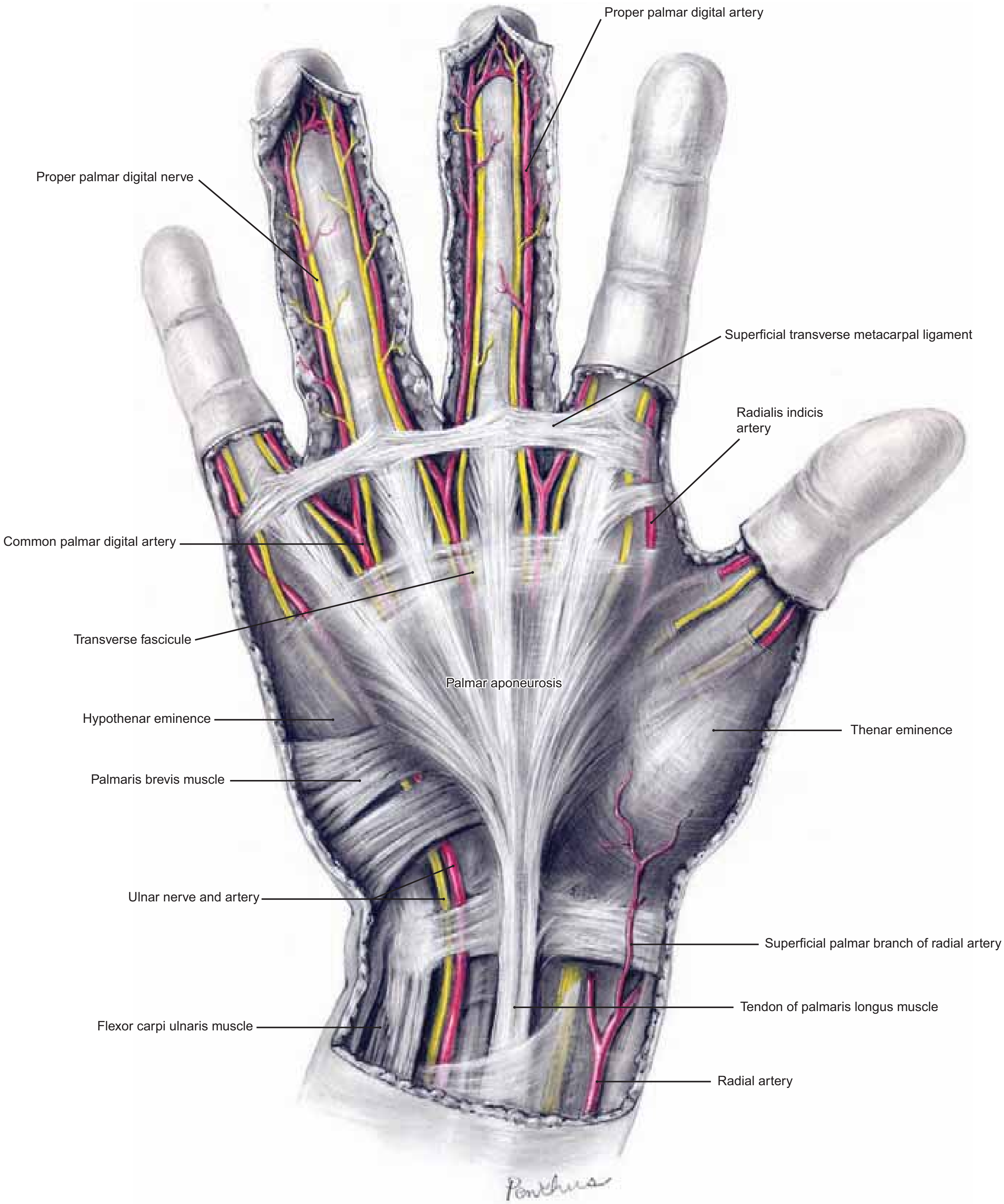


FIGURE 95 Superficial Dissection of the Palm and the Extensions Distally of the Middle and Ring Fingers

NOTE the distal course of the proper digital nerves and arteries along the fingers. These vessels and nerves are especially vulnerable both proximal and distal to the superficial transverse metacarpal ligaments. There are anastomoses at the distal ends of the fibers beyond the distal phalanx. (From C.D. Clemente. *Gray's Anatomy*, 30th American Edition. Philadelphia: Lea & Febiger, 1985.)

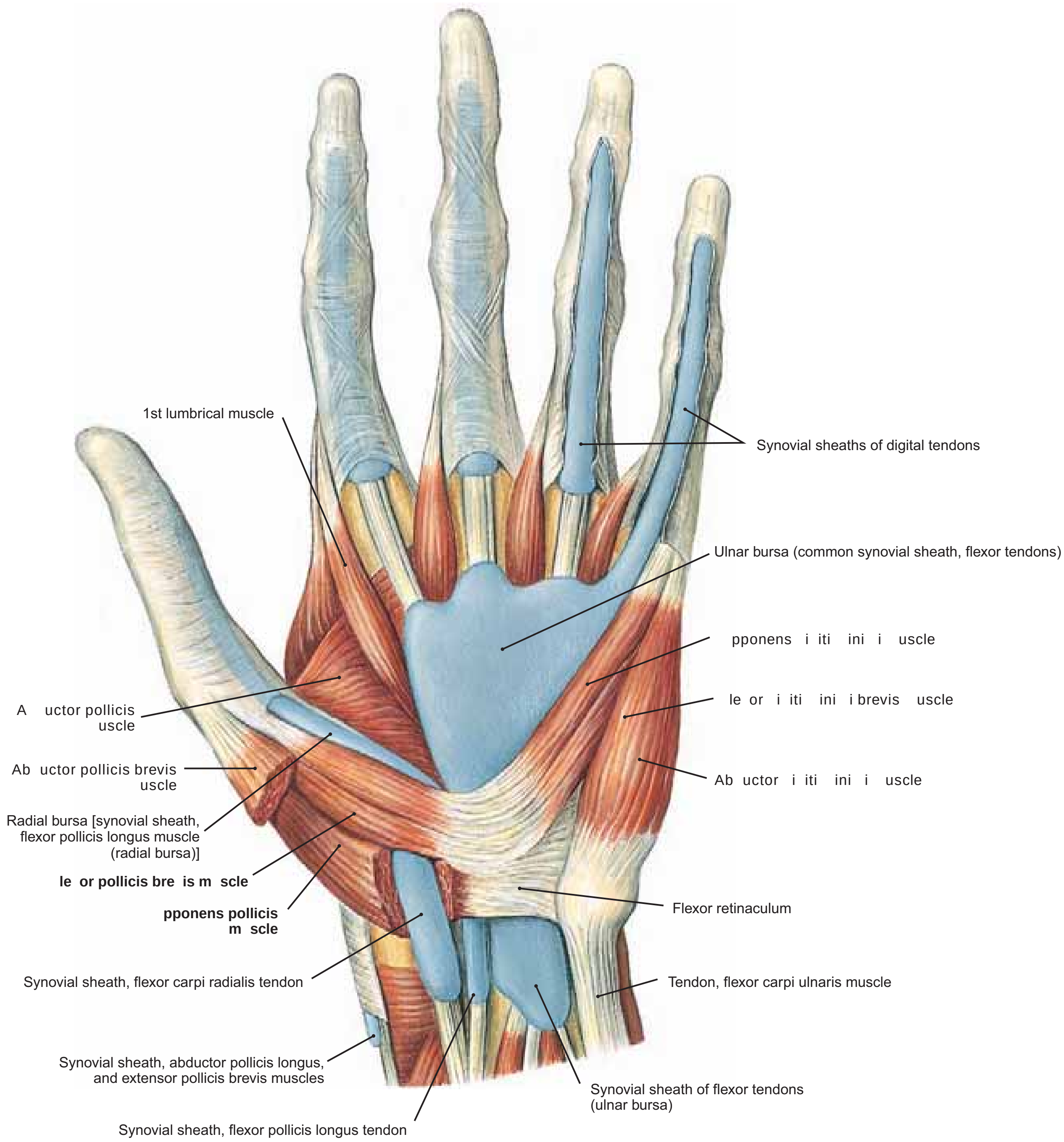


FIGURE 96 Muscles, Synovial Sheaths, and Tendons of the Left Wrist and Palm

THENAR MUSCLES Muscle	Origin	Insertion	Innervation	Action
Flexor pollicis brevis	**Superficial head:** Flexor retinaculum and tubercle of the trapezium **Deep head:** Trapezoid and capitate bones	Radial side of base of proximal phalanx of thumb	**Superficial head:** Median nerve (C8, T1). **Deep head:** Deep branch of ulnar nerve (C8, T1).	Flexes proximal phalanx of thumb; flexes metacarpal bone and rotates it medially
Adductor pollicis	**Oblique head:** Capitate bone and bases of second and third metacarpal bones. **Transverse head:** Palmar surface of third metacarpal bone	Ulnar side of base of proximal phalanx of thumb	Deep branch of ulnar nerve (C8, T1)	Adducts the thumb

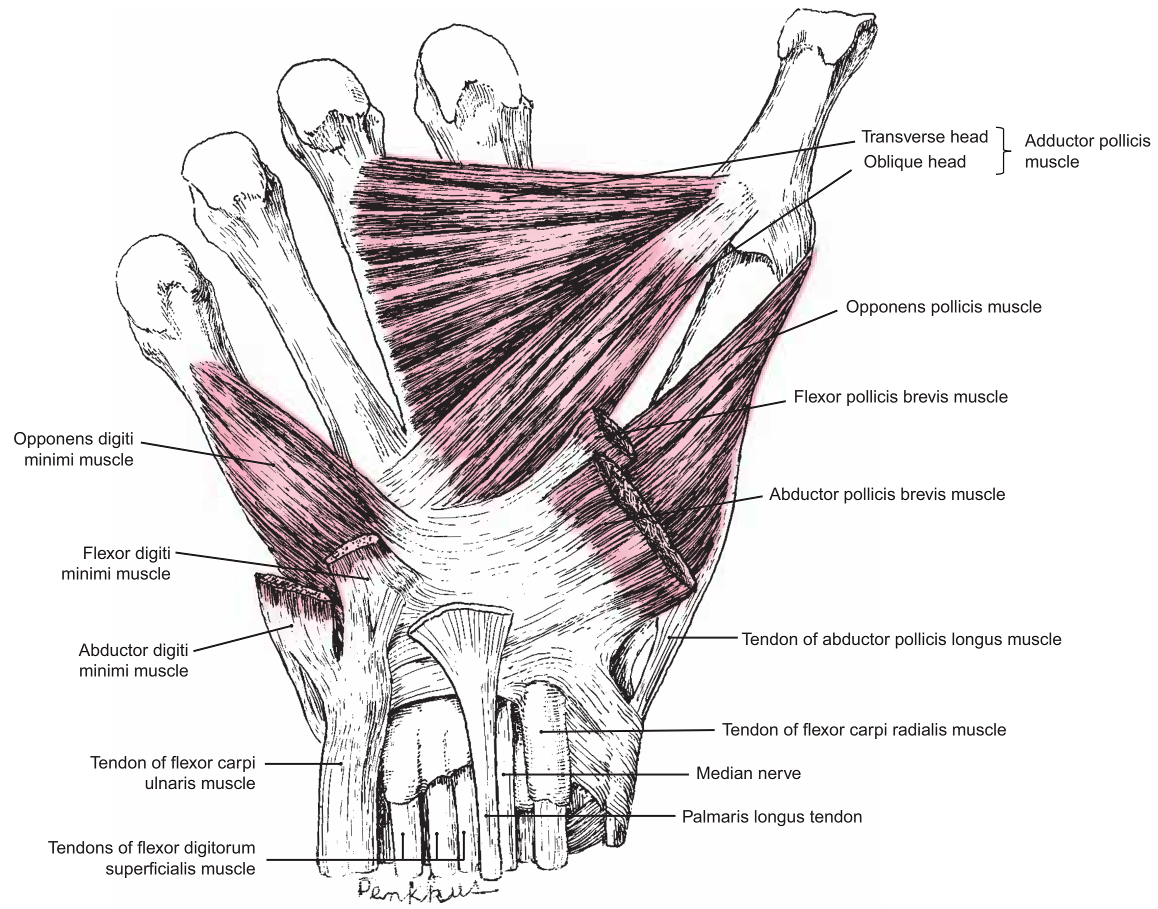


FIGURE 97.1 Thenar and Hypothenar Muscles of the Right Hand

NOTE: (1) The abductor pollicis brevis muscle has been cut and pulled laterally to separate it from the flexor pollicis brevis and to uncover the opponens pollicis.
(2) The flexor digiti minimi brevis has been cut and retracted to show where it separates from the abductor digiti minimi muscle.

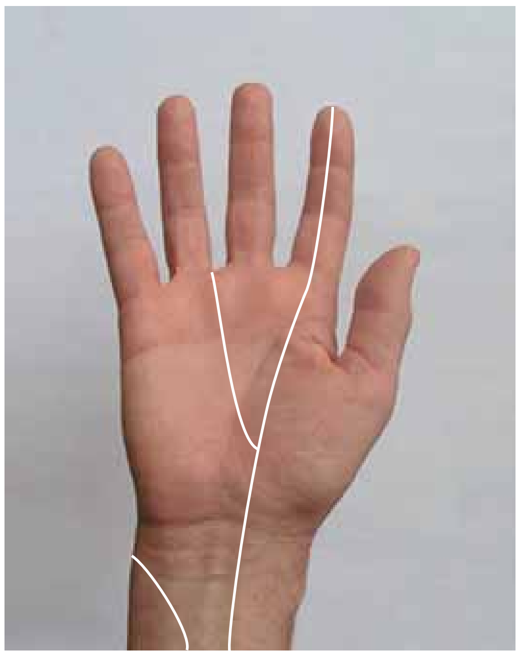


FIGURE 97.2 Dermatomes on the Palmar Aspect of the Hand

NOTE that C6, C7, and C8 segmental nerves supply cutaneous innervation to the palmar surface of the hand.

THENAR (THUMB) MUSCLES OF HAND (CONT.)

Muscle	Origin	Insertion	Innervation	Action
Abductor pollicis brevis	Flexor retinaculum and the tubercle of the trapezium	Base of proximal phalanx of thumb; dorsal digital expansion of thumb	Median nerve (C8, T1)	Abducts thumb
Opponens pollicis	Flexor retinaculum and the tubercles of the scaphoid and trapezium bones	Whole length of lateral border of metacarpal bone of the thumb	Median nerve (C8, T1) and often a small branch of deep ulnar nerve	Opposes the thumb to the other fingers

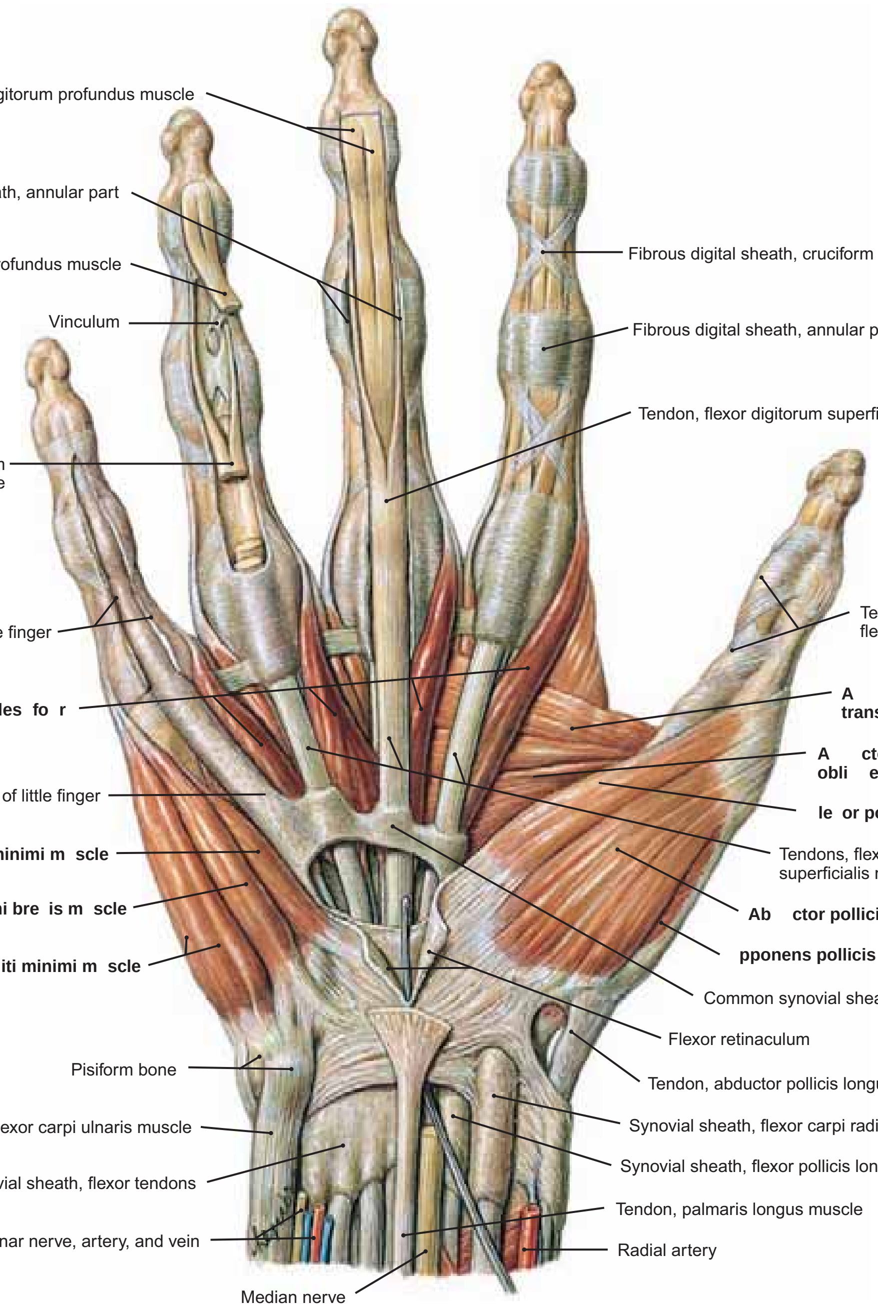


FIGURE 98 Muscles of the Right Hand

HYPOTHENAR (LITTLE FINGER) MUSCLES OF HAND

Muscle	Origin	Insertion	Innervation	Action
Palmaris brevis (see Fig. 94)	Palmar aponeurosis and flexor retinaculum	Into the dermis on the ulnar side of the hand	Ulnar nerve, superficial branch (C8, T1)	Helps tense the skin over the hypothenar muscles
Abductor digiti minimi	Pisiform bone and tendon of flexor carpi ulnaris	Base of proximal phalanx and dorsal aponeurosis of little finger	Ulnar nerve, deep branch (C8, T1)	Abducts the little finger
Flexor digiti minimi	Hamulus of the hamate bone and flexor retinaculum	Base of proximal phalanx of the little finger	Ulnar nerve, deep branch (C8, T1)	Flexes the little finger at metacarpophalangeal joint
Opponens digiti minimi	Hamulus of the hamate bone and flexor retinaculum	Ulnar side of fifth metacarpal bone	Ulnar nerve, deep branch (C8, T1)	Brings the little finger into opposition with the thumb

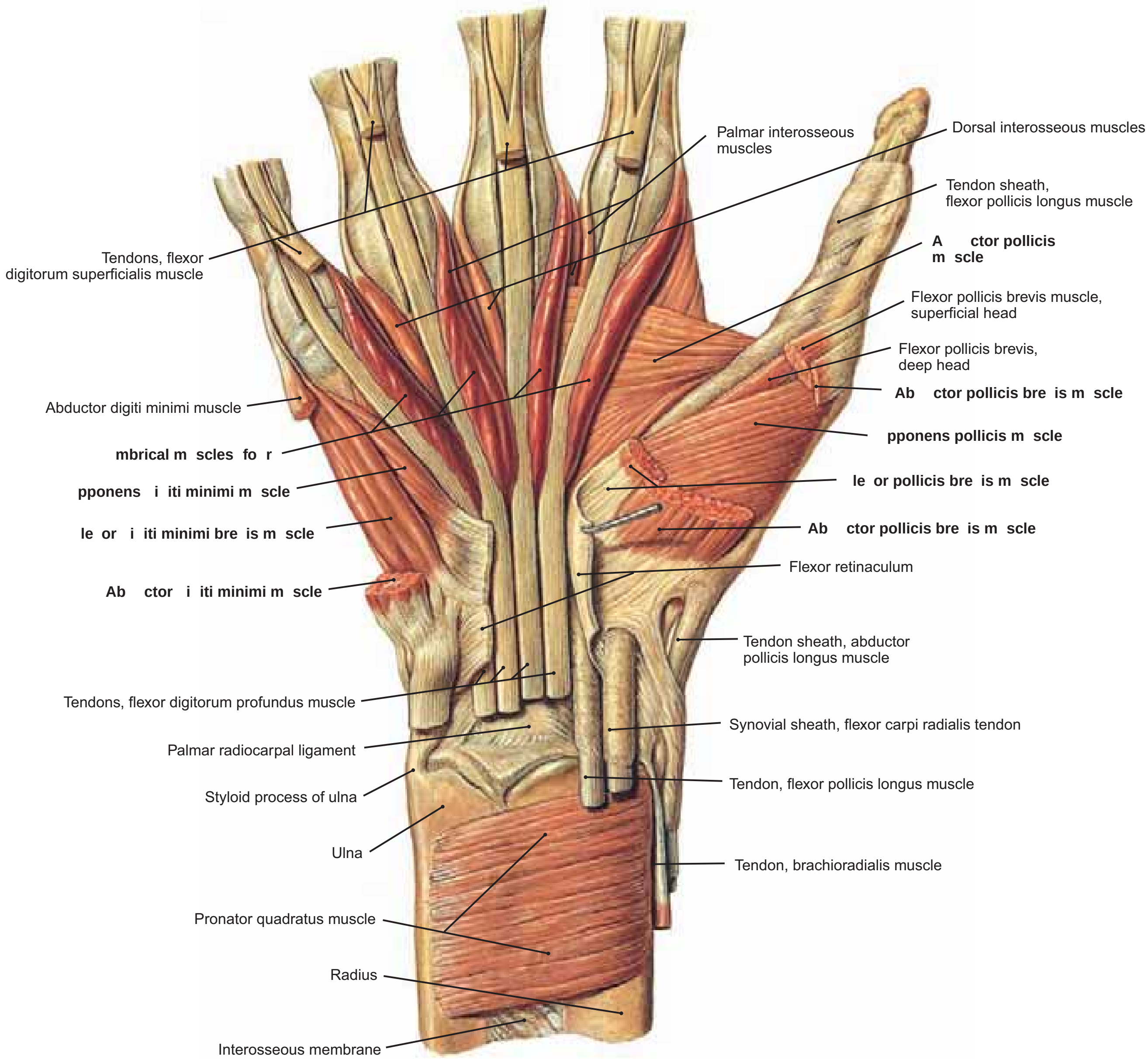


FIGURE 99.1 Deep Muscles of the Right Hand (Palmar View)

NOTE: (1) The tendon of the flexor digitorum superficialis divides into two slips and allows the flexor digitorum profundus to pass and insert onto the distal phalanx.

(2) In the fingers the tendons are encased in a synovial sheath and then bound by both crossed and transverse (cruciform and annular) fibrous sheaths (see Fig. 98).

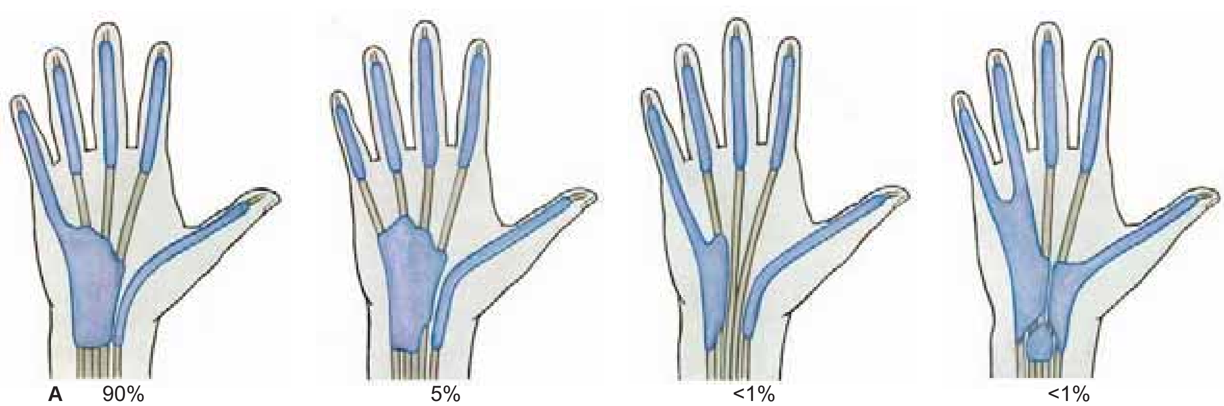


FIGURE 99.2A–D Variations in the Synovial Tendon Sheathes within the Carpal Tunnel and Hand

NOTE that because of these variations the hand surgeon must be careful when repairing carpal tunnel syndrome, since infections spread rapidly within the synovial sheathes of the hand.

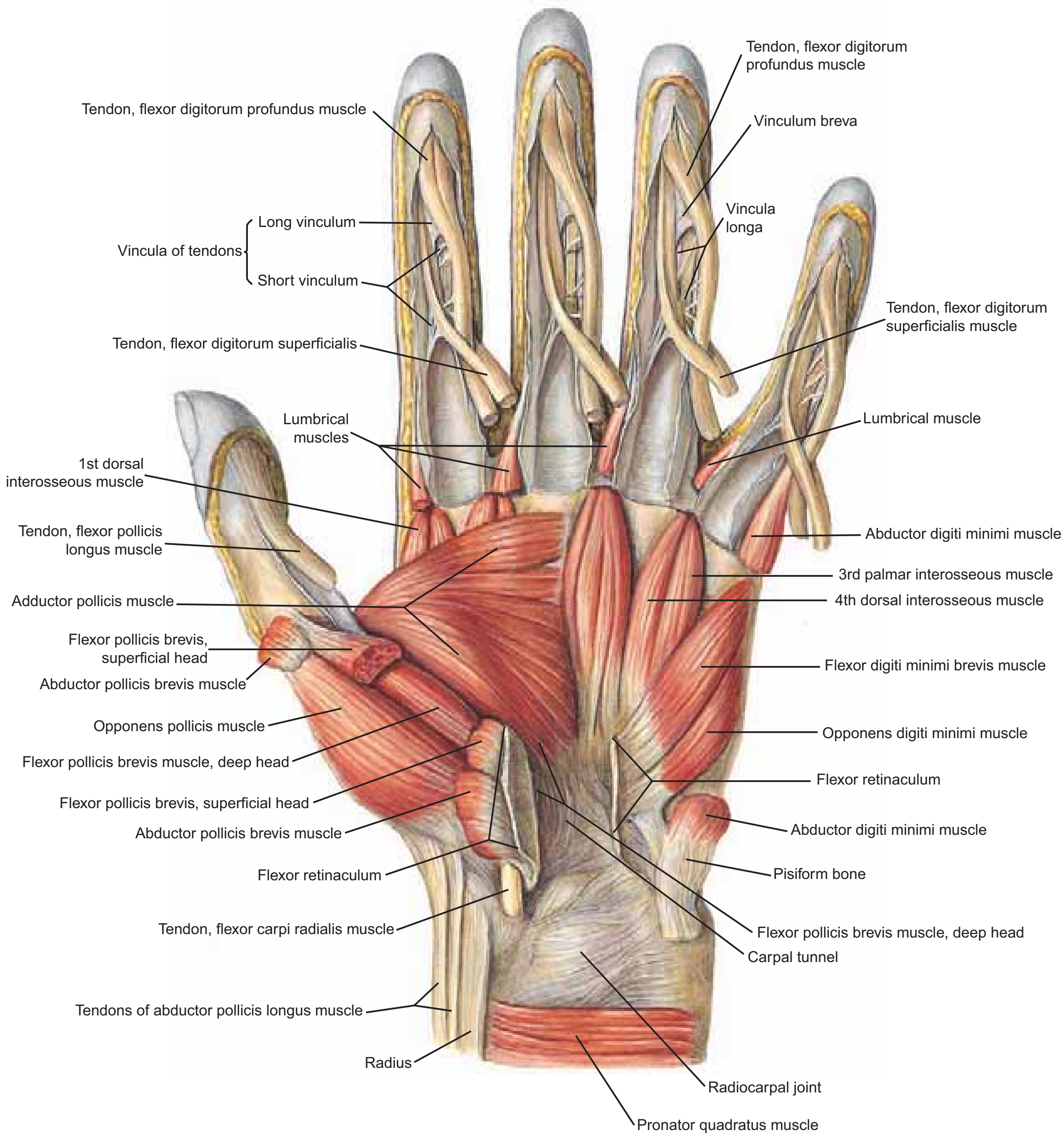


FIGURE 100 Muscles of the Left Hand: Deep Layer and Superficial and Deep Flexor Tendons

NOTE: (1) The adductor pollicis muscle. This muscle has oblique and transverse heads that course across and cover the palmar side of the first dorsal and first palmar interosseous muscles.

(2) Observe how the tendons of the flexor digitorum superficialis split in order to allow the tendons of the flexor digitorum profundus to reach the distal phalanx of each finger.

(3) The tendons of the flexor digitorum superficialis insert onto the middle phalanx of the fingers, whereas the tendons of the flexor digitorum profundus insert onto the distal phalanx.

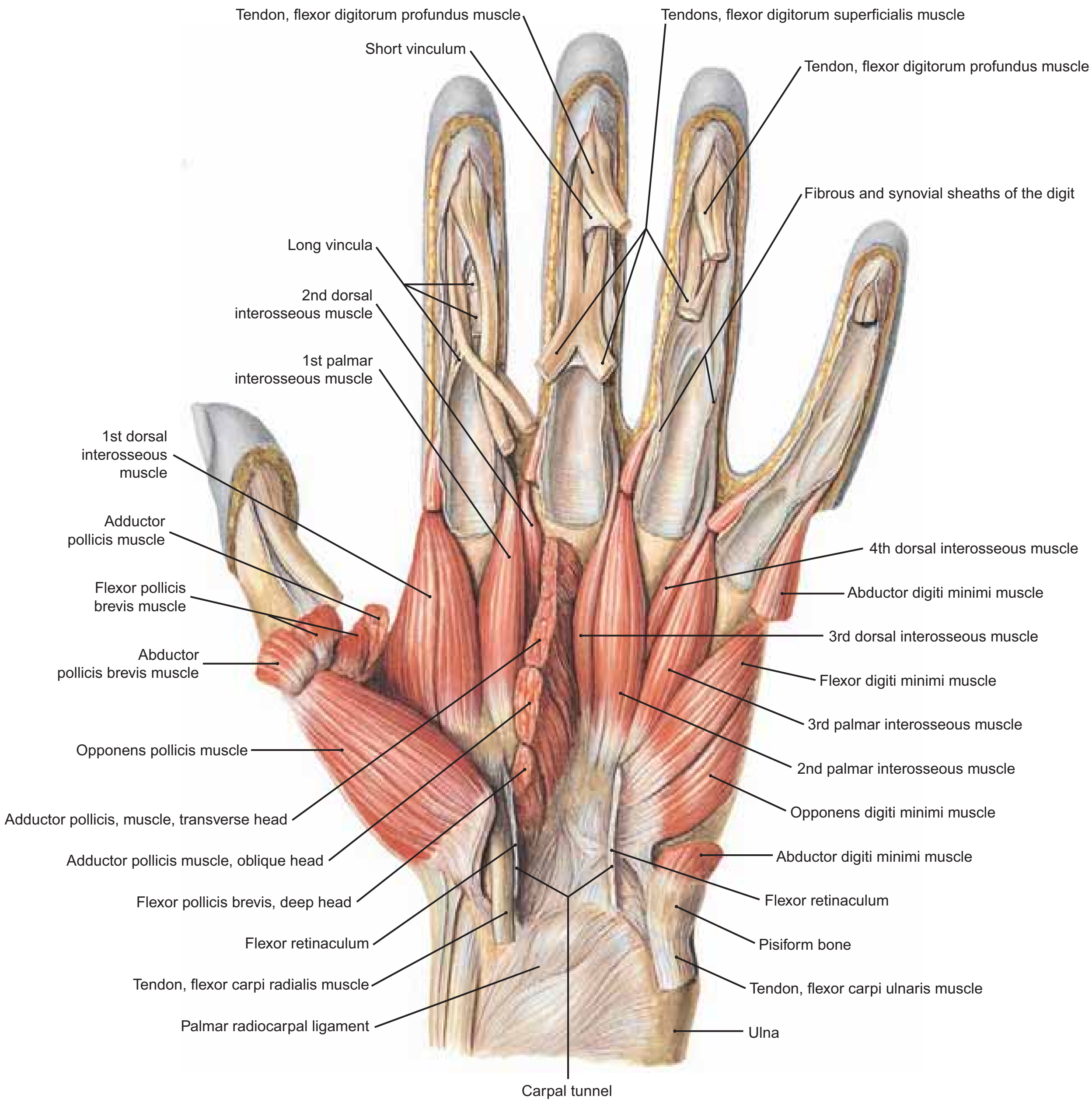


FIGURE 101 Deepest Muscle Dissection of the Left Hand with Adductor Pollicis Muscle Severed

NOTE: (1) The tendons of the three palmar and four dorsal interosseous muscles are intact and can be seen to course around to the dorsal surface of the fingers to participate in the formation of the dorsal expansion hoods.

(2) Both oblique and transverse heads of the adductor pollicis muscle have been severed to uncover the interosseous muscles more completely.

(3) Each finger requires muscles that allow adduction and abduction. The three palmar interossei adduct the second, fourth, and fifth digits. The four dorsal interossei abduct the second, third laterally, third medially, and fourth digits. To these seven interossei are added the abductor pollicis brevis, adductor pollicis, and abductor digiti minimi, resulting in the required 10 muscles for abduction and adduction of the five digits.

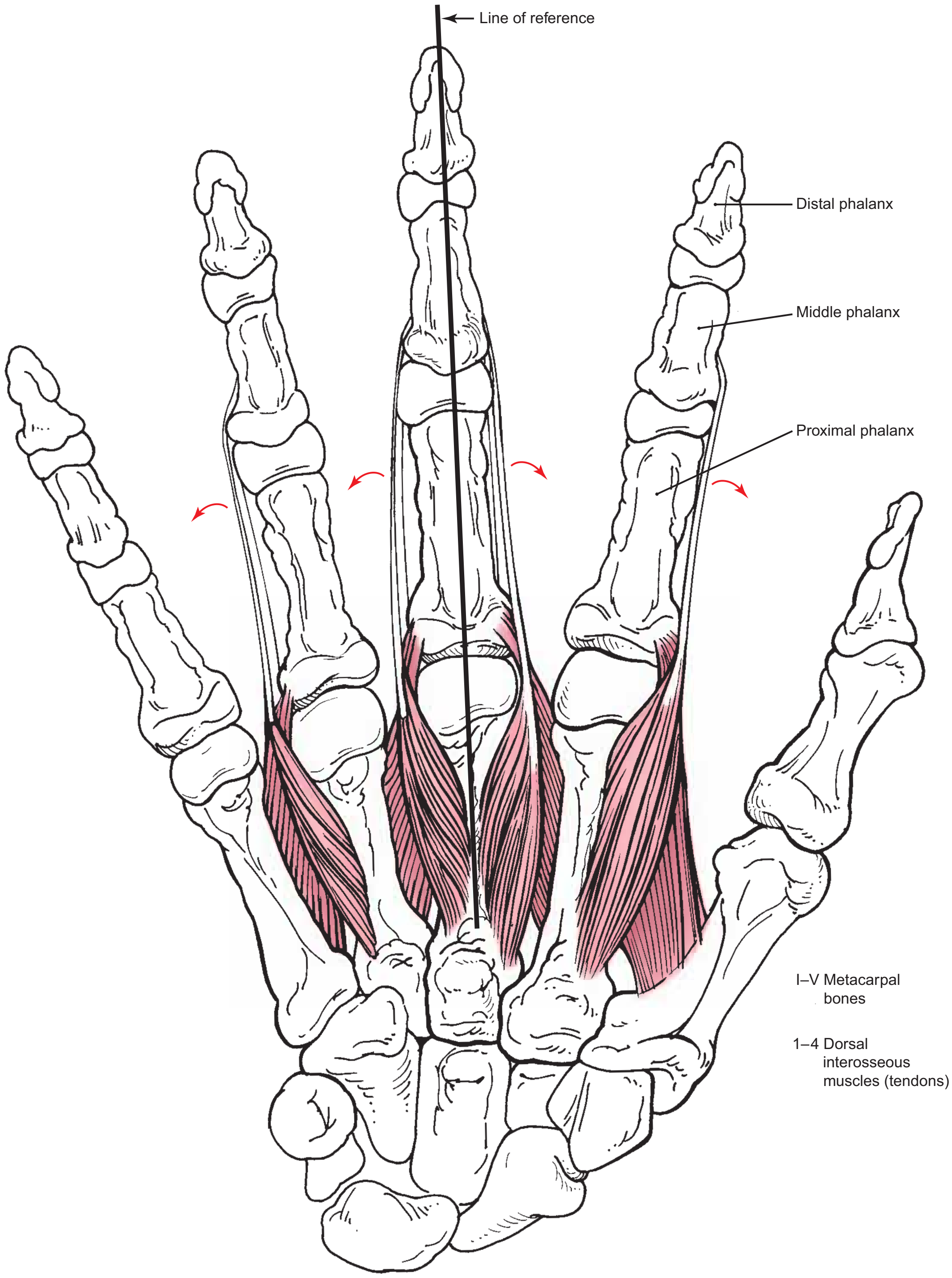


FIGURE 102 **The Four Dorsal Interosseous Muscles**

NOTE that the dorsal interosseous muscles abduct the fingers, flex the metacarpophalangeal joints, and extend the interphalangeal joints. Observe that the middle finger (III) has two muscles, one abducting the finger toward the radial side and the other abducting it toward the ulnar side. The line of reference for abduction is midway down the middle finger.

Muscle	Origin	Insertion	Innervation	Action
Dorsal interossei (four)	Each arises by two heads from the adjacent sides of metacarpal bones	Bases of the proximal phalanges and the dorsal expansions of the second, third, and fourth fingers	Ulnar nerve, deep palmar branch (C8, T1)	Abduct fingers; flex at metacarpophalangeal joints and extend at interphalangeal joints

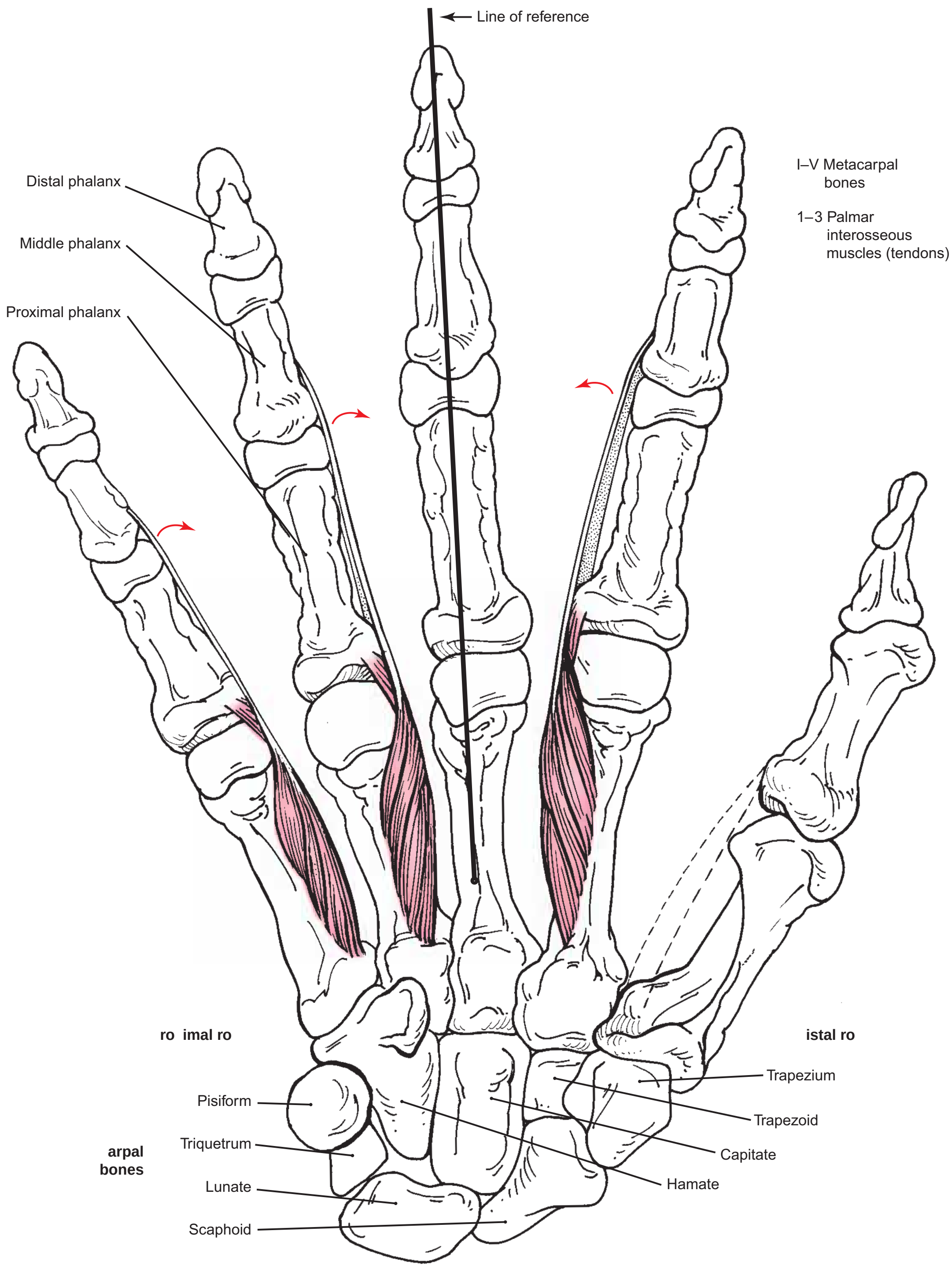


FIGURE 103 The Three Palmar Interosseous Muscles

NOTE: (1) The palmar interosseous muscles adduct the fingers; the middle finger has no palmar interosseous muscle attaching to it. The palmar interosseous muscles also flex the metacarpophalangeal joint and extend the interphalangeal joints. Observe that the line of reference for adduction is midway down the middle finger.

(2) The carpal bones are described as consisting of a **proximal row** of four bones and a **distal row** of four bones, and they articulate proximally with the bones of the forearm and distally with the metacarpal bones of the hand.

Muscle	Origin	Insertion	Innervation	Action
Palmar interossei (three)	Each arises by one head from the second, fourth, and fifth metacarpal bones	Dorsal digital expansions of the second, fourth, and fifth fingers	Ulnar nerve, deep palmar branch (C8, T1)	Adduct fingers; flex at metacarpophalangeal joints and extend at interphalangeal joints

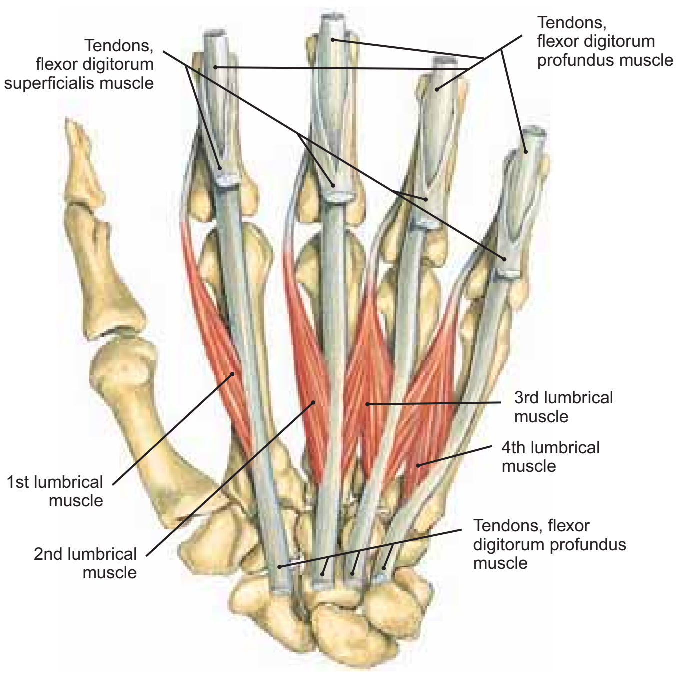


FIGURE 104.1 The Lumbrical Muscles

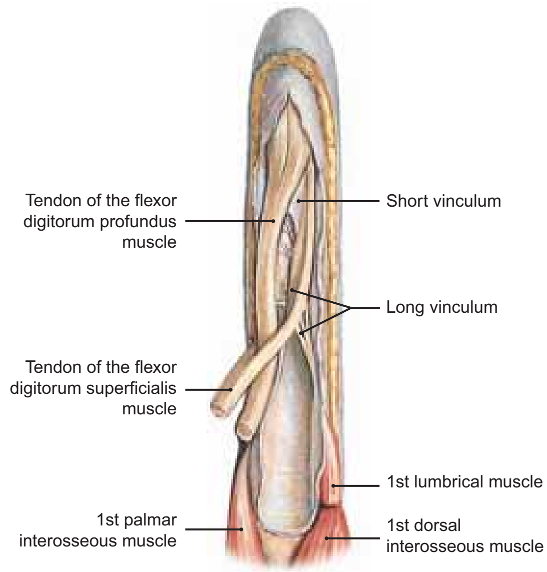
NOTE: (1) The four lumbrical muscles arise from the tendons of the flexor digitorum profundus. Each courses around the radial side of the fingers (i.e., fingers 2, 3, 4, and 5) and inserts on the dorsal digital expansion hood of the same finger.

(2) The lumbricals flex the metacarpophalangeal joints and extend the interphalangeal joints.

(3) The first and second lumbricals are supplied by the median nerve, while the third and fourth lumbricals are supplied by the ulnar nerve.

FIGURE 104.2 Tendon Insertions on the Palmar Surface of the (Index) Finger

NOTE that the dorsal and palmar interosseous muscles course around the palmar side of the finger to insert onto the dorsal expansion hood. The expansion hood cannot be seen from this palmar view.



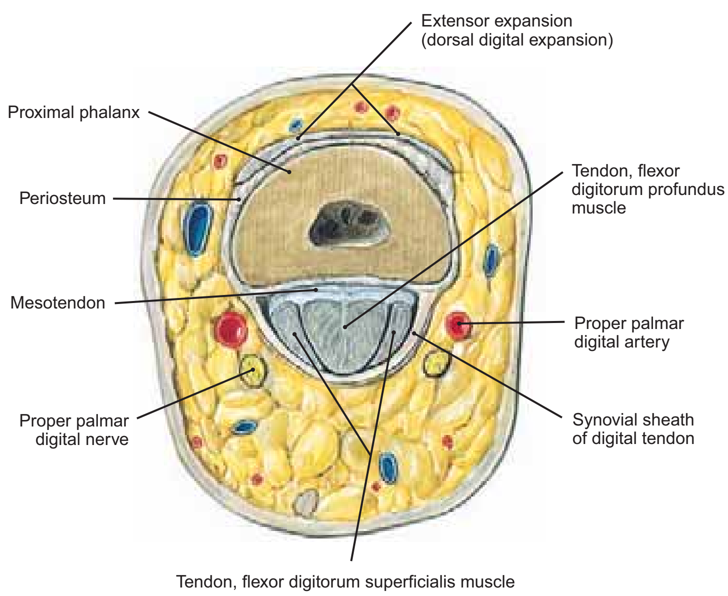


FIGURE 104.3 Cross Section of the Middle Finger through the Proximal Phalanx

NOTE: (1) The extensor expansion (or extensor hood) extends over the dorsal aspect of the proximal phalanx and part of the middle phalanx.

(2) Into the extensor expansion blend the tendon of the extensor digitorum and the tendons of insertion of the adjacent interosseous and lumbrical muscles.

(3) The synovial sheath on the palmar side of the phalanx surrounds the superficial and deep flexor tendons of the digit.

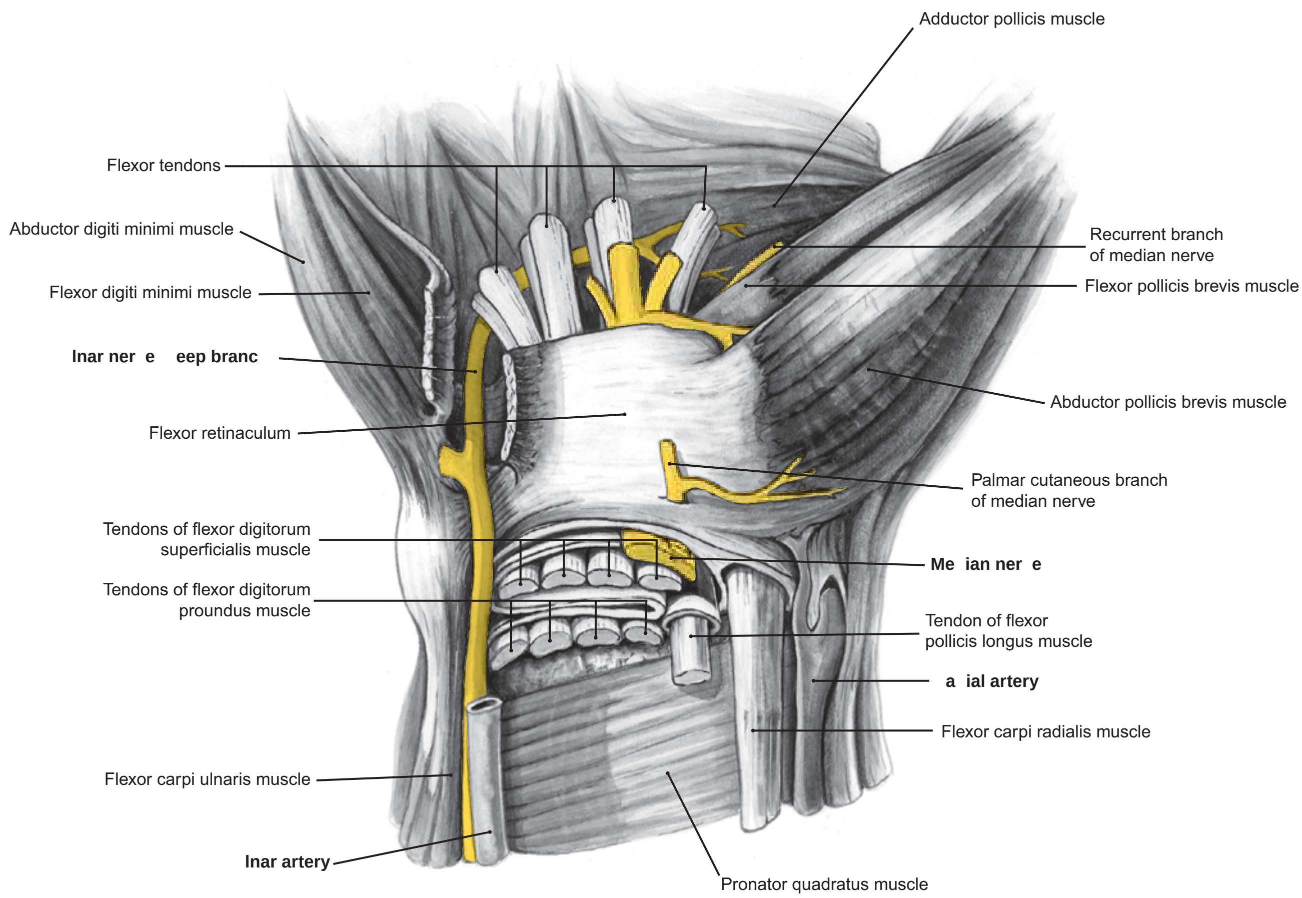


FIGURE 105.1 Flexor Retinaculum and the Carpal Tunnel

NOTE: (1) The flexor retinaculum anteriorly and the carpal bones posteriorly form a restricted space called the **carpal tunnel** at the anterior wrist region. Through the space pass the superficial and deep flexor digitorum tendons, the median nerve, and the tendon of the flexor pollicis longus muscle.

(2) If a pathological process occurs within the space, such as fibrosis due to trauma or an inflammatory process that results in scar formation, the space could diminish in size and undue pressure could be put on the median nerve. This could result in a wasting of the thenar muscles, and this condition is called a **carpal tunnel syndrome**.

(3) In addition to the median nerve, the carpal tunnel has coursing through it the tendons of the superficial and deep flexor digitorum muscles, along with the tendon of the flexor pollicis longus muscle. The ulnar nerve and ulnar artery and the radial artery are NOT structures within the space.

(Contributed by Dr. Gene L. Colborn, Medical College of Georgia.)

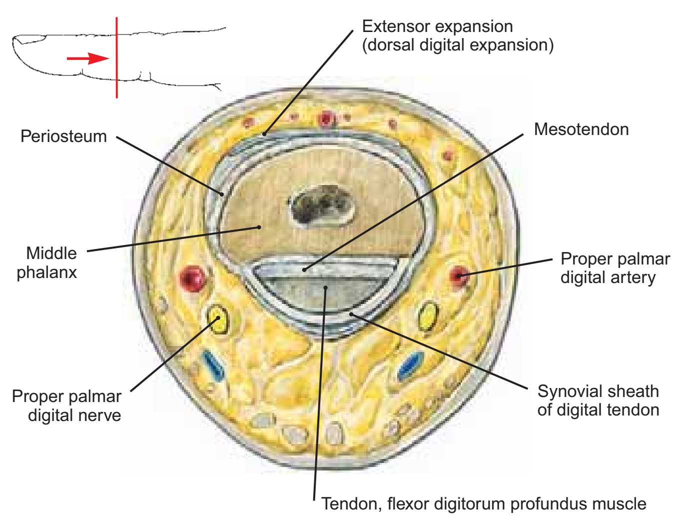


FIGURE 105.2 Cross Section of the Middle Finger through the Middle Phalanx

NOTE: (1) The location of the proper digital nerves and arteries within the subcutaneous tissue on the sides of the deep flexor tendon.

(2) Knowing the location of these neurovascular structures in the fingers is important both for the application of local anesthesia to the digit and for the cessation of severe bleeding.

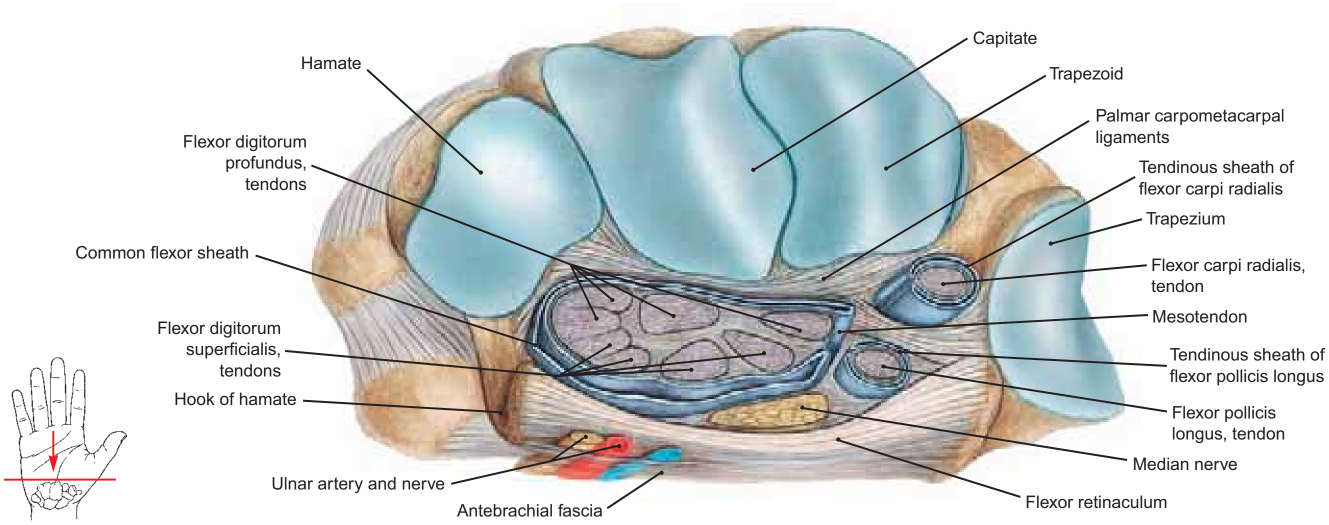


FIGURE 106.1 Transverse Section through the Right Wrist Showing the Carpal Tunnel and Its Contents

NOTE that the median nerve can be compressed and, thereby, be functionally compromised if there is edema or fibrosis due to trauma within the carpal tunnel (**carpal tunnel syndrome**). In this condition, weakness is experienced in muscles innervated by the median nerve. Especially reduced are the functions of the abductor pollicis brevis, the flexor pollicis brevis, and the opponens pollicis muscles.

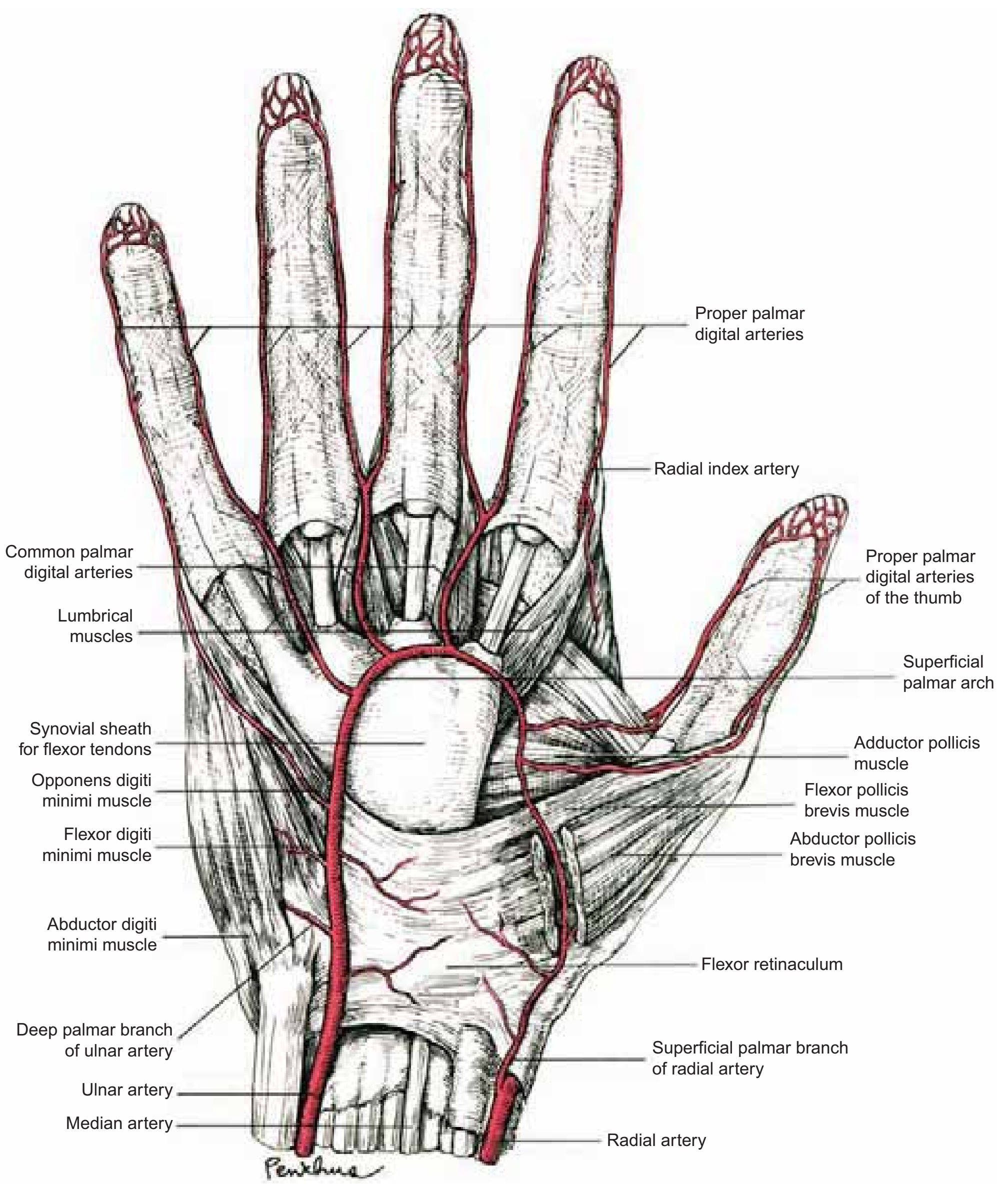


FIGURE 106.2 The Superficial Palmar Arch and the Common and Proper Digital Arteries of the Right Hand

NOTE that the ulnar artery is the principal contributor to the superficial palmar arch.
(From C.D. Clemente. *Gray's Anatomy*, 30th American Edition. Philadelphia: Lea & Febiger, 1985.)

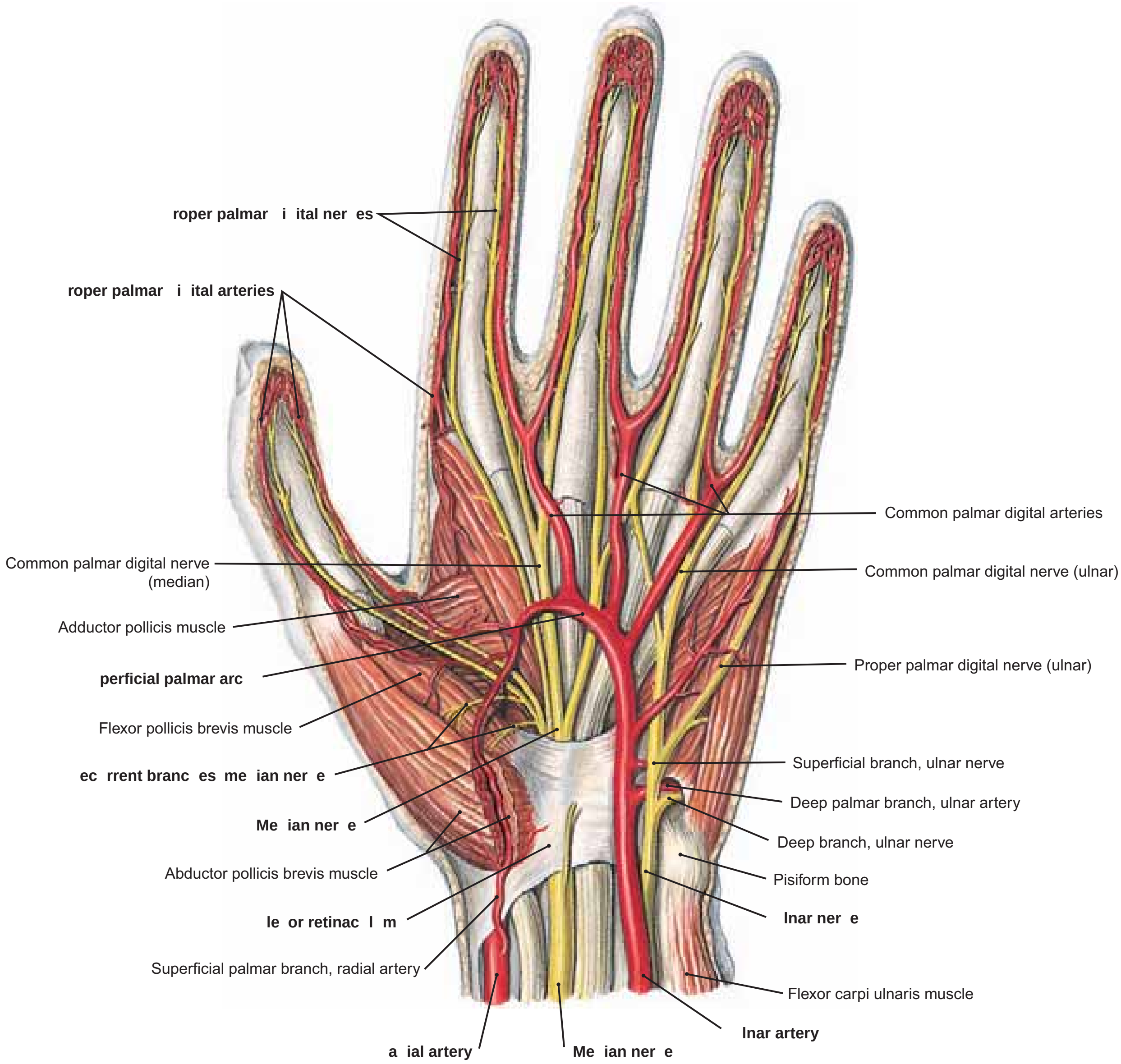


FIGURE 107.1 Nerves and Arteries of the Left Palm, Superficial Palmar Arch

NOTE: (1) The **median nerve** enters the palm beneath the flexor retinaculum and supplies the muscles of the thenar eminence: abductor pollicis brevis, opponens pollicis, and the superficial head of the flexor pollicis brevis.

(2) The **median nerve** also supplies the radial (lateral) two lumbrical muscles as well as the palmar surface of the lateral hand and lateral 3½ fingers.

(3) The superficial location of the **recurrent branches of the median nerve,** which supply the thenar muscles. Just deep to the superficial fascia, these branches are easily injured.

(4) The **ulnar nerve** enters the palm superficial to the flexor retinaculum, and it supplies the ulnar 1½ fingers and all the remaining muscles in the hand.

(5) The **superficial palmar arterial arch** is derived principally from the ulnar artery. The arch is completed by the **palmar branch of the radial artery.** From the arch three or four **common palmar digital arteries** course distally and divide into **proper palmar digital arteries.** These accompany the corresponding digital nerves along the fingers.

FIGURE 107.2 Variations of the Superficial Palmar Arch

A: Complete arch
B: Ulnar three fingers supplied by the ulnar artery
C: All fingers supplied by ulnar artery

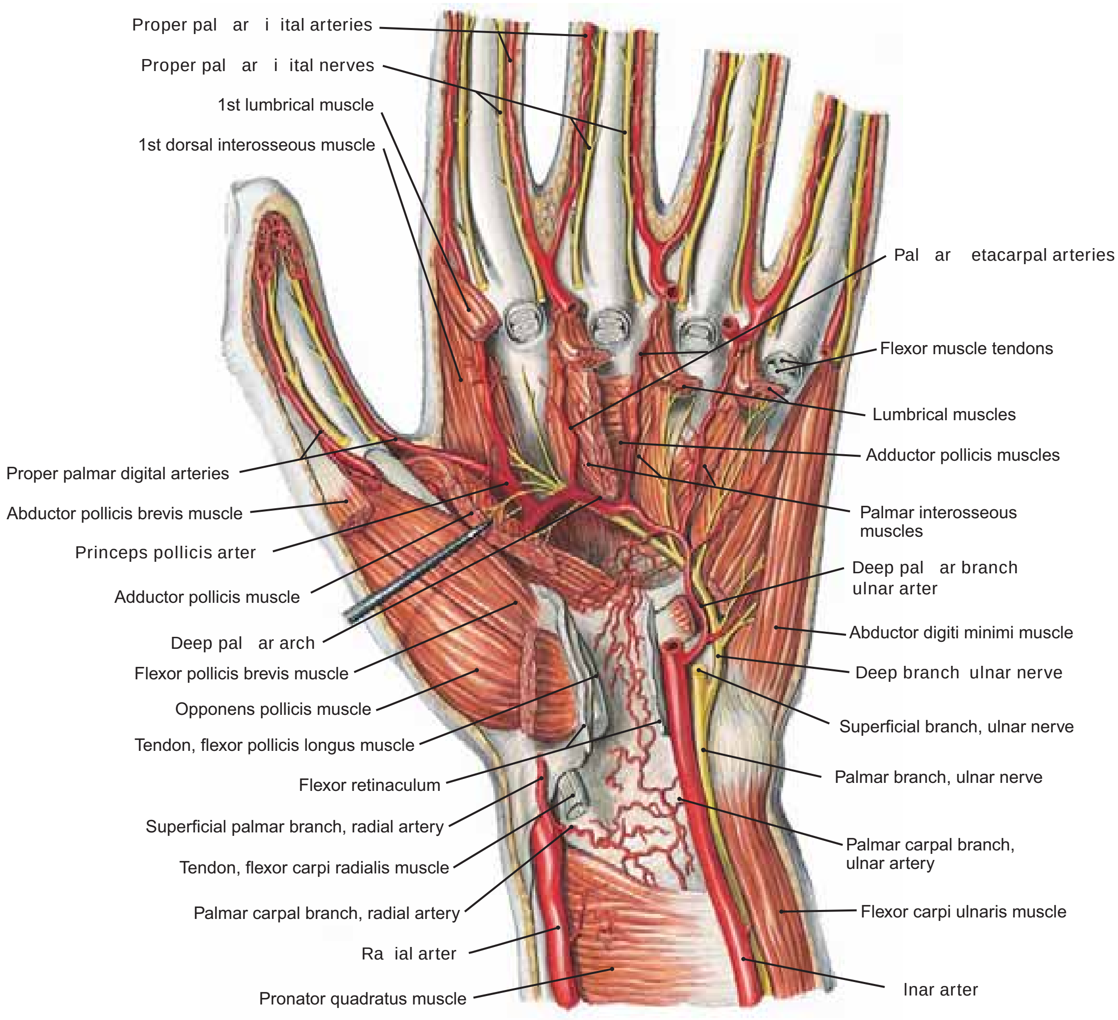


FIGURE 108.1 Nerves and Arteries of the Left Palm, Deep Palmar Arch ▲

NOTE: (1) The **radial artery** at the wrist enters the hand dorsally through the "anatomical snuff box" (see Figs. 93.1 and 93.2) and then passes distally, perforates the two heads of first dorsal interosseous muscle, and reaches the palm of the hand.

(2) In the palm, the radial artery forms the **deep palmar arch,** uniting medially with the **deep palmar branch** of the ulnar artery.

(3) From the deep arch arise the **palmar metacarpal arteries** as well as the **princeps pollicis artery**.

(4) The **deep branch of the ulnar nerve** courses with the deep palmar arterial arch. It supplies all the muscles in the deep palm.

(5) There is a rich anastomosis between the superficial and deep arches and between the ulnar and radial arteries.

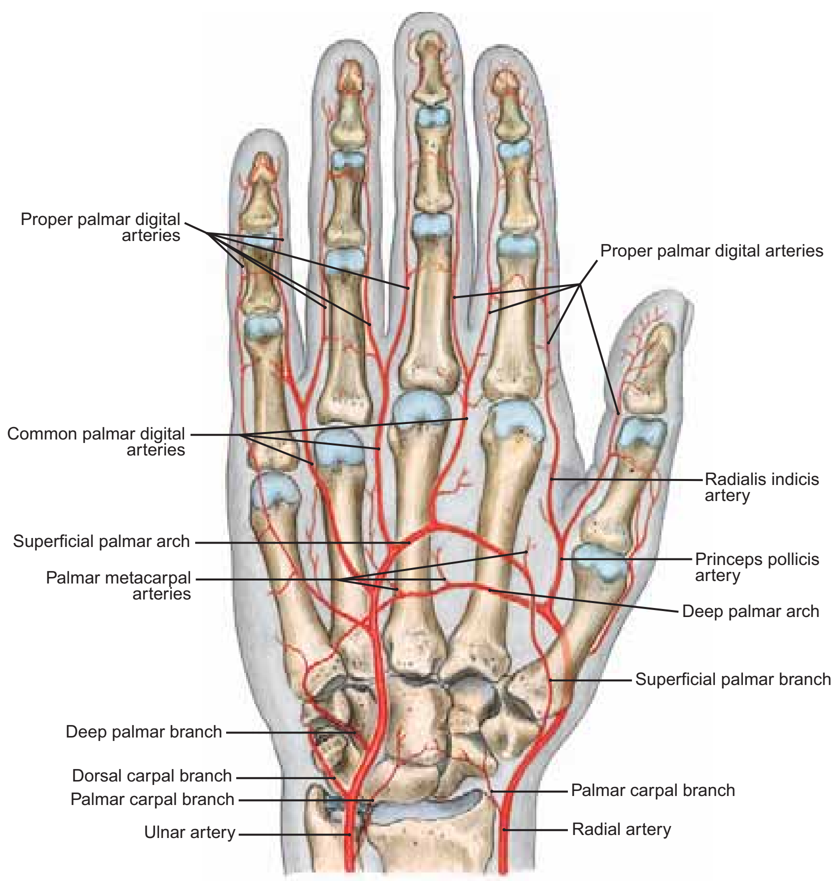


FIGURE 108.2 Arteries of the Right Hand Showing the Palmar Arterial Arches ▶

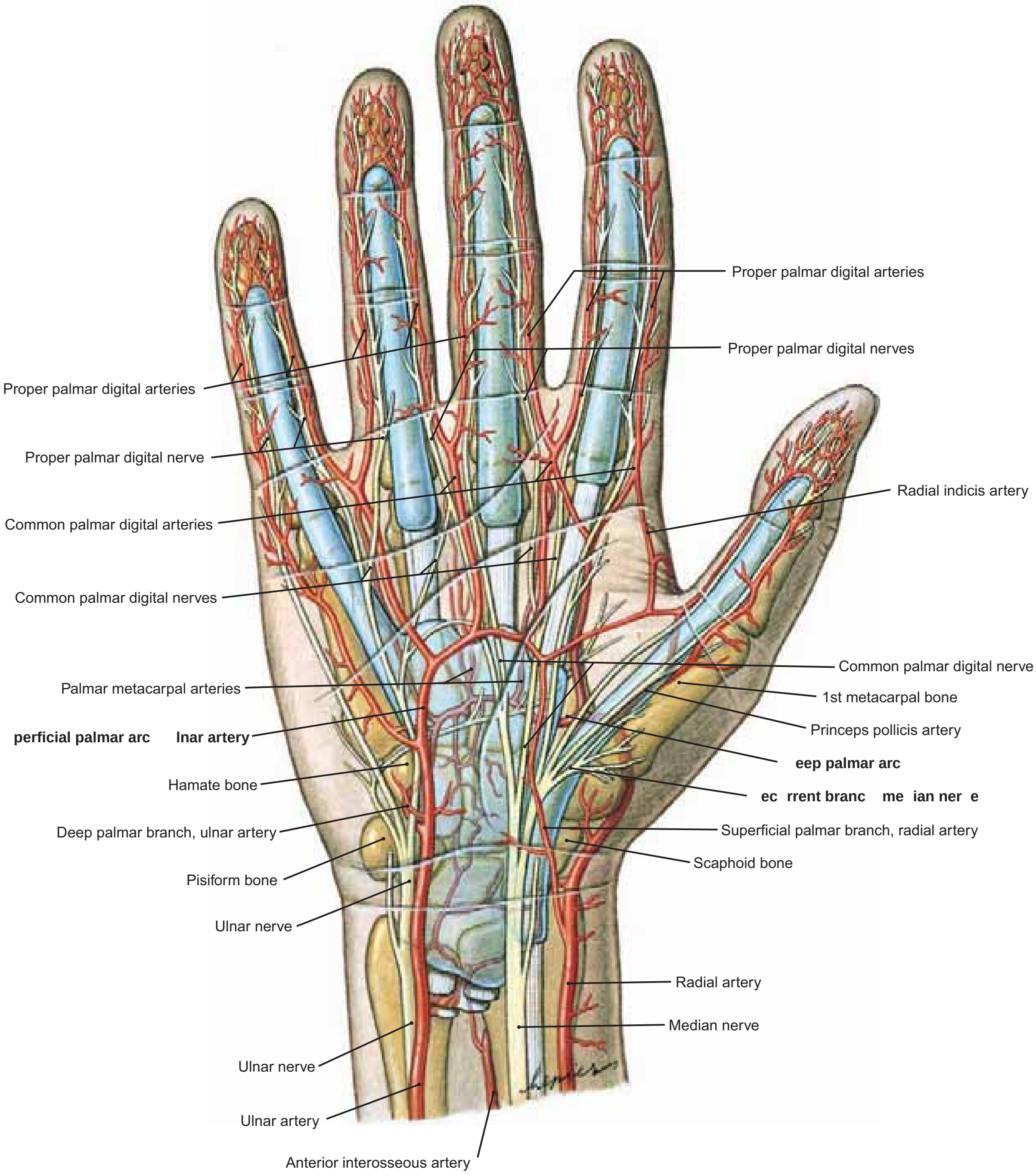


FIGURE 109.1 Surface Projection of Arteries and Nerves to the Palm of the Hand

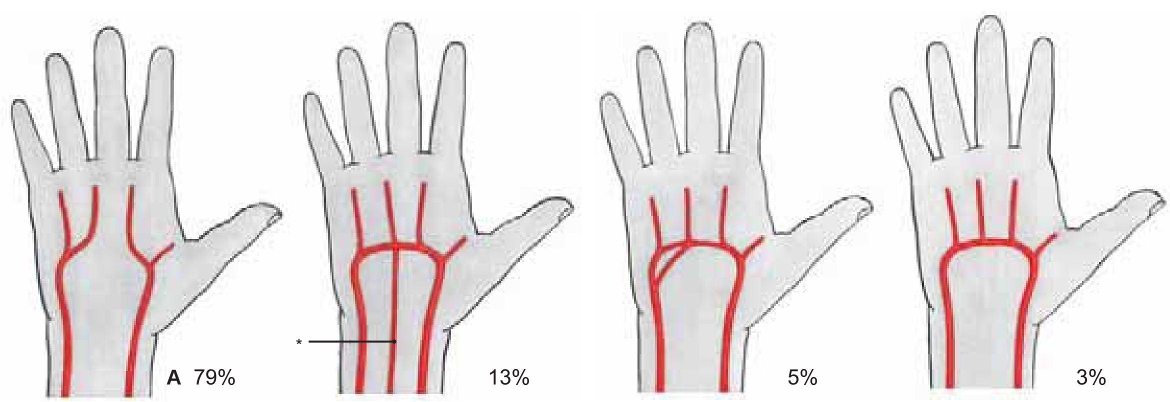


FIGURE 109.2 Variations in the Formation of the Deep Palmar Arch

A: Complete deep palmar arch. **B:** Double ulnar contribution. **C:** Anastomosis with anterior interosseous artery. **D:** Radial two digits supplied by the radial artery, ulnar three digits supplied by the ulnar artery.

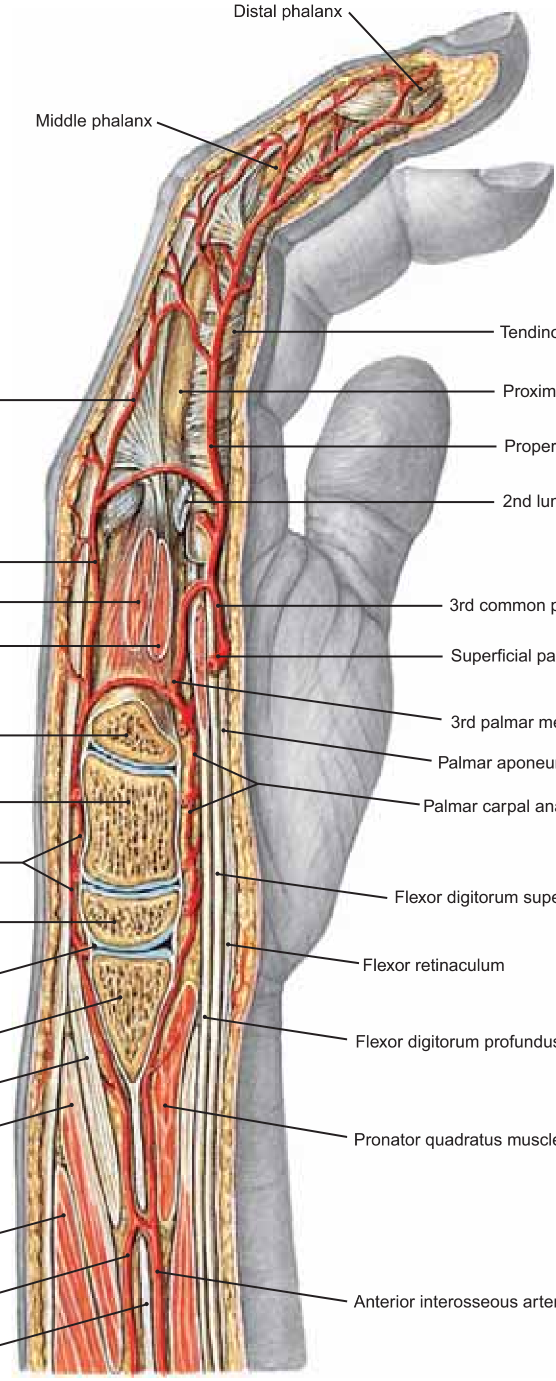
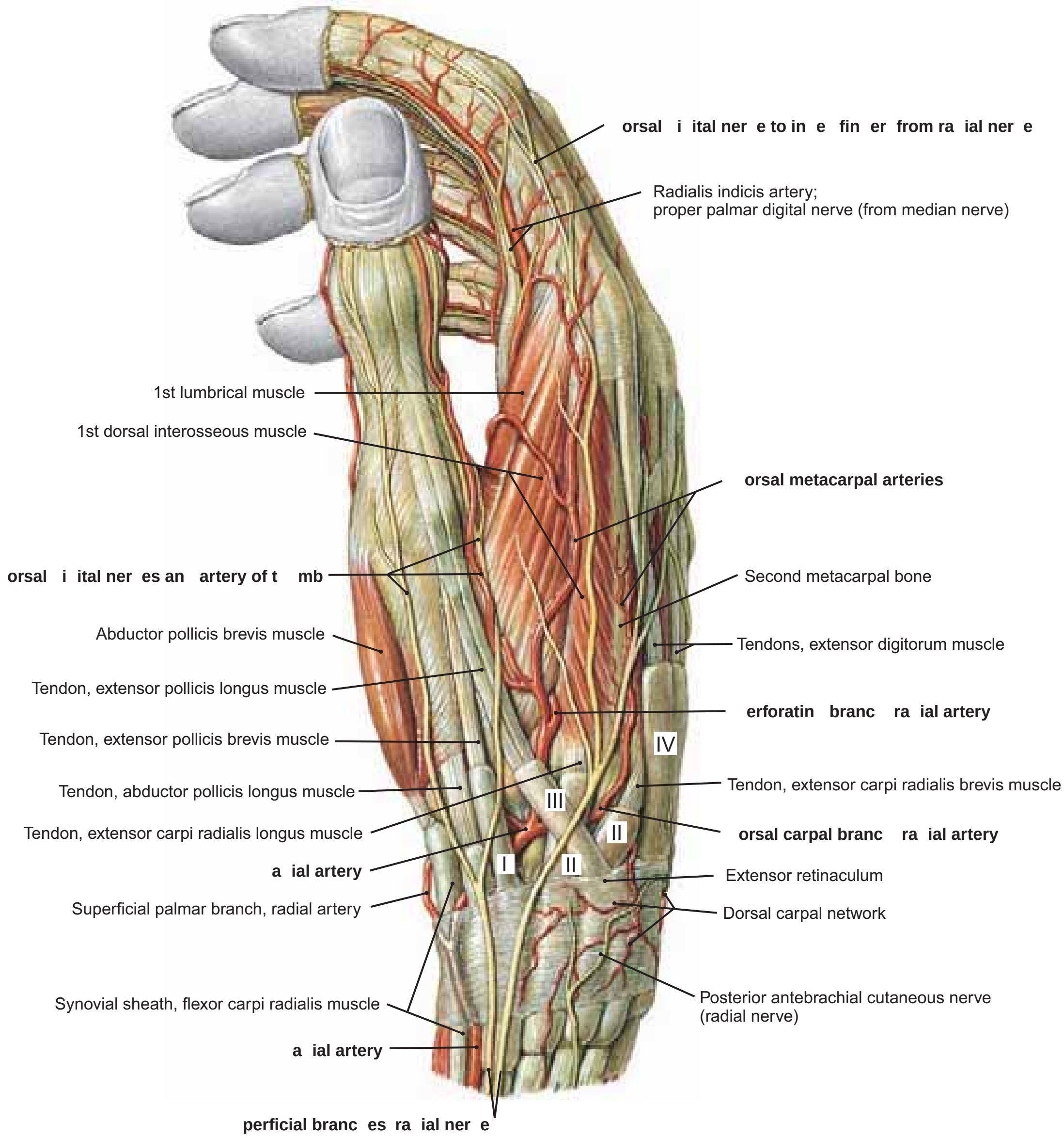


FIGURE 110 Sagittal Section through the Middle Finger: Right Hand (Ulnar View)

NOTE: (1) There is a rich blood supply and abundant anastomoses along the entire extent of the finger.
(2) The second palmar interosseous muscle of the ring finger and the third dorsal interosseous muscle of the middle finger.
(3) The skeletal continuum from proximal to distal: radius, lunate and capitate bones; the third metacarpal; and the proximal, middle, and distal phalanges.
(4) The anastomosis just proximal to the wrist joint between the anterior and posterior interosseous arteries.



I–IV = Synovial tendon sheaths
I = Abductor pollicis longus and extensor pollicis brevis tendon sheaths
II = Extensor carpi radialis longus and brevis tendon sheaths
IIII = Extensor pollicis longus tendon sheath
IV = Extensor digitorum and extensor indicis tendon sheath

FIGURE 111 Superficial Nerves, Arteries, and Tendons on the Radial Aspect of the Right Hand

NOTE: (1) Only the skin and superficial fascia have been removed in this dissection, and the cutaneous nerves and superficial arteries to the thumb, radial side of the index finger, and dorsum of the hand have been retained.

(2) The **superficial branches of the radial nerve** to the hand (see Figs. 68, 89, and 90.1). These supply the dorsum of the thumb, nearly to the tip, as well as the lateral (radial) half of the dorsum of the hand.

(3) The radial nerve also supplies the proximal part of the dorsum of the index, middle, and lateral half of the ring fingers, as far as the proximal interphalangeal joint because the median nerve sends branches around the digits to supply the more distal parts of the fingers.

(4) The distribution of the radial artery to the thumb and dorsum of the hand (see Figs. 93.1 and 93.2). Observe: (a) the **dorsal digital branch** to the thumb; (b) the **radial indicis branch** to the index finger; (c) the **perforating branch** that penetrates between the two heads of the first dorsal interosseous muscle; and (d) the **dorsal carpal branch,** from which the dorsal metacarpal arteries arise.

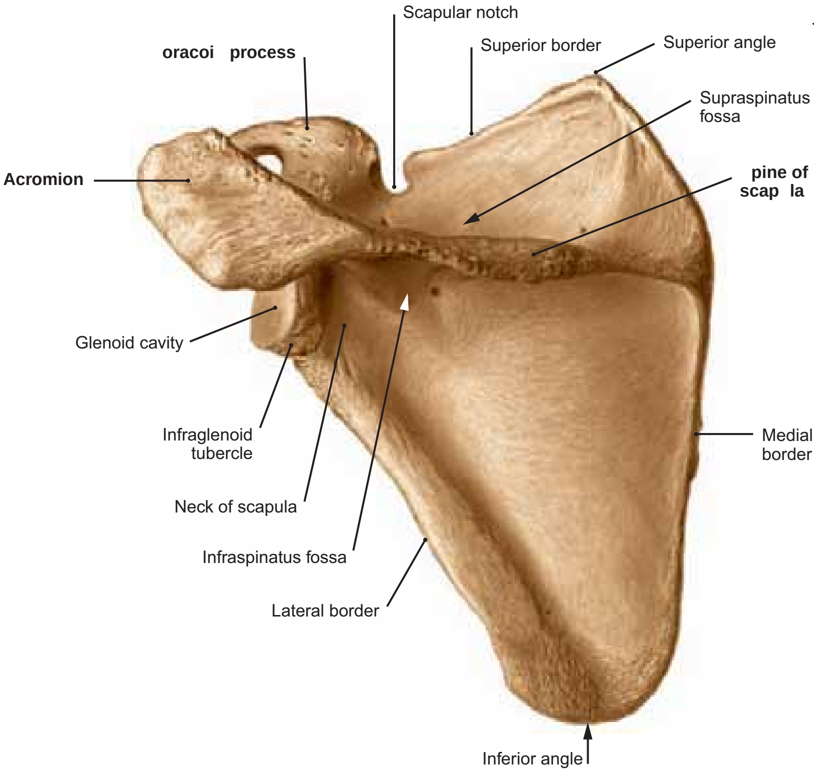


FIGURE 112.1 Left Scapula (Dorsal Surface)

NOTE: (1) The socket for the head of the humerus is formed by the glenoid cavity.
(2) The acromion and coracoid process give additional protection to the socket superiorly, anteriorly, and posteriorly.
(3) The spine of the scapula separates the dorsal surface into supraspinatus and infraspinatus fossae.

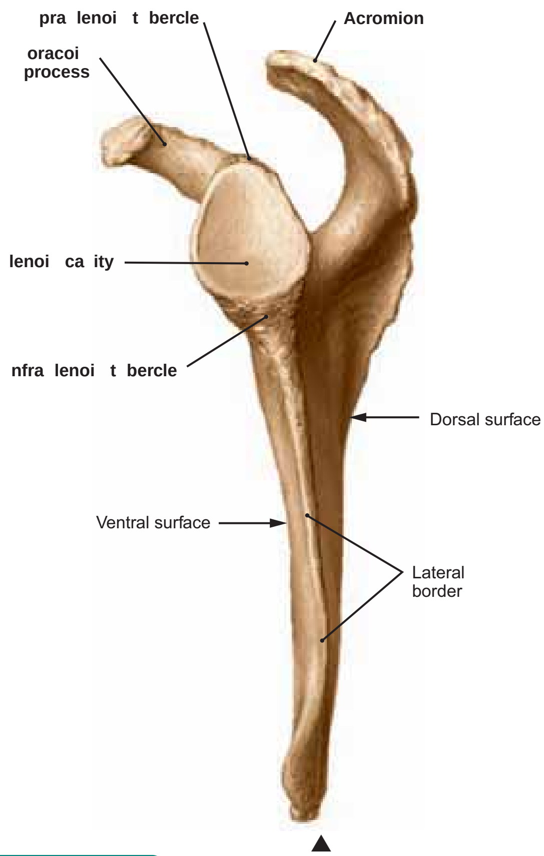


FIGURE 112.2 Left Scapula (Lateral View)

NOTE: (1) The supraglenoid and infraglenoid tubercles from which arise the long heads of the biceps and triceps muscles (see Fig. 118.1).
(2) The anteriorly projecting coracoid process to which are attached the pectoralis minor, short head of biceps, and coracobrachialis muscles.

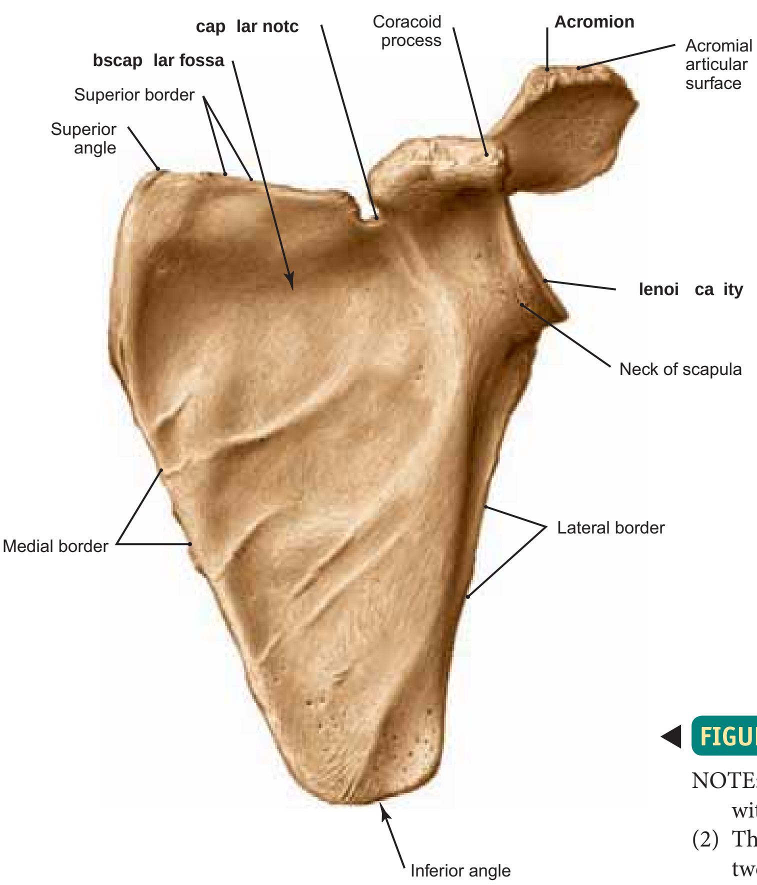


FIGURE 112.3 Left Scapula (Ventral Surface)

NOTE: (1) Much of the ventral surface of the scapula is a concave fossa within which lies the subscapularis muscle.
(2) The scapula has three borders: medial, lateral, and superior; it also has two angles: superior and inferior.

FIGURE 113.1 and 113.2
Left Humerus

NOTE: (1) The hemispheric head of the humerus articulates with the glenoid cavity of the scapula.

(2) The surgical neck of the humerus is frequently a site of fractures.

(3) On the greater tubercle insert the supraspinatus, infraspinatus, and teres minor, in that order. On the lesser tubercle inserts the subscapularis. These four muscles form the **rotator cuff.**

(4) Within the intertubercular sulcus passes the tendon of the long head of the biceps.

(5) Adjacent to the **radial groove** courses the radial **nerve,** which is endangered by fractures of the humerus.

(6) Injury to the radial nerve in the arm results in a condition called **wrist drop,** because innervation to the extensors of the wrist and fingers is lost.

(7) The distal extremity of the humerus articulates with the radius and ulna, the **capitulum** with the head of the radius, and the trochlea with the **trochlear** notch of the ulna.

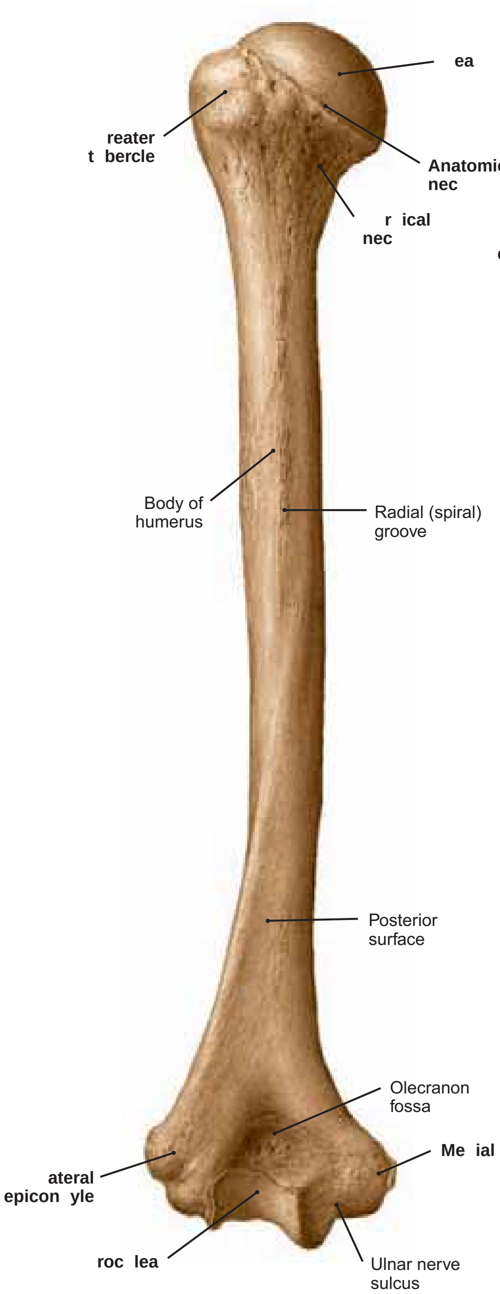


FIGURE 113.1 Posterior View

FIGURE 113.2 Anterior View

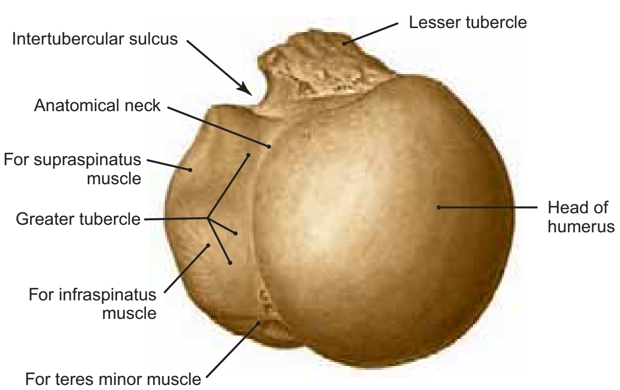


FIGURE 113.3 Head of the Left Humerus (Viewed from Above)

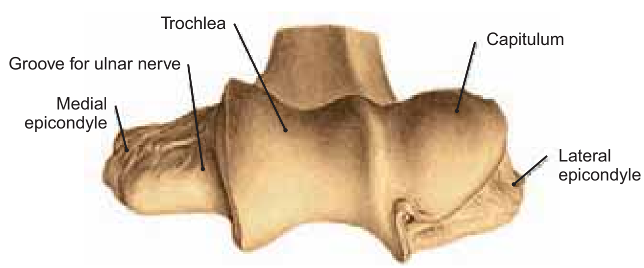


FIGURE 113.4 Distal Extremity of the Left Humerus (Viewed from Below)

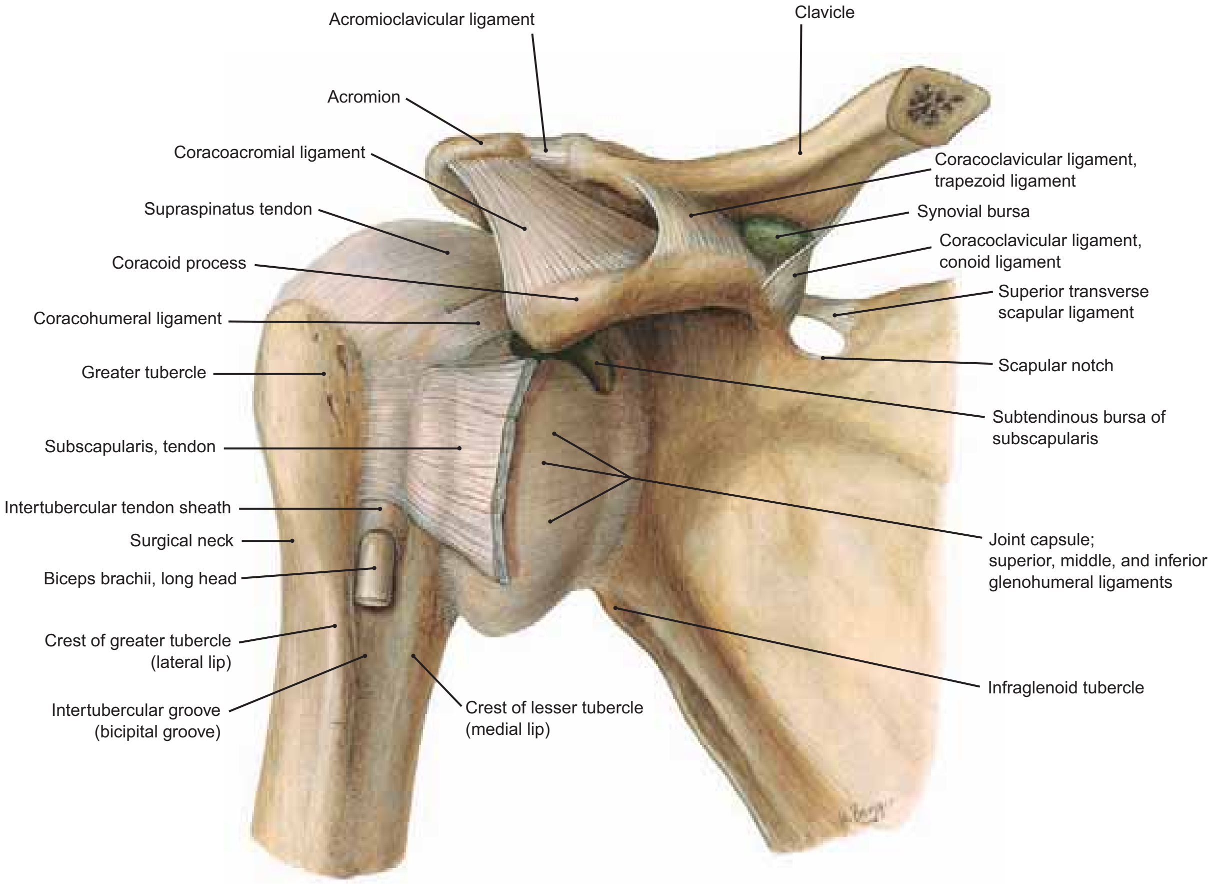


FIGURE 114.1 **Ligaments of the Right Shoulder (Glenohumeral) Joint (Anterior View)**

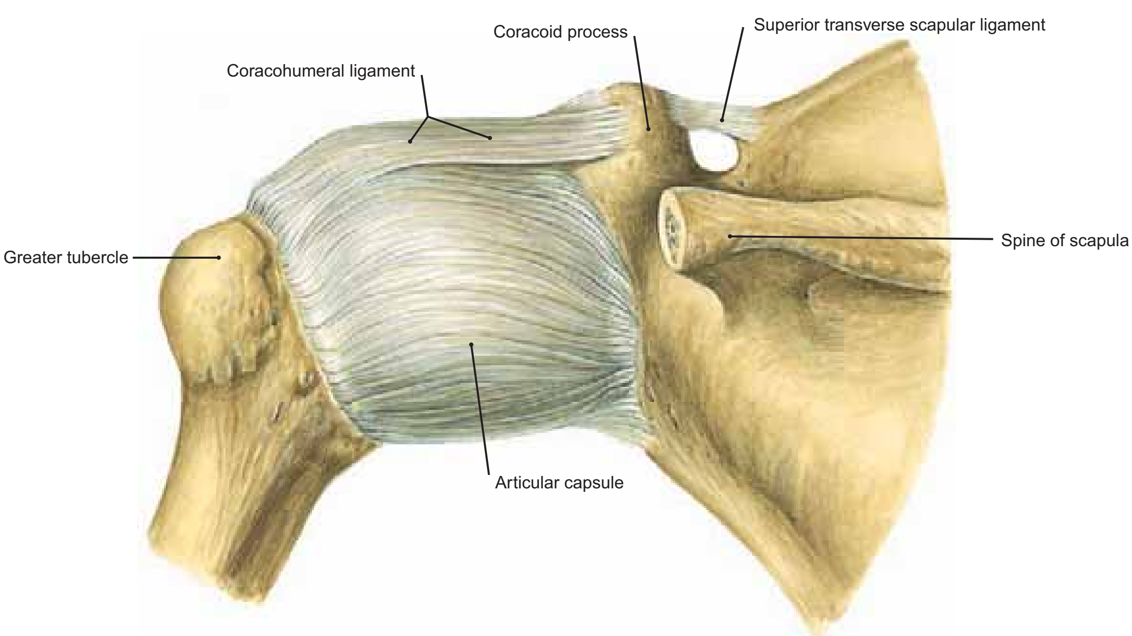


FIGURE 114.2 **Capsule of Left Shoulder Joint (Posterior View)**

NOTE: (1) The articular capsule completely surrounds the joint. It is attached beyond the glenoid cavity on the scapula above and to the anatomical neck of the humerus below.

(2) The superior part of the capsule is further strengthened by the coracohumeral ligament.

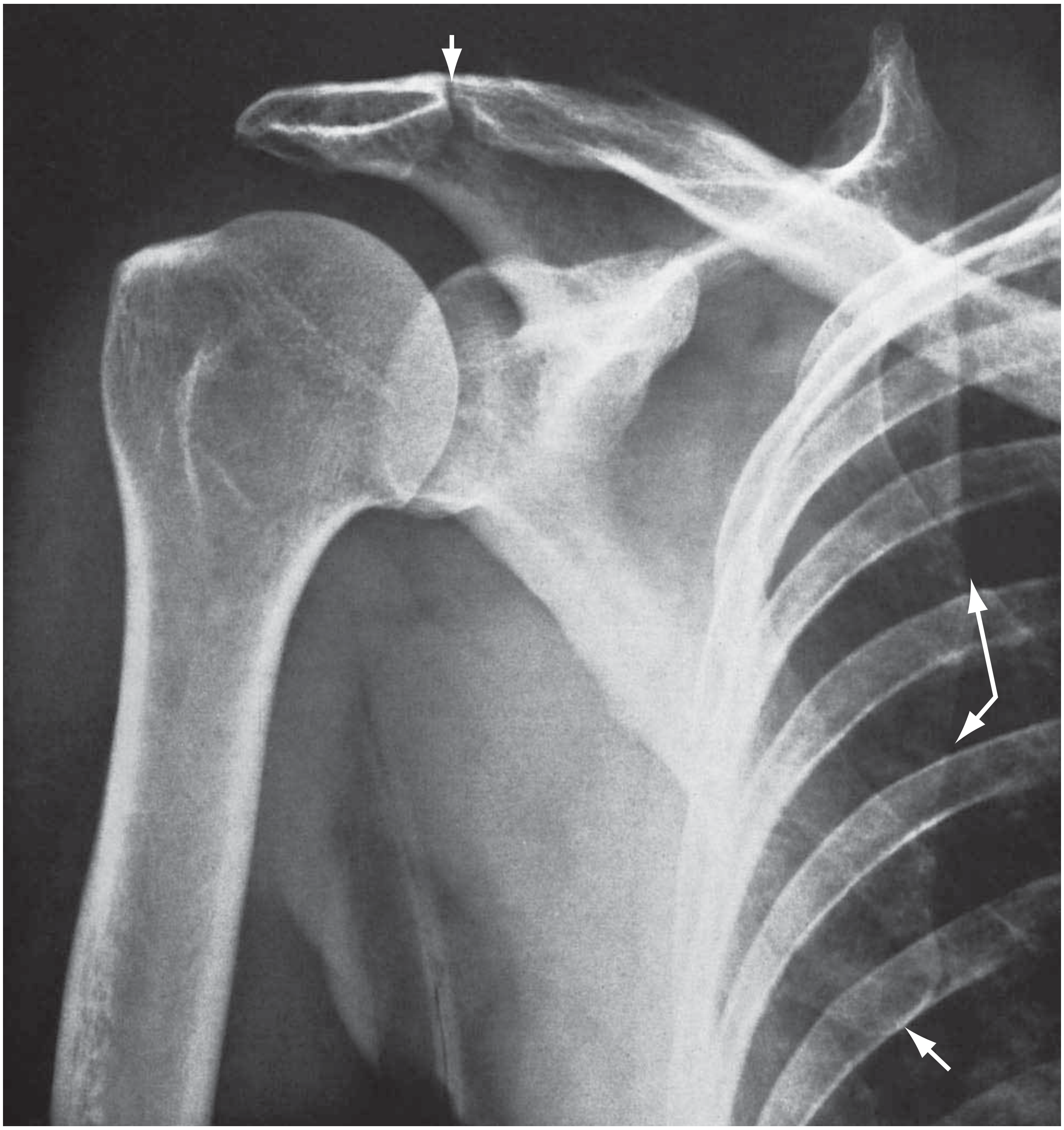


FIGURE 115 Radiograph of the Right Shoulder Region

1. Superior angle of scapula
2. Spine of scapula
3. Clavicle
4. Medial margin of scapula
5. Second rib
6. Inferior angle of scapula
7. Lateral margin of scapula
8. Surgical neck of humerus
9. Coracoid process
10. Glenoid cavity
11. Lesser tubercle
12. Anatomical neck of humerus
13. Greater tubercle
14. Head of humerus
15. Acromion
16. Acromioclavicular joint

NOTE: (1) The clavicle, scapula, and humerus are involved in radiography of the shoulder region. The acromioclavicular joint is a **planar** type formed by the lateral end of the clavicle and the medial border of the acromion.

(2) The glenohumeral, or shoulder, joint is remarkably loose and provides a free range of movement. Observe the wide separation between the humeral head and the glenoid cavity.

(3) Inferior **dislocations** of the head of the humerus are common because of minimal protection below. A **shoulder separation** results from a dislocation of the acromion under the lateral edge of the clavicle due to a strong blow to the lateral side of the joint.

(4) The hemispheric smooth surface of the humeral head. Covered with hyalin cartilage, the head of the humerus is slightly constricted at the anatomical neck, where a line separates the articular part superomedially from the greater and lesser tubercles below.

(5) Below these tubercles, the humerus shows another constriction, called the surgical neck, where fractures frequently occur.

(From Wicke, 6th ed.)

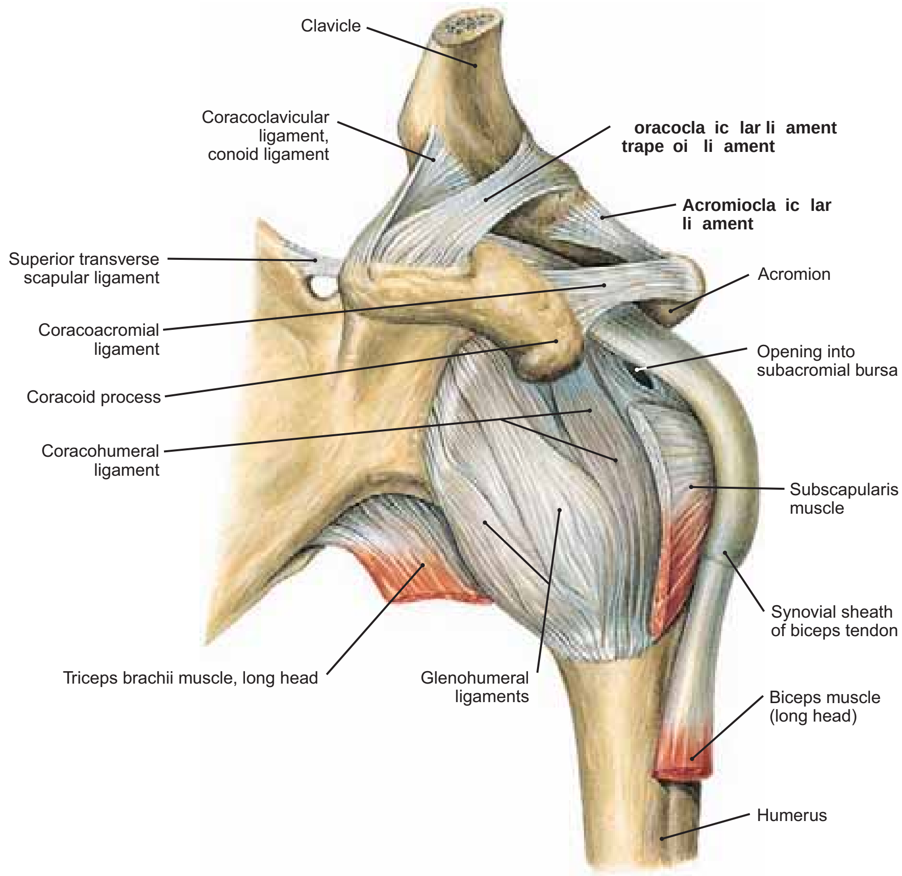


FIGURE 116.1 Left Shoulder Joint and Acromioclavicular Joint (Anterior View)

NOTE: (1) The clavicle is attached to the acromion and coracoid process of the scapula by the **acromioclavicular** and **coracoclavicular ligaments.**
(2) The acromion and coracoid process are interconnected by the **coracoclavicular ligament.**
(3) Neither the acromion nor the clavicle attaches to the humerus, but the glenoid labrum and the coracoid process do.
(4) The acromion, coracoid process, and clavicle protect the shoulder from above. The joint is weakest inferiorly and anteriorly, the directions in which most dislocations occur.
(5) The **glenohumeral ligaments** are thickened bands that tend to strengthen the joint capsule anteriorly.

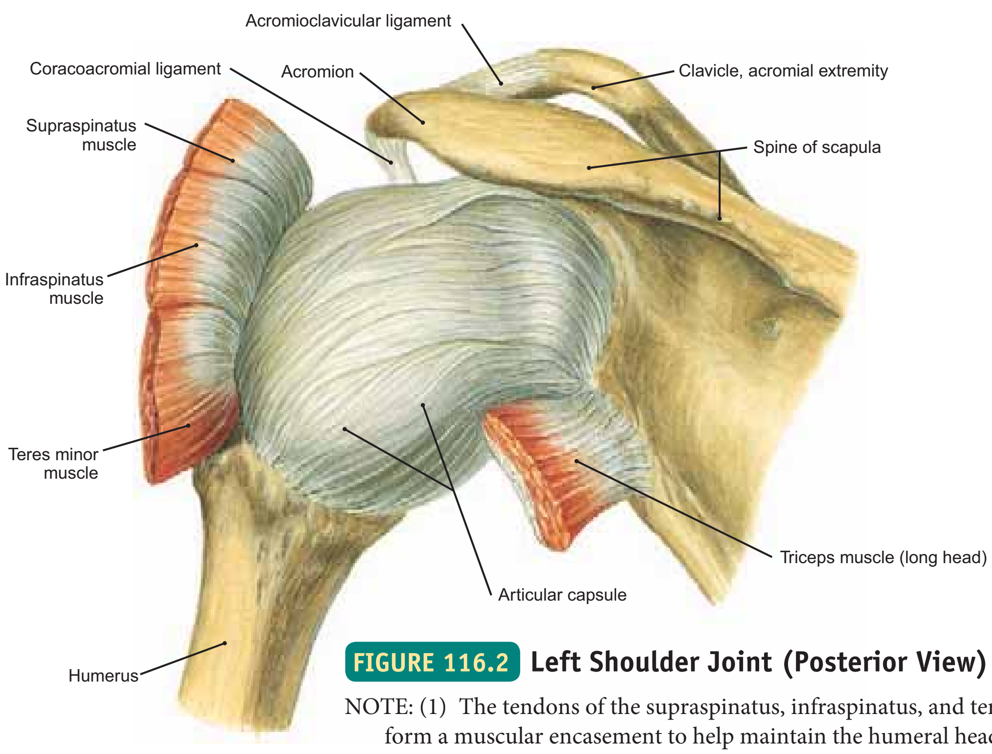


FIGURE 116.2 Left Shoulder Joint (Posterior View)

NOTE: (1) The tendons of the supraspinatus, infraspinatus, and teres minor blend with the joint capsule and form a muscular encasement to help maintain the humeral head in the socket.
(2) The long head of the triceps is attached close to the joint capsule. It is drawn even closer in abduction of the arm and helps prevent dislocation.

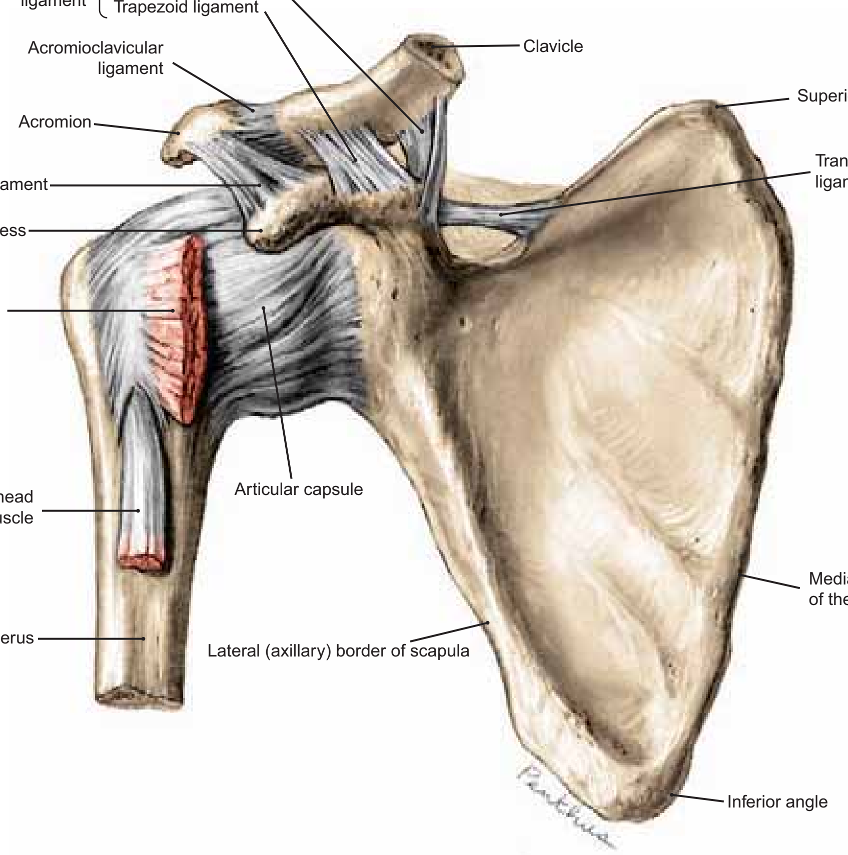


FIGURE 117.1 **The Right Shoulder Joint (Anterior View)**

Compare this figure with Figure 116.1.

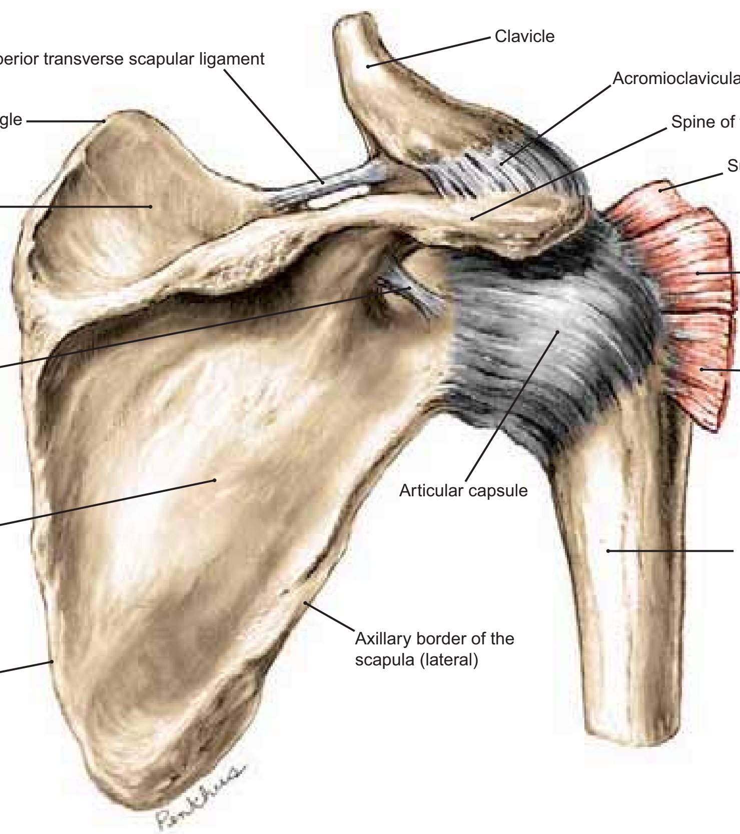


FIGURE 117.2 **The Right Shoulder Joint (Posterior View)**

Compare this figure with Figure 116.2.

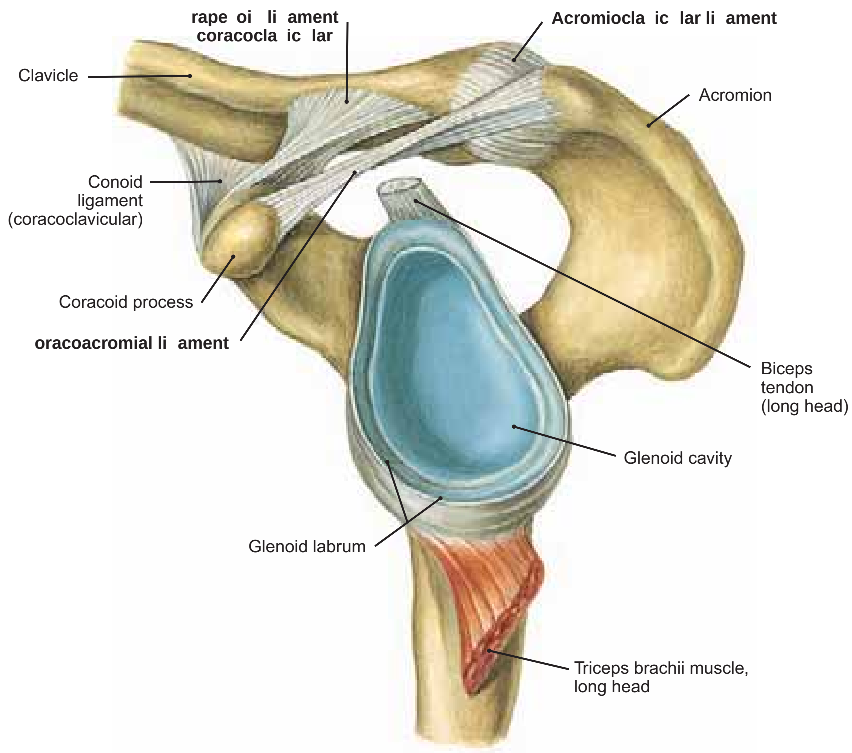


FIGURE 118.1 **Left Glenoid Cavity (Lateral View); Scapuloclavicular Joint**

NOTE: (1) The glenoid cavity was exposed by removing the articular capsule at the glenoid labrum.

(2) The attachments of the long head of the biceps at the supraglenoid and the long head of the triceps at the infraglenoid tubercles are still intact.

(3) The shallowness of the glenoid cavity is somewhat deepened 3 to 5 mm by the glenoid labrum.

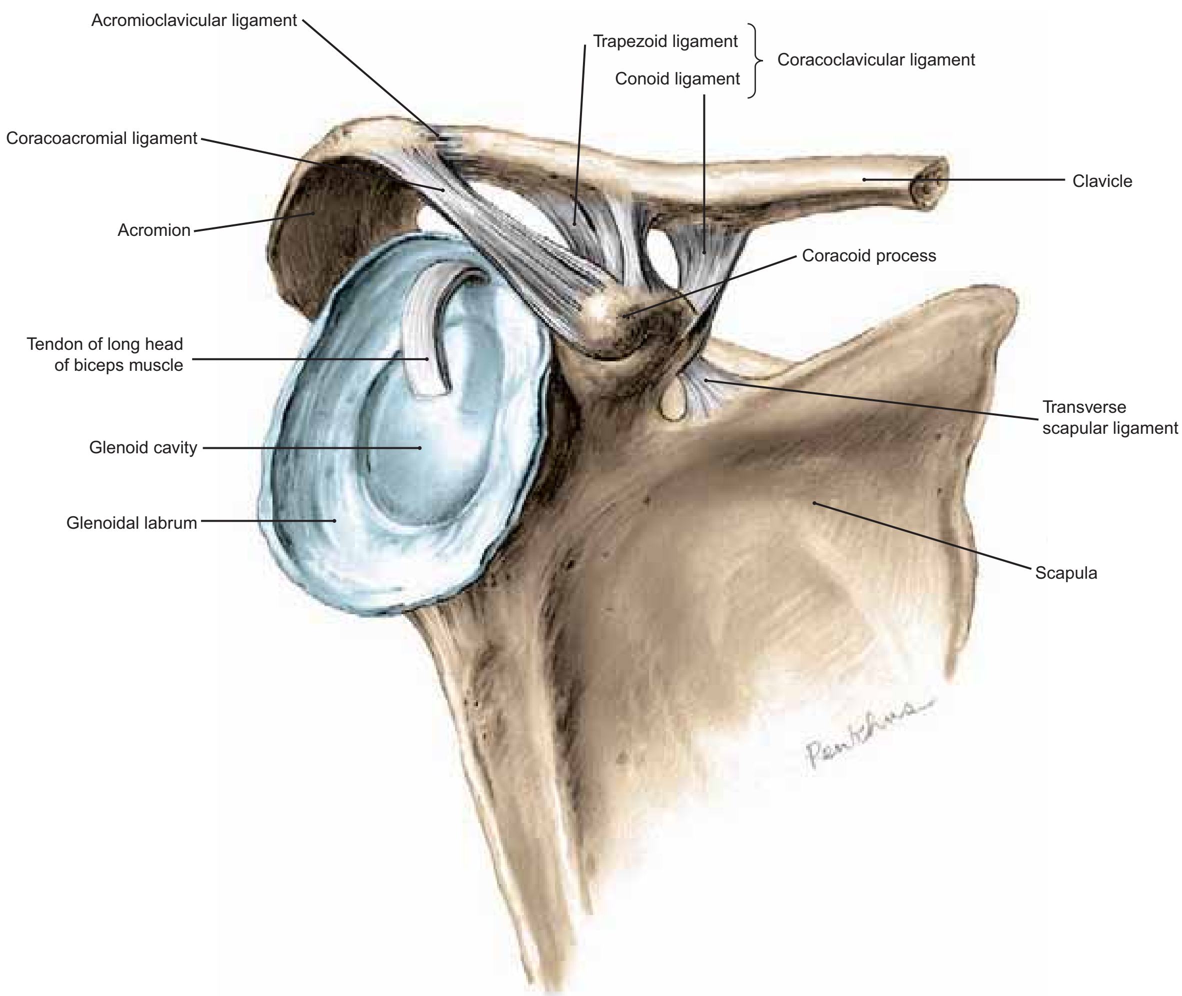


FIGURE 118.2 **Right Scapula and Clavicle; Glenoid Fossa (Anterolateral View)**

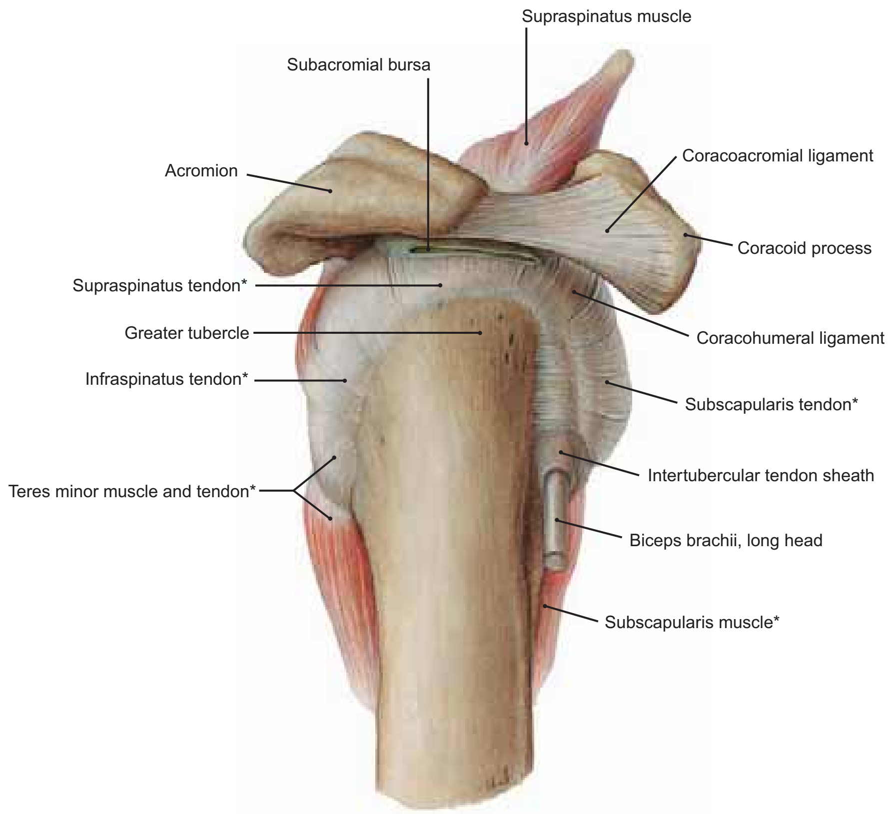


FIGURE 119.1 Right Shoulder Joint after Removal of the Deltoid Muscle

NOTE: (1) A fibrous capsule surrounds the shoulder joint.
(2) The tendon of the long head of the biceps enters the capsule on its way to the supraglenoid tubercle of the scapula.
(3) The tendons of the supraspinatus, infraspinatus, teres minor, and subscapularis muscles (noted with asterisks [*]) form the protective "rotator cuff" of the shoulder joint.

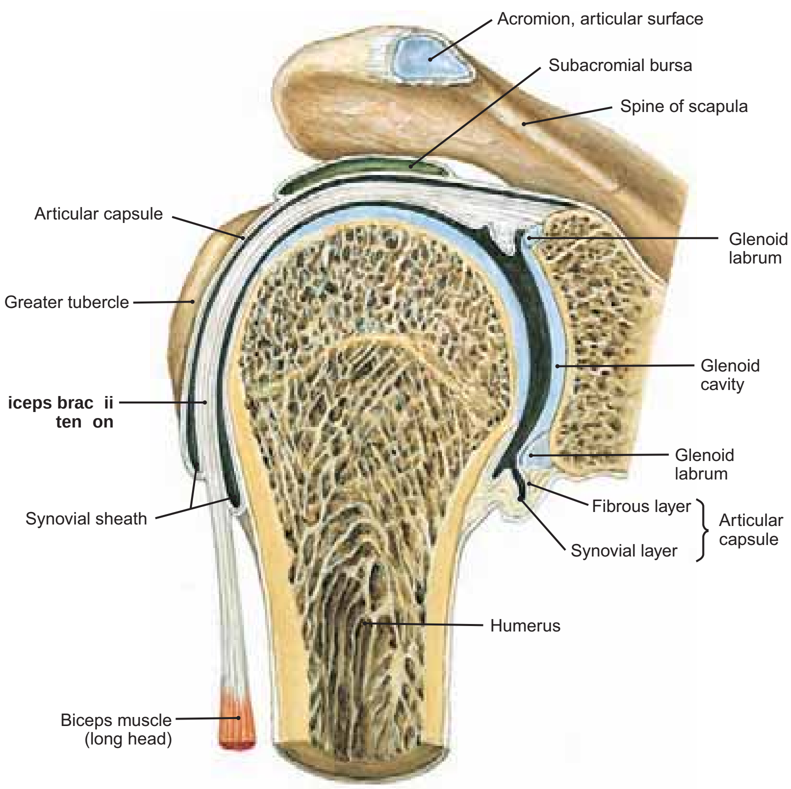


FIGURE 119.2 Frontal Section through the Right Shoulder Joint

NOTE: (1) The tendon of the long head of the biceps is enclosed by a synovial sheath. Although the tendon passes through the joint, it is not within the synovial cavity.
(2) The capsule of the joint is composed of a dense outer fibrous layer and a thin synovial inner layer.
(3) A bursa is a sac lined by a synovial-like membrane. It is found at sites subjected to friction and usually does not communicate with the joint cavity.
(4) In the shoulder, bursae are found between the capsule and muscle tendons such as the subscapularis, infraspinatus, and deltoid. The **subacromial bursa** lies deep to the coracoid and acromial processes.

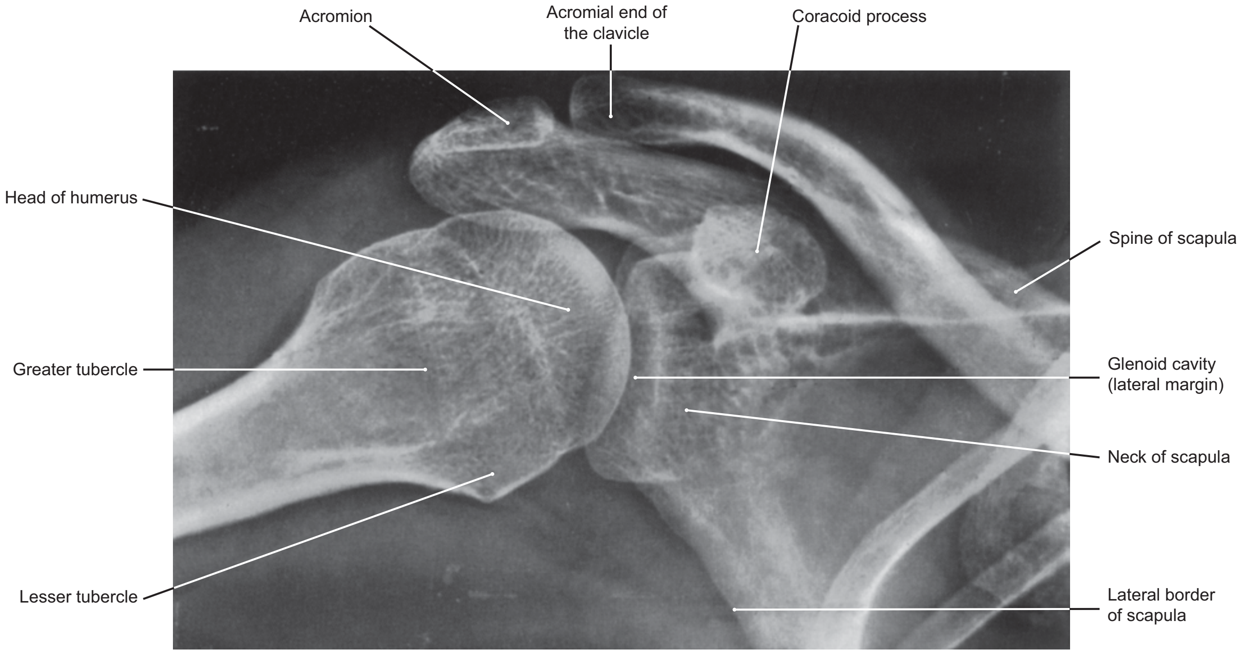


FIGURE 120.1 Radiograph of the Right Shoulder Joint

NOTE that this radiograph was taken in an anteroposterior direction. The subject was supine with the upper limb abducted and rotated medially. (From R. Brickner. *Normal Radiologic Patterns and Variations of the Human Skeleton*, Urban and Schwarzenberg, Munich, 1977.)

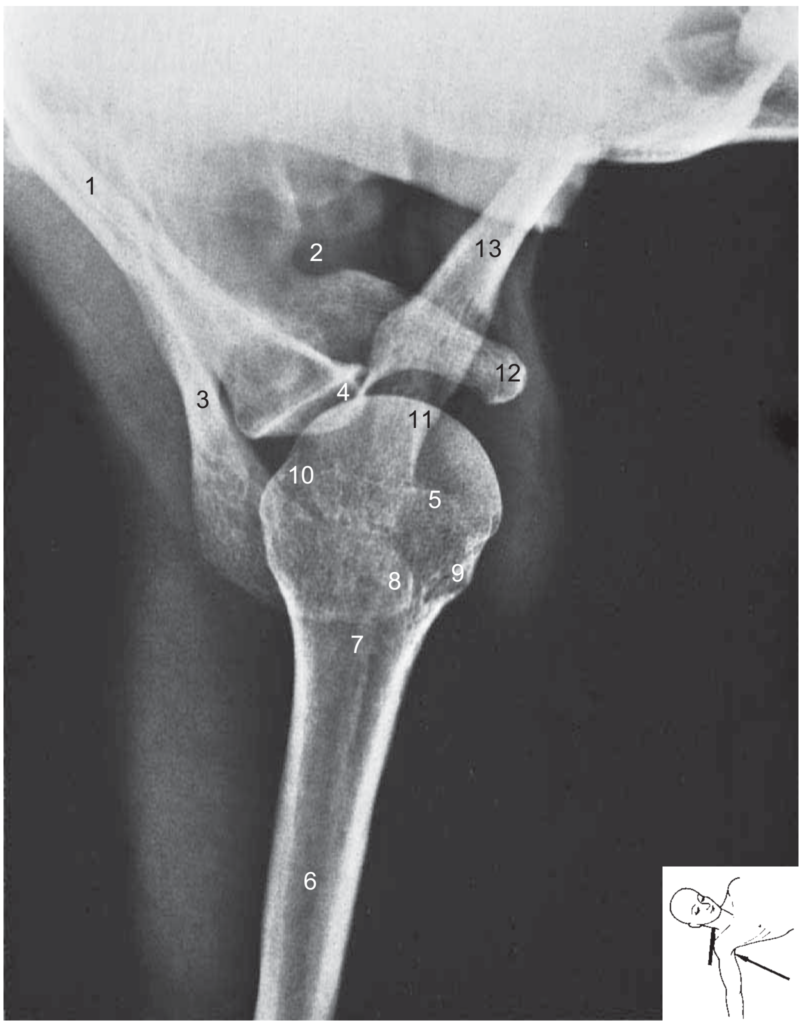


FIGURE 120.2 Radiograph of the Right Shoulder Joint

NOTE that this is an axial (longitudinal) view of the shoulder joint with the scapula and clavicle superior and the shaft of the humerus projecting inferiorly.

1. Scapula
2. Scapular notch
3. Spine of the scapula
4. Glenoid fossa
5. Greater tubercle
6. Shaft of the humerus
7. Surgical neck of the humerus
8. Acromion
9. Lesser tubercle
10. Anatomical neck of the humerus
11. Head of the humerus
12. Coracoid process
13. Clavicle

(From Wicke, 6th ed.)

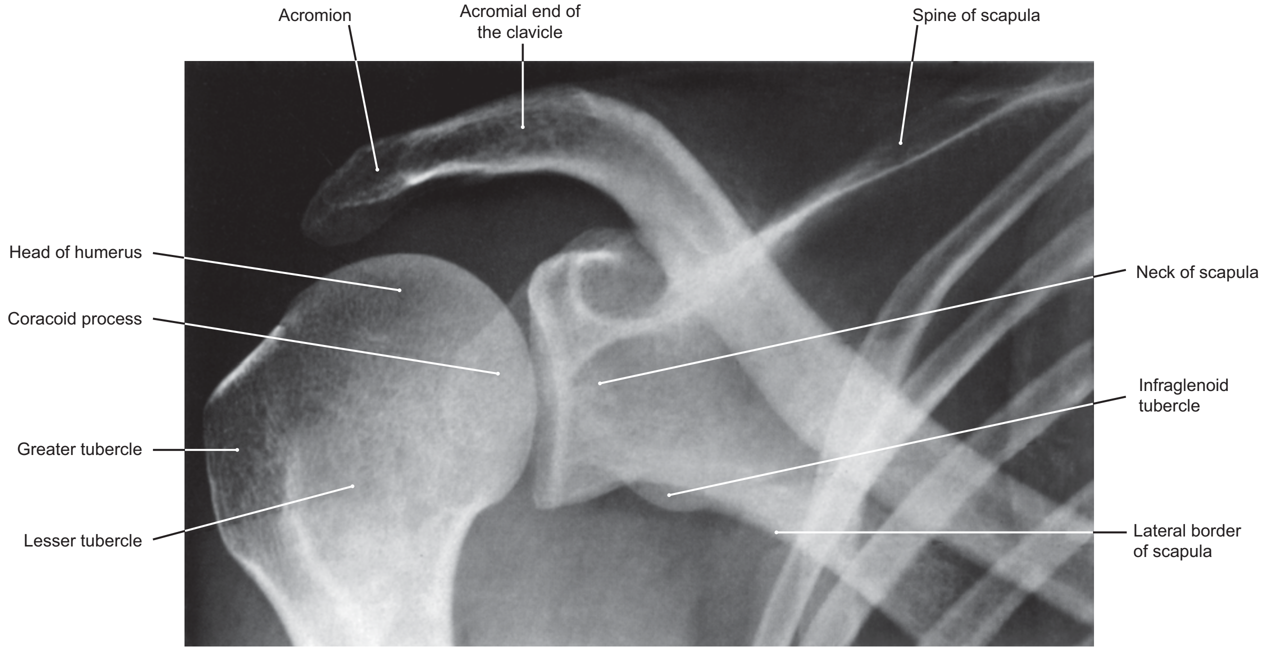


FIGURE 121.1 Radiograph of the Right Shoulder Joint (Humerus Alongside the Body)

NOTE that this radiograph was taken in an anteroposterior direction. The subject was supine with the upper arm rotated medially. (From R. Brickner. *Normal Radiologic Patterns and Variations of the Human Skeleton*. Munich: Urban and Schwarzenberg, 1977.)

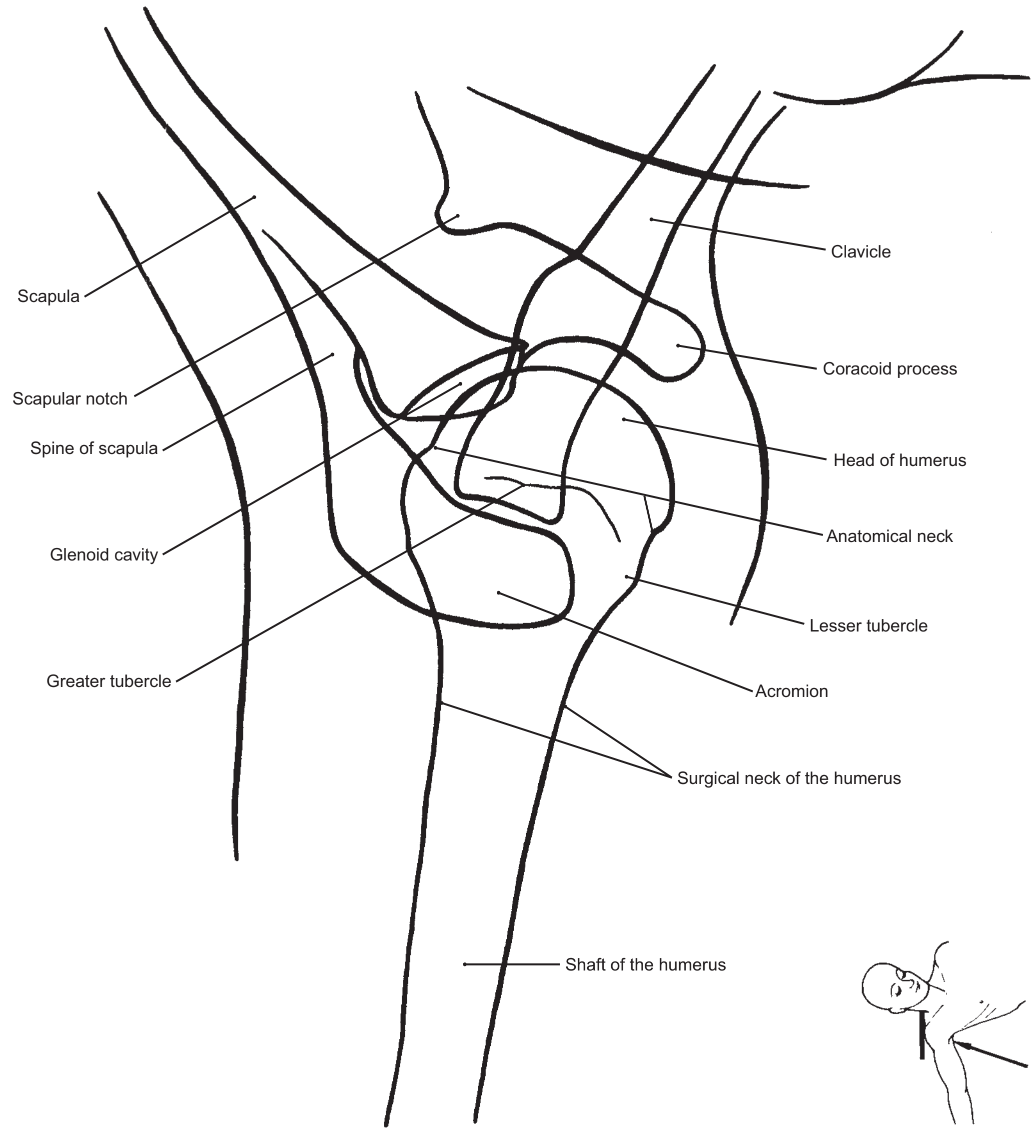


FIGURE 121.2 Diagrammatic Representation of the Radiograph in Figure 120.2

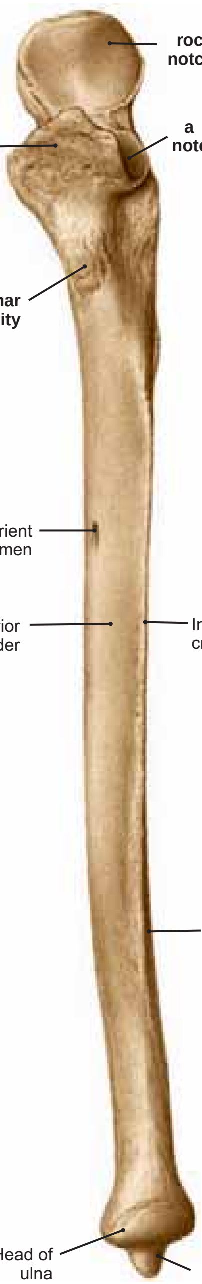


FIGURE 122.1 Anterior Ulna

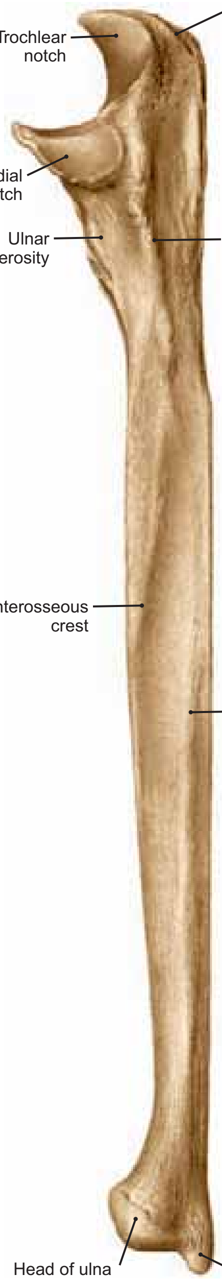


FIGURE 122.2 Lateral Ulna

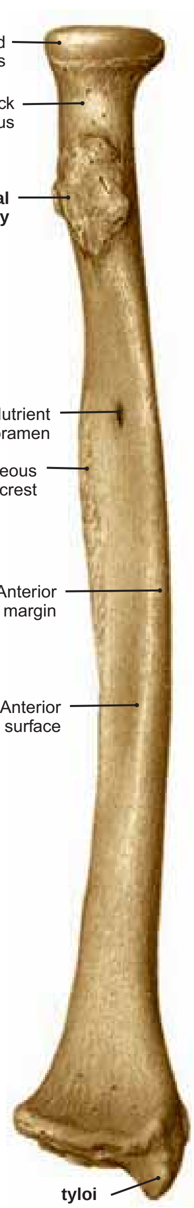


FIGURE 122.3 Anterior Radius

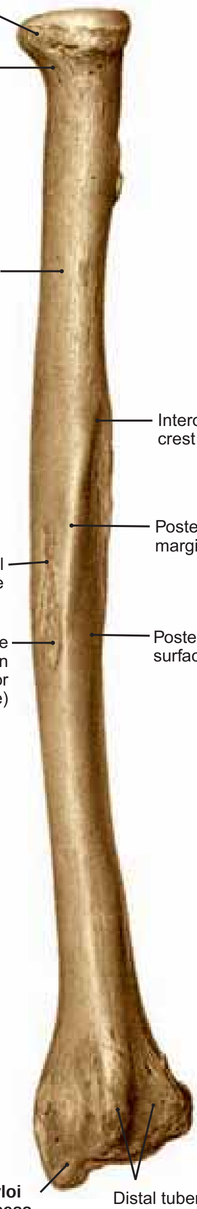


FIGURE 122.4 Posterior Radius

Left Ulna (Figs. 122.1 and 122.2)

NOTE: (1) The ulna is the medial bone of forearm. It has a superior extremity, a body or shaft, and an inferior extremity.

(2) The **superior extremity** contains the **olecranon** and **coronoid processes** and two cavities: the **radial notch** for articulation with the radius and the **trochlear notch** for the trochlea of the humerus.

(3) The brachialis muscle inserts on the tuberosity of the ulna.

(4) Along the **body** of the ulna attaches the interosseous membrane.

(5) The **distal extremity** is marked by the **ulnar head** laterally and the **styloid process** posteromedially.

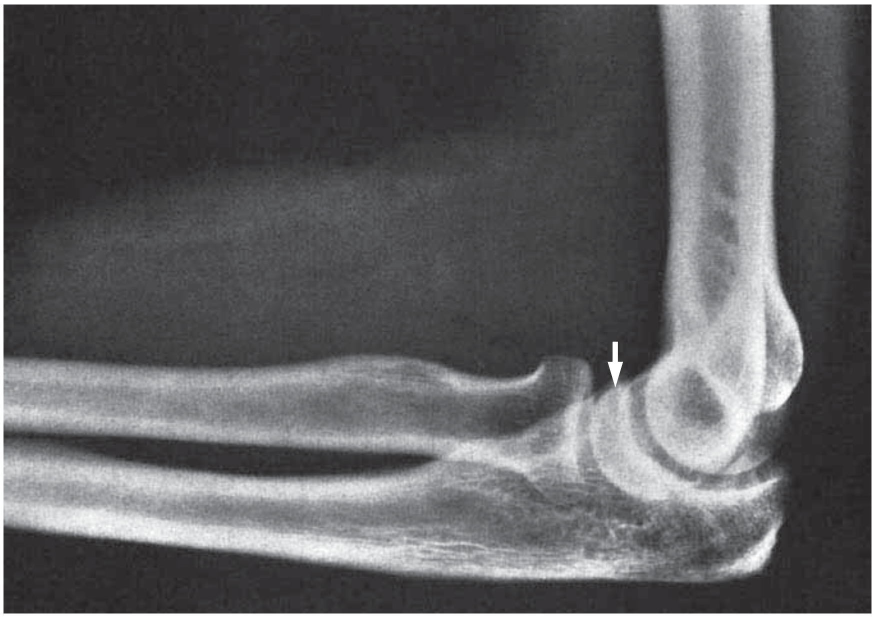
Left Radius (Figs. 122.3 and 122.4)

NOTE: (1) The radius is situated lateral to the ulna, and it has a body and two extremities. Proximally, it attaches to both the humerus and the ulna. Distally, it articulates with the carpal bones (scaphoid, lunate, and triquetrum) and with the ulna.

(2) The **proximal extremity** contains a cylindrical head that articulates with both the **capitulum** of the humerus and the **radial notch** of the ulna.

(3) Onto the **radial tuberosity** inserts the tendon of the biceps brachii.

(4) Onto the **styloid process** attaches the brachioradialis muscle and the radial collateral ligament of the radiocarpal joint.



NOTE the following bony structures:

1. Body of humerus
2. Radial fossa
3. Olecranon fossa
4. Medial epicondyle
5. Coronoid process of ulna
6. Trochlea of humerus
7. Body of radius
8. Radial tuberosity
9. Neck of radius
10. Head of radius
11. Capitulum of humerus
12. Trochlear notch
13. Olecranon

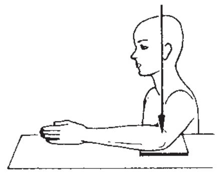
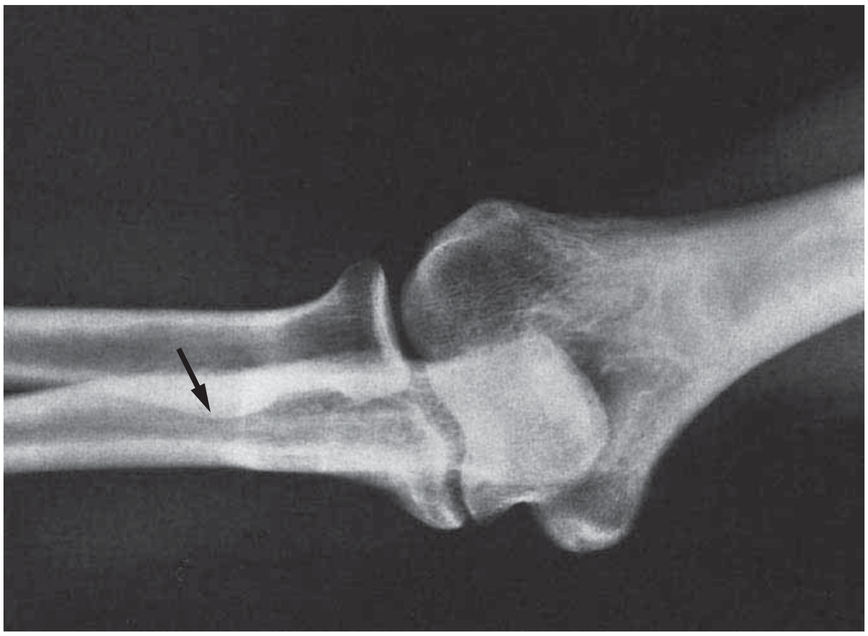


FIGURE 123.1 Radiograph of the Left Elbow Joint in an Adult (Lateral View)

(From Wicke, 6th ed.)



NOTE the following bony structures:

1. Body of humerus
2. Olecranon fossa
3. Olecranon
4. Lateral epicondyle
5. Medial epicondyle
6. Capitulum of humerus
7. Trochlea of humerus
8. Head of radius
9. Coronoid process of ulna
10. Neck of radius
11. Ulna
12. Radial tuberosity
13. Body of radius

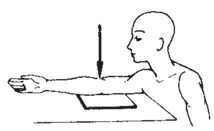


FIGURE 123.2 Radiograph of the Right Elbow Joint in an Adult (Anteroposterior View)

(From Wicke, 6th ed.)

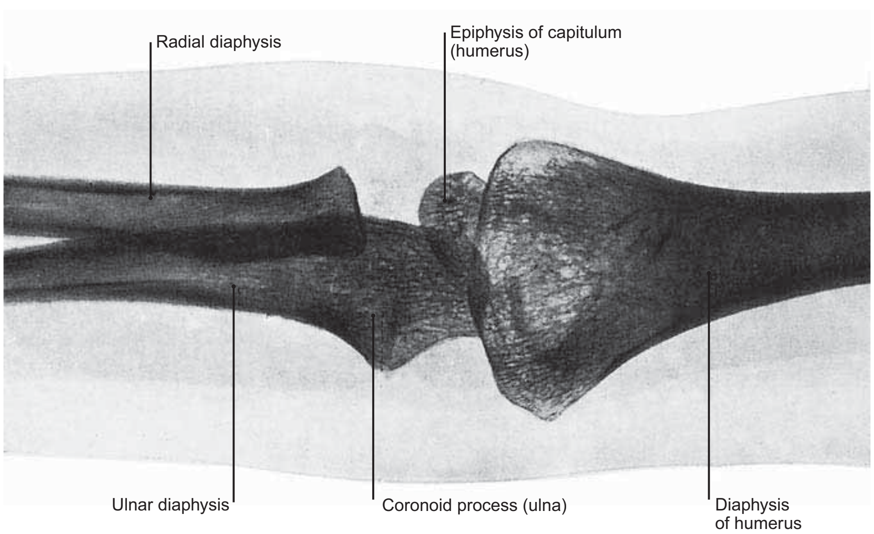


FIGURE 123.3 Radiograph of the Elbow Joint in a 5½-Year-Old Boy

NOTE: (1) The shaft of a long bone is called the **diaphysis,** whereas a center of ossification, distinct from the shaft and usually at the end of a long bone, is called an **epiphysis.**

(2) The epiphysis of the head of the radius is, as yet, not formed in the 5½-year-old child, although ossification has started in the humeral capitulum.

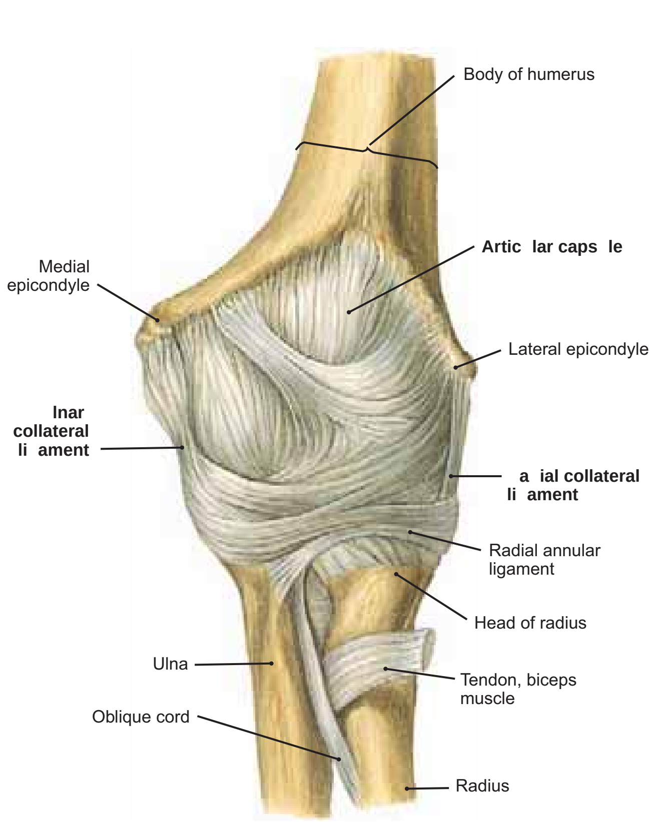


FIGURE 124.1 Left Elbow Joint (Anterior View)

NOTE: (1) The elbow joint is a hinge, or ginglymus, joint.
(2) The **trochlea** of the humerus is received in the trochlear notch of the ulna.
(3) The capitulum of the humerus articulates with the head of the radius.
(4) The articular capsule is loose but is thickened medially and laterally by the ulnar and **radial collateral** ligaments

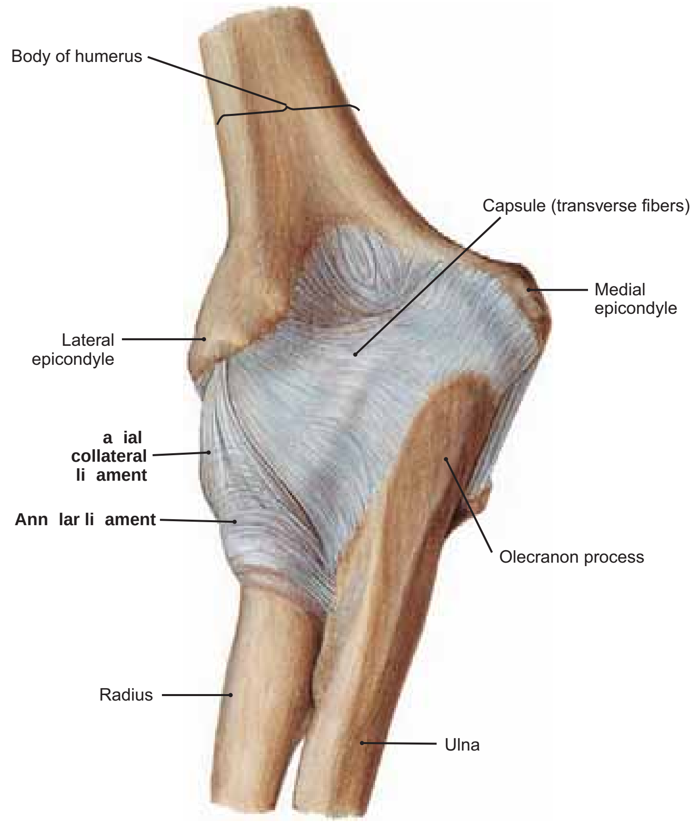
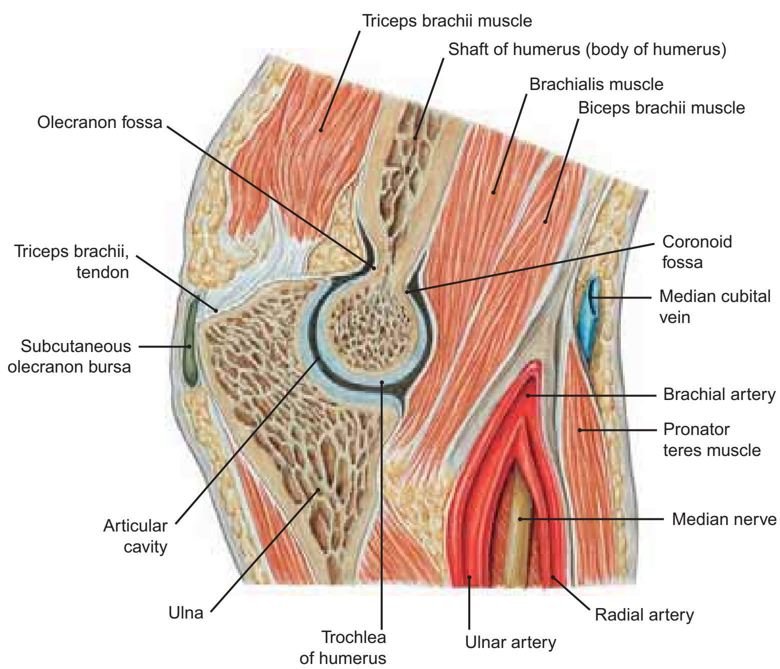


FIGURE 124.2 Left Elbow Joint (Posterolateral View)

NOTE: (1) The fan-shaped **radial collateral ligament** attaches above to the lateral epicondyle and blends with the capsule.
(2) The upper border of the **radial annular ligament** also blends with the joint capsule.

FIGURE 124.3 Left Elbow Joint (Sagittal Section)

NOTE: (1) The adaptation of the trochlea of the humerus with the trochlear notch of the ulna allows only flexion and extension, not lateral displacement.
(2) The posterior surface of the olecranon is separated from the skin by a subcutaneous bursa and the insertion of the triceps.
(3) **Fractures** of the distal end of the humerus occur most often from falls on the outstretched hand, because the force is transmitted through the bones of the forearm to the humerus.
(4) **Fractures** of the olecranon result from direct trauma to the bone by a fall on the point of the elbow.
(5) **Posterior dislocation** of the ulna and attached radius is the most common dislocation at the elbow joint, again from falls on the outstretched and abducted hand.



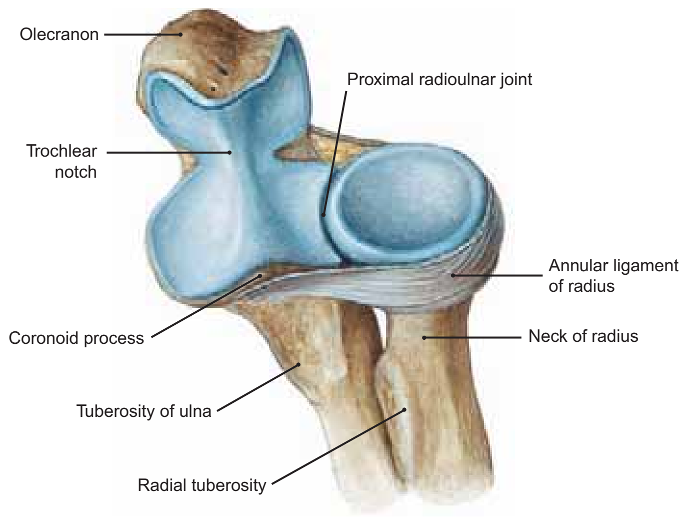


FIGURE 125.1 Left Proximal Radioulnar Joint

NOTE: (1) This anterior view of the proximal radioulnar joint (oriented similar to Fig. 124.1) shows the annular ligament surrounding the head of the radius. The ligament attaches to the ulna both anteriorly and posteriorly.
(2) The radial tuberosity onto which inserts the biceps brachii and the olecranon where the triceps brachii inserts

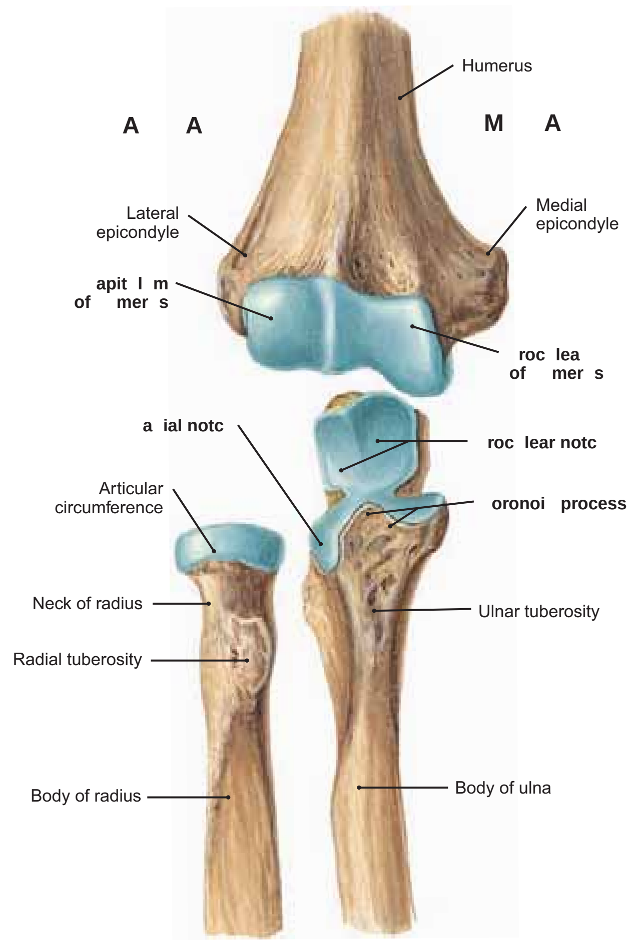


FIGURE 125.2 Bones of the Right Elbow and Radioulnar Joints (Anterior View)

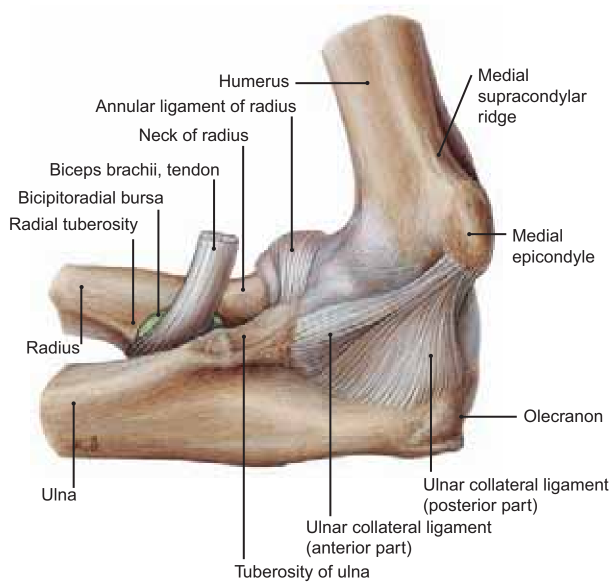


FIGURE 125.3 Flexed and Supinated Right Elbow Joint (Medial Aspect)

NOTE: (1) The anterior and posterior parts of the ulnar (medial) collateral ligament.
(2) The annular ligament encasing the head of the radius.
(3) The insertion of the biceps brachii tendon onto the tuberosity of the radius.
(4) The olecranon of the ulna onto which the triceps brachii (not shown) inserts.

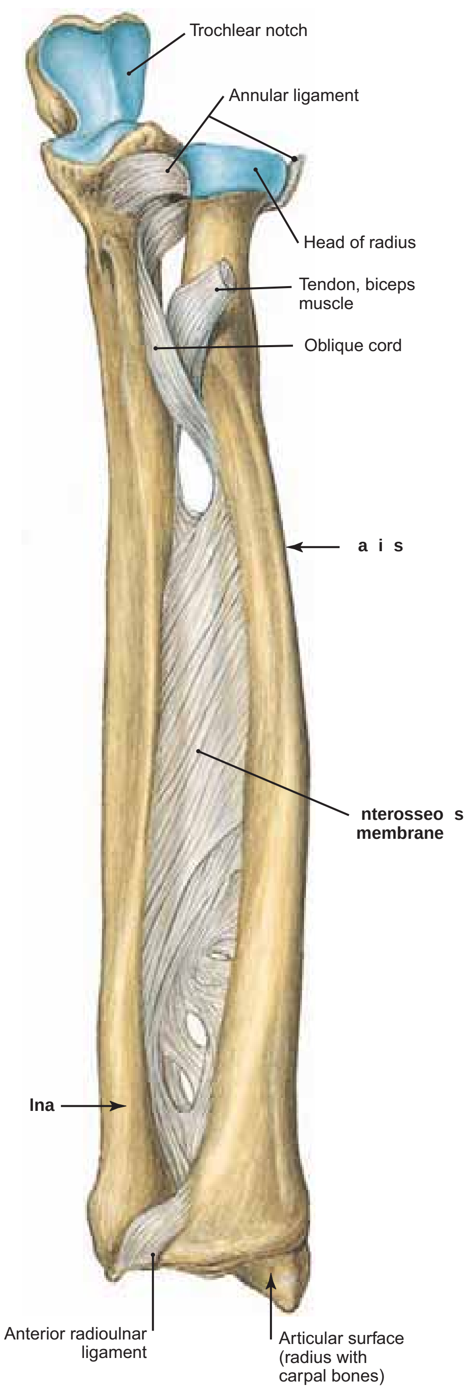


FIGURE 126.1 Radioulnar Joints (Anterior View, Left)

NOTE: (1) The radius and ulna articulate proximally, along the shafts of the two bones, and distally.

(2) Proximally, the head of the radius rotates within the radial notch of the ulna (pivot or trochoid joint).

(3) The **annular ligament,** attached at both ends to the ulna, encircles the head of the radius, protecting the joint.

(4) The interosseous membrane extends obliquely between the shafts of the two bones, whereas distally the head of the ulna attaches to the ulnar notch of the radius.

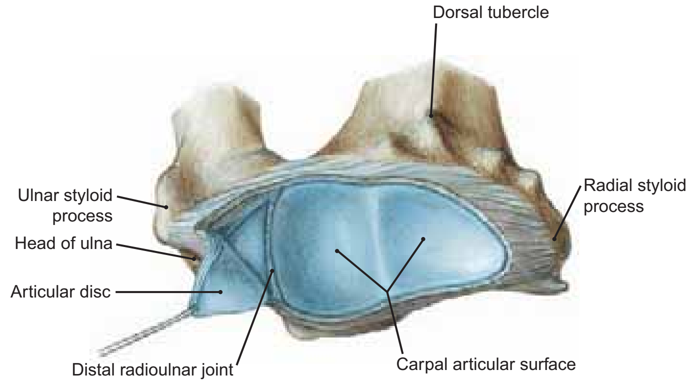


FIGURE 126.2 Right Radioulnar Joint

NOTE: (1) The lateral surface of the distal radius and the medial surface of the distal ulna form the distal radioulnar joint.

(2) The synovial cavity at this joint is L-shaped and is interposed between the distal end of the ulna and an articular disk. This cavity extends superiorly between the lateral surface of the distal radius and the medial surface of the distal ulna.

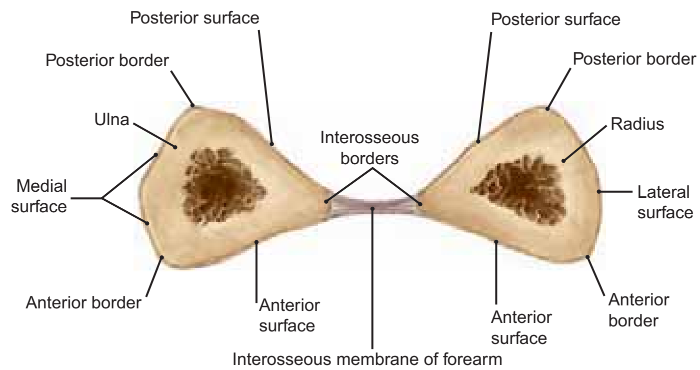


FIGURE 126.3 Bones of the Forearm (Transverse Section)

NOTE: (1) The interosseous membrane between the shafts of the radius and ulna. This membrane greatly strengthens the bony structures of the forearm.

(2) If a significant force ascends in the forearm (such as from a fall onto the outstretched hand), the interosseous membrane helps dissipate the impact of the fall. It does this by transmitting a part of the force to the other bone, thereby helping prevent fractures of the forearm bones.

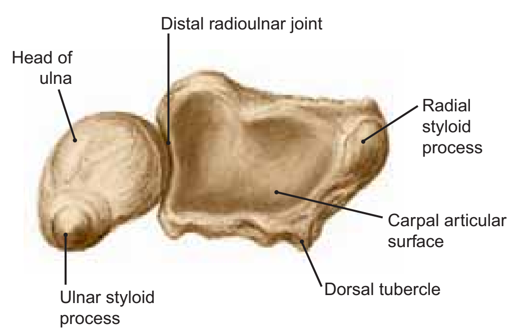


FIGURE 126.4 Distal Aspect of the Left Radius and Ulna

NOTE that the distal extremity of both bones is marked by a styloid process. Between the lateral side of the distal end of the ulna and the medial side of the wide lower end of the radius is located the distal radioulnar joint.

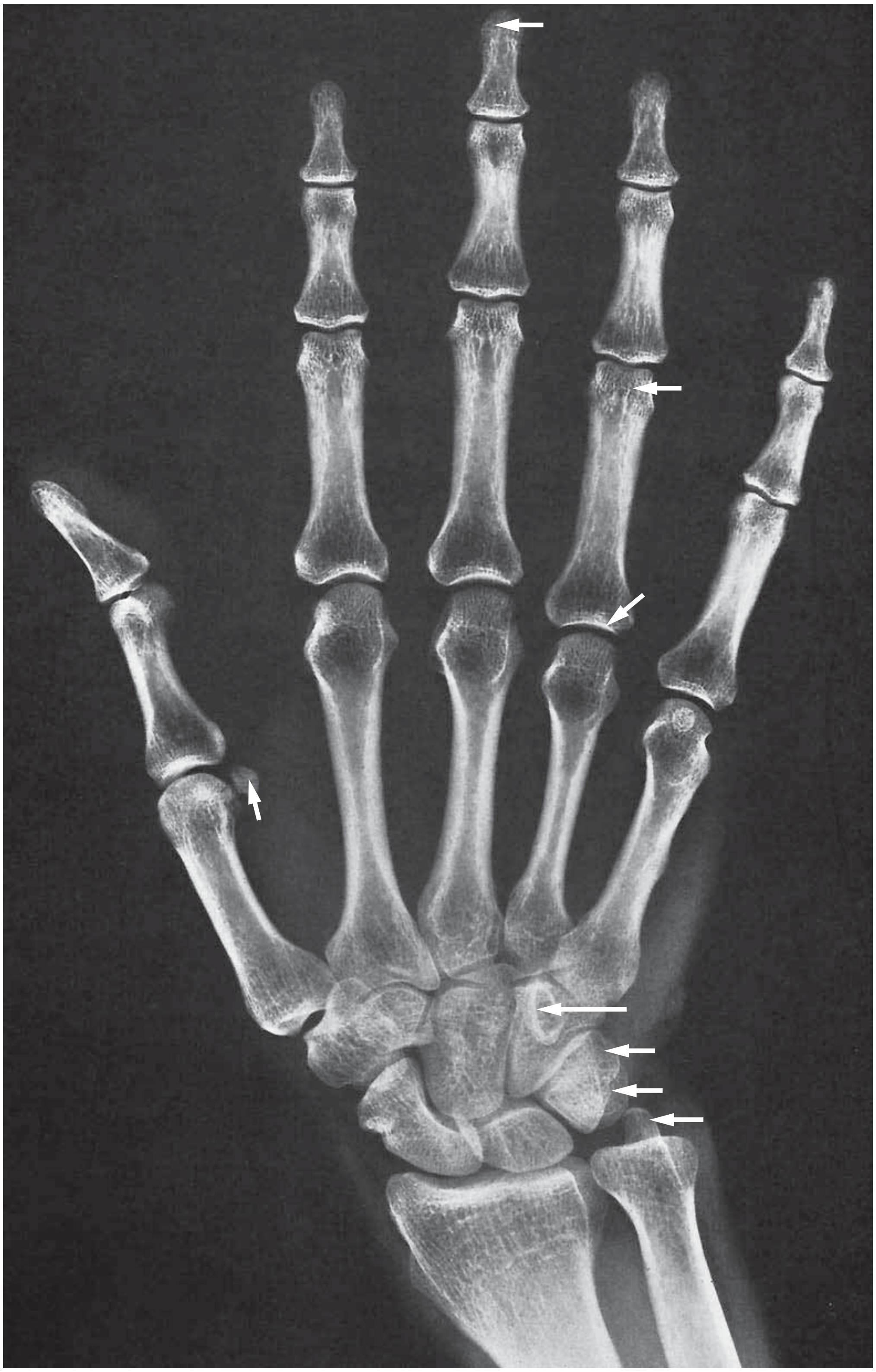


FIGURE 127 **Radiograph of the Right Wrist and Hand (Dorsopalmar View)**

1. Ulna
2. Styloid process of ulna
3. Radius
4. Styloid process of radius
5. Scaphoid
6. Lunate
7. Triquetral
8. Pisiform
9. Trapezium
10. Trapezoid
11. Capitate
12. Hamate
13. Hamulus of hamate
14. Base of first metacarpal bone
15. Head of first metacarpal bone
16. Sesamoid bone
17. Metacarpophalangeal joint
18. Proximal interphalangeal joint
19. Distal interphalangeal joint
20. Tuberosity of distal phalanx
21. Distal phalanx
22. Middle phalanx
23. Head of phalanx
24. Proximal phalanx
25. Base of phalanx
26. Fifth metacarpal bone

(From Wicke, 6th ed.)

FIGURE 128.1 Skeleton of the Right Wrist and Hand (Palmar View)

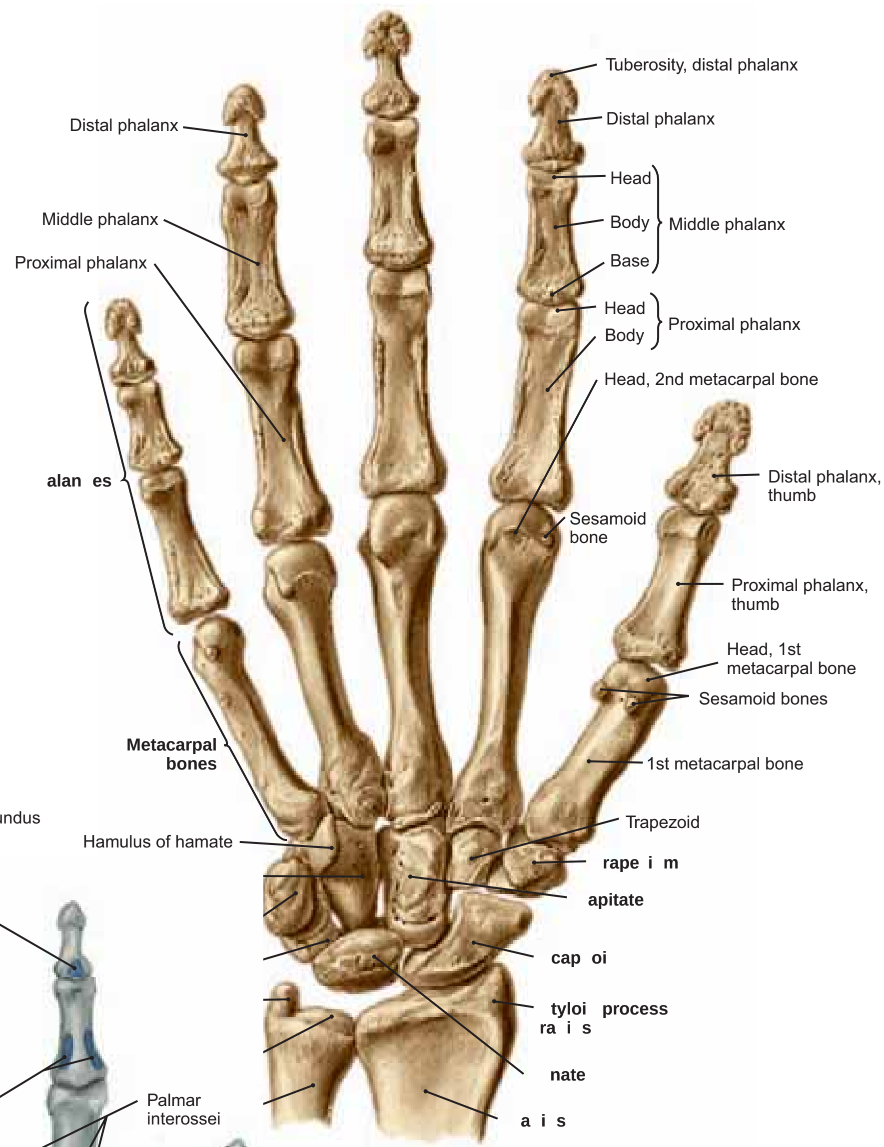
NOTE: (1) **Carpal bones:** 8; **metacarpal bones:** 5; **phalanges:** 14 (thumb has 2, each of the other 4 fingers has 3)

(2) **Carpal bones,** lateral to medial:

Proximal Row	**Distal Row**
Scaphoid	Trapezium
Lunate	Trapezoid
Triquetrum	Capitate
Pisiform	Hamate

(3) **Metacarpal bones:**
- (a) First is shortest
- (b) Second is longest
- (c) Each has a **base** (carpal end), a **body**, and a **head** (distal end)

(4) **Phalanges:**
- (a) Those of four medial fingers are set in transverse rows—**proximal, middle,** and **distal.**
- (b) The thumb has only a proximal and a distal phalanx.



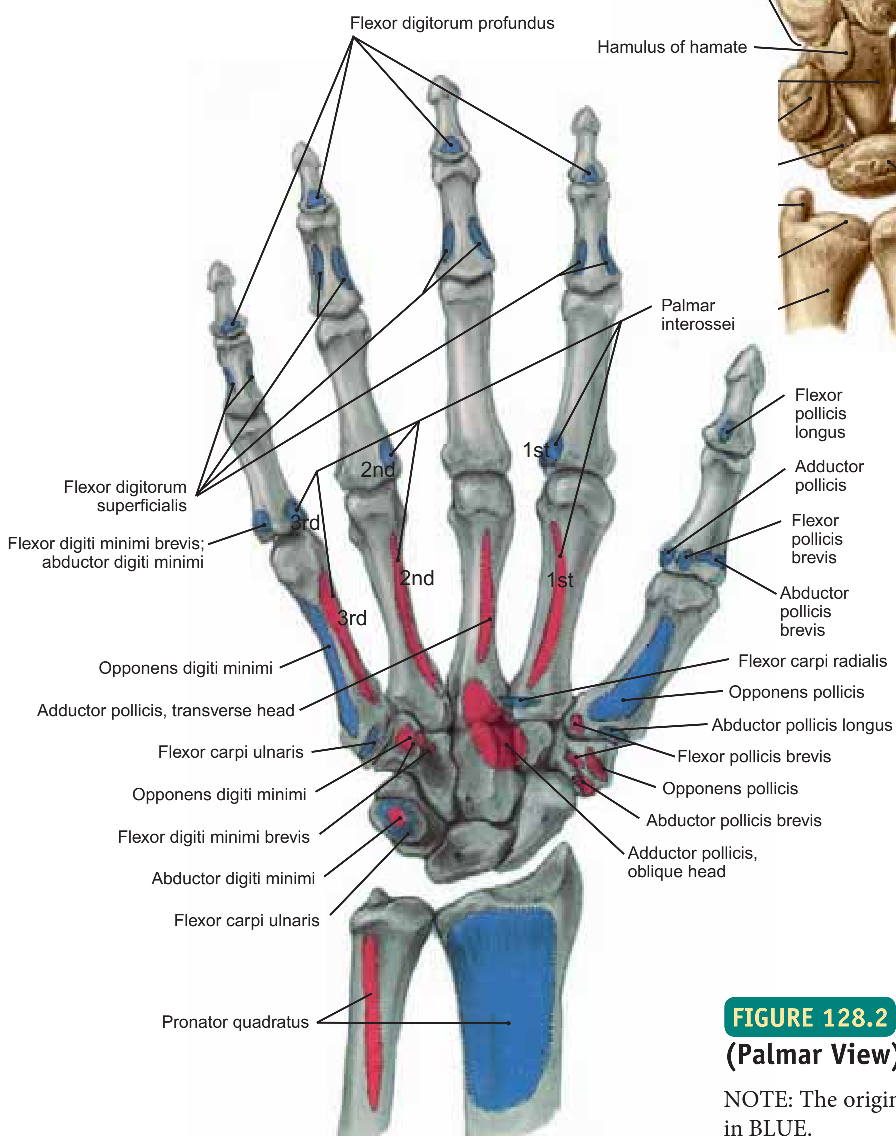


FIGURE 128.2 Bones of the Right Wrist and Hand (Palmar View), Showing the Attachment of Muscles

NOTE: The origins of muscles are in RED, whereas the insertions are in BLUE.

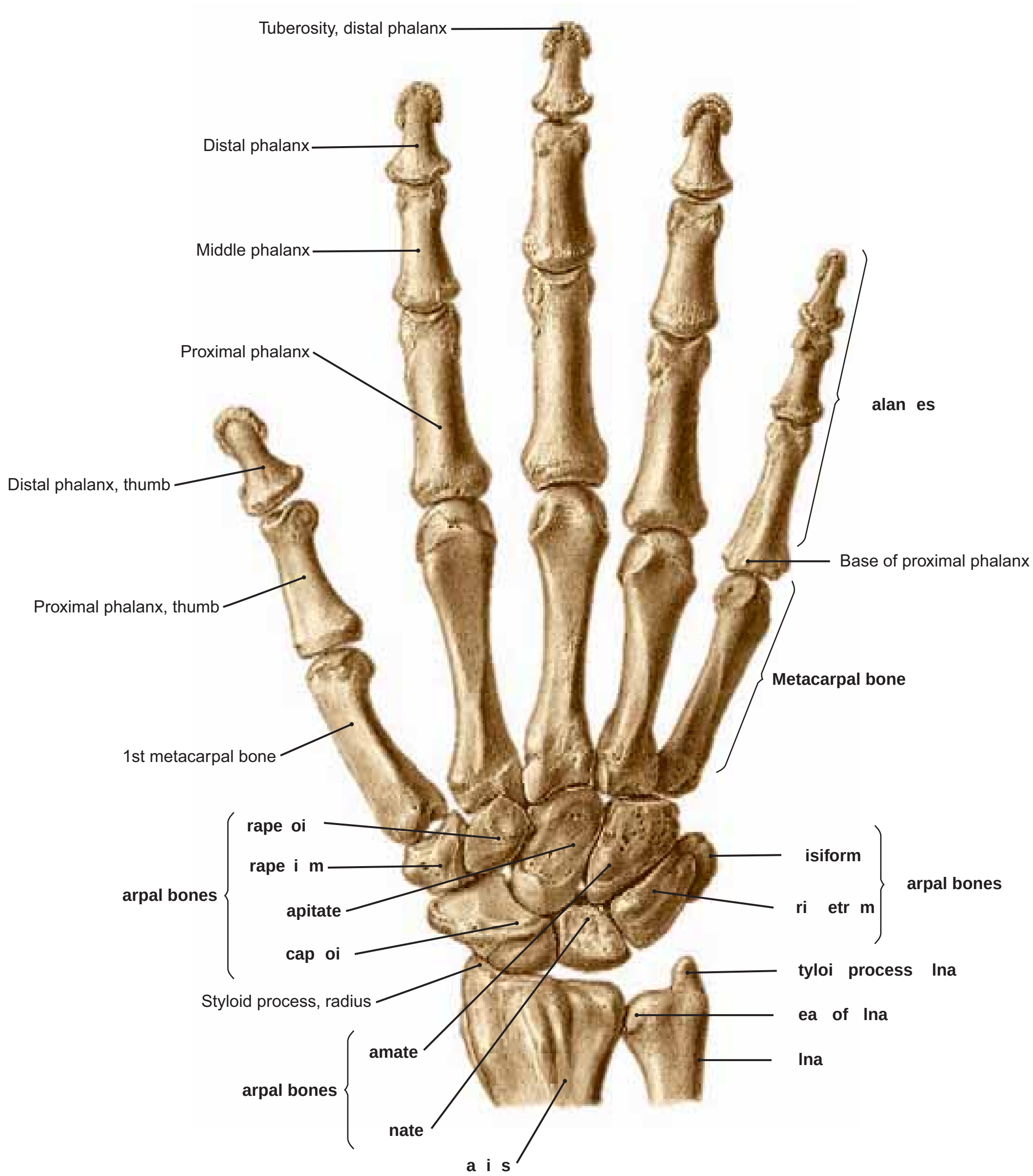


FIGURE 129.1 Skeleton of the Right Wrist and Hand (Dorsal View)

FIGURE 129.2 Radiograph of the Right Wrist (Dorsoventral Projection)

NOTE: The following numbered structures:

1. Base of first metacarpal bone (thumb)
2. Trapezium bone
3. Trapezoid bone
4. Capitate bone
5. Hamate bone
6. Hamulus of hamate bone
7. Base of the fifth metacarpal bone (little finger)
8. Scaphoid bone
9. Lunate bone
10. Triquetral bone
11. Pisiform bone
12. Styloid process of radius
13. Ulnar notch (distal radioulnar joint)
14. Styloid process of ulna
15. Radius
16. Ulna

(From Wicke, 6th ed.)

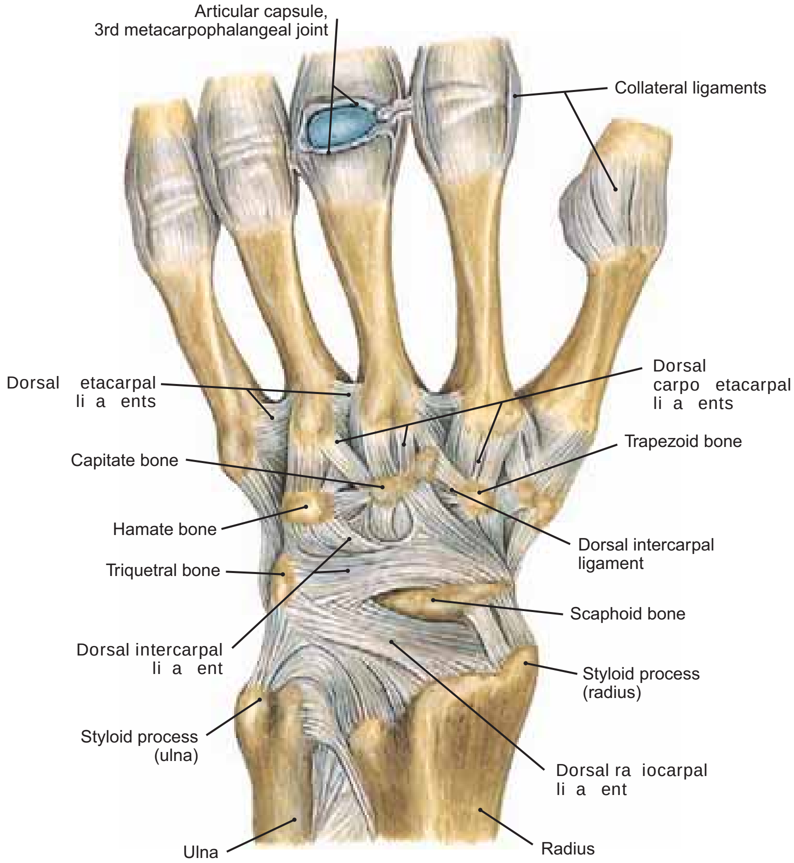
FIGURE 130.1 Joints and Ligaments of the Wrist and Hand (Dorsal View, Left Hand)

NOTE: (1) Most ligaments of joints in the wrist and hand are named according to the bones they interconnect.

(2) The dorsal radiocarpal ligament strengthens the radiocarpal joint capsule dorsally. It is joined medially and laterally by the ulnar and radial collateral ligaments (see Fig. 131.3), which extend distally from the styloid processes of both the radius and the ulna.

(3) The intercarpal and carpometacarpal ligaments are short, dense connective-tissue strands extending between adjacent bones.

(4) The articular capsule has been cut on the dorsal aspect of the third metacarpophalangeal joint to reveal the rounded head of the metacarpal bone and the concave base of the proximal phalanx.



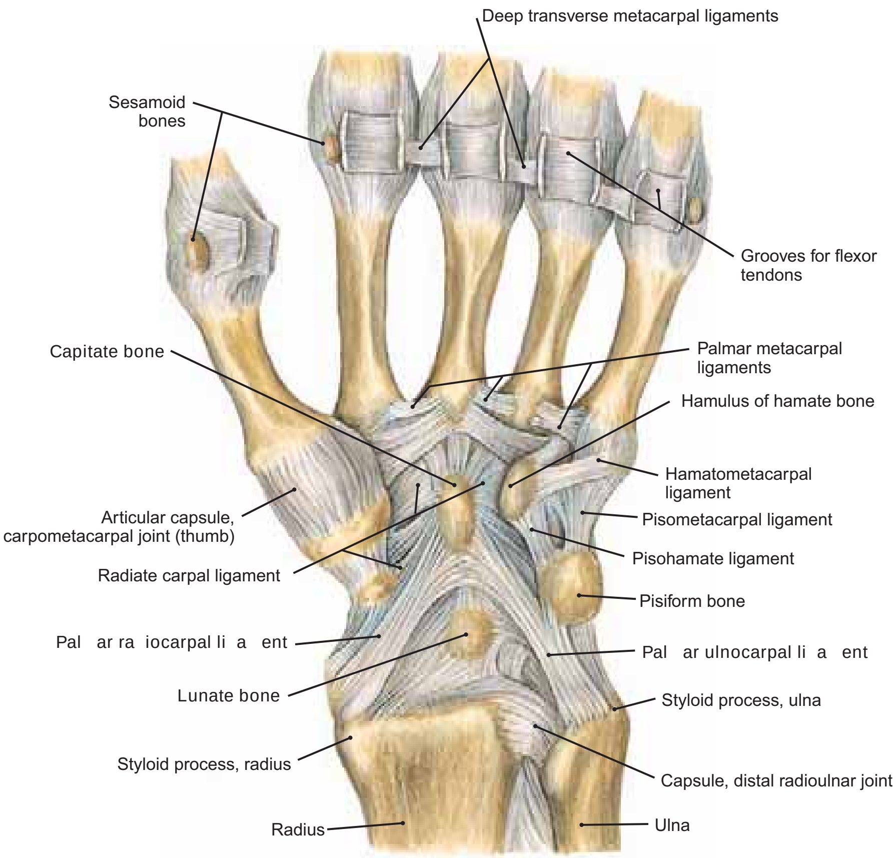
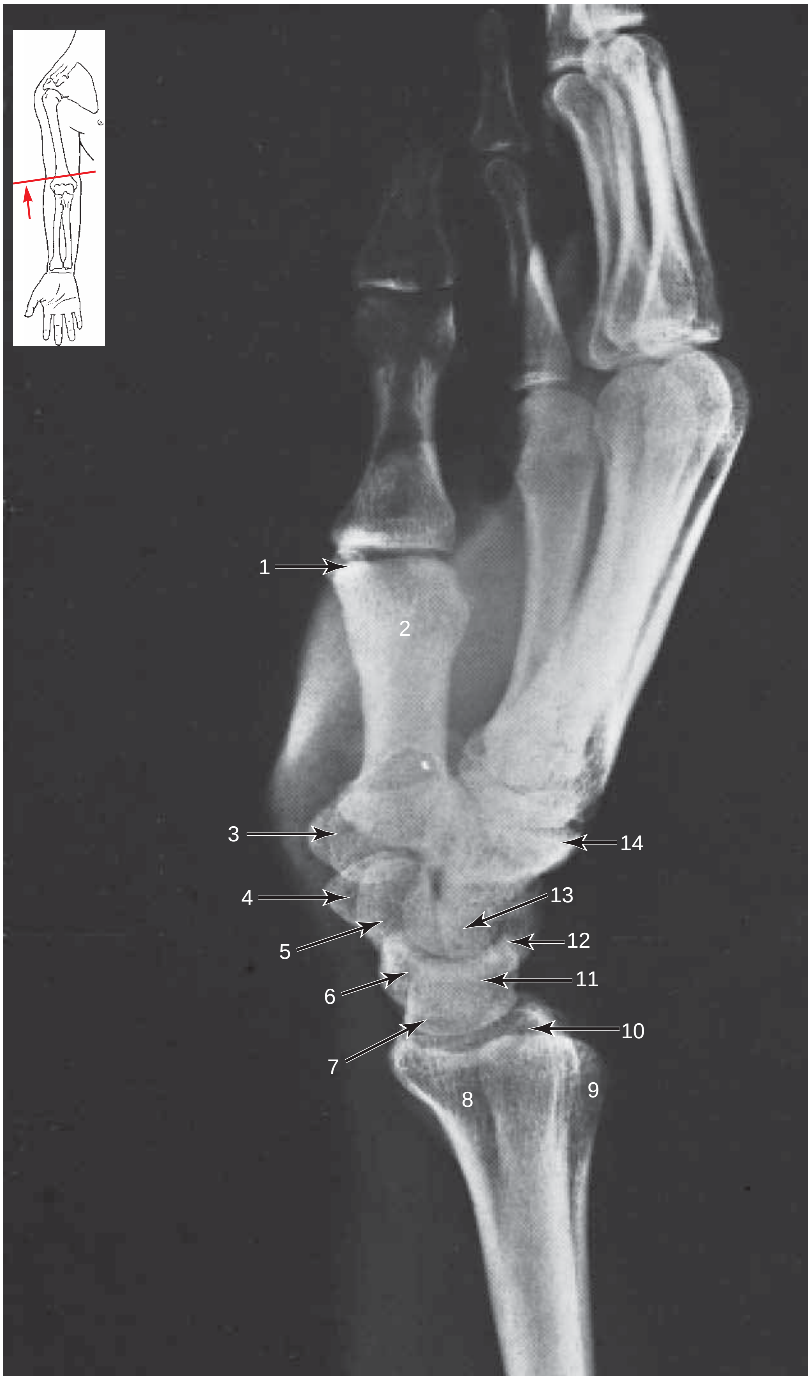


FIGURE 130.2 Joints and Ligaments of the Wrist and Hand (Palmar View, Left Hand)

NOTE: (1) Several strong ligaments in the palmar hand: the radiate ligament surrounding the capitate bone as well as pisohamate and pisometacarpal ligaments.

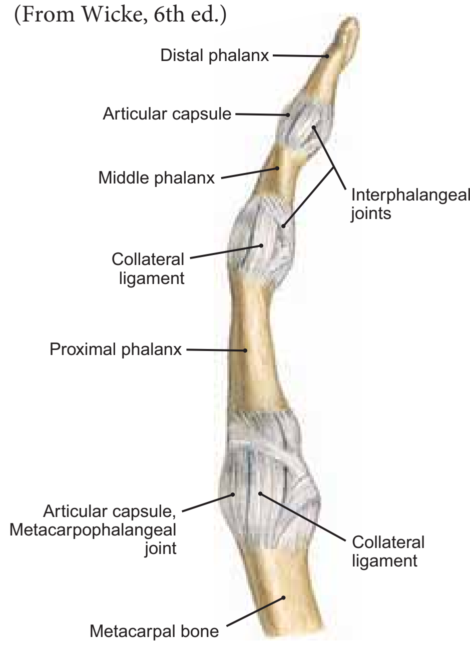
(2) The bases of the metacarpal bones are joined by the palmar metacarpal ligaments and the distal heads by the deep transverse metacarpal ligament.



◀ **FIGURE 131.1 Radiograph of the Right Hand (Lateral Projection)**

1. Sesamoid bone
2. First metacarpal bone
3. Trapezium bone
4. Tuberosity of scaphoid bone
5. Pisiform bone
6. Styloid process of radius
7. Scaphoid bone
8. Radius
9. Ulna
10. Styloid process of ulna
11. Lunate bone
12. Triquetral bone
13. Head of capitate bone
14. Hamate bone

(From Wicke, 6th ed.)



▲ **FIGURE 131.2 Joints and Ligaments of the Middle Finger**

NOTE: The articular capsules of the joints in the fingers are strengthened by longitudinally oriented collateral ligaments.

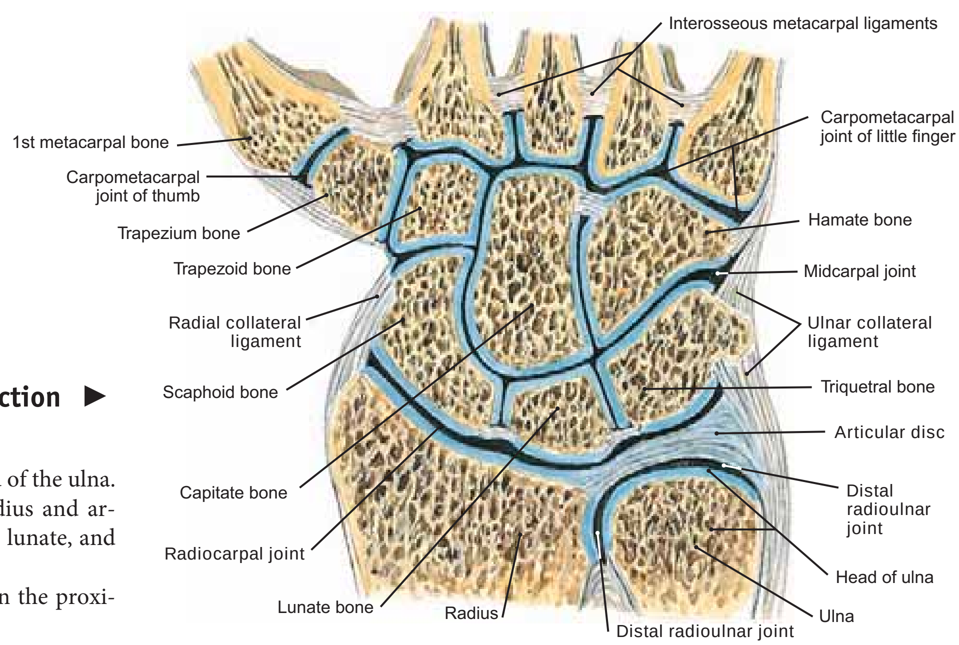


FIGURE 131.3 Coronal (Frontal) Section through the Left Wrist Joints ▶

NOTE: (1) The articular disk at the distal end of the ulna.
(2) The radiocarpal joint consists of the radius and articular disk proximally and the scaphoid, lunate, and triquetrum distally.
(3) The midcarpal joint that extends between the proximal and distal rows of carpal bones.

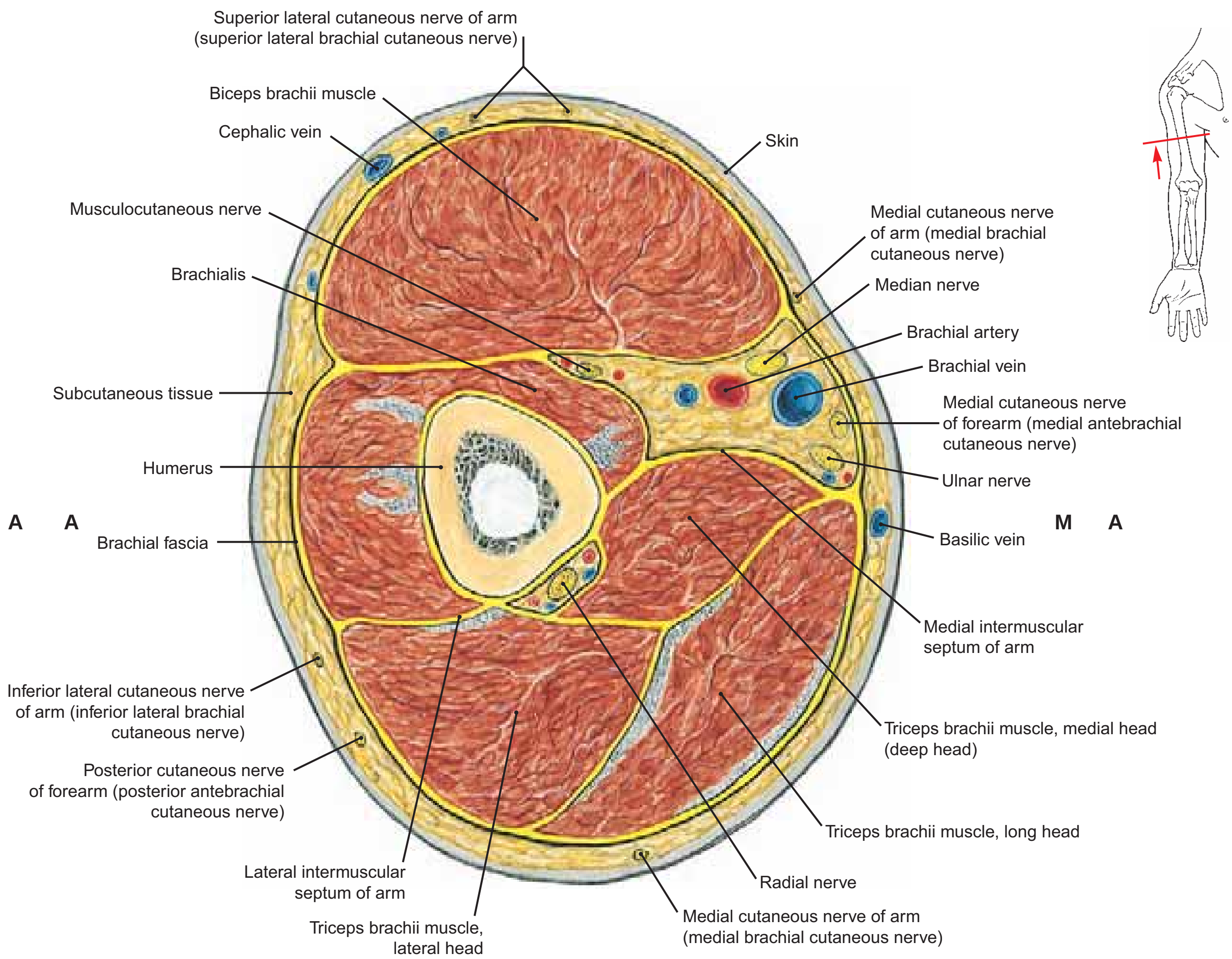


FIGURE 132.1 Cross Section of the Right Upper Extremity through the Middle of the Humerus

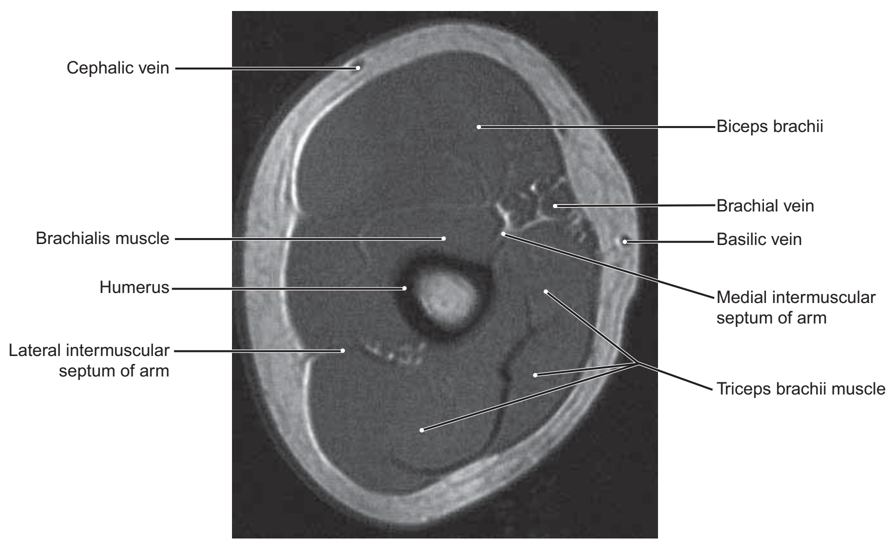


FIGURE 132.2 Magnetic Resonance Image (MRI) of the Right Upper Limb through the Middle of the Humerus

NOTE that this MRI may be compared with the cross section in Figure 132.1.

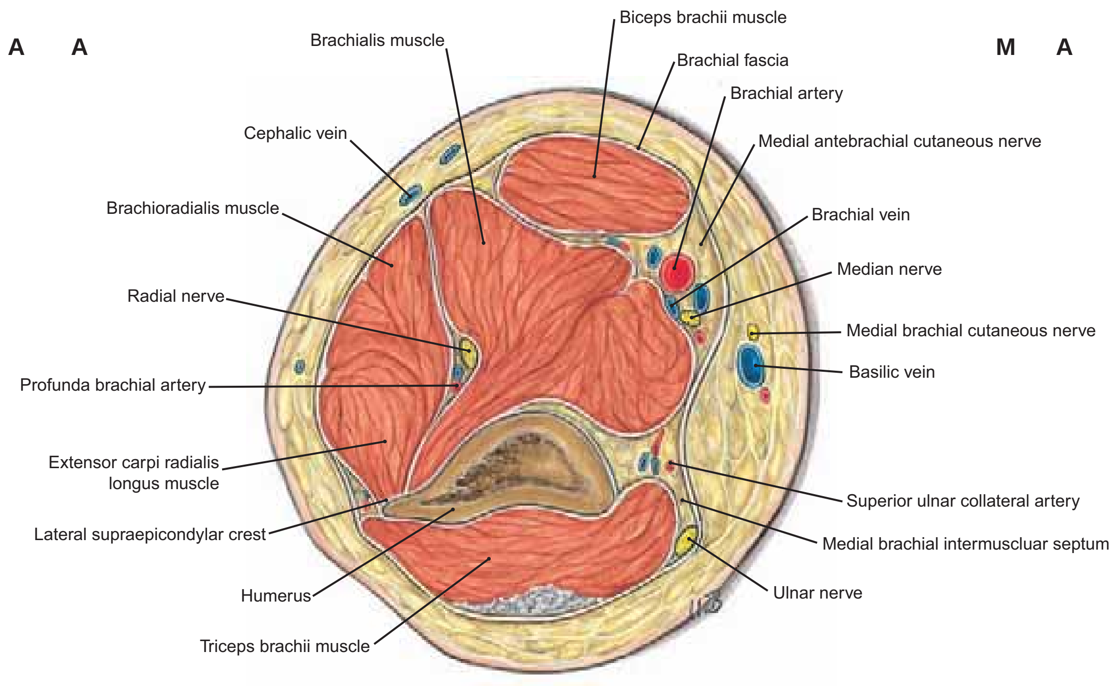


FIGURE 133.1 Transverse Section through the Lower Third of the Arm

NOTE the brachial artery, basilic vein, and the median, ulnar, and radial nerves.

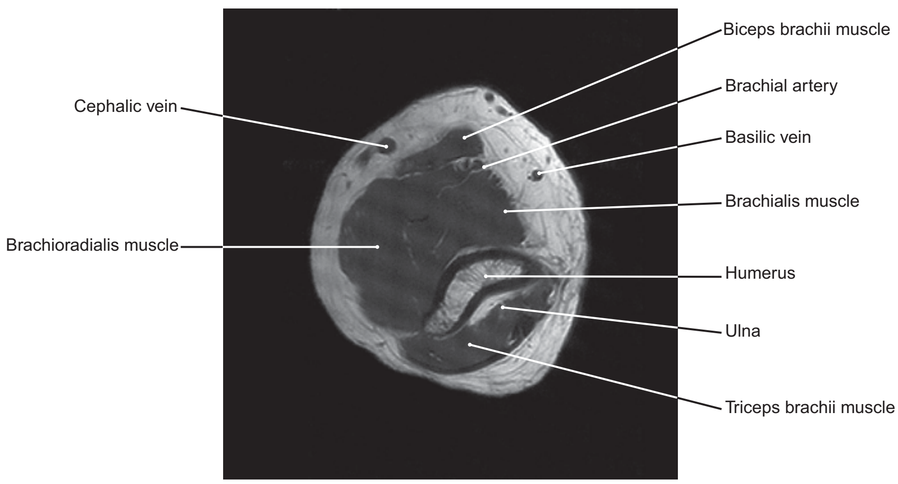


FIGURE 133.2 Magnetic Resonance Image (MRI). Cross Section at the Lower Third of the Arm

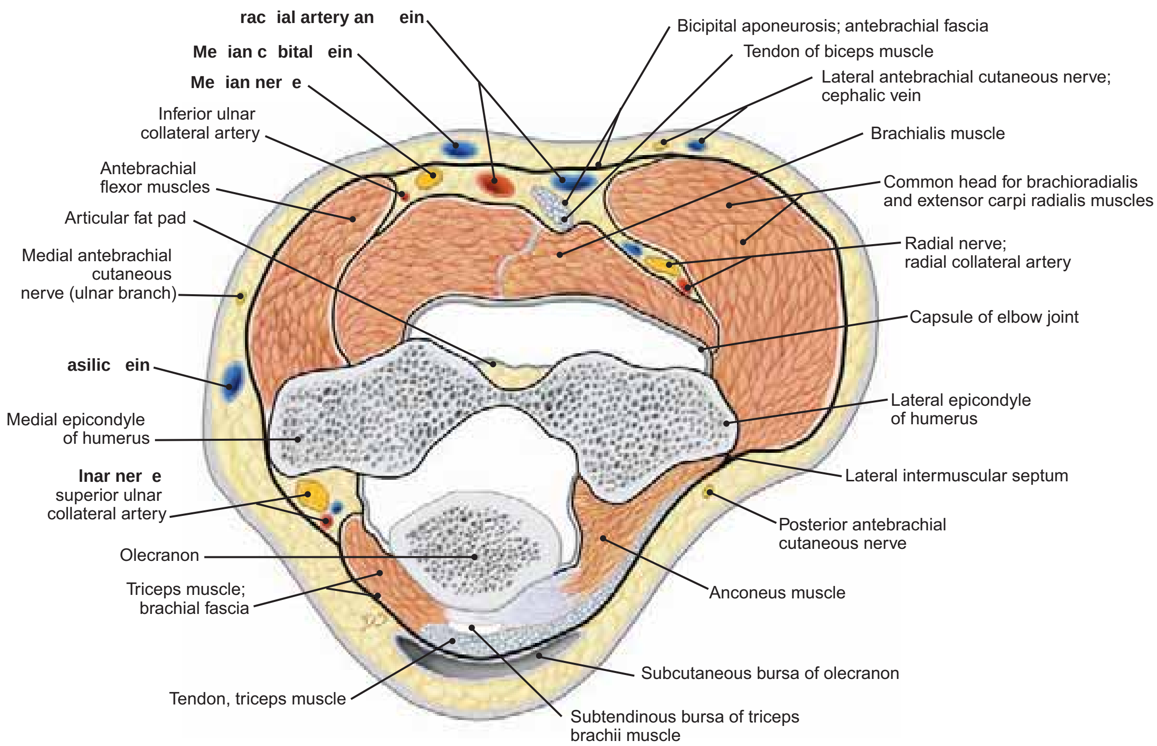


FIGURE 134.1 Cross Section through the Right Upper Extremity at the Level of the Elbow Joint

NOTE: (1) The ulnar nerve and superior ulnar collateral artery lie behind the medial epicondyle of the humerus, medial to the olecranon of the ulna.

(2) The median nerve lies to the ulnar (medial) side of the brachial vein and artery in the cubital fossa, and all three structures lie deep to the cubital fascia and median cubital vein.

(3) At this level, the radial nerve and radial collateral artery lie between the common origins of the extensor muscles and the deeply located brachialis muscle.

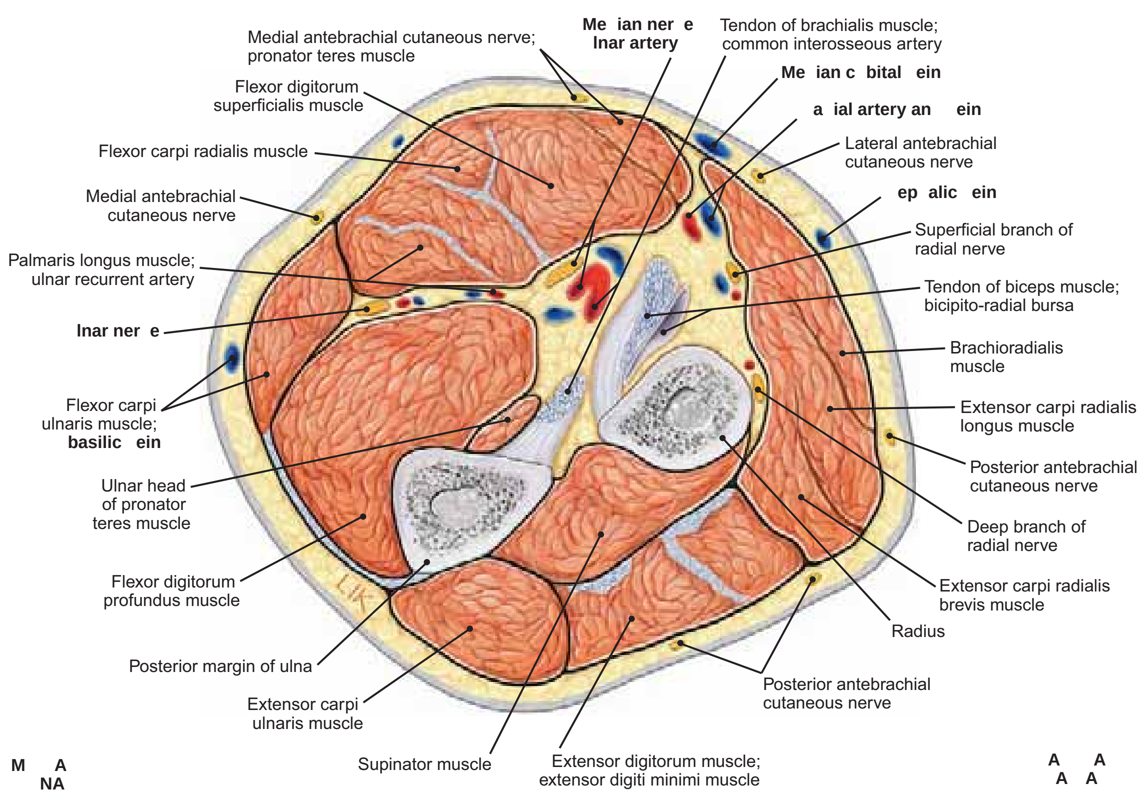


FIGURE 134.2 Cross Section through the Proximal Third of the Right Forearm

NOTE: (1) The common interosseous artery branching from the ulnar artery and the insertions of the biceps brachii and brachialis muscles to the radius and ulna, respectively.

(2) The radial nerve has already divided into its superficial and deep branches.

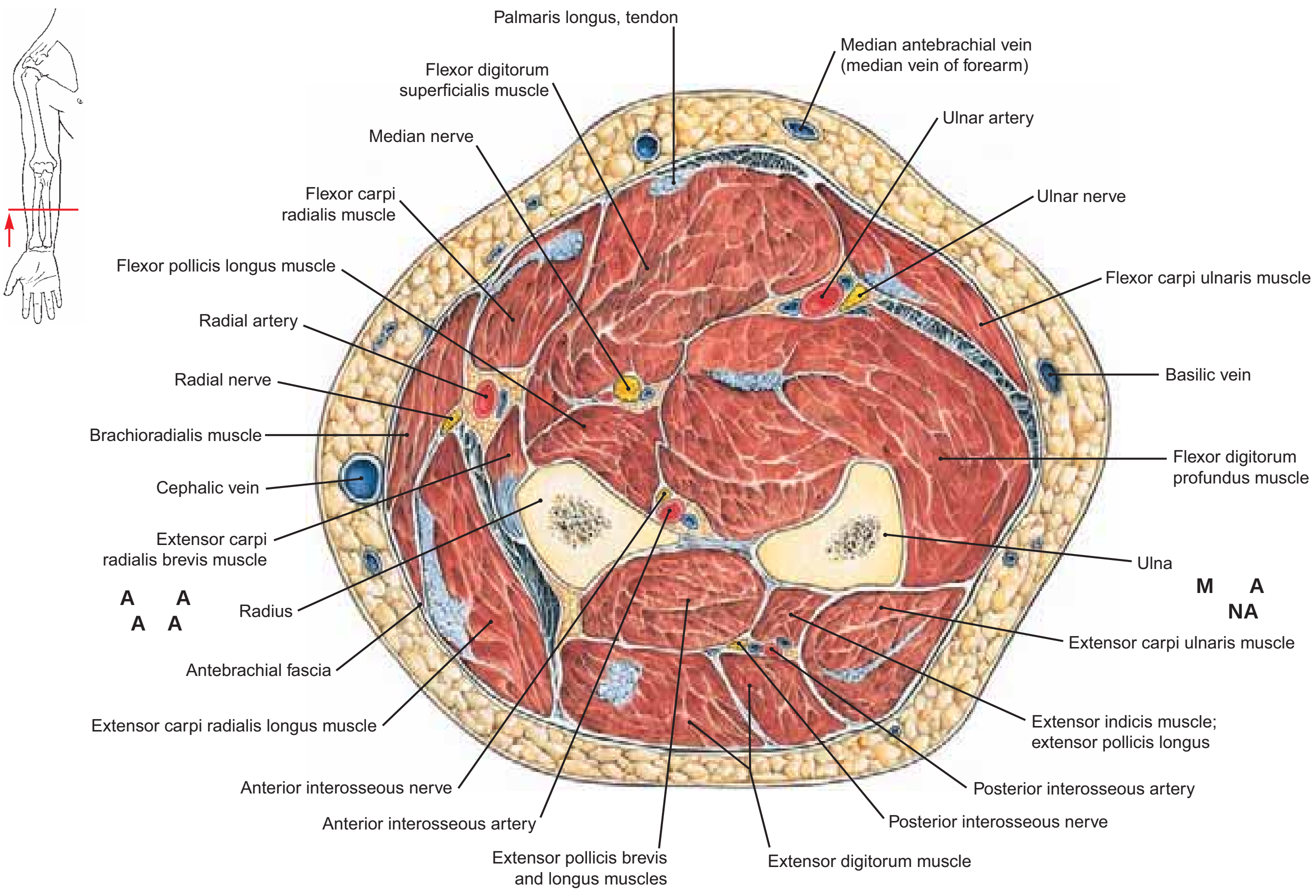


FIGURE 135.1 Cross Section through the Middle Third of the Right Forearm

NOTE: (1) At this level, the ulna, radius, interosseous membrane, and intermuscular septum clearly delineate the **posterior compartment,** extending dorsally and laterally, from the **anterior compartment** located anteriorly and medially.

(2) The **median nerve** coursing down the forearm deep to the flexor digitorum superficialis and anterior to the flexor digitorum profundus and flexor pollicis longus.

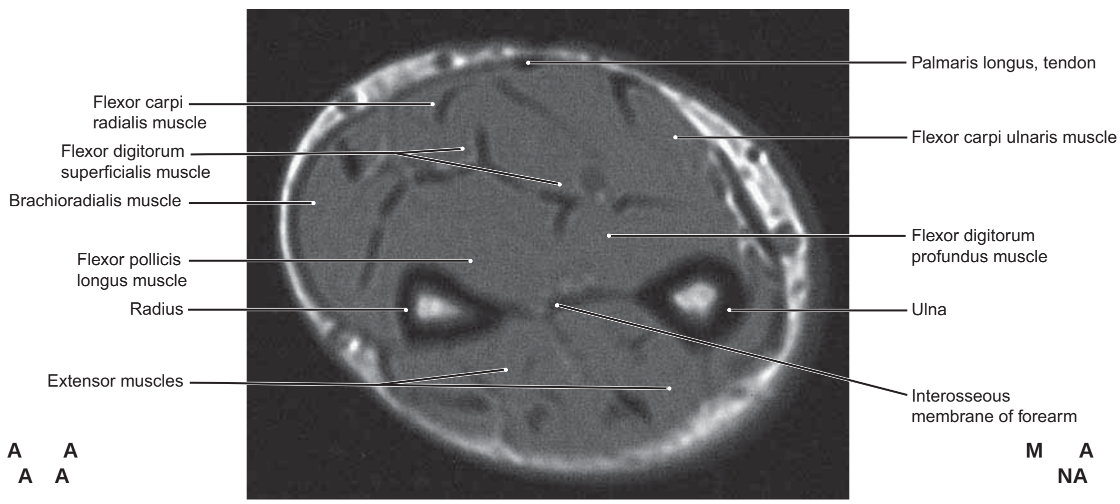


FIGURE 135.2 Transverse MRI Section through the Middle of the Forearm

NOTE that this figure should be compared with Figure 135.1. Observe the locations of the anterior and posterior forearm muscle groups and judge where the important vessels and nerves would be found in the MRI.

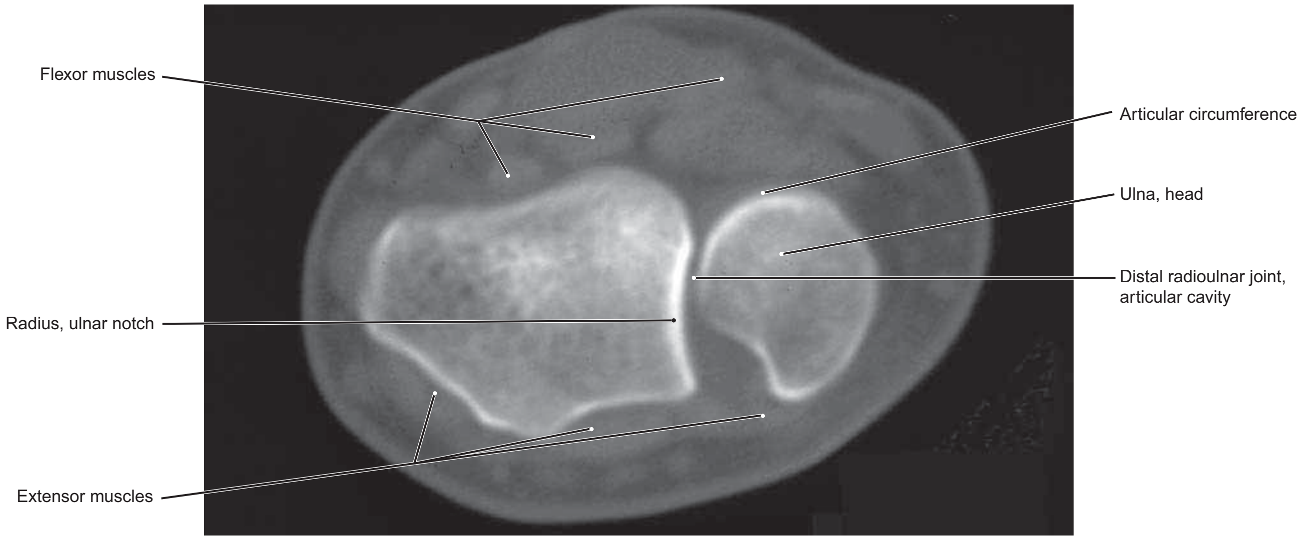


FIGURE 136.1 CT of the Right Distal Radioulnar Joint

NOTE: (1) The **head of the ulna** fits into the **ulnar notch** of the radius and the articular cavity of the distal radioulnar joint between.

(2) The distal end of the radius is large, while its proximal end is relatively small. In contrast, the distal end of the ulna is small in comparison to the proximal end at the elbow joint. Compare with the bones in Figures 137.1 and 137.2.

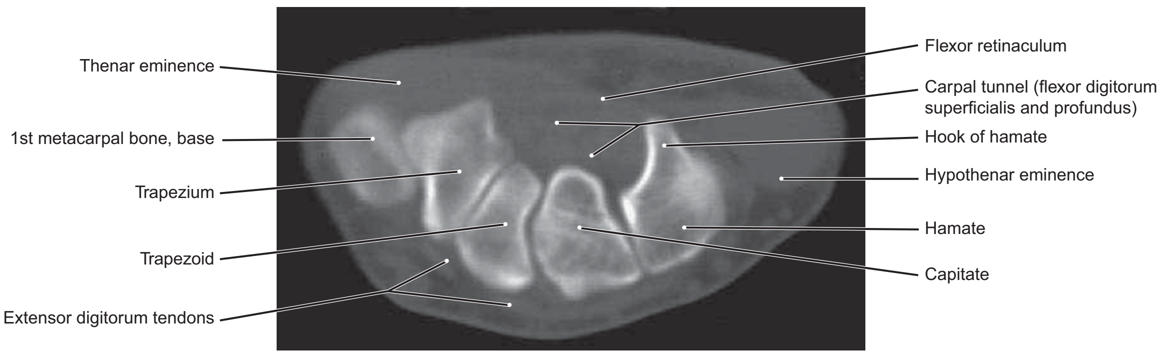


FIGURE 136.2 CT of the Right Wrist

NOTE: (1) This image is taken at the level of the distal row of carpal bones (from lateral to medial: trapezium, trapezoid, capitate, and hamate).

(2) The base of the first metacarpal bone as it articulates proximally with the trapezium to form the carpometacarpal joint of the thumb. Compare this figure with the radiograph in Figure 127.

(3) The hook (hamulus) of the hamate bone projects from the palmar surface of the bone. It can be felt through the skin over the proximal part of the hypothenar eminence.

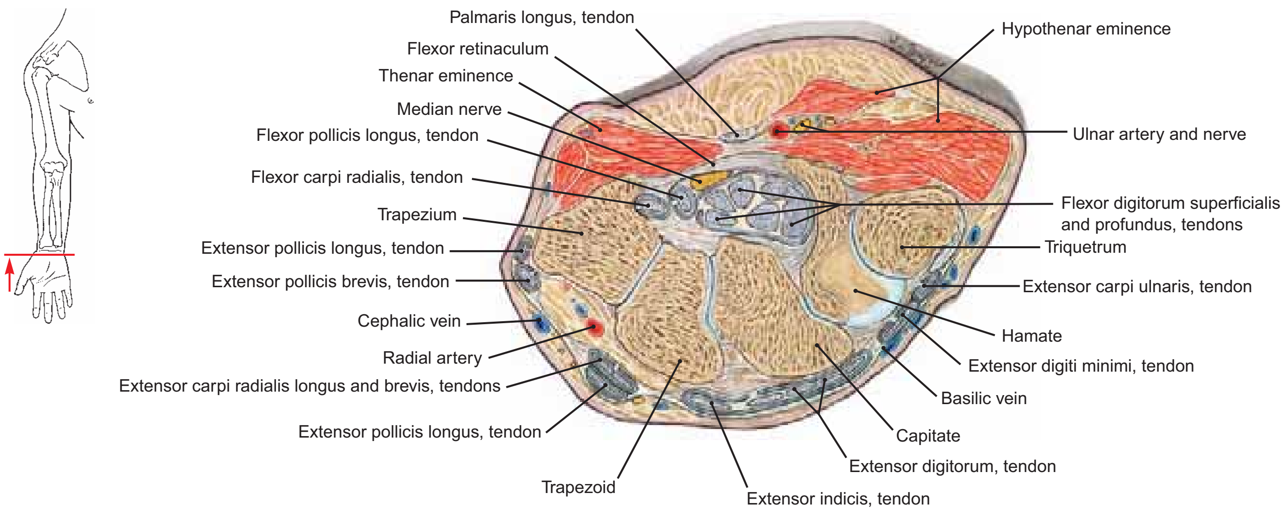


FIGURE 137.1 Transverse Section through the Wrist Joint

NOTE: (1) This cross section is at the level of the distal row of carpal bones. Compare the carpal bones in this section with the figures in Plate 91.

(2) The locations of the **median nerve** in the **carpal tunnel** and the ulnar nerve and artery superficial to the carpal tunnel adjacent to the hypothenar muscles.

(3) The strong **flexor retinaculum** bounds the carpal tunnel anteriorly, while the carpal bones bound the tunnel posteriorly. In addition to the median nerve, the flexor tendons enter the hand within the tunnel.

(4) Significant trauma to this region of the hand can result in excessive pressure on the median nerve; this condition is called **carpal tunnel syndrome,** and it severely limits the functions of the thenar muscles supplied by the median nerve.

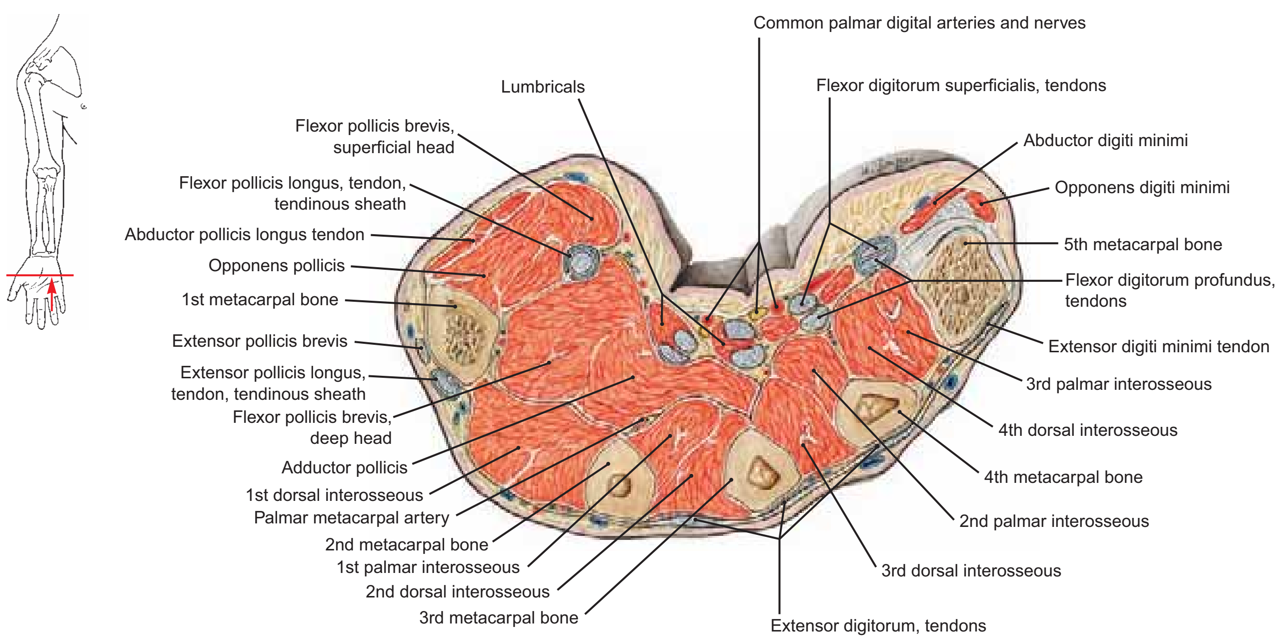


FIGURE 137.2 Cross Section of the Right Hand through the Metacarpal Bones

NOTE: (1) The four **dorsal interosseous muscles** that act as abductors of the fingers and fill the intervals between the metacarpal bones.

(2) The three **palmar interosseous muscles** that serve as adductors of the fingers.

(3) The **thenar muscles** on the radial side of the hand and the **hypothenar muscles** on the ulnar side.

(4) There are seven **interosseous muscles**—three palmar and four dorsal. In addition to flexing the metacarpophalangeal joints, these muscles abduct and adduct the fingers. The thumb has its own abductors and adductor and the little finger has its own abductor. This accounts for adduction and abduction actions for the five fingers.

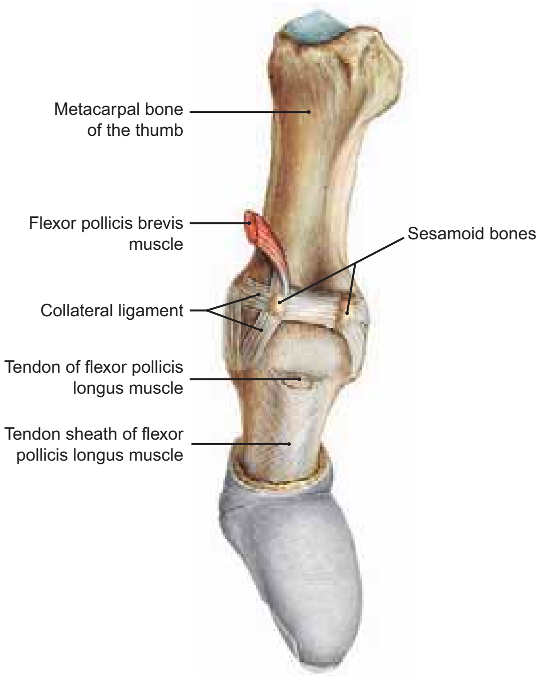


FIGURE 138.1 Metacarpophalangeal Joint of the Thumb

NOTE the sesamoid bones, collateral ligaments, and flexor muscle insertions.

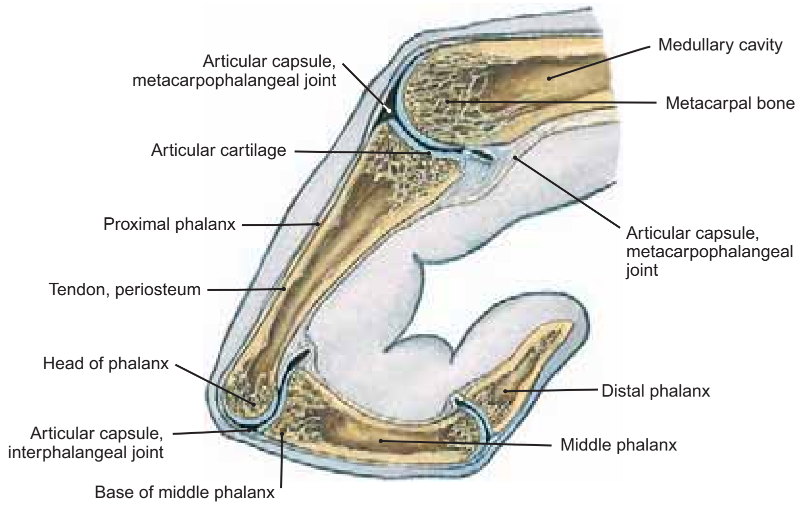


FIGURE 138.2 Longitudinal Section through a Flexed Finger

NOTE: The location of the flexion creases in relation to the corresponding joints.

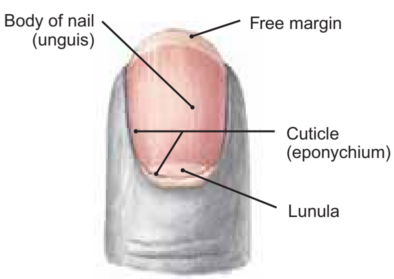


FIGURE 138.3 Fingernail, Normal Position (Dorsal View) Finger

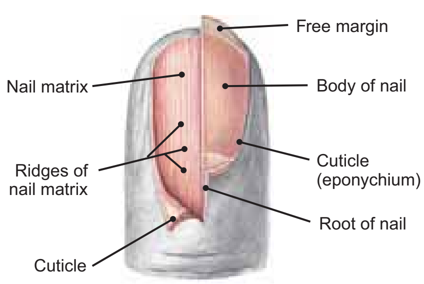


FIGURE 138.4 Left Half of Finger Nail Bed Exposed

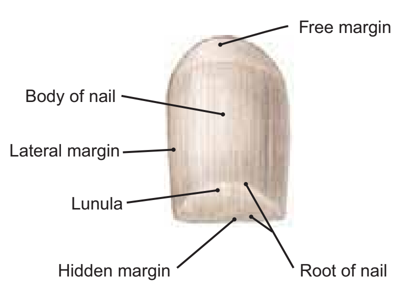


FIGURE 138.5 Body of Fingernail Removed from the Nail Bed

CHAPTER 2 The Thorax

Plates

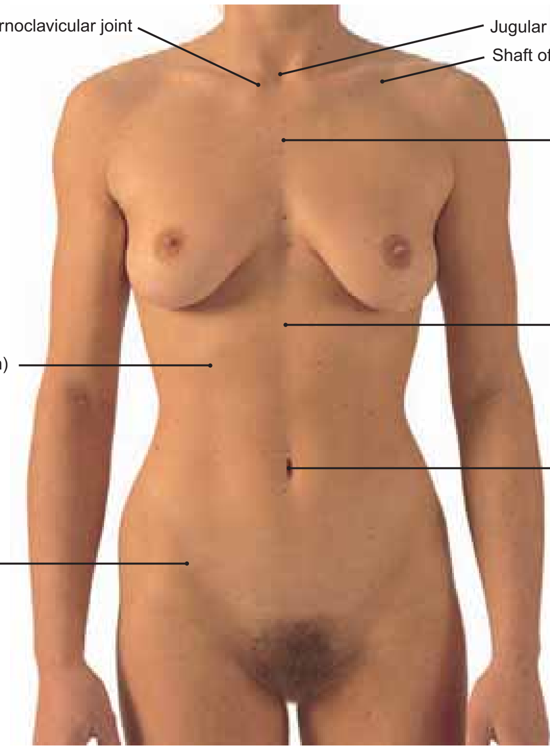


FIGURE 139.1 Surface Anatomy of the Thoracic and Abdominal Walls in a Young Female

NOTE that the prominent bony structures are labeled along with the jugular notch and umbilicus.

FIGURE 139.2 Surface Anatomy of the Thoracic and Abdominal Walls in a Young Male

NOTE that the surface contours of prominent muscles are labeled.

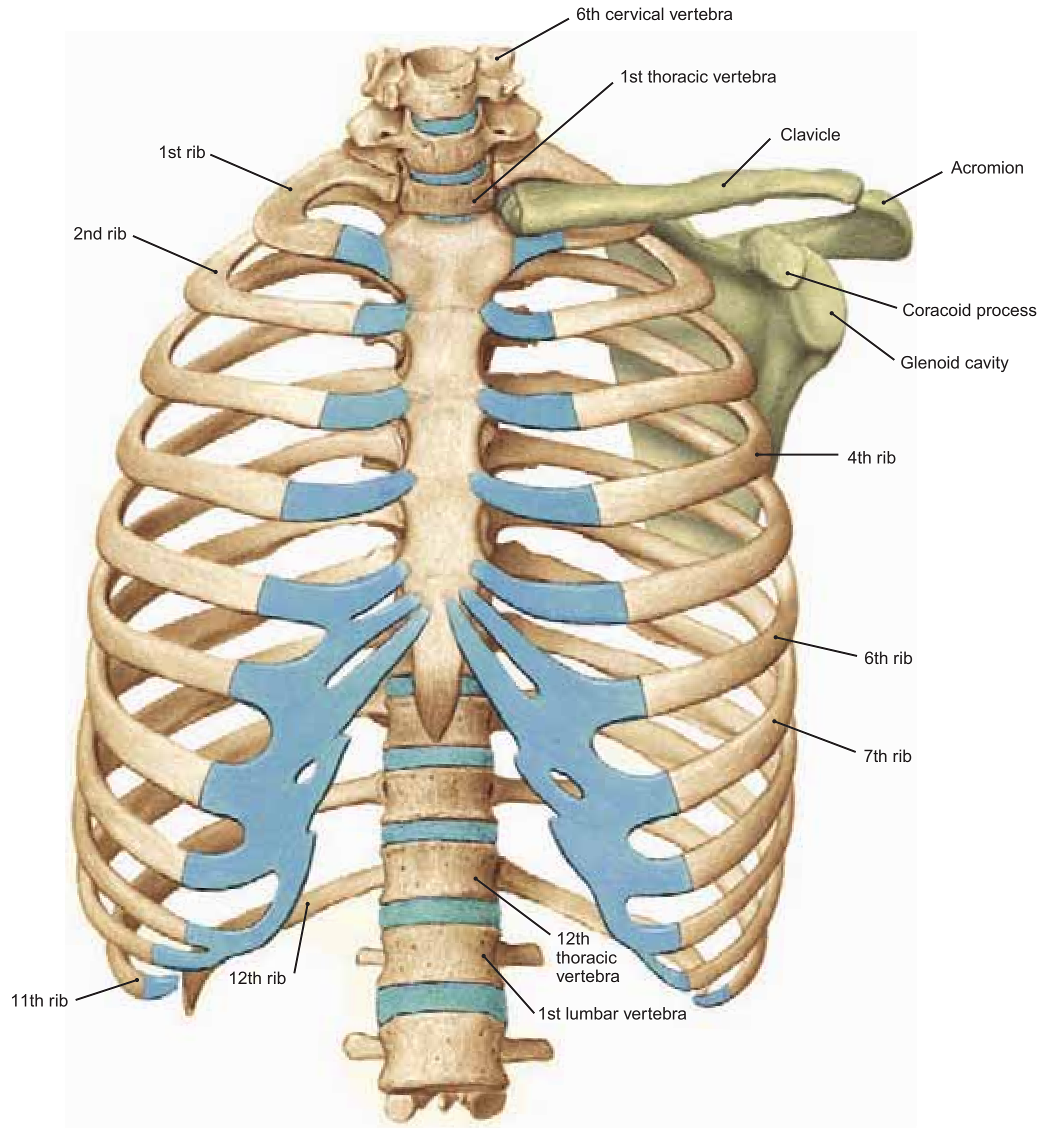


FIGURE 140.1 Thoracic Skeleton (Anterior View)

Left clavicle and scapula are shown in yellow; costal cartilages and intervertebral disks are in blue.

NOTE: (1) The skeleton of the thorax protects the thoracic organs. It is formed by 12 pairs of ribs that articulate posteriorly with the 12 thoracic vertebrae. Anteriorly, the bony parts of the ribs are continued as cartilages, the upper seven pairs of which are attached directly to the sternum.

(2) The bony parts of the ribs fall progressively more lateral to the sternum from above downward, resulting in longer costal cartilages in lower ribs than in higher ones.

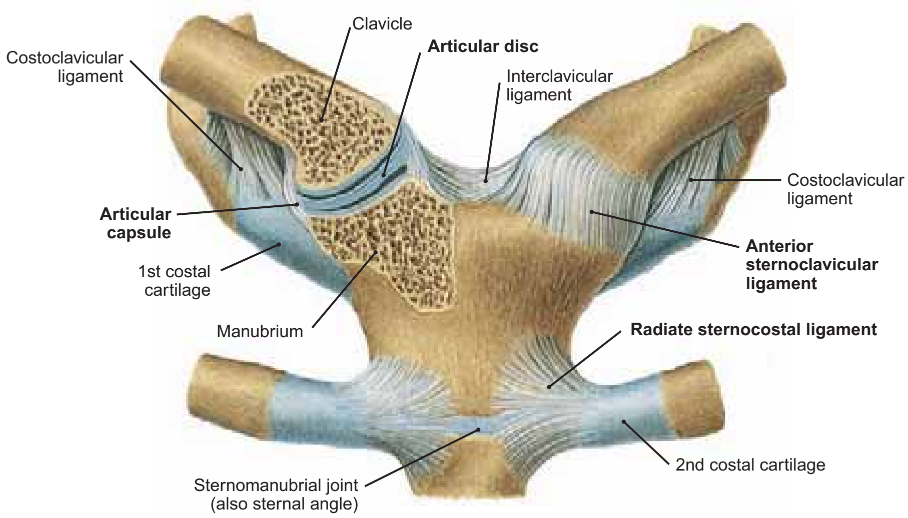
(3) The thoracic cage is narrow superiorly at its inlet, but is more broad inferiorly, where it is closer to abdominal structures.

FIGURE 140.2 Sternoclavicular and the First Two Sternocostal Joints

NOTE: (1) The sternoclavicular joint is formed by the junction of the clavicle with (a) the upper lateral aspect of the manubrium and (b) the cartilage of the 1st rib.

(2) An articular disk is interposed between the clavicle and the sternum, and an articular capsule and fibrous ligamentous bands protect the joint.

(3) The cartilages of the 2nd to the 7th ribs (see Fig. 140.1) articulate with the sternum by movable (diarthrodial) joints. The cartilage of the 1st rib, however, directly joins the sternum and, without a joint cavity, forms an immovable joint (synarthrosis).



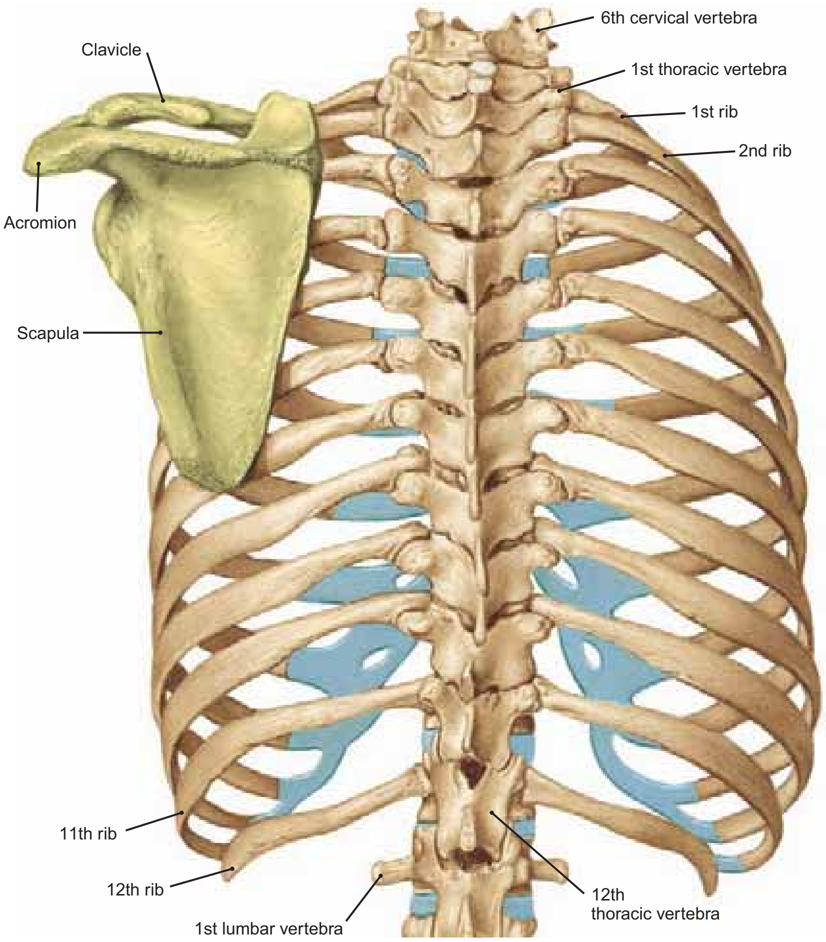


FIGURE 141.1 Thoracic Skeleton (Posterior View)

Left clavicle and scapula are shown in yellow.

NOTE: (1) The posterior skeleton of the thoracic cage consists of 12 thoracic vertebrae and the posterior parts of 12 pairs of ribs.

(2) The extremity on the head of typical ribs possesses two articular facets separated by a crest (see Fig. 142: eighth rib).

(3) These two facets articulate with the bodies of two adjacent vertebrae, whereas the crest is attached to the intervertebral disk. The lower facet articulates with the vertebra that corresponds with the rib, whereas the upper facet articulates with the adjacent vertebra above.

(4) The crest between the facets articulates with the intervertebral disk.

(5) The scapula affords some bony protection posteriorly to the upper lateral aspect of the thoracic cage.

FIGURE 141.2 Sternum (Anterior View)

NOTE: (1) The sternum consists of the manubrium, the body, and the xiphoid process and forms the middle portion of the anterior thoracic wall.

(2) The manubrium articulates with the body at the **sternal angle.** The xiphoid process is thin and often cartilaginous.

(3) The concave jugular notch, two clavicular notches, and 1st costal notches on the manubrium.

FIGURE 141.3 Sternum (Lateral View)

NOTE: (1) The clavicle and the1st rib articulate with the manubrium. The 2nd rib articulates at the sternal angle. The 3rd to the 6th ribs articulate with the body of the sternum, whereas the 7th rib joins the sternum at the junction of the xiphoid process.

(2) A line projected backward through the sternal angle crosses at the 4th thoracic level, whereas the xiphisternal junction lies at T9.

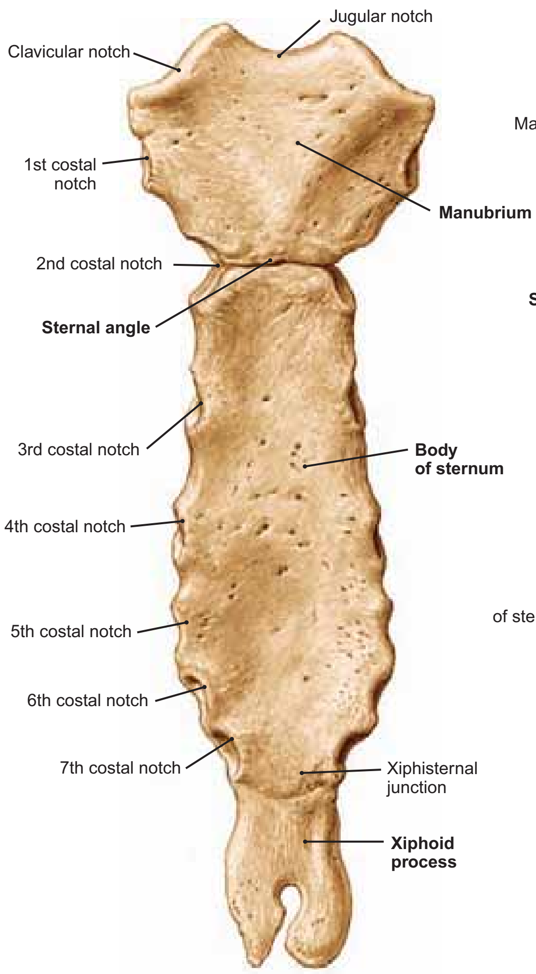


FIGURE 141.2

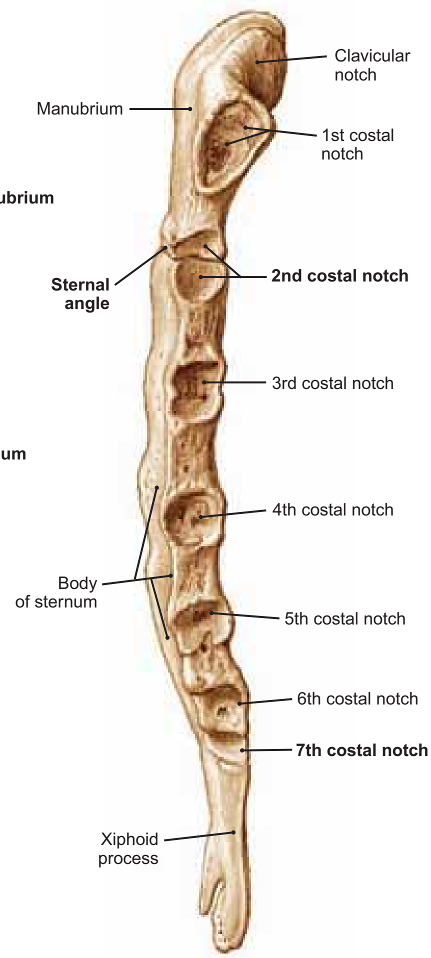


FIGURE 141.3

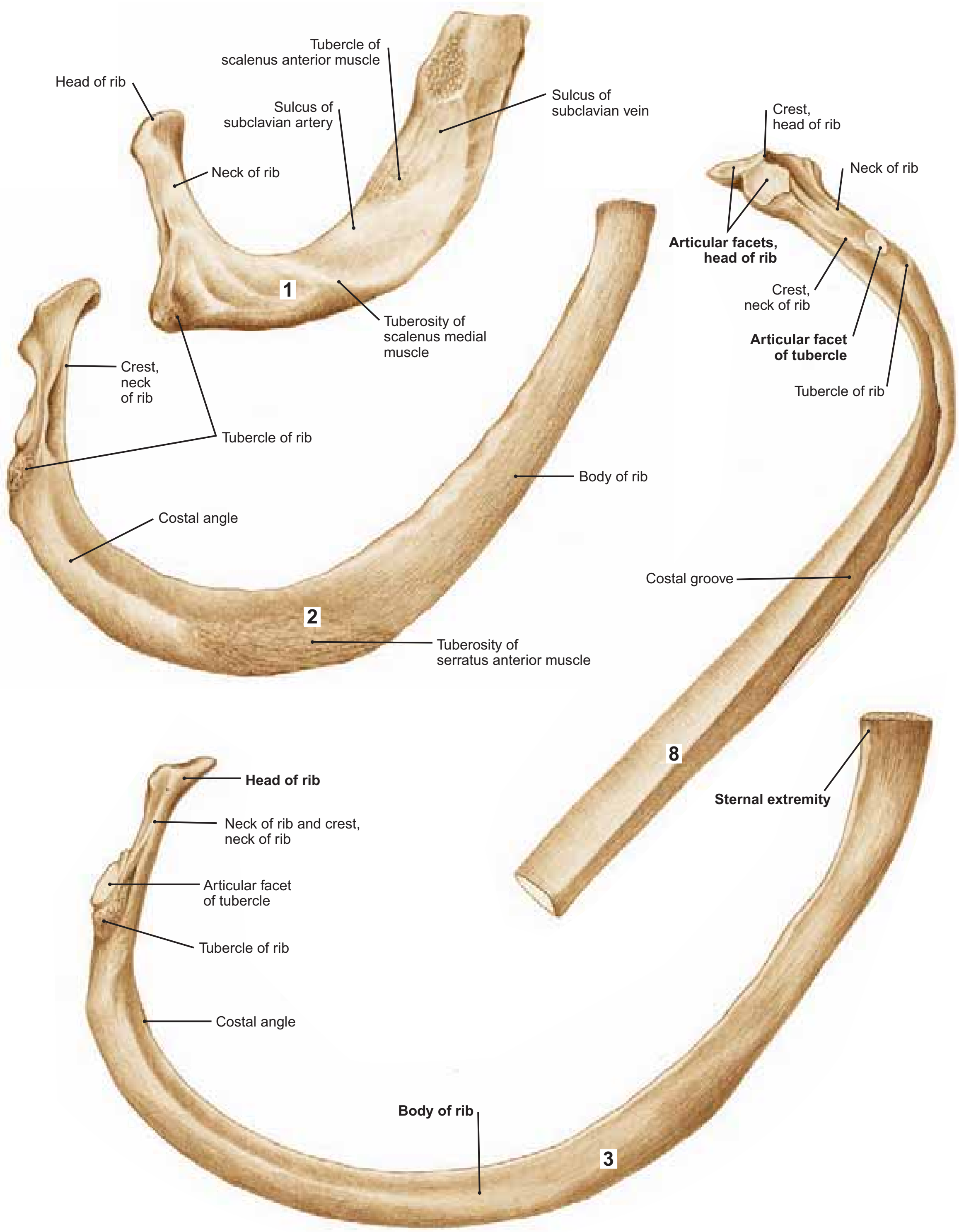


FIGURE 142 1st, 2nd, 3rd, and 8th Right Ribs

NOTE: (1) The superior surfaces of the 1st, 2nd, and 3rd ribs are illustrated, whereas the inferior surface of the 8th rib is shown.

(2) Each rib has a vertebral extremity directed posteriorly and a sternal extremity directed anteriorly. The body of the rib is the shaft that stretches between the extremities.

(3) The vertebral end is marked by a **head,** a **neck,** and a **tubercle.** The head contains two facets for articulation with the bodies of the thoracic vertebrae, whereas the tubercle has a nonarticular roughened elevation and an articular facet, which attaches to the transverse process of thoracic vertebrae.

(4) The 1st, 2nd, 10th, 11th, and 12th ribs present certain structural differences from the 3rd through the 9th ribs. The 1st rib is the most curved, and the 2nd is shaped similar to the 1st, but it is longer. The 10th, 11th, and 12th ribs also have only a single facet on the rib head.

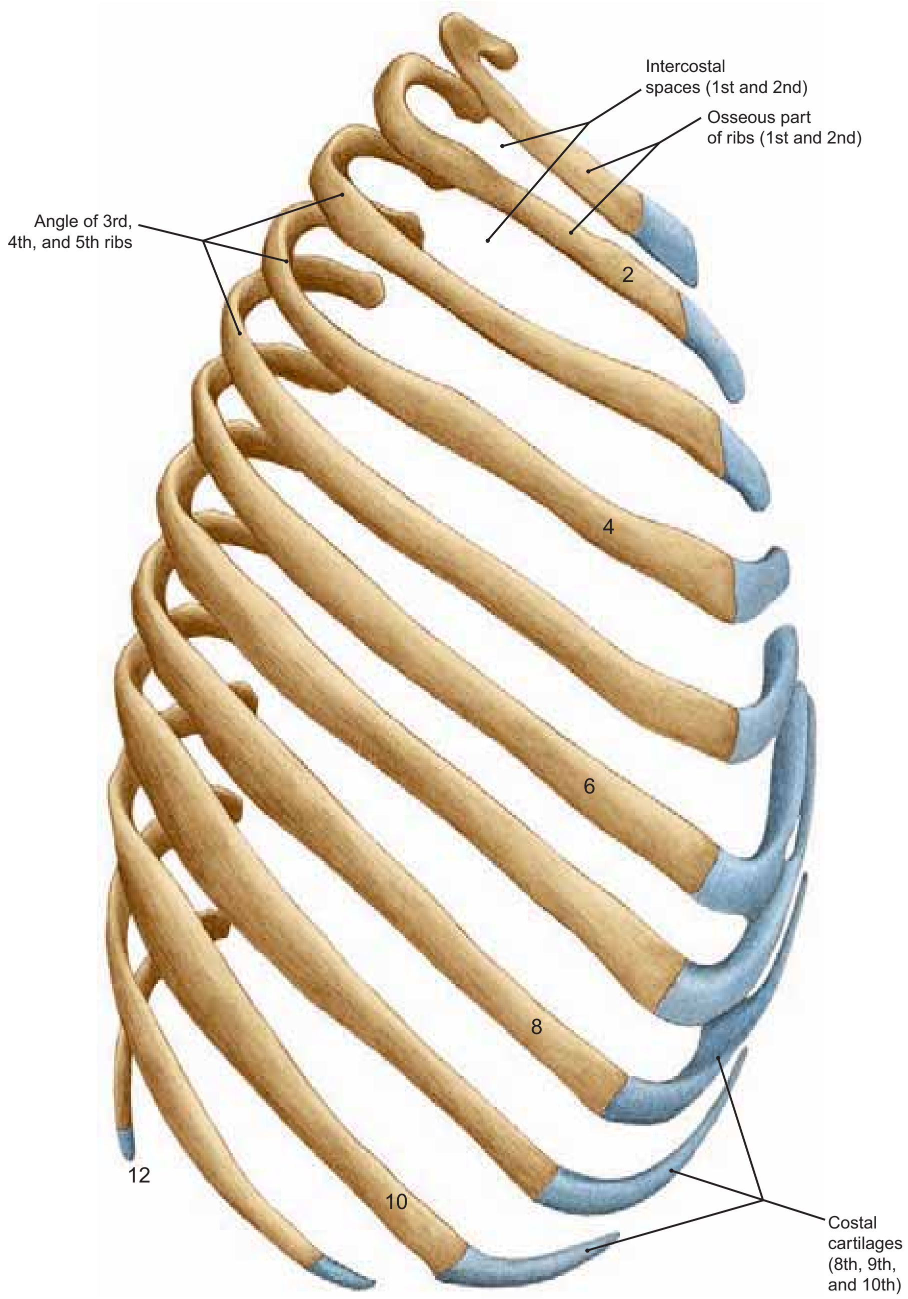


FIGURE 143 **12 Right Ribs Showing the Natural Contour of the Thoracic Cage (Lateral View)**

NOTE: (1) The posterior end of each rib is located more superiorly than the costal end that attaches to the costal cartilage; thus, as each rib leaves its vertebral articulation, it courses around the chest in a rounded, descending manner.

(2) Ribs 5 to 10 are longer than ribs 1 to 4 and 11 and 12. The latter two ribs are considered "floating ribs" because they do not attach to the sternum or the costal margin.

Muscle	Origin	Insertion	Innervation	Action
External intercostal (11 muscles)	Lower border of a rib	Upper border of the rib below	Intercostal nerves	Elevate the ribs; active during normal inspiration
	Within intercostal space, each extends from the tubercle of the rib dorsally to the cartilage of the rib ventrally			
Internal intercostal (11 muscles)	Ridge on the inner surface near lower border of the rib	Upper border of the rib below	Intercostal nerves	Elevate the ribs; active during inspiration and expiration
	Within intercostal space, each extends from the sternum ventrally to the angle of the rib dorsally			

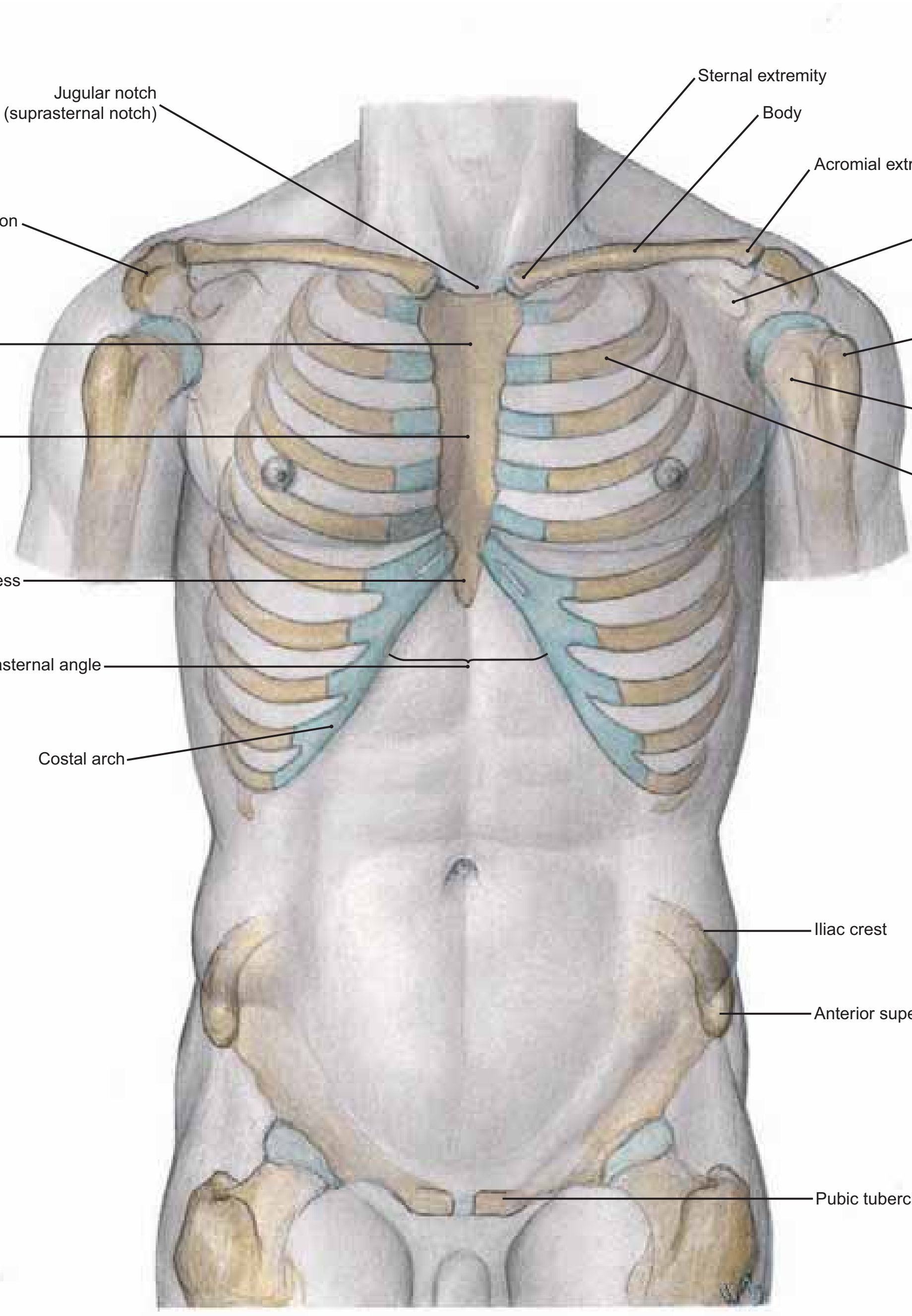


FIGURE 144 Projection of the Skeleton onto Both the Thoracic and Abdominal Walls

NOTE: (1) The clavicular attachments to the sternum medially and the acromion process of the scapula laterally.
(2) The cartilaginous margin that bounds the infrasternal angle.
(3) The costal cartilage of the 2nd rib articulates with the sternum at the junction of the manubrium with the body of the sternum.
(4) Inferiorly, observe the projection of the iliac crest and the anterior superior iliac spine.

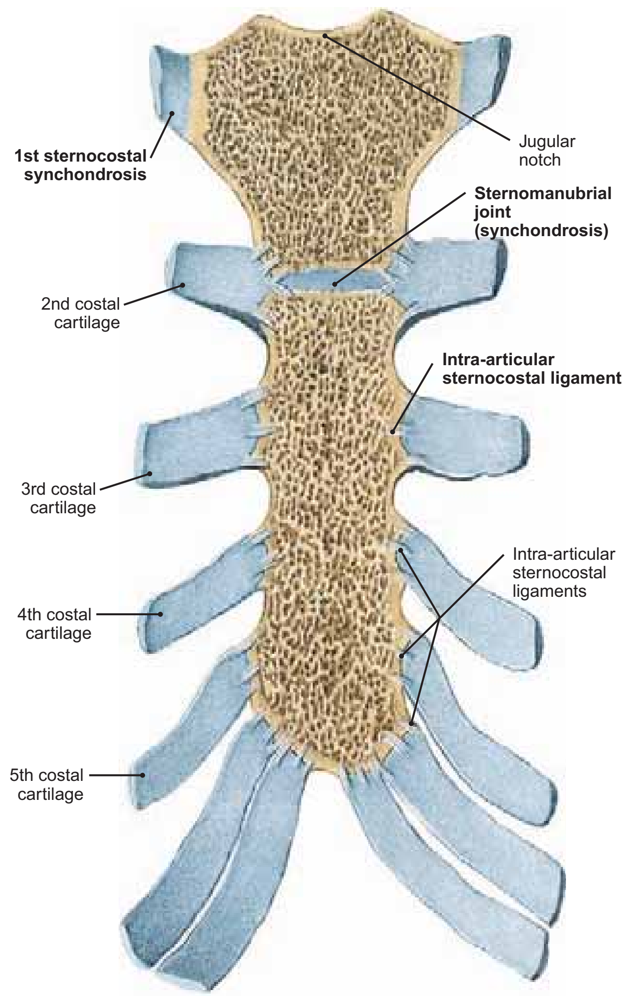
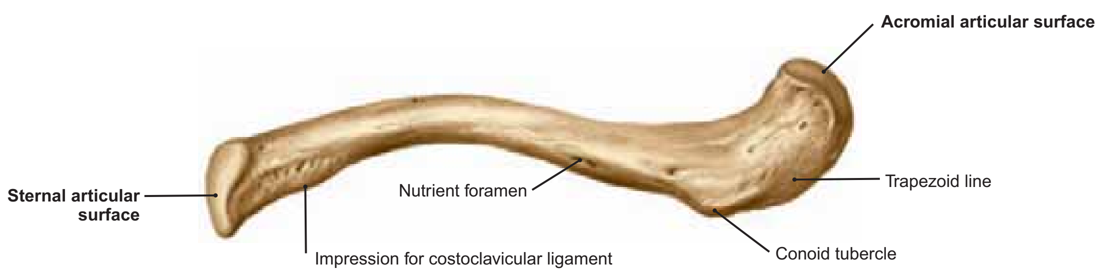


FIGURE 145.1 **Sternocostal Articulations, Frontal Section (Posterior View)**

NOTE: (1) The articulations of the first pair of ribs do not have joint cavities, but are direct cartilaginous unions (synchondroses), similar to the joint between the manubrium and body of the sternum.

(2) Each of the other sternocostal joints contains a true joint cavity surrounded by a capsule. Intra-articular sternocostal ligaments also attach the rib cartilage to the sternum. These are most frequently found at the junctions of the 2nd and 3rd cartilages with the sternum but may also be seen in lower sternocostal joints.

FIGURE 145.2 **Left Clavicle (Inferior View)** ▼



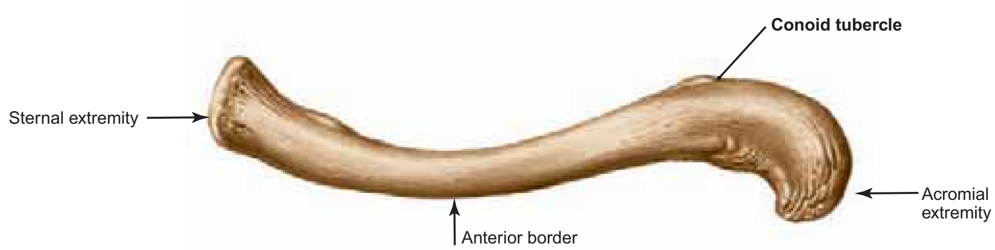


FIGURE 145.3 **Left Clavicle (Superior View)** ▲

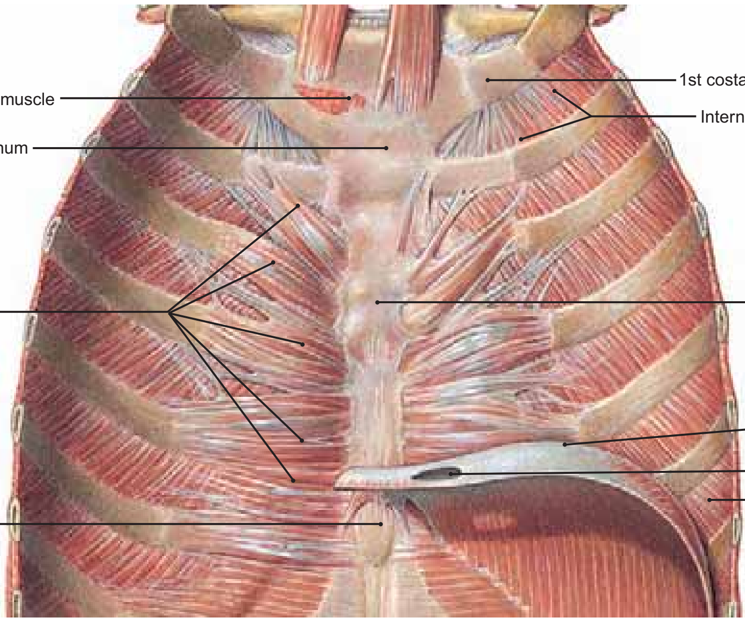


FIGURE 146.1 **Internal Surface of the Thoracic Cage (Anterior Part)**

NOTE: (1) The transversus thoracis muscle. It arises from the inferior half of the body of the sternum and the xiphoid process. Its fibers course laterally and superiorly to insert on the inner surfaces of the 2nd to the 6th ribs and their costal cartilages.
(2) The intercostal nerves supply the transversus thoracis muscle and its fascicles depress the costal cartilages to which the fibers attach.

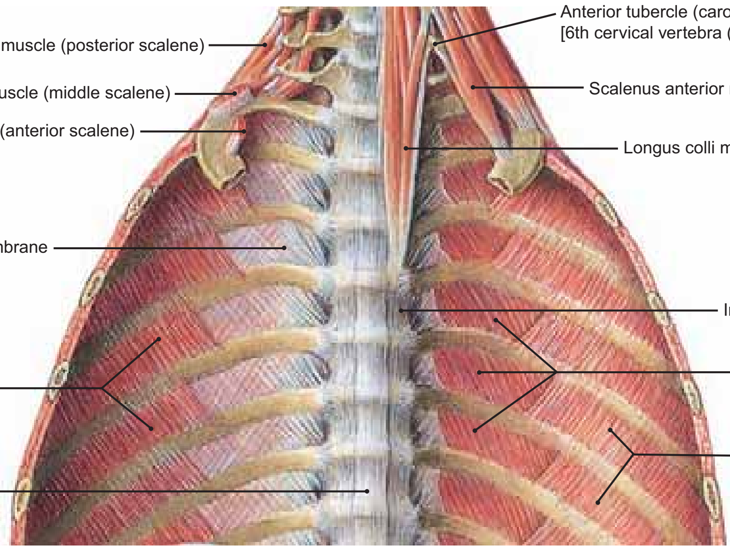


FIGURE 146.2 **Internal Surface of the Thoracic Cage (Posterior Part)**

NOTE: (1) The internal intercostal muscle fibers can be seen to extend between the ribs as far posteriorly as the bodies of the thoracic vertebrae.
(2) In contrast to the external intercostal muscle fibers, the internal intercostal muscle fibers are replaced by the internal intercostal membrane medial to the posterior costal angles of the ribs and as far as the bodies of the thoracic vertebrae.

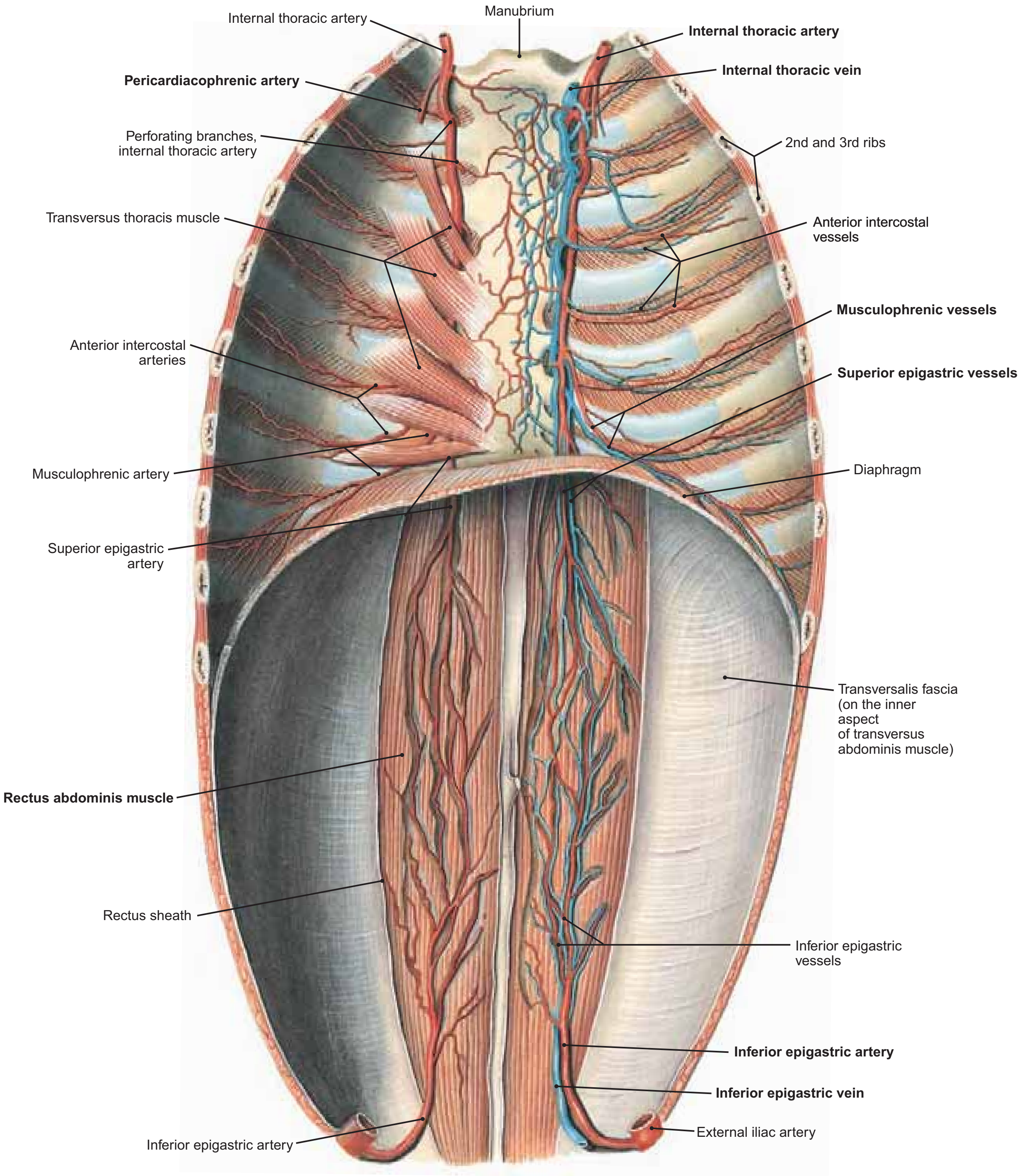


FIGURE 147 Muscles and Blood Vessels of the Thoracic and Abdominal Wall, Viewed from the Inside

NOTE: (1) The principal vessels dissected include the **internal thoracic** and **inferior epigastric** arteries and veins and their terminal branches.

(2) The internal thoracic artery is a branch of the subclavian artery, and it descends behind the costal cartilages along the inner surface of the anterior thoracic wall in front of the transversus thoracis muscle and parallel to the margin of the sternum.

(3) The internal thoracic artery gives rise to (a) the pericardiacophrenic artery, (b) small vessels to the thymus and to bronchial structures, (c) perforating branches to the chest wall, (d) anterior intercostal branches, and finally it terminates as (e) **the musculophrenic** and **superior epigastric arteries**.

(4) The superior epigastric artery anastomoses with the **inferior epigastric artery**, a branch of the external iliac artery. The anastomosis occurs within the rectus abdominis muscle.

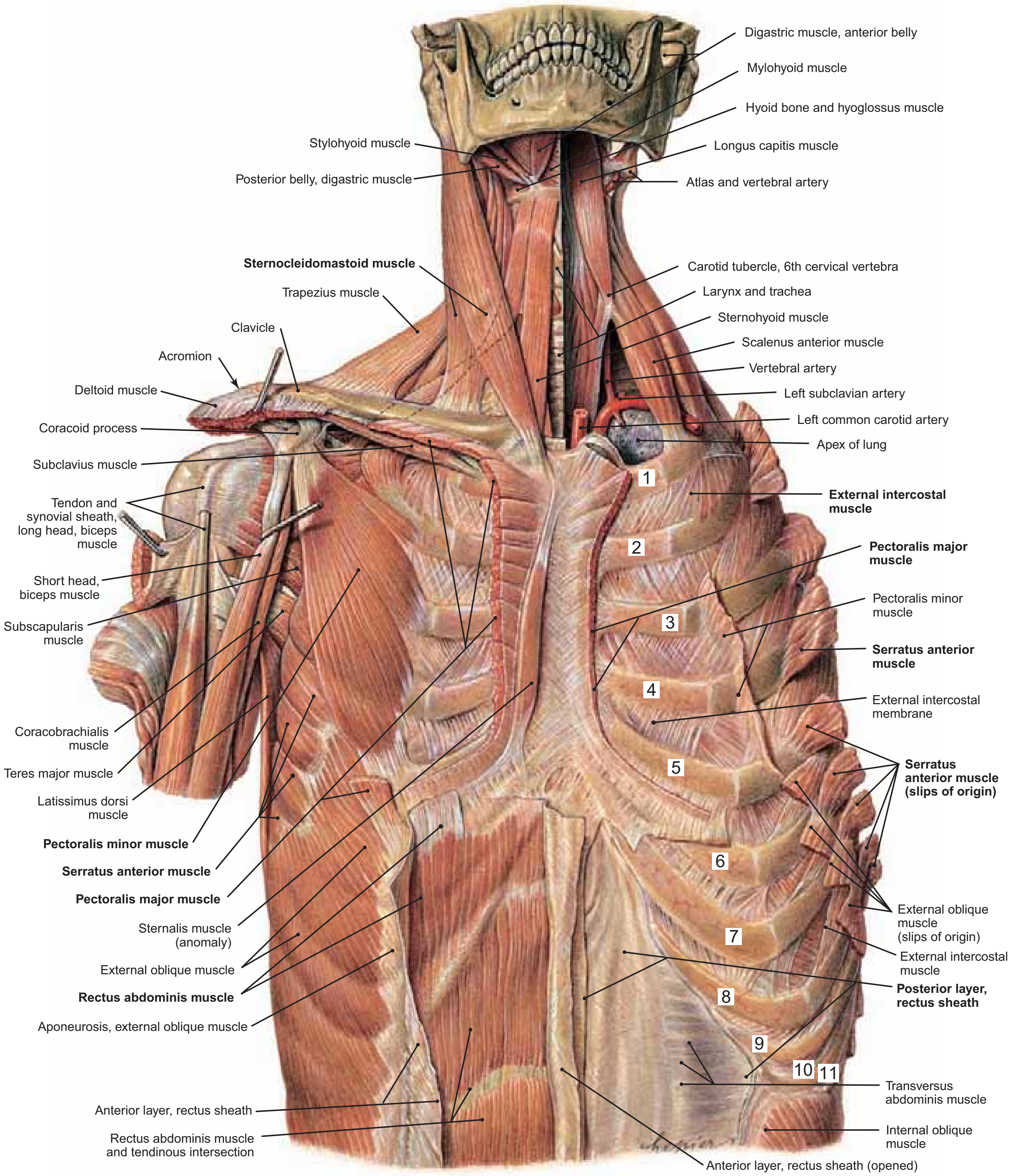


FIGURE 148 Musculature of the Anterior Thoracic Wall Deep to the Pectoralis Major and the Adjacent Cervical and Abdominal Muscles

NOTE: (1) On the right side (reader's left), the anterior thoracic wall and upper arm are shown after removal of the pectoralis major muscle.
(2) On the left (reader's right), the upper limb and the superficial trunk and cervical muscles have been removed, exposing the ribs and intercostal tissues.

Muscle	Origin	Insertion	Innervation	Action
Subclavius	First rib and its cartilage at their junction	Groove on the lower surface of middle third of the clavicle	Nerve to subclavius from upper trunk of brachial plexus (C5, C6)	Depresses and pulls clavicle forward

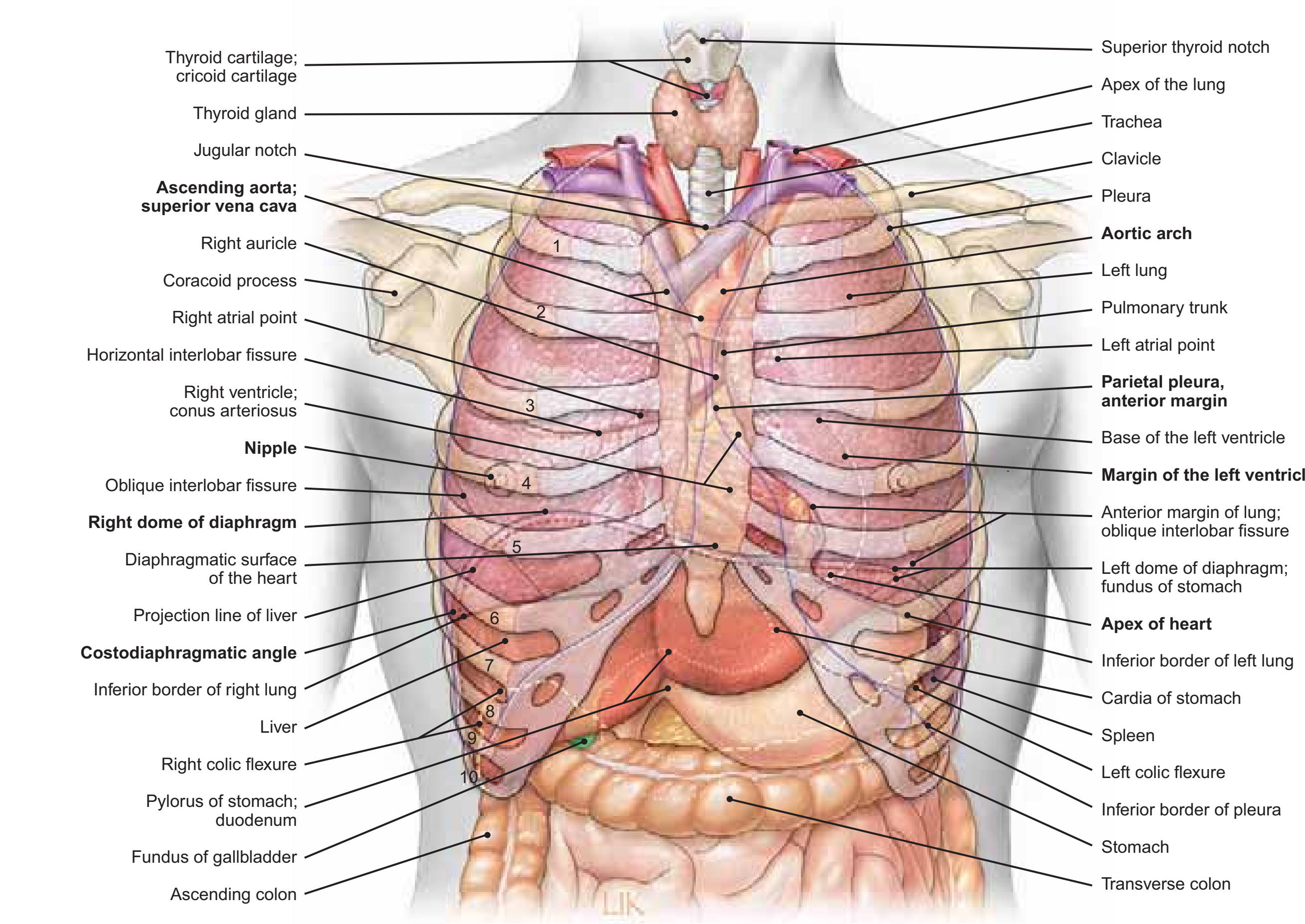


FIGURE 149.1 Thoracic and Upper Abdominal Viscera Projected onto the Anterior Surface of the Body

NOTE: (1) The outline of the heart and great vessels (white broken line) deep to the anterior border of the lungs.

(2) The liver, lying below the diaphragm, extends upward as high as the 4th interspace on the right and to the 5th interspace on the left (red broken line).

(3) The superficial location of the superior vena cava and ascending aorta just deep to the manubrium of the sternum.

(4) A triangular region containing the great vessels above and a lower triangular region over the heart (area of superficial cardiac dullness) are not covered by pleura.

(5) The reflections of the pleura over the lungs. Observe that the anterior margins of the lung and pleura on the left side are indented to form the cardiac notch.

(6) The position of the nipple over the 4th rib (or 4th intercostal space) in the male and in the young female. Also observe the apex of the heart deep to the 5th interspace.

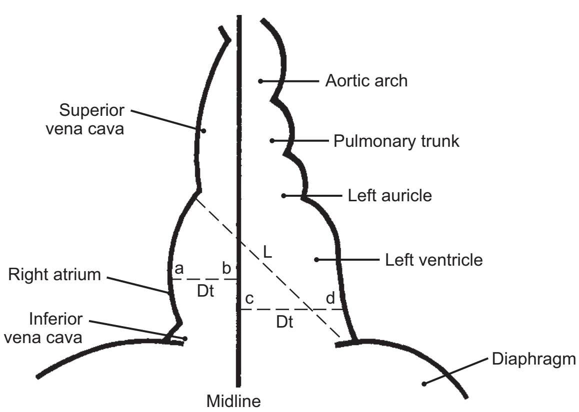


FIGURE 149.2 Shadow Outline of Heart and Great Vessels in Radiograph of the Thorax

Dt: Transverse diameter (normal)
a to b: about 4 cm
c to d: about 9 cm

L: Longitudinal axis of heart: 15 to 16 cm
(measured from the upper end of the right atrial shadow to the apex of the heart)

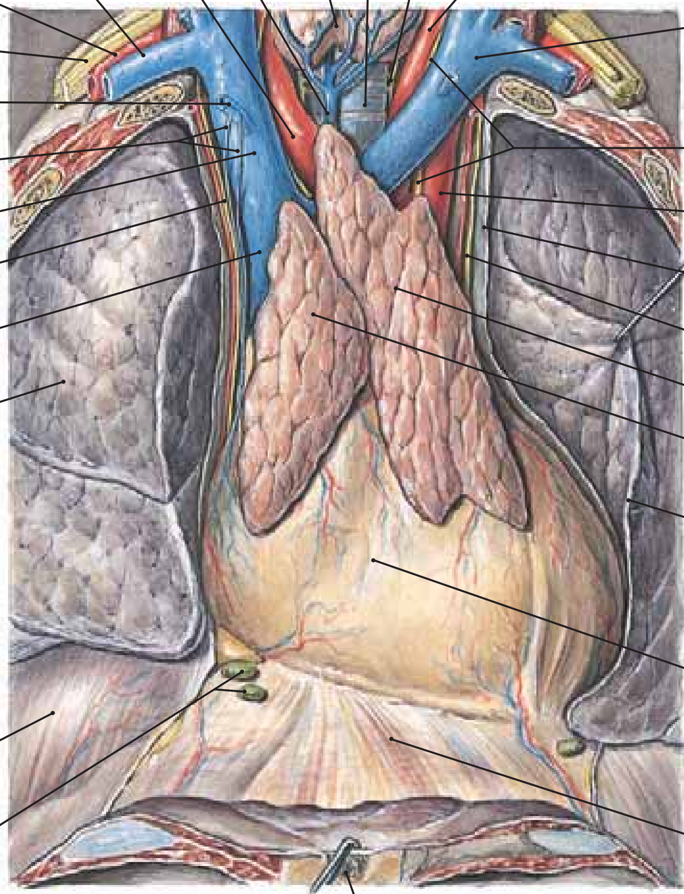


FIGURE 150.1 Thymus in an Adolescent

NOTE that the chest wall is removed and the parietal pleura has been opened.

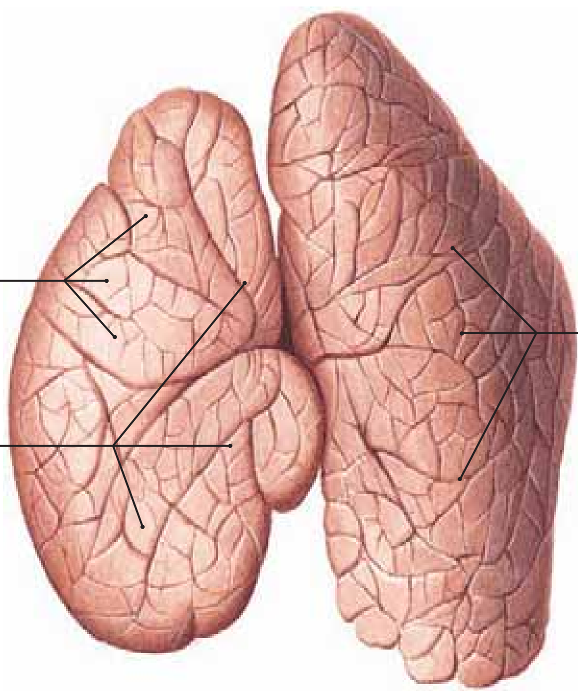


FIGURE 150.2 Thymus of a 2-Year-Old Child

NOTE: (1) The thymus is the central organ of the immune-lymphoid system.

(2) At birth it weighs under 15 g and at puberty it has grown to about 35 g. In the adult it diminishes in size, becoming atrophic and being replaced by fat.

(3) The thymus lies in the anterior and superior mediastina, and it receives branches from the internal thoracic and inferior thyroid arteries. Its veins drain into the brachiocephalic, internal thoracic, and inferior thyroid veins.

(4) The thymus differentiates lymphocytes into thymocytes (T cells), which are released into peripheral blood and become capable of cell-mediated immunologic responses to antigenic foreign substances. Also, these cells act with B lymphocytes for humoral responses.

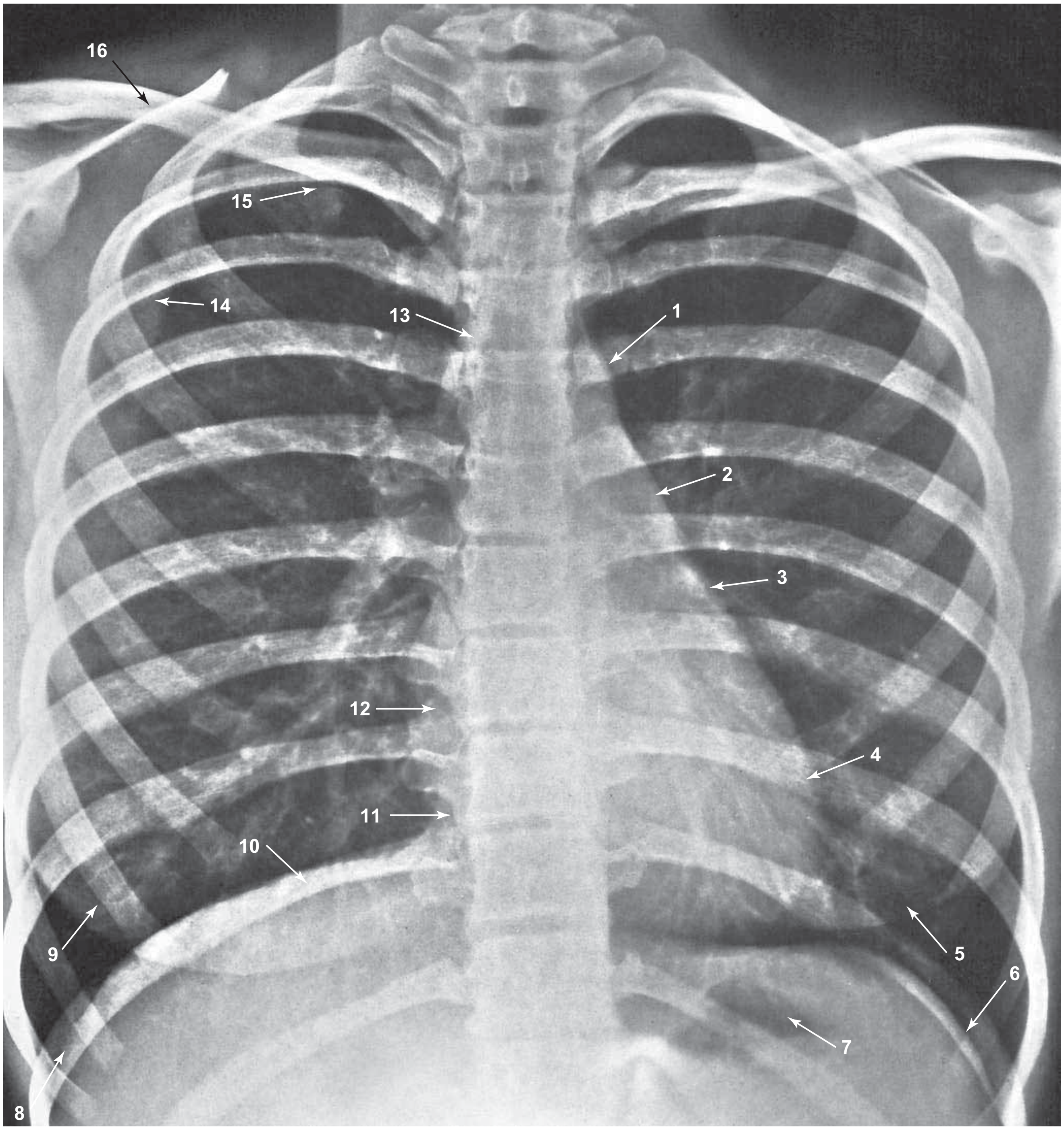


FIGURE 151 **Posterioanterior Radiograph of the Thorax Showing the Heart and Lungs**

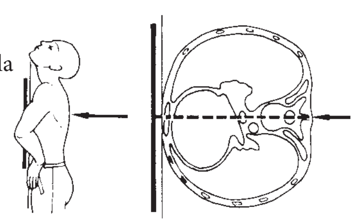
NOTE: (1) The contour of the heart and great vessels: arch of aorta [1], pulmonary trunk [2], inferior vena cava [11], and superior vena cava [13], and the relationship of these structures to the vertebral column.

(2) The left margin of the heart is formed by the left auricle [3] and left ventricle [4], and it slopes toward the apex, which usually lies about 9 cm to the left of the midsternal line, deep to the 5th intercostal space.

(3) The right margin of the heart [12] projects as a curved line slightly to the right of the vertebral column (and sternum). Observe that the heart rests on the diaphragm [6], and note the contours of the left [5] and right [9] breasts.

(From Wicke, 6th ed.)

1. Arch of aorta
2. Pulmonary trunk
3. Left auricle
4. Left ventricle
5. Contour of left breast
6. Diaphragm
7. Air in fundus of stomach
8. Costodiaphragmatic recess
9. Contour of right breast
10. Diaphragm
11. Inferior vena cava
12. Right atrium
13. Superior vena cava
14. Medial border of scapula
15. First rib
16. Right clavicle



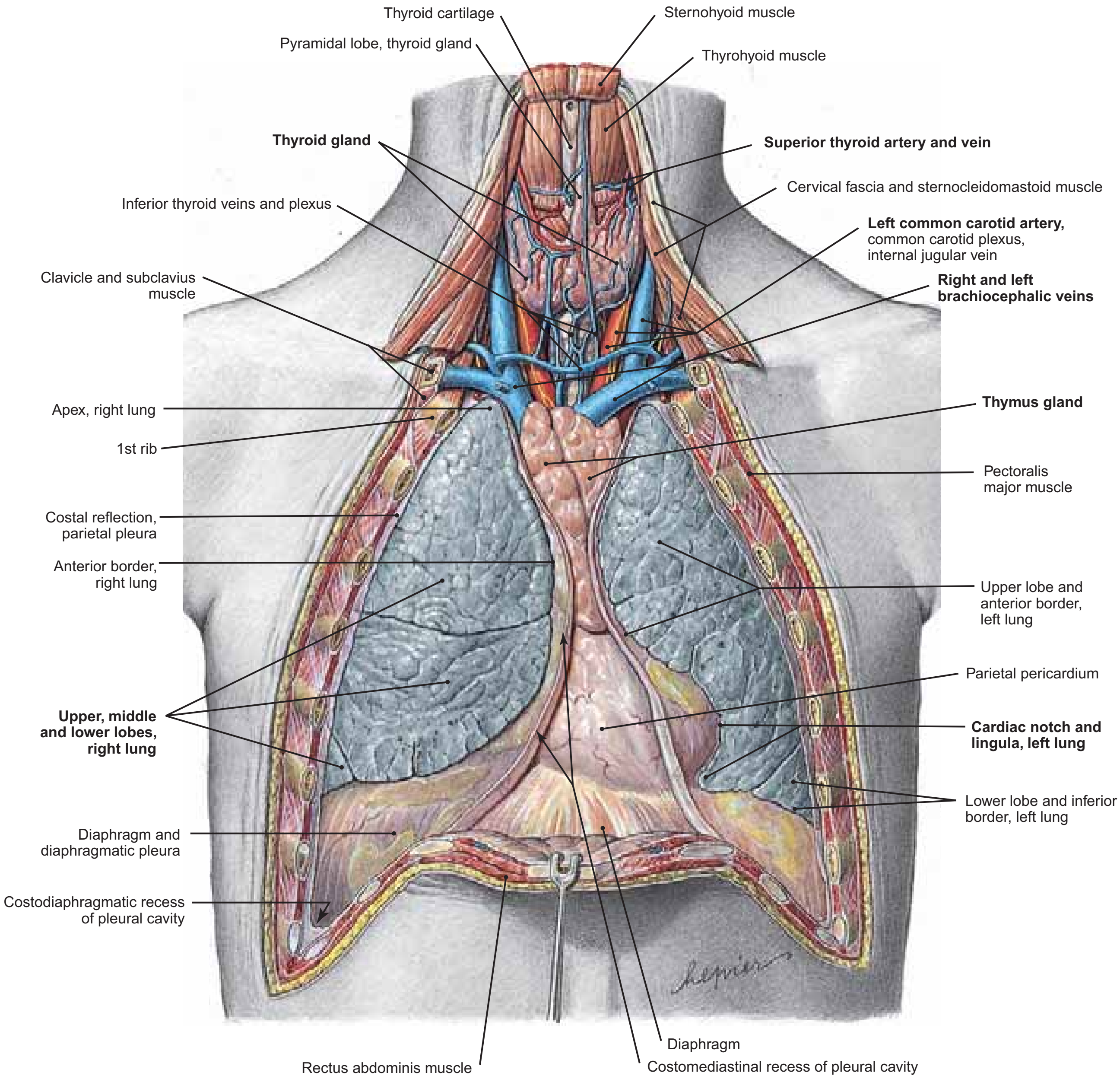


FIGURE 152 Thoracic Viscera and the Root of the Neck (Anterior Exposure)

NOTE: (1) The anterior thoracic wall has been removed along with the medial parts of both clavicles to reveal the normal position of the heart, lungs, thymus, and thyroid gland. The great vessels in the superior aperture of the thorax are also exposed.

(2) The parietal pleura has been removed anteriorly. The thymus is situated between the two lungs superiorly, whereas inferiorly is found the bare area of the heart. Observe the **cardiac notch** along the anterior border of the left lung adjacent to the heart.

(3) The basal surface of both lungs and the inferior aspect of the heart rest on the diaphragm, whereas the apex of each lung extends superiorly above the level of the 1st rib.

(4) The rather transverse course in the superior mediastinum of the left brachiocephalic vein in contrast to the nearly vertical course of the right brachiocephalic vein. The two brachiocephalic veins join, deep to the thymus, to form the superior vena cava.

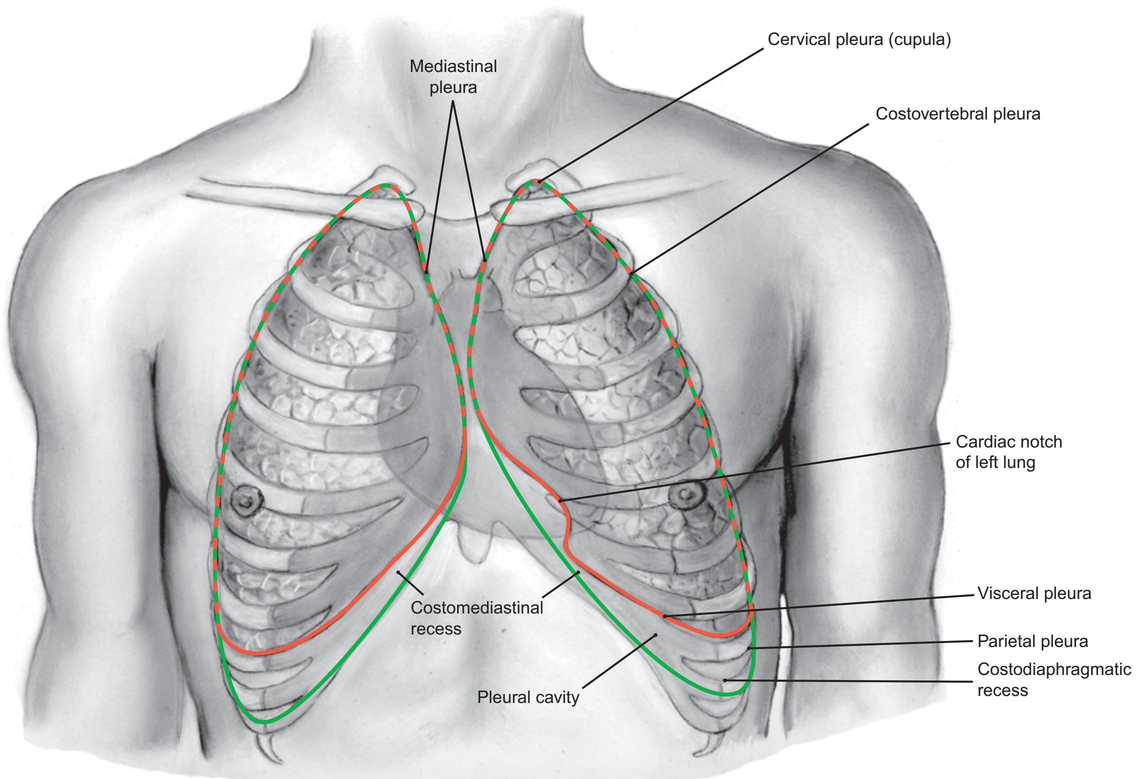


FIGURE 153.1 Projections of the Lungs, Pleura, and Heart onto the Anterior Thoracic Wall

NOTE: (1) The borders of the parietal and visceral layers of pleura. The **parietal layer** on each side completely lines the internal surface of the thorax, and it consists of a **costal** portion lining the ribs, a **mediastinal** portion adjacent to the mediastinum, a **diaphragmatic** part over the diaphragm, and a **cervical** part that ascends into the lower neck.

(2) The **visceral layer** closely adheres to the lungs, and the potential space between the two layers of pleura is called the **pleural cavity**.

(3) The apex of each lung ascends above the medial one-third of the clavicle on that side, and at these sites, the lungs are covered by the **cervical pleura**.

(4) The parietal and visceral layers of the pleura are continuous at the hilum of the lung on each side as shown in the figure below.

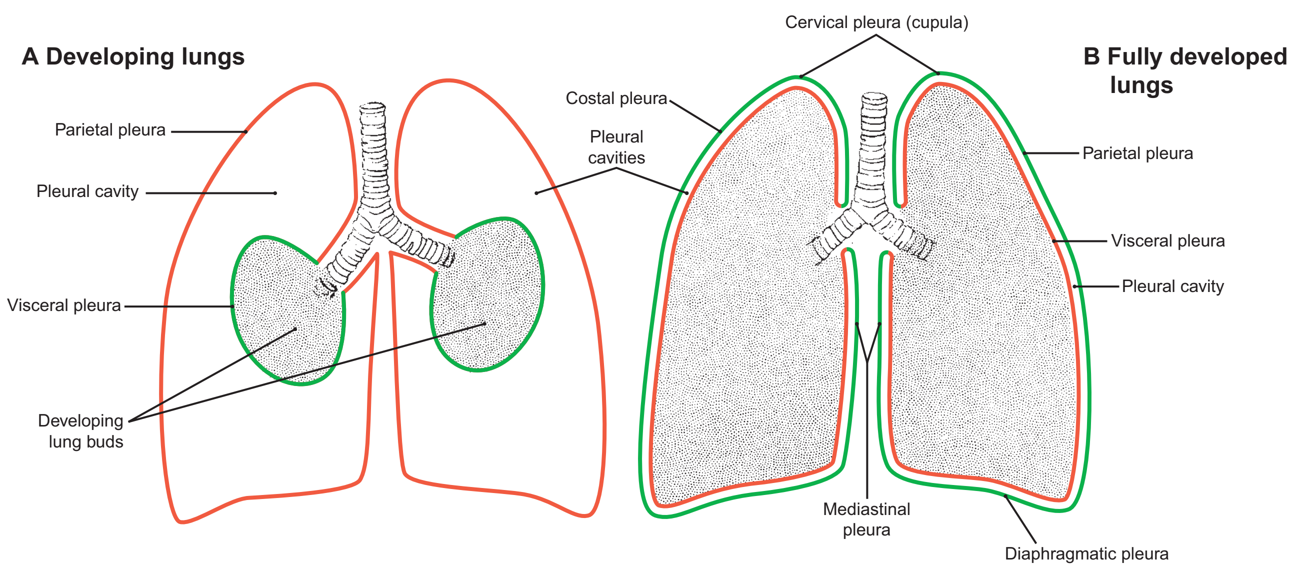


FIGURE 153.2 Diagrammatic Representation of Lung Development into the Pleural Membranes

NOTE: (1) The primordium of each lung (**A**) develops soon after the trachea bifurcates, and it grows on both left and right sides into the pleural membranes. In this manner, the primitive lung buds get surrounded by the visceral pleura.

(2) As the lung growth continues (**B**), the organs fill the pleural coeloms and a potential space develops on both sides between the lung buds (covered by visceral pleura) and parietal pleurae that line the inner surface of the developing thoracic cage. This results in the formation of a pleural cavity between the visceral and parietal layers of pleura.

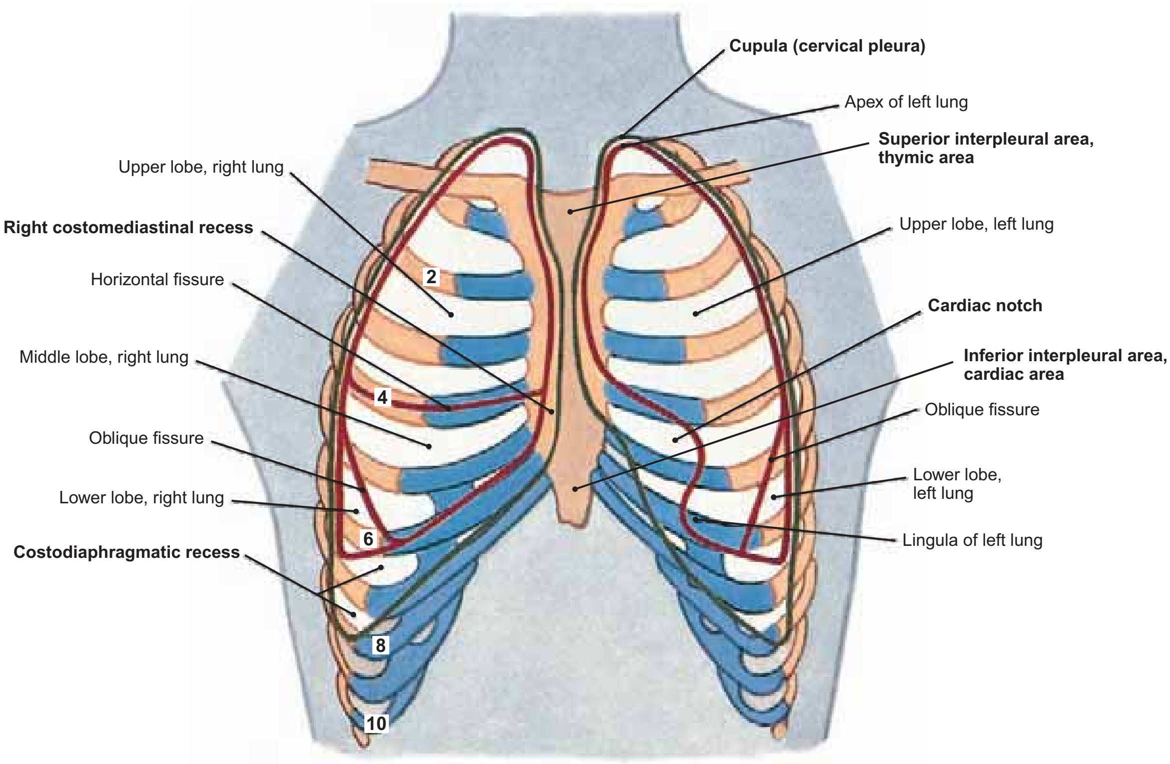


FIGURE 154.1 Parietal (Green) and Visceral (Red) Pleural Reflections Projected onto the Anterior Thoracic Wall

NOTE: (1) Each lung is invested by two layers of pleura that are continuous at the hilum of the lung, and thereby form an invaginated sac.

(2) The **parietal layer of pleura** (shown in green) is the outermost of the two layers, and it lines the inner surface of the thoracic wall and the superior surface of the diaphragm. The **visceral layer** of **pleura** closely invests and adheres to the surfaces of the lungs (in red).

(3) The potential space between the two pleural layers is called the **pleural cavity** and contains only a small amount of serous fluid in the healthy person, but it may contain considerable fluid and blood in pathologic conditions.

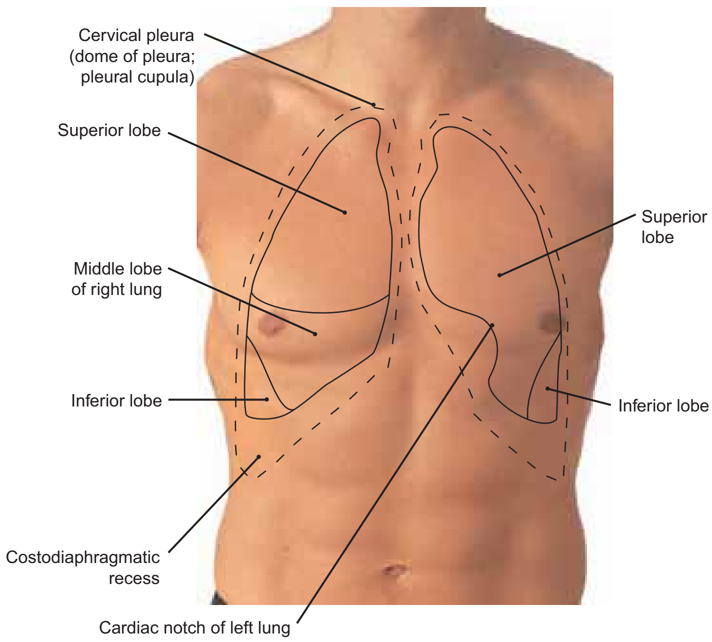


FIGURE 154.2 Outline Directly onto the Anterior Thoracic Wall of Pleural Reflections

NOTE: The boundaries of the lungs are shown by solid lines, while those of the parietal pleura are shown by broken lines.

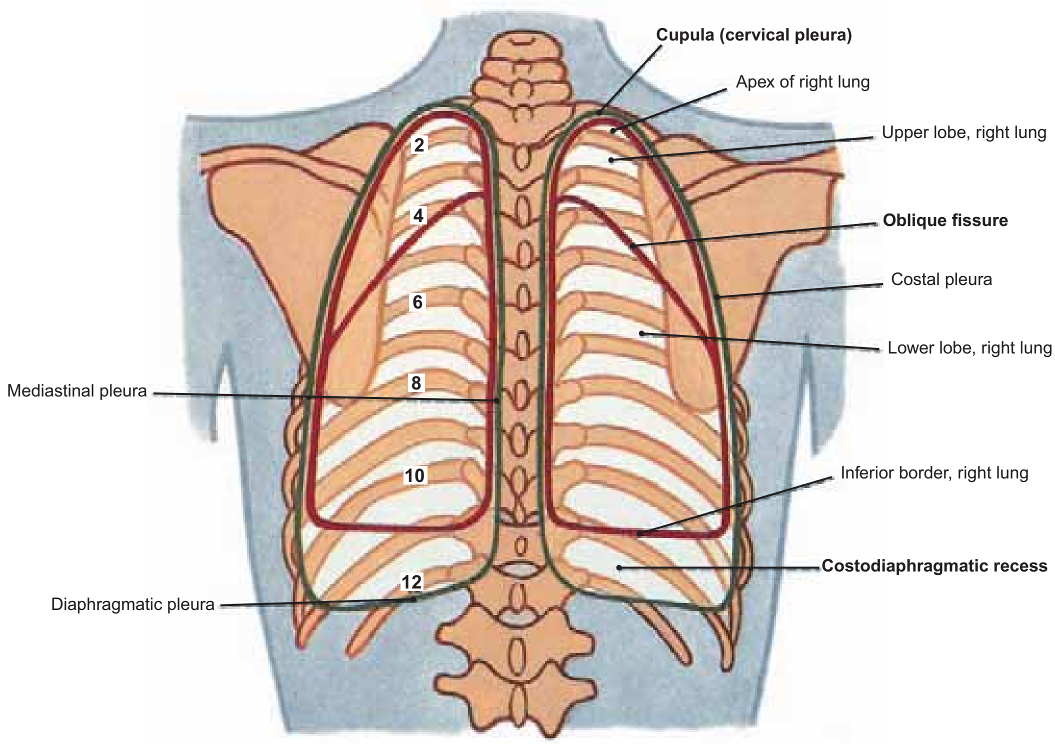


FIGURE 155.1 Parietal (Green) and Visceral (Red) Pleural Reflections onto the Posterior Thoracic Wall

NOTE: (1) The parietal pleura is a continuous sheet, but parts of it are named in relation to their adjacent surfaces. Lining the inner surface of the ribs is the **costal pleura**, while the **diaphragmatic** and **mediastinal pleurae** are found on the surfaces of the diaphragm and mediastinum. Overlying the apex of each lung is the **cupula** or **cervical pleura**.

(2) Because of the curvature of the diaphragm, a narrow recess is formed around its periphery into which the lung (visceral pleura) does not extend. An important potential space lies between the costal and diaphragmatic pleurae called the **costodiaphragmatic recess,** which may be punctured and drained of fluid without damage to the lung tissue.

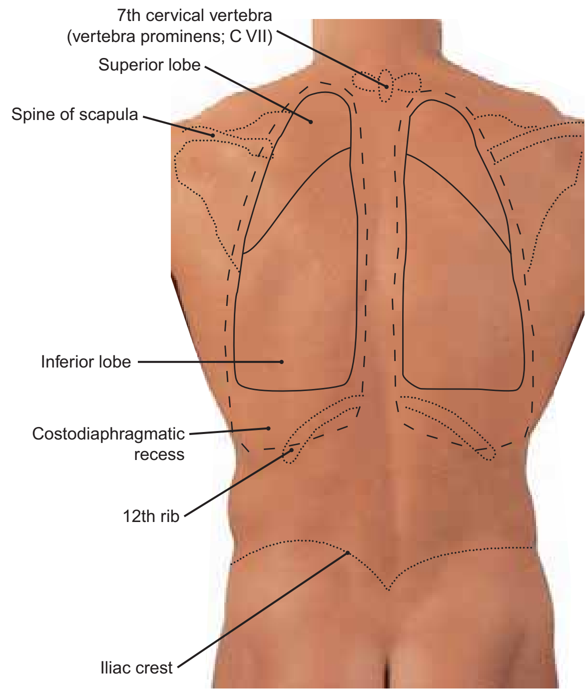
FIGURE 155.2 Outline of Pleural Reflections Directly ▶ onto the Posterior Thoracic Wall

NOTE: (1) The boundaries of the lungs are the solid lines, while the boundaries of the pleura are the broken (dash) lines.

(2) The "rib-level" relationships of the lungs (visceral pleura) and the parietal pleura are as follows:

	Visceral pleura	Parietal pleura
(a) Anterior (midclavicular line)	6th rib	8th rib
(b) Lateral (midaxillary line)	8th rib	10th rib
(c) Posterior (medial border of the scapula)	10th rib	12th rib

(**Summary of Rib Levels**)	**Visceral Pleura**	**Ribs 6, 8, 10**
	Parietal Pleura	**Ribs 8, 10, 12**



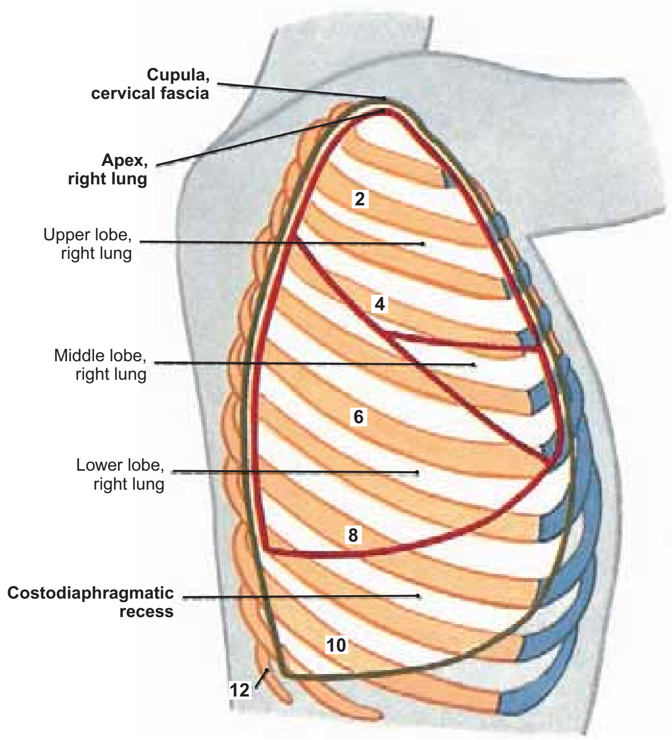


FIGURE 156.1 Right Lateral View

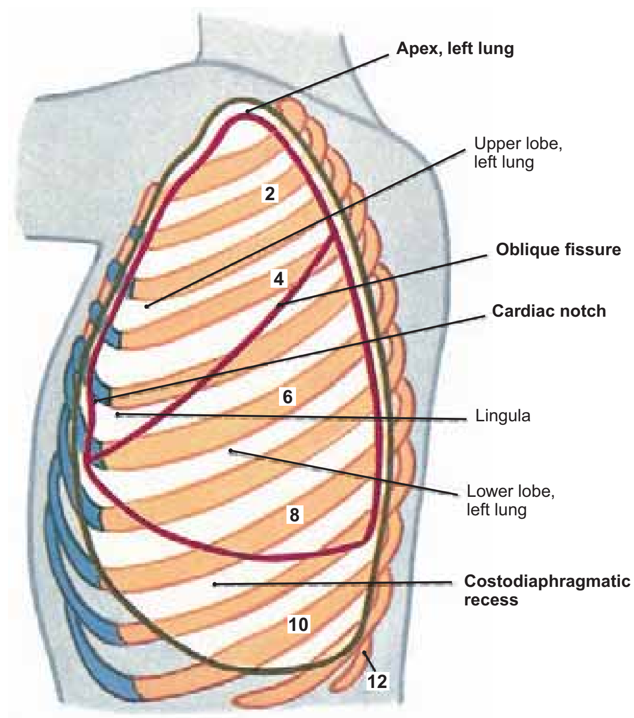


FIGURE 156.2 Left Lateral View

Pleural Reflections (Green) and Lungs (Red) Projected onto Thoracic Wall

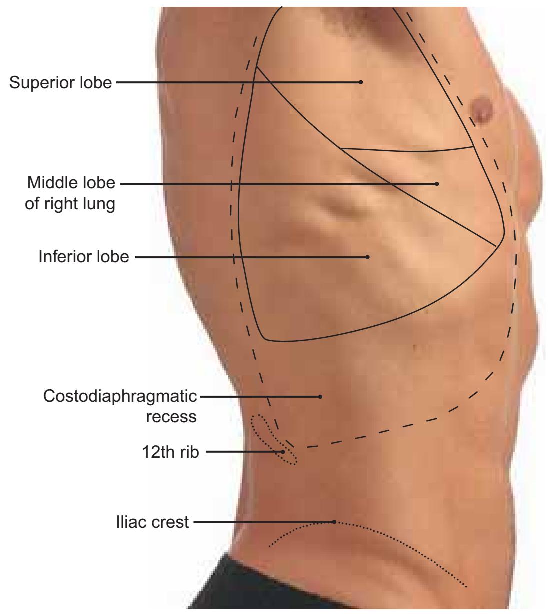


FIGURE 156.3 Projection of Pleural and Pulmonary Borders (Right Lateral Aspect)

NOTE that the borders of the lung are shown by solid lines, while borders of the pleura are shown by broken (dashed) lines.

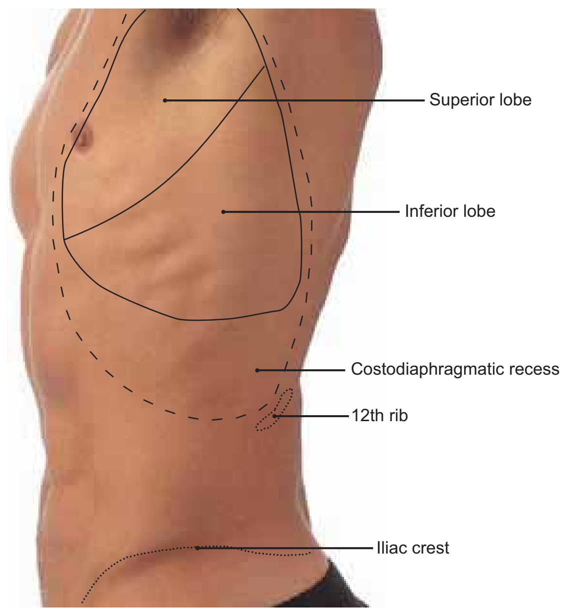


FIGURE 156.4 Projection of Pleural and Pulmonary Borders (Left Lateral Aspect)

NOTE that the borders of the lung are shown by solid lines, while borders of the pleura are shown by broken (dashed) lines.

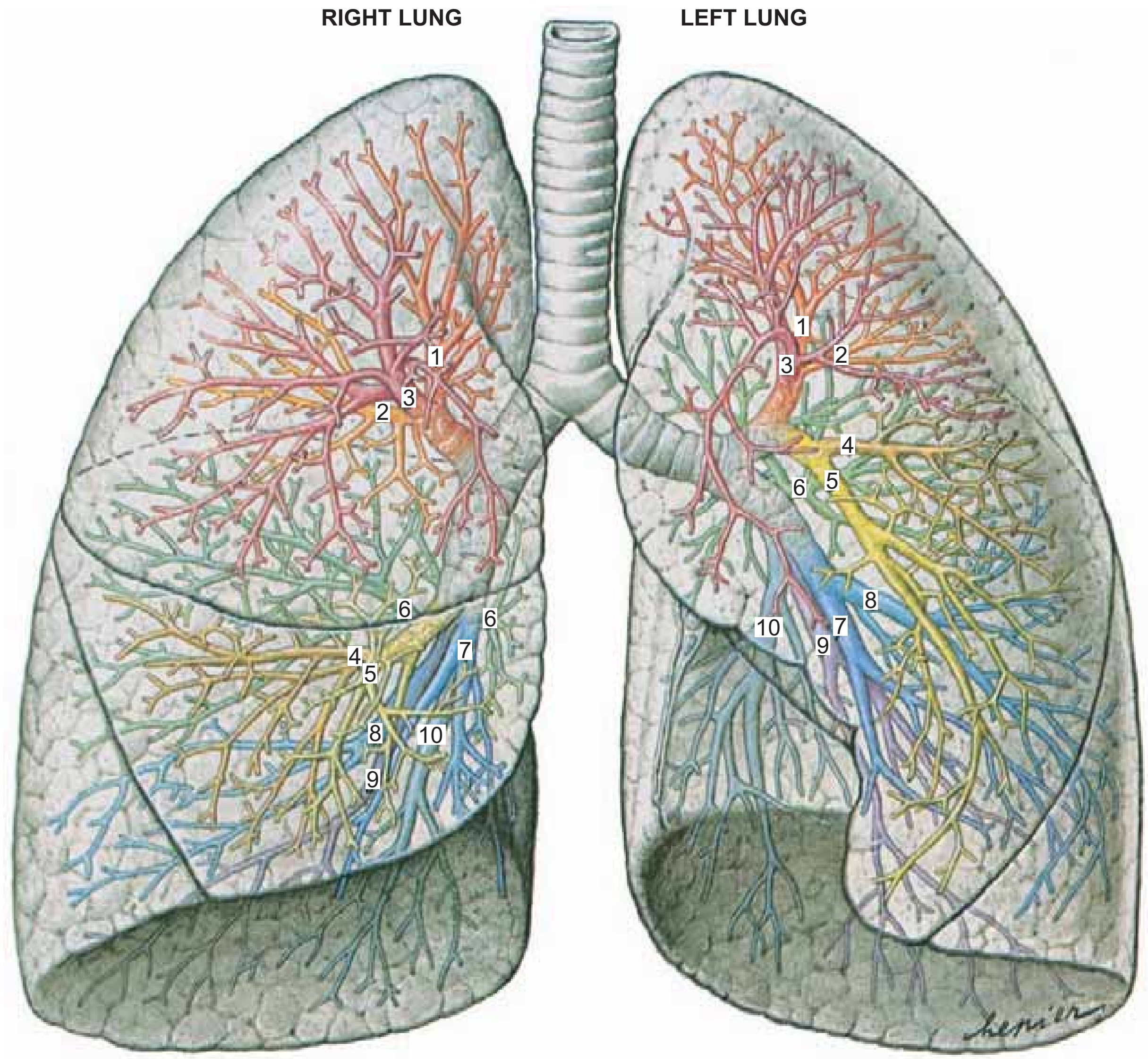


FIGURE 157 **Bronchial Tree and Its Lobar and Bronchopulmonary Divisions (Anterior View)**

NOTE: (1) As the trachea divides, the **left primary bronchus** diverges at a greater angle than the **right primary bronchus** to reach the left lung. The left bronchus, therefore, is directed more transversely and the right bronchus more inferiorly.

(2) **On the right side,** the upper lobar bronchus branches from the primary bronchus almost immediately, even above the pulmonary artery (eparterial), while the bronchus is directed toward the middle and lower lobes branches below the main stem of the pulmonary artery (hyparterial).

(3) **On the left side,** the initial lobar bronchus, branching from the primary bronchus, is directed upward and lateral to the upper lobe segments and its lingular segments. The remaining lobar bronchus is directed inferiorly and soon divides into the segmental bronchi of the lower lobe.

(4) The segmental bronchi numbered in the figure above are as follows:

Right lung

1. Apical
2. Posterior
3. Anterior
4. Lateral
5. Medial
6. Superior
7. Medial basal
8. Anterior basal
9. Lateral basal
10. Posterior basal

Left lung

1. Apical
2. Posterior
3. Anterior
4. Superior lingular
5. Inferior lingular
6. Superior
7. Medial basal
8. Anterior basal
9. Lateral basal
10. Posterior basal

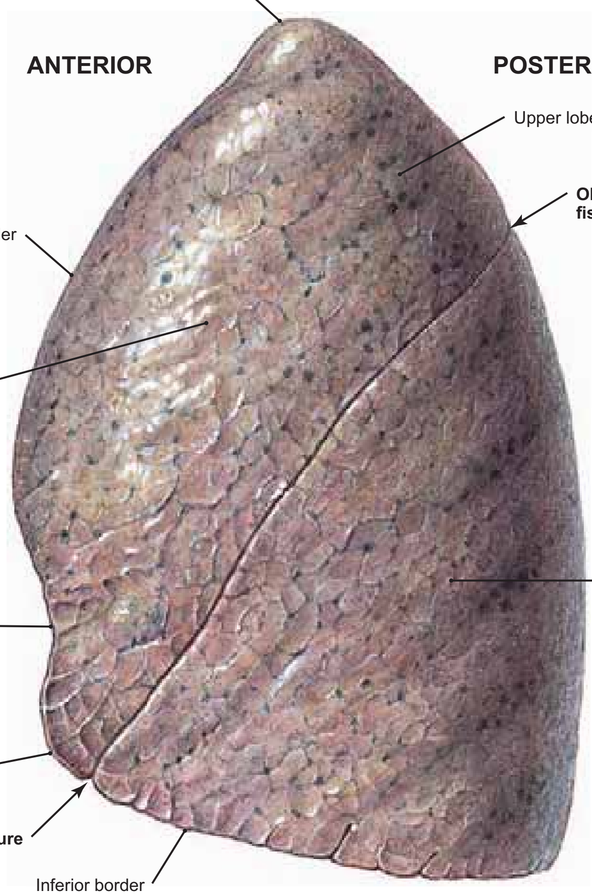


FIGURE 158.1 Left Lung (Lateral View)

NOTE: (1) The lateral view of the left lung shows a rounded convex costal surface directed toward the thoracic wall and divided into upper and lower lobes by the **oblique fissure.**

(2) The **upper lobe** has a rounded apex, which is pointed above. The upper lobe forms virtually all of the **anterior border** of the left lung and, inferiorly, it is indented by the **cardiac notch.** A small tongue-like anterior projection below the cardiac notch is called the **lingula.**

(3) The **lower lobe** is somewhat larger than the upper, and its base is the **diaphragmatic surface** of the left lung. This is adapted to the dome shape of the diaphragm.

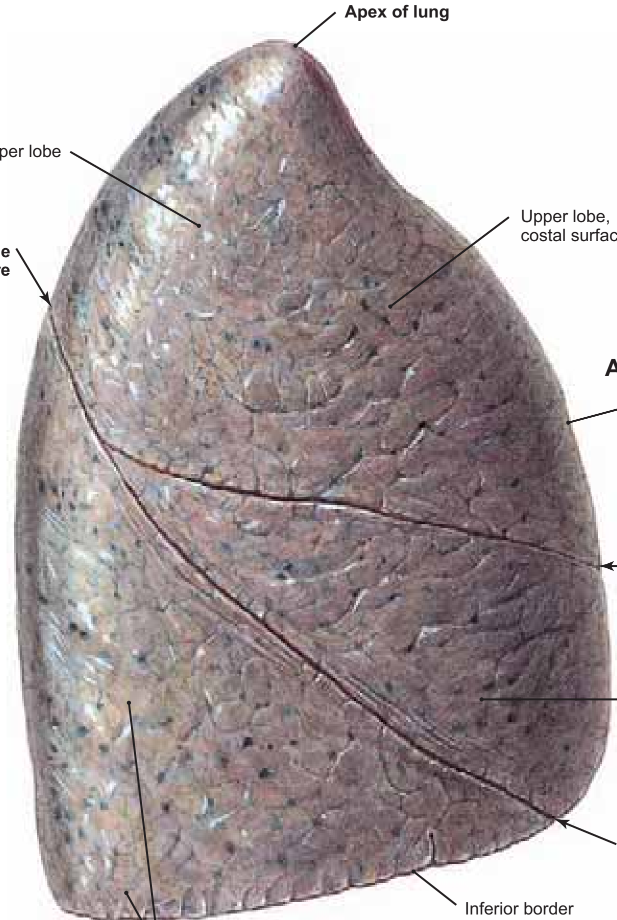


FIGURE 158.2 Right Lung (Lateral View)

NOTE: (1) The lateral or costal surface of the right lung is smooth and rounded and presents three lobes separated by two fissures. The **oblique fissure** separates the lower lobe from the middle and upper lobes and corresponds to the oblique fissure of the left lung. The **horizontal fissure** separates the upper and middle lobes.

(2) The upper lobe is capped by the apex of the lung. This lobe forms the upper two-thirds of the **anterior border.** The middle lobe forms the lower third of the anterior border, while the lower lobe (as in the left lung) constitutes the entire **inferior border** and diaphragmatic surface.

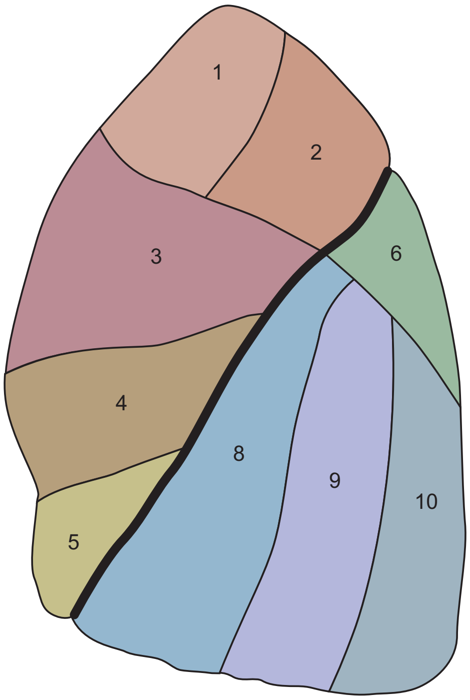


FIGURE 159.1 Left Lung, Bronchopulmonary Segments (Lateral View)

NOTE: (1) Bronchopulmonary segments are anatomical subdivisions of the lung, each supplied by its own segmental (tertiary) bronchus and artery and drained by intersegmental veins.

(2) The trachea divides into two primary bronchi, each of which serves an entire lung. The primary bronchi divide into secondary, or lobar, bronchi. There are two lobar bronchi on the left and three on the right, each supplying a separate lobe.

(3) Secondary bronchi divide into segmental or tertiary bronchi, distributed to the bronchopulmonary segments. Usual descriptions of the bronchopulmonary segments define 8 to 10 segments in the left lung.

(4) In the left lung, the segments are numbered and named as follows:

Upper lobe
1. Apical
2. Posterior — Frequently considered as a single segment (1–3)
3. Anterior
4. Superior — Lingular (4–5)
5. Inferior

Lower lobe
6. Superior
7. Medial basal — Usually considered as a single segment; medial basal cannot be seen from lateral view. (7–8)
8. Anterior basal
9. Lateral basal
10. Posterior basal

(5) In the left lower lobe the medial basal bronchus arises separately from the anterior basal bronchus in only about 13% of humans studied.

FIGURE 159.2 Right Lung, Bronchopulmonary Segments (Lateral View) ►

NOTE: (1) Subdivision of the lungs into functional bronchopulmonary segments allows the surgeon to determine whether segments of lung might be resected in operations in preference to entire lobes.

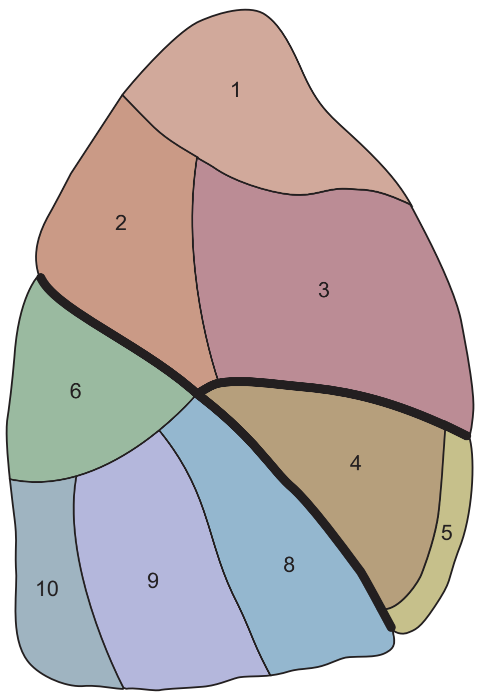
(2) Although minor variations exist in the division of the bronchial tree, a consistency has become accepted in the naming of bronchopulmonary segmentation. The nomenclature used here was published by Jackson and Huber (Dis Chest 1943;9:319–326) and is now used because it is the simplest and most straightforward of those that have been suggested.

(3) The bronchopulmonary segments of the right lung are numbered and named as follows:

Upper lobe
1. Apical
2. Posterior
3. Anterior

Middle lobe
4. Lateral
5. Medial

Lower lobe
6. Superior
7. Medial basal (cannot be seen from lateral view)
8. Anterior basal
9. Lateral basal
10. Posterior basal



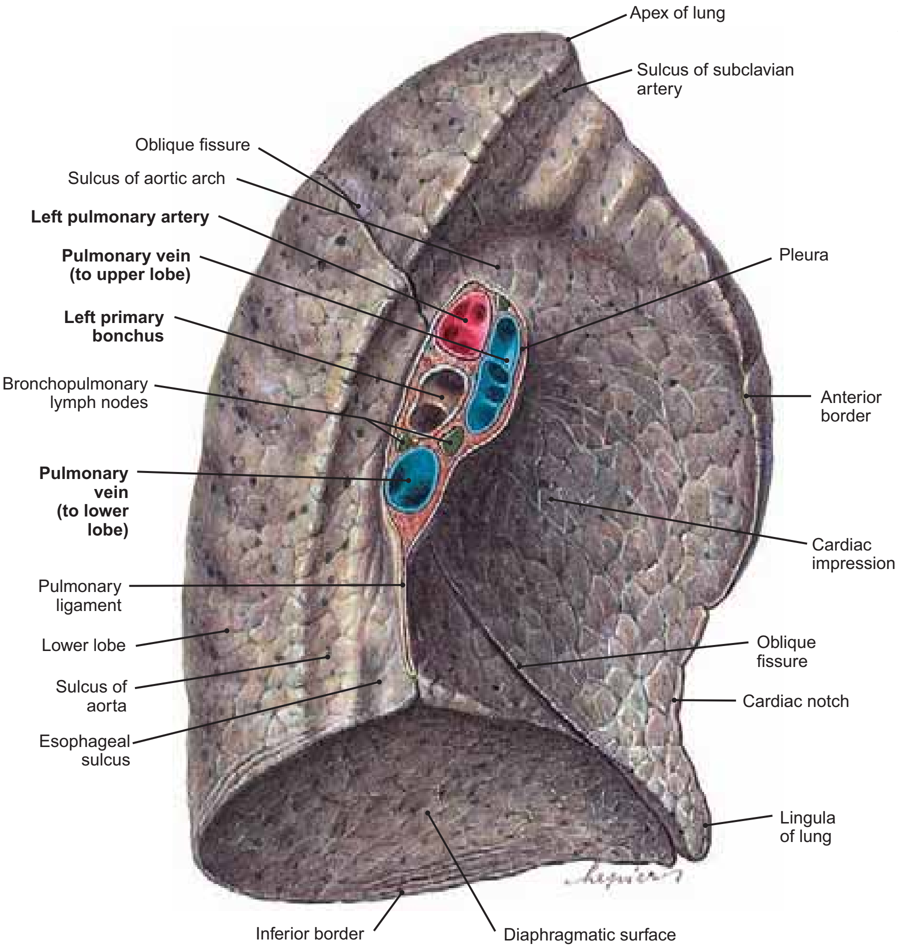


FIGURE 160.1 Left Lung, Mediastinal and Diaphragmatic Surfaces

NOTE: (1) The concave diaphragmatic surface on the left lung covers most of the convex dome of the diaphragm, which is completely covered by parietal diaphragmatic pleura.

(2) The mediastinal (or medial) surface of the left lung is also concave and presents the contours of the organs of the mediastinum. The large anterior concavity is the cardiac impression. Observe the grooves for the aortic arch, the aorta, and the subclavian artery as well as the esophagus inferiorly.

(3) The structures at the hilum of the left lung include the **left pulmonary artery**, found superiorly, and below this the **left primary bronchus.** The **left pulmonary veins** lie anterior and inferior to the artery and bronchus. The **oblique fissure** completely divides the lung into two lobes.

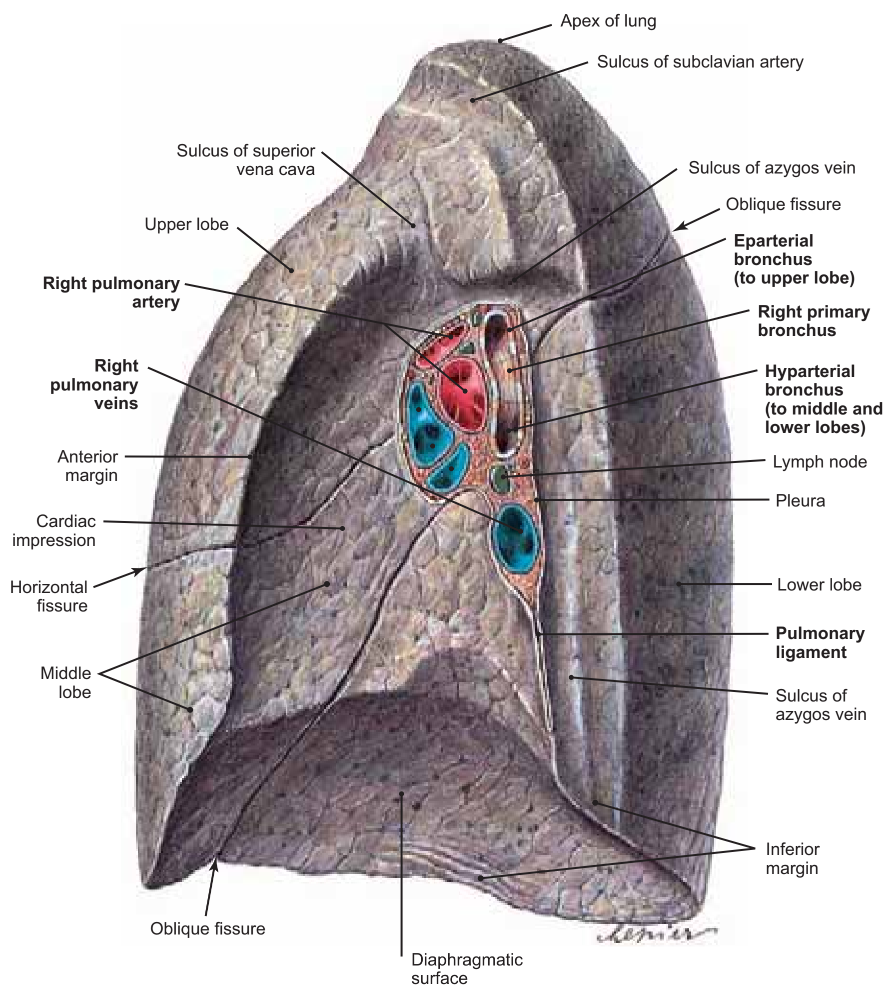
FIGURE 160.2 Right Lung, Mediastinal and Diaphragmatic Surfaces

NOTE: (1) The **diaphragmatic surface** of the right lung, similar to the left, is shaped to the contour of the diaphragm, while the **mediastinal surface** shows grooves for the superior vena cava and subclavian artery.

(2) Above the **hilum** of the right lung is the arched sulcus for the azygos vein, which continues inferiorly behind the hilum of the lung. The cardiac impression on the right lung is more shallow than on the left.

(3) The right bronchus frequently branches before the right pulmonary artery. Thus, often the most superior structure at the hilum of the right lung is the bronchus to the upper lobe (eparterial bronchus). The pulmonary artery lies anterior to the bronchus, while the pulmonary veins are located anterior and inferior to these structures.

(4) The root of the lung is ensheathed by parietal pleura, the layers of which come into contact below to form the **pulmonary ligament.** This extends from the inferior border of the hilum to a point just above the diaphragm.



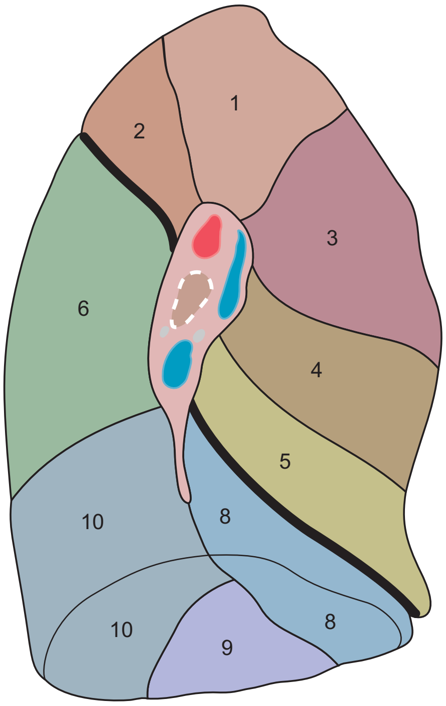


FIGURE 161.1 Left Lung: Bronchopulmonary Segments (Medial View)

NOTE: The bronchopulmonary segments of the left lung are identified as follows:

Upper lobe
1. Apical ⎤ Frequently considered
2. Posterior ⎦ as a single segment
3. Anterior
4. Superior ⎤ Lingular
5. Inferior ⎦

Lower lobe
6. Superior
7. Medial basal*
8. Anterior basal*
9. Lateral basal
10. Posterior basal

* The medial basal and anterior basal segments were at one time frequently considered as a single bronchopulmonary segment. Today, however, they have been recognized as separate segments in a majority of left lungs. Therefore, on this figure, the portion of segment 8 just inferior to the oblique fissure should be marked 7 and identified as medial basal.

FIGURES 161.1 and 161.2 Bronchopulmonary Segments: General Statements

NOTE: (1) Bronchopulmonary segments are separated by connective-tissue septa that are continuous with the visceral pleura. These septa maintain the air content of each segment and prevent leakage of air into adjacent segments.
(2) Each segment is pyramidal in shape. The apex of each pyramid is oriented toward the hilum of the lung, while the base faces the surface of the pulmonary lobe.
(3) It is important to know the bronchopulmonary segmental patterns in order, accurately, to read and interpret radiographs of the lungs.
(4) Knowledge of segmental anatomy is also important for the localization of pathologic conditions such as tumors, abscesses, or bronchiectasis or small foreign objects that have been aspirated into a lung.

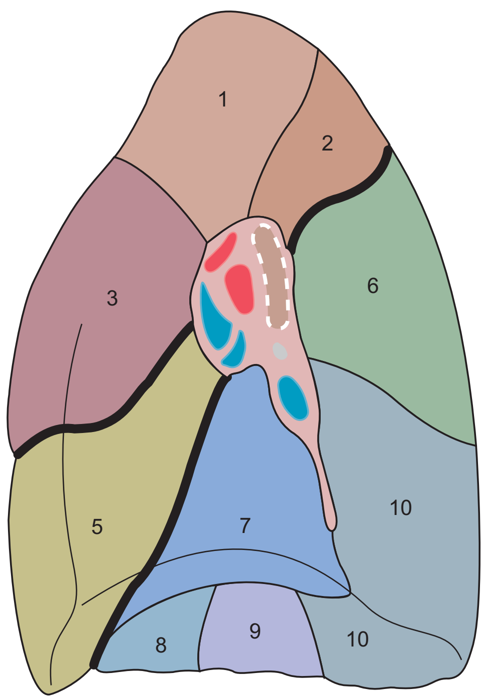
FIGURE 161.2 Right Lung: Bronchopulmonary Segments (Medial View) ►

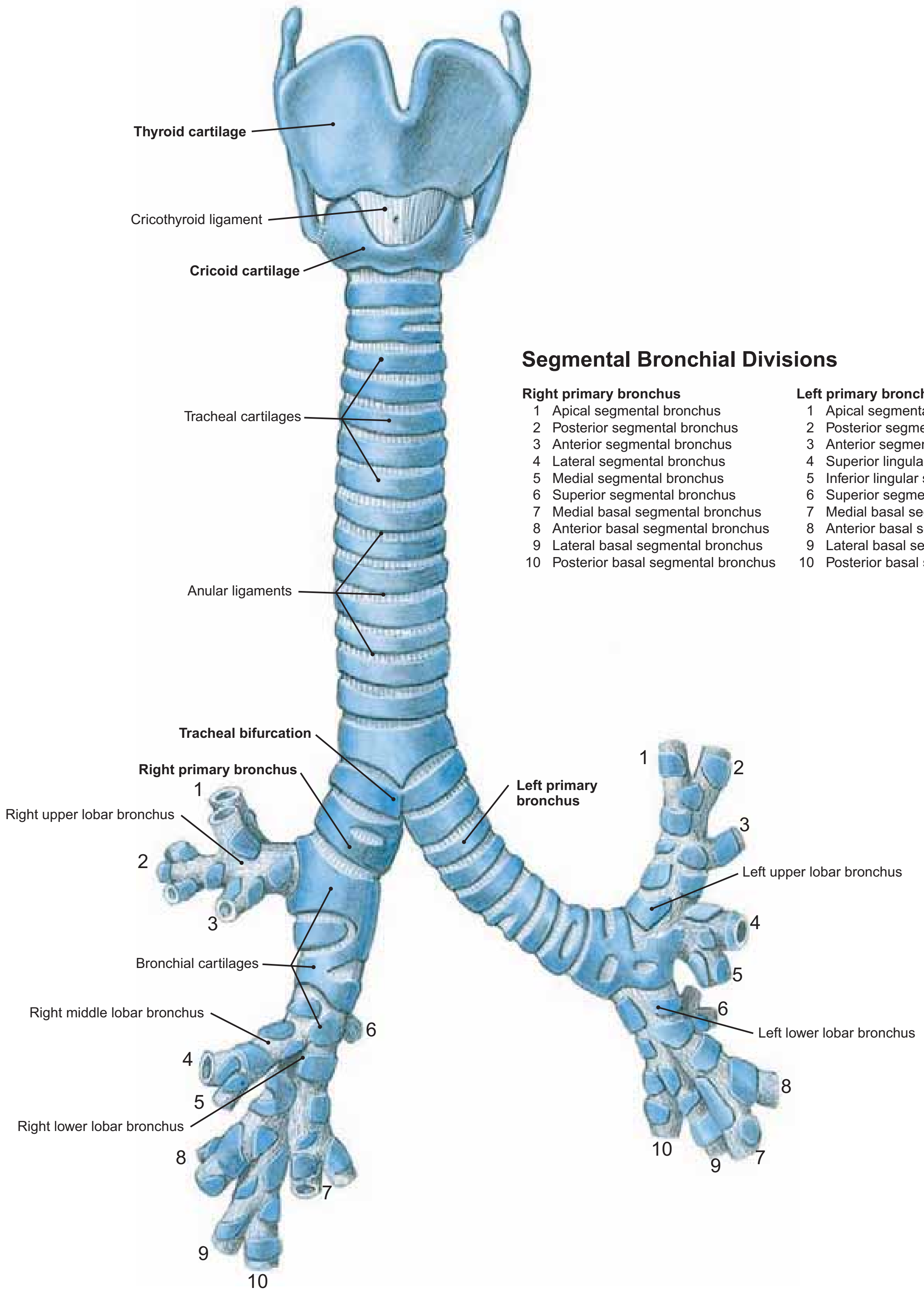
NOTE: The bronchopulmonary segments of the right lung are identified as follows:

Upper lobe
1. Apical
2. Posterior
3. Anterior

Middle lobe
4. Lateral (not seen from this view)
5. Medial

Lower lobe
6. Superior
7. Medial basal
8. Anterior basal
9. Lateral basal
10. Posterior basal





Segmental Bronchial Divisions

	Right primary bronchus		Left primary bronchus
1	Apical segmental bronchus	1	Apical segmental bronchus
2	Posterior segmental bronchus	2	Posterior segmental bronchus
3	Anterior segmental bronchus	3	Anterior segmental bronchus
4	Lateral segmental bronchus	4	Superior lingular segmental bronchus
5	Medial segmental bronchus	5	Inferior lingular segmental bronchus
6	Superior segmental bronchus	6	Superior segmental bronchus
7	Medial basal segmental bronchus	7	Medial basal segmental bronchus
8	Anterior basal segmental bronchus	8	Anterior basal segmental bronchus
9	Lateral basal segmental bronchus	9	Lateral basal segmental bronchus
10	Posterior basal segmental bronchus	10	Posterior basal segmental bronchus

FIGURE 162 Anterior Aspect of Larynx, Trachea, and Bronchi

NOTE: (1) The **trachea** bifurcates into two **principal** (primary) **bronchi.** These then divide into **lobar** (secondary) **bronchi,** which give rise to **segmental** (tertiary) **bronchi.**

(2) The larynx is located in the anterior aspect of the neck, and its thyroid and cricoid cartilages can be felt through the skin.

(3) The **thyroid cartilage,** projected posteriorly, lies at the level of the fourth and fifth cervical vertebrae, while the **cricoid cartilage** is at the sixth cervical level.

(4) The trachea commences at the lower end of the cricoid cartilage and extends slightly more than 4 in. before bifurcating into the two primary bronchi at the level of T4 to T5 intervertebral disc. Two inches of the trachea lie above the suprasternal notch in the neck, and about 2 in. of trachea are within the thorax above the tracheal bifurcation.

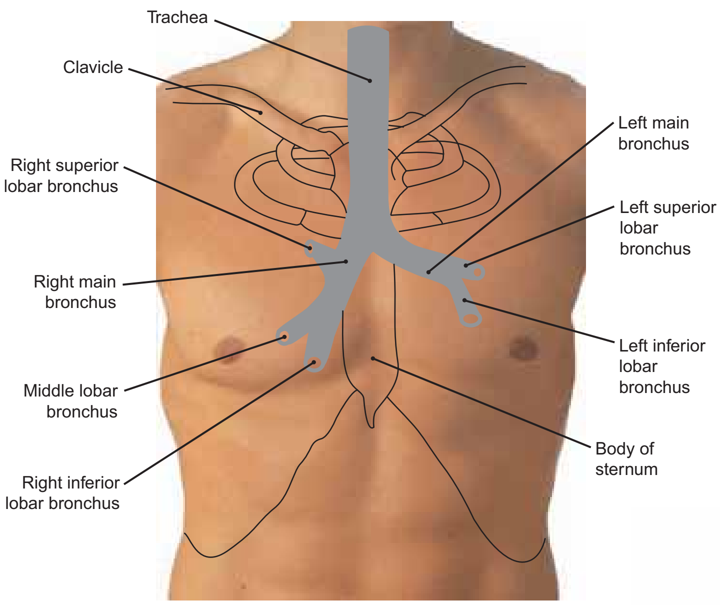


FIGURE 163.1 Surface Projection of the Trachea and Bronchi in a Living Person

NOTE that the bifurcation occurs at approximately the level of the sternal angle located anteriorly on the sternum.

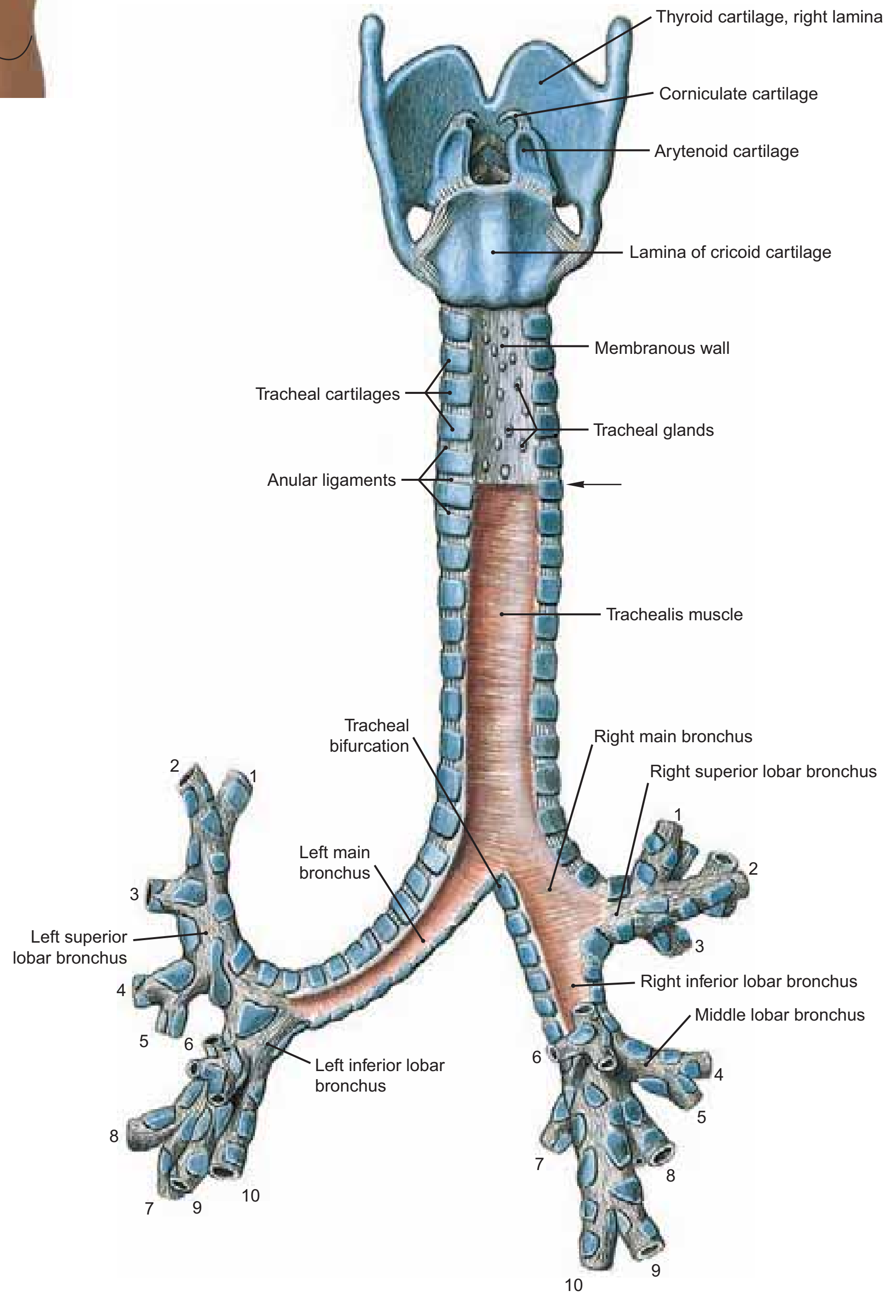


FIGURE 163.2 Opened Trachea and Bronchi (Posterior View)

NOTE: (1) The numbers refer to the bronchopulmonary segments listed in Plate 162.

(2) Below the arrow, observe the trachealis muscle along the posterior surface of the trachea. It is composed of nonstriated muscle fibers, and it extends along the posterior surface of the bronchi.

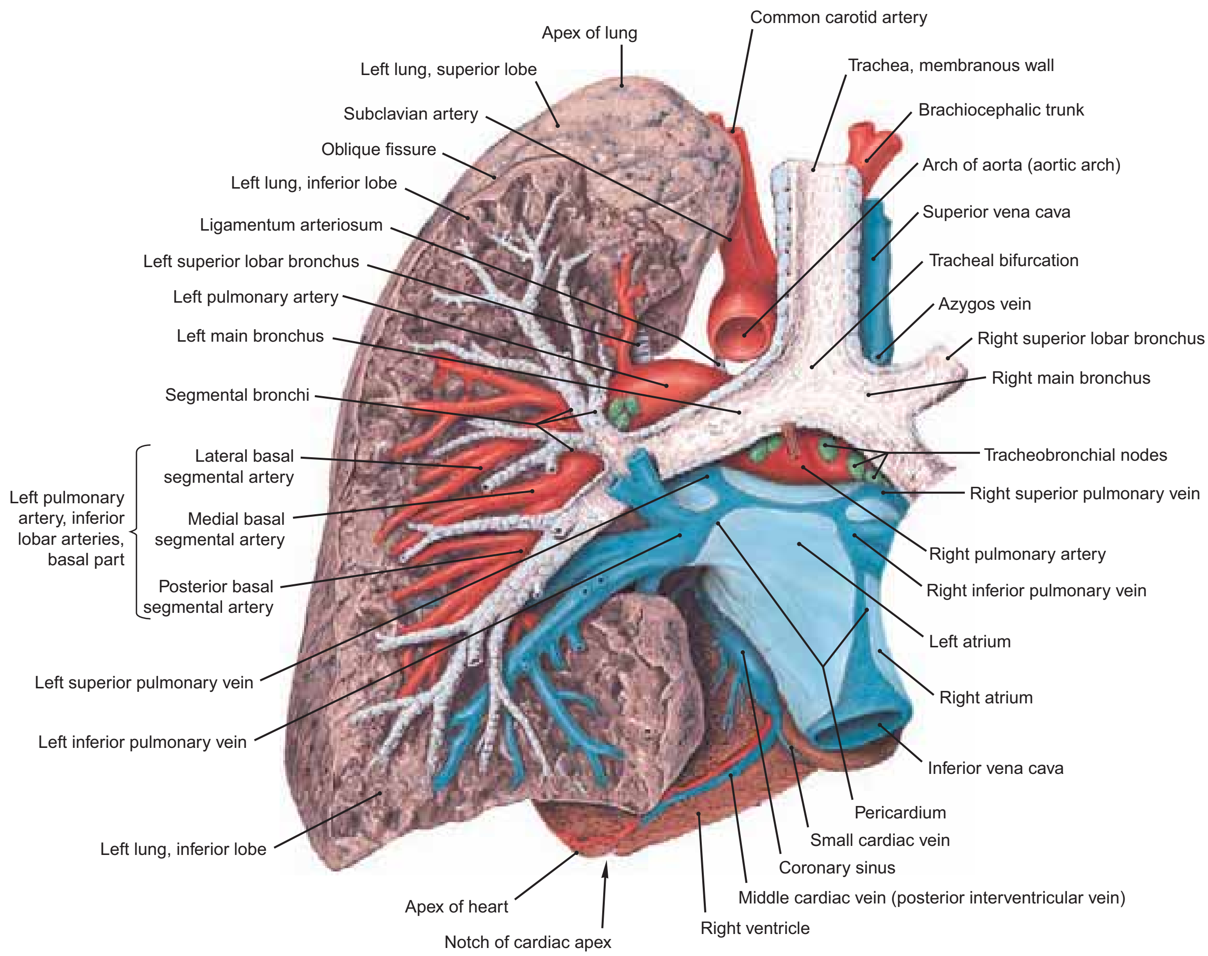


FIGURE 164.1 Dissected Hilum of the Left Lung (Posterior View)

NOTE that the bronchus is more posterior to the pulmonary vessels.

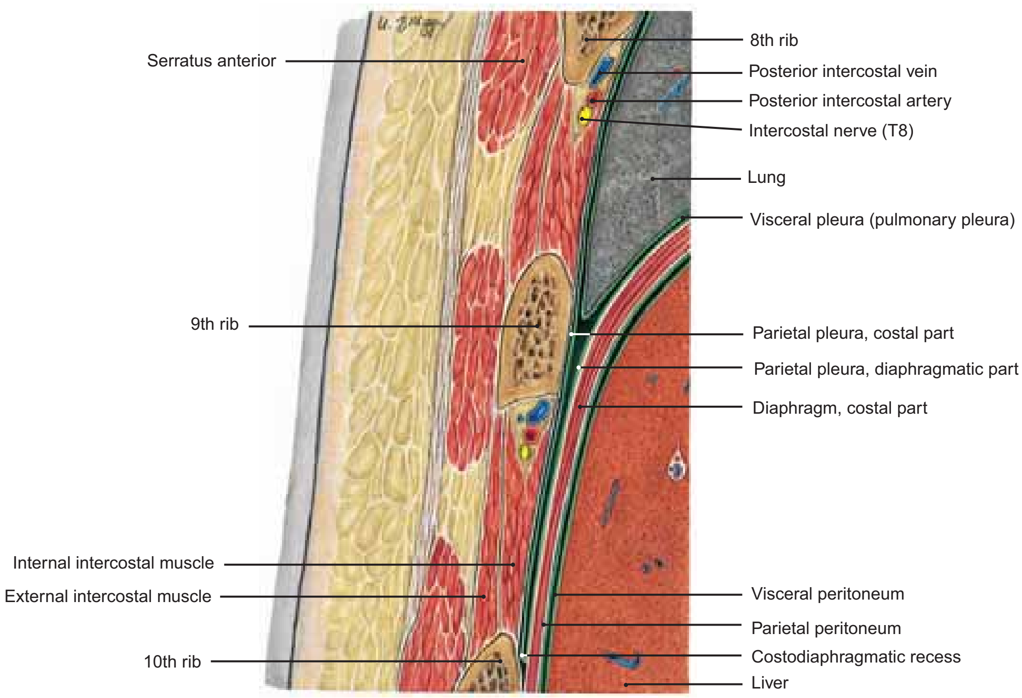


FIGURE 164.2 Costodiaphragmatic Recess (Frontal Section of Region)

NOTE: (1) The costodiaphragmatic recesses are located in the lowest lateral regions of the two pleural cavities.

(2) When aspiration of fluid is necessary, care must be taken not to puncture the liver or right lung on the right side, or the spleen or left lung on the left side.

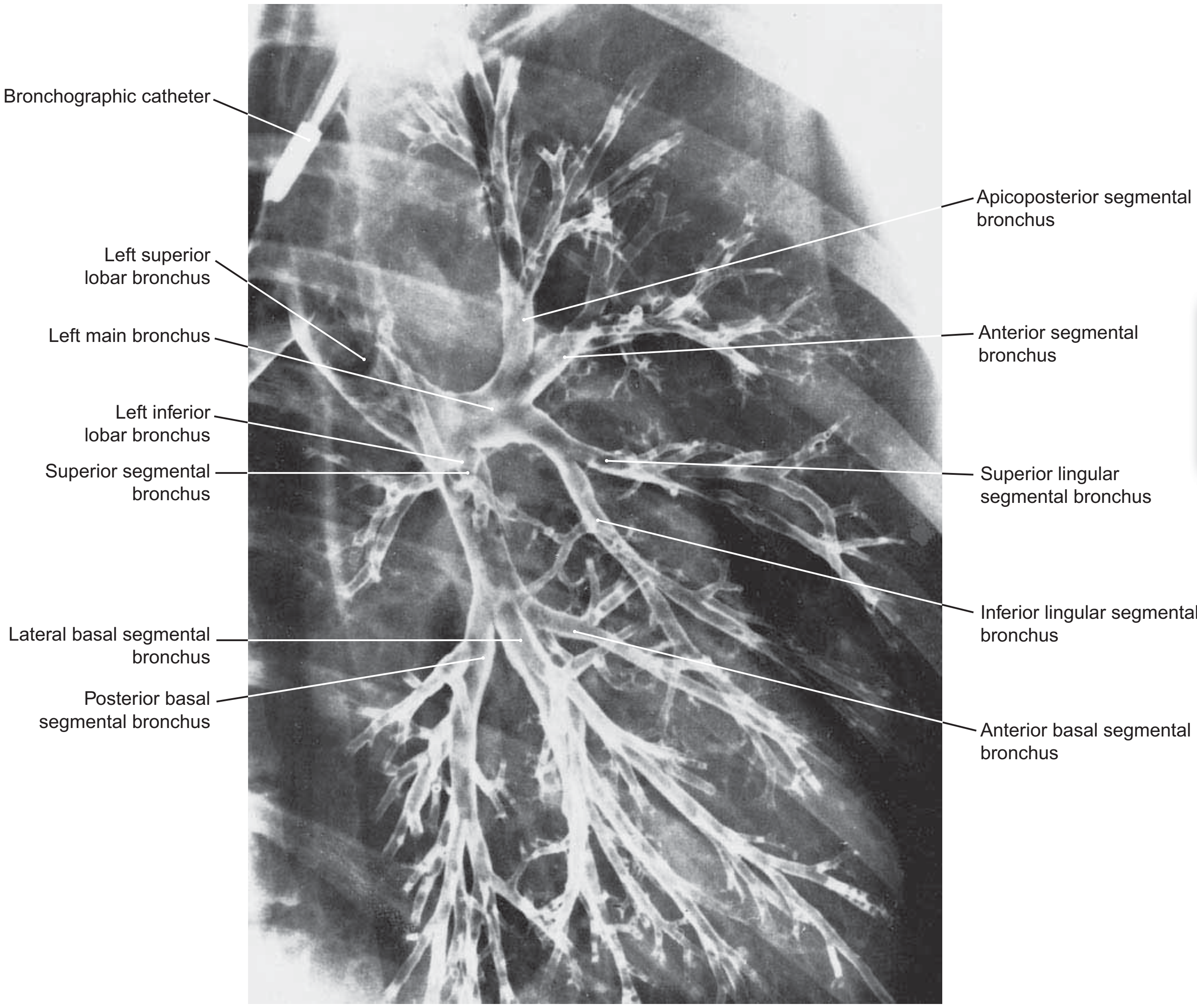


FIGURE 165.1 Left Bronchogram Showing the Bronchial Tree

NOTE: (1) A powder was administered through the trachea by a catheter to visualize the bronchial tree.
(2) The apical and posterior segmental bronchi (apicoposterior) and the anterior segmental bronchus of the **superior lobe.**
(3) The superior and inferior segmental bronchi of the **lingular part** of the **superior lobe.**
(4) The superior segment and the lateral, posterior, and anterior basal segments of the **inferior lobe.** The medial basal segment of the inferior lobe is mostly missing in this bronchogram. (Compare this bronchogram with Plate 157.)

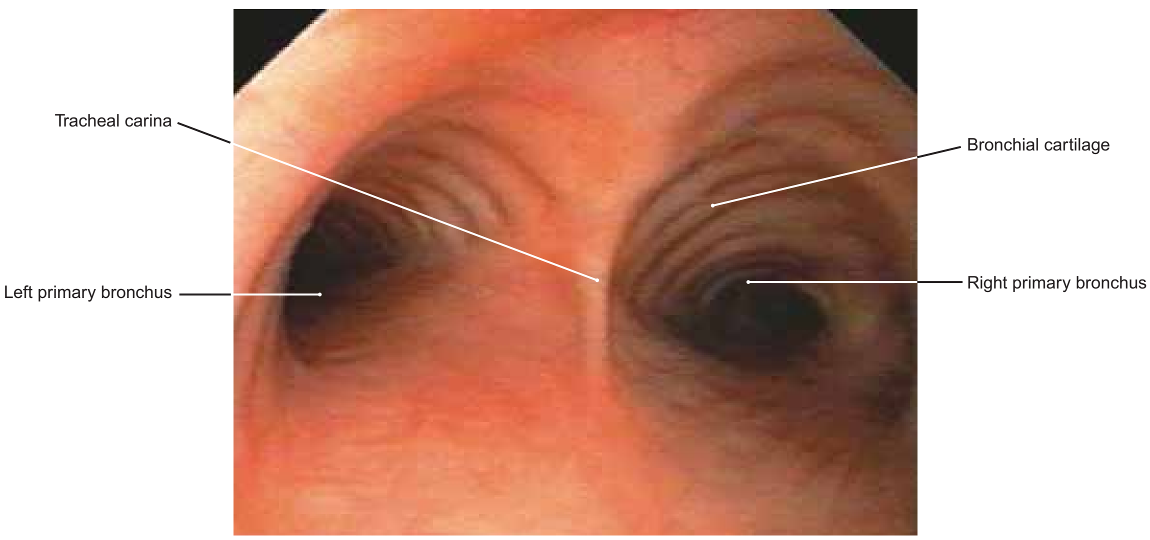


FIGURE 165.2 Bronchoscopy of a Healthy Individual Showing the Tracheal Bifurcation and the Carina of the Trachea

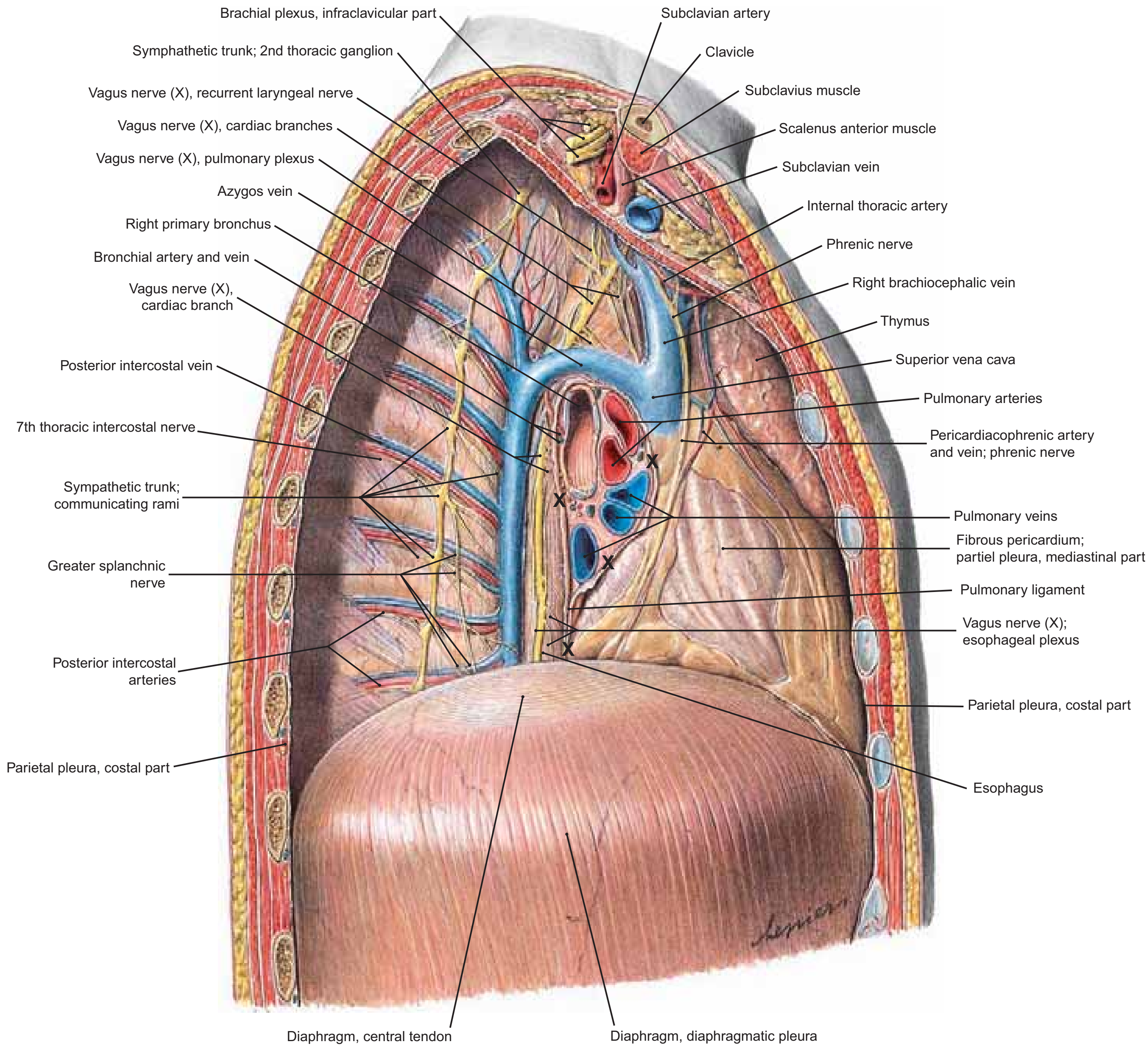


FIGURE 166 Right Side of the Mediastinum with the Mediastinal Pleura and Some Costal Pleura Removed

NOTE: (1) The lung has been removed, the structures at the hilum transected, and the mediastinal pleura stripped away. This exposes the organs of the mediastinum, and their right lateral surface is presented.

(2) The right side of the heart is covered by pericardium and the course of the **phrenic nerve** and **pericardiacophrenic vessels** is visible.

(3) The ascending course of the **azygos vein,** its arch, and its junction with the superior vena cava.

(4) The **right vagus nerve** descends in the thorax behind the root of the right lung to form the **posterior pulmonary plexus.** It then helps form the **esophageal plexus** and leaves the thorax on the posterior aspect of the esophagus.

(5) The **dome of the diaphragm** on the right side as it takes the rounded form of the underlying liver. The inferior (diaphragmatic) surface of the heart rests on the diaphragm.

(6) The position of the thoracic **sympathetic chain** of ganglia coursing longitudinally along the inner surface of the thoracic wall. Observe the **greater thoracic splanchnic nerve.**

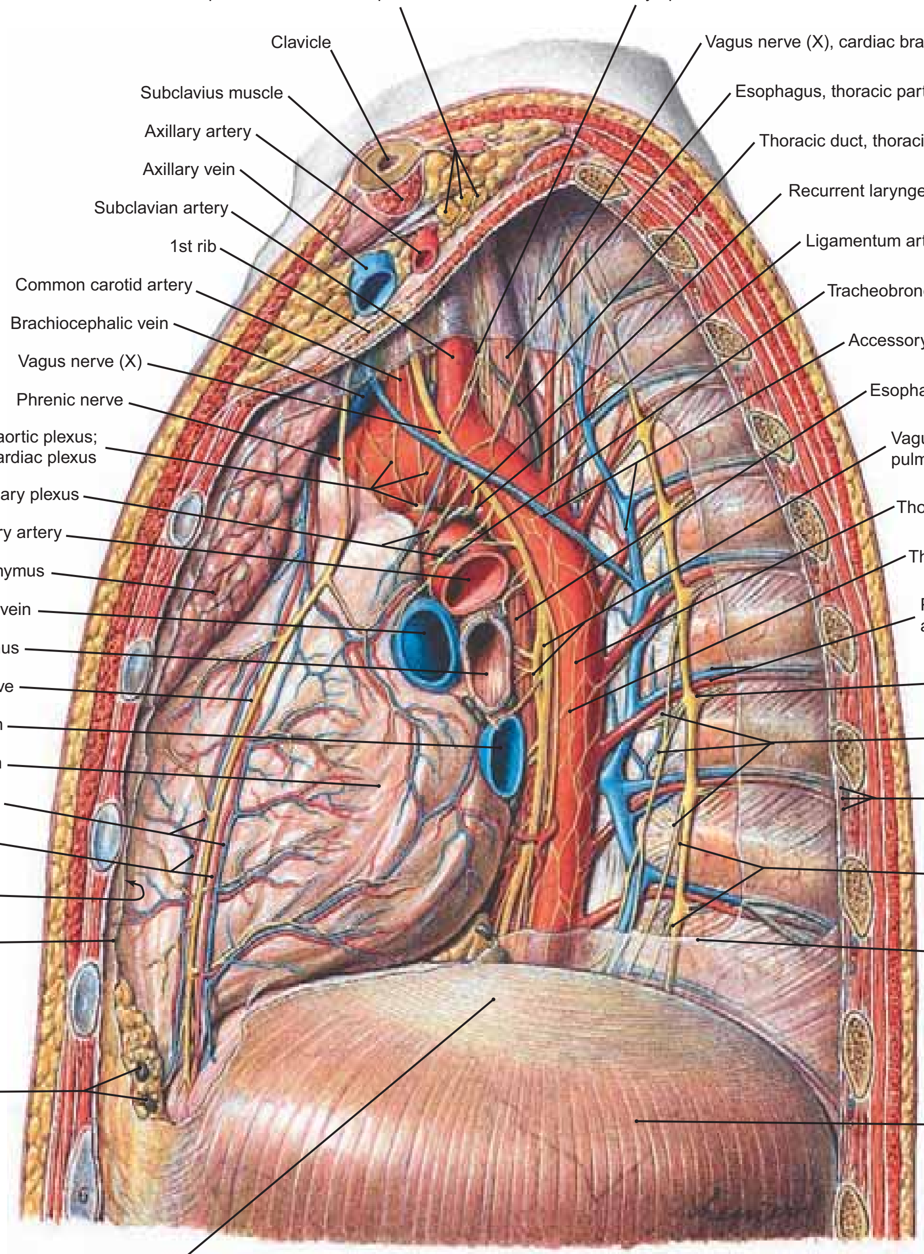


FIGURE 167 **Left Side of the Mediastinum with the Mediastinal Pleura and Some Costal Pleura Removed**

NOTE: (1) With the left lung removed along with most of the mediastinal pleura, the structures of the mediastinal pleura and the structures of the mediastinum are observed from their left side.

(2) The **left phrenic nerve** and **pericardiacophrenic vessels** course to the diaphragm along the pericardial covering over the left side of the heart.

(3) The **aorta** ascends about 2 in. before it arches posteriorly and to the left of the vertebral column.

(4) The descending **thoracic aorta** commences at about the level of the fourth thoracic vertebra. As it descends, it comes to lie anterior to the vertebral column.

(5) The **intercostal arteries** branch directly from the thoracic aorta. The typical intercostal artery and vein course along the inferior border of their respective rib. Because the superior border of the ribs is free of vessels and nerves, it is a safer site for injection or drainage of the thorax.

(6) The **left vagus nerve** lies lateral to the aortic arch and gives off the **recurrent laryngeal branch,** which passes inferior to the **ligamentum arteriosum.** The main trunk then continues to descend, contributes to the esophageal plexus, and enters the abdomen on the anterior aspect of the esophagus.

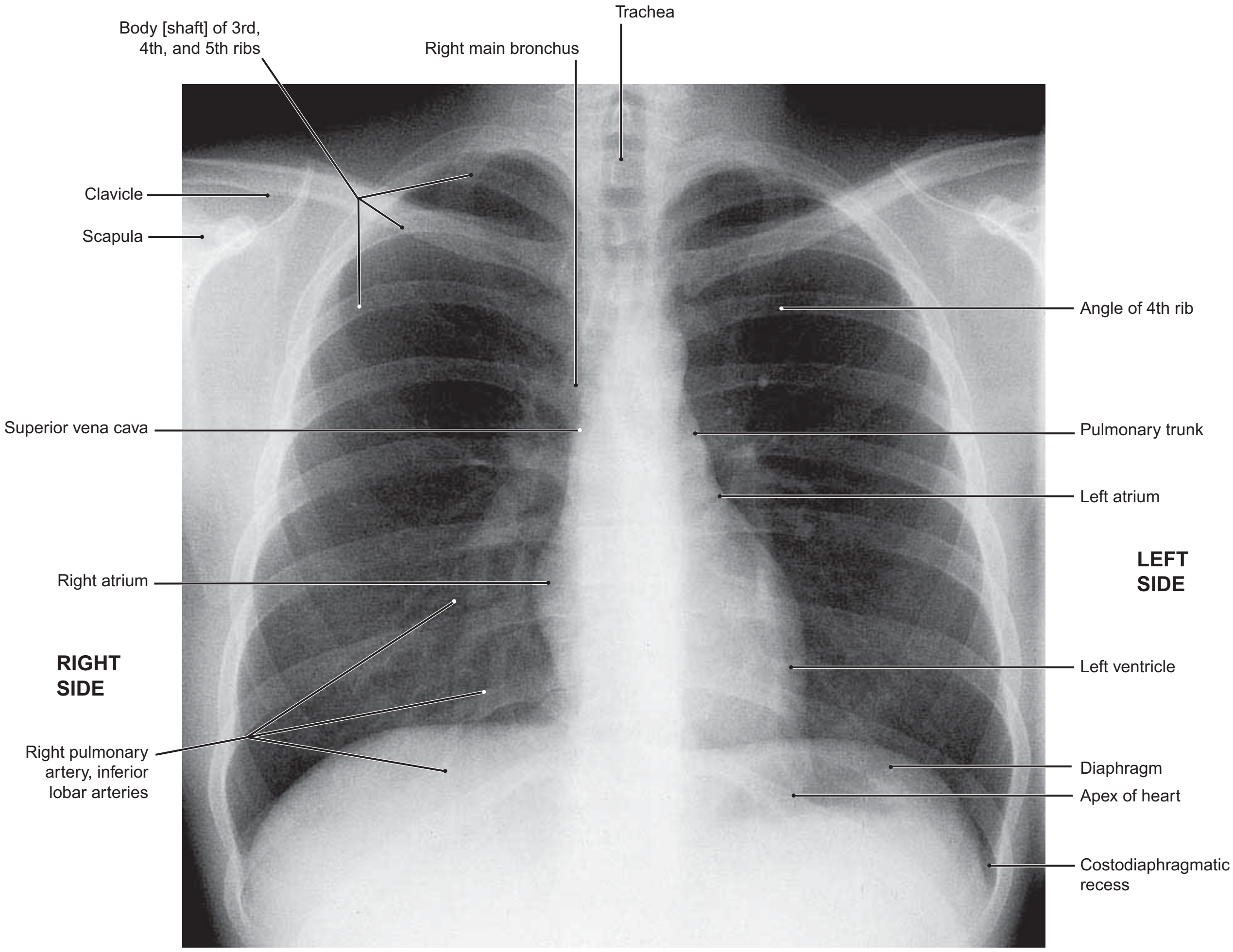


FIGURE 168.1 Posteroanterior Radiograph of the Thorax in a 27-Year-Old Male

NOTE: (1) A normal-appearing heart within the chest. Realize that it lies substernally with about two-thirds of the normal heart to the left of the midline and one-third to the right.
(2) Compare the labeled structures on the x-ray with those on the diagram seen in Figure 168.2.
(3) The right dome of the diaphragm is somewhat more superior than the dome on the left. This is because of the liver in the right upper abdomen.

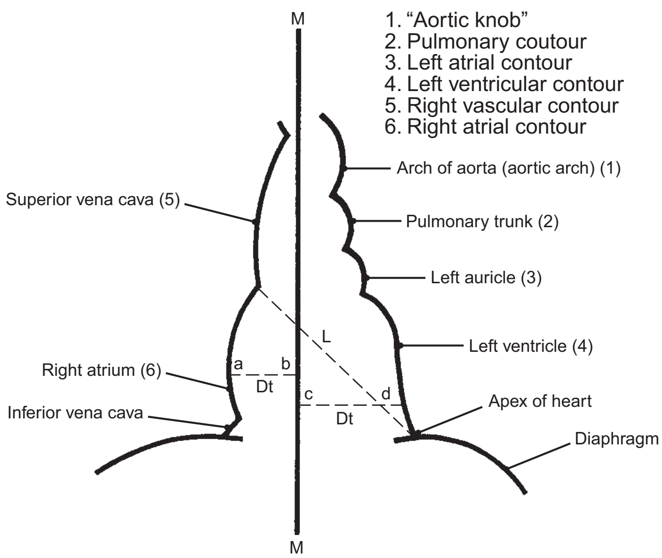


FIGURE 168.2 Schematic Diagram of the Heart Seen in the Radiograph of Figure 168.1

NOTE: (1) The midline of the body (**M**) and the longitudinal (**Ld**) and transverse (**ab** + **cd**) dimensions (**Dt**) of the heart.
(2) Transverse diameter: ab + cd = 13 to 14 cm. Longitudinal axis (Ld): From the superior contour of the right atrium to the apex: 15 to 16 cm.

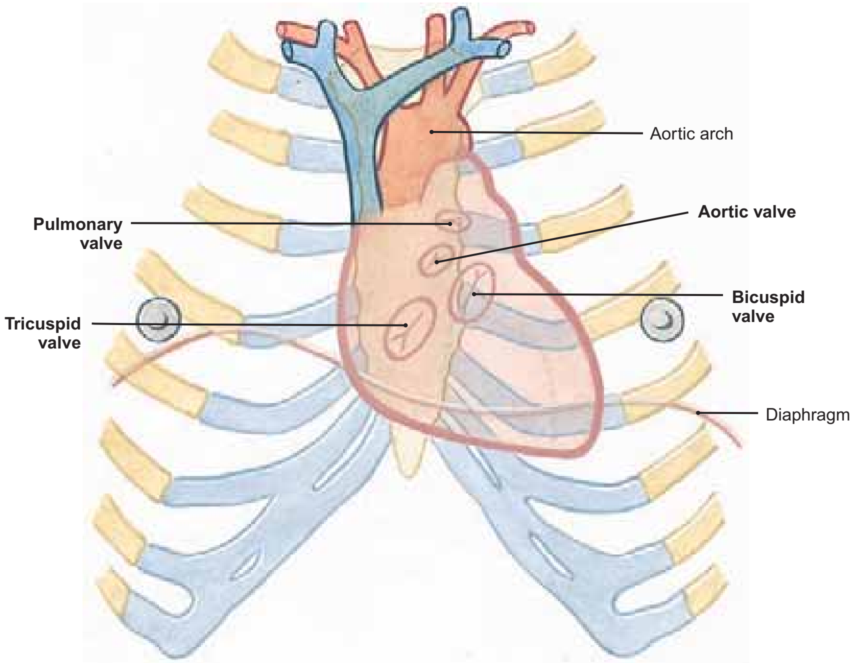


FIGURE 169.1 Projection of the Heart and Its Valves onto the Anterior Thoracic Wall

NOTE: (1) The **pulmonary valve** lies behind the sternal end of the third left costal cartilage. The **aortic valve** is behind the sternum at the level of the third intercostal space. The **mitral valve** (bicuspid) lies behind the fourth left sternocostal joint, and the **tricuspid valve** lies posterior to the middle of the sternum at the level of the fourth intercostal space.

