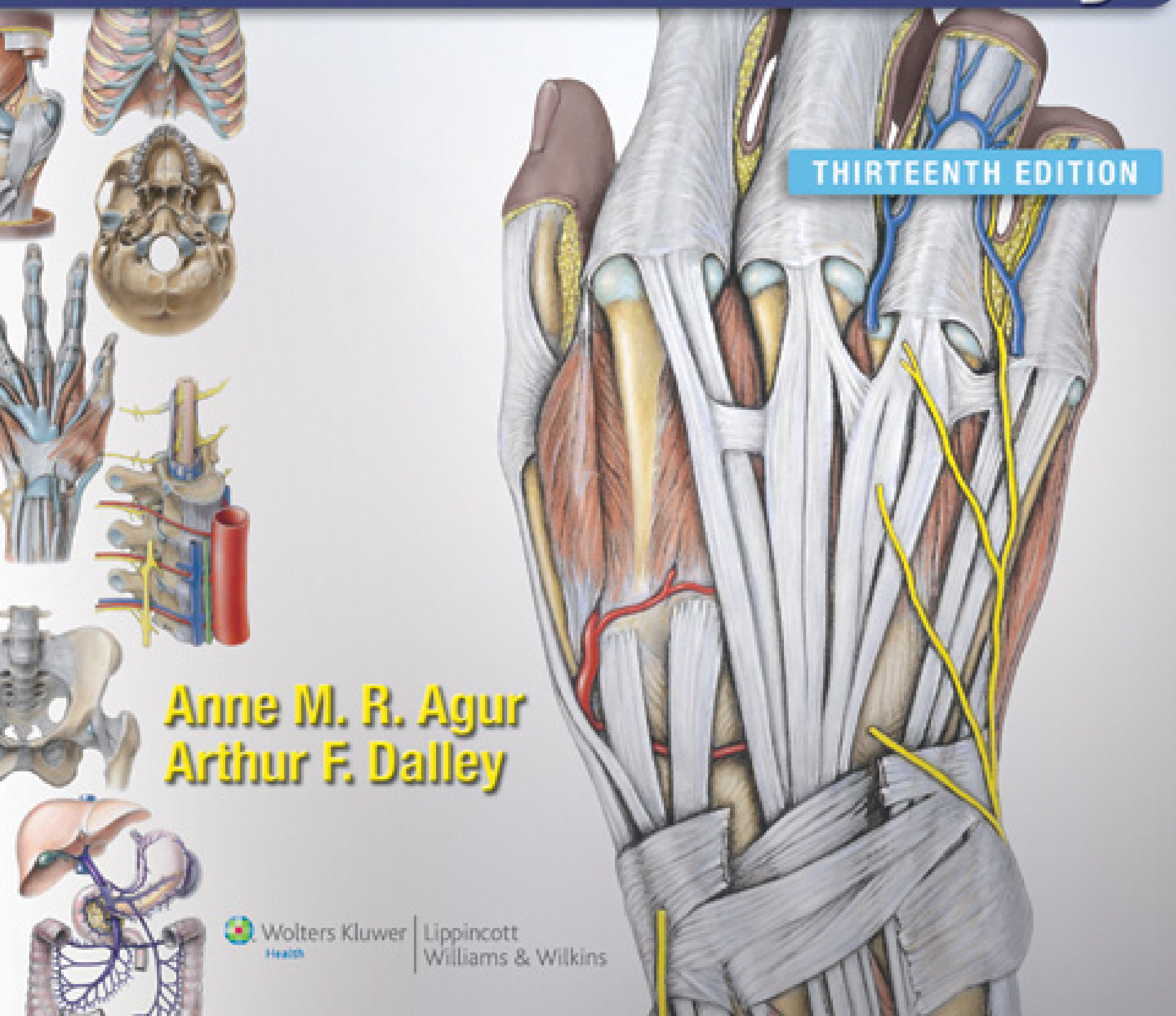
Grant's Atlas of Anatomy

THIRTEENTH EDITION



Anne M. R. Agur
Arthur F. Dalley

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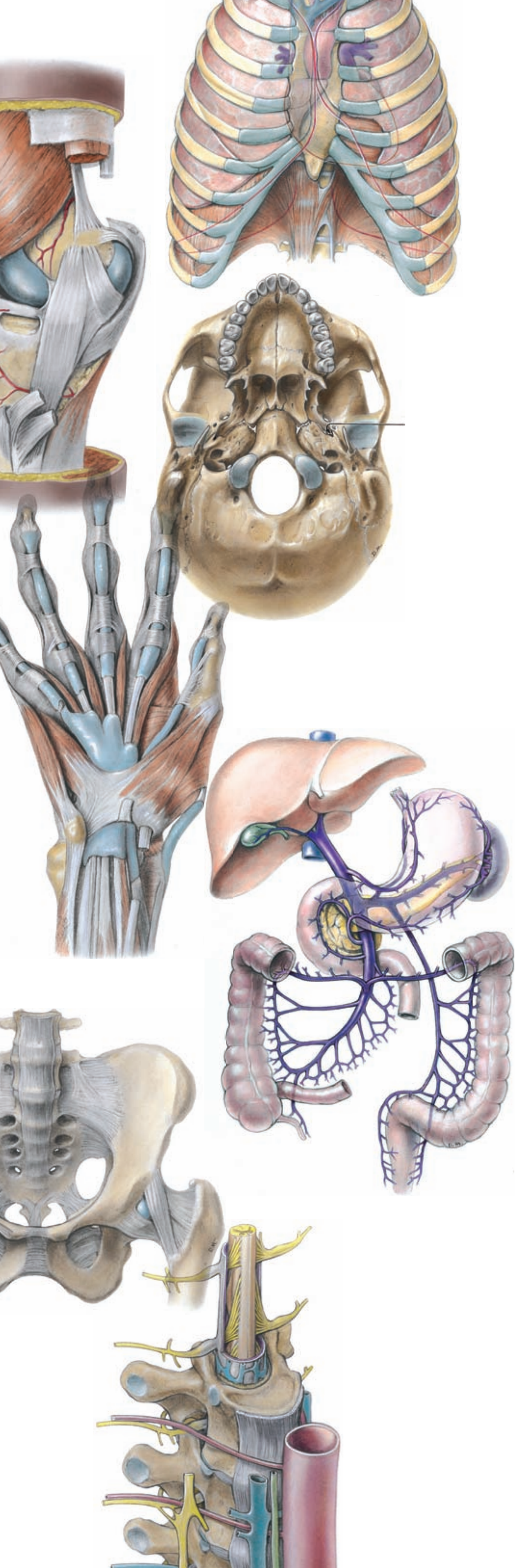

Grant's Atlas of Anatomy

THIRTEENTH EDITION

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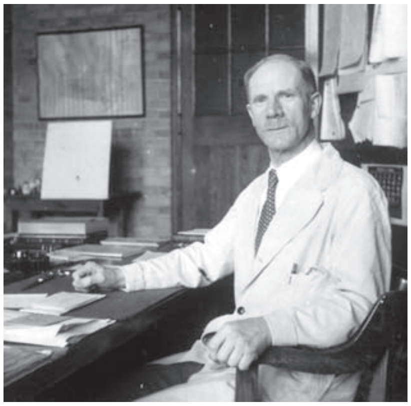
To my husband Enno and my children Erik and Kristina
for their support and encouragement
(A.M.R.A.)

To Muriel
My bride, best friend, counselor, and mother of our sons;
To my family
Tristan, Lana, Elijah, Finley, Sawyer,
Denver, and Skyler
With great appreciation for their support, humor, and patience
(A.F.D.)

And with sincere appreciation for the anatomical donors
Without whom our studies would not be possible

DR. JOHN CHARLES BOILEAU GRANT • 1886–1973

by Dr. Carlton G. Smith, M.D., Ph.D. (1905–2003)
Professor Emeritus, Division of Anatomy, Department of Surgery
Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada



Dr. J.C. Boileau Grant in his office, McMurrich Building, University of Toronto, 1946. Through his textbooks, Dr. Grant made an indelible impression on the teaching of anatomy throughout the world. *(Courtesy of Dr. C. G. Smith.)*

The life of Dr. J.C. Boileau Grant has been likened to the course of the seventh cranial nerve as it passes out of the skull: complicated, but purposeful.[1] He was born in the parish of Lasswade in Edinburgh, Scotland, on February 6, 1886. Dr. Grant studied medicine at the University of Edinburgh from 1903 to 1908. Here, his skill as a dissector in the laboratory of the renowned anatomist, Dr. Daniel John Cunningham (1850–1909), earned him a number of awards.

Following graduation, Dr. Grant was appointed the resident house officer at the Infirmary in Whitehaven, Cumberland. From 1909 to 1911, Dr. Grant demonstrated anatomy in the University of Edinburgh, followed by two years at the University of Durham, at Newcastle-on-Tyne in England, in the laboratory of Professor Robert Howden, editor of *Gray's Anatomy*.

With the outbreak of World War I in 1914, Dr. Grant joined the Royal Army Medical Corps and served with distinction. He was mentioned in dispatches in September 1916, received the Military Cross in September 1917 for "conspicuous gallantry and devotion to duty during attack," and received a bar to the Military Cross in August 1918.[1]

In October 1919, released from the Royal Army, he accepted the position of Professor of Anatomy at the University of Manitoba in Winnipeg, Canada. With the frontline medical practitioner in mind, he endeavored to "bring up a generation of surgeons who knew exactly what they were doing once an operation had begun."[1] Devoted to research and learning, Dr. Grant took interest in other projects, such as performing anthropometric studies of Indian tribes in northern Manitoba during the 1920s. In Winnipeg, Dr. Grant met Catriona Christie, whom he married in 1922.

Dr. Grant was known for his reliance on logic, analysis, and deduction as opposed to rote memory. While at the University of Manitoba, Dr. Grant began writing *A Method of Anatomy, Descriptive and Deductive,* which was published in 1937.[2]

In 1930, Dr. Grant accepted the position of Chair of Anatomy at the University of Toronto. He stressed the value of a "clean" dissection, with the structures well defined. This required the delicate touch of a sharp scalpel, and students soon learned that a dull tool was anathema. Instructive dissections were made available in the Anatomy Museum, a means of student review on which Dr. Grant placed a high priority. Illustrations of these actual dissections are included in *Grant's Atlas of Anatomy*.

The first edition of the *Atlas*, published in 1943, was the first anatomical atlas to be published in North America.[3] *Grant's Dissector* preceded the *Atlas* in 1940.[4]

Dr. Grant remained at the University of Toronto until his retirement in 1956. At that time, he became Curator of the Anatomy Museum in the University. He also served as Visiting Professor of Anatomy at the University of California at Los Angeles, where he taught for 10 years.

Dr. Grant died in 1973 of cancer. Through his teaching method, still presented in the Grant's textbooks, Dr. Grant's life interest—human anatomy—lives on. In their eulogy, colleagues and friends Ross MacKenzie and J. S. Thompson said, "Dr. Grant's knowledge of anatomical fact was encyclopedic, and he enjoyed nothing better than sharing his knowledge with others, whether they were junior students or senior staff. While somewhat strict as a teacher, his quiet wit and boundless humanity never failed to impress. He was, in the very finest sense, a scholar and a gentleman."[1]

PREFACE

This edition of *Grant's Atlas* has, like its predecessors, required intense research, market input, and creativity. It is not enough to rely on a solid reputation; with each new edition, we have adapted and changed many aspects of the *Atlas* while maintaining the commitment to pedagogical excellence and anatomical realism that has enriched its long history. Medical and health sciences education, and the role of anatomy instruction and application within it, continually evolve to reflect new teaching approaches and educational models. The health care system itself is changing, and the skills and knowledge that future health care practitioners must master are changing along with it. Finally, technologic advances in publishing, particularly in online resources and electronic media, have transformed the way students access content and the methods by which educators teach content. All of these developments have shaped the vision and directed the execution of this thirteenth edition of *Grant's Atlas*, as evidenced by the following key features.

Classic "Grant's" images updated for today's students. A unique feature of *Grant's Atlas* is that, rather than providing an idealized view of human anatomy, the classic illustrations represent actual dissections that the student can directly compare with specimens in the lab. Because the original models used for these illustrations were real cadavers, the accuracy of these illustrations is unparalleled, offering students the best introduction to anatomy possible. Over the years and in this edition, we have made many changes to the illustrations to match the shifting expectations of students, adding more vibrant colors and updating the style. All figures were carefully analyzed to ensure that label placement remained effective and that the illustration's relevance was still clear.

Schematic illustrations. Full-color schematic illustrations and orientation figures supplement the dissection figures to clarify anatomical concepts, show the relationships of structures, and give an overview of the body region being studied. The illustrations conform to Dr. Grant's admonition to "keep it simple": extraneous labels were deleted, and some labels were added to identify key structures and make the illustrations as useful as possible to students.

Legends with easy-to-find clinical applications. Admittedly, artwork is the focus of any atlas; however, the *Grant's* legends have long been considered a unique and valuable feature of the *Atlas*. The observations and comments that accompany the illustrations draw attention to salient points and significant structures that might otherwise escape notice. Their purpose is to interpret the illustrations without providing exhaustive description. Readability, clarity, and practicality were emphasized in the editing of this edition. Clinical comments, which deliver practical "pearls" that link anatomic features with their significance in health care practice, appear in blue text within the figure legends. New clinical comments have been added in this edition, providing even more relevance for students searching for medical application of anatomical concepts.

Enhanced diagnostic imaging and surface anatomy. Because medical imaging has taken on increased importance in the diagnosis and treatment of injuries and illnesses, diagnostic images are used liberally throughout the chapters, and a special imaging section appears at the end of each chapter. Over 100 clinically relevant magnetic resonance images (MRIs), computed tomography (CT) scans, ultrasound scans, and corresponding orientation drawings are included in this edition. Labeled surface anatomy photographs with ethnic diversity continue to be an important feature in this new edition.

Updated and improved tables. Tables help students organize complex information in an easy-to-use format ideal for review and study. In addition to muscles, tables featuring nerves, arteries, and other relevant structures are included. The table format in this edition received a substantial update; a consistent color code is used to clearly demarcate columns. Tables are strategically placed on the same page as the illustrations that demonstrate the structures listed in the tables.

Logical organization and layout. The organization and layout of the *Atlas* have always been determined with ease-of-use as the goal. Although the basic organization by body region was maintained in this edition, the order of plates within every chapter was scrutinized to ensure that it is logical and pedagogically effective. Sections within each chapter further organize the region into discrete subregions; these subregions appear as headings on the pages. Readers need only glance at these headings to orient themselves to the region and subregion that the figures on the page belong to. A chapter table of contents comprises the first page of each chapter.

Helpful learning and teaching tools. The thirteenth edition of *Grant's Atlas* offers a wide range of online resources for both the student and the instructor on Lippincott Williams & Wilkins' thePoint site: http://thePoint.lww.com/GrantsAtlas13e. Students have access to an online e-book, an interactive atlas containing all of the atlas images, an interactive question bank, and selected video clips from the best-selling *Acland's Video Atlas of Human Anatomy* collection. For instructors, online ancillaries include an interactive atlas with slideshow and image-export functions as well as an image bank.

We hope that you enjoy using this thirteenth edition of *Grant's Atlas* and that it becomes a trusted partner in your educational experience. We believe that this new edition safeguards the *Atlas's* historical strengths while enhancing its usefulness to today's students.

Anne M.R. Agur
Arthur F. Dalley II

ACKNOWLEDGMENTS

Starting with the first edition of this *Atlas* published in 1943, many people have given generously of their talents and expertise and we acknowledge their participation with heartfelt gratitude. Most of the original carbon-dust halftones on which this book is based were created by Dorothy Foster Chubb, a pupil of Max Brödel and one of Canada's first professionally trained medical illustrators. She was later joined by Nancy Joy, who is Professor Emeritus in the Division of Biomedical Communications, University of Toronto. Mrs. Chubb was mainly responsible for the artwork of the first two editions and the sixth edition; Miss Joy, for those in between. In subsequent editions, additional line and halftone illustrations by Elizabeth Blackstock, Elia Hopper Ross, and Marguerite Drummond were added. In recent editions, the artwork of Valerie Oxorn and the surface anatomy photography of Anne Rayner of Vanderbilt University Medical Center's Medical Art Group have augmented the modern look and feel of the atlas.

Much credit is also due to Charles E. Storton for his role in the preparation of the majority of the original dissections and preliminary photographic work. We also wish to acknowledge the work of Dr. James Anderson, a pupil of Dr. Grant, under whose stewardship the seventh and eighth editions were published.

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THIRTEENTH EDITION

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We would like to thank the hundreds of instructors and students who have over the years communicated via the publisher and directly with the editor their suggestions for how this *Atlas* might be improved. Finally, we would like to acknowledge the reviewers who reviewed previous editions of the *Atlas* as well as the following reviewers who reviewed the twelfth edition and provided expert advice on the development of this edition in particular:

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Leah Phillabaum

We hope that readers and reviewers will find many of their suggestions incorporated into the twelfth edition and will continue to provide their valuable input.

Anne M.R. Agur
Arthur F. Dalley II

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7.35A,B Courtesy of I. Verschuur, Joint Department of Medical Imaging, UHN/Mount Sinai Hospital, Toronto, Canada
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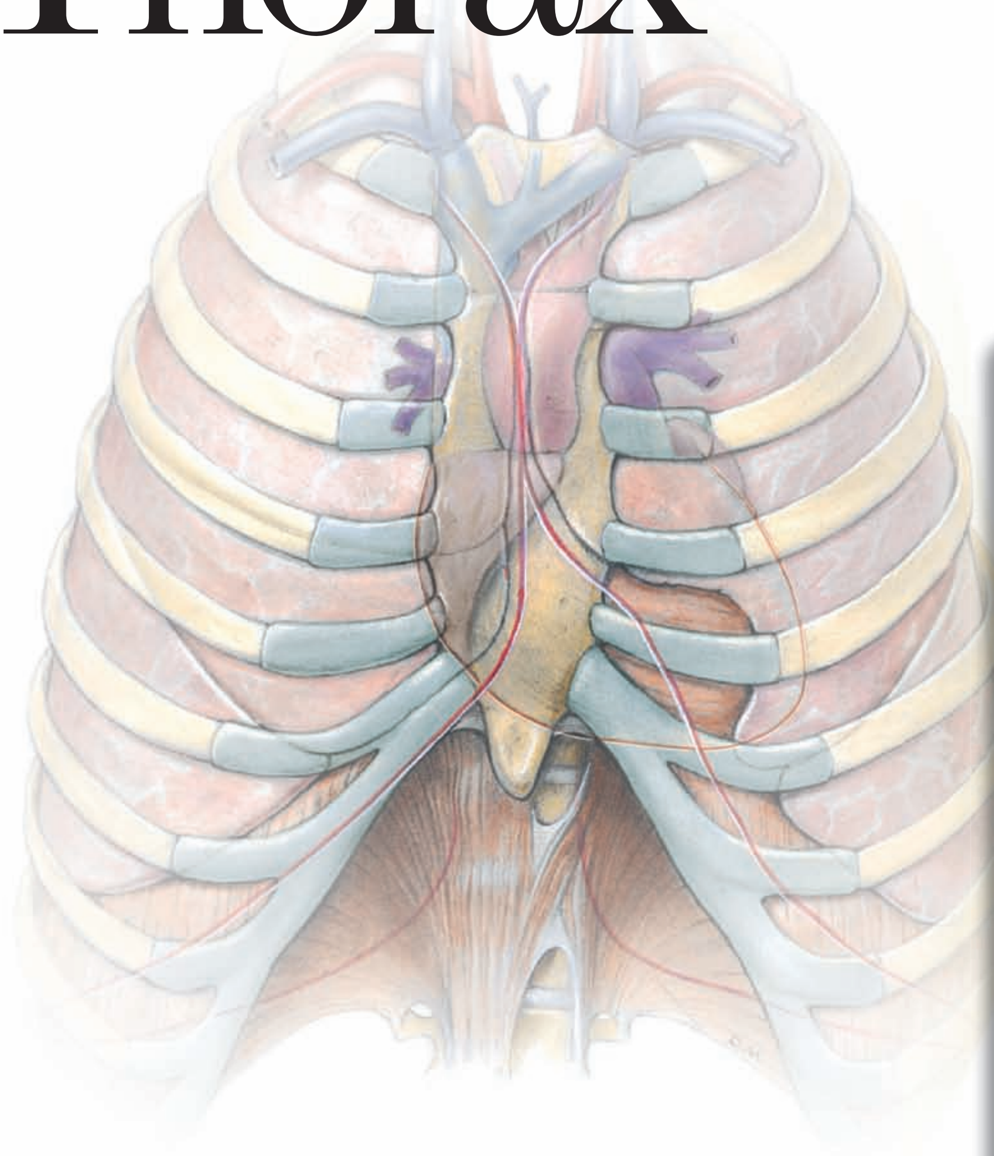
7.39B Melloni,R. Melloni's Illustrated Review of Human Anatomy by Structures-Arteries, Bones, Muscles, Nerves, Veins, 1988, p. 198
7.42A-D Modified from Girard, Louis, Anatomy of the Huma Eye. II. The Extra-ocular Muscles. Teaching Films, Inc. Houston, TX
7.45C Melloni,R. Melloni's Illustrated Review of Human Anatomy by Structures-Arteries, Bones, Muscles, Nerves, Veins, 1988, p. 189.
7.46A Courtesy of J.R. Buncic, University of Toronto, Canada
7.56 CTs and MRIs from Langland OE, Langlais RP, Preece JW. Principles of Dental Imaging, 2002:278 (Figs. 11.32A, B; 11.33A, B).
7.65A Langland OE, Langlais RP, Preece JW. Principles of Dental Imaging, 2002:334 (Fig. 14.1).
7.65B Courtesy of M.J. Phatoah, University of Toronto, Canada.
7.66E Courtesy of Dr. B. Libgott, Division of Anatomy/Department of Surgery, University of Toronto, Ontario, Canada
7.67B,C Woelfel JB, Scheid RC. Dental Anatomy: Its Relevance to Dentistry. 6th ed, 2002:86,46 (Figs. 3.5 & 3.6).
7.76B Courtesy of D. Armstrong, University of Toronto, Canada
7.76C Courtesy of E. Becker, University of Toronto, Canada
7.77C Courtesy of E. Becker, University of Toronto, Canada
7.78B Modified from Paff, GH Anatomy of the Head & Neck. Philadelphia: WB Sanders Co., 1973. figs 238–240, p. 142–143.
7.84D Courtesy of Welch Allyn, Inc. Skaneateles Falls, NY. (Appeared in Moore KL, Dalley AF. Clinically Oriented Anatomy. 4th ed, 1999:966 (Fig. 8.2)
7.94B-D Courtesy of W. Kucharczyk, University of Toronto, Canada
7.95B Courtesy of Dr. W. Kucharczyk, University of Toronto, Canada
7.96A-C All photos courtesy of The Visible Human Project; National Library of Medicine; Visible Man 1107 and 1168.
7.99–7.102, 7.104, 7.105B,C and 7.106 Colorized from photographs provided courtesy of Dr. C.G. Smith, which appears in Smith CG. Serial Dissections of the Human Brain. Baltimore: Urban & Schwarzenber, Inc. and Toronto: Gage Publishing Ltd., 1981 (© Carlton G. Smith)
7.103A-F MRIs courtesy of Dr. D. Armstrong, University of Toronto, Canada
7.107A-E MRIs courtesy of Dr. D. Armstrong, University of Toronto, Canada
7.108A-F MRIs courtesy of Dr. D. Armstrong, University of Toronto, Canada
7.109A-C MRIs courtesy of Dr. D. Armstrong, University of Toronto, Canada
7.53 Illustrations from Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2002:76,74,79 (Figs.3.17, 3.15, 3.19).
7.64 (bottom left illustration) Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment, 2002:80 (Fig. 3.22).

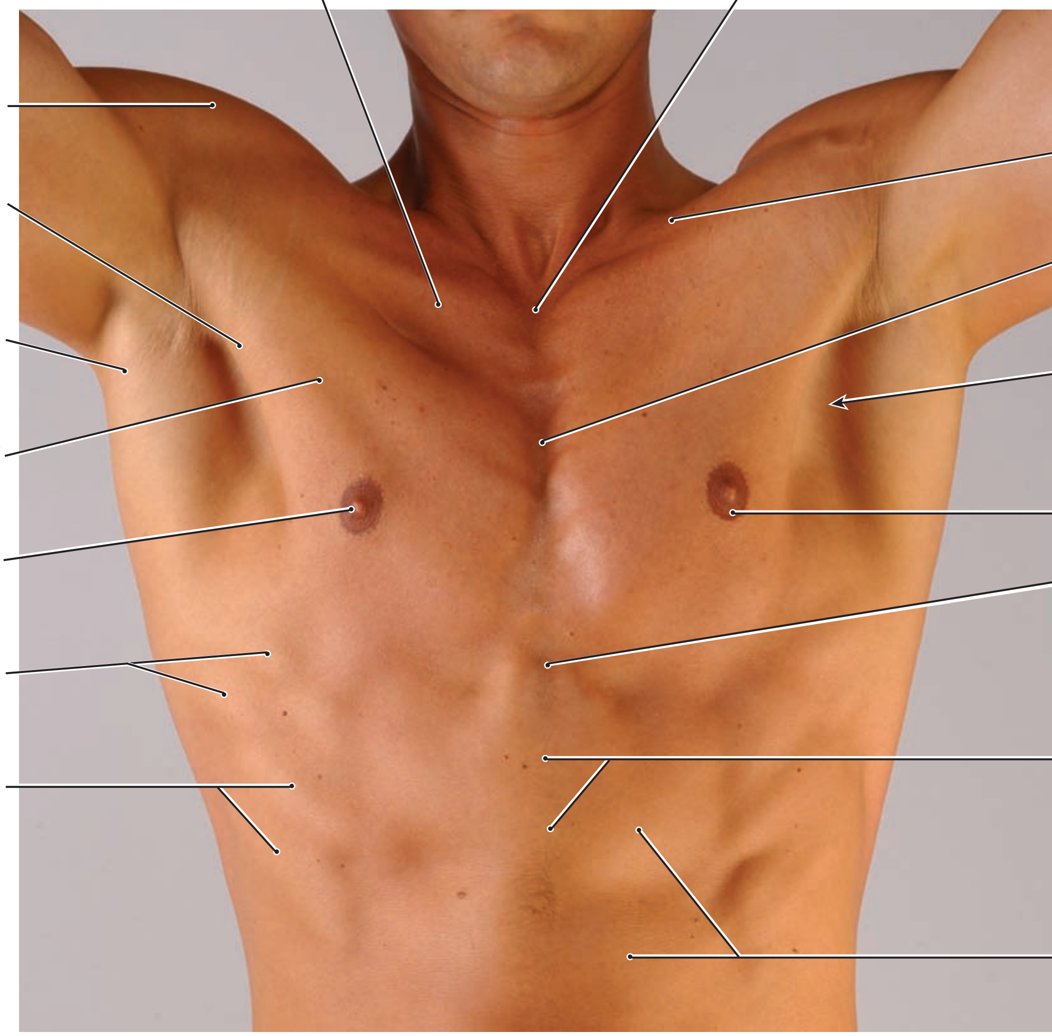
CHAPTER 8
8.5B Courtesy of J. Heslin, University of Toronto, Canada
8.7 Modified from Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2003:90,91 (Figs. 3.36, 3.48)
8.12A Modified from Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2003:88 (Fig. 3.34)
8.15B Courtesy of Dr. D. Armstrong, University of Toronto, Canada
8.24B Modified from Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2003:92 (Fig. 3.40)
8.25A Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2003:101,128 (Figs. 3.53, 4.17)
8.25B Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2nd ed, 2008:103. (Fig. 3.40)
8.25C Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2nd ed, 2008:140. (Fig. 4.17)
8.25D Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2nd ed, 2008:67. (Fig. 3.6)
8.28 Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2003:96,100,104 (Figs. 3.48, 3.52, 3.56)
8.34A Abrahams P. The Atlas of the Human Body. San Diego, CA: Thunder Bay Press, 2002, p. 86.
8.34B From Liebgott B. The Anatomical Basis of Dentistry. Philadelphia, PA: Mosby, 1982.
8.41A Rohen JW, Yokochi C, Lutjen-DrecollE, Romrell LJ. Color Atlas of Anatomy: A Photographic Study of the Human Body. 5th ed, 2002.
8.41C Courtesy of Dr. D. Salonen, University of Toronto, Canada.
8.44A-C Courtesy of Dr. D. Salonen, University of Toronto, Canada;
8.46B Courtesy of Dr. E. Becker, University of Toronto, Canada
8.47 Siemens Medical Solutions USA, Inc.

CHAPTER 9
9.23A-F Courtesy of Dr. W. Kucharczyk, University of Toronto, Canada
9.24A-C Photos courtesy of Dr. W. Kucharczyk, University of Toronto, Canada

CHAPTER 1

Thorax

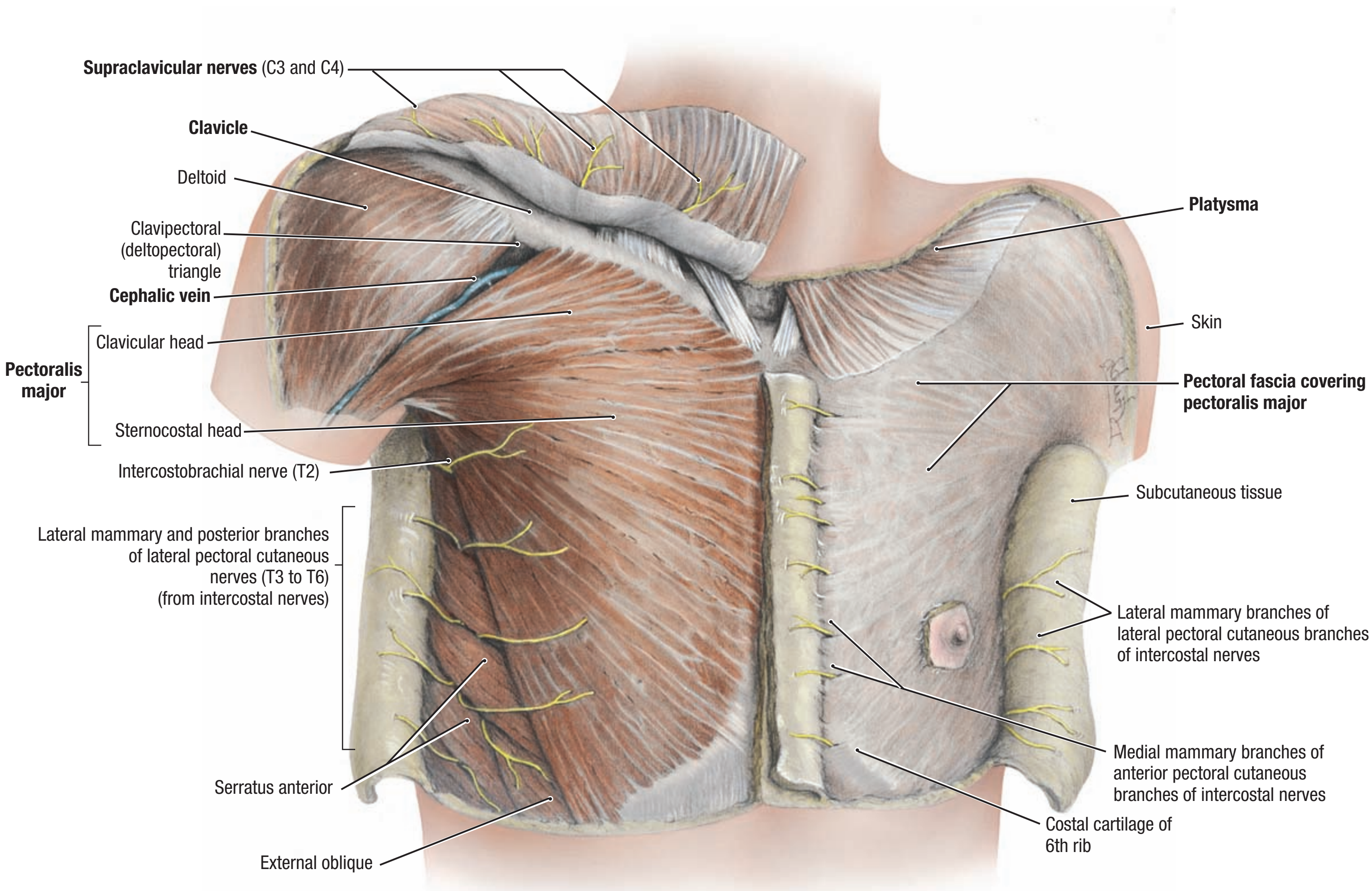




Anterior View

1.1 SURFACE ANATOMY OF MALE PECTORAL REGION

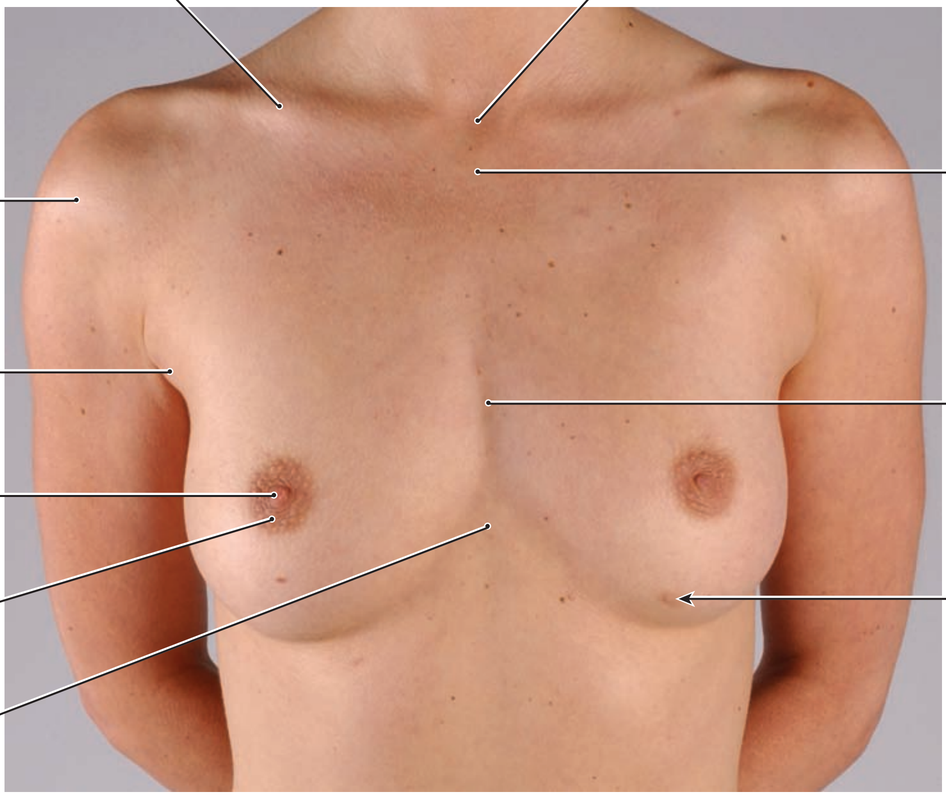
- The subject is adducting the shoulders against resistance to demonstrate the pectoralis major muscle.
- The sternum (breastbone) lies subcutaneously in the anterior median line and is palpable throughout its length.
- The suprasternal notch can be palpated between the prominent medial ends of the clavicle.
- The pectoralis major muscle has two parts, the sternocostal and clavicular heads.
- The inferior border of the sternocostal head of the pectoralis major muscle forms the anterior axillary fold. The axillary fossa ("armpit") is a surface feature overlying a fat-filled space, the axilla, posterior to the anterior fold.
- The male nipple overlies the fourth intercostal space.



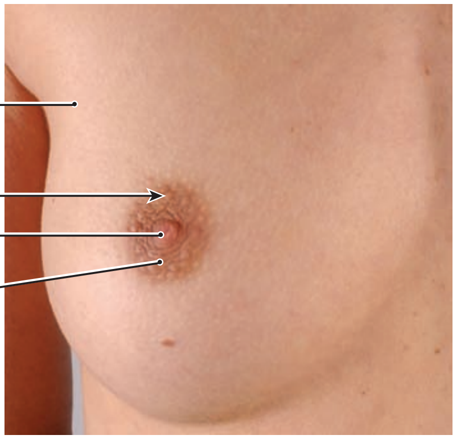
Anterior View

1.2 SUPERFICIAL DISSECTION, MALE PECTORAL REGION

- The platysma muscle, which descends to the 2nd or 3rd rib, is cut short on both sides of the specimen; together with the supraclavicular nerves, it is reflected superiorly on the right side.
- The pectoral fascia covers the pectoralis major.
- The clavicle lies deep to the subcutaneous tissue and the platysma muscle.
- The cephalic vein passes deeply in the clavipectoral (deltopectoral) triangle to join the axillary vein.
- Supraclavicular (C3 and C4) and upper thoracic nerves (T2 to T6) supply cutaneous innervation to the pectoral region.
- The clavipectoral (deltopectoral) triangle, bounded by the clavicle superiorly, the deltoid muscle laterally, and the clavicular head of the pectoralis major muscle medially, underlies a surface depression called the infraclavicular fossa.



A. **Anterior View**

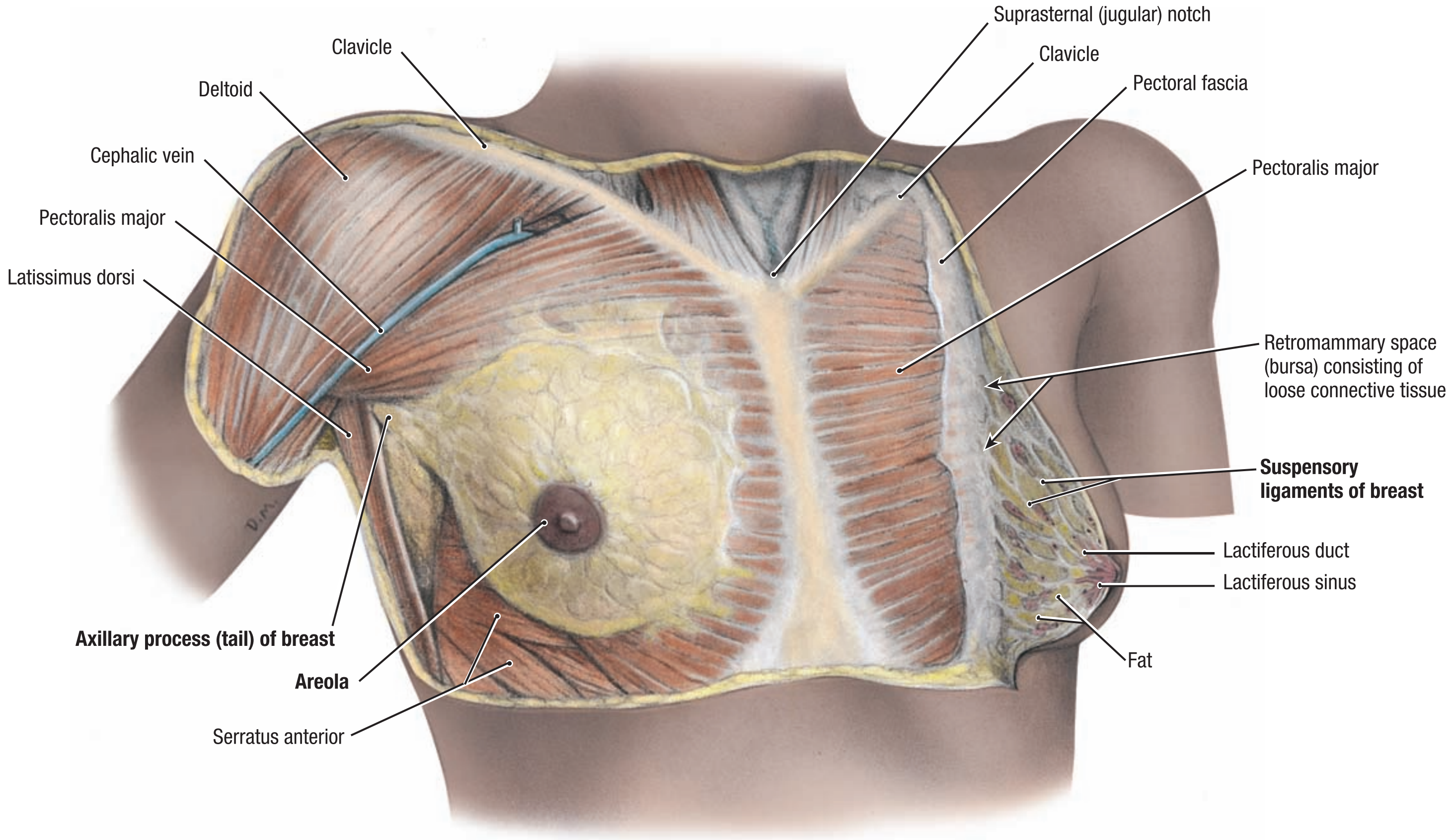


B. **Anterior View**

1.3 SURFACE ANATOMY OF FEMALE PECTORAL REGION

A. Overview. **B.** Breast. The roughly circular base of the female breast extends transversely from the lateral border of the sternum to the midaxillary line and vertically from the 2nd to 6th ribs. A small part of the breast may extend along the inferolateral edge of the pectoralis major muscle toward the axillary fossa, forming an axillary process or tail (of Spence).