(2) The unbroken blue line indicates the **area of deep cardiac dullness,** which produces a dull resonance by percussion. Lung tissue covers this area but does not cover the area limited by the blue dotted line from which a less-resonant **superficial cardiac** dullness is obtained.

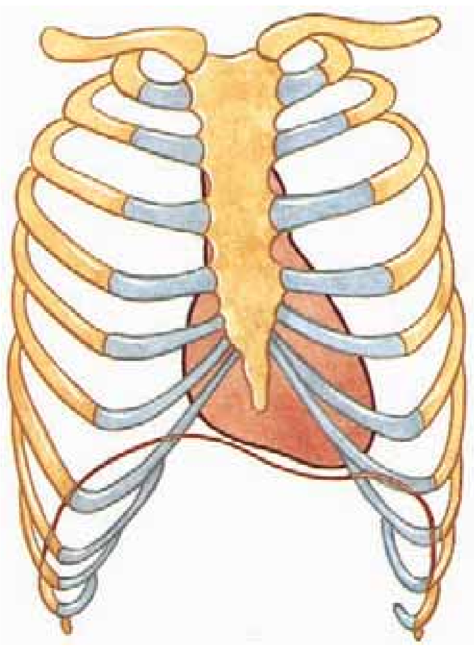


FIGURE 169.2 Inspiration

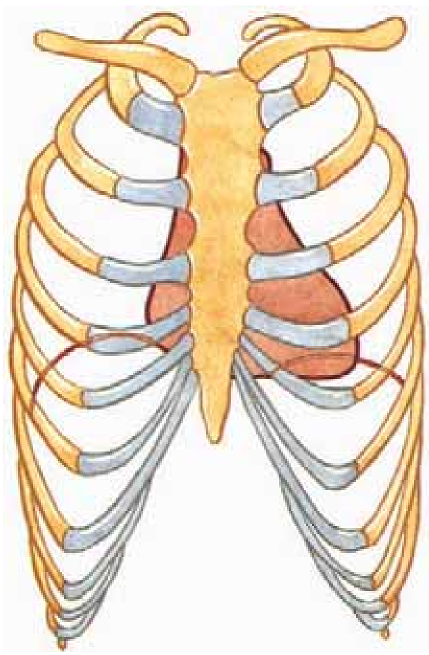
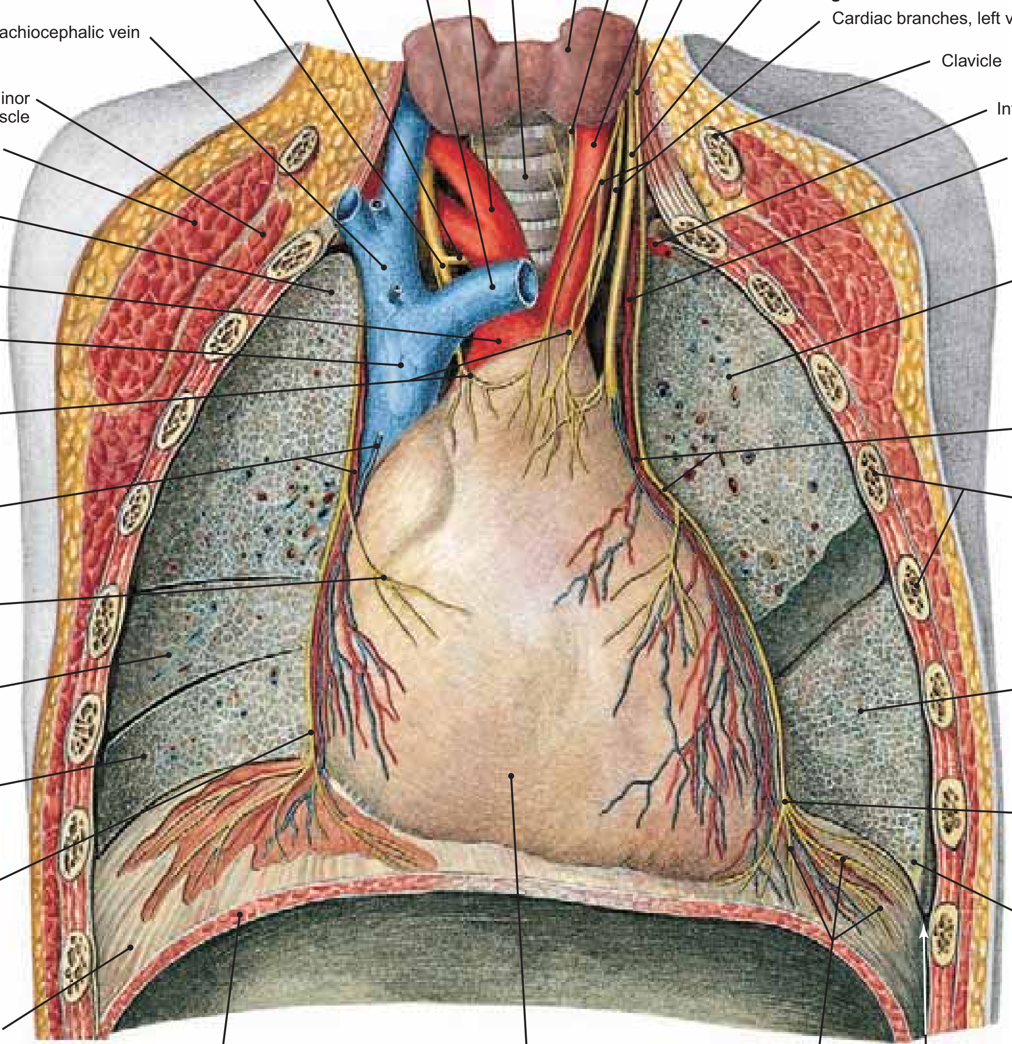


FIGURE 169.3 Expiration

FIGURES 169.2 and 169.3 Positions of the Heart during Full Inspiration (Fig. 169.2) and during Full Expiration (Fig. 169.3)

NOTE: (1) During **full inspiration (Fig. 169.2).**
- (a) The thorax is enlarged by a lowering of the diaphragm due to contraction of its muscle fibers and by elevation and expansion of the thorax (ribs and sternum).
- (b) The chest expands anteroposteriorly, transversely, and vertically, resulting in the heart becoming more oblong (i.e., its transverse diameter is decreased), and its apex and diaphragmatic surface are lowered.
- (c) Inspiration is accompanied by relaxation of the anterior abdominal wall muscles, protrusion of the abdomen, and a lowering of abdominal viscera.

(2) During **full expiration (Fig. 169.3).**
- (a) The diaphragm is elevated because its muscle fibers relax and because the ribs and sternum contract the size of the thorax.
- (b) With the capacity of the thoracic cage diminished, there is an elevation of the diaphragmatic surface of the heart and the apex of the heart. This results in an increase in the transverse diameter of the heart.
- (c) Expiration is accompanied by contraction of the anterior abdominal wall muscles and an elevation of the abdominal viscera, which also pushes the relaxed diaphragm upward.



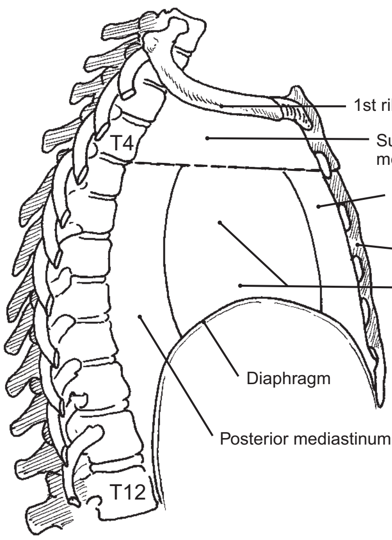


FIGURE 170.2 **Subdivisions of the Mediastinum**

▲

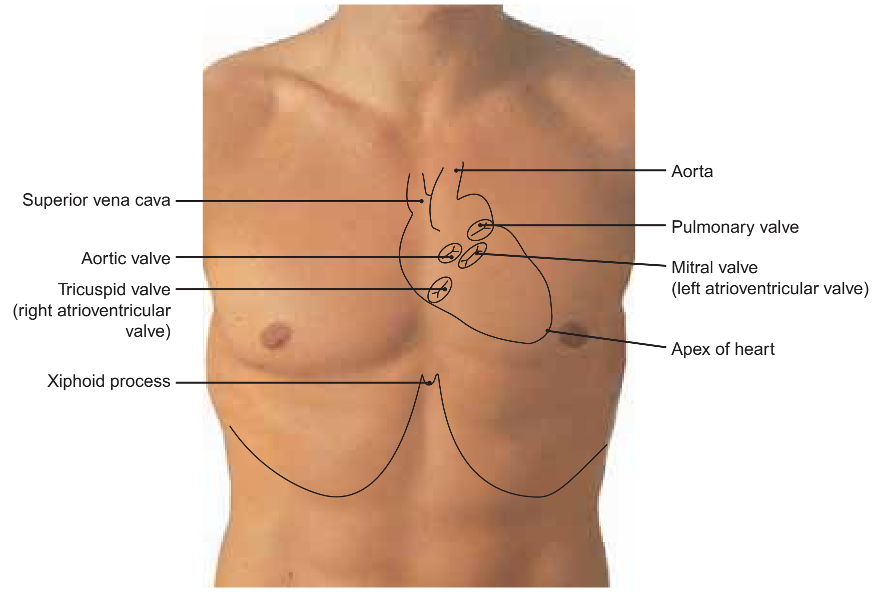
FIGURE 170.1 **Adult Heart, Pericardium, and Superior Mediastinum (Anterior View)**

NOTE: (1) In this frontal section, the anterior thoracic wall and the anterior part of the lungs and diaphragm have been removed, leaving the **pericardium** and its vessels and nerves intact. The **vagus nerves** and some of their branches are also shown.

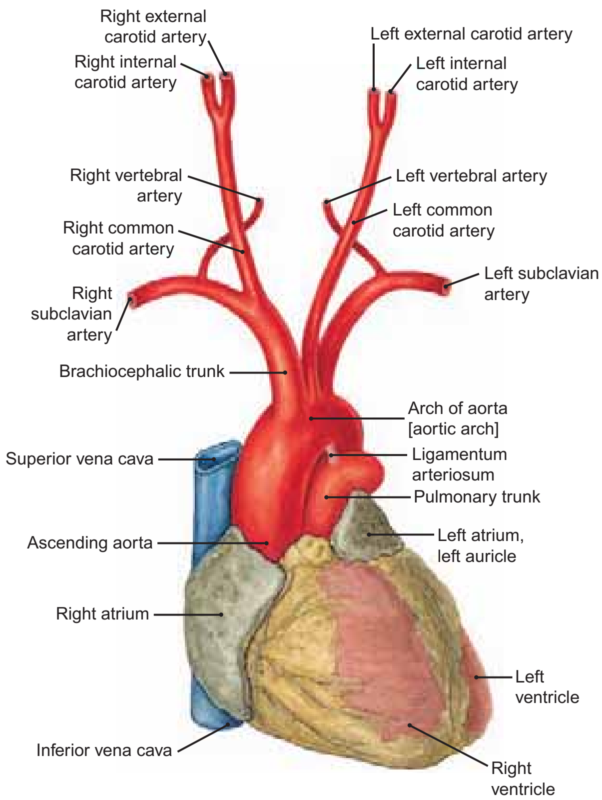
(2) The **phrenic nerves** form in the neck (C3, C4, and C5) and descend with the pericardiacophrenic vessels to innervate the diaphragm, but they also send some sensory fibers to the pericardium.

(3) The pericardium is formed by an outer **fibrous layer,** which is lined by an inner serous sac. As the heart develops, it invaginates into the serous sac and becomes covered by a **visceral layer of serous pericardium** (epicardium) and a **parietal layer of serous pericardium.**

(4) The visceral layer clings closely to the heart, while the parietal layer lines the inner surface of the fibrous pericardium. The potential space between the visceral and parietal layers contains a little serous fluid and is called the **pericardial cavity.**



▲ **FIGURE 171.1 Projection of the Heart and Cardiac Valves onto the Thoracic Wall**



◀ **FIGURE 171.2 Heart, Aortic Arch, and the Great Arteries from the Arch**

NOTE also the pulmonary trunk and the superior and inferior vena cavae.

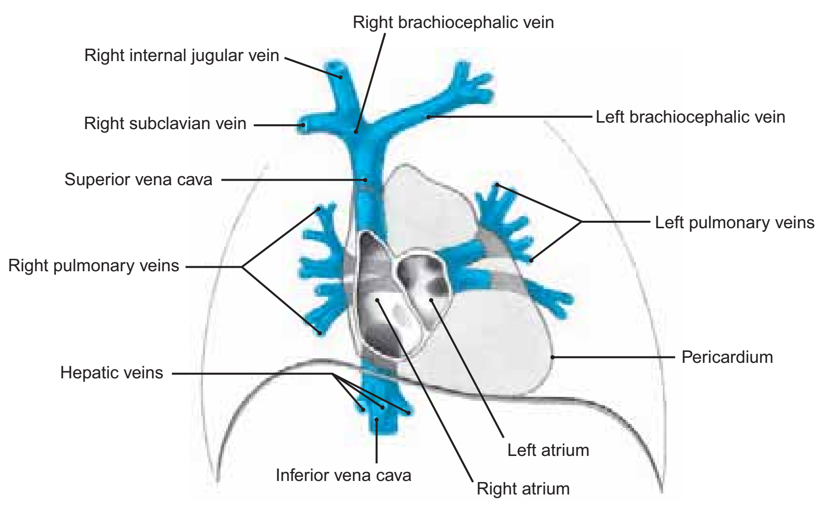


FIGURE 171.3 Great Veins That Drain into the Heart (Anterior View) ▶

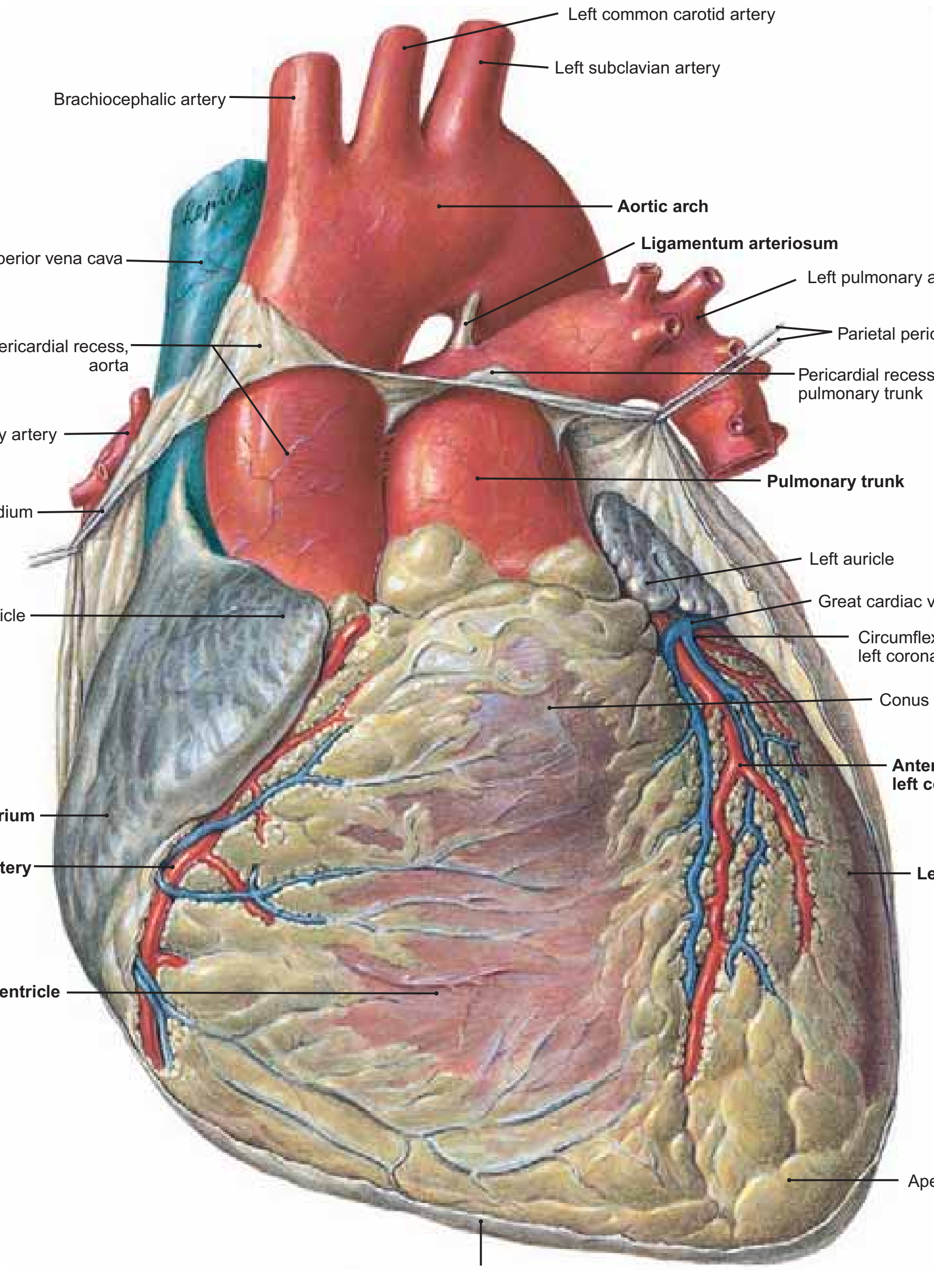


FIGURE 172 Ventral View of the Heart and Great Vessels

NOTE: (1) The heart is a muscular organ in the middle mediastinum, and its **apex** points inferiorly, to the left, and slightly anteriorly. The **base** of the heart is opposite to the apex and is directed superiorly and to the right.

(2) The great vessels attach to the heart at its base, and the pericardium is reflected over these vessels at their origin.

(3) The anterior surface of the heart is its **sternocostal surface.** The auricular portion of the **right atrium** and much of the **right ventricle** is seen from this anterior view; also a small part of the **left ventricle** is visible along the left border.

(4) The **pulmonary trunk** originates from the right ventricle. To its right can be seen the **aorta,** which arises from the left ventricle. The **superior vena cava** can be seen opening into the upper aspect of the right atrium.

(5) The **ligamentum arteriosum.** This fibrous structure between the left pulmonary artery and the aorta is the remnant of the fetal **ductus arteriosus,** which, before birth, served to shunt blood directed to the lungs back into the aorta for systemic distribution.

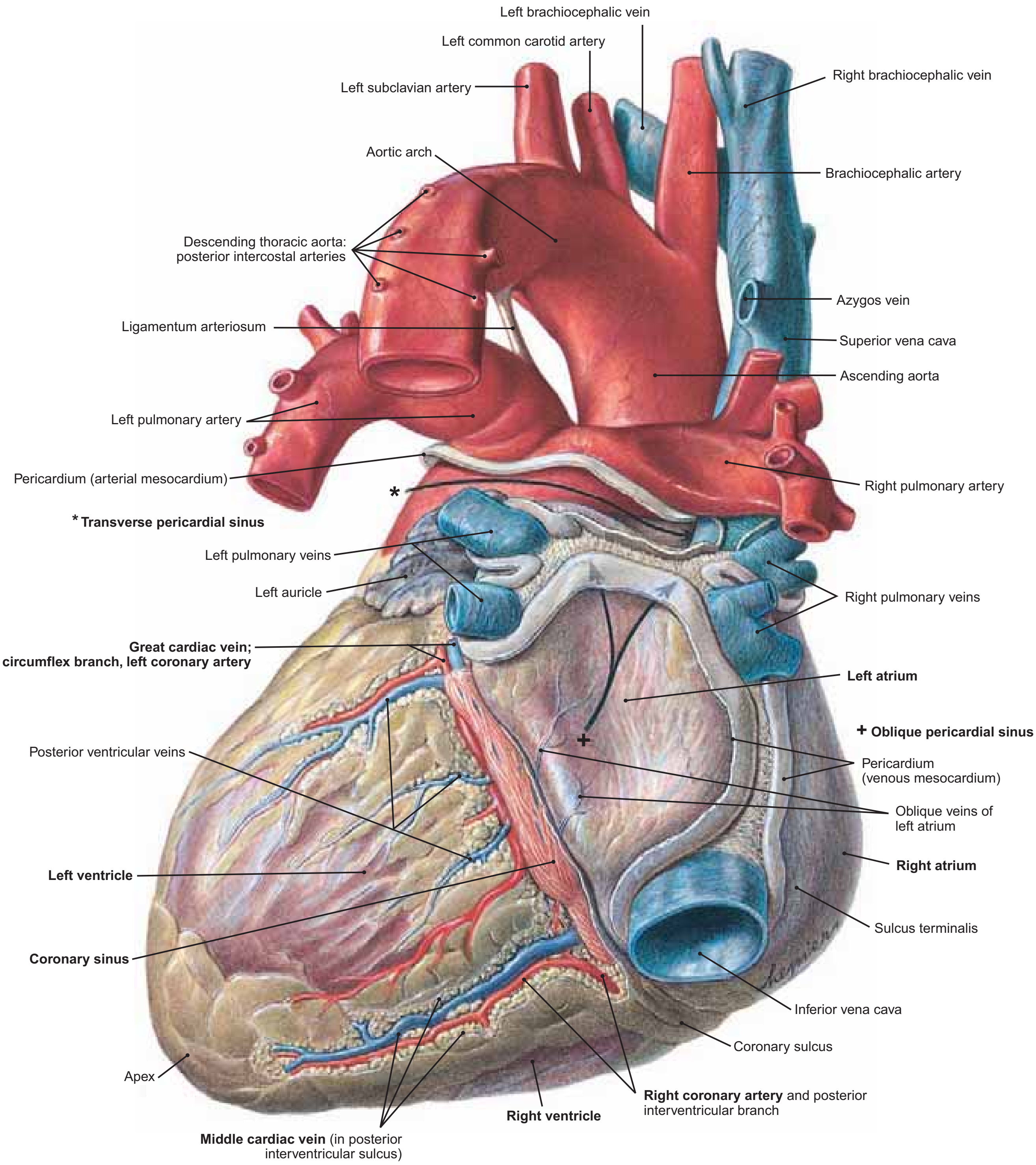


FIGURE 173 Heart and Great Vessels (Posterior View)

NOTE: (1) The two pericardial sinuses. The black horizontal arrow indicates the **transverse pericardial sinus,** which lies between the arterial mesocardium and the venous mesocardium. The vertical diverging double arrows lie in the **oblique pericardial sinus,** the boundary of which is limited by the pericardial reflections around the pulmonary veins.

(2) The transverse sinus can be identified by placing your index finger behind the pulmonary artery and aorta with the heart in place. The oblique sinus is open inferiorly and can be felt by cupping your fingers behind the heart and pushing upward; superiorly this sinus forms a closed cul-de-sac.

(3) The **coronary sinus** is a large vein, and it separates the posterior atrial and ventricular surfaces. The posterior atrial surface consists principally of the left atrium, into which flow the pulmonary veins, but also note the right atrium and its superior vena cava below and to the right.

(4) The posterior ventricular surface is formed principally by the left ventricle, and this surface lies over the diaphragm.

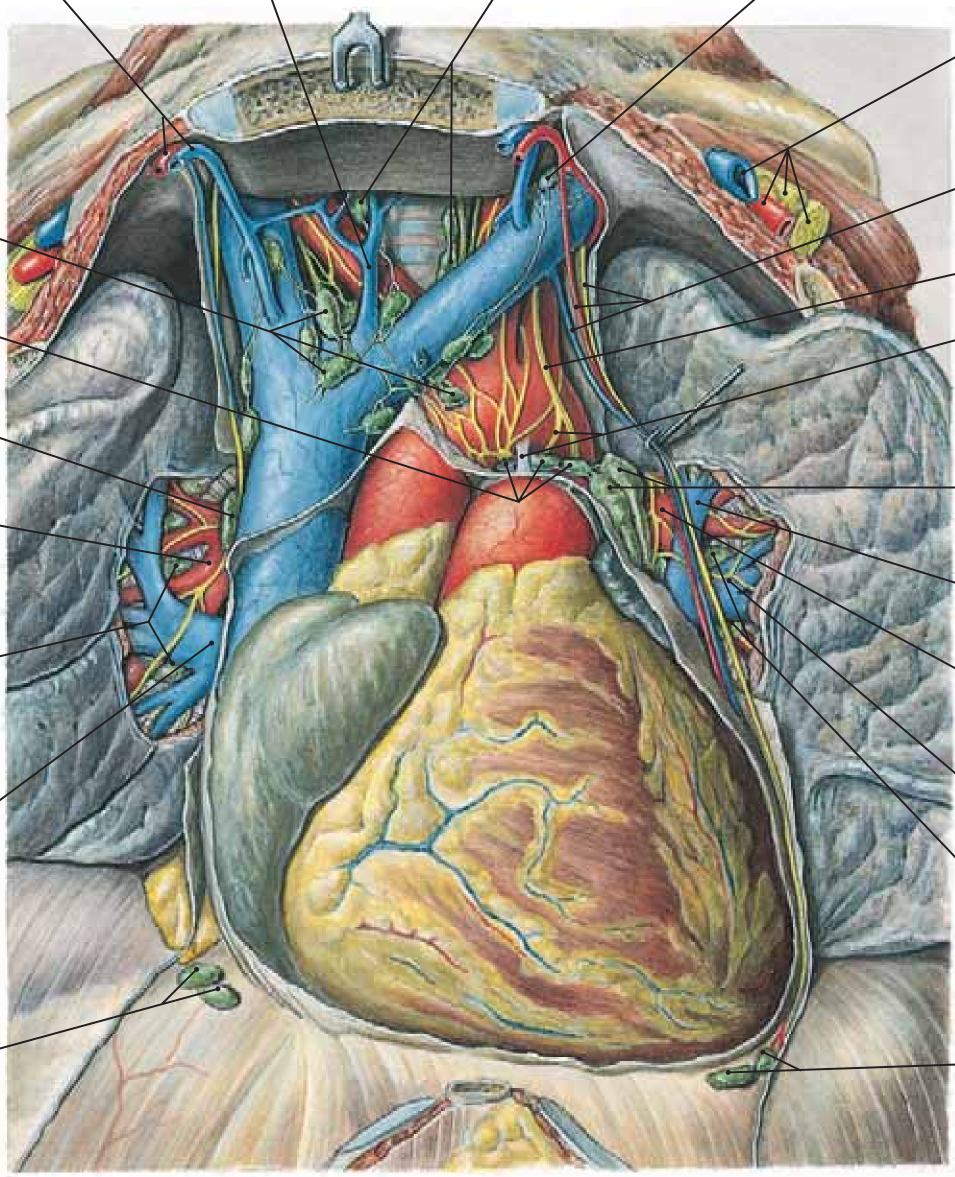


FIGURE 174 Lymphatics of the Thorax (Anterior Aspect)

NOTE: (1) The anterior thoracic wall was removed, along with the ventral portion of the fibrous pericardium. The anterior borders of the lungs have been pulled laterally to reveal the lymph nodes at the roots of the lungs.

(2) Removal of the thymus and its related fat and reflection of the manubrium superiorly exposes the organs at the thoracic inlet and their associated lymphatics.

(3) Lymph nodes in the anterior part of the thorax may be divided into those associated with the thoracic cage (parietal) and those associated with the organs (visceral). Probably all the nodes indicated in this figure are visceral nodes.

(4) Situated ventrally are the **anterior mediastinal nodes,** which include a superior group, which lies ventral to the brachiocephalic veins and a more centrally located group that lies ventral to the arch of the aorta. Inferiorly, anterior diaphragmatic nodes are sometimes also classified as part of the anterior mediastinal nodes.

(5) Large numbers of lymph nodes are associated with the trachea, the bronchi, and the other structures at the root of the lung. These nodes have been aptly named **tracheal, tracheobronchial, bronchopulmonary,** and **pulmonary.**

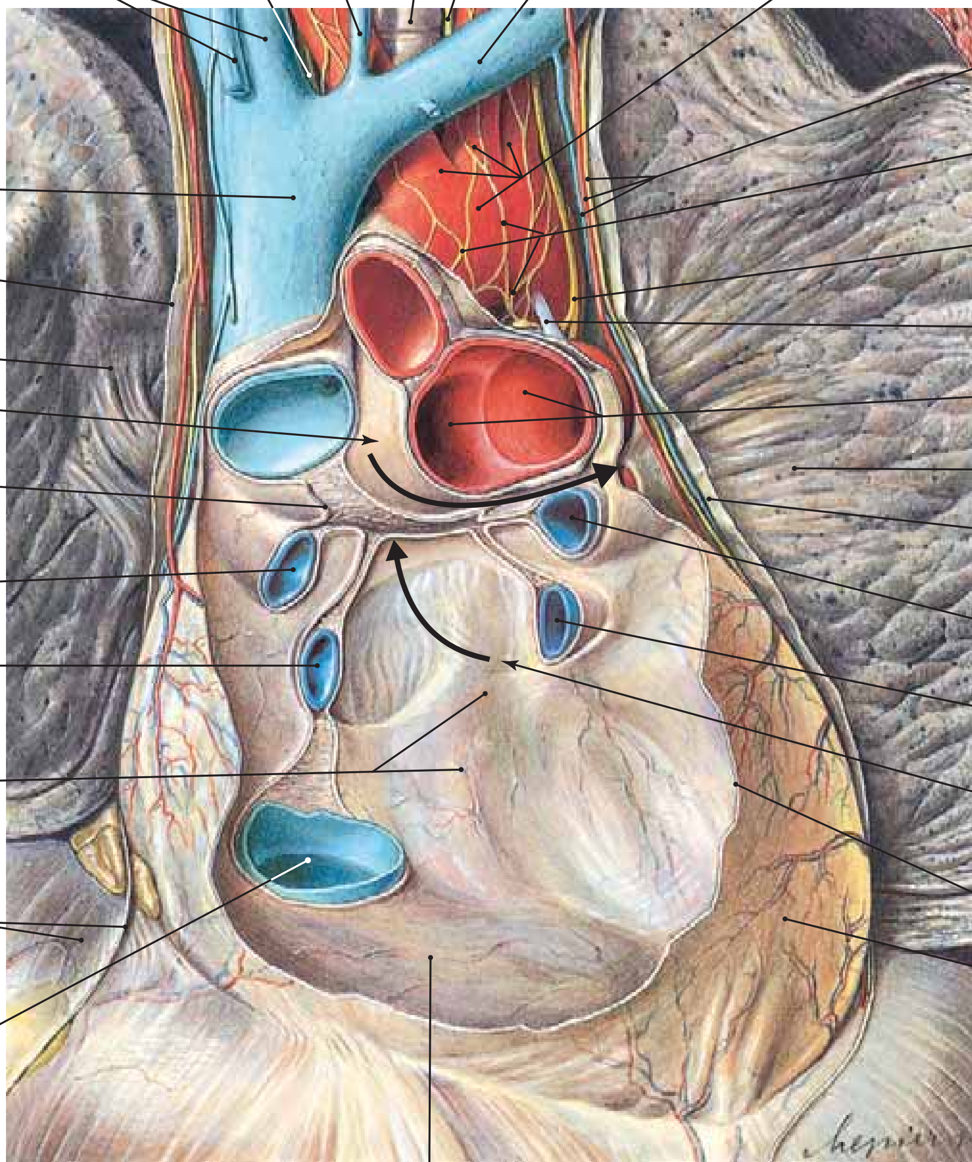


FIGURE 175 Interior of the Pericardium (Anterior View)

NOTE: (1) The pericardium has been opened anteriorly, and the heart has been severed from its attachment to the great vessels and removed. Eight vessels have been cut: the superior and inferior venae cavae, the four pulmonary veins, the pulmonary artery, and the aorta.

(2) The **oblique pericardial sinus** is located in the central portion of the posterior wall of the pericardium and is bounded by the pericardial reflections over the pulmonary veins and the venae cavae (venous mesocardium).

(3) With the heart in place and the pericardium opened anteriorly, the oblique pericardial sinus may be palpated by inserting several fingers behind the heart and probing superiorly until the blind pouch (cul-de-sac) of the sinus is felt.

(4) The **transverse pericardial sinus** lies behind the pericardial reflection surrounding the aorta and pulmonary artery (arterial mesocardium). It may be located by probing with the index finger from right to left immediately behind the pulmonary trunk.

(5) The site of bifurcation of the pulmonary trunk beneath the arch of the aorta and the course of the **left recurrent laryngeal nerve** beneath the **ligamentum arteriosum.**

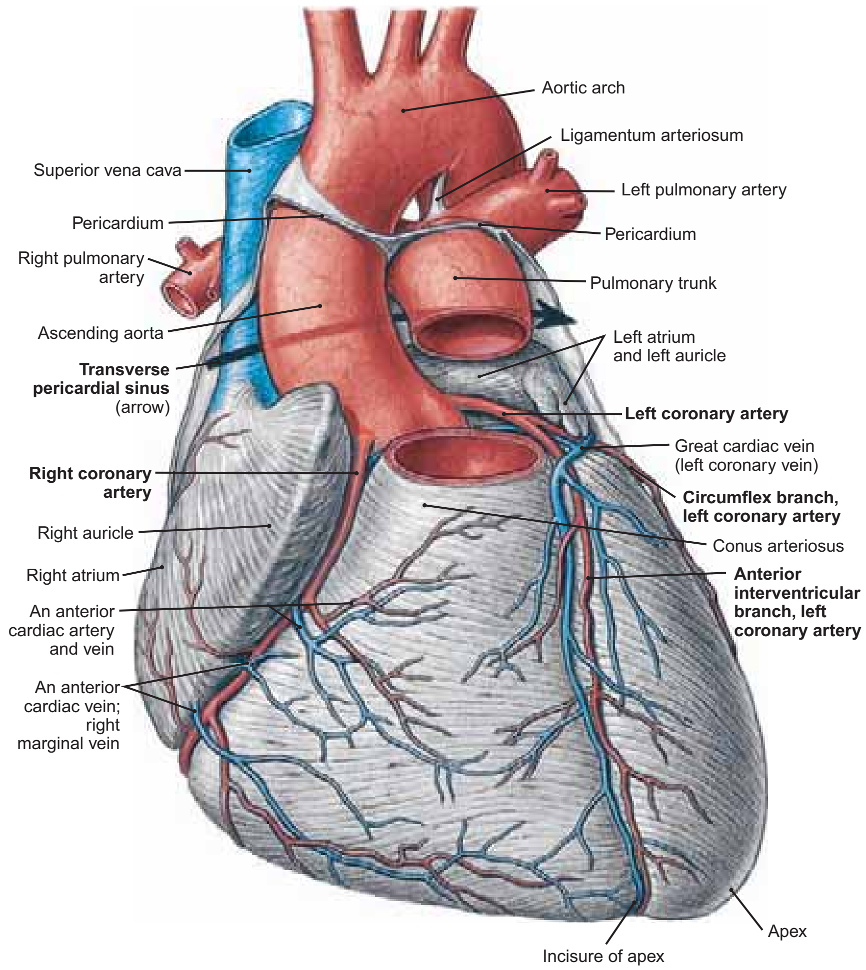


FIGURE 176.1 Coronary Vessels (Anterior View)

NOTE: (1) Both the left and right coronary arteries arise from the ascending aorta. The **left coronary** is directed toward the left and soon divides into an **anterior interventricular branch,** which descends toward the apex, and a **circumflex branch,** which passes posteriorly to the back of the heart.

(2) The **right coronary** is directed toward the right and passes to the posterior heart within the coronary sulcus. In its course, branches from the right coronary supply the anterior surface of the right side (anterior cardiac artery). Its largest branch is the **posterior interventricular artery,** which courses toward the apex on the posterior or diaphragmatic surface of the heart.

(3) The principal veins of the heart drain into the **coronary sinus,** which flows into the right atrium. The distribution and course of the veins is similar to the arteries (see Figs. 177.1 and 177.2).

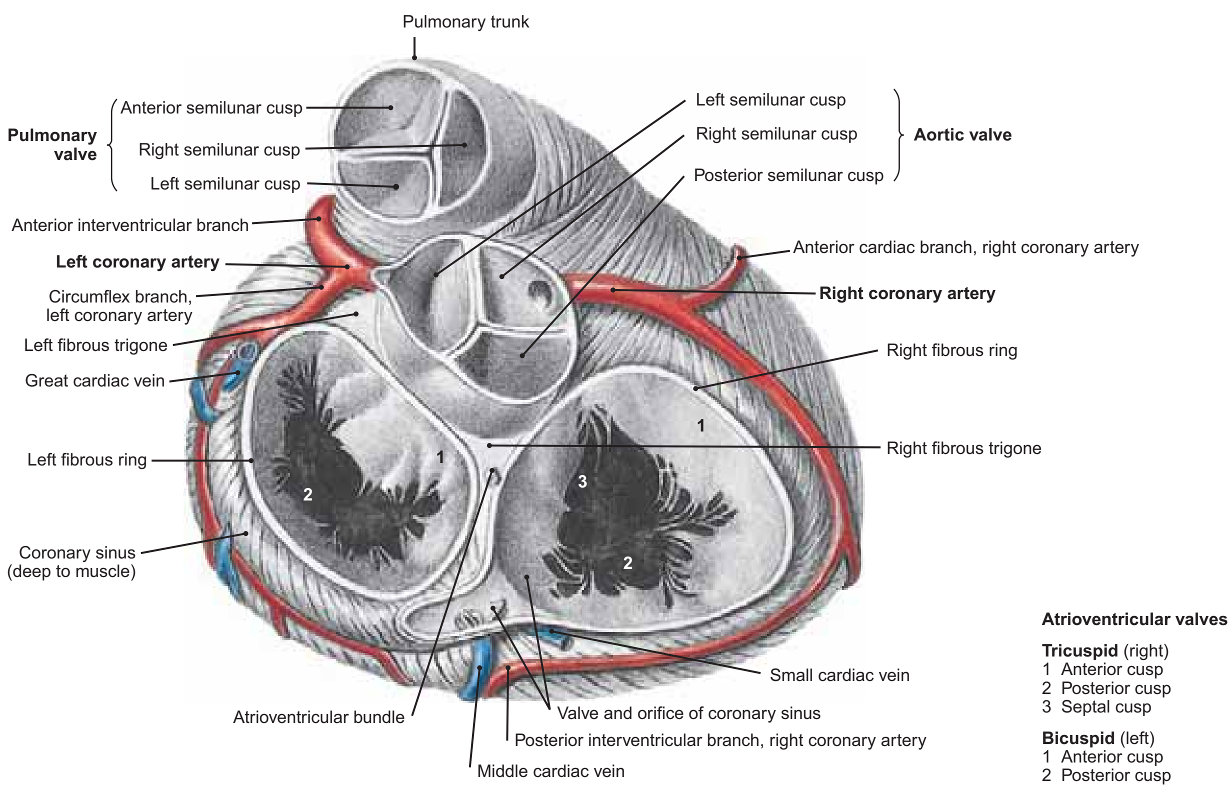


FIGURE 176.2 Valves of the Heart and the Origin of the Coronary Vessels (Superior View)

NOTE that the left coronary artery arises from the aortic wall in the left aortic sinus behind the left semilunar cusp, and the right coronary artery stems from the aorta behind the right aortic sinus and right semilunar cusp.

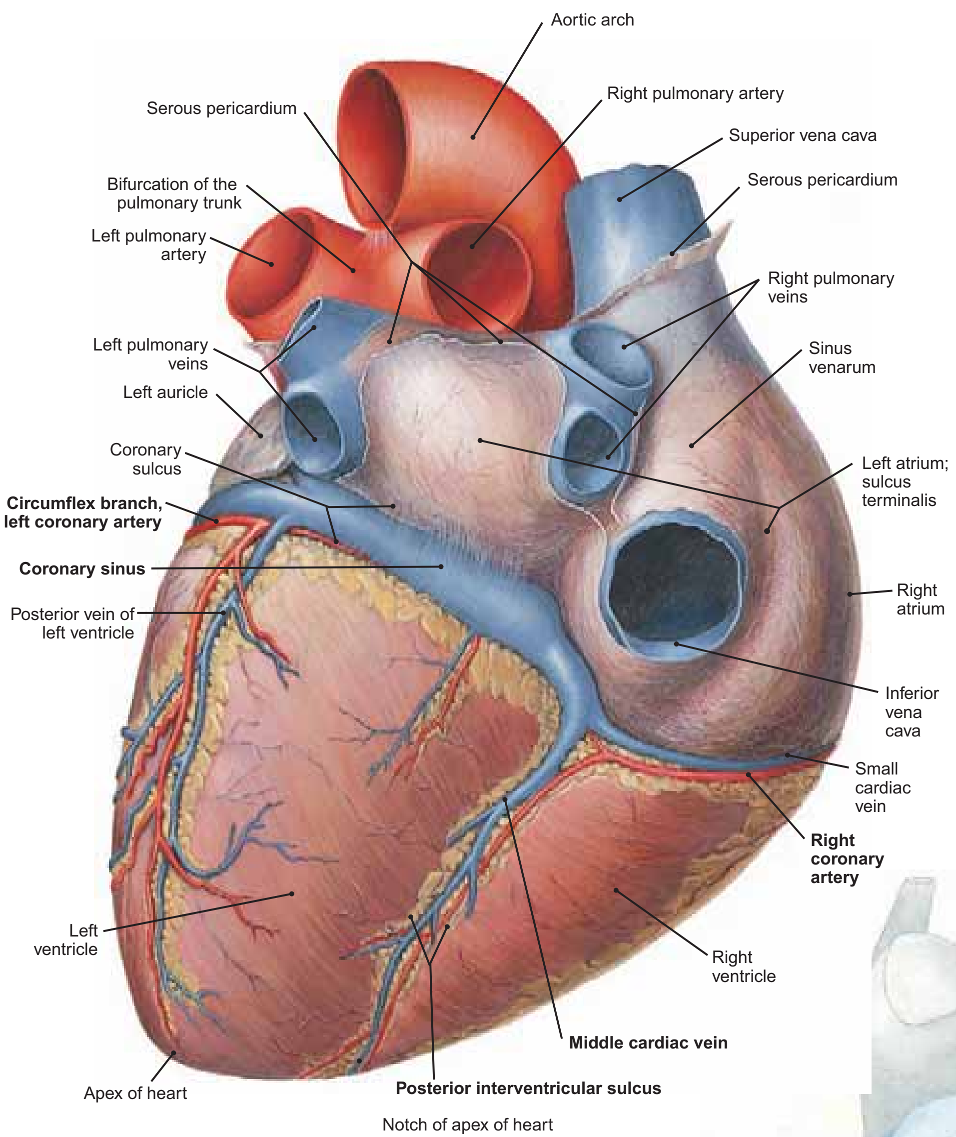


FIGURE 177.1 Coronary Vessels, Diaphragmatic Surface of the Heart

NOTE: (1) Both the left and right coronary arteries course around to the posterior or diaphragmatic surface of the heart to supply the left and right ventricles in that region.

(2) The posterior interventricular artery is usually a branch of the right coronary, and it courses with the middle cardiac vein in the posterior interventricular sulcus.

(3) The left coronary artery contributes one or more posterior ventricular arteries.

(4) The two coronary arteries anastomose on this posterior surface of the heart, and their anterior and posterior interventricular branches anastomose at the apex.

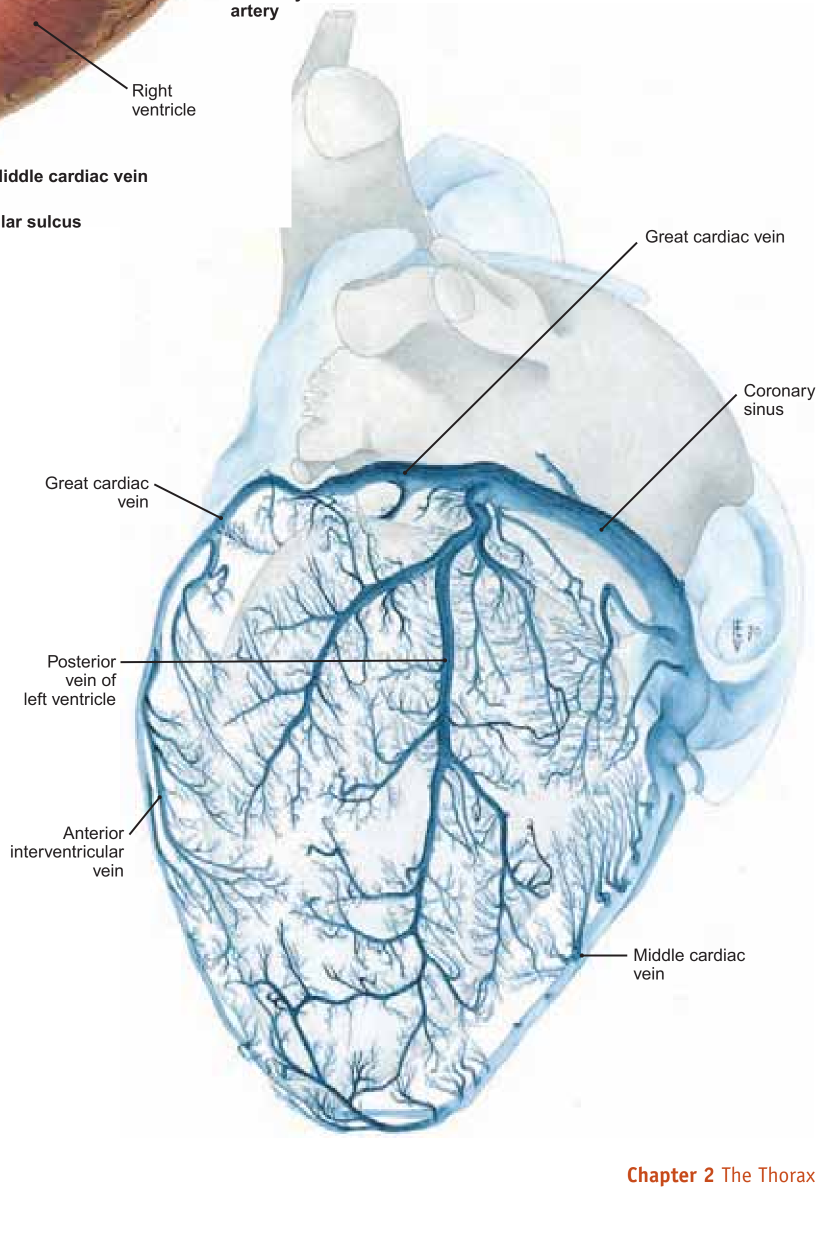


FIGURE 177.2 Venous Drainage of the Ventricles: Coronary Sinus

NOTE: (1) The left side and left margin of the heart are oriented forward such that the anterior interventricular vein is seen on the left and the middle cardiac vein is seen on the right.

(2) The anterior **interventricular** vein becomes the **great cardiac vein.** As the great cardiac vein courses in the coronary sulcus, it gradually enlarges to form the **coronary sinus** and receives the **posterior vein of the left ventricle.** The **middle cardiac vein,** which runs in the posterior interventricular sulcus, also drains directly into the coronary sinus.

(3) The coronary sinus opens into the right atrium.

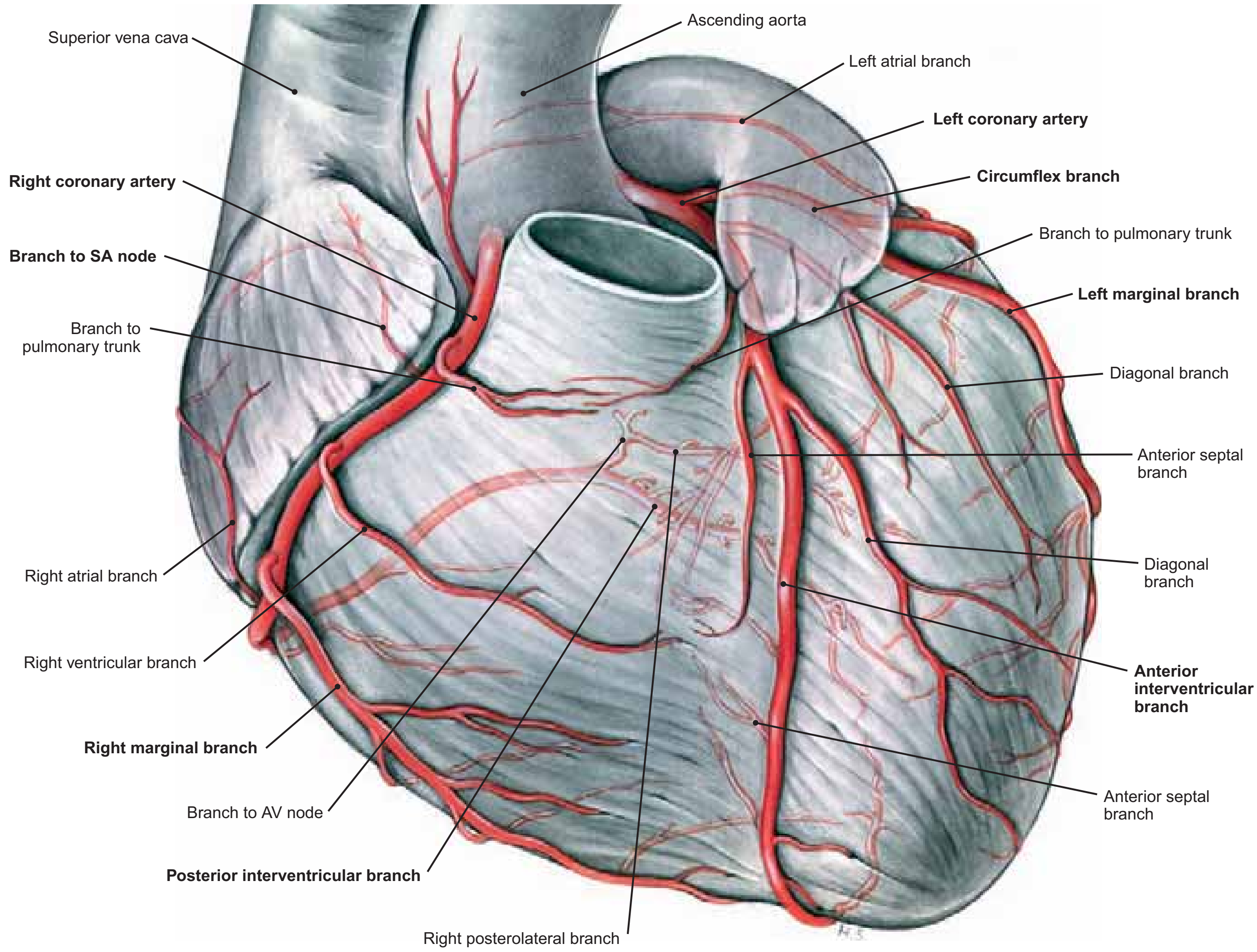
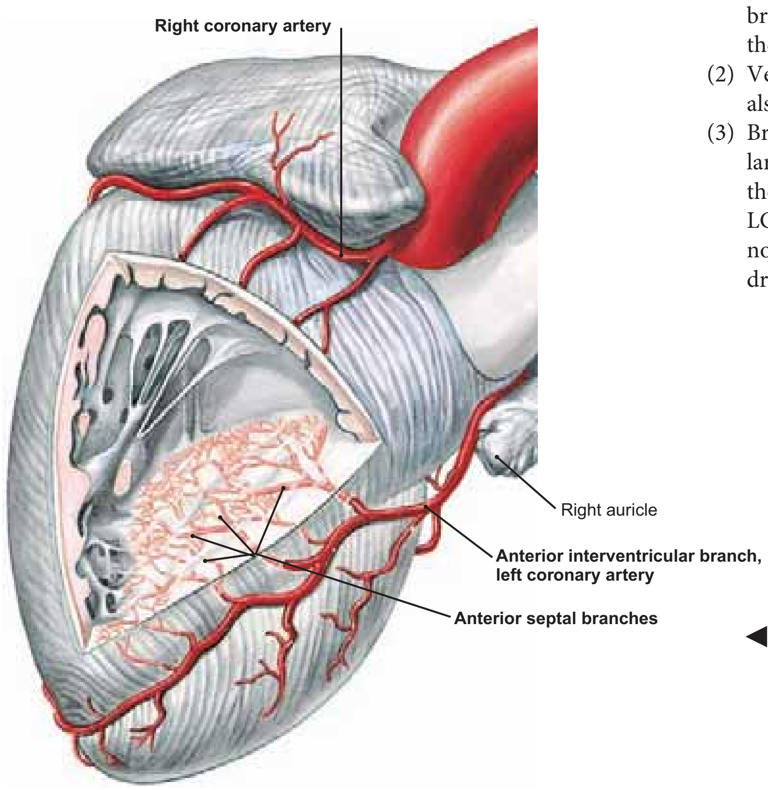


FIGURE 178.1 Complete Coronary Arterial System ▲

NOTE: (1) Anastomoses between branches from the left and right coronary arteries (LCA and RCA) are visible in the substance of the posterior wall of the heart. These occur between the posterior interventricular branch of the RCA and the anterior interventricular branch of the LCA, which continues around the apex of the heart to the posterior wall.

(2) Vessels from the circumflex and left marginal branches of the LCA also anastomose with branches from the RCA in the posterior wall.

(3) Branches supplying the sinoatrial (SA) node and the atrioventricular (AV) node arise from the RCA. In about 35% of cases, however, the artery to the SA node comes from the circumflex branch of the LCA. Similarly, in about 20% of specimens, the vessel to the AV node is derived from the circumflex branch of the LCA. (From a drawing by Professor Helmut Ferner at the University of Vienna.)



◀ FIGURE 178.2 Blood Supply to the Interventricular Septum

Note that the **anterior septal branches** of the anterior interventricular artery course backward and downward to supply the interventricular septum.

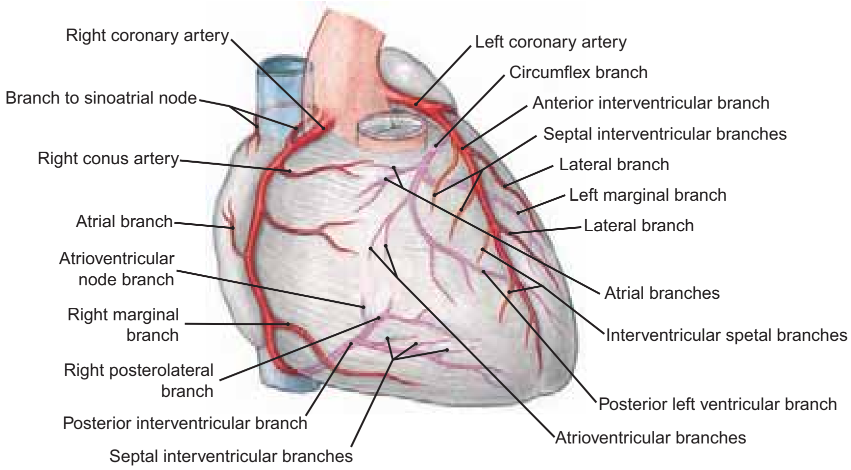


FIGURE 179A Balanced Distribution of the Left and Right Coronary Arteries

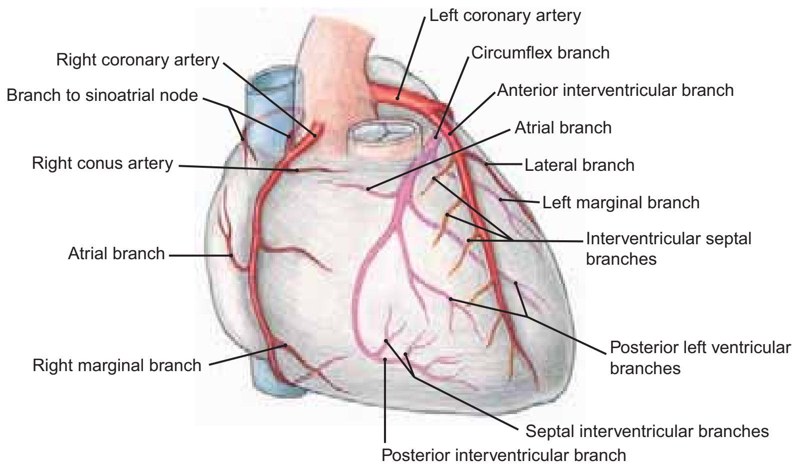


FIGURE 179B Left Dominant Distribution of the Coronary Arteries

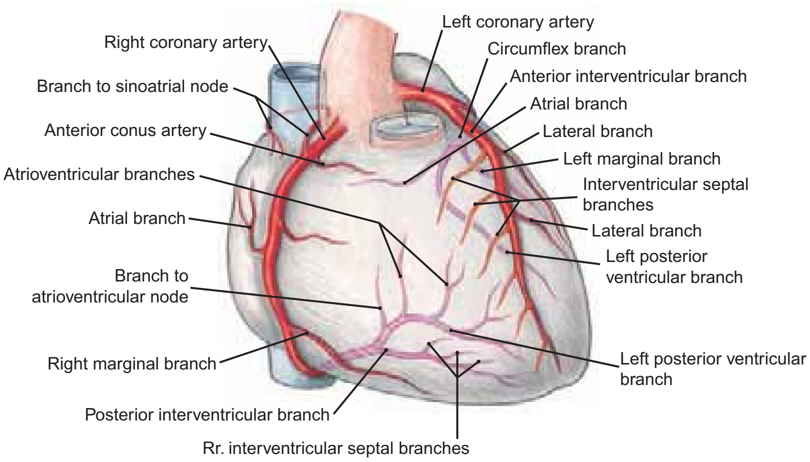


FIGURE 179C Right Dominant Distribution of the Coronary Arteries

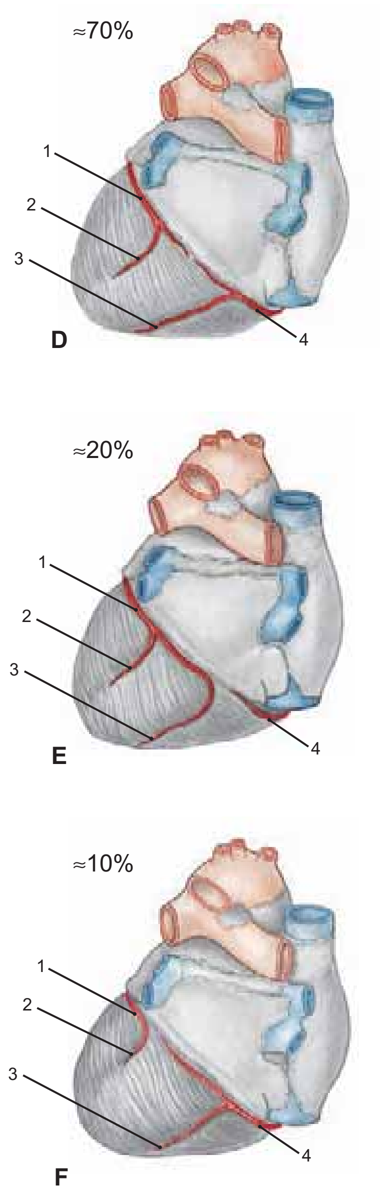


FIGURE 179D–F Variations in the Arterial Supply on the Posterior Wall of the Heart (Dorsal View)

1. Circumflex branch (left coronary artery)
2. Left posterior ventricular branch (left coronary artery)
3. Posterior ventricular branch of right coronary artery
4. Right coronary artery

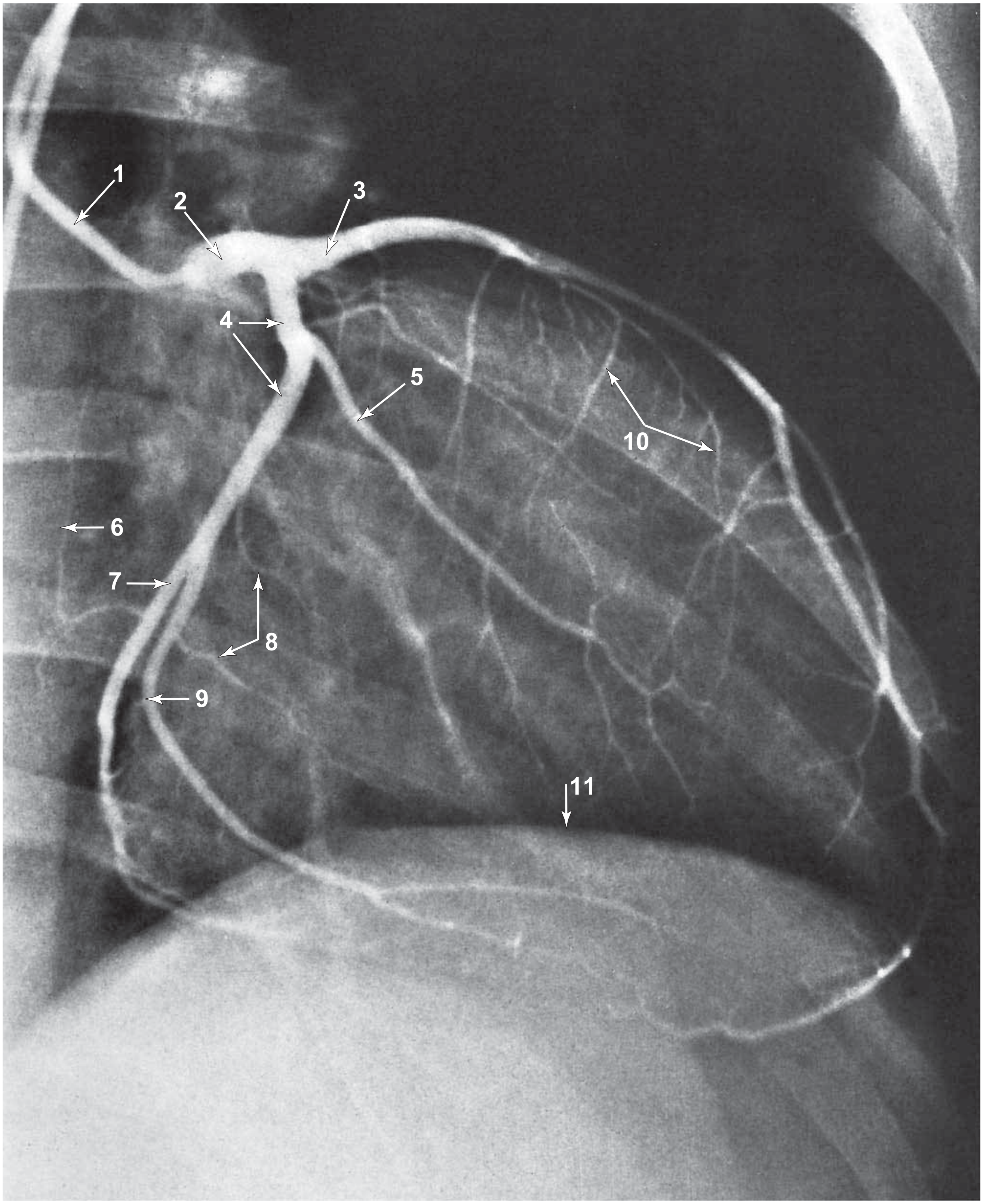


FIGURE 180 Left Coronary Arteriogram

NOTE that this arteriogram of the left coronary artery is viewed from a right anterior oblique direction.

1. Catheter
2. Left coronary artery
3. Anterior interventricular branch
4. Circumflex branch
5. Left marginal branch of circumflex
6. Posterior atrial branch
7. Left posterolateral branch of circumflex
8. Posterior ventricular branches
9. Posterior interventricular branch
10. Septal branches
11. Diaphragm

(From Wicke, 6th ed.)

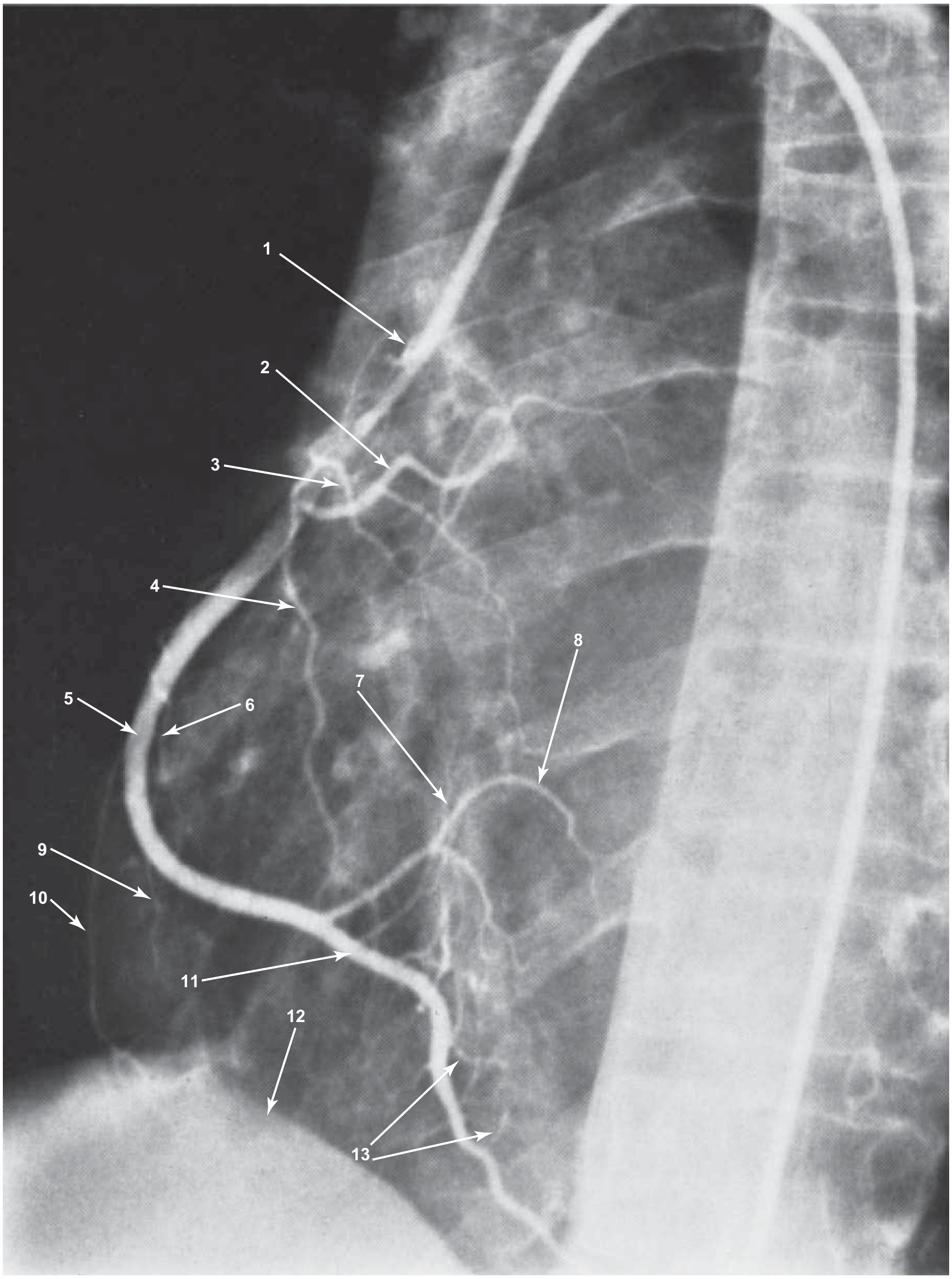


FIGURE 181 Right Coronary Arteriogram

NOTE that this arteriogram of the right coronary artery is viewed from the left anterior oblique direction.

1. Catheter
2. Sinoatrial node branch
3. Conus arteriosus branch
4. Anterior ventricular branch
5. Right coronary artery
6. Anterior ventricular branch
7. Atrioventricular node branch
8. Posterior ventricular branch
9. Posterior ventricular branch
10. Right marginal branch
11. Posterior interventricular branch
12. Diaphragm
13. Posterior septal branches

(From Wicke, 6th ed.)

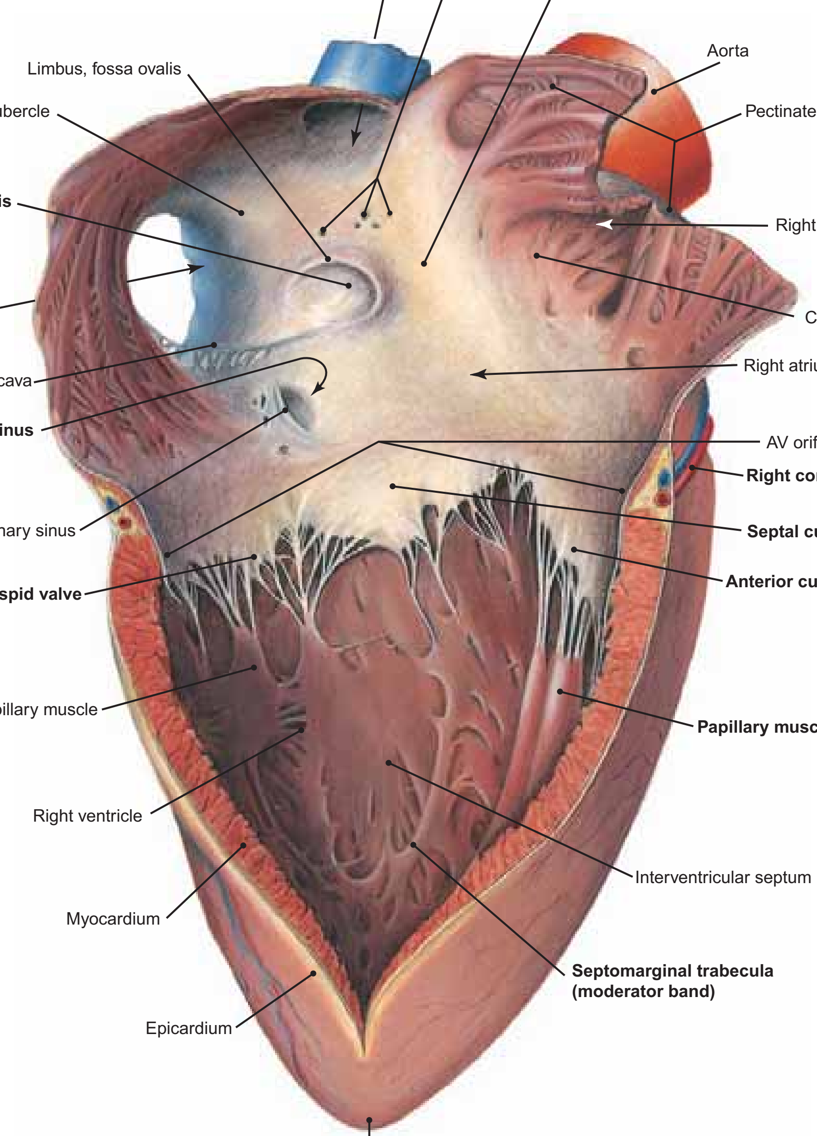


FIGURE 182 Right Atrium and Right Ventricle

NOTE: (1) The right atrium consists of (a) a smooth area (at times called the **sinus venarum**) located between the openings of the superior vena cava and the inferior vena cava and (b) the **right auricle,** which is marked by parallel muscle ridges called the **pectinate muscles.**

(2) Opening into the right atrium are the **superior vena cava,** the **inferior vena cava,** the **coronary sinus,** and the small **venarum minimarum** (Thebesian veins).

(3) Crescent-shaped valves are found at the right atrial openings of both the inferior vena cava and the coronary sinus.

(4) The right atrioventricular (AV) opening is surrounded by the three cusps of the **tricuspid valve.** These are called the **anterior, posterior,** and **septal** cusps, and they are attached to the heart wall by way of the **chordae tendineae** and papillary **muscles.**

(5) The thickness of the right ventricular wall (4–5 mm) is about one-third that of the left ventricle. Normal right ventricular systolic blood pressure ranges between 25 and 30 mm Hg, and it is also much less than normal left ventricular systolic pressure, which ranges between 120 and 140 mm Hg.

(6) The **septomarginal trabecula** (moderator band) within which courses the right crus, or branch, of the **atrioventricular bundle** (of His).

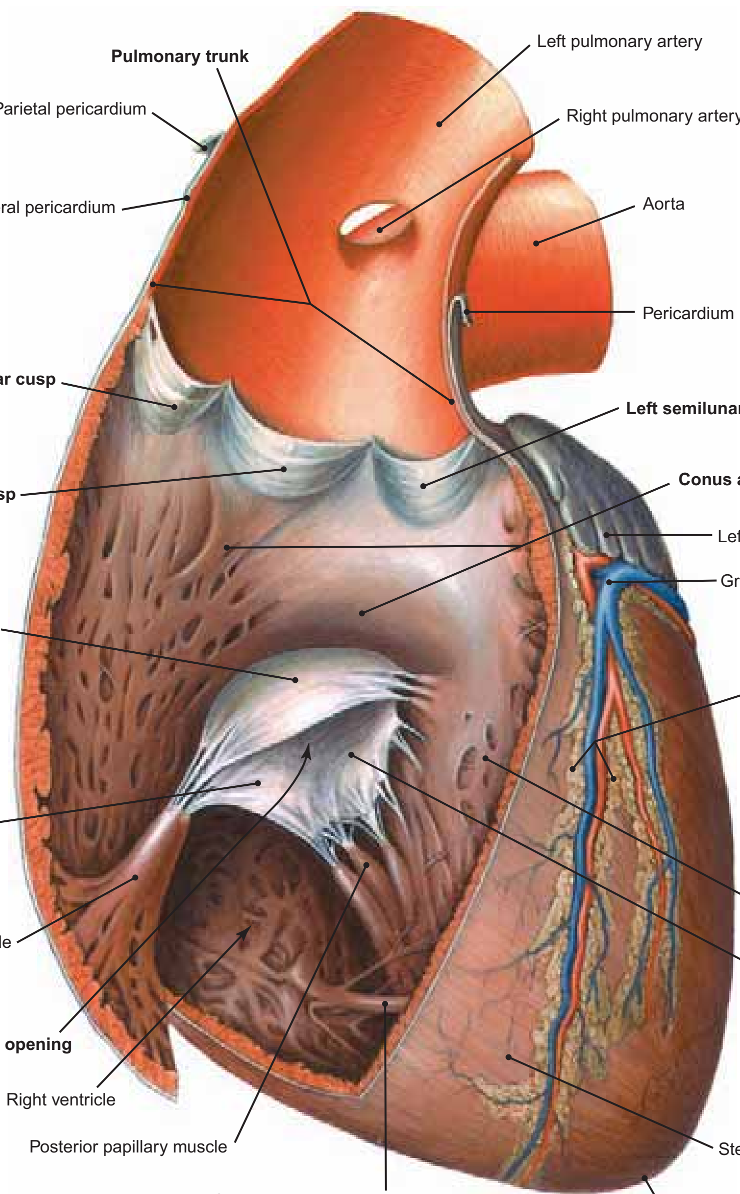


FIGURE 183 **Right Ventricle and Pulmonary Trunk**

NOTE: (1) The musculature of the right ventricle has been cut along a V-shaped incision, thereby forming a flap in the anterior wall of the ventricle. As the flap is reflected to the right, the origin of the **pulmonary trunk** and the cusps of its valve are exposed.

(2) The three semilunar pulmonary cusps—the **right, left,** and **anterior** semilunar pulmonary cusps—are interposed between the right ventricle and the pulmonary artery. Together they comprise the **pulmonary valve.**

(3) The **septal, anterior,** and **posterior cusps** form the **right atrioventricular** (AV) or **tricuspid valve.** Note their attachments to the papillary muscles.

(4) The smooth surface of the right ventricular wall at the site of origin of the pulmonary trunk. This is called the **conus arteriosus** of the right ventricle.

(5) The attachment and shape of the tricuspid valve allow the cusps to open into the right ventricle when blood pressure in the atrium exceeds that in the ventricle. At some point during the cardiac cycle, ventricular pressure exceeds atrial pressure, and the cusps close. Blood is prevented from regurgitating into the atrium because the perimeter of the cusps is secured to the heart wall and the free edges of the cusps are attached to the papillary muscles in the ventricle below.

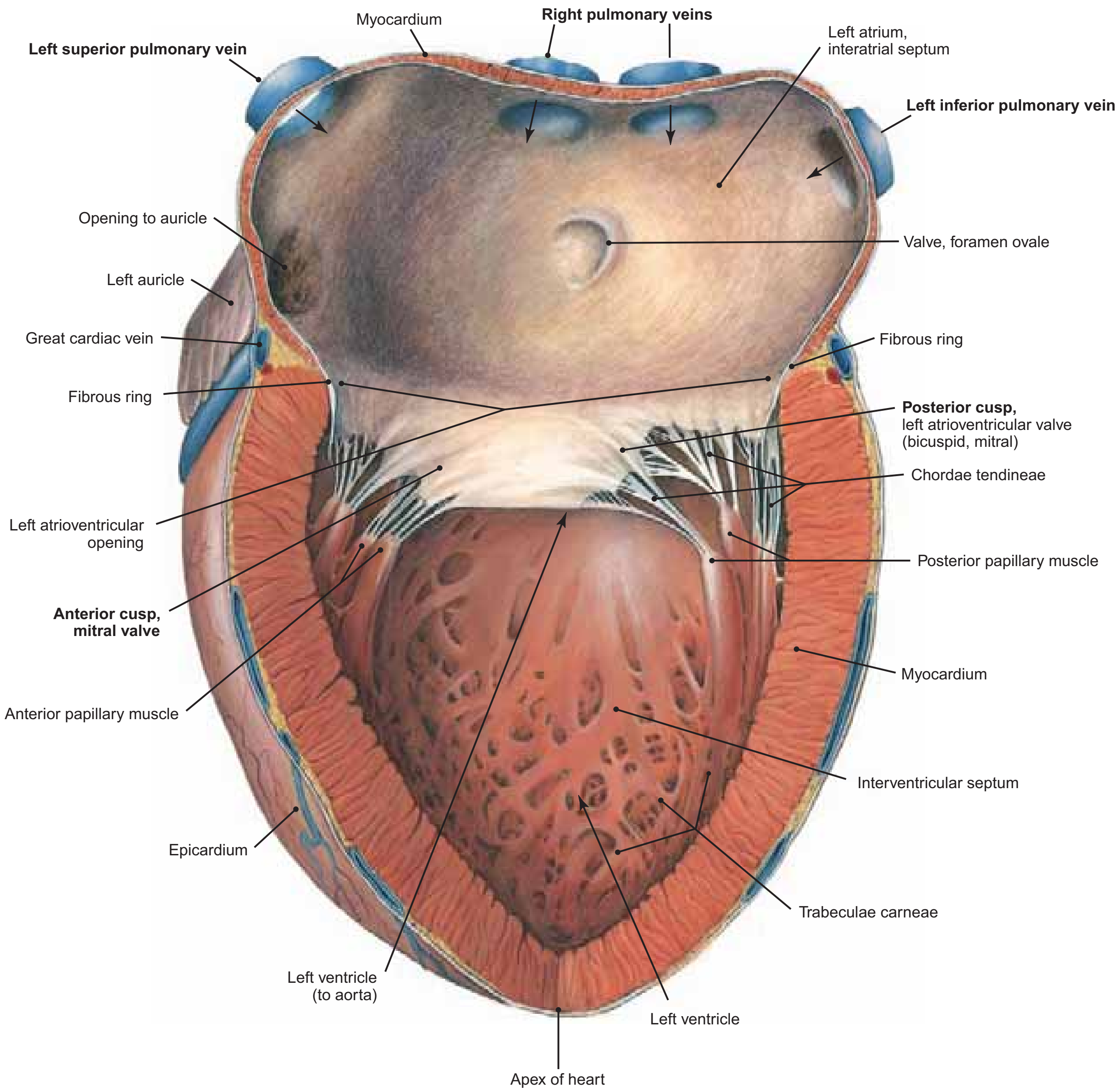


FIGURE 184 Left Atrium and Left Ventricle (Internal Surface)

NOTE: (1) In this specimen, the heart has been opened to expose the inner surface of the left atrium and left ventricle. Likewise, the left atrioventricular opening has been cut behind the **posterior cusp of the mitral valve,** thereby making that cusp visible.

(2) The left atrium receives the four **pulmonary veins** (two from each lung), while the left ventricle leads into the aorta (arrow).

(3) The **interatrial septum** on the left side is marked by the valve of the foramen ovale (falx septi), which represents the remnant of the **septum primum** during the development of the interatrial septum. The crescent-shaped structure around the border of the valve is the limbus of the fossa ovalis and is the remnant of the **septum secundum.**

(4) The mitral valve consists of **anterior** and **posterior cusps**. The cusps are attached to the left ventricular wall by means of chordae tendineae and papillary muscles in a manner similar to that seen in the right ventricle.

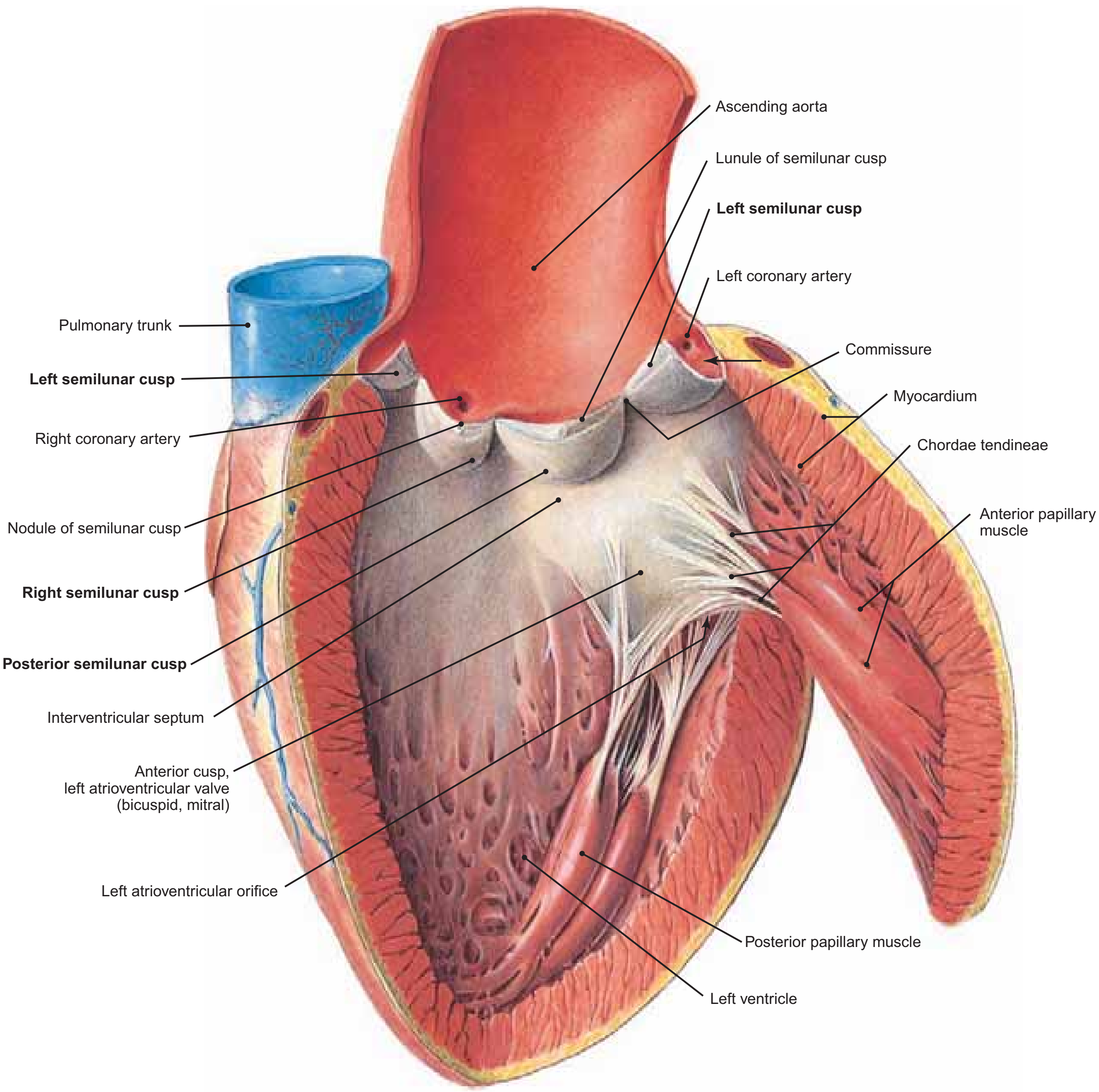


FIGURE 185 **Opened Left Ventricle and Aorta**

NOTE: (1) In this dissection, the left ventricle was opened first to show the anterior and posterior papillary muscles that are related to the cusps of the left AV valve. A second cut was then made in the wall of the left ventricle (near the interventricular septum) that extends through the aortic opening to show the cusps of the **aortic valve.**

(2) The opening of the left coronary artery in the aortic wall behind the (cut) left **semilunar cusp.** Also see the opening of the right coronary artery behind the **right semilunar cusp.** The **posterior cusp** of the aortic valve is the noncoronary cusp.

(3) Between the cusps and the wall of the aorta are pockets called the **aortic sinuses.** These trap blood during the cardiac cycle, thereby closing the valve.

(4) Each cusp is marked by a thickened fibrocartilaginous **nodule** at the center of its free margin. Extending out from the nodule on each side of the cusp are clear crescentic areas of thinning of the free edges called **lunulae,** while the points at which two adjacent cusps come together are called **commissures.**

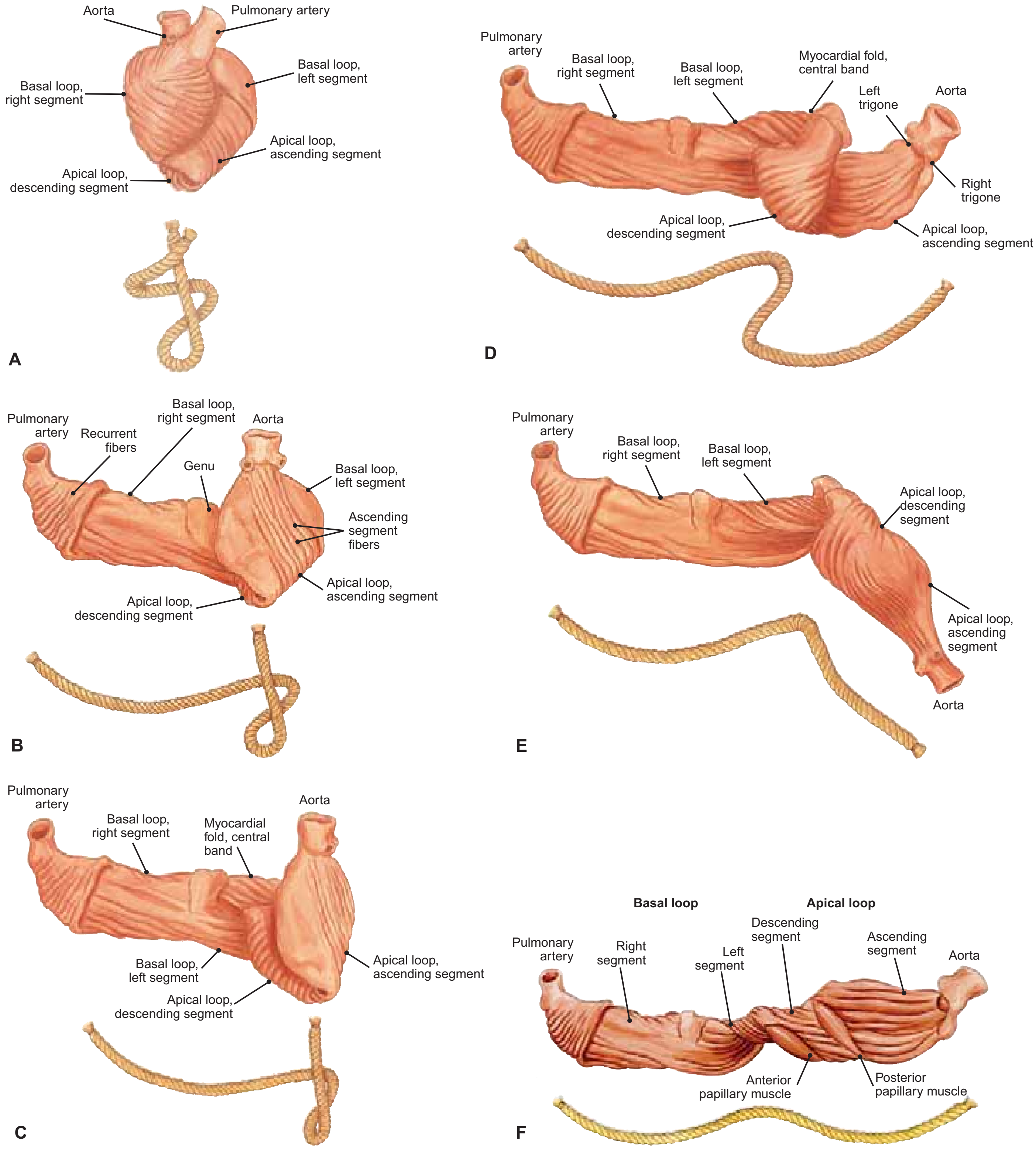
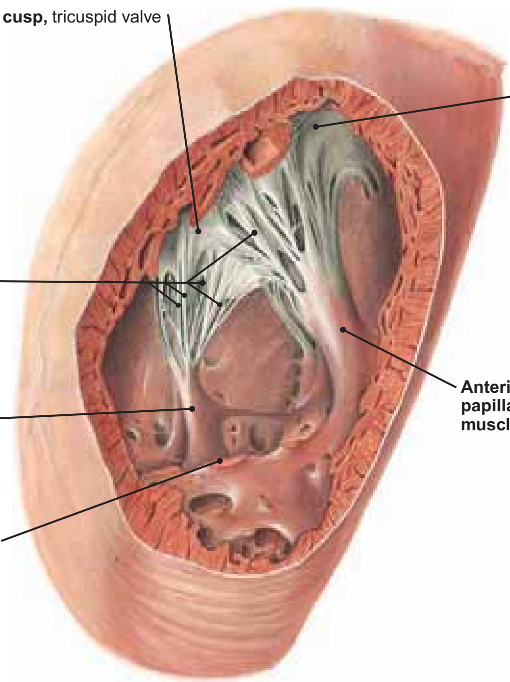
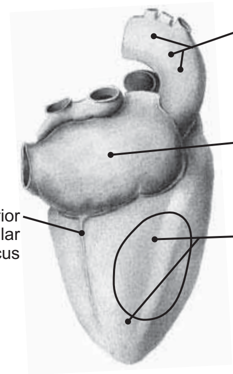


FIGURE 186A–F Progressive Unscrolling of the Cardiac Muscle that Forms the Heart (from F. Torrent-Guasp)

NOTE: (1) Upon unscrolling the muscle that forms the heart, the unfolded myocardium has a rope-like configuration (shown by the rope model) comprising a **transverse basal loop,** with fibers running almost horizontally, and a **longitudinal apical loop,** with fibers that course almost vertically from apex to base. **Figure 186A** shows the intact heart. **Figure 186B** shows that detachment of the right ventricular free wall exposes the transverse orientation of the basal loop fibers. The pulmonary outflow tract is limited by **recurrent fibers** coming from the right free wall. These bend all along the anterior interventricular groove to ascend toward the ventricular base. A **genu** at the basal extreme of the posterior interventricular sulcus separates the right and left ventricles or segments of the basal loop.

(2) **Figure 186C:** Further unfolding of the basal loop displays the **left basal segment,** beyond the genu (left), and exposes the central band **myocardial fold** by which fibers of the left segment, subendocardially, become nearly vertical fibers of the descending segment. These course deeper, subendocardially, toward the region of the apex, where they reflect and ascend to become the ascending segment fibers that connect to the aorta. In **Figure 186D,** both **trigones of the aorta** are detached and the ascending segment is unfolded and moved laterally, thereby demonstrating the deeper descending segment of the apical loop. **(Continued on next page.)**





Location of the window cut in Fig. 187.1

FIGURE 187.1 Right Ventricle: View of the Tricuspid Valve

NOTE: (1) The anterior and posterior cusps (two of the three) of the tricuspid valve and their attached papillary muscles are exposed.

(2) The **anterior papillary muscle** arises from the anterior and septal walls and attaches to both the anterior and posterior cusps, while the **posterior papillary muscle** arises from the anterior and septal walls and attaches to both the anterior and posterior cusps. Observe the septomarginal trabeculae, or moderator bands, that contain the atrioventricular bundle.

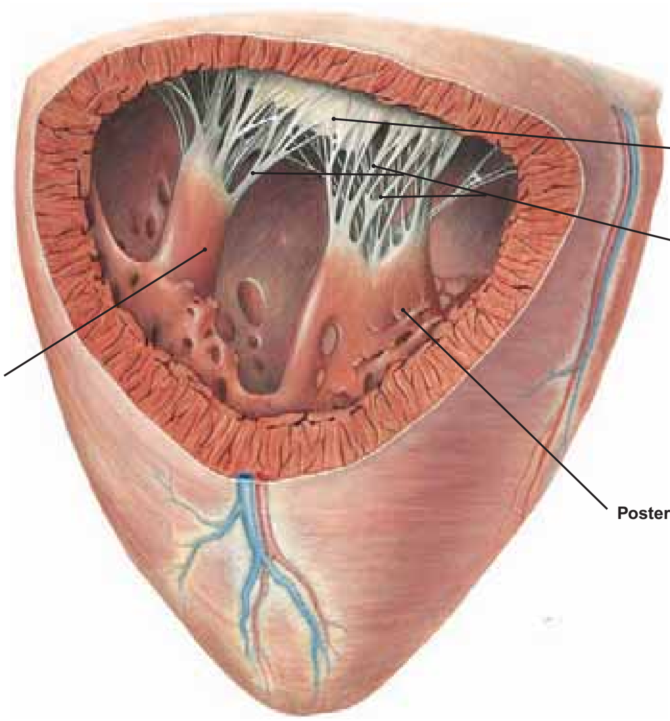


FIGURE 187.2 Left Ventricle: View of the Mitral Valve

NOTE that the **posterior and anterior papillary muscles** attach to the cusps of the mitral valve.

(Continued from the previous page.)

(3) **Figure 186E** shows the further unwrapping of the helix to clarify the apical loop that now is seen to be composed of the outer surfaces of descending and ascending segments. **Figure 186F:** The complete transverse myocardial band is seen with the central muscle twist that separates the basal and apical loops. In this figure can be seen the anterior and posterior papillary muscles in the apical loop. The left component is the transverse basal loop, and the right component is the apical loop. Observe that before this folding, both segments have a transverse orientation. The oblique orientation of the unscrolled descending and ascending segments derives from the spiral architectural folding of the myocardial band between the basal and apical loops. (From Buckberg GD, Clemente CD, Cox JL, Coghlan HC, Castella M, Torrent-Guasp F, Gharib M. The structure and function of the helical heart and its buttress wrapping. IV. Concepts of dynamic function from the normal macroscopic helical structure. Semin Thorac Cardiovasc Surg 2001;14:342–357.)

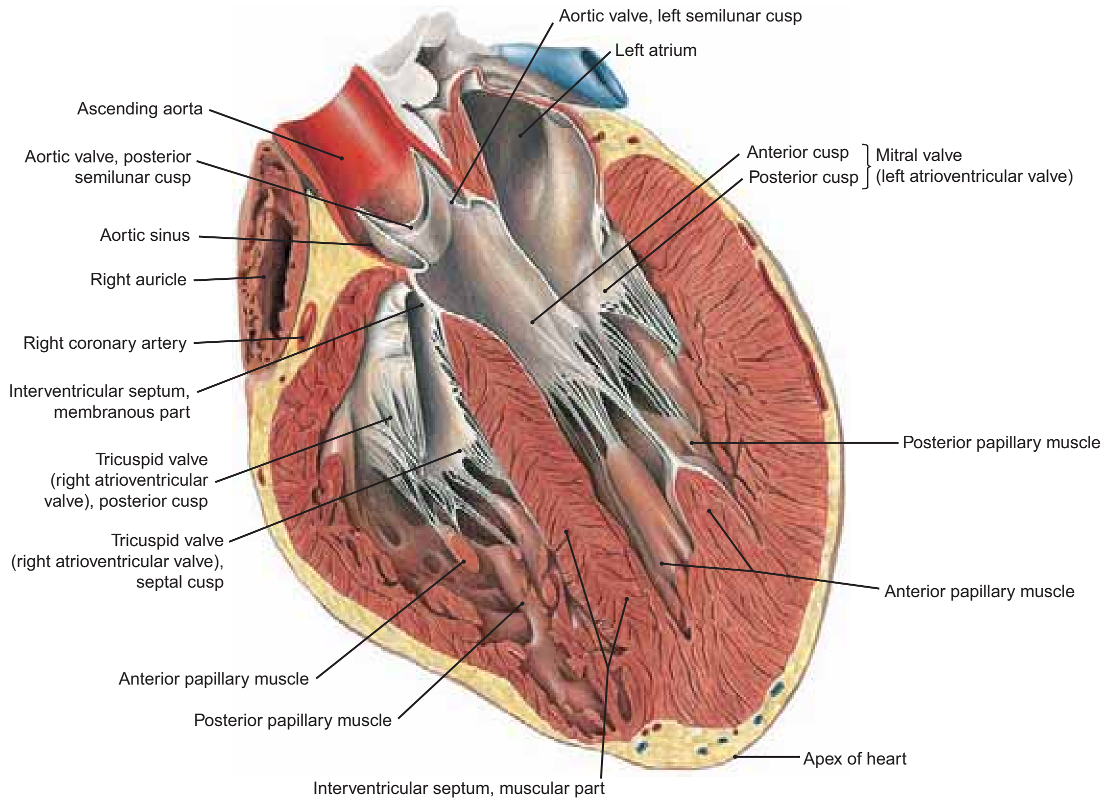


FIGURE 188.1 Frontal Section through the Heart

NOTE: (1) This frontal section exposes both atria and both ventricles.

(2) The right and left atrioventricular valves (tricuspid and mitral valves) and their cusps. Observe the papillary muscles attached to these cusps by way of the chordae tendineae (the latter are not labeled).

(3) The muscular and membranous parts of the interventricular septum. Observe the difference in thickness of the muscular walls of the two ventricles.

(4) The aorta emerging from the left ventricle and the cusps of the aortic valve.

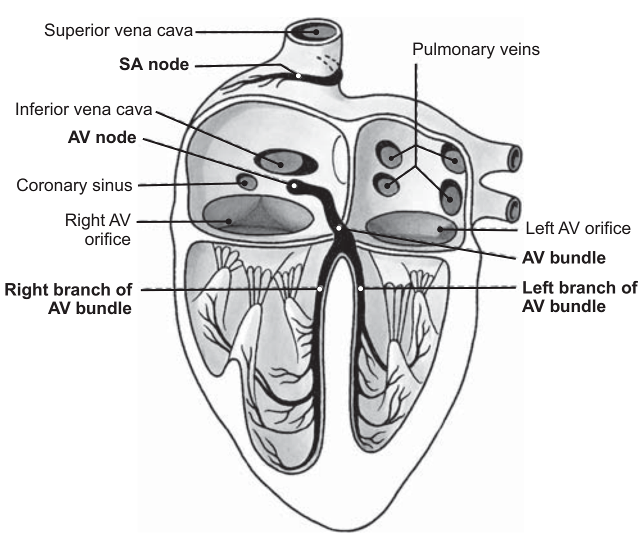


FIGURE 188.2 Diagram of the Conduction System of the Heart

NOTE: (1) The cardiac cycle begins at the SA (sinoatrial) node located in the sulcus terminalis between the superior vena cava and the right atrium.

(2) From this pacemaker, a wave of negativity (excitation) spreads over both atria and initiates atrial contraction, thereby increasing atrial blood pressure.

(3) When atrial pressure exceeds ventricular pressure, both atrioventricular (AV) valves open and blood rushes into both ventricles. Soon the impulse reaches the AV node and is passed along the AV bundle to the two ventricles, causing them to contract.

(4) When ventricular pressure exceeds atrial pressure, the AV valves close, and this can be heard with a stethoscope as the first of the two heart sounds of the heartbeat.

(5) Continued ventricular contraction forces the pulmonary and aortic valves to open, and blood rushes simultaneously into the pulmonary artery and the aorta.

(6) When the pressure in these vessels exceeds ventricular pressure, blood tends to rush back into the ventricles, but it gets trapped in the sinuses behind the semilunar cusps. This closes both the pulmonary and aortic valves, resulting in the second of the two heart sounds heard with the stethoscope.

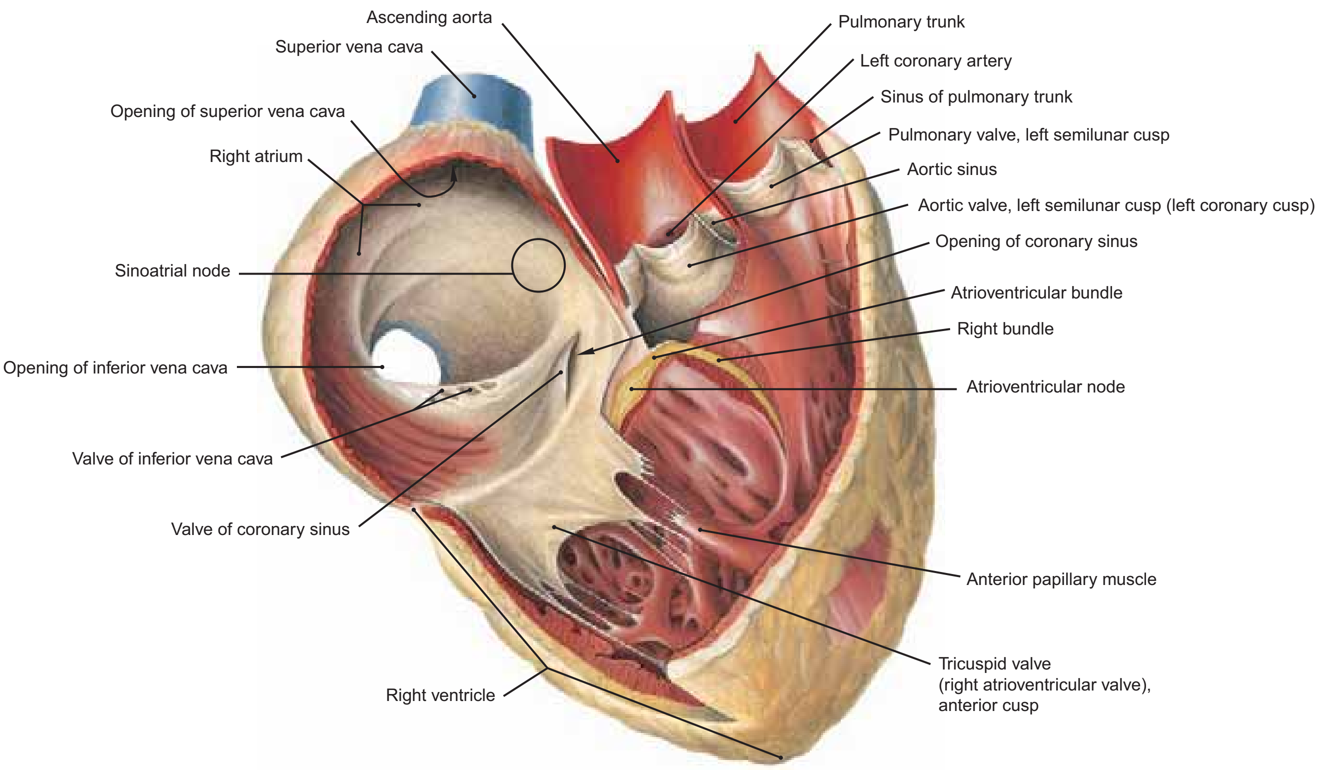


FIGURE 189.1 Atrioventricular Bundle Dissected in the Right Ventricle

NOTE: (1) The atrioventricular (AV) bundle forms a part of the conduction system of the heart. It is formed by modified cardiac muscle fibers called Purkinje fibers. It commences at the AV node in the interatrial septum near the opening of the coronary sinus in the right atrium.

(2) The bundle is then directed toward the interventricular septum, where it divides into right and left branches. The **right** branch, dissected in this figure, courses in the wall of the right ventricle and is distributed toward the apex.

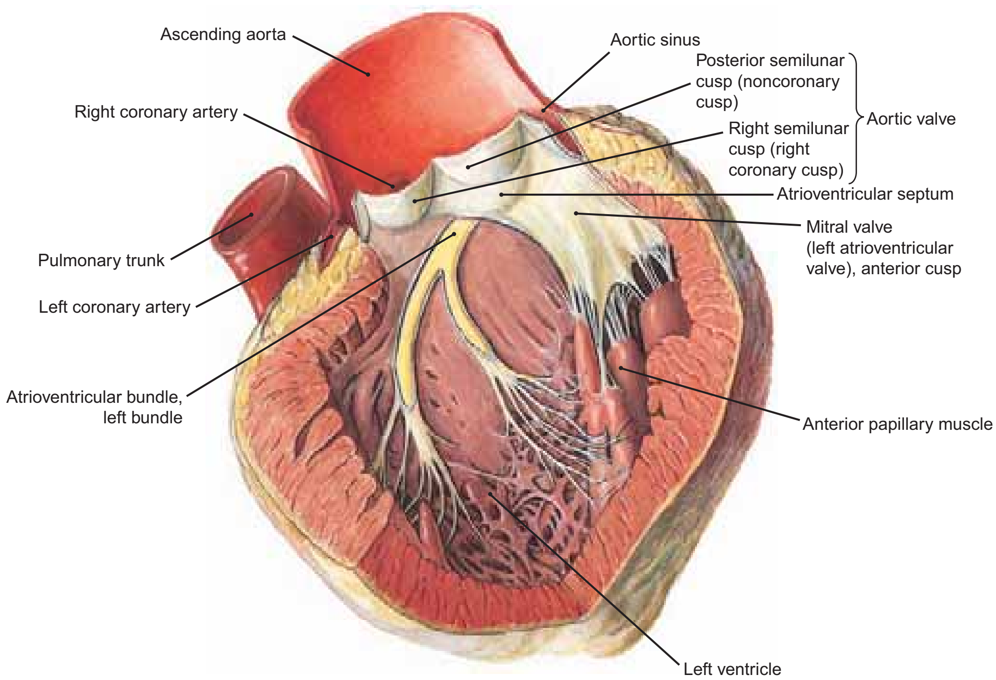


FIGURE 189.2 Atrioventricular Bundle Dissected in the Left Ventricle

NOTE: (1) The left branch of the atrioventricular bundle is dissected on the left side of the interventricular wall. It commences as a rather wide band of tissue and soon divides into several strands. These fan out to become distributed among the papillary muscles and trabeculae carneae of the left ventricle.

(2) The conduction system of the heart transmits to the cardiac muscle the rhythmic impulses that characterize the rate of the heartbeat. This rhythm is superimposed on the natural contractile property of cardiac musculature, and the rate responds to regulation by cardiac nerves that innervate the heart.

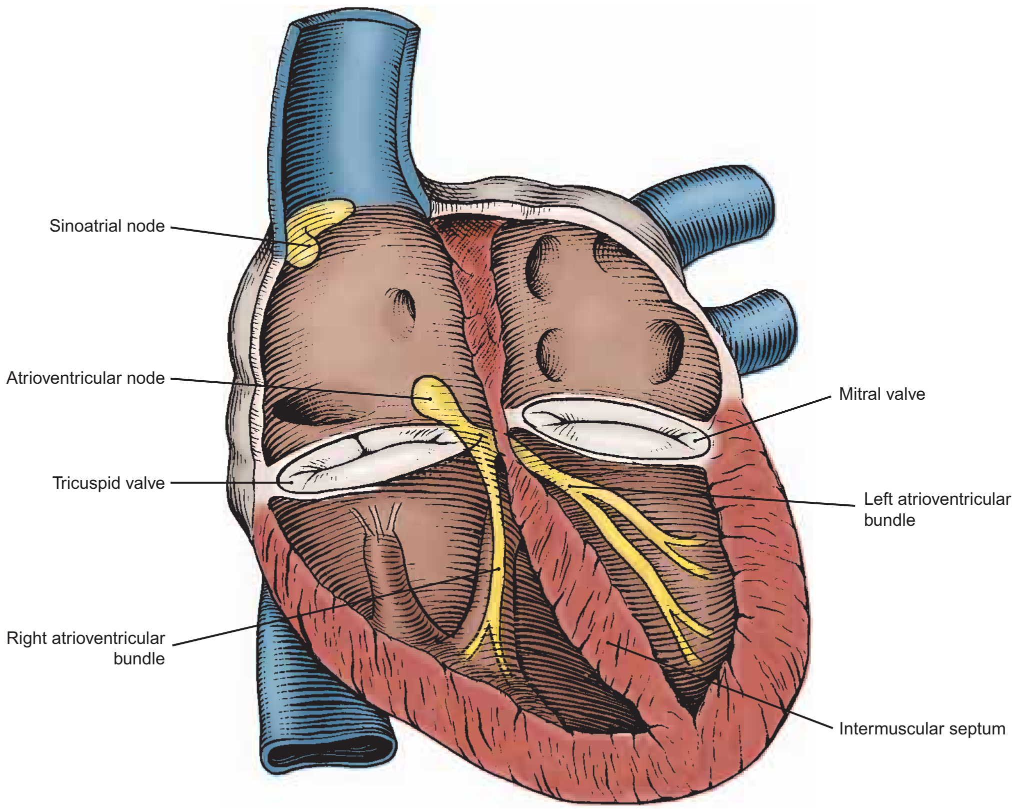


FIGURE 190.1 **Sinoatrial and Atrioventricular Nodes and the Atrioventricular Bundles (Frontal View)**

(Contributed by Dr. Gene L. Colborn, Medical College of Georgia.)

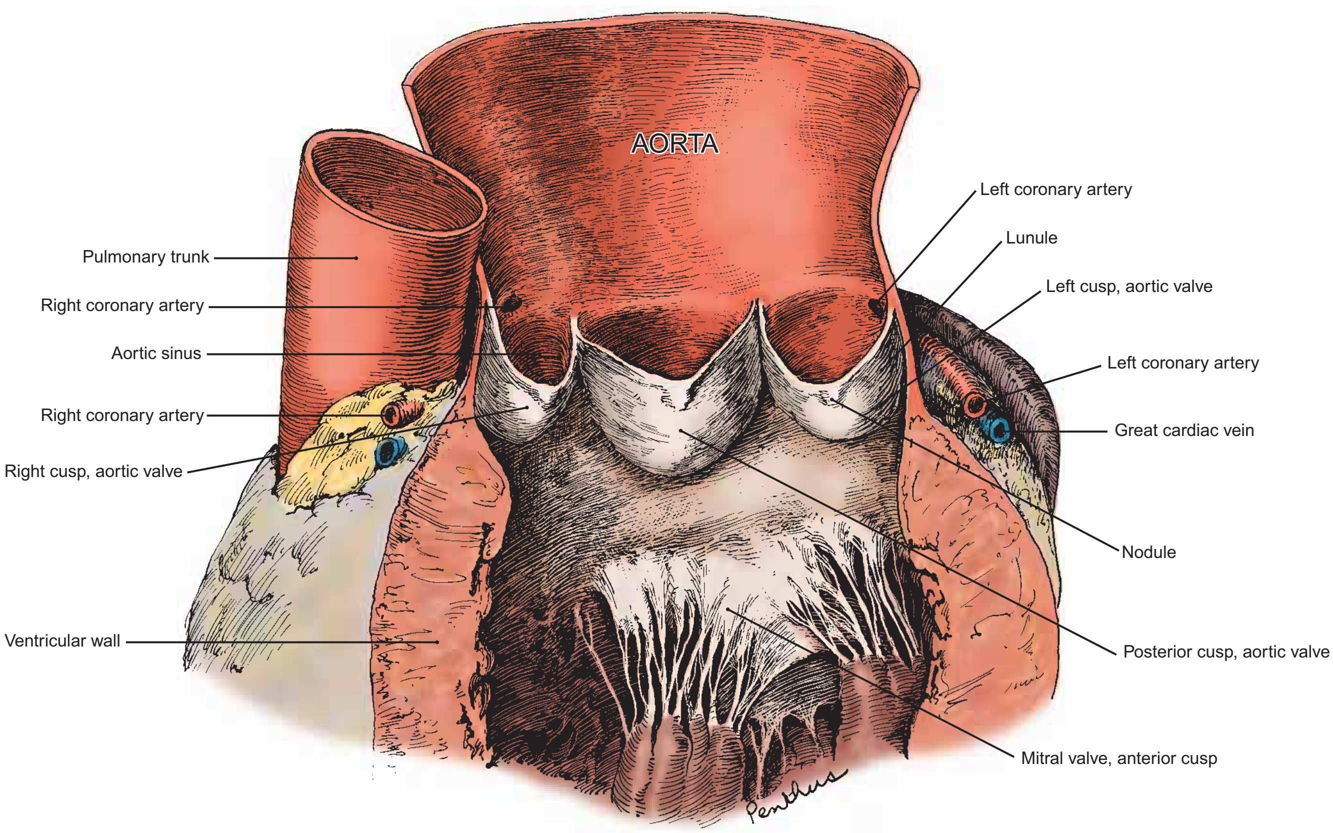


FIGURE 190.2 **Left Ventricular and Aortic Junction and the Cusps of the Aortic Valve (Frontal Section)**

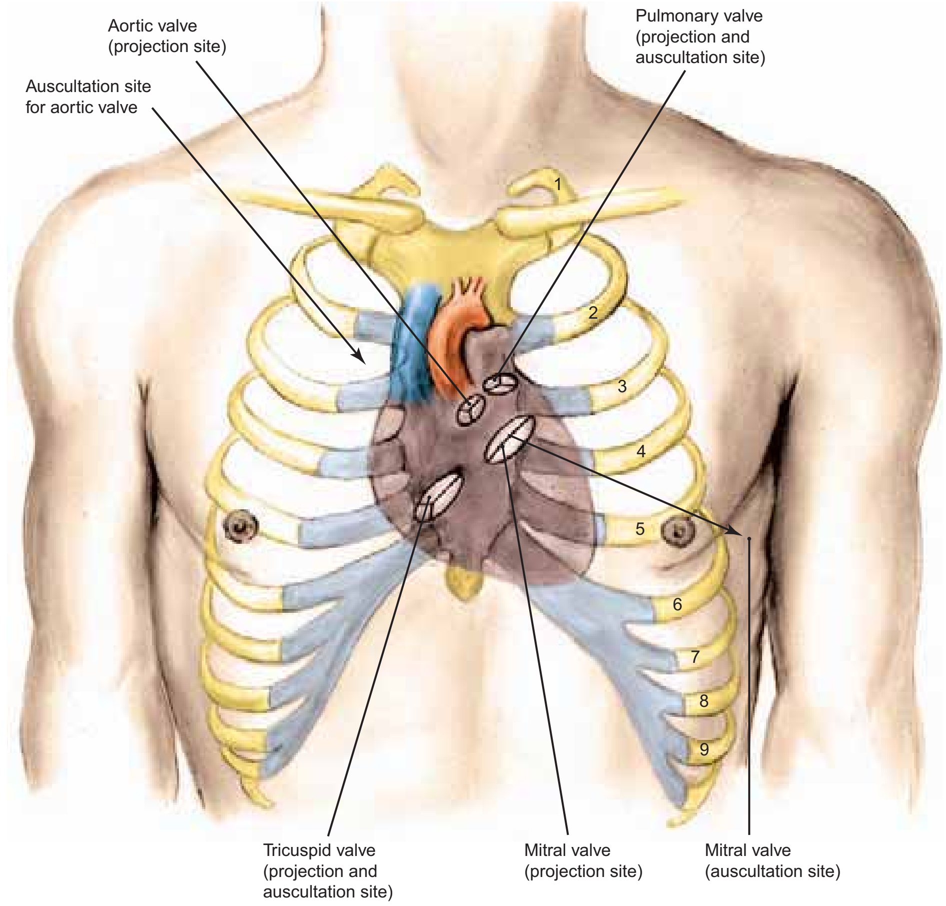


FIGURE 191.1 Projection and Auscultation Sites of the Four Heart Valves (Anterior View)

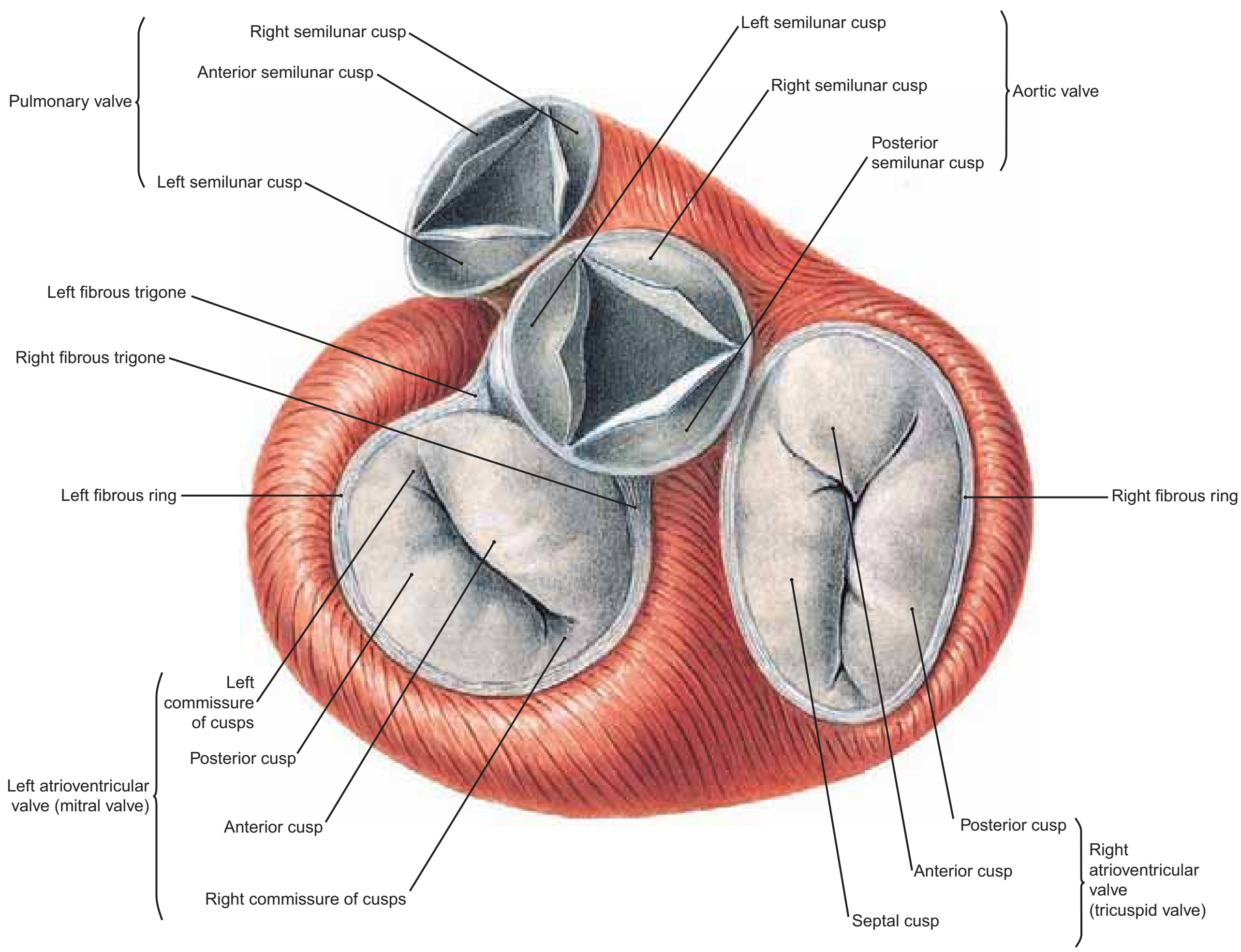


FIGURE 191.2 Four Heart Valves and Their Cusps; Fibrous Rings and Trigones (Superior View)

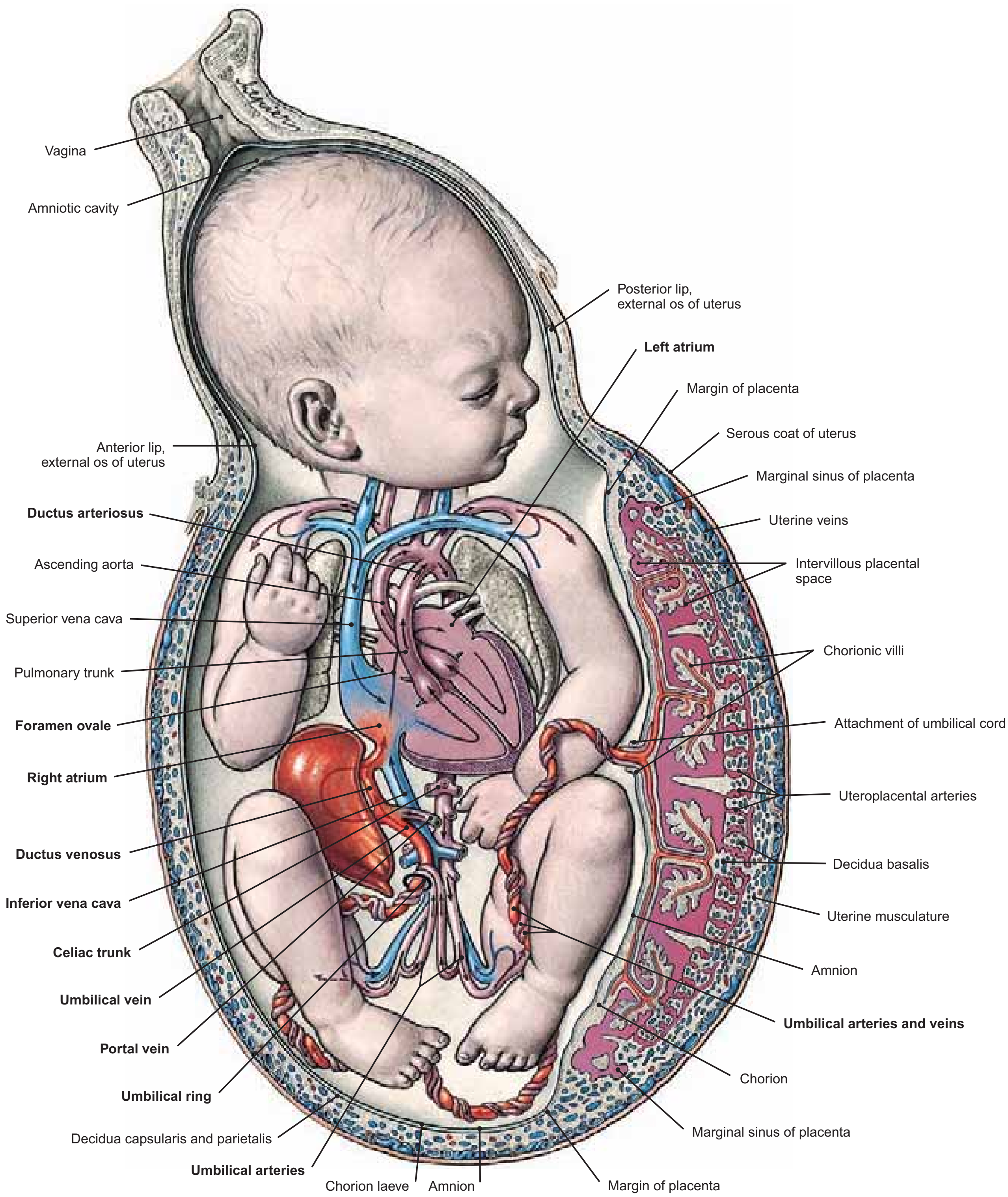


FIGURE 192 Circulation in the Fetus, as Seen in Utero

NOTE: In the fetus:

(1) Deoxygenated blood courses to the placenta by way of the **umbilical arteries.** It is then both nourished and oxygenated and leaves the placenta by way of the **umbilical vein.**

(2) Much of the oxygenated blood bypasses the liver, coursing from the umbilical vein, through the **ductus venosus,** to reach the inferior vena cava.

(3) From the inferior vena cava, blood enters the right atrium, as does blood from the superior vena cava. Right atrial blood bypasses the lungs by two routes:

  (a) across to the left atrium through the **foramen ovale,** then to the left ventricle and out the aorta to the rest of the fetal body, and

  (b) to the right ventricle, out the pulmonary artery and through the **ductus arteriosus** to reach the aorta, and then to the rest of the fetal body (also see Fig. 193).

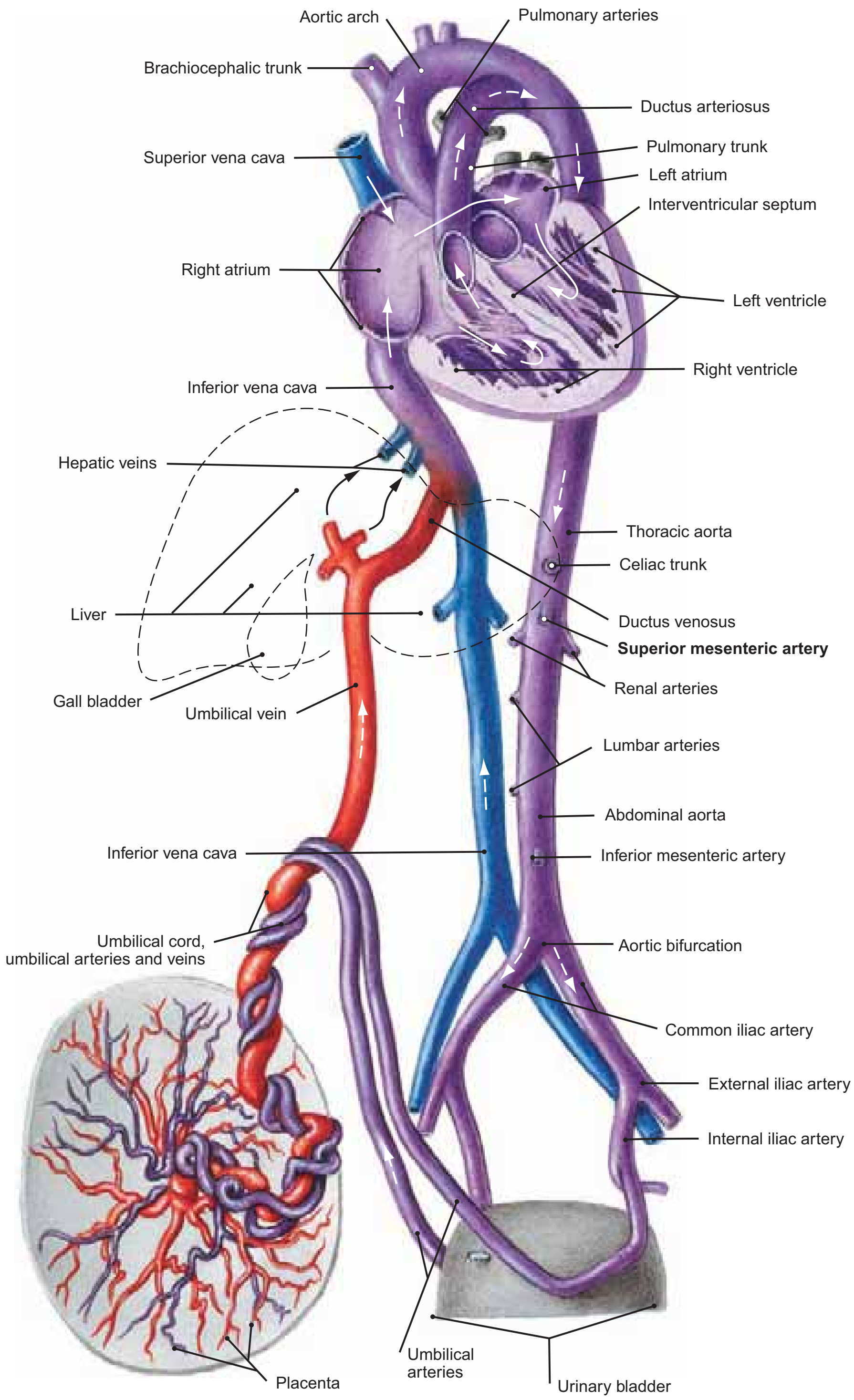


FIGURE 193 Diagrammatic Representation of the Circulation in the Fetus

NOTE the changes in the vascular system after birth. The colors indicate the degree of oxygen saturation of the blood, **red** being highest, **blue** the lowest, and **violet,** an intermediate level. Because the newborn infant becomes dependent on the lungs for oxygen:

(1) Breathing commences and the lungs begin to function, thereby oxygenating the blood and removing carbon dioxide.
(2) The **foramen ovale** decreases in size, and blood ceases to cross from the right atrium to the left atrium.
(3) The **ductus arteriosus** that interconnected the pulmonary artery and aorta constricts and gradually closes to become a fibrous cord called the **ligamentum arteriosum.**
(4) The **umbilical arteries** cease to carry blood to the placenta, and they become fibrosed, to form the **medial umbilical ligaments.**
(5) The umbilical vein becomes fibrosed and forms the **ligamentum teres** (of the liver), while the **ductus venosus** is no longer functional and forms the **ligamentum venosum.**

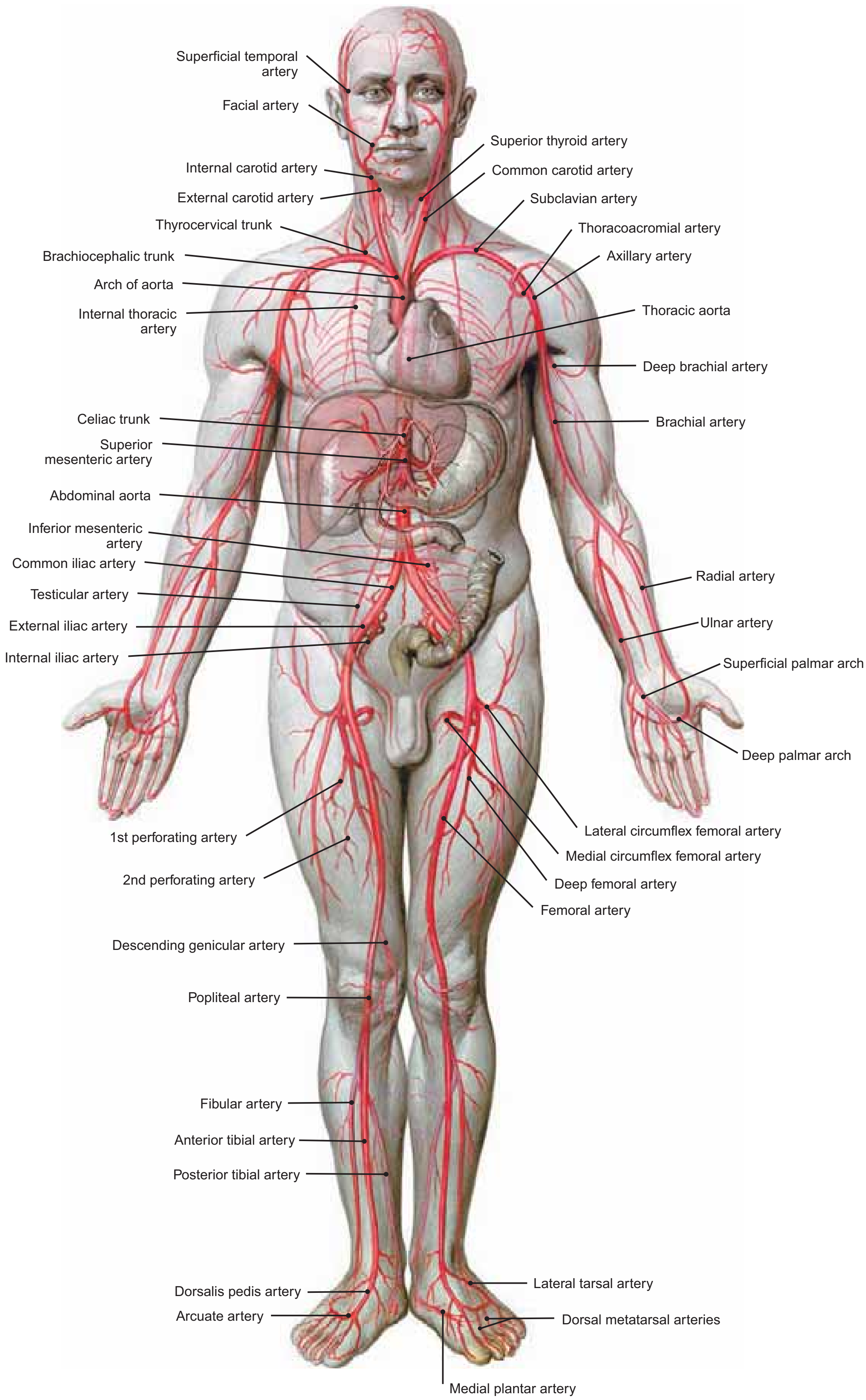


FIGURE 194 Adult Systemic Arterial System (Male)

NOTE: Most, but not all, of the named arteries in the systemic circulation are shown in this figure. In addition, the pulmonary arteries coursing to the lungs from the right ventricle are not included.

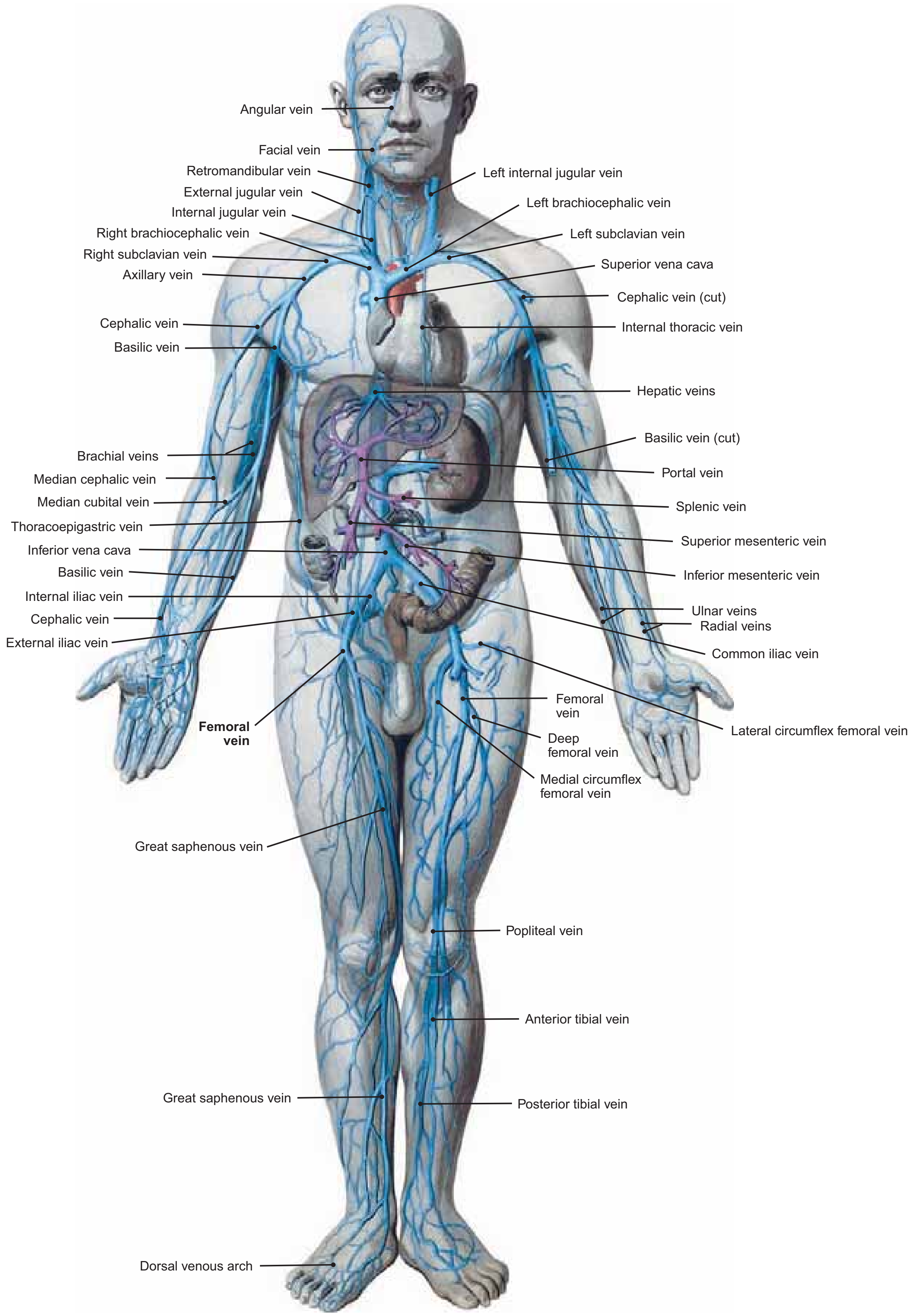


FIGURE 195 **Adult Systemic and Portal Venous Systems (Male)**

NOTE: Many, but not all, of the named veins are shown in this figure. The pulmonary veins that return blood to the left atrium from the lungs are not included. The portal system is shown in purple, while the other veins are shown in blue.

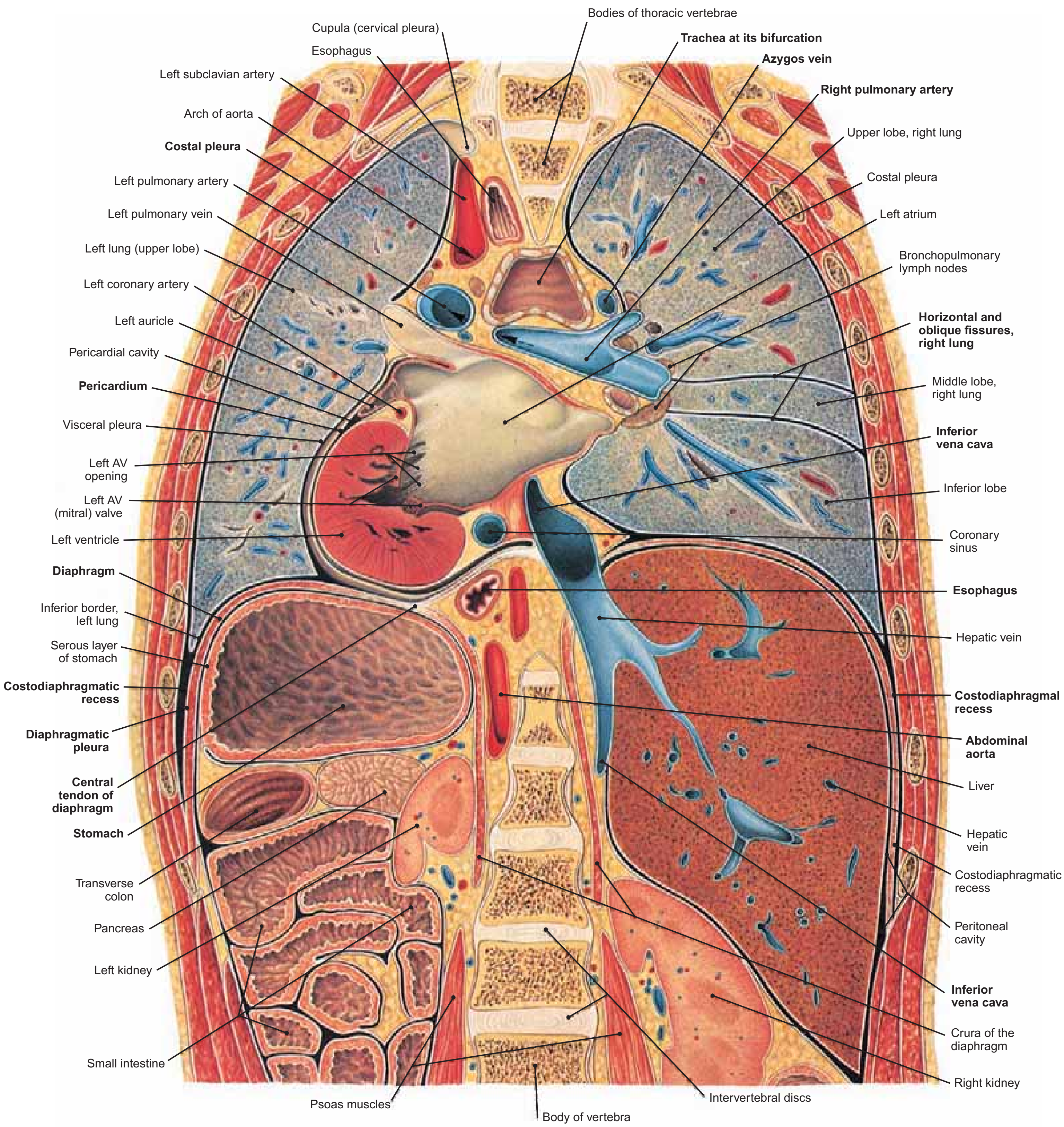
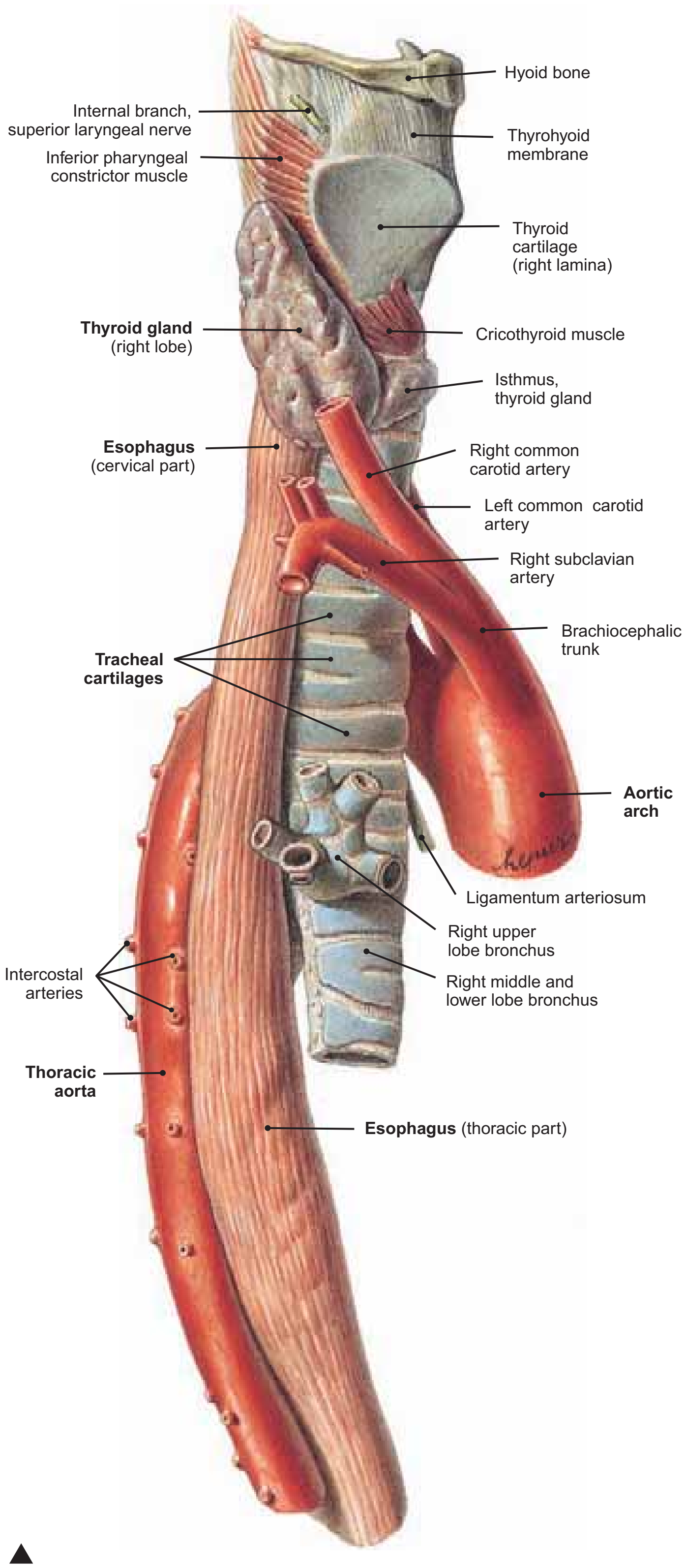


FIGURE 196 Frontal Section of the Thorax and Abdomen from Behind (Dorsal View)

NOTE: (1) From this dorsal view, the right side of the specimen is on the reader's right. The pulmonary arteries and their branches are shown in blue, as are veins (such as the hepatic veins) that also carry blood with low levels of oxygen saturation.

(2) The anteroposterior plane of this frontal section in the thorax lies through the inferior vena cava and in front of the descending aorta. The esophagus is seen only in the superior mediastinum and at its entrance into the abdomen just below the diaphragm, while the trachea has been cut at its point of bifurcation.



▲ **FIGURE 197.1 Relationship of the Esophagus to the Aorta and Trachea, Viewed from Right Side**

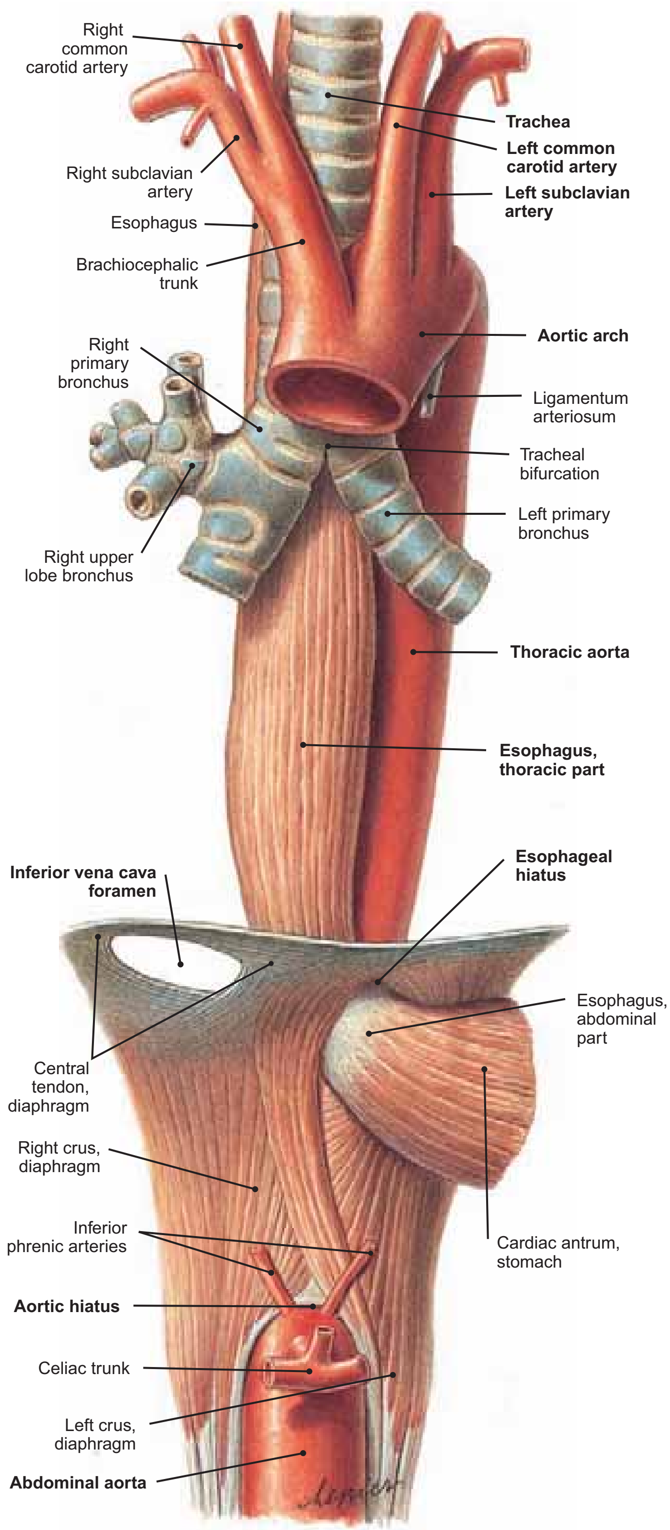
NOTE: (1) The **esophagus** commences above as an inferior extension of the pharynx, and it is initially in relationship with the larynx and thyroid gland.

(2) Its **middle third** courses in relation to the trachea, bronchi and the arch of the aorta, while its lower third descends with the thoracic aorta.

FIGURE 197.2 Aorta and Lower Esophagus at the Tracheal Bifurcation and Diaphragm

NOTE: (1) At the level of the bifurcation of the trachea (T5), the esophagus lies between the trachea and the thoracic aorta. It then descends into the thorax with the aorta somewhat to its left. In the lower thorax, the esophagus bends to the left and crosses the aorta anteriorly from right to left.

(2) The esophagus enters the abdomen through the **esophageal hiatus** of the diaphragm, while the aorta passes through the **aortic hiatus.** ▼



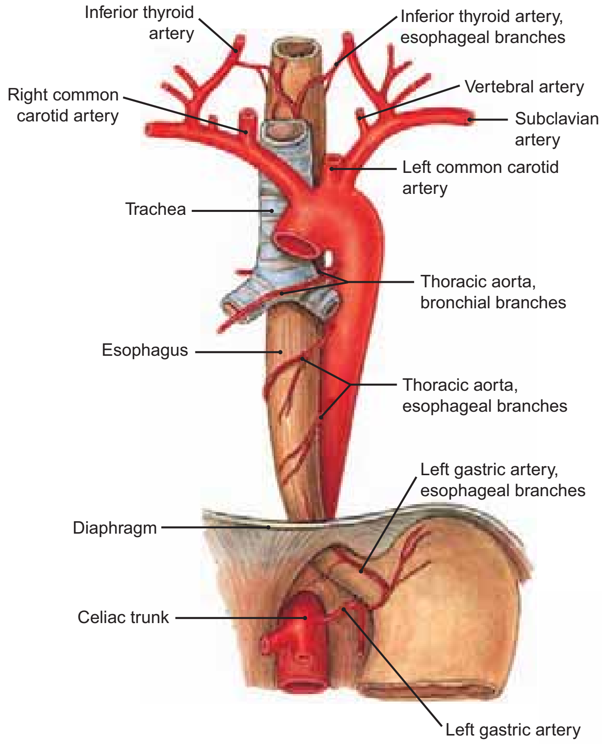


FIGURE 198.1 Arterial Blood Supply of the Esophagus

NOTE: (1) Because the esophagus is an elongated organ extending from the neck to the abdomen, it receives arterial blood from at least three sources:

(a) **In the neck:** most frequently from the **inferior thyroid** of the **thyrocervical trunk,** but it may come from the subclavian or vertebral arteries or from the costocervical trunk.

(b) **In the thorax:** multiple **esophageal branches** coming directly from the **aorta.**

(c) **In the abdomen:** from the **inferior phrenic artery** or the **left gastric artery.**

(2) These vessels anastomose with each other in the substance of the esophagus.

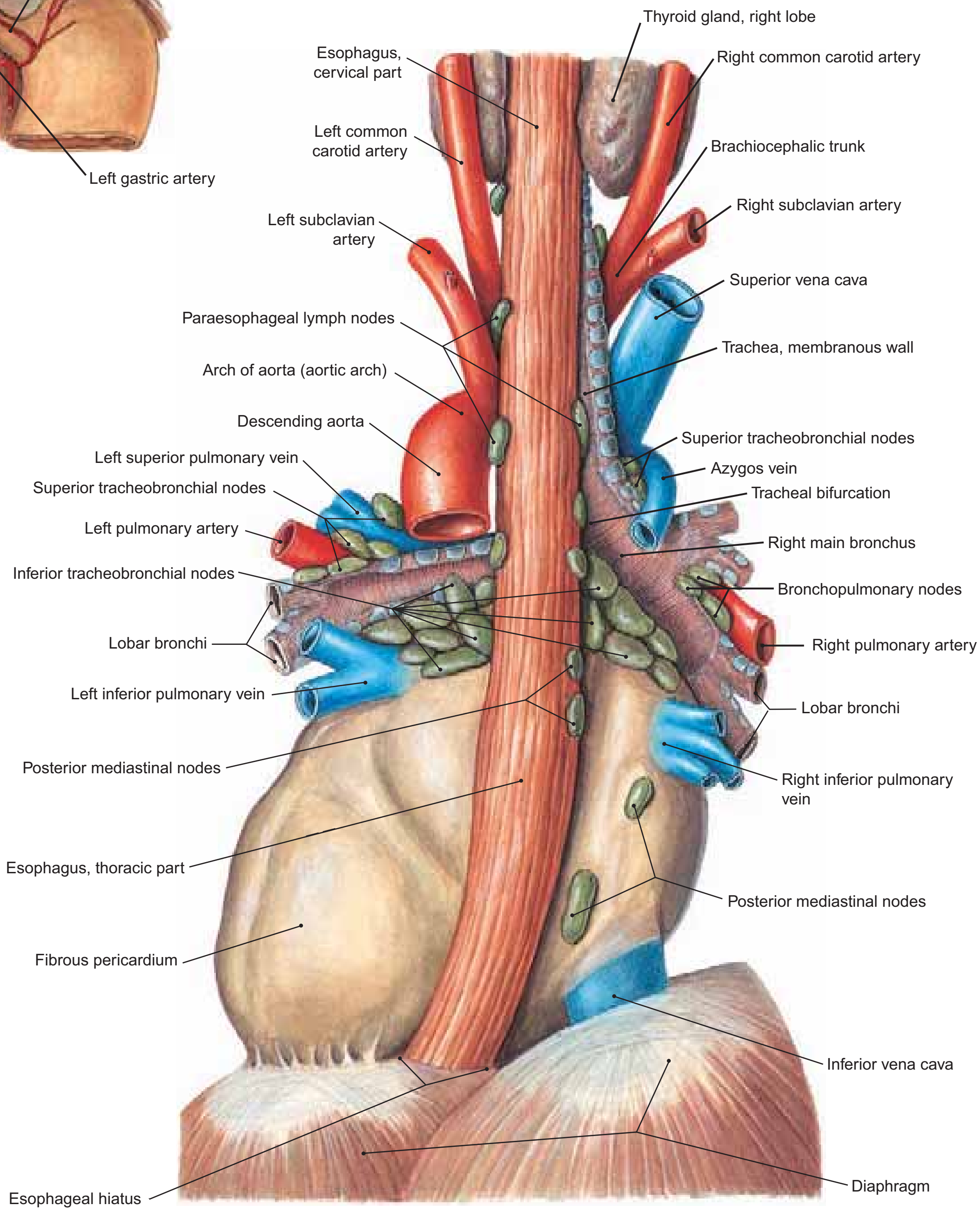


FIGURE 198.2 Posterior View of the Esophagus and the Paraesophageal and Tracheobronchial Lymph Nodes

NOTE the large number of nodes near the bifurcation of the trachea (into the two primary bronchi). These many nodes may be located at this site for the receipt of macrophages coursing from the lungs, which may have ingested foreign elements from the air we breathe.

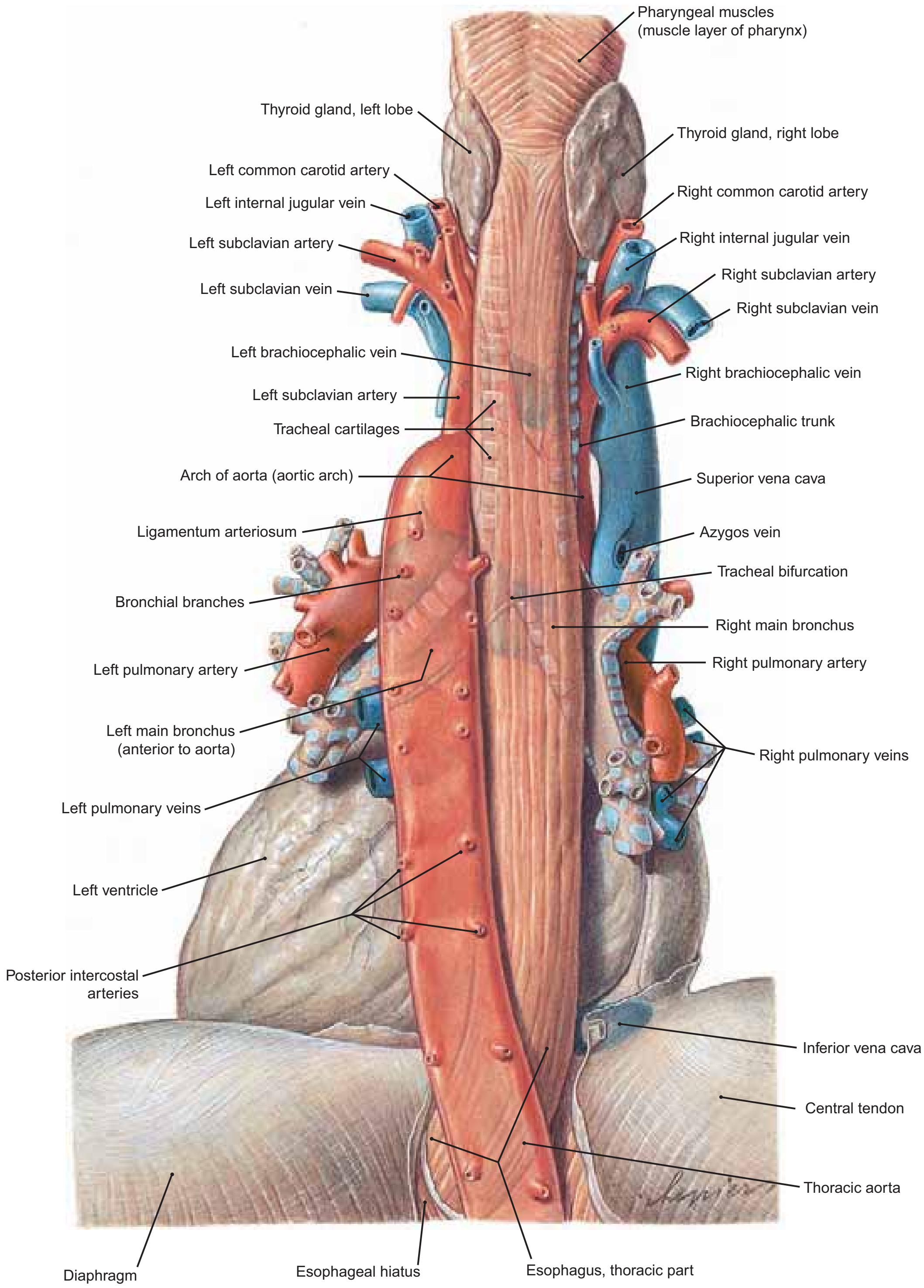


FIGURE 199 Posterior View of the Esophagus, Aorta, and Pericardium

NOTE: (1) The origins of the intercostal arteries from the posterior aspect of the thoracic aorta.

(2) The relationship of the esophagus and the thoracic aorta is well shown in this dorsal view. Observe how the aorta courses posterior to the esophagus from left to right. It then descends in the midline ventral to the vertebral column to the level of L1, where it enters the posterior abdomen.

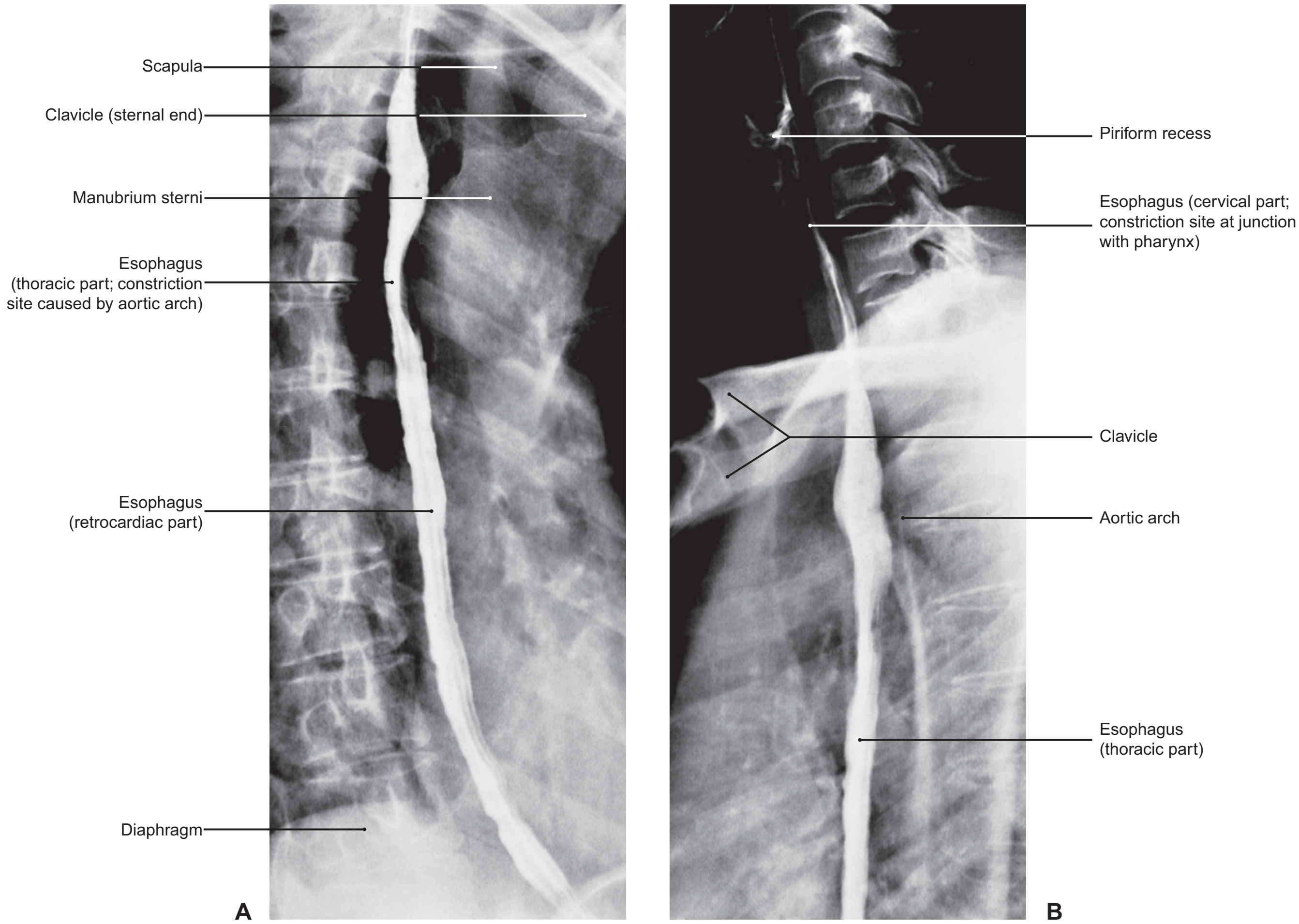


FIGURE 200.1AB Radiographic Views of the Esophagus After Swallowing Contrast Medium

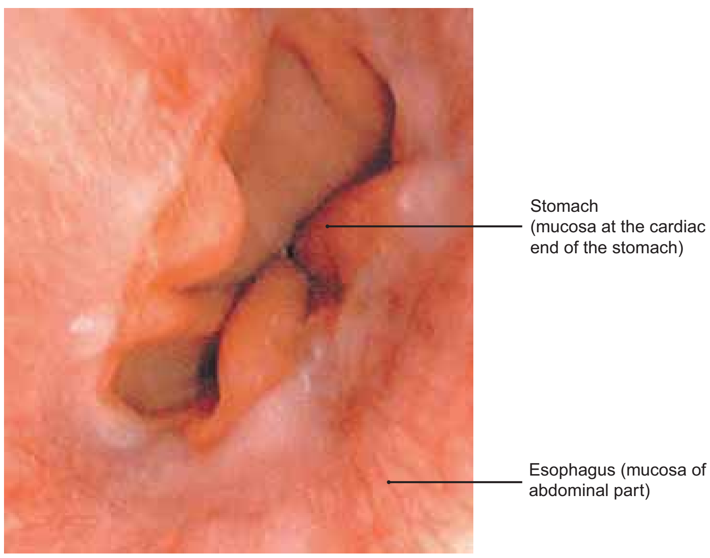


FIGURE 200.2 Esophagus As Seen through an Esophagoscope, Superior View

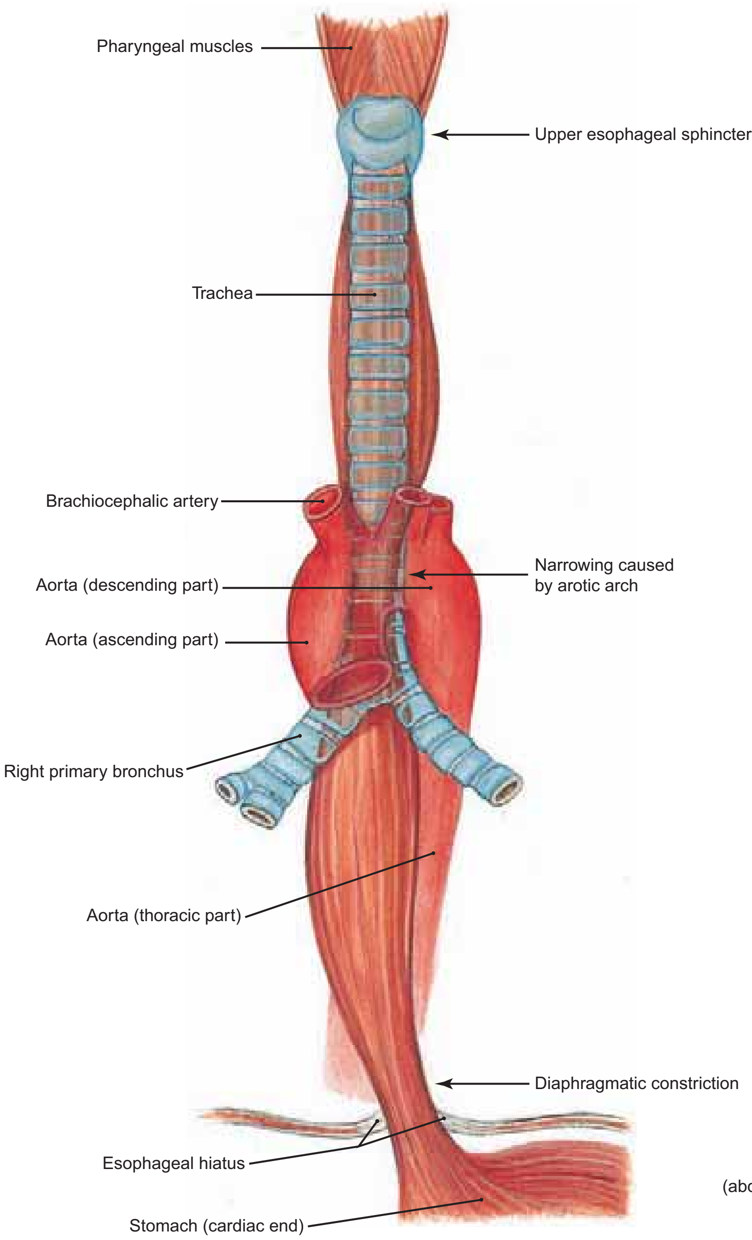


FIGURE 201.1 Esophagus Showing Sites of Constrictions

Three sites:

(1) Constriction caused by upper esophageal sphincter
(2) Narrowing caused by aortic arch
(3) Constriction at the esophageal-diaphragmatic junction

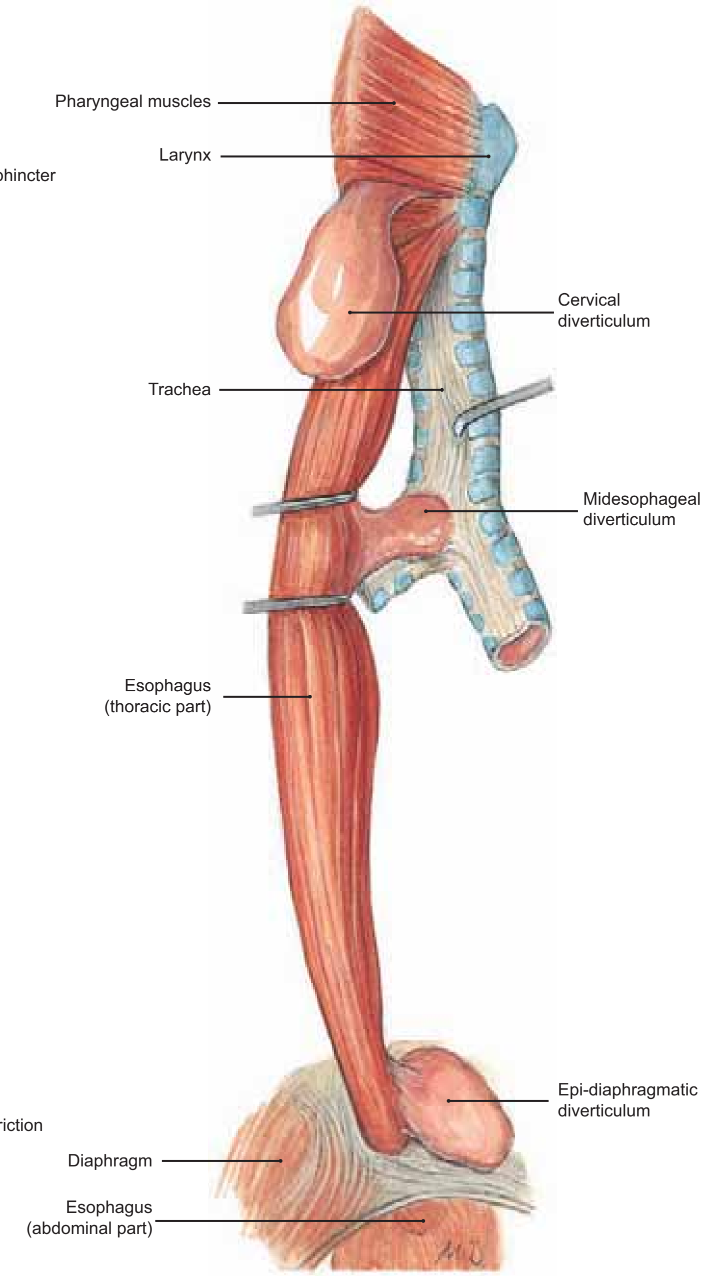


FIGURE 201.2 Esophagus Showing Typical Locations of Diverticula

Cervical diverticula (most frequent; 70%)
Midesophageal diverticula (22%)
Epidiaphragmatic diverticula (8%)

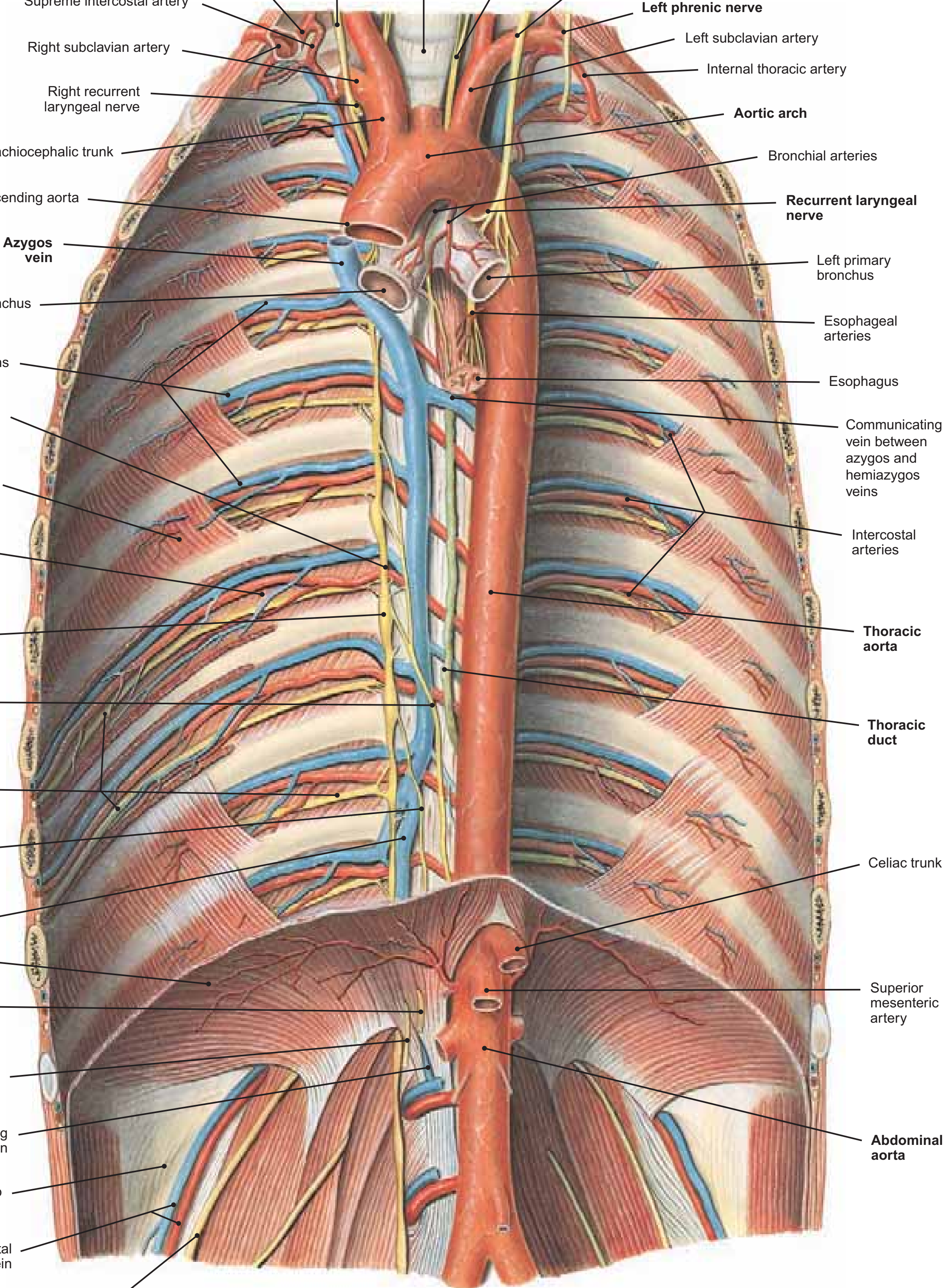


FIGURE 202 Vessels and Nerves of the Dorsal Thoracic Wall

NOTE: (1) The aorta ascends from the left ventricle, arches behind the left pulmonary hilum, and descends through most of the thorax just to the left side of the vertebral column.

(2) In its course through the posterior mediastinum, the aorta gradually shifts toward the midline, which it has achieved when it traverses the diaphragm at the aortic hiatus to enter the abdomen.

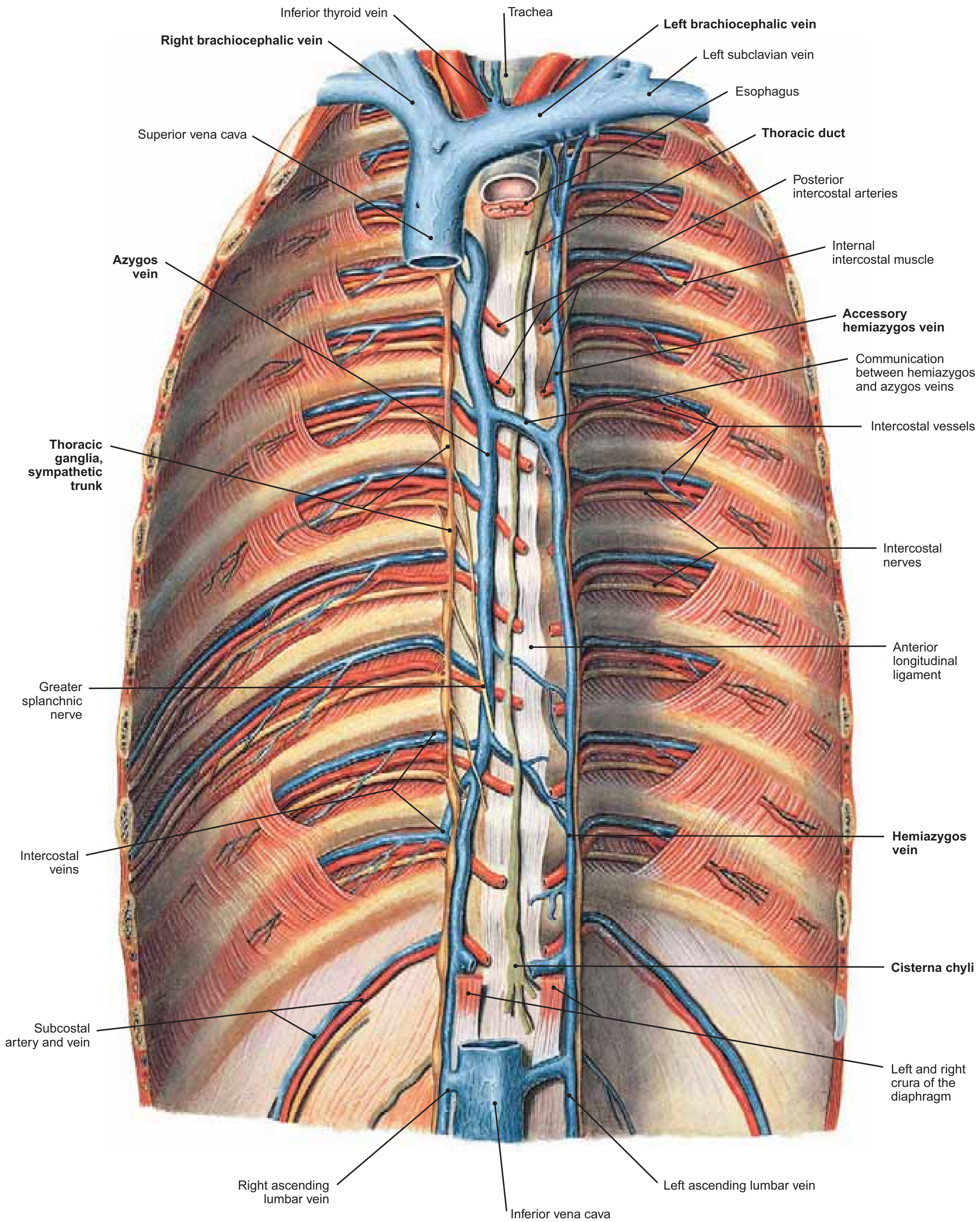


FIGURE 203 **Azygos System of Veins, the Thoracic Duct, and Other Posterior Thoracic Wall Structures**

NOTE: (1) With most of the organs of the thorax and mediastinum removed or cut, the **hemiazygos and accessory hemiazygos veins** to the left of the vertebral column are seen communicating across the midline with the larger **azygos vein.**

(2) The azygos vein is seen ascending in the right thorax to open into the superior vena cava.

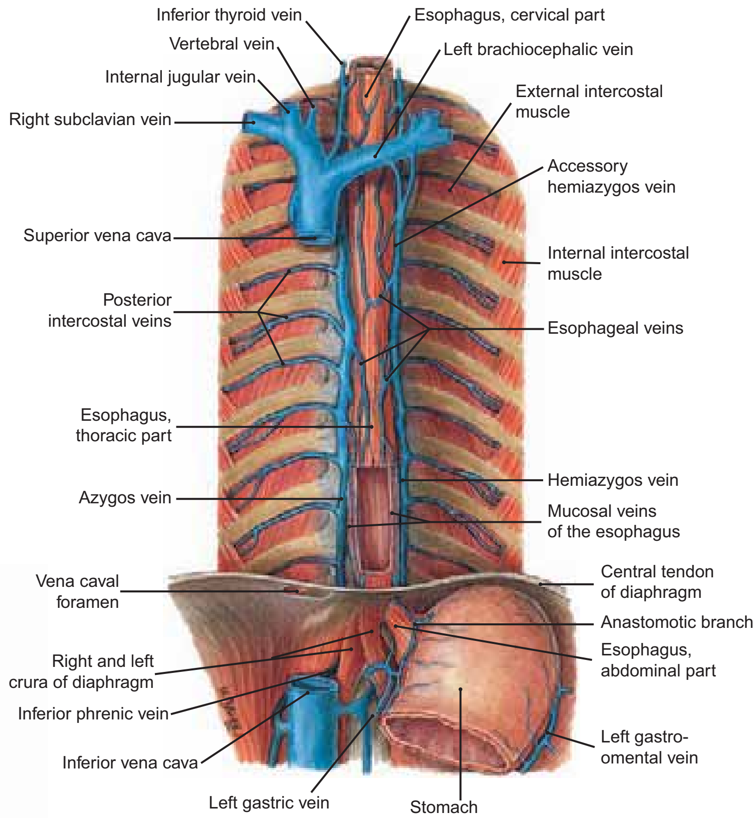
(3) The **thoracic duct** arises from the cisterna chyli at the first lumbar level and ascends in the thorax anterior to the vertebral column.

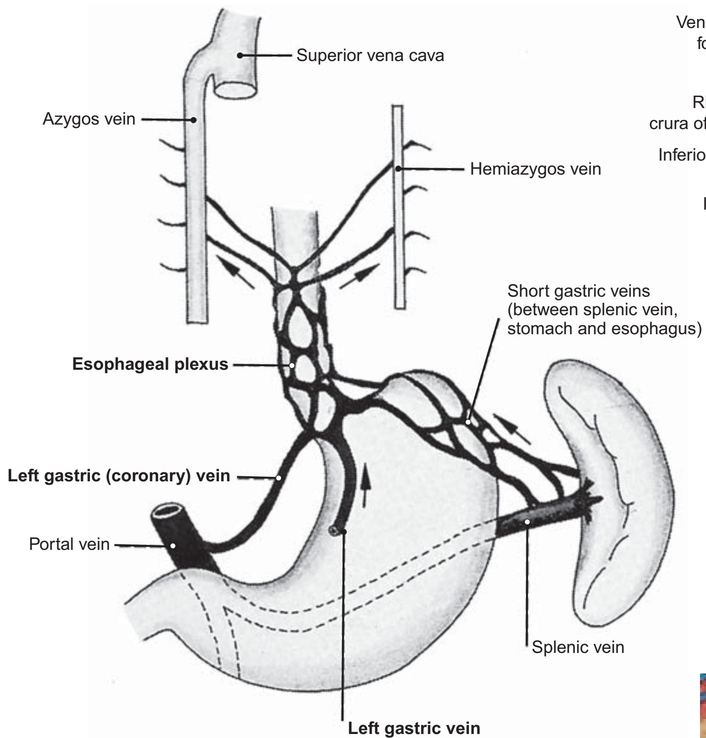
FIGURE 204.1 Veins That Drain the Esophagus ▶

NOTE: (1) Veins that drain the **cervical part** of the esophagus empty into the inferior thyroid vein, while those from the **thoracic part** drain into the azygos, hemiazygos, and accessory hemiazygos veins.

(2) Veins that drain the **abdominal part** of the esophagus drain partially into the left gastric vein and partially into the azygos vein.

(3) In this figure, the inferior part of the esophagus has been severed just above the diaphragm.





◀ FIGURE 204.2 Anastomosis between the Portal Vein and the Superior Vena Cava through the Esophageal Venous Plexus

This figure shows the anastomosis often used to return blood from the portal vein to the inferior vena cava. Persons who have hypertension in the portal system may have blood diverted from the **portal vein** to the **coronary** and **left gastric veins.** Blood then ascends through the **hemiazygos** and **azygos veins** and finally into the **superior vena cava.**

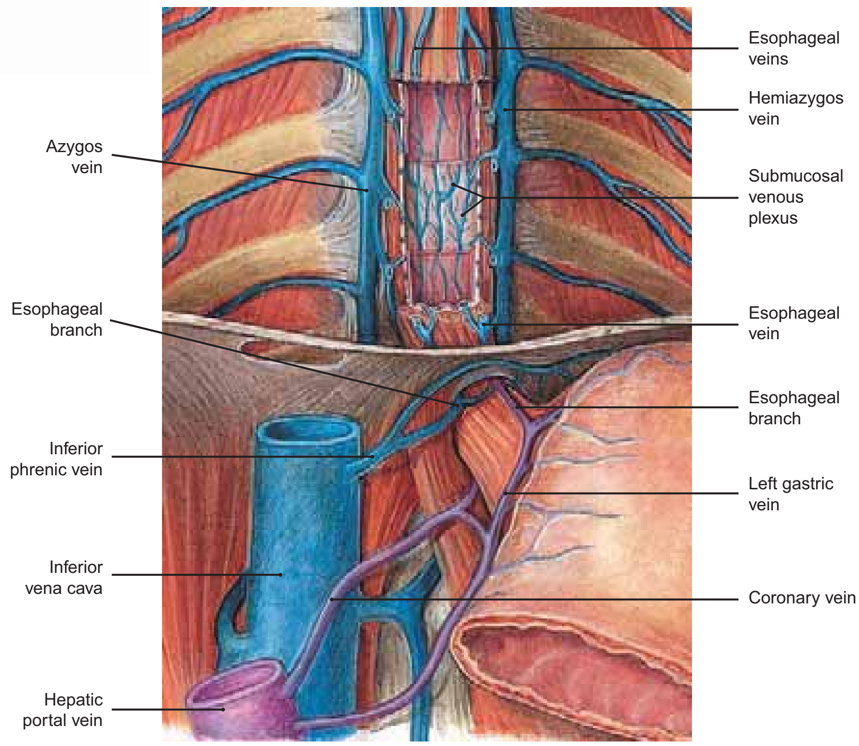


FIGURE 204.3 Portal-Caval Shunt Dissection ▶

NOTE: (1) This figure shows the hepatic portal vein in the color purple and the inferior vena cava in blue. Observe the anastomosis between the portal vein and the coronary and left gastric veins (also in blue).

(2) Esophageal veins from these two vessels anastomose through the diaphragm with the azygos and hemiazygos veins in the chest.

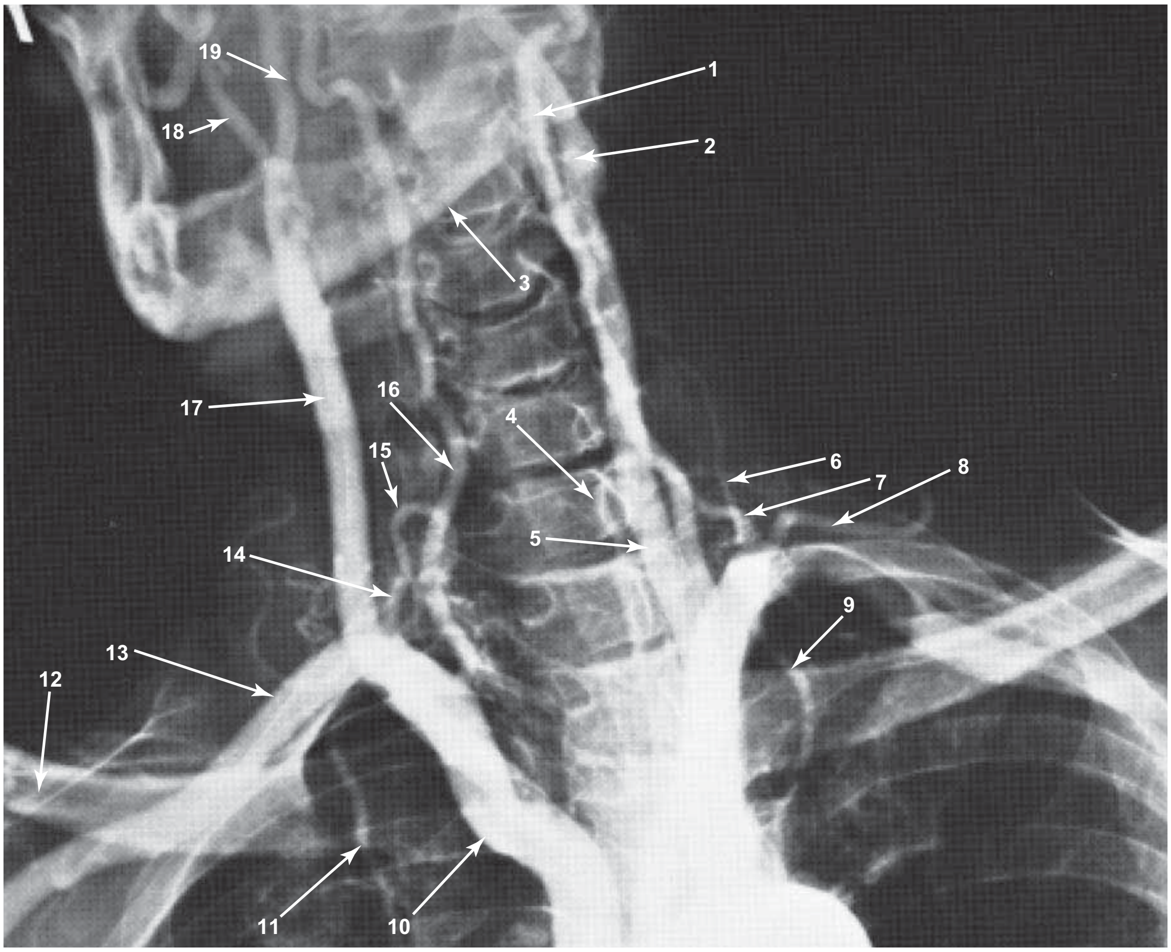


FIGURE 205.1 Angiogram of the Aortic Arch and Its Branches

1. Left vertebral artery
2. Left internal carotid artery
3. Body of the mandible
4. Left inferior thyroid artery
5. Left common carotid artery
6. Left ascending cervical artery
7. Left thyrocervical trunk
8. Left transverse cervical artery
9. Left internal thoracic artery
10. Brachiocephalic trunk
11. Right internal thoracic artery
12. Clavicle
13. Right subclavian artery
14. Right thyrocervical trunk
15. Right inferior thyroid artery
16. Right vertebral artery
17. Right common carotid artery
18. Right external carotid artery
19. Right internal carotid artery

(From Wicke, 6th ed.)

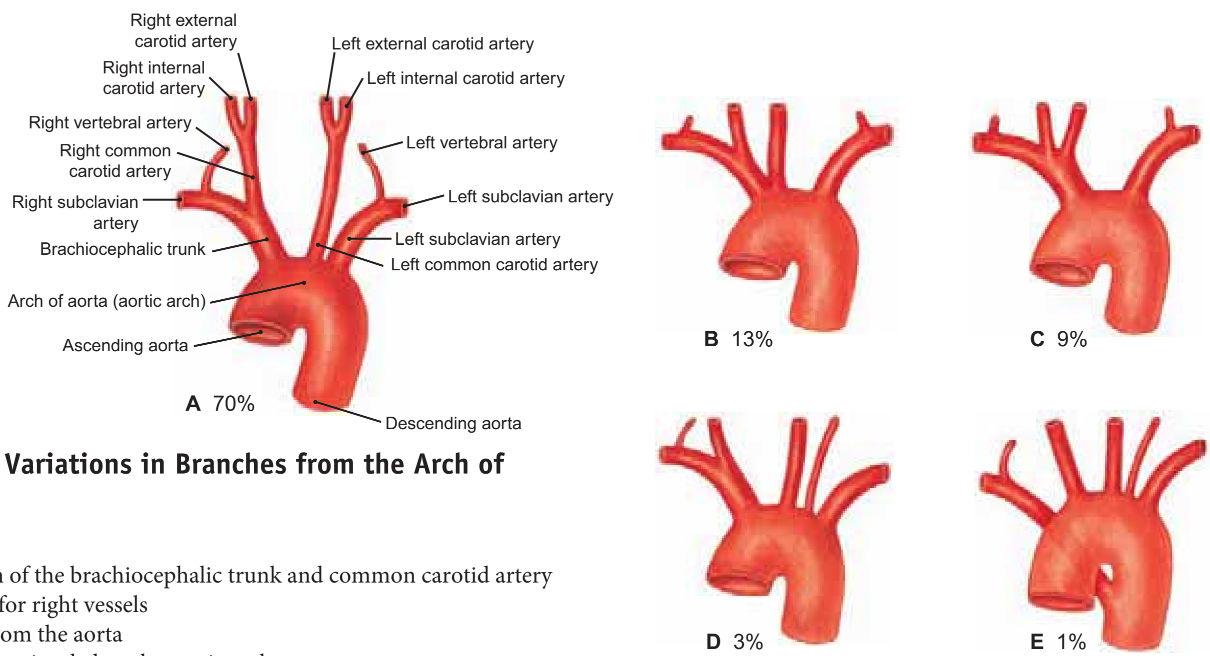


FIGURE 205.2 Variations in Branches from the Arch of the Aorta

A: Normal
B: Common origin of the brachiocephalic trunk and common carotid artery
C: Common stem for right vessels
D: Left vertebral from the aorta
E: Right subclavian arises below the aortic arch.

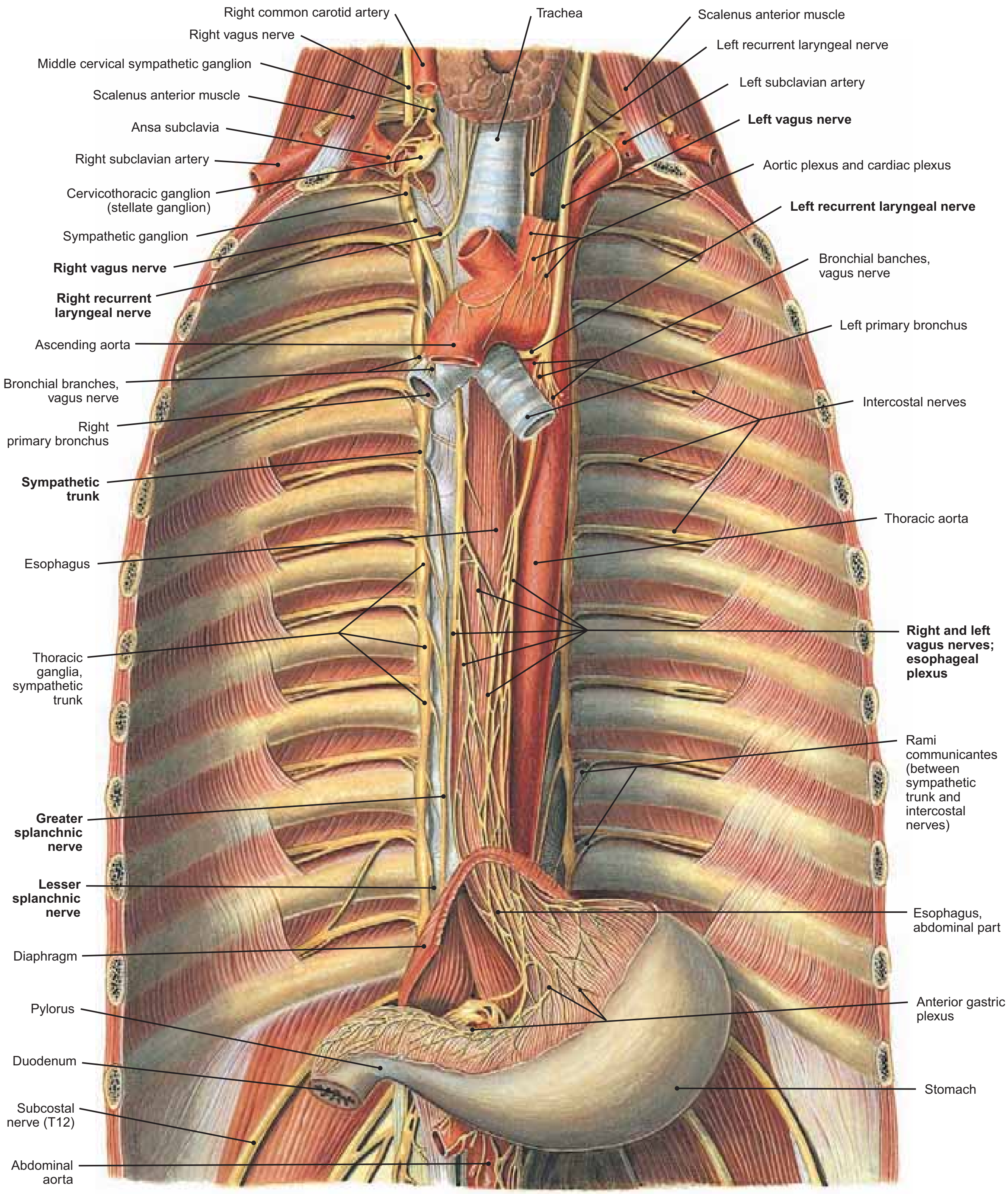


FIGURE 206 Sympathetic Trunks and Vagus Nerves in the Thorax and Upper Abdomen

NOTE: (1) The ganglionated sympathetic trunks lie lateral to the bodies of the thoracic vertebrae on each side and are continued into the neck superiorly and the abdomen inferiorly.

(2) Each ganglion is connected to an intercostal nerve by means of **rami communicantes. White rami** consist principally of preganglionic sympathetic fibers coursing to the ganglia, while the **gray rami** carry postganglionic fibers back to the spinal nerves.

(3) The course of the vagus nerves in the thorax. Below the aortic arch they send branches to the bronchi and then descend to form much of the esophageal plexus.

(4) Below the diaphragm, most of the fibers of the **left vagus** form the **anterior gastric nerve,** while most of the fibers of the **right vagus** form the **posterior gastric nerve.**

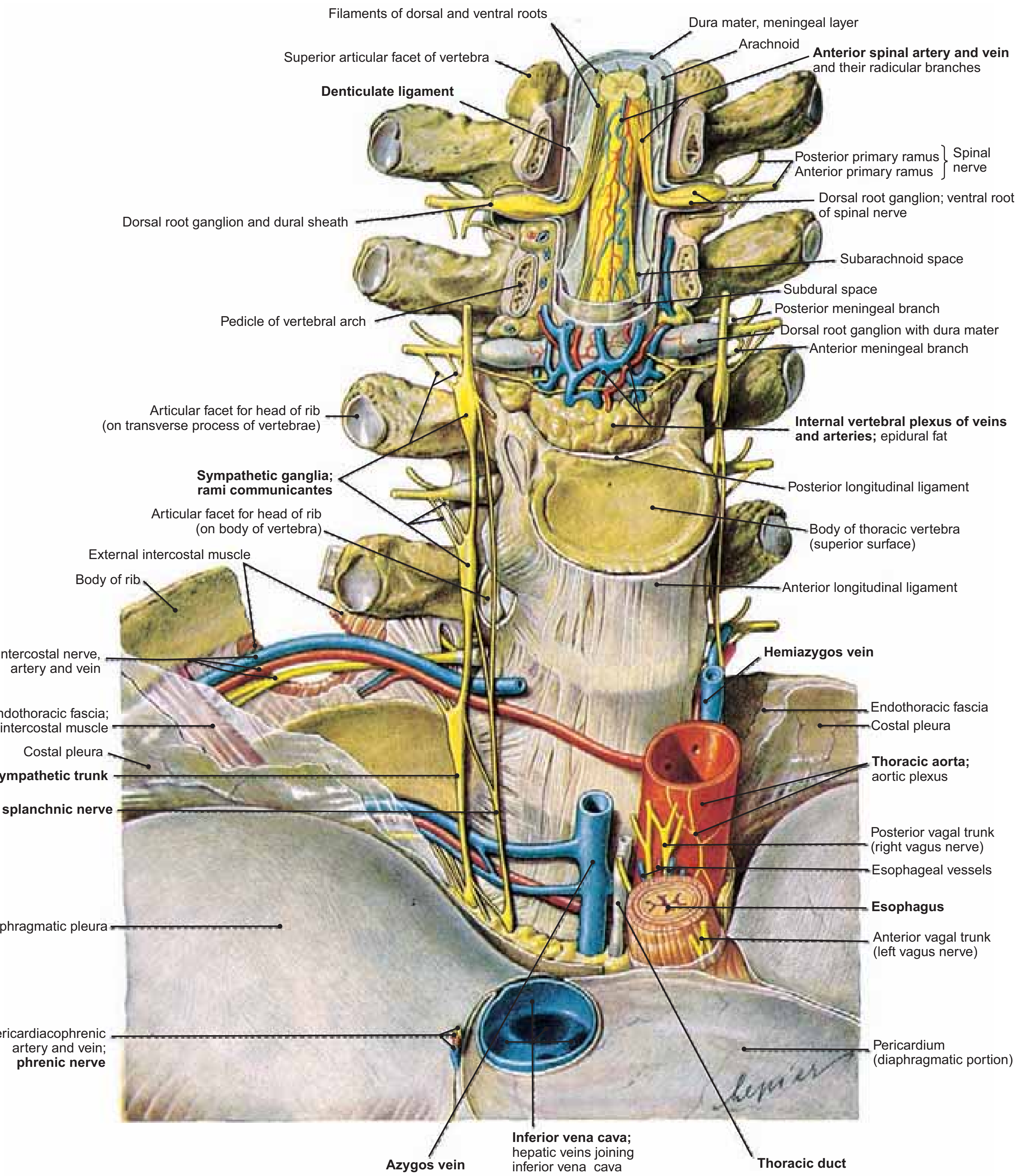


FIGURE 207 **Anterior Dissection of Vertebral Column, Spinal Cord, and Prevertebral Structures at a Lower Thoracic Level**

NOTE: (1) The internal vertebral plexus of veins and arteries that lie in the epidural space, where the epidural fat is also found. These should not be confused with the spinal vessels, which are situated in the pia mater and which are seen to be intimately applied to the spinal cord tissue.

(2) The ganglionated sympathetic chain observable here in the thoracic region receiving and giving communicating rami with the spinal nerves. Also note the formation of the greater splanchnic nerve and its descent prevertebrally into the abdomen.

(3) The aorta, inferior vena cava, azygos and hemiazygos veins, esophagus, and thoracic duct all lying anterior or somewhat to the left of the vertebral column and passing through the diaphragm.

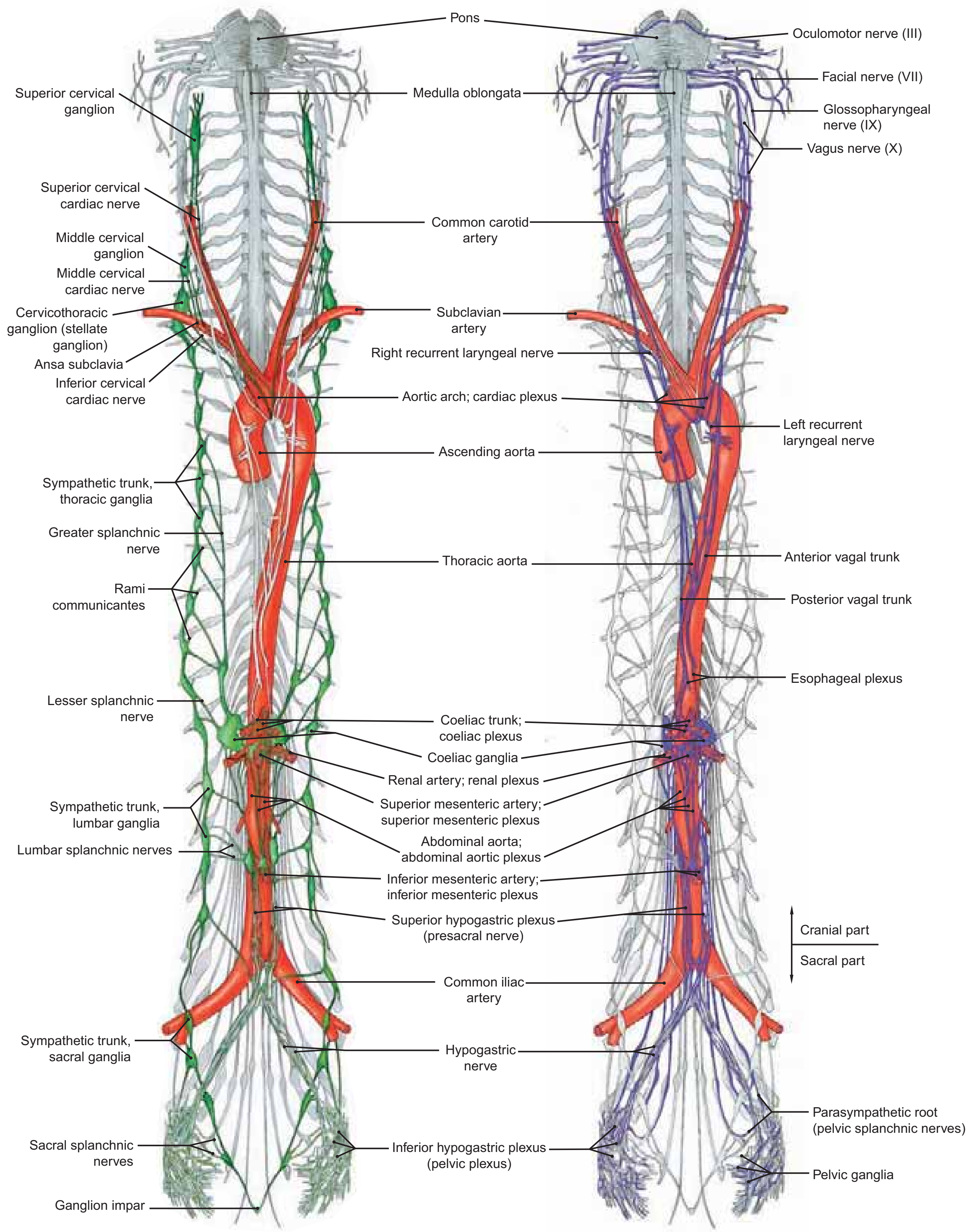


FIGURE 208.1 Sympathetic Division of the Autonomic Nervous System

NOTE that the sympathetic chain and its ganglia and branches are shown in green. Preganglionic sympathetic fibers emerge from the spinal cord between the T1 and L3 spinal levels. Also called the **thoracolumbar outflow.**

FIGURE 208.2 Parasympathetic Division of the Autonomic Nervous System

NOTE that the parasympathetic fibers are shown in purple. Preganglionic fibers emerge from the central nervous system in cranial nerves III, VII, IX, and X and the sacral levels S2, S3, and S4. Also called **craniosacral outflow.**

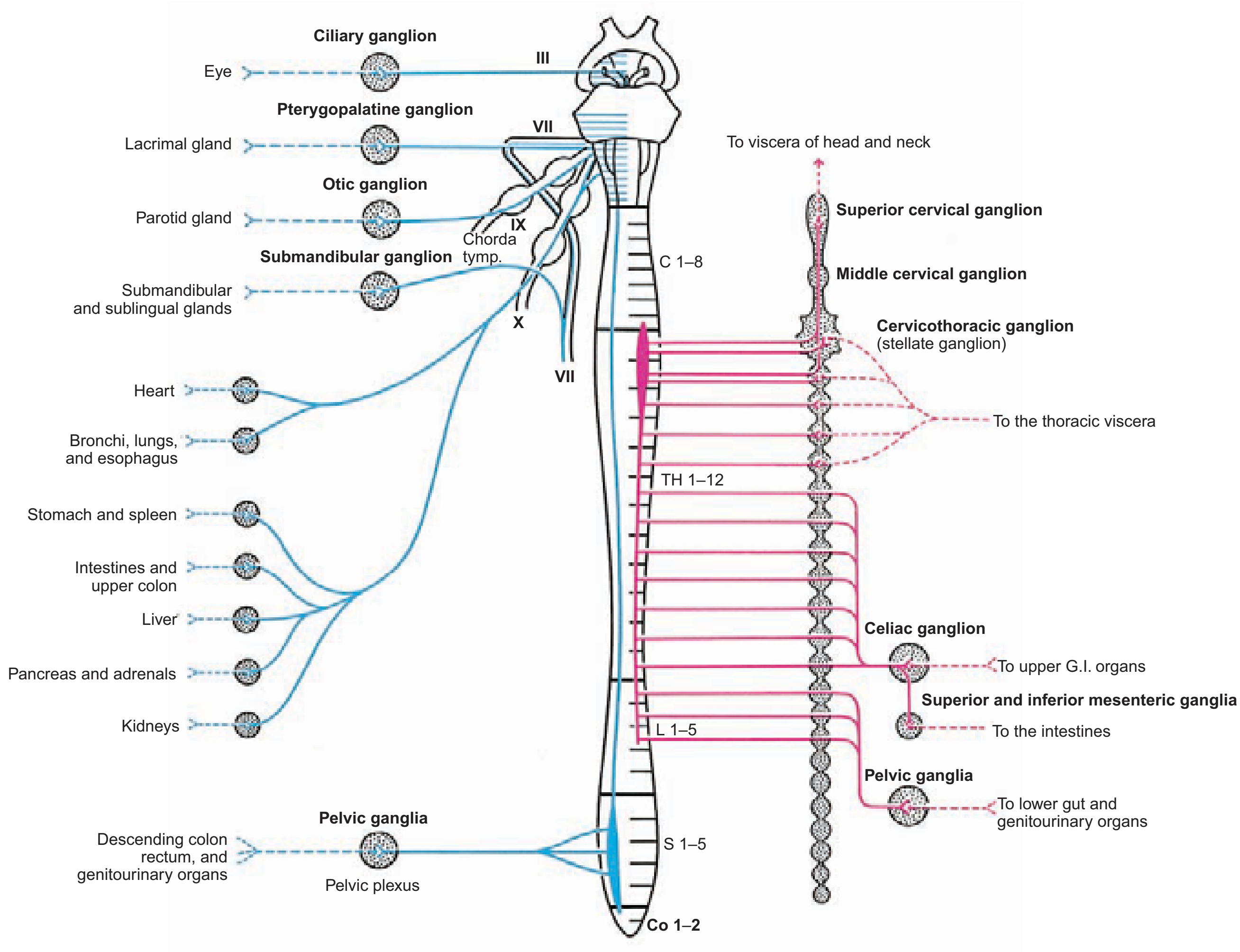


FIGURE 209 Diagram of the Autonomic Nervous System

Blue = parasympathetic; red = sympathetic; solid lines = presynaptic neurons; broken lines = postsynaptic neurons.

NOTE: (1) The autonomic nervous system, by definition, is a two-motor neuron system with the neuron cell bodies of the *presynaptic neurons* (solid lines) somewhere within the central nervous system and the cell bodies of the *postsynaptic neurons* (broken lines) located in ganglia distributed peripherally in the body.

(2) The autonomic nervous system comprises the nerve fibers, which supply all the glands and blood vessels of the body, including the heart. In doing so, all the smooth and cardiac muscle tissues (sometimes called involuntary muscles) are thereby innervated.

(3) The autonomic nervous system is composed of two major divisions, called the parasympathetic (in blue) and sympathetic (in red) divisions. The autonomic regulation of visceral function is, therefore, a dualistic control—that is, most organs receive postganglionic fibers of both parasympathetic and sympathetic sources.

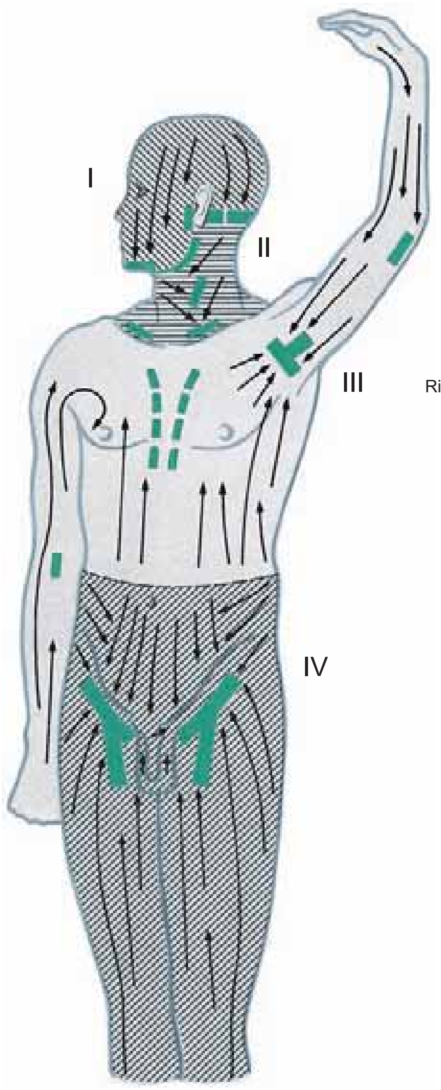
(4) The *parasympathetic division* is sometimes called a craniosacral outflow because the preganglionic cell bodies of this division lie in the brainstem and in the sacral segments of the spinal cord. Parasympathetic preganglionic fibers are found in four cranial nerves, III (oculomotor), VII (facial), IX (glossopharyngeal), and X (vagus) and in the second, third, and fourth sacral nerves.

(5) These *pre*ganglionic parasympathetic fibers then synapse with *post*ganglionic parasympathetic cell bodies in peripheral ganglia. From these ganglia the *post*ganglionic nerve fibers innervate the various organs.

(6) The *sympathetic division* is sometimes called the thoracolumbar outflow because the *pre*ganglionic sympathetic neuron cell bodies are located in the lateral horn of the spinal cord between the first thoracic spinal segment and the second or third lumbar spinal segment (i.e., from T1 to L3).

(7) These *pre*ganglionic fibers emerge from the cord with their corresponding spinal roots and communicate with the sympathetic trunk and its ganglia, where some *pre*synaptic sympathetic fibers synapse with *post*ganglionic sympathetic neurons. Other presynaptic fibers (especially those of the upper thoracic segments) ascend in the sympathetic chain and synapse with *post*ganglionic neurons in the cervicothoracic and middle and superior cervical ganglia. *Post*ganglionic fibers from these latter ganglia are then distributed to the viscera of the head and neck. Still other *pre*synaptic sympathetic fibers do not synapse in the sympathetic chain of ganglia at all but collect to form the splanchnic nerves. These nerves course to the collateral sympathetic ganglia (celiac, superior and inferior mesenteric, and aorticorenal ganglia), where they synapse with the *post*ganglionic neurons. The *post*ganglionic neurons of the sympathetic division then course to the viscera to supply sympathetic innervation.

(8) The functions of the parasympathetic and sympathetic divisions of the autonomic nervous system are antagonistic to each other. The parasympathetic division constricts the pupil, decelerates the heart, lowers blood pressure, relaxes the sphincters of the gut, and contracts the longitudinal musculature of the hollow organs. It is the division that is active during periods of calm and tranquility, and it aids in digestion and absorption. In contrast, the *sympathetic division* dilates the pupil, accelerates the heart, increases blood pressure, contracts the sphincters of the gut, and relaxes the longitudinal musculature of hollow organs. It is active when the organism is challenged. It prepares for fight and flight and generally comes to the individual's defense during periods of stress and adversity.



→ = Direction of flow of lymph in the following large areas of the body:
I = Head
II = Neck
III = Upper extremity and thorax
IV = Lower trunk and lower extremity
■ = Sites of lymphatic channel convergence

FIGURE 210.1 Diagram of Lymphatic Channel Flow

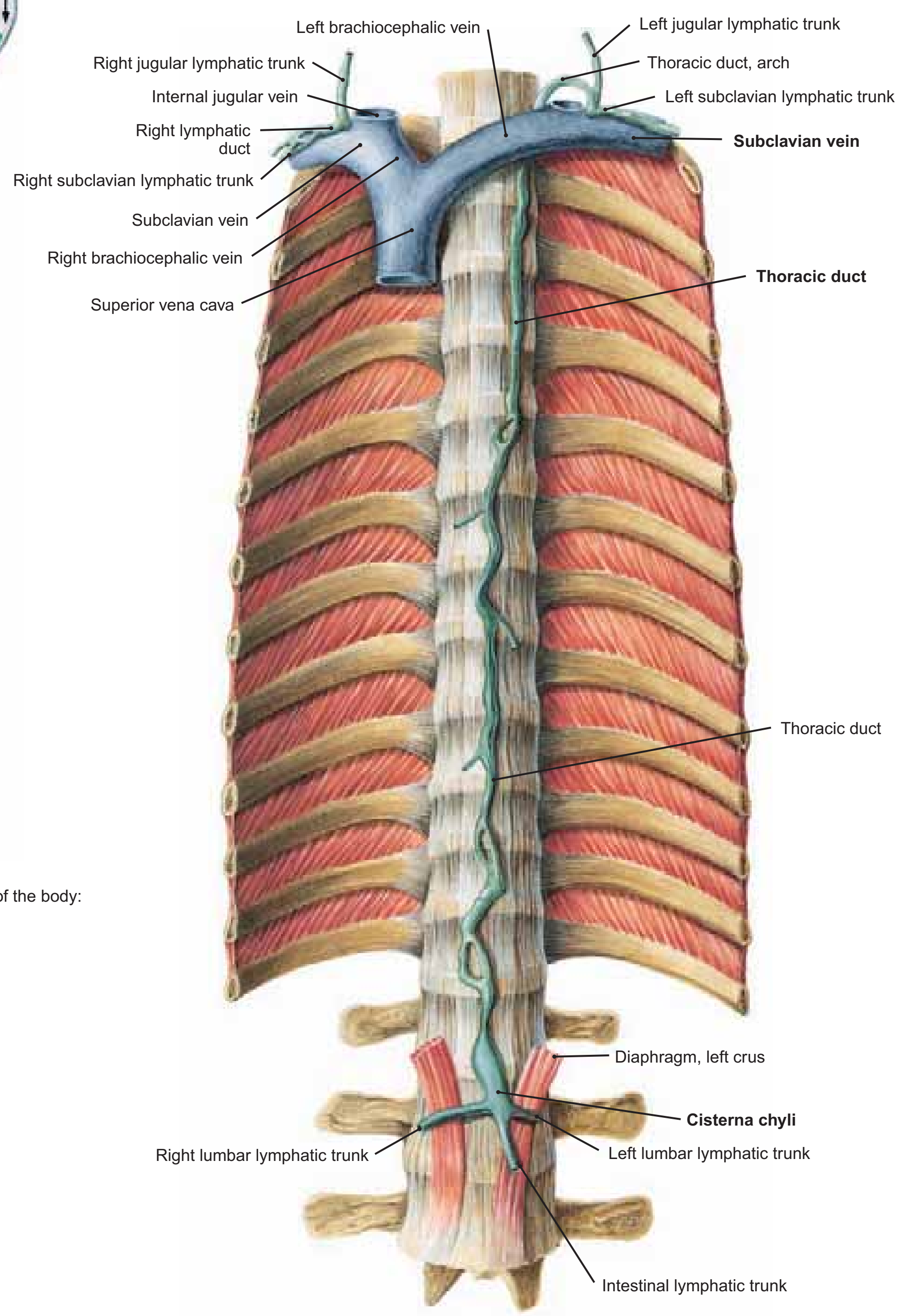


FIGURE 210.2 Thoracic Duct: Its Origin and Course

NOTE: (1) The **thoracic duct** collects lymph from most of the body regions and conveys it back into the bloodstream. The duct originates in the abdomen anterior to the second lumbar vertebra at the **cisterna chyli.**

(2) The thoracic duct enters the thorax through the **aortic hiatus** of the diaphragm, slightly to the right of the midline. Within the posterior mediastinum of the thorax, still coursing just ventral to the vertebral column, it gradually crosses the midline from right to left.

(3) The duct then ascends into the root of the neck on the left side and opens into the **left subclavian vein** near the junction of the **left internal jugular vein.**

(4) The **right lymphatic duct** receives lymph from the right side of the head, neck, and trunk and from the right upper extremity. It empties into the **right subclavian vein.**

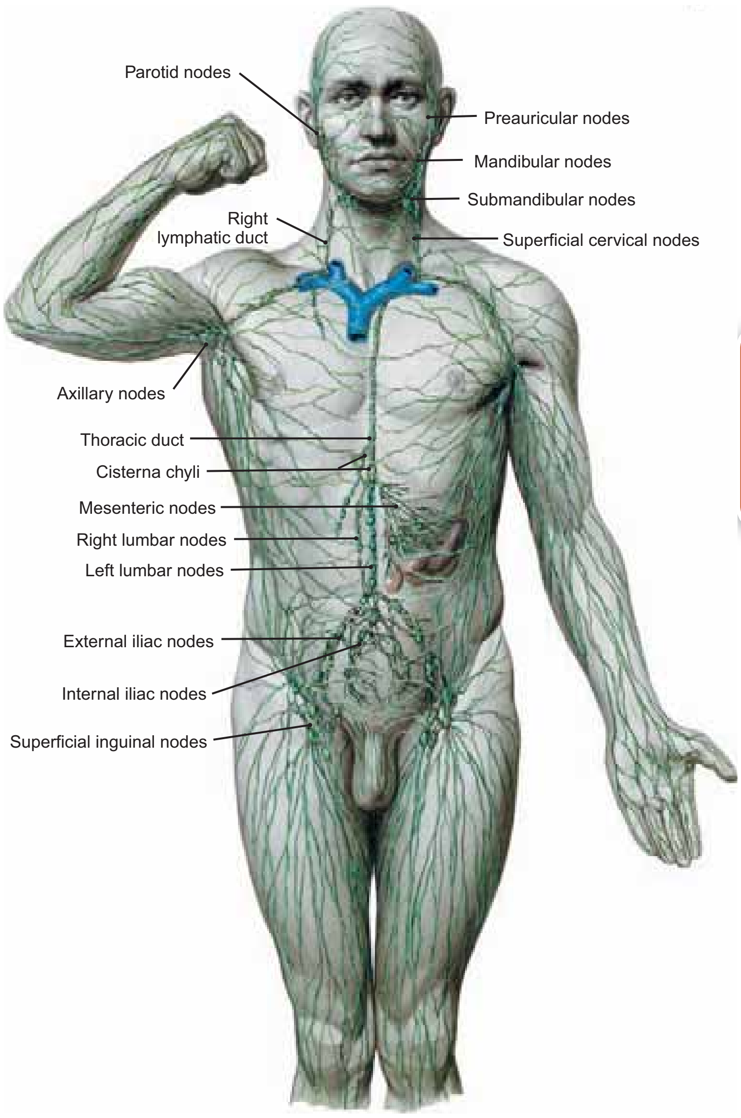


FIGURE 211.1 Certain Lymphatics of the Head, Abdomen, Pelvis, and Limbs

NOTE: (1) In addition to its physiologic importance in returning tissue fluids and cells to the blood vascular system, the lymphatic system may serve as pathways for the spread of disease.

(2) Lymph channels may be used as preformed tubes for the spread of infectious diseases as well as metastatic cells from established tumors.

(3) Enlarged or painful lymph nodes are often clinical signs of disease processes elsewhere in the body or of the lymphoid organs themselves.

(4) This figure shows the lymphatic channels that drain the upper limb into axillary nodes and those of the lower limb into the inguinal nodes. Also seen are the iliac and lumbar nodes as well as the mesenteric nodes. Not shown are the deep nodes of the head, neck, and thorax or many of the visceral nodes of the thorax, abdomen, and pelvis.

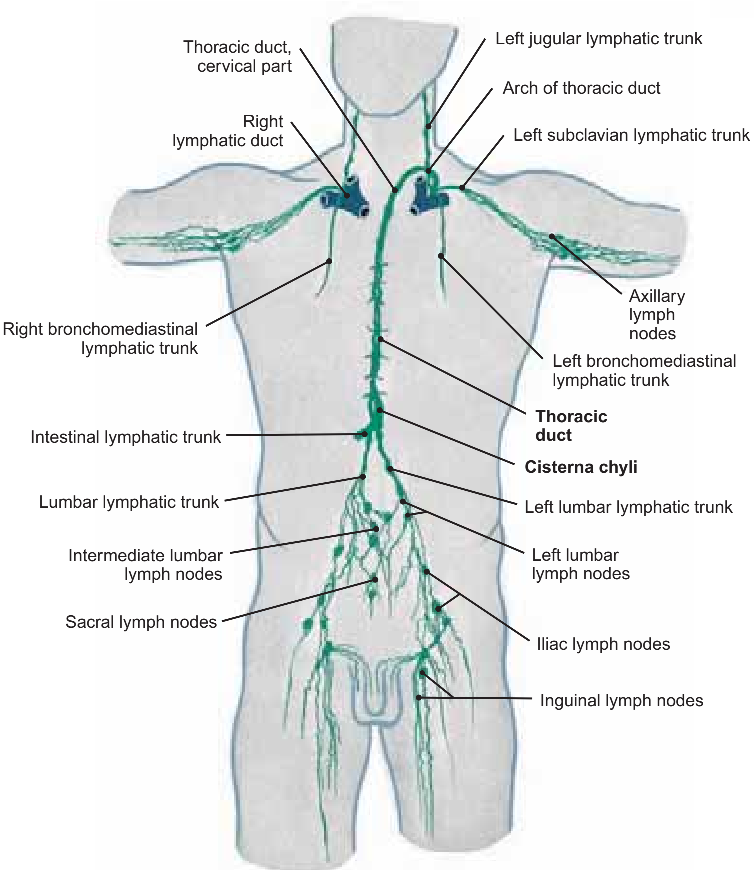


FIGURE 211.2 Large Lymphatic Vessels

NOTE: (1) The **inguinal lymph nodes** drain the lower limb. The inguinal nodes drain into the **iliac nodes,** which also receive lymph from the pelvic organs.

(2) The iliac nodes drain into the **right** and **left lumbar nodes.** The lumbar lymphatic trunks join the **intestinal trunk(s)** to form the **cisterna chyli,** which opens into the **thoracic duct.**

(3) The thoracic duct receives the **left jugular** and **left subclavian trunks** as well as the **left bronchomediastinal trunk** before it opens into the **left subclavian vein.**

(4) The **right lymphatic duct** drains the **right jugular trunk** and the **right subclavian trunk** (shown but not labeled), as well as the **right bronchomediastinal** trunk before opening into the **right subclavian vein.**

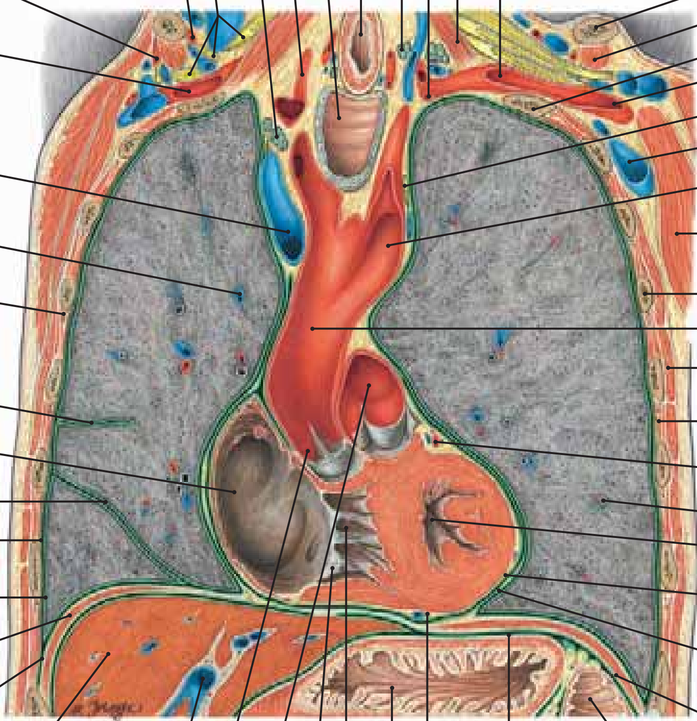
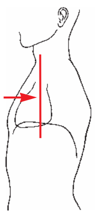



FIGURE 212.1 **Frontal Section through the Thoracic Cavity (Anterior View)**

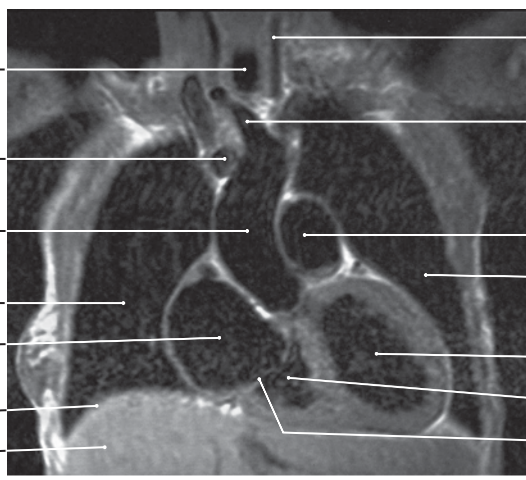


FIGURE 212.2 **MRI of Thorax at the Level of the Superior Vena Cava (Anterior View)**

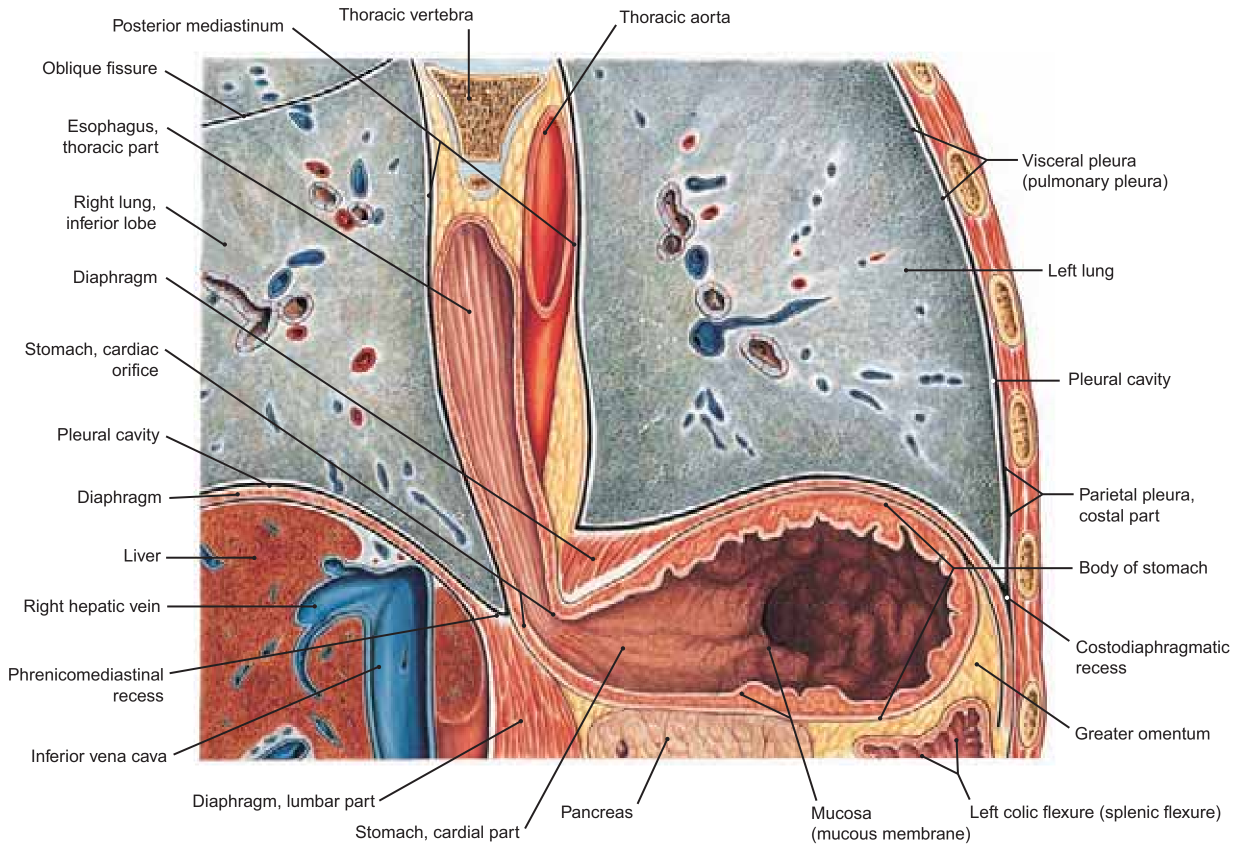


FIGURE 213.1 Frontal Section through the Lower Left Thorax and Upper Left Abdomen (Anterior View)

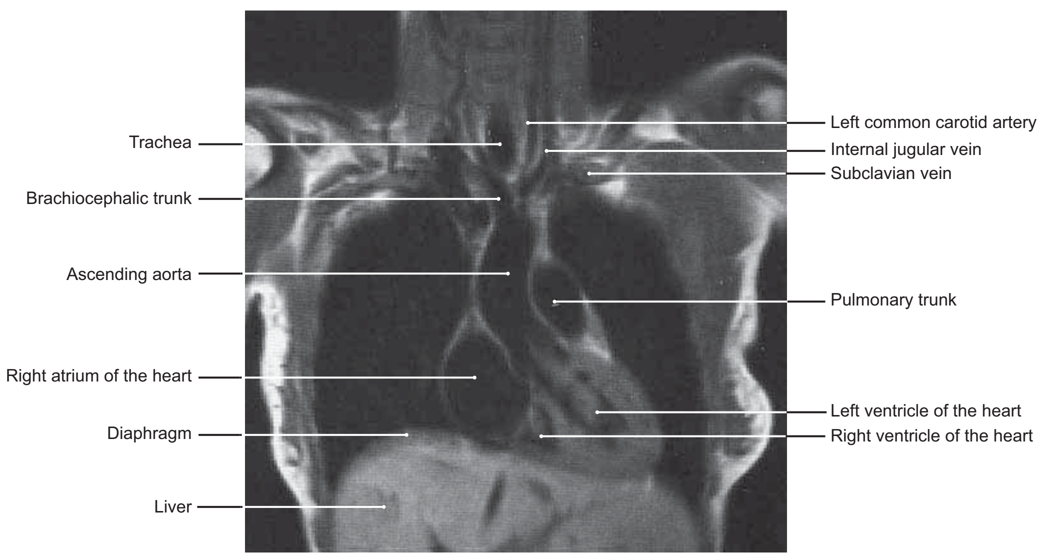


FIGURE 213.2 MRI of Thorax at the Level of the Aortic Valve (Superior View)

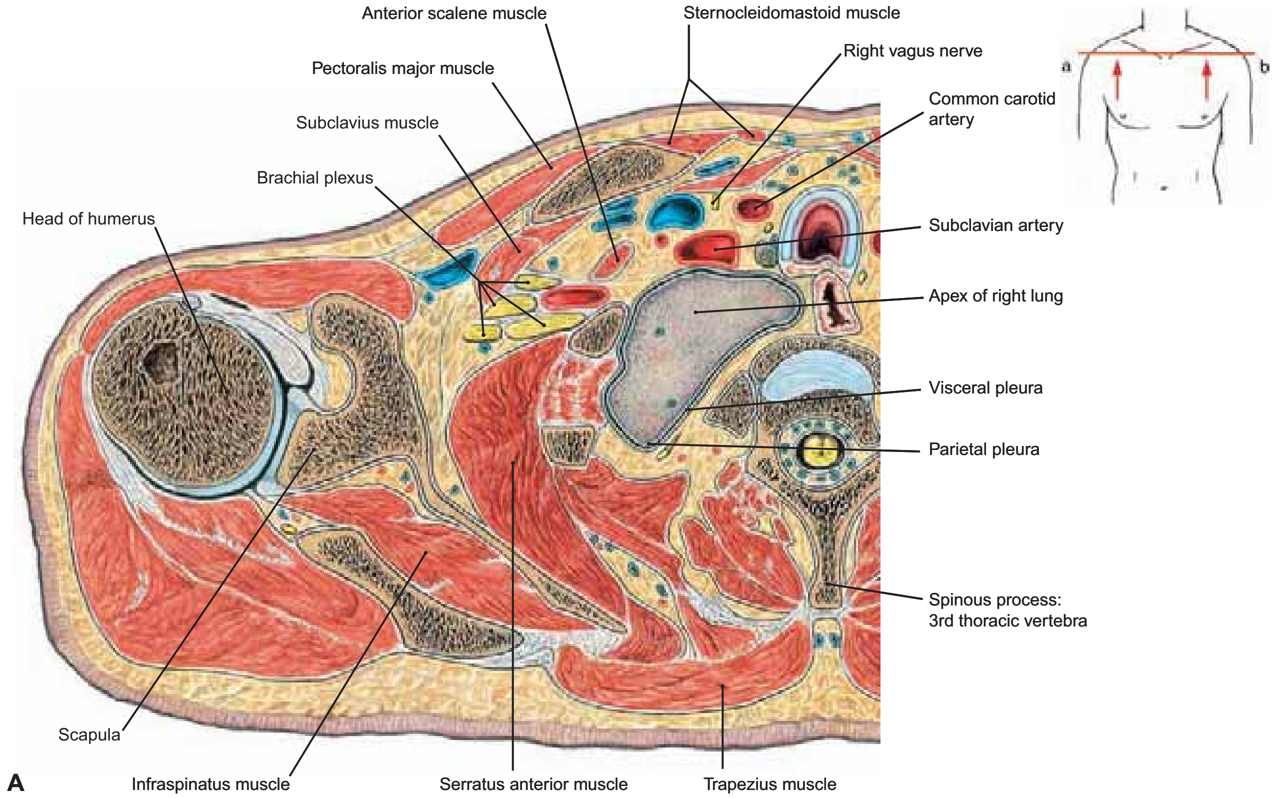


FIGURE 214A Right Side of Body

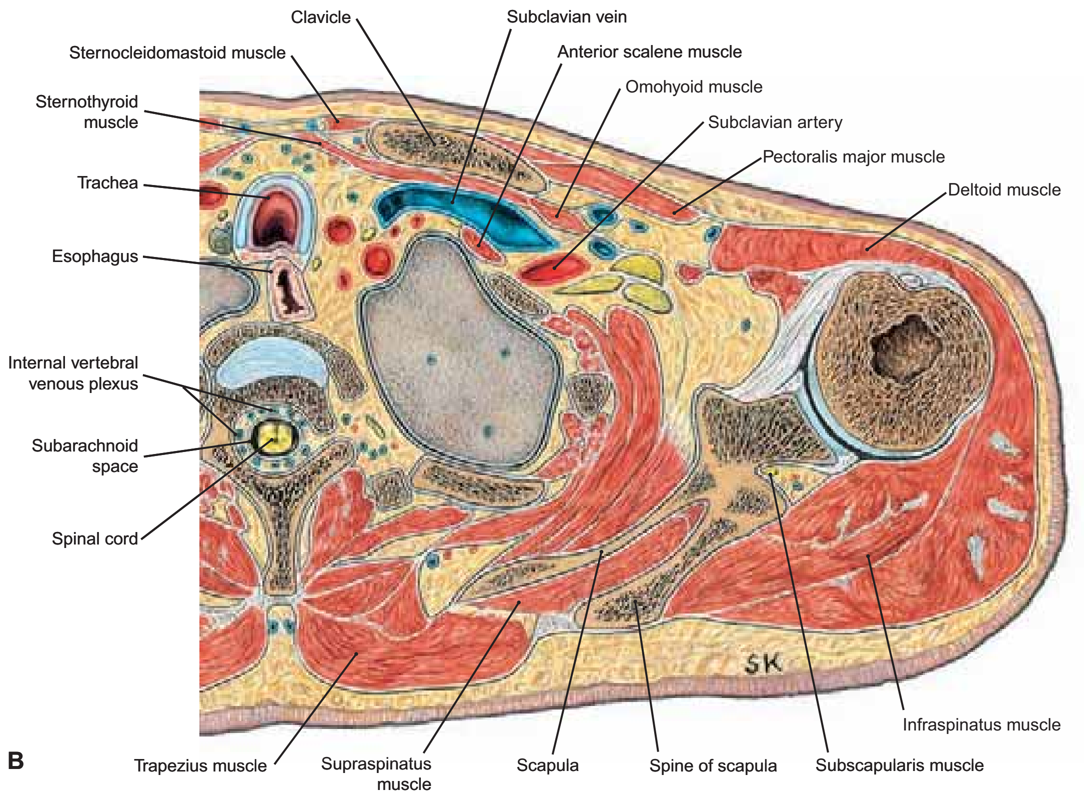


FIGURE 214B Left Side of Body

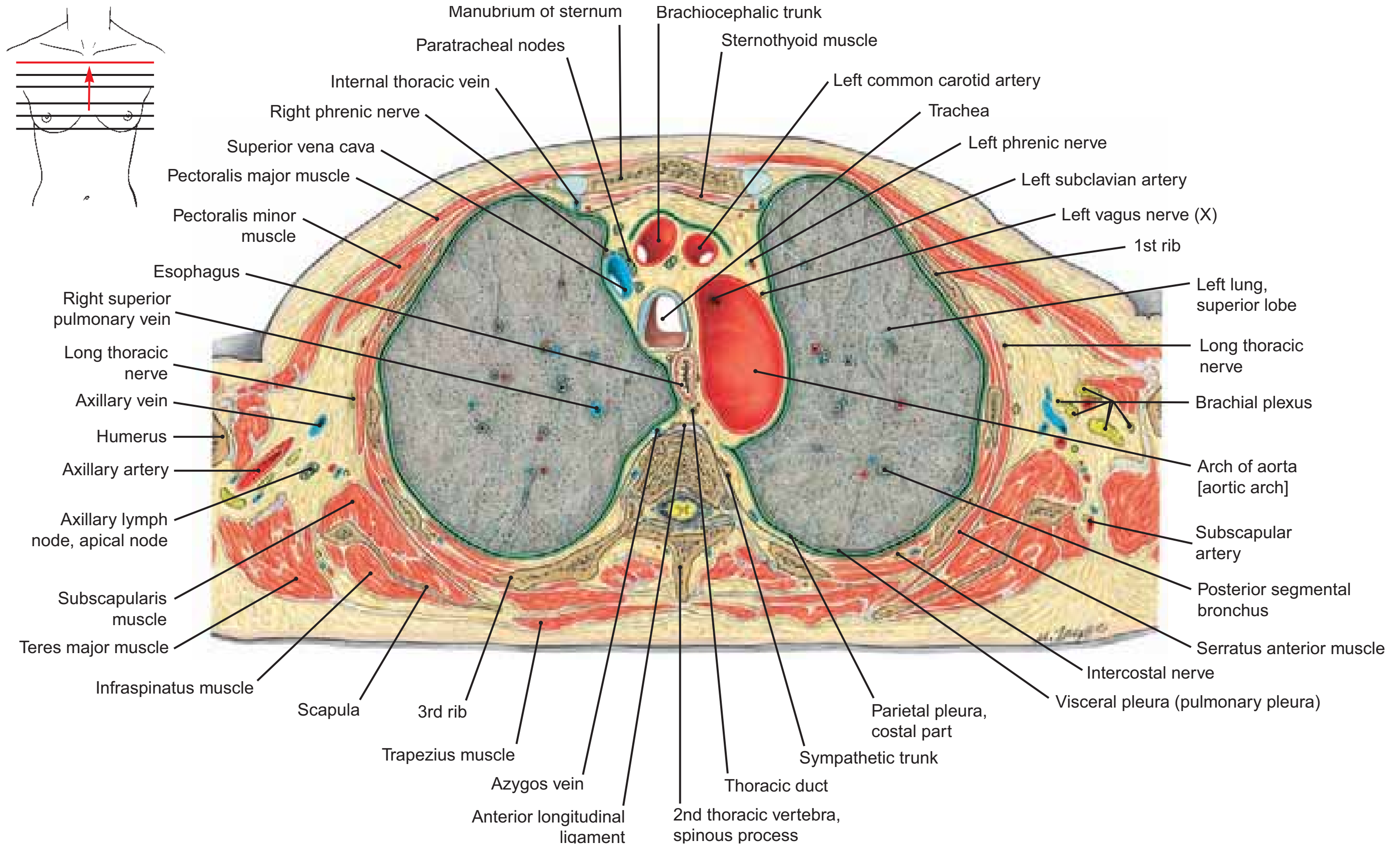


FIGURE 215.1 Horizontal Section through the Thorax at the Level of the Arch of the Aorta (Caudal View)

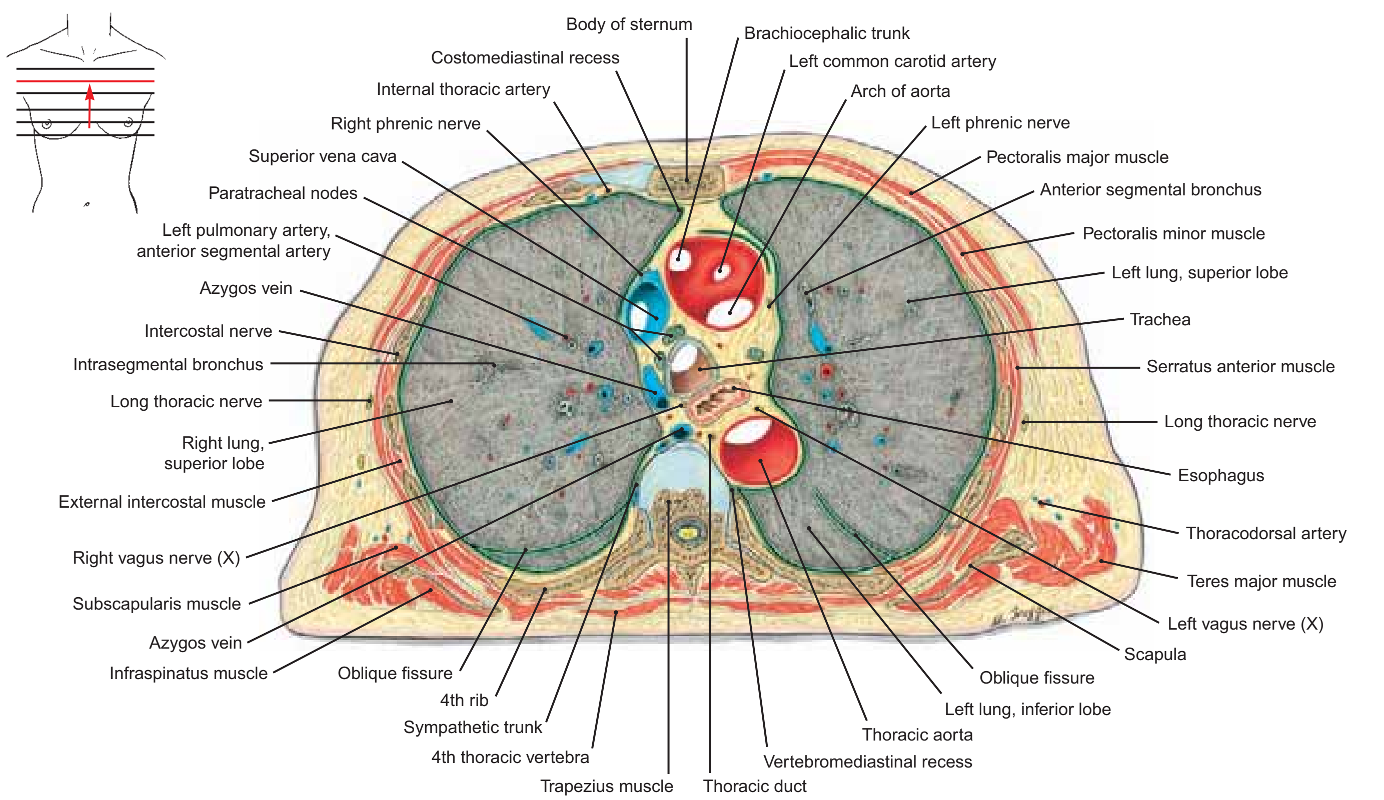


FIGURE 215.2 Horizontal Section through the Thorax at the Level of the Fourth Thoracic Vertebra (Caudal View)

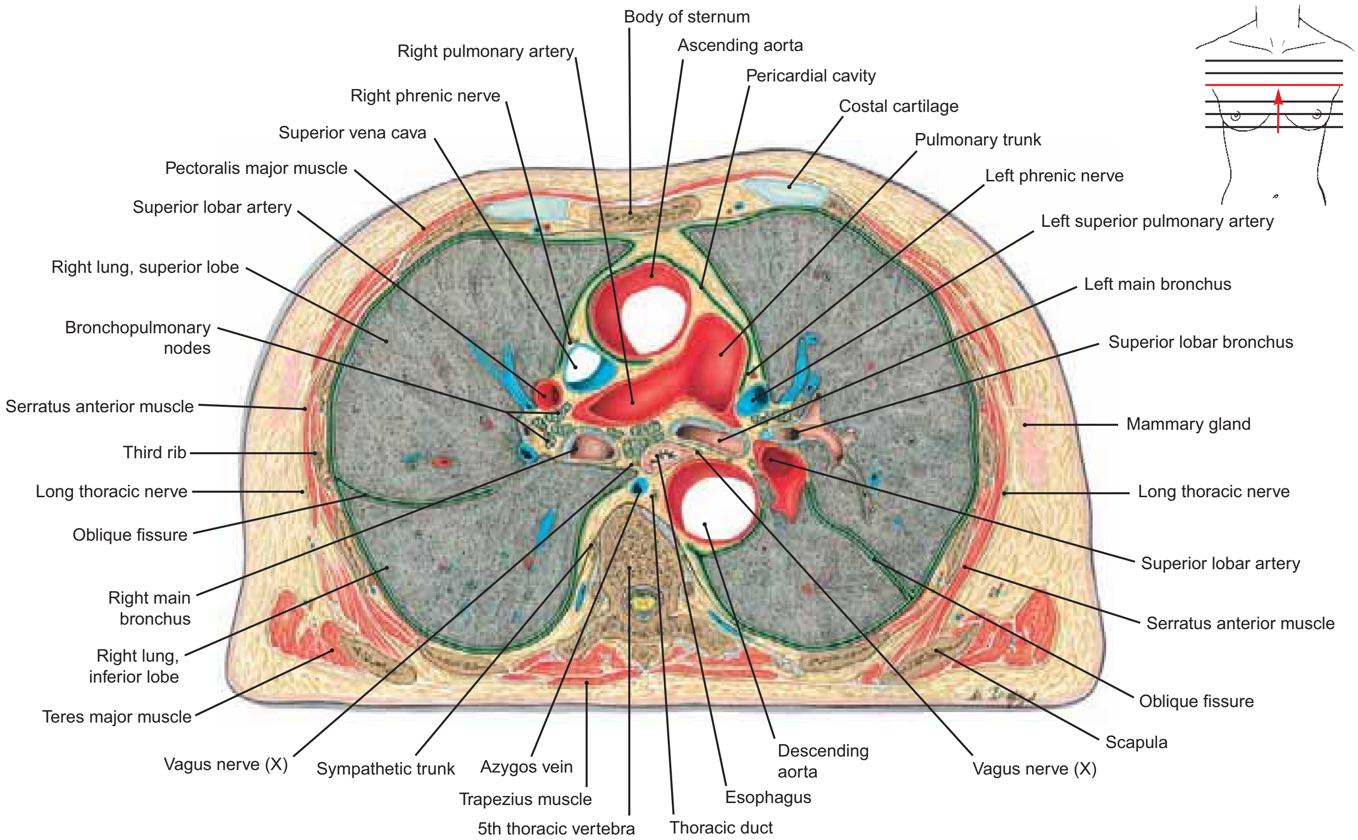


FIGURE 216.1 Horizontal Section through the Thorax at the Bifurcation of the Pulmonary Trunk (Caudal View)

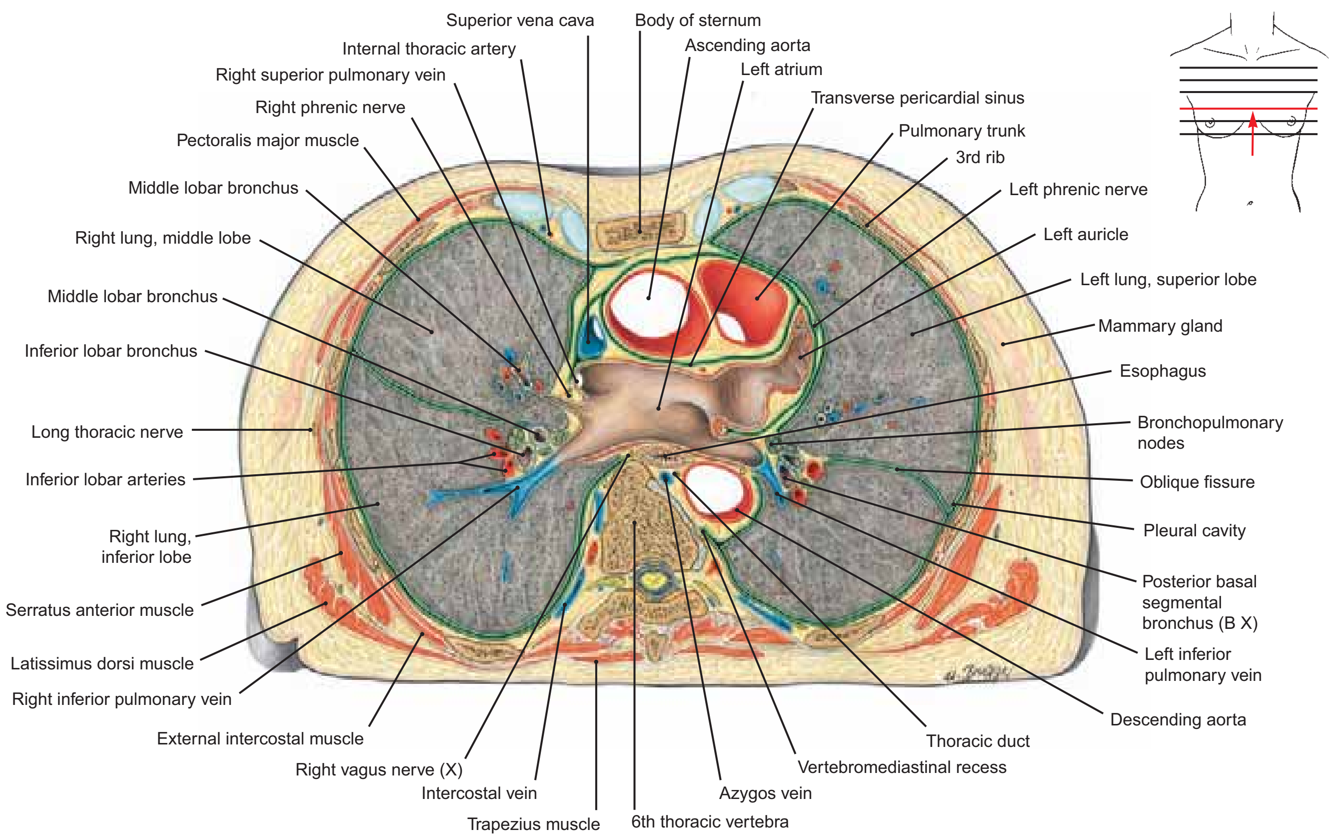


FIGURE 216.2 Horizontal Section through the Thorax at the Level of the Left Atrium (Caudal View)

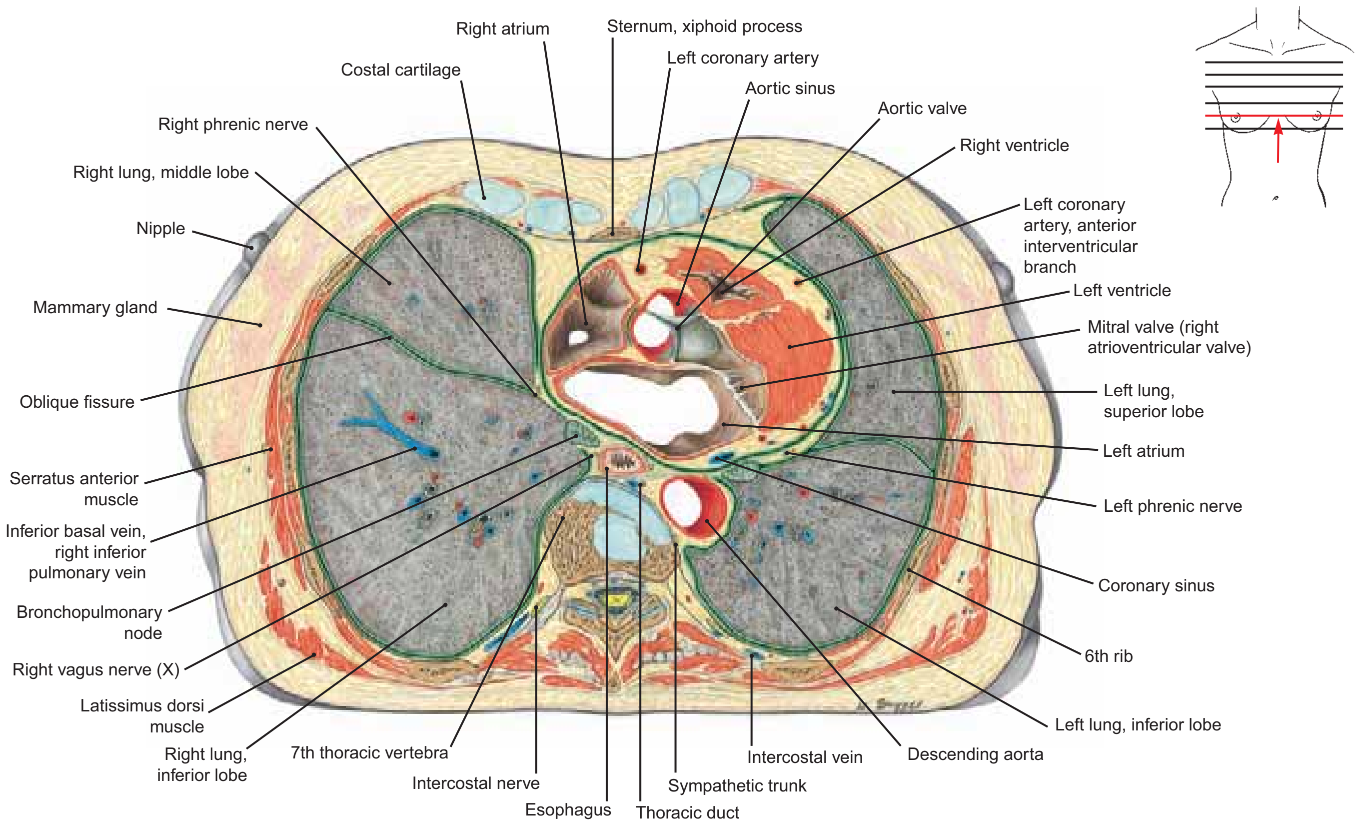


FIGURE 217.1 Horizontal Section through the Thorax at the Level of the Seventh Thoracic Vertebra (Caudal View)

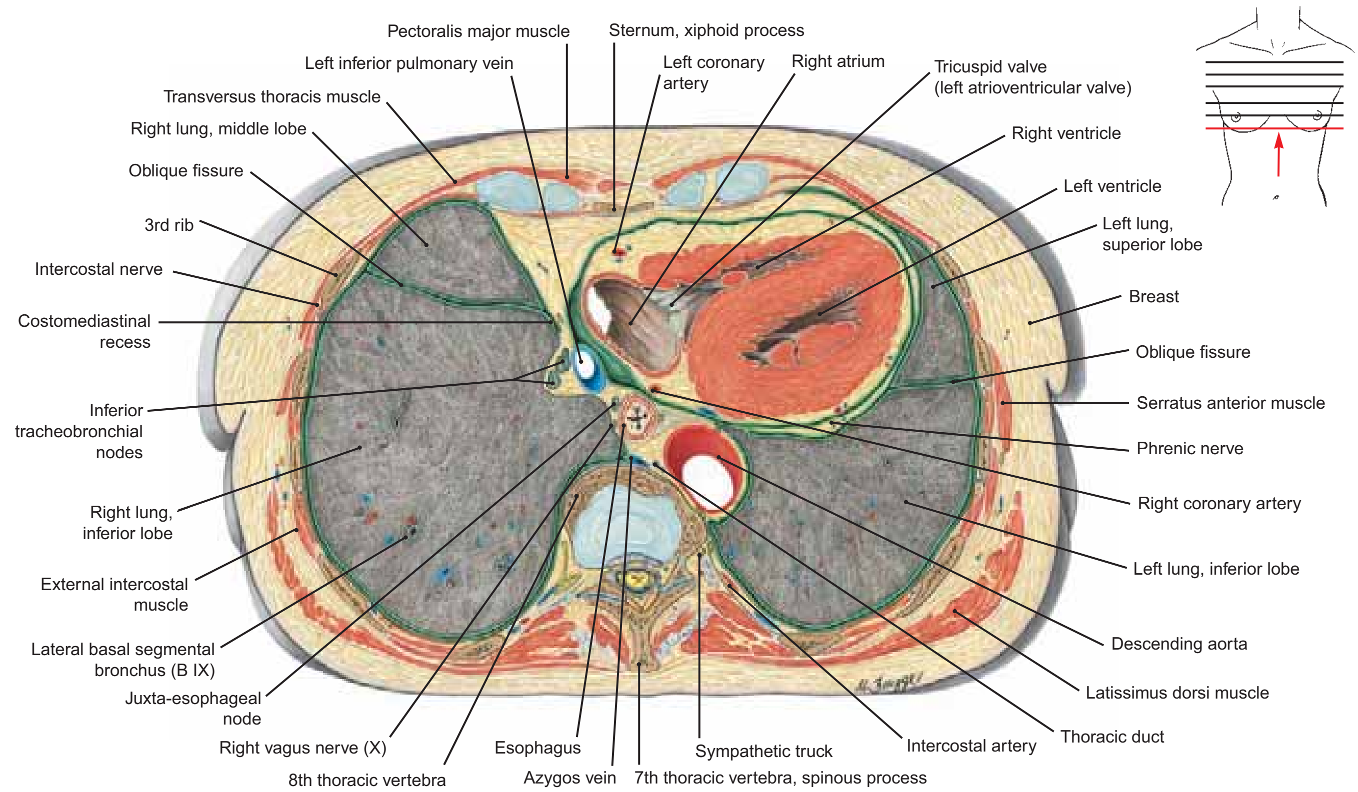


FIGURE 217.2 Horizontal Section through the Thorax at the Level of the Eighth Thoracic Vertebra (Caudal View)

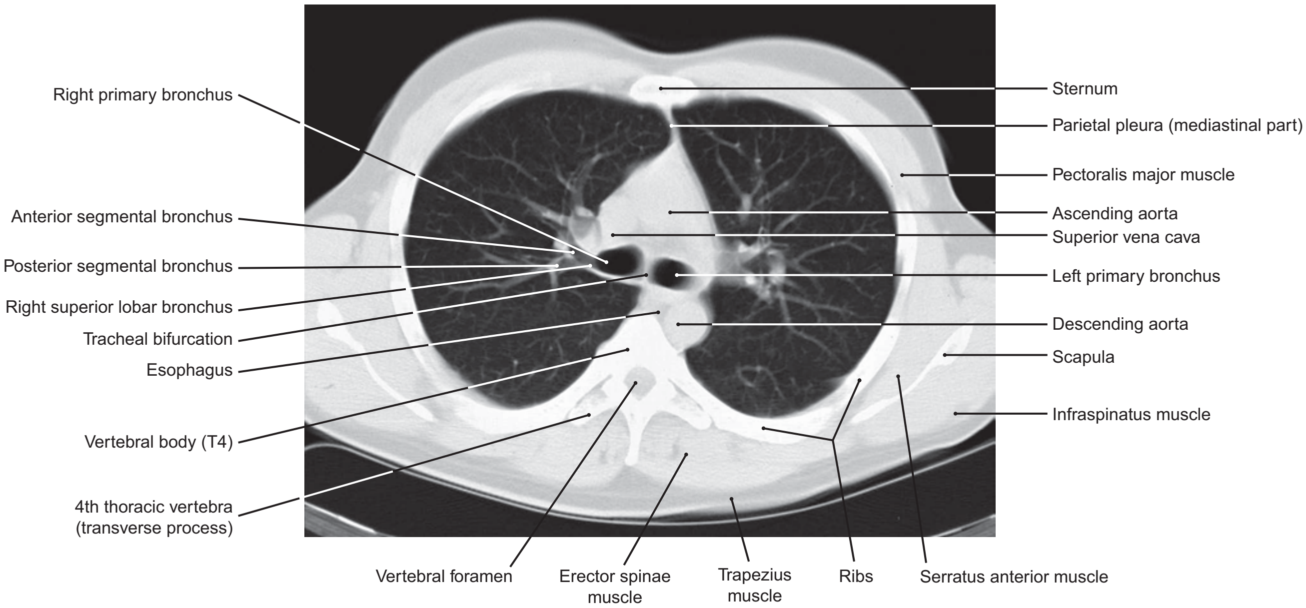


FIGURE 218.1 Computed Tomographic Cross Section of the Thorax

NOTE that this CT is just inferior to the bifurcation of the trachea.

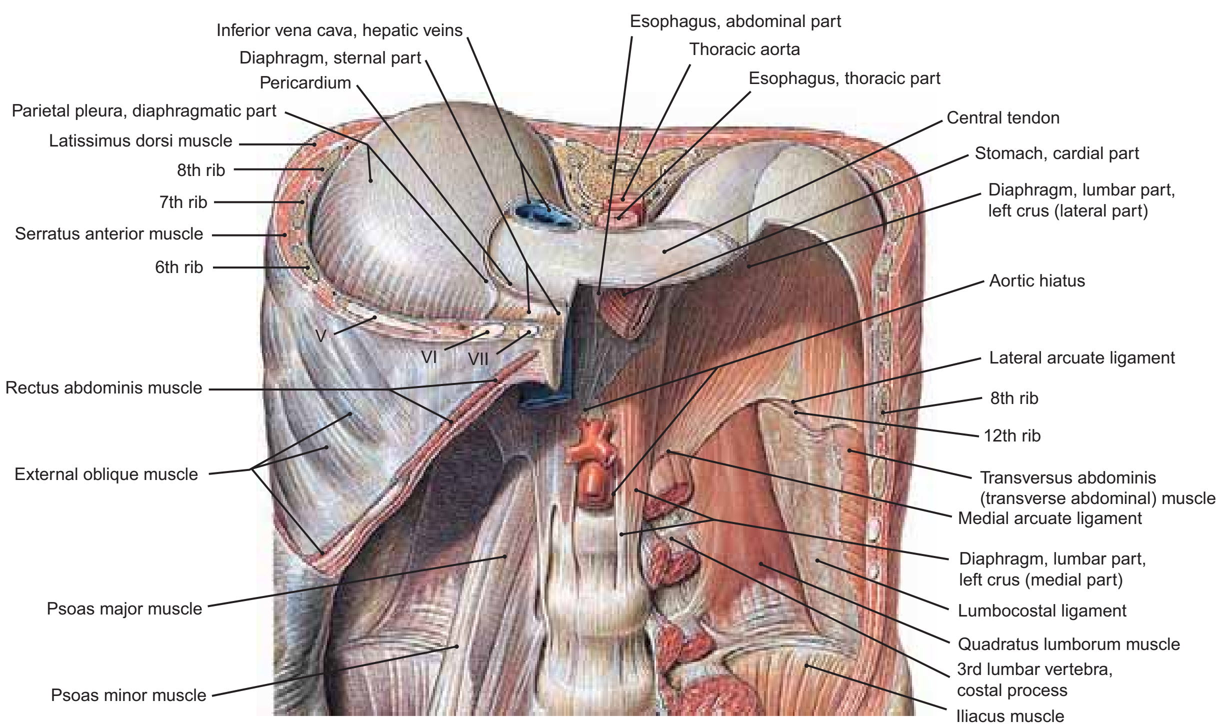


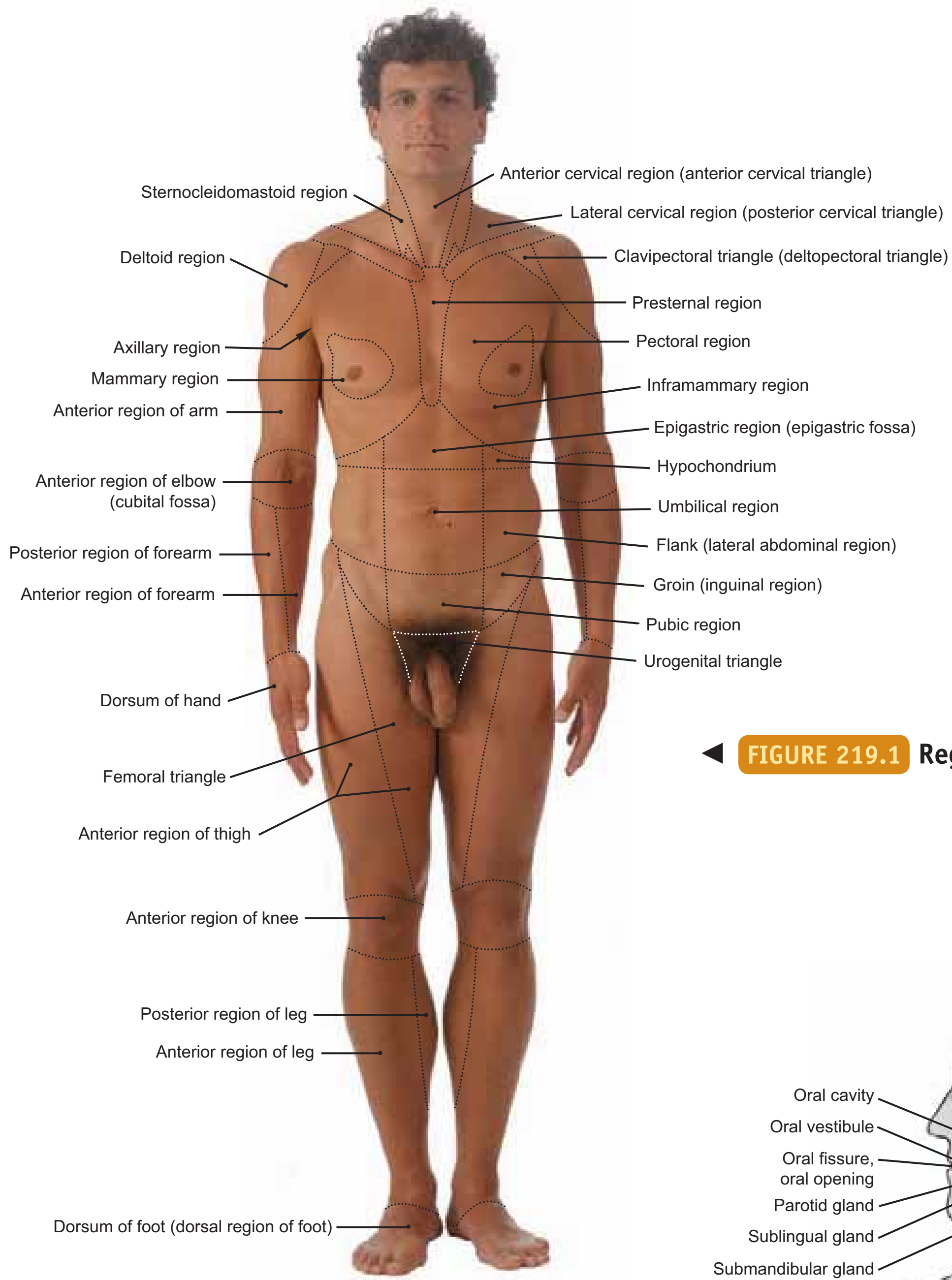
FIGURE 218.2 The Diaphragm

NOTE the inferior vena cava **(vena caval orifice: level of T8),** the esophagus **(esophageal hiatus: level of T10),** and the aorta **(aortic hiatus: at the level of L1).**

CHAPTER 3

The Abdomen

Plates



◀ FIGURE 219.1 Regions of the Body (Anterior View)

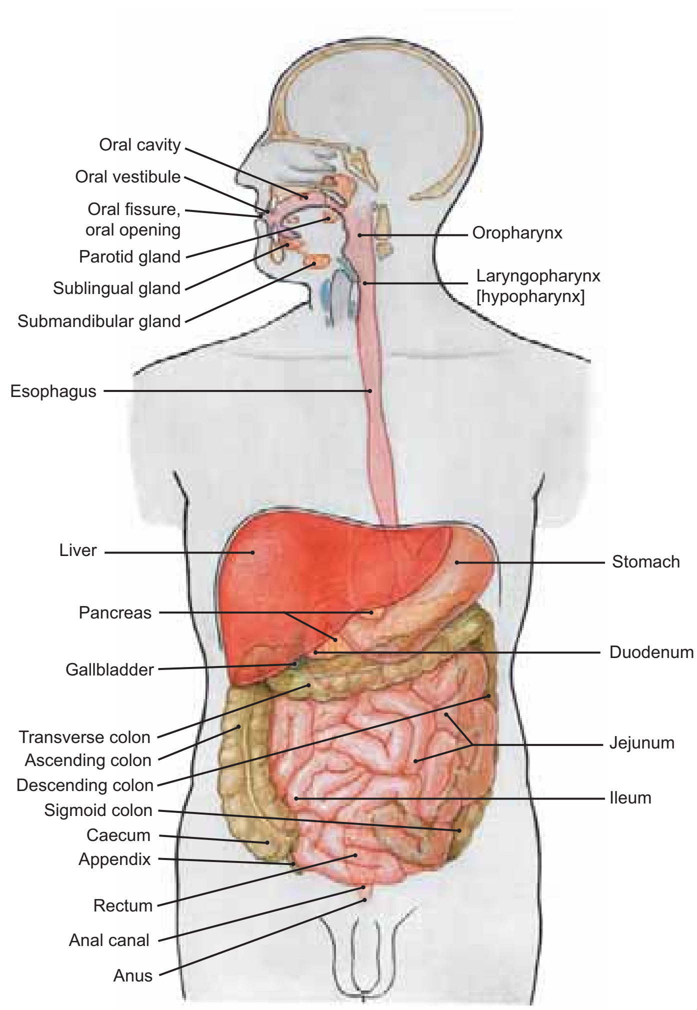


FIGURE 219.2 Organs of the Gastrointestinal System ▶

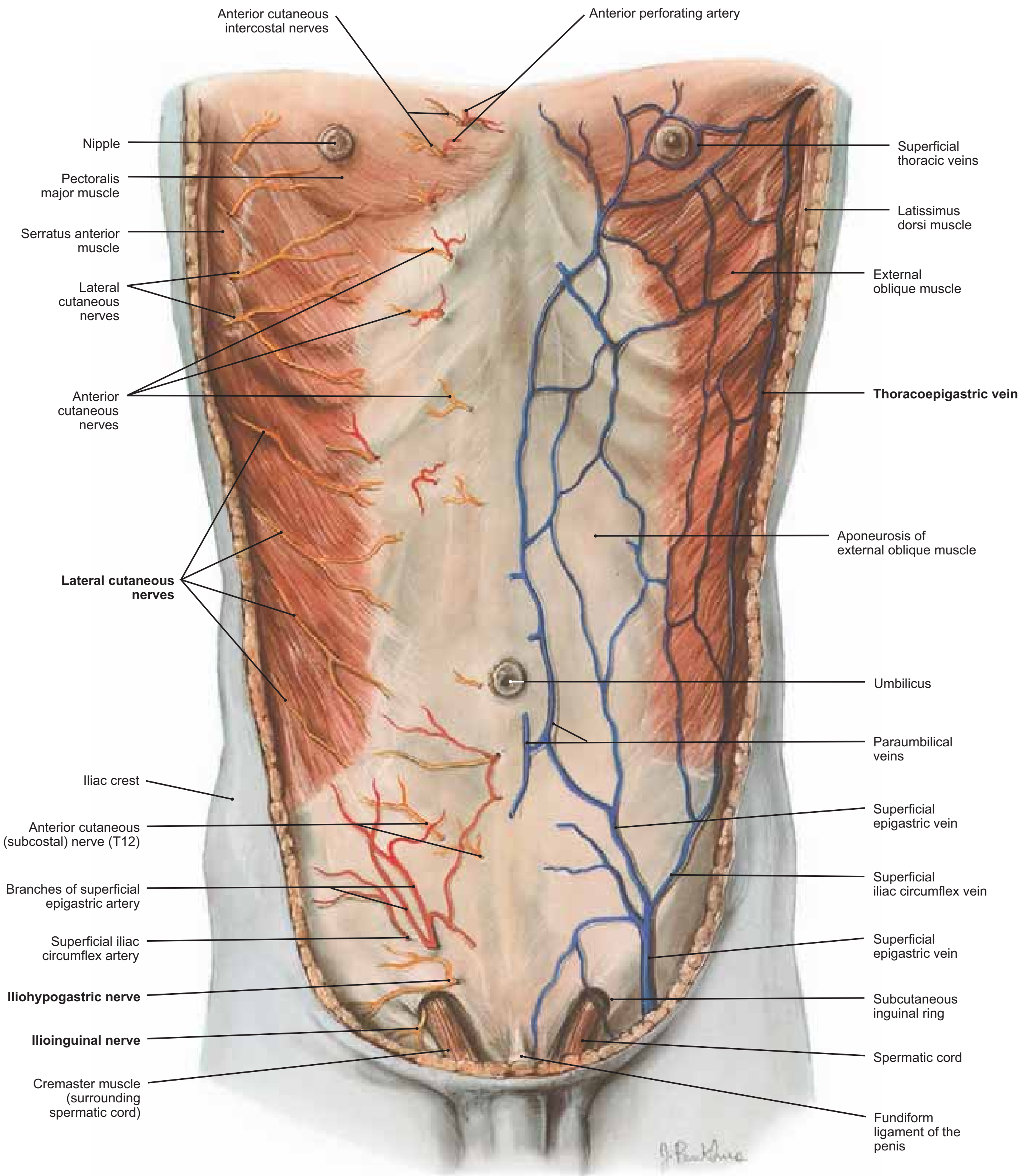


FIGURE 220 Superficial Nerves and Vessels of the Anterior Abdominal Wall

NOTE: (1) The distribution of the superficial vessels and cutaneous nerves upon the removal of the skin and fascia from the lower thoracic and anterior abdominal wall.

(2) The intercostal nerves supply the abdominal surface with lateral and anterior cutaneous branches.

(3) The ilioinguinal and iliohypogastric branches of the first lumbar nerve become superficial in the region of the **superficial inguinal ring.**

(4) The branches of the **superficial epigastric artery** (which arises from the femoral artery) ascending toward the umbilicus from the inguinal region.

(5) The **thoracoepigastric vein** serves as a means of communication between the femoral vein and the axillary vein. In cases of portal vein obstruction, these superficial veins become greatly enlarged (varicosed), a condition called caput medusae.

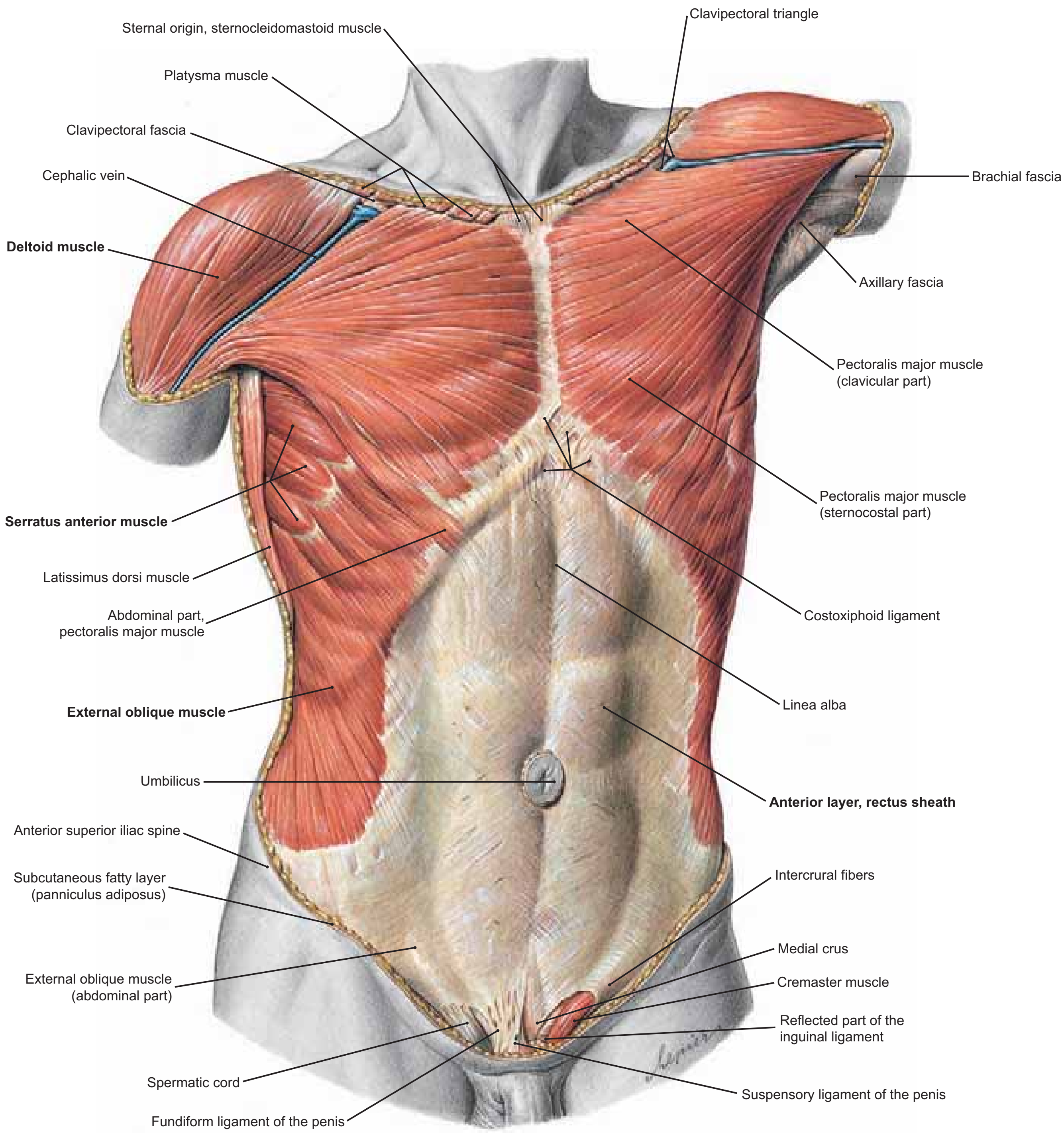


FIGURE 221 Superficial Musculature of the Anterior Abdominal and Thoracic Wall

NOTE: (1) The first layer on the anterior abdominal wall consists of the **external oblique muscle** and its broad flat aponeurosis. Medially, this aponeurosis helps form the sheath of the rectus abdominis muscle, and inferiorly, it becomes the **inguinal ligament.**

(2) The external oblique muscle arises by means of seven or eight fleshy slips from the outer surfaces of the lower seven or eight ribs, thereby interdigitating with the fleshy origin of the **serratus anterior muscle.**

(3) The fibers of the external oblique muscle course inferomedially, or in the same direction as you would insert your hands in the side pockets of your trousers or slacks.

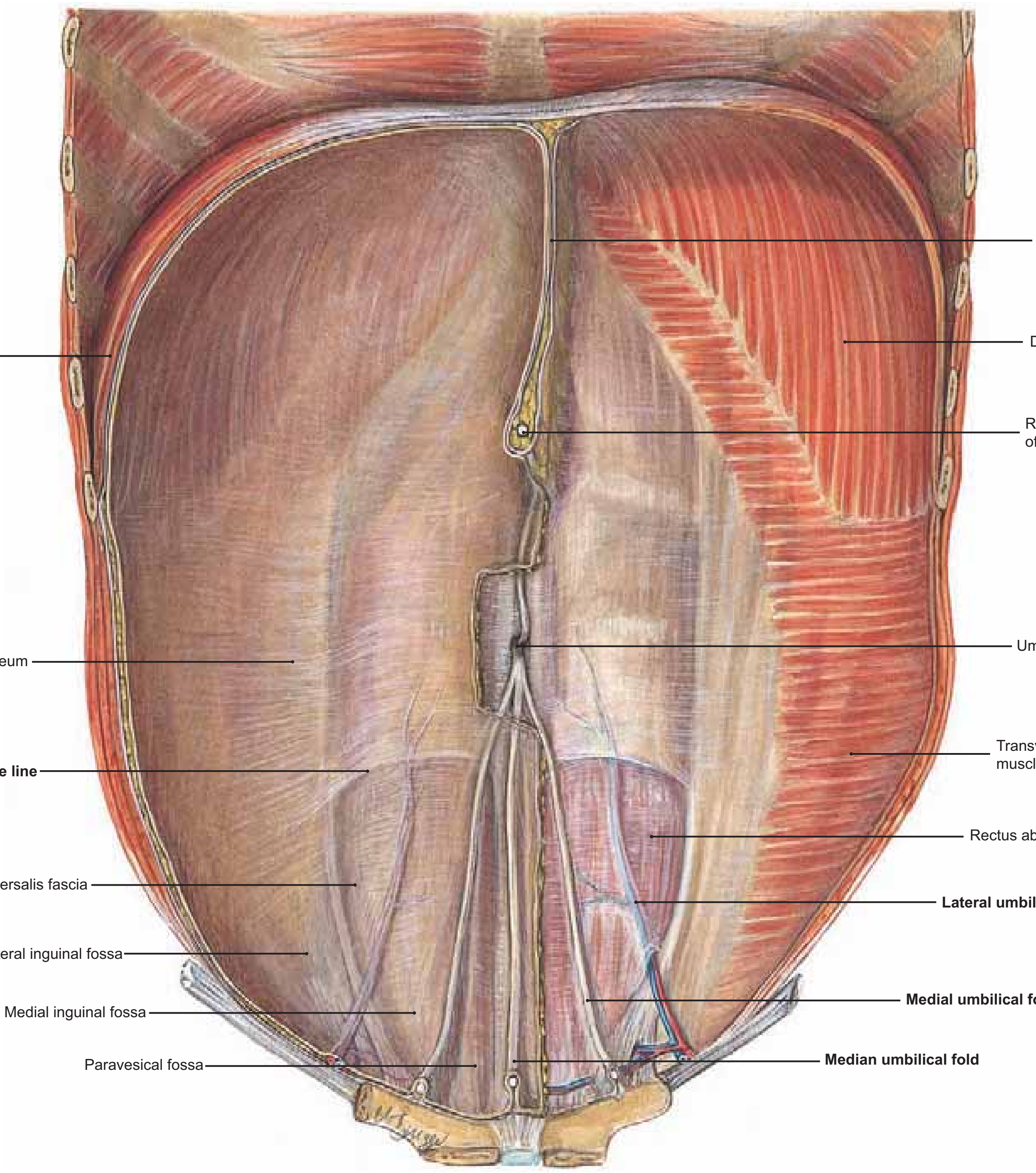


FIGURE 222 Inner Aspect of the Anterior Abdominal Wall

NOTE: (1) This posterior view of the anterior abdominal wall shows to good advantage, inferiorly, the posterior layer of the rectus sheath and the relationship of the **arcuate line** to the umbilicus.

(2) The breadth of the transversus abdominis, which lies adjacent to the next inner layer, the fascia transversalis, deep to which is the parietal peritoneum.

(3) The **median umbilical fold,** which is the remnant of the **urachus** that extended between the apex of the fetal bladder and the umbilicus during development.

(4) The **medial umbilical folds,** which are the obliterated umbilical arteries, covered by a peritoneal layer. These vessels were the continuation of the superior vesical arteries to the umbilicus in the fetus.

(5) The **lateral umbilical folds,** which are folds of parietal peritoneum covering the inferior epigastric arteries and veins.

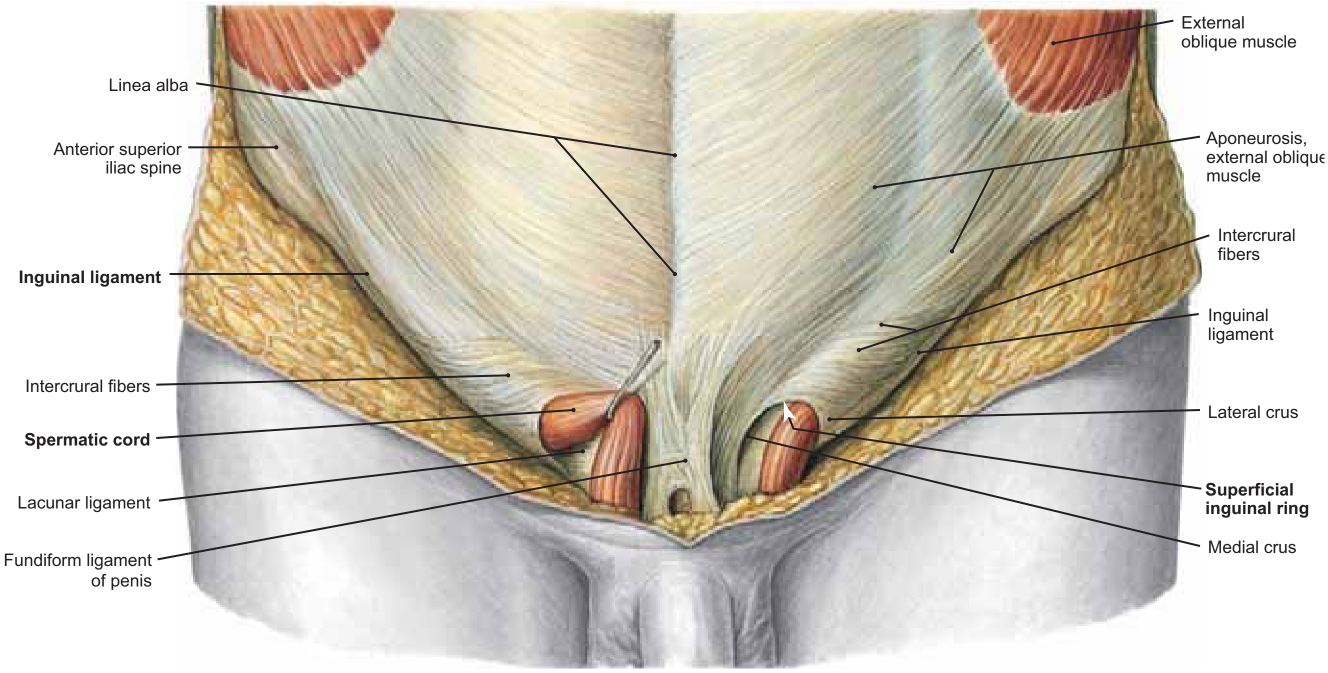


FIGURE 223.1 Superficial Inguinal Ring and Spermatic Cord

NOTE: (1) The superficial inguinal ring transmits the **spermatic cord** in the male and the **round ligament of the uterus** in the female. In this dissection, the right spermatic cord has been lifted to show the border of the ring as well as the **lacunar ligament.**

(2) The tendinous fibers of the aponeurosis are continuous with the fleshy fibers of the external oblique. They are directed inferomedially and decussate across the linea alba.

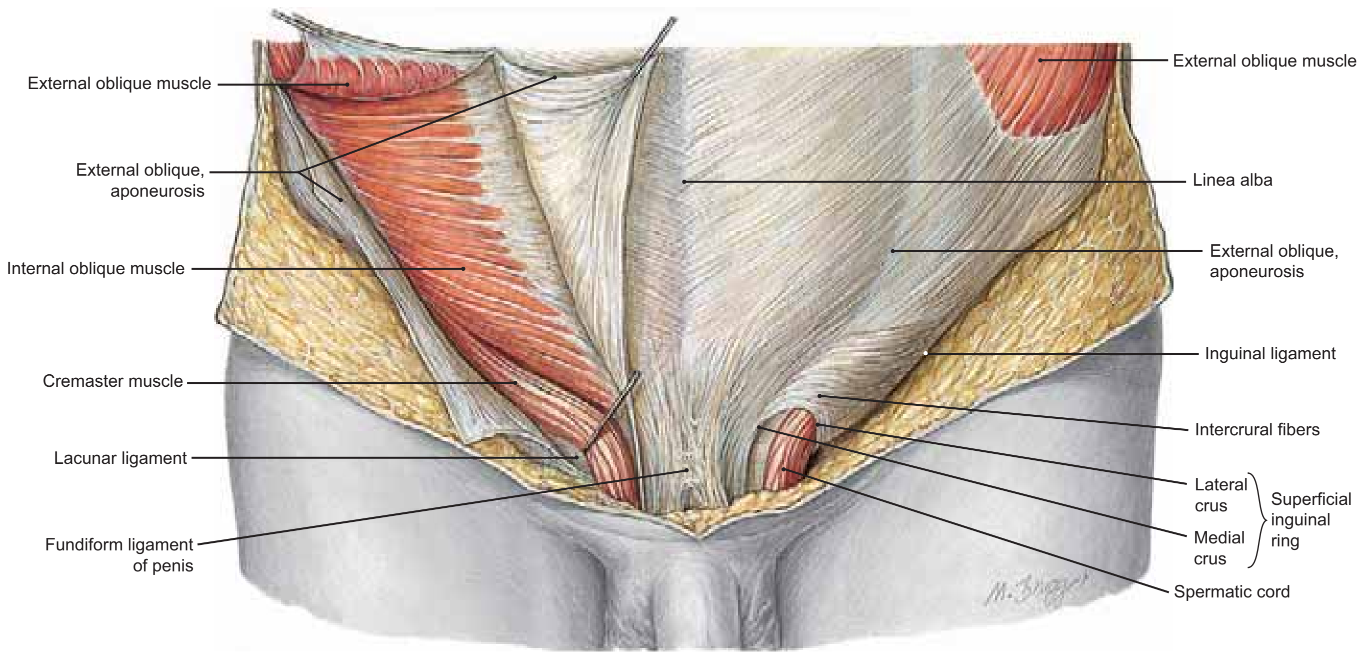


FIGURE 223.2 Right Internal Oblique Muscle (Inferior Part) and the Superficial Inguinal Ring

NOTE: (1) The aponeurosis of the external oblique muscle (reader's left) has been severed and lifted to show the inferior part of the internal oblique muscle.

(2) The right superficial inguinal ring has been opened and the right spermatic cord has been hooked and lifted.

(3) The superficial inguinal ring is a slit-like opening in the external oblique muscle. Observe how **the intercrural fibers** strengthen the lateral aspect of the superficial ring by extending between the **medial and lateral crura.**

(4) The **inguinal ligament** extends between the anterior superior iliac spine and the pubic tubercle. This ligament is formed by the lowermost fibers of the external oblique aponeurosis and **lends** support to the inferior part of the anterior abdominal wall.

(5) The fundiform ligament of the penis extends downward from the aponeurosis of the external oblique muscle.

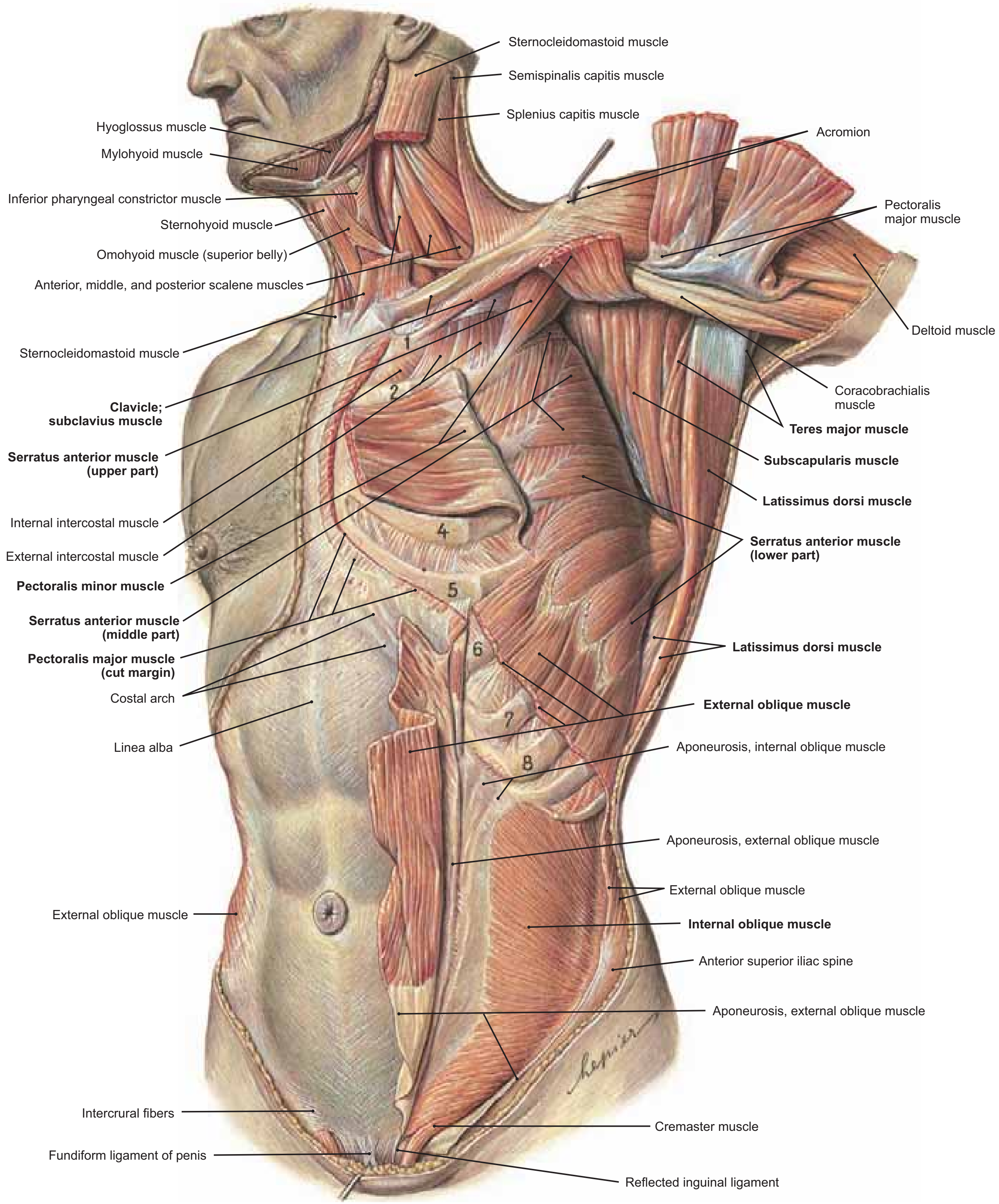


FIGURE 224 Deeper Layers of the Musculature of the Trunk, Axilla, and Neck

NOTE: (1) The pectoralis major and minor muscles have been reflected to expose the underlying digitations of the serratus anterior muscle, which attaches to the upper nine ribs.

(2) The external oblique muscle and the lower lateral part of its aponeurosis have been severed in a semicircular manner near their origin to reveal the underlying internal oblique muscle, which comprises the second layer of anterior abdominal wall muscles.

(3) The fibers of the external oblique muscle course inferomedially (or in the same direction as you would put your hands in your side pockets), whereas **most** of the fibers of the internal oblique muscle course in the opposite direction, at a 90-degree angle to the external oblique fibers.

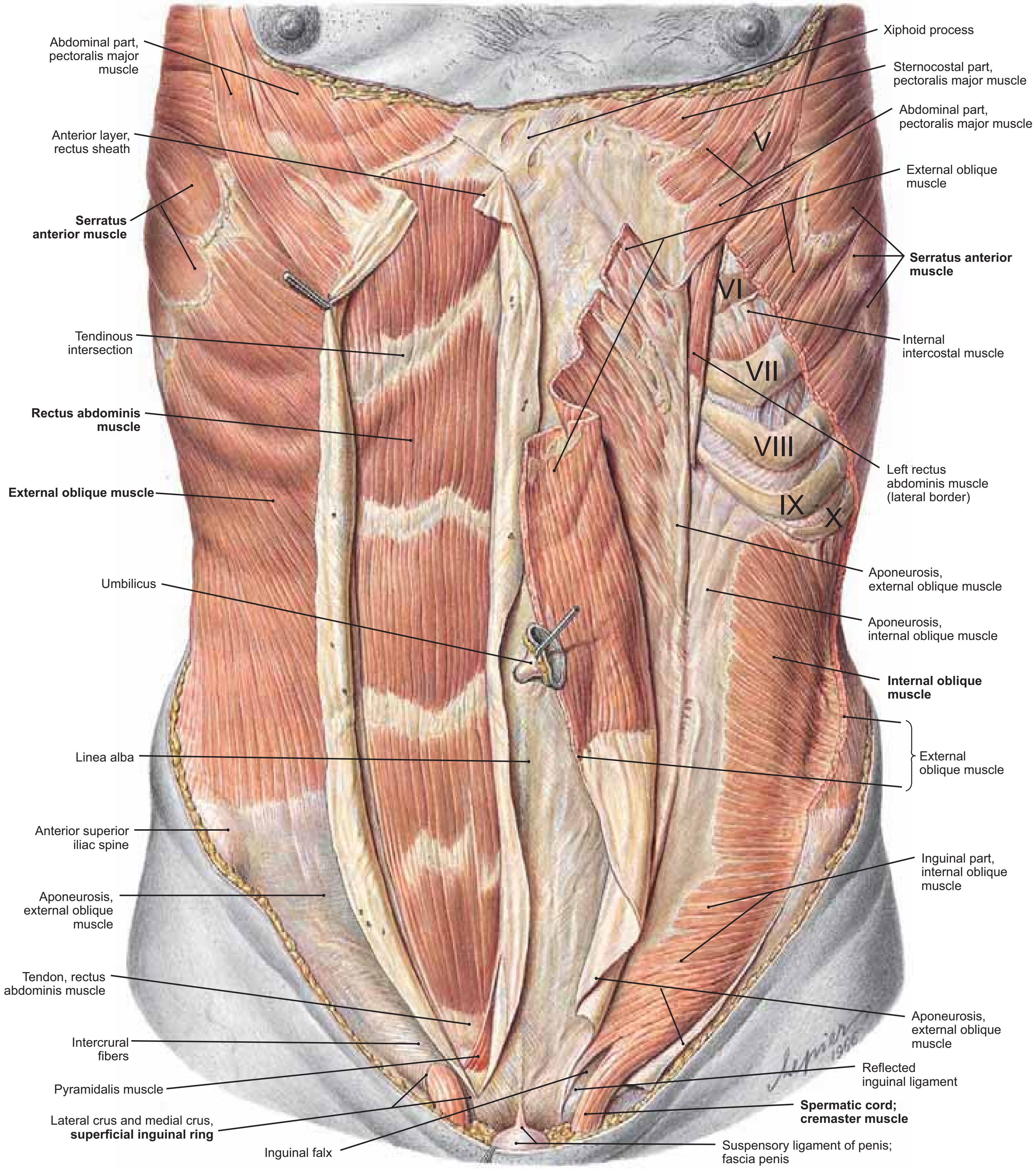


FIGURE 225 **Anterior Abdominal Wall: Rectus Abdominis and Internal Oblique Muscles**

Muscle	Origin	Insertion	Innervation	Action
External oblique	Fleshy slips from the outer surface of the lower eight ribs (ribs 5 to 12)	Outer lip of the iliac crest; aponeurosis of external oblique, which ends in a midline raphe, the **linea alba**	Lower seven thoracic nerves (T6–T12)	Compresses the abdominal viscera; **both muscles:** flex the trunk forward; **each muscle:** bends the trunk to that side and rotates the front of the abdomen to the **opposite** side

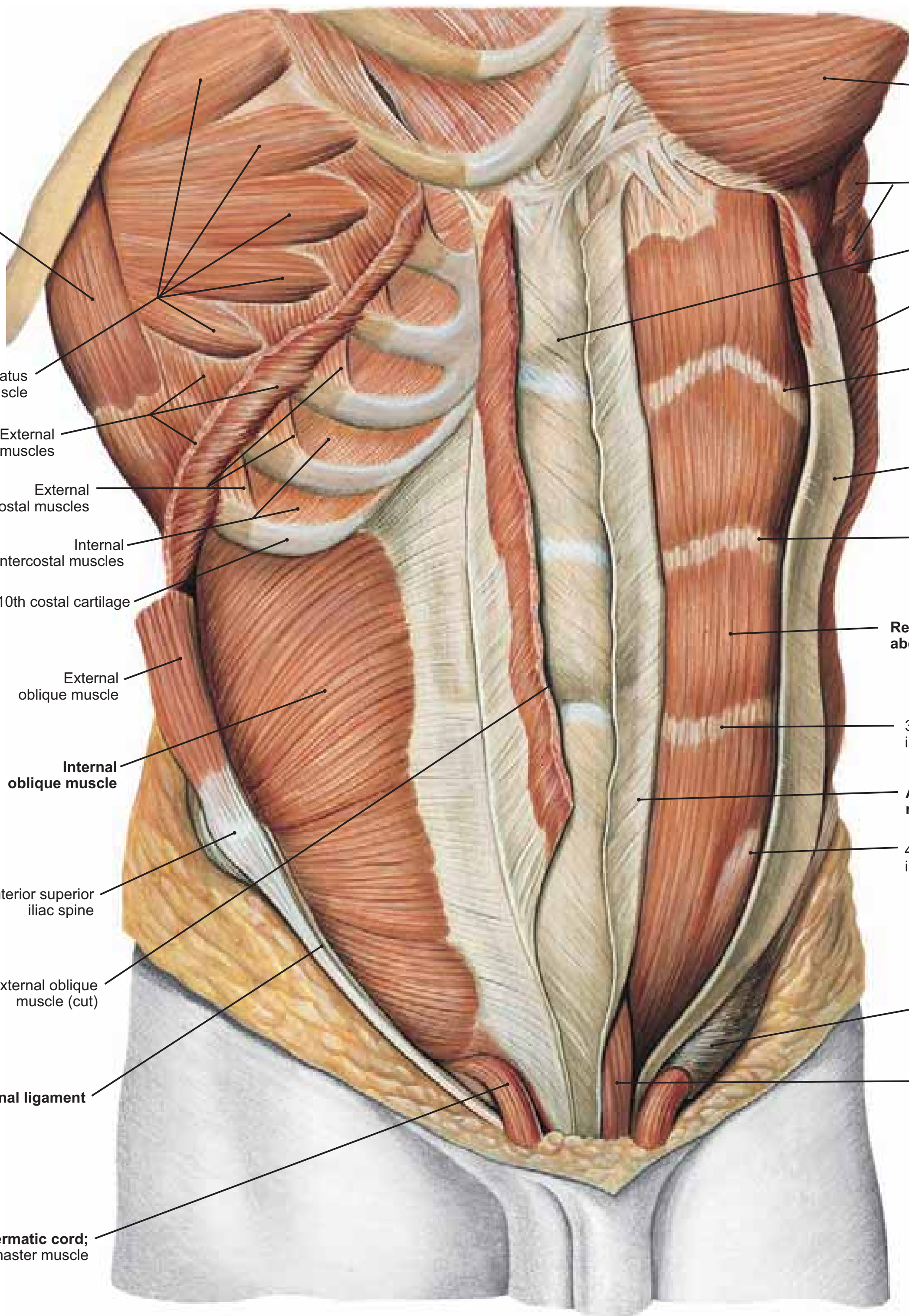


FIGURE 226 Middle Layer of Abdominal Musculature: Internal Oblique Muscle

Muscle	Origin	Insertion	Innervation	Action
Internal oblique	Lateral two-thirds of inguinal ligament; the middle lip of the iliac crest; the thoracolumbar fascia	Inferior border of the lower three or four ribs; the **linea alba;** aponeurosis fuses with that of the external oblique to help form the rectus sheath	Lower five thoracic nerves and the first lumbar nerve (T8–L1)	Compresses the abdominal viscera; **both muscles:** flex the trunk forward; **each muscle:** bends the trunk to that side but rotates the front of the abdomen toward the **same** side

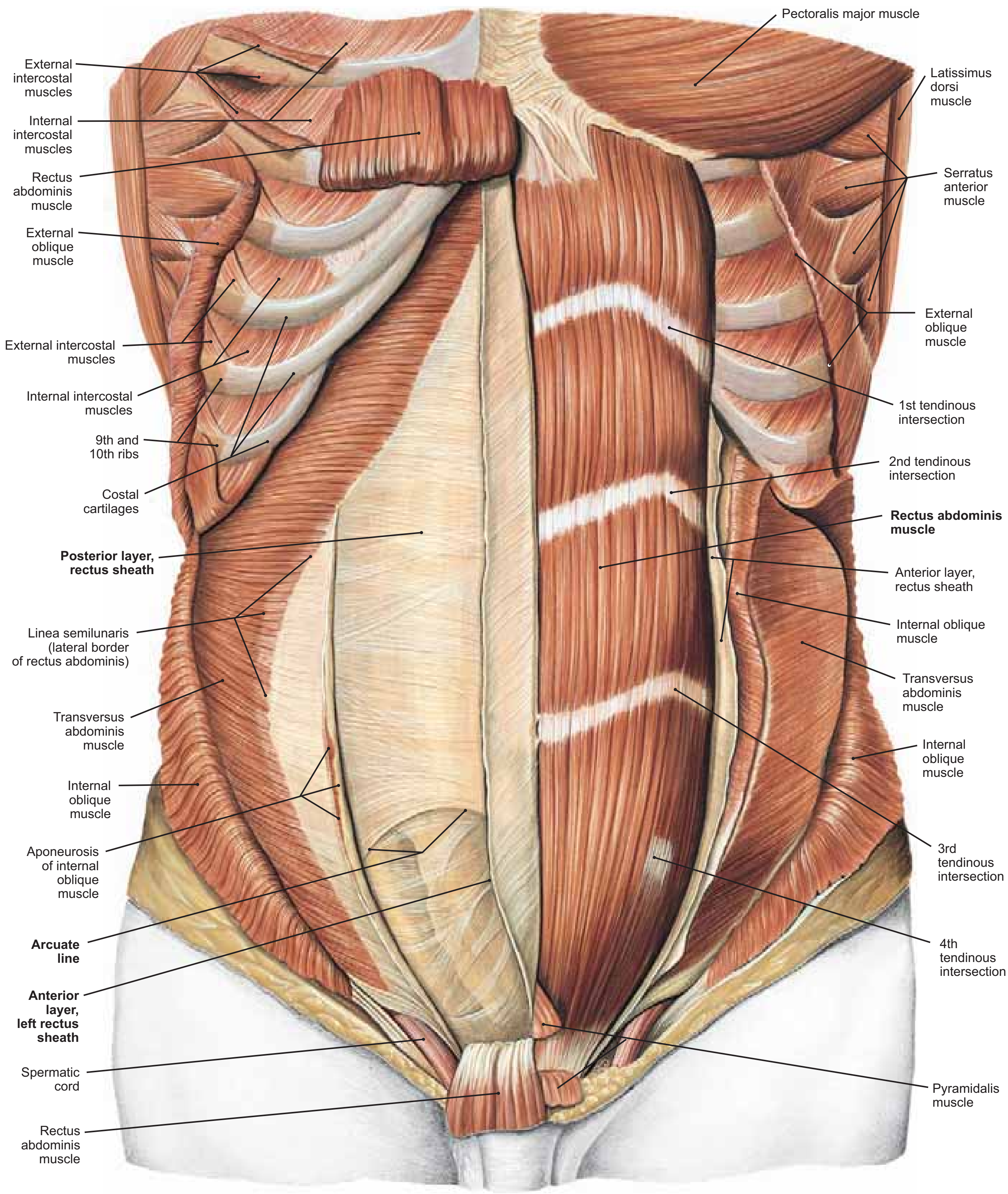


FIGURE 227 **Deep Layer of Abdominal Musculature: Transversus Abdominis Muscle**

Muscle	Origin	Insertion	Innervation	Action
Transversus abdominis	Lateral third of inguinal ligament and inner lip of iliac crest; thoracolumbar fascia; inner surface of lower six ribs	Ends in an aponeurosis; **upper fibers:** to linea alba, help form posterior layer of rectus sheath; **lower fibers:** attach to pubis to form **conjoined tendon**	Lower six thoracic and first lumbar nerves (T7–L1)	Tenses abdominal wall; compresses abdominal contents

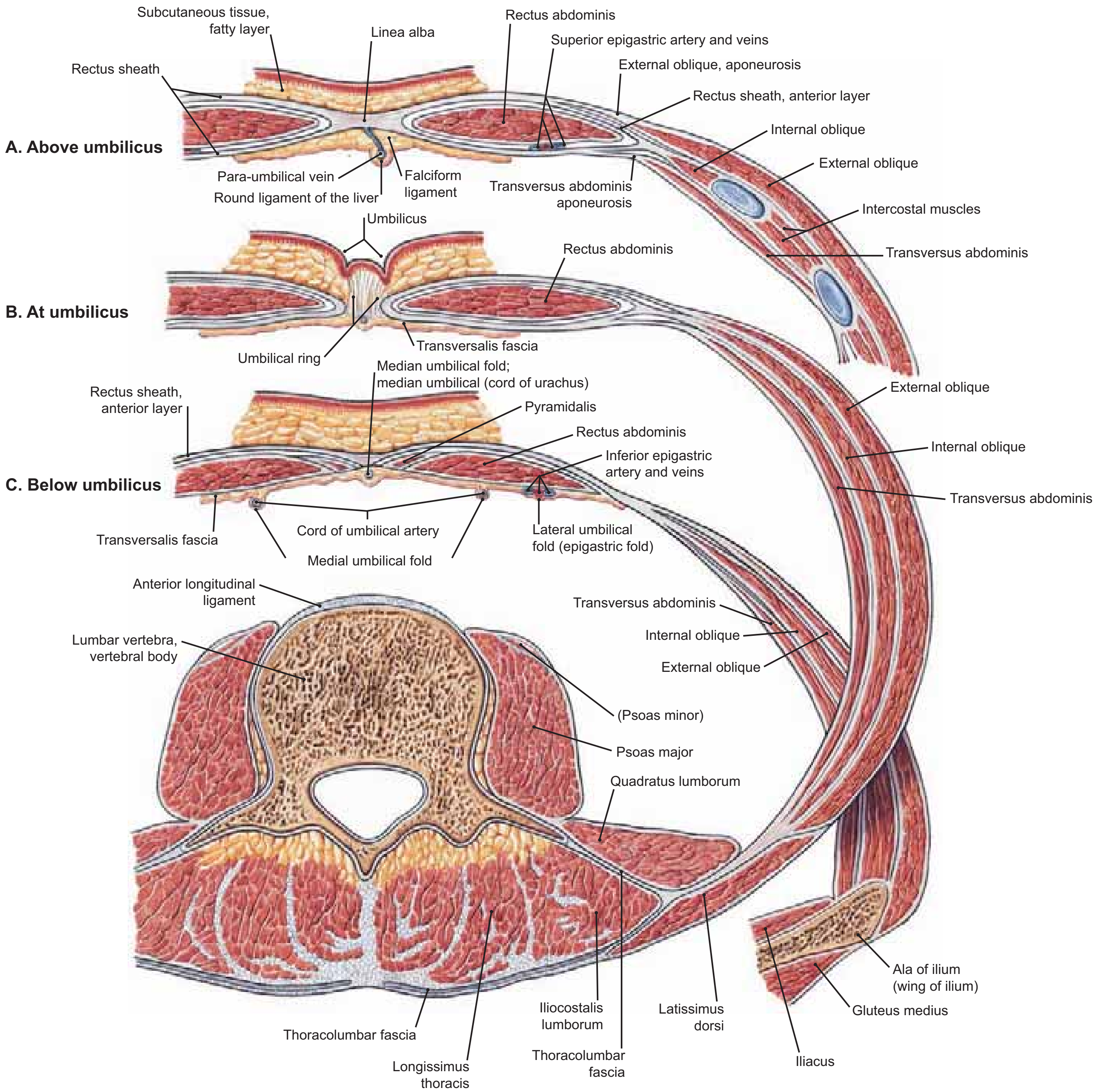


FIGURE 228 **Transverse Sections of the Abdomen at Three Different Levels**

NOTE: (1) In **A,** the section is above the umbilicus; in **B,** the section is at the level of the umbilicus; in **C,** the section is below the umbilicus and below the arcuate line. Observe that in **C** only the **transversalis fascia** is found deep to the rectus abdominis muscle and that the posterior layer of the rectus sheath is absent.

(2) The complete transaction seen at the bottom of the figure is continuous with the lateral and anterior muscles at the level of the umbilicus (**B**).

(3) The differences in the sheath of the rectus abdominis (see Figs. 230.1 and 230.2).

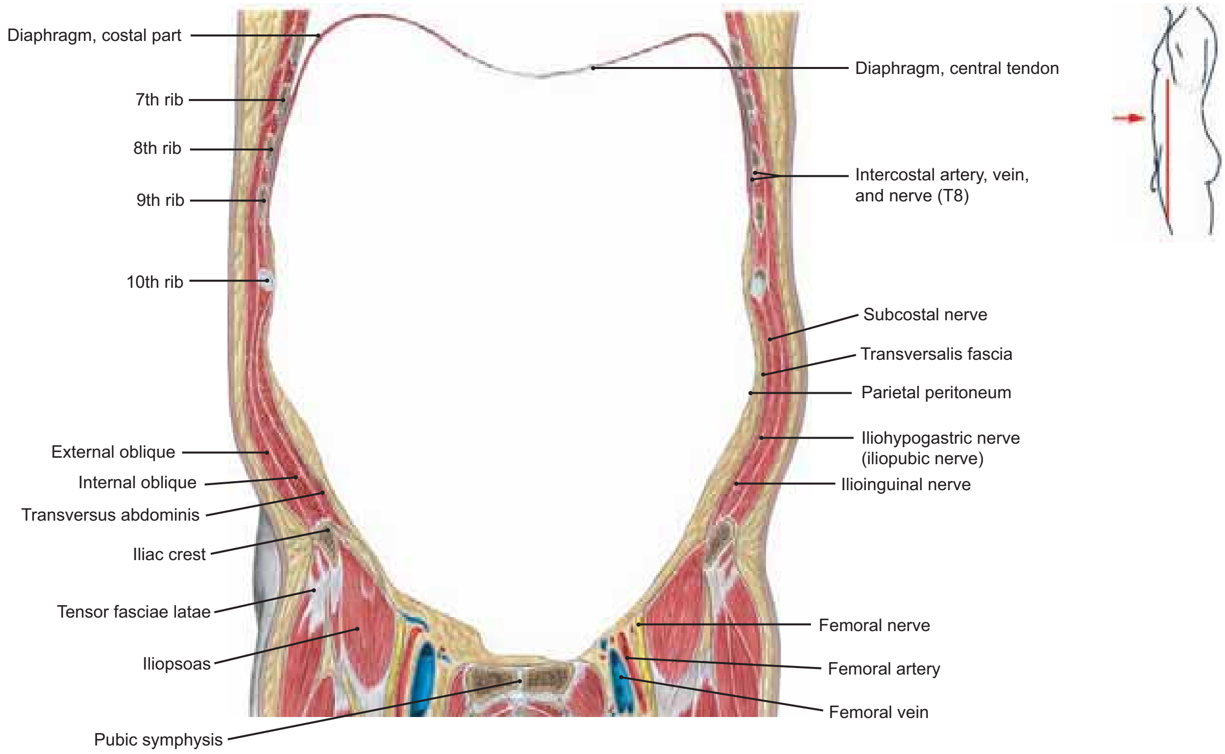


FIGURE 229.1 Frontal Section of the Abdomen through the Iliac Crest and Symphysis Pubis

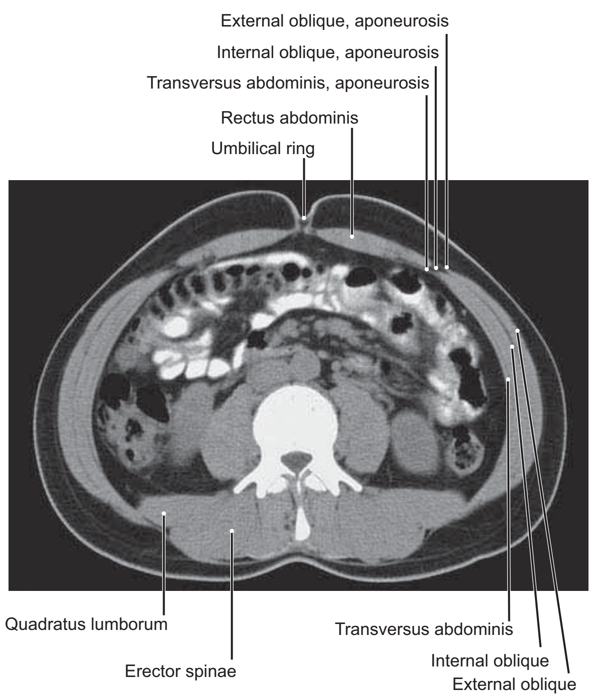


FIGURE 229.2 Computed Tomography (CT) of the Muscles of the Abdomen at the Level of the Umbilicus

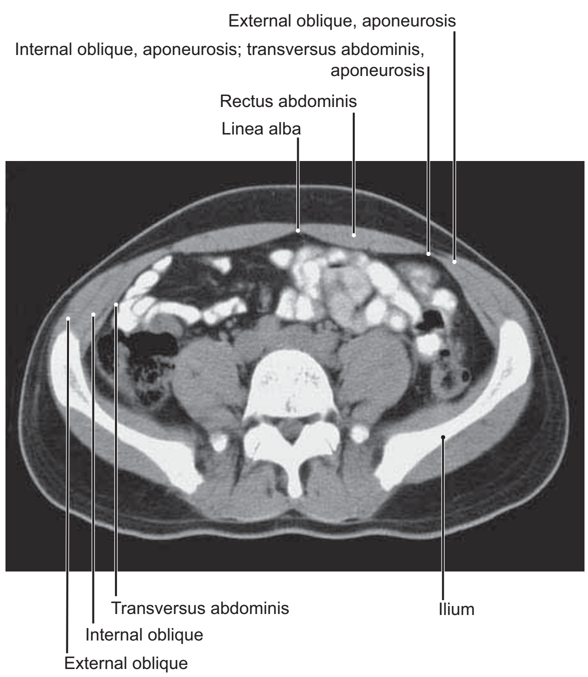


FIGURE 229.3 CT of the Muscles of the Abdomen at the Level of the Fifth Lumbar Vertebra

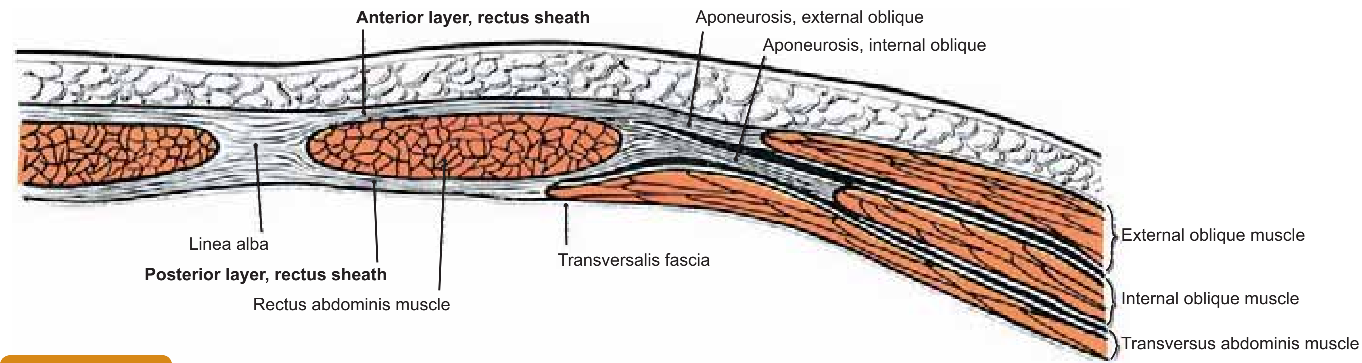


FIGURE 230.1

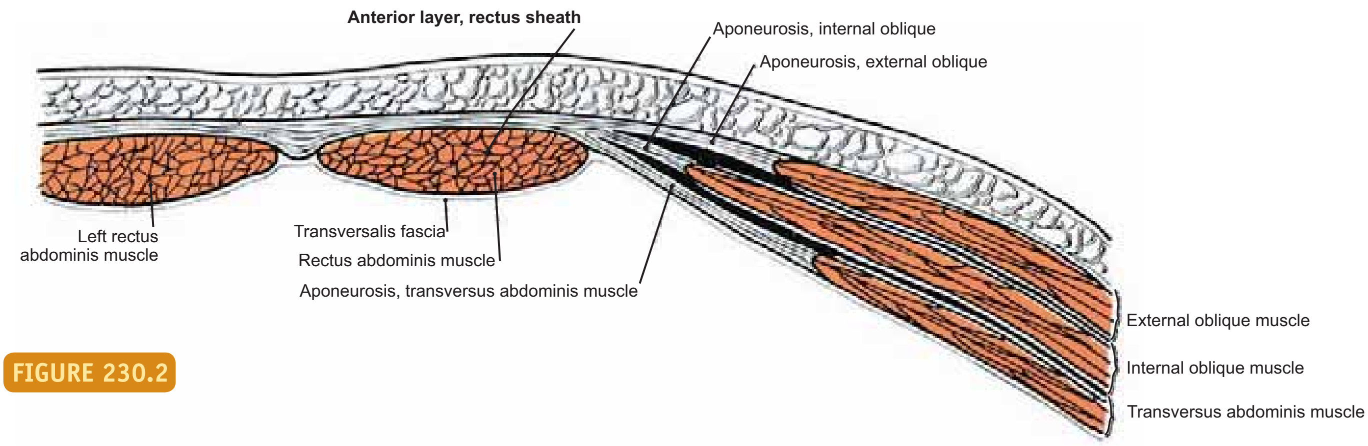


FIGURE 230.2

FIGURES 230.1 and 230.2 Transverse Sections of the Anterior Abdominal Wall: Above the Umbilicus (Fig. 230.1) and Below the Arcuate Line (Fig. 230.2)

NOTE: (1) The sheath of the rectus abdominis is formed by the aponeurosis of the external oblique, internal oblique, and transversus abdominis muscles.

(2) The upper two-thirds of the sheath encloses the rectus muscle both anteriorly and posteriorly. To accomplish this, the internal oblique aponeurosis splits. Part of the internal oblique aponeurosis joins the aponeurosis of the external oblique to form the **anterior layer**, while the other portion joins the aponeurosis of the transversus abdominis to form the **posterior layer** (Fig. 230.1).

(3) The lower third of the sheath, located below the arcuate line, is deficient posteriorly, since the aponeuroses of all three muscles pass anterior to the rectus abdominis muscle (Fig. 230.2).

(4) Deep to the sheath and transversus muscle is located the **transversalis fascia,** interposed between the peritoneum and the anterior wall structures.

Muscle	Origin	Insertion	Innervation	Action
Rectus abdominis	Fifth, sixth, and seventh costal cartilages; costoxiphoid ligaments and xiphoid process	Crest of pubis and pubic tubercle; front of symphysis pubis	Lower seven thoracic nerves (T6–T12)	Flexes vertebral column; tenses anterior abdominal wall; compresses abdominal contents
Cremaster	Midway along the inguinal ligament as a continuation of internal oblique muscle	Onto tubercles and crest of pubis and sheath of rectus abdominis muscle (forms loops over spermatic cord that reach as far as testis)	Genital branch of genitofemoral nerve (L1, L2)	Pulls the testis upward toward the superficial inguinal ring
Pyramidalis	Anterior surface of pubis and anterior pubic ligament	Into **linea alba** between umbilicus and symphysis pubis (muscle variable in size; average, 6 to 7 cm in length)	12th thoracic nerve (T12)	Tenses **linea alba**

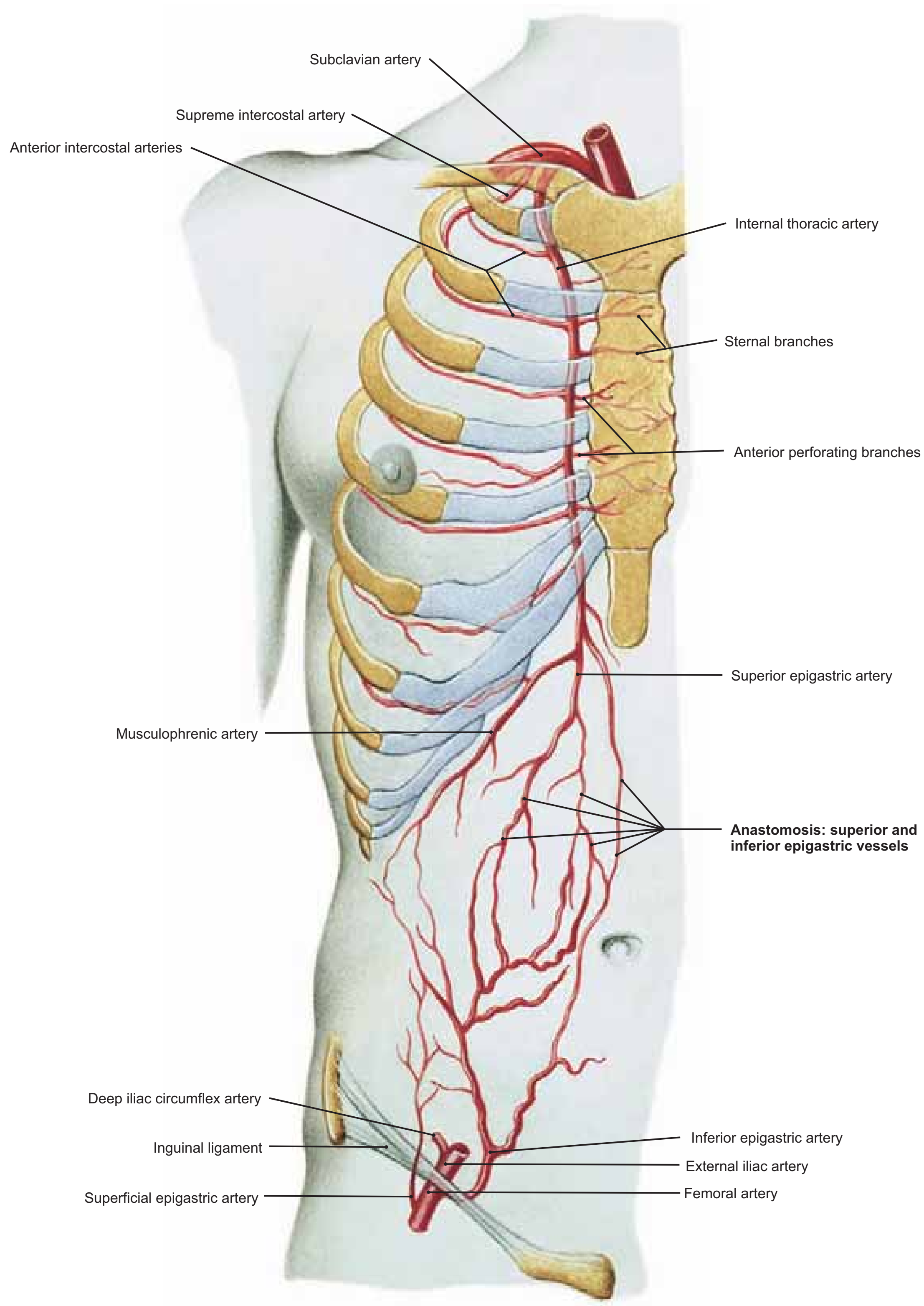


FIGURE 231 Schematic Diagram of the Epigastric Anastomosis

NOTE: (1) The **internal thoracic artery** arises from the subclavian artery and descends behind the ribs parallel to the sternum.

(2) Below the sternum, the internal thoracic artery terminates by dividing into the **musculophrenic** and **superior epigastric arteries**.

(3) The musculophrenic artery courses laterally adjacent to the costal margin and helps supply the diaphragm, while the superior epigastric artery descends within the rectus sheath, where it enters the substance of the rectus abdominis muscle.

(4) The inferior epigastric artery is a branch of the external iliac artery. It ascends and enters the rectus sheath at the arcuate line and also ramifies within the rectus abdominis muscle, where it anastomoses with the superior epigastric artery. This anastomosis forms a functional interconnection between arteries that serve the upper and lower limbs.

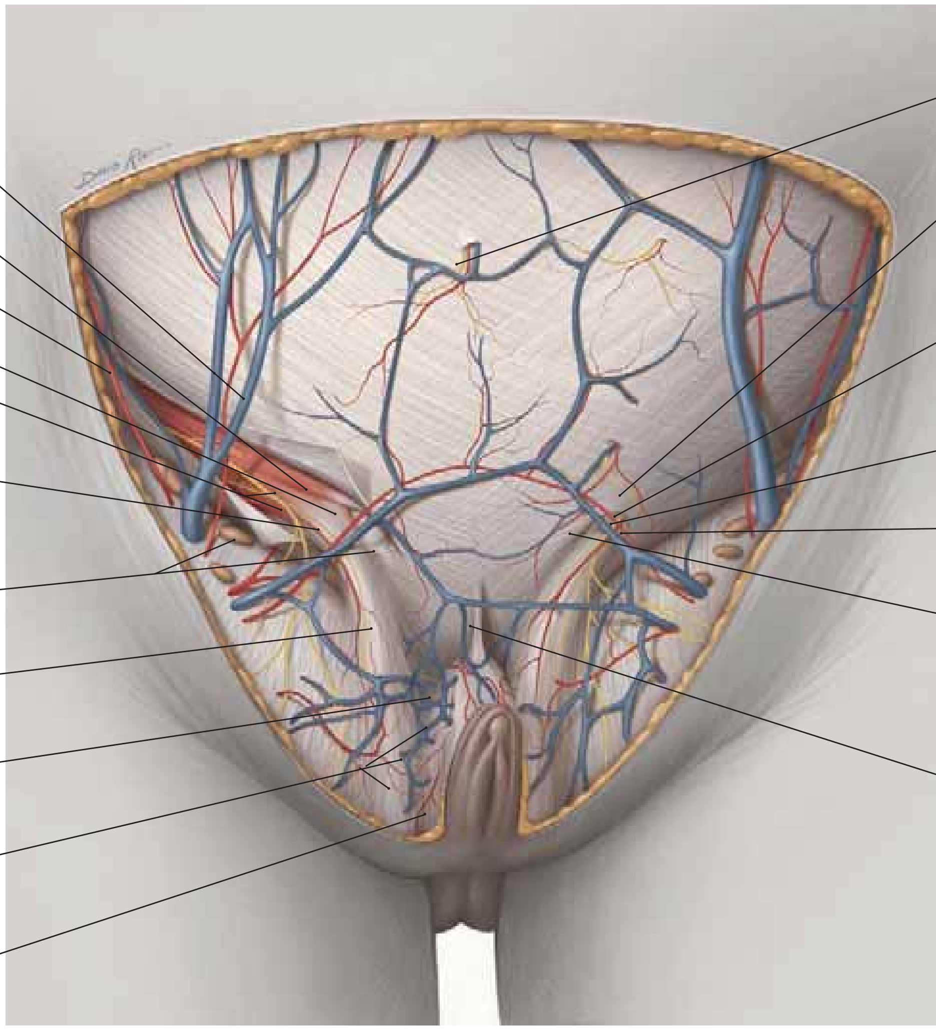


FIGURE 232 Inguinal Region of the Anterior Abdominal Wall in the Female: Aponeurosis of the External Oblique

NOTE: (1) The skin and superficial fascia have been reflected from the inguinal region, exposing the aponeurosis of the external oblique muscle, the superficial inguinal ring, the superficial vessels and nerves of the lower abdominal wall, and the muscles and nerves of the clitoris.

(2) The **superficial inguinal ring** is an opening in the aponeurosis of the external oblique muscle. On the specimen's left (reader's right) the ring has been opened to reveal the lower course of the round ligament and the ilioinguinal nerve.

(3) The iliohypogastric nerve (branch of L1) as it penetrates the aponeurosis to become a sensory nerve after supplying motor fibers to the underlying musculature.

(4) Of the superficial vessels, observe the **superficial external pudendal**, the **superficial iliac circumflex**, and the **superficial epigastric.** The latter vessels ascend within the superficial fascia between its superficial fatty (Camper's) and deep (Scarpa's) layers.

(5) The **superficial dorsal vein of the clitoris,** which may drain into either the left or right superficial external pudendal vein.

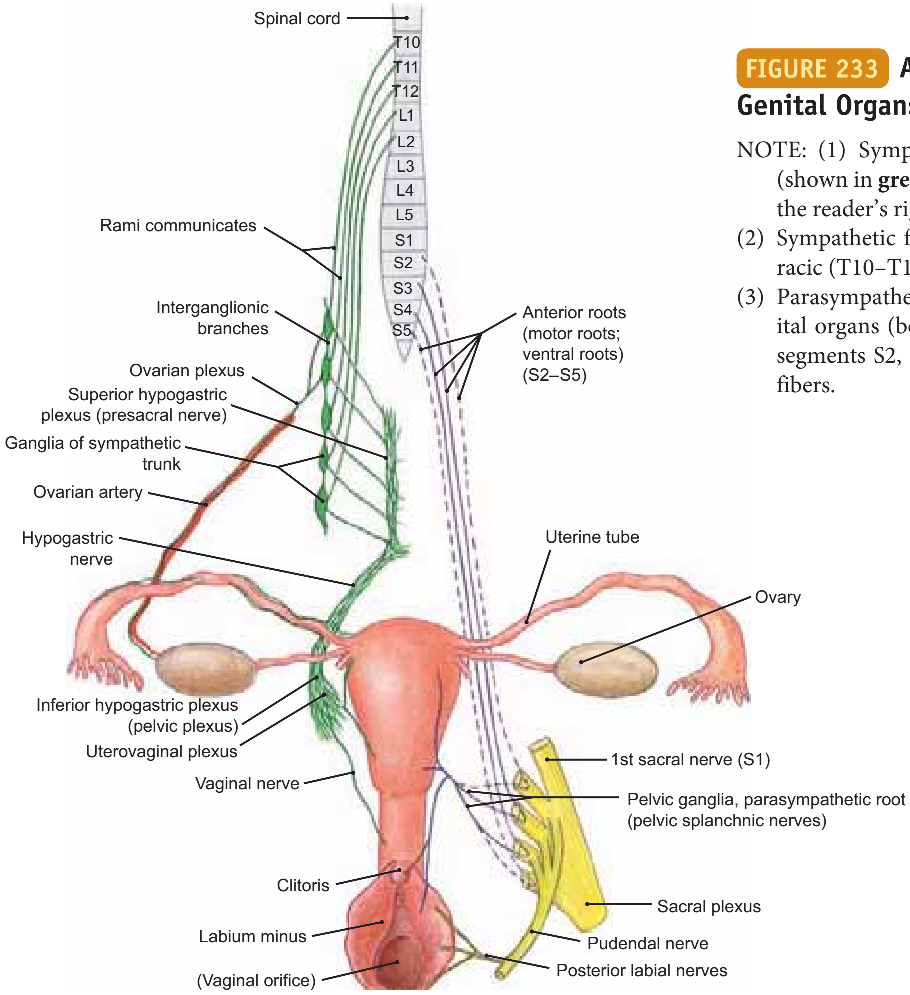


FIGURE 233 Autonomic Innervation of the Female Genital Organs

NOTE: (1) Sympathetic fibers are indicated on the reader's left (shown in **green**), while the parasympathetic fibers are shown on the reader's right (in **purple**).

(2) Sympathetic fibers descend into the pelvis from the lower thoracic (T10–T12) and the upper lumbar (L1–L3) segments.

(3) Parasympathetic preganglionic fibers that supply the female genital organs (both internal and external) are derived from sacral segments S2, S3, and S4. At times S1 and/or S5 also contribute fibers.

INNERVATION OF FEMALE GENITAL ORGANS (BOTH INTERNAL AND EXTERNAL)

	Origin	Course	Organ	Function
Parasympathetic part	Spinal cord, sacral part (S1) **S2, S3, S4,** (S5)	Pelvic ganglia, parasympathetic root [pelvic splanchnic nerves] ↓ Cavernous nerves of clitoris	Uterine tube Uterus Vagina Clitoris	Vasodilatation Vasodilatation Production of fluid (transudate) Erection
Sympathetic part	Spinal cord, thoracic part **(T10 to T12)** Spinal cord, lumbar part **(L1 to L2 or L3)**	Superior mesenteric plexus ↓ Ovarian plexus ↓ Renal plexus Sympathetic trunk ↓ Superior hypogastric plexus ↓ Hypogastric nerve ↓ Inferior hypogastric plexus ↓ Uterovaginal plexus	Ovary Uterine tube Uterus Vagina	Vasoconstriction Contraction
Somatic efferent **Somatic afferent**		Pudendal nerve Dorsal nerve of clitoris Posterior labial nerves	Clitoris Labia majora Ischiocavernosus Bulbospongiosus	 Contraction

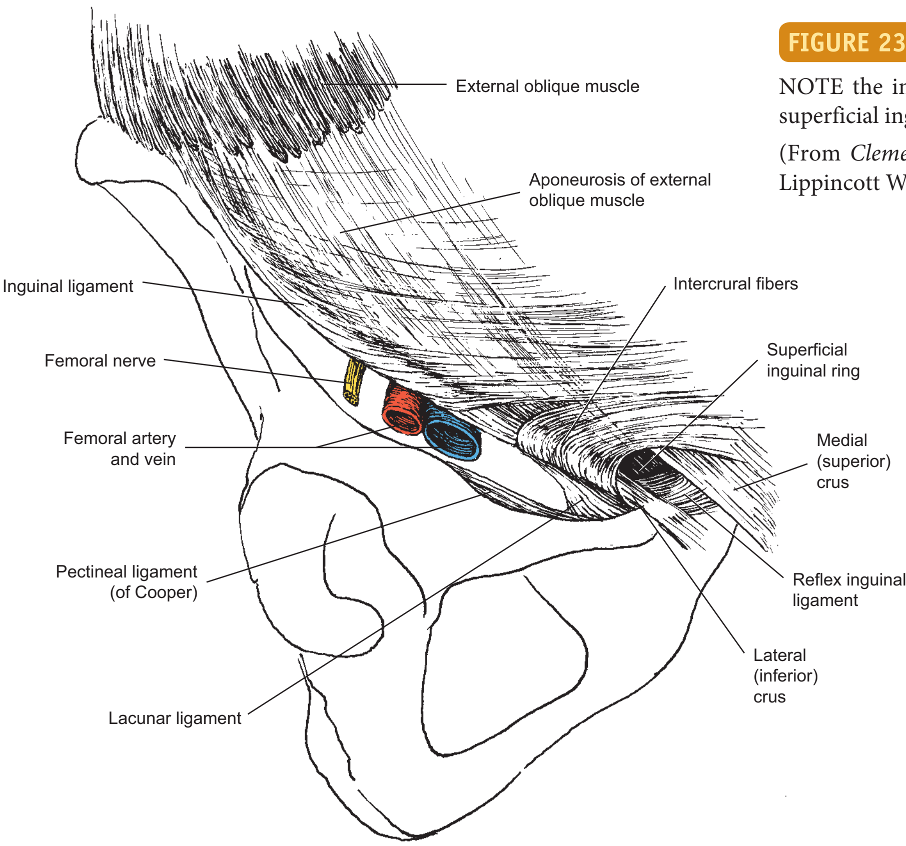


FIGURE 234.1 Ligaments in the Inguinal Region

NOTE the inguinal, lacunar, and pectineal ligaments and the superficial inguinal ring.

(From *Clemente's Anatomy Dissector,* 2nd Edition. Baltimore: Lippincott Williams & Wilkins, 2007.)

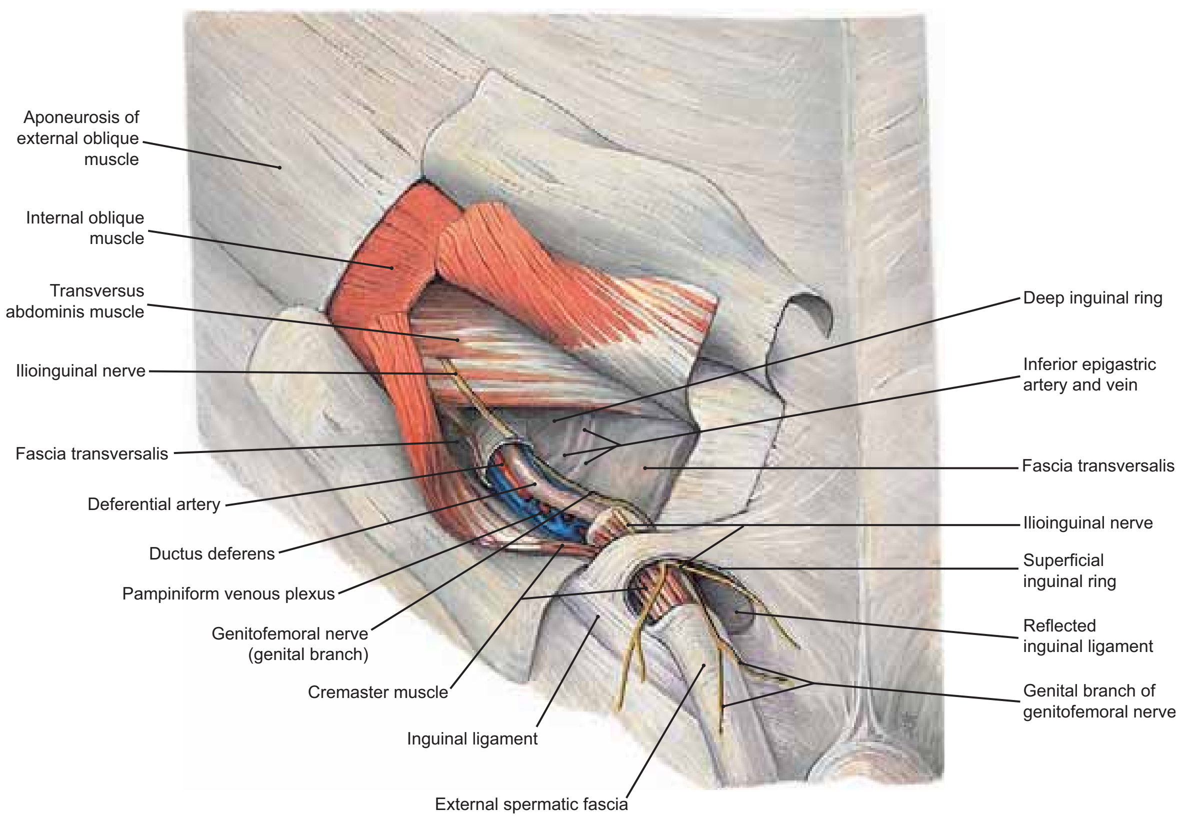


FIGURE 234.2 The Walls of the Inguinal Canal

NOTE: (1) That the aponeurosis of the external oblique muscle and the internal abdominal oblique muscle have both been opened and the structures of the **spermatic cord** have been exposed.

(2) That the **ilioinguinal** and **genitofemoral nerves** along with the **ductus deferens** and **deferential artery** are all shown and labeled.

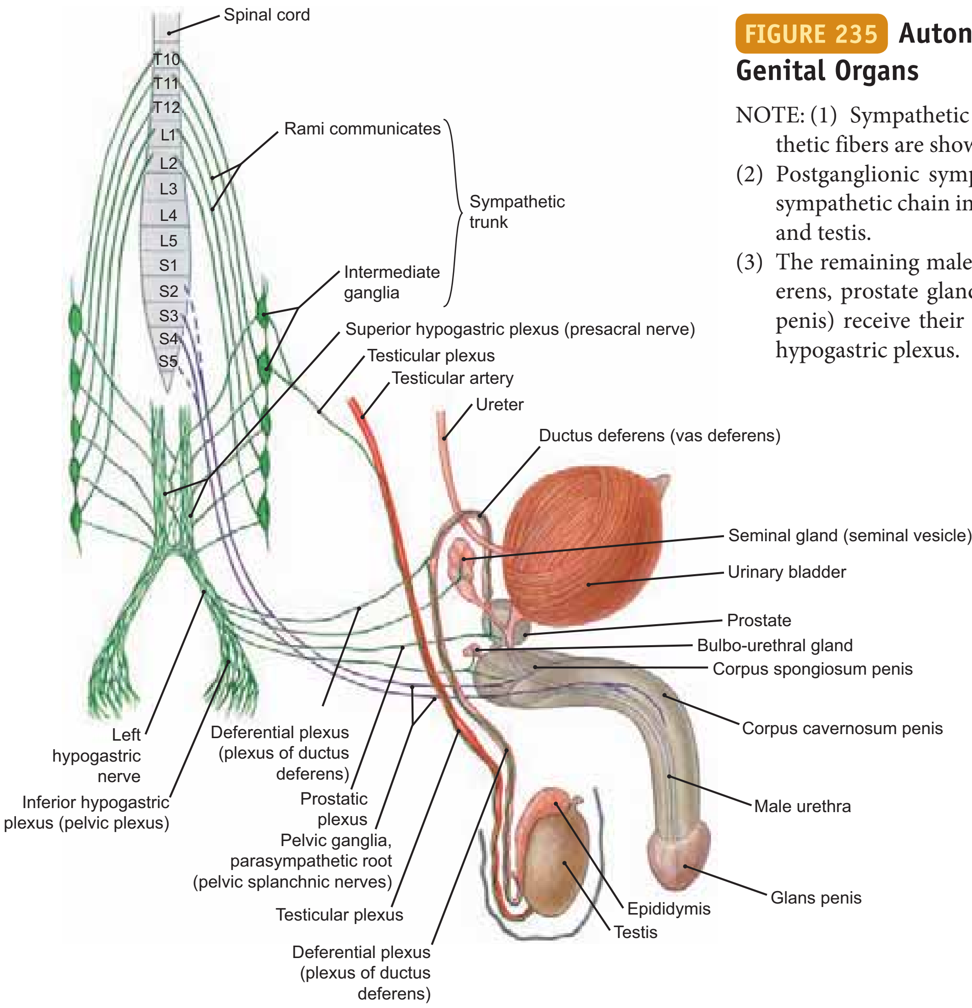


FIGURE 235 Autonomic Innervation of the Male Genital Organs

NOTE: (1) Sympathetic fibers are shown in **green,** while parasympathetic fibers are shown in **purple.**

(2) Postganglionic sympathetic fibers derived from ganglia in the sympathetic chain in the sacral region supply the testicular artery and testis.

(3) The remaining male genital organs (seminal vesicle, ductus deferens, prostate gland, bulbourethral gland, and the bulb of the penis) receive their postganglionic sympathetic fibers from the hypogastric plexus.

INNERVATION OF MALE GENITALS

	Origin	Course	Organ	Function
Parasympathetic part	Spinal cord, sacral part (S1) **S2, S3, S4,** (S5)	Pelvic ganglia, parasympathetic root [pelvic splanchnic nerves]	Penis Corpora cavernosa and spongiosum	Vasodilatation Erection
Sympathetic part	Spinal cord, thoracic part (T10–T12) Spinal cord, lumbar part (L1–L2)	Superior and inferior mesenteric plexus ↓ Sympathetic trunk ↓ Testicular plexus ↓ Superior hypogastric plexus ↓ Hypogastric nerve ↓	Testis	Regulation of blood flow
		Inferior hypogastric plexus	Bulbo-urethral gland Ductus deferens [vas deferens] Seminal gland [seminal vesicle] Prostate	Secretion Contraction, transportation of sperm into urethra Ejaculation into urethra
Somatic efferent **Somatic afferent**	Spinal cord, sacral part (S2–S4)	Pudendal nerve	(Sphincter of bladder) Ischiocavernosus Bulbospongiosus	Closure of bladder prevents retrograde ejaculation into the bladder Expulsion of ejaculate from urethra
		Posterior scrotal nerves Dorsal nerve of penis	Skin of scrotum Skin of penis	

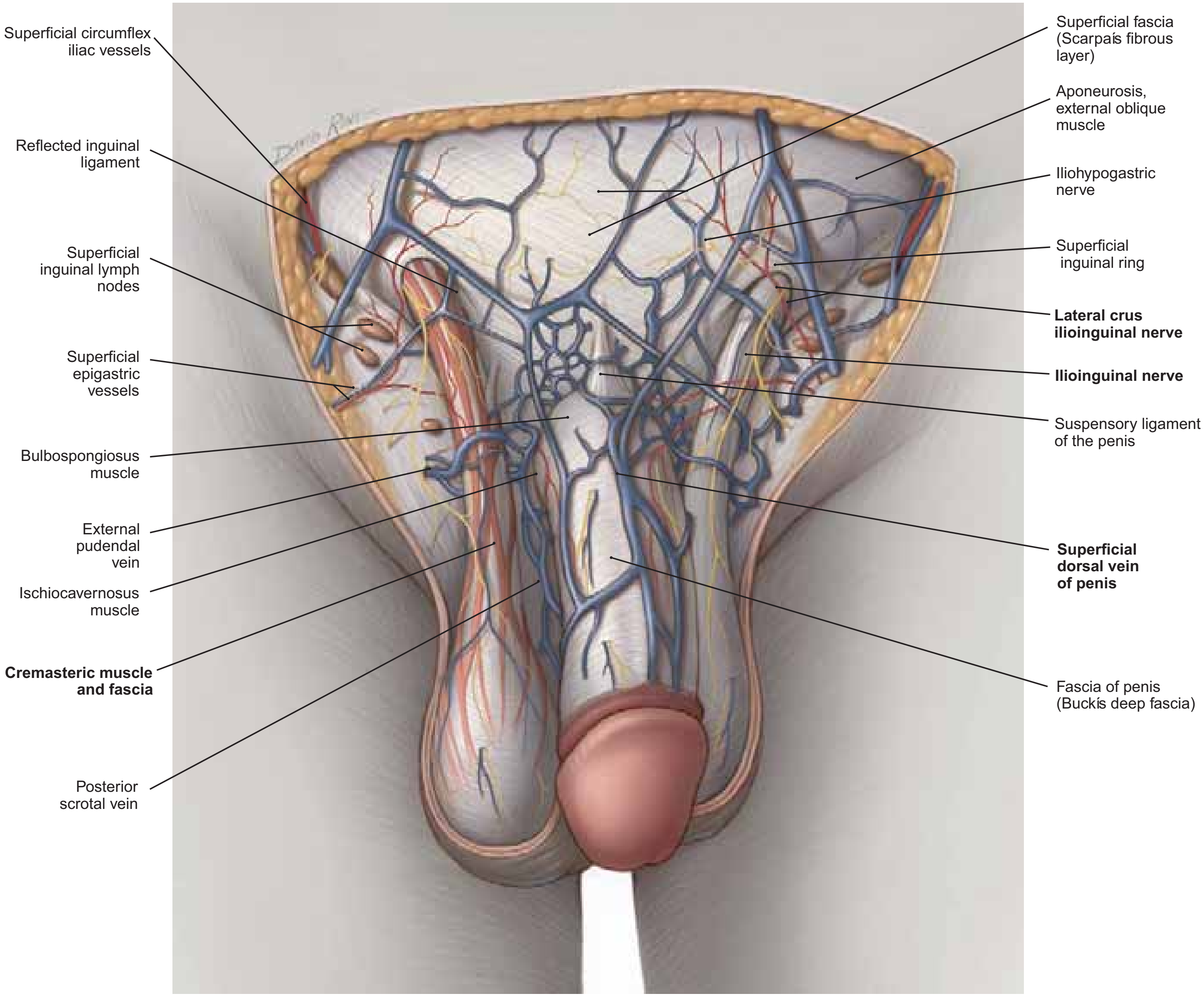


FIGURE 236 Inguinal Region of the Anterior Abdominal Wall in the Male: Superficial Inguinal Rings and the Cremaster Muscle

NOTE: (1) On the specimen's right (reader's left), the skin and superficial fatty layer (Camper's) has been removed, while on the left side the skin, fatty layer, and superficial fibrous layer (Scarpa's) have been resected, revealing the aponeurosis of the external oblique muscle.

(2) The superficial inguinal rings have been exposed and the scrotal sacs opened. Observe the course of the **spermatic cord** from the scrotum to the superficial inguinal ring and the cremaster muscle and fascia surrounding the spermatic cord on the left.

(3) The **iliohypogastric nerve** penetrates the aponeurosis of the external oblique just above the superficial inguinal ring, and the **ilioinguinal nerve** emerges from the ring to supply the inguinal region and then continues as the **anterior scrotal nerve.**

(4) The external spermatic fascia (not labeled) covering the spermatic cord is seen on the right, while the cremasteric fascia and cremaster muscle are seen on the left after removal of the external spermatic fascia.

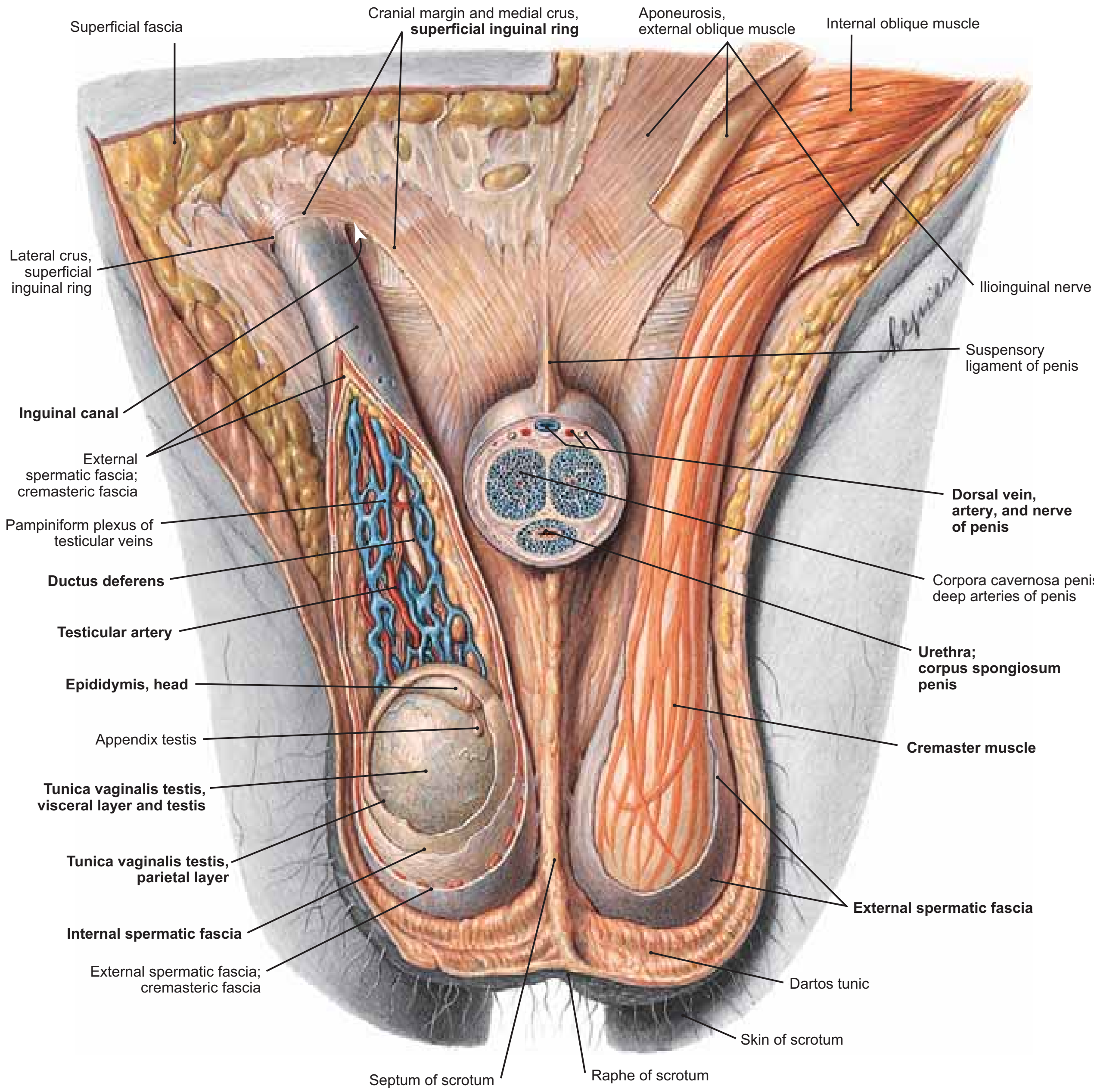


FIGURE 237 Spermatic Cord, Testis, Scrotum, and Cross Section of the Penis (Anterior View)

NOTE: (1) The **cremaster muscle** descends within the spermatic cord to the testis. It represents a continuation of muscle fibers of the internal oblique muscle of the anterior abdominal wall.

(2) The **testicular vessels** and **ductus deferens** within the spermatic cord. Observe the covering layers of the right testis, the innermost one of which is the **visceral layer of the tunica vaginalis testis.**

(3) Venous blood from the **pampiniform plexus of veins** ascends in the testicular vein. On the right side this vein drains into the inferior vena cava, while on the left side it drains into the left renal vein. If the veins of the left scrotum become varicosed, it may indicate a problem with the left kidney or in the left pelvis along the course of the vein. This could be due to a renal tumor.

(4) The cremaster muscle is responsible for elevating the testis in the scrotal sac when the testicular environment is especially cold (as in a cold shower). It also elevates if the skin of the upper medial thigh is stimulated. This reaction is due to the so-called cremasteric reflex.

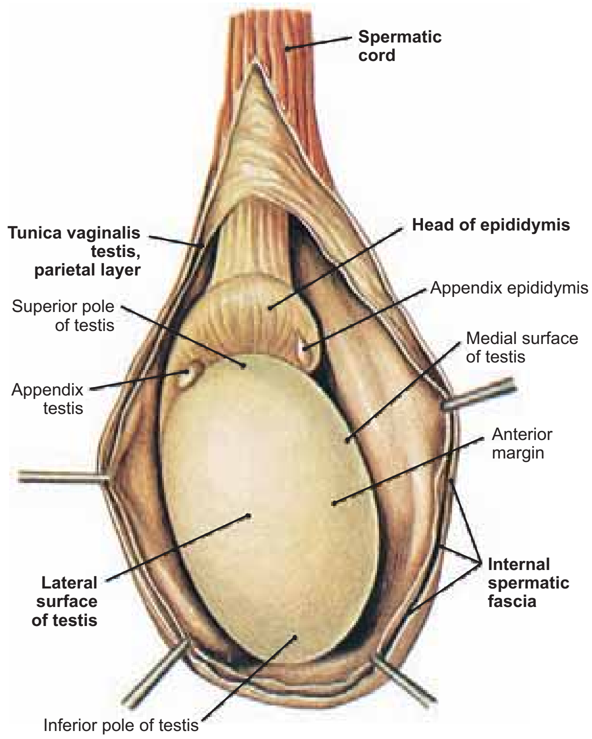
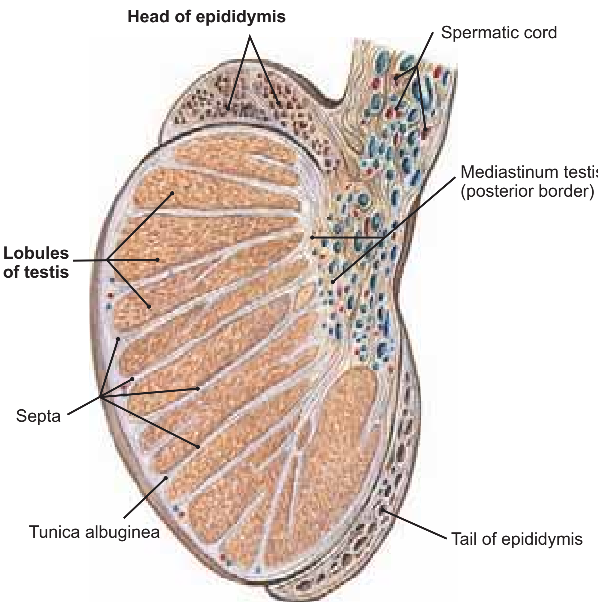


FIGURE 238.1 Right Testis and Epididymis (Anterior View) ▶

NOTE: The testis is suspended by its efferent duct system, which consists of the head, body, and tail of the epididymis, and this convoluted organ eventually leads to the ductus deferens (see Fig. 239.1).



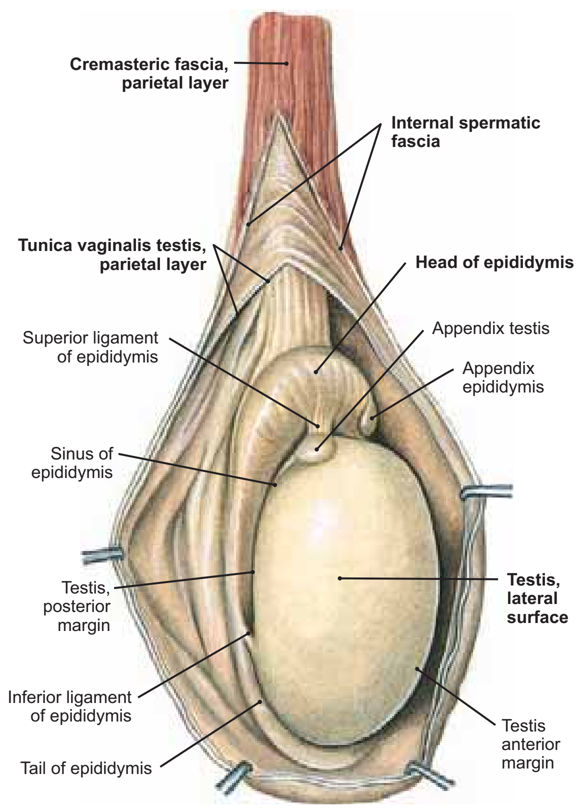
◀ FIGURE 238.2 Longitudinal Section of Testis and Epididymis

NOTE: The lobular separation of the testis by the septa, and the thickened **tunica albuginea,** which encases the lobules. The vessels supplying the testis can be seen at its posterior border (mediastinum).

FIGURE 238.3 Right Testis and Epididymis (Lateral View) ▶

NOTE: The coverings of the testis represent evaginations of the layers forming the anterior abdominal wall. These evaginations precede the testis during its descent in the latter half of gestation. The comparable layers are as follows:

Anterior Abdominal Wall	Coverings of Testis
1. Skin	1. Skin } Scrotum
2. Superficial fascia	2. Dartos tunic } Scrotum
3. External oblique	3. External spermatic fascia
4. } Internal oblique	4. } Cremaster muscle and
5. } Transversus abdominis	5. } Cremasteric fascia
6. Transversalis fascia	6. Internal spermatic fascia
7. Extraperitoneal fat	7. Fatty layer
8. Peritoneum	8. Processus vaginalis



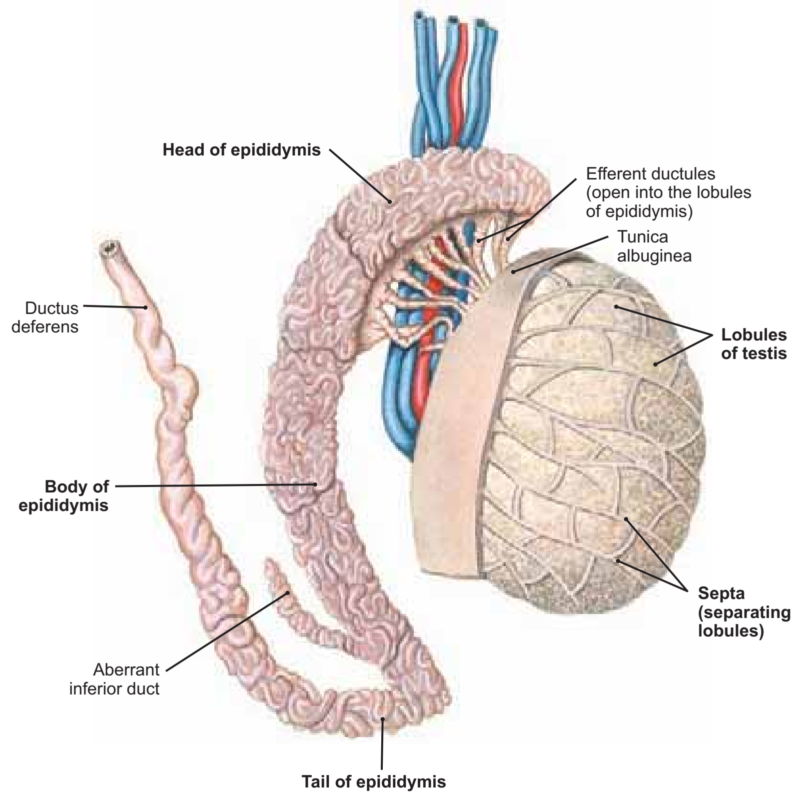


FIGURE 239.1 Testis, Epididymis, and the Beginning of the Ductus Deferens

NOTE: (1) With the tunica vaginalis and tunica albuginea removed, the testicular lobules, separated by septa and containing the seminiferous tubules, are exposed.

(2) From the lobules a group of 8 to 10 fine efferent ductules open into the **head of the epididymis.** Observe the highly convoluted nature of the epididymis. The head of the epididymis leads into the **body** and **tail,** which becomes the **ductus deferens.**

(3) The **testicular artery** (from the aorta) courses with the spermatic cord and the **pampiniform plexus** of veins.

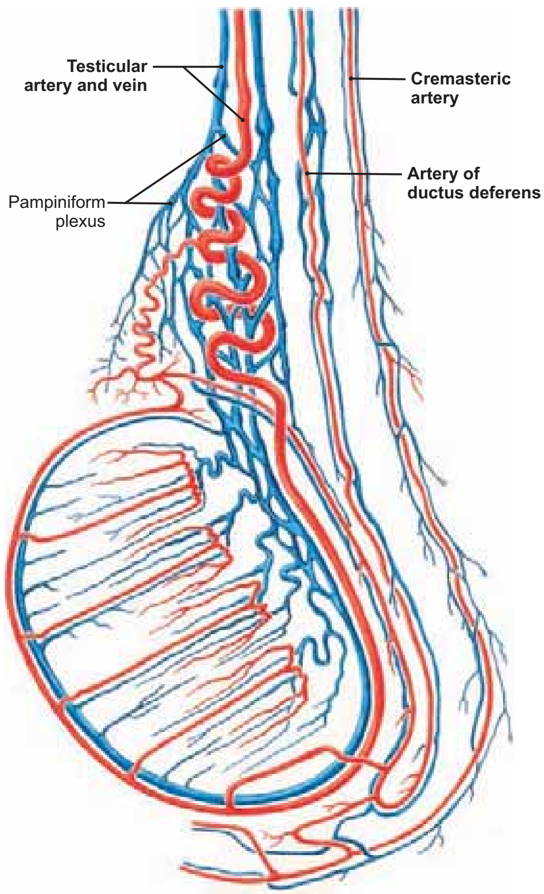


FIGURE 239.2 Schematic Representation of the Blood Supply of the Testis and Epididymis

(1) The testis and epididymis are served by the **testicular artery** (from the aorta), the **artery of the ductus deferens** (usually from the superior vesical artery), and the **cremasteric artery** (from the inferior epigastric artery).

(2) The **pampiniform plexus** of veins drains into the testicular vein, which on the left side flows into the left renal vein and on the right side opens into the inferior vena cava.

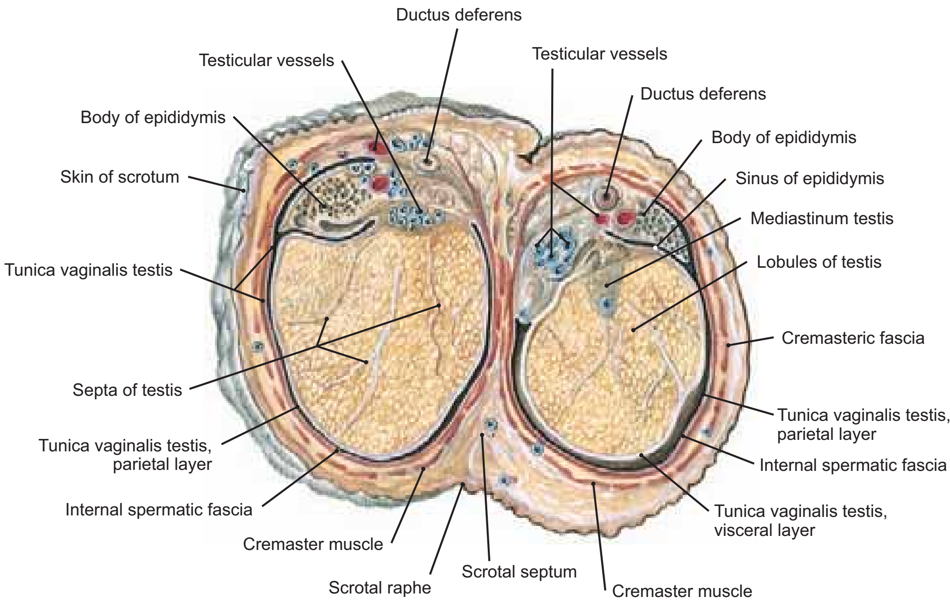


FIGURE 240.1 Cross Section of Testis and Scrotum

NOTE: (1) The scrotum is divided by the median raphe and septum into two lateral compartments, each surrounding an ovoid-shaped testis. The two scrotal compartments normally do not communicate.

(2) The **tunica vaginalis testis** consists of a **visceral layer** closely adherent to the testis and a **parietal layer,** which lines the inner surface of the internal spermatic fascia in the scrotum. A serous cavity or potential space between these two layers is a site where fluid might collect to form a **hydrocele.** These may be acquired or congenital.

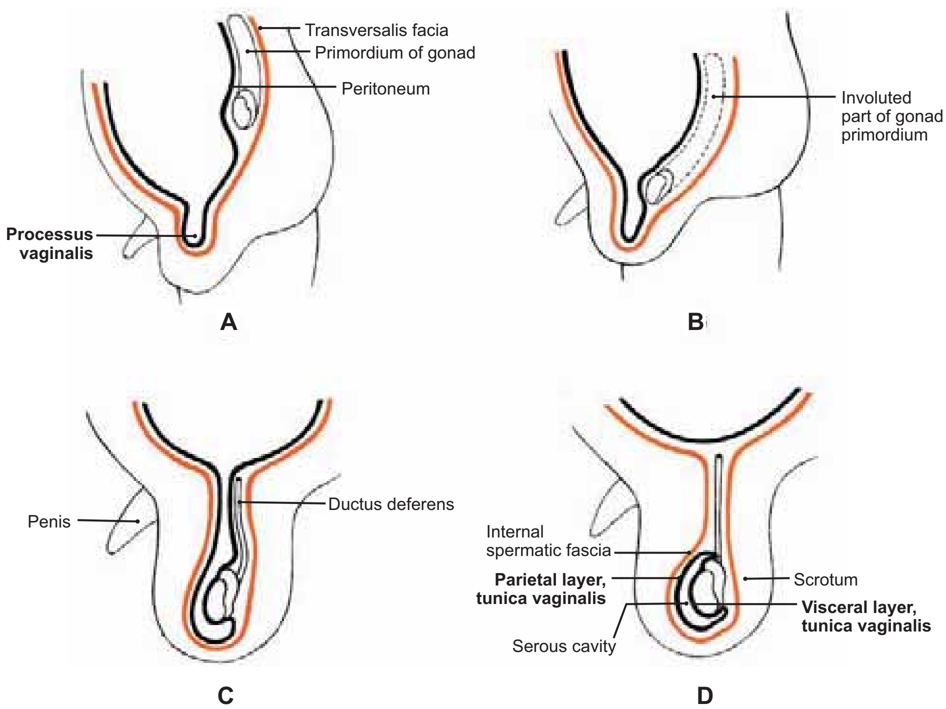


FIGURE 240.2 Diagrammatic Representation of Four Stages in the Descent of the Testis

NOTE: (1) (**A**) The testes commence development on the posterior wall of the fetus; (**B**) during the second trimester they attach to the posterior wall of the lower trunk at the boundary between the abdomen and pelvis in what is often called the "false pelvis."

(2) During the latter half of the seventh month of gestation, the testes begin their descent into the scrotum (**B** and **C**); this is normally completed by the ninth month (**D**).

(3) Attached to the peritoneum, each testis carries with it a peritoneal sac that surrounds the organ in the scrotum as the **parietal and visceral layers of the tunica vaginalis.** The peritoneum lining the inguinal canal then fuses, closing off its communication with the abdominal cavity.

(4) When this fusion does not occur, the pathway may be used by a loop of intestine to enter the scrotum, forming **an indirect or congenital hernia.**

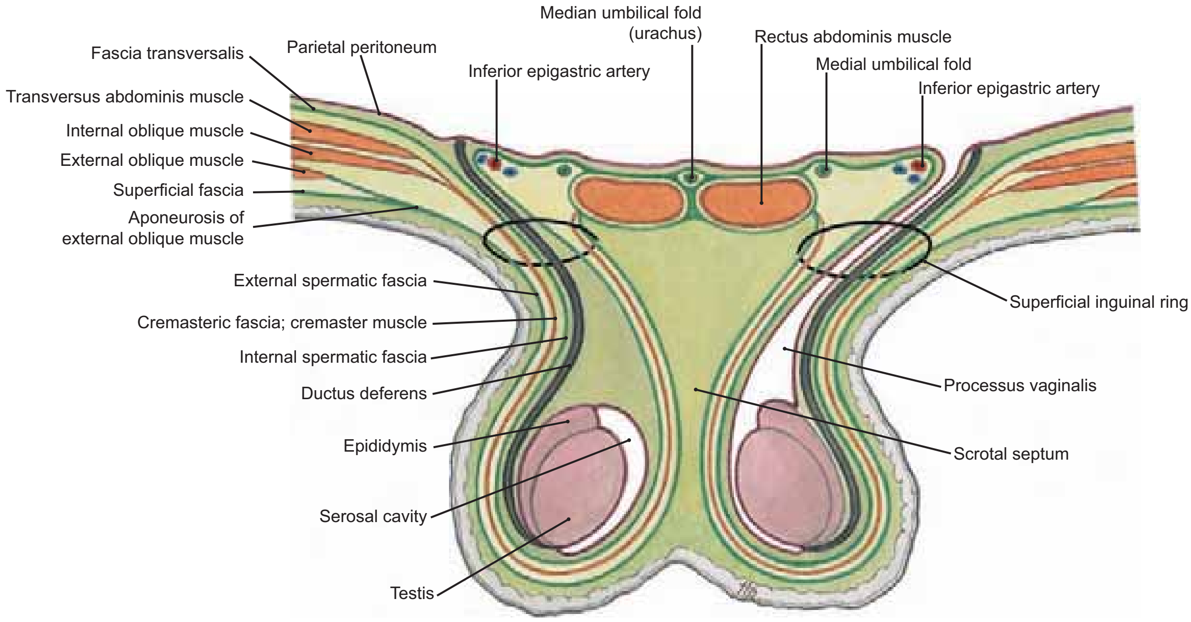


FIGURE 241.1 **Diagram of the Inguinal Canal**

NOTE: (1) On the right side (reader's left), the testis is descended into the scrotum, and the processus vaginalis is sealed, thereby obliterating the pathway of the testis into the scrotum. This situation would not allow a loop of intestine to descend into the scrotum.
(2) On the left side (reader's right), the processus vaginalis is still open. This could allow a loop of intestine the opportunity to descend into the scrotum, thereby creating an indirect (congenital) hernia (also see left side of Fig. 241.2).

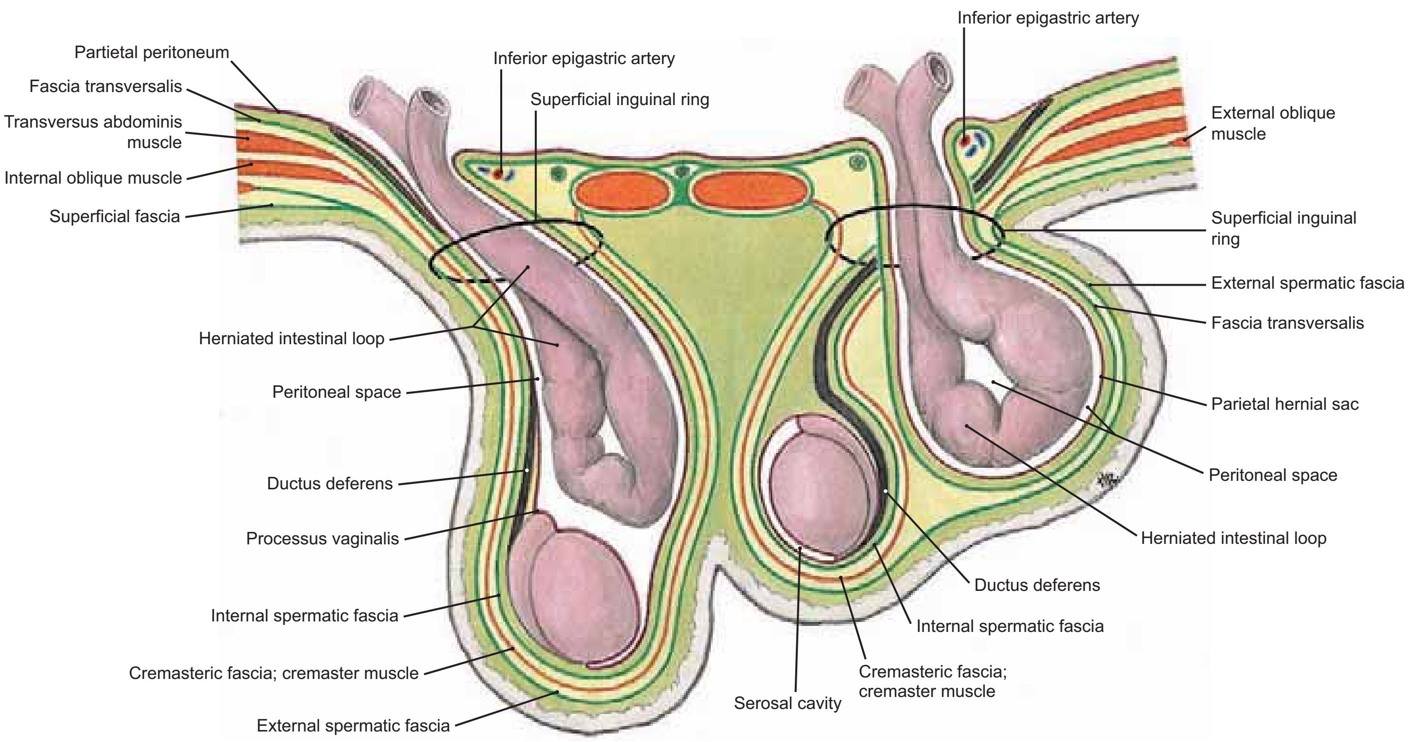


FIGURE 241.2 **Congenital (Indirect) and Acquired (Direct) Inguinal Hernias**

NOTE: (1) On the reader's left, a loop of intestine is shown entering the inguinal canal lateral to the inferior epigastric artery through the abdominal inguinal ring, thereby creating an indirect, congenital hernia.
(2) On the reader's right, a loop of intestine is shown herniated medial to the inferior epigastric artery (within the inguinal triangle), thereby forming a direct (acquired) inguinal hernia.

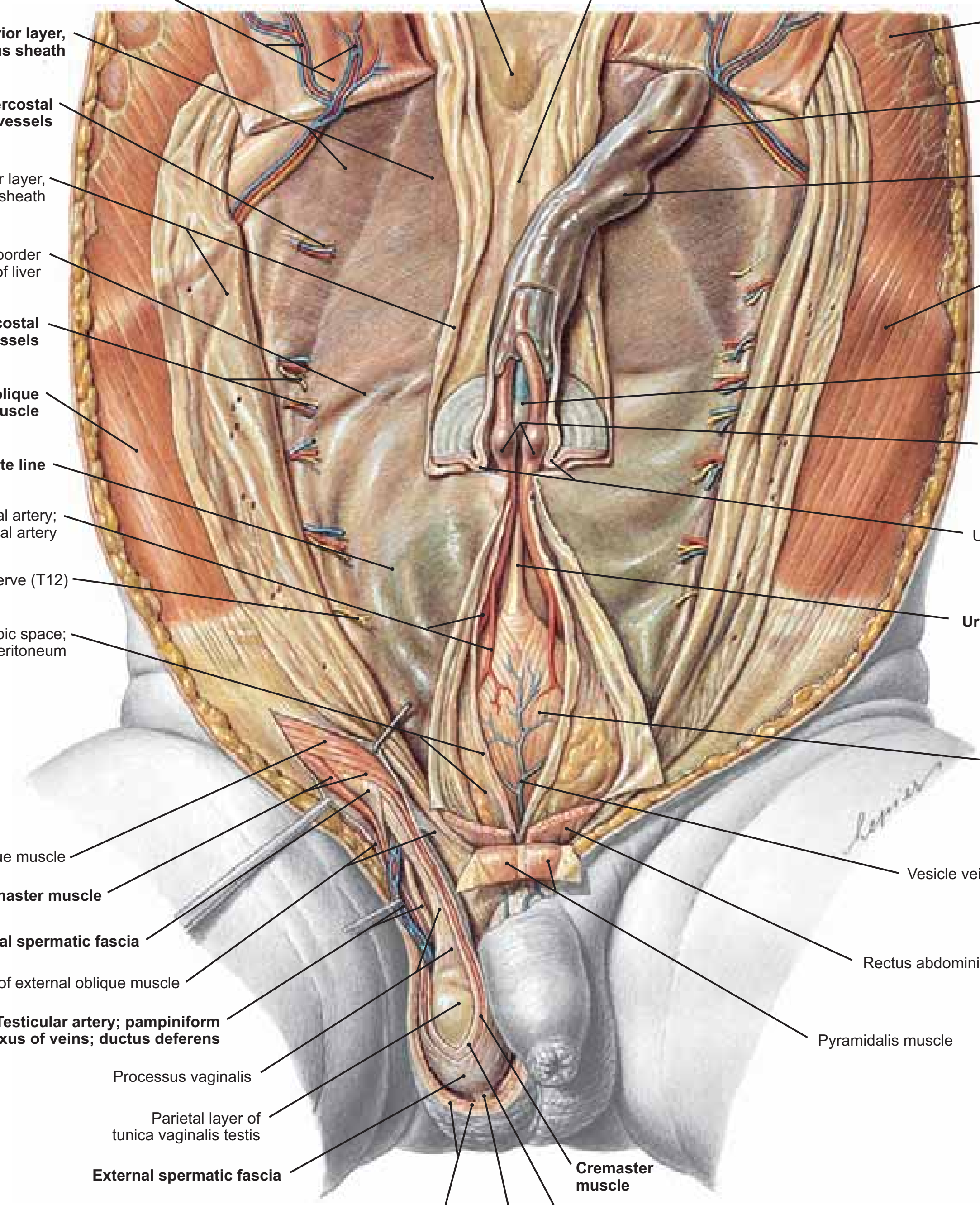


FIGURE 242 Deep Dissection of the Anterior Abdominal Wall and the Umbilical Region in the Newborn

NOTE: (1) The anterior layer of the rectus sheath is reflected laterally, and the two rectus abdominis muscles have been cut near the symphysis pubis and turned upward (almost out of view). This exposes the posterior layer of the rectus sheath and the **arcuate line.**

(2) An incision has been made in the midline between the umbilicus and the pubic symphysis exposing the **bladder, urachus,** the **umbilical arteries,** and the **umbilical vein.**

(3) The anterior aspect of the right spermatic cord and scrotal sac have been opened to show the ductus deferens and the **tunica vaginalis testis** surrounding the testis.

(4) The severed umbilical cord, usually 1 to 2 cm in diameter and about 50 cm, or 20 in., long. It contains the two umbilical arteries and the umbilical vein surrounded by a mucoid form of connective tissue called Wharton's jelly.

(5) At times, the umbilical vessels form harmless loops in the umbilical cord called "false knots." More rarely, looping of the cord may be of functional significance and such "true knots" may alter the circulation to and from the fetus.

(6) The bulges in the umbilical arteries. These are in situ blood clots that occlude the arteries but which are probably postmortem phenomena in this dissection.

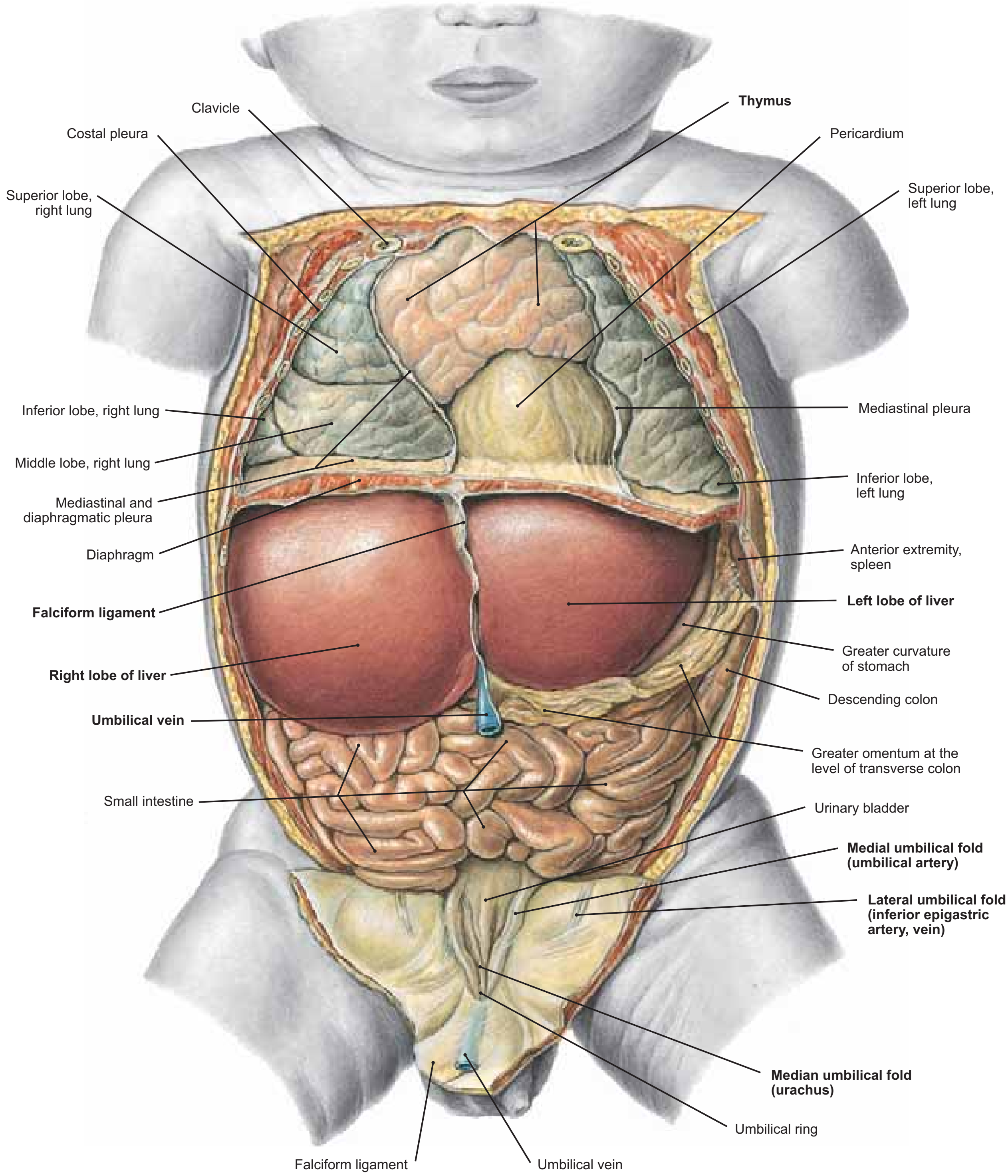


FIGURE 243 Abdominal and Thoracic Viscera Observed In Situ in the Newborn Child

NOTE: (1) The anterior body wall has been removed in this newborn child, uncovering the viscera. Observe the umbilical ligaments on the inner surface of the lower wall.

(2) The average newborn child weighs about 3300 g (7 lb) and measures about 50 cm (20 in.) from the top of the head to the sole of the foot. The umbilicus is located about 1.5 cm below the midpoint of this crown-to-heel length.

(3) The transverse diameter of the abdomen in the newborn is greatest above the umbilicus due to the inordinate proportion of the abdomen occupied by the liver. The average weight of the liver in the neonate is about 120 g (4% of the body weight). In the adult the liver weighs 12 to 13 times that at birth (but only 2.5%–3.5% of the body weight).

(4) The truncated shape of the thorax and the large thymus, weighing about 10 g at birth (0.42% of body weight at birth compared with 0.03%–0.05% in the adult).

(5) The facts above are taken from: Crelin ES. Functional anatomy of the newborn, New Haven, CT: Yale University Press, 1973, which is an excellent short monograph (87 pages).