Polymastia (supernumerary breasts) or **polythelia** (accessory nipples) may occur superior or inferior to the normal pair, occasionally developing in the axillary fossa or anterior abdominal wall. Supernumerary breasts usually consist of only a rudimentary nipple and areola, which may be mistaken for a mole (nevus) until they change pigmentation with the normal nipples during pregnancy.



A. **Anterior View**

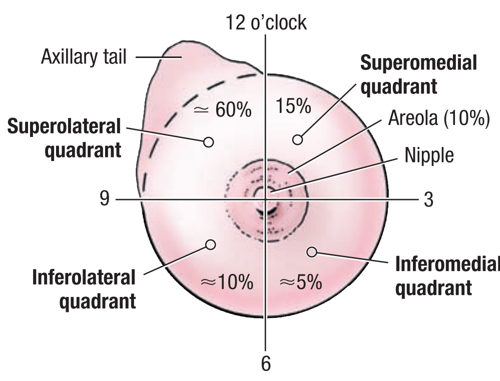
1.4 SUPERFICIAL DISSECTION, FEMALE PECTORAL REGION

A. Dissection.

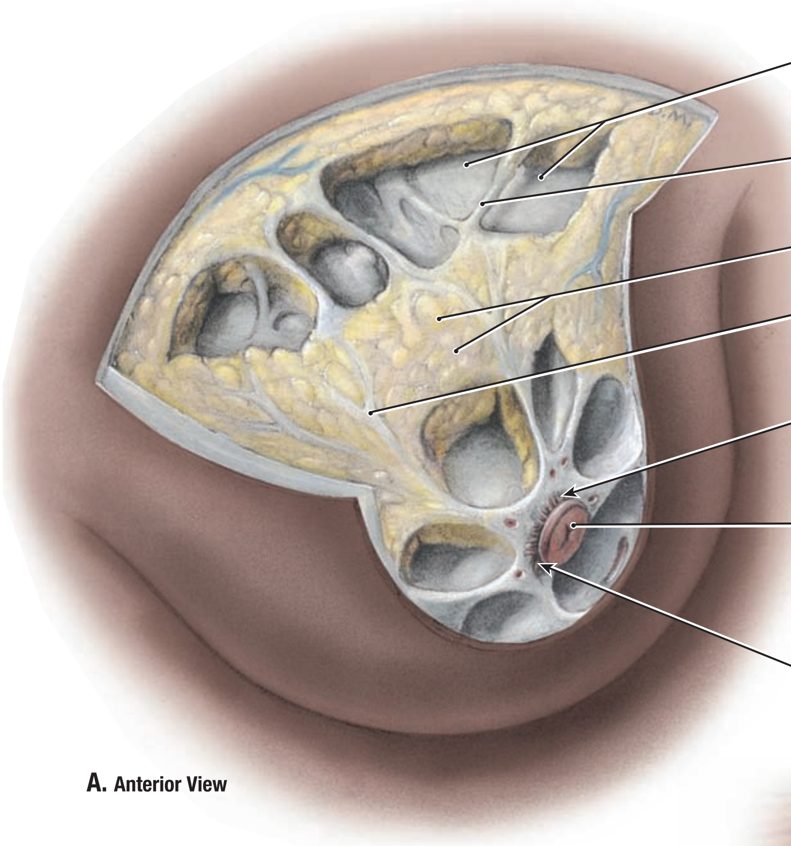
- On the specimen's right side, the skin is removed; on the left side, the breast is sagittally sectioned.
- Two thirds of the breast rests on the pectoral fascia covering the pectoralis major; the other third rests on the fascia covering the serratus anterior muscle.
- The region of loose connective tissue between the pectoral fascia and the deep surface of the breast, the retromammary space (bursa), permits the breast to move on the deep fascia.

Cancer can spread by contiguity (invasion of adjacent tissue). When **breast cancer** cells invade the retromammary space, attach to or invade the pectoral fascia overlying the pectoralis major, or metastasize to the interpectoral nodes (Fig. 1.7), the breast elevates when the muscle contracts. This movement is a clinical sign of advanced cancer of the breast.

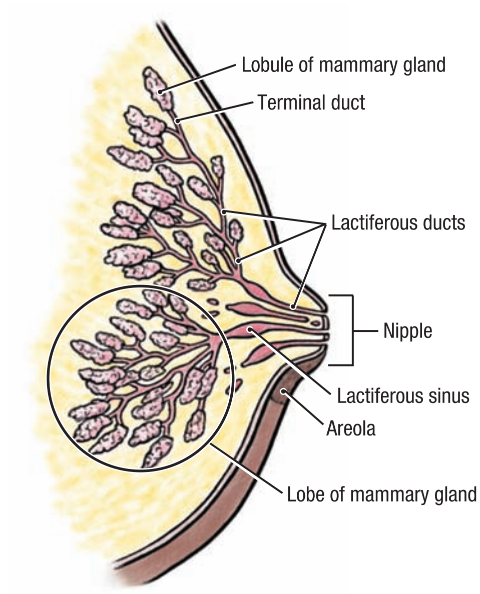
B. Breast Quadrants. For the anatomical location and description of tumors and cysts, the surface of the breast is divided into four quadrants. For example: "A hard irregular mass was felt in the superior medial quadrant of the breast at the 2 o'clock position, approximately 2.5 cm from the margin of the areola."



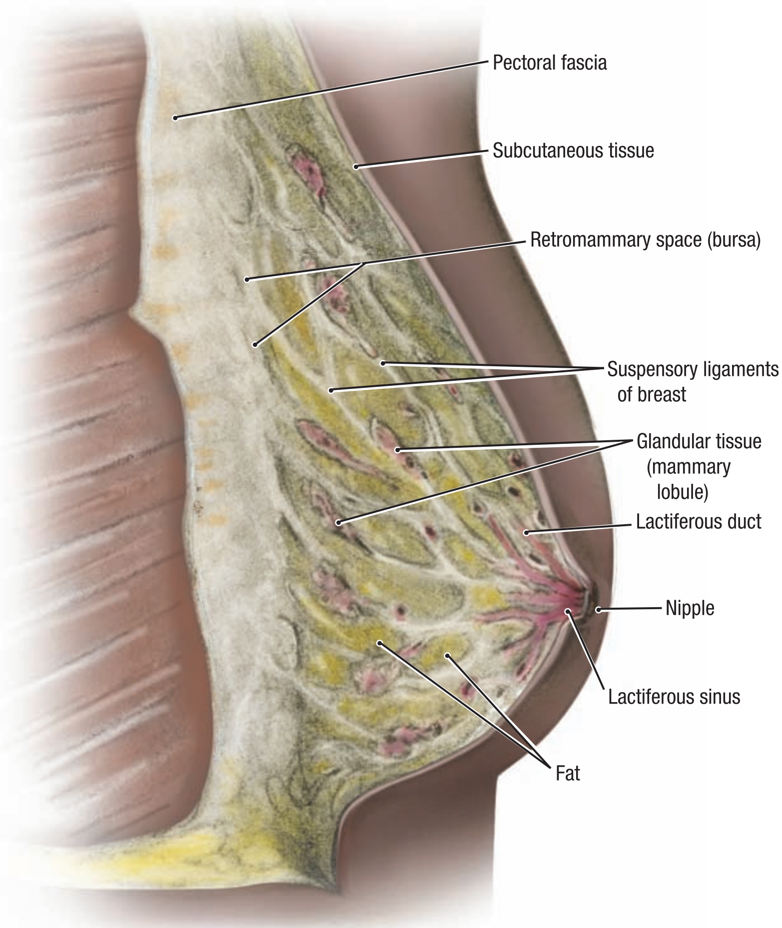
B. **Quadrants of Breast: Percentage of Malignant Tumors**



A. **Anterior View**



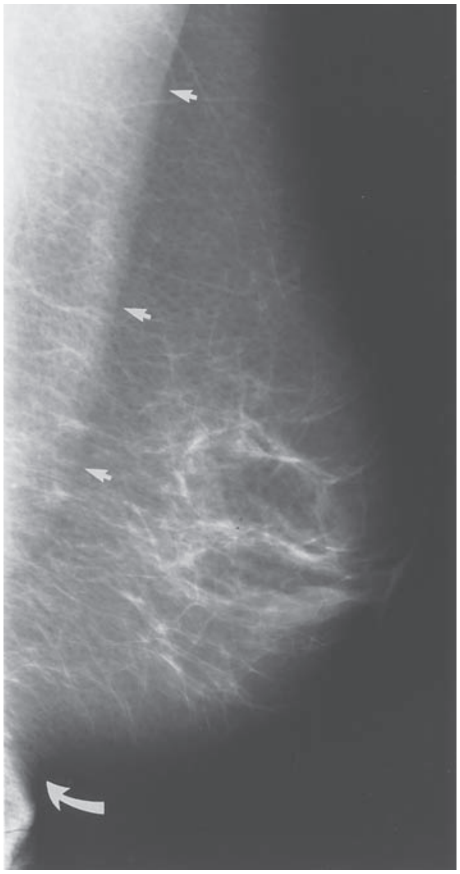
B. **Schematic Sagittal Section**



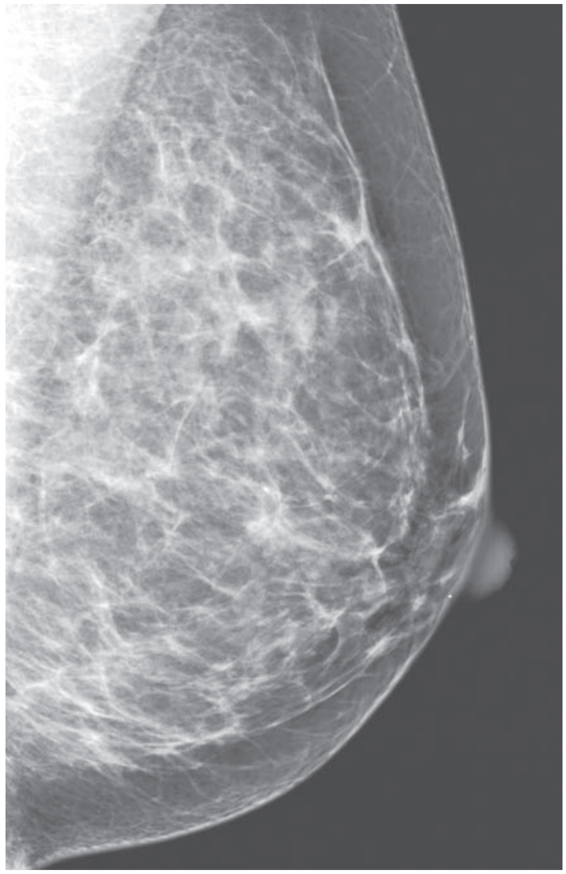
C. **Sagittal Section of Breast**

1.5 FEMALE MAMMARY GLAND

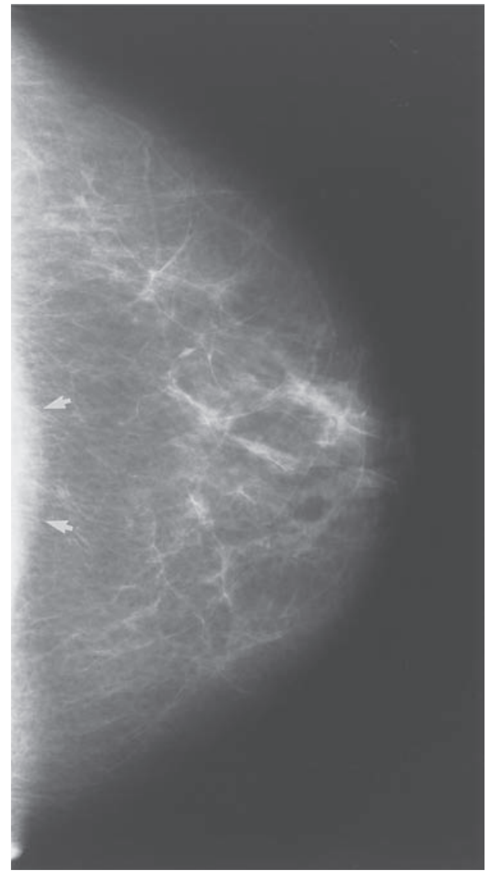
A. Dissection. Areas of subcutaneous fat were removed to show the suspensory ligaments of the breast. The mammary glands are modified sweat glands located in the subcutaneous tissue. They consist of glandular tissue, the parenchyma, and supporting fibrous tissue, the stroma. The mammary glands are attached to the dermis of the skin by suspensory ligaments. **B. and C.** Sagittal sections. The glandular tissue consists of 15 to 20 lobes, each composed of lobules. Each lobe has a lactiferous duct that widens to form the lactiferous sinus before opening on the nipple. **Interference with the lymphatic drainage by cancer** may cause lymphedema (edema, excess fluid in the subcutaneous tissue), which in turn may result in deviation of the nipple and a leathery, thickened appearance of the breast skin. Prominent (puffy) skin between dimpled pores may develop, which gives the skin an orange-peel appearance (*peau d'orange* sign). Larger dimples may form if pulled by cancerous invasion of the suspensory ligaments of the breast.



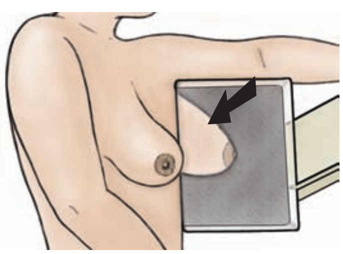
A. Lateral View



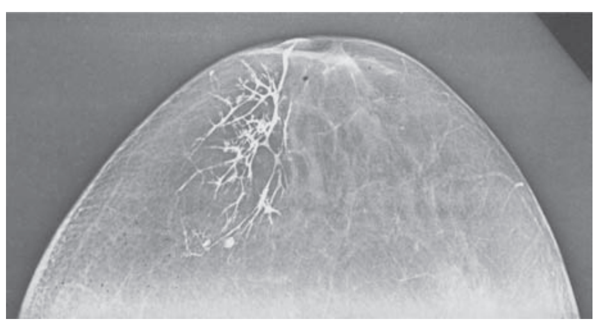
B. Lateral View



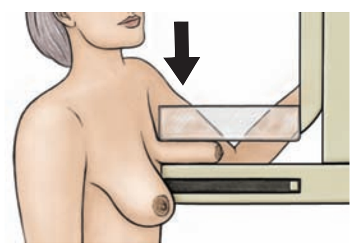
C. Superior View



Orientation for A and B



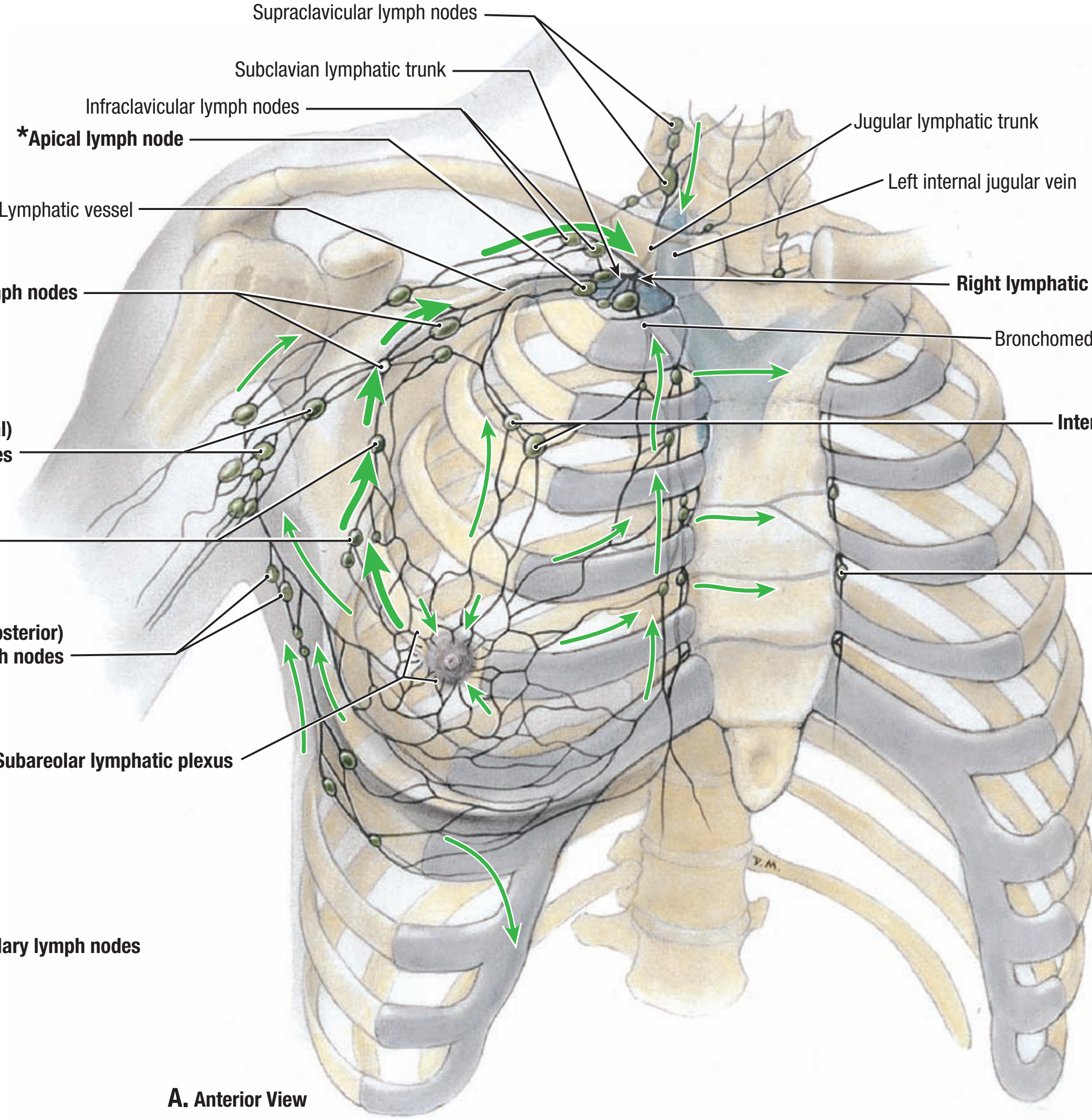
D. Superior View



Orientation for C and D

1.6 IMAGING OF BREAST

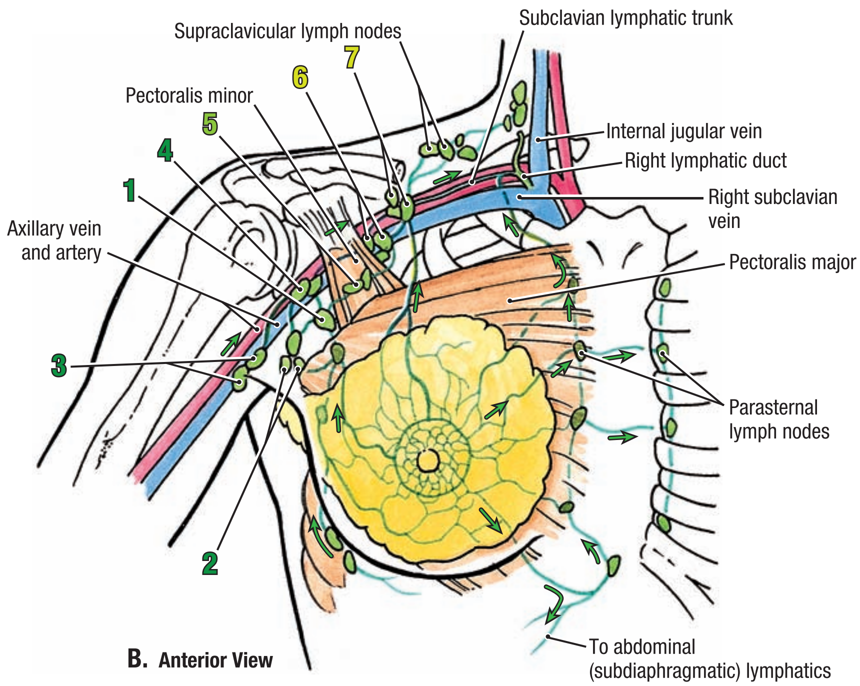
A. Mediolateral oblique (MLO) mammogram of left breast. The pectoralis major muscle is indicated with *white arrowheads* and the inframammary fold with a *curved white arrow*. The nipple is seen in profile. Observe the connective tissue network of the breast. The stroma is radiopaque and changes with age and during lactation. **B.** Digital mammogram. **C.** Craniocaudal (CC) mammogram of left breast. Pectoralis major (*white arrows*). **D.** Glactogram. Contrast has been injected into a lactiferous duct, outlining the branching pattern of its tributaries.