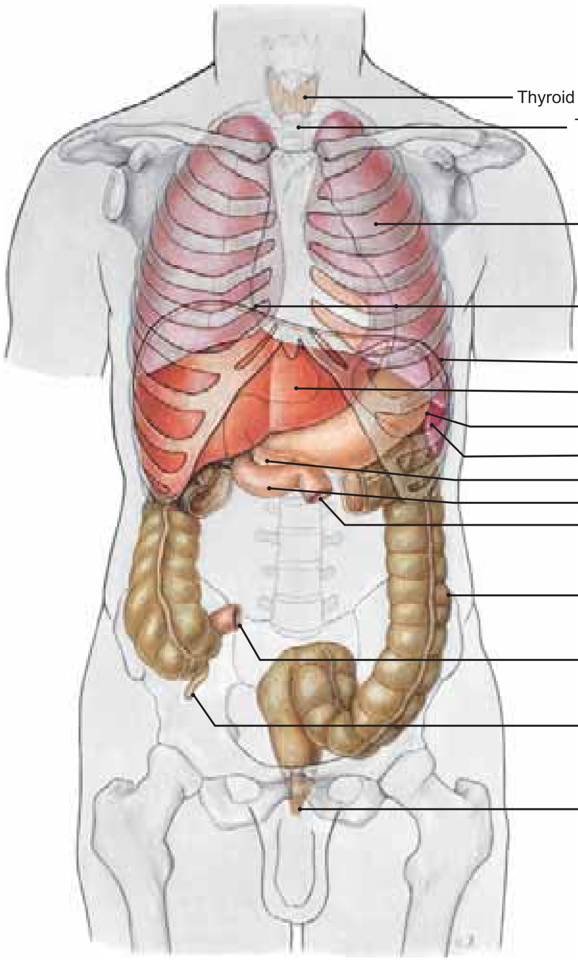


FIGURE 244.1 **Surface Projection of Thoracic and Abdominal Organs (Anterior View)**

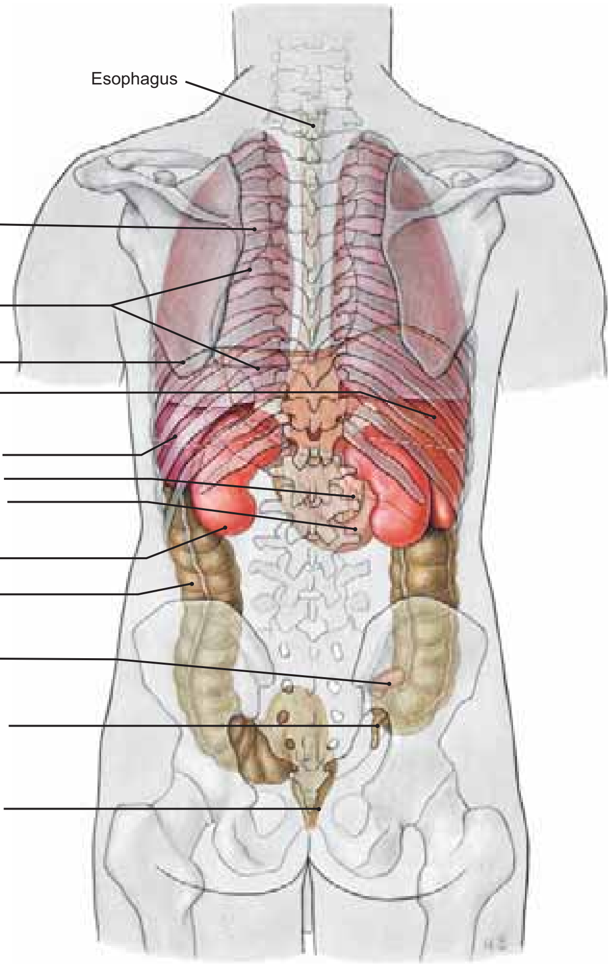


FIGURE 244.2 **Surface Projection of Thoracic and Abdominal Organs (Posterior View)**

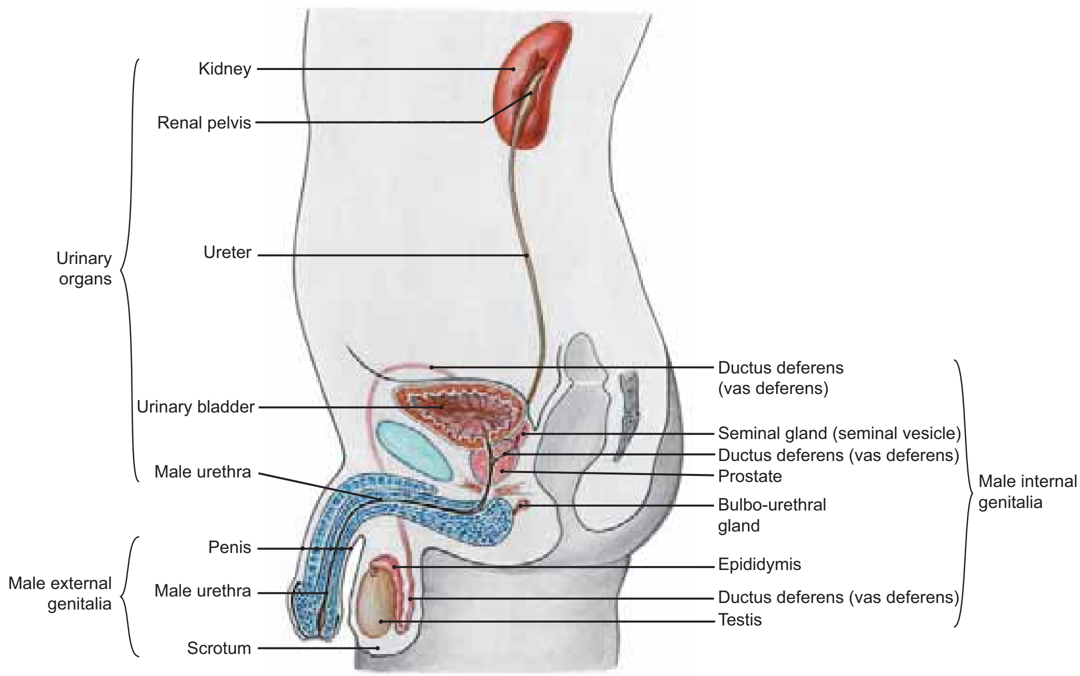


FIGURE 244.3 **Surface Projection of Male Urogenital Organs (Left Lateral View)**

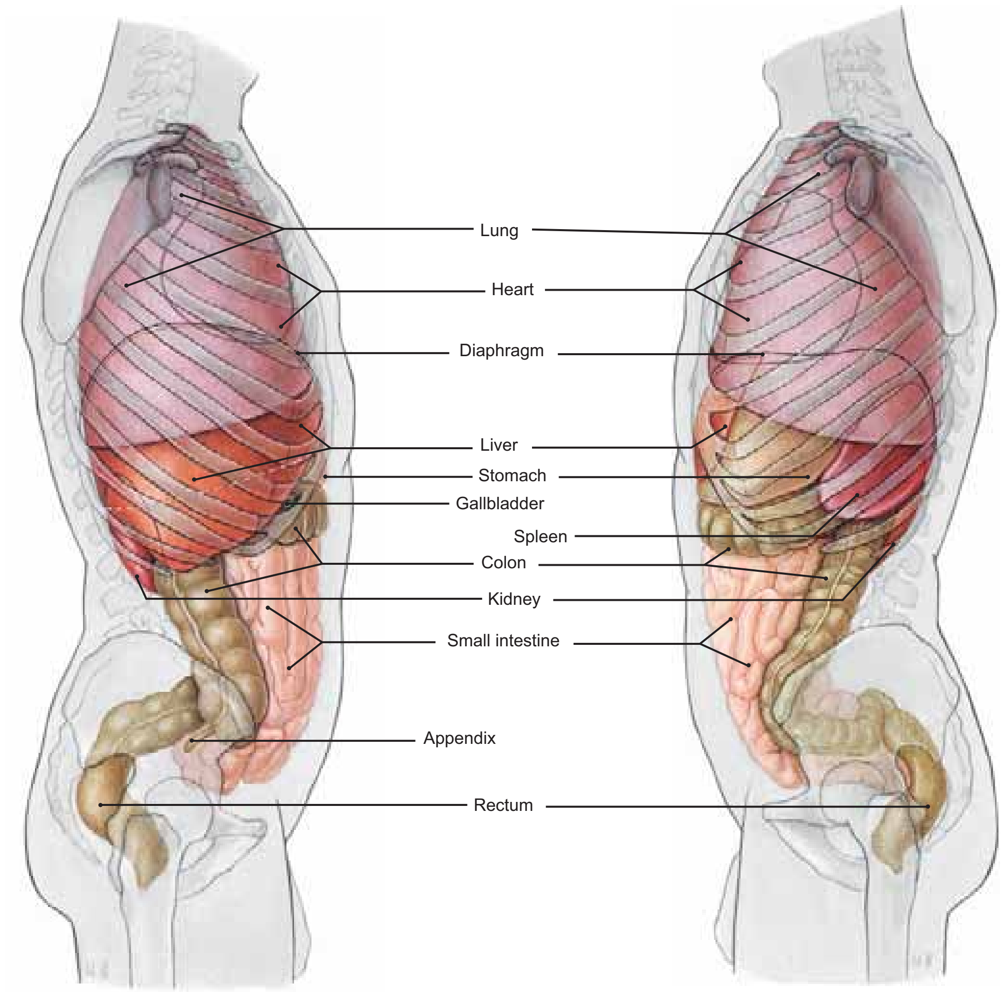


FIGURE 245.1 Surface Projection of Thoracic and Abdominal Organs (Right Lateral View)

FIGURE 245.2 Surface Projection of Thoracic and Abdominal Organs (Left Lateral View)

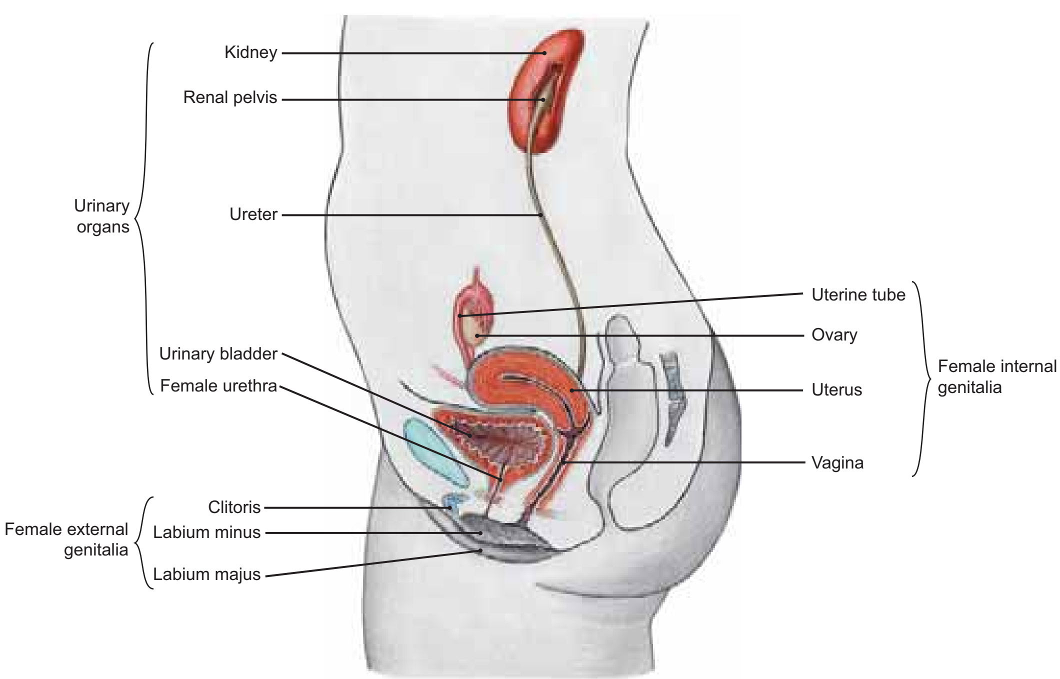


FIGURE 245.3 Surface Projection of Female Urogenital Organs (Left Lateral View)

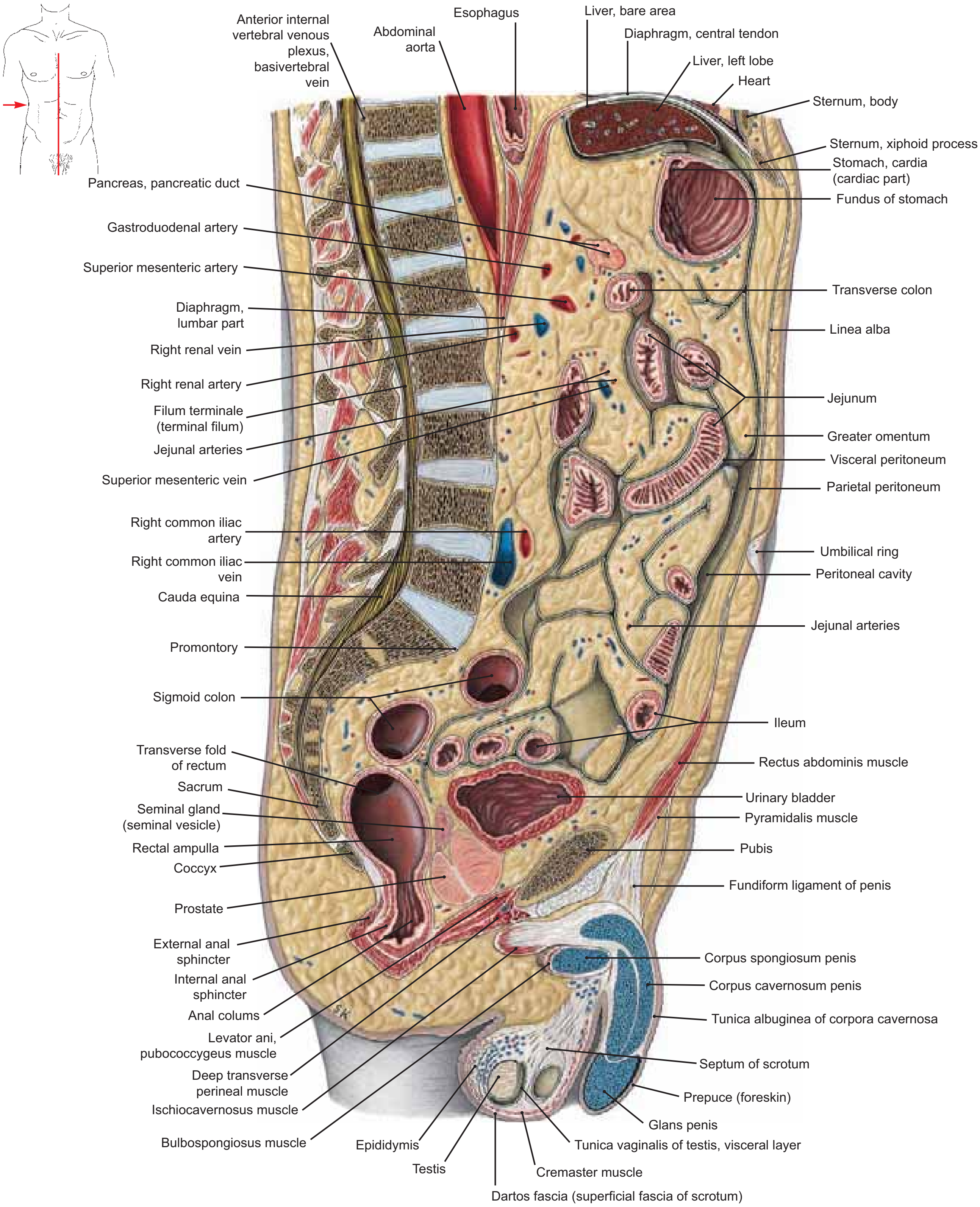


FIGURE 246 Median Sagittal Section of the Male Abdomen and Pelvis

NOTE: (1) This figure is viewed from the right lateral aspect. Observe, however, that the external genitalia and anterior aspect of the pelvis are sectioned to the left of the median plane.

(2) The **filum terminale** and **cauda equina** within the central canal of the vertebral column. Also observe the seminal vesicle and prostate gland on the posterior aspect of the urinary bladder.

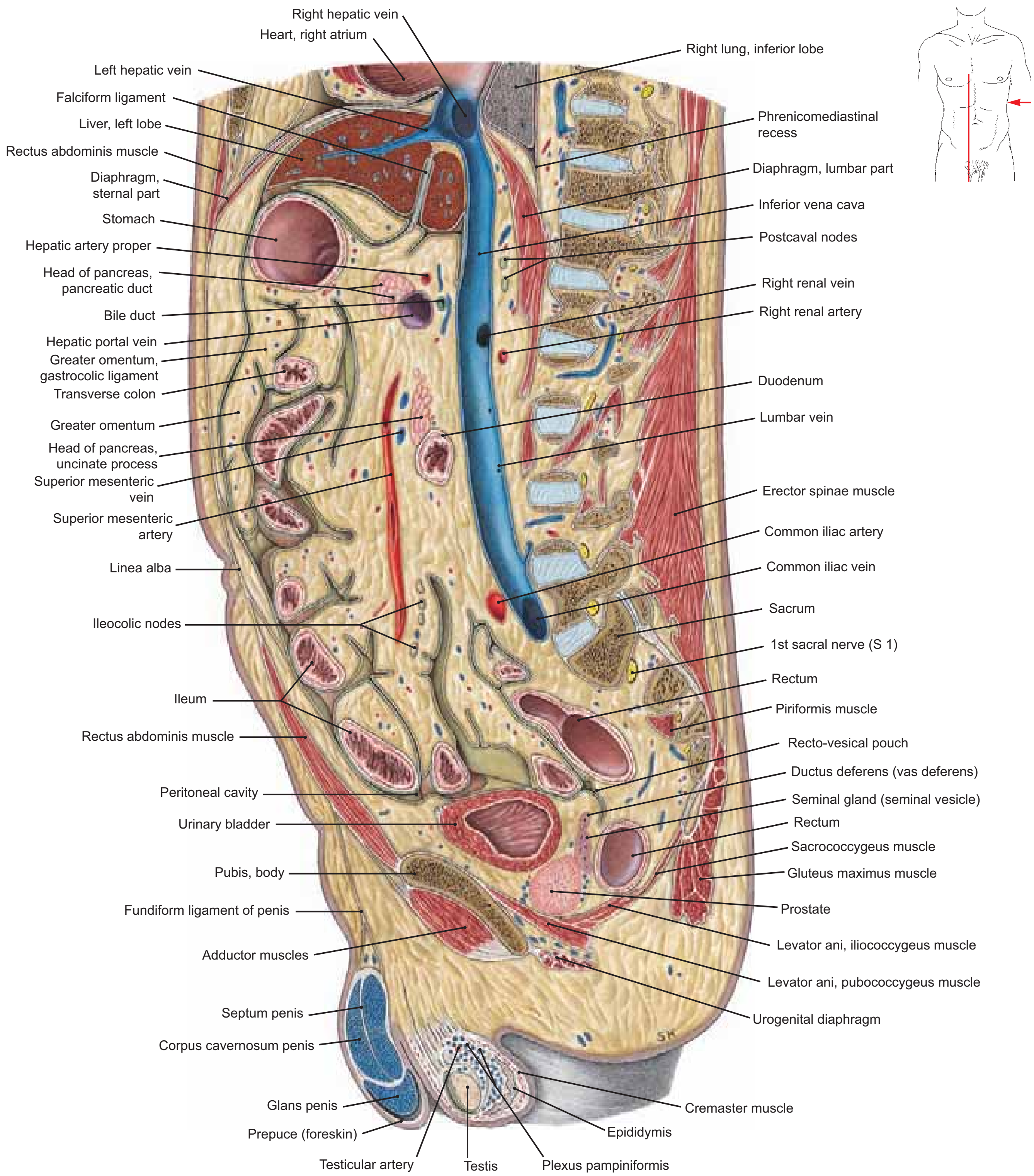


FIGURE 247 Paramedian Section of the Male Abdomen and Pelvis

NOTE: (1) This section bisects the inferior vena cava longitudinally as that vessel ascends along the posterior abdominal wall. Thus, this section was made to the right of the midline, and it is viewed from the left side.

(2) The head and the uncinate process of the pancreas, the hepatic artery, and the portal vein, all right-sided structures.

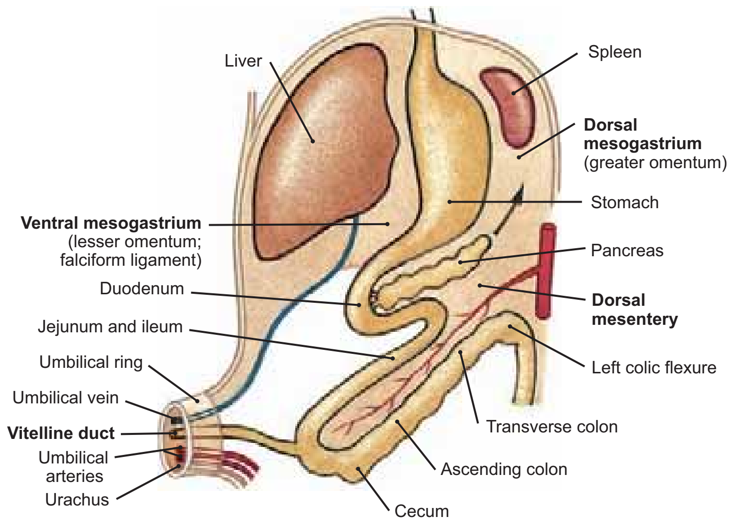


FIGURE 248.1 Developing Gastrointestinal Organs and Their Mesenteries

NOTE: (1) As the primitive gastrointestinal tube develops within the abdominal celom, it is suspended from the body wall by primitive peritoneal reflections, both ventrally and dorsally. The early peritoneal attachments to the expanding stomach are called the ventral mesogastrium and dorsal mesogastrium, whereas the dorsal mesentery develops on the posterior aspect of the primitive small and large intestine.

(2) The embryonic liver develops into the ventral mesogastrium, thereby dividing this ventral peritoneal attachment into:
  (a) A portion between the anterior body wall and the liver, which eventually becomes the falciform ligament and
  (b) A portion between the liver and the stomach, which becomes the lesser omentum.

(3) On the dorsal aspect:
  (a) The pancreas develops in relation to the primitive duodenum, both of which lose their mesenteries during gut rotation to become retroperitoneal.
  (b) The dorsal mesogastrium, attaching along the greater curvature of the stomach and, rotating with the stomach, becomes the greater omentum. This eventually encases the transverse colon.
  (c) The dorsal mesentery remains attached to the small intestine, while the ascending and descending colon become displaced to the right and left side, respectively, becoming adherent to the posterior body wall.
  (d) The sigmoid colon usually retains its mesentery, while that of the rectum becomes obliterated.

(4) Near the cecal end of the small intestine, the developing gastrointestinal canal communicates with the vitelline duct. Before birth, this duct usually becomes resorbed; when it persists (3% of cases), it results in a diverticulum of the ileum called Meckel's diverticulum.

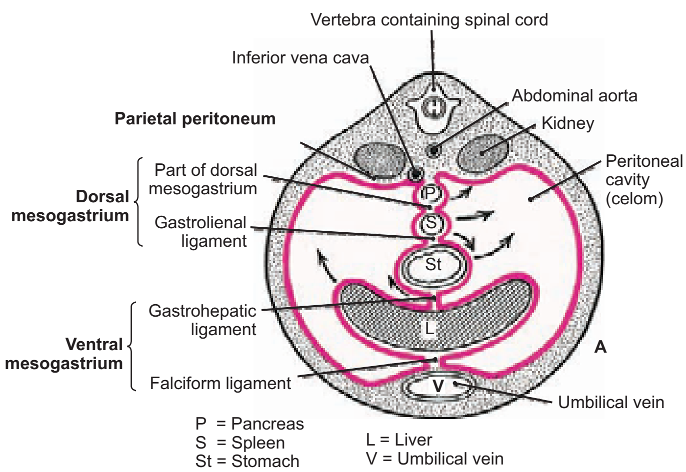


FIGURE 248.2A Cross-Sectional Diagram of Development of Mesogastria: Early Stage (Approximately 6 Weeks)

NOTE: (1) The primitive peritoneal reflections are indicated in red. The arrows show the direction of growth and movement by the various organs shown in Figure 249.1B.

(2) At this early stage, the peritoneum completely surrounds the organs in the upper abdominal region (visceral peritoneum) and attaches peripherally to the body wall (parietal peritoneum). Attaching along the posterior border of the stomach, the dorsal mesogastrium then surrounds the spleen and pancreas. Anterior to the stomach, the liver becomes interposed between the stomach and the anterior body wall. This forms the gastrohepatic ligament (also called the lesser omentum) between the lesser curvature of the stomach and the liver and the falciform ligament between the liver and the anterior body wall.

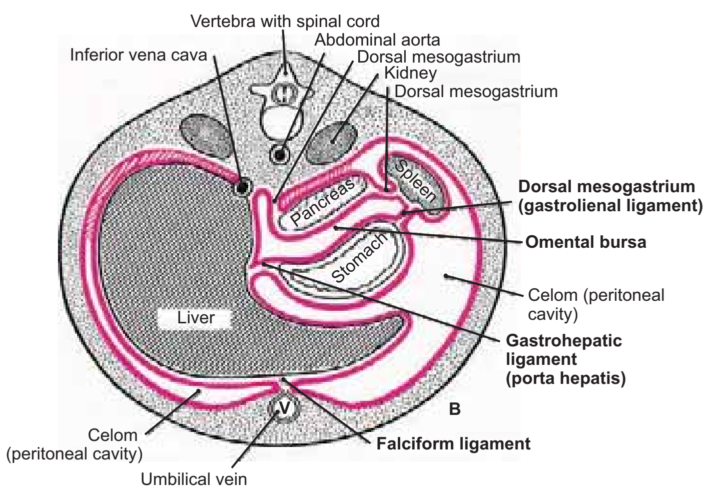
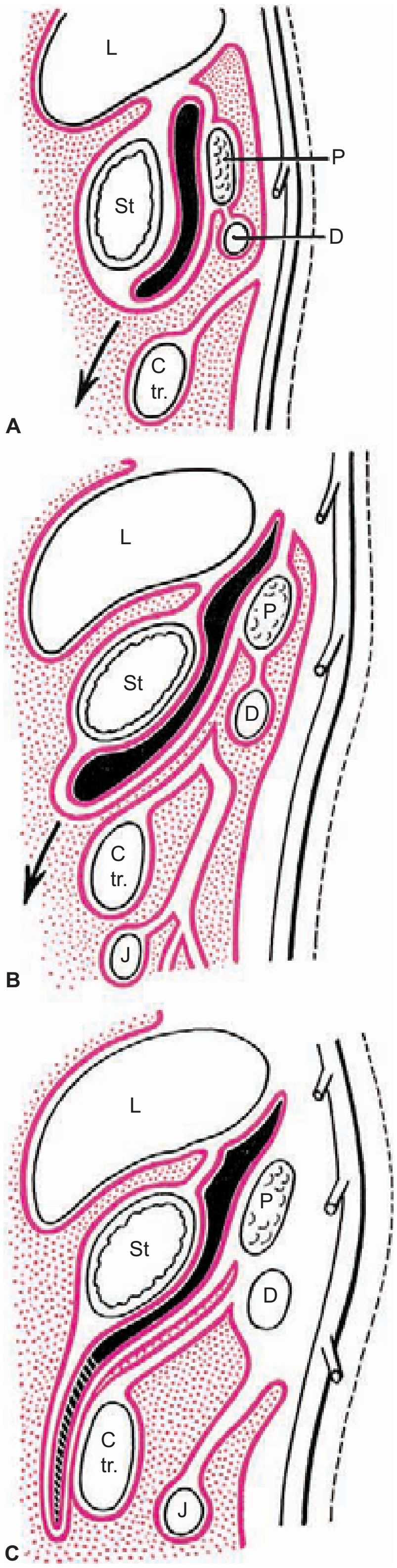
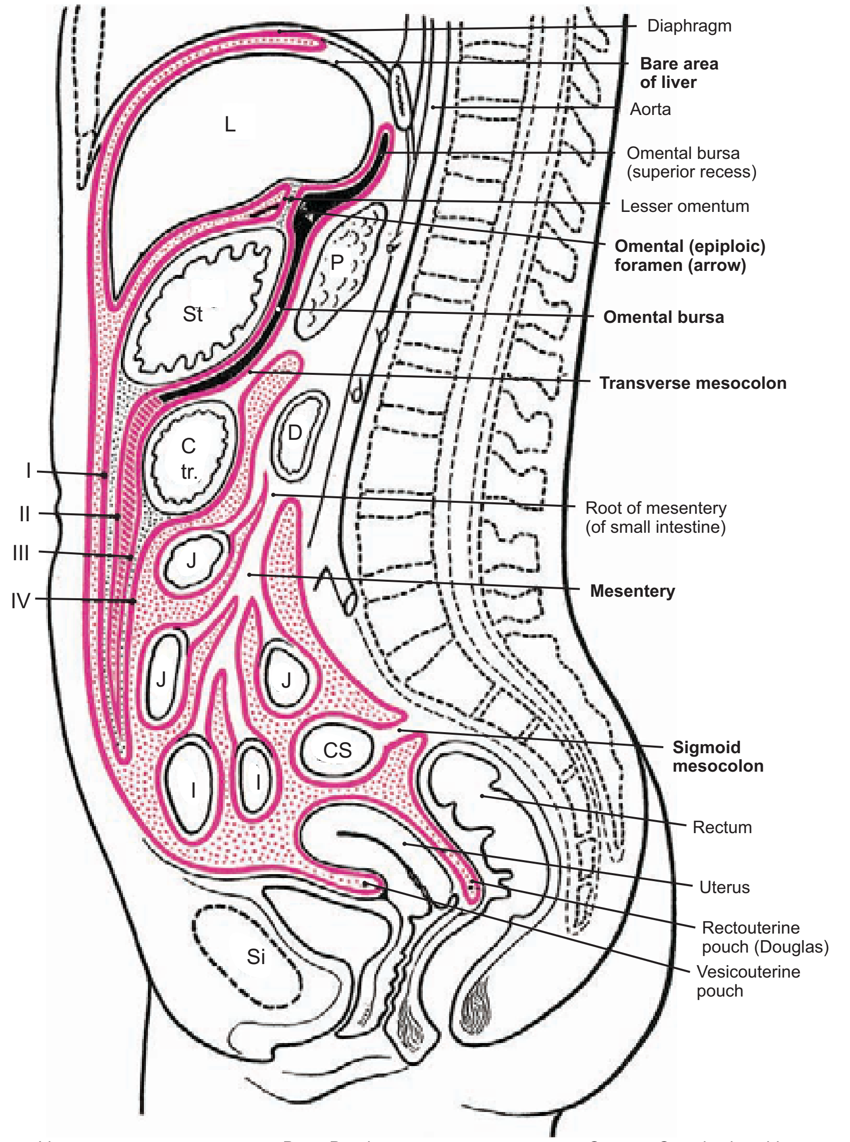


FIGURE 248.2B Cross-Sectional Diagram of Development of Mesogastria: Late Fetal Stage

NOTE: (1) With the rotation of the organs (in the direction of the arrows in Fig. 248.2A), the liver grows into the celomic cavity toward the right and contacts the inferior vena cava, while the stomach rotates such that its dorsal mesogastrium (greater curvature) is shifted to the left.

(2) The reflection of dorsal mesogastrium between the stomach and the spleen becomes established as the gastrolienal ligament, while one layer of mesogastrium surrounding the pancreas and duodenum fuses to the posterior body wall. This fixates these two organs with a layer of peritoneum on their anterior surface, causing them to become retroperitoneal. The omental bursa also develops posterior to the stomach and anterior to the pancreas.





L = Liver
P = Pancreas
St = Stomach
C tr. = Transverse colon

D = Duodenum
J = Jejunum
CS = Sigmoid colon
I = Ileum

S = Symphysis pubis
I to IV = The four layers of greater omentum (dorsal mesogastrium)

FIGURE 249.2 Peritoneal Reflections in Adult Female ▲

NOTE: (1) The greater peritoneal sac (red stippled) lies between the layers of visceral and parietal peritoneum. The greater peritoneal sac communicates with the lesser peritoneal sac (omental bursa; black) through the omental (epiploic) foramen (of Winslow).

(2) Dorsally, the roots of three distinct peritoneal mesenteries can be observed:
- (a) The transverse mesocolon,
- (b) The mesentery surrounding the small intestine, and
- (c) The sigmoid mesocolon.

(3) Behind the stomach and transverse colon, observe the retroperitoneal pancreas and duodenum. A portion of the liver is not surrounded by peritoneum (bare area of the liver) and lies adjacent to the diaphragm.

FIGURE 249.1A–C Stages in the Development of the Omental Bursa (Sagittal Diagrams)

NOTE: (1) At 4 weeks, the dorsal border of the stomach grows faster than the ventral border, assisting in the rotation of the stomach on its long axis. The greater curvature and its dorsal mesogastrium become directed to the left, whereas the lesser curvature and the ventral mesogastrium are directed to the right.

(2) By 8 weeks (**A**), the omental bursa (black) forms behind the stomach between the two leaves of dorsal mesogastrium. The pancreas and duodenum are still surrounded by dorsal mesentery. As gut rotation continues, the dorsal mesogastrium extends inferiorly (**B,** arrow) to form the greater omentum, which becomes a double reflection (four leaves) of the dorsal mesogastrium "trapping" the cavity of the omental bursa between the second and third leaves.

(3) Continued development (**C**) results in a further descent of the greater omentum over the abdominal viscera and a fusion (cross-hatched) of the second and third leaves inferiorly.

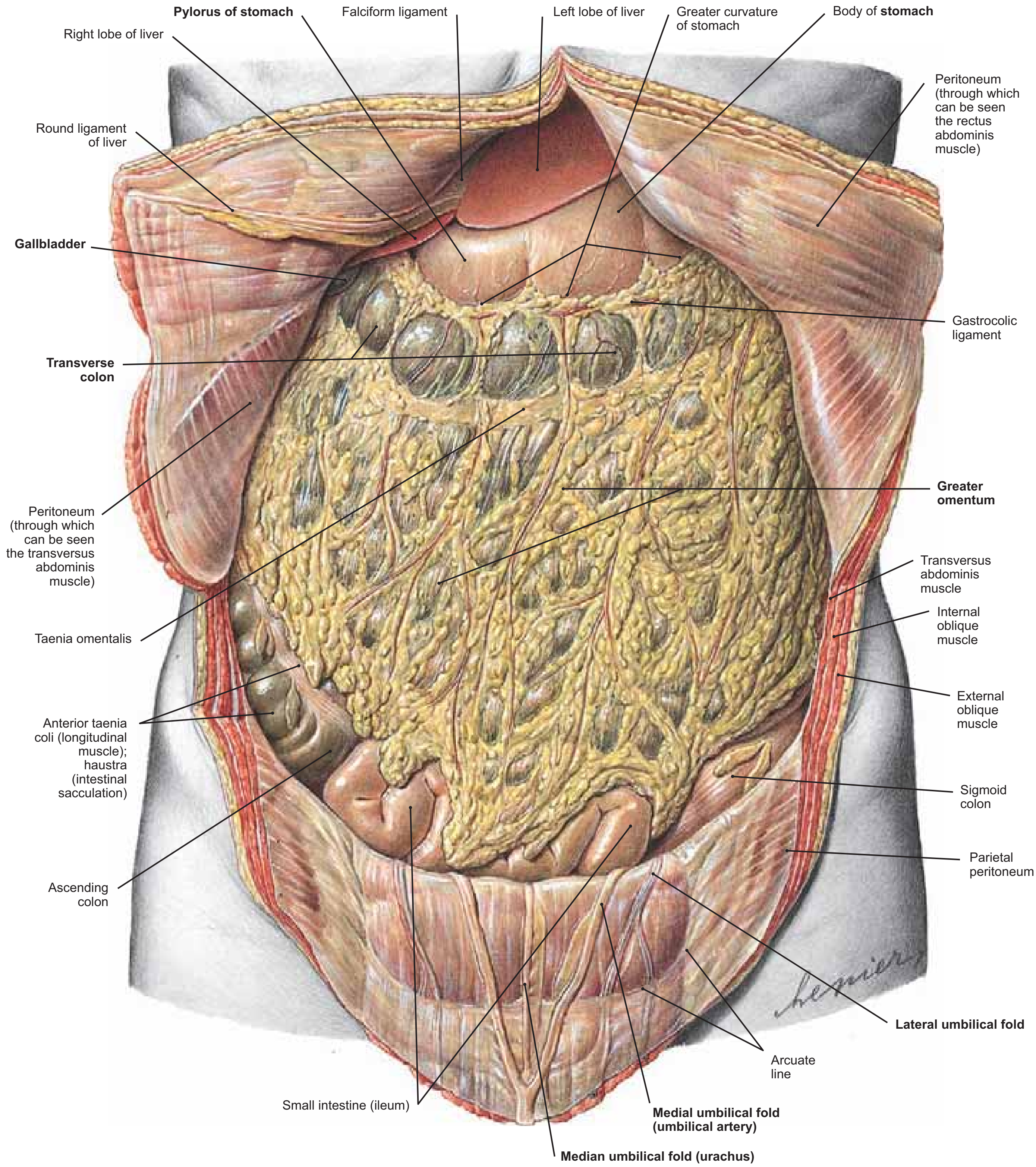


FIGURE 250 Abdominal Cavity, Viscera Left Intact

NOTE: (1) The **greater omentum.** It attaches along the greater curvature of the stomach, covers the intestines like an apron, and extends inferiorly almost to the pelvis.

(2) The **falciform ligament,** a remnant of the ventral mesogastrium, extends between the liver and the anterior body wall and separates the left and right lobes of the liver. The **round ligament** is the remnant of the obliterated umbilical vein.

(3) On the inner surface of the anterior abdominal wall, identify the following folds:

(a) **Median umbilical fold:** remnant of the urachus, which extended between the bladder and the umbilicus in the fetus.

(b) **Medial umbilical folds:** the obliterated umbilical arteries, which were the continuation of the superior vesical arteries to the umbilicus in the fetus.

(c) **Lateral umbilical folds:** a folds of peritoneum over the inferior epigastric vessels.

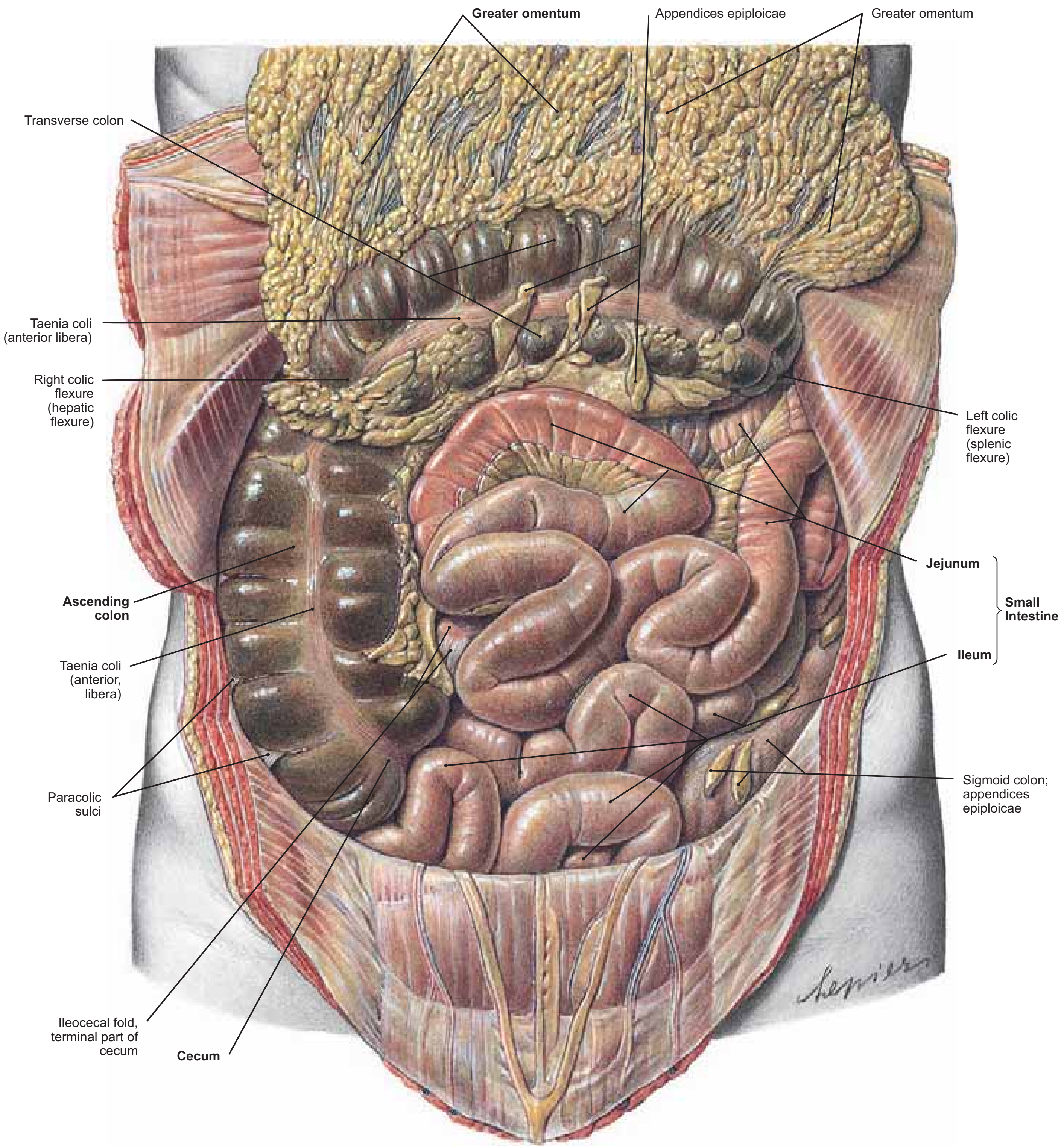


FIGURE 251 Abdominal Cavity, Ascending Colon, and Transverse Colon and Its Mesocolon

NOTE: (1) With the greater omentum reflected upward, the transverse colon is crossing the abdominal cavity from right to left in continuity with the ascending colon on the right and the descending colon on the left.

(2) Longitudinal muscles called **taeniae,** along the outer surface of the colon. These muscles are shorter than the other coats of the large intestine causing sacculations, which are called **haustrae.**

(3) Smooth irregular fatty masses called **appendices epiploicae** are suspended from the large intestine. These assist in the identification of the large gut.

(4) Below the mesocolon (inframesocolic) can be seen the small intestine, which consists of three portions: the **duodenum, jejunum,** and **ileum.** The outer wall of the small intestine is smooth and glistening and is not sacculated.

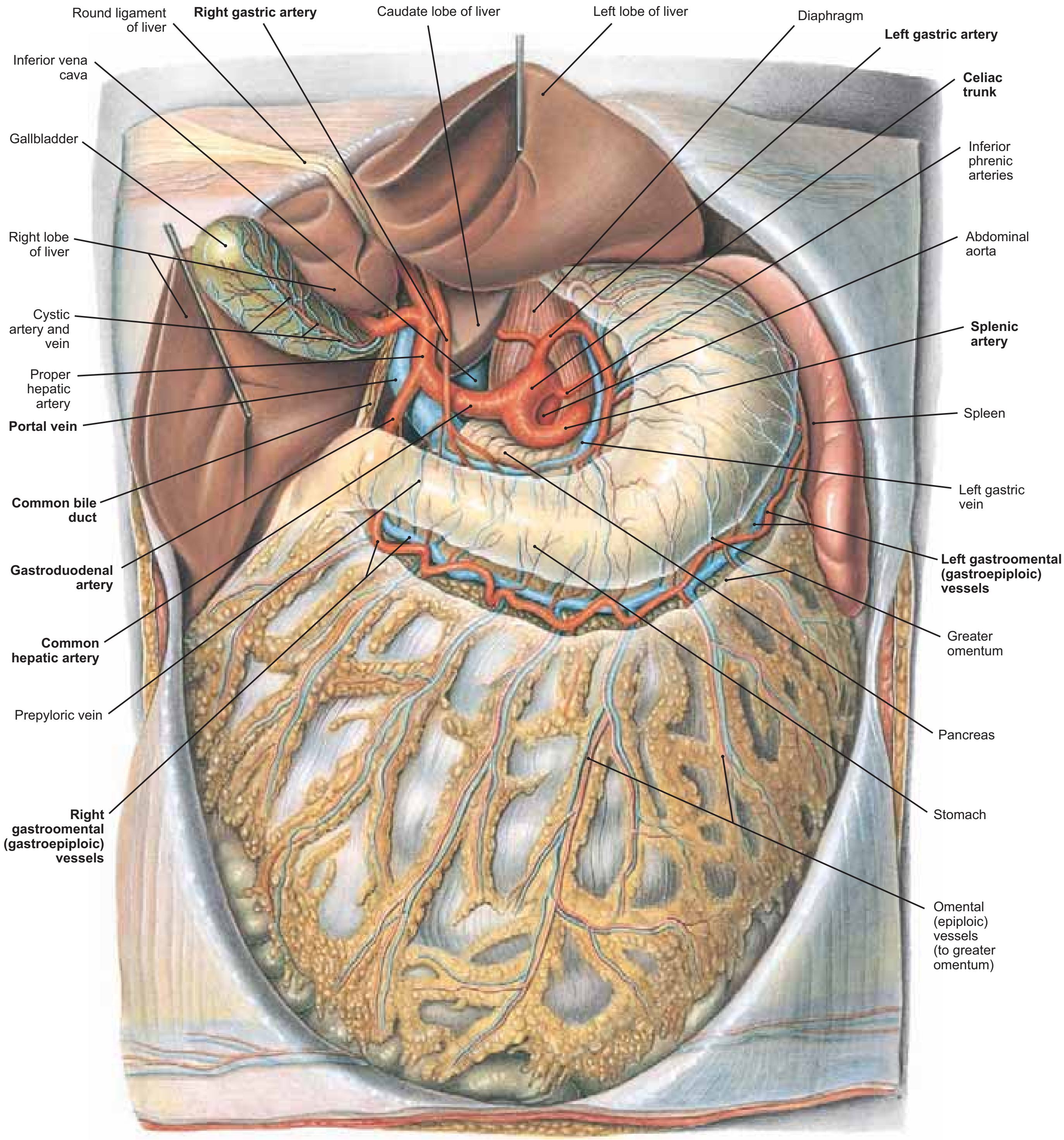


FIGURE 252 Abdominal Cavity: Celiac Trunk and Its Branches

NOTE: (1) The lobes of the liver have been elevated and the lesser omentum has been removed between the lesser curvature of the stomach and the liver to reveal the **celiac trunk** (located anterior to the T12 vertebra) and its branches. These are:

(a) The **left gastric artery,** which courses along the lesser curvature of the stomach and anastomoses with the right gastric artery, a branch of the hepatic artery.

(b) The **splenic artery,** which courses to the left toward the hilum of the spleen.

(c) The **hepatic artery,** which courses to the right and gives off the gastroduodenal artery before dividing to enter the lobes of the liver.

(2) The **gastroduodenal artery** gives rise to the **right gastroomental (gastroepiploic) artery,** which follows along the greater curvature of the stomach to anastomose with the **left gastroomental (gastroepiploic) branch** of the splenic artery.

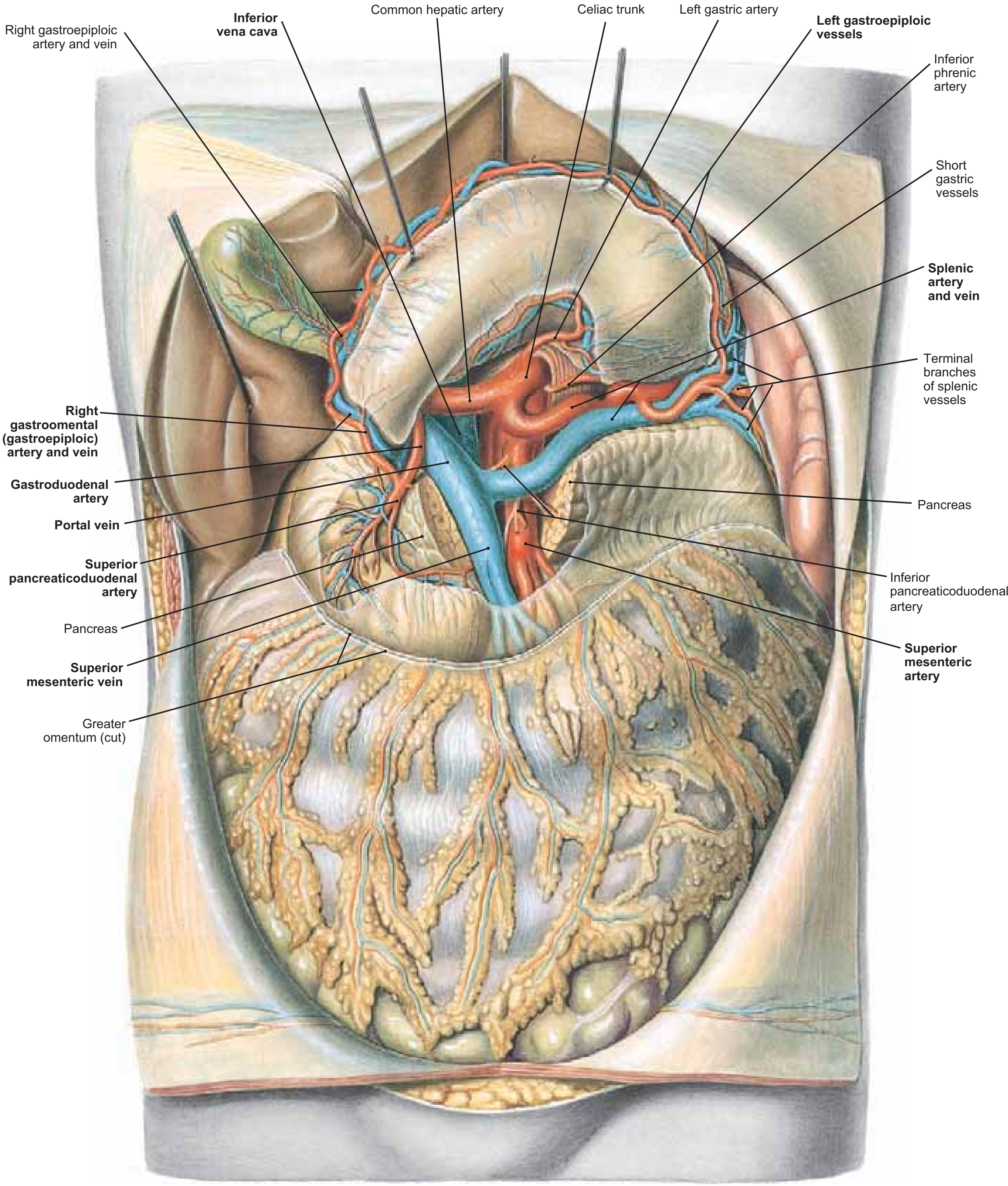


FIGURE 253 **Abdominal Cavity (4): Splenic Vessels and Formation of the Portal Vein**

NOTE: (1) The greater omentum has been cut along the greater curvature of the stomach. The stomach is lifted to expose its posterior surface and the underlying pancreas, duodenum, and blood vessels. A part of the pancreas has been removed to reveal the **portal vein** formed by the junction of the **splenic and superior mesenteric veins.**

(2) The tortuous **splenic artery** in its course to the splenic hilum, and the **gastroduodenal artery,** behind the pyloric end of the stomach dividing into **right gastroomental** and **superior pancreaticoduodenal arteries.**

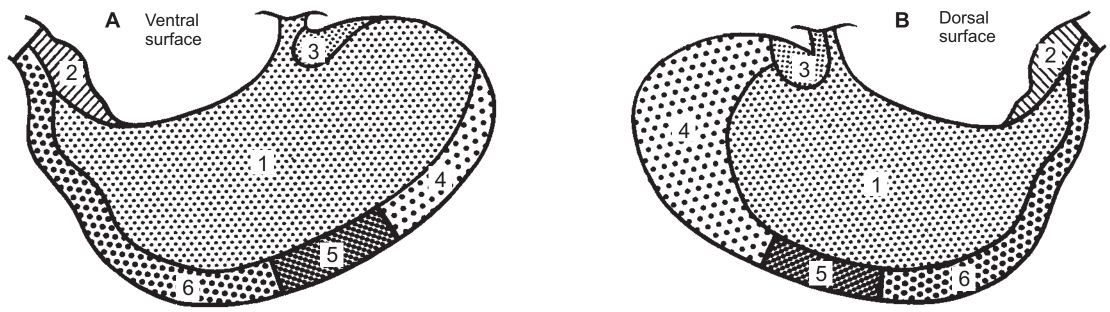


FIGURE 254.1A, B Regional Arterial Supply to the Stomach

1. Left gastric artery
2. Right gastric artery
3. Left inferior phrenic artery
4. Short gastric artery
5. Left gastroomental artery
6. Right gastroomental artery

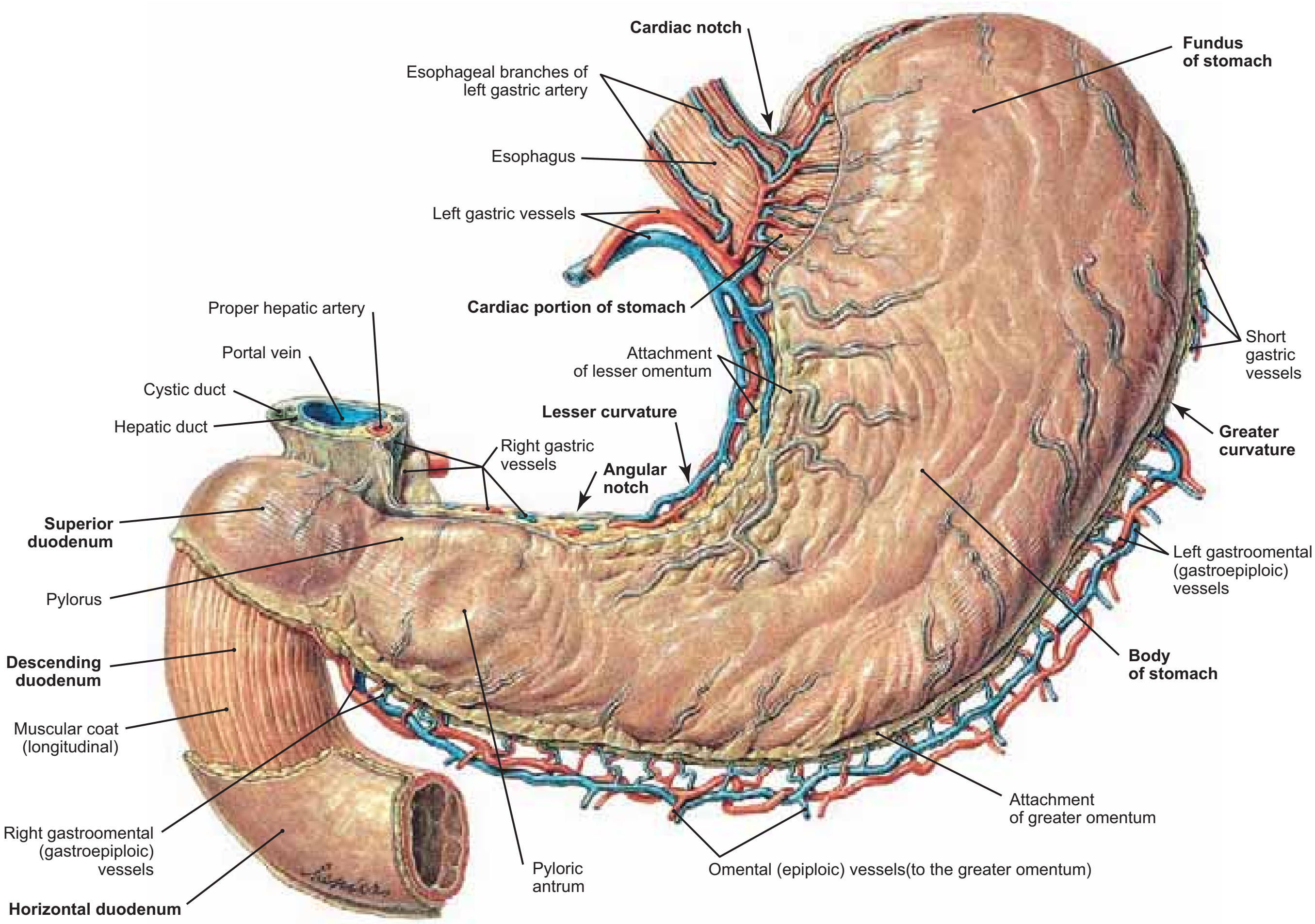


FIGURE 254.2 Anterior View of Stomach

NOTE: (1) The stomach is a dilated muscular sac situated in the gastrointestinal tract between the esophagus (cardiac end) and the duodenum (pyloric end). It consists of an upper portion called the **fundus,** a middle portion, the **body,** and a tapering lower part, the **pyloric region.**

(2) Although the shape of the stomach varies, it presents two curvatures as borders. The **greater curvature** is directed toward the left and to it is attached the **greater omentum.** This border forms an acute angle with the esophagus called the **cardiac notch.**

(3) The **lesser curvature** constitutes the right border of the stomach and along this edge the **lesser omentum** is attached.

(4) The blood vessels supplying the stomach include:

(a) The **left and right gastric arteries** along the lesser curvature,

(b) The **left and right (gastroepiploic) arteries** along the greater curvature, and

(c) The **short gastric branches** of the **splenic artery.** Observe that the **esophageal branches** of the left **gastric artery** supply the cardiac end of the stomach.

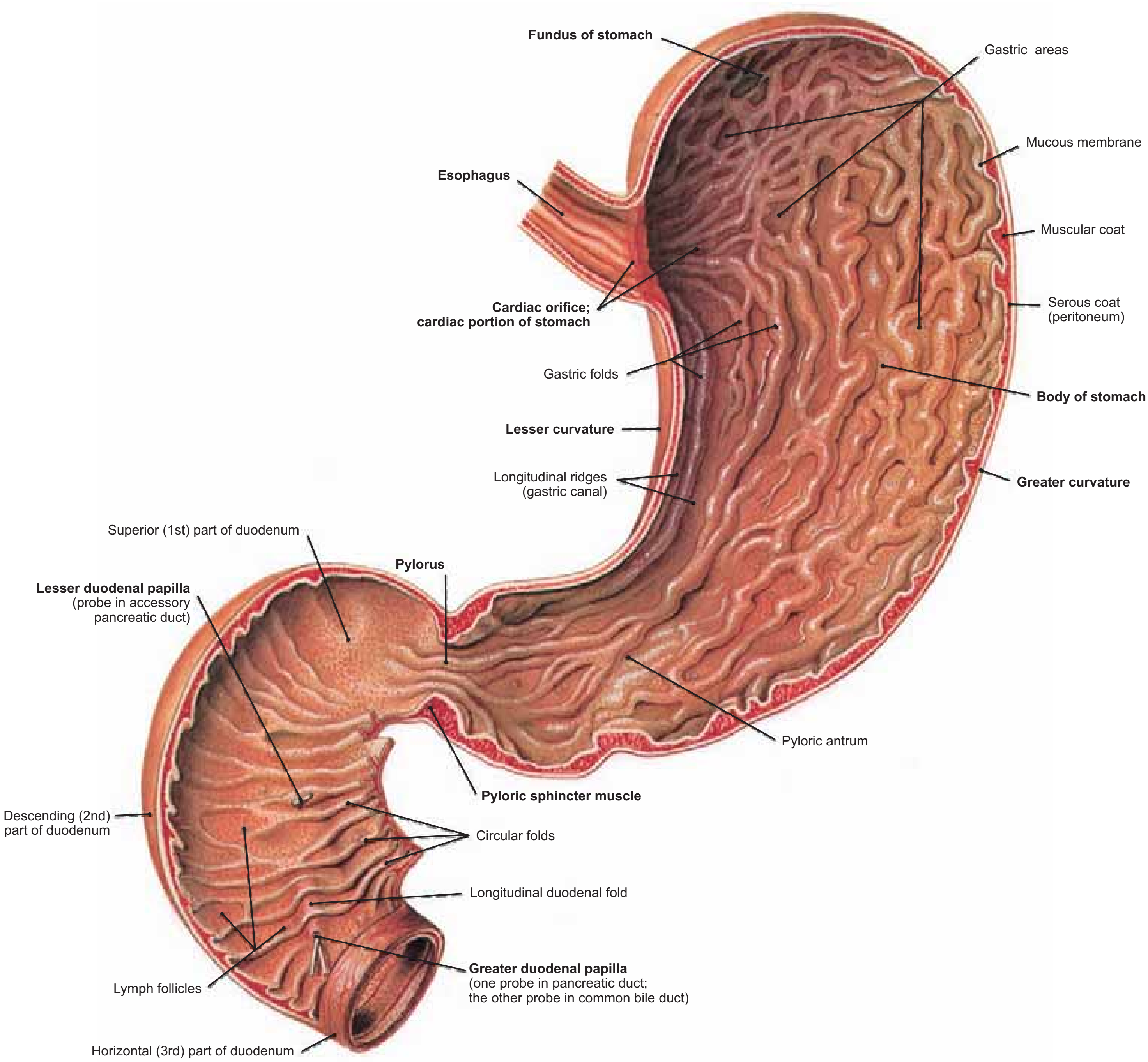


FIGURE 255 Interior of the Stomach and Upper Duodenum

NOTE: (1) The mucosal lining of the stomach shows a series of longitudinally oriented gastric folds or empty rugae, which tend to disappear when the stomach is full and distended. These folds are more regular along the lesser curvature and form the grooved gastric canal. Food does not travel along this canal (magenstrasse).

(2) The surface of the first part of the duodenum is smooth, but the circular ridges characteristic of the small intestine commence in the second, or descending, portion of the duodenum.

(3) A circular muscle, the **pyloric sphincter,** guards the pyloric junction of the stomach with the duodenum. It diminishes the lumen of the gastrointestinal tract at this point. The pylorus is to the right of midline at the level of the first lumbar vertebra.

(4) The openings in the wall of the duodenum. The **greater duodenal papilla** serves as the site of the openings of both the common bile duct and the main pancreatic duct. The accessory pancreatic duct opens 2 cm more proximally through the lesser duodenal papilla.

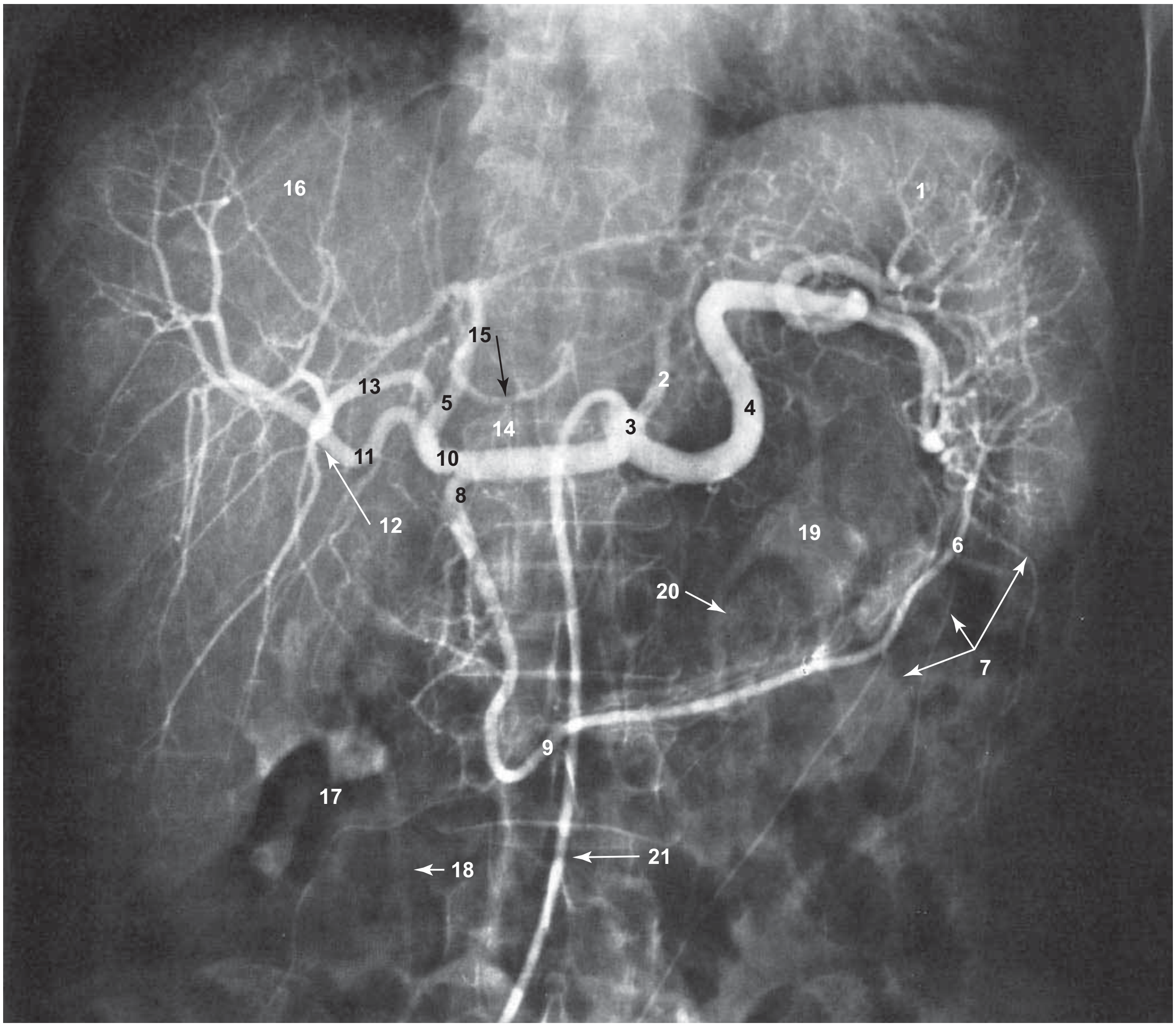


FIGURE 256 Celiac Trunk Arteriogram

NOTE: (1) This figure is a negative print from a radiograph of the upper abdomen after injection of a contrast medium through a catheter (21, arrow) in the abdominal aorta directed upward to the point where the **celiac trunk** [3] branches from the aorta.

(2) The three primary vessels arising from the celiac trunk [3] are the **left gastric artery** [2], the **splenic artery** [4], directed toward the spleen [1], and the **common hepatic artery** [5], which courses directly to the right toward the liver [16].

(3) The **left gastroomental (gastroepiploic) artery** arises from one of the lower hilar branches of the splenic artery. As it courses along the greater curvature to anastomose with the **right gastroomental (gastroepiploic) artery,** the **left gastroomental (gastroepiploic)** artery gives rise to omental **(epiploic) arteries** [7, arrows], which descend to supply the greater omentum. The right gastroomental (gastroepiploic) artery [9] arises from the **gastroduodenal artery** [8], which courses downward from the **common hepatic artery** [5].

(4) Beyond the origin of the gastroduodenal artery [8] the common hepatic artery [5] is called the **proper hepatic artery** [10].

(5) The proper hepatic artery [10] divides into the **right hepatic artery** [11], from which branches the **cystic artery** [12] to the gallbladder, the **middle hepatic artery** [13], and the **left hepatic artery** [14, arrow]. The hepatic vessels supply the liver.

(6) From the right hepatic artery [14] in this individual branches the **right gastric artery** [15, arrow]. Just as frequently, the right gastric artery arises from the common hepatic artery [5]. The right gastric artery courses along the lesser curvature of the stomach to anastomose with the **left gastric artery** [2].

(7) The right renal pelvis [17] and the right ureter [18, arrow] can be seen inferiorly. Because of the liver, these structures on the right side are significantly lower than the left renal pelvis [19] and the origin of the left ureter [20, arrow].

(From Wicke, 4th ed.)

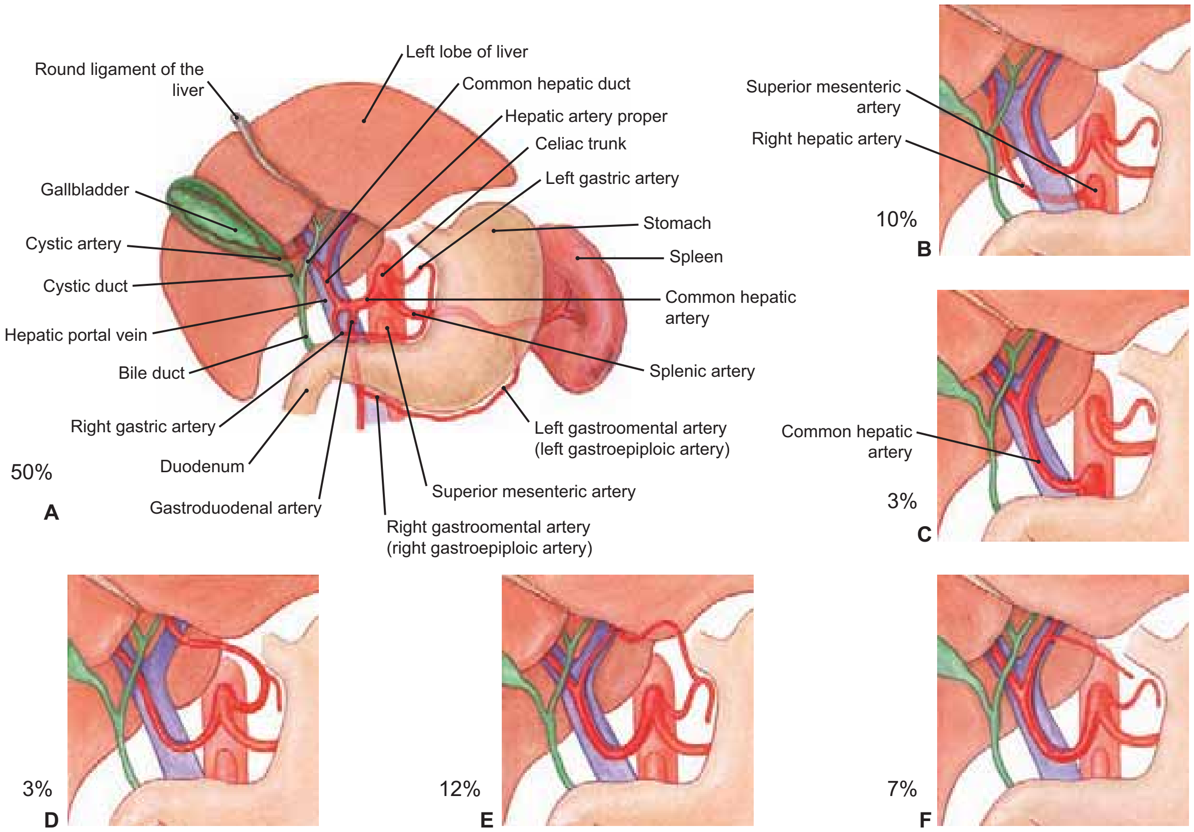


FIGURE 257.1A–F Variations in the Blood Supply to the Liver

A: Normal pattern as shown in most diagrams.
B: Superior mesenteric artery helping to supply the liver.
C: Common hepatic artery arising from the superior mesenteric artery.
D: Left gastric artery supplying the left lobe of the liver.
E: Branch of the left gastric artery helping to supply the left lobe of the liver (with the left branch of the hepatic artery).
F: An accessory branch from the proper hepatic artery supplying the lesser curvature of the stomach.

(In 25% of cases, the superior mesenteric artery participates in the arterial supply to the liver.)

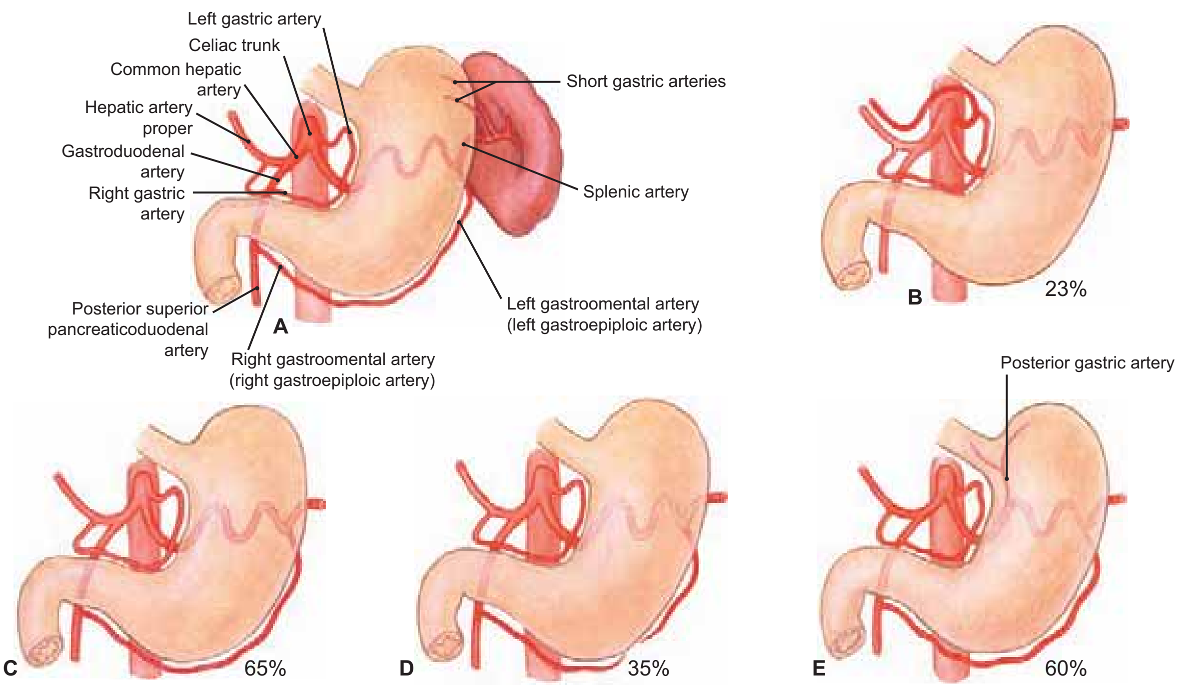


FIGURE 257.2A–E Variations in the Arterial Blood Supply to the Stomach

A: Normal pattern as shown in most diagrams.
B: Left gastric artery participating in the supply of the left lobe of the liver.
C: Anastomosis between the right and left gastroomental (gastroepiploic) arteries along the greater curvature.
D: No anastomosis between the right and left gastroomental (gastroepiploic) arteries along the greater curvature.
E: An accessory posterior gastric artery (from the splenic) that helps supply the posterior surface of the stomach.

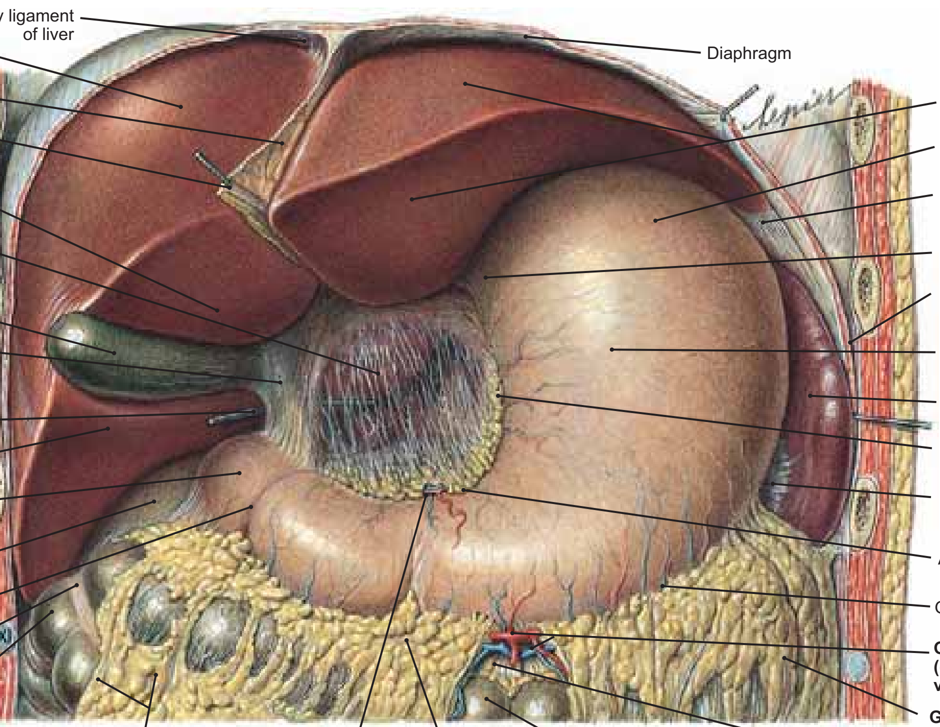


FIGURE 258.1 Lesser Omentum, Stomach, Liver, and Spleen

NOTE: (1) The liver is elevated and a probe inserted through the **omental (epiploic) foramen** into the vestibule of the **omental bursa.** By way of this opening, the greater peritoneal sac communicates with the lesser peritoneal sac (omental bursa). The **lesser omentum** consists of the **hepatogastric** and **hepatoduodenal ligaments.**

(2) The omental (epiploic) foramen is situated just below the liver and readily admits two fingers. It is bound **superiorly** by the caudate lobe of the liver, **inferiorly** by the superior part of the duodenum, **posteriorly** by the inferior vena cava, and **anteriorly** by the lesser omentum, which ensheathes the hepatic artery, portal vein, and bile ducts at the **porta hepatis.**

(3) The greater omentum extends along the greater curvature from spleen to duodenum.

(4) The gallbladder is situated between the right and quadrate lobes of the liver and projects just beyond the inferior border of the liver, thereby coming into contact directly with the anterior abdominal wall at this site.

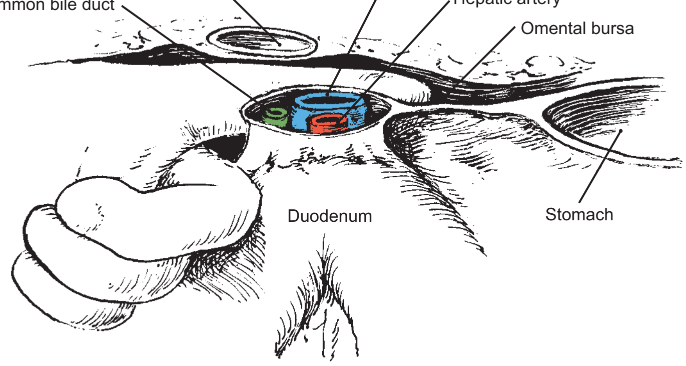


FIGURE 258.2 Structures at the Porta Hepatis

NOTE that the finger is entering the **omental foramen (of Winslow)** that allows communication between the **greater peritoneal sac** and the **omental bursa** or **lesser peritoneal sac.**

(From *Clemente's Anatomy Dissector,* 2nd Edition, Lippincott Williams & Wilkins, Baltimore, 2007.)

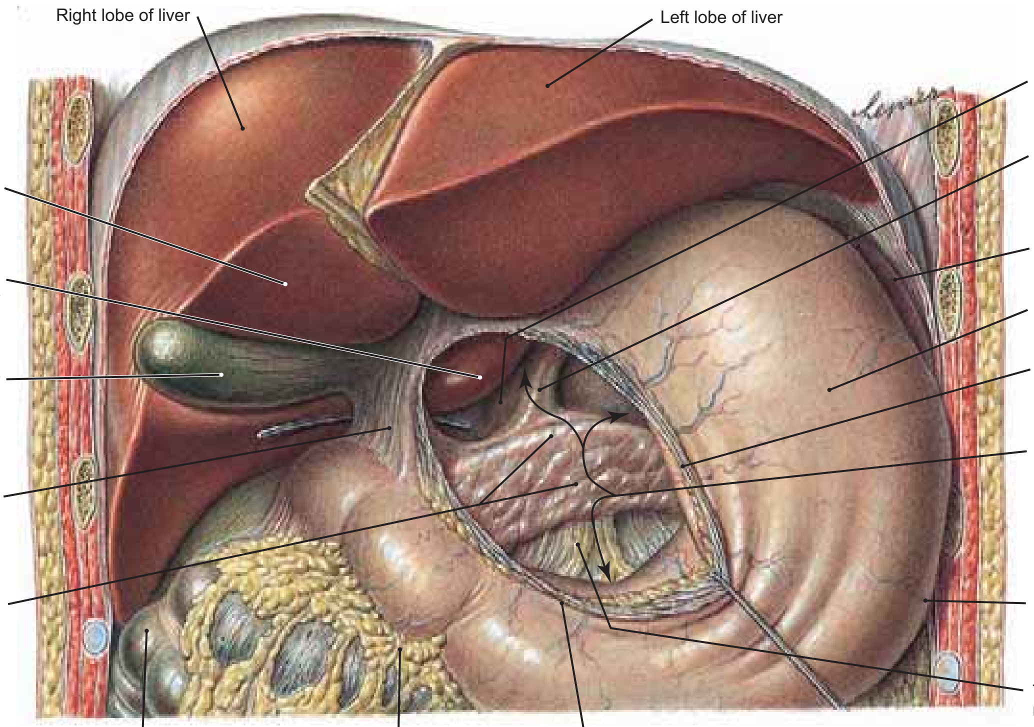


FIGURE 259.1 Omental Bursa, Caudate Lobe of Liver, and Body of Pancreas

NOTE: (1) With the liver elevated and the lesser curvature of the stomach pulled to the left, the exposure obtained by opening the omental bursa through the hepatogastric part of the lesser omentum has been enlarged. The superior, splenic, and inferior recesses of this bursa are indicated by arrows.

(2) The portion of the omental bursa adjacent to the omental (epiploic) foramen is called the **vestibule.** Observe the **gastropancreatic fold,** which crosses the dorsal wall of the bursa. This fold is a reflection of peritoneum covering the left gastric artery coursing from the celiac trunk to its destination, the lesser curvature of the stomach.

(3) Exposure of the omental bursa reveals the **caudate lobe** of the liver situated on the dorsal surface of the **right lobe.** Also seen is the anterior surface of the body of the pancreas coursing transversely behind the stomach.

(4) The **left lobe** of the liver overlies the lesser curvature, the fundus, and part of the body of the stomach. The **caudate lobe** behind the porta hepatis and the **quadrate lobe,** located between the fossa of the gall bladder and the round ligament, come into contact with the pylorus and the first part of the duodenum.

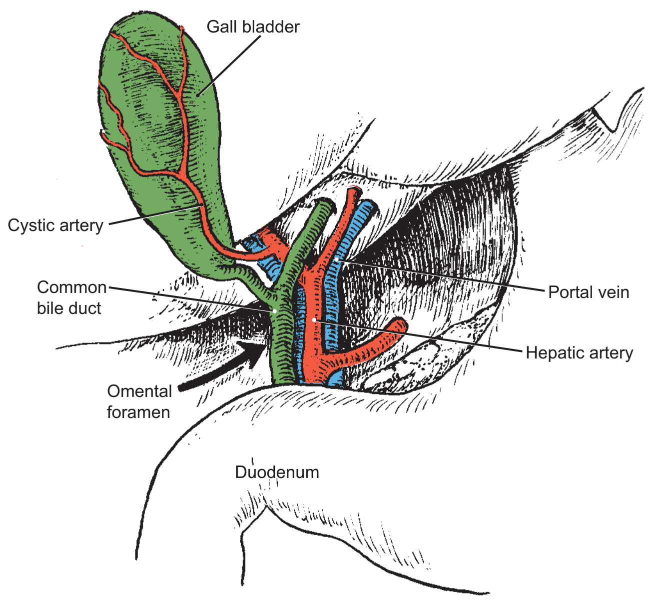


FIGURE 259.2 The Omental Foramen (of Winslow)

NOTE the black arrow behind (posterior to) the hepatic artery, portal vein, and common bile duct, thereby demonstrating the omental foramen. Through this foramen, the greater peritoneal sac communicates with the omental bursa, or lesser peritoneal sac.

(From *Clemente's Anatomy Dissector,* 2nd Edition, Lippincott Williams & Wilkins, Baltimore, 2007.)

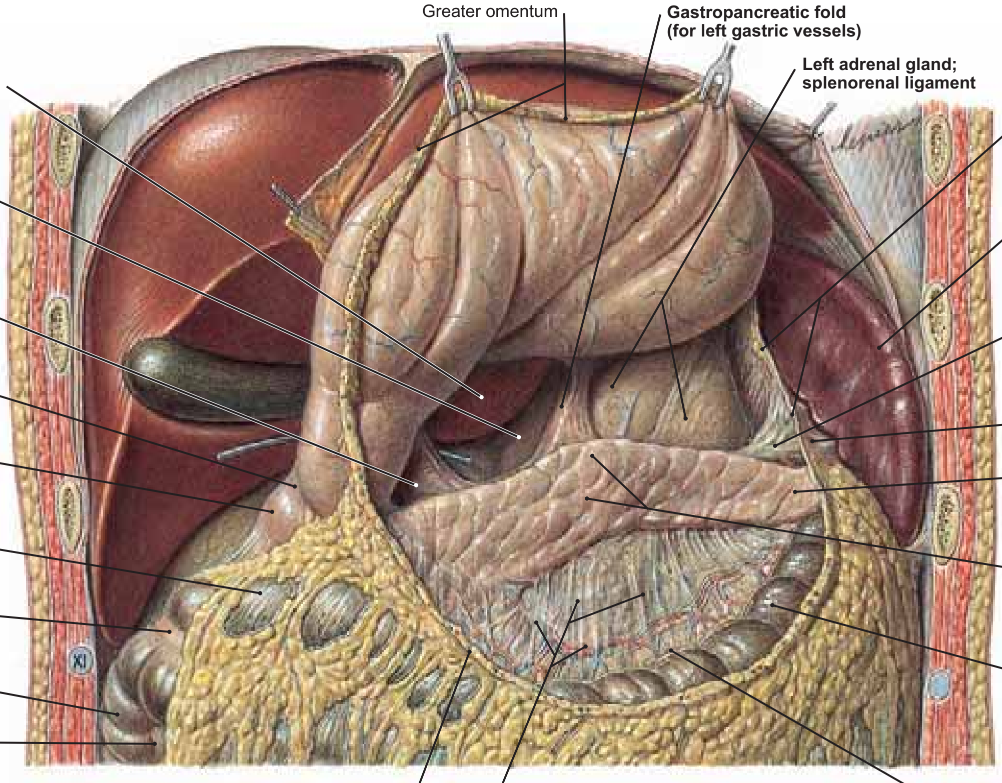


FIGURE 260.1 Omental Bursa and Structures in the Stomach Bed

NOTE that the greater omentum has been cut along the entire greater curvature of the stomach, and the organ has been lifted to expose the omental bursa. Also note that the **gastrosplenic** and **splenorenal** ligaments have been cut, and that the tail of the pancreas is oriented toward the hilum of the spleen.

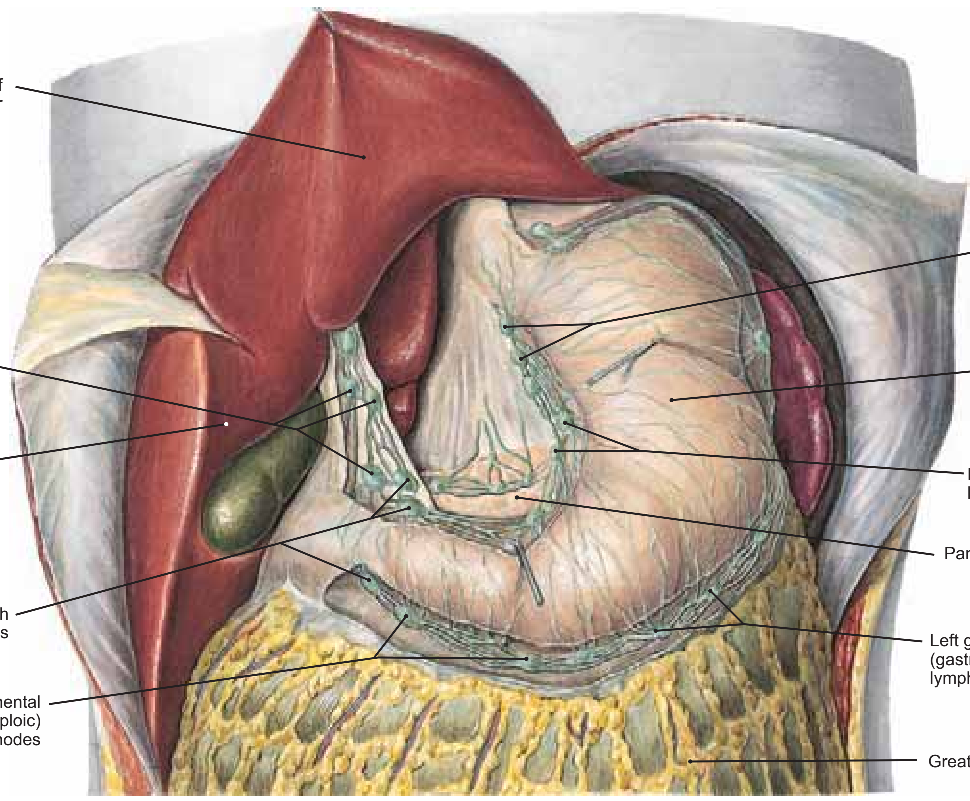


FIGURE 260.2 Lymph Vessels and Nodes of the Stomach, Porta Hepatis, and Pancreas

NOTE that lymph nodes lie along the greater and lesser curvatures of the stomach with the gastroomental (gastroepiploic) and left gastric vessels. Those in the porta hepatis follow the branches of the hepatic artery and posterior to the stomach the pancreatic nodes are located along the splenic vessels. Most of these nodes drain to the **preaortic nodes.**

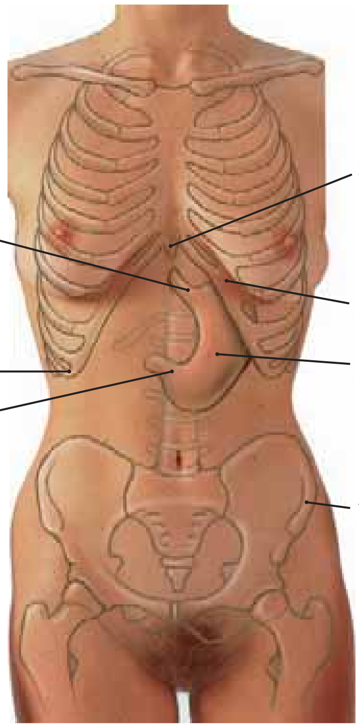


FIGURE 261.1 Surface Projection of "Normal" Stomach

NOTE: (1) In this figure the person is standing upright.
(2) The shape and positioning of the stomach are often altered by changes in its content and by organs surrounding the stomach.
(3) The adult stomach has a capacity of about 1500 ml, while at birth it is only about 30 ml.

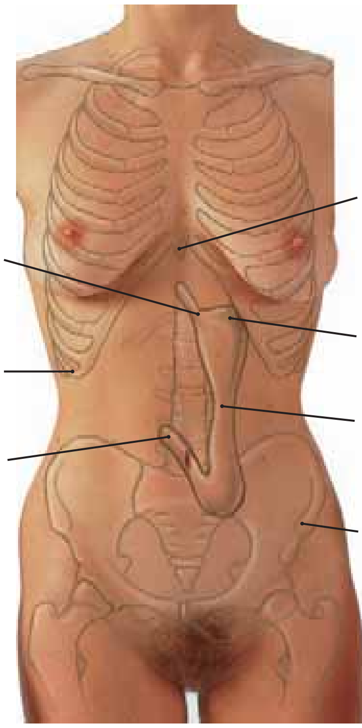


FIGURE 261.2 Surface Projection of "Normal Fishhook" Stomach

NOTE: (1) In this figure the person is standing upright.
(2) A "long stomach" of the type shown here can extend as far inferiorly as the upper pelvis (see radiograph in Fig. 261.3)

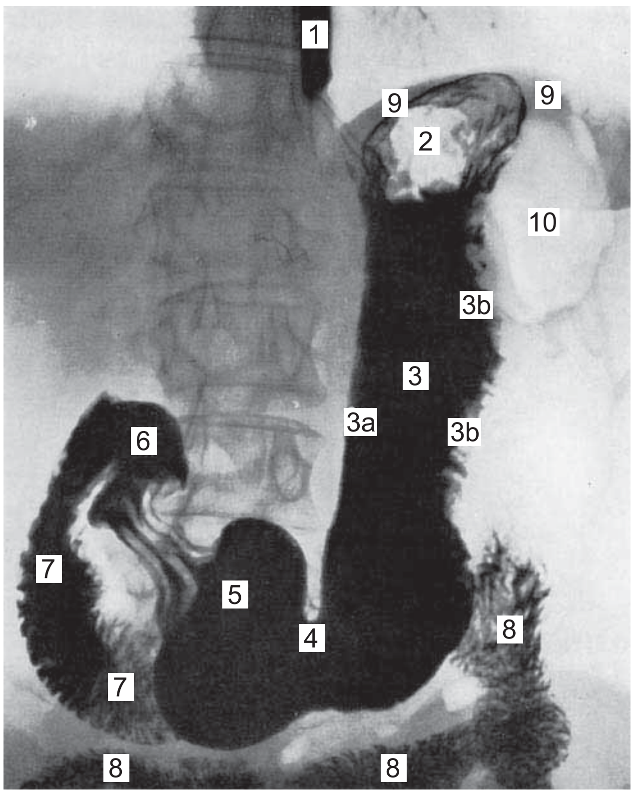


FIGURE 261.3 Radiograph of the Lower Esophagus, Stomach, Duodenum, and Proximal Jejunum

NOTE: This is a normal "J-shaped" or "fishhook" stomach. The cardiac and pyloric ends of the stomach are more securely attached to the posterior body wall, whereas the body and pyloric parts are more mobile. Frequently in the upright position, the greater curvature hangs as low as the brim of the pelvis.

1. Esophagus
2. Stomach fundus (air bubble)
3. Body of stomach
3a. Lesser curvature
3b. Greater curvature
4. Peristaltic constriction at angular notch
5. Pyloric antrum (expanded)
6. Bulb of superior duodenum (first part)
7. Descending duodenum (second part)
8. Jejunum
9. Left dome of diaphragm
10. Gas in left colic flexure

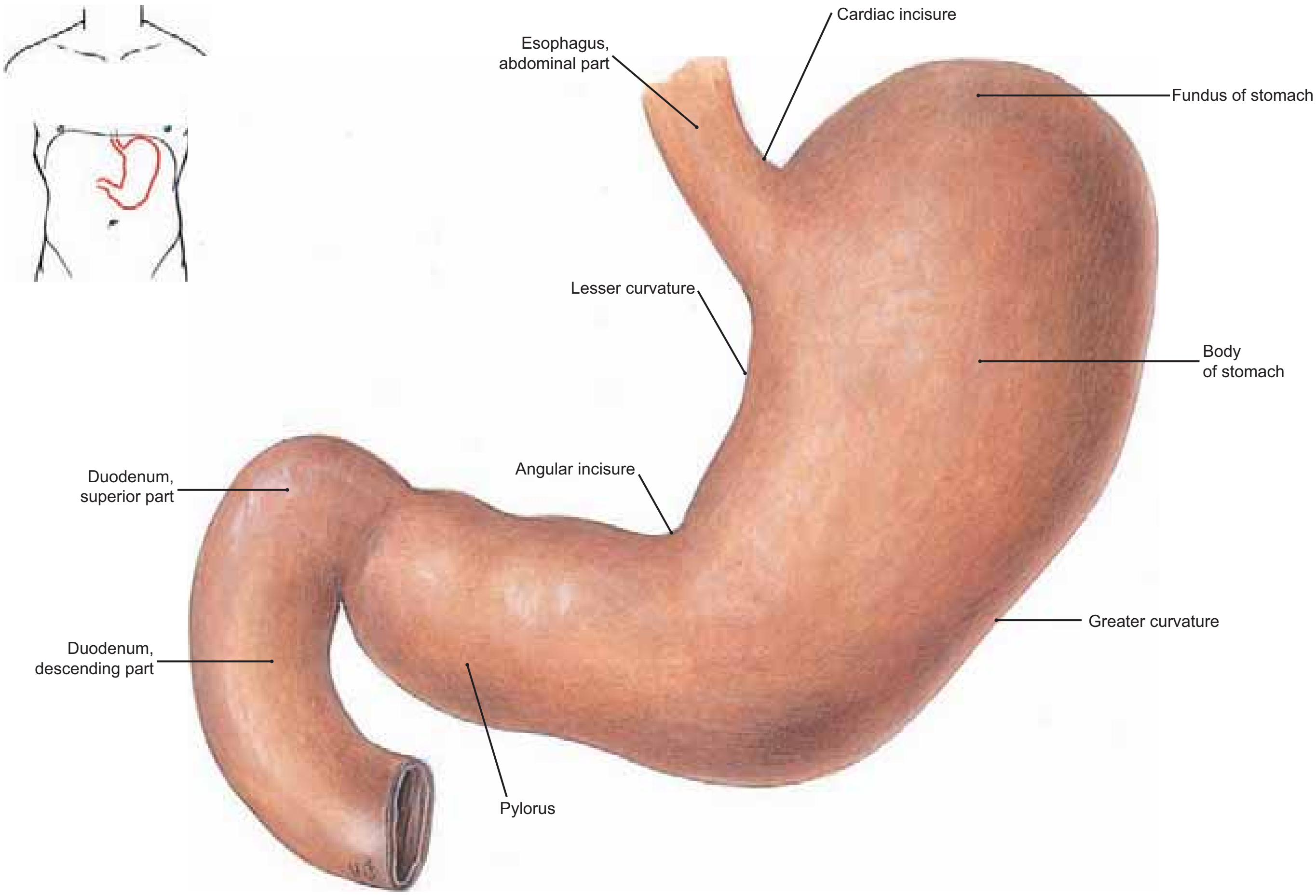


FIGURE 262.1 Anterior View of the Stomach and Its Junction with the Duodenum

NOTE the **cardiac incisure, greater and lesser curvatures, angular incisure,** and **pylorus.**

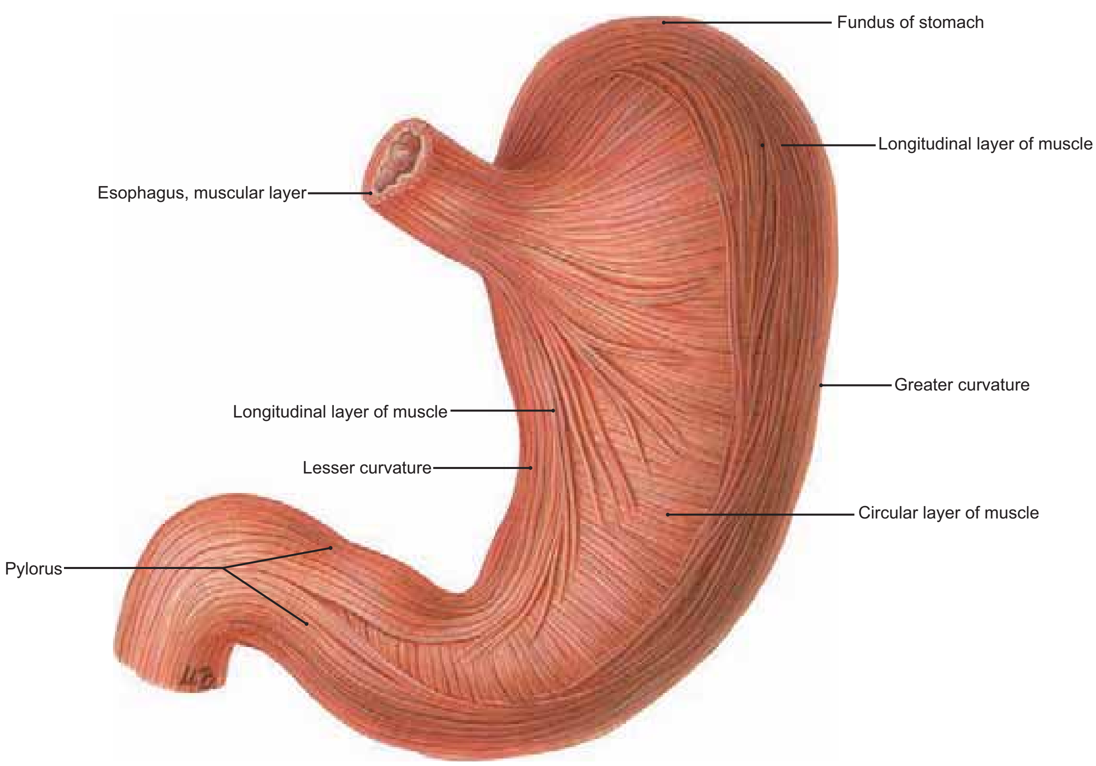


FIGURE 262.2 The External Muscular Layers of the Stomach

NOTE the longitudinal and circular muscle layers.

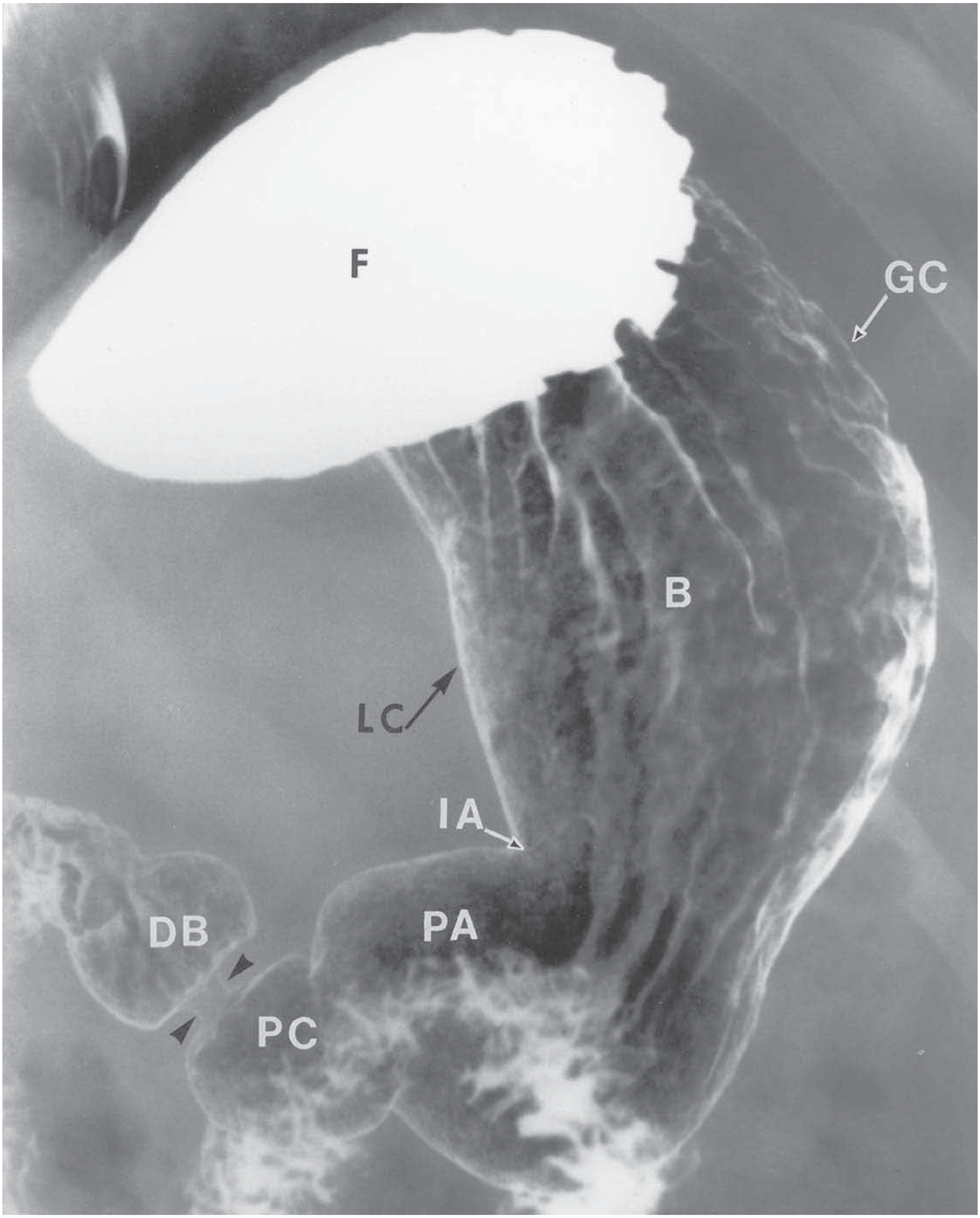


FIGURE 263 **X-Ray of the J-Shaped Stomach Showing Its Different Parts**

NOTE that the fundus is full of barium, explaining the solid white color. **F,** fundus; **GC,** greater curvature; **B,** body; **LC,** lesser curvature; **IA,** angular incisure; **PA,** pyloric antrum; **PC,** pyloric canal; **DB,** duodenal bulb.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

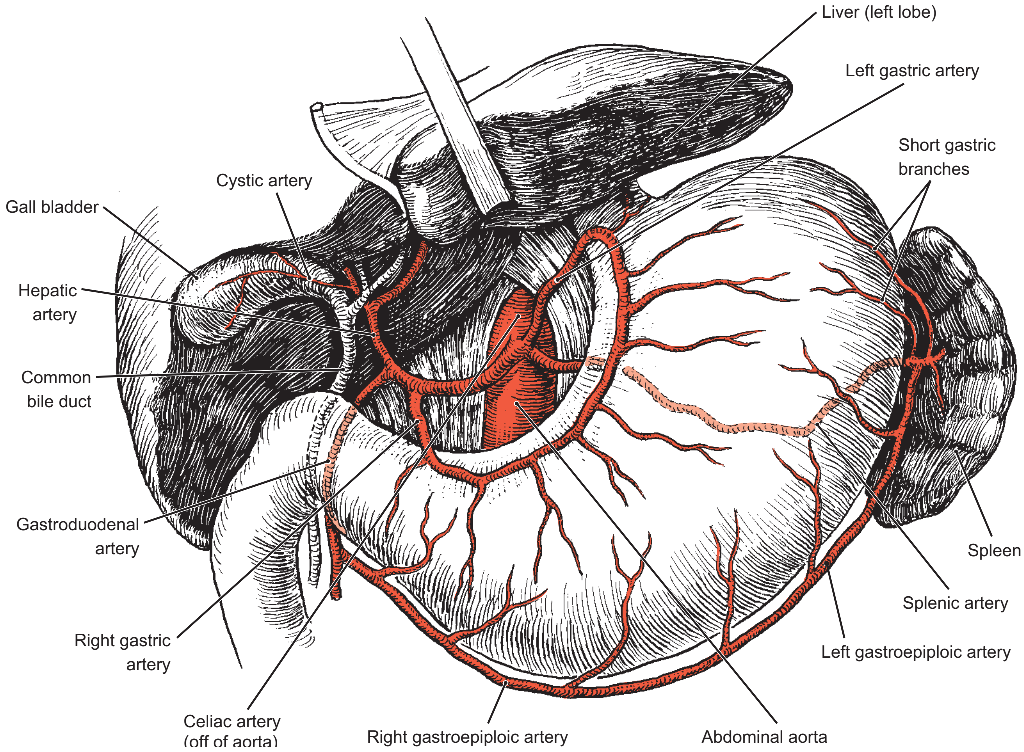


FIGURE 264.1 The Celiac Trunk (Artery) and Its Branches

NOTE: (1) The celiac trunk divides into the **splenic, left gastric,** and **hepatic arteries.**

(2) The **left** and **right gastric arteries** supply the lesser curvature of the stomach, while the **right** and **left gastroepiploic arteries** supply the greater curvature of the stomach.

(3) The **gastroduodenal artery** descends behind the duodenum and gives off the right gastroepiploic artery.

(From *Clemente's Anatomy Dissector,* 2nd Edition, Baltimore, Lippincott Williams & Wilkins, 2007.)

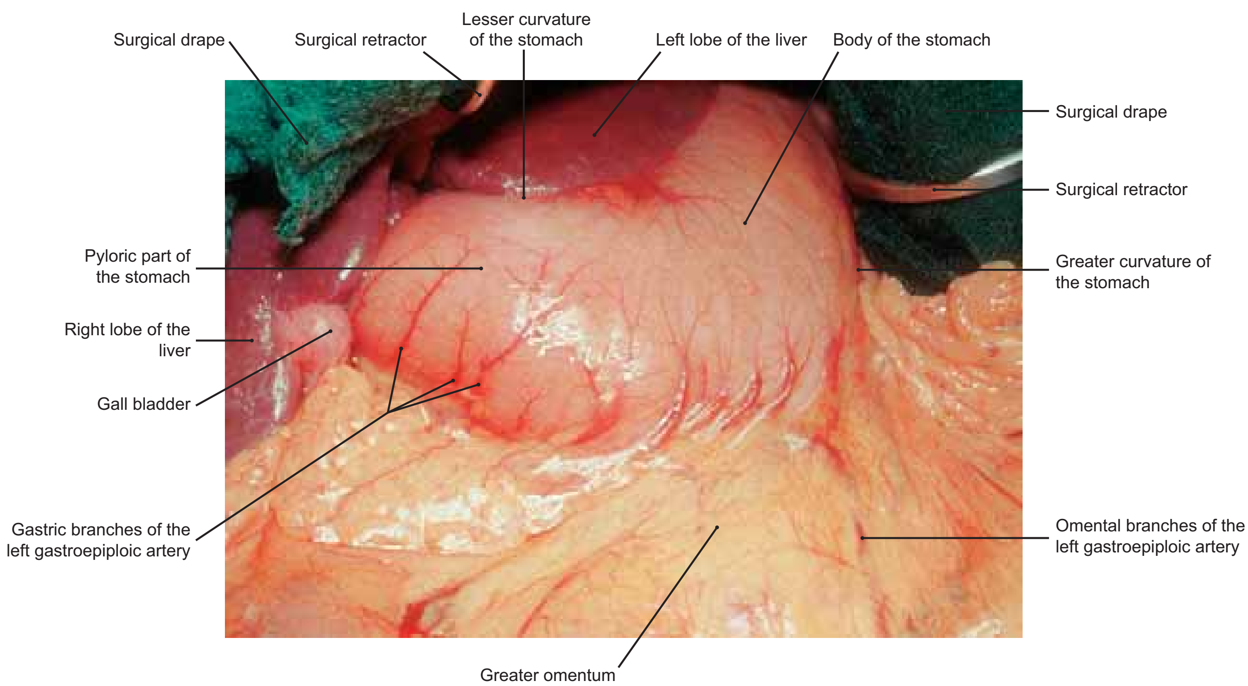


FIGURE 264.2 The Stomach and Greater Omentum

NOTE that the arteries supplying the stomach are gastric branches that ascend from the gastroepiploic arteries that course along the greater curvature.

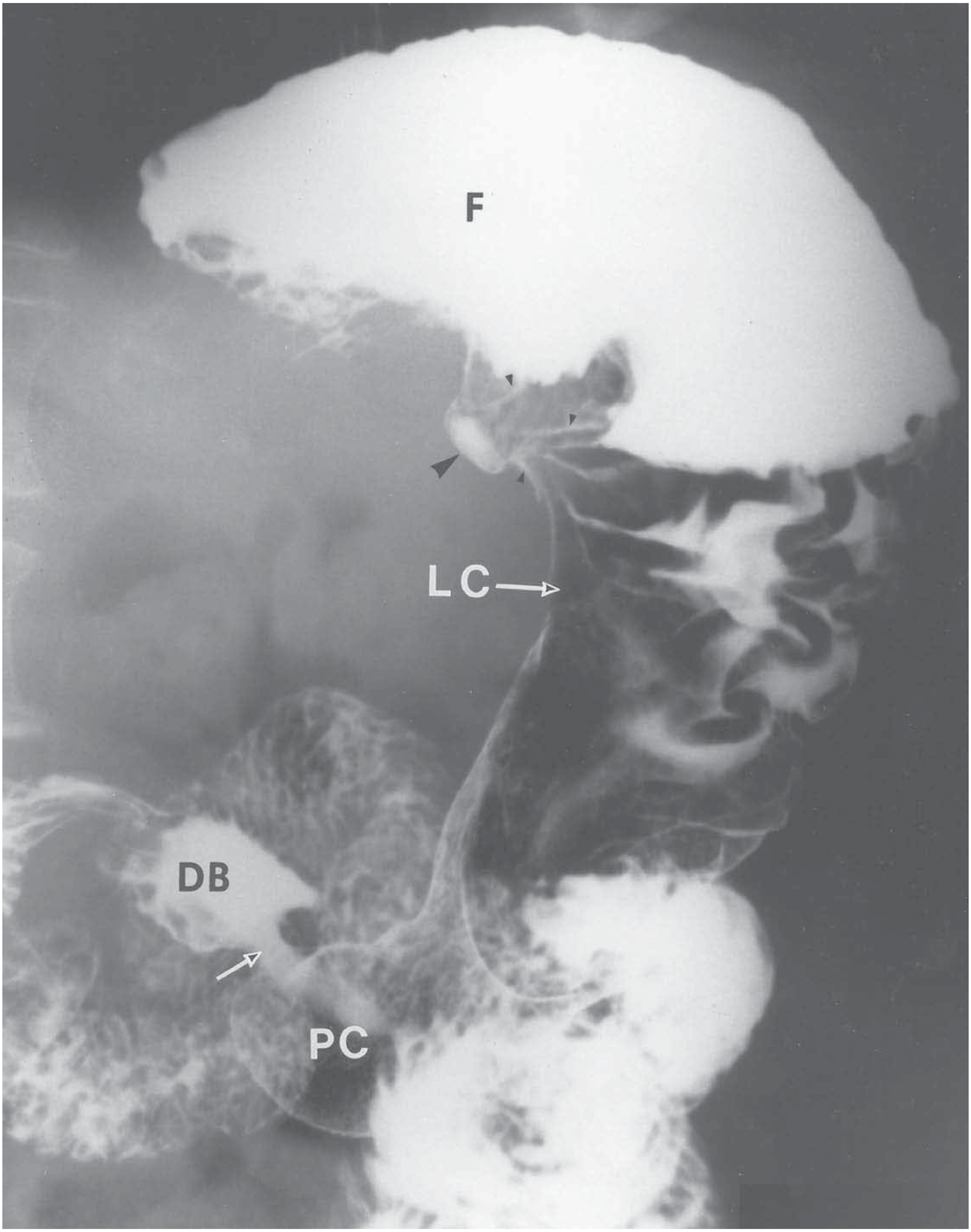


FIGURE 265 An X-Ray of the Stomach Showing a Small Ulcer

NOTE that a small ulcer (bold arrowhead) is located along the upper part of the lesser curvature (**LC**). Small arrowheads indicate the mucosal folds radiating from the ulcer center. The contrast medium has filled the fundus (**F**) and the pyloric canal (**PC**). The pyloric sphincter (arrow) separates the duodenal bulb **(DB)** from the pyloric canal (**PC**). Know that ulcers of the stomach are potentially malignant.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

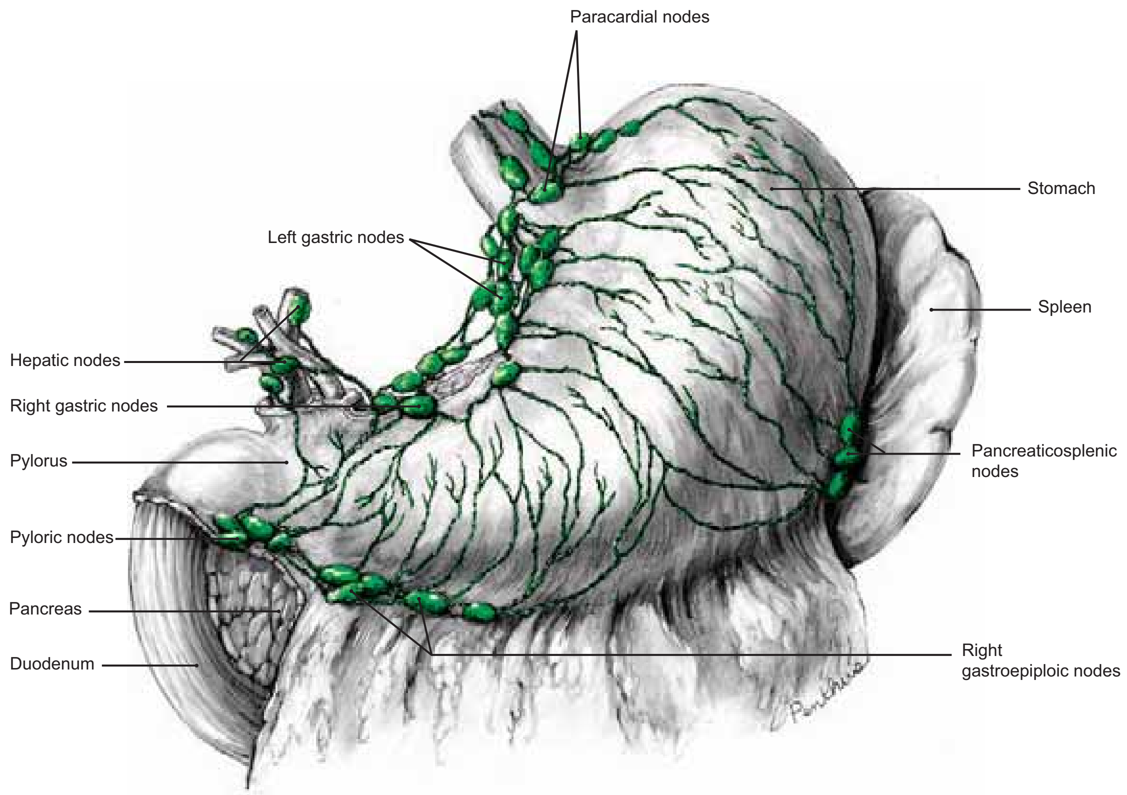


FIGURE 266.1 Lymphatic Vessels and Nodes of the Stomach

(From C.D. Clemente. *Gray's Anatomy,* 30th American Edition. Baltimore: Lea & Febiger, 1985.)

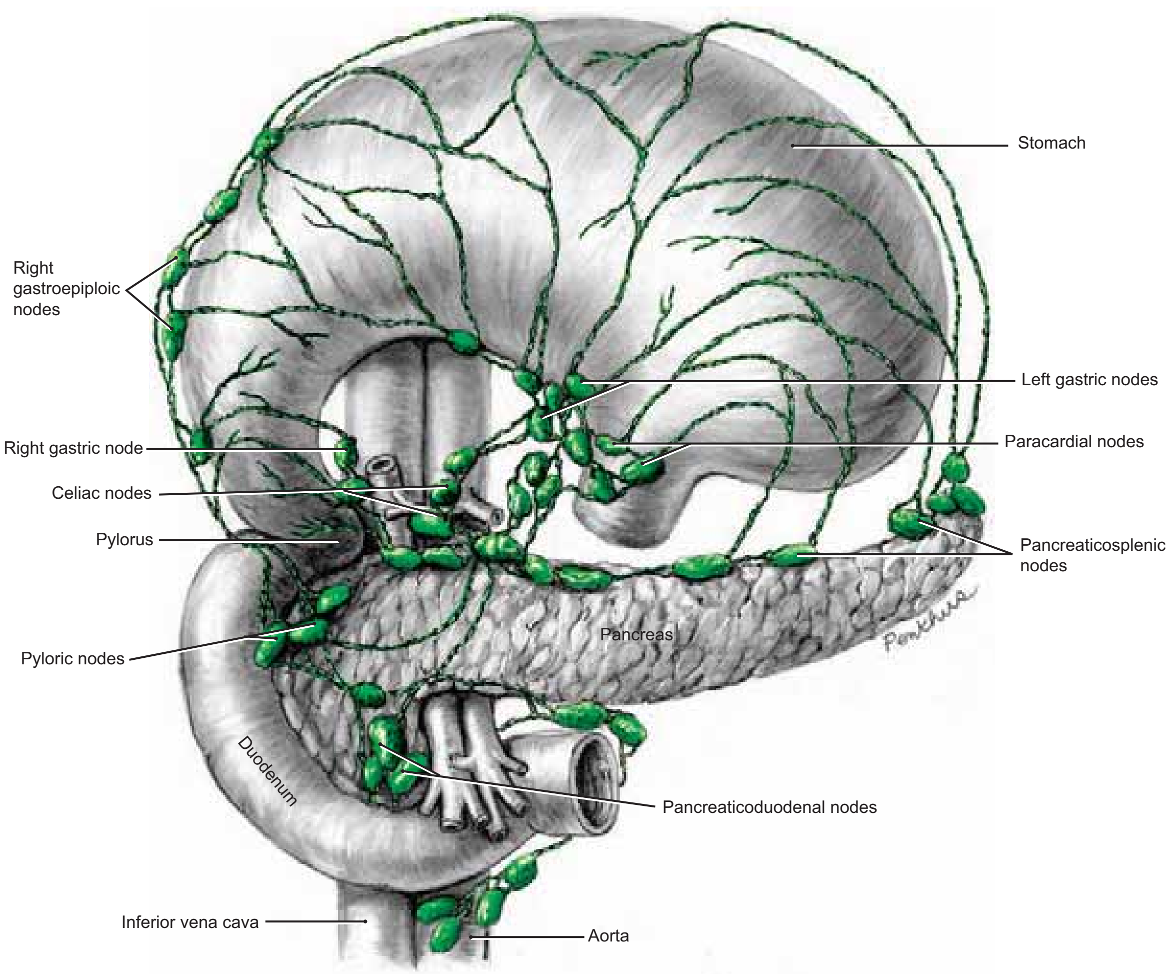


FIGURE 266.2 Lymphatic Vessels and Nodes of the Stomach, Pancreas, and Duodenum

(From C.D. Clemente. *Gray's Anatomy,* 30th American Edition. Baltimore: Lea & Febiger, 1985.)

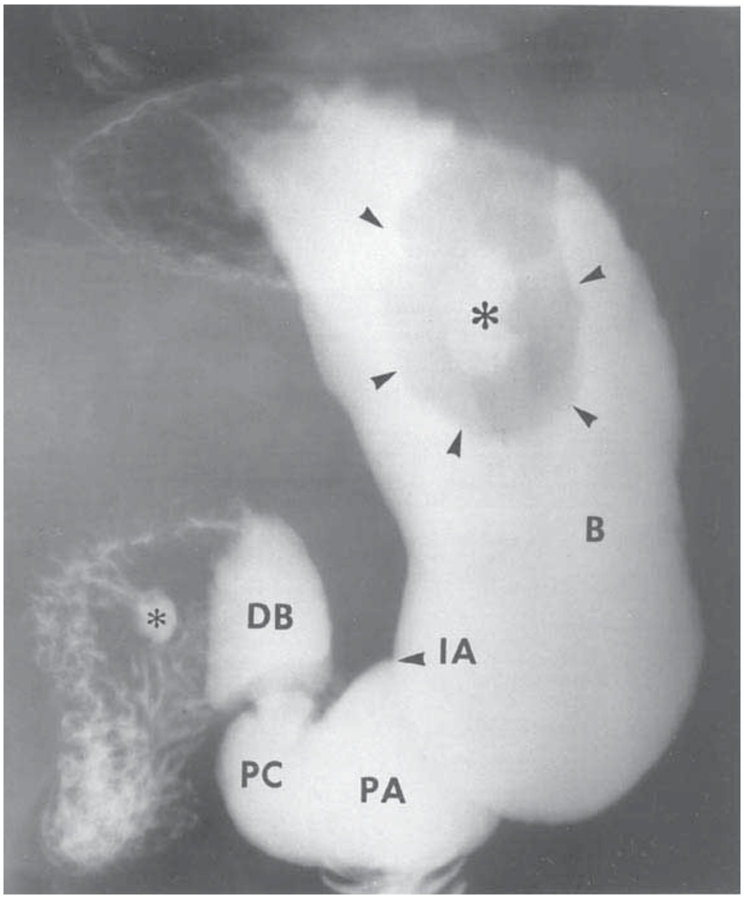


FIGURE 267.1 X-Ray of the Stomach Showing a Large Ulcer on the Posterior Wall

NOTE: (1) This is an X-ray of the stomach (filled with contrast medium) showing a large ulcer (outlined by arrows) on the posterior wall located at the junction of the fundus and body of the stomach. An asterisk indicates the central part of the ulcer.

(2) Perforations of ulcers on the posterior wall often allow stomach contents to enter the omental bursa. Since ulcers of the stomach have a greater propensity to become malignant, they are treated more aggressively and with greater care.

(3) A small diverticulum (small asterisk) filled with contrast medium is seen in the ascending part of the duodenum.

B, body of stomach; **PA,** pyloric antrum; **PC,** pyloric canal; **DB,** duodenal bulb; **IA,** angular incisure.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

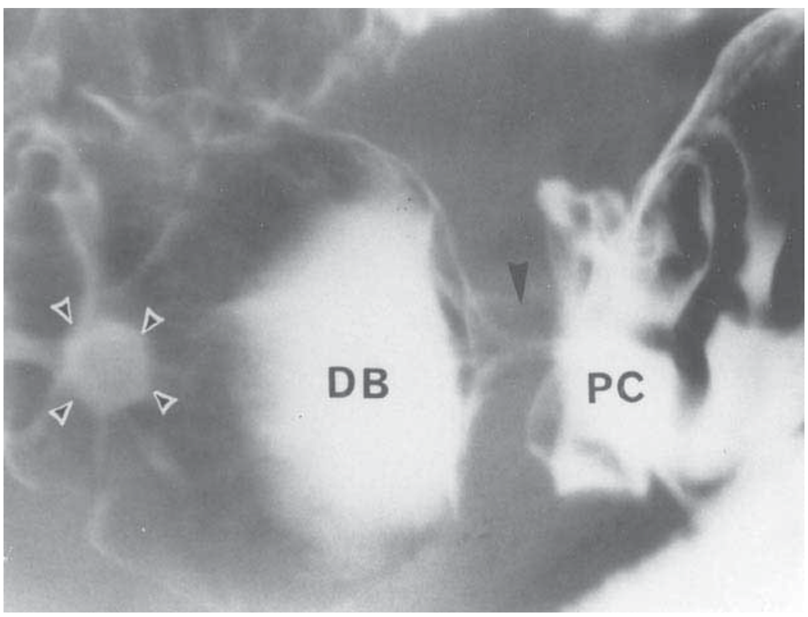


FIGURE 267.2 X-Ray of the Pyloroduodenal Junction Showing a Duodenal Ulcer

NOTE: (1) The anatomy of the pyloroduodenal junction is shown in this X-ray. The pyloric sphincter (black arrowhead) marks the junction of the pyloric canal (**PC**) with the duodenal bulb (**DB**). Observe that a duodenal ulcer is outlined by the white arrowheads.

(2) Duodenal ulcers are generally benign and, hence, treated conservatively or less aggressively. The pyloric sphincter is located at the narrow site between the pyloric canal and the duodenal bulb.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

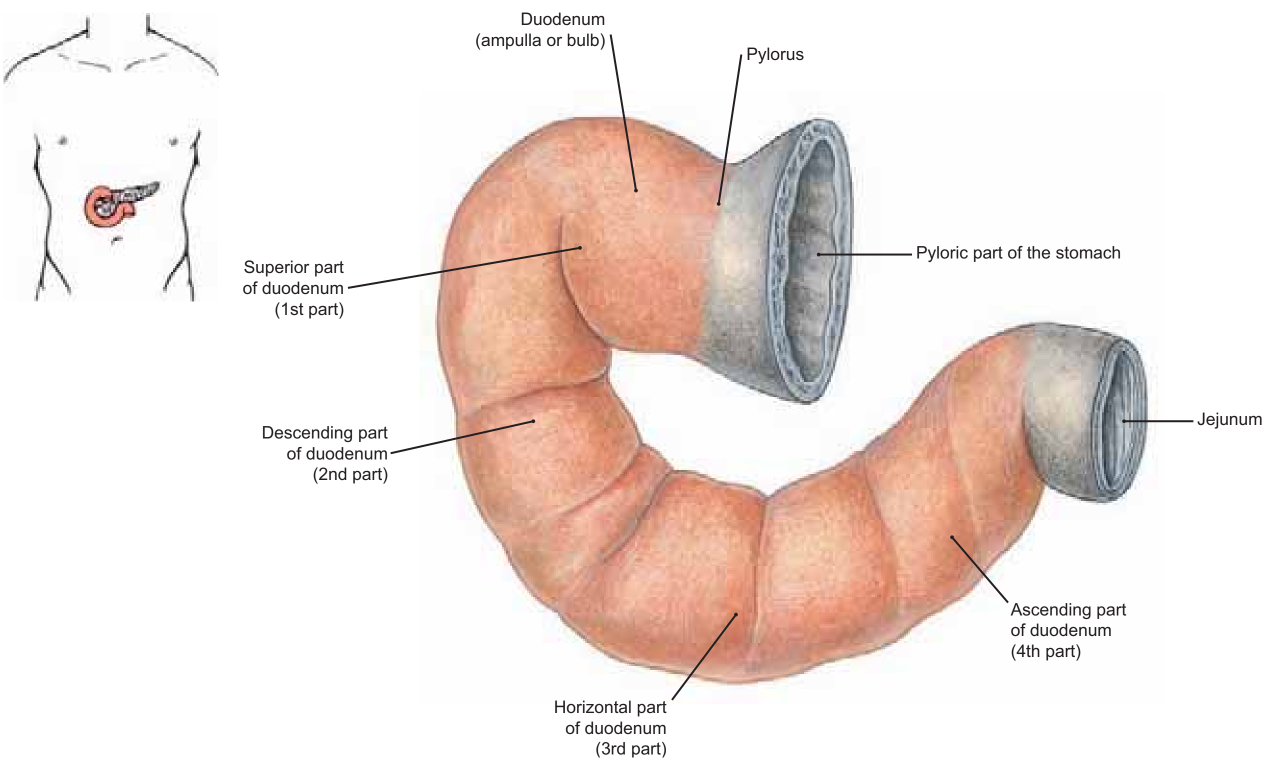


FIGURE 268.1 The Duodenum: Anterior View

NOTE the superior (1st part), descending (2nd part), transverse (3rd part), and ascending (4th part) parts of the duodenum. The duodenum is 10 in. in length (25 cm) and leads into the jejunum.

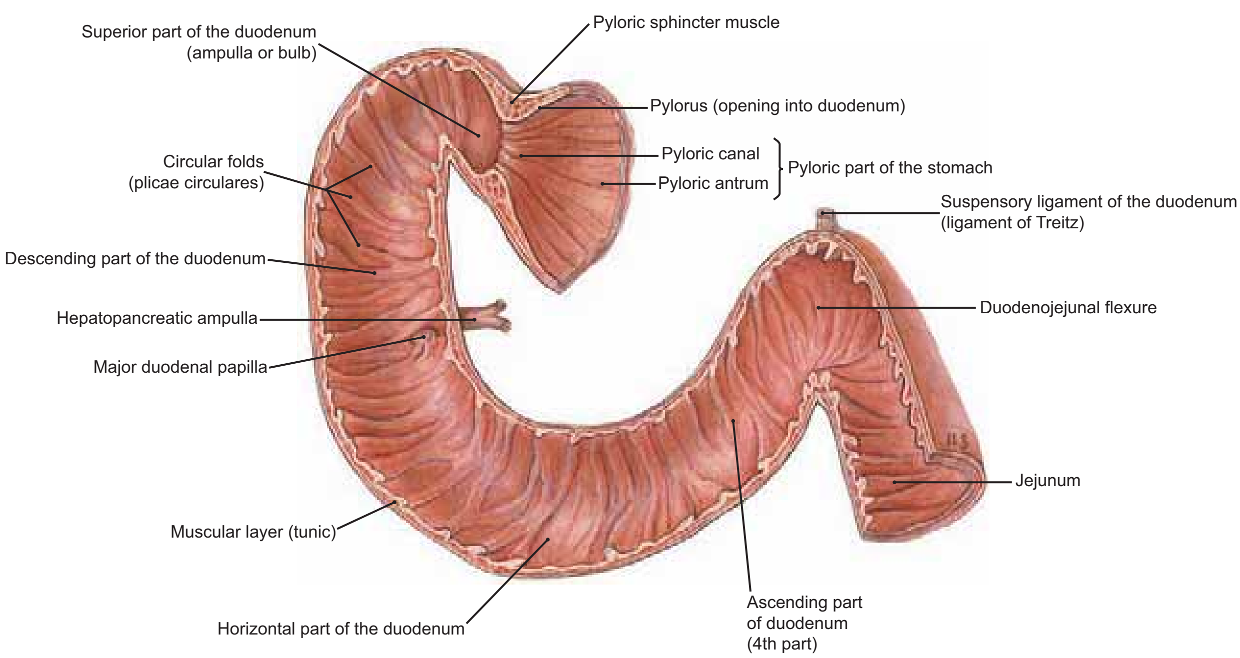


FIGURE 268.2 Longitudinal Section of the Duodenum

NOTE: (1) The **major hepatopancreatic ampulla** and **papilla** (opening) where the combined common bile duct and pancreatic duct open into the duodenum.

(2) The **minor pancreatic ampulla** and **papilla** (not shown in this figure) open about 2 cm proximal to the major ampulla and papilla. It is the site where the accessory pancreatic duct opens into the duodenum.

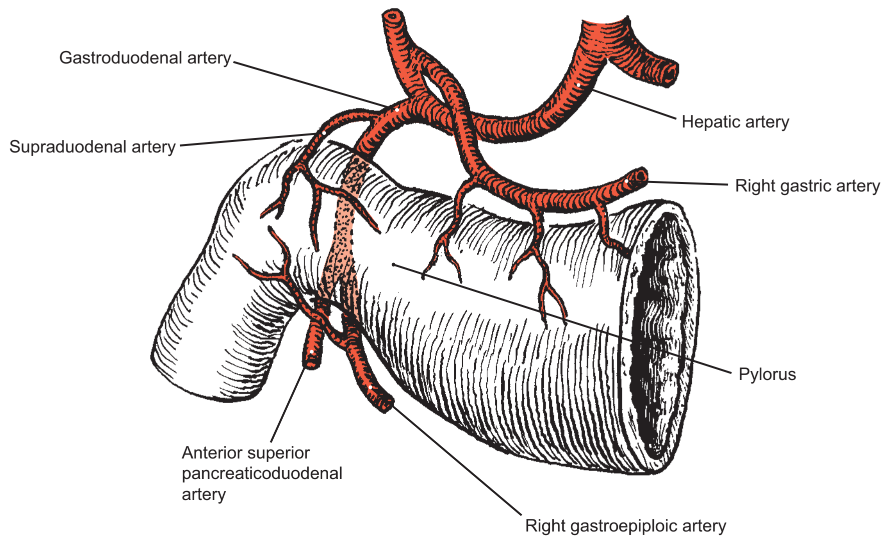


FIGURE 269.1 Arteries to the Pyloric-Duodenal Region (Anterior View)

NOTE the **gastroduodenal artery** and its **supraduodenal branch.**

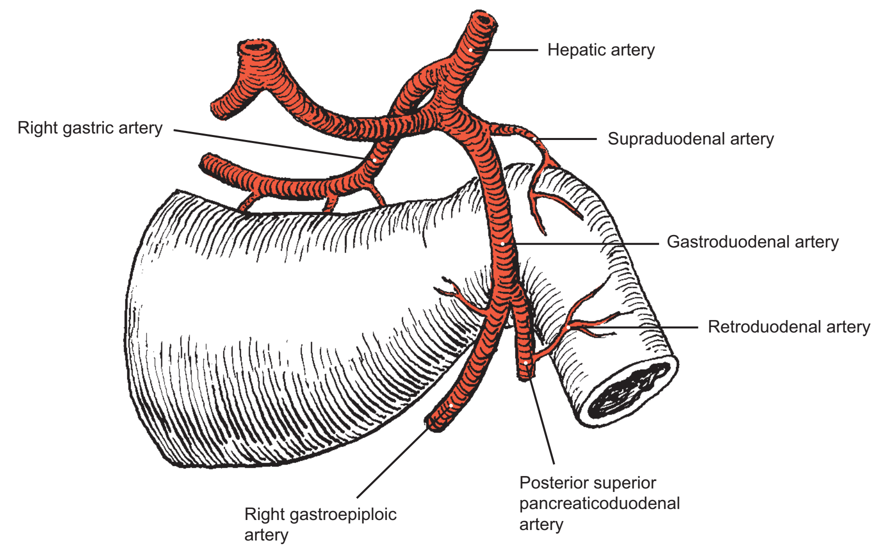


FIGURE 269.2 Arteries to the Pyloric-Duodenal Region (Posterior View)

NOTE the **gastroduodenal artery.** Also see its **supraduodenal** and **retroduodenal branches.**

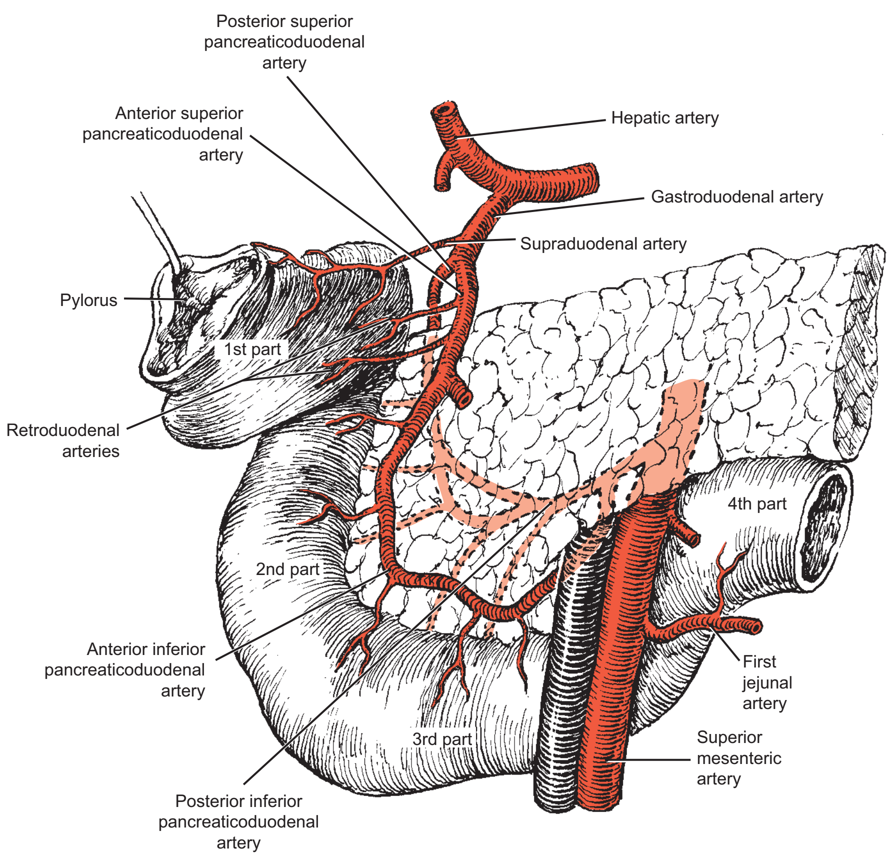


FIGURE 269.3 Gastroduodenal Artery and Its Pancreaticoduodenal Branch

NOTE the superior mesenteric artery and vein. In persons who lose a lot of weight quickly, these vessels can obstruct the third part of the duodenum, giving rise to the **superior mesenteric syndrome.**

(From *Clemente's Anatomy Dissector,* 2nd Edition. Baltimore: Lippincott Williams & Wilkins, 2007.)

FIGURE 270.1 Surface Projection of the Liver during the Midrespiratory Phase

NOTE: (1) The position of the healthy liver is related to the various phases of the respiratory cycle. This figure demonstrates the position of the liver between inspiration and expiration (midrespiratory phase).

(2) During inspiration, the diaphragm descends and pushes the liver inferiorly. During expiration, the diaphragm elevates and with it also the liver. The dome of the right lobe of the liver during expiration rises to the level of the right fifth rib.

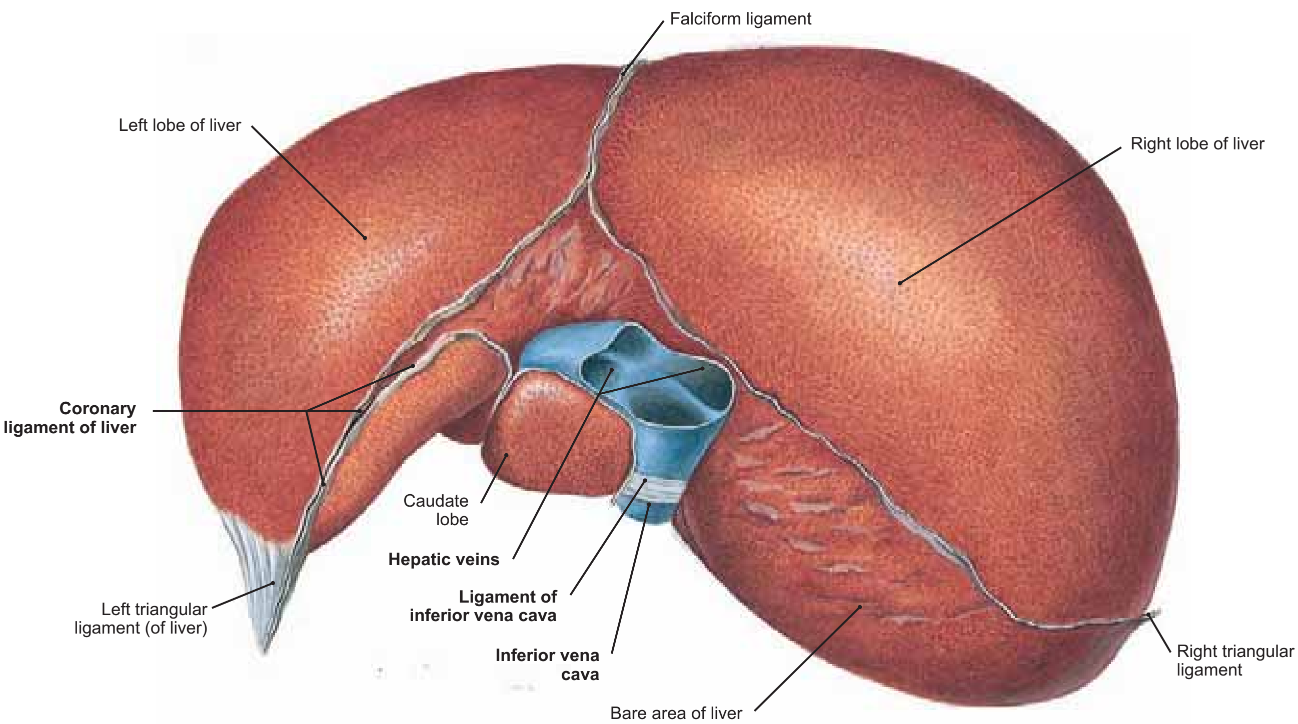


FIGURE 270.2 Dorsocranial View of the Liver

NOTE: (1) The visceral peritoneum closely adheres to the surface of the liver and is called the **coronary ligament.** Between its two leaves a portion of the liver, called the **bare area,** is devoid of peritoneum and is in contact with the abdominal surface of the diaphragm.

(2) The **hepatic veins** converge superiorly to empty into the superior vena cava.

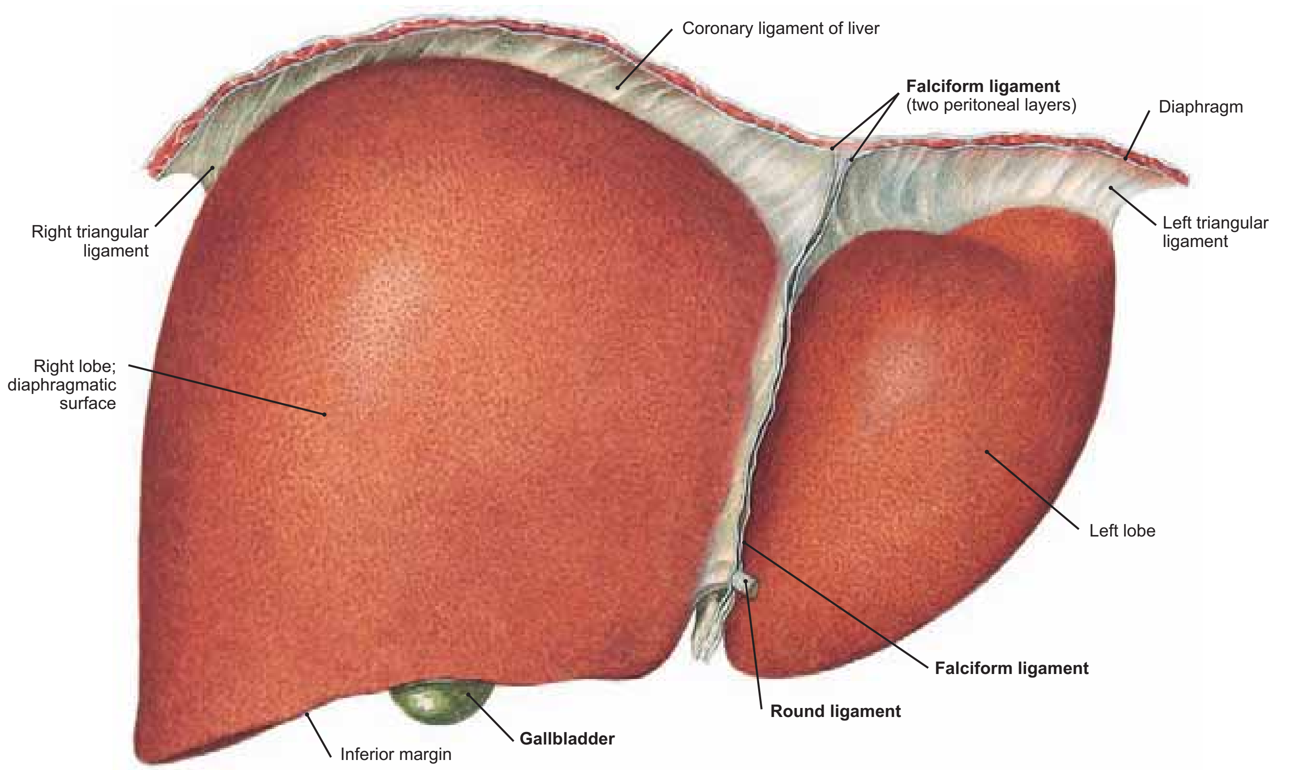


FIGURE 271.1 Anterior Surface of the Liver (with Diaphragmatic Attachment)

NOTE: The **falciform ligament** separates the right and left lobes of the liver. It contains a fibrous cord, the **round ligament of the liver,** which was the **umbilical vein** during fetal life. Also observe the fundus of the gall bladder below the inferior margin of the liver.

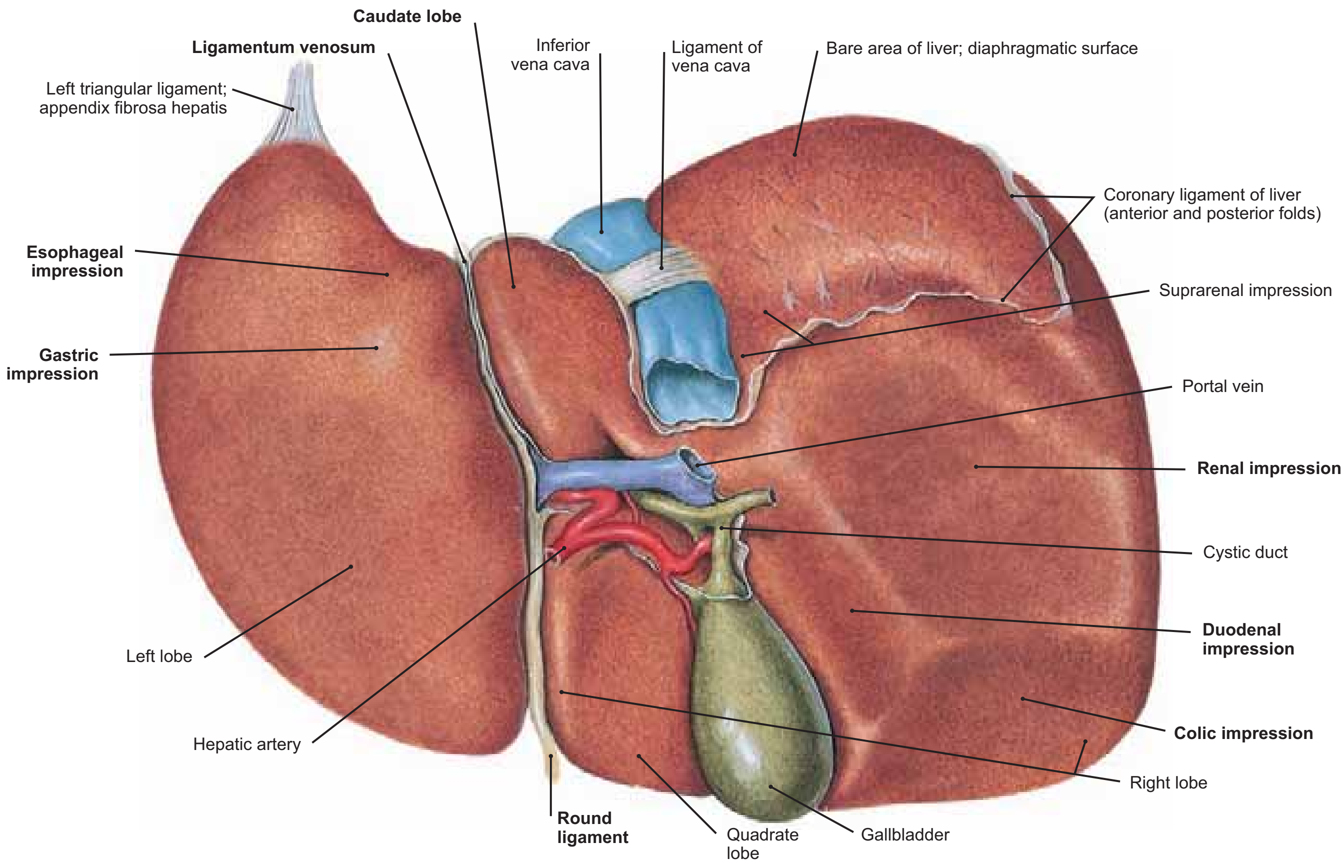


FIGURE 271.2 Posterior (Visceral) Surface of the Liver and the Gallbladder

NOTE the impressions made by the abdominal organs on the ventral surface of the liver, and the inferior vena cava, which separates the **caudate** and **right lobes.** The gallbladder, portal vein, hepatic artery, and common bile duct bound the **quadrate lobe,** and the **ligamentum venosus** (ductus venosus) extends from the round ligament (umbilical vein).

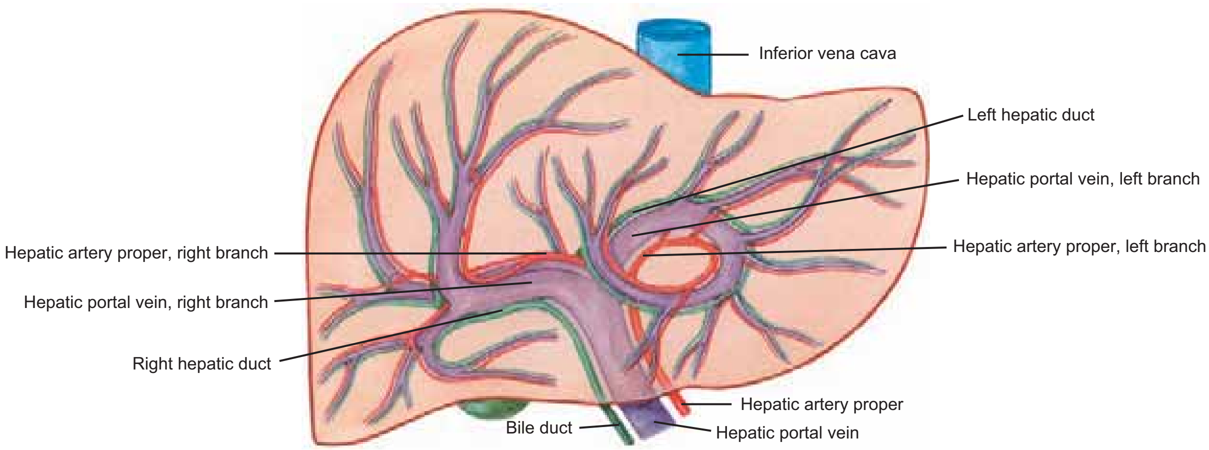


FIGURE 272.1 **Branching of the Portal Vein, Hepatic Artery, and Bile Duct**

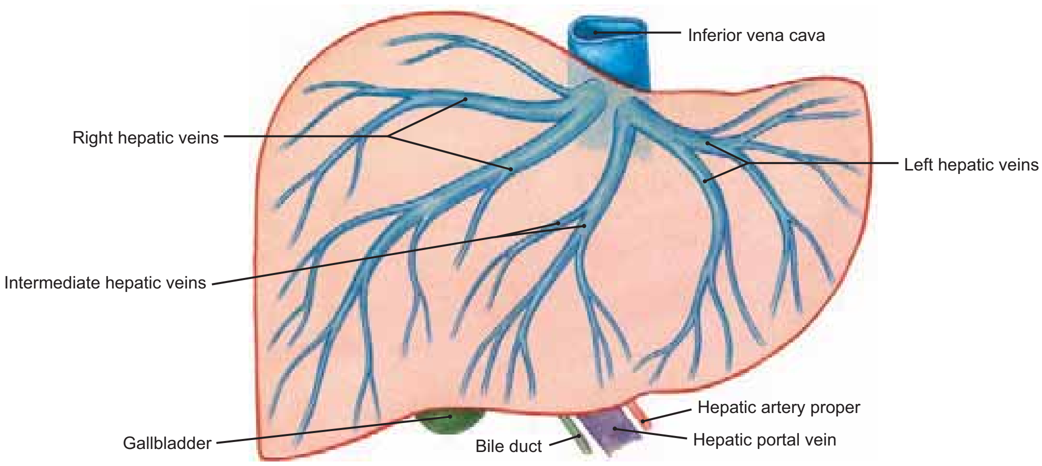


FIGURE 272.2 **Draining Pattern of the Hepatic Veins**

FIGURES 272.1 and 272.2 Branching Patterns of the Portal Vein, Hepatic Artery, and Tributaries of the Hepatic Vein

NOTE: (1) The portal vein and hepatic artery branch in such a way that segmental regions of the liver that receive their own arterial and venous branches.

(2) The portal vein and hepatic artery and veins divide the organ functionally and anatomically into a right and a left liver.

(3) The branching of these vessels forms the basis of the segmental anatomy of the liver, which is extremely important surgically, since they allow segmental resection of the liver when appropriate.

(4) The portal vein initially divides into right and left branches, as does the hepatic artery. The main fissure of this division is along a line that "passes from the tip of the gallbladder to the site where the falciform ligament disappears posteriorly." (From Launois B and Jamieson GG (eds). Surgical anatomy of the liver and associated structures. In: Modern operative techniques in liver surgery. Edinburgh: Churchill Livingstone, 1993.)

(5) There are eight liver **segments.** The right and left livers each divides into sectors that then divide into segments (four on the left and four on the right). Each segment receives a branch of the portal vein and the hepatic artery and drains into its own segmental hepatic vein.

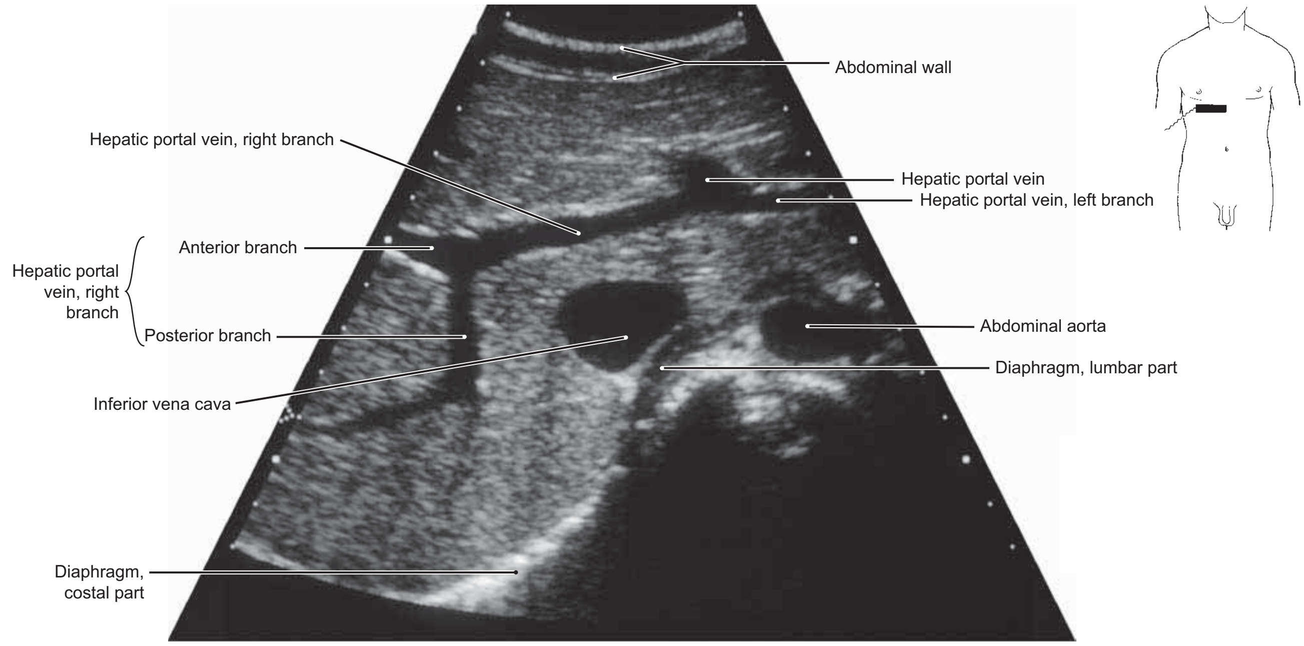


FIGURE 273.1 **Ultrasound of Openings of the Hepatic Veins into the Inferior Vena Cava (Inferior Aspect)**

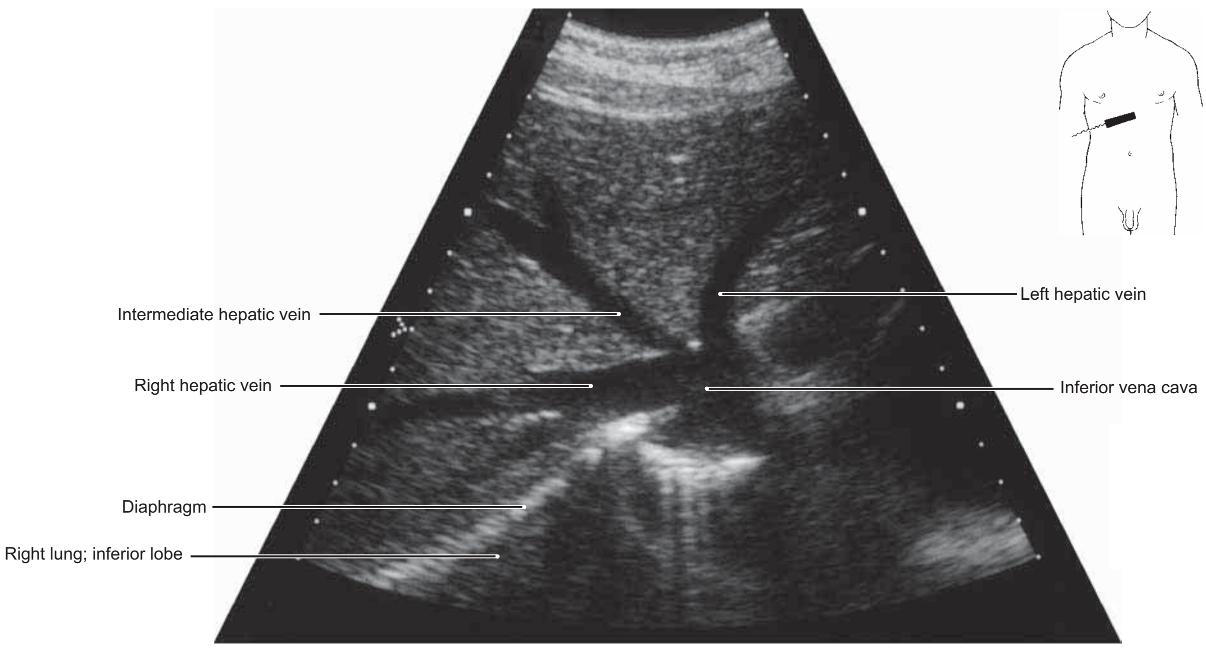


FIGURE 273.2 **Ultrasound of the Portal Vein and Its Division into Right and Left Branches**

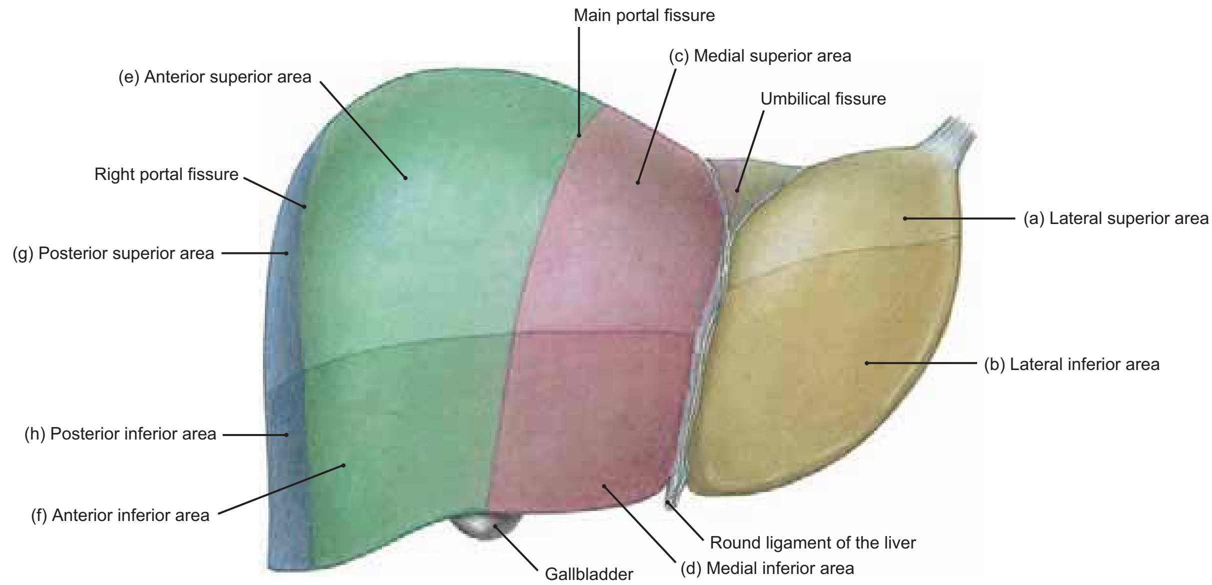


FIGURE 274.1 Segments of the Liver: Anterior (Diaphragmatic) Surface

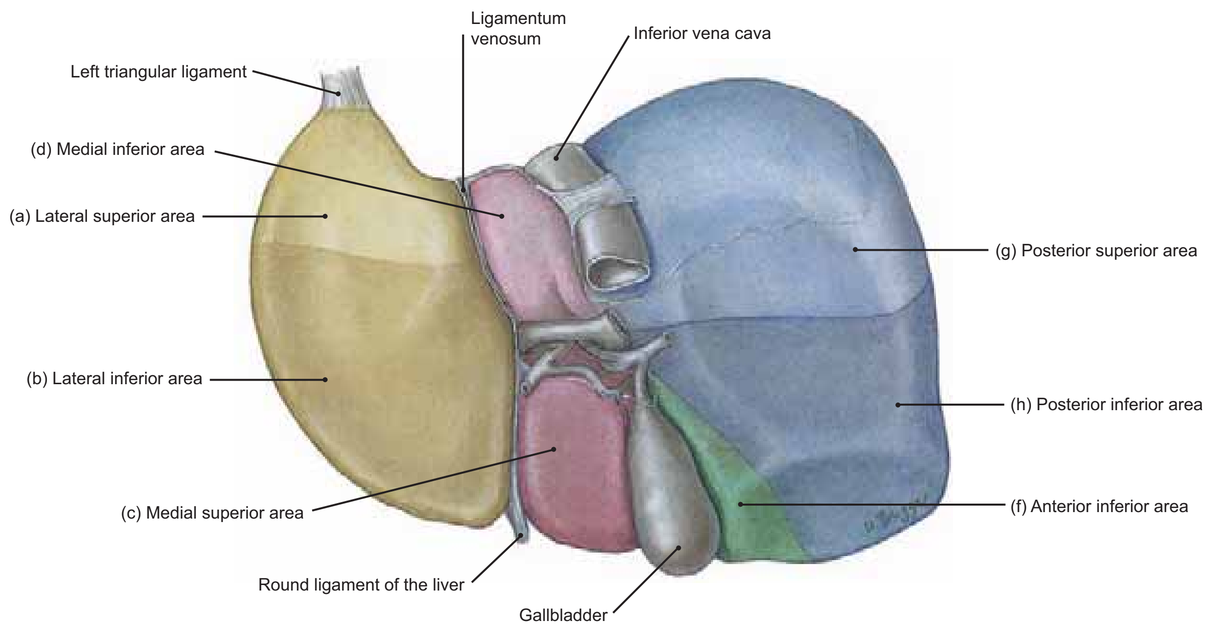


FIGURE 274.2 Segments of the Liver: Posterior (Visceral) Surface

NOTE: (1) Topographically, there are four lobes of the liver: the right and left lobes (separated by the falciform ligament) and the **caudate** and **quadrate** lobes (best seen on the visceral surface).

(2) The caudate lobe is located between the **ligamentum venosum** and the **inferior vena cava** and the quadrate lobe lies between the **gallbladder** and the **round ligament of the liver** (see Fig. 271.2).

(3) Of considerable surgical importance is the division of the liver into **hepatic divisions and segments.** These have been determined in relationship to the divisions of the hepatic artery and the accompanying branching of the hepatic ducts and portal vein.

(4) There are **four hepatic divisions: anterior, posterior, medial,** and **lateral**. Each of these is divided into **superior** and **inferior areas,** making a total of **eight hepatic segments:**

(a) Lateral superior segment
(b) Lateral inferior segment
(c) Medial superior segment
(d) Medial inferior segment
(e) Anterior superior segment
(f) Anterior inferior segment
(g) Posterior superior segment
(h) Posterior inferior segment

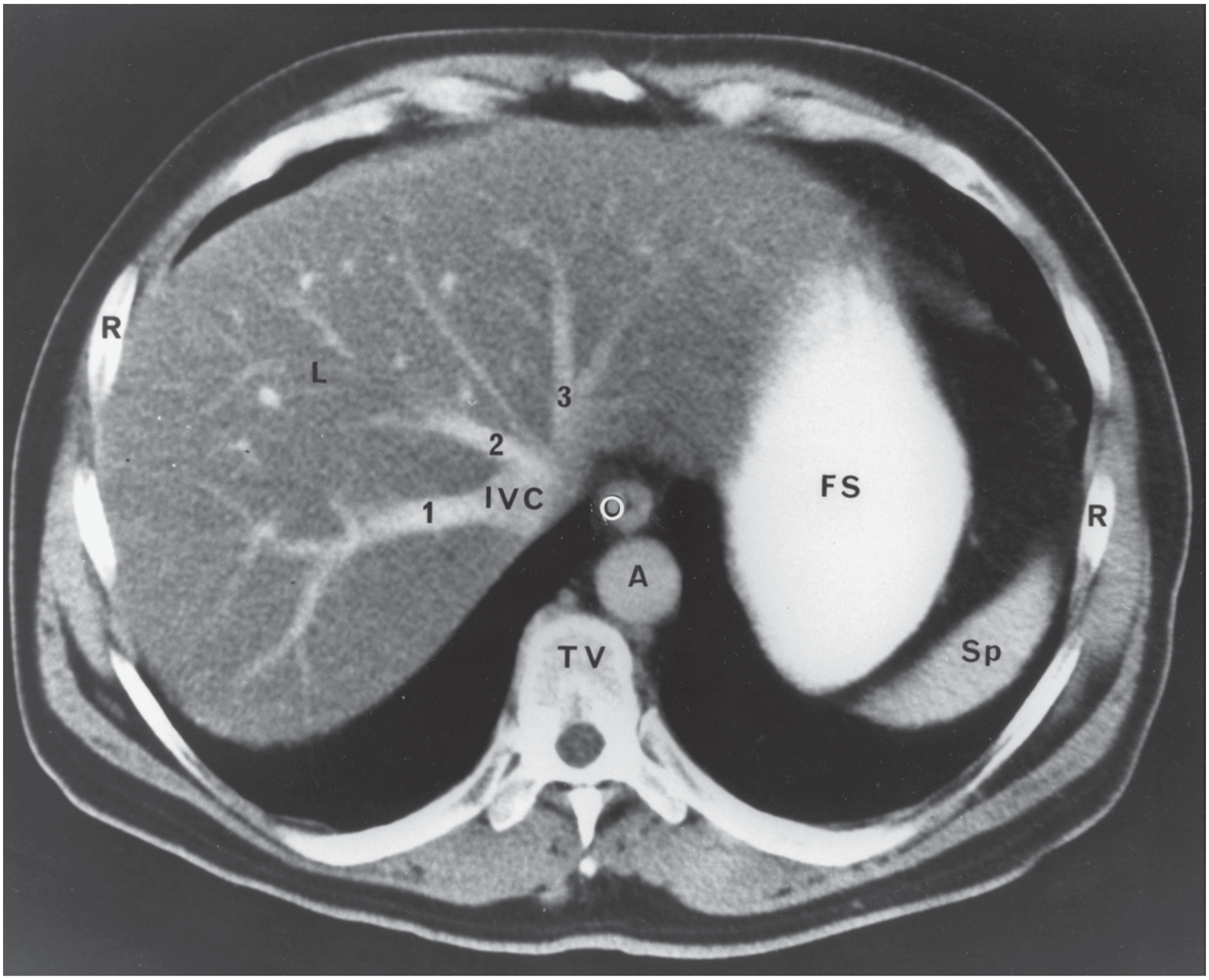


FIGURE 275.1 CT of the Upper Abdomen at Thoracic Level T10–T11

NOTE: (1) Three hepatic veins, labeled **1, 2,** and **3,** are draining blood from the **right lobe,** intermediate region (**caudate** and **quadrate lobes**), and the **left lobe** into the inferior vena cava (**IVC**).

(2) The distribution of hepatic veins provides lines of segmental demarcation for the abdominal surgeon performing hepatic resection. Observe that the fundus of the stomach (**FS**), which is filled with contract medium, and the spleen (**Sp**) are seen.

L, liver; **A,** aorta; **O,** esophagus; **TV,** thoracic vertebra (T10); **R,** ribs.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

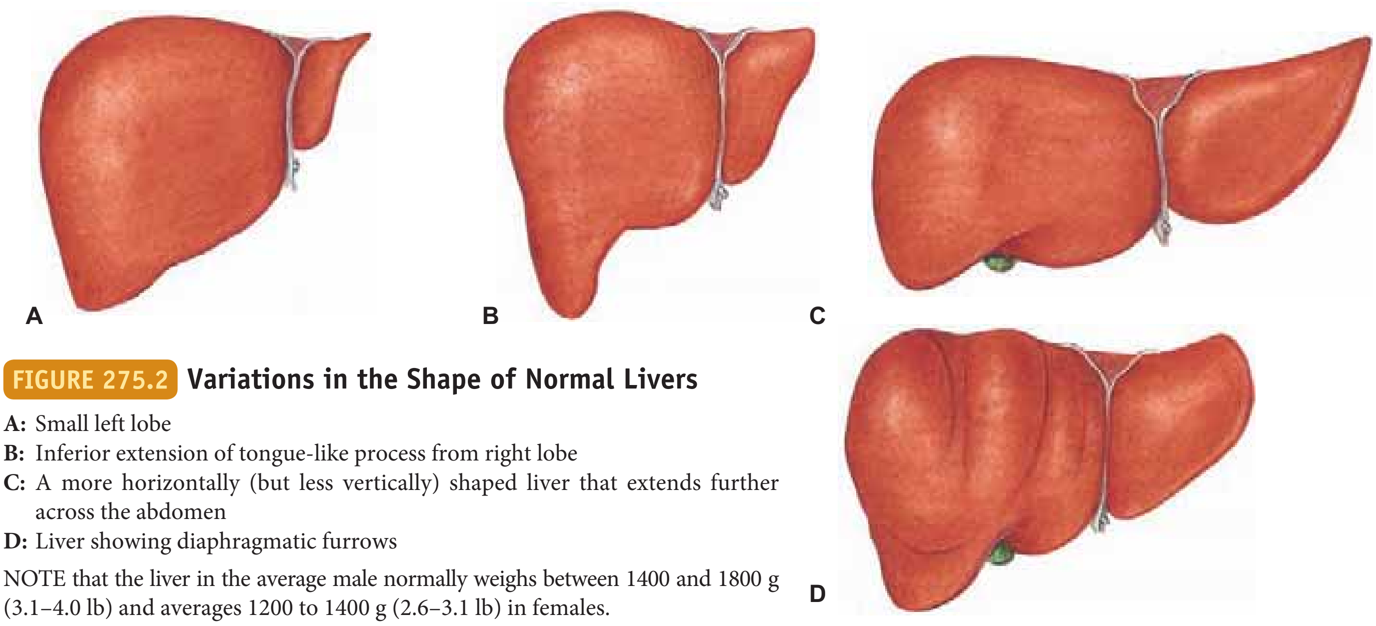


FIGURE 275.2 Variations in the Shape of Normal Livers

A: Small left lobe
B: Inferior extension of tongue-like process from right lobe
C: A more horizontally (but less vertically) shaped liver that extends further across the abdomen
D: Liver showing diaphragmatic furrows

NOTE that the liver in the average male normally weighs between 1400 and 1800 g (3.1–4.0 lb) and averages 1200 to 1400 g (2.6–3.1 lb) in females.

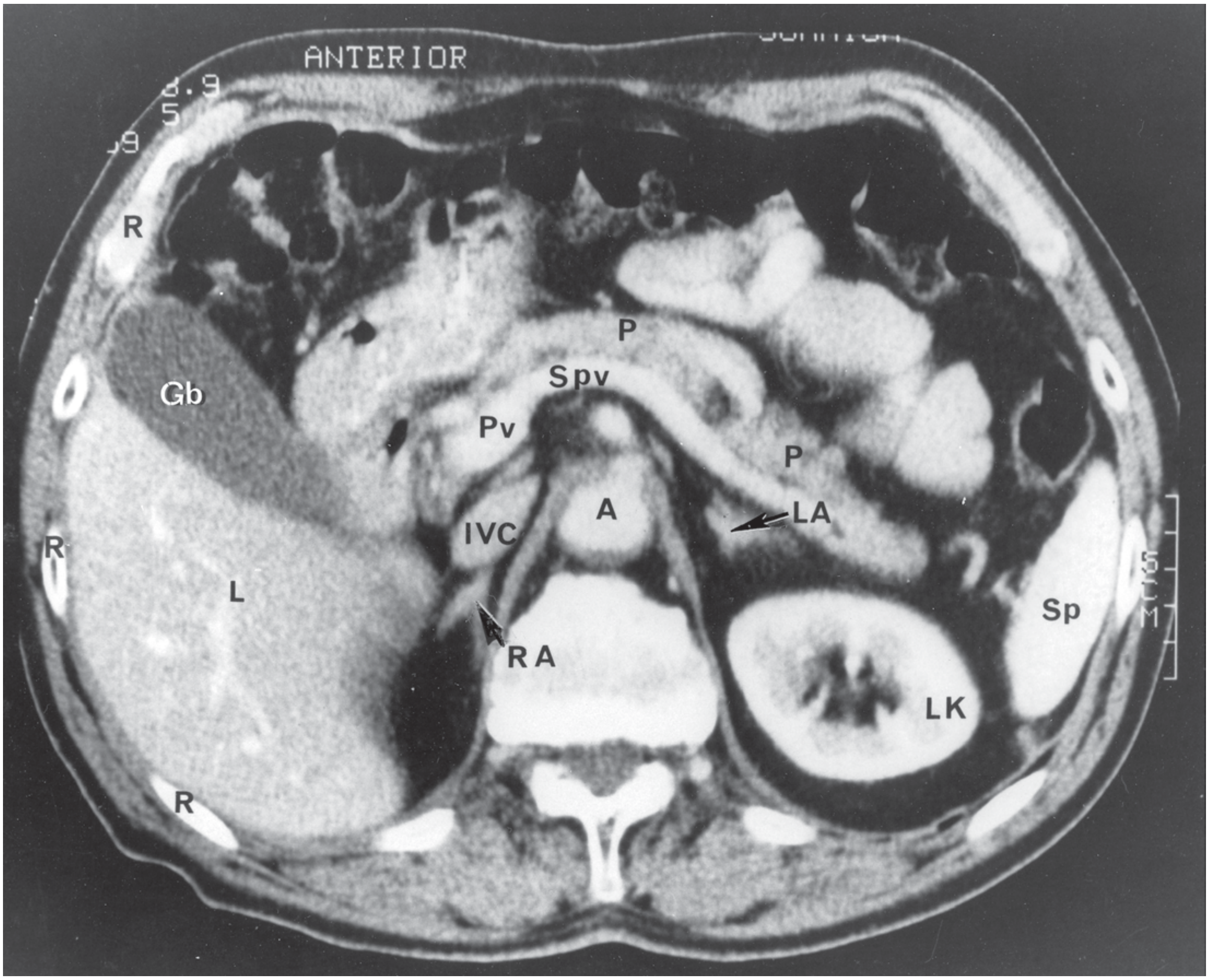


FIGURE 276 CT of the Upper Abdomen Showing the Organs at the Level of About L1

NOTE: (1) The splenic vein (**Spv**) flowing into the portal vein (**Pv**). Note also the aorta (**A**), the inferior vena cava (**IVC**), the right adrenal (suprarenal) gland (**RA**), and the left adrenal gland (**LA**); **see arrows.**

(2) The pancreas (**P**) is oriented across the abdomen and is directed toward the hilum of the spleen (**Sp**). Observe the gallbladder (**Gb**), the liver (**L**), the left kidney (**LK**), and the ribs (**R**).

(3) The aorta (**A**) anterior to the body of the vertebra and, to its right side, the inferior vena cava (**IVC**). Observe the bony rib cage affording protection for these important organs.

L, Liver; **P,** Pancreas; **IVC,** Inferior Vena Cava; **Gb,** Gall bladder; **LK,** Left Kidney; **A,** Aorta; **RA,** Right Adrenal (Suprarenal) Gland; **SpV,** Splenic Vein; **R,** Ribs; **LA,** Left Adrenal Gland; **Sp,** Spleen; **PR,** Portal Vein.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

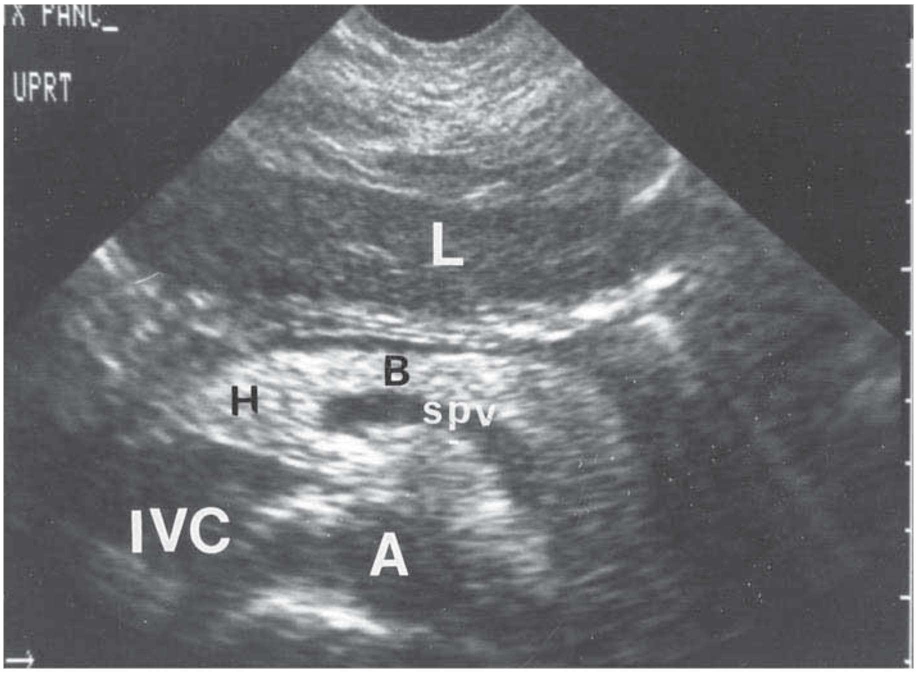


FIGURE 277.1 Transverse Ultrasound of the Upper Abdomen

NOTE that the normal pancreas is seen with splenic vein (**spv**) located just posterior to the pancreatic head (**H**) and pancreatic body (**B**) and is seen as a curved dark structure. Observe the locations of the aorta (**A**) and the inferior vena cava (**IVC**).

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

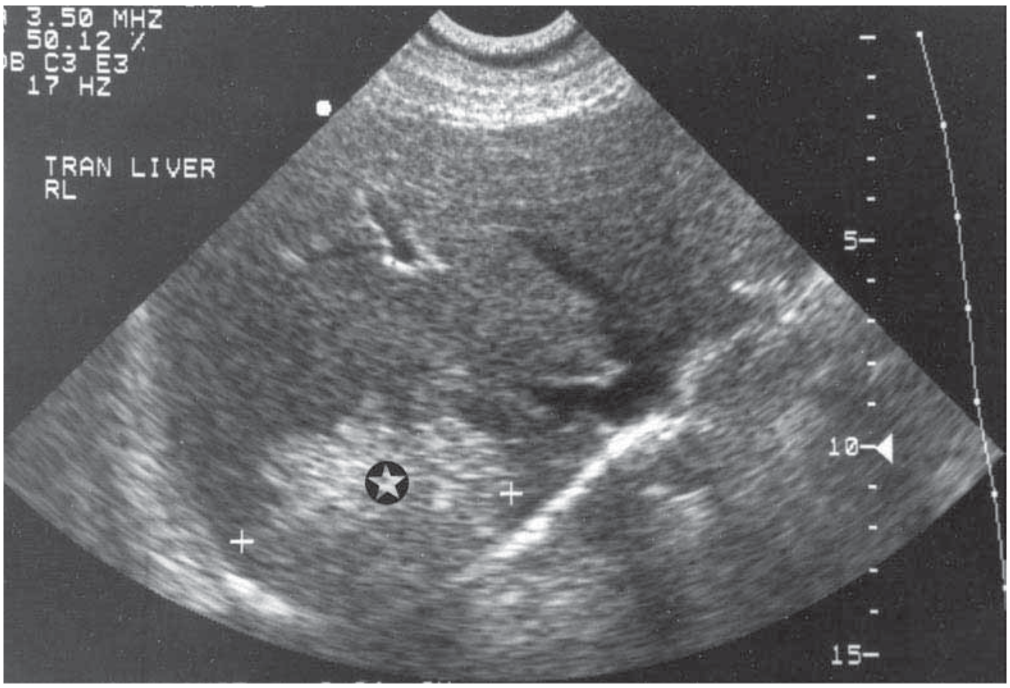


FIGURE 277.2 Transverse Ultrasound of Abdomen Showing a Tumor Mass in the Liver

NOTE that the tumor in this figure (**asterisk, star**), which measures 6.8 cm (indicated by the electronic calipers), is a metastatic mass, which in this patient, is secondary to a primary cancer in the transverse colon. The liver is a common site for metastases from cancers in the abdominal organs since the portal vein and hepatic veins have a capillary anastomosis system where metastatic cells can become attached and then continue to divide.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

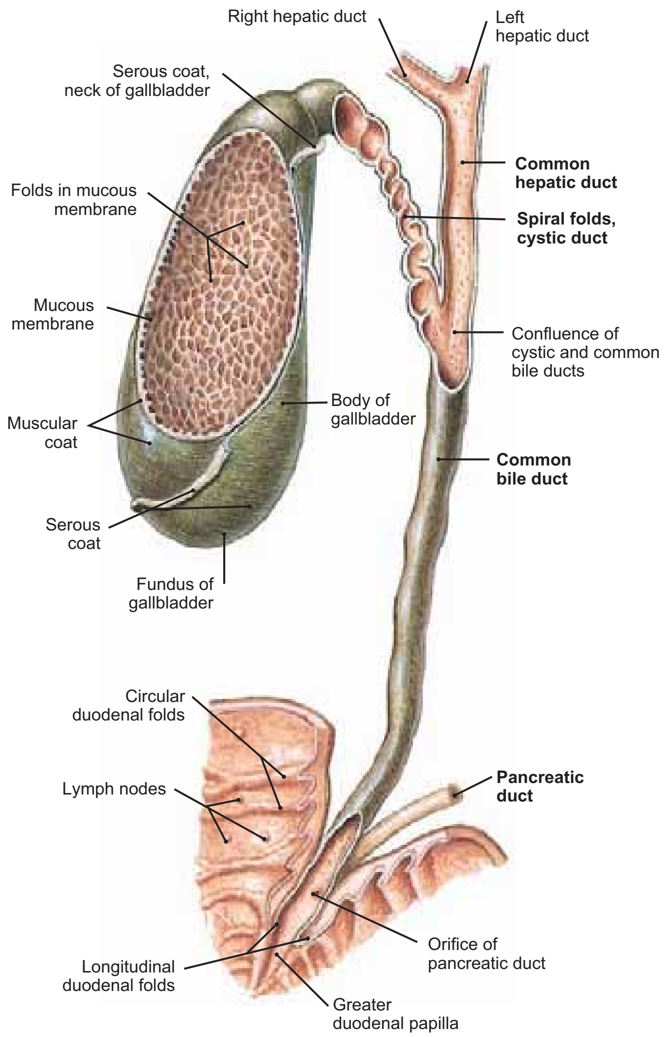


FIGURE 278.1 Gallbladder and Biliary Duct System

NOTE: (1) The wall of the gallbladder has been opened to reveal the meshwork characteristic of the surface of the mucosal layer. The pear-shaped gallbladder stores bile, which reaches it from the liver. Its capacity is about 35 ml.

(2) The spiral nature of the **cystic duct,** which emerges from the neck of the gallbladder. Normally, the cystic duct measures about 1½ in. in length and joins the **common hepatic duct** (which also is about 1½ in. long) to form the **common bile duct.**

(3) The common bile duct descends about 3 in. to open into the second or descending portion of the duodenum.

(4) At its point of entrance into the duodenum (greater duodenal papilla), the common bile duct is joined by the **main pancreatic duct** (duct of Wirsung).

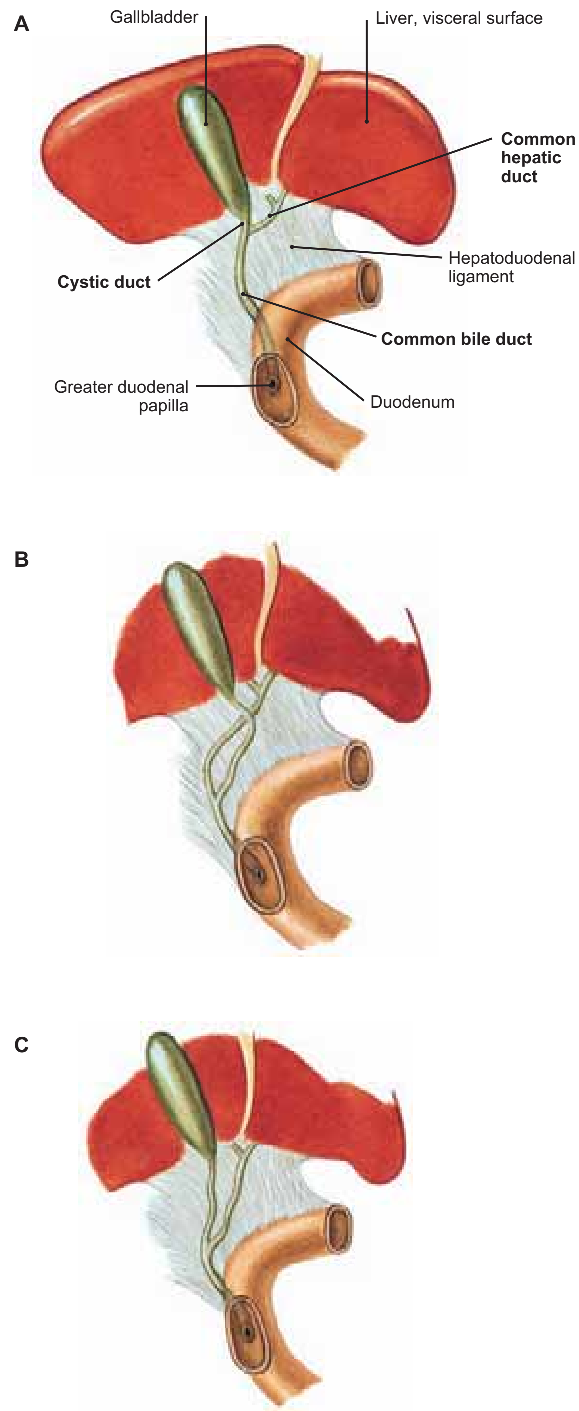


FIGURE 278.2A–C Variations in the Union of the Cystic and Common Hepatic Ducts

NOTE: Usually the cystic duct lies to the right of the common hepatic duct at a point just superior to the level of the first part of the duodenum. Variations in this schema occur as indicated in the following three examples:

A: The union of the cystic and common hepatic ducts occurs close to the liver, resulting in short cystic and common hepatic ducts and a long common bile duct.

B: The cystic duct crosses to the left of the common hepatic duct and joins the hepatic duct low, resulting in a short common bile duct.

C: The cystic duct remains to the right of the common hepatic duct but still joins it close to the site of penetration of the duodenum, again resulting in a short common bile duct.

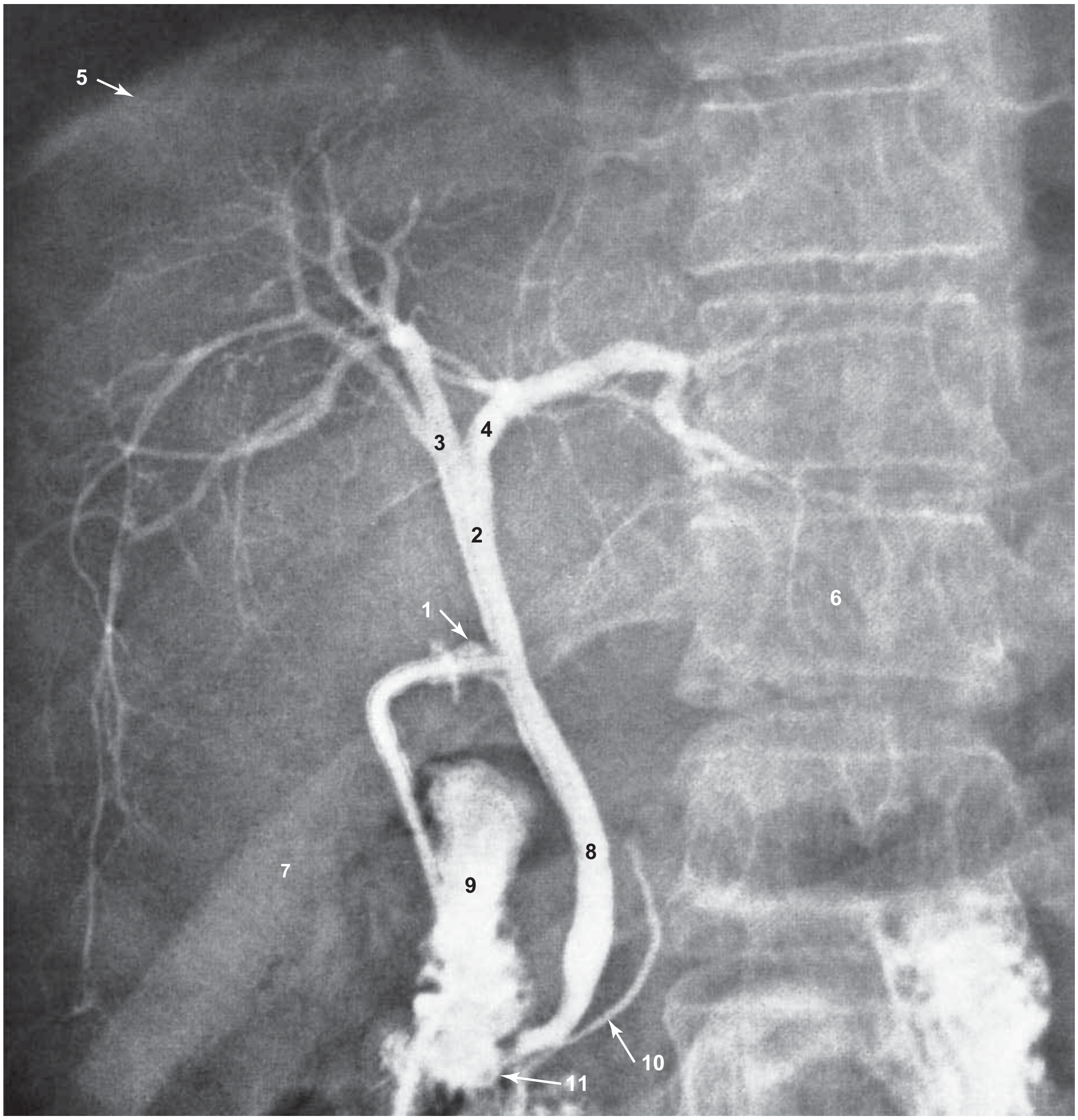


FIGURE 279.1 Intraoperative Cholangiogram: Radiograph of Biliary Duct System

NOTE: The gallbladder has been removed and a catheter and tube have been inserted through the stump of the cystic duct (**1**) into the common hepatic duct (**2**) and contrast medium injected into the biliary system. Other structures are numbered as follows:

3. Right hepatic duct
4. Left hepatic duct
5. Diaphragm
6. 11th thoracic vertebra
7. 11th rib
8. Common bile duct
9. Duodenum (second, descending part)
10. Main pancreatic duct
11. Greater duodenal papilla

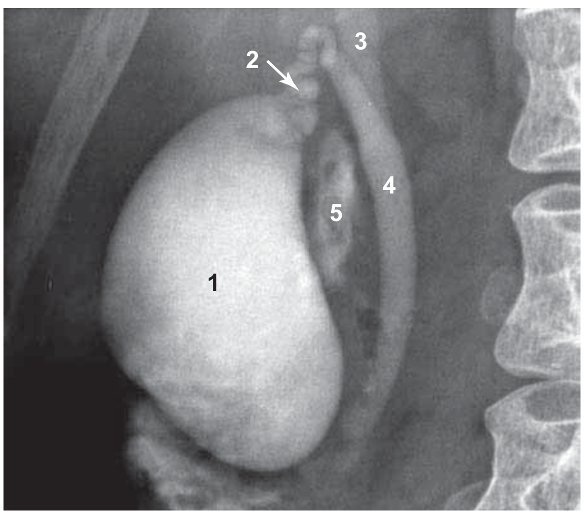


FIGURE 279.2 Radiograph of Gallbladder and Biliary Ducts

1. Body of the gallbladder
2. Cystic duct with spiral valves
3. Common hepatic duct
4. Union of common hepatic and cystic ducts to form common bile duct
5. Contrast medium in duodenum

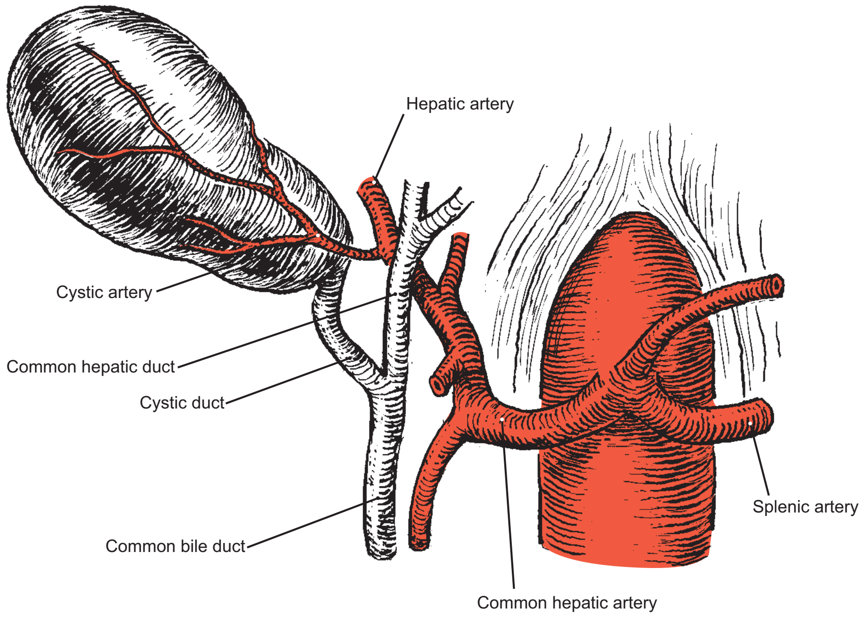


FIGURE 280.1 The Cystic Artery and the Bile Ducts

NOTE: (1) The cystic artery most often arises from the right hepatic artery to achieve the neck of the gallbladder. One or more accessory branches usually derive from the main cystic vessel.

(2) The origin of the cystic artery is important to the surgeon when performing gallbladder operations. In a large study, the following was found: **64%** derived from the right hepatic artery; **27%** from the hepatic trunk; **6%** from the left hepatic artery; and **2.5%** from the gastroduodenal artery and, in more rare cases, from the superior pancreaticoduodenal artery, right gastric artery, celiac trunk, or superior mesenteric artery.

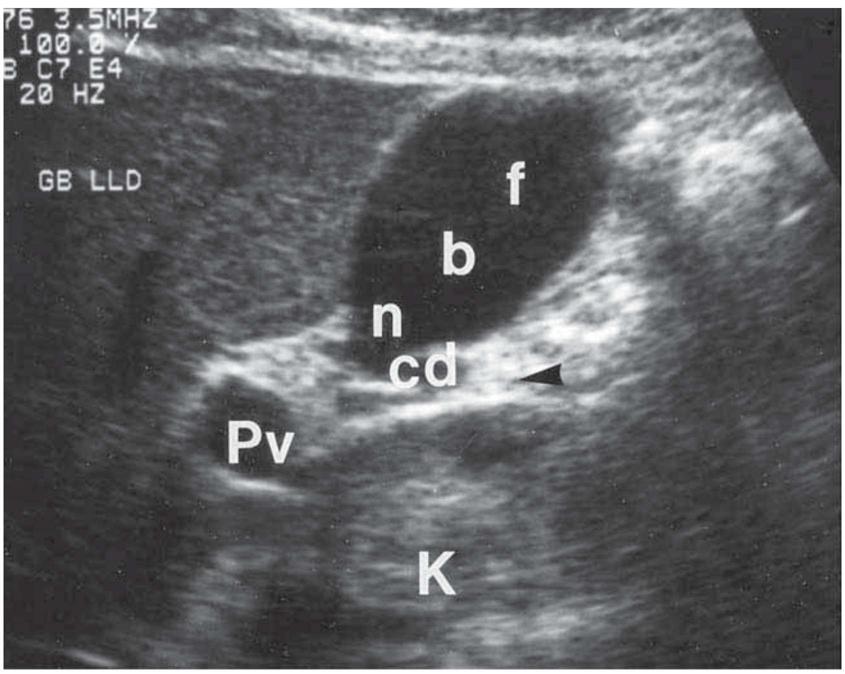


FIGURE 280.2 Parasagittal Ultrasound of Abdomen Demonstrating the Parts of the Gallbladder

NOTE: (1) This scan is of the right upper abdominal quadrant and shows the fundus (f), body (b), and neck (n) of the gallbladder.

(2) The other structures seen are the cystic duct, portal vein, and right kidney. The arrow points to a potential space known as the hepatorenal pouch of Morrison.

f, fundus of the gallbladder, **b;** body of the gallbladder; **n,** neck of the gallbladder; **cd,** cystic duct; **Pv,** portal vein; **K,** right kidney.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

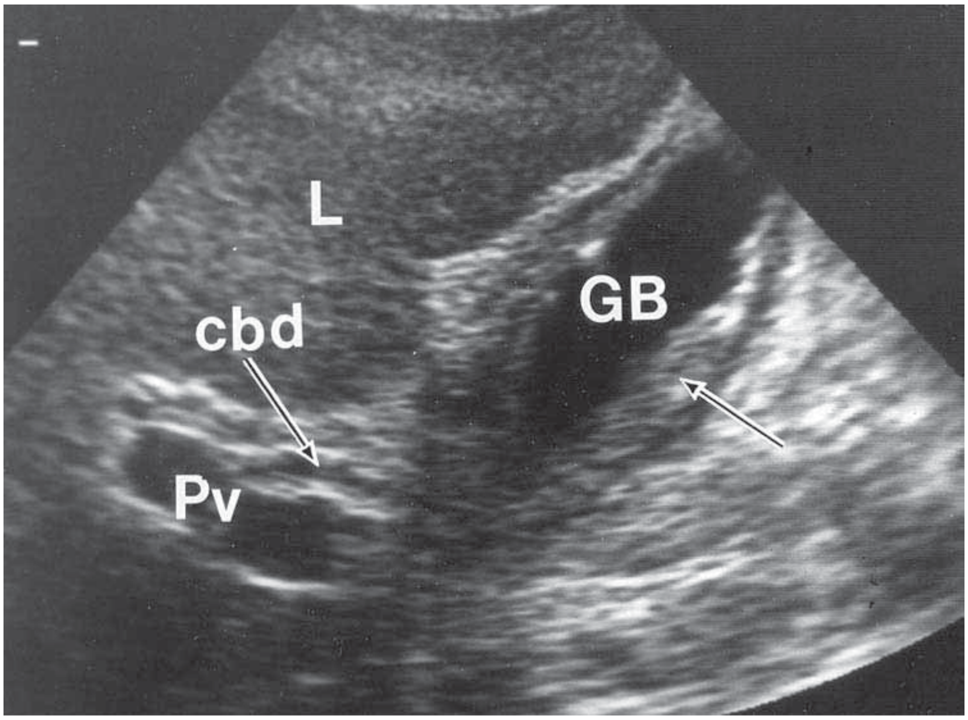


FIGURE 281.1 Parasagittal Ultrasound of Abdomen Showing Inflammation of the Gallbladder

NOTE that the wall of the gallbladder shows a thickening as the result of inflammation or **cholycystitis.** This condition often is caused by an impacted gallstone in the biliary tract, for example, within the cystic duct. This may lead to a stasis of bile within the gallbladder, causing an inflammation of its wall. In a case when bile cannot pass through the biliary tract, it then may become absorbed into the bloodstream and cause a yellowish skin discoloration called **jaundice.**

GB, gallbladder; **L,** liver; **Pv,** portal vein; **cbd,** common bile duct.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

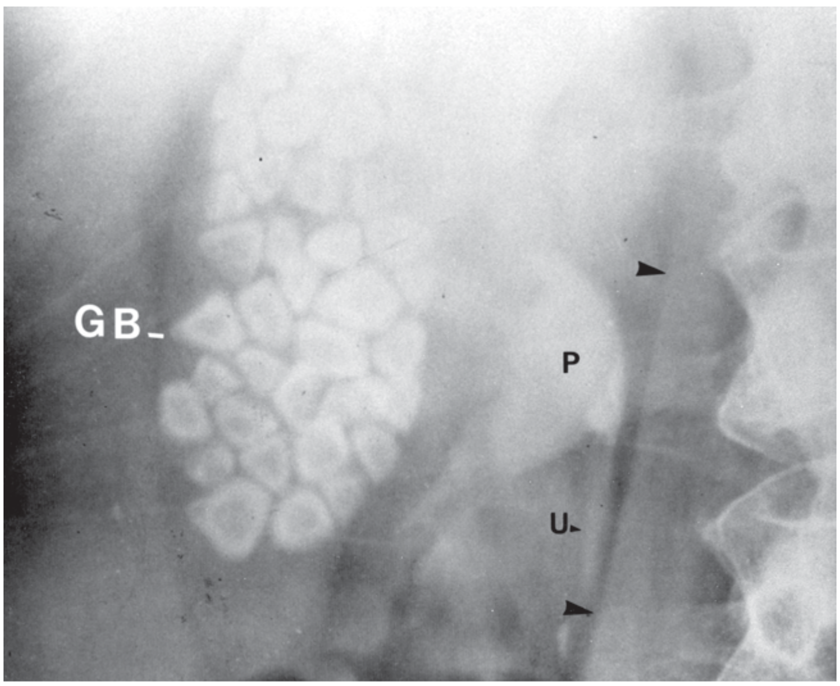


FIGURE 281.2 X-Ray of the Gallbladder Showing the Presence of Numerous Gallstones

NOTE: (1) The gallbladder in this X-ray is filled with gallstones. It is thought that gallstones form when there is a blockage for the release of bile into the duodenum along the biliary tract. This may be due to pressure of a tumor in the region or to a small stone in the biliary tract.

(2) The stasis of bile in the gallbladder, due to delayed emptying, appears to be one of the conditions that predispose a person to form gallstones. An increased secretion of cholesterol from the liver into the bile has long been considered a precipitating condition in the formation of gallstones. This may be related to dietary factors. There are also good twin studies that point to a genetic factor that may also be involved in gallstone formation.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

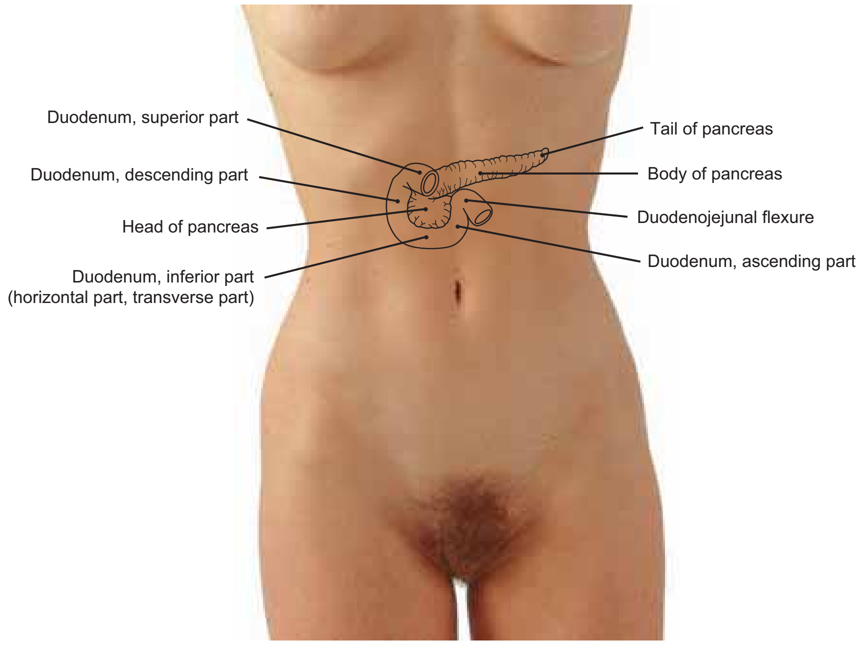


FIGURE 282.1 Surface Projection of the Duodenum and Pancreas

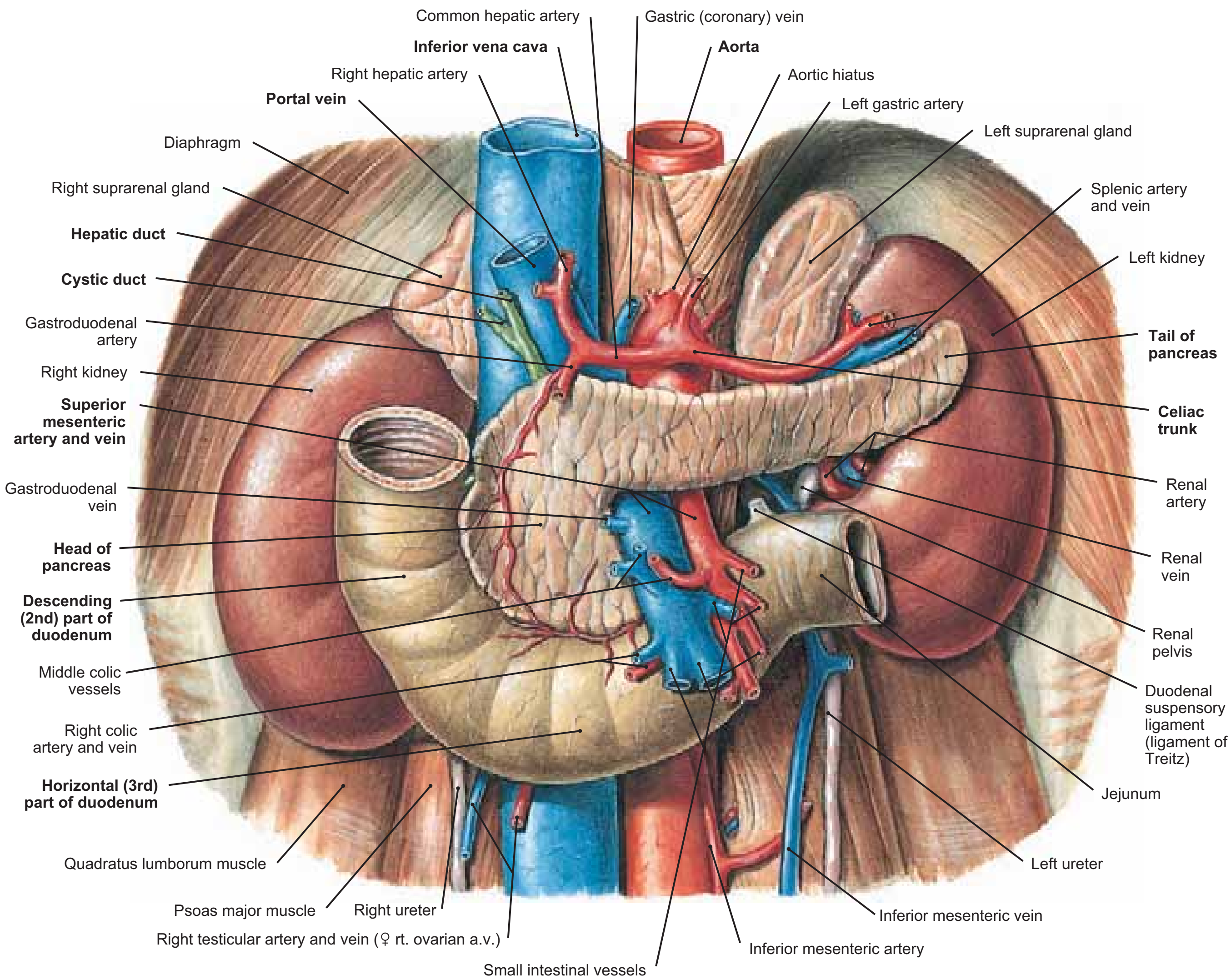


FIGURE 282.2 Pancreas and Duodenum

NOTE: (1) The **head** of the pancreas lies to the right of the midline and is in contact with the inferior vena cava and the common bile duct dorsally and the transverse colon (not shown) ventrally.

(2) The **body** of the pancreas crosses the midline at the L1 level, and it is in contact posteriorly with the aorta, the superior mesenteric vessels, the left kidney, and the left adrenal gland.

(3) The **tail** of the pancreas is in contact with the spleen laterally, the left kidney posteriorly, and the splenic flexure of the colon anteriorly.

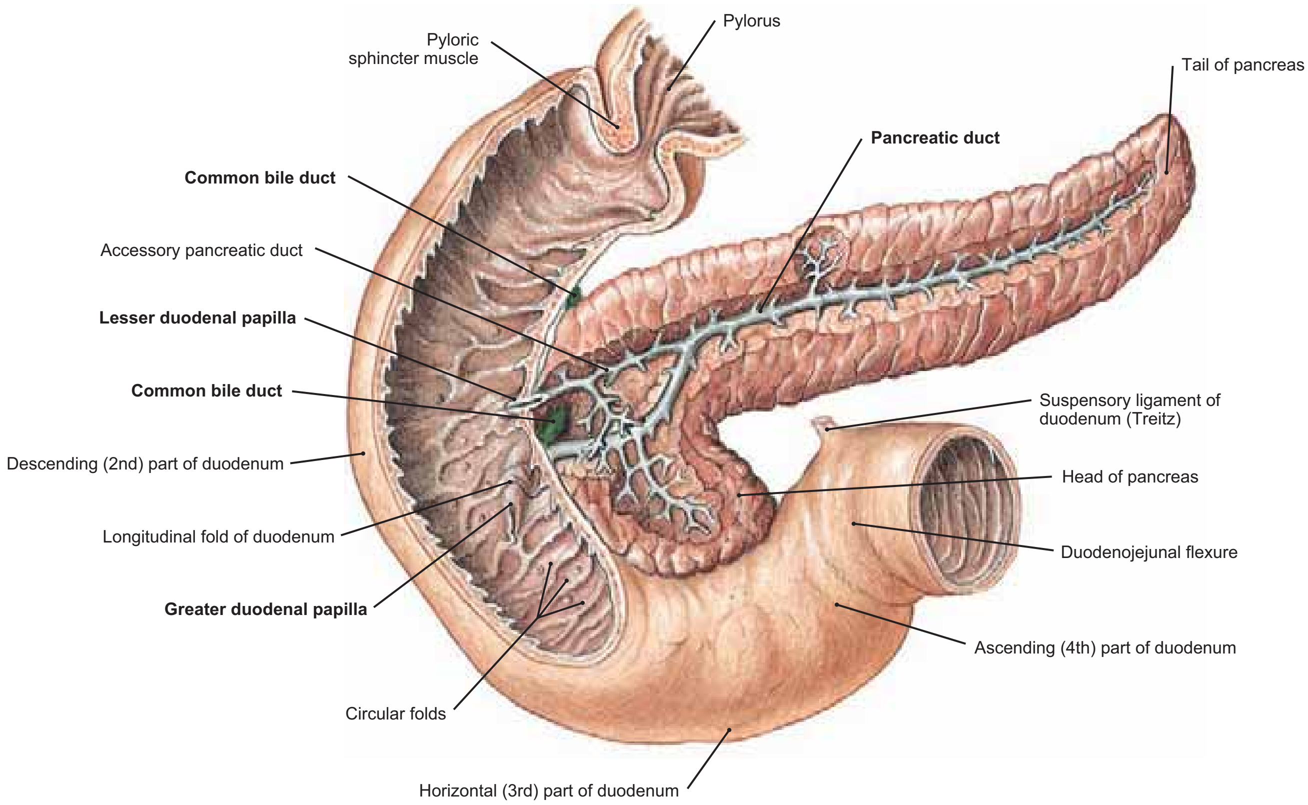


FIGURE 283.1 Pancreatic Duct System

NOTE: (1) The main pancreatic duct system has been dissected in this specimen. Observe how the accessory pancreatic duct extends straight into the duodenum through the lesser duodenal papilla. The main pancreatic duct, however, bends caudally to drain most of the head of the pancreas and then opens into the greater duodenal papilla with the common bile duct.

(2) From the pylorus to the duodenojejunal flexure, the duodenum measures about 10 in. At its termination, a suspensory ligament (of Treitz) marks the commencement of the jejunum. Here the small intestine becomes surrounded by peritoneum and is suspended from the posterior abdominal wall by the mesentery of the small intestine.

(3) The duodenum and pancreas are both retroperitoneal structures.

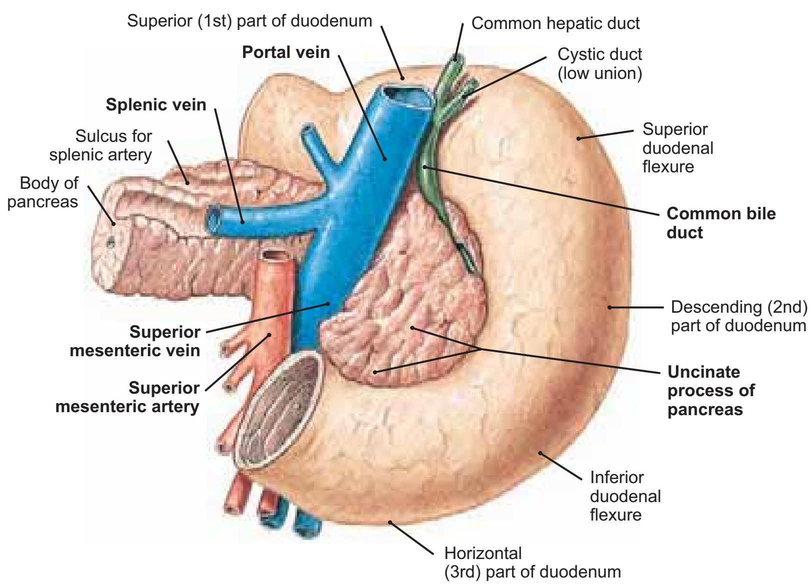


FIGURE 283.2 Head of Pancreas and Duodenum (Dorsal View)

NOTE: (1) This posterior view of the pancreatic head and its **uncinate process** shows the **common bile duct** embedded in the pancreas as the duct descends adjacent to the duodenum.

(2) Observe the **portal vein** as it ascends to the liver coursing posterior to the pancreatic head. Realize that the portal vein is the continuation superiorly beyond the junction of the **splenic vein** and the **superior mesenteric vein.**

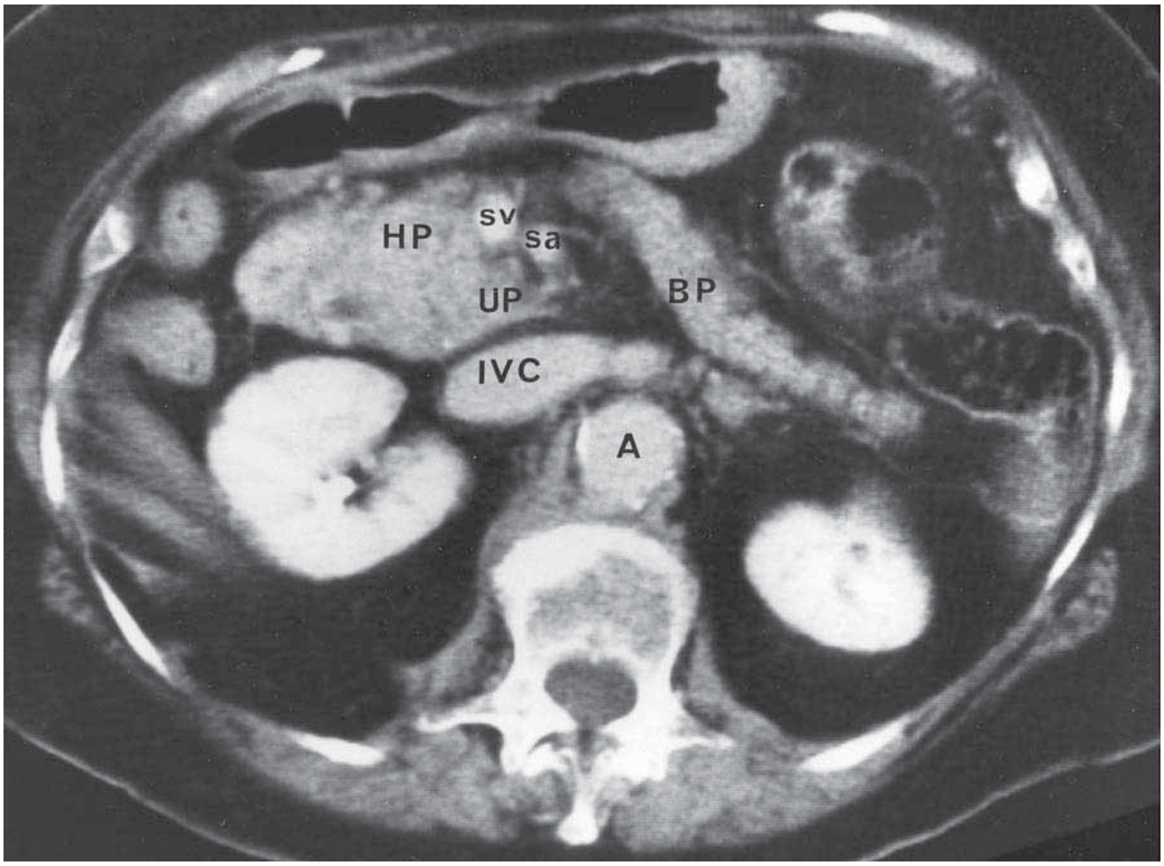


FIGURE 284.1 CT Passing through the Level of the Second Lumbar Vertebra in a Normal Abdomen

NOTE the head, body, and uncinate process of the pancreas.

HP, head of the pancreas; **BP,** body of the pancreas; **UP,** uncinate process of the pancreas; **A,** aorta; **IVC,** inferior vena cava; **sv,** superior mesenteric vein; **sa,** superior mesenteric artery.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

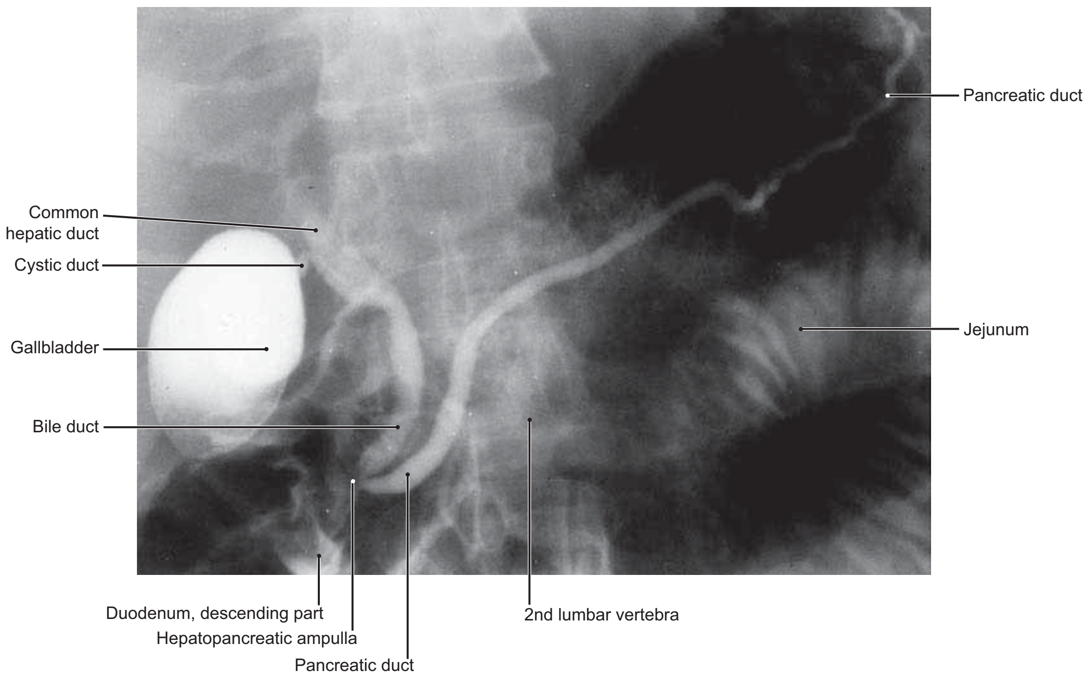


FIGURE 284.2 Pancreatic Duct, Common Bile Duct, and Gallbladder

NOTE: (1) This radiograph was taken following the injection of a contrast medium through a cannula placed in the common duct formed by junction of the main pancreatic duct and the common bile duct along the second part of the duodenum.

(2) The pancreatic duct is visible throughout its extent (i.e., from the splenic hilum to the hepatopancreatic ampulla). Also visible are the common hepatic duct and the common bile duct along with the gallbladder and a short part of the cystic duct.

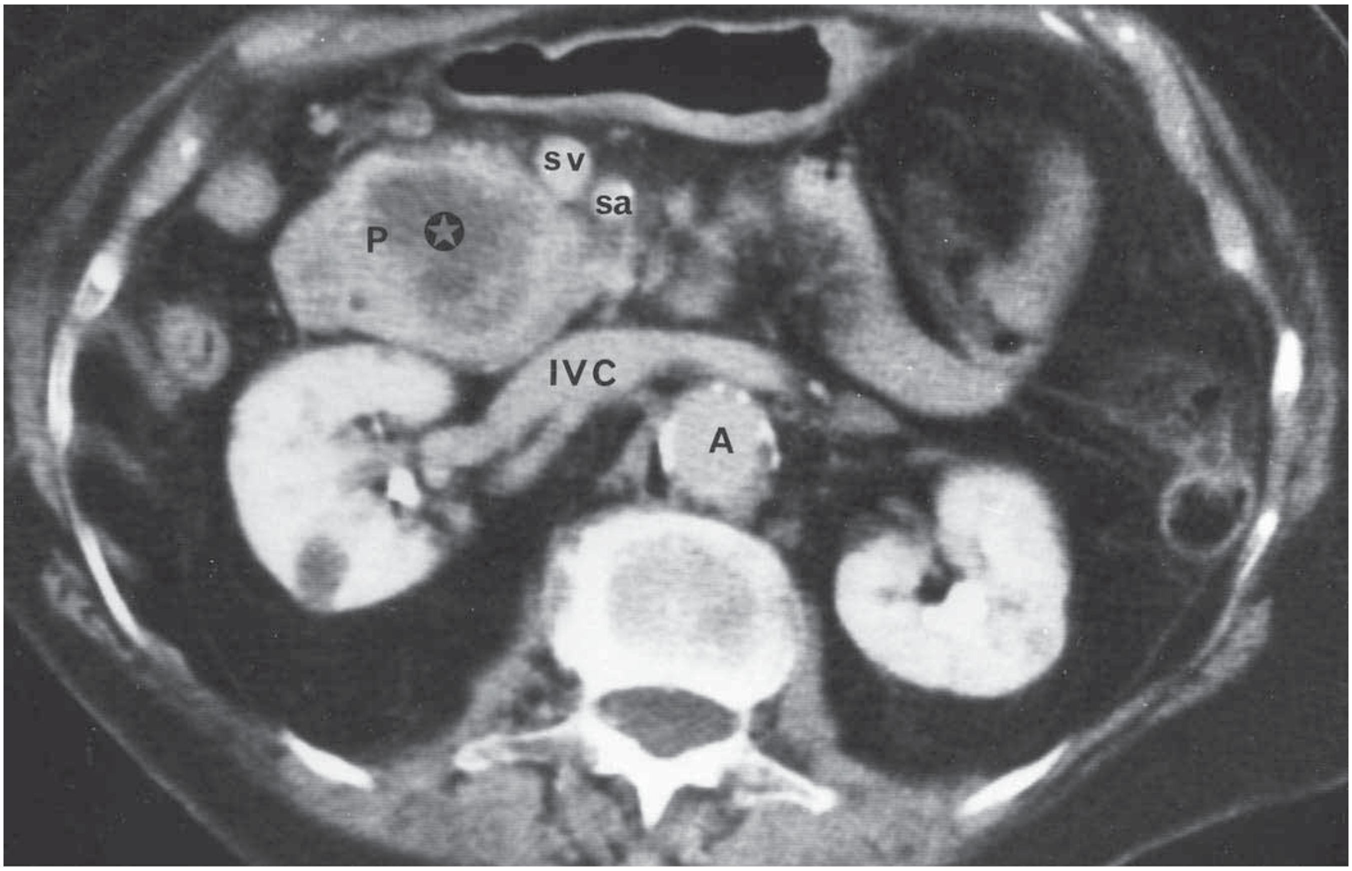


FIGURE 285.1 Transaxial Image Showing a Tumor in the Head of the Pancreas

NOTE: (1) A low-density tumor in the head of the pancreas. Tumors in the head of the pancreas are located in a deep-seated location. Because of this, they are often not diagnosed until very late when the prognosis is poor.

(2) A noninvasive technique such as a CT scan provides a valuable tool for an early diagnosis and for a more favorable outcome. Observe the inferior vena cava receiving the left and right renal veins.

P, pancreas; sv, superior mesenteric vein; **sa,** superior mesenteric artery; **A,** aorta; **IVC,** inferior vena cava.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

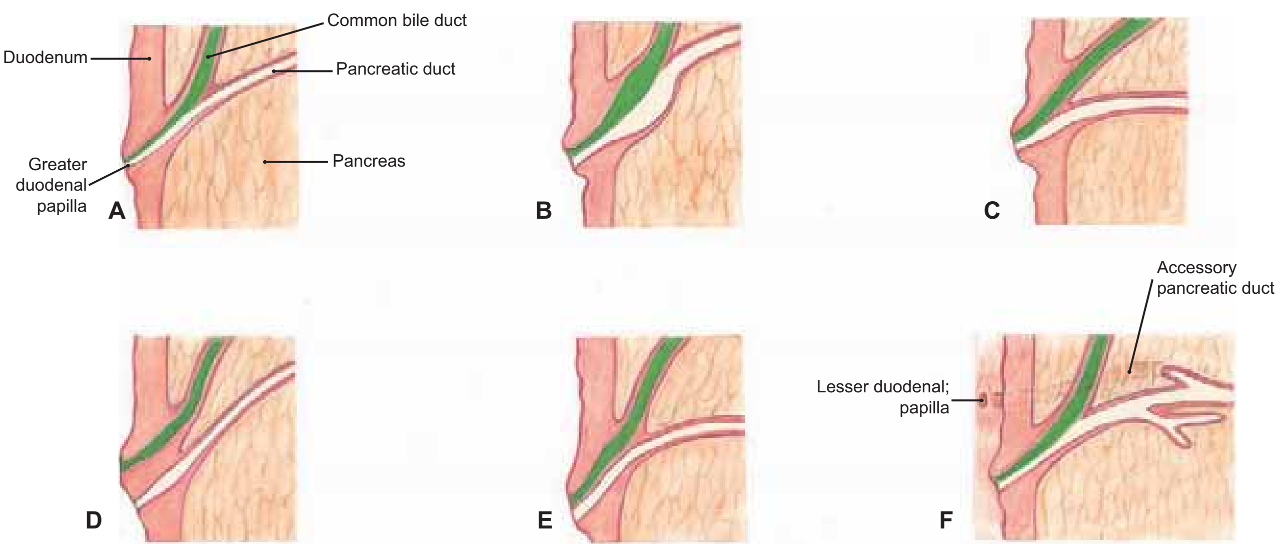


FIGURE 285.2A–F Variations in Union of the Common Bile Duct and the Pancreatic Duct

A: Pancreatic and common bile ducts join early, resulting in a long hepatopancreatic duct.
B: A long hepatopancreatic duct is modified by an expanded ampulla.
C: Pancreatic and common bile ducts join very close to the greater duodenal papilla, resulting in a short hepatopancreatic duct.
D: Both pancreatic and common bile ducts open separately on a somewhat larger duodenal papilla.
E: Pancreatic and common bile ducts drain through a single opening. The ducts are separated by a septum.
F: Long hepatopancreatic duct along with a well-developed accessory pancreatic duct (seen behind), which opens through the lesser duodenal papilla.

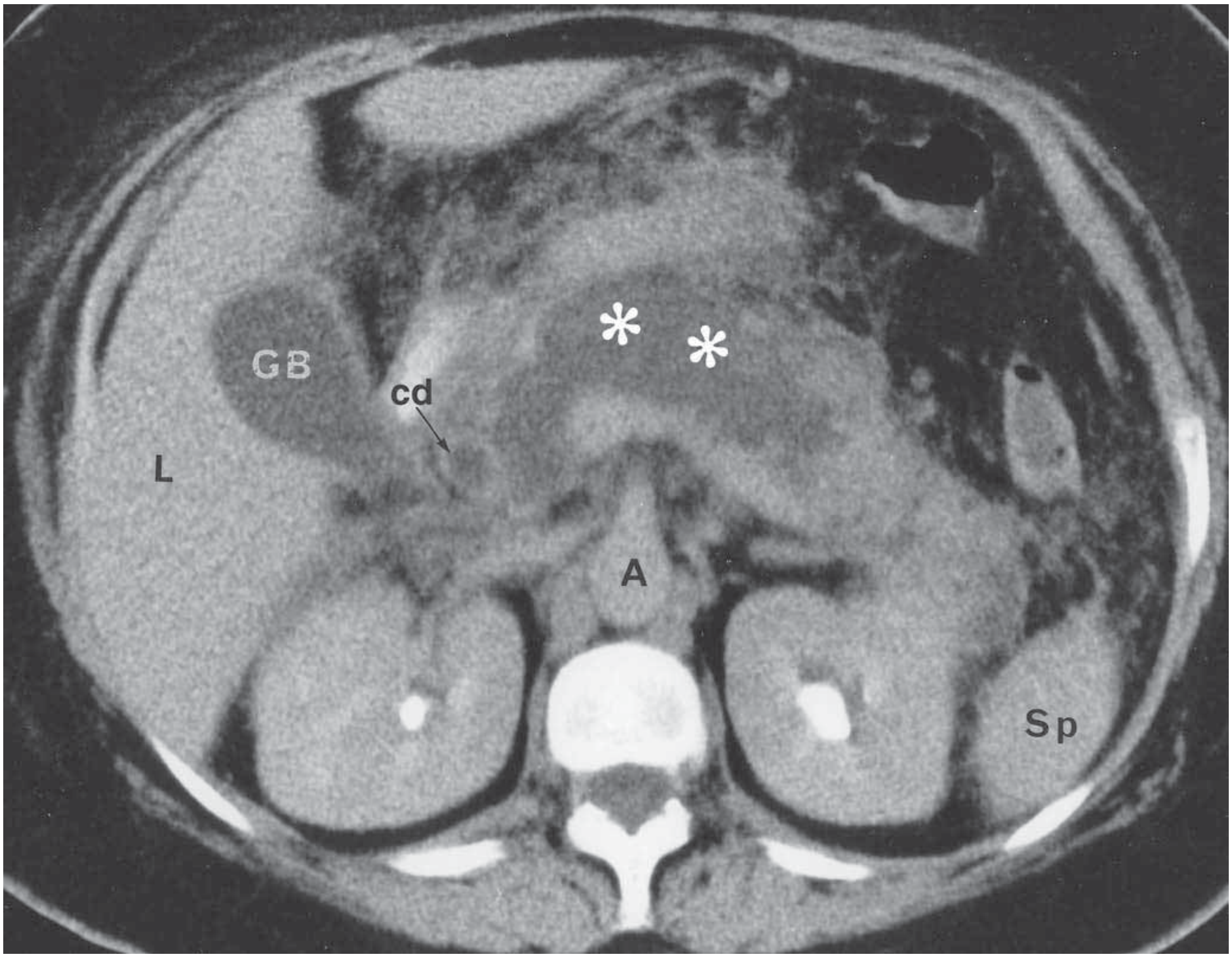


FIGURE 286.1 CT Showing Diffuse Inflammation of the Pancreas

NOTE: (1) Inflammation of the pancreas is called pancreatitis, which is an extremely painful condition. The darker area indicates regions of pancreatic necrosis (**asterisks**).

(2) Pancreatitis is frequently seen in alcoholics and in patients with gallstones that impact the ampulla of Vater.

(3) The dilated common bile duct (cd).

L, liver; **GB,** gallbladder; **Sp,** spleen; **A,** aorta; **cd,** common bile duct.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

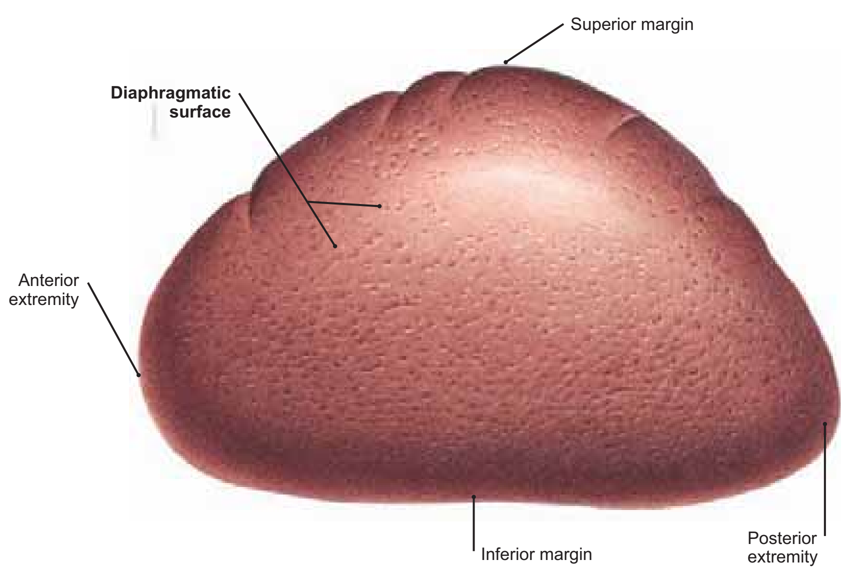


FIGURE 286.2 Spleen (Diaphragmatic Surface)

NOTE: The diaphragmatic surface of the spleen is directed posterolaterally. The normal spleen may vary in weight from 100 to 400 g. Its proximity to the 9th, 10th, and 11th ribs makes it vulnerable to rib fractures in this region.

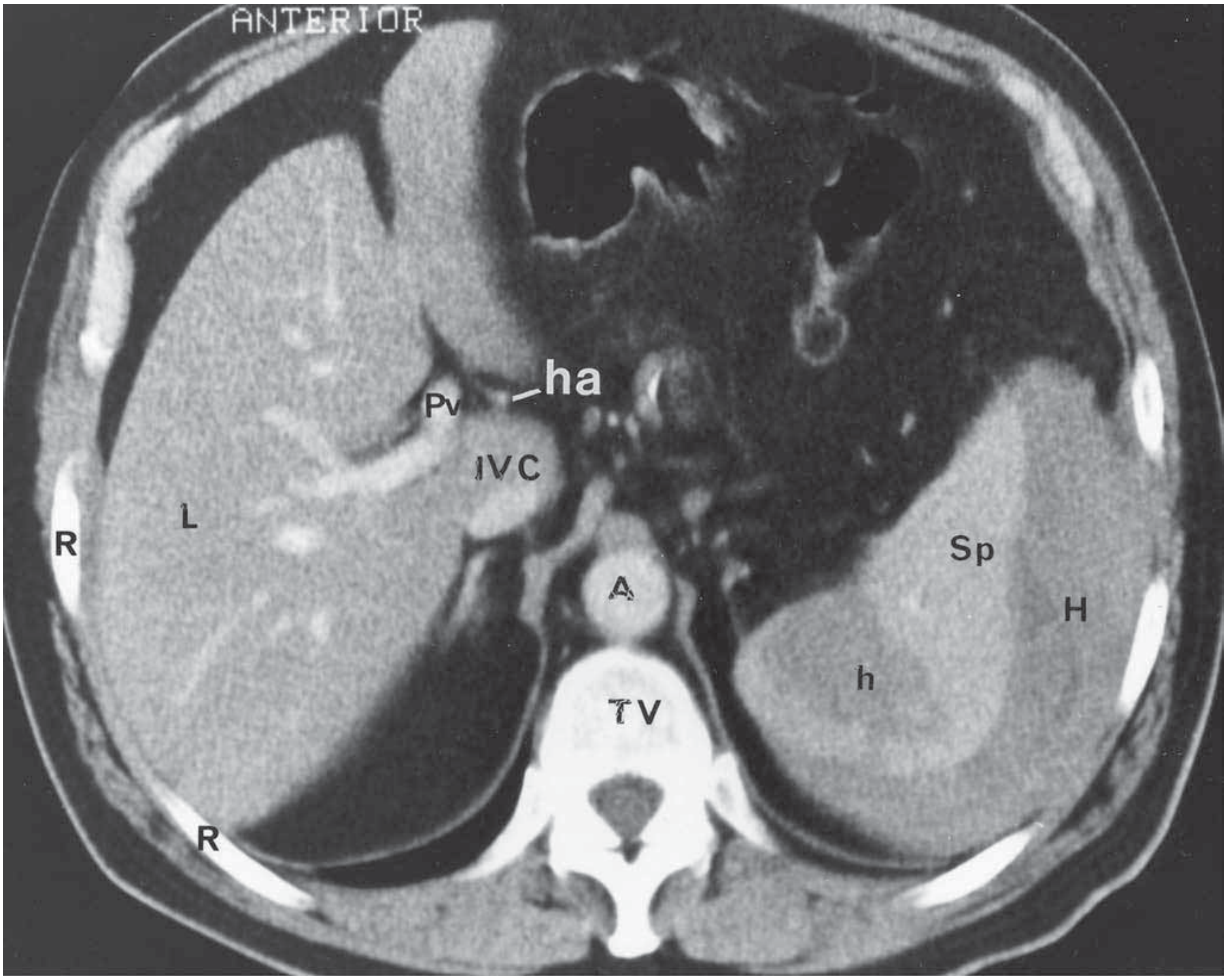


FIGURE 287.1 CT through the Upper Abdomen

NOTE: (1) The liver **(L)** and the portal vein **(Pv)** entering it. Observe the small diameter of the hepatic artery **(ha)** that supplies the liver in contrast to the large portal vein emphasizing the amount of blood brought by these two vessels to the liver.

(2) The large subcapsular hemorrhage (**H**) in the spleen (**Sp**). Also observe the wedge-shaped hemorrhage (**h**). See the profiles of the ribs (**R**) and realize how they protect the many important thoracic organs and some of the upper abdominal organs. **TV**, thoracic vertebrae; **A,** aorta; **IVC,** inferior vena cava.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

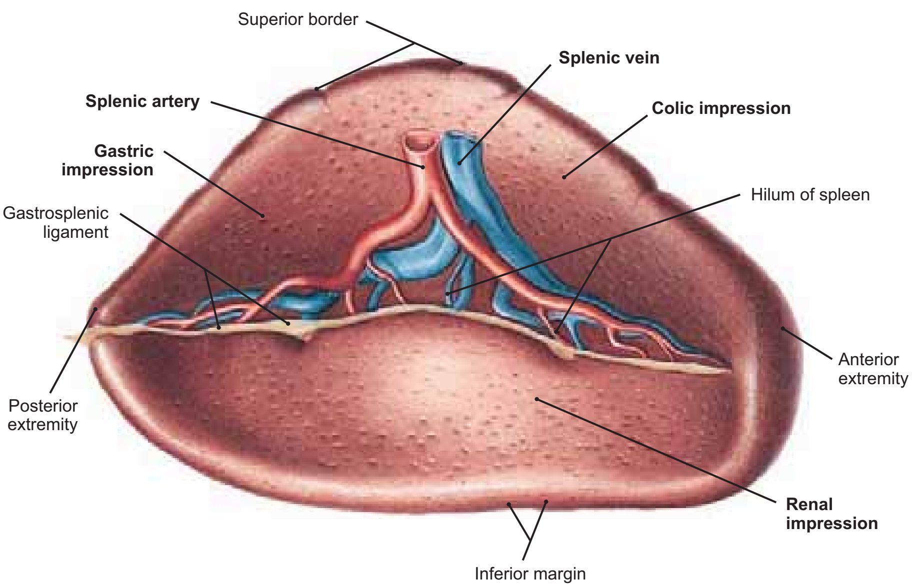


FIGURE 287.2 Spleen (Visceral Surface)

NOTE: The spleen is situated in the left hypochondriac region between the fundus of the stomach and the diaphragm. Its visceral surface shows the gastric and renal impressions that conform to the shapes of the stomach and left kidney. In addition, the left colic flexure, the tail of the pancreas, and the left adrenal gland, which overlies the left kidney, are related to this visceral surface.

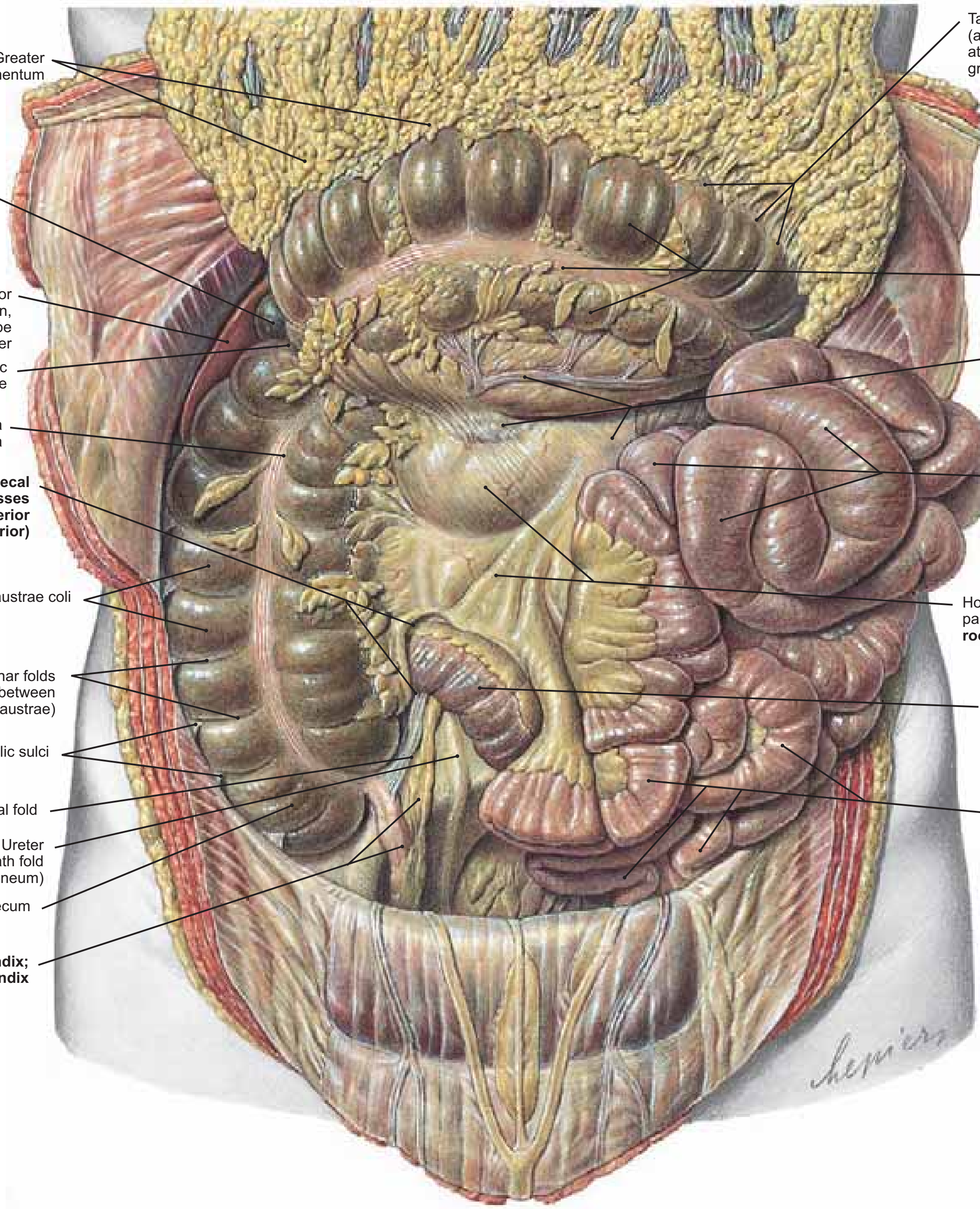


FIGURE 288 Abdominal Cavity: Jejunum, Ileum, and Ascending and Transverse Colons

NOTE: (1) The greater omentum has been reflected superiorly, and the jejunum and ileum have been pulled to the left to expose the **root of the mesentery of the small intestine**.

(2) The horizontal (third) part of the duodenum, which is retroperitoneal and is covered by the smooth and glistening peritoneum.

(3) The junction of the distal portion of the ileum with the cecum. At this **ileocecal junction** the **ileocecal fold,** the **appendix,** and the **mesoappendix** can be identified. The appendix may extend cranially behind the cecum, toward the left and behind the ileum, or as demonstrated here, inferiorly over the pelvic brim.

(4) The transverse colon and the small intestine beyond the duodenal junction are more mobile than most other organs because they are attached to the transverse mesocolon and the mesentery.

(5) The retroperitoneal position of the **right ureter** as it descends over the pelvic brim on its course toward the urinary bladder in the pelvis.

FIGURE 289 Jejunum and Ileum Filled with a Contrast Medium

NOTE: (1) The **jejunum** and **ileum** extend between the duodenojejunal junction and the ileocecal valve. This part of the small intestine is completely covered with peritoneum and can be seen to be arranged in a series of coils;

(2) The jejunum is about 1½ in. in diameter and about two-fifths of the small intestine beyond the duodenum, while the ileum is the distal three-fifths and is slightly smaller in diameter.

(From Wicke, 4th ed.)

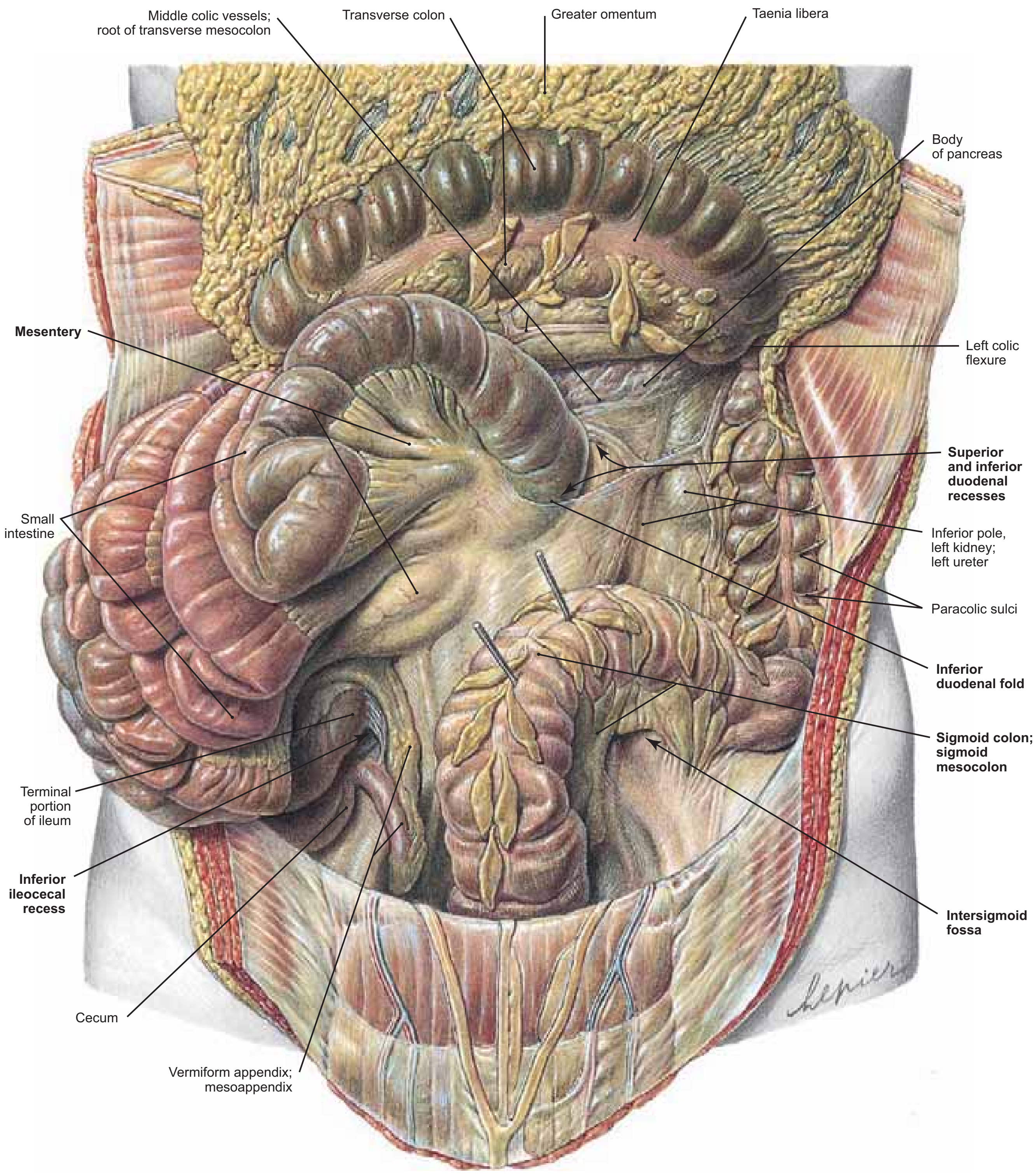


FIGURE 290 Abdominal Cavity: Descending and Sigmoid Colons and the Duodenojejunal Junction

NOTE: (1) The transverse colon and greater omentum have been reflected upward and the jejunum and ileum have been pulled to the right to reveal the **duodenojejunal junction** and the **descending** and **sigmoid colon.**

(2) At the duodenojejunal junction the small intestine acquires a mesentery. At this site, there are frequently found duodenal fossae or recesses located in relationship to the junction. Among these, the **superior** and **inferior duodenal recesses** are found in more than 50% of cases. These are of importance because they represent possible sites of herniation.

(3) The sigmoid colon is mobile (because of its mesocolic attachment), whereas the descending colon is fixed to the posterior wall of the abdomen.

(4) The **intersigmoid fossa** is located behind the sigmoid mesocolon and between that mesocolon and the peritoneum reflected over the external iliac vessels.

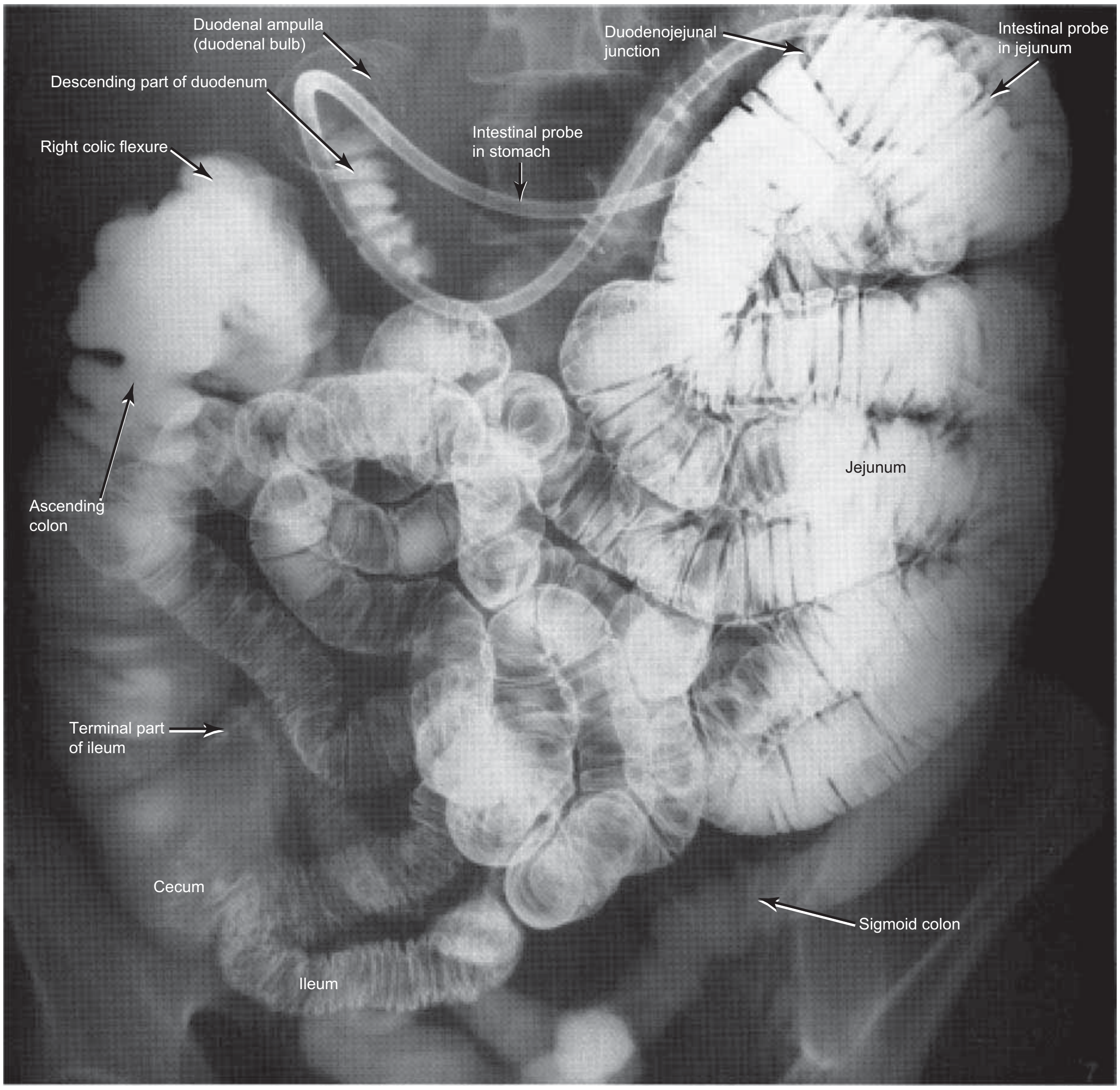


FIGURE 291 Radiograph of the Jejunum, Ileum, Cecum, and Ascending Colon

NOTE: (1) This radiograph of the small bowel was obtained following an injection of a contrast medium into the gastrointestinal tract. The intestinal probe in this case was introduced through the stomach and duodenum to the jejunum.
(2) The cecum, ascending colon, right colic flexure, and sigmoid colon are also recognizable.
(3) Some of the medium had entered the descending part of the duodenum also to be visualized.

(From Wicke, 4th ed.)

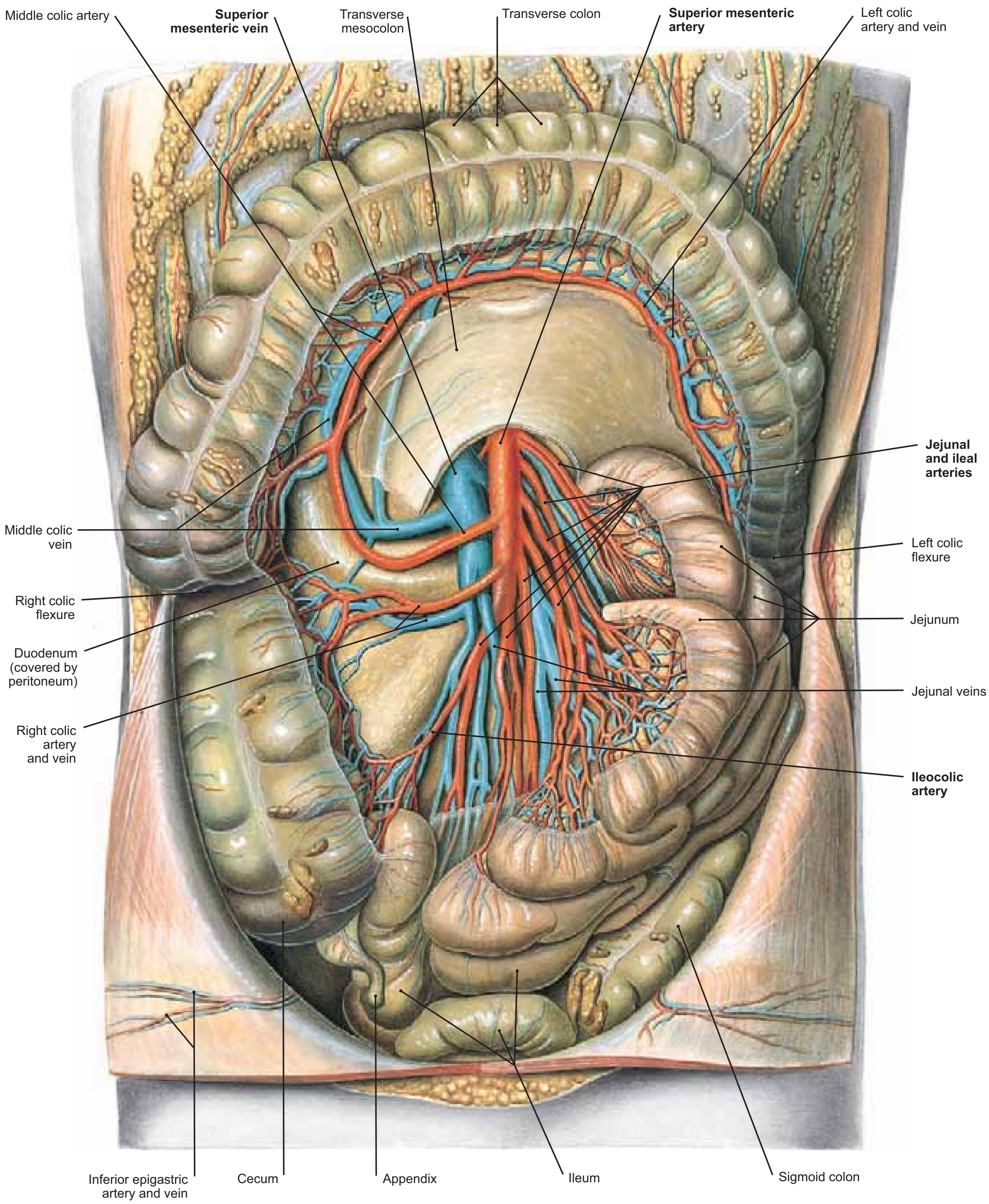


FIGURE 292 Abdominal Cavity: Superior Mesenteric Vessels and Branches

NOTE: (1) The small intestine is pushed to the left and the loops of bowel have been dissected to expose the branches of the superior mesenteric vessels.

(2) The **jejunal and ileal arteries** branch from the left side of the mesenteric artery. There are about 15 of these vessels.

(3) Branching from the right side of the superior mesenteric artery are the **ileocolic, right colic,** and **middle colic arteries.** These vessels form rich anastomoses.

(4) The small intestine measures about 22 ft in length, commencing at the pyloric end of the stomach and extending to the ileocecal junction, where the large intestine starts.

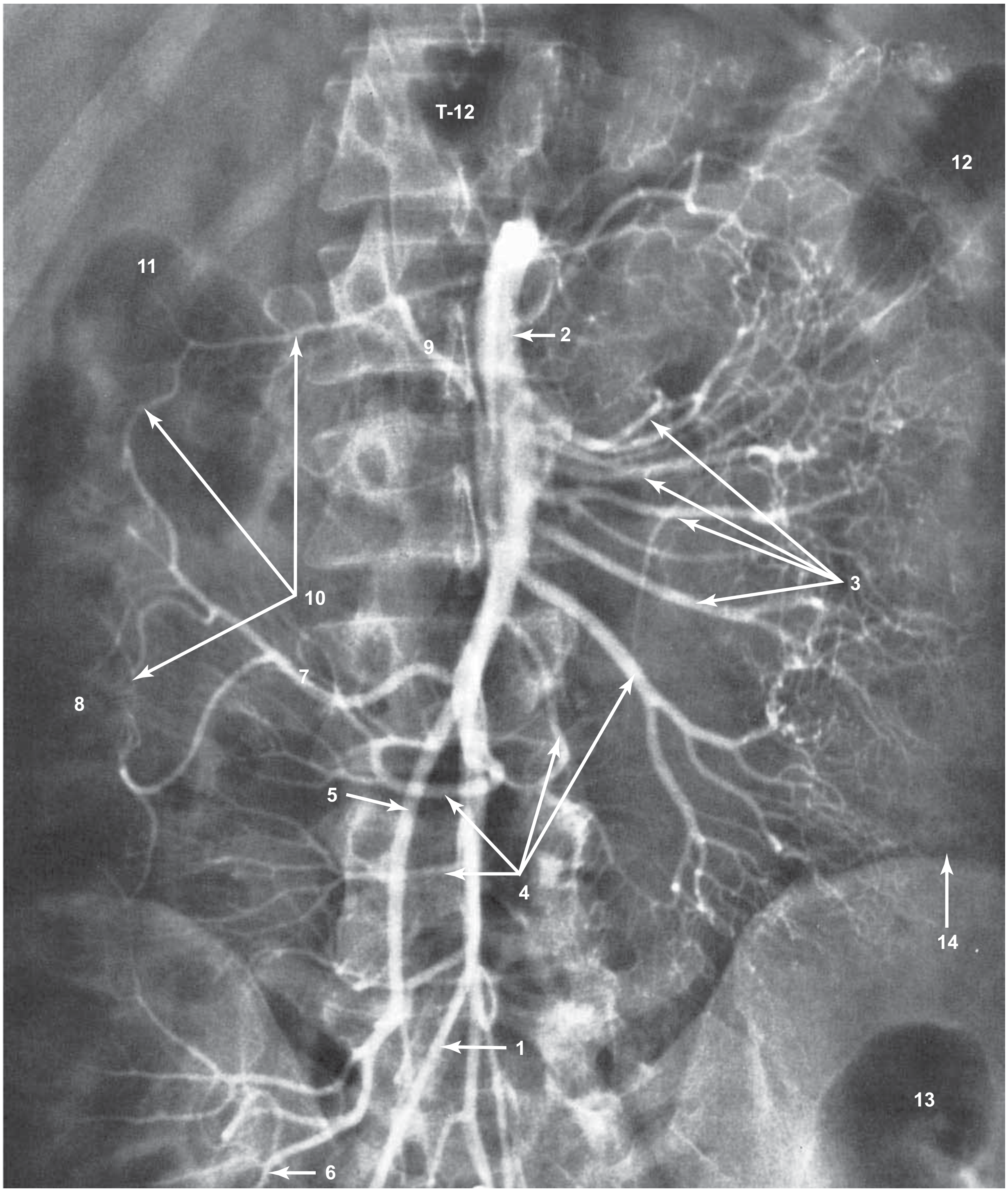


FIGURE 293 Superior Mesenteric Arteriogram

NOTE: (1) A catheter [1] has been inserted into the common iliac artery and through the abdominal aorta to the point of branching of the superior mesenteric artery [2]. Contrast medium was injected to visualize the principal branches of that vessel. The original radiograph is shown as a negative print.

(2) The jejunal [3] and ileal [4] arteries branching as a sequence of vessels (about 15 in number), which supply all of the small intestine beyond the duodenum.

(3) The ileocolic artery [5] and its appendicular branch [6], the right colic [7] and middle colic [9] arteries, which supply the cecum, ascending colon [8], and transverse colon. Anastomoses among these vessels along the margin of the colon contribute to the formation of the marginal artery [10].

(4) Other structures can be identified. These include the right colic flexure [11], the left colic flexure [12], the sigmoid colon [13], the body of the T12 vertebra, and the iliac crest [14].

(From Wicke, 3rd ed.)

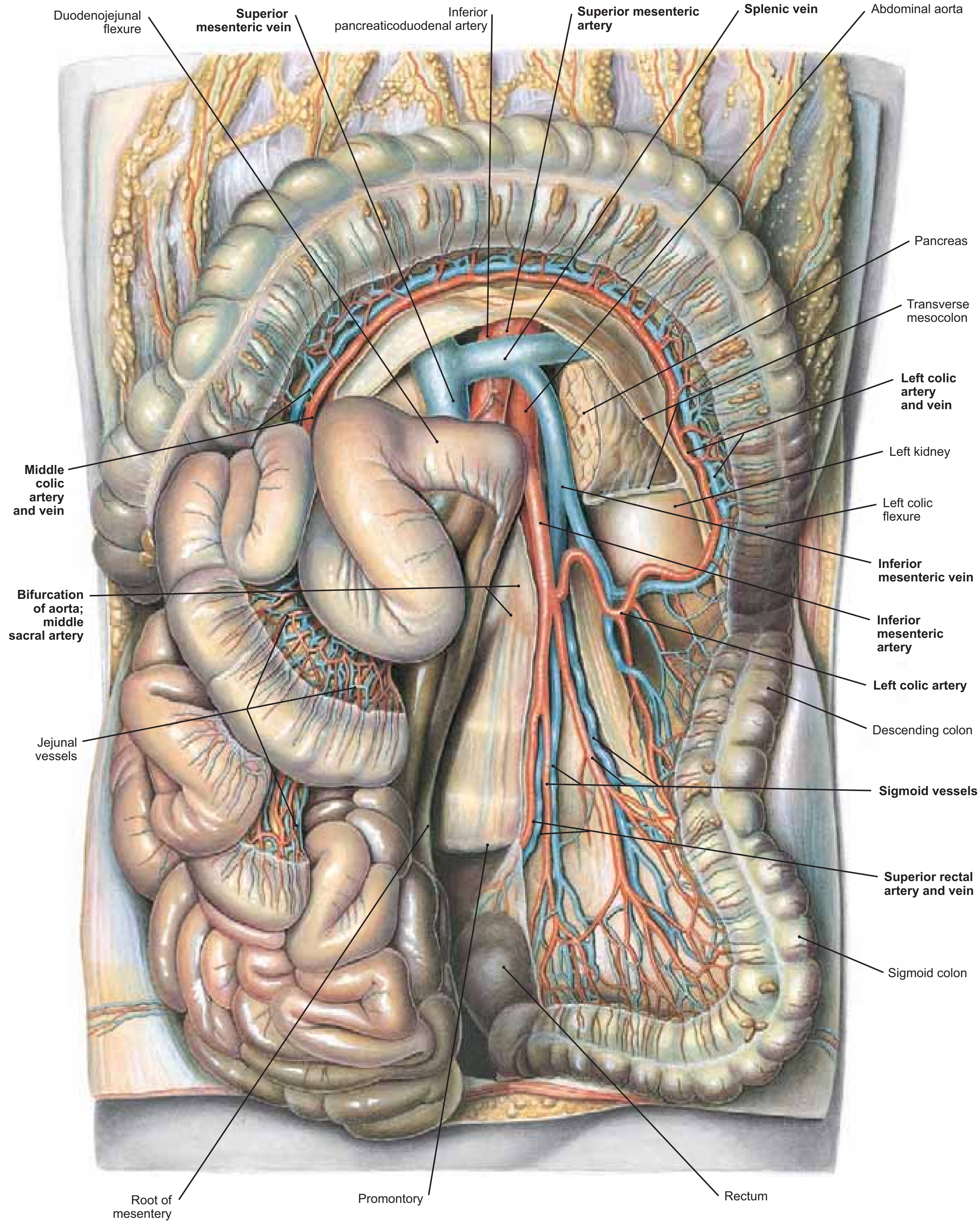


FIGURE 294 Abdominal Cavity: Inferior Mesenteric Vessels and Branches

NOTE: (1) The small intestine has been pushed to the right and parts of the pancreas and transverse mesocolon have been removed to expose the origin of the superior mesenteric artery from the aorta and the drainage of the superior mesenteric vein into the splenic vein.

(2) The inferior mesenteric artery supplies the descending colon via the **left colic artery** and the sigmoid colon and rectum via the **sigmoid** and **superior rectal arteries.**

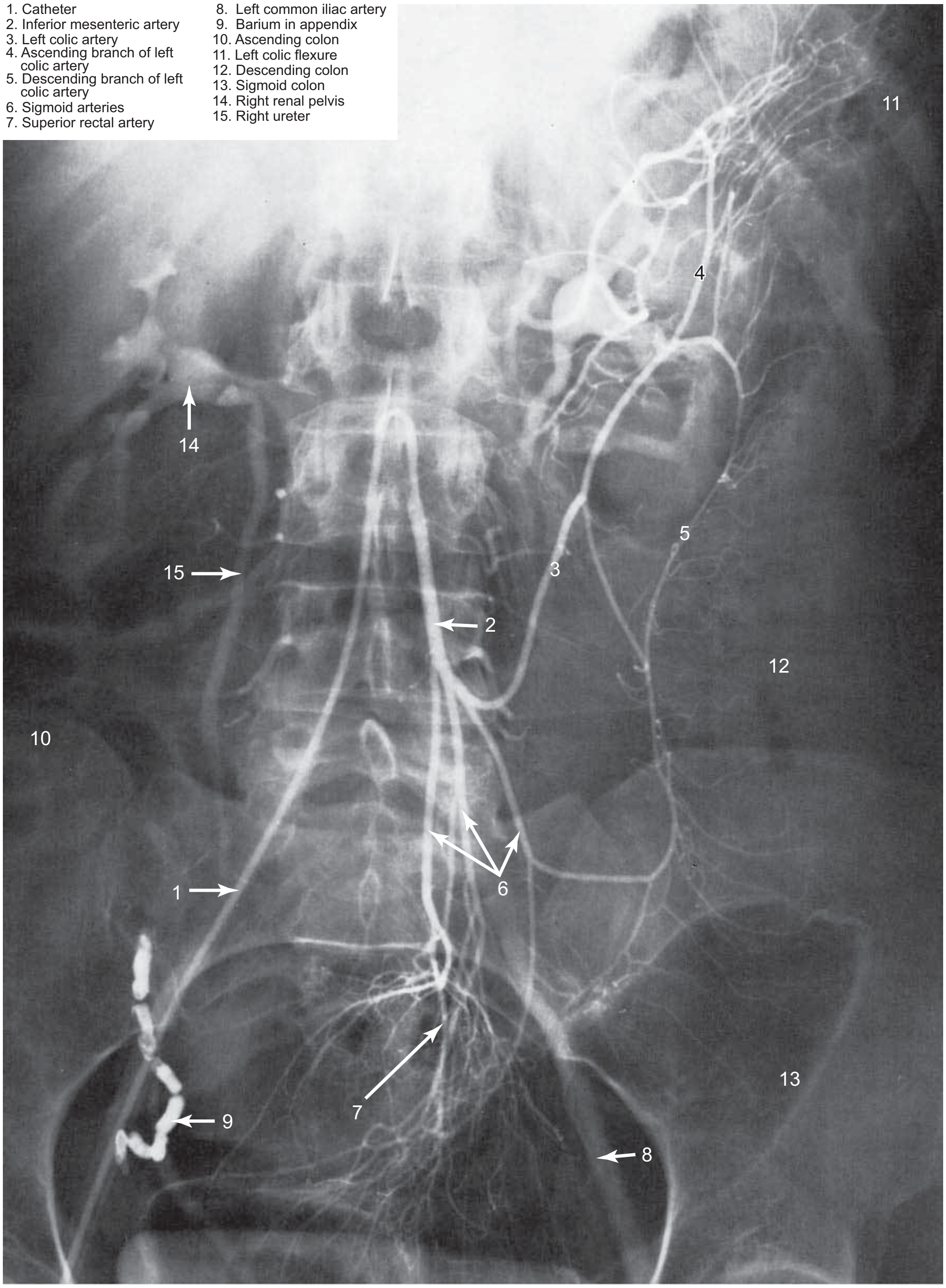


FIGURE 295 Inferior Mesenteric Arteriogram

NOTE: (1) A catheter [1] was inserted through the right internal iliac artery and directed upward into the abdominal aorta to the origin of the **inferior mesenteric artery** [2]. Contrast medium was injected into that artery to demonstrate its field of distribution.

(2) The branches of the inferior mesenteric artery shown above are normal. The **left colic artery** [3] shows both an ascending [4] and a descending [5] branch.

(3) Several **sigmoid arteries** [6] supply the sigmoid colon [13], and these anastomose above with branches of the left colic artery [3] and below with the **superior rectal artery** [7].

(From Wicke, 3rd ed.)

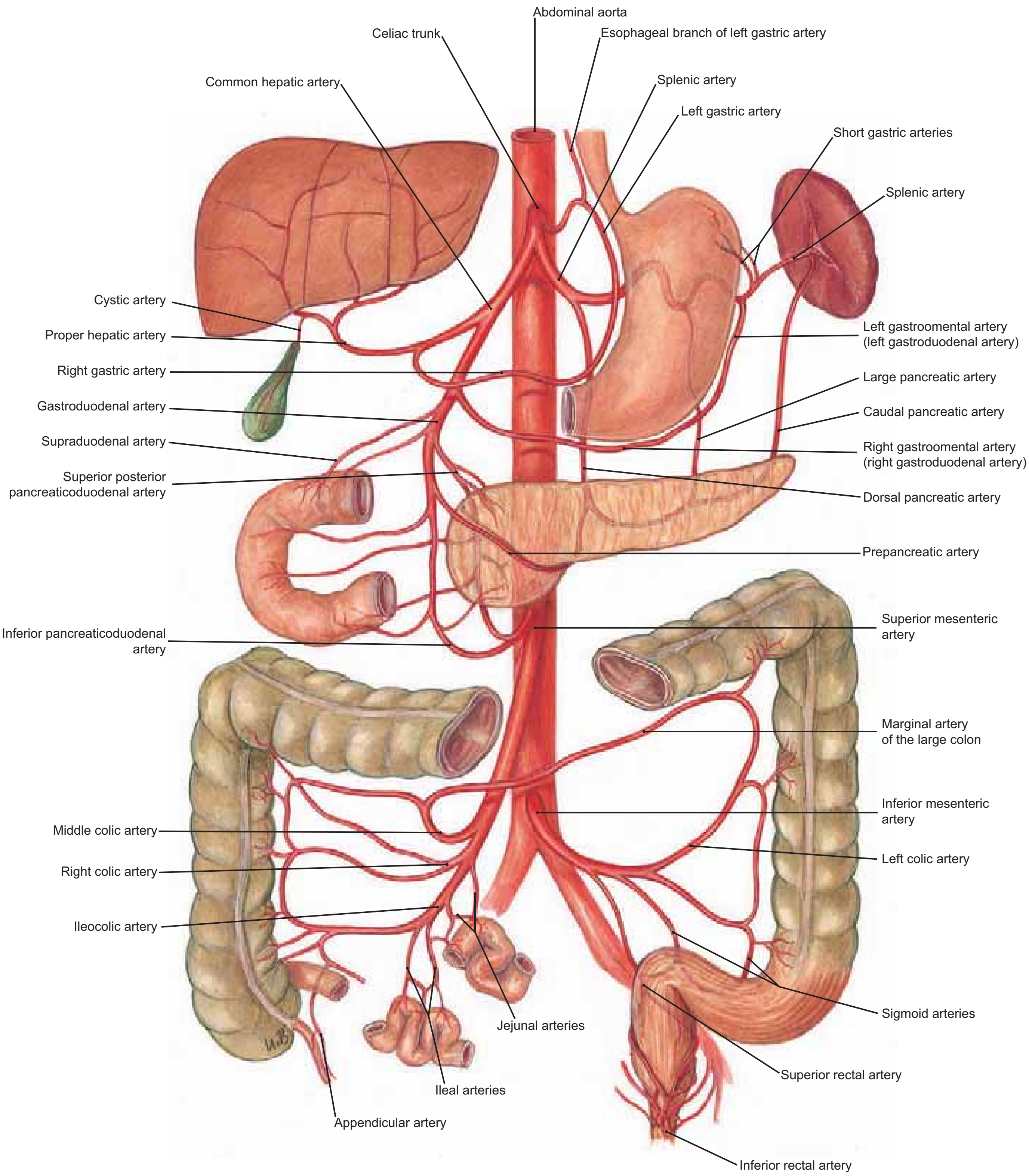


FIGURE 296 Arteries to the Abdominal Viscera

NOTE that these abdominal arteries are branches from the **celiac trunk, superior mesenteric artery,** or **inferior mesenteric artery.**

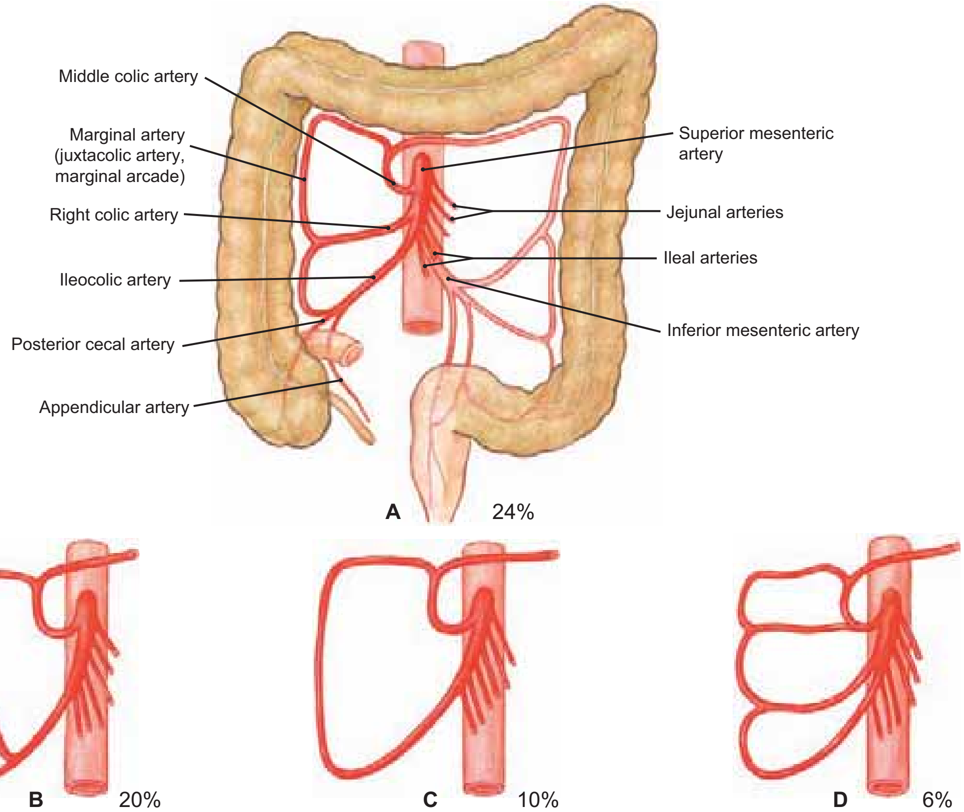


FIGURE 297.1 Variations in the Branching of the Superior Mesenteric Artery

NOTE: (1) Normal pattern: ascending and transverse colon supplied by three branches.
(2) Formation of an ileocolic and right colic trunk.
(3) Only two branches with the right colic artery absent.
(4) Two right colic arteries.

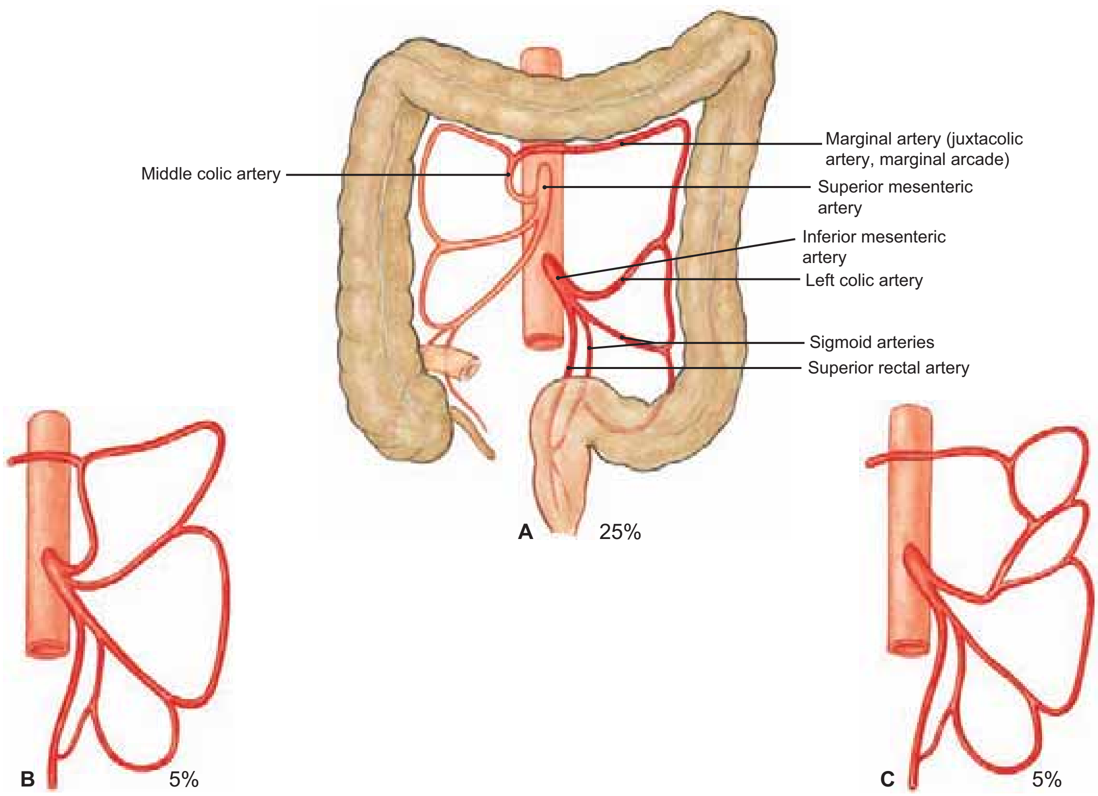


FIGURE 297.2 Variations in the Branching of the Inferior Mesenteric Artery

NOTE: (1) Single trunk that divides into three branches (for descending colon, sigmoid colon and rectum);
(2) An accessory middle colic artery branching from the inferior mesenteric artery;
(3) An accessory middle colic artery from the left colic artery. (For "normal pattern," see Fig. 294.)

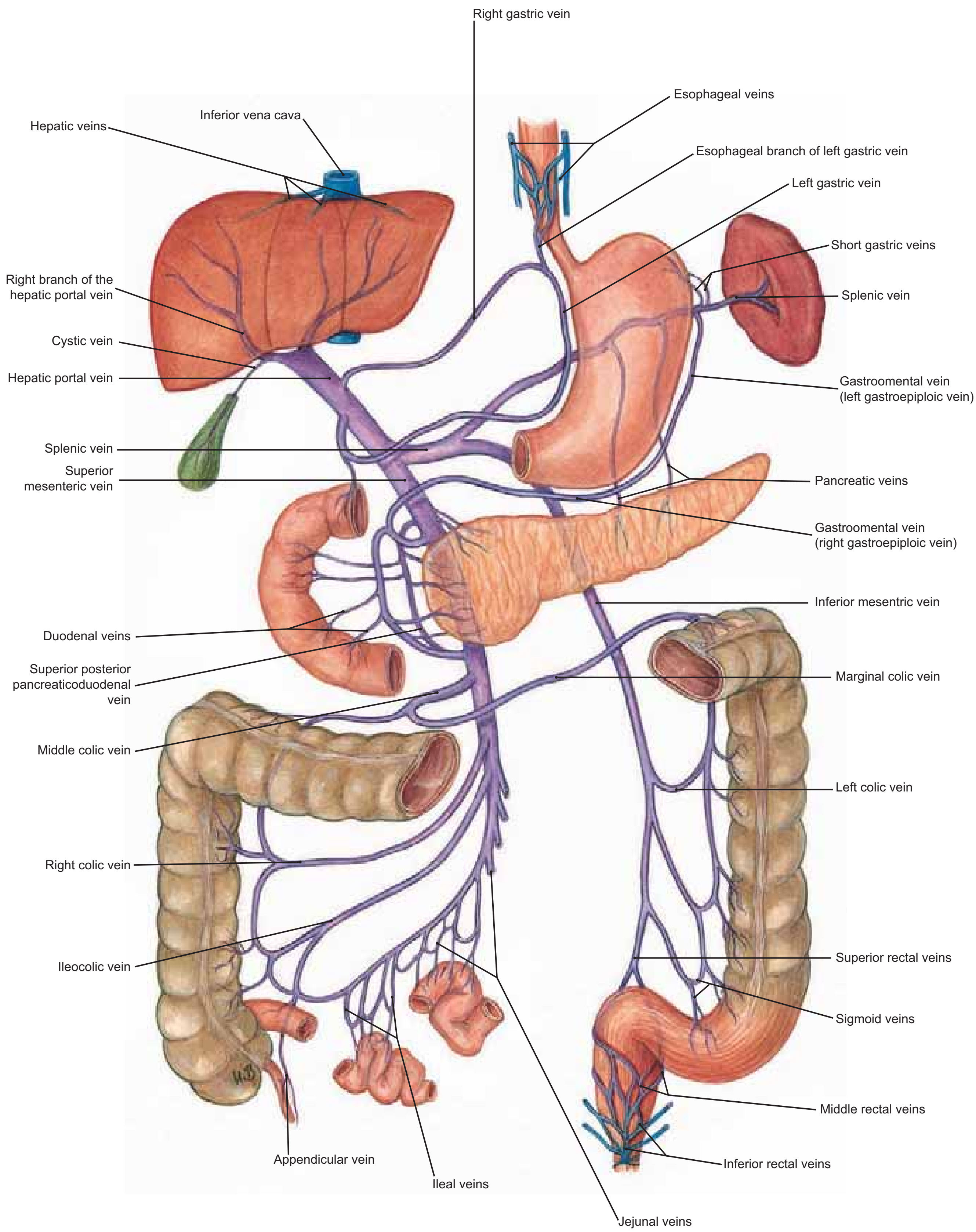


FIGURE 298 Venous Drainage of Abdominal Organs: Hepatic Portal Vein and Its Tributaries

NOTE: (1) The **inferior mesenteric vein** drains part of the transverse colon and the descending and sigmoid colons, and it flows into the splenic vein.

(2) The **superior mesenteric vein** drains the jejunum, ileum, ileocolic region, ascending colon, and part of the transverse colon. It ascends and receives pancreaticoduodenal branches, and **then** it is joined by the splenic vein to form the **portal vein.**

(3) The **splenic vein** not only receives venous blood from the inferior mesenteric vein but also drains the veins of the stomach. Esophageal veins draining the inferior part of the esophagus flow directly into the portal vein.

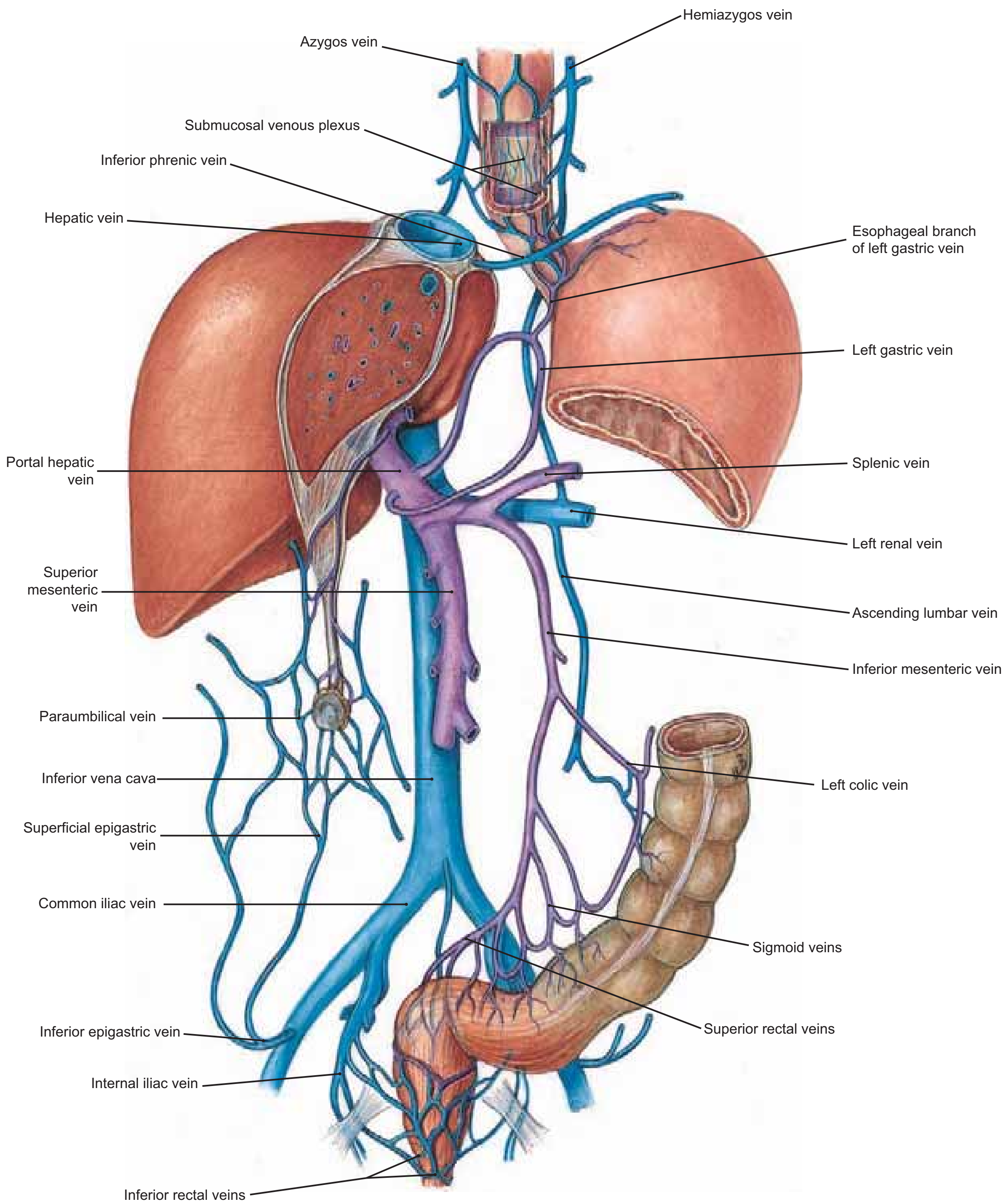


FIGURE 299 The Relationship of the Hepatic Portal Vein and the Inferior Vena Cava

NOTE: (1) The **paraumbilical veins** allow an anastomosis between veins on the anterior thoracic wall (paraumbilical and inferior epigastric veins) and the hepatic portal system of veins.
(2) The superior vena cava ascends posterior to the liver, but it receives the hepatic veins just before it courses through the diaphragm on its way to the right atrium.
(3) The inferior mesenteric vein joins the splenic vein, which then joins the superior mesenteric vein to form the portal vein.

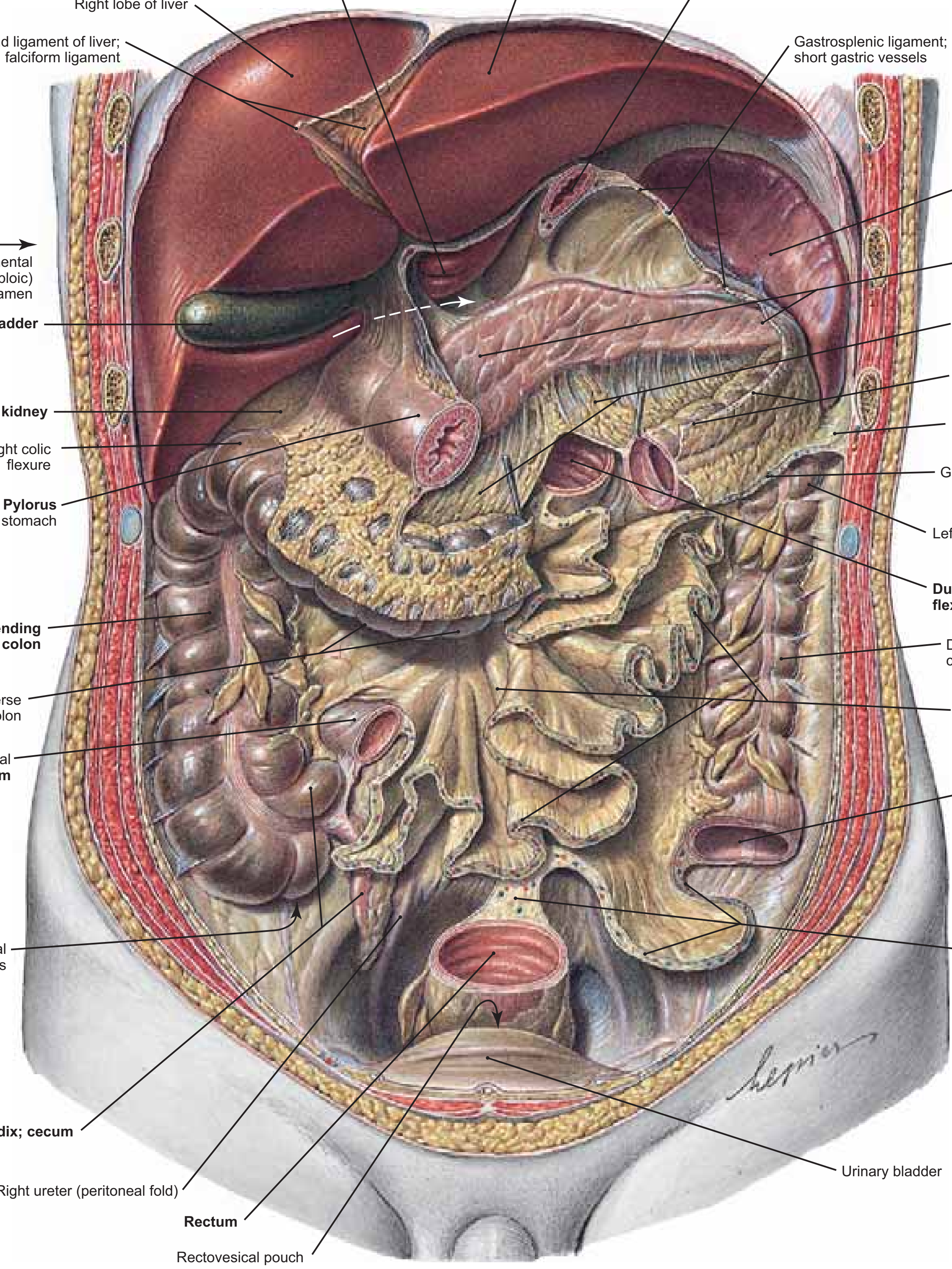


FIGURE 300 Abdominal Cavity: Large Intestine and Mesenteries

NOTE: (1) The stomach was cut just proximal to the pylorus and removed; the small intestine was severed at the duodenojejunal junction and at the distal ileum and also removed (by cutting the mesentery). A part of the transverse colon was resected along the greater omentum, and the sigmoid colon was removed to reveal its mesocolon.

(2) The **mesentery of the small intestine** extends obliquely across the posterior abdominal wall from the **duodenojejunal junction** to the **ileocecal junction.** In this 6 or 7 in., the mesenteric folds accommodate all of the loops of jejunum and ileum.

(3) The **ascending colon** and **descending colon** are fused to the posterior abdominal wall, whereas the **transverse colon** and **sigmoid colon** are suspended by their respective mesocolons.

(4) Vessels and nerves supplying the small intestine course between the layers of the mesentery to achieve the organ.

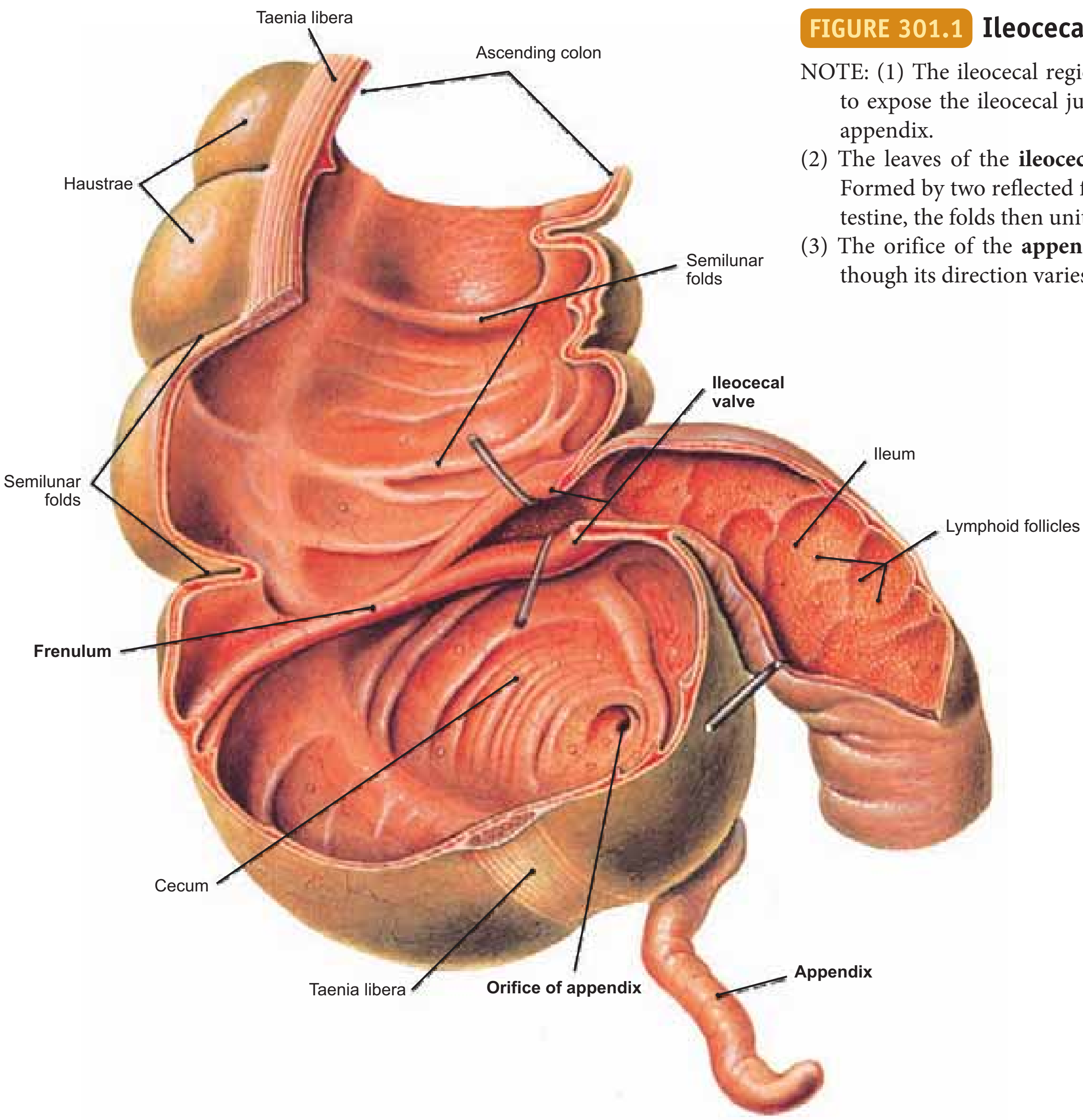


FIGURE 301.1 Ileocecal Junction

NOTE: (1) The ileocecal region has been opened anteriorly to expose the ileocecal junction and the opening of the appendix.

(2) The leaves of the **ileocecal valve** have been separated. Formed by two reflected folds of the wall of the large intestine, the folds then unite to form the **frenulum.**

(3) The orifice of the **appendix** opens into the cecum, although its direction varies (see Figs. 302.2 and 303.1).

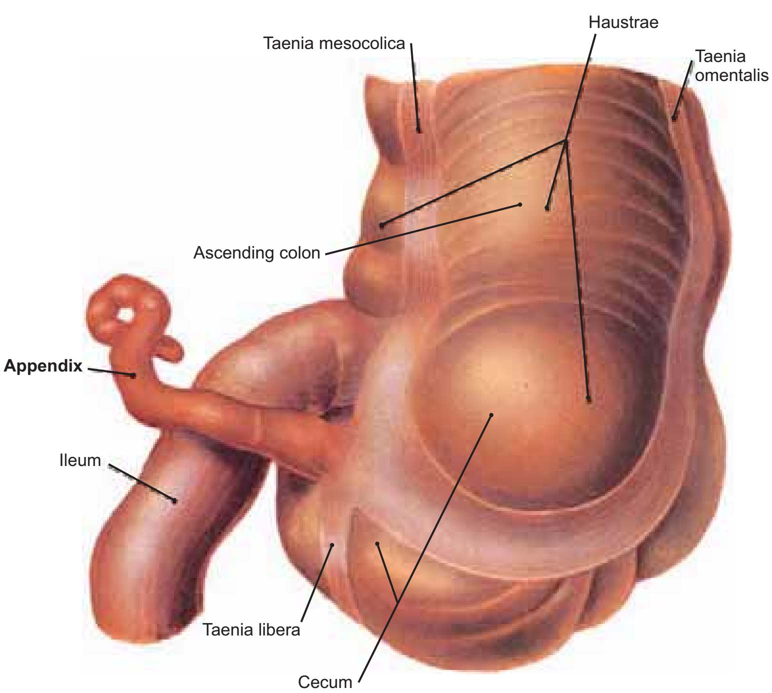


FIGURE 301.2 Dorsal View of the Cecum and Appendix

NOTE: (1) The attachments of the ileum and appendix to the cecum are clearly visualized with the peritoneum stripped away.

(2) The **taeniae coli** (three) are strips of longitudinal smooth muscle. The **taenia libera** is located anterior on the cecum, the **taenia mesocolica** is situated posteromedially, whereas the **taenia omentalis** is located posterolaterally on the cecum.

(3) The three taeniae come together at the origin of the appendix on the cecum.

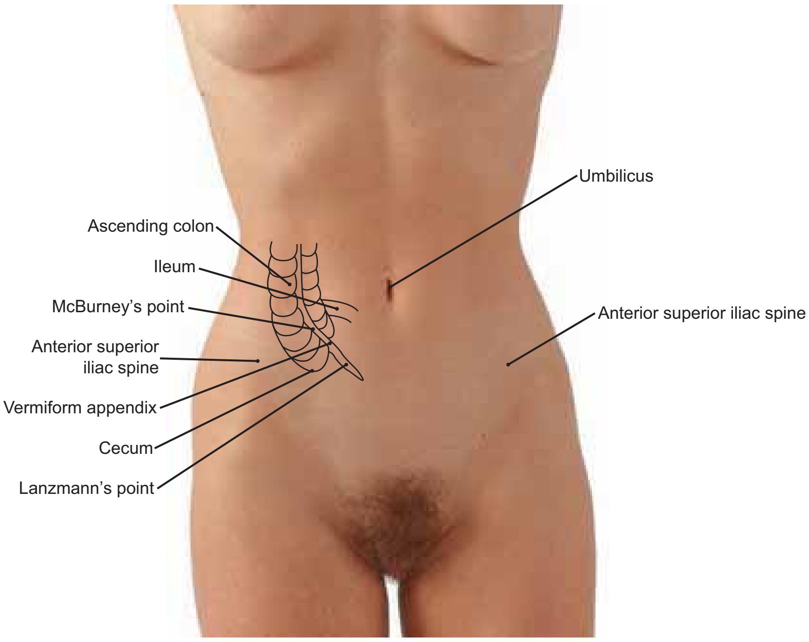


FIGURE 302.1 Surface Projection of the Cecum and the Vermiform Appendix

NOTE: (1) The vermiform appendix emerges from the posteromedial wall of the cecum slightly less than 1 in. (about 2 cm) distal to the end of the ileum.

(2) Inflammation of the appendix, called **appendicitis,** is indicated by severe abdominal pain. This often results from an obstruction of the lumen of the appendix that may be due to a proliferation of lymphatic nodules or by a fecalith (a hardened intestinal concretion that forms around a center of fecal matter). After a period of time, the walls of the appendix become inflamed, and pain is usually felt with or without pressure in the lower right quadrant.

(3) Another cause of appendicitis can be an interruption of the blood supply to the appendix.

***Lanzmann's Point:** A tender point in appendicitis situated on a line between the two anterior superior iliac spines, 5 to 6 cm from the right spine and 2 cm below McBurney's point.

****McBurney's Point:** A point of special tenderness in acute appendicitis situated about 2 in. (5 cm) from the right anterior superior iliac spine on a line between the spines and the umbilicus.

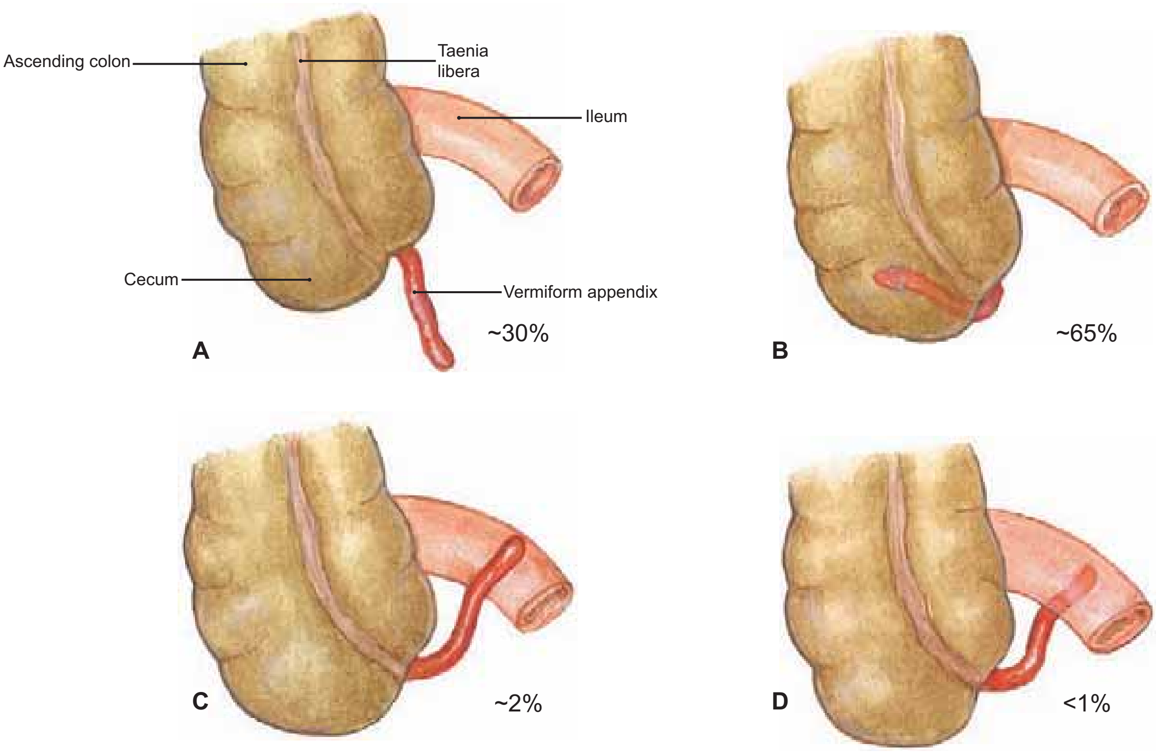


FIGURE 302.2 The Appendix: Variations in Location

A: Descending over the pelvic brim; **B:** retrocecal location; **C:** anterior to the ileum; **D:** posterior to the ileum.

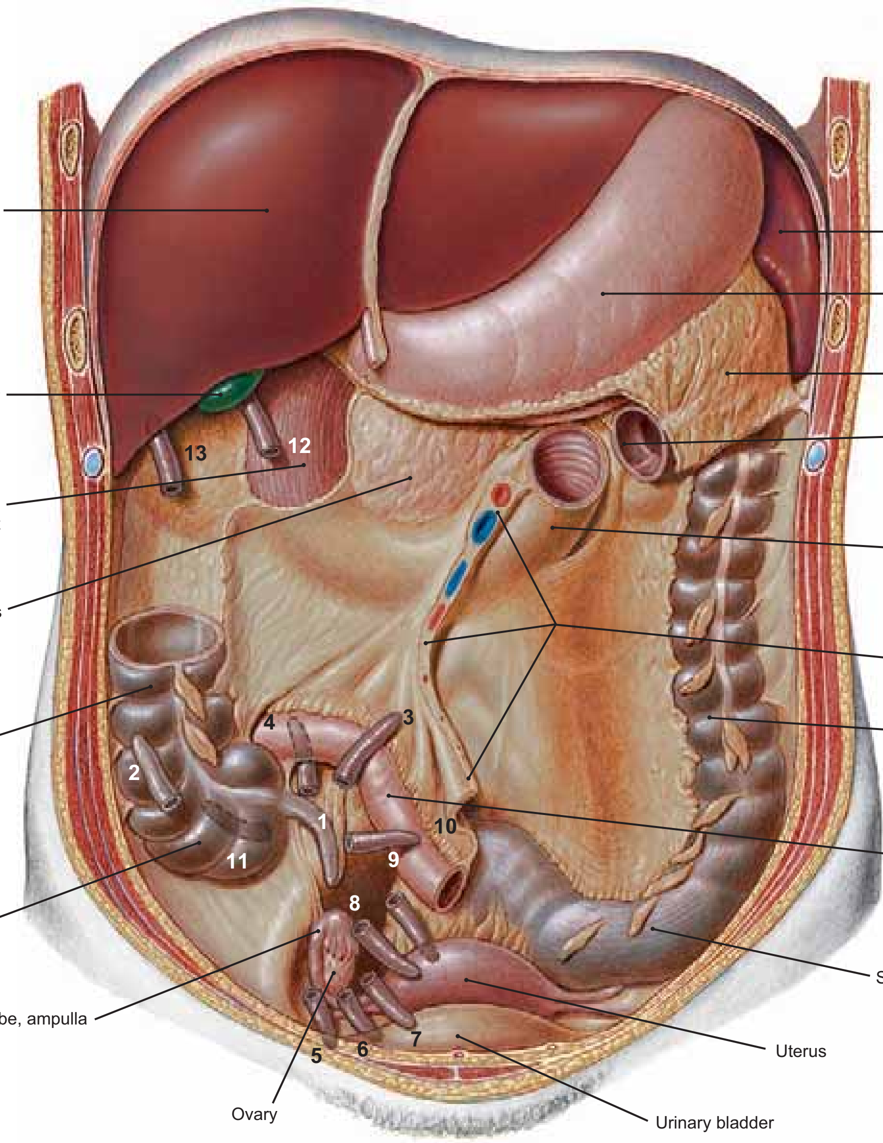


FIGURE 303.1 Variations in the Location of the Appendix

NOTE that at least 13 sites for the appendix have been reported; most common are 11, 1, 3, 10, and 4, respectively.

1. Over the pelvic brim
2. Anterolaterally
3. Toward the root of the mesentery
4. Dorsal to the terminal ileum
5. Toward the deep inguinal ring
6. In the uterovesical pouch
7. Anterior to the bladder
8. On the uterus or uterine tube
9. In the rectouterine pouch
10. Medially, anterior to the ileum
11. Behind the cecum
12. Toward the gallbladder
13. Toward the liver

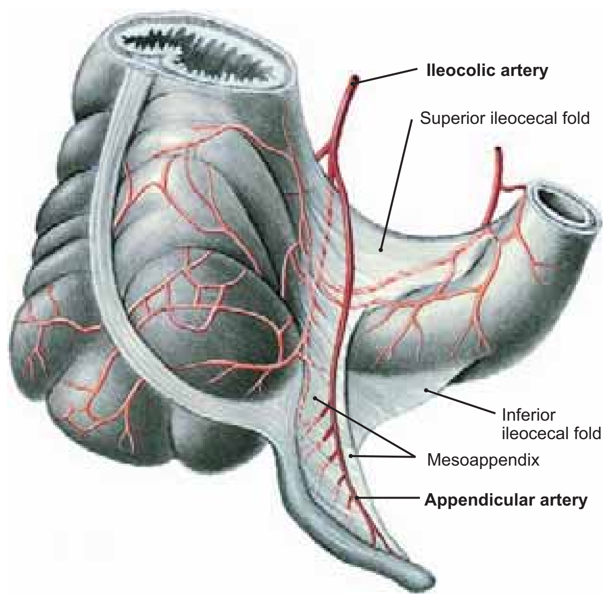


FIGURE 303.2 Blood Supply to the Vermiform Appendix

NOTE: The appendix usually receives its vascular supply by way of the **appendicular artery,** a branch of the ileocolic artery, and it descends either anterior to the ileocecal junction (as shown) or behind it.

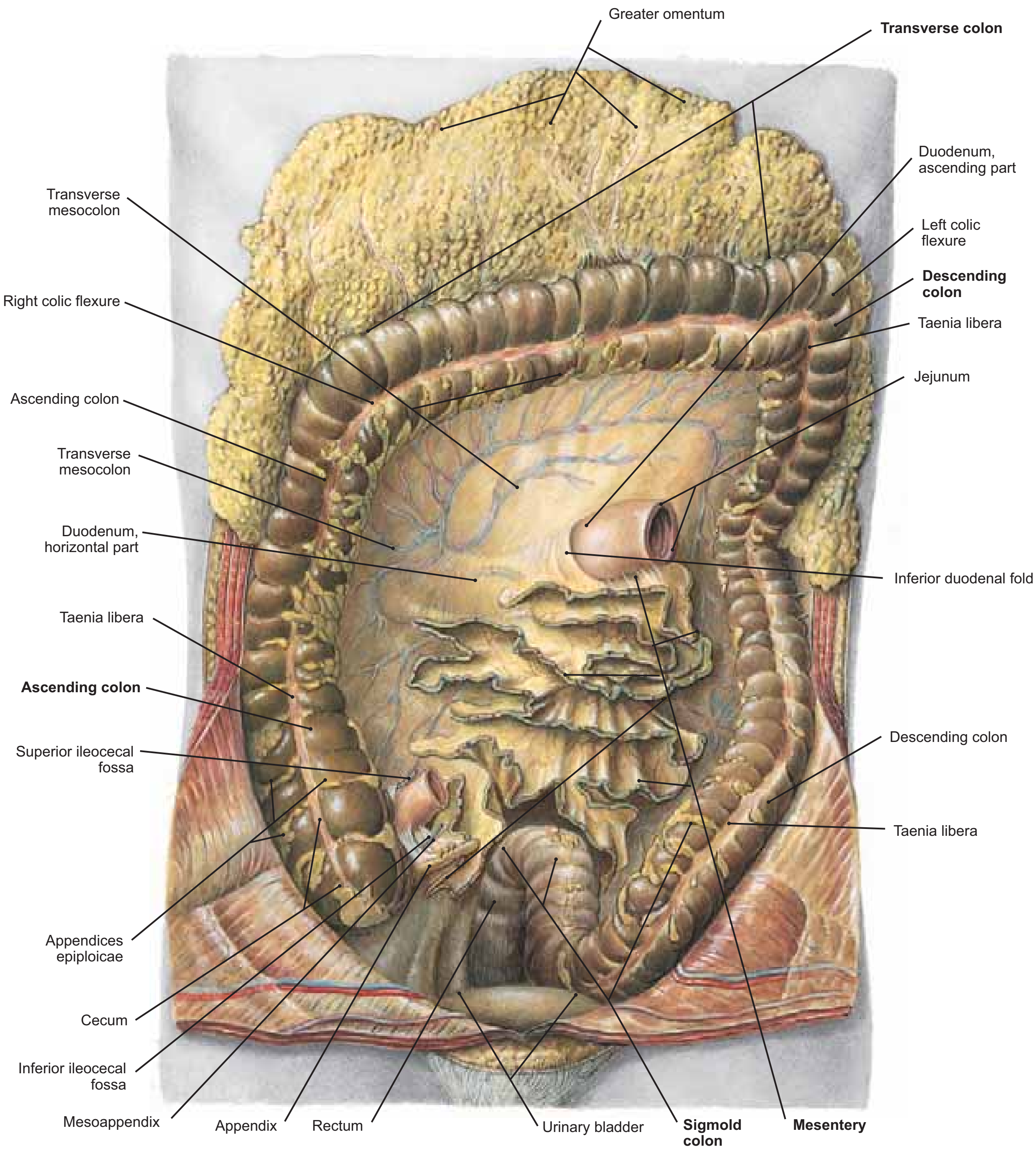


FIGURE 304.1 Large Intestine from Cecum to Rectum ▲

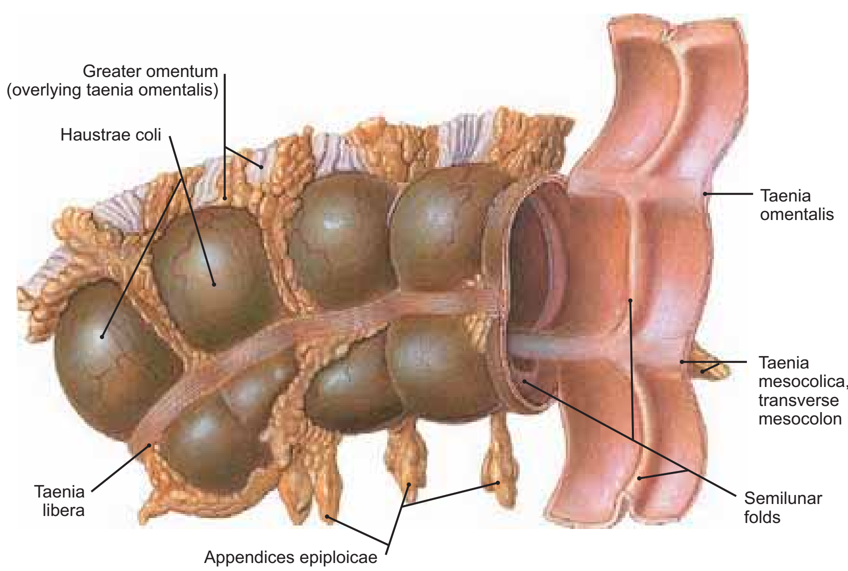


FIGURE 304.2 Segment of Transverse Colon

NOTE: (1) A cut was made along the **taenia libera** at the right of this segment of transverse colon, and its wall opened to show its inner surface.

(2) The greater omentum attaches along the **taenia omentalis,** the transverse mesocolon attaches along the **taenia mesocolica,** whereas the **taenia libera** is free from such attachments.

(3) The large intestine is about 5 ft long and its diameter (1.5–3 in.) varies, being widest at the cecum, then narrowing, and dilating again at the rectal ampulla.

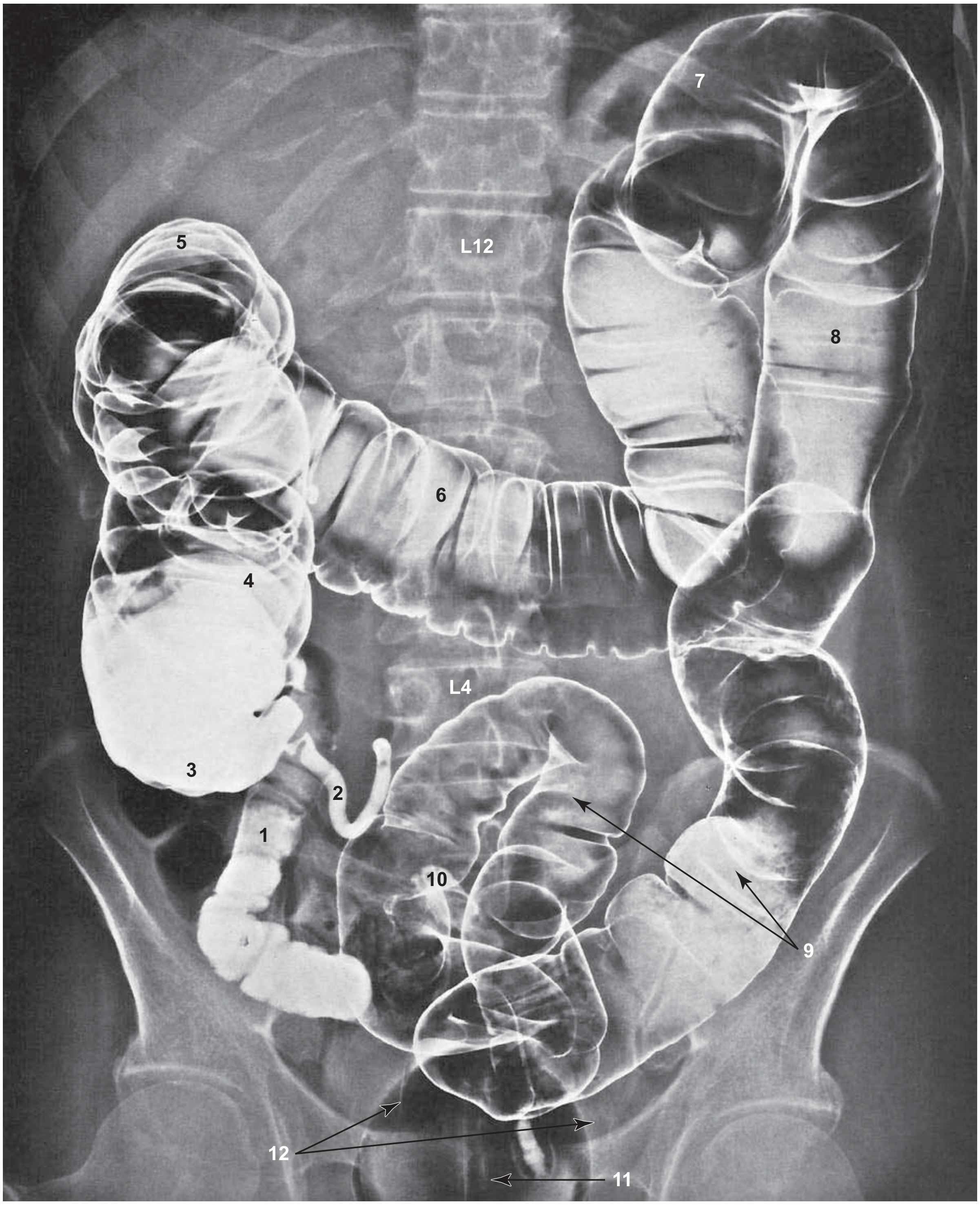


FIGURE 305 **Radiographic Anatomy of the Large Intestine (Double Contrast)**

NOTE: (1) In this patient, barium sulfate was administered as an enema and the mixture was then expelled and the colon insufflated with air (barium–air double contrast method).

(2) The cecum [3] is usually located in the iliac fossa of the lower right quadrant, and it forms a cul-de-sac that opens into the ascending colon [4]. The terminal ileum [1] most often joins the cecum on its medial or posterior surface. The appendix [2] extends from the cecum about 2 cm below the ileocecal opening. The right colic flexure [5] continues to the left to become the transverse colon [6].

(3) The transverse colon, suspended by its mesentery, crosses the abdomen. It turns inferiorly at the left colic flexure [7] as the descending colon [8].

(4) The descending colon becomes the sigmoid colon [9] at the inlet to the lesser pelvis. With its mesentery, the sigmoid colon leads into the rectum [10], within the true pelvis.

(5) The locations of the T12 and L4 vertebrae, the symphysis pubis [11], and an air-filled balloon [12].

(From Wicke, 3rd ed.)

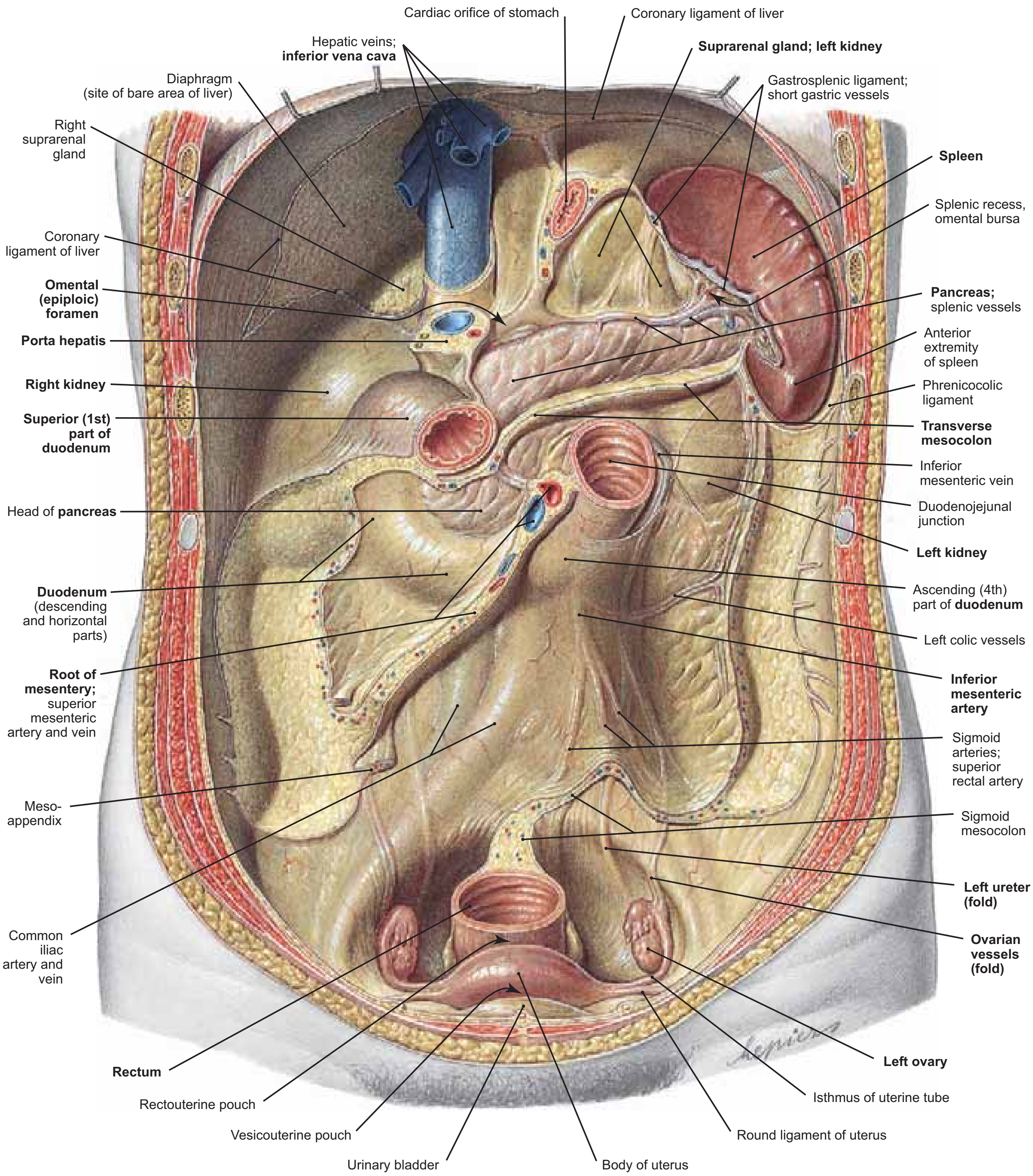


FIGURE 306 Abdominal Cavity; Posterior Abdominal Peritoneum (Female)

NOTE: (1) The stomach and the intestines (except for the duodenum and rectum) have been removed and their mesenteries cut close to their roots on the posterior abdominal wall. The liver and gallbladder were also removed, but the spleen and the retroperitoneal organs (duodenum, pancreas, adrenal glands, kidneys and ureters, aorta, and inferior vena cava) are intact.

(2) The ascending and descending portions of the large intestine are fused to the posterior abdominal wall with peritoneum covering their anterior surfaces.

(3) The course of the ureters and ovarian vessels descending over the pelvic brim. Observe the ovaries, uterine tubes, and uterus located in the pelvis and their relationship to the rectum and bladder.

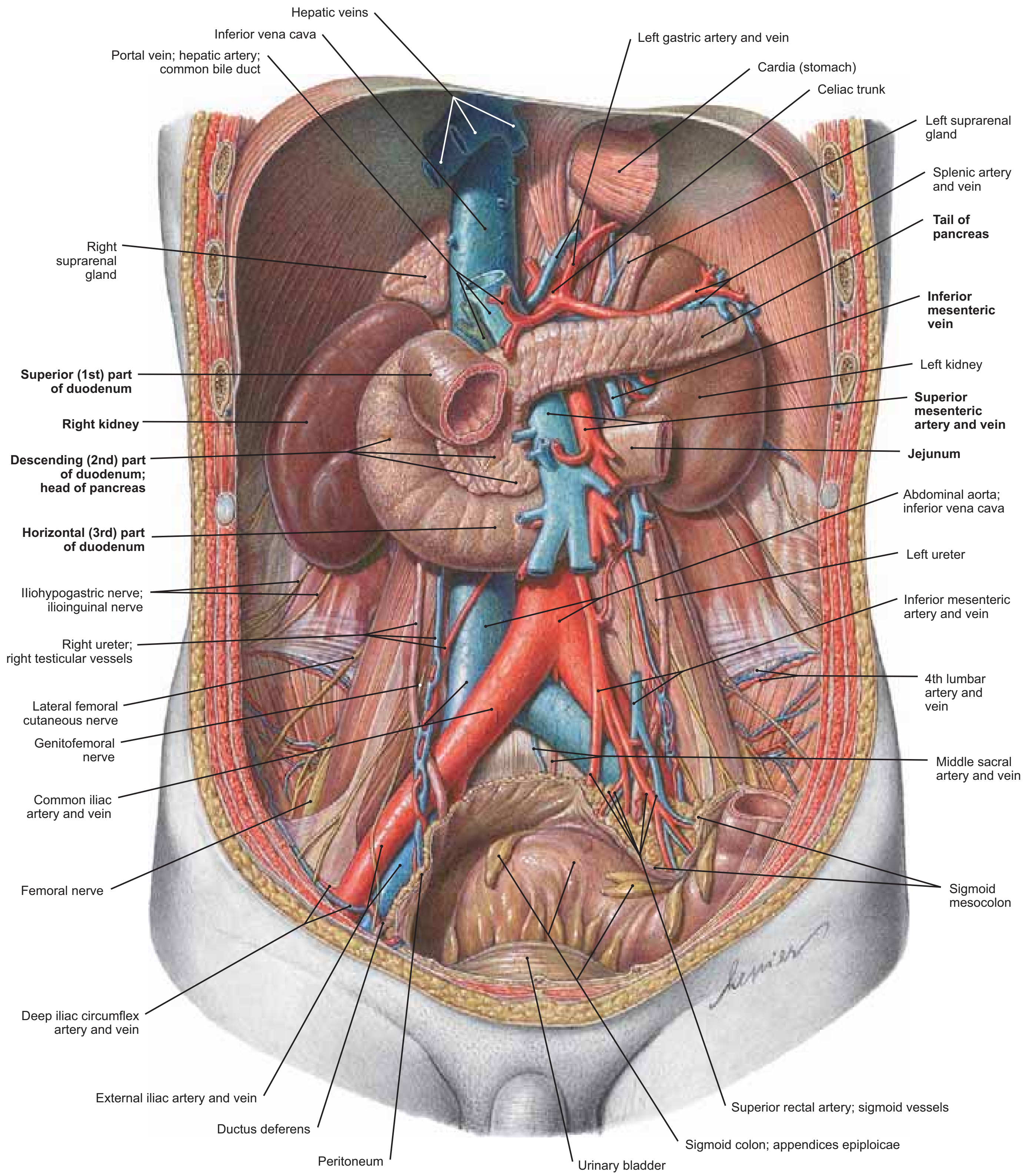


FIGURE 307 Abdominal Cavity: Retroperitoneal Organs (Male)

NOTE: (1) The curvature of the duodenum lies ventral to the hilum of the right kidney, and the duodenojejunal junction is ventral to the lower medial border of the left kidney. The right kidney is slightly lower than the left.

(2) The head of the pancreas lies anterior to the inferior vena cava and within the curve of the duodenum. An extension of the pancreatic head, the uncinate process (see Fig. 283.2) lies behind the root of the superior mesenteric vessels.

(3) Upon crossing the midline at the L1 level, the posterior surface of the body and tail of the pancreas is in contact with the middle third of the left kidney.

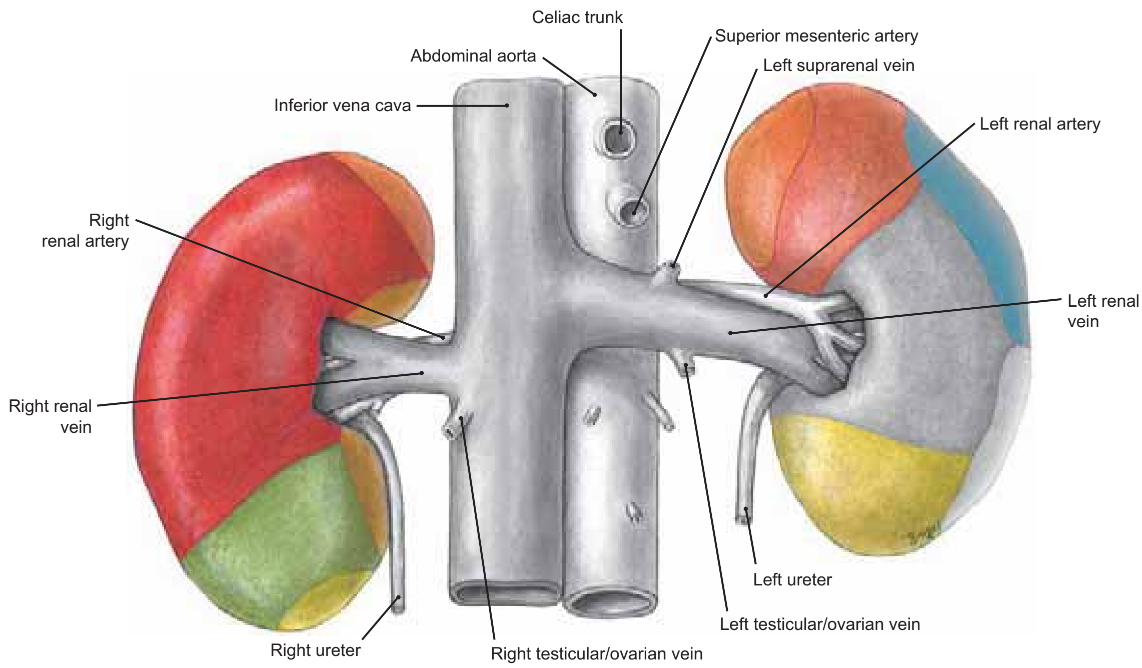


FIGURE 308.1 Anterior Surface Contact Relationships of the Kidneys

NOTE: (1) The relationships of abdominal organs to the anterior surface of the kidneys are characterized either by a peritoneal reflection (**serosal**) intervening between the overlying organ and the kidney or by a direct contact between the kidney and the overlying organ (**fibrous**).

(2) The structures in contact with the anterior surface of the **right kidney** are the right suprarenal gland, hepatorenal ligament, duodenum (second part), liver, right colic flexure and transverse colon, and a small area of the jejunum.

(3) The structures in contact with the anterior surface of the **left kidney** are the left suprarenal gland, stomach, spleen, pancreas, jejunum, and left colic flexure. (See **Color Code** below.)

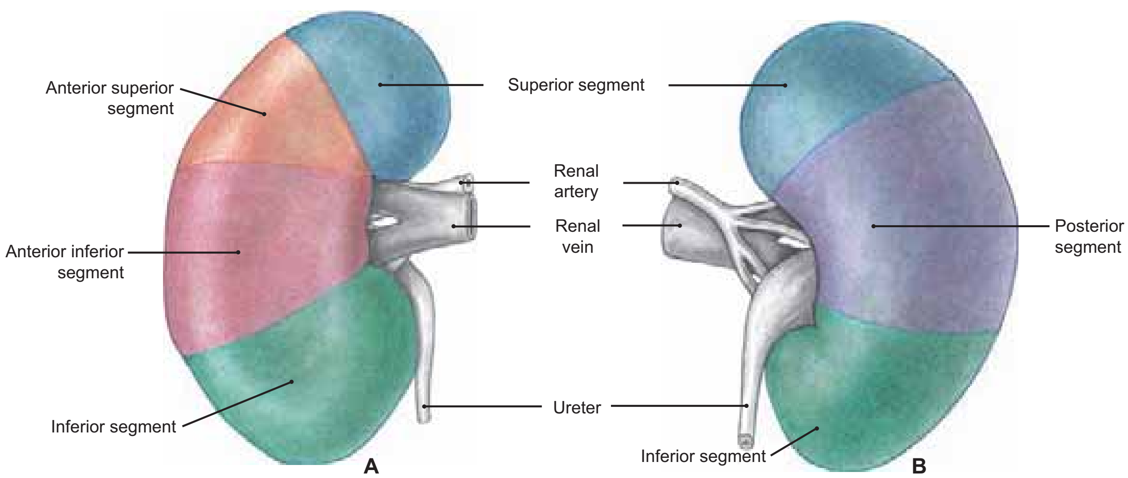


FIGURE 308.2 Segments of the Right Kidney

NOTE: **A:** Anterior surface of the renal segments.
B: Posterior surface of the renal segments.
Each segment has the same color on both anterior (**A**) and posterior (**B**) views of this right kidney.

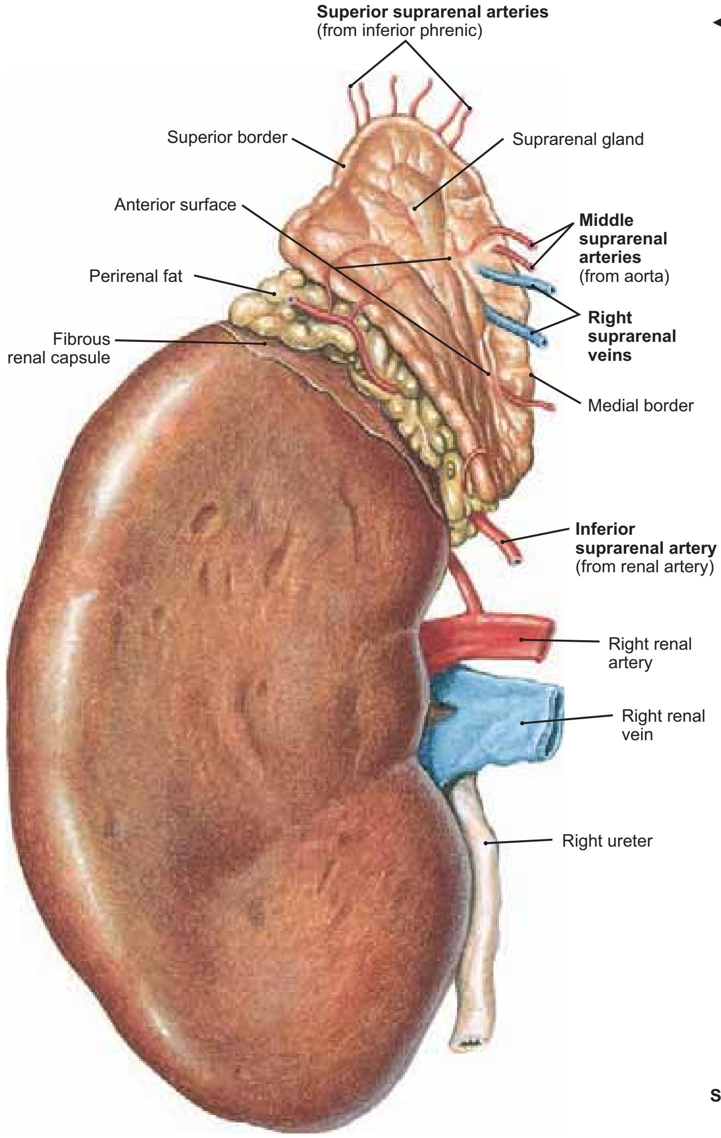


FIGURE 309.1 Right Kidney and Suprarenal Gland

NOTE: (1) The suprarenal or adrenal gland is an endocrine gland whose secretions are vital for life. The glands are located in the posterior abdominal region and situated adjacent to the superior poles of the kidneys.

(2) The **right suprarenal gland** is pyramidal in shape, and its anterior surface lies behind the inferior vena cava and adjacent to the right lobe of the liver. Its posterior surface is in contact with the diaphragm and the right kidney.

(3) The suprarenal glands are highly vascular and receive arterial blood from branches directly off the aorta and others from the inferior phrenic and renal arteries. Venous blood is drained by a single vein or by a pair of veins that, on the right side, flow directly into the inferior vena cava, and on the left, into the renal vein.

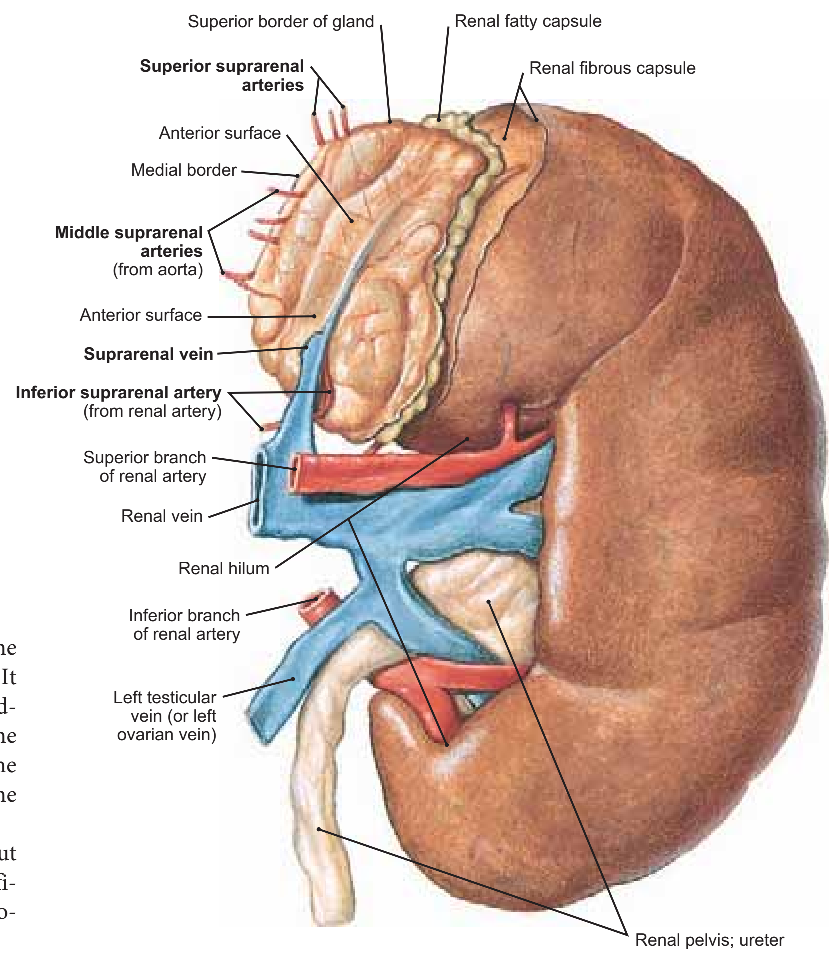


FIGURE 309.2 Left Kidney and Suprarenal Gland

NOTE: (1) The **left suprarenal gland** is oriented onto the medial surface of the upper pole of the left kidney. It presents a crescentic shape with its concave surface adjacent to the kidney. Its anterior surface lies behind the cardiac end of the stomach and pancreas (behind the omental bursa), whereas its posterior surface rests on the crus of the diaphragm.

(2) The combined weight of the two glands averages about 10 g. The glands are each surrounded by an investing fibrous capsule, around which is a certain amount of areolar tissue.

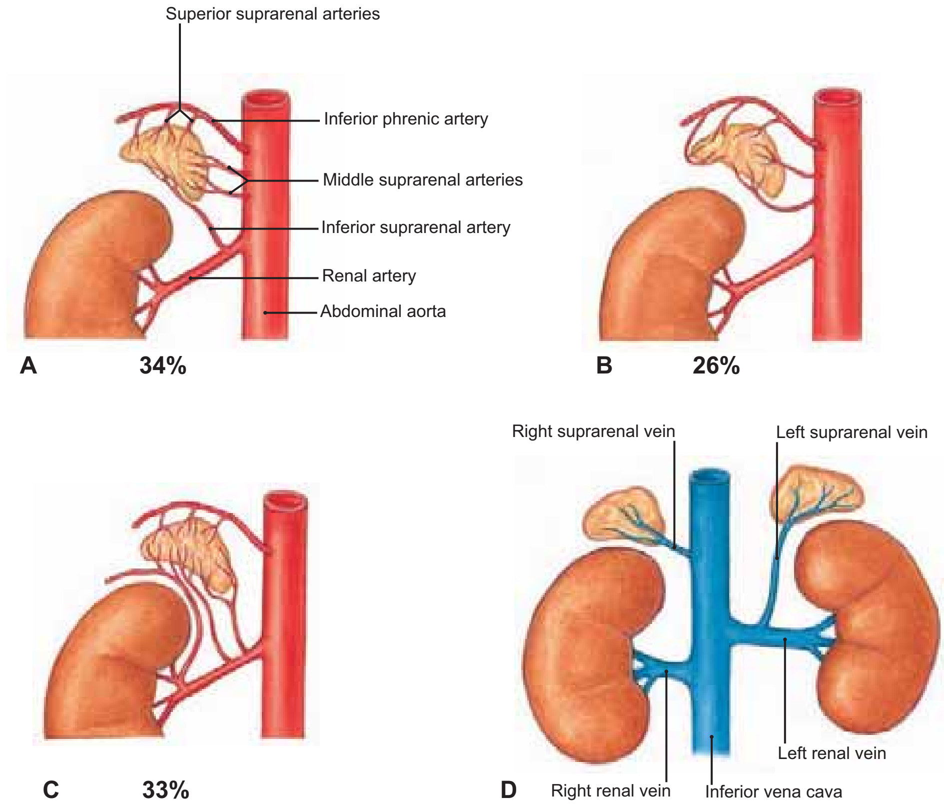


FIGURE 310.1A–D Variations of the Arteries to the Suprarenal Gland; Suprarenal Veins

NOTE that the suprarenal glands receive blood directly from the aorta and/or the renal arteries. Drainage of the veins differs on the two sides of the body.

A: Four arteries supplying the suprarenal gland (textbook case). **B:** Arterial supply only from the aorta. **C:** Arterial supply from the aorta and multiple vessels from the renal artery. **D:** Drainage from the renal veins.

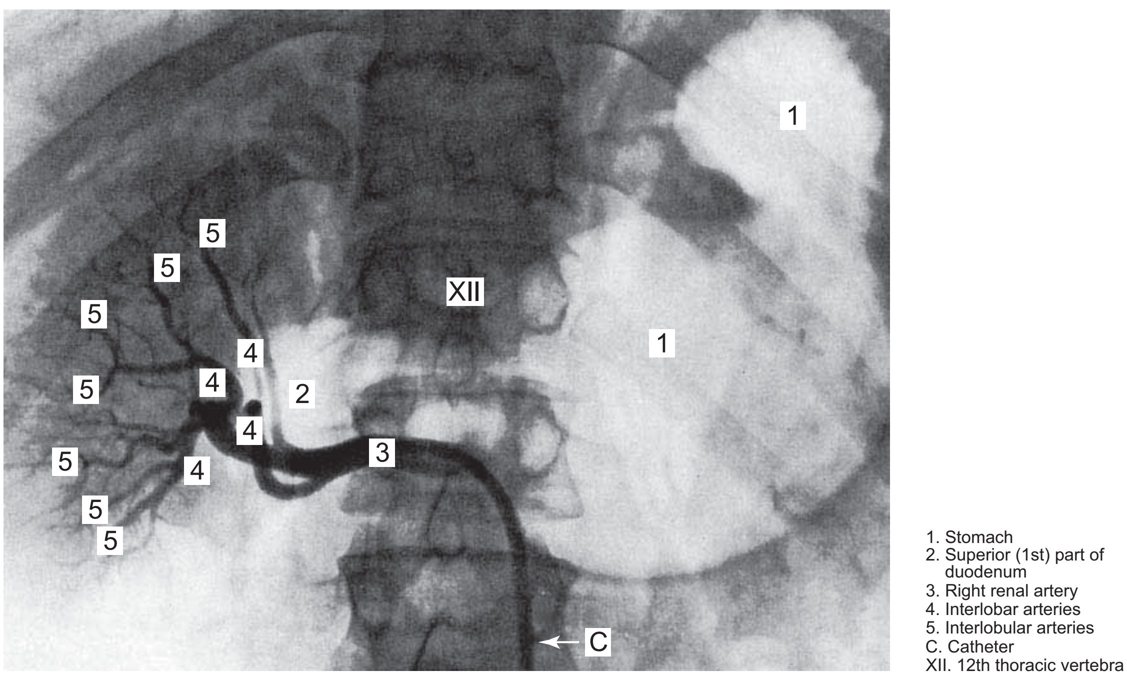


FIGURE 310.2 Arteriogram of Right Renal Artery and Its Branches

NOTE: (1) An arterial catheter [C] has been inserted into the femoral artery and passed through the abdominal aorta and then the **right renal artery.** Observe the division of the renal artery successively into **interlobar arteries.**

(2) As the interlobar arteries reach the junction of the renal cortex and medulla, they arch over the bases of the pyramids, forming **arcuate arteries** (not numbered in this figure). From the arcuate arteries branch a series of **interlobular arteries** [5], which extend through the afferent arterioles entering the renal glomeruli.

(3) The stomach [1] and superior part of the duodenum [2], which are filled with air.

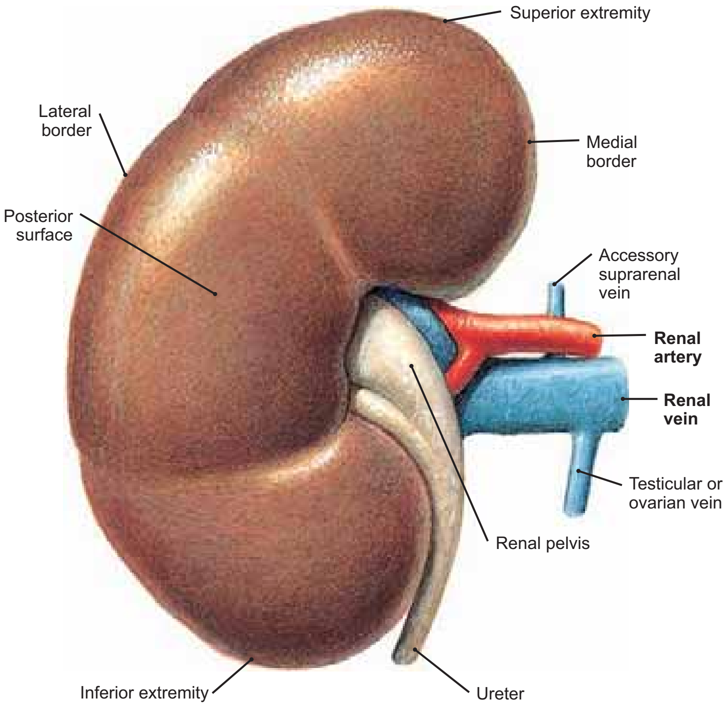


FIGURE 311.1 **Left Kidney (Dorsal View)**

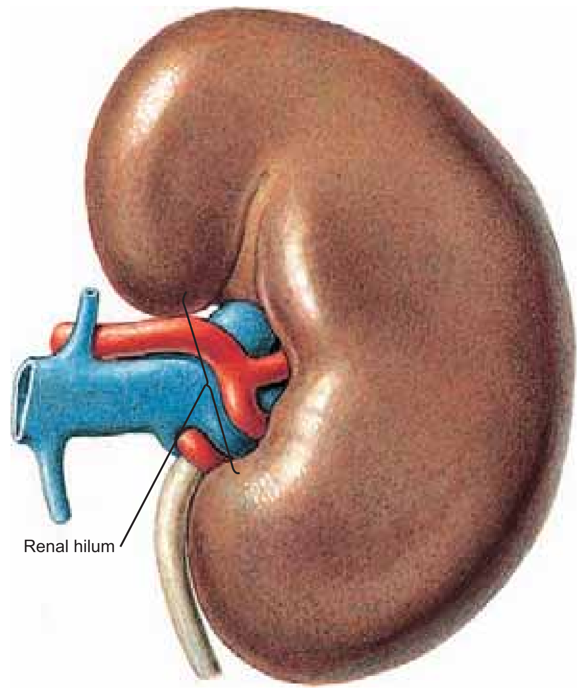


FIGURE 311.2 **Left Kidney (Ventral View)**

NOTE: (1) The kidneys are paired, bean-shaped organs, and normally weigh about 125 to 150 g each. Their lateral borders are convex and their medial borders concave, the latter being interrupted by the renal vessels and the ureter.

(2) The **ureter** is the most posterior structure at the hilum (see Fig. 311.1). The **renal vein** is the most anterior structure at the hilum, but the **renal artery** frequently divides into anterior and posterior branches (or divisions), and the anterior branch often enters the kidney ventral to the renal vein, as shown in Figure 311.2.

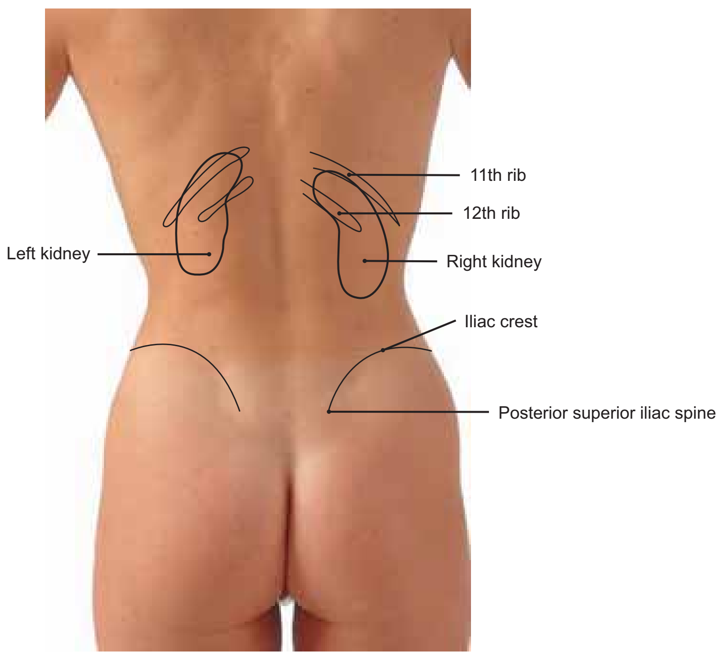


FIGURE 311.3 **Surface Anatomy of the Back, Showing the Projection of the Kidney**

NOTE: (1) The right kidney is more caudal than the left. Note that the large right lobe of the liver lies just superior to the right kidney.

(2) The inferior poles of the two kidneys are oriented more laterally than the superior poles. Observe the relationship of the kidneys to the 11th and 12th ribs on the two sides.

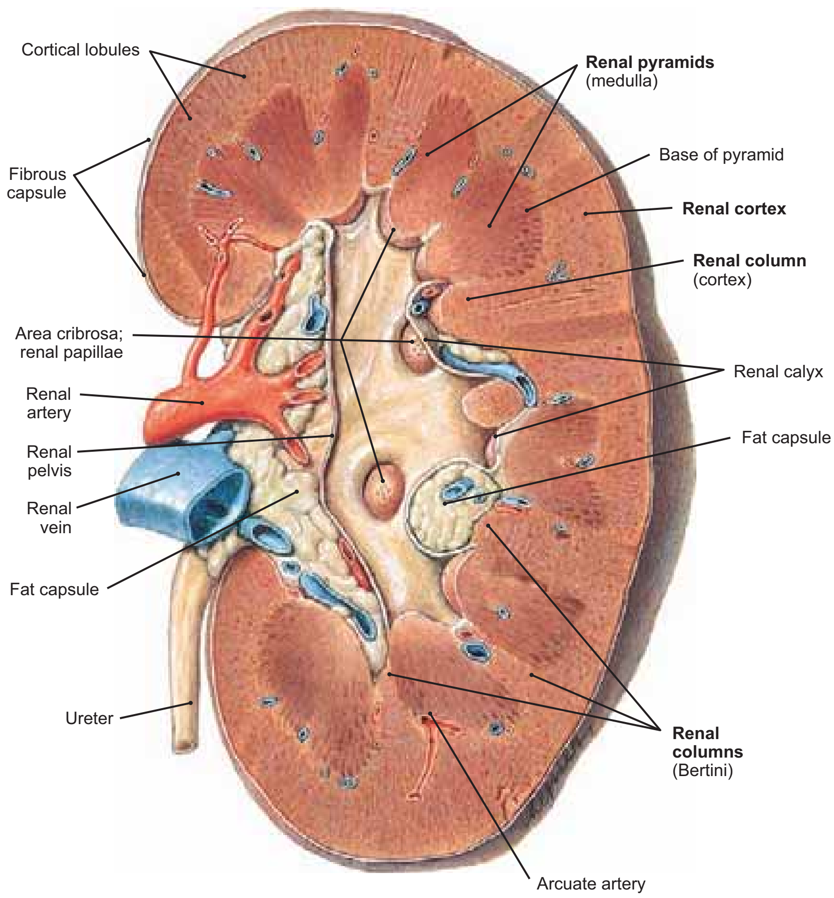


FIGURE 312.1 Left Kidney: Frontal Section through Renal Vessels

NOTE: (1) The **cortex** of the kidney consists of an outer layer of somewhat lighter and granular-looking tissue, which is also seen to dip as **renal columns** (of Bertini) toward the pelvis of the kidney, thereby separating the conical **renal pyramids** of the **medulla.**

(2) Within the cortex are found the tufted glomeruli and convoluted tubules, whereas the renal pyramids principally contain the loops of Henle and the collecting tubes.

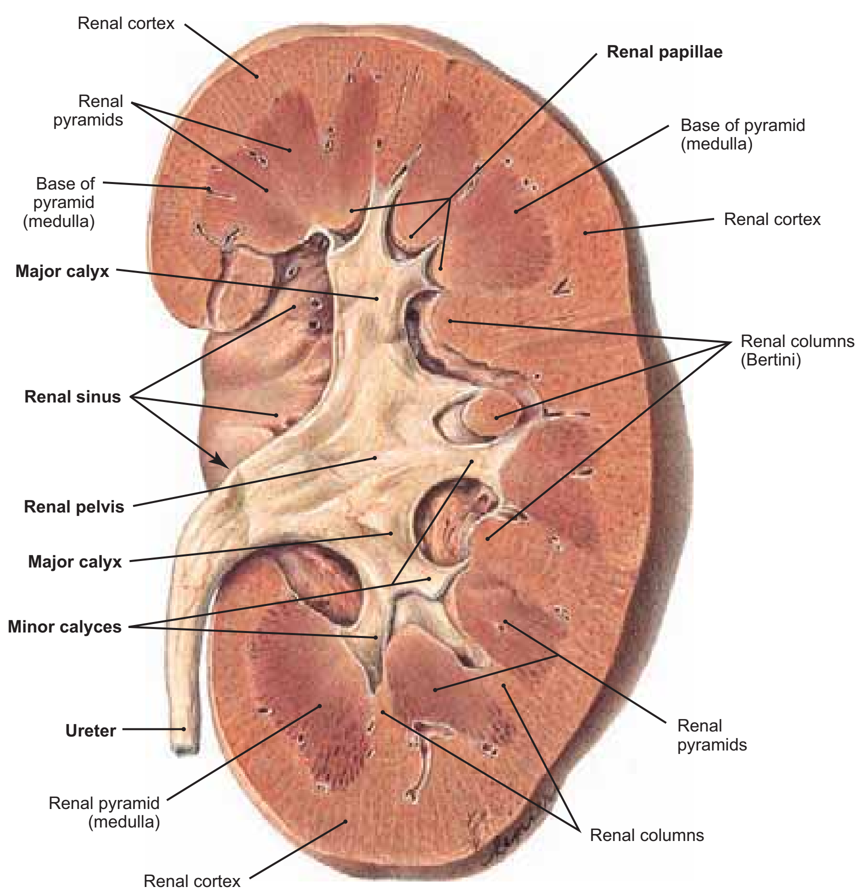


FIGURE 312.2 Left Kidney: Frontal Section through Renal Pelvis

NOTE: (1) This frontal section cuts through the renal pelvis and ureter. The **renal papillae** are cupped by small collecting tubes, the **minor calyces.**

(2) Several minor calyces unite to form a **major calyx,** whereas the **renal pelvis** is formed by the union of two or three major calyces. Leading from the renal pelvis is the somewhat more narrowed **ureter.**

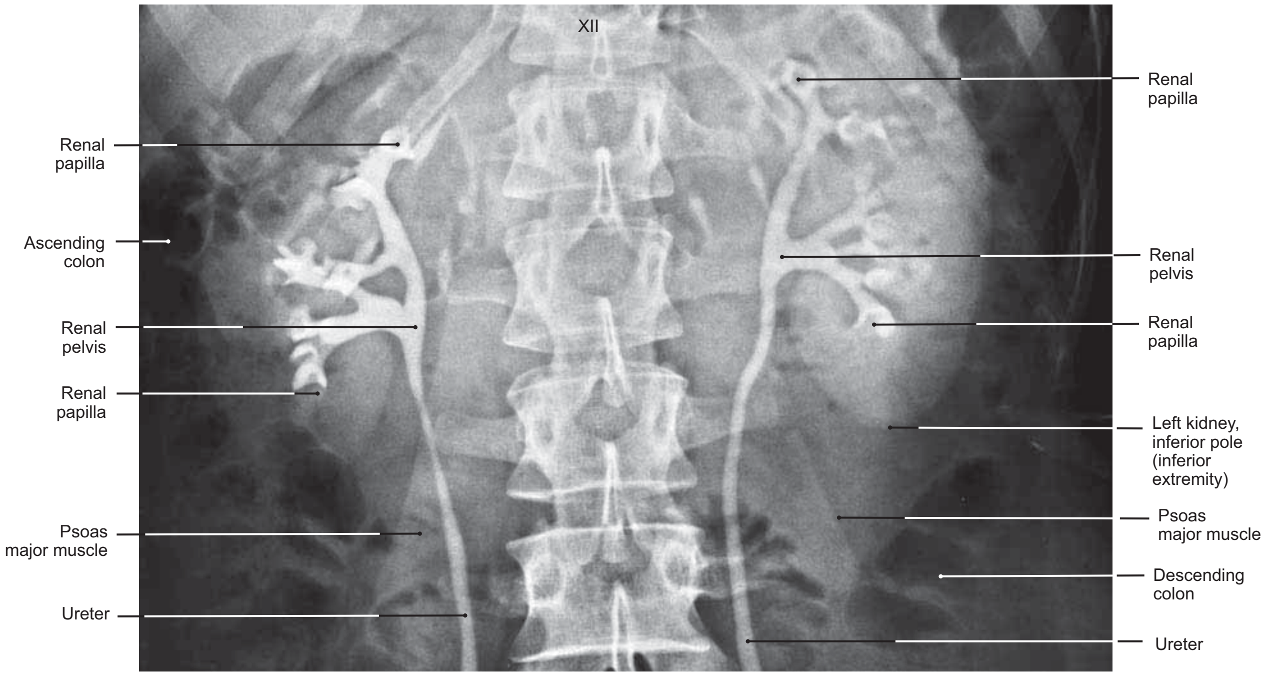


FIGURE 313.1 Retrograde Pyelogram

NOTE: (1) A radiopaque substance has been introduced into each ureter and forced into the renal pelvis, major calyces, and minor calyces of each side. Observe that into the minor calyces project the renal papillae, resulting in radiolucent invaginations into the radiopaque minor calyces.
(2) The shadow of the superior extremity of the left kidney extending to top of the body of the T12 vertebra, while the right kidney is somewhat more inferior.
(3) The lateral margins of the psoas major muscles. The ureters course toward the pelvis along their anterior surfaces.

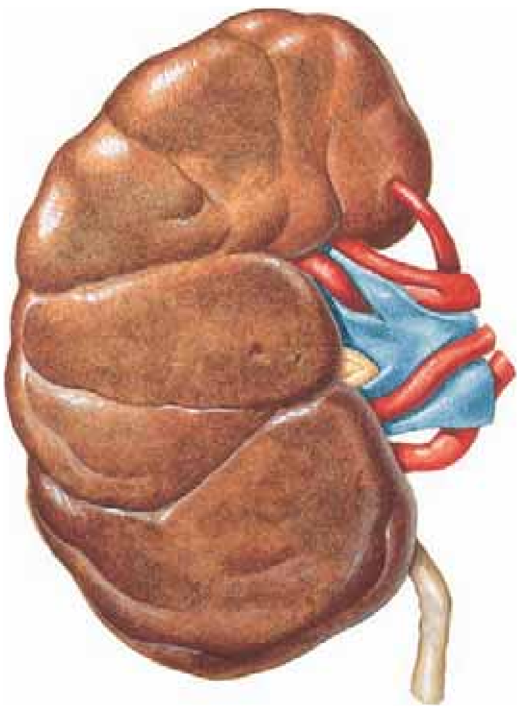


FIGURE 313.2 Fetal Lobulation May Persist in the Adult Kidney

NOTE: The kidney of the fetus is divided into small lobules that are separated by interlacing grooves on the renal surface. This lobulation usually disappears during the first postnatal year but may persist in the adult but with **no functional impairment.**

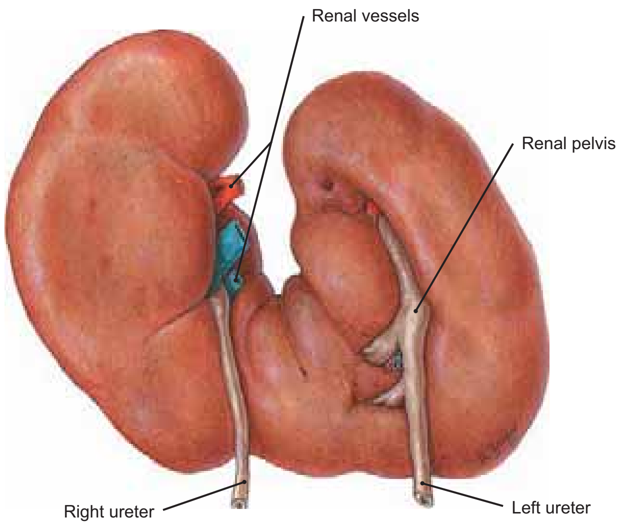


FIGURE 313.3 Horseshoe Kidney (Anterior View)

NOTE: (1) **Horseshoe kidney** is a common anomaly (1 in 500 persons) in which the lower poles of the kidneys are fused.
(2) The fusion crosses the midline and is often found at the level of the aortic bifurcation. The ureters in the horseshoe kidney lie ventral to the renal vessels.

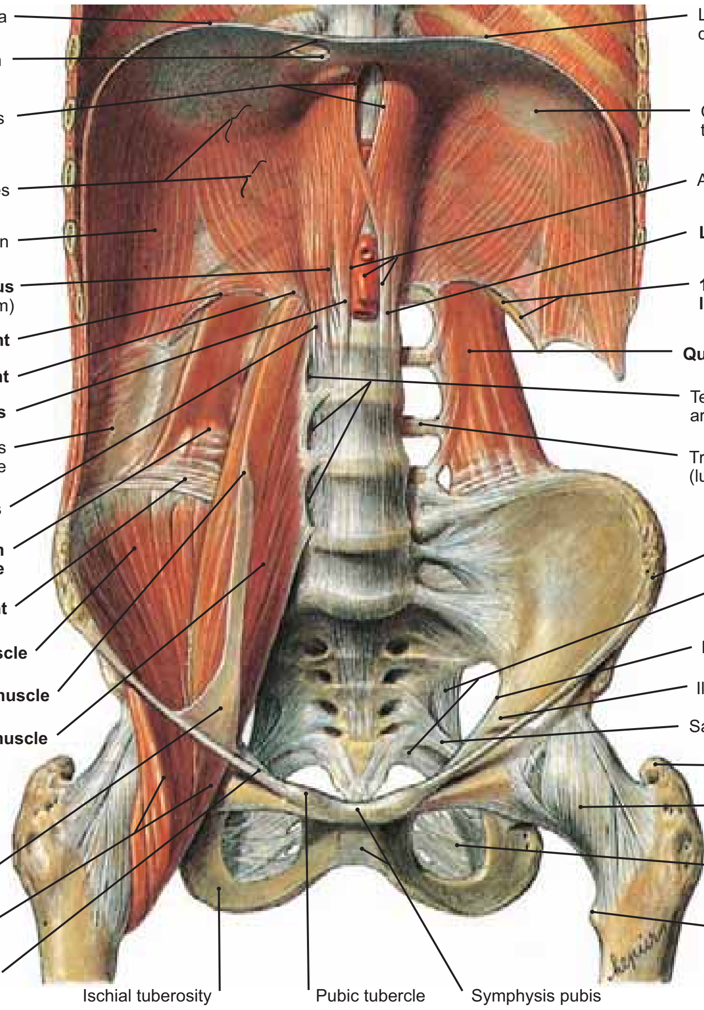


FIGURE 314 Diaphragm and Posterior Abdominal Wall Structures

NOTE: (1) The posterior attachments of the **diaphragm:** (a) the **right and left crura** arising from the bodies of the upper three or four lumbar vertebrae; (b) the **right and left medial arcuate ligaments** (thickenings in the psoas fascia); (c) the **lateral arcuate ligaments** along the 12th rib that lie superior to the quadratus lumborum muscle.

Muscle	Origin	Insertion	Innervation	Action
Diaphragm	**Sternal part:** Dorsum of xiphoid process. **Costal part:** Inner surfaces of cartilages and adjacent parts of lower six ribs. **Lumbar part:** Medial and lateral arcuate ligaments; crura from bodies of upper two or three lumbar vertebrae.	Central tendon of diaphragm	Phrenic nerve C3, C4, C5	Active during inspiration; assists in increasing intra-abdominal pressure
Quadratus lumborum	Iliolumbar ligament and the adjacent iliac crest	Medial half of the 12th rib and into the transverse processes of upper four lumbar vertebrae	Branches from T12, L1, L2, L3 (L4) nerves	Flexes vertebral column to the same side; fixes 12th rib in breathing; both muscles together extend lumbar vertebrae
Psoas major	Transverse process and body of T12 and upper four lumbar vertebrae; intervertebral disks between T12 and L5	Lesser trochanter of femur (also receives the fibers of iliacus muscle)	Branches from upper four lumbar nerves	Powerful flexor of thigh at hip; when femurs are fixed, they flex the trunk, as in sitting up from a supine position
Psoas minor (muscle present in about 40% of cadavers)	Lateral surface of bodies of T12 and L1 vertebrae	Pectineal line and iliopectineal eminence and the iliac fascia (often merges with psoas major tendon)	Branch from L1 nerve	Weak flexor of the thigh at the hip joint
Iliacus	Iliac fossa; anterior inferior iliac spine	Lesser trochanter of femur in common with tendon of psoas major muscle	Femoral nerve (L2, L3)	Powerful flexor of thigh at the hip joint

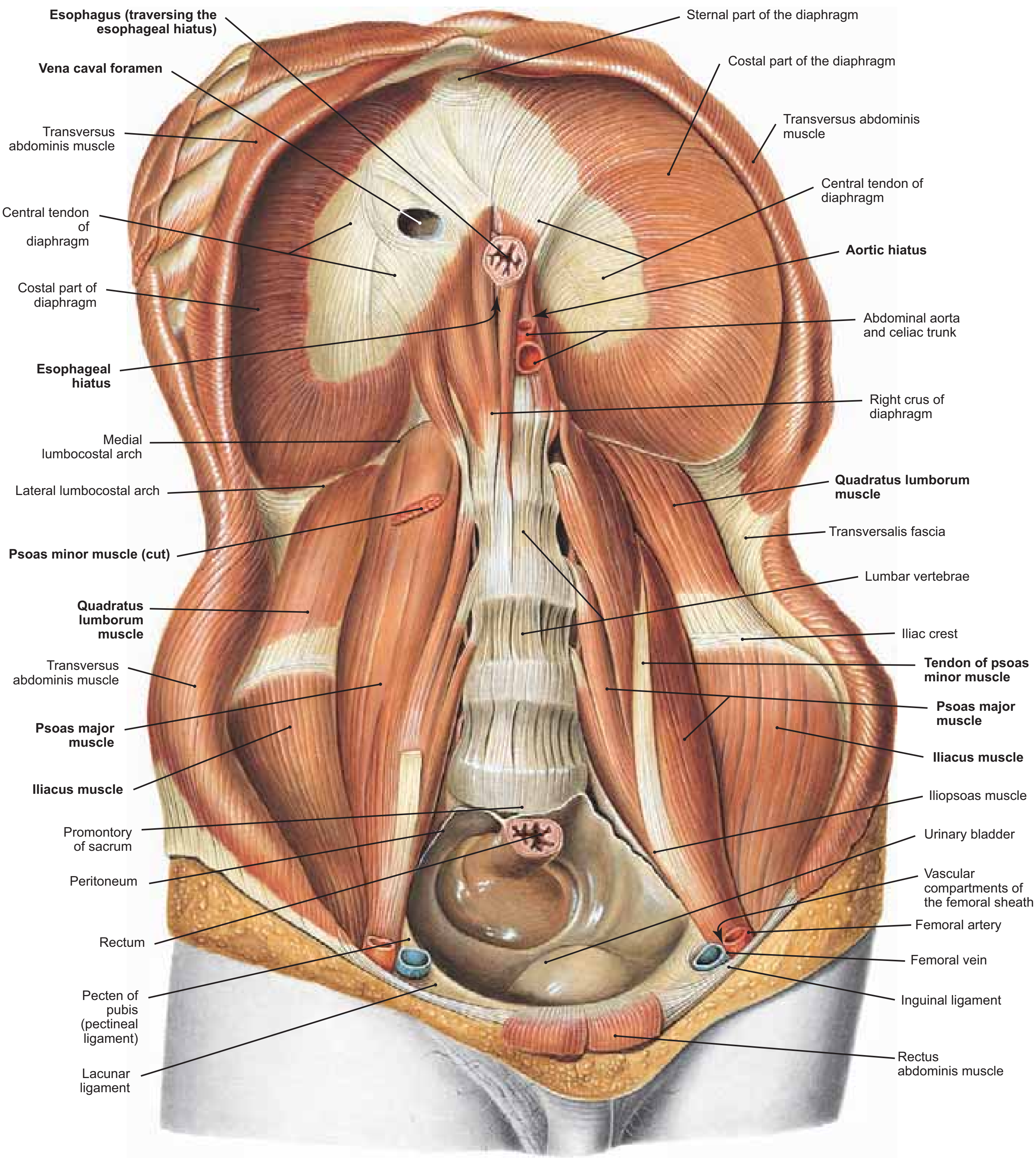


FIGURE 315 Psoas Minor, Psoas Major, Iliacus, and Quadratus Lumborum Muscles and Diaphragm

NOTE: (1) The **psoas minor muscle** lies anterior to the psoas major, and it merges with the lower part of the psoas major above the inguinal ligament.
(2) The **psoas major muscle** descends deep to the inguinal ligament and is joined by the iliacus muscle.
(3) The **iliacus muscle** arises from the iliac fossa, converges with the psoas major, and their joint tendon inserts onto the lesser trochanter of the femur.
(4) The **quadratus lumborum muscle** is a four-sided muscle on the dorsal wall of the abdomen, and it is located between the 12th rib, the iliac crest, and the transverse processes of the upper four lumbar vertebrae.

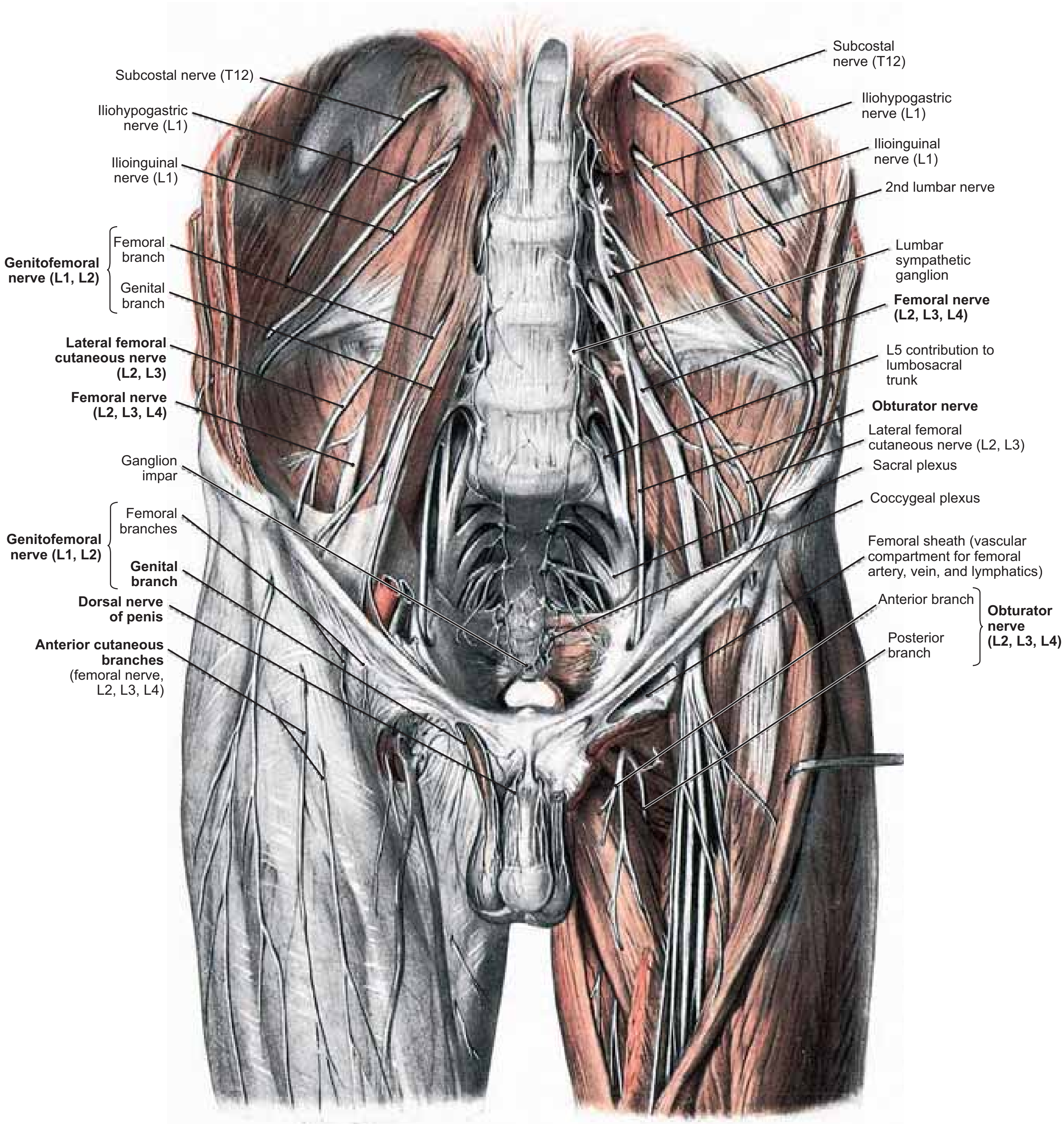


FIGURE 316 Lumbosacral Plexus: Posterior Abdominal Wall and Anterior Thigh

NOTE: (1) On the left side, the psoas muscles have been removed to reveal the **lumbar plexus** more completely. The lumbar nerves emerge from the spinal cord and descend along the posterior abdominal wall within the substance of the psoas muscles. The **12th thoracic** (subcostal) **nerve** courses around the abdominal wall below the 12th rib.

(2) The **first lumbar nerve** divides into **iliohypogastric** and **ilioinguinal branches.** The ilioinguinal nerve descends obliquely toward the iliac crest and penetrates the transversus and internal oblique muscles to join the spermatic cord, becoming cutaneous at the superficial inguinal ring.

(3) The **genitofemoral nerve** courses superficially on the surface of the psoas major muscle. It divides into a **genital branch** (which supplies the cremaster muscle and the skin of the scrotum) and a **femoral branch** (which is sensory to the upper anterior thigh).

(4) The **femoral** and **obturator nerves** derived from the posterior and anterior divisions of **L2, L3,** and **L4,** respectively, descend to innervate the anterior and medial groups of the femoral muscles.

(5) The femoral nerve enters the thigh beneath the inguinal ligament and divides into both sensory and motor branches, whereas the obturator nerve courses more medially through the obturator foramen to innervate the adductor muscle group.

(6) **L4** and **L5** nerve roots (**lumbosacral trunk**) join with the upper three sacral nerves to form the **sacral plexus,** from which is derived, among other nerves, the large **sciatic nerve,** which reaches the gluteal region through the greater sciatic foramen.

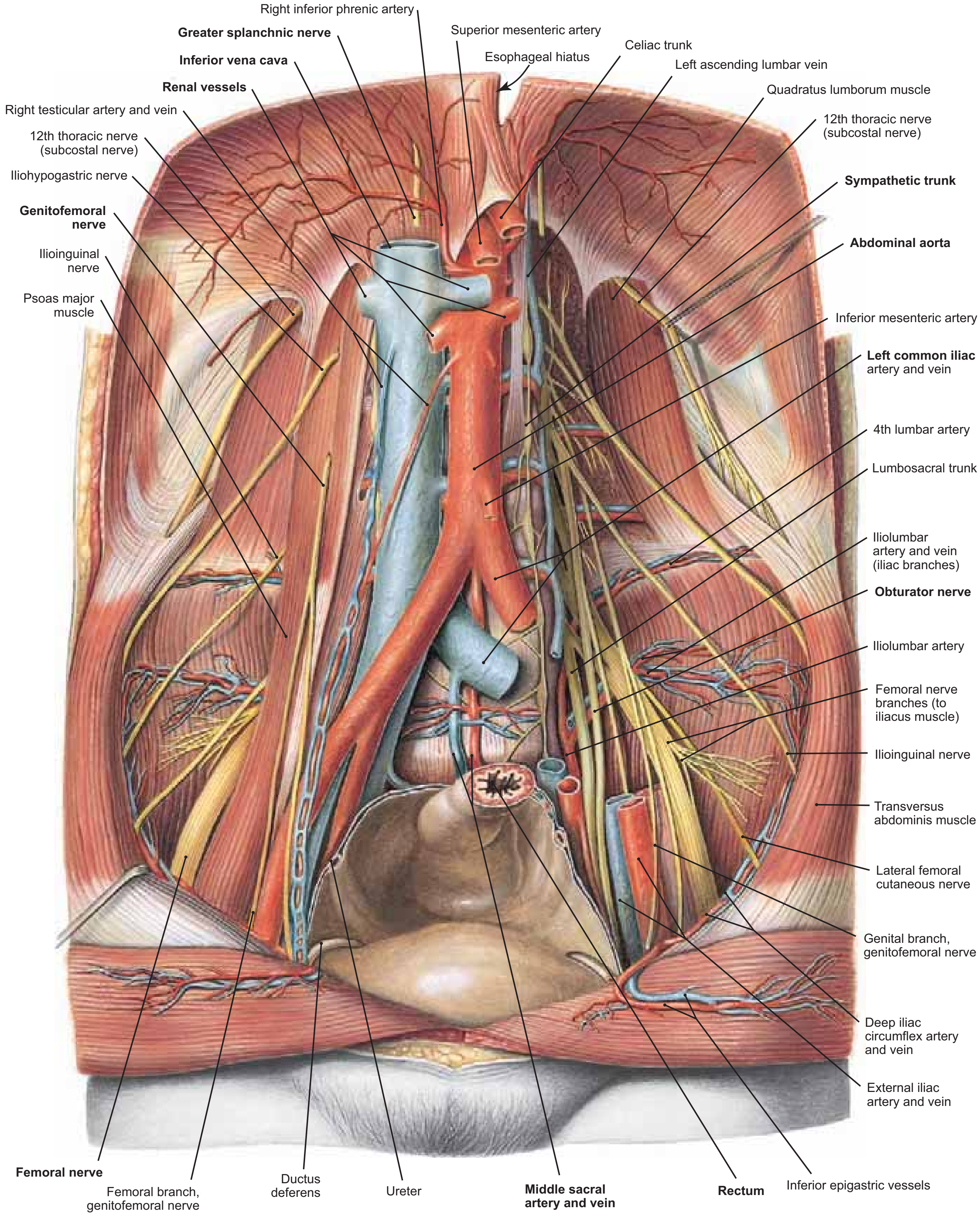


FIGURE 317 Posterior Abdominal Vessels and Nerves

NOTE: (1) The abdominal organs and the left psoas muscle have been removed. See the **greater splanchnic nerves** enter the abdomen through the diaphragmatic crura. Identify the **inferior phrenic arteries** and the **abdominal sympathetic chain.**

(2) The **testicular arteries** arising from the aorta below the renal arteries. Inferiorly, the testicular artery and vein join the **ductus deferens** to enter the inguinal canal through the abdominal inguinal ring just lateral to the inferior epigastric vessels. Observe the **middle sacral vessels** descending into the pelvis in the midline.

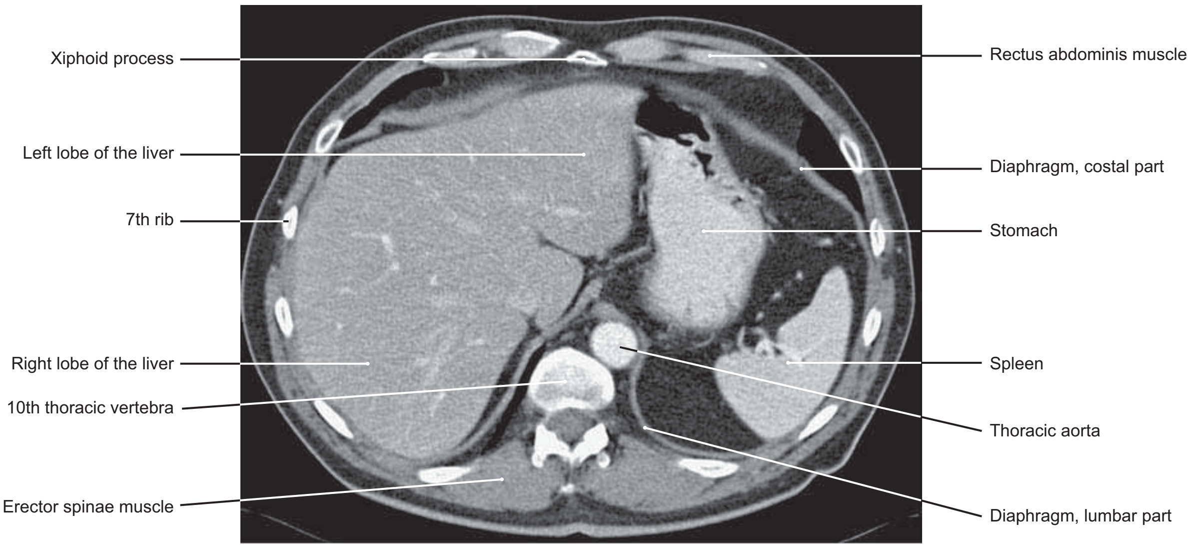


FIGURE 318.1 CT Transverse Section of the Abdomen at the Level of T10

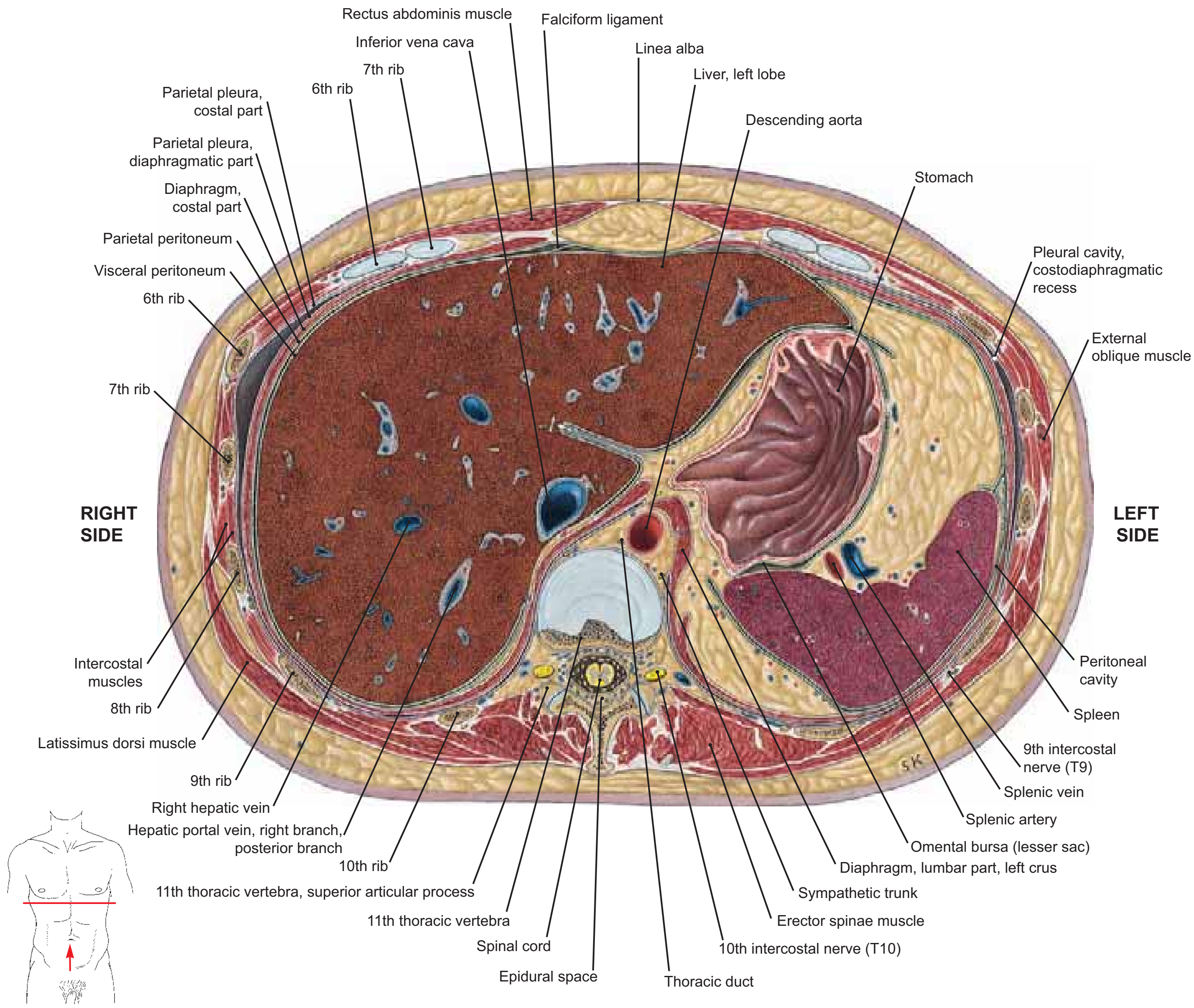


FIGURE 318.2 Transverse Section of the Abdomen at the Level of T11 (Caudal Aspect)

NOTE: (1) The aorta is seen to the left of the bodies of the thoracic vertebrae above the diaphragm. Observe the thoracic duct slightly to the right of the aorta.

(2) Below the diaphragm, the liver is mostly to the right and the spleen is to the left of the midline. Observe the location of the inferior vena cava posterior to the liver and to the right of the midline.