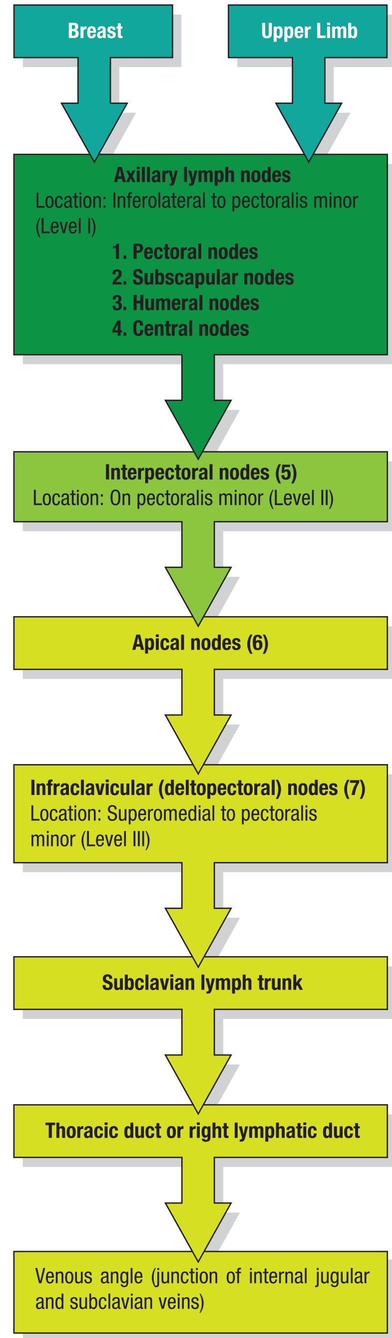
A. Anterior View

1.7 LYMPHATIC DRAINAGE OF BREAST

A. Overview. Lymph drained from the upper limb and breast passes through nodes arranged irregularly in groups of axillary lymph nodes: (1) pectoral, along the inferior border of the pectoralis minor muscle; (2) subscapular, along the subscapular artery and veins; (3) humeral, along the distal part of the axillary vein; (4) central, at the base of the axilla, embedded in axillary fat; and (5) apical, along the axillary vein between the clavicle and the pectoralis minor muscle. Most of the breast drains via the pectoral, central, and apical axillary nodes to the subclavian lymph trunk, which joins the venous system at the junction of the subclavian and internal jugular veins. The medial part of the breast drains to the parasternal nodes, which are located along the internal thoracic vessels.



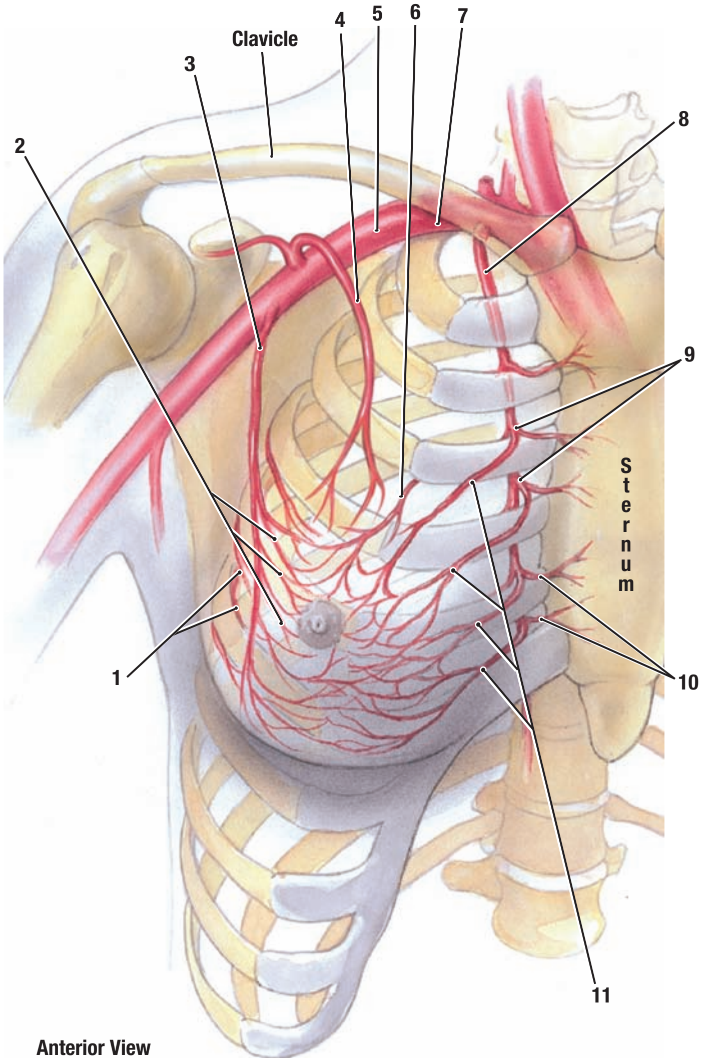
B. Anterior View



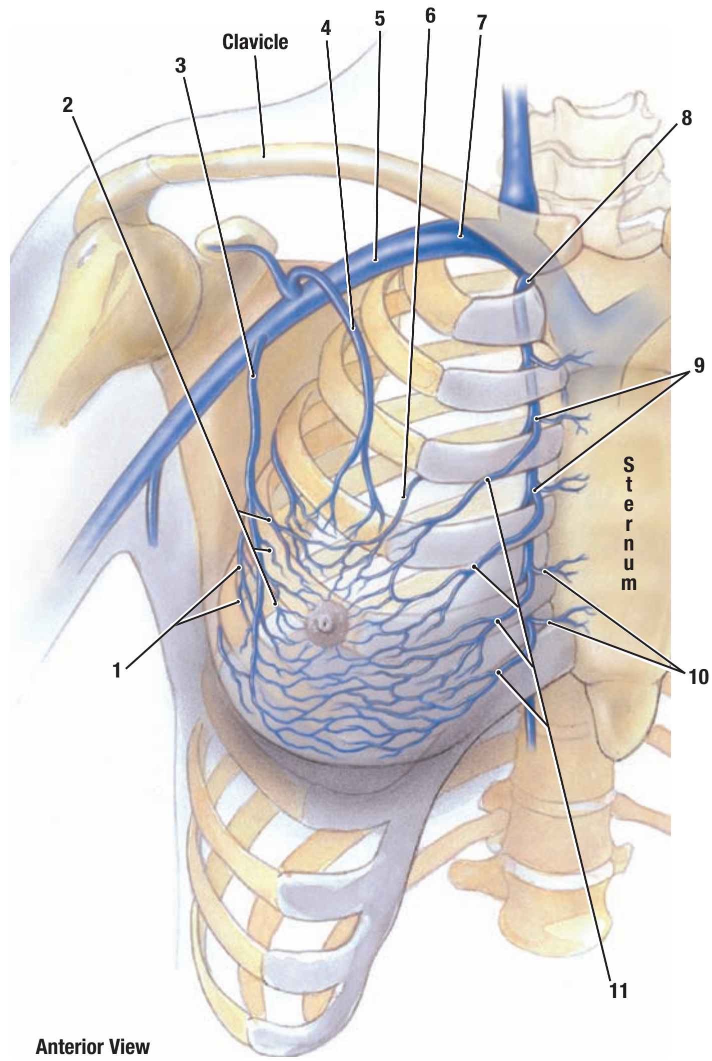
C. Flow of lymph from the breast and upper limb to the venous angle.

1.7 LYMPHATIC DRAINAGE OF BREAST *(CONTINUED)*

B. Pattern of lymphatic drainage. **Breast cancer** typically spreads by means of lymphatic vessels (lymphogenic metastasis), which carry cancer cells from the breast to the lymph nodes, chiefly those in the axilla. The cells lodge in the nodes, producing nests of tumor cells (metastases). Abundant communications among lymphatic pathways and among axillary, cervical, and parasternal nodes may also cause metastases from the breast to develop in the supraclavicular lymph nodes, the opposite breast, or the abdomen. The prognosis of breast cancer has been correlated with the level of metastasis (I, II, or III) and to the number of involved axillary lymph nodes. **C.** Flow of lymph from the breast and upper limb to the venous angle.



Anterior View



Anterior View

Arteries:

1. Lateral mammary branches of lateral cutaneous branches of posterior intercostal arteries
2. Lateral mammary branches of lateral thoracic artery
3. Lateral thoracic artery
4. Pectoral branch of thoraco-acromial artery
5. Axillary artery
6. Mammary branch of anterior intercostal artery
7. Subclavian artery
8. Internal thoracic artery
9. Perforating branches
10. Sternal branches
11. Medial mammary branches

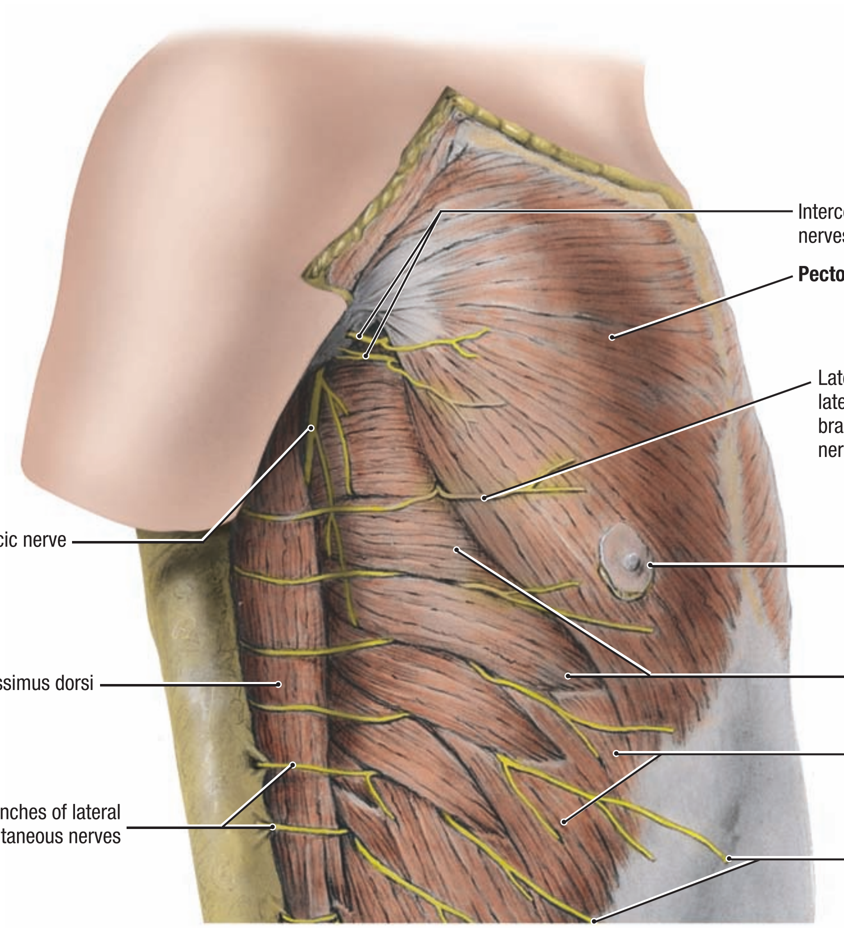
Veins:

1. Lateral mammary branches of lateral cutaneous branches of posterior intercostal veins
2. Lateral mammary branches of lateral thoracic vein
3. Lateral thoracic vein
4. Pectoral branch of thoraco-acromial vein
5. Axillary vein
6. Mammary branch of anterior intercostal vein
7. Subclavian vein
8. Internal thoracic vein
9. Perforating branches
10. Sternal branches
11. Medial mammary veins

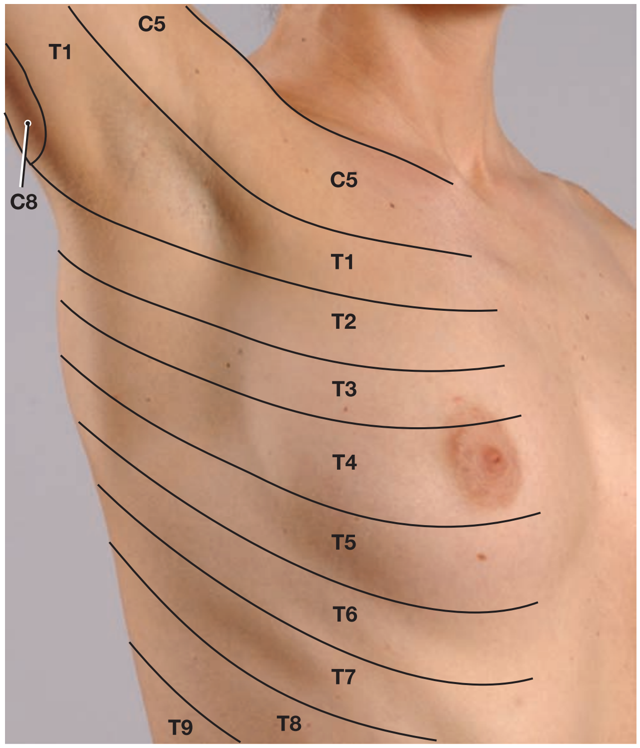
1.8 ARTERIAL SUPPLY AND VENOUS DRAINAGE OF BREAST

Arteries enter and veins drain the breast from its superomedial and superolateral aspects; vessels also penetrate the deep surface of the breast. The vessels branch profusely and anastomose with each other.

Breast incisions are placed in the inferior breast quadrants when possible because these quadrants are less vascular than the superior ones.



A. Anterolateral View (Male)

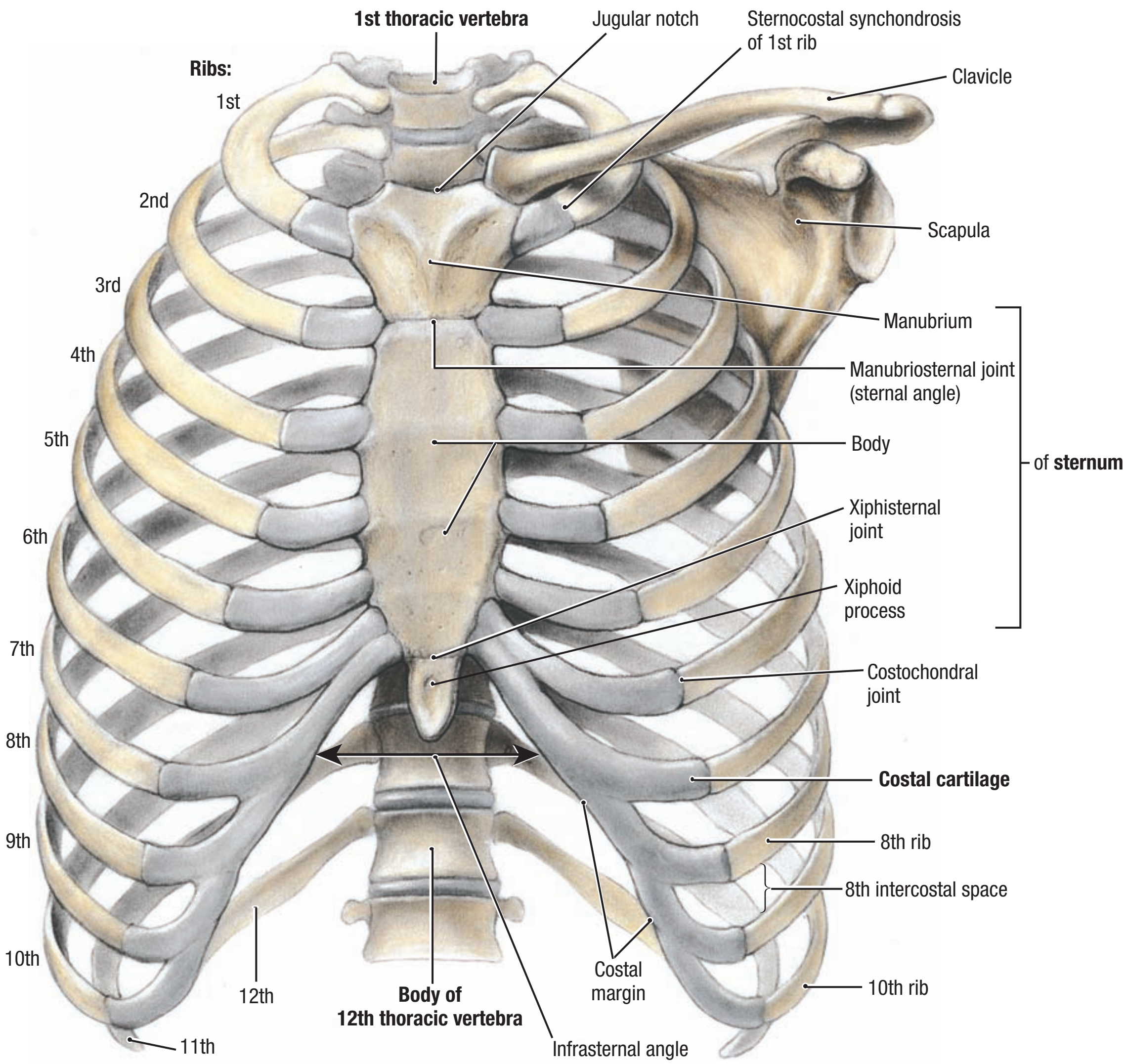


B. Anterolateral View (Female)

1.9 MUSCLES AND NERVES OF BED OF BREAST

A. Muscles comprising bed and cutaneous nerves. **B.** Dermatomes.

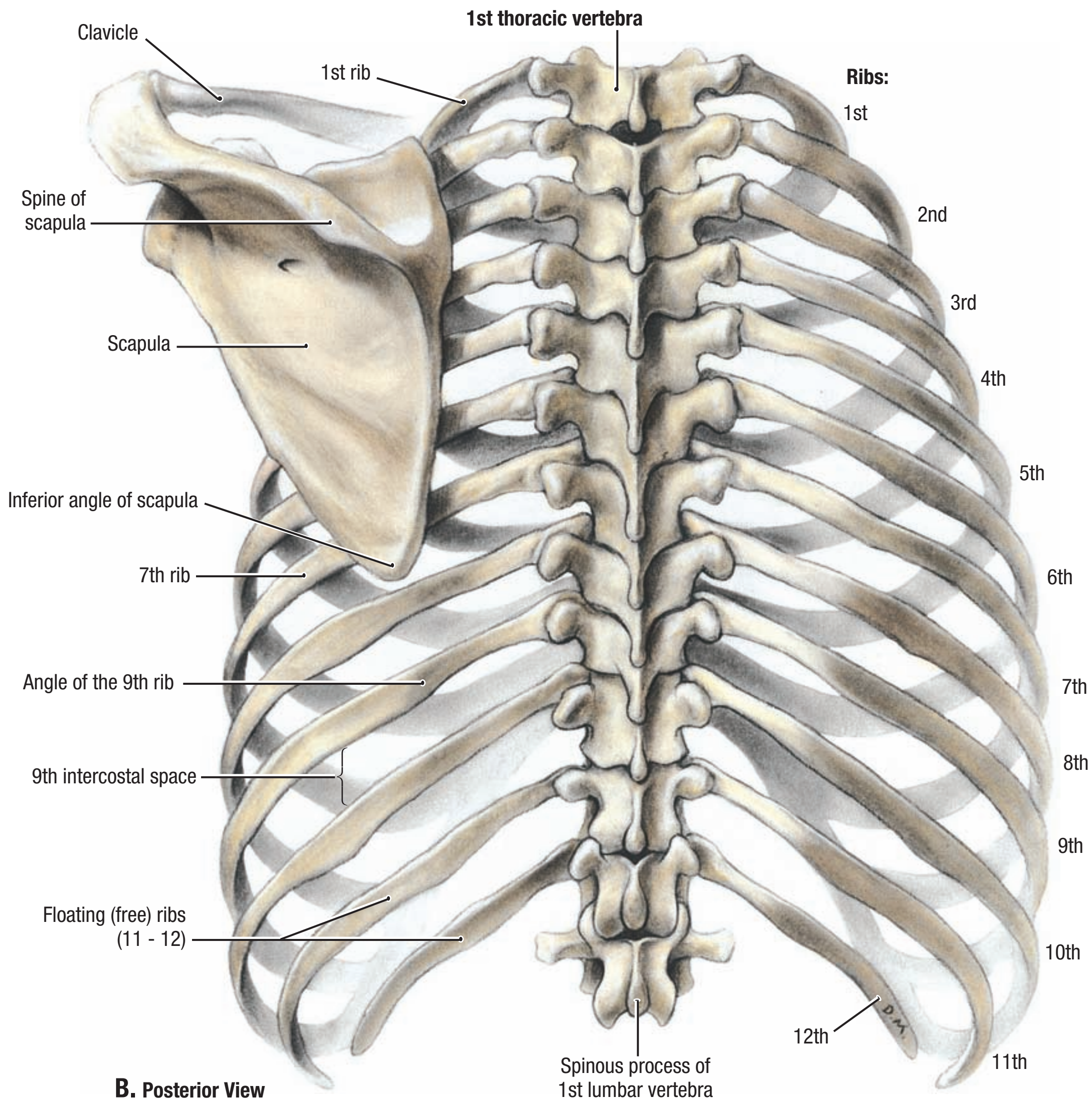
Local anesthesia of an intercostal space (intercostal nerve block) is produced by injecting a local anesthetic agent around the intercostal nerves between the paravertebral line and the area of required anesthesia. Because any particular area of skin usually receives innervation from two adjacent nerves, considerable overlapping of contiguous dermatomes occurs. Therefore, complete loss of sensation usually does not occur unless two or more intercostal nerves are anesthetized.



A. Anterior View

1.10 BONY THORAX

- The thoracic cage consists of 12 thoracic vertebrae, 12 pairs of ribs and costal cartilages, and the sternum.
- Anteriorly, the superior seven costal cartilages articulate with the sternum; the 8th, 9th, and 10th cartilages articulate with the cartilage above forming the costal margin; the 11th and 12th are "floating" ribs, that is, their cartilages do not articulate anteriorly.
- The clavicle lies over the 1st rib, making it difficult to palpate. The 2nd rib is easily palpable because its costal cartilage articulates with the sternum at the sternal angle, located at the junction of the manubrium and body of the sternum.
- The 3rd to 10th ribs can be palpated in sequence inferolaterally from the 2nd rib; the fused costal cartilages of the 7th to 10th ribs form the costal arch (margin), and the tips of the 11th and 12th ribs can be palpated posterolaterally.
- A **rib dislocation** is the displacement of a costal cartilage from the sternum; a **rib separation** refers to dislocation of the costochondral joint.

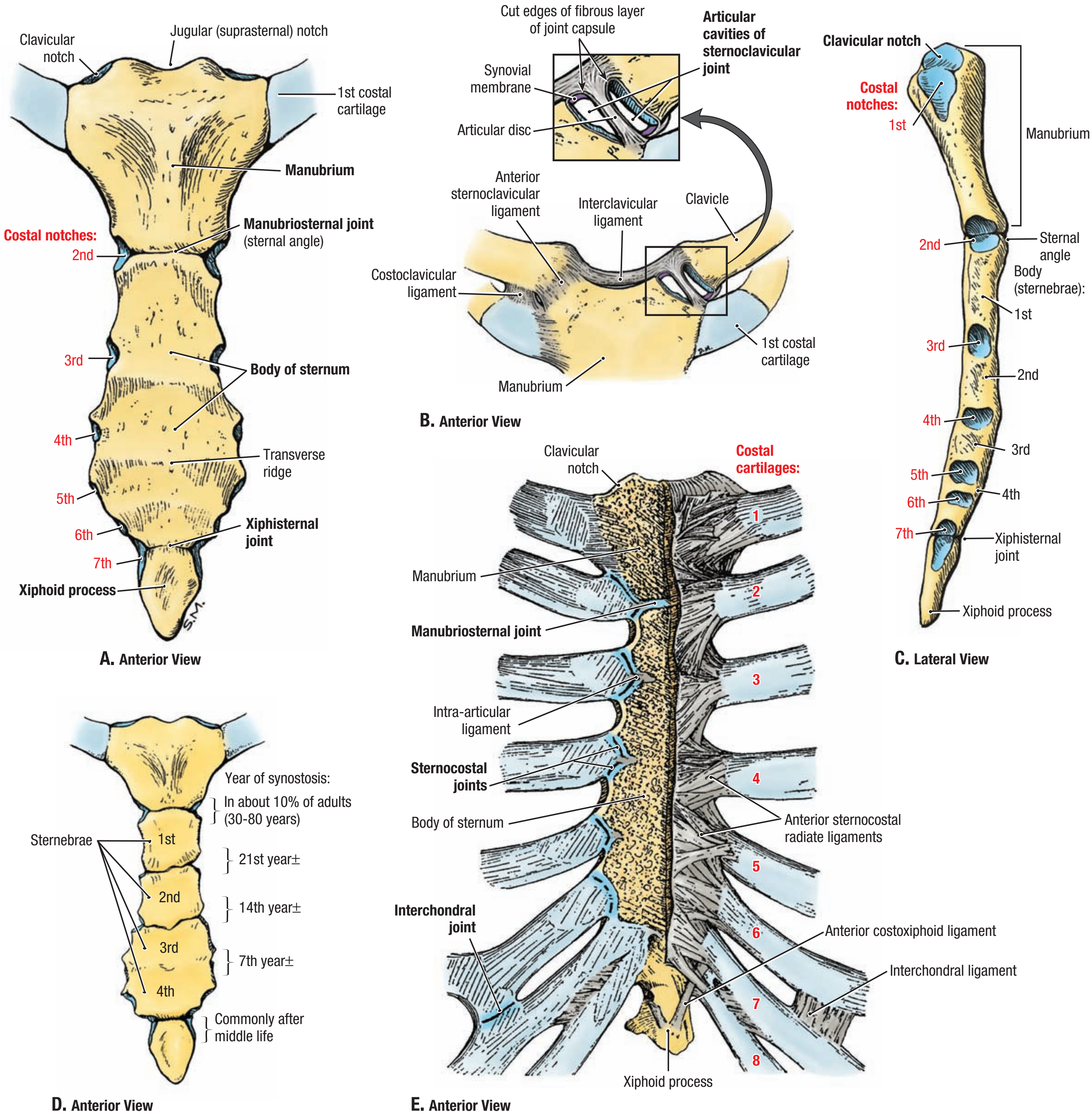


B. **Posterior View**

1.10 BONY THORAX (*CONTINUED*)

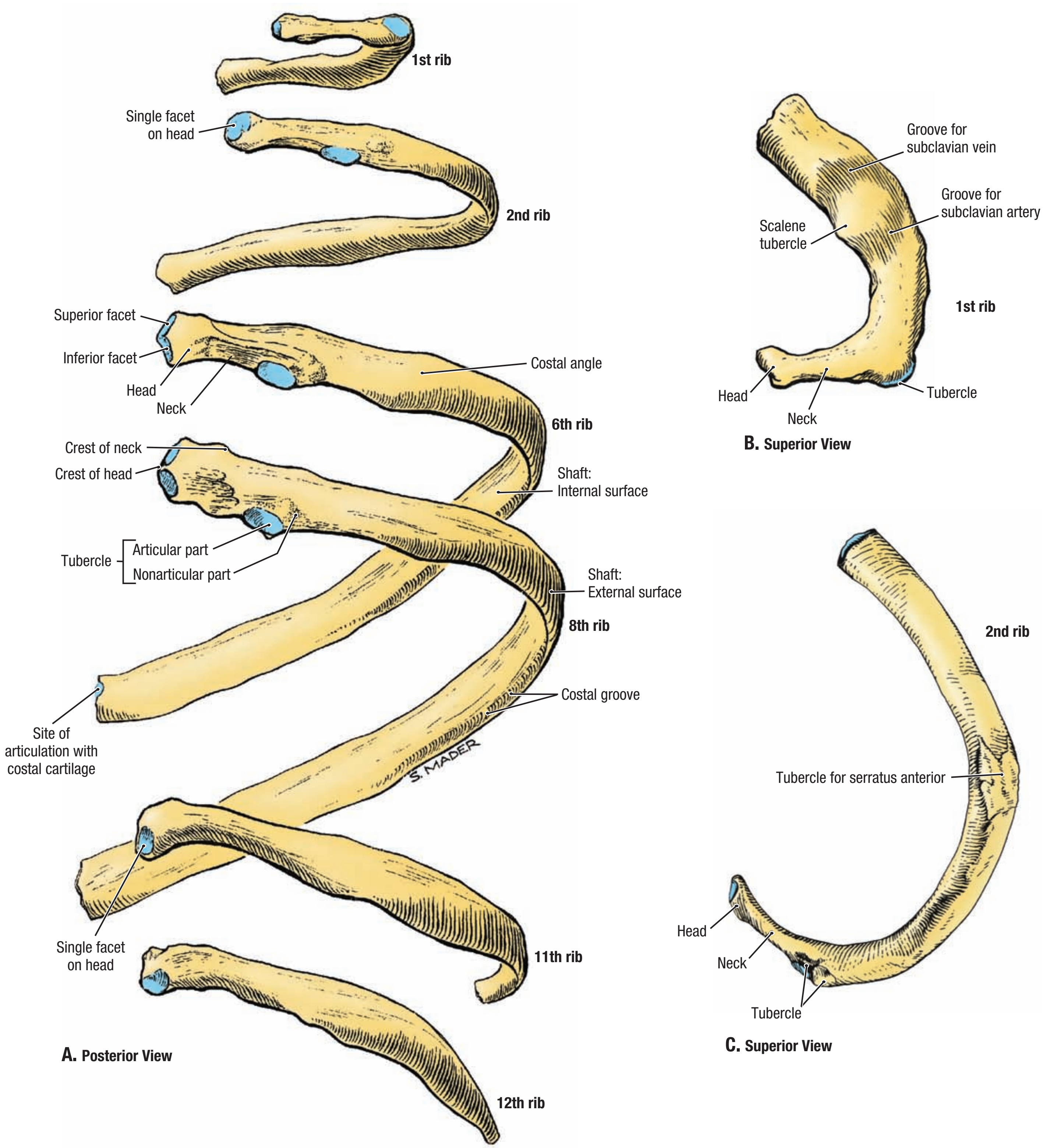
- The superior thoracic aperture (thoracic inlet) is the doorway between the thoracic cavity and the neck region; it is bounded by the 1st thoracic vertebra, the 1st ribs and their cartilages, and the manubrium of the sternum.
- Each rib articulates posteriorly with the vertebral column.
- Posteriorly, all ribs angle inferiorly; anteriorly, the 3rd to 10th costal cartilages angle superiorly.
- The scapula is suspended from the clavicle and extends across the 2nd to 7th ribs posteriorly.

- When clinicians refer to the superior thoracic aperture as the thoracic "outlet," they are emphasizing the important nerves and arteries that pass through this aperture into the lower neck and upper limb. Hence, various types of **thoracic outlet syndromes** exist, such as the costoclavicular syndrome—pallor and coldness of the **skin of the upper limb** and diminished radial pulse—resulting from compression of the subclavian artery between the clavicle and the 1st rib.



1.11 STERNUM AND ASSOCIATED JOINTS

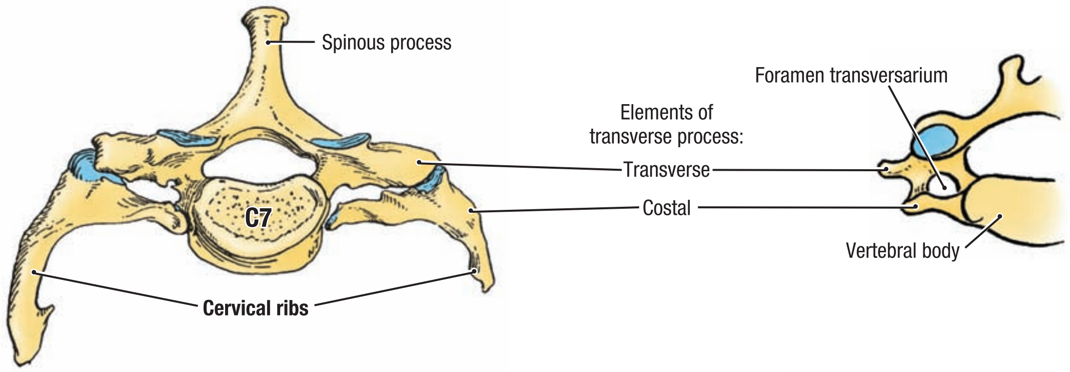
A. Parts of sternum. **B.** Sternoclavicular joint. **C.** Features of the lateral aspect of the sternum. **D.** Ages of ossification of sternum. **E**. Sternocostal, manubriosternal, and interchondral joints. On the right side of the specimen, the cortex of the sternum and the external surface of the costal cartilages have been shaved away.



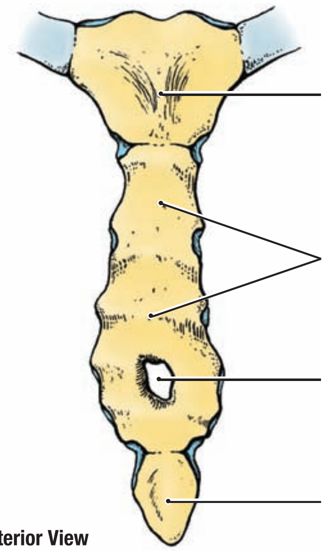
1.12 RIBS

A. "Typical" (6th and 8th) and "atypical" (1st and 2nd and 11th and 12th) ribs. **B.** First rib. **C.** Second rib.

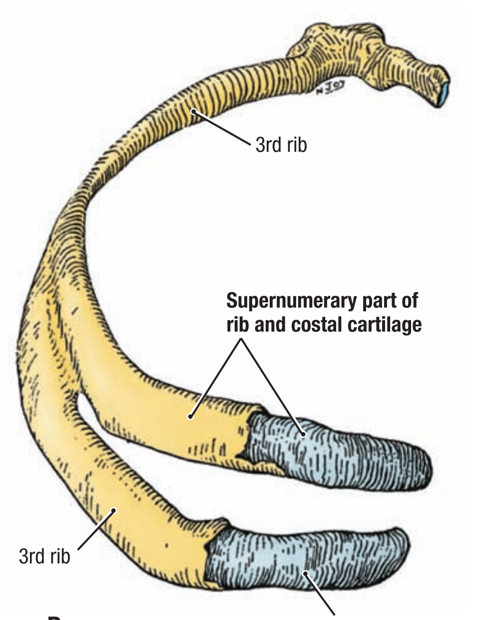
Rib fractures. The weakest part of a rib is immediately anterior to its angle. The middle ribs are most commonly fractured.



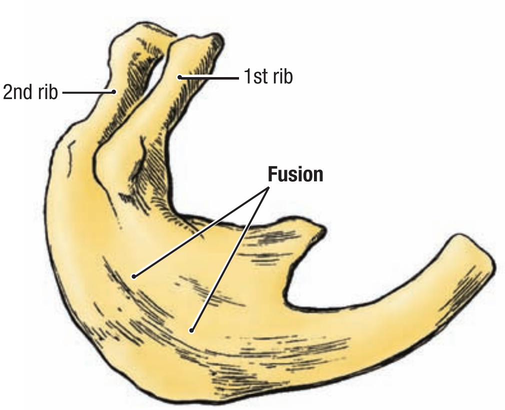
A. Superior View



D. Anterior View



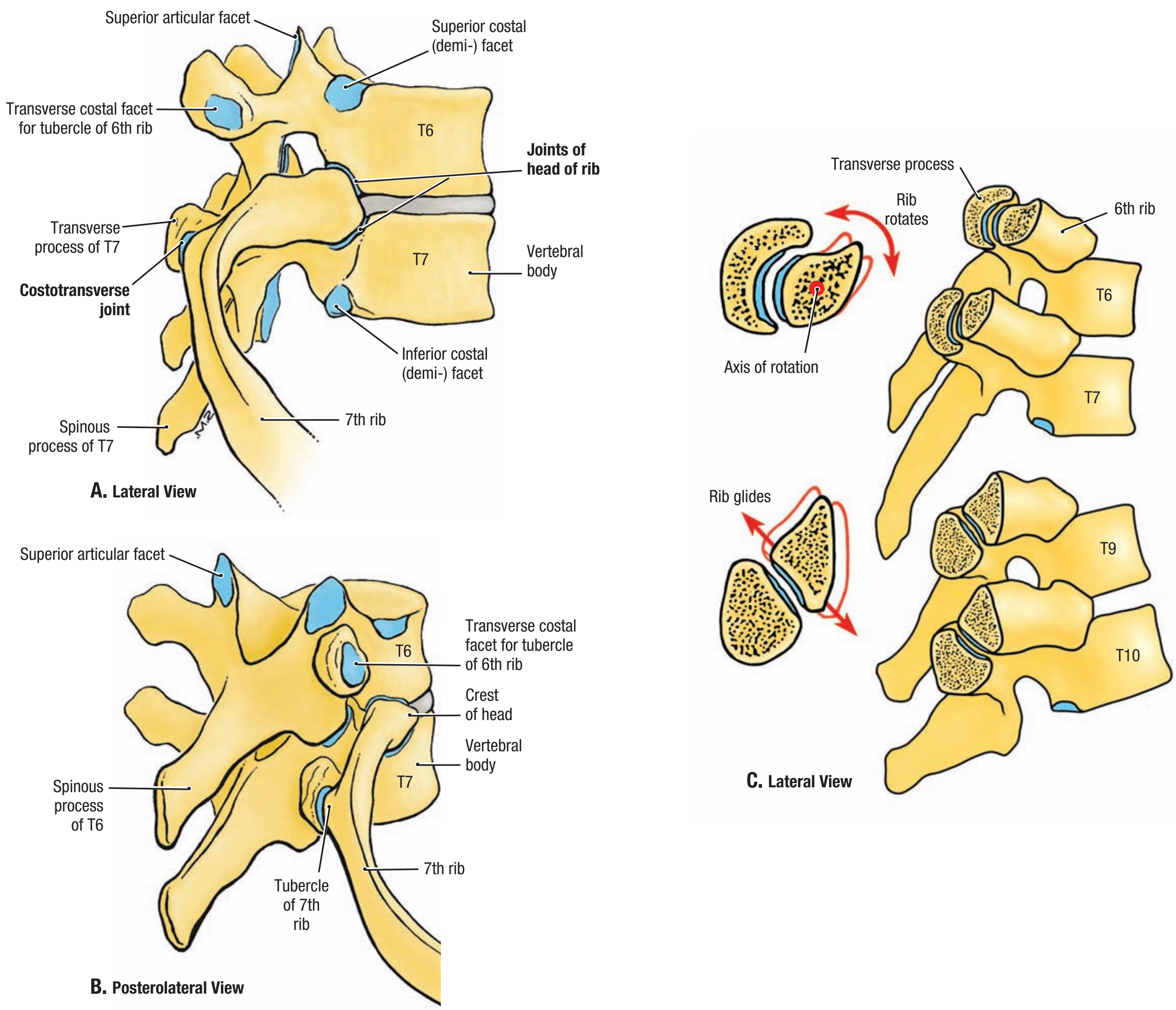
B. Anterior View



C. Superior View

1.13 RIB AND STERNUM ANOMALIES

A. Cervical ribs. People usually have 12 ribs on each side, but the number may be increased by the presence of cervical and/or lumbar ribs (supernumerary ribs) or decreased by a failure of the 12th pair to form. **Cervical ribs** (present in up to 1% of people) articulate with the C7 vertebra and are clinically significant because they may compress spinal nerves C8 and T1 or the inferior trunk of the brachial plexus supplying the upper limb. Tingling and numbness may occur along the medial border of the forearm. They may also compress the subclavian artery, resulting in **ischemic muscle pain** (caused by poor blood supply) in the upper limb. **Lumbar ribs** are less common than cervical ribs, but have clinical significance in that they may confuse the identity of vertebral levels in diagnostic images. **B.** Bifid rib. The superior component of this 3rd rib is supernumerary and articulated with the lateral aspect of the 1st sternebra. The inferior component articulated at the junction of the 1st and 2nd sternebrae. **C.** Bicipital rib. In this specimen, there has been partial fusion of the first two thoracic ribs. **D.** Sternal foramen.