FIGURE 319.1 CT of Transverse Section of the Abdomen at L1 (Caudal Aspect)

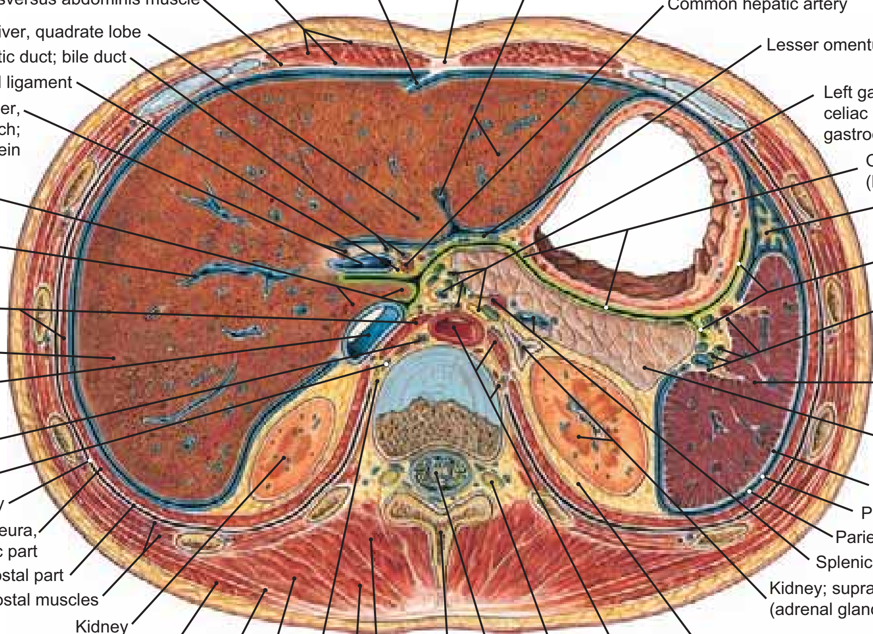


FIGURE 319.2 Transverse Section of the Abdomen between T12 and L1 (Caudal Aspect)

NOTE: (1) Both the parietal and the visceral layers of the peritoneum of the greater peritoneal sac (cavity) are shown in blue, while surrounding the lesser sac, the peritoneum is shown in blue–green.

(2) The kidneys, located anterior to the posterior abdominal wall, have been sectioned transversely. Also observe the perirenal fat surrounding them.

(3) The abdominal aorta is near or at the midline and the inferior vena cava to the right of the midline.

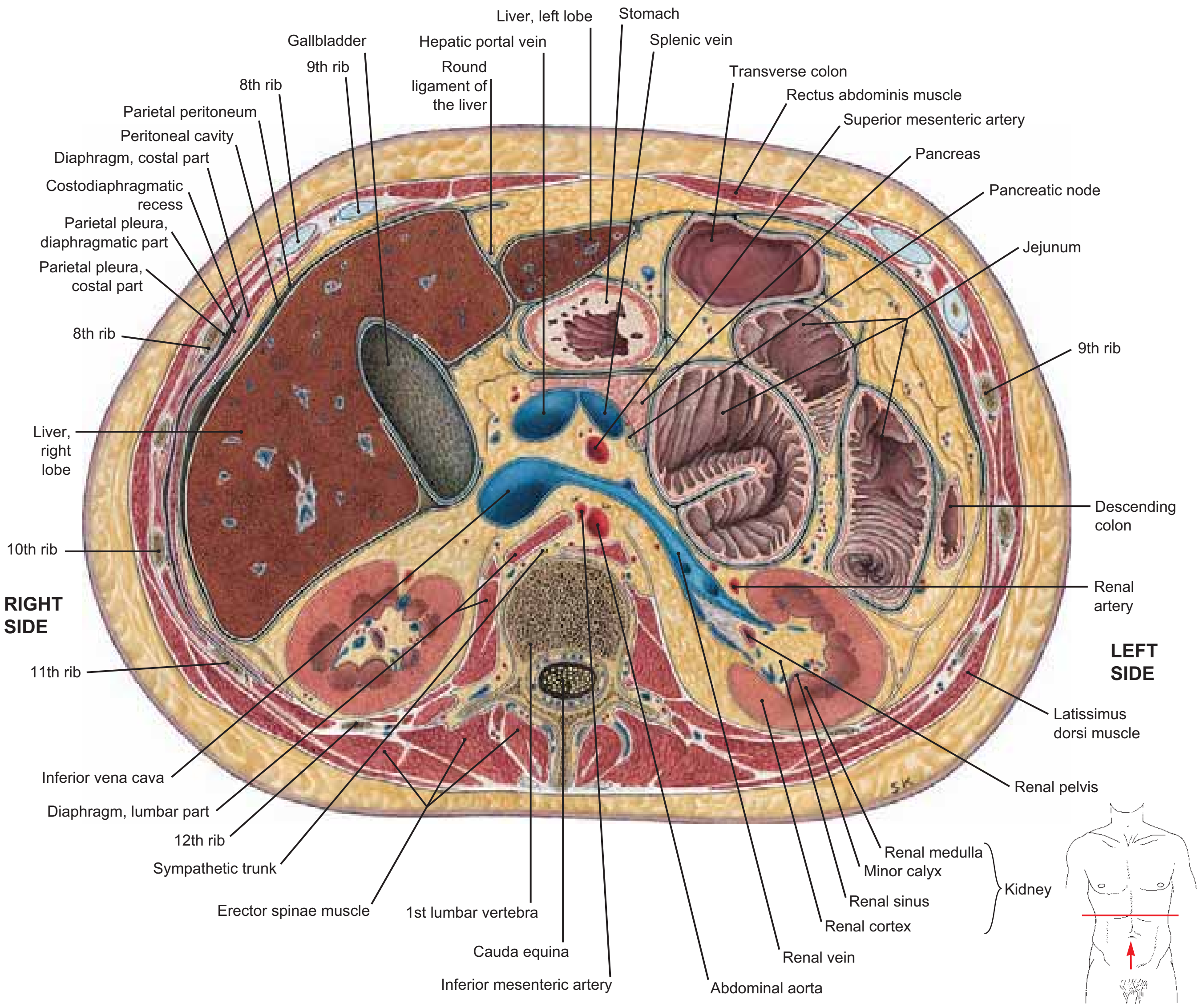


FIGURE 320.1 Transverse Section through the Upper Abdomen at the Level of L1

NOTE: (1) This section goes through the hilum of the left kidney and shows the left renal vein crossing the vertebral column to then enter the inferior vena cava.
(2) The loops of jejunum on the left and the pancreas forming a bed for the posterior aspect of the stomach.

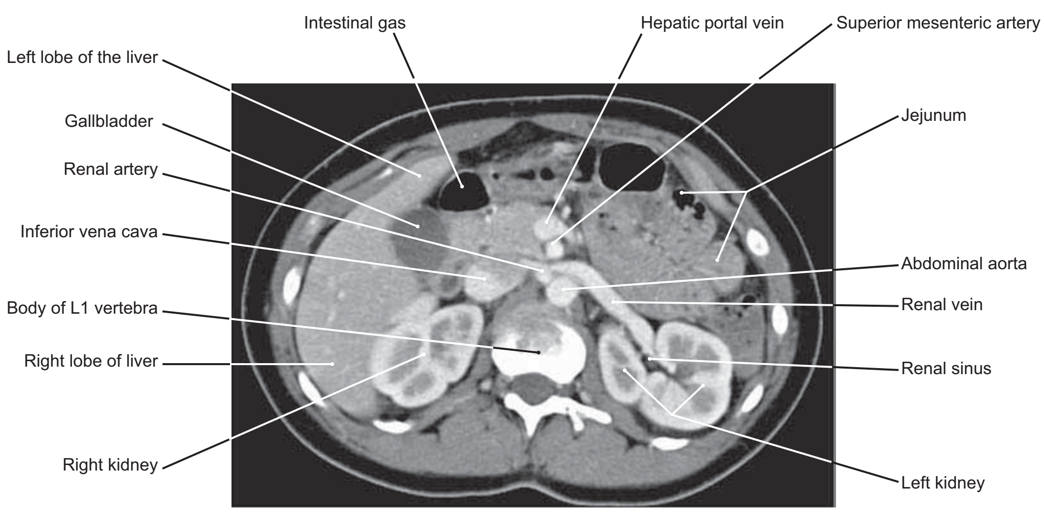


FIGURE 320.2 CT of the Abdomen at the Level of L1

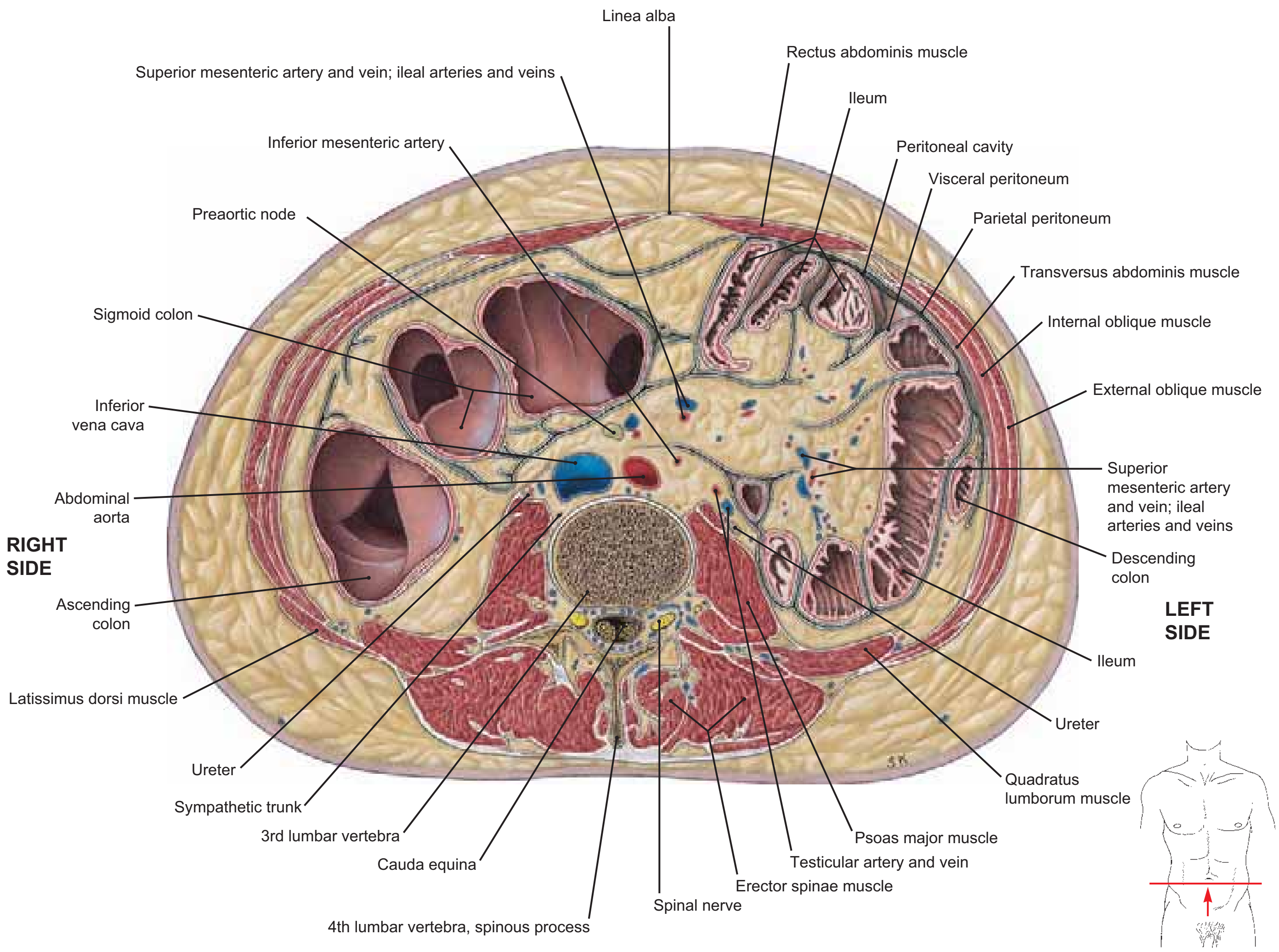


FIGURE 321.1 **Transverse Section of the Abdomen at the Level of L3 (Caudal Aspect)**

NOTE: (1) This section is through the lower abdomen and visualized from the caudal aspect.
(2) A loop of sigmoid colon extends far superiorly in the abdomen, and two parts of it are sectioned in this specimen.
(3) The inferior vena cava to the right of the midline and the aorta directly anterior to the body of the L3 vertebra.
(4) The spinal cord at this level shows the cauda equina. These are the roots of the lower lumbar and sacral nerves.

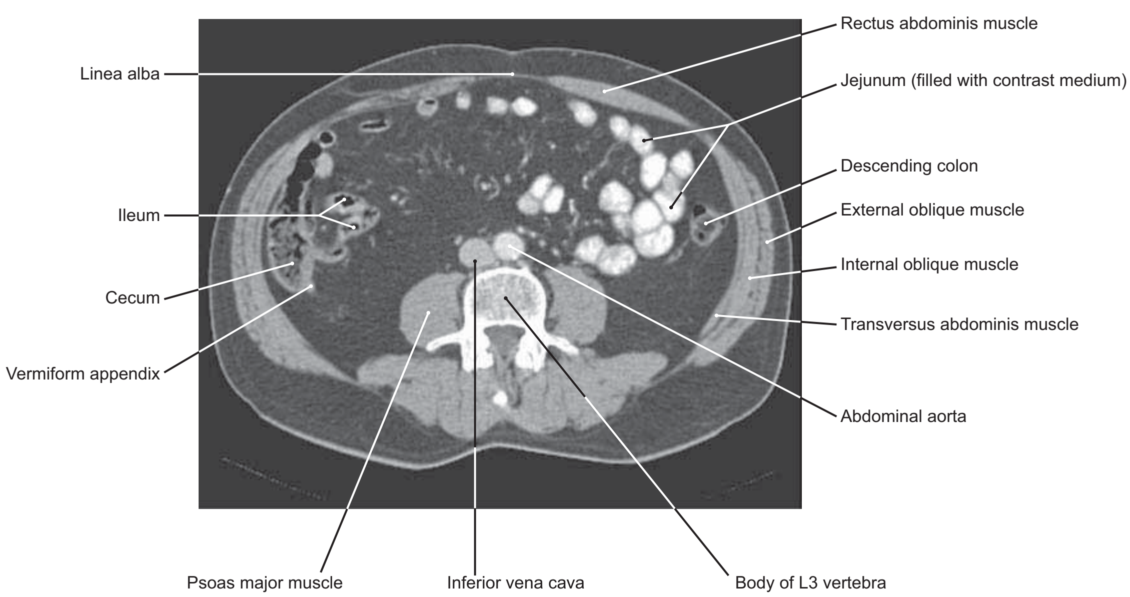


FIGURE 321.2 **CT of the Abdomen at the Level of L3**

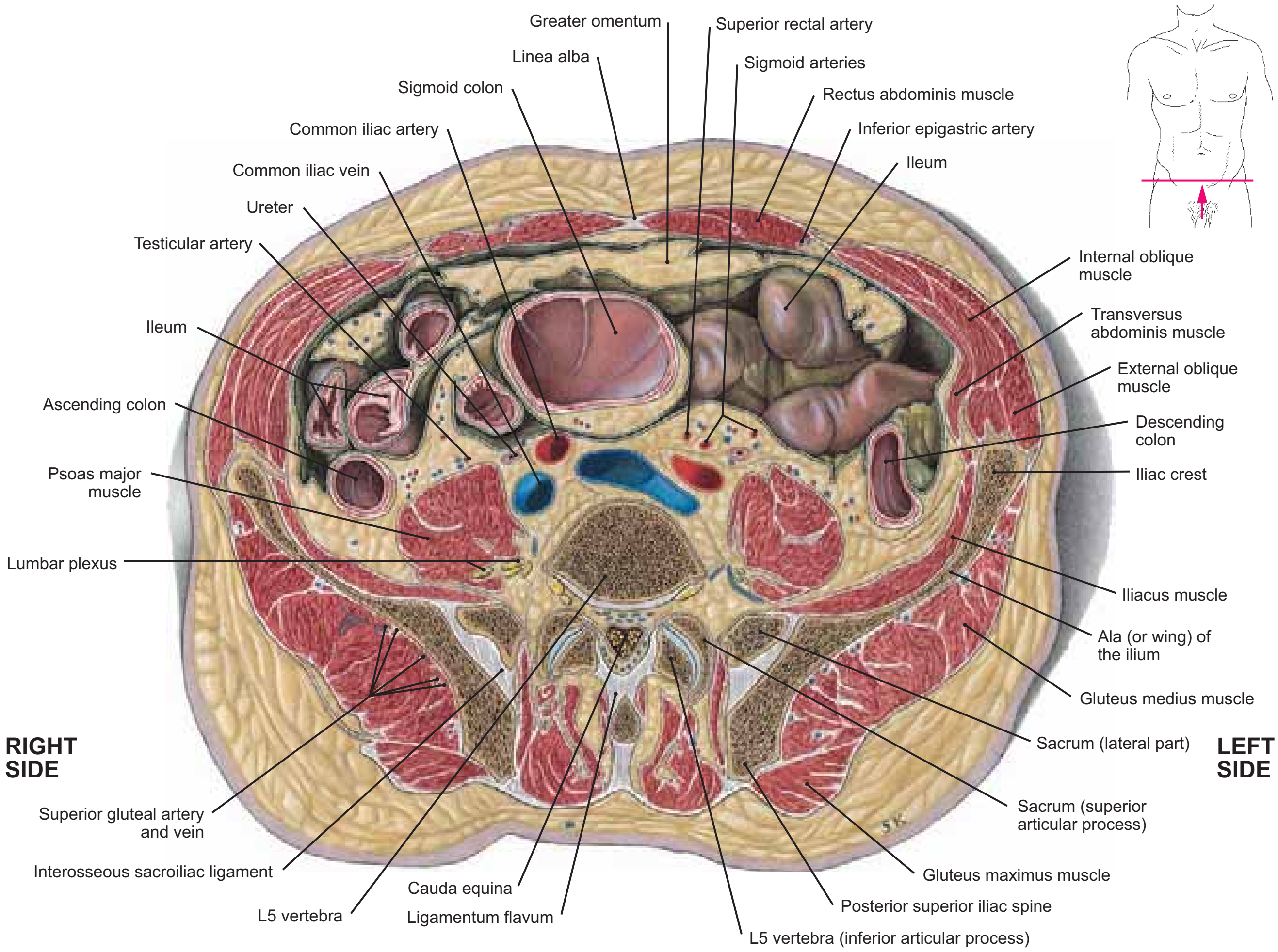


FIGURE 322.1 Transverse Section through the Abdomen at the Fifth Lumbar Level (Sacroiliac Joint)

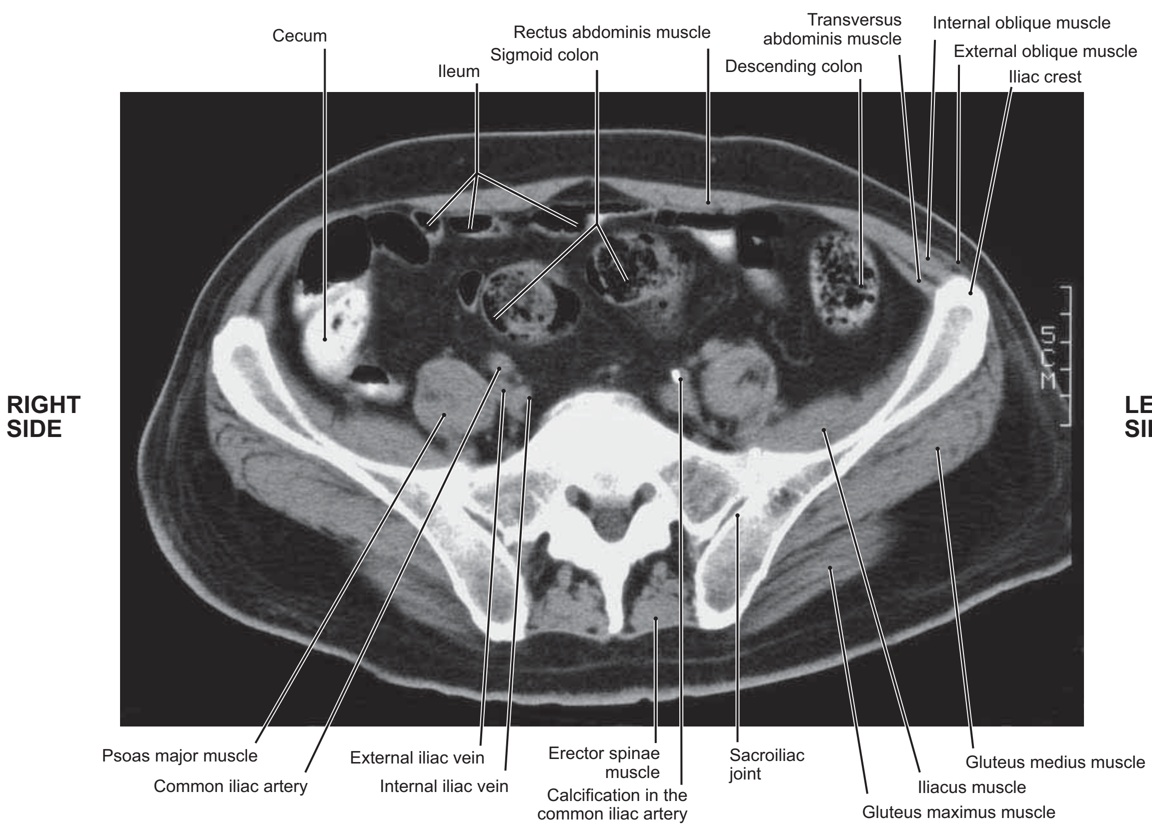


FIGURE 322.2 CT at the Fifth Lumbar Level (Sacroiliac Joint)

CHAPTER 4

The Pelvis and Perineum

Plates

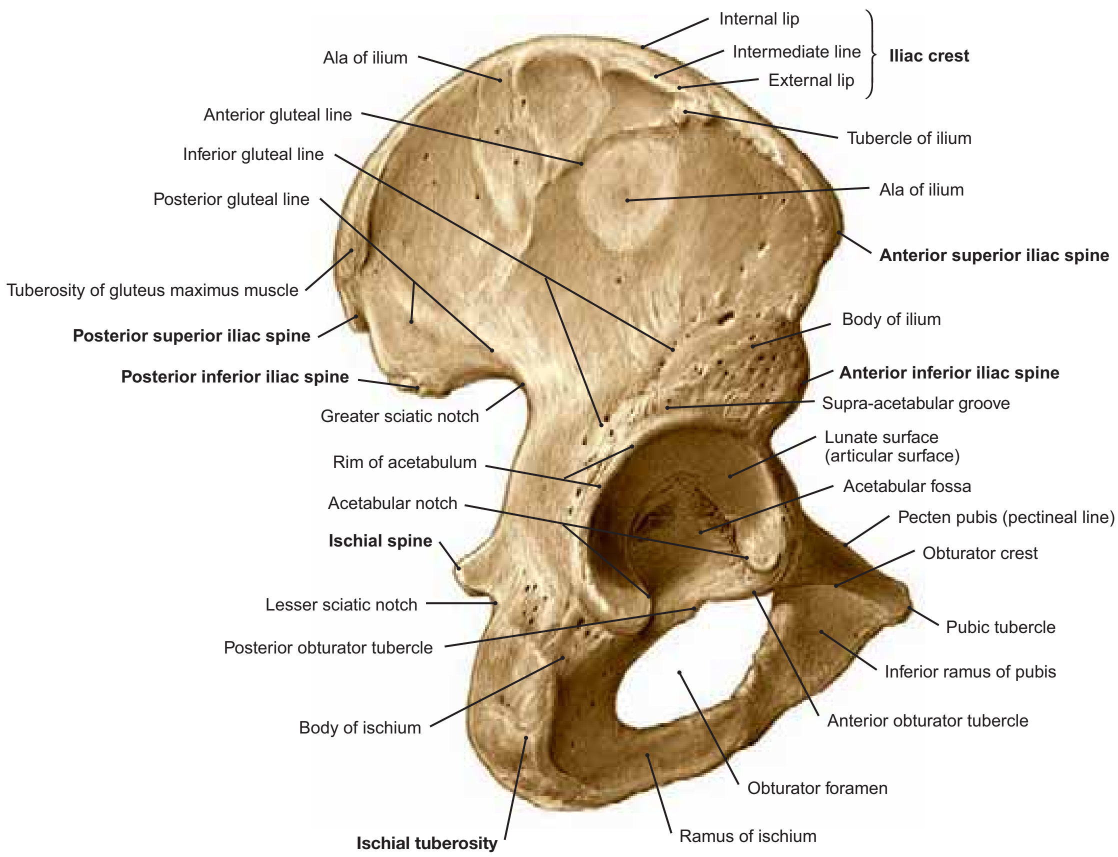


FIGURE 323.1 Lateral View of the Adult Right Hip Bone

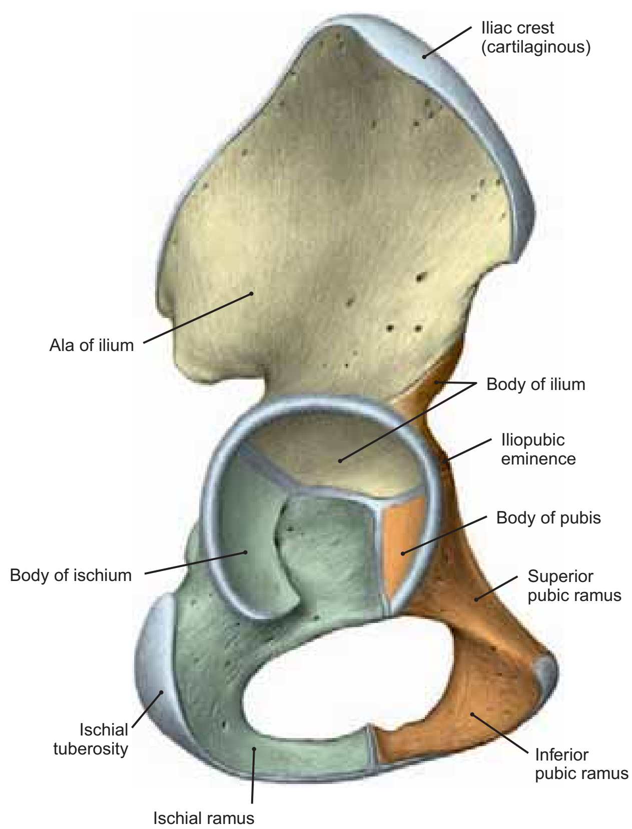


FIGURE 323.2 Hip Bone of 5-Year-Old Child (Lateral View)

NOTE: The hipbone is formed by a fusion of the **ilium** (yellow), **ischium** (green), and **pubis** (orange). Although ossification of the inferior pubic ramus occurs during the 7th or 8th year, complete fusion of the three bones at the **acetabulum** occurs sometime between the 15th and 20th years.

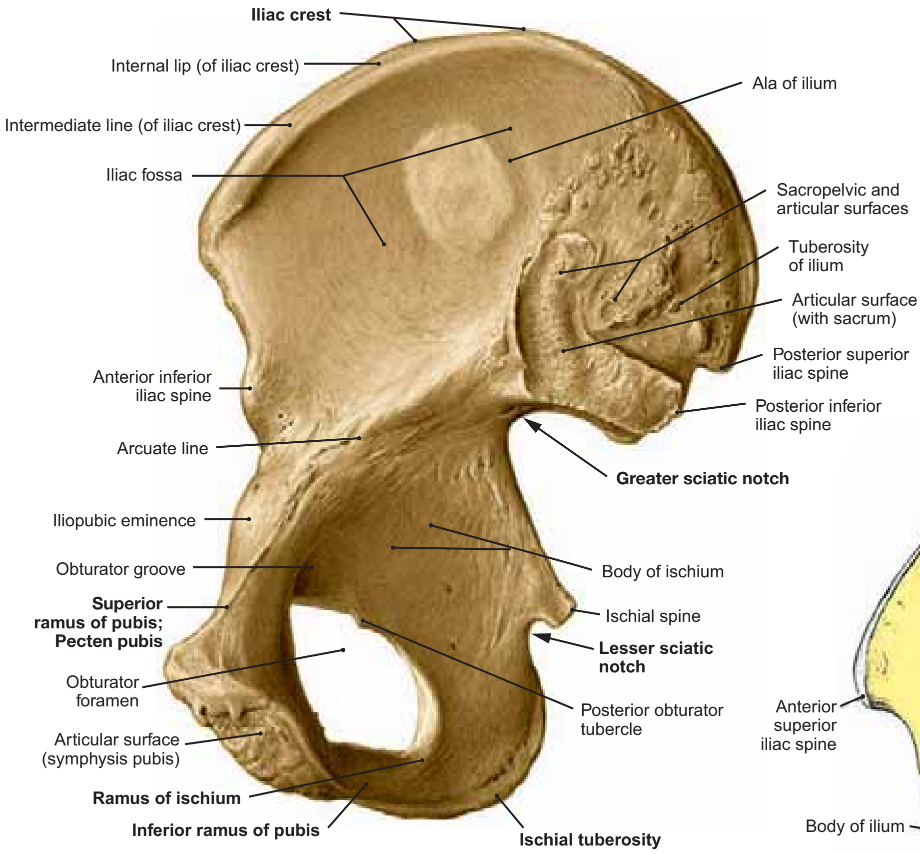


FIGURE 324.1 Medial View of the Adult Right Hip Bone ▲

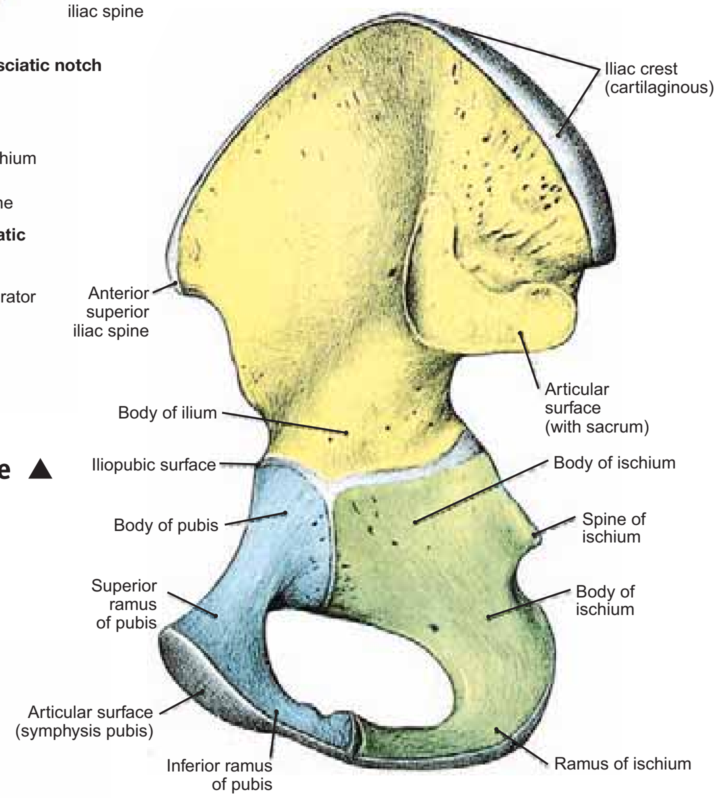


FIGURE 324.2 Hip Bone of 5-Year-Old Child (Medial View) ▲

NOTE: The lines of fusion of the three bones above the obturator foramen and the fusion of the inferior pubic ramus and the ischial ramus below that foramen.

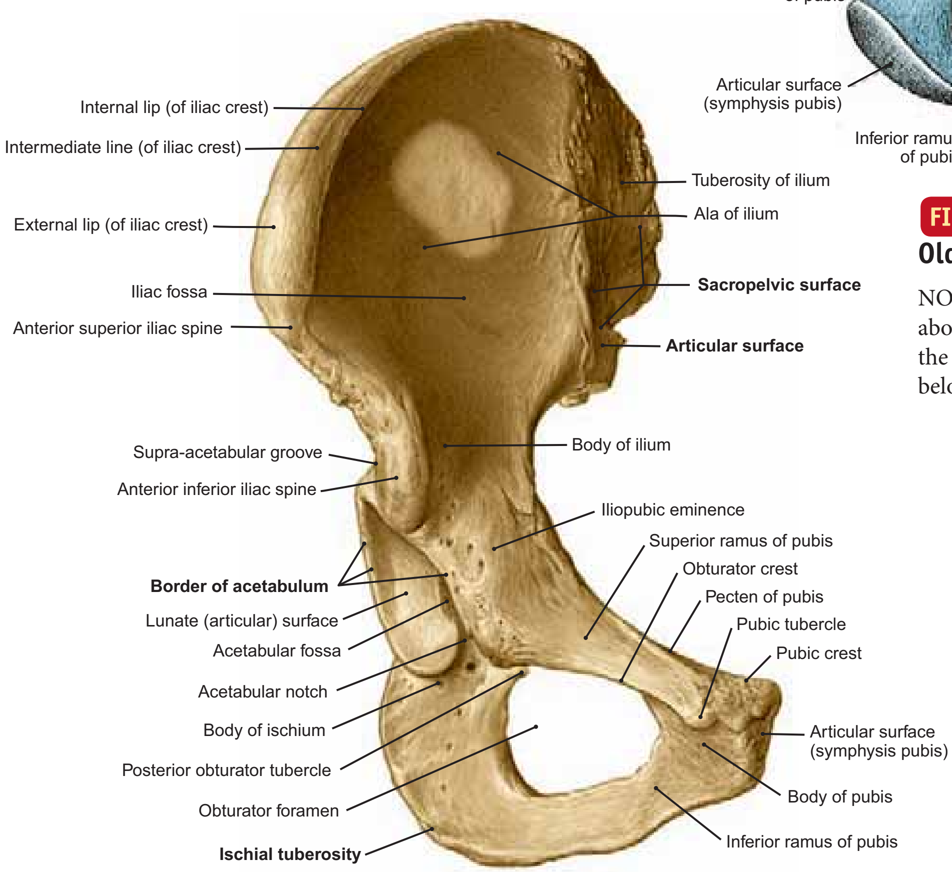


FIGURE 324.3 Anterior View of the Adult Right Hip Bone

FIGURE 325.1 Radiograph of the Pelvis and the Sacroiliac and Hip Joints ▲

(From Wicke, 6th ed.)

1. Iliac crest
2. Gas bubble in colon
3. Ala of ilium
4. Lateral part of sacrum
5. Sacroiliac joint
6. Posterior inferior iliac spine
7. Anterior superior iliac spine
8. Anterior inferior iliac spine
9. Lunate surface of acetabulum
10. Spine of ischium
11. Greater trochanter
12. Intertrochanteric crest
13. Lesser trochanter
14. Ischial tuberosity
15. Superior ramus of pubis
16. Symphysis pubis
17. Inferior ramus of pubis
18. Obturator foramen
19. Neck of femur
20. Head of femur
21. Fovea on head of femur
22. Acetabular fossa
23. Iliopubic eminence
24. Greater sciatic notch
25. Transverse process, L5 vertebra
26. Gas bubble in colon
27. Urinary bladder

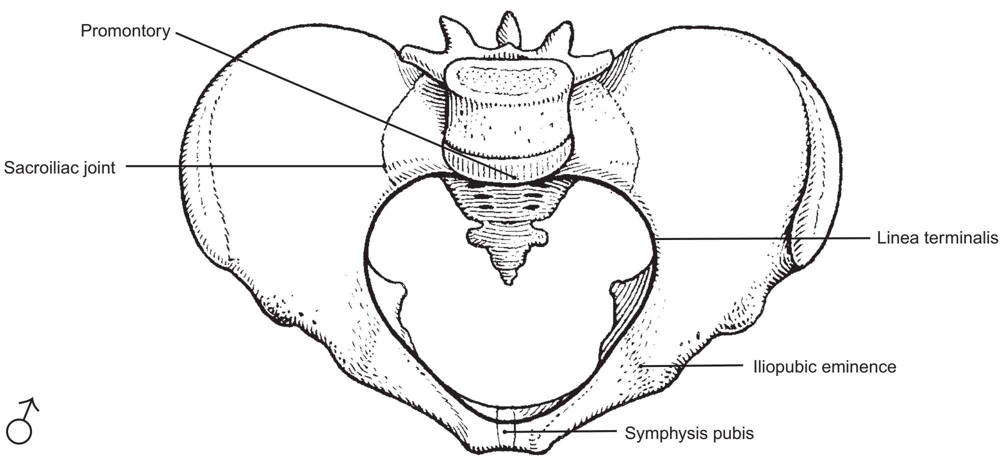


FIGURE 325.2 Diagram of the Male Pelvis

NOTE the following differences between the female and male pelvis

(1) The **pubic arch (subpubic angle)** is greater in females and, therefore, the **ischial tuberosities** are farther apart than in males.

(2) The **obturator foramen** is usually oval in shape in women but more rounded in men.

(3) The female **pelvic bones** are more delicate and lighter than the male pelvic bones.

(4) The **sacrum** is shorter and wider in females, and it is usually less curved than in males.

(5) The **ischial spines** project less in females, and the **sciatic notches** are usually wider and more shallow than in males.

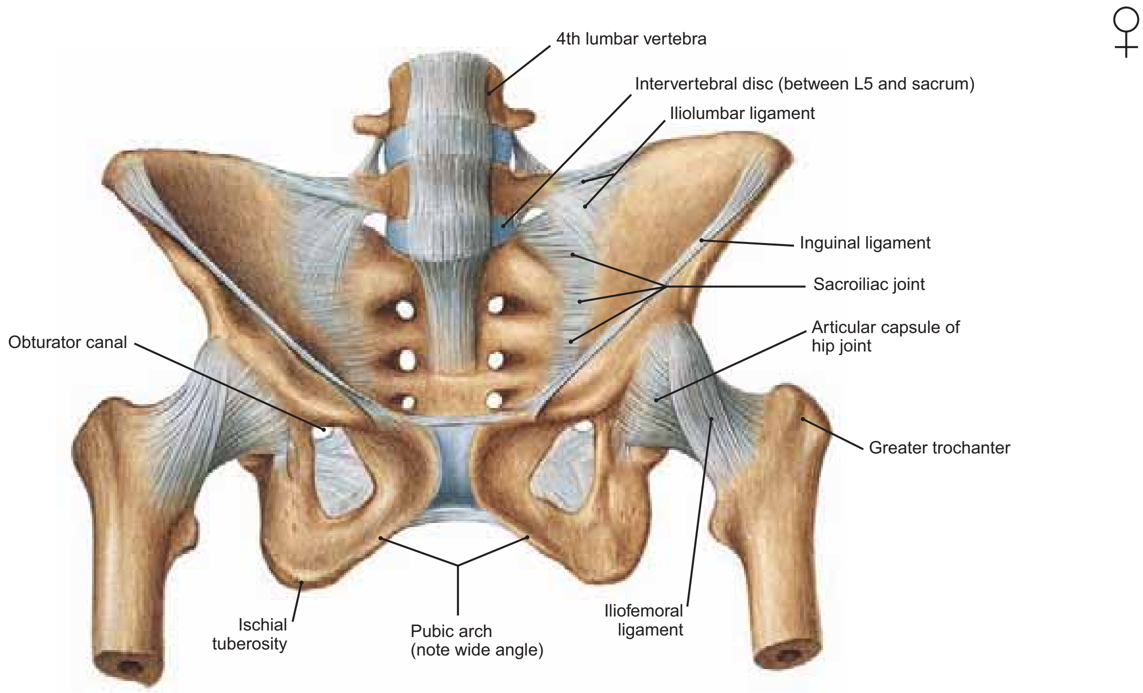


FIGURE 326.1 **Female Pelvis and Ligaments: Articulations of the Pelvic Girdle and Hip Joints (Anteroinferior View)**

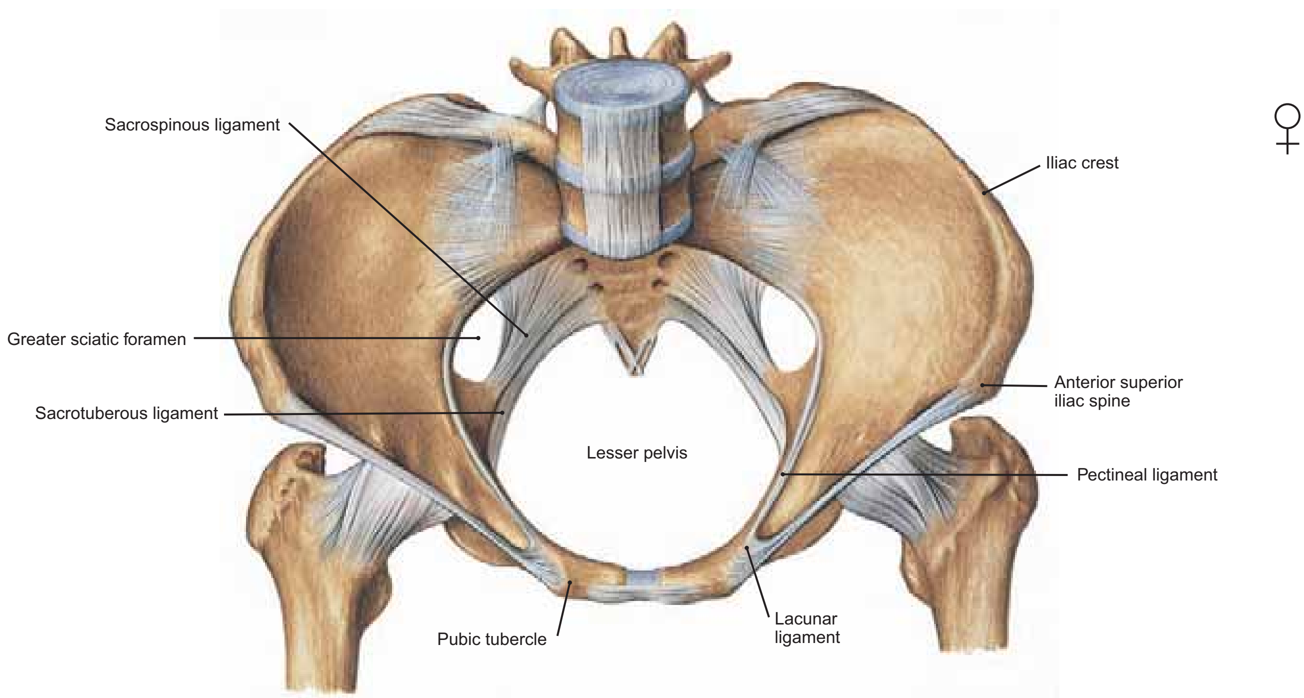


FIGURE 326.2 **Female Pelvis and Ligaments Viewed from Front**

NOTE: (1) The forward inclination of the pelvis shown here corresponds to the position of the pelvis while the person is standing upright.

(2) In addition to having wider diameters both at the pelvic inlet and outlet, the female lesser pelvis is more circular in shape than that in the male (compare with Fig. 327.2).

(3) The larger capacity of the lesser or true pelvis in the female, and the fact that the female hormones of pregnancy tend to relax the pelvic ligaments, serve to facilitate the function of childbearing.

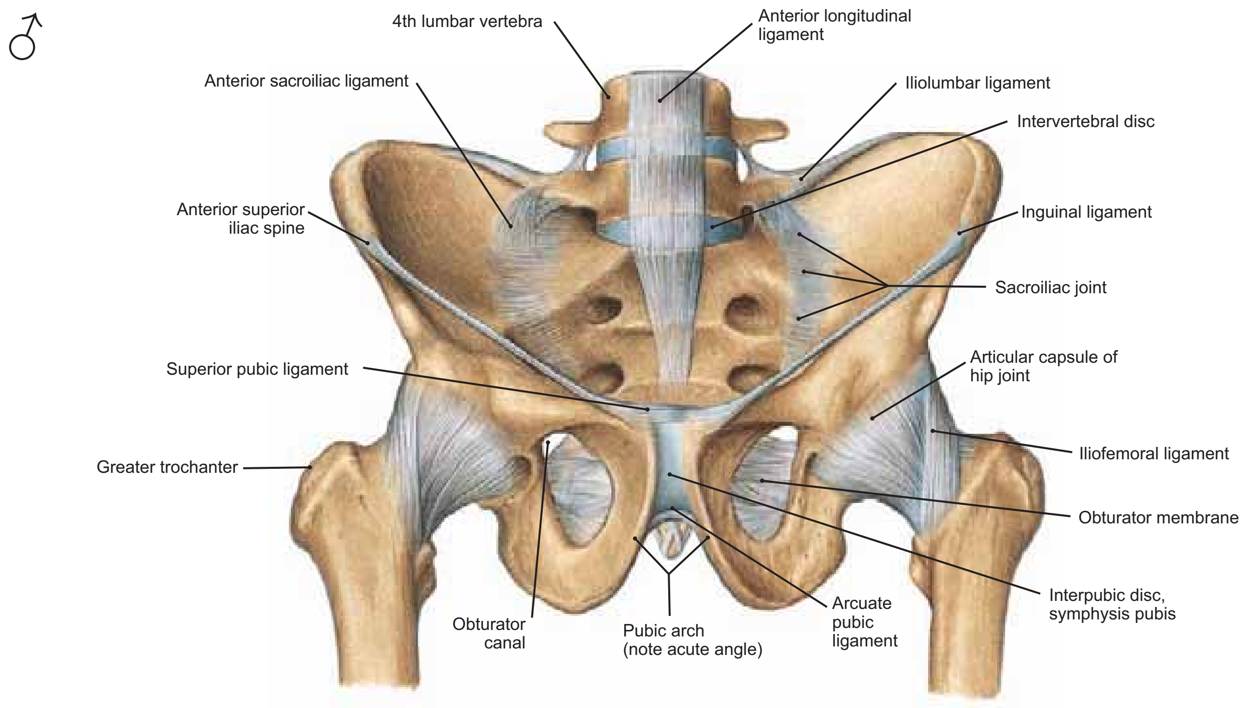


FIGURE 327.1 Male Pelvis and Associated Ligaments (Anteroinferior Aspect)

NOTE: (1) The pelvis is formed by the articulations of the left and right hip bones anteriorly at the **symphysis pubis** and posteriorly with the sacrum, coccyx, and fifth lumbar vertebra of the vertebral column.
(2) The articulations inferiorly of the pelvis with the two femora allow the weight of the head, trunk, and upper extremities to be transmitted to the lower limbs, thereby maintaining the upright posture characteristic of the human.

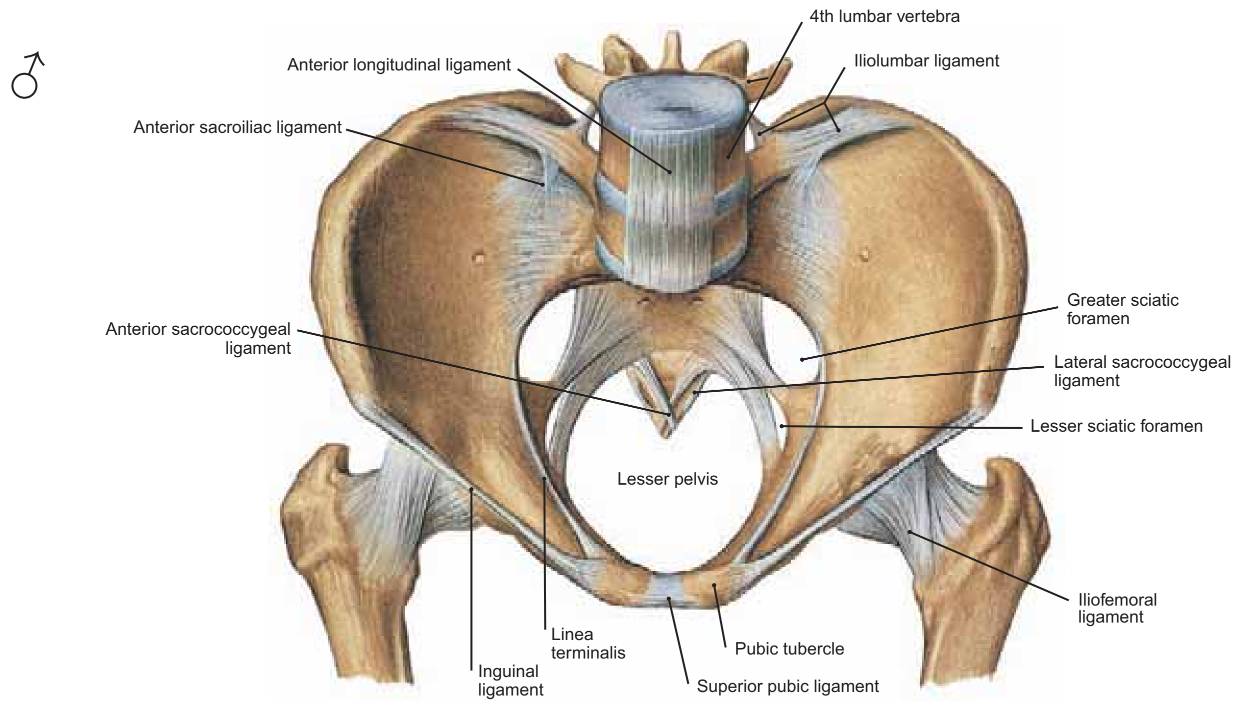


FIGURE 327.2 Male Pelvis and Ligaments Viewed from Above

NOTE: The size of the **pelvic inlet** (superior aperture of the **lesser pelvis**) and **inferior outlet** of the male pelvis is smaller than that in the female (see Fig. 326.2). Thus, the **lesser pelvis** is deeper and more narrow in the male, and its cavity has a smaller capacity than that seen in the female. In the male, the pelvic bones are thicker and heavier, and generally, the **major pelvis** (above the pelvic brim) is larger than that in the female.

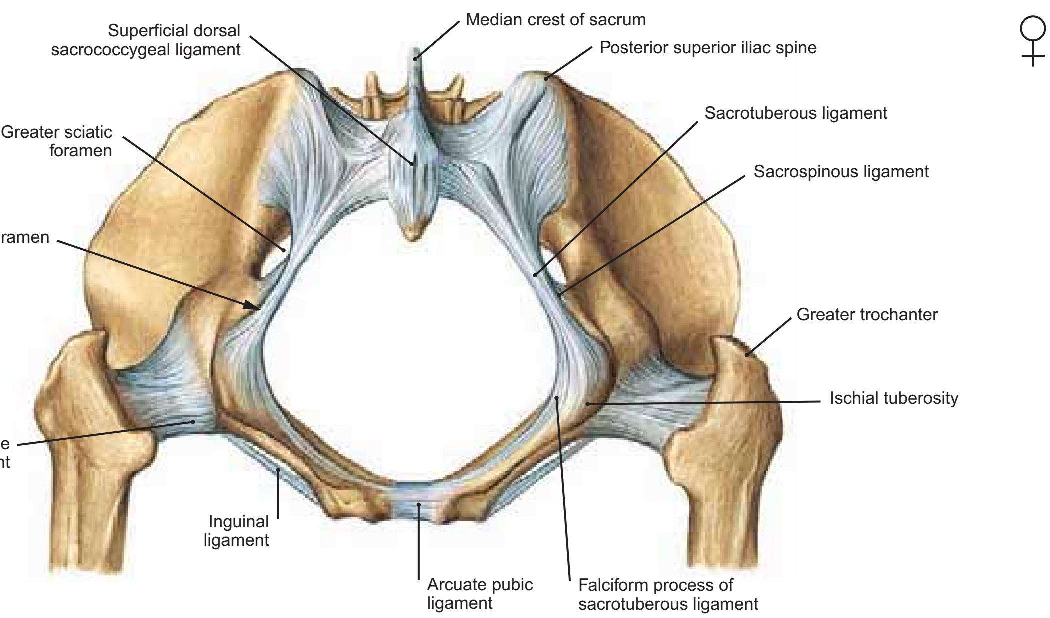


FIGURE 328.1 **Female Pelvic Outlet Showing the Pelvic Ligaments; Posteroinferior View**

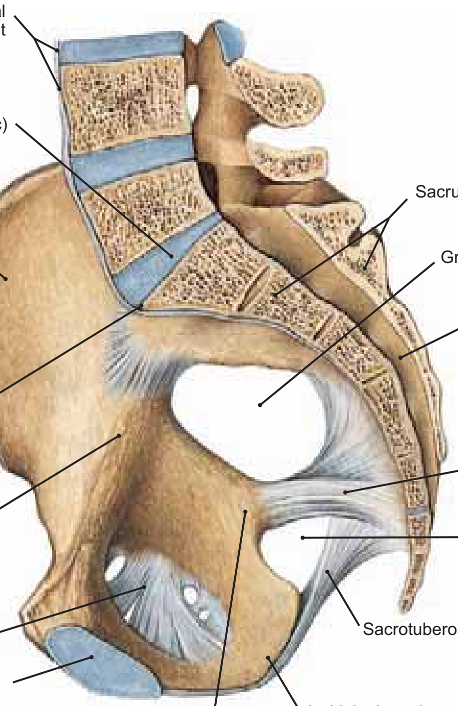


FIGURE 328.2 **Articulations and Ligaments of the Female Hemisected Pelvis**

NOTE: (1) The **sacrospinous ligament** courses between the **sacrum** and the **ischial spine** and forms the lower border of the **greater sciatic foramen.**

(2) The **lesser sciatic foramen** is bounded above by the **sacrospinous ligament** and below by the **sacrotuberous ligament**. The latter extends between the **sacrum** and the **ischial tuberosity**.

(3) These two foramina allow the emergence of muscles, nerves, and arteries from the pelvis to the gluteal region and the entrance of veins from the gluteal region to the pelvis.

(4) Because the sacrum lies beneath the remainder of the vertebral column, considerable weight is transmitted to it from above. This tends to rotate the upper end of the sacrum forward and downward and its lower end and the coccyx backward and upward. The sacrotuberous and sacrospinous ligaments add stability to the sacroiliac joint by resisting these forces.

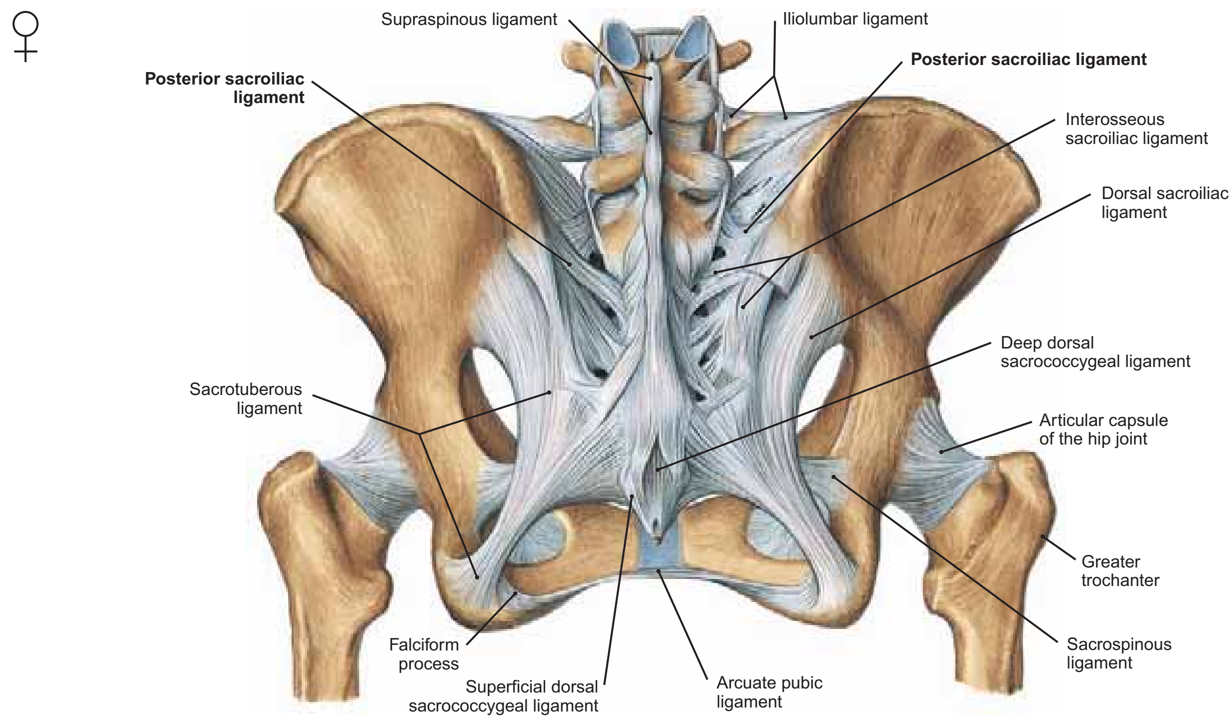


FIGURE 329.1 Female Pelvis with Joints and Ligaments (Posterior Aspect)

NOTE: (1) Broad ligamentous bands articulate the two hip bones posteriorly with the sacrum and coccyx. Observe the strong **posterior (dorsal) sacroiliac ligament.**

(2) The posterior sacroiliac ligament is composed of short **transverse fibers** that interconnect the ilium with the upper part of the lateral crest of the sacrum, whereas the longer **vertical fibers** attach the third and fourth transverse tubercles of the sacrum to the superior and inferior posterior iliac spines, many blending with fibers of the sacrotuberous ligament.

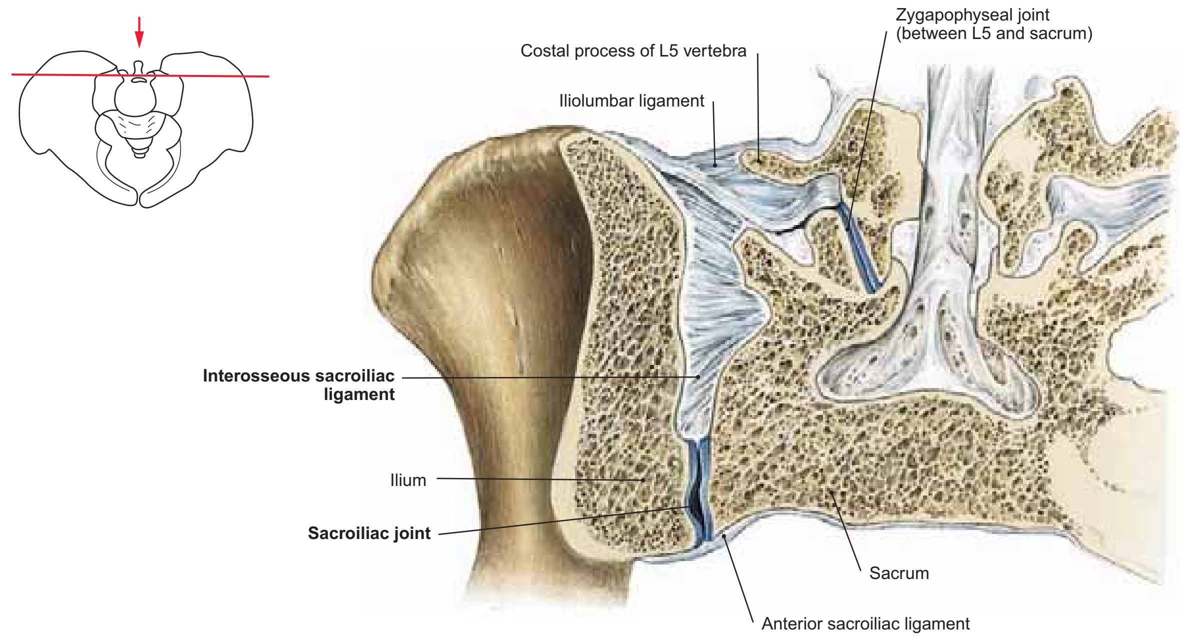


FIGURE 329.2 Frontal Section through the Sacroiliac Joint

NOTE: (1) The **sacroiliac joint** is a synovial joint connecting the **auricular surface** of the sacrum with the reciprocally curved **auricular surface** of the ilium.

(2) This joint is bound by the **anterior** and **interosseous sacroiliac ligaments** (shown in this figure) as well as the **posterior** (dorsal) **sacroiliac ligament** (shown in Fig. 329.1).

(3) The interosseous sacroiliac ligament is the strongest ligament between the sacrum and the ilium, and it stretches above and behind the synovial joint.

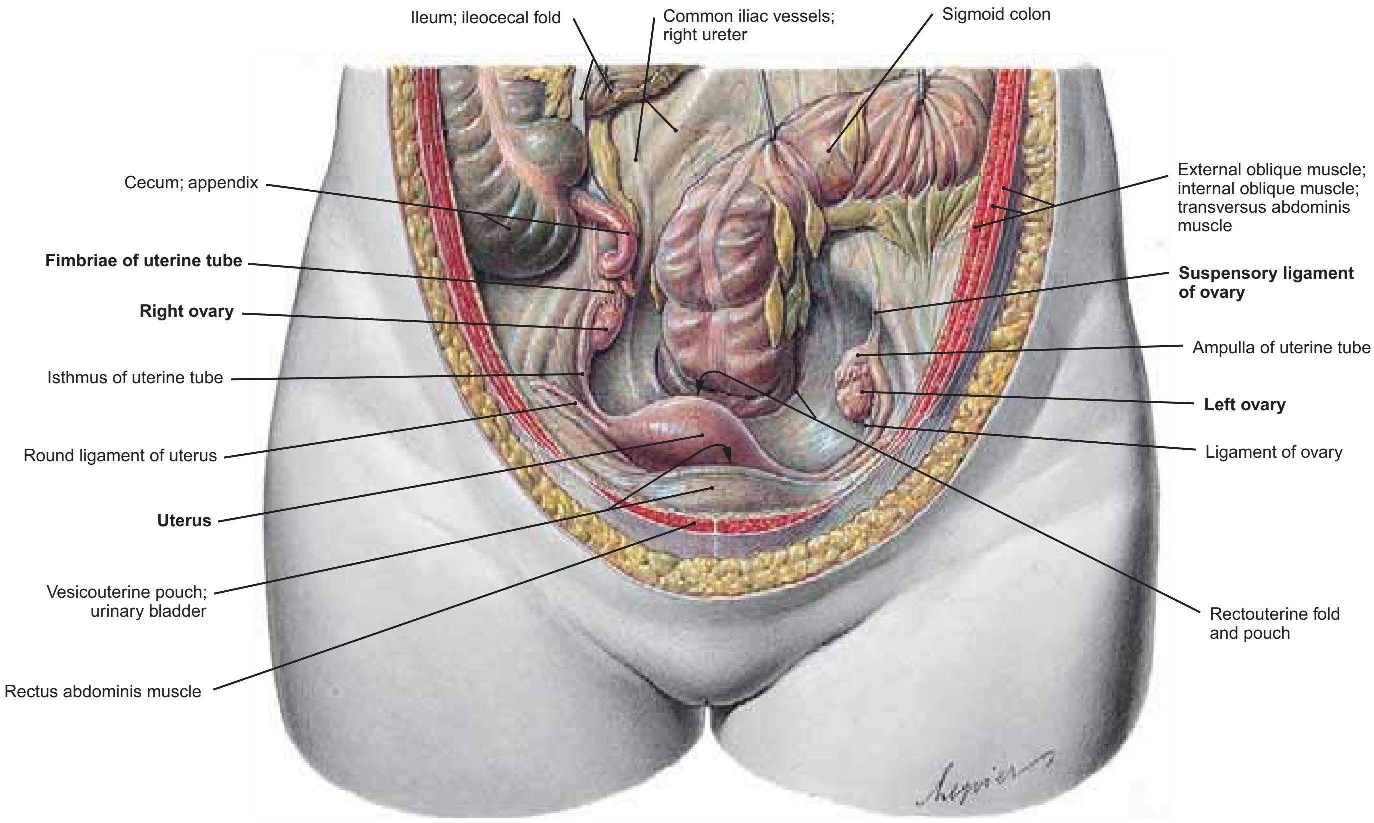


FIGURE 330.1 Pelvic Viscera of an Adult Female (Anterior View)

NOTE: (1) The ovaries are situated on the posterolateral aspect of the true pelvis on each side. Having descended from the posterior abdominal wall to their location just below the pelvic brim, the ovaries are held in position by peritoneal ligamentous attachments. The suspensory ligament of the ovary transmits the ovarian vessels and ovarian autonomic nerves.
(2) The uterus is positioned between the bladder and the rectum, and frequently it is located somewhat to one or the other side of the midline.
(3) The fimbriae of the uterine tubes extend from the ampullae of the tubes to encircle the upper medial surface of the ovaries. The uterine tubes vary from 3 to 6 in. in length, and they convey the ova to the uterus. It is within the uterine tube that fertilization of the ovum usually occurs.

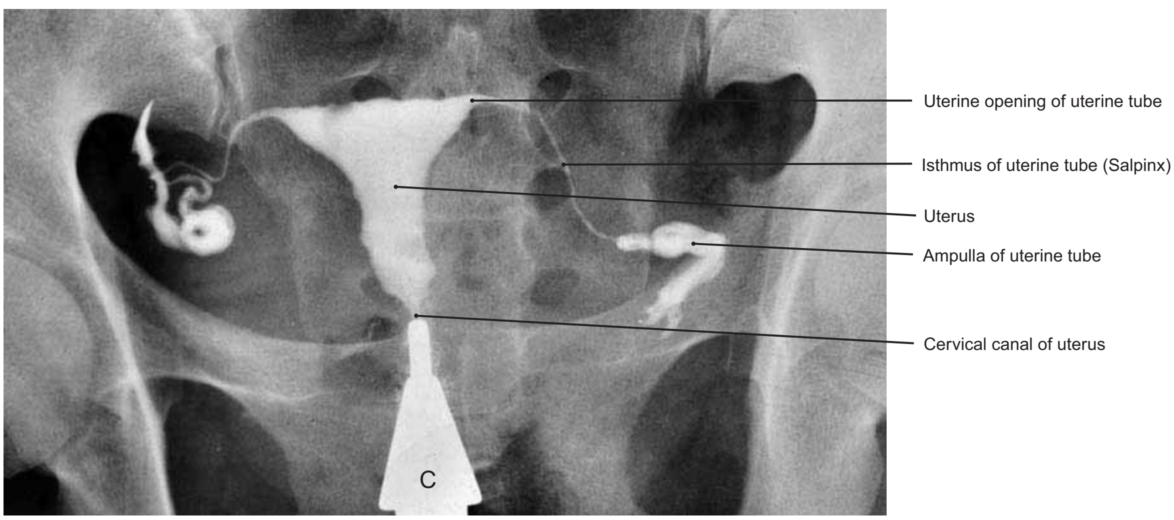


FIGURE 330.2 Uterosalpingogram

NOTE: (1) A cannula (C) was placed in the vagina, and radiopaque material was injected into the uterus and uterine tube. Observe the narrow lumen of the isthmus of the uterine tubes and how the tubes enlarge at the ampullae.
(2) On the specimen's left side (reader's right), even the fimbriated end of the tube is discernible, whereas on the specimen's right side (reader's left) a small portion of the radiopaque material has been forced into the pelvis through the opening in the uterine tube.

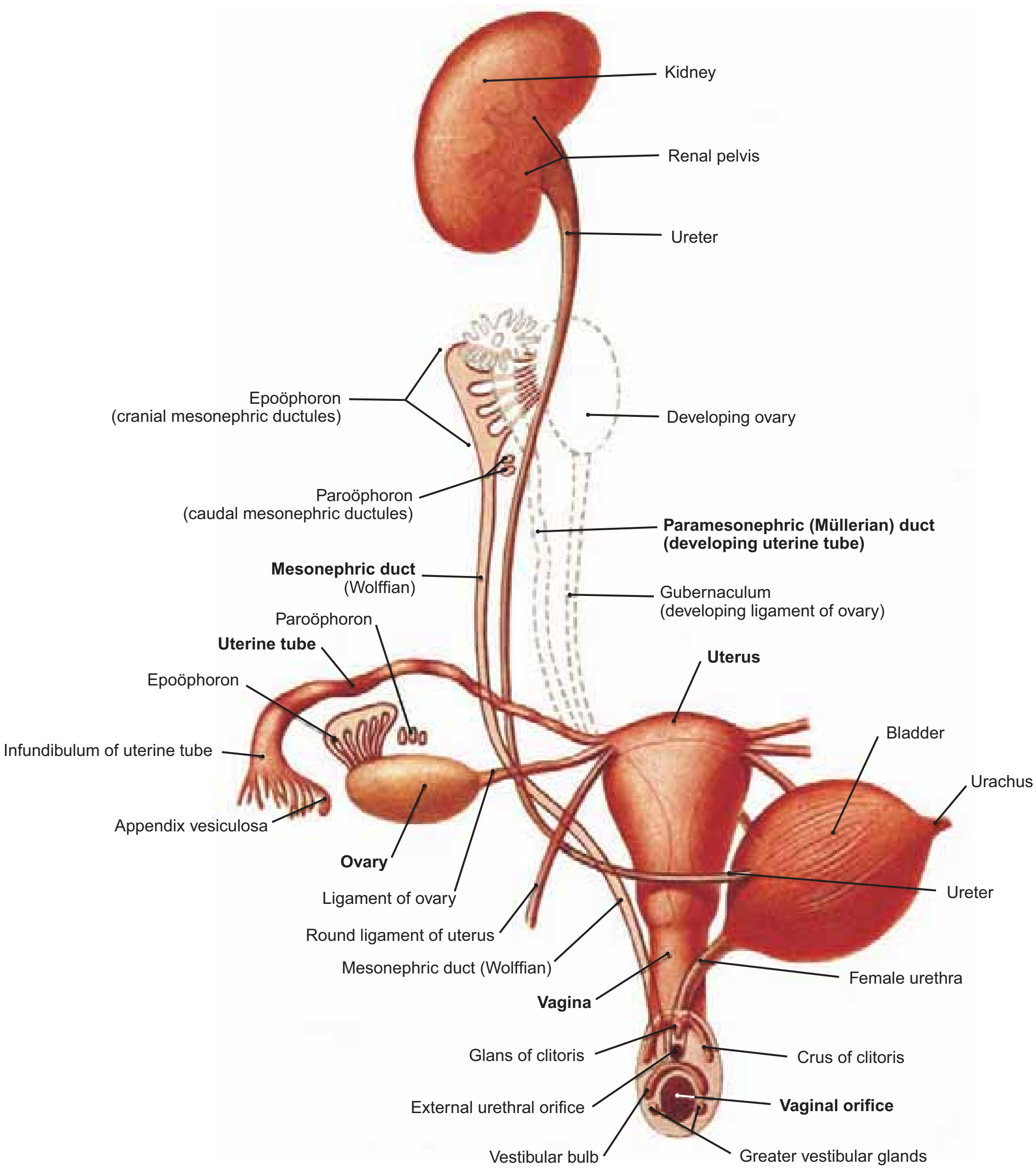


FIGURE 331 Diagram of the Female Genitourinary Organs and Their Embryologic Precursors

NOTE: (1) This figure shows:
- (a) All of the organs of the adult female genitourinary system (dark red-brown).
- (b) The structures and relevant positions of the female genital organs (gonad and ligament of the ovary and uterine tube) prior to their descent into the pelvis (interrupted lines).
- (c) The structures that become atrophic during development (pink with red outline).

(2) The urinary system of females (as in males) includes the kidney, which produces urine from the blood; and the ureter, which conveys the urine to the bladder, where it is stored. Leading from the bladder is the urethra, through which urine passes to the external urethral orifice during micturition.

(3) The adult female genital system includes the **ovary, uterine tube, uterus,** and **vagina,** plus the associated glands and external genital organs.

(4) At one time during development, structures capable of developing into both male and female genital systems existed. In the female, the Müllerian, or paramesonephric, duct becomes vestigial. Also, the developing gonads become ovaries, while their attachments become the ligaments of the ovaries.

(5) The ovaries produce ova that are discharged periodically between adolescence and menopause. The ova are captured by the uterine tube, where fertilization may occur. If this happens, the fertilized ovum is transported to the uterus, and about a week after fertilization, implantation occurs in the wall of the uterus.

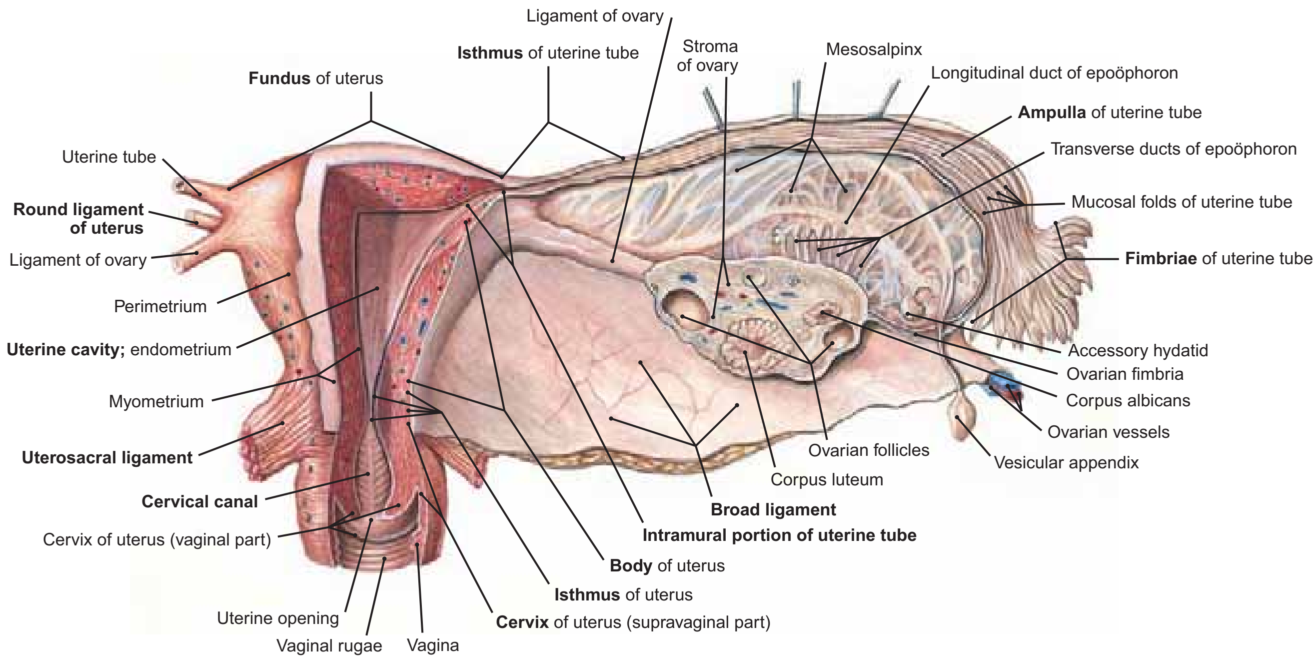


FIGURE 332.1 **Frontal Section of Uterus, Uterine Tube, and Ovary**

NOTE: (1) The vagina communicates with the pelvic cavity through the uterus and the uterine tube. The lumen of this pathway varies in diameter, and its most narrow sites are the isthmus of the uterus and the intrauterine (intramural) part of the uterine tube.

(2) The uterus consists of the **cervix** (vaginal and supravaginal portions), the **body,** and the **fundus.** The cervix and the body are interconnected by the **isthmus.**

(3) The attachments of the uterus include:

(a) The **broad ligaments** that attach to the lateral margins of the uterus.

(b) The fibrous **round ligaments** and the **ligaments of the ovaries** attached just below the uterine tubes.

(c) The **uterosacral ligaments.**

(d) The **cardinal ligaments (of Mackenrodt)** that attach along the lateral border of the uterus and vagina. With the pelvic diaphragm, the cardinal ligaments offer important support to the uterus and vagina.

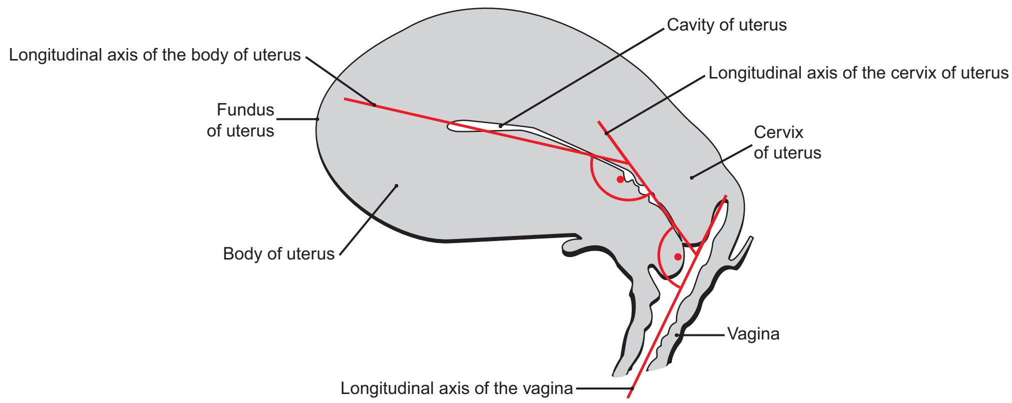


FIGURE 332.2 **Normal Angles between the Vagina, Cervix, and Body of Uterus**

NOTE that the uterus is in a normal anteverted, anteflexed position.

FIGURE 332.3A–C **Variations in the Position of the Uterus in the Pelvis**

A: Anteverted, anteflexed position. **B:** Anteverted but no anteflexion. **C:** Retroverted, retroflexed position.

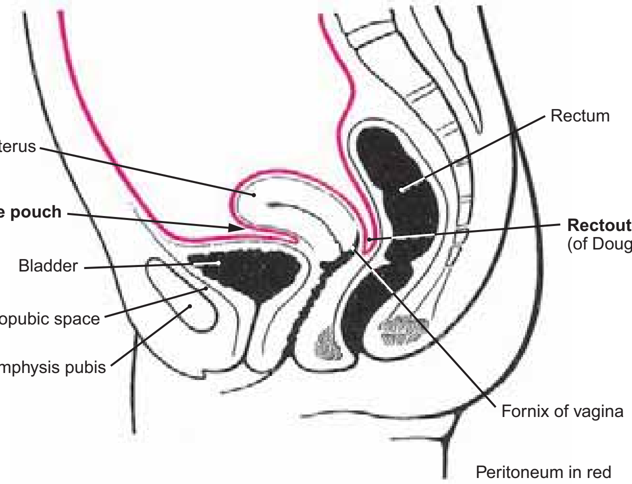


FIGURE 333.1 Diagram of Peritoneal Reflections over Female Pelvic Organs (Midsagittal Section)

NOTE: (1) The parietal peritoneum is reflected over the free abdominal surface of the pelvic organs. Observe that as the uterus and vagina are interposed between the bladder and the rectum, peritoneal pouches are formed between the bladder and the uterus (vesicouterine) and between the rectum and the uterus (rectouterine pouch of Douglas).

(2) The **vesicouterine pouch** is shallow. The forward tilt, or inclination, of the uterus (anteversion) toward the superior surface of the bladder reduces the potential size of the vesicouterine pouch.

(3) The vesicouterine pouch does not extend as far inferiorly as the vagina, whereas the deeper **rectouterine pouch** dips to the level of the posterior fornix of the vagina. This important anatomical relationship stresses the fact that the posterior fornix is separated from the peritoneal cavity only by the thin vaginal wall and the peritoneum.

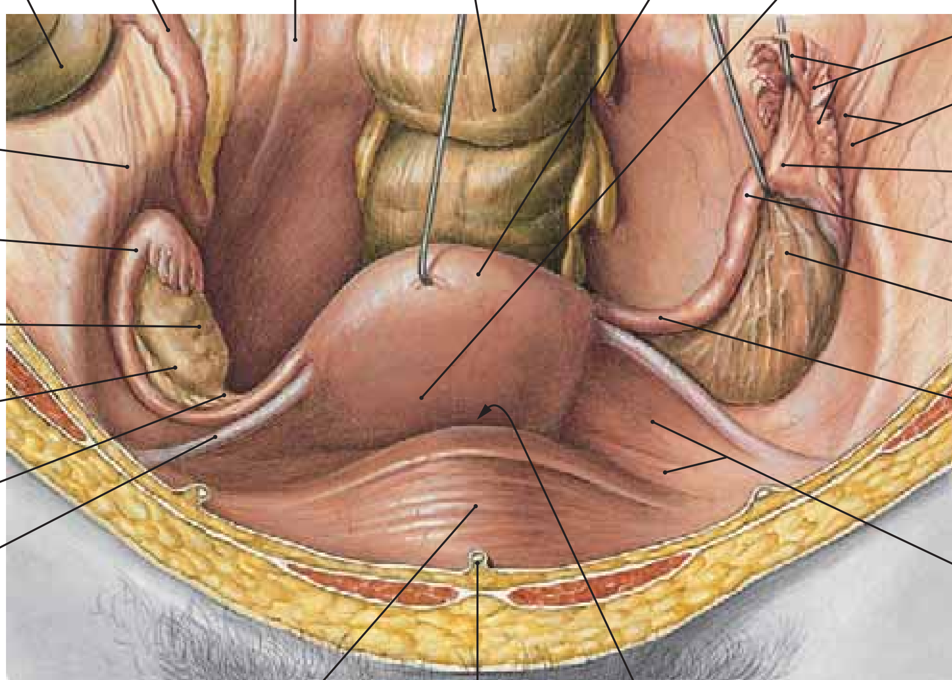


FIGURE 333.2 Female Pelvic Organs (Anterosuperior View)

NOTE: The body of the uterus has been elevated, thereby exposing the **vesicouterine pouch** and demonstrating the **broad ligaments.**

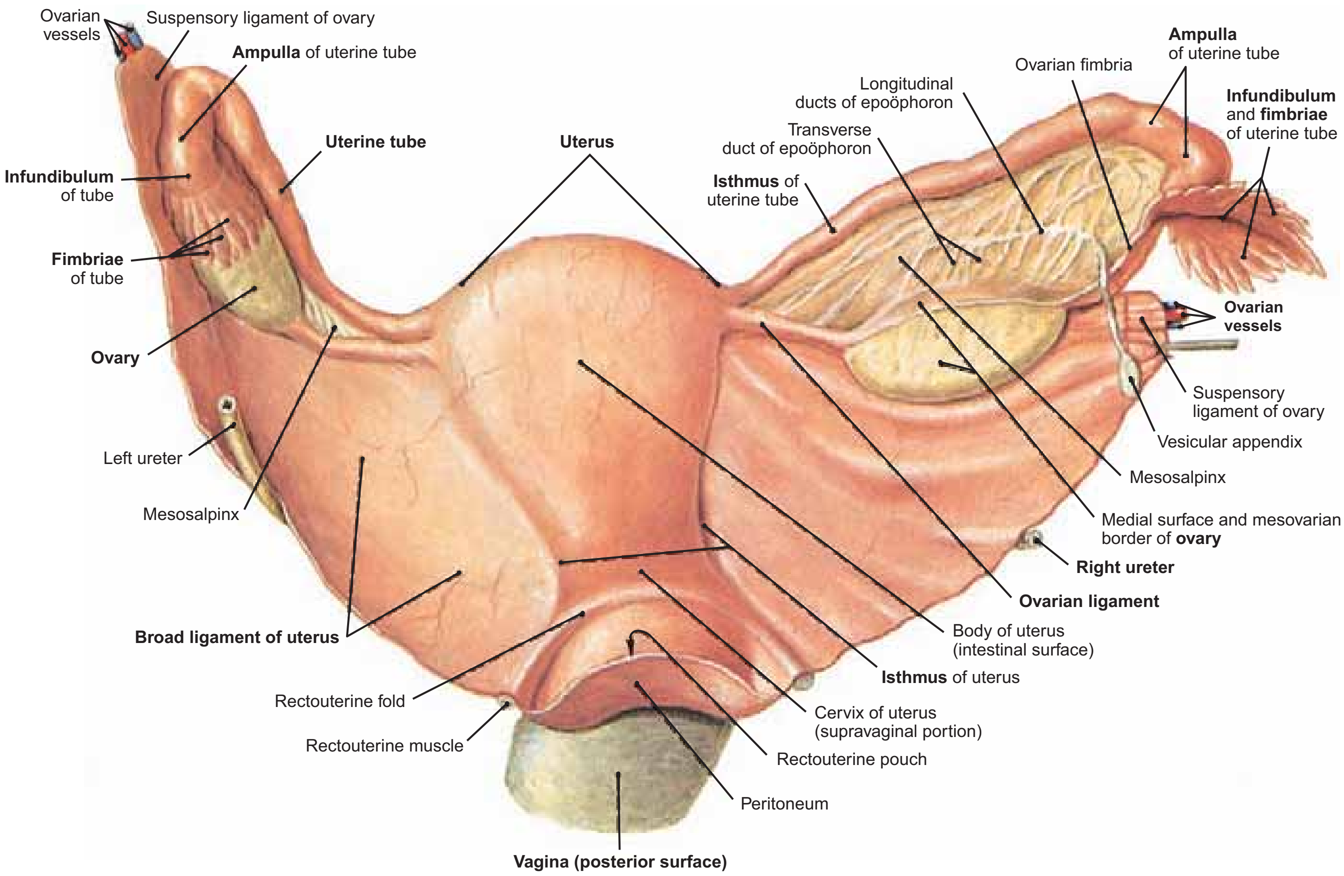


FIGURE 334.1 Pelvic Reproductive Organs of an Immature Girl (Posterior View)

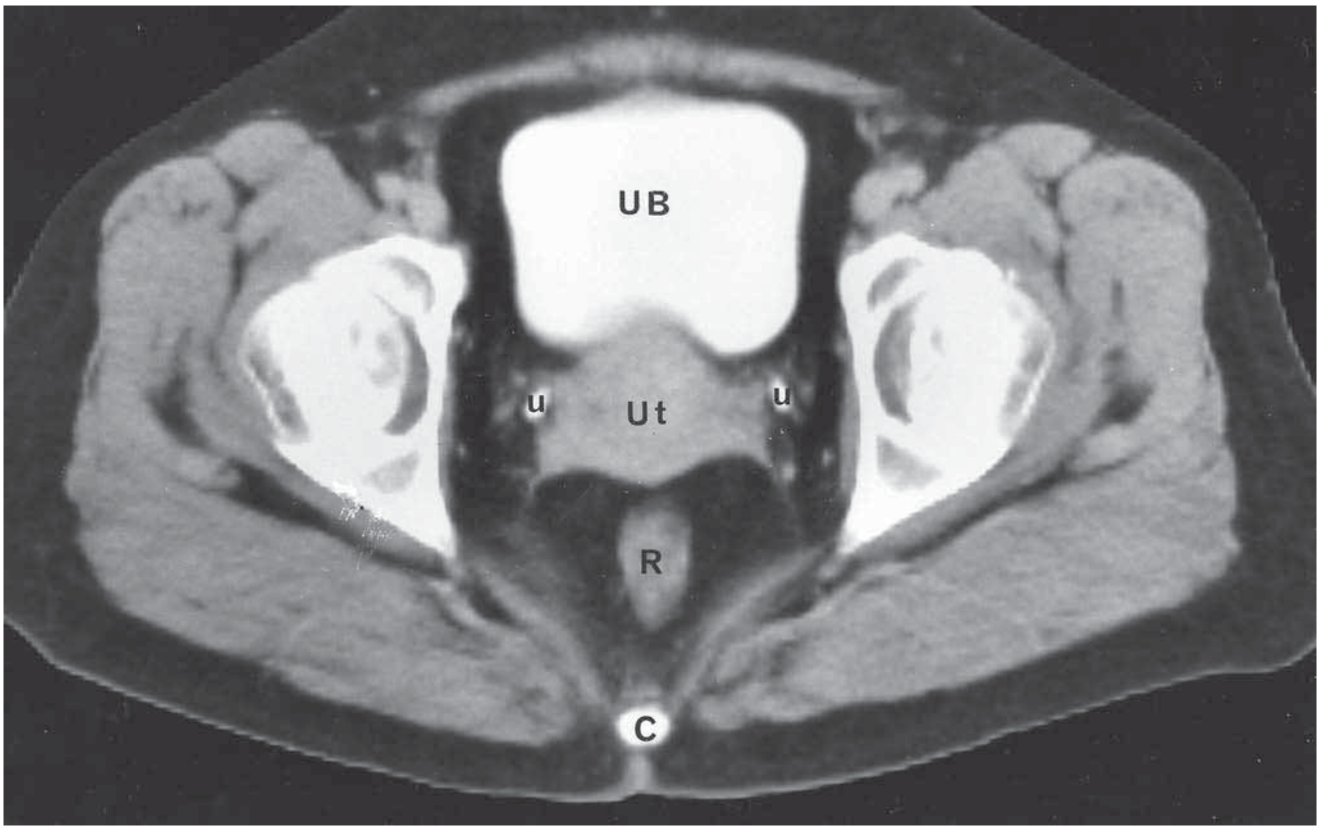


FIGURE 334.2 CT of the Female Pelvis

UB, urinary bladder; **u,** ureter; **Ut,** uterus; **R,** rectum; **C,** coccyx.

(Contributed by Edward J.H. Nathanial, MD, PhD, Professor of Anatomy, University of Manitoba, Winnipeg, Canada.)

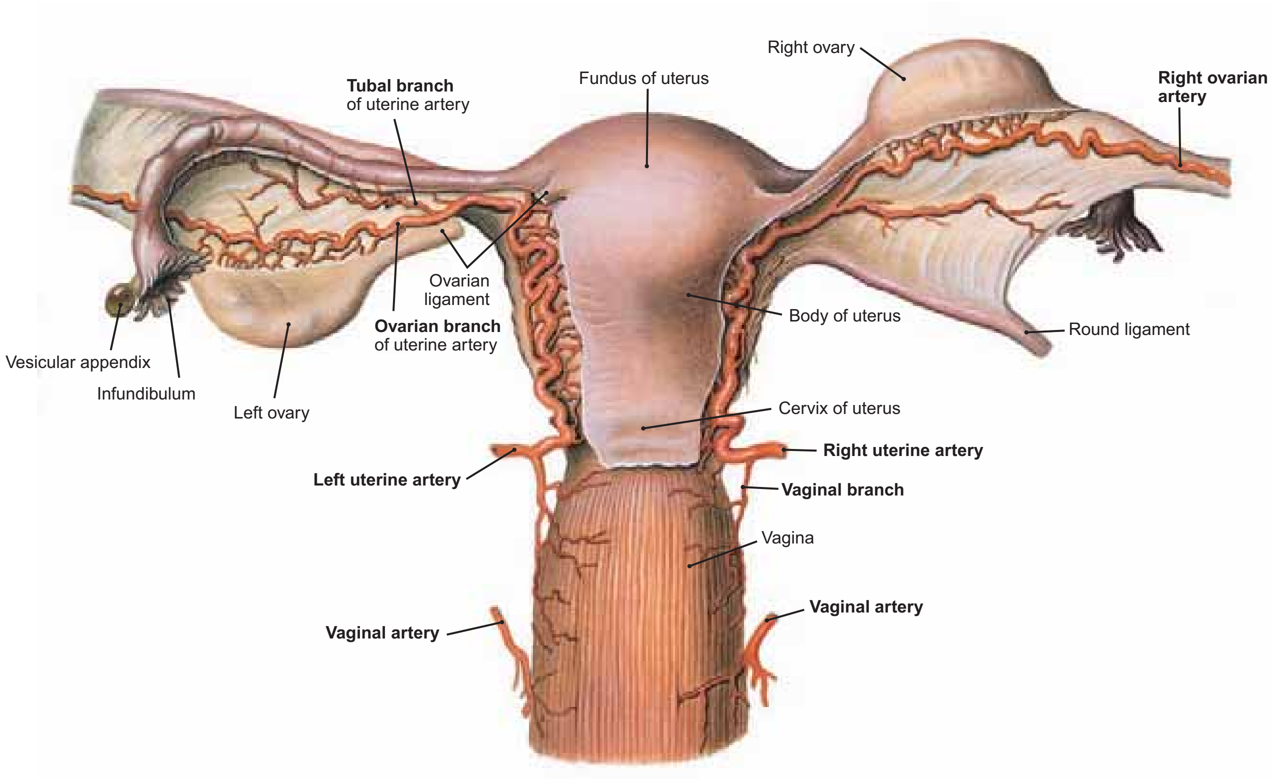


FIGURE 335.1 Arterial Supply to Female Pelvic Genital Organs

NOTE: (1) The vessels supplying the female pelvic genital organs are the **uterine arteries** from the internal iliac and the **ovarian arteries** that stem from the aorta. They anastomose freely along both lateral borders of the uterus.
(2) The uterine artery also anastomoses with the arterial supply to the vagina. Often the **vaginal arteries** arise from the uterine arteries, but they may branch from the inferior vesical artery or even directly from the internal iliac artery.

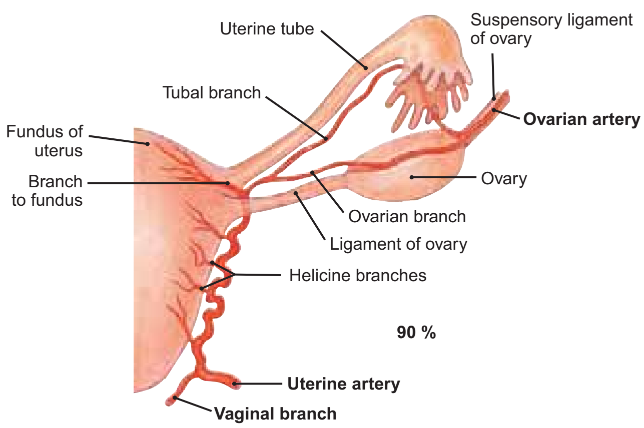


FIGURE 335.2 Diagram of Uterine and Ovarian Arteries

NOTE: This arterial pattern (similar to that shown in Fig. 335.1) is seen in about 90% of humans.

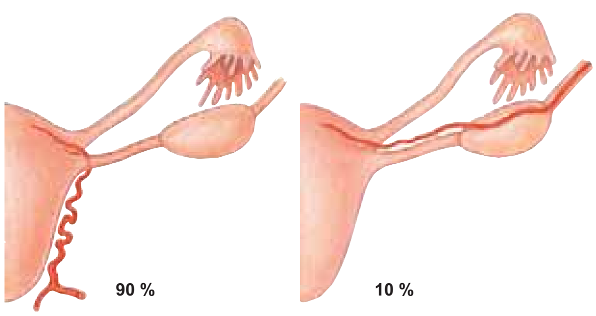


FIGURE 335.3 Arterial Supply to the Fundus of the Uterus

NOTE: In 90% of cases the fundus gets blood from the uterine artery, whereas in 10% it comes from the ovarian artery.

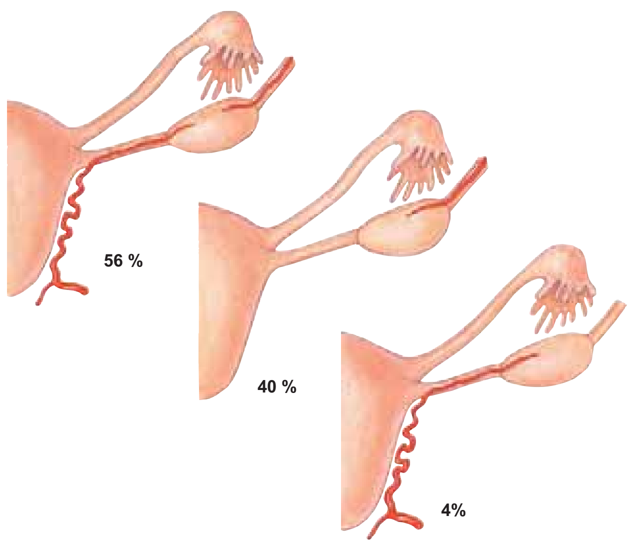


FIGURE 335.4 Arterial Supply to the Ovary

NOTE: In 56% of cases, blood to the ovary comes from both the ovarian and uterine arteries, in 40% from the ovarian artery only, and in 4% from the uterine artery only.

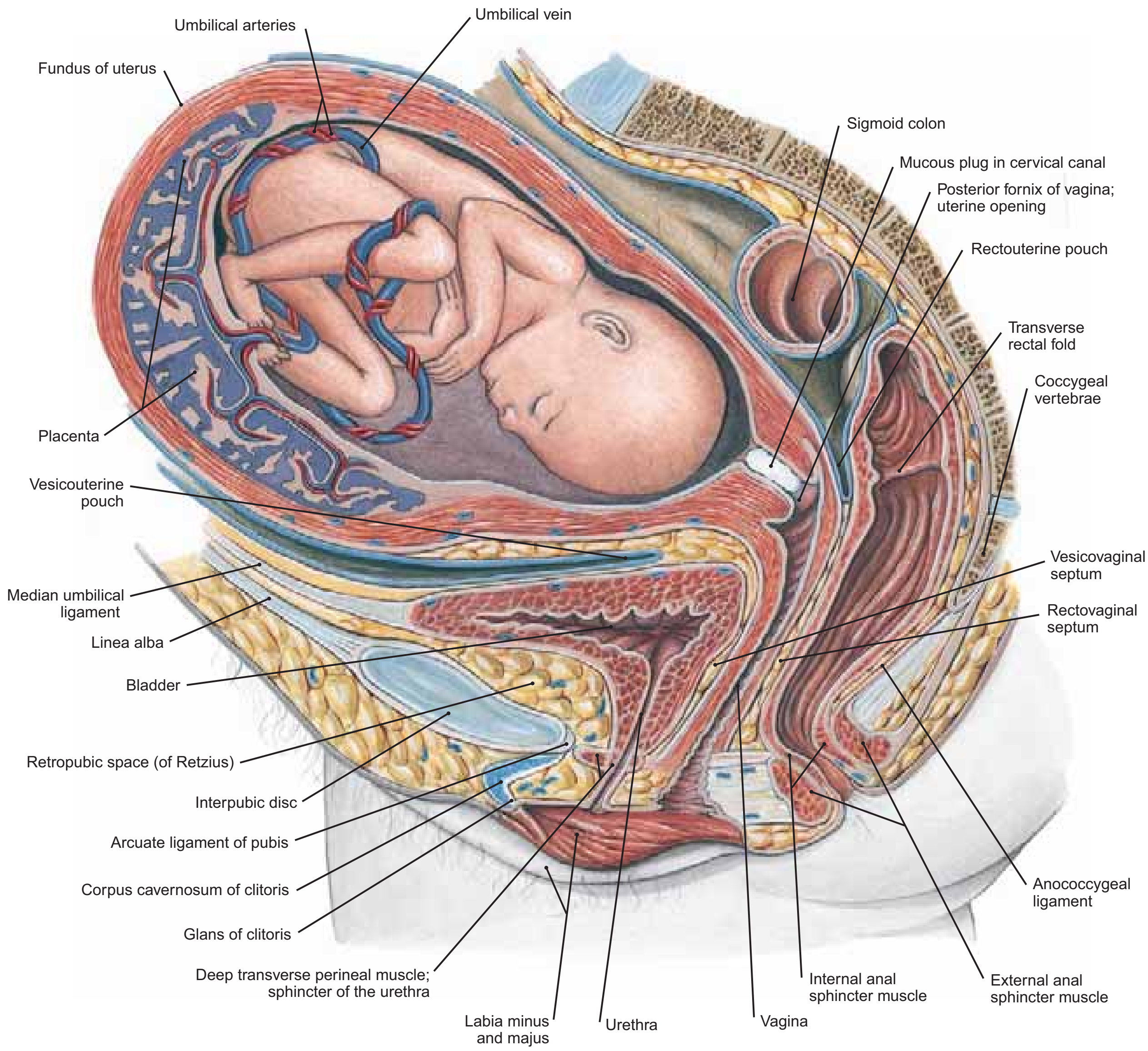


FIGURE 336.1 Pregnant Uterus Shortly before Birth, Right Half of Pelvis

NOTE: (1) The pelvis, including the uterus, has been hemisected, while the newborn fetus is shown intact.
(2) In this cephalic longitudinal presentation of the fetus, the placenta is oriented toward the maternal anterior abdominal wall, in contrast to the longitudinal presentation shown in Figure 337, which shows the back **positioned to the left side of the pelvis.**

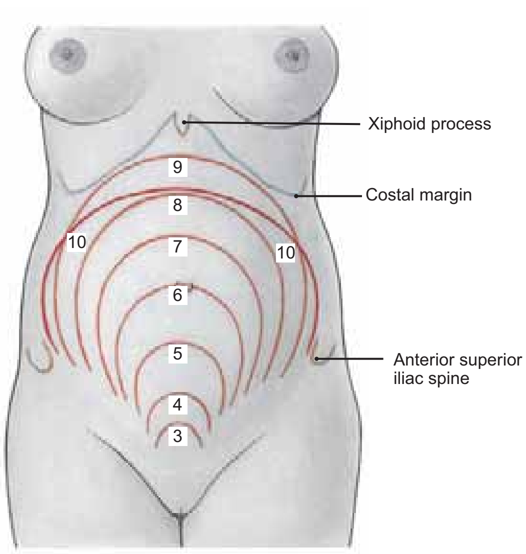


FIGURE 336.2 Diagrammatic Representation of Uterine Growth during Pregnancy (Anterior View)

NOTE: (1) Growth of the uterus is shown in 28-day **lunar months,** hence 10 months rather than 9 calendar months.
(2) By the end of the fourth lunar month, the uterus occupies most of the pelvis. Near the end of pregnancy, it occupies most of the abdomen and extends to the costal margin.
(3) During the last lunar month, the fetus (and fundus of the uterus) descends somewhat, in preparation for the birth process.

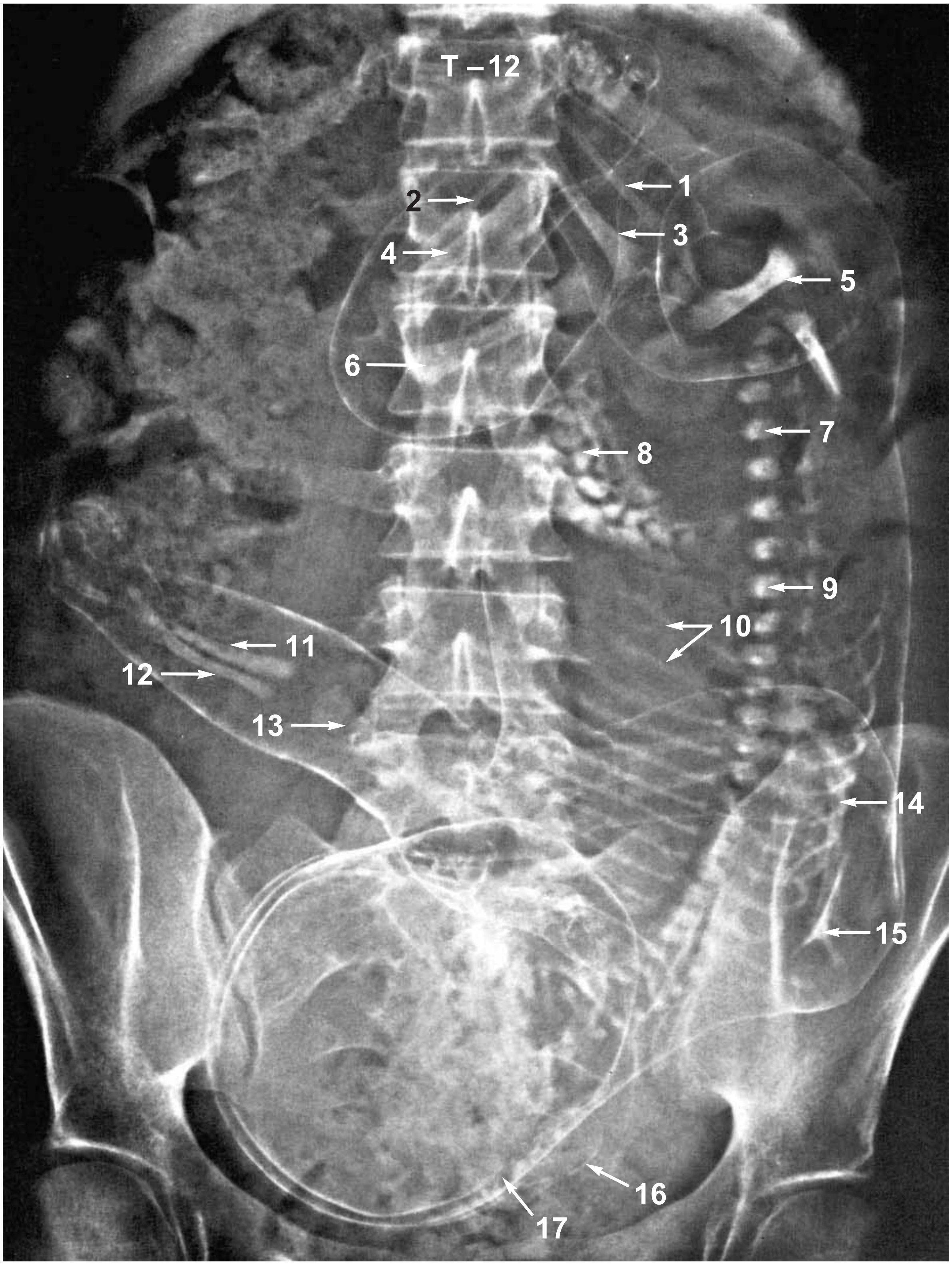


FIGURE 337 Fetal Roentgenogram

NOTE: The body contours of the near-term fetus in utero and a number of the ossifying bones. Observe that the uterus extends to the maternal T12 vertebral body level.

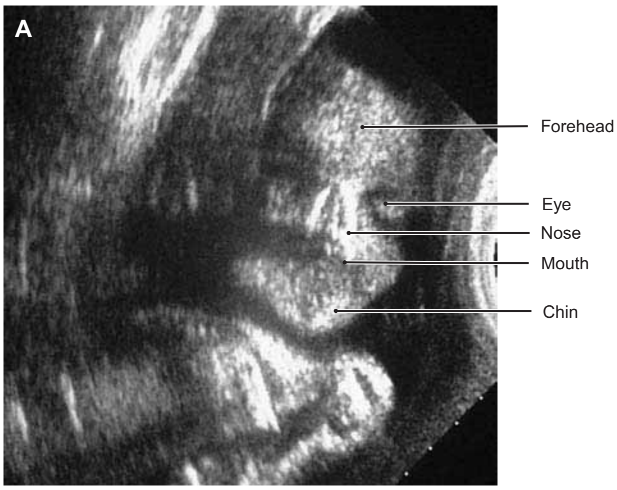
(From Wicke, 6th ed.)

1. Right fibula
2. Left fibula
3. Right tibia
4. Left tibia
5. Right femur
6. Left femur
7. L5 vertebra (fetal)
8. Small intestine (fetal)
9. L1 vertebra (fetal)
10. Ribs
11. Left ulna
12. Left radius
13. Left humerus
14. Right humerus
15. Right scapula
16. External ear
17. Fetal head

FIGURE 338.1 Sonogram of Uterus during the 10th Week of Pregnancy

NOTE: The embryo is oriented longitudinally within the chorionic cavity: head to the left, trunk, and lower limbs to the right.

(The figures on this plate are from Dr. H. Schillinger, Professor of Anatomy, University of Freiburg im Breisgau, Germany.)



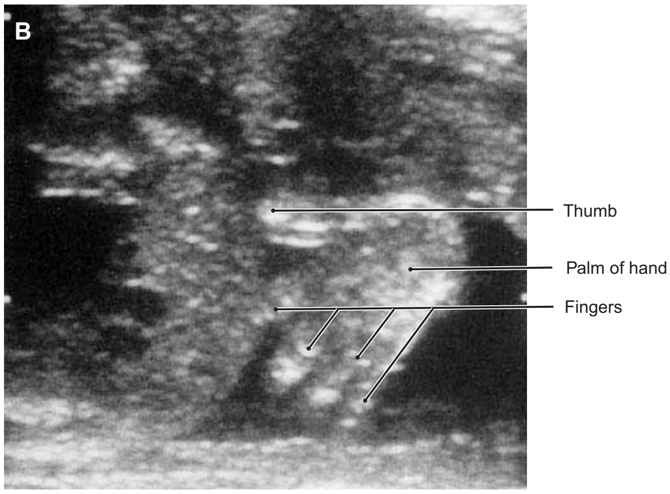
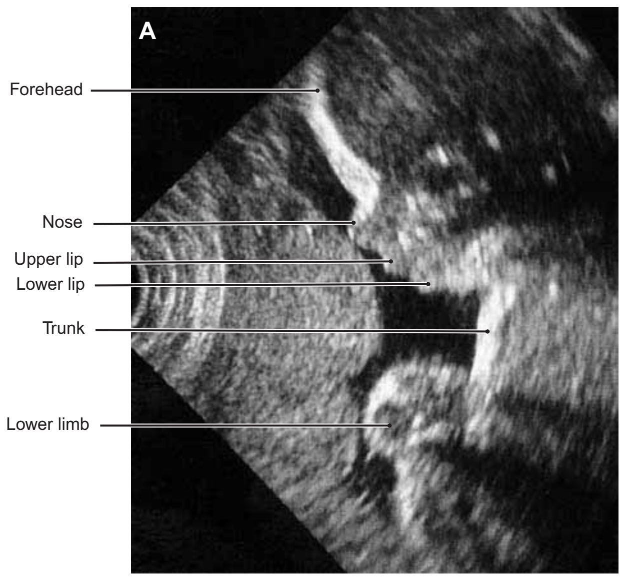


FIGURE 338.2A and B Sonogram of Uterus during the 24th Week of Pregnancy

NOTE: (1) In **A,** a frontal section through the face shows the facial features of the fetus, presenting the fetal "portrait."
(2) In **B,** the sonogram shows the fetal hand, clearly demonstrating all of the fingers and the thumb.



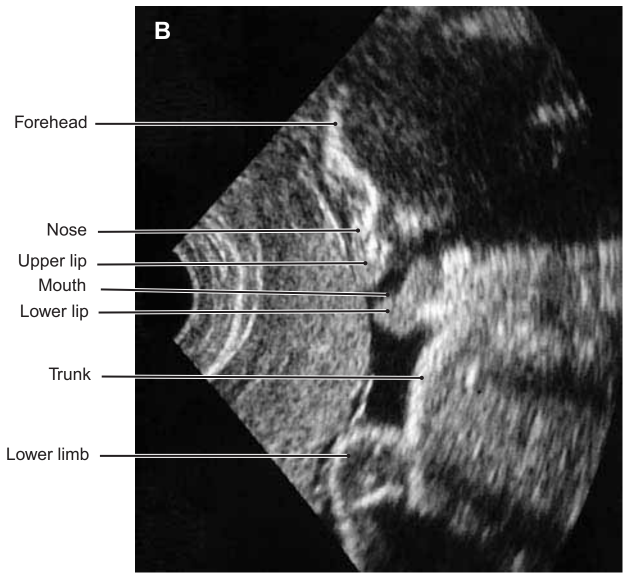


FIGURE 338.3A and B Sonogram of Uterus during 28th Week of Pregnancy

NOTE: (1) In **A,** the longitudinal section shows the fetal head and body in profile.
(2) In **B,** the fetus has opened its mouth and expanded its trunk, indicating the sporadic diaphragmatic and swallowing movements that occur during the latter part of fetal life, when large amounts of amniotic fluid are ingested.

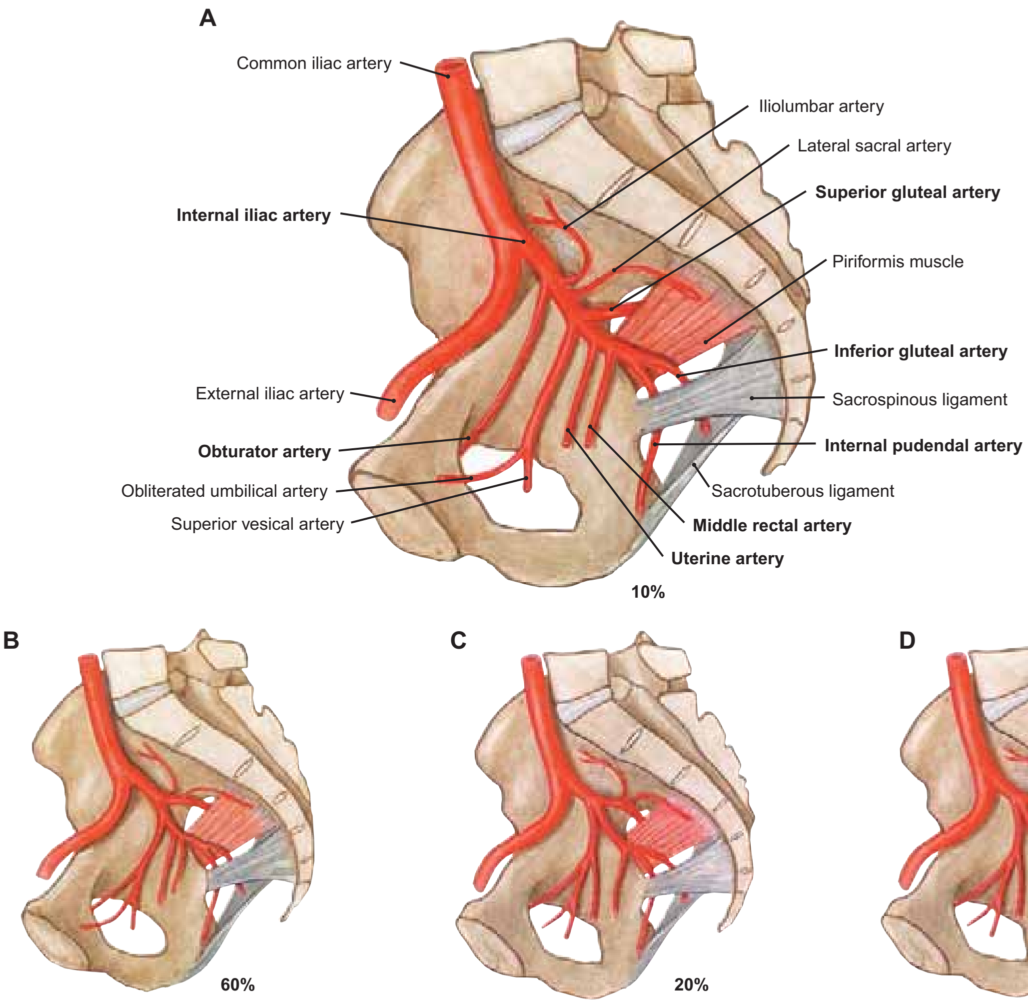


FIGURE 339.1 Variations in the Divisions of the Internal Iliac Artery

NOTE: (1) In 10% of specimens (shown in **A**) the internal iliac artery itself gives off all branches.
(2) In 60% of specimens (shown in **B**) the internal iliac artery divides into two main branches—an anterior and a posterior trunk.
(3) In 20% of specimens (shown in **C**) the internal iliac artery divides into three branches.
(4) In 10% of specimens (shown in **D**) the internal iliac artery divides into more than three branches.

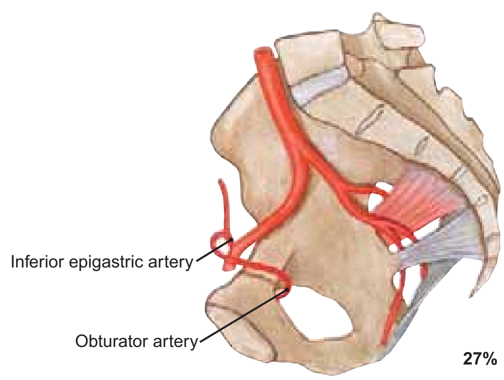


FIGURE 339.2 Aberrant Origin of the Obturator Artery

NOTE: (1) The obturator artery arises from the internal iliac artery or one of its branches in nearly 70% of bodies, but in 27% of cases the obturator artery arises from the **inferior epigastric artery,** as shown in this figure.
(2) If the course of the aberrant obturator artery is lateral to the lacunar ligament, then repair of a femoral hernia is relatively safe, but if it curves along the free margin of the lacunar ligament, the vessel could easily be injured during hernia repair.

(From Picks, J.W., Anson, B.J., and Ashley, F.H. *Am J Anat.* 70:317–344, 1942.)

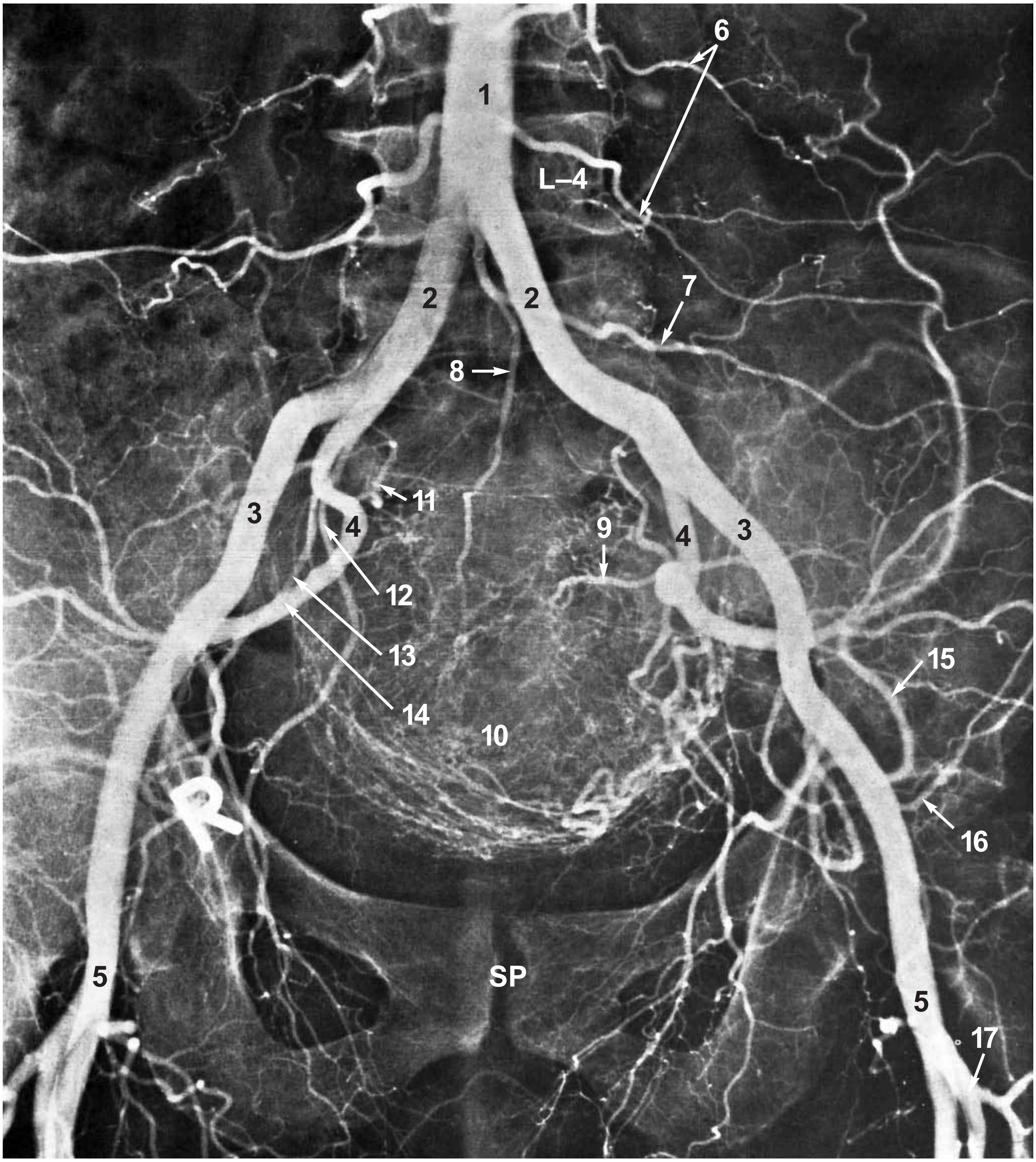


FIGURE 340 Arteriogram of the Iliac Arteries and Their Branches in a Female

NOTE: The bifurcation of the aorta (1) into the two common iliac arteries (2) occurs at the lower border of the body of the L4 vertebra. The common iliac vessels branch into external (3) and internal (4) iliac arteries. The internal iliac artery (4) on each side serves a number of branches to the pelvis, perineum, and gluteal region, whereas the external iliac artery (3), after giving off the inferior epigastric (15) and deep circumflex iliac (16) arteries, becomes the femoral artery below the inguinal ligament.

(From Wicke, 6th ed.)

1. Abdominal aorta
2. Common iliac artery
3. External iliac artery
4. Internal iliac artery
5. Femoral artery
6. Lumbar arteries
7. Iliolumbar artery
8. Median sacral artery
9. Uterine artery
10. Uterus
11. Lateral sacral artery
12. Obturator artery
13. Internal pudendal artery
14. Superior gluteal artery
15. Inferior epigastric artery
16. Deep circumflex iliac artery
17. Deep femoral artery

SP = Symphysis pubis
L4 = 4th lumbar vertebra

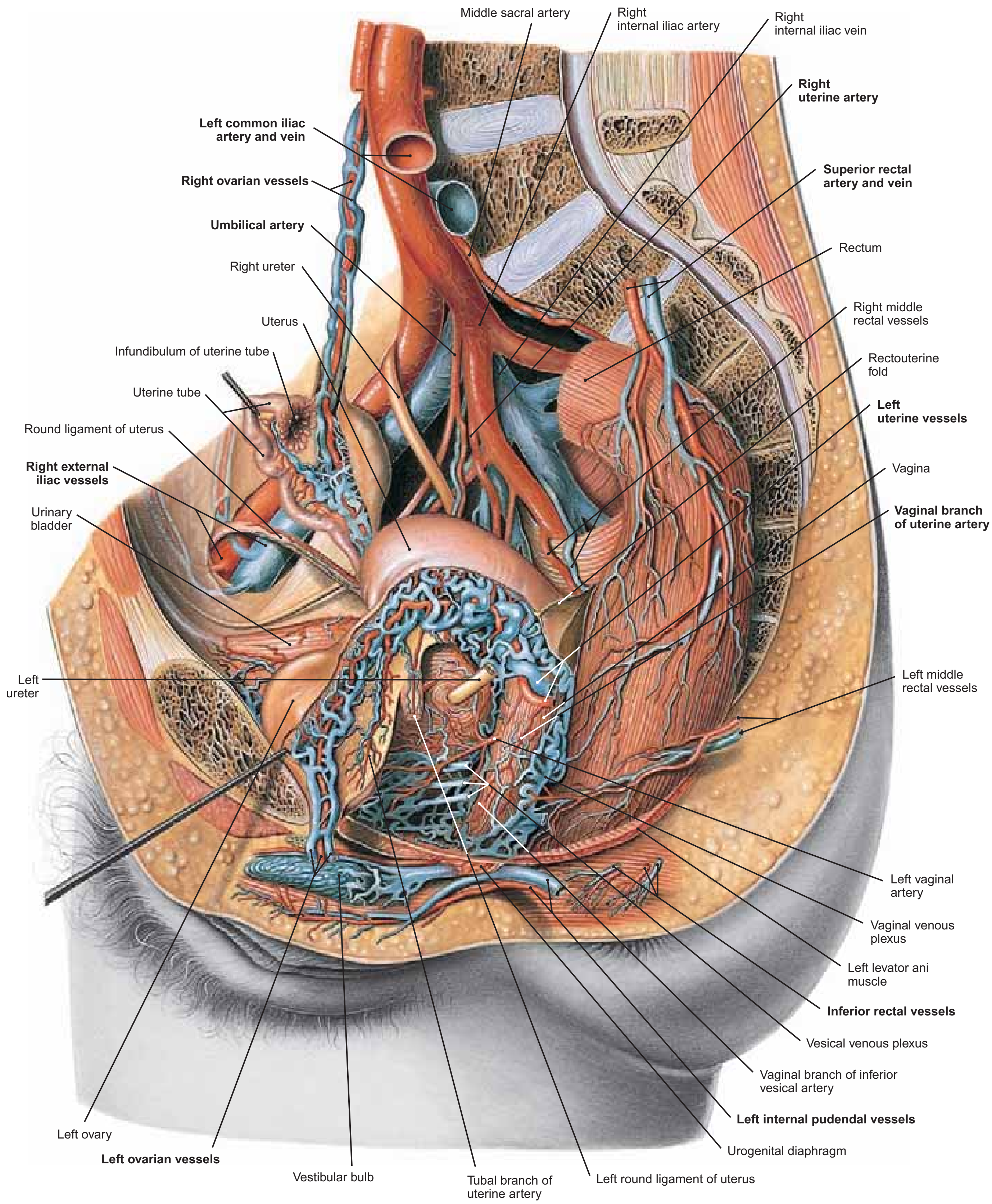


FIGURE 341 Blood Vessels of the Female Pelvis and Genital System

NOTE: (1) The left half of the pelvis has been removed to expose the pelvic organs and their dense plexuses of veins (**ovarian, vaginal, uterine,** and **vesical**), which accompany their respective arteries.

(2) With the exception of the **ovarian artery** (from the aorta) and the **superior rectal artery** (from the inferior mesenteric) all other arteries to the pelvic organs, perineum, and genital tract are derived from the **internal iliac artery** or its branches.

(3) The course of the **ureter** is a descending one, crossing the external iliac vessels over the pelvic brim. The ureter then courses **under the uterine vessels** before entering the bladder.

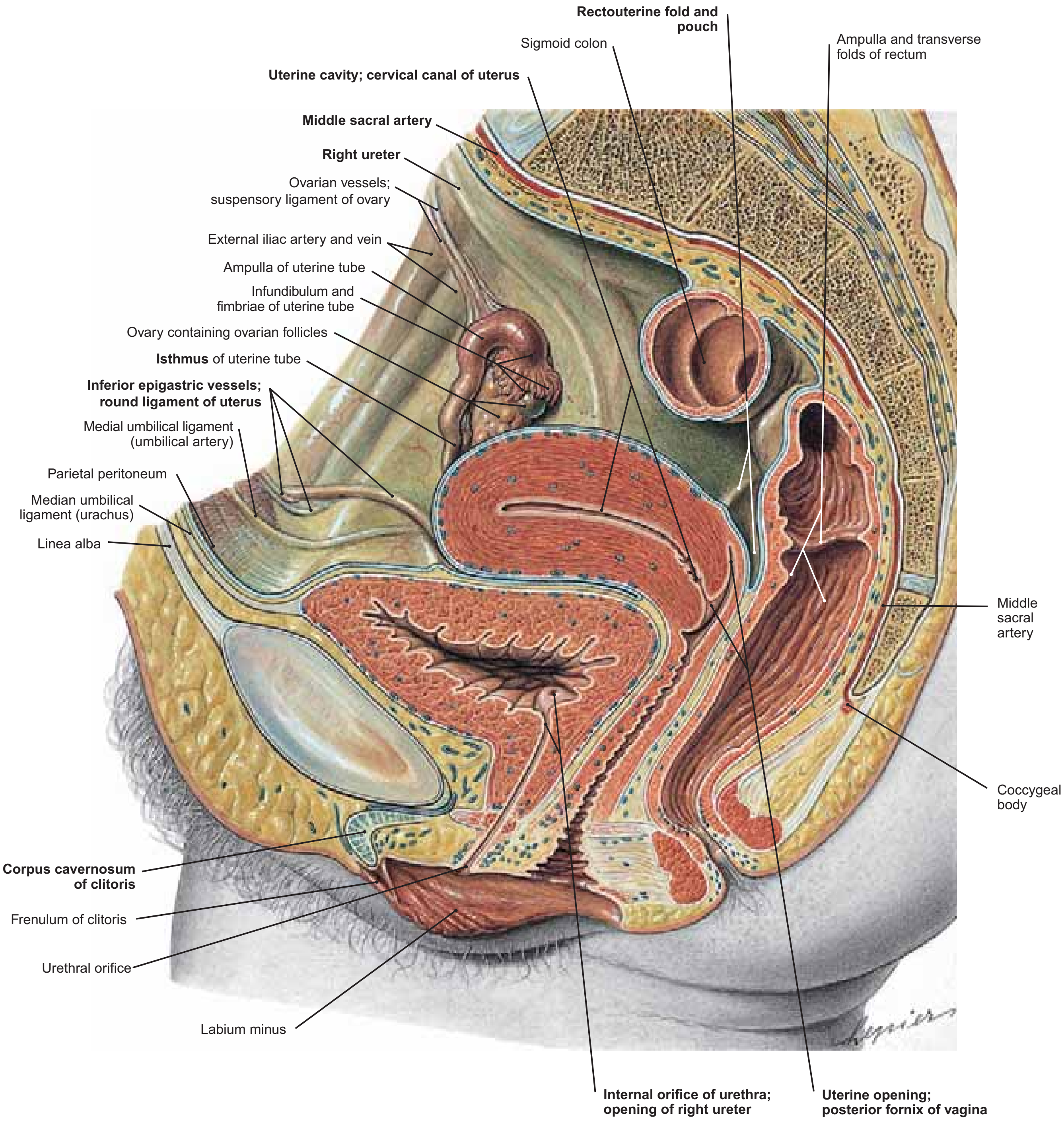


FIGURE 342 Adult Female Pelvis (Median Sagittal Section)

NOTE: (1) This medial view of the hemisected female pelvis shows the relationships of the **bladder, uterus, vagina, rectum, ovary,** and **uterine tube.** Observe the retropubic position of the empty bladder and the short course of the female urethra, leading from the bladder through the **urogenital diaphragm** to open in the midline, anterior to the vagina.

(2) The **posterior fornix** of the vagina reaches superiorly to lie in front of the **rectouterine pouch** (**of Douglas**), being separated from it only by the vaginal wall. Observe that the vagina and uterus are interposed between the bladder and the rectum.

(3) The **round ligament of the uterus** is directed laterally and anteriorly to enter the deep inguinal ring, and note the course of the **inferior epigastric vessels** in relation to this ligament. Observe the **ovarian vessels** within the **suspensory ligament of the ovary** and the **ureter** along the posterolateral wall of the pelvis.

(4) Shown are the **large bowel** and the direct course of the **rectum** toward the **anal canal.** The peritoneum is reflected over the anterior surface of the rectum, thereby lining the rectouterine pouch.

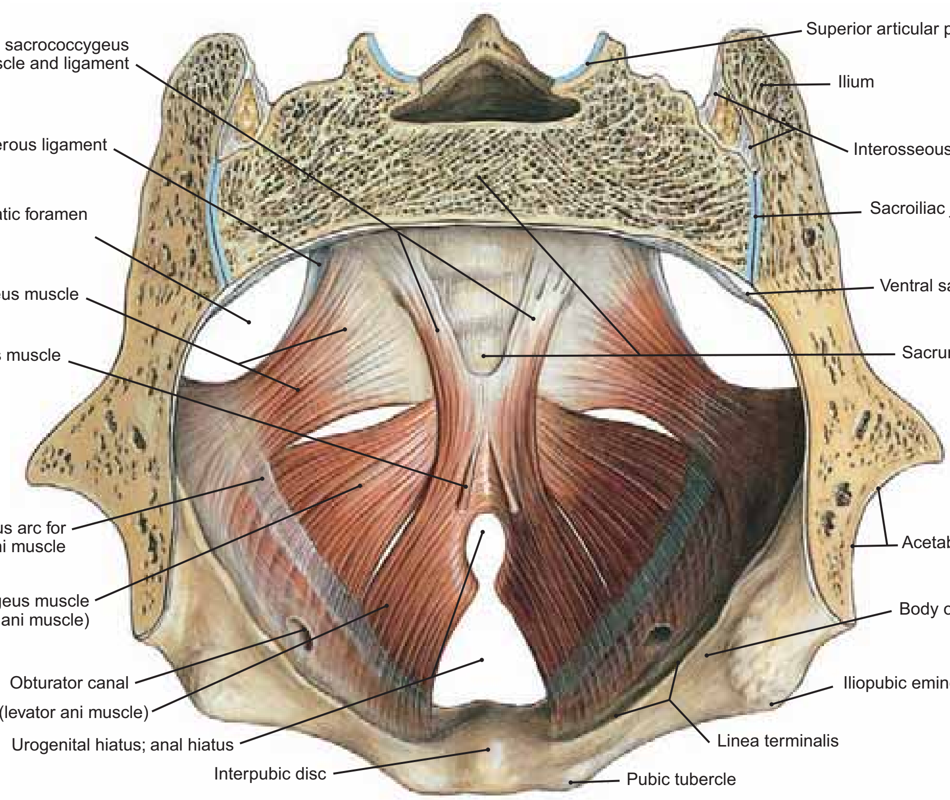


FIGURE 343.1 Muscular Floor of the Female Pelvis Viewed from Above

NOTE: (1) The muscular floor of the pelvis is formed anteriorly by the **pubococcygeus** and anterolaterally by the **iliococcygeus** portions of the **levator ani muscle** and posterolaterally by the **coccygeus muscle,** which lies above the sacrotuberous ligament.

(2) At the **urogenital hiatus** is located the **urogenital (UG) diaphragm,** which is formed by the deep transverse perineal muscles and the membranous sphincter of the urethra, which lie between two layers of fascia (see Fig. 345.2). The urethra and vagina penetrate through the UG diaphragm in the female.

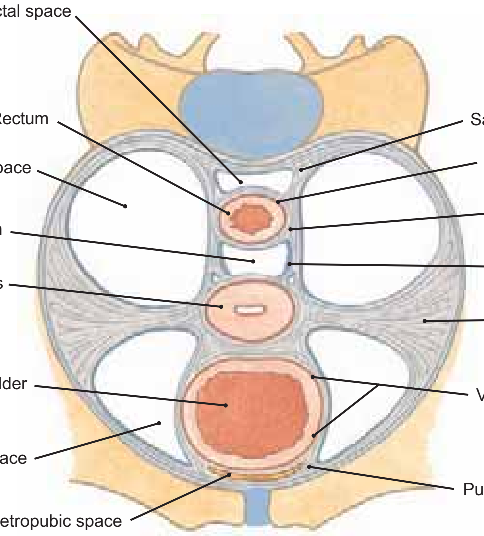


FIGURE 343.2 Uterine Ligaments at the Cervix Just above the Pelvic Floor (Diagram)

NOTE: (1) Just above the floor of the pelvis (formed by the levator ani and coccygeus muscles) is located the cervix of the uterus in women. Extending laterally from the uterine cervix and from the upper vagina to the fascia covering the levator ani muscles are the **transverse cervical ligaments** (also called **lateral cervical, cardinal,** or **Mackenrodt's ligaments**).

(2) The transverse cervical ligaments are located at the base of the broad ligaments and below the uterine vessels. Observe that the **uterosacral ligaments** also attach to the cervix and upper vagina but course backward around the rectum to the front of the sacrum.

(3) The uterus is supported in position by (a) its attachment to the bladder and rectum, (b) the transverse cervical and uterosacral ligaments, and (c) the musculature that forms the pelvic floor and urogenital diaphragm.

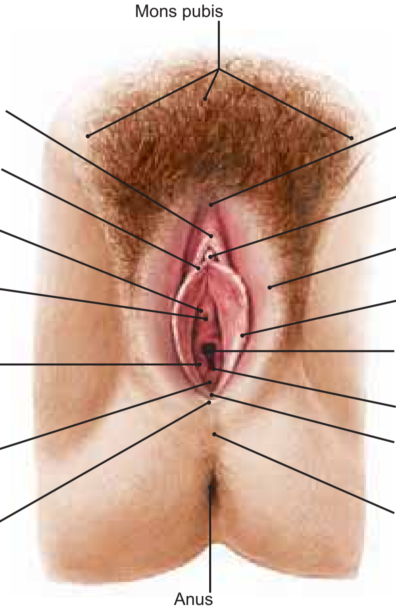


FIGURE 344.1 External Genitalia of an 18-Year-Old Virgin

NOTE: (1) The female **external genitalia** are (a) the mons pubis, (b) the labia majora, (c) the labia minora, (d) the clitoris, and (e) the vestibule of the vagina. The **orifices** of the female perineum include the openings of the (a) urethra, (b) vagina, (c) ducts of the two greater vestibular glands, (d) small paraurethral ducts (of Skene), and (e) anus.

(2) The **mons pubis** is a rounded mound of skin and adipose tissue anterior to the symphysis pubis; in the adult it is covered with genital hair.

(3) The **labia majora** are two elongated folds of skin and fat extending from the mons pubis toward the anus. They vary in size and thickness depending on age and obesity, and their anterior ends receive the fibrous round ligaments of the uterus. The labia majora are the female structures homologous to the male scrotum.

(4) The **labia minora** are two thin folds of skin situated between the labia majora. They commence at the glans clitoris, and small extensions pass over the dorsum of the clitoris to form the **prepuce.** Posteriorly, they meet in the midline to form the **frenulum.**

(5) The **clitoris** is the homologue of the male penis. It is an erectile organ that measures 1 in. or less in length and consists of two corpora cavernosa attached by crura to the pubic rami. It is suspended by a fibrous ligament and capped by the **glans.**

(6) The **vestibule** of the vagina is the region between the two labia minora. Into it open the **urethra,** the **ducts of the greater vestibular glands,** and the **vagina.** In the virgin, the vaginal orifice is partially closed by a thin membrane, the **hymen,** which usually is ruptured at first copulation. Since its form and extent are quite variable, virginity cannot be absolutely determined by its absence.

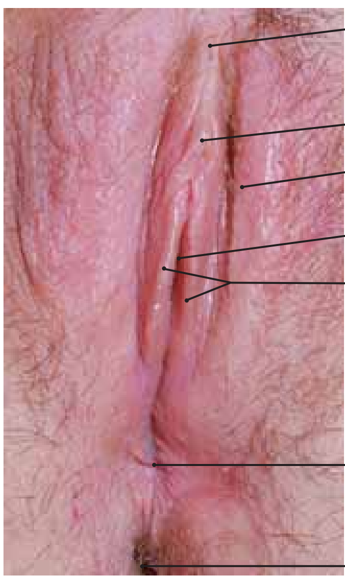


FIGURE 344.2 Perineal Structures in a 26-Year-Old Woman

NOTE: In this photograph the labia minora are approximated so that the vaginal and urethral orifices are not visible.

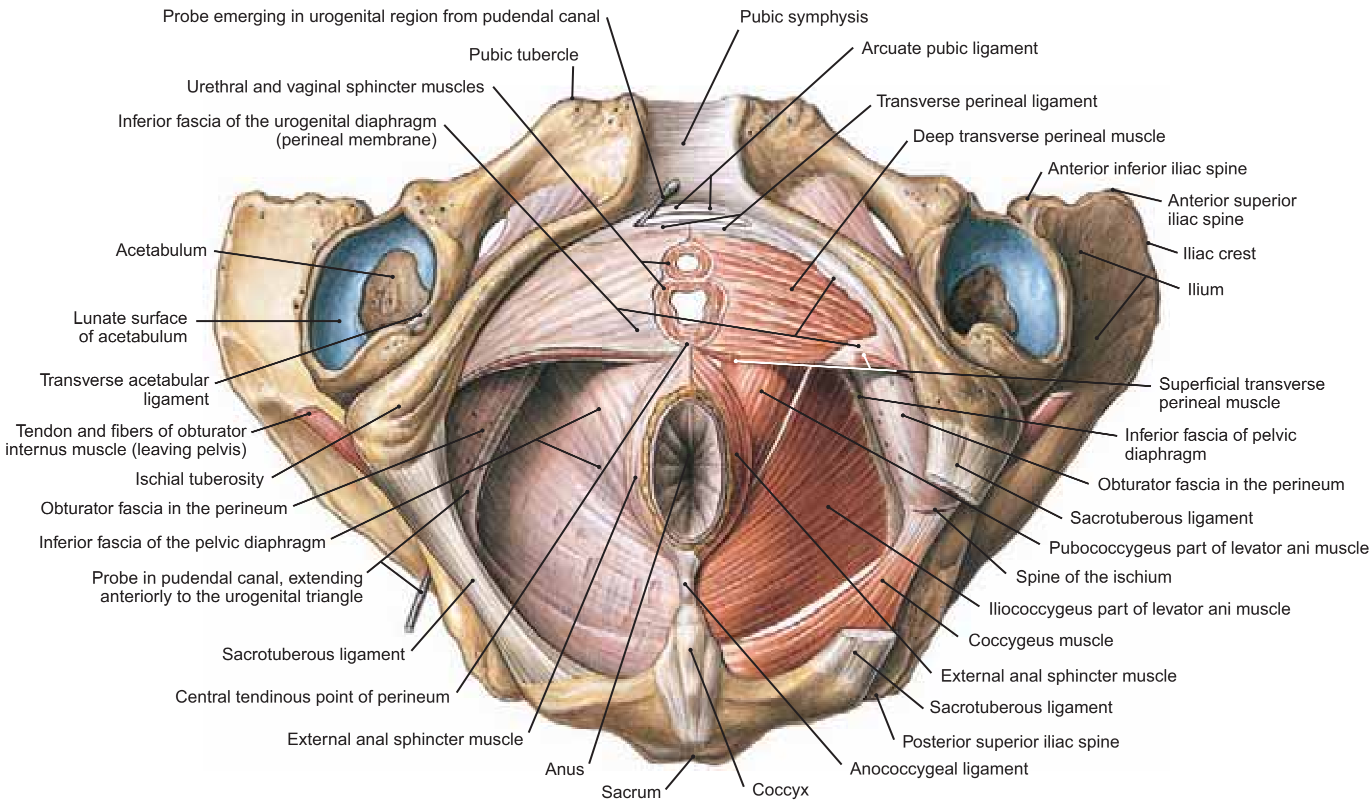


FIGURE 345.1 Musculature of the Floor of the Female Pelvis, Viewed from the Inferior, or Perineal, Aspect

NOTE: (1) On the left side (reader's right) the inferior fascias of the pelvic and urogenital diaphragms have been removed.

(2) The musculature of the urogenital diaphragm completes the anterior part of the female pelvic floor but allows the urethra and vagina to traverse the urogenital hiatus.

(3) The **central point of the perineum** interposed in the midline between the urogenital diaphragm and the anterior end of the raphe formed by the two external anal sphincters.

(4) The anal hiatus is surrounded by the **pubococcygeus** parts of the levator ani muscles. These are reinforced above by the puborectalis muscle and below by the external sphincter. Observe that the **iliococcygeus** sweeps medially to the coccyx, but some fibers also insert into the short midline **anococcygeal raphe** and **ligament.**

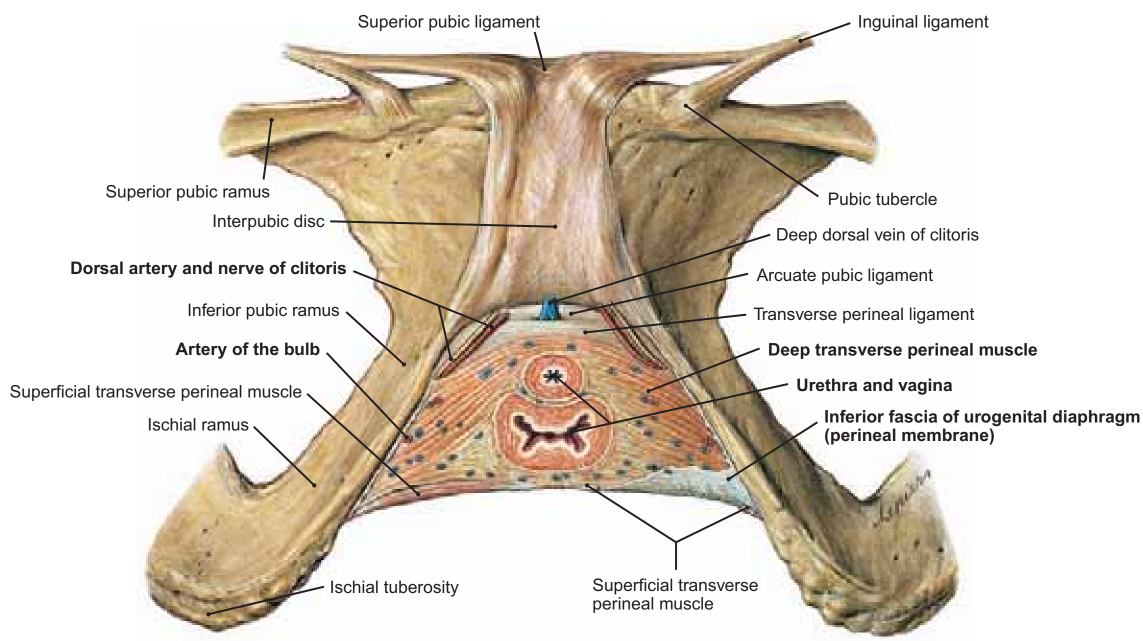


FIGURE 345.2 Urogenital Diaphragm in the Female

NOTE: The female **urethra** and **vagina** both pass through the **urogenital diaphragm.** Observe the circular **sphincter** surrounding the membranous urethra and the **deep transverse perineal muscles** that are covered by deep fascia on both their superior and inferior surfaces.

MUSCLES RELATED TO THE PELVIC DIAPHRAGM

Muscle	Origin	Insertion	Innervation	Action
Levator ani consisting of: **pubococcygeus** **iliococcygeus** **pubovaginalis** **levator of prostate** **puborectalis**	From a tendinous arch (along the fascia of the obturator internus muscle). The arch extends from the symphysis pubis to the ischial spine	Into the coccyx; the anococcygeal raphe and ligament; the external anal sphincter, central tendinous point of the perineum	Pudendal nerve (S3, S4, S5)	Supports and slightly raises the floor of the pelvis; it resists intra-abdominal pressure, as in forced expiration
Coccygeus	Spine of the ischium; sacrospinous ligament	Lateral margin of coccyx and sacrum	Pudendal plexus (S4, S5 nerves)	Draws coccyx forward during parturition or defecation Supports pelvic floor
External anal sphincter:				
Subcutaneous part (a band of fibers just deep to the skin)	Attached anteriorly to the perineal body or central tendinous point and posteriorly to the anococcygeal ligament			
Superficial part (lies deep to the subcutaneous part; main part of muscle)	From the anococcygeal ligament	Into the perineal body or central tendinous point	Pudendal nerve, rectal branch (S4)	Anal sphincter is in a state of tonic contraction; upon defecation, the muscle relaxes
Deep part (forms a complete sphincter of the anal canal)	Fibers surround the anal canal and are applied closely to the internal anal sphincter			

DEEP MUSCLES OF THE UROGENITAL REGION

Muscle	Origin	Insertion	Innervation	Action
Deep transverse perineal muscle (female)	Inferior ramus of the ischium	To the side of the vagina, meeting fibers of the muscle from the other side	Perineal branch of the pudendal nerve (S2, S3, S4)	Helps fix the perineal body and assists the urethrovaginal sphincter
Deep transverse perineal muscle (male)	Inferior ramus of the ischium	Fibers course to the median line, where they interlace in a tendinous raphe with fibers from the other side	Perineal branch of the pudendal nerve (S2, S3, S4)	Helps fix the perineal body and assists the urethral sphincter
Urethrovaginal sphincter (female)	Inferior fibers: From the transverse perineal ligament Superior fibers: From the inner surface of the pubic ramus	Course backward on both sides of the urethra Encircle the lower end of the urethra	Perineal branch of the pudendal nerve (S2, 3, 4)	Acts as a voluntary constrictor of the urethra and vagina
Sphincter of the urethra (male) (surrounds the membranous part of the urethra)	Superficial part: From the transverse perineal ligament Deep part: From the ramus of the pubis	Most fibers form a circular sphincter that invests the membranous urethra; some fibers join the perineal body	Perineal branch of the pudendal nerve (S2, S3, S4)	Acts as the voluntary constrictor of the membranous urethra

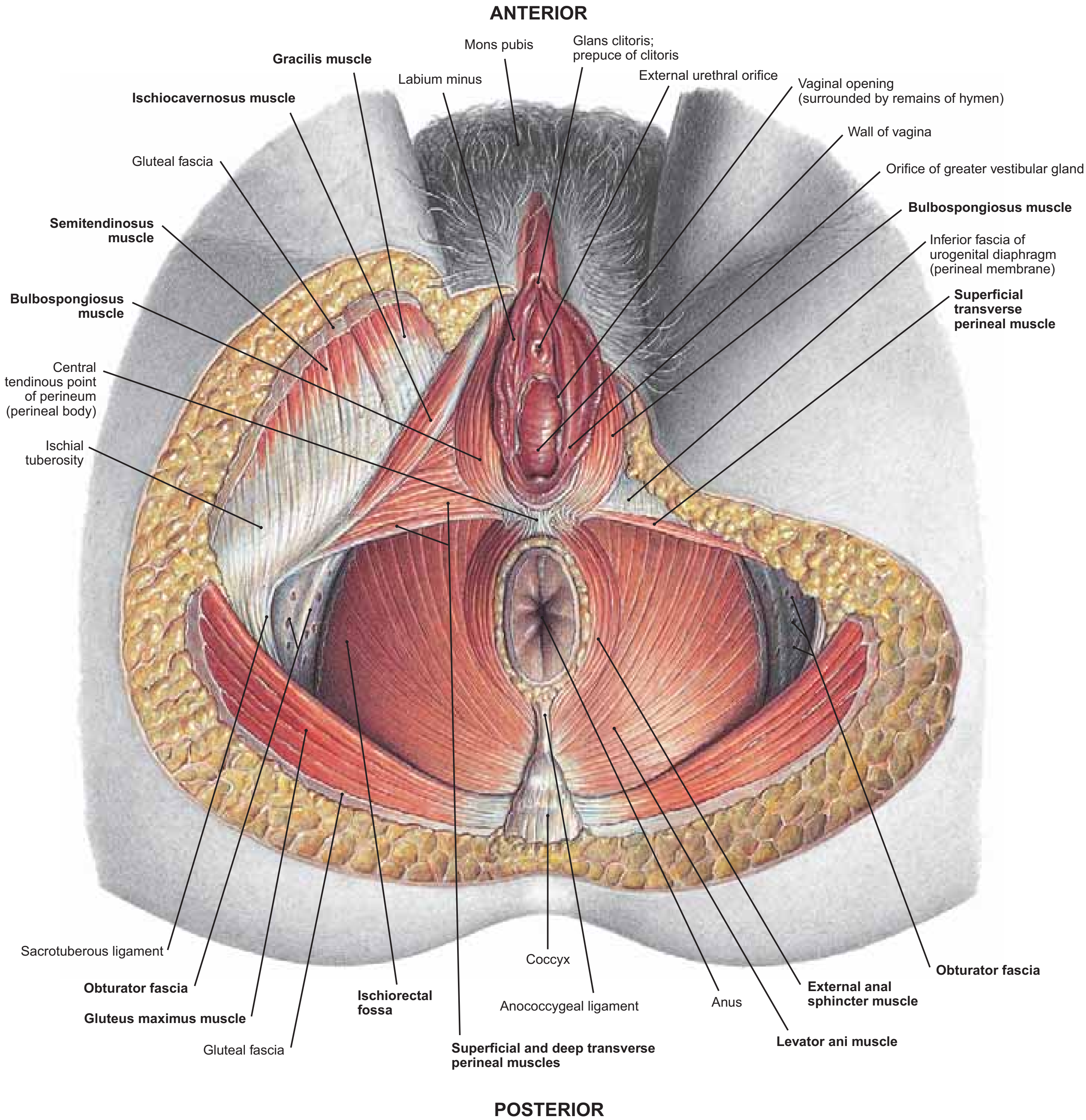


FIGURE 347 Muscles of the Female Perineum

NOTE: (1) The perineum is a diamond-shaped region located below the pelvis and separated from it by the muscular pelvic diaphragm. The perineum is bounded by the **symphysis pubis** anteriorly, the **coccyx** posteriorly, and the two **ischial tuberosities** laterally. A line drawn across the perineum anterior to the anus between the two ischial tuberosities divides the perineum into an anterior **urogenital region** and a posterior **anal region.**

(2) The *urogenital region* contains the external genitalia and the associated muscles and glands. Often books refer to *superficial and deep perineal compartments* (spaces or pouches). The **superficial perineal compartment** lies superficial to the inferior layer of fascia of the urogenital diaphragm, and it contains the ischiocavernosus, bulbocavernosus, and superficial transverse perineal muscles and the perineal vessels and nerves. It is limited superficially by a layer of deep fascia (the external perineal fascia) just deep to **Colles' fascia.**

(3) The **deep perineal compartment** is the space enclosed between the two layers of the urogenital diaphragm. It contains the deep transverse perineal and urethral sphincter muscles and is traversed by the urethra and the vagina in the female.

(4) The *anal region* is situated posterior to the urogenital region; it contains the anus surrounded by the external anal sphincter muscle. A large portion of the anal region is occupied by the two fat-filled **ischiorectal fossae.**

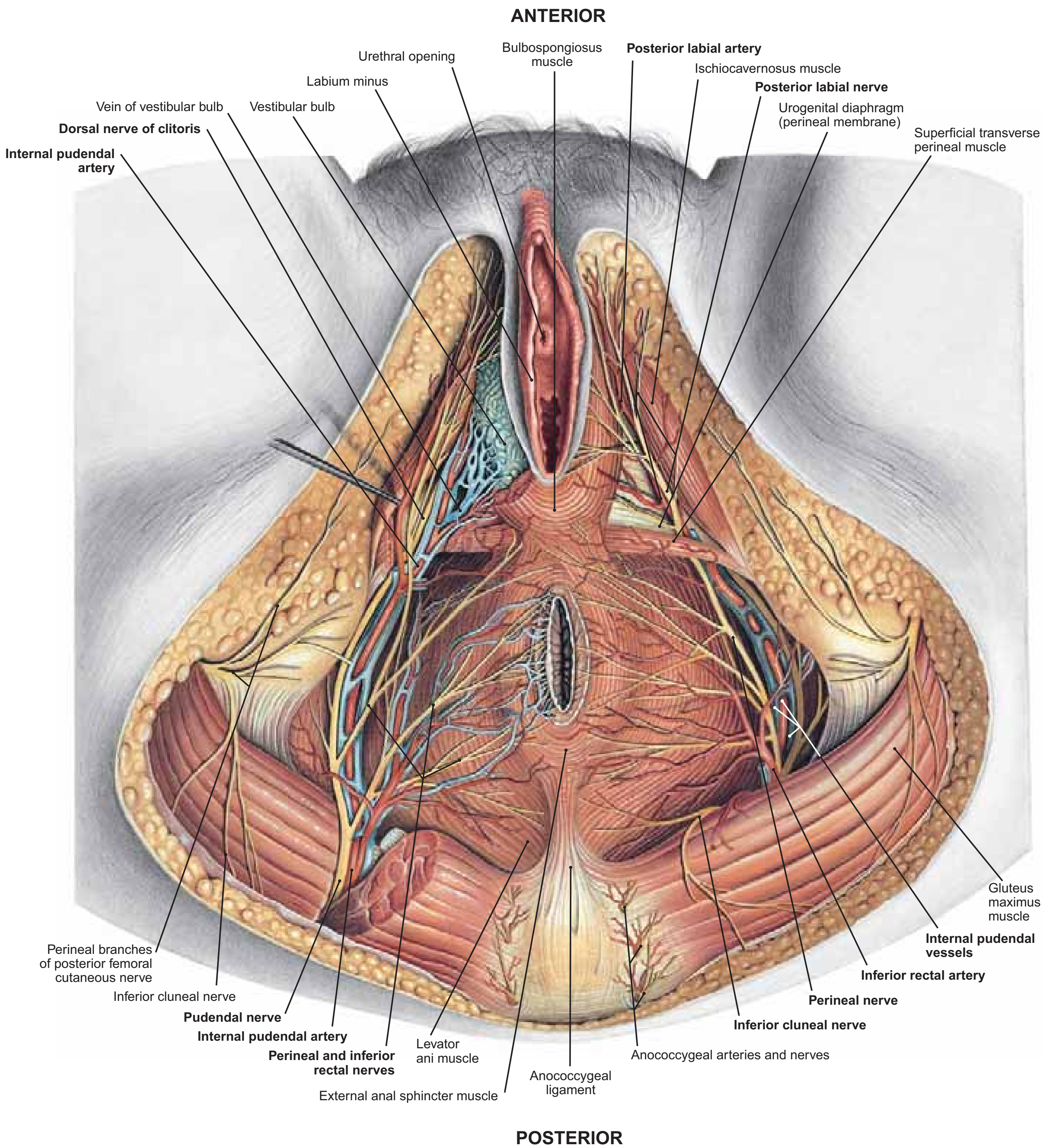


FIGURE 348 Nerves and Blood Vessels of the Female Perineum

NOTE: (1) The branches of the **pudendal nerve** supply most of the perineal structures. This nerve arises from the second, third, and fourth sacral segments of the spinal cord. Within the pelvis it is joined by the **internal pudendal artery and vein.** The vessels and nerve leave the pelvis through the greater sciatic foramen along the lower border of the piriformis muscle and cross the ischial spine to reenter the pelvis through the lesser sciatic foramen.

(2) The pudendal structures reach the perineum by way of the **pudendal canal** (of Alcock) deep to the fascia of the obturator internus muscle. Their branches, the **inferior rectal vessels** and **nerves,** cross the ischiorectal fossa toward the midline to supply the levator ani and external anal sphincter muscles as well as other structures in the anal region.

(3) The pudendal vessels and nerve then continue anteriorly as the **perineal vessels** and **nerve** and enter the urogenital region by penetrating the urogenital diaphragm. They branch again into superficial and deep branches to supply structures in the superficial and deep compartments. The superficial branches supply the labia majora and the external genital structures, whereas the deep branches supply the muscles, vestibular bulb, and clitoris.

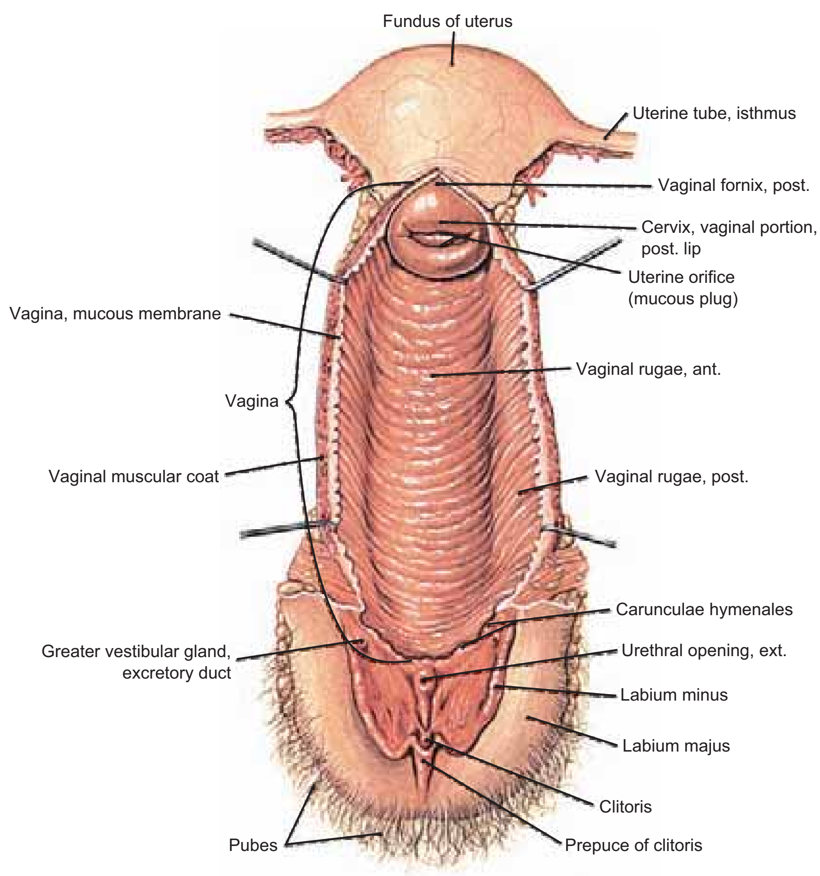
SUPERFICIAL MUSCLES OF THE UROGENITAL REGION

Muscle	Origin	Insertion	Innervation	Action
Superficial transverse perineal muscle (male and female)	Medial and anterior part of the ischial tuberosity	Into the perineal body (female) or central tendinous point (male) in front of the anus	Perineal branch of the pudendal nerve (S2, S3, S4)	Simultaneous contraction of the two muscles helps fix the central tendinous point of the perineum
Ischiocavernosus muscle (female)	Inner surface of the ischial tuberosity behind the crus clitoris and from the adjacent part of the ramus of the ischium	Fibers end in an aponeurosis, which inserts onto the sides and under the surface of the crus clitoris	Perineal branch of the pudendal nerve (S2, S3, S4)	Compresses the crus clitoris, retarding the return of blood and therapy helping to maintain erection of the clitoris
Ischiocavernosus muscle (male)	Inner surface of the ischial tuberosity behind the crus penis and from the ramus of the ischium on each side of the crus	Fibers end in an aponeurosis attached to the sides and under surface of the corpus cavernosum on each side as they join to form the body of the penis	Perineal branch of the pudendal nerve (S2, S3, S4)	Compresses the crus penis and thereby helps maintain erection
Bulbospongiosus muscle (female)	Fibers attached posteriorly to the perineal body	Fibers pass anteriorly around the vagina and are inserted into the corpora cavernosa clitoris	Perineal branch of the pudendal nerve (S2, S3, S4)	Decreases the orifice of the vagina; anterior fibers assist erection of the clitoris by compressing the deep dorsal vein of the clitoris
Bulbospongiosus muscle (male)	From the central tendinous point and the ventral extension of the median raphe between the two bulbospongiosus muscles	**Posterior fibers:** end in connective tissue of the fascia of UG diaphragm **Middle fibers:** encircle the bulb of the penis and the corpus spongiosum **Anterior fibers:** spread over the side of the corpus cavernosum and extend anteriorly as a tendinous expansion over the dorsal vessels	Perineal branch of the pudendal nerve (S2, S3, S4)	Aids in emptying the urethra at end of urination; by compressing the dorsal vein, it also helps maintain penile erection; contracts during ejaculation

FIGURE 349 Internal Anatomy of the Vaginal Wall

NOTE: (1) The uterus, external female genitalia, and opened vaginal wall are viewed from above.

(2) The vaginal rugae that characterize the inner vaginal wall. Also note the slit-like external os of the uterus and a mucous plug between its anterior and posterior lips.



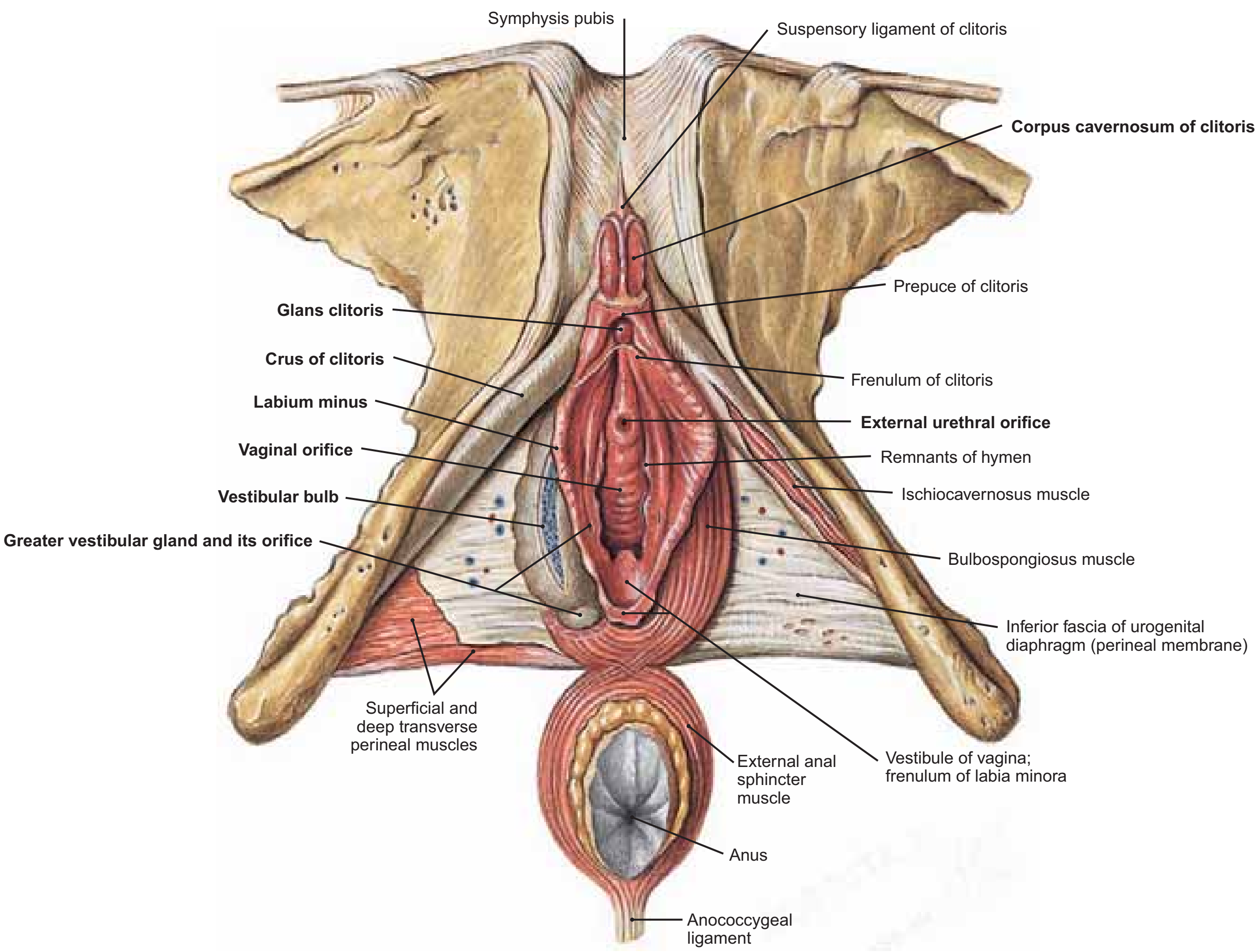


FIGURE 350.1 **Dissected Female External Genitalia**

NOTE: (1) The skin and fascia of the labia majora have been removed. Observe the **crura, body** and **glans clitoris,** the **vestibular bulbs,** and the location of the **greater vestibular glands.**
(2) Each crus of the clitoris is covered by an **ischiocavernosus muscle,** and the vestibular bulbs are surrounded by the **bulbospongiosus muscles.**
(3) The **greater vestibular glands** (of Bartholin) are found just behind the vestibular bulbs. During sexual stimulation, they secrete a viscous fluid that lubricates the vagina.

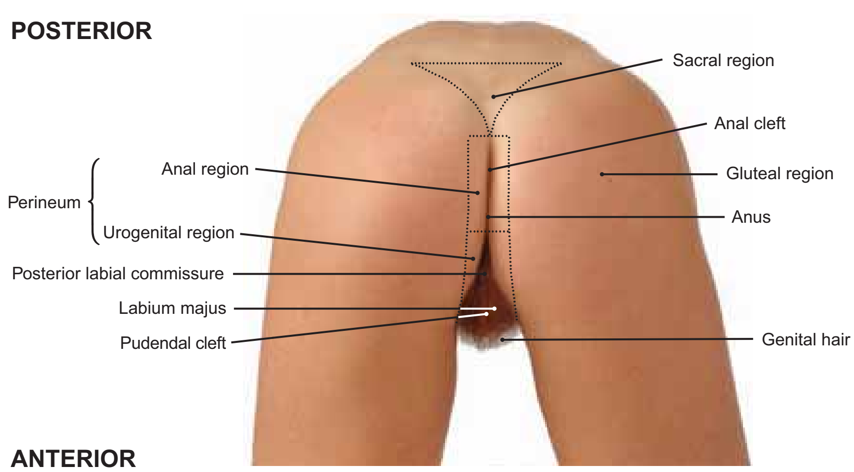


FIGURE 350.2 **Surface Anatomy of the Female Sacral, Gluteal, and Perineal Regions (Posteroinferior View)**

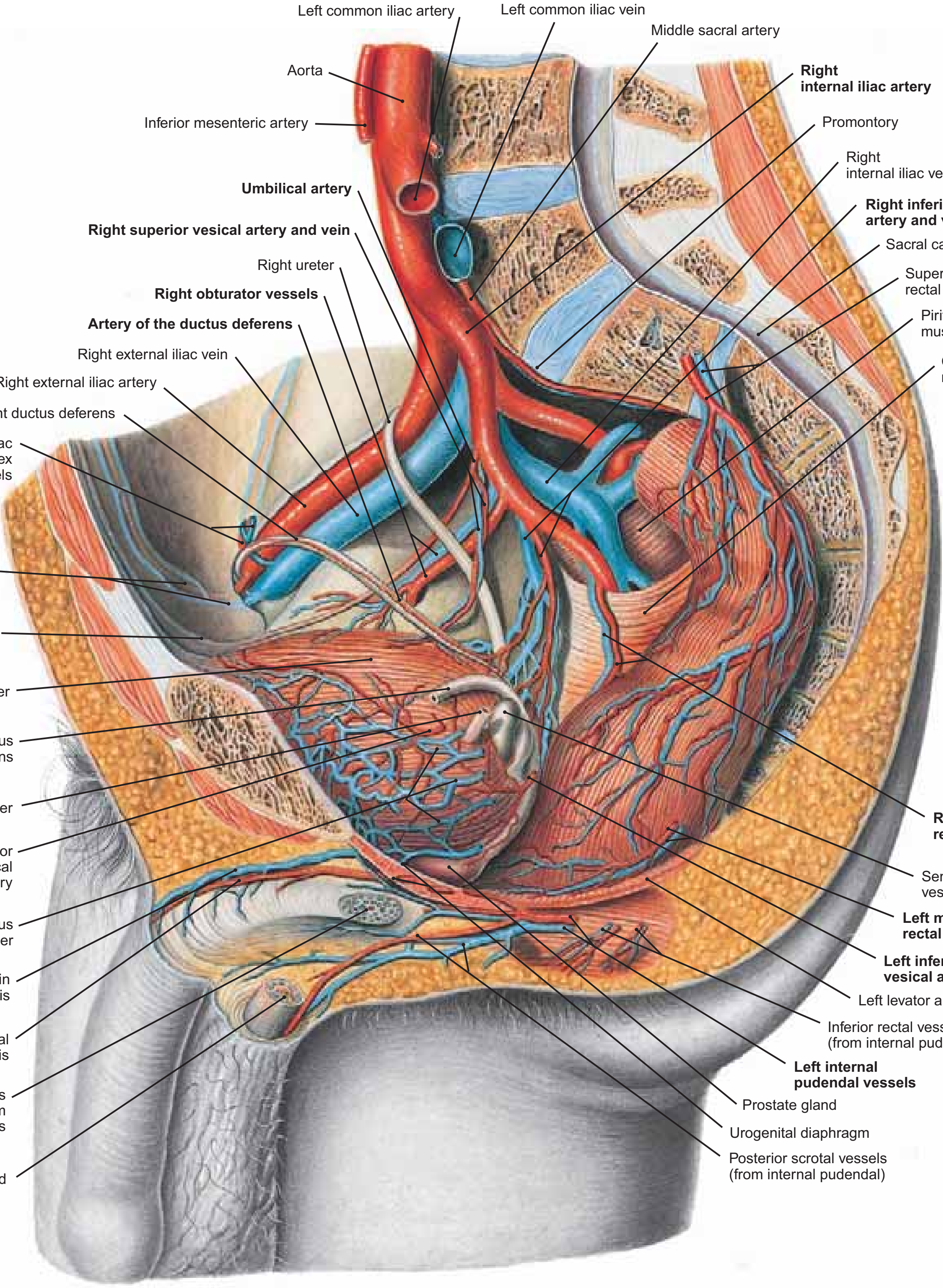


FIGURE 351 Blood Vessels of the Male Pelvis, Perineum, and External Genitalia

NOTE: (1) The aorta bifurcates into the **common iliac arteries,** which then divide into the **external** and **internal iliac arteries.** The external iliac becomes the principal arterial trunk of the lower extremity, whereas the internal iliac artery supplies the organs of the pelvis and perineum.

(2) The **visceral branches** of the internal iliac are: (a) the umbilical (from which is derived the superior vesical artery), (b) the inferior vesical, (c) the artery of the vas deferens (uterine artery in females), and (d) the middle rectal.

(3) The **parietal branches** include: (a) the iliolumbar, (b) lateral sacral, (c) superior gluteal, (d) inferior gluteal, (e) obturator, and (f) internal pudendal.

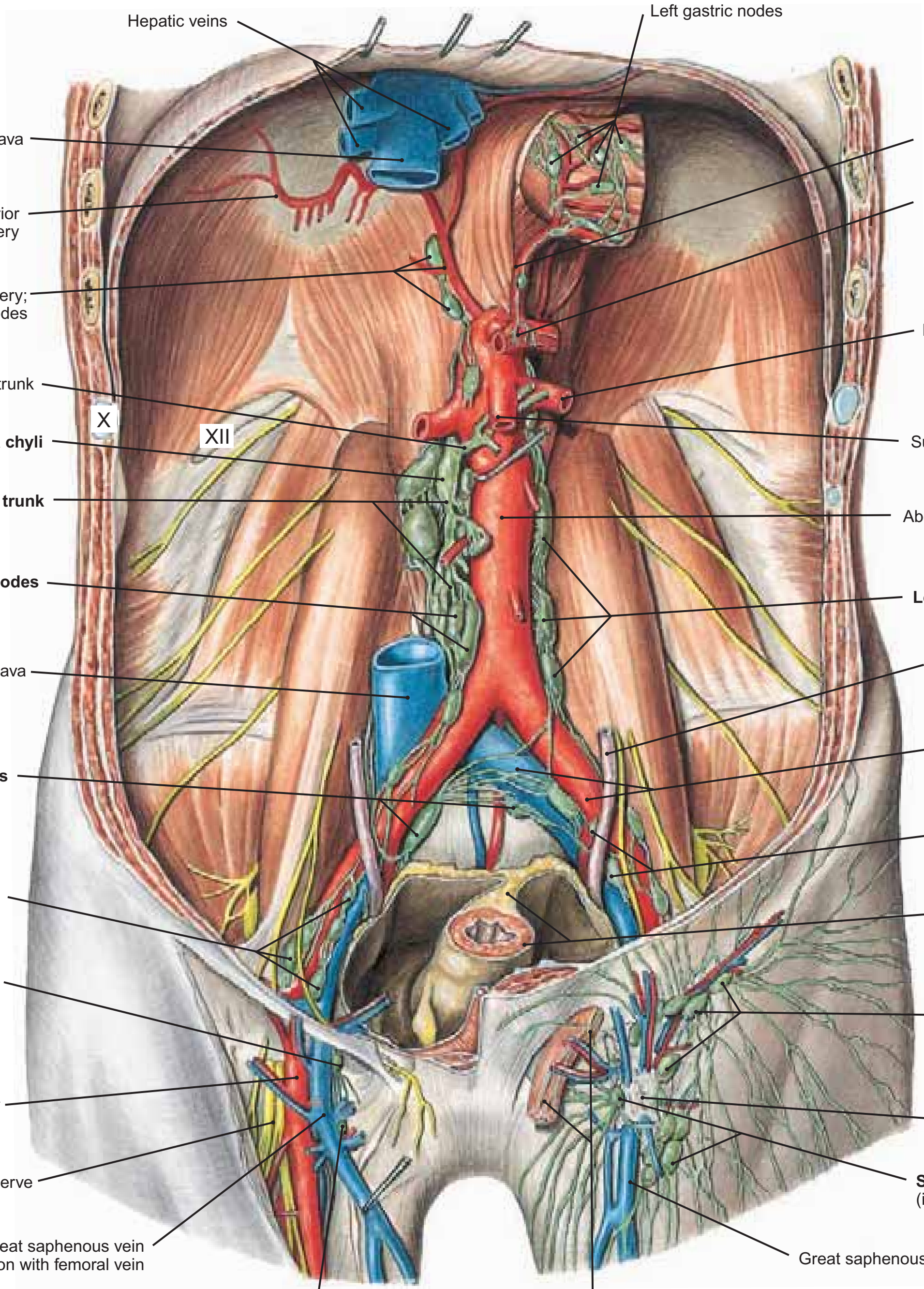


FIGURE 352 **Inguinal, Pelvic, and Lumbar (Aortic) Lymph Nodes**

NOTE: (1) Chains of lymph nodes and lymphatic vessels lie along the paths of major blood vessels from the inguinal region to the diaphragm. The **superficial inguinal nodes** lie just distal to the inguinal ligament within the superficial fascia.

(2) There are 10 to 20 superficial inguinal nodes, and they receive drainage from the genitalia, perineum, gluteal region, and anterior abdominal wall. More deeply, **subinguinal nodes** drain the lower extremity, one of which lies in the femoral ring (Rosenmüller's or Cloquet's node).

(3) Within the pelvis, visceral lymph nodes lie close to the organs that they drain and they channel lymph along the paths of major blood vessels, such as the **external, internal,** and **common iliac nodes** located along these vessels in the pelvis.

(4) On the posterior abdominal wall are located the **right** and **left lumbar** chains coursing along the abdominal aorta, while **preaortic nodes** are arranged around the roots of the major unpaired aortic branches, forming the **celiac** and **superior** and **inferior mesenteric nodes.**

(5) At the level of the L2 vertebra, there is a confluence of lymph channels that forms a dilated sac, the **cisterna chyli.** This is located somewhat posterior and to the right of the aorta, and it marks the commencement of the **thoracic duct.**

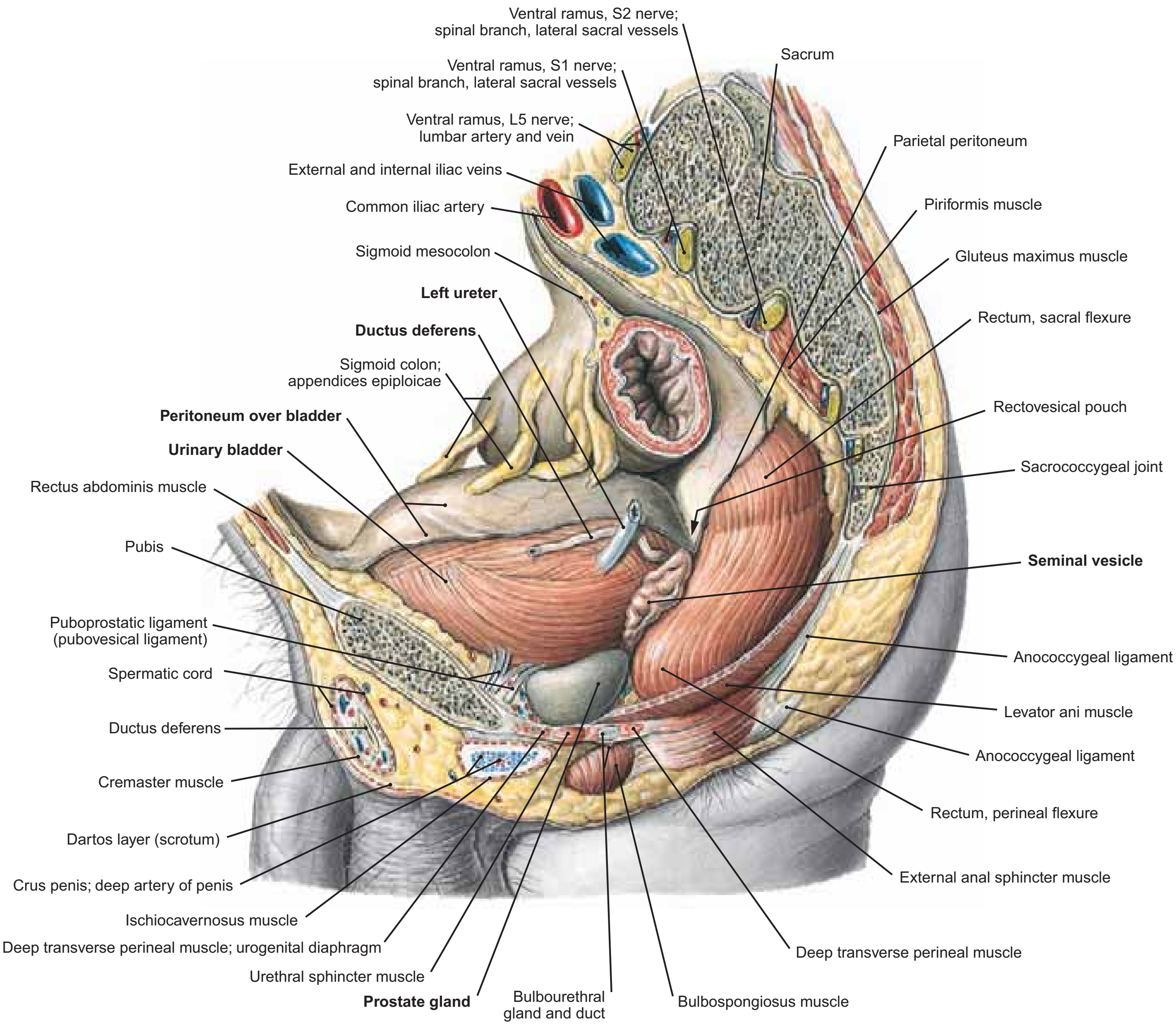


FIGURE 353.1 Male Pelvic Organs Viewed from the Left Side

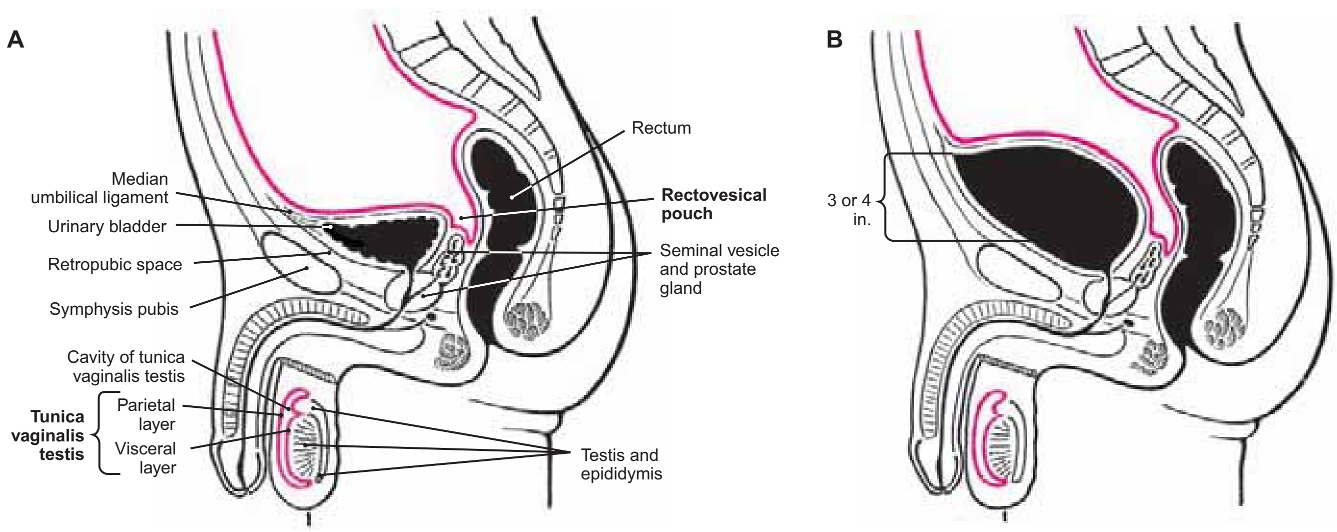


FIGURE 353.2A and B Peritoneal Reflection over the Pelvic Organs: Empty and Full Bladder

NOTE: (1) When the bladder is empty **(A),** the peritoneum extends down to the level of the symphysis pubis, but when the bladder is full **(B),** the peritoneum is elevated 3 or 4 in.

(2) The prostate and bladder may be reached **without entering the peritoneal cavity** anteriorly above the pubis and through the perineum by ascending in front of the rectum.

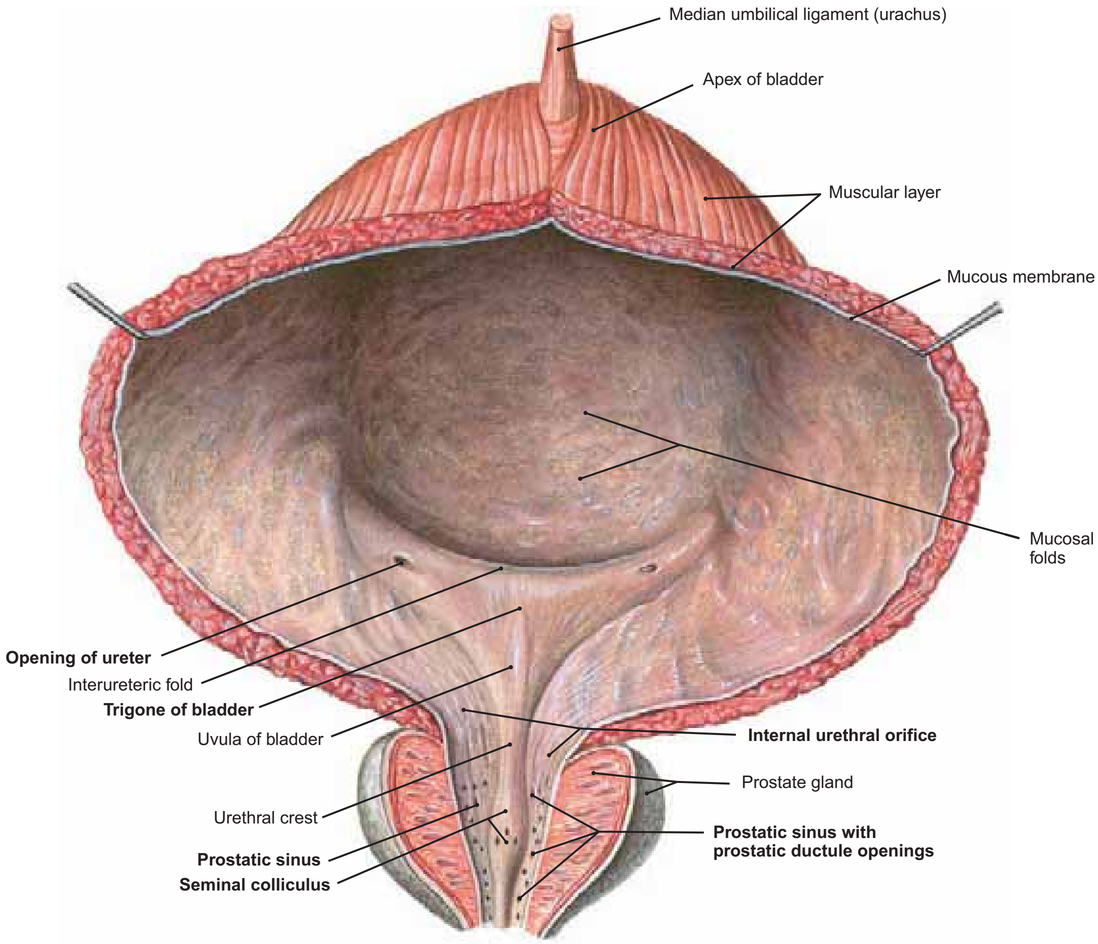


FIGURE 354.1 Bladder and Prostatic Urethra Incised Anteriorly

NOTE: (1) The smooth triangular area at the base of the bladder called the **trigone,** which is bounded by the two orifices of the ureters and the opening of the prostatic urethra.

(2) The **seminal colliculus** is a mound on the posterior wall of the prostatic urethra, on both sides of which lie the **prostatic sinuses.** Into these open the ducts of the prostate gland. In the center of the colliculus is a small blind pouch, the **prostatic utricle;** on both sides of the utricle are the single orifices of the **ejaculatory ducts** (openings not labeled).

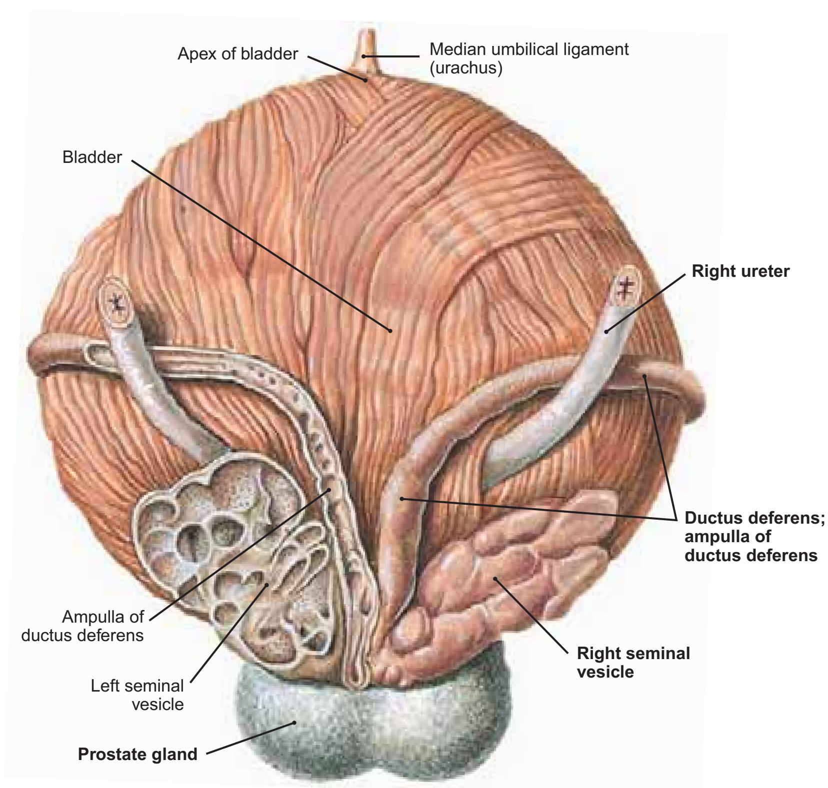


FIGURE 354.2 Posterior Surface of the Bladder: Seminal Vesicles, Ureters, and Deferent Ducts

NOTE: (1) The ureters, deferent ducts, seminal vesicles, and prostate gland are all in contact with the inferior aspect of the posterior surface of the bladder.

(2) The **ureters** penetrate the bladder diagonally at points about 2 in. apart. Upon entering the bladder, each ureter is crossed anteriorly by the ductus deferens.

(3) The deferent ducts join the ducts of the lobulated seminal vesicles to form the two ejaculatory ducts.

(4) The prostate hugs the bladder at its outlet, surrounding the prostatic urethra.

(5) All of these organs lie directly in front of the rectum and can be palpated during a rectal examination.

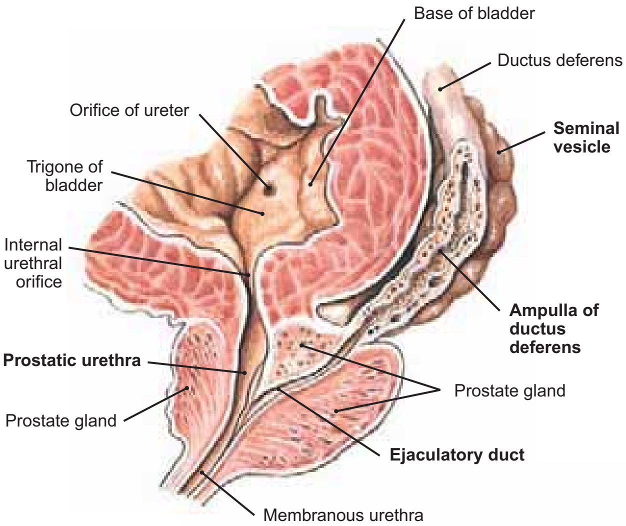


FIGURE 355.1 Midsagittal Section of Base of Bladder, Prostate, and Ductus Deferens

NOTE: The ejaculatory duct is formed by the junction of the duct of the seminal vesicle and the ductus deferens. Surrounded by the prostate gland, the ejaculatory ducts measure about 2 cm in length and open into the prostatic urethra.

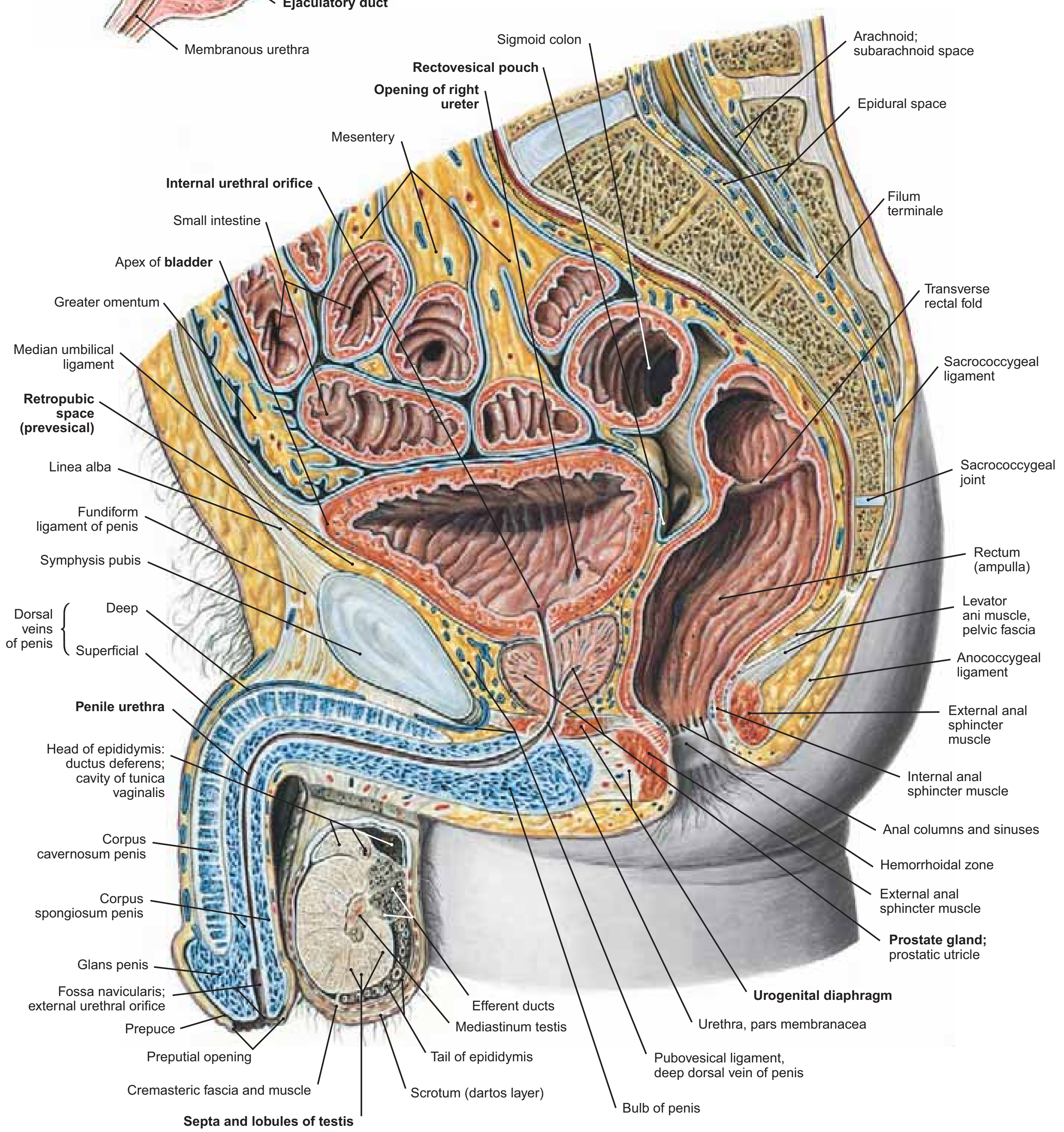


FIGURE 355.2 Median Sagittal Section of the Male Pelvis and Perineum Showing the Pelvic Viscera and the External Genitalia

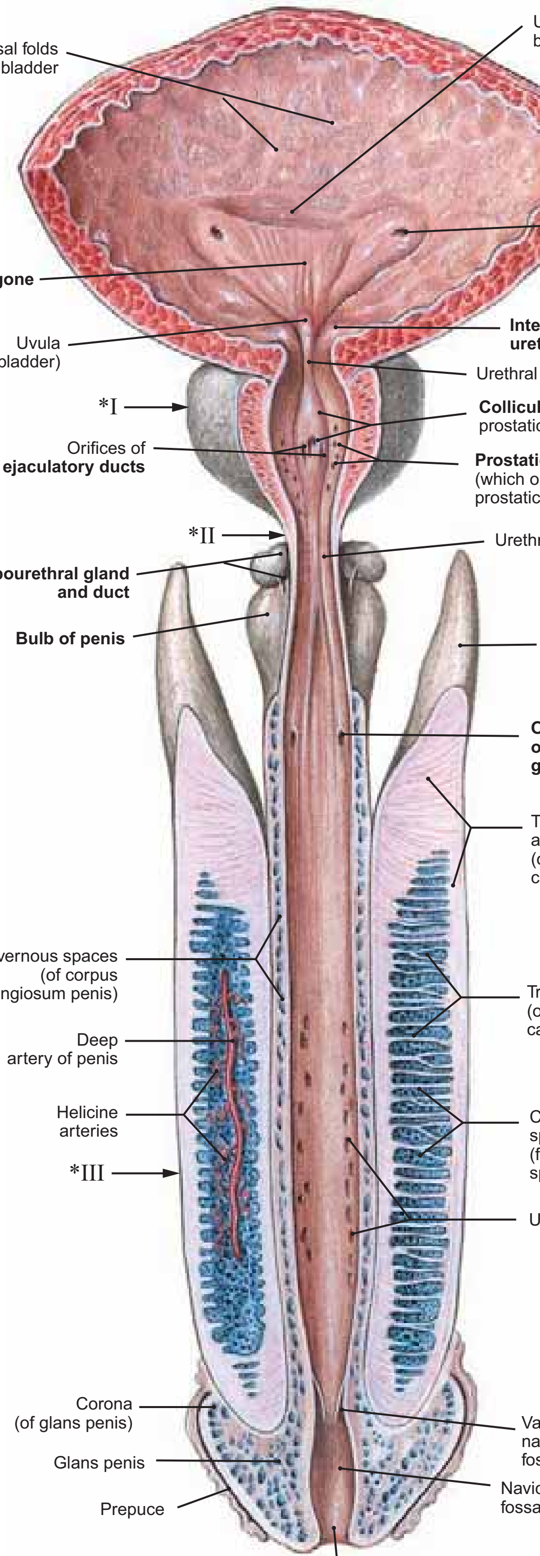


FIGURE 356.1 Male Urethra and Its Associated Orifices

NOTE: (1) The male urethra extends from the internal urethral orifice at the bladder to the external urethral orifice at the end of the glans penis. In males, it traverses the prostate gland, the urogenital diaphragm (membrane), and penis, and is, therefore, divided into **prostatic, membranous,** and **penile** parts.

(2) Before ejaculation, a viscous fluid from the **bulbourethral glands** (of Cowper) lubricates the urethra. These glands are located in the urogenital diaphragm, but their ducts open 1 in. distally in the penile urethra.

(3) The total urethra measures between 7 and 8 in. in length, the prostatic part about 1½ in., the membranous part about ½ in., and the penile part 5 to 6 in. The **prostatic urethra** receives the secretions of the ejaculatory ducts along with those from the prostate. Enlargement of the prostate, often occurring in older men, tends to constrict the urethra at this site, resulting in difficulty in urination.

(4) The **membranous urethra** is short and narrow and it is completely surrounded by the circular fibers of the voluntary urethral sphincter muscle. Relaxation of this sphincter initiates urination, while its tonic contraction constricts the urethra and maintains urinary continence.

(5) The **penile urethra** is surrounded initially by the bulb of the penis and the bulbospongiosus muscle. It traverses the penile shaft within the corpus spongiosum penis. The internal surface of the distal half is marked by small recesses called the urethral lacunae.

* Parts of urethra
I = Prostatic part
II = Membranous part
III = Penile part

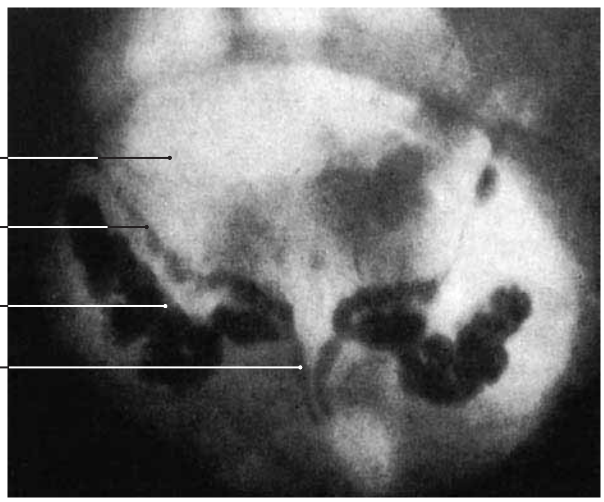


FIGURE 356.2 Radiograph of Bladder, Seminal Vesicles, Deferent Ducts, and Ejaculatory Ducts

NOTE: The bladder has been filled with air and appears light, while the seminal vesicles, deferent ducts, and ejaculatory ducts stand out as dark because of an injected contrast medium.

FIGURE 357.1 Diagram of the Male Genitourinary System ▶

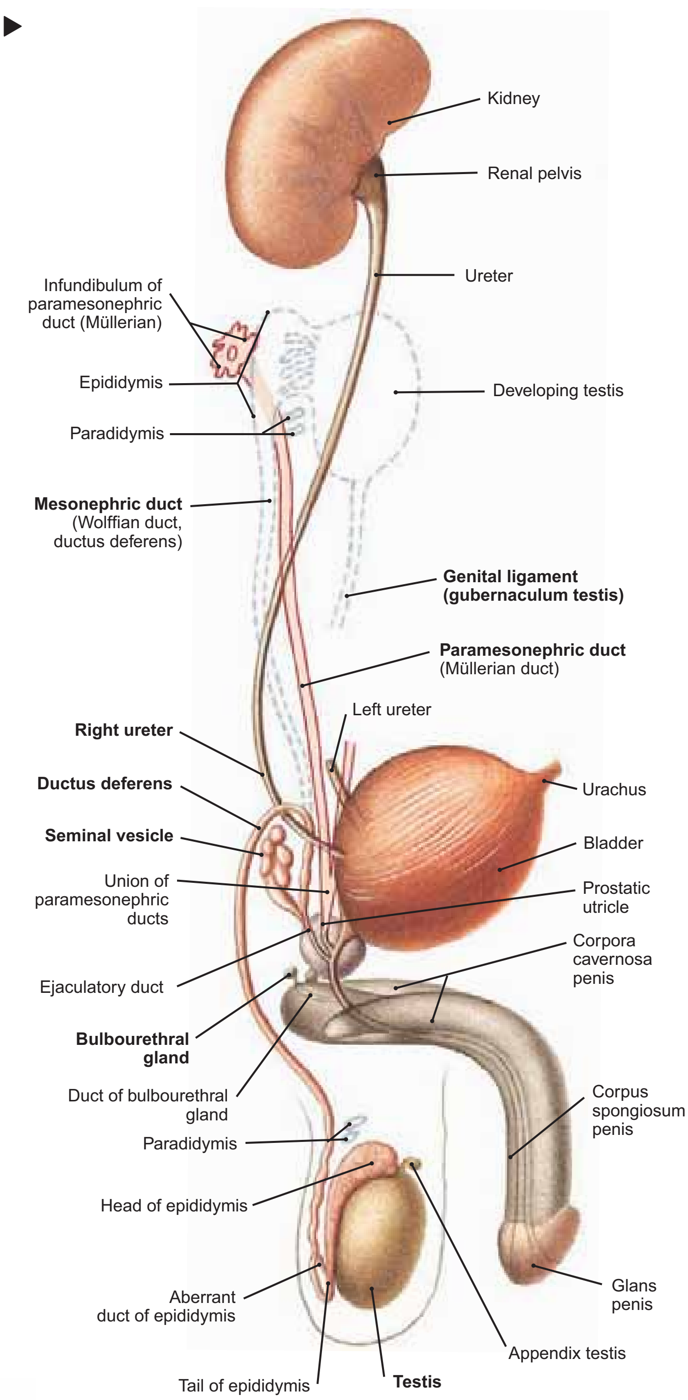
NOTE: (1) This figure shows: (a) the organs of the adult male genitourinary system (dark red-brown), (b) the structures of the genital system prior to the descent of the testis (interrupted blue lines), and (c) those structures that partially or entirely became atrophic and disappeared during development (pink structures with red outlines).

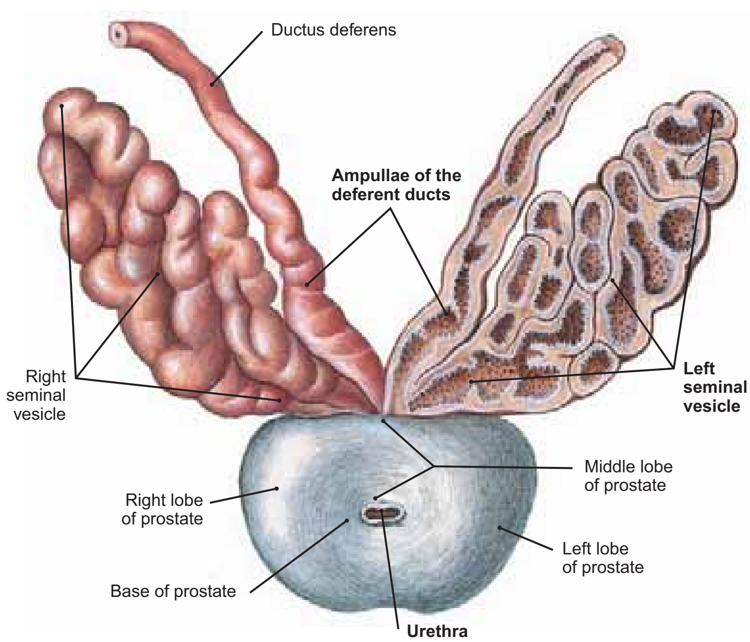
(2) The **urinary system** includes the *kidneys,* which produce urine by filtration of the blood, the *ureters,* which convey urine to the *bladder,* where it is stored, and the *urethra,* through which urine is discharged.

(3) The adult male genital system includes the *testis,* where sperm is generated, and the *epididymis* and *ductus deferens,* which transport sperm to the *ejaculatory duct,* where the *seminal vesicle* joins the genital system. The *prostate* and *bulbourethral glands,* along with the ejaculatory ducts, join the *urethra,* which then courses through the prostate and *penis*.

(4) Embryologically, structures capable of developing into either sex exist in all individuals. In the male the **mesonephric** (Wolffian) **duct** becomes the epididymis, ductus deferens, ejaculatory duct, and seminal vesicle along with the penis, while the **paramesonephric** (Müllerian) **duct** is suppressed.

(5) The testes are developed on the posterior abdominal wall, to which each is attached by a fibrous genital ligament called the **gubernaculum testis.** As development continues, each testis *migrates* from its site of formation so that by the fifth month it lies adjacent to the abdominal inguinal ring. The gubernaculum is still attached to anterior abdominal wall tissue, which by this time has evaginated as the developing scrotum. The testes then commence their descent through the inguinal canal so that by the eighth month they usually lie in the scrotum attached by a peritoneal reflection, the processus vaginalis testis, which becomes the **tunica vaginalis testis.**





◀ FIGURE 357.2 Prostate Gland, Seminal Vesicles, and Ampullae of the Deferent Ducts (Superior View)

NOTE: (1) The left seminal vesicle and ductus deferens were cut longitudinally, while the urethra was cut transversely, distal to the bladder.

(2) The **prostate gland** is conical in shape and normally measures just over 1½ in. across, 1 in. in thickness, and slightly longer than 1 in. vertically. In the young adult, it weighs about 25 g and is formed by two lateral lobes surrounding a middle lobe.

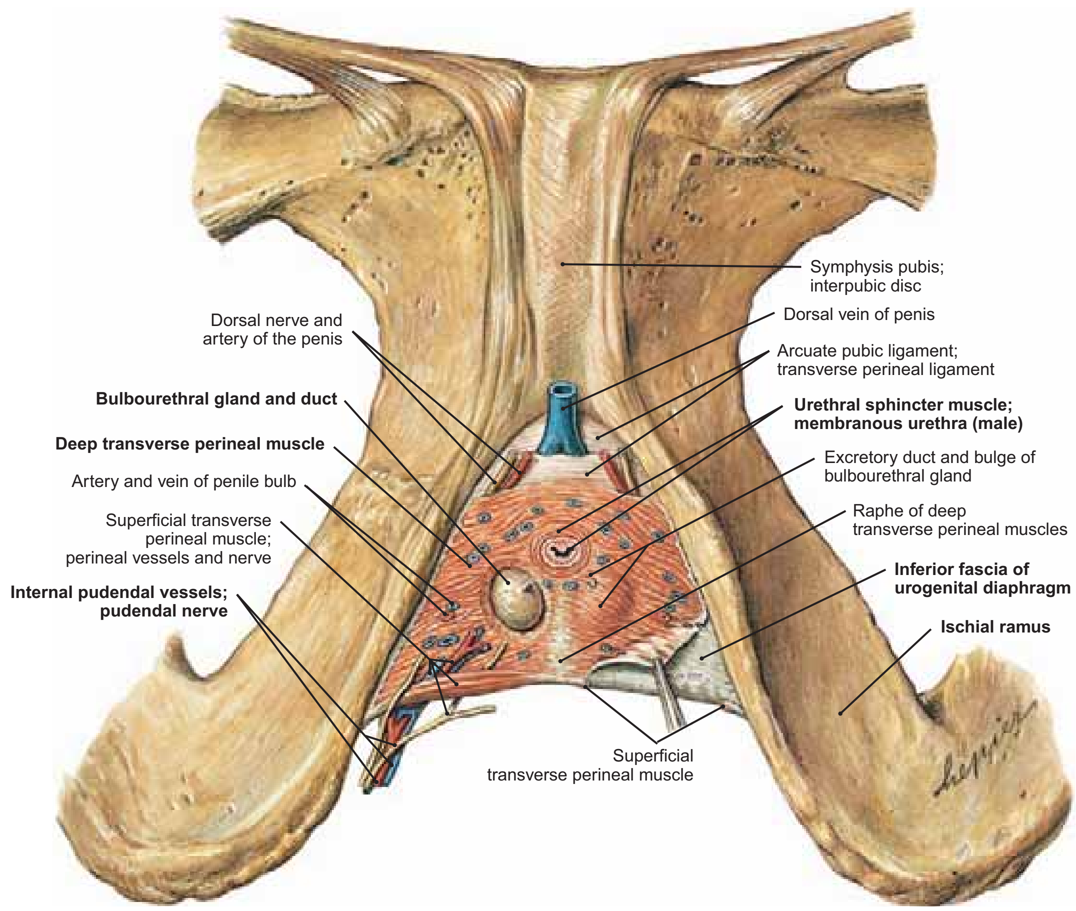


FIGURE 358.1 Urogenital Diaphragm; Deep Transverse Perineal Muscle (Male)

NOTE: (1) The **deep transverse perineal muscle** stretches between the ischial rami and is covered by fascia on both its internal (pelvic or superior) surface and its external (perineal or inferior) surface. These two fascias and the muscle form the **urogenital diaphragm.**

(2) The region between the two fascias is often referred to as the **deep perineal compartment** (pouch, cleft, or space). In the male it contains: (a) the deep transverse perineal muscle, (b) the sphincter of the urethra, (c) the bulbourethral glands, (d) the membranous urethra, and (e) branches of the internal pudendal vessels and nerve.

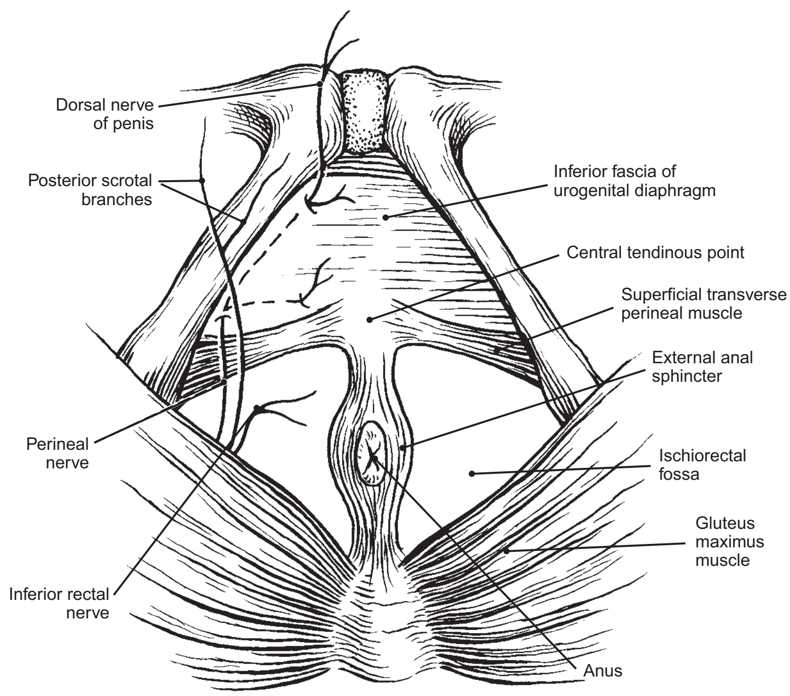


FIGURE 358.2 Branches of the Pudendal Nerve in the Perineum

NOTE: (1) The perineal branches of the pudendal nerve emerge at the lateral aspect of the ischiorectal fossa.

(2) The inferior rectal nerve crosses the fossa to supply the levator ani and external anal sphincter muscles.

(3) The remaining branches course anteriorly into the urogenital triangle region and supply sensory innervation to all structures there and motor innervation to the urogenital muscles.

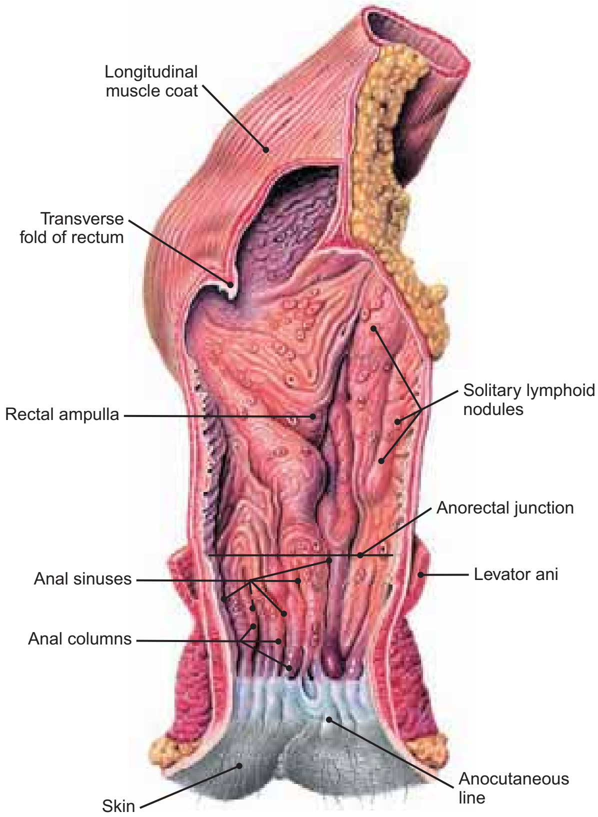


FIGURE 359.1 Inner Surface of the Rectum and Anal Canal

NOTE: (1) The sigmoid colon becomes the **rectum** at the level of the middle of the sacrum. The rectum, 5 in. in length, then becomes the **anal canal,** the terminal 1½ in. of the gastrointestinal tract. The rectum is dilated near its junction with the anal canal, giving rise to the **rectal ampulla.**

(2) The rectal mucosa is thrown into transverse folds, usually three in number, called **horizontal folds** or **valves of Houston.**

(3) Below the rectal ampulla is a series of vertical folds, called the **anal columns,** each containing an artery and a vein. Between the anal columns are the **anal sinuses.** If the veins in this region become varicosed, a condition called hemorrhoids, or piles, results.

(4) Distal to the anal columns is a zone, **Hilton's line,** where the epithelium changes from columnar to stratified squamous.

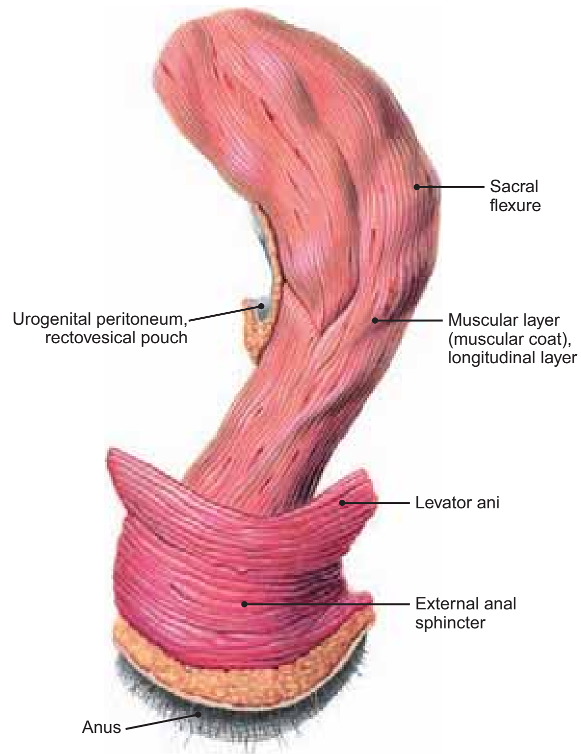


FIGURE 359.2 External Surface of the Rectum (Lateral View)

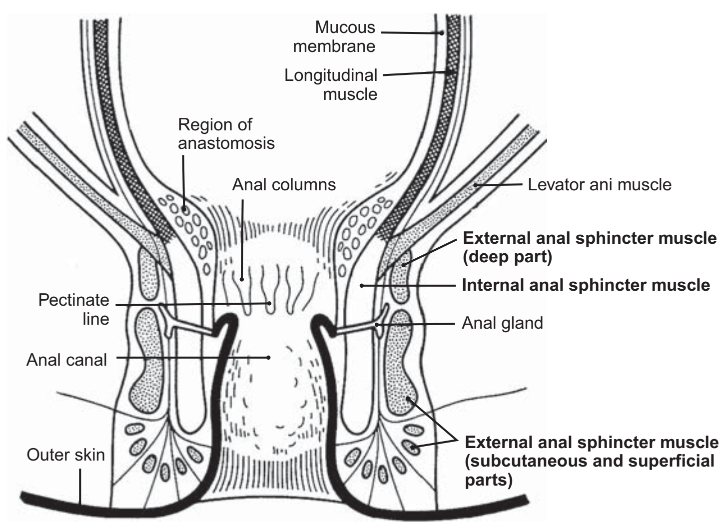
NOTE: (1) The rectum shows a dorsally directed **sacral flexure** proximally and a less pronounced **perineal flexure** distally. Peritoneum ensheathes the rectum ventrally almost as far as the ampulla (to the bladder in the male and the uterus in the female).

(2) The fibers of the **levator ani muscle** (which form the floor of the pelvis) surround the rectum and are continued distally as the **external anal sphincter muscle.**

(3) The **internal anal sphincter muscle** (seen in Figs. 359.1 and 359.3) is composed of smooth muscle and really represents a thickening of the muscular layer in the wall of the rectum.

FIGURE 359.3 Frontal Section through the Rectum (Diagrammatic)

NOTE: The **external anal sphincter** consists of **subcutaneous, superficial,** and **deep** parts. Compare this diagram with Figure 359.1.



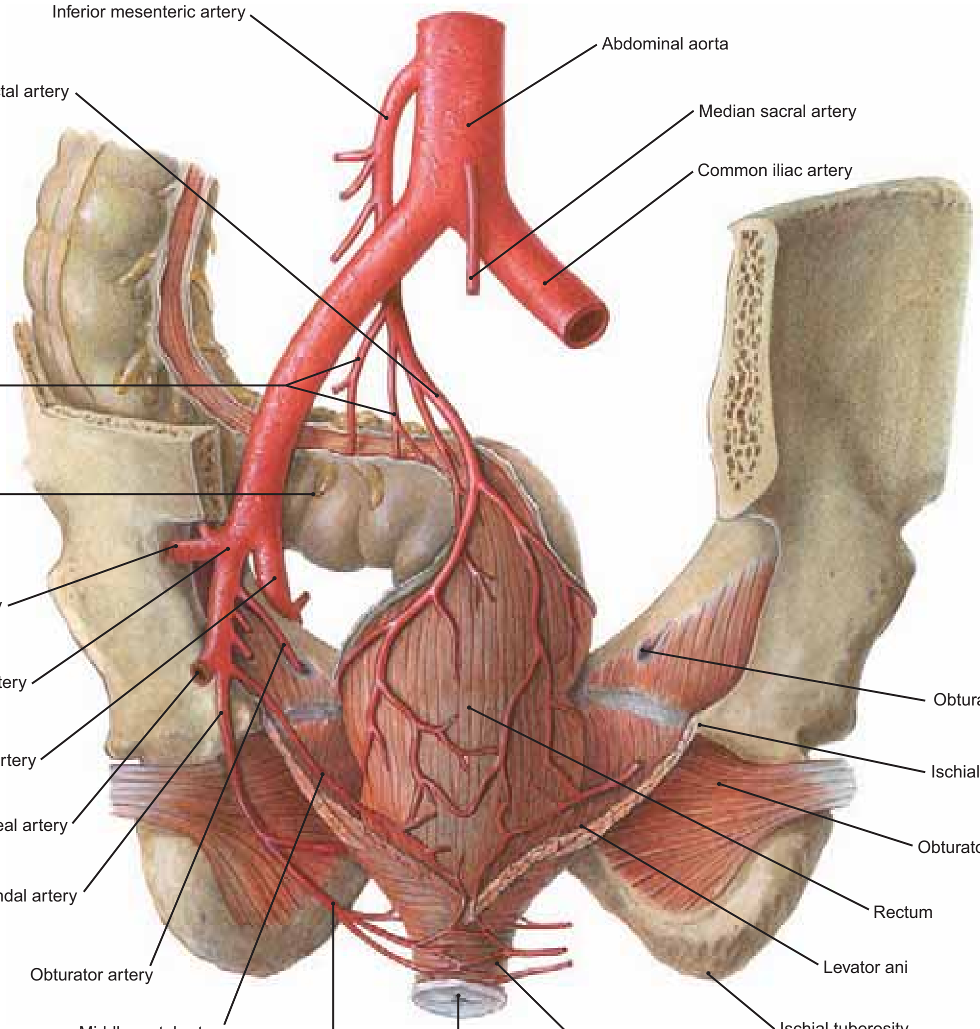


FIGURE 360.1 Arterial Blood Supply to the Rectum (Posterior View)

NOTE: (1) The superior, middle, and inferior rectal arteries form an anastomosis along the entire rectum.
(2) The **superior** rectal artery has an **abdominal source,** the **middle** rectal artery has a **pelvic source,** and the **inferior** rectal artery has a **perineal source.**

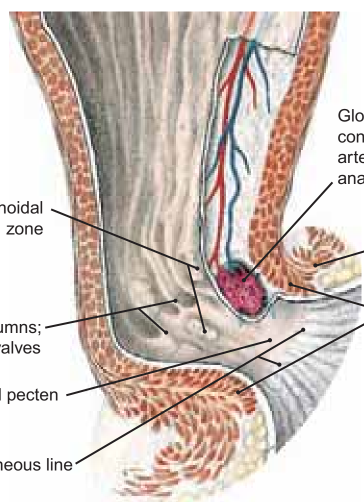


FIGURE 360.2 Rectum and Anal Canal: Median Section

NOTE: (1) The **anal canal** commences where the ampulla of the rectum narrows, and it ends at the anus.
(2) There are 6 to 11 vertical folds called **anal columns.** Each contains arteriovenous anastomoses. The anal columns are joined by folds of mucous membranes called **anal valves.**
(3) The anal valves are situated along a line called the **pectinate line** or **anal pectin.** The **anocutaneous line** is seen adjacent, where usually there is a transition to stratified squamous epithelium from the columnar epithelium of the gastrointestinal tract.

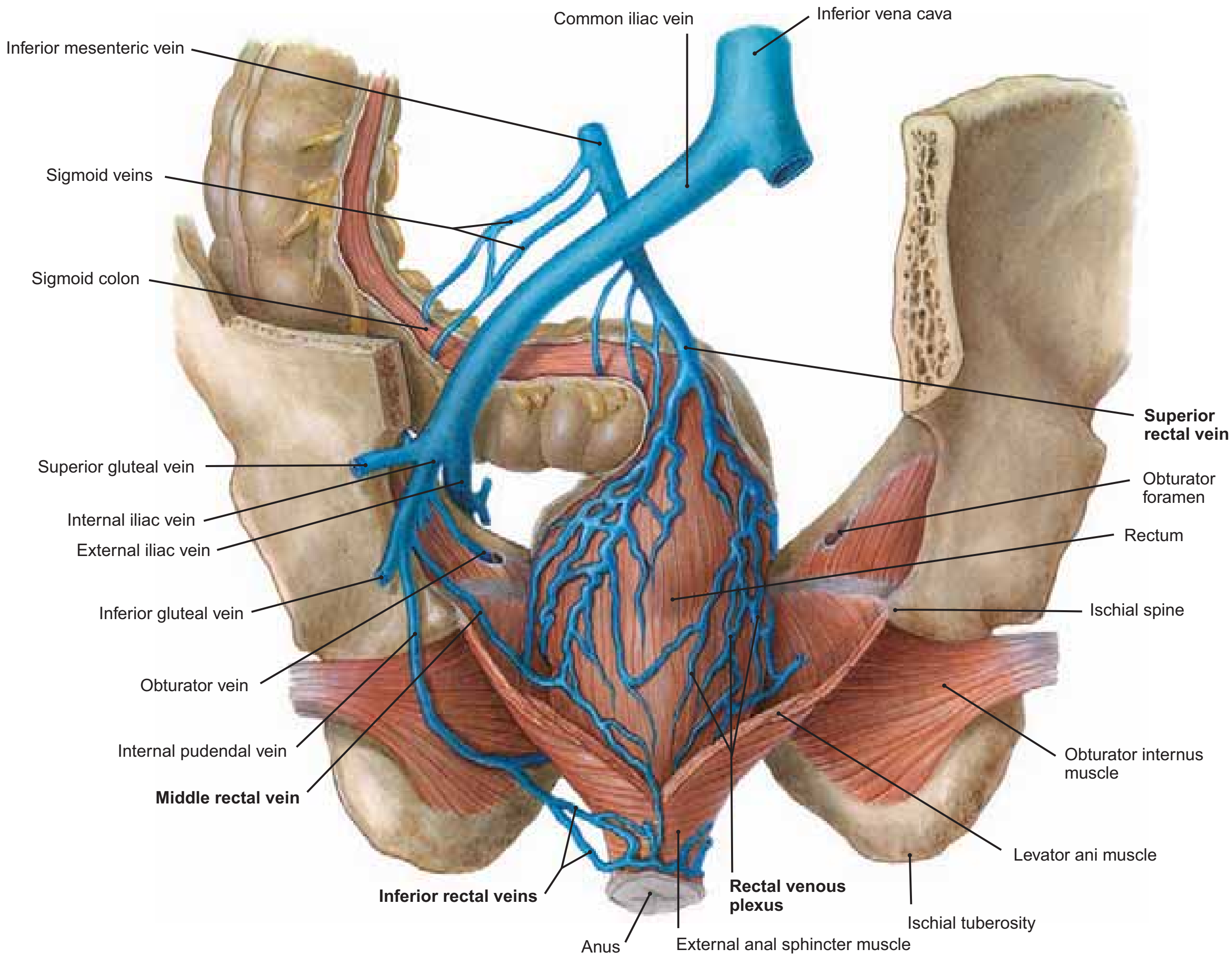


FIGURE 361.1 Venous Drainage of the Rectum (Posterior View)

NOTE: Blood from the middle and inferior rectal veins eventually drains into the inferior vena cava, while blood returning from the superior rectal vein drains into the portal circulation by way of the inferior mesenteric vein. This allows a route of **collateral circulation** between these two venous systems.

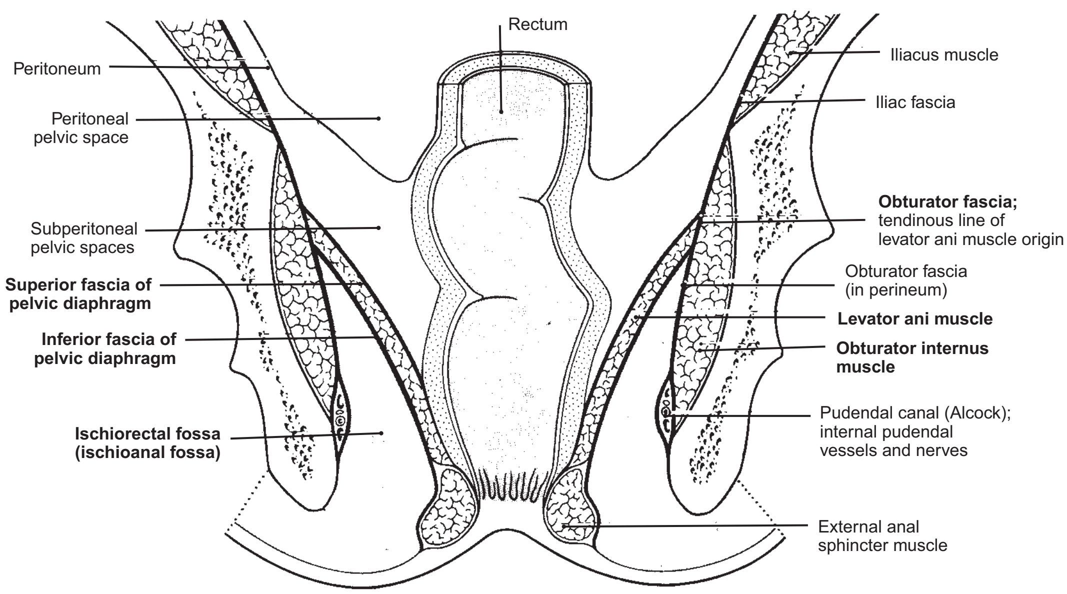


FIGURE 361.2 Diagram of Frontal Section through Pelvis and Perineum

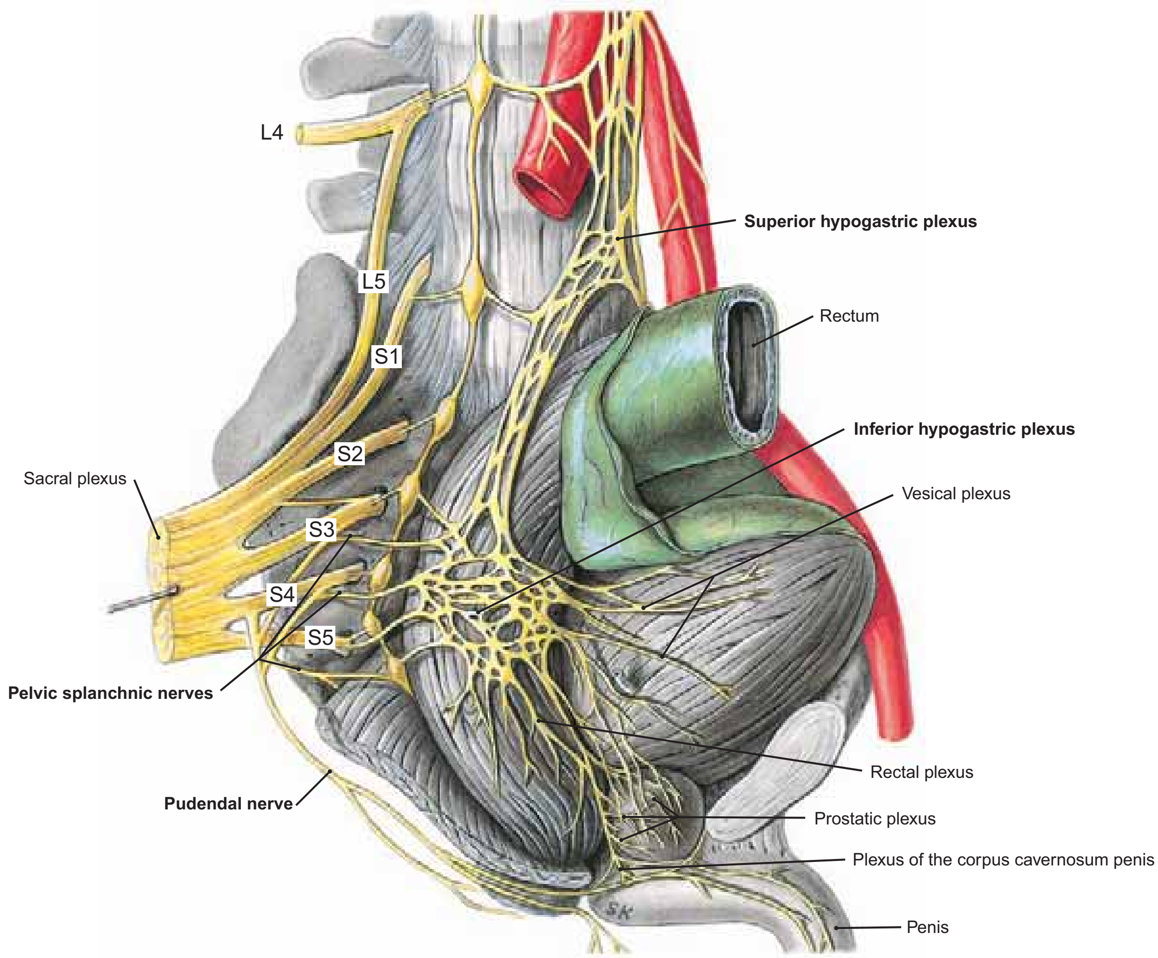


FIGURE 362.1 **Autonomic and Visceral Afferent Innervation of the Pelvic Organs**

NOTE: (1) *Postganglionic sympathetic fibers* course downward in the **superior hypogastric plexus** from lower lumbar ganglia and continue in the specific visceral plexuses (i.e., rectal, vesical, etc.) to supply pelvic organs with sympathetic innervation.

(2) *Preganglionic parasympathetic fibers* to the pelvic organs emerge from the S2, S3, and S4 spinal nerves to form the **pelvic splanchnic nerves.** They also course through the specific visceral plexuses and then synapse with postganglionic parasympathetic neurons within the walls of the viscera.

(3) **Visceral afferent fibers** from the pelvic organs course centrally along with these autonomic fibers. Their cell bodies lie in their respective dorsal-root ganglia, and they enter the spinal cord by way of the dorsal roots from these ganglia.

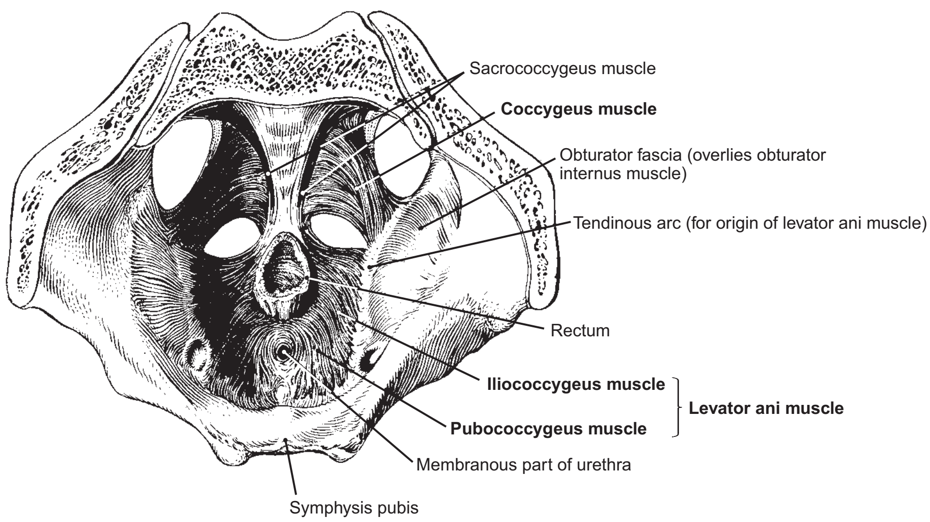


FIGURE 362.2 **Muscular Floor of the Pelvis: Pelvic Diaphragm**

NOTE: (1) The **pelvic diaphragm** consists of the **levator ani** (iliococcygeus and pubococcygeus parts) **muscle** and the **coccygeus muscle** along with two fascial layers, which cover the *pelvic* (supra-anal fascia) and *perineal* (infra-anal fascia) surfaces of these two muscles.

(2) The muscles composing the pelvic diaphragm stretch across the pelvic floor in a concave sling-like manner and separate the structures of the pelvis from those in the perineum below. In males, the pelvic diaphragm is perforated by the anal canal and the urethra.

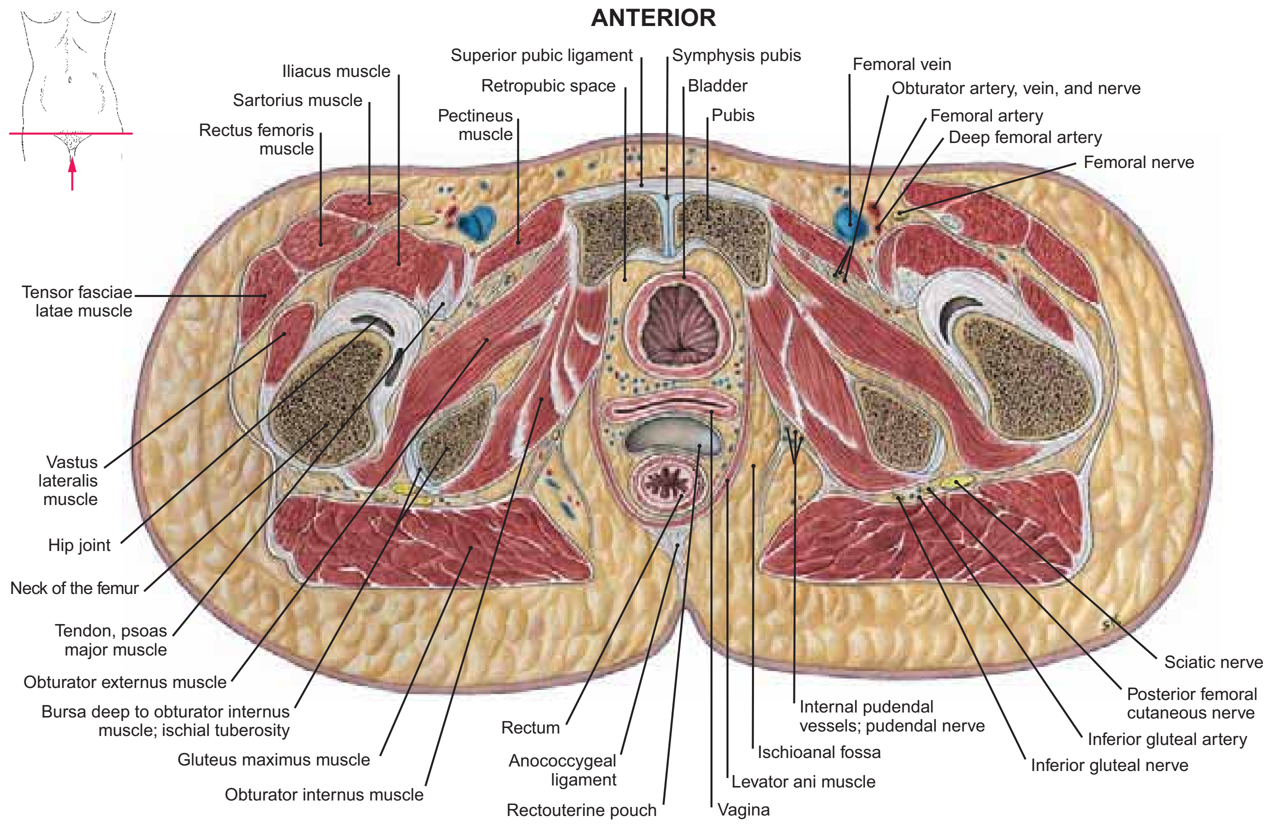


FIGURE 363.1 Cross Section of the Female Pelvis at the Level of the Symphysis Pubis

NOTE: The viscera medially and the **obturator internus muscle** laterally in the pelvis. Also observe the attachment of the **levator ani muscle** from the fascia overlying the obturator internus muscle and how the levator separates the pelvis from the perineum below. Compare this figure with Figure 363.2.

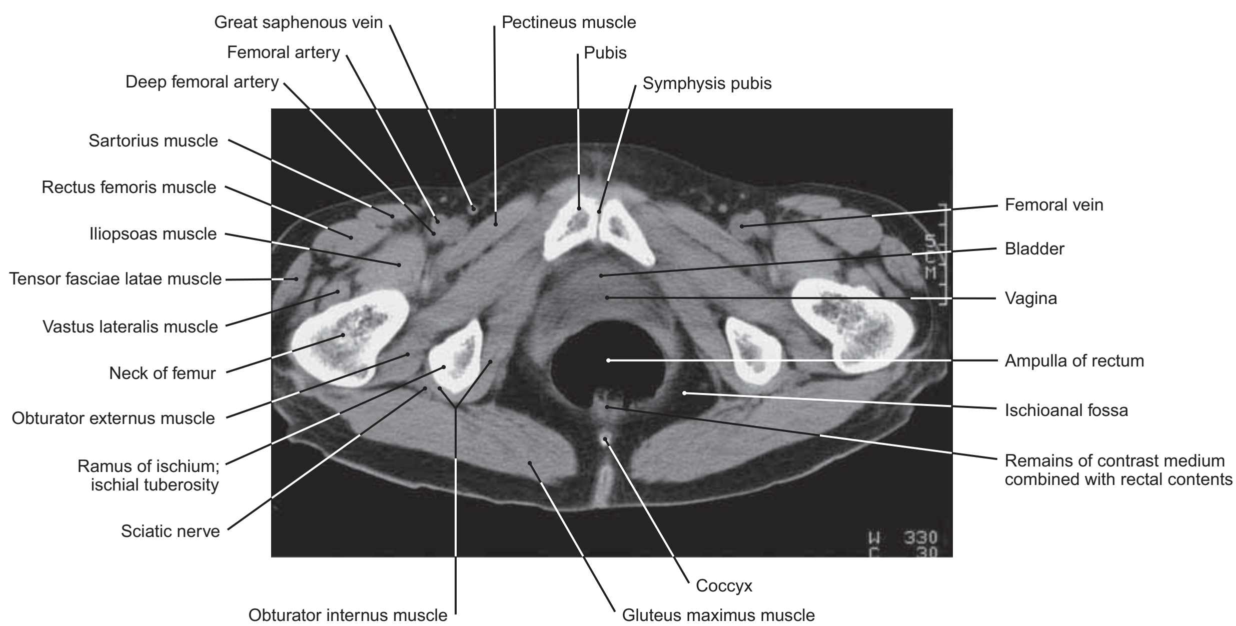


FIGURE 363.2 CT of the Female Pelvis Taken from Below

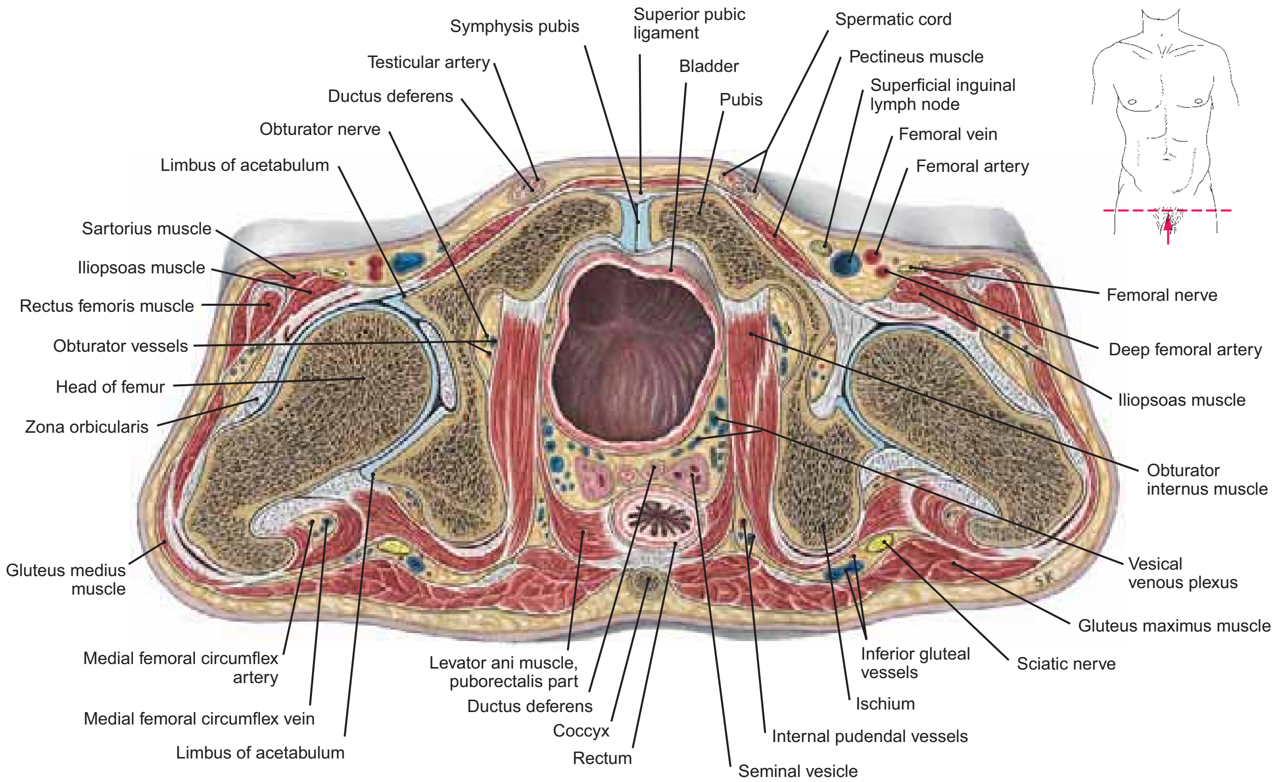


FIGURE 364.1 Cross Section of the Male Pelvis at the Level of the Symphysis Pubis

NOTE: (1) The **ductus deferens** and the **seminal vesicle** are located behind the **bladder** on both sides, and behind these, observe the position of the **rectum.**

(2) The **obturator internus muscle** forms the lateral wall of the true pelvis and the levator ani (in this figure, its puborectalis part) arises from the obturator fascia that covers its medial surface.

(3) The **vesical plexus of veins** surrounding the bladder. This plexus anastomoses with the prostatic plexus below, and both drain into the internal iliac vein. Thus, venous blood from the bladder and prostate usually enters the inferior vena cava and goes to the lungs, although anastomoses also exist with the rectal system of veins and with the vertebral system of veins.

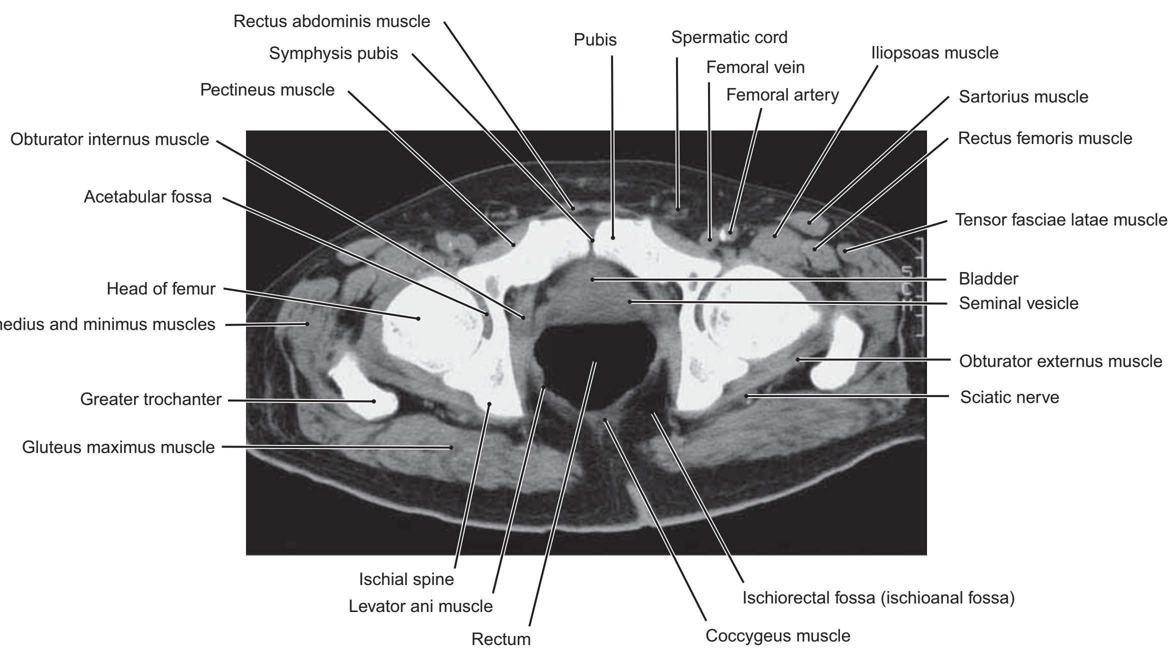


FIGURE 364.2 CT of the Male Pelvis Taken from Below

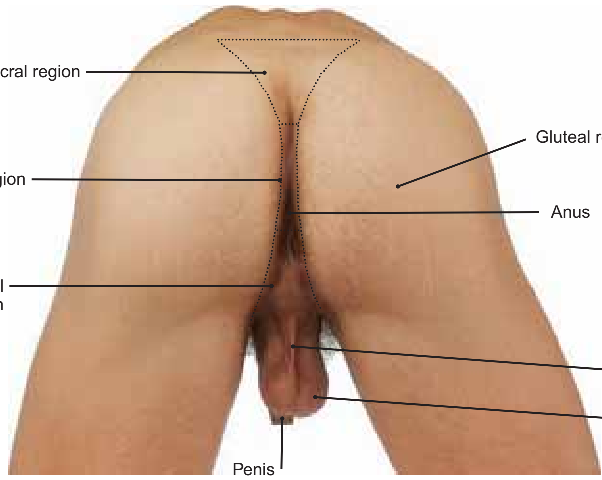


FIGURE 365.1 Surface Anatomy of the Male Perineum

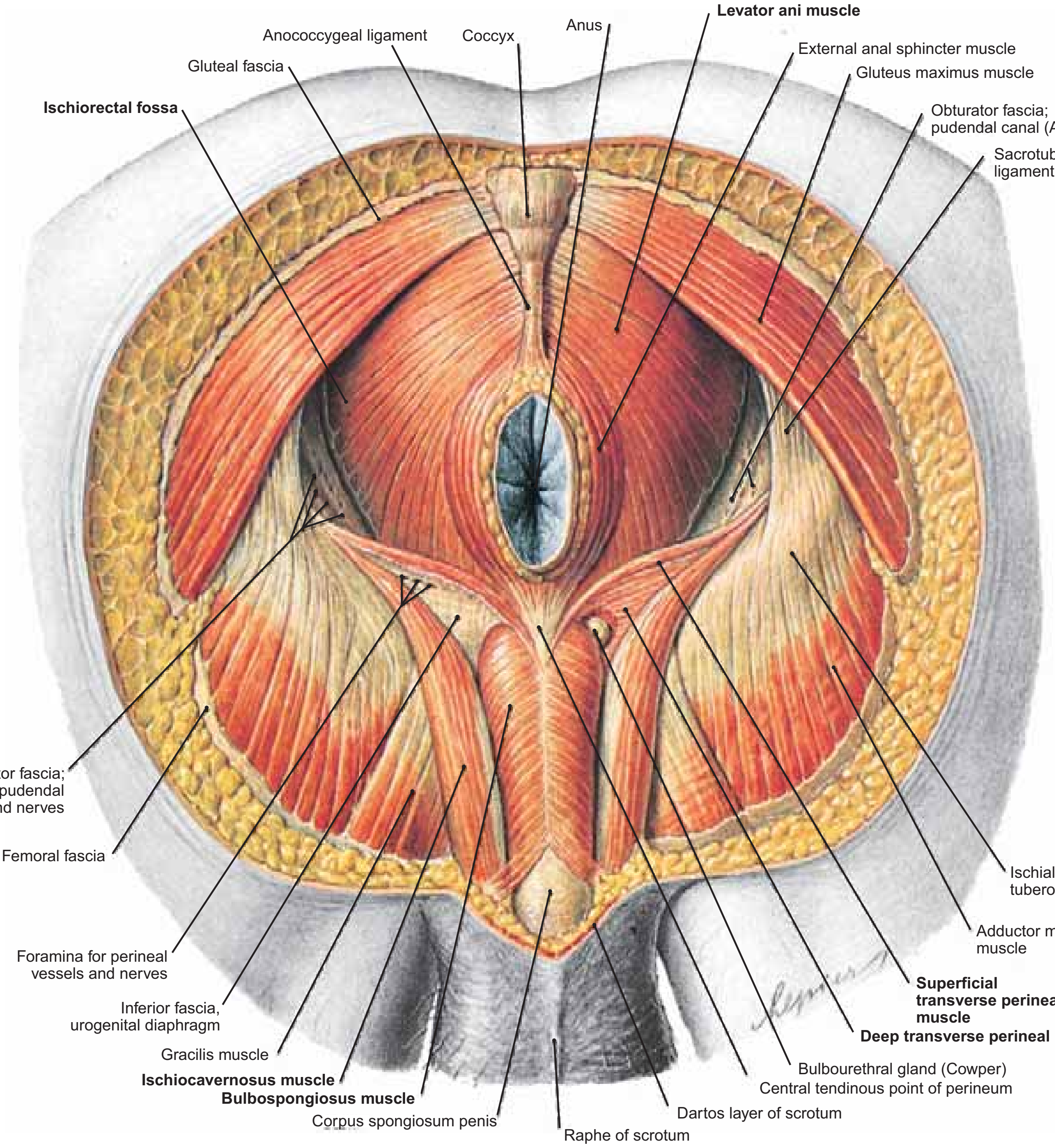


FIGURE 365.2 Superficial Muscles of the Male Perineum

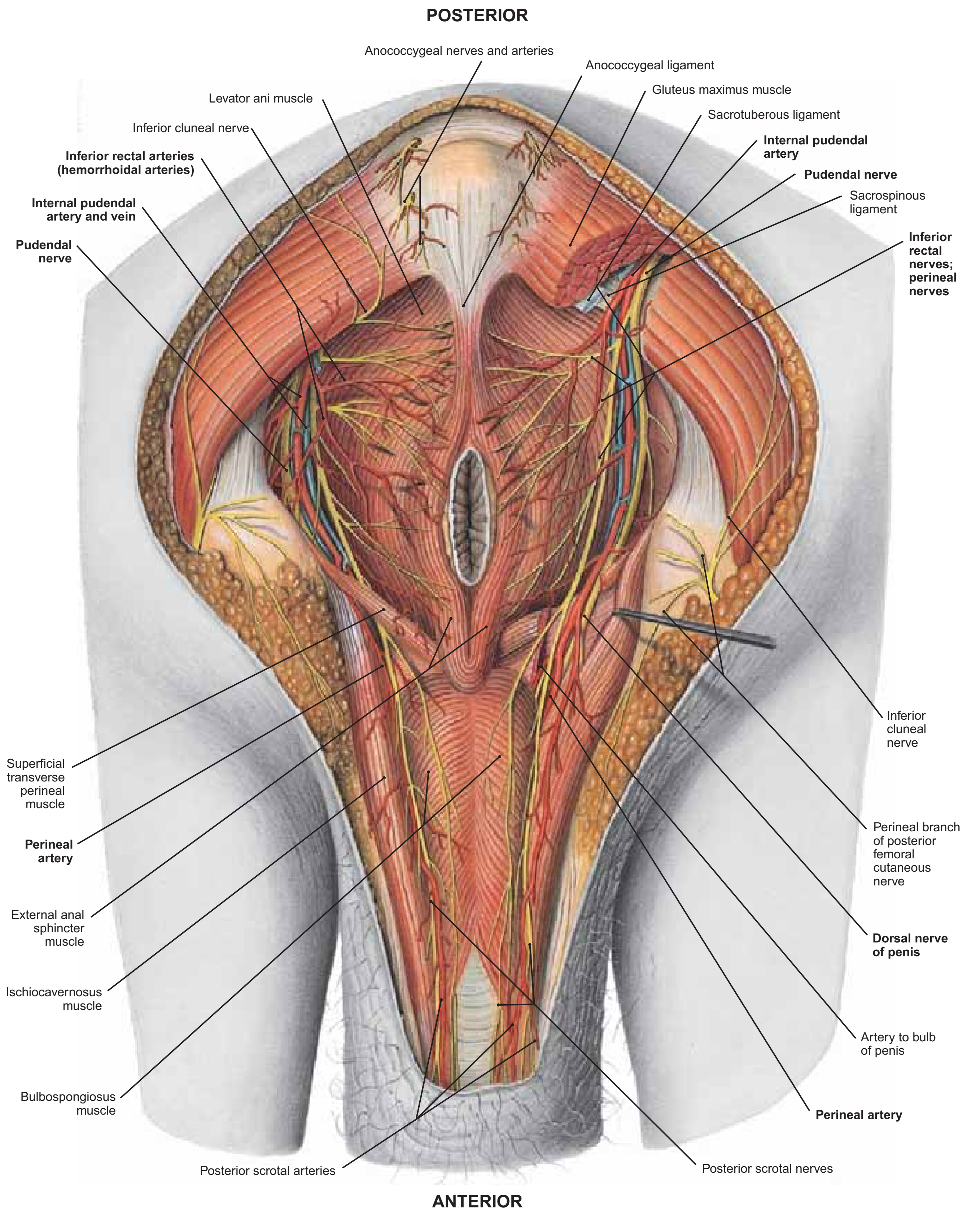


FIGURE 366 Nerves and Blood Vessels of the Male Perineum

NOTE: (1) The skin of the perineum and the fat of the ischiorectal fossa have been removed to expose the muscles, vessels, and nerves of both the **anal** and **urogenital regions.**

(2) The **internal pudendal vessels** and **nerves** emerge from the pelvis to the gluteal region and then course to the perineum by way of the **pudendal canal** (of Alcock). At the lateral border of the **ischiorectal fossa** their branches, the **inferior rectal vessels** and **nerves,** cross the fossa transversely to supply the levator ani and external anal sphincter muscles.

(3) The main trunks of the vessels and nerve continue anteriorly, pierce the urogenital diaphragm, and become the **perineal vessels** and **nerve** and the **dorsal vessels** and **nerve of the penis.** The muscles of the urogenital triangle are innervated by the perineal nerve, while the dorsal nerve of the penis is the main sensory nerve of that organ.

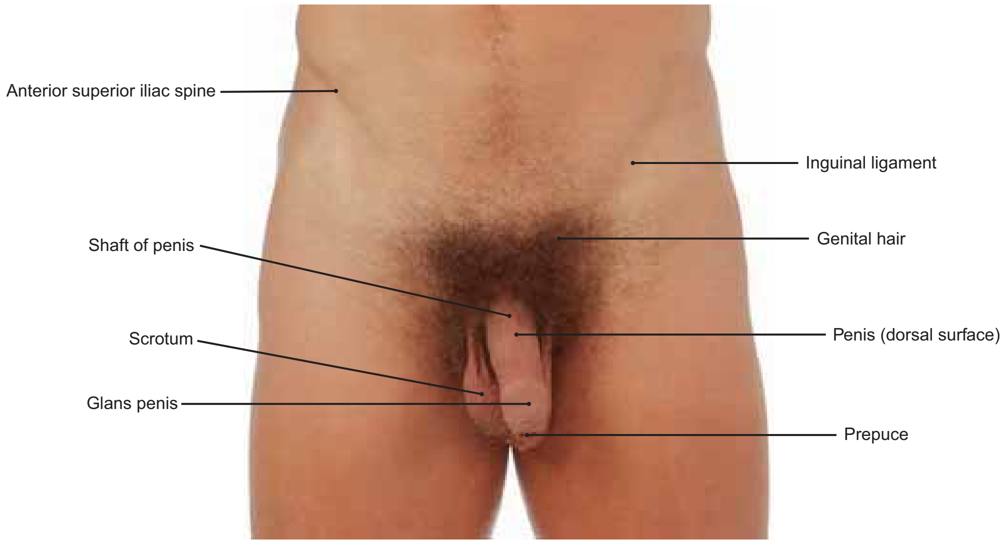


FIGURE 367.1 Surface Anatomy of the Male External Genitalia

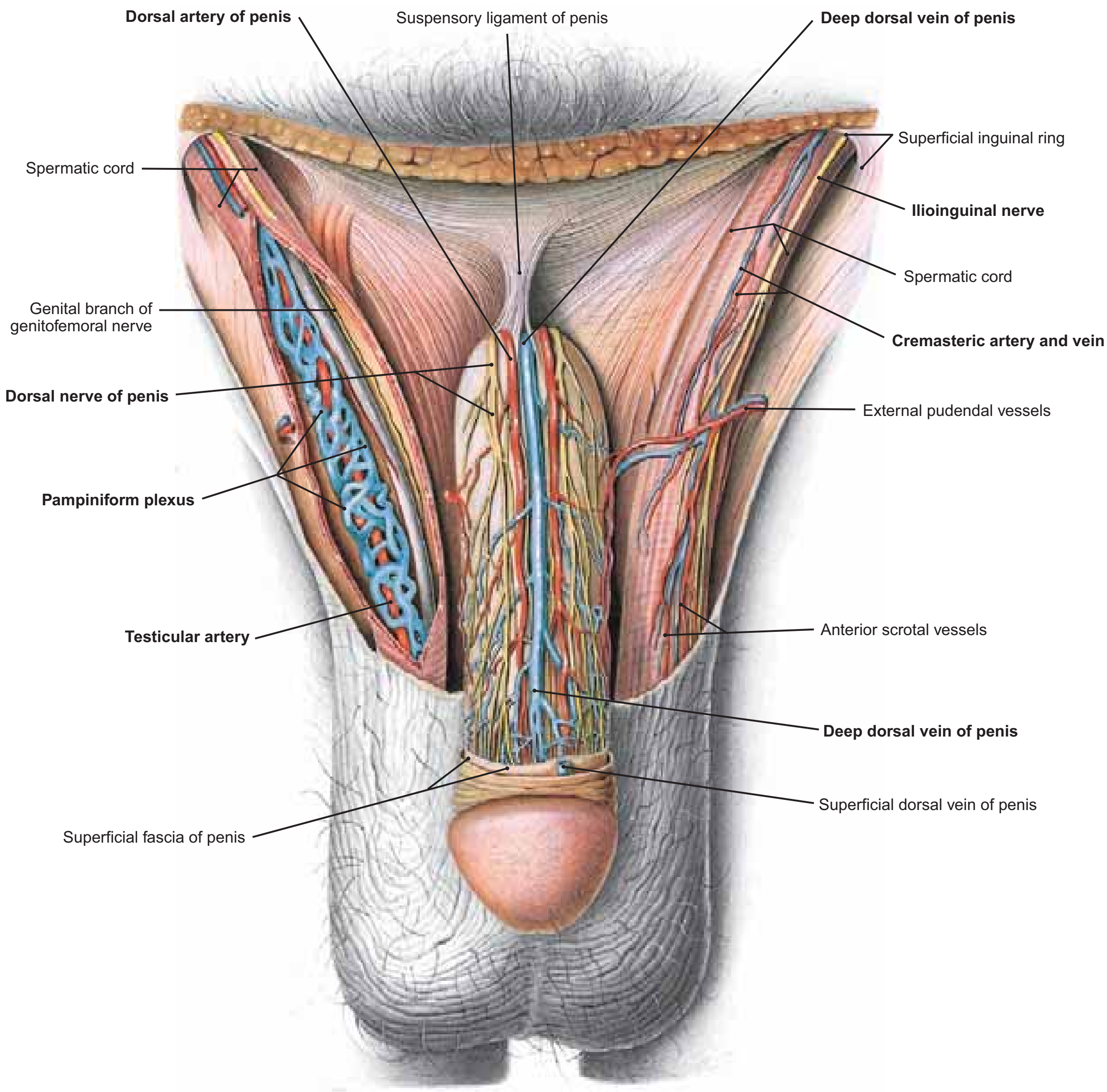


FIGURE 367.2 Vessels and Nerves of the Penis and Spermatic Cord

NOTE: (1) The skin has been removed from the anterior pubic region and the penis, revealing the superficial vessels and nerves of the penis and left **spermatic cord.** The right spermatic cord has been slit open to show the deeper structures within (see Fig. 369.1).

(2) Along the surface of the spermatic cord course the **ilioinguinal nerve** and the **cremasteric artery** and **vein.** Within the cord are found the **ductus deferens** and **testicular artery** surrounded by the **pampiniform plexus of veins.**

(3) Beneath the fascia of the penis and in the midline, courses the unpaired **deep dorsal vein of the penis.** Along the sides of the vein, observe the paired **dorsal arteries** and **nerves of the penis.**

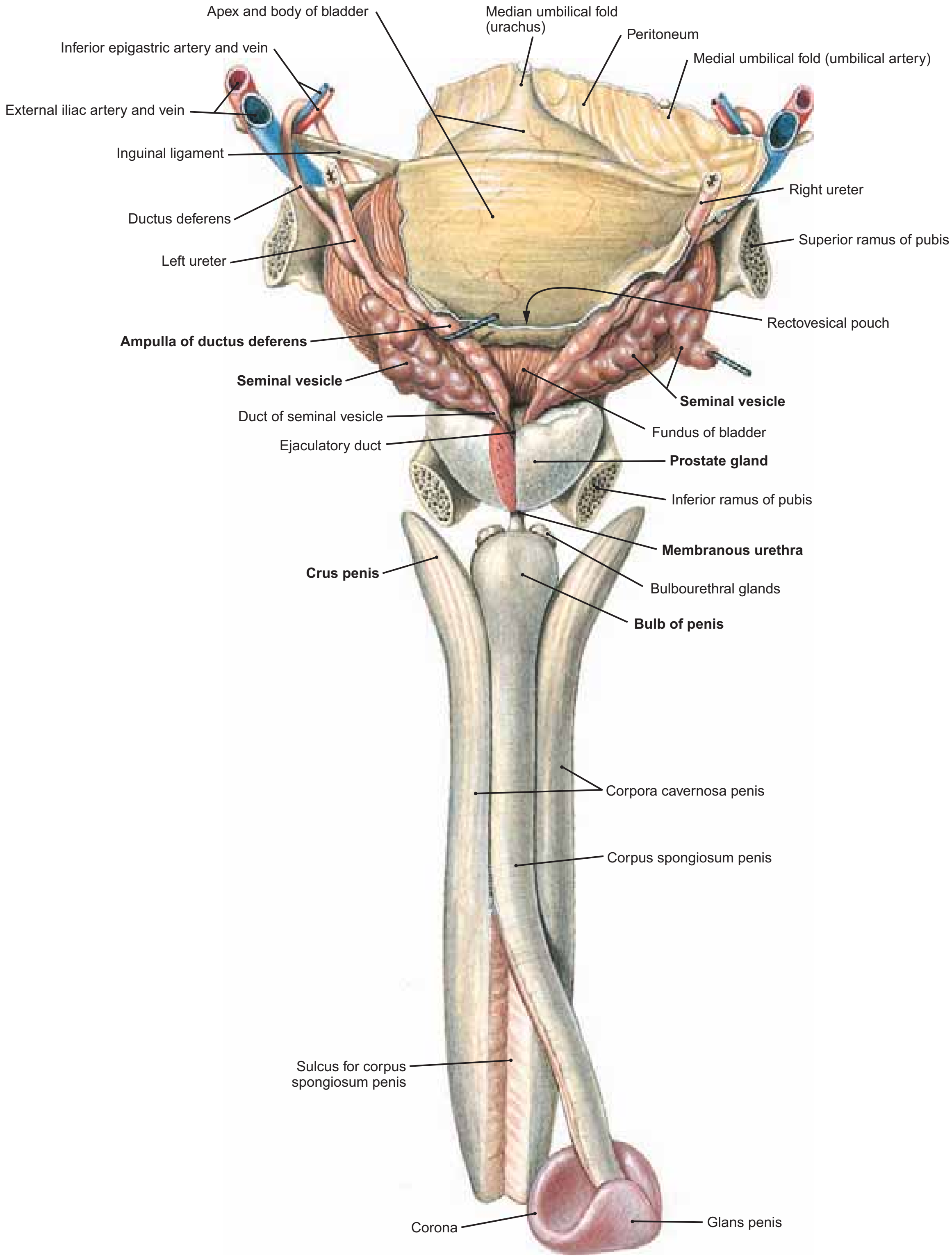


FIGURE 368 Erectile Bodies of the Penis Attached to the Bladder and Other Organs by the Membranous Urethra

NOTE: (1) The deep fascia, which closely invests the erectile bodies of the penis, has been removed, and the distal part of the **corpus spongiosum penis** (which contains the penile urethra) has been displaced from its position between the two **corpora cavernosa penis.**

(2) The posterior surface of the **bladder** and **prostate** and the associated **seminal vesicles, ductus deferens,** and **bulbourethral glands** are also demonstrated. These structures all communicate with the **urethra,** the membranous part of which is in continuity with the **penile urethra.**

(3) The tapered **crura** of the corpora cavernosa penis, which diverge laterally to become adherent to the ischial and pubic rami. They are surrounded by fibers of the ischiocavernosus muscles (see Fig. 366). The base of the corpus spongiosum penis is also expanded and is called the **bulb of the penis.** It is surrounded by the bulbocavernosus muscle (see Fig. 365.2).

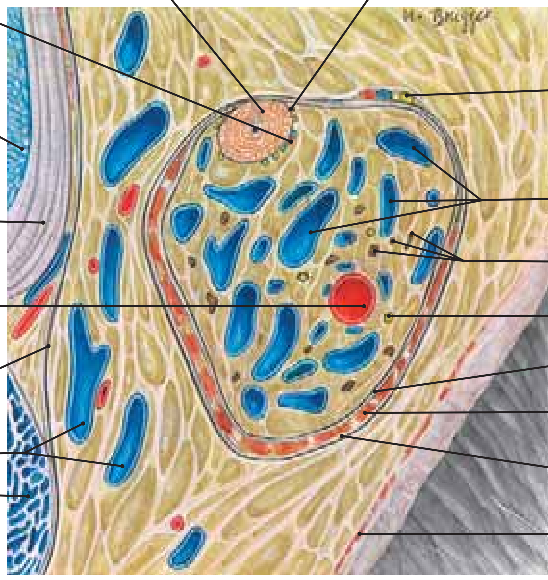


FIGURE 369.1 Transverse Section of the Spermatic Cord within the Scrotum

NOTE: (1) The spermatic cord contains the: (a) ductus deferens, (b) artery of the ductus deferens, (c) testicular artery, (d) cremasteric artery, (e) pampiniform plexus of veins, (f) lymphatic vessels, and (g) sympathetic and sensory nerve fibers and some fat. These are surrounded by the internal and external spermatic fascial layers and the cremaster muscle.

(2) The spermatic cord traverses the superficial inguinal ring, the inguinal canal, and the abdominal inguinal ring.

(3) The arteries and nerves descend to the testis from the abdomen, while the ductus deferens, the veins, and the lymphatics ascend to the abdomen from the scrotum.

(4) The spermatic cord is covered by the external spermatic fascia, the internal spermatic fascia, and the cremaster muscle.

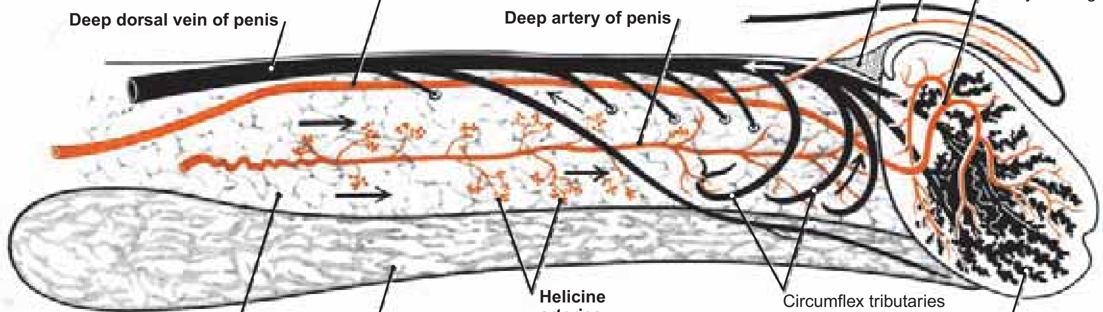


FIGURE 369.2 Longitudinal Section through the Penis, Showing Its Vascular Circulation

NOTE: (1) The dorsal and deep arteries of the penis supply blood principally to the corpora cavernosa but also to the glans penis of the corpus spongiosum.

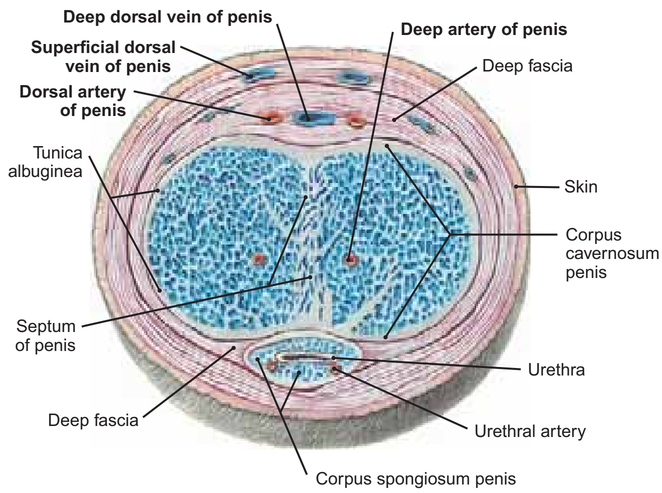
(2) The **helicine branches** of the deep artery and the **circumflex tributaries** of the deep dorsal vein that return blood from the corpora and the glans.

(3) The venous drainage from the glans penis, the corpora cavernosa, and the corpus spongiosum is along the **deep dorsal vein of the penis,** while the superficial dorsal vein (not shown in this figure) drains the prepuce and skin of the penis.

FIGURE 370.1 Section through Middle of Penis ▶ (see Fig. 370.4)

NOTE: (1) The penis is composed of two corpora cavernosa penis containing erectile tissue and one corpus spongiosum penis seen ventrally and in the midline that contains the penile portion of the urethra.

(2) The three corpora are surrounded by a closely investing layer of deep fascia. In erection, blood fills the erectile tissue, causing the corpora to become rigid. The thin-walled veins are compressed between the corpora and the deep fascia. Erection is maintained by preventing venous blood from draining back into the general circulation.



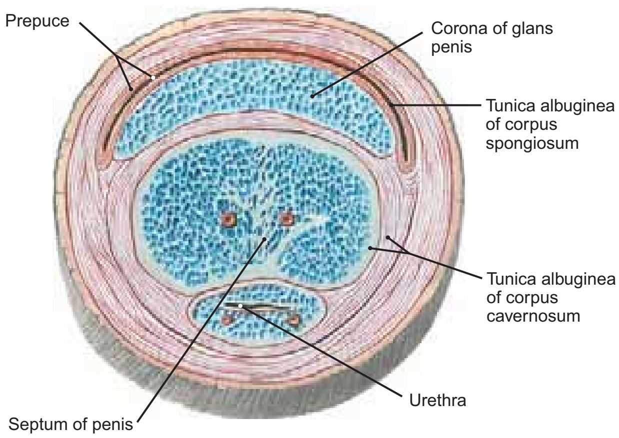


FIGURE 370.2 Section at Neck of the Glans Penis (see Fig. 370.4)

NOTE: This section is taken from the proximal part of the glans penis. The corpora cavernosa penis become smaller distally, while the corona of the glans penis is formed by the spongy tissue of the corpus spongiosum penis.

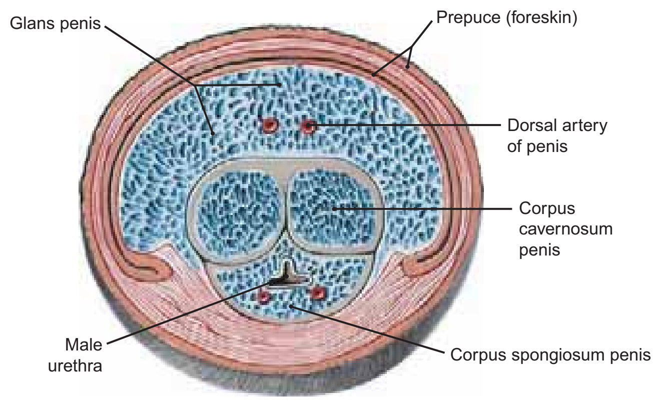


FIGURE 370.3 Section Midway along the Glans Penis ▶ (see Fig. 370.4)

NOTE: This cross section at the level of the middle of the glans penis shows that the corpora cavernosa penis are diminishing in size. At this site, the glans occupies a larger portion of the cross section.

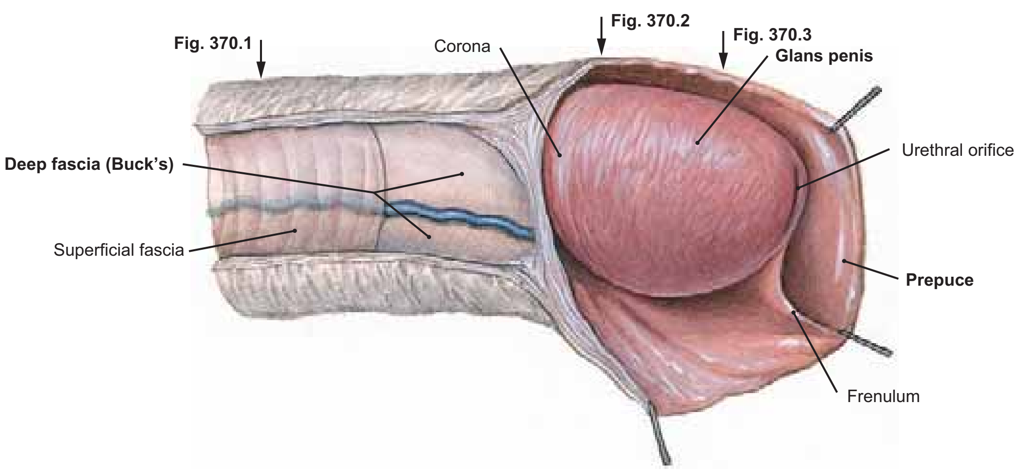


FIGURE 370.4 Distal End of Penis

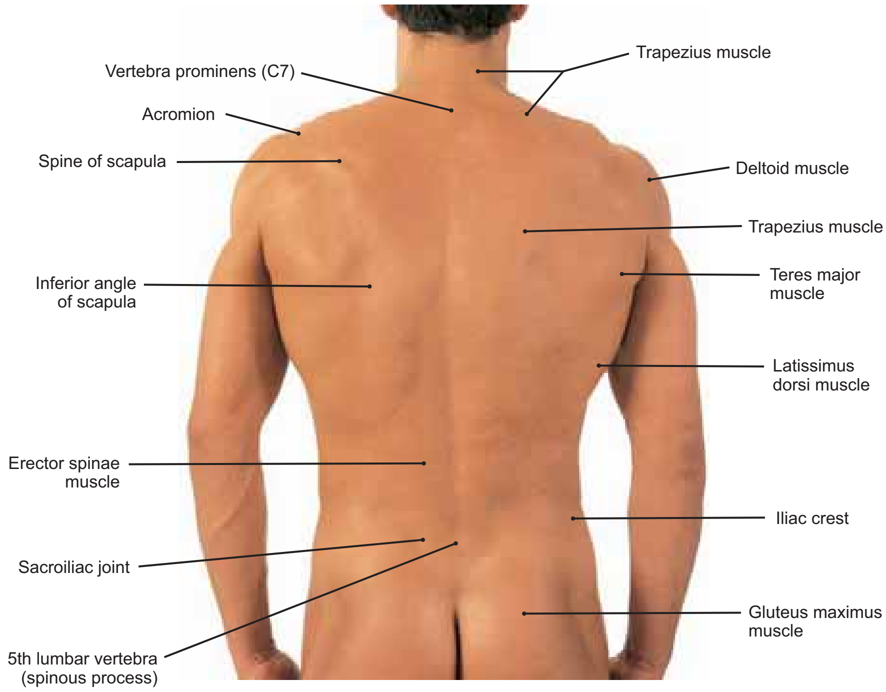
NOTE: The distal end of the penis consists of the glans penis, which is attached by the frenulum to a duplicated fold of skin, the prepuce. Observe that the skin of the penis is thin and delicate and is loosely attached to the underlying deep fascia and corpora, accounting for its freely movable nature. (Arrows indicate cross sections seen above.)

CHAPTER 5

The Back, Vertebral Column, and Spinal Cord

Plates

FIGURE 371.1 Surface Anatomy of the Back



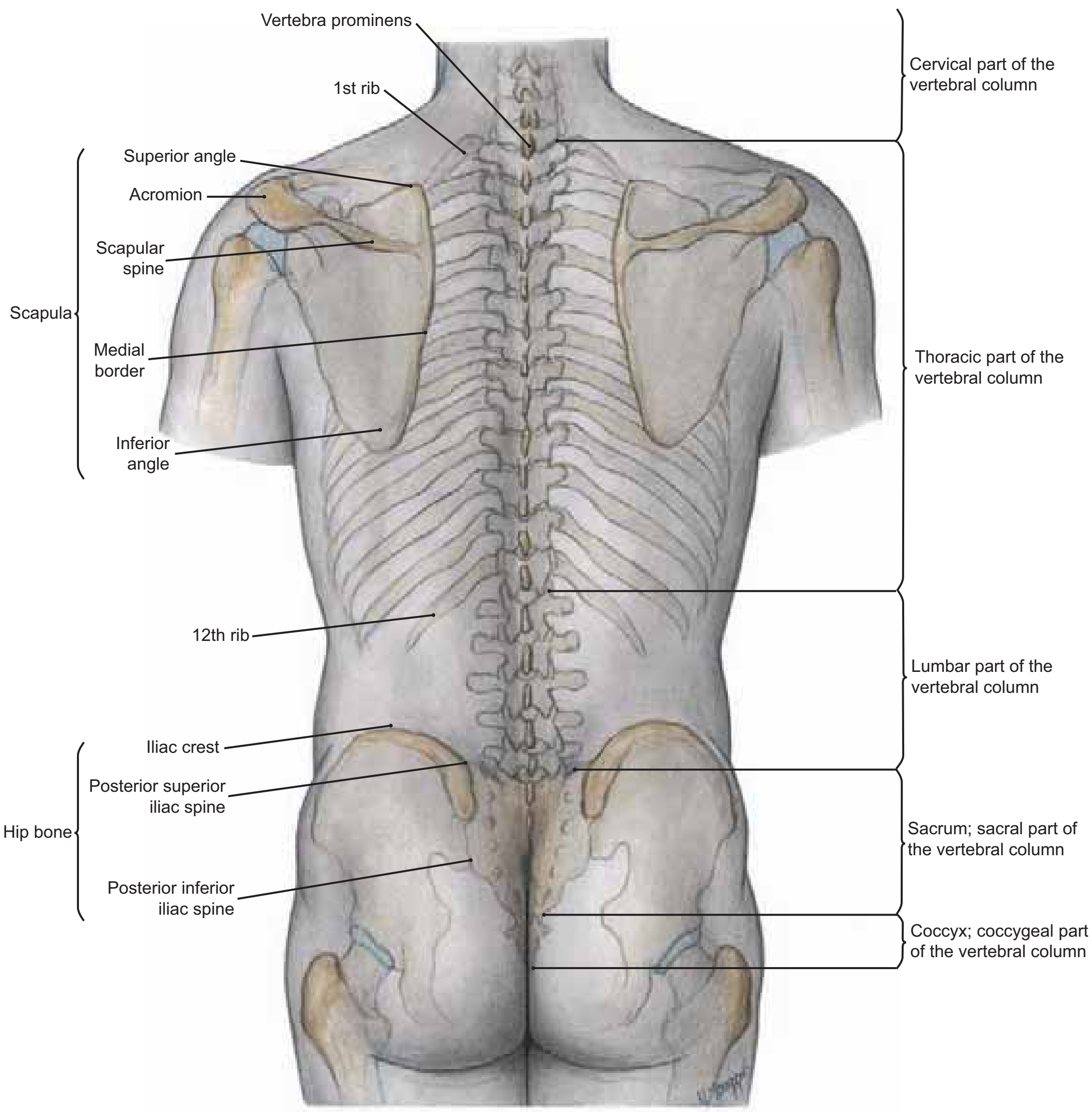


FIGURE 371.2 Skeletal Structures in the Back of the Trunk

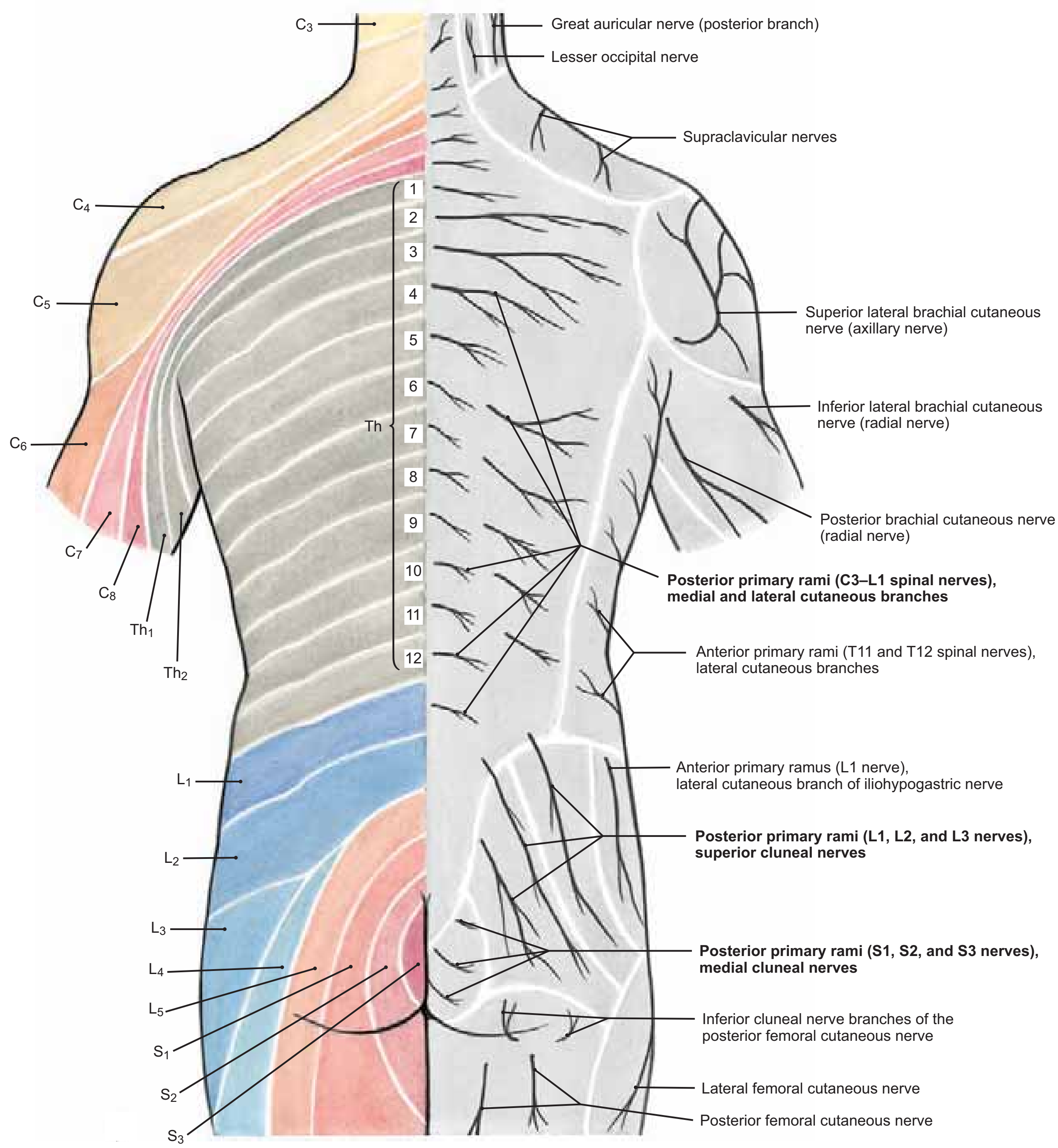


FIGURE 372 Dermatomes and Cutaneous Nerve Distribution (Posterior Aspect of the Body)

NOTE: (1) **Dermatomes** are shown on the left and the **cutaneous nerve** distribution and surface areas for the dorsum of the trunk are shown on the right.

(2) An area of skin supplied by the cutaneous branches of a single nerve is called a dermatome. There is considerable overlap between adjacent segmental nerves and, although the loss of a single spinal nerve produces an area of altered sensation, it does not result in total sensory loss.

(3) Destruction of at least three consecutive spinal nerves is required to produce a total sensory loss of the dermatome supplied by the middle nerve of the three.

(4) Mapping of skin areas affected by herpes zoster (shingles) has added to our knowledge of dermatome distribution. Another experimental procedure is that of "remaining sensibility." In the latter, dermatome areas are established in animals after severance of several roots above and below the intact root whose dermatome is being studied.

(5) The posterior primary rami of spinal nerves C3 through L1 (boldface) supply the posterior skin of the trunk, while the lateral neck, upper limb, and lateral trunk are supplied by anterior primary rami.

(6) The posterior primary rami (boldface) of L1, L2, and L3 (superior cluneal nerves) as well as the posterior primary rami (boldface) of S1, S2, and S3 (medial cluneal nerves) supply the gluteal and sacral regions. The remaining nerves of the posterior lower trunk and limbs are from anterior primary rami.

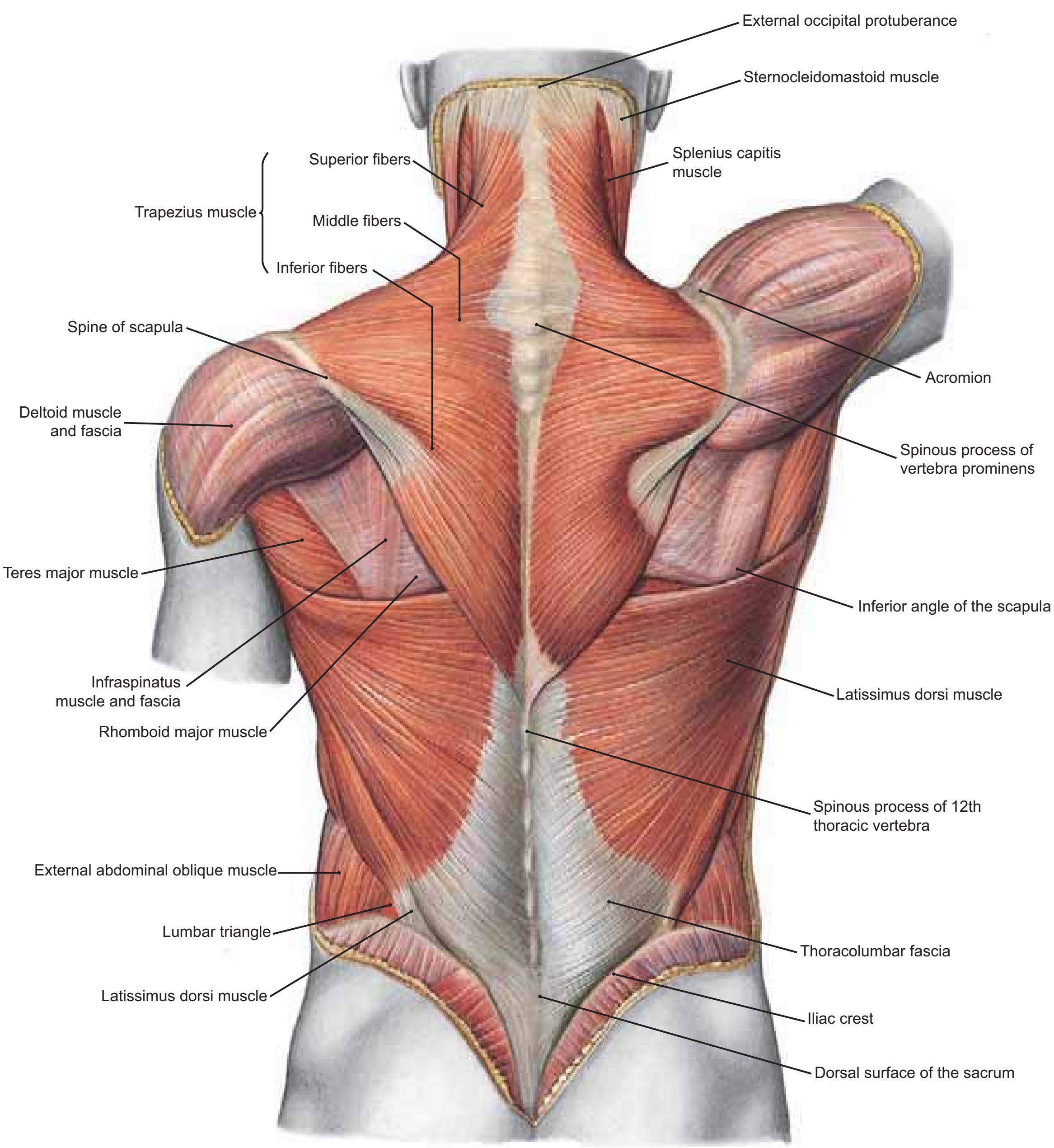


FIGURE 373 **The Superficial Muscles of the Back: Trapezius and Latissimus Dorsi**

NOTE that although the trapezius and latissimus dorsi are superficial muscles of the back, they both insert onto pectoral girdle bones—that is, the scapula and the humerus.

SUPERFICIAL MUSCLES OF THE BACK

Muscle	Origin	Insertion	Innervation	Action
Trapezius	Middle third of the superior nuchal line; external occipital protuberance; ligamentum nuchae; spinous processes of C7 and T1 to T12 vertebrae	Lateral third of the clavicle; medial margin of acromion; spine of the scapula	Motor fibers from spinal part of the accessory nerve (XI); sensory fibers from C3, C4	Assists serratus anterior in rotating the scapula during abduction of the humerus between 90 and 180 degrees; upper fibers elevate the scapula; lower fibers depress the scapula; middle fibers adduct the scapula; occipital fibers draw the head laterally
Latissimus dorsi	Thoracolumbar fascia; spinous processes of lower six thoracic vertebrae and five lumbar vertebrae and the sacrum; iliac crest; lower three or four ribs	Floor of the intertubercular sulcus of the humerus	Thoracodorsal nerve from the posterior cord of the brachial plexus (C6, C7, C8)	Extends, adducts, and medially rotates humerus; with insertion fixed, it elevates the trunk to the arms, as in climbing

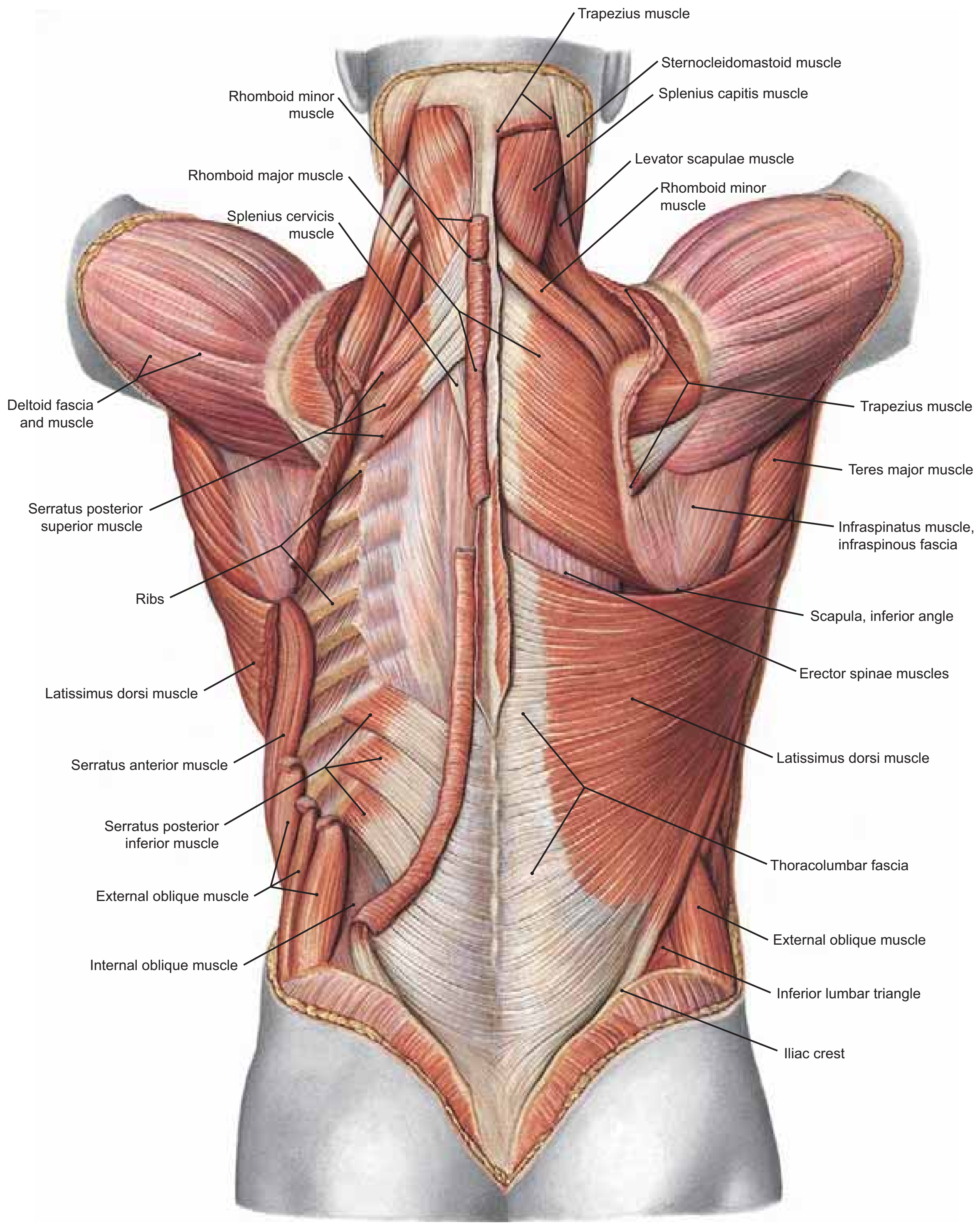


FIGURE 374 Superficial and Intermediate Back Muscles (Posterior View)

NOTE: (1) On the right side, the trapezius has been removed to reveal the rhomboid muscles, the levator scapulae, and the splenius capitis. The latissimus dorsi and the thoracolumbar fascia are still intact.

(2) On the left side, the trapezius, the latissimus dorsi, and the rhomboid muscles have been removed to expose the serratus posterior superior, the serratus posterior inferior, and several ribs.

(3) The erector spinae muscle and its overlying fascia (labeled on the right and shown extensively on the left but not labeled) extends longitudinally and considered the strongest and most important deep back muscle (see Fig. 375).

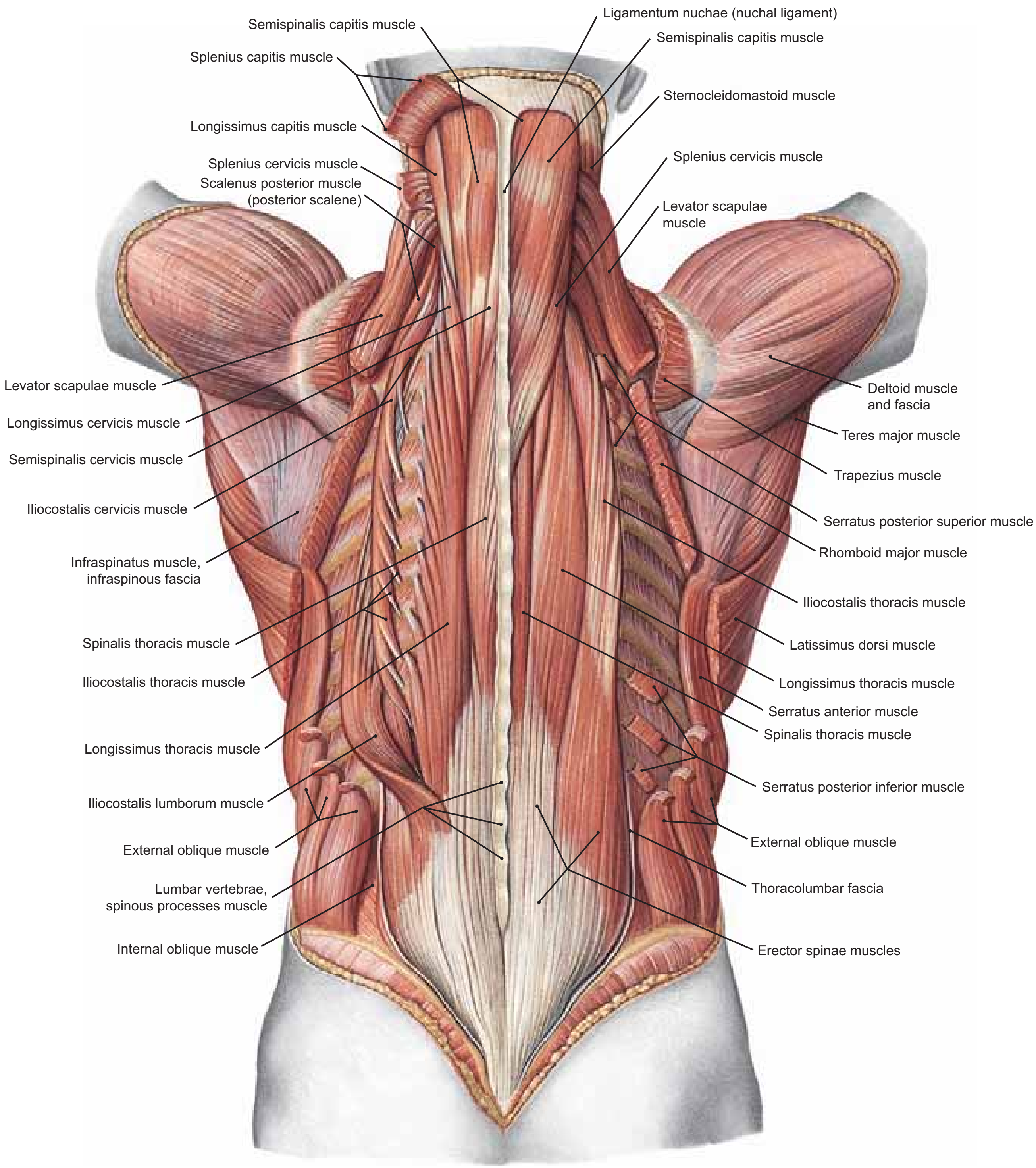


FIGURE 375 Erector Spinae Muscles and Semispinalis Capitis Muscles

NOTE: (1) The trapezius and latissimus dorsi muscles have been removed, as have the rhomboid muscles and the serratus posterior (superior and inferior) muscles.

(2) The erector spinae muscle is seen intact on the right side, while its iliocostalis, longissimus, and spinalis columns have been separated on the left side. This muscle is a strong extensor and lateral flexor of the vertebral column (and head).

(3) The two semispinalis capitis muscles superiorly following the removal of the splenius capitis muscles. Observe the tendinous intersections that are characteristic of this muscle.

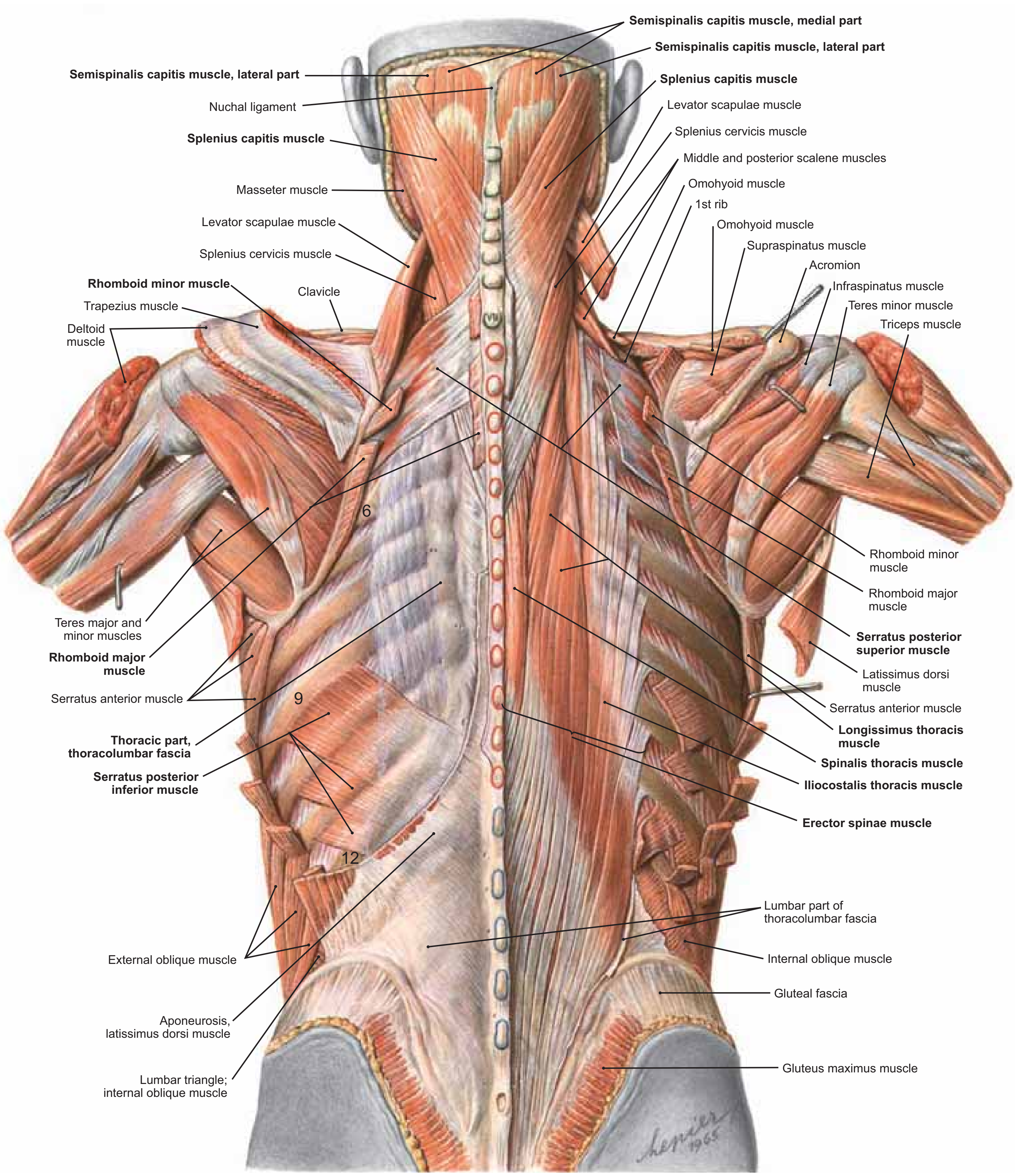


FIGURE 376 Muscles of the Back: Intermediate Layer (Left), Deep Layer (Right)

NOTE: (1) On the left side, the superficial back muscles (trapezius and latissimus dorsi) have been cut, as have the rhomboids, which attach the vertebral border of the scapula to the vertebral column. Observe the underlying serratus posterior superior and inferior muscles.

(2) On the right side, the serratus posterior muscles and the thoracolumbar fascia have been removed, exposing the erector spinae muscle (formerly called sacrospinalis muscle).

(3) In the neck, the splenius cervicis, splenius capitis, and semispinalis capitis underlie the trapezius.

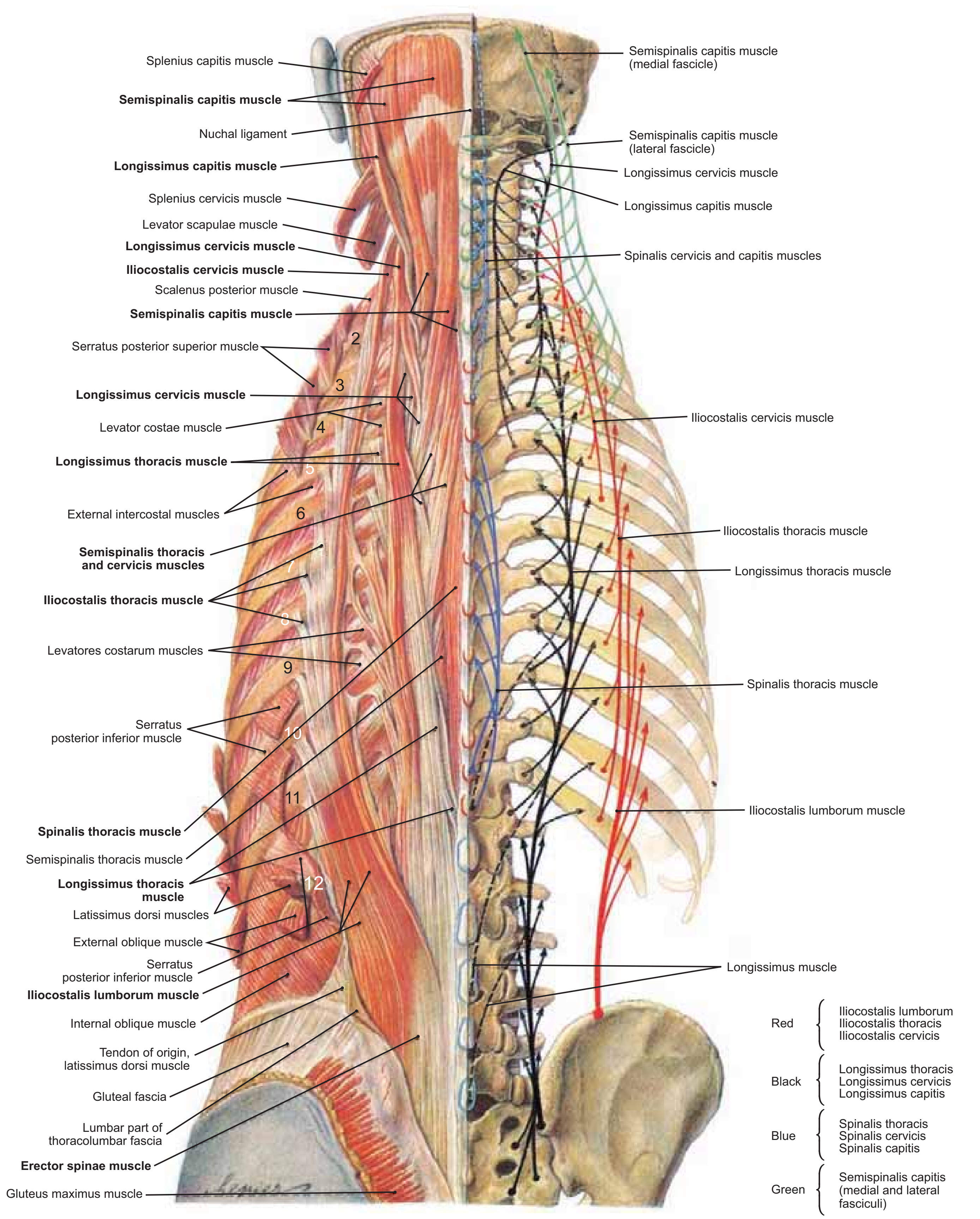


FIGURE 377 Deep Muscles of the Back and Neck: Erector Spinae Muscle

NOTE: (1) **On the left,** the erector spinae (sacrospinalis) muscle is separated into iliocostalis, longissimus, and spinalis parts. In the neck, observe the semispinalis capitis, which has both medial and lateral fascicles. The semispinalis cervicis and thoracis extend inferiorly from above and lie deep to the sacrospinalis layer of musculature.

(2) **On the right,** all of the muscles have been removed and their attachments have been diagrammed by means of colored lines and arrows.

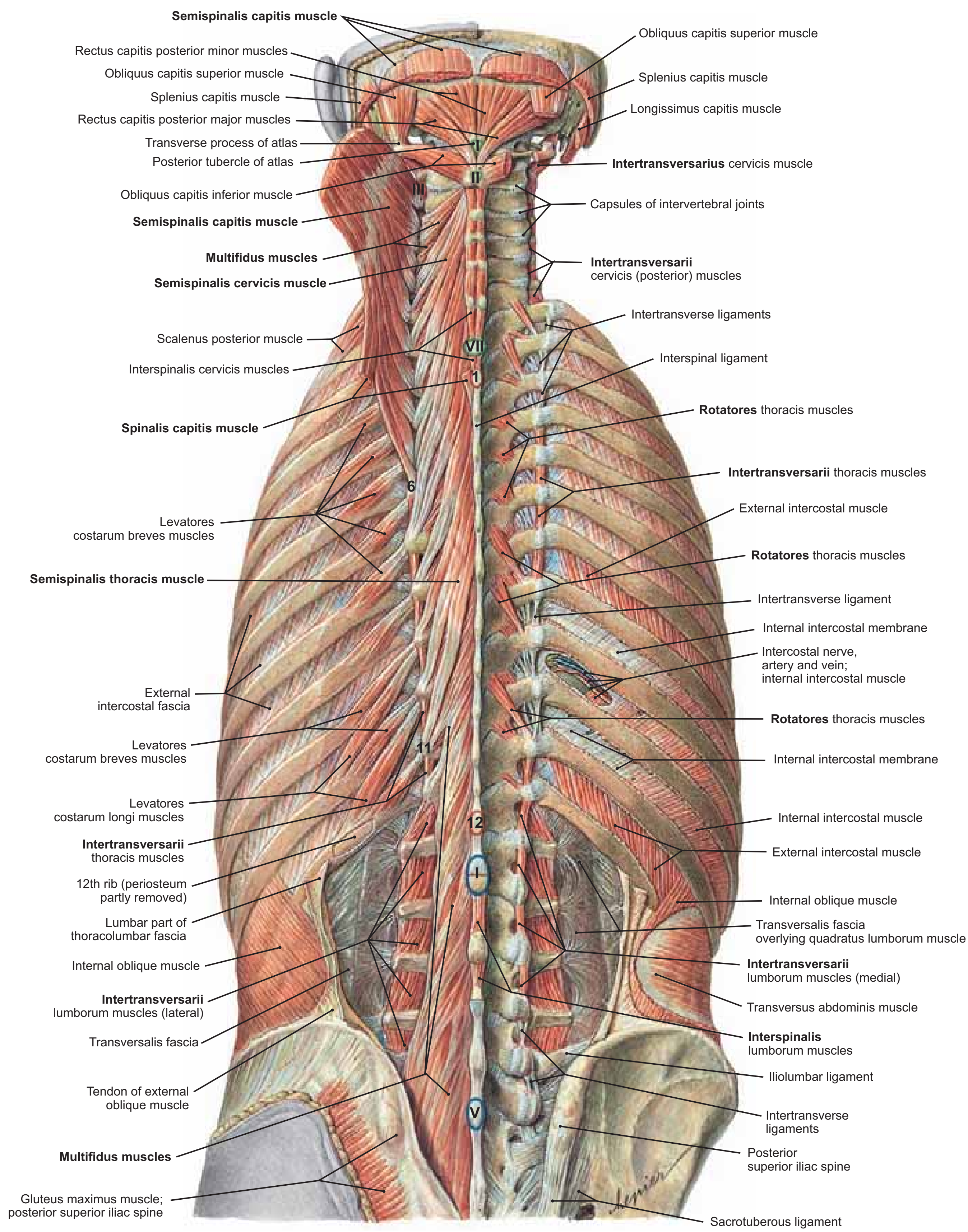


FIGURE 378 Deep Muscles of the Back and Neck: Transversospinal Group

NOTE: (1) **The transversospinal** groups of muscles lie deep to the **erector spinae,** and they extend between the transverse processes of the vertebrae and the spinous processes of higher vertebrae. These muscles are extensors of the vertebral column or acting individually and on one side, they bend and rotate the vertebrae of that side.

(2) Within this group of muscles are the **semispinalis** (thoracis, cervicis, and capitis), the **multifidus,** the **rotatores** (lumborum, thoracis, cervicis), the **interspinales** (lumborum, thoracis, cervicis), and the **intertransversarii.**

INTERMEDIATE MUSCLES OF THE BACK				
Muscle	**Origin**	**Insertion**	**Innervation**	**Action**
Rhomboid major	Spinous processes of T2 to T5 thoracic vertebrae	Medial border of scapula between the scapular spine and inferior angle	Dorsal scapular nerve (C5)	Adducts the scapula by pulling it medially toward the vertebral column; rotates the scapula by depressing the lateral angle; helps fix scapula to thoracic wall
Rhomboid minor	Spinous process of C7 and T1 vertebrae	Medial border of scapula at the level of the spine of the scapula	Dorsal scapular nerve (C5)	Assists the rhomboid major muscle
Levator scapulae	Transverse processes of atlas and axis and the posterior tubercles of the transverse processes of C3 and C4 vertebrae	Superior angle and upper medial border of scapula	C3 and C4 nerves and the dorsal scapular nerve (C5)	Elevates superior border of scapula; rotates scapula laterally thereby tilting the glenoid cavity downward
Serratus posterior superior	Spinous processes of C7 and T1 to T3 thoracic vertebrae	Onto the upper borders of the second, third, fourth, and fifth ribs	Ventral primary rami of T1 to T4 spinal nerves	Elevates the second to fifth ribs
Serratus posterior inferior	Spinous processes of T11, T12, and upper three lumbar vertebrae	Onto the inferior border of the lower four ribs	Ventral primary rami of T9, T10, T11, and T12 spinal nerves	Draws the lower four ribs downward and backward

DEEP MUSCLES OF THE BACK				
Muscle	**Origin**	**Insertion**	**Innervation**	**Action**
ERECTOR SPINAE MUSCLES				
ILIOCOSTALIS MUSCLE (Lateral Column)				
Iliocostalis lumborum	Posteromedial part of the iliac crest and from the most lateral part of the common tendon of the erector spinae muscle	By six or seven muscle fascicles onto the inferior borders of the lower six or seven ribs at their angles	Dorsal primary rami of lower thoracic and upper lumbar nerves	Extends, laterally flexes, and assists in rotation of the vertebral column; can depress the ribs
Iliocostalis thoracis	Upper borders of the lower six ribs at their angles	Upper borders of the first six ribs at their angles and on the transverse process of the seventh cervical vertebra	Dorsal primary rami of the C8 and upper six thoracic spinal nerves	Extends, laterally flexes, and assists in rotation of the thoracic vertebrae
Iliocostalis cervicis	Angles of the third, fourth, fifth, and sixth ribs	Posterior tubercles of transverse processes of fourth, fifth, and sixth cervical vertebrae	Dorsal primary rami of the lower cervical and upper thoracic spinal nerves	Extends, laterally flexes, and assists in rotation of lower cervical and upper thoracic vertebrae
LONGISSIMUS MUSCLE (Intermediate Column)				
Longissimus thoracis	Intermediate continuation of the erector spinae muscle; transverse processes of the lumbar vertebrae	Onto the tips of transverse processes of all thoracic vertebrae; onto the lower 9 or 10 ribs between their tubercles and angles	Dorsal primary rami of the thoracic and lumbar spinal nerves	Extends and laterally flexes the vertebral column; also able to depress the ribs
Longissimus cervicis muscle	Tips of transverse processes of upper four or five thoracic vertebrae	Posterior tubercles of transverse processes of C2 to C6 cervical vertebrae	Dorsal primary rami of upper thoracic and lower cervical spinal nerves	Extends vertebral column and bends it to one side
Longissimus capitis	From transverse processes of upper four or five thoracic vertebrae; articular processes of lower three or four cervical vertebrae	Posterior margin of the mastoid process of the temporal bone	Dorsal primary rami of middle and lower cervical spinal nerves	Extends the head; muscle of one side bends head to the same side and turns face to that side
SPINALIS MUSCLE (Medial Column)				
Spinalis thoracis	From spinous processes of T11, T12, L1, and L2 vertebrae	Spinous processes of upper four to eight thoracic vertebrae	Dorsal primary rami of thoracic spinal nerves	Extends vertebral column
Spinalis cervicis	Spinous processes of C7, T1, and T2 vertebrae and ligamentum nuchae	Spinous process of the axis and those of the C3 and C4	Dorsal primary rami of lower cervical spinal nerves	Extends the cervical vertebrae
Spinalis capitis	Spinous processes of lower cervical and upper thoracic vertebrae	Inserts with the semispinalis capitis muscle between the superior and inferior nuchal lines of the occipital bone	Dorsal primary rami of upper cervical spinal nerves	Extends the head

DEEP MUSCLES OF THE BACK (Continued)

Muscle	Origin	Insertion	Innervation	Action
TRANSVERSOSPINALIS GROUP OF MUSCLES				
SEMISPINALIS MUSCLES				
Semispinalis thoracis	Transverse processes of the 6th to 10th thoracic vertebrae	Spinous processes of C7, C8, and upper four thoracic vertebrae	Dorsal primary rami of lower cervical and upper thoracic spinal nerves	Extends vertebral column and rotates it to the opposite side
Semispinalis cervicis	Transverse processes of upper five or six thoracic vertebrae	Spinous processes of the axis and third, fourth, and fifth cervical vertebrae	Dorsal primary rami of the middle cervical spinal nerves	Extends cervical spinal column; rotates vertebrae to opposite side
Semispinalis capitis	Tips of transverse processes of the C7 and upper six or seven thoracic vertebrae	Between the superior and inferior nuchal lines on the occipital bone	Dorsal primary rami of the cervical spinal nerves	Extends the head and rotates it such that the face is turned to the opposite side
MULTIFIDUS MUSCLES				
Lumborum thoracis cervicis	From the back of the sacrum; mamillary processes of lumbar vertebrae; transverse processes of all thoracic vertebrae; articular processes of lower four cervical vertebrae	Onto the spinous processes of higher vertebrae; each multifidus muscle spans two to four vertebrae	Supplied segmentally by dorsal primary rami of the lumbar, thoracic spinal nerves	Bends or laterally flexes the vertebral column and rotates it to the opposite side; both multifidi columns acting together extend the vertebral column
ROTATORES MUSCLES				
Rotatores thoracis	From transverse processes of thoracic vertebrae deep to the multifidus muscles	On the base of the spine of thoracic vertebra above the origin or the one above that	Dorsal primary rami of the thoracic spinal nerves	Extend the vertebral column and bend it toward the opposite side
Rotatores cervicis (These are less well defined.)	From the articular processes of the cervical vertebrae	To the base of the spines of the cervical vertebra immediately above	Dorsal primary rami of cervical spinal nerves	Extend cervical vertebrae and bend them to the opposite side
Rotatores lumborum (These are less well defined.)	From the mamillary processes of the lumbar vertebrae	To the base of the spines of the lumbar vertebra immediately above	Dorsal primary rami of lumbar spinal nerves	Extend lumbar vertebrae and bend them to the opposite side

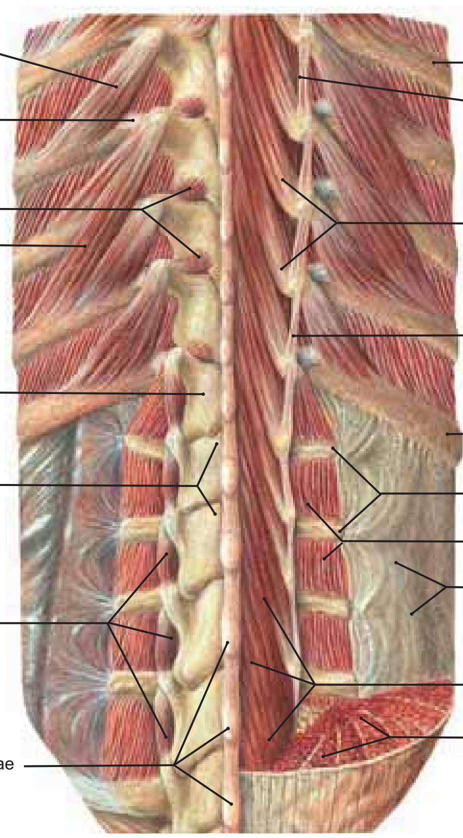


FIGURE 380 Multifidus, Rotator, Levator Costae, and Intertransverse Muscles of the Deep Back

NOTE: The erector spinae and semispinalis muscles have been removed.

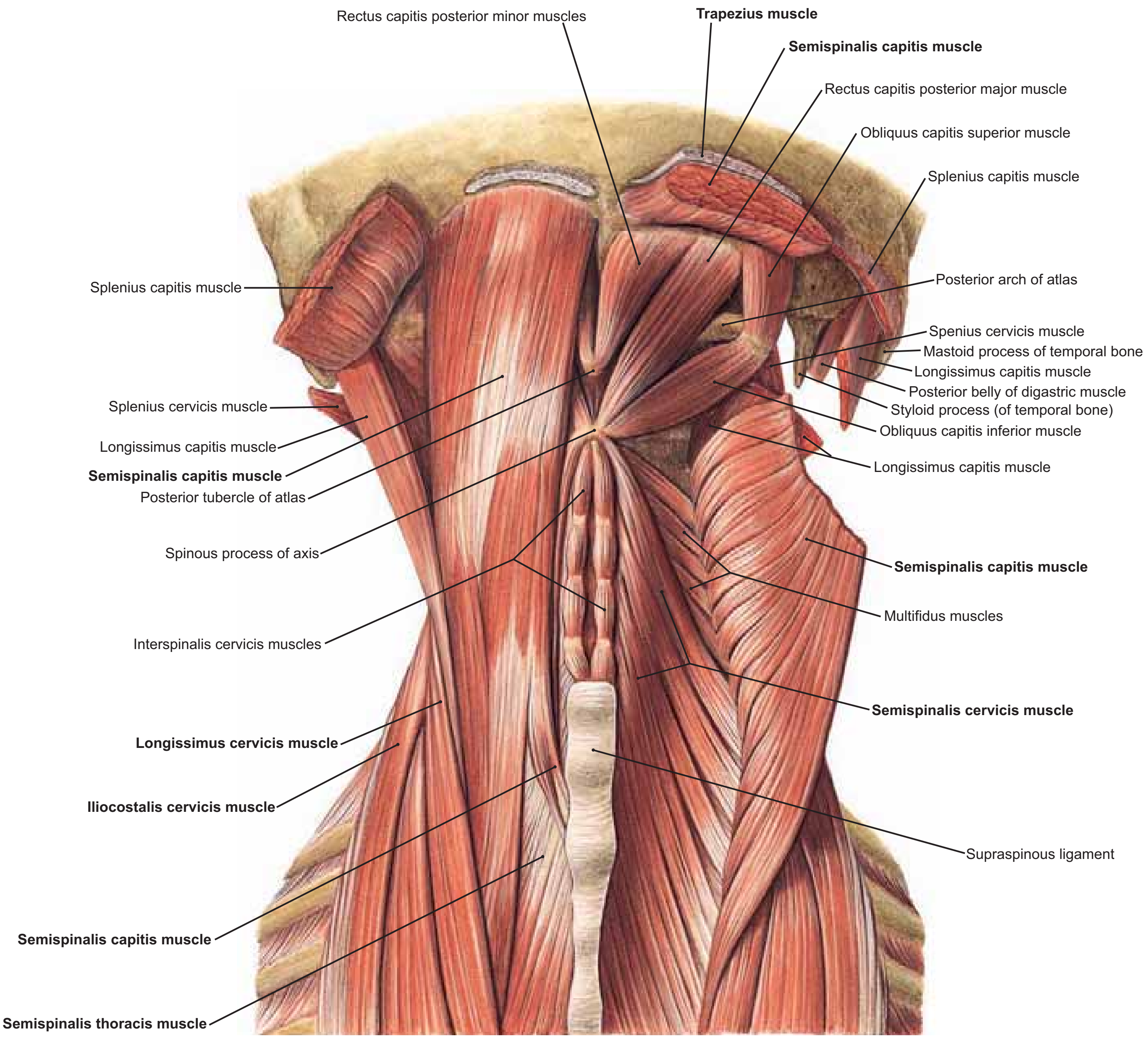


FIGURE 381.1 **The Semispinalis Capitis Muscle (Left) and Suboccipital Triangle (Right)**

NOTE that the semispinalis capitis is a strong extensor of the head, and at the same time, it rotates the head so that the face turns to the opposite side.

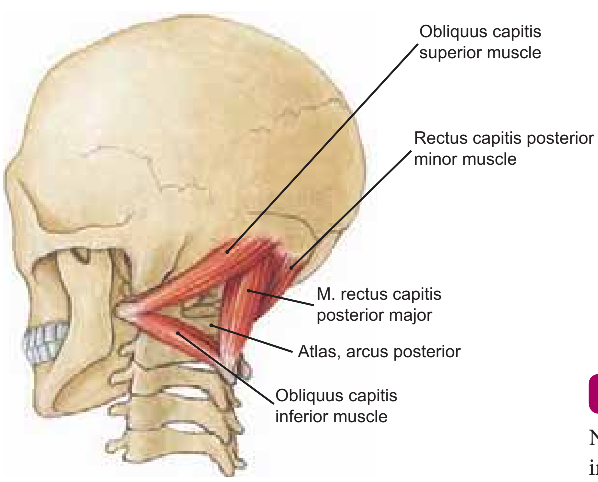


FIGURE 381.2 **Left Suboccipital Triangle**

NOTE that the suboccipital triangle is bounded by the obliquus capitis superior and inferior and the rectus capitis posterior major muscles.

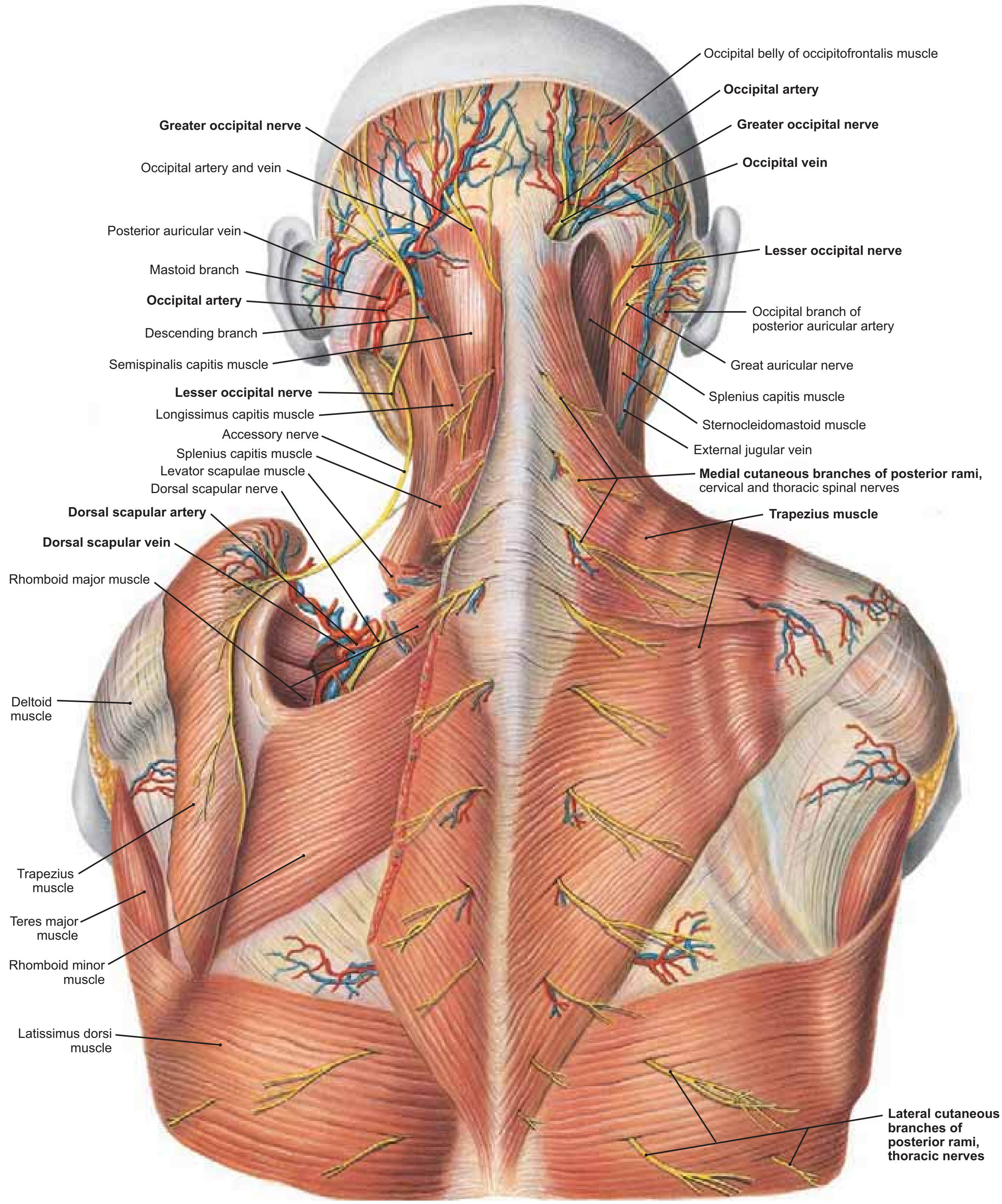


FIGURE 382 Nerves and Vessels of the Superficial and Intermediate Muscle Layers of the Upper Back and Posterior Neck

NOTE: (1) The cutaneous branches of the **posterior primary rami** of the cervical and thoracic spinal nerves supplying the posterior neck and back segmentally. Observe the **accessory nerve (XI)** as it descends to supply the trapezius and sternocleidomastoid muscles.

(2) The **greater occipital nerve,** a sensory nerve from the posterior primary ramus of the C2 spinal nerve. It is accompanied by the occipital vessels. Also observe the **lesser occipital nerve,** which courses to the skin of the lateral posterior scalp and arises from the **anterior primary ramus** of C2.

(3) The **dorsal scapular nerve** and **vessels** that course beneath the **levator scapulae** and **rhomboid muscles.**

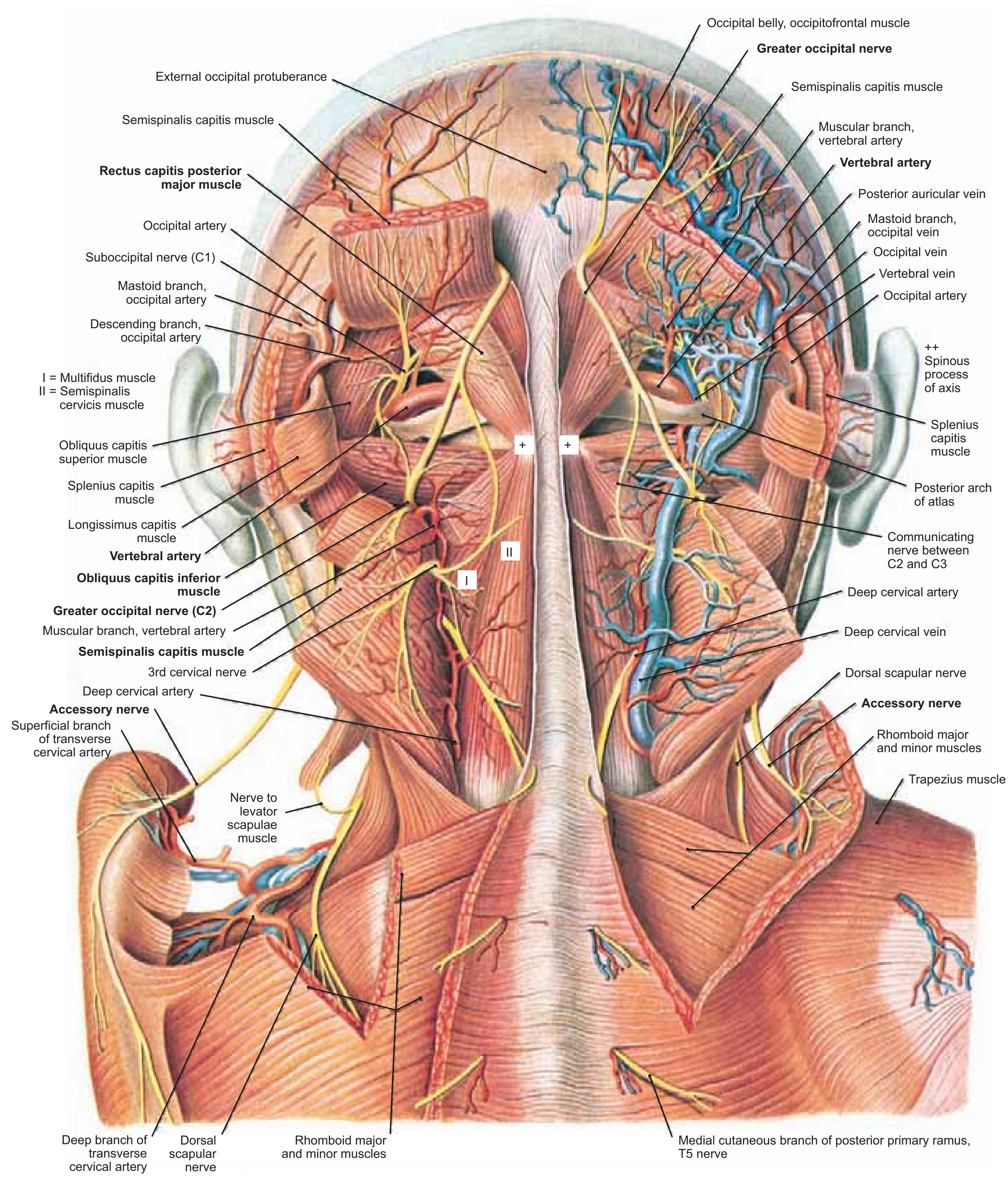


FIGURE 383 Deep Vessels and Nerves of the Suboccipital Region and Upper Back; Suboccipital Triangle

NOTE: (1) The **suboccipital triangle** lies deep to the semispinalis muscle and is bounded by the **rectus capitis posterior major, obliquus capitis superior,** and **obliquus capitis inferior.**

(2) The **vertebral artery** crosses the base of the suboccipital triangle, while the **suboccipital nerve** (posterior primary ramus of C1) courses *through* the triangle to supply motor innervation to the three muscles that bound the triangle as well as to the rectus capitis posterior minor and the overlying semispinalis capitis muscle.

(3) The **greater occipital nerve** (posterior primary ramus of C2), a sensory nerve, emerges below the obliquus capitis inferior and then courses medially and superiorly to become subcutaneous just lateral to and below the external occipital protuberance.

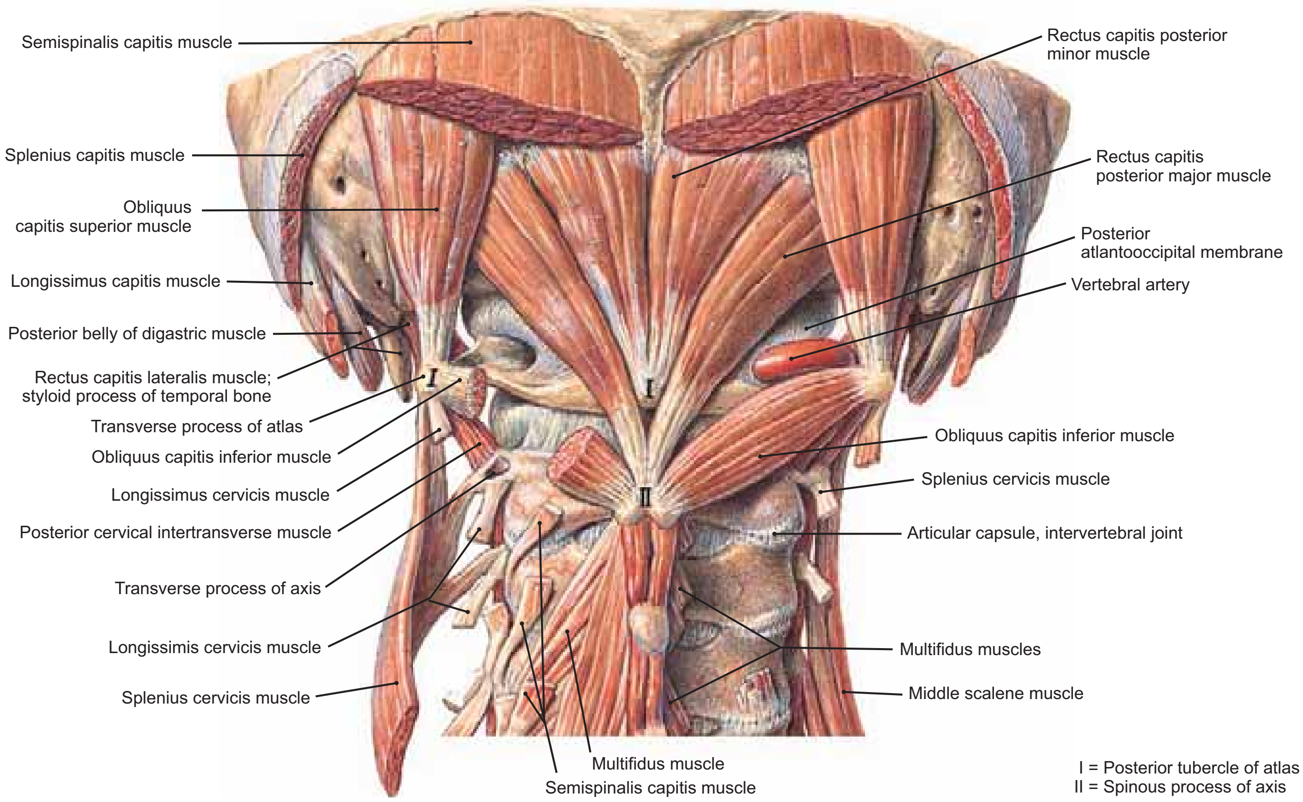


FIGURE 384.1 Muscles of the Suboccipital Triangle

NOTE: (1) The **obliquus capitis inferior, obliquus capitis superior,** and **rectus capitis posterior major muscles** outline the **suboccipital triangle.**

(2) The **vertebral artery** crosses the floor of the triangle and penetrates the posterior atlantooccipital membrane to enter the foramen magnum. There the two vertebral arteries join to form the **basilar artery** on the ventral aspect of the brainstem.

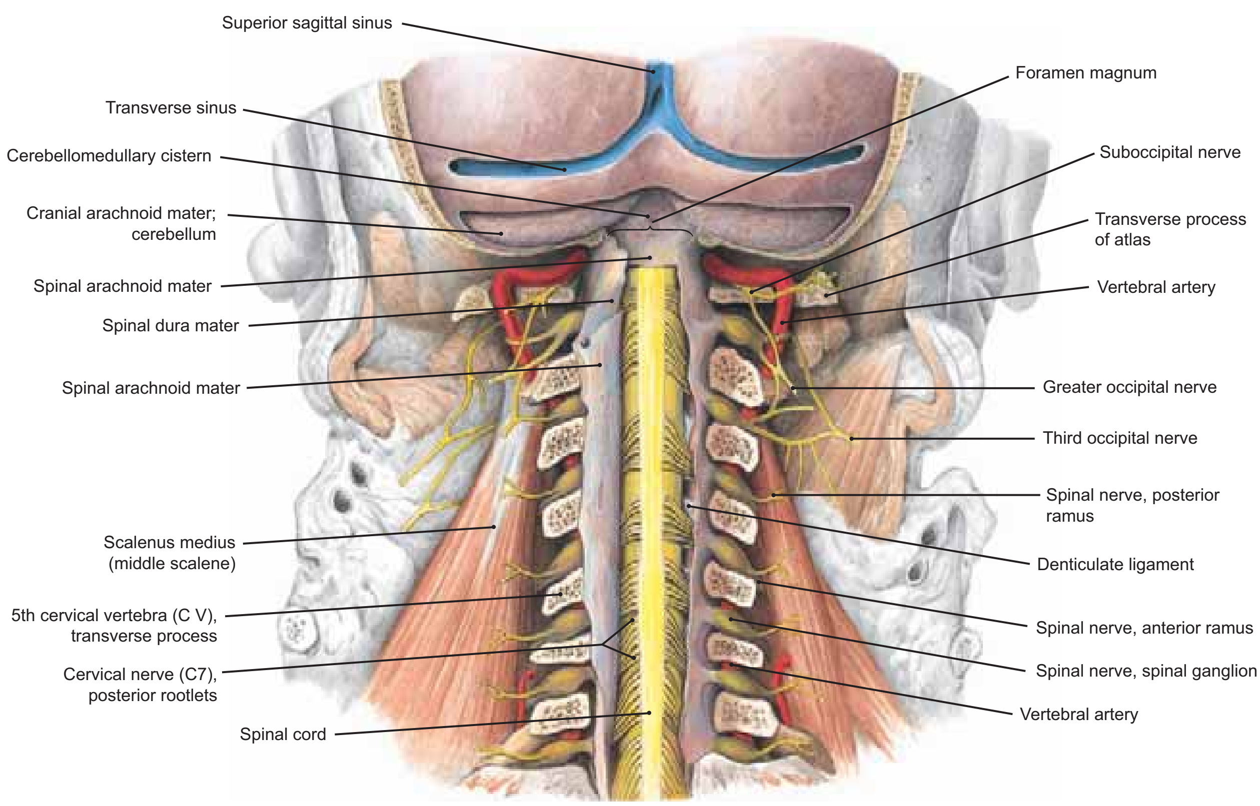


FIGURE 384.2 Suboccipital Region: Vertebral Artery and Occipital Nerves

NOTE: The assent and 90-degree turn medially taken by the vertebral arteries along the superior border of the atlas to achieve the ventral surface of the medulla oblongata.

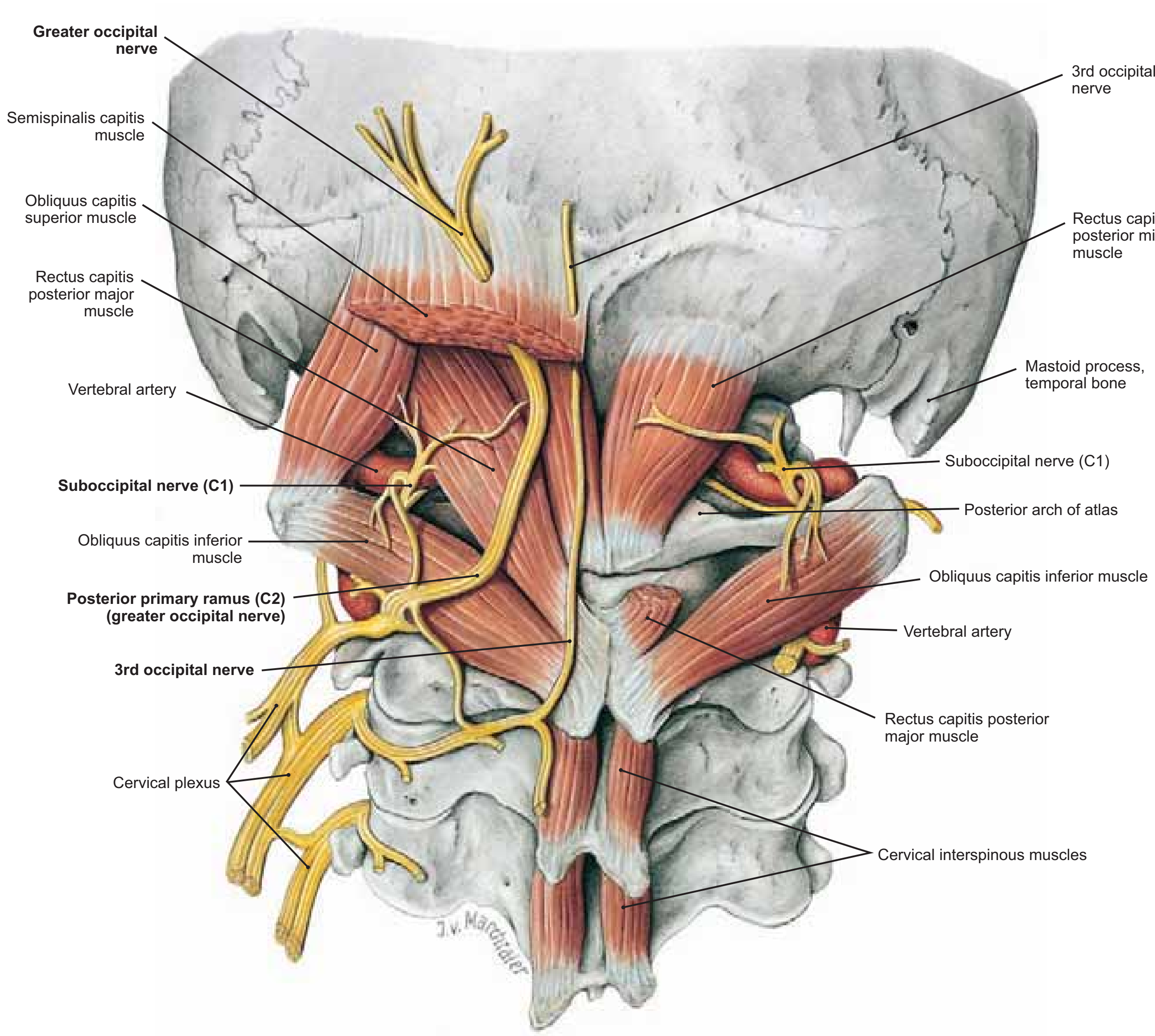


FIGURE 385 Nerves of the Suboccipital Region

NOTE: (1) The **suboccipital nerve (C1),** primarily a motor nerve, emerges from the spinal cord above the atlas, courses through the suboccipital triangle, and supplies motor innervation to all four suboccipital muscles.

(2) The **greater occipital (C2)** and **third occipital (C3) nerves** branch from the posterior primary rami of those segments. After passing through the deep muscles of the back, they become purely sensory to supply the skin on the posterior scalp and neck.

MUSCLES OF THE SUBOCCIPITAL REGION

Muscle	Origin	Insertion	Innervation	Action
Rectus capitis posterior major	Spinous process of axis	Lateral part of inferior nuchal line of occipital bone	Suboccipital nerve (dorsal ramus of C1)	Extends the head and rotates it to the same side
Rectus capitis posterior minor	Tubercle on the posterior arch of the atlas	Medial part of inferior nuchal line of occipital bone	Suboccipital nerve (dorsal ramus of C1)	Extends the head
Obliquus capitis superior	Upper surface of transverse process of the atlas	Onto occipital bone between superior and inferior nuchal lines	Suboccipital nerve (dorsal ramus of C1)	Extends the head and bends it laterally
Obliquus capitis inferior	Apex of spinous process of axis	Inferior and dorsal part of transverse process of the atlas	Suboccipital nerve (dorsal ramus of C1)	Rotates the atlas and thereby turns the face toward the same side

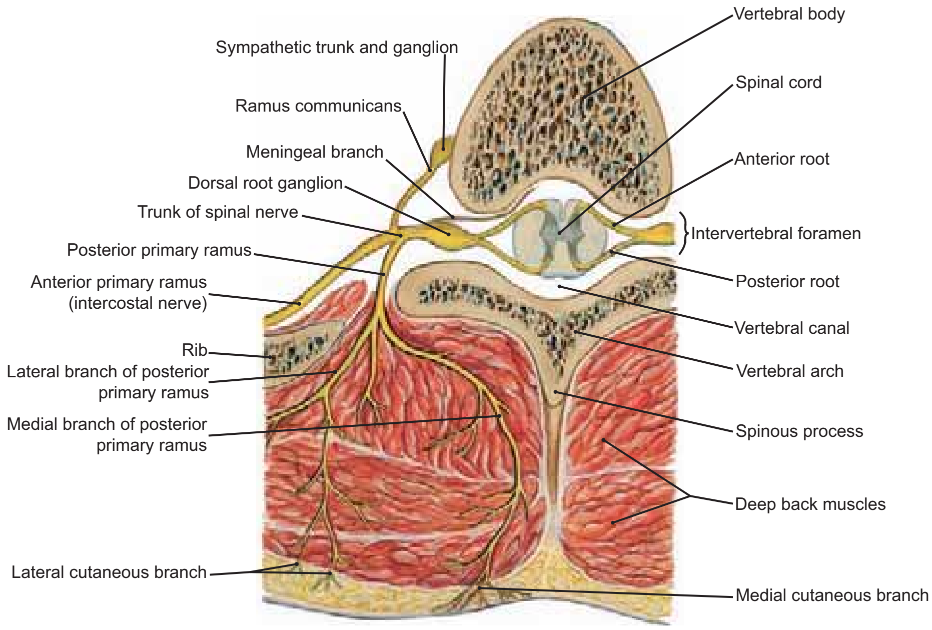


FIGURE 386.1 Branching of a Typical Spinal Nerve

NOTE: (1) Fibers from both **dorsal** and **ventral roots** join to form a **spinal nerve.** That nerve soon divides into a **posterior** and an **anterior primary ramus.** The posterior primary ramus courses dorsally to innervate the muscles and skin of the back. The anterior primary ramus courses anteriorly around the body to innervate the rest of the segment.

(2) The posterior primary rami of typical spinal nerves are smaller than the anterior rami, and each usually divides into medial and lateral branches, which contain both motor and sensory fibers innervating back structures.

(3) Unlike anterior primary rami, which join to form the cervical, brachial, and lumbosacral plexuses, the peripheral nerves derived from the posterior rami do not intercommunicate and form plexuses. There is, however, some segmental overlap of peripheral sensory fields, as seen with the anterior rami.

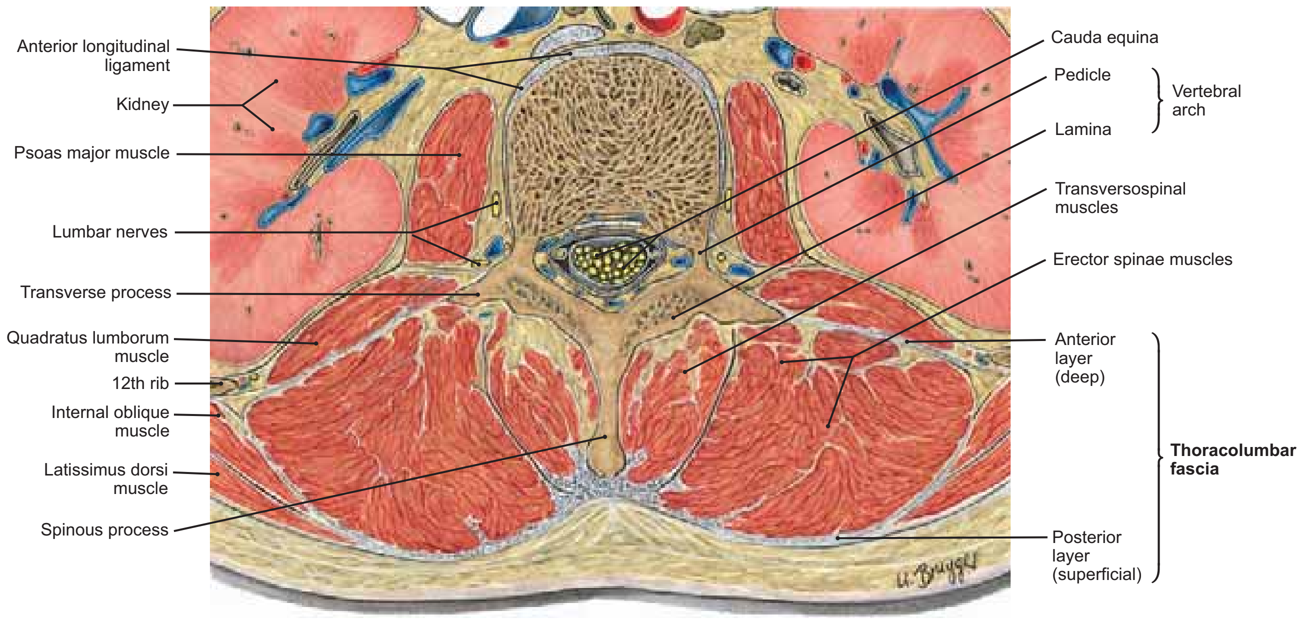


FIGURE 386.2 Cross Section at the L2 Vertebral Level: Deep Back Muscles and Thoracolumbar Fascia

NOTE: (1) This cross section of the deep back shows the lumbar part of the **thoracolumbar fascia** as it encloses the divisions of the erector spinae and transversospinal muscles. The fascia is formed by a posterior (superficial) layer and an anterior (deep) layer.

(2) Medially, the layers of the thoracolumbar fascia attach to the spinous and transverse processes of the lumbar vertebrae, and laterally, they become continuous with the aponeuroses and fascias of the latissimus dorsi and anterior abdominal muscles.

(3) The quadratus lumborum and psoas major muscles located deep to the erector spinae. Observe the relationship of the kidneys anterior to the quadratus lumborum muscles.

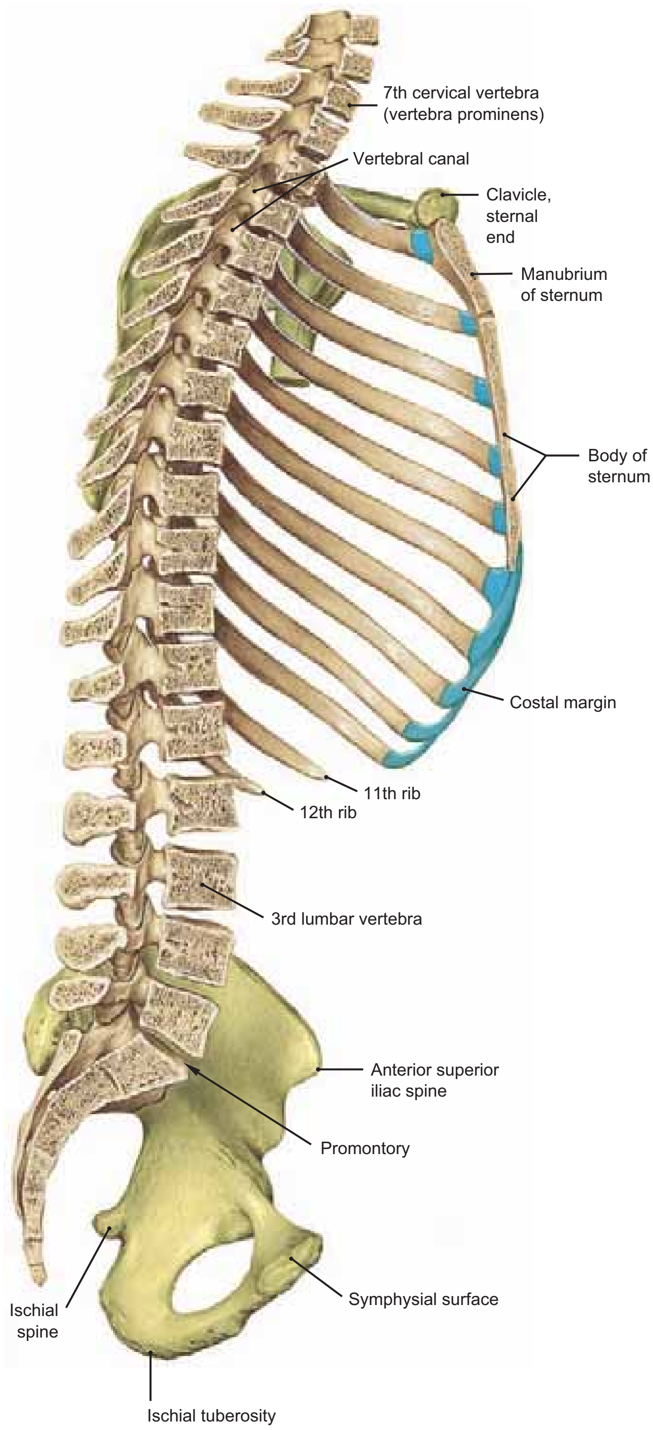


FIGURE 387.1 Left Medial Surface of the Vertebral Column Sectioned in the Median Plane

NOTE: (1) The sectioned vertebral column is shown from vertebra C5 inferiorly to the tip of the coccyx.
(2) The **vertebral canal** within which descends the spinal cord from the medulla oblongata of the brain.
(3) The C7 vertebra has a spinous process that is usually longer than the other cervical vertebrae and, therefore, is often called the **vertebra prominens.**

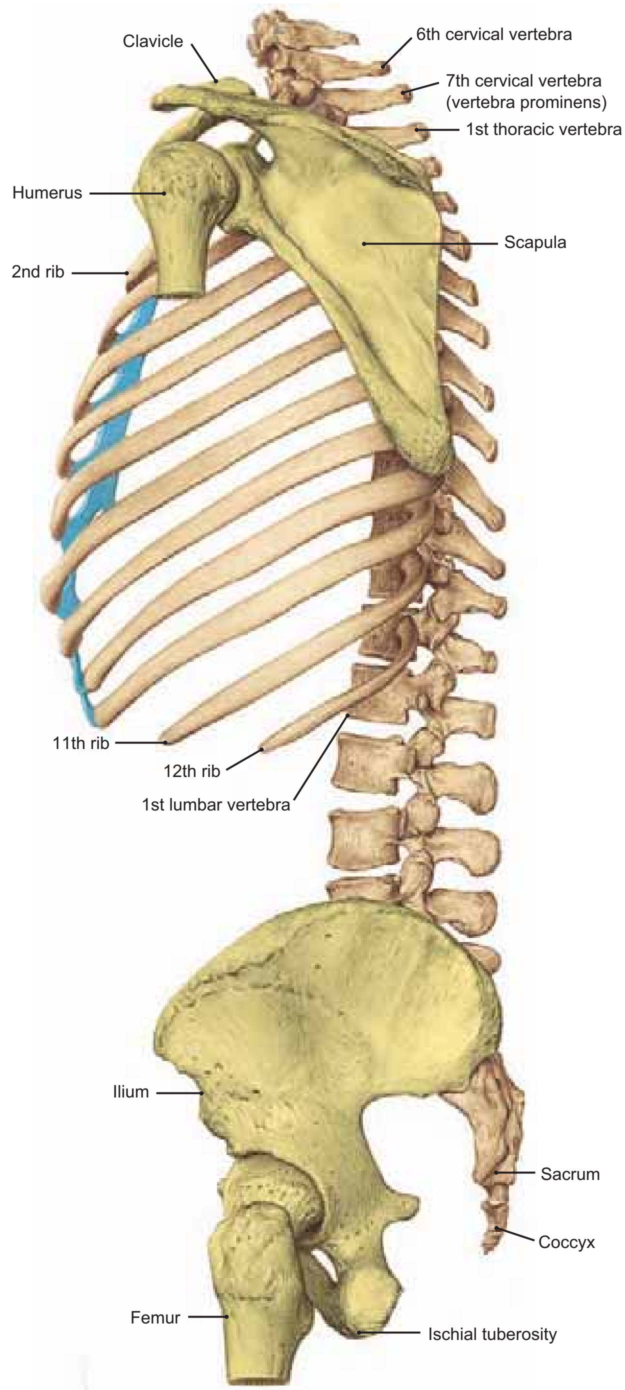


FIGURE 387.2 Left Lateral Surface of the Vertebral Column Sectioned in the Median Plane

NOTE: The scapula does not articulate with the vertebral column, whereas the pelvis articulates with the sacrum to form the **sacroiliac joint.**

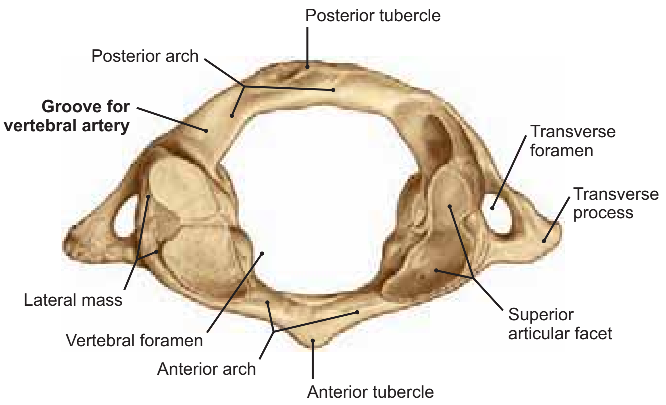


FIGURE 388.1 Atlas, Viewed from Above

NOTE: The superior articular facets are the sites of the occipito-atlantal joints behind which are the grooves for the vertebral arteries.

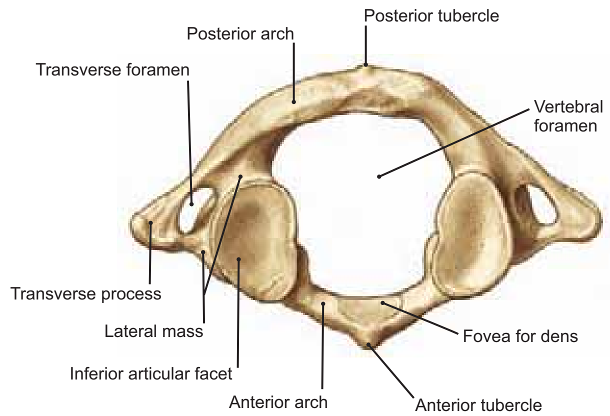


FIGURE 388.2 Atlas (Caudal View)

NOTE: The inferior articular facets on the inferior surface of the lateral mass articulate with the axis below.

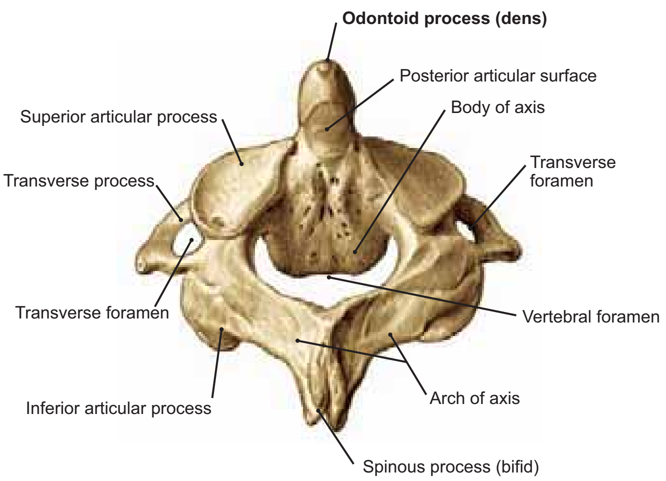


FIGURE 388.3 Posterior View of the Axis

NOTE: The large body and the odontoid process of the axis and the posterior articular facet articulates with the anterior arch of the atlas.

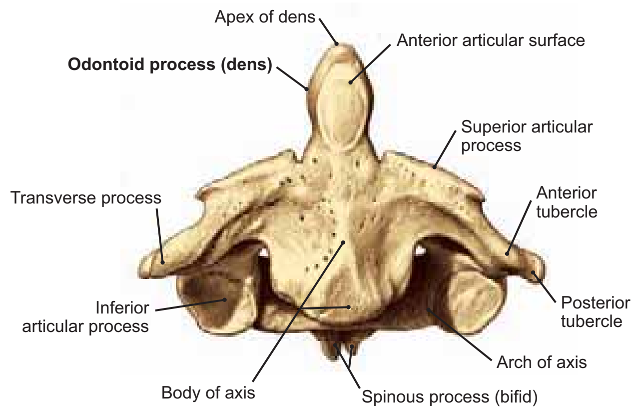


FIGURE 388.4 Anterior View of the Axis

NOTE: The articular facet on the anterior surface of the odontoid process behind (posterior) extends the transverse ligament of the atlas.

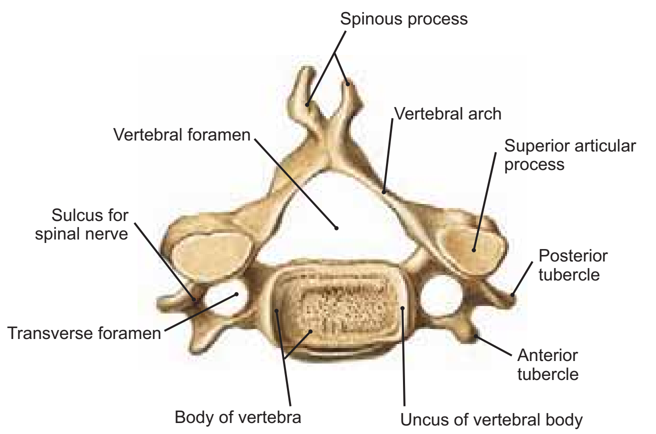


FIGURE 388.5 Fifth Cervical Vertebra (from Above)

NOTE: The fifth cervical vertebra is typical of third, fourth, and sixth cervical vertebrae, and different from the first (atlas), second (axis), and seventh, which present special features. Also note the delicate structure of this vertebra.

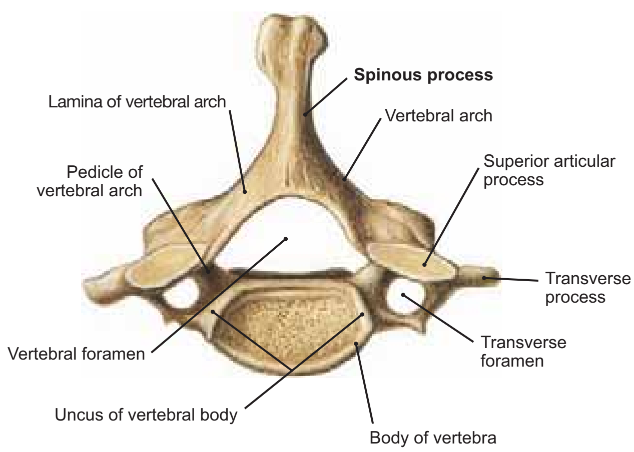


FIGURE 388.6 Seventh Cervical Vertebra (from Above)

NOTE: The seventh cervical vertebra, being transitional between cervical and thoracic vertebrae, has a transverse foramen similar to the cervical and a large spinous process similar to the thoracic. The latter gives it the name **vertebra prominens.**

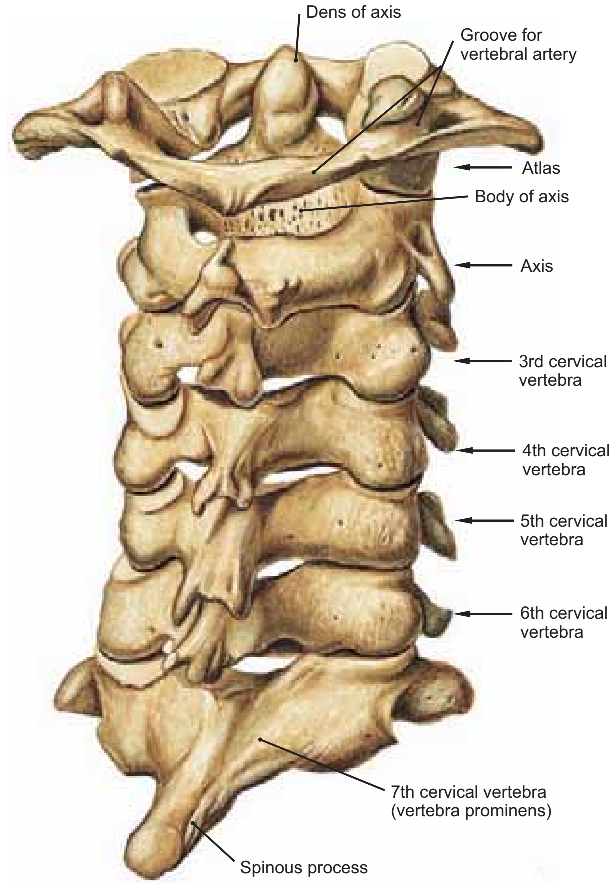


FIGURE 389.1 Cervical Spinal Column (Dorsal)

NOTE: While flexion and extension of the head are performed at the atlantooccipital joint, turning of the head to the left or right is the result of rotation of the atlas on the axis.

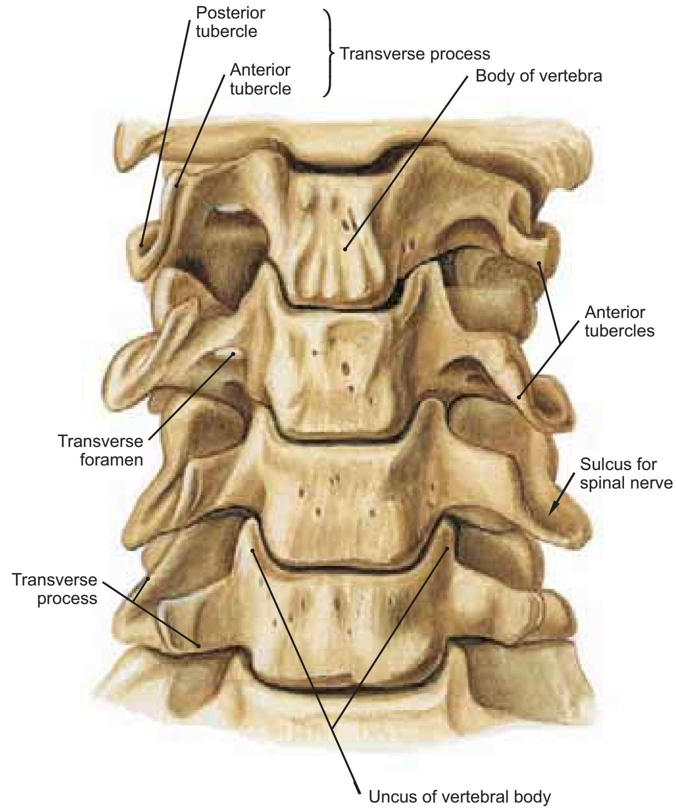


FIGURE 389.2 Cervical Vertebrae (Ventral View)

NOTE: Only a small part of the second to seventh cervical vertebrae is shown above and below the convex anterior surfaces of the bodies of the third to sixth vertebrae.

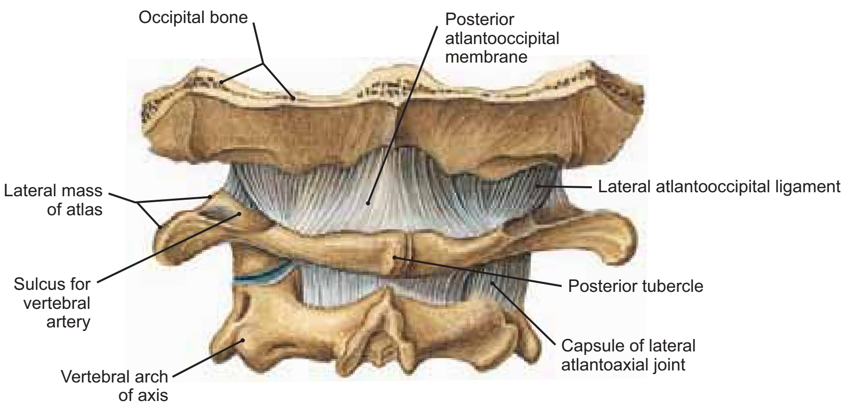
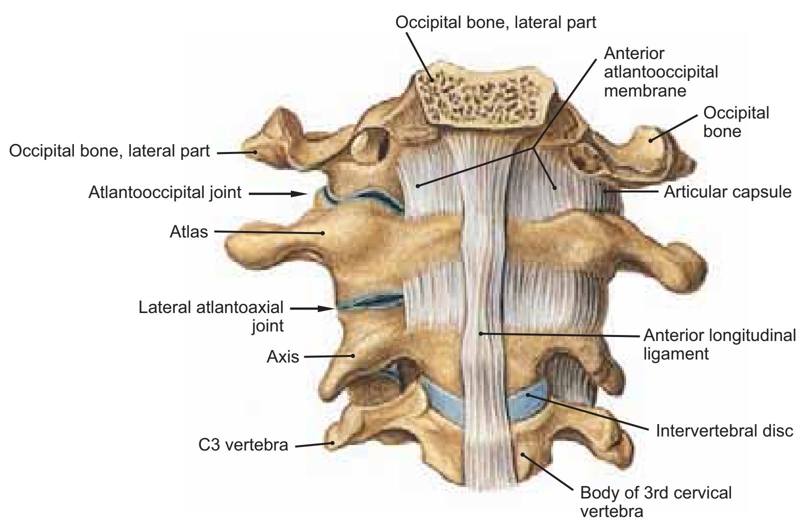


FIGURE 389.3 Atlantooccipital and Atlantoaxial Joints (Posterior View)

NOTE: From the posterior margin of the foramen magnum to the upper border of the posterior arch of the atlas stretches the posterior atlantooccipital membrane.

FIGURE 389.4 Articulations of Occipital Bone and First Three Vertebrae (Anterior View)

NOTE: Extending between the occipital bone and the anterior arch of the atlas is the anterior atlantooccipital membrane, which continues laterally to join the articular capsules. Also observe the anterior longitudinal ligament.



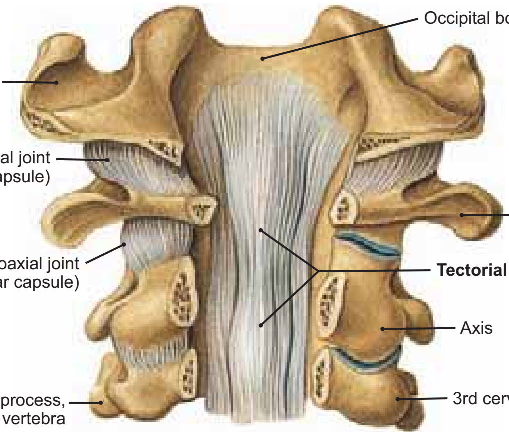


FIGURE 390.1 Tectorial Membrane (Dorsal View)

NOTE: The tectorial membrane is a broadened upward extension of the posterior longitudinal ligament and attaches the axis to the occipital bone (see also, Fig. 391.1). It covers the posterior surface of the odontoid process and lies dorsal to the cruciform ligament, covering it as well.

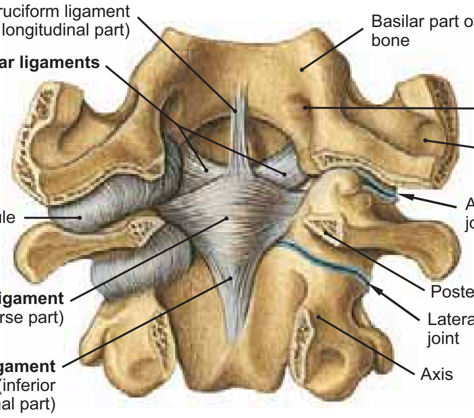


FIGURE 390.2 Atlantooccipital and Atlantoaxial Joints Showing the Cruciform Ligament (Posterior View)

NOTE: The posterior arches to the atlas and axis have been removed, and the cruciform ligament is seen from this posterior view. It consists of the transverse ligament (see Fig. 390.4) and the longitudinal fascicles that extend superiorly and inferiorly.

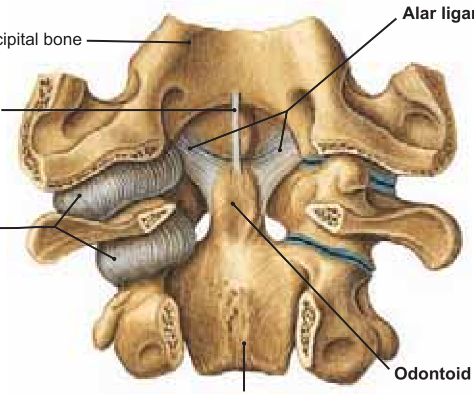


FIGURE 390.3 Alar and Apical Ligaments (Posterior View)

NOTE: This figure is oriented the same as Figure 390.2. The cruciform ligament has been removed to reveal the odontoid process of the axis. This is attached superiorly to the occipital bone by the two alar ligaments and the apical ligament of the dens. These ligaments tend to limit lateral rotation of the skull.

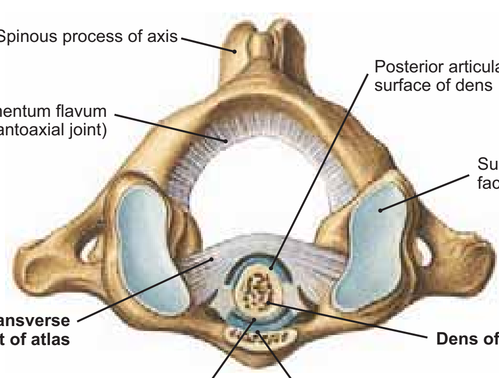


FIGURE 390.4 Median Atlantoaxial Joint (from Above)

NOTE: The odontoid process of the axis articulates with the anterior arch of the atlas, thereby forming the median atlantoaxial joint, and the thick and strong transverse ligament (part of the cruciform) of the atlas retains the dens on its posterior surface.

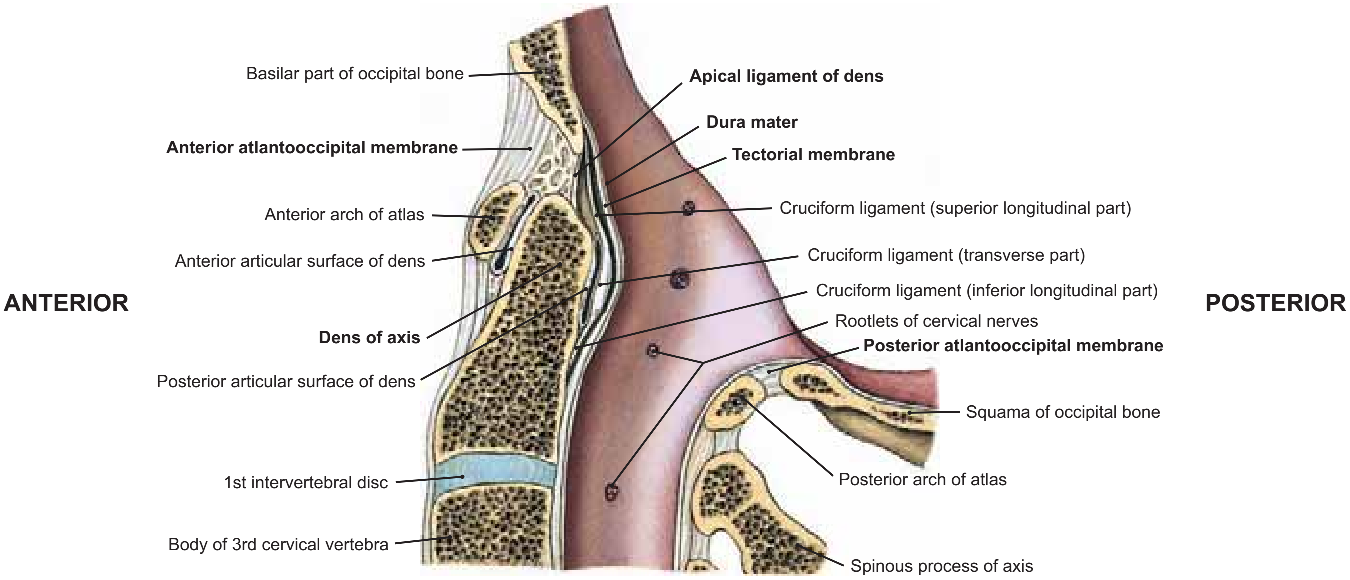
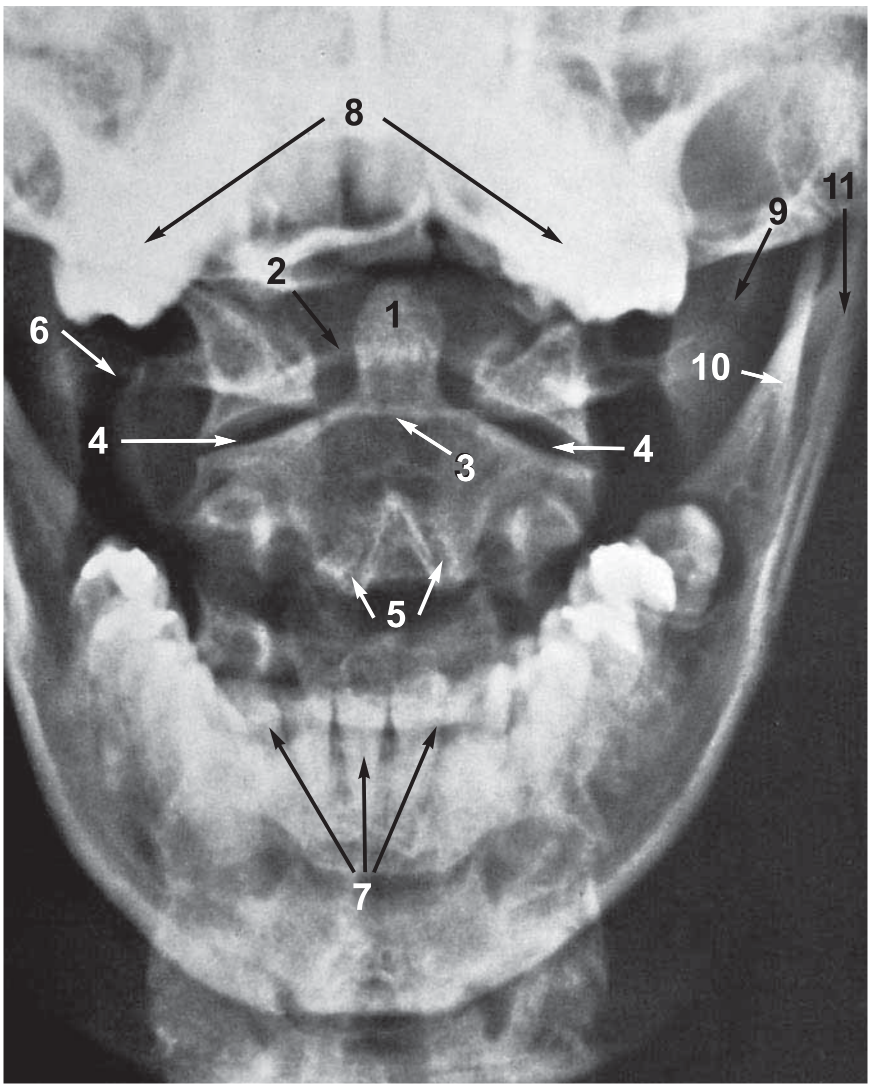


FIGURE 391.1 Median Sagittal Section of Atlantooccipital and Atlantoaxial Regions

NOTE: The relationships from anterior to posterior of the following structures: the anterior arch of the atlas, the joint between the atlas and the odontoid process (median atlantoaxial joint), the "joint" between the odontoid process and the transverse ligament of the atlas, the tectorial membrane, and finally, the dura mater covering the spinal cord.



1. Odontoid process of axis
2. Anterior arch of atlas (inferior margin)
3. Posterior arch of atlas (inferior margin)
4. Lateral atlantoaxial joints
5. Spinous process of axis (bifid)
6. Transverse process of atlas
7. Inferior dental arch
8. Superior dental arch
9. Styloid process of temporal bone
10. Coronoid process of mandible
11. Condylar process of mandible

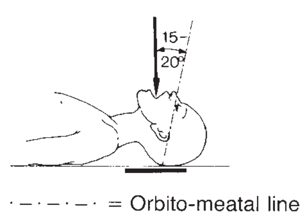


FIGURE 391.2 Radiograph of the Odontoid Process and the Atlantoaxial Joints

NOTE: This is an anteroposterior projection taken through the oral cavity as shown in the diagram.

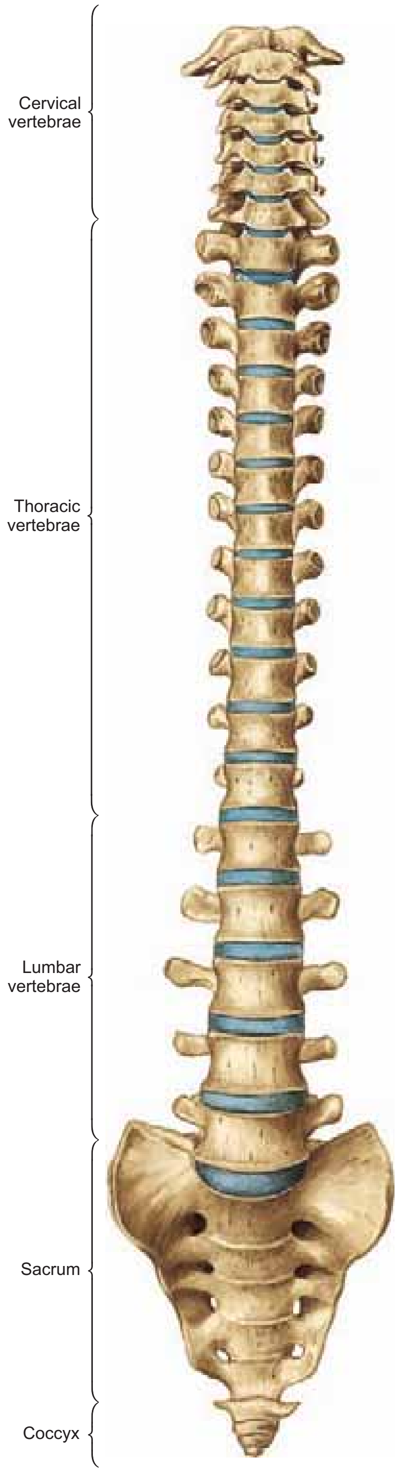


FIGURE 392.1 Anterior View

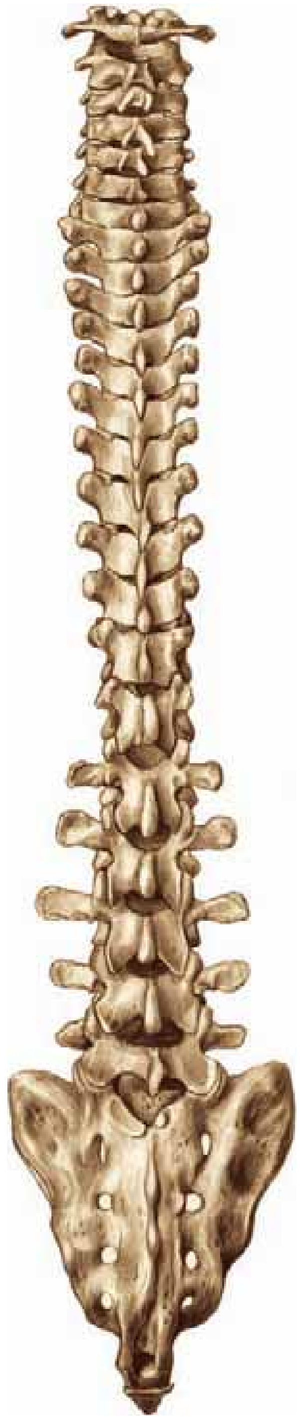


FIGURE 392.2 Posterior View

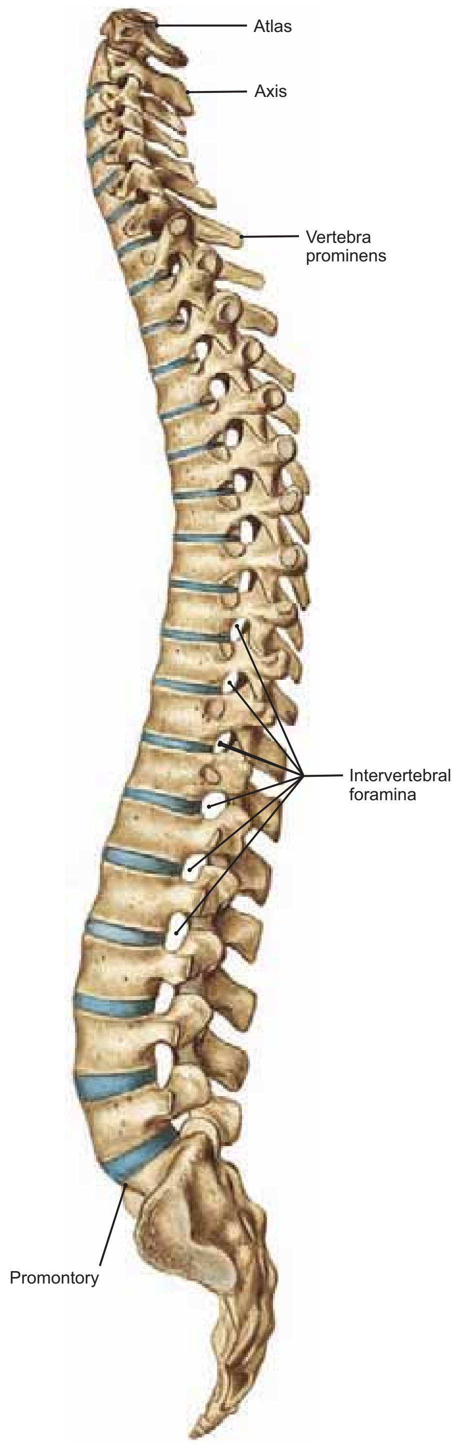


FIGURE 392.3 Left Lateral View

FIGURE 392.1–392.3 Vertebral Column, Including the Sacrum and Coccyx

NOTE: (1) The vertebral column normally consists of 7 **cervical,** 12 **thoracic,** and 5 **lumbar** vertebrae and the **sacrum** and **coccyx.** Its principal functions are to assist in the maintenance of the erect posture in humans, to encase and protect the spinal cord, and to allow attachments of the musculature important for movements of the head and trunk.

(2) From a dorsal or ventral view, the normal spinal column is straight. When viewed from the side, the vertebral column presents two ventrally convex curvatures (cervical and lumbar) and two dorsally convex curvatures (thoracic and sacral).