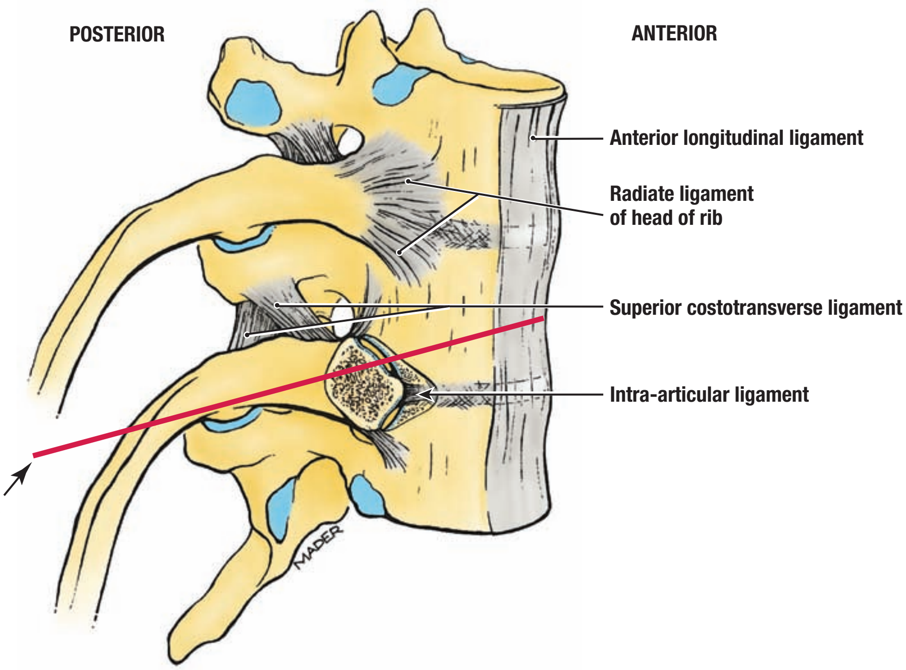


1.14 COSTOVERTEBRAL ARTICULATIONS

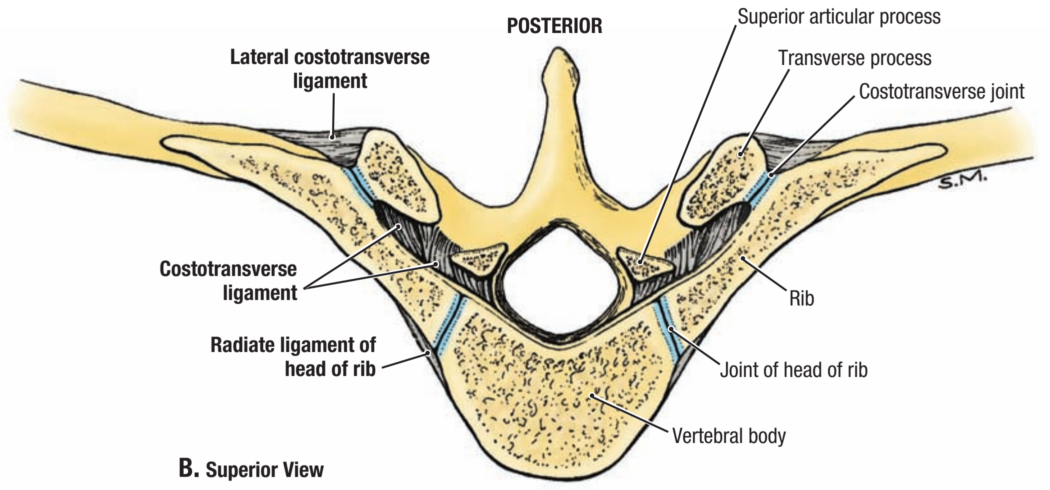
A. and B. Articulating structures.

- There are two articular facets on the head of the rib: a larger, inferior costal facet for articulation with the vertebral body of its own number, and a smaller, superior costal facet for articulation with the vertebral body of the vertebra superior to the rib.
- The crest of the head of the rib separates the superior and inferior costal facets.
- The smooth articular part of the tubercle of the rib, the transverse costal facet, articulates with the transverse process of the same numbered vertebra at the costotransverse joint.

C. Movements at the costotransverse joints. At the 1st to 7th costotransverse joints, the ribs rotate, increasing the anteroposterior diameter of the thorax; at the 8th, 9th, and 10th, they glide, increasing the transverse diameter of the upper abdomen.



A. Lateral View



B. Superior View

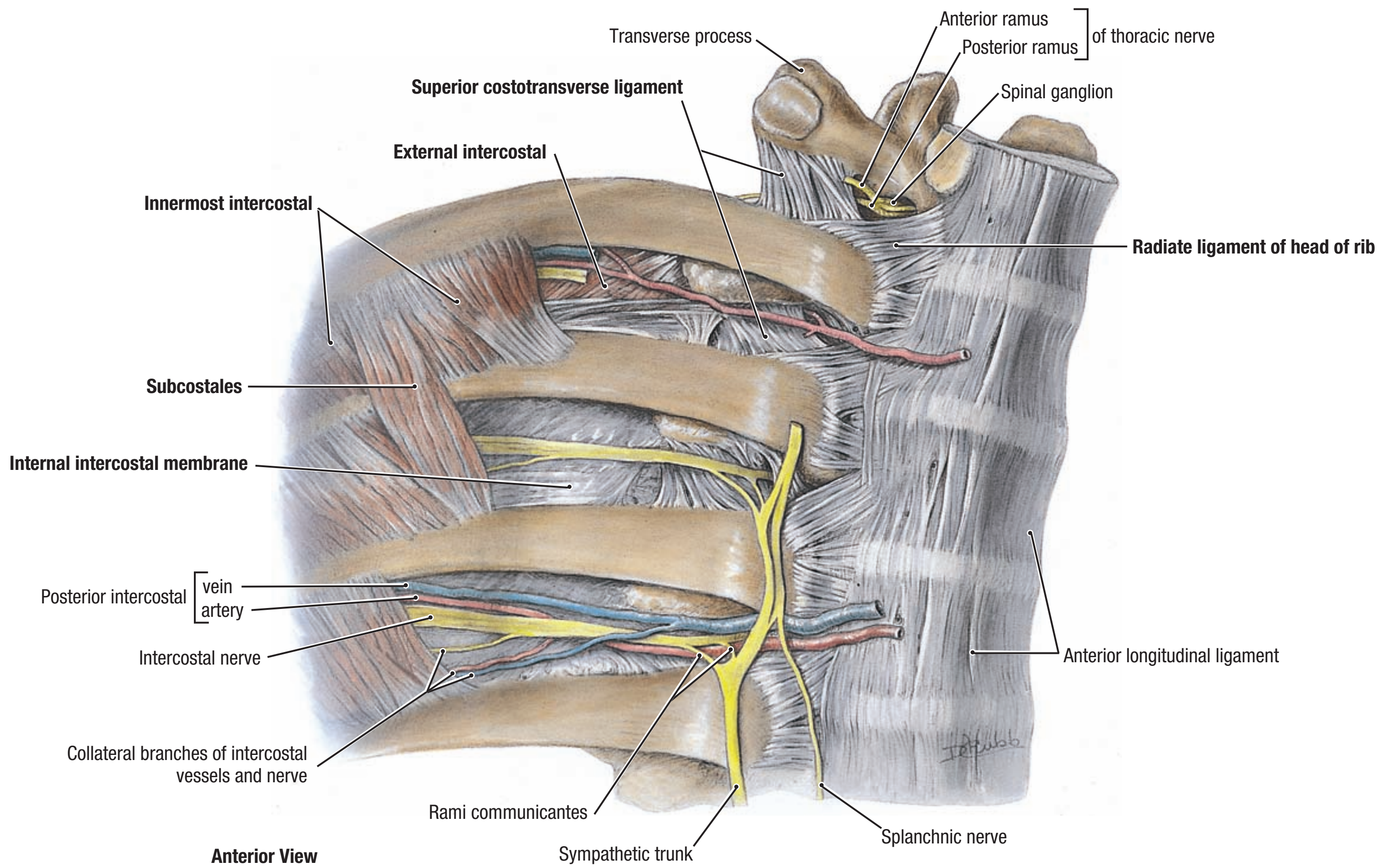
1.15 LIGAMENTS OF COSTOVERTEBRAL ARTICULATIONS

A. External and internal ligaments.

- The radiate ligament joins the head of the rib to two vertebral bodies and the interposed intervertebral disc.
- The superior costotransverse ligament joins the crest of the neck of the rib to the transverse process above.
- The intra-articular ligament joins the crest of the head of the rib to the intervertebral disc.

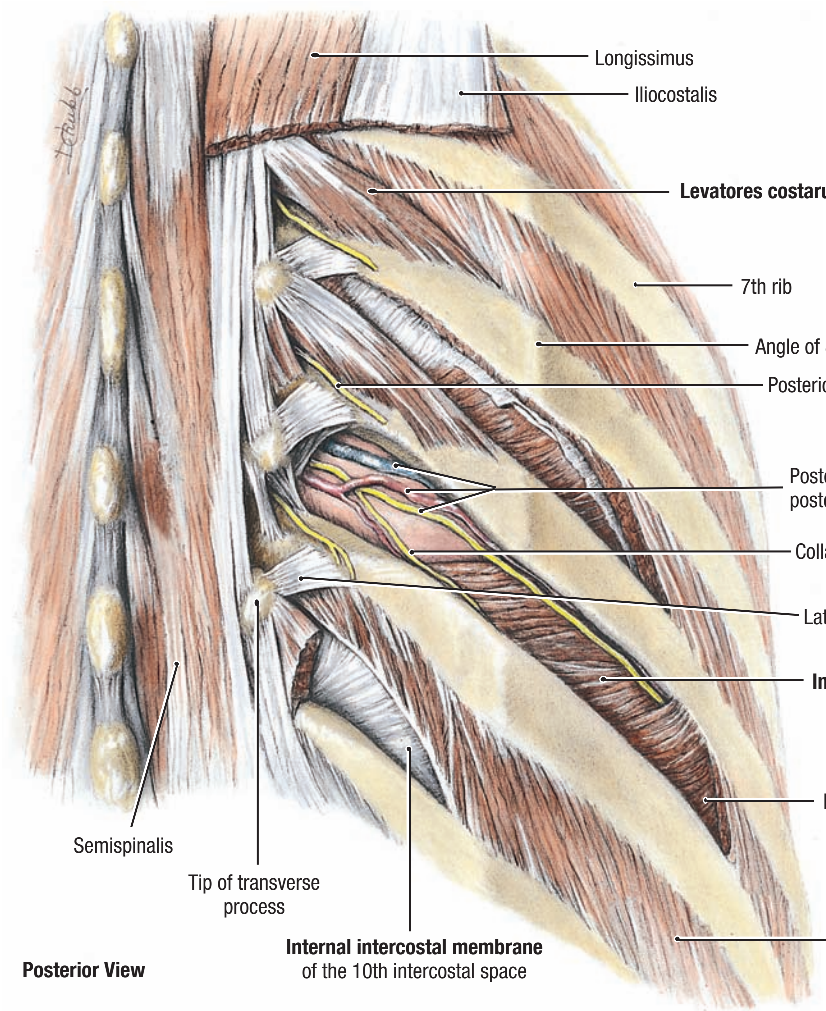
B. Transverse section.

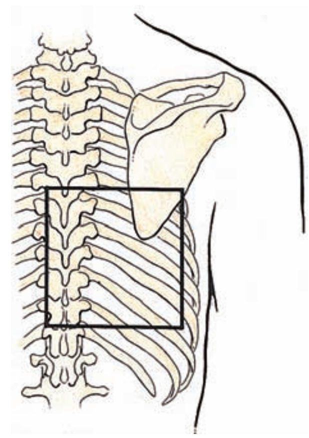
- The vertebral body, transverse processes, superior articulating processes, and posterior elements of the articulating ribs have been transversely sectioned to visualize the joint surfaces and ligaments.
- The costotransverse ligament joins the posterior aspect of the neck of the rib to the adjacent transverse process.
- The lateral costotransverse ligament joins the nonarticulating part of the tubercle of the rib to the tip (apex) of the transverse process.



1.16 VERTEBRAL ENDS OF INTERNAL ASPECT OF INTERCOSTAL SPACES

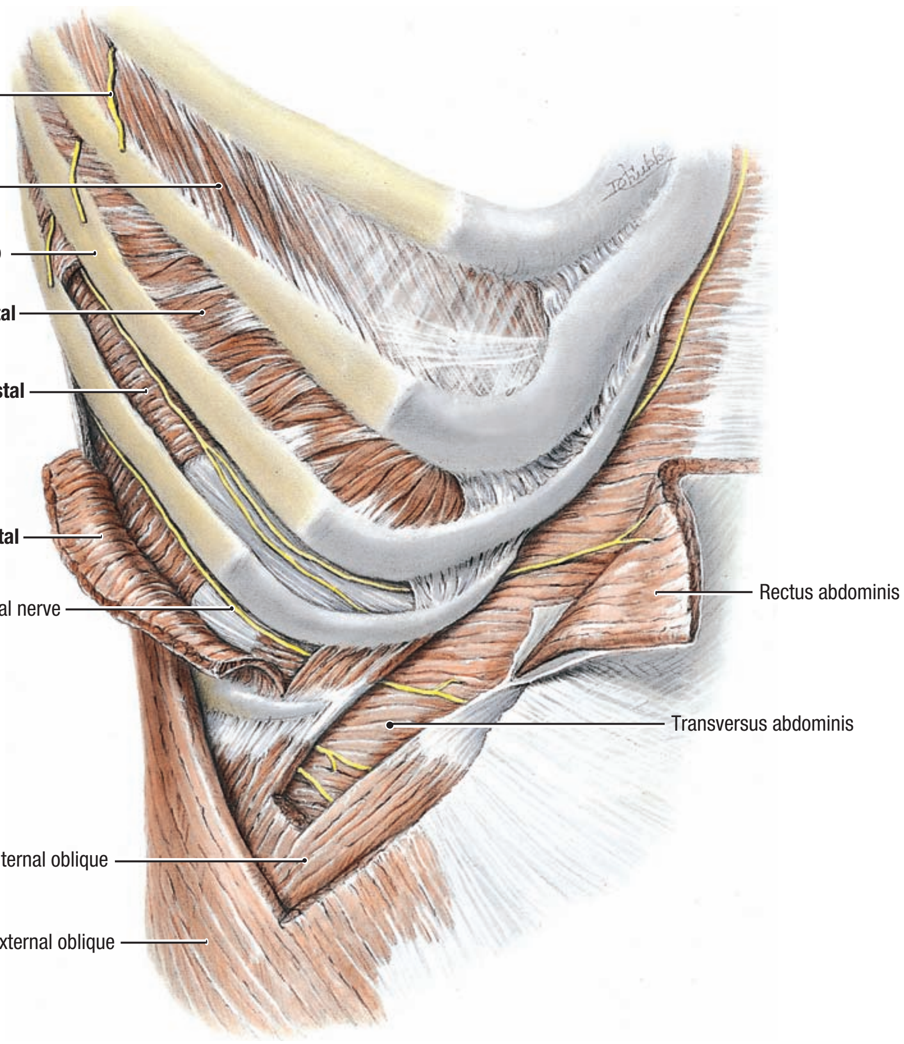
- Portions of the innermost intercostal muscle that bridge two intercostal spaces are called subcostales muscles.
- The internal intercostal membrane, in the middle space, is continuous medially with the superior costotransverse ligament.
- Note the order of the structures in the most inferior space: posterior intercostal vein and artery, and intercostal nerve; note also their collateral branches.
- The anterior ramus crosses anterior to the superior costotransverse ligament; the posterior ramus is posterior to it.
- The intercostal nerves attach to the sympathetic trunk by rami communicantes; the splanchnic nerve is a visceral branch of the trunk.



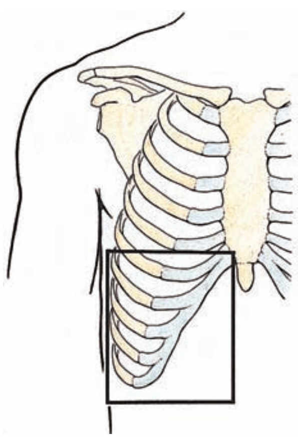


1.17 VERTEBRAL ENDS OF EXTERNAL ASPECT OF INFERIOR INTERCOSTAL SPACES

- The iliocostalis and longissimus muscles have been removed, exposing the levatores costarum muscle. Of the five intercostal spaces shown, the superior two (6th and 7th) are intact. In the 8th and 10th spaces, varying portions of the external intercostal muscle have been removed to reveal the underlying internal intercostal membrane, which is continuous with the internal intercostal muscle. In the 9th space, the levatores costarum muscle has been removed to show the posterior intercostal vessels and intercostal nerve.
- The intercostal vessels and nerve disappear laterally between the internal and innermost intercostal muscles.
- The intercostal nerve is the most inferior of the neurovascular trio (posterior intercostal vein and artery and intercostal nerve) and the least sheltered in the intercostal groove; a collateral branch arises near the angle of the rib.
- **Thoracocentesis.** Sometimes it is necessary to insert a hypodermic needle through an intercostal space into the pleural cavity (see Fig. 1.27) to obtain a sample of pleural fluid or to remove blood or pus. To avoid damage to the intercostal nerve and vessels, the needle is inserted superior to the rib, high enough to avoid the collateral branches.

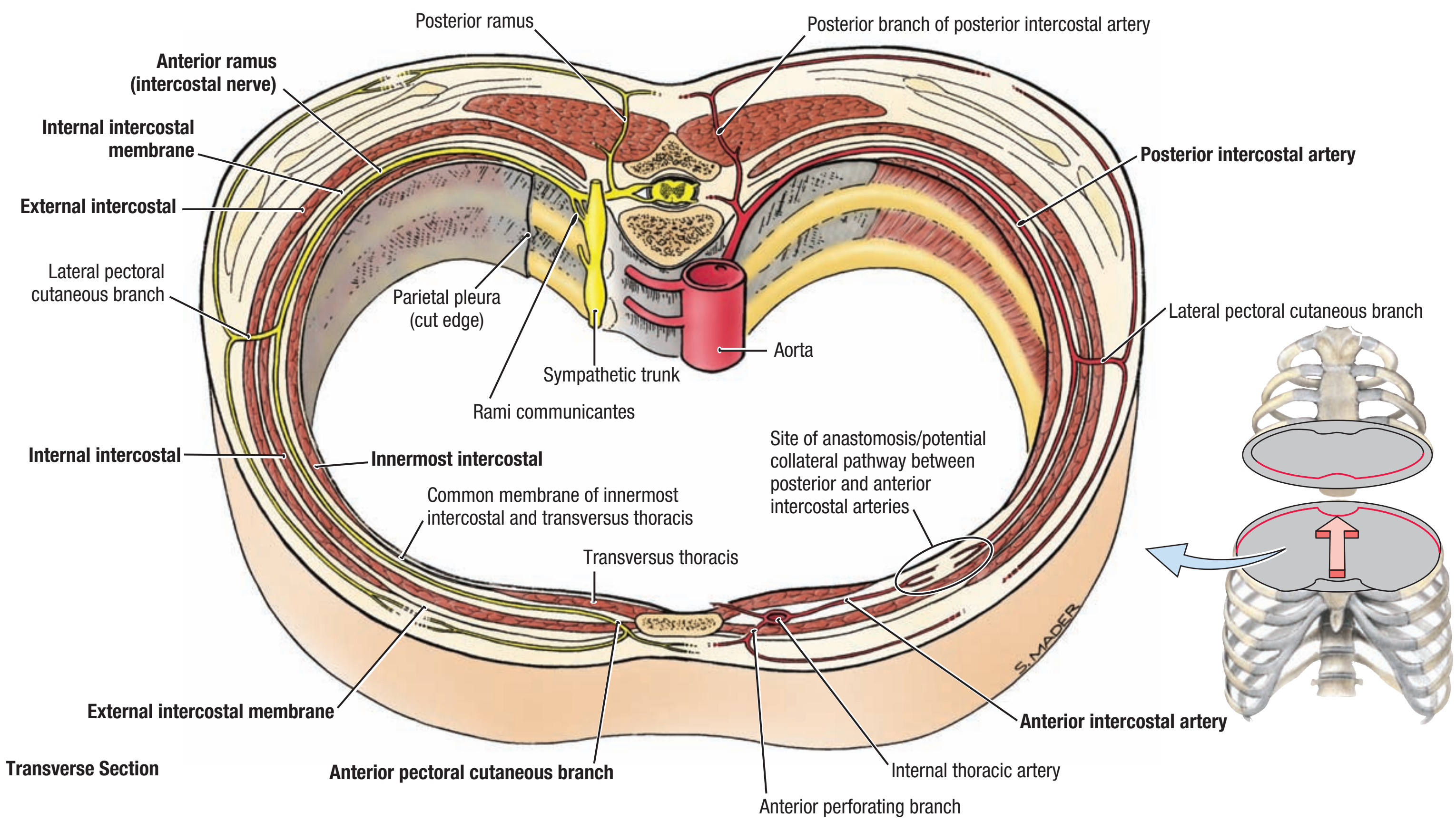


Anterior View



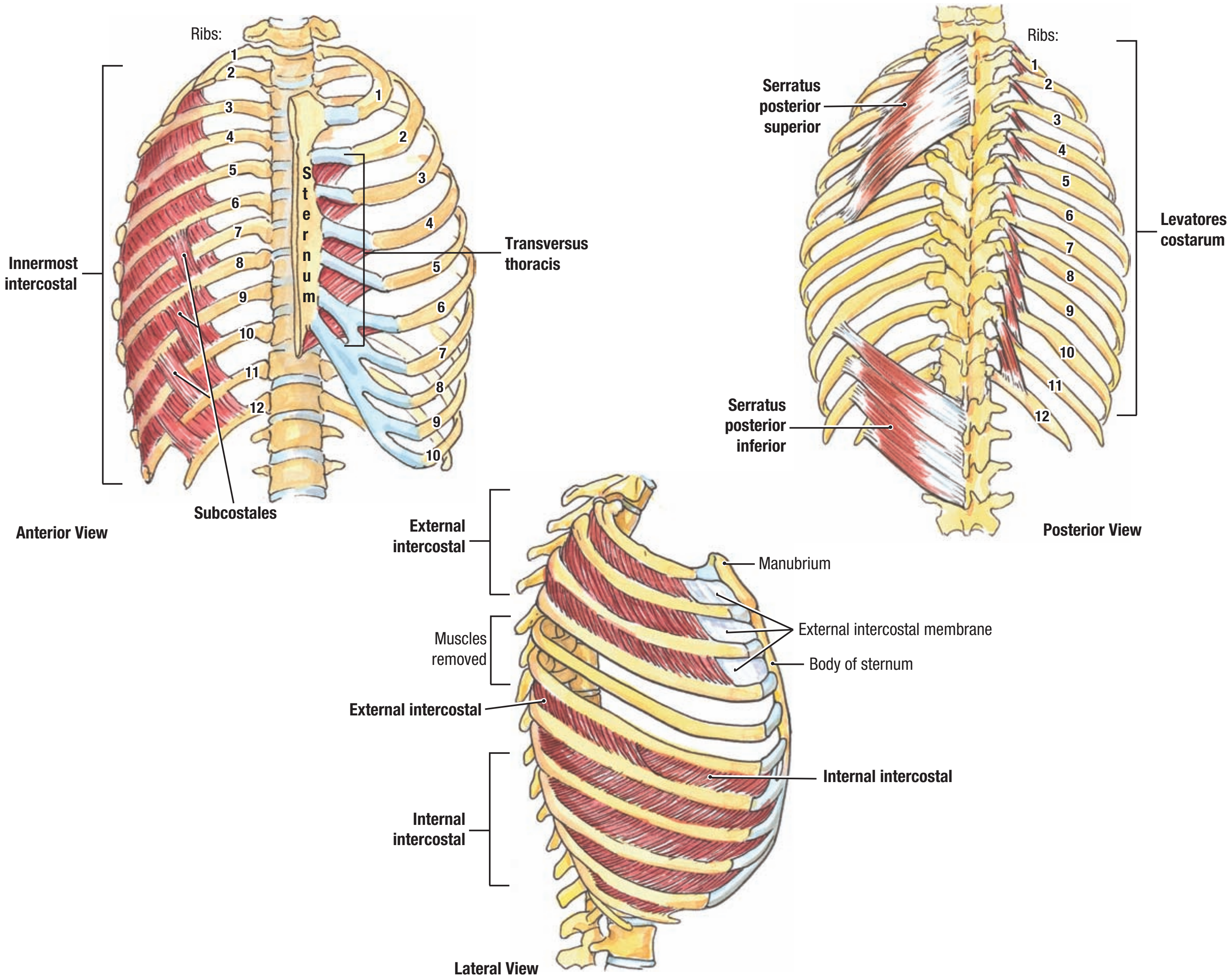
1.18 ANTERIOR ENDS OF INFERIOR INTERCOSTAL SPACES

- The fibers of the external intercostal and external oblique muscles run inferomedially.
- The internal intercostal and internal oblique muscles are in continuity at the ends of the 9th, 10th, and 11th intercostal spaces.
- The intercostal nerves lie deep to the internal intercostal muscle but superficial to the innermost intercostal muscle; anteriorly, these nerves lie superficial to the transversus thoracis or transversus abdominis muscles.
- Intercostal nerves run parallel to the ribs and costal cartilages; on reaching the abdominal wall, nerves T7 and T8 continue superiorly, T9 continues nearly horizontally, and T10 continues inferomedially toward the umbilicus. These nerves provide cutaneous innervation in overlapping segmental bands.



1.19 CONTENTS OF INTERCOSTAL SPACE, TRANSVERSE SECTION

- The diagram is simplified by showing nerves on the right and arteries on the left.
- The three musculomembranous layers are the external intercostal muscle and membrane, internal intercostal muscle and membrane, and the innermost intercostal muscle, transversus thoracis muscle, and the membrane connecting them.
- The intercostal nerves are the anterior rami of spinal nerves T1 to T11; the anterior ramus of T12 is the subcostal nerve.
- Posterior intercostal arteries are branches of the aorta (the superior two spaces are supplied from the superior intercostal branch of the costocervical trunk); the anterior intercostal arteries are branches of the internal thoracic artery or its branch, the musculophrenic artery.
- The posterior rami innervate the deep back muscles and skin adjacent to the vertebral column.

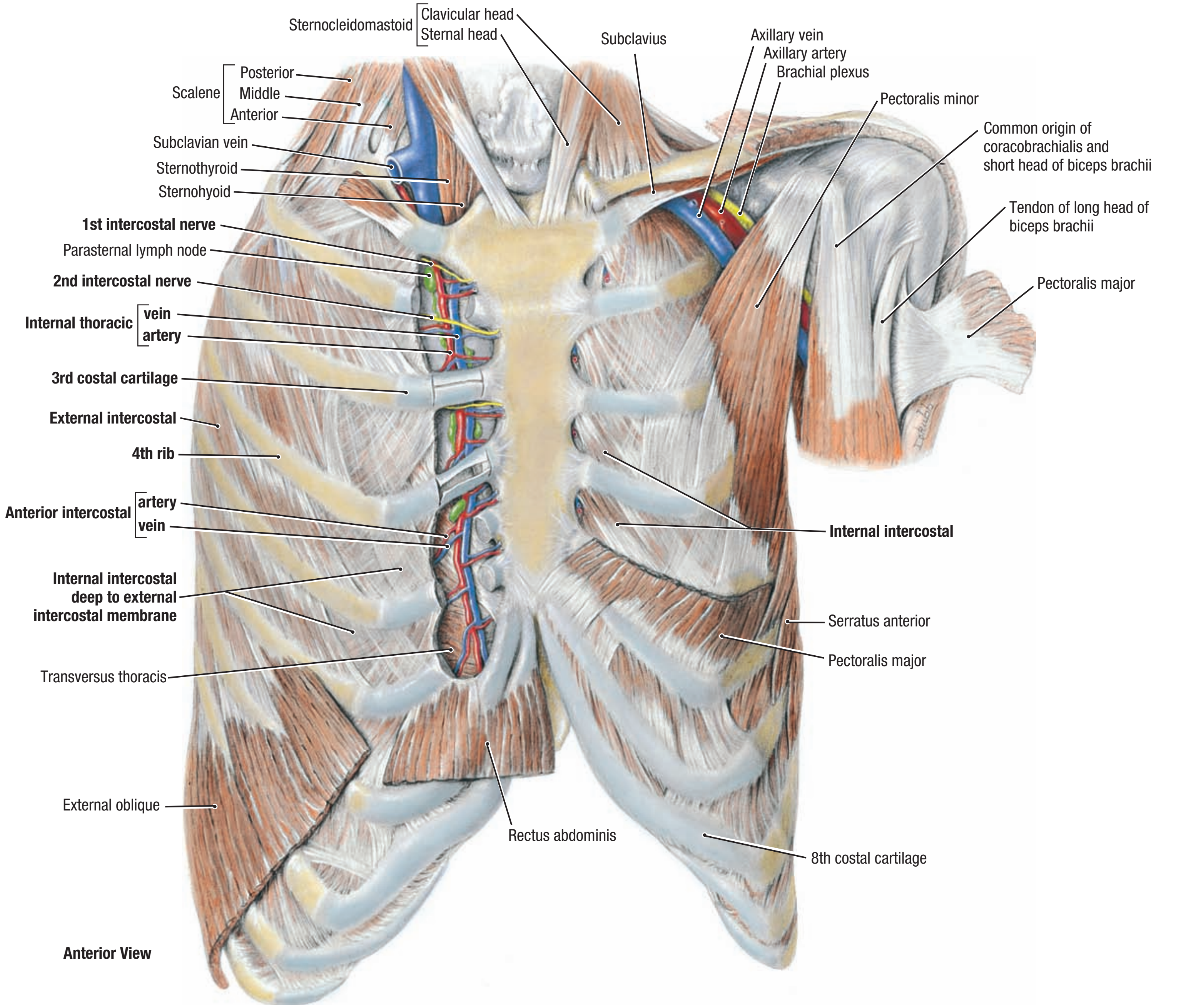


1.20 MUSCLES OF THORACIC WALL

TABLE 1.1 MUSCLES OF THORACIC WALL

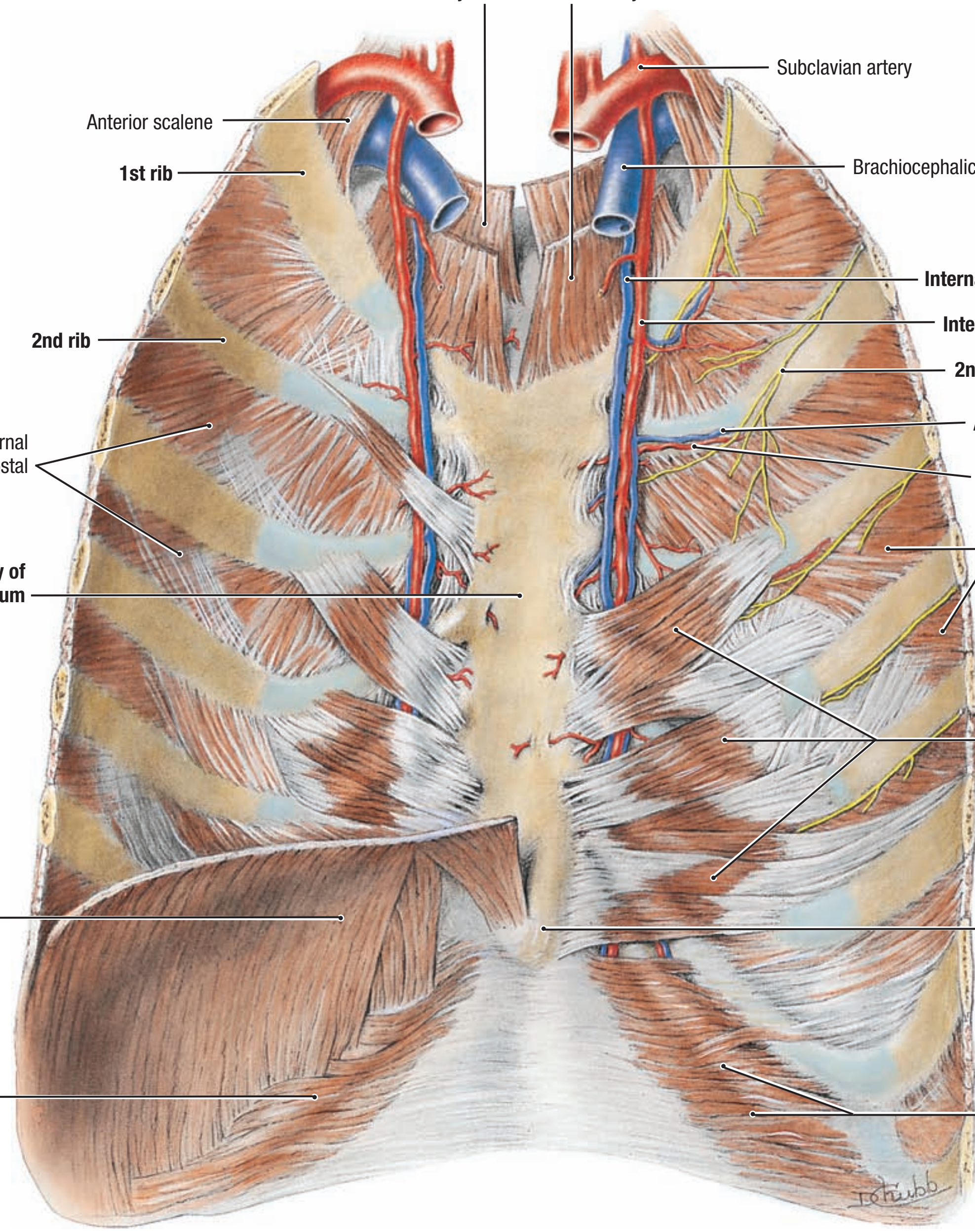
Muscle	Superior Attachment	Inferior Attachment	Innervation	Action[a]
External intercostal	Inferior border of ribs	Superior border of rib below	Intercostal nerve	Elevate ribs
Internal intercostal				Depress ribs
Innermost intercostal				Probably elevate ribs
Transversus thoracis	Posterior surface of lower sternum	Internal surface of costal cartilages 2–6		Depress ribs
Subcostales	Internal surface of lower ribs near their angles	Superior borders of 2nd or 3rd ribs below		
Levatores costarum	Transverse processes of C7–T11	Subjacent ribs between tubercle and angle	Posterior rami of C8–T11 nerves	Elevate ribs
Serratus posterior superior	Nuchal ligament, spinous processes of C7–T3	Superior borders of 2nd–4th ribs	Second to fifth intercostal nerves	Depress ribs
Serratus posterior inferior	Spinous processes of T11–L2	Inferior borders of 8th–12th ribs near their angles	Anterior rami of T9–T12 nerves	

[a]The tonus of all intercostal muscles keep intercostal spaces rigid, thereby preventing them from bulging out during expiration and from being drawn in during inspiration. Role of individual intercostal muscles and accessory muscles of respiration in moving the ribs is difficult to interpret despite many electromyographic studies. The role of the respiratory muscles depends on which accessory muscles are contracting at the same time.



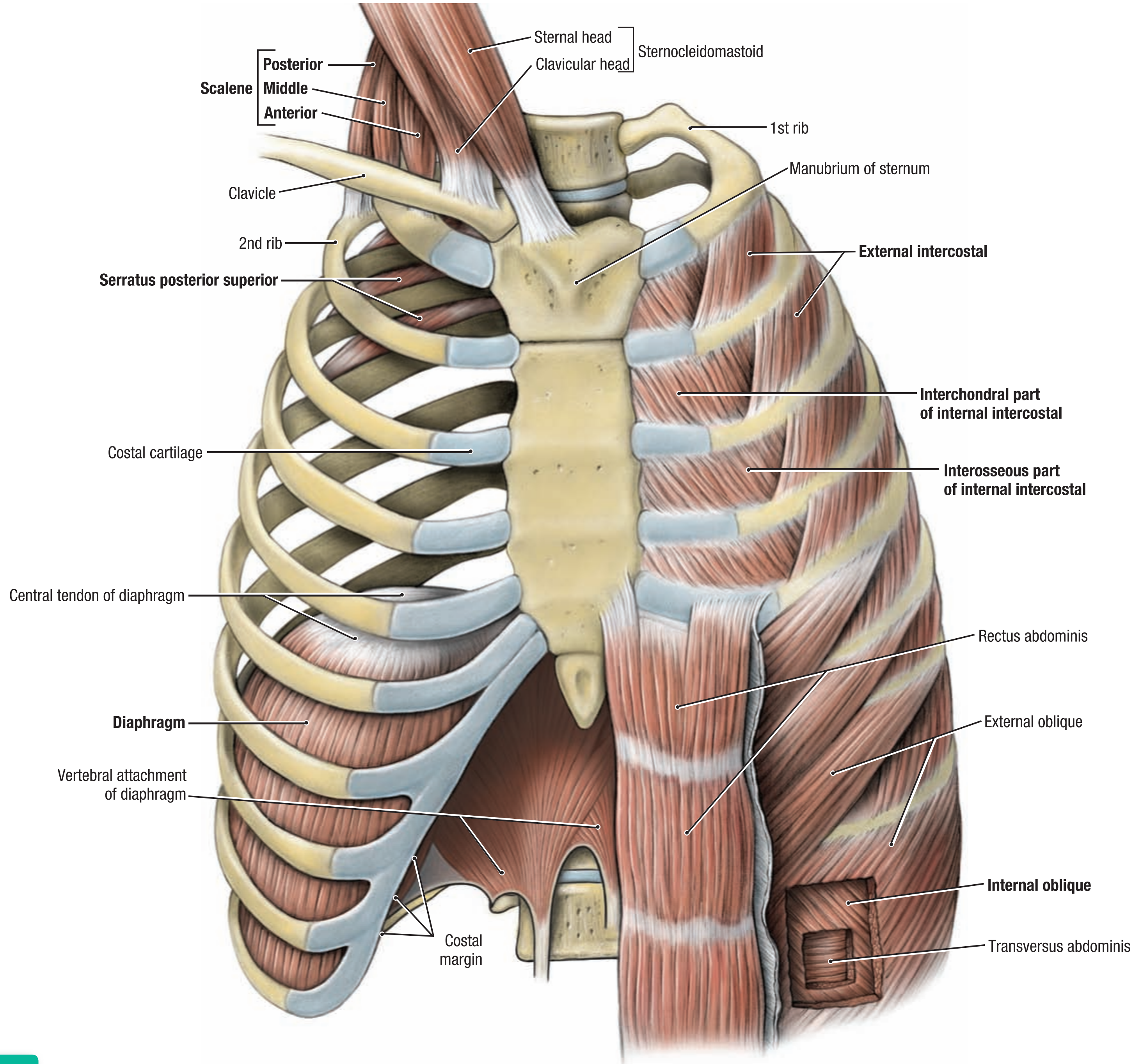
1.21 EXTERNAL ASPECT OF THORACIC WALL

- H-shaped cuts were made through the perichondrium of the 3rd and 4th costal cartilages to shell out segments of cartilage. During surgery, retaining perichondrium promotes regrowth of removed cartilages.
- The internal thoracic (internal mammary) vessels run inferiorly deep to the costal cartilages and just lateral to the edge of the sternum, providing anterior intercostal branches.
- The parasternal lymph nodes (*green*) receive lymphatic vessels from the anterior parts of intercostal spaces, the costal pleura and diaphragm, and the medial part of the breast.
- The subclavian vessels are "sandwiched" between the 1st rib and clavicle and are "padded" by the subclavius.
- **Surgical access to thorax**. To gain access to the thoracic cavity for surgical procedures, the sternum is divided in the median plane (median sternotomy) and retracted (spread apart). After surgery, the halves of the sternum are held together with wire structures.



1.22 INTERNAL ASPECT OF THE ANTERIOR THORACIC WALL

- The inferior portions of the internal thoracic vessels are covered posteriorly by the transversus thoracis muscle; the superior portions are in contact with the parietal pleura (removed).
- The transversus thoracis muscle (superior to diaphragm) is continuous with the transversus abdominis muscle (inferior to diaphragm); these form the innermost layer of the three flat muscles of the thoracoabdominal wall.
- The internal thoracic (internal mammary) artery arises from the subclavian artery and is accompanied by two venae comitantes up to the 2nd costal cartilage in this specimen and, superior to this, by the single internal thoracic vein, which drains into the brachiocephalic vein.