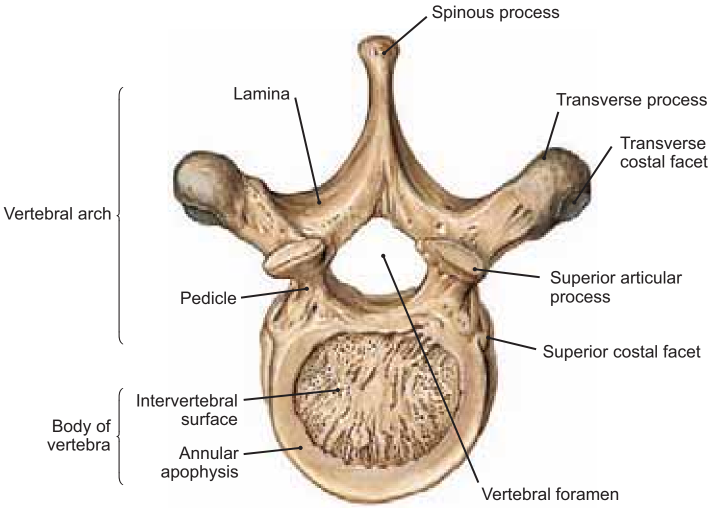


FIGURE 393.1 Sixth Thoracic Vertebra (from Above)

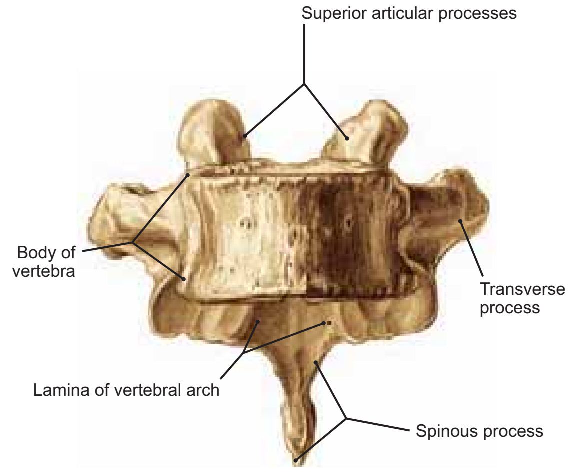


FIGURE 393.2 Tenth Thoracic Vertebra (Ventral View)

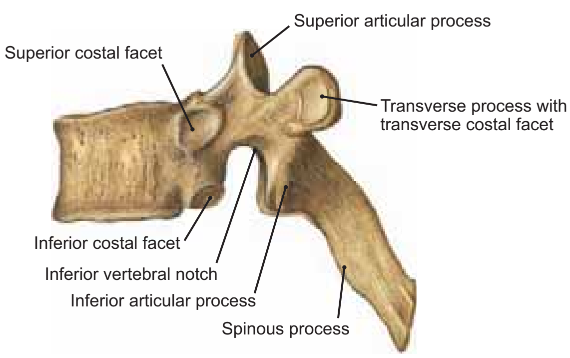


FIGURE 393.3 Sixth Thoracic Vertebra (from Left Lateral Side)

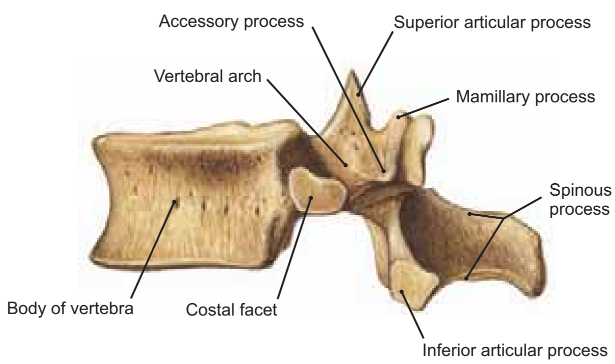


FIGURE 393.4 Twelfth Thoracic Vertebra (Lateral View)

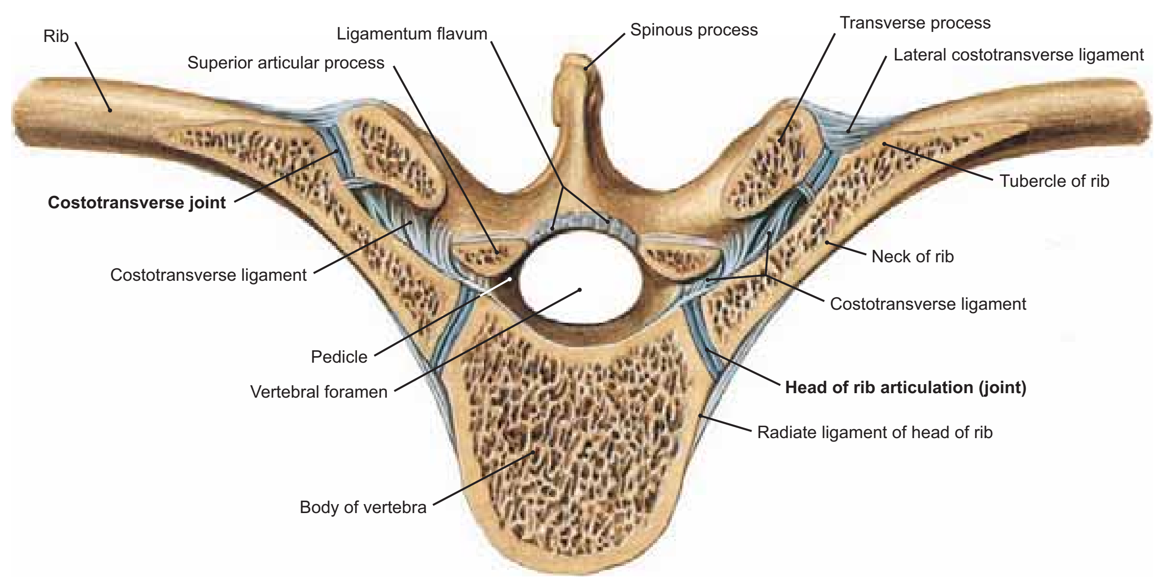


FIGURE 393.5 Costovertebral Joints, Transverse Section as Seen from Above

NOTE: Each rib articulates with the thoracic vertebrae at two places: (a) the **head of the rib** with the **vertebral body** and (b) the **tubercle** on the **neck of the rib** with the **transverse process** of the vertebra.

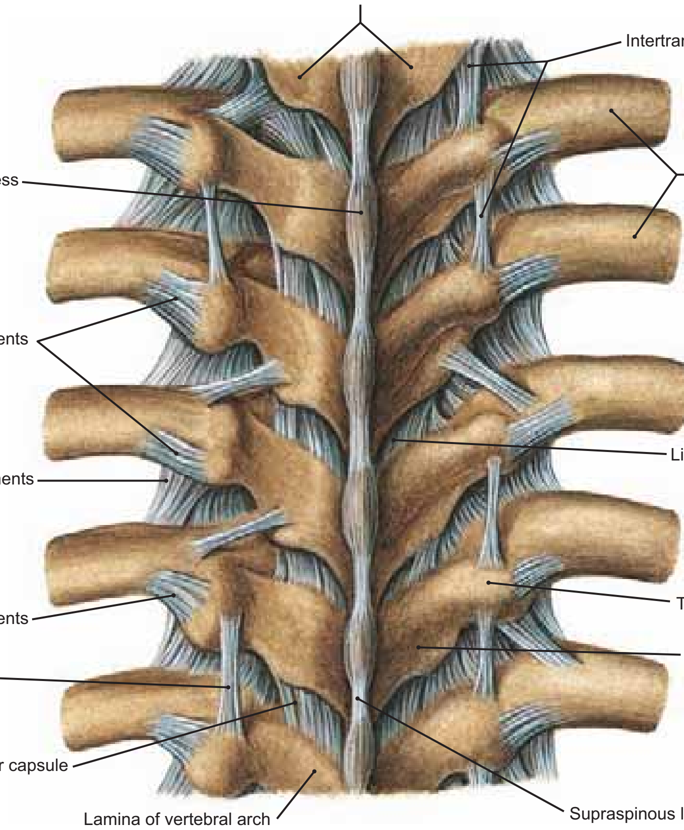


FIGURE 394.1 Lower Costovertebral Joints (Posterior View)

NOTE: (1) Five pairs of costovertebral joints, viewed from behind, show to advantage the articulations between the necks and the tubercles of the ribs and the transverse processes of the thoracic vertebrae.

(2) The ligaments that connect these gliding joints are the **costotransverse, lateral costotransverse,** and **superior costotransverse.**

(3) The costotransverse joints (neck of rib with transverse process) are not to be confused with the joints between the heads of the ribs and the bodies of the vertebrae.

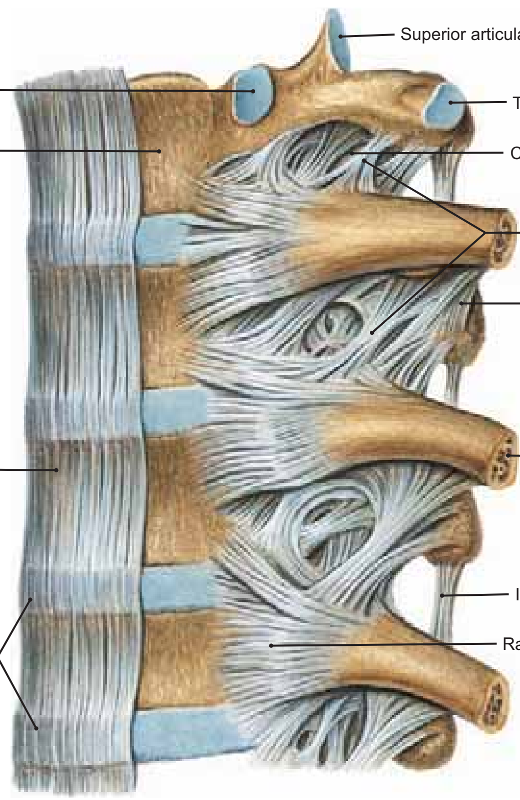


FIGURE 394.2 Costovertebral Joints (Lateral View Showing the Radiate Ligaments of the Heads of the Ribs)

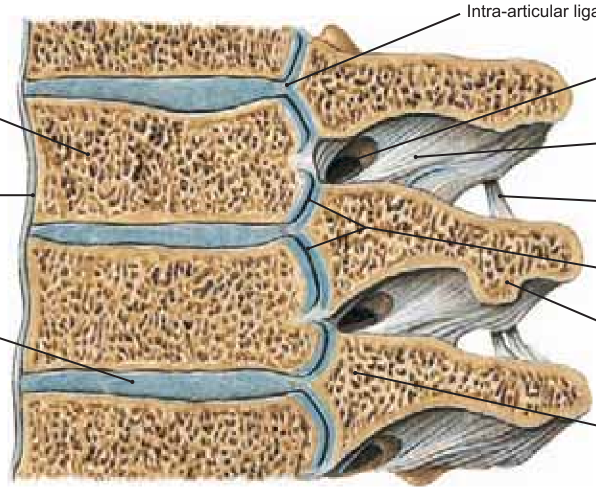
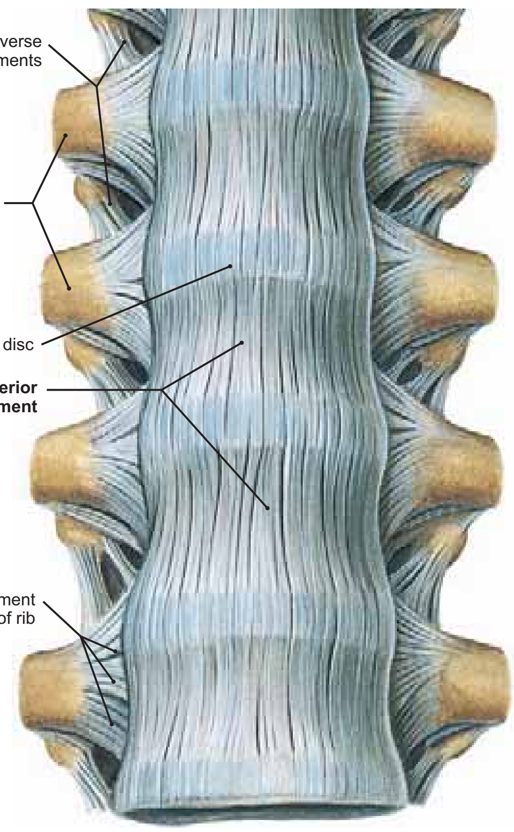


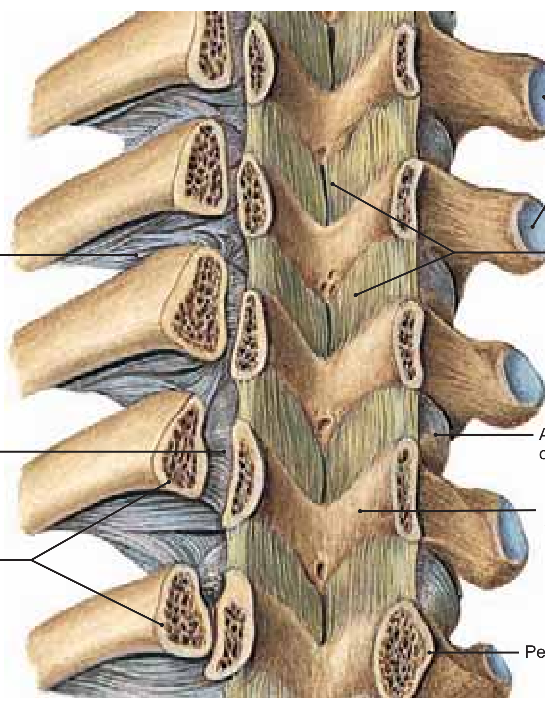
FIGURE 395.1 **Sagittal Section through the Spinal Column Showing the Costovertebral Joints**

NOTE: The following important structures are shown: the intervertebral disks, the intra-articular and costotransverse ligaments, and the intervertebral foramina, which transmit the spinal nerves and their accompanying vessels.

FIGURE 395.2 **Anterior Longitudinal Ligament ▶ (Ventral View)**

NOTE: The **anterior longitudinal ligament** extends from the axis to the sacrum along the anterior aspect of the bodies of the vertebrae and the intervertebral disks to which it is firmly attached. Its fibers are white and glistening and can readily be identified.





◀ **FIGURE 395.3** **Ligamenta Flava (Anterior View)**

NOTE: The bodies of the thoracic vertebrae have been removed, revealing from within the vertebral foramina the ligamenta flava interconnecting the laminae of the dorsal vertebral arches. The pedicles have been cut, and on the left, the ribs have been removed. The **ligamenta flava** are formed by yellow, elastic tissue.

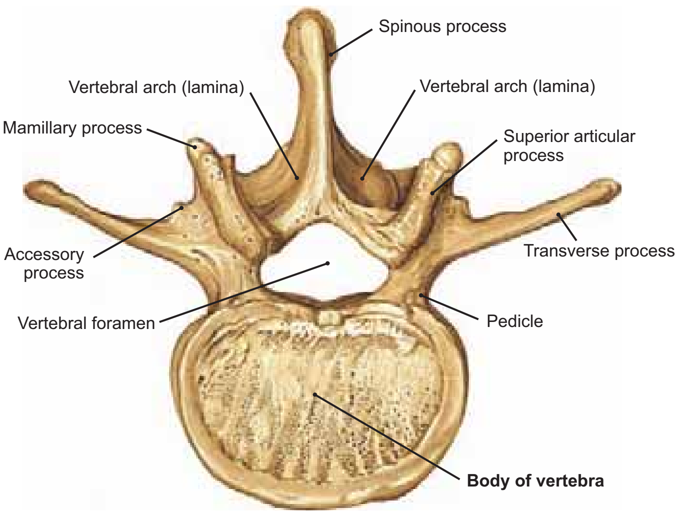


FIGURE 396.1 Lumbar Vertebra (Cranial View)

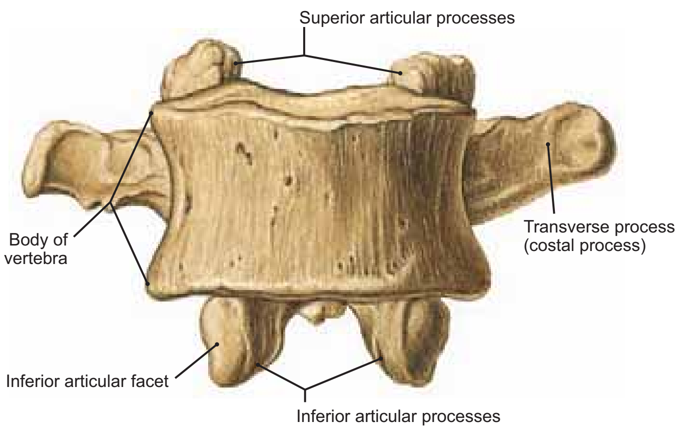


FIGURE 396.2 Lumbar Vertebra (Anterior View)

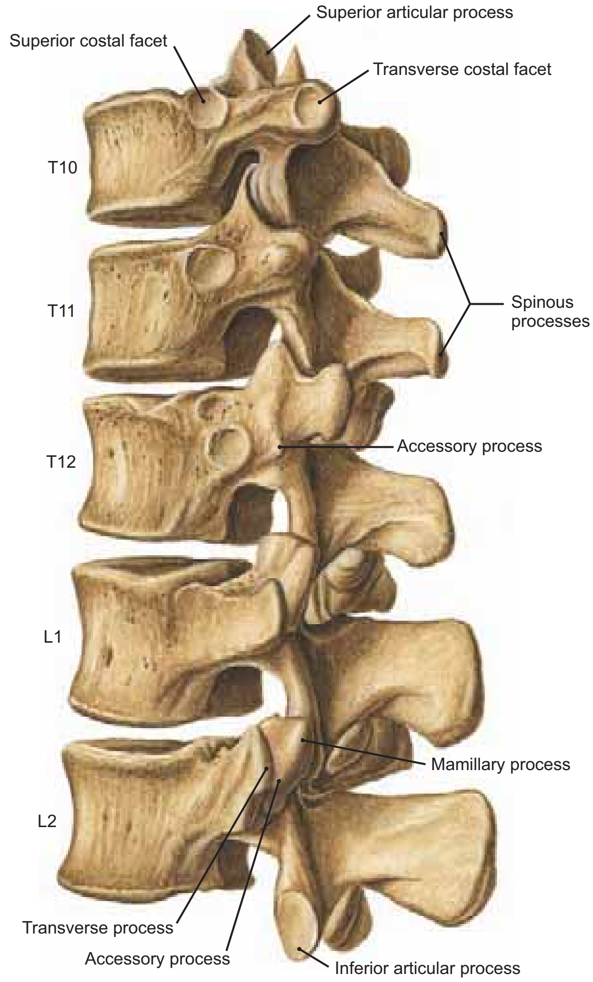


FIGURE 396.3 Last Three Thoracic and First Two Lumbar Vertebrae (Lateral View)

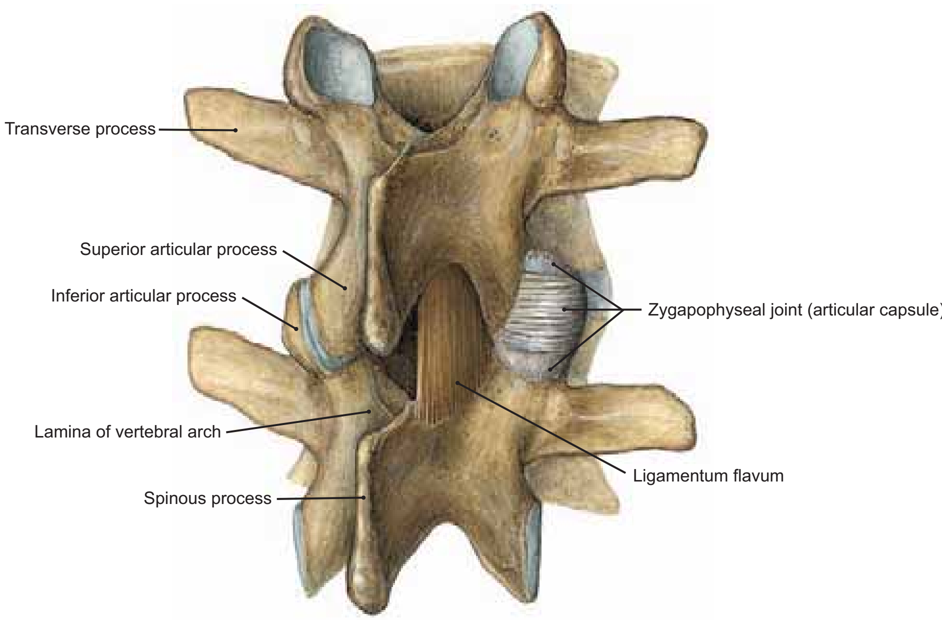


FIGURE 396.4 Zygapophyseal Joints and Ligamenta Flava between Adjacent Lumbar Vertebrae

NOTE: (1) In this posterior view, the articular capsule of the zygapophyseal joint (between the articular processes) and the ligamentum flavum have been removed on the left side.

(2) Each ligamentum flavum is attached to the anterior surface of the lamina above and to the posterior surface of the lamina below. They are elastic and permit separation of the laminae during flexion of the spine, and they inhibit abrupt and extreme movements of the vertebral column, thus protecting the intervertebral disks (see also, Fig. 395.3).

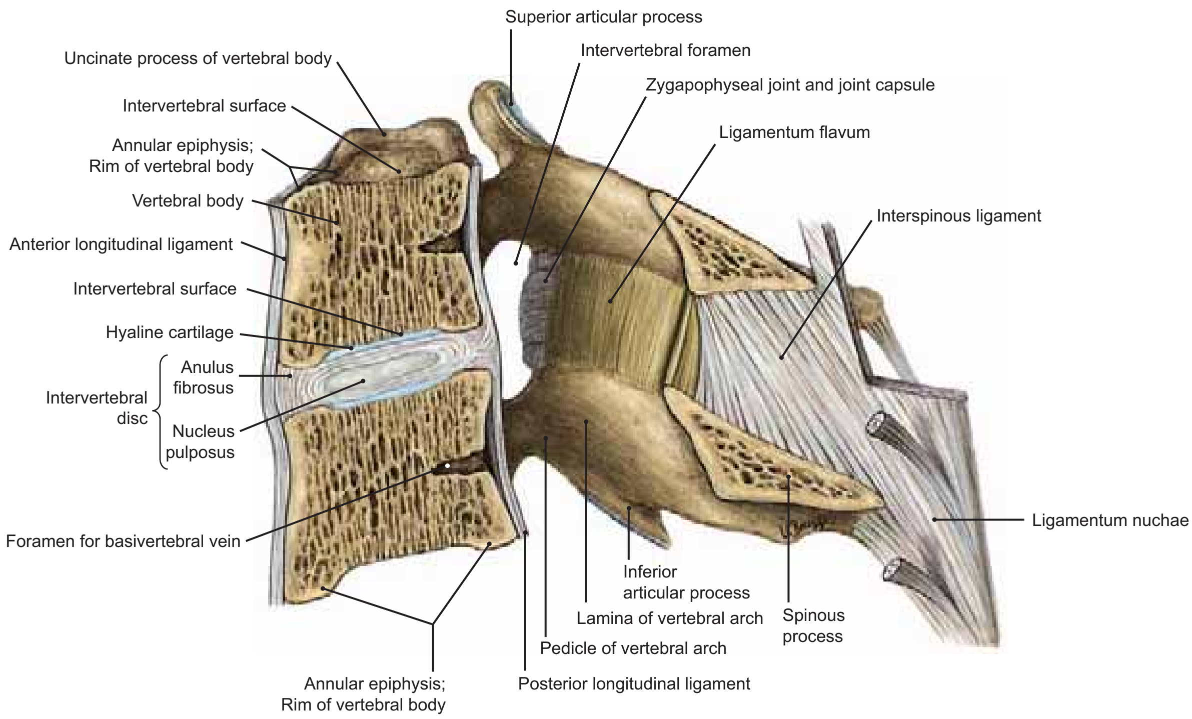


FIGURE 397.1 Cervical Intervertebral Joints: Median Sagittal Section

NOTE: (1) The long spinous processes of the cervical vertebrae and the strong interspinous ligaments. Observe the blending of fibers of the interspinous ligaments with the ligamentum nuchae of the dorsal cervical region.
(2) The intervertebral disk between the bodies of the two cervical vertebrae is shown; also note the nucleus pulposus surrounded by the annulus fibrosis.
(3) The anterior and posterior longitudinal ligaments and the foramina for the basivertebral veins.

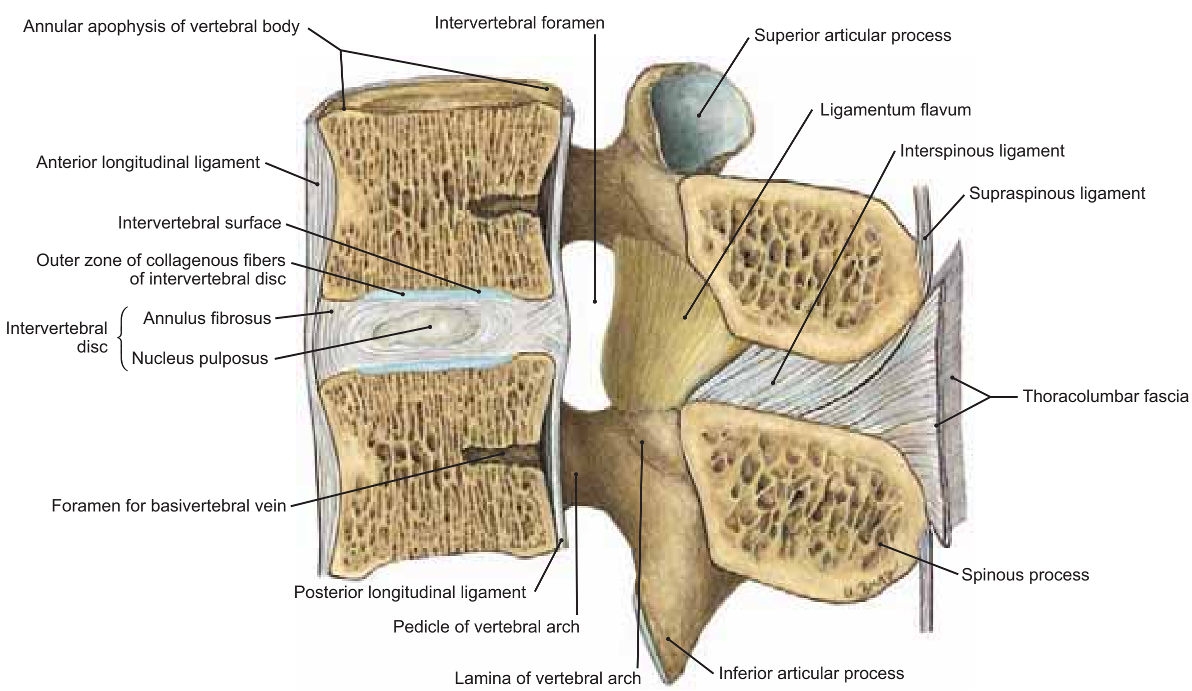


FIGURE 397.2 Median Sagittal Section through Two Lumbar Vertebrae and an Intervertebral Disk

NOTE: (1) The anterior and posterior longitudinal ligaments ventral and dorsal to the bodies of the lumbar vertebrae.
(2) The ligamentum flavum forms an important ligamentous connection between the laminae of adjacent vertebral arches on the dorsal aspect of the vertebral canal.

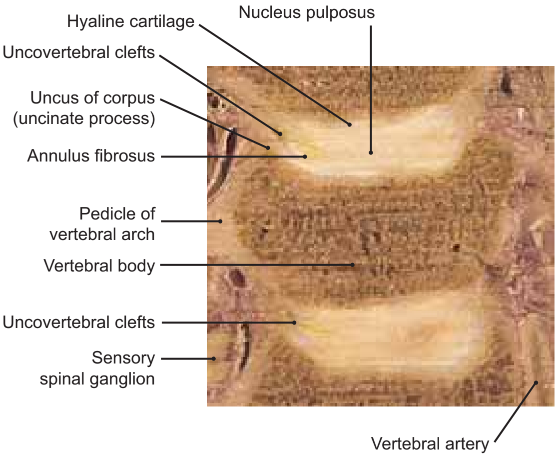


FIGURE 398.1 Two Cervical Intervertebral Disks: Frontal Section through the Centers of the Vertebral Bodies

NOTE: (1) The intervertebral disks are located between the bodies of adjacent vertebrae (in this case cervical vertebrae).

(2) Hyaline cartilage covers the end plates of the vertebral bodies and lies adjacent to the annulus fibrosus.

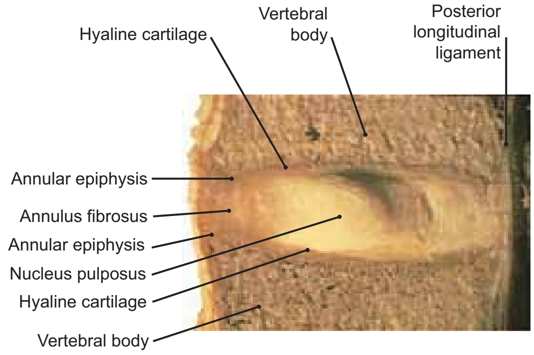


FIGURE 398.2 Median Sagittal Section through a Lumbar Intervertebral Disk

NOTE: (1) The **nucleus pulposus** that forms the inner core is soft and gelatinous in early years and consists of mucoid material and a few cells.

(2) After 10 or 12 years of age the mucoid material is gradually replaced by fibrocartilage, and the center of the disk becomes more like the annulus that surrounds it. (See notes for Fig. 398.3.)

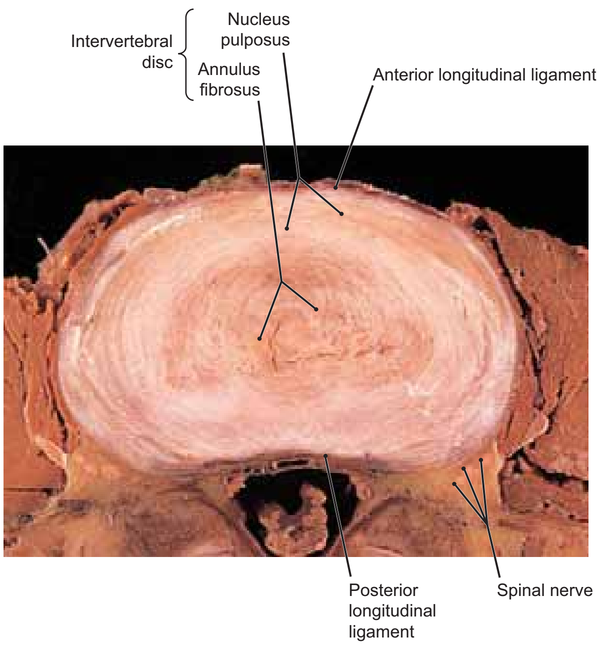


FIGURE 398.3 Photograph of a Lumbar Intervertebral Disk (Viewed from Above)

NOTE: (1) The annulus fibrosus consists of a thin band of collagenous fibers and a thicker band of fibrocartilage.

(2) In later adolescence and in the young adult, the intervertebral disks are strong and can withstand most vertical forces that impinge on the vertebral column, such as jumping or sitting upright.

(3) After several decades, some degeneration may occur that weakens the annulus fibrosus. These changes may account for the fact that in the elderly there may be a displacement of the nucleus pulposus (after even a mild strain) into or through the annulus, resulting in pain.

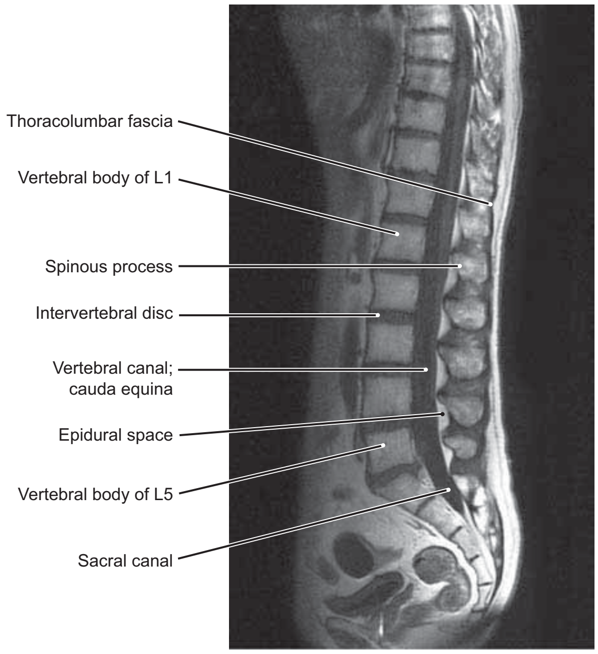


FIGURE 398.4 Magnetic Resonance Image of the Lumbar Vertebrae (Median Sagittal Section)

NOTE: (1) The spinous processes and the bodies of the lumbar vertebrae.

(2) The intervertebral disks arranged sequentially between the vertebral bodies.

(3) The so-called disk problem that results from displacement of disk material is most likely to occur in the cervical or lumbar regions and especially between the L4-L5 vertebral body.

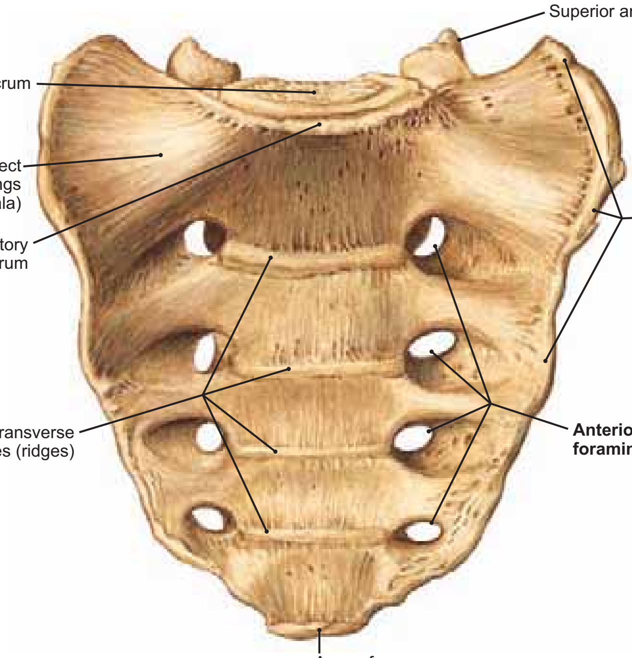


FIGURE 399.1 Sacrum, Anterior or Pelvic Surface

NOTE: (1) The sacrum is a large triangular bone formed by the fusion of five sacral vertebrae, and it is wedged between the two hip bones, with which it articulates laterally.
(2) Superiorly, the sacrum articulates with the fifth lumbar vertebra, and inferiorly with the coccyx.
(3) The anterior (pelvic) surface of the sacrum is concave and shows four pelvic foramina on each side. These transmit the ventral rami of the upper four sacral nerves.

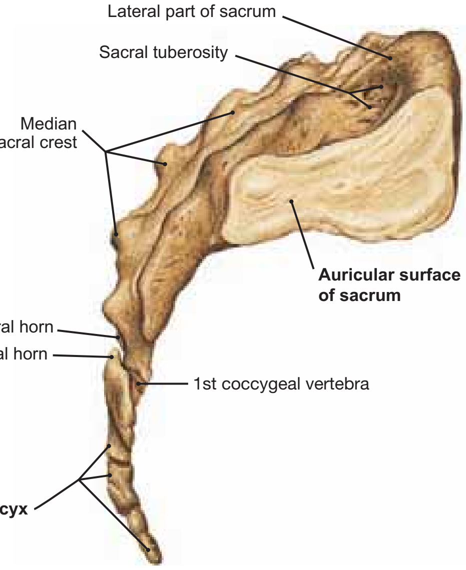


FIGURE 399.2 Sacrum and Coccyx (Lateral View)

NOTE: The auricular (ear-shaped) surface of the sacrum articulates with the iliac portion of the pelvis. Inferiorly, the sacral apex joins the coccyx.

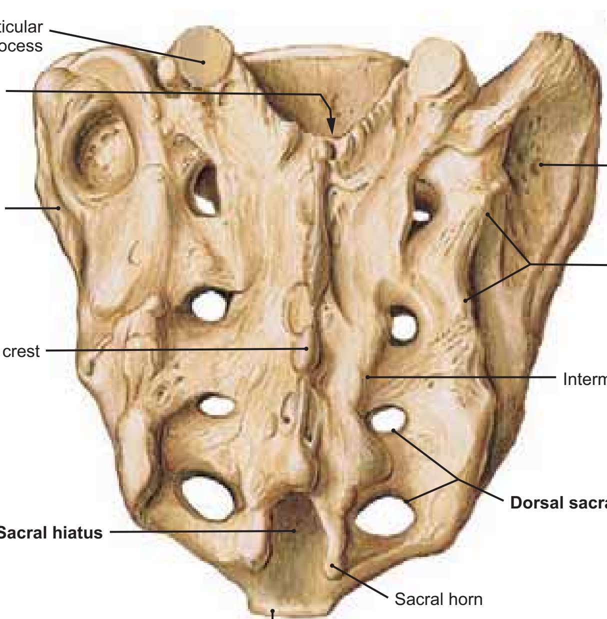


FIGURE 399.3 Sacrum (Posterior Surface)

NOTE: On the dorsal surface of the sacrum, the foramina transmit the dorsal rami of the sacral nerves. The dorsal laminae of the fifth sacral vertebra fail to fuse, thereby leaving a midline opening into the sacral canal called the sacral hiatus.

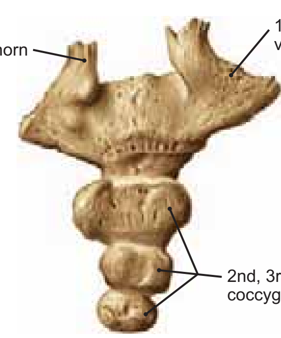


FIGURE 399.4 Coccyx (Dorsal View)

NOTE: This coccyx has four segments, but in many people there are three or five.

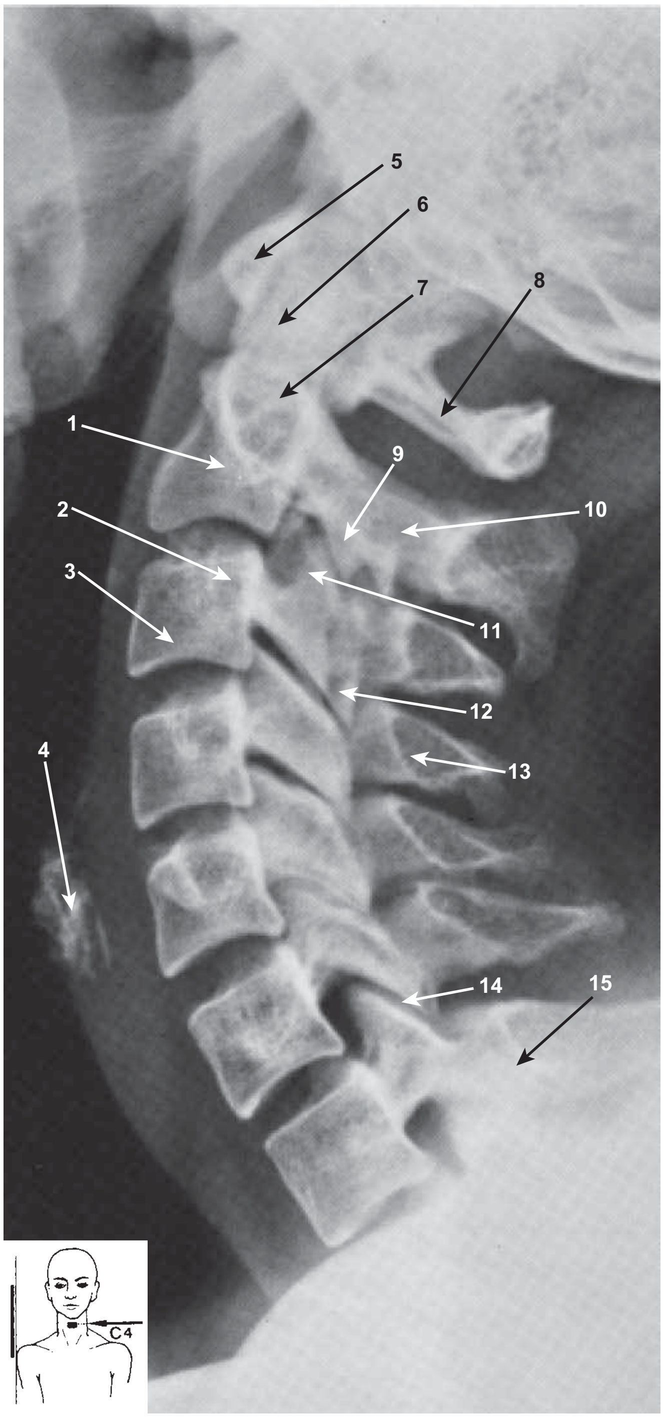


FIGURE 400.1 Cervical Spinal Column (Lateral View)

1. Body of axis
2. Transverse process of C3 vertebra
3. Body of C3 vertebra
4. Lamina of cricoid cartilage
5. Anterior arch of atlas
6. Odontoid process of axis
7. Transverse process of axis
8. Posterior arch of atlas
9. Inferior articular process
10. Spinous process
11. Superior articular process
12. Inferior articular process
13. Spinous process
14. Intervertebral articulation
15. Spinous process, vertebra prominens (C7)

(From Wicke, 6th ed.)

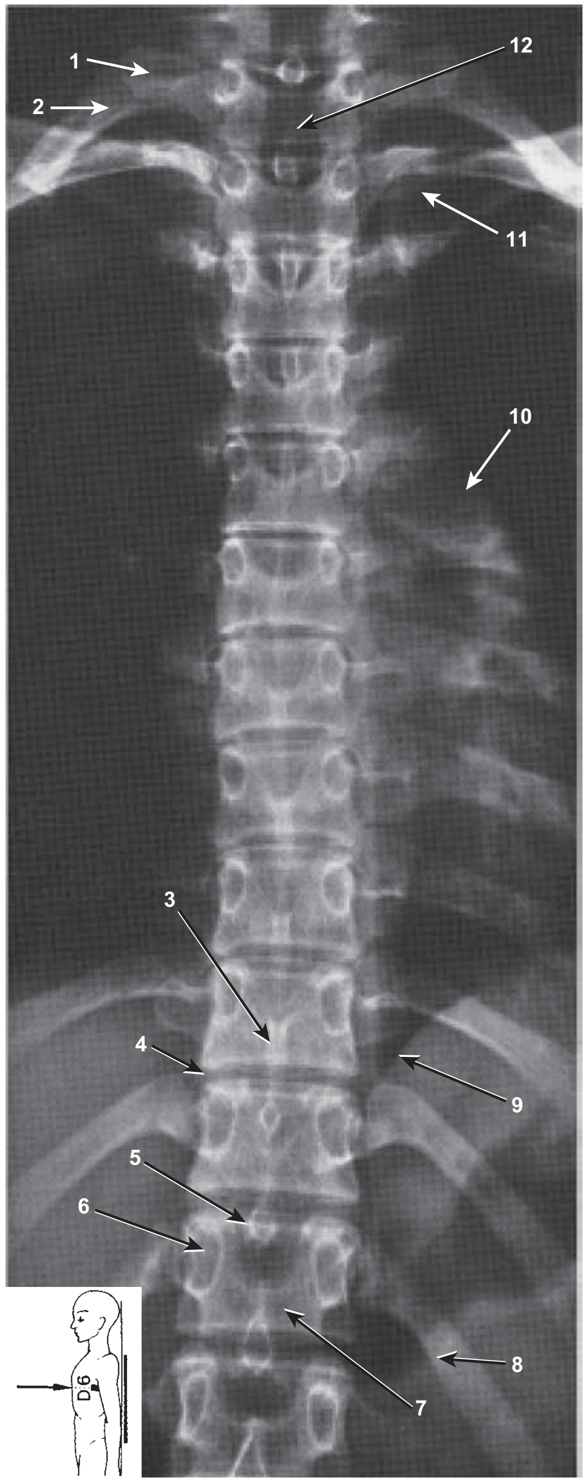


FIGURE 400.2 Spinal Column, Thoracic Region (Anteroposterior Projection)

1. Neck of first rib
2. First rib
3. Spinous process
4. Inferior articular process
5. Superior articular process
6. Pedicle of vertebral arch
7. Twelfth thoracic vertebra
8. Twelfth rib
9. Diaphragm
10. Left contour of the heart
11. Clavicle
12. T1 vertebra

(From Wicke, 6th ed.)

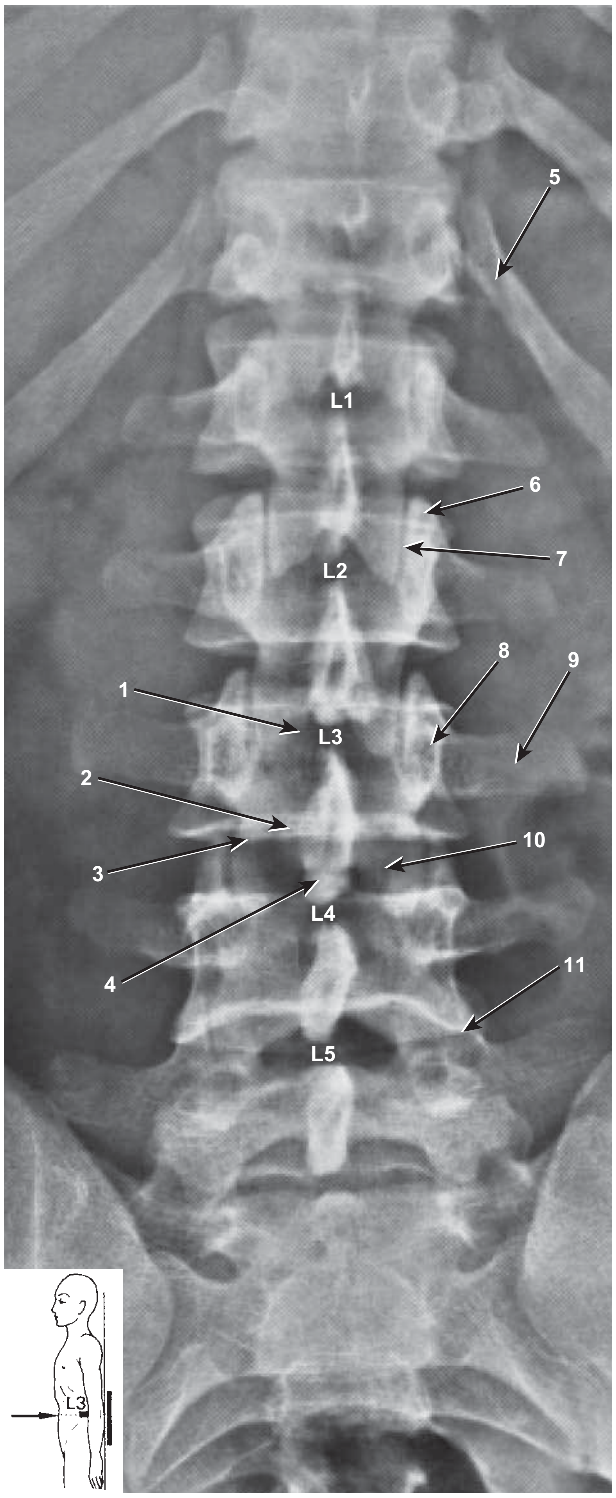


FIGURE 401.1 **Spinal Column, Lumbar Region (Anteroposterior Projection)**

1. Body of L3 vertebra
2. Posterior margin of L3 vertebra
3. Anterior margin of L4 vertebra
4. Spinous process of L3
5. Twelfth rib
6. Superior articular process
7. Intervertebral articulation (zygapophyseal joint)
8. Pedicle of vertebral arch
9. Costal process
10. Lamina of vertebral arch
11. Inferior articular process

(From Wicke, 6th ed.)

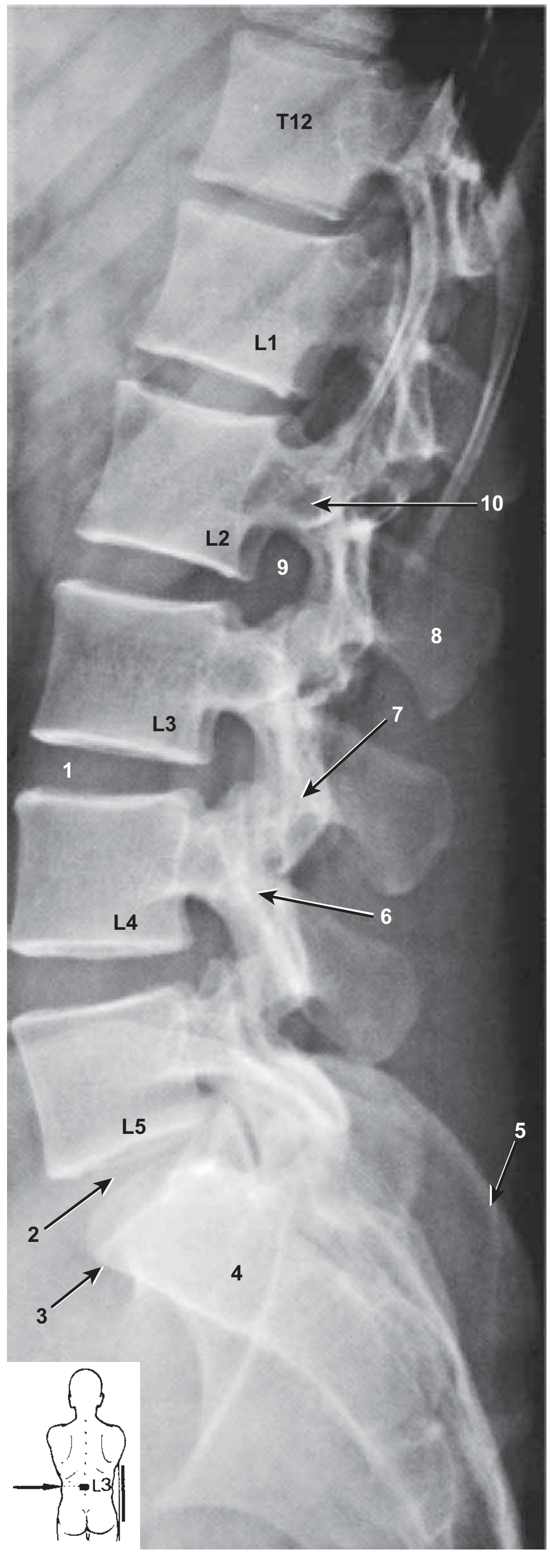


FIGURE 401.2 **Spinal Column, Lumbar Region (Lateral Projection)**

1. Intervertebral disk space
2. Lumbosacral joint
3. Promontory
4. Sacrum
5. Iliac crest
6. Superior articular process of L4 vertebra
7. Inferior articular process of L3 vertebra
8. Spinous process of L2 vertebra
9. Intervertebral foramen
10. Costal process

(From Wicke, 6th ed.)

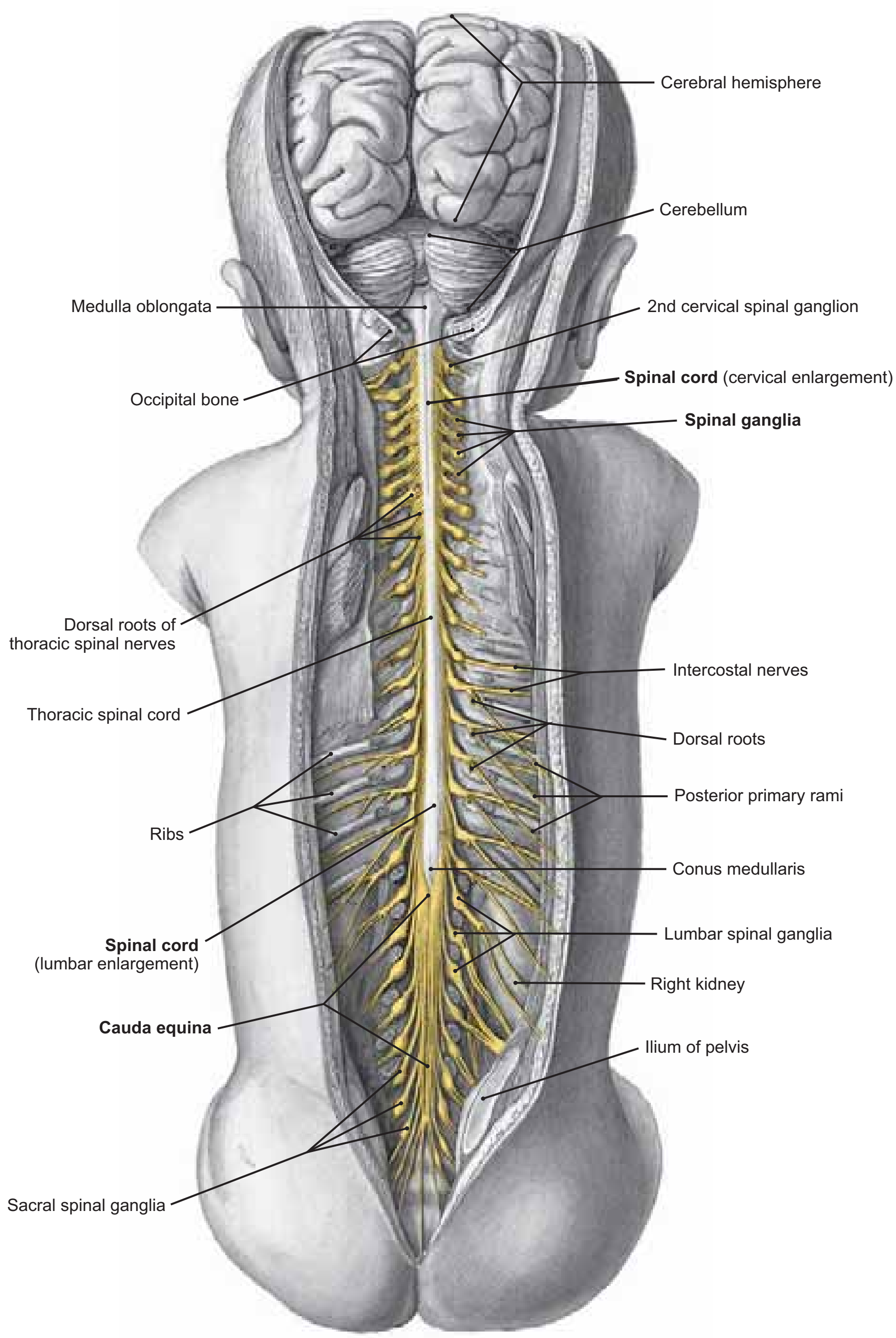


FIGURE 402.1 Spinal Cord and Brain of a Newborn Child (Posterior View)

NOTE: (1) The central nervous system has been exposed by the removal of the dorsal part of the spinal column and of the dorsal cranium. The spinal ganglia have been dissected, as have their corresponding spinal nerves.

(2) Although in this dissection it appears as though the substance of the spinal cord terminates at about L1, it is more usual in the newborn for the cord to end at about L3 or L4, thereby filling the spinal canal more completely than in the adult.

(3) The dorsal root ganglion of the first cervical nerve may be very small and often absent (see small ganglion above that of C2). Both anterior and posterior primary rami of C1 are principally motor, although from time to time C1 will have a small cutaneous branch.

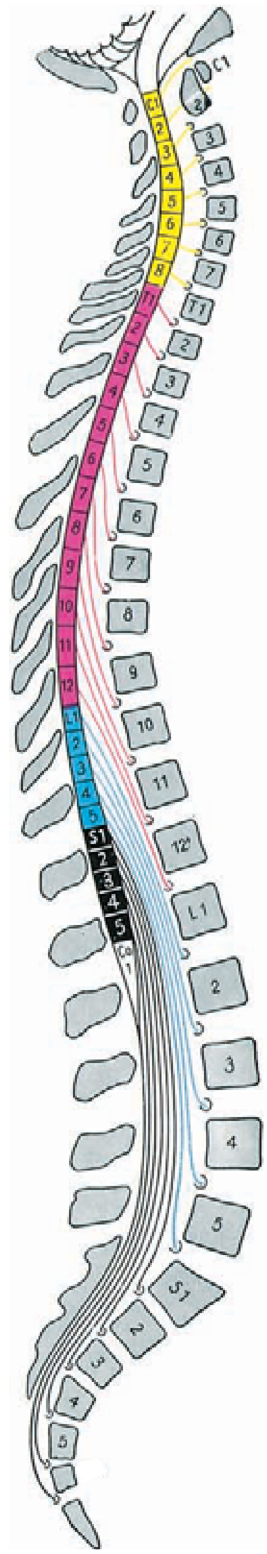


FIGURE 402.2 Emerging Spinal Nerves and Segments in the Adult

Yellow: Cervical segments (C1–C8)
Red: Thoracic segments (T1–T12)
Blue: Lumbar segments (L1–L5)
Black: Sacral segments (S1–S5)
White: Coccygeal segments (C0)

NOTE: Many spinal nerves travel long distances before they leave the vertebral canal in the adult.

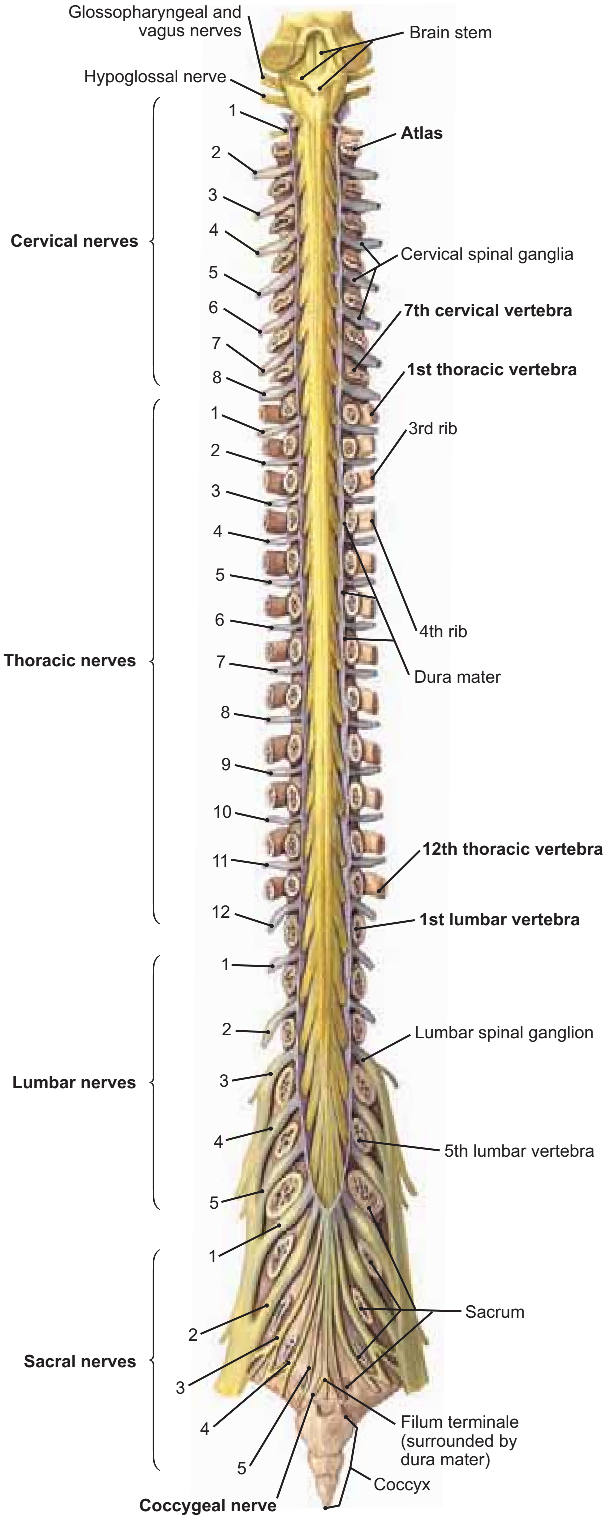


FIGURE 403.1 **Spinal Cord within the Vertebral Canal (Dorsal View)**

NOTE: (1) The first cervical nerve emerges above the first vertebra and the eighth cervical nerve emerges below the seventh vertebra.

(2) The cervical spinal cord is continuous above with the medulla oblongata of the brainstem.

(3) Each spinal nerve is formed by the union of the dorsal and ventral roots of that segment, and it emerges between the two adjacent vertebrae through the intervertebral foramen.

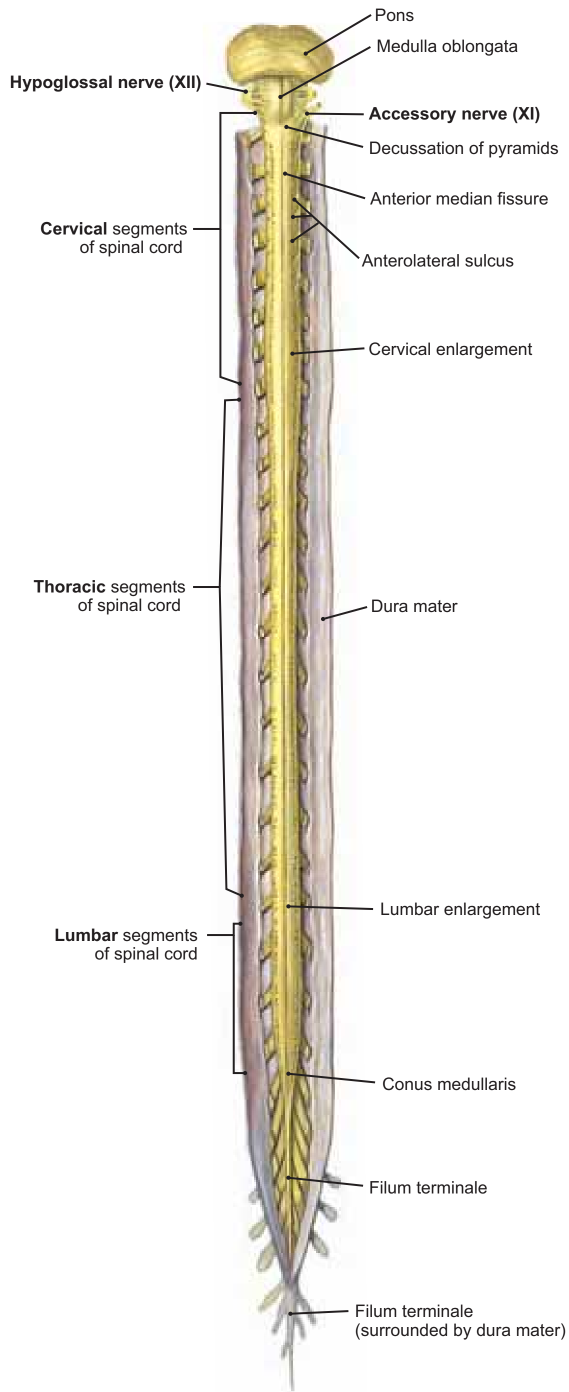


FIGURE 403.2 **Spinal Cord (Ventral View)**

NOTE: (1) The origin of the spinal portion of the accessory nerve (XI) arising from the cervical spinal cord and ascending to join the bulbar portion of that nerve.

(2) The alignment of the rootlets of the hypoglossal nerve (XII) with the ventral roots of the spinal cord.

(3) The anterior median fissure is located in the longitudinal midline of the spinal cord. Within this fissure courses the anterior spinal artery (see Fig. 404.1).

(4) The cervical and lumbar enlargements caused by the large numbers of sensory and motor neurons located in these regions that are required to supply innervation to the upper and lower limbs.

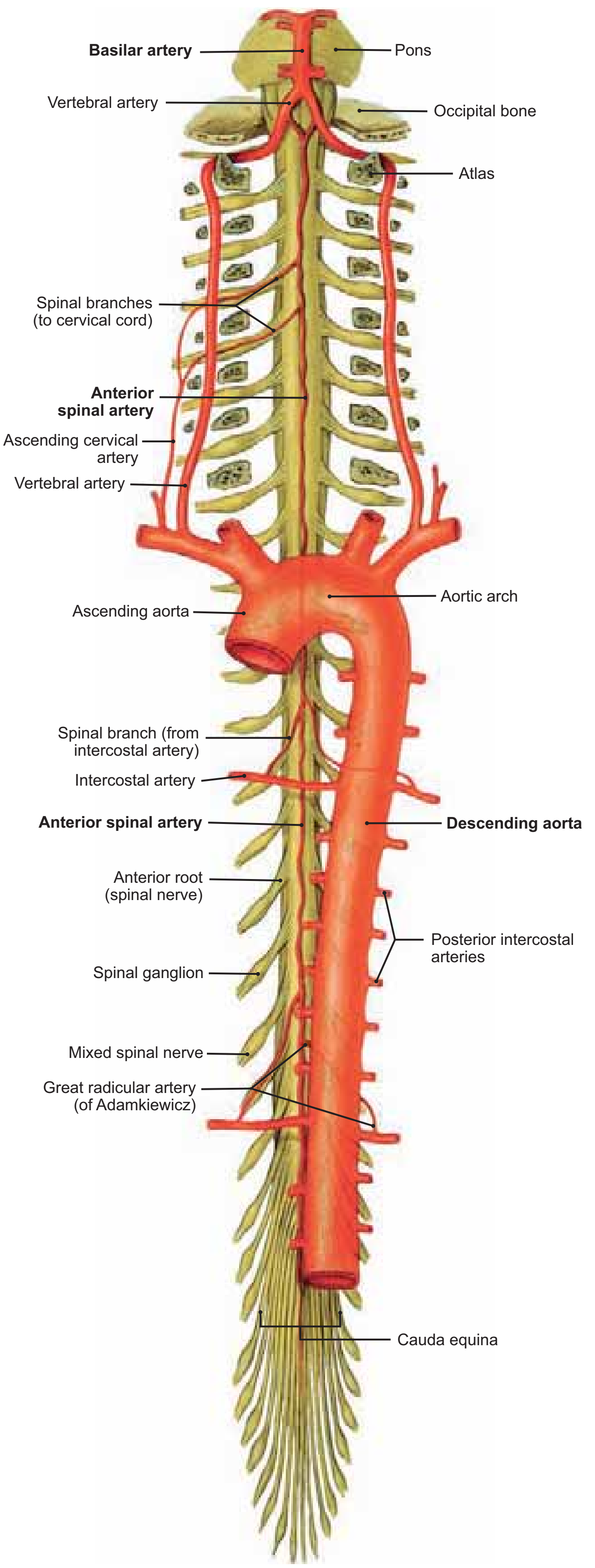


FIGURE 404.1 Anterior Spinal Artery

NOTE: The anterior spinal artery is formed by vessels from the vertebral arteries. It receives anastomotic branches from certain cervical, thoracic, and lumbar segmental arteries along the spinal roots. An especially large branch (artery of Adamkiewicz) arises in the lower thoracic or upper lumbar region.

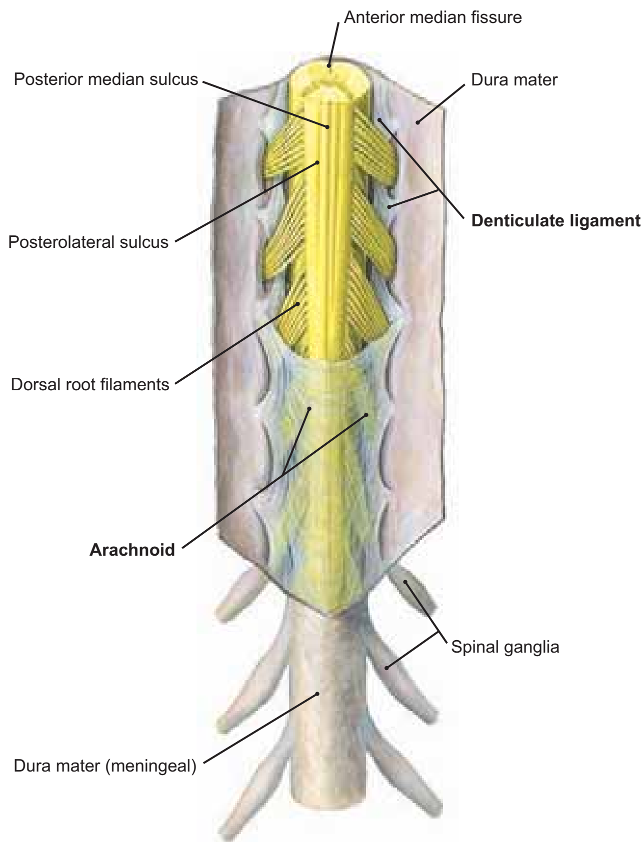


FIGURE 404.2 Spinal Cord with Dura Mater Dissected Open (Dorsal View)

NOTE: Extensions of the pia mater to the meningeal dura mater between the roots of the spinal nerves are called **denticulate ligaments.** The arachnoid sends fine attachments to both the pia and the dura.

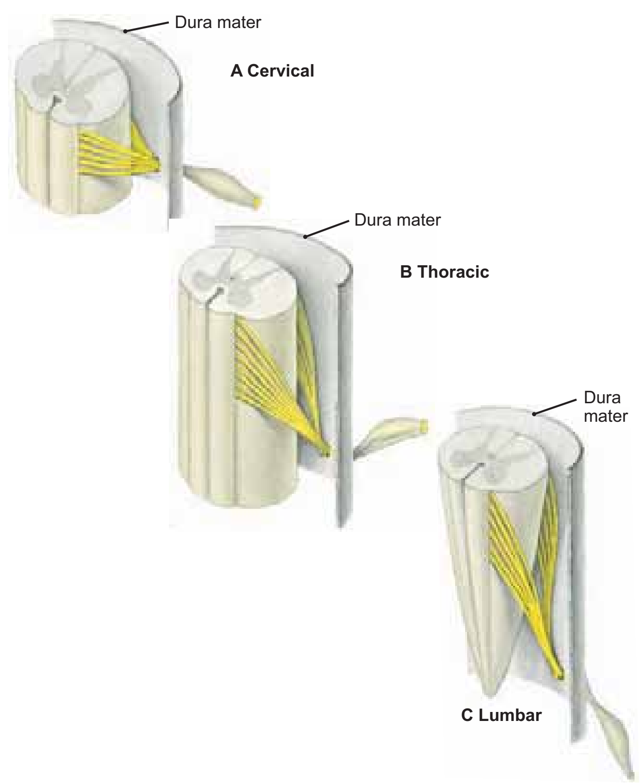
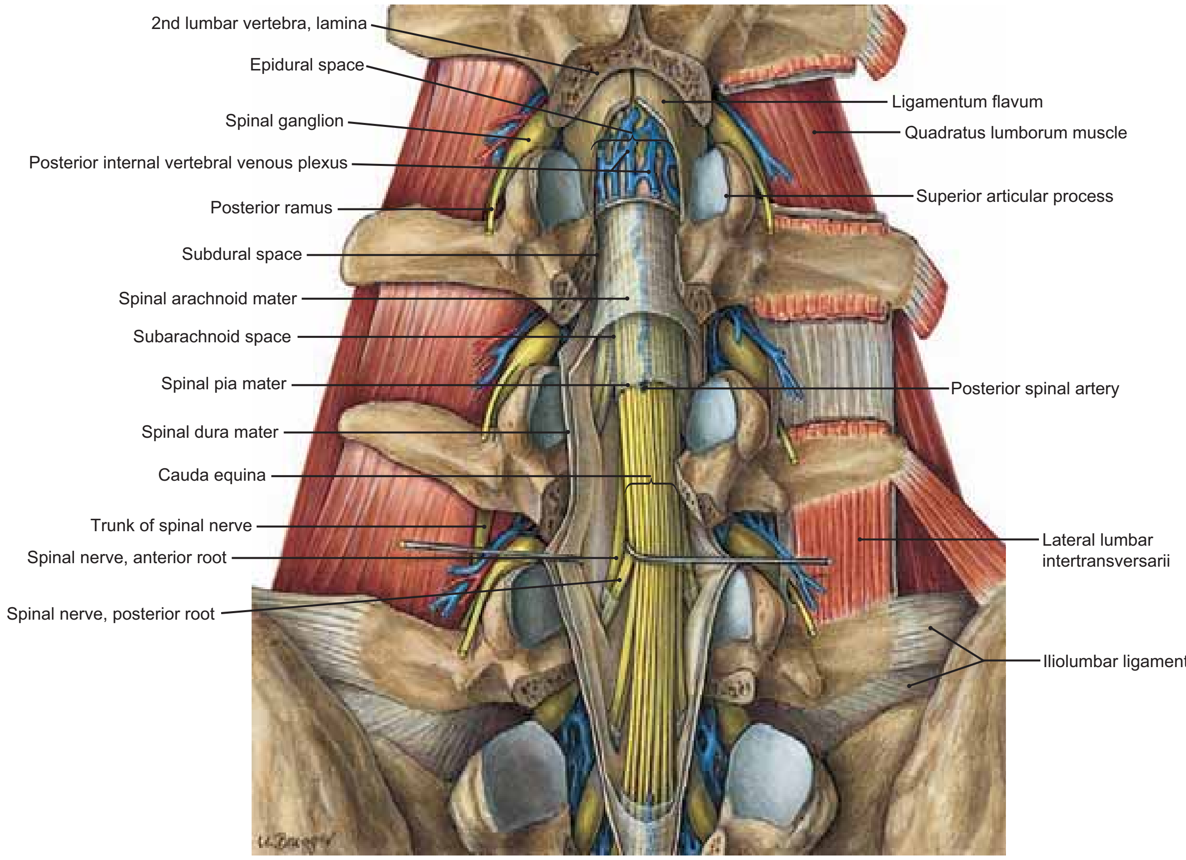
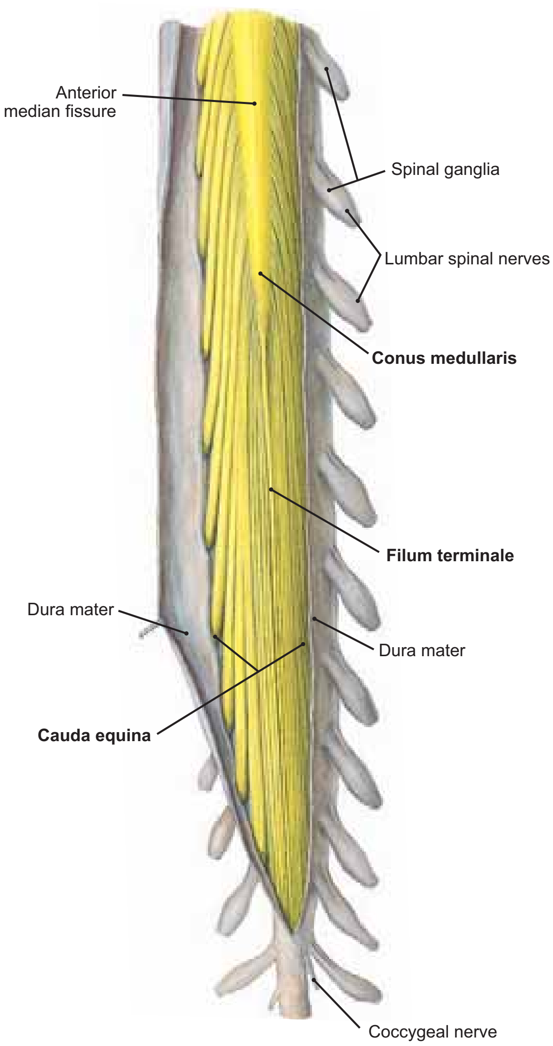


FIGURE 404.3A–C Relationship of the Dorsal and Ventral Roots to the Dura Mater (Various Spinal Levels)



▲ **FIGURE 405.1 Dorsal View of the Vertebral Canal from the Second to the Fifth Lumbar Vertebral Level**

NOTE: (1) The vertebral arches have been removed to show the vertebral canal below the conus medullaris.
(2) The anterior (ventral) and posterior (dorsal) roots coursing together through the intervertebral foramina in the lumbar region.
(3) The dorsal root ganglia at each segmental lumbar level.
(4) The formation of spinal roots below the conus medullaris (L2 level of the spinal cord) is often called the **cauda equina** (horse's tail).



◀ **FIGURE 405.2 Conus Medullaris and Cauda Equina (Ventral)**

NOTE: (1) The termination of the neural part of the spinal cord at the conus medullaris. Its membranous continuation as the filum terminale measures about 20 cm and extends as far as the coccyx.
(2) The cauda equina refers to the roots of the spinal nerves below the conus, and these are seen to surround the filum.
(3) Prolongations of the dura continue to cover the spinal nerves for some distance as they enter the intervertebral foramen.

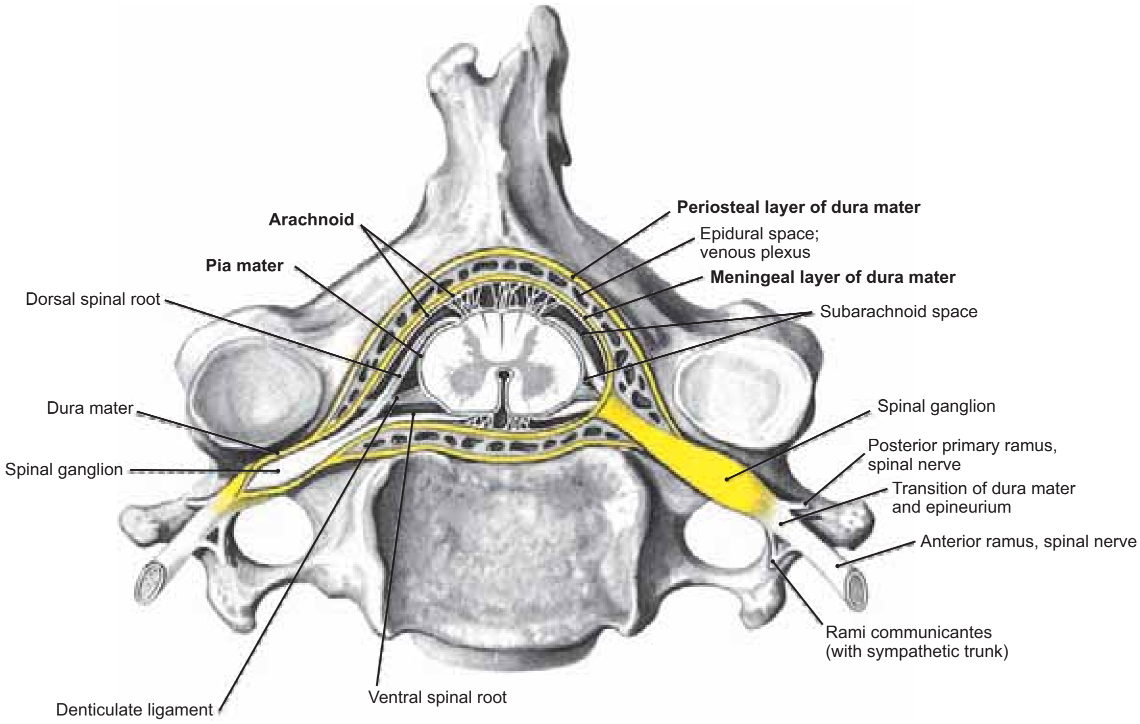


FIGURE 406.1 Meninges of the Spinal Cord Shown at Cervical Level (Transverse Section)

NOTE: (1) The meningeal dura mater (inner layer of yellow) surrounds the spinal cord and continues along the spinal nerve through the intervertebral foramen. Its outer periosteal layer is formed of connective tissue that closely adheres to the bone of the vertebrae forming the vertebral canal.

(2) The delicate filmlike arachnoid, which lies between the meningeal layer of the dura mater and the vascularized pia mater, which is closely applied to the cord.

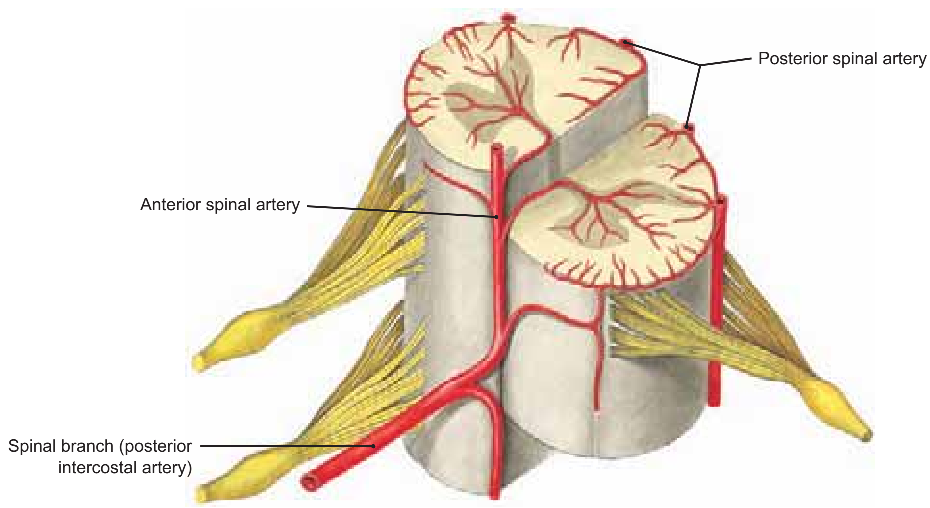


FIGURE 406.2 Spinal Arteries and Their Sulcal Branches

NOTE: (1) As the **anterior spinal artery** descends in the anterior median sulcus, it gives off **sulcal branches** that penetrate the spinal cord.

(2) These sulcal branches usually arise singly, and each turns to the right or left to supply that half of the spinal cord. When each branch is given off it *does not bifurcate* to supply both sides.

(3) Each sulcal branch turns to one side of the cord, and the next branch turns to the other. This alternating pattern (as shown in this figure) occurs along the length of the spinal cord.

(4) Each of the two **posterior spinal arteries** supplies its respective side of the cord.

(5) The spinal arteries anastomose with the spinal branches of the segmental arteries (especially those from the intercostal and lumbar arteries).

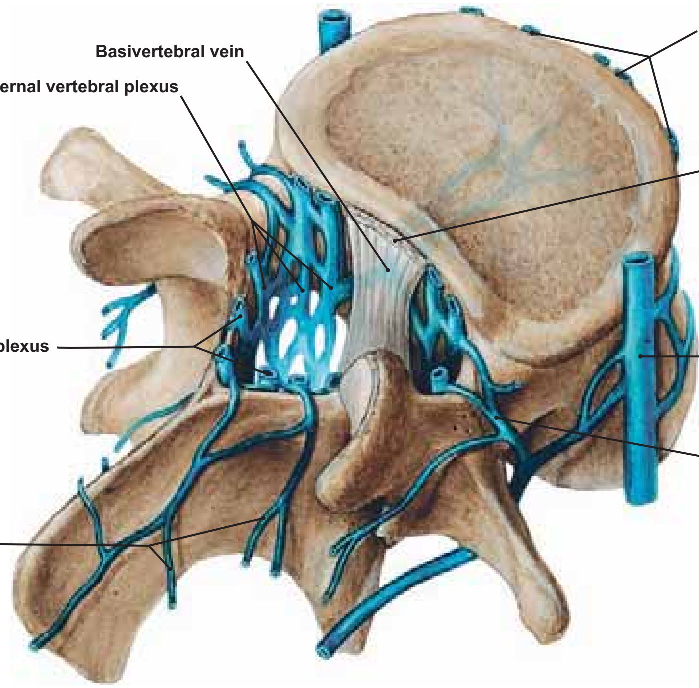


FIGURE 407.1 Veins of the Vertebral Column

NOTE: (1) The veins drain blood from the vertebrae, and the contents of the spinal canal form plexuses that extend the entire length of the spinal column (Batson's veins).

(2) The plexuses are grouped according to whether they lie external to or within the vertebral canal. Thus, they include **external vertebral, internal vertebral**, **basivertebral**, **intervertebral**, and **veins of the spinal cord**.

(3) The basivertebral veins drain the bodies of the vertebrae and may flow into anterior external or anterior internal vertebral plexuses.

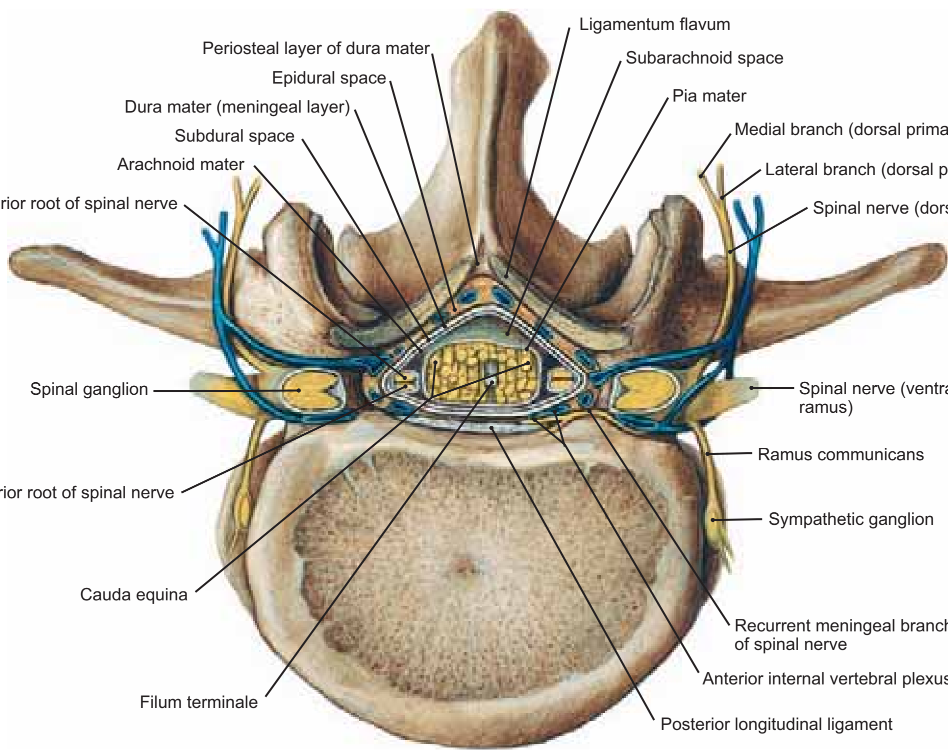


FIGURE 407.2 Cross Section of the Cauda Equina within the Vertebral Canal

NOTE: (1) This cross section is at the level of the third lumbar vertebra, one segment or more below the site where the spinal cord ends.

(2) Specimens of cerebrospinal fluid may be obtained by performing lumbar punctures between the laminae or spines of the third and fourth or fourth and fifth lumbar vertebrae.

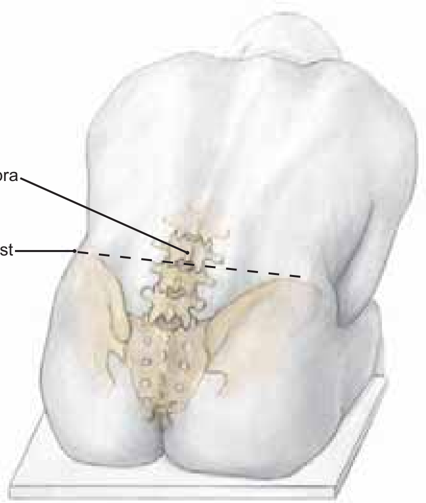


FIGURE 408.1 Position of Patient for Lumbar Puncture

NOTE that the patient is sitting and bent forward as far as possible in order to increase the space between the vertebrae. For orientation, observe that the junction between the L3 and L4 vertebrae is at the level of the iliac crest.

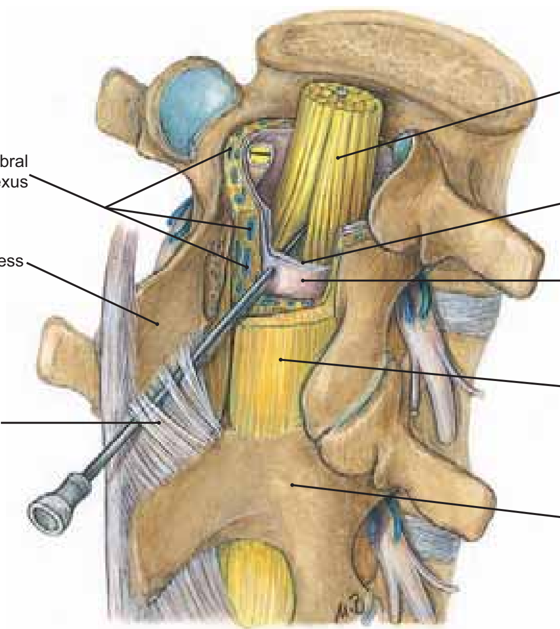


FIGURE 408.2 Lumbar Injection into the Cauda Equina

NOTE that the needle is inserted just below the spinous process of the L3 vertebra, and realize that the spinal cord becomes the nonneural conus medularis just below the L2 vertebra.

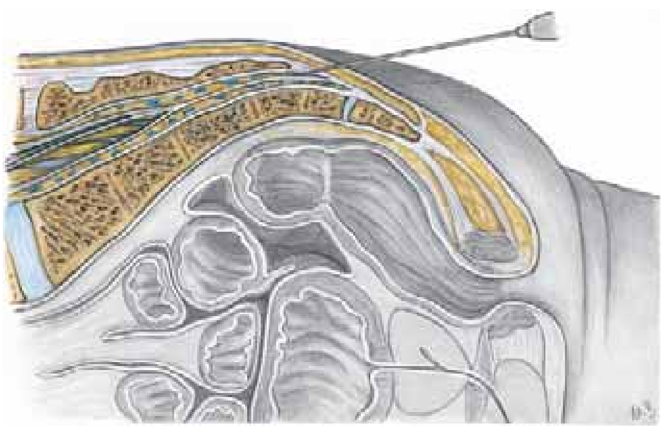


FIGURE 408.3 Sacral Puncture into the Cauda Equina

NOTE that the needle is inserted into the sacral hiatus in order to produce a caudal epidural anesthesia. This method can be used to anesthetize the lower sacral and coccygeal nerves.

CHAPTER 6

The Lower Limb

Plates

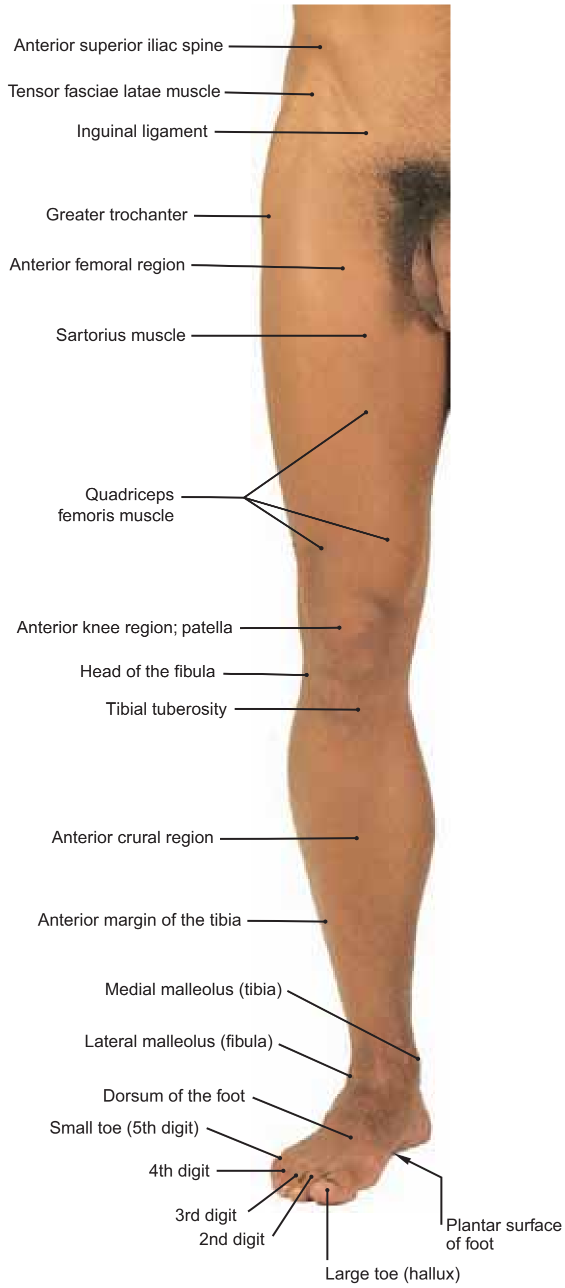


FIGURE 409.1 Photograph of the Anterior Surface of the Lower Limb

NOTE: (1) The following bony landmarks are shown:
- (a) Anterior superior iliac spine
- (b) Greater trochanter
- (c) Patella
- (d) Head of the fibula
- (e) Tibial tuberosity
- (f) Anterior margin of the tibia
- (g) Medial and lateral malleoli

(2) The inguinal ligament, which forms the lower anterior boundary of the abdominal wall, separating it from the anterior thigh inferiorly.

(3) Deep to the surface areas shown in this figure course branches of the cutaneous nerves that supply the anterior and lateral aspects of the thigh and leg and the dorsum of the foot. These branches are shown in Figure 411.1.

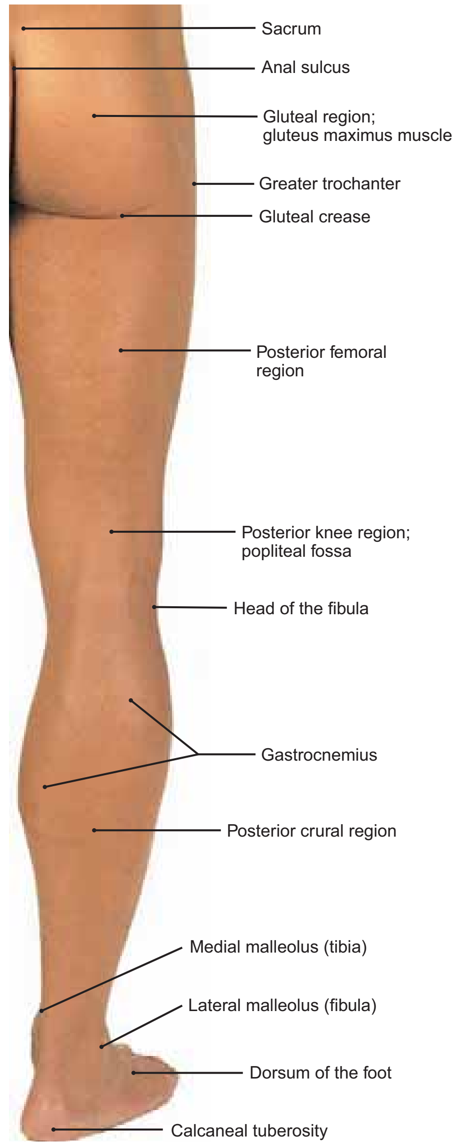


FIGURE 409.2 Photograph of the Posterior Surface of the Lower Limb

NOTE: (1) The following bony landmarks are shown:
- (a) Sacrum
- (b) Greater trochanter
- (c) Head of the fibula
- (d) Medial and lateral malleoli
- (e) Calcaneal tuberosity

(2) The **gluteal crease.** Midway between the greater trochanter laterally and the ischial tuberosity medially and deep to this crease is found the large **sciatic nerve** descending in the posterior thigh. **The nerve is vulnerable at this site because only skin and superficial fascia overlie it.**

(3) The **popliteal fossa** located behind the knee joint. Deep to the skin at this site are found the tibial and fibular divisions of the sciatic nerve and the popliteal artery and vein.

(4) The **calcaneal tuberosity** into which inserts the calcaneus tendon formed as the common tendon of the gastrocnemius, soleus, and plantaris muscles.

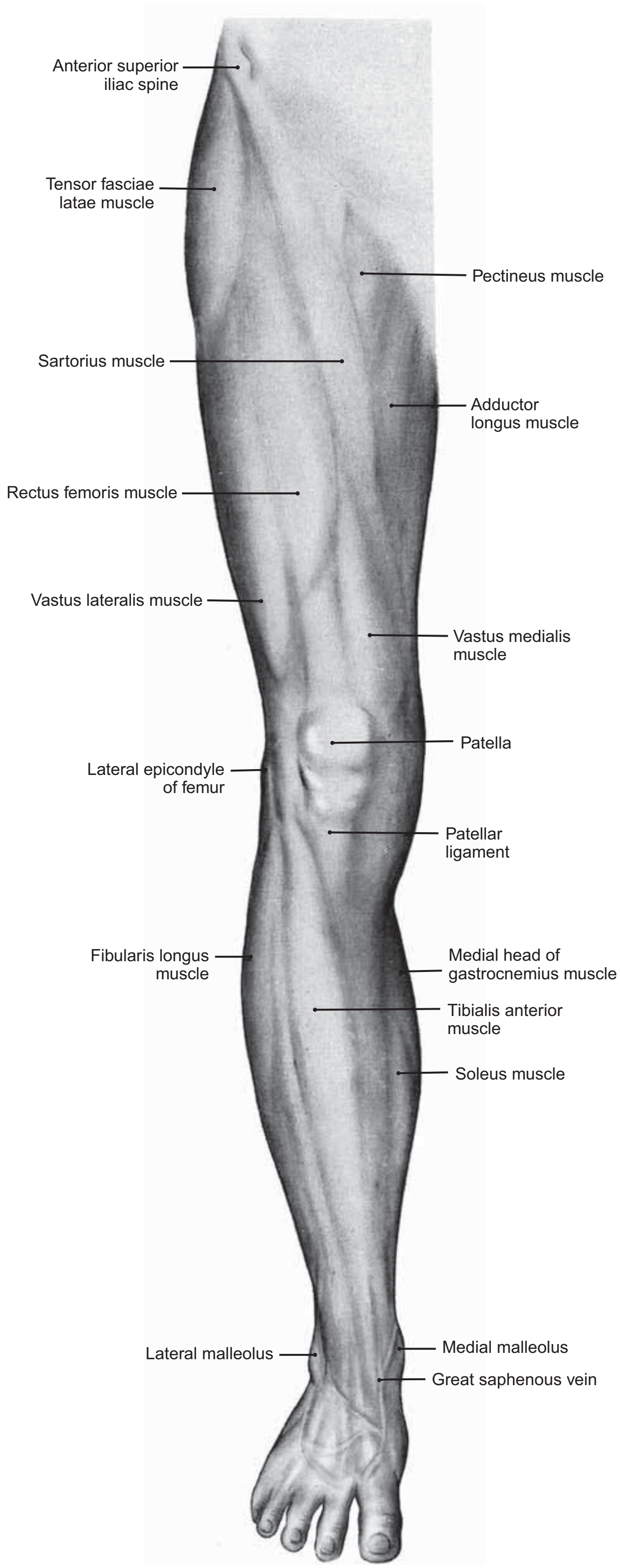


FIGURE 410.1 Surface Anatomy of the Right Lower Limb (Anterior View)

NOTE: (1) The pectineus and adductor longus muscles forming the floor of the femoral triangle. Also observe the sartorius muscle coursing inferomedially and the tensor fasciae latae that shapes the rounded upper lateral contour of the thigh.

(2) The leg is shaped laterally by the fibularis muscles, anteriorly by the tibialis anterior, and medially by the gastrocnemius and soleus muscles.

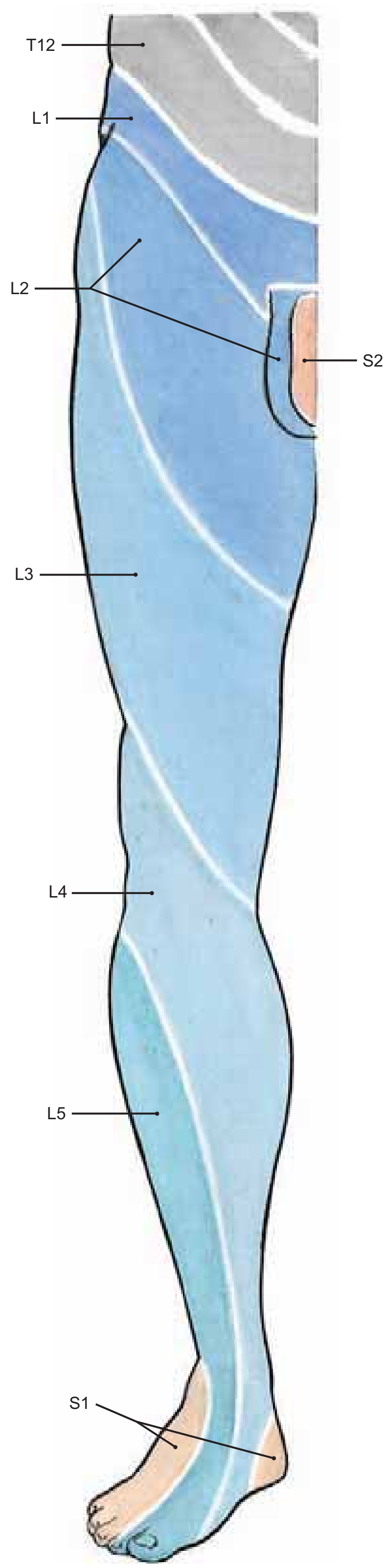
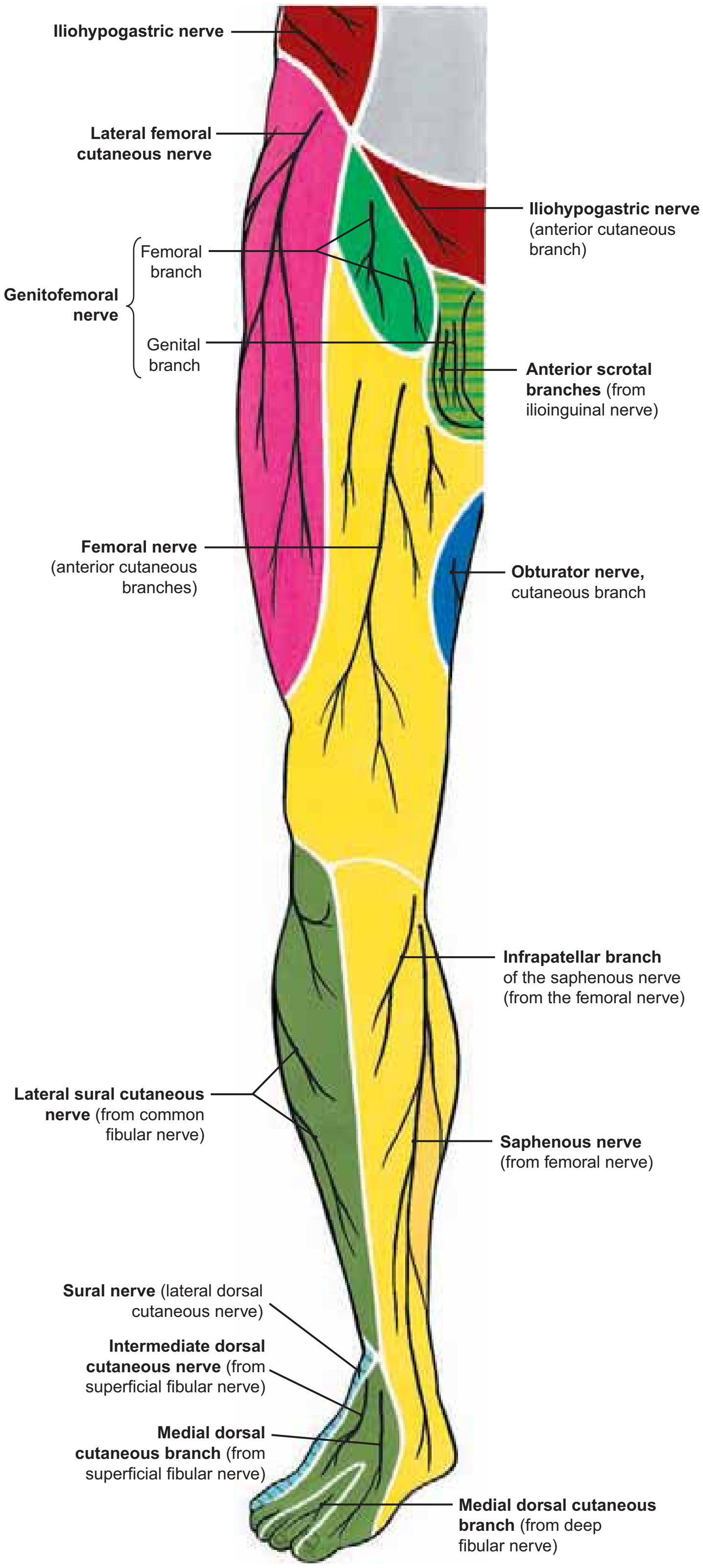


FIGURE 410.2 Segmental Cutaneous Innervation of the Right Lower Extremity (Dermatomes: Anterior View)

NOTE: (1) As a rule, the lumbar segments of the spinal cord supply cutaneous innervation to the anterior aspect of the lower limb, and the dermatomes are segmentally arranged in order from L1 to L5.

(2) The first sacral segment supplies the skin over the medial malleolus and the dorsolateral aspect of the foot.



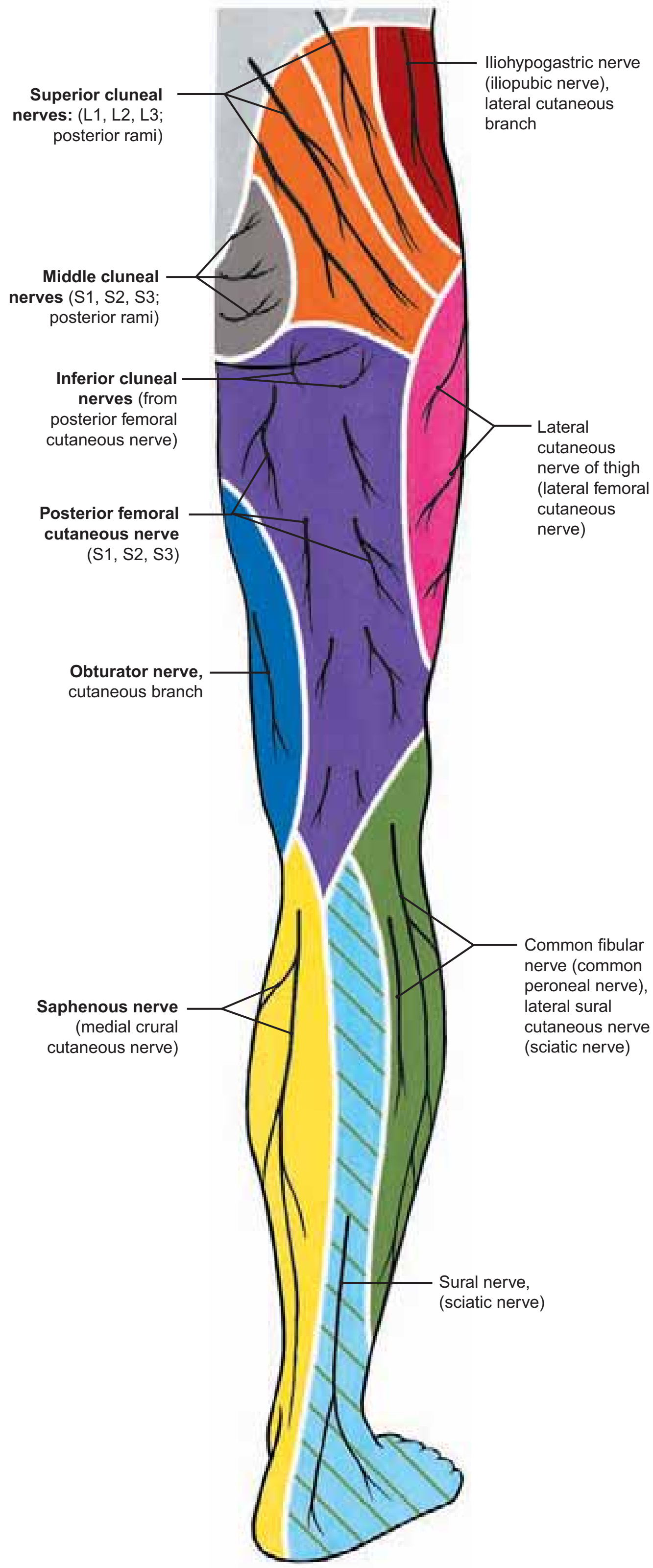


FIGURE 411.1 Cutaneous Nerve Branches (Anterior Surface)

NOTE: (1) Cutaneous branches of the femoral nerve supply the skin of the anteromedial thigh, and the **saphenous nerve** supplies the anteromedial and posteromedial leg.
(2) The **lateral sural branch** of the **common fibular nerve** supplies the anterolateral and posterolateral leg skin.
(3) The fields supplied by the **superficial and deep fibular nerves** on the anterior leg and foot dorsum.
(4) The knowledge of the course of these nerves is important in administering local anesthesia.

FIGURE 411.2 Cutaneous Nerve Branches (Posterior Surface)

NOTE: (1) Cutaneous innervation of the gluteal region:
(a) Lateral branch of **iliohypogastric nerve** (anterior ramus: L1)
(b) **Superior cluneal nerves** (posterior rami: L1–L3)
(c) Middle cluneal nerves (posterior rami: S1–S3)
(d) Inferior cluneal nerves (S1–S3)
(2) Skin of posterior thigh supplied by the **posterior and lateral femoral cutaneous nerves** and **obturator nerve.**
(3) Skin of posterior leg supplied the **saphenous, sural,** and **lateral sural nerves.**

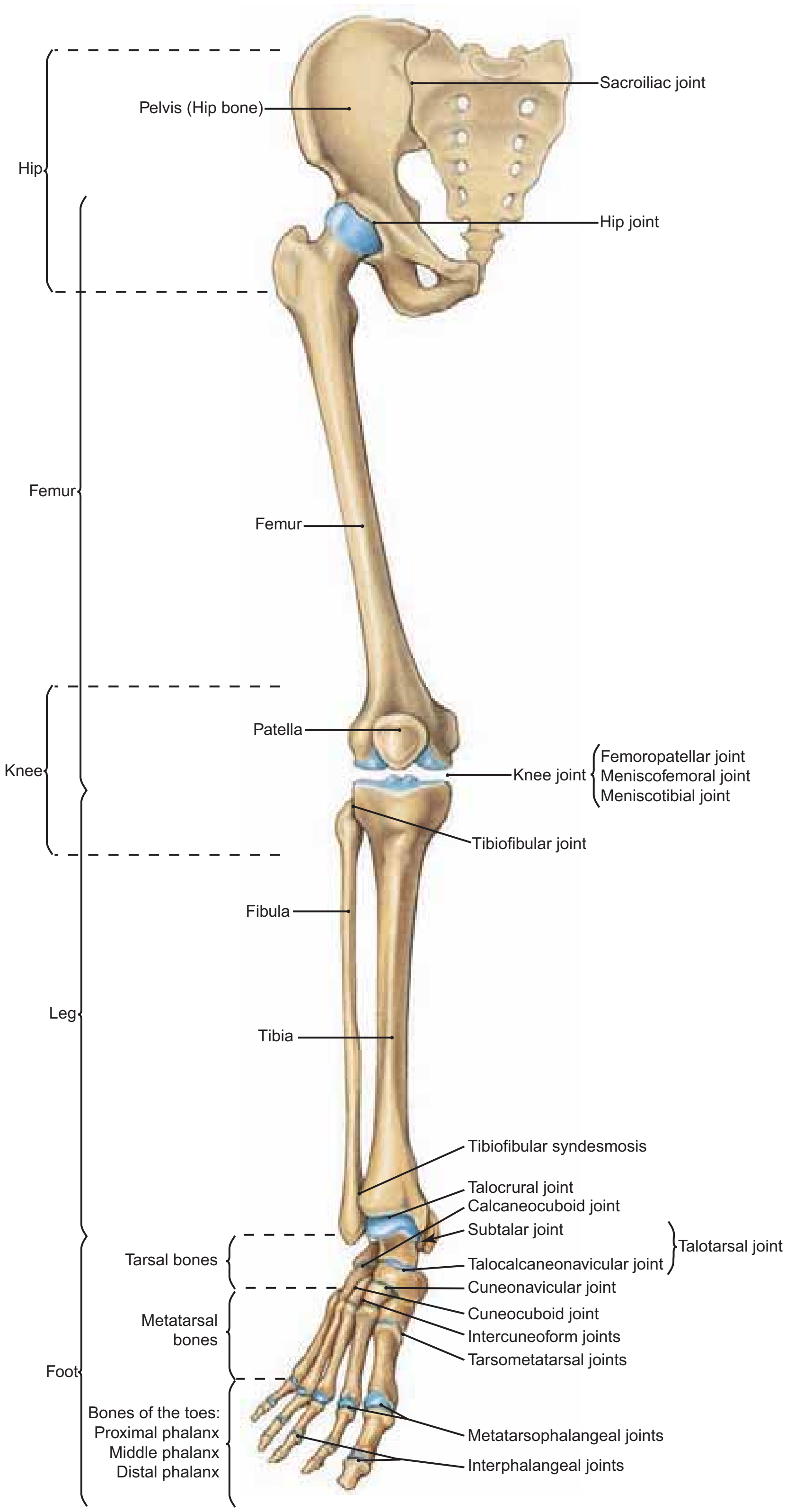


FIGURE 412 Bones and Joints of the Lower Limb

NOTE the following joints: **hip, knee, tibiofibular, ankle (talocrural), tarsal, tarsometatarsal, metatarsophalangeal, and interphalangeal joints.**

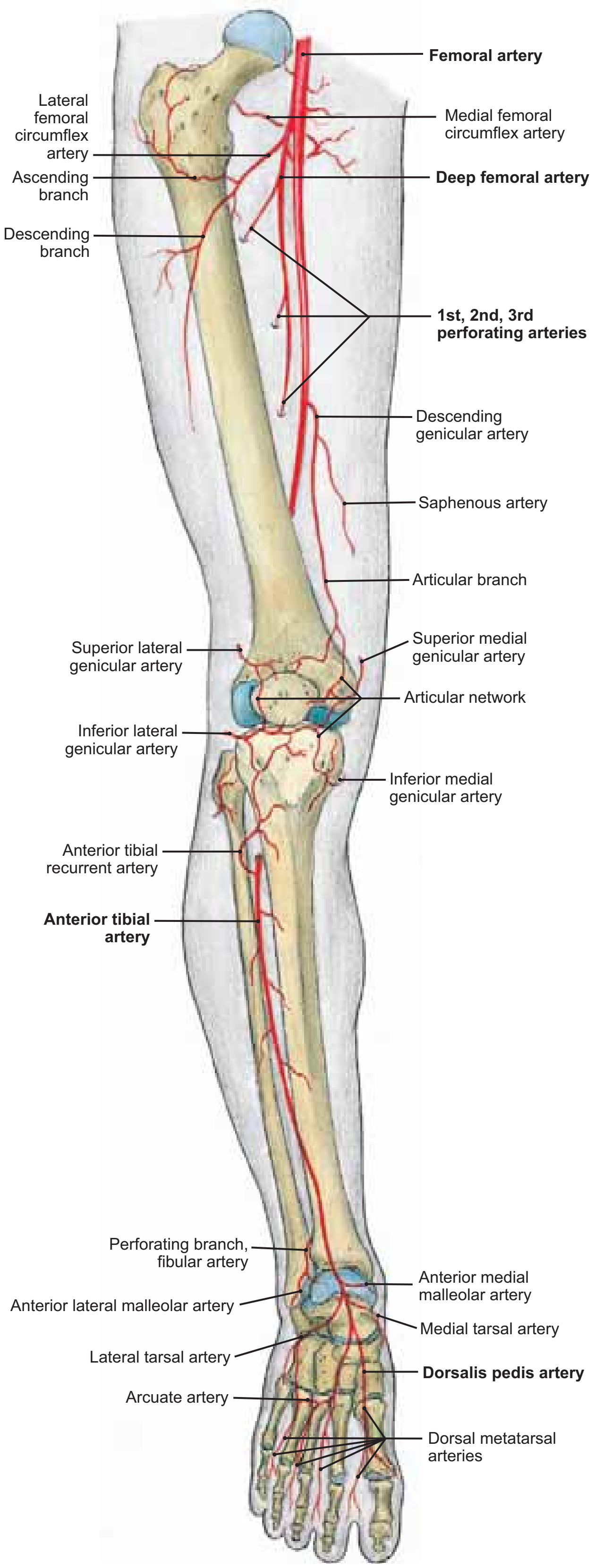


FIGURE 413.1 **Arteries and Bones of the Lower Limb (Anterior View)**

NOTE: The anastomoses in the hip and knee regions, and the **perforating branches** of the **deep femoral artery.** In the anterior leg, the **anterior tibial artery** descends between the tibia and the fibula to achieve the malleolar region and the foot dorsum.

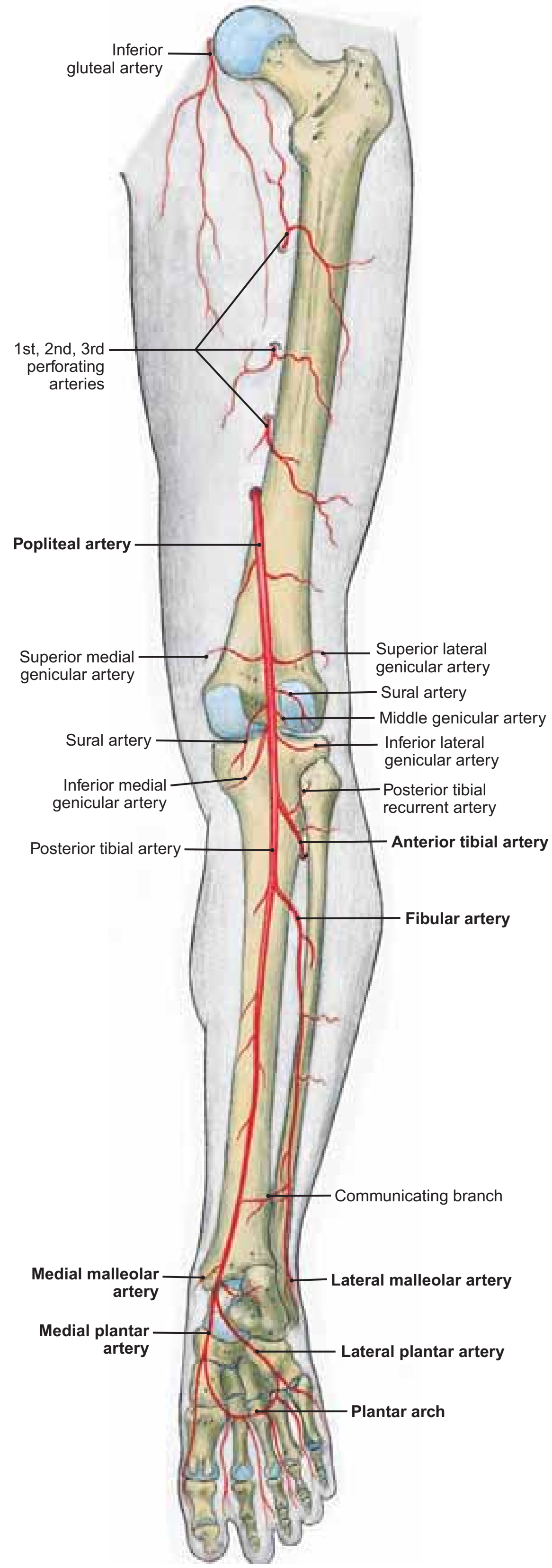


FIGURE 413.2 **Arteries and Bones of the Lower Limb (Posterior View)**

NOTE: The branches of the **popliteal artery** at the knee and its continuation as the **posterior tibial artery.** In the foot this vessel divides to form the **medial** and **lateral plantar arteries,** which then anastomose to form the **plantar arch.**

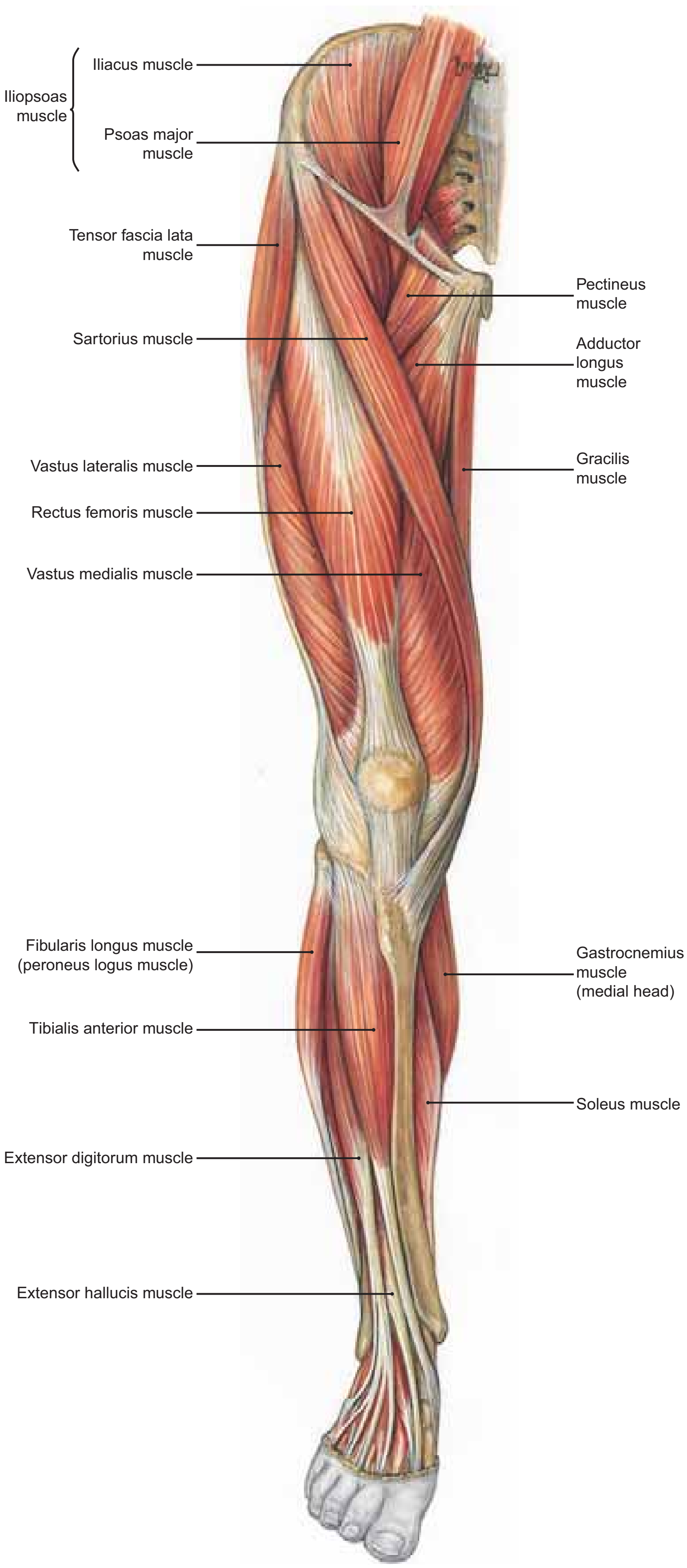


FIGURE 414.1 **Muscles of the Lower Limb**

NOTE the anterior and medial thigh muscles and also the anterior and lateral muscles of the leg.

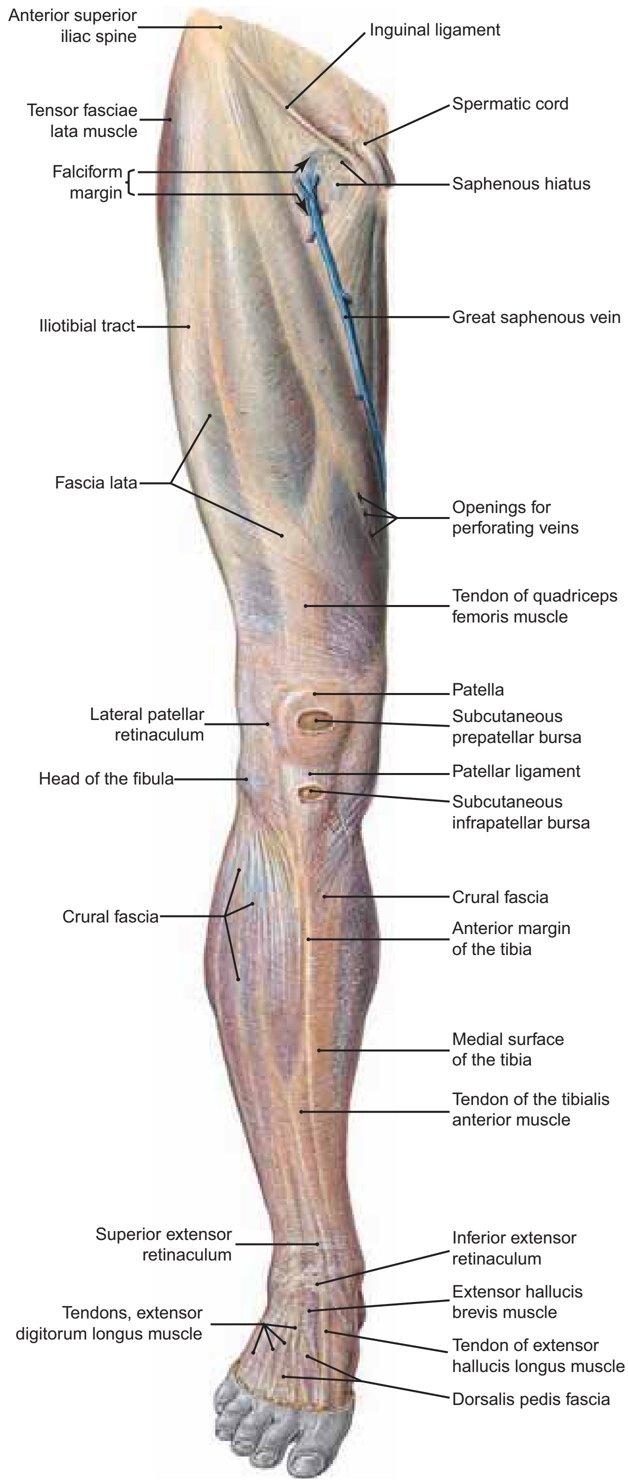


FIGURE 414.2 **The Deep Fasciae of the Anterior and Medial Thigh (Fascia Lata) and the Crural Fascia of the Leg**

NOTE the great saphenous vein, the saphenous hiatus, and the fascia lata of the anterior thigh. Observe the closely investing crural fascia over the anterior and lateral compartment muscles of the leg.

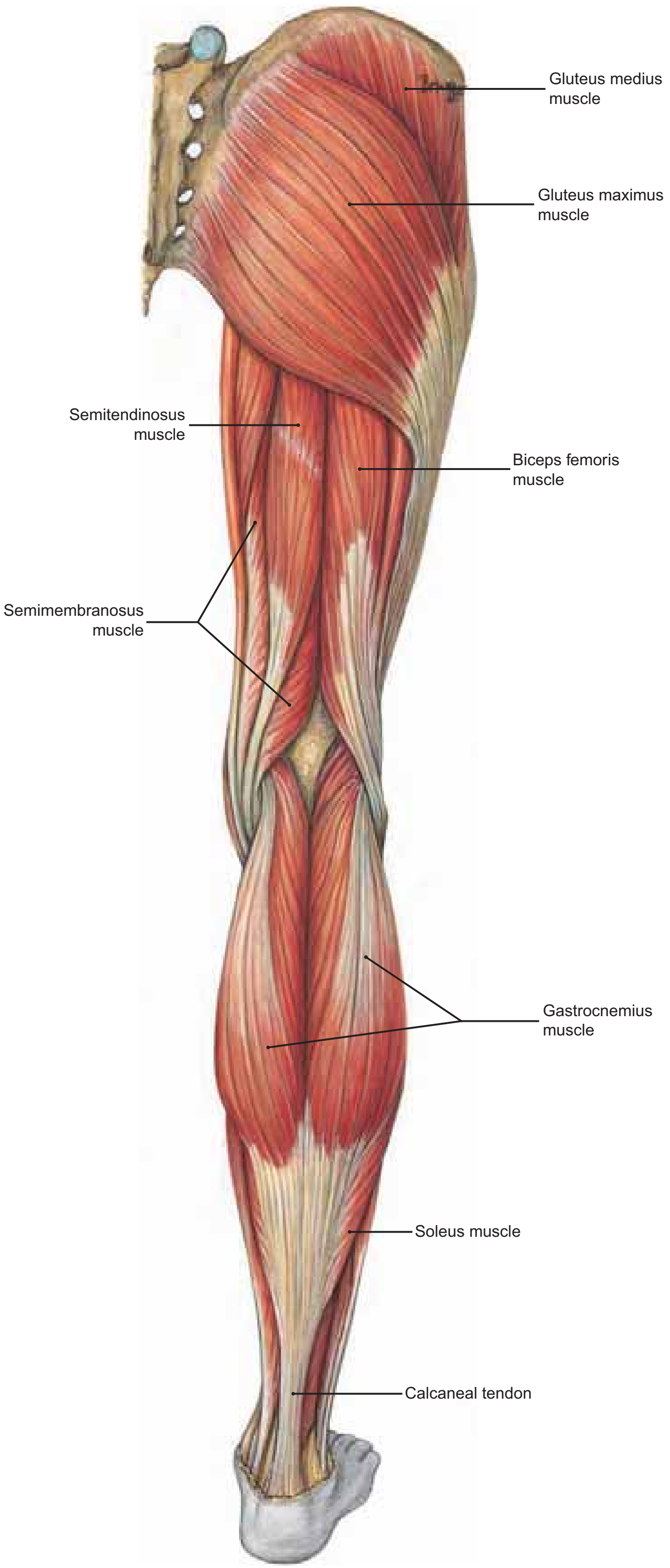


FIGURE 415.1 Muscles of the Lower Limb: Posterior Aspect of Thigh and Leg

NOTE the hamstring muscles of the posterior thigh and the gastrocnemius and soleus muscles of the posterior leg.

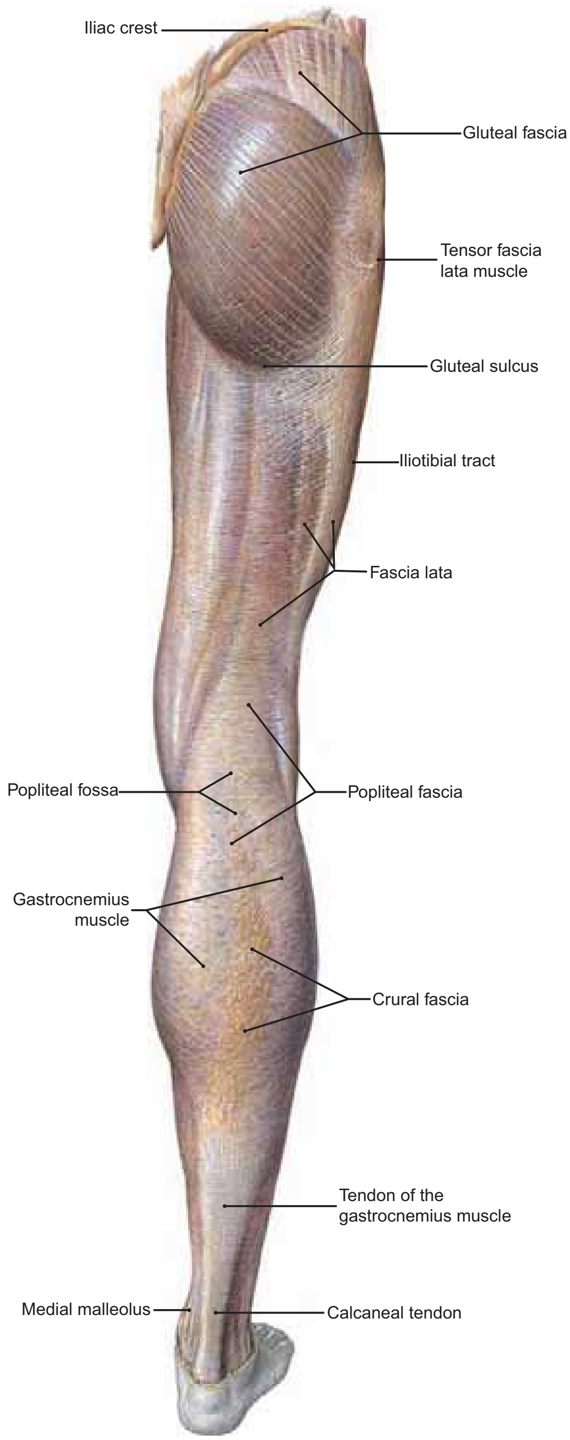


FIGURE 415.2 Fascia of the Gluteal Region and the Fascia Lata of the Posterior Thigh and Crural Fascia of the Posterior Leg

NOTE the iliac crest, gluteal sulcus, iliotibial band, and the crural fascia below the knee.

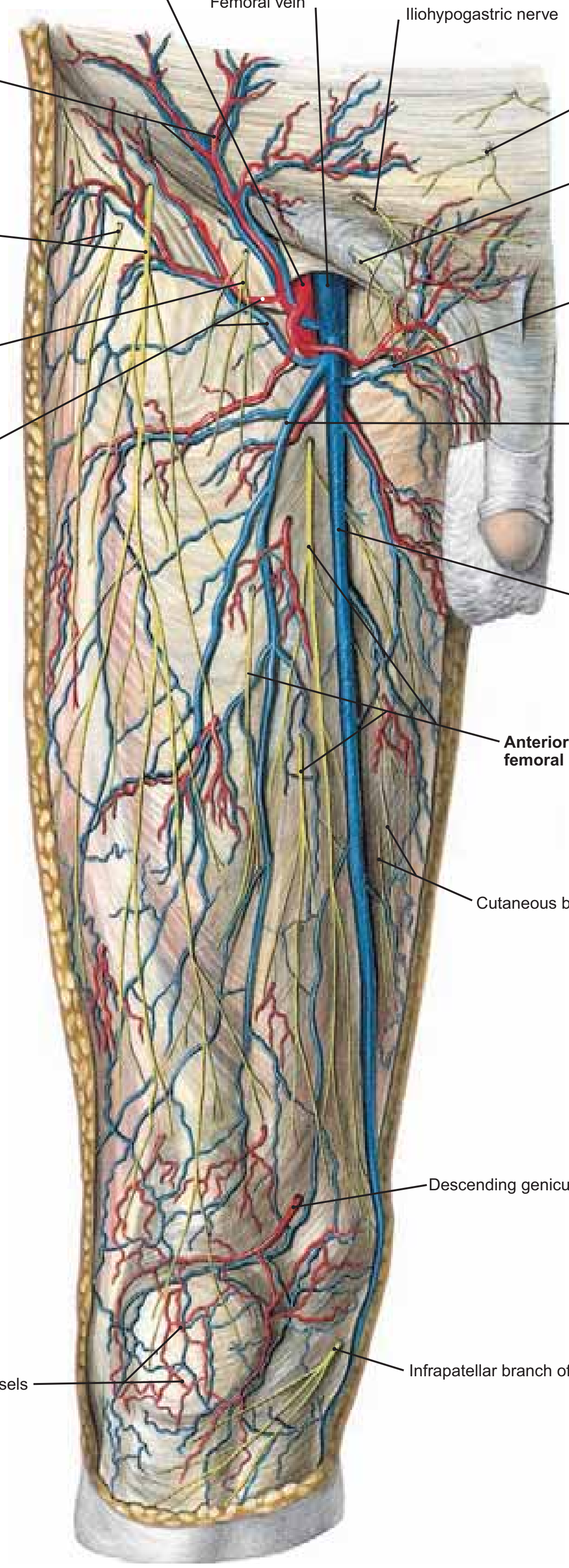


FIGURE 416 Superficial Nerves and Blood Vessels of the Anterior Thigh

NOTE: (1) The **great saphenous vein** as it ascends the anterior and medial aspect of the thigh. Just below (1½ in.) the inguinal ligament, it penetrates the deep fascia through the **saphenous opening** to enter the **femoral vein.**

(2) The superficial branches of the **femoral artery** and the superficial veins drain into the **great saphenous vein.** These include the: (a) **superficial epigastric,** (b) **external pudendal,** and (c) **superficial circumflex iliac** arteries and veins.

(3) The principal cutaneous nerves of the anterior thigh. Compare these with those shown in Figure 411.1.

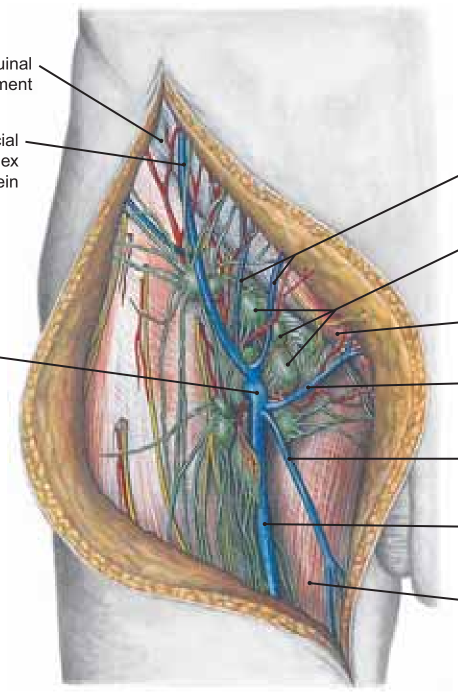
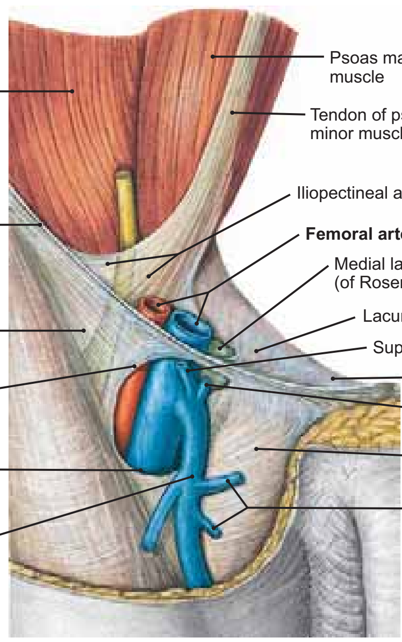


FIGURE 417.1 Superficial Inguinal Lymph Nodes

NOTE: (1) The superficial tissues of the genitalia, lower anterior abdominal wall, inguinal region, and anterior thigh drain into the **superficial inguinal lymphatic nodes.**
(2) These nodes are located around the femoral vessels just inferior to the inguinal ligament and usually number between 10 and 15. In turn, these nodes drain into the external iliac nodes within the pelvis.

FIGURE 417.2 Saphenous Opening in the Fascia Lata

NOTE: (1) The *femoral sheath* (dense connective tissue that surrounds the femoral artery and vein) has been removed in this dissection, revealing the sharply defined **falciform margin** of the **saphenous opening.**
(2) The great saphenous vein receives its superficial tributaries before it enters the saphenous opening.



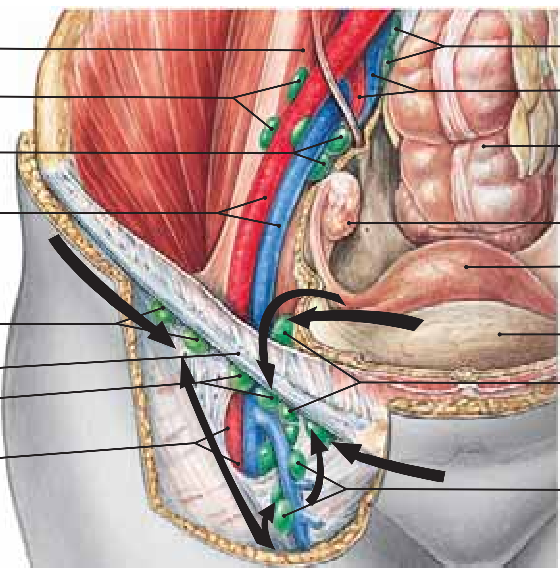


FIGURE 417.3 Superficial and Deep Inguinal Lymphatic Nodes

NOTE: The directions of flow (arrows) of lymph from adjacent tissues into the superficial and deep inguinal nodes. The superficial nodes are divided into superolateral, superomedial, and inferomedial groups, while the deep nodes are closest to the femoral vessels.

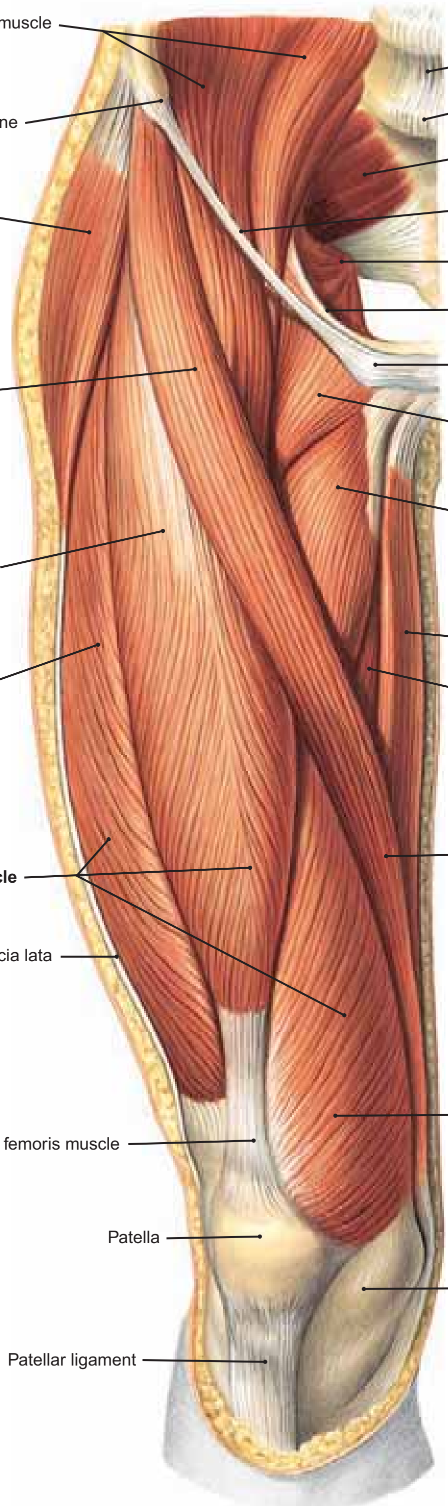


FIGURE 418 Anterior Muscles of the Thigh: Superficial View (Right)

NOTE: (1) The long narrow **sartorius muscle,** which arises on the anterior superior iliac spine and passes obliquely across the anterior femoral muscles to insert on the medial aspect of the body of the tibia. The sartorius flexes, abducts, and rotates the thigh laterally at the hip joint, and it flexes and rotates the leg medially at the knee joint.

(2) The **quadriceps femoris muscle** forms the bulk of the anterior femoral muscles, and both the sartorius and quadriceps muscles are innervated by the femoral nerve.

(3) Above and medial to the sartorius muscle are visible, in order, the iliopsoas, pectineus, adductor longus, adductor magnus, and gracilis muscles.

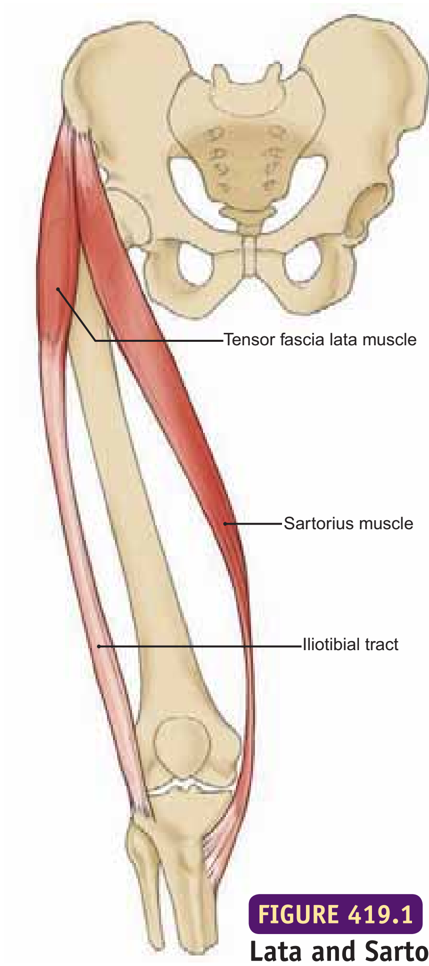


FIGURE 419.1 The Tensor Fascia Lata and Sartorius Muscles

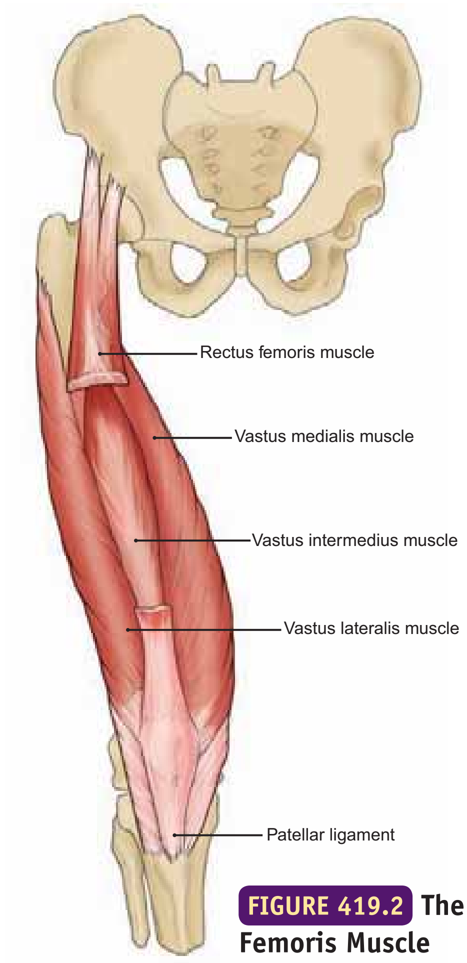


FIGURE 419.2 The Quadriceps Femoris Muscle

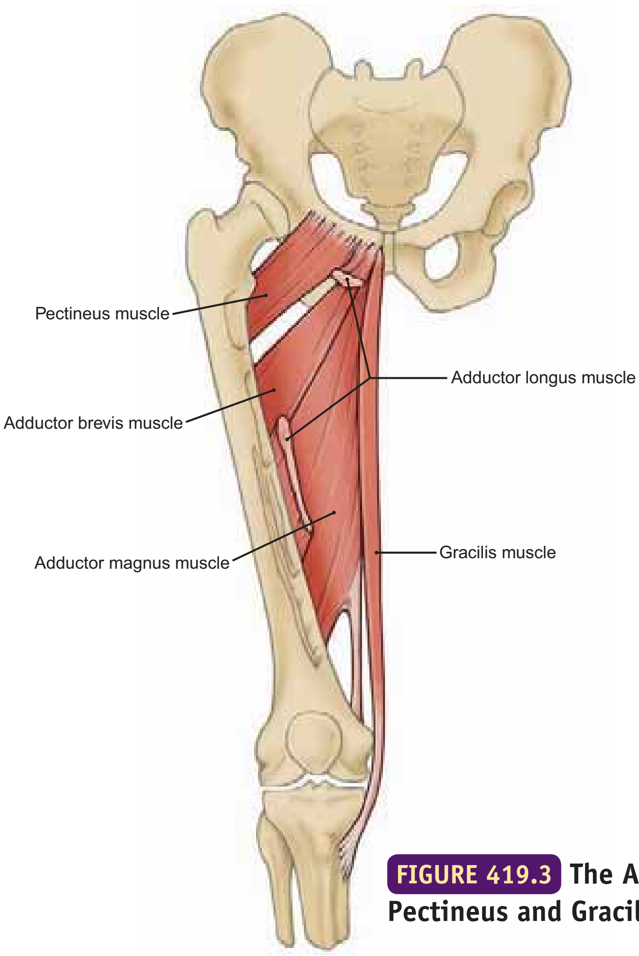


FIGURE 419.3 The Adductor Muscles and the Pectineus and Gracilis Muscles

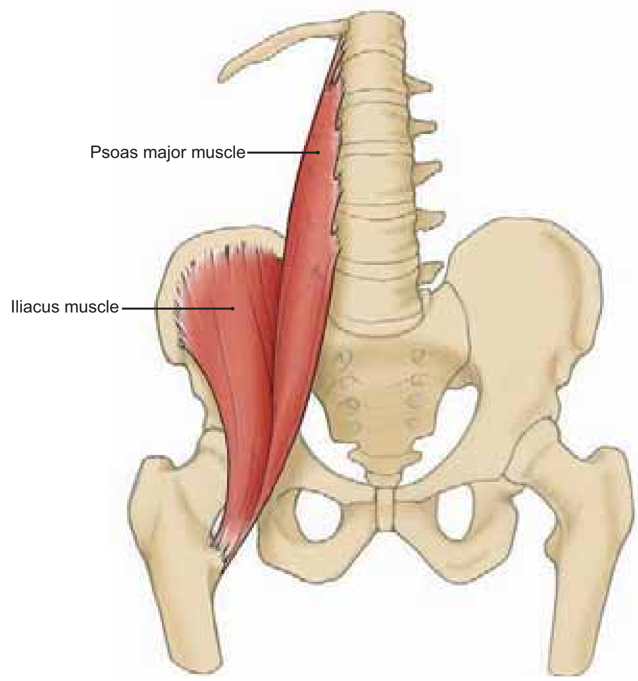


FIGURE 419.4 The Iliopsoas Muscle

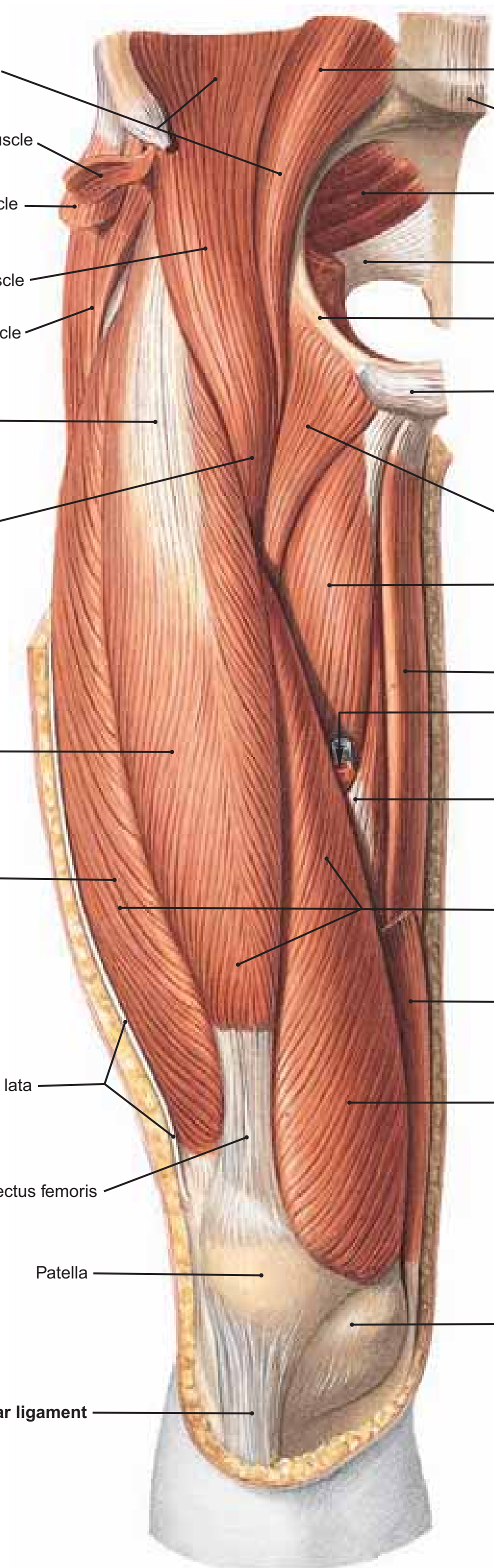


FIGURE 420 Quadriceps Femoris, Iliopsoas, and Pectineus Muscles

NOTE: (1) The **quadriceps femoris muscle** consists of the rectus femoris and the three vastus muscles (lateralis, intermedius, and medialis) as it converges inferiorly to form a powerful tendon that encases the patella and inserts onto the **tuberosity of the tibia.** The entire quadriceps extends the leg at the knee, while the rectus femoris also flexes the thigh at the hip.

(2) The **iliopsoas muscle** is the most powerful flexor of the thigh at the hip joint, and it inserts on the **lesser trochanter.**

(3) The quadrangular and flat **pectineus muscle** medial to the iliopsoas. Sometimes called the key to the femoral triangle, this muscle is normally supplied by the femoral nerve, but in slightly over 10% of cases it also receives a branch from one of the obturator nerves.

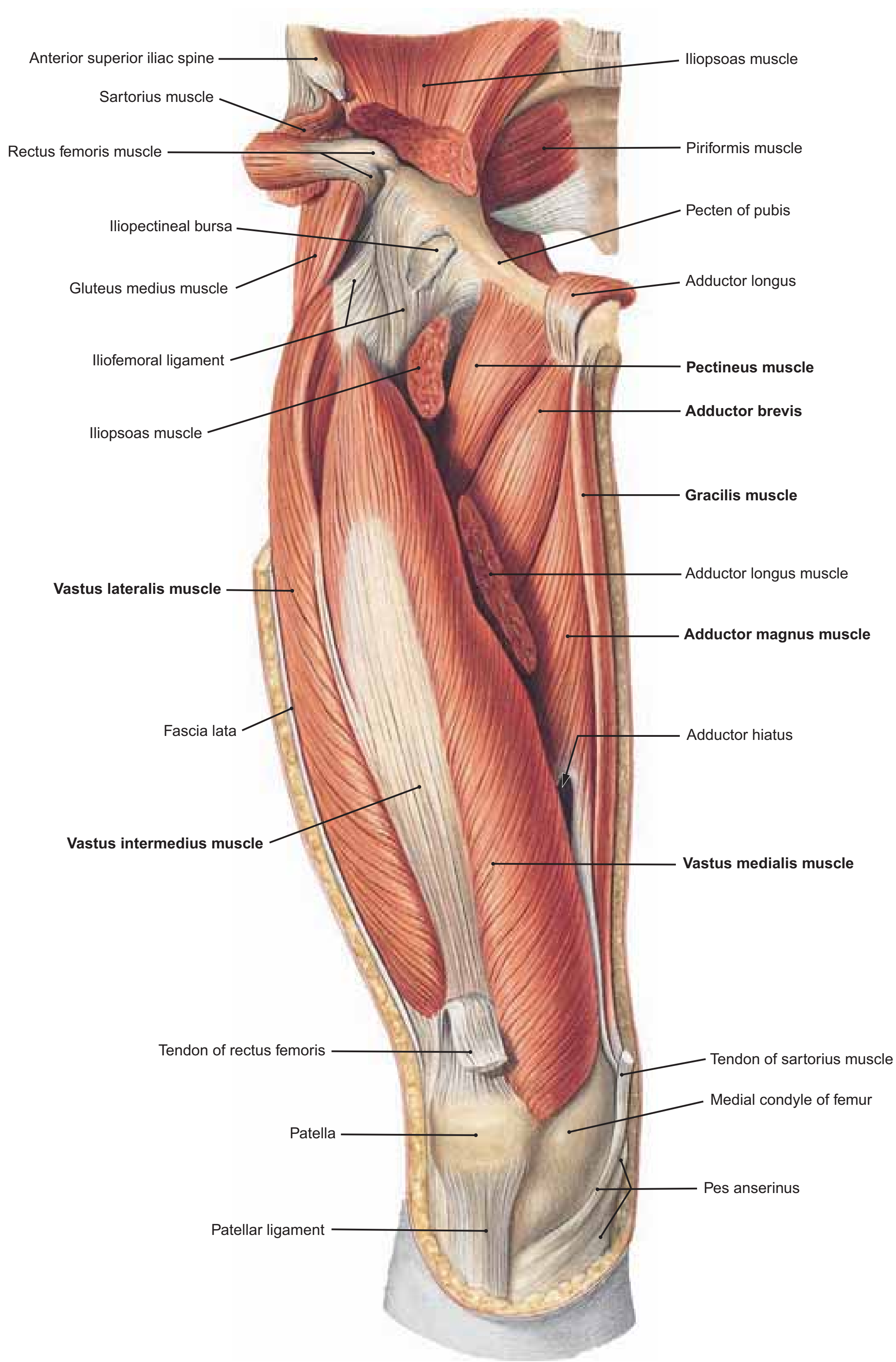


FIGURE 421 **Intermediate Layer of Anterior and Medial Thigh Muscles**

NOTE: (1) The **rectus femoris** and **iliopsoas muscles** are cut to expose the underlying **vastus intermedius,** situated between the **vastus lateralis** and the **vastus medialis.**

(2) The **adductor longus** has also been reflected. This displays the **pectineus, adductor brevis,** and **magnus muscles** and the long **gracilis muscle.**

(3) The quadriceps femoris is the most powerful extensor of the leg. During extension, however, there is a natural tendency to displace the patella laterally out of its groove on the patellar surface of the femur because of the natural angulation of the femur with respect to the bones of the leg.

(4) The muscle fibers of the **vastus medialis** descend further inferiorly than those of the vastus lateralis, and the lowest fibers insert directly along the medial border of the patella. The medial pull of these fibers is thought to be essential in maintaining the stability of the patella on the femur.

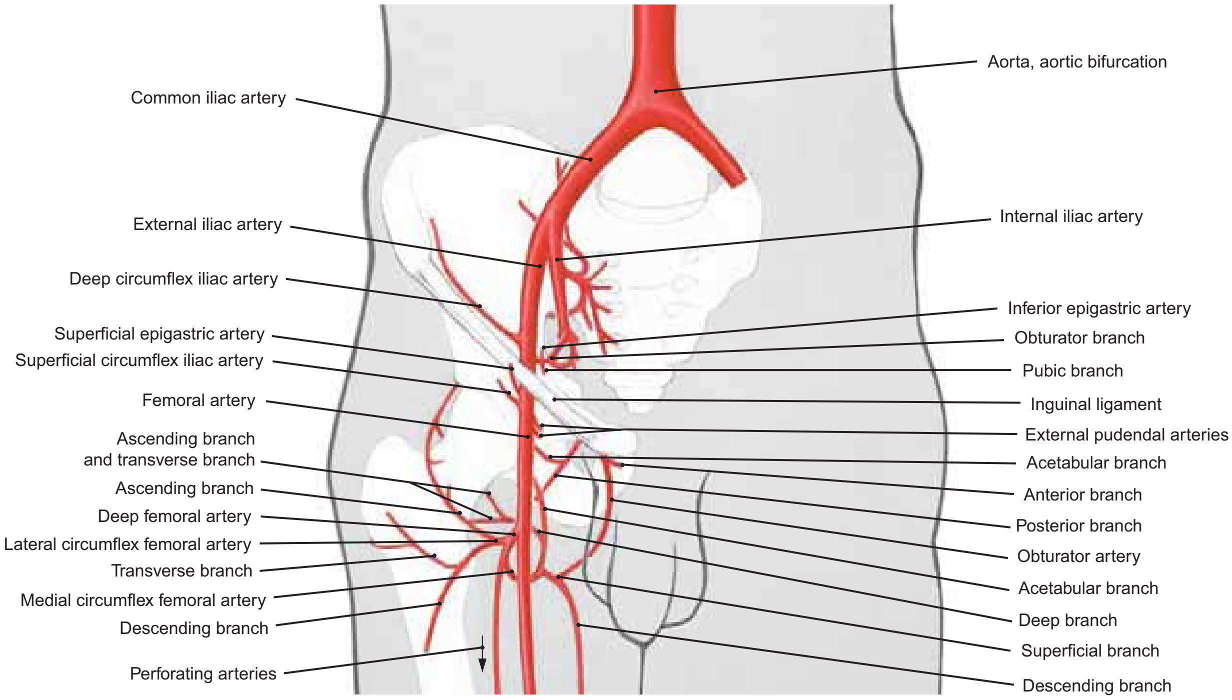


FIGURE 422.1 Arteries of the Right Hip Region and the Thigh

NOTE: (1) The branching pattern of the deep femoral artery (profundus femoris) shown in this drawing is observed in 55% to 60% of cases studied.
(2) A number of the branches of the internal iliac artery are not labeled in this figure, but these can be seen in Figures 339 and 340.

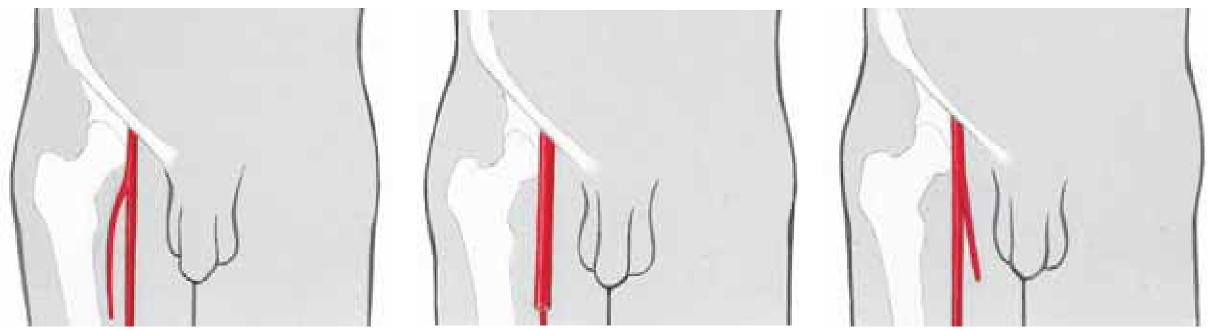


FIGURE 422.2 Variations in the Position of the Deep Femoral Artery

NOTE: (1) In **A,** the vessel is lateral or lateral and dorsal to the femoral artery.
(2) In **B,** the vessel is posterior to the femoral artery.
(3) In **C,** the vessel is medial to the femoral artery.

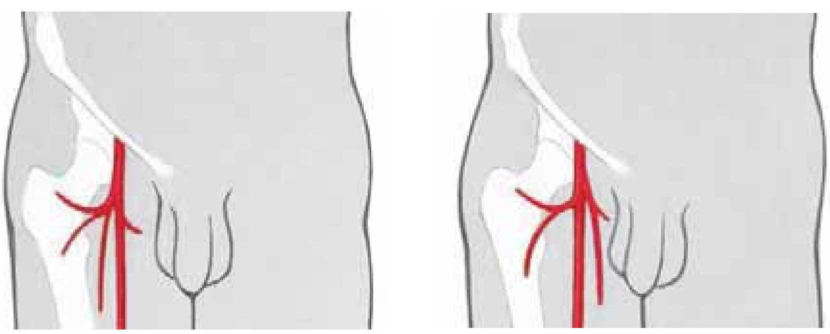


FIGURE 422.3 Variations in the Origins of the Femoral Circumflex Arteries

NOTE: (1) In **A,** the separate origin of the medial femoral circumflex artery is shown.
(2) In **B**, the separate origin of the lateral femoral circumflex artery is shown.

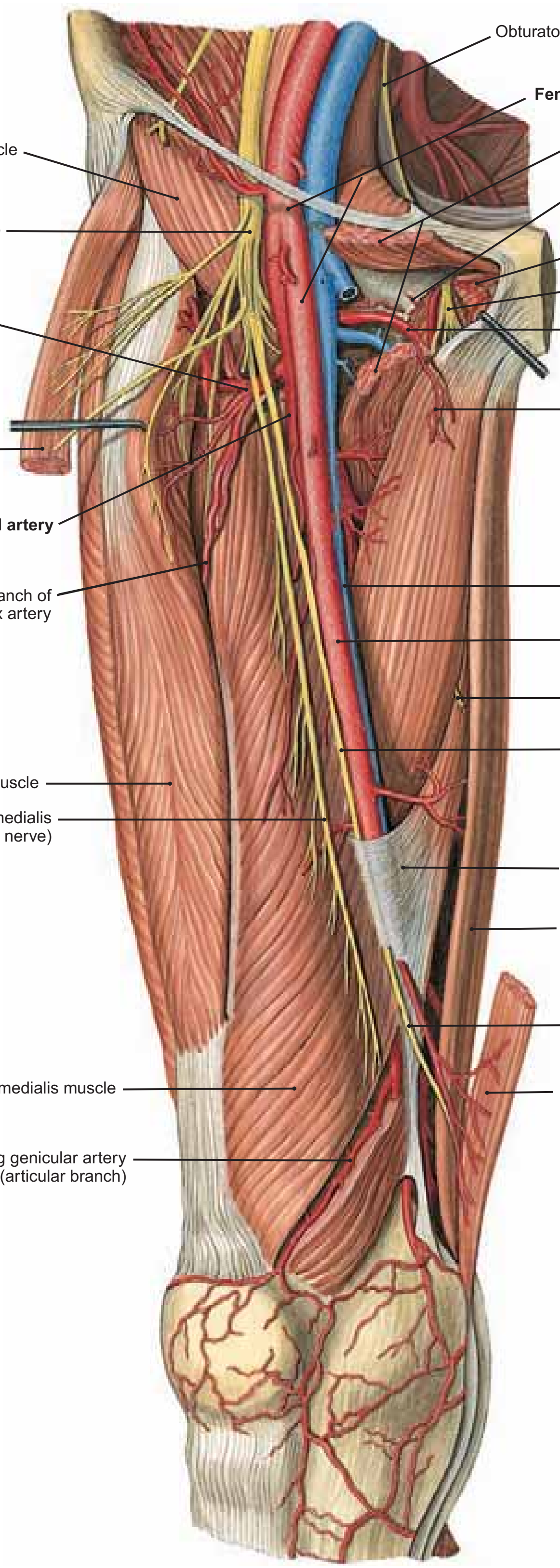


FIGURE 423 Femoral Vessels and Nerves

NOTE: (1) The femoral vessels, the saphenous branch of the femoral nerve, and the nerve to the vastus medialis all enter the **adductor canal (of Hunter).**

(2) The **saphenous nerve,** after coursing some distance in the canal, penetrates the overlying fascia to reach the superficial leg region; the **nerve to the vastus medialis** traverses the more proximal part of the canal and then divides into muscular branches to supply the vastus medialis muscle.

(3) The **femoral artery and vein** course through the entire canal and then leave it by way of an opening in the adductor magnus muscle called the **adductor hiatus.** The vessels course to the back of the lower limb to become the **popliteal artery and vein.**

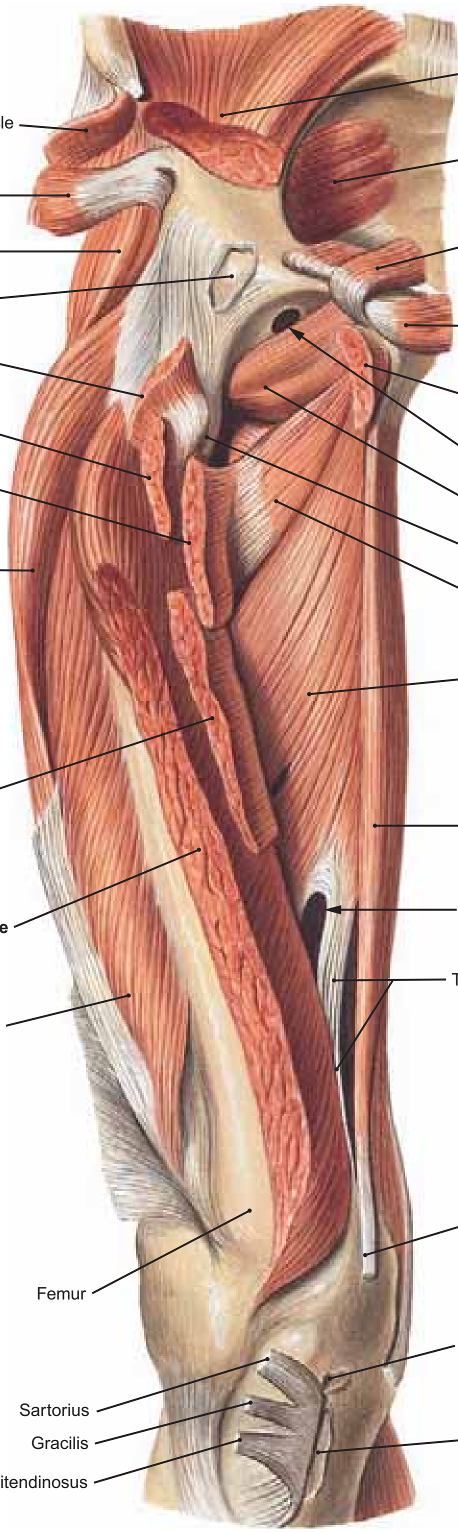


FIGURE 424 Deep Layer of Anterior and Medial Thigh Muscles (Right)

NOTE: (1) The rectus femoris and vastus medialis have been removed, thereby exposing the shaft of the femur. Likewise, the adductor longus and brevis and the pectineus muscles have been reflected, exposing the **obturator externus,** the **adductor magnus,** and the **adductor minimus** (which usually is just the upper portion of the adductor magnus).

(2) The common insertion of the tendons of the **sartorius, gracilis,** and **semitendinosus muscles** on the medial aspect of the medial condyle of the tibia. The divergent nature of this insertion resembles a goose's foot (pes anserinus). This tendinous formation can be used by surgeons to strengthen the medial aspect of the capsule of the knee joint.

(3) The tendinous opening on the adductor magnus, called the **adductor hiatus,** through which the femoral vessels course to (or from) the popliteal fossa.

(4) The **obturator externus muscle** stretching across the inferior surface of the obturator membrane to insert laterally on the neck of the femur. This muscle rotates the femur laterally, and it is not part of the adductor group of muscles.

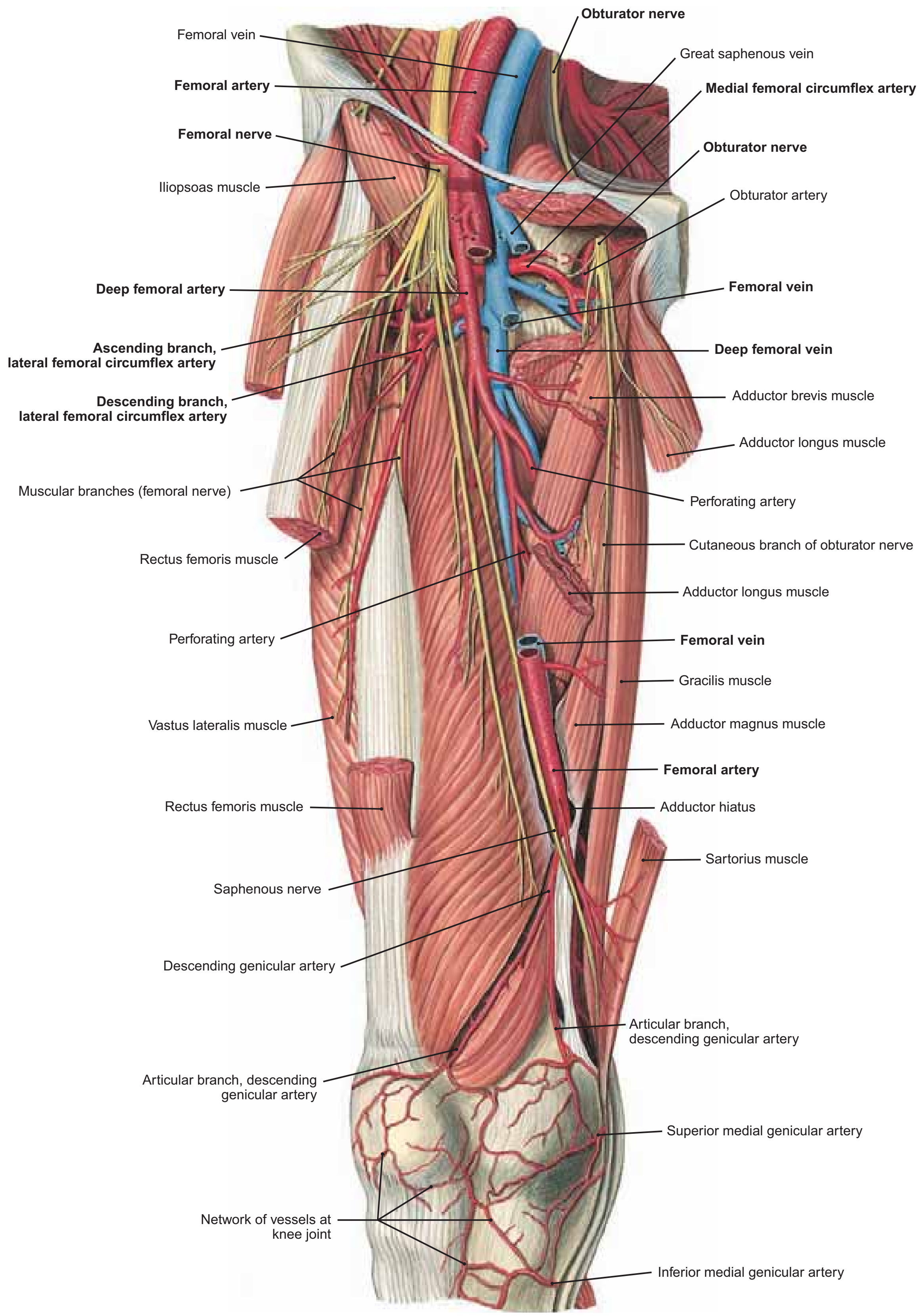


FIGURE 425 Femoral and Obturator Nerves and Deep Femoral Artery

NOTE: (1) The **obturator nerve** supplies the adductor muscles, the gracilis, and the obturator externus while the femoral nerve innervates all the other anterior thigh muscles.

(2) The **deep femoral artery** is the largest branch of the femoral artery, and it gives off both the **medial** and **lateral femoral circumflex arteries**. Observe the femoral vessels traversing the femoral canal.

(3) In about 50% of cases, the deep femoral artery branches from the lateral side of the femoral artery; in 40%, it branches from the posterior aspect of the femoral artery and courses behind it; and in 10%, the deep femoral artery arises from the medial side of the femoral artery.

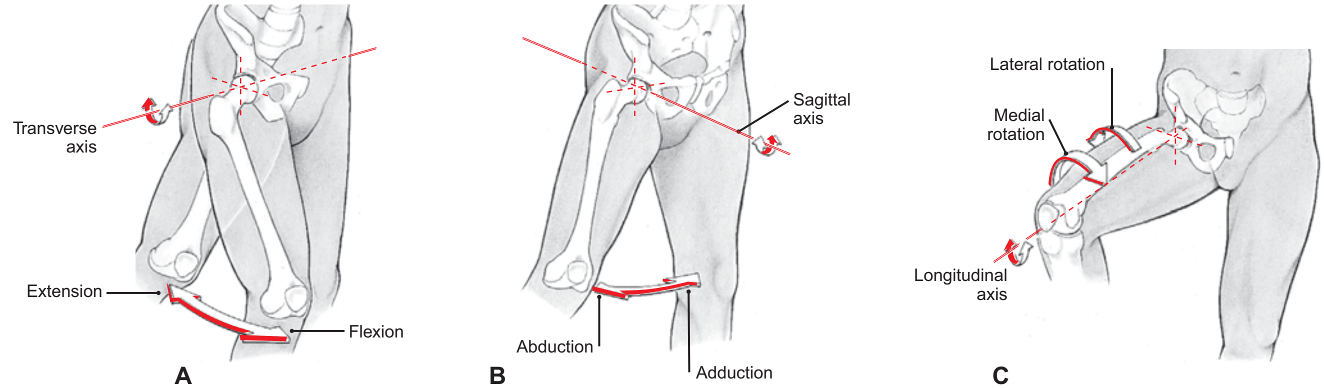


FIGURE 426 **Movements of the Thigh at the Hip Joint**

In **A, flexion** and **extension** occur through the transverse axis of the hip joint.
In **B, abduction** and **adduction** occur through the sagittal axis of the hip joint.
In **C, medial rotation** and **lateral rotation** occur around the longitudinal axis of the hip joint.

ANTERIOR MUSCLES OF THE HIP

Muscle	Origin	Insertion	Innervation	Action
Rectus femoris head of the quadriceps femoris	Straight head: Anterior inferior iliac spine Reflected head: The groove above the acetabulum	With the other three parts of the quadriceps femoris, the rectus forms a common tendon that encases the patella and inserts onto the tibial tuberosity	Femoral nerve (L2, L3, L4)	All four parts extend the leg at the knee joint; the rectus femoris also helps flex the thigh at the hip joint
Psoas major	Transverse process and body of T12 and upper four lumbar vertebrae; intervertebral disks between T12 and L5	Lesser trochanter of femur (also receives the fibers of iliacus muscle)	Branches from upper four lumbar nerves	Powerful flexor of thigh at hip; when femurs are fixed, they flex the trunk, as in sitting up from a supine position
Psoas minor (muscle present in about 40% of cadavers)	Lateral surface of bodies of T12 and L1 vertebrae	Pectineal line and iliopectineal eminence and the iliac fascia (often merges with psoas major tendon)	Branch from L1 nerve	Weak flexor of the trunk
Iliacus	Iliac fossa; anterior inferior iliac spine	Lesser trochanter of femur in common with tendon of psoas major muscle	Femoral nerve (L2, L3)	Powerful flexor of thigh at the hip joint

ANTERIOR THIGH MUSCLES

Muscle	Origin	Insertion	Innervation	Action
Sartorius	Anterior superior iliac spine	Superior part of the medial surface of the tibia	Femoral nerve (L2, L3)	Flexes, abducts, and laterally rotates the thigh at the hip joint; flexes and medially rotates the leg at the knee joint
Quadriceps femoris muscle **Rectus femoris**	Straight head: Anterior inferior iliac spine Reflected head: the groove above the acetabulum	All four parts of the quadriceps femoris form a common tendon that encases the patella and finally inserts onto the tibial tuberosity	Femoral nerve (L2, L3, L4)	All four parts extend the leg at the knee joint; the rectus femoris also helps flex the thigh at the hip joint
Vastus medialis	Intertrochanteric line and the medial lip of the linea aspera on the femur			
Vastus lateralis	Greater trochanter and the lateral lip of the linea aspera			
Vastus intermedius	Anterior and lateral surface of the body of the femur			
Articularis genu	Anterior surface of the lower part of the femur	Upper part of the synovial membrane of the knee joint	Femoral nerve (L2, L3, L4)	Draws the synovial membrane upward during extension of the leg to prevent its compression

MEDIAL THIGH MUSCLES Muscle	Origin	Insertion	Innervation	Action
Pectineus	Pectineal line of the pubis	Along the pectineal line of the femur, between the lesser trochanter and the linea aspera	Femoral nerve (L2, L3); may also receive a branch from the obturator or the accessory obturator nerve when present	Flexes, adducts, and medially rotates the femur
Adductor longus	From the anterior pubis, where the pubic crest joins the symphysis pubis	Middle third of the femur along the linea aspera	Obturator nerve (L2, L3, L4)	Adducts, flexes, and medially rotates the femur
Adductor brevis	Outer surface of the inferior pubic ramus between the gracilis and the obturator externus	Along the pectineal line of the femur and the upper part of the linea aspera behind the pectineus	Obturator nerve (L2, L3, L4)	Adducts, flexes, and medially rotates the femur
Adductor magnus	Inferior ramus of pubis; ramus of the ischium and the ischial tuberosity	Medial lip of the upper two-thirds of the linea aspera; the medial supracondylar line and the adductor tubercle	Obturator nerve (L2, L3, L4): sciatic nerve (tibial division) for the hamstring part of the muscle	Powerful adductor of the thigh; upper part flexes and medially rotates the thigh; lower part extends and laterally rotates the thigh
Adductor minimus	The upper more horizontal part of the adductor magnus, which receives the name adductor minimus when it forms a distinct muscle			
Gracilis	From the body of the pubis and the adjacent inferior pubic ramus	Upper part of the medial surface of the tibia below the medial condyle	Obturator nerve (L2, L3)	Adducts the thigh; also flexes the leg at the knee and medially rotates the leg
Obturator externus	Medial part of the outer surface of obturator membrane and medial margin of obturator foramen	Trochanteric fossa of the femur	Obturator nerve (L3, L4)	Laterally rotates the thigh

LATERAL THIGH MUSCLE Muscle	Origin	Insertion	Innervation	Action
Tensor fasciae latae	Outer lip of the iliac crest; also from the anterior superior iliac spine	Iliotibial tract, which then descends to attach to the lateral condyle of the tibia	Superior gluteal nerve (L4, L5)	Abducts, flexes, and medially rotates the thigh; tenses the iliotibial tract, thereby helping extend the leg at the knee

POSTERIOR THIGH MUSCLES Muscle	Origin	Insertion	Innervation	Action
Biceps femoris	Long head: Ischial tuberosity in common with other hamstring muscles, Short head: Lateral lip of the linea aspera of the femur	Lateral surface of the head of the fibula and a small slip to lateral condyle of the tibia	Long head: Tibial part of sciatic nerve (S1, S2, S3) Short head: Common fibular part sciatic nerve (L5, S1, S2)	Flexes the leg and rotates the tibia laterally; long head also extends the thigh at the hip joint
Semitendinosus	Ischial tuberosity in common with other hamstring muscles	Medial surface of the upper part of the body of the tibia	Tibial part of the sciatic nerve (L5, S1, S2)	Flexes the leg and rotates the tibia medially; extends the thigh
Semimembranosus	Ischial tuberosity in common with other hamstring muscles	Posterior aspect of the medial condyle of the tibia	Tibial part of the sciatic nerve (L5, S1, S2)	Flexes the leg and rotates it medially; extends the thigh

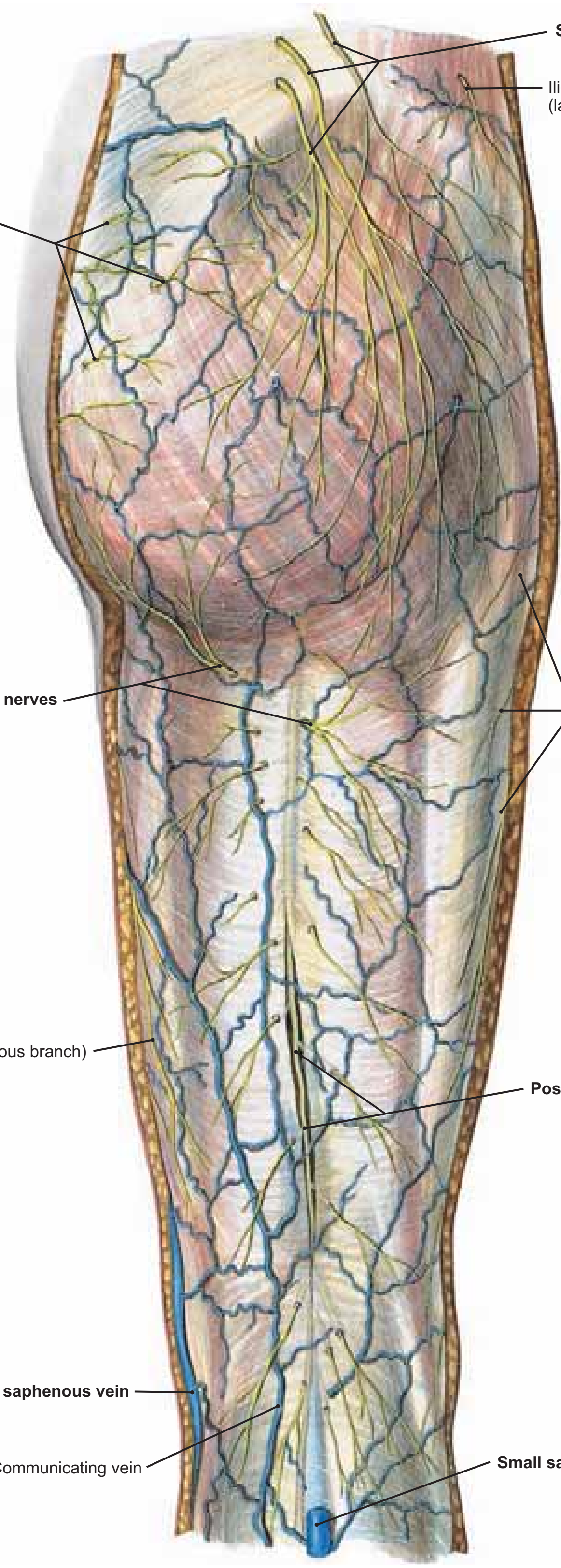


FIGURE 428 Superficial Veins and Nerves of the Gluteal Region and Posterior Thigh

NOTE: (1) The principal cutaneous nerves supplying the **gluteal region** are the:

(a) **Superior cluneal nerves** (from the posterior primary rami of L1, L2, L3),

(b) **Medial cluneal nerves** (from the posterior primary rami of S1, S2, S3), and

(c) **Inferior cluneal nerves** (from the posterior femoral cutaneous nerve: anterior primary rami of S1, S2, S3).

(2) The skin of the **posterior thigh** is supplied primarily by the **posterior femoral cutaneous nerve (S1, S2, S3),** but posterolaterally it also receives branches from the lateral femoral cutaneous nerve, and posteromedially, cutaneous branches from the obturator nerve.

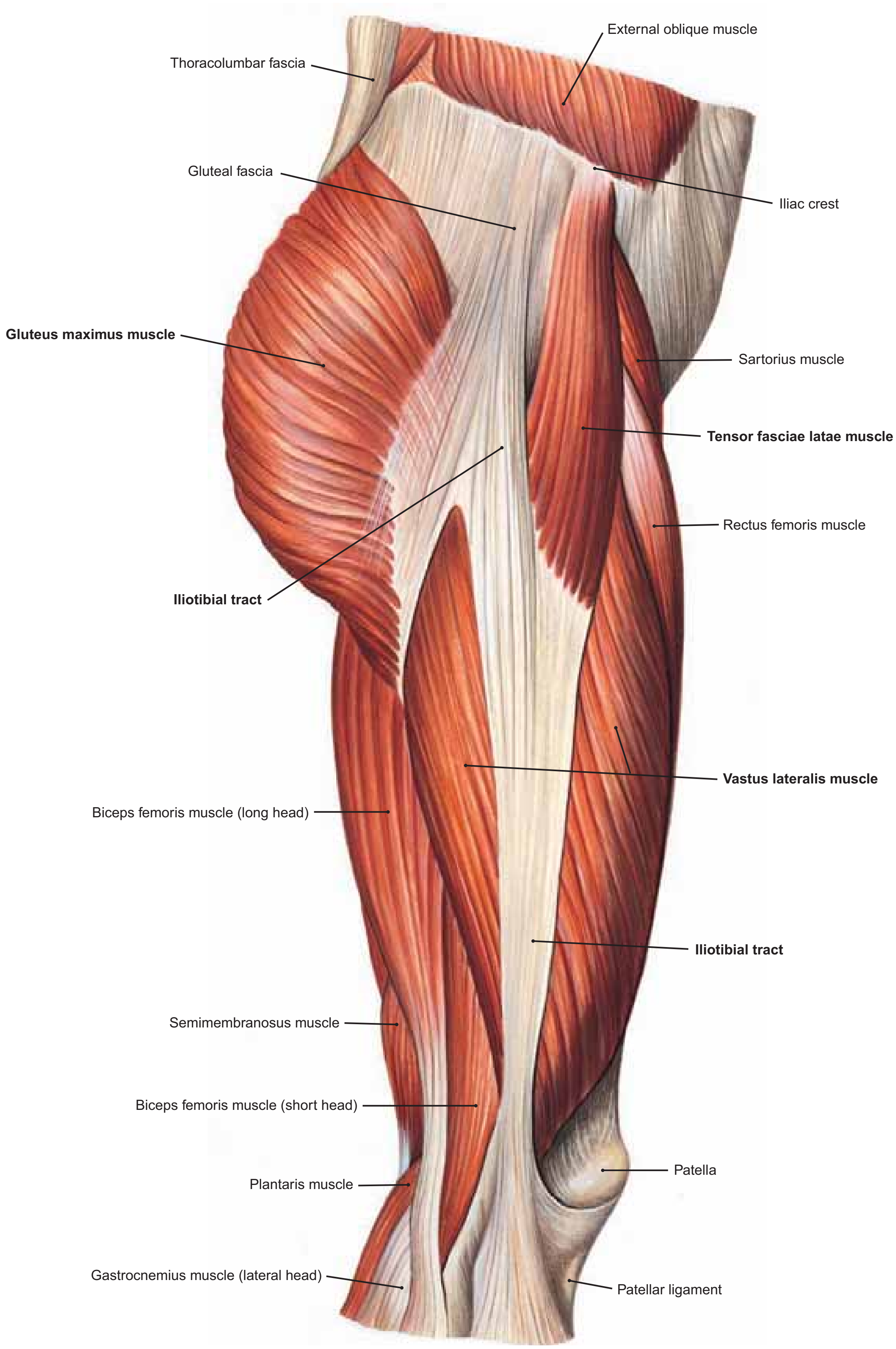


FIGURE 429 **Superficial Thigh and Gluteal Muscles (Lateral View)**

NOTE: (1) The massive size of the **vastus lateralis, biceps femoris,** and **gluteus maximus muscles** is seen from this lateral side.

(2) The **iliotibial tract** (or band) stretches, superficially, the length of the thigh. Its muscle, the **tensor fasciae latae,** helps keep the dense fascia lata taut.

(3) The fascia lata is a very tight layer of deep fascia that surrounds the thigh muscles (see Fig. 414.2). Because of this, the tensor fasciae latae assists in extension of the leg at the knee joint and in helping maintain an erect posture.

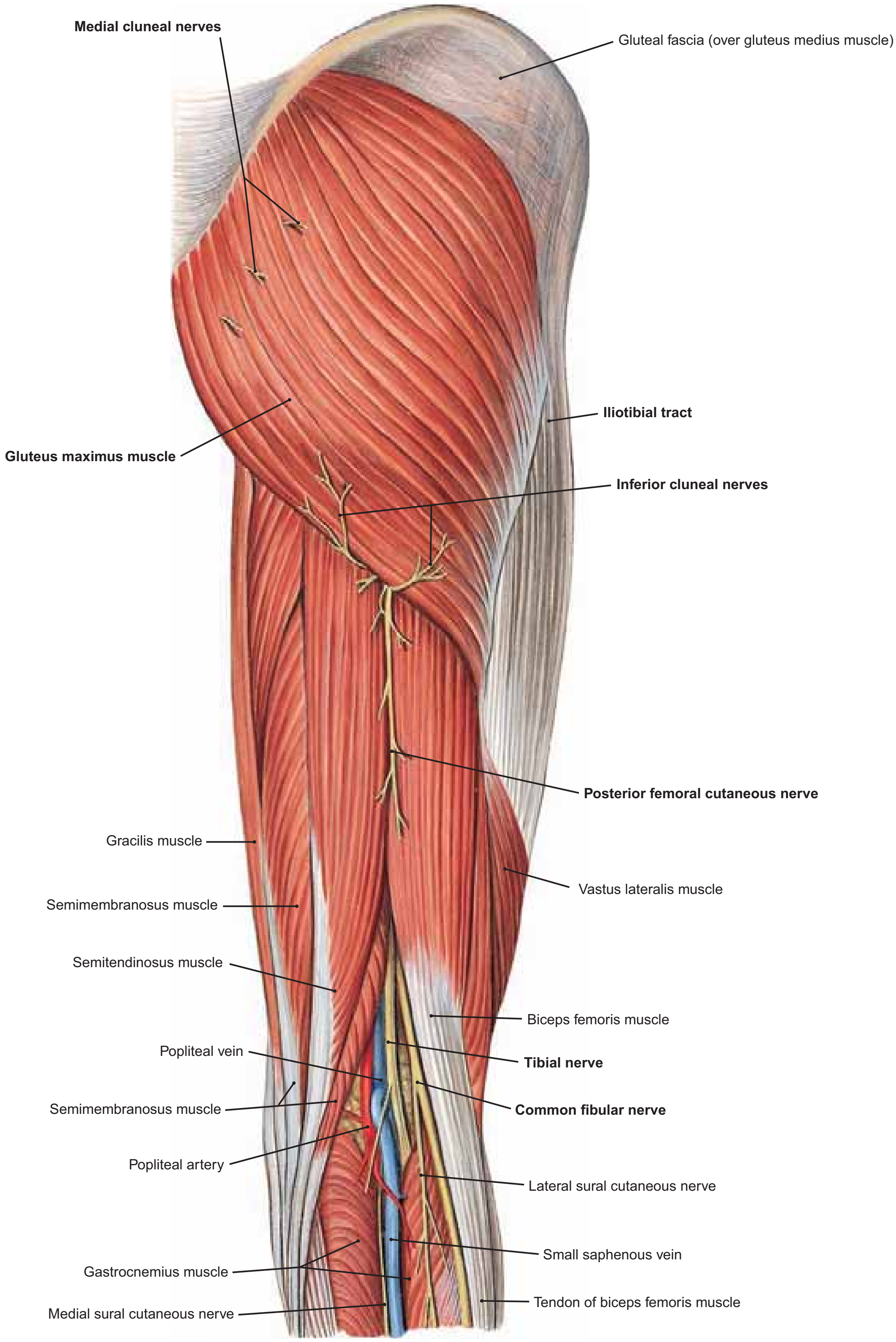


FIGURE 430 Hamstring Muscles of Posterior Thigh and Gluteus Maximus (Superficial Dissection)

NOTE: (1) The emergence of the posterior femoral cutaneous nerve below the inferior border of the gluteus maximus muscle, and its descent down the middle of the thigh.

(2) The appearance of the major vessels (popliteal artery and vein) and the sciatic nerve (tibial and common fibular nerves) in the popliteal fossa.

(3) The posterior thigh contains the **hamstring muscles.** These include four muscles, the **long head of the biceps femoris,** the **semitendinosus muscle,** the **semimembranosus muscle,** and the ischiocondylar part of the **adductor magnus muscle.**

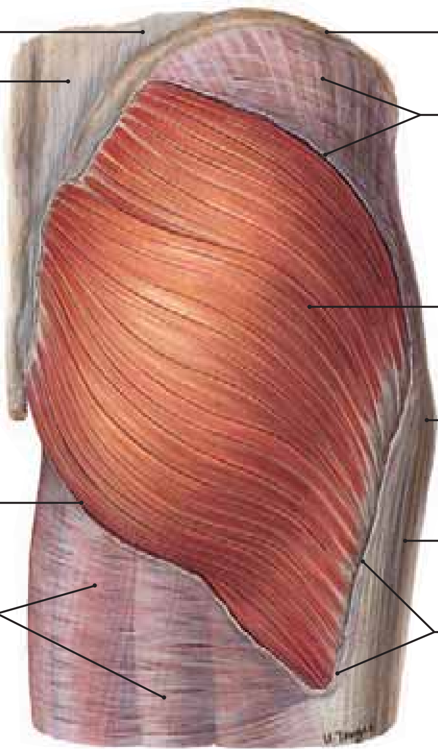


FIGURE 431.1 **Right Gluteus Maximus Muscle (Posterior View)**

NOTE: (1) The gluteus maximus muscle forms the contour of the buttocks. It arises from the posterior gluteal line of the ilium and the posterior surfaces of the sacrum, coccyx, and sacrotuberous ligament.

(2) The muscle fibers extend inferolaterally and end in a broad tendon that crosses the greater trochanter to insert on the iliotibial band of the fascia lata and the gluteal tuberosity of the femur.

(3) While the gluteus maximus is a powerful extensor and lateral rotator of the thigh, its upper fibers abduct the thigh and its lower fibers adduct the thigh.

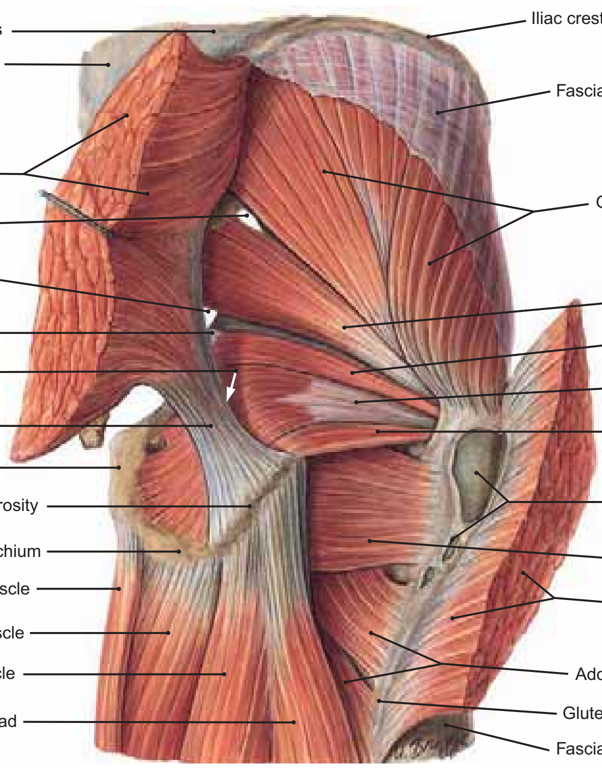


FIGURE 431.2 **Deep Muscles of the Gluteal and Hip Regions (Posterior View)**

NOTE: (1) Deep to the gluteus maximus are found the gluteus medius, gluteus minimus, piriformis, the two gemellus muscles (superior and inferior), the obturator internus, and the quadratus femoris.

(2) The gluteus medius (and the gluteus minimus deep to the medius) are abductors and **medial** rotators, while the other gluteal muscles are also abductors, but they are **lateral** rotators of the thigh. The piriformis also helps abduct the flexed thigh.

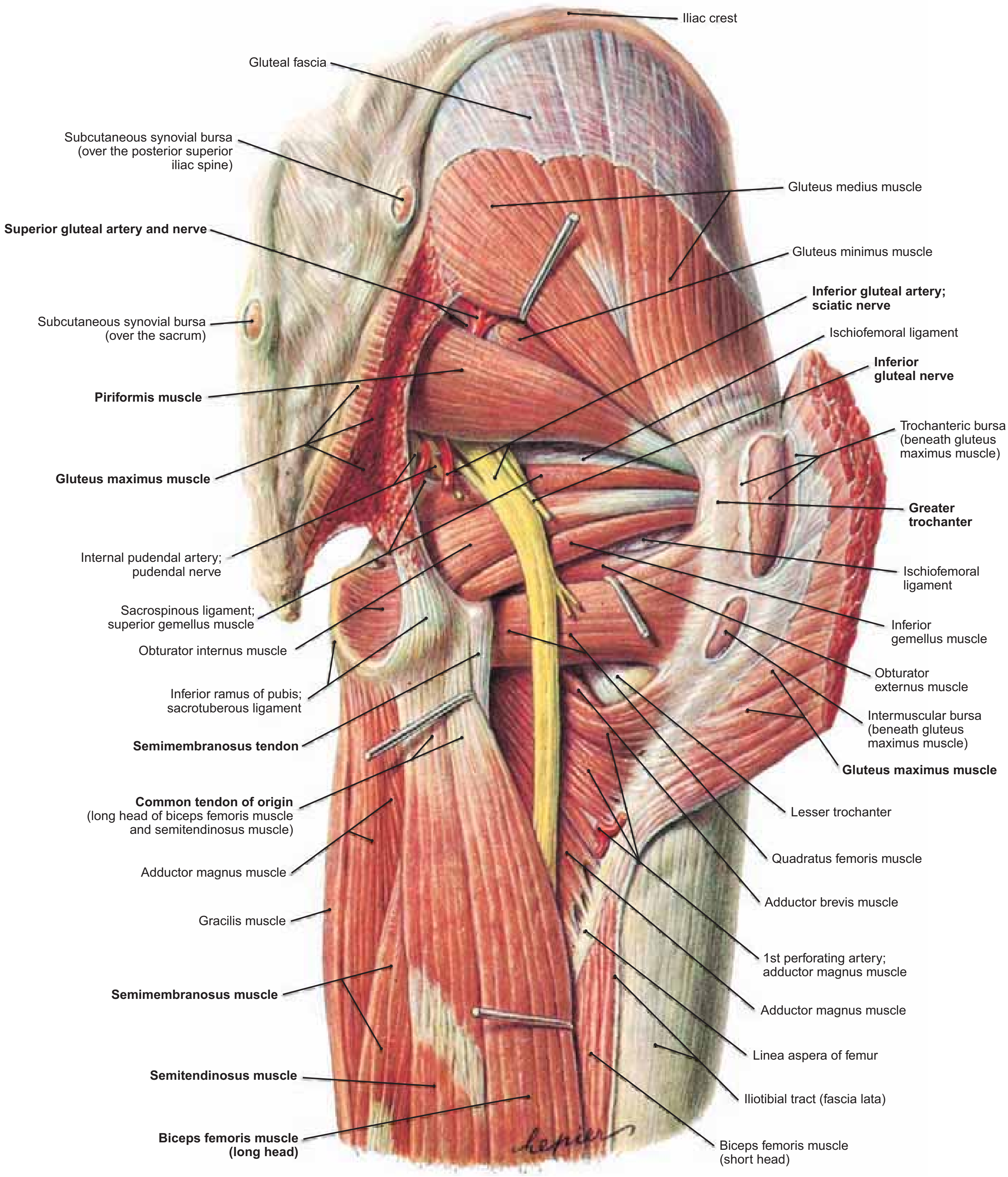


FIGURE 432 Middle and Deep Gluteal Muscles and the Sciatic Nerve

NOTE: (1) The gluteus maximus has been reflected to show the centrally located **piriformis muscle,** which is the key structure in understanding the anatomy of this region.

(2) The piriformis muscle, as do most other structures that leave the pelvis to enter the gluteal region, passes through the **greater sciatic foramen.** The nerves and vessels enter the gluteal region from the pelvis either above or below the piriformis muscle. The important **sciatic nerve** enters the gluteal region **below** the piriformis.

(3) In addition to the piriformis, observe the **gluteus medius, the obturator internus,** with two **gemelli** above and below it, and the **quadratus femoris** muscles. The gluteus medius and minimus muscles are abductors and medial rotators of the thigh and all the other muscles are lateral rotators.

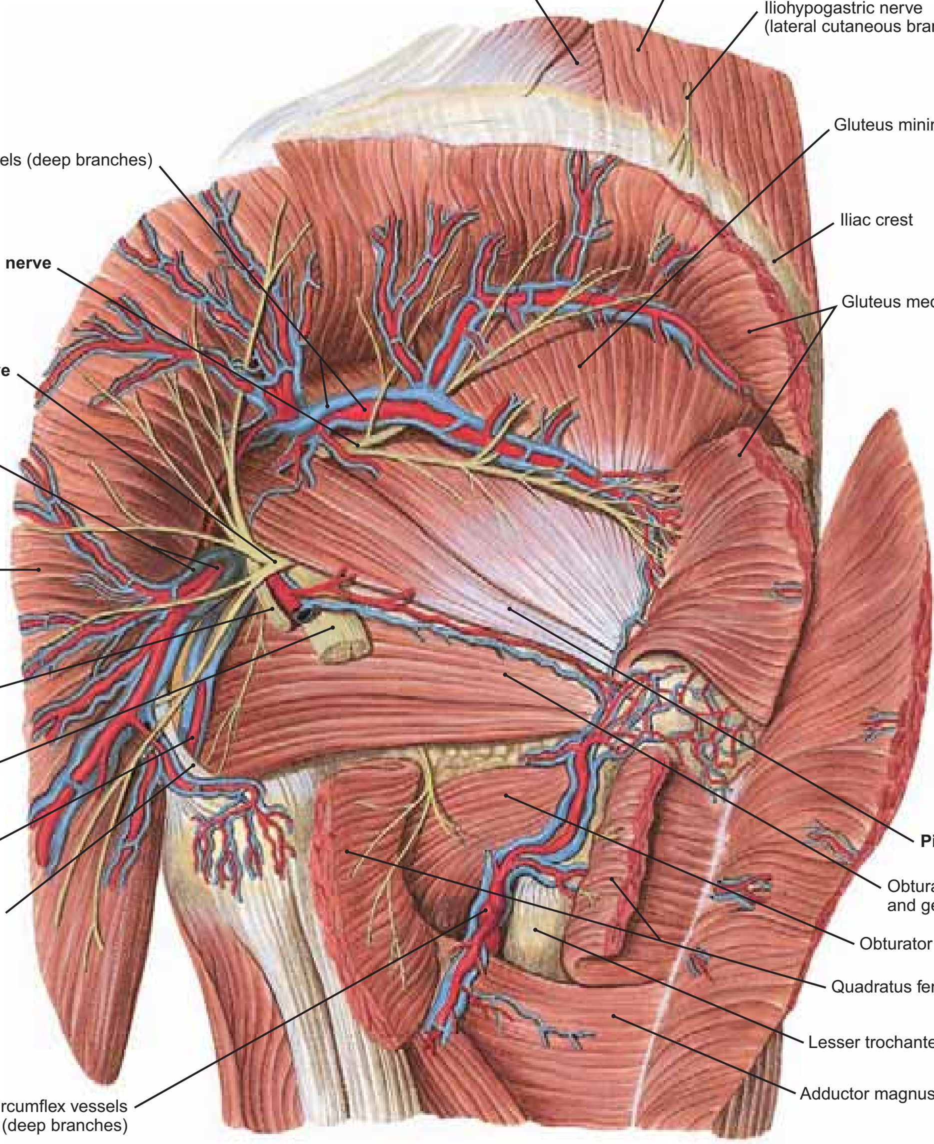


FIGURE 433 Deep Vessels and Nerves of the Gluteal Region

NOTE: (1) The gluteus maximus and gluteus medius muscles and the sciatic nerve have been cut to expose the short lateral rotators and the **gluteus minimus muscle**.

(2) **Above the piriformis** the **superior gluteal artery, vein,** and **nerve** enter the gluteal region through the greater sciatic foramen; **below the piriformis** the following structures enter the gluteal region by way of the greater sciatic foramen: the **inferior gluteal vessels** and **nerve,** the **sciatic nerve,** the **nerve to the obturator internus muscle,** the **posterior femoral cutaneous nerve,** the **nerve to the quadratus femoris muscle,** and the **internal pudendal vessels** and **pudendal nerve.**

(3) The internal pudendal artery and vein and the pudendal nerve, after entering the gluteal region through the greater sciatic foramen, cross the sacrospinous ligament and reenter the pelvis through the **lesser sciatic foramen** and course in the pudendal canal to get to the perineum. The other structure that passes through the lesser sciatic foramen is the **tendon of the obturator internus muscle.**

(4) To separate the gluteus medius muscle from the gluteus minimus muscle as shown in this figure, dissect along the course of the superior gluteal vessels and nerve, since these structures lie in the plane between the medius and minimus.

Chart of Gluteal Muscles; Safe Zone for Gluteal Injections

MUSCLES OF THE GLUTEAL REGION

Muscle	Origin	Insertion	Innervation	Action
Gluteus maximus	Outer surface of the ilium and iliac crest; dorsal surface of the sacrum; lateral side of coccyx and the sacrotuberous ligament	Into the iliotibial band, which then descends to attach to the lateral condyle of tibia; also onto the gluteal tuberosity of the femur	Inferior gluteal nerve (L5, S1, S2)	Powerful extensor of the thigh; lateral rotator of the thigh; helps steady the extended leg; extends the trunk when distal end is fixed
Gluteus medius	External surface of the ilium between the anterior and posterior gluteal lines	Lateral surface of greater trochanter of the femur	Superior gluteal nerve (L4, L5, S1)	Abducts and medially rotates the thigh; helps steady the pelvis
Gluteus minimus	Outer surface of ilium between the anterior and inferior gluteal lines	Anterior border of greater trochanter and on the fibrous capsule of the hip joint	Superior gluteal nerve (L4, L5, S1)	Abducts and medially rotates the thigh; helps steady the pelvis
Piriformis	Anterior (pelvic) surface of the sacrum and the inner surface of sacrotuberous ligament	Upper border of the greater trochanter of the femur	Muscular branches from the S1 and S2 nerves	Laterally rotates the extended thigh; when the thigh is flexed, it abducts the femur
Obturator internus	Pelvic surface of obturator membrane and from the bone surrounding the obturator foramen	Medial surface of greater trochanter proximal to the trochanteric fossa	Nerve to the obturator internus (L5, S1)	Laterally rotates the extended thigh and abducts the flexed thigh
Superior gemellus	Outer surface of the ischial spine	Medial surface of greater trochanter with tendon of the obturator interius	Nerve to the obturator internus (L5, S1)	Laterally rotates the extended thigh and abducts the flexed thigh
Inferior gemellus	From the ischial tuberosity	Medial surface of greater trochanter with tendon of the obturator internus	Nerve to the quadratus femoris (L5, S1)	Laterally rotates the extended thigh and abducts the flexed thigh
Quadratus femoris	Lateral border of the ischial tuberosity	Quadrate tubercle on the posterior surface of the femur; also onto the intertrochanteric crest of the femur	Nerve to the quadratus femoris (L5, S1)	Laterally rotates the thigh

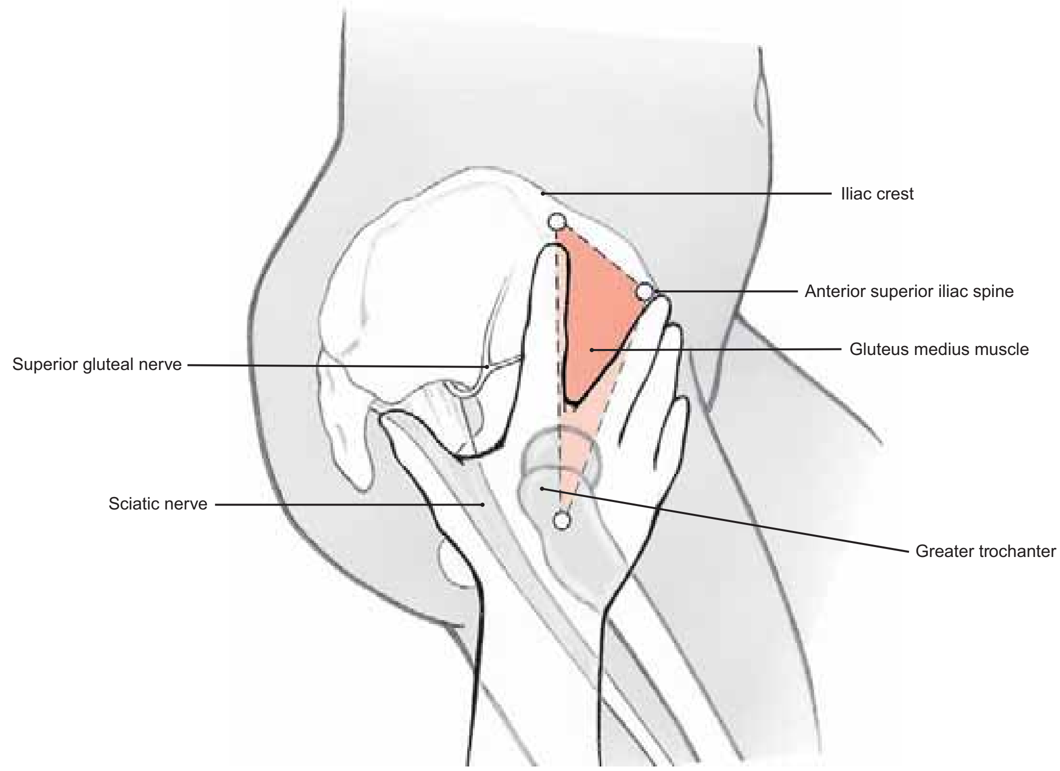


FIGURE 434 Quick Method of Determining the Safe Zone for Intramuscular Gluteal Injection

NOTE: The safe zone can be visualized quickly by:

(1) Placing the palm of the right hand over the right greater trochanter (or left hand over the left greater trochanter),

(2) Directing the index finger vertically to the iliac crest and spreading the middle finger to the anterior superior iliac spine,

(3) The colored region shown in this diagram between the index and middle fingers is the safe zone and avoids the superior gluteal vessels and nerve as well as the sciatic nerve and other important gluteal structures.

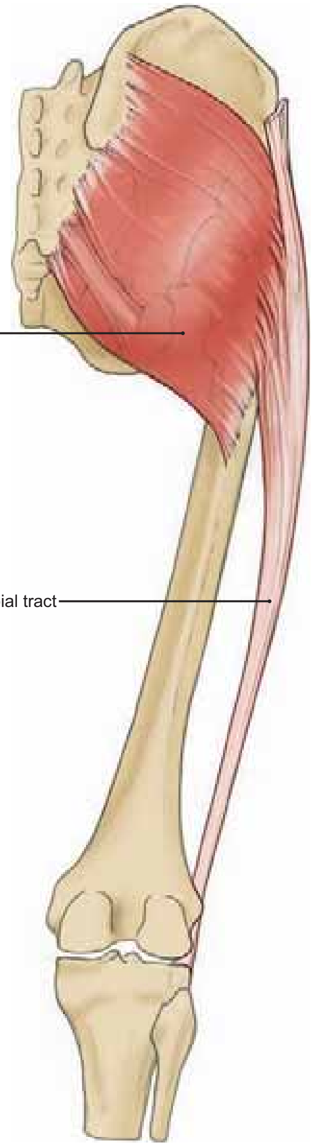
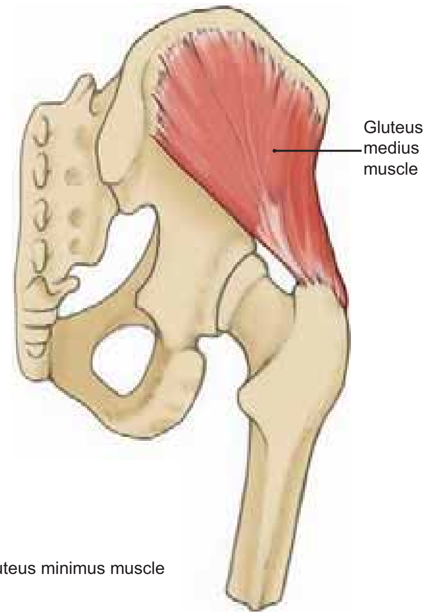


FIGURE 435.1 Gluteus Maximus ▲ and Iliotibial Tract

FIGURE 435.2 The Gluteus ▶ Medius Muscle



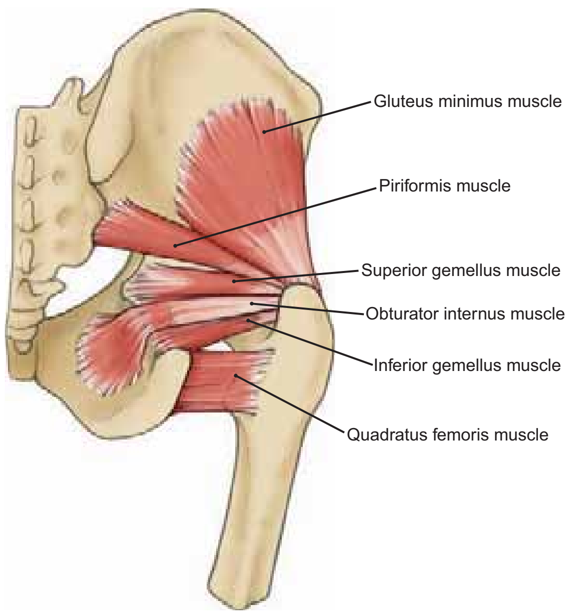


FIGURE 435.3 The Gluteus Minimus and ▲ the Lateral Rotators of the Femur

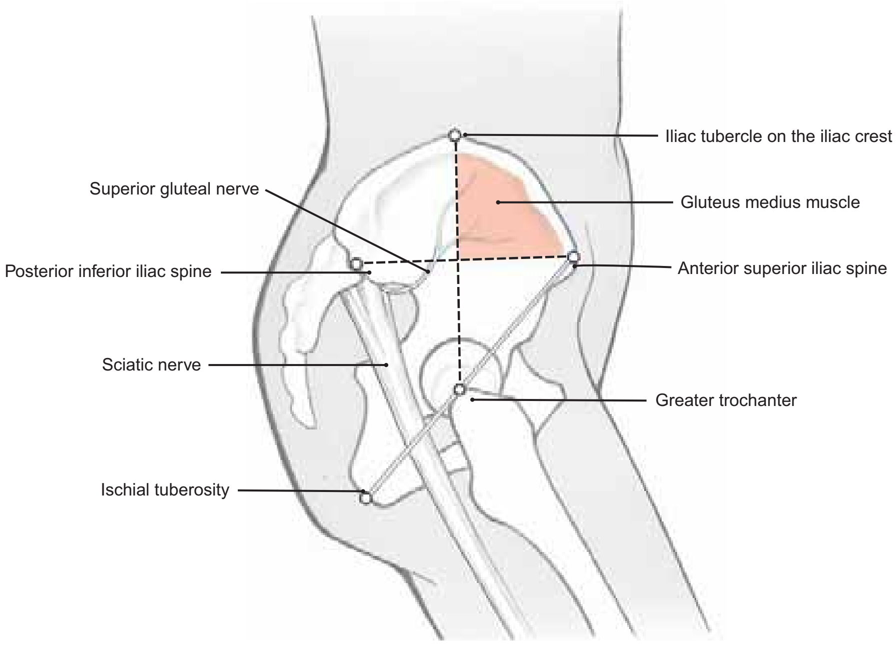


FIGURE 435.4 Safe Quadrant for Injections into the Gluteal Region

NOTE: In this figure the four quadrants of the gluteal region are determined by a **transverse line** between the **anterior superior iliac spine** anteriorly and the **posterior inferior iliac spine** posteriorly that intersects a **vertical line** between the **greater trochanter** inferiorly and the **iliac crest** superiorly. The colored upper lateral quadrant is the safe zone for intramuscular injection.

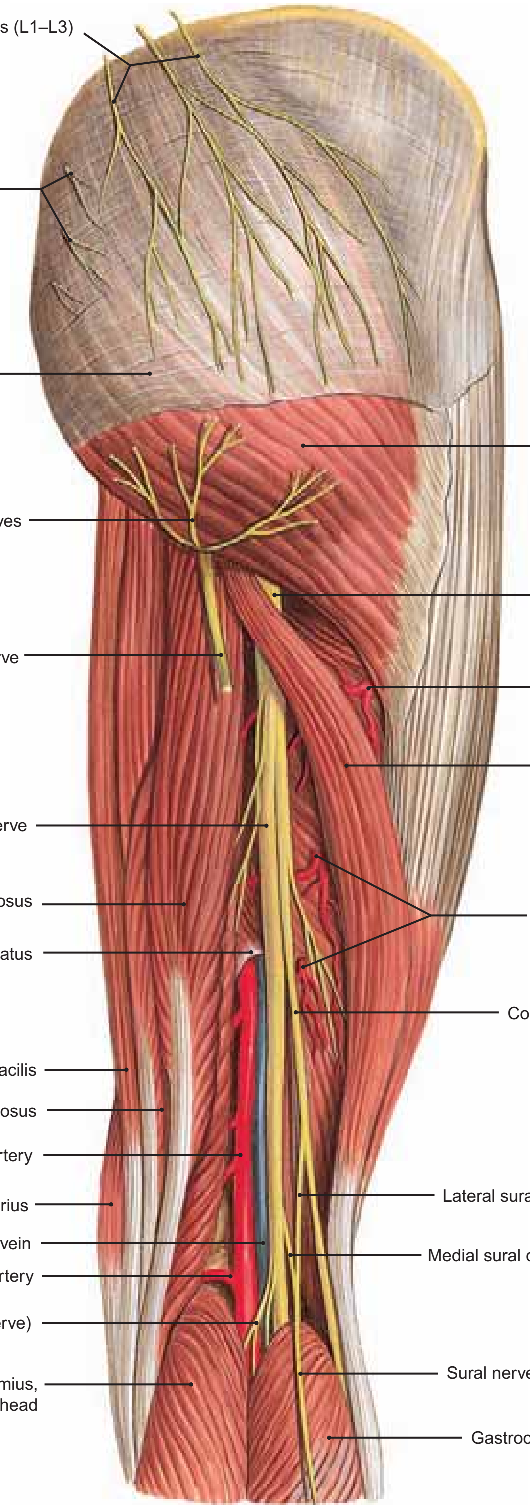


FIGURE 436 Descent of the Sciatic Nerve from the Gluteus Maximus to the Popliteal Fossa; the Popliteal Vessels

POSTERIOR THIGH MUSCLES

Muscle	Origin	Insertion	Innervation	Function
Biceps femoris	Long head: Ischial tuberosity in common with other hamstring muscles Short head: Lateral lip of the linea aspera of the femur	Lateral surface of the head of the fibula and a small slip to lateral condyle of tibia	Long head: Tibial part of sciatic nerve (S1, S2, S3) Short head: Peroneal part of the sciatic nerve (L5, S1, S2)	Flexes the leg and rotates the tibia laterally; long head also extends the thigh at the hip joint
Semitendinosus	Ischial tuberosity in common with other hamstring muscles	Medial surface of the upper part of the body of the tibia	Tibial part of the sciatic nerve (L5, S1, S2)	Flexes the leg and rotates the tibia medially; extends the thigh
Semimembranosus	Ischial tuberosity in common with other hamstring muscles	Posterior aspect of the medial condyle of the tibia	Tibial part of the sciatic nerve (L5, S1, S2)	Flexes the leg and rotates it medially; extends the thigh

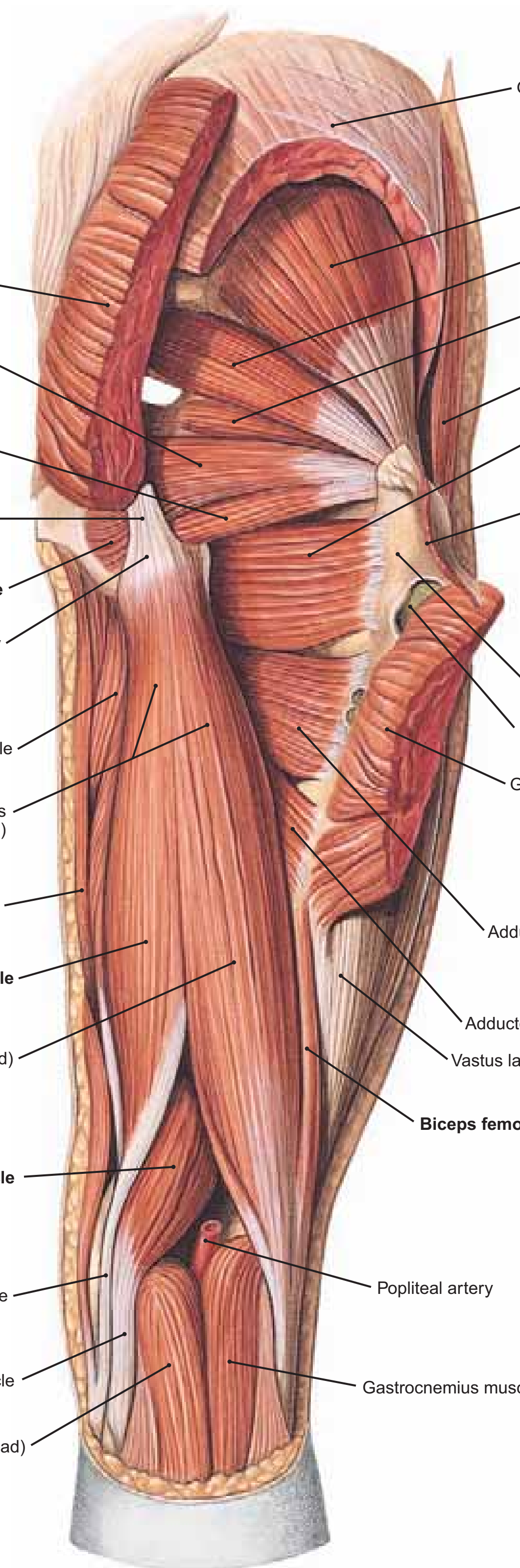


FIGURE 437 **Hamstring Muscles of Posterior Thigh and Deep Muscles of Gluteal Region**

NOTE: (1) For a muscle to be considered a **hamstring muscle,** it must:
- (a) arise from the **ischial tuberosity,**
- (b) receive innervation from the **tibial division of the sciatic nerve,** and
- (c) cross **both** the hip and knee joints.

(2) The long head of the biceps is a hamstring, but the short head is not, because it arises from the femur and is supplied by the common fibular division of the sciatic nerve.

(3) The **ischiocondylar part** of the adductor magnus meets two criteria as a hamstring but crosses only the hip joint. Its insertion, however, on the adductor tubercle is embryologically continuous with the tibial collateral ligament, which does attach below on the tibia.

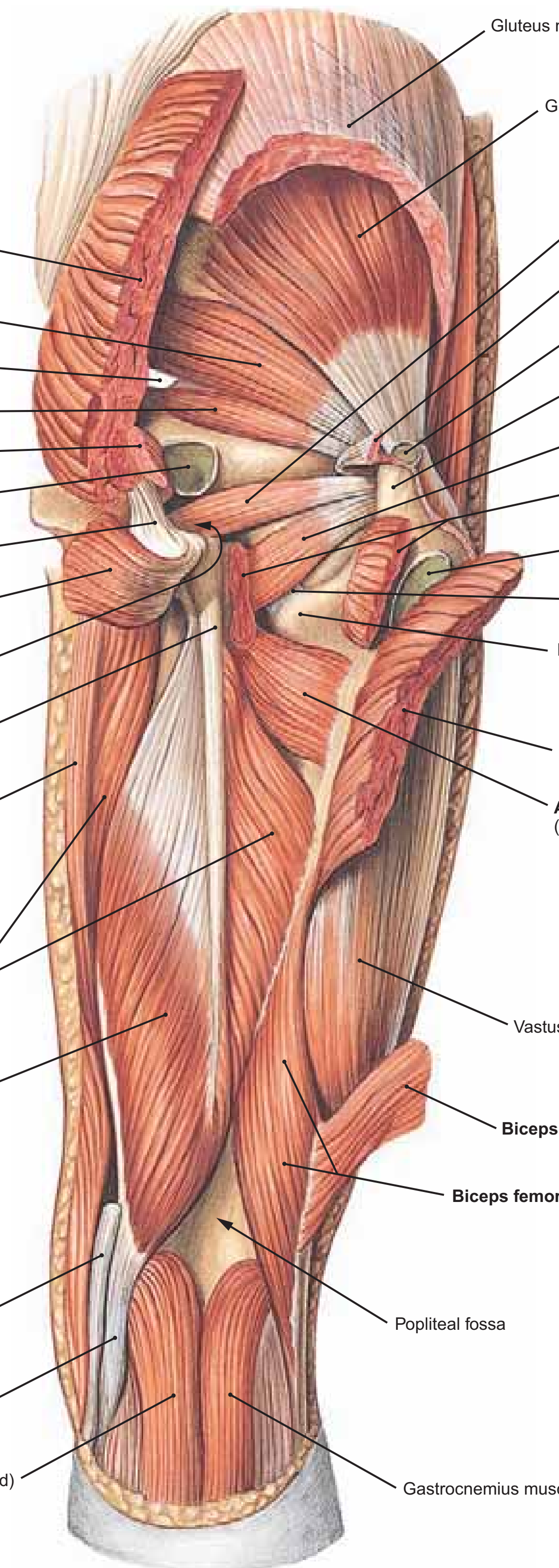


FIGURE 438 Hamstring Muscles of Posterior Thigh (Deep Dissection) and Deep Gluteal Muscles

NOTE: (1) The common tendon of the long head of the biceps femoris and semitendinosus muscles has been cut in the thigh close to the ischial tuberosity. This exposes the origin of the **semimembranosus muscle,** the breadth of the **adductor magnus muscle,** and the **short head of the biceps femoris muscle.**

(2) The **short head of the biceps femoris muscle** arising from the lateral lip of the linea aspera of the femur, between the attachments of the vastus lateralis and the adductor magnus muscles. It descends to join the tendon of the long head before insertion.

(3) In the gluteal region, the quadratus femoris muscle has been severed and reflected, thereby revealing the **obturator externus muscle** beneath. Also, the tendon of the obturator internus muscle has been cut (between the gemelli) exposing the bursa deep to that tendon.

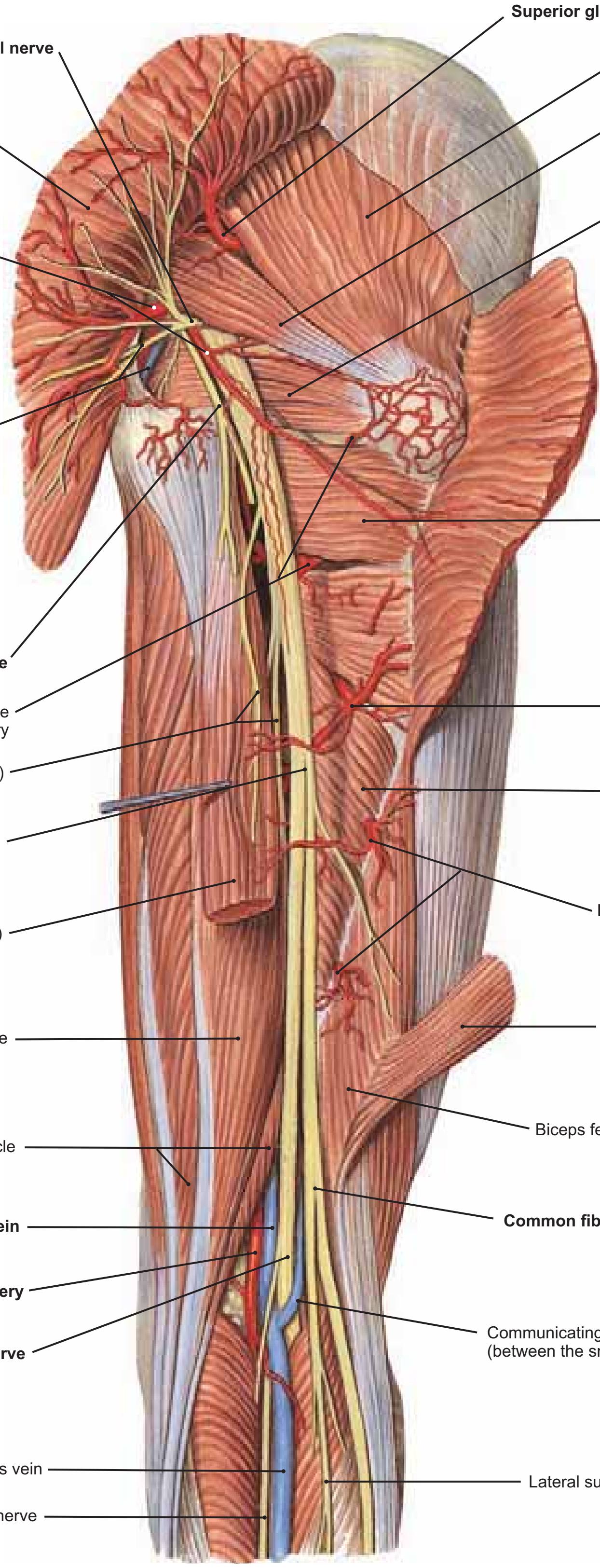


FIGURE 439 Vessels and Nerves of the Posterior Thigh and Gluteal Region (Deep Dissection)

NOTE: (1) The course of the **sciatic nerve** as it passes through the greater sciatic foramen in the gluteal region, inferior to the piriformis muscle, lateral to the ischial tuberosity and under cover of the gluteus maximus muscle. It enters the thigh nearly midway between the ischial tuberosity and the greater trochanter.

(2) The **superior and inferior gluteal arteries** and the **posterior femoral cutaneous nerve** in the gluteal region. In the thigh, observe the **perforating arteries,** branches of the **deep femoral artery,** and the fact that the sciatic nerve splits to become the **tibial and common fibular nerves.**

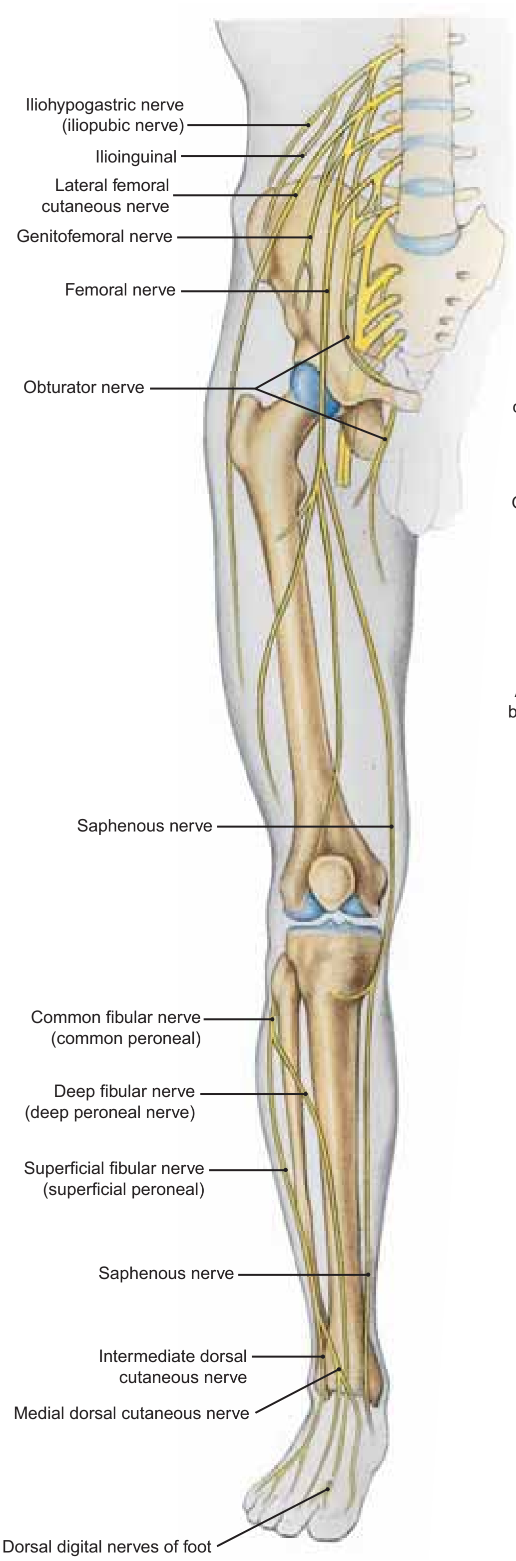


FIGURE 440.1 Nerves of the Lower Limb (Anterior Aspect)

NOTE: (1) The **femoral nerve** is the principal nerve of the anterior thigh, but the **obturator nerve** supplies muscles of the medial thigh.
(2) The **lateral femoral cutaneous nerve** (L2, L3) supplies the skin of the lateral thigh.
(3) The **saphenous nerve** (a sensory branch of the femoral nerve) supplies the skin of the medial leg.
(4) All **other branches** below the knee are derived from the **sciatic nerve.**

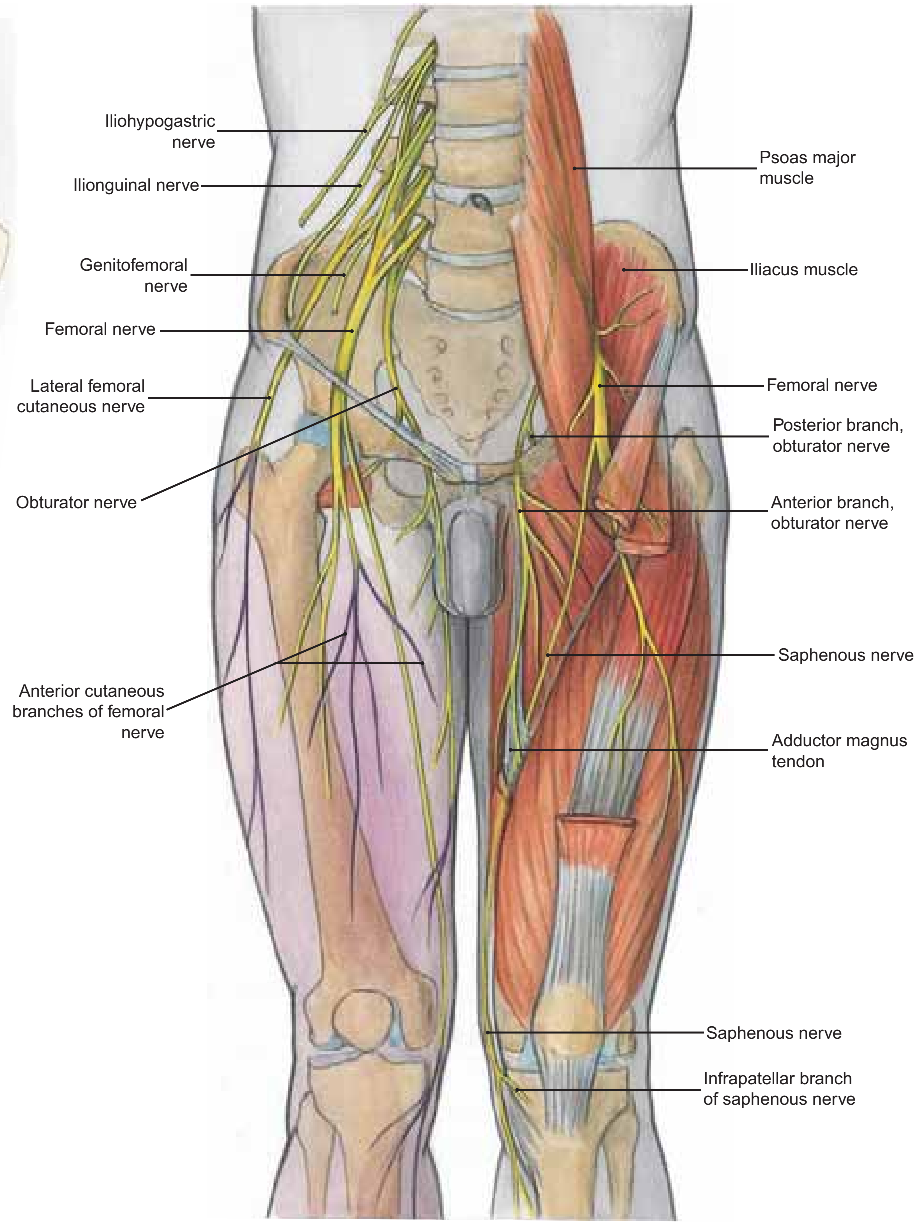


FIGURE 440.2 Diagrammatic Representation of the Femoral and Obturator Nerves

NOTE: Purple color indicates cutaneous innervation.

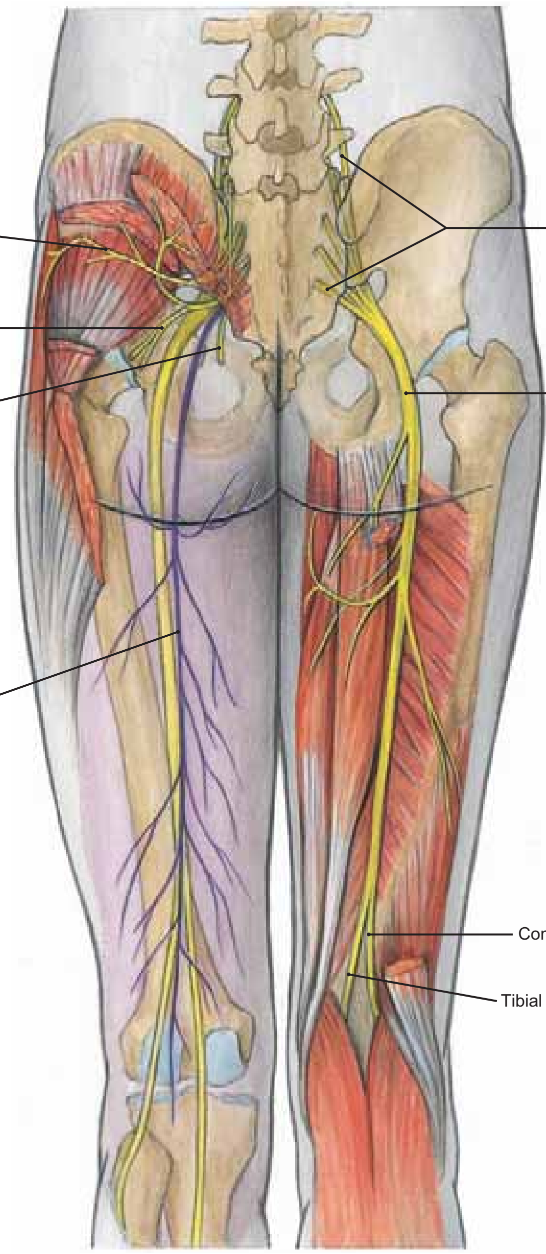


FIGURE 441.1 Diagrammatic Representation of the Sciatic and Posterior Femoral Cutaneous Nerves

NOTE: Purple color indicates cutaneous innervation.

FIGURE 441.2 Nerves of the Lower Limb (Posterior Aspect)

NOTE: (1) The **sciatic nerve** supplies the posterior thigh and all other structures below the knee *EXCEPT* the skin of the medial leg, which is supplied by the **saphenous nerve,** a branch of the **femoral nerve.**

(2) The **fibular nerves (superficial** and **deep)** supply all of the muscles of the leg and foot and the skin of the dorsal and plantar surfaces of the foot.

(3) The **common fibular nerve** divides into superficial and deep fibular branches as it courses around the head of the fibula (see Fig. 440.1).

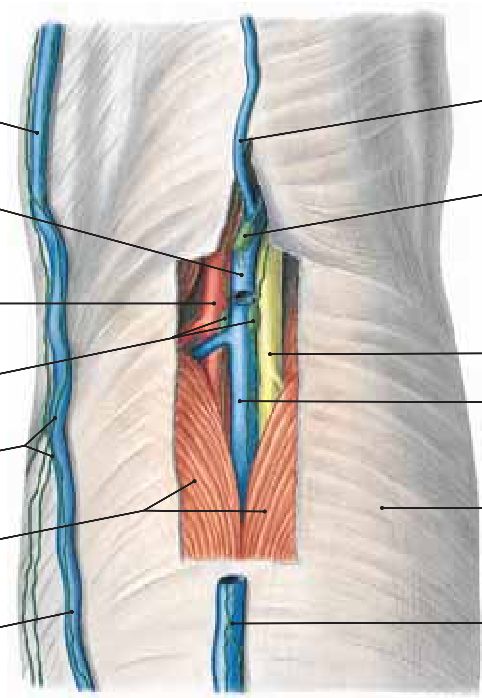


FIGURE 442.1 Subcutaneous Dissection of the Popliteal Fossa

NOTE: The skin and crural fascia have been removed over the popliteal fossa and a part of the small saphenous vein has been resected. Observe the popliteal vessels and nerves and the **popliteal lymphatic nodes** and **channels** deeper in the fossa.

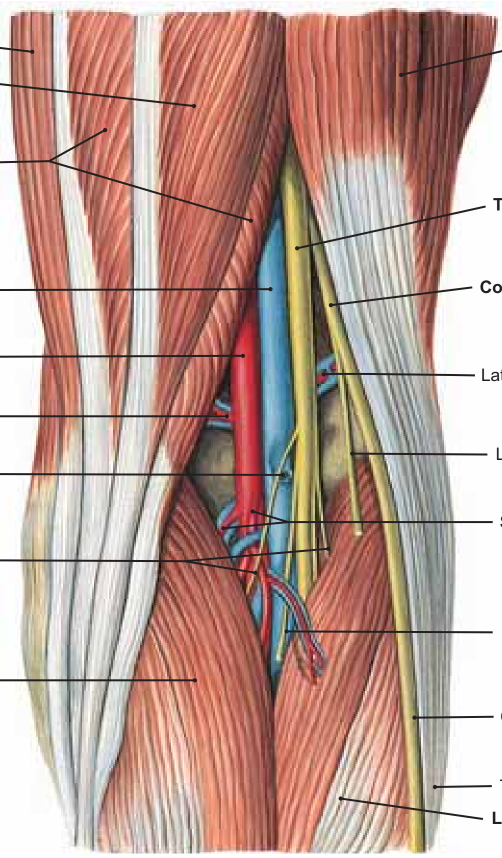


FIGURE 442.2 Nerves and Vessels of the Popliteal Fossa (Superficial View)

NOTE: (1) The relationships of the **popliteal vessels** and **nerve** within the popliteal fossa. The **sciatic nerve** has already divided into the laterally directed **common fibular nerve** and the **tibial nerve,** which continues directly into the calf. Both the common fibular and the tibial nerves lie superficial to the vessels in the popliteal fossa.

(2) The popliteal vein is located between the tibial nerve and popliteal artery, while the artery is the deepest (most anterior) and most medial of three structures.

(3) The two muscular branches of the tibial nerve innervating the two heads of the gastrocnemius muscle, and a descending sensory branch, the **medial sural cutaneous nerve,** to the calf. Also note the **lateral sural cutaneous nerve** from the common fibular nerve.

(4) The popliteal fossa is about 2.5 cm (1 in.) wide at its maximum, and in the undissected specimen, the fossa is filled with fat, and the vessels and nerves are initially difficult to see.

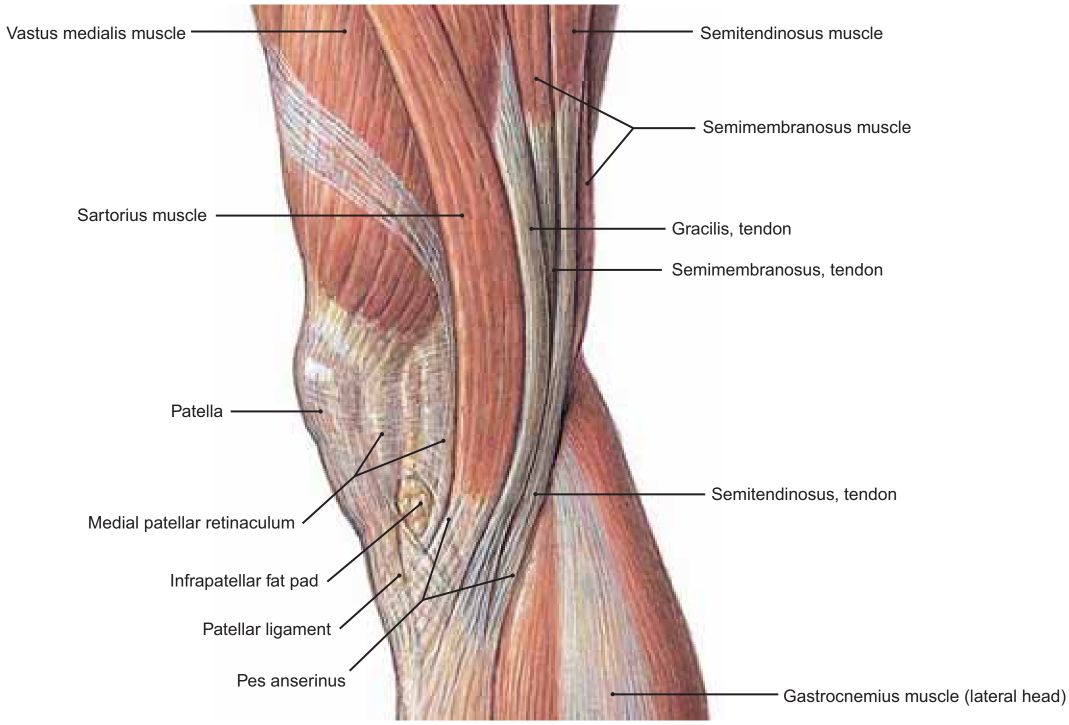


FIGURE 443.1 **Medial Surface of the Knee Region**

NOTE: The tendons of the sartorius, gracilis, and semitendinosus form the so-called pes anserinus (goose's foot). This formation of tendons strengthens the medial aspect of the knee joint.

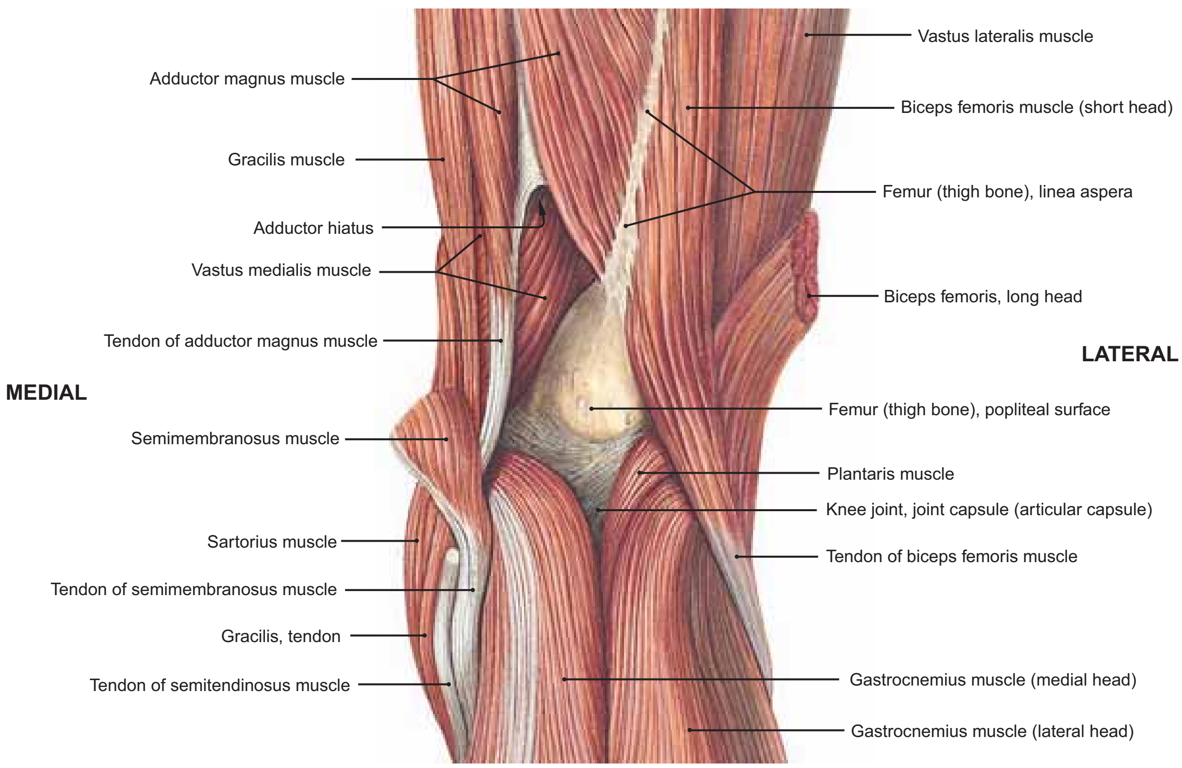


FIGURE 443.2 **Deep Muscles That Bound the Popliteal Fossa**

NOTE: (1) The **popliteal fossa** is a diamond-shaped space behind the knee joint. Its *superior boundaries* are the **long head of the biceps femoris muscle** laterally and the **semimembranosus** and **semitendinosus muscles** medially (see Fig. 442.2). All three of these muscles have been cut in this dissection, exposing the more deeply located **adductor magnus** and **vastus medialis** medially and the **short head of the biceps femoris** laterally.

(2) The *inferior boundaries* of the fossa are the **medial** and **lateral heads of the gastrocnemius muscle,** which arise from the medial and lateral condyles of the femur.

(3) The inferior opening of the **adductor canal** (the adductor hiatus), which transmits the **femoral artery** and **vein** from and to the anterior aspect of the thigh.

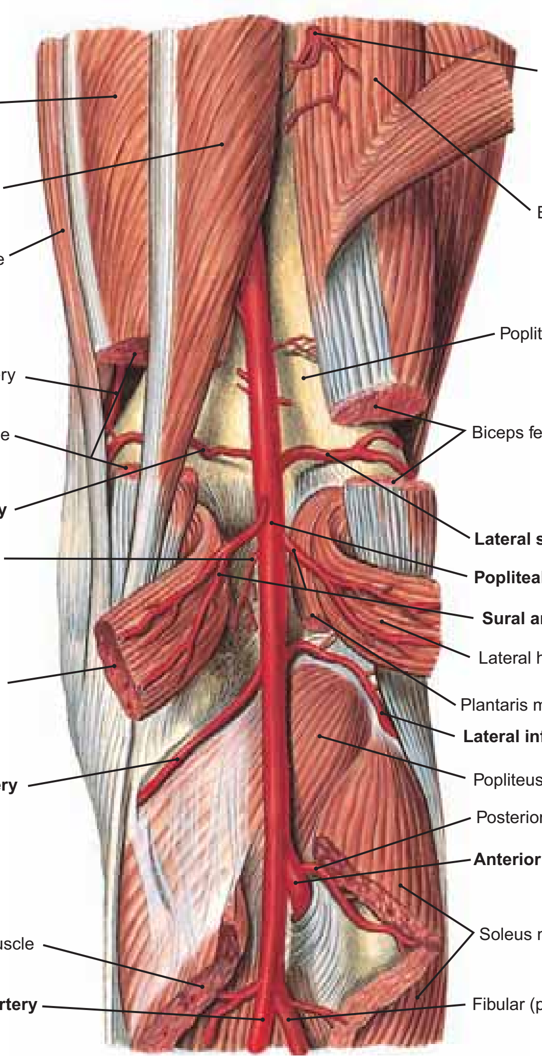


FIGURE 444.1 Branches of the Popliteal Artery

NOTE: (1) Within the popliteal fossa, the popliteal artery most frequently gives rise to two **superior (lateral** and **medial) genicular,** one **middle genicular,** and two **inferior (lateral** and **medial) genicular arteries.**

(2) The **popliteal artery** bifurcates into the **posterior tibial** and the **anterior tibial.** The latter penetrates an aperture above the interosseous membrane to reach the anterior compartment. Somewhat lower, the **fibular artery** branches from the posterior tibial. The pattern shown here occurs in about **90% of cases.** Variations in this pattern are shown in Figure 444.2.

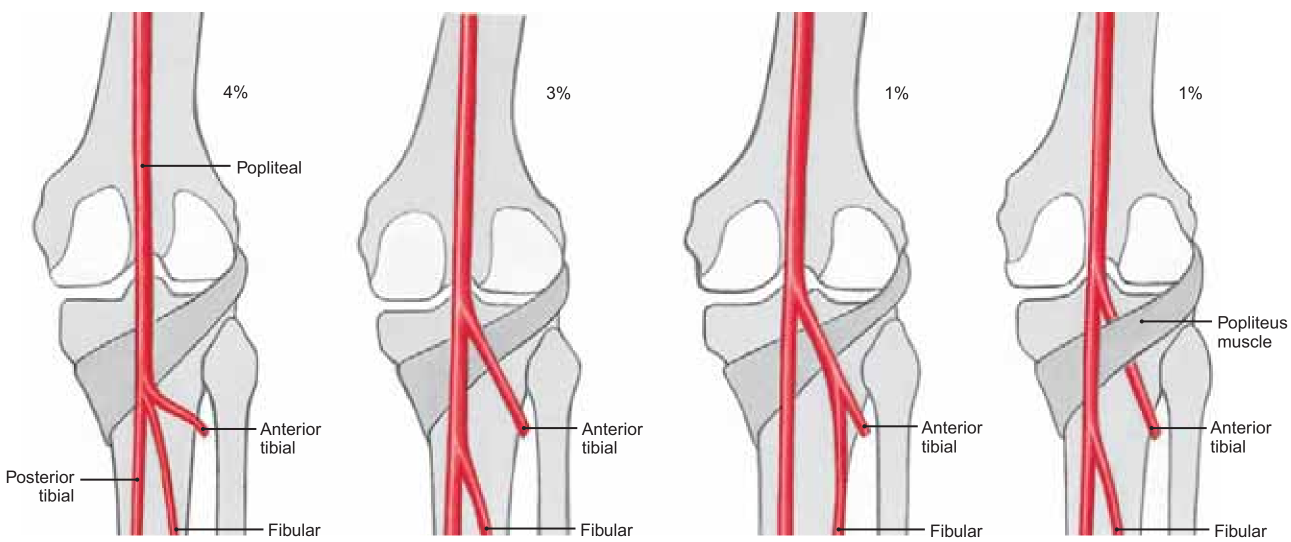
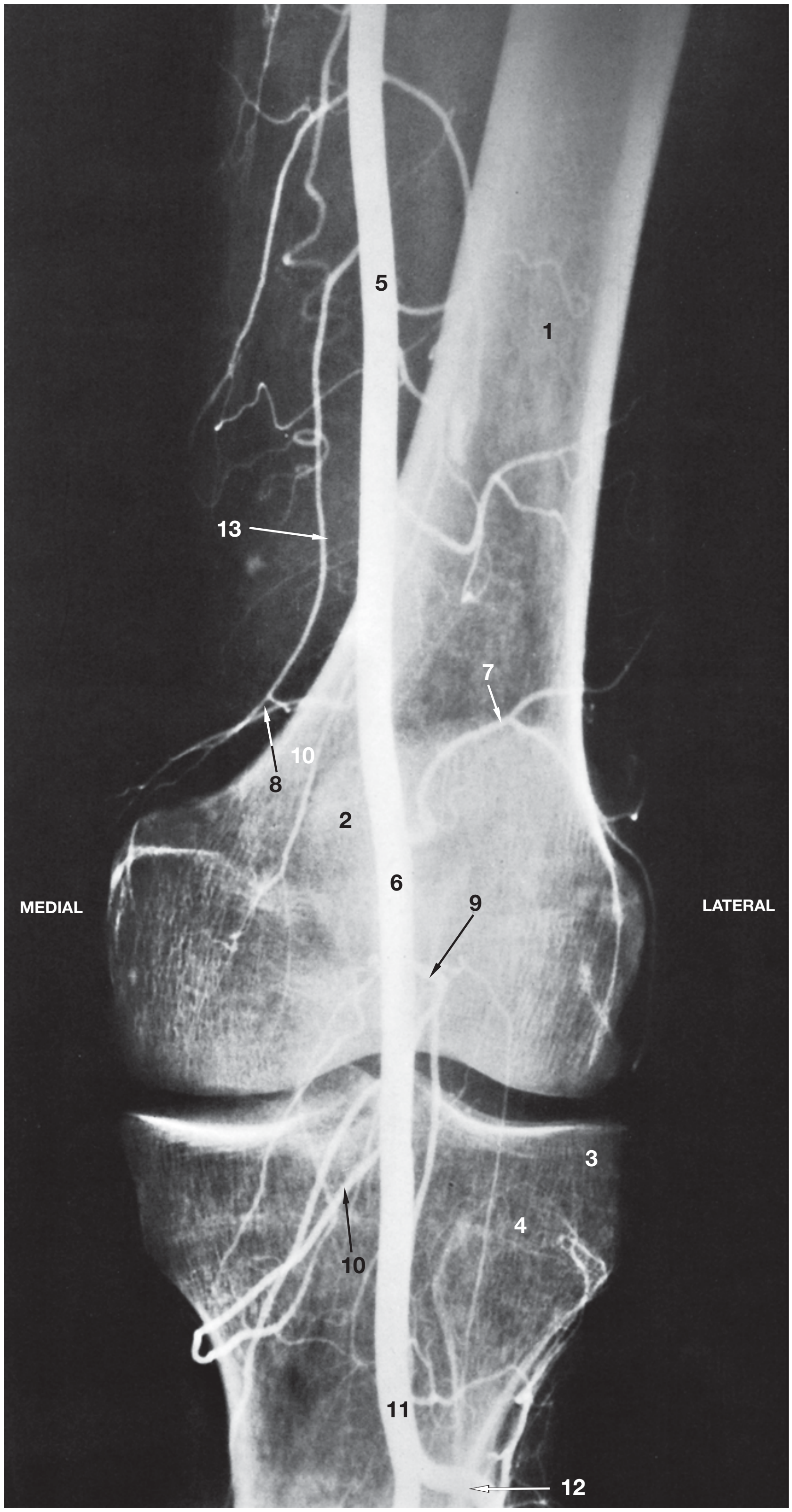


FIGURE 444.2 Variations in the Branching Pattern of the Anterior Tibial and Fibular Arteries

See NOTE 2 under Figure 444.1.



1. Femur
2. Patella
3. Tibia
4. Head of fibula
5. Femoral artery
6. Popliteal artery
7. Lateral superior genicular artery
8. Medial superior genicular artery
9. Middle genicular artery
10. Inferior genicular artery
11. Popliteal artery
12. Anterior tibial artery
13. Descending genicular artery

FIGURE 445 Arteriogram of the Left Femoral–Popliteal–Tibial Arterial Tree (Anteroposterior Projection)

NOTE: (1) This arteriogram shows the branches from the femoral, popliteal, and tibial arteries in the lower third of the thigh and the upper part of the calf. Observe the following bony structures: **femur** [1], **patella** [2], **tibia** [3], and **fibula** [4].

(2) The course of the **femoral artery** [5] as it becomes the **popliteal artery** [6] just above the popliteal fossa. Observe the following branches from the popliteal artery: **superior genicular** [7, 8], **middle genicular** [9], and single **inferior genicular** [10] in this patient.

(3) Below the popliteal fossa the **popliteal artery** [11] can be seen giving off the **anterior and posterior tibial arteries** just above the lower edge of the angiogram.

(4) The **descending genicular artery** [13], a branch of the femoral above the popliteal fossa, as it courses downward to participate in the anastomosis around the knee joint.

(From Wicke, 6th ed.)

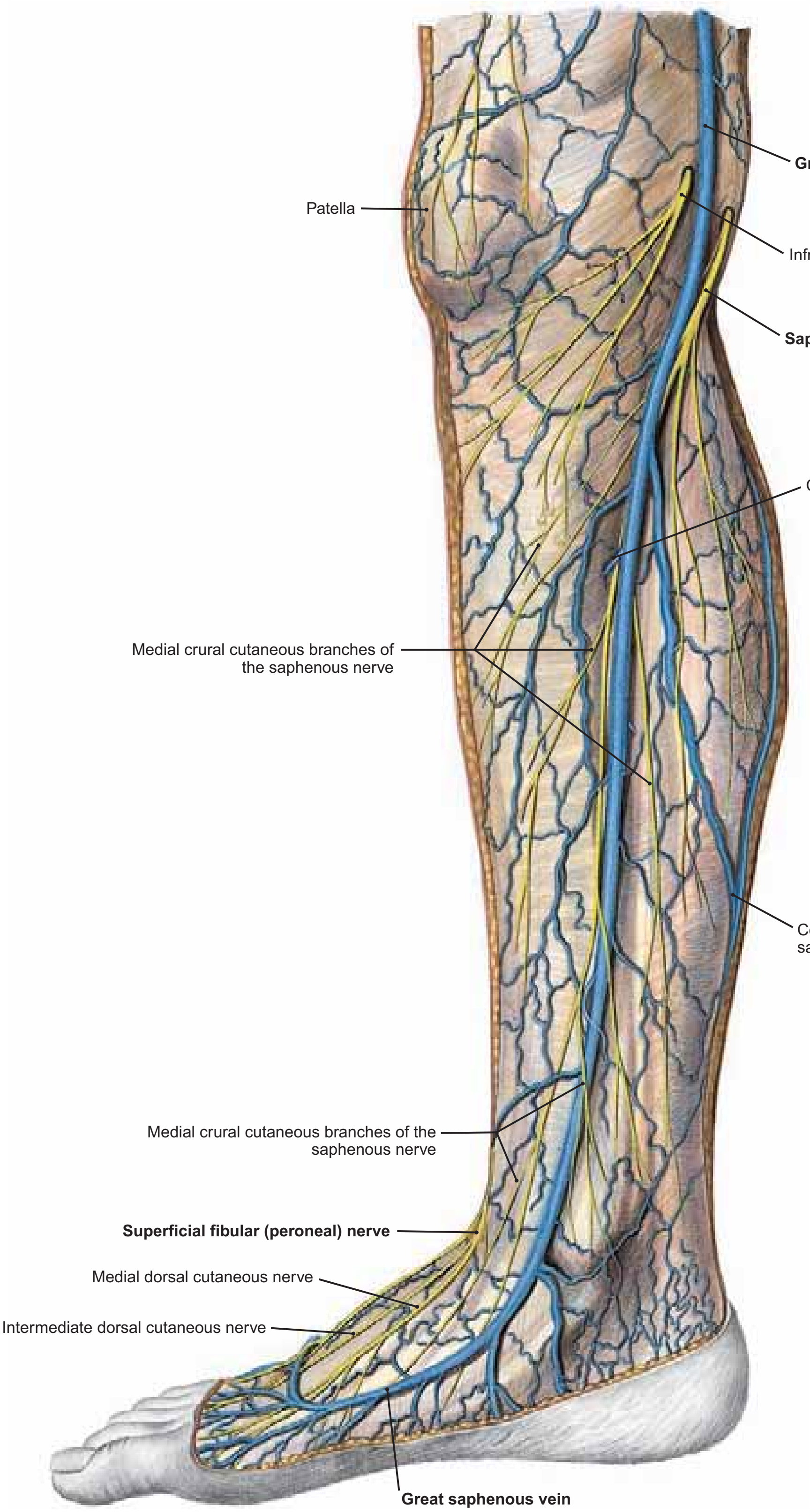


FIGURE 446 Superficial Veins and Nerves on the Anterior and Medial Aspects of the Leg and Foot

NOTE: (1) The **great saphenous vein** is formed on the medial aspect of the foot, courses anterior to the medial malleolus, and ascends along the medial side of the leg.

(2) Branches of the **saphenous nerve** accompany the great saphenous vein below the knee. This nerve becomes superficial medially just below the knee and is the largest branch of the femoral nerve. It functions as the sensory nerve that supplies the skin over most of the medial half of the leg region (i.e., between the knee and the ankle).

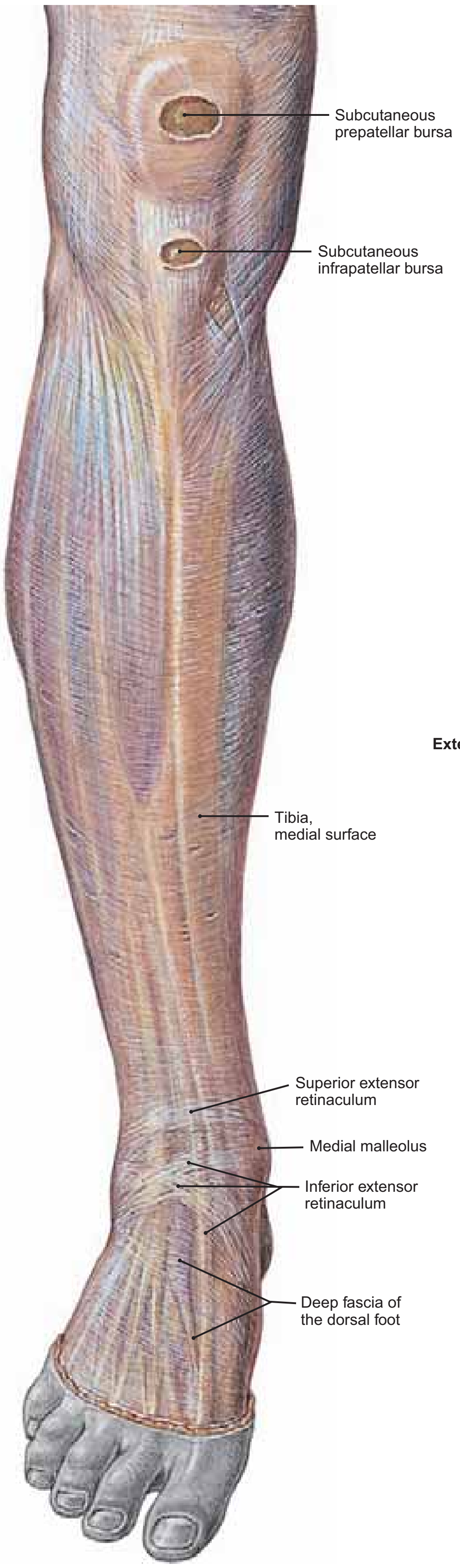


FIGURE 447.1 **Deep Fascia Investing the Leg and Dorsal Foot**

NOTE: The deep fascia binds the muscles and the **superior and inferior extensor retinacula** bind the tendons of the anterior and lateral leg muscles.

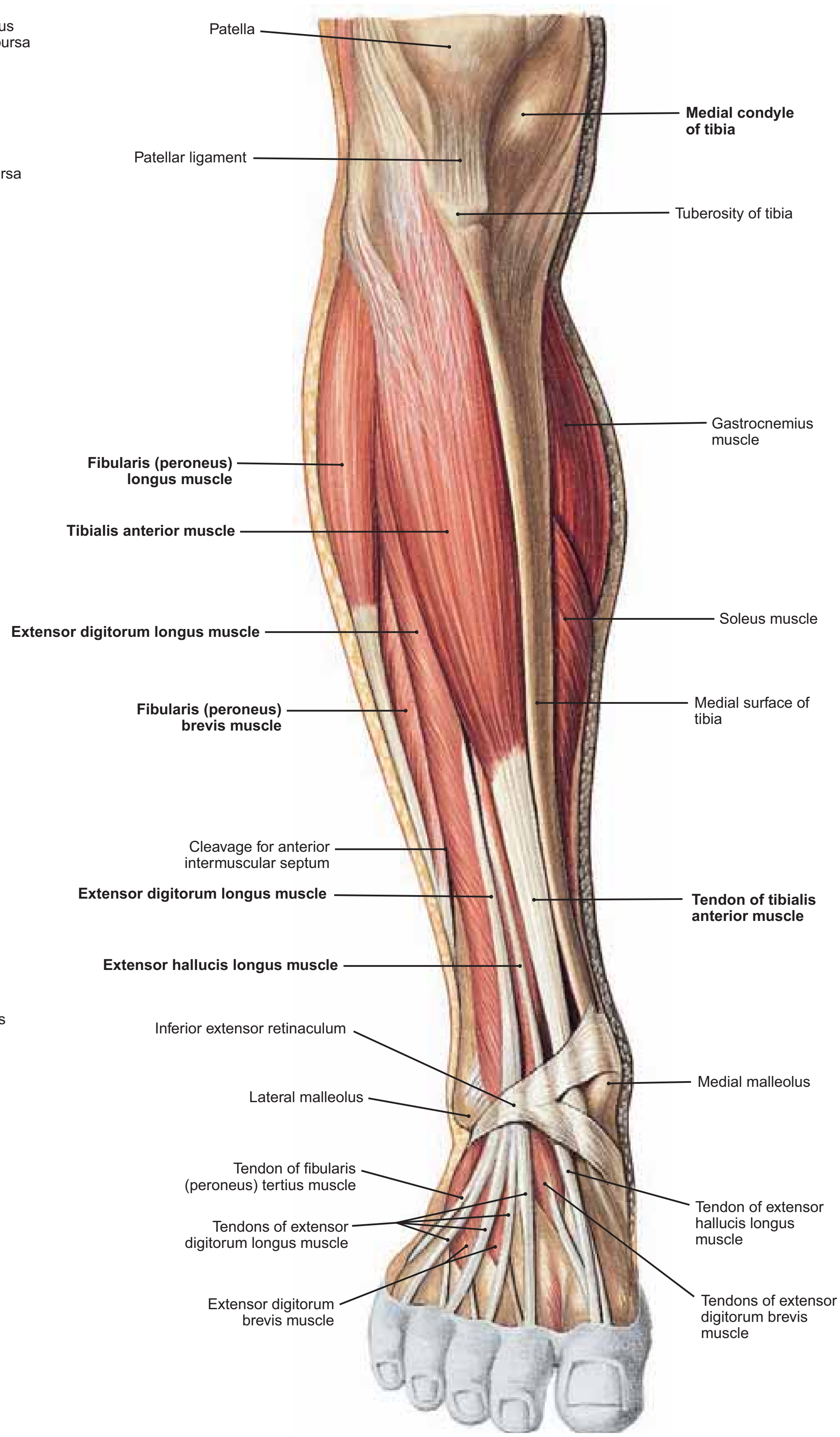


FIGURE 447.2 **Muscles of Anterior Compartment of Leg**

NOTE: (1) The medial surface of the tibia separates muscles in the anterior compartment from those of the calf, posteriorly.

(2) The anterior compartment muscles include the **tibialis anterior, extensor hallucis longus, extensor digitorum,** and **fibularis tertius,** which dorsiflex the foot. The long extensors also extend the toes (Plate 449).

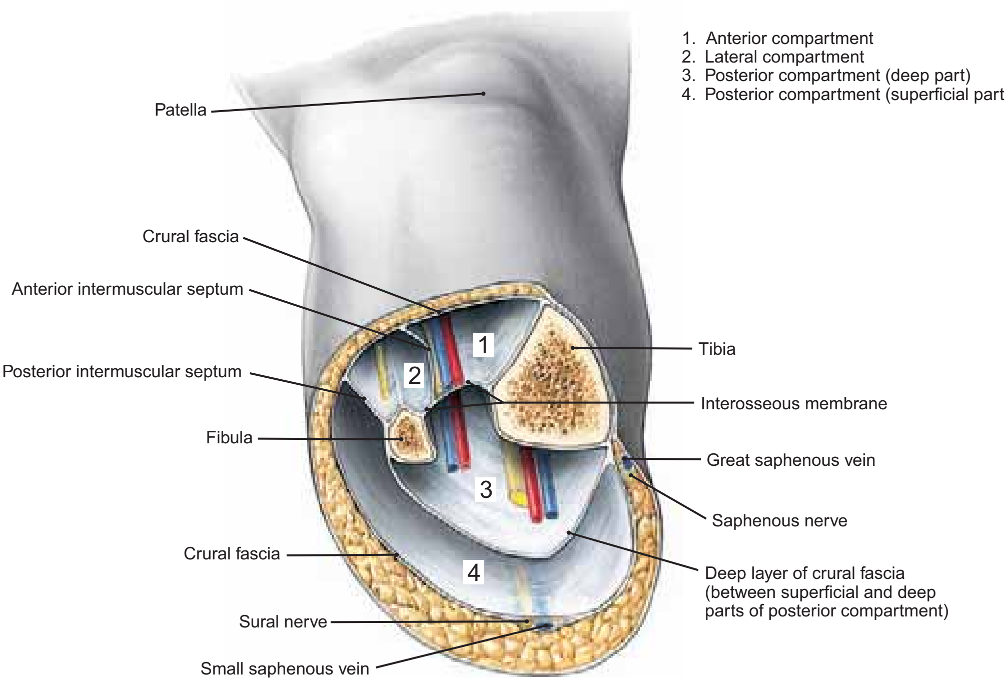


FIGURE 448 Compartments of the Leg, Diagrammatic Representation: Cross Section

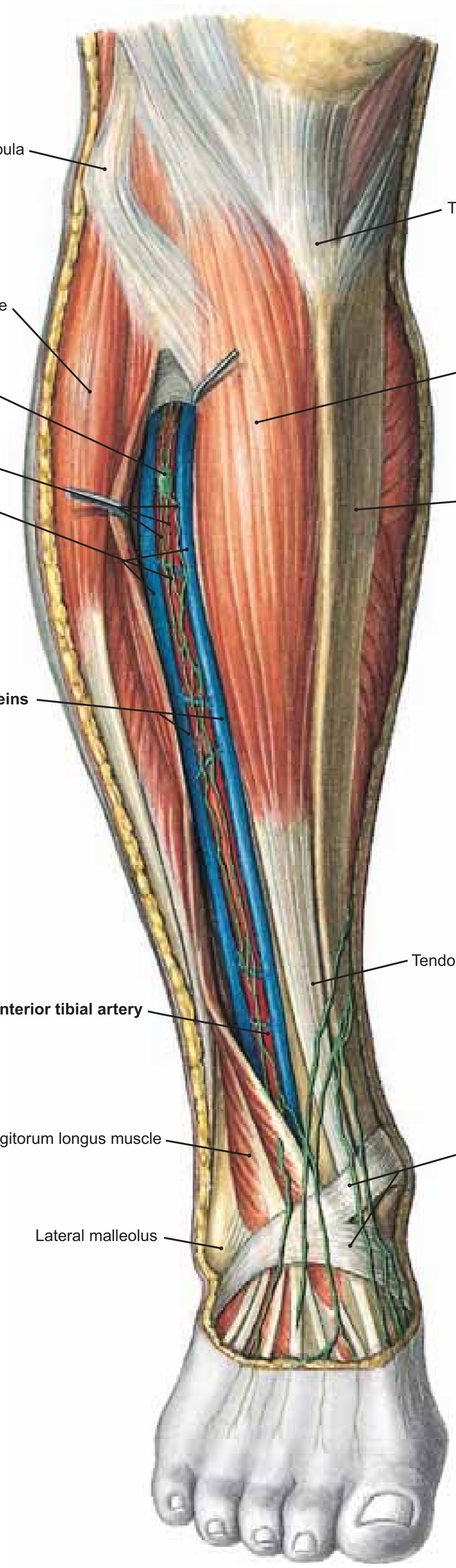
NOTE: This figure shows the compartments of the **left leg** viewed upward from below.

MUSCLES OF THE ANTERIOR COMPARTMENT OF THE LEG

Muscle	Origin	Insertion	Innervation	Action
Tibialis anterior	Lateral condyle and lateral surface of upper half of the tibia; the interosseous membrane and crural fascia	On the medial and plantar surfaces of the 1st metatarsal bone and the medial cuneiform bone	Deep fibular (peroneal) nerve (L4, L5)	Dorsiflexes the foot at the ankle joint; inverts and adducts the foot at the subtalar and midtarsal joints
Extensor hallucis longus	Medial surface of the fibula; the anterior part of the interosseous membrane and the crural fascia	Dorsal surface of the base of the distal phalanx of the great toe (or hallux)	Deep fibular (peroneal) nerve (L5, S1)	Extends the great toe; dorsiflexes the foot and tends to invert (supinate) the foot
Extensor digitorum longus	Lateral condyle of the tibia; upper three-fourths of anterior surface of the fibula and the interosseous membrane	On the distal phalanges of the four lateral toes	Deep fibular (peroneal) nerve (L5, S1)	Extends the lateral four digits; dorsiflexes the foot and tends to evert (pronate) the foot
Fibularis tertius	Distal third of the anterior surface of the fibula and the interosseous membrane	Dorsal surface of the base of the fifth metatarsal bone	Deep fibular (peroneal) nerve (L5, S1)	Dorsiflexes the foot and assists in everting (i.e., pronating) the foot

MUSCLES OF THE LATERAL COMPARTMENT OF THE LEG

Muscle	Origin	Insertion	Innervation	Action
Fibularis longus	Head and upper two-thirds of the lateral surface of the body of the fibula	Lateral aspect of the base of the first metatarsal bone and the medial cuneiform bone (on the plantar surface of the foot)	Superficial fibular (peroneal) nerve (L4, S1, S2)	Everts the foot (i.e., tends to pronate the foot); it also is a weak plantar flexor of the foot
Fibularis brevis	Distal two-thirds of the lateral surface of the fibula and the intermuscular septum	Lateral surface and base of the fifth metatarsal bone	Superficial fibular (peroneal) nerve (L4, L5, S1)	Everts the foot (i.e., tends to pronate the foot); also acts as a weak plantar flexor of the foot



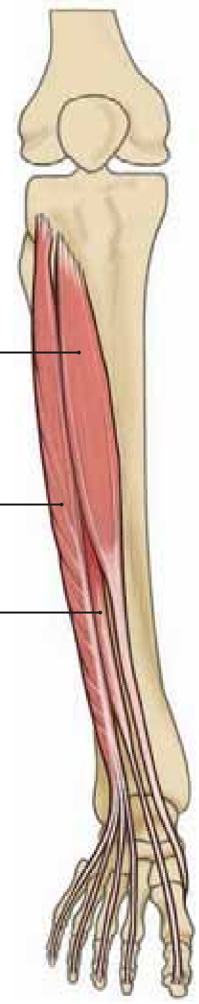


FIGURE 449.2 **The Anterior Compartment Muscles**

FIGURE 449.1 **Anterior Tibial Compartment: Vessels and Lymphatic Channels**

NOTE: (1) By separating the **tibialis anterior muscle** from the other muscles in the anterior compartment, the **anterior tibial artery** is exposed descending to the dorsum of the foot.

(2) The artery is accompanied by a pair of **anterior tibial veins (venae comitantes),** which ascend to join the posterior tibial vein to help form the popliteal vein.

(3) Lymphatic channels from the dorsum of the foot course superiorly along the path of these vessels, and at times, a lymph node can be found just below the knee.

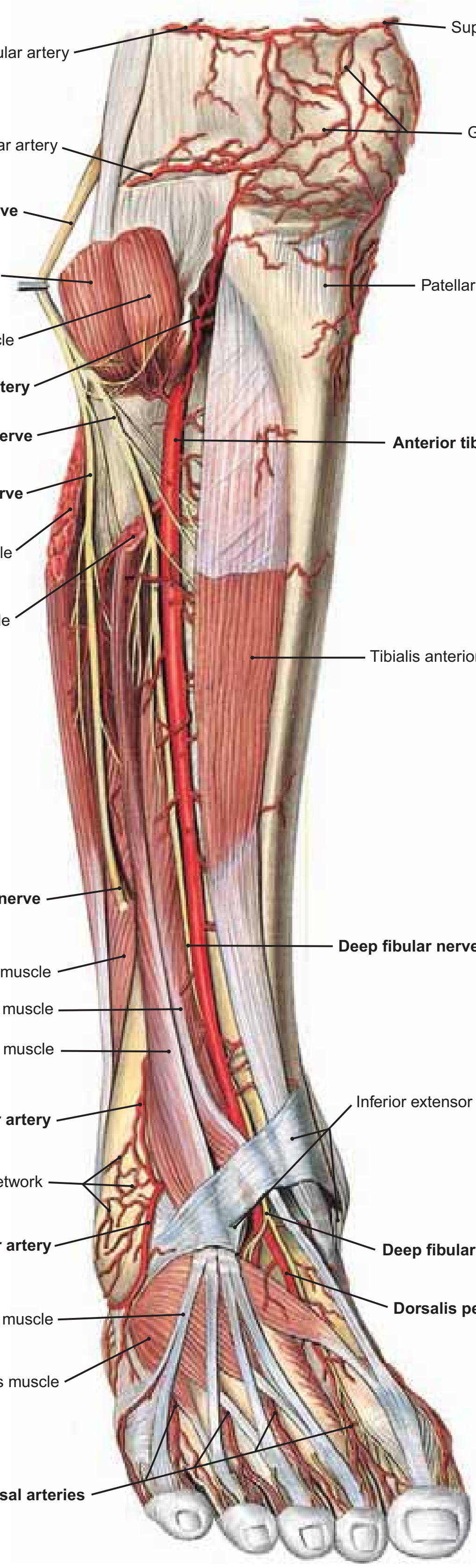


FIGURE 450 Deep Dissection of the Anterior and Lateral Compartments: Nerves and Arteries

NOTE: (1) As the **common fibular nerve** courses laterally around the head of the fibula, it divides into the **superficial** and **deep fibular nerves**, which innervate the muscles of the lateral and anterior compartments.

(2) The deep fibular nerve is joined by the **anterior tibial artery,** which descends toward the foot, where it becomes the **dorsalis pedis artery.**

(3) The superficial fibular nerve becomes cutaneous about 7 in. above the lateral malleolus, while the deep fibular nerve becomes cutaneous between the large and second toes.

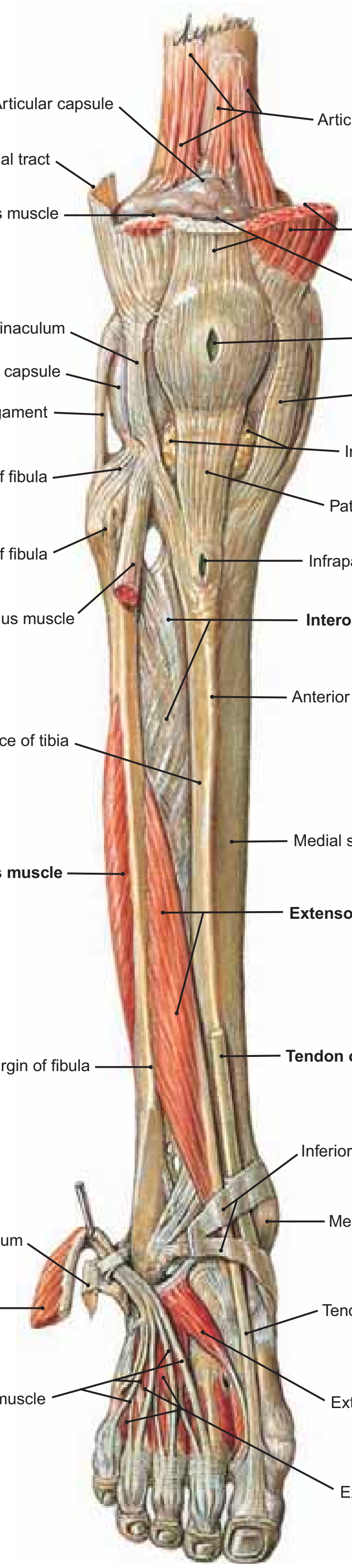
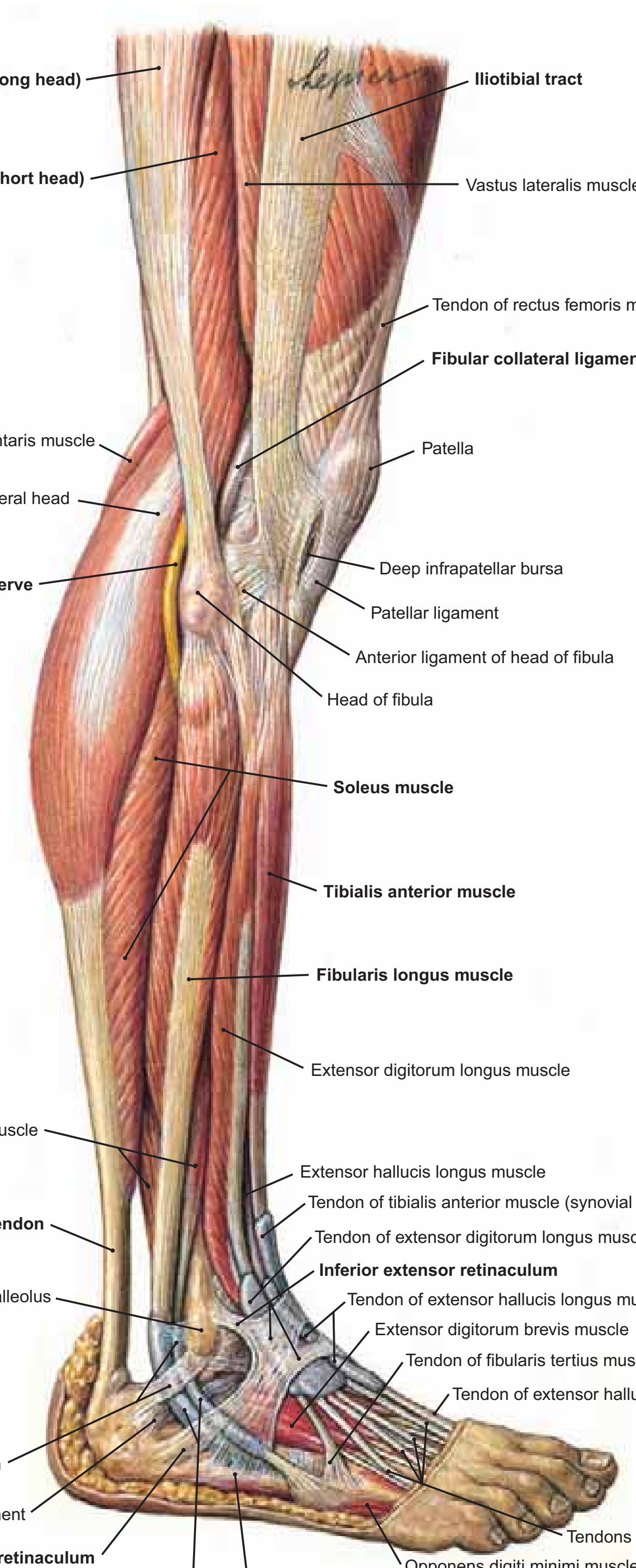


FIGURE 451 Deep Dissection of the Anterior and Lateral Compartments: Muscles

NOTE: (1) The bellies of the tibialis anterior and fibularis longus muscles have been removed and the extensor digitorum longus muscle has been reflected. Observe the full extent of the **extensor hallucis longus** and the belly of the **fibularis brevis muscle**.

(2) The interosseous membrane between the tibia and the fibula and the opening above its upper border through which course the anterior tibial vessels.



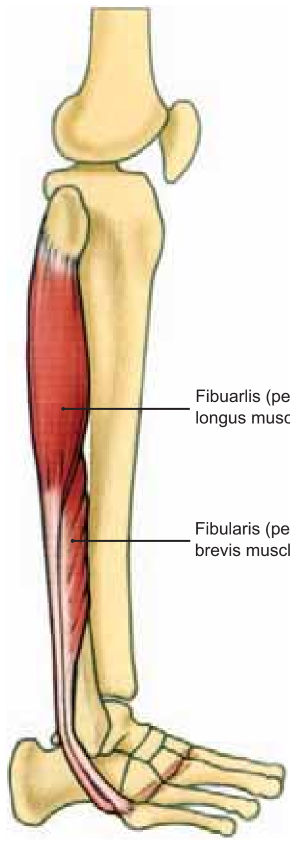


FIGURE 452.2 **The Lateral Compartment (Fibular Muscles)**

FIGURE 452.1 **Lateral Compartment Muscles and Tendons of the Right Leg (Lateral View)**

NOTE: (1) The **fibularis longus** and **brevis** occupy the lateral compartment of the leg, and their tendons descend into the foot behind the lateral malleolus. The fibularis longus tendon crosses the sole of the foot to insert on the base of the first metatarsal bone, while the fibularis brevis inserts directly onto the base of the fifth metatarsal bone.

(2) The superficial location of the **head of the fibula** and its relationship to the **common fibular nerve**. Trauma to the lateral side of the leg could cause injury to this nerve, resulting in a condition called foot drop, because the dorsiflexors would be denervated and the action of the plantar flexors in the posterior compartment would no longer be opposed.

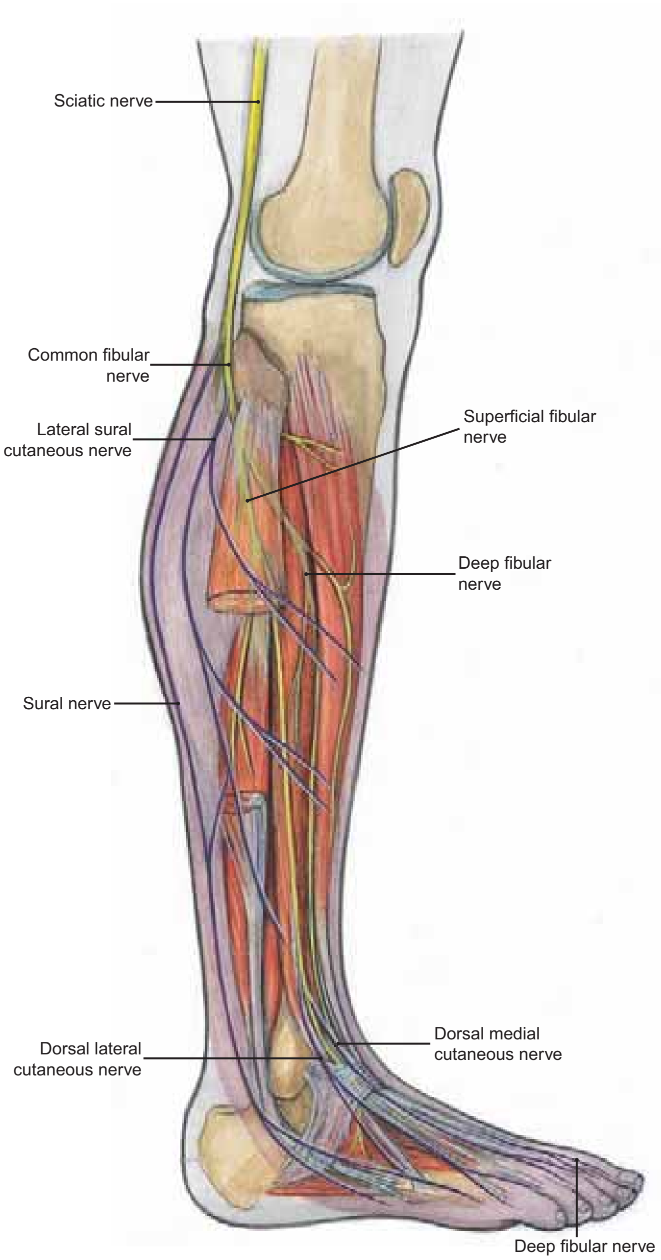


FIGURE 453.1 Superficial and Deep Fibular Nerves

NOTE: The cutaneous nerves are in purple.

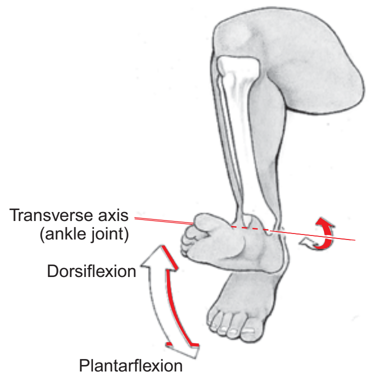


FIGURE 453.2 Dorsiflexion and Plantar Flexion of the Foot (at Ankle Joint)

NOTE: that (1) **Dorsiflexion:**
- (a) Attempts to approximate the dorsum of the foot to the anterior leg surface.
- (b) Is considered as extension at ankle joint.
- (c) Is performed by muscles in the anterior compartment of the leg.

(2) **Plantar flexion:**
- (a) Reverses dorsiflexion and also occurs when one stands on one's toes.
- (b) Is considered as flexion at ankle joint.
- (c) Is performed by muscles in the posterior compartment of the leg.

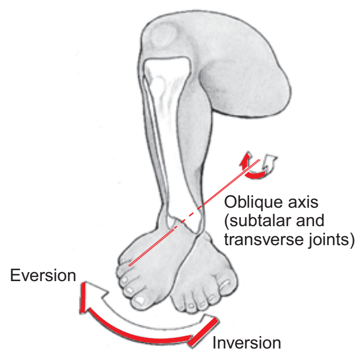


FIGURE 453.3 Inversion and Eversion of the Foot (at Subtalar and Transverse Joint)

NOTE: that (1) **Inversion:**
- (a) Attempts to supinate the foot, that is, to turn the sole medially or inward.
- (b) Is performed by muscles in the leg that attach medially on the foot (tibialis anterior *and* posterior; extensor *and* flexor hallucis longus).

(2) **Eversion:**
- (a) Attempts to pronate the foot, that is, to turn the sole laterally or outward.
- (b) Is performed by muscles in the leg that attach laterally on the foot such as fibularis longus, brevis, and tertius.

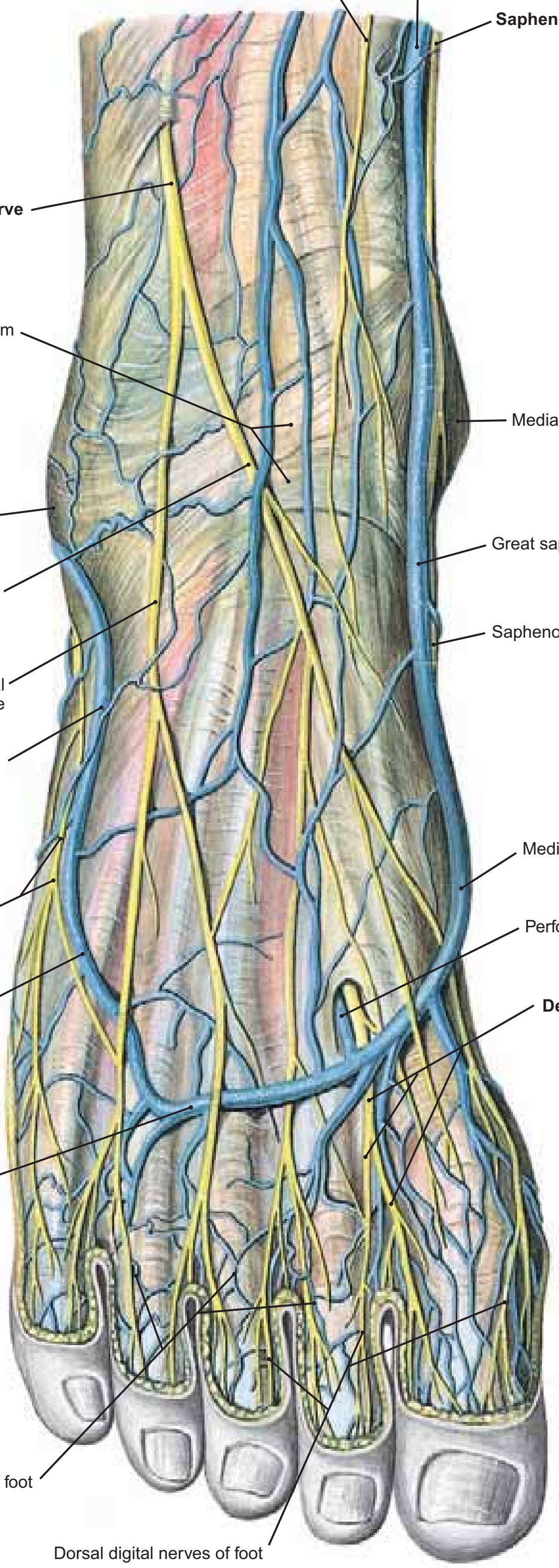


FIGURE 454 Superficial Nerves and Veins of the Dorsal Right Foot

NOTE: (1) Cutaneous innervation of the dorsal foot is supplied principally by the **superficial fibular nerve** (L4, L5, S1). In addition, the **deep fibular nerve** (L4, L5) supplies the adjacent sides of the first and second toes, while the **lateral dorsal cutaneous nerve** (S1, S2; terminal branch of the sural nerve in the foot) supplies the lateral and dorsal aspects of the fifth digit.

(2) The digital and metatarsal veins drain back from the toes to form the dorsal venous arch of the foot. From this arch, the **great saphenous vein** ascends medially and the **small saphenous vein** laterally on the foot dorsum.

(3) The cutaneous branch of the **saphenous nerve** extends downward as far as the ankle joint anteriorly. Medially, the main trunk of the saphenous nerve can extend inferiorly as far as the metatarsophalangeal joint of the large toe.

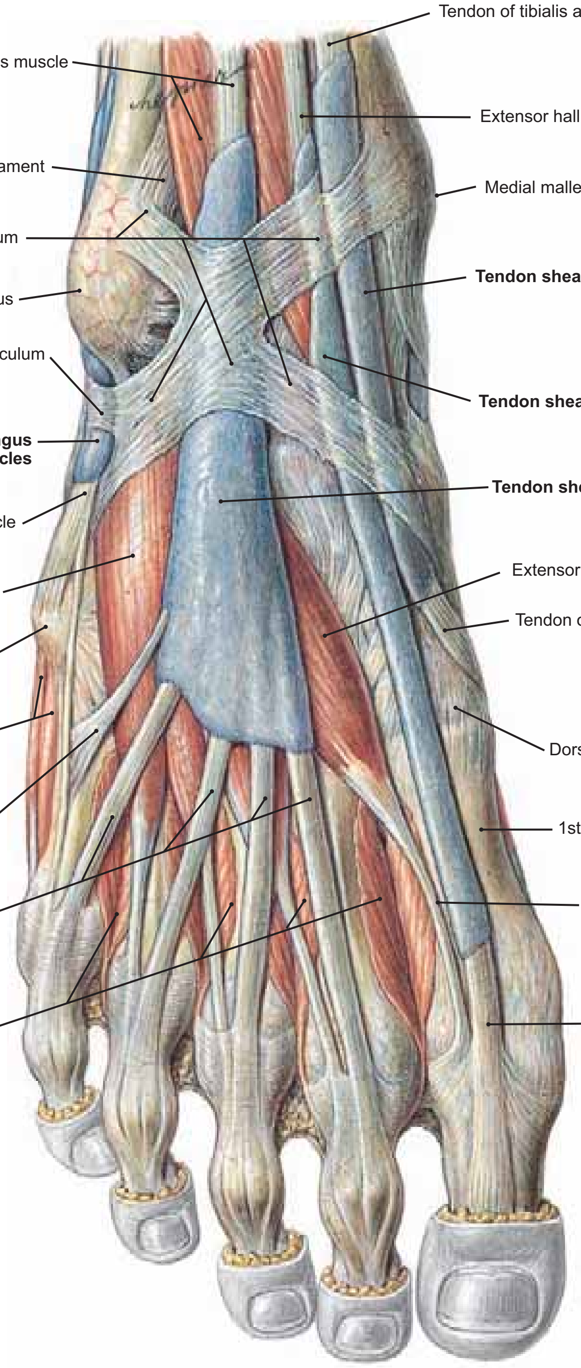


FIGURE 455 Muscles, Tendons, and Tendon Sheaths of the Dorsal Right Foot (Superficial View)

NOTE: (1) The tendons of the tibialis anterior, extensor hallucis longus, and extensor digitorum longus are bound by the Y-shaped (or X-shaped) inferior extensor retinaculum as they enter the dorsum of the foot at the level of the ankle joint.

(2) The extensor tendons insert onto the dorsal aspect of the distal phalanx of each toe. In addition, the tendons of the extensor digitorum longus also insert onto the dorsum of the middle phalanx of the four lateral toes.

(3) The tendon of the fibularis tertius inserts on the base of the fifth metatarsal bone (and at times the fourth also).

(4) Separate synovial sheaths (shown in blue) surround the tendons of the tibialis anterior and extensor hallucis longus. Also note the common synovial sheath for the main tendon and the individual digital tendons of the extensor digitorum longus.

(5) The tendon sheaths laterally and medially under the two malleoli are shown in Figures 456.1 and 456.2.

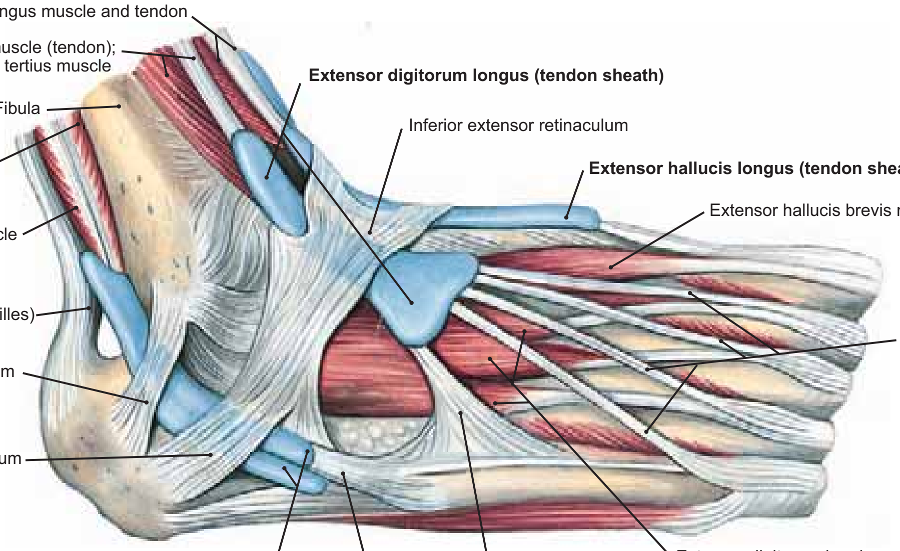


FIGURE 456.1 Tendons and Synovial Sheaths: Right Dorsum of Foot and Ankle Region (Lateral View)

NOTE: (1) Similar to the wrist, tendons at the ankle region passing from the leg into the foot are bound by closely investing **retinacula** and are surrounded by **synovial sheaths**, which are indicated in blue in this figure and in Figure 456.2.

(2) Anterior to the ankle joint and on the dorsum of the foot are three separate synovial sheaths, one that includes the extensor digitorum longus and the fibularis tertius, a second for the extensor hallucis longus, and a third for the tibialis anterior (see Figs. 452.1 and 455).

(3) Behind the lateral malleolus is a single tendon sheath for the fibularis longus and brevis muscles, which then splits distally to continue along each individual tendon for some distance.

(4) The inferior extensor retinaculum and the superior and inferior fibular retinacula, which bind the tendons and their sheaths close to the bone.

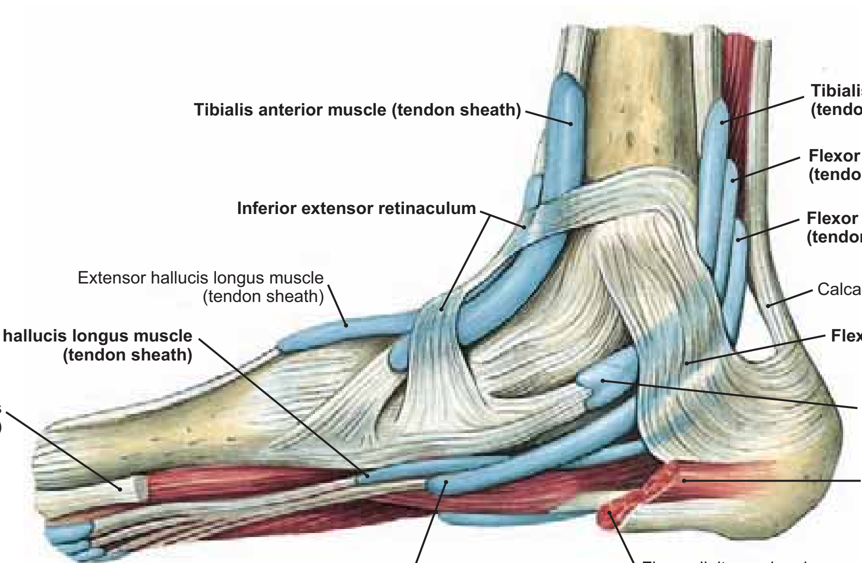


FIGURE 456.2 Tendons and Synovial Sheaths: Right Dorsum of Foot and Ankle Region (Medial View)

NOTE: (1) From this medial view can be seen the synovial sheaths and tendons of the tibialis anterior and extensor hallucis longus on the dorsum of the foot as well as the three tendons that course beneath the medial malleolus into the plantar aspect of the foot from the posterior compartment: the tibialis posterior, the flexor digitorum longus, and the flexor hallucis longus.

(2) The bifurcating nature of the inferior extensor retinaculum, and the manner in which the flexor retinaculum secures the structures beneath the medial malleolus.

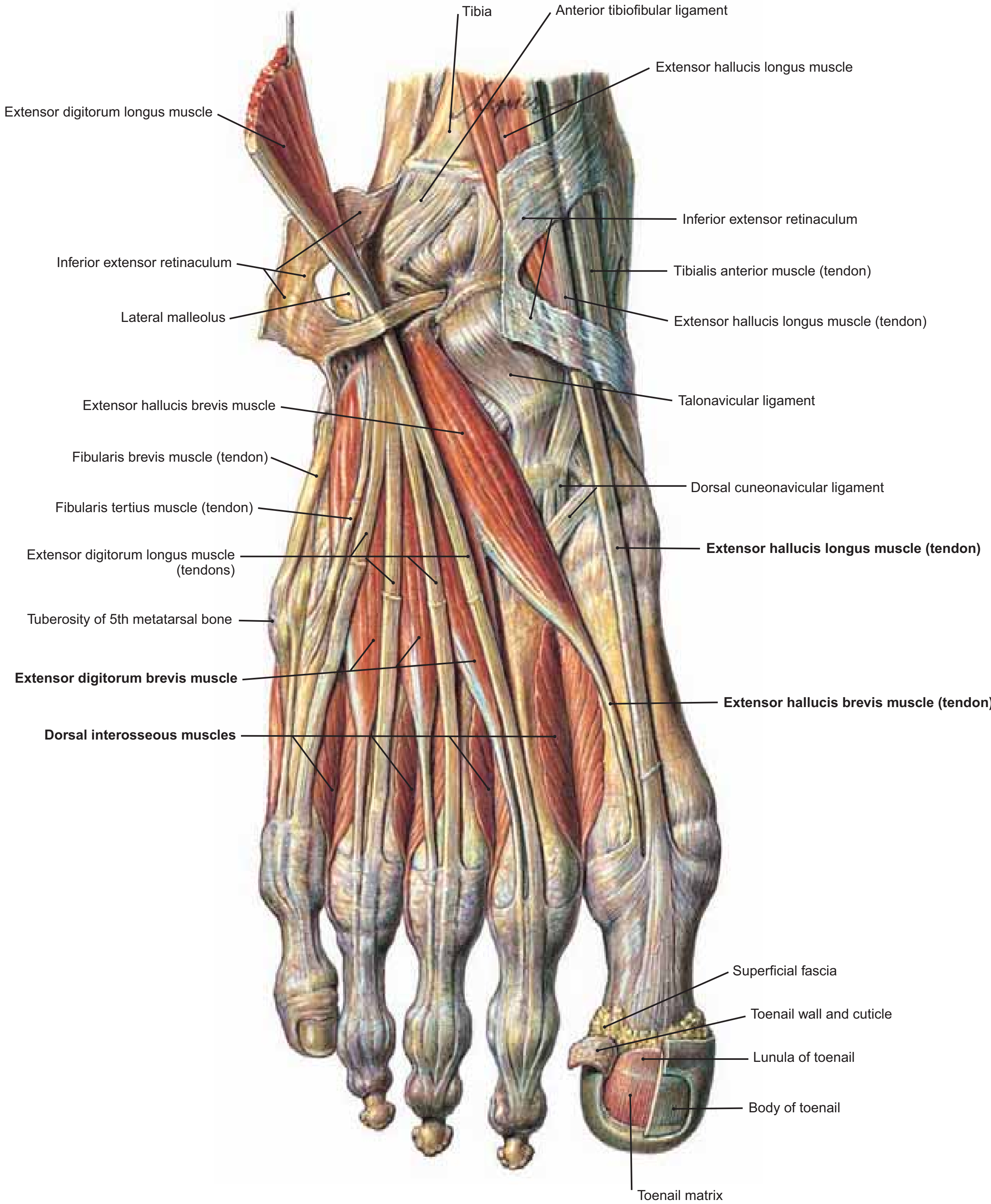


FIGURE 457 Muscles and Tendons on the Dorsal Aspect of the Right Foot

MUSCLES ON THE DORSUM OF THE FOOT				
Muscle	**Origin**	**Insertion**	**Innervation**	**Function**
Extensor hallucis brevis	Dorsal aspect of the calcaneus bone	Lateral side of the base of the proximal phalanx of the great toe	Deep fibular nerve (L5, S1)	Helps extend the proximal phalanx of the great toe
Extensor digitorum brevis	Dorsal and lateral aspect of the calcaneus bone	Lateral side of the tendons of the extensor digitorum longus muscle for the second, third, and fourth toes	Deep fibular nerve (L5, S1)	Helps extend the proximal phalanges of the second, third, and fourth toes

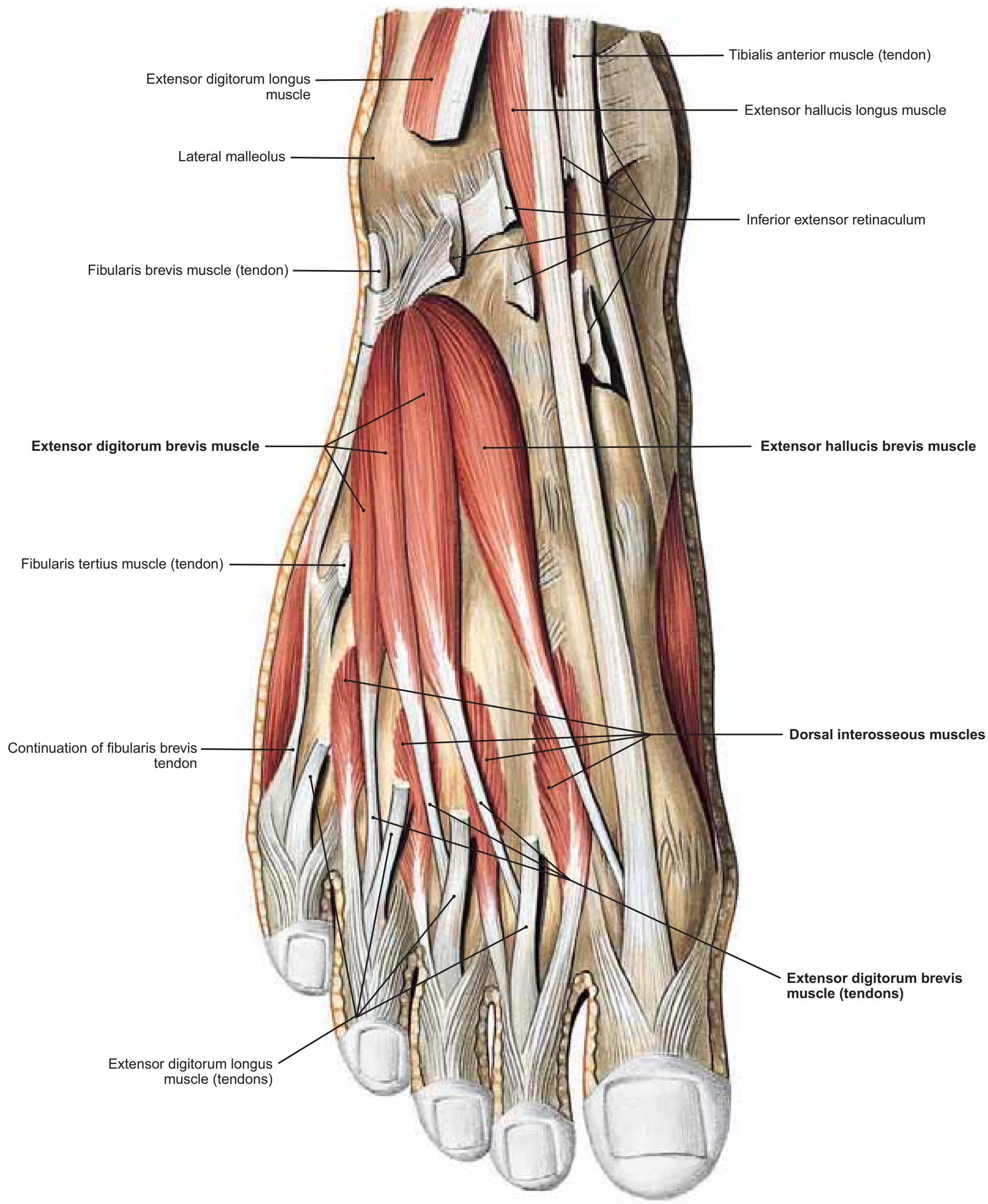


FIGURE 458 Intrinsic Muscles of the Dorsal Foot (Right)

NOTE: (1) The inferior extensor retinaculum has been opened and the tendons of the extensor digitorum longus and fibularis tertius muscles have been severed.

(2) The **extensor hallucis brevis muscle** and the three small bellies of the **extensor digitorum brevis.** The delicate tendons of these muscles insert on the proximal phalanx of the medial four toes.

(3) The four **dorsal interosseous muscles**. These muscles abduct the toes from the longitudinal axis of the foot (down the middle of the second toe). The first dorsal interosseous muscle inserts on the medial side of the second toe, while the remaining three insert on the lateral side of the second, third, and fourth toes.

(4) Although the dorsal interosseous muscles are usually designated as the deepest layer of muscles on the **plantar** aspect of the foot, they can best be seen on the dorsal surface following reflection of the tendons of the extensor digitorum longus and brevis muscles.

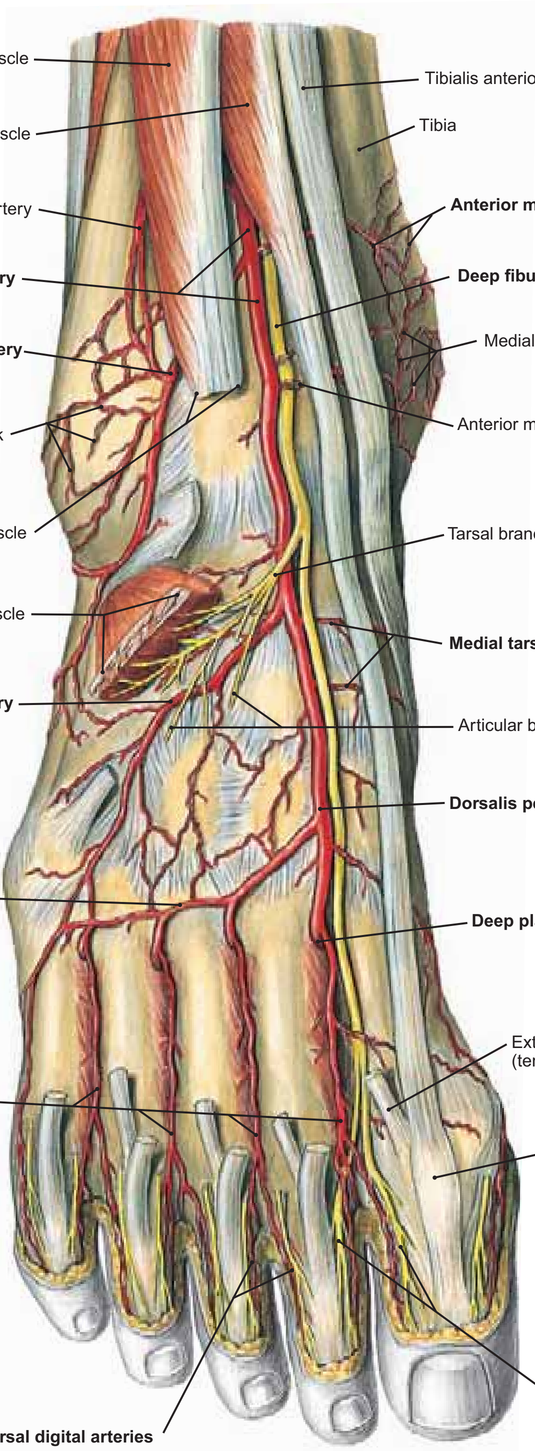


FIGURE 459 Deep Nerves and Arteries of the Dorsal Foot

NOTE: (1) The deeply coursing **anterior tibial artery** and **deep fibular nerve** and their branches have been exposed. They enter the foot between tendons of the extensor hallucis longus and extensor digitorum longus muscles.

(2) The anterior tibial artery becomes the **dorsalis pedis artery** below the ankle joint. The **deep plantar artery** branches from the dorsalis pedis and perforates the tissue between the first two metatarsal bones to enter the plantar foot. Also note the **malleolar, tarsal, arcuate, dorsal metatarsal,** and **digital arteries.**

(3) The **deep fibular nerve** supplies the extensor hallucis and extensor digitorum brevis muscles in the foot and continues distally to terminate as two dorsal digital nerves, which supply sensory innervation to the adjacent sides of the great toe and the second toe. Sensory innervation on the dorsal aspect of the other toes is derived from the **superficial fibular nerve.**

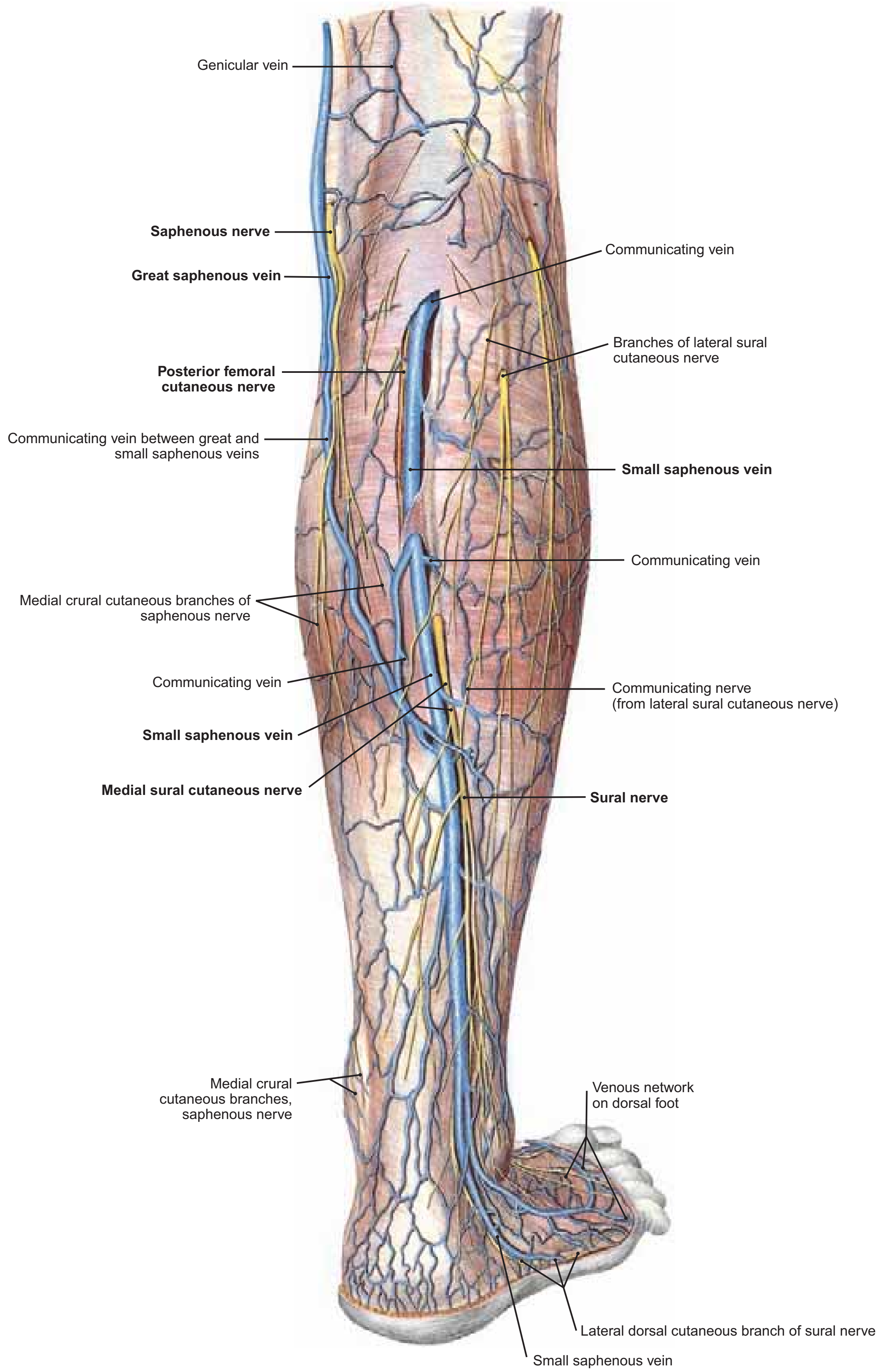


FIGURE 460 Superficial Veins and Cutaneous Nerves of the Posterior Leg and Dorsal Foot

NOTE: (1) The **small saphenous vein** forms on the dorsolateral aspect of the foot and ascends to the popliteal fossa, and superficial communicating branches interconnect it to the great saphenous vein.

(2) The **sural nerve** is formed by the junction of a large branch, the medial sural cutaneous nerve (from the tibial nerve), and the lateral sural cutaneous branches from the common fibular nerve. This nerve supplies most of the posterolateral part of the leg, and medial crural cutaneous branches of the **saphenous nerve** supply the posteromedial leg.

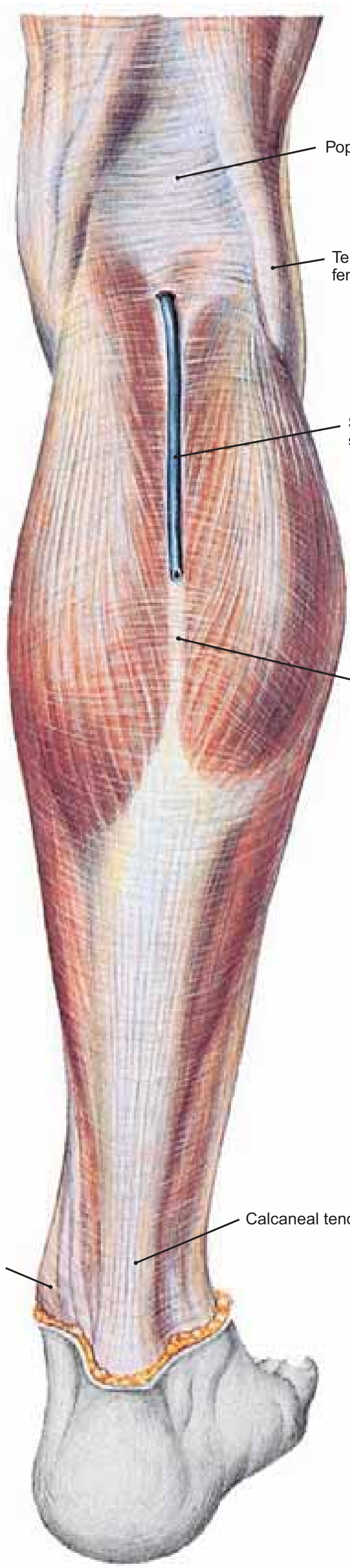


FIGURE 461.1 Deep Fascia of the Leg (the Crural Fascia) (Posterior View)

NOTE: The deep fascia of the leg closely invests all the muscles between the knee and the ankle and forms the fascial covering over the popliteal fossa. It is continuous above with the fascia lata of the thigh and below with the retinacula that bind the tendons close to the bones in the ankle region.

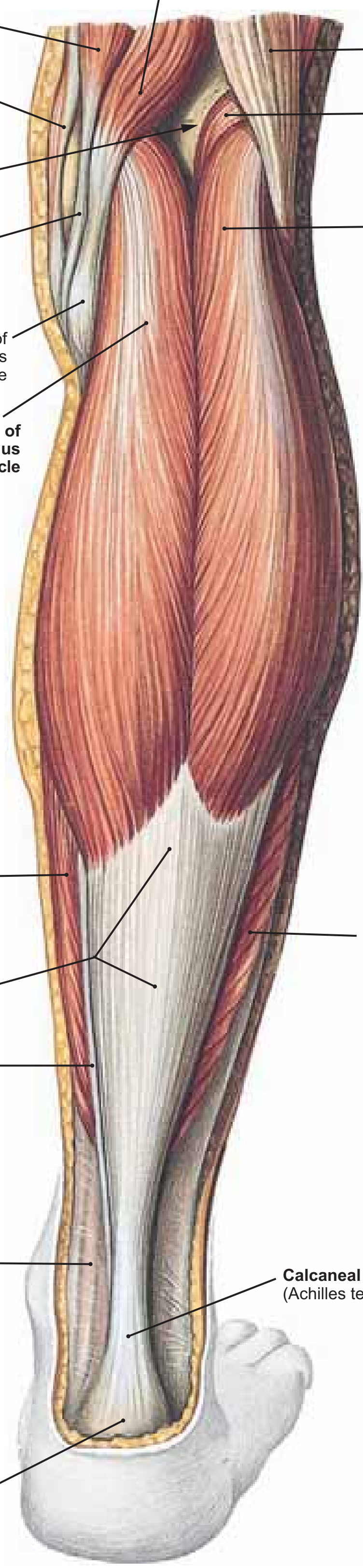


FIGURE 461.2 Muscles of the Posterior Leg: Superficial Calf Muscles

NOTE: (1) The **gastrocnemius muscle** arises by two heads from the condyles and posterior surface of the femur. It inserts by means of the strong **calcaneal tendon** onto the tuberosity of the calcaneus.

(2) The gastrocnemius is a strong plantar flexor of the foot, and its continued action also flexes the leg at the knee.

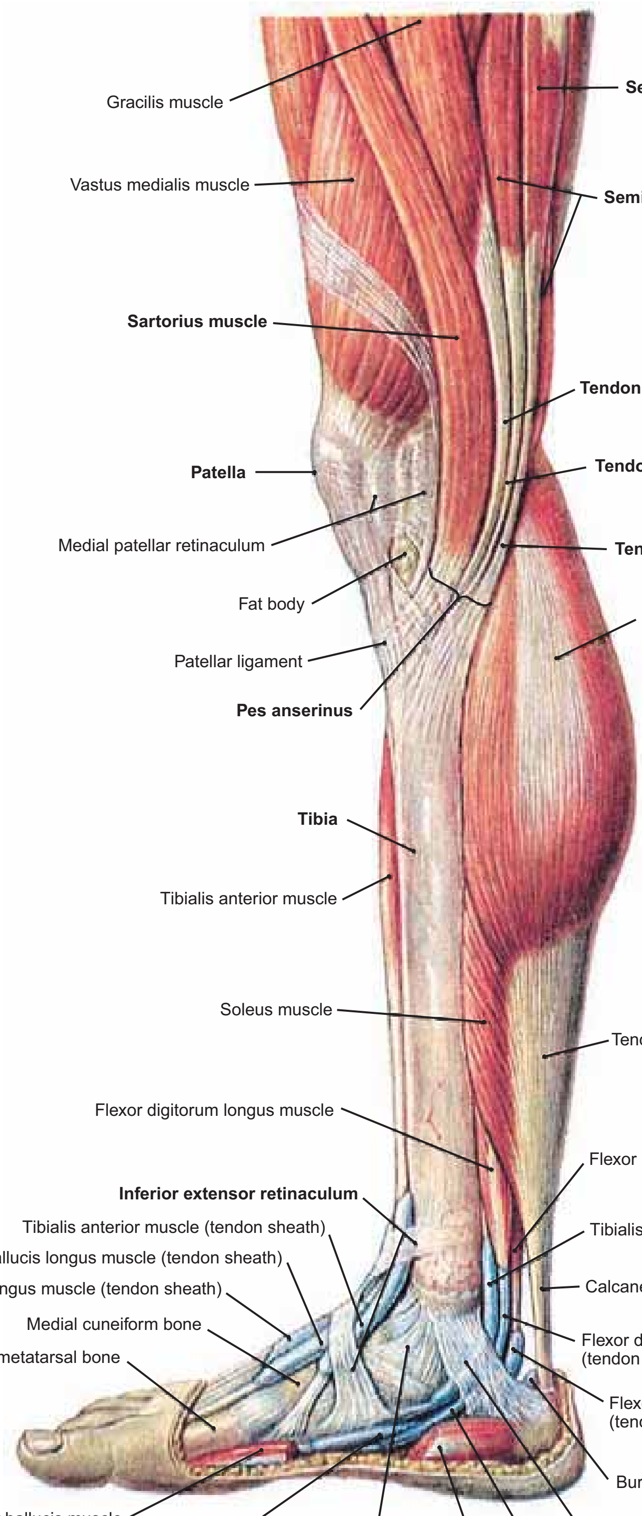


FIGURE 462 Medial View of the Leg: Knee, Posterior Compartment, Ankle and Foot Regions

NOTE: (1) The medial head of the gastrocnemius muscle. Observe how its tendon inserts onto the tuberosity of the calcaneus, while the tendons of the tibialis posterior, flexor digitorum longus, and flexor hallucis longus enter the plantar surface of the foot.

(2) The flexor retinaculum holds these deep posterior compartment muscles close to the bone, thereby increasing their efficiency when they contract. Without these retinacula, muscular contraction would result in a bowing of the tendons and a loss of power.

(3) The tendons of the sartorius, gracilis, and semitendinosus form the so-called pes anserinus (goose's foot). This tendinous formation helps protect the medial aspect of the knee, while the tendon of the semimembranosus helps reinforce the capsule of the knee joint posteriorly.

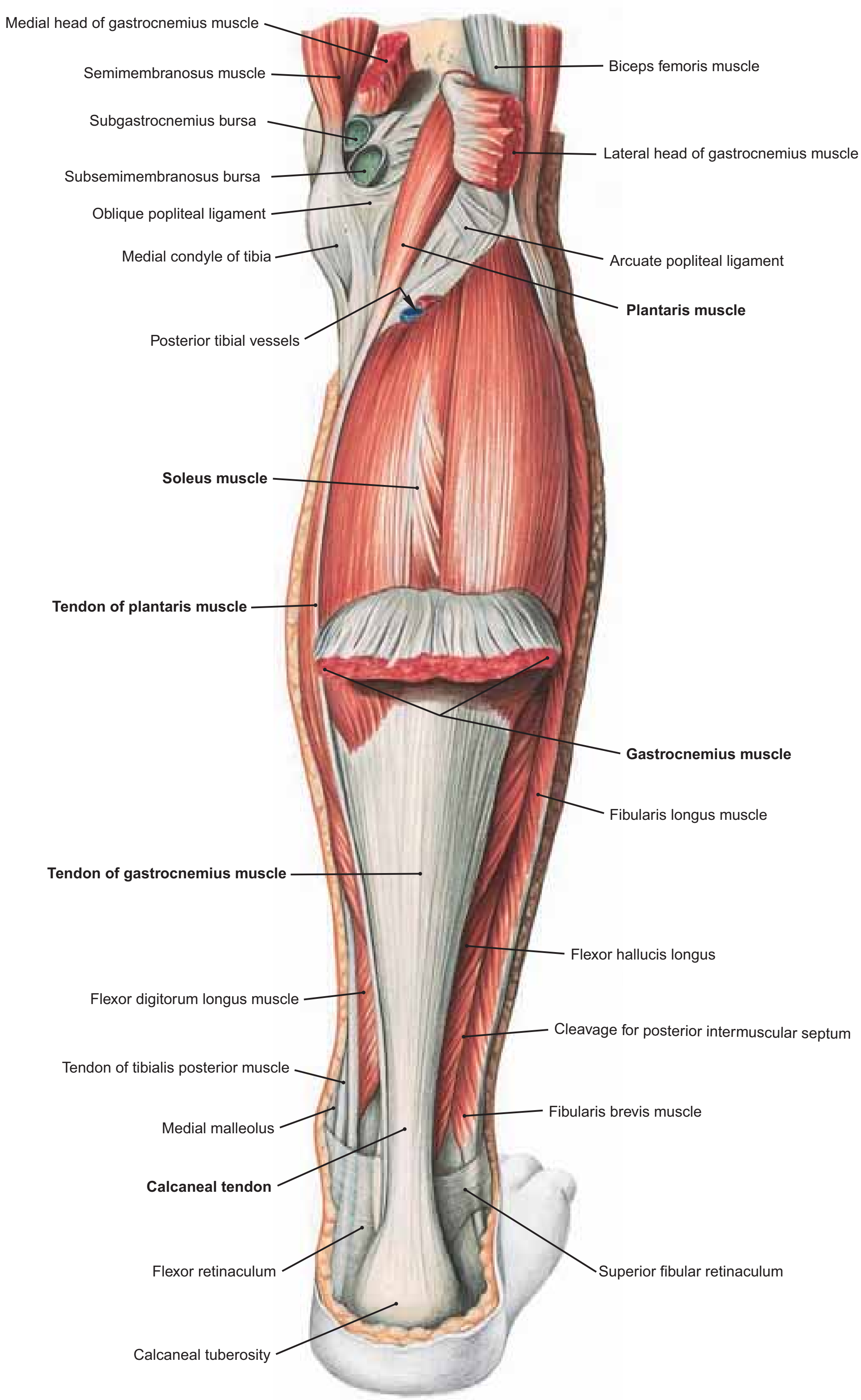


FIGURE 463 Muscles of the Posterior Leg: Soleus and Plantaris Muscles

NOTE: (1) Both heads of the gastrocnemius muscle have been severed. Observe the stumps of their origins from the femur above and the lower flap reflected downward to uncover the **soleus** and **plantaris muscles**.

(2) The soleus muscle is broad and thick and arises from the posterior surface of the fibula, the intermuscular septum, and the dorsal aspect of the tibia. Its fibers join the calcaneal tendon and insert in common with the gastrocnemius muscle.

(3) The small plantaris muscle has a long thin tendon that also joins the calcaneal tendon. Although the function of the plantaris is of little significance, its long tendon can be used by surgeons when that type of tissue is required.

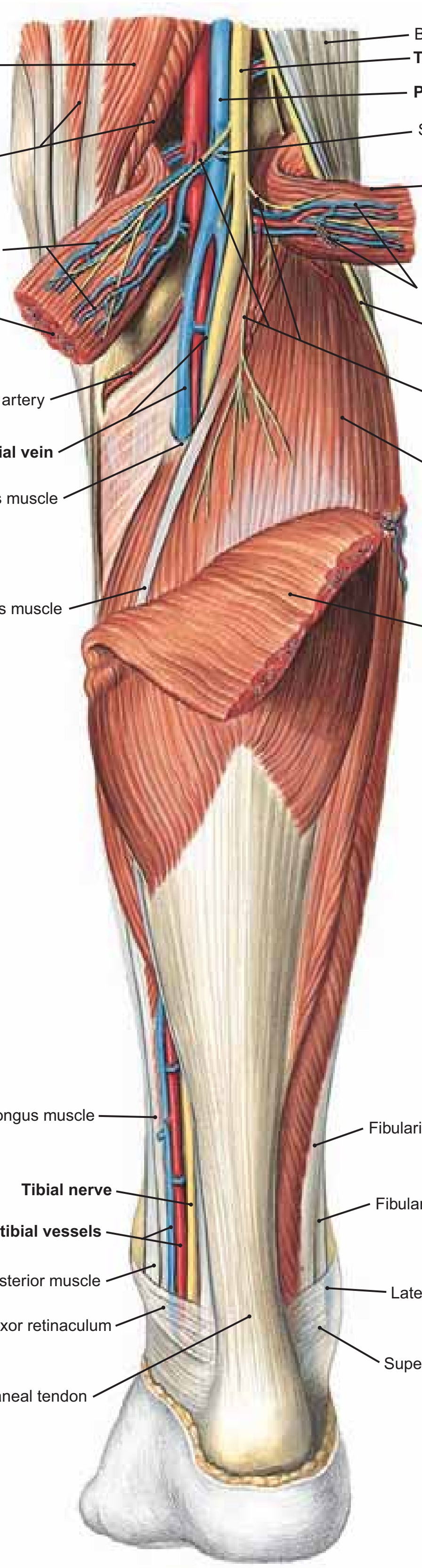


FIGURE 464 Nerves and Vessels of the Posterior Leg above and below the Soleus Muscle

NOTE: (1) The popliteal vessels and tibial nerve, descending from the popliteal fossa into the posterior compartment and the leg, commence to course medially in a gradual manner so that at the ankle they lie behind the medial malleolus.

(2) From the popliteal fossa, sural branches of the popliteal artery and muscular branches of the tibial nerve descend to supply the gastrocnemius and soleus muscles. These neurovascular structures course through a tendinous arch in the soleus muscle and descend deep to the soleus and become superficial again several inches above the medial malleolus.

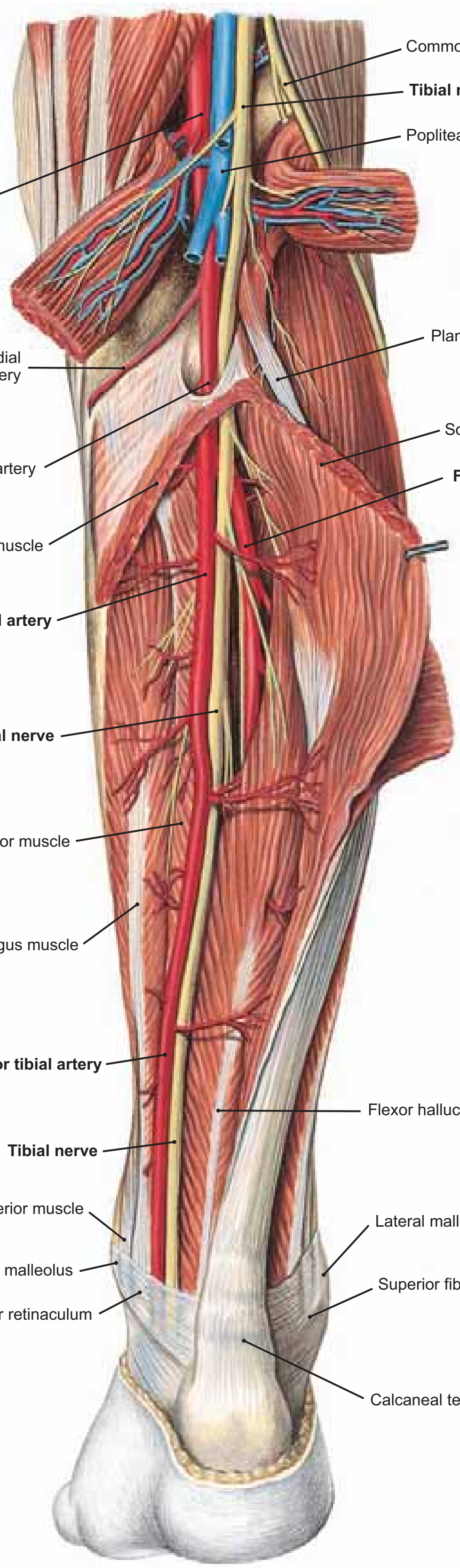


FIGURE 465.1 Nerves and Vessels of the Right Posterior Leg: Intermediate Dissection

NOTE: (1) The soleus muscle was severed and reflected laterally to expose the course of the tibial nerve and posterior tibial artery.

(2) This vessel and nerve descend in the leg between the superficial and deep muscles of the posterior compartment, between the flexor hallucis longus and flexor digitorum longus.

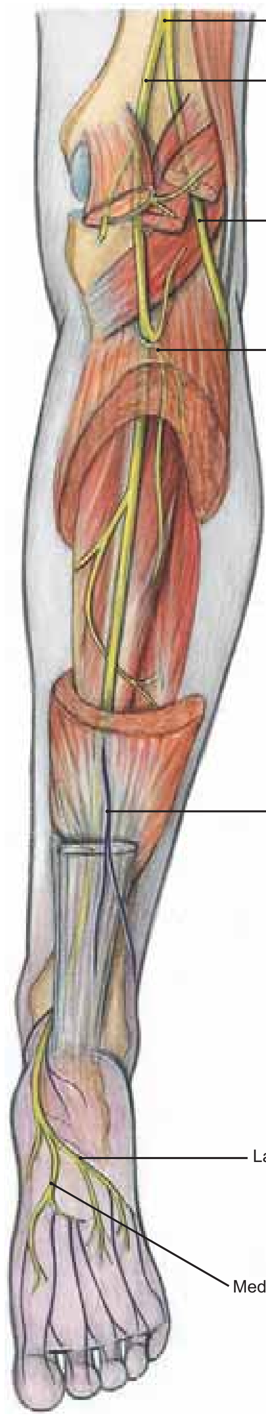


FIGURE 465.2 The Tibial Nerve in the Posterior Compartment of the Leg

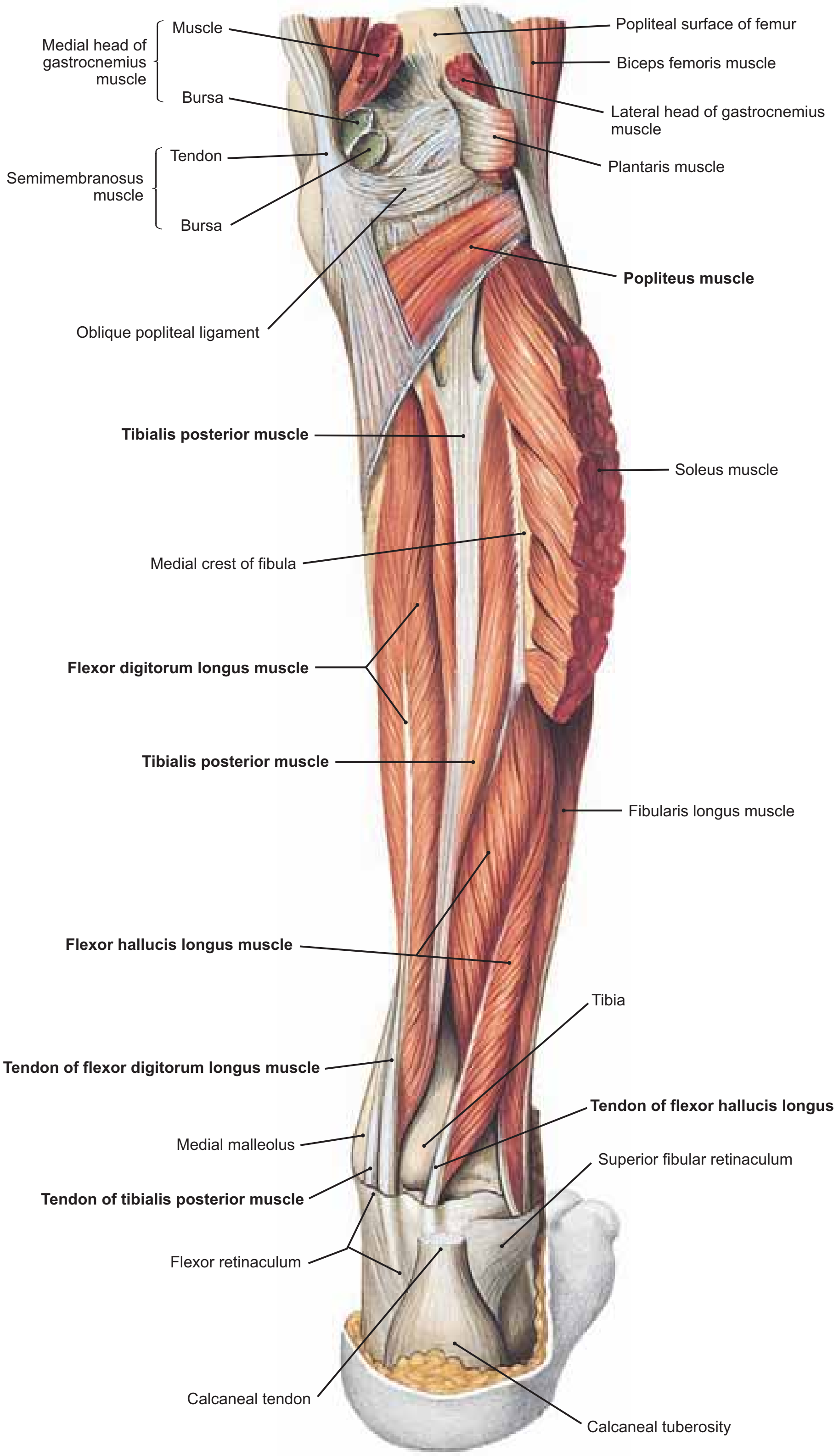


FIGURE 466.1 Deep Muscles of the Posterior Compartment of the Leg

NOTE: (1) The four deep posterior compartment muscles are: (a) the **popliteus,** (b) the **flexor digitorum longus,** (c) the **tibialis posterior,** and (d) the **flexor hallucis longus.**

(2) The **popliteus** is a femorotibial muscle and it tends to rotate the leg medially; however, when the tibia is fixed and the knee joint is **locked,** this muscle rotates the femur laterally on the tibia and thereby it "**unlocks**" the knee joint.

(3) The other three muscles are cruropedal muscles, and as a group, they invert the foot, flex the toes, and assist in plantar flexion at the ankle joint.

(4) The tibialis posterior is closest to bone behind the medial malleolus, the flexor hallucis longus is most lateral, and the flexor digitorum is in between the two.

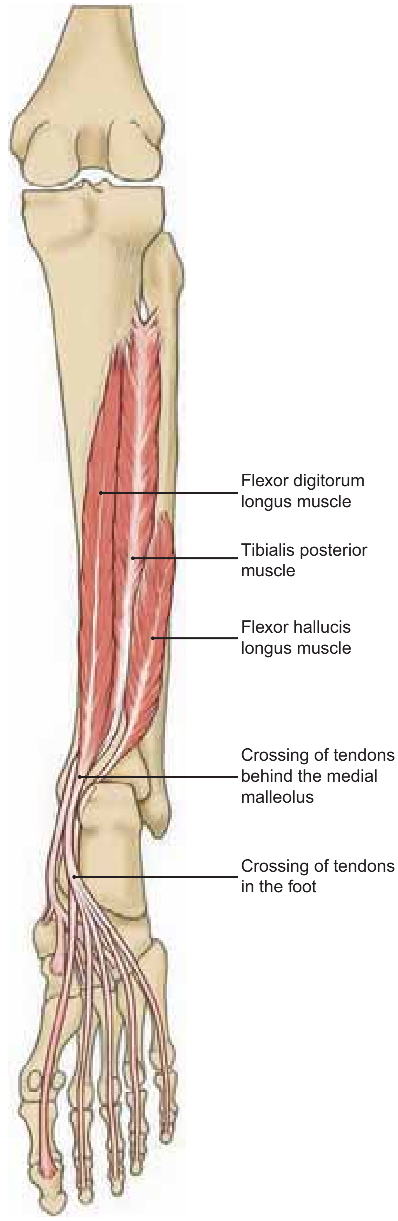


FIGURE 466.2 Deep Muscles of the Posterior Leg

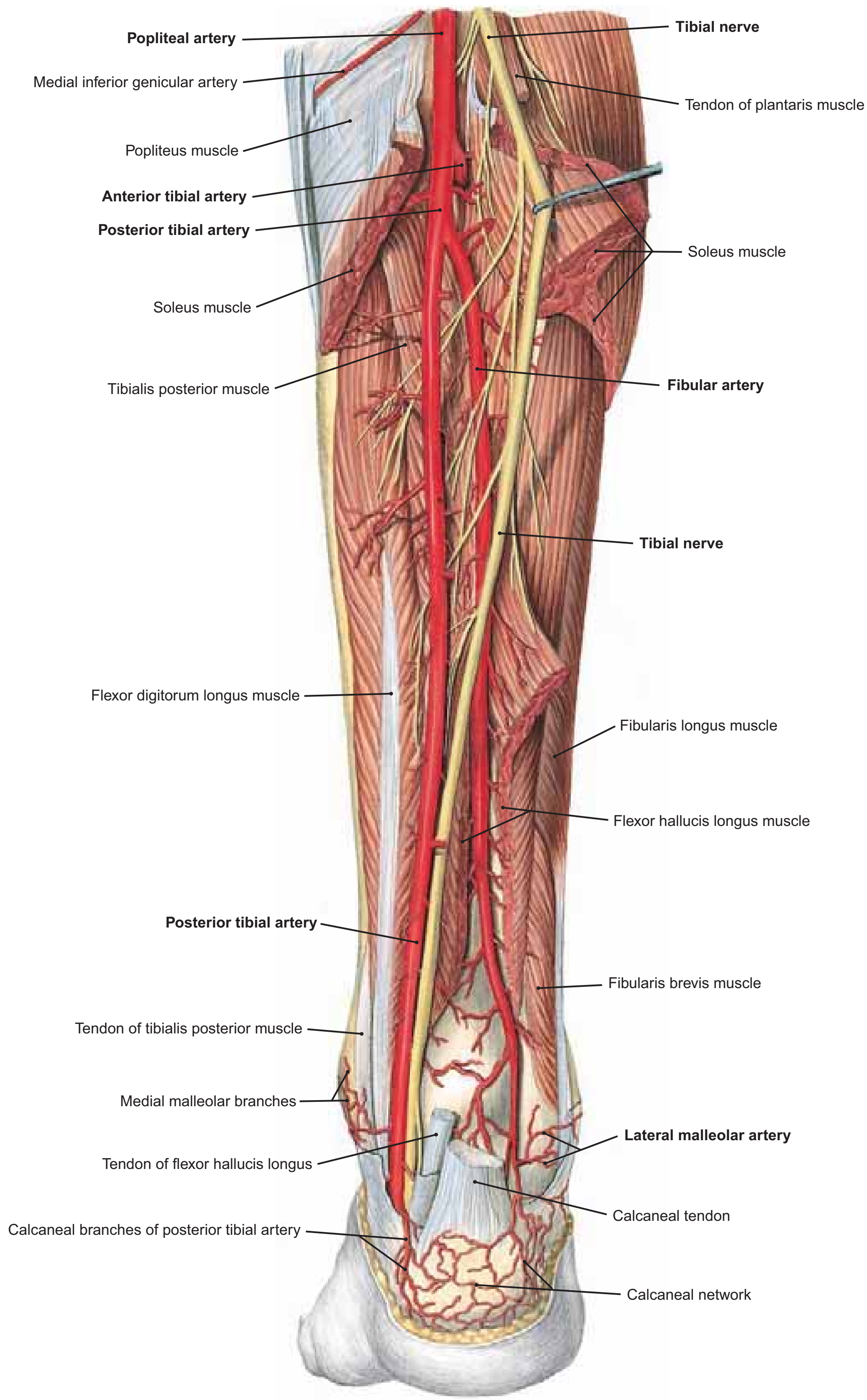


FIGURE 467 Deep Nerves and Arteries of the Posterior Compartment of the Leg

NOTE: (1) The soleus muscle was resected and the tibial nerve pulled laterally. Observe the branching of the **fibular artery** from the posterior tibial and its descending course toward the lateral malleolus.

(2) In the popliteal fossa, the tibial nerve courses superficially to the popliteal artery, whereas at the ankle, the posterior tibial artery is superficial to the tibial nerve.

(3) Behind the medial malleolus, the neurovascular structures are located between the tendons of the flexor digitorum longus and flexor hallucis longus.

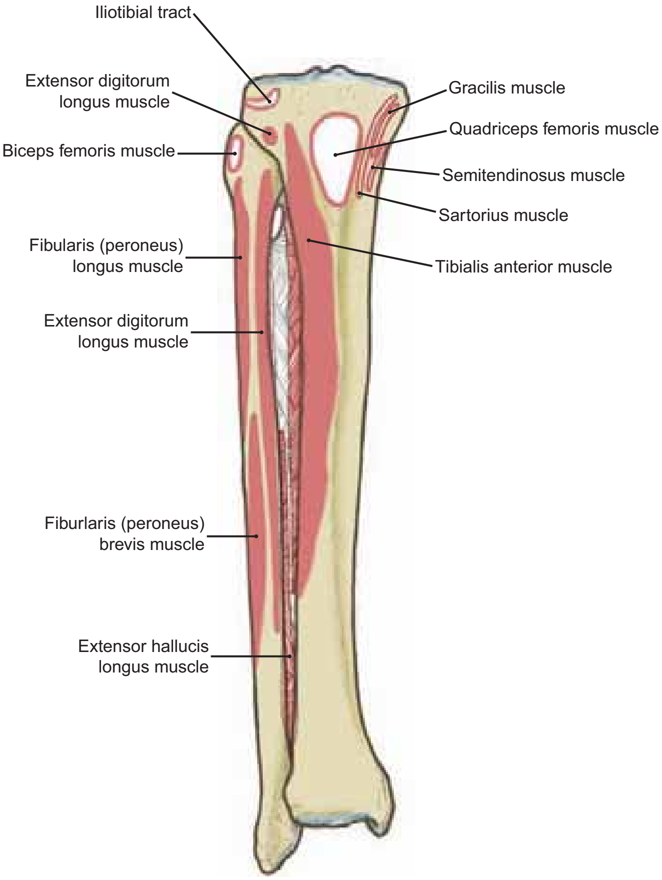


FIGURE 468.1 Attachments of the Anterior and Lateral Compartment Muscles on the Anterior Surfaces of the Fibula and Tibia

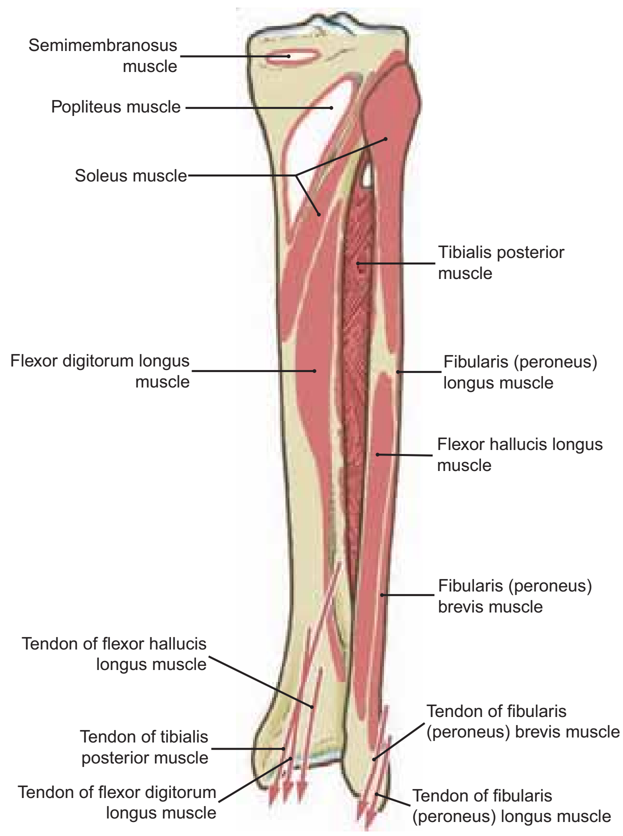


FIGURE 468.2 Attachments of the Lateral and Deep Posterior Compartment Muscles on the Posterior Surfaces of the Fibula and Tibia

MUSCLES OF THE POSTERIOR COMPARTMENT OF THE LEG

Muscle	Origin	Insertion	Innervation	Action
SUPERFICIAL GROUP				
Gastrocnemius	Medial head: Medial epicondyle of the femur Lateral head: Lateral epicondyle of the femur	Posterior surface of the calcaneus by means of the calcaneal tendon	Tibial nerve (S1, S2)	Plantar flexes the foot; flexes the leg at knee joint, tends to supinate the foot
Soleus	Posterior surface of head and upper third or body of fibula; soleal line and medial border of tibia	Joins the tendon of the gastrocnemius to insert on the calcaneus by means of the calcaneal tendon	Tibial nerve (S1, S2)	Plantar flexes the foot; important as a postural muscle during ordinary standing
Plantaris	Posterior aspect of lateral epicondyle of femur and from the oblique popliteal ligament	Into the calcaneal tendon with the gastrocnemius and soleus muscles	Tibial nerve (S1, S2)	Assists the gastrocnemius in plantar flexion of the foot and flexing the leg (weak action)
DEEP GROUP				
Popliteus	Lateral epicondyle of the femur; the lateral meniscus of the knee joint	Posterior surface of the body of the tibia proximal to the soleal line	Tibial nerve (L4, L5, S1)	Flexes and medially rotates the tibia when femur is fixed; laterally rotates the femur to unlock the knee joint when the tibia is fixed
Tibialis posterior	Posterior surface of interosseous membrane; posterior surface of tibia and medial surface of the fibula	Tuberosity of the navicular bone; slips to calcaneus, the three cuneiforms, the cuboid, and the second, third, and fourth metatarsal bones	Tibial nerve (L5, S1)	Plantar flexes the foot; inverts and adducts the foot (tends to supinate the foot)

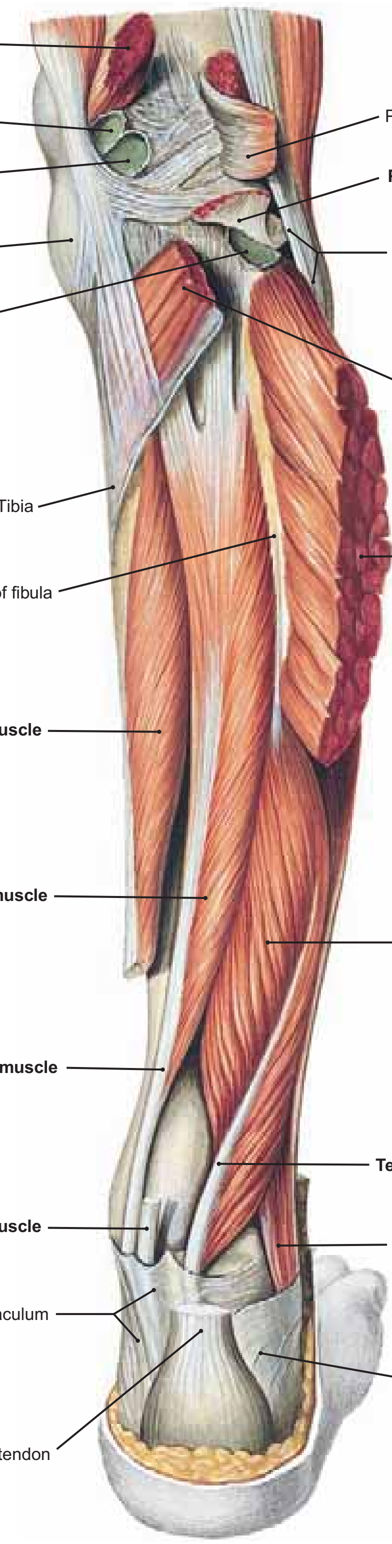


FIGURE 469 Tibialis Posterior and Flexor Hallucis Longus Muscles

MUSCLES OF THE POSTERIOR COMPARTMENT OF THE LEG (Continued)

Muscle	Origin	Insertion	Innervation	Action
Flexor digitorum longus	Posterior surface of tibia and fascia over tibialis posterior	Bases of the distal phalanx of the four lateral toes	Tibial nerve (S1, S2)	Flexes distal phalanx of lateral four toes; plantar flexes and supinates the foot
Flexor hallucis longus	Lower two-thirds of the posterior fibula and lower part of the interosseous membrane	Base of the distal phalanx of the large toe (hallux)	Tibial nerve (S1, S2)	Flexes distal phalanx of large toe; plantar flexes and supinates the foot

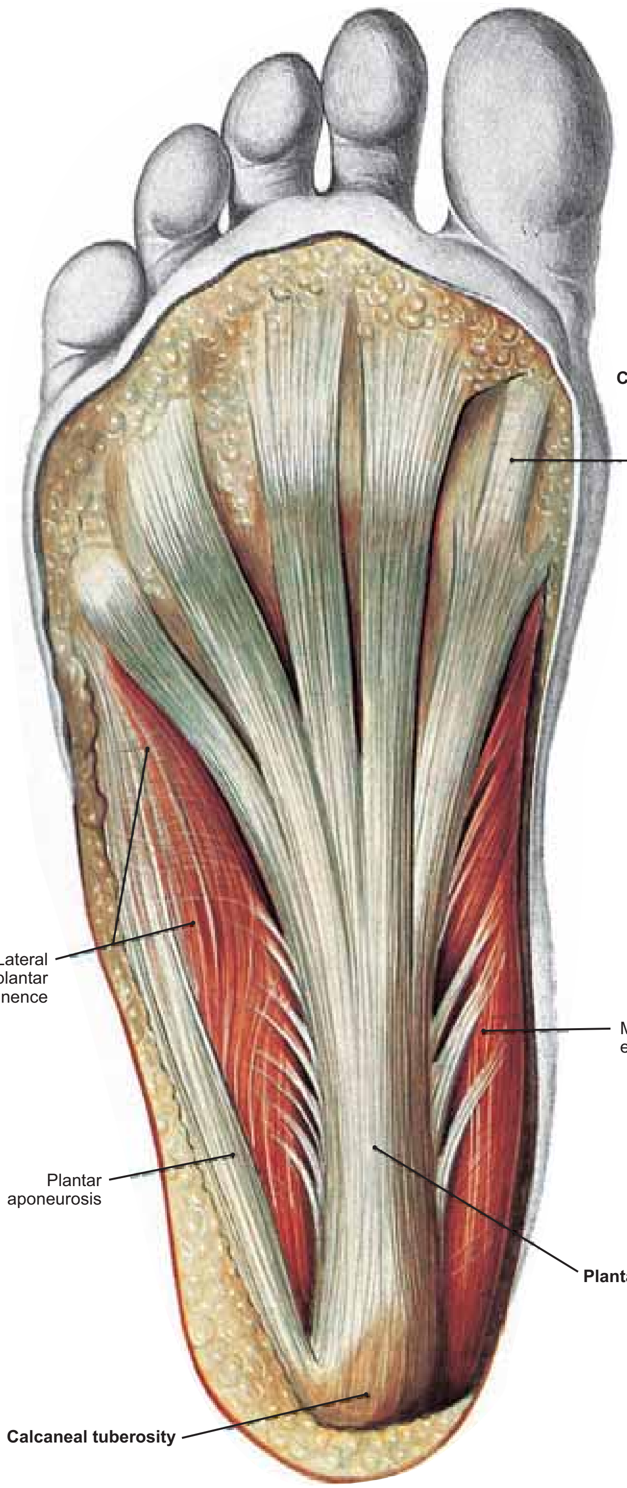


FIGURE 470.1 Sole of the Right Foot: Plantar Aponeurosis

NOTE: (1) The **plantar aponeurosis** stretching along the sole of the foot. Similar to the palmar aponeurosis in the hand, the plantar aponeurosis is a thickened layer of deep fascia serving a protective function to underlying muscles, vessels, and nerves.

(2) The longitudinal orientation of the plantar aponeurosis and its attachment behind to the calcaneal tuberosity. The aponeurosis divides distally into digital slips, one to each toe. At the margins, fibers partially cover the medial and lateral plantar eminences.

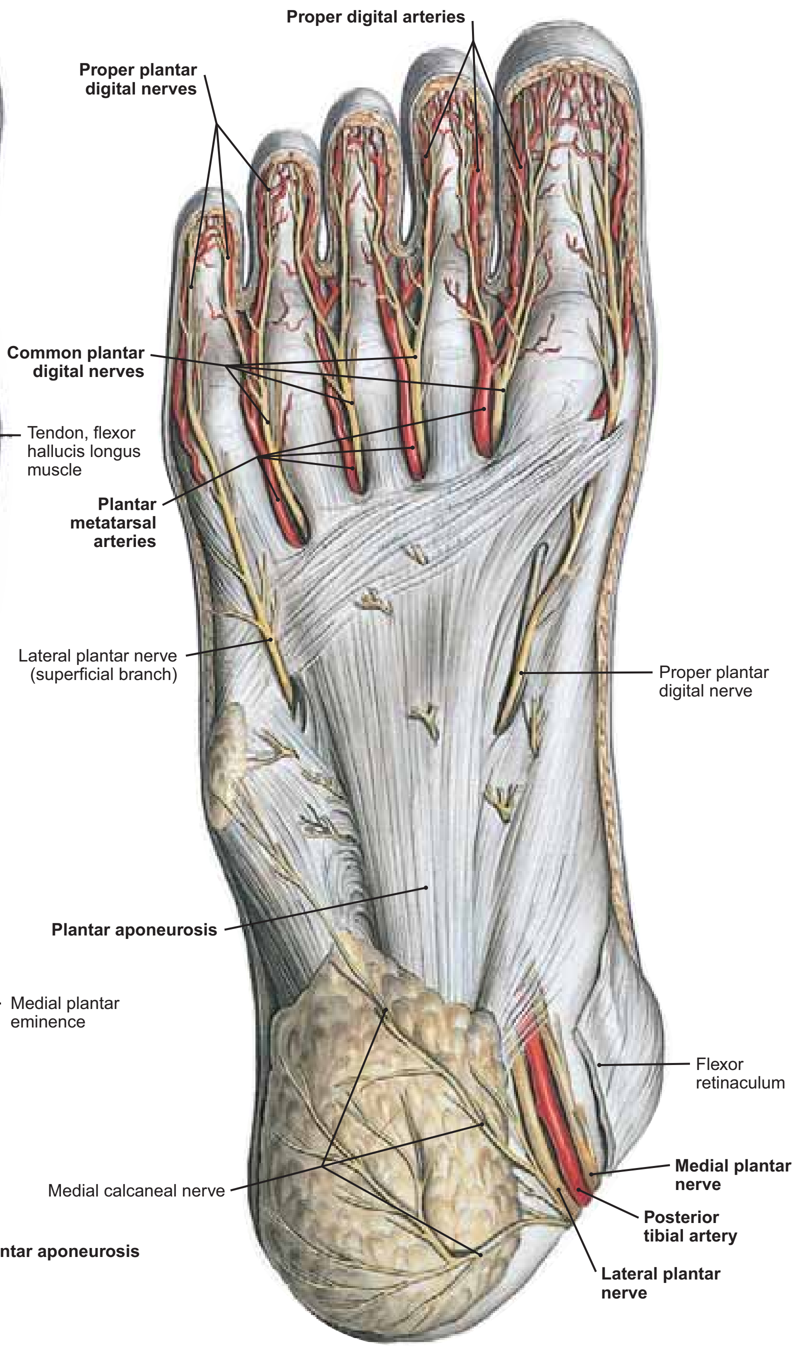


FIGURE 470.2 Sole of the Right Foot: Superficial Nerves and Arteries

NOTE: (1) The **medial** and **lateral plantar nerves** and **posterior tibial artery** as they enter the foot behind the medial malleolus and then immediately course beneath the plantar aponeurosis toward the digits. Cutaneous branches of the nerves penetrate the aponeurosis to supply the overlying skin and fascia.

(2) Between digital slips of the plantar aponeurosis, the vessels and nerves course superficially toward the toes. **Metatarsal arteries** and **common plantar digital nerves** divide to supply adjacent portions of the toes as **proper plantar digital arteries** and **nerves.**

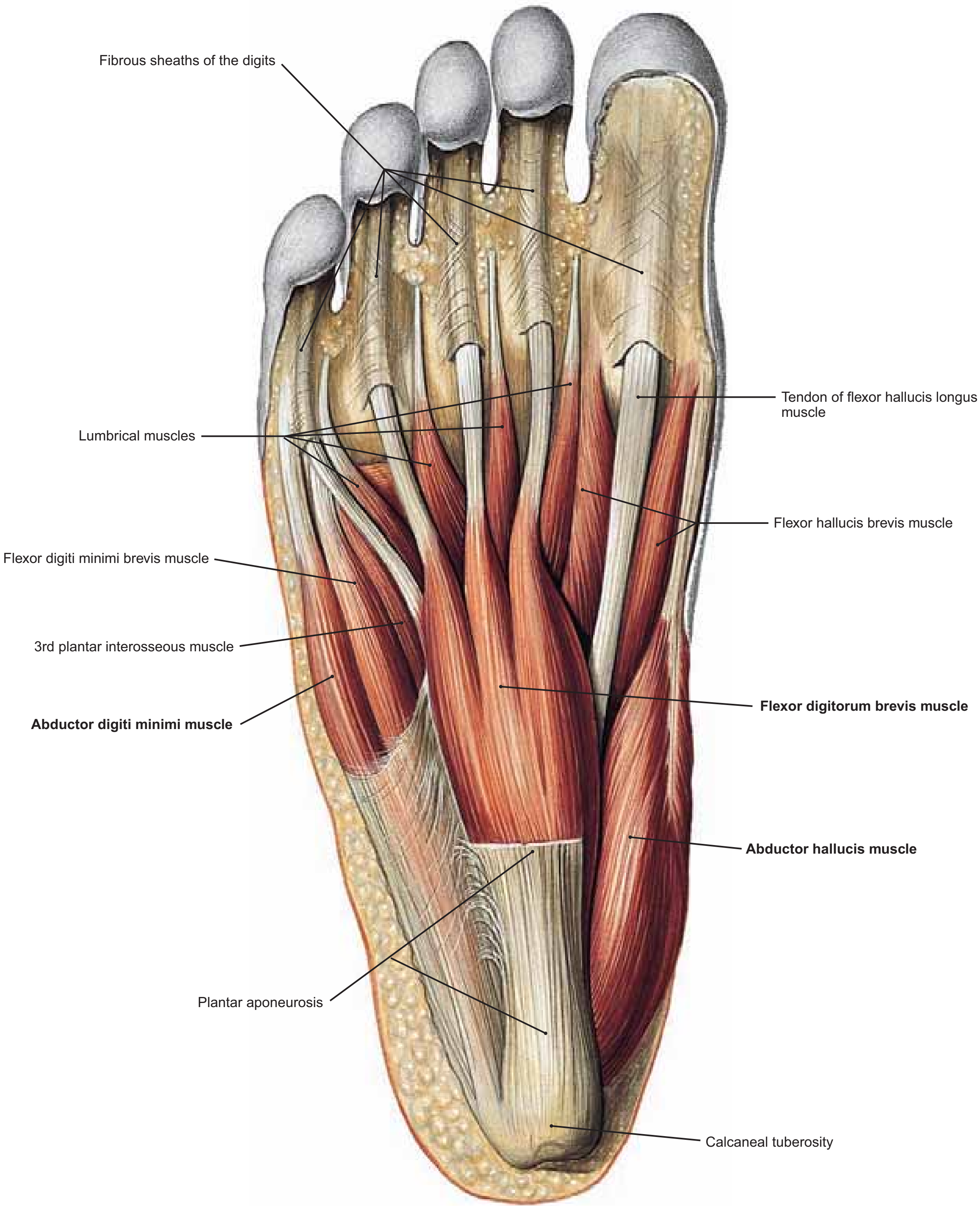


FIGURE 471 Sole of the Foot: First Layer of Plantar Muscles

NOTE: (1) With most of the plantar aponeurosis removed, three muscles comprising the first layer of plantar muscles are exposed. These are the **abductor hallucis,** the **flexor digitorum brevis,** and the **abductor digiti minimi**.

(2) All three muscles of the first layer arise from the tuberosity of the calcaneus. The abductor hallucis inserts on the proximal phalanx of the large toe. The flexor digitorum brevis separates into four tendons that insert onto the middle phalanges of the four lateral toes. The abductor digiti minimi inserts on the proximal phalanx of the small toe.

(3) The terminal parts of the tendons of the short and long flexors of the toes course within osseous–aponeurotic canals to their insertions on bone.

(4) These canals are covered inferiorly by **digital fibrous sheaths** that arch over the tendons and attach to the sides of the phalanges. Within the canals, **synovial sheaths** are closely reflected around the tendons, allowing for their movement upon muscular contraction.

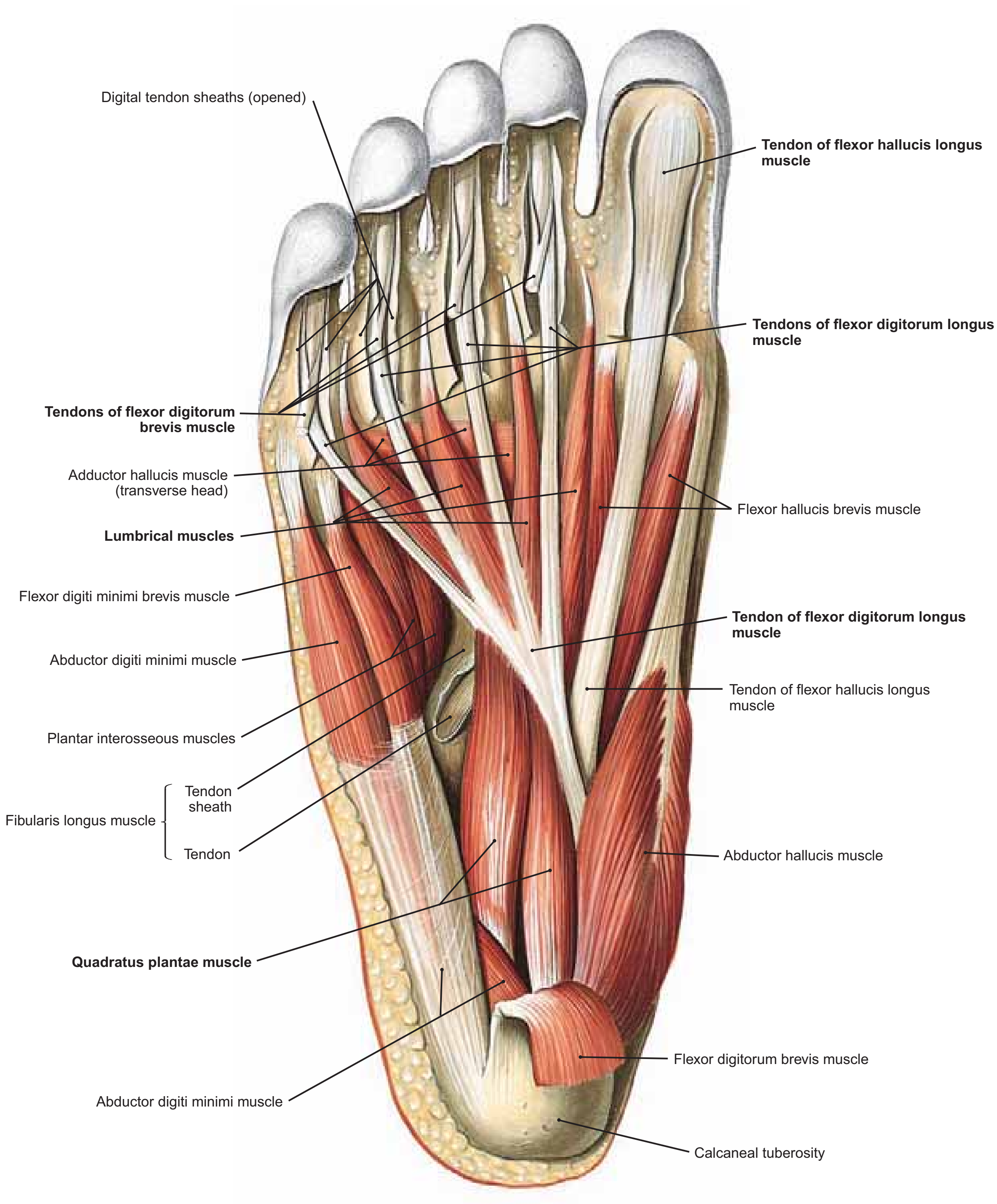


FIGURE 472 Sole of the Right Foot: Second Layer of Plantar Muscles

NOTE: (1) The tendons of the flexor digitorum brevis muscle were severed and removed, thereby exposing the underlying tendons of the **flexor digitorum longus muscle.**

(2) The muscles of the **second layer** in the plantar foot include the **quadratus plantae muscle** and the four **lumbrical muscles.** The quadratus plantae arises by two heads from the calcaneus and inserts into the tendon of the flexor digitorum longus muscle.

(3) The four lumbrical muscles arise from the tendons of the flexor digitorum longus muscle. They insert on the medial aspect of the first phalanx of the lateral four toes as well as on the dorsal extensor hoods of the toes.

(4) The quadratus plantae muscle helps align the pull of the tendons of the flexor digitorum longus by straightening the diagonal vector of the long tendon.

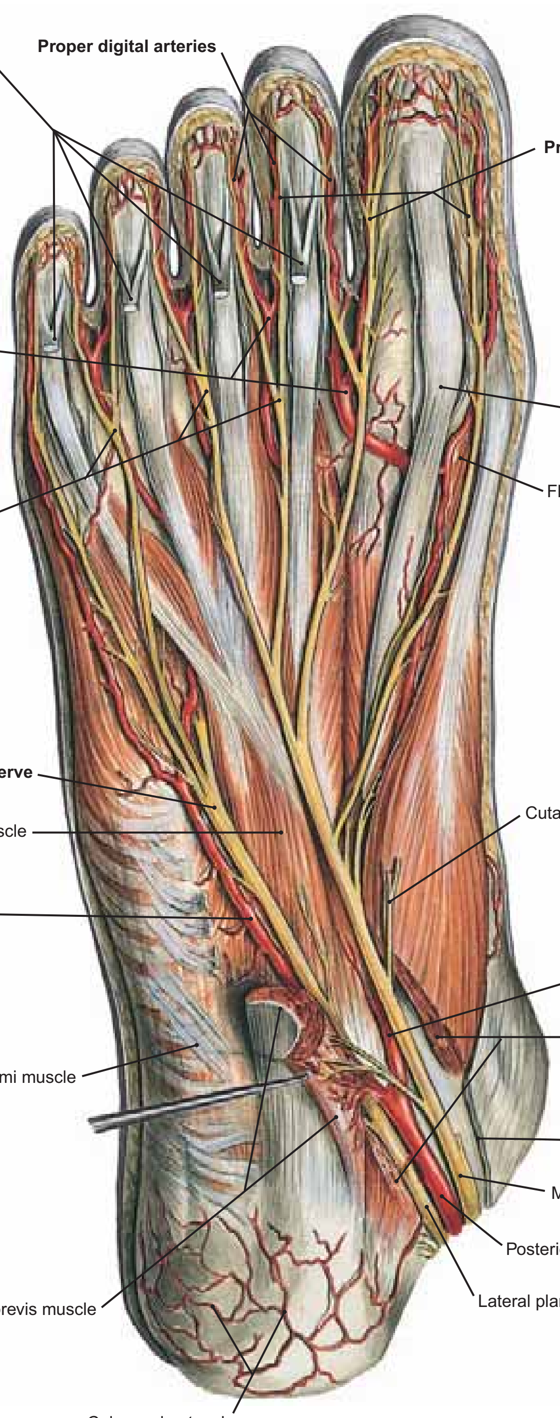


FIGURE 473 Sole of the Right Foot: The Plantar Nerves and Arteries

NOTE: (1) While the tibial nerve divides into **medial** and **lateral plantar nerves** just below the medial malleolus, the posterior tibial artery enters the plantar surface of the foot as a single vessel and then divides into **medial** and **lateral plantar arteries** beneath or at the medial border of the abductor hallucis muscle.

(2) The lateral plantar nerve supplies the lateral 1½ digits with cutaneous innervation, while the medial plantar nerve supplies the medial 3½ digits. Observe the formation of the **common plantar digital nerves**, which then divide into the **proper plantar digital nerves**.

(3) The main trunks of the plantar vessels and nerves cross the sole of the foot from medial to lateral deep to the flexor digitorum brevis and abductor hallucis muscles (first layer) but superficial to the quadratus plantae and lumbrical muscles (second layer).

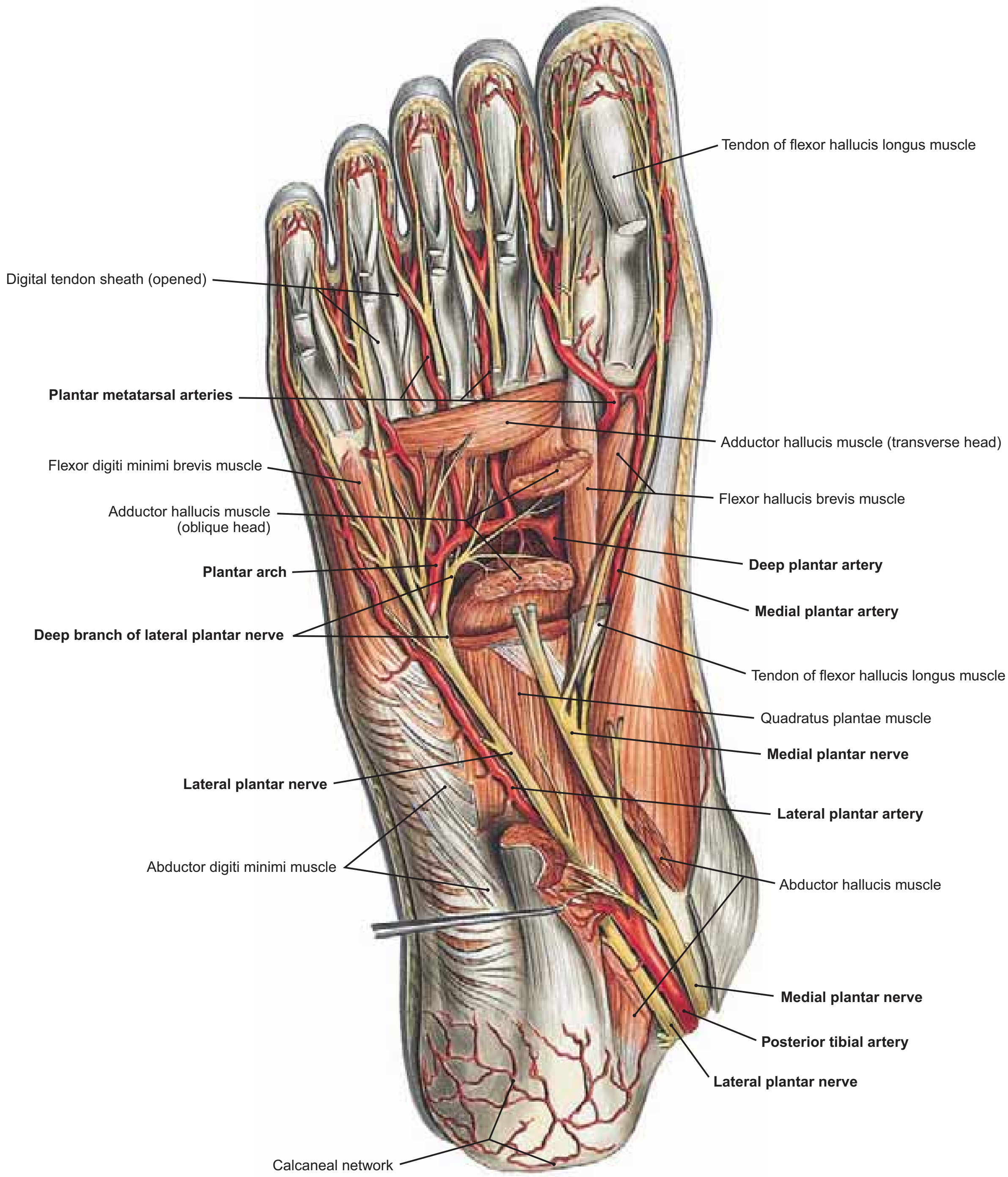


FIGURE 474 Sole of the Right Foot: Plantar Arch and Deep Vessels and Nerves

NOTE: (1) The formation of the **deep plantar arch** principally from the lateral plantar artery and the junction of the deep plantar arch with the deep plantar artery from the foot dorsum (see Fig. 459). From the plantar arch branch **plantar metatarsal arteries,** which divide into **proper original arteries.**

(2) The muscles of the foot are innervated in the following manner:

	Medial plantar nerve	Lateral plantar nerve
First layer	Abductor hallucis; flexor digitorum brevis	Abductor digiti minimi
Second layer	First lumbrical	Quadratus plantae; second, third, and fourth lumbrical
Third layer	Flexor hallucis brevis	Adductor hallucis; flexor digiti minimi brevis
Fourth layer		Plantar interossei; dorsal interossei

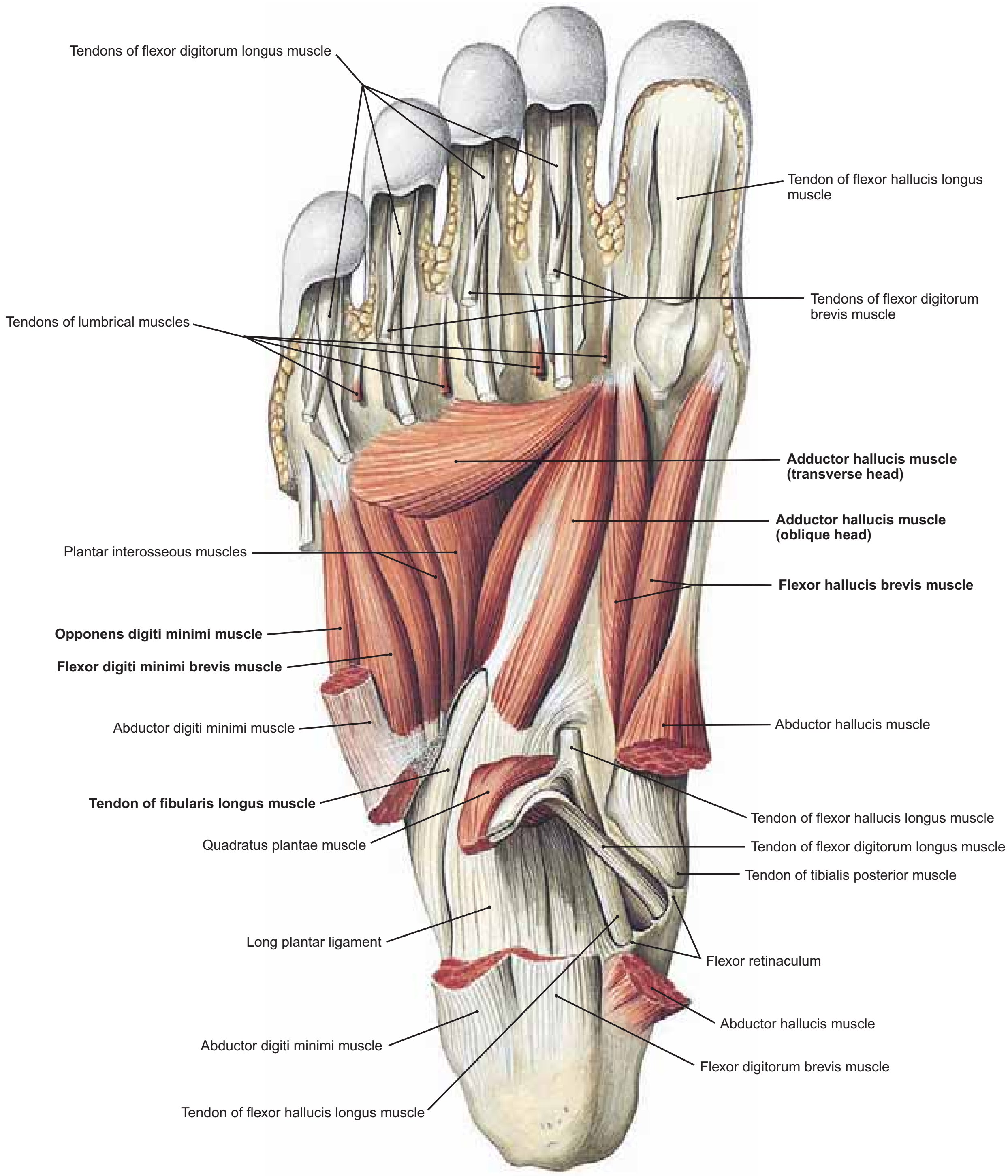


FIGURE 475 Sole of the Right Foot: Third Layer of Plantar Muscles

NOTE: (1) The third layer of plantar muscles consists of two flexors and an *ad*ductor (with two heads), in contrast to the first layer, which contains one flexor and two *ab*ductors. Thus, the **flexor hallucis brevis, the flexor digiti minimi brevis,** and the **oblique** and **transverse heads** of the **adductor hallucis** form the third layer of plantar muscles.

(2) At times, the fibers of the flexor digiti minimi brevis that insert on the lateral side of the first phalanx of the fifth toe are referred to as a separate muscle: the **opponens digiti minimi**.

(3) The tendon of the **fibularis longus muscles**, which crosses the plantar aspect of the foot obliquely to insert on the lateral side of the base of the first metatarsal and the first (medial) cuneiform bone.

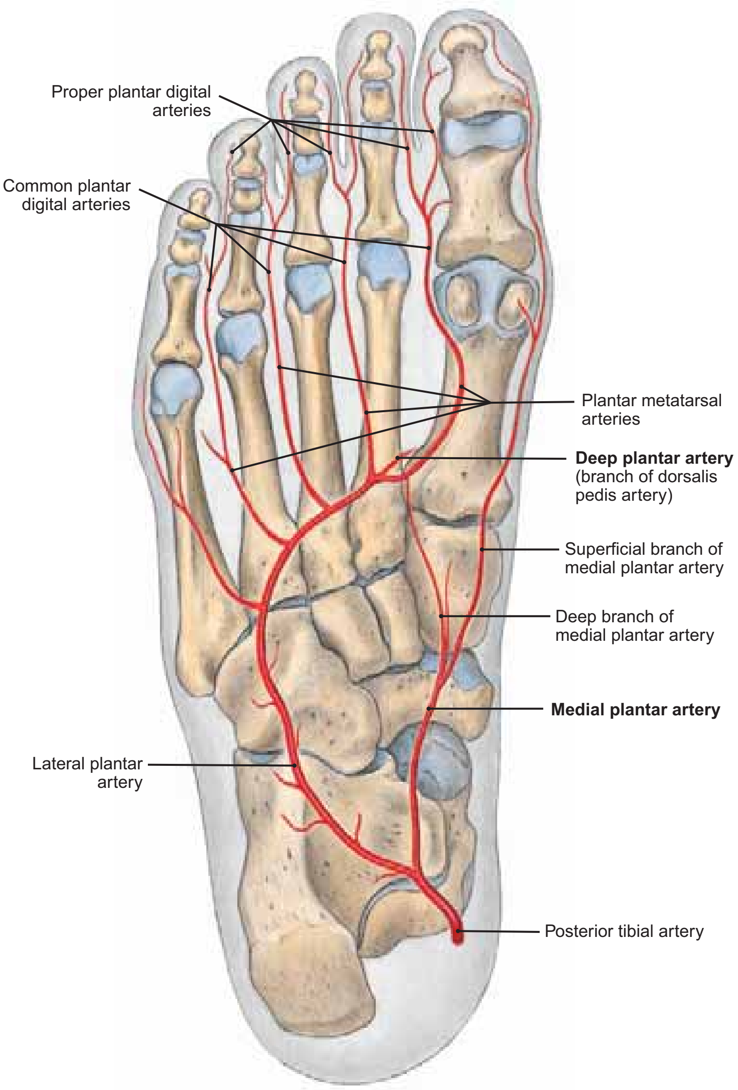


FIGURE 476.1 Plantar Aspect of the Foot: Diagram of Arteries and Bones

NOTE: The **posterior tibial artery** enters the foot medially behind the medial malleolus, divides into **medial** and **lateral plantar arteries**, and anastomoses with the deep plantar branch of the **dorsalis pedis artery** between the first and second digits.

FIGURE 476.2 Plantar Interossei

FIGURE 476.3 Dorsal Interossei

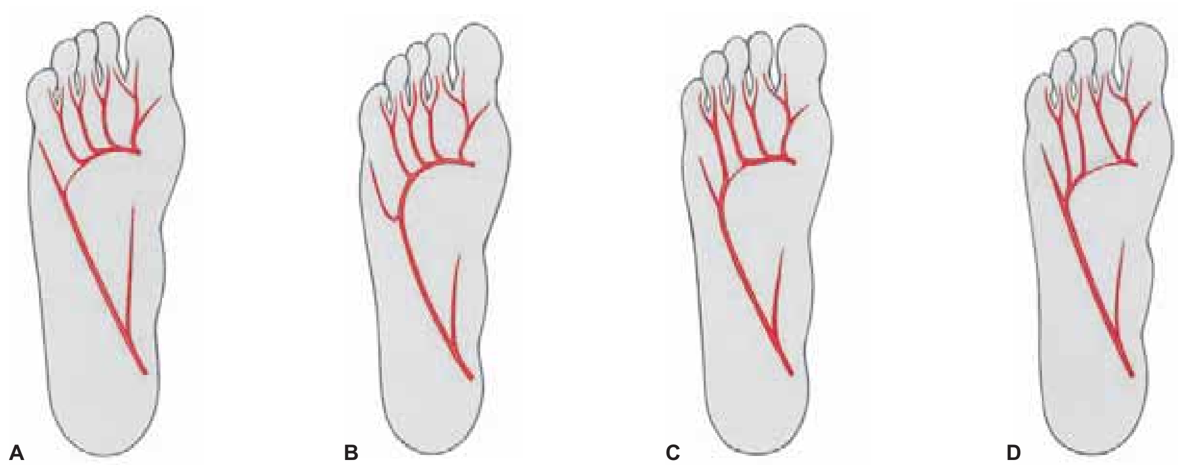


FIGURE 476.4 Variations in the Arteries on the Plantar Aspect of the Foot

NOTE: **A:** Deep plantar arch principally from the dorsalis pedis artery (from the foot dorsum).
B: Deep plantar arch supplied mainly from the lateral plantar branch of the posterior tibial artery.
C: Fifth and part of fourth toes by lateral plantar artery, medial toes by dorsalis pedis artery.
D: Fifth, fourth, and lateral part of third toe by lateral plantar artery, medial toes by dorsalis pedis artery.

MUSCLES OF THE SOLE OF THE FOOT Muscle	Origin	Insertion	Innervation	Action
FIRST LAYER OF MUSCLES				
Abductor hallucis	Flexor retinaculum; medial process of calcaneal tuberosity; plantar aponeurosis	Medial side of the base of the proximal phalanx of the large toe	Medial plantar nerve (L5, S1)	Abducts and flexes the large toe; helps maintain the medial longitudinal arch
Flexor digitorum brevis	Medial process of calcaneal tuberosity; plantar aponeurosis	By four tendons onto the middle phalanx of the lateral four toes	Medial plantar nerve (L5, S1)	Flexes the lateral four toes
Abductor digiti minimi	Medial and lateral processes of the calcaneal tuberosity; plantar aponeurosis	Lateral side of the base of the proximal phalanx of the small toe	Lateral planter nerve (S2, S3)	Abducts and flexes the little toe
SECOND LAYER OF MUSCLES				
Quadratus plantae	By two heads from the plantar surface of the calcaneus; long plantar ligament	Lateral and deep surfaces of the tendons of the flexor digitorum longus muscle	Lateral plantar nerve (S2, S3)	Assists the flexor digitorum longus; straightens the pull of flexor digitorum longus along longitudinal axis of foot
First lumbrical	Medial side of the first tendon (to second toe) of the flexor digitorum longus	Passes along the medial side of second toe and inserts on its dorsal digital expansion	Medial plantar nerve (L5, S1)	Flexes the proximal phalanx at the metatarsophalangeal joint; extends the interphalangeal joints
Second, third, and fourth lumbrical	Each muscle by two heads from the adjacent surfaces of the second, third, and fourth tendons (to the third, fourth, and fifth toes) of the flexor digitorum longus muscle	Course along the medial sides of the third, fourth, and fifth toes and insert on their respective dorsal digital expansions	Lateral plantar nerve (S2, S3)	Action same as the first lumbrical
THIRD LAYER OF MUSCLES				
Flexor hallucis brevis	Plantar surface of cuboid and lateral (third) cuneiform bones; tendon of the tibialis posterior	By two tendons onto the sides of the base of the proximal phalanx of the large toe	Medial plantar nerve (L5, S1)	Flexes the proximal phalanx of the large toe at the metatarsophalangeal joint
Flexor digiti minimi	Base of the fifth metatarsal bone; the sheath of the tendon of the fibularis longus	Lateral side of the base of the proximal phalanx of the small toe	Lateral plantar nerve (S2, S3)	Flexes the proximal phalanx of the small toe at the metatarsophalangeal joint
Adductor hallucis Transverse head	Plantar metatarsophalangeal ligaments of third, fourth, and fifth toes; deep transverse metatarsal ligaments between the toes	By a common tendon to lateral aspect of the base of the proximal phalanx of the large toe	Lateral plantar nerve (S2, S3)	Adducts large toe; flexes large toe at metatarsophalangeal joint
Oblique head	Bases of the second, third, and fourth metatarsal bones; sheath of the tendon of fibularis longus muscle			
FOURTH LAYER OF MUSCLES				
Plantar interossei (three muscles)	Bases and medial sides of third, fourth, and fifth metatarsal bones	Bases of proximal phalanx of third, fourth, and fifth toes (medial side); onto the dorsal digital expansions	Lateral plantar nerve (S2, S3)	Adduct third, fourth, and fifth toes; flex metatarsophalangeal joints; extend interphalangeal joints
Dorsal interossei (four muscles)	Each by two heads from adjacent sides of metatarsal bones	Proximal phalanx and dorsal digital expansions of second, third, and fourth toes	Lateral plantar nerve (S2, S3)	Abduct second, third, and fourth toes; flex metatarsophalangeal joints and extend interphalangeal joints

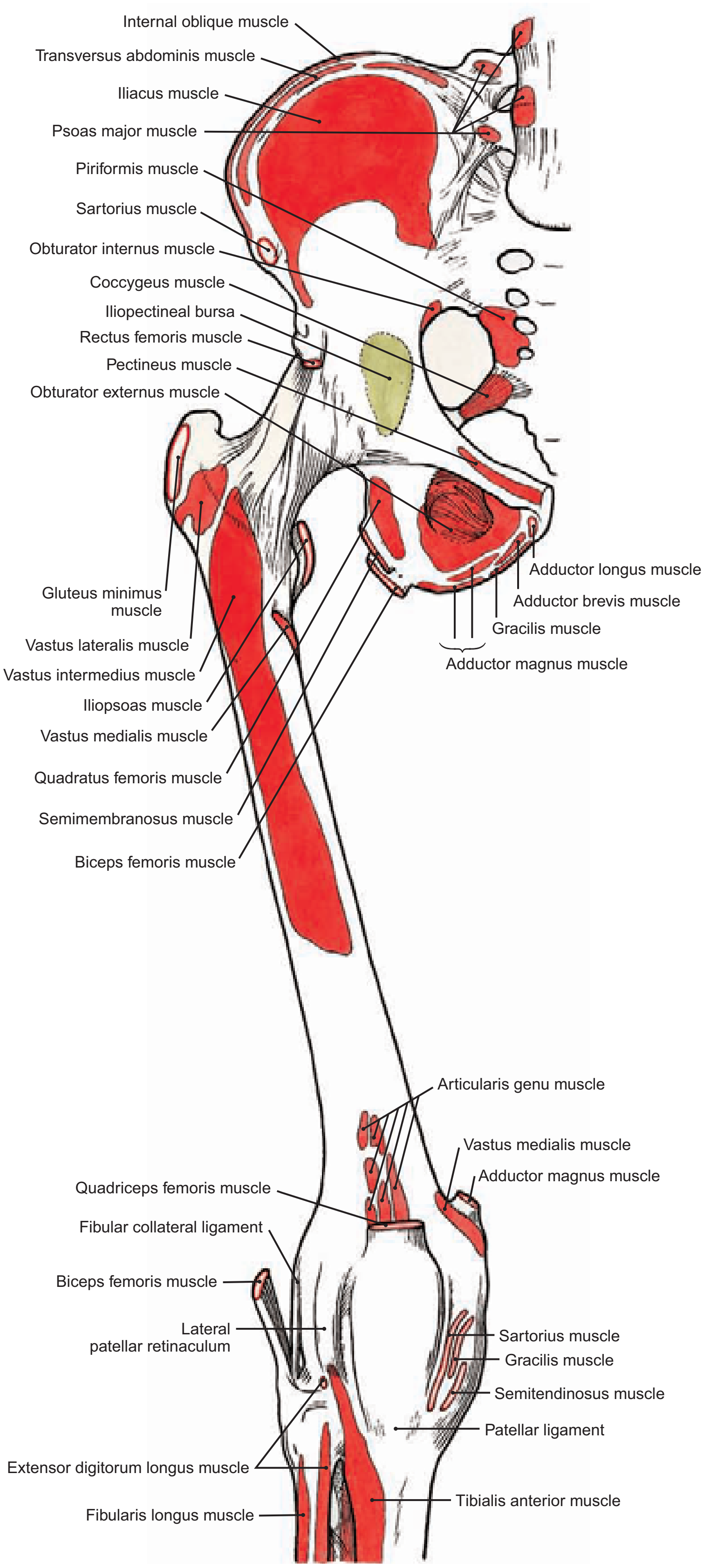


FIGURE 478.1 Anterior View of Right Pelvis and Femur Showing Muscle Attachments

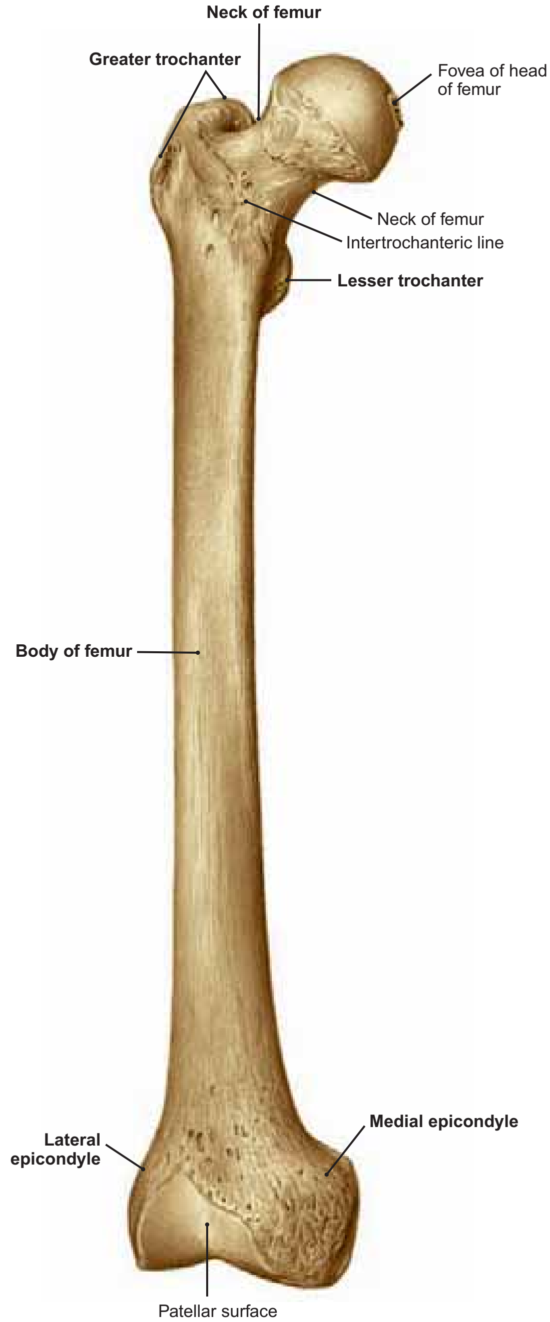


FIGURE 478.2 Right Femur (Anterior View)

NOTE: (1) The femur is the longest and strongest bone in the body and it transmits to the tibia and feet the weight of the body above the hip joints. It consists of an upper extremity, the **head,** the **body** or **shaft,** and a **distal extremity** enlarged by two **condyles.**

(2) The spherical head of the femur fits into the **acetabulum** of the pelvis. Below the head of the femur is the somewhat narrowed femoral **neck** and two prominent tubercles, the **greater** and **lesser trochanters.**

(3) The anterior surface of the body of the femur is smooth and its proximal two-thirds gives origin to the vastus intermedius muscle.

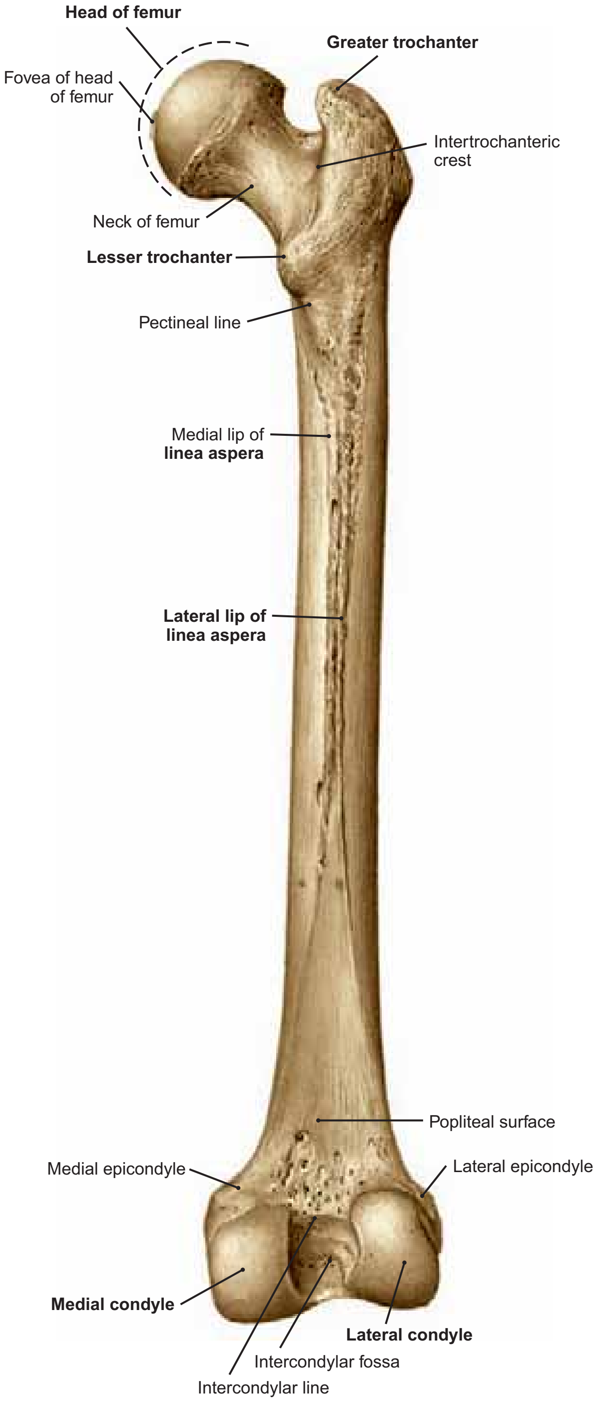


FIGURE 479.1 Right Femur (Posterior View)

NOTE: (1) The **greater** and **lesser trochanters** and the intertrochanteric crest in between. Onto the greater trochanter insert the gluteus medius and minimus, the piriformis, and the obturator internus. On the lesser trochanter inserts the iliopsoas, while the quadratus femoris attaches along the intertrochanteric crest.

(2) The thick, longitudinally oriented ridge, the **linea aspera,** along the posterior surface of the body of the femur. It also serves for muscle attachments.

(3) The **medial** and **lateral condyles** and **epicondyles** inferiorly. The condyles articulate with the tibia and the intercondyloid fossa affords attachment for the cruciate ligaments.

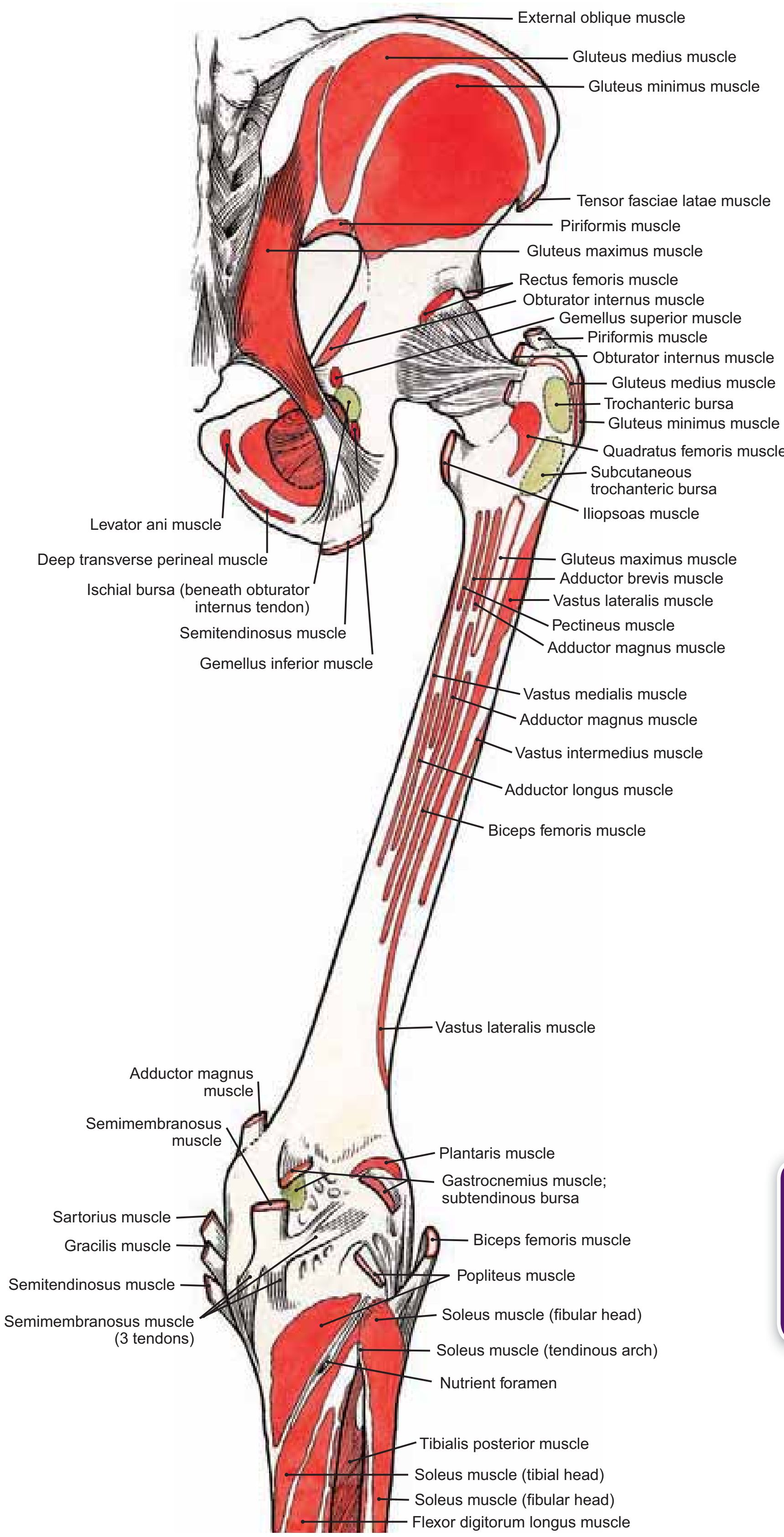


FIGURE 479.2 Posterior View of Right Pelvis and Femur Showing Muscle Attachments

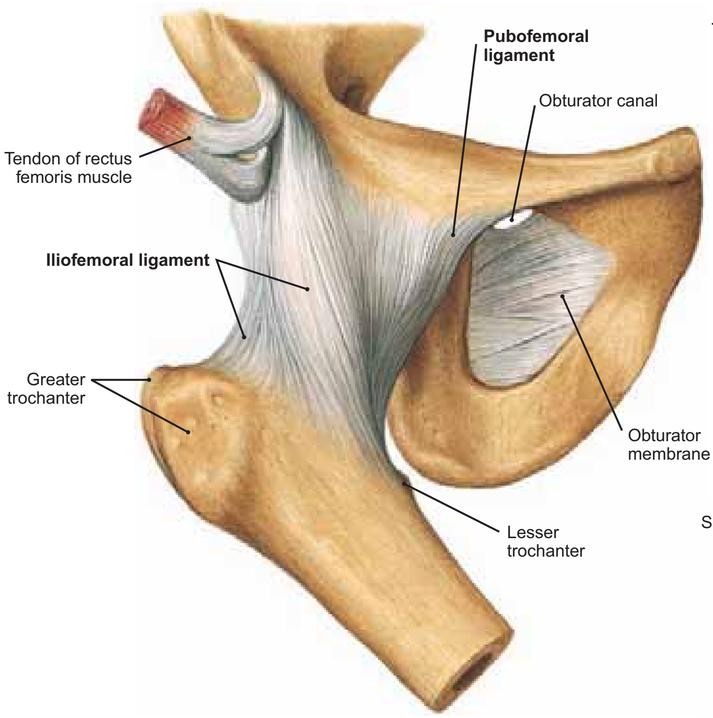


FIGURE 480.1 Right Hip Joint (Anterior View)

NOTE: (1) The hip joint is a typical ball-and-socket joint and consists of the **head of the femur,** which fits snugly in a deepened cavity, the **acetabular fossa.** The bones are held in position by a series of extremely strong ligaments.

(2) The **articular capsule** of the hip joint is reinforced by the **iliofemoral, pubofemoral,** and **ischiofemoral ligaments,** the **acetabular labrum,** the **transverse acetabular ligament,** and the **ligament of the head of the femur.**

(3) The longitudinally oriented fibers of the iliofemoral and pubofemoral ligaments seen anteriorly on the capsule.

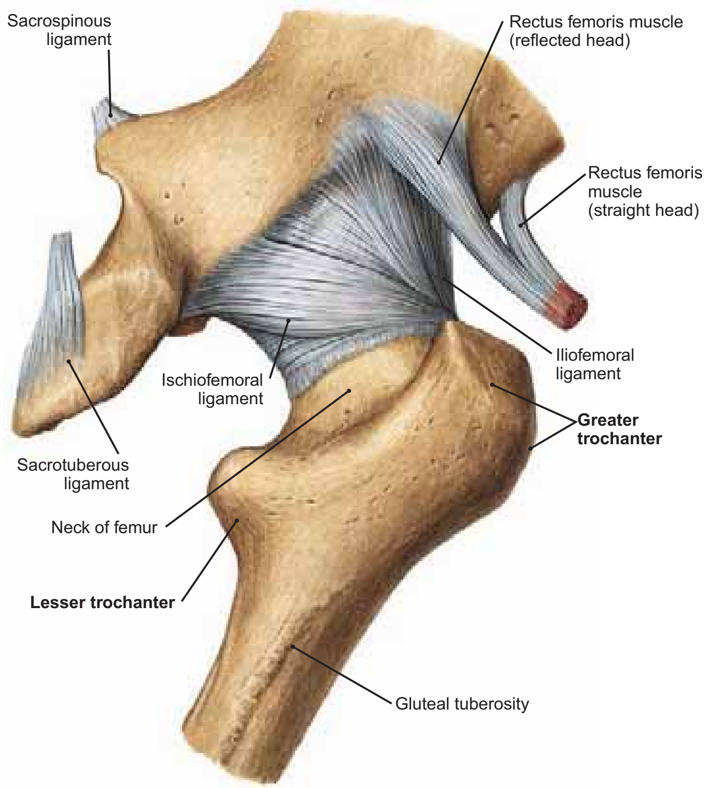


FIGURE 480.2 Right Hip Joint (Posterior View)

NOTE: Fibers of the **ischiofemoral ligament** are directed almost horizontally across the capsule of the hip joint. Whereas anteriorly (Fig. 478.2) the capsule attaches along the intertrochanteric line of the femur, posteriorly it encircles the femoral neck. The capsule is thinnest and weaker posteriorly.

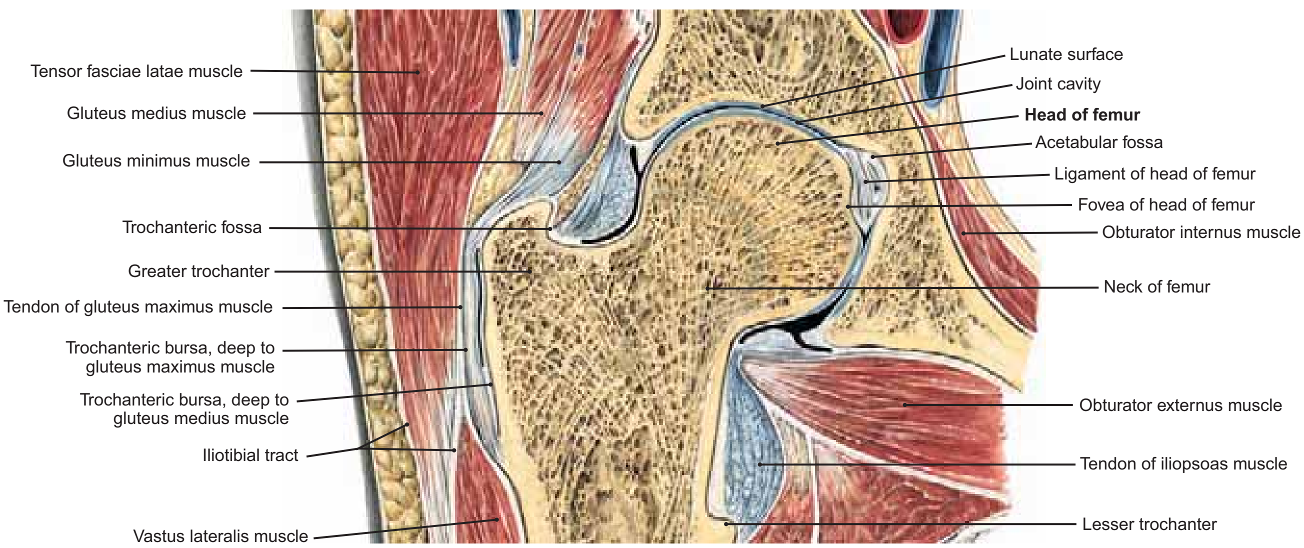


FIGURE 480.3 Frontal Section through the Right Hip Joint and Some Surrounding Soft Tissues

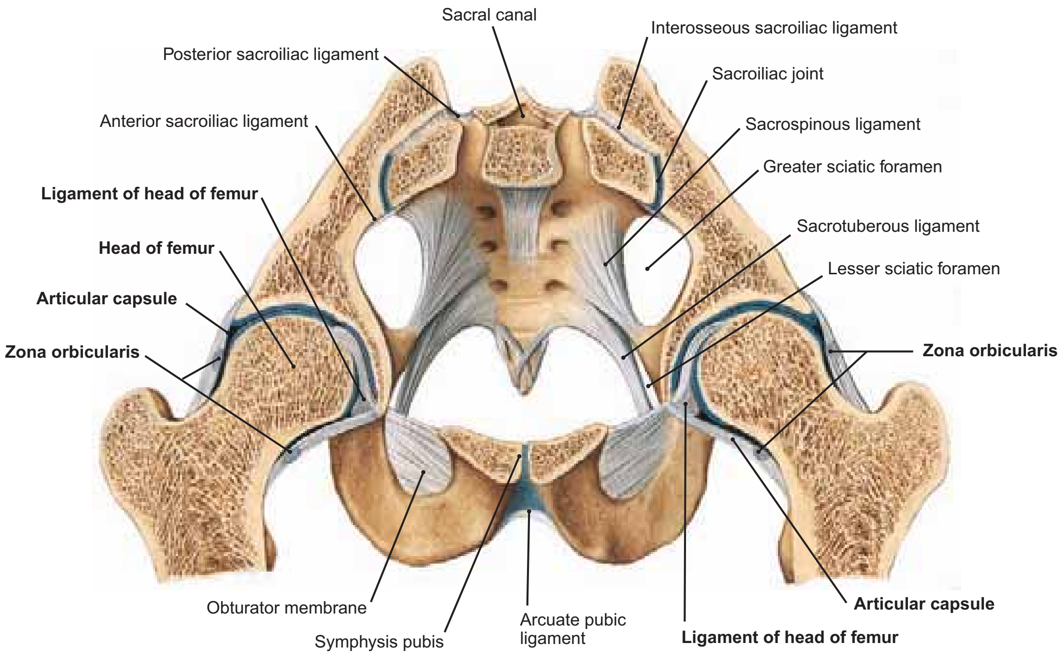


FIGURE 481.1 Frontal Section of the Pelvis Showing Both Hip Joints

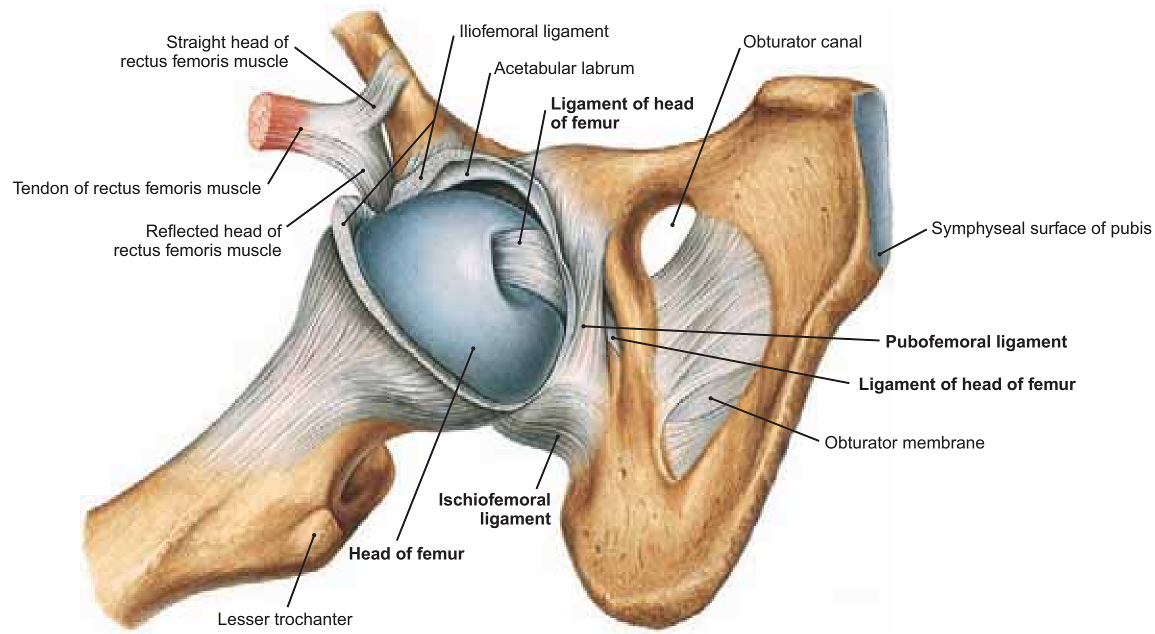


FIGURE 481.2 Anterior Exposure of the Right Hip Joint

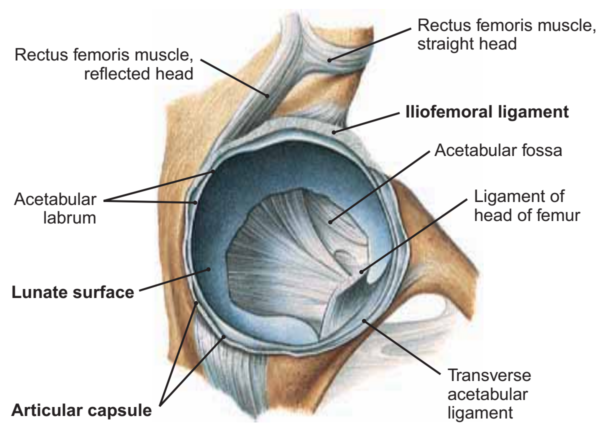
NOTE: The articular capsule of the hip joint has been opened near the acetabular labrum. This exposes the cartilage-covered head of the femur within the joint cavity. Observe the ligament of the femoral head attached to the femur where cartilage is lacking.

FIGURE 481.3 Socket of the Right Hip Joint ▶

NOTE: (1) The acetabulum is surrounded by a fibrocartilaginous rim, the **acetabular labrum.** This deepens the joint cavity and accommodates enough of the distal head of the femur so that it cannot be pulled from its socket without injuring the acetabular labrum.

(2) The bony acetabulum is incomplete below. Here the acetabular notch is partially covered by the **transverse acetabular ligament.** Through the free portion of the acetabular notch course vessels and nerves that supply the head of the **femur.**

(3) The **ligament of the head of the femur** attaches the femoral head by two bands to either side of the acetabular notch.



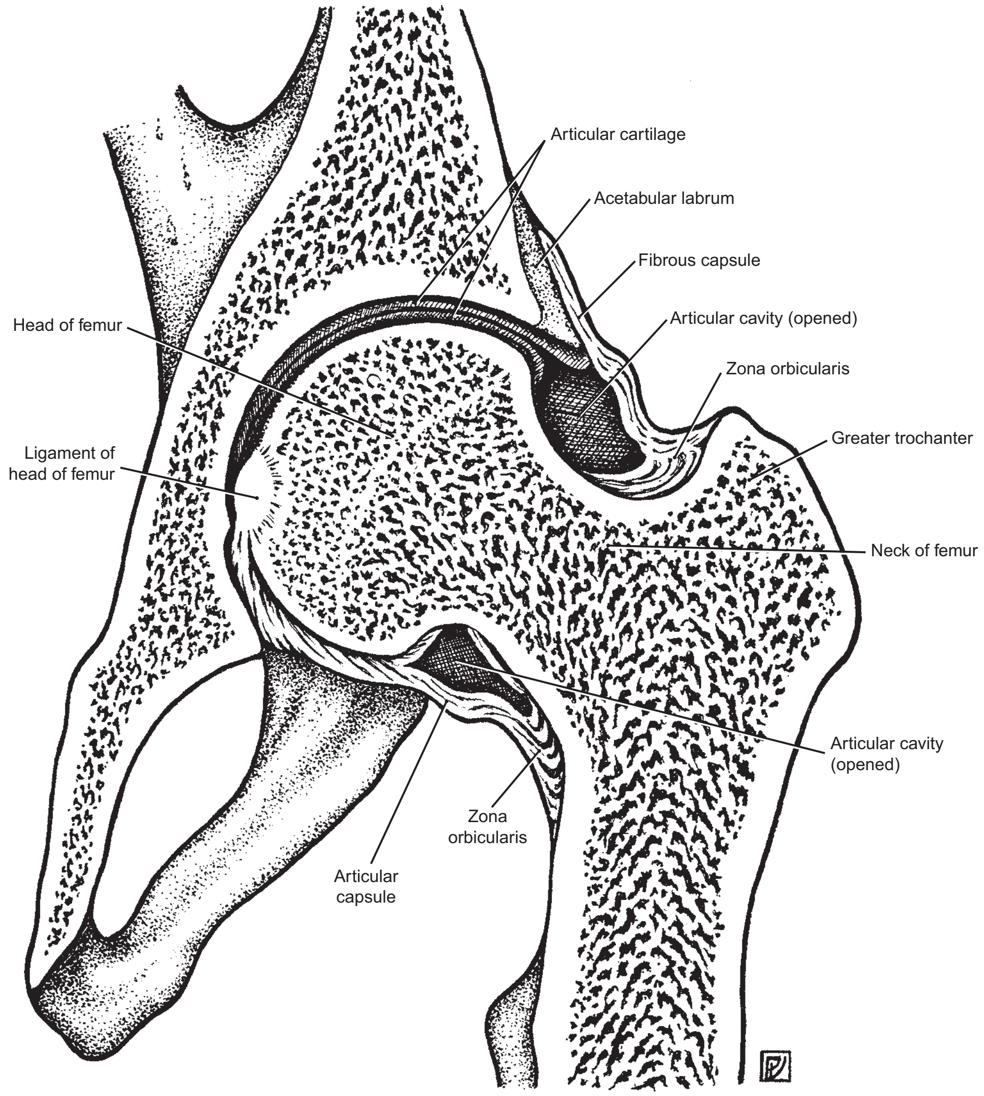


FIGURE 482.1 Frontal Section through the Hip Joint

(From *Clemente's Anatomy Dissector,* 2nd Edition, Lippincott Williams & Wilkins, Baltimore, 2007.)

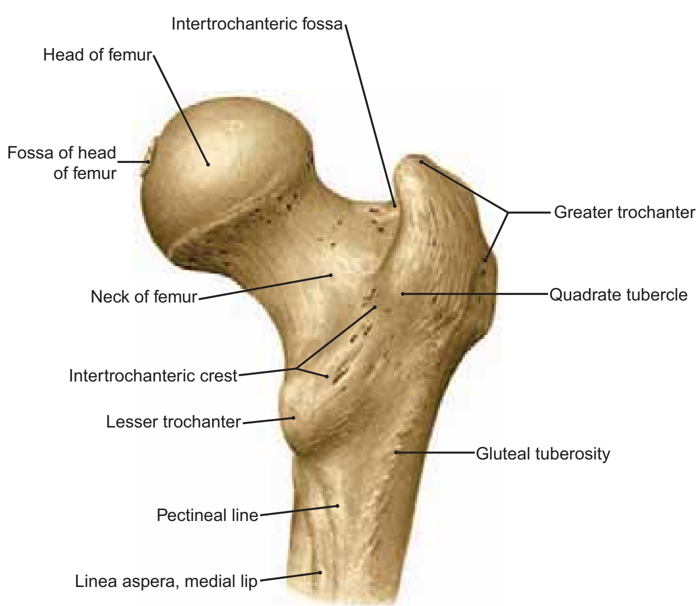


FIGURE 482.2 Superior End of the Femur

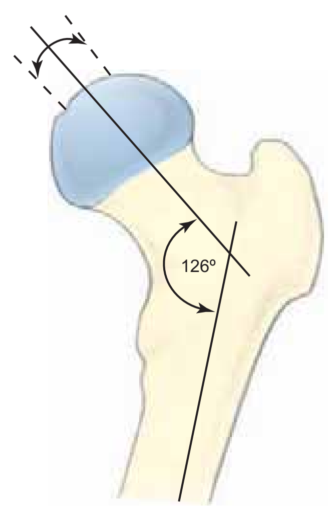


FIGURE 482.3 Variation in the Angle between the Femoral Neck and the Shaft

NOTE that this angle is about 150 degrees in infancy and about 126 degrees in the adult.

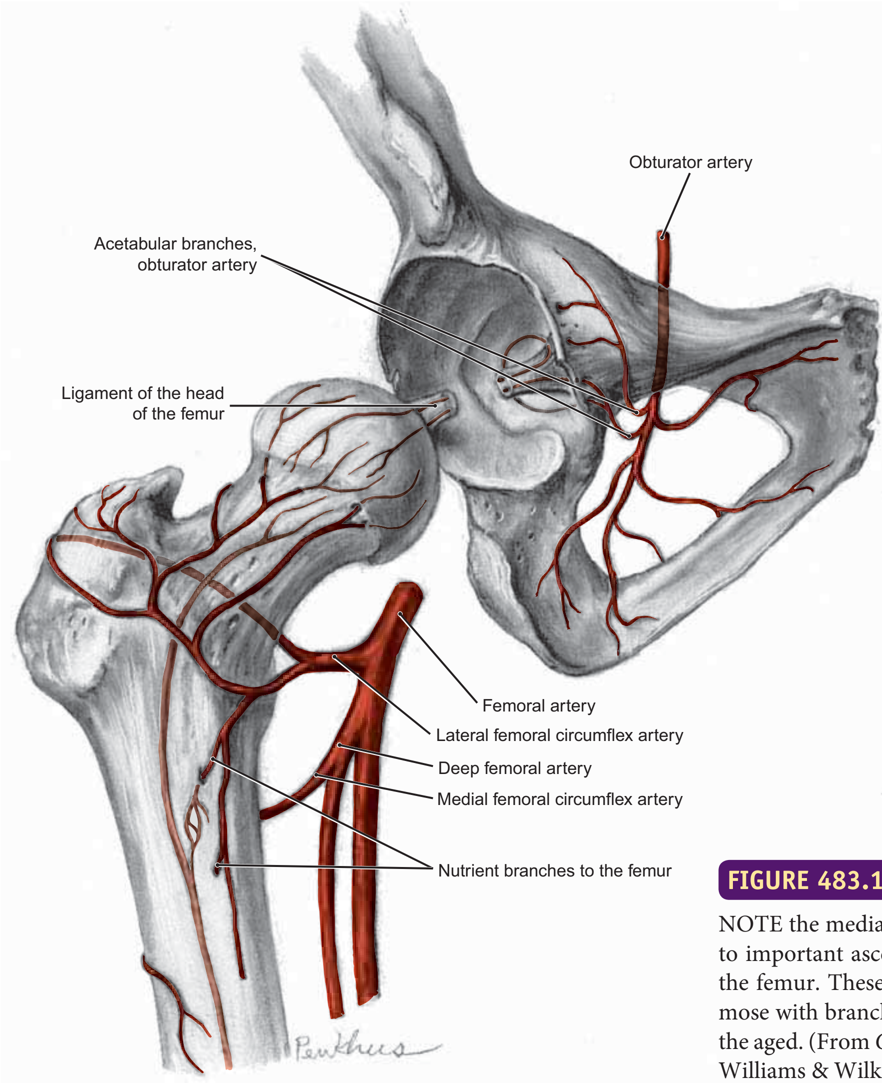


FIGURE 483.1 Arterial Supply to the Hip Joint

NOTE the medial and lateral femoral circumflex arteries that give rise to important ascending branches of the femoral artery to the neck of the femur. These supply the neck and head of the femur and anastomose with branches above in the young. These connections are lost in the aged. (From *Clemente's Anatomy Dissector,* 2nd Edition, Lippincott Williams & Wilkins, Baltimore, 2007.)

FIGURE 483.2 Radiograph of the Hip Joint

NOTE that the thigh is abducted and flexed and the subject is in the supine position.

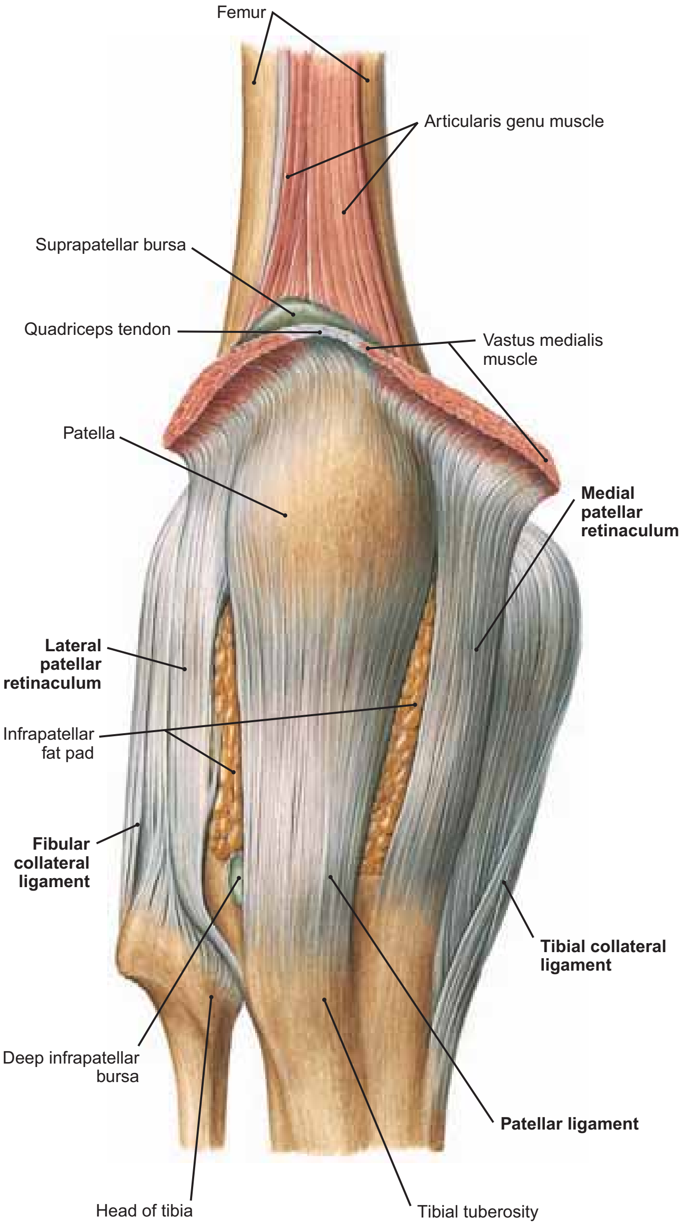


FIGURE 484.1 Right Knee Joint (Anterior View)

NOTE: (1) The deep fascia has been removed, and the bellies of the four heads of the quadriceps femoris muscle have been cut to expose the quadriceps tendon, the patella, and the patellar ligament.

(2) The **patellar ligament** inserts onto the tibial tuberosity located on the proximal aspect of the anterior tibial surface.

(3) The **medial** and **lateral patellar retinacula.** These structures reinforce the anteromedial and anterolateral parts of the fibrous capsule of the knee joint and often (but not shown in this figure) they are attached to the borders of the patellar ligament and patella.

(4) The **tibial** and **fibular collateral ligaments** and the location of the **deep infrapatellar bursa.**

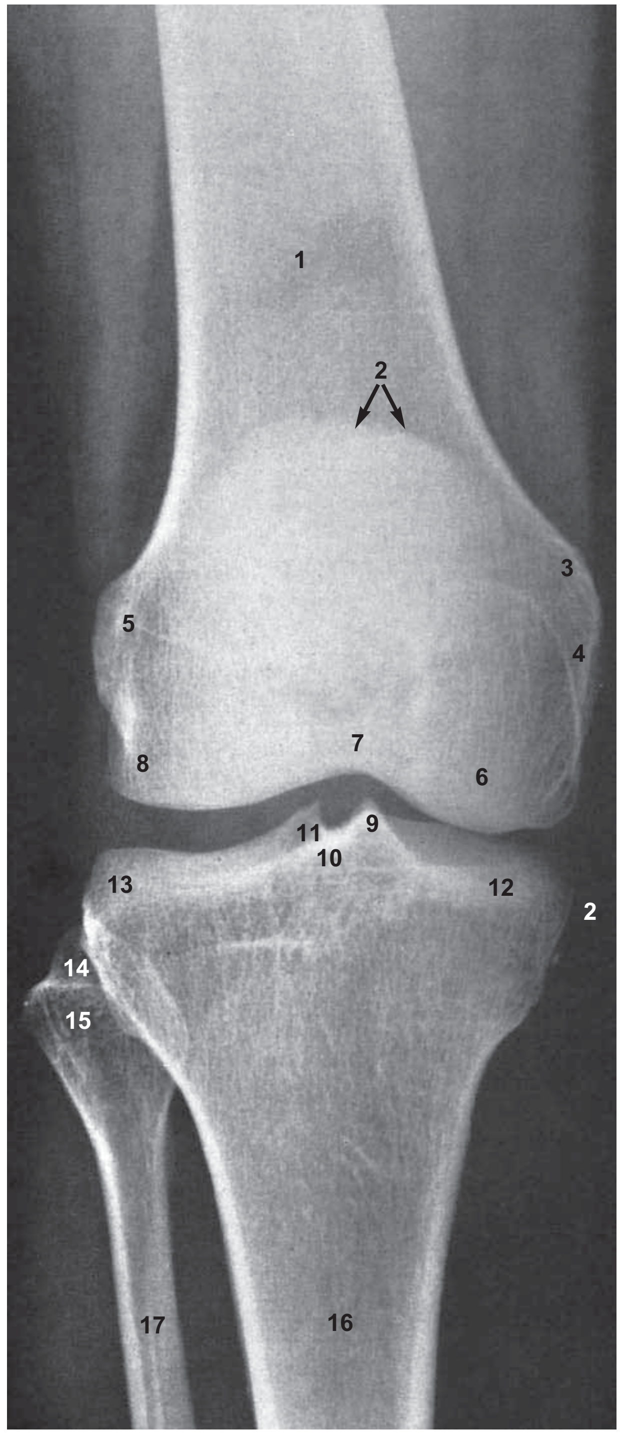


FIGURE 484.2 Radiograph of the Right Knee (Anteroposterior Projection)

NOTE: The following bony structures on the femur, tibia, and fibula in the region of the knee.

1. Body of femur
2. Margin of patella
3. Adductor tubercle
4. Medial epicondyle
5. Lateral epicondyle
6. Medial condyle of femur
7. Intercondylar fossa
8. Lateral condyle of femur
9. Medial intercondylar tubercle
10. Anterior intercondylar area
11. Lateral intercondylar tubercle
12. Medial condyle of tibia
13. Lateral condyle of tibia
14. Apex of head of fibula
15. Head of fibula
16. Body of tibia
17. Body of fibula

(From Wicke, 6th ed.)

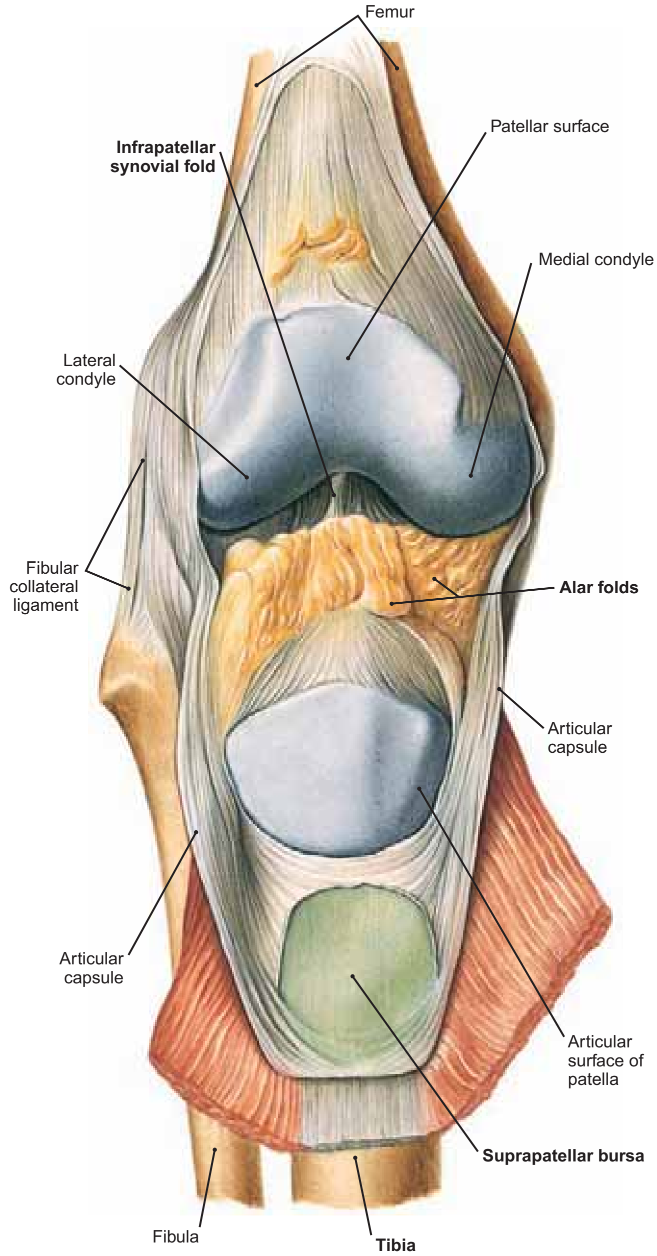


FIGURE 485.1 Knee Joint Opened Anteriorly

NOTE: (1) In this dissection, the anterior part of the articular capsule and the quadriceps tendon have been cut and reflected downward along with the **suprapatellar bursa.** The articular surface of the **patella** has also been pulled inferiorly away from its normal position on the femur.

(2) From the medial and lateral borders of the patella, the synovial membrane projects as fringe-like **alar folds** on each side. These converge in the midline to form the **infrapatellar synovial fold,** which attaches above to the intercondylar fossa of the femur.

(3) Upon removal of the infrapatellar synovial fold and any fat in the region, the anterior cruciate ligament and the menisci become exposed, as seen in Figure 485.2.

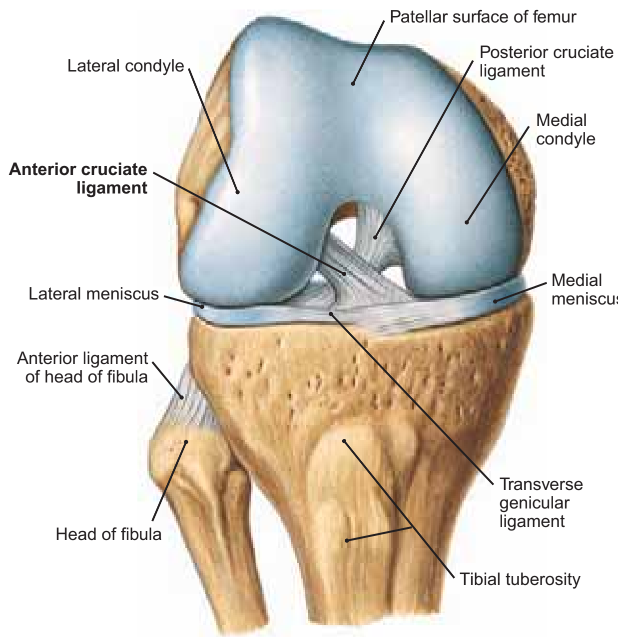


FIGURE 485.2 Flexed Right Knee Joint (Anterior View) Showing the Cruciate Ligaments

NOTE: (1) The **anterior cruciate ligament** is best exposed from this frontal approach. It extends from the posterior part of the medial surface of the lateral femoral condyle to the anterior surface of the tibial plateau.

(2) The anterior cruciate ligament helps prevent the posterior, or backward, displacement of the femur on the upper tibial plateau.

(3) More importantly, however, the anterior cruciate ligament limits extension of the lateral condyle to which it is attached. When it becomes taut, it causes medial rotation of the femur. This allows the medial condyle, which has a longer and more curved articular surface than the lateral condyle, to reach its full extension, placing the knee joint in a "locked position."

(4) Thus, the "locked" knee joint is achieved because:
- (a) The medial condyle has a longer articular surface and a greater curvature than that of the lateral condyle.
- (b) After the anterior cruciate ligament becomes taut, the lateral condyle can rotate around the "radius of the ligament" and forces the medial condyle to glide backward into its full extension.
- (c) Medial rotation of the femur at the same time causes the oblique popliteal ligament and the medial and lateral collateral ligaments to tighten as well. (From Last RJ. Anatomy, Regional and Applied. Edinburgh: Churchill Livingstone, 1978.)

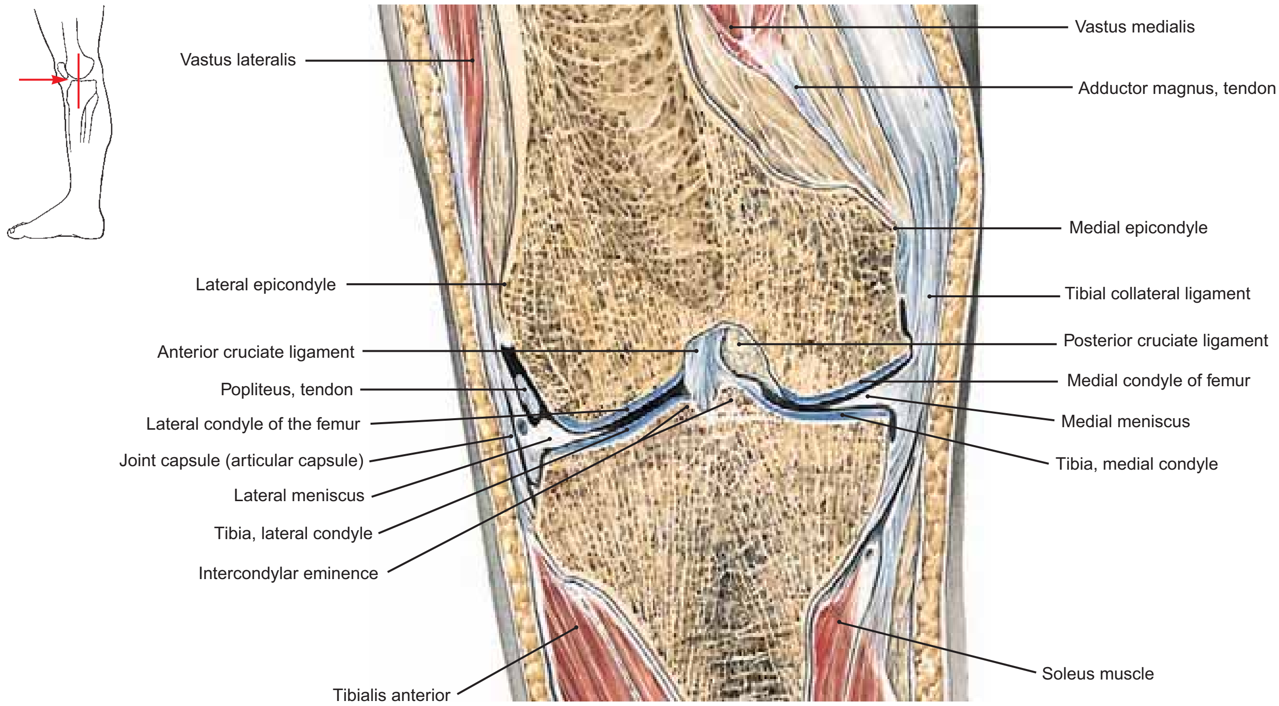


FIGURE 486.1 Frontal Section through the Right Knee Joint

NOTE: (1) The anterior and posterior cruciate ligaments and the medial and lateral menisci.

(2) The tendon of the popliteus muscle adjacent to the lateral meniscus and lateral condyle. It attaches to both of these structures, and during the first phase of flexion of the knee in taking a step, this muscle retracts the meniscus in order not to have it crushed between the lateral condyles of the tibia and femur (see Fig. 466.1).

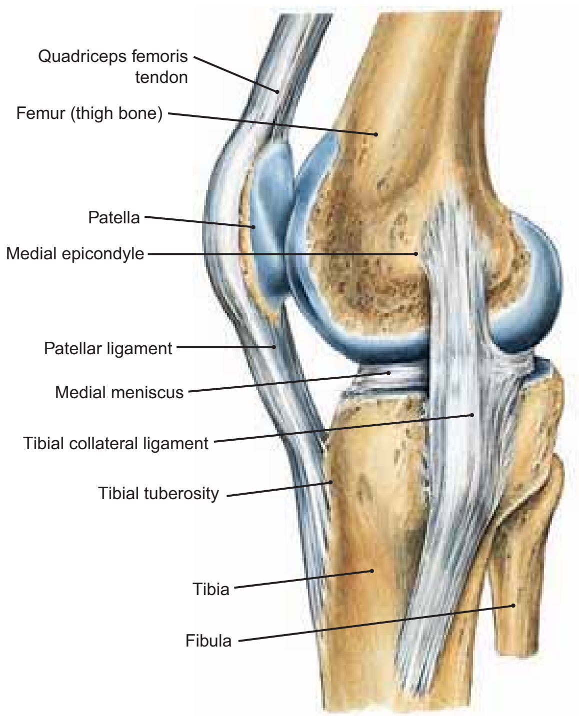


FIGURE 486.2 Right Knee Joint and the Tibial Collateral Ligament in Full Extension

NOTE: Only the posterior fibers of the tibial collateral ligament attach to the medial meniscus, while all the other fibers attach to the medial condyles of both the femur and the tibia.

FIGURE 486.3 Right Knee Joint and the Tibial Collateral Ligament in Flexion

NOTE: During flexion, the posterior fibers of the tibial collateral ligament and those attaching to the femur become twisted and, thus, help stabilize the medial meniscus to which the ligament is attached.

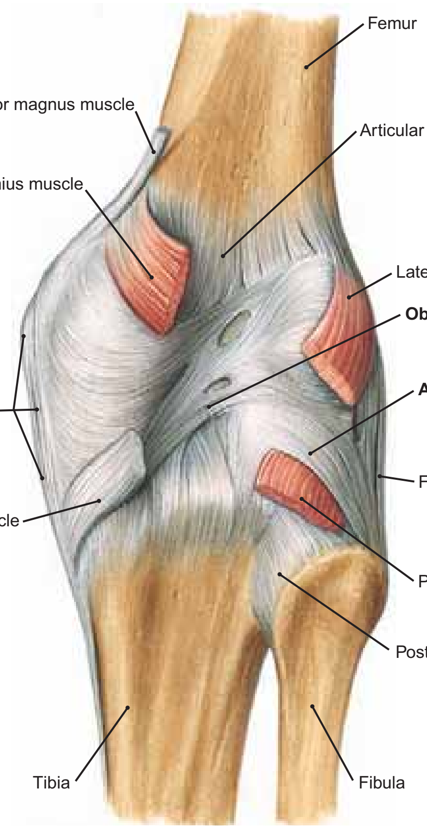


FIGURE 487.1 Knee Joint (Posterior View, Superficial Dissection)

NOTE: (1) The posterior aspect of the articular capsule is reinforced by the oblique and arcuate popliteal ligaments, and, to some extent, by the tendons of origin and insertion of muscles.

(2) From its insertion, the tendon of the semimembranosus muscle expands upward and laterally across the posterior surface of the articular capsule of the knee joint as the **oblique popliteal ligament.**

(3) The **arcuate popliteal ligament** is a band of fibers attached to the head of the fibula and courses superficially to the popliteus muscle to blend with the oblique popliteal ligament and the fibular collateral ligament.

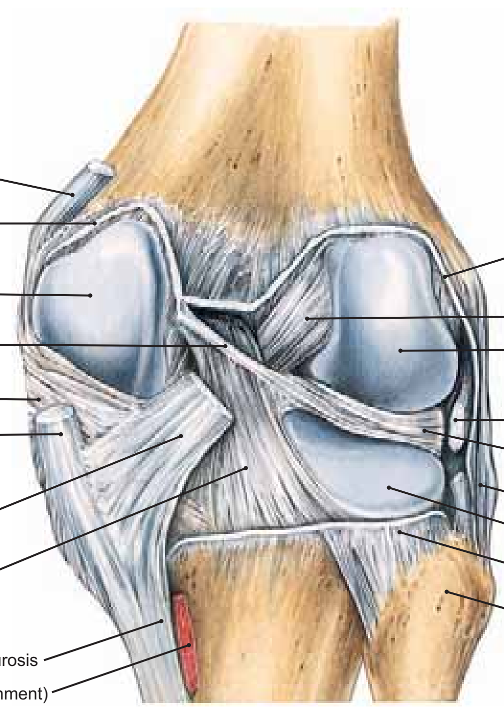


FIGURE 487.2 Posterior View of the Knee Joint with the Articular Capsule Opened

NOTE: This more diagrammatic figure should be compared with the dissection in Figure 487.1.

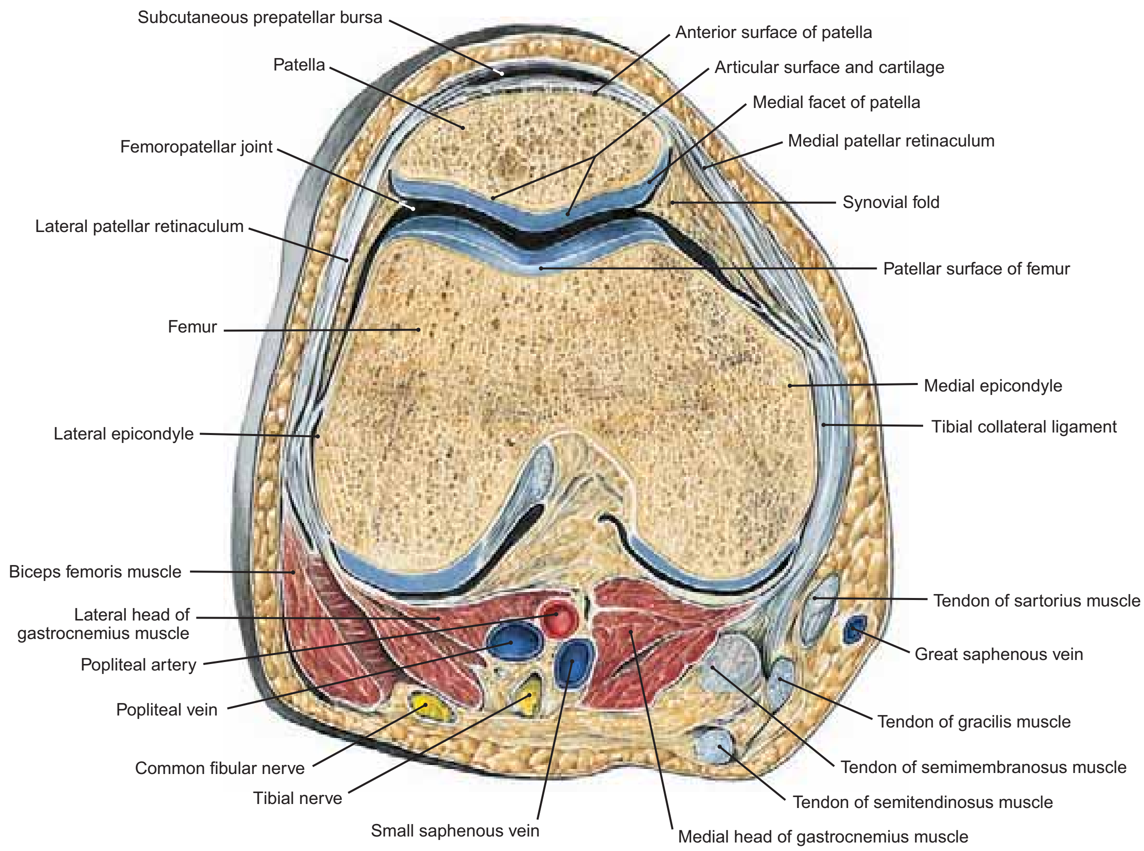
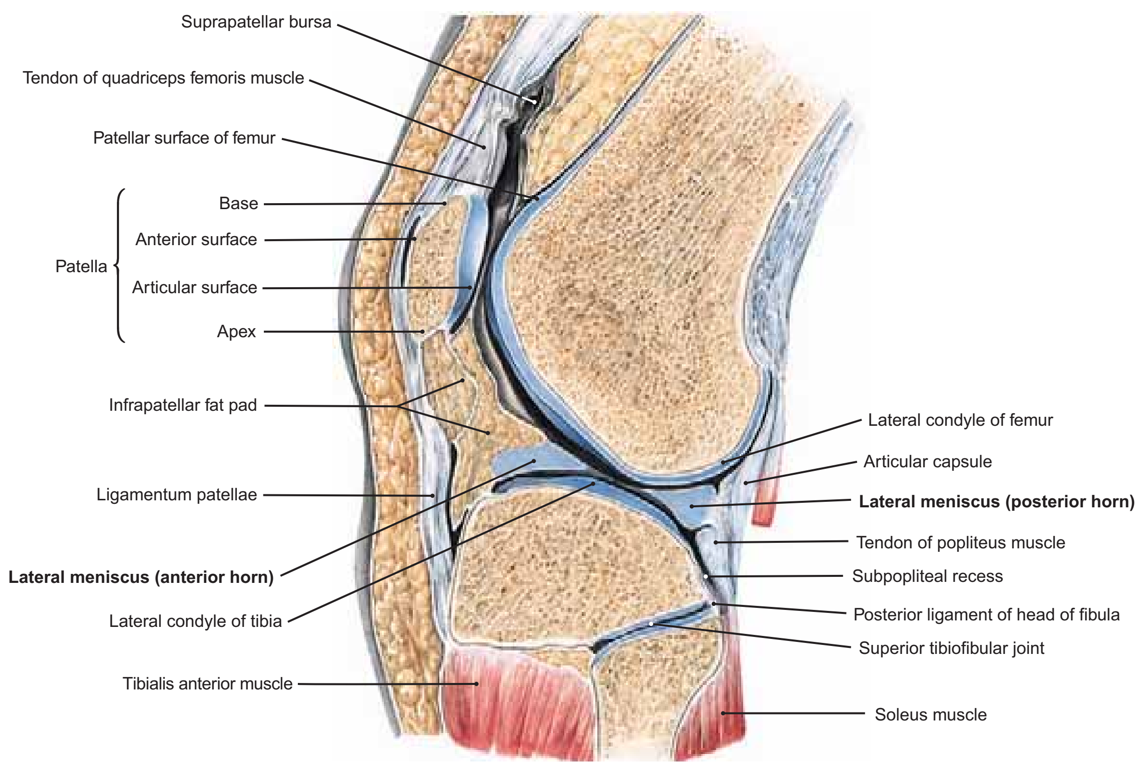


FIGURE 488.1 Transverse Section through the Knee Joint and the Popliteal Fossa

NOTE: The relationship of the muscles, vessels, and nerves in the popliteus fossa to the bony structures of the knee joint.



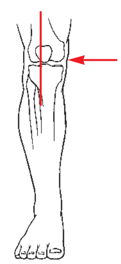
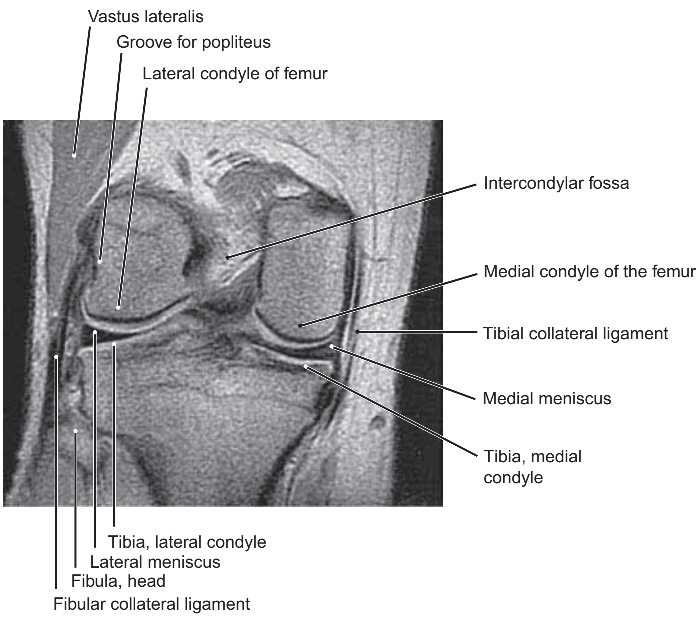


FIGURE 488.2 Sagittal Section through the Lateral Part of the Knee Joint

NOTE: The horns of the lateral meniscus, the tendon of the popliteus muscle, and the superior tibiofibular joint. Compare these structures in this drawing with those in the MRI section seen in Figure 489.2.



◀ FIGURE 489.1 MRI of the Knee Joint (Frontal Section)

NOTE: This MRI frontal section cuts through the intercondylar eminence of the tibia (not labeled) and the intercondylar fossa of the femur. Observe the menisci, which in this frontal section, have a triangular shape.

For Figures 489.1 and 489.2

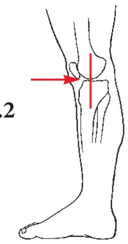
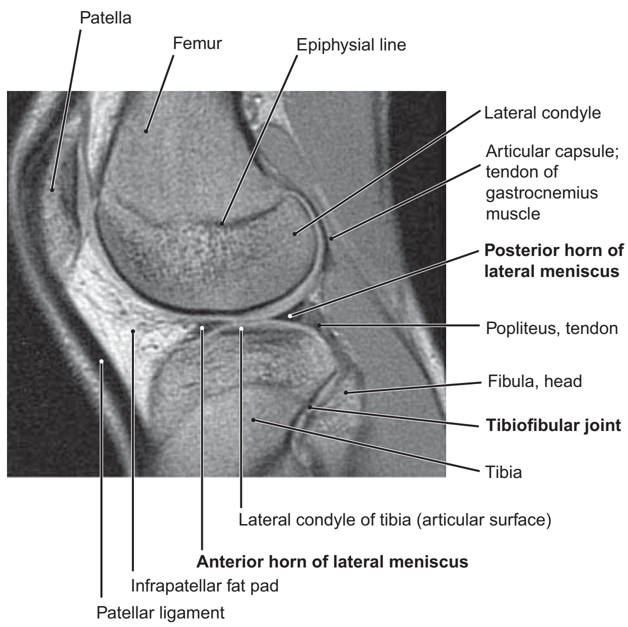
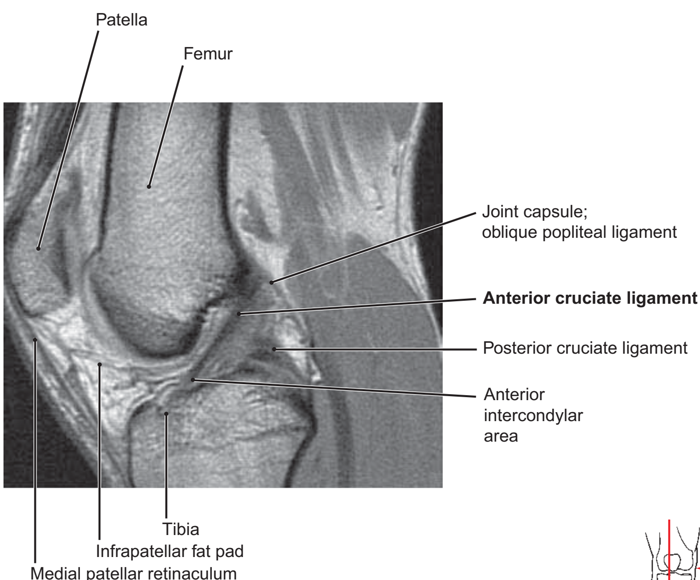


FIGURE 489.2 MRI of the Knee Joint (Sagittal Section) ▶

NOTE: This sagittal section cuts through the lateral part of the knee joint and shows the **horns of the lateral meniscus,** the **tendon of the popliteus muscle,** and the **superior tibiofibular joint.** Compare this image with Figure 488.2.

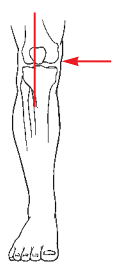




◀ FIGURE 489.3 MRI of the Knee Joint in Extension A

NOTE: This sagittal section shows both the anterior and posterior cruciate ligaments.

For Figures 489.3 and 489.4



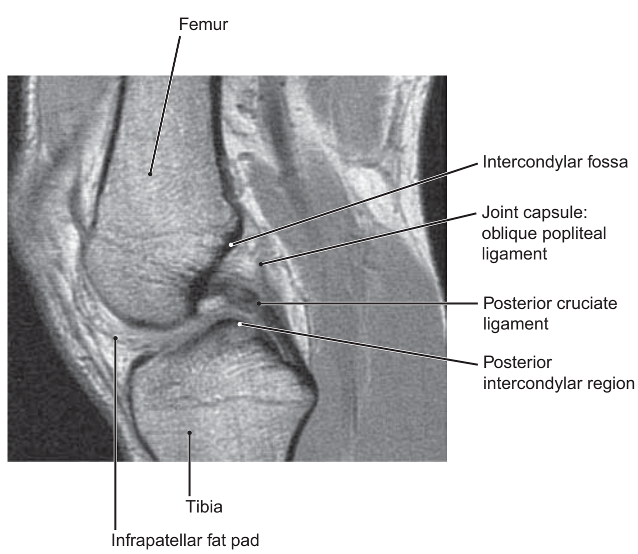
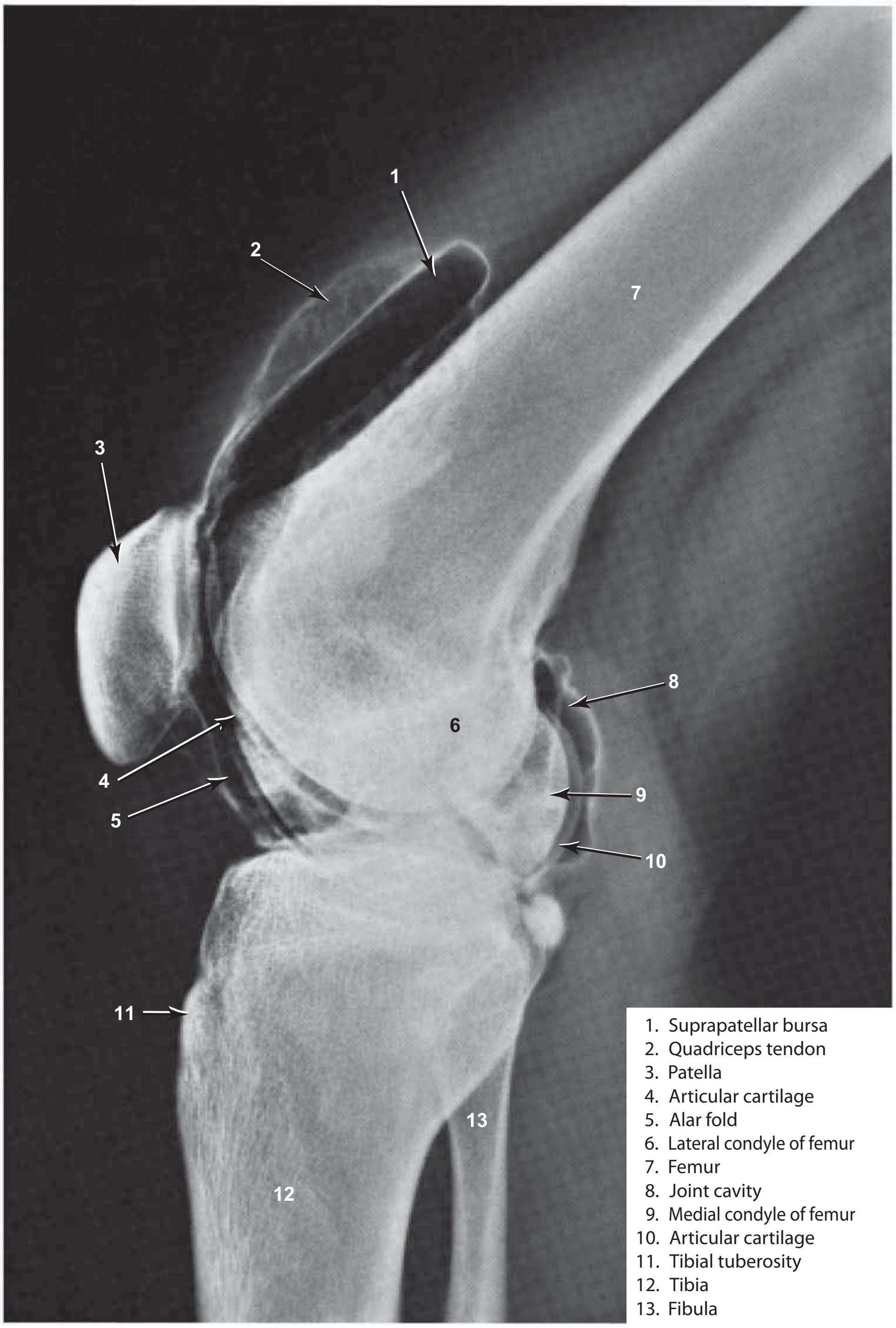


FIGURE 489.4 MRI of the Knee Joint in Extension B ▶

NOTE: This sagittal section shows the posterior cruciate ligament to good advantage.



1. Suprapatellar bursa
2. Quadriceps tendon
3. Patella
4. Articular cartilage
5. Alar fold
6. Lateral condyle of femur
7. Femur
8. Joint cavity
9. Medial condyle of femur
10. Articular cartilage
11. Tibial tuberosity
12. Tibia
13. Fibula

FIGURE 490 Arthrogram of the Knee Joint

NOTE: (1) An arthrogram is a radiograph of a joint taken during arthrography, which is an examination of a joint following the injection into the joint of a radiopaque agent (or gas).

(2) An arthroscope is an instrument that uses fiber optics and permits visualization of the inside of a joint. This is achieved by puncturing the joint through a small incision in the joint capsule (see Plate 491).

(3) The large **suprapatellar bursa.** The **patella** is a bony structure within the tendon of the quadriceps femoris muscle. The tendon then continues inferiorly to the knee and inserts onto the **tibial tuberosity** as the patellar ligament.

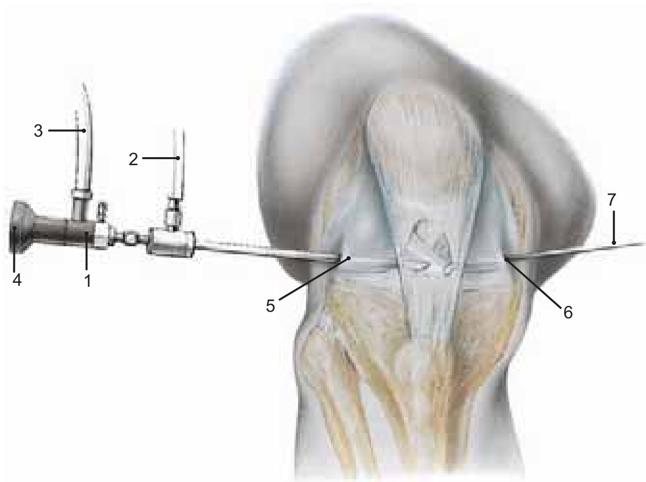
(4) During development, the fibers of the quadriceps tendon and the patellar ligament that attaches to the **tibial tuberosity** were continuous, but upon further development the central part of the tendon becomes ossified to form the **patella.**

(5) People who kneel a lot may have inflammation of the bursae anterior to the patella and superior to the **patella.** This is sometimes called housemaid's knee.

(From Wicke, 6th ed.)

FIGURE 491.1 Arthroscopic Approaches to the Knee

1. Arthroscope
2. Inlet and outlet for rinsing solution
3. Cold light source
4. Ocular or connector for visual system
5. Anterolateral approach
6. Anteromedial approach
7. Supplementary instrument



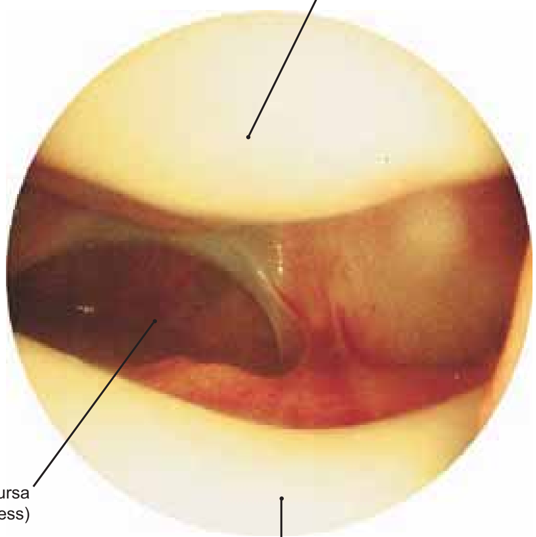
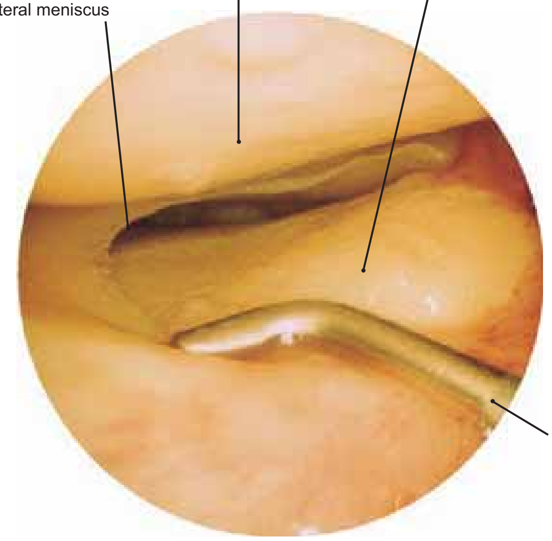


FIGURE 491.2 Knee Joint Arthroscopy A

NOTE: This is an inferior view of the femoropatellar joint.

FIGURE 491.3 Knee Joint Arthroscopy B

NOTE: This image shows the medial free border of the lateral meniscus; the anterior part of the meniscus is being depressed by a probe.



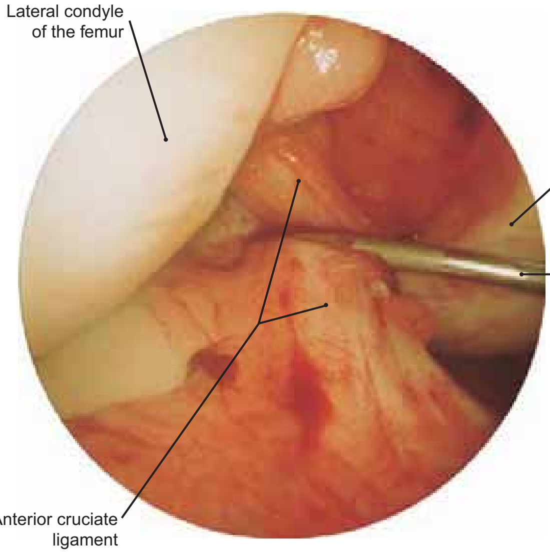


FIGURE 491.4 Knee Joint Arthroscopy C

NOTE: The distal part of the right anterior cruciate ligament is visible, and the highly vascular synovial membrane is being retracted by a probe.

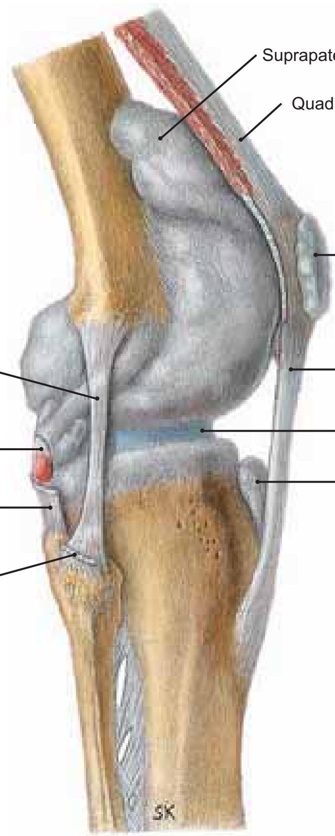


FIGURE 492.1 Cast of Knee Joint (Distended) Showing Bursae and Joint Cavity (Lateral View)

NOTE: (1) This lateral view of the distended synovial cavity of the right knee joint demonstrates the extensive nature of the synovial membrane of this joint. It is more extensive in this joint than in any other in the body.

(2) The synovial membrane reaches *superiorly* above the patella to form a large pouch called the **suprapatellar bursa. Laterally,** it courses deep to the popliteal tendon and fibular collateral ligament. **Posteriorly,** it extends above the menisci as high as the origins of the gastrocnemius muscle. **Inferiorly,** the joint cavity descends below both the lateral and medial menisci.

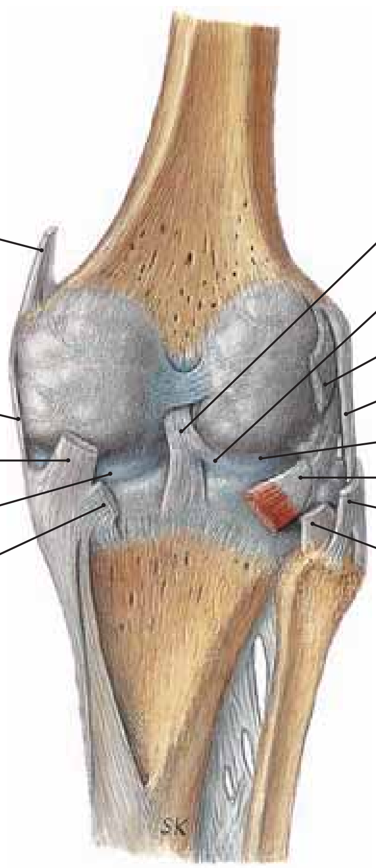


FIGURE 492.2 Cast of Knee Joint Showing Bursae and Joint Cavity (Posterior View)

NOTE: In this posterior diagram of the right knee joint, the fibrous capsule has been removed to expose the joint cavity. The synovial membrane extends above the menisci, deep to the heads of the gastrocnemius muscle, and below the menisci, deep to the popliteus muscle laterally and the semimembranosus medially.

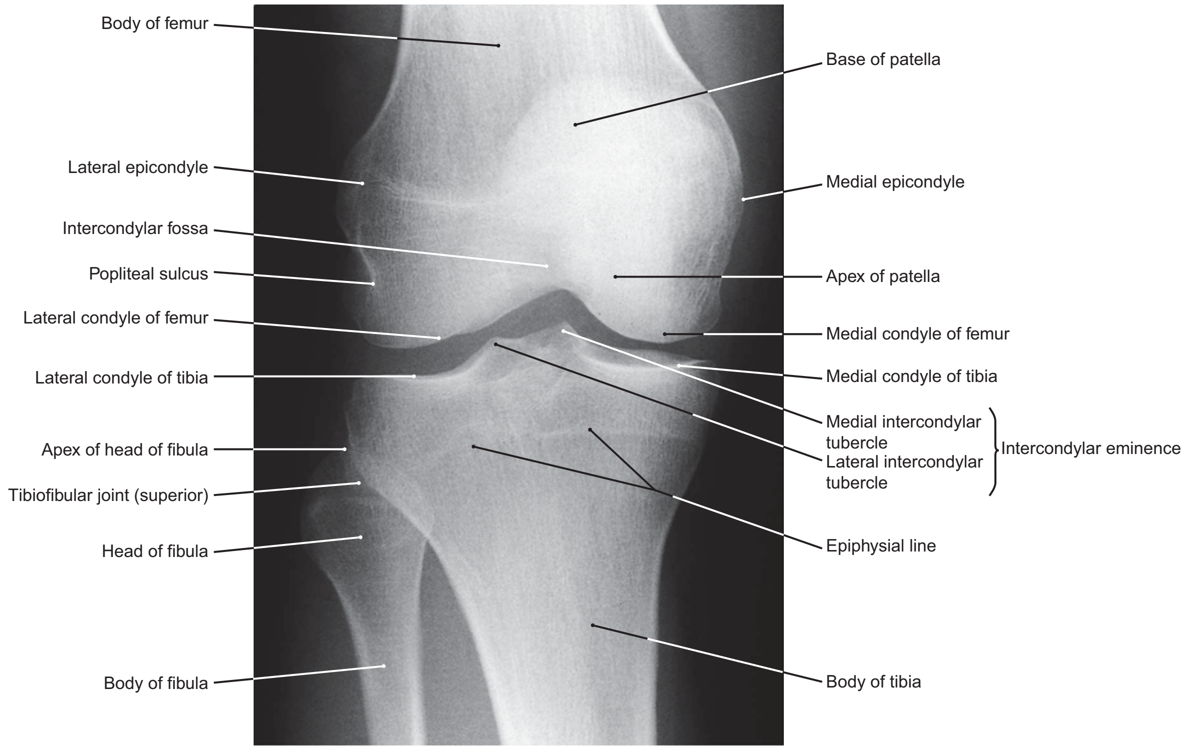


FIGURE 493.1 Anterior–Posterior Radiograph of the Knee Joint

NOTE: This X-ray was made while the subject was reclined and the central beam was directed to the middle of the joint.

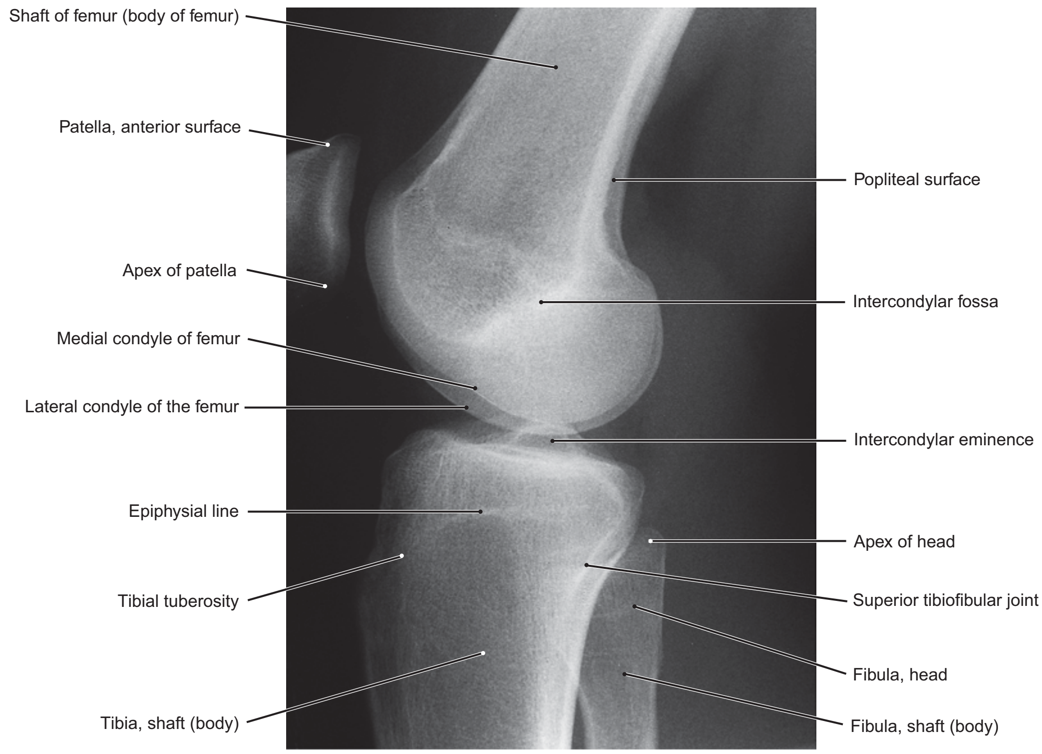


FIGURE 493.2 Lateral Radiograph of the Knee Joint

NOTE: This X-ray was made while the subject was reclined and the central beam was directed to the middle of the joint.

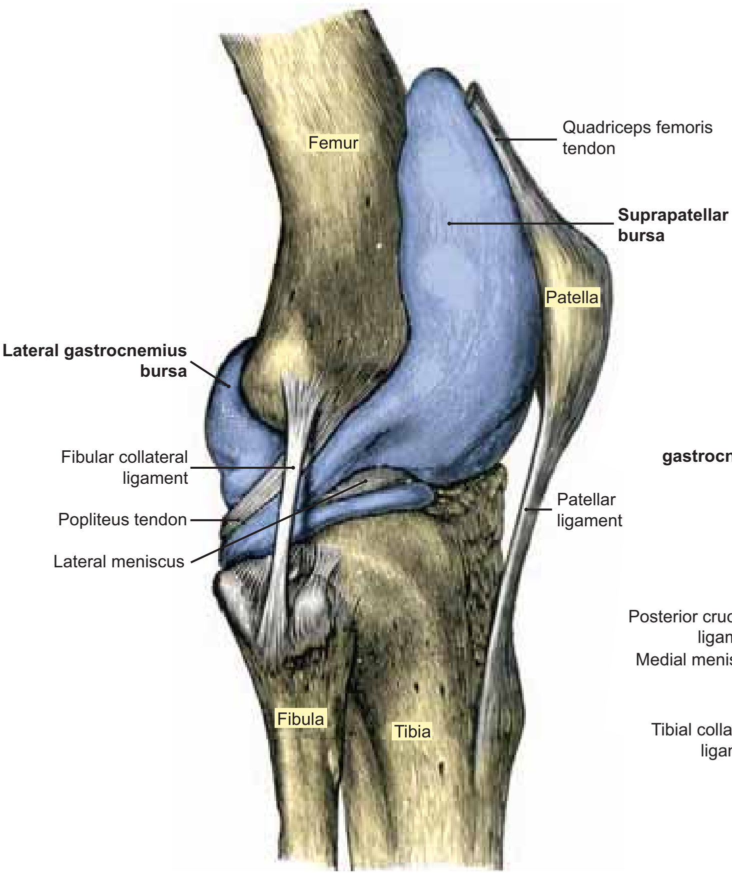


FIGURE 494.1 Synovial Membrane within the Capsule of the Right Knee Joint (Distended), Lateral Aspect

(From C.D. Clemente. *Gray's Anatomy,* 30th American Edition. Baltimore: Lea & Febiger, 1985.)

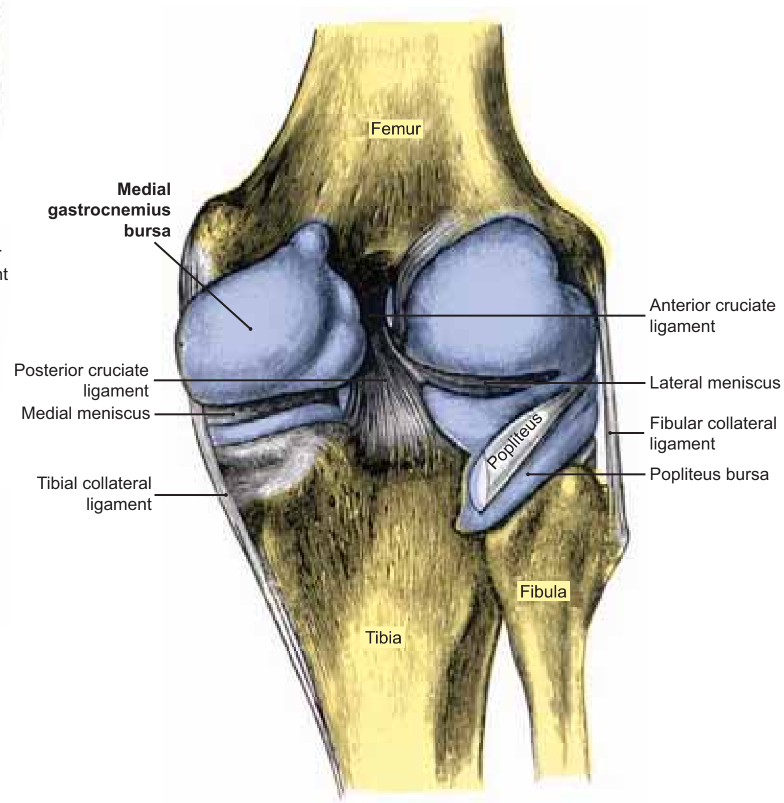


FIGURE 494.2 Synovial Membrane within the Capsule of the Right Knee Joint (Distended), Posterior Aspect

(From C.D. Clemente. *Gray's Anatomy,* 30th American Edition. Baltimore: Lea & Febiger, 1985.)

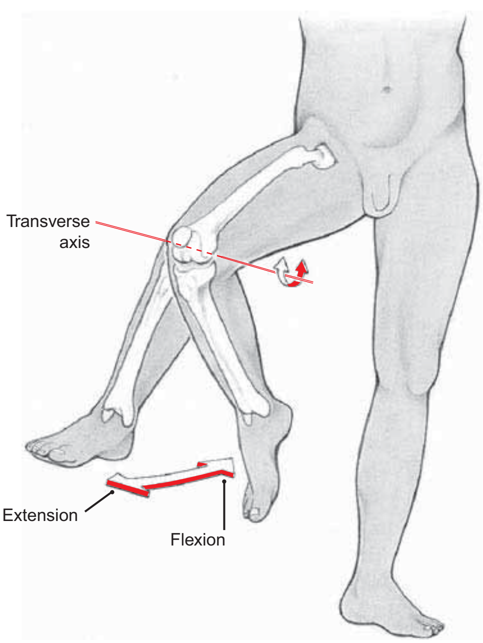


FIGURE 494.3 Knee Joint Movement (Sagittal Plane)

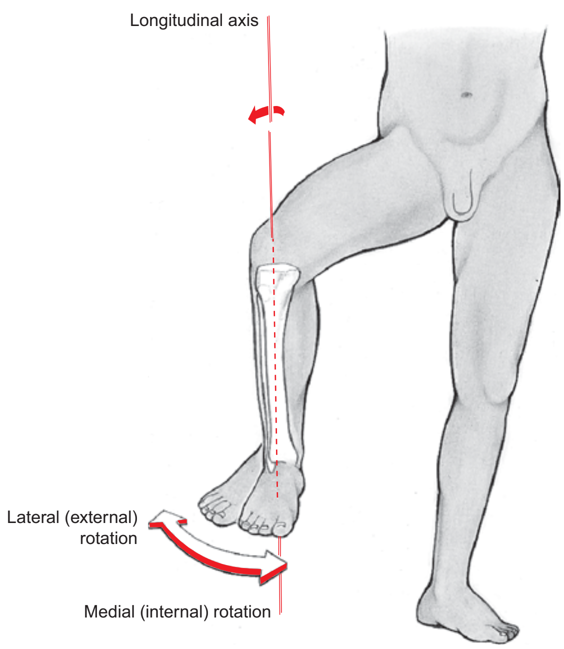


FIGURE 494.4 Knee Joint Movement (Transverse Plane)

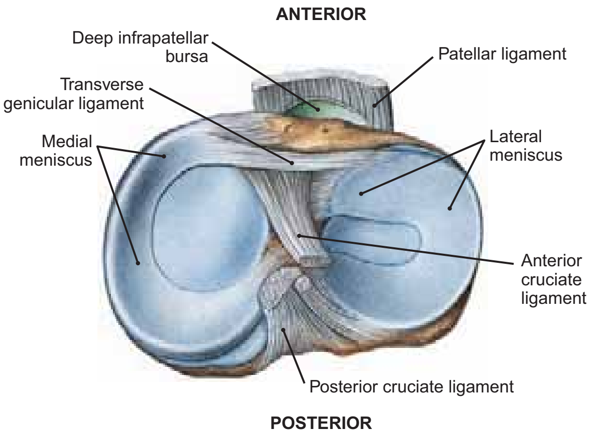


FIGURE 495.1 Condyles of the Right Tibia, Viewed from Above: Showing the Menisci and the Attachments on the Tibia of the Cruciate Ligaments

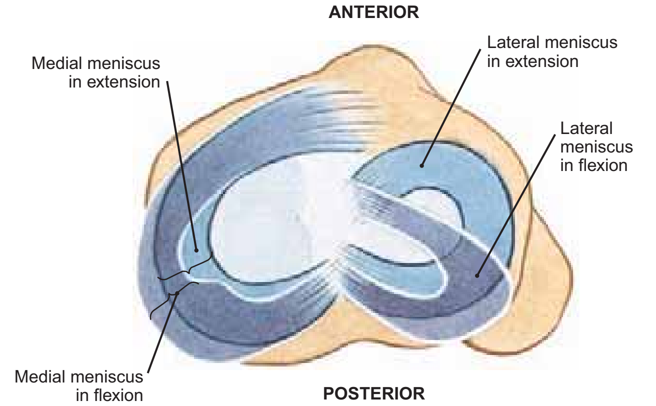


FIGURE 495.2 Superior Surface of the Right Tibial Surface Showing the Locations of the Menisci during Extension (Light Blue) and Their Changes in Position during Flexion (Purple)

NOTE: (1) The C-shaped menisci lie above the condyles of the tibia; they are triangular in cross section and composed of fibrous connective tissue and NOT of cartilage.

(2) The **medial meniscus** is larger and has a more open curve than that of the **lateral meniscus.** Both menisci are attached at their anterior and posterior horns to the tibial surface.

(3) The **lateral meniscus** receives a flat tendon of insertion from the upper fibers of the **popliteus muscle,** and this muscle comes into action during "unlocking" of the knee joint by slightly rotating the femur laterally in preparation to take a step. In addition, these fibers draw the posterior convexity of the lateral meniscus backward "out of harm's way" during flexion of the tibia at the knee joint.

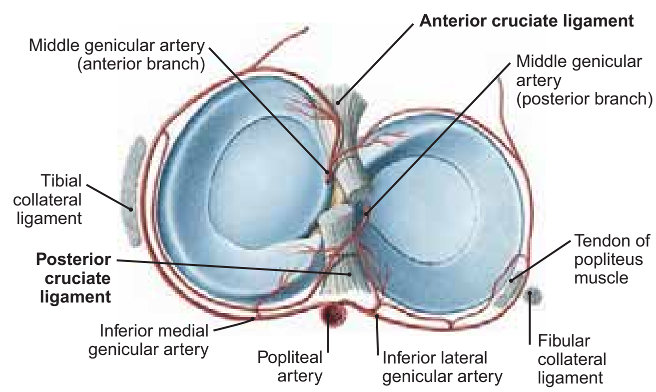
(4) In addition to its attachment on the tibia, the **medial meniscus** is securely attached to the tibial collateral ligament and is frequently injured in athletes when:

(a) The foot of the victim is planted firmly on the ground and the knee is semiflexed, and

(b) The victim is hit from behind ("clipping in football"), causing the weight of the body to severely rotate the femur medially. Thus, the leg is abducted and the tibial collateral ligament and the medial meniscus can be torn.

FIGURE 495.3 Arterial Supply of the Menisci, Right Knee ▶

NOTE: The **medial** and **lateral genicular** arteries encircle the tibia and supply the menisci. The **middle genicular artery** supplies the cruciate ligaments.



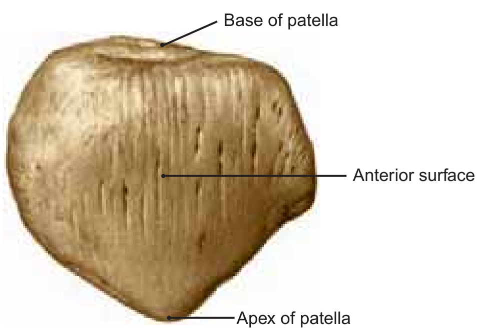


FIGURE 495.4 Anterior Aspect of the Right Patella

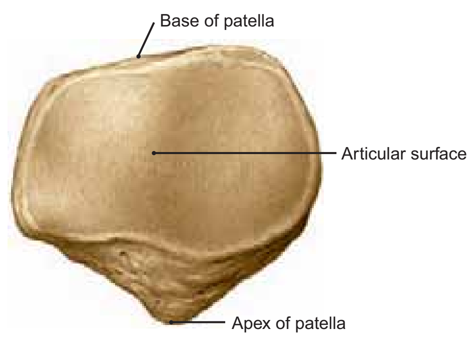
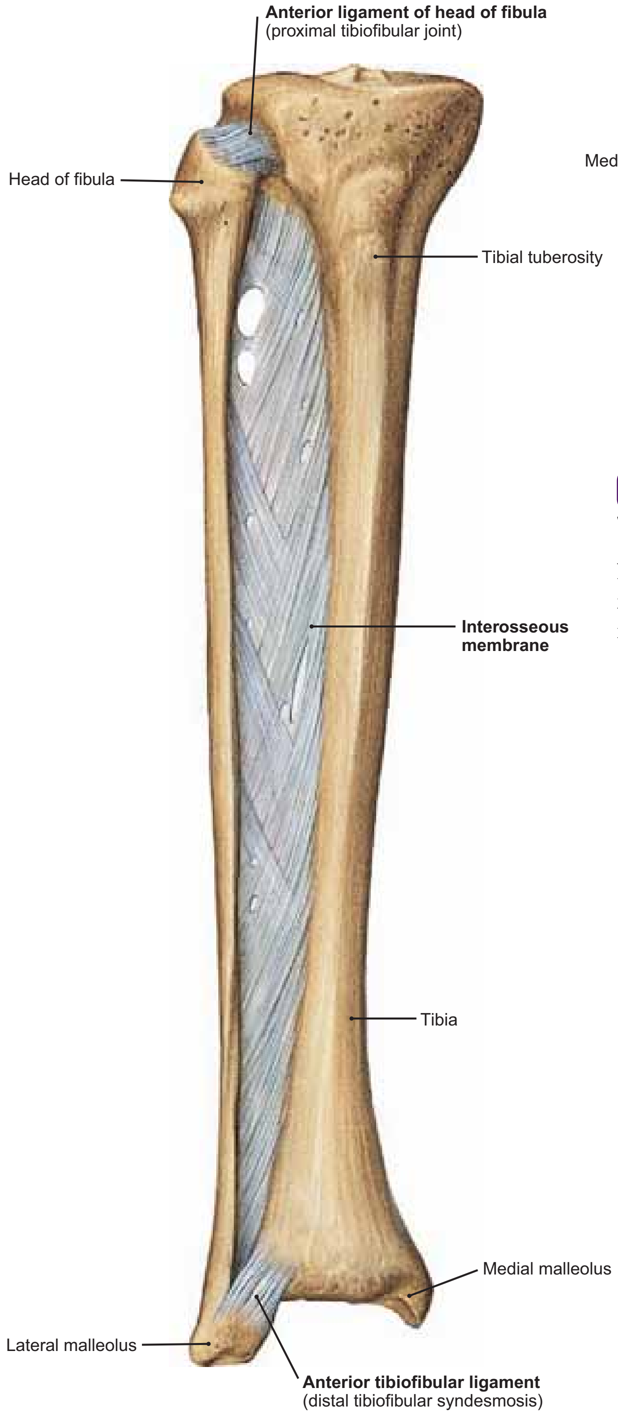


FIGURE 495.5 Posterior Aspect of the Right Patella

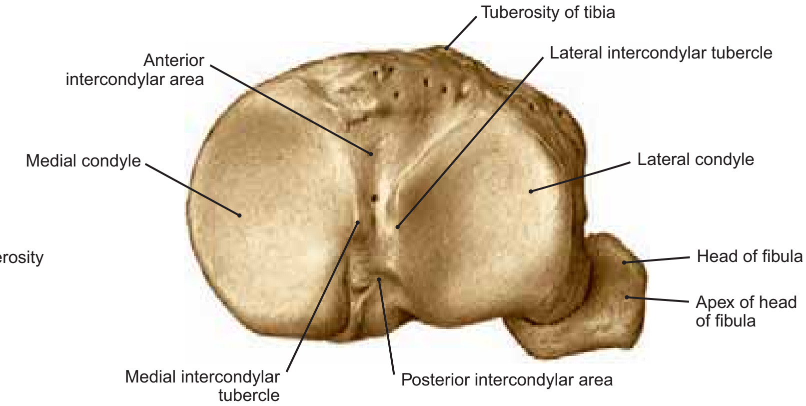


▲ FIGURE 496.1 Tibiofibular Unions and the Interosseous Membrane (Right Leg)

NOTE: (1) From this anterior view the shafts of the fibula and tibia are connected from the knee to the ankle by the **interosseous membrane.** In addition, the two bones are joined proximally (the tibiofibular joint) and distally (the tibiofibular syndesmosis).

(2) The head of the fibula articulates with the inferolateral aspect of the lateral condyle of the tibia. This is a gliding joint whose fibrous capsule is strengthened by **anterior** and **posterior ligaments of the head of the fibula.**

(3) The syndesmosis between the distal ends of the fibula and the tibia is bound by anterior and posterior tibiofibular ligaments.



▲ FIGURE 496.2 Proximal Ends of the Right Tibia and Fibula, Viewed from Above

NOTE: The menisci and femoral condyles rest on the concave lateral and medial tibial condyles. The cruciate ligaments and the menisci attach to the intercondylar areas.

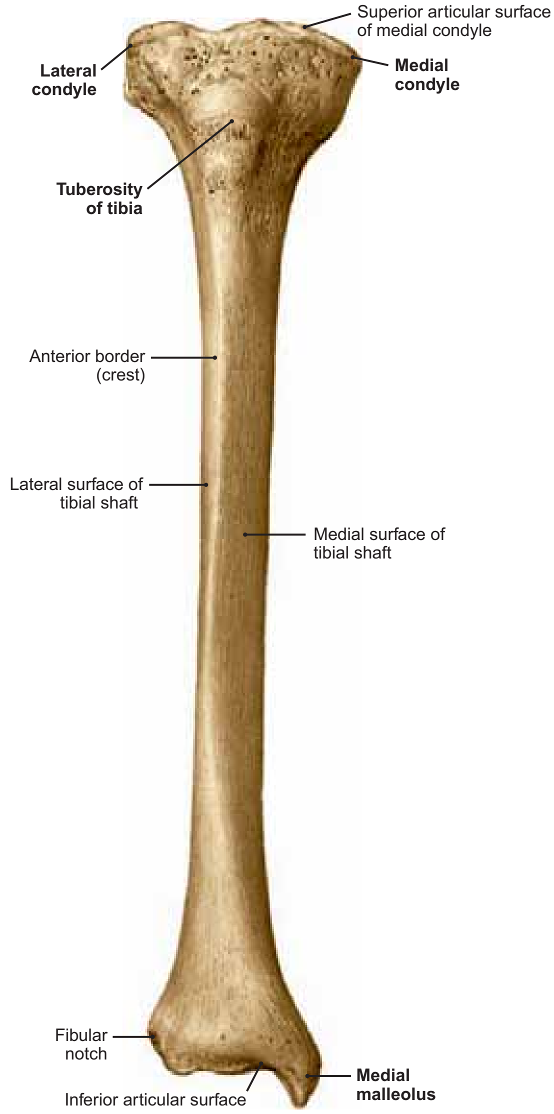


FIGURE 496.3 Right Tibia (Anterior View) ▲

NOTE: The proximal extremity is marked by the tibial condyles and the tibial tuberosity. The medial aspect of the distal extremity forms the medial malleolus.

FIGURES 497.1 and 497.2 Right Fibula ▶ (Medial and Lateral Views)

NOTE: (1) The fibula is a long slender bone situated lateral to the tibia, to which it articulates proximally and distally. The fibula expands inferiorly to form the **lateral malleolus.** The medial aspect of its inferior articular surface articulates with the tibia to form the **talocrural joint (ankle joint).**

(2) Although the fibula does not bear any weight of the trunk (not participating in the knee joint), it is important, since numerous muscles attach to its surface (see Figs. 468.1 and 468.2) and because it helps form the ankle joint.

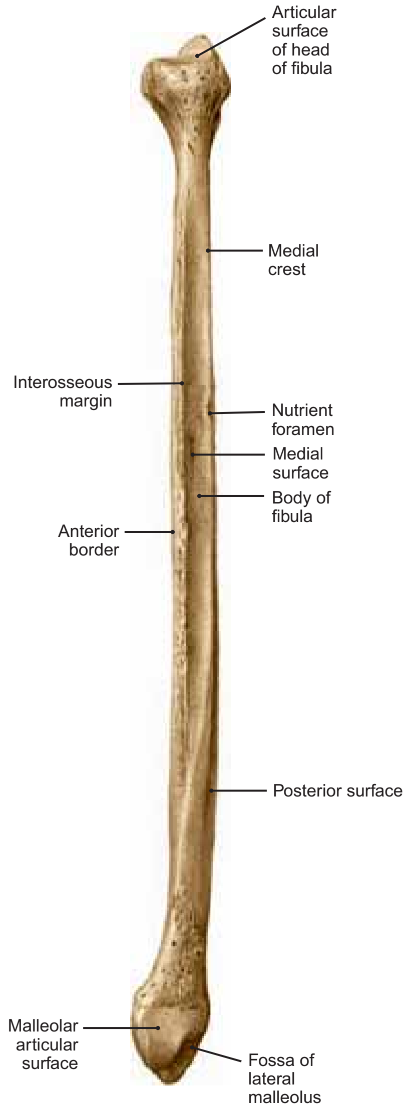


FIGURE 497.1 Medial View

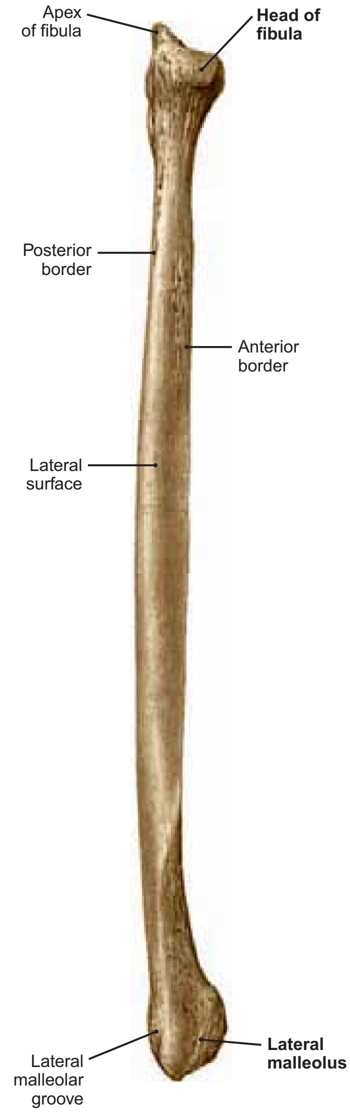
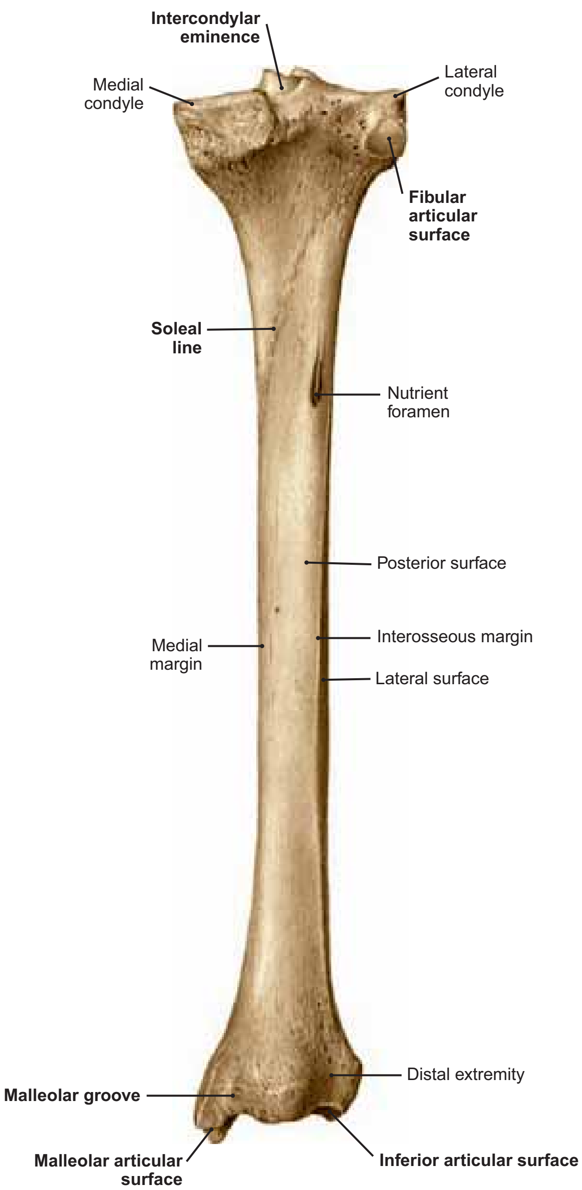


FIGURE 497.2 Lateral View



◀ FIGURE 497.3 Right Tibia (Posterior View)

NOTE: (1) The smooth posterior surface of the shaft of the tibia is marked by a prominent ridge, the **soleal line,** and a large oblong **nutrient foramen.** The tibial shaft tapers toward a larger proximal extremity and a somewhat less pronounced distal extremity.

(2) Proximally, the medial and lateral condyles are separated by the intercondylar eminence, anterior and posterior to which attach the cruciate ligaments. Distally, the tibia articulates with the **talus,** and on this posterior surface, presents grooves for the passage of the tendons of the tibialis posterior, flexor digitorum longus, and flexor hallucis longus.

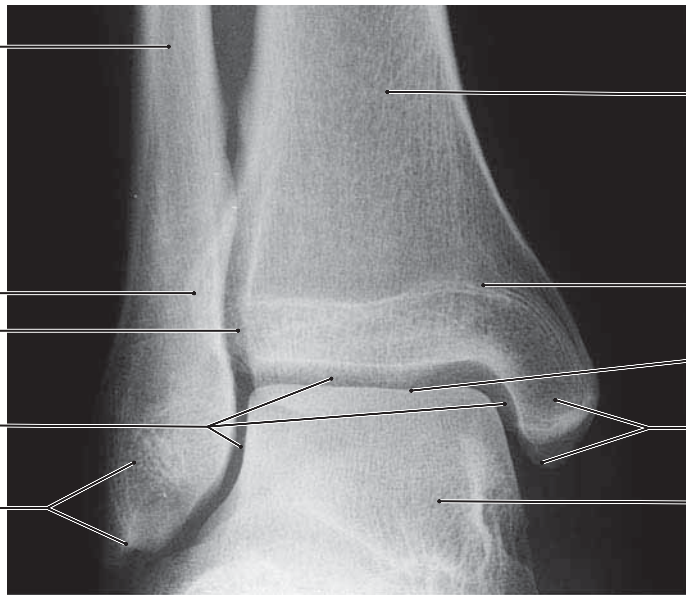


FIGURE 498.1 X-Ray of the Talocrural (Ankle) Joint and the Inferior Tibiofibular Syndesmosis

NOTE: (1) This is an anteroposterior radiograph showing both the ankle joint and the tibiofibular syndesmosis.

(2) The ankle joint is a ginglymus, or hinge, joint. The bony structures participating in this joint superiorly are the distal end of the **tibia** and its **medial malleolus** and the distal **fibula** and its **lateral malleolus.** Together these structures form a concave receptacle for the convex proximal surface of the **talus.**

(3) The inferior tibiofibular joint connects the convex or medial side of the lower part of the fibula with the concavity of the fibular notch of the tibia. These surfaces are separated by the upward prolongation (4–5 mm) of the synovial membrane of the talocrural joint. The part of the articulation that is fibrous is called **tibiofibular syndesmosis.**

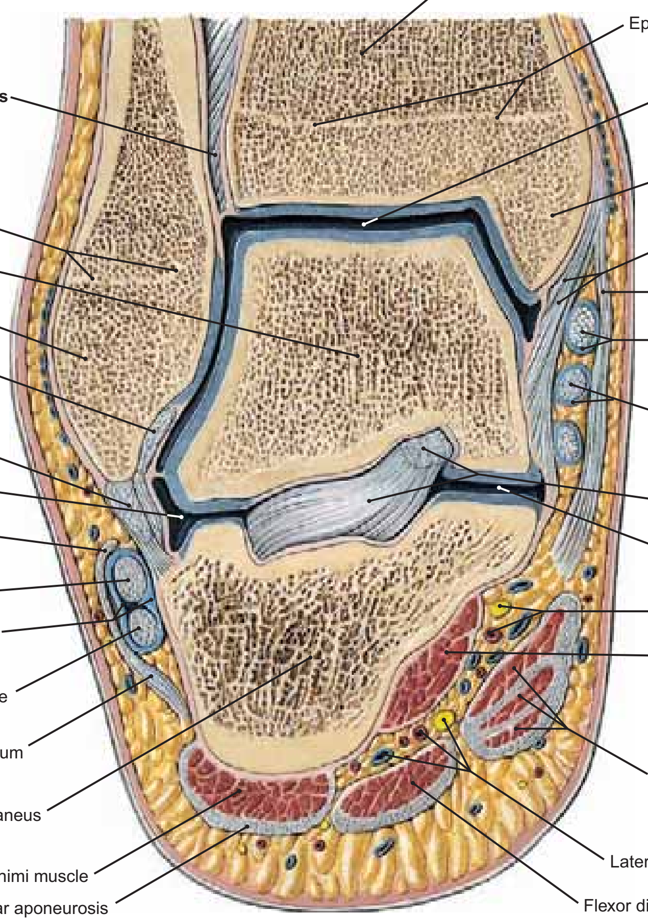


FIGURE 498.2 Coronal Section through the Talocrural (Ankle) and Subtalar Joints and the Tibiofibular Syndesmosis

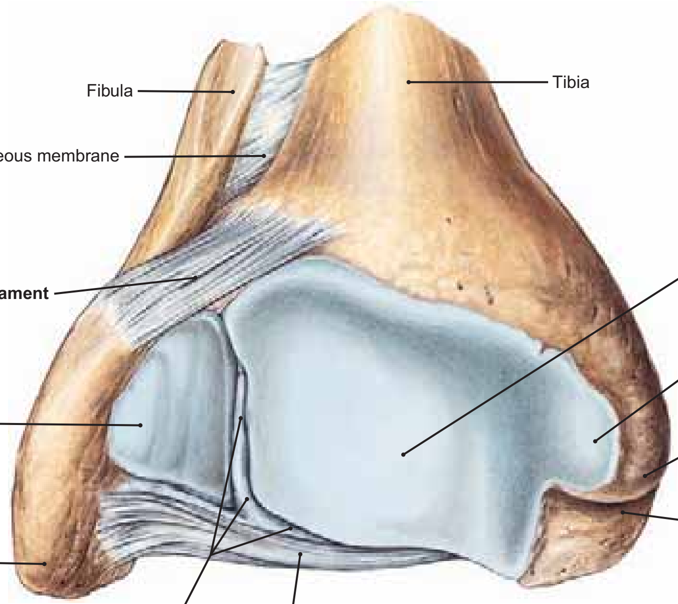


FIGURE 499.1 **Inferior Articular Surface of the Tibia and Fibula at the Talocrural (Ankle) Joint**

NOTE: (1) The medial and lateral sides of the upper part of the talocrural (ankle) joint are formed by the articular surfaces of the medial malleolus (tibia) and lateral malleolus (fibula). These grasp the sides of the talus.
(2) The inferior articular surface of the tibia is wider anteriorly than posteriorly to accommodate the broader anterior surface of the talus. In full dorsiflexion, the ankle joint is very stable and does not allow any side-to-side movement, but in full plantar flexion, a degree of side-to-side movement can occur.
(3) The synovial fold of the ankle joint that extends upward between the inferior surfaces of the fibula and tibia.

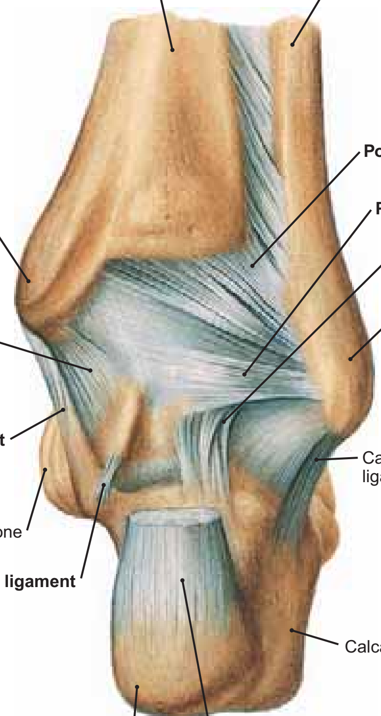


FIGURE 499.2 **Ankle Joint (Talocrural) Viewed from Behind (Right Foot)**

NOTE: (1) The posterior aspect of the articular capsule is somewhat strengthened by the posterior talofibular and posterior tibiofibular ligaments. The calcaneofibular ligament laterally and the strong deltoid ligament medially assist in protecting this joint.
(2) The ligamentous bands that help stabilize the talocalcaneal articulation posteriorly: the posterior and medial talocalcaneal ligaments.

FIGURE 500.1 Dorsal Aspect of the Bones of the Right Foot Showing the Attachments of Muscles

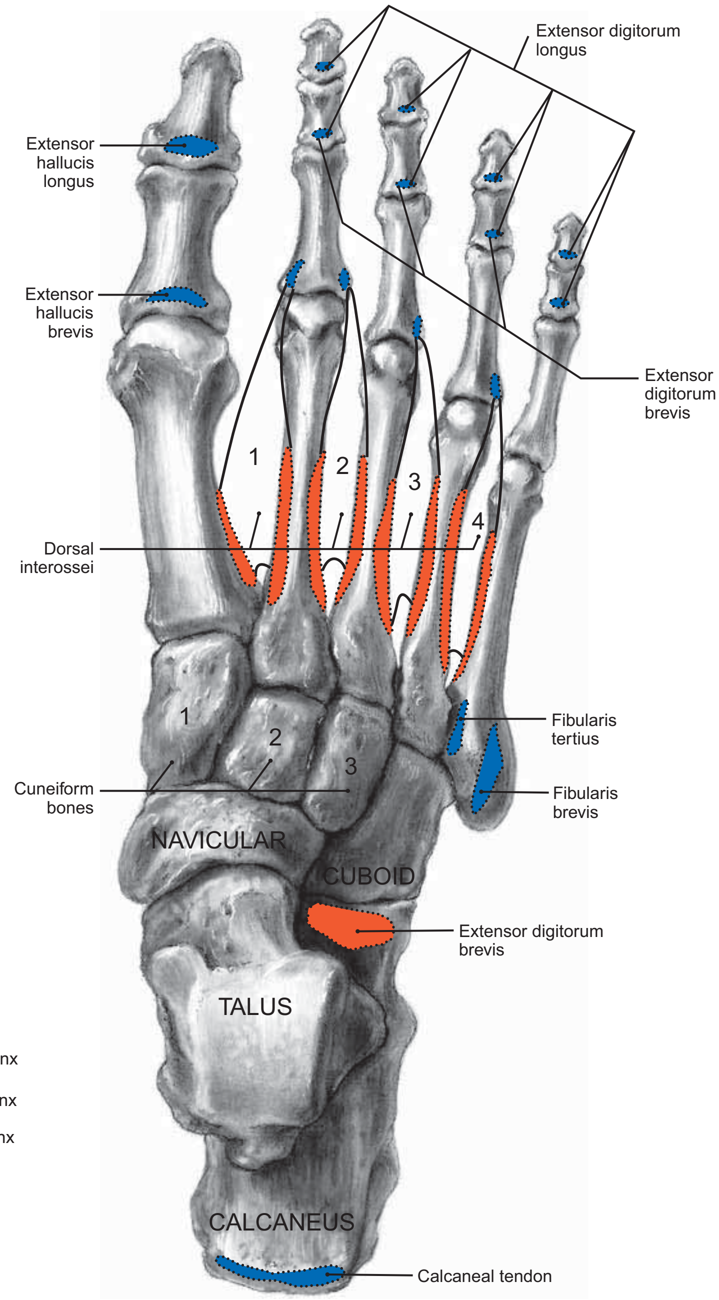
Red = origin; Blue = insertion

NOTE: (1) The insertion of the **calcaneal tendon** (of Achilles) on the posterior surface of the calcaneus. This tendon is the strongest in the body, and a bursa is interposed between the bone and the tendon.

(2) The only other muscle that attaches to the tarsal bones on this dorsal aspect is the **extensor digitorum brevis,** which arises from the dorsolateral surface of the calcaneus, distal to its articulation with the talus. Its medial part inserts on the proximal phalanx of the large toe, while its other three tendons insert on the middle phalanx of the second, third, and fourth toes.

(3) The insertions of the **fibularis brevis** and **tertius** onto the base of the fifth metatarsal.

(4) The four dorsal interosseous muscles, two of which insert on the second toe and the third and fourth insert on the dorsolateral aspect of the third and fourth toes.



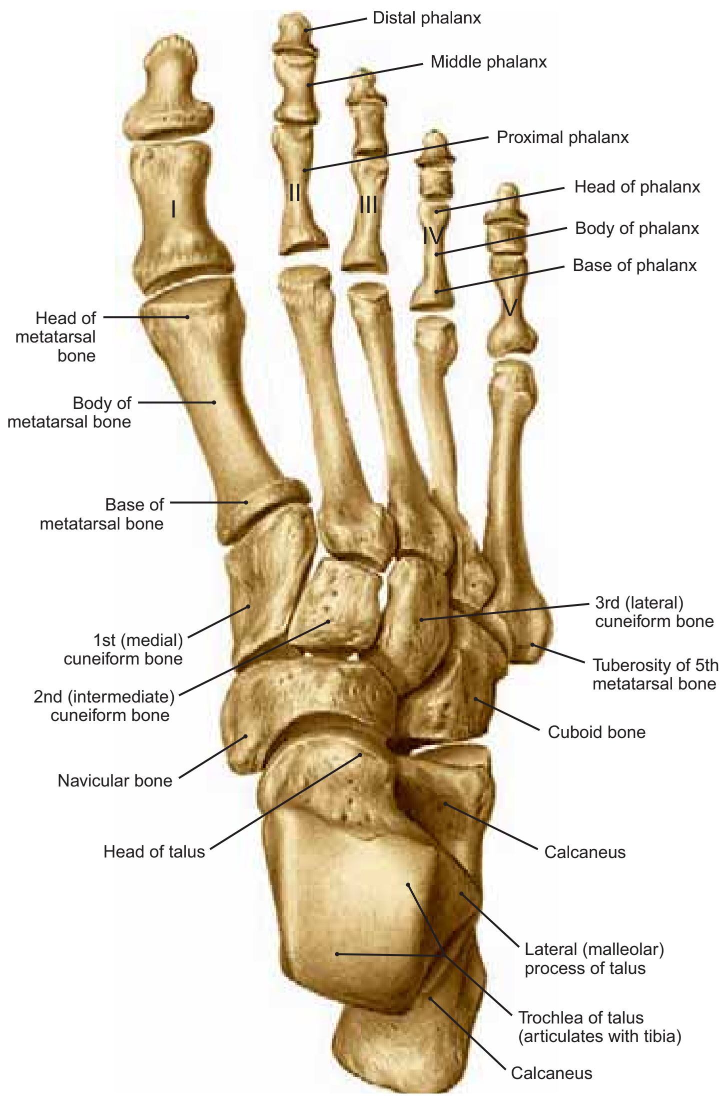


FIGURE 500.2 Bones of the Right Foot (Dorsal View)

NOTE: (1) The skeleton of the foot consists of 7 **tarsal bones,** 5 **metatarsal bones,** and 14 **phalanges.** The toes are numbered in order from medial to lateral: the large toe is the first digit, while the small toe is the fifth digit.

(2) The weight of the body is transmitted by the tibia to the **talus,** which then redistributes this weight to the **calcaneus** inferiorly (the heel of the foot) and the **navicular bone** distally (toward the heads of the metatarsals and the "ball" of the foot).

(3) Distal to the navicular and calcaneus are the three **cuneiform bones** and the **cuboid;** these articulate with the individual metatarsal bones of the digits.

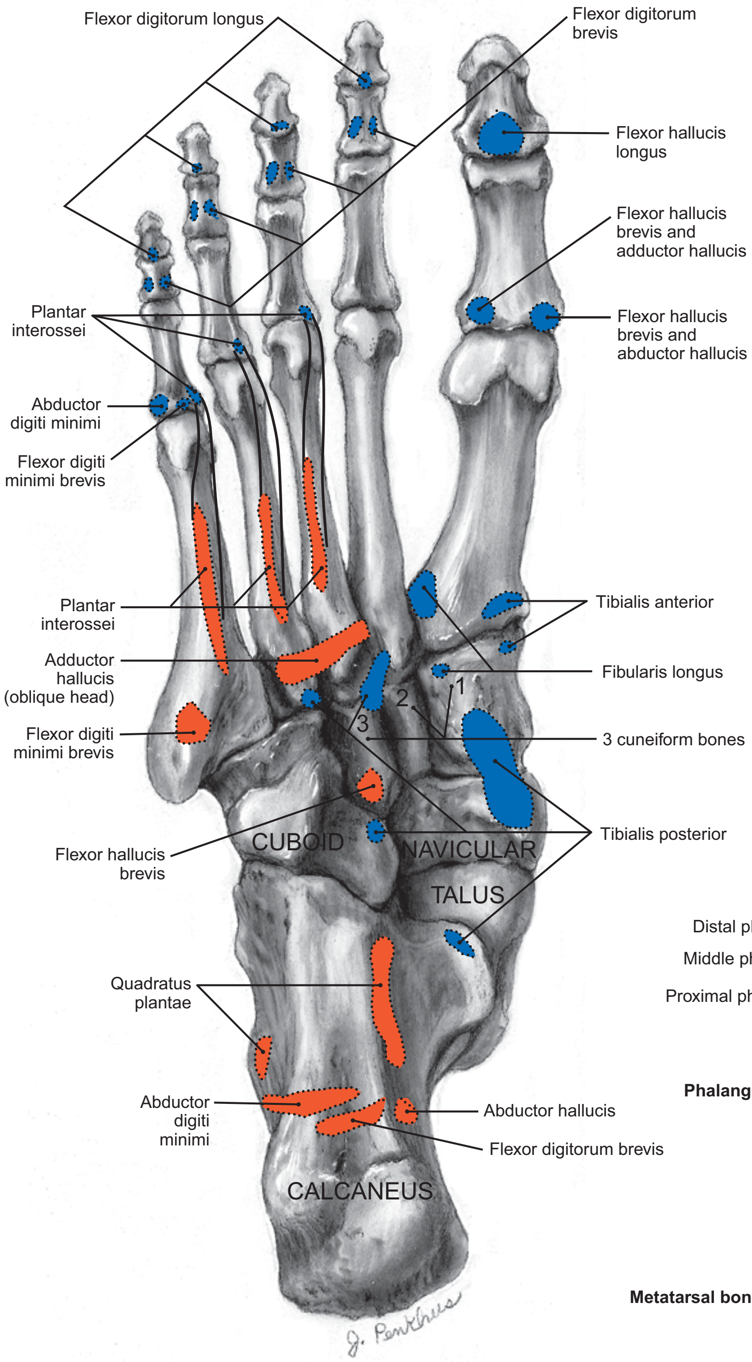


FIGURE 501.1 Plantar Aspect of the Bones of the Right Foot Showing the Attachments of Muscles

Red = origin; Blue = insertion

NOTE: (1) The muscles comprising the first and second layers (except the lumbricals) all arise from the plantar surface of the calcaneal bone. These are the **abductors hallucis** and **digiti minimi,** the **flexor digitorum brevis,** and the **quadratus plantae.**

(2) The tendons of five extrinsic muscles of the foot (arising in the leg) insert on the plantar surface. These are the **fibularis longus,** the **tibialis anterior** and **posterior,** and the **flexors hallucis longus** and **digitorum longus.** The tibialis posterior inserts on six of the seven tarsal bones (only the talus is omitted).

(3) The three **plantar interossei** act as adductors of the third, fourth, and fifth toes, moving them toward the second toe, the center of which serves as the longitudinal axis of the foot.

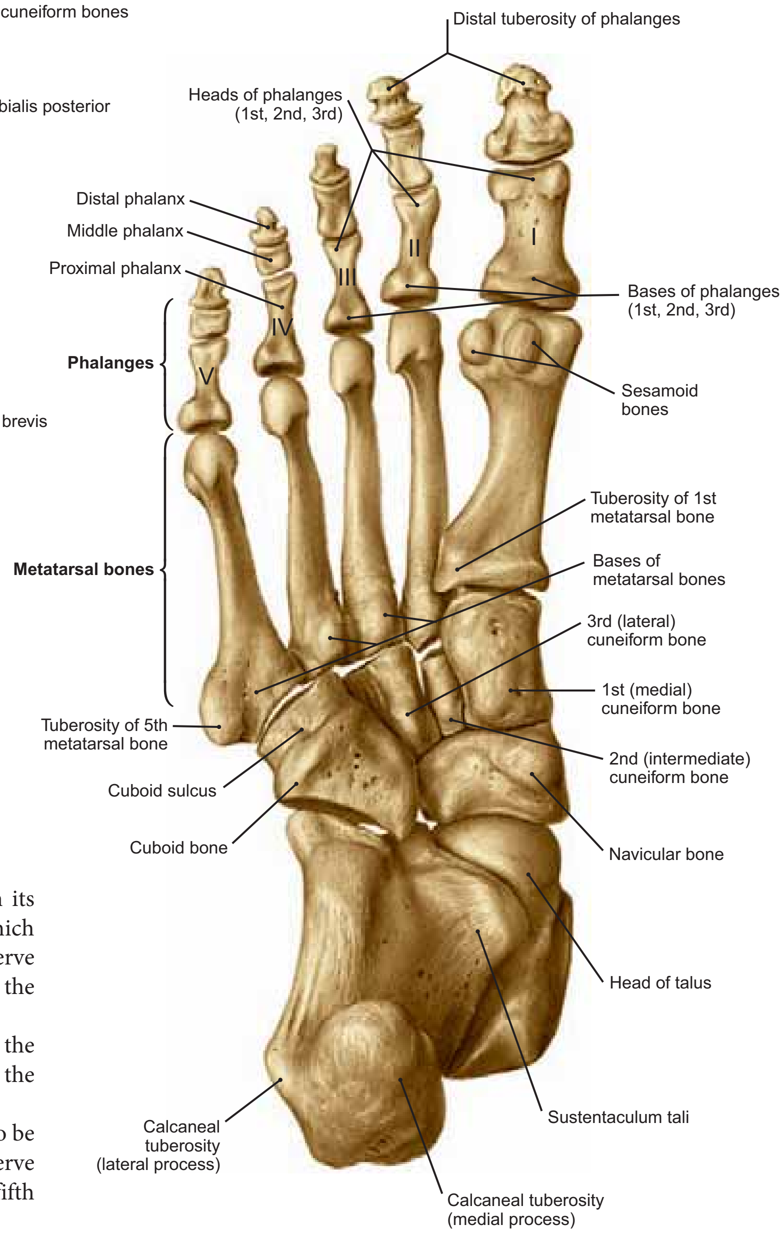


FIGURE 501.2 Bones of the Right Foot (Plantar View)

NOTE: (1) The largest bone in the foot is the **calcaneus.** On its plantar surface can be seen the **calcaneal tuberosity,** which projects posteriorly and inferiorly (forming the heel). Observe the **sustentaculum tali,** the dorsal surface of which contains the articular facets for the talus.

(2) The **cuboid bone** and the sulcus on its plantar surface for the passage of the fibularis longus tendon that stretches across the sole of the foot.

(3) The long slender metatarsal bones, which are curved so as to be concave on their plantar surface and convex dorsally. Observe the large tuberosity on the lateral side of the base of the fifth metatarsal bone.

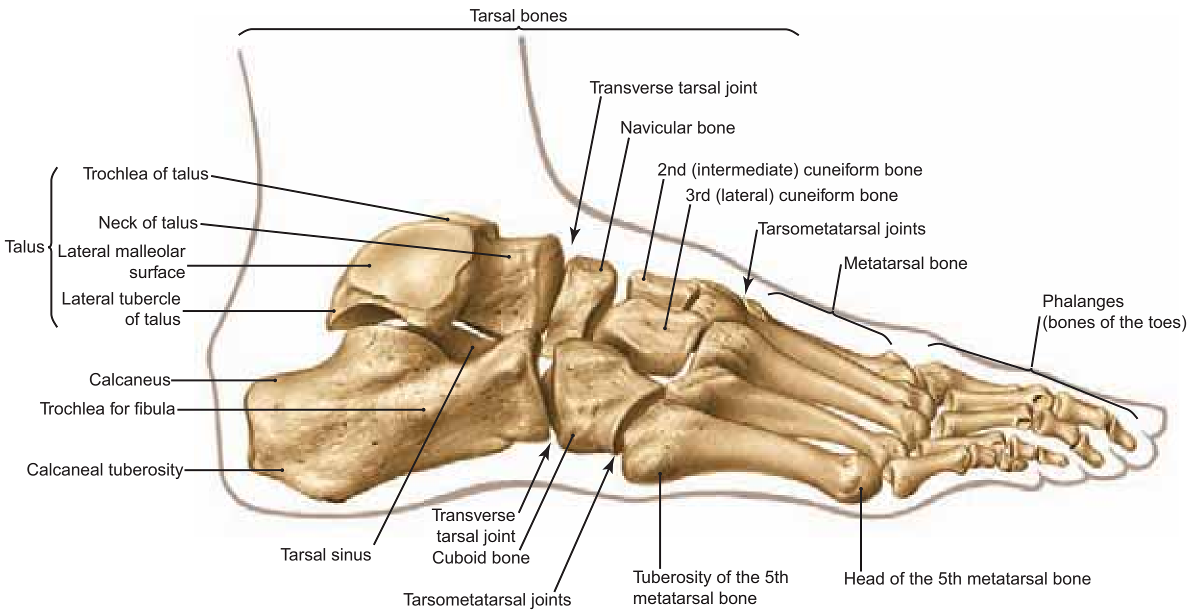


FIGURE 502.1 Skeleton of the Right Foot (Lateral View)

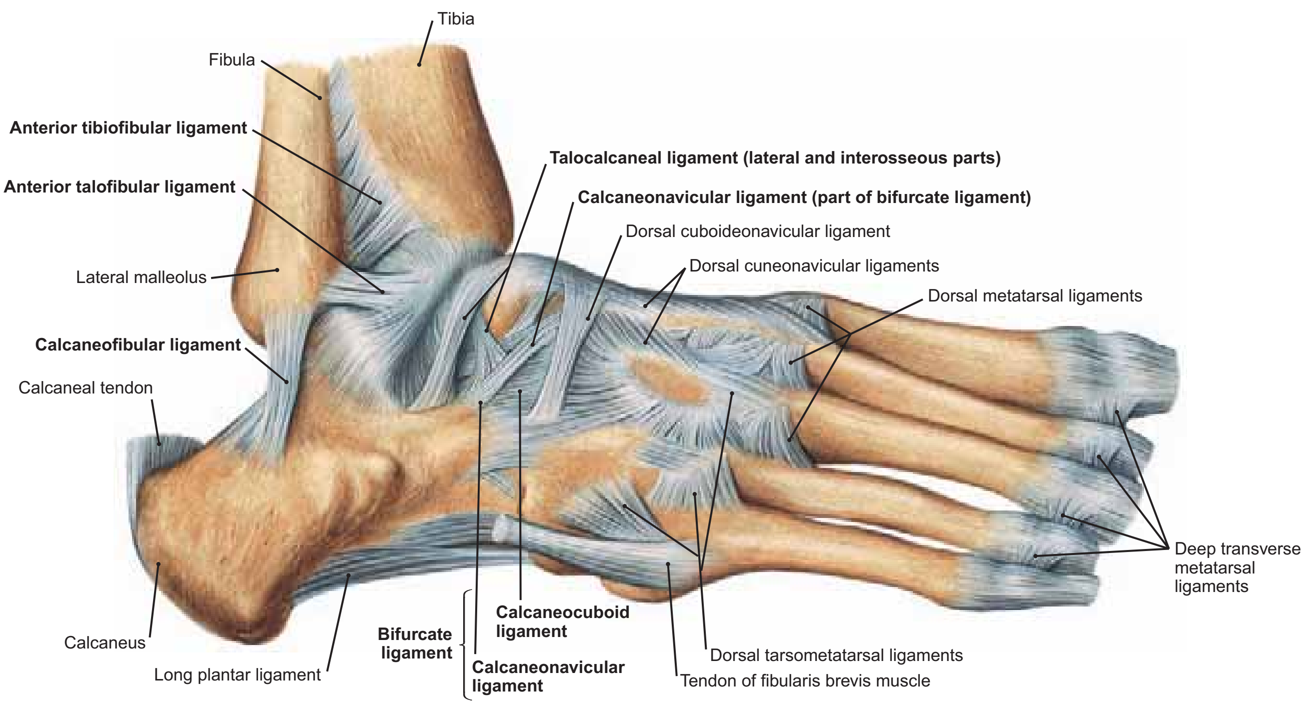


FIGURE 502.2 Lateral Ligaments of the Ankle Joint and of the Dorsolateral Foot (Right)

NOTE: (1) The fibula is attached to the tibia distally by the **anterior (inferior) tibiofibular ligament.** In addition, the lateral malleolus of the fibula is attached to the talus by the relatively weak **anterior talofibular ligament** and the much stronger **posterior talofibular ligament** (Fig. 499.2). The fibula is attached to the calcaneus by the **calcaneofibular ligament.** Together these latter three bands constitute the lateral ligament of the ankle.

(2) The **interosseous talocalcaneal ligament** is the principal ligament that strengthens the **subtalar joint** (between talus and calcaneus); the **lateral talocalcaneal ligament** also helps strengthen this joint as does the **medial talocalcaneal ligament,** which blends with the deltoid ligament (not shown).

(3) The (dorsal) **calcaneonavicular ligament,** part of the **bifurcate ligament,** attaches the dorsolateral aspect of the navicular bone with the calcaneus. Along with this (dorsal) calcaneonavicular ligament, the (dorsal) calcaneocuboid ligament constitutes the **"bifurcate" ligament.**

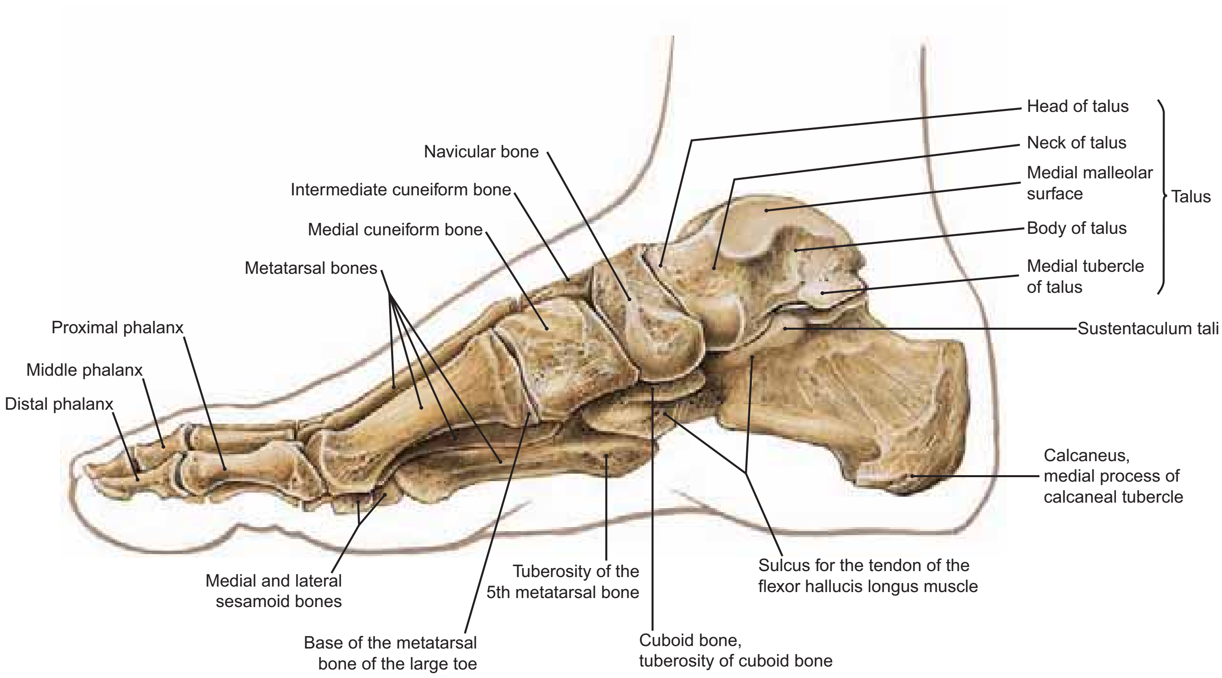


FIGURE 503.1 Skeleton of the Right Foot (Medial View)

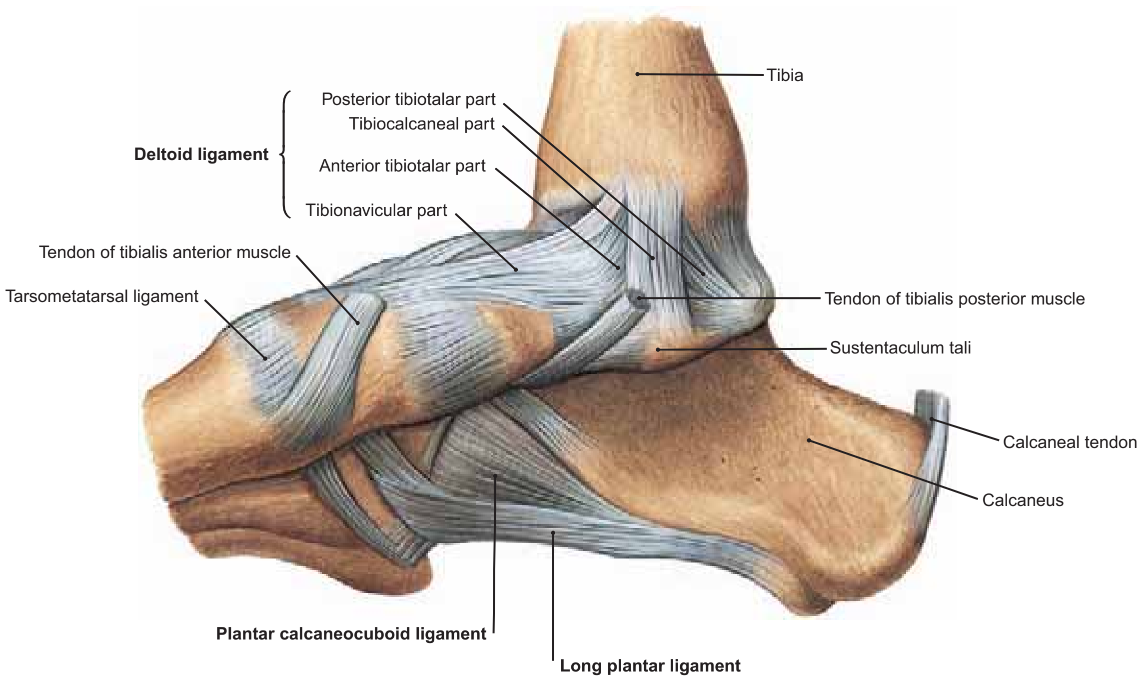


FIGURE 503.2 Ligaments of the Ankle and Foot: Medial View (Right Foot)

NOTE: (1) The medial aspect of the ankle joint is protected by the triangular **deltoid ligament,** which connects the tibia to the navicular, calcaneus, and talus. The deltoid ligament has four parts: (a) an **anterior tibionavicular** part that attaches the medial malleolus to the navicular, (b) a superficial **tibiocalcaneal part** attaching the malleolus to the sustentaculum tali of the calcaneus, and (c and d) the **anterior** and **posterior tibiotalar parts** that lie more deeply and attach the malleolus to the adjacent talus.

(2) The insertions of the tendons of the tibialis anterior and posterior muscles attach on this medial aspect of the foot. Also observe the **long plantar** and **plantar calcaneocuboid ligaments** on the plantar surface.

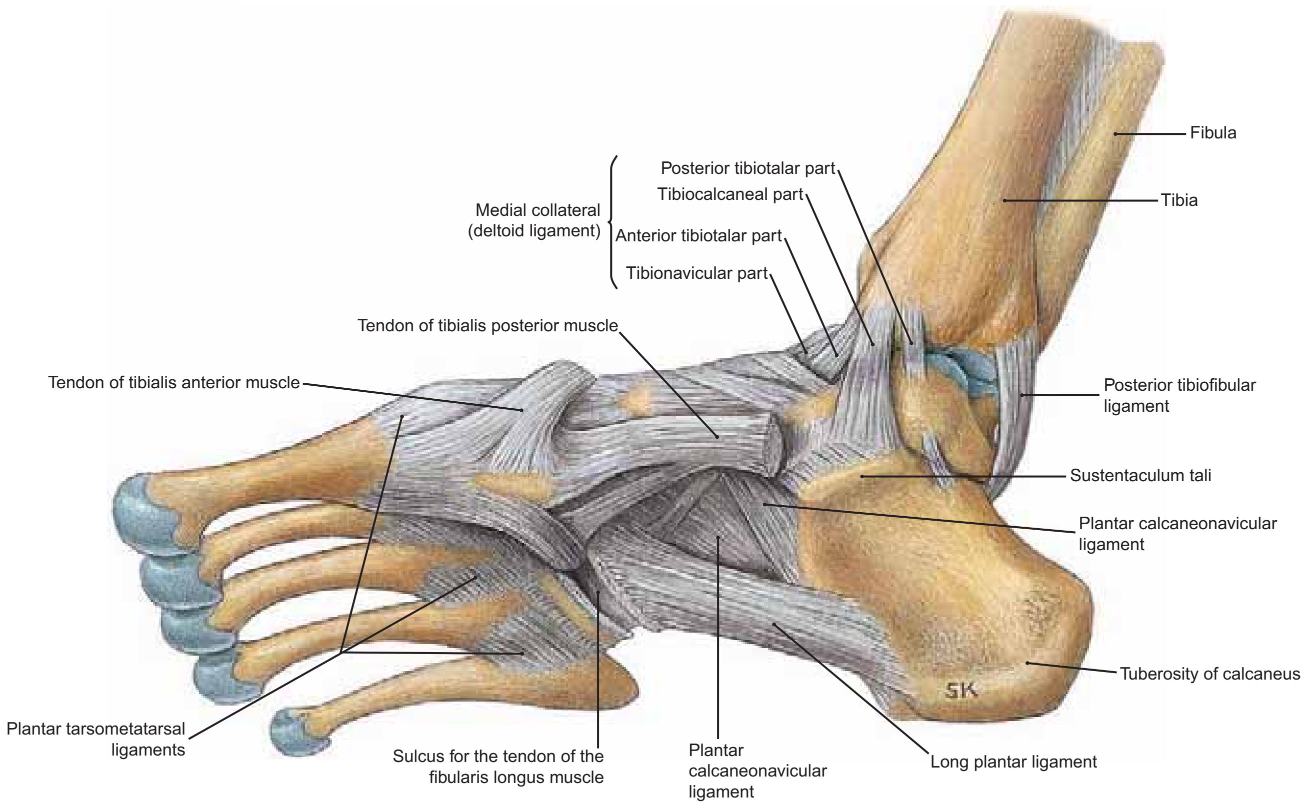


FIGURE 504.1 Ligaments on the Medial Aspect of the Ankle Joint and Foot

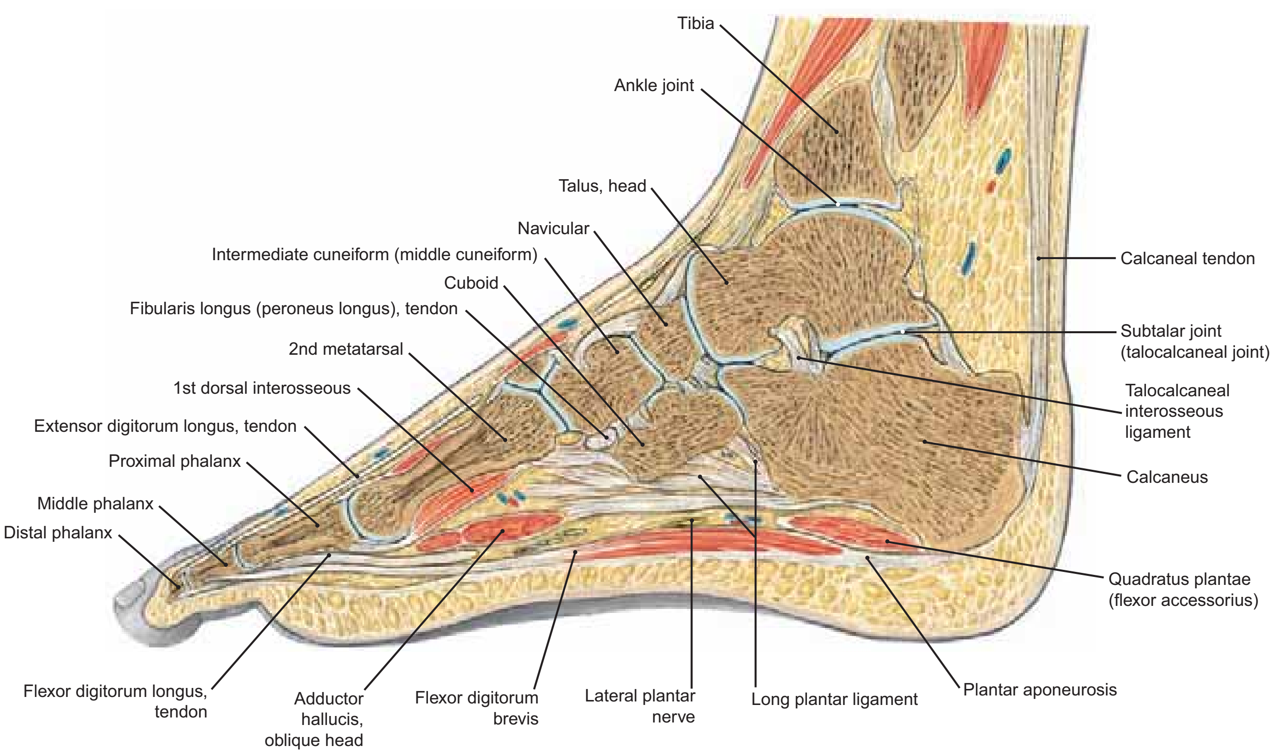


FIGURE 504.2 Sagittal Section through the Foot, Viewed from the Medial Aspect

NOTE: (1) This longitudinal section goes through the second toe.

(2) The relationship between the head of the talus proximally and the **navicular bone** distally, and the subtalar joint between the talus superiorly and the calcaneus inferiorly.

(3) The long plantar ligament. Observe this ligament also in Figure 506.1.

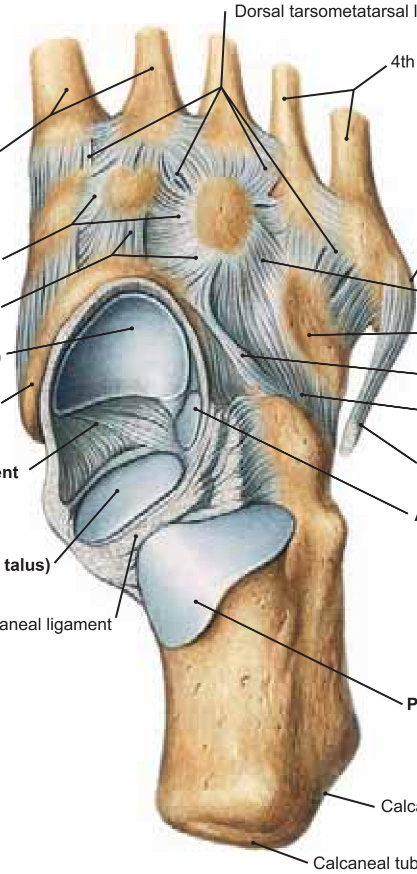


FIGURE 505.1 Right Talocalcaneonavicular Joint (Viewed from Above)

NOTE: (1) The talus has been removed, which exposes the three articulations it makes inferiorly with the **calcaneus** and the one articulation it makes anteriorly with the **navicular bone.**

(2) The plantar **calcaneonavicular (spring) ligament** stretches across the plantar aspect of the talocalcaneonavicular joint.

(3) The stability of this joint is assisted dorsally by the calcaneonavicular part of the **bifurcate ligament;** however, the plantar calcaneonavicular (or spring) ligament is the principal support of the longitudinal arch of the foot.

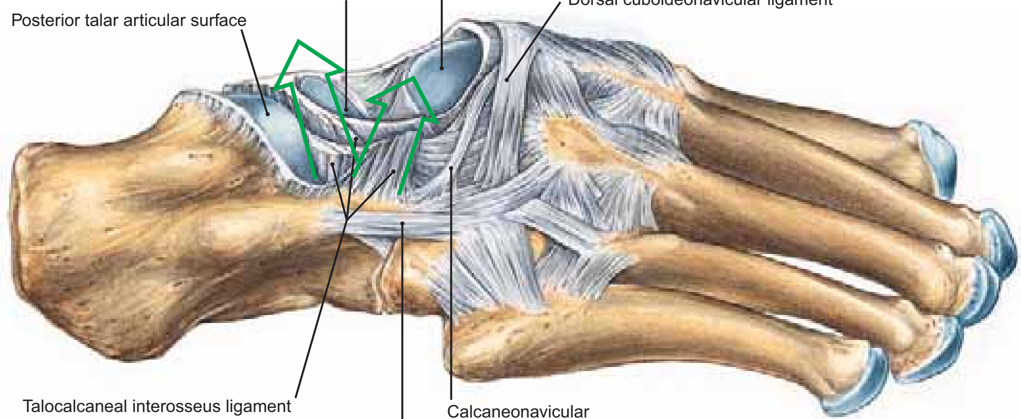


FIGURE 505.2 Articular Surfaces of the Right Talocalcaneonavicular Joint

NOTE: (1) The posterior and middle articular surfaces of the talus articulate with the underlying calcaneus, while the anterior articular surface articulates with the navicular bone anteriorly.

(2) The **bifurcate ligament** is a strong band that attaches posteriorly to the superior surface of the calcaneus. Anteriorly, it bifurcates into the calcaneocuboid and calcaneonavicular ligaments and forms a lateral ligament of the talocalcaneonavicular joint.

(3) The two green arrows indicate the torsion of the talocalcaneal ligament.

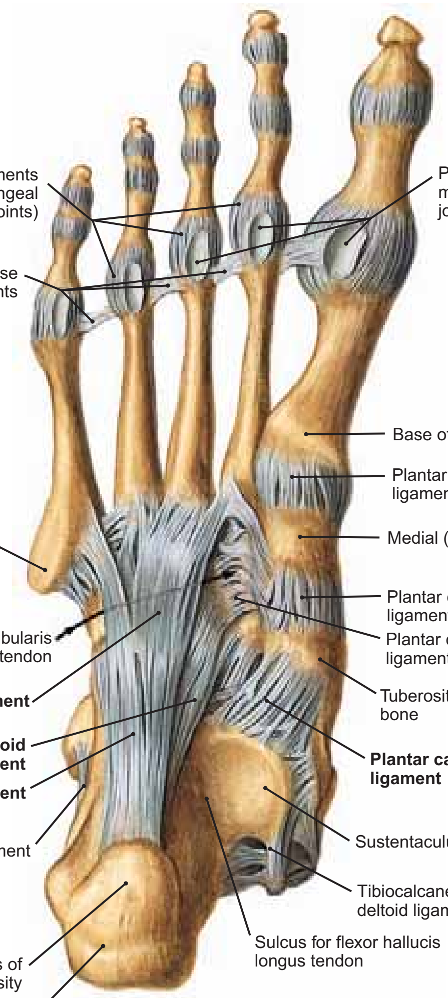


FIGURE 506.1 Ligaments on the Plantar Surface of the Right Foot (Superficial)

NOTE: (1) The **long plantar ligament** is the longest and most superficial of the plantar tarsal ligaments. It stretches from the calcaneus posteriorly to an oblique ridge on the plantar surface of the cuboid, where most of its fibers terminate.

(2) The superficial fibers of the long plantar ligament pass over the cuboid to insert on the bases of the lateral three metatarsal bones, thereby forming a tunnel for the **fibularis longus tendon**.

(3) The **plantar calcaneocuboid** or **short plantar ligament** is very strong and lies deep to the long plantar ligament and closer to the bones.

(4) Identify the **plantar calcaneonavicular (spring) ligament** medially. It is attached to the sustentaculum tali of the calcaneus and extends along the entire inferior surface of the navicular bone. It is important for the support of the medial arch of the foot.

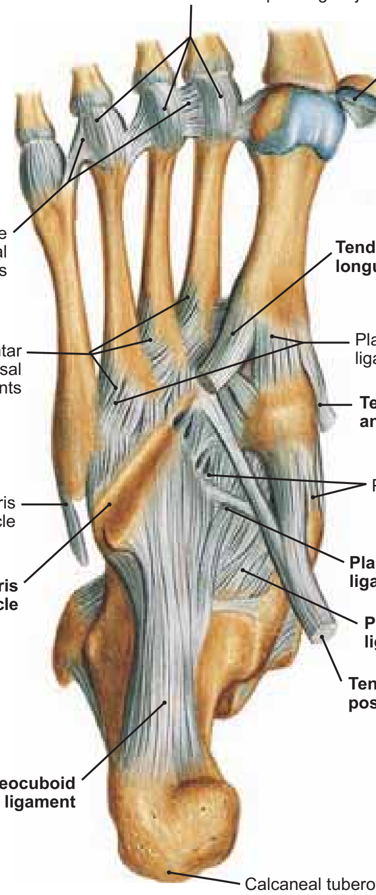


FIGURE 506.2 Plantar Calcaneonavicular Ligament and the Insertions of Three Tendons (Right Foot)

NOTE: (1) The metatarsal extensions of the long plantar ligament have been cut away to reveal the groove for the tendon of the fibularis longus muscle. This tendon inserts onto the base of the first metatarsal bone and the first (medial) cuneiform bone.

(2) Two other tendons insert on the medial side of the plantar surface: the tibialis anterior and posterior tendons.

(3) The fibers of the calcaneocuboid (short plantar) and calcaneonavicular (spring) ligaments all stem from the calcaneus and then diverge in a radial manner toward the medial side of the foot.

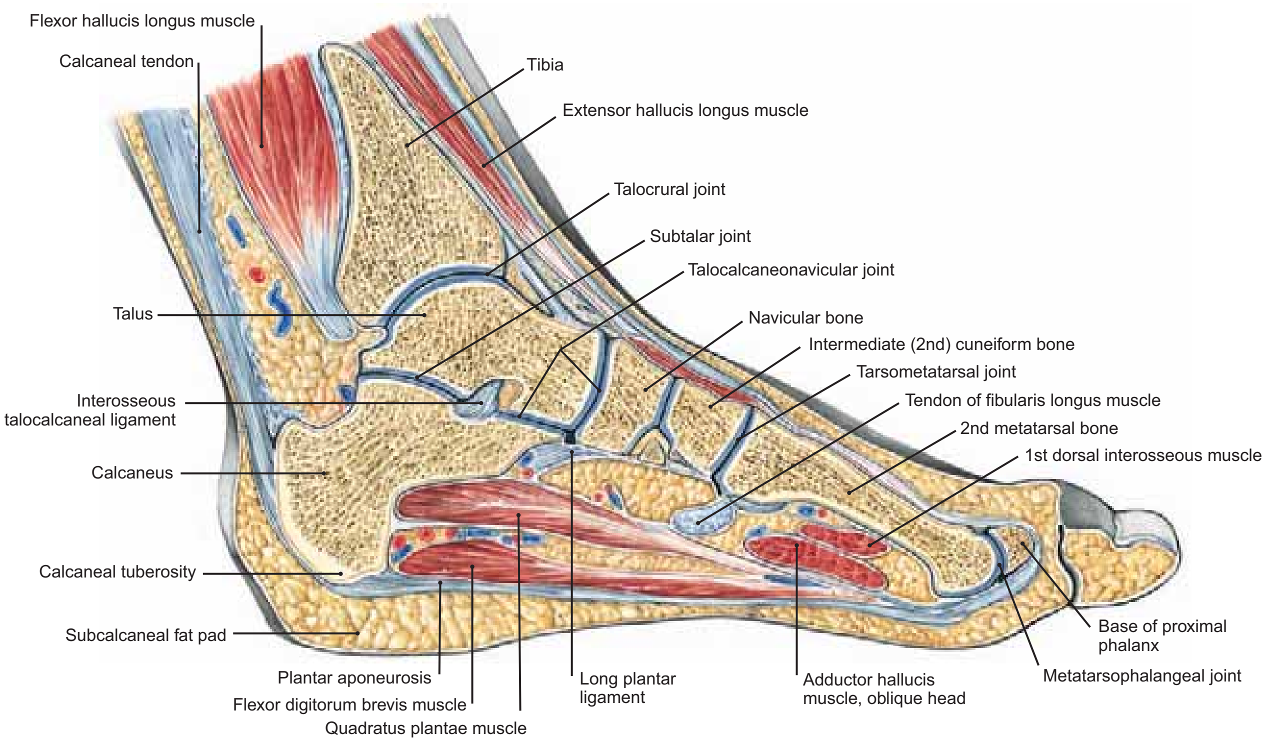


FIGURE 507.1 **Sagittal Section of Foot Showing Talocrural, Subtalar, and Talocalcaneonavicular Joints**

NOTE: (1) This sagittal section, viewed from the medial aspect, cuts through the trochlea, neck, and head of the talus.
(2) The **talocalcaneonavicular joint** anteriorly is of clinical significance because the weight of the body tends to push the head of the talus downward between the navicular and the calcaneus. This results in flat feet.

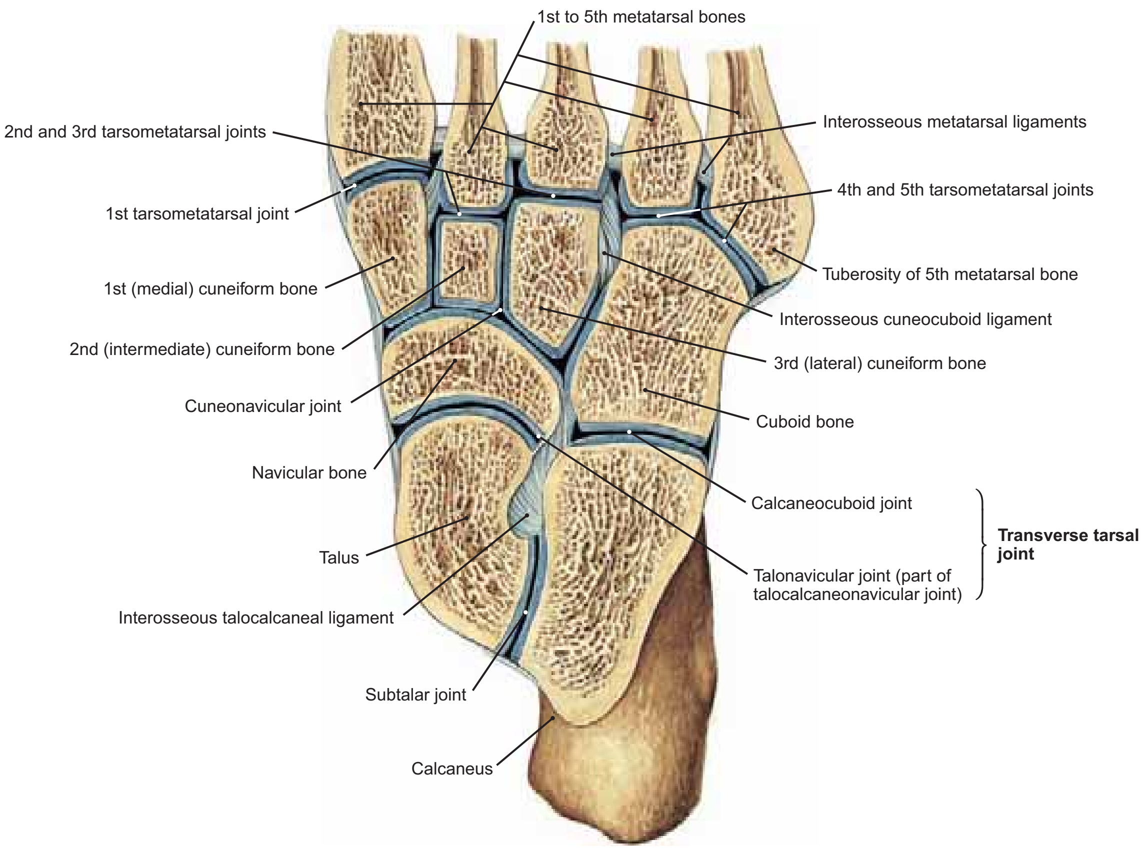


FIGURE 507.2 **Intertarsal and Tarsometatarsal Joints (Horizontal Section of the Right Foot)**

NOTE: The **transverse tarsal (midtarsal) joint** extends across the foot and actually is formed by two separate joint cavities, the **calcaneocuboid joint** laterally and the **talonavicular** part of the talocalcaneonavicular joint medially. These two joints allow some eversion and inversion movements of the foot.

Radiograph and MRI of Ankle, Subtalar, and Talocalcaneonavicular Joints

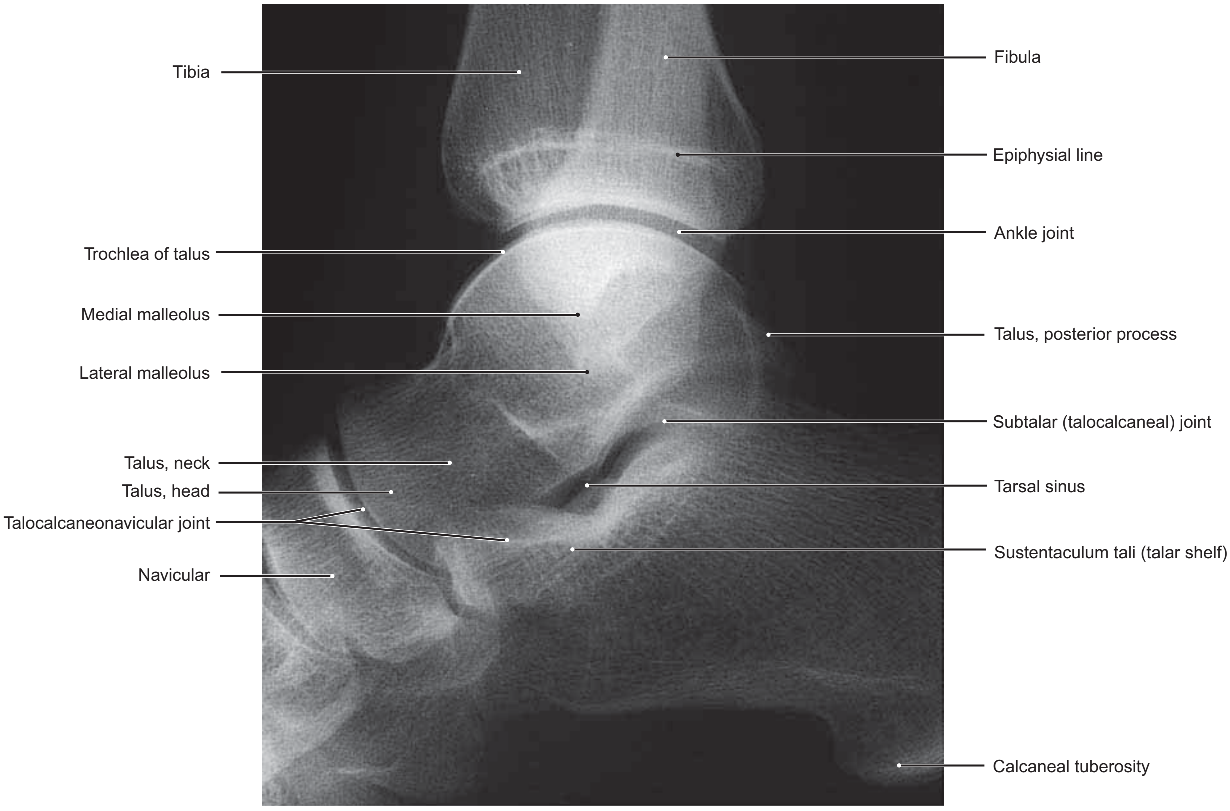


FIGURE 508.1 **Lateral Radiograph of the Subtalar and Talocalcaneonavicular Joints**

NOTE: The convex head of the talus articulates with the oval, concave posterior **surface** of the navicular bone.

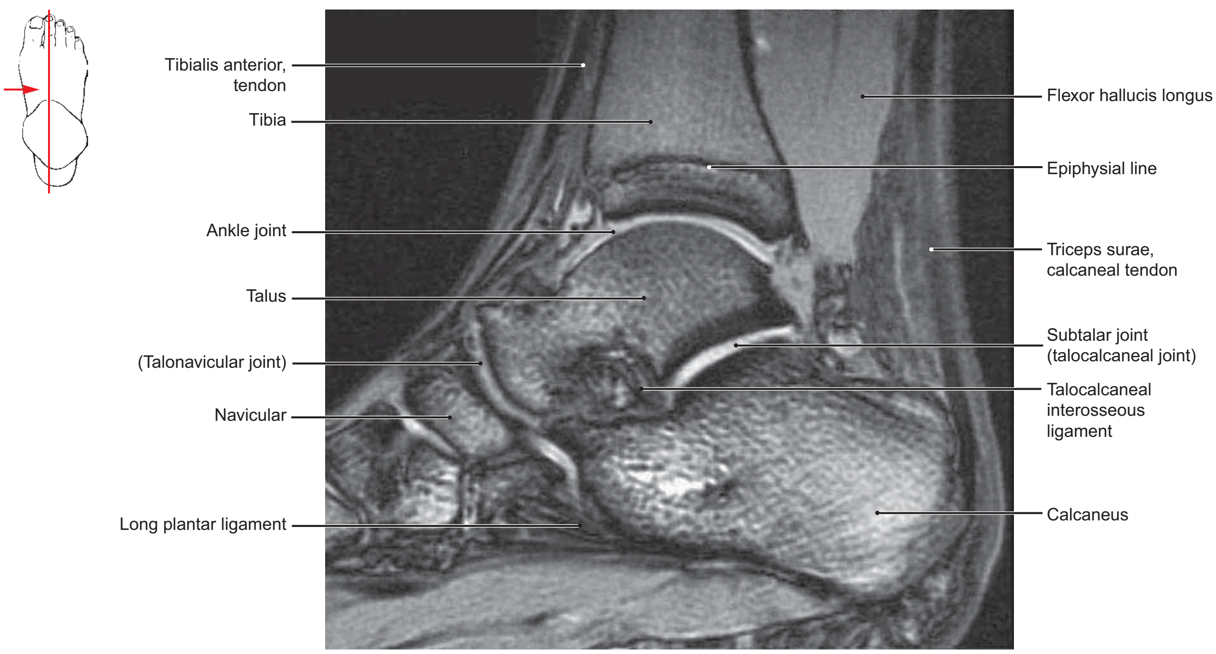


FIGURE 508.2 **MRI Showing the Ankle, Subtalar, and Talonavicular Joints**

NOTE: This image is taken through the longitudinal axis of the foot.

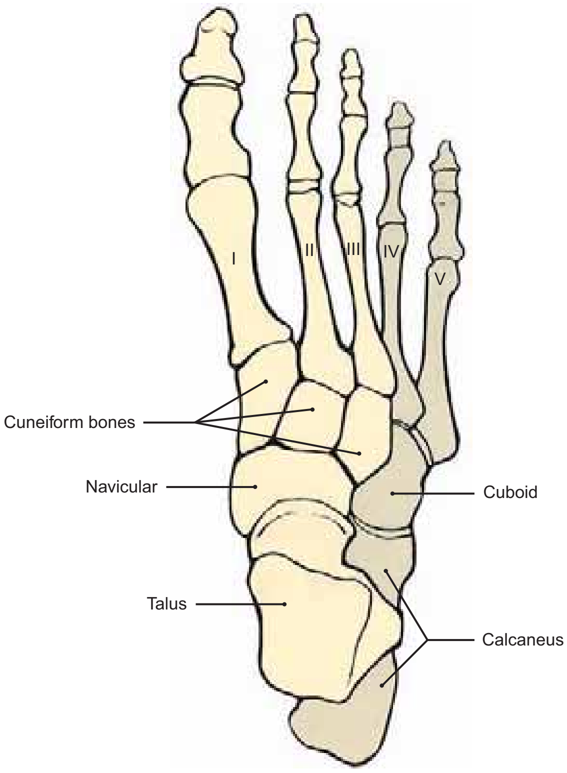


FIGURE 509.1 **Longitudinal Arches of the Foot (Dorsal View)**

NOTE: The **medial longitudinal arch** consists of the talus, navicular, three cuneiform bones, three medial metatarsal bones, and the phalanges of the large toe and those of the second and third toes.

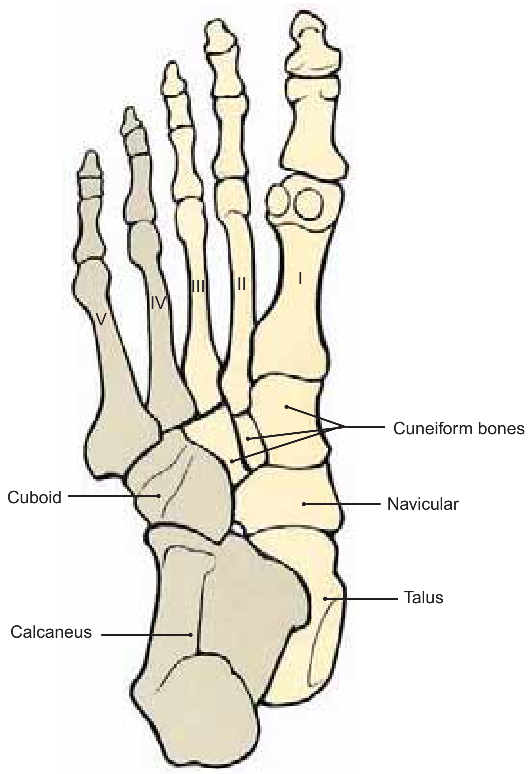


FIGURE 509.2 **Longitudinal Arches of the Foot (Plantar View)**

NOTE: The **lateral longitudinal arch consists** of the calcaneus and cuboid bones, the two lateral metatarsal bones, and the phalanges of the fourth and fifth toes.

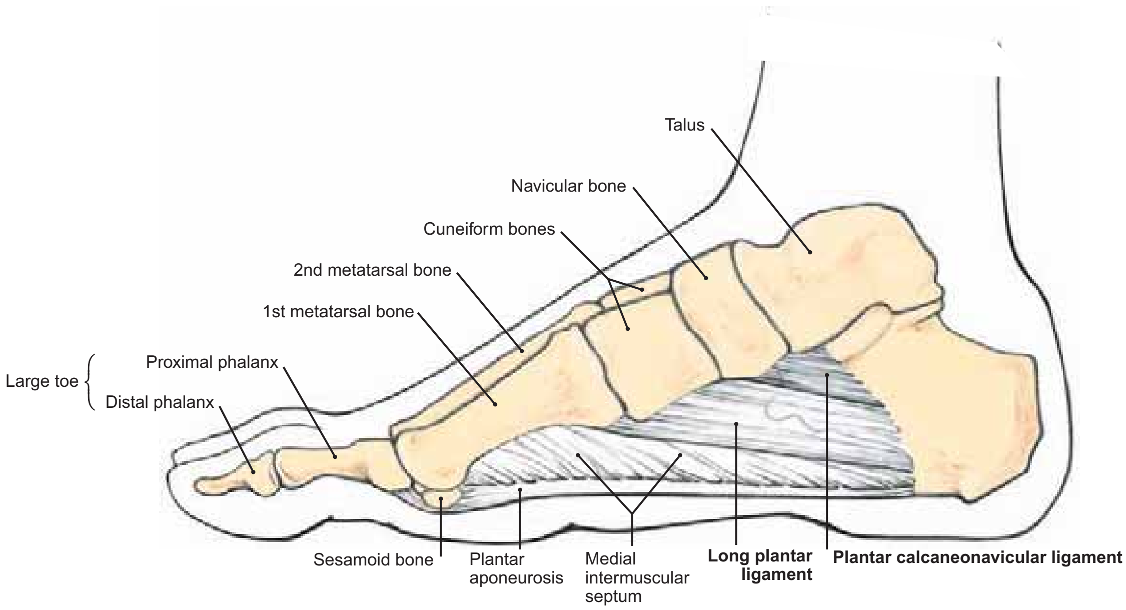
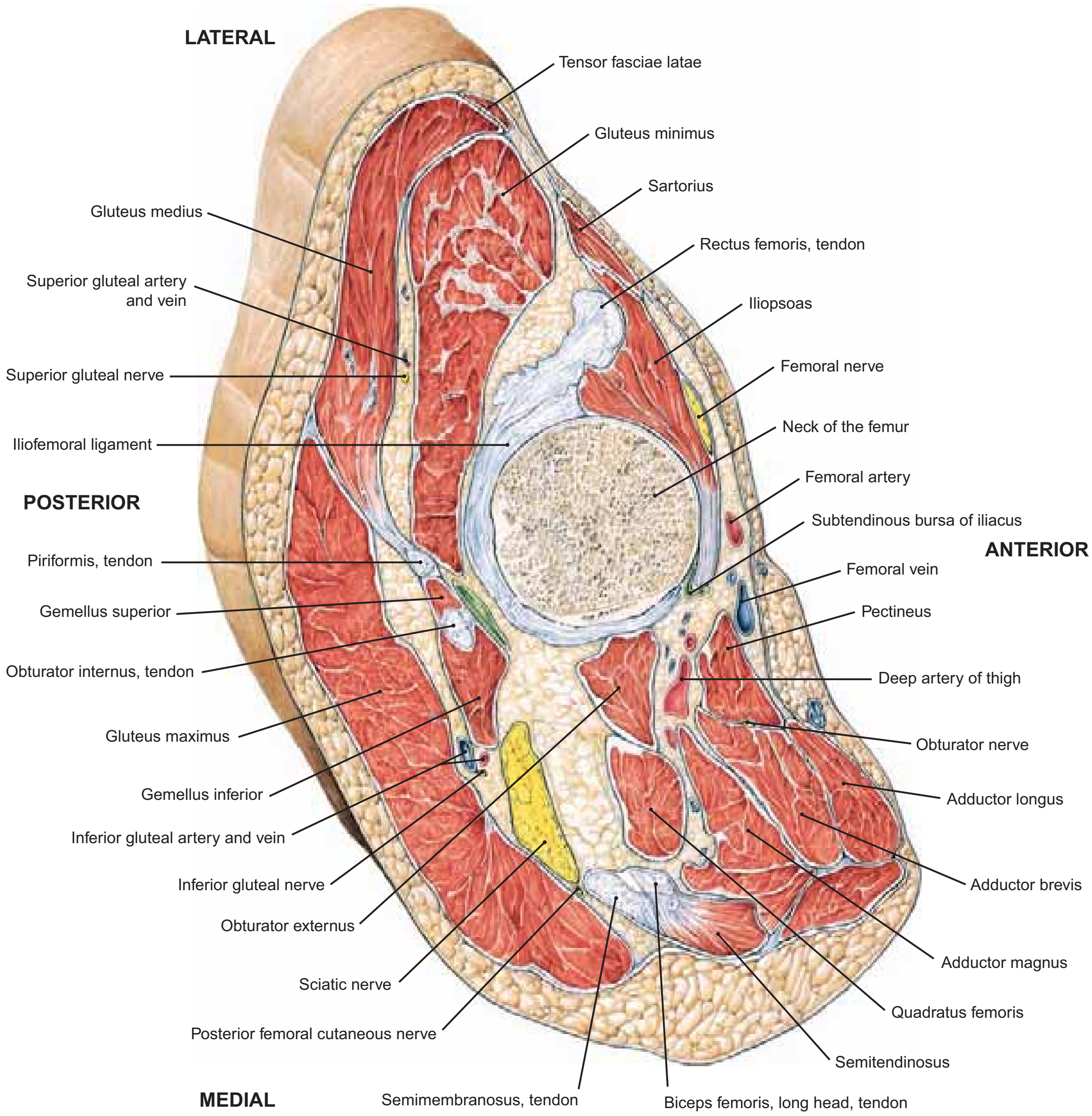


FIGURE 509.3 **Longitudinal Arch of the Foot: Underlying Support Structures**

NOTE: (1) The medial longitudinal arch of the foot is formed by the calcaneus, talus, navicular, three cuneiform, and the medial three metatarsal bones. Observe the arched nature of the medial margin of the foot.

(2) The integrity of the medial longitudinal arch depends on structures underlying the talocalcaneonavicular septum, but much more important are the **long plantar ligament** and especially the **plantar calcaneonavicular ligament.**



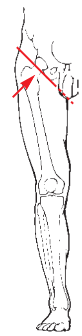


FIGURE 510 Cross Section through the Superior Aspect of the Right Thigh

NOTE: (1) This section is through the femoral neck. See the tendon of the rectus femoris and the iliofemoral ligament. Observe the gluteus maximus, gluteus medius, and gluteus minimus along with the tendon of the obturator internus and the gemellus superior and gemellus inferior in the **gluteal region.**

(2) The sartorius, iliopsoas, pectineus, and femoral vessels and nerves in the **anterior thigh.** Observe the obturator externus located deep to the quadratus femoris, and note the adductor magnus, longus, and brevis in the **medial thigh.**

(3) The biceps femoris, semimembranosus, tendon of the semitendinosus, and the **sciatic nerve** in the **posterior thigh.**

CLINICAL NOTES from Professor Constantine P. Karakousis, Professor of Surgery, University of Buffalo, Buffalo, N.Y, (by personal communication):

(4) "In a medial compartment resection of the thigh due to sarcoma, resection of the adductor magnus may be required, and it should be kept in mind that as soon as the insertion of the adductor magnus to the linea aspera is divided, directly behind the medial portion of the adductor magnus lies the **sciatic nerve,** which is subject to injury unless some care is exercised."

(5) "The **sciatic nerve** lies between the ischial tuberosity and the greater trochanter, being lateral to the hamstring muscles. As it descends to the midthigh, the sciatic nerve assumes a position between the biceps femoris (long head) and the semitendinosus–semimembranosus muscles. For sarcomas in the buttocks, a longitudinal or slightly oblique incision is preferable to an incision along the fibers of the gluteus maximus. Such an incision can extend from the crest of the ilium to midway between the ischial tuberosity and the greater trochanter into the upper thigh. This provides an early exposure of the sciatic nerve below the lowermost fibers of the gluteus maximus and, therefore, resection of the gluteus maximus and any other gluteal muscles can be done safely by visualizing the sciatic nerve from this more distal point to the site where the nerve leaves the pelvis below the piriformis."

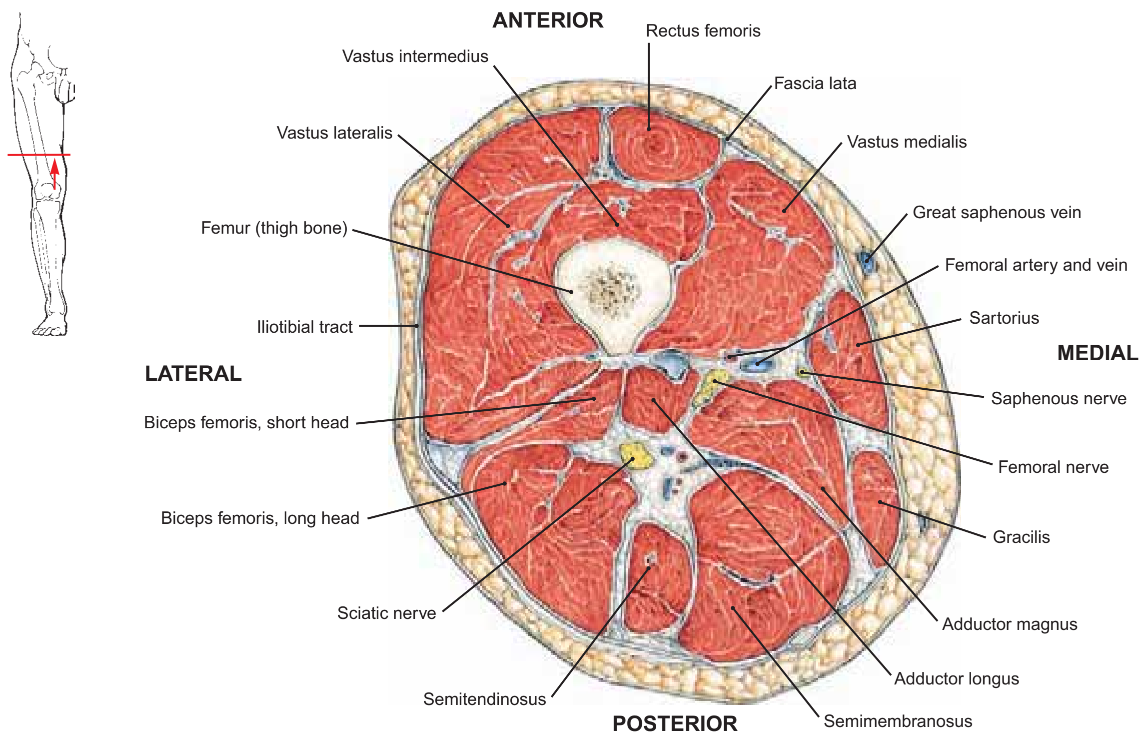


FIGURE 511.1 Cross Section through the Middle of the Right Thigh Viewed From the Distal Aspect

NOTE: (1) Compare this figure with the MRI seen in Figure 511.2.
(2) The **posterior** group of structures: biceps femoris, semitendinosus, semimembranosus, and the **sciatic nerve**.
(3) The **medial** structures: gracilis, adductor magnus, and adductor longus (the adductor brevis is more superior to this section).
(4) The **anterior** structures: four heads of the quadriceps muscle: rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis.

CLINICAL NOTES from Professor Constantine P. Karakousis, Professor of Surgery, University of Buffalo, Buffalo, N.Y. (personal communication):
(5) "The bulk of the motor branches of the femoral nerve in the proximal groin deviate in an inferolateral direction along the branches of the lateral femoral circumflex artery and vein in a course between the rectus femoris, vastus intermedius, and vastus lateralis. A slender branch of the femoral nerve, however, remains outside the musculature until it reaches the middle of the vastus medialis, where it enters the muscle to provide its motor supply."
(6) "The difference in the course of the branch to vastus medialis as compared to the branches to the other heads of the quadriceps is useful in performing a modified anterior compartment resection of the anterior thigh for suitable cases of sarcoma, providing the tumor can adequately be resected, since it could potentially preserve the extensor action at the knee."

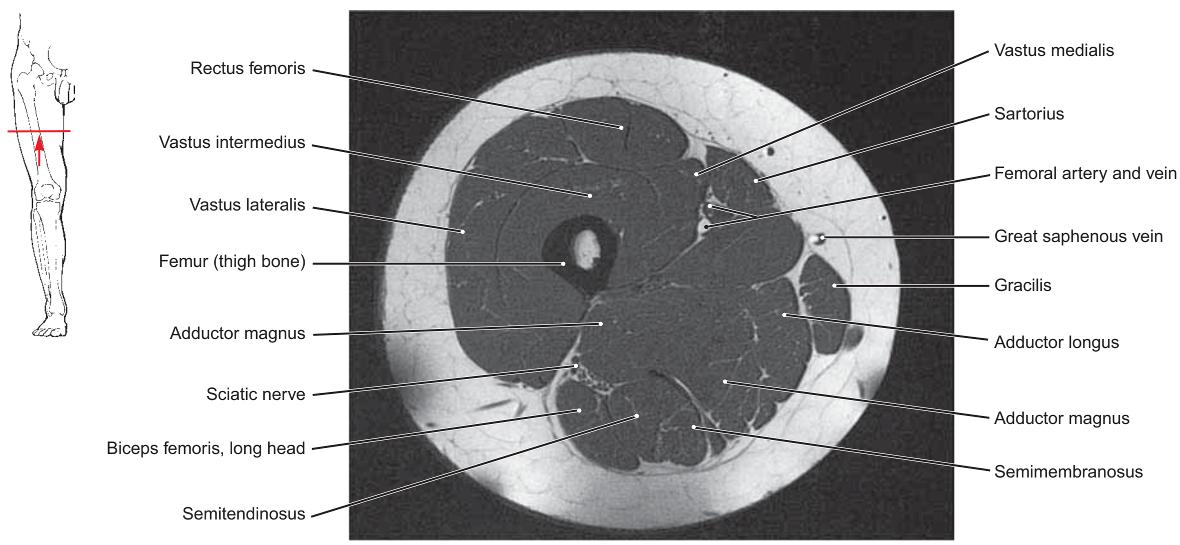
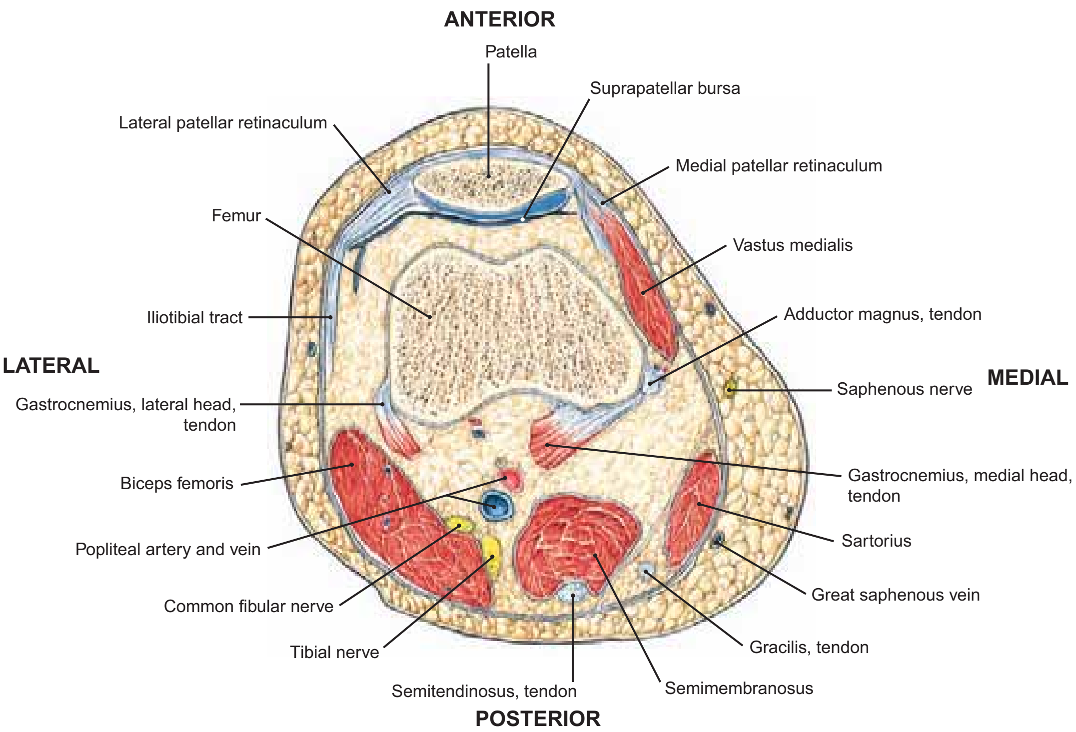


FIGURE 511.2 MRI Near the Middle of the Right Thigh



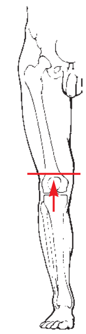


FIGURE 512.1 Cross Section of the Inferior Thigh at the Level of the Popliteal Fossa Viewed from the Distal Aspect

NOTE: (1) Compare this figure with the MRI in Figure 512.2.

(2) In this cross section through the inferior aspect of the right femur, see the **popliteal vessels, tibial nerve,** and **common fibular** (common peroneal) **nerve** in the popliteal fossa posterior to the femur. Observe that the nerves are superficial (i.e., more posterior) to the vessels and that the artery is most deeply located and the vein is between the nerves and the artery.

(3) The patella and the suprapatellar bursa are anterior to the femur and the lateral patellar retinaculum and the iliotibial tract are lateral to the femur.

(4) Posteriorly, identify the two heads of the gastrocnemius muscle, the inferior parts of the "hamstring muscles" (biceps femoris, tendon of the semitendinosus and semimembranosus muscles), the two superior ends of the gastrocnemius muscle, and the sartorius muscle (that has coursed around the thigh to the medial aspect of the knee at this level).

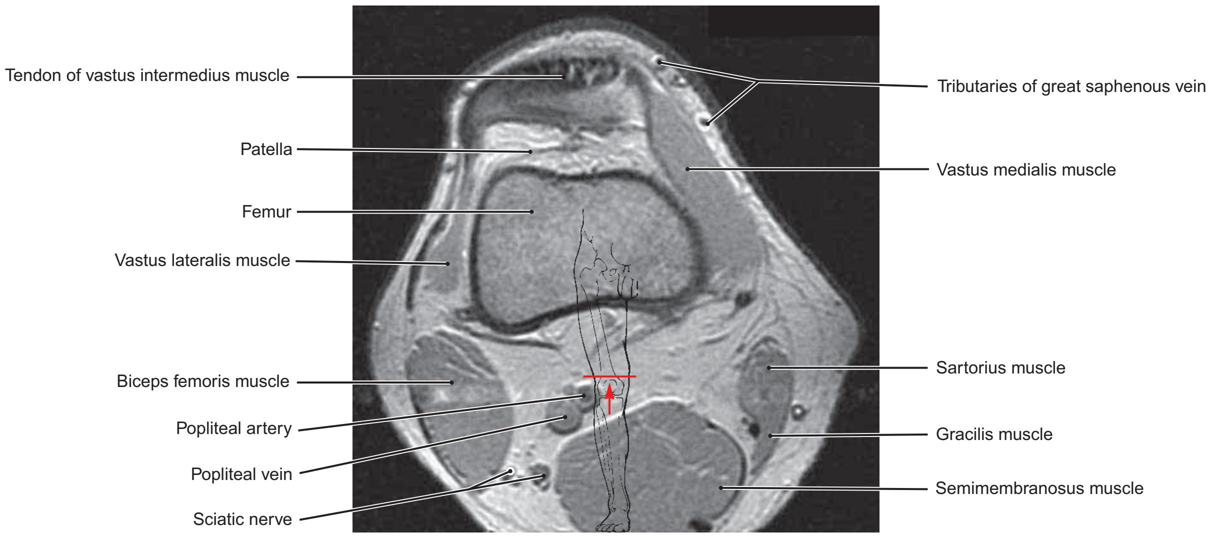
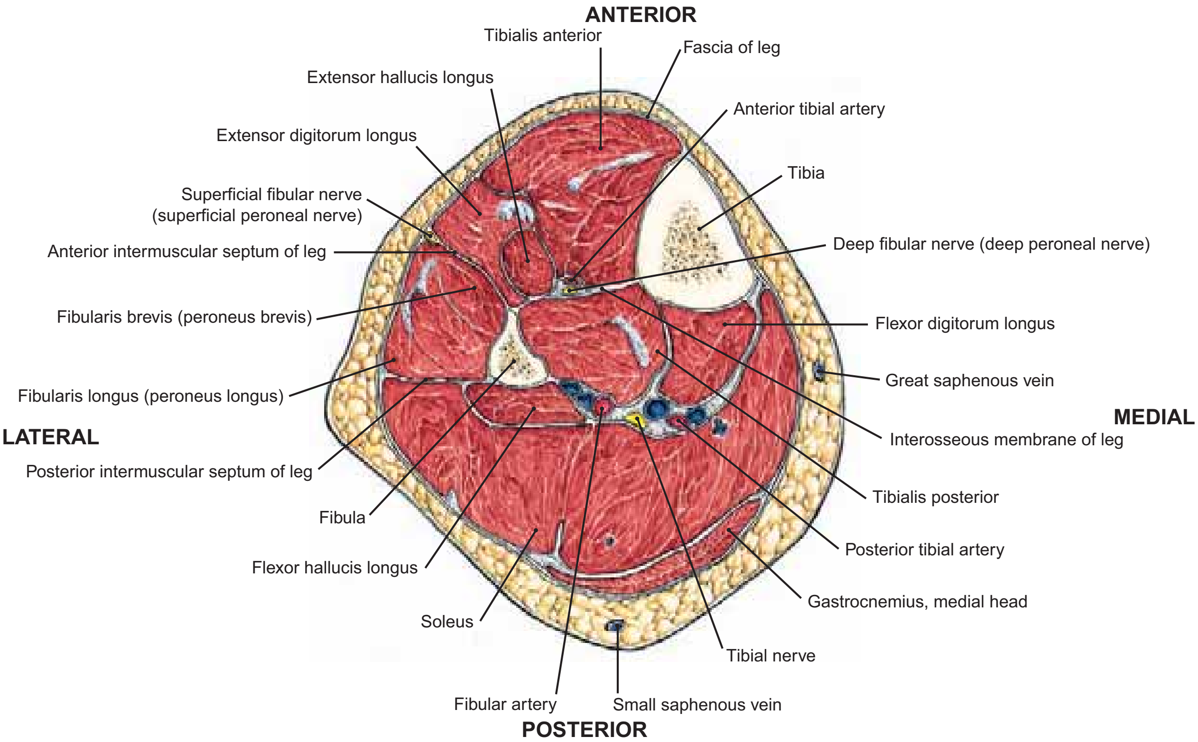


FIGURE 512.2 MRI: Cross Section through the Distal Part of the Right Thigh



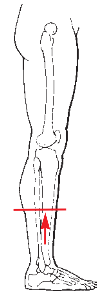


FIGURE 513.1 **Cross Section through the Middle of the Right Leg**

NOTE: (1) The tibia, fibula, and interosseous membrane (that interconnects the bones) and the intermuscular septa divide the leg into **anterior, lateral,** and **posterior compartments.**

(2) The **tibialis anterior, extensor hallucis longus, extensor digitorum longus, deep fibular nerve** (from the common fibular nerve), and **anterior tibial artery** are all located in the **anterior compartment.**

(3) The **fibularis longus, fibularis brevis** (peroneal longus and brevis), and **superficial fibular nerve** (from the common fibular nerve) that supply the two muscles are all located in the lateral compartment.

(4) The **posterior compartment** contains **superficial and deep parts.**

(5) The **superficial part** of the posterior compartment contains the **gastrocnemius muscle,** the **soleus muscle,** and the **tendon of the plantaris muscle** (this latter structure is not shown in this figure; see Fig. 464).

(6) The **deep part** of the posterior compartment contains the **flexor digitorum longus, tibialis posterior,** and **flexor hallucis longus** muscles.

(7) The **posterior tibial artery** (and **vein**), the **fibular artery** (a branch of the posterior tibial) and **vein,** and the **posterior tibial nerve** course in the plane between the superficial and deep posterior compartment structures.

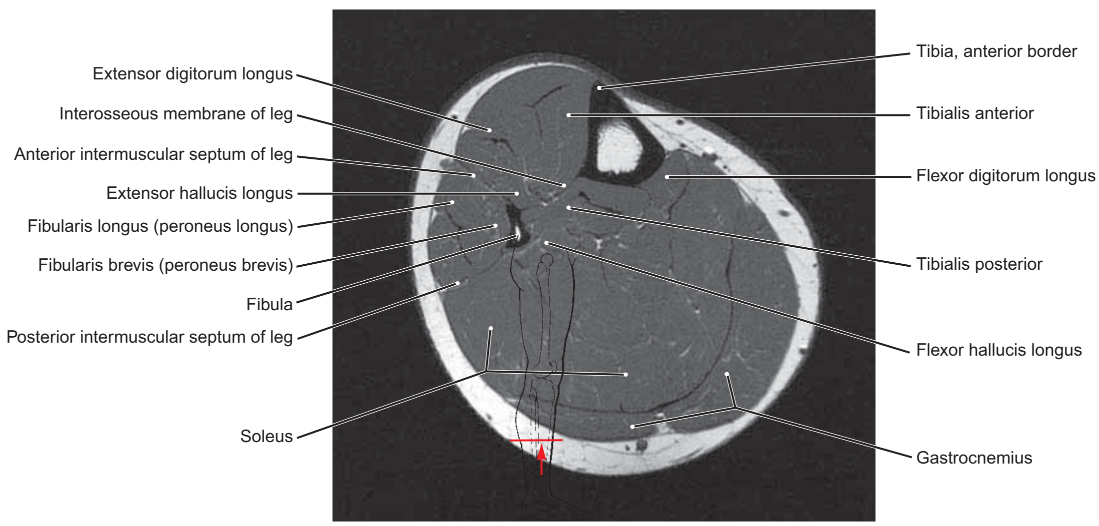


FIGURE 513.2 **MRI: Cross Section through the Middle of the Right Leg**

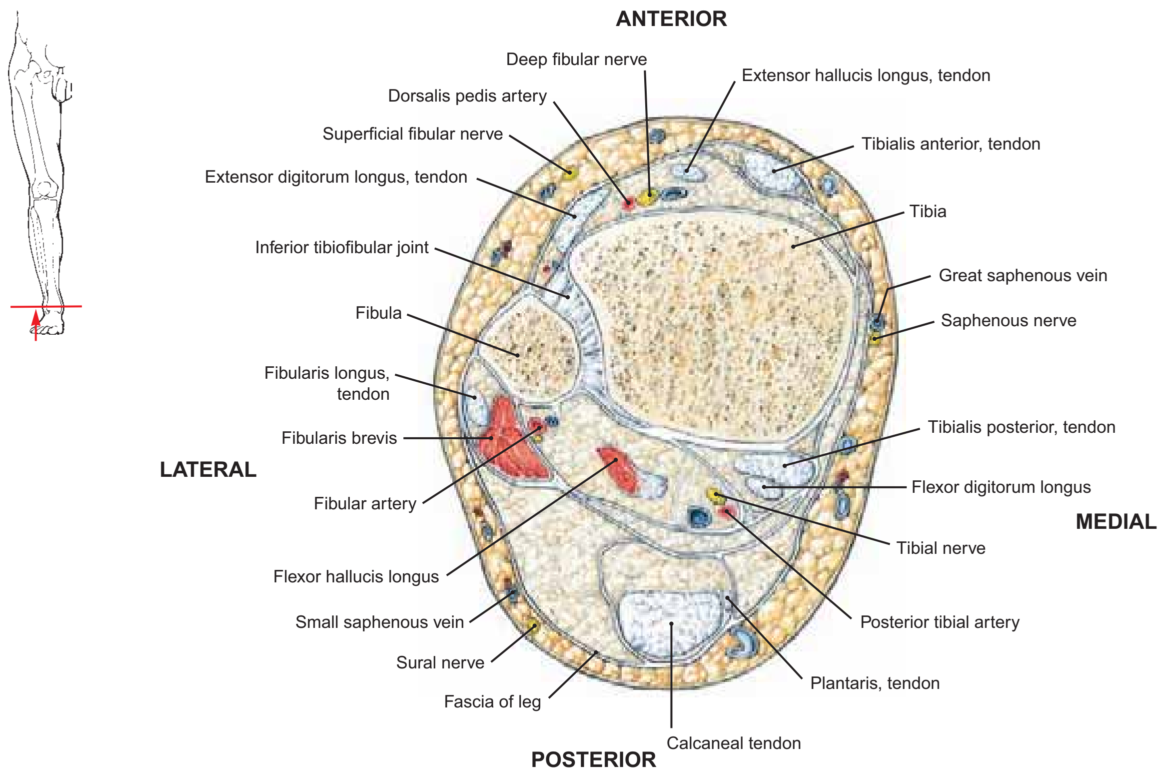


FIGURE 514.1 Cross Section through the Right Leg Just Proximal to the Malleoli

NOTE: (1) The **anterior compartment** tendons, the superficial and deep fibular nerves, and the dorsalis pedis artery anterior to the tibia.

(2) The fibula, tendon of the fibularis longus, and the fibularis brevis muscle in the **lateral compartment.**

(3) The flexor hallucis longus, tendons of the tibialis posterior and flexor digitorum longus, the tibial nerve, the posterior tibial artery and its branch, and the fibular artery are all in the **deep part** of the **posterior compartment.**

(4) The calcaneal tendon and the small tendon of the plantaris muscle in the superficial part of the posterior compartment.

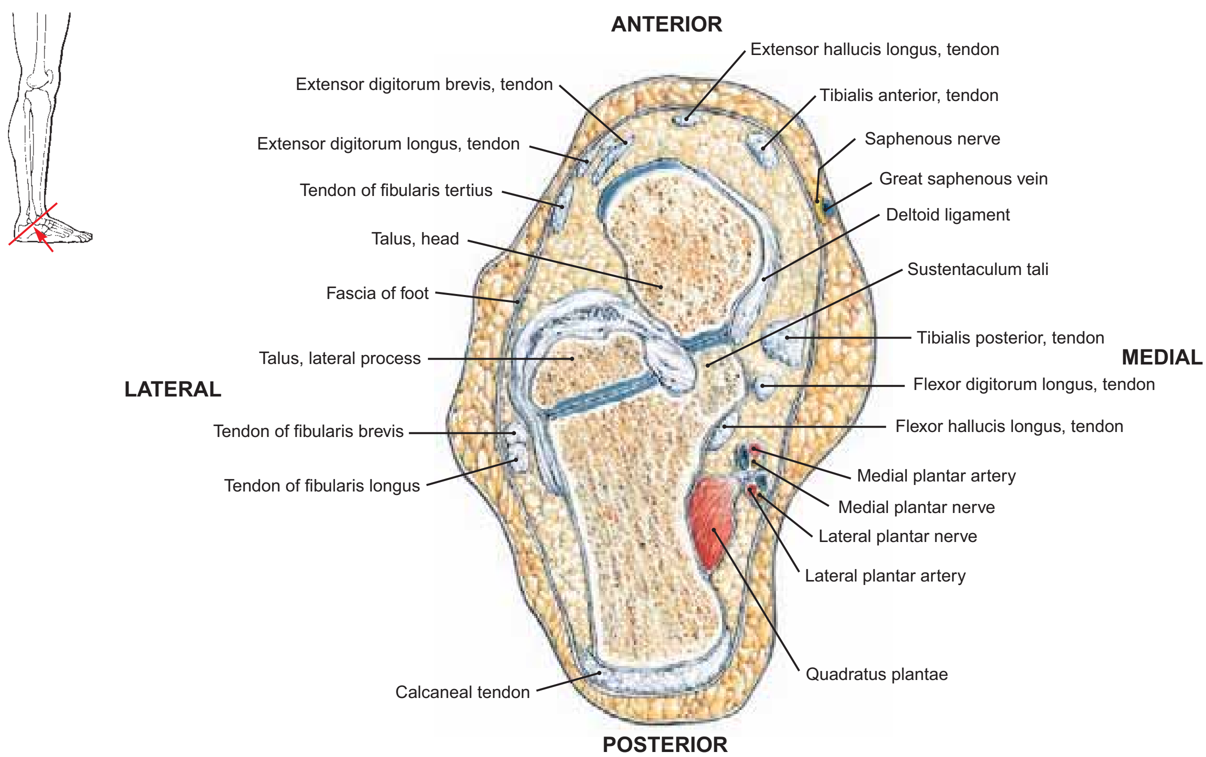
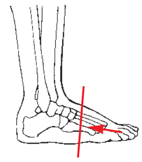


FIGURE 514.2 Oblique Section through the Calcaneus and Talus of the Right Foot

NOTE: The sustentaculum tali deep to the talus and the tendons of the leg descending anterior, lateral, and medial to the bony structures.



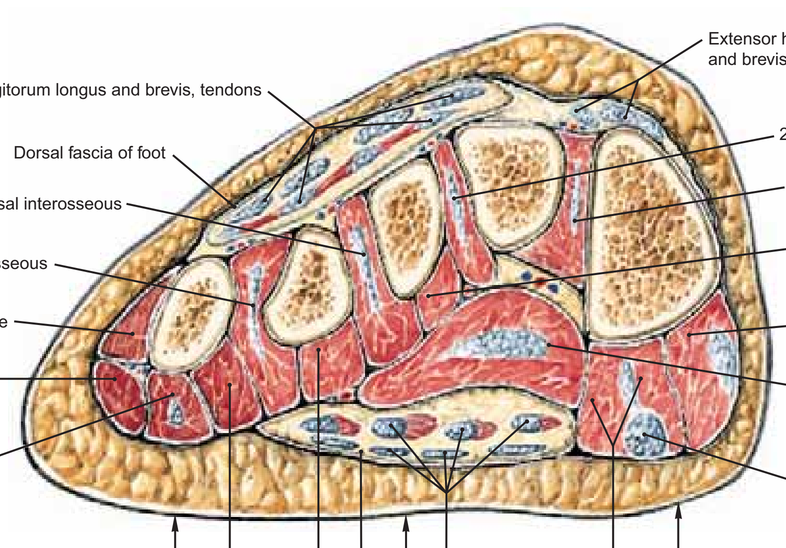


FIGURE 515.1 Frontal Section through the Metatarsal Bones of the Right Foot

NOTE: (1) Compare this figure with Figure 515.2 and identify the metatarsal bones and the plantar and dorsal interosseous muscles.
(2) The abductor hallucis, flexor hallucis brevis, and tendon of the flexor hallucis longus on the medial side of plantar aspect of the foot.
(3) The tendons of the extensor digitorum longus and brevis muscles on the dorsum of the foot.
(4) The plantar aponeurosis and the tendons of the flexors digitorum longus and brevis on the plantar aspect of the foot; just dorsal to these is located the adductor hallucis.

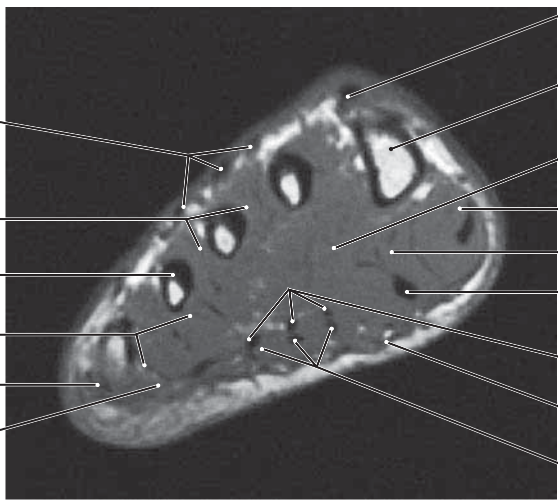
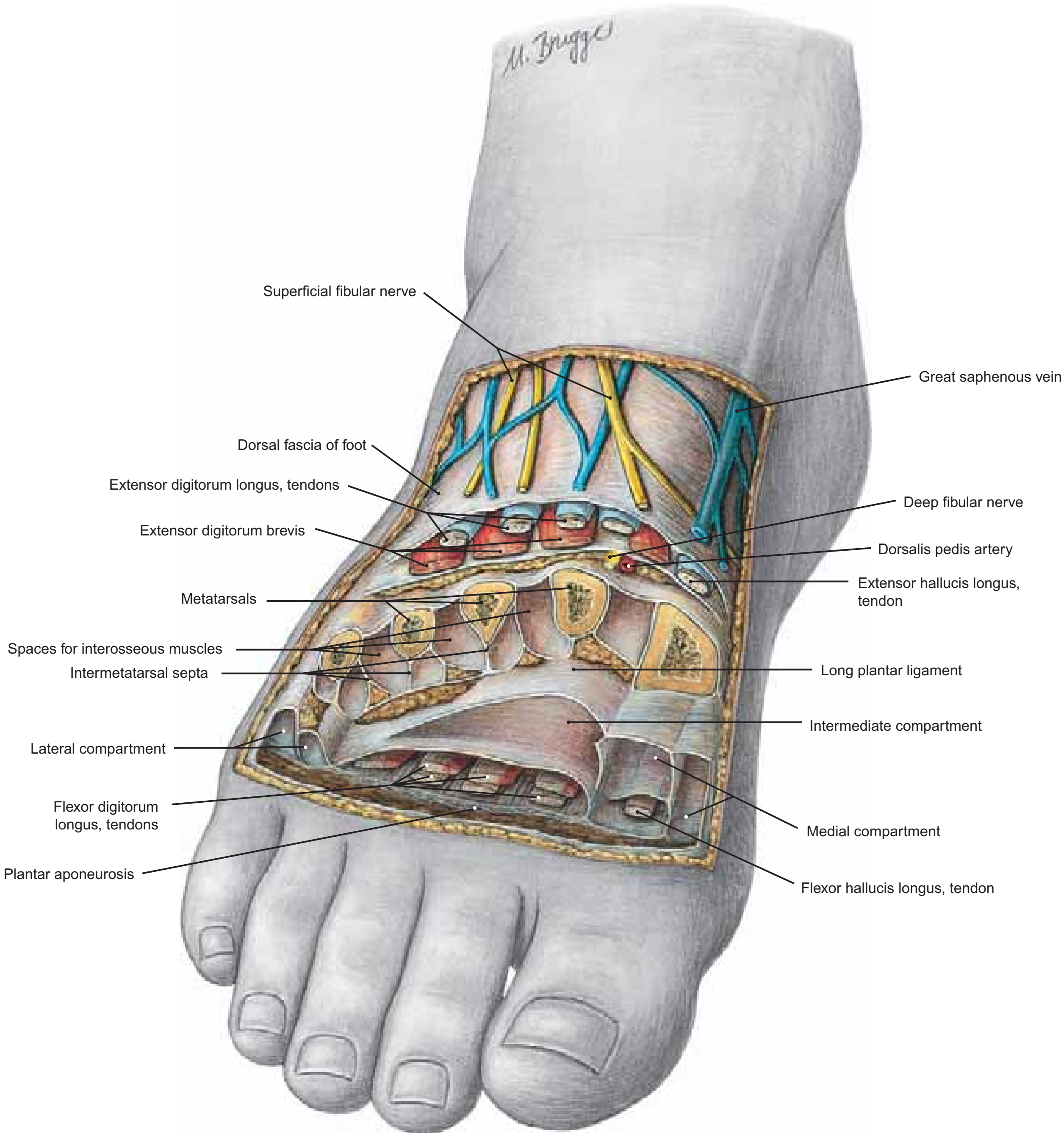


FIGURE 515.2 MRI through the Metatarsal Bones of the Right Foot



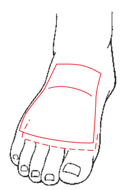


FIGURE 516 Compartments of the Foot Shown by a Frontal Section at the Midmetatarsal Level

NOTE compartments sequentially from dorsal to plantar sides:

(1) The superficial fibular nerve and superficial veins at the subcutaneous level on the foot dorsum.

(2) The extensor digitorum longus and extensor hallucis longus tendons and the bellies of the **extensor** digitorum brevis muscle of the foot dorsum. On the plantar aspect of these, observe the deep fibular nerve and dorsalis pedis artery.

(3) The metatarsal bones and the spaces for the dorsal and plantar interosseous muscles.

(4) On the plantar aspect of the metatarsal bones and interosseous muscles are the lateral, intermediate, and medial compartments that contain the intrinsic muscles on the plantar aspect of the foot (see Fig. 472).

The muscles of the **medial compartment** include the abductor hallucis and the flexor hallucis brevis, and just deep to these is the tendon of the flexor hallucis longus muscle.

The muscles of the **intermediate compartment** include the transverse and oblique heads of the adductor hallucis, and just on the plantar aspect of these are the quadratus plantae muscle, the tendons of the flexor digitorum longus muscle, and the lumbrical muscles.

The muscles of the **lateral compartment** are the opponens, flexor, and abductor digiti minimi muscles.

CHAPTER 7

The Neck and Head

Plates

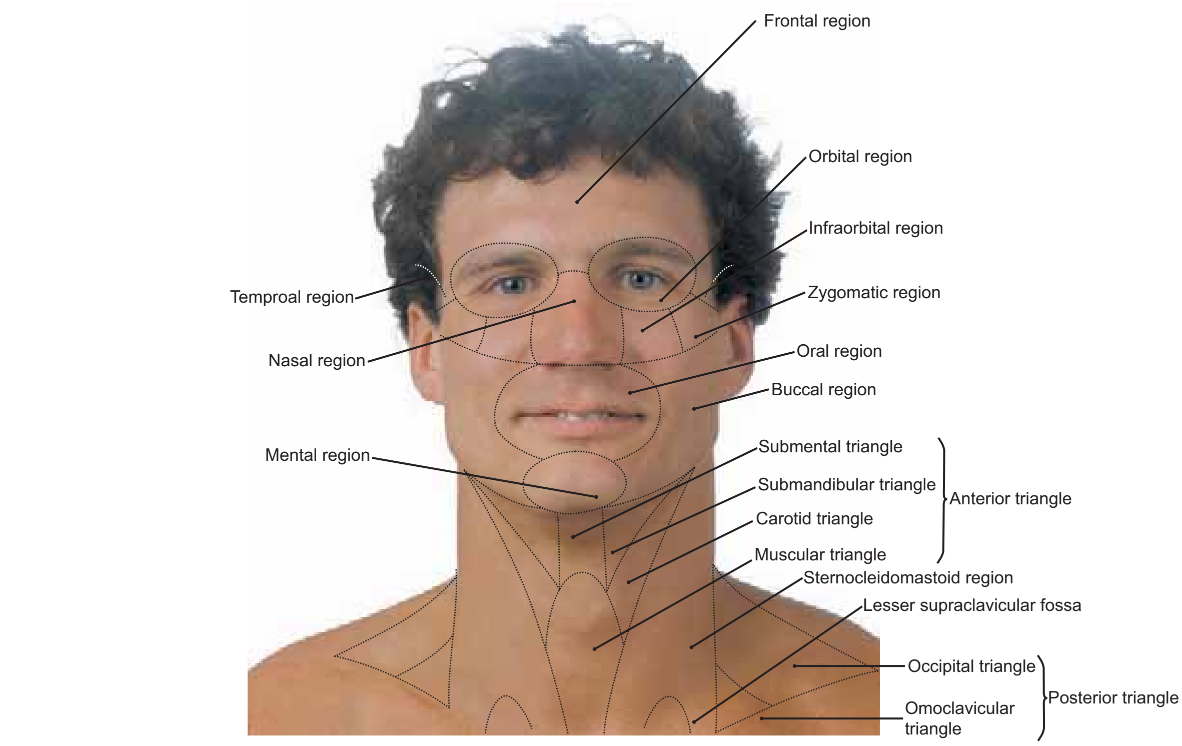


FIGURE 517.1 Regions of the Head and Neck (Anterior Aspect)

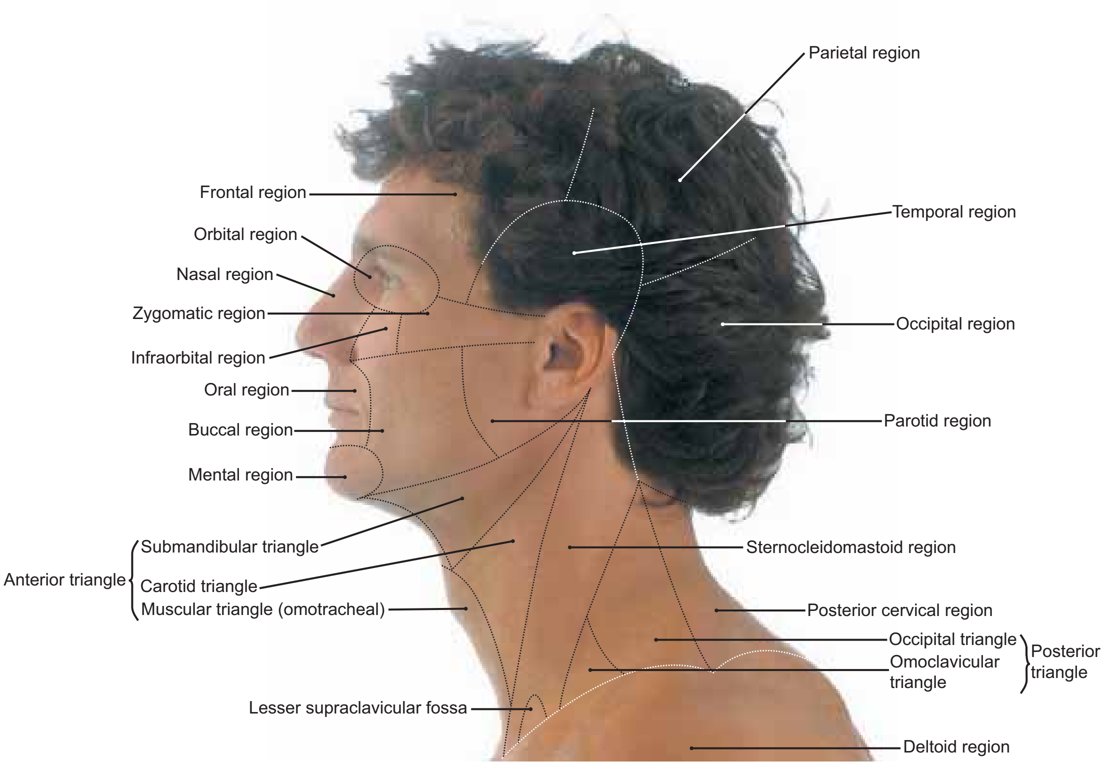


FIGURE 517.2 Regions of the Head and Neck (Lateral Aspect)

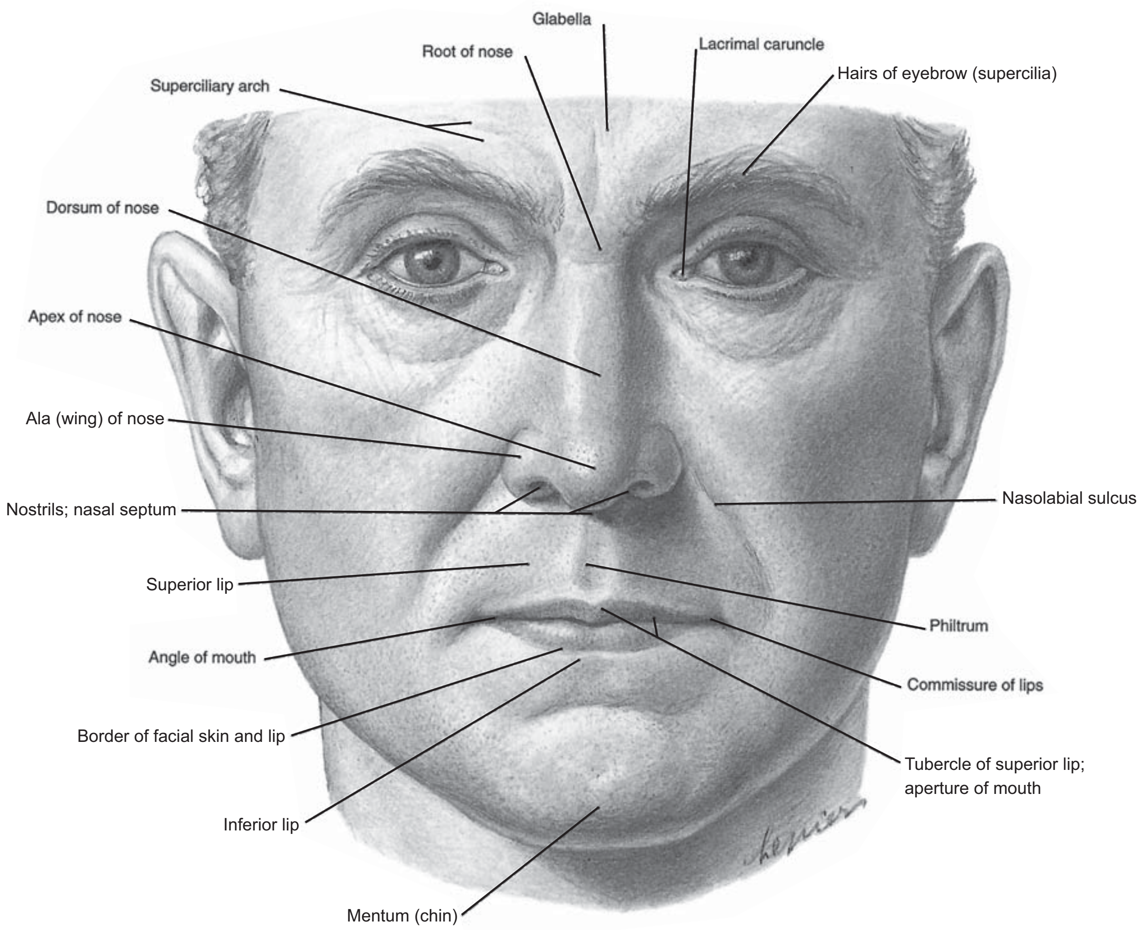


FIGURE 518.1 Surface Features of the Anterior Face

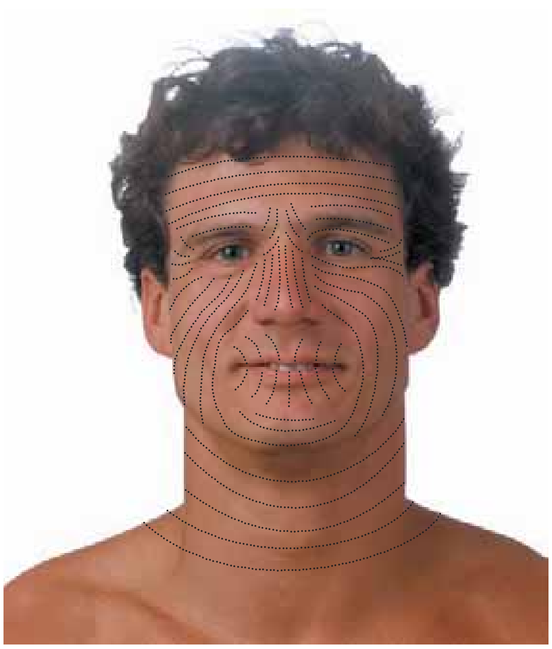


FIGURE 518.2 Tension Lines of the Skin of the Head and Neck (Anterior Aspect)

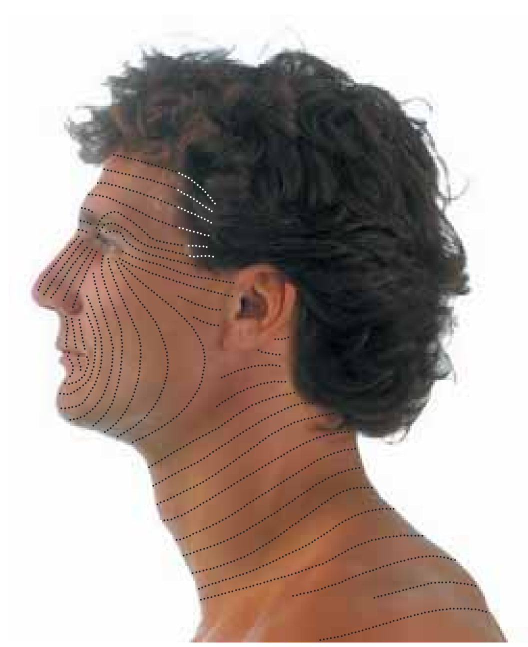


FIGURE 518.3 Tension Lines of the Skin of the Head and Neck (Lateral Aspect)

NOTE: For optimal healing, incision lines in the skin should be made along the lines of tension (Langer's lines).

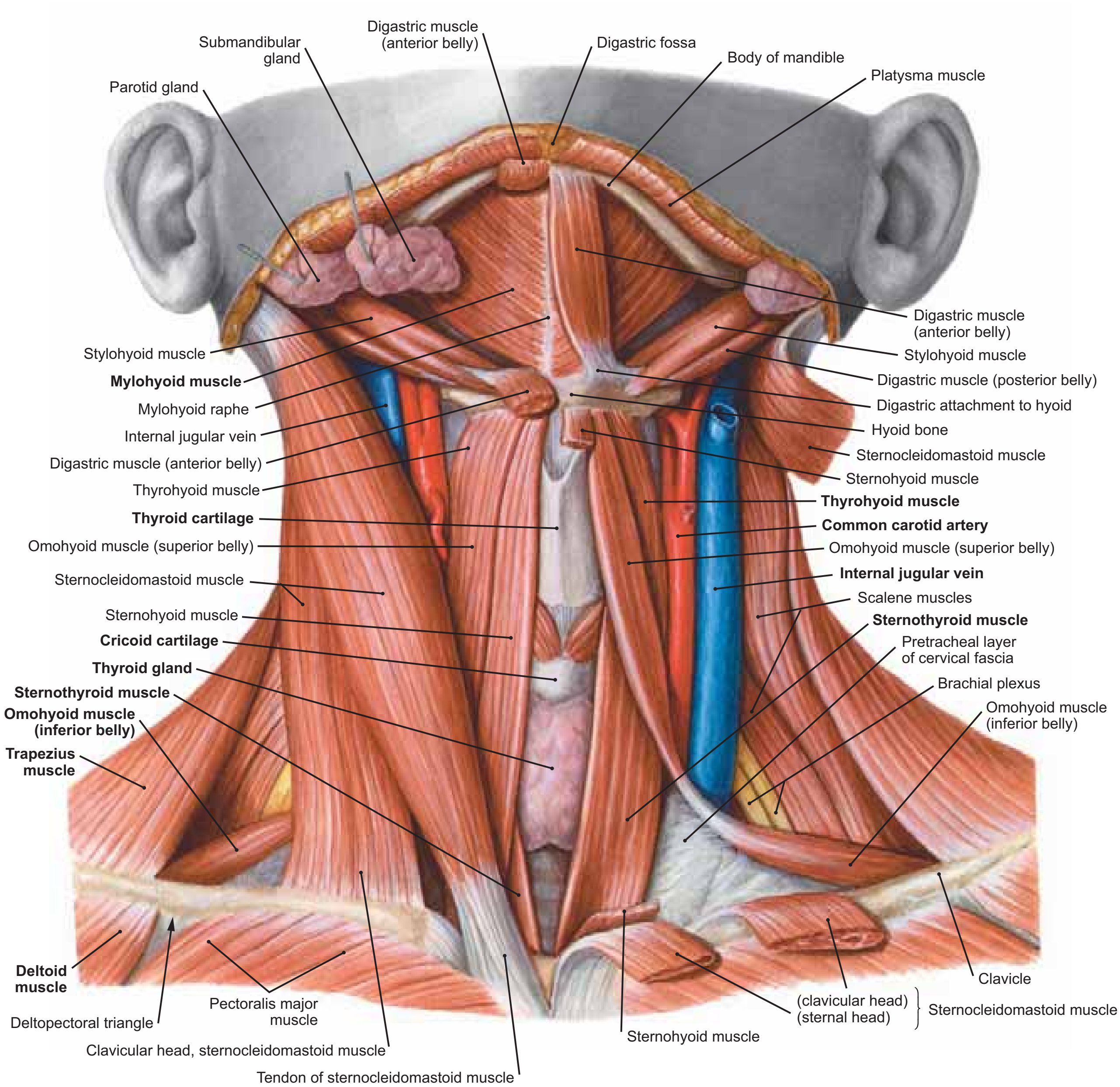


FIGURE 519 Anterior View of the Musculature of the Neck

NOTE: (1) The right superior belly of the digastric muscle was removed and the submandibular gland elevated to show the mylohyoid muscle. On the left side (reader's right), the sternocleidomastoid and sternohyoid muscles have been transected and the submandibular gland removed.

(2) Observe the relationship of the strap muscles to the thyroid gland and realize that below the thyroid gland and above the suprasternal notch, the trachea lies immediately under the skin.

INFRAHYOID MUSCLES OF THE NECK

Muscle	Origin	Insertion	Innervation	Action
Sternohyoid	Manubrium of sternum and the medial end of the clavicle	Body of hyoid bone	Ansa cervicalis (C1, C2, C3)	Depresses the hyoid bone after food is swallowed
Sternothyroid	Posterior surface of the manubrium of the sternum	Oblique line on the lamina of the thyroid cartilage	Ansa cervicalis (C1, C2, C3)	Depresses the hyoid bone and the larynx
Thyrohyoid	Oblique line on the lamina of the thyroid cartilage	Lower border of the greater horn of the hyoid bone	Fibers from the C1 spinal nerve that course for a short distance with the hypoglossal nerve XII	Depresses the hyoid bone or elevates the larynx
Omohyoid	Upper border of the scapula near the suprascapular notch	Lower border of the body of the hyoid bone	Ansa cervicalis (C1, C2, C3)	Depresses and helps stabilize the hyoid bone

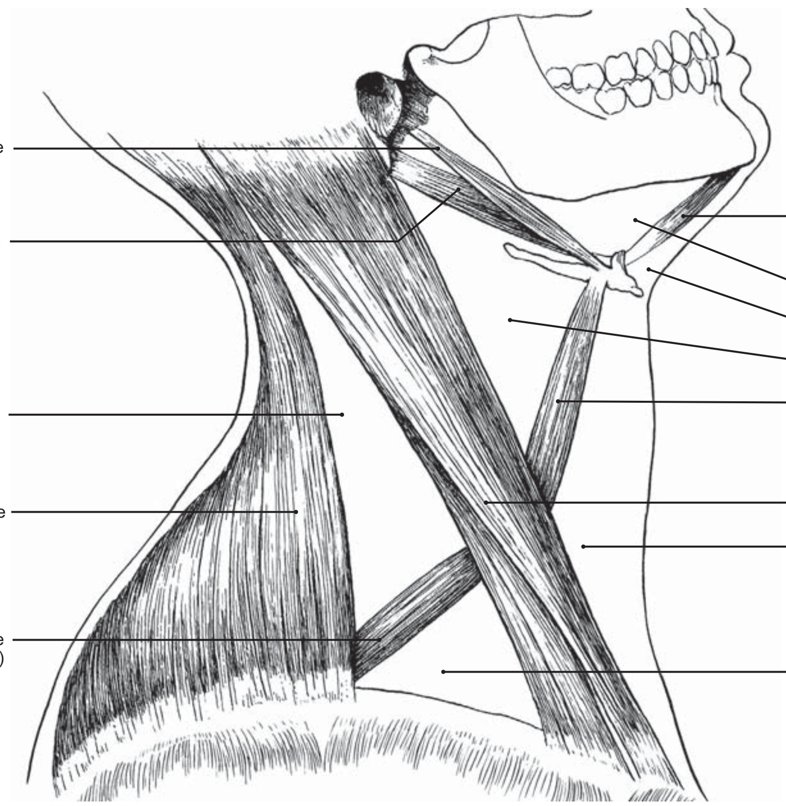


FIGURE 520.1 Triangles of the Neck (Lateral View)

NOTE: The triangles of the neck are useful in describing the location of cervical organs and other structures. The entire area anterior to the sternocleidomastoid muscle is called the **anterior triangle**, whereas the area posterior to this muscle is the **posterior triangle.**

Muscle	Origin	Insertion	Innervation	Action
Sternocleidomastoid	**Sternal head:** Upper part of the ventral surface of the manubrium of the sternum **Clavicular head:** Upper border and anterior surface of the medial third of the clavicle	Lateral surface of the mastoid process and the lateral half of the superior nuchal line	Motor fibers: Accessory nerve Sensory fibers: Anterior rami of C2 and C3 nerves	When one side acts: Bends the head laterally toward the shoulder of the same side; rotates the head, turning the face upward, directing it to the opposite side When both sides act: Flexes the head and neck

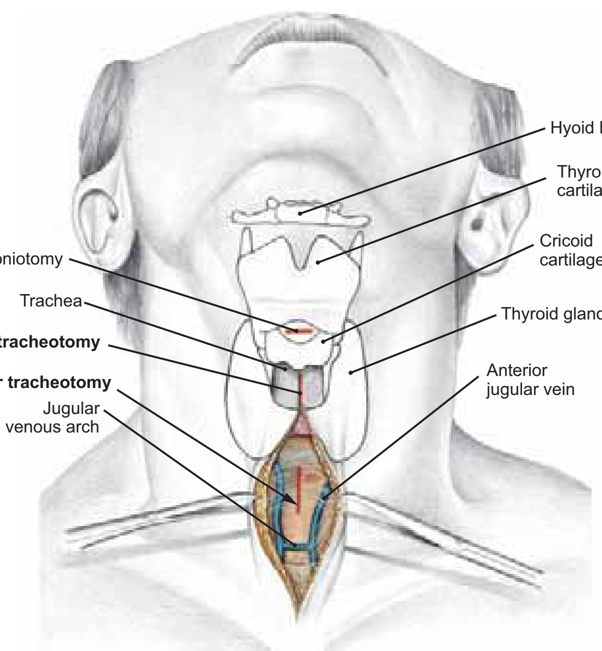


FIGURE 520.2 Projection of Larynx and Trachea Showing Sites for Entry into the Respiratory Pathway

NOTE: (1) The hyoid bone, laryngeal cartilages (thyroid and cricoid), thyroid gland, and tracheal region of the anterior neck are projected to the surface, as are three sites where entrance into the respiratory tract may be achieved readily (in red).

(2) The upper transverse incision cuts through the cricothyroid ligament and conus elasticus and can be called a **cricothyrotomy** or **coniotomy**, while the **upper tracheotomy** and **lower tracheotomy** can be made in the trachea above or below the thyroid gland.

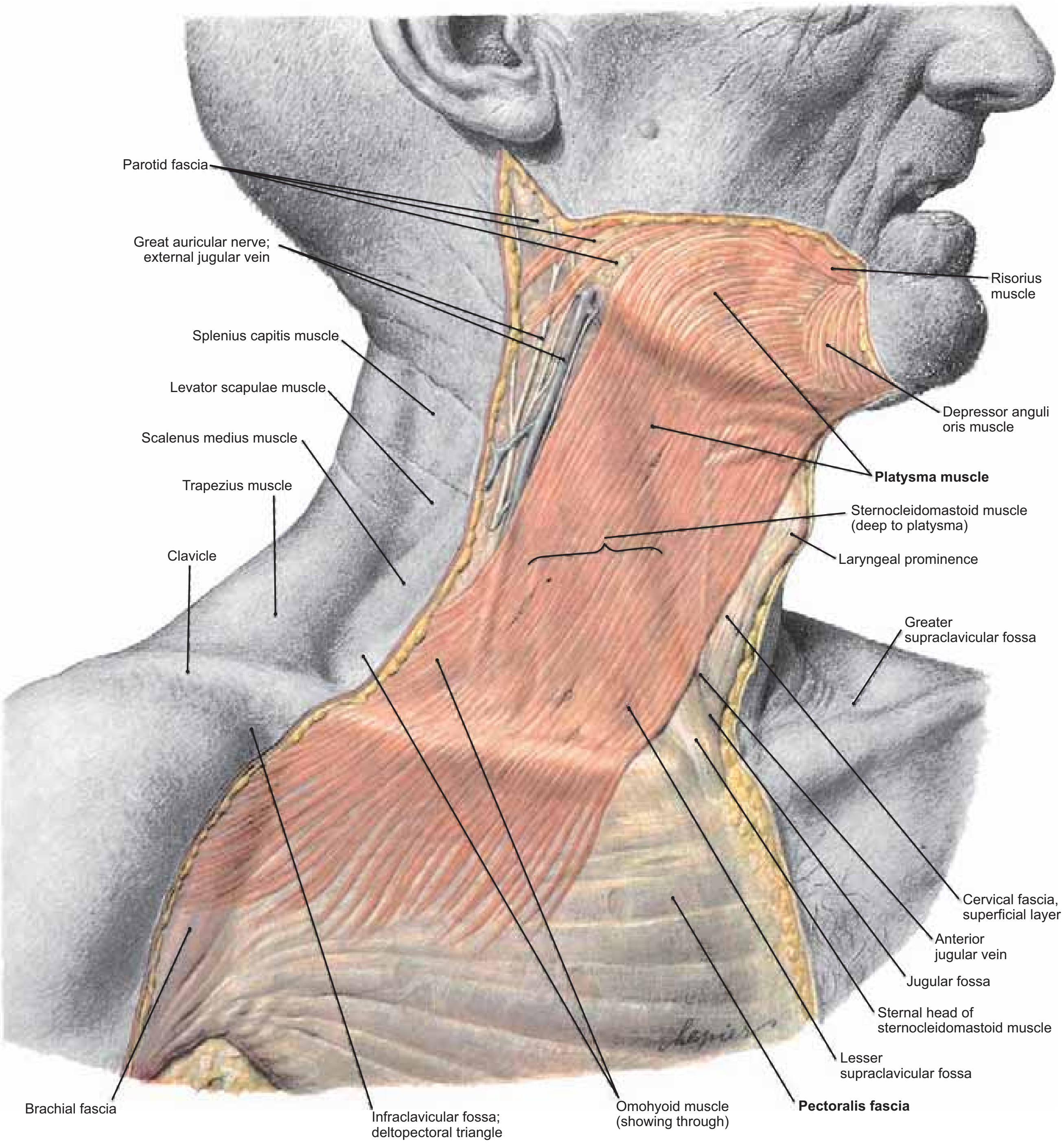


FIGURE 521 Right Platysma Muscle and Pectoral Fascia

NOTE: (1) The **platysma muscle** is a broad, thin quadrangular muscle located in the superficial fascia; it extends from the angle of the mouth and chin downward across the clavicle to the upper part of the thorax and anterior shoulder.

(2) The platysma is considered one of the muscles of facial expression, many of which do not attach to bony structures but arise and insert within the superficial fascia.

(3) Upon concentration, the platysma tends to depress the angle of the mouth and wrinkle the skin of the neck, thereby participating in the formation of facial expressions of anxiety, sadness, dissatisfaction, and suffering.

(4) Similar to other muscles of facial expression, the platysma is innervated by the **facial nerve (cervical branch)**, the seventh cranial nerve (VII).

(5) Overlying the pectoralis major is the well-developed pectoralis fascia, which extends from the midline in the thorax laterally to the axilla. Observe the external jugular vein and great auricular nerve exposed in the upper lateral aspect of the neck.

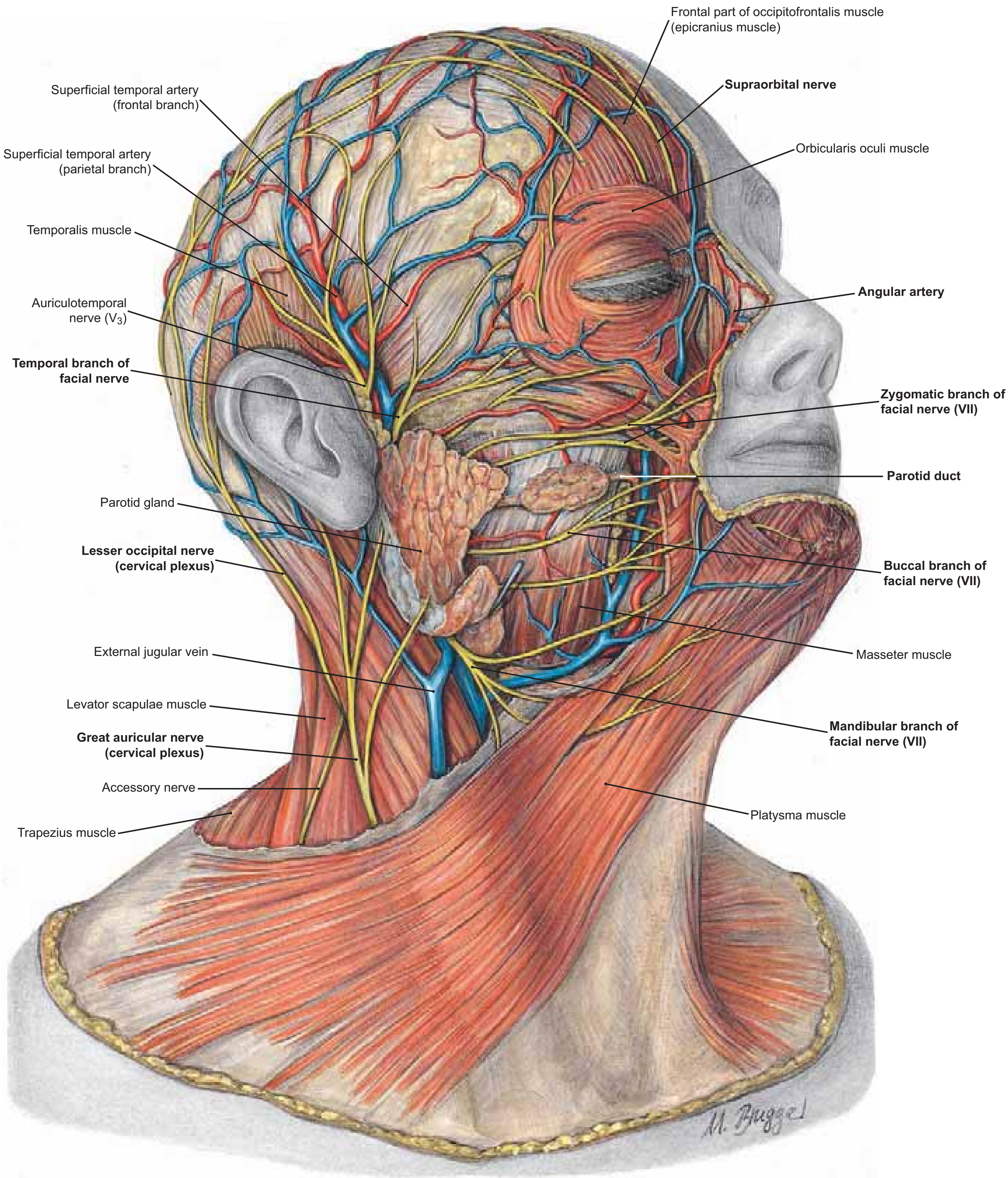


FIGURE 522 **Superficial Lateral Vessels and Nerves of the Neck and Temporal and Facial Regions of the Head**

NOTE: (1) The superficial temporal vessels, the branches of the facial nerve, and two branches of the cervical plexus of nerves (great auricular and lesser occipital).

(2) Also observe the supraorbital nerve, angular artery, and parotid duct.

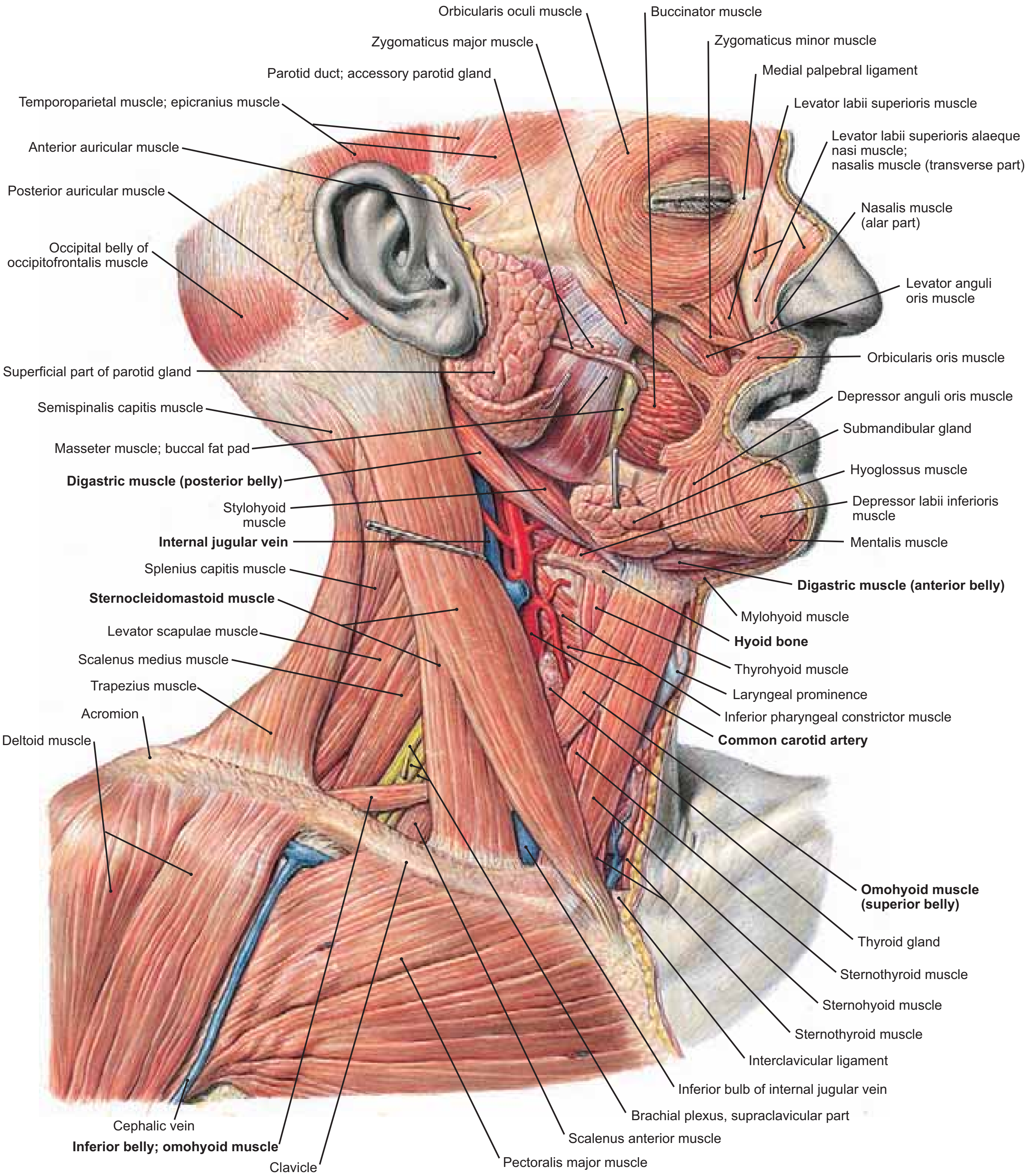


FIGURE 523 Anterior and Posterior Triangles of the Neck

NOTE: (1) The **anterior triangle** of the neck is bounded by the midline of the neck, the anterior border of the sternocleidomastoid muscle, and the mandible. This area is further subdivided by the superior belly of the omohyoid muscle and the two bellies of the digastric into:

(a) **Muscular triangle** (midline, superior belly of omohyoid, and sternocleidomastoid).
(b) **Carotid triangle** (superior belly of omohyoid, sternocleidomastoid muscle, and posterior belly of digastric).
(c) **Submandibular triangle** (anterior and posterior bellies of digastric, and the inferior margin of the mandible).
(d) **Submental triangle** (midline, anterior belly of digastric, and hyoid bone).

(2) The **posterior triangle** of the neck is bounded by the posterior border of the sternocleidomastoid muscle, the trapezius, and the clavicle. This area is further subdivided into the **occipital triangle** above and the **omoclavicular triangle** below by the inferior belly of the omohyoid.

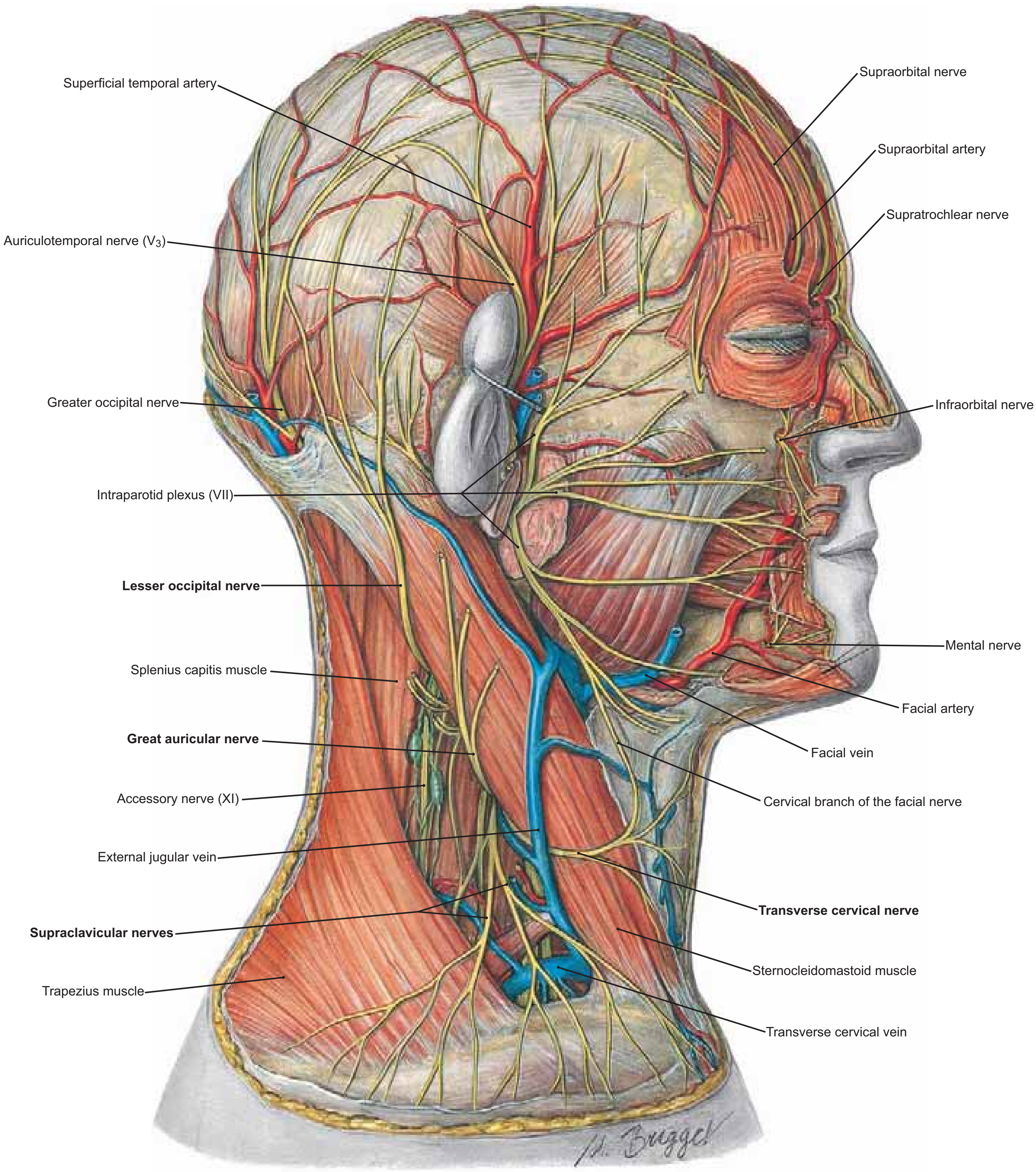


FIGURE 524 **Nerves of the Face, Scalp, and Lateral Neck**

NOTE: (1) The great auricular, lesser occipital, transverse cervical, and supraclavicular branches of the cervical plexus.

(2) Observe the auriculotemporal branch of the mandibular division of the trigeminal nerve ascending in the temporal region anterior to the external ear.

(3) See the branches (not labeled) of the facial nerve as they emerge from the intraparotid plexus. These would include the temporal, zygomatic, buccal, mandibular, and cervical branches (see Fig. 522).

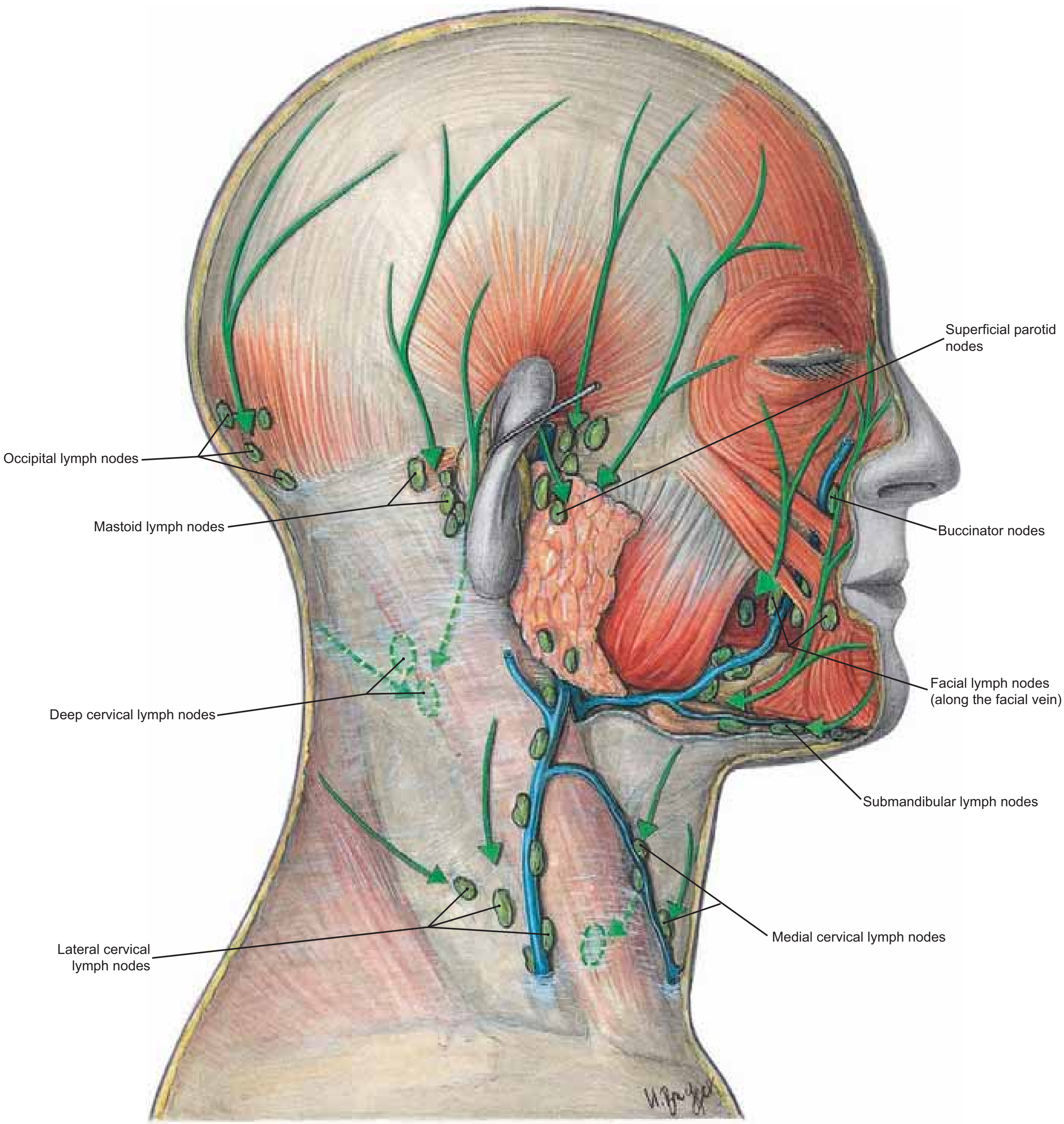


FIGURE 525 Drainage Patterns of Lymph nodes on the Lateral Scalp and Face

NOTE: (1) The drainage patterns of lymph from the lateral scalp descend to mastoid nodes posterior to the external ear, and then this lymph continues inferiorly to deep cervical nodes. Lymph from the anterolateral scalp drains inferiorly toward parotid nodes anterior to the ear, and then it descends to lateral cervical nodes.

(2) Lymph from the anterior face (lateral to the nose and mouth) descends to submandibular nodes and then courses along veins in the anterior and lateral neck.

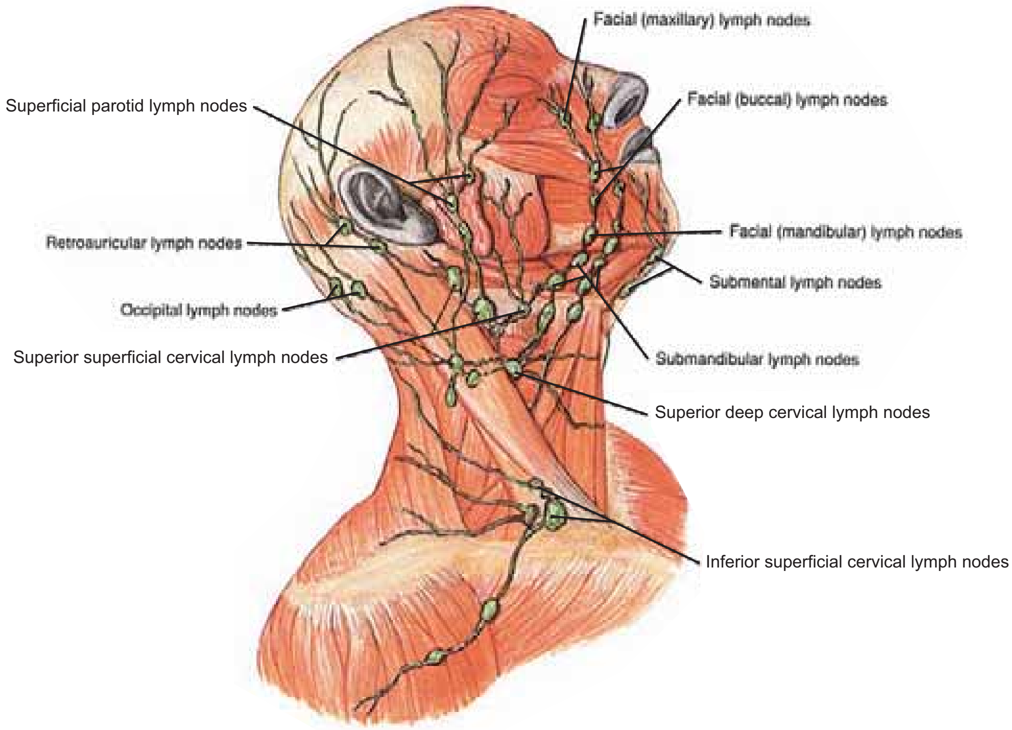


FIGURE 526.1 Superficial Lymph Nodes and Vessels of the Head and Neck

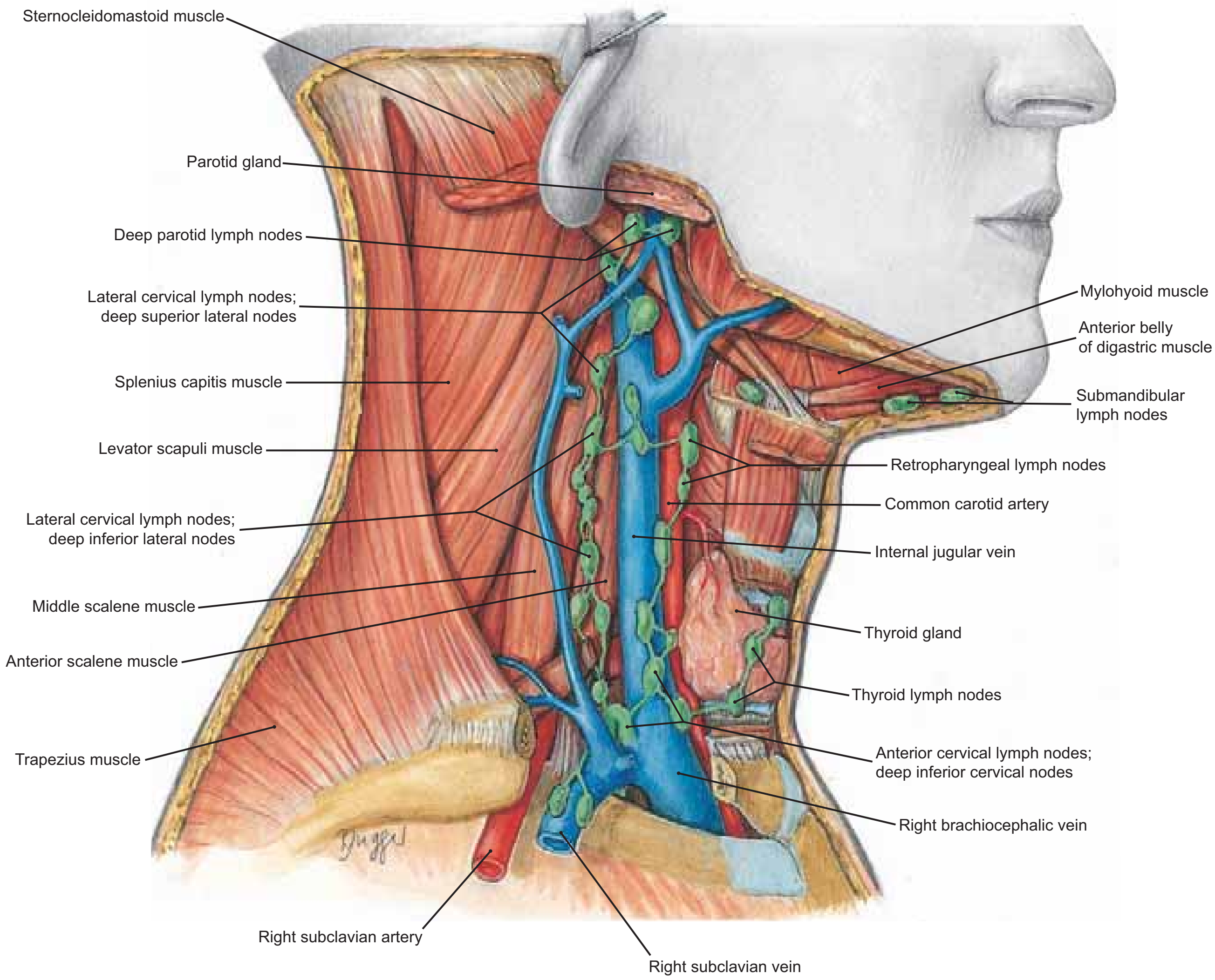


FIGURE 526.2 Chains of Lymph Nodes in the Lateral Neck

NOTE that in the lateral neck, there are chains of nodes that are collected along major veins such as the internal jugular vein and the external jugular vein (which are not labeled in this figure).

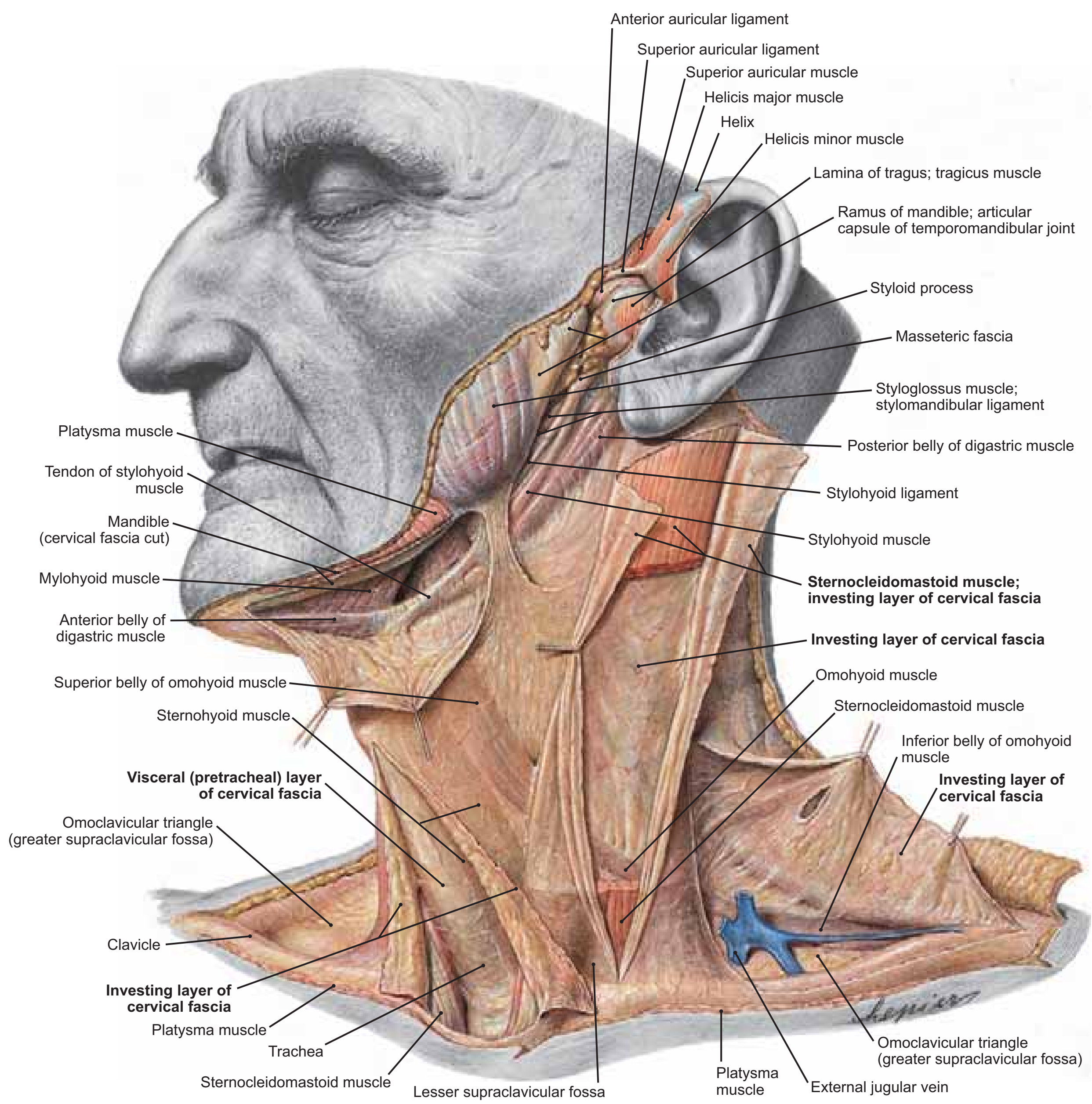
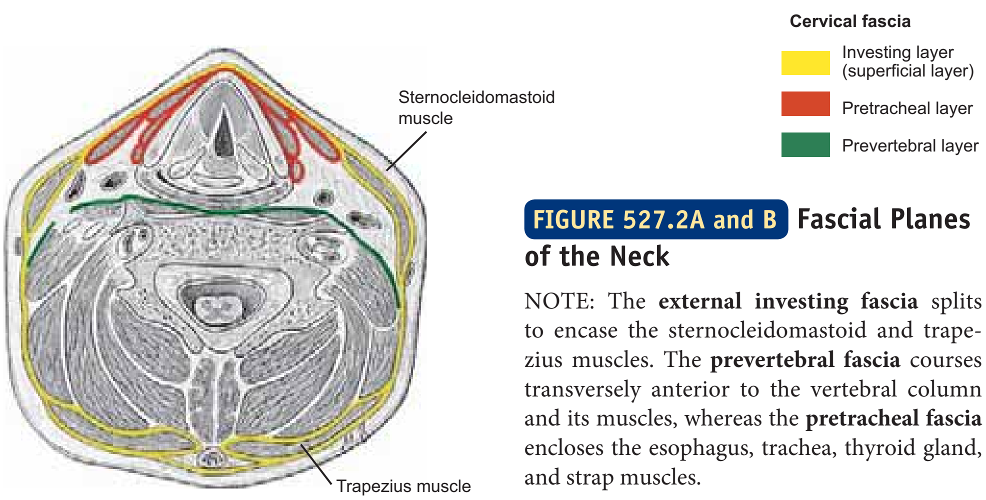


FIGURE 527.1 External Investing and Pretracheal Fascial Layers of the Neck

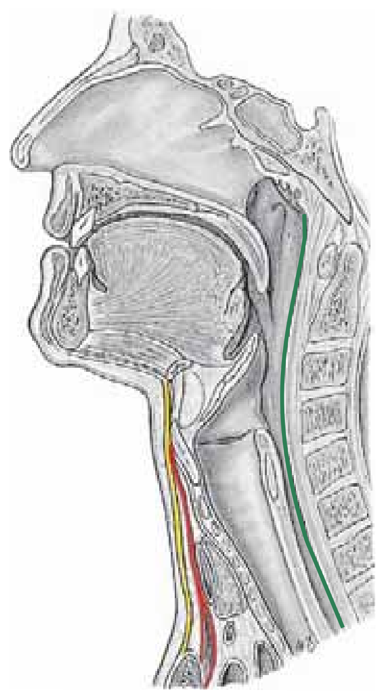
NOTE: The **external investing layer** of deep fascia surrounds the sternocleidomastoid muscle, whereas the **pretracheal layer** of deep fascia is located deep to the investing layer and encloses the strap muscles.



A Transverse section

FIGURE 527.2A and B Fascial Planes of the Neck

NOTE: The **external investing fascia** splits to encase the sternocleidomastoid and trapezius muscles. The **prevertebral fascia** courses transversely anterior to the vertebral column and its muscles, whereas the **pretracheal fascia** encloses the esophagus, trachea, thyroid gland, and strap muscles.



B Median section

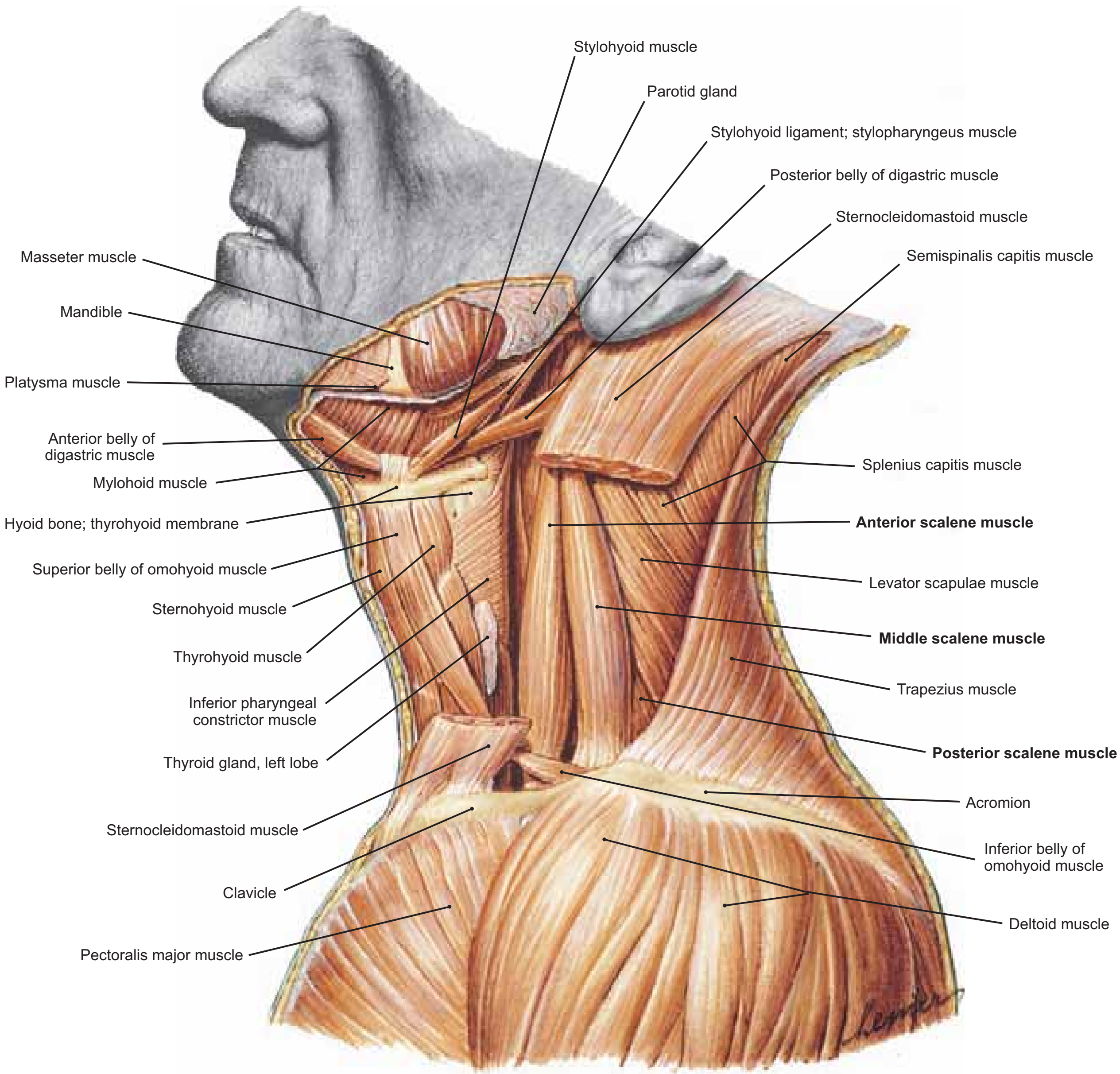


FIGURE 528 Muscular Floor of the Posterior Triangle of the Neck and the Scalene Muscles

MUSCLES OF THE POSTERIOR TRIANGLE OF THE NECK*

Muscle	Origin	Insertion	Innervation	Action
Anterior scalene	By four tendons, each one from the transverse processes of the third, fourth, fifth, and sixth cervical vertebrae	Onto the scalene tubercle of the first rib	Anterior rami of the fourth, fifth, and sixth cervical spinal nerves	When neck is fixed: elevates the first rib. When first rib is fixed: Bends neck forward and laterally, and rotates it to the opposite side
Middle scalene	Transverse processes of C2 to C7 vertebrae (often also from the atlas)	Superior surface of first rib between the tubercle and the groove for subclavian artery	Anterior rami of the third through the eighth cervical nerves	Same as anterior scalene muscle
Posterior scalene	Transverse processes of fourth, fifth, and sixth cervical vertebrae	Outer surface of the second rib	Anterior rami of the C6, C7, and C8 spinal nerves	Raises the second rib; or, bends and rotates the neck
Splenius capitis	Caudal half of the ligamentum nuchae; spinous processes of C7, and upper four thoracic vertebrae	Lateral third of the superior nuchal line and onto the mastoid process of the temporal bone	Dorsal rami of the middle cervical spinal nerves	Laterally flexes head; rotates head and neck to same side; when both muscles act they extend head and neck

*__Levator scapulae__ and **semispinalis capitis** are described on **Plate 379.**

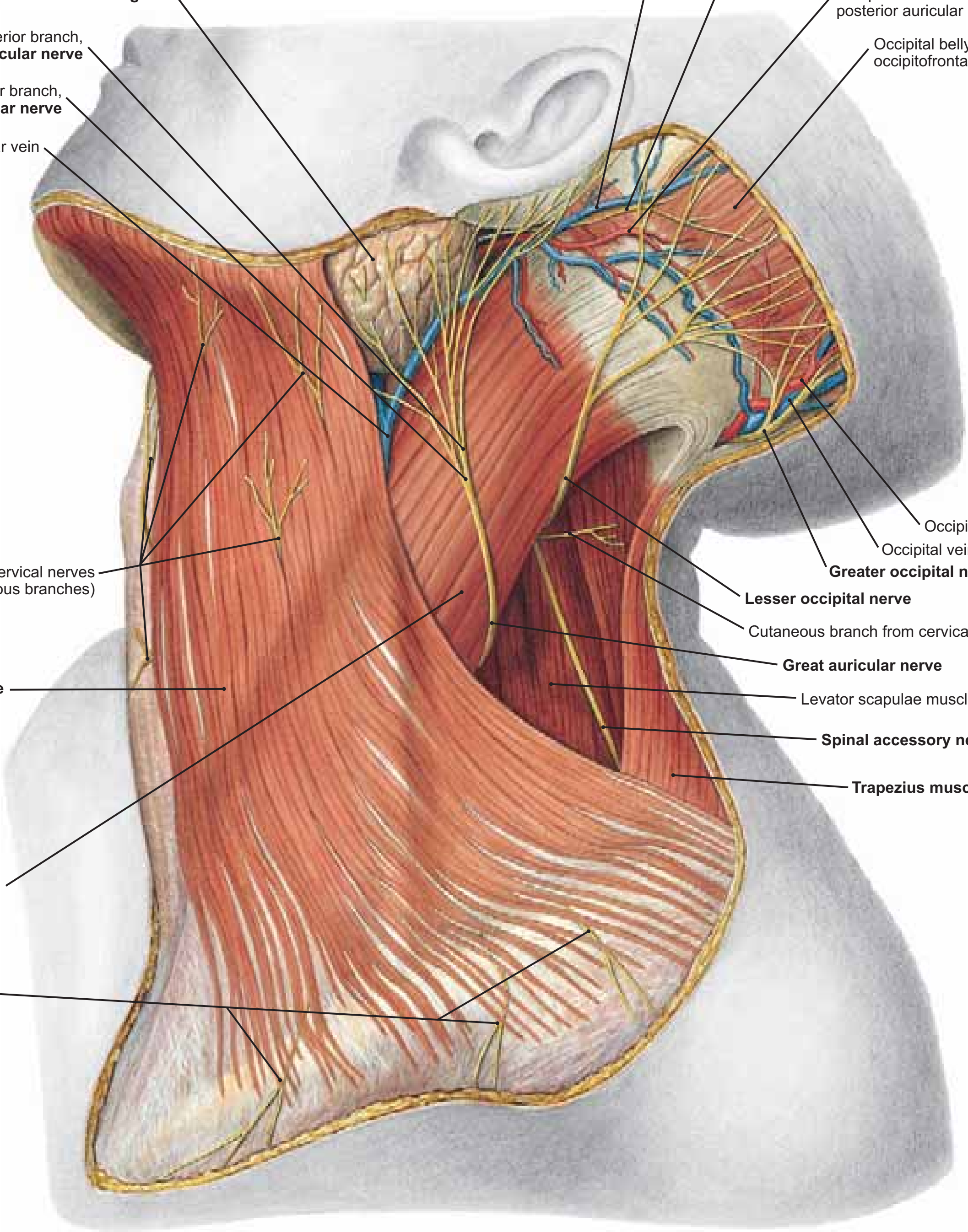


FIGURE 529 Nerves and Blood Vessels of the Neck, Stage 1: Platysma Layer

NOTE: (1) The skin has been removed from both the anterior and posterior triangle areas to reveal the platysma muscle. Observe the cutaneous branches of the **transverse cervical nerves**, derived from the cervical plexus and penetrating through the platysma and superficial fascia to reach the skin of the anterolateral aspect of the neck.

(2) Four other nerves: the **great auricular (C2, C3);** the **lesser occipital (C2);** the **greater occipital (C2);** and the **accessory (XI)**.

(3) After it has supplied the sternocleidomastoid muscle, the accessory nerve (XI) descends in the posterior triangle to reach the trapezius muscle, which it also supplies.

(4) The **supraclavicular nerves**. These descend in the neck under cover of the deep fascia and platysma muscle. They become superficial just above the clavicle and then cross that bone as the medial, intermediate, and lateral supraclavicular nerves (see also Fig. 530). They derive from the third and fourth cervical nerves and supply skin over the clavicle, the upper trunk (down to the second rib), and the shoulder from the acromion laterally to the midline anteriorly.

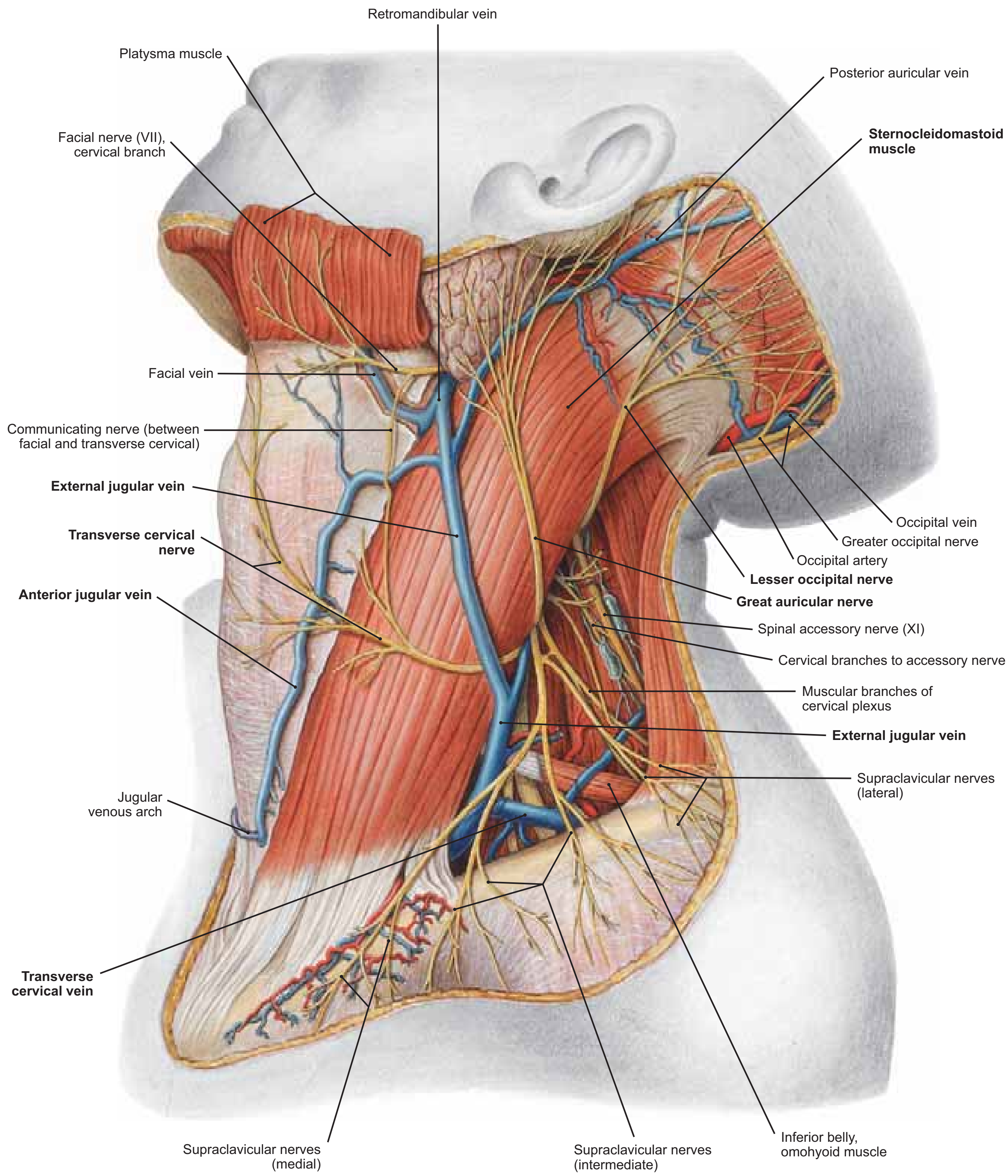


FIGURE 530 **Nerves and Blood Vessels of the Neck, Stage 2: Sternocleidomastoid Layer**

NOTE: (1) With the platysma muscle reflected upward, the full extent of the sternocleidomastoid muscle is exposed.

(2) The nerves of the cervical plexus diverge at the posterior border of the sternocleidomastoid muscle: the **great auricular** and **lesser occipital** ascend to the head, the **transverse cervical** (transverse colli) course across the neck, while the **supraclavicular nerves** descend over the clavicle.

(3) The **external jugular vein**, formed by the junction of the **retromandibular** and **posterior auricular veins**. The external jugular vein crosses the sternocleidomastoid muscle obliquely and receives tributaries from the anterior jugular, posterior external jugular (not shown), transverse cervical, and suprascapular vein (not shown) before it ends in the subclavian vein.

(4) The cervical branch of the **facial (VII) nerve** supplying the inner surface of the platysma muscle with motor innervation.

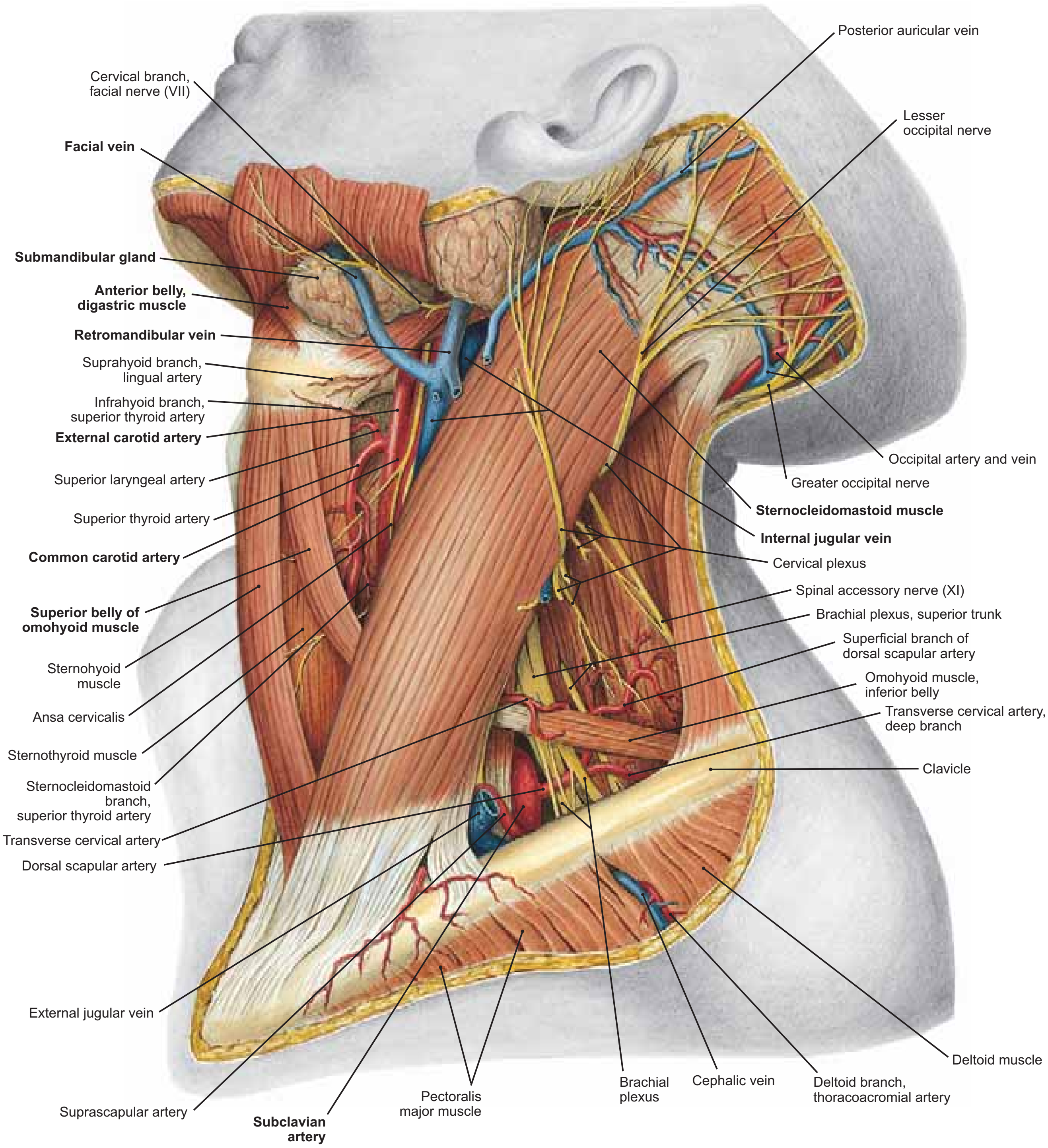


FIGURE 531 Nerves and Blood Vessels of the Neck, Stage 3: The Anterior Triangle

NOTE: (1) With the investing layer of fascia removed, the outlines of the muscular, carotid, and submandibular triangles within the anterior region of the neck are revealed.

(2) The infrahyoid (strap) muscles, which cover the thyroid gland and the lateral aspect of the larynx in the **muscular triangle.** This is bounded by the sternocleidomastoid, the midline, and the superior belly of the digastric muscle.

(3) The carotid vessels and internal jugular vein can be seen in the **carotid triangle,** which is bounded by the superior belly of the omohyoid, posterior belly of the digastric (not labeled), and the sternocleidomastoid.

(4) With the platysma muscle cut and reflected upward, the submandibular gland is seen in the **submandibular triangle,** between the anterior and posterior bellies of the digastric and the inferior border of the mandible.

(5) The spinal accessory nerve descending in the posterior triangle from beneath the sternocleidomastoid, which it supplies, to reach the trapezius muscle (not labeled), which it also supplies with motor innervation.

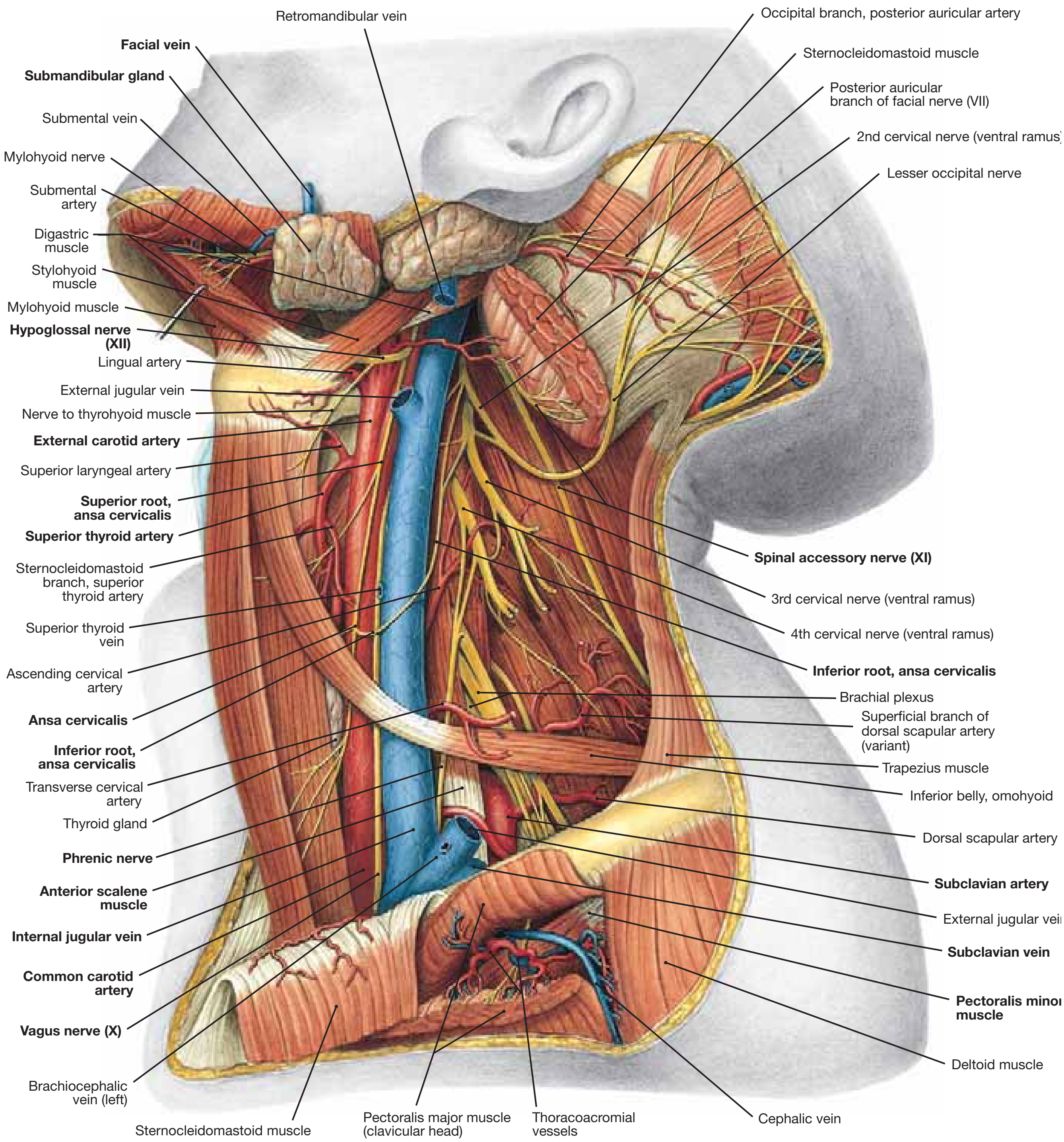


FIGURE 532 **Nerves and Blood Vessels of the Neck, Stage 4: Large Vessels**

NOTE: (1) The sternocleidomastoid and the superficial veins and nerves have been removed to expose the **carotid arteries, internal jugular vein, omohyoid muscle, vagus nerve,** and **ansa cervicalis**.

(2) Superiorly, the facial vein has been cut and the submandibular gland has been elevated, thereby exposing the **hypoglossal nerve (XII)**.

(3) Nerve fibers, originating from C1 and traveling for a short distance with the hypoglossal nerve, leave that nerve to descend in the neck. They form the **superior root of the ansa cervicalis** and are joined by other descending fibers from C2 and C3, which are called the **inferior root of the ansa cervicalis.** The ansa cervicalis supplies motor innervation for a number of strap muscles.

(4) The **common carotid artery, internal jugular vein,** and **vagus nerve**. These form a vertically oriented neurovascular bundle in the neck that is normally surrounded by the carotid sheath of deep fascia. The common carotid artery bifurcates at about the level of the hyoid bone to form the **external** and **internal carotid arteries**.

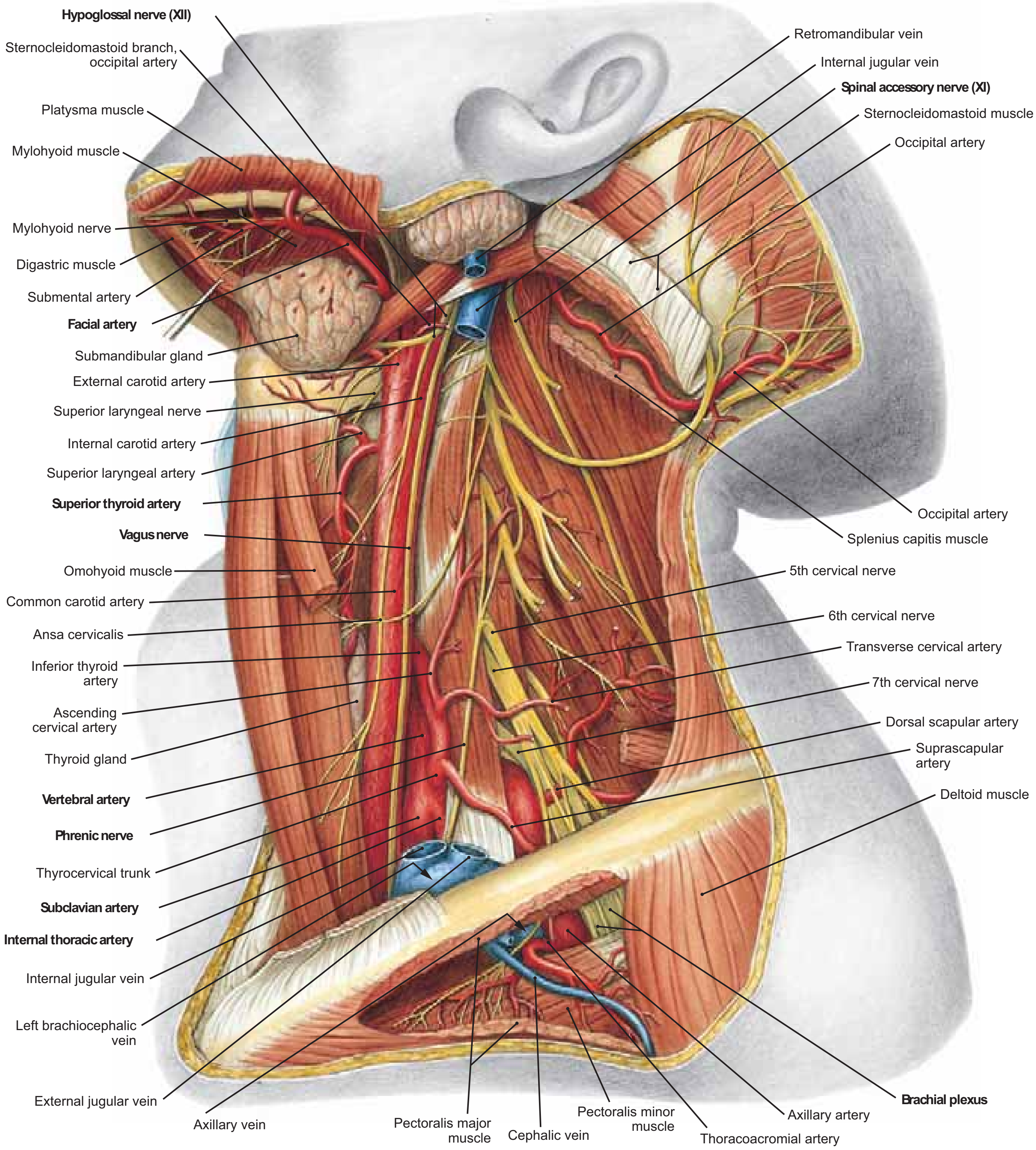


FIGURE 533 Nerves and Blood Vessels of the Neck, Stage 5: Subclavian Artery

NOTE: (1) With the internal and external jugular veins removed, the subclavian artery is exposed as it ascends from the thorax and loops within the subclavian triangle of the neck to descend beneath the clavicle into the axilla. Observe its **vertebral, thyrocervical,** and **internal thoracic** branches.

(2) The **transverse cervical artery** is a branch of the thyrocervical trunk from the subclavian.

(3) The **vagus nerve** coursing with the internal and common carotid arteries, and the **phrenic nerve** descending in the neck along the surface of the anterior scalene muscle.

(4) The **superior thyroid, facial,** and **occipital** branches of the external carotid artery. The occipital artery courses posteriorly, deep to the sternocleidomastoid and splenius capitis muscles, and it becomes superficial on the posterior aspect of the scalp.

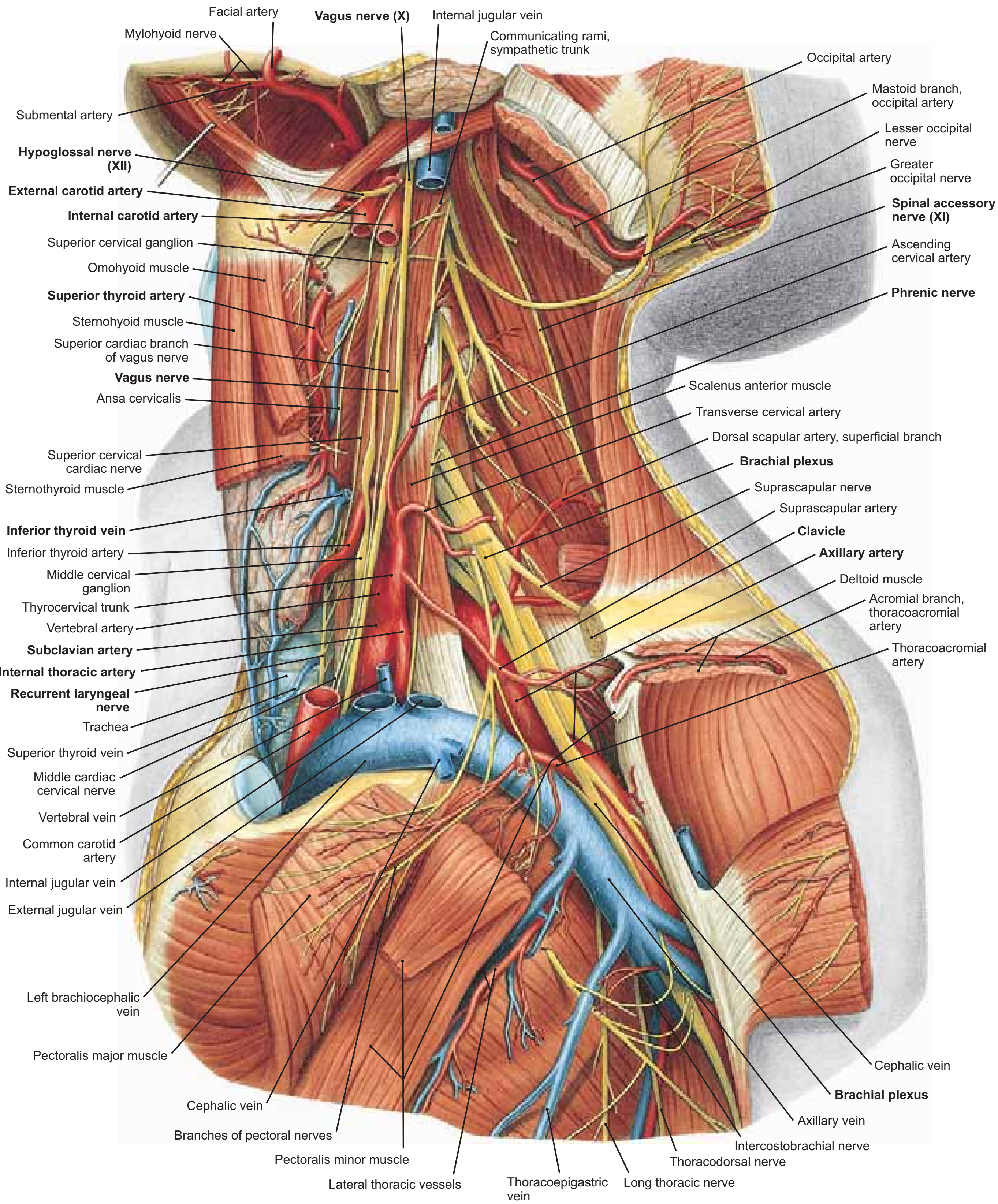


FIGURE 534 **Nerves and Blood Vessels of the Neck, Stage 6: Brachial Plexus**

NOTE: (1) With the carotid arteries, jugular veins, and clavicle removed, the roots and trunks of the **brachial plexus** are exposed as they divide into cords that surround the axillary artery in the axilla.

(2) The **sympathetic trunk** lying deep to the carotid arteries and coursing with the vagus nerve and the superior cardiac branch of the vagus nerve.

(3) The **thyroid gland, superior** and **inferior thyroid arteries,** and the **thyroid veins**. Also note the proximity of the **recurrent laryngeal nerve** to the thyroid gland.

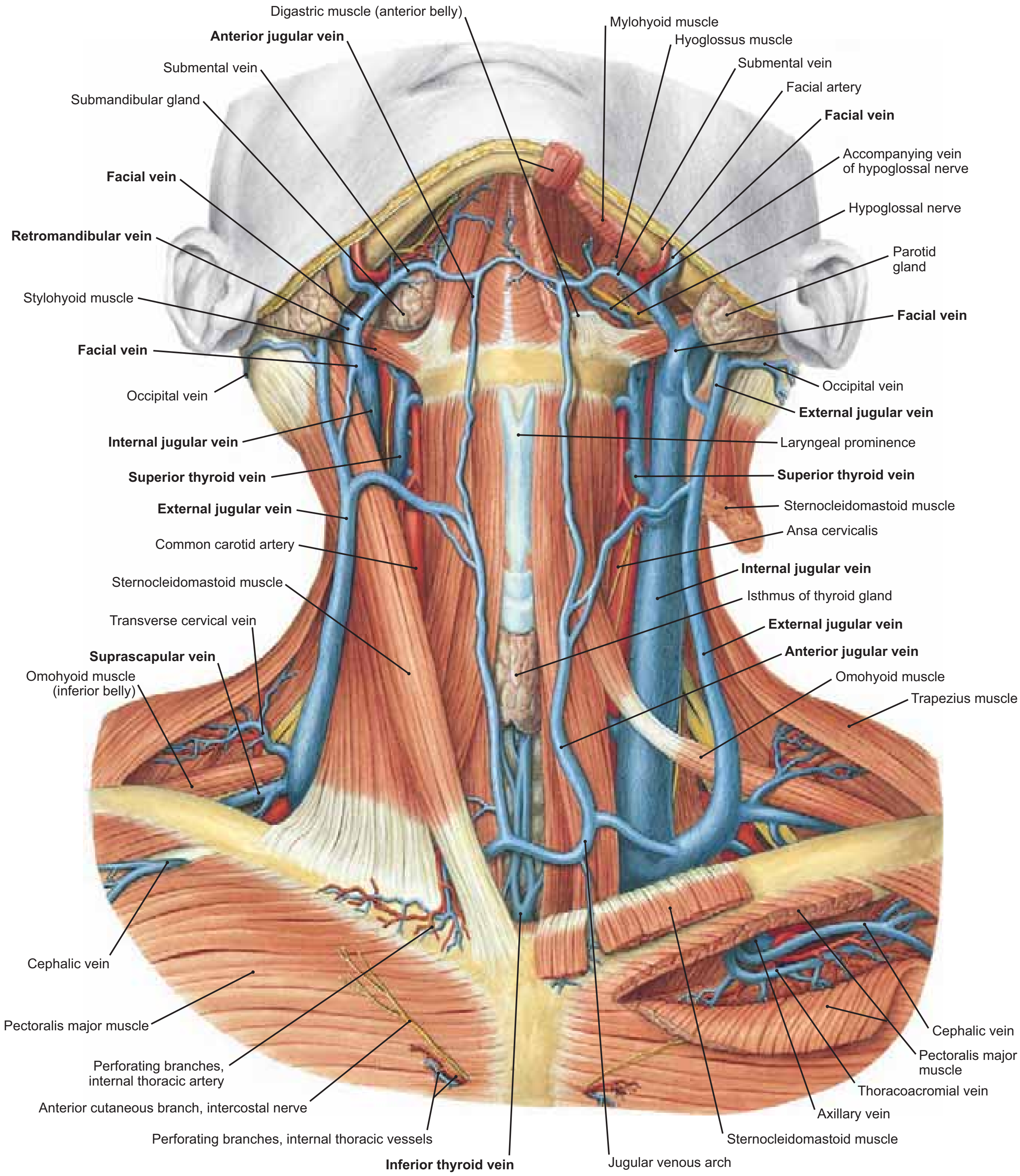


FIGURE 535 Veins of the Neck and Infraclavicular Region

NOTE: (1) The **jugular system of veins** consists of anterior, external, and internal jugular veins, all shown on the left side, where the sternocleidomastoid muscle was removed.

(2) The **anterior jugular** descends close to the midline, is frequently small, and drains laterally into the external jugular. The **external jugular** courses along the surface of the sternocleidomastoid muscle. It forms within the parotid gland and enlarges because of its occipital, retromandibular, and posterior auricular tributaries. The external jugular flows into the subclavian vein after it receives tributaries from the scapular and clavicular regions.

(3) The **internal jugular** is large and collects blood from the brain, face, and neck. At its junction with the subclavian, the **brachiocephalic vein** is formed.

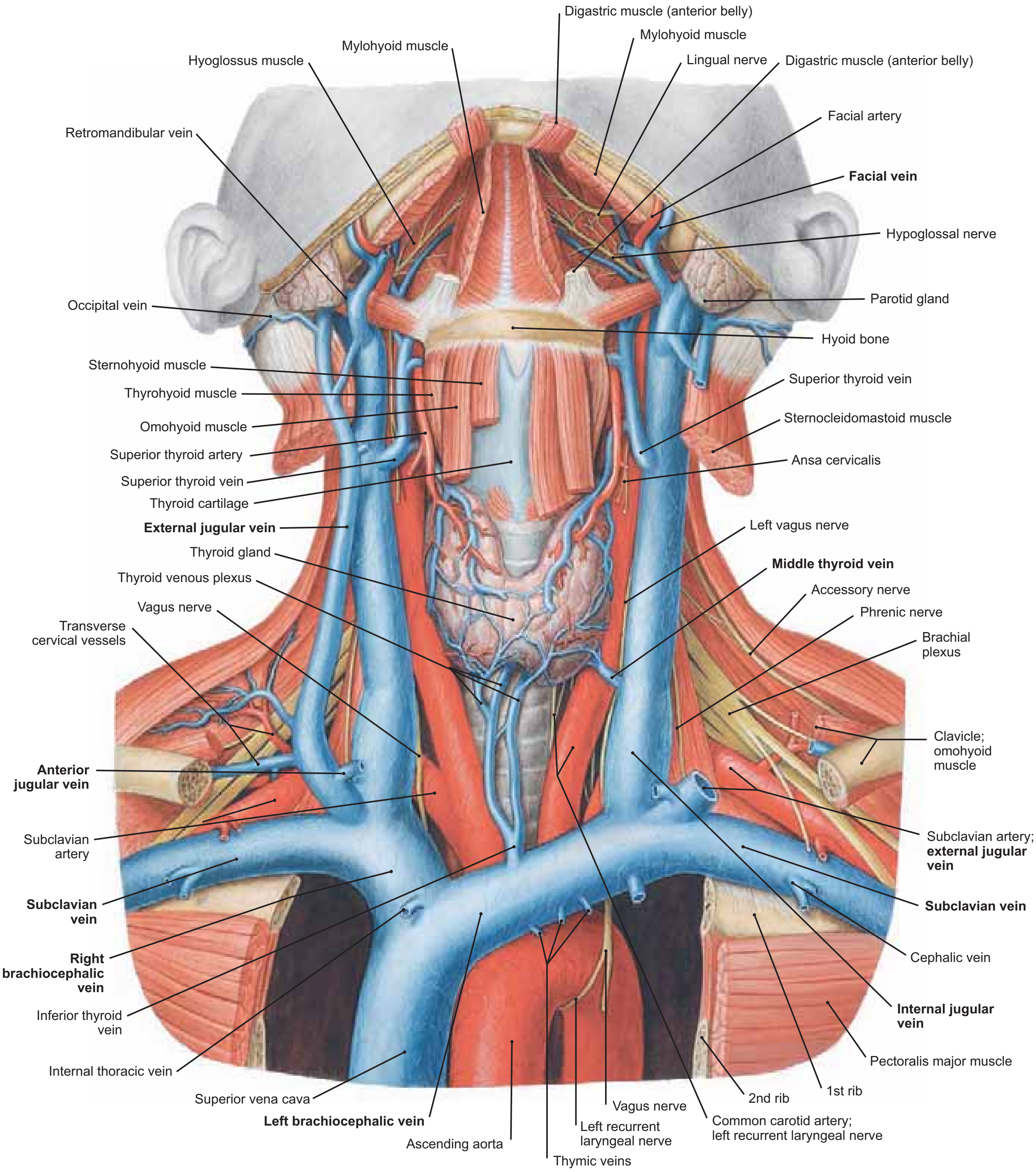


FIGURE 536 **Deep Arteries and Veins of the Neck and Great Vessels of the Thorax**

NOTE: (1) The sternocleidomastoid and strap muscles have been removed from the neck, thereby exposing the carotid arteries, internal jugular veins, and thyroid gland.
(2) The middle portion of the anterior thoracic wall has been resected to show the aortic arch and its branches, the brachiocephalic veins and their tributaries, the superior vena cava and the vagus nerves.
(3) In the submandibular region, the mylohyoid and anterior digastric muscles have been cut, revealing the lingual and hypoglossal nerves.

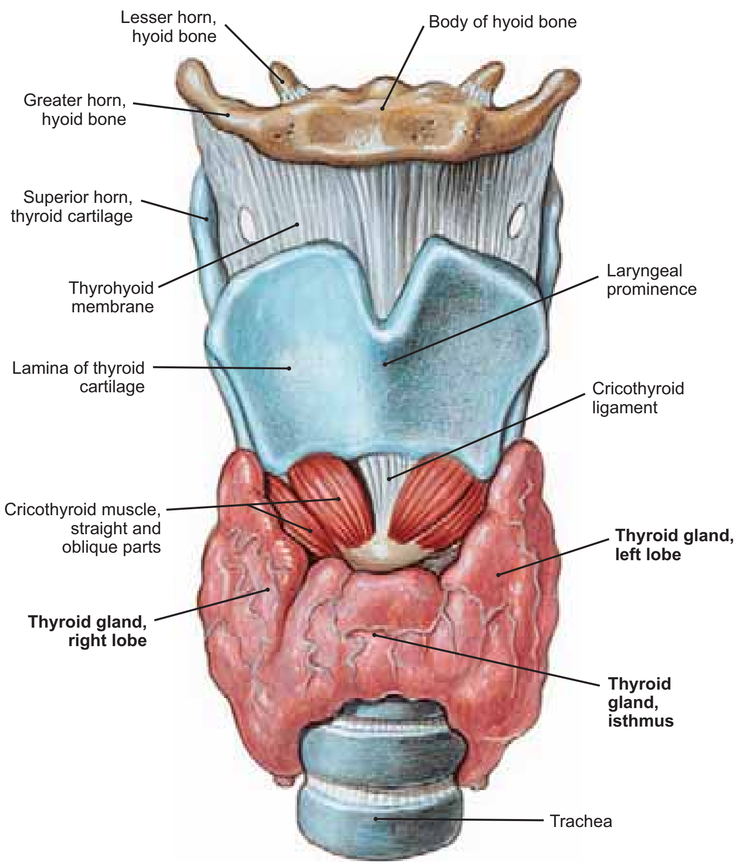


FIGURE 537.1 Ventral View of Thyroid Gland Showing Relation to Larynx and Trachea

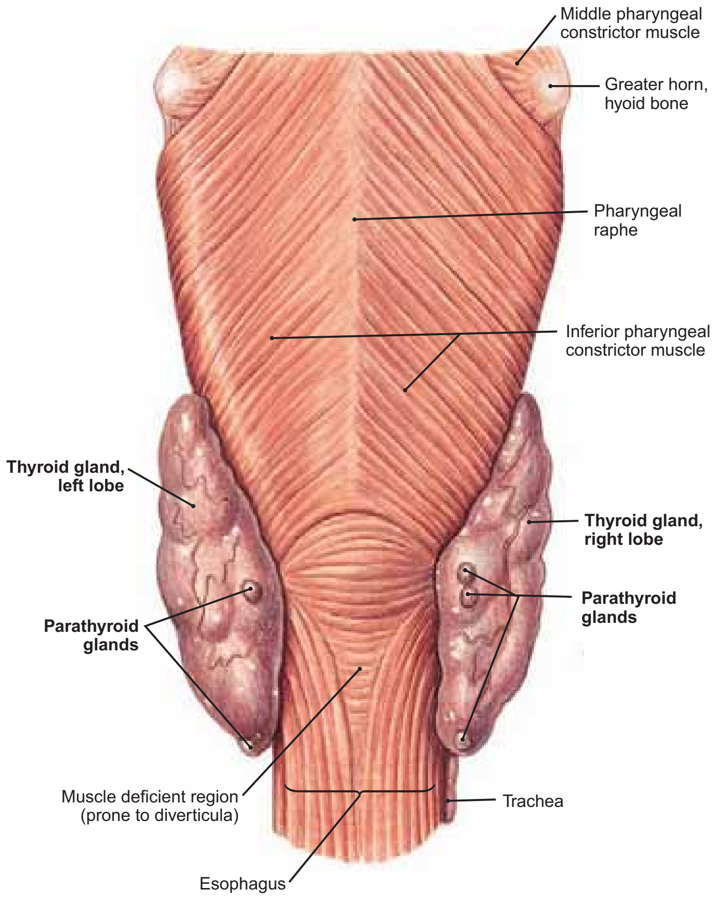


FIGURE 537.2 Dorsal View of Thyroid Gland Showing Relation to Pharynx and Parathyroids

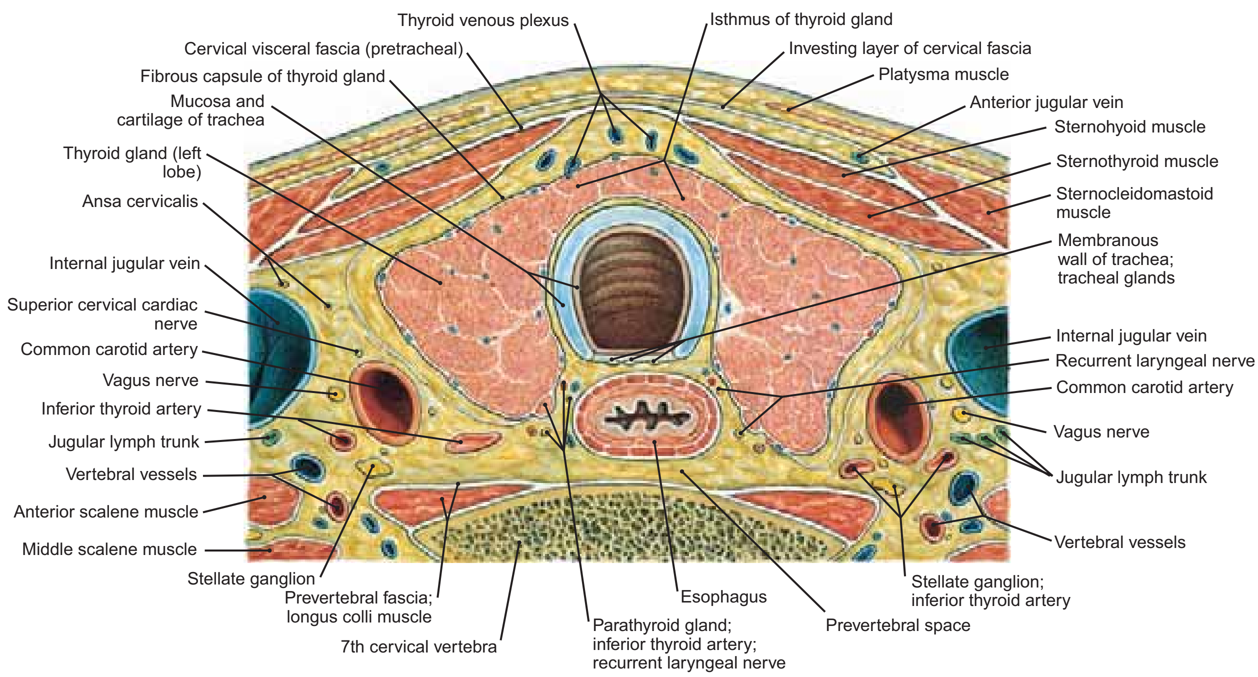


FIGURE 537.3 Cross Section of the Anterior Neck at the Level of the C7 Vertebra

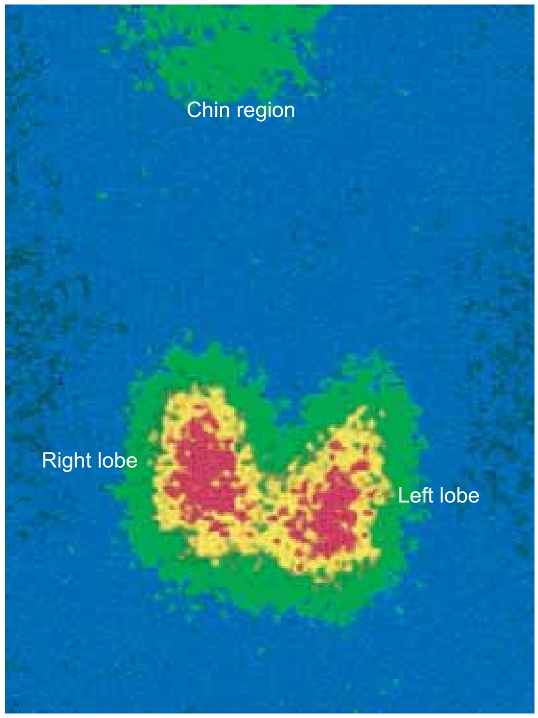
NOTE: Observe the relationship of the isthmus and lobes of the thyroid gland to the trachea. Also observe the location of the parathyroid glands, the recurrent laryngeal nerves, and the inferior thyroid arteries along the posteromedial border of the thyroid gland.

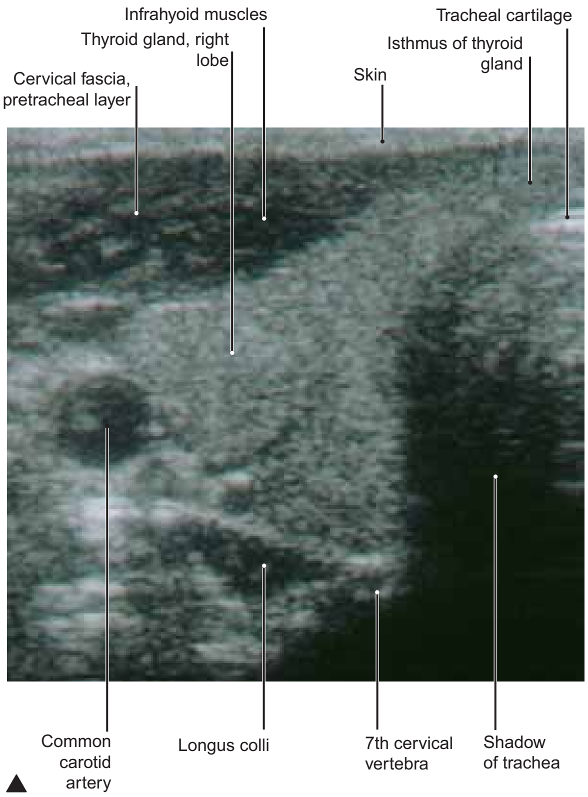
FIGURE 538.1 Scintiscan of the Thyroid Gland ▶

NOTE: (1) A scintiscan (scintigram, scintigraph, or gamma image) is the visual representation of the distribution in an entire body (whole-body scan) or in an organ of a gamma-emitting radioactive substance as detected by a scintillation scanner or gamma camera.

(2) Radioactive iodine (^{123}I) and technetium-99m (^{99m}Tc) have excellent properties for imaging the thyroid gland, and the latter radionuclide was used to obtain this image 35 minutes after injection.

(3) This technique is used to detect thyroid nodules and tumors of thyroid glandular tissue in the bed of the thyroid and throughout the body as a follow-up technique after the removal of a thyroid cancer.

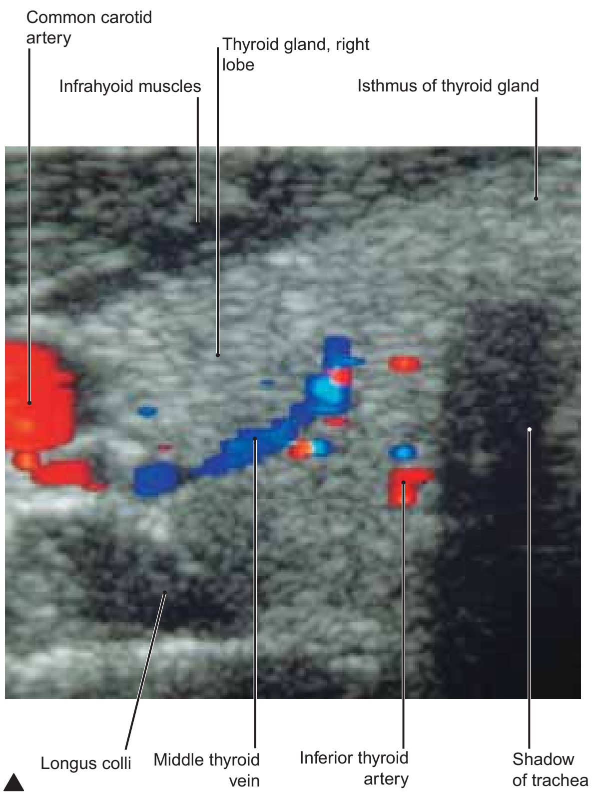




▲

FIGURE 538.2 Ultrasound Scan of the Thyroid Gland

NOTE: This is a horizontal ultrasound scan with the sound being administered in a ventrodorsal direction.



▲

FIGURE 538.3 Ultrasound Scan of the Thyroid Gland

NOTE: This scan shows the direction of blood flow (color flow Doppler sonogram).

Red = toward the transducer (arteries)

Blue = away from the transducer (veins)

◀

FIGURE 538.4 Enlarged Thyroid (often called Graves' disease)

NOTE that common symptoms of Graves' disease include goiter (seen here), fine tremor, increased nervousness and emotional instability, intolerance to heat, increased sweating, loss of weight, and diminished strength. (From Harrison, T.R., and Isselbacher, K.J. *Harrison's Principles of Internal Medicine*, 9th Edition. New York: McGraw-Hill, 1980.)

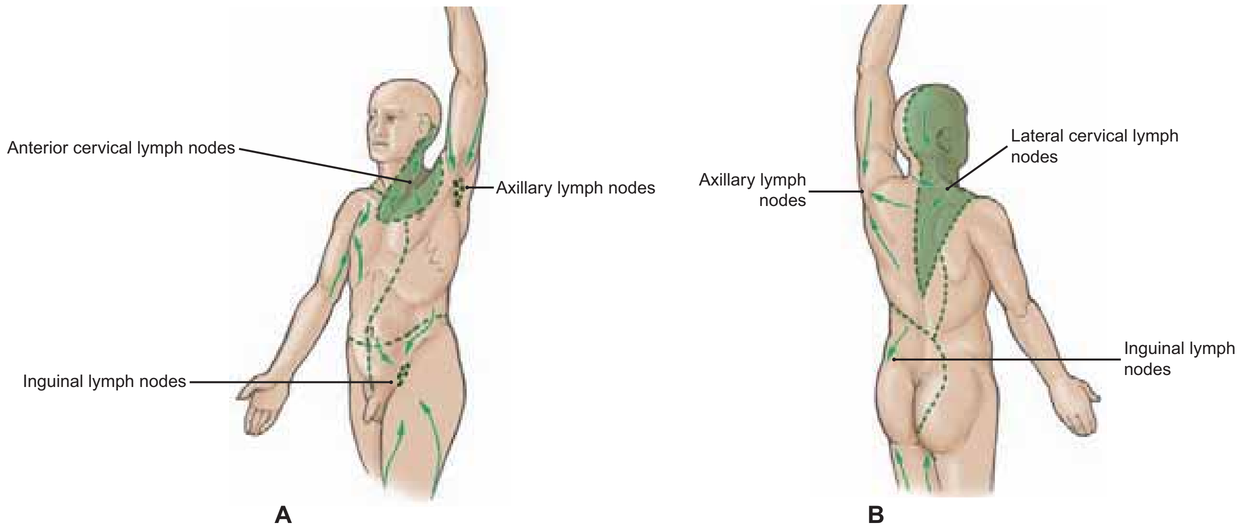


FIGURE 539.1A and B **Drainage Patterns of Lymph Nodes on the Anterior (A) and Posterior (B) Aspects of the Body**

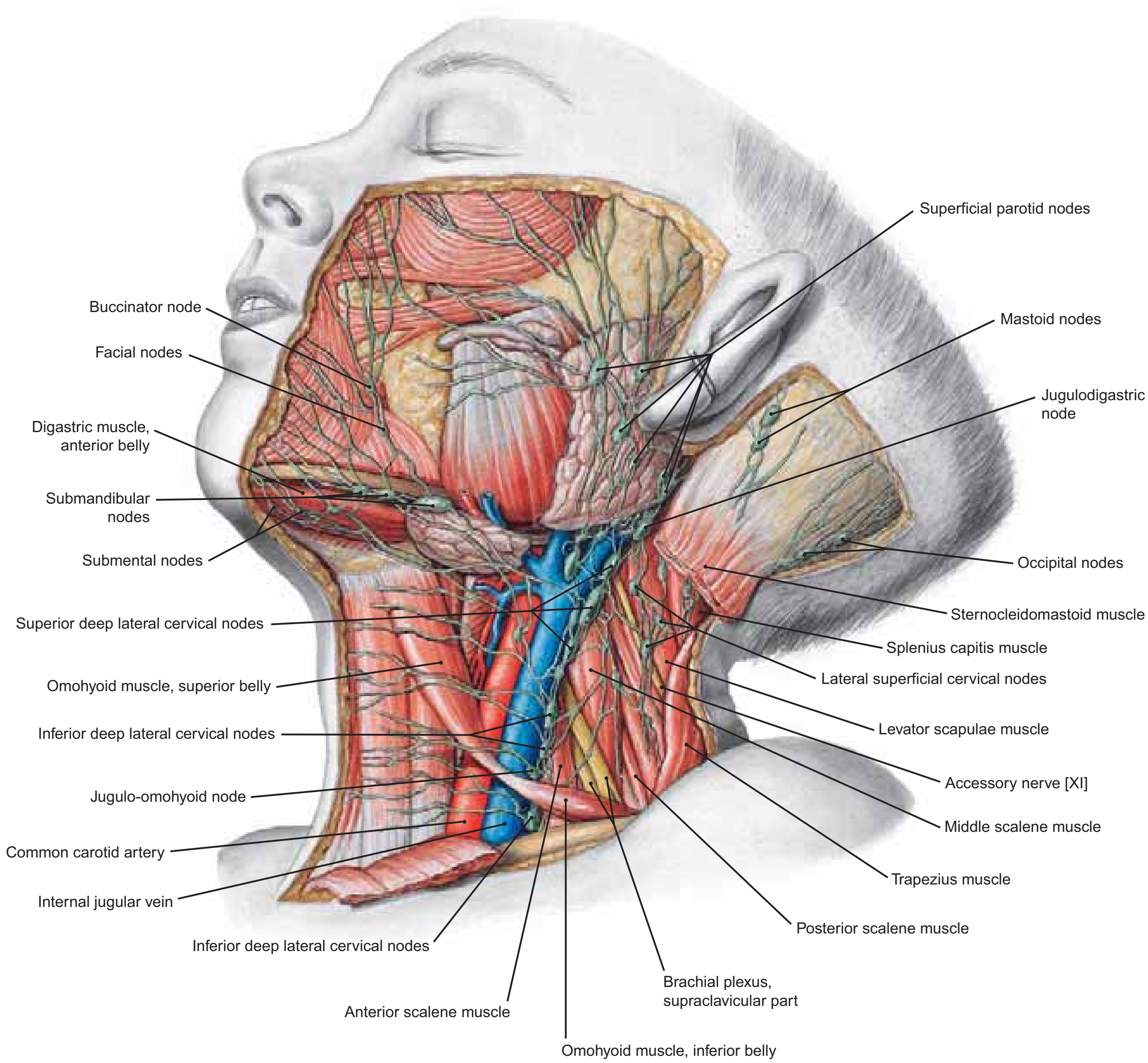


FIGURE 539.2 **Superficial Nodes of the Face and Neck in an 8-Year-Old Boy**

NOTE: The platysma muscle has been removed and the sternocleidomastoid muscle has been sectioned.

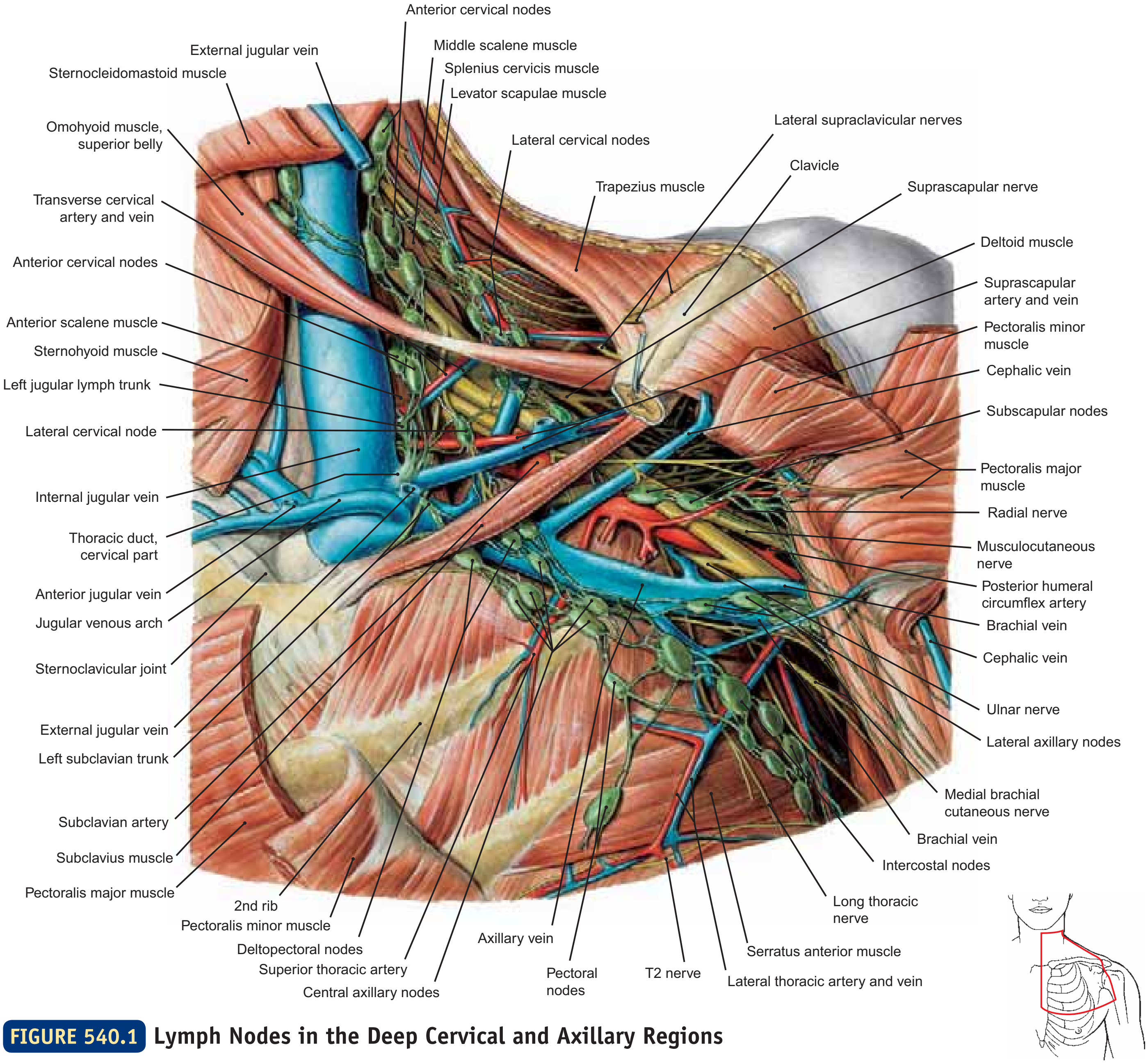


FIGURE 540.1 Lymph Nodes in the Deep Cervical and Axillary Regions

NOTE: Most of the clavicle and pectoralis muscles have been removed.

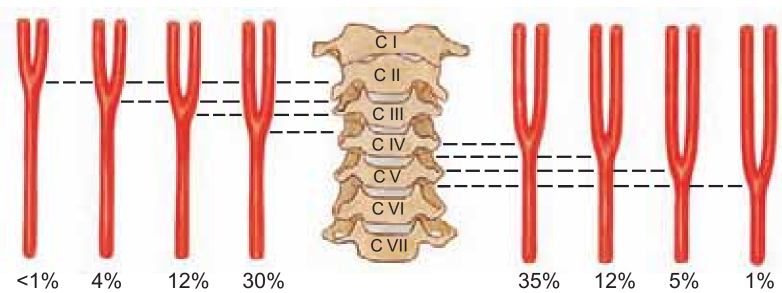


FIGURE 540.2 Variations in the Vertebral Level for the Bifurcation of the Common Carotid Artery

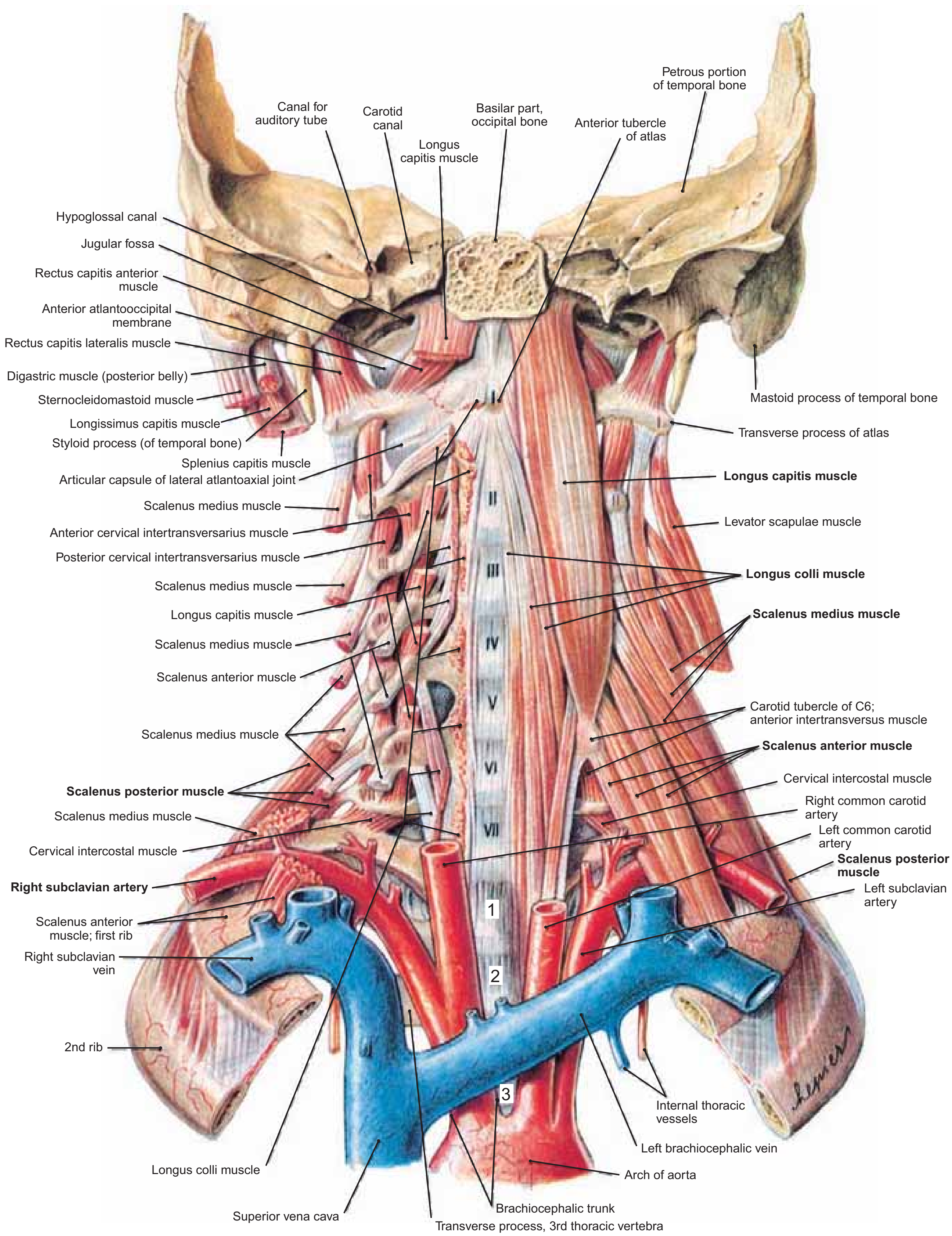


FIGURE 541 Prevertebral Region and Root of the Neck (Anterior View)

NOTE: (1) On the specimen's right, the longus colli, longus capitis, and scalene muscles have been removed, exposing the transverse processes of the cervical vertebrae onto which these muscles are seen to attach.

(2) There are two long (longus colli and longus capitis) and two short (rectus capitis anterior and lateralis) prevertebral muscles. These flex the head and neck forward and bend the head and neck laterally.

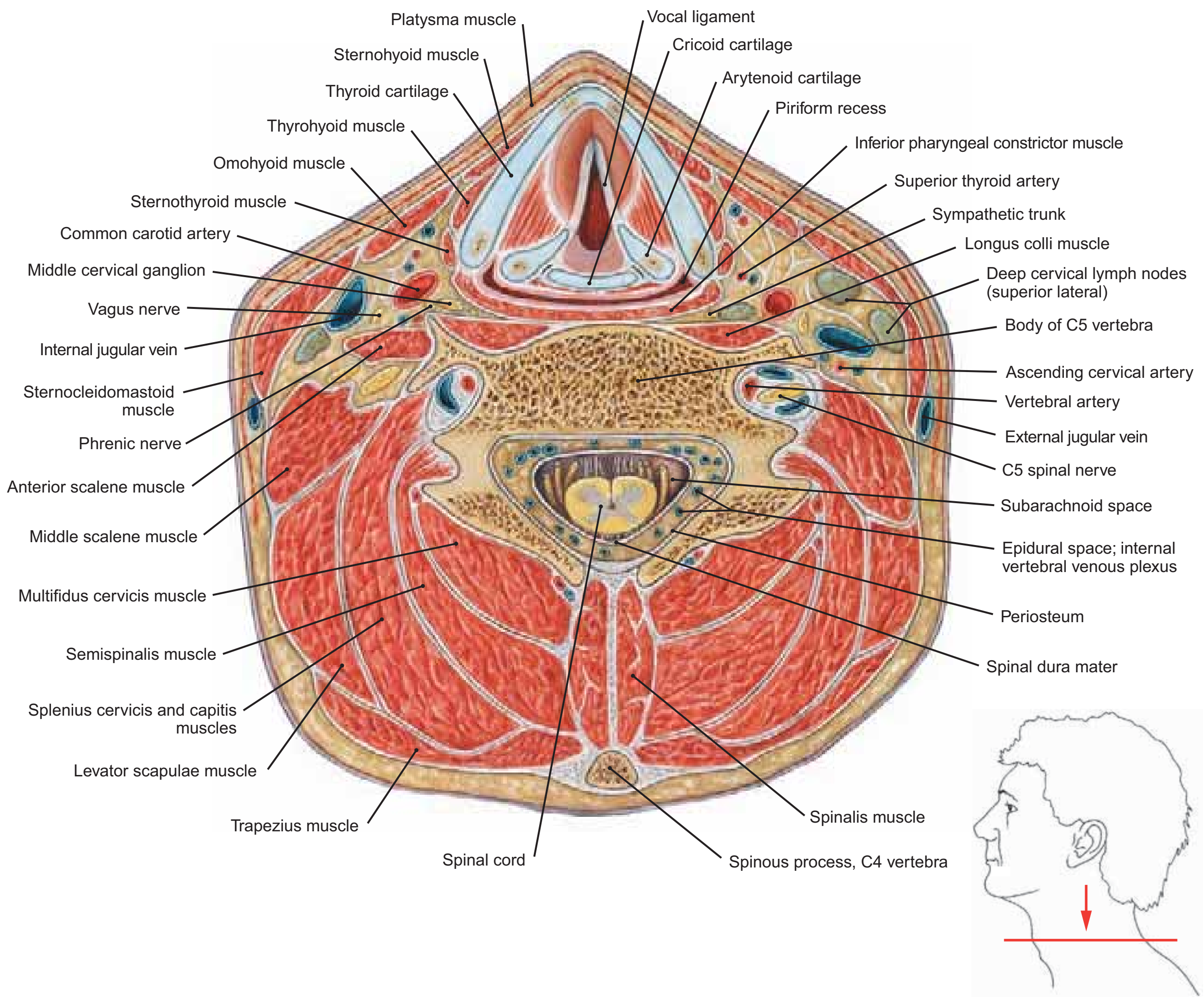


FIGURE 542 **Cross Section of the Neck at the C5 Vertebral Level**

ANTERIOR VERTEBRAL MUSCLES Muscle	Origin	Insertion	Innervation	Action
SUPERIOR OBLIQUE PART				
Longus colli	Anterior tubercles of transverse processes of third, fourth, and fifth cervical vertebrae	Tubercle of the anterior arch of the atlas	Ventral rami of the C2 to C6 spinal nerves	
INFERIOR OBLIQUE PART				
	Anterior surface of the bodies of the first two or three thoracic vertebrae	Anterior tubercles of the transverse processes of the fifth and sixth cervical vertebrae		Weak flexor of the neck; slightly rotates and bends neck laterally
VERTICAL PART				
	Anterolateral surfaces of the last three cervical and upper three thoracic vertebrae	Anterior surfaces of the bodies of second, third, and fourth cervical vertebrae		
Longus capitis	By tendinous slips from the transverse processes of the third, fourth, fifth, and sixth cervical vertebrae	Inferior surface of the basilar part of the occipital bone	Branches from the anterior rami of C1, C2, and C3 nerves	Flexes the head and the upper cervical spine
Rectus capitis anterior	Anterior surface of the lateral mass of the atlas and its transverse process	Inferior surface of the basilar part of the occipital bone	Fibers from the anterior rami of C1 and C2	Flexes the head and helps stabilize the atlantooccipital joint
Rectus capitis lateralis	Superior surface of the transverse process of the atlas	Inferior surface of the jugular process of the occipital bone	Anterior rami of the C1 and C2 nerves	Bends the head laterally to the same side

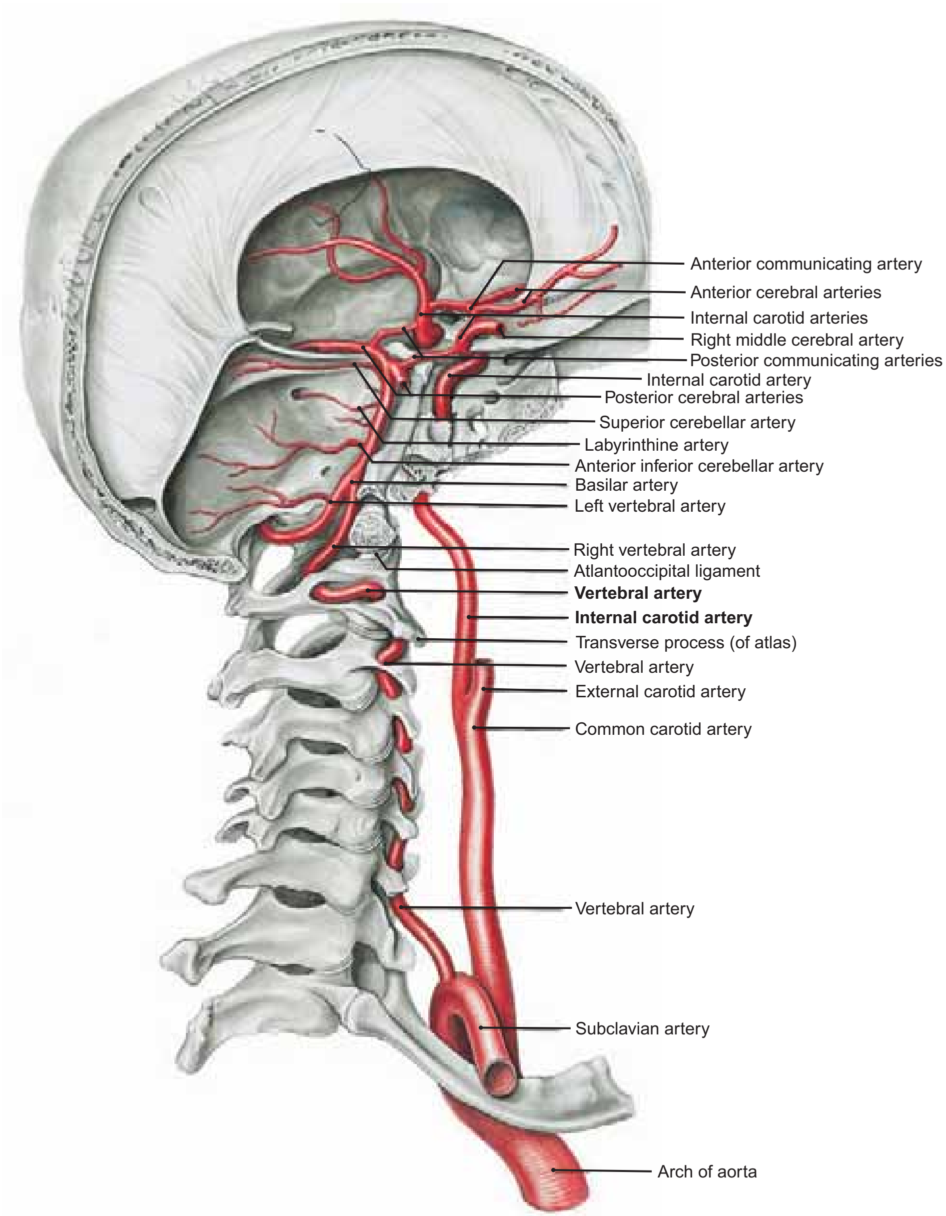


FIGURE 543.1 Vertebral and Internal Carotid Arteries

NOTE: (1) Both the internal carotid and the vertebral arteries ascend in the neck to enter the cranial cavity to supply blood to the brain. Although the vertebral arteries give off some spinal and muscular branches in the neck prior to entering the skull, the internal carotid arteries do not have branches in the neck.

(2) The origin of the **vertebral artery** from the subclavian ascends in the neck through the foramina in the transverse processes of the cervical vertebrae.

(3) The two vertebral arteries join to form the **basilar artery**. This vessel courses along the ventral aspect of the brainstem.

(4) The **internal carotid artery** begins at the bifurcation of the common carotid and ascends to its entrance in the carotid canal in the petrous part of the temporal bone. After a somewhat tortuous course, it enters the cranial cavity.

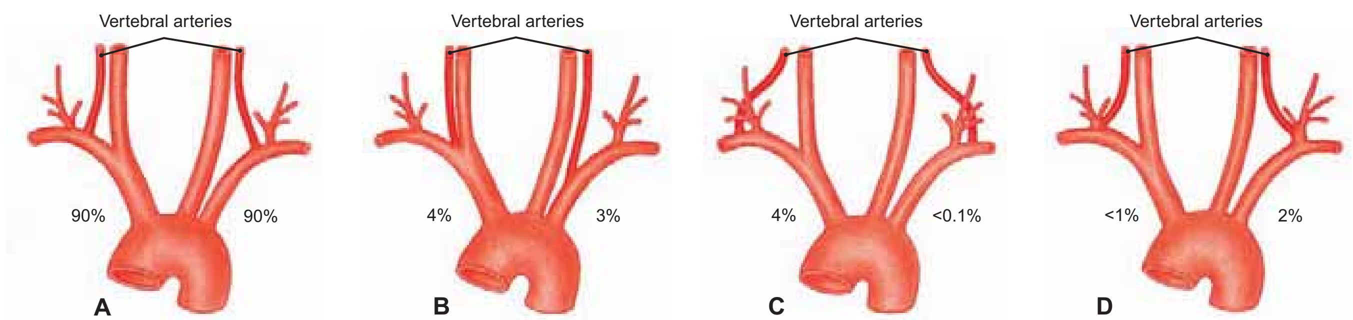


FIGURE 543.2 Variations (and Percentages) in the Origin of the Vertebral Arteries

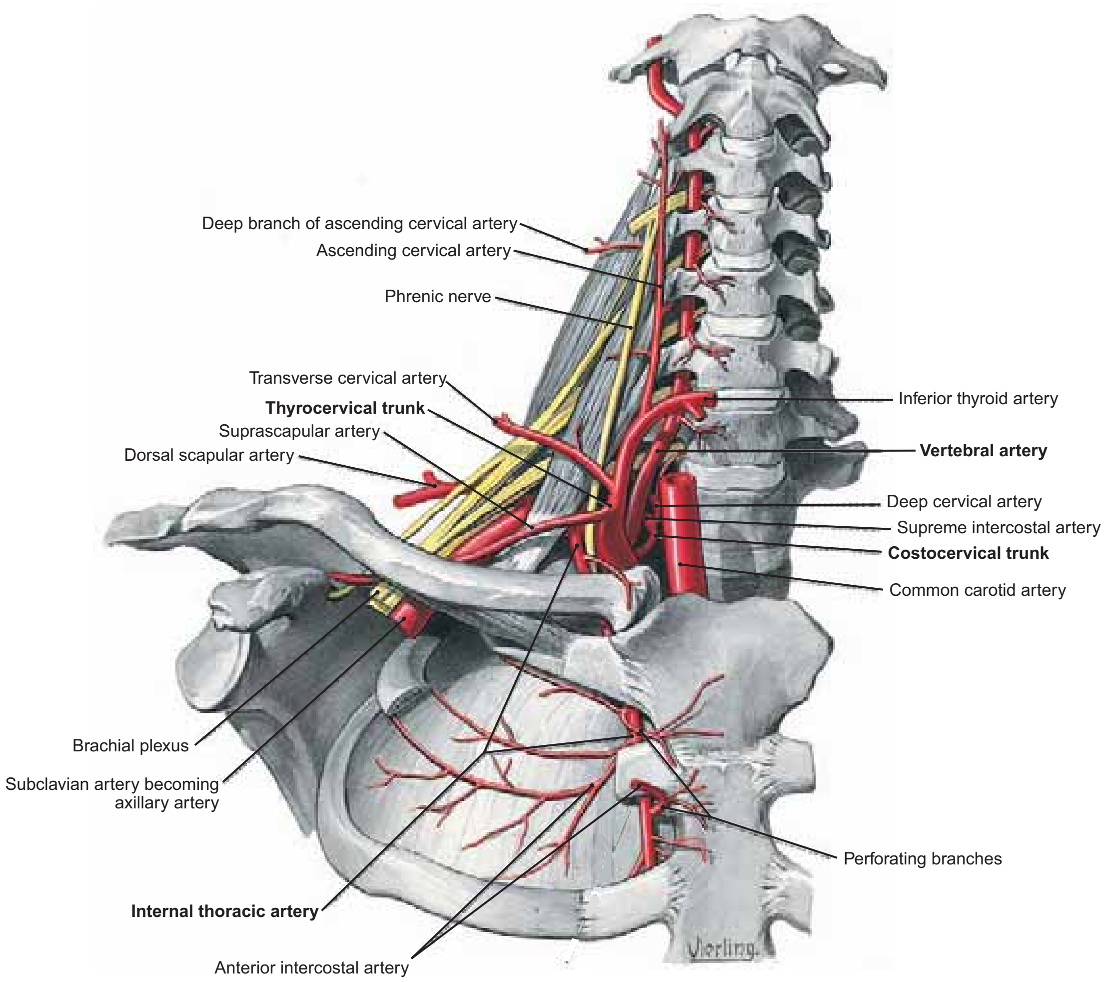


FIGURE 544.1 Right Subclavian Artery and Its Branches

NOTE: (1) The right subclavian artery arises from the brachiocephalic trunk, although on the left it branches from the aorta. It ascends into the root of the neck, arches laterally, and then descends between the first rib and clavicle to become the axillary artery.

(2) The subclavian artery generally has four major branches and sometimes five. These are the **vertebral artery**, the **internal thoracic artery,** the **thyrocervical trunk,** and the **costocervical trunk**.

(3) In about 40% of bodies, there is also a **dorsal scapular artery** arising directly from the subclavian. Thus, in this region there is considerable variation in the origin of vessels such as the suprascapular artery, the transverse cervical artery, and this latter vessel's superficial and deep branches, the superficial cervical artery and the descending scapular artery. (For a complete description of these vessels see: Clemente CD, ed. *Gray's Anatomy of the Human Body,* 30th Edition, Lea & Febiger, Philadelphia, 1985:703–709.)

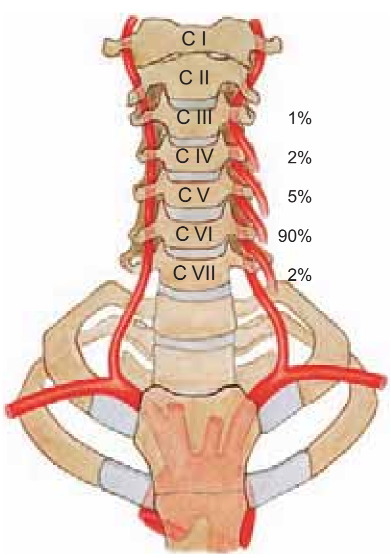


FIGURE 544.2 Variations in the Level of Entry of the Vertebral Artery into the Transverse Foramina of Cervical Vertebrae

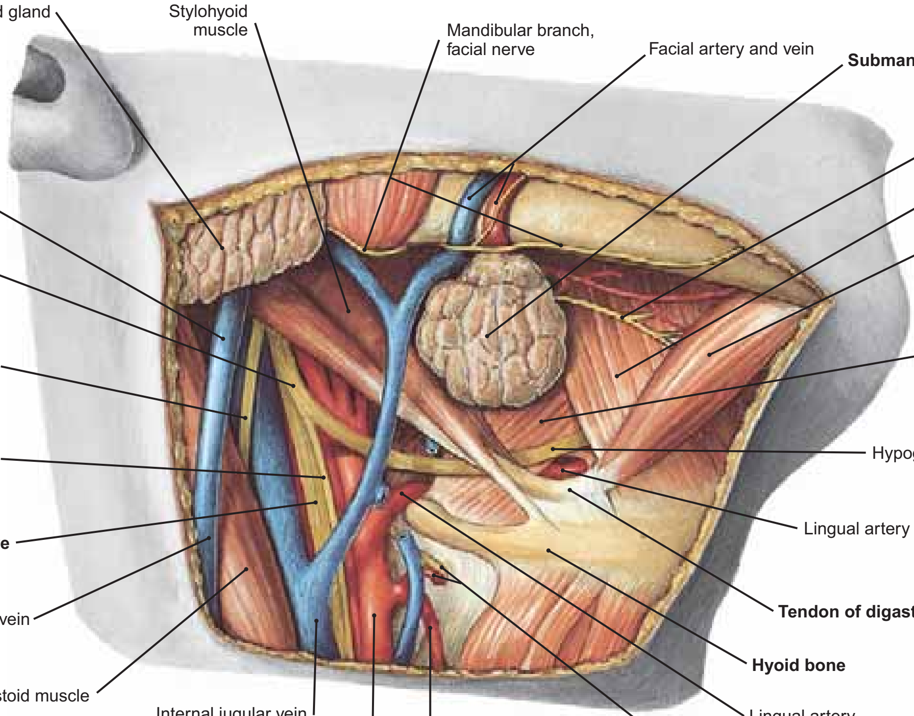


FIGURE 545.1 Right Submandibular Triangle and Submandibular Gland

NOTE: The **submandibular triangle** is bounded by the two bellies of the digastric muscle and by the lower border of the mandible. The floor of the triangle is formed by the mylohyoid and hyoglossus muscles, between which the **hypoglossal nerve** enters the oral cavity.

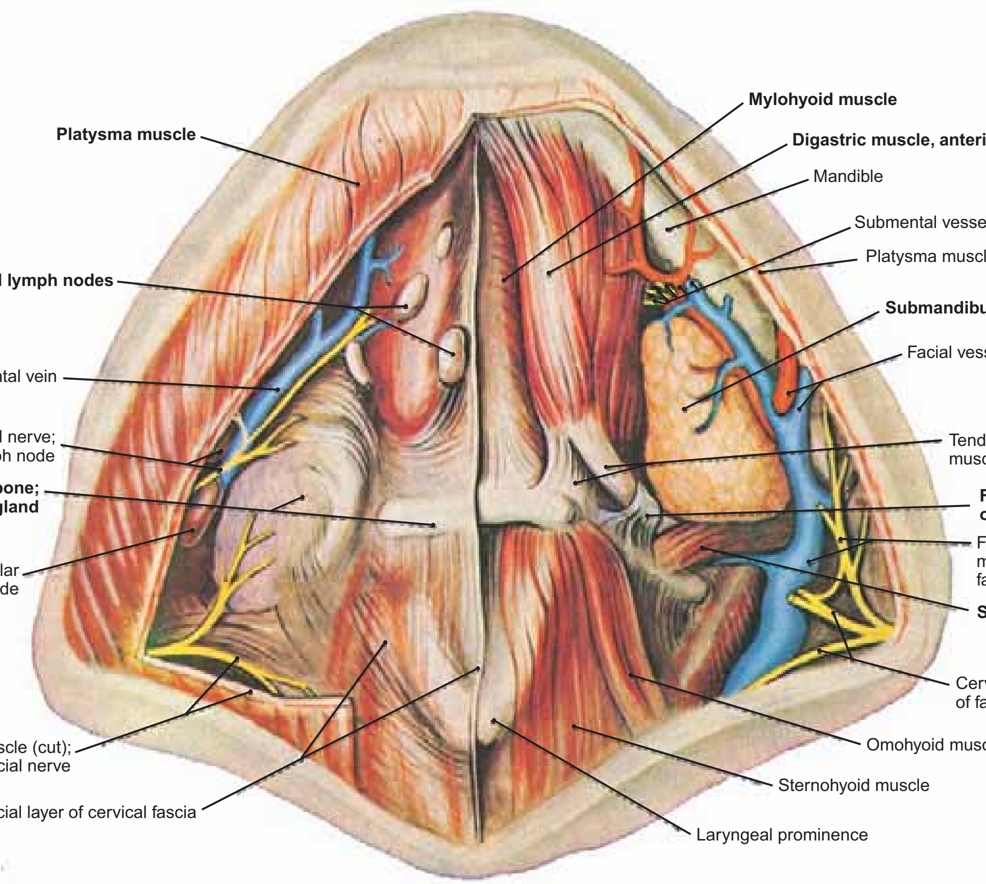


FIGURE 545.2 Submandibular and Submental Regions (Dissection Stages 1 and 2)

NOTE: In dissection **Stage 1** (reader's left), the superficial fascia with the platysma has been opened, showing the submandibular gland and lymph nodes. In dissection **Stage 2** (reader's right), the superficial layer of cervical fascia has been opened, showing the digastric, mylohyoid, and stylohyoid muscles.

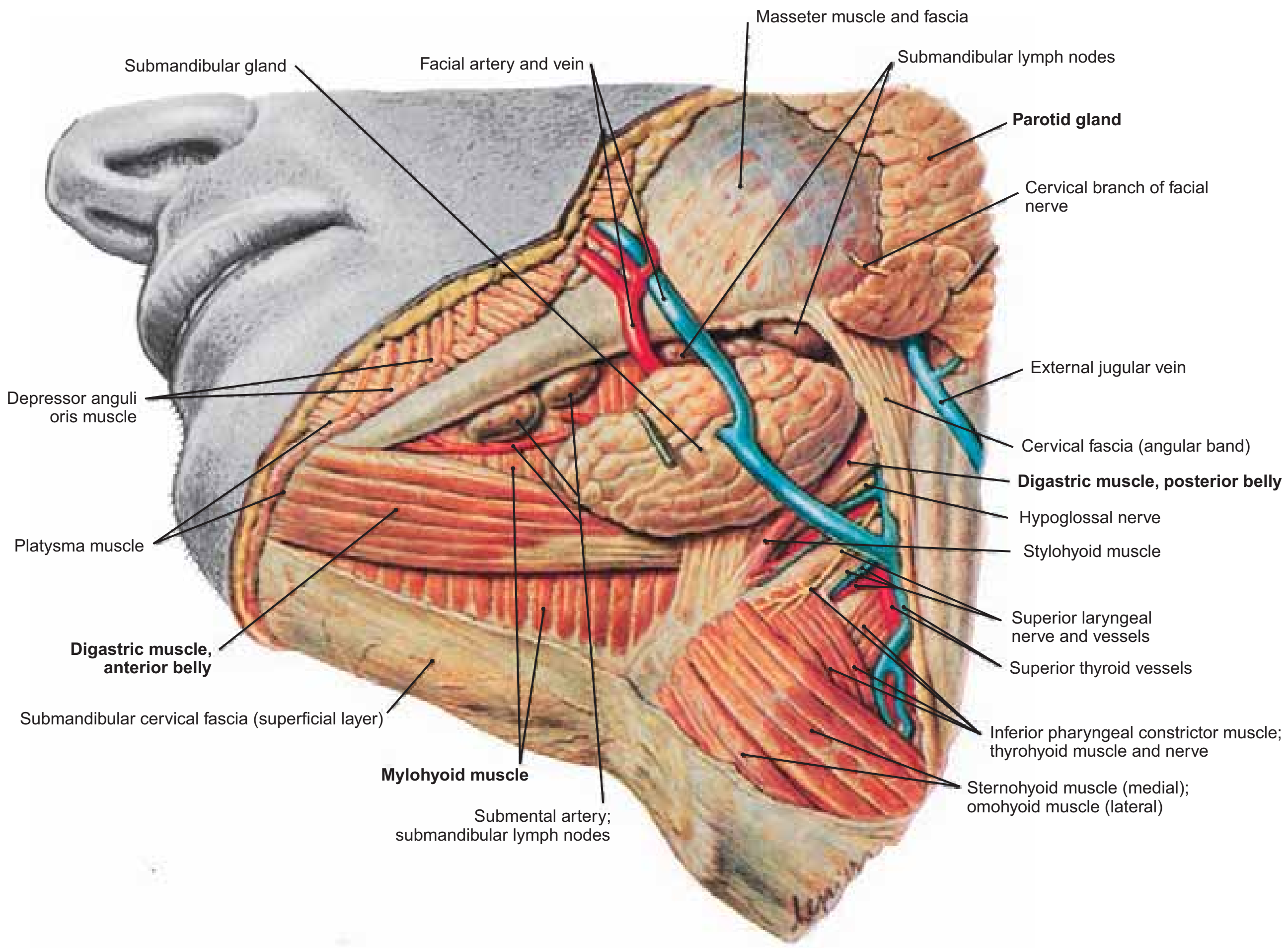


FIGURE 546.1 **Left Submandibular Triangle and Submandibular Gland (Viewed from Below)**

NOTE: Crossing the submandibular triangle are the **anterior facial vein** and the **facial artery**. Also observe the **submandibular** and **parotid glands** and the **submandibular lymph nodes**.

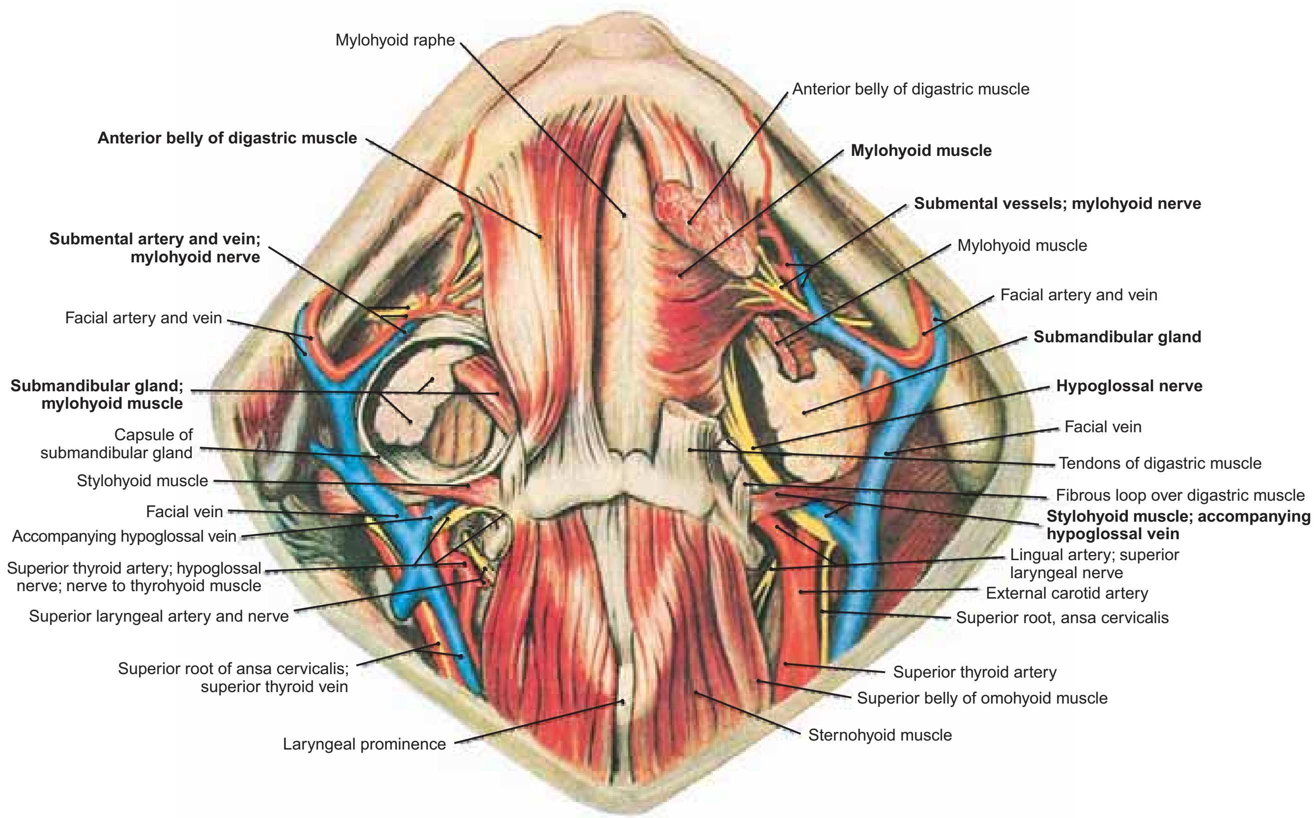


FIGURE 546.2 **Submandibular and Submental Regions (Dissection Stages 3 and 4)**

NOTE: In dissection **Stage 3** (reader's left), much of the submandibular gland has been removed, revealing the **submental nerve** and the **mylohyoid nerve**. In **Stage 4** (reader's right), the anterior digastric nerve and part of the mylohyoid nerve were removed, exposing the **hypoglossal nerve** and **accompanying vein**.

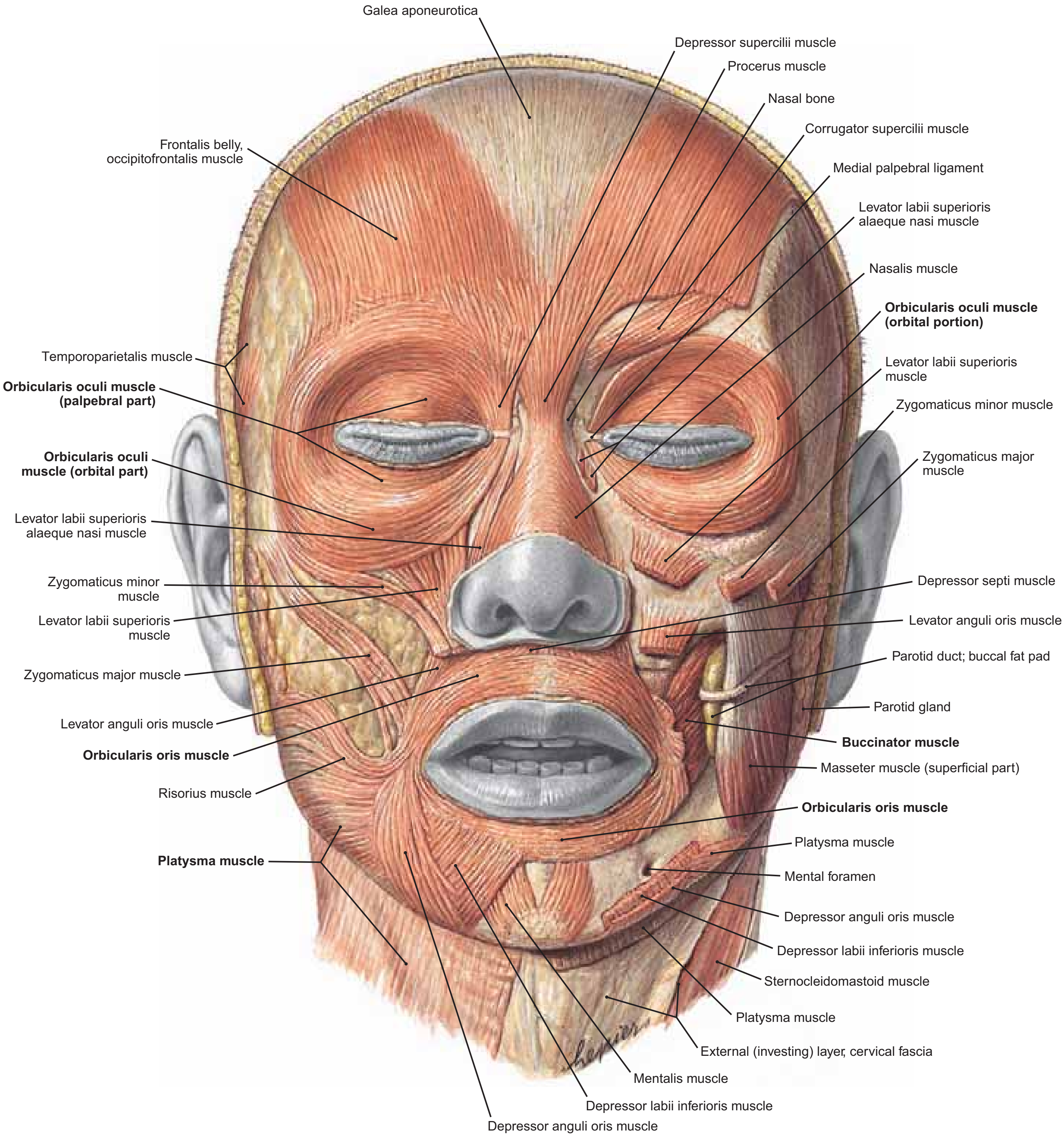


FIGURE 547 Muscles of Facial Expression (Anterior View)

NOTE: (1) The muscles of facial expression are located within the layers of superficial fascia. Having developed from the mesoderm of the **second branchial arch**, they are innervated by the nerve of that arch, the seventh cranial or **facial nerve**.

(2) Facial muscles may be grouped into: (a) muscles of the **scalp**, (b) muscles of the **external ear**, (c) muscles of the **eyelid**, (d) the **nasal muscles**, and (e) the **oral muscles**. The borders of some facial muscles are not easily defined. The **platysma muscle** also belongs to the facial group, although it extends over the neck.

(3) The circular muscles surrounding the eyes (**orbicularis oculi**) and the mouth (**orbicularis oris**) assist in closure of the orbital and oral apertures and thus contribute to functions such as closing the eyes and the ingestion of liquids and food.

(4) Since facial muscles respond to thoughts and emotions, they aid in communication.

(5) The **buccinator muscles** are flat and are situated on the lateral aspects of the oral cavity. They assist in mastication by pressing the cheeks against the teeth, preventing food from accumulating in the oral vestibule.

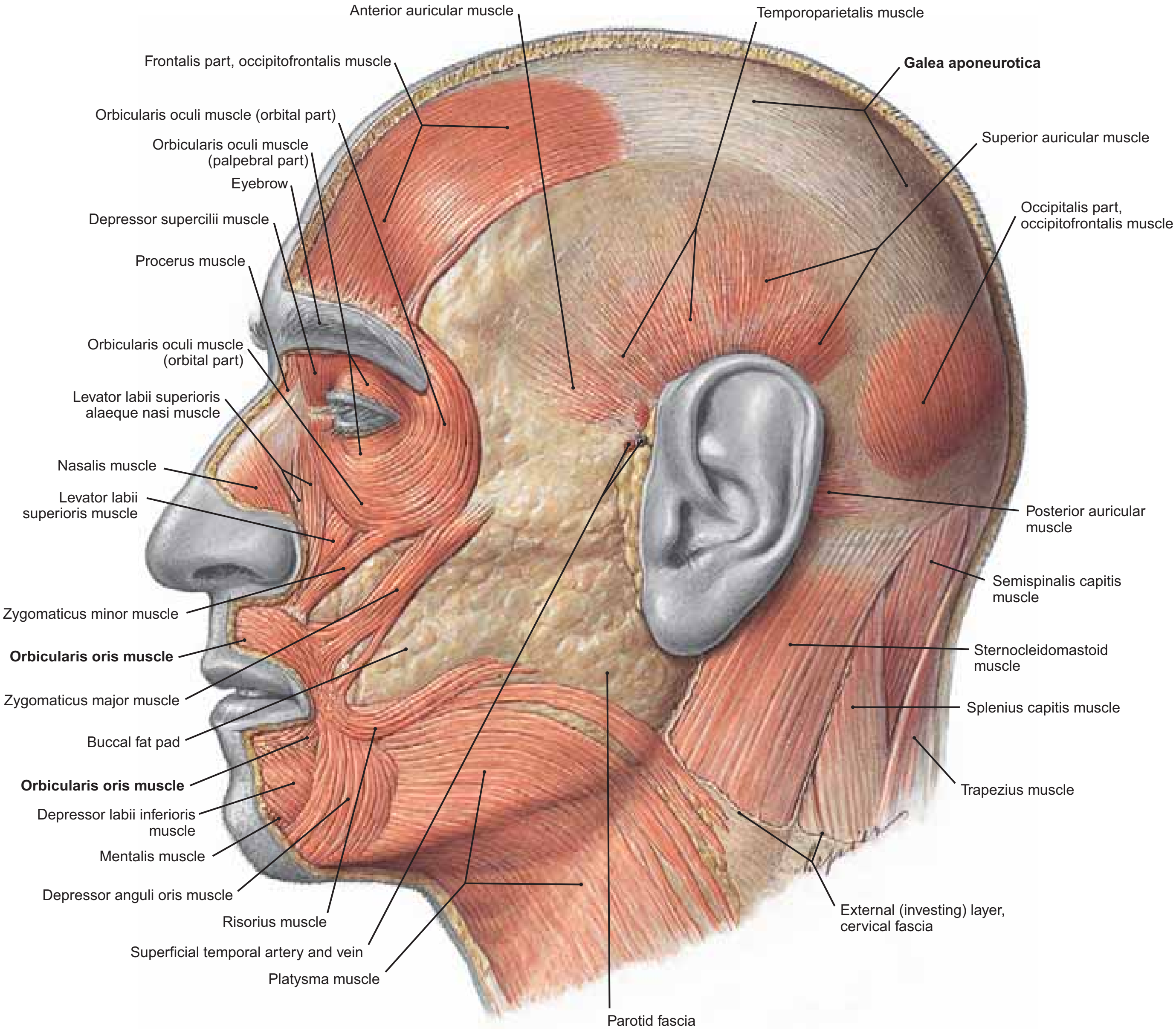
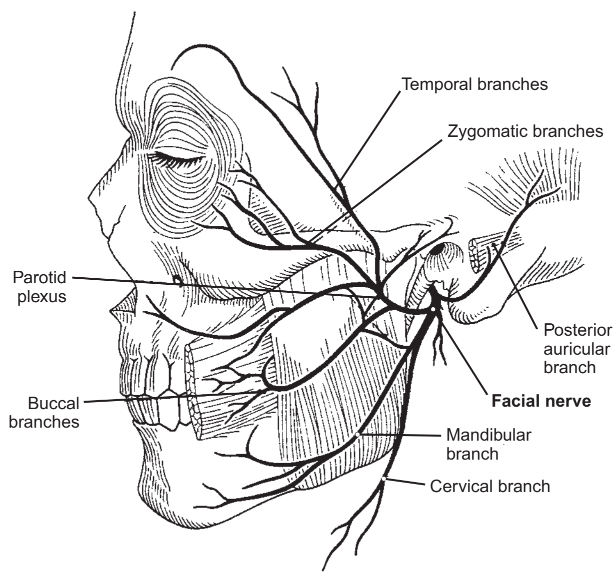


FIGURE 548.1 **Muscles of Facial Expression and the Superficial Posterior Cervical Muscles**

NOTE: (1) The **frontalis** and **occipitalis** portions of the occipitofrontalis muscle are continuous with an epicranial aponeurosis called the **galea aponeurotica**.
(2) The **orbicularis oculi** consists of orbital, palpebral, and lacrimal (not shown) portions.
(3) Into the **orbicularis oris** merge a number of facial muscles in a somewhat radial manner.

FIGURE 548.2 **Branches of the Facial Nerve Supplying ▶ the Superficial Facial Muscles**

NOTE: All the muscles of facial expression are innervated by branches of the seventh cranial nerve, the **facial nerve.** These branches are the **temporal, zygomatic, buccal, mandibular, cervical,** and **posterior auricular nerves.**



SUPRAHYOID MUSCLES

Muscle	Origin	Insertion	Innervation	Action
Digastric	Anterior belly: Digastric fossa on inner aspect of lower border of mandible Posterior belly: Mastoid notch of the temporal bone	Ends by an intermediate tendon between the two bellies that attaches to the hyoid bone	Anterior belly: Mylohyoid branch of trigeminal nerve (V) Posterior belly: Digastric branch of the facial nerve (VII)	Opens the mouth by depressing the mandible; elevates the hyoid bone
Stylohyoid	Posterior and lateral surface of styloid process of temporal bone	Body of the hyoid bone near the greater horn	Stylohyoid branch of the facial nerve (VII)	Elevates, fixes, and retracts the hyoid bone
Mylohyoid The two mylohyoid muscles form the floor of the oral cavity	Entire length of the mylohyoid line of the mandible	Posterior fibers: Into body of the hyoid bone Middle and anterior fibers: The median raphe between the muscles of both sides	Mylohyoid branch of the trigeminal nerve (V)	During swallowing, both muscles raise floor of mouth, elevate the hyoid bone, and depress the mandible in opening the mouth
Geniohyoid	Inferior mental spine on the inner surface of the symphysis menti	Anterior surface of the body of hyoid bone	First cervical nerve carried along the hypoglossal nerve	Elevates and draws hyoid bone forward; when hyoid is fixed, it retracts and depresses mandible

SUPERFICIAL MUSCLES OF THE FACE AND HEAD

MUSCLES OF THE SCALP

Muscle	Origin	Insertion	Innervation	Action
Occipitofrontalis	Occipital belly: Lateral two-thirds of superior nuchal line on occipital bone and mastoid part of temporal bone	Into the galea aponeurotica	Posterior auricular branch of the facial nerve (VII)	Draws scalp back; raises eye brow and wrinkles forehead in expression of surprise
	Frontal belly: Fibers continuous with those of procerus medially and orbicularis oculi laterally	Into the galea aponeurotica	Temporal branch of the facial nerve (VII)	
Temporoparietalis	From temporal fascia above and in front of auricle of ear	Onto the temporal fascia and skin on the side of the head	Temporal branch of the facial nerve (VII)	Tightens the scalp and draws back the skin of the temples

EXTRINSIC MUSCLES OF THE EAR

Muscle	Origin	Insertion	Innervation	Action
Anterior auricular	Anterior part of the temporal fascia	Onto the spine of the helix	Temporal branch of the facial nerve (VII)	Draws auricle of ear forward and upward (minimal action)
Superior auricular	Epicranial aponeurosis on the side of the head	Upper part of the cranial surface of auricle of ear	Temporal branch of the facial nerve (VII)	Draws the auricle of the ear upward (minimal action)
Posterior auricular	Mastoid process of the temporal bone	Medial surface of auricle at convexity of concha	Posterior auricular branch of the facial nerve (VII)	Draws the auricle backward (minimal action)

MUSCLES OF EYELIDS

Muscle	Origin	Insertion	Innervation	Action
Orbicularis oculi: Palpebral part	Medial palpebral ligament	Cross the eyelids and interlace to form the lateral palpebral raphe	Temporal and zygomatic branches of the facial nerve (VII)	Closes the eyelids gently as in sleeping and blinking
Orbital part	Nasal part of frontal bone; frontal process of the maxilla; medial palpebral ligament	Forms ellipse around orbit without being interrupted on the lateral side	Temporal and zygomatic branches of the facial nerve (VII)	Closes the eyelids when a more forceful contraction is necessary, as in winking one eye
Corrugator supercilii	Medial end of the superciliary arch	Deep surface of the skin above the middle of the supraorbital margin	Temporal branch of the facial nerve (VII)	Draws the eyebrow medially and down

SUPERFICIAL MUSCLES OF THE FACE AND HEAD (Continued)

MUSCLES OF THE NOSE

Muscle	Origin	Insertion	Innervation	Action
Procerus	From fascia over the lower part of the nasal bone	Into the skin of the lower part of the forehead between eyebrows	Buccal branch of the facial nerve (VII)	Draws down the medial angle of eyebrow such as in frowning or concentration
Nasalis	Transverse part: From the maxilla lateral to the nasal notch Alar part: From the maxilla above the lateral incisor tooth	Ascends to bridge of nose; meshes with opposite insertion Attaches to the cartilaginous ala of the nose	Buccal branch of the facial nerve (VII) Buccal branch of the facial nerve (VII)	Compresses the nasal aperture Assists in opening the nasal aperture in deep inspiration
Depressor septi	From the maxilla above the medial incisor	Into the mobile part of the nasal septum	Buccal branch of the facial nerve (VII)	Assists alar part of nasalis muscle in widening nares

MUSCLES OF THE MOUTH

Muscle	Origin	Insertion	Innervation	Action
Levator labii superioris	Along lower part of orbit from maxilla and zygomatic bones	Upper lip between levators anguli oris and labii superioris alaeque nasi	Buccal branch of the facial nerve (VII)	Raises the upper lip and carries it forward
Levator labii superioris alaeque nasi	Upper part of the frontal process of the maxilla	Inserts by two slips: into alar cartilage and into upper lip with levator labii superioris	Buccal branch of the facial nerve (VII)	Raises the upper lip and dilates the nostril
Levator anguli oris	Canine fossa of the maxilla just below the infraorbital foramen	Into angle of mouth merging with orbicularis oris, depressor anguli oris, and zygomaticus major	Buccal branch of the facial nerve (VII)	Raises the angle of the mouth and forms the nasolabial furrow
Zygomaticus minor	Lateral surface of the zygomatic bone	Upper lip between levator labii superioris and zygomaticus major	Buccal branch of the facial nerve (VII)	Elevates the upper lip and helps form the nasolabial furrow
Zygomaticus major	From the zygomatic bone in front of the zygomatico-temporal suture	Into angle of mouth with levator and depressor anguli oris and orbicularis oris muscles	Buccal branch of the facial nerve (VII)	Draws the angle of the mouth upward and backward as in laughing
Risorius	From parotid fascia over masseter muscle	Into the skin at the angle of the mouth	Buccal branch of the facial nerve (VII)	Retracts the angle of the mouth
Depressor labii inferioris	Oblique line of mandible between symphysis menti and the mental foramen	Into lower lip and at midline blending with muscle from other side	Mandibular branch of the facial nerve (VII)	Draws the lower lip downward and a bit laterally
Depressor anguli oris	From oblique line of mandible, lateral and below depressor labii inferioris	Into the angle of the mouth blending with orbicularis oris and risorius	Mandibular branch of the facial nerve (VII)	Draws angle of mouth down and laterally as in expression of sadness
Mentalis	From the incisive fossa of the mandible	Into the skin of the chin	Mandibular branch of the facial nerve (VII)	Raises and protrudes lower lip; wrinkles chin in expression of doubt or disdain
Orbicularis oris	Fibers derived from other facial muscles (buccinator, levators, and depressors of lips and angles, zygomatic muscles) pass into lips; also some intrinsic muscle fibers make up orbicularis oris	Several strata of muscle fibers form a sphincter-like muscle with fibers that decussate at the angles of the mouth	Buccal branch of the facial nerve (VII)	Closes the lips, and its deep fibers can press the lips against the teeth; also it protrudes the lips and is important in speech
Buccinator	Alveolar processes of mandible and maxilla opposite upper and lower molar teeth; posteriorly, it arises from the pterygomandibular raphe opposite superior constrictor	Fibers course forward to blend into the formation of the orbicularis oris, decussating at the angles of the mouth	Buccal branch of the facial nerve (VII)	Compresses the cheeks during chewing; also compresses the distended cheeks as in blowing a horn

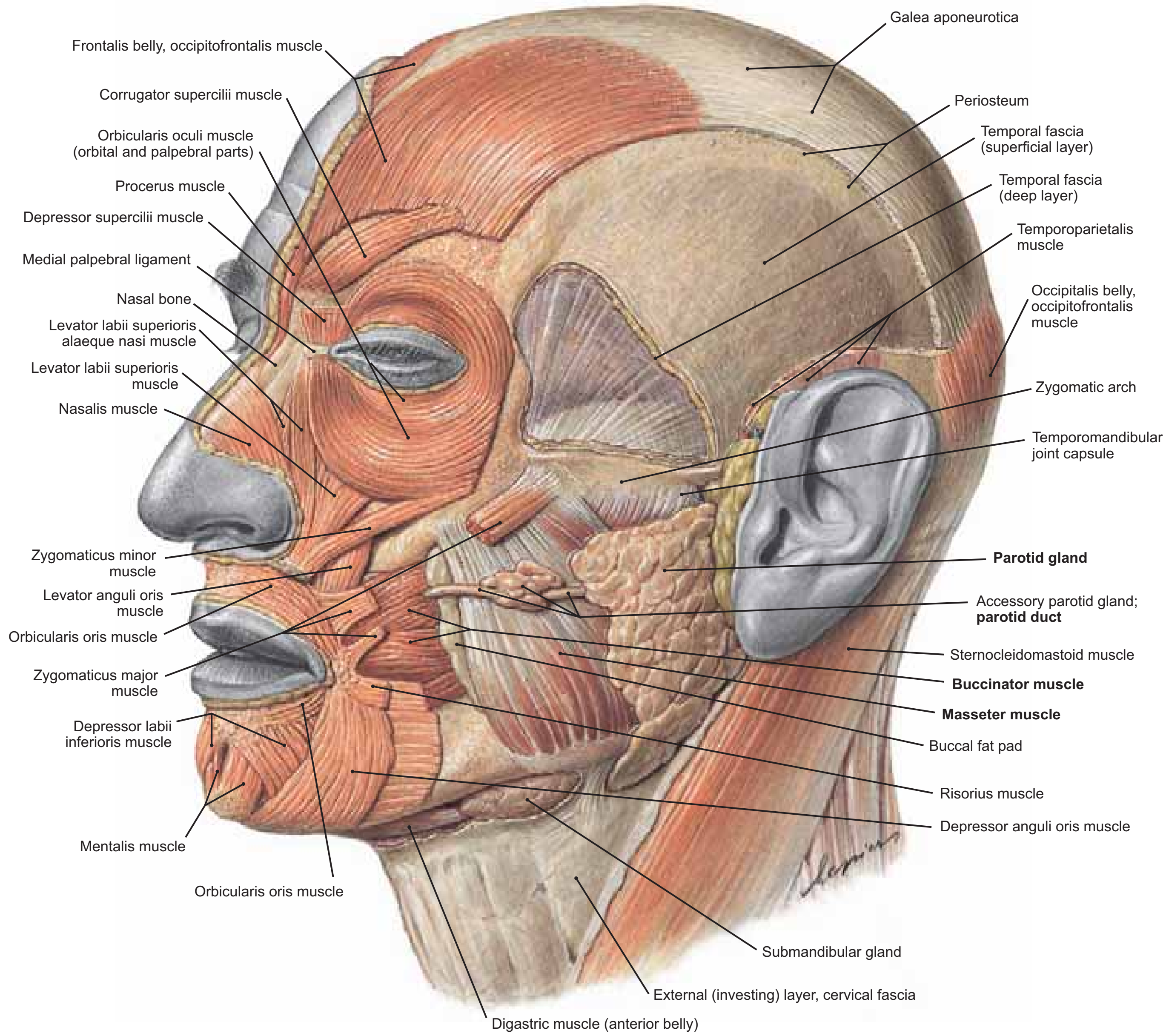


FIGURE 551.1 Parotid Gland and Duct and the Masseter Muscle

NOTE: (1) The **parotid gland** extends from the zygomatic arch to below the angle of the mandible. It lies anterior to the ear and superficial to the **masseter muscle**. It is enclosed in a tight fascial sheath, and its duct courses medially across the face to enter the oral cavity through the fibers of the **buccinator muscle**.

(2) The masseter muscle extends from the zygomatic bone to the ramus, angle, and body of the mandible. It elevates the mandible (closes the mouth) and is supplied by the trigeminal nerve.

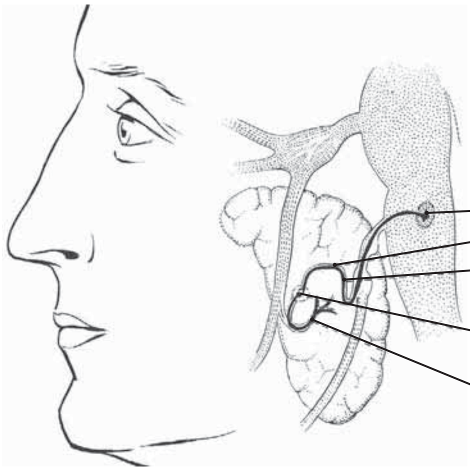


FIGURE 551.2 Parasympathetic Innervation of the Parotid Gland

NOTE: (1) Preganglionic parasympathetic fibers that innervate the parotid gland emerge from the brainstem in the ninth (glossopharyngeal) nerve.

(2) These fibers then travel along the **tympanic nerve** to the middle ear and then form the **lesser petrosal nerve** that joins the **otic ganglion**.

(3) Postganglionic fibers then travel within the **auriculotemporal nerve** to reach the parotid gland.

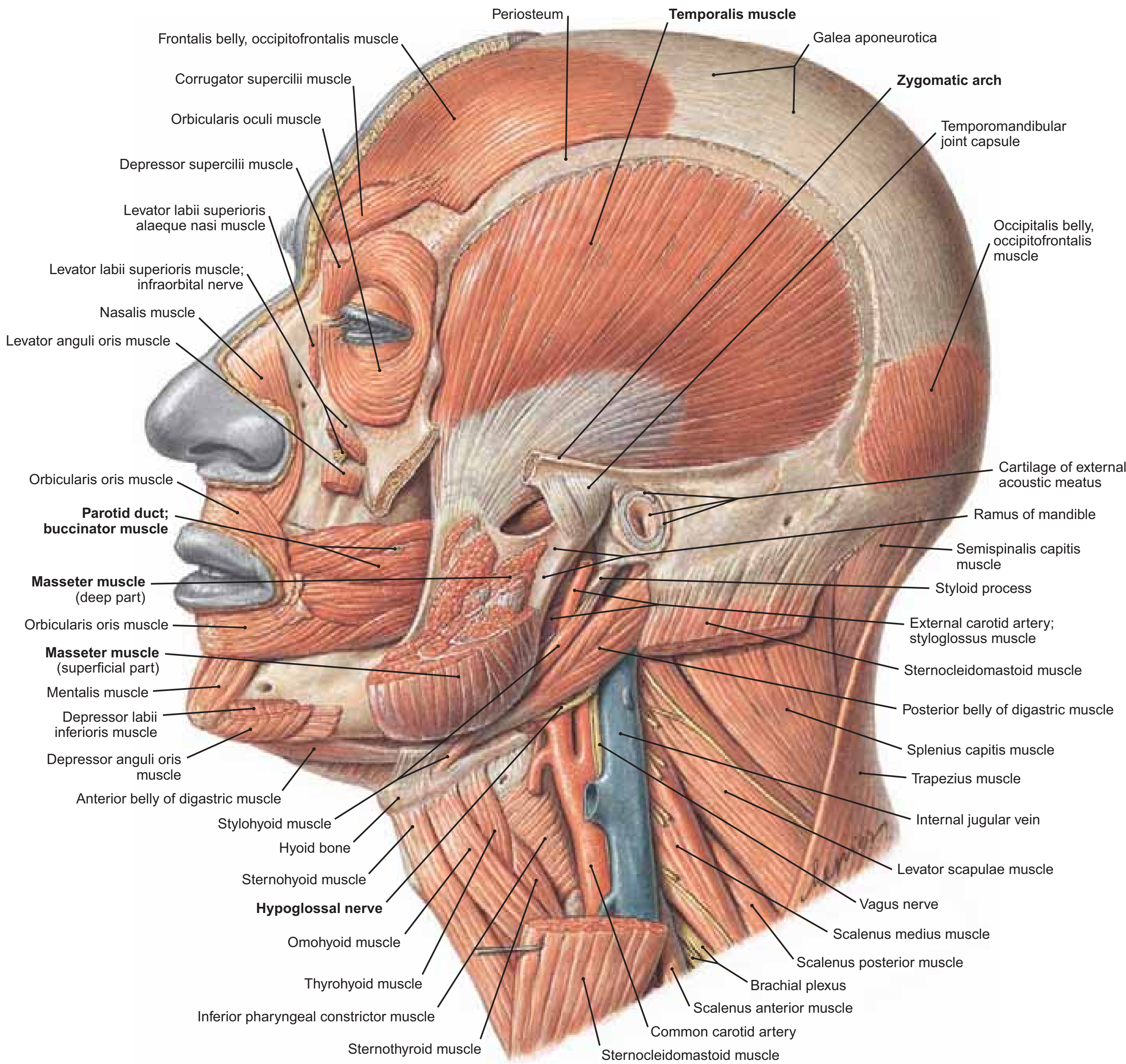


FIGURE 552.1 Temporalis and Buccinator Muscles

NOTE: (1) The external ear and zygomatic arch have been removed, along with most of the masseter muscle to demonstrate the origin of the temporalis muscle from the temporal fossa and its insertion on the coronoid process of the mandible. Similar to the masseter, the temporalis is innervated by the mandibular branch of the trigeminal nerve.

(2) The various fiber bundles of the buccinator muscle as they extend directly into the orbicularis oris at both the upper and lower lips. Similar to the other facial muscles, the buccinator is supplied by the facial nerve (VII, buccal branch).

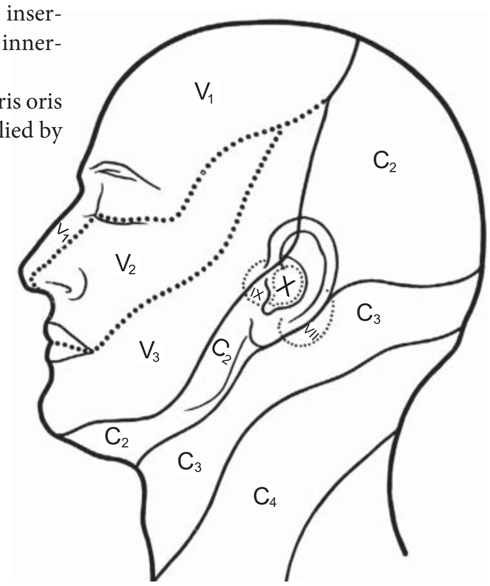


FIGURE 552.2 Cutaneous Nerve Patterns (Dermatomes) of the ▶ Head and Neck

NOTE: (1) The anterior and lateral surfaces of the head and face are supplied by the divisions of the trigeminal nerve.

(2) The posterior and lateral surfaces of the head and neck are supplied by the cervical nerves. Small areas of skin around the ear are innervated by the facial (VII), glossopharyngeal (IX), and vagus (X) nerves.

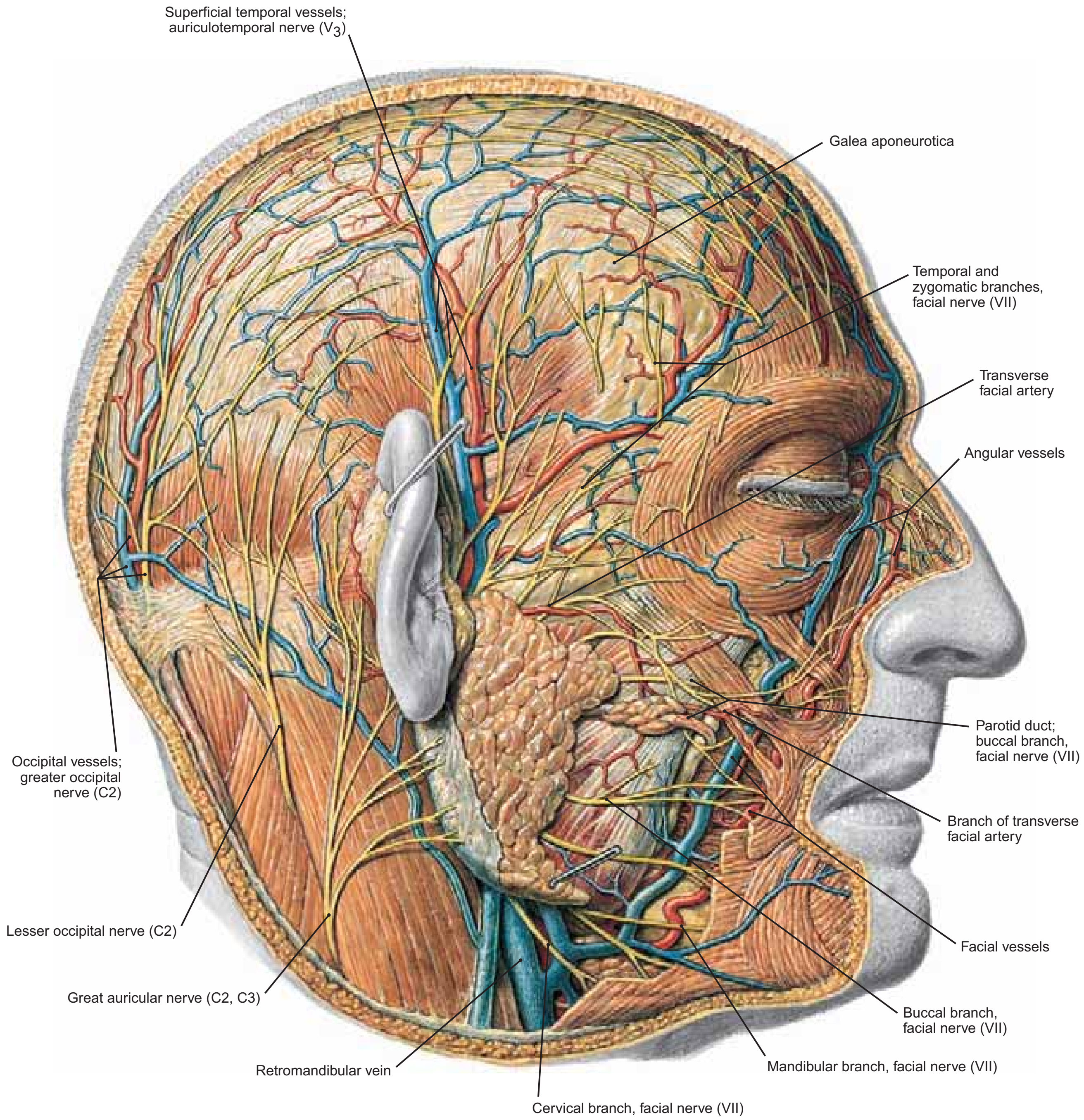


FIGURE 553 **Superficial Dissection of the Face: Vessels and Nerves (Dissection 1)**

NOTE: (1) In this dissection the capsule of the parotid gland has been opened to reveal the substance of the gland and the branches of the **facial nerve** that emerge from under its borders. These cross the face to supply the muscles of facial expression (see Fig. 554) for a more complete view of the facial branches.

(2) The cervical nerves. The **greater occipital nerve** is a sensory nerve from the *posterior* primary ramus of C2, and it courses upward with the occipital vessels to supply the posterior scalp. The **lesser occipital (C2)** and **great auricular (C2, C3) nerves** are from the anterior primary rami and are also sensory nerves. They supply the posterolateral neck region and the lateral scalp behind the ear.

(3) The course of the **facial artery and vein** is partially covered by the muscles of facial expression. These vessels have been exposed to demonstrate their ascent lateral to the nose to reach the medial side of the orbit where they are called the **angular artery and vein**.

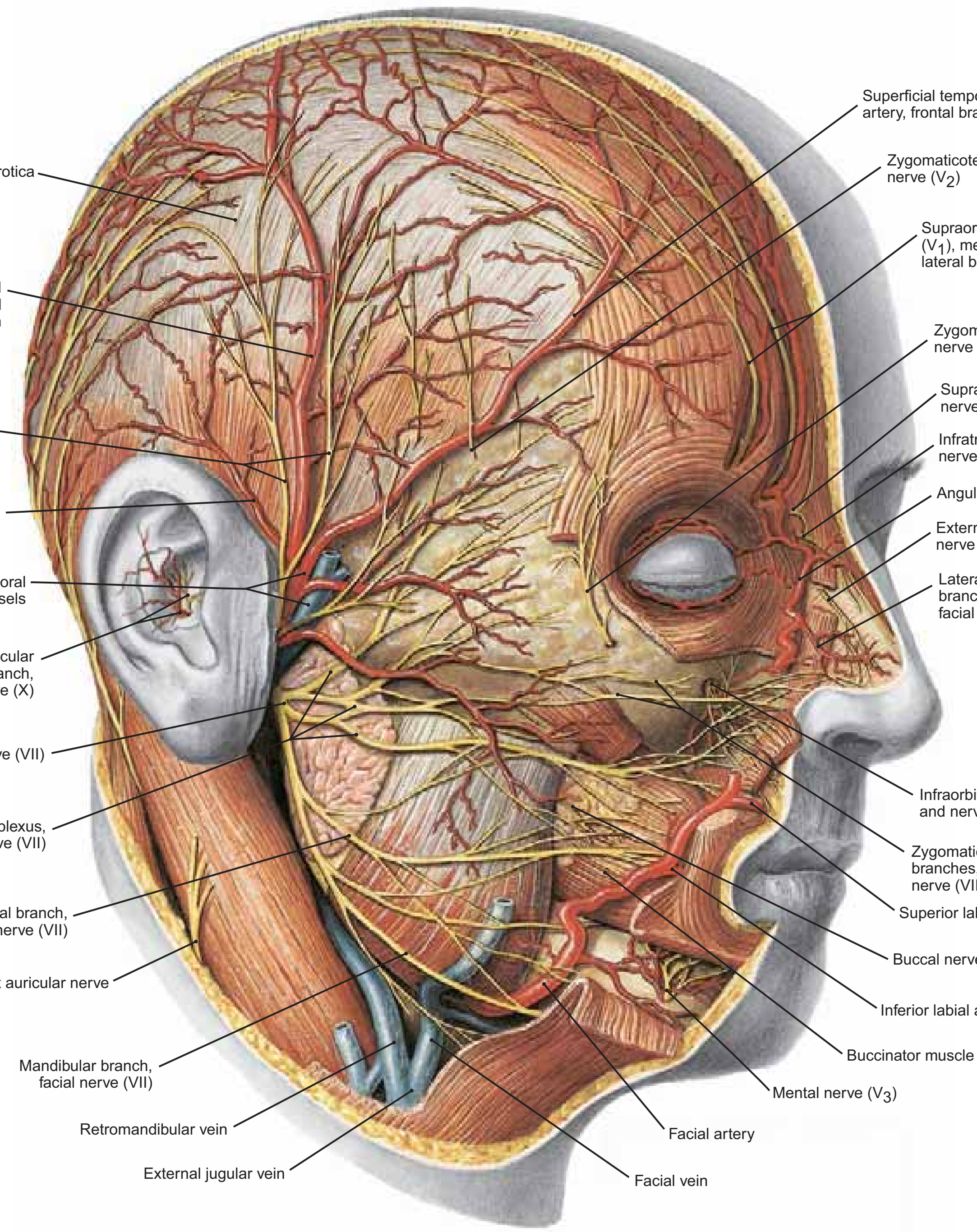


FIGURE 554 Superficial Dissection of the Face: Vessels and Nerves (Dissection 2)

NOTE: (1) The superficial part of the parotid gland has been removed to show the branches of the **facial nerve**, which emerge from the substance of the gland. Identify the **temporal, zygomatic, buccal, mandibular,** and **cervical** branches. The **posterior auricular** branch is not shown.

(2) The superficial sensory branches of the **trigeminal nerve**:

(a) From the **ophthalmic division**: the supraorbital, supratrochlear, the ascending and descending branches of the infratrochlear, and the external nasal.

(b) From the **maxillary division**: the zygomaticotemporal, the zygomaticofacial, and the infraorbital.

(c) From the **mandibular division**: the buccal, mental, and auriculotemporal.

(3) The general distribution of **superficial temporal artery**. Also observe the course of the **facial artery** as it ascends on the face to become the **angular artery**. Among other structures, the facial artery supplies the chin and the upper and lower lips and it anastomoses with vessels emerging from the orbit.

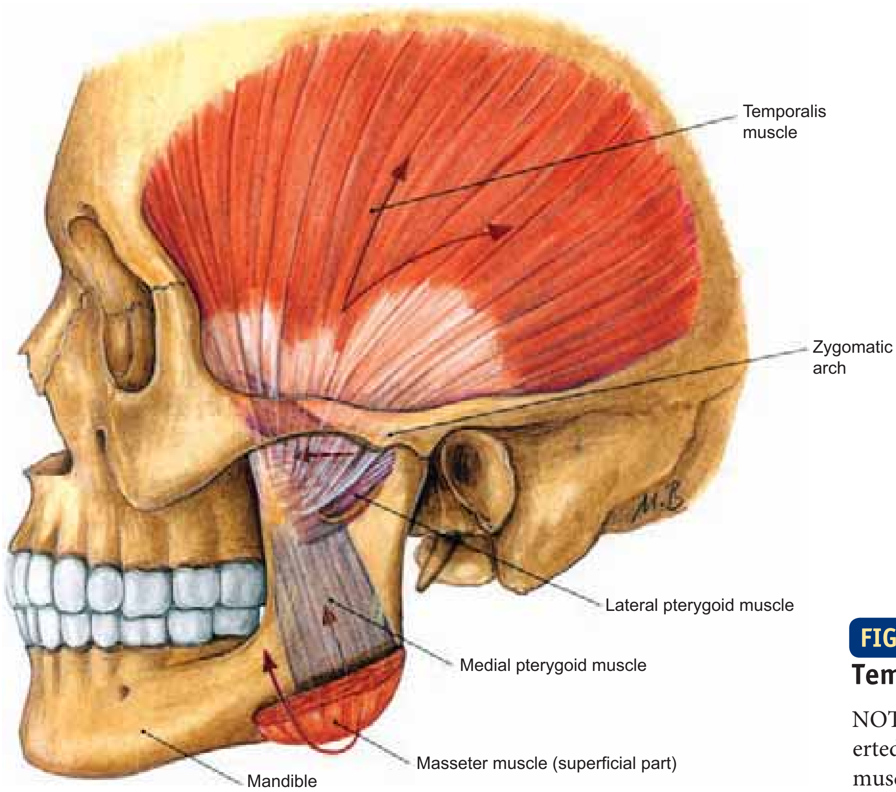


FIGURE 555.1 Actions of the Masseter and Temporalis Muscles

NOTE that the arrows indicate the directions of force exerted by the temporalis, masseter, and medial pterygoid muscles in closing the jaw.

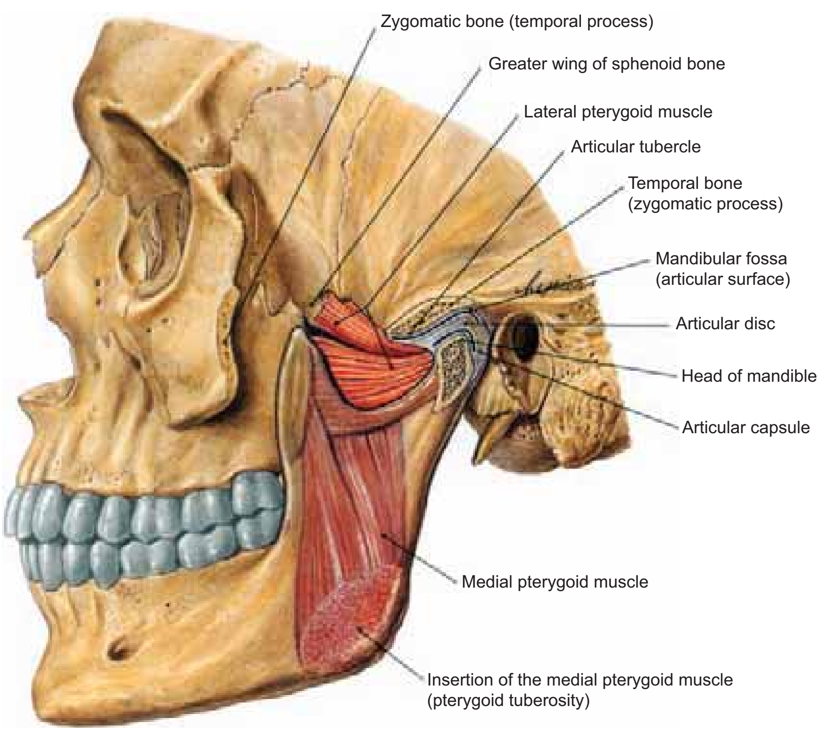


FIGURE 555.2 Medial and Lateral Pterygoid Muscles (Lateral View)

NOTE: (1) The left zygomatic arch has been removed. Posteriorly, the bone has been cut to show the **temporomandibular joint** and the articular disk. The medial pterygoid muscle and part of the lateral pterygoid muscle on the inner aspect of the mandible are represented as though the bone was transparent.

(2) The **medial pterygoid muscle** arises from the medial surface of the lateral pterygoid plate of the sphenoid as well as from the palatine bone and inserts on the medial surface of the ramus and angle of the mandible. It assists the masseter and temporalis in closing the jaw.

(3) The lateral pterygoid arises by two heads, one from the sphenoid bone and one from the palatine bone. It inserts on the medial ramus and angle of the mandible. It assists the masseter and temporalis to close the jaw.

MUSCLES OF MASTICATION

Muscle	Origin	Insertion	Innervation	Action
Masseter	Zygomatic surface of maxilla and the zygomatic arch	Lateral surface of ramus of mandible and the coronoid process of mandible	Masseteric branch of mandibular nerve	Closes the jaw by elevating the mandible
Temporalis	Temporal fossa and deep surface of the temporal fascia	Medial surface of anterior border of coronoid process; anterior border of ramus of mandible	Deep temporal branches of the mandibular nerve	Elevates mandible and closes the jaw; posterior fibers retract mandible

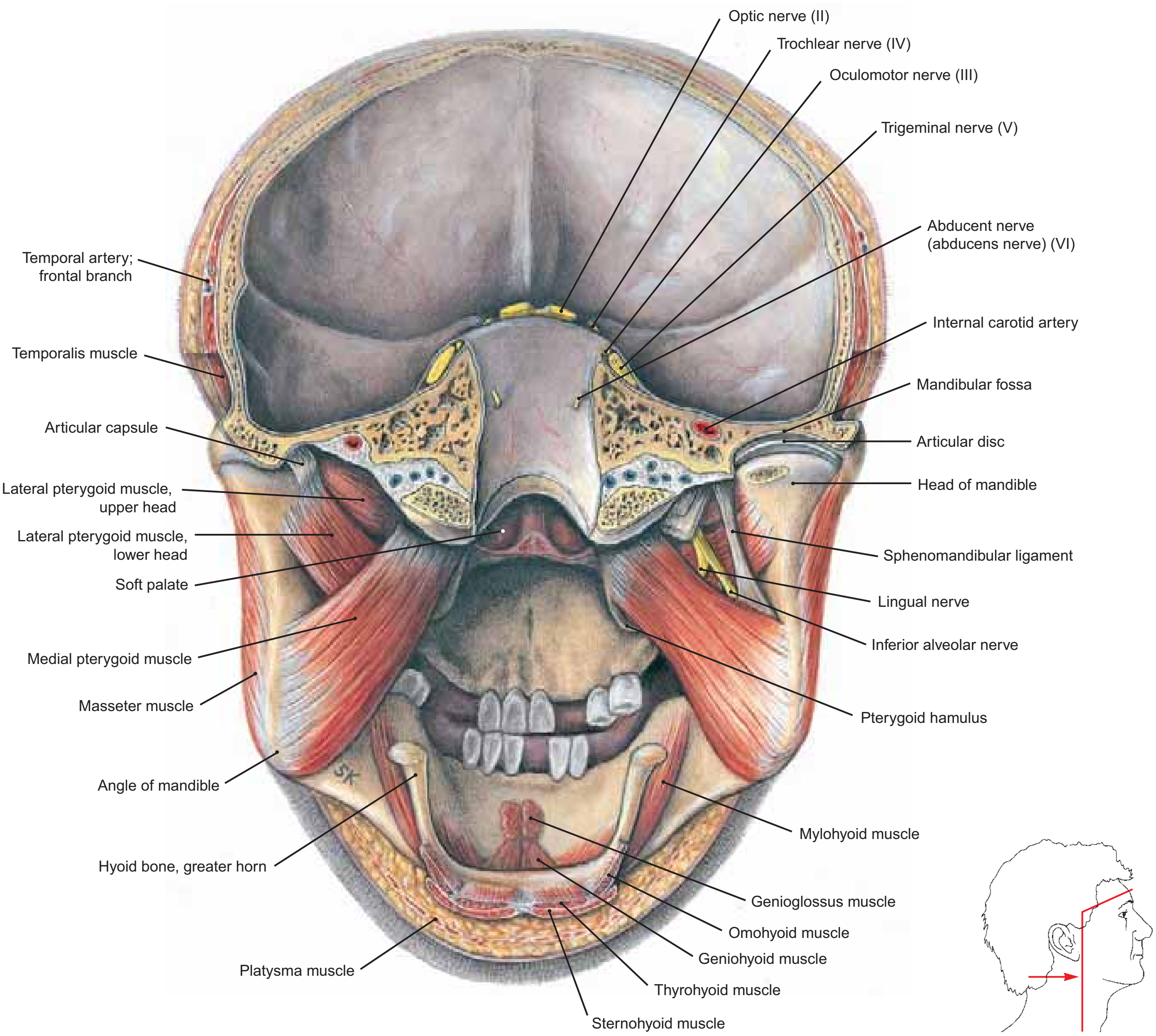


FIGURE 556 **Pterygoid, Mylohyoid, and Geniohyoid Muscles as Seen from Below and Behind**

NOTE: (1) A muscular sling is formed around the ramus of mandible to its angle by the insertions of the **medial pterygoid** and **masseter muscles** (seen on the left). The medial pterygoid muscle descends to attach along the medial aspect of the mandible, while the masseter courses down to insert on the outer aspect of the jaw.

(2) The fibers of the lateral pterygoid course principally in the horizontal plane. The **mylohyoid** and **geniohyoid muscles** attach the mandible to the hyoid bone. Other muscles shown are the **tensor** and **levator veli palatini muscles**.

MUSCLES OF MASTICATION (Continued)

Muscle	Origin	Insertion	Innervation	Action
Lateral pterygoid	**Superior head:** Infratemporal crest and lateral surface of greater wing of sphenoid bone **Inferior head:** Lateral surface of lateral pterygoid plate of sphenoid	Neck of condyle of mandible; articular disk and capsule of temporomandibular joint	Lateral pterygoid branch of mandibular nerve	Opens mouth by drawing condyle and disk forward Acting together: protrudes mandible Acting alternately: grinding action
Medial pterygoid	**Deep head:** Medial surface of lateral pterygoid plate of sphenoid; pyramidal process of palatine bone **Superficial head:** Pyramidal process of palatine bone; tuberosity of maxilla	Lower and posterior part of medial surface of ramus and angle of mandible	Medial pterygoid branch of mandibular nerve	Elevates mandible closing jaw Acting together: protrudes mandible Acting alone: protrudes one side Acting alternately: grinding action

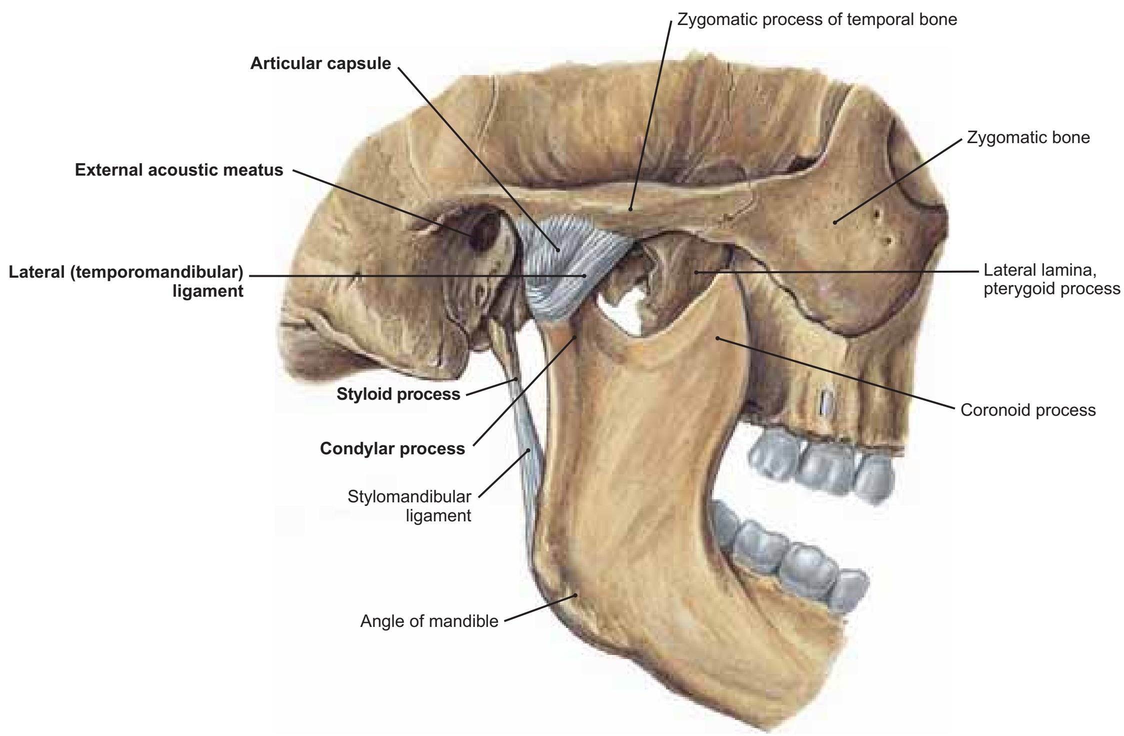


FIGURE 557.1 Right Temporomandibular Joint (Lateral View)

NOTE: (1) The articular capsule and the **lateral** (temporomandibular) **ligament** extend between the zygomatic process of the temporal bone above and the neck of the condylar process of the mandibular ramus below.

(2) The articular capsule is a loose sac that is fused anteriorly and laterally with the **lateral ligament.** Also note the **stylomandibular ligament** extending from the tip of the styloid process to the angle and posterior border of the mandible.

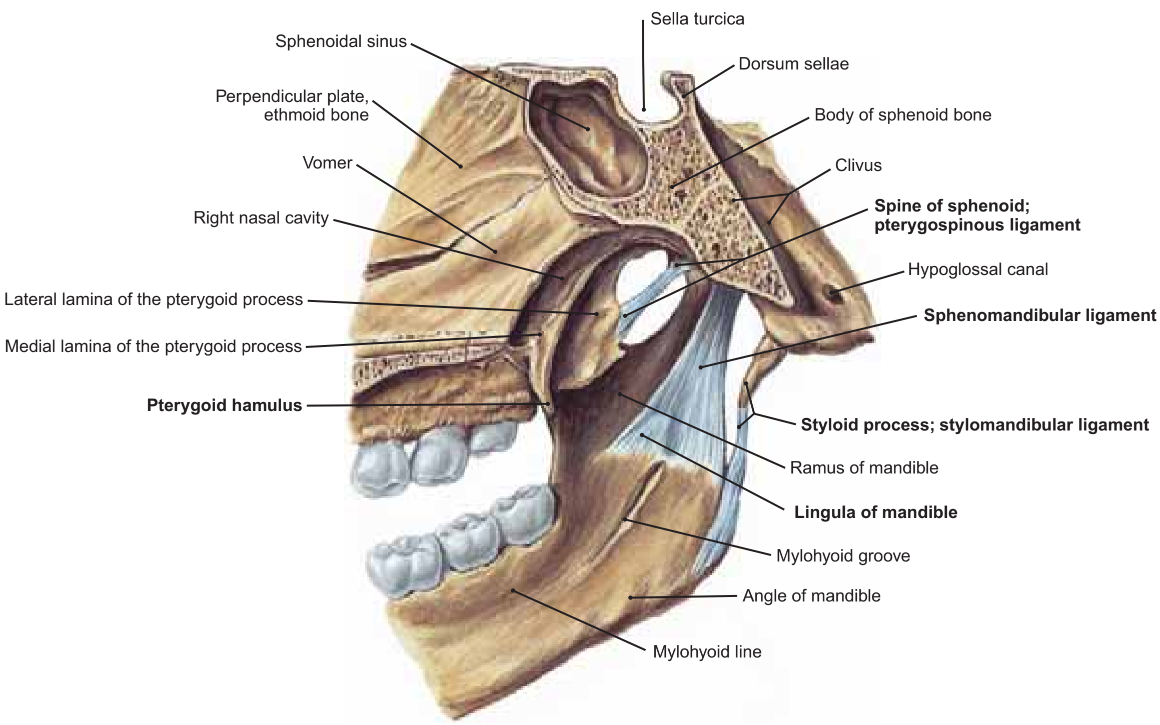


FIGURE 557.2 Right Temporomandibular Region (Medial View)

NOTE: Medial to the temporomandibular joint, the **pterygospinous ligament** extends from the sphenoidal spine to the posterior margin of the lateral pterygoid plate. The **sphenomandibular ligament** descends from the sphenoidal spine to the lingula of the mandible.

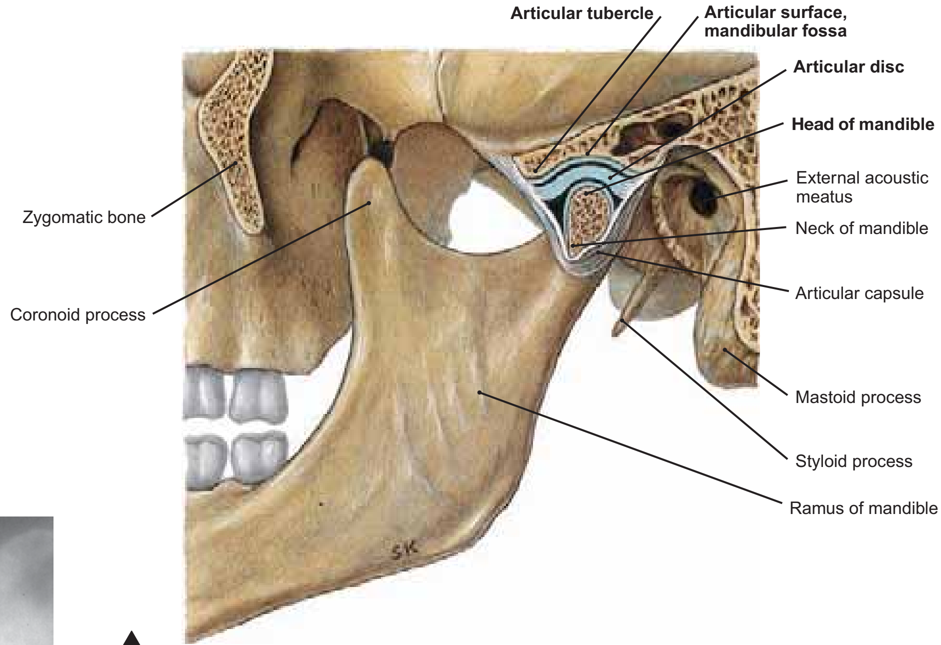


FIGURE 558.1 Sagittal Section of the Temporomandibular Joint with the Jaw Closed

NOTE: (1) An **articular disk** is interposed between the mandibular fossa of the temporal bone and the mandibular condyle, creating two joint cavities.

(2) With the jaw closed, the head of the condyle of the mandible and the articular disk lie totally within the mandibular fossa.

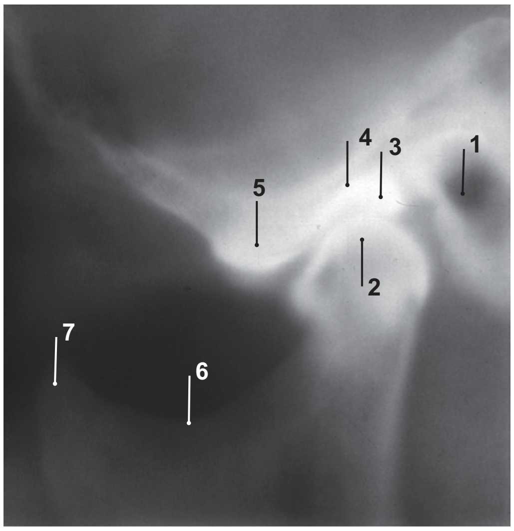


FIGURE 558.2 Arthrograph of the Temporomandibular Joint with the Jaw Closed

Key for Figures 558.2 and 558.4

1. External acoustic meatus
2. Condylar process
3. Articular disk
4. Mandibular fossa, temporal bone
5. Articular tubercle, temporal bone
6. Mandibular notch
7. Coronoid process

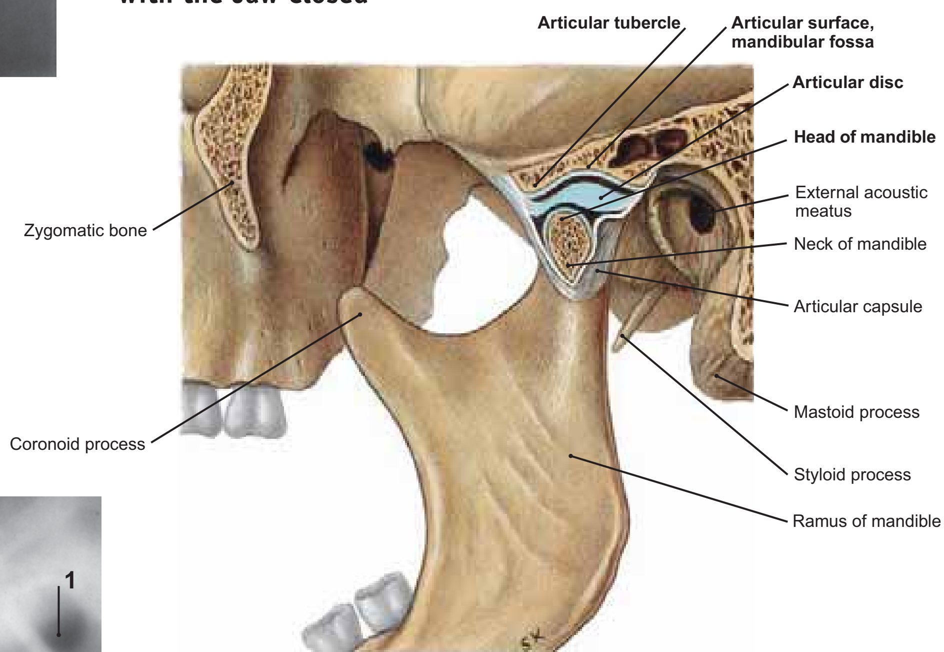


FIGURE 558.3 Sagittal Section of the Temporomandibular Joint with the Jaw Opened

NOTE: When the jaw is opened, the condyle **glides forward** within the joint capsule to lie opposite the **articular tubercle** of the temporal bone.

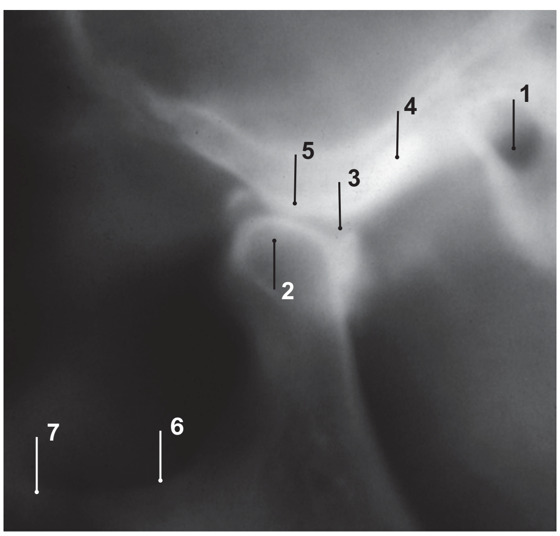


FIGURE 558.4 Arthrograph of the Temporomandibular Joint with the Jaw Opened

NOTE: The mandibular condyle moves forward significantly when the jaw is opened. In Figures 558.2 and 558.4, compare the distance between the condyle (2) and the external acoustic meatus (1).

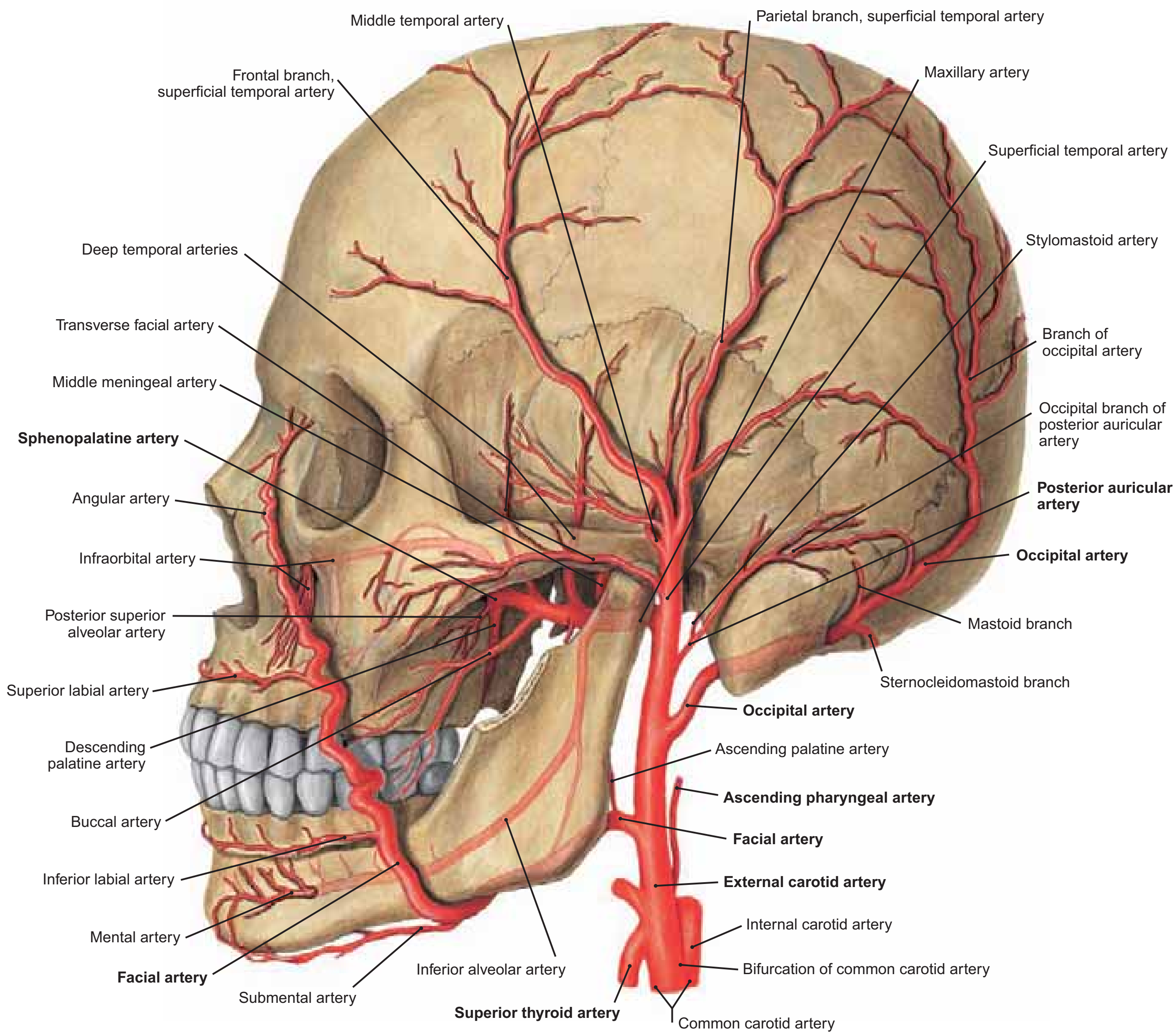


FIGURE 559 External Carotid Artery and Its Branches

NOTE: (1) The **external carotid artery** branches from the common carotid and is the principal artery that supplies the anterior neck, the face, the scalp, the walls of the **oral** and **nasal cavities**, the bones of the skull, and the dura mater, but not the orbit or brain.

(2) Its main branches from inferior to superior are:

(a) The **superior thyroid**, which courses downward to supply the thyroid gland. It also supplies the sternocleidomastoid and infrahyoid muscles and the inner aspect of the larynx by way of the **superior laryngeal artery**.

(b) The **ascending pharyngeal**, which ascends to supply the pharyngeal constrictor muscles and other small branches to the prevertebral muscles, middle ear, and dura mater.

(c) The **lingual**, which is the principal artery of the tongue. It also gives branches to suprahyoid muscles and the sublingual gland.

(d) The **facial**, which ascends to supply the anteromedial aspect of the face. It also gives branches to the palatine tonsil, the submandibular gland, and on the face, to both lips and the nose. It ends as the **angular artery**, which anastomoses with the infraorbital.

(e) The **occipital**, which courses to the back of the head to supply the scalp. On its way it sends branches to the sternocleidomastoid and other muscles and to the dura mater.

(f) The **posterior auricular**, which courses behind the external ear. It helps supply the scalp, the middle ear, and the external auricle.

(g) The **superficial temporal**, which supplies the side of the head and gives off the **transverse facial artery**, which courses across the face.

(h) The **maxillary**, which is the principal artery of the deep face. It has three parts and many branches. It supplies the tympanic membrane, gives rise to the **middle meningeal artery**, and supplies the muscles of mastication, all lower and some upper teeth, the infraorbital region, the hard and soft palate, and the walls of the nasal cavity.

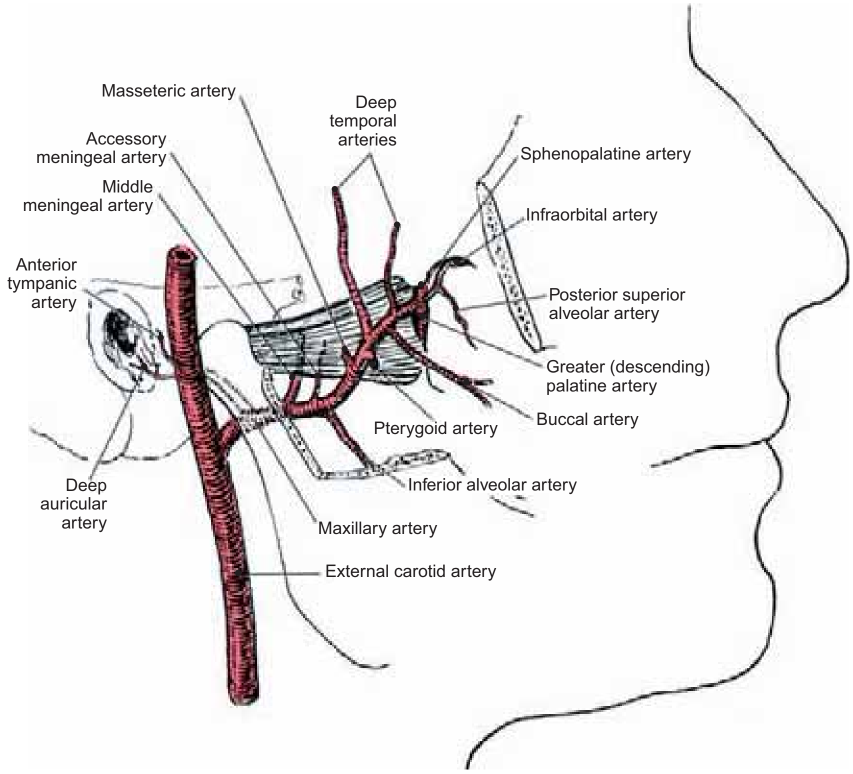


FIGURE 560.1 Branches of the Maxillary Artery (after Grant, J.C.B., Atlas of Anatomy, 6th Edition. Baltimore: Williams and Wilkins, 1972)

NOTE: Branches from the maxillary artery are given off from all three parts of the vessel: from the first part: **anterior tympanic, deep auricular, middle and accessory meningeal,** and **inferior alveolar;** from the second part: **masseteric, deep temporal, pterygoid,** and **buccal;** and from the third part: **sphenopalatine, infraorbital, greater (descending) palatine, posterior superior alveolar,** and **the artery of the pterygoid canal.**

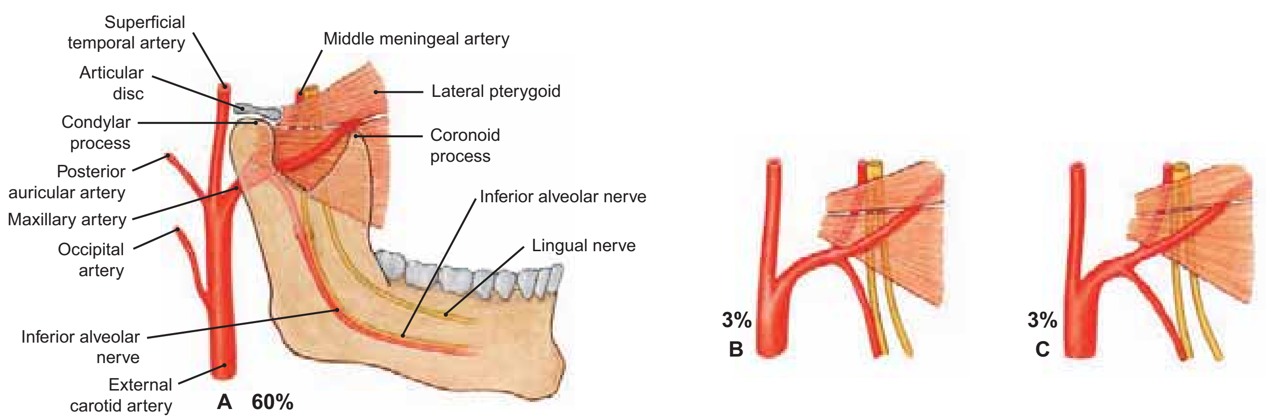


FIGURE 560.2 Variations in the Maxillary Artery Passing Lateral to the Lateral Pterygoid Muscle

NOTE: The maxillary artery courses lateral (superficial) to the lateral pterygoid muscle in about two-thirds of the cases. In 60% of these cadavers **(A)**, the middle meningeal artery arises proximal to the inferior alveolar artery. In 3% of these cadavers **(B)**, the middle meningeal artery arises opposite the inferior alveolar artery. In 3% of these cadavers **(C)**, the middle meningeal artery arises distal to the inferior alveolar artery.

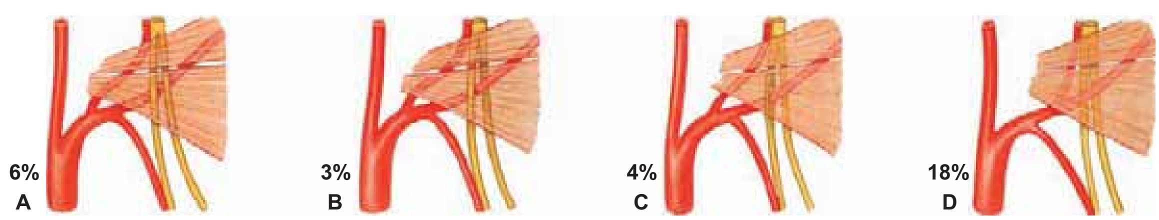


FIGURE 560.3 Variations in the Maxillary Artery Passing Medial to the Lateral Pterygoid Muscle

NOTE: The maxillary artery courses medial to the lateral pterygoid muscle in about 31% to 33% of cadavers. In **A**, the maxillary artery courses medial to the lingual and inferior alveolar nerves in 6%; in **B**, the maxillary artery courses between the lingual and inferior alveolar nerves in 3%; in **C**, the maxillary artery courses through a loop in the inferior alveolar nerve in 4%; and in **D**, the maxillary artery gives origin to the middle meningeal artery distal to the inferior alveolar artery.

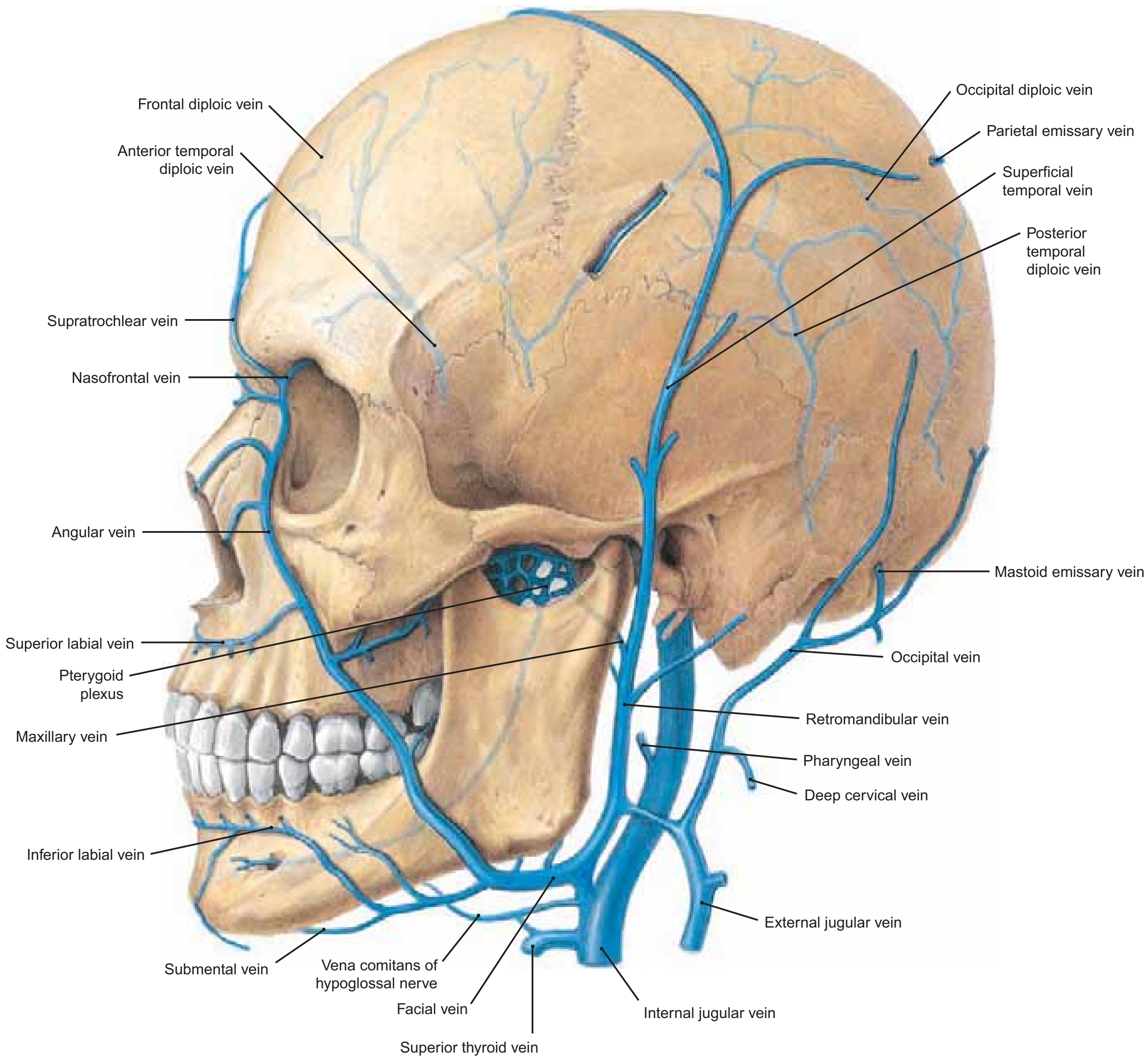


FIGURE 561 Principal Superficial Veins of the Face and Head, Showing Connections to Deeper Veins

NOTE: (1) The **angular vein** is formed at the root of the nose and courses inferolaterally to become the **facial vein**. The angular-facial trunk communicates by way of deeper vessels with the **cavernous sinus** within the cranial cavity and with **pterygoid plexus** of veins in the infratemporal fossa.

(2) The **superficial temporal vein**, which drains the lateral aspect of the superficial head and the **maxillary vein**, which drains the deep face. They join to form the **retromandibular vein**.

(3) The **occipital vein**, which forms on the posterolateral aspect of the scalp and which courses downward into the **external jugular vein**. The diploic veins and the various emissary veins (condylar, mastoid, and parietal veins) interconnect the superficial veins with the **dural sinuses**.

(4) Within the cranial cavity, the **sigmoid sinus**, draining most of the other dural sinuses, terminates at the jugular foramen. Just below this foramen, the sigmoid sinus becomes the **internal jugular vein**, which descends in the neck to the thorax.

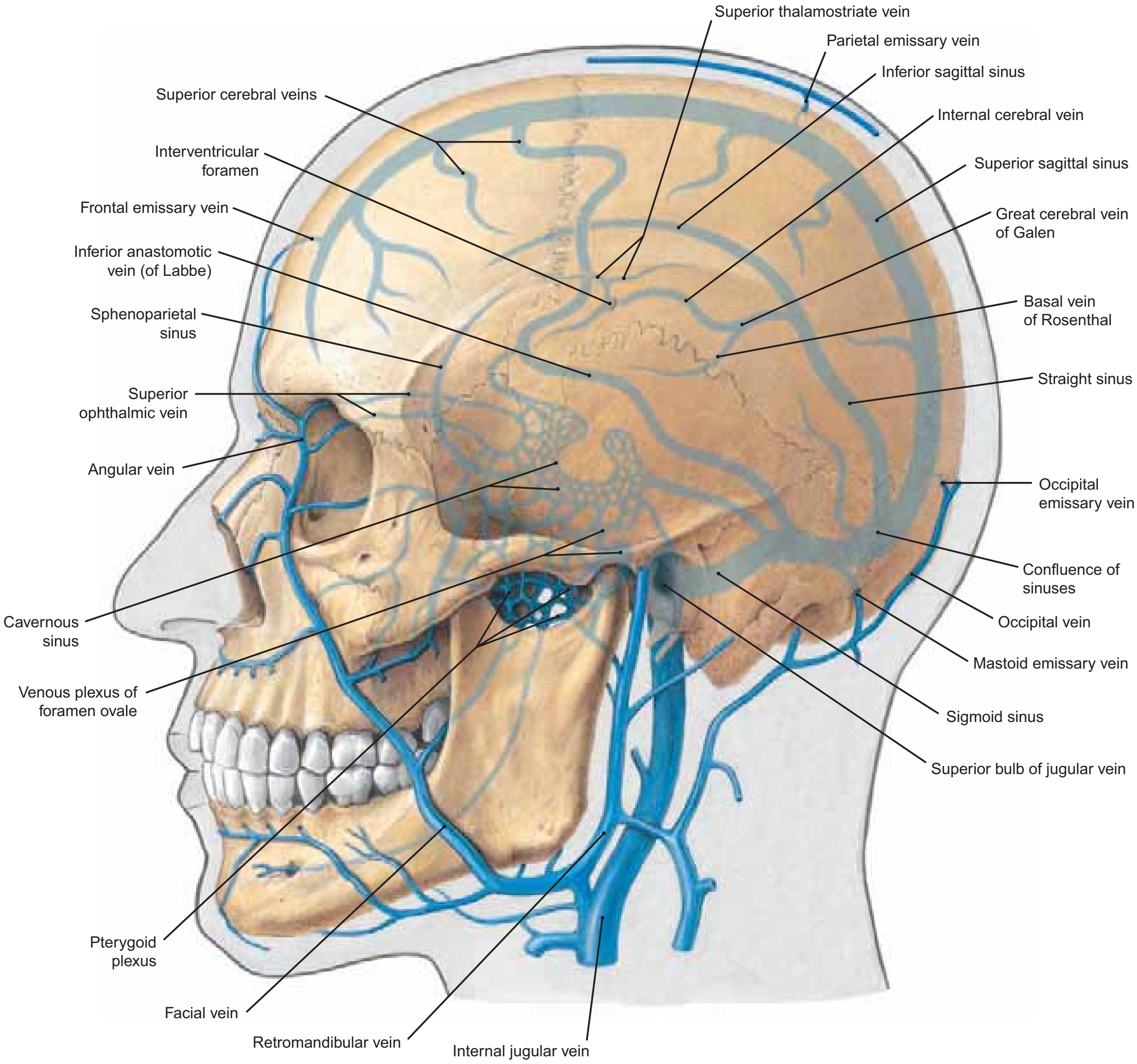


FIGURE 562 Internal Jugular Vein and Its Extracranial Tributaries

NOTE: (1) The superficial face is drained by the **angular vein** and the **superior** and **inferior labial** veins. These flow into the large facial vein that descends obliquely adjacent to the facial (not shown) artery (see Fig. 563).

(2) The internal jugular vein forms at the base of the skull. Within the skull, blood in the **sigmoid sinus** drains through the jugular foramen, and as the sigmoid sinus emerges from the jugular foramen in the neck it becomes the **internal jugular vein**.

(3) Within the skull, observe the confluence of sinuses. This large venous channel receives blood from the **superior sagittal sinus**, the **straight sinus,** and **the inferior anastomotic vein** (of Labbé).

(4) The **cavernous sinus** and its communications with the ophthalmic veins of the orbit and the pterygoid plexus of veins in the deep face.

(5) The many emissary veins passing through the skull and forming many connections between the dural sinuses and the veins on the exterior of the skull.

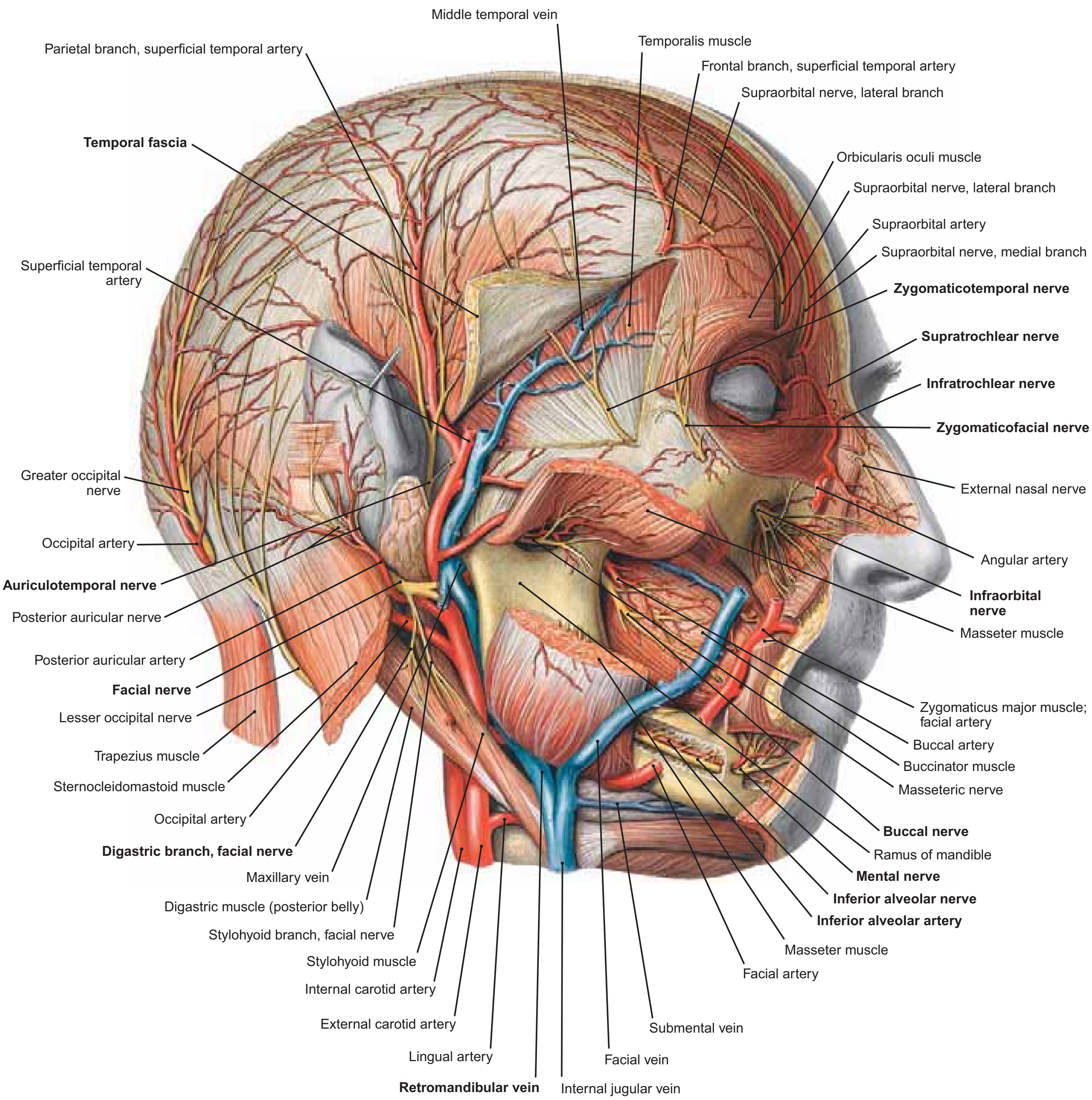


FIGURE 563 Vessels and Nerves of the Deep Face (Dissection 1)

NOTE: (1) The temporal fascia has been cut and partially reflected. The superficial muscles on the side of the face and the parotid gland have been removed. The main trunk of the facial nerve has been cut and its branches across the face removed. The masseter muscle was severed and reflected upward to show the masseteric artery and nerve.

(2) The following are branches of the **trigeminal nerve**:

(a) **Ophthalmic division:** supraorbital, supratrochlear, infratrochlear, and external nasal branches.

(b) **Maxillary division**: zygomaticotemporal, zygomaticofacial, and infraorbital branches.

(c) **Mandibular division:** auriculotemporal, masseteric, buccal, inferior alveolar, and mental branches.

(3) The posterior auricular, digastric, and stylohyoid branches of the facial nerve arise from the facial nerve trunk prior to its division within the parotid gland.

(4) The anastomosis of arteries above and at the medial aspect of the orbit. The vessels involved include the frontal branch of the superficial temporal, the supraorbital, supratrochlear, and angular arteries and their branches.

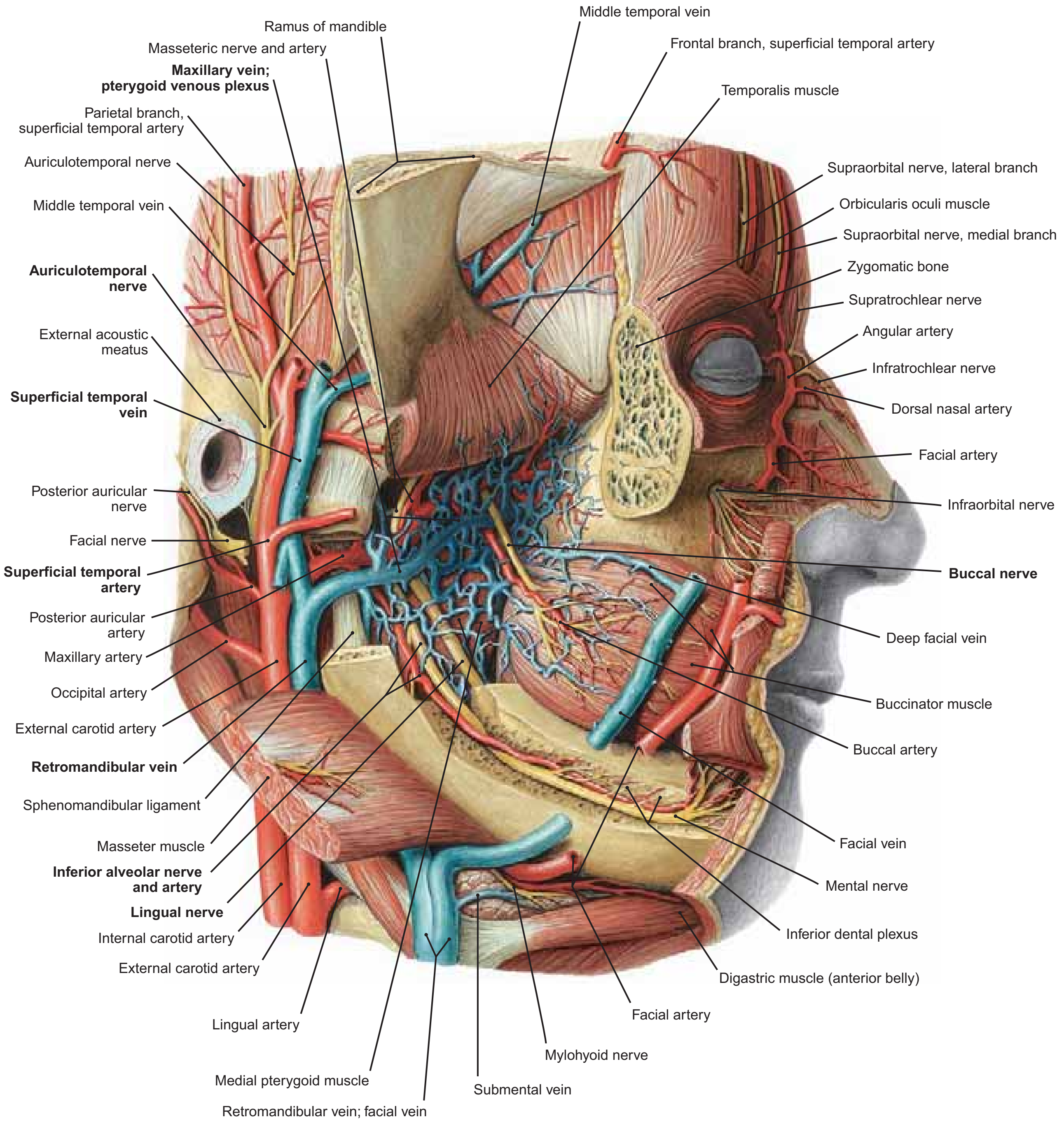


FIGURE 564 Infratemporal Region of the Deep Face (Dissection 2)

NOTE: (1) The zygomatic arch has been cut and reflected upward along with the insertion of the temporalis muscle. A portion of the mandible has also been removed to show the course of the **maxillary vein** and **artery** deep to the mandible. The branches of the artery in the infratemporal region can better be seen in Figure 565.

(2) The maxillary vein forms from the **pterygoid plexus** of veins, which lies adjacent to the pterygoid muscles and which anastomoses with the facial vein by way of the **deep facial vein**. This plexus also anastomoses with the cavernous sinus through communicating veins in the foramen lacerum and foramen ovale and by way of the inferior ophthalmic vein.

(3) The body of the mandible has been opened to expose the inferior alveolar artery and nerve.

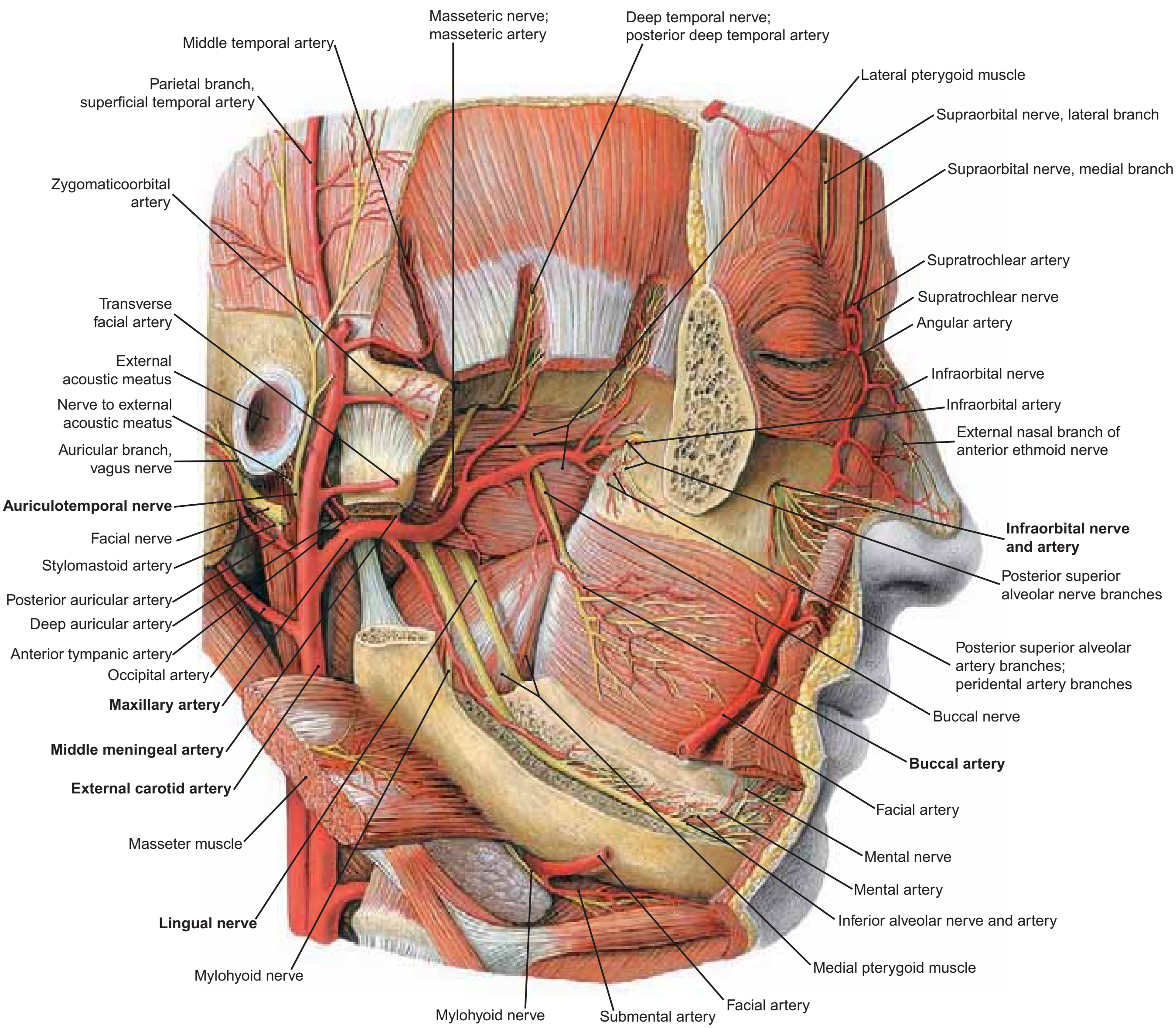


FIGURE 565 Infratemporal Region of the Deep Face: Maxillary Artery (Dissection 3)

NOTE: (1) The **infratemporal fossa** has been opened laterally to show the pterygoid muscles, the maxillary artery and its branches, and some of the branches of the mandibular division of the trigeminal nerve.

(2) In this dissection, the following branches of the **maxillary artery** are shown: (a) deep auricular, (b) anterior tympanic, (c) inferior alveolar, (d) middle meningeal, (e) masseteric (cut), (f) deep temporal, (g) pterygoid (not labeled), (h) buccal, (i) posterior superior alveolar, and (j) infraorbital. **NOT** shown in this view are the descending palatine branch, the artery of the pterygoid canal, and the pharyngeal and sphenopalatine branches.

(3) The following are branches of the **mandibular division** of the **trigeminal nerve:** (a) auriculotemporal, (b) lingual, (c) inferior alveolar, (d) mylohyoid, (e) masseteric, (f) deep temporal, and (g) buccal. Observe the course of the inferior alveolar nerve, accompanied by the inferior alveolar artery within the mandible.

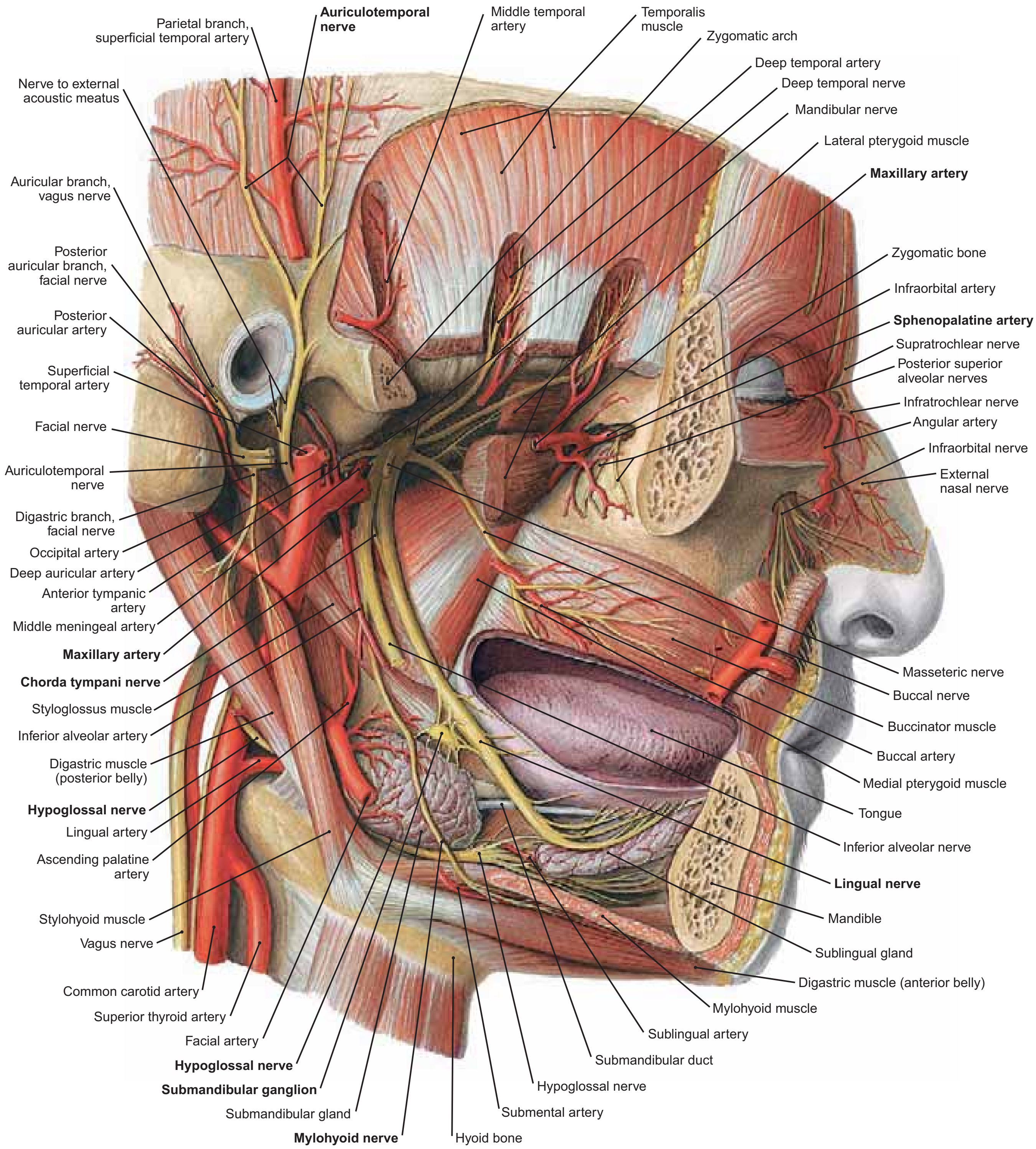


FIGURE 566 Infratemporal Region of the Deep Face: Mandibular Nerve Branches (Dissection 4)

NOTE: (1) The zygomatic arch, much of the right mandible, and the lateral pterygoid muscle have been removed in this dissection. Also, a portion of the maxillary artery has been cut away, along with the distal part of the inferior alveolar nerve beyond the point where the mylohyoid nerve branches.

(2) The **lingual nerve** coursing to the tongue. High in the infratemporal fossa, the **chorda tympani nerve** (a branch of the facial) joins the lingual. The chorda tympani carries both special sensory **taste** fibers from the anterior two-thirds of the tongue and **preganglionic parasympathetic** fibers from the facial to the **submandibular ganglion**.

(3) The distal part of the maxillary artery as it courses toward the sphenopalatine foramen. After giving off the infraorbital artery, the sphenopalatine branch enters the nasal cavity through the foramen and serves as the principal vessel to the nasal mucosa.

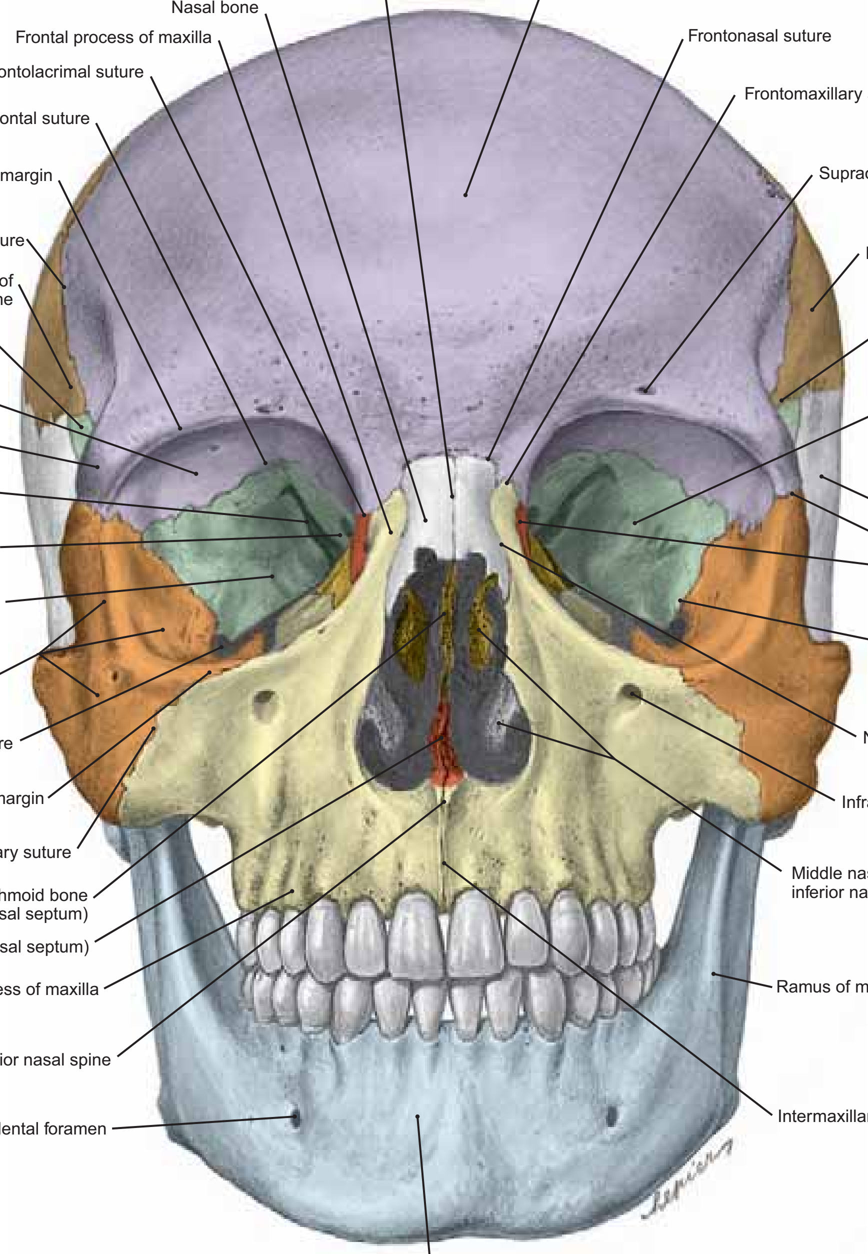


FIGURE 567.1 Anterior Aspect of the Skull

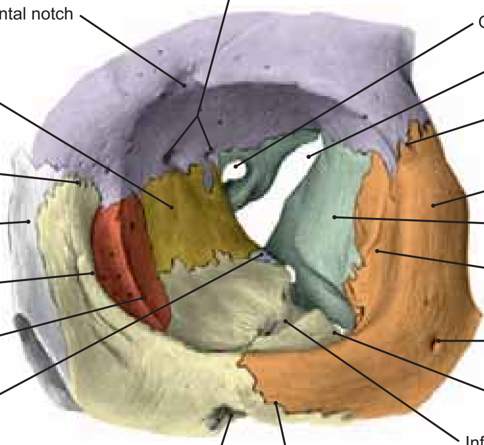


FIGURE 567.2 Left Bony Orbital Cavity (Anterior View)

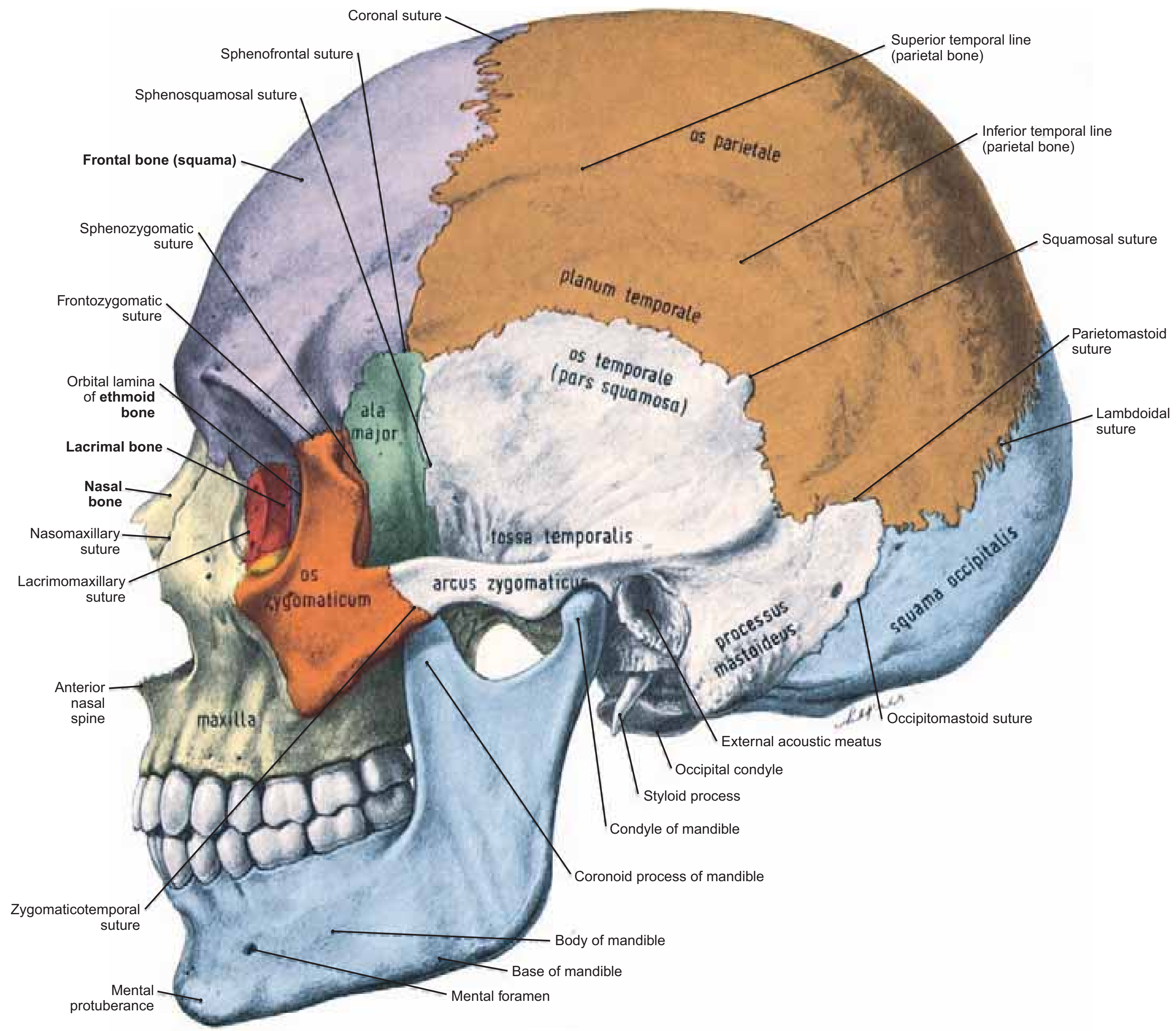


FIGURE 568.1 Lateral Aspect of the Skull

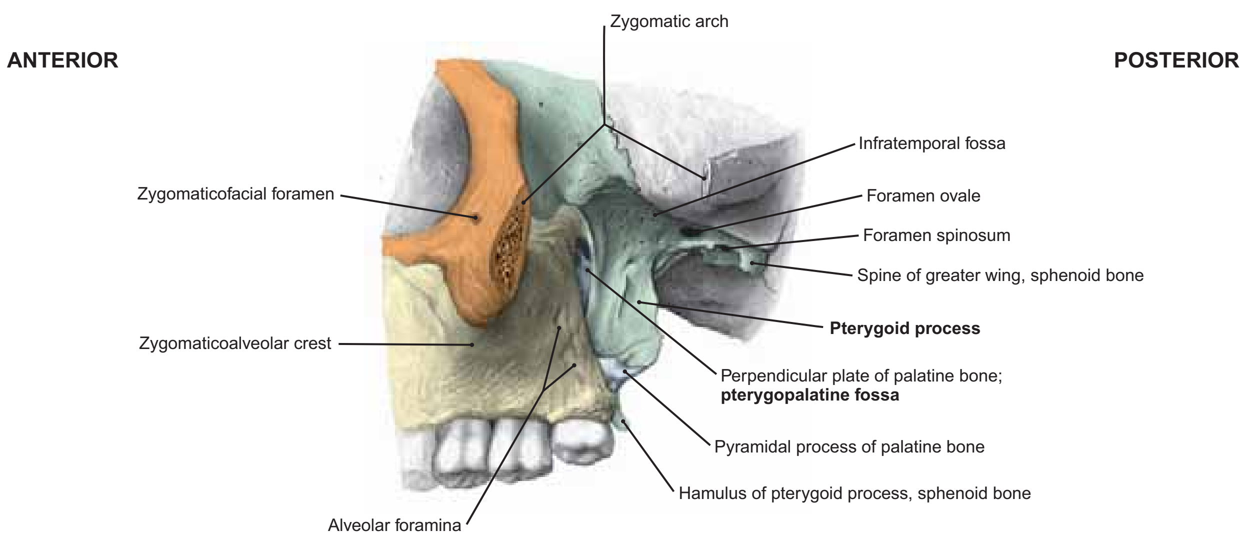


FIGURE 568.2 Inferolateral Aspect of the Skull with the Zygomatic Arch Removed

NOTE: The pterygopalatine fossa and the pterygoid process of the sphenoid bone.

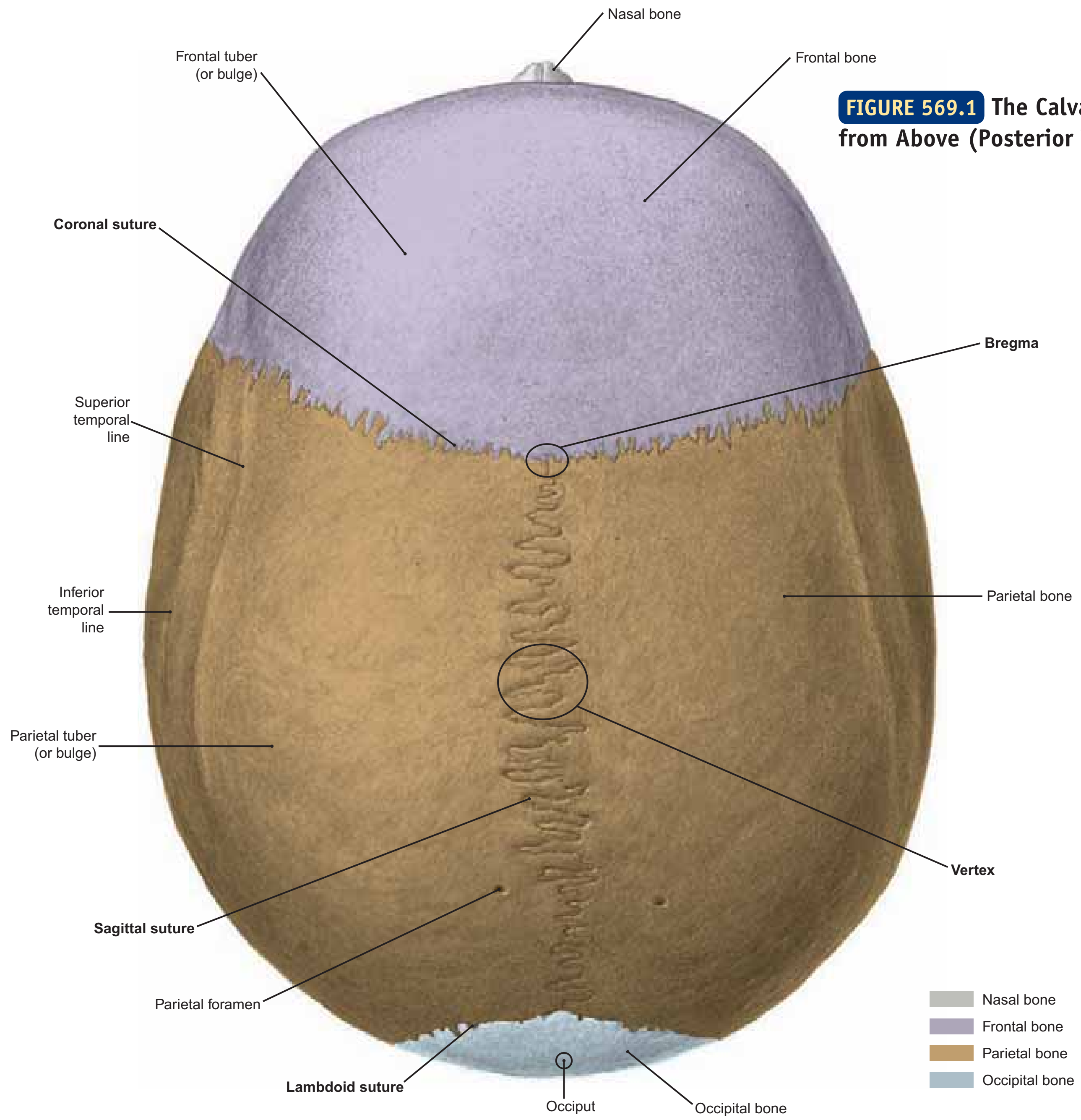


FIGURE 569.1 The Calvaria Seen from Above (Posterior View)

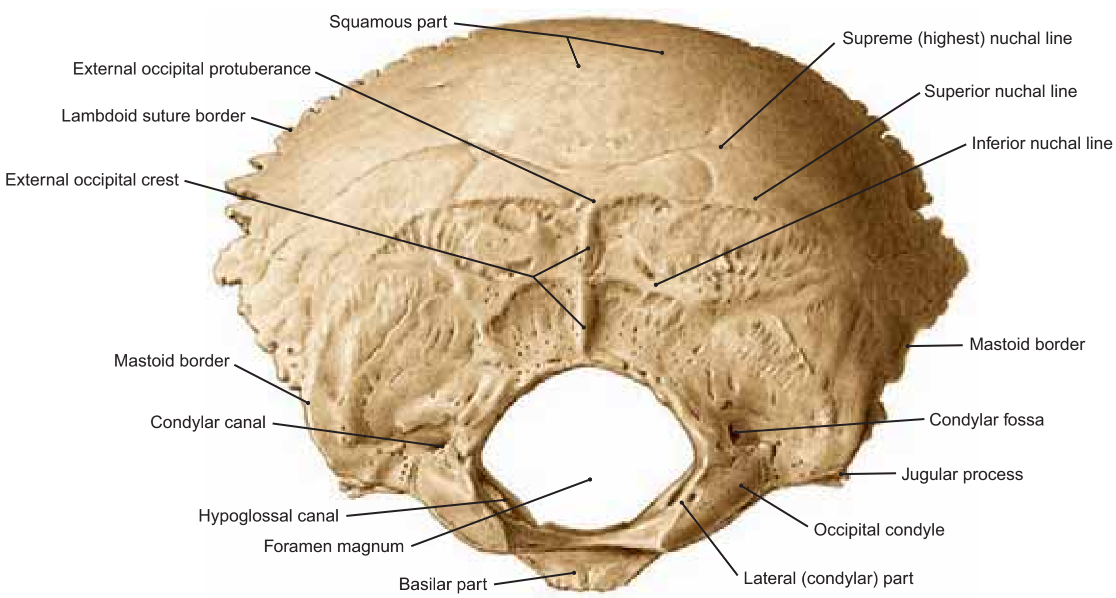


FIGURE 569.2 Occipital Bone from Behind Showing Some Posterior Features of the Skull

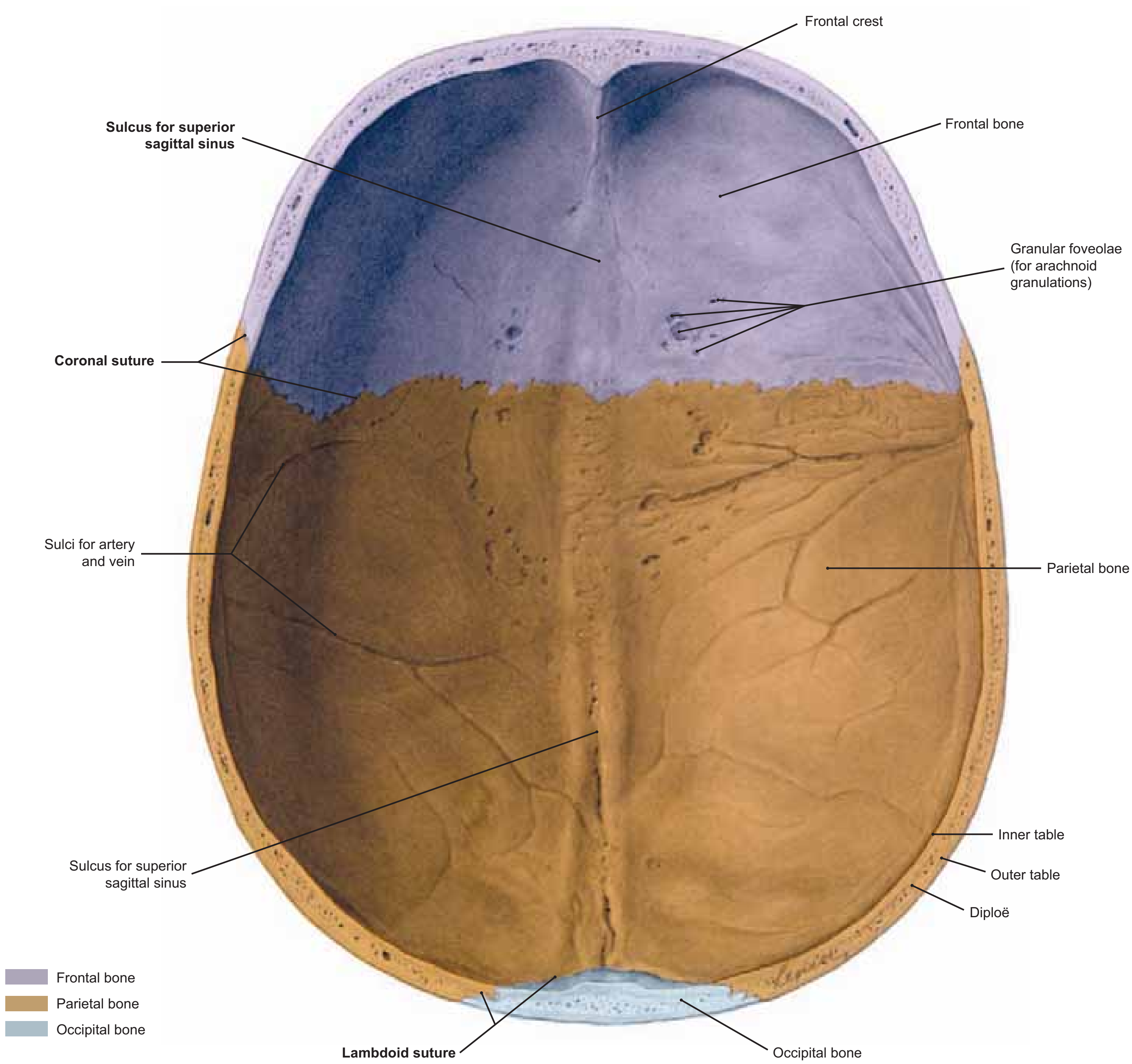


FIGURE 570.1 The Calvaria: Internal Surface (Seen from Above)

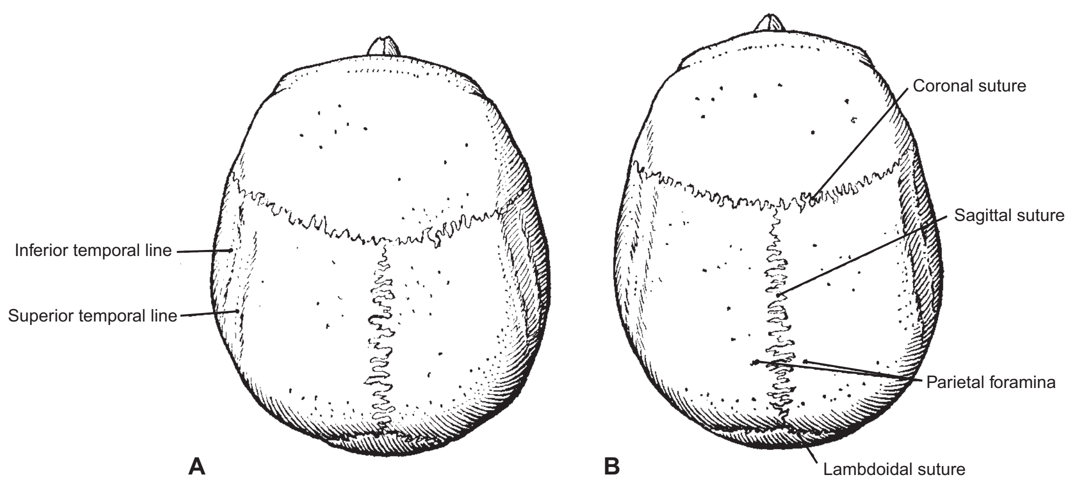


FIGURE 570.2 Brachycephalic Skull (A) and Dolichocephalic Skull (B)

NOTE: Skulls are classified by comparing their width to their length. When the greatest width exceeds 80% of the length, the skull is more round and called **brachycephalic (A)**. When the width is less than 75% of length, the more oblong skull is called **dolichocephalic (B)**. When the comparison is between 75% and 80%, the skull is classified as **mesaticephalic**.

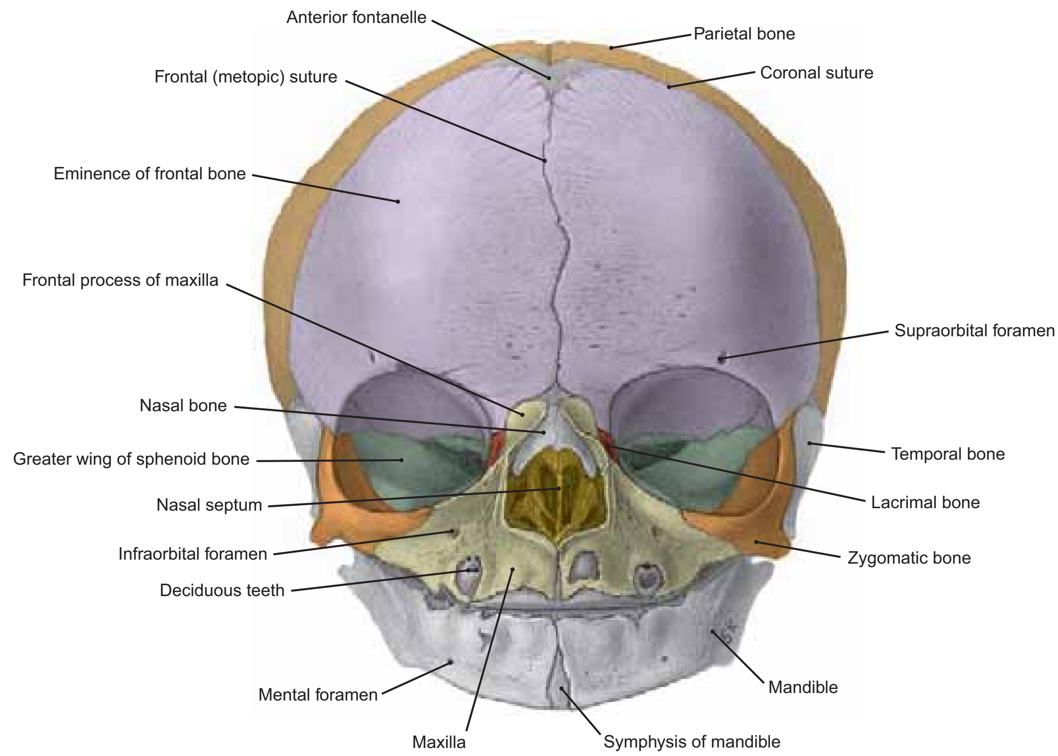


FIGURE 571.1 Skull at Birth (Frontal View)

NOTE: (1) The bones that enclose the cranial cavity (neurocranium) include the **frontal, parietal, occipital, temporal** and **sphenoid bones,** and the **cribriform plate** of the **ethmoid bone**.

(2) The bones that form the face and hard palate and enclose the nasal cavity are the **mandible, maxilla, zygomatic, lacrimal, nasal** and **palatine bones**, **inferior concha,** most of the **ethmoid bone**, and the **vomer**.

(3) The skull at birth is large in comparison to the size of the rest of the body because of the precocious growth of the brain; the facial bones, however, are still not well developed.

(4) The maxilla and mandible are rudimentary at birth and the teeth have yet to erupt. In addition, the maxillary sinuses and nasal cavity are small, as are the frontal, ethmoid and sphenoid sinuses.

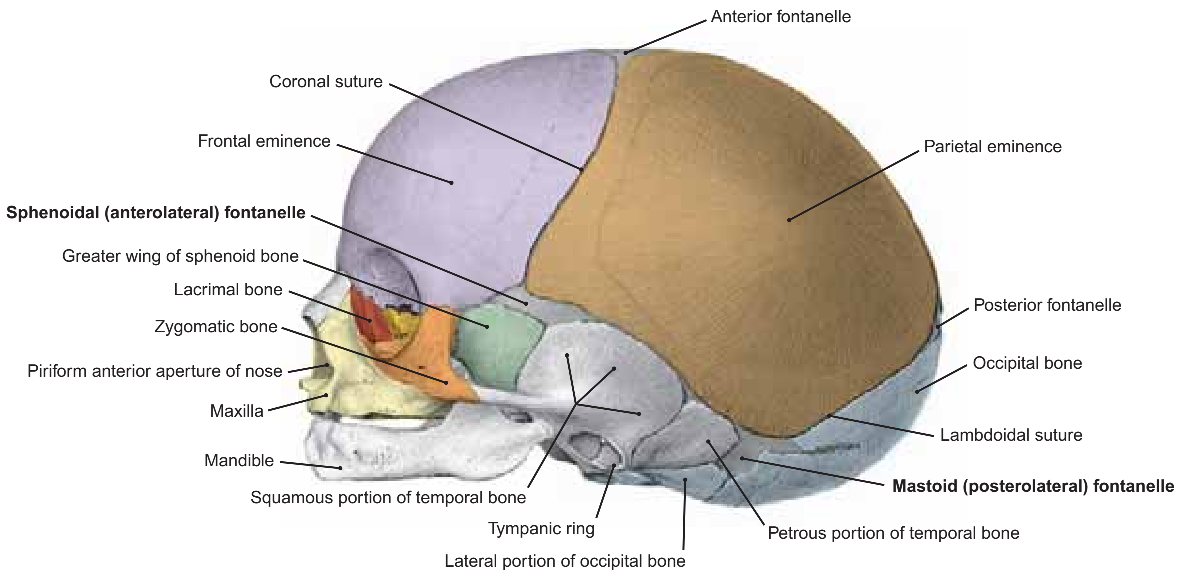


FIGURE 571.2 Skull at Birth (Lateral View)

NOTE: (1) Ossification of the maturing **flat bones of the skull** is accomplished by the intramembranous process of bone formation. At birth this process is incomplete, thereby leaving soft membranous sites between the growing bones. Bones forming the base of the cranial cavity develop by ossification in cartilage.

(2) The incompletely ossified nature of the skull just prior to birth is of some benefit, however, since the mobility of the bones permits changes in skull shape, as may be required during the birth process.

(3) The **sphenoidal** (or anterolateral) fontanelle located at the pterion and the **mastoid** (or posterolateral) found at the asterion.

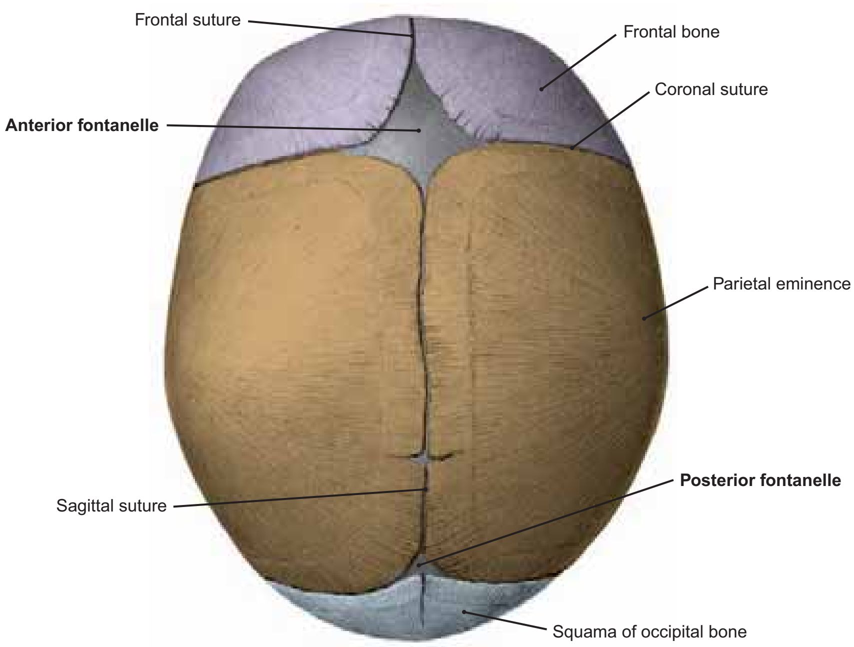


FIGURE 572.1 Skull at Birth (Seen from Above)

NOTE: (1) The soft sites on the skull of the newborn infant are called **fontanelles**. From this superior view can be seen the **anterior** and **posterior fontanelles**.

(2) The largest of the fontanelles at birth is the **anterior fontanelle** located at the bregma and interconnecting the frontal and parietal bones. It is approximately diamond-shaped and is situated at the junction of the coronal and sagittal sutures.

(3) Following the sagittal suture to its junction with the occipital bone will locate the **posterior fontanelle** (at the lambda). This is generally triangular in shape and is small at birth.

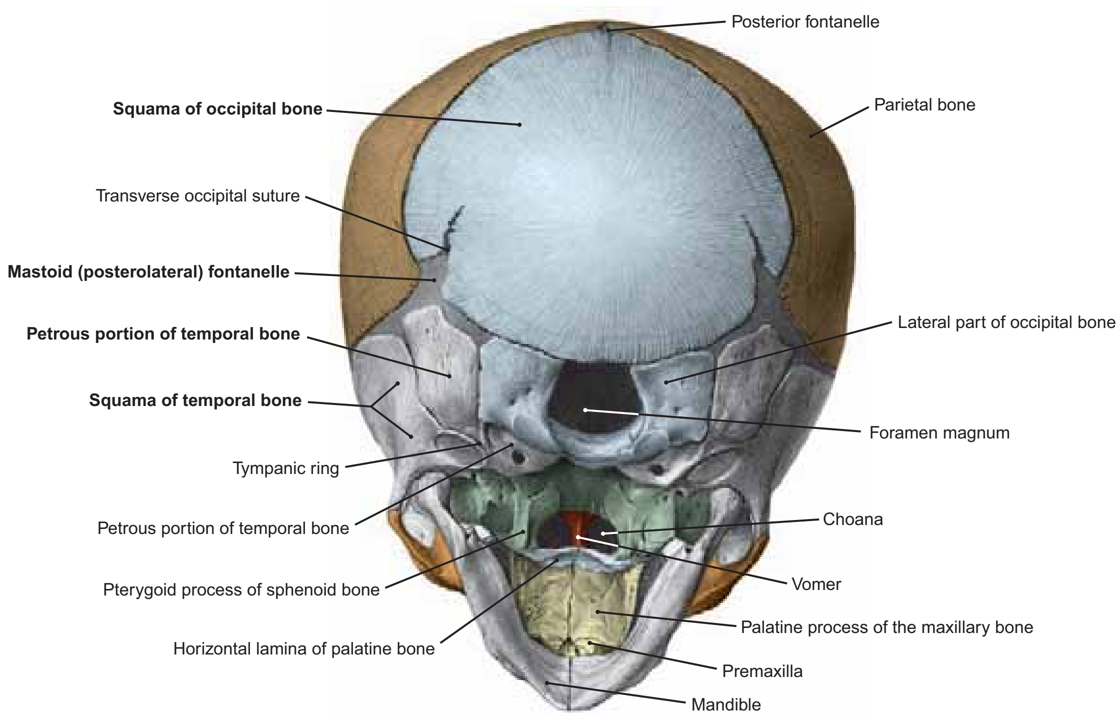


FIGURE 572.2 Skull at Birth (Posteroinferior View)

NOTE: (1) The separate ossification of the petrous and squamous portions of the temporal bone as well as the basilar and squamous parts of the occipital bone.

(2) The **mastoid** (posterolateral) **fontanelles** are found at the articulation of the occipital, temporal, and parietal bones.

(3) Growth and ossification of the bones that encase the brain are more precocious than the bones that form the facial skeleton. Facial bones continue growth through puberty. This differential accounts for the marked differences in facial features seen in a 4- or 5-year-old child with that same person at 15 or 16 years of age.

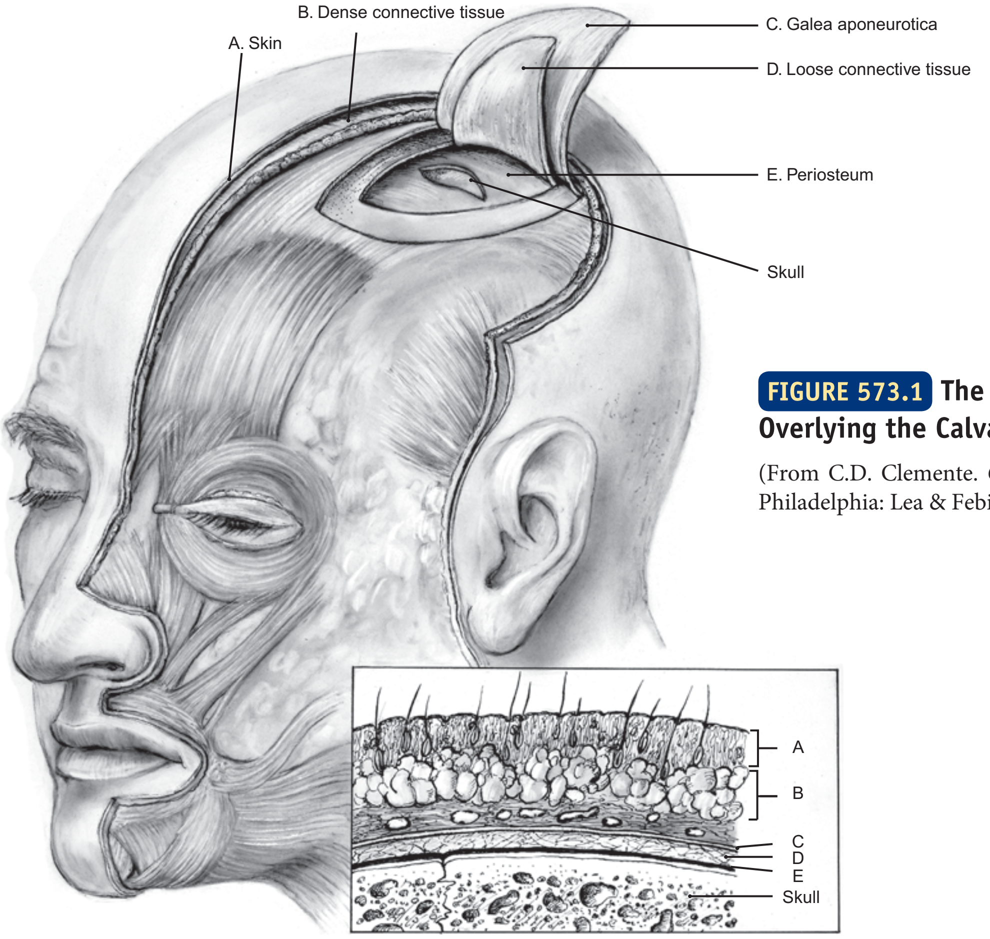


FIGURE 573.1 The Five Layers of the Scalp Overlying the Calvaria

(From C.D. Clemente. *Gray's Anatomy,* 30th American Edition. Philadelphia: Lea & Febiger, 1985.)

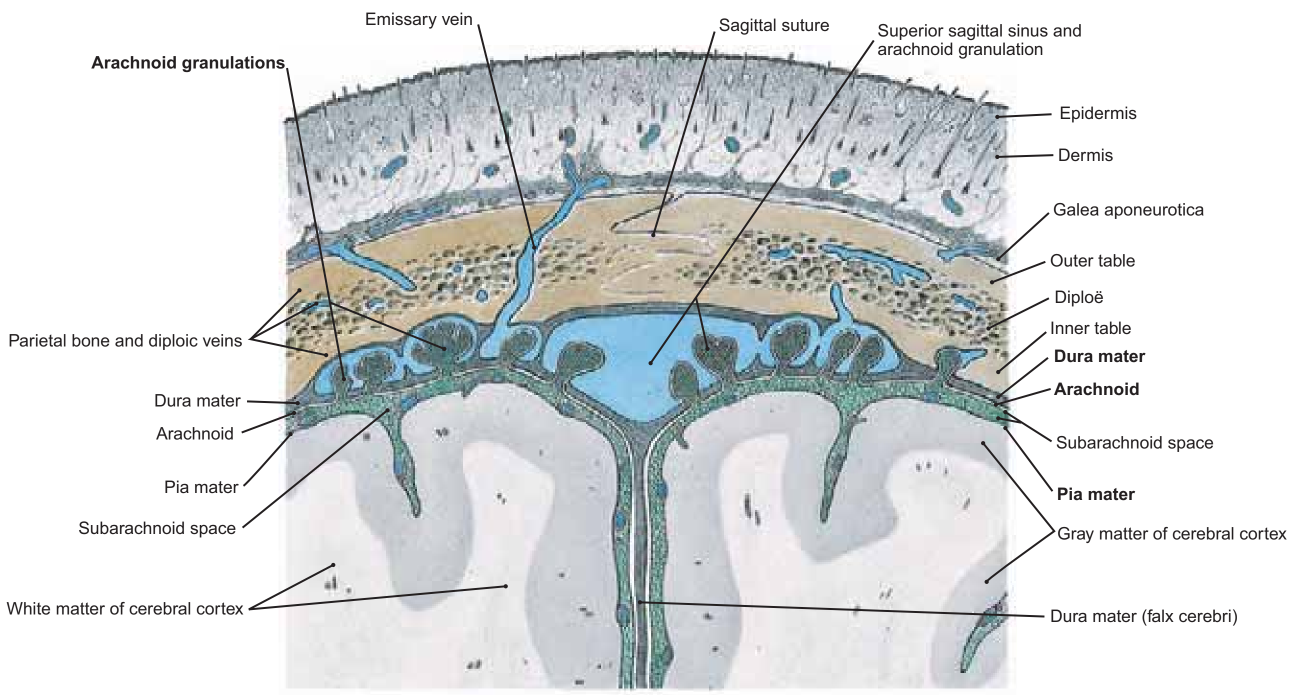


FIGURE 573.2 Scalp, Skull, Meninges, and Brain

NOTE: (1) This is a frontal section through the cranium and upper cerebrum and shows the bony and soft coverings of the brain. The veins and dural sinuses are colored in blue while the bone is light brown.

(2) Superficial to the dura mater, arachnoid, and pia mater that encase the neural tissue of the brain are found the bony skull and the layers of the scalp.

(3) The **arachnoid granulations**. Tufts of arachnoid (sometime called arachnoid villi) lie next to the endothelium of the sinuses and allow passage of the cerebrospinal fluid from the subarachnoid space into the venous system.

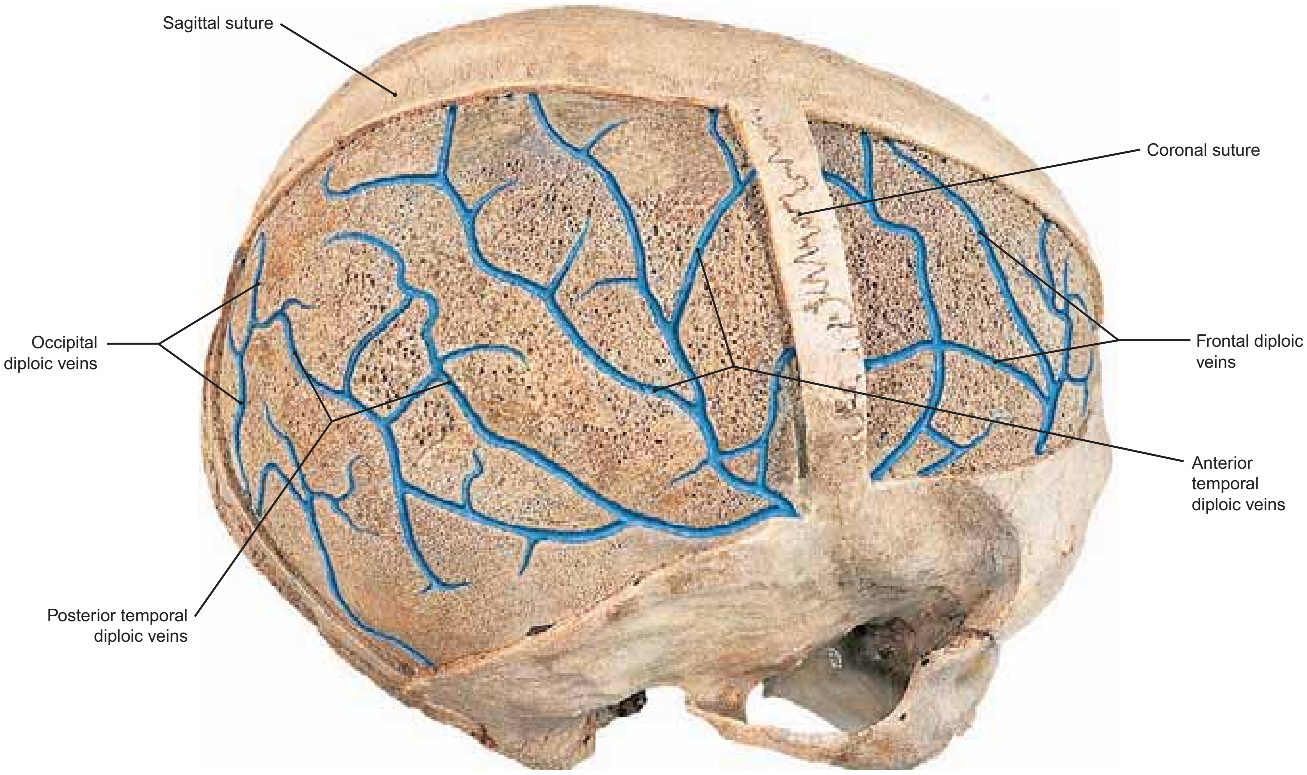
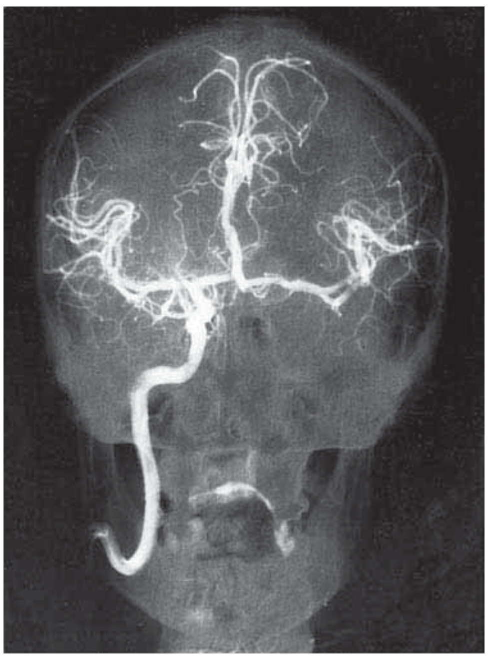


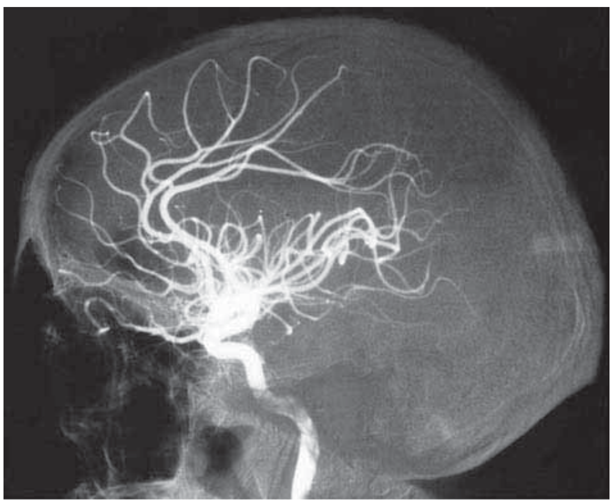
FIGURE 574.1 **Diploic Veins**

NOTE: (1) Removing the outermost table of compact bone reveals a more spongy layer of bone. Within this latter layer course venous channels called the **diploic veins**. These veins communicate with the scalp on the exterior and the dural sinuses within the skull.

(2) The diploic veins are named according to their location: **frontal, temporal,** and **occipital.**



A



B

FIGURE 574.2A and B **Radiograph Showing the Distribution of the Internal Carotid Artery**

NOTE: (1) Contrast medium injected into one internal carotid artery (in this case, the left artery) becomes distributed to both sides of the brain. This points to the fact that the contralateral side of the brain can receive blood when the medium is injected ipsilaterally.

(2) This occurs because of the vascular arrangement at the circle of Willis so that each carotid artery has some bilateral distribution.

(These radiographs were achieved with digital subtraction angiography, which diminishes all other tissues and concentrates on demonstrating [in this case] only the arterial tree.)

A. Anterior–posterior radiograph. **B.** Lateral radiograph.

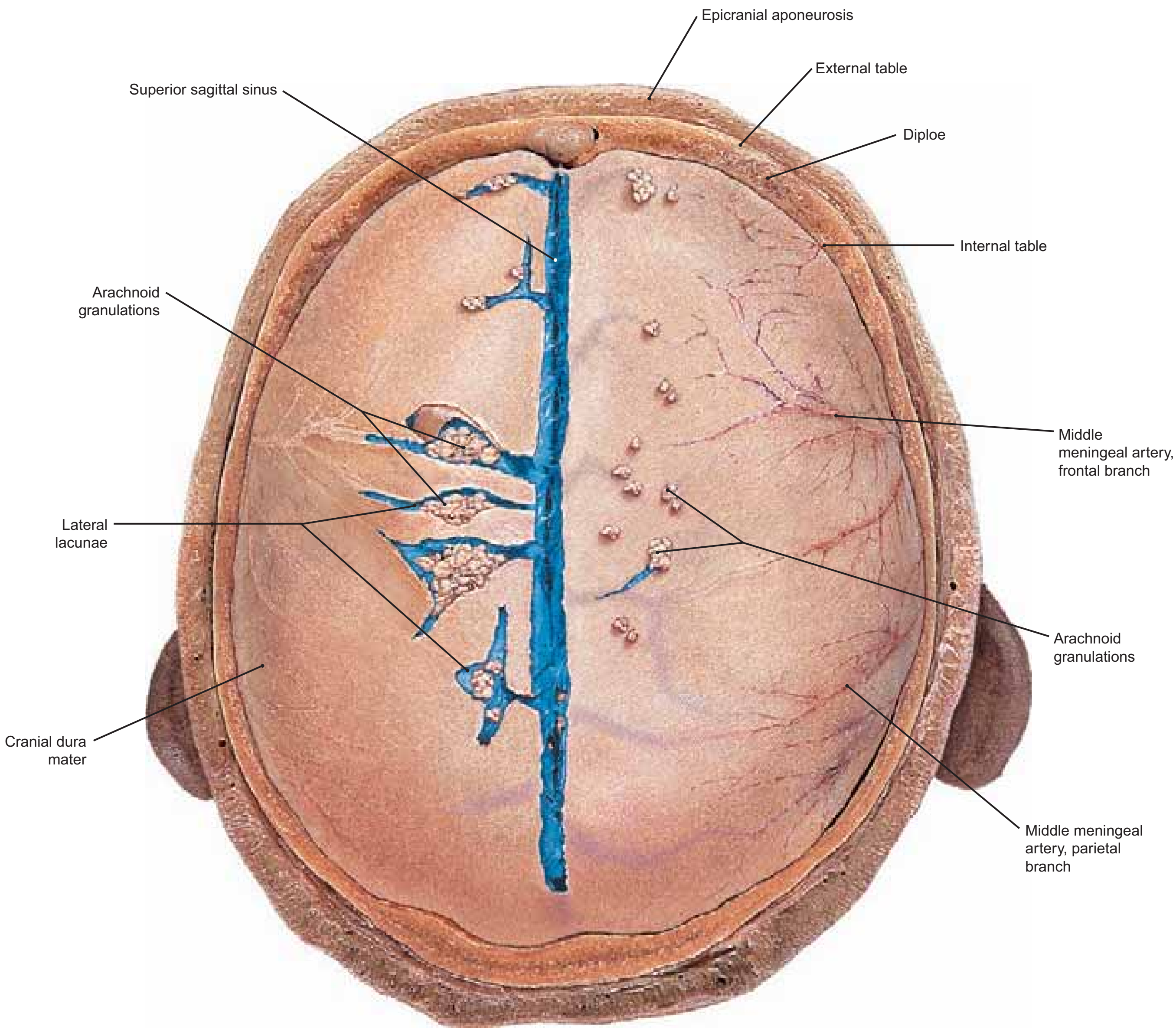


FIGURE 575 Surface of the Dura Mater with the Superior Sagittal Sinus Opened (Viewed from Above)

NOTE: (1) The skull cap (also called the **calvaria**) has been removed, leaving the **dura mater** intact. The dura is a two-layered structure (an inner **meningeal layer** and an outer **periosteal layer**), but these layers are inseparably fused throughout much of their expanse. In this dissection the "two layers" were stripped from the skull as a single membrane.

(2) In some regions, the meningeal and periosteal layers are separated to form the cavities for the **venous sinuses** in the dura mater. In this dissection the longitudinally oriented **superior sagittal sinus** has been opened, as have a number of lateral venous lacunae that communicate with this sinus.

(3) The **arachnoid granulations**. These are elevated bulbous protrusions of the arachnoid into the dura mater and, since they grow from infancy through childhood, they eventually form pits on the inner surface of the skull (see Fig. 570.1).

(4) The projections from the arachnoid are called **arachnoid villi** and appear as diverticula of the subarachnoid space into the venous sinuses. Cerebrospinal fluid passes from the subarachnoid space through the arachnoid villi into the venous blood of the dural sinus (see also Fig. 573.2).

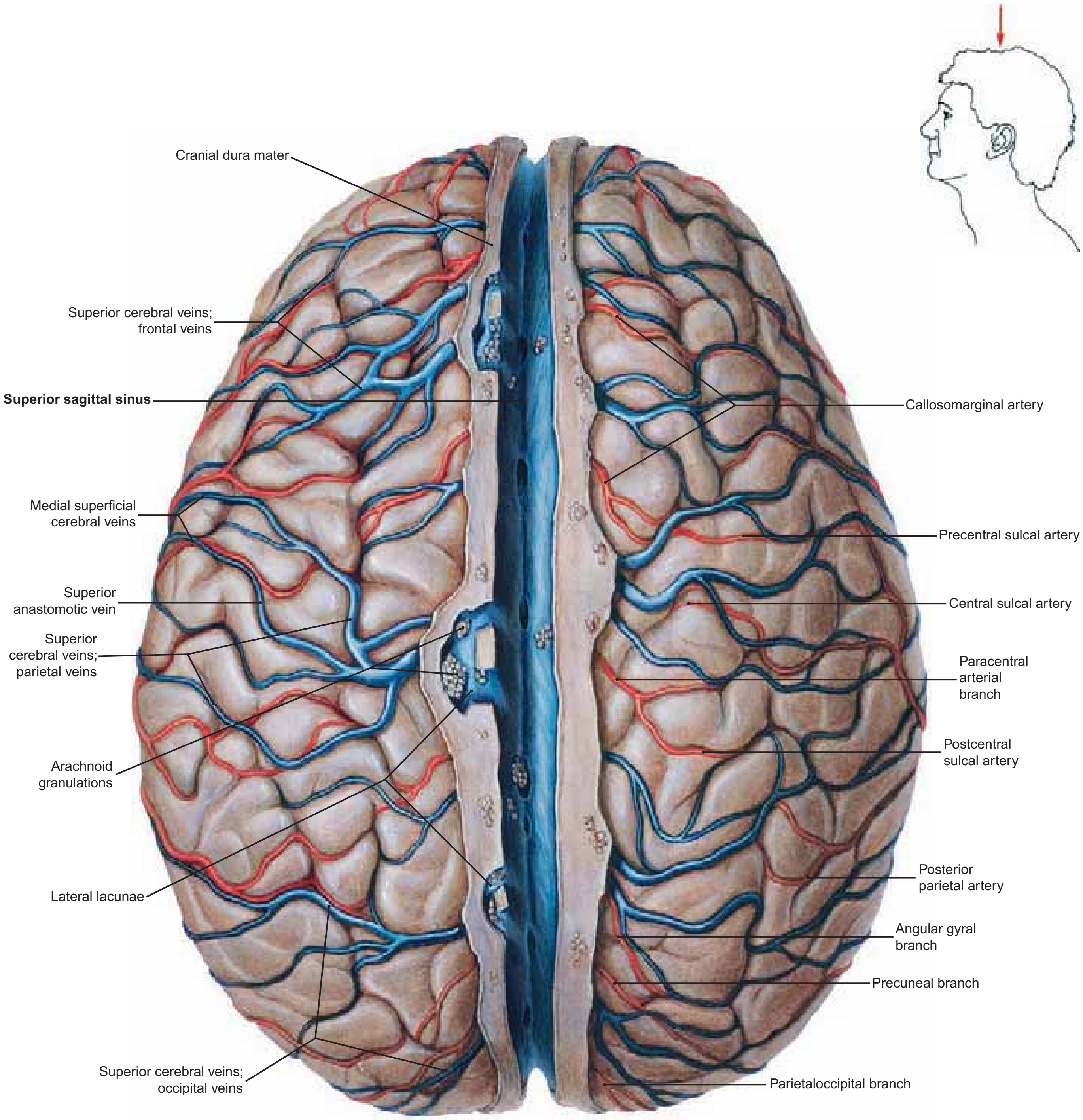


FIGURE 576 **Arteries and Veins on the External Surface of the Cerebral Cortex**

NOTE: (1) The **superior sagittal sinus** into which drain the superficial veins on the surface of the cerebral cortex.
(2) The **precentral, central, and postcentral sulcal arteries** that supply much of the parietal lobe of the cortex.
(3) The **arachnoid granulations** through which filters the cerebrospinal fluid that is returned to the venous system.

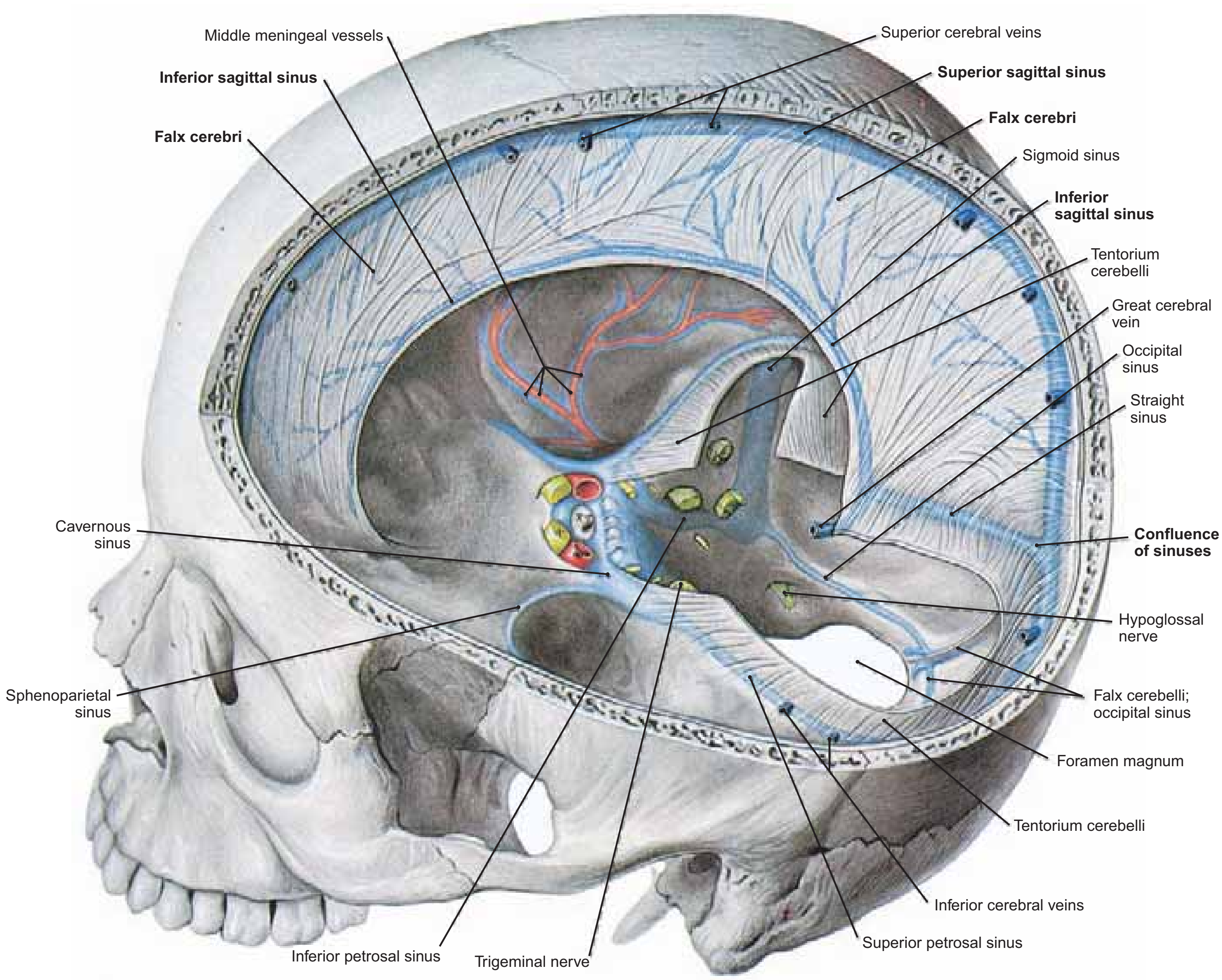


FIGURE 577 Intracranial Dura Mater and the Dural Sinuses

NOTE: (1) With the skull opened and the brain removed, the reflections of the dura mater are exposed. The sinuses are colored blue, the arteries red. Most of the left **tentorium cerebelli** and part of the right were cut away to open the posterior cranial fossa.

(2) The six **unpaired sinuses**: the **superior** and **inferior sagittal sinuses**, the **occipital sinus**, and the **straight sinuses**. Two other unpaired sinuses (not labeled) at the base of the skull are the **intercavernous** and **basilar sinuses**. These can be seen in Figure 578.

(3) The six **paired sinuses**: **transverse, sigmoid, superior** and **inferior petrosal, cavernous**, and **sphenoparietal**. The dural sinuses consist of spaces between the two layers of dura, which drain the cerebral blood, returning it to the **internal jugular vein**.

(4) The **sphenoparietal sinuses** course near the posterior margin of the lesser wings of the sphenoid bone and help form the boundary between the anterior and middle cranial fossae. Similarly, the **superior petrosal sinuses** course along the superior margins of the petrous parts of the temporal bone at the boundary between the middle and posterior cranial fossae.

(5) The sickle-shaped **falx cerebri**. This double-layered, midline reflection of dura mater extends from the crista galli anteriorly to the tentorium cerebelli posteriorly. It also extends vertically between the two cerebral hemispheres. Within the layers of the falx, observe the **superior** and **inferior sagittal sinuses** and the **straight sinus**, all of which flow into the **transverse sinus** or the **confluence of sinuses**.

(6) The **tentorium cerebelli** is a tentlike reflection of dura mater that forms a partition between the occipital lobes of the cerebral cortex and the cerebellum. The **falx cerebelli** extends vertically between the two cerebellar hemispheres.

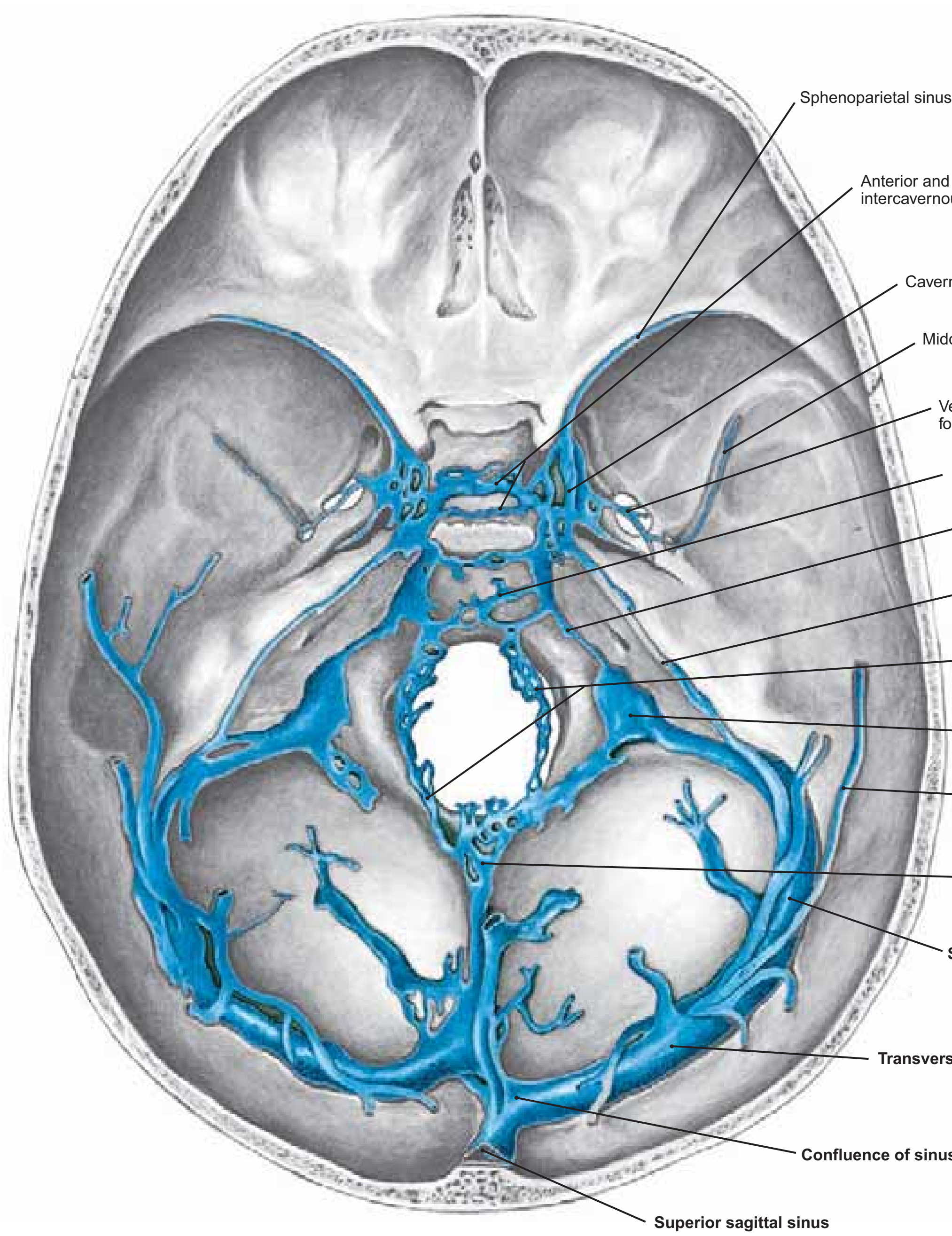


FIGURE 578 Dural Sinuses at the Base of the Cranial Cavity Seen from Above

NOTE: (1) The falx cerebri and the tentorium cerebelli and other dural reflections at the base of the cranial cavity have been removed to expose the venous sinuses from above.

(2) On both sides, the **transverse sinus** courses laterally from the **confluence of sinuses** and then continues as the **sigmoid sinus**. Just above the jugular foramen, the sigmoid sinus enlarges as the **superior bulb of the internal jugular vein**. Below the jugular foramen it becomes the **internal jugular vein** (see Fig. 562).

(3) Venous blood also flows to the transverse-sigmoid sinus from the **occipital sinus** and the **superior** and **inferior petrosal sinuses**. In addition, the **cavernous, intercavernous,** and **basilar sinuses** adjacent to the body of the sphenoid bone and the basilar part of the occipital bone also drain posteriorly and laterally into the sigmoid sinus at the jugular foramen.

(4) Anastomoses between these internal sinuses and the external veins occur through the various foramina, such as the superior orbital fissure (with the ophthalmic veins) and through the foramen lacerum and the foramen ovale (with the pterygoid plexus of veins). Other anastomoses occur with the cerebral, meningeal, and emissary veins.

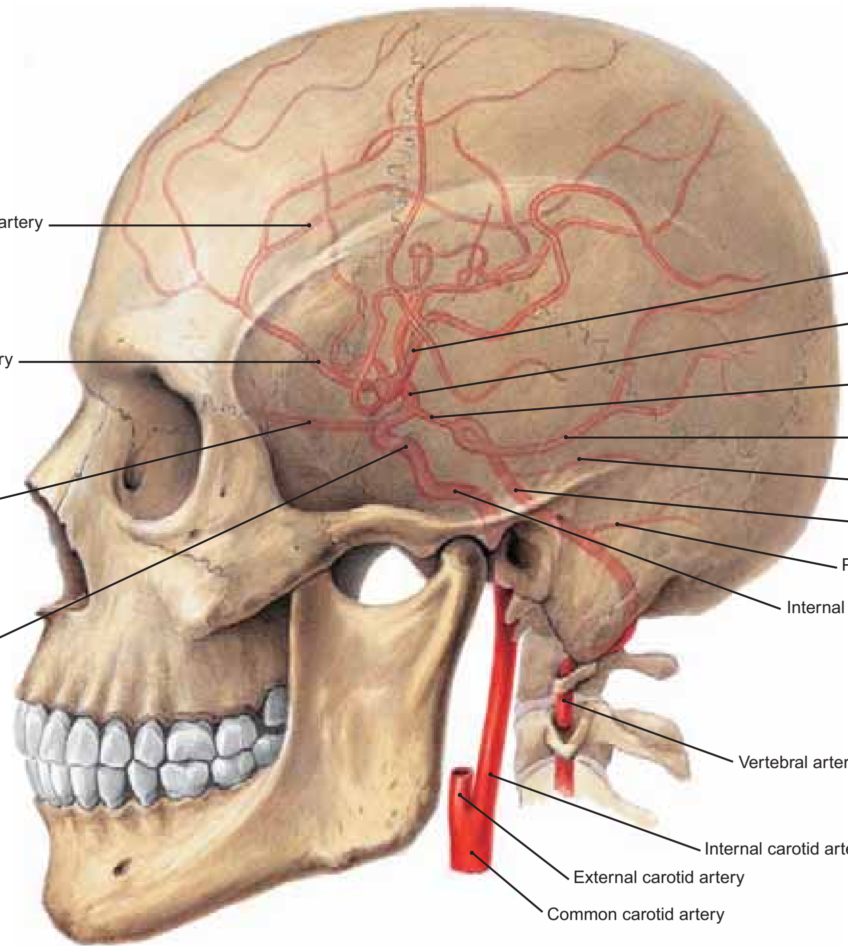


FIGURE 579.1 Internal Carotid and Vertebral Arteries: Intracerebral Branches

NOTE: The direct branches off of the internal carotid artery in the skull are the ophthalmic arteries; the anterior and middle cerebral arteries; and the posterior communicating branch to the circle of Willis.

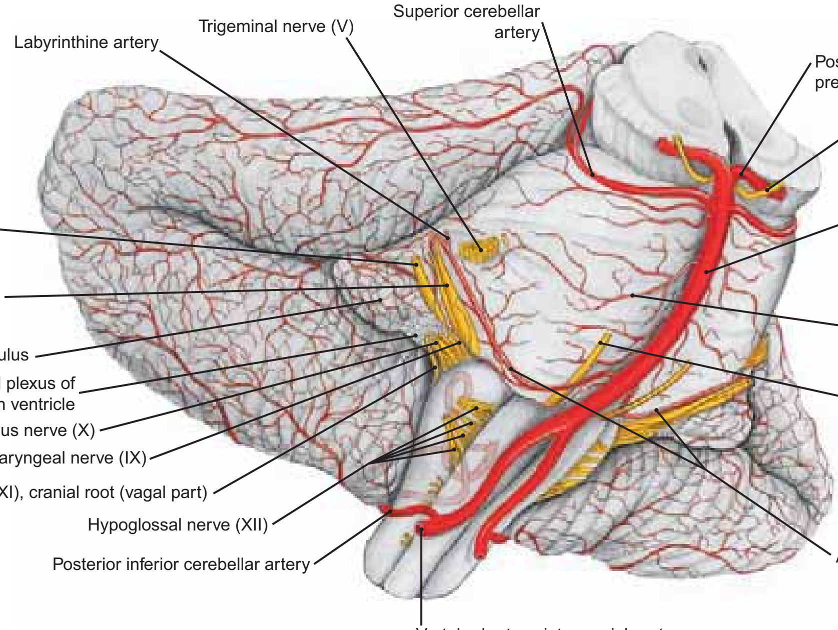


FIGURE 579.2 Basilar Artery and Its Branches

NOTE: The two vertebral arteries join to form the **basilar artery**, which ascends on the ventral surface of the brainstem. These vessels supply the cerebellum, medulla oblongata, pons, and posterior aspect of the cerebral cortex. The vertebral arteries also send descending branches to supply the spinal cord.

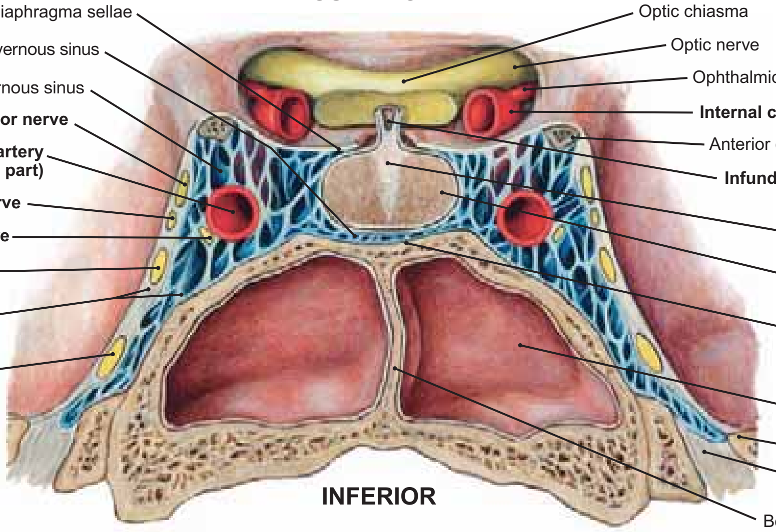


FIGURE 580.1 Frontal Section through the Cavernous Sinus and Base of the Skull Showing the Internal Carotid Artery

NOTE: (1) This is an anterior view of the cavernous sinus and shows the internal carotid artery (which is seen to have turned back on itself) and the oculomotor, trochlear, V_2, V_3, and abducens nerves all within the cavernous sinus.

(2) Upon traversing the carotid canal, the internal carotid artery courses anteriorly, medially, and superiorly to enter the cavernous sinus.

(3) **Within the sinus**, the artery initially courses forward (medial to the abducens nerve and the sphenoid bone, as shown in this figure). The vessel then curves superiorly and then posteriorly in a U-shaped manner and pierces the dura mater medial to the anterior clinoid process. At this site the **ophthalmic artery** branches from the main stem.

(4) The internal carotid artery then gives off the **anterior** and **middle cerebral arteries,** as shown in Figure 580.2.

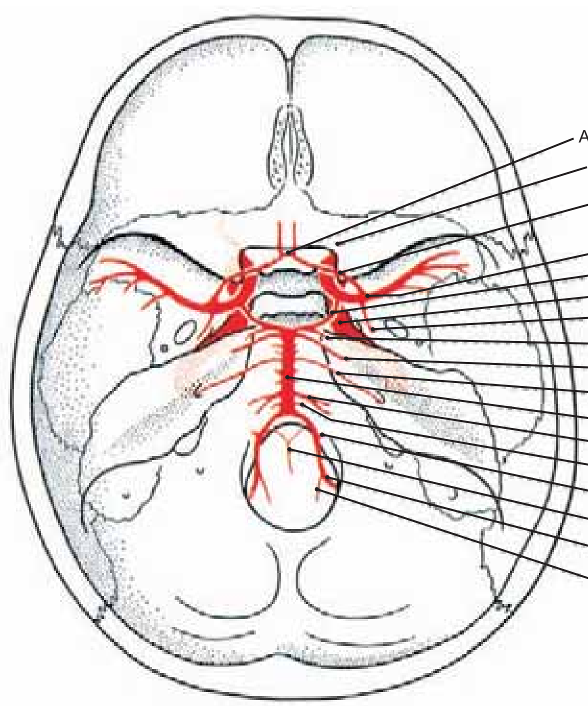
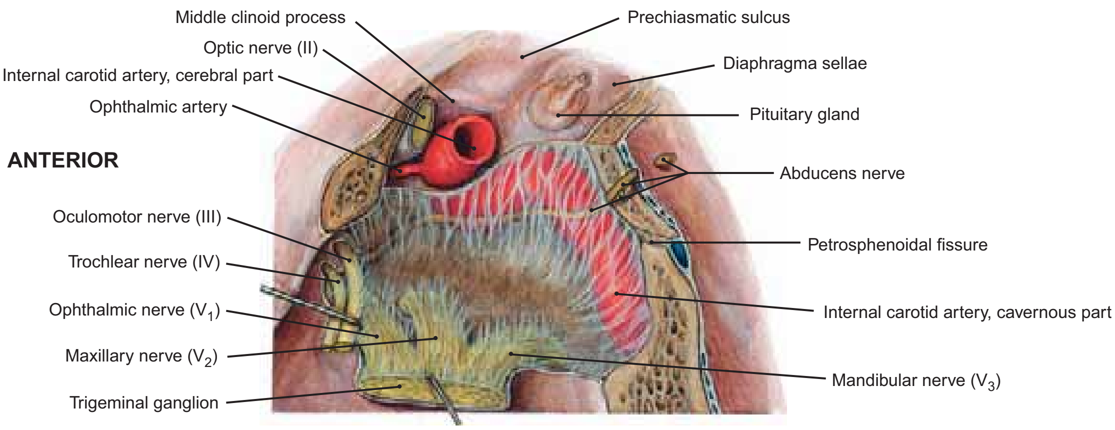


FIGURE 580.2 Cerebral Part of the Internal Carotid Artery and Other Vessels at the Base of the Brain

NOTE: The two internal carotid arteries (cerebral parts) and the basilar artery (formed by the two vertebral arteries) give rise to all the named vessels in this figure (see also Fig. 581.2).



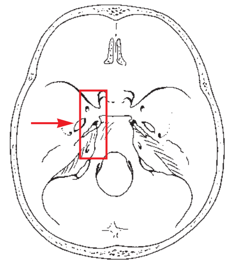


FIGURE 581.1 Internal Carotid Artery within the Cavernous Sinus

NOTE: The lateral dural wall of the cavernous sinus has been removed and the trigeminal ganglion has been pulled laterally. Observe the loop formed by the internal carotid artery before entering the base of the skull and the ophthalmic artery branching anteriorly to enter the orbit in the optic canal with the optic nerve.

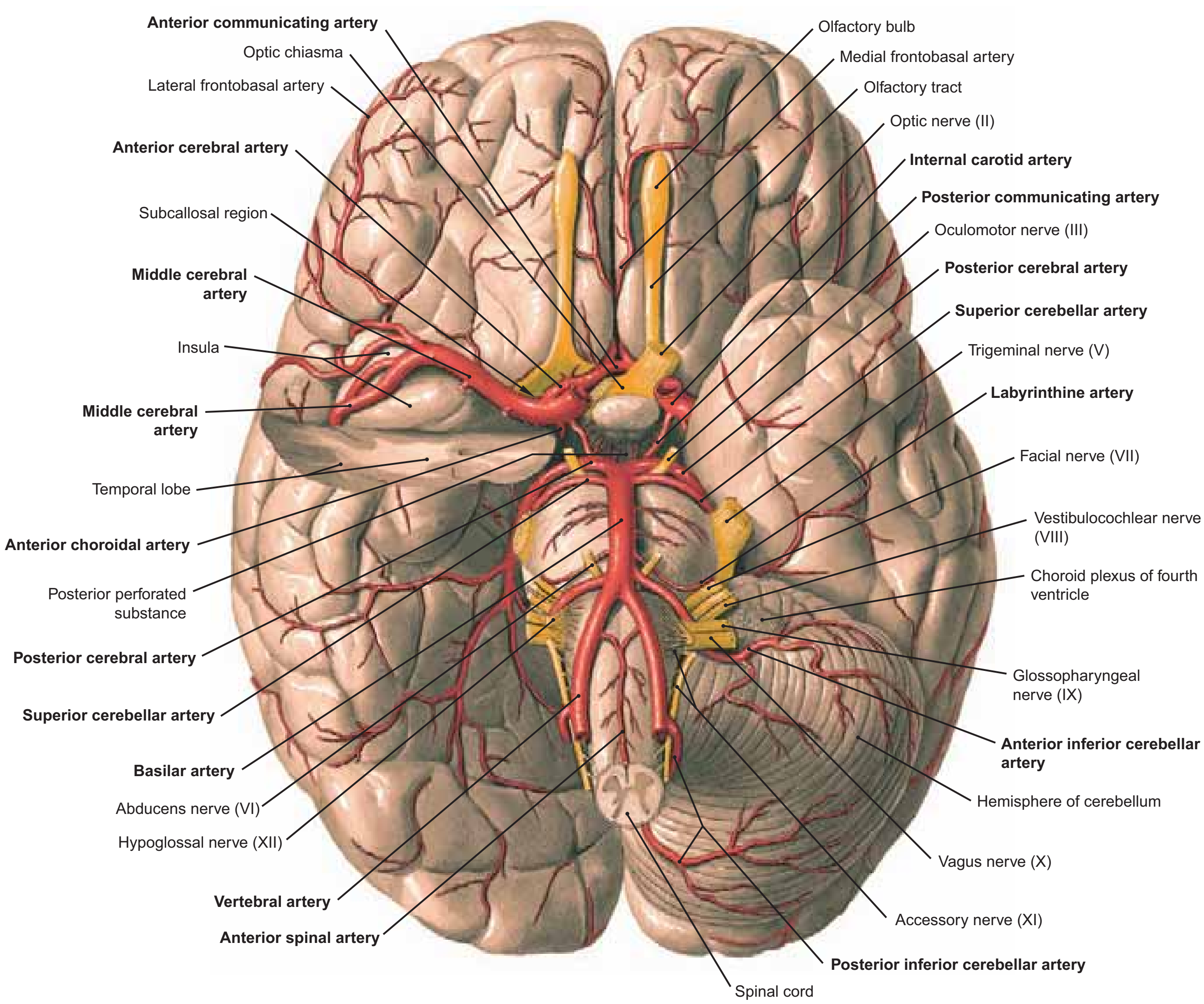


FIGURE 581.2 Arteries at the Base of the Brain

NOTE: (1) Branches of the **vertebral arteries** form the anterior spinal artery medially and the posterior inferior cerebellar arteries *laterally*.

(2) The **basilar artery** is formed near the pontomedullary junction and gives off the anterior inferior cerebellar, labyrinthine, pontine (not labeled), superior cerebellar, and posterior cerebral arteries successively as it ascends.

(3) The **internal carotid arteries** connect with the posterior cerebral by way of the posterior communicating arteries and then give off the middle and anterior cerebral arteries. The anterior cerebral arteries are joined by the anterior communicating artery.

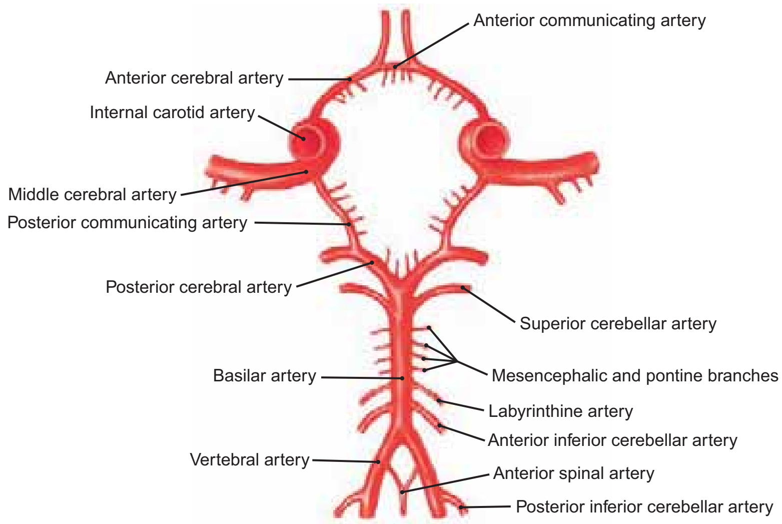


FIGURE 582.1 Circle of Willis

NOTE: The circle of Willis is formed by the **posterior cerebral, posterior communicating, internal carotid, anterior cerebral,** and **anterior communicating arteries.**

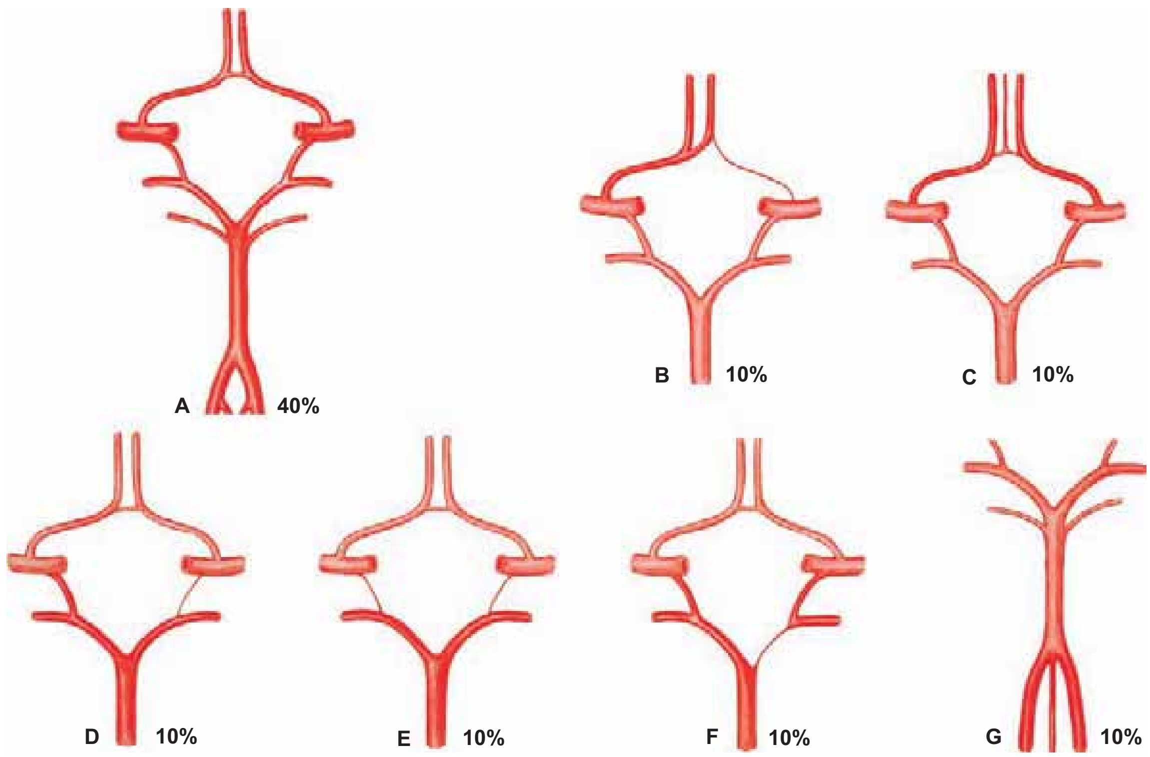


FIGURE 582.2 Variations in the Formation of the Circle of Willis

NOTE: Only about 40% of cadavers show the "normal" pattern of formation seen in **A.**

A shows the "normal" textbook pattern.
B shows a narrow anterior cerebral artery on one side.
C shows a small branch coursing forward from the anterior communicating artery.
D shows a narrow posterior communicating artery on one side.
E shows narrow posterior communicating arteries on both sides.
F shows a narrow posterior cerebral artery on one side. The posterior cerebral artery on the side with the anomaly is substituted for by a continuation of the posterior communicating artery of that same side.
G shows a low junction of the two vertebral arteries in the formation of the basilar artery.

FIGURE 583 **Carotid Arteriogram (Lateral View)**

NOTE: (1) This is a lateral view of a left carotid arteriogram showing the internal carotid artery and its **cervical, petrous,** and **cavernous** parts before entering the cranial cavity as the **cerebral** part.

(2) The cervical part courses in the carotid canal, whereas the cavernous part courses through the cavernous sinus.

(3) The ophthalmic artery is a branch of the internal carotid artery that enters the orbital cone posteriorly. Also note the anterior and middle cerebral arteries that branch from the anterior end of the circle of Willis.

1. Internal carotid artery (cervical part)
2. Internal carotid artery (petrous part)
3. Internal carotid artery (cavernous part)
4. Ophthalmic artery
5. Anterior cerebral artery
6. Middle cerebral artery

(From Wicke, 6th ed.)

FIGURE 584 **Vertebral Arteriogram (Posterior View)**

NOTE: (1) The two vertebral arteries ascend in the neck through foramina in the transverse processes of the first six cervical vertebrae. Above the atlas the arteries bend medially and lie in a groove on the superior surface of the atlas.

(2) The two vessels perforate the atlantooccipito membrane and join on the ventral surface of the medulla oblongata to form the **basilar artery.** This vessel ascends along the pons and finally terminates as it divides into the two **posterior cerebral arteries.**

(3) On their ascent, the vertebral and basilar arteries supply the cerebellum, the medulla, and pons and also give off the branches that form the **anterior spinal artery.**

1. Vertebral artery
2. Basilar artery
3. Posterior inferior cerebellar artery
4. Anterior inferior cerebellar artery
5. Superior cerebellar artery
6. Posterior cerebral artery (sometimes referred to as the artery of sight)
7. Occipital branch of the posterior cerebral artery

(From Wicke, 6th ed.)

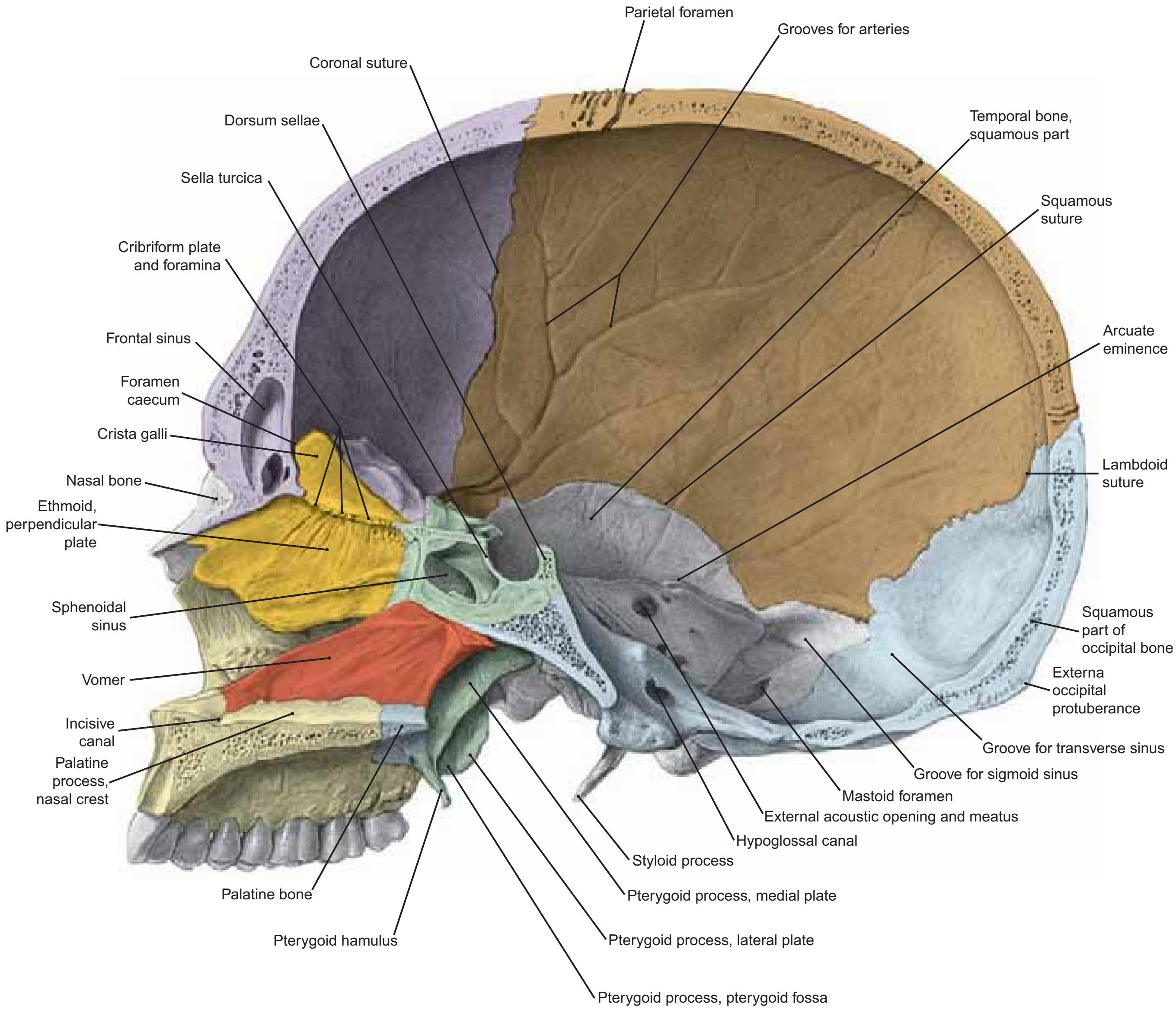


FIGURE 585.1 Paramedian Section of the Skull

NOTE: This section was made slightly to the left of the midline so that a medial view of the right half of the skull is presented. Observe that the vomer (a midline bone) is shown in its entirety and the palatine and maxilla are cut slightly to the left of the midline.

- Frontal bone
- Parietal bone
- Occipital bone
- Nasal bone
- Ethmoid (ethmoidal bone)
- Sphenoid (sphenoidal bone)
- Temporal bone
- Maxilla
- Vomer
- Palatine bone

FIGURE 585.2 Base of the Skull: Internal Aspect (Superior View)

NOTE: There are important structures that traverse the foramina at the base of the skull.

(1) **Anterior cranial fossa**:
- (a) **Foramen cecum**: a small vein
- (b) **Cribriform plate**: filaments of olfactory receptor neurons to the olfactory bulb
- (c) **Anterior ethmoid foramen**: anterior ethmoidal vessels and nerve
- (d) **Posterior ethmoid foramen**: posterior ethmoidal vessels and nerve

(2) **Middle cranial fossa**:
- (a) **Optic foramen**: optic nerve; ophthalmic artery
- (b) **Superior orbital fissure**: oculomotor nerve; trochlear nerve; ophthalmic nerve; abducens nerve; sympathetic nerve fibers; superior ophthalmic vein; orbital branch of middle meningeal artery; dural recurrent branch of the lacrimal artery
- (c) **Foramen rotundum**: maxillary nerve

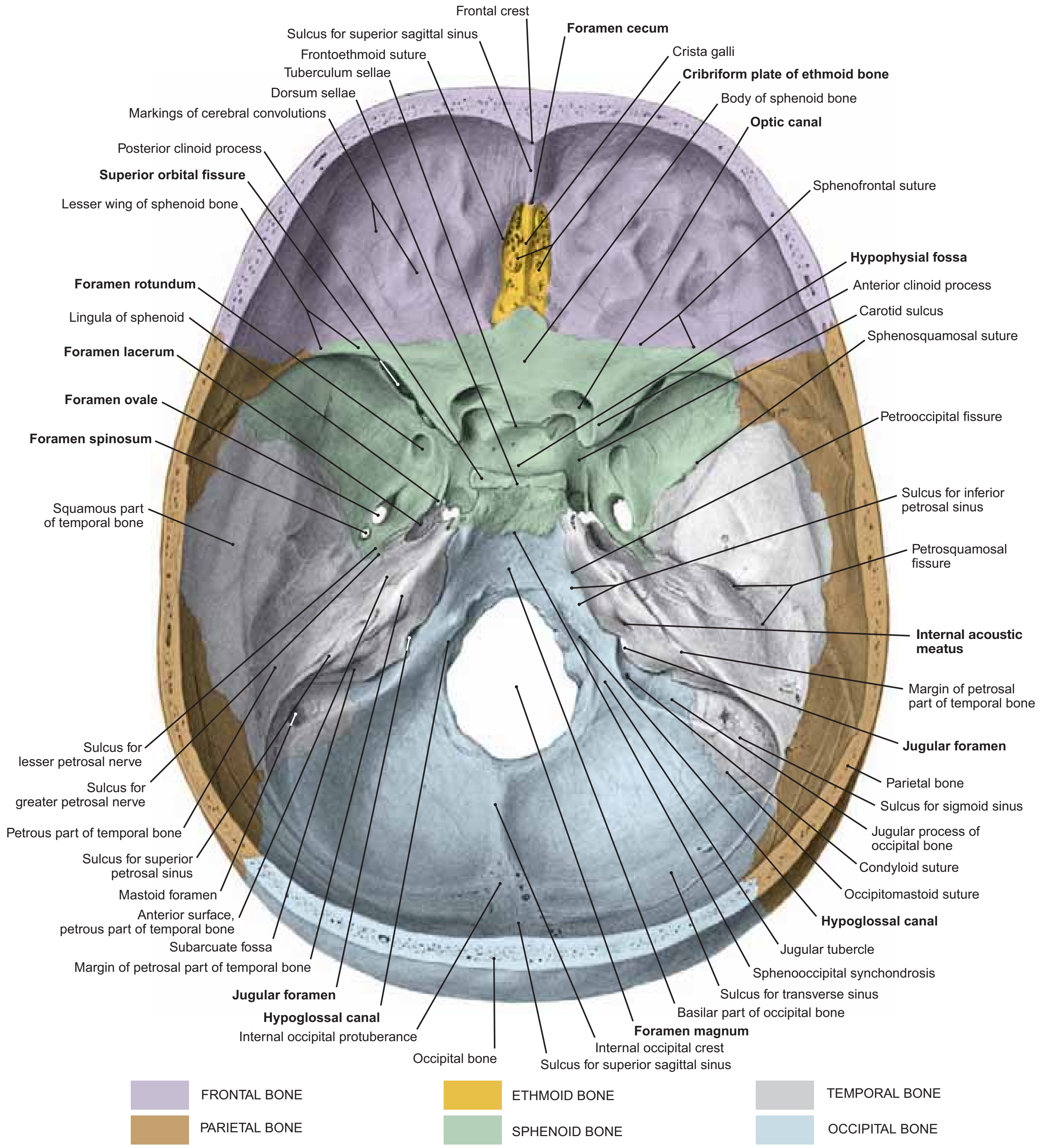


FIGURE 586 Base of the Skull: Internal Aspect (Continued from Previous Page)

(d) **Foramen ovale**: mandibular nerve; accessory meningeal artery
(e) **Foramen spinosum**: middle meningeal artery; a recurrent dural branch of mandibular nerve
(f) **Foramen lacerum**: The internal carotid artery passes across the foramen above the fibrocartilaginous plate but does *not* traverse it. The nerve of the pterygoid canal emerges from the foramen to enter the pterygoid canal. The meningeal branch of the ascending pharyngeal artery actually traverses the foramen

(3) **Posterior cranial fossa**:
(a) **Internal acoustic meatus**: facial nerve; vestibulocochlear nerve; labyrinthine artery
(b) **Jugular foramen**: sigmoid sinus, which becomes internal jugular vein; meningeal branches of occipital and ascending pharyngeal arteries; glossopharyngeal nerve; vagus nerve; accessory nerve
(c) **Hypoglossal canal**: hypoglossal nerve
(d) **Foramen magnum**: spinal cord; spinal part of accessory nerve; anterior and posterior spinal arteries; vertebral arteries; tectorial membrane

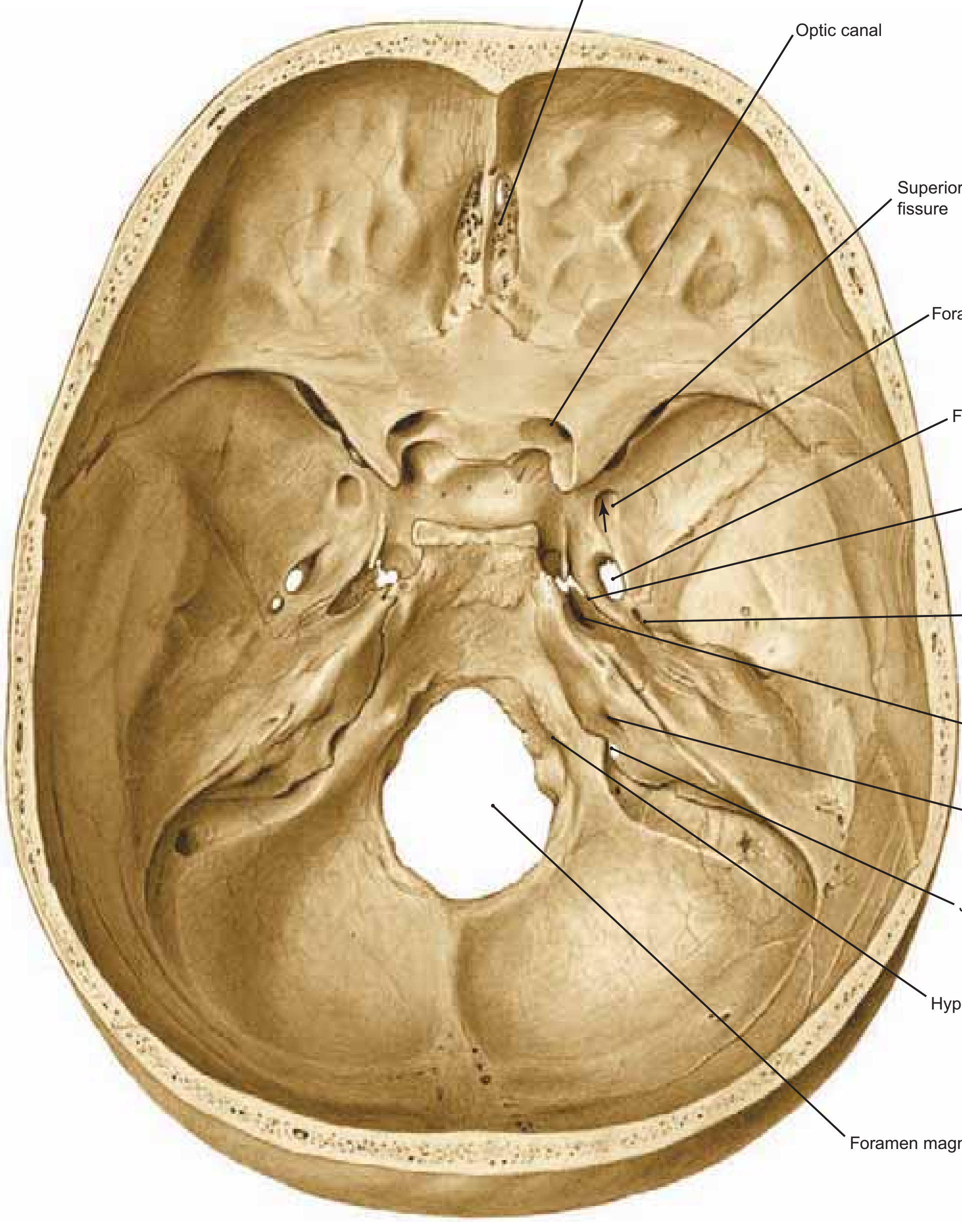


FIGURE 587.1 Internal Surface of the Bony Floor of the Cranial Cavity

NOTE the anterior, middle, and posterior cranial fossae. The **anterior fossa** sustains the frontal lobes, while the **middle fossa** holds the temporal lobes. The **posterior fossa** is continuous with the vertebral column, and it houses the cerebellum, pons, and medulla oblongata. The latter is continuous with the spinal cord.

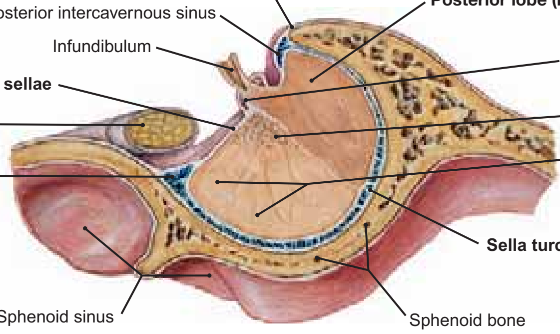


FIGURE 587.2 Median Sagittal Section through the Pituitary Gland and the Sella Turcica of the Sphenoid Bone

NOTE: The **sella turcica** (hypophysial fossa) in the sphenoid bone is lined and covered **(diaphragma sellae)** by dura mater. The anterior and posterior lobes form a single organ that lies below and slightly behind the optic chiasma.

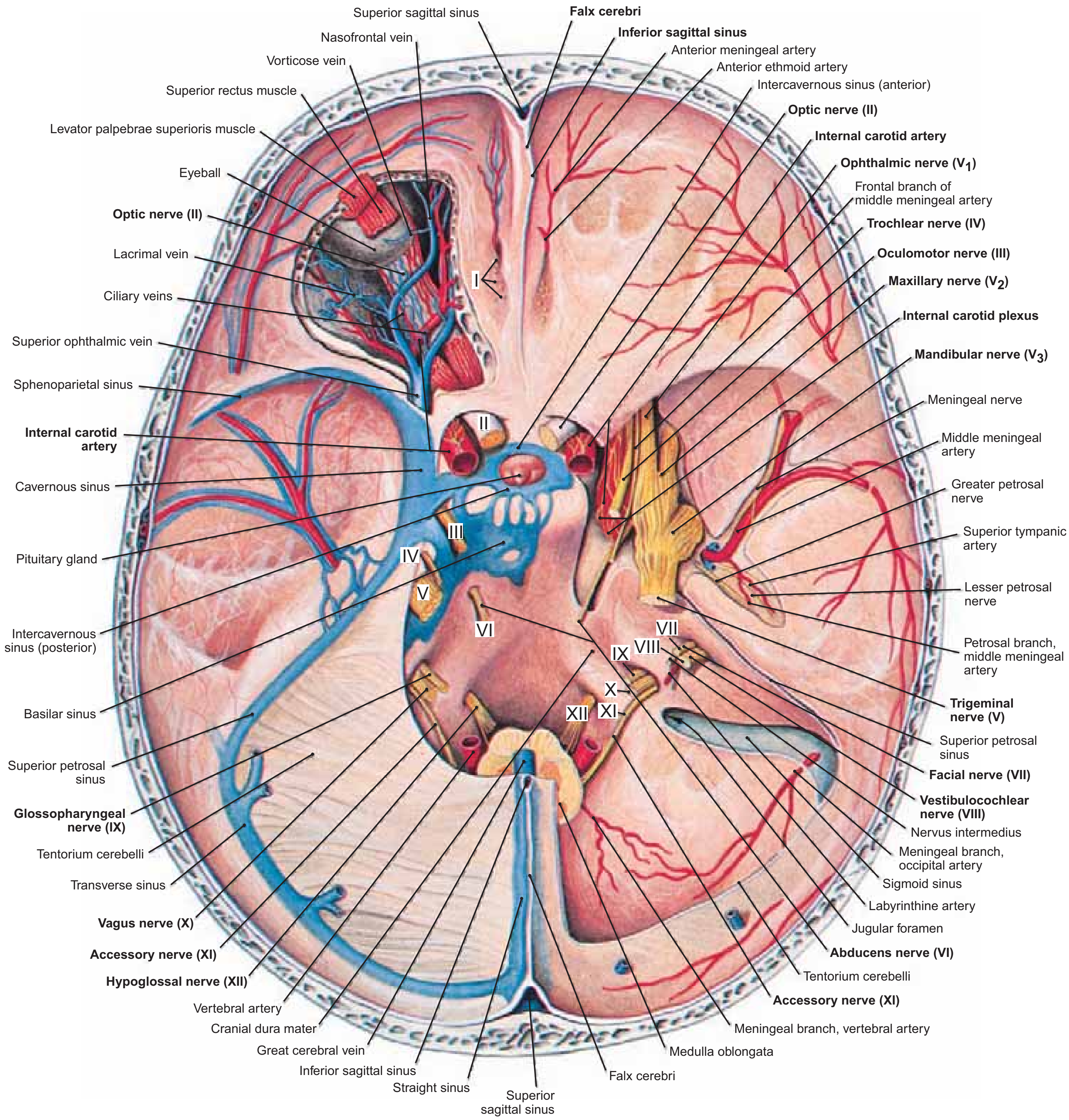


FIGURE 588 Base of the Cranial Cavity: Vessels, Nerves, and Dura Mater

NOTE: (1) The anterior, middle, and posterior **cranial fossae** in the floor of the cranial cavity. In the anterior fossae rest the **frontal lobes** of the brain, whereas the **temporal lobes** lie in the middle fossae and the **brainstem** and **cerebellum** rest in the posterior fossa.

(2) The dura mater and the orbital plate of the frontal bone have been removed to expose the left orbit from above. The **superior ophthalmic vein** drains posteriorly into the cavernous sinus and the **optic nerve** is seen to course from the orbit through the optic canal.

(3) The medial aspect of the middle fossa shows the cavernous sinus, the internal carotid artery, the third, fourth, fifth, and sixth cranial nerves coursing toward the orbit or the face, and the middle meningeal artery traversing the foramen spinosum.

(4) The foramina for the last six pairs of cranial nerves in the posterior fossa. The 7th and 8th nerves pass through the internal acoustic meatus, whereas the 9th, 10th, and 11th nerves traverse the jugular foramen and the 12th nerve traverses at the hypoglossal canal.

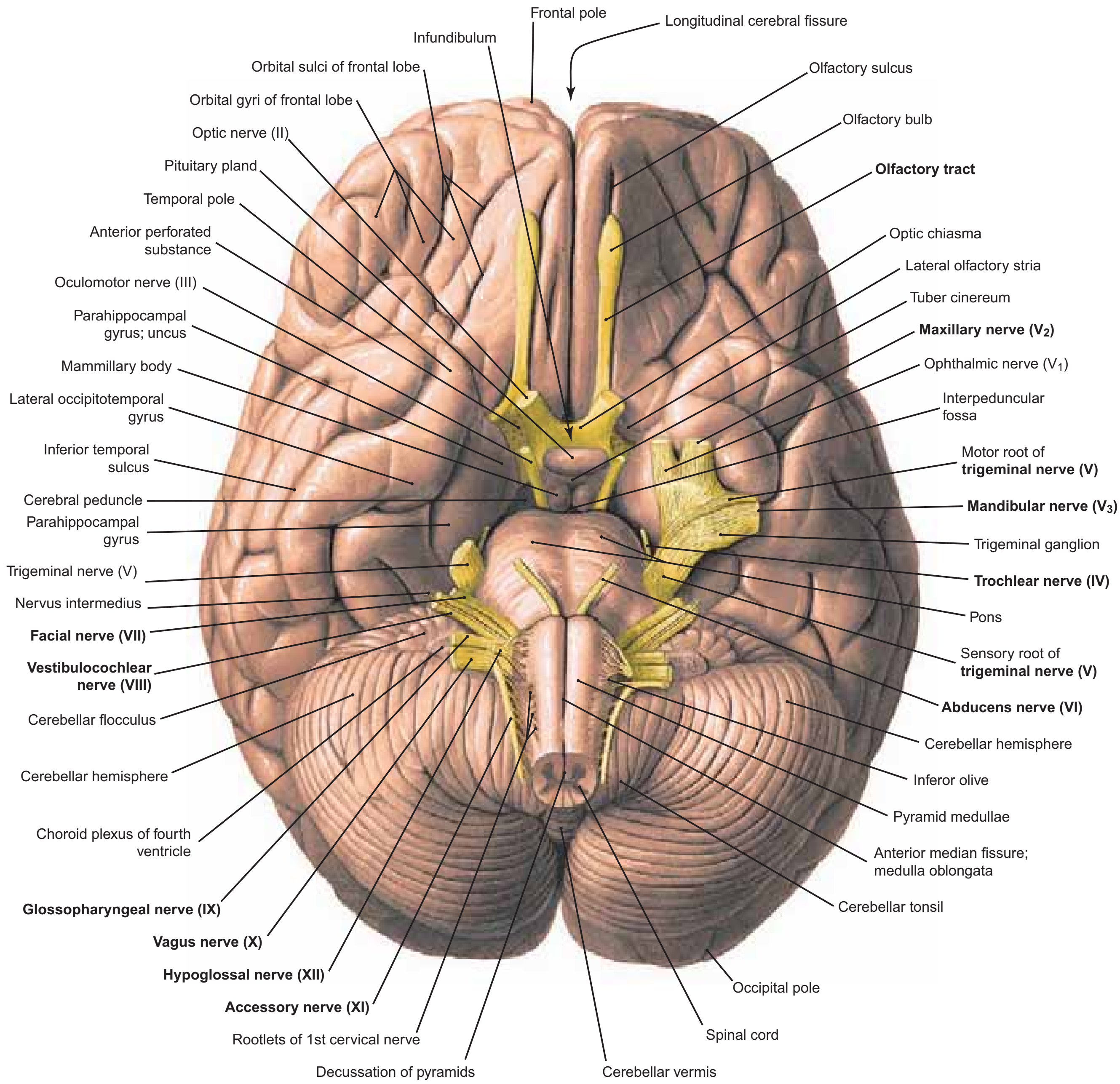


FIGURE 589 Ventral View of the Brain Showing the Origins of the Cranial Nerves

NOTE: (1) The cranial nerves attach to the base of the brain. The **olfactory tracts** and **optic nerves** (**I** and **II**) subserve receptors of special sense in the nose and eye, and as cranial nerve trunks attach to the base of the forebrain in contrast to all other cranial nerves that attach to the midbrain, pons, or medulla of the brainstem.

(2) The **oculomotor (III), trochlear (IV),** and **abducens (VI) nerves** are motor nerves to the extraocular muscles. The **trigeminal nerve (V)** is the largest of the cranial nerves, and the **trochlear** is the smallest. The abducens nerve attaches to the brainstem at the junction of the pons and medulla (pontomedullary junction) medial to the attachments of the **facial (VII)** and **vestibulocochlear (VIII) nerves**.

(3) The **glossopharyngeal (IX)** and **vagus (X) nerves** emerge from the medulla laterally in a line comparable to the spinal and medullary parts of the **accessory nerve (XI)**. In contrast, the **hypoglossal nerve (XII)** rootlets emerge from the ventral medulla in a line consistent with the ventral rootlets of the cervical nerves of the spinal cord.

(4) The cranial nerves are of the utmost importance as signposts in localizing disorders both inside and outside the cranial cavity. The functions of most cranial nerves are tested in each complete physical examination performed by competent physicians.

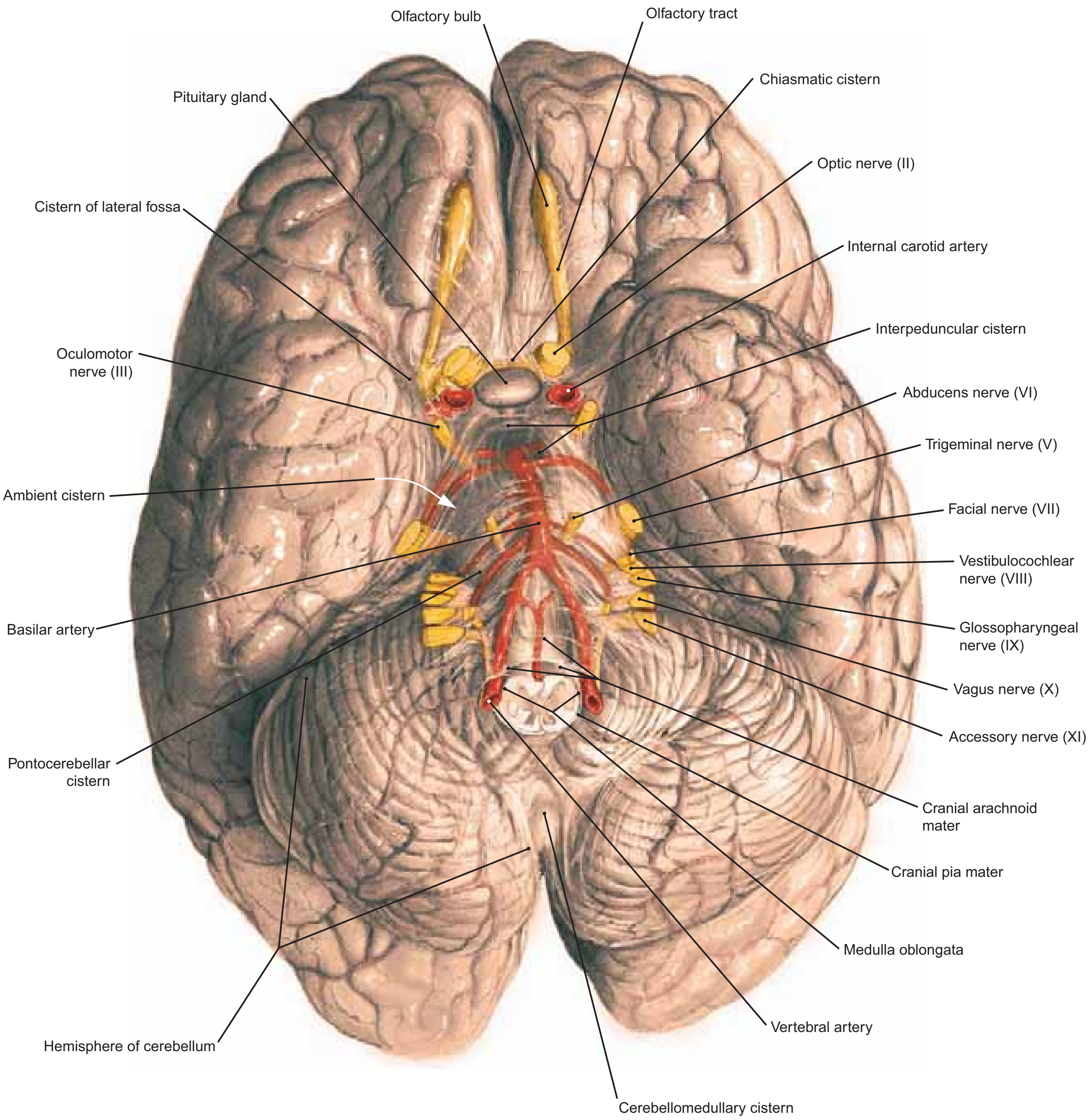


FIGURE 590 Base of the Brain: Arteries and Cranial Nerves with the Arachnoid Mater Intact

NOTE: (1) The dura mater has been completely removed from the brain, leaving intact the arachnoid mater and pia mater. Observe the vertebral arteries joining to form the basilar artery and, anteriorly, the internal carotid arteries severed upon entering the cranial cavity at the base of the brain.

(2) Between the arachnoid mater and the pia mater and the cerebral vessels is the **subarachnoid space**, within which is found the cerebrospinal fluid that is formed in the choroid plexuses. At certain sites the arachnoid mater separates from the pia mater to form pools of cerebrospinal fluid called **cisterns**.

(3) In this figure are seen the cisterns on the ventral aspect of the brainstem; however, they also are located on the dorsal aspect of the brainstem, especially between the cerebellum and the pons and medulla oblongata.

(4) Identify the following cisterns:

(a) The **cistern of the lateral fossa** extends between the orbital surface of the frontal lobe and the anteromedial surface of the temporal lobe. It contains the internal carotid artery.

(b) The **ambient cistern** (also called the **cistern of the great cerebral vein**) is located between the splenium of the corpus callosum and the rostral surface of the cerebellum. It contains the great cerebral vein and the pineal gland.

(c) The **pontocerebellar cistern** on the anterior surface of the pons containing the basilar artery. It communicates superiorly with the interpeduncular cistern and inferiorly with the subarachnoid space of the spinal cord.

(d) The large **cerebellomedullary cistern** (also called the **cisterna magna**) between the medulla oblongata and the inferior surface of the cerebellum.

(e) The **interpeduncular cistern** contains the circle of Willis; it also continues anteriorly as the **chiasmatic cistern** anterior to the pituitary gland and adjacent to the optic chiasma.

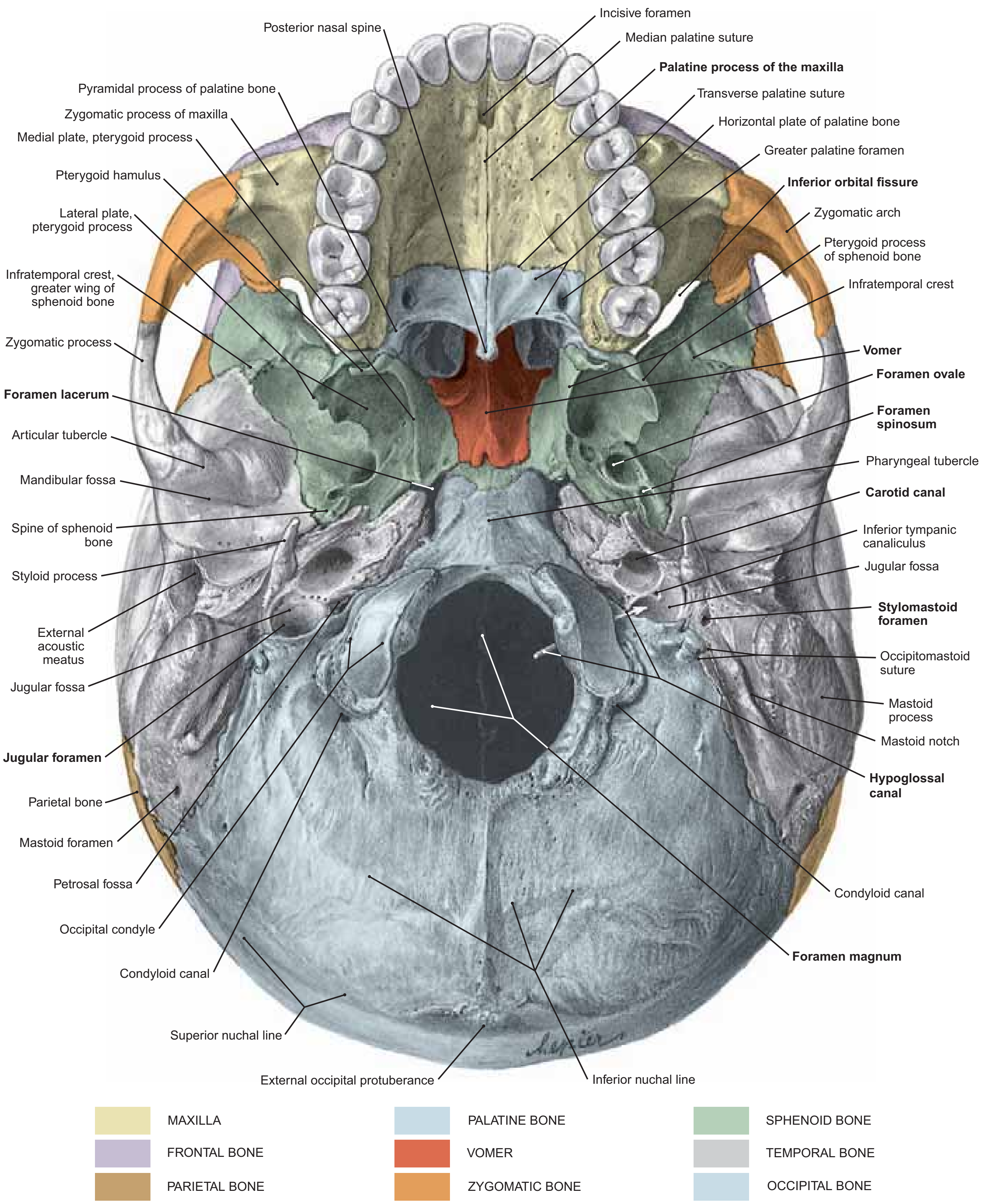


FIGURE 591 Base of the Skull: External Aspect (Inferior View)

NOTE: (1) The posterior part of the base of the skull consists of the **occipital** and **temporal bones**. Anteriorly are the facial bones: the **maxilla, palatine, zygomatic,** and **vomer**. Interposed between these two groups of hones is the **sphenoid bone.**

(2) The bony palate is formed by the transverse processes of the two maxillae and the horizontal plates of the palatine bones.

(3) The medial and lateral plates of the pterygoid process of the sphenoid bone, behind which are the foramen ovale and foramen spinosum in the greater wings of the sphenoid.

(4) The **foramen lacerum, carotid canal, jugular foramen, styloid process** (of temporal bone), **hypoglossal canal** (arrow), and the **foramen magnum**.

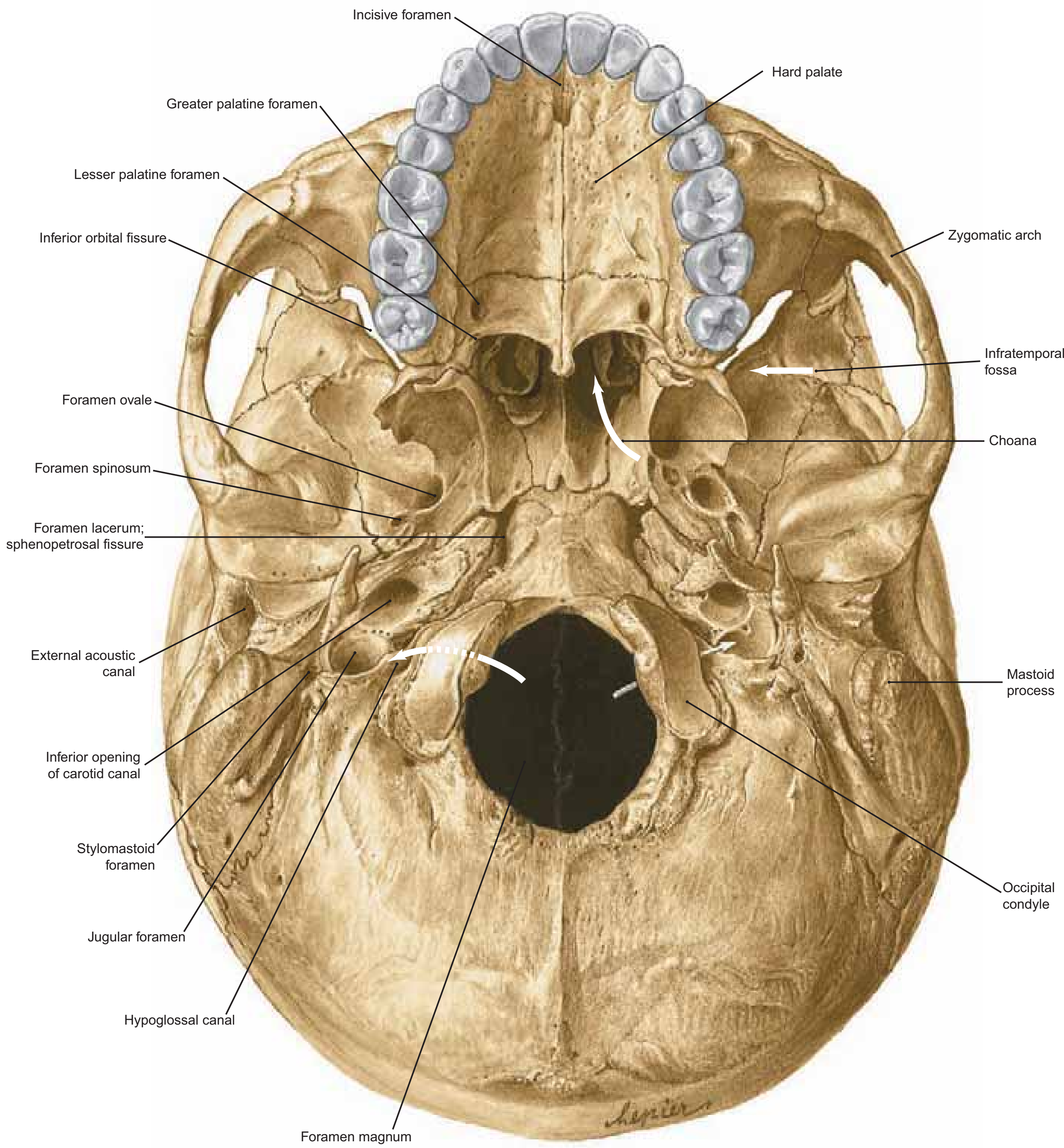


FIGURE 592 **Inferior Surface of the Bony Skull**

NOTE: (1) The white arrows indicate the **infratemporal fossa**, one **choana**, and the **two hypoglossal canals**. Also observe the **greater and lesser palatine foramina** through which course the greater and lesser palatine arteries and nerves that serve the palate in the oral cavity.

(2) The **foramen lacerum** that is covered inferiorly by a small plate of cartilage across which the internal carotid artery passes prior to its ascending course lateral to the body of the sphenoid bone. The vessel then opens into the floor of the cranial cavity adjacent to the optic nerves.

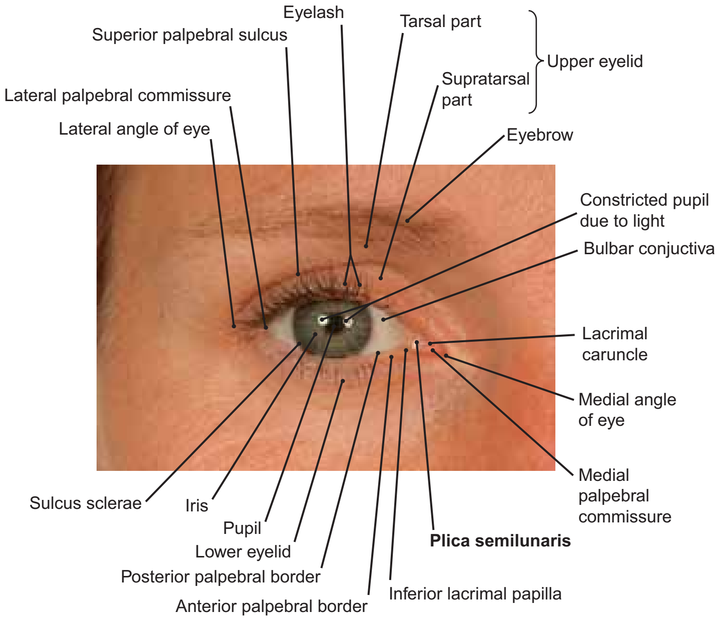


FIGURE 593.2 Photograph of Living Eye Identical to Figure 593.1

FIGURE 593.1 Right Eye and Eyelids

NOTE: (1) The eyeball, protected in front by two movable and thin **eyelids** or **palpebrae**, is covered by a transparent mucous membrane, the **conjunctiva**, which reflects along the inner surface of both eyelids as the **palpebral conjunctiva**.

(2) At the medial angle of the eye is located a small, reddish island of tissue called the **lacrimal caruncle**.

(3) The **pupil** is the opening in the **iris.** Constriction and dilation of the pupil is controlled autonomically. Parasympathetic fibers in the oculomotor nerve innervate the constrictor muscle of the pupil, whereas sympathetic fibers from the superior cervical ganglion supply the pupillary dilator muscle.

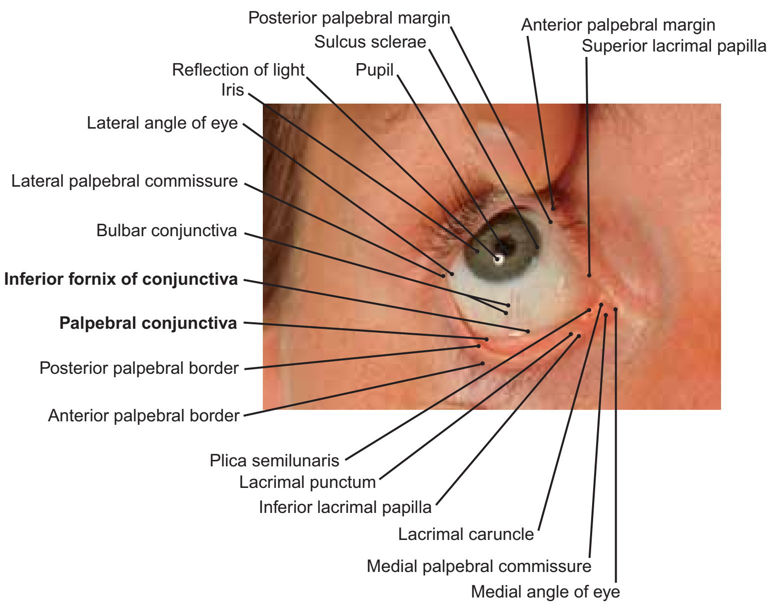


FIGURE 593.4 Photograph of Living Eye Identical to Figure 538.3

FIGURE 593.3 Right Lower Eyelid and Medial Angle

NOTE: (1) The right lower eyelid has been pulled downward to show the inner surface of the lower lid (i.e., the palpebral conjunctiva) and to enlarge the exposure of the medial angle (also called the **medial canthus**).

(2) The conjunctiva is highly vascular, and its bulbar part (over the eyeball) and inferior palpebral part (on the inner surface of the lower eyelid) are continuous along a line of reflection called the **inferior conjunctival fornix**. A similar reflection line, the **superior conjunctival fornix**, lies between the eyeball and the upper eyelid.

(3) When the medial angle is more completely exposed, a pair of small openings, the **lacrimal puncta**, can be found located above and below the lacrimal caruncle. These openings lead into small **lacrimal canals** through which tears enter the **lacrimal sac**.

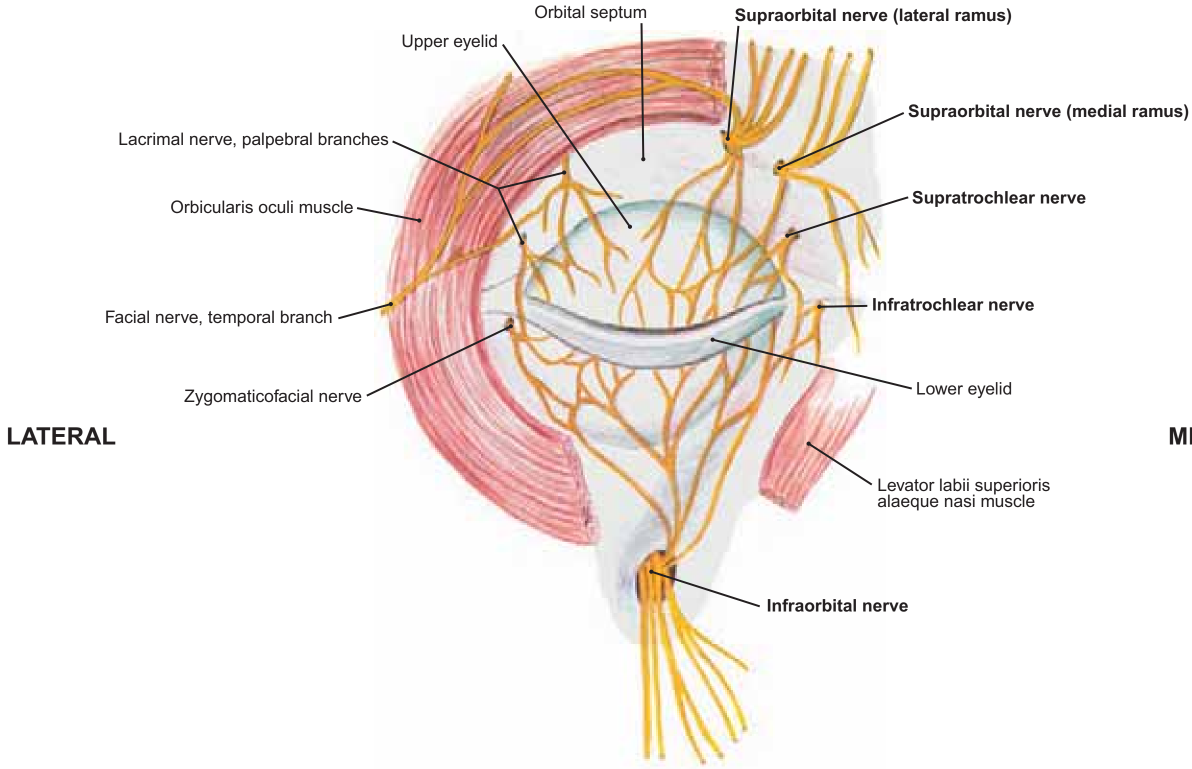


FIGURE 594.1 Innervation of the Eyelids (Anterior View, Right Eye)

NOTE: (1) The rich cutaneous innervation found around the anterior orbit is derived from the ophthalmic and maxillary divisions of the trigeminal nerve, which achieve the anterior orbital region through foramina in the frontal, zygomatic, and maxillary bones.

(2) Superomedially are found the large rami of the **supraorbital** branch of the frontal nerve (V_1), which emerges through the supraorbital foramen or notch. Also note the **supratrochlear** branch of the frontal nerve, which appears through a small foramen above the trochlea of the superior oblique muscle.

(3) The **infratrochlear nerve** is a terminal branch of the nasociliary nerve (V_1) that becomes superficial below the trochlea of the superior oblique. Along with palpebral branches of the **infraorbital nerve** (V_2), it sends fibers to the lower eyelid.

(4) The **lacrimal nerve** (V_1) superolaterally, supplying the upper eyelid; the **zygomaticofacial nerve** (V_2) to the lower eyelid and skin over the cheek bone; the **temporal branch of the facial nerve,** which is a motor nerve to the orbicularis oculi muscle.

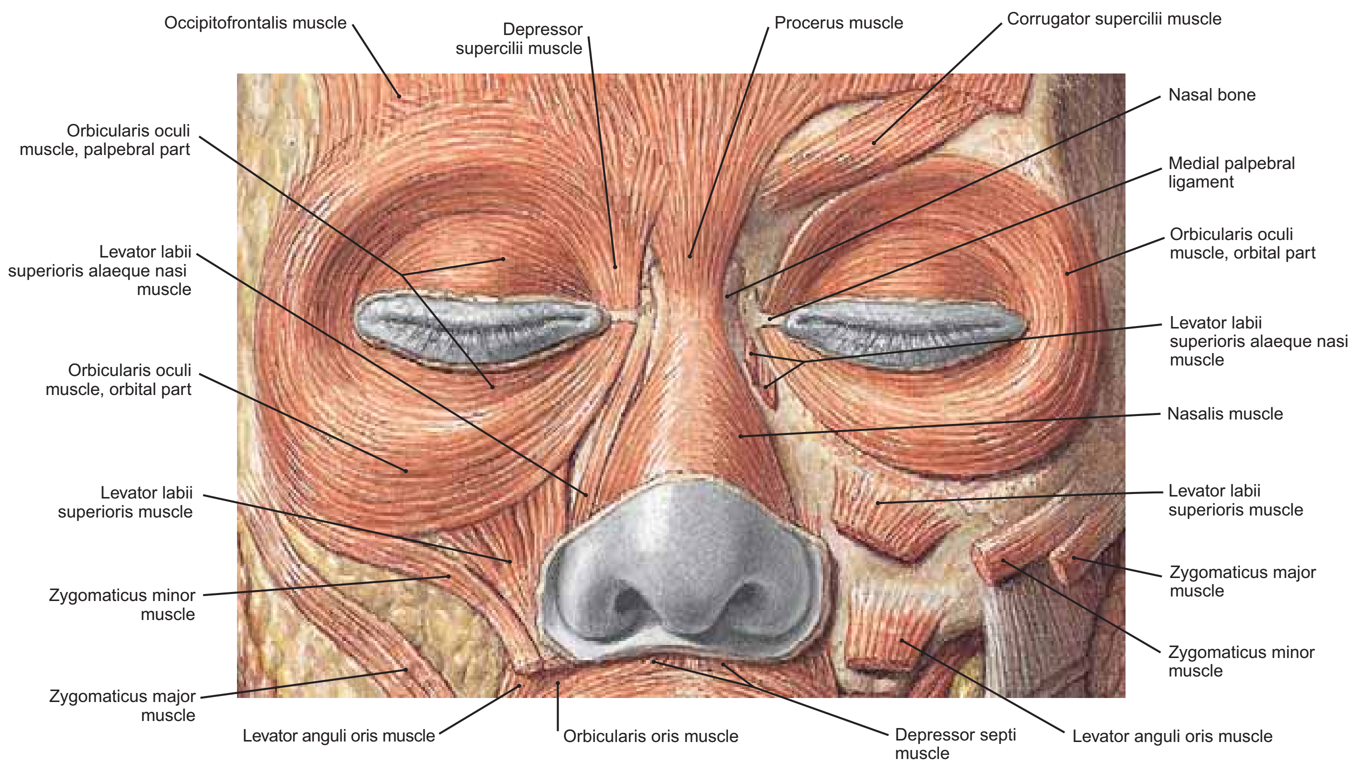


FIGURE 594.2 Superficial Facial Muscles around the Orbit (Anterior View)

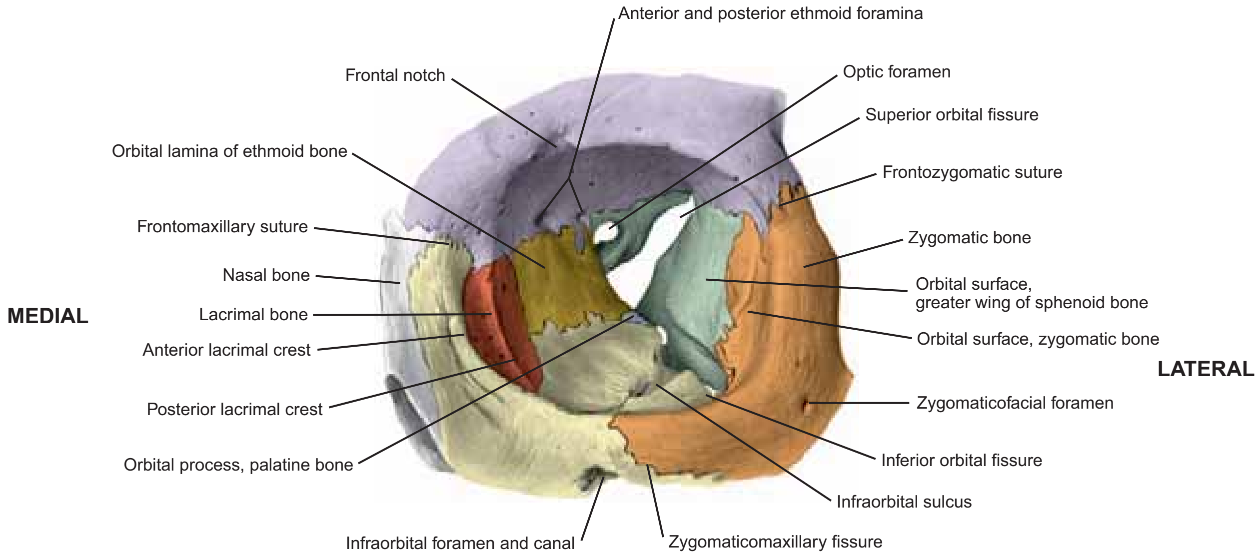


FIGURE 595.1 Bones That Form the Orbital Cavity (Left Side, Anterior View)

NOTE: (1) The bony structure of the orbit is composed of parts of seven bones: the **maxilla, zygomatic, frontal, lacrimal, palatine, ethmoid**, and **sphenoid.**

(2) The **roof** of the orbit is formed by the orbital plate of the **frontal bone**; the **floor** consists of the orbital plate of the **maxilla**, the **palatine,** and the **zygomatic bones**; the **medial wall** is thin and delicate and is formed by the frontal process of the **maxilla**, the orbital lamina of the **ethmoid,** and the **lacrimal bone**; and the strong **lateral wall** consists of the orbital processes of the **sphenoid** and **zygomatic bones.**

(3) The **optic foramen**, the **superior** and **inferior orbital fissures**, and the **anterior** and **posterior ethmoid foramina.**

Key for Figures 595.1 and 595.2:

NASAL BONE	VOMER	TEMPORAL BONE
FRONTAL BONE	ZYGOMATIC BONE	INFERIOR NASAL CONCHA
PALATINE BONE	MAXILLA	SPHENOID BONE
ETHMOID BONE		LACRIMAL BONE

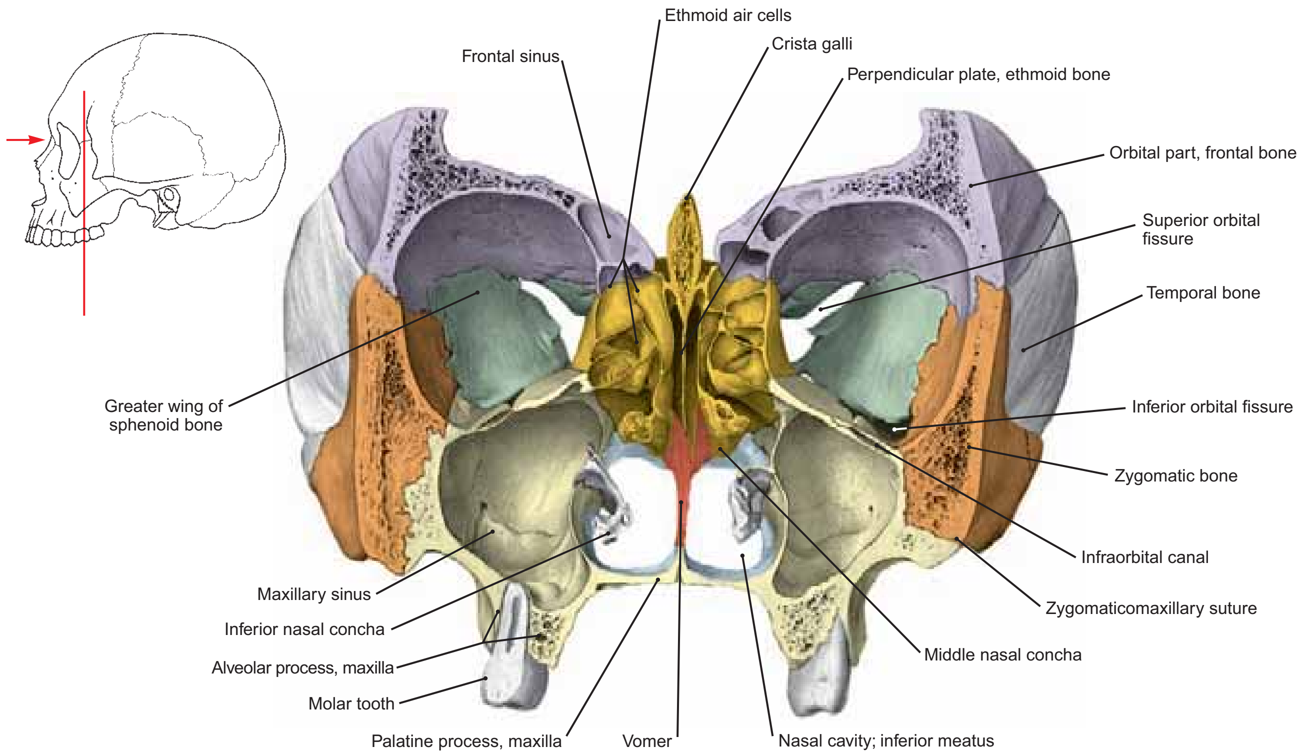


FIGURE 595.2 Frontal Section through the Orbital and Nasal Cavities and the Maxillary Sinus

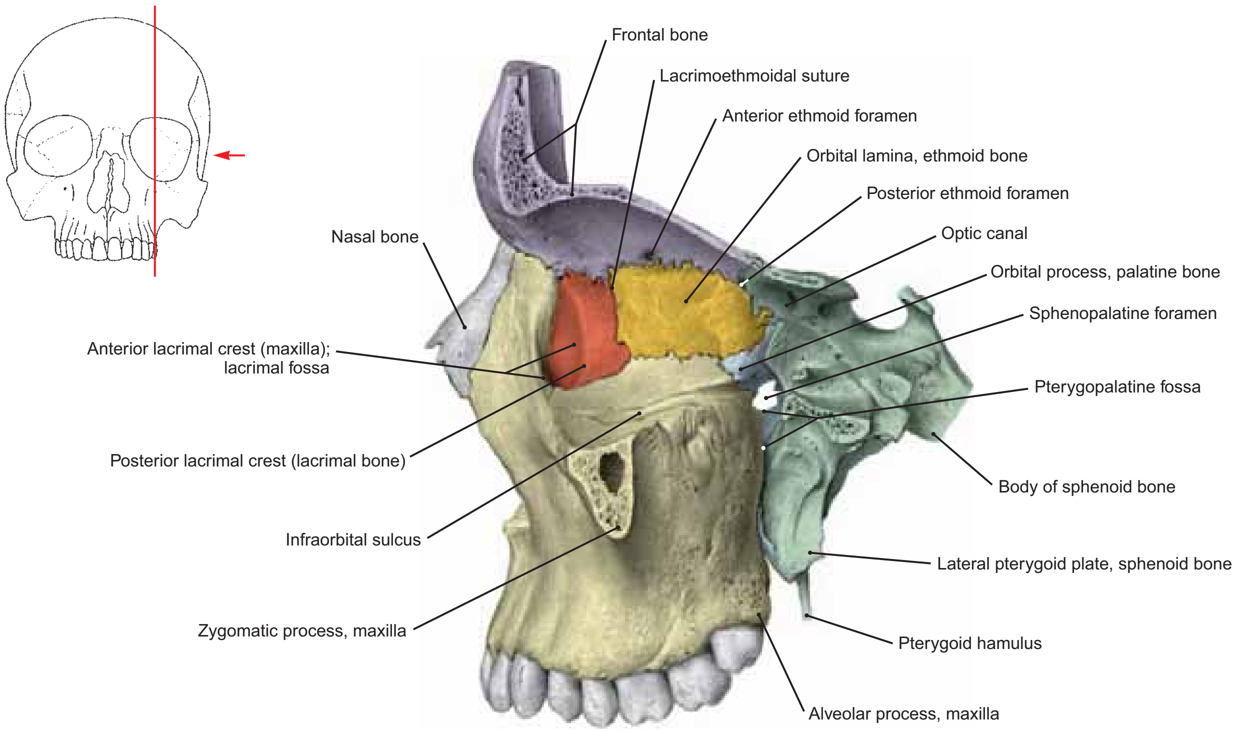


FIGURE 596.1 Medial Wall of the Left Orbital Cavity and a Lateral View of the Pterygopalatine Fossa

NOTE: (1) Anteriorly on the thin medial wall of the orbital cavity is found the **lacrimal fossa** for the **lacrimal sac**. The fossa is limited in front by the anterior lacrimal crest of the maxilla and behind by the posterior lacrimal crest of the lacrimal bone.

(2) The medial wall is formed by the orbital lamina of the **ethmoid bone** and the **lacrimal bone**. The **maxilla** inferiorly and the **sphenoid** and **palatine bones** posteriorly also contribute to this wall. Also observe the **anterior** and **posterior ethmoidal foramina**.

Key for Figures 596.1 and 596.2:

FRONTAL BONE; LACRIMAL BONE; SPHENOID BONE; NASAL BONE; PALATINE BONE; ETHMOID BONE; MAXILLA; TEMPORAL BONE; ZYGOMATIC BONE

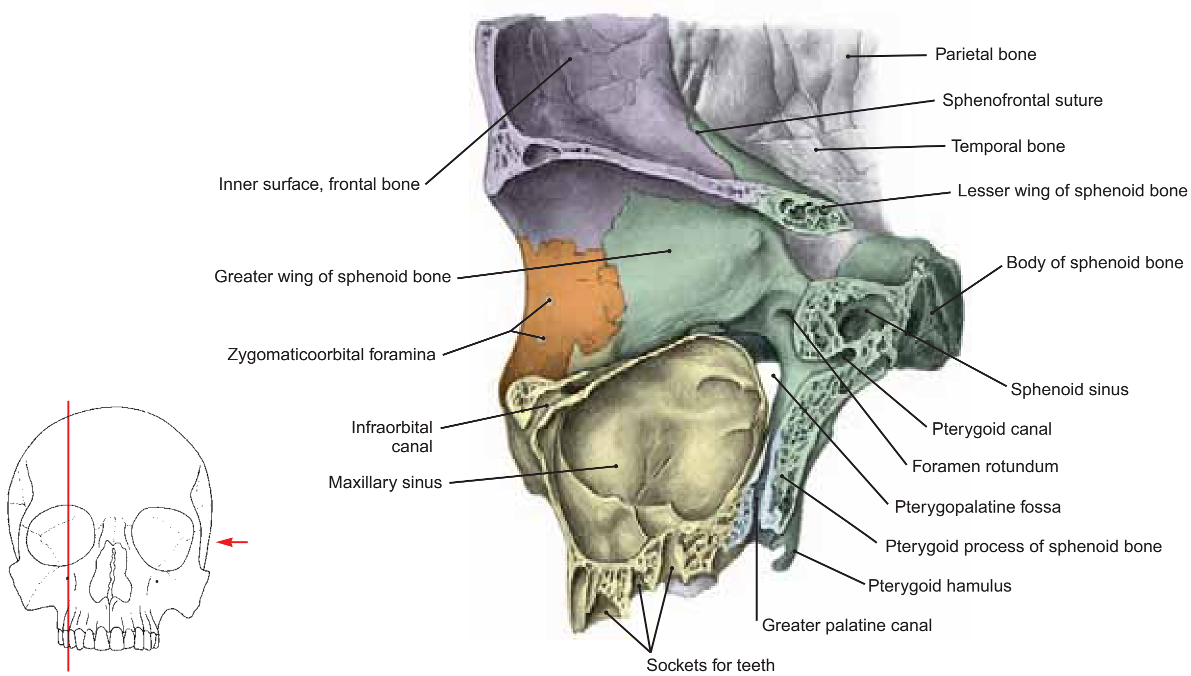


FIGURE 596.2 Lateral Wall of the Right Orbital Cavity and a Medial View of the Pterygopalatine Fossa

NOTE: (1) The lateral wall of the orbit is formed by the orbital surface of the greater wing of the **sphenoid bone** and the frontal process of the **zygomatic bone**. Note the small zygomaticoorbital foramina through which course the **zygomaticofacial** and **zygomaticotemporal** branches of the maxillary nerve (sensory nerves).

(2) The **foramen rotundum** and the **infraorbital canal** for the **maxillary nerve**. Also note the **maxillary sinus** below the orbit and the **pterygopalatine fossa** and **greater palatine canal** behind the maxillary sinus and below the apex of the orbit.

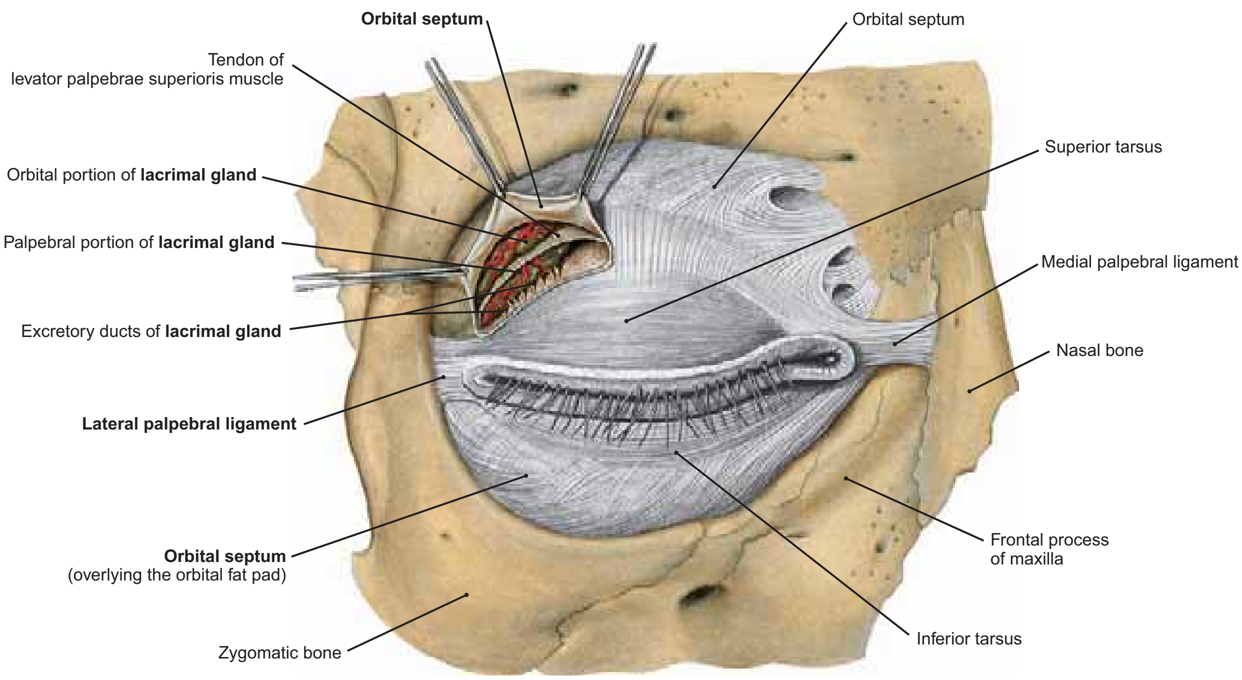


FIGURE 597.1 Orbital Septum, Lacrimal Gland, and Tarsi of the Right Eye

NOTE: (1) With the skin, superficial fascia, and orbicularis oculi muscle removed, the orbital septum has been exposed anteriorly. The septum attaches to the periosteum of the bone peripherally around the orbit and to the tarsi of the eyelids centrally.
(2) The lacrimal gland and its excretory ducts in the upper lateral aspect of the anterior orbit lying just beneath the orbital septum.

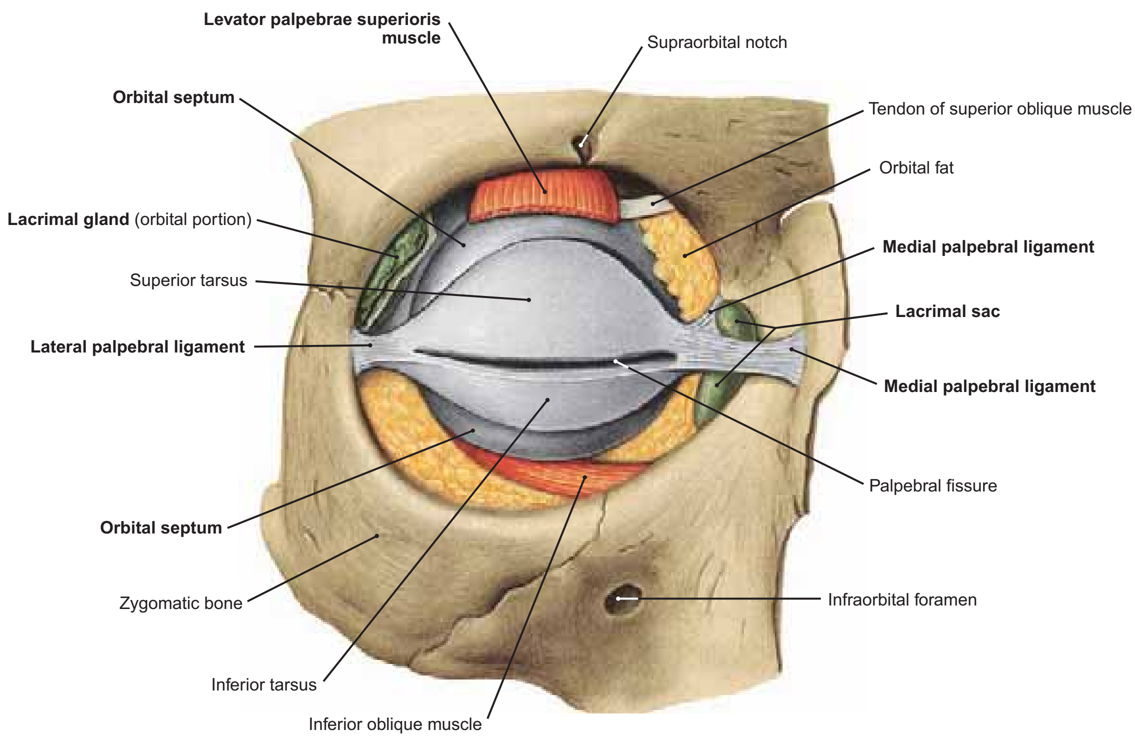


FIGURE 597.2 Palpebral Ligaments and Tarsal Plates (Anterior View)

NOTE: (1) The superficial structures of the orbit have been removed along with the orbital septum and the tendon of the levator palpebrae superioris muscle.
(2) The lateral and medial margins of the tarsal plates are attached to the lateral and medial palpebral ligaments, which in turn are attached to bone. The medial ligament is located just anterior to the lacrimal sac.
(3) From this anterior view, both the tendon of the superior oblique muscle and the inferior oblique muscle can be visualized. Also note the location of the orbital portion of the lacrimal gland in the upper lateral part of the orbit.

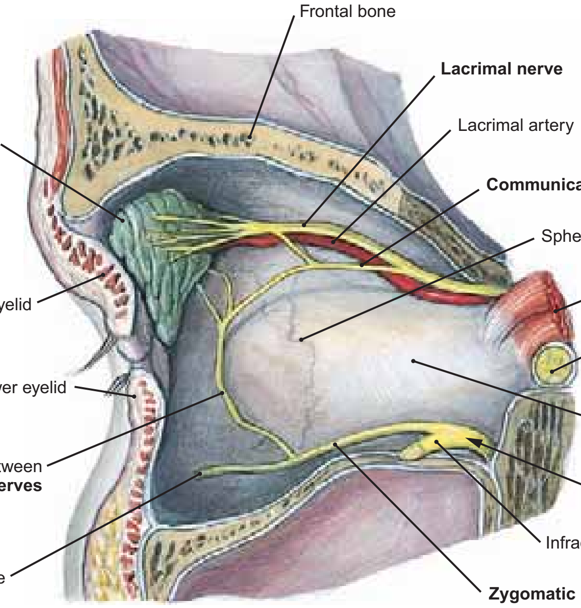


FIGURE 598.1 **Innervation of the Lacrimal Gland**

NOTE: (1) The lacrimal gland is supplied by the lacrimal artery, which is a thin, tortuous branch of the ophthalmic artery that courses anteriorly in the orbital cavity.

(2) The lacrimal gland receives postganglionic parasympathetic fibers that are secretomotor in type. Preganglionic fibers are said to emerge from the brain in the nervus intermedius part of the facial nerve (VII). These fibers then synapse with the cell bodies of the postganglionic neurons in the pterygopalatine ganglion.

(3) The preganglionic parasympathetic fibers reach the pterygopalatine ganglion by way of the greater petrosal nerve, which then becomes part of the nerve of the pterygoid canal. The postganglionic fibers leave the ganglion and travel for a short distance with the zygomatic nerve, a branch of the infraorbital nerve. From this nerve, in the inferior part of the orbit, the parasympathetic fibers, by way of a communicating branch to the lacrimal nerve, travel to the lacrimal gland.

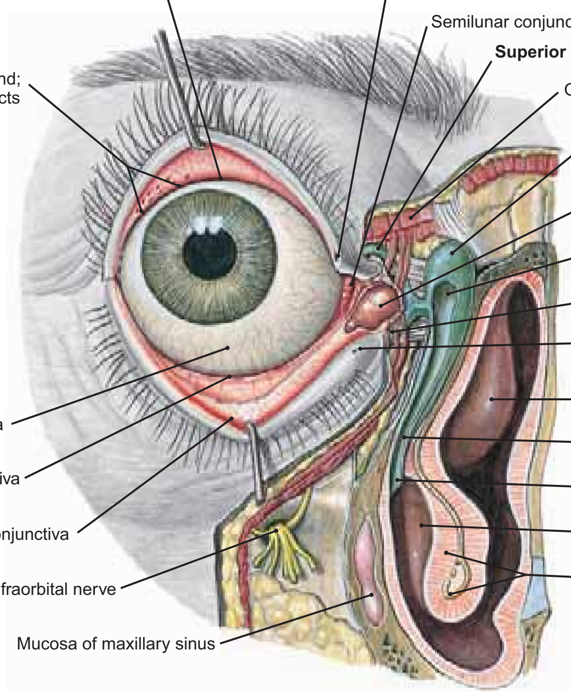


FIGURE 598.2 **Lacrimal Canaliculi, Lacrimal Sac, and Nasolacrimal Duct**

NOTE: From the ducts of the lacrimal gland, tears moisten the surface of the eyeball and drain medially through the lacrimal canaliculi to the lacrimal sac and then descend to the nasal cavity by way of the nasolacrimal duct.

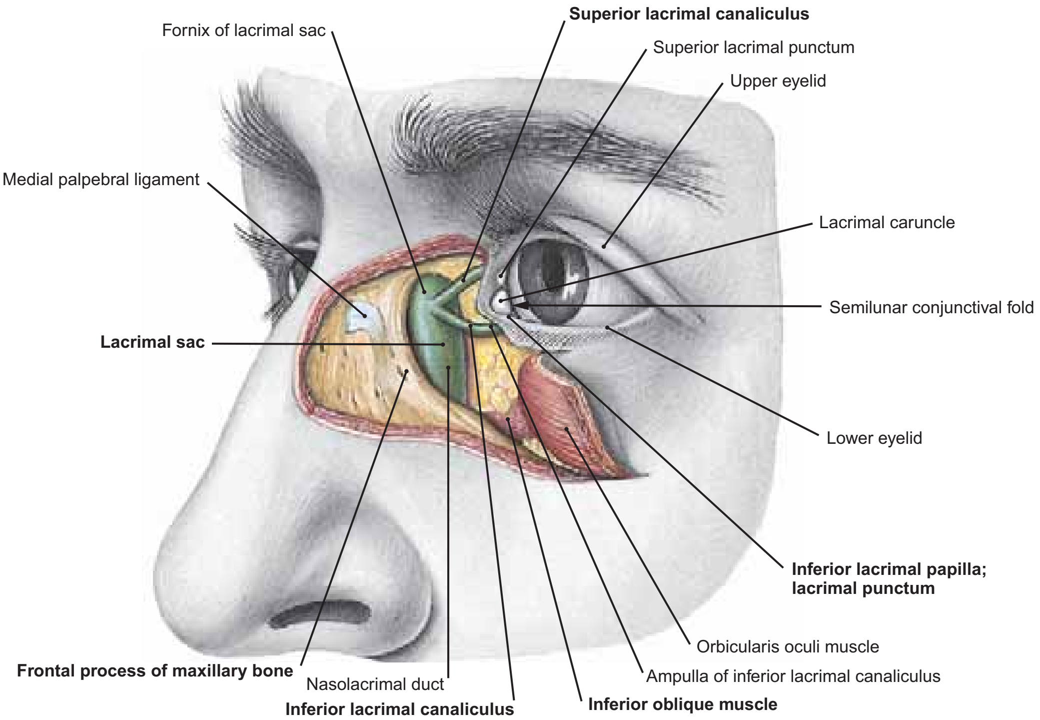


FIGURE 599.1 Lacrimal Canaliculi and Lacrimal Sac (Left Side, Superficial Dissection)

NOTE: (1) The skin and superficial fascia have been removed over the medial angle of the orbit. Observe the cut orbicularis oculi muscle and medial palpebral ligament. The latter structure is still attached to the frontal process of the maxilla.

(2) Severance of the medial palpebral ligament exposes the underlying lacrimal sac, which is located in a small fossa formed by the maxilla and lacrimal bone. This sac receives a lacrimal canaliculus from each eyelid, and each of these two ducts is about 1 cm long.

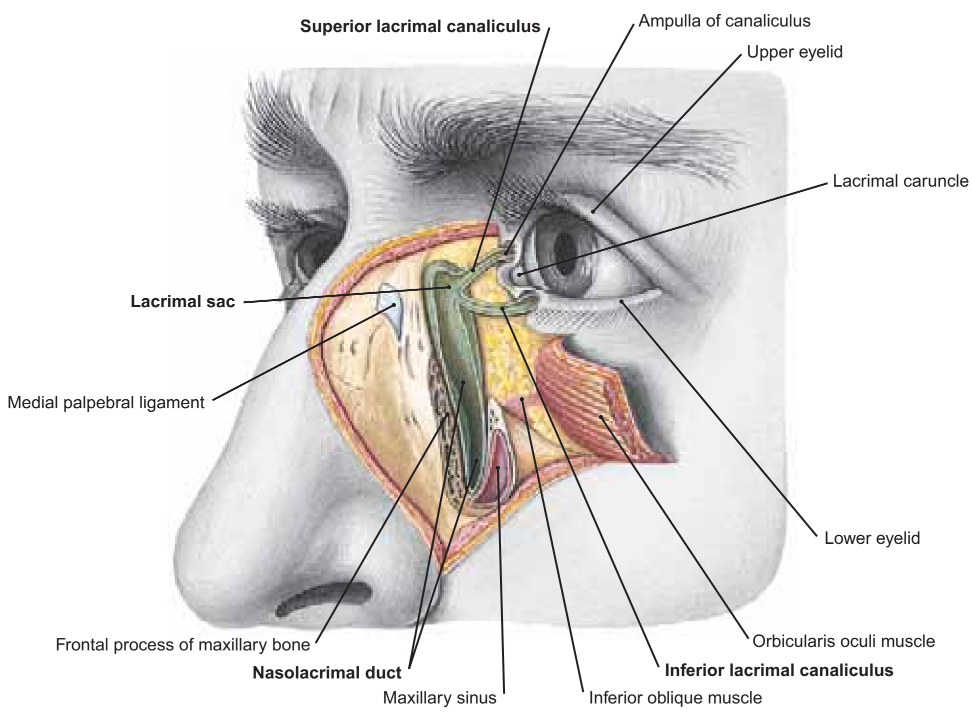


FIGURE 599.2 Lacrimal Canaliculi, Lacrimal Sac, and Nasolacrimal Duct (Left Side, Deep Dissection)

NOTE: (1) At the medial edge of both eyelids are found single minute orifices (lacrimal puncta) of the lacrimal canaliculi, which lead from the eyelids to the lacrimal sac.

(2) The lacrimal sac forms the upper end of the nasolacrimal duct, which then extends about 2 cm into the inferior meatus of the nasal cavity.

(3) Lacrimal secretions pass across the surface of the eyeball toward the canaliculi and then are transported to the nasal cavity by the nasolacrimal duct. Excessive secretions, as in crying, roll over the edge of the lower eyelid as tears.

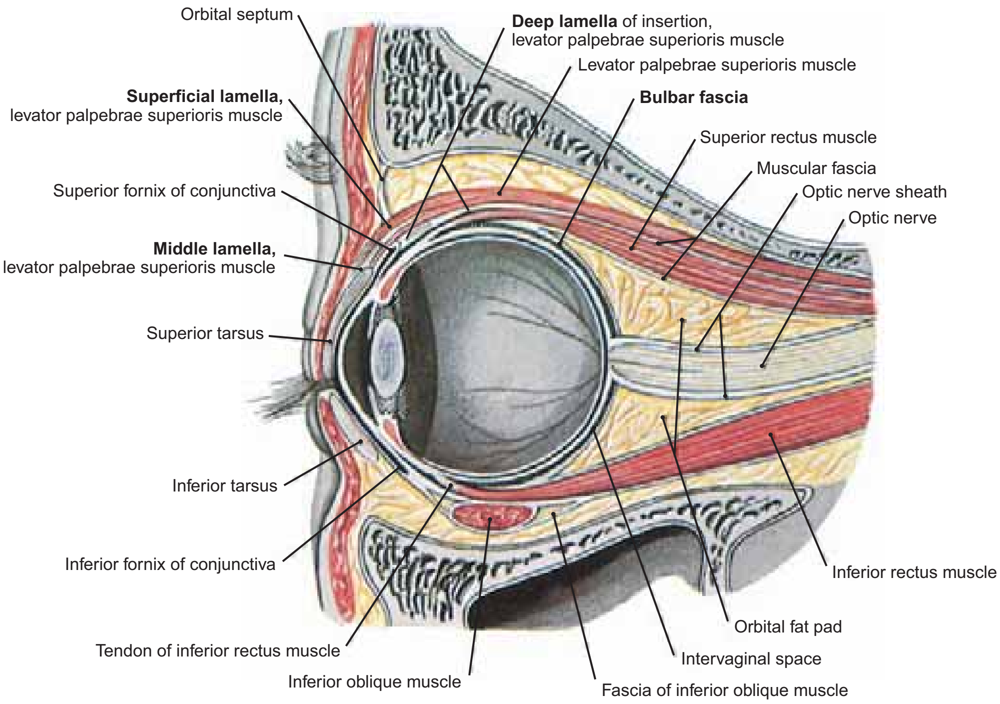


FIGURE 600.1 Sagittal View of the Orbital Cavity and Eyeball

NOTE: (1) The **bulbar fascia** is a thin membrane that encloses the posterior three-fourths of the eyeball and separates the eyeball from the orbital fat and other contents of the orbital cavity.

(2) The bulbar fascia is prolonged over the bellies of the ocular muscles but then is pierced by the tendons of these muscles as they insert on the outer coat of the eyeball.

(3) The insertion of the **levator palpebrae superioris** is trilaminar. The superficial layer inserts into the upper eyelid, the middle layer into the superior tarsus, and the deep layer into the superior fornix of the conjunctiva.

(4) The palpebral **conjunctiva** is a thin transparent mucous membrane on the innermost aspect of the eyelid. At the conjunctival angle (fornix), it reflects over the eyeball as far as the sclerocorneal junction.

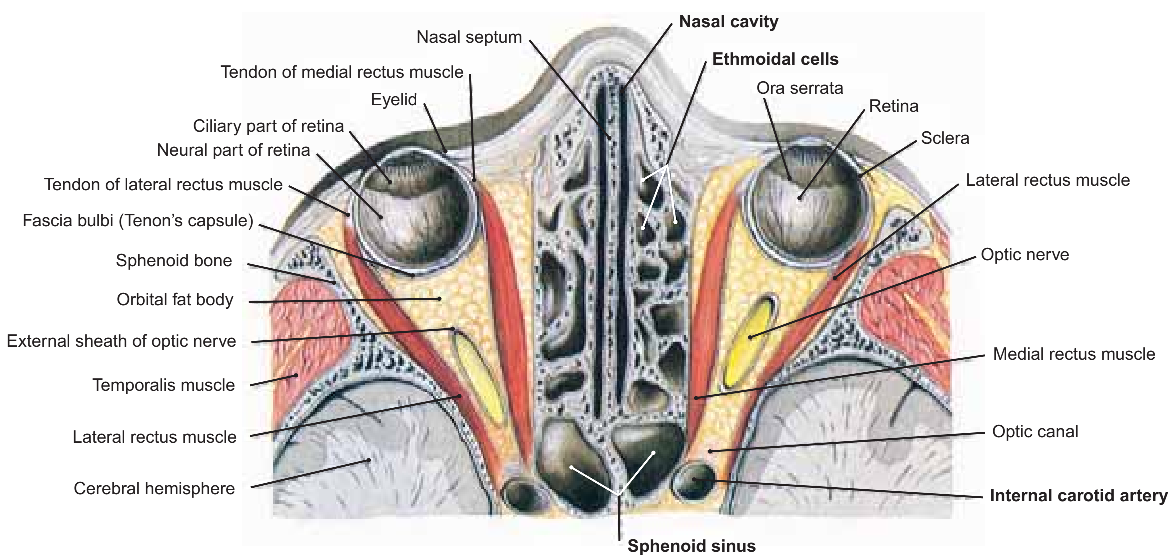


FIGURE 600.2 Horizontal Section through Both Orbits at the Level of the Sphenoid Sinus

NOTE: (1) Between the orbital cavities is situated the **ethmoid bone**, containing the ethmoidal air sinuses (air cells). The vertically oriented perpendicular plate of the ethmoid serves as part of the nasal septum, and it subdivides the nasal cavity into two chambers.

(2) The posterior portion of the orbits is separated by the **sphenoid sinuses**, located within the body of the sphenoid bone. These sinuses frequently are not symmetrical.

FIGURE 601 Nerves and Arteries of the Orbit (Stage 1), Superior View: Ophthalmic Nerve and Artery

NOTE: (1) The orbital plate of the frontal bone has been removed and the superior orbital fissure opened to expose the structures of the right orbit from above. The ophthalmic division of the trigeminal nerve divides into **lacrimal**, **frontal,** and **nasociliary branches**.

(2) The **lacrimal nerve** courses anteriorly and laterally in the orbit and accompanies the lacrimal branch of the ophthalmic artery to supply the lacrimal gland.

(3) The **frontal nerve** overlies the levator palpebrae superioris muscle and soon divides into a delicate **supratrochlear branch** and larger medial and lateral **supraorbital branches**. These course to the front of the orbit, where they emerge on the forehead.

(4) The **nasociliary nerve** crosses the orbit from lateral to medial, deep to the superior rectus muscle, and accompanies the ophthalmic artery for a short distance.

(5) The **trochlear nerve** enters the orbit medial to the ophthalmic nerve to supply the superior oblique muscle.

(6) The **optic nerve** leaves the orbit and enters the cranial cavity just medial to the internal carotid artery and the ophthalmic artery enters the orbit through the optic canal.

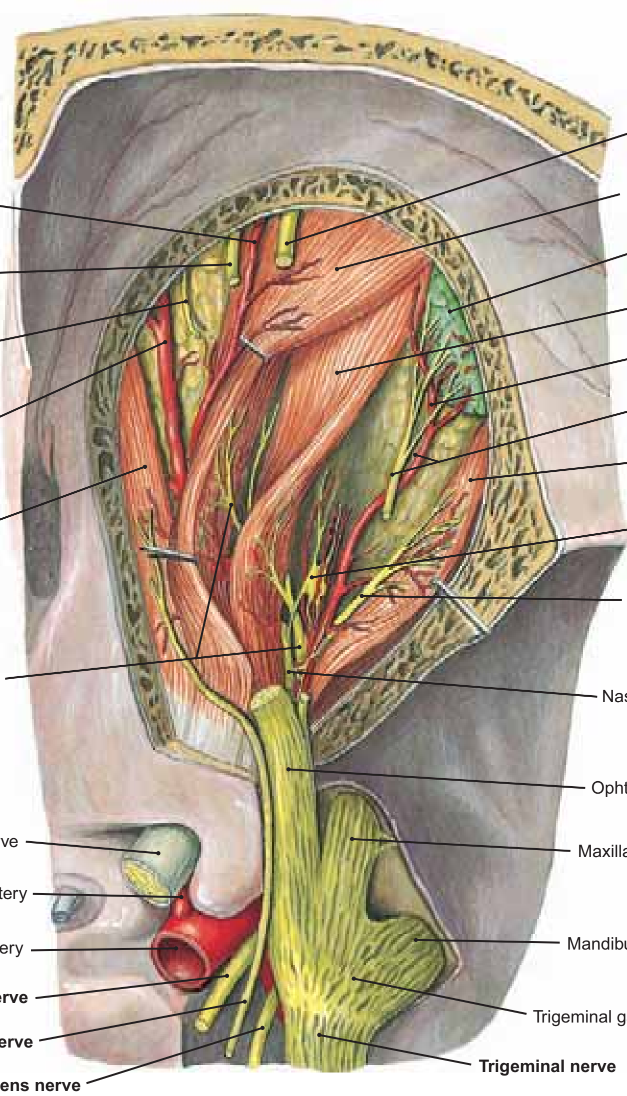


FIGURE 602 **Nerves and Arteries of the Orbit (Stage 2), Superior View: Trochlear and Abducens Nerves**

NOTE: (1) With the right orbit opened from above, the ophthalmic division of the trigeminal nerve and its lacrimal, supratrochlear, and frontal branches have been cut. The levator palpebrae superioris and superior rectus muscles have been pulled medially to reveal their inferior surfaces, where filaments from the **superior branch of the oculomotor nerve** innervate the two muscles.

(2) The **nasociliary branch** of the ophthalmic nerve is still intact as it is seen turning medially deep to the superior rectus muscle. Also note that a fine communicating filament containing sensory fibers interconnects the ciliary ganglion and nasociliary nerve.

(3) The **trochlear nerve** supplies the superior oblique muscle along its upper surface. If this nerve is injured, a patient has difficulty turning the eyeball laterally and down; when asked to look inferolaterally, the affected eye rotates medially, resulting in double vision, or diplopia.

(4) The **abducens nerve** supplies the lateral rectus muscle along its medial surface. After emerging from the brainstem at the pontomedullary junction, this nerve follows a long course in the floor of the cranial cavity and enters the orbit through the superior orbital fissure.

(5) Injury to the abducens nerve produces a diminished ability to move the eyeball laterally. From the resulting medial or convergent gaze of the affected eyeball, the patient experiences diplopia (double vision).

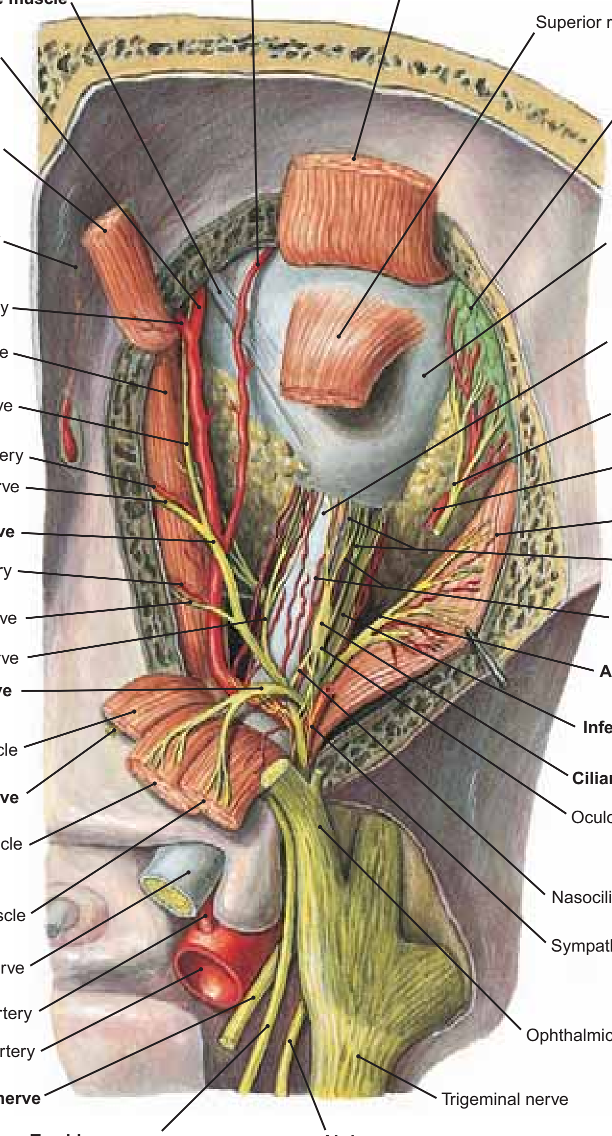


FIGURE 603 Nerves and Arteries of the Orbit (Stage 3), Superior View: Optic Nerve and Ciliary Ganglion

NOTE: (1) With the levator palpebrae superioris, superior rectus, and superior oblique muscles cut and reflected, the **nasociliary nerve** and **ophthalmic artery** are seen crossing over the **optic nerve** from lateral to medial.

(2) The relationship to the optic nerve of the longitudinally oriented **long posterior ciliary arteries** (from the ophthalmic) and the **long ciliary nerves** (two or three branches from the nasociliary nerve).

(3) The **ciliary ganglion** lies lateral to the optic nerve. Its **parasympathetic root** comes from the oculomotor nerve and its **sensory root** from the nasociliary nerve. Postganglionic parasympathetic fibers reach the eyeball by the **short ciliary nerves**.

(4) Postganglionic parasympathetic nerve fibers supply the **sphincter of the pupil** and the muscle responsible for accommodation of the lens, the **ciliary muscle**.

(5) Some **sympathetic fibers** that arrive in the orbit along the ophthalmic artery also course through the ciliary ganglion. These are principally vasoconstrictor fibers to arteries that supply the eyeball. Sympathetic fibers that supply the **dilator of the pupil** course to the posterior pole of the eyeball by way of the **long ciliary nerves**.

(6) Although the supratrochlear nerve is derived from the frontal branch of the ophthalmic nerve, the **infratrochlear nerve** (as well as the **anterior** and **posterior ethmoid nerves**) is derived from the nasociliary branch of the ophthalmic nerve.

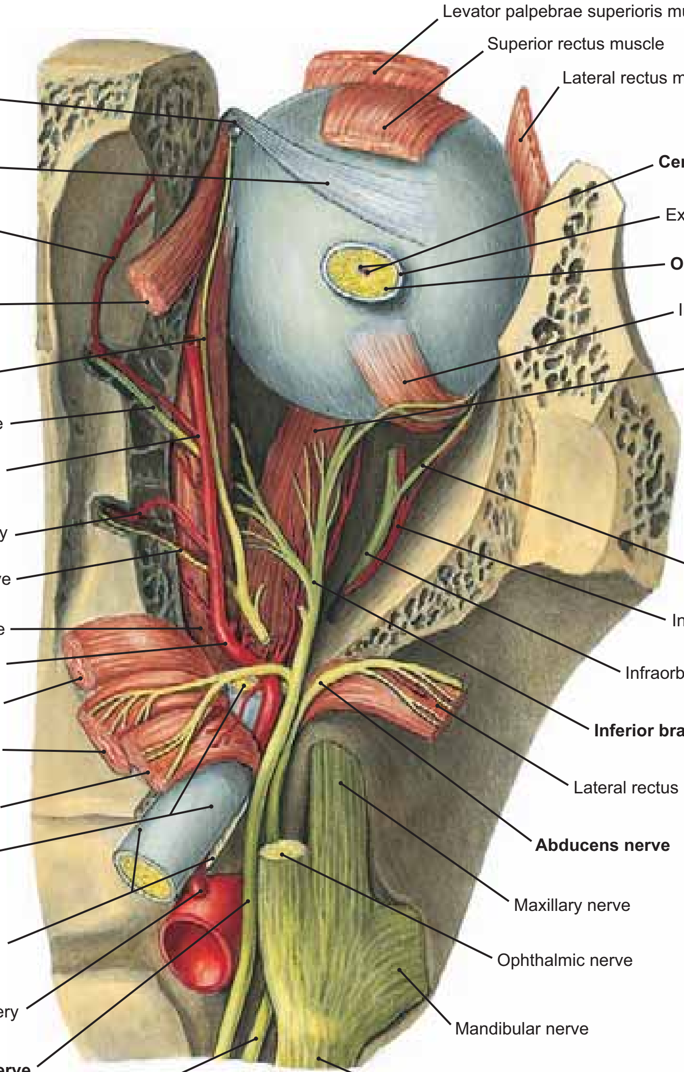


FIGURE 604 Nerves and Arteries of the Orbit (Stage 4), Superior View: Oculomotor Nerve (Inferior Branch)

NOTE: (1) The levator palpebrae superioris, superior rectus, superior oblique, and lateral rectus muscles have been cut and reflected; the optic nerve has also been severed. The anterior half of the eyeball has been depressed and its posterior pole directed upward. Observe the **central retinal vessels** as well as the insertions of the superior oblique and inferior oblique muscles.

(2) The **oculomotor nerve** courses through the superior orbital fissure and the common tendinous ring. It quickly gives off its **superior branch**, which courses upward in the orbit to supply the levator palpebrae superioris and superior rectus muscles. The **inferior branch** of the oculomotor nerve courses anteriorly in the deep part of the orbit to supply the inferior rectus, medial rectus, and inferior oblique muscles.

(3) The anterior and posterior ethmoid arteries and nerves and the infratrochlear nerve all located medially in the orbit. Also note the **infraorbital nerve** and **artery** in the infraorbital groove more laterally.

(4) The **ophthalmic artery** is the first branch of the internal carotid artery within the cranial cavity; it immediately enters the orbit through the optic canal with the optic nerve. Probably, the most important of the branches of the ophthalmic artery is the **central retinal artery**, which courses with its **vein** within the optic nerve.

(5) The central artery is the **only** source of blood to the neural retina and an increase in pressure on the posterior part of the orbital cavity or edema of the optic nerve caused by an inflammatory process can seriously compromise vision either by blockage of the artery or by diminishing the flow in the **central retinal vein.**

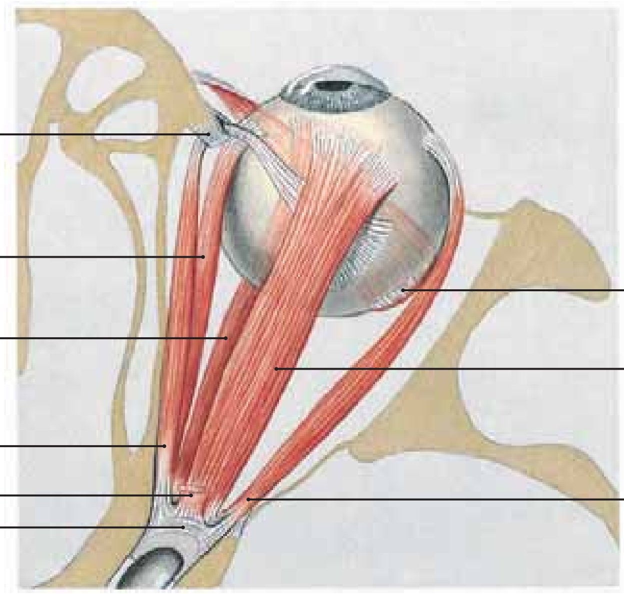


FIGURE 605.1 Superior View of the Extraocular Muscles of the Right Eye

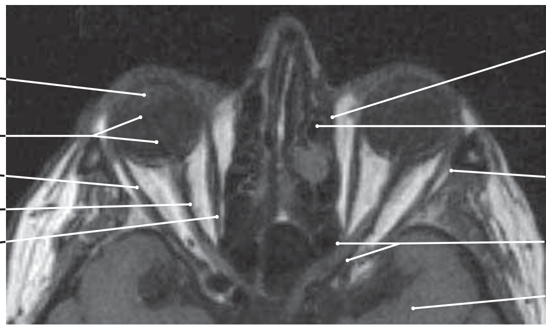


FIGURE 605.2 MRI of Both Orbits

NOTE the optic nerve seen in the left orbit and the optic canal seen in the right orbit.

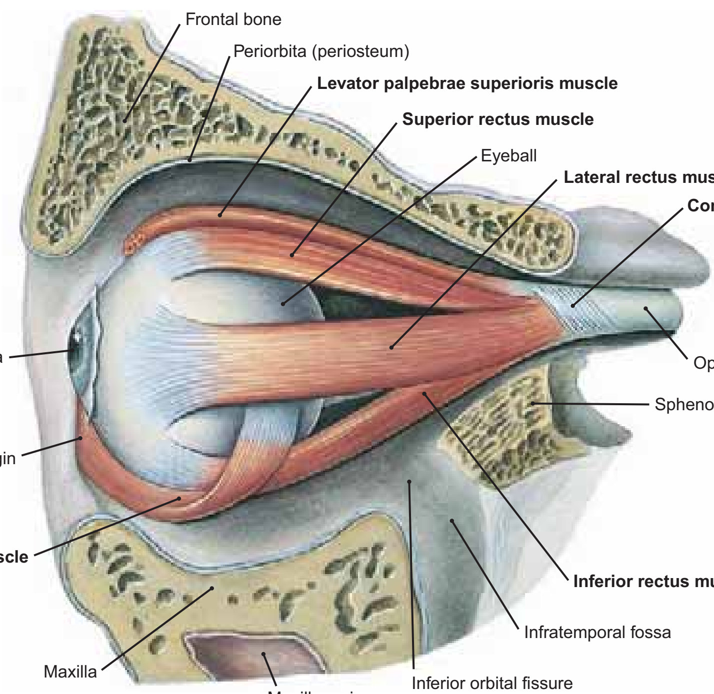


FIGURE 605.3 Eye Muscles (Left Lateral View)

NOTE: (1) With the lateral wall of the left orbit removed along with the bulbar fascia and eyelids, five of the seven extraocular muscles become exposed. Those evident from this view are the superior, lateral, and inferior rectus muscles, along with the levator palpebrae superioris and inferior oblique. Not seen are the medial rectus and superior oblique.

(2) Of the seven muscles, all except the levator palpebrae superioris and the inferior oblique take origin from the common tendinous ring that surrounds the optic nerve.

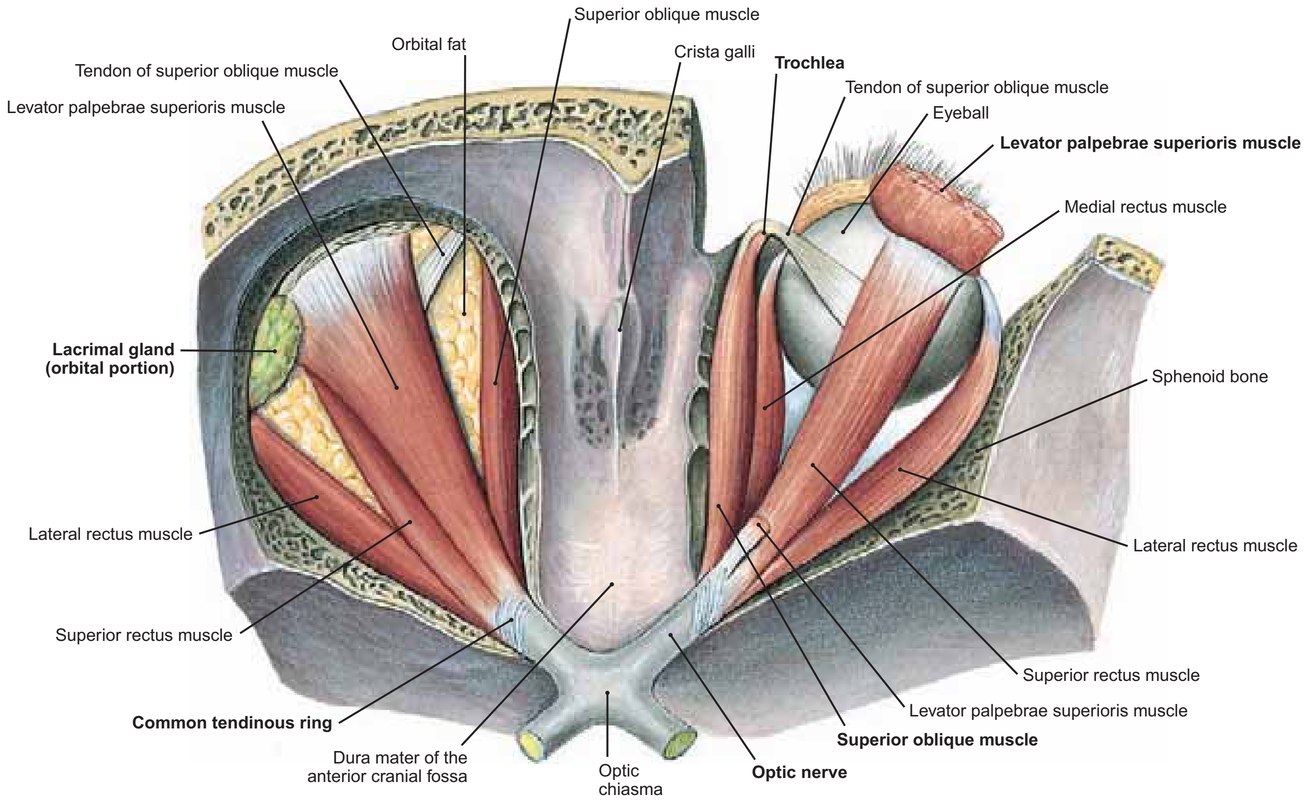


FIGURE 606.1 Muscles of the Orbital Cavity (Seen from Above)

NOTE: (1) The orbital plates of the frontal bones have been removed from within the cranial cavity. On the left side, only the bony roof of the orbit has been opened and the muscles, orbital fat, and lacrimal gland have been left intact.
(2) On the right side, the levator palpebrae superioris muscle has been resected and the orbital fat removed to expose the ocular muscles.

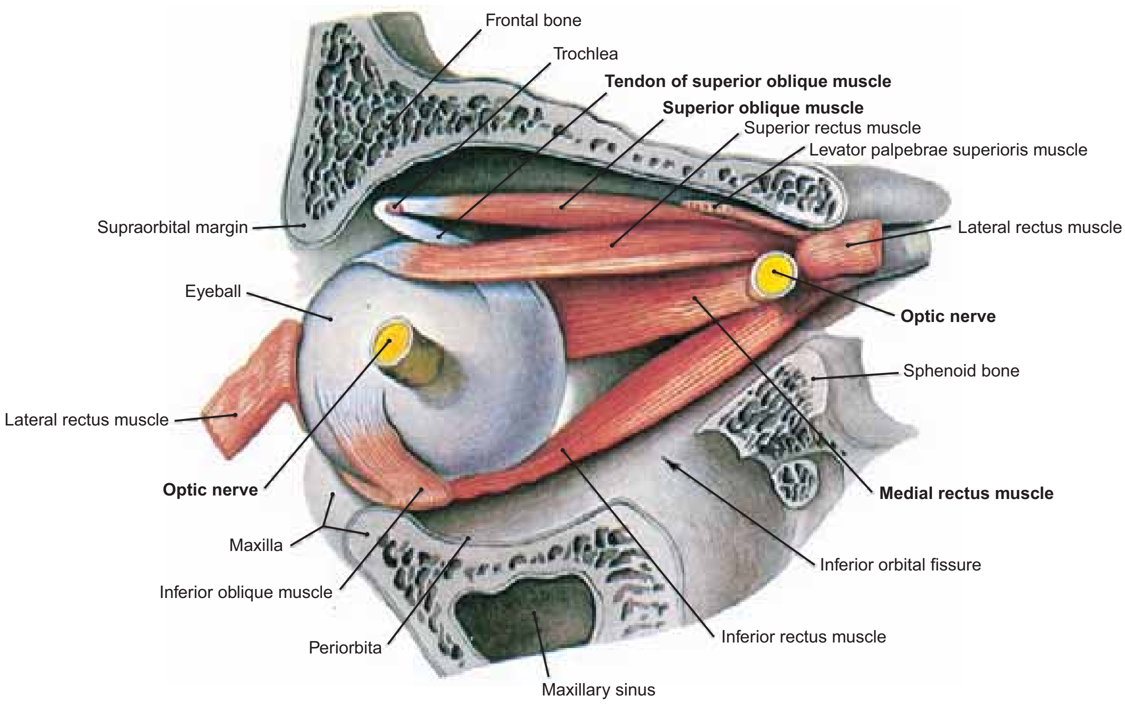


FIGURE 606.2 Eye Muscles, Left Lateral View (Lateral Rectus Muscle and Optic Nerve Cut)

NOTE: The eyeball has been rotated 90 degrees so that its posterior pole is directed laterally. This reveals to advantage the insertion of the inferior oblique muscle and the superior oblique muscle and tendon as it bends around the trochlea to insert on the eyeball.

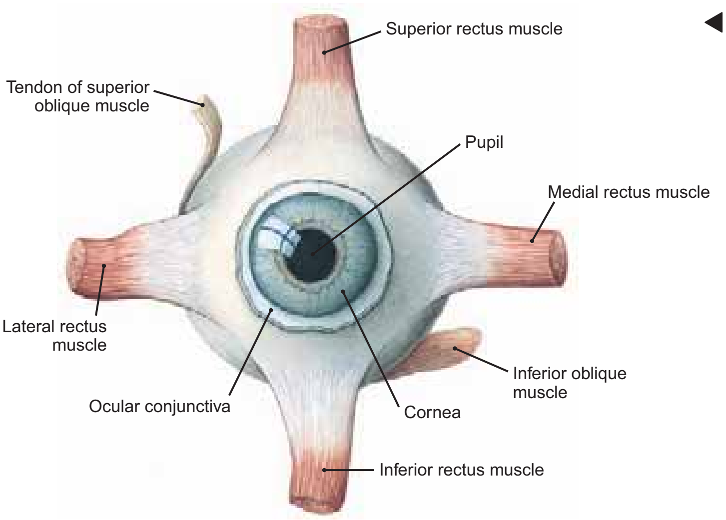


FIGURE 607.1 Right Eyeball and Muscle Insertions (Front)

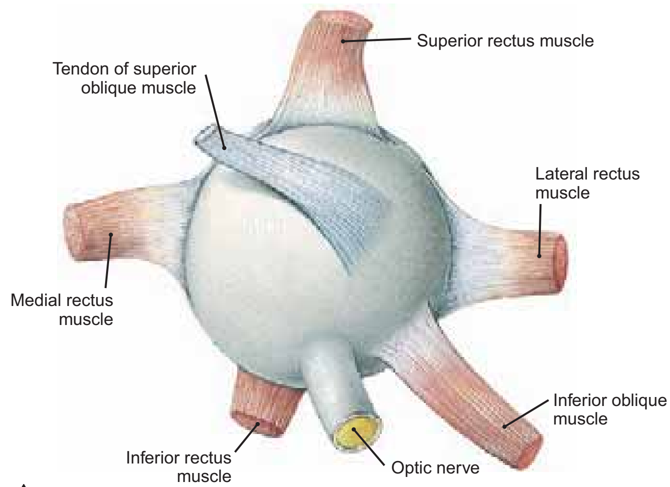


FIGURE 607.2 Right Eyeball and Muscle Insertions (Behind and Above)

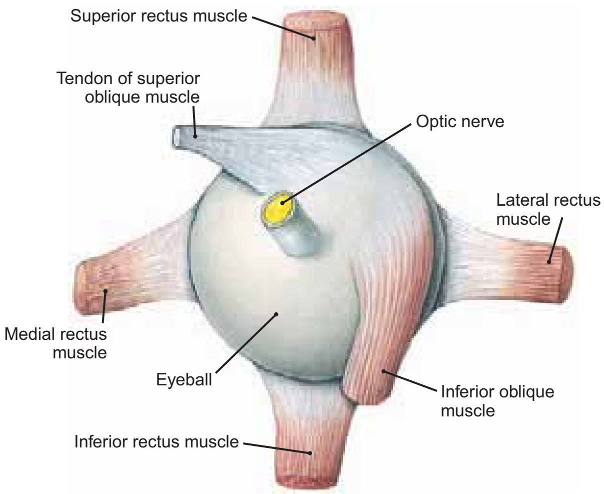


FIGURE 607.3 Right Eyeball and Muscle Insertions (Behind and Below)

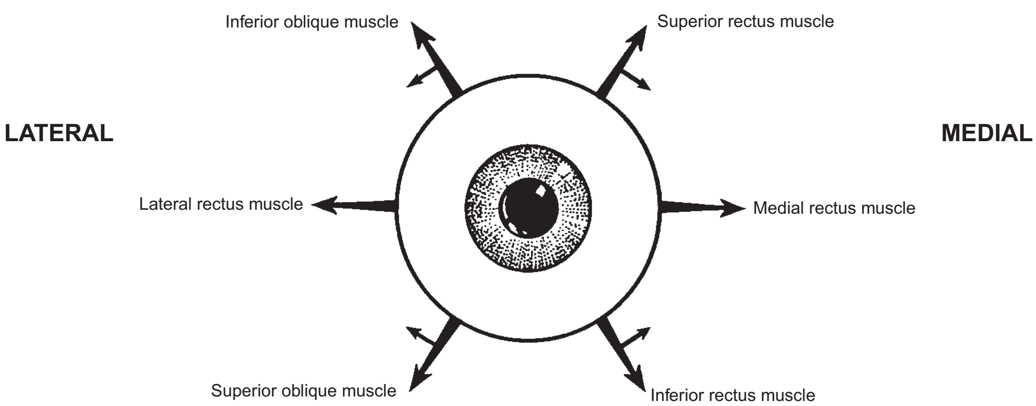


FIGURE 607.4 Schema of Extraocular Muscle Actions

NOTE:
(1) The **lateral rectus** *abducts* the eyeball only.
(2) The **superior oblique** *abducts, depresses*, and *medially rotates* the eyeball.
(3) The **inferior oblique** *abducts, elevates*, and *laterally rotates* the eyeball.
(4) The **medial rectus** *adducts* the eyeball only.
(5) The **inferior rectus** *adducts, depresses*, and *laterally rotates* the eyeball.
(6) The **superior rectus** *adducts, elevates*, and *medially rotates* the eyeball.

NOTE the following muscle innervations:
(1) The **oculomotor nerve (III)**: levator palpebrae superioris, superior rectus, medial rectus, inferior rectus, inferior oblique muscles.
(2) The **trochlear nerve (IV)**: superior oblique muscle.
(3) The **abducens nerve (VI)**: lateral rectus muscle.

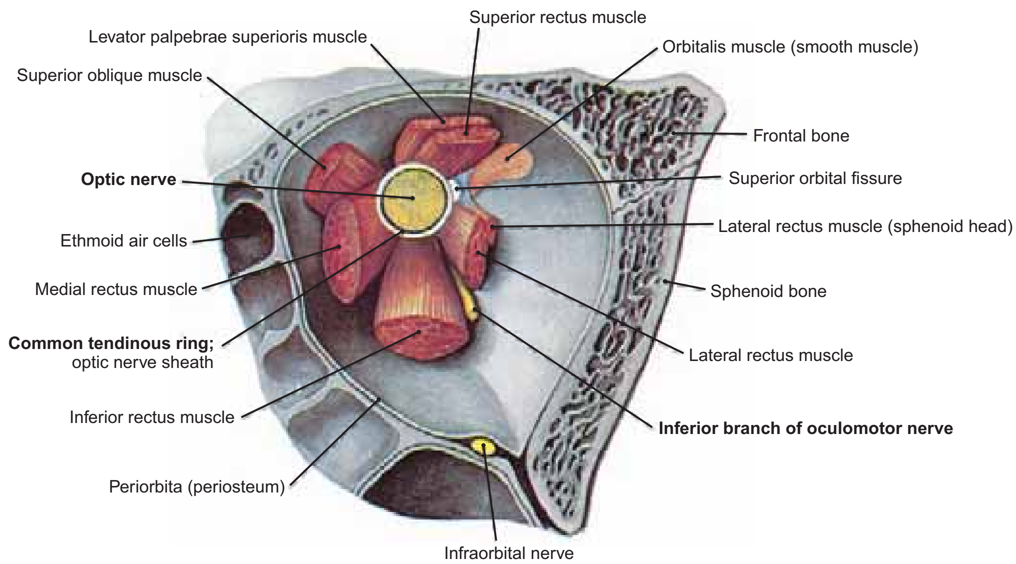


FIGURE 608.1 Origins of the Ocular Muscles, Apex of Left Orbit

NOTE: (1) This anterior view of the apex of the left orbit shows the stumps of the ocular muscles, which have been cut close to their origins.

(2) The four rectus muscles arise from a tendinous ring surrounding the optic canal. The levator palpebrae superioris and superior oblique arise from the sphenoid bone close to the tendinous ring, whereas the inferior oblique (not shown here, see Fig. 597.2) arises from the orbital surface of the maxilla.

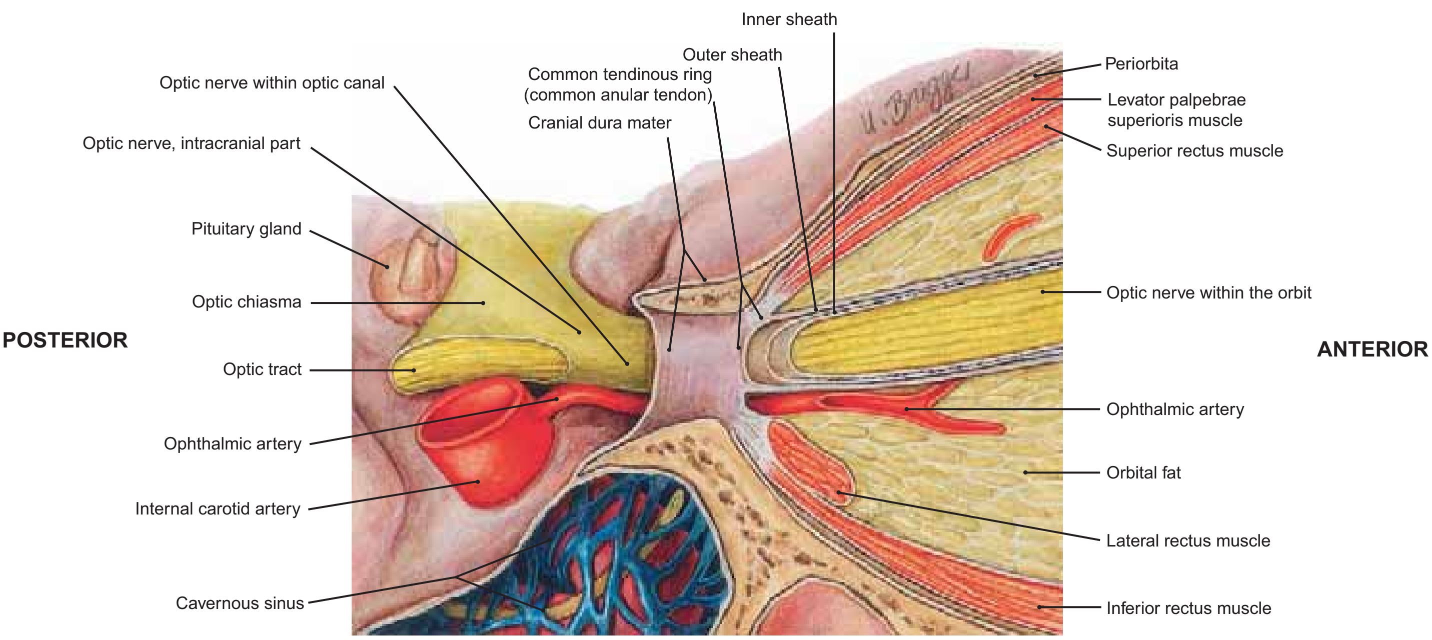
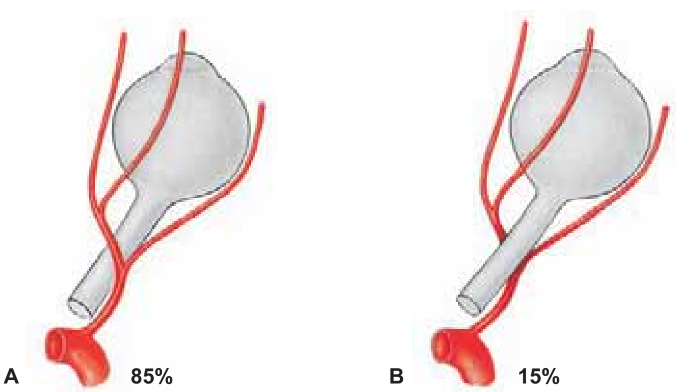


FIGURE 608.2 Ophthalmic Artery and Optic Nerve in the Optic Canal



◀ **FIGURE 608.3 Variations in the Ophthalmic Artery (also see Fig. 603)**

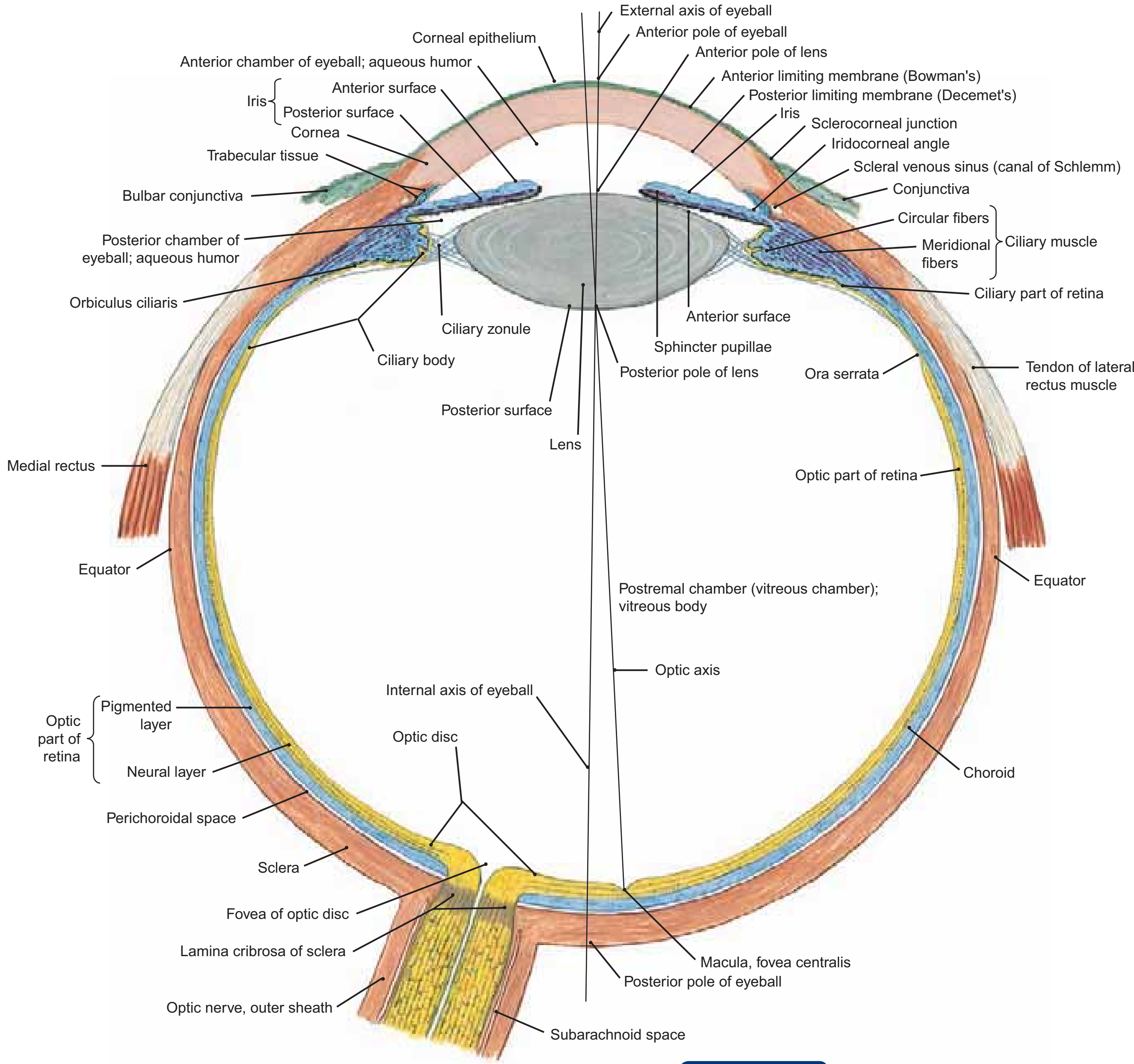


FIGURE 609.1 Horizontal Section of the Left Eyeball through the Optic Disk and Nerve

NOTE: The eyeball is composed of three concentric layer or tunics:

(1) An **outer fibrous tunic,** which consists of the tough **sclera** posteriorly and the translucent **cornea** anteriorly **(brown).**

(2) The **middle vascular tunic** including the **choroid** posteriorly and the **ciliary body** and **iris** anteriorly **(blue).**

(3) The **inner neural tunic**, which is **retina**. It consists of a **neural part** posteriorly, and a **nonneural part** that underlies the ciliary body and iris. The junction between these two parts is the **ora serrata (yellow).**

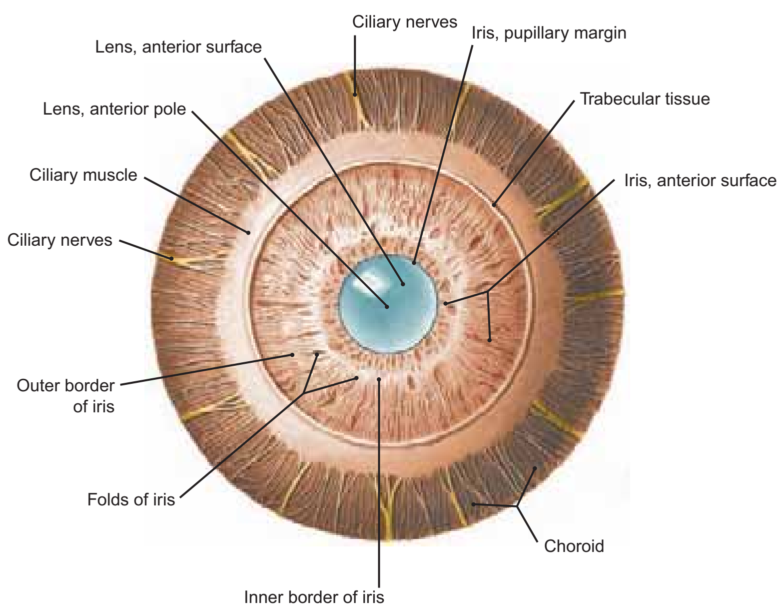


FIGURE 609.2 Iris and Pupil (Anterior View)

NOTE: The anterior pole of the lens is located behind the iris.

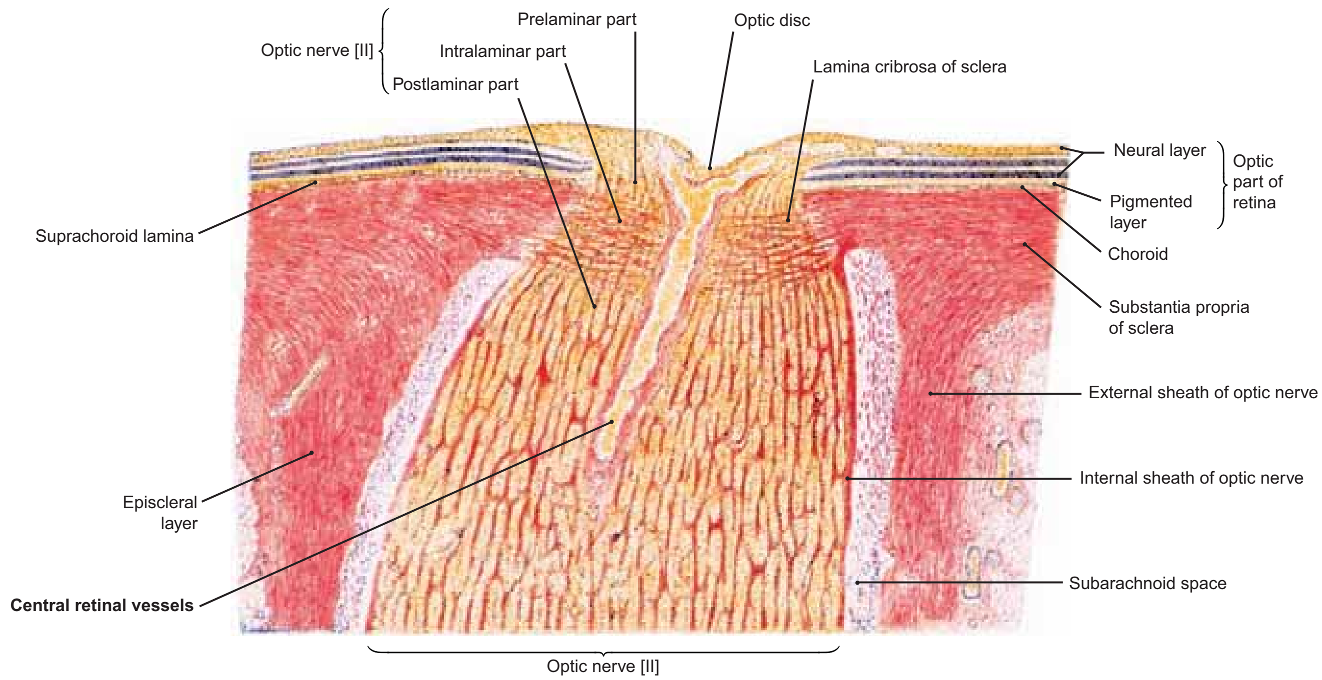


FIGURE 610.1 Horizontal Section of the Optic Disk Region of the Eyeball

NOTE: The axons of the optic nerve leave the eyeball at the **optic disk,** or blind spot, where there are no visual receptors.

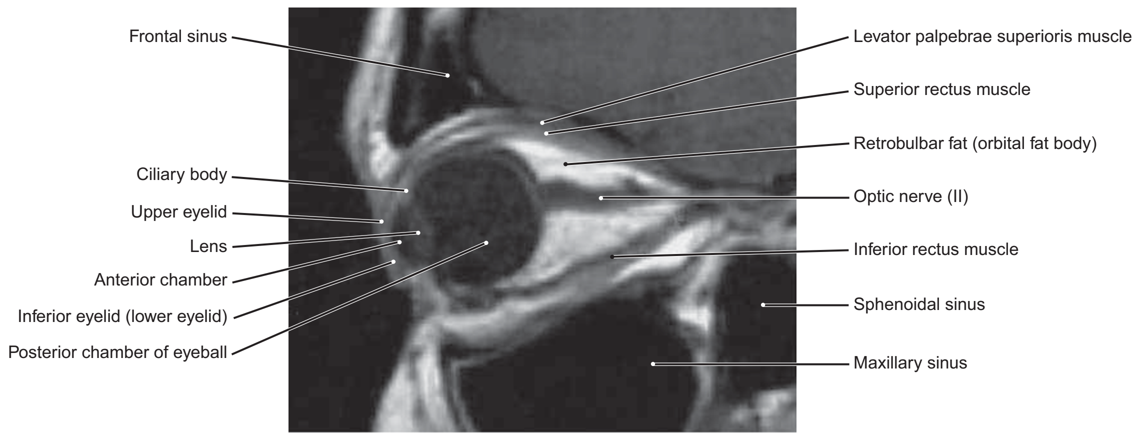


FIGURE 610.2 Magnetic Resonance Image through the Right Orbit: Lateral View

NOTE: This is a sagittal section through the optic nerve.

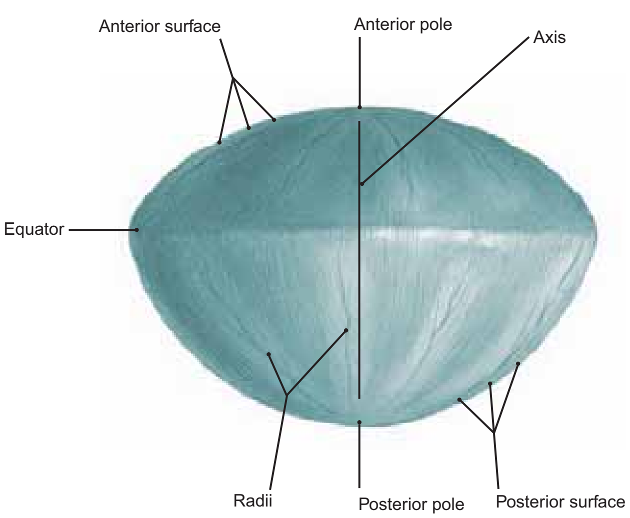


FIGURE 610.3 Lens

NOTE: The anteroposterior axis and the equator.

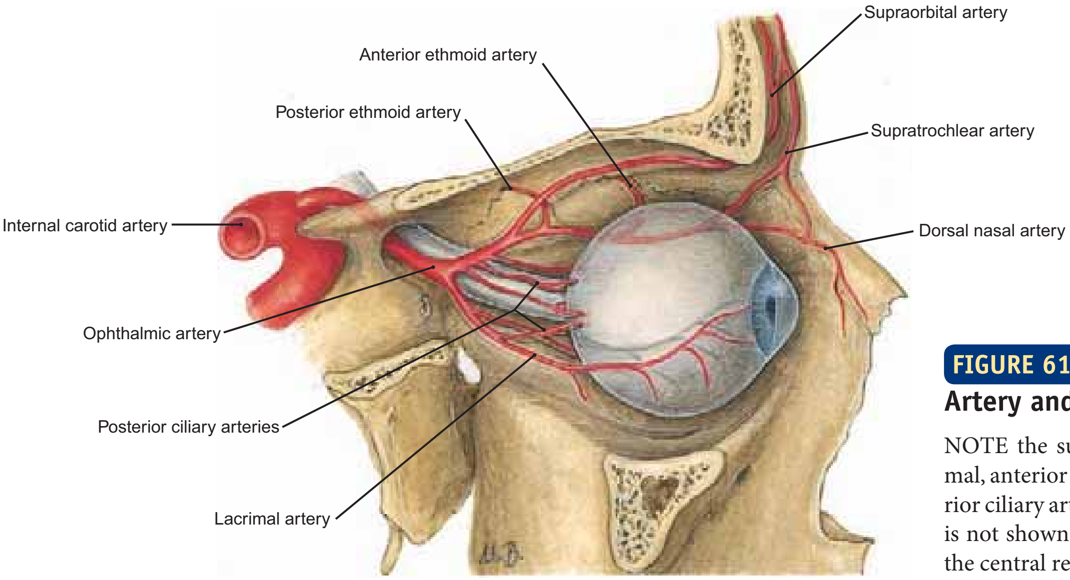


FIGURE 611.1 The Ophthalmic Artery and Its Branches

NOTE the supraorbital, supratrochlear, lacrimal, anterior and posterior ethmoid, and posterior ciliary arteries, but the central retinal artery is not shown or labeled. See some branches of the central retinal artery in **Figure 611.2.**

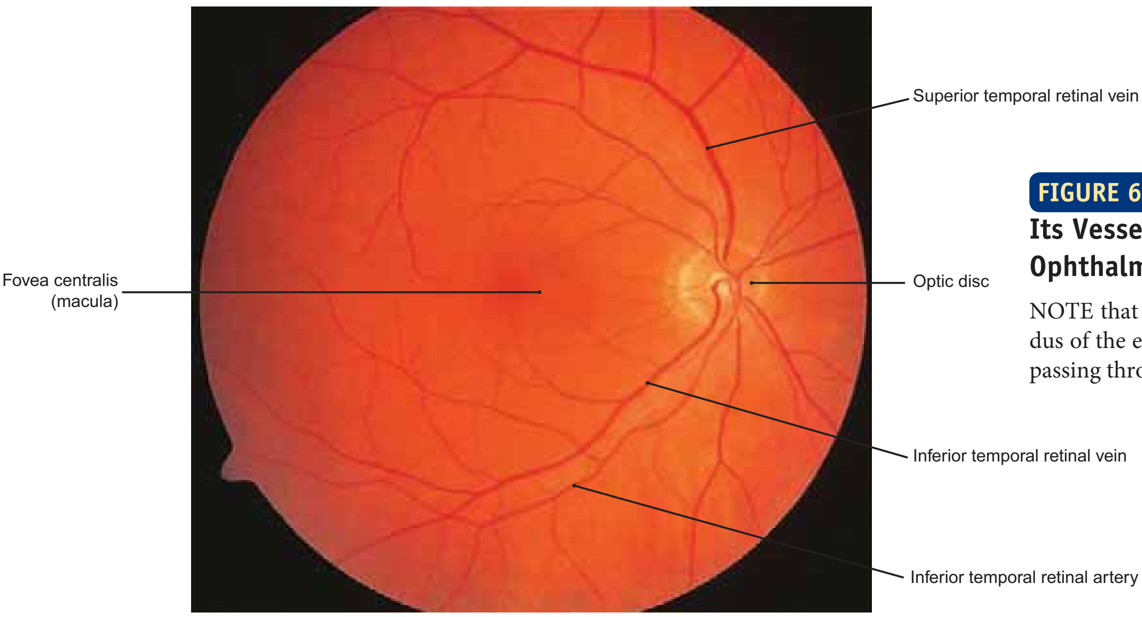


FIGURE 611.2 Retina and Its Vessels as Seen with an Ophthalmoscope

NOTE that this figure shows the fundus of the eye with the **retinal vessels** passing through the optic disc.

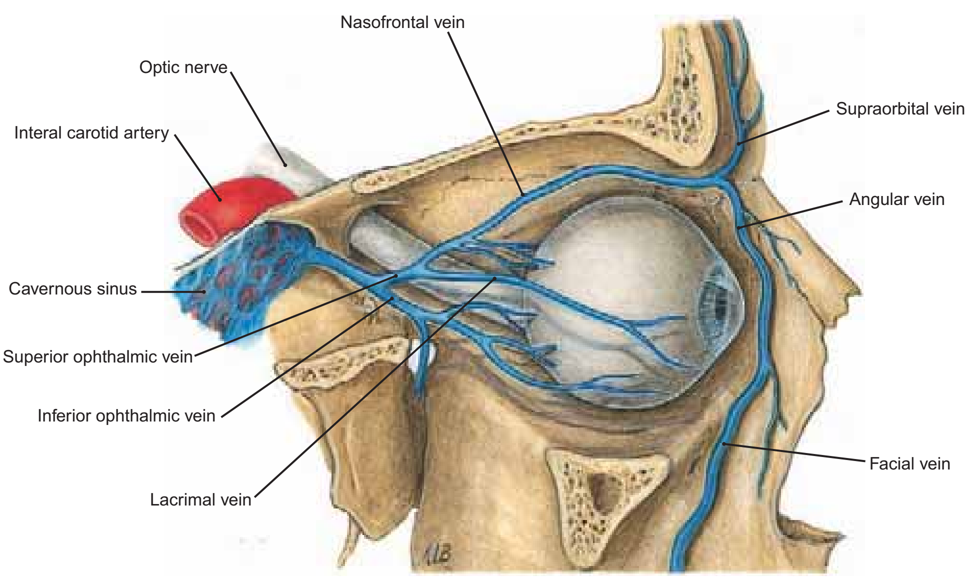


FIGURE 611.3 Veins Draining the Orbit

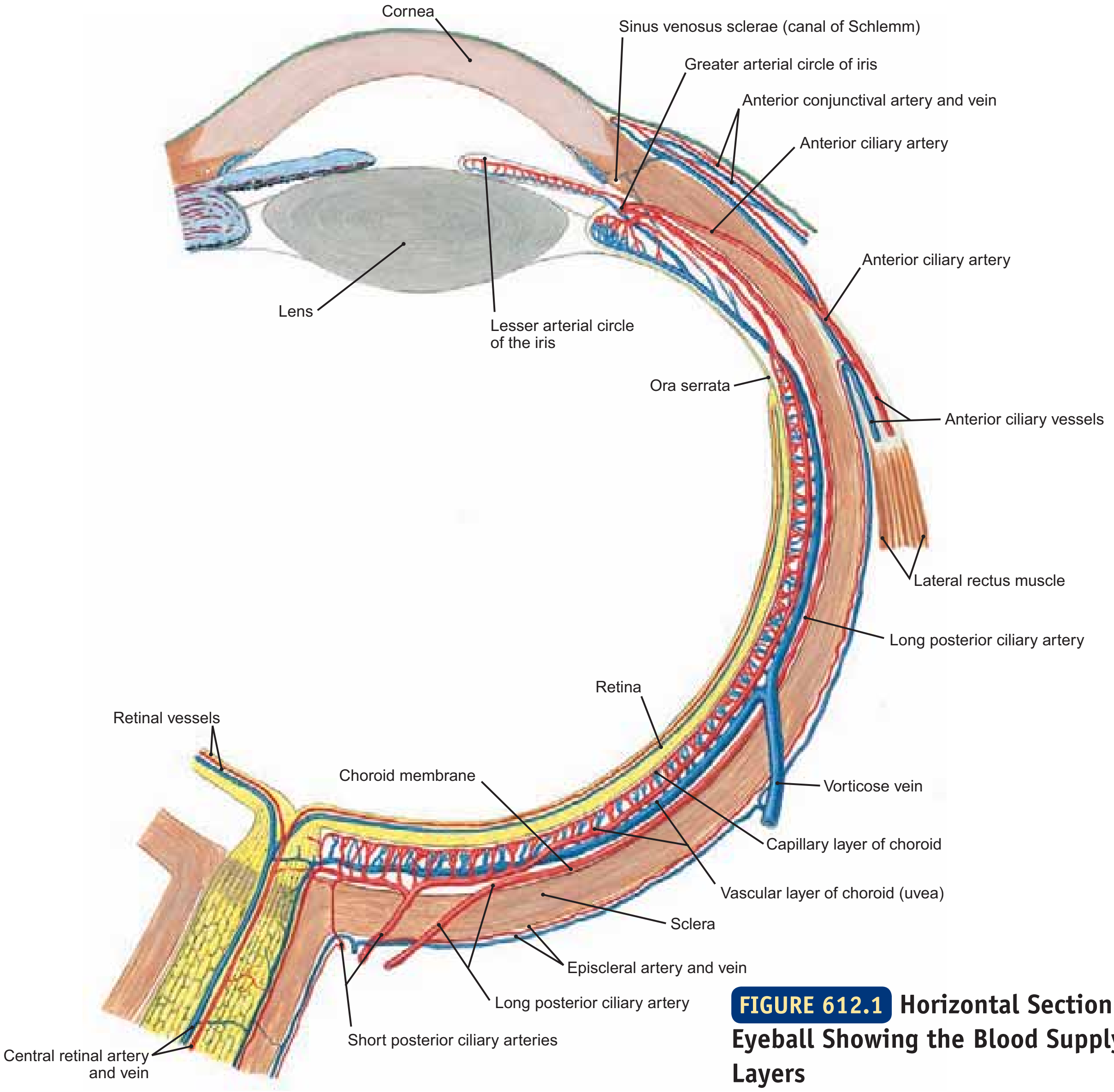


FIGURE 612.1 Horizontal Section through the Eyeball Showing the Blood Supply to Its Three Layers

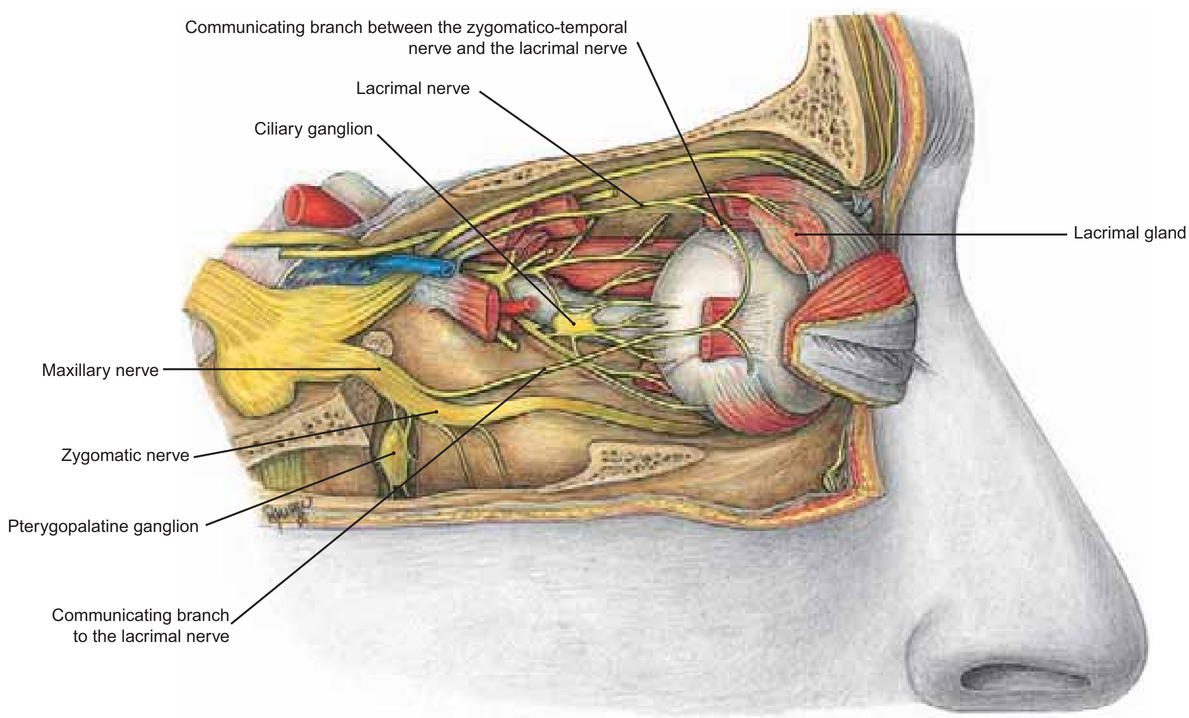


FIGURE 612.2 Select Nerves within the Orbital Cavity

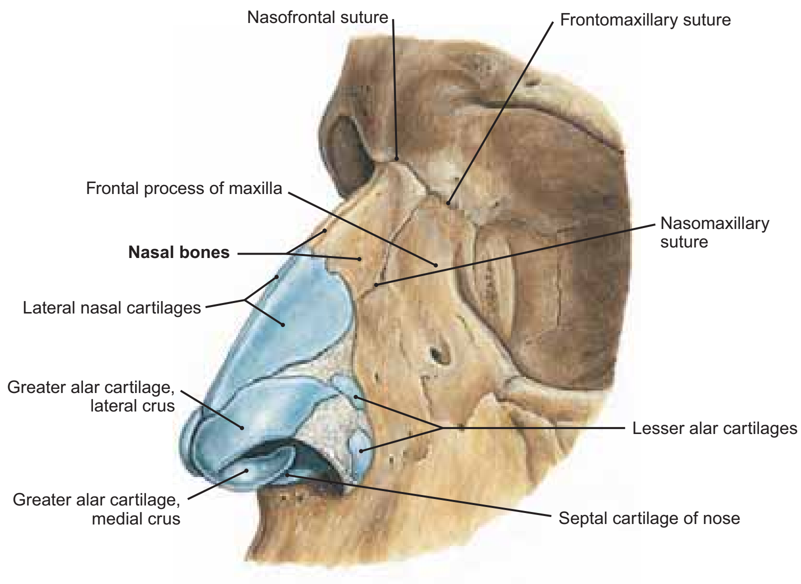


FIGURE 613.1 Cartilages and Bones of the External Nose

NOTE: (1) The distal and lateral parts of the external nose consist mostly of nasal cartilages. The bony framework that forms the base of the nose consists of the nasal bones and the nasal processes of the maxillary and frontal bones.

(2) The oval-shaped external openings are called the external nares (or nostrils). These lead into the nasal vestibules, which are continuous with the nasal cavities.

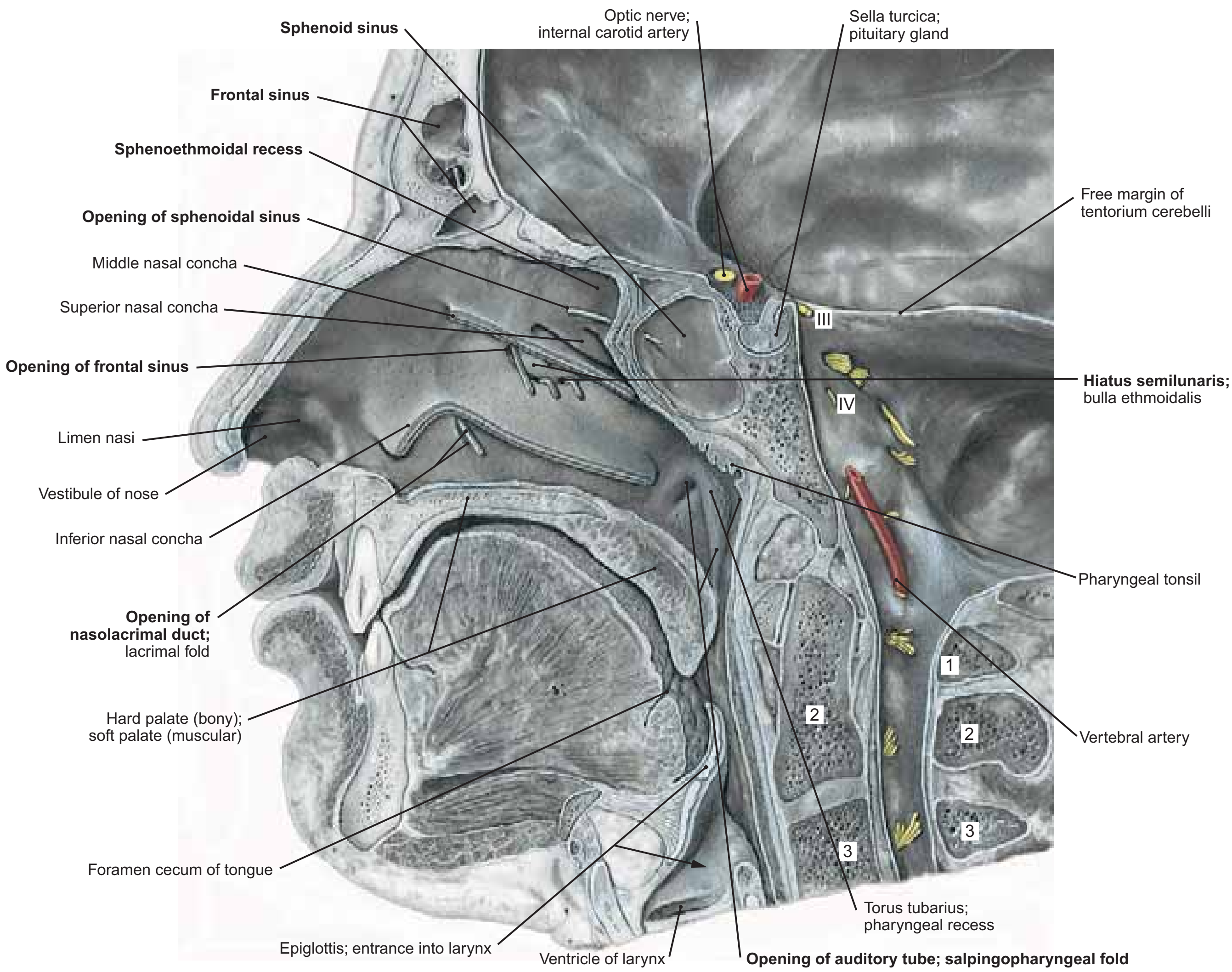


FIGURE 613.2 Lateral Wall of the Right Nasal Cavity Showing Openings of the Paranasal Air Sinuses and the Nasopharynx

NOTE: (1) This paramedian sagittal section of the head shows the right nasal cavity after the middle and inferior nasal conchae were removed. The nasal cavity communicates anteriorly with the exterior through the nostril and posteriorly with the nasopharynx.

(2) The openings of the paranasal sinuses and other structures:

(a) The **sphenoid sinus**, which drains into the **sphenoethmoid recess** above the superior concha.

(b) The **frontal** and **maxillary sinuses**, both of which open in a groove called the **hiatus semilunaris** in the middle meatus below the middle concha.

(c) The **nasolacrimal duct**, which opens into the inferior meatus below the inferior concha.

(d) The **auditory tube**, which opens into the nasopharynx just behind the inferior concha.

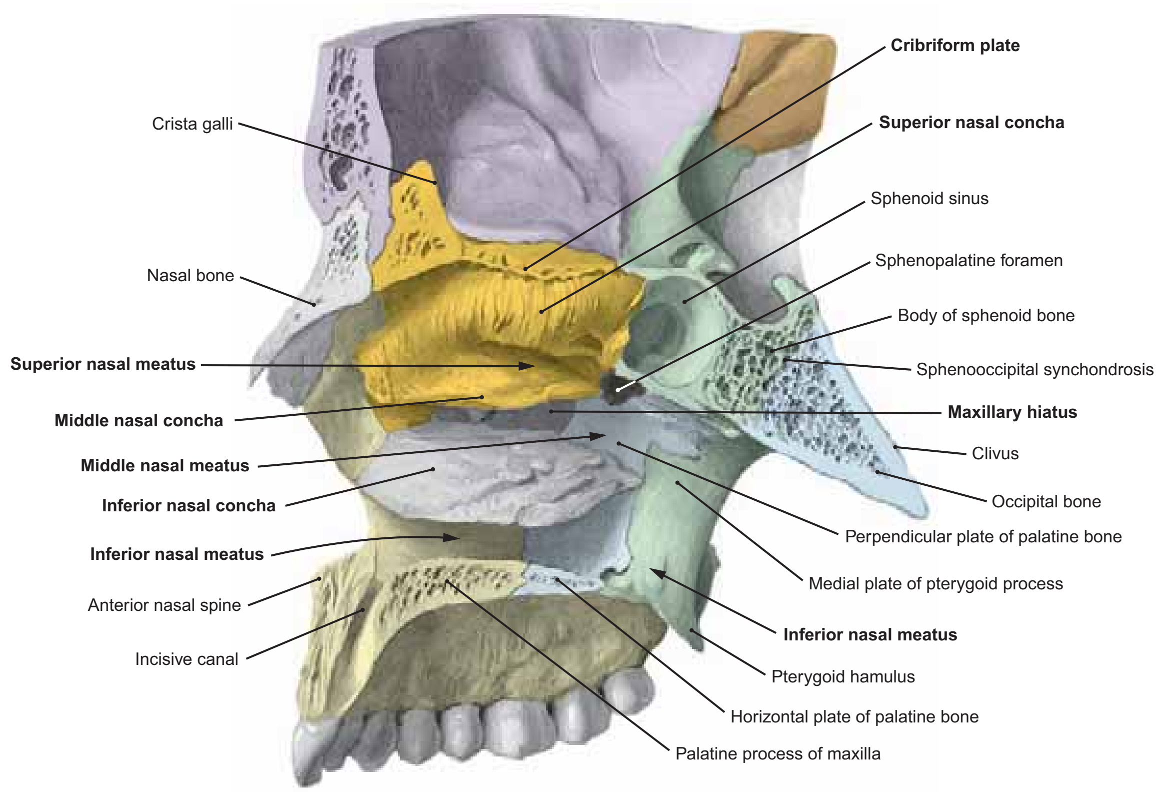


FIGURE 614.1 **Bony Lateral Wall of the Right Nasal Cavity**

NOTE: (1) The nasal septum has been removed and the mucosa stripped from the irregular lateral wall of the nasal cavity and the hard palate. Also note that in front of the nasal conchae are the **nasal bone** (gray) and the **maxilla**, and behind is the **perpendicular plate** of the **palatine bone** (blue).

(2) The **crista galli**, **cribriform plate,** and the **superior** and **middle nasal conchae** are all parts of the **ethmoid bone** (light orange). Below these is the **inferior nasal concha**, which is a separate bone (gray). The bony floor of the nasal cavity is the hard palate, formed by the **palatine process** of the **maxilla** and the **horizontal plate** of the **palatine bone**.

(3) The arrows that follow the courses of the **superior**, **middle**, and **inferior meatuses**, each under its respective nasal concha. Also note the **sphenoid sinus**, the **sphenopalatine foramen**, and the opening of the maxillary sinus **(maxillary hiatus)**.

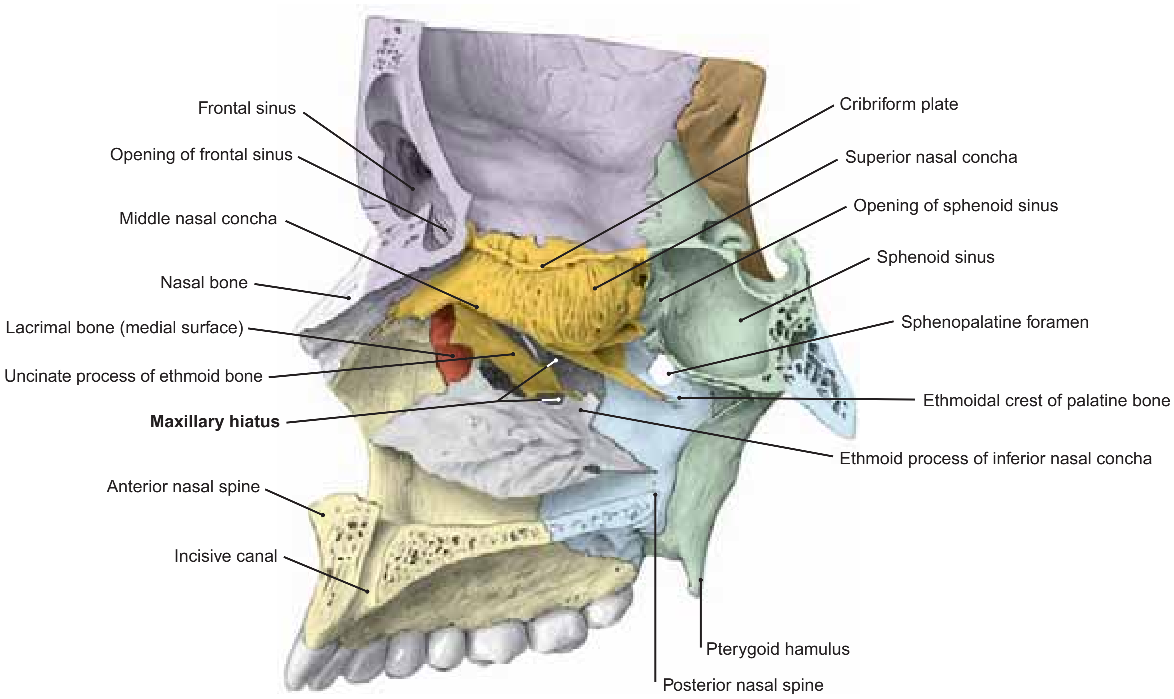


FIGURE 614.2 **Bony Lateral Wall of the Right Nasal Cavity with the Middle Nasal Concha Removed**

NOTE: More complete exposure of the **maxillary hiatus** and the bony structures deep to (lateral to) the middle nasal concha. Compare with Figure 614.1.

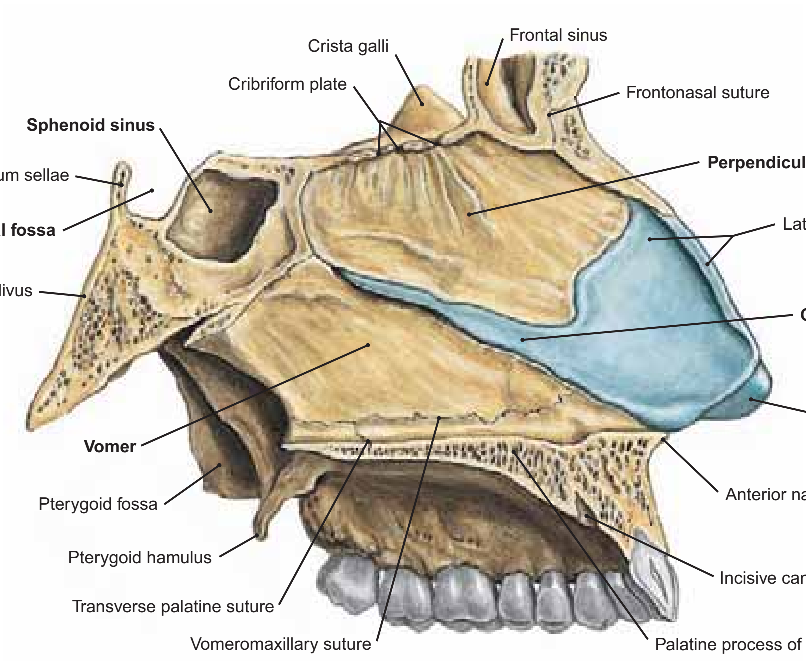


FIGURE 615.1 Nasal Septum: Structure and Blood Supply (Notes)

NOTE: (1) The skeletal structure of the nasal septum includes the **perpendicular plate of the ethmoid bone,** the **vomer bone,** and the **cartilage of the nasal septum**.

(2) The arteries of the septum include: superior and posterior—the **anterior and posterior ethmoid arteries** and the **posterior septal branches** of the **sphenopalatine artery**; inferior and anterior—the **septal branch** of the **superior labial artery**, which enters through the nostrils, and the **septal branch** of the **greater palatine artery**, which enters the nasal cavity by way of the incisive foramen.

(3) The **septal nerves** include: branches of the **anterior ethmoid nerve** (from the ophthalmic nerve), the **nasopalatine nerve** (from the maxillary nerve), and the **internal nasal branches** of the infraorbital nerves that enter the nasal cavities through the nostrils.

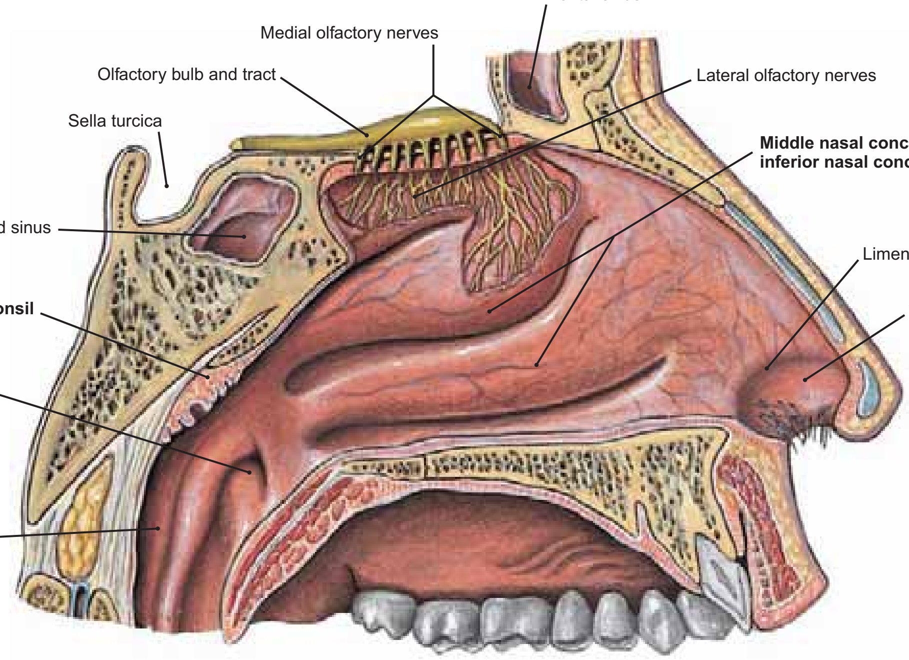


FIGURE 615.2 Lateral Wall of the Left Nasal Cavity Showing the Olfactory Nerves

NOTE: The mucous membrane overlying the **lateral olfactory nerves** has been removed. The lateral wall of the nasal cavity is marked by the **superior**, **middle,** and **inferior nasal conchae**. Beneath each concha courses the corresponding nasal passage, or **meatus**.

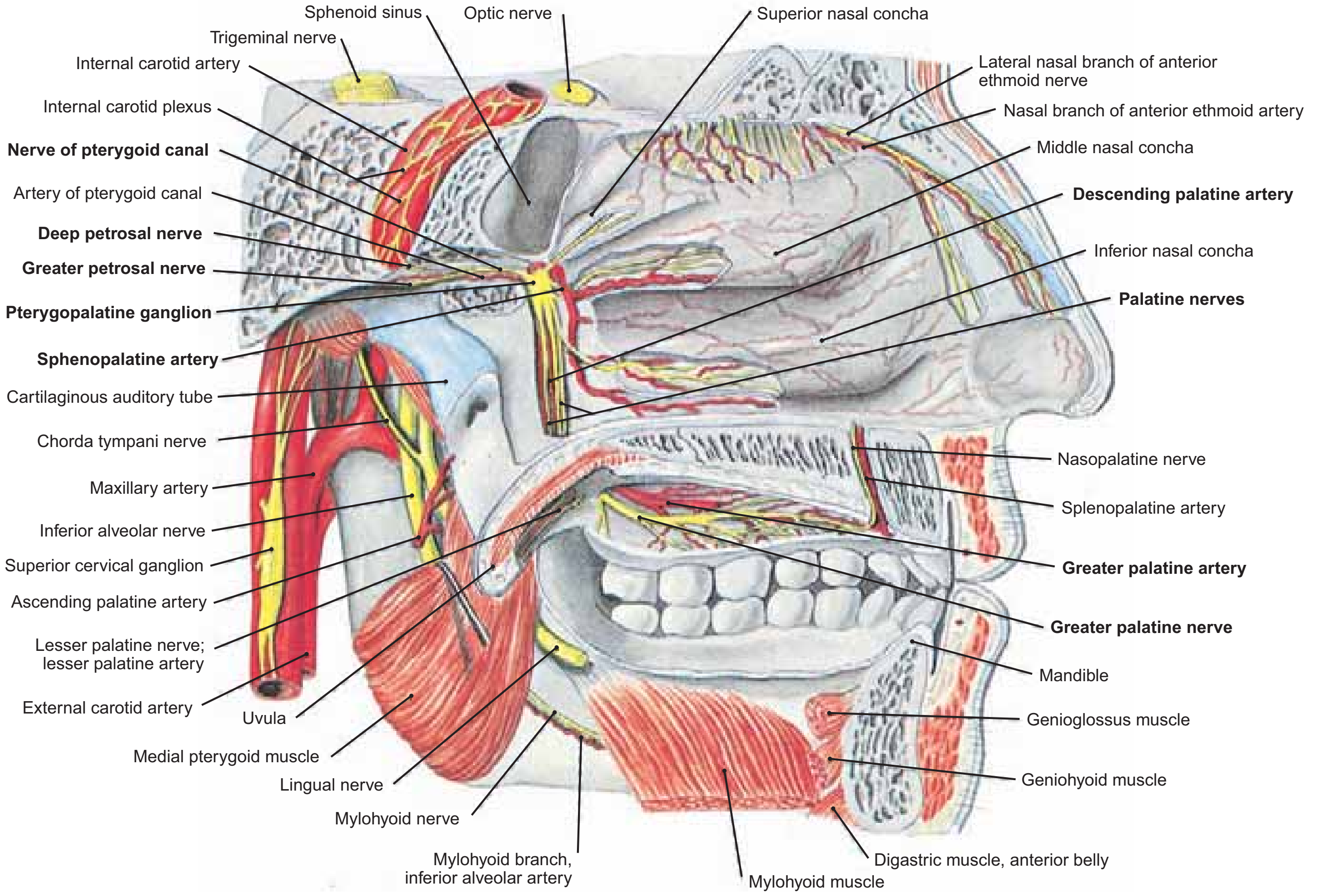


FIGURE 616.1 Pterygopalatine Ganglion and Its Branches

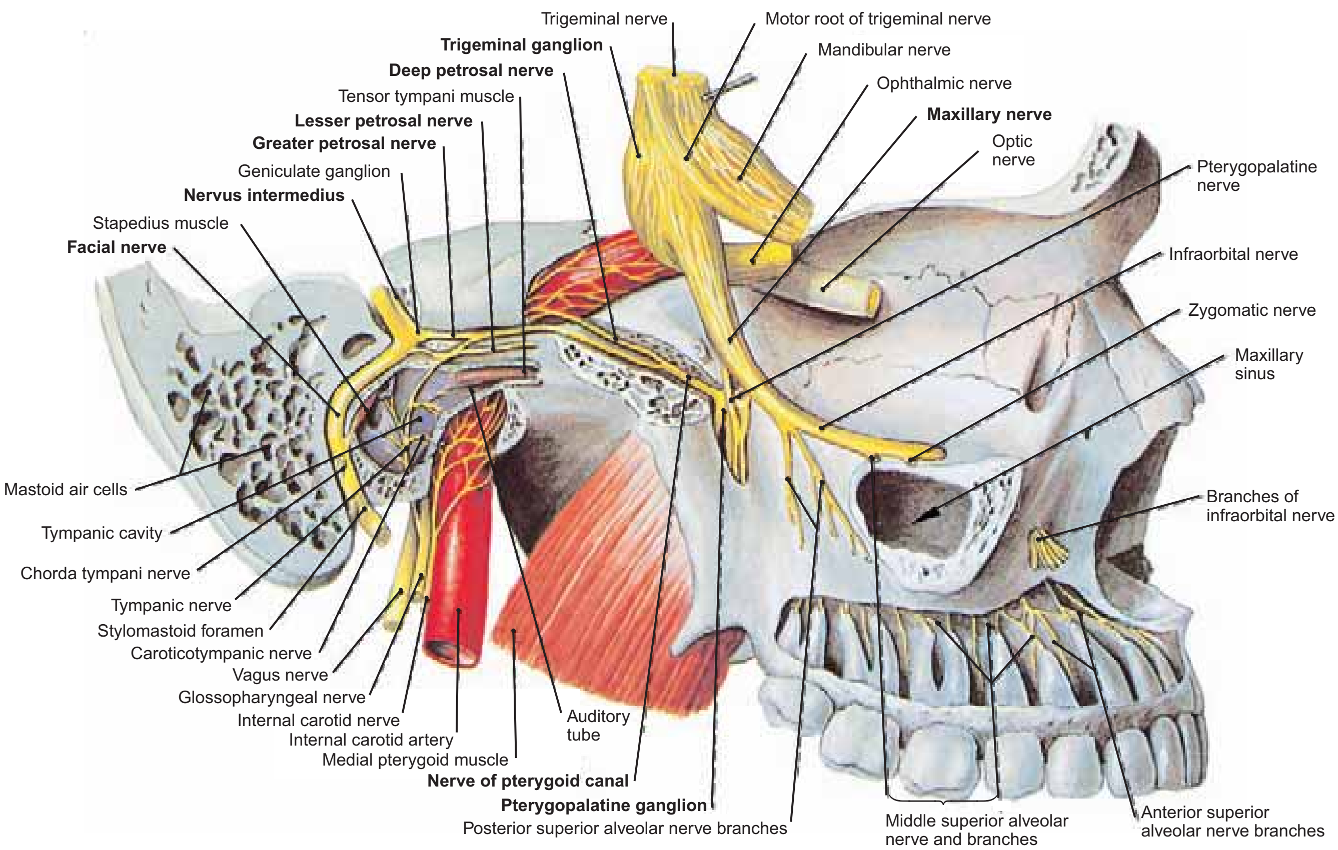


FIGURE 616.2 Maxillary Nerve, Petrosal Nerves, and Facial Nerve

NOTE: The **nerve of the pterygoid canal** is formed by the union of the **deep petrosal nerve** (postganglionic sympathetic) and the **greater petrosal nerve** (sensory and preganglionic, **VII**, parasympathetic fibers). The **lesser petrosal nerve** carries preganglionic, **IX**, parasympathetic fibers to the **otic ganglion**.

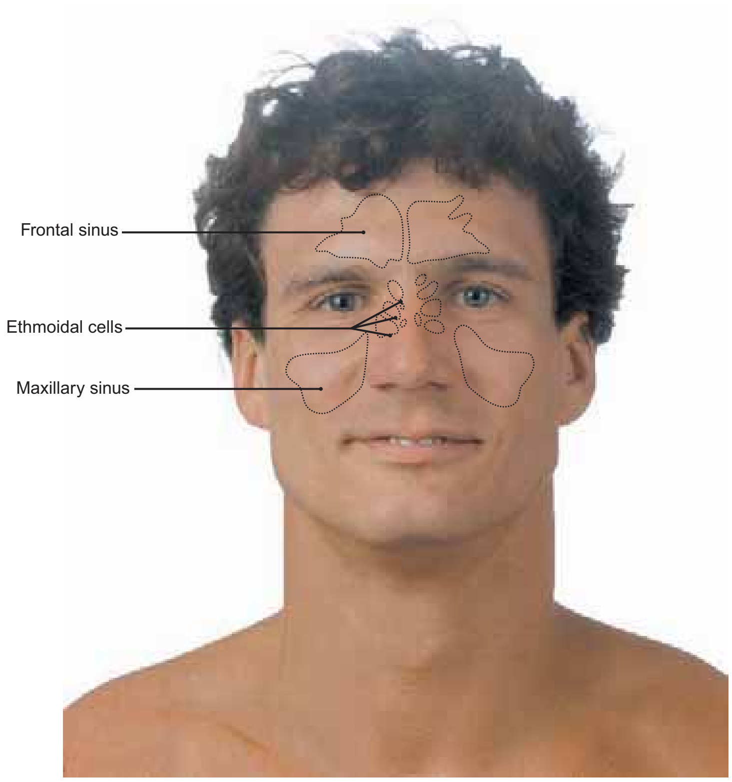


FIGURE 617.1 Surface Projection of the Paranasal Sinuses onto the Anterior Aspect of the Face

NOTE: The sphenoid sinus is not shown in this figure.

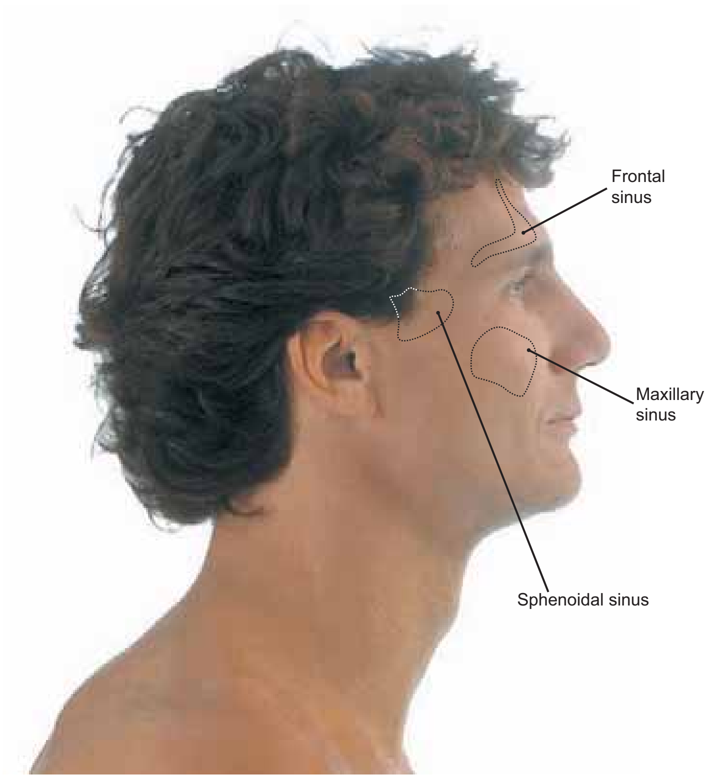


FIGURE 617.2 Surface Projection of the Paranasal Sinuses onto the Lateral Aspect of the Face

NOTE: The ethmoid sinuses are not shown in this figure.

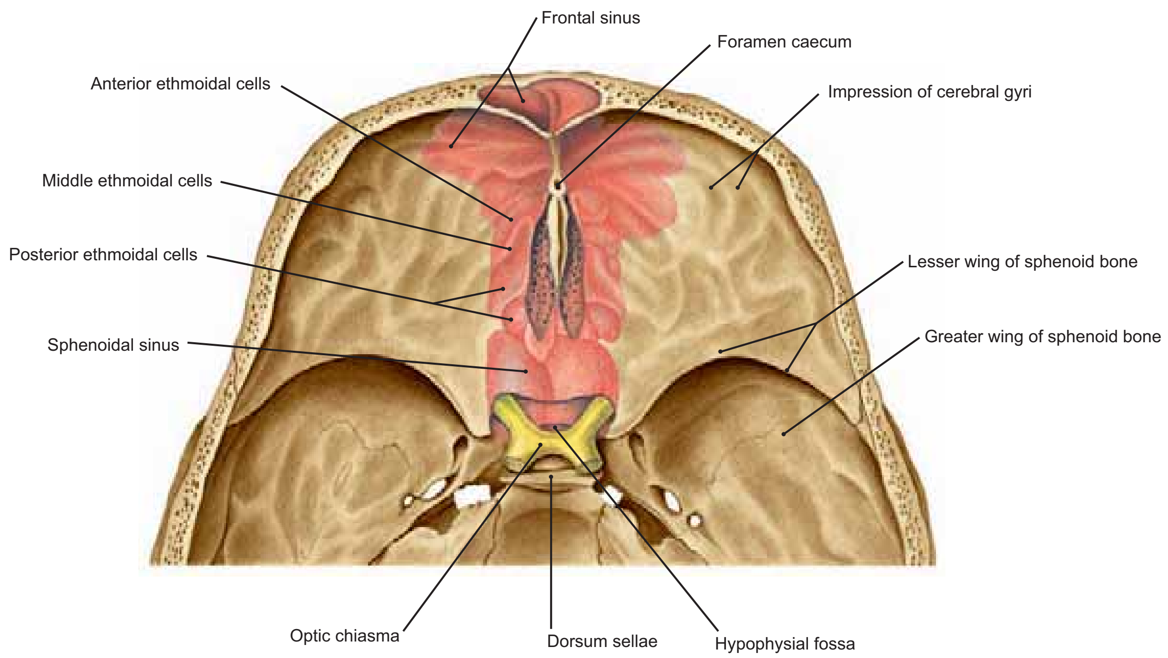


FIGURE 617.3 Paranasal Sinuses Viewed from Above

NOTE: (1) The frontal anterior ethmoid, middle ethmoid, posterior ethmoid, and sphenoid sinuses are projected onto the base of the anterior cranial fossa; the maxillary sinus is not shown.

(2) The sinuses are named for the bones that contain them.

(3) The **frontal sinus** drains into the middle meatus of the nasal cavity through the ethmoidal infundibulum or the frontonasal duct; the **anterior ethmoid air cells** open into the ethmoidal infundibulum or the frontonasal duct, **the middle ethmoid cells** open onto the ethmoid bulla in the middle meatus, and the **posterior ethmoid air cells** open into the superior meatus; the **sphenoid sinus** opens into the sphenoethmoidal recess posterior to the superior concha.

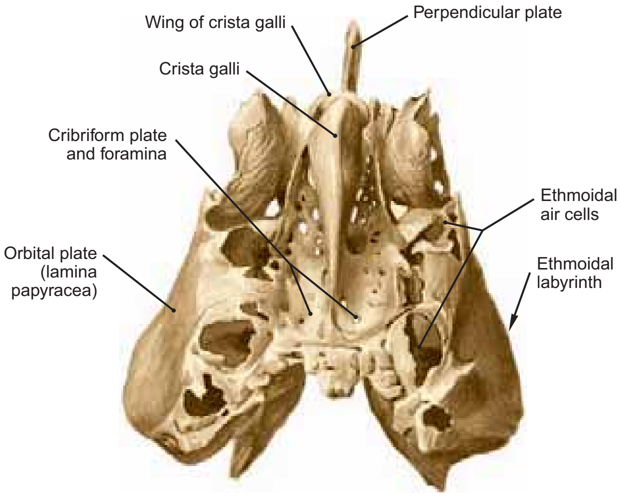


FIGURE 618.1 Superior Surface of the Ethmoid Bone

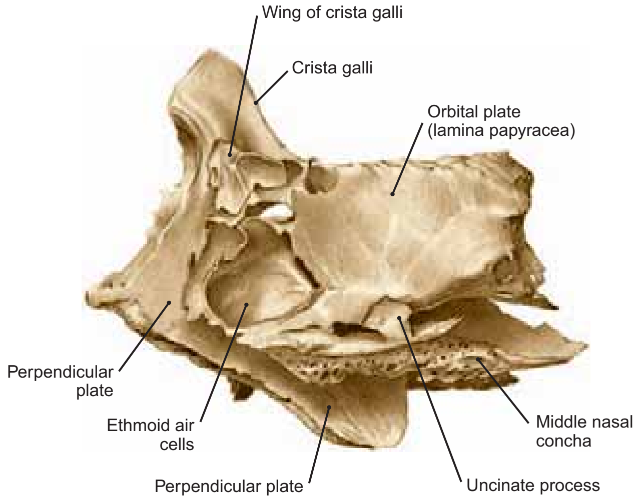


FIGURE 618.2 Ethmoid Bone (Left Lateral View)

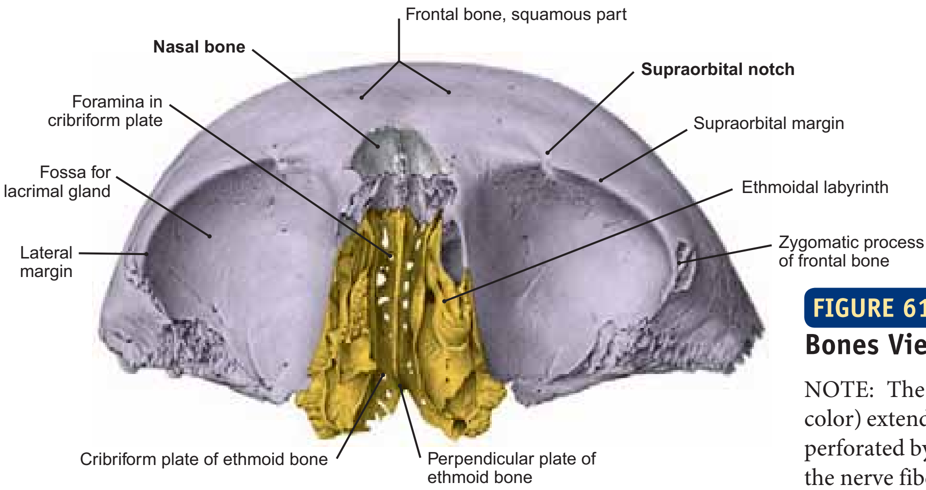


FIGURE 618.3 Frontal, Ethmoid, and Nasal Bones Viewed from Above

NOTE: The cribriform plate of the ethmoid bone (orange color) extends laterally from the midline on both sides and it is perforated by many foramina. Through these foramina course the nerve fibers of the primary olfactory receptor cells.

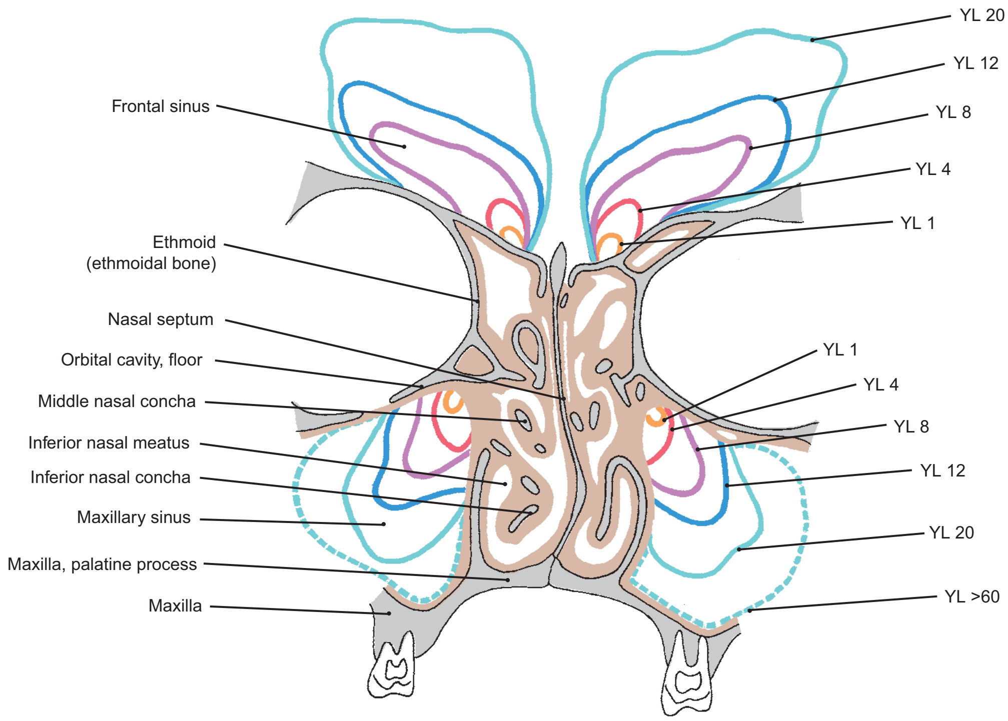


FIGURE 618.4 Enlargement of the Frontal and Maxillary Sinuses

NOTE: The growth of the frontal sinus is indicated from the 1st year of life (YL) to the 20th year, whereas the maxillary sinus is shown from the 1st year of life to the 20th year, and then at the 60th year.

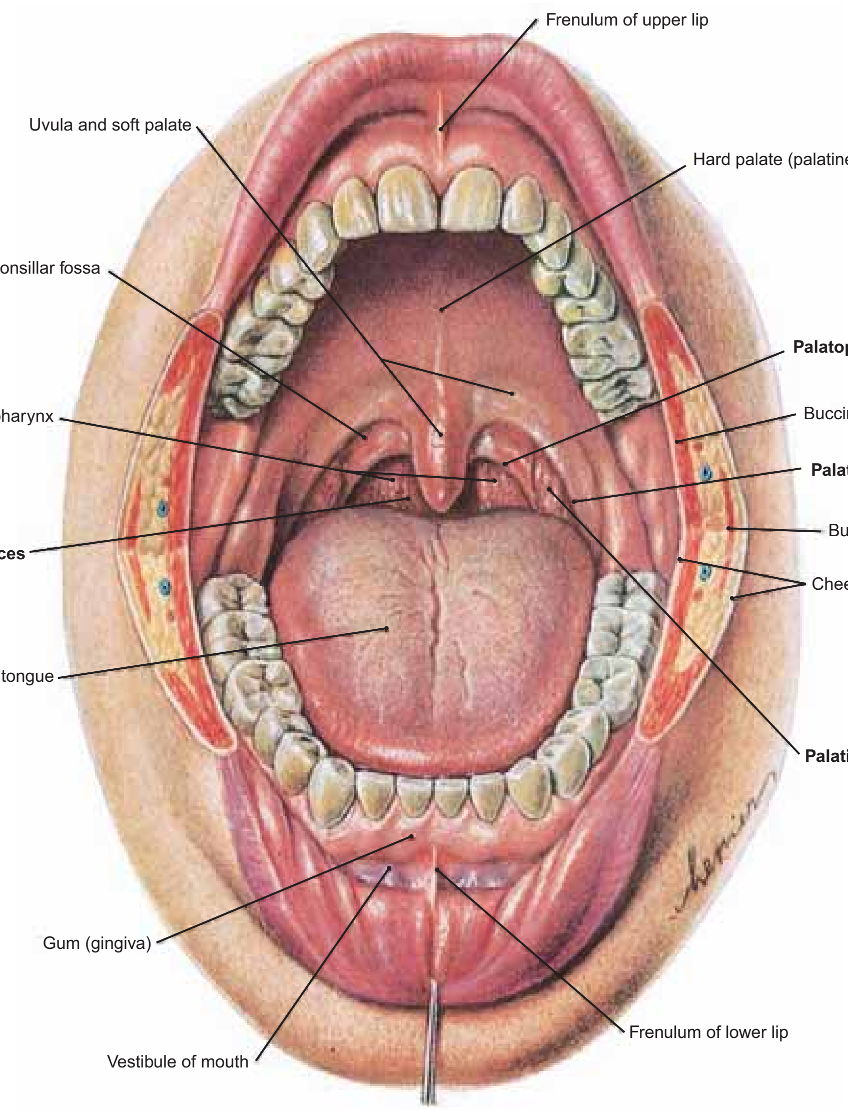


FIGURE 619.1 Oral Cavity

NOTE: (1) The position of the **palatine tonsils** located on each side of the oral cavity within fossae between the **palatoglossal** and **palatopharyngeal folds** (or **arches**).

(2) The passage between the oral cavity and the oral pharynx is called the **fauces**. This aperture or isthmus commences anteriorly at the palatoglossal arches on each side and is also bounded by the soft palate superiorly and the dorsum of the tongue inferiorly.

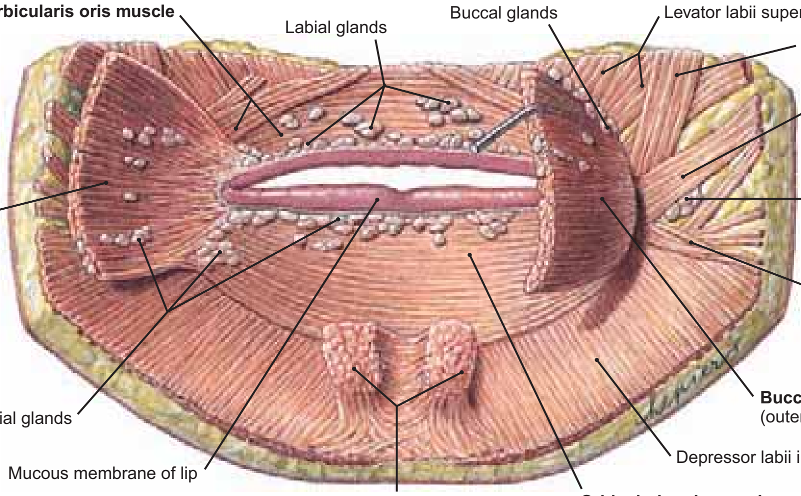


FIGURE 619.2 Lips Viewed from within the Oral Cavity

NOTE: The contour of the lips depends on the arrangement of the muscular bundles, which interlace at the labial margins. These include the elevators and depressors of the lips and their angles along with the **orbicularis oris** and **buccinator muscles**.

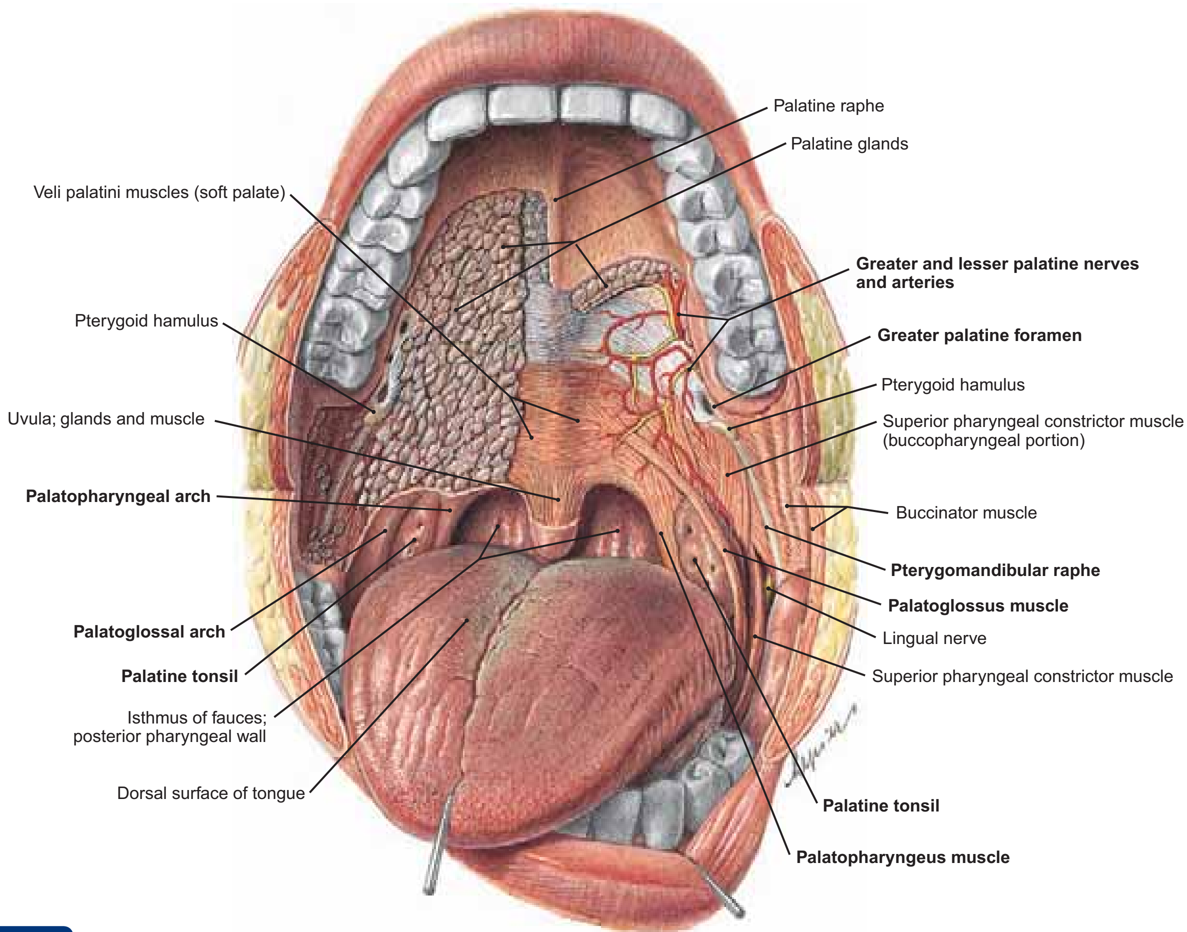


FIGURE 620.1 Palate: Muscular Folds and Glands

NOTE: The oral mucosa has been removed from both the hard and soft palate, revealing the palatal musculature, vessels, and glands. Observe the **palatoglossus** and **palatopharyngeus muscles**, along with the **greater** and **lesser palatine nerves** and **vessels**.

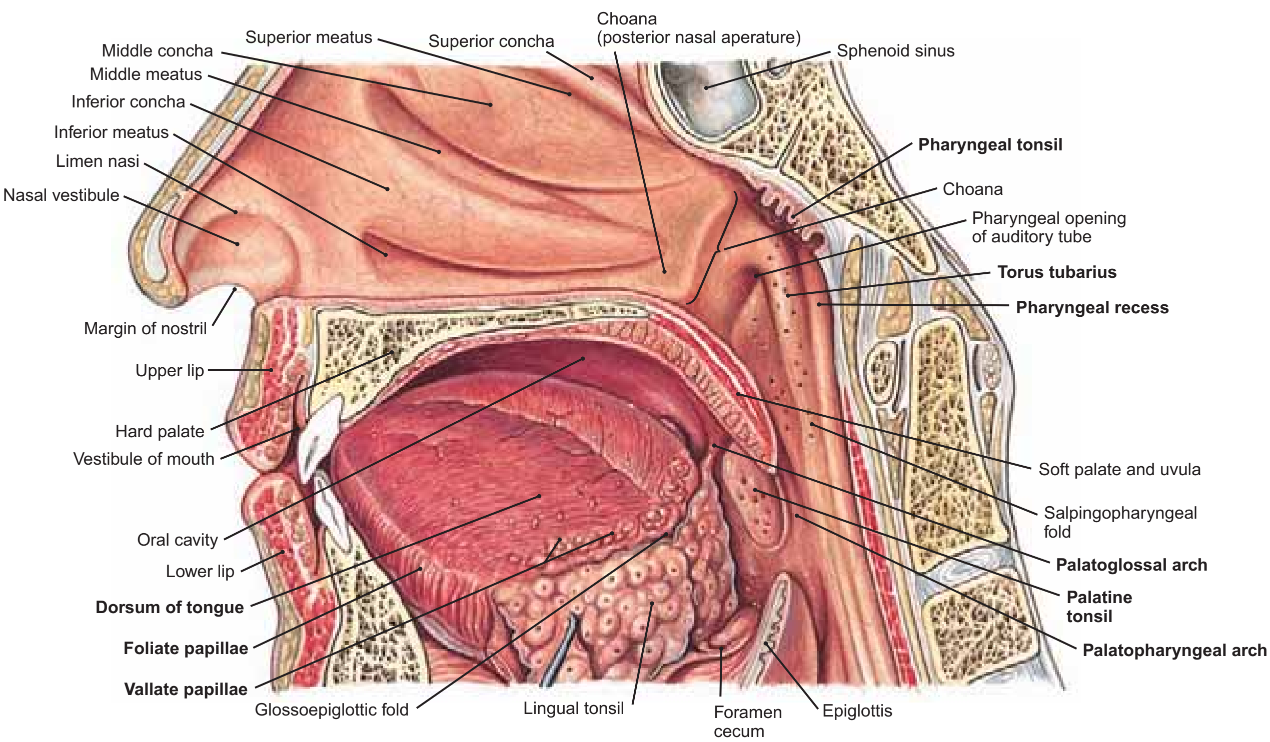


FIGURE 620.2 Tongue, Palatine Tonsil, and the Oropharynx

NOTE: (1) In this sagittal view, the tongue has been deviated to demonstrate the right palatoglossal arch and right palatine tonsil. Observe the large **vallate papillae**.

(2) The opening of the **auditory tube** in the nasopharynx, behind which is a cartilaginous elevation of the tube called the **torus tubarius**. Also note the **pharyngeal tonsil** (**adenoid**).

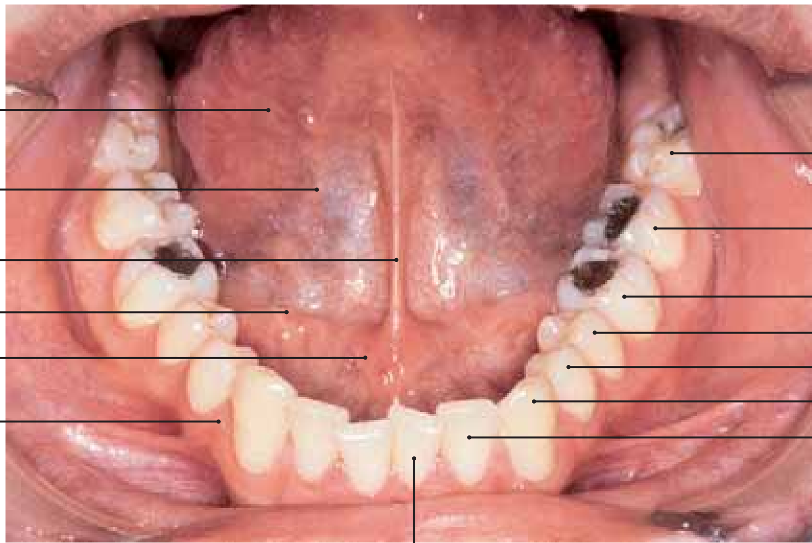


FIGURE 621.1 Anterior Sublingual Region of the Oral Cavity

NOTE: (1) The mucous membrane covering the floor of the oral cavity continues over the inferior surface of the tongue and meets at the midline as an elevated fold called the **frenulum of the tongue.**

(2) The **sublingual folds**. Along these open the **ducts of the sublingual glands**, and at their anterior end on each side is an orifice for the **submandibular duct** called the **sublingual caruncle.**

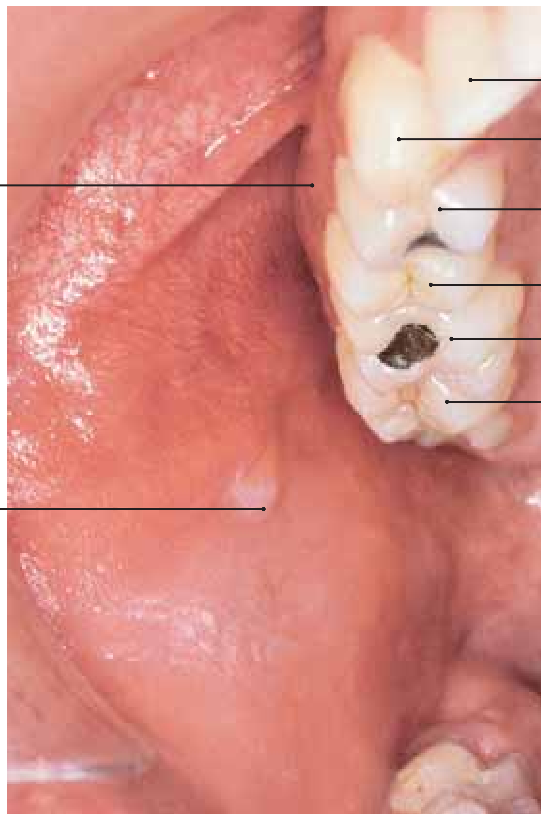


FIGURE 621.2 Orifice of the Parotid Duct

NOTE: The opening of the parotid duct (sometimes called Stensen's duct) in the oral cavity is marked by a small elevation called the parotid papilla, which is located opposite the upper (maxillary) second molar tooth.

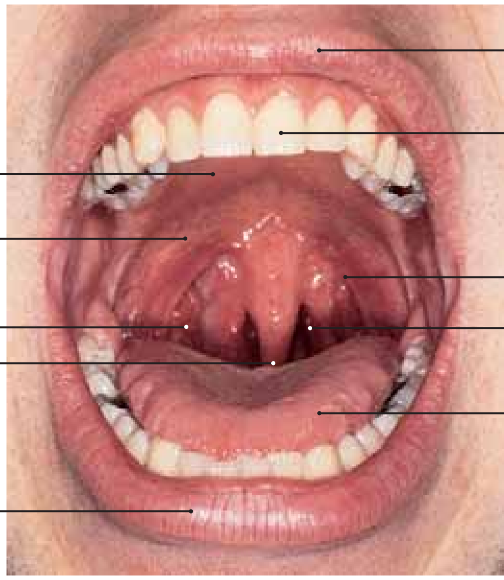


FIGURE 622.1 Oral Cavity; Anterior View of the Palate and Dorsum of the Tongue

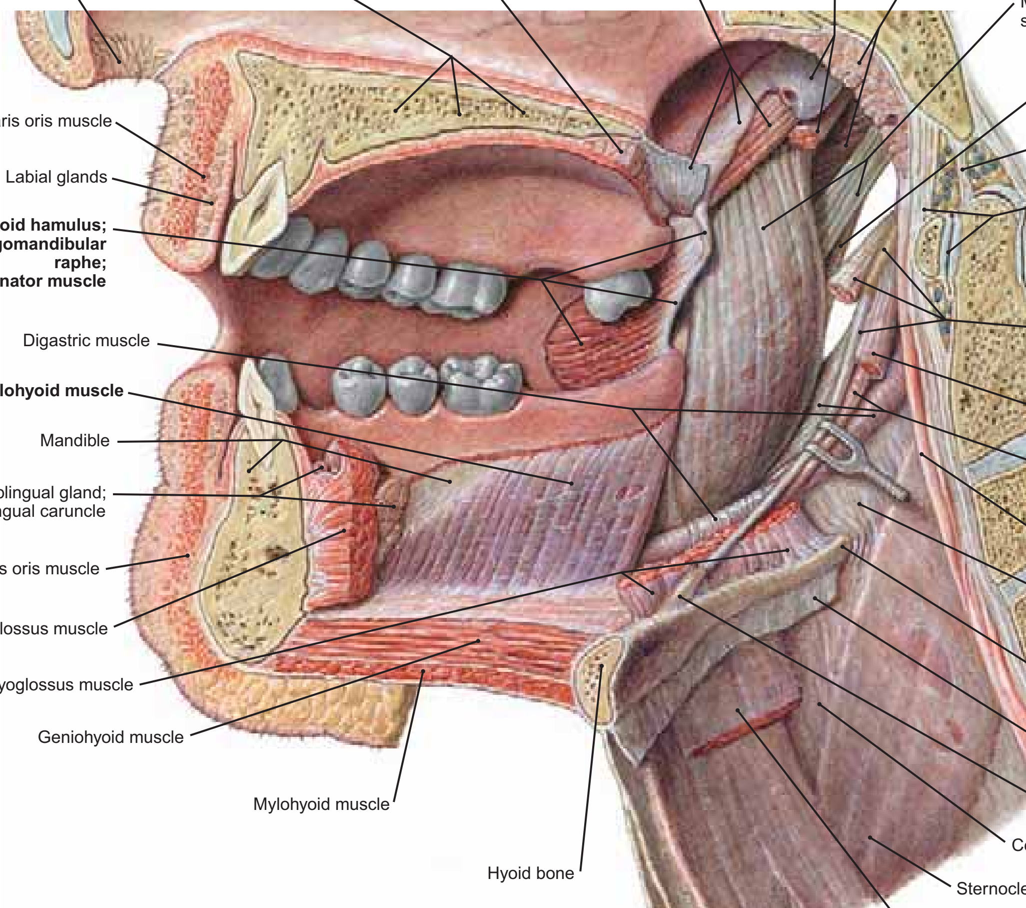


FIGURE 622.2 Paramedian Sagittal View of the Interior of the Right Oral Cavity and the Upper Neck (Muscles and Ligaments)

NOTE: In this dissection, the right half of the oral cavity was exposed and the mucous membrane removed from the floor of the mouth to reveal the **mylohyoid muscle**. Also observe the **pterygomandibular raphe** and **buccinator muscle**.

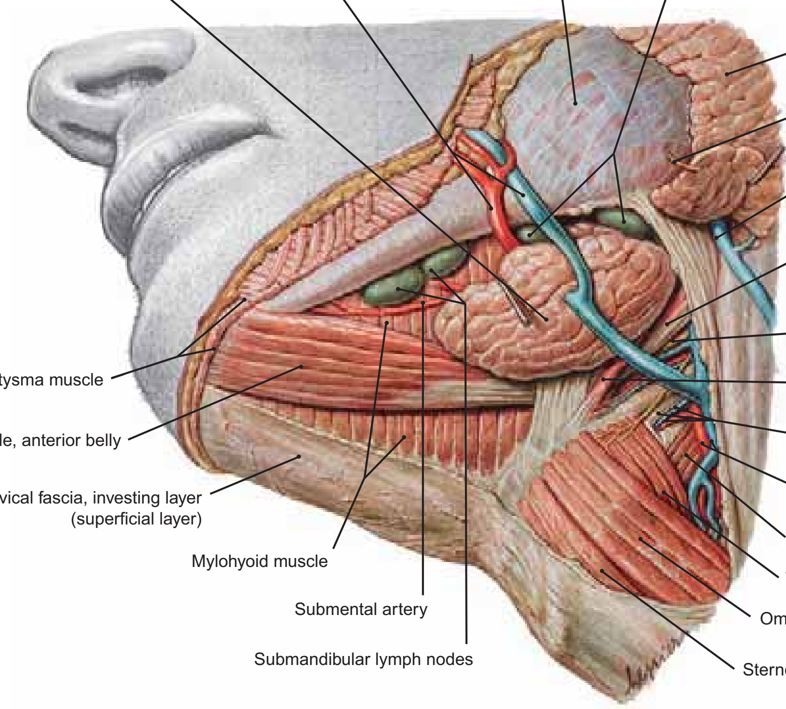


FIGURE 623.1 Floor of the Oral Cavity: Intact and Viewed from the Submandibular Region in the Upper Neck

NOTE: (1) The **submandibular** and **parotid glands** that produce saliva that is transported by secretory ducts to the oral cavity.
(2) The **submandibular triangle** bounded by the anterior and posterior bellies of the digastric muscle and the mandible.
(3) The **mylohyoid muscle** forming the largest part of the floor of the oral cavity. Compare this figure with Figures 626.1 and 626.2.

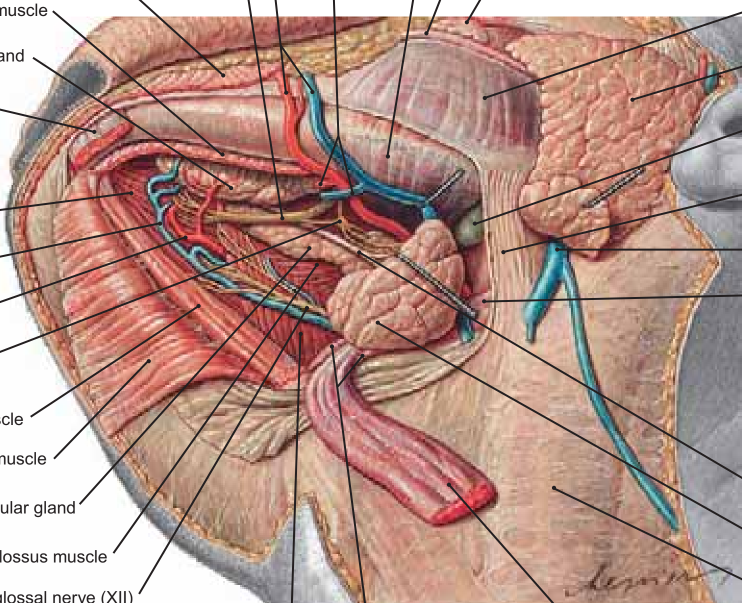


FIGURE 623.2 Floor of the Oral Cavity: Opened Inferiorly from the Submandibular Region

NOTE: (1) The anterior belly of the digastric and mylohyoid muscles has been reflected to reveal: the **sublingual gland, lingual nerve, submandibular ganglion** and **duct, hypoglossal nerve** and **vein,** and **lingual artery**.
(2) The hypoglossal nerve is the motor nerve to all tongue muscles *except* the palatoglossus. The lingual nerve supplies the anterior two-thirds of the tongue with general sensation.
(3) The three salivary glands are all shown in this figure: the **parotid gland** on the side of the face, the **submandibular gland** in the suprahyoid region, and the **sublingual gland**, which lies in its entirety within the oral cavity. Compare this figure with Figures 623.1, 624.1, and 624.2.

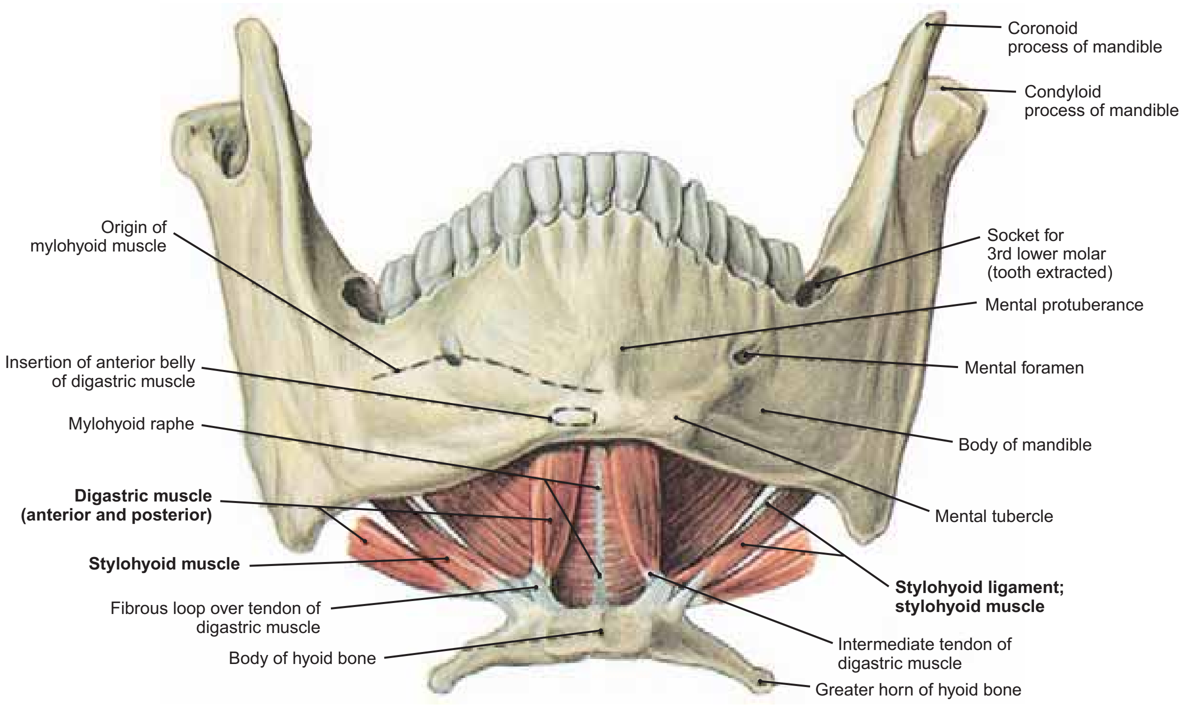


FIGURE 624.1 Suprahyoid Muscles and Floor of the Mouth (Viewed from Below)

NOTE: (1) On the mandible are the inner attachments of the **mylohyoid muscle** (broken line) and the **anterior belly of the digastric muscle** (circle). Observe the attachments of the **mylohyoid, digastric,** and **stylohyoid muscles** and the **stylohyoid ligament** on the hyoid bone.

(2) The tendon between the anterior and posterior bellies of the digastric muscle is anchored by a fibrous loop to the hyoid bone.

(3) The stylohyoid muscle is supplied by the facial (or seventh) cranial nerve, as is the posterior belly of the digastric muscle. The action of the stylohyoid muscle is to retract and elevate the hyoid bone, thus, elongating the floor of the mouth.

(4) The two bellies of the digastric muscle also elevate the hyoid bone, while the mylohyoid muscle raises the floor of the mouth when swallowing and is capable of pushing the tongue upward in the mouth and protruding the tongue forward.

(5) In addition, the mylohyoid muscles depress the mandible in chewing, swallowing, sucking, and blowing air out of the mouth.

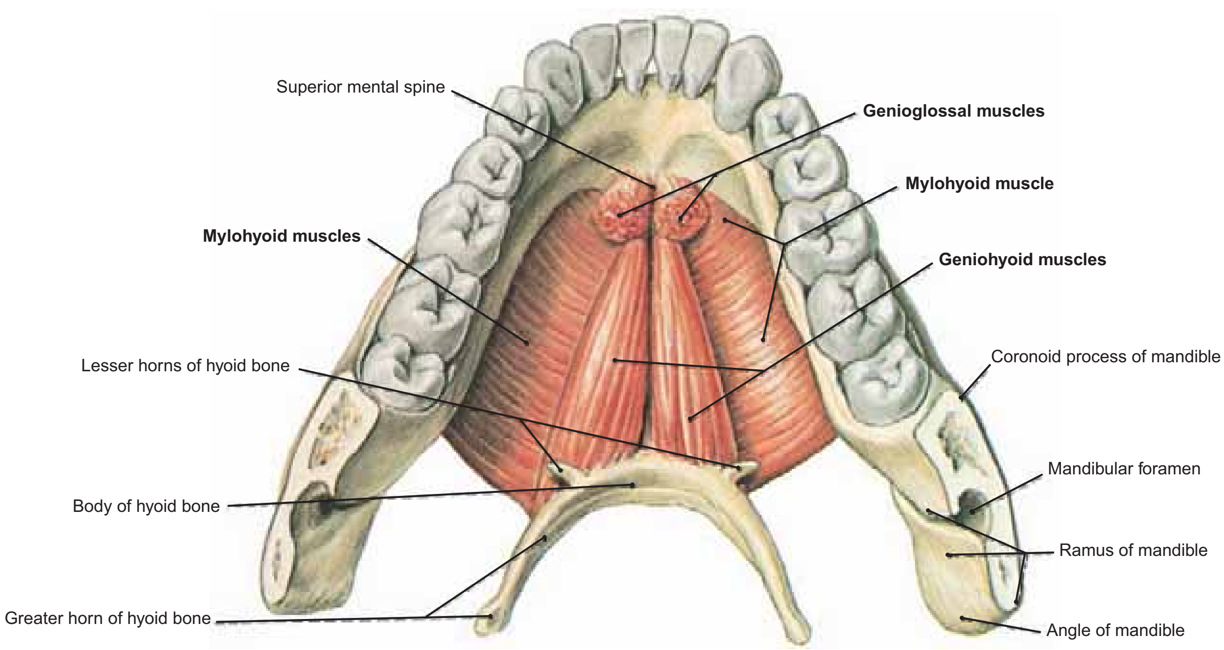


FIGURE 624.2 Mylohyoid and Geniohyoid Muscles (Viewed from Above)

NOTE: The **mylohyoid** and **geniohyoid muscles** form the floor of the oral cavity. The mylohyoids arise along the mylohyoid lines of the mandible and insert into the median raphe, which extends from the hyoid bone to the symphysis menti. The genioglossal muscles have been severed near their origin.

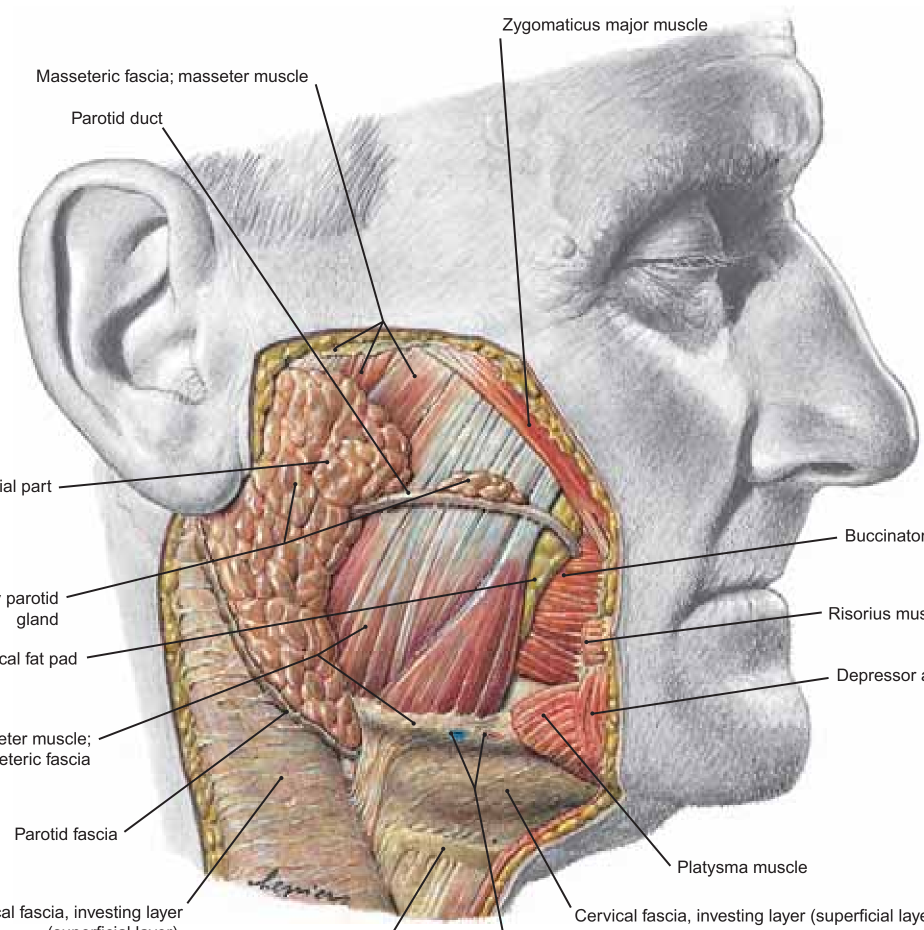


FIGURE 625 Lateral View of the Parotid Gland and an Accessory Parotid Gland Attached to the Parotid Duct

PAROTID GLAND

DEVELOPMENT: Arises during the sixth week of gestation as an epithelial outgrowth from the mouth and forms a tube that grows backward toward the ear. The posterior part of the tube branches into lobes that become the gland, and it enmeshes the facial nerve. The tube remains as the **parotid duct**, which opens into the mouth opposite the second upper molar tooth.

ADULT GLAND: A serous gland, weighing about 25 g, on either side of the face in front of the ear. Located between the mandible and the sternocleidomastoid muscle.

ARTERIES: Branches of the external carotid artery as it passes behind the gland.

VEINS: Empty into the external jugular vein.

INNERVATION: *Sympathetic*: Postganglionic vasomotor fibers come from the superior cervical ganglion by way of the external carotid plexus. *Parasympathetic*: Preganglionic secretomotor fibers course in the **glossopharyngeal nerve** and then the **lesser petrosal nerve** to the **otic ganglion**, where they synapse. Postganglionic fibers course to the parotid gland by way of the **auriculotemporal nerve (V)**.

LYMPH DRAINAGE: Superficial and deep parotid nodes drain into cervical lymph nodes.

SUBMANDIBULAR GLAND

DEVELOPMENT: Arises during the sixth week of gestation from an epithelial ridge in a groove between the tongue and the lower jaw. The caudal end of the ridge forms numerous branches that extend backward and ventrally beneath the mandible as glandular lobules. The main stalk, connected to the deep part of the gland persists as the **submandibular duct**.

ADULT GLAND: A seromucous gland of about 8 g on each side. The **superficial part** is the size of a walnut and is located in the digastric triangle of the upper neck. The **deep part** extends above the mylohyoid muscle into the oral cavity. The **submandibular duct** extends forward from the deep part and opens at the **sublingual caruncle** at the side of the frenulum below the tongue.

ARTERIES: Submental branches of the **facial artery** in neck and of **lingual artery** in oral cavity.

VEINS: Drain into the facial and lingual veins and then into the **internal jugular vein**.

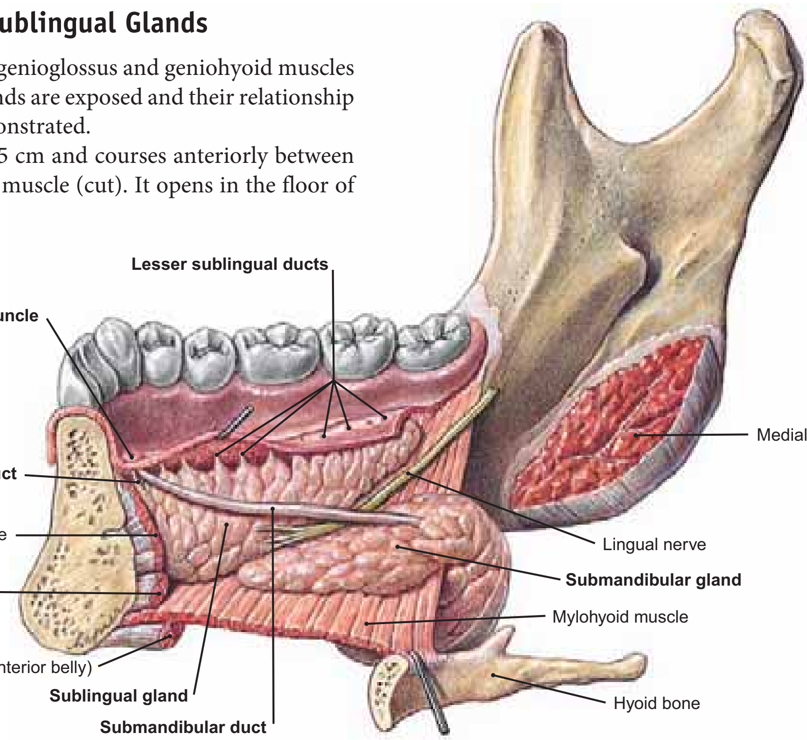
INNERVATION: *Sympathetic:* Postganglionic vasomotor fibers come from the superior cervical ganglion by way of the external carotid plexus. *Parasympathetic:* Preganglionic fibers course in the **nervus intermedius** part of the **facial nerve**. They travel to the **submandibular ganglion** by way of the **chorda tympani nerve** and then the **lingual nerve**. Postganglionic fibers from the ganglion **course directly** to the gland.

LYMPH DRAINAGE: Into submandibular nodes and then into upper and lower deep cervical nodes.

FIGURE 626.1 Submandibular and Sublingual Glands

NOTE: (1) With the tongue removed and the genioglossus and geniohyoid muscles cut, the submandibular and sublingual glands are exposed and their relationship to the inner aspect of the mandible is demonstrated.

(2) The submandibular duct measures about 5 cm and courses anteriorly between the sublingual gland and the genioglossus muscle (cut). It opens in the floor of the mouth at the sublingual caruncle.



SUBLINGUAL GLAND

DEVELOPMENT: Appears as a series of epithelial buds along the groove between the lower jaw and the tongue during the eighth week of gestation, just lateral to the submandibular primordium. The buds enlarge and some of the more anterior ones join to form a duct that opens near the submandibular duct. The remaining buds open by separate ducts (8–10) in the floor of the mouth above the sublingual fold.

ADULT GLAND: A seromucous gland on each side (30% serous, 70% mucous) weighing about 4 g. It is narrow and flattened and located deep to the mucous membrane in the floor of the mouth. Its ducts (10–20) open in a line along the surface of the sublingual fold. Several anterior ducts join to form the main sublingual duct. This opens near the caruncle of the submandibular duct.

ARTERIES: **Sublingual branch** of the **lingual artery**, which anastomoses with the **submental branch** of the **facial artery**.

VEINS: Drain into lingual vein and then into internal jugular vein.

INNERVATION: Same as for the submandibular gland.

LYMPH DRAINAGE: Superficial and deep submandibular nodes and then into deep cervical nodes.

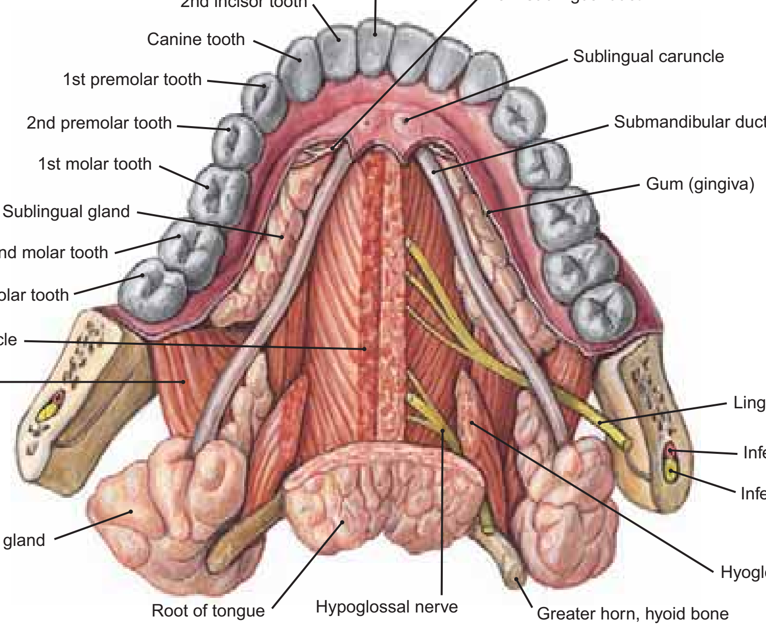


FIGURE 626.2 Salivary Glands in the Floor of the Oral Cavity (Seen from Above)

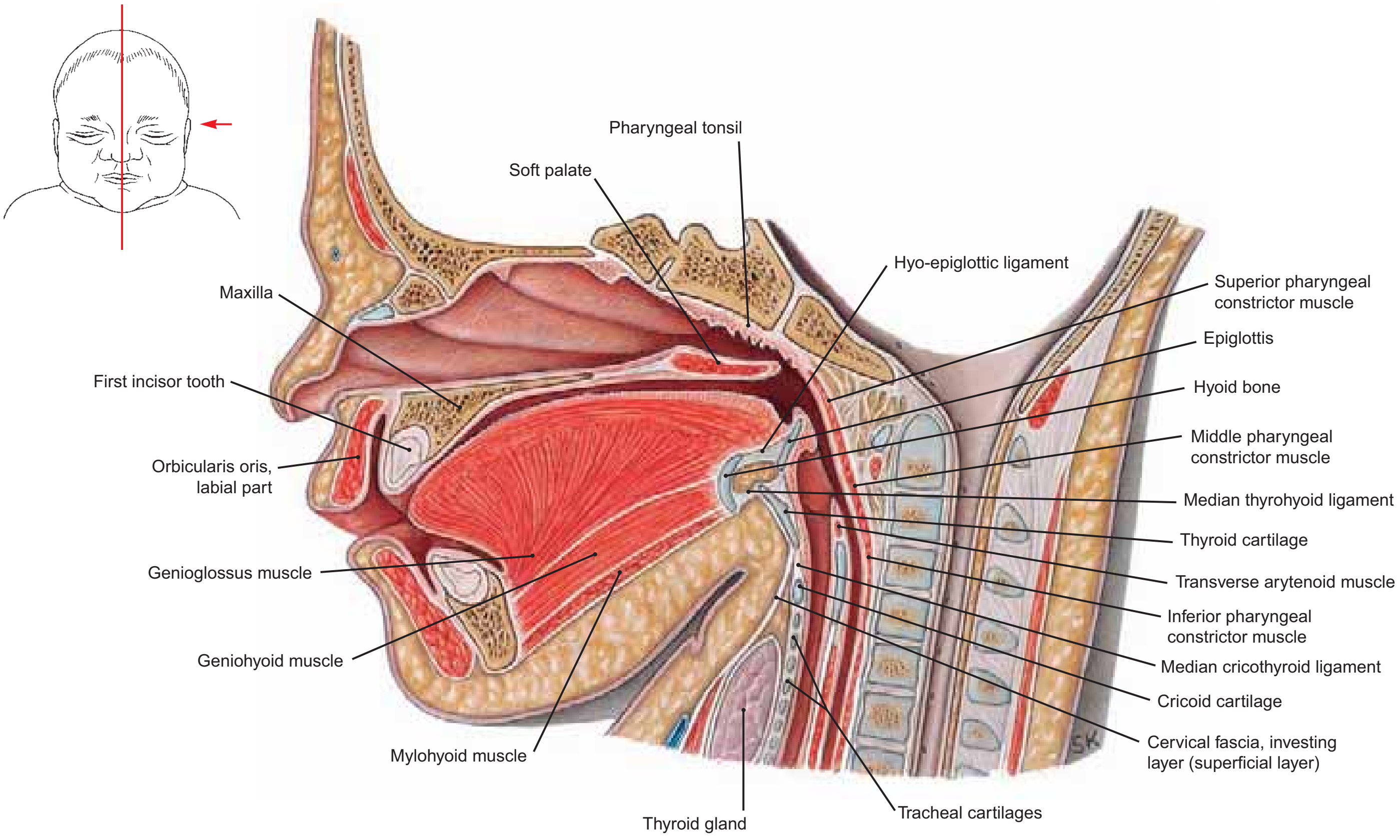


FIGURE 627.1 Median Section through the Head of a Newborn Child

NOTE: (1) The midline section of the tongue and its underlying muscles, the geniohyoid and the mylohyoid.
(2) In the newborn, the larynx is considerably higher than in the adult.
(3) The genioglossus muscle is shown in this figure and in Figure 627.2.

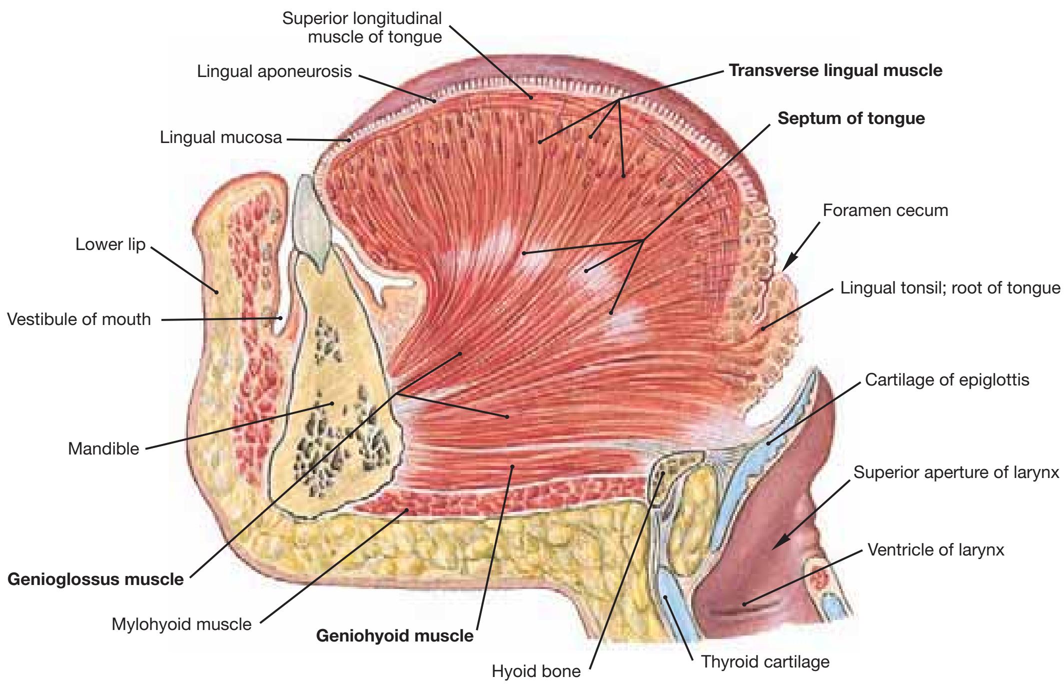


FIGURE 627.2 Genioglossus and Intrinsic Muscles of the Tongue

NOTE: (1) In this midsagittal section can be seen the median fibrous septum of the tongue and the **intrinsic** tongue musculature, which includes the longitudinal, transverse, and vertical muscles of the tongue.
(2) The **genioglossus** constitutes most of the tongue musculature, and its fibers radiate backward and upward in a fanlike manner from the uppermost of the mental spines (genial tubercles) on the inner surface of the mandible, just above the origin of the geniohyoid muscle.

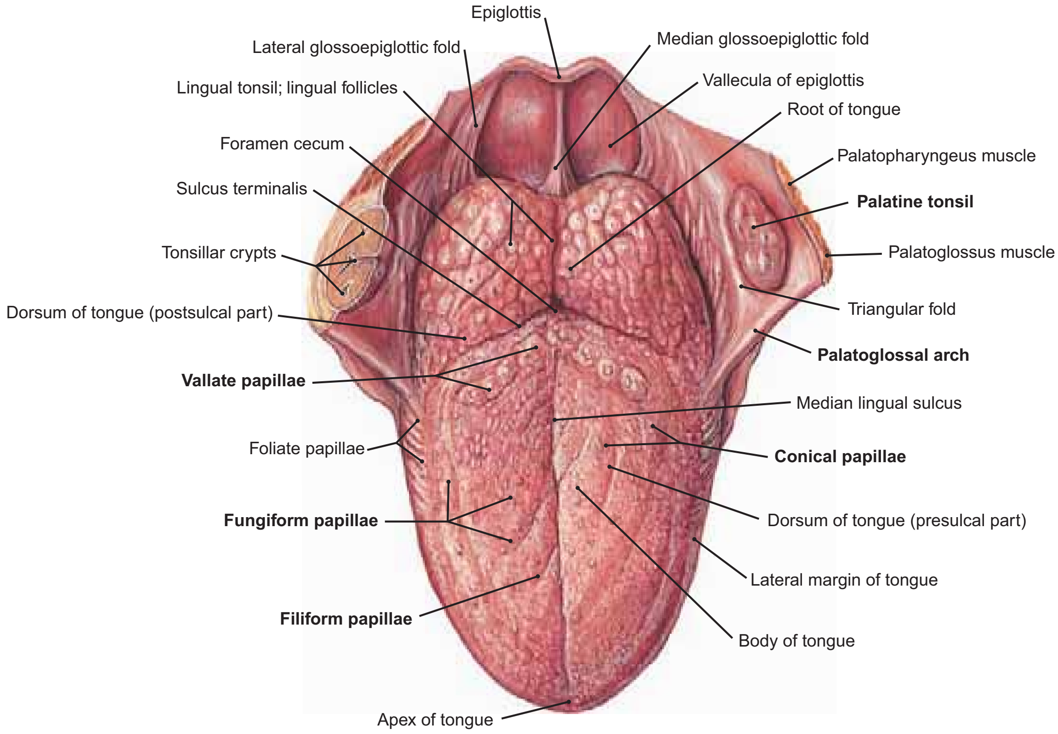


FIGURE 628.1 Dorsal Surface of the Tongue

NOTE: (1) The dorsum of the tongue is marked by numerous elevations called papillae. These serve as location sites of receptors for the special sense of **taste**. Observe the inverted V-shaped group of large **vallate papillae**.

(2) The **fungiform papillae** are found principally at the sides and apex of the tongue. These are large, round, and deep red.

(3) The **filiform** (conical) **papillae**. These are small and arranged in rows that course parallel to the vallate papillae.

(4) The parallel vertical folds (about five in number) called the **foliate papillae** on the lateral border of the tongue just anterior to the palatoglossal arch. These are studded with taste receptors.

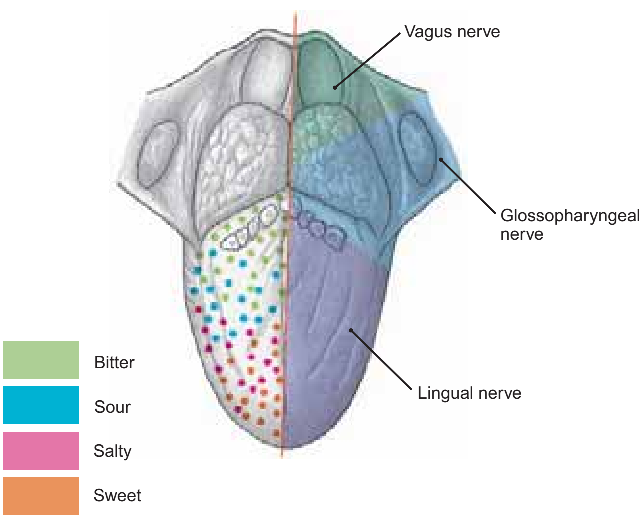


FIGURE 628.2 Innervation and Location of Taste Qualities on the Dorsum of the Tongue

NOTE: On the right: fields of innervation by the **lingual, glossopharyngeal** and **vagus nerves**. On the left: Receptors for the basic tastes of **salt** and **sweet** are clustered anterior to those for **bitter** and **sour**.

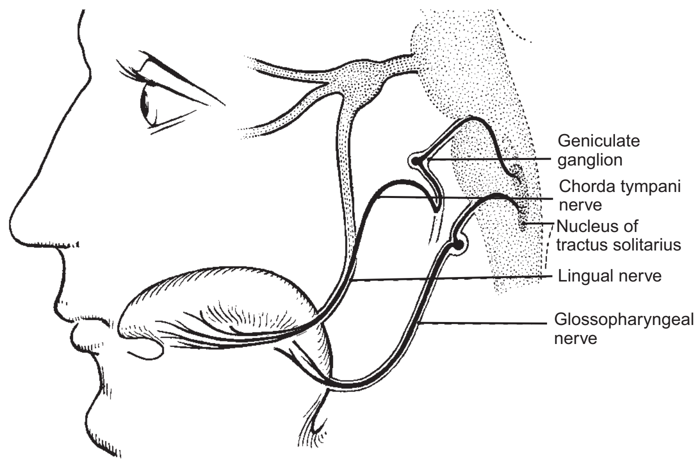


FIGURE 628.3 Principal Pathways for Taste

NOTE: (1) The two principal pathways for taste are along the **lingual nerve** to the **chorda tympani nerve** for the anterior two-thirds of the tongue and the **glossopharyngeal nerve** for the posterior third of the tongue.

(2) Two lesser pathways (not shown) are:

(a) From the epiglottis along the **internal laryngeal branch** of the **vagus**.

(b) From the palate along the **palatine nerves** and the **nerve of the pterygoid canal** to the **greater petrosal nerve** and then the **nervus intermedius part** of the **facial nerve.**

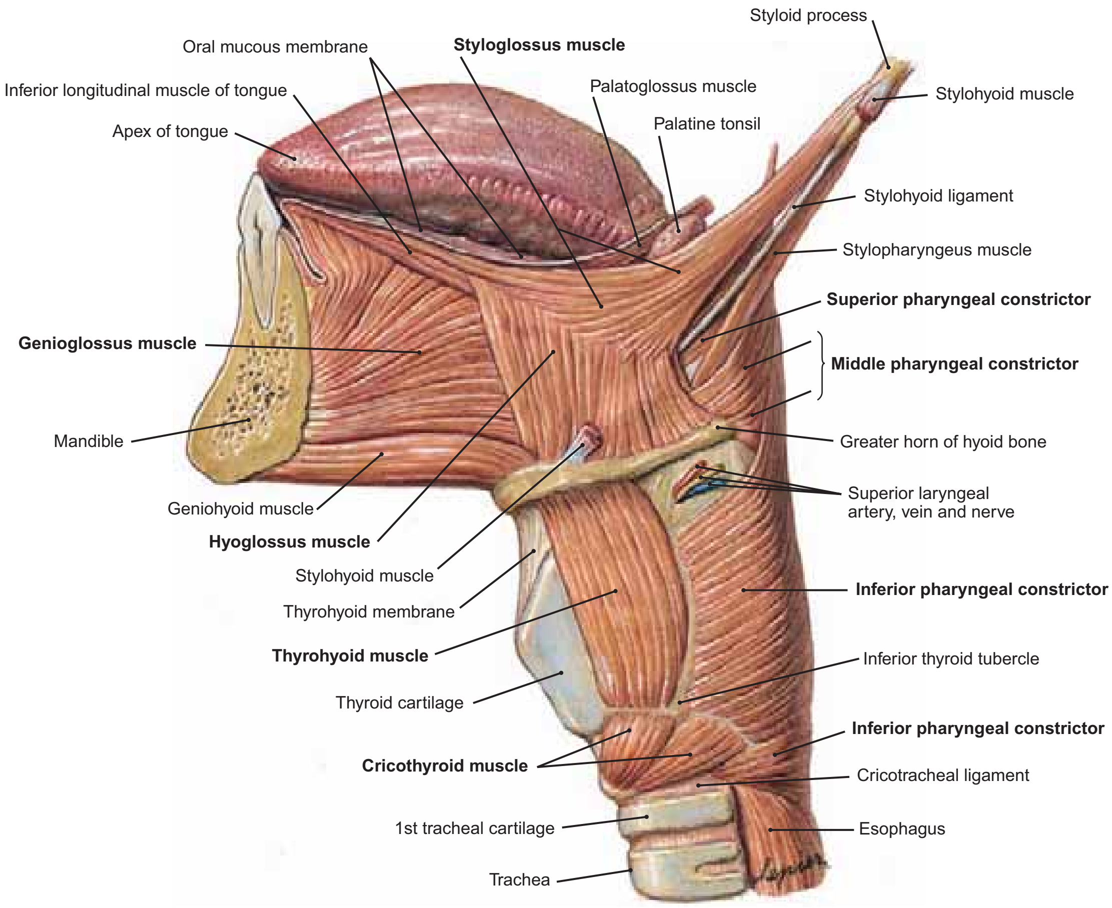


FIGURE 629.1 Extrinsic Tongue Muscles; External Larynx and Pharynx (Lateral View 1)

NOTE: The tongue is attached to the hyoid bone, the mandible, the styloid process, the soft palate, and the pharyngeal wall.

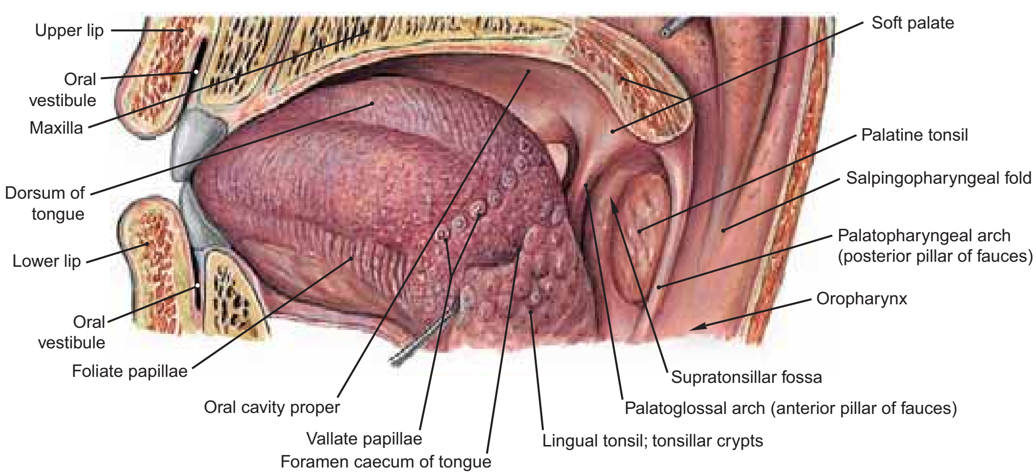


FIGURE 629.2 Paramedian Section of the Oral Cavity, Oral Pharynx, and Tongue

NOTE: (1) The lingual tonsil covering the posterior third of the tongue. Also observe the vallate papillae located in a line between the anterior two-thirds of the tongue and the posterior third.

(2) The palatine tonsil in the tonsillar bed located between the palatoglossal and palatopharyngeal folds.

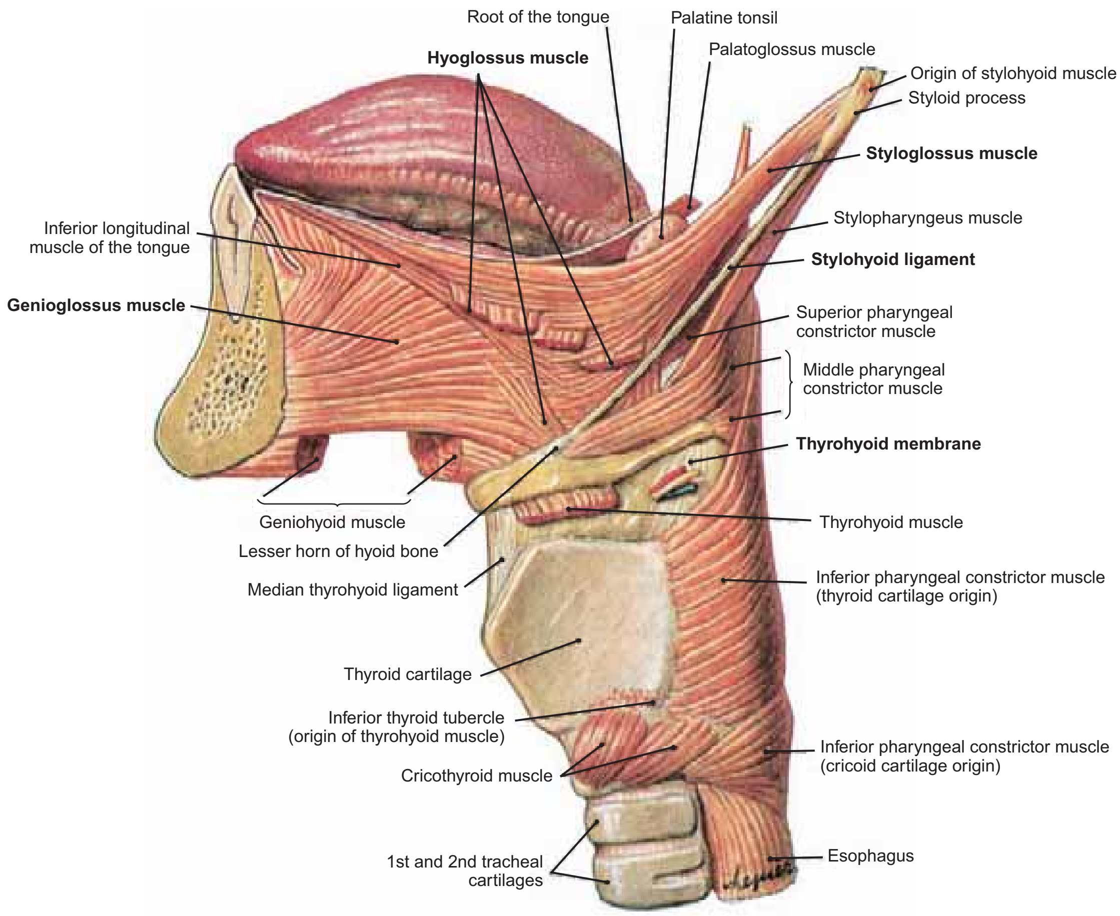


FIGURE 630.1 Extrinsic Tongue Muscles; External Larynx and Pharynx (Lateral View 2)

NOTE: (1) In this dissection, the hyoglossus muscle has been removed, revealing the attachments of the **stylohyoid ligament** and the **middle pharyngeal constrictor muscle** along the hyoid bone. The geniohyoid muscle has been cut and the thyrohyoid **muscle removed.**
(2) The blending of the fibers of the styloglossus, hyoglossus, and genioglossus at the base of the **tongue.**
(3) The penetration through the **thyrohyoid membrane** by the **superior laryngeal vessels** and **nerve.**

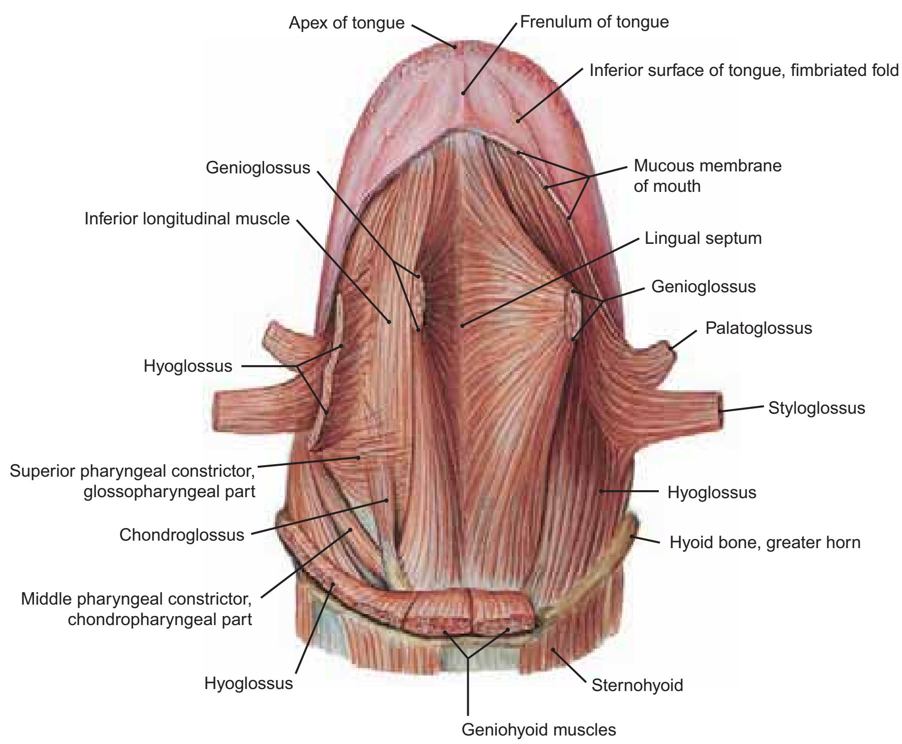


FIGURE 630.2 Ventral View of the Muscles of the Tongue

NOTE: The large genioglossus muscle detached from the mandible and the hyoglossus muscle inserting into the side of the tongue from its origin on the hyoid bone. Also observe the insertions of the palatoglossus and styloglossus muscles.

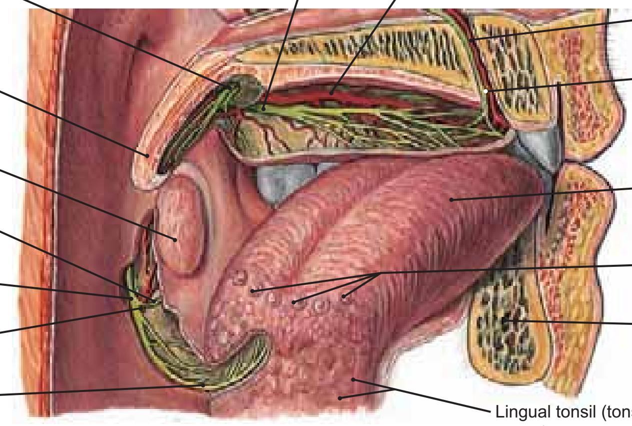


FIGURE 631.1 Nerves and Arteries of the Posterior Tongue and Palate

NOTE: (1) The **glossopharyngeal nerve** supplies both general sensation and the special sense of taste to the posterior third of the tongue.
(2) The **greater palatine artery** and **nerve** supply the palate in the roof of the oral cavity and the **ascending** pharyngeal artery, one of several vessels that supply the palatine tonsil located in the oropharynx.

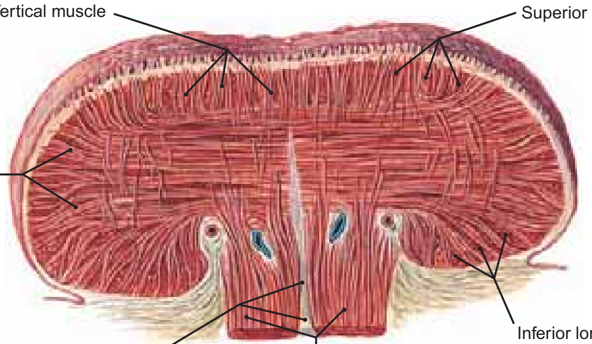


FIGURE 631.2 Transverse Section through the Middle of the Tongue (Anterior View)

NOTE: The transverse and vertical fibers of the intrinsic tongue muscles can best be seen in a transverse section. Observe, however, the cut longitudinal fibers both superiorly and inferiorly.

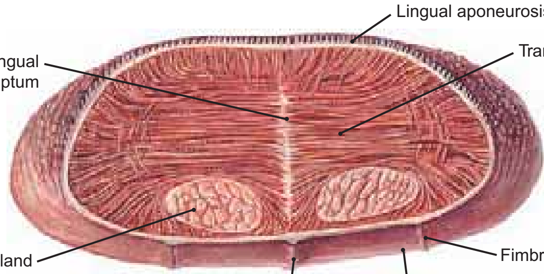


FIGURE 631.3 Transverse Section through the Tip of the Tongue

NOTE: The sublingual glands deep to the anterior part of the tongue.

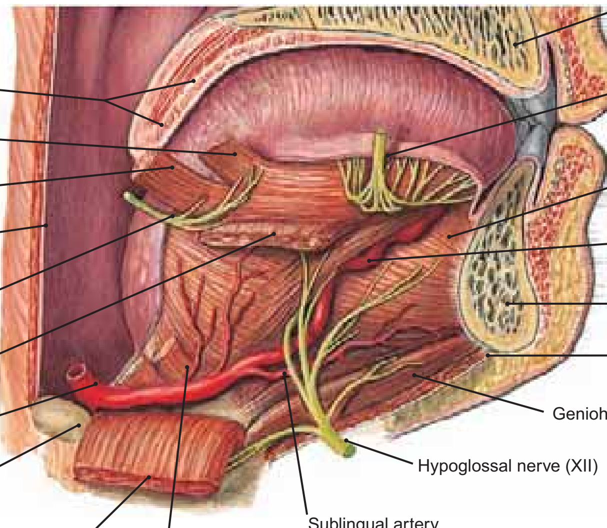


FIGURE 632 **Opened Oral Cavity Showing the Tongue and Its Nerves and Arterial Supply**

NOTE: (1) The longitudinal and medial course of the **lingual artery**. Also observe the **lingual, glossopharyngeal,** and **hypoglossal nerves**.
(2) The **hypoglossal nerve** supplies the genioglossus, hyoglossus, and styloglossus muscles as well as all of the intrinsic muscles of the tongue.
(3) The **lingual nerve** is sensory to the anterior two-thirds of the tongue (both general sensation and taste, the latter by way of the **chorda tympani** nerve fibers), while the **glossopharyngeal nerve** supplies the posterior third of the tongue (both general sensation and taste).
(4) The **geniohyoid muscle** extending from the mental spine of the mandible (posterior to the symphysis menti) to the anterior surface of the hyoid bone.
(5) The **hyoglossus muscle** has been severed in order to show the forward course of the lingual artery.

EXTRINSIC MUSCLES OF THE TONGUE

Muscle	Origin	Insertion	Innervation	Action
Genioglossus	Upper part of the mental spine of mandible	In a fanlike manner along the ventral surface of tongue; anterior surface of body of hyoid bone	Hypoglossal nerve	Draws the tongue forward and protrudes the apex of the tongue
Hyoglossus	Entire length of the greater horn of hyoid bone and lateral part of body of hyoid bone	Into the side of tongue	Hypoglossal nerve	Depresses the tongue
Styloglossus	Styloid process of temporal bone and the stylohyoid ligament	Side and inferior aspect of the tongue	Hypoglossal nerve	Draws the tongue upward and backward
Palatoglossus	Oral surface of the palatine aponeurosis	Side and dorsum of the tongue	Pharyngeal branch of the vagus nerve (fibers emerge from brain in cranial part of accessory nerve [i.e., XI via X])	Elevates the posterior part of the tongue

In addition, the tongue contains longitudinal, transverse, and vertical muscles whose fibers commence and terminate within the tongue itself and, hence, are considered **intrinsic tongue muscles.** These are all supplied by the **hypoglossal nerve.**

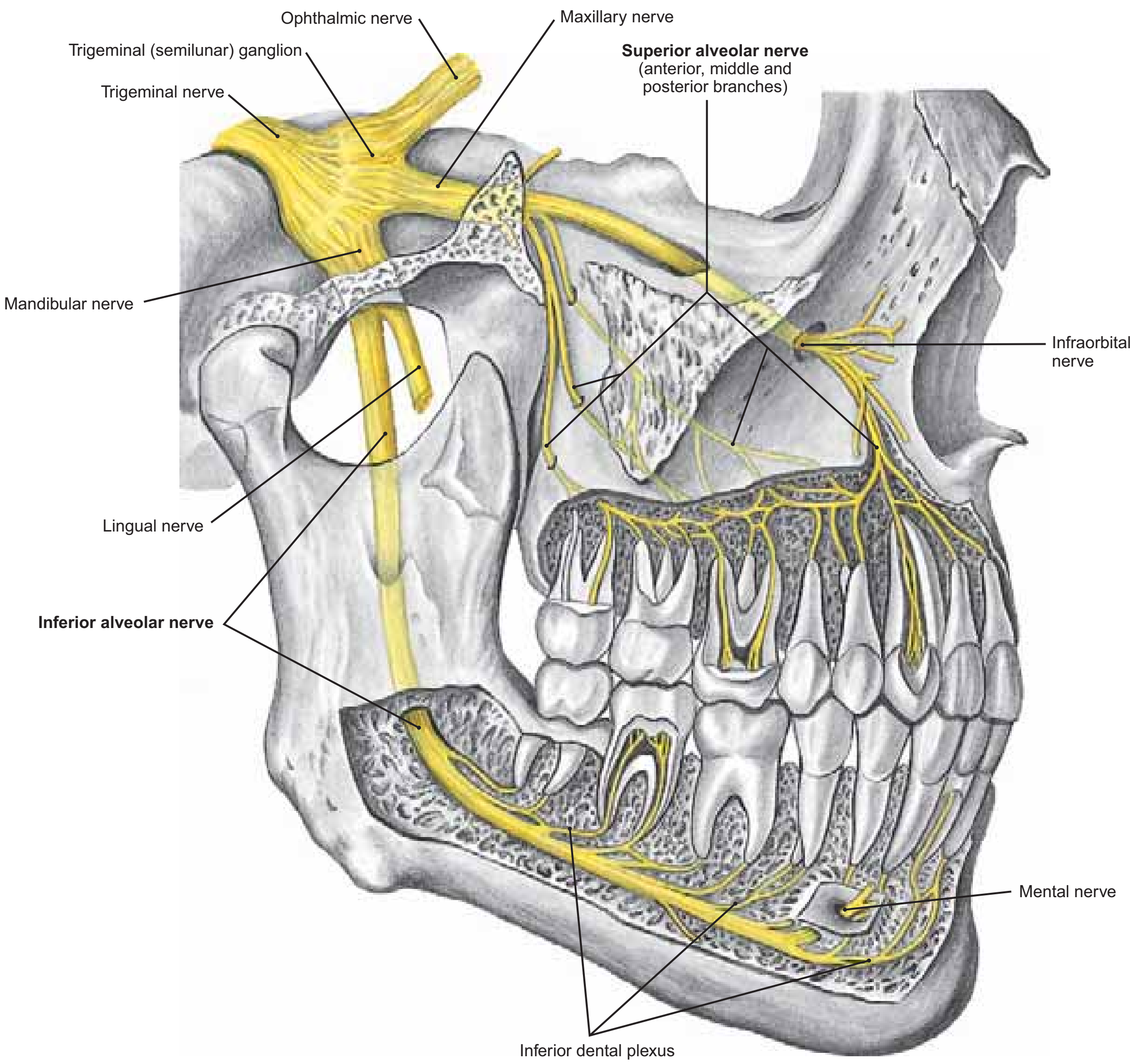


FIGURE 633.1 Superior Alveolar Nerves (Maxillary) and Inferior Alveolar Nerve (Mandibular) and Their Branches to the Upper and Lower Teeth

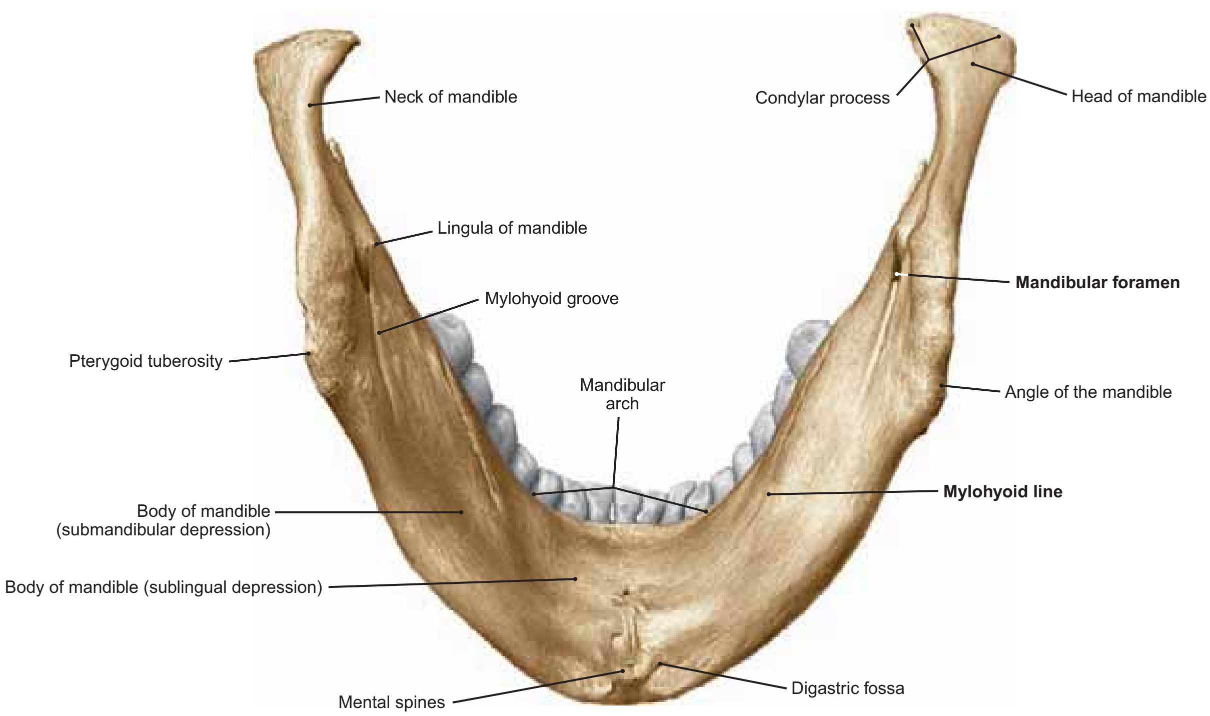


FIGURE 633.2 Mandible as Seen from Below

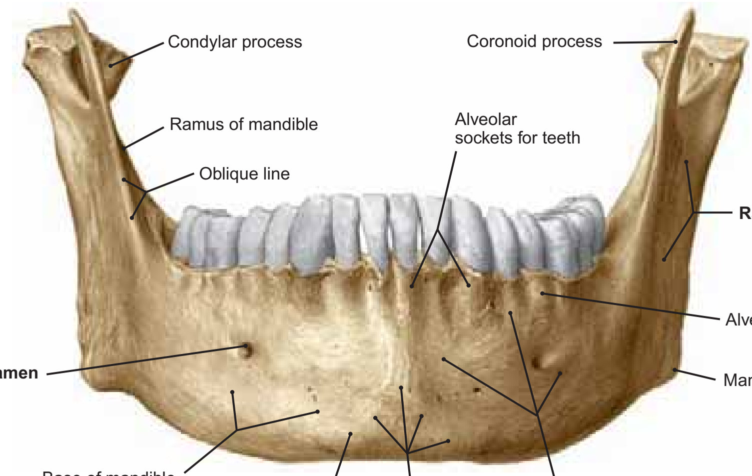


FIGURE 634.1 Mandible (Seen from Front)

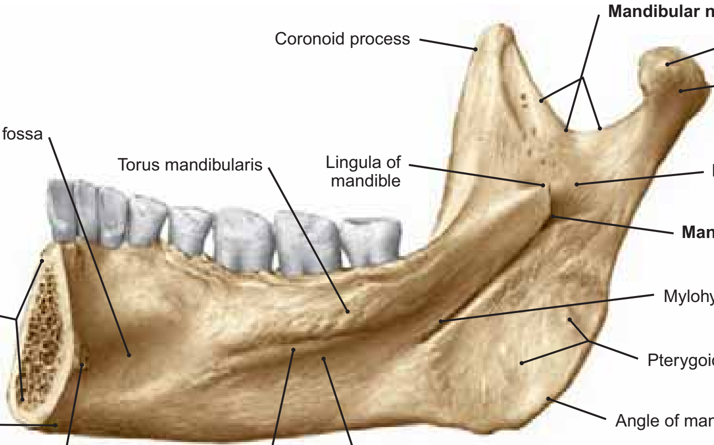


FIGURE 634.2 Right Mandible (Inner Surface)

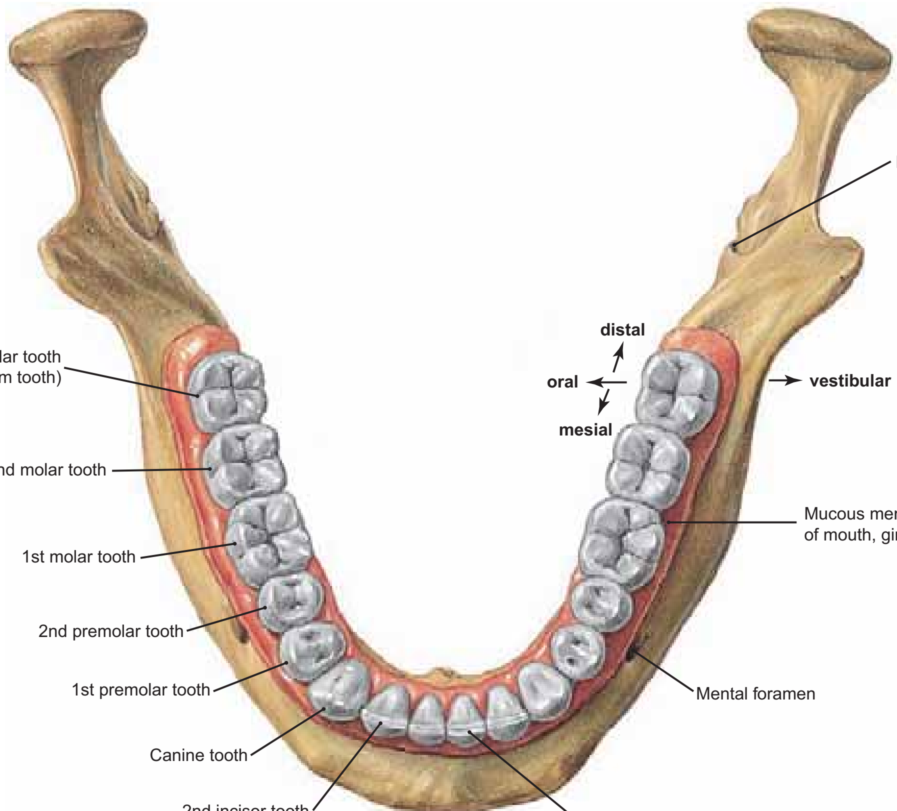


FIGURE 634.3 Mandibular Arch and the Lower Teeth (Seen from Above)

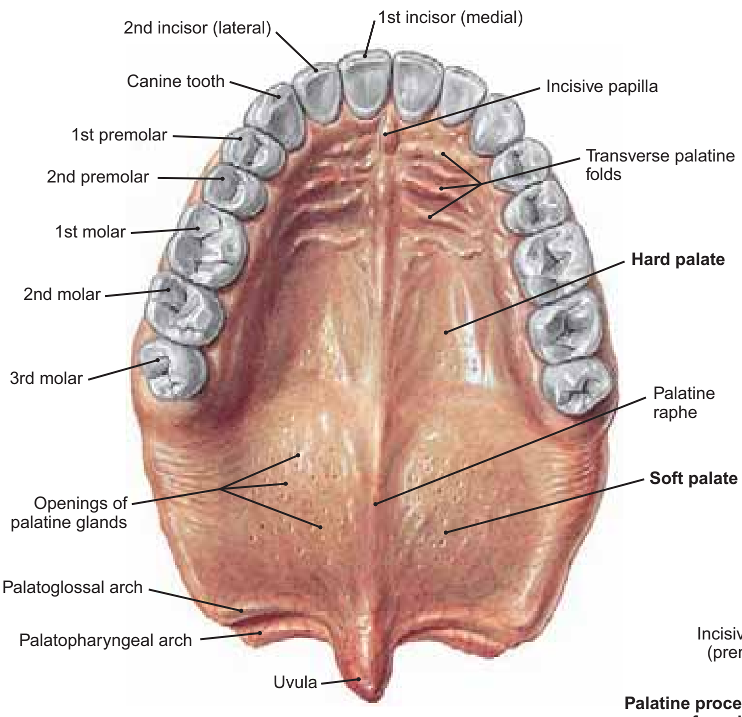


FIGURE 635.1 Hard and Soft Palates and Upper Teeth (Seen from Below)

NOTE: The palate consists of an anterior **hard** region and a posterior **soft** region. Transverse ridges mark the anterior palatal surface, while a median palatal raphe extends from the incisive papilla to the uvula. The upper teeth are named similarly to the lower teeth.

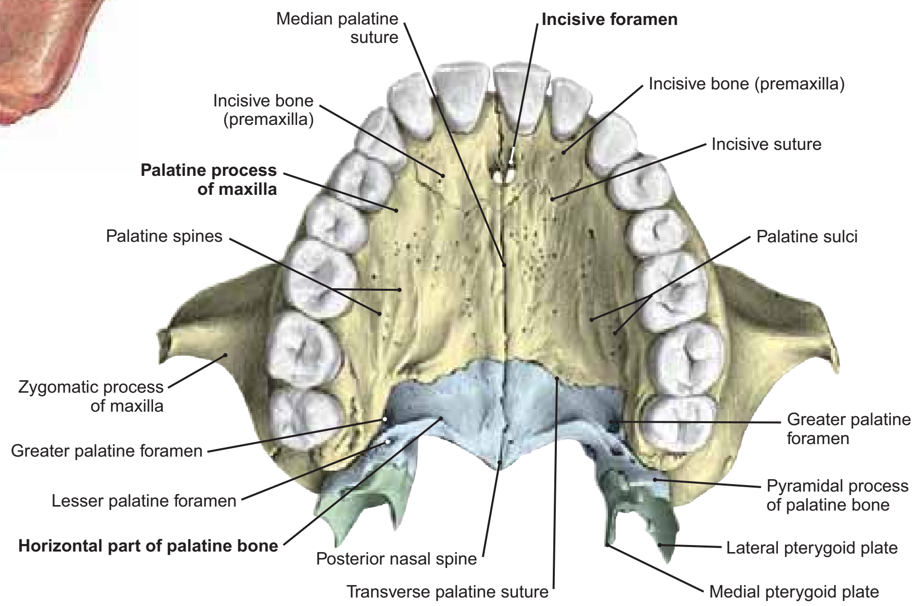


FIGURE 635.2 Bony Hard Palate and Upper Teeth (Seen from Below)

NOTE: The hard palate is formed principally by the palatine processes of the two maxillae and the horizontal laminae of the palatine bones.

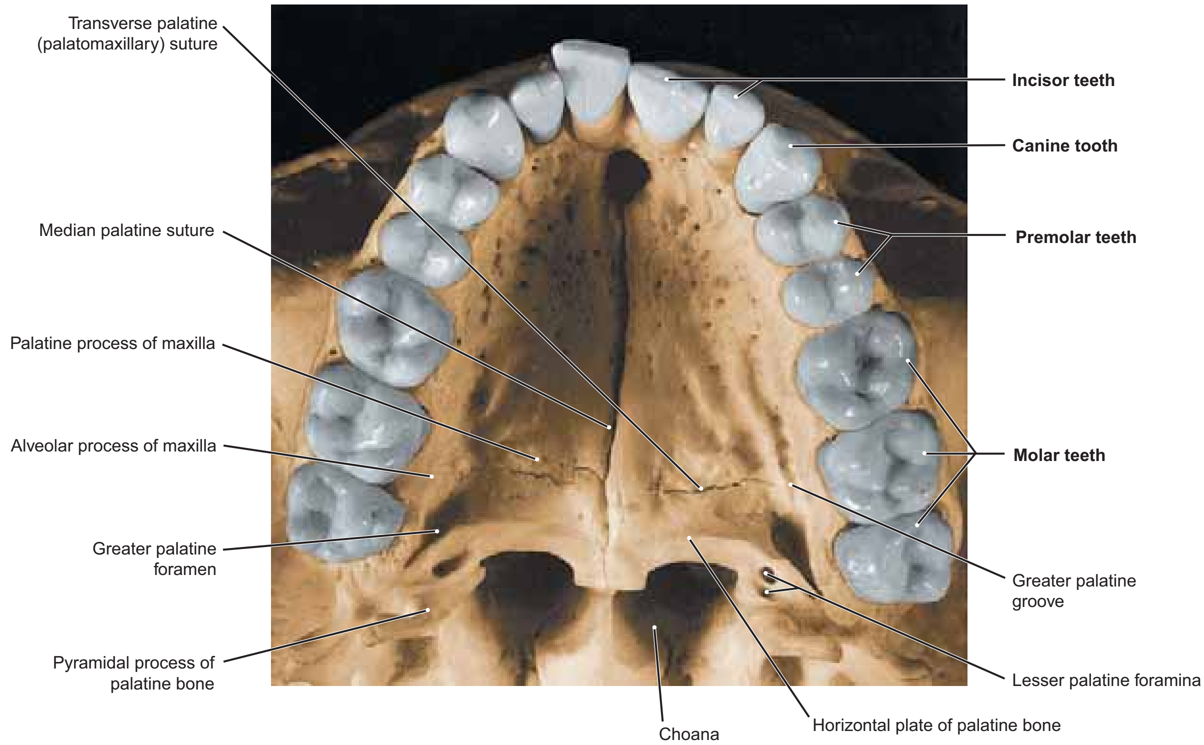


FIGURE 635.3 Photograph of the Bony Palate Showing the Maxillary Arch and Upper Teeth

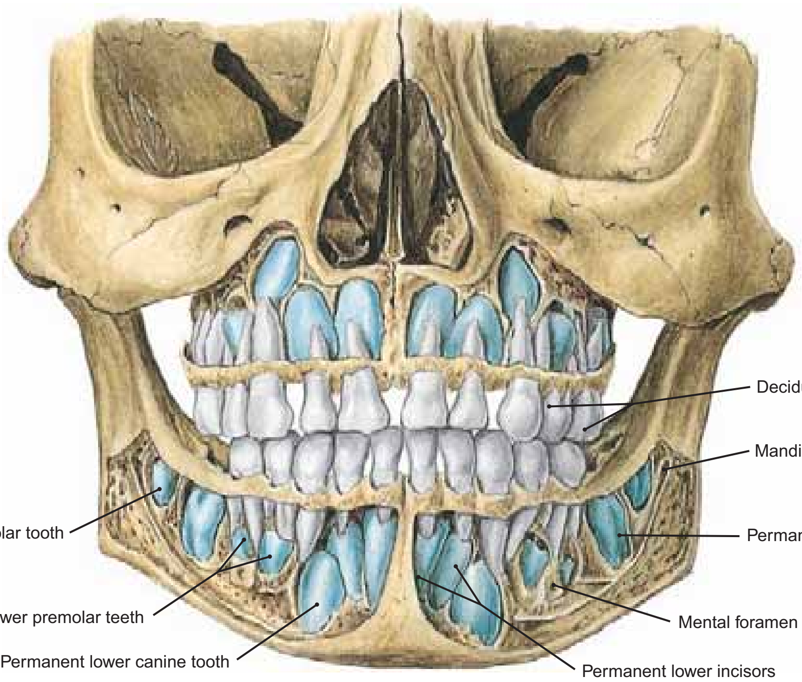


FIGURE 636.1 Facial Skeleton of a 5-Year-Old Child Showing Full Deciduous Dentition (20 Teeth)

NOTE: (1) The **deciduous teeth** are shown as white, whereas the rudiments of the **permanent teeth**, shown in blue, have been exposed by removing the outer walls of the alveolar processes of both maxillae and the mandible.

(2) All 20 deciduous teeth have erupted: eight incisors, four canines, and eight molars. Normally all deciduous teeth are replaced by the 12th year.

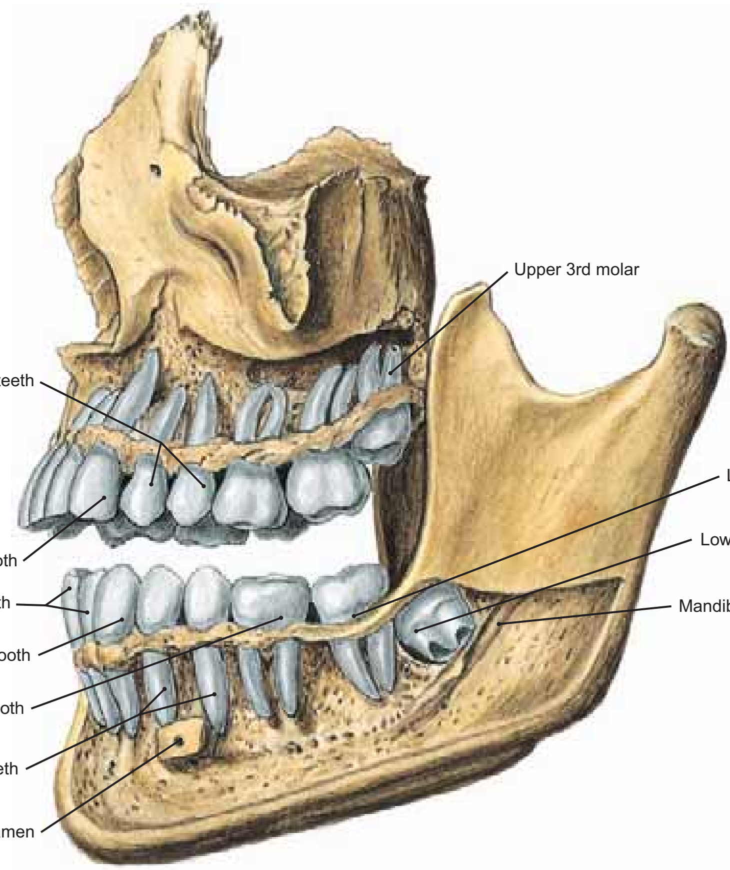


FIGURE 636.2 Dentition of a 20-Year-Old Person (Seen from Left Side)

NOTE: (1) The roots of the permanent teeth have been exposed by removing the alveolar walls. All of the permanent teeth have erupted through the gums, with the exception of the lower third molar.

(2) The canines and incisors have but one root, as generally do the premolars, although the latter may have two roots. The first and second molars usually have three roots, whereas the smaller third molar may have less than three and may even be single-rooted.

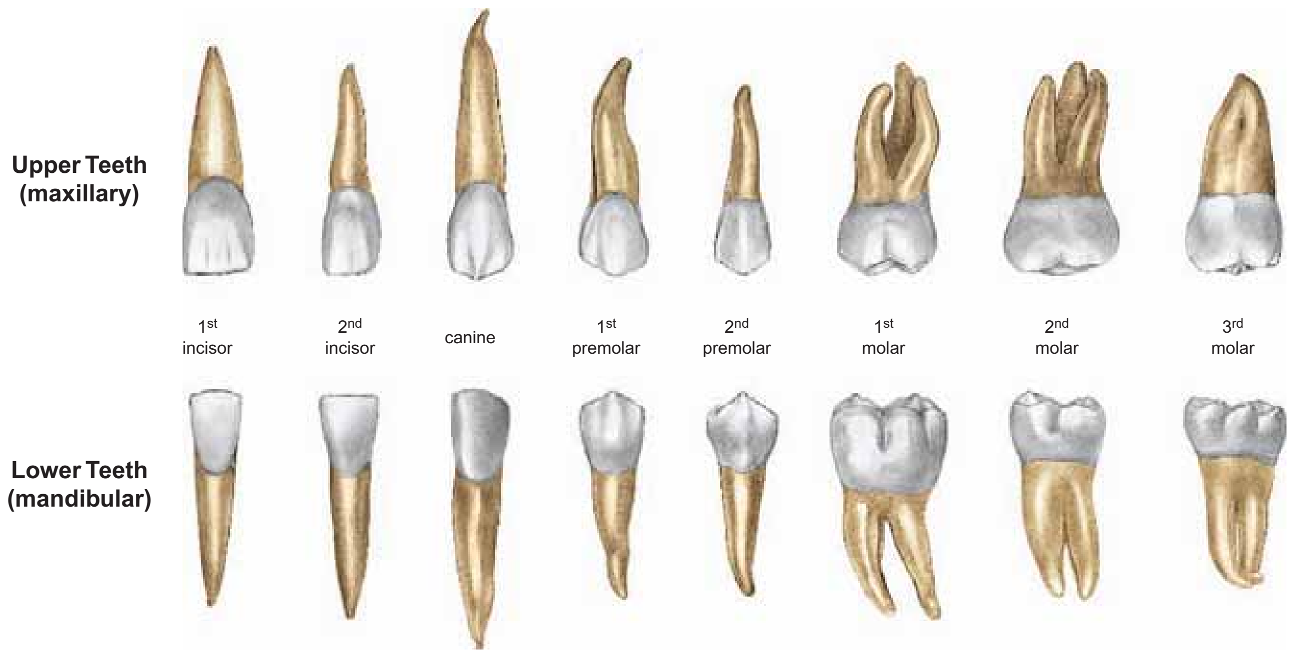


FIGURE 637.1 Left Adult Permanent Teeth: Vestibular View

NOTE: (1) The orientations of **"vestibular," "medial** or **mesial," "oral,"** and **"distal"** are shown in Figure 634.3.

(2) The **incisor teeth** have a sharp edge and a single root. Observe that the first maxillary incisor is larger than the first mandibular incisor, and the roots of the maxillary incisors are rounded, whereas the roots of the mandibular incisors are flattened.

(3) The **canine tooth** is somewhat larger than the incisors, and it has a single cusp. It is also the longest of all the teeth.

(4) The **premolar teeth** have a buccal and a palatal cusp (hence they are often called bicuspids). The upper first premolar usually has two roots and the upper second premolar usually has one root, but it may have two. Both lower premolars have a single root, but the root of the first lower premolar may be bifid.

(5) Vestibular refers to the vestibule of the mouth, and depending on the tooth is either from the anterior direction or from the lateral direction.

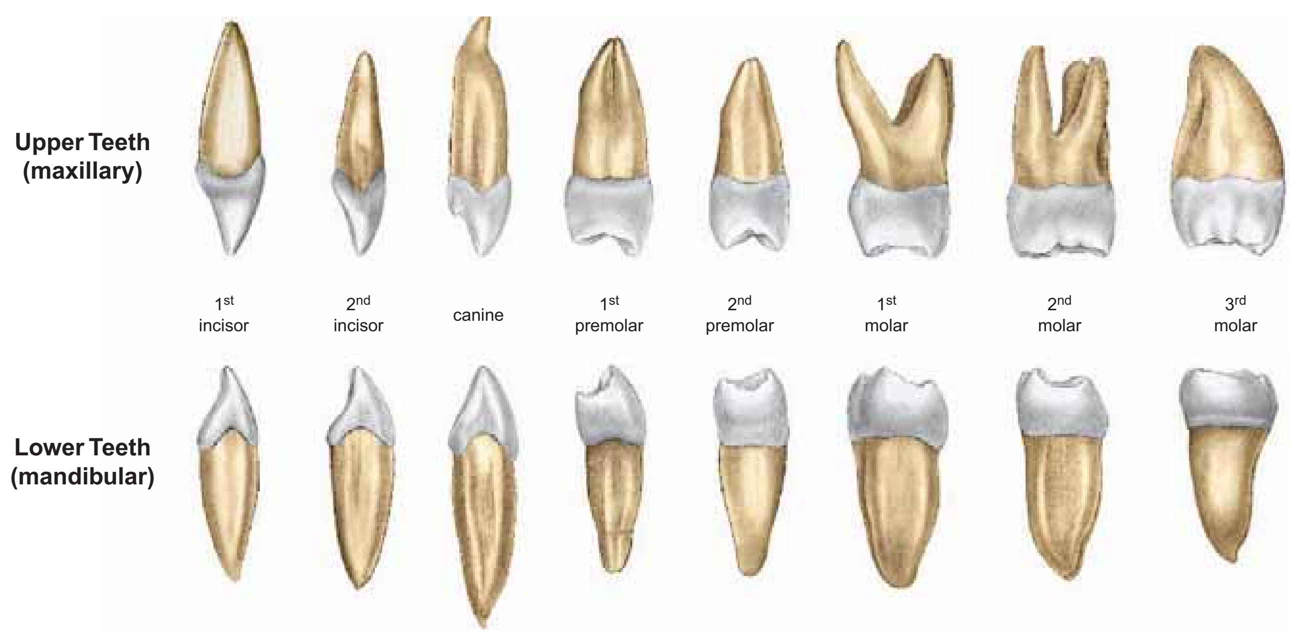


FIGURE 637.2 Left Adult Permanent Teeth: Medial or Mesial View

NOTE: The **molar teeth** decrease in size posteriorly. They have four or five cusps. The first and second molars generally have three roots, whereas the third molar (wisdom tooth) often may have only a single root.

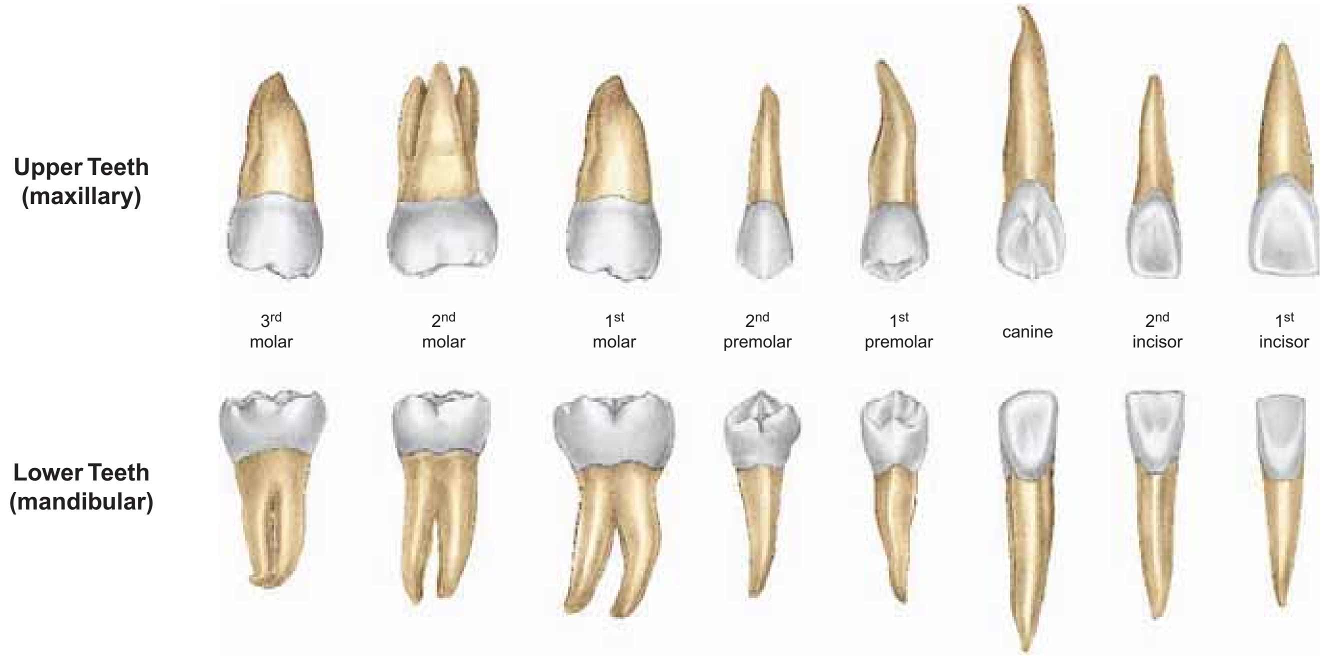


FIGURE 638.1 **Left Adult Permanent Teeth: Oral View**

NOTE that "oral" in the mandibular region means **"lingual,"** whereas in the maxillary region, oral refers to **"palatal."**

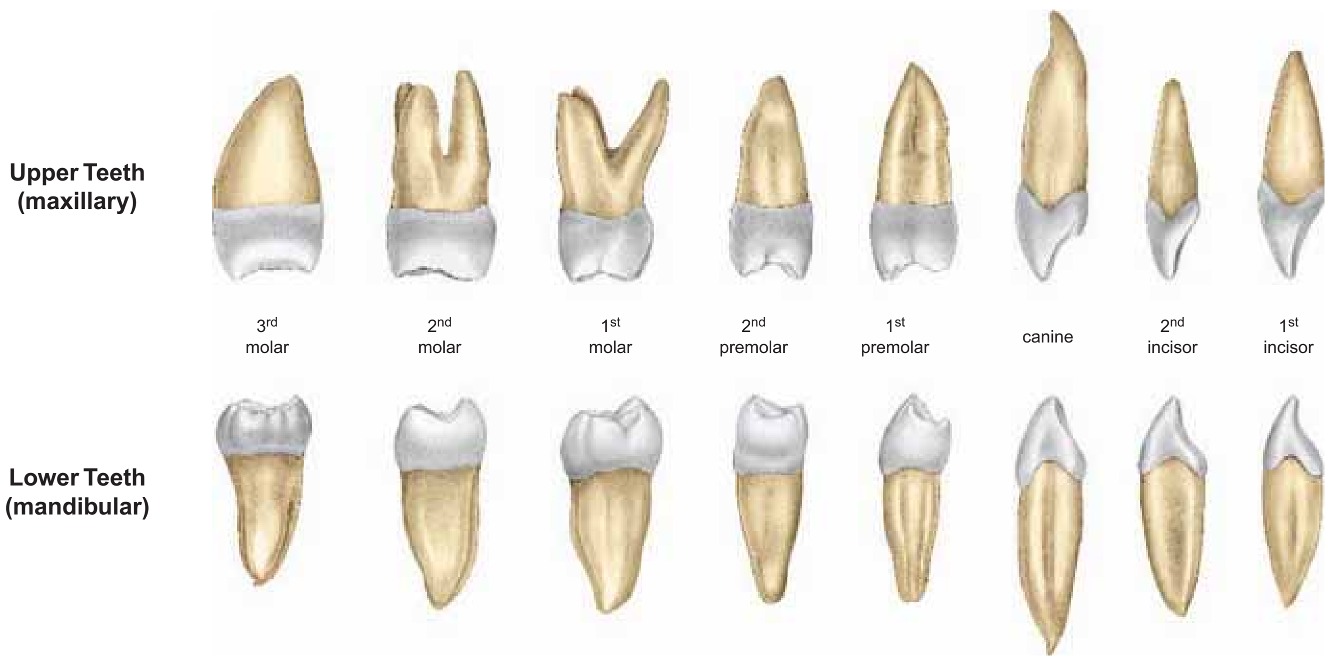


FIGURE 638.2 **Left Adult Permanent Teeth: Distal View**

See Fig. 634.3.

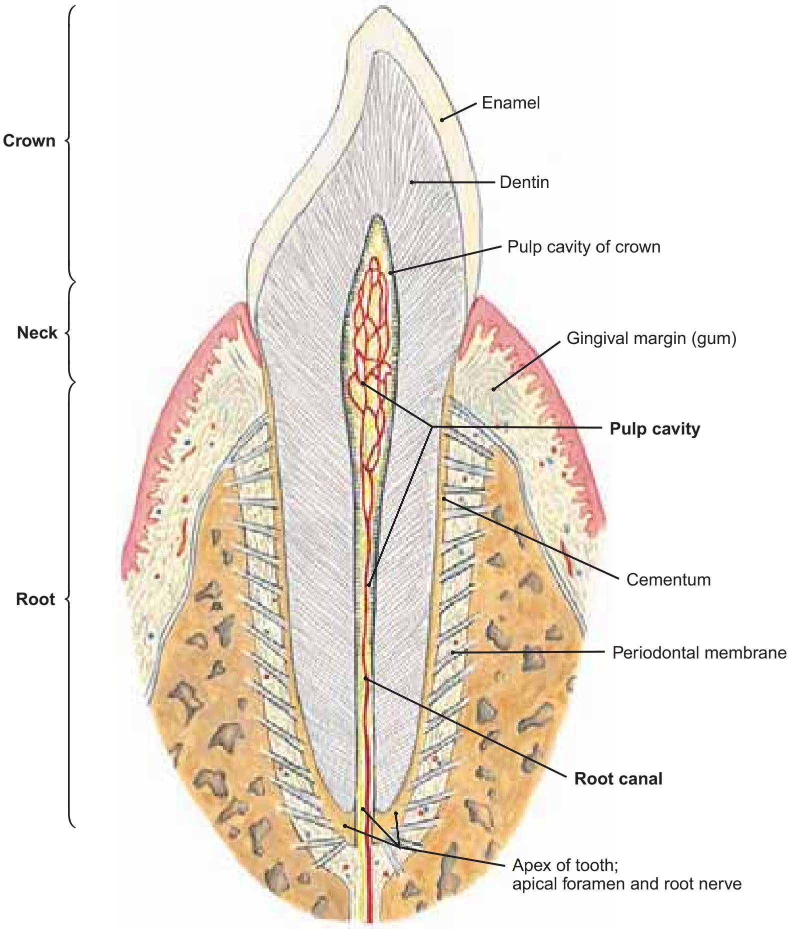


FIGURE 639.1 Longitudinal Section of the Tooth

NOTE: (1) The crown of the tooth is covered with **enamel** and projects from the **gingiva,** or gum. The root is embedded within the alveolar bony **socket** and covered by a thin layer of **cementum.**

(2) The main portion of the tooth consists of **dentin,** which surrounds the **root canal** and **pulp cavity** containing the **dental artery** and **nerve.**

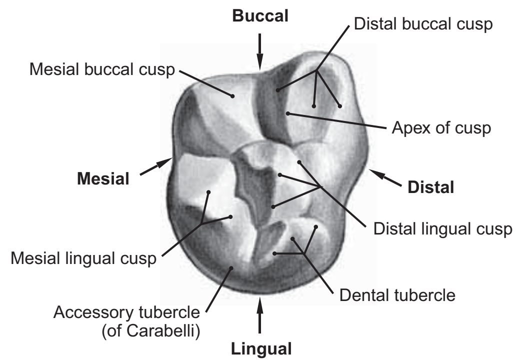


FIGURE 639.2 Occlusal Surface of the Right Upper First Molar

NOTE: The upper first molar may have a fifth cusp, the tubercle of Carabelli, on the mesiolingual surface of the crown.

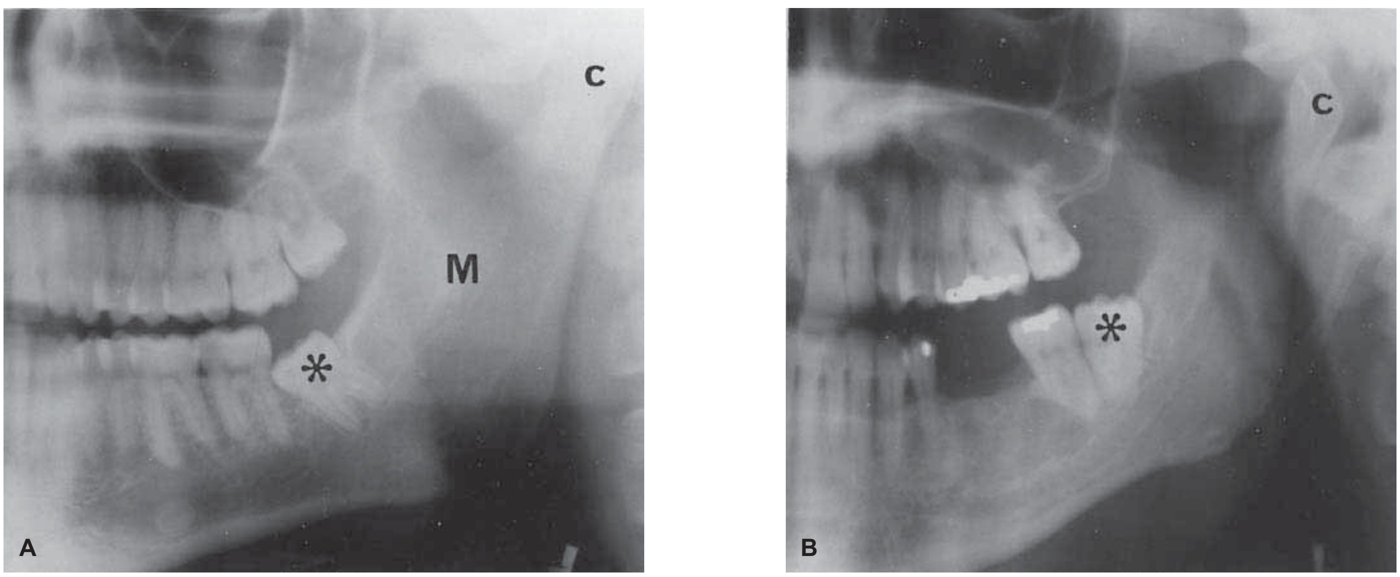


FIGURE 639.3, 639.4, and 640.3 Three Examples of Commonly Encountered Patterns of Impacted Lower Third Molar Teeth: A. Mesioangular Impaction (Fig. 639.3); B. Distoangular Impaction (Fig. 639.4); C. Horizontal Impaction (See Fig. 640.3, next plate)

Asterisk (*) = impacted molar tooth; M = mandible; c = condyloid process
(Contributed by Edward J.H. Nathanial, MD, PhD, Department of Anatomy, University of Manitoba, Winnipeg, Canada.)

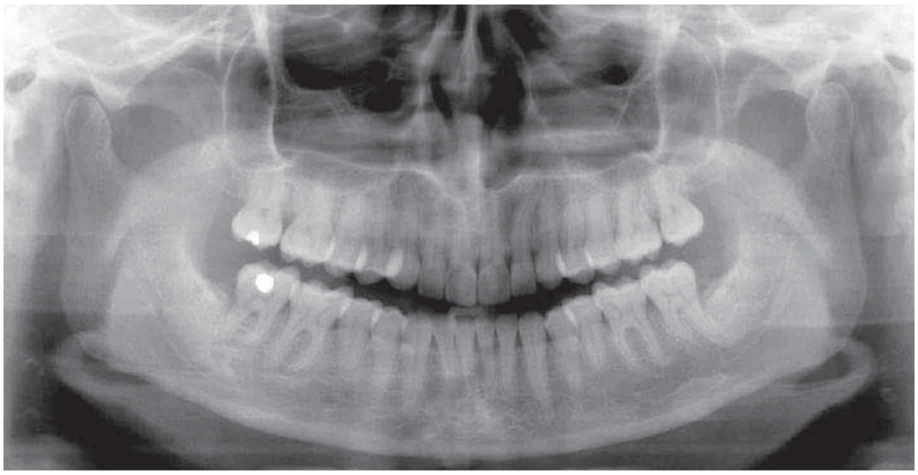


FIGURE 640.1 Radiograph of the Maxilla and Mandible. Plain Film with No Labels. For Labels, See Below (Fig. 640.2)

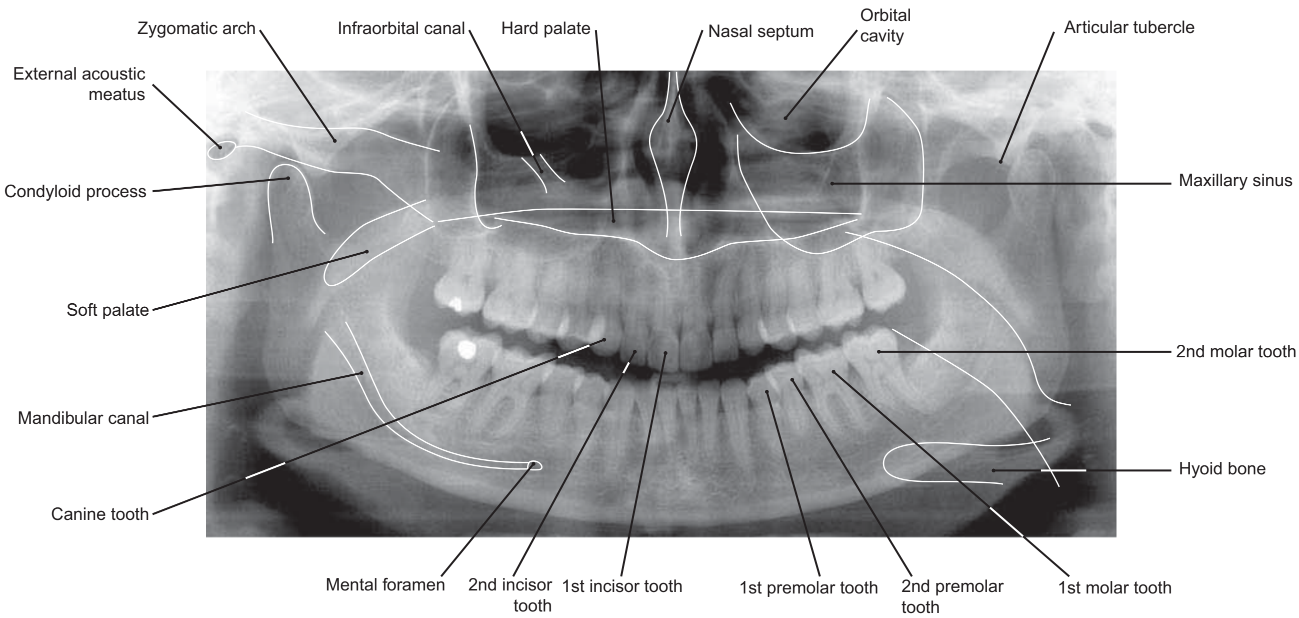


FIGURE 640.2 Radiograph of the Maxilla and Mandible

NOTE: the locations of adjacent structures to the oral cavity such as the nasal septum, maxillary sinus, hyoid bone, mandibular canal, infraorbital canal, and hard palate.

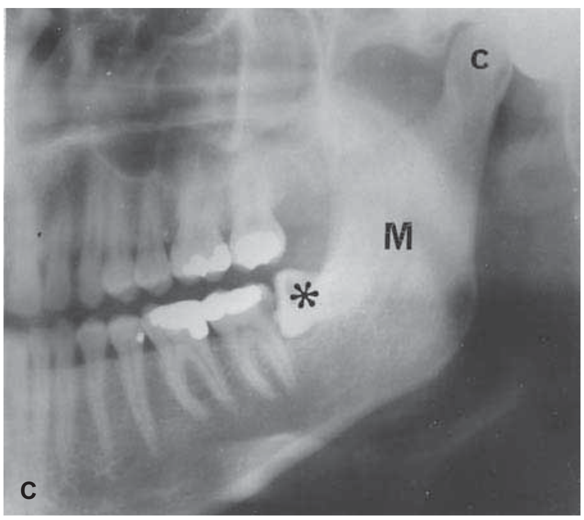


FIGURE 640.3 Horizontal Impaction

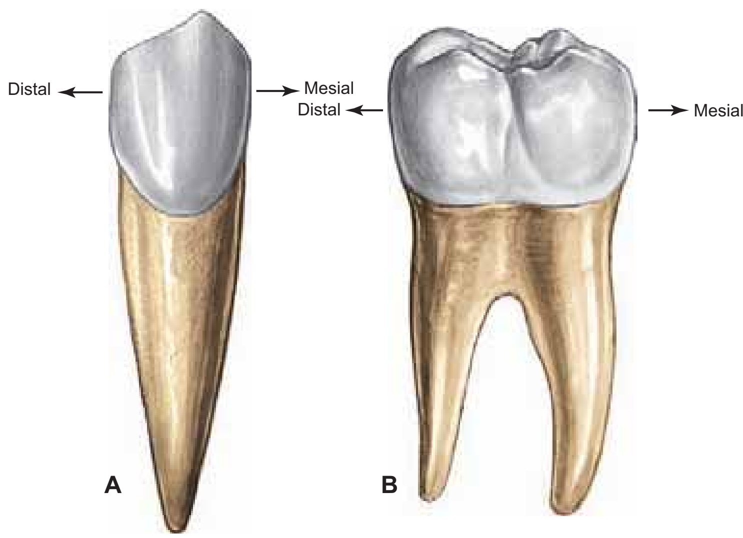


FIGURE 640.4 A. Lower Canine (Vestibular Surface); B. Lower Second Molar (Vestibular Surface)

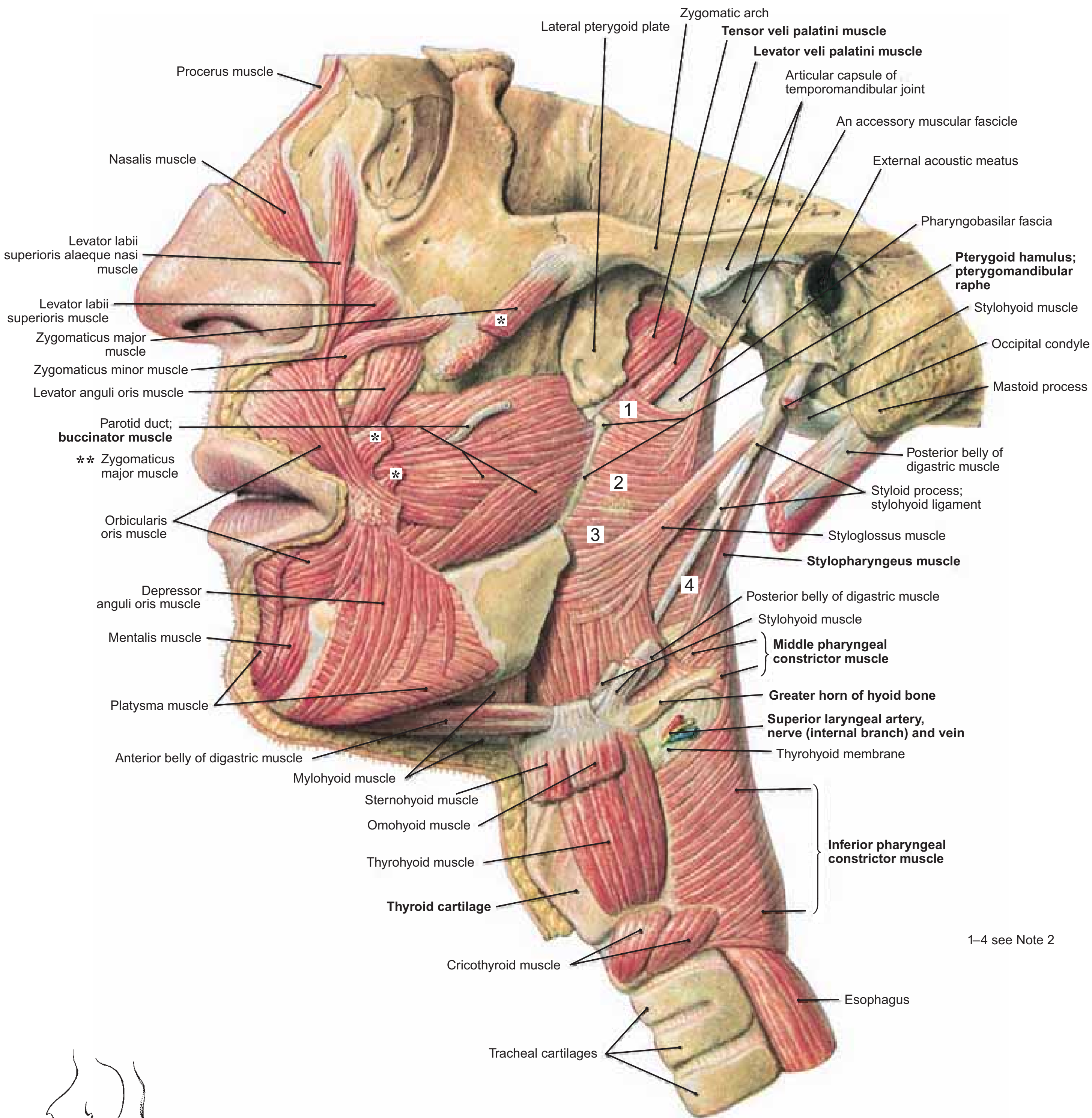
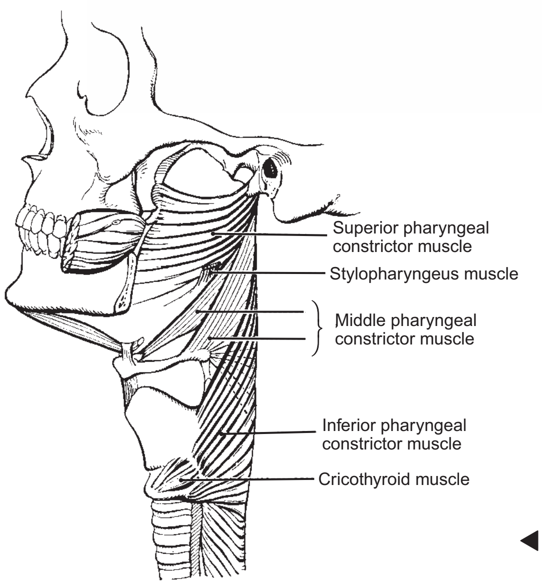


FIGURE 641.1 Muscles of the Pharynx and Face ▲

NOTE: (1) The tendinous **pterygomandibular raphe**. It extends between the pterygoid hamulus superiorly and the mylohyoid line of the mandible inferiorly and serves as a common site of origin for the **buccinator** and **superior pharyngeal constrictor**.

(2) The **superior constrictor** arises by four parts: (1) from the hamulus of the medial pterygoid plate; (2) from the pterygomandibular raphe; (3) from the mylohyoid line of the mandible; and (4) by certain fibers that blend with tongue muscles and emerge from the side of the tongue.

(3) The **middle constrictor** arises from the greater and lesser horns of the hyoid bone, whereas the larger and thicker **inferior constrictor** arises from the thyroid and cricoid cartilages.



◀ FIGURE 641.2 Diagram of the Origins of the Pharyngeal Constrictor Muscles

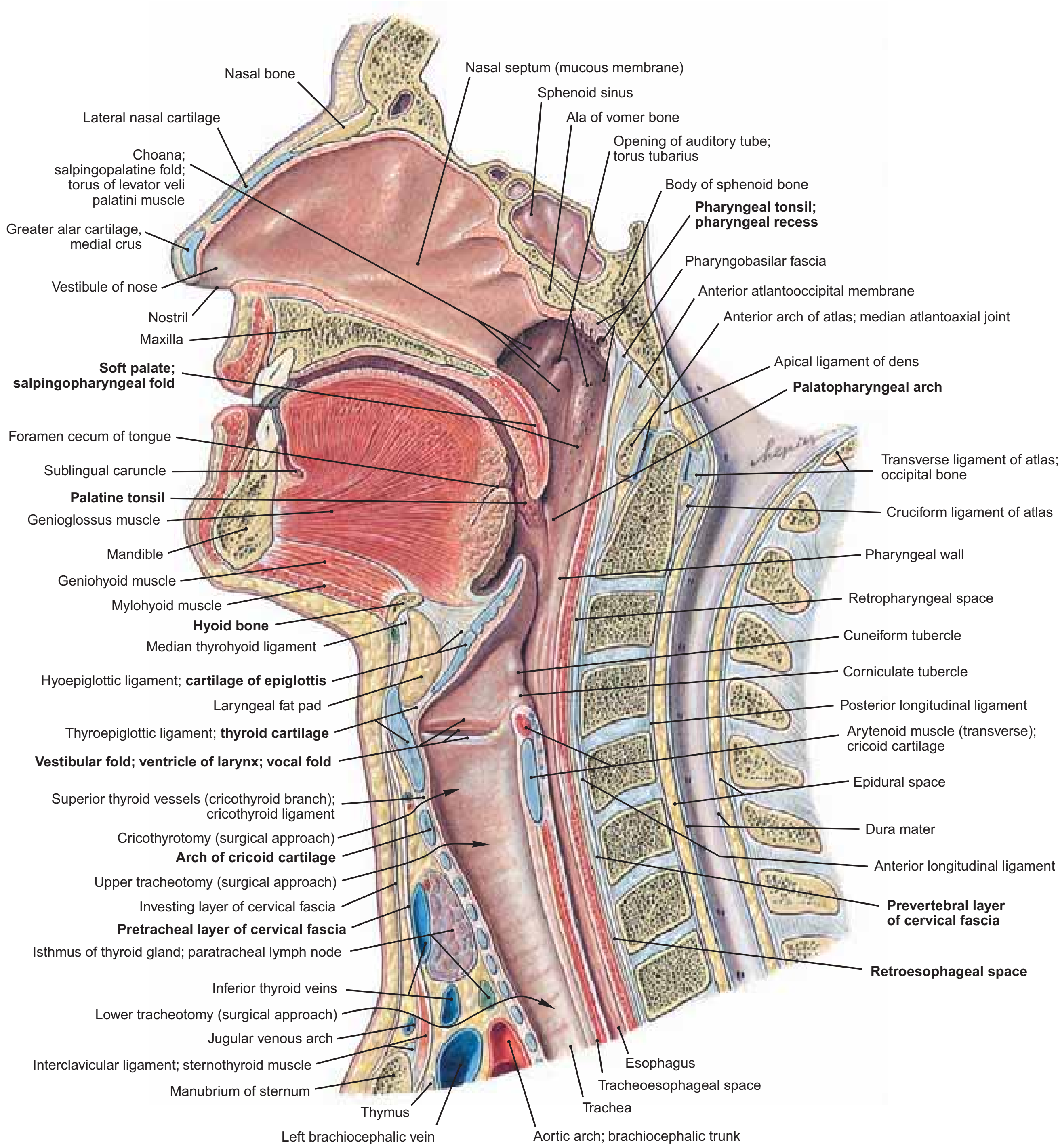


FIGURE 642 Midsagittal Section of the Mouth, Pharynx, Larynx, and Other Head and Neck Viscera

NOTE: (1) The closed oral cavity is occupied principally by the tongue. The posterior end of the oral cavity opens into the **oropharynx**. Superiorly, the posterior nasal cavities are continuous with the **nasopharynx**, whereas inferiorly the **laryngeal part of the pharynx** (between the levels of the epiglottis and cricoid cartilages) communicates with the larynx.

(2) The pharynx continues inferiorly as the **esophagus**, whereas the larynx becomes the **trachea** below the level of the cricoid cartilage.

(3) During **deglutition** (swallowing) food gets directed toward the posterior part of the oral cavity. The soft palate is then elevated and tensed (levator and tensor veli palatini muscles) thereby closing off the nasopharynx so that food enters the oropharynx. At the same time the larynx is drawn upward toward the epiglottis and the pharynx ascends as well. This action closes off the laryngeal orifice (aditus) and prevents food from entering the larynx.

(4) The arrows indicate surgical approaches to the airway (larynx and trachea).

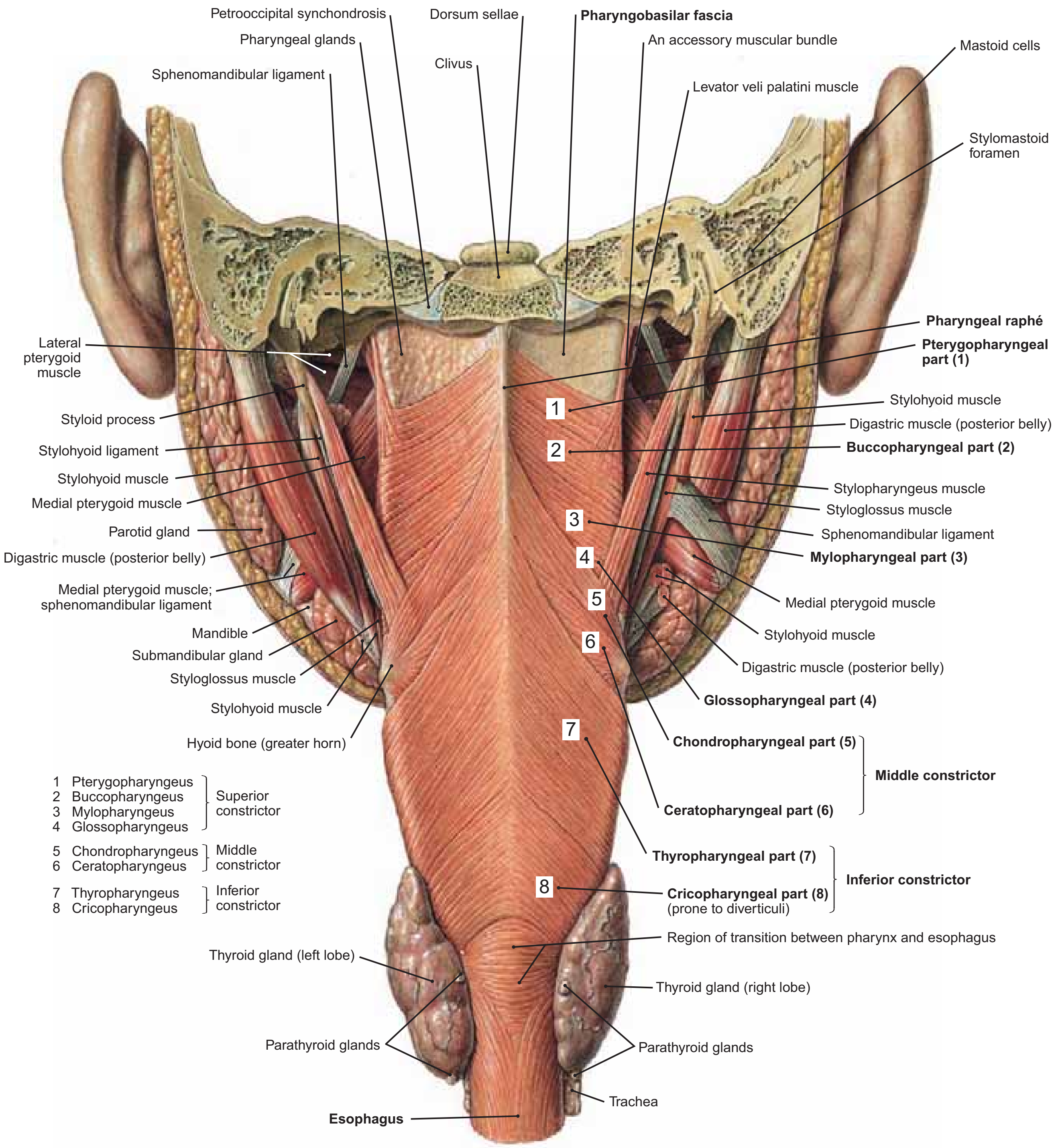


FIGURE 643 Dorsal View of the Pharyngeal Muscles

NOTE: (1) This posterior view of the pharynx was achieved by making a frontal transection through the petrous and mastoid parts of the temporal bone and through the body of the occipital bone. The styloid processes and their muscular attachments are left intact.

(2) The divisions of the **pharyngeal constrictors**. Their muscle fibers arise laterally to insert in a posterior raphe in the midline. The **superior constrictor** is divisible into four parts, whereas the **middle and inferior constrictors** are each divisible into two.

(3) Above the superior constrictor is found the fibrous **pharyngobasilar fascia**, which attaches to the basal portion of the occipital bone and to the temporal bones. Below the inferior constrictor, the pharynx is continuous with the muscular esophagus.

(4) The superior and middle constrictor muscles and the thyropharyngeal part of the inferior constrictor are innervated by the **pharyngeal branch of the vagus nerve**. These fibers have their cell bodies in the nucleus ambiguus in the medulla oblongata; they emerge from the brain in the rootlets of the bulbar part of the accessory nerve and then, by a communicating branch, join the vagus nerve.

(5) The cricopharyngeal part of the inferior constrictor is supplied by the recurrent laryngeal branch of the vagus nerve.

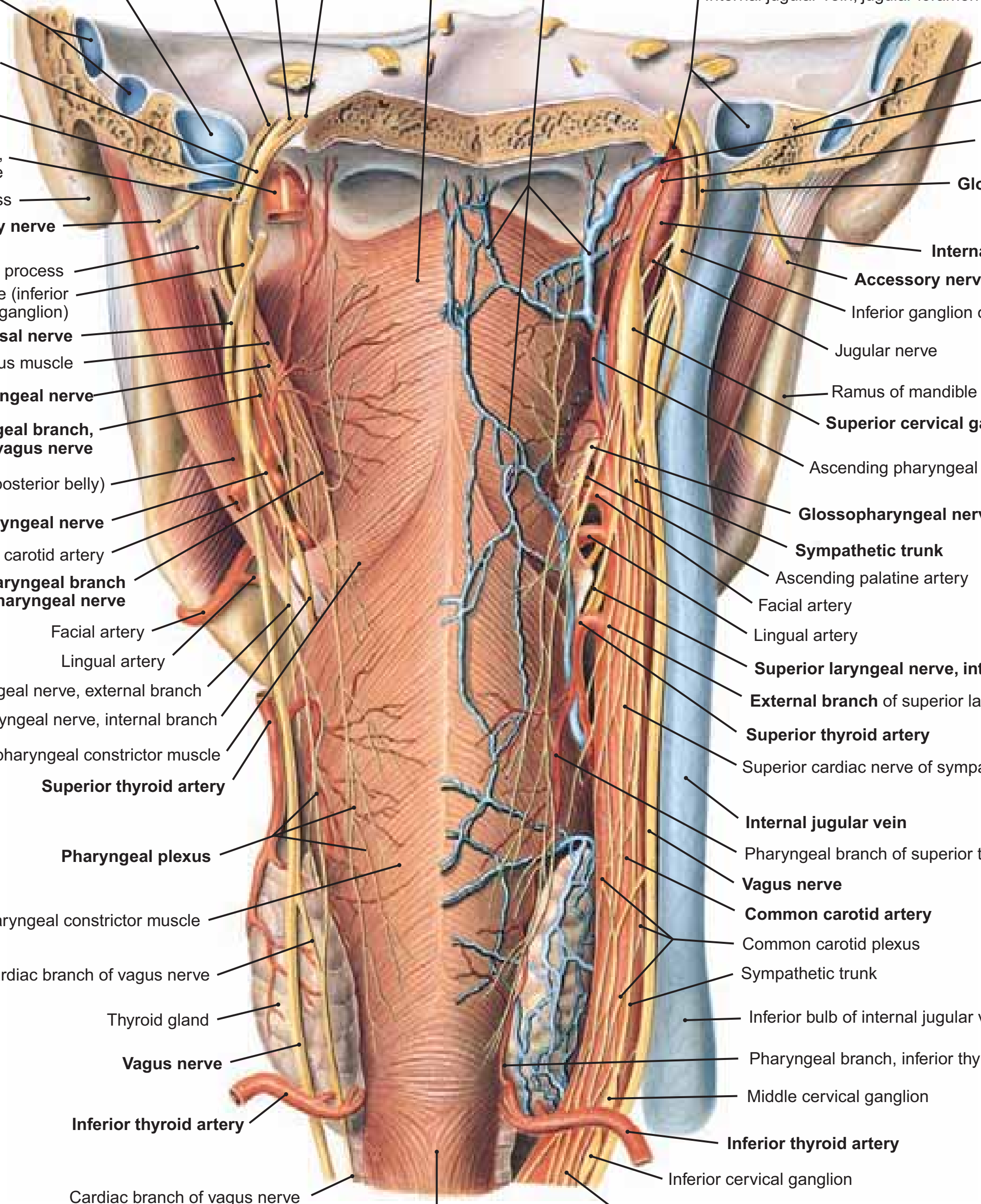


FIGURE 644 Nerves and Vessels on the Dorsal and Lateral Walls of the Pharynx

NOTE: (1) The head has been split longitudinally. The pharynx, larynx, and facial structures were separated from the vertebral column and its associated muscles. This posterior view of the pharynx also shows the large nerves and blood vessels that course through the neck. On the right side, observe the **carotid artery, internal jugular vein, vagus nerve,** and the **sympathetic trunk**.

(2) On the left side are the **glossopharyngeal** and **hypoglossal nerves**, which were exposed by removing the carotid arteries and internal jugular vein. In addition to the jugular vein, the **jugular foramen** transmits the 9th, 10th, and 11th cranial nerves.

(3) The **thyroid gland** and its **superior and inferior thyroid arteries**. The superior and middle thyroid veins drain into the internal jugular vein, whereas the inferior thyroid veins (not shown) usually drain into the left brachiocephalic vein.

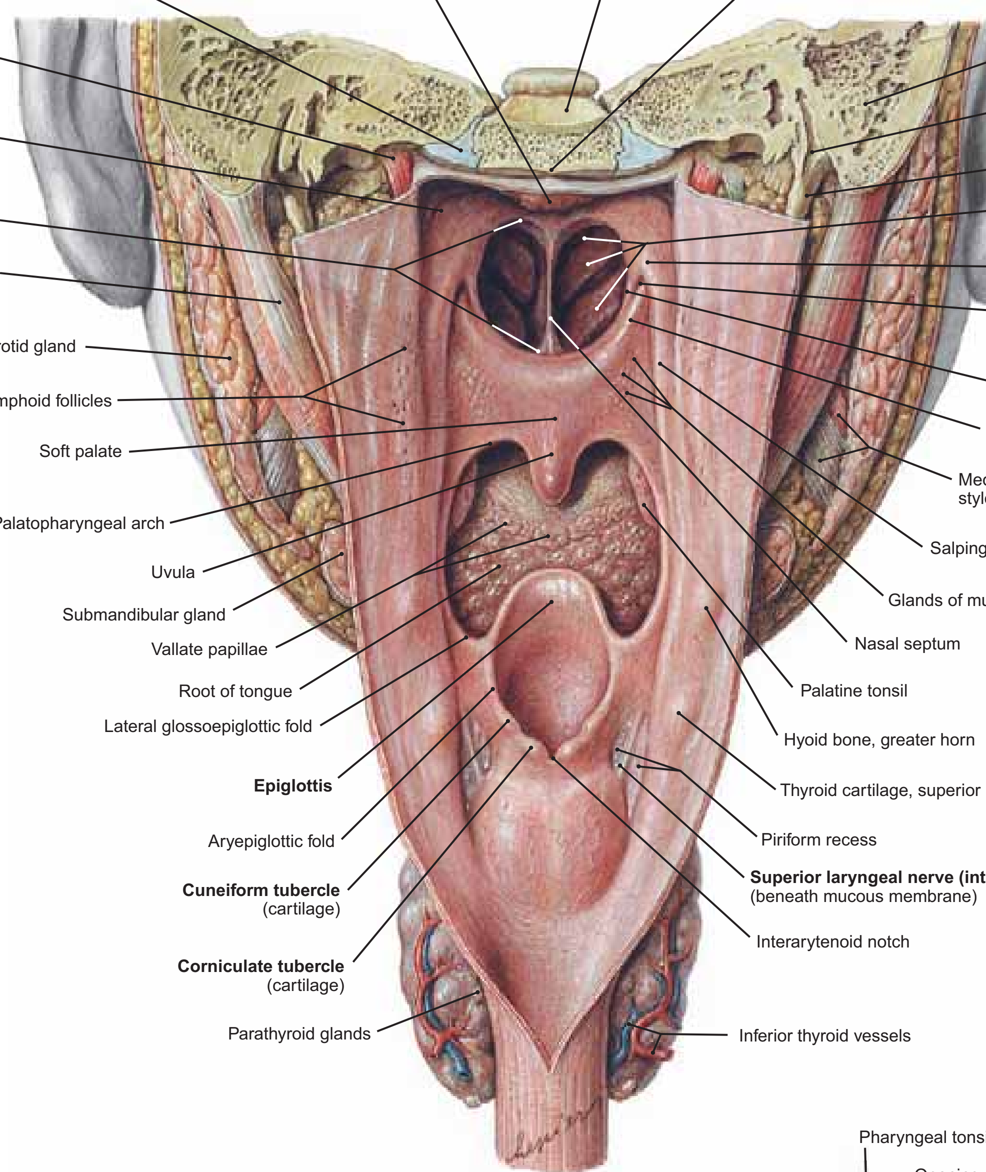


FIGURE 645.1 Pharynx and Its Related Cavities (Dorsal) ▲

NOTE: (1) The pharynx has been opened by a posterior longitudinal incision, thereby exposing its three parts: nasopharynx, oropharynx, and laryngopharynx. The **nasopharynx** lies above the soft palate, and it communicates with the nasal cavities by the choanae.

(2) The **oropharynx** communicates with the oral cavity through the isthmus of the fauces. It extends between the soft palate and the larynx.

(3) The **laryngopharynx** lies behind the larynx and is continuous below with the esophagus. The superior part of the laryngopharynx communicates with the larynx through the laryngeal inlet called the aditus.

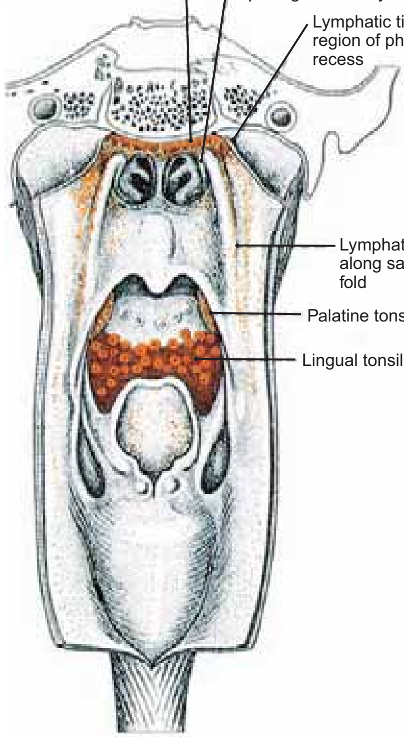


FIGURE 645.2 Oronasopharyngeal Lymphatic Ring ▶

NOTE: The lymphatic ring is shown in red. This circular accumulation of lymphatic tissue includes the lingual tonsil (which consists of lymphoid follicles on the posterior third of the tongue), the palatine tonsils, the pharyngeal tonsil, and more diffuse lymphoid tissue in the wall of the nasopharynx along the salpingopharyngeal fold.

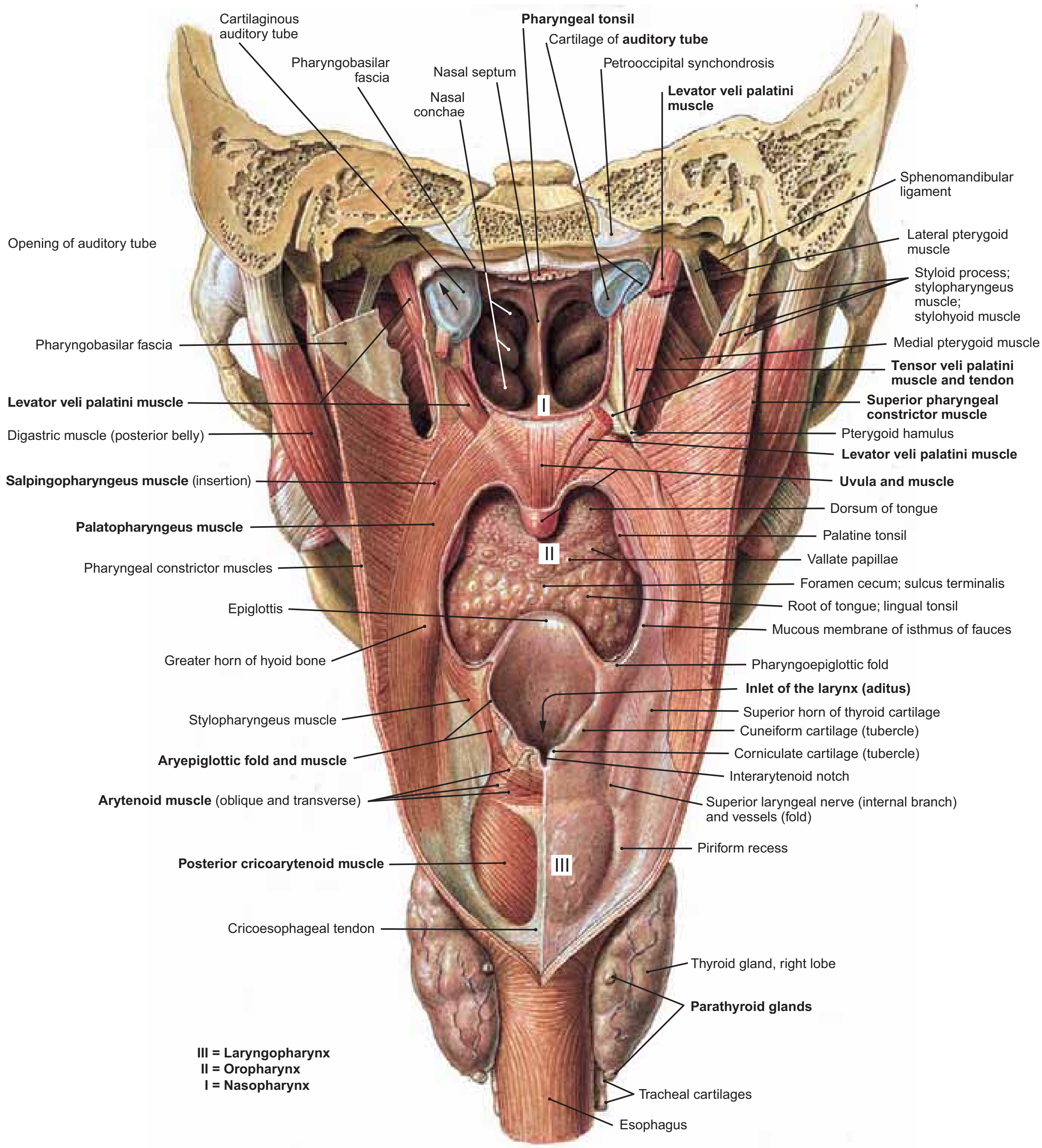


FIGURE 646 Muscles of the Soft Palate, Pharynx, and Posterior Larynx

NOTE: (1) This dissection is similar to that in Figure 645. The pharynx has been opened dorsally by a midline incision and the mucous membrane has been removed from the soft palate, pharynx, and left posterior larynx. On the right, a part of the levator veli **palatini muscle** has been removed to expose the adjacent **tensor veli palatini muscle**.

(2) The **muscles of the soft palate**. Both the muscle of the uvula and the levator veli palatini muscle are innervated by the pharyngeal branch of the vagus nerve, whereas the tensor veli palatini is supplied by the mandibular division of the trigeminal nerve.

(3) The **palatopharyngeus muscle** arises by two fascicles from the soft palate. The muscle fibers of these fascicles arise posterior and anterior to the insertion of the levator veli palatini muscle. The fascicles descend and merge and then insert into the posterior border of the thyroid cartilage and onto the adjacent pharyngeal wall.

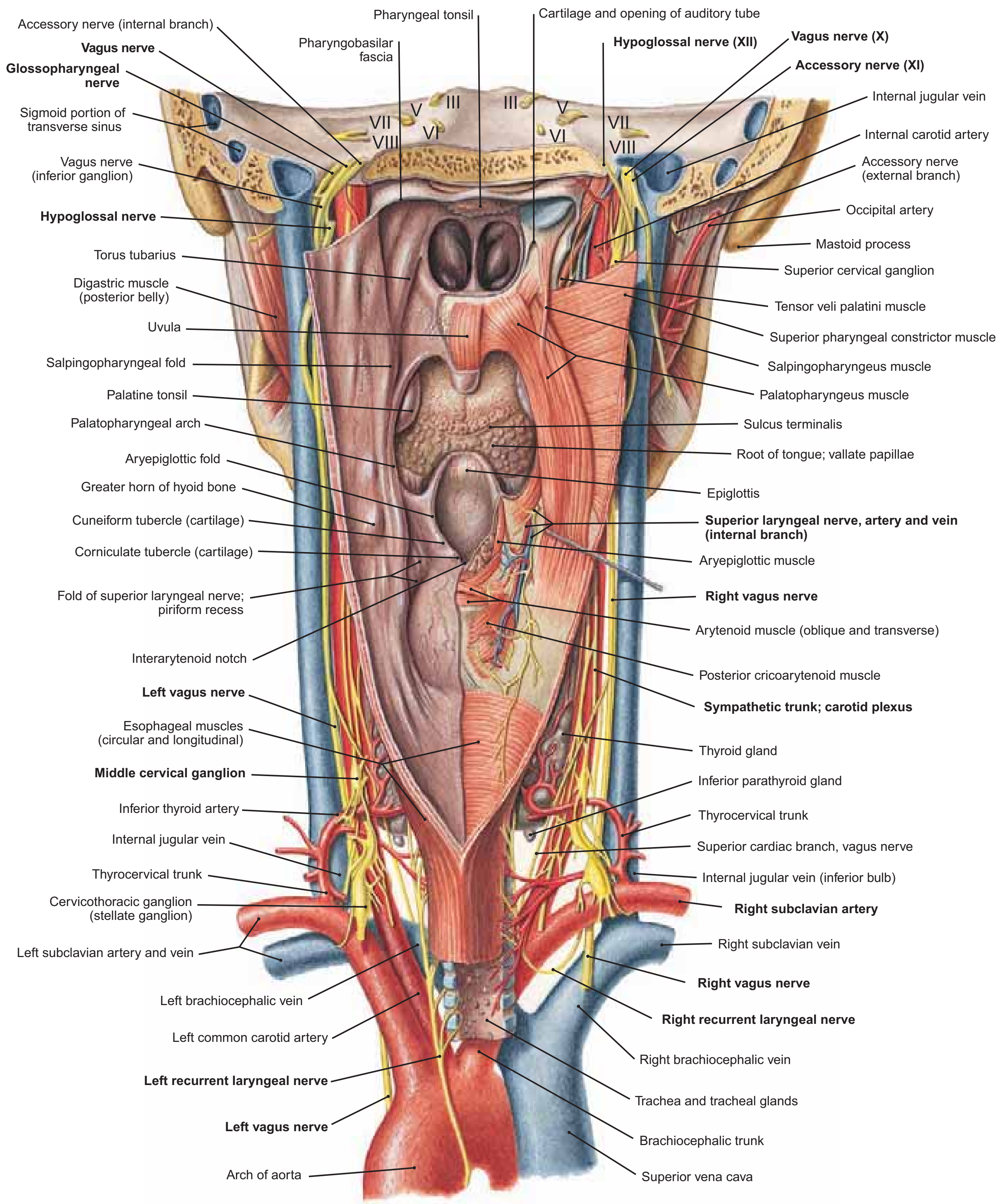


FIGURE 647 Pharynx Opened from Behind: Cervical Viscera, Muscles, Vessels, and Nerves

NOTE: (1) The nasal, oral, and laryngeal orifices communicate with the pharynx. Observe the **superior laryngeal artery, vein,** and **nerve (internal branch)** entering the larynx from above.

(2) The **recurrent laryngeal nerves** ascend to the larynx from the thorax. The left nerve courses around the arch of the aorta, while on the right side the recurrent laryngeal nerve curves around the subclavian artery.

(3) The **inferior cervical ganglion** at the level of the seventh cervical vertebra is fused with the first thoracic ganglion (in about 80% of cases). When fused, the joint ganglion is called the **stellate ganglion.**

MUSCLES OF THE PALATE Muscle	Origin	Insertion	Innervation	Action
Musculus uvulae	Posterior nasal spine (palatine bone); palatine aponeurosis	Descends into the mucous membrane of the uvula	Pharyngeal branch of the vagus nerve	Pulls the uvula up and contracts the uvula on its own side
Tensor veli palatini	Scaphoid fossa of pterygoid process; cartilaginous part of auditory tube; spine of sphenoid	Tendon courses around the pterygoid hamulus and then inserts into the palatine aponeurosis	Branch of the mandibular division of the trigeminal nerve	Tenses the soft palate; acting singly, it pulls the soft palate to one side
Levator veli palatini	Inferior surface of temporal bone; cartilaginous part of auditory tube	Upper surface of the palatine aponeurosis	Pharyngeal branch of the vagus nerve	Elevates the soft palate
Palatoglossus	Oral surface of the palatine aponeurosis	Into the side of the tongue	Pharyngeal branch of the vagus nerve	Elevates root of tongue; two muscles together close off oral cavity from oropharynx
Palatopharyngeus	Posterior border of the hard palate; palatine aponeurosis	Posterior border of thyroid cartilage; lateral wall of pharynx	Pharyngeal branch of the vagus nerve	Pulls the pharynx upward during swallowing

MUSCLES OF THE PHARYNX				
Superior pharyngeal constrictor	**Pterygopharyngeal Part**		Motor fibers: Pharyngeal branch of vagus nerve (fibers originating in the medullary part of accessory nerve)	The constrictor muscles act as sphincters of the pharynx and induce peristaltic waves during swallowing
	Pterygoid hamulus of sphenoid bone	Pharyngobasilar fascia and the midline raphe		
	Buccopharyngeal Part			
	Pterygomandibular raphe	Posterior midline pharyngeal raphe		
	Mylopharyngeal Part			
	Mylohyoid line of mandible	Posterior midline pharyngeal raphe		
	Glossopharyngeal Part			
	A few fibers arise from the side of tongue	Posterior midline pharyngeal raphe	Sensory fibers of mucosa: Glossopharyngeal nerve and some trigeminal nerve fibers	
Middle pharyngeal constrictor	**Chondropharyngeal Part**			
	Lesser horn of hyoid bone	Posterior midline pharyngeal raphe		
	Ceratopharyngeal Part			
	Greater horn of hyoid bone	Posterior midline pharyngeal raphe		
Inferior pharyngeal constrictor	**Thyropharyngeal Part**			
	Oblique line on the lamina of thyroid cartilage	Posterior midline pharyngeal raphe		
	Cricopharyngeal Part			
	Side of the cricoid cartilage	Posterior midline pharyngeal raphe	Cricopharyngeus: Recurrent laryngeal branch of vagus	
Stylopharyngeus	Medial side of base of styloid process	Lateral wall of pharynx between the superior and middle constrictors	Glossopharyngeal nerve	Elevates the lateral wall of the pharynx during swallowing and speech
Salpingopharyngeus	Inferior part of the cartilage of the auditory tube	Blends with the palatopharyngeus on the lateral wall of the pharynx	Pharyngeal branch of vagus nerve	Raises upper lateral wall of the pharynx
Palatopharyngeus	Described with the palatal muscles above			

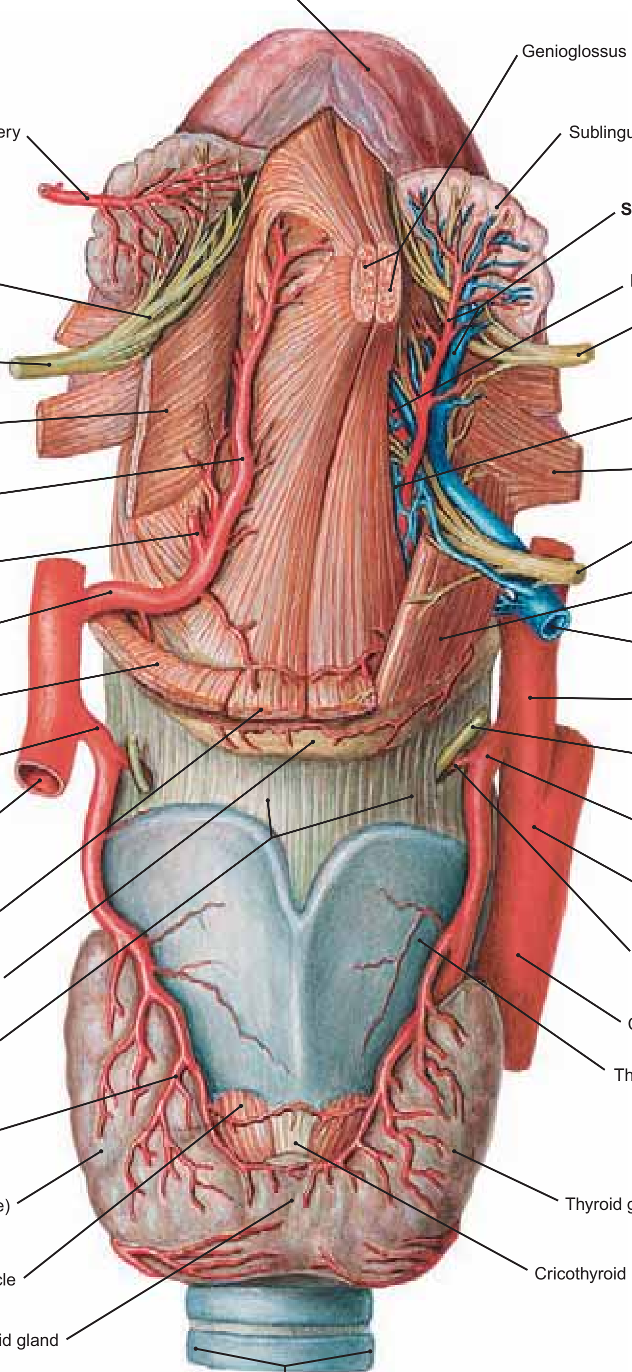


FIGURE 649 Anterior View of Larynx, Tongue and Thyroid Gland, Vessels, and Nerves

NOTE: (1) The **superior thyroid arteries** descend to the thyroid gland. In their course, they give off the **superior laryngeal arteries**, which penetrate the thyrohyoid membrane to enter the interior of the larynx. They are accompanied by the **internal laryngeal branch** of the **superior laryngeal nerve**.

(2) The cranial and medial course of the **lingual artery** deep to the hyoglossus muscle and its suprahyoid (not labeled), sublingual, and deep lingual branches.

(3) The **lingual nerves** as they enter the tongue to supply its anterior two-thirds with general sensation. The motor nerve to the tongue is the **hypoglossal**, seen coursing along with its accompanying veins. It enters the base of the tongue just above the hyoid bone, passing anteriorly across the external carotid and lingual arteries.

(4) The **common carotid artery** bifurcates at about the level of the upper border of the thyroid cartilage. The lingual artery branches from the external carotid above the hyoid bone, while the superior laryngeal arises at the level of the thyrohyoid membrane.

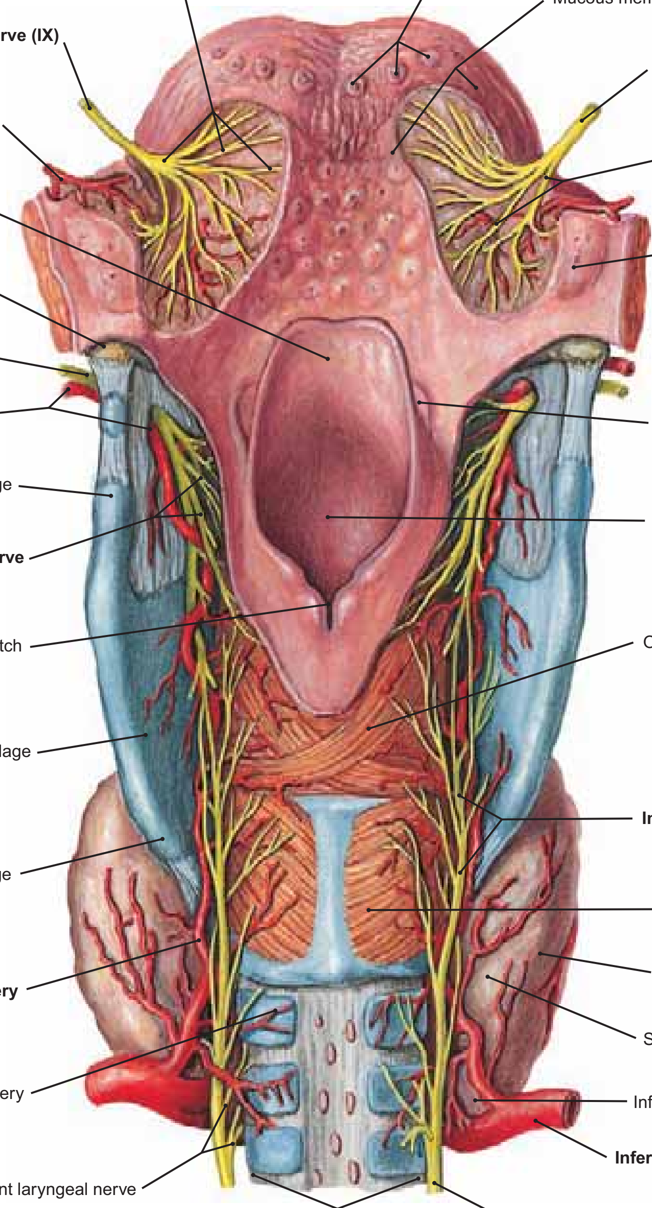


FIGURE 650 Posterior View of the Larynx, Tongue and Thyroid Gland, Vessels, and Nerves

NOTE: (1) The **glossopharyngeal nerves (IX)** enter the root or pharyngeal part of the tongue to supply the posterior third of the surface of the tongue with both general sensation and the special sense of taste. Also note the **tonsillar branch** of the **ascending palatine artery** (from facial artery) supplying the palatine tonsil.

(2) The course of the **internal branch** of the **superior laryngeal nerve**. It is sensory to the laryngeal mucous membrane on the interior of the larynx as far down as the vocal folds.

(3) The **recurrent laryngeal nerve** is the principal motor nerve to the larynx, and it supplies all of the laryngeal muscles *except* the cricothyroid muscle (which is supplied by the external branch of the superior laryngeal nerve). In addition, the recurrent laryngeal nerve supplies sensory innervation to the interior of the larynx below the vocal folds.

(4) The **important relationship** of the recurrent laryngeal nerves to the inferior thyroid artery and its inferior laryngeal branches. Also observe the proximity of the recurrent laryngeal nerves to the posterior aspect of the thyroid glands.

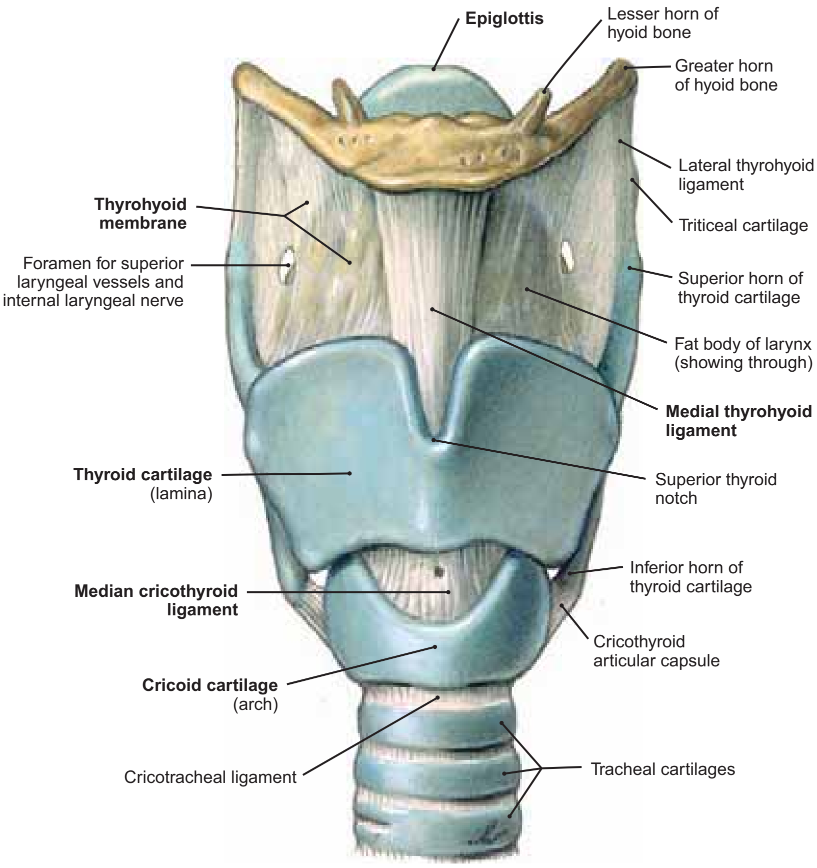


FIGURE 651.1 Cartilages and Ligaments of the Larynx (Ventral View)

NOTE: (1) The laryngeal cartilages form the skeleton of the larynx, and they are interconnected by ligaments and membranes. There are three larger **unpaired** cartilages (**cricoid, thyroid,** and **epiglottis**) and three sets of **paired** cartilages (**arytenoid, corniculate,** and **cuneiform**). In this anterior view, the unpaired cricoid, thyroid, and epiglottis are all visible.

(2) The **thyrohyoid membrane** and the centrally located thyrohyoid ligament. Attached to the upper border of the thyroid cartilage, this membrane stretches across the posterior surfaces of the greater horns of the hyoid bone. The medial thyrohyoid ligament extends from the thyroid notch to the body of the hyoid bone. The membrane is pierced by the **superior laryngeal vessels** and the **internal laryngeal branch of the superior laryngeal nerve**.

(3) The **cricothyroid ligament** attaches the apposing margins of the cricoid and thyroid cartilages. This ligament underlies the cricothyroid muscles.

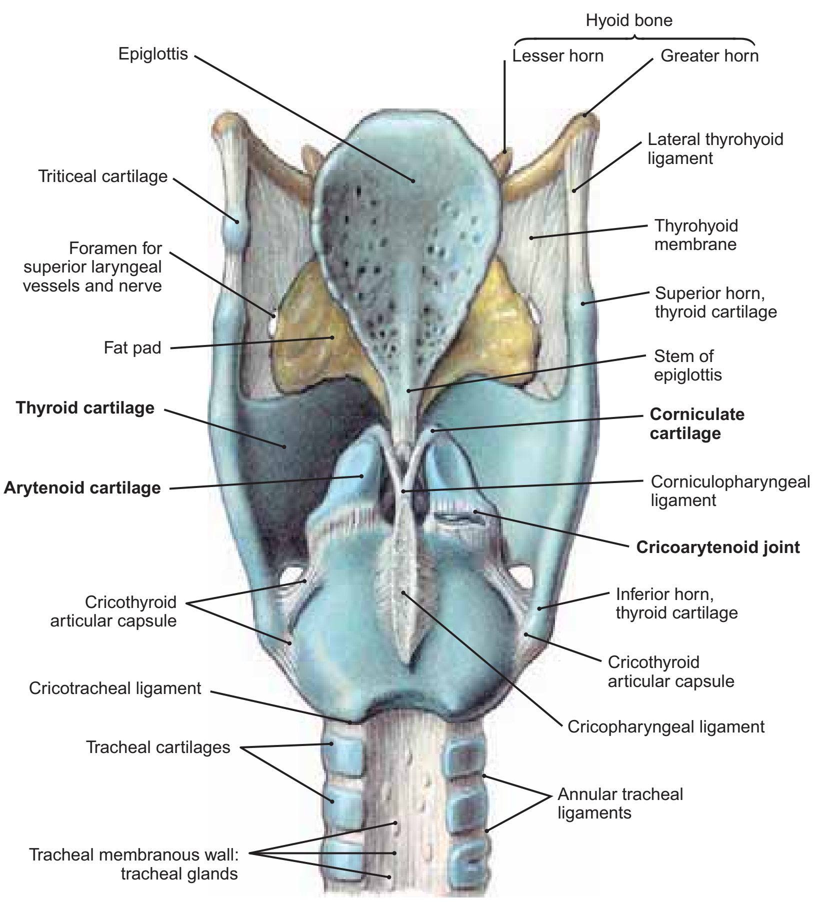


FIGURE 651.2 Cartilages and Ligaments of the Larynx (Dorsal View)

NOTE: (1) The articulation of the paired arytenoid cartilages with the cricoid cartilage below. These synovial cricoarytenoid joints are surrounded by articular capsules and strengthened by the posterior cricoarytenoid ligaments.

(2) The cricoarytenoid joints allow for: (a) **rotation of the arytenoid cartilage** on an axis that is nearly vertical and (b) the **horizontal gliding movement** of the arytenoid cartilages.

(3) Rotation of the arytenoid cartilages results in medial or lateral displacement of the vocal folds, thereby increasing or decreasing the size of the opening between the folds, the **rima glottis**.

(4) Horizontal gliding of the arytenoid cartilages permits the bases of these cartilages to be approximated or moved apart. Medial rotation and medial gliding of the arytenoid cartilages occur simultaneously, as do the two lateral movements.

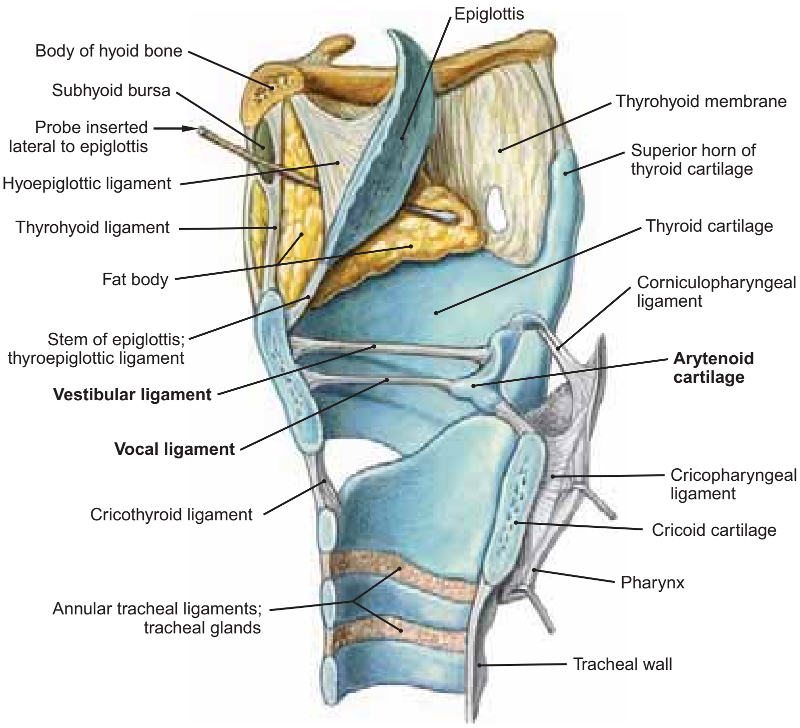


FIGURE 652.1 Right Half of the Larynx Showing the Cartilages and Vestibular and Vocal Ligaments

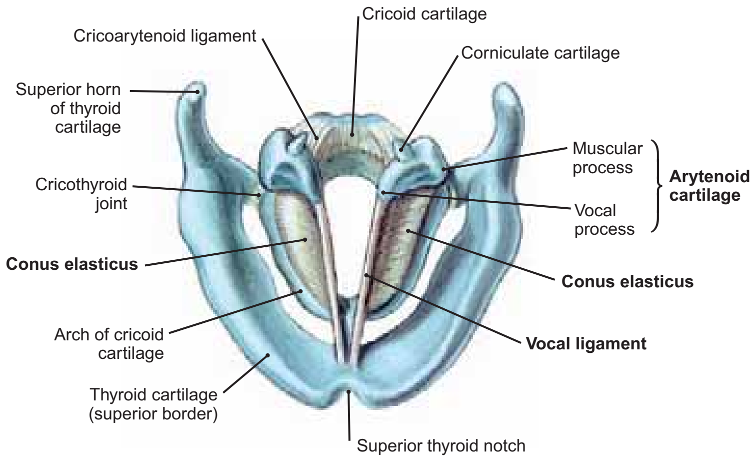
NOTE: (1) The **vestibular ligament** is a compact band of fibrous tissue attached anteriorly to the thyroid cartilage and posteriorly to the anterior and lateral surface of the arytenoid cartilage. It is enclosed by mucous membrane to form the vestibular fold (or false vocal fold).

(2) The **vocal ligament** consists of elastic tissue and is attached anteriorly to the thyroid cartilage and posteriorly to the vocal process of the arytenoid cartilage. It, too, is covered by mucous membrane, which, along with the vocalis muscle forms the vocal fold. Laryngeal sounds are produced by oscillations of the vocal folds initiated by puffs of air.

FIGURE 652.2 Vocal Ligaments and Conus Elasticus (Seen from Above)

NOTE: (1) The **conus elasticus** is a membrane consisting principally of yellow elastic fibers; it interconnects the thyroid, cricoid, and arytenoid cartilages. It underlies the mucous membrane below the vocal folds and is overlaid to some extent by the thyroarytenoid and cricothyroid muscles on the exterior of the larynx.

(2) The symmetry of the arytenoid cartilages and their related vocal ligaments.



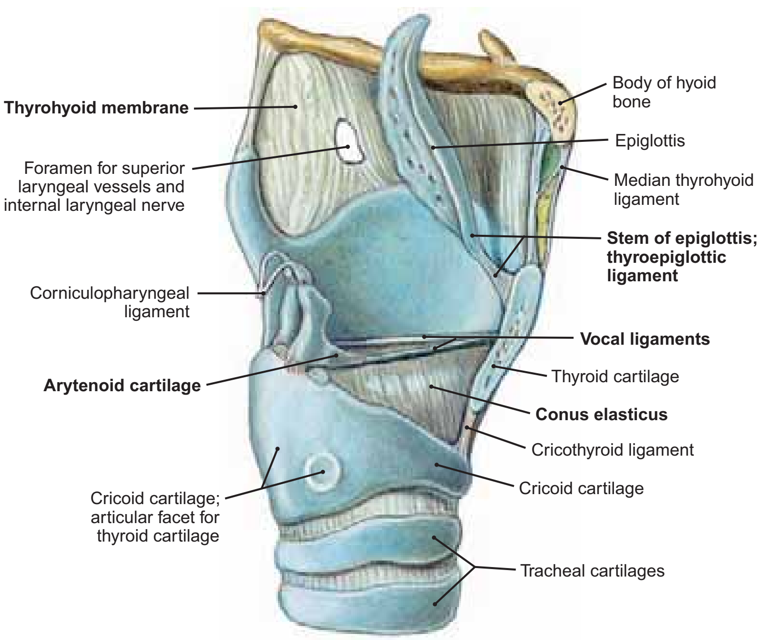


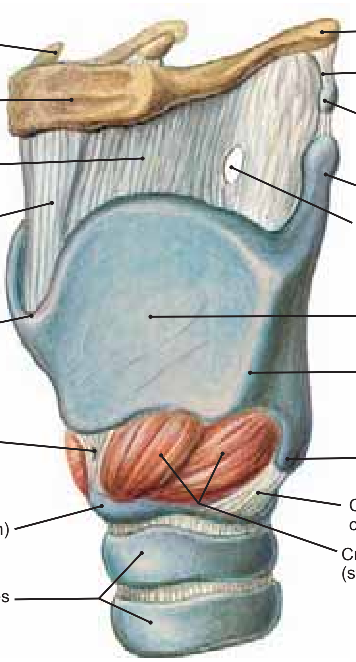
FIGURE 652.3 Upper Left Part of the Larynx

NOTE: (1) The right halves of the hyoid bone, epiglottis, and thyroid cartilage have been removed to open the upper left portion of the larynx. The two vocal ligaments, the arytenoid cartilages, and the conus elasticus are also displayed.

(2) The attachment of the stem of the epiglottis to the thyroid cartilage by means of the thyroepiglottic ligament.

(3) The conus elasticus as it forms the vocal ligament and attaches to the arytenoid, thyroid, and cricoid cartilages.

(4) Although sounds are initiated at the vocal folds, the pitch, range, quality, volume, tone, and overtones of the human voice also incorporate structures in the mouth (tongue, teeth, and palate), nasal sinuses, pharynx, rest of the larynx, lungs, diaphragm, and abdominal muscles.



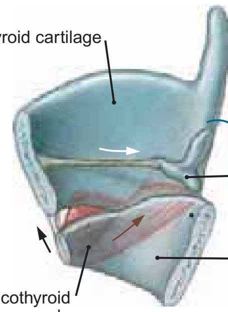
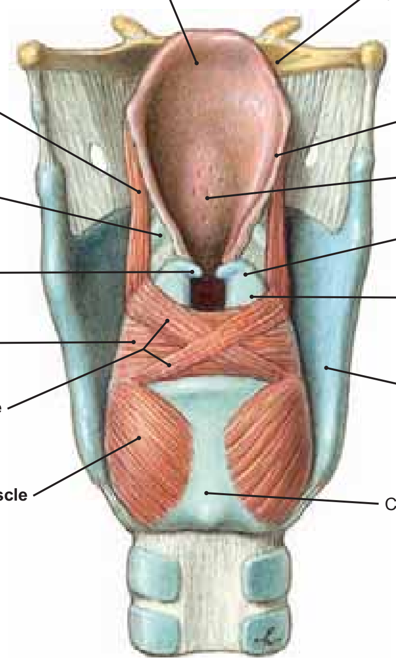


FIGURE 653.2 Action of Cricothyroid Muscle See NOTE 2 below.

FIGURE 653.1 Ventrolateral View of the Exterior Larynx and the Cricothyroid Muscle

NOTE: (1) The **cricothyroid muscle** consists of **straight** and **oblique** heads. The straight head is more vertical and inserts onto the lower border of the lamina of the thyroid cartilage, whereas the oblique head is more horizontal and inserts onto the inferior horn of the thyroid cartilage.

(2) The cricothyroid muscle tilts the anterior part of the cricoid cartilage upward. In so doing, the arytenoid cartilages (which are attached to the cricoid) are pulled dorsally. In addition, the thyroid cartilage is pulled forward and downward. These actions increase the distance between the arytenoid and thyroid cartilages, thereby increasing the tension of and elongating the vocal folds (see insert diagram above).



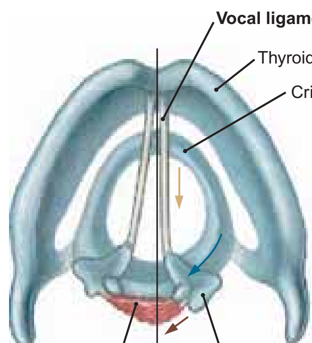


FIGURE 653.4 Action of Arytenoid Muscle See NOTE 2 below.

FIGURE 653.3 Posterior View of the Larynx: Muscles

NOTE: (1) The **arytenoid muscle** consists of a **transverse portion** that spans the zone between the arytenoid cartilages and an **oblique portion** that consists of muscular fascicles that cross posterior to the transverse fibers. Each of the fascicles of the oblique part extends from the base of the one arytenoid cartilage to the apex of the other cartilage. Some oblique fibers continue to the epiglottis as the **aryepiglottic muscle**.

(2) The transverse arytenoid approximates the arytenoid cartilages closing the posterior part of the rima glottis. The oblique arytenoid and the aryepiglottic muscles tend to close the inlet into the larynx by pulling the aryepiglottic folds together and approximating the arytenoid cartilages and epiglottis.

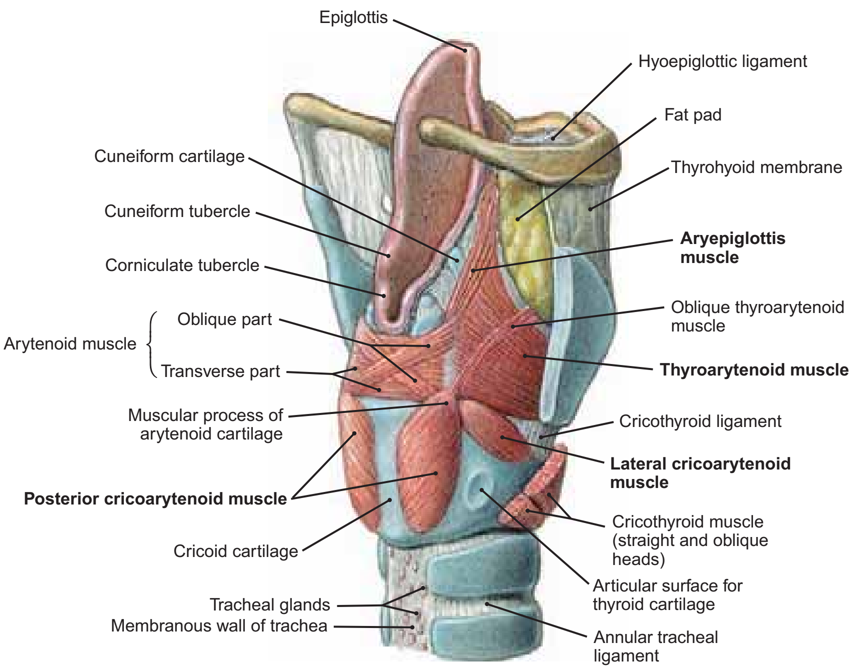


FIGURE 654.1 Posterolateral View of the Laryngeal Muscles

NOTE: (1) The right lamina of the thyroid cartilage and the thyrohyoid membrane have been partially cut away to expose the lateral cricoarytenoid and thyroarytenoid muscles.

(2) The **posterior cricoarytenoid muscle** extends from the lamina of the cricoid cartilage to the muscular process of the arytenoid cartilage, whereas the **lateral cricoarytenoid muscle** arises laterally from the arch of the cricoid cartilage and inserts with the posterior cricoarytenoid muscle onto the arytenoid cartilage.

(3) The posterior cricoarytenoids are the only **abductors** of the vocal folds, whereas the lateral cricoarytenoids act as antagonists and **adduct** the vocal folds. The posterior muscle abducts by pulling the base of the arytenoid cartilages medially and posteriorly, whereas the lateral muscle adducts by pulling these same cartilages anteriorly and laterally.

(4) The **thyroarytenoid muscle** is a thin sheet of muscle radiating from the thyroid cartilage backward toward the arytenoid cartilage. Its upper fibers continue to the epiglottis and, joining the aryepiglottic fibers, become the **thyroepiglottic muscle.** Its deepest and most medial fibers form the **vocalis muscle** which is attached to the lateral aspect of the vocal fold. The thyroarytenoid muscles draw the arytenoid cartilages toward the thyroid cartilage and, thus shorten (relax) the vocal folds.

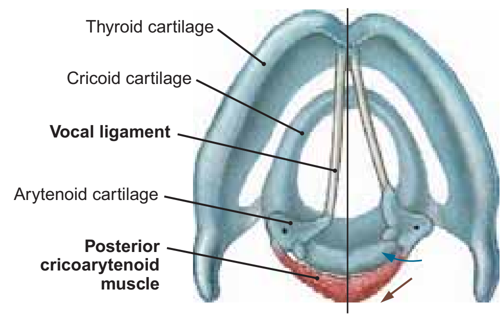


FIGURE 654.2 Action of Posterior Cricoarytenoid See NOTE 3 below.

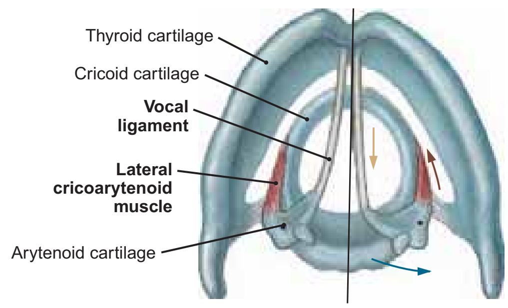


FIGURE 654.3 Action of Lateral Cricoarytenoid See NOTE 3 below.

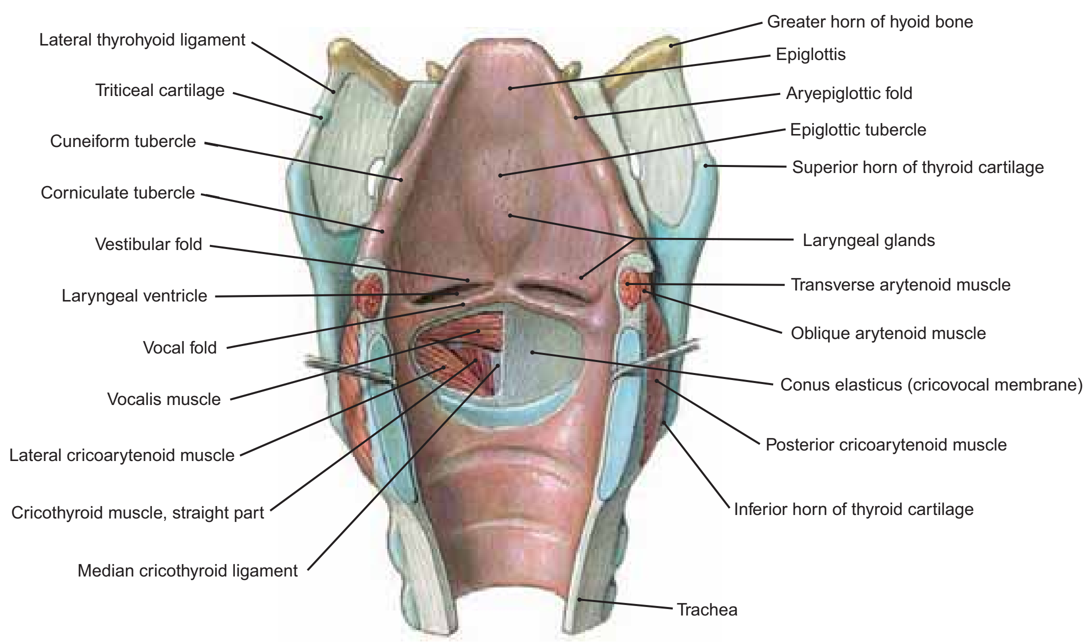


FIGURE 654.4 Larynx Opened from Behind (Posterior View)

NOTE: The lateral walls of the larynx have been opened widely, and the left part of the conus elasticus has been removed.

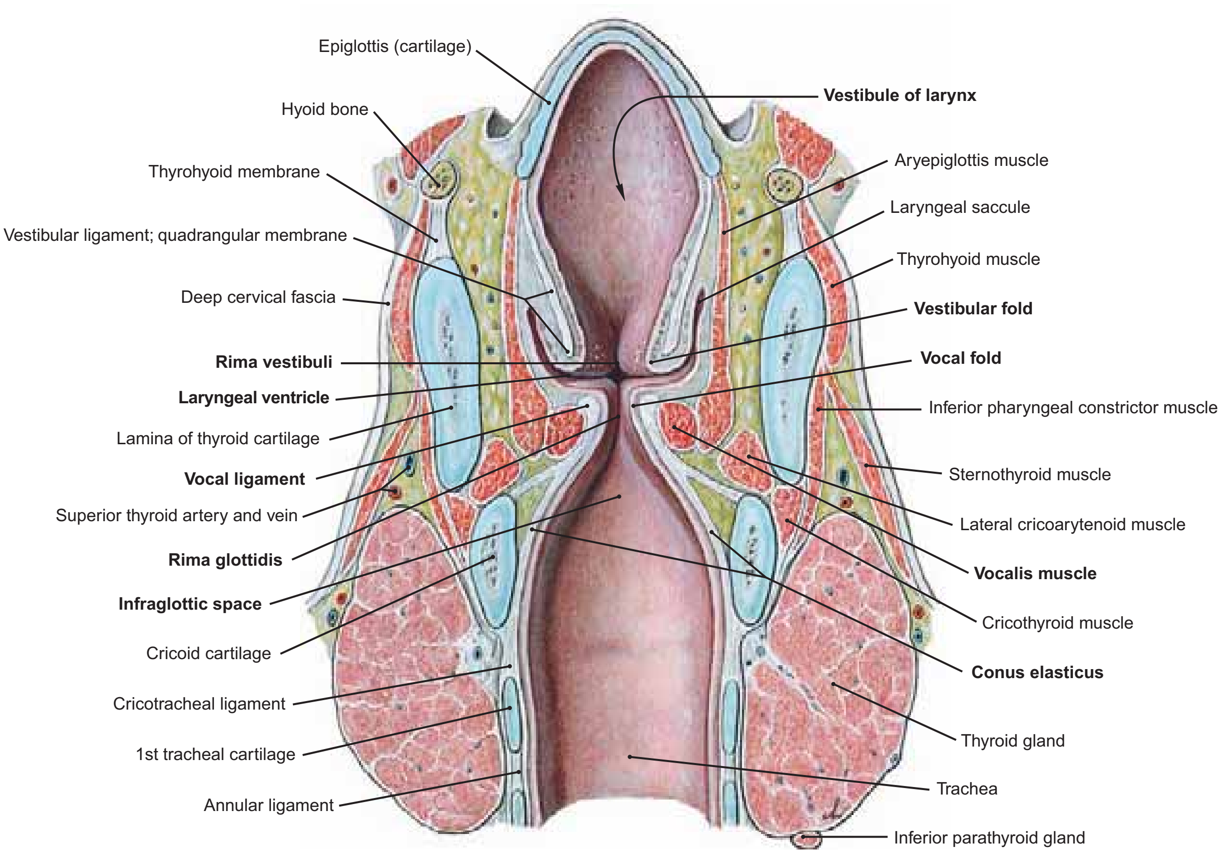


FIGURE 655.1 Frontal Section through the Larynx Showing the Laryngeal Folds and Cavities in Its Anterior Half

NOTE: (1) The paired **vocal folds** consist of mucous membrane overlying the **vocal ligaments** and **vocalis muscles**. Just superior to the vocal folds observe the **vestibular folds**, which are separated from the vocal folds by a recess called the **laryngeal ventricle** (or sinus).

(2) Above the vestibular folds is the **vestibule** of the larynx, which lies just below the laryngeal inlet. Below the vocal folds is the **infraglottic space,** which communicates with the trachea below and is limited above by the **rima glottis** between the two vocal folds.

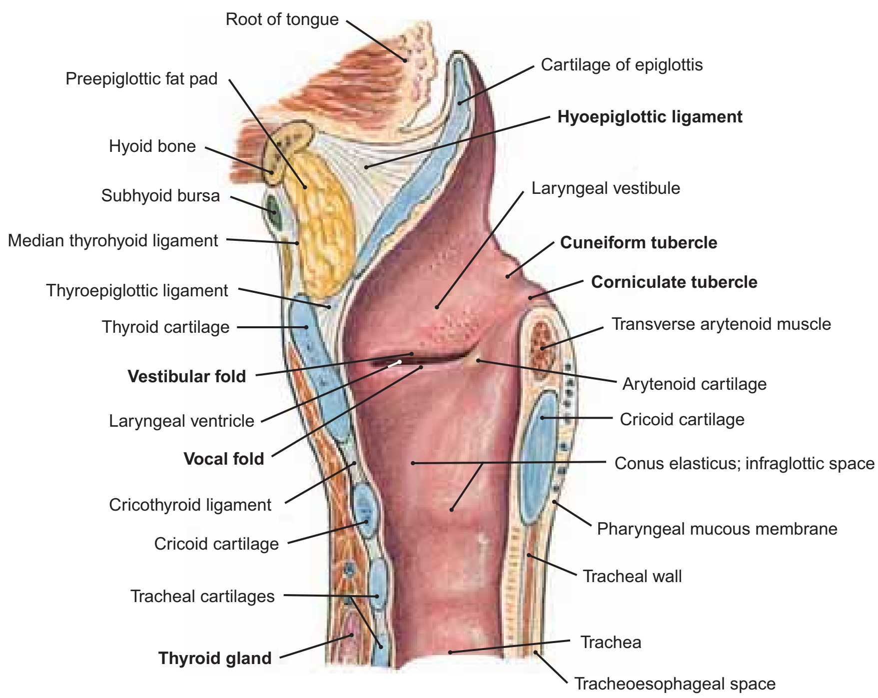


FIGURE 655.2 Midsagittal Section of Larynx

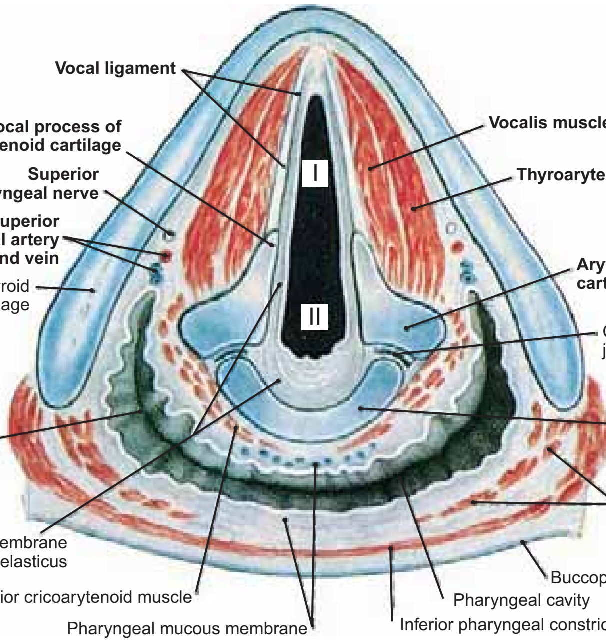
NOTE: (1) The laryngeal inlet leads to the laryngeal vestibule, the anterior border of which is the epiglottis. The **aryepiglottic folds**, marked by oval elevations (cuneiform and corniculate cartilages), define the borders of the laryngeal inlet.

(2) The epiglottis attaches **superiorly** to the hyoid bone (by the hyoepiglottic ligament); **inferiorly** to the thyroid cartilage (by the thyroepiglottic ligament); and **laterally** to the arytenoid cartilages (by the aryepiglottic folds).

FIGURE 656.1 Cross Section of Larynx at the Vocal Folds

NOTE: (1) The orientation of the arytenoid cartilages and their articulations with the cricoid cartilage.
(2) The vocal folds consist of mucous membrane over the vocal ligaments, lateral to which extend the deeper part of the thyroarytenoid muscle.
(3) By drawing the arytenoid cartilages forward, the thyroarytenoids shorten and relax the vocal folds. At the same time, they medially rotate the arytenoid cartilages and, thus, approximate the vocal folds.
(4) The intercartilaginous part of the rima glottidis is bounded by the arytenoid and cricoid cartilages, whereas the intermembranous part is bounded by the vocal fold mucous membrane.

I = intermembranous part of the rima glottidis
II = intercartilaginous part of the rima glottidis



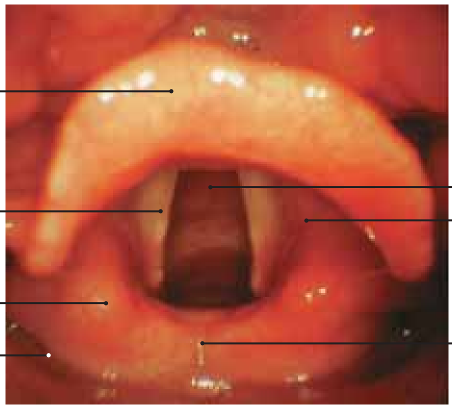


FIGURE 656.2 Rima Glottidis in Forced or Deep Inspiration (Direct Laryngoscopy)

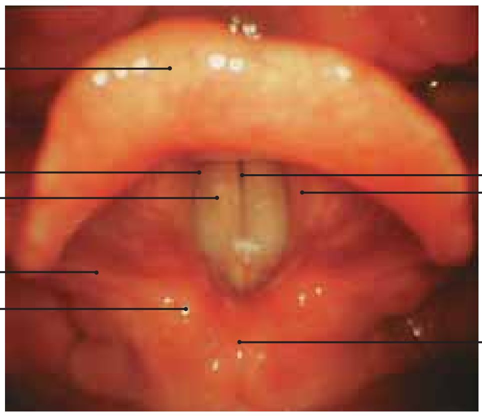


FIGURE 656.3 Rima Glottidis during Shrill Tone Phonation (Direct Laryngoscopy)

FIGURE 656.5 Indirect Laryngoscopy

NOTE: Protraction of the tongue creates space for a laryngoscopic mirror so that the vocal folds can be visualized indirectly by their reflection in the mirror.

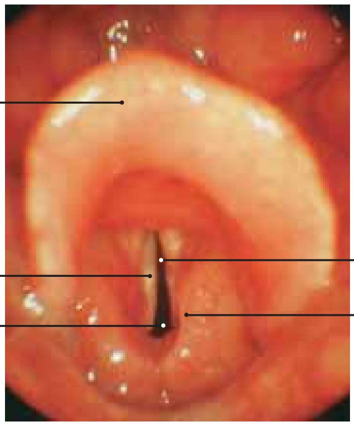


FIGURE 656.4 Rima Glottidis during Whispering: Intercartilaginous Part Open (Direct Laryngoscopy)

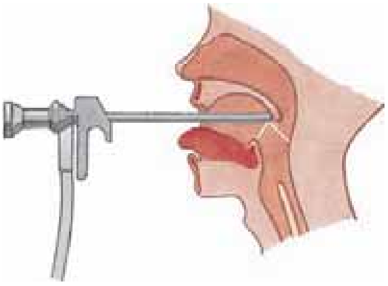


FIGURE 656.6 Direct Laryngoscopy

NOTE: The use of an endoscope allows visualization of the vocal folds directly.

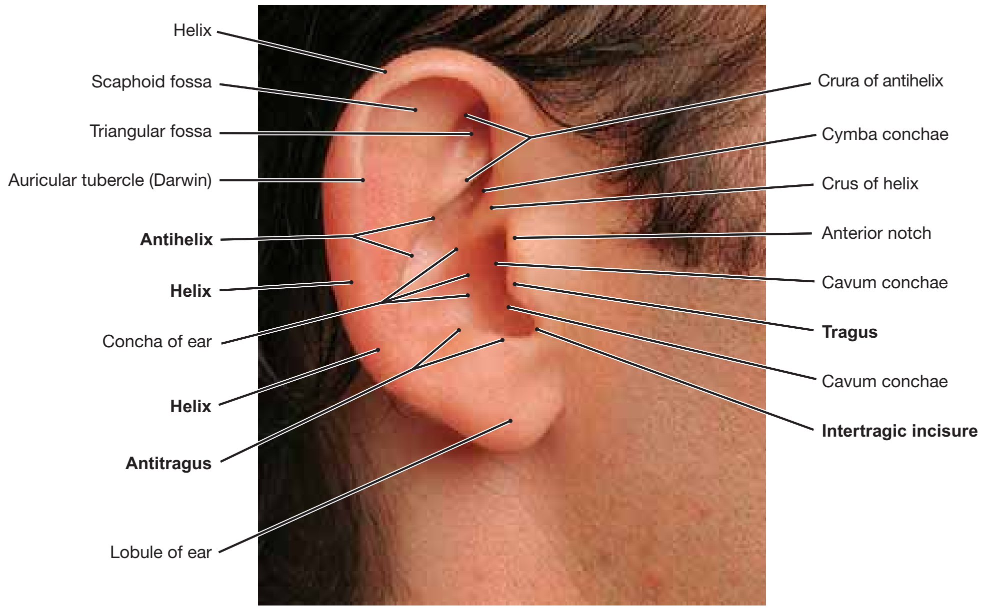


FIGURE 657.1 Right External Ear (Lateral View)

NOTE: (1) The external ear (or auricle) consists of skin overlying an irregularly shaped elastic fibrocartilage. The ear lobe, or lobule, does not contain cartilage but is soft and contains connective tissue and fat.

(2) The **external acoustic meatus** courses through the auricle to the tympanic membrane. It is an oval canal that extends for about 2.5 cm in an S-shaped curve to the tympanic membrane. It consists of an outer cartilaginous part (1 cm) and a narrower more medial part that is osseous (1.5 cm).

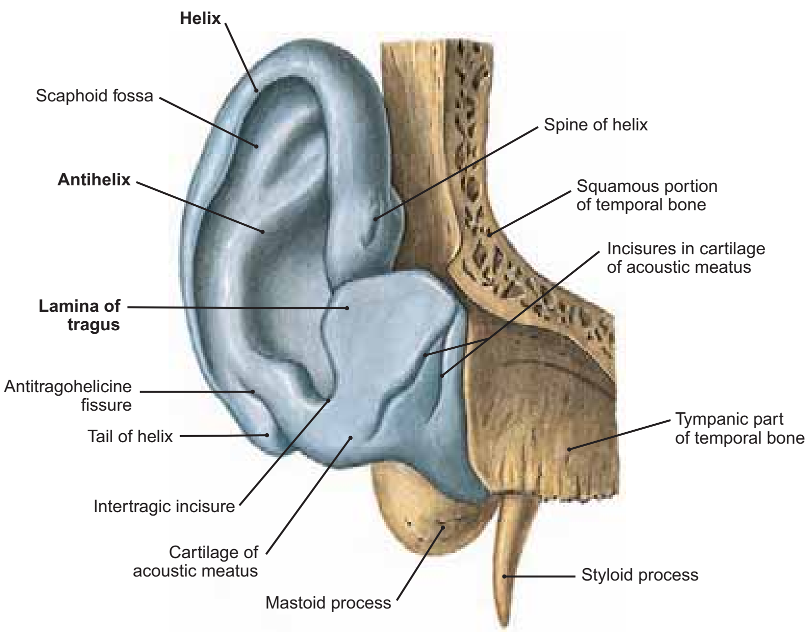


FIGURE 657.2 Cartilage of the Right External Ear ▲ (Seen from Front)

NOTE: (1) With the skin of the external ear removed, the contours of the single cartilage conform generally with those of the intact auricle. The cartilage is seen to be absent inferiorly at the site of the ear lobe.

(2) The external rim of the auricle is called the **helix.** Another curved prominence anterior to the helix is the **antihelix.** A notch inferiorly (intertragic incisure) separates the **tragus** anteriorly from the **antitragus** posteriorly.

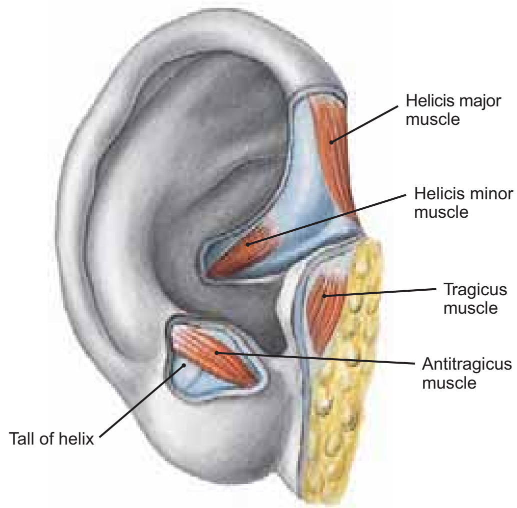


FIGURE 657.3 Intrinsic Muscles of External Ear (Lateral Surface)

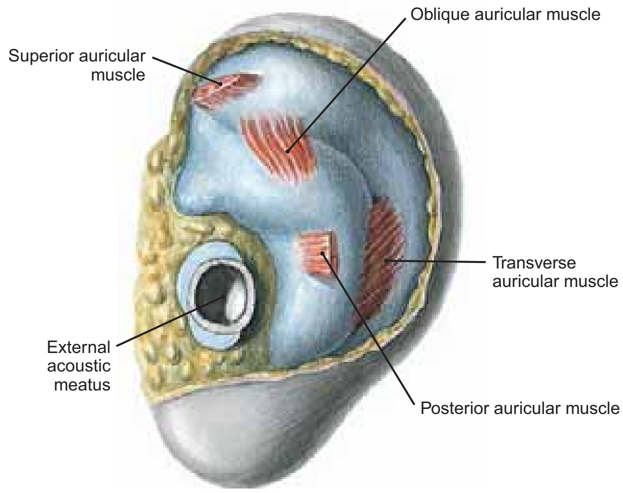


FIGURE 657.4 Muscles Attaching to the Medial Surface of External Ear

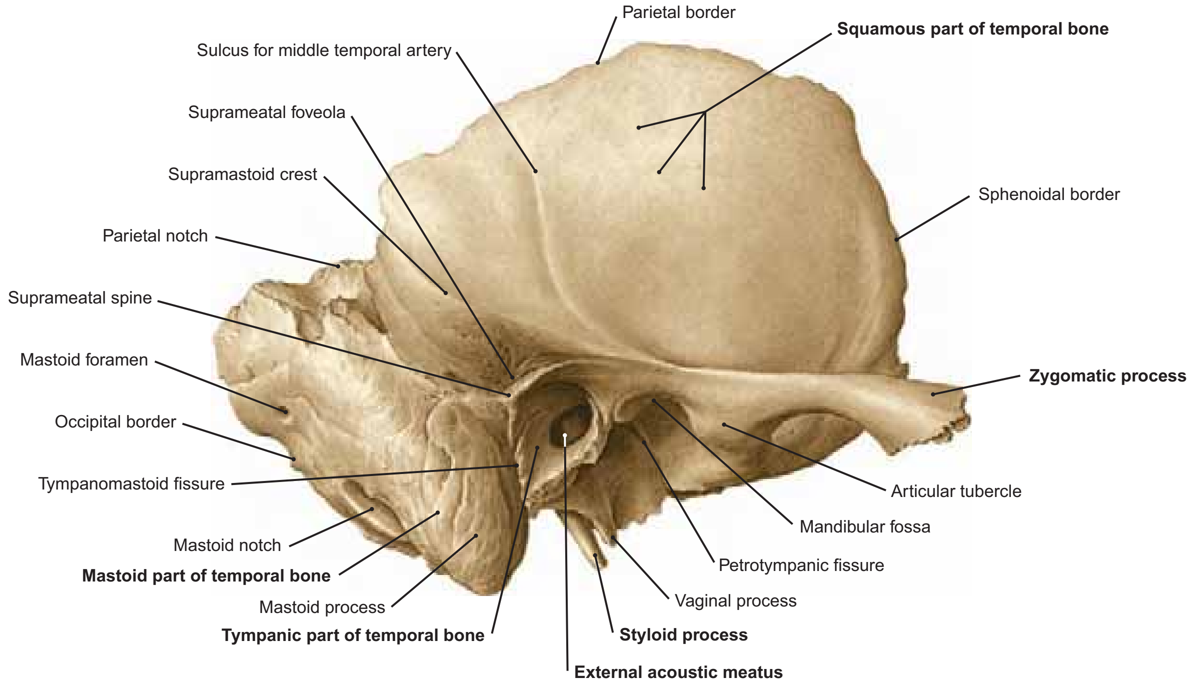


FIGURE 658.1 **Right Temporal Bone (Lateral View)**

NOTE: (1) The temporal bone forms the osseous encasement for the middle and internal ear and consists of three parts: **squamous, tympanic,** and **petrous.**

(2) The **squamous part** is broad in shape, and it is thin and flat. From it extends the zygomatic process. The **tympanic part** is interposed below the squamous and anterior to the petrous parts. The external acoustic meatus, which leads to the tympanic membrane, is surrounded by the tympanic part of the temporal bone.

(3) The hard **petrous part** contains the organ of hearing and the vestibular canals. Its mastoid process is not solid but contains many air cells, and its external surface affords attachment to several muscles.

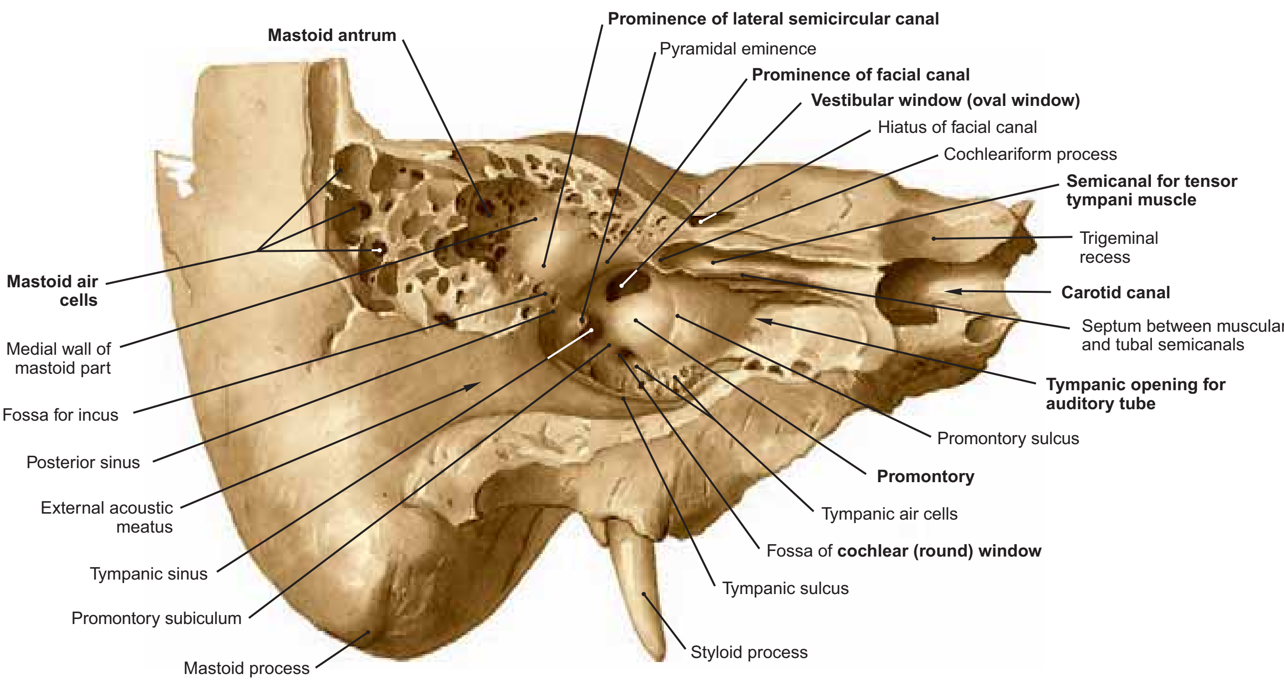


FIGURE 658.2 **Lateral Dissection of the Right Temporal Bone Showing the Tympanic Cavity**

NOTE: (1) The tympanic cavity (middle ear) communicates posteriorly with the mastoid antrum and, in turn, with the mastoid air cells. It also is in communication with the nasopharynx by way of the auditory tube.

(2) The **lateral wall** of the tympanic cavity is formed by the tympanic membrane (not shown), while the **medial wall** (or labyrinthine wall) presents the following important structures: the **promontory** (projection of the first turn of the cochlea); the **vestibular window** (oval window); the **cochlear window** (round window); the bony prominence of the **facial canal;** and posteriorly, the prominence of the **lateral semicircular canal** and the **pyramidal eminence**.

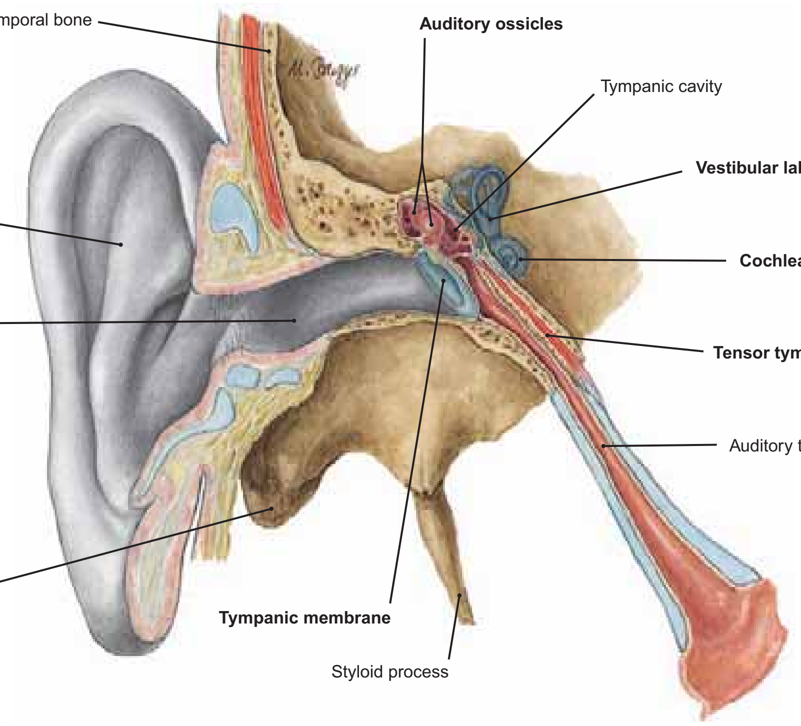


FIGURE 659.1 Frontal Section through the Right External, Middle, and Internal Ear

NOTE: (1) The external acoustic meatus commences at the auricle and leads to the external surface of the tympanic membrane. Through the meatus course the sound waves that cause vibration of the tympanum.

(2) The **middle ear** (or tympanic cavity) contains three ossicles (malleus, incus, and stapes) and two muscles (tensor tympani and stapedius; the latter is not shown).

(3) The cavity of the middle ear communicates with the **mastoid antrum** and **mastoid air cells** posteriorly, and the nasopharynx by way of the **auditory tube**. This tube courses downward, forward, and medially from the middle ear.

(4) The ossicles interconnect the tympanic membrane with the inner ear. The inner ear contains the coiled **cochlea** (or organ of hearing) and the three **semicircular canals** (the vestibular organ) and their associated vessels and nerves.

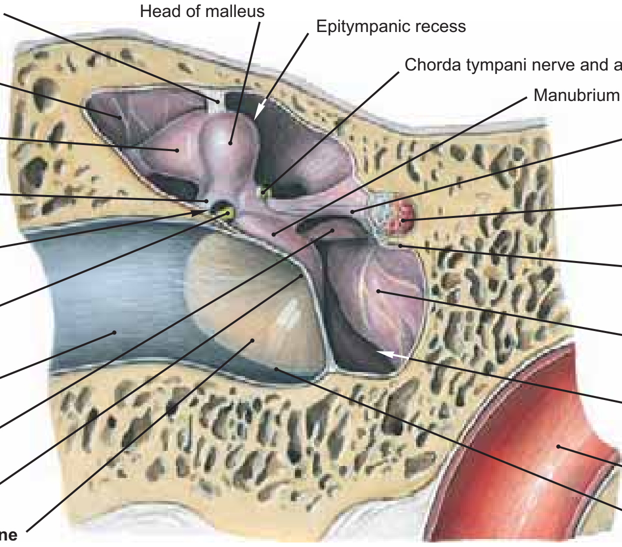


FIGURE 659.2 Frontal Section through the Right External and Middle Ear

NOTE: (1) The slender tendon of the *tensor tympani muscle* turns sharply upon reaching the tympanic cavity to terminate on the manubrium of the malleus.

(2) The tympanic cavity is extended superiorly by the epitympanic recess located above the level of the tympanic membrane. On the medial wall of the middle ear observe the promontory that protrudes into the tympanic cavity. This bony prominence is formed by the spiral cochlea of the internal ear.

(3) The lateral and superior ligaments attaching to the head of the malleus. The anterior ligament of the malleus, which interconnects the neck of the malleus to the anterior wall of the tympanic cavity, is not shown.

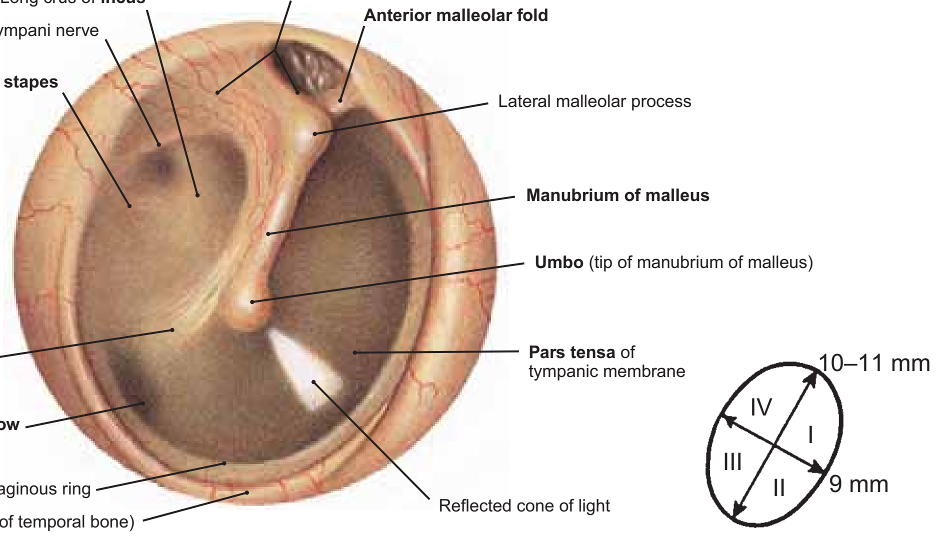


FIGURE 660.1 **Right Tympanic Membrane as Seen with an Otoscope in a Living Person**

NOTE: (1) The tympanic membrane is oval and measures about 9 mm across and from 10 to 11 mm vertically; it often is described as consisting of four quadrants (see lower inset diagram).

(2) The **anterior** and **posterior malleolar folds**. The more lax part (pars flaccida) of the tympanic membrane lies above and between these folds, whereas the rest is more tightly stretched (pars tensa).

(3) The blood supply of the membrane is derived from the **deep auricular** and **anterior tympanic branches** of the maxillary artery and the **stylomastoid branch** of the posterior auricular artery.

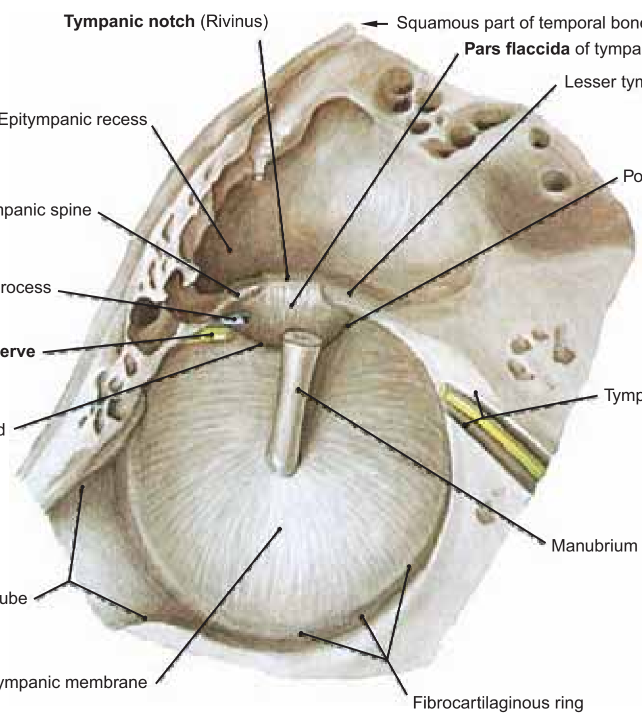


FIGURE 660.2 **Lateral Wall of the Right Middle Ear (Tympanic Membrane Viewed from within the Tympanic Cavity)**

NOTE: (1) The **manubrium** of the **malleus** has been severed from the remainder of the ossicle and left attached to the tympanic membrane. The fibrocartilaginous tympanic ring is deficient superiorly, forming the **tympanic notch** (of Rivinus). The looser portion of the tympanic membrane (**pars flaccida**) covers this zone.

(2) The tympanic membrane below the malleolar folds is the **pars tensa**. This portion is made taut by the **tensor tympani muscle**, which attaches to the manubrium of the malleus.

(3) The external surface of the tympanic membrane is innervated by the **auriculotemporal branch** of the mandibular nerve (V) and the **auricular branch** of the vagus nerve (X). The internal surface of the membrane is supplied by the **tympanic branch** of the glossopharyngeal nerve (ix).

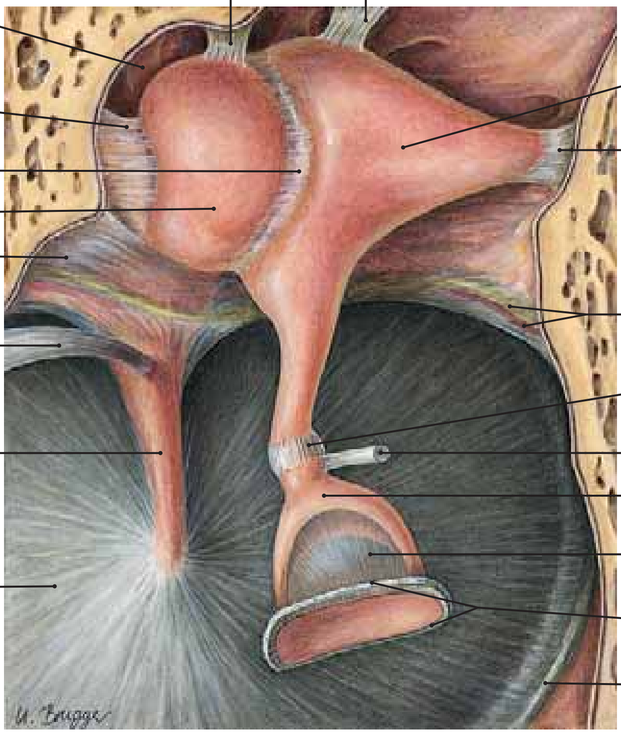


FIGURE 661.1 Middle Ear Ossicles and Attachment of Muscle Tendons (Right Side)

NOTE: (1) The tendon of the **tensor tympani muscle** inserts on the manubrium of the malleus and the short tendon of the **stapedius muscle** inserts onto the neck of the stapes close to its articulation with the incus.

(2) The tensor tympani draws the manubrium medially, thereby making the tympanic membrane taut. At the same time its action pushes the base of the stapes more securely into the vestibular window. The tensor is innervated by the mandibular division of the **trigeminal nerve**.

(3) The stapedius opposes the action of the tensor at the vestibular window, tilting the head of the stapes away from the window. Its denervation results in hyperacusis, a condition in which sounds are perceived as unduly loud. The stapedius is supplied by the **facial nerve.**

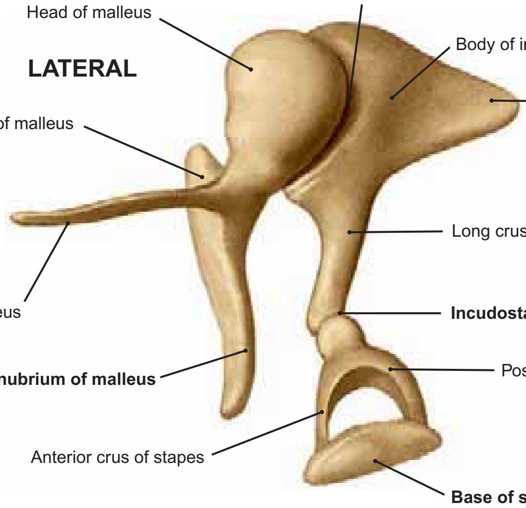


FIGURE 661.2 Right Auditory Ossicles

NOTE: (1) When sound waves are received at the tympanic membrane, they cause a **medial** displacement of the manubrium of the malleus. The head of the malleus is then tilted **laterally**, pulling with it the body of the incus. At the same time the long process of the incus is displaced **medially**, as is the articulation between the incus and the stapes.

(2) The base of the stapes rocks as if it were on a fulcrum at the vestibular window, thereby establishing waves in the perilymph. These waves stimulate the auditory receptors and become dissipated at the secondary tympanic membrane covering the cochlear window.

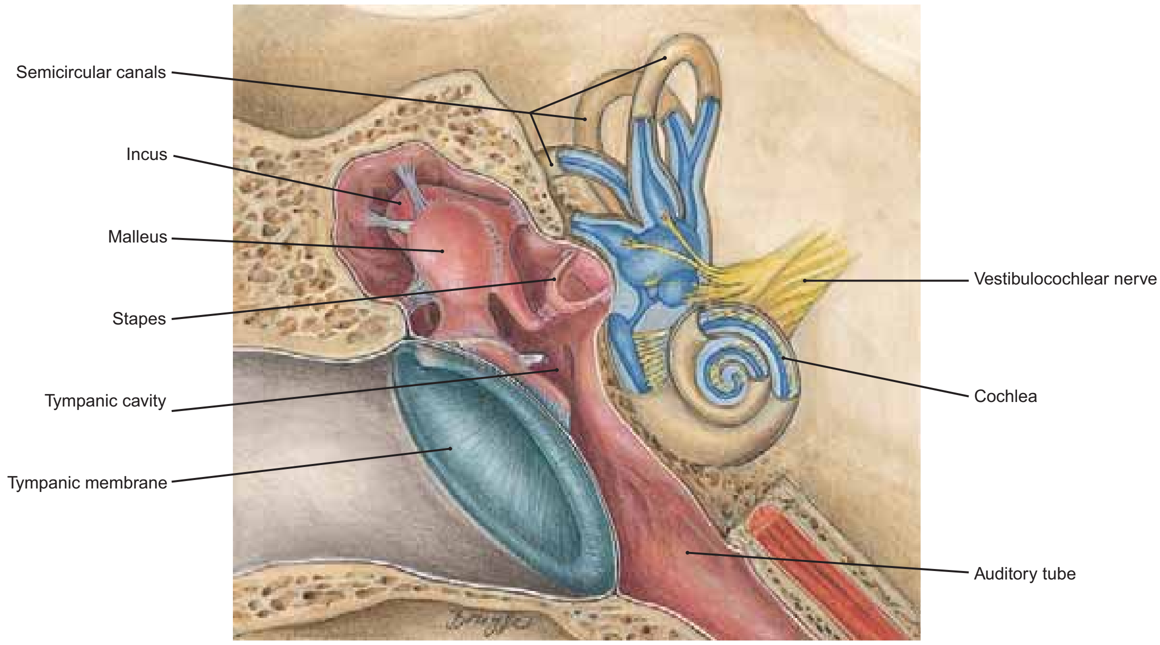


FIGURE 662.1 Structures in the Middle and Internal Ear

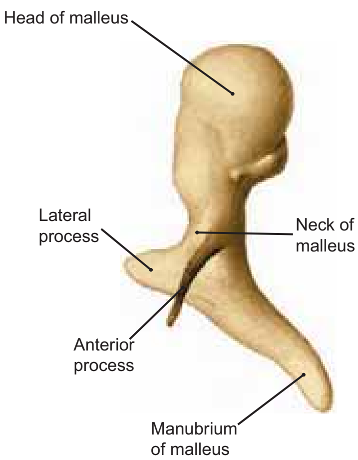


FIGURE 662.2 Malleus: Anterior View

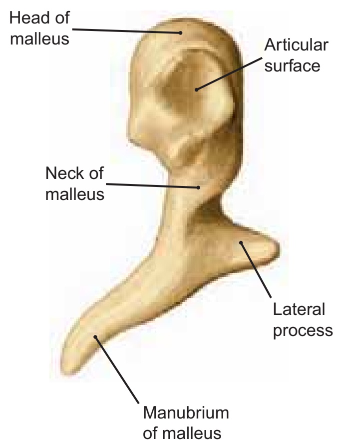


FIGURE 662.3 Malleus: Posterior View

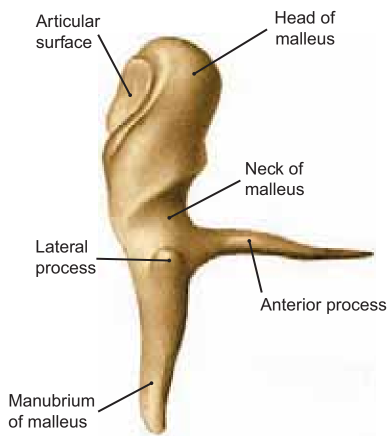


FIGURE 662.4 Malleus: Lateral View

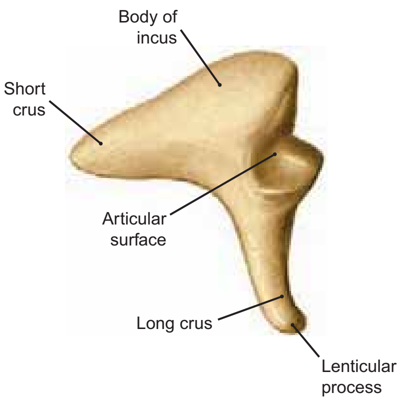


FIGURE 662.5 Incus: Lateral View

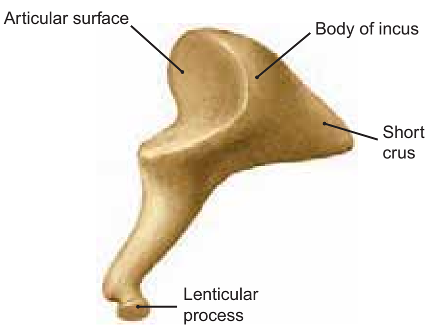


FIGURE 662.6 Incus: Medial View

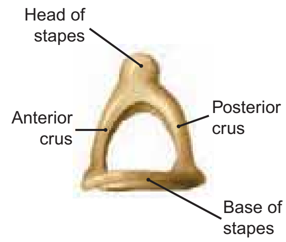


FIGURE 662.7 Stapes: Superior View

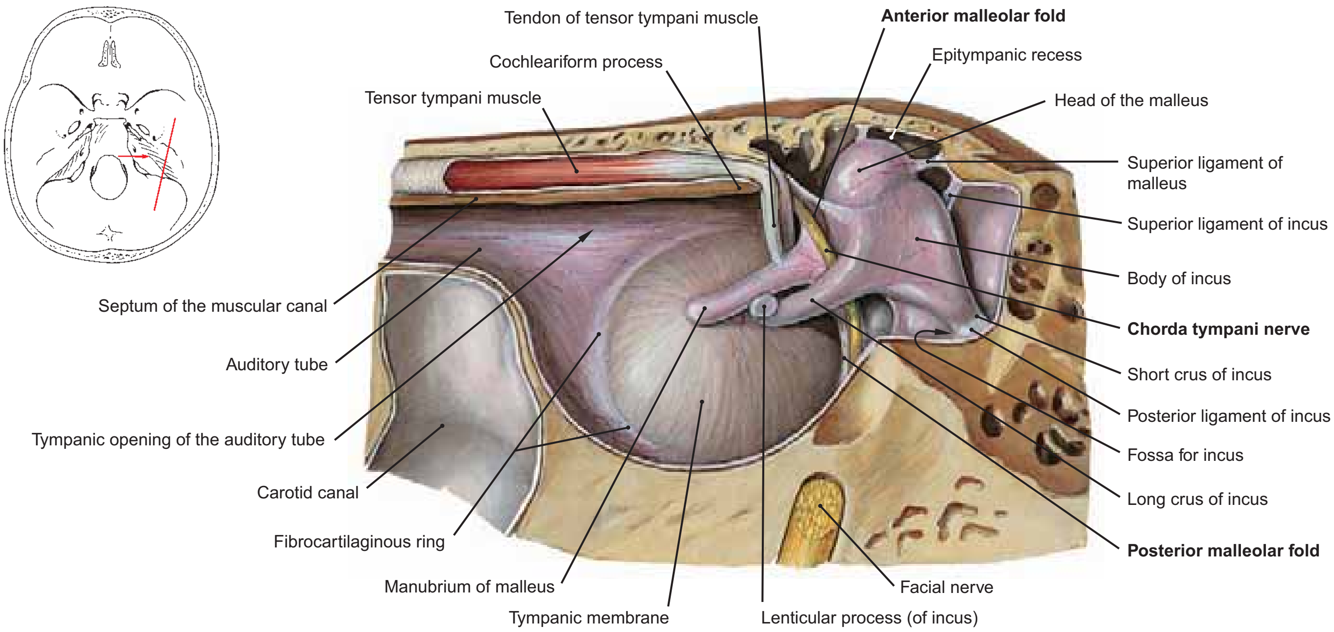


FIGURE 663.1 Lateral Wall of the Right Tympanic Cavity (Viewed from the Medial Aspect)

NOTE: (1) The tympanic cavity is completely lined with a mucous membrane that attaches onto the surface of all the structures of the middle ear. This tympanic mucosa is continuous with that lining the mastoid air cells posteriorly and the auditory tube anteriorly.

(2) Reflections of the tympanic mucous membrane form the **anterior** and **posterior malleolar folds.** These are also reflected around the **chorda tympani nerve** as it curves along the medial side of the manubrium of the malleus.

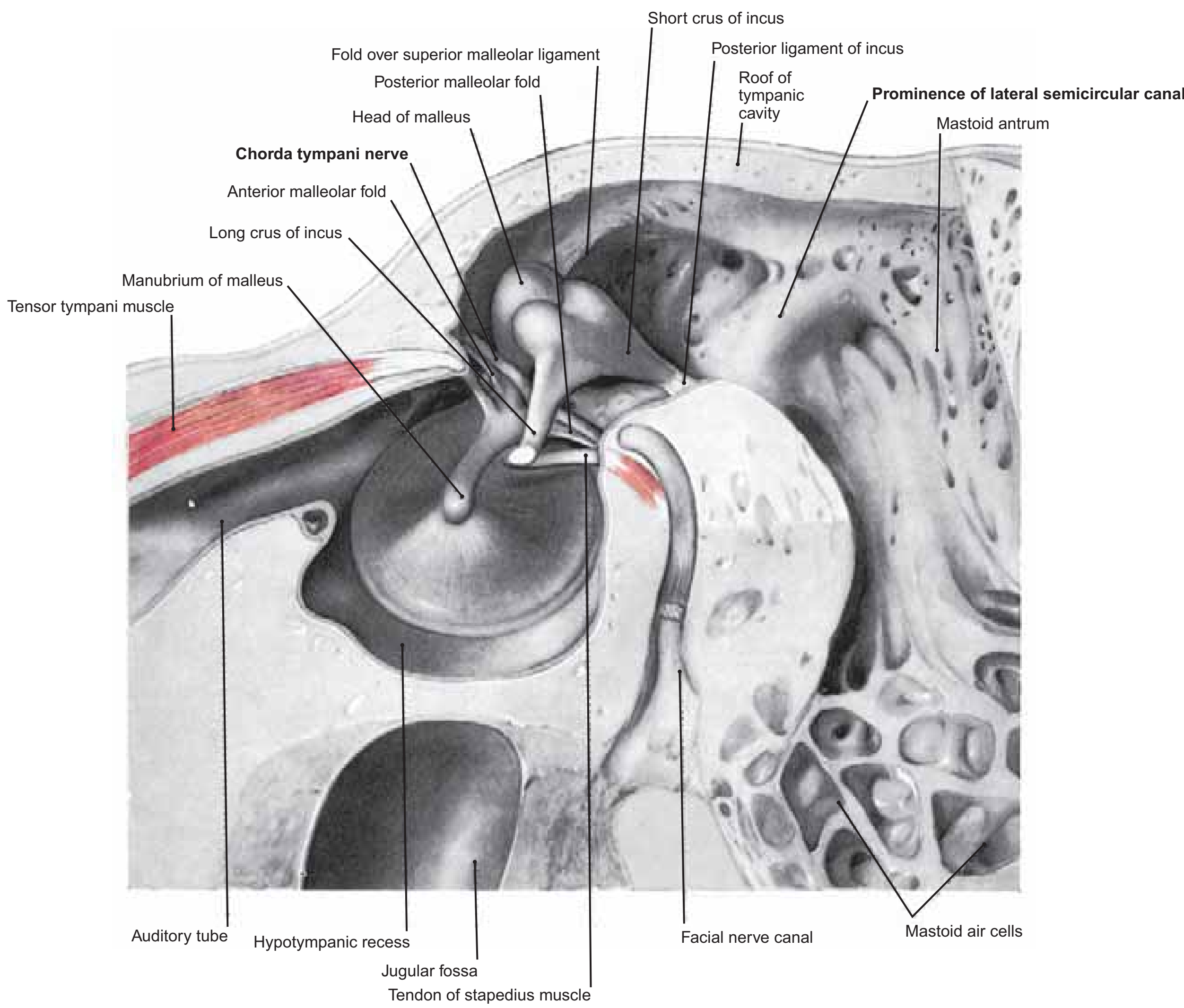


FIGURE 663.2 Tensor Tympani and Stapedius Muscles and Chorda Tympani Nerve (Right Side)

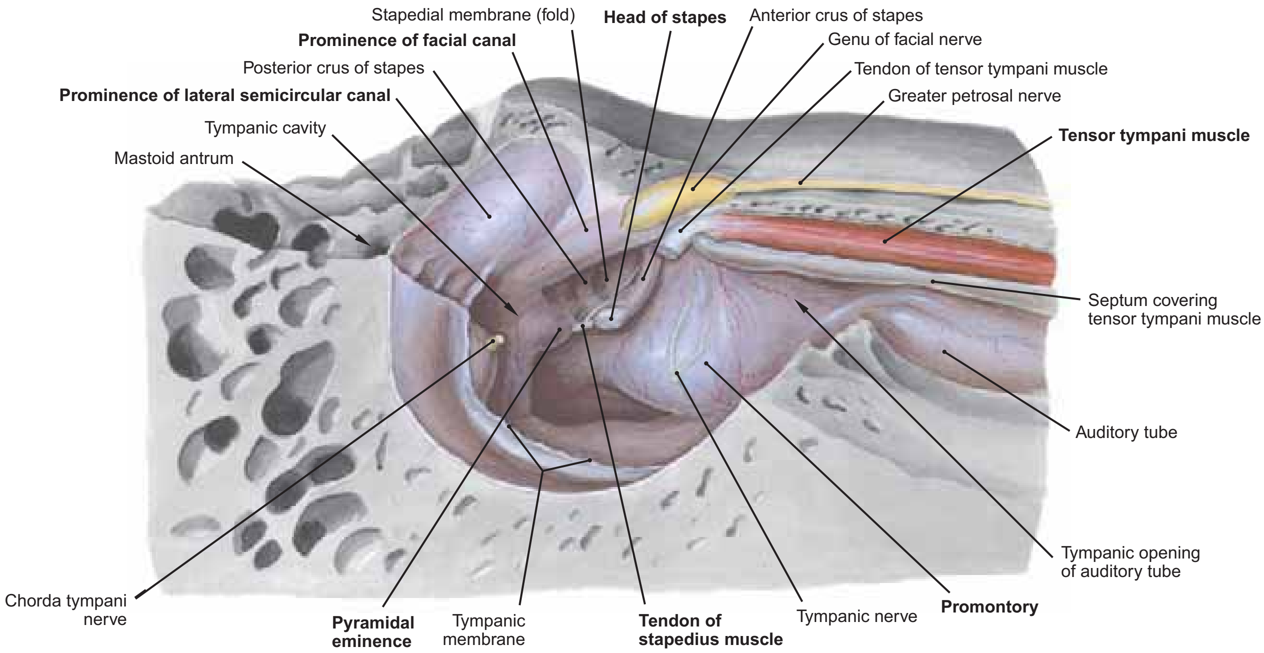


FIGURE 664.1 Medial Wall of the Right Tympanic Cavity (Viewed from Lateral Aspect)

NOTE: (1) The tympanic membrane has been removed, along with the bony roof of the tympanic cavity. The malleus and incus have also been removed and the tendon of the tensor tympani severed. Observe the **stapes** with its base directed toward the vestibular window and the **stapedius muscle** still attached to its neck.

(2) Several bony markings: (a) the prominence containing the **lateral semicircular canal,** (b) the curved prominence of the **facial canal** with its facial nerve, (c) the **promontory,** which is a rounded thin bony covering over the **cochlea,** and (d) the hollow **pyramidal eminence,** from which arises the **stapedius muscle.**

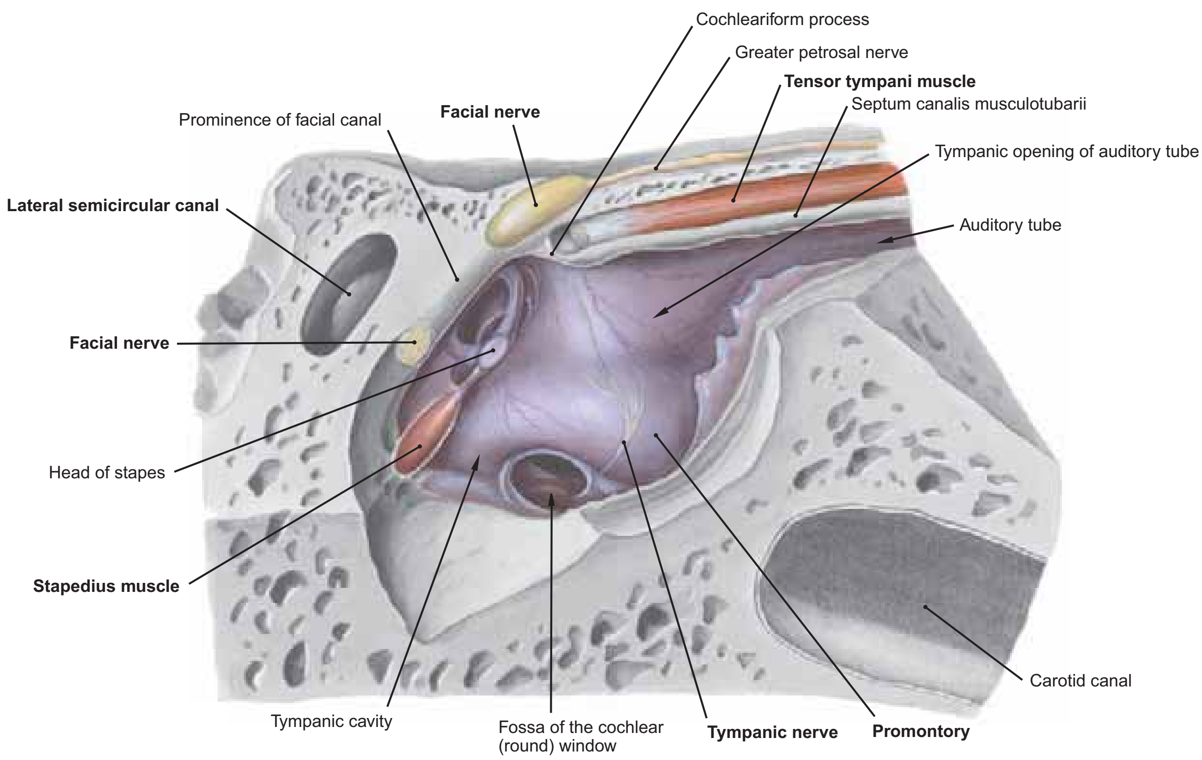


FIGURE 664.2 Medial Wall of the Right Tympanic Cavity Showing the Stapedius Muscle

NOTE: (1) The stapedius muscle emerges through the apex of the pyramidal eminence and it is about 4 mm in length. It pulls the base of the stapes laterally and protects the inner ear from damage caused by loud sounds.

(2) The **tympanic** branch of the **glossopharyngeal nerve** (IX) coursing along the promontory. This nerve is sensory to the mucous membrane of the middle ear and is also known as the nerve of Jacobson. Its fibers are joined by sympathetic fibers to form the **tympanic plexus**.

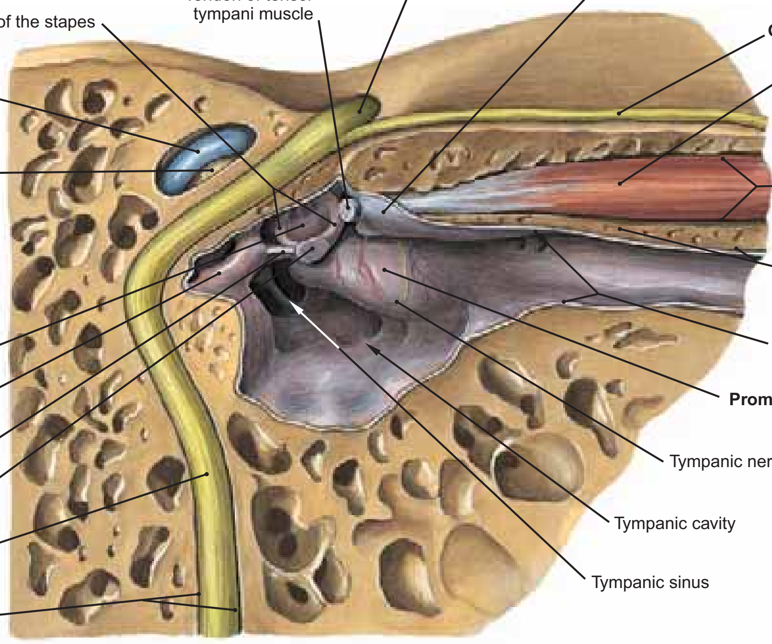


FIGURE 665.1 Medial Wall of Right Tympanic Cavity (Lateral View)

NOTE: (1) The bone forming the prominences of the **lateral semicircular canal** and the **facial canal** has been removed to reveal their internal structures.

(2) The **greater petrosal nerve** carries preganglionic parasympathetic fibers from the facial nerve to the pterygopalatine ganglion as well as many taste fibers from the soft palate.

(3) Coursing along the surface of the promontory can be seen the **tympanic branch** of the **glossopharyngeal nerve** and the tympanic vessels along with sympathetic fibers from the carotid plexus (caroticotympanic nerves).

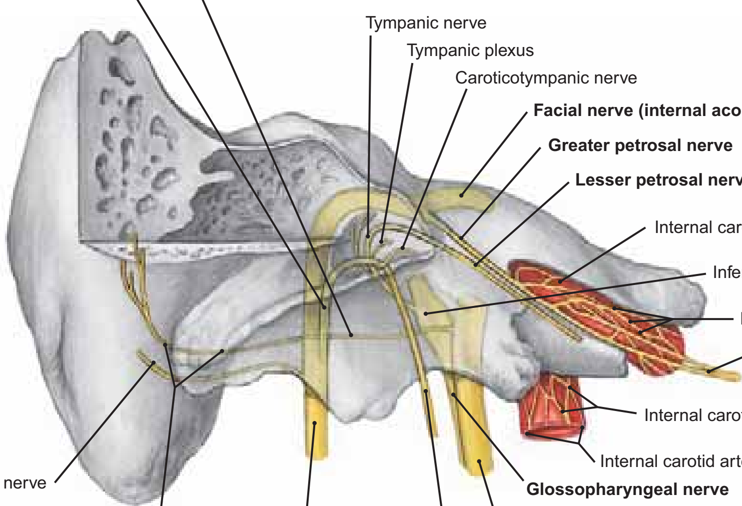


FIGURE 665.2 Facial, Glossopharyngeal, and Vagus Nerves Projected on Temporal Bone

NOTE: (1) From the tympanic plexus (see NOTE 3, Fig. 665.1) emerges the **lesser petrosal nerve**, which courses to the **otic ganglion**.

(2) The **greater petrosal nerve** joins with sympathetic branches of the internal carotid plexus (actually the **deep petrosal nerve**) to form the nerve of the **pterygoid canal**.

(3) The **auricular branch** of the **vagus nerve** is distributed to the upper surface of the external auricle, to the posterior wall and floor of the external acoustic meatus, and to part of the lateral (outer) surface of the tympanic membrane.

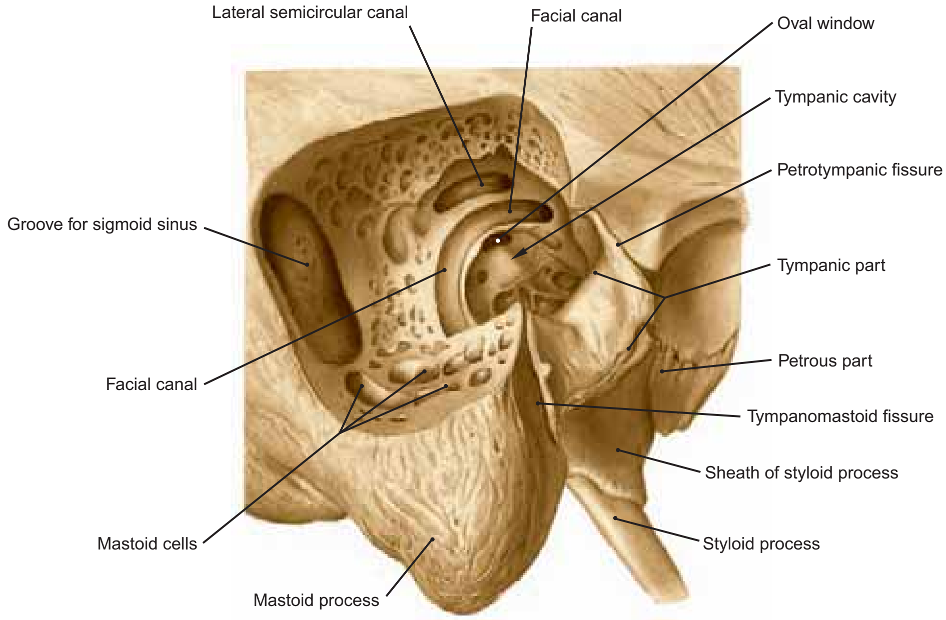


FIGURE 666.1 **Dissected Right Temporal Bone**

NOTE: (1) Through the facial canal courses the **facial nerve**. The canal commences at the internal auditory meatus and continues through the petrous part of the temporal bone to its exit at the stylomastoid foramen (see Fig. 665.1).

(2) In its descent, the facial canal courses posterior to the cavity of the middle ear (tympanic cavity), where the facial nerve gives off the nerve to the stapedius muscle and the chorda tympani branch.

(3) The location of the lateral semicircular canal superiorly and the groove for the sigmoid sinus posteriorly.

(4) Within the tympanic cavity is located the oval window adjacent to which would be found the base of the stapes.

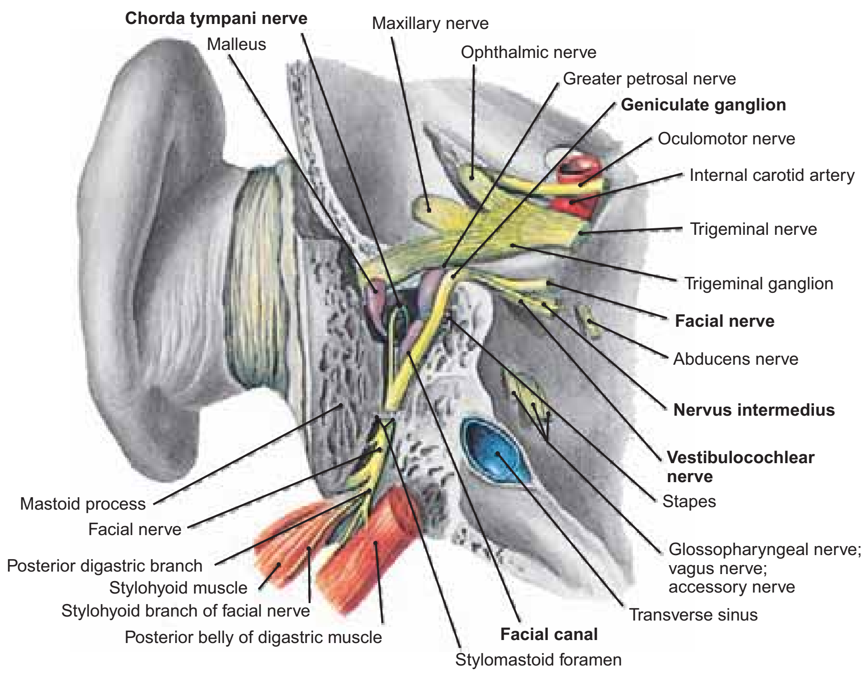


FIGURE 666.2 **Intracranial Course of the Facial Nerve Viewed Posteriorly**

NOTE: (1) This is a frontal section of the temporal bone that opens the facial canal from behind. Observe the **chorda tympani nerve** coursing from the **facial nerve** across (from posterior to anterior) the tympanic cavity along the inner surface of the tympanic membrane.

(2) The internal acoustic meatus in the floor of the skull transmits the facial nerve (and **nervous intermedius**) and the **vestibulocochlear nerve**.

(3) Distal to the **geniculate ganglion** (the sensory ganglion of the facial nerve) the facial nerve enters the facial canal where it first courses laterally and then turns sharply backward and inferiorly (see Fig. 665.1).

(4) Beyond the chorda tympani branch, the trunk of the facial nerve descends in the temporal bone to emerge on the side of the face through the stylomastoid foramen posterior to the ear lobe.

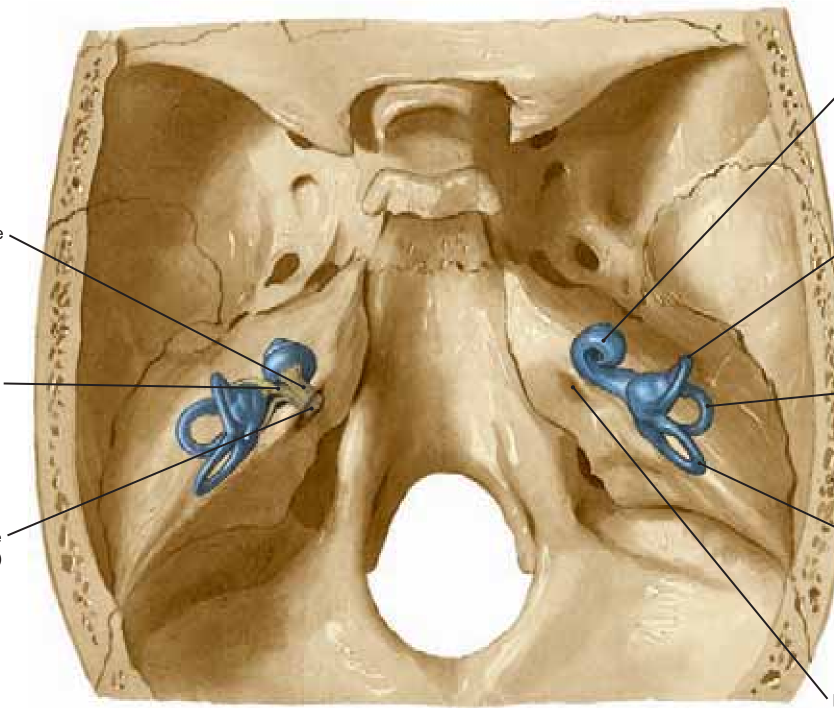


FIGURE 667.1 Cochlea and Semicircular Canals Projected onto the Petrous Part of the Temporal Bone

NOTE: (1) The internal ear lies in the petrous part of the temporal bone just deep to the crest of that bone (called the arcuate eminence [not labeled]) that separates the middle cranial fossa from the posterior cranial fossa. Also observe the internal acoustic (auditory) meatus on the posterior aspect of the arcuate eminence through which pass the facial and vestibulocochlear nerves.

(2) The orientation of the anterior, lateral, and posterior semicircular canals, and the cochlea is positioned slightly medial and anterior to the canals. Also note (on the reader's left) the vestibular and cochlear divisions of the vestibulocochlear nerve that carries impulses from the vestibular receptors in the semicircular canals that inform the brain of the position of the head in space and the receptors in the cochlea that transmit the special sense of hearing.

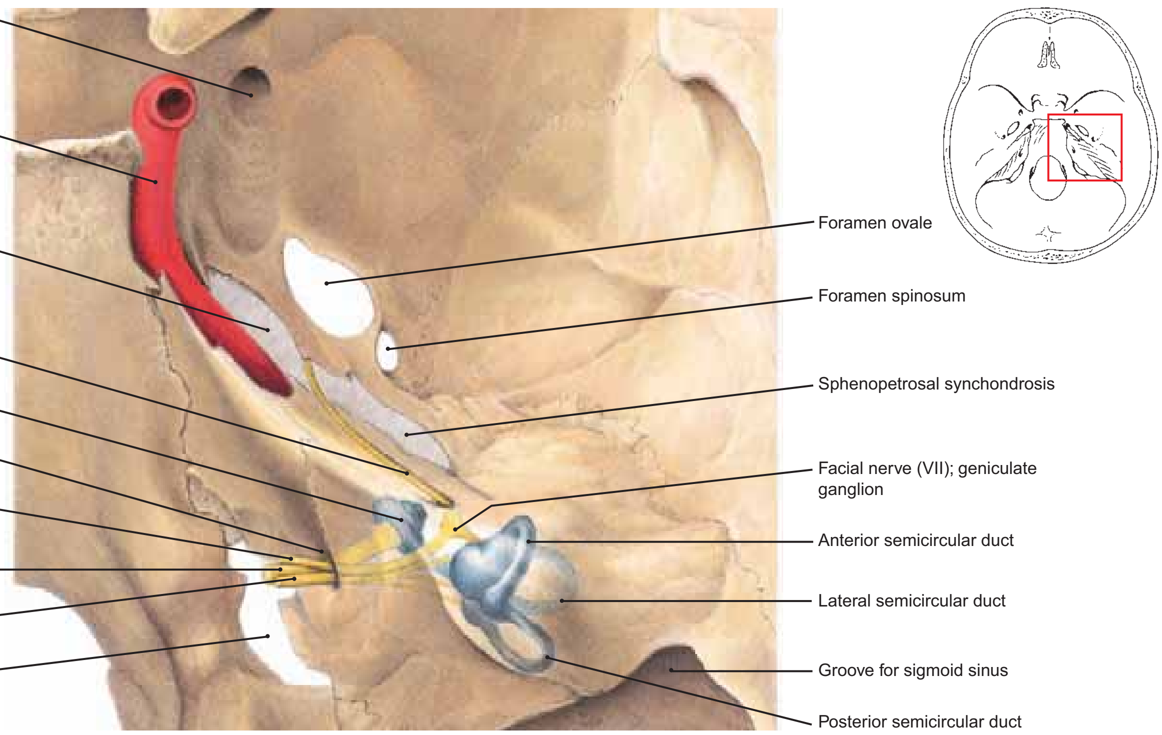


FIGURE 667.2 Structures of the Right Inner Ear and the Vestibulocochlear and Facial Nerves Visualized from Above

NOTE: (1) The semicircular canals and the cochlea of the inner ear are projected onto the superior surface of the petrous portion of the temporal bone. Also observe the **facial nerve** and **the vestibular and cochlear divisions** of the **vestibulocochlear nerve** traversing the internal acoustic (auditory) meatus.

(2) The orientation of the cochlea is similar to that in Figure 667.1. Also note the **geniculate ganglion** through which course the fibers that form the greater petrosal nerve. This ganglion contains the cell bodies for the taste fibers in the chorda tympani nerve for the anterior two-thirds of the tongue.

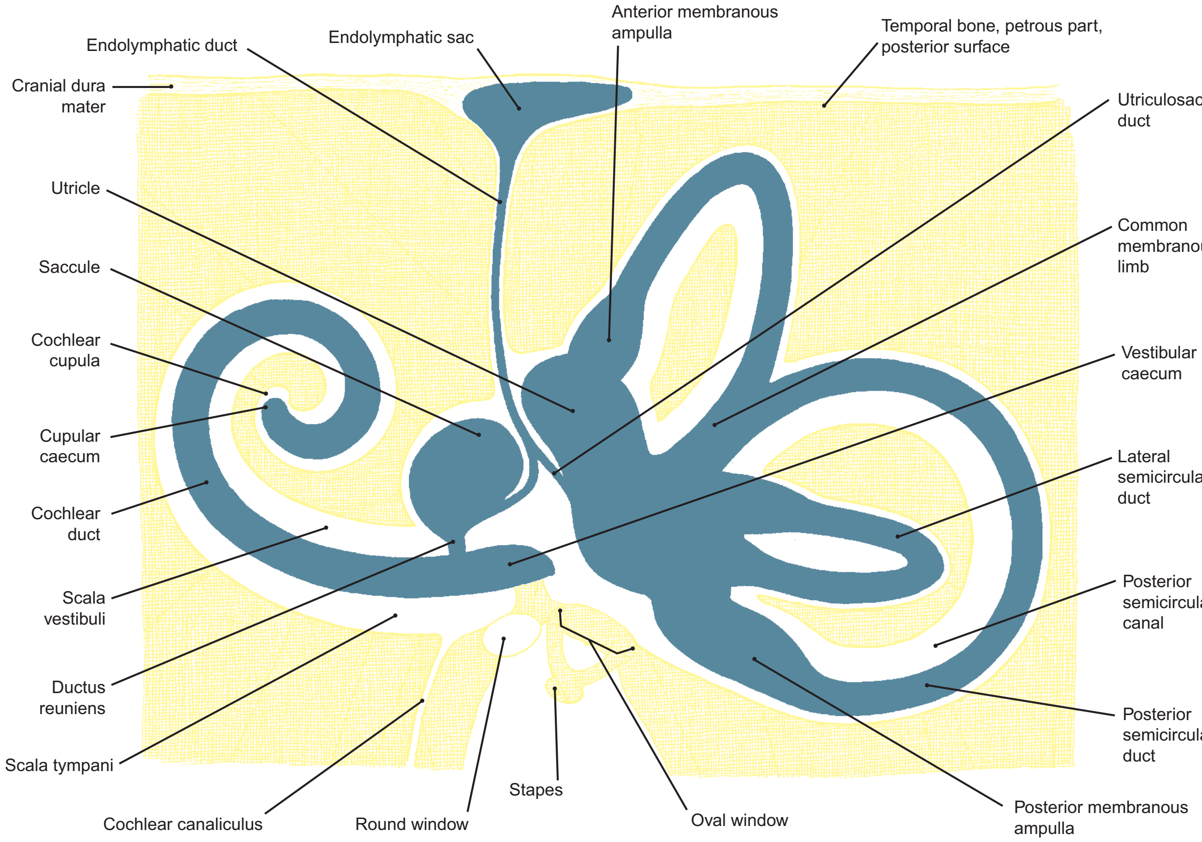


FIGURE 668.1 **Membranous Labyrinth of the Inner Ear**

NOTE: The membranous labyrinth is a closed system of ducts and sacs surrounded by the bony labyrinth of the inner ear. It contains endolymph surrounded by perilymph and consists of the ducts of the semicircular canals, the utricle, the saccule, the endolymphatic duct, and the duct of the cochlea.

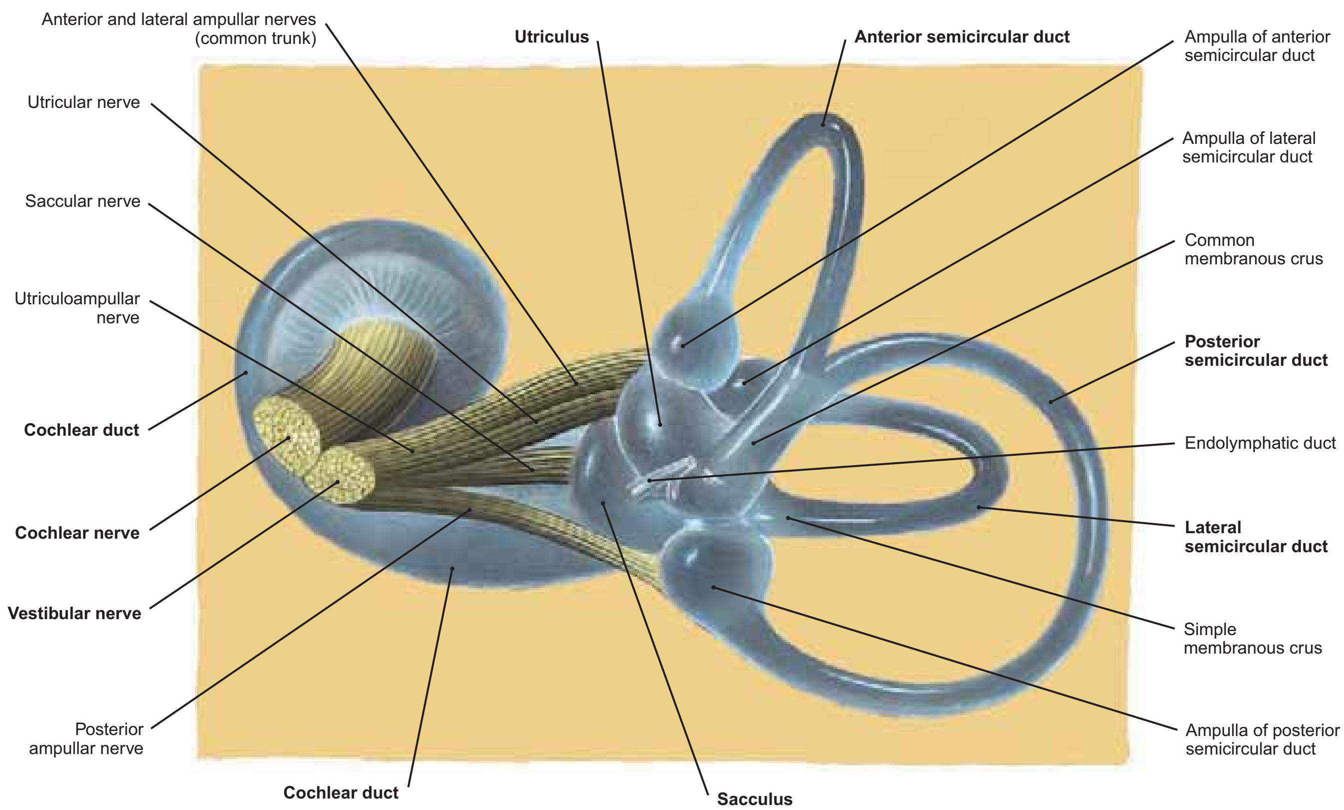


FIGURE 668.2 **Right Membranous Labyrinth (Medial View)**

NOTE: The ampullae of the three semicircular ducts, the sacculus, the utriculus, and the cochlear duct, and the connections of the endolymphatic duct to the utriculus and sacculus.

CHAPTER 8

Cranial Nerves

Plates

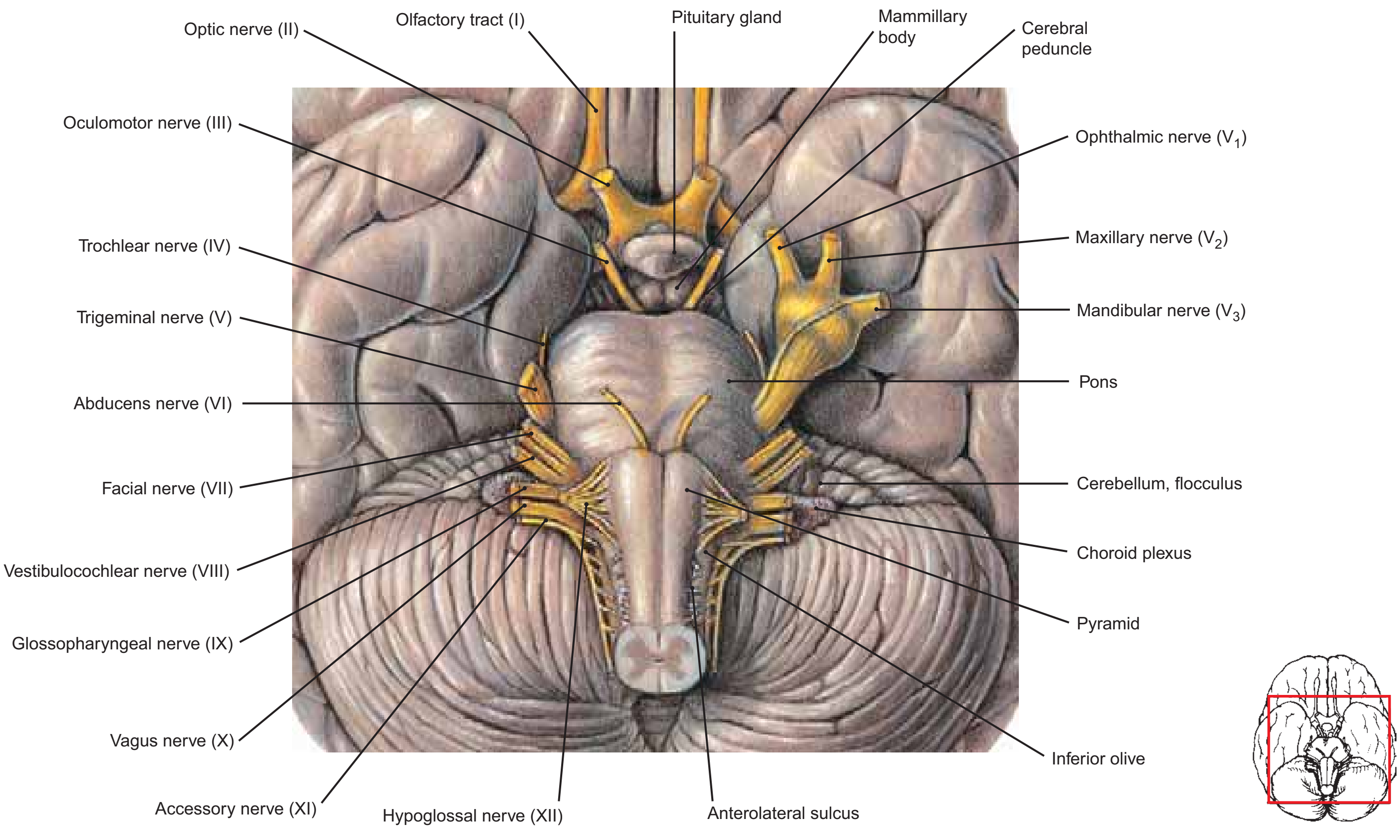


FIGURE 669 Ventral View of the Brain and the Sites of Attachment of the Cranial Nerves

NOTE: (1) The cranial nerves (CN) supply motor and sensory innervation to the head and, in some instances, to other region of the body. There are 12 pairs of cranial nerves, and these are attached to the brain from the basal forebrain to the medulla oblongata.

(2) The cranial nerves pass through openings in the skull to (or from) extracranial structures, and they are subject to damage along their paths due to vascular or traumatic incidents or from infections or neoplasms.

SITES OF ATTACHMENT OF THE CRANIAL NERVES TO THE BRAIN

I **Olfactory Nerves:** These are neurons from receptors for the special sense of smell in the nasal cavity that pierce through foramina in the cribriform plate of the ethmoid bone and terminate on neurons of the olfactory bulb (about 20 bundles). The axons from neurons in the olfactory bulbs (which are second-order neurons in the olfactory pathway) form the **olfactory tracts** that attach to the basal forebrain.

II **Optic Nerves:** These join at the optic chiasma. The **anterior cerebral artery** lies anterior to the optic chiasma and the **internal carotid artery** is located lateral to the chiasma. The optic tracts then course posteriorly and laterally to enter the diencephalon.

III **Oculomotor Nerve:** Emerges on the medial side of the ventral midbrain and passes between the posterior cerebral artery (superior to the nerve) and the superior cerebellar artery (inferior to the nerve).

IV **Trochlear Nerve:** Most slender of cranial nerves. It is the only cranial nerve that emerges from the posterior aspect of the brainstem. It attaches to the brain immediately below the inferior colliculus in the upper pons.

V **Trigeminal Nerve:** It is attached to the anterior surface of the pons near its upper border. The smaller motor root is covered by the large sensory root.

VI **Abducens Nerve:** Emerges at the lower border of the pons, in a furrow between the pons and the pyramid of the medulla oblongata (the pontomedullary junction).

VII **Facial Nerve:** Also attaches at the lower border of the pons (at the cerebellopontine angle) medial and slightly anterior to the vestibulocochlear nerve.

VIII **Vestibulocochlear Nerve:** Attaches in the same groove as the facial nerve but lateral to the facial nerve.

IX **Glossopharyngeal Nerve:** Attached to the upper aspect of the medulla oblongata in front of the vagus nerve in a groove between the medulla and the cerebellar peduncle.

X **Vagus Nerve:** Attached by 8 to 10 filaments in the same groove as the glossopharyngeal nerve but just posterior to it.

XI **Accessory Nerve:** The **cranial root** is formed by filaments that emerge just caudal to the rootlets that form the vagus nerve. The **spinal root** arises from fibers from the upper five segments of the spinal cord.
The fibers from the cranial root join the **vagus nerve** and become distributed in the pharyngeal and laryngeal branches of the vagus. The fibers of the spinal root leave the cranial fibers and descend from the jugular foramen to supply the sternocleidomastoid and trapezius muscles.

XII **Hypoglossal Nerve:** Fibers emerge from the ventrolateral aspect of the caudal medulla in line with the ventral roots spinal cord. They represent the four fused precervical nerves.

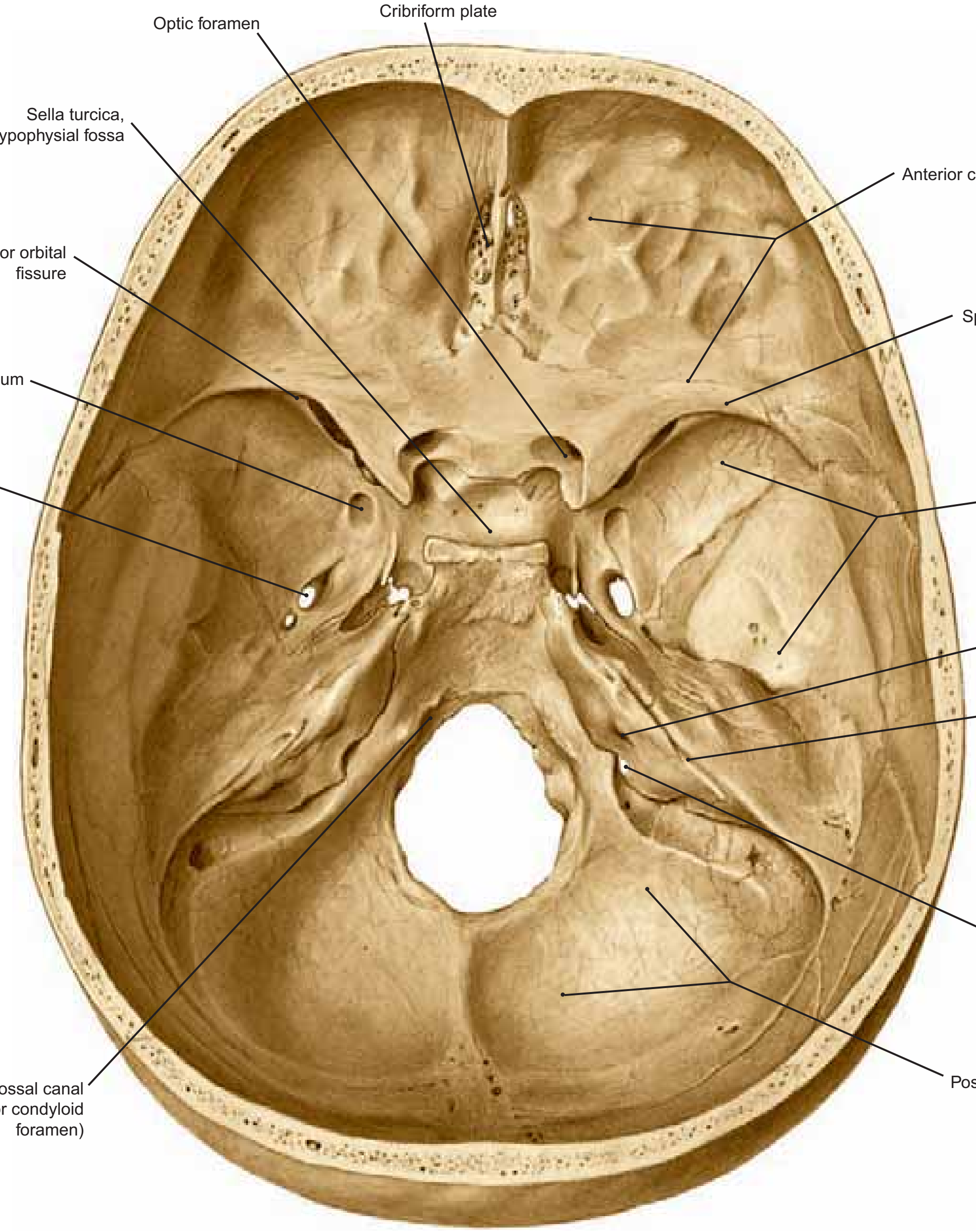


FIGURE 670 Base of the Skull Showing Foramina through Which the Cranial Nerves Traverse

	Nerve	Location
I	Olfactory	**Cribriform plate** of the ethmoid bone
II	Optic	**Optic foramen** of sphenoid bone (with the ophthalmic artery)
III	Oculomotor	**Superior orbital fissure** of sphenoid bone
IV	Trochlear	
V_1	Ophthalmic division, trigeminal	
V_2	Maxillary division, trigeminal	**Foramen rotundum** of sphenoid bone
V_3	Mandibular division, trigeminal	**Foramen ovale** of sphenoid bone
VI	Abducens	**Superior orbital fissure** of sphenoid bone
VII	Facial	**Internal acoustic meatus** of temporal bone (petrous part)
VIII	Vestibulocochlear	
IX	Glossopharyngeal	**Jugular foramen,** between the occipital bone and the petrous portion of temporal bone
X	Vagus	
XI	Accessory	
XII	Hypoglossal	**Hypoglossal Canal** (anterior condylar foramen)

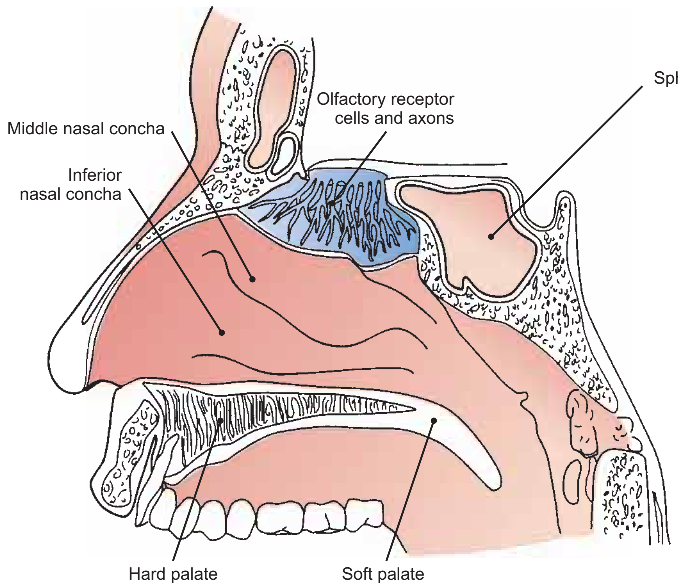


FIGURE 671.1 **Lateral Wall of the Nasal Cavity and Olfactory Receptors (Olfactory Nerve/Cranial Nerve I)**

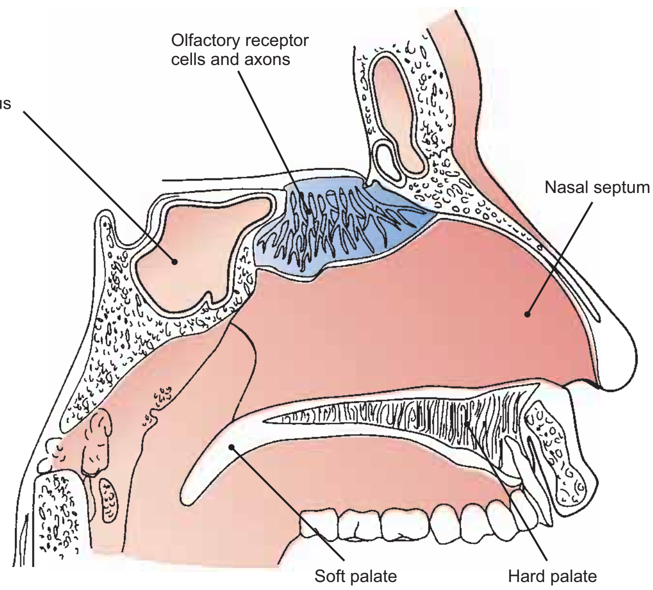


FIGURE 671.2 **Nasal Septum and Olfactory Receptors (Olfactory Nerve/Cranial Nerve I)**

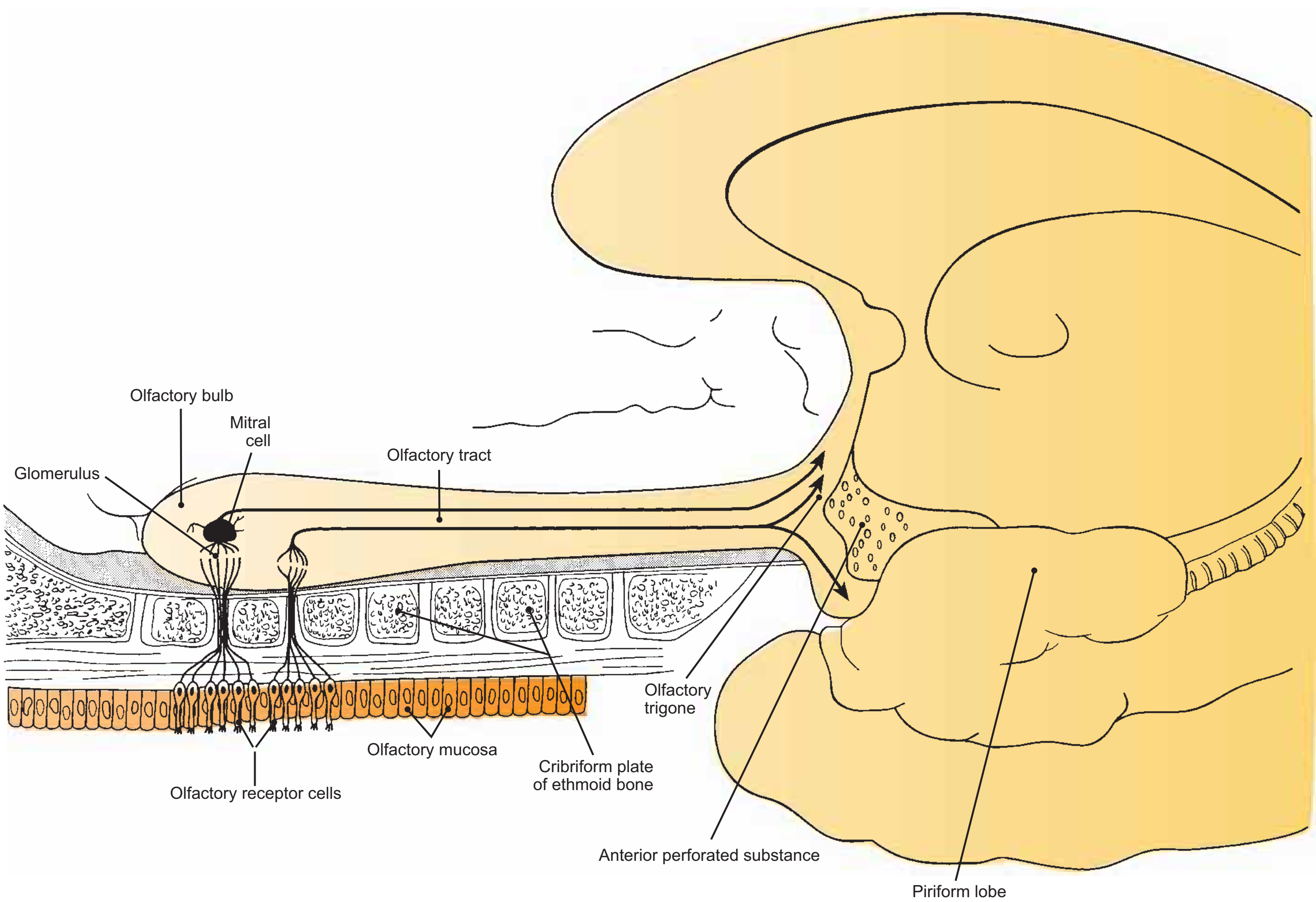


FIGURE 671.3 **Olfactory Mucosa, Receptors, and Nerves (CN I) and Olfactory Bulb and Tract of the Central Nervous System (CNS)**

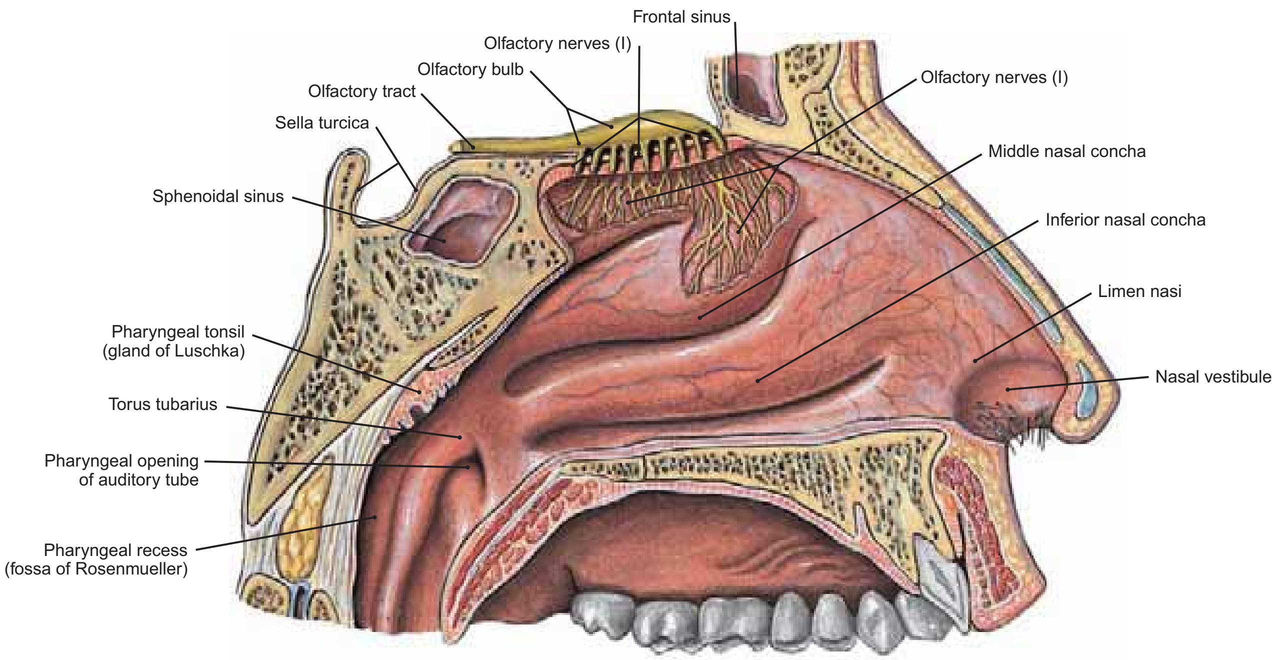


FIGURE 672.1 **Lateral Wall of the Nasal Cavity: Olfactory Nerves (CN I) and Olfactory Bulb and Tract**

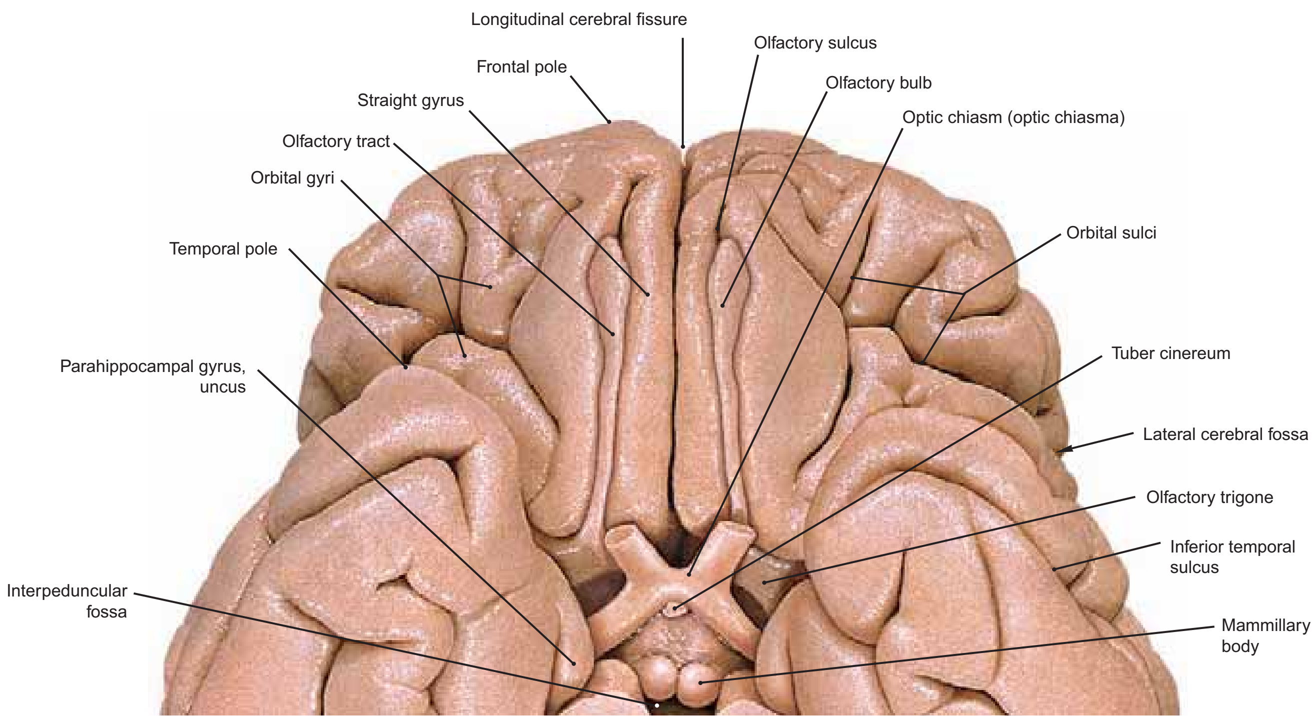


FIGURE 672.2 **Basal Forebrain Showing the Olfactory Bulb, Olfactory Tract, and Olfactory Trigone (Central Nervous System)**

FIGURES 672.1 and 672.2

NOTE: (1) The olfactory receptor cells and their axons that enter the olfactory bulb constitute the first cranial nerve. These are peripheral nerves, while the olfactory bulb and olfactory tract are brain (central nervous system [CNS]) structures.

(2) The olfactory receptors are located in the **olfactory epithelium** that overlies the superior concha in the lateral wall of the nasal cavity and the adjoining mucosa that covers the superior aspect of the nasal septum (see Figs. 671.1 and 671.2).

(3) About 20 small bundles of nerve fibers from the receptor cells enter the olfactory bulbs on each side by passing through the foramina of the cribriform plate of the ethmoid bone (see Fig. 671.3).

(4) The receptor neuron fibers synapse with tufted and mitral cells in the olfactory bulb and project their axons centrally to form the olfactory tracts (see Figs. 671.3 and 672.2). These tracts are often mistakenly considered the first pair of cranial nerves. The receptor cells and their axons form the first cranial nerve. Second-order neurons (such as the tufted cells and mitral cells in the olfactory bulb) send their axons posteriorly to form the olfactory tract, which is completely a CNS tract.

(5) Damage to the olfactory filaments or the olfactory tracts may occur following fractures of the skull in the anterior cranial fossa or by tumors or inflammation in this fossa. This can result in anosmia (loss of the sense of smell).

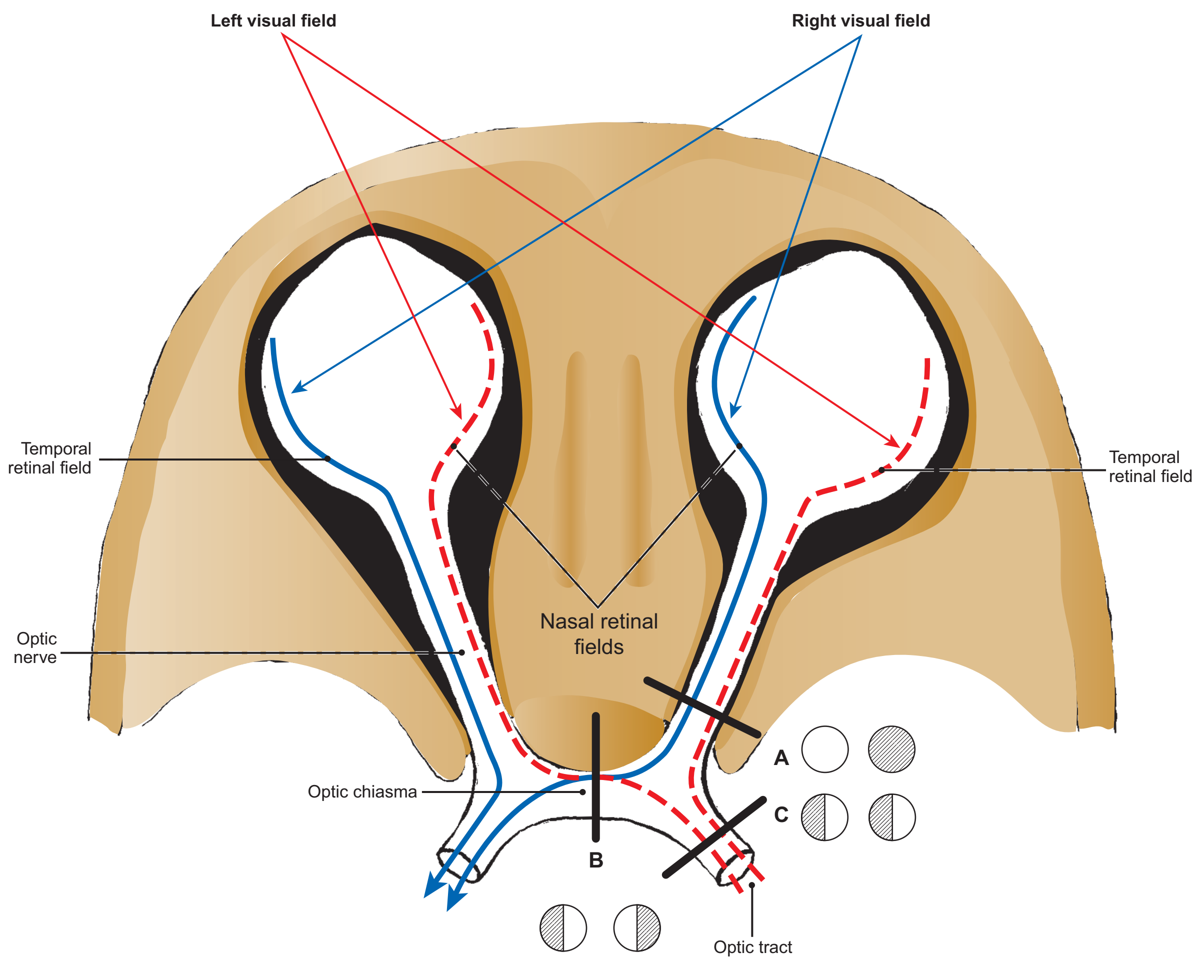


FIGURE 673 Visual Fields; Retinal Fields; Retina; Optic Nerve; Optic Chiasma (Diagram)

NOTE: (1) The **optic nerves** transmit visual impulses from the retina posteriorly to the brainstem. The fibers that form the optic nerves are axons from the ganglion cells in the retina. These cells form the innermost layer of the retina and emerge from the bulb of the eye at the optic disk (see Plates 609–612).

(2) A **visual field** is the area in space that is visible to an eye at a given position. A visual field is also called a field of vision. The **nasal retina** is the nasal half of the retina medial to the optic disk (sometimes called the **nasal retinal field**); the **temporal retina** is the outer half of the retina lateral to the optic disk (sometimes called the **temporal retinal field**).

(3) As the optic nerves course posteriorly from the eyeball, half of its fibers cross to the opposite side of the brain at the **optic chiasma.** Fibers from the temporal retina of both eyes DO NOT cross at the optic chiasma, whereas fibers from the nasal retinas of the two eyes CROSS at the optic chiasma.

(4) Posterior to the optic chiasma the optic fibers form the **optic tracts** that carry the fibers to the midbrain, where they synapse with neurons in the lateral geniculate body. These latter neurons send their fibers to the cerebral cortex.

(5) Because of the crossed and uncrossed fibers in the optic chiasma, different lesions in the visual pathway will result in varying losses of vision:

(a) An **optic nerve** lesion results in a loss of vision in that eye; thus, there is a loss of both nasal and temporal field vision in that one eye **(A).**

(b) An **optic chiasma** [**B**] lesion that cuts though the middle of the optic chiasma results in a loss of vision from the nasal half of the retina of the right eye (right temporal visual field) and the nasal half of the retina of the left eye (left temporal visual field). This condition is called **bitemporal hemianopia** because both temporal visual fields are lost and indicates that the crossed fibers at the optic chiasma are cut, whereas the uncrossed fibers are intact.

(c) A lesion in the **optic tract** [**C**] on one side (e.g., in the right optic tract) will eliminate vision from the temporal half of the retina of the right eye and the nasal half of the retina of the left eye. This means that there is a loss of input from the contralateral visual fields to both eyes, resulting in a loss of input to the left nasal retinal field and to the right temporal retinal field. This is called **homonymous hemianopia.**

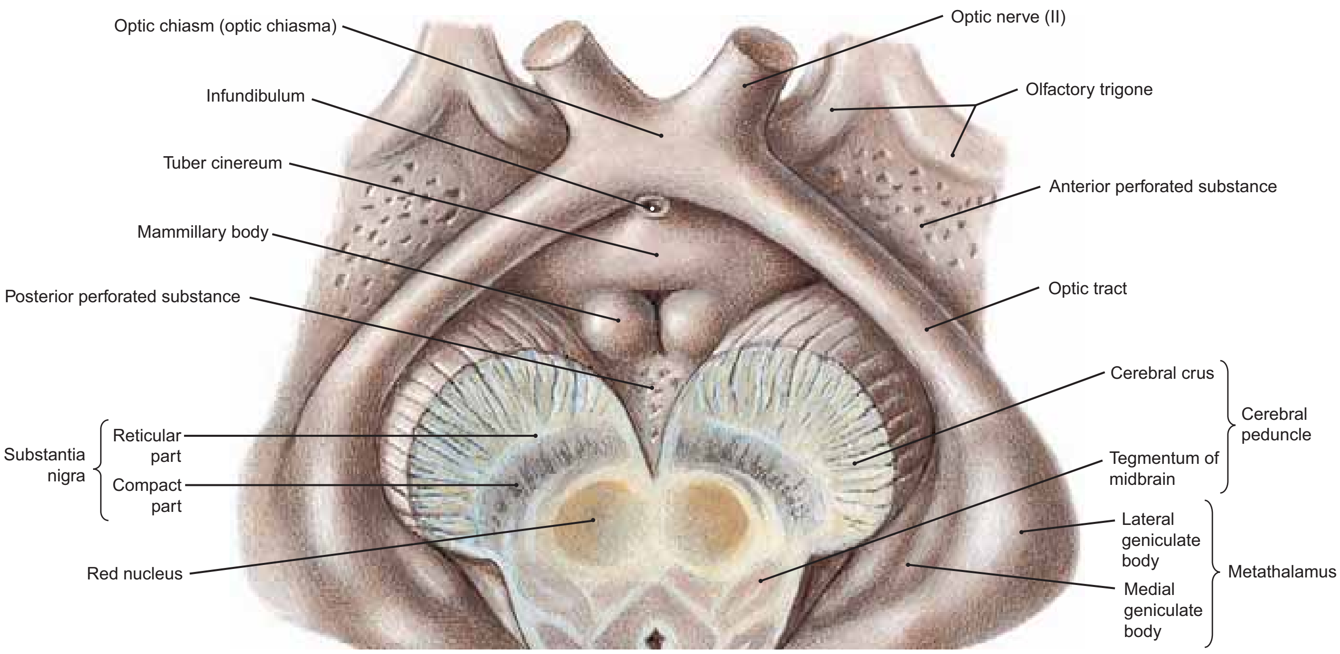


FIGURE 674.1 Optic Chiasma, Optic Tract, and Lateral Geniculate Body; Severed Midbrain (Caudal View)

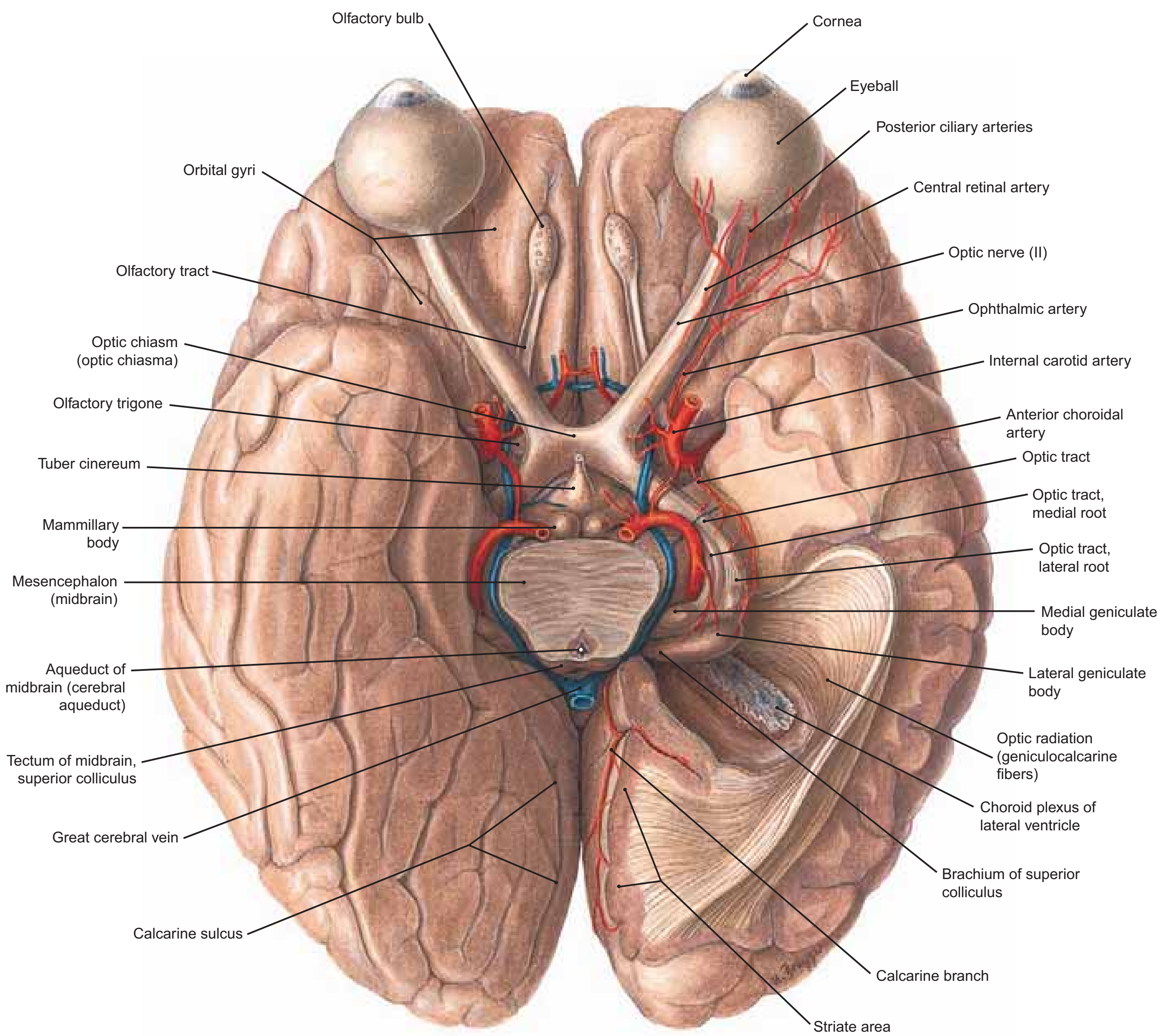


FIGURE 674.2 Visual Pathway from the Optic Nerve to the Cerebral Cortex; Ophthalmic Artery

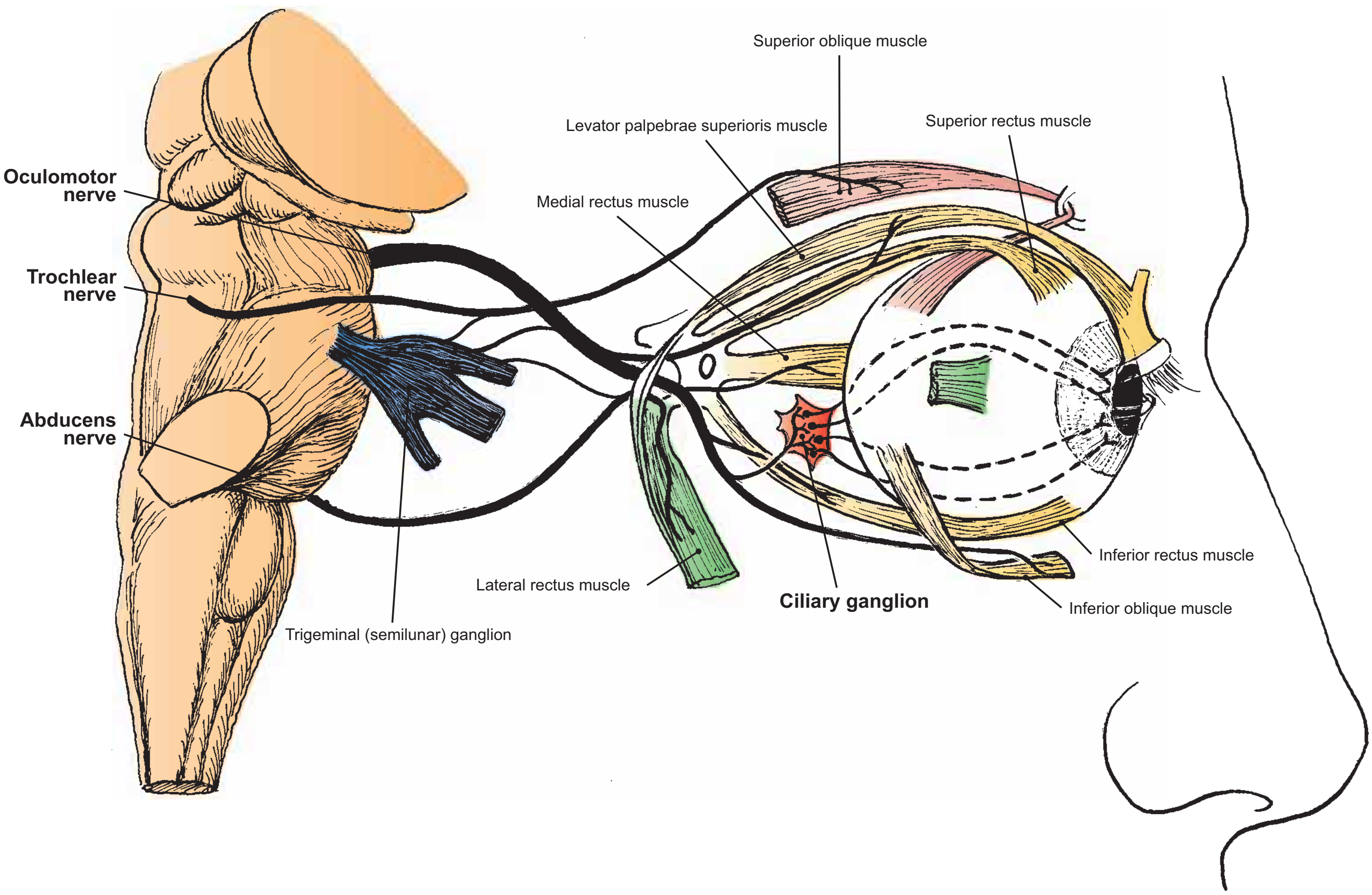


FIGURE 675 Oculomotor (CN III), Trochlear (CN IV), and Abducens (CN VI) Nerves: Lateral View (Diagram)

OCULOMOTOR NERVE (III)

NOTE: (1) The **oculomotor nerve** principally carries **somatomotor fibers** to five extraocular muscles and **preganglionic parasympathetic fibers** to the **ciliary ganglion**. These fibers have their cell bodies in the midbrain: those to the extraocular muscles in the **main oculomotor nucleus**, while the preganglionic parasympathetic fibers have their cell bodies in the **accessory** or **autonomic nucleus** (of Edinger–Westphal).

(2) The oculomotor nerve emerges from the midbrain between the posterior cerebral artery (superior to the nerve) and the superior cerebellar artery (just caudal to the nerve). Hardening of these pulsating arteries and plaques within them can injure the nerve.

(3) The oculomotor nerve courses through the cavernous sinus and enters the orbit by way of the superior orbital fissure and within the annulus tendinous; the nerve then divides into **superior and inferior divisions** and within the orbit supplies five extraocular muscles.

(4) The **superior division** is the smaller of the two and ascends lateral to the optic nerve to supply the **levator palpebrae superioris** and the **superior rectus muscles**; the **inferior division** divides into three branches to supply the **medial rectus**, the **inferior rectus**, and the **inferior oblique muscles**.

(5) The **preganglionic parasympathetic fibers** emerge from the midbrain with the somatomotor fibers and course in the inferior division of the oculomotor nerve in the branch to the inferior oblique muscle. The parasympathetic fibers then leave the nerve to the inferior oblique and pass directly to the **ciliary ganglion,** where they synapse with postganglionic parasympathetic cell bodies.

(6) The postganglionic parasympathetic fibers emerge from the ganglion and course along the **short ciliary nerves** to supply the **ciliary muscle** and the **constrictor of the pupil**. The ciliary muscle controls the shape of the lens, whereas the constrictor of the pupil controls the size of the pupil by reducing its diameter.

(7) Lesions of the oculomotor nerve result in a condition called **ophthalmoplegia.** Its symptoms include (a) **strabismus,** which is the inability to direct both eyes to the same object; this effect results in a downward and abducted eyeball, (b) **a dilated pupil,** (c) **a droopy eyelid** because the levator muscle is denervated, and (d) **a loss of accommodation.**

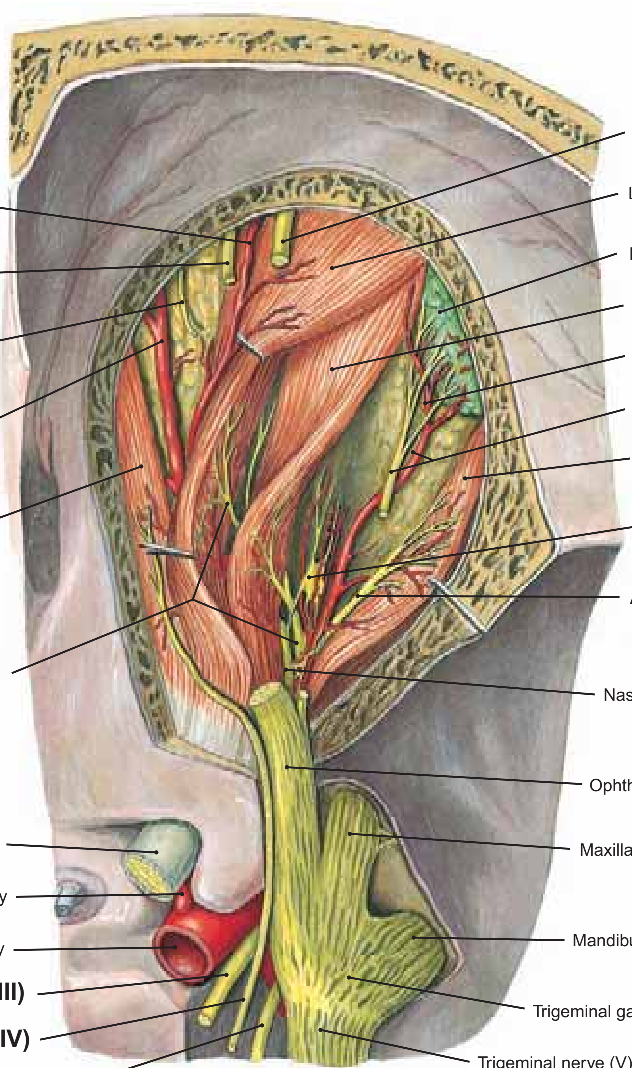


FIGURE 676 **Oculomotor, Trochlear, and Abducens Nerves as They Enter the Orbital Cavity (Superior View)**

TROCHLEAR NERVE (IV)

NOTE: (1) The **trochlear nerve** is the smallest of all the cranial nerves and it supplies only the **superior oblique muscle** in the orbit. It is the only cranial nerve to emerge from the central nervous system on the dorsal aspect of the brain.

(2) The fibers of the trochlear nerve cross to the contralateral side before leaving the dorsal midbrain; after emerging, the nerve is directed laterally around the brainstem immediately above the pons between the posterior cerebral and superior cerebellar arteries.

(3) The nerve then passes rostrally in the lateral wall of the **cavernous sinus** below the oculomotor nerve and superior to the ophthalmic division of the trigeminal nerve (see Fig. 580.1). Anteriorly, it crosses the oculomotor nerve from lateral to medial and it enters the orbit through the **superior orbital fissure** outside the annulus tendineus. In the orbit, the nerve lies superior to the extraocular muscles and it pierces the superior surface of the superior oblique muscle.

(4) **If the oculomotor nerve is injured**, the superior oblique muscle is denervated and it causes an impairment in turning the eye downward and outward. The eye is extorted (outward rotation) because the inferior oblique muscle is acting unopposed.

ABDUCENS NERVE (VI)

NOTE: (1) The **abducens nerve** supplies only the **lateral rectus muscle** within the orbit. Its fibers descend from the abducens nucleus located in the caudal pons, just deep to the fourth ventricle.

(2) The abducens fibers emerge from the ventral surface of the brainstem in the sulcus between the anterior medulla and the posterior border of the pons.

(3) The nerve then courses superiorly, anteriorly, and laterally through the pontine cistern. It then bends acutely forward to traverse the cavernous sinus and it enters the orbital cavity through the **superior orbital fissure** and within the annulus tendineus. It pierces the lateral rectus along the medial surface of the muscle.

(4) The nerve travels a long course from the lower pons to the orbit and is subject to damage due to skull fractures or in cases involving increased intracranial pressure.

(5) If the lateral rectus muscle is denervated, the medial rectus acts unopposed **(internal strabismus).**

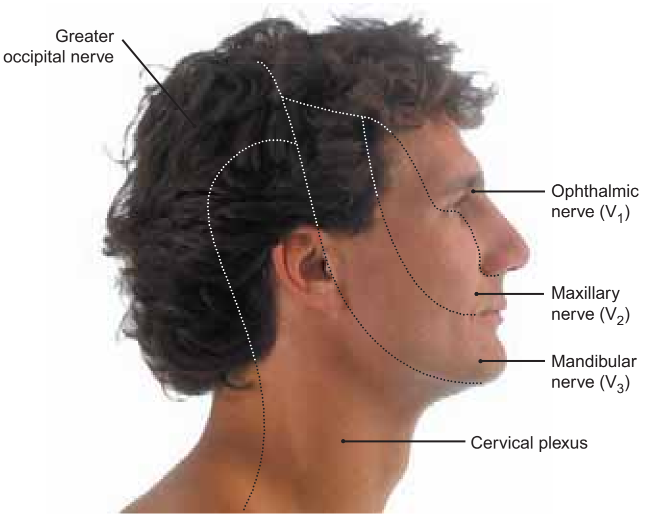


FIGURE 677.1 Lateral View of the Face: Surface Areas Supplied by the Three Divisions of the Trigeminal Nerve

NOTE: (1) The **ophthalmic nerve** supplies the skin of nose, the upper eyelid, and the scalp from the eyebrow posteriorly to the vertex or top of the skull cap.

(2) The **maxillary nerve** supplies the region between the eyelid and the upper lip, including the skin over the cheek bone.

(3) The **mandibular nerve** supplies the skin of the lower jaw, the lateral part of the face anterior to the ear, and the skin of the temple region on the lateral side of the head.

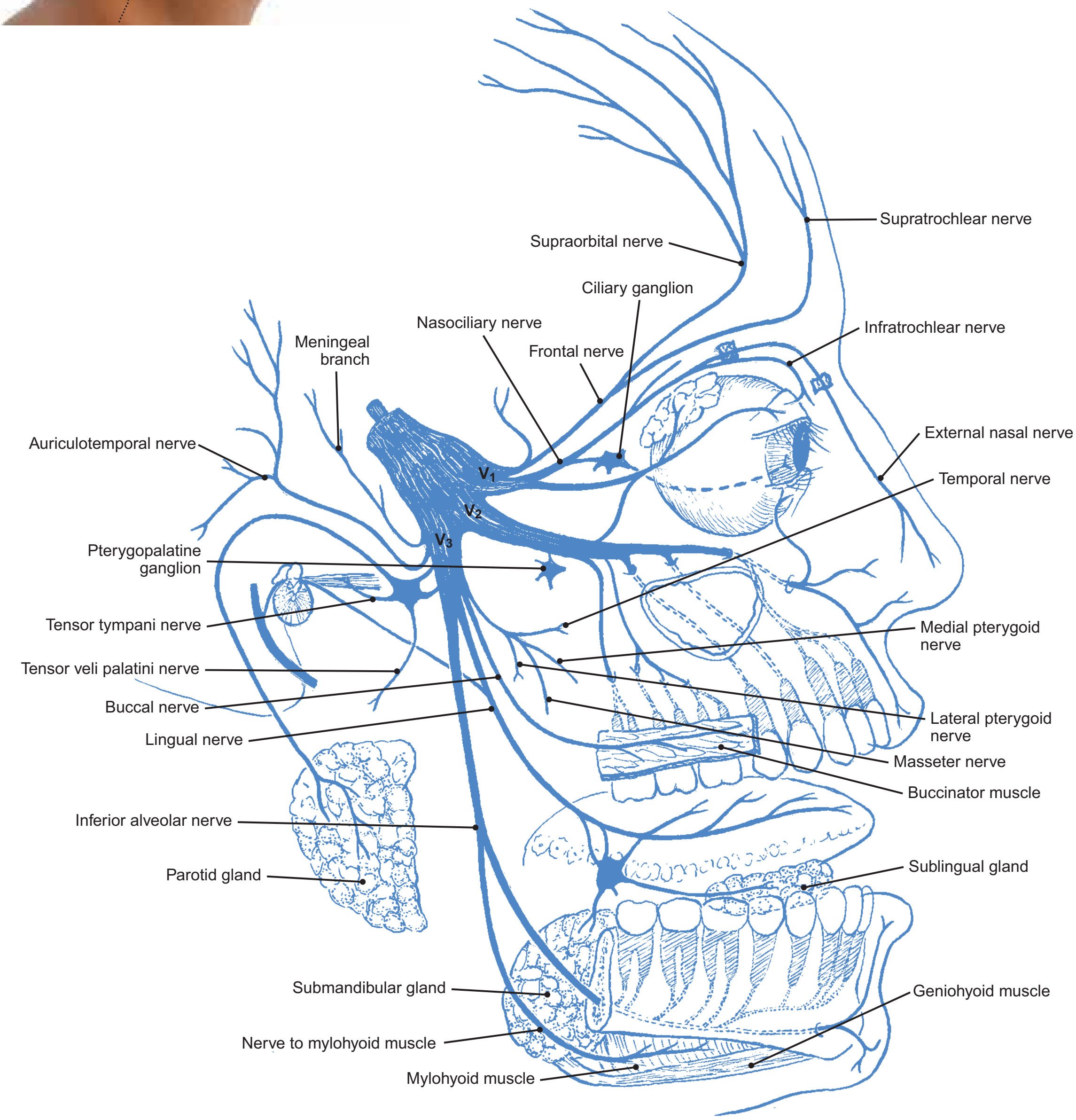


FIGURE 677.2 Diagrammatic Representation of the Trigeminal Nerve and Its Branches

NOTE: (1) The trigeminal nerve is the largest of the cranial nerves, and it is the great sensory nerve of the face and of the orbital, oral and nasal cavities; it also supplies much of the anterior scalp and all of the teeth.

(2) In addition to its sensory functions the trigeminal nerve, through its mandibular division, supplies the **four muscles of mastication**, as well as the **mylohyoid muscle**, the **anterior belly of the digastric muscle,** and two tensors: the **tensor veli palatini** and the **tensor tympani** muscles.

(3) The cell bodies of the sensory fibers in the o**phthalmic, maxillary,** and **mandibular divisions** of the **trigeminal** nerve are located within the trigeminal (or semilunar) **ganglion.** The ganglion is located in a cleft or recess covered by dura mater, called the **trigeminal cave,** on the anterior aspect of the petrous portion of the temporal bone in the middle cranial fossa of the bony base of the skull.

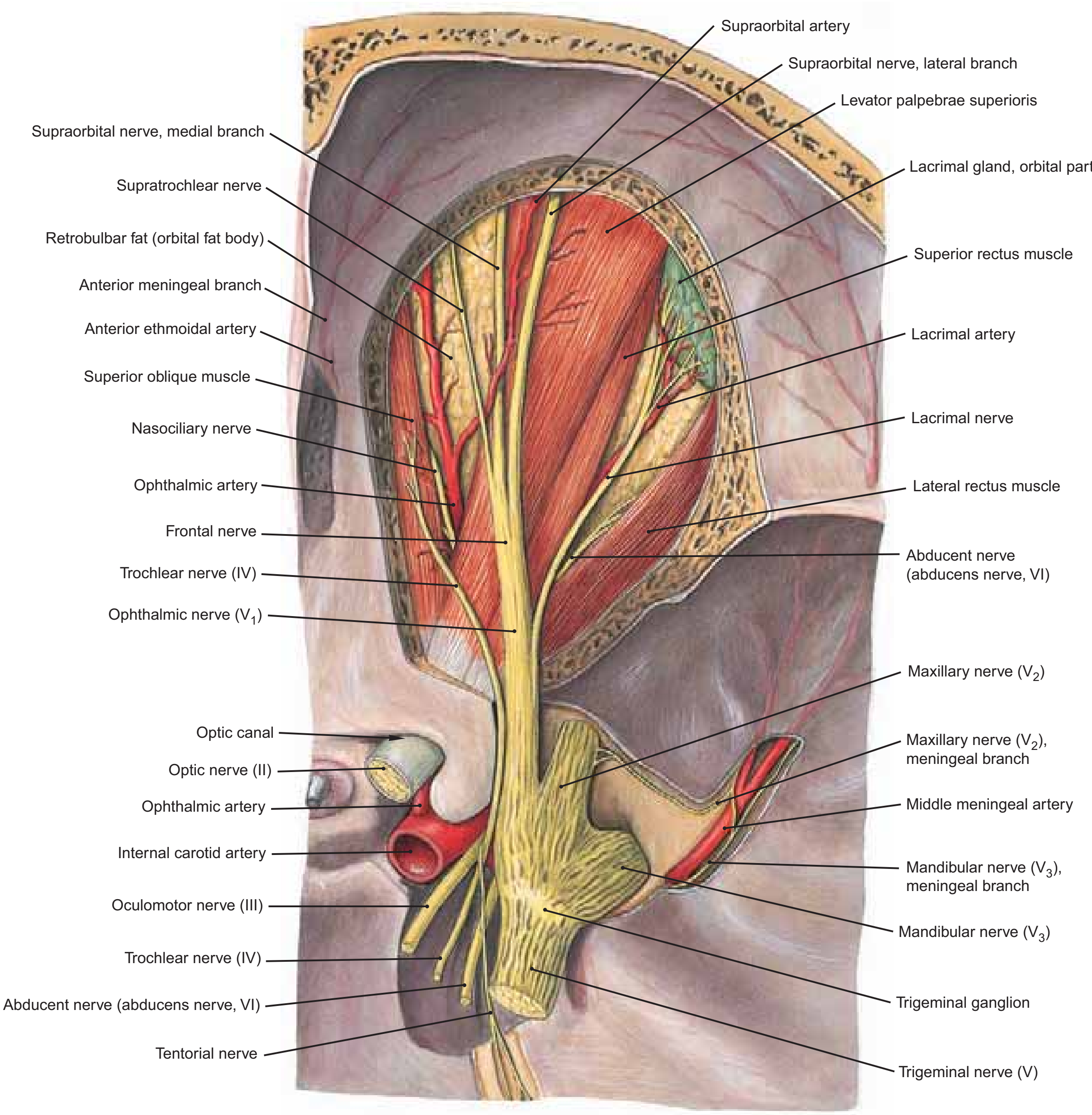


FIGURE 678.1 Branches of the Ophthalmic Division of the Trigeminal Nerve upon Its Entrance into the Orbit

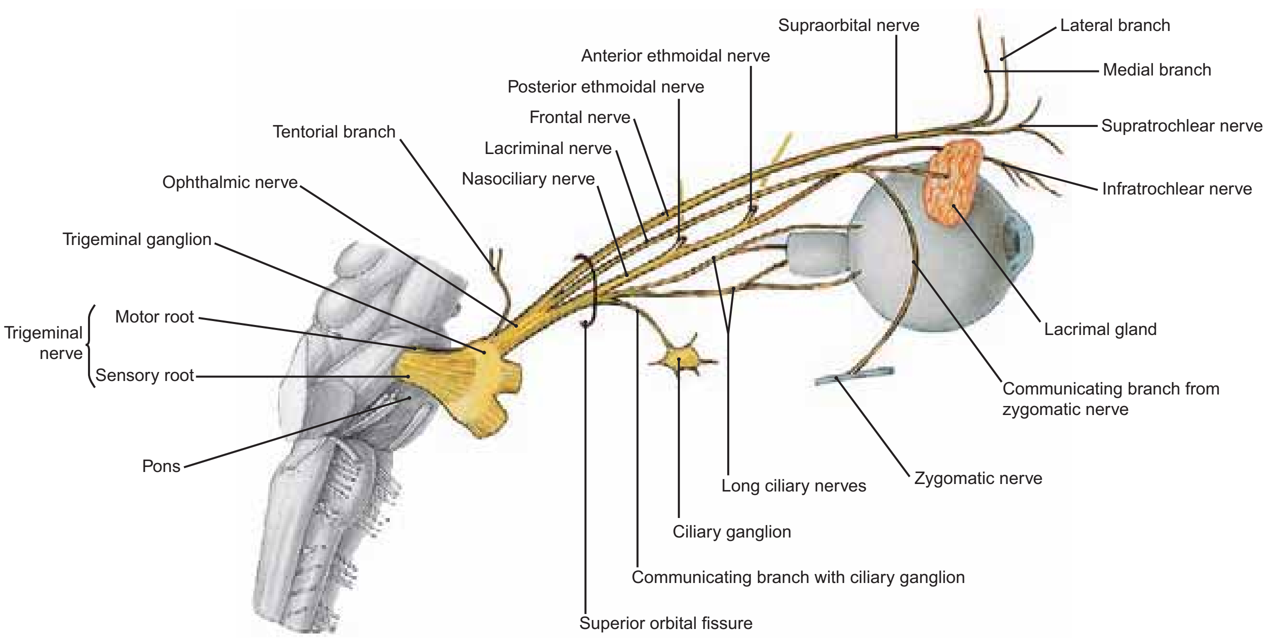


FIGURE 678.2 Ophthalmic Division of the Trigeminal Nerve

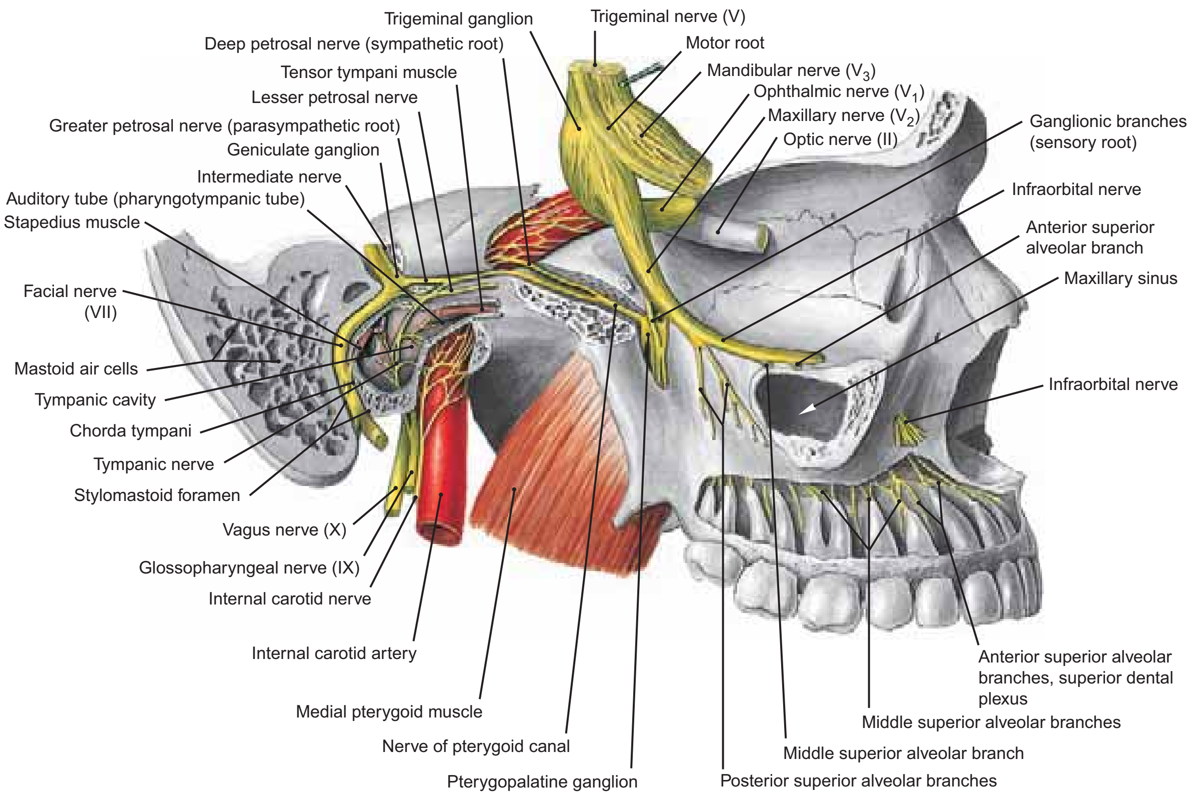


FIGURE 679.1 Maxillary Nerve and Its Infraorbital and Superior Alveolar Branches

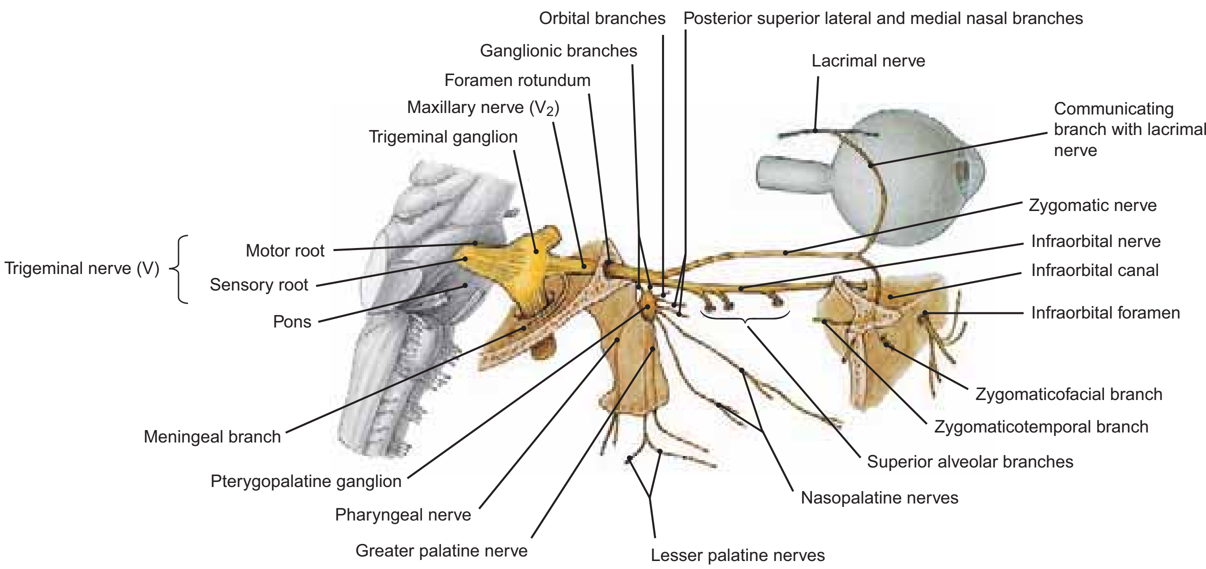


FIGURE 679.2 Maxillary Division of the Trigeminal Nerve

NOTE: (1) The **zygomatic, infraorbital, nasopalatine, greater** and **lesser palatine, lateral** and **medial nasal,** and **pharyngeal** branches derive from the trunk of the maxillary nerve. These are all sensory nerves.

(2) This nerve supplies all of the upper teeth through the superior alveolar branches that come off of the infraorbital nerve. After emerging on the face, the infraorbital nerve supplies the skin from the upper lip to the lower eyelid.

(3) The nasopalatine and greater and lesser palatine branches supply the nasal septum and the hard and soft palates, whereas the pharyngeal nerve supplies the mucosa of the nasopharynx.

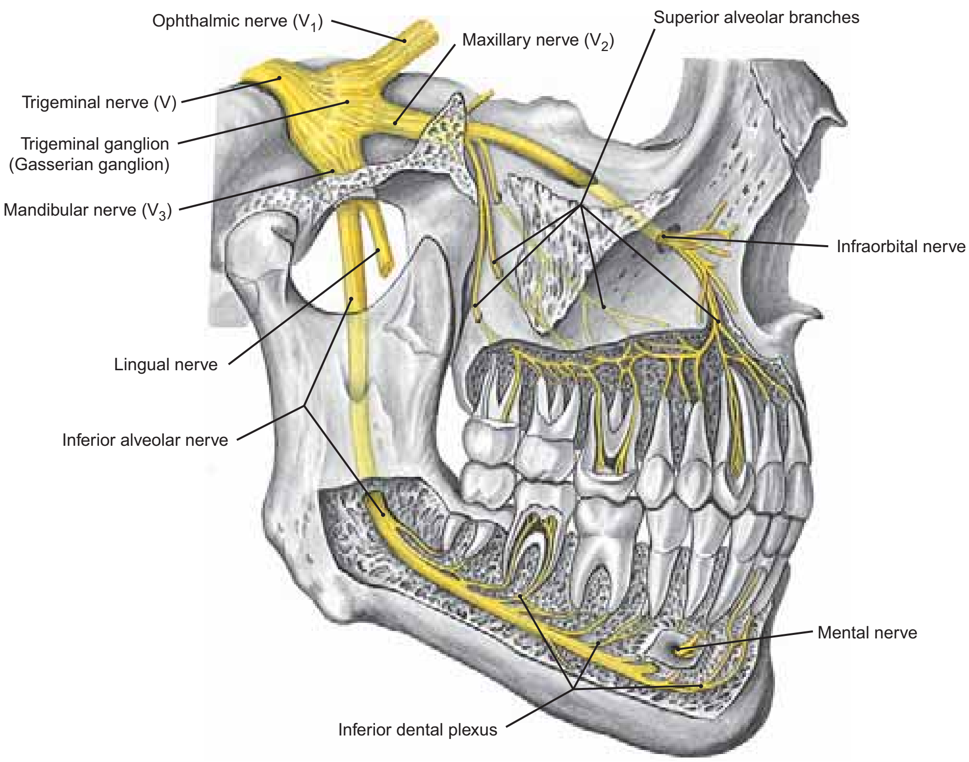


FIGURE 680.1 Maxillary and Mandibular Nerves

NOTE: (1) In this figure, only the **inferior alveolar nerve** and the proximal stump of the cut **lingual nerve** from the mandibular nerve are shown.
(2) The infraorbital and superior alveolar branches of the maxillary nerve are seen supplying structures in the maxillary region.

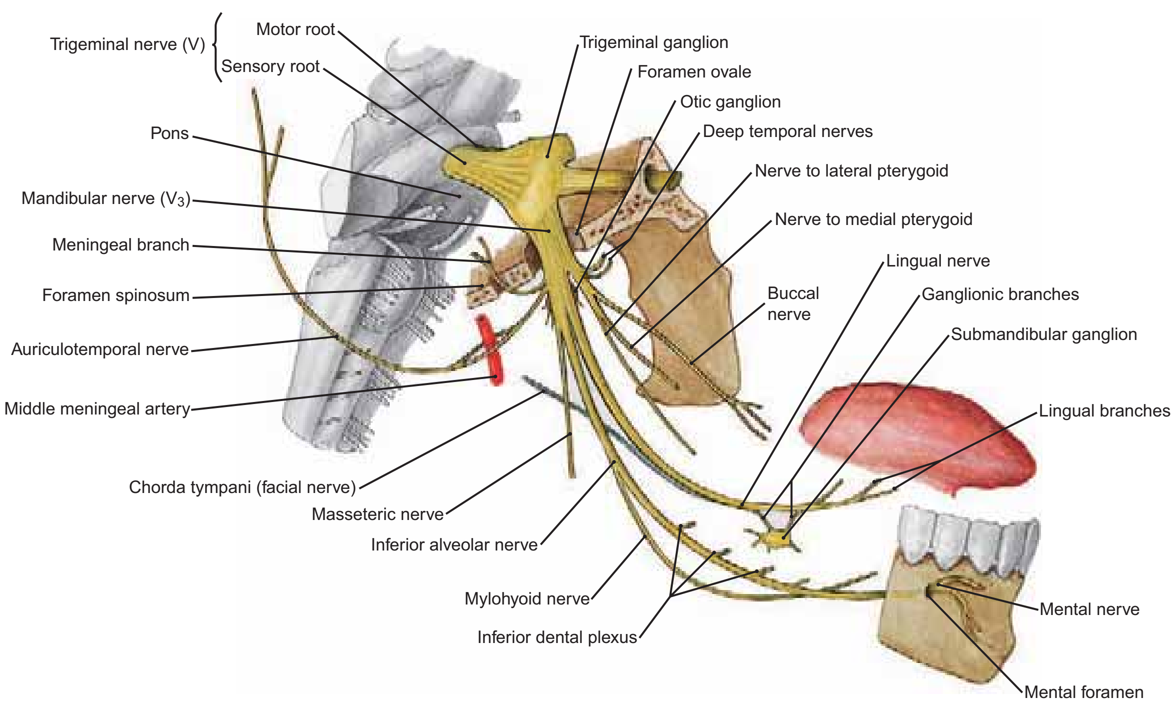


FIGURE 680.2 Mandibular Division of the Trigeminal Nerve

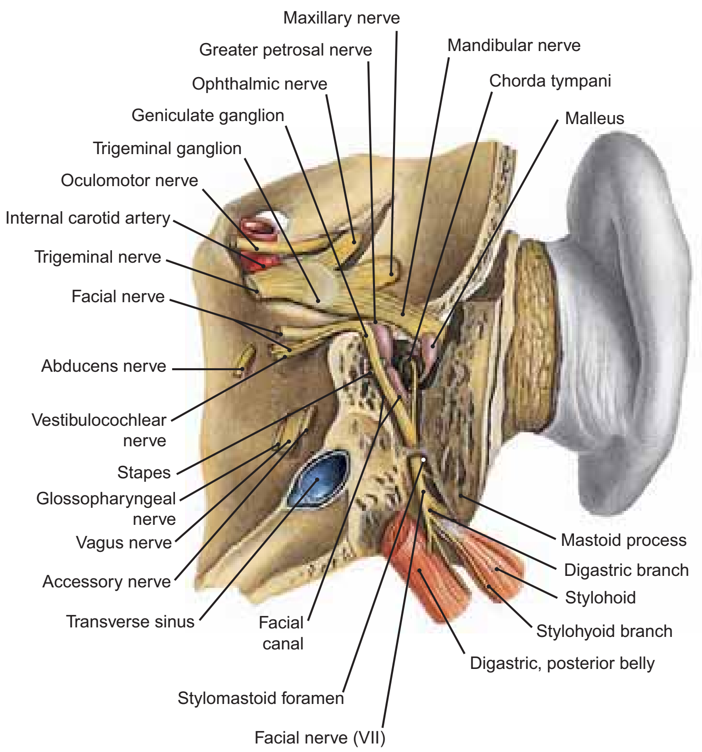
NOTE: (1) The **auriculotemporal, inferior alveolar,** and **lingual nerves** and the branches that supply the muscles of mastication: the **masseteric** and **deep temporal nerves** and the **nerves to the lateral and medial pterygoid muscles**.
(2) The mylohyoid branch of the inferior alveolar nerve that supplies the mylohyoid muscle and the anterior belly of the digastric muscle.
(3) Not shown in this figure but shown in Figure 677.2, are the small, delicate branches that supply two tensor muscles: the **tensor veli palatini** that tenses the soft palate and the **tensor tympani muscle** that tenses the tympanic membrane in the middle ear.
(4) The mandibular nerve supplies sensory innervation to all of the lower teeth, the skin of the chin, lower lip, and the side of the face and head anterior to the external ear.

FIGURE 681.1 Facial Nerve Descending in the Facial Canal

NOTE: (1) The facial nerve emerges from the brainstem by motor and sensory roots. The cells bodies of the fibers in the sensory root are located in the **geniculate ganglion**.

(2) The sensory fibers of the facial nerve are of two types: **general sensation** and **special sense** of **taste** from the anterior two-thirds of the tongue that course centrally in chorda tympani nerve.

(3) The motor fibers of the facial nerve also are of two types: **somatomotor** to the muscles of facial expression, the stapedius muscle, and to the posterior belly of the digastric muscle and stylohyoid muscle and **visceromotor** (preganglionic parasympathetic) that go to the pterygopalatine and submandibular ganglia.



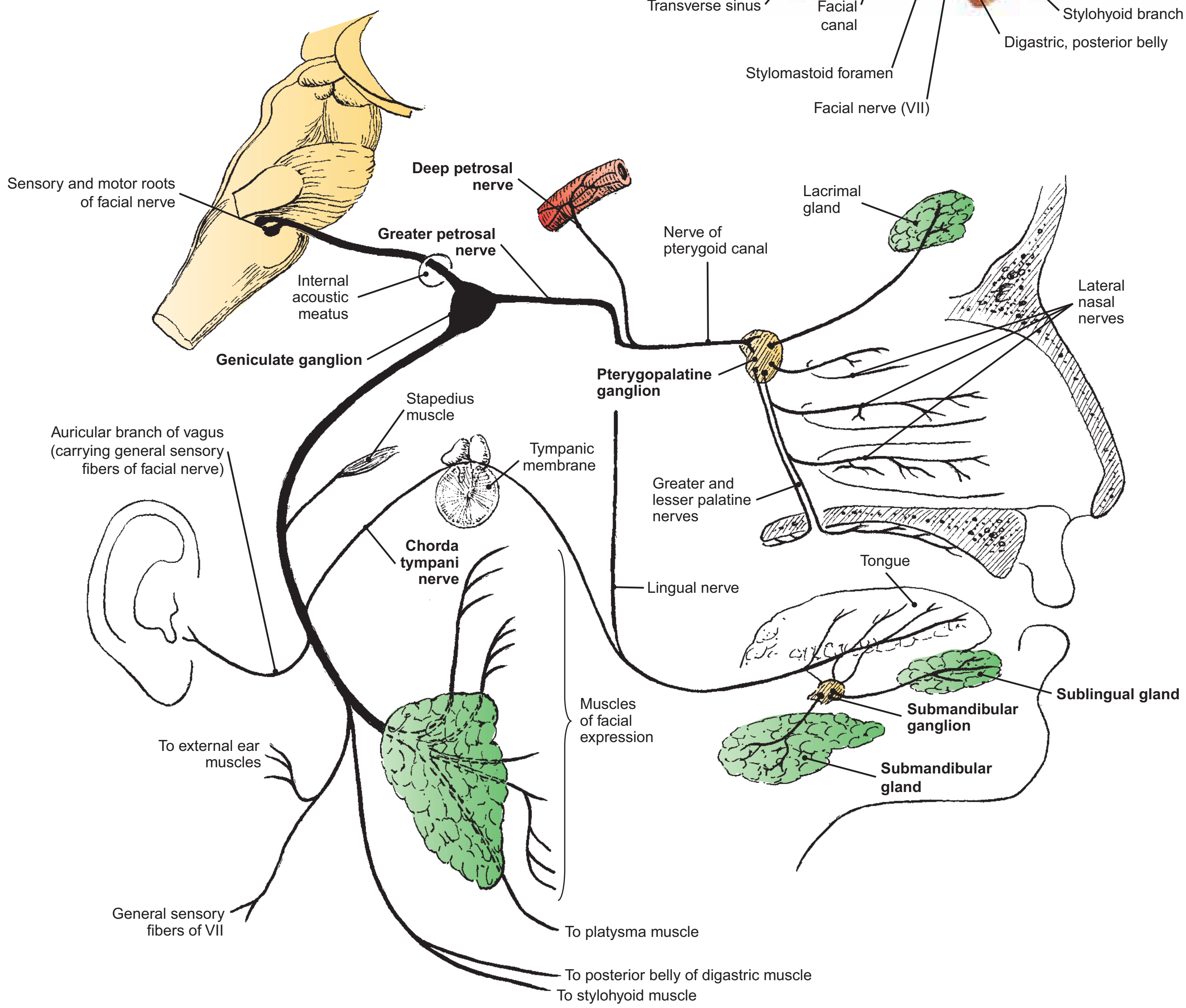


FIGURE 681.2 Diagrammatic View of the Facial Nerve

NOTE: (1) The **greater petrosal nerve** branches from the main stem of the facial nerve at the genu of the facial nerve (i.e., where the nerve turns about 90 degrees inferiorly from its horizontal course through the internal acoustic meatus).

(2) The **chorda tympani nerve** branches along the facial canal posterior to the middle ear. It then enters the middle ear cavity courses across the tympanic membrane and emerges in the deep face. It joins the **lingual nerve** (a branch of the trigeminal nerve) and descends to the submandibular ganglion.

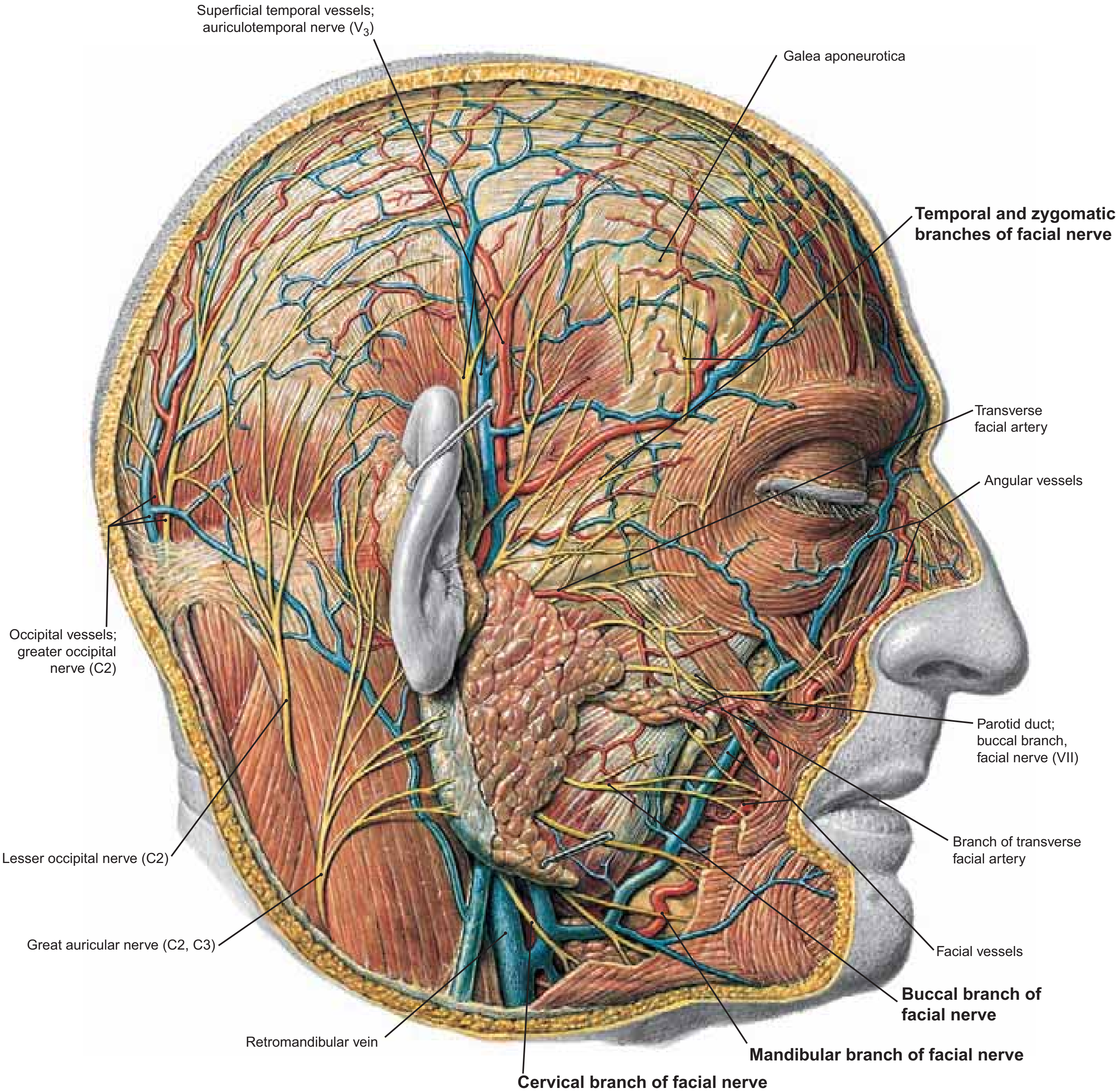


FIGURE 682 Facial Nerve on the Side of the Face

NOTE: (1) The facial nerve emerges from the facial canal at the stylomastoid foramen behind the ear lobe, courses through the parotid gland, and divides into muscular branches for the muscles of facial expression.

(2) The following branches of the facial nerve supply the muscles of facial expression: **temporal, zygomatic, buccal, mandibular,** and **cervical** branches. These nerves contain somatomotor fibers that are under voluntary control.

(3) Injury to the facial nerve or dysfunction of the facial nerve on one side because of paralysis (Bell's palsy) leaves that side of the face expressionless and results in a loss of tone of the superficial facial muscles. This is usually recognizable because of a loss of firmness and a sagging of the face on the afflicted side compared with the normal side.

(4) Because the branches of the facial nerve cross the face horizontally, any incision that might be necessary should be a horizontal one and *not vertical.*

(5) The parotid gland overlies the facial nerve anterior and inferior to the external ear.

(6) The posterior aspect of the scalp is supplied by sensory fibers from the greater occipital nerve (posterior primary ramus of C2), and the skin posterior to the ear and on the lateral side of the upper neck is supplied with sensory fibers from lesser occipital nerve and the great auricular nerve from the cervical plexus and not from either the facial or trigeminal nerves.

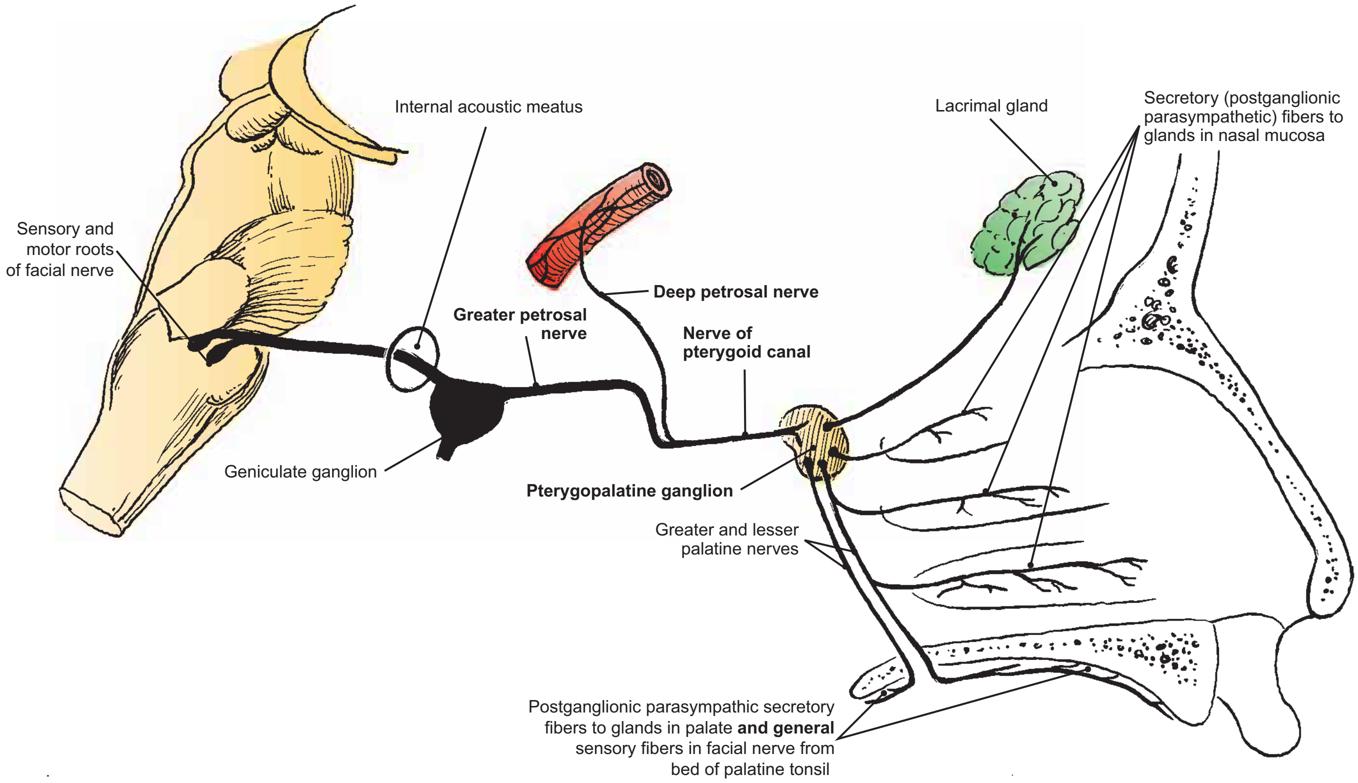


FIGURE 683.1 Diagrammatic Representation of the Facial Nerve and Its Connections

NOTE: (1) The **greater petrosal nerve** commences at the **geniculate ganglion** and is joined by the **deep petrosal nerve** to form the nerve of the pterygoid canal. The greater petrosal nerve is carrying preganglionic parasympathetic fibers to the pterygopalatine ganglion and taste fibers from the palate. It receives postganglionic sympathetic fibers from the **deep petrosal nerve**, and together these various fibers form the **nerve of the pterygoid canal.**

(2) From the pterygopalatine ganglion postganglionic parasympathetic fibers course (a) to the lacrimal gland by way of the zygomatic branch of the maxillary nerve and then the lacrimal branch of the ophthalmic nerve, (b) to mucous glands in the lining of the lateral wall of the nasal cavity and septum, and (c) to mucous glands in the lining of the soft and hard palate by way of the greater and lesser palatine nerves. It is also thought that these nerves carry taste fiber from the palate as well.

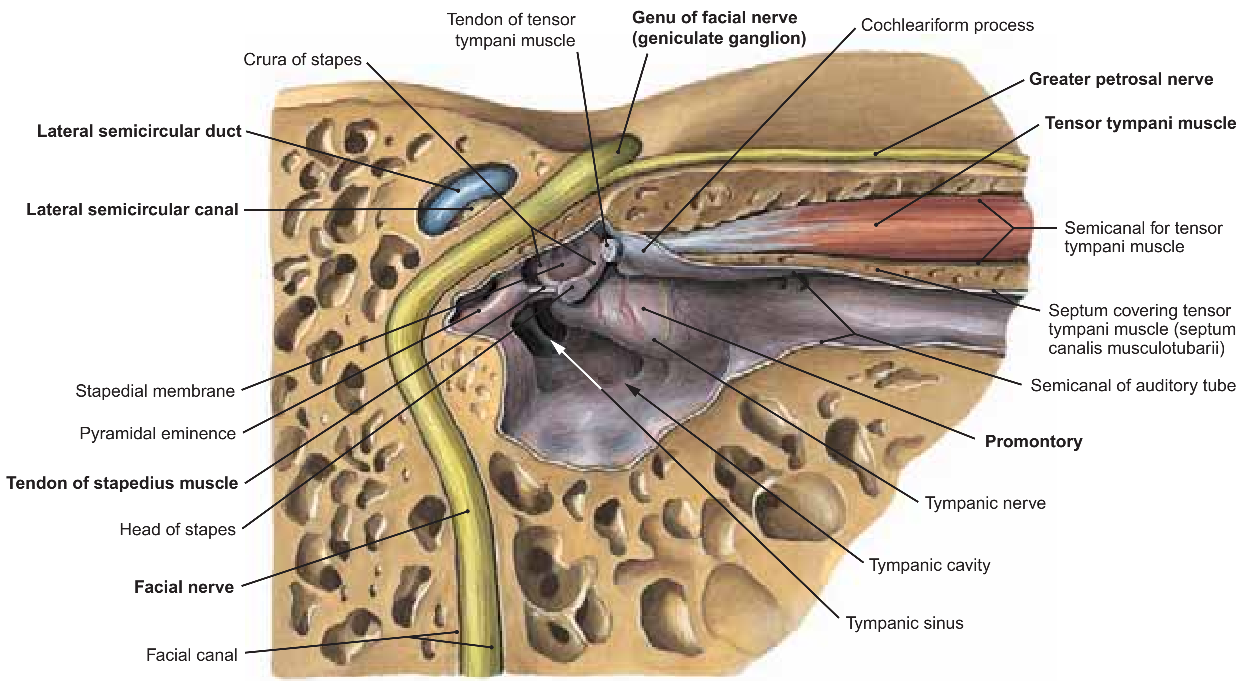


FIGURE 683.2 Facial Nerve in the Facial Canal and Its Greater Petrosal Branch

NOTE: The greater petrosal nerve branches from the facial nerve at the genu (90-degree turn). It carries preganglionic parasympathetic fibers and taste fibers from the palate.

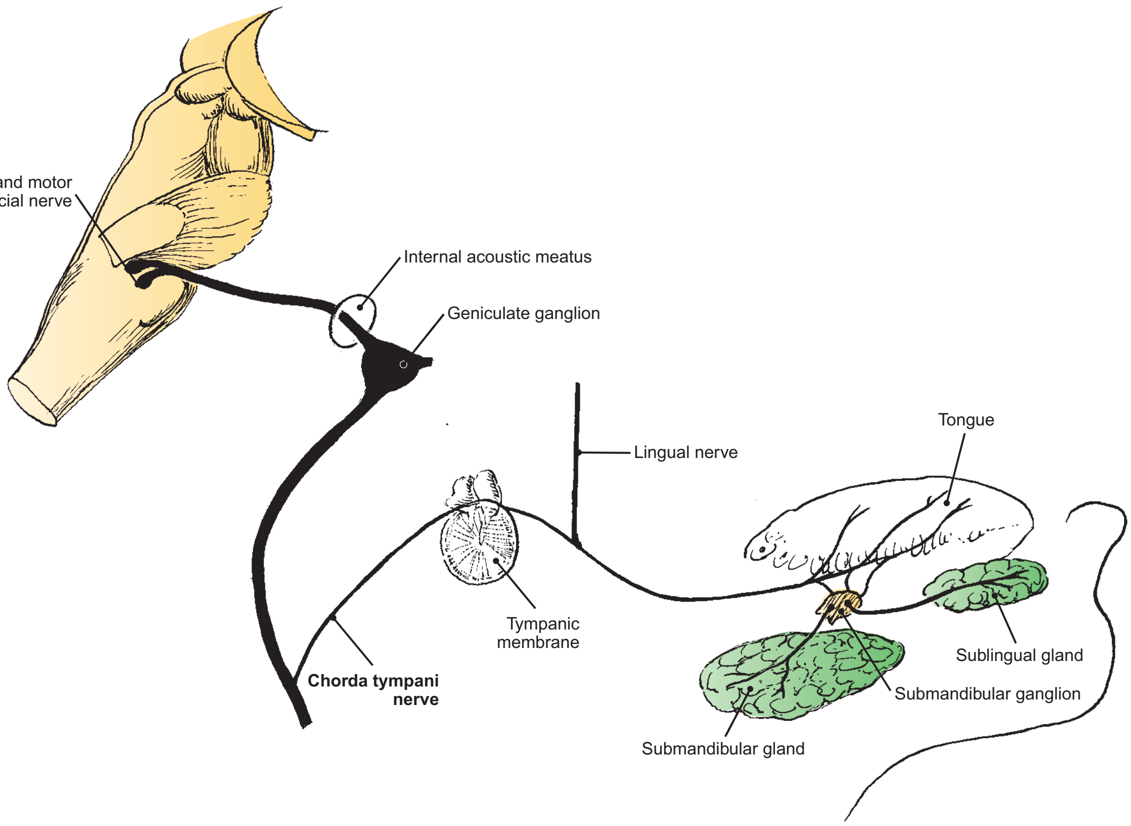


FIGURE 684.1 Diagrammatic Representation of the Facial Nerve and Its Chorda Tympani Branch

NOTE: (1) The facial nerve descends in the facial canal and at the level of the tympanic cavity it gives off the chorda tympani nerve that pierces the bone to enter the tympanic cavity.

(2) This nerve carries visceromotor (preganglionic parasympathetic) nerve fibers that synapse in the submandibular ganglion to supply the submandibular and sublingual glands. It also carries special sensory taste fibers from the anterior two-thirds of the tongue.

(3) Within the tympanic cavity the nerve courses over the medial surface of the tympanic membrane adjacent to the superior border of the membrane.

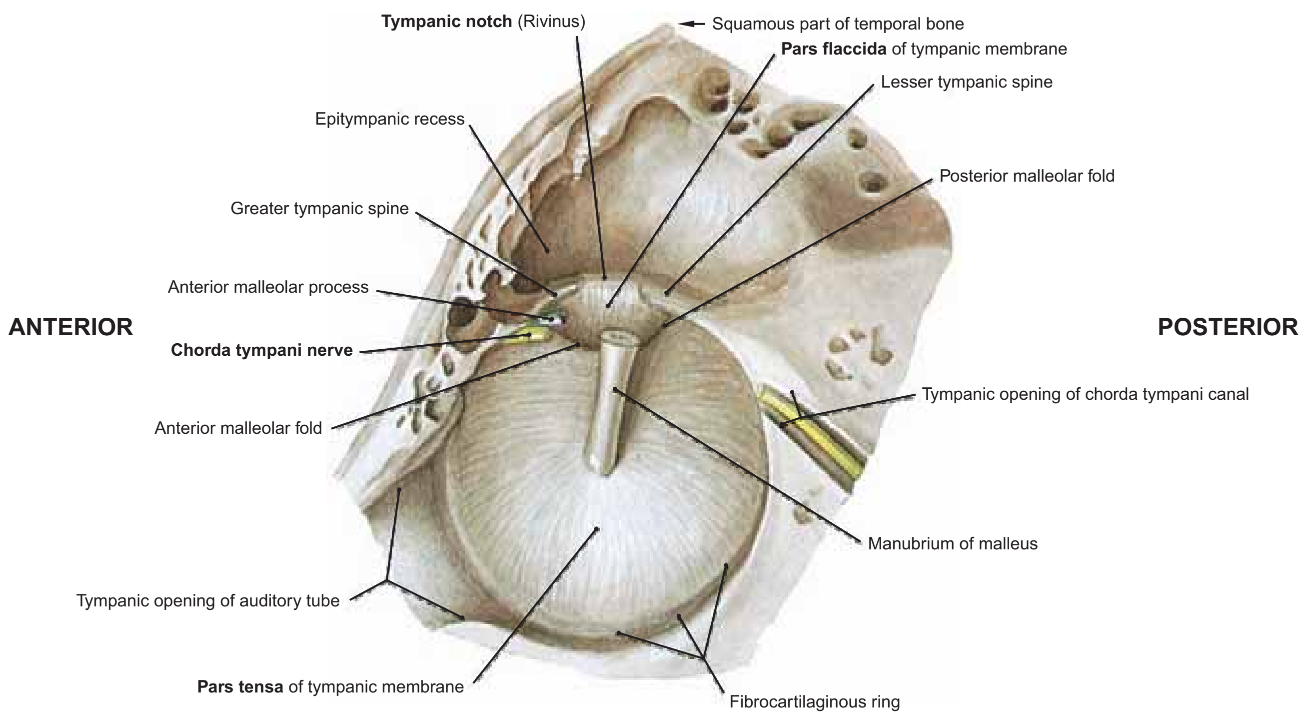


FIGURE 684.2 Medial View of the Tympanic Membrane in the Middle Ear Cavity

NOTE: The chorda tympani nerve enters the posterior aspect of the tympanic cavity and after crossing the tympanic membrane, it leaves the cavity anteriorly to enter the superior aspect of the deep face (see Fig. 566).

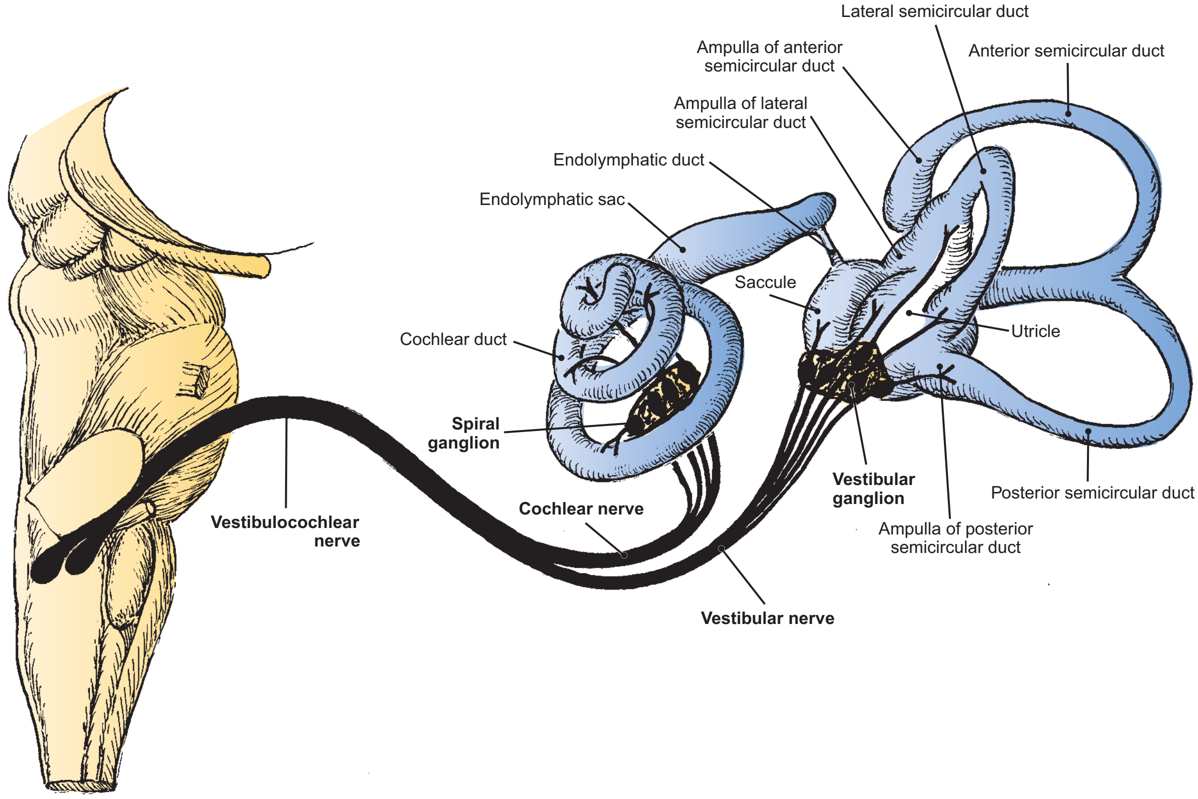


FIGURE 685.1 Vestibulocochlear Nerve (CN VIII)

NOTE: (1) The **spiral organ of Corti** within the internal ear contains the receptor cells for the special sense of hearing. These receptors, called **hair cells**, are in the **cochlear duct,** and they are innervated by the peripheral processes of sensory neurons whose cell bodies are in the **spiral ganglion.** The central processes of these neurons form the **cochlear nerve.**

(2) The **vestibular apparatus** of the eighth cranial nerve consists of three semicircular canals, the utricle, the saccule, receptors within these structures, and the neurons in the **vestibular ganglion.** These neurons send peripheral processes to these receptor cells and their central processes to the brain by way of the **vestibular nerve.**

(3) The cochlear and vestibular nerves join to form the **vestibulocochlear** or **eighth cranial nerve.**

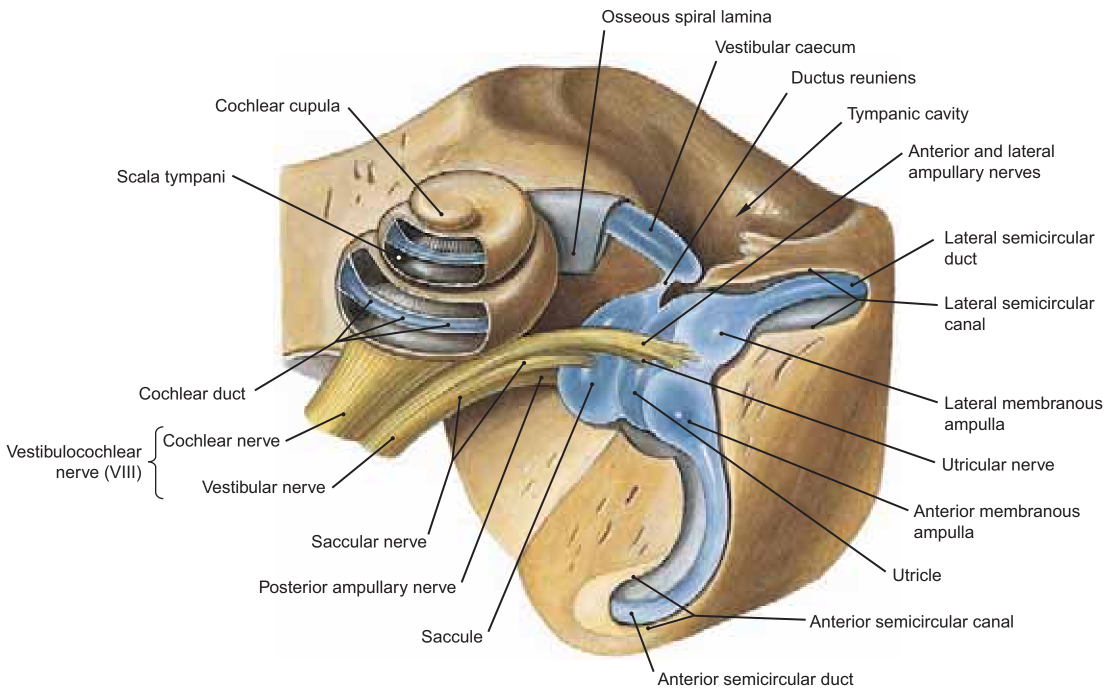


FIGURE 685.2 Right Vestibulocochlear Nerve, the Cochlea, and the Membranous Labyrinth of the Internal Ear

NOTE: (1) The anterior, lateral, and posterior **ampullary nerves** of the semicircular canals and the delicate **saccular** and **utricular nerves** all join to form the **vestibular nerve.**

(2) The fibers of the cochlear nerve receive input from the cochlear receptor cells in the **spiral organ of Corti.**

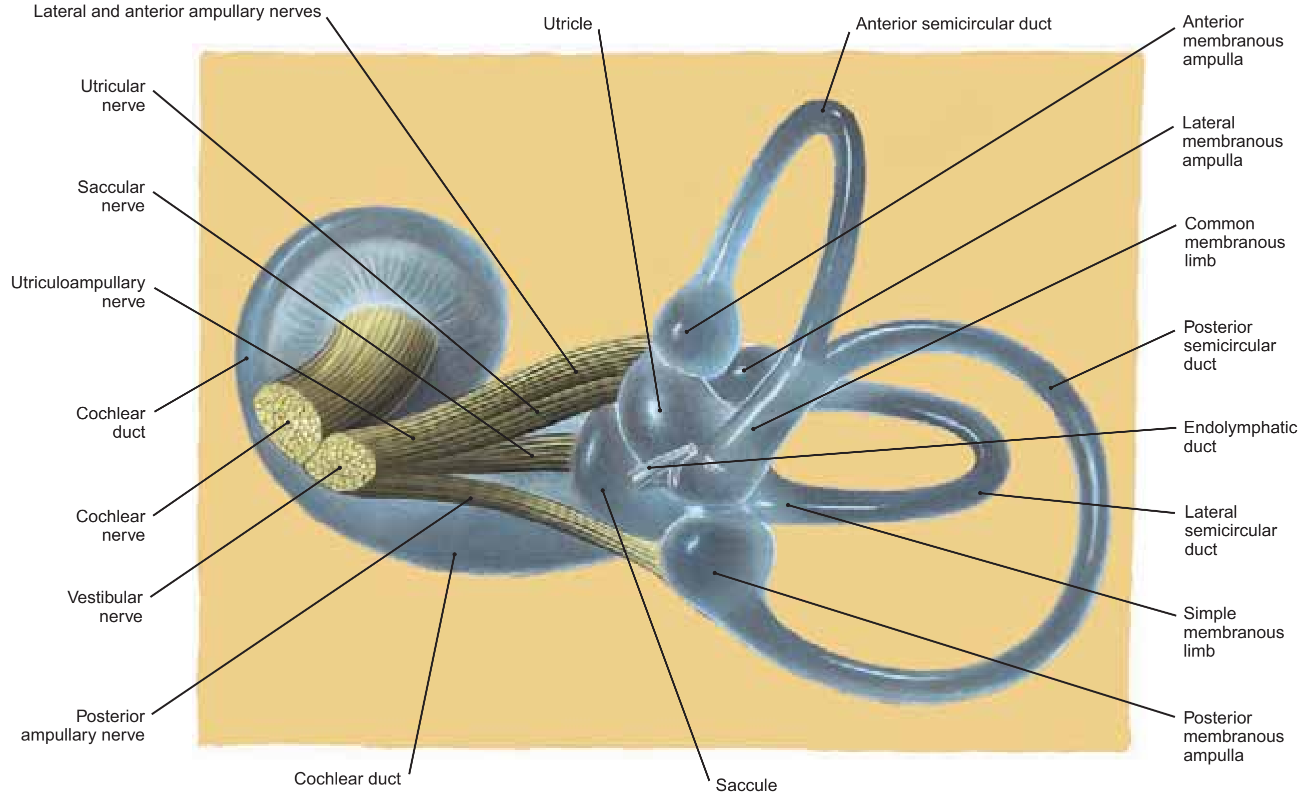


FIGURE 686.1 Membranous Labyrinth, the Organ of Corti, and the Vestibular and Cochlear Nerves

NOTE: (1) The vestibular nerve is the nerve of equilibrium, and because of its connections in the brain, sensory input from this nerve is able to alter eye movements and movements of the head and body that might counteract a loss of balance in an attempt to prevent a fall and thereby maintain equilibrium.

(2) The membranous labyrinth lies within the walls of the bony or osseous labyrinth.

(3) The receptors within the saccule and utricle are able to sense the position of the head with respect to gravity and are sometimes called the **static labyrinthine receptors.** These receptors (**maculae**) contain ciliated hair cells with a gelatinous substance over them and small crystals (**otoliths**) within the gel; since they react to head position in relationship to gravity, they are considered the organ of **static balance**.

(4) The receptors on the ampullae of the semicircular canals are related to kinetic balance and are stimulated by angular acceleration of the head. These are referred to as organs of **kinetic balance.**

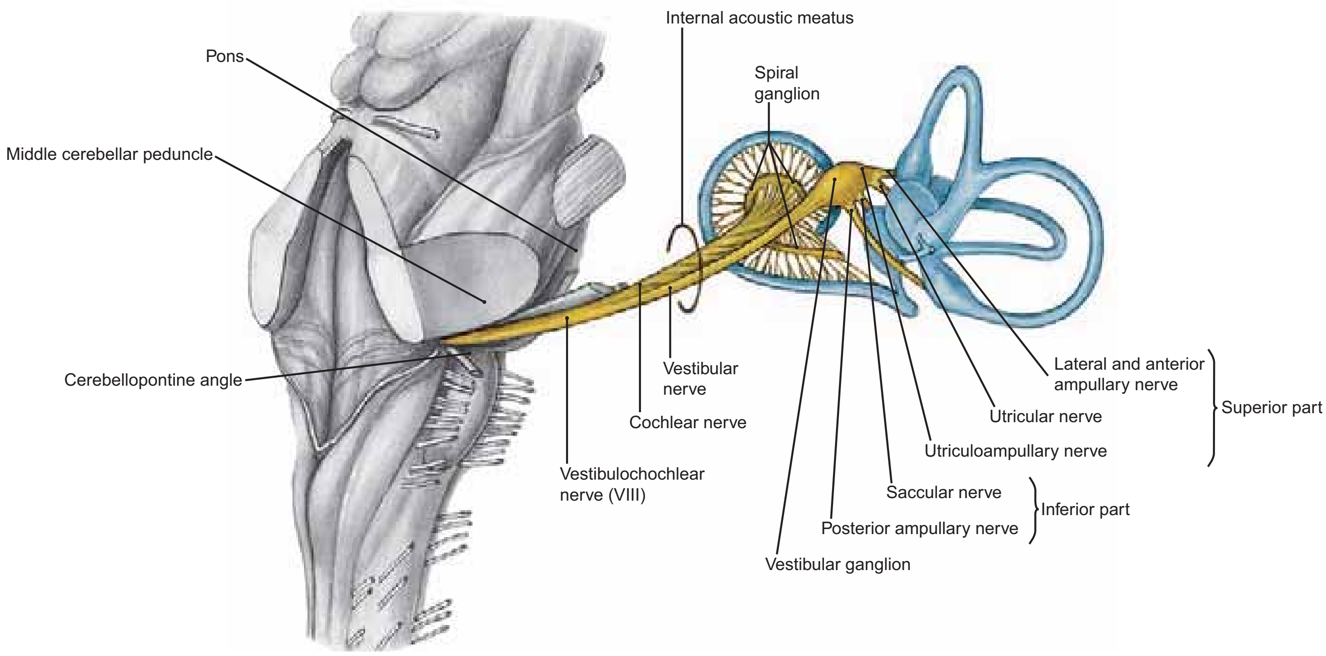
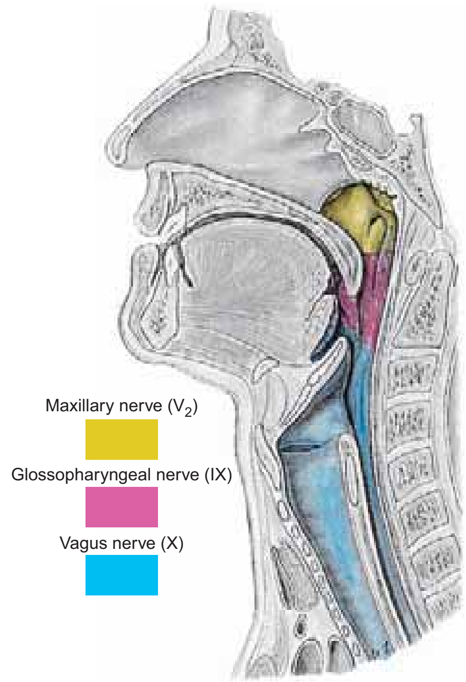


FIGURE 686.2 Diagrammatic Schema of the Vestibulocochlear Nerve

NOTE: The vestibulocochlear and facial nerves attach to the brain at the cerebellopontine angle just posterior to the middle cerebellar peduncle.

FIGURE 687.1 Sensory Innervation of the Pharynx ▶

NOTE: The glossopharyngeal nerve supplies the oral pharynx with sensory innervation and is the afferent limb of the gag reflex.



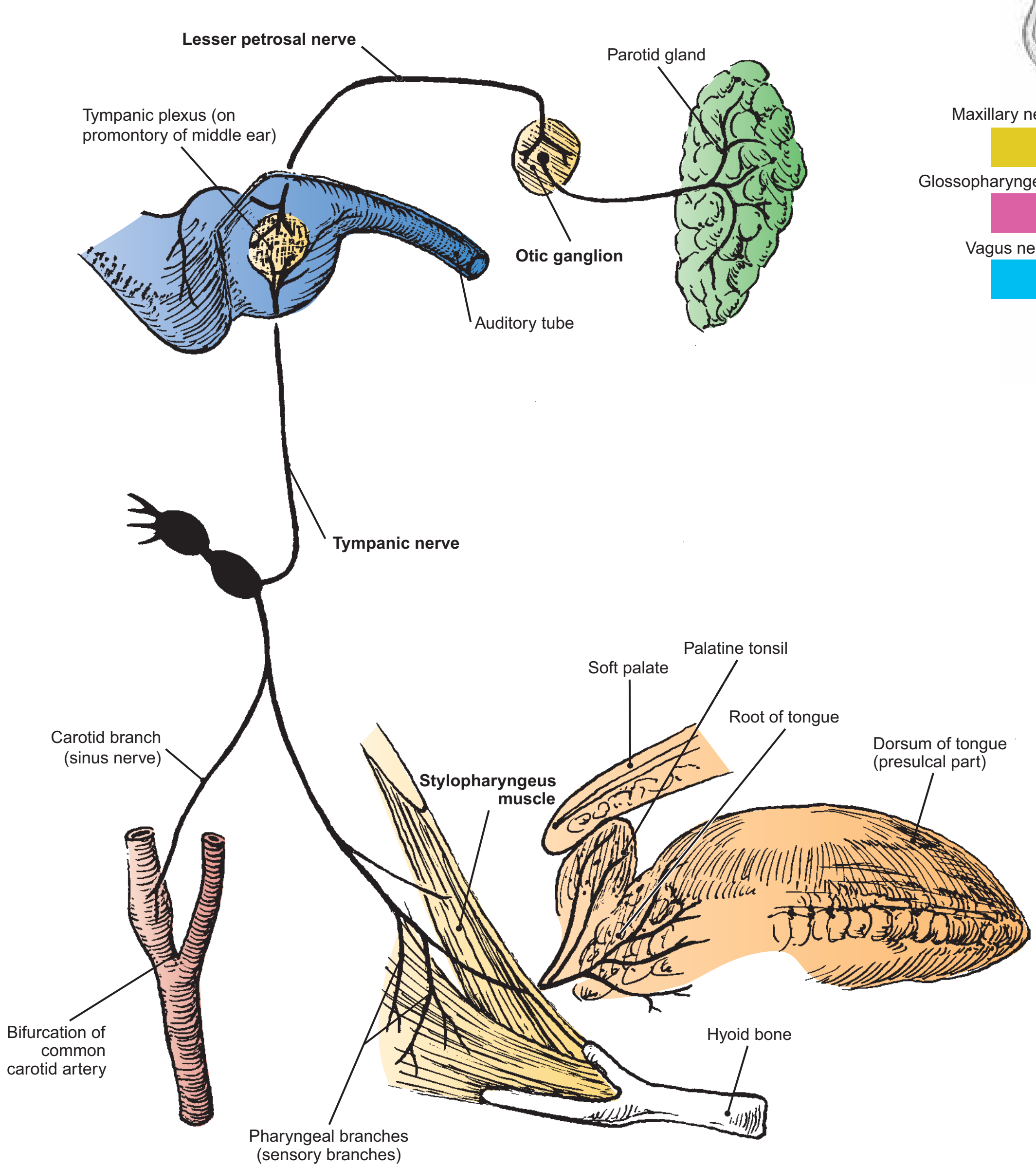


FIGURE 687.2 Diagrammatic Representation of the Glossopharyngeal Nerve

NOTE: (1) The glossopharyngeal nerve supplies one voluntary muscle, the **stylopharyngeus.** This muscle (on both sides) elevates the pharynx during the act of swallowing. After supplying this muscle, the nerve supplies the posterior third of the tongue with both general sensory fibers and fibers of the special sense of **taste.**

(2) The glossopharyngeal nerve also has preganglionic parasympathetic nerve fibers that ascend in the **tympanic branch** to the middle ear and divide to form the **tympanic plexus** over the surface of the promontory.

(3) From this plexus, the fibers reassemble to form the **lesser petrosal nerve**, which enters the base of the skull on the superior surface of the temporal bone. It leaves the skull base through a small foramen adjacent the greater petrosal nerve and passes through the foramen ovale to join the **otic ganglion.**

(4) From the otic ganglion, postganglionic parasympathetic fibers join the **auriculotemporal nerve** and innervate the parotid gland.

(5) The **pharyngeal branches** of the glossopharyngeal nerve supply sensory innervation to the mucosa of the oropharynx and participate in the **gag reflex** (see Fig. 687.1).

(6) The **carotid branch** contains visceral afferent fibers and with the vagus nerve supplies the carotid body.

(After Grant, J.C.B., Atlas of Anatomy, 6th Edition. Baltimore: Williams & Wilkins, 1972).

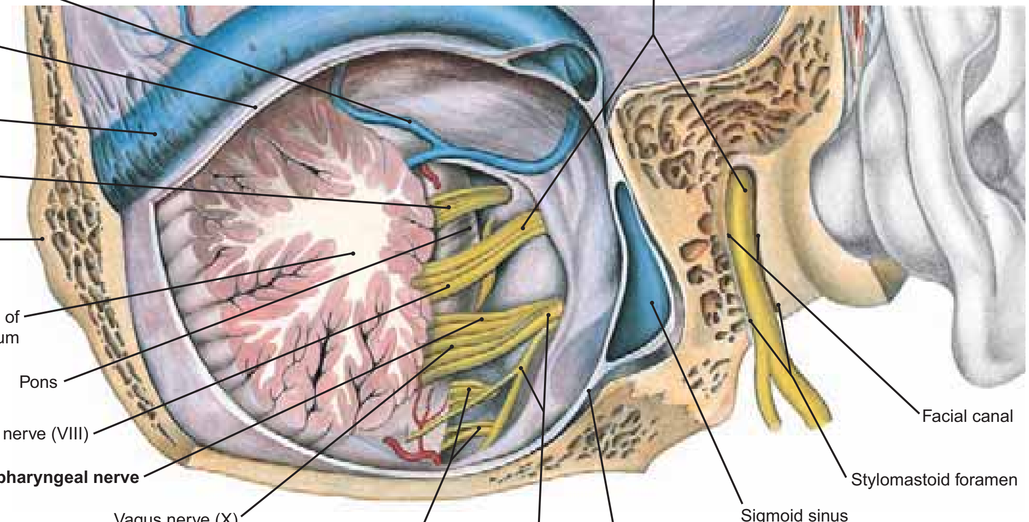


FIGURE 688.1 Glossopharyngeal Nerve Coursing from the Skull Base through the Jugular Foramen

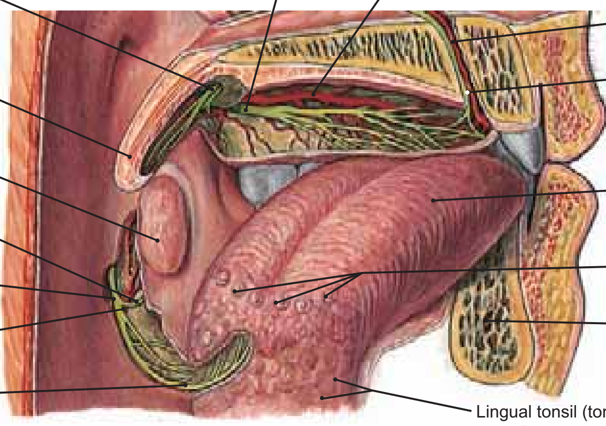


FIGURE 688.2 Glossopharyngeal Nerve in the Oropharynx and Penetrating the Posterior Third of the Tongue

NOTE: At this site the glossopharyngeal nerve is sensory and carries general sensory and special sensory fibers (taste) to the posterior third of the tongue.

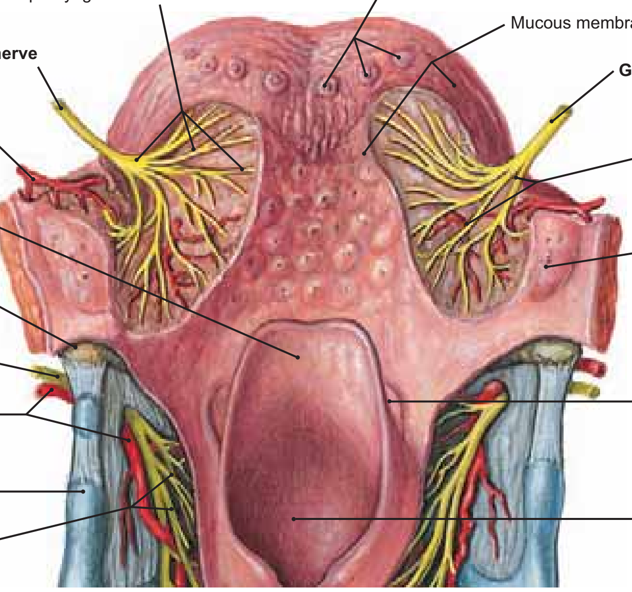


FIGURE 688.3 Glossopharyngeal Nerve and Its Lingual Branches to the Posterior Tongue and to the Vallate Papillae

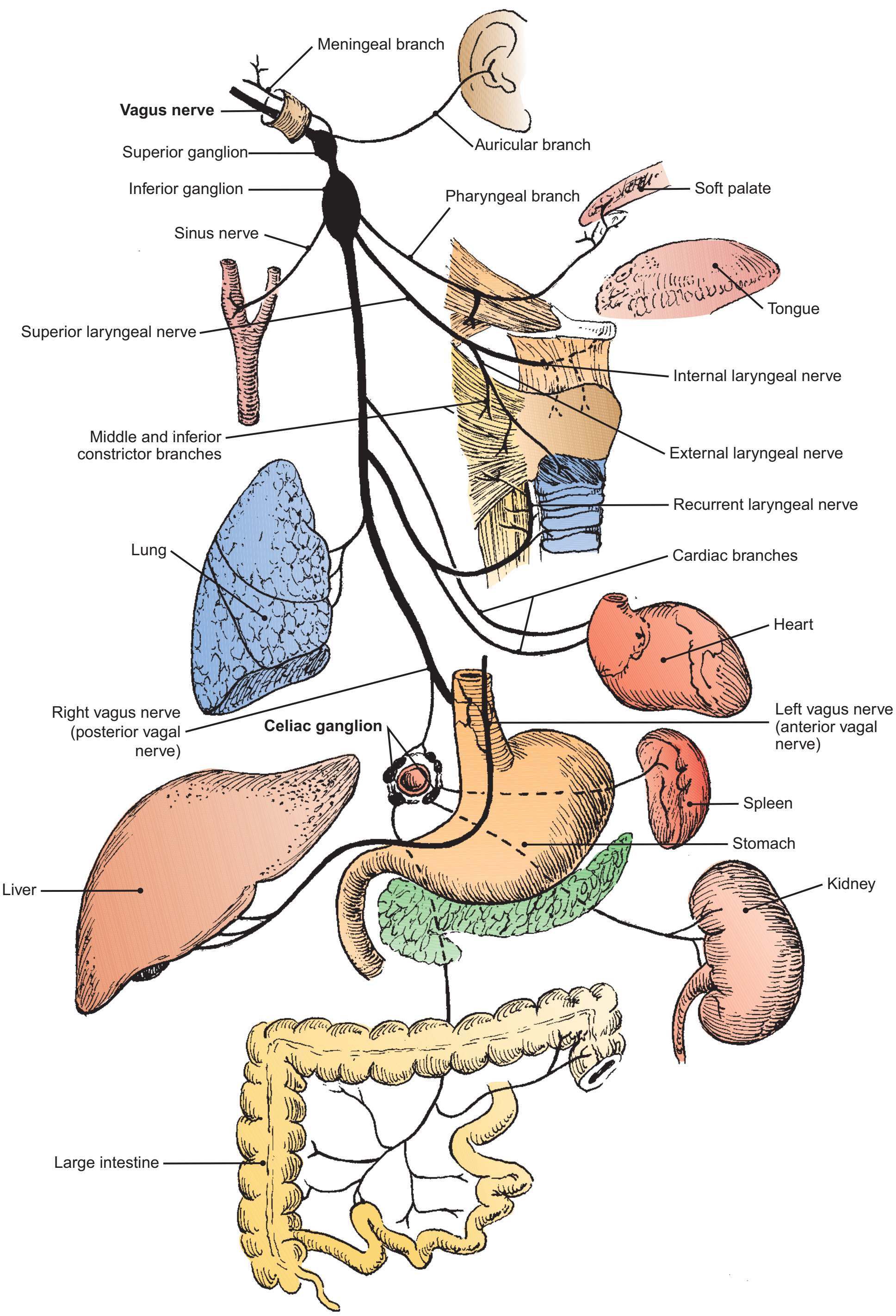


FIGURE 689 Diagrammatic Representation of the Vagus Nerve

NOTE: (1) The vagus nerve contains both visceromotor and viscerosensory fibers as well as somatomotor fibers. The latter come from the medullary part of the accessory nerve, and they supply voluntary muscles in the larynx, pharynx, and soft palate.

(2) The visceromotor fibers are preganglionic parasympathetic fibers that innervate the organs in the neck, the thorax, and the abdomen as far as the splenic flexure of the transverse colon.

(3) The vagus also contains a few somatosensory fibers in its **auricular branch** that supply some skin of the external ear; other sensory fibers are in the **superior laryngeal** and **recurrent laryngeal** branches that supply the internal mucosa of the larynx. In addition, the vagus contains visceral afferent fibers from organs in the neck, thorax, and abdomen. All of these sensory fibers have their cell bodies in the **superior and inferior ganglia** of the vagus.

(4) Visceral afferent fibers in the **carotid sinus** nerve are from pressoreceptor cells that respond to blood pressure changes.

(5) The **pharyngeal branch** of the vagus supplies motor fibers to the pharyngeal constrictor muscles as well as to the muscles of the soft palate (except the tensor veli palatini muscle). These motor fibers in the vagus are from the accessory nerve and are often described as 11 via 10 (i.e., accessory via the vagus).

(6) The **superior laryngeal branch** has an **external branch** supplying the cricothyroid muscle and an **internal branch** to the mucosa of the upper larynx. All other muscles of the larynx are supplied by the recurrent laryngeal branch.

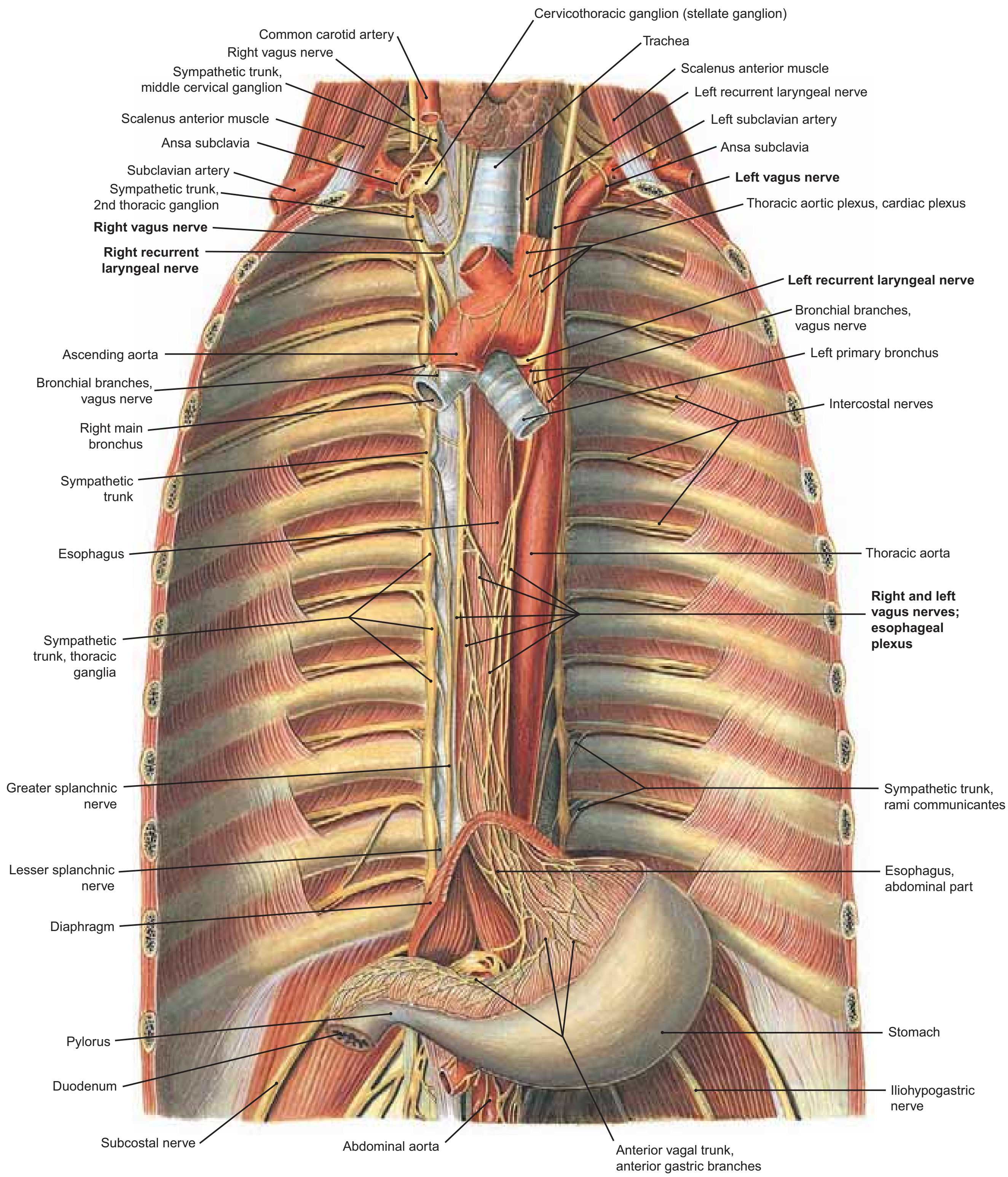


FIGURE 690 Vagus Nerve in the Thorax

NOTE: (1) The vagus nerves enter the superior mediastinum, give off the recurrent laryngeal nerves, and then course medially toward the bronchi, where they form bronchial plexuses, and then toward the esophagus.

(2) The **left vagus nerve** splits into branches and forms the **anterior** esophageal plexus, while the **right vagus nerve** forms the **posterior** esophageal plexus.

(3) The fibers of these plexuses enter the abdomen through the esophageal hiatus. The left vagal fibers become the **anterior gastric branches** and the right vagal fibers become the **posterior gastric branches.** The anterior branches supply the anterosuperior aspect of the stomach, whereas the posterior branches supply the posteroinferior aspect of the stomach.

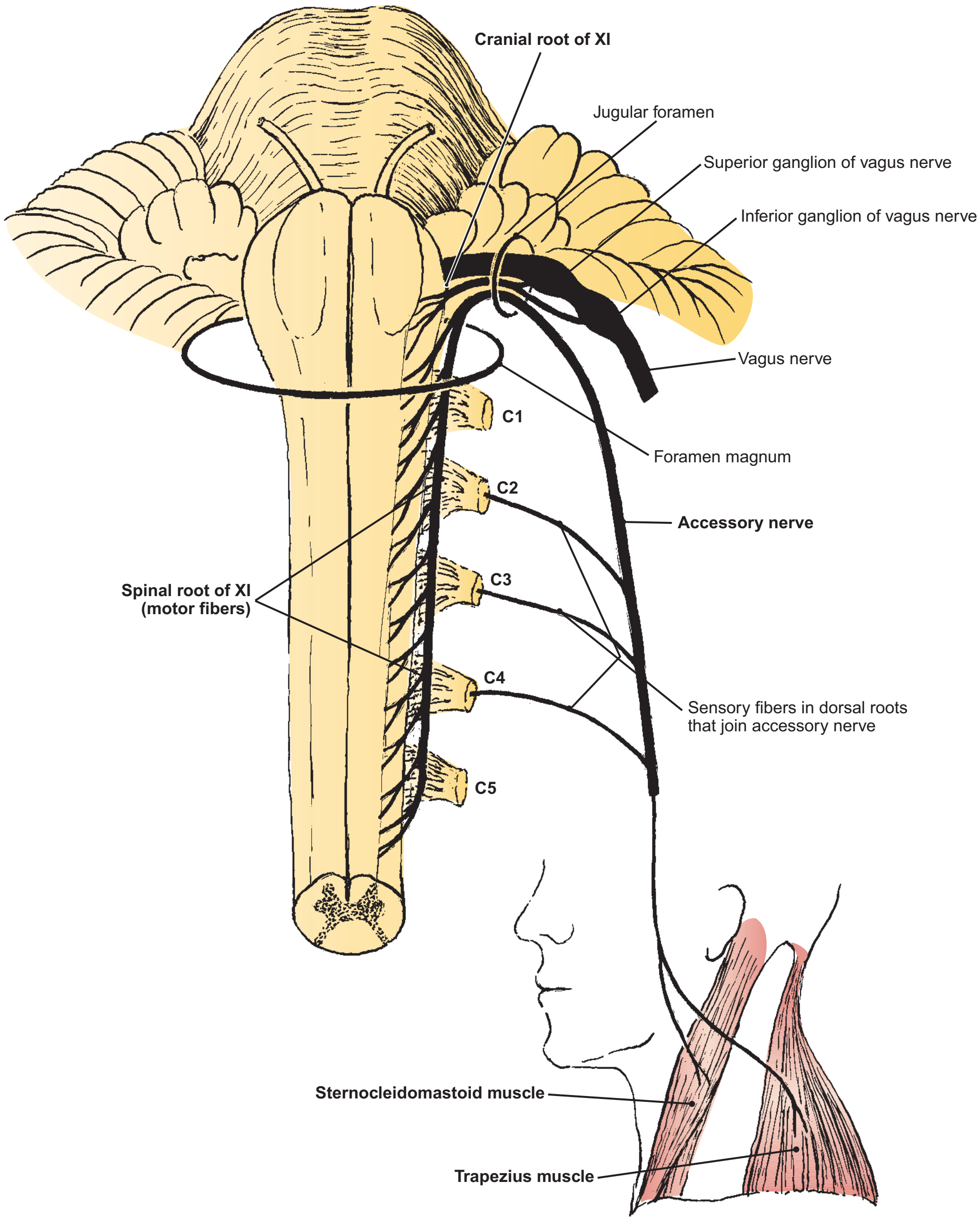


FIGURE 691 Diagrammatic Representation of the Accessory Nerve (XI Cranial Nerve)

NOTE: (1) The **accessory nerve** (sometimes called the spinal accessory nerve) is formed by the brief union of fibers that originate in the spinal cord and others that emerge from the medulla oblongata.

(2) Motor nerve fibers leave the spinal cord from cervical segmental levels down as far as C5. The fibers from these upper cervical segments join to form a single trunk that ascends in the spinal canal and enters the cranial cavity through the foramen magnum. This constitutes the **spinal root**.

(3) Within the cranial cavity the spinal root is joined by the smaller **cranial root**, which consists of five or six delicate rootlets that leave the medulla oblongata just inferior to the rootlets of the vagus nerve.

(4) The cranial root briefly joins the spinal root and then **separates from it and merges with the rootlets of the vagus nerve**, with which it descends through the jugular foramen.

(5) The spinal root (now consisting of the original spinal motor fibers) turns inferiorly and also leaves the cranial cavity through the jugular foramen to enter the neck, where it supplies the **sternocleidomastoid muscle,** and crosses the posterior triangle to innervate the **trapezius muscle**.

(6) The medullary fibers that join the vagus nerve become distributed in its pharyngeal and recurrent laryngeal branches to supply striated fibers of the pharyngeal and laryngeal muscles and the muscles of the soft palate (except for the tensor veli palatini muscle).

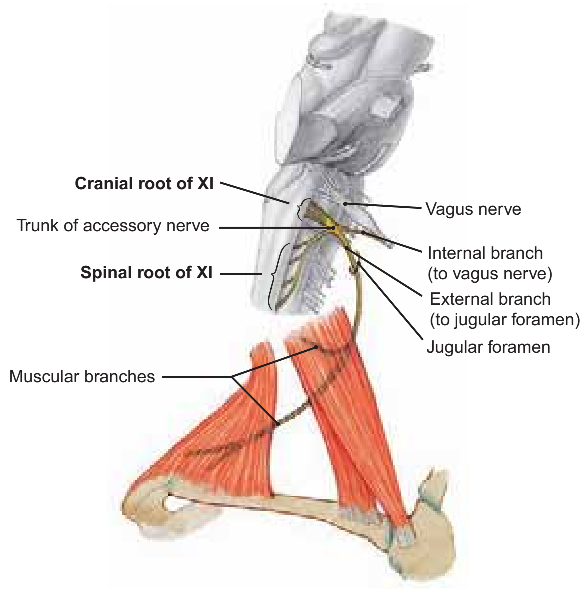


FIGURE 692.1 Schema of the Accessory Nerve

NOTE: (1) The spinal and cranial roots of the accessory nerve join for a short distance within the cranial cavity.

(2) The "internal branch" (cranial root) joins the vagus nerve, and the "external branch" (spinal root) descends in the neck as the **accessory nerve** to supply motor innervation to the **sternocleidomastoid** and the **trapezius** muscles.

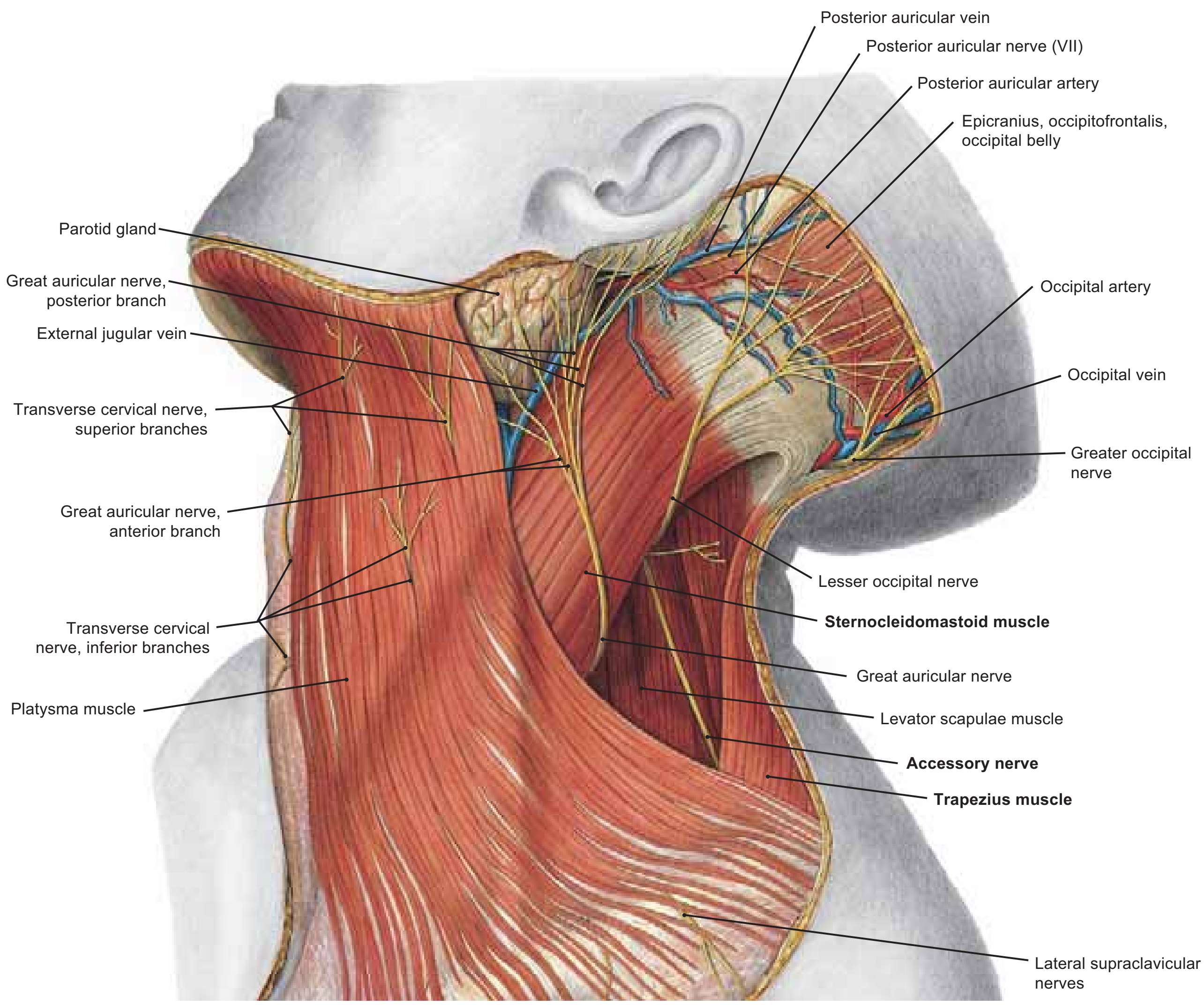


FIGURE 692.2 Accessory Nerve Traversing the Posterior Triangle of the Neck

NOTE: (1) Distal to the jugular foramen, the accessory nerve descends in the neck deep to the **sternocleidomastoid muscle** as it innervates it. Then it crosses the posterior triangle of the neck to the deep surface of the **trapezius muscle**, which it also supplies.

(2) Sensory fibers from the **C3, C4,** and **C5** segments also join the nerve. Some of these supply proprioceptors that allow the individual to know the positions of the head and shoulder as the muscles act.

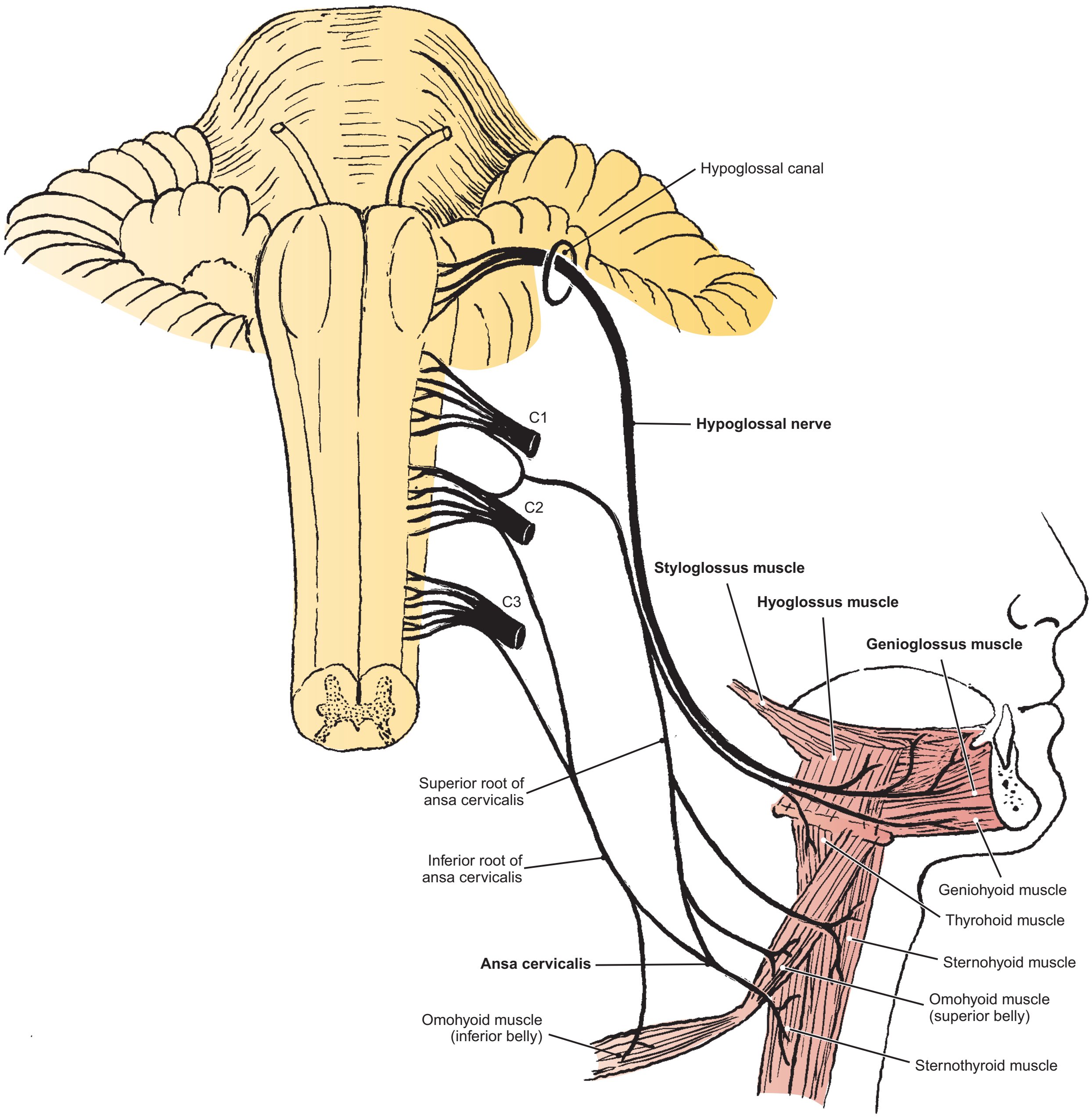


FIGURE 693 Hypoglossal Nerve (Diagrammatic Representation)

NOTE: (1) The hypoglossal nerve is the motor nerve of the tongue. Its fibers emerge from the medulla oblongata in a line with the oculomotor, trochlear, and abducens nerves and the anterior roots (motor) of the spinal cord.

(2) This nerve supplies all the **intrinsic muscles** (longitudinal, transverse, and vertical) of the tongue and all of the **extrinsic muscles** (except the palatoglossus) that move the tongue (i.e., the **styloglossus, hyoglossus,** and **genioglossus).**

(3) The palatoglossus muscle is innervated by the pharyngeal branch of the vagus and forms the anterior pillar of the fauces in the oral cavity. It is the only muscle with the term "glossus" in its name not supplied by the hypoglossal nerve.

(4) In the upper neck, the hypoglossal nerve takes a 270-degree turn deep to the posterior belly of the digastric muscle and enters the oral cavity between the hypoglossus and mylohyoid muscles (see Fig. 694.2).

(5) The C1, C2, and C3 nerves emerge from the spinal cord and form two descending nerve trunks: the **superior** and **inferior roots** of the **ansa cervicalis**. The superior root (C1 and C2 fibers) courses with the hypoglossal nerve for a short distance, *but they are NOT hypoglossal fibers.*

(6) The superior root (C1 and C2) joins the inferior root (C2 and C3) and together they join as a loop called the **ansa cervicalis.** From this cervical nerve formation the strap muscles of the neck are innervated.

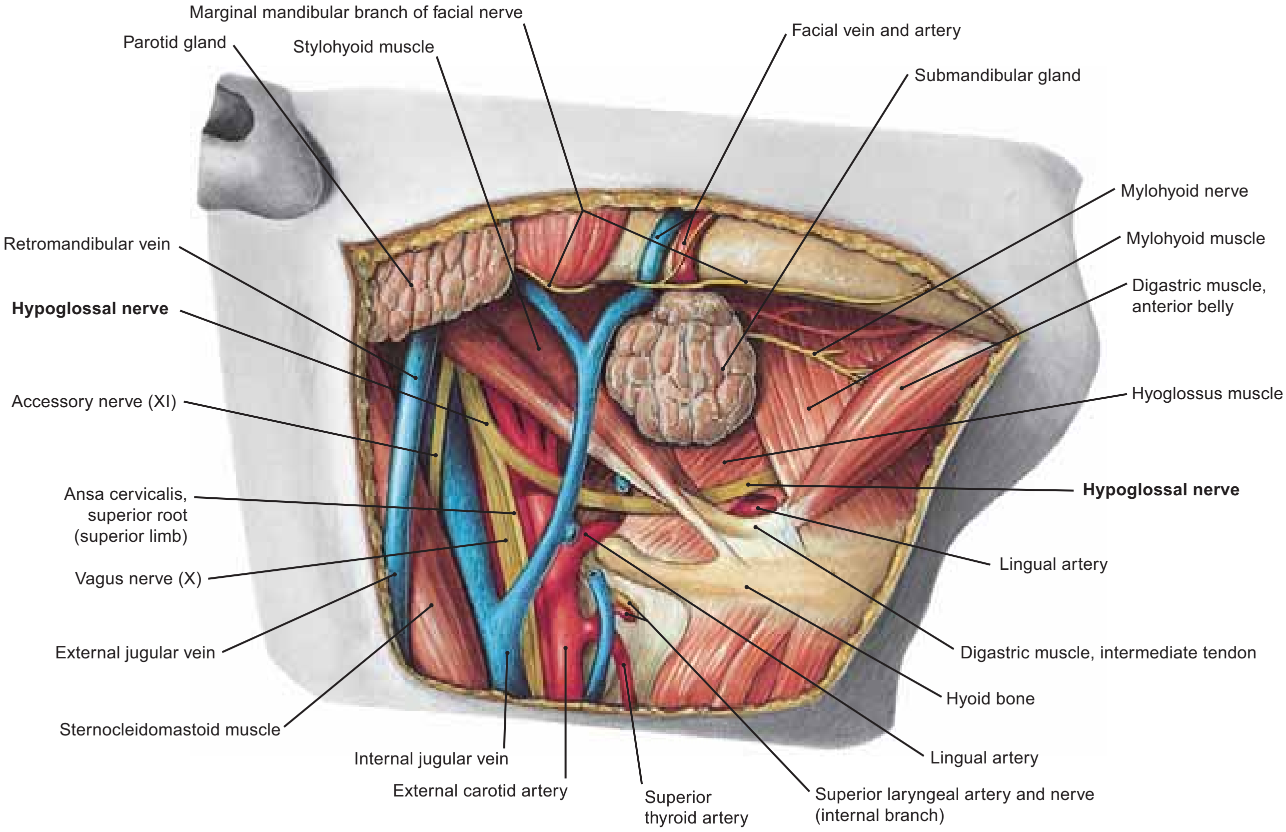


FIGURE 694.1 Hypoglossal Nerve in the Superior Neck Region

NOTE that in the submandibular triangle, the hypoglossal nerve courses superficial to the hyoglossus muscle and deep to the mylohyoid muscle to enter the oral cavity

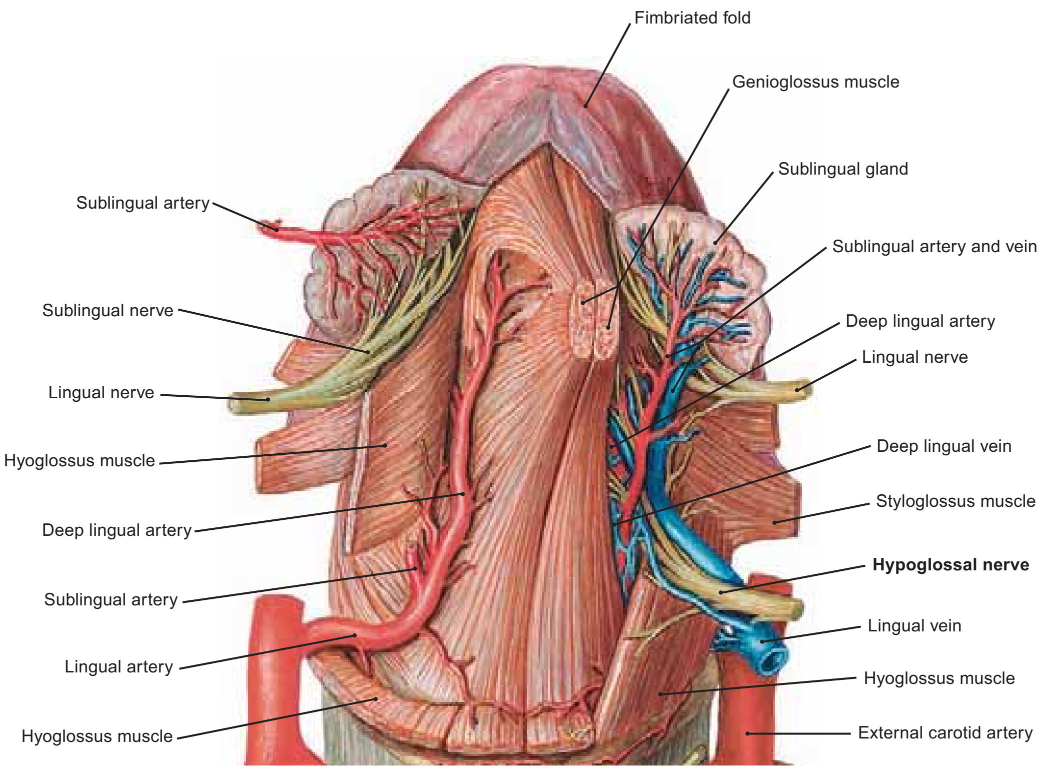


FIGURE 694.2 Hypoglossal Nerve as It Enters the Tongue (Inferior View)

NOTE that when the hypoglossal nerve is injured, the muscles on that side of the tongue are denervated. When the patient is asked to protrude the tongue, it is directed to the paralyzed side because the innervated muscles on the normal side act unopposed.

Index

Numbers refer to Plates.
Numbers in **boldface** type indicate main references.
*Muscle chart describes action, innervation, insertion, and origin.

A

B

C

G

H

I

M

N

Q

R

S

T

U

V

W

X

Z