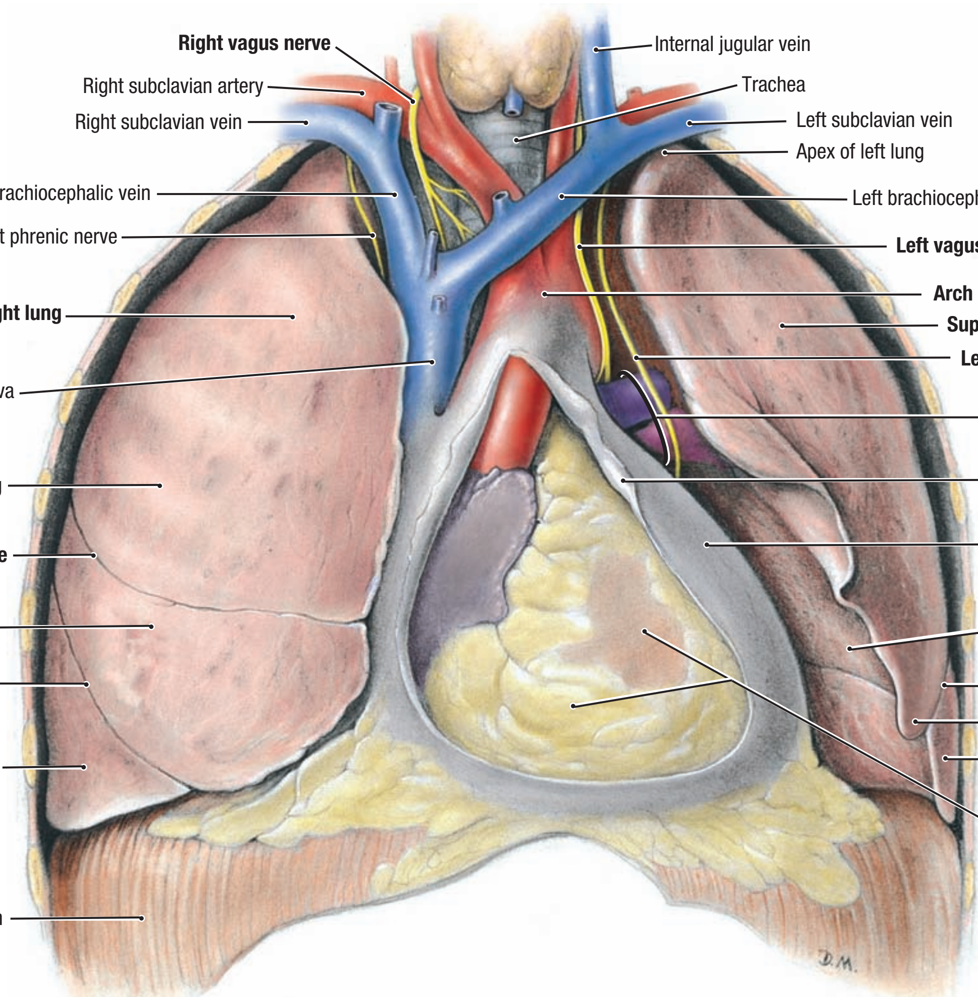


1.23 MUSCLES OF RESPIRATION

TABLE 1.2 MUSCLES OF RESPIRATION

Inspiration			Expiration
Normal (Quiet)	Major	Diaphragm (Active Contraction)	Passive (Elastic) Recoil of Lungs and Thoracic Cage
	Minor	*Tonic contraction* of external intercostals and interchondral portion of internal intercostals to resist negative pressure	*Tonic contraction* of muscles of anterolateral abdominal walls (rectus abdominis, external and internal obliques, transversus abdominis) to antagonize diaphragm by maintaining intra-abdominal pressure
Active (Forced)		In addition to the above, *active contraction* of sternocleido-mastoid, descending (superior) trapezius, pectoralis minor, and scalenes, to elevate and fix upper rib cage	In addition to the above, *active contraction* of muscles of anterolateral abdominal wall (antagonizing diaphragm by increasing intra-abdominal pressure and by pulling inferiorly and fixing inferior costal margin): rectus abdominis, external and internal obliques, and transversus abdominis
		External intercostals, interchondral portion of internal intercostals, subcostales, levatores costarum, and serratus posterior superior[a] to elevate ribs	Internal intercostal (interosseous part) and serratus posterior inferior[a] to depress ribs

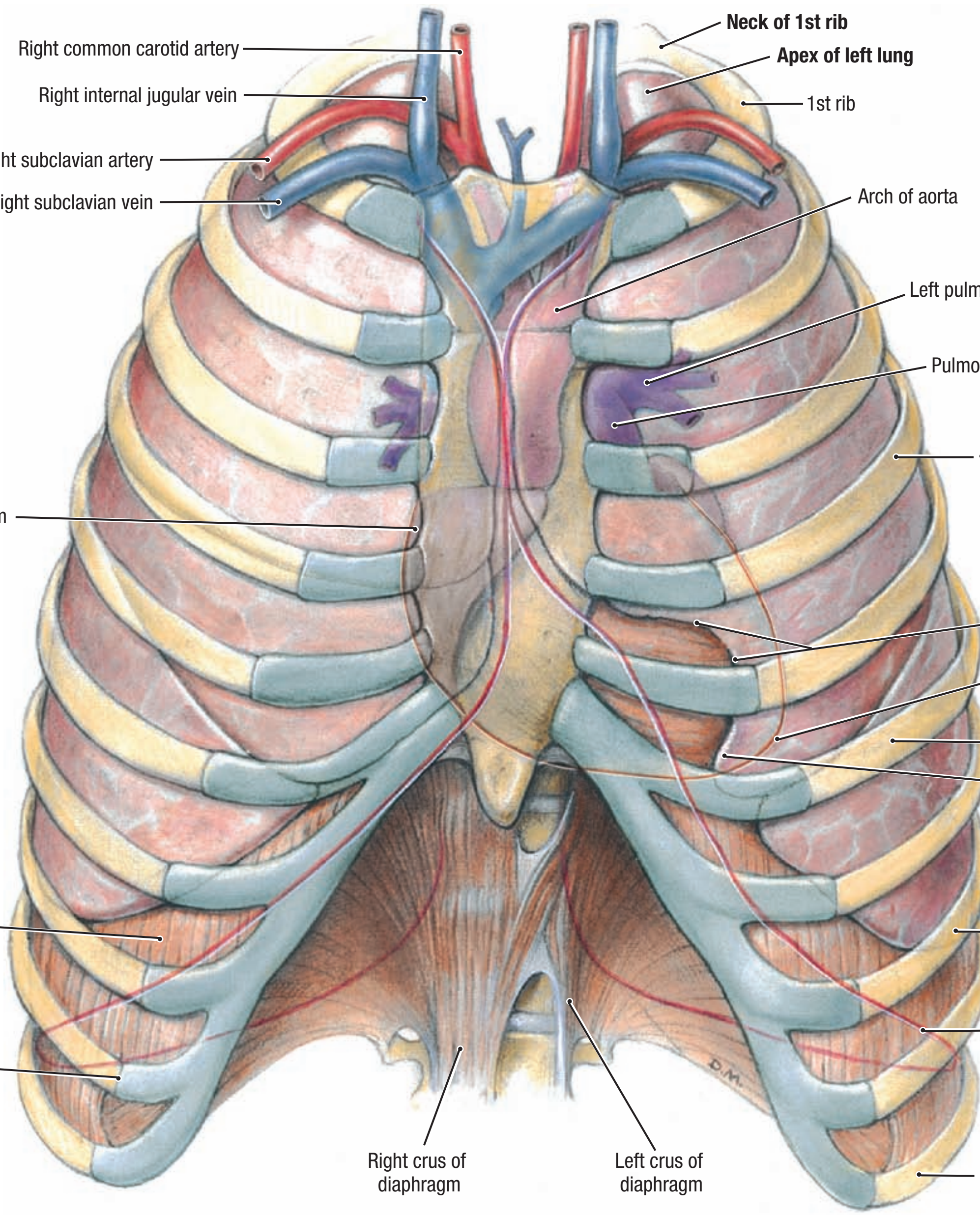
[a]Recent studies indicate that the serratus posterior superior and inferior muscles may serve primarily as organs of proprioception rather than motion.



Anterior View

1.24 THORACIC CONTENTS IN SITU

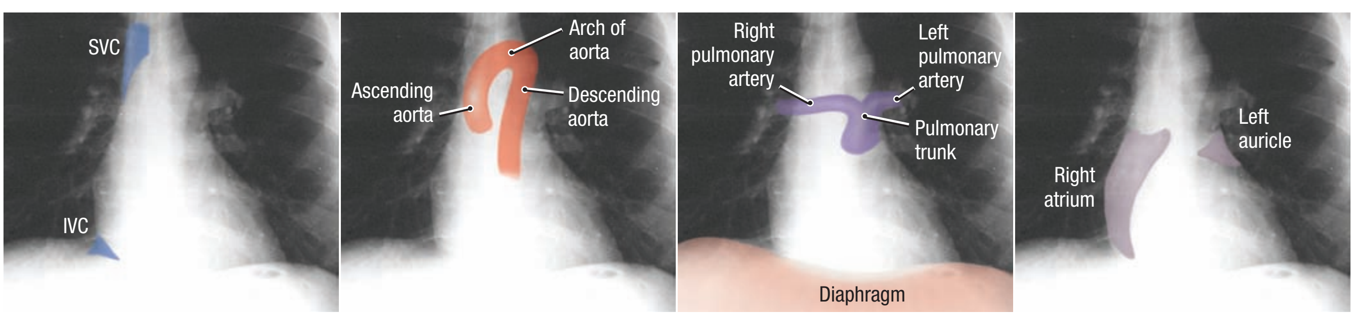
- The fibrous pericardium, lined by the parietal layer of serous pericardium, is removed anteriorly to expose the heart and great vessels.
- The right lung has three lobes; the superior lobe is separated from the middle lobe by the horizontal fissure, and the middle lobe is separated from the inferior lobe by the oblique fissure. The left lung has two lobes, superior and inferior, separated by the oblique fissure.
- The anterior border of the left lung is reflected laterally to visualize the phrenic nerve passing anterior to the root of the lung and the vagus nerve lying anterior to the arch of the aorta and then passing posterior to the root of the lung.
- As the right vagus nerve passes anterior to the right subclavian artery, it gives rise to the recurrent branch and then divides to contribute fibers to the esophageal, cardiac, and pulmonary plexuses.



1.25 TOPOGRAPHY OF THE LUNGS AND MEDIASTINUM

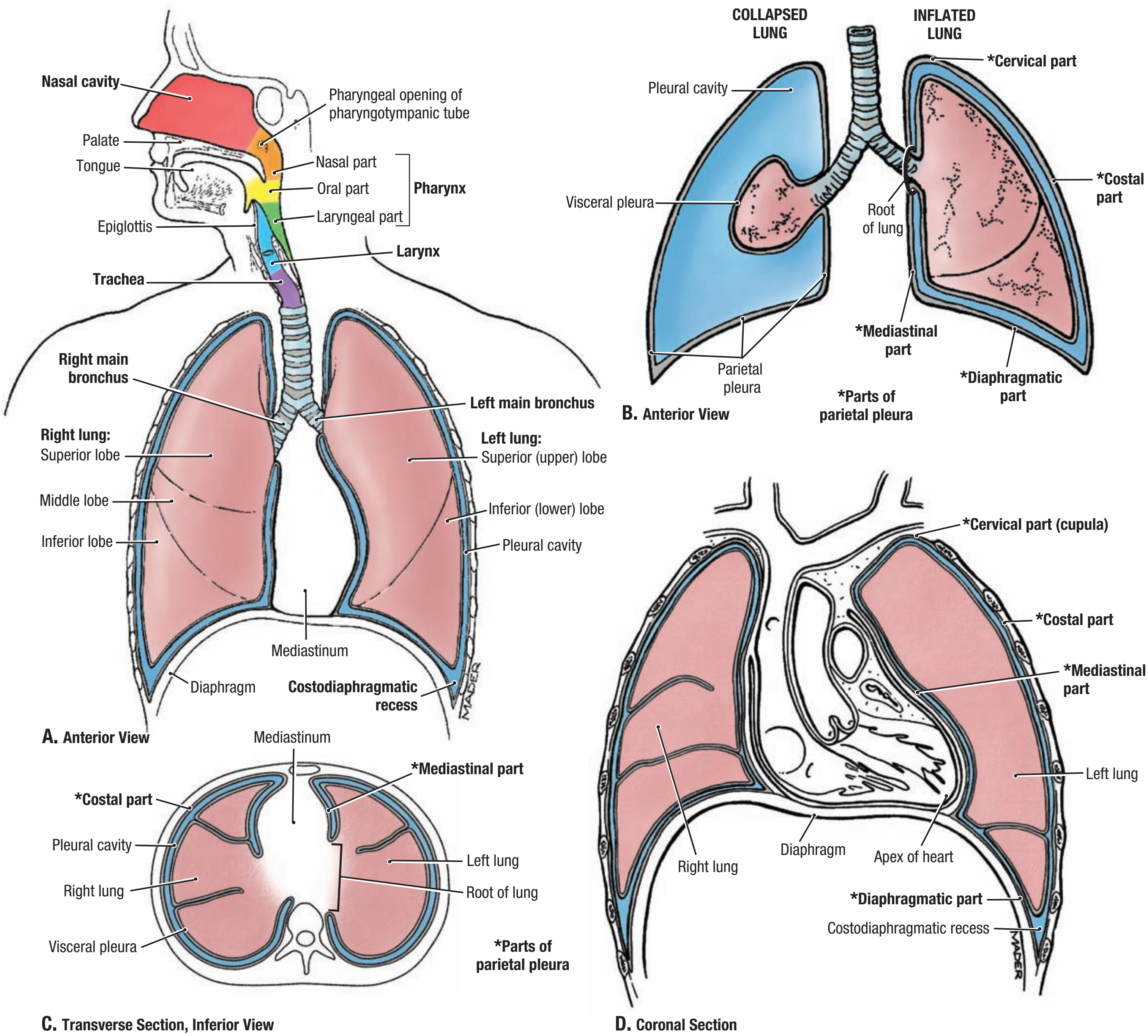
- The mediastinum is located between the pleural cavities and is occupied by the heart and the tissues anterior, posterior, and superior to the heart.
- The apex of the lungs is at the level of the neck of the 1st rib, and the inferior border of the lungs is at the 6th rib in the left midclavicular line and the 8th rib at the lateral aspect of the bony thorax at the midaxillary line.
- The cardiac notch of the left lung and the corresponding deviation of the parietal pleura are away from the median plane toward the left side.
- The inferior reflection of parietal pleura is at the 8th costochondral junction in the midclavicular line, at the 10th rib in the midaxillary line.
- The apex of the heart is in the 5th intercostal space at the left midclavicular line.
- The right atrium forms the right border of the heart and extends just beyond the lateral margin of the sternum.
- The branches of the great vessels pass through the superior thoracic aperture.

Posteroanterior View



1.26 RADIOGRAPH OF CHEST

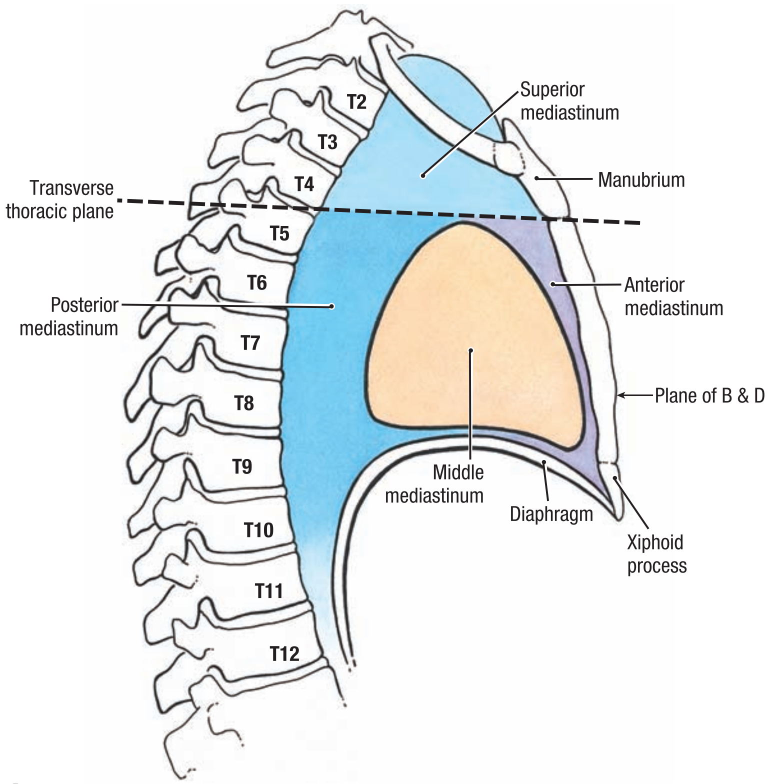
- The right dome of the diaphragm is higher than the left dome due primarily to the large underlying liver.
- The convex right mediastinal border of the heart is formed by the right atrium; above this, the superior vena cava and ascending aorta produce less convex borders.
- The left border of the mediastinal silhouette is formed by the arch of the aorta, pulmonary trunk, left auricle (normally not prominent), and left ventricle.
- Follow the 1st rib to where it curves laterally and then medially to cross inferior to the clavicle.
- Any structure in the mediastinum may contribute to **pathological widening of the mediastinal silhouette**, e.g., after trauma that produces hemorrhage into the mediastinum, malignant lymphoma (cancer of lymphatic tissue) that produces massive enlargement of mediastinal lymph nodes, or enlargement (hypertrophy) of the heart occurring with congestive heart failure.



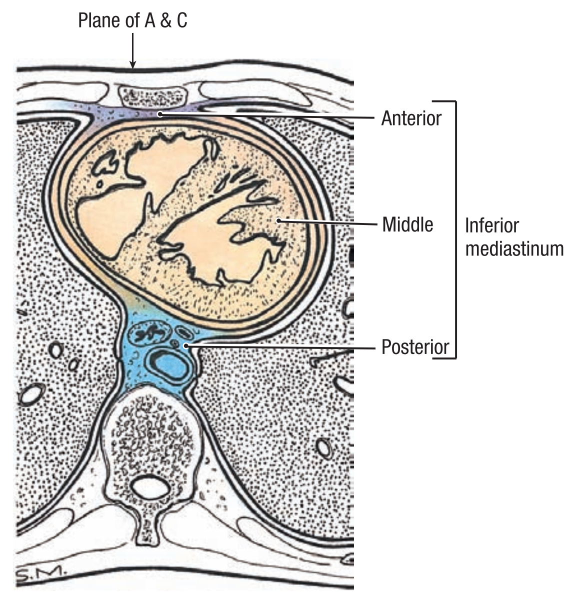
1.27 RESPIRATORY SYSTEM

A. Overview. **B.** Pleural cavity and pleura. **C.** Transverse section. **D**. Coronal section through heart and lungs.

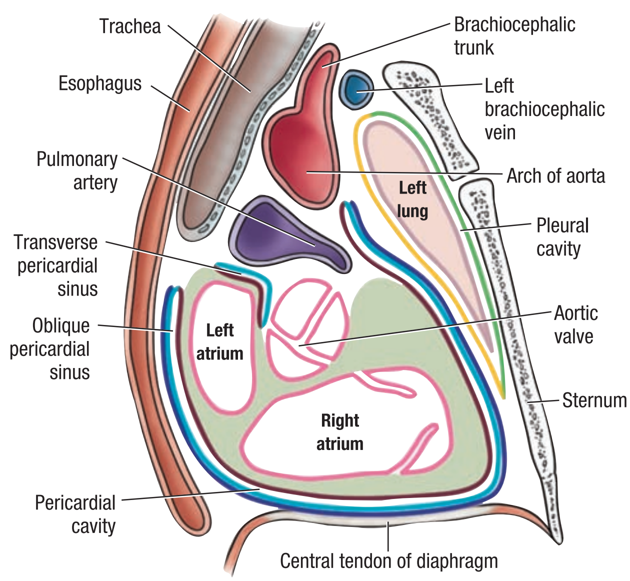
- The lungs invaginate a continuous membranous pleural sac; the visceral (pulmonary) pleura covers the lungs, and the parietal pleura lines the thoracic cavity; the visceral and parietal pleurae are continuous around the root of the lung.
- The parietal pleura can be divided regionally into the costal, diaphragmatic, mediastinal, and cervical parts; note the costodiaphragmatic recess.
- The pleural cavity is a potential space between the visceral and parietal pleurae that contains a thin layer of fluid. If a sufficient amount of air enters the pleural cavity, the surface tension adhering visceral to parietal pleura (lung to thoracic wall) is broken, and the lung collapses (**atelectasis**) because of its inherent elasticity (elastic recoil). When a lung collapses, the pleural cavity—normally a potential space—becomes a real space (**B**) and may contain air (**pneumothorax**), blood (**hemothorax**), etc.



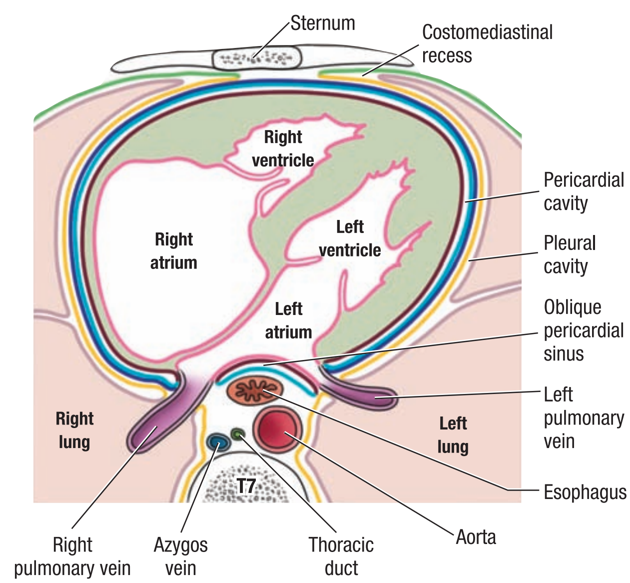
A. Median Section, Left Lateral View



B. Transverse Section, Inferior View



C. Median Section, Right Lateral View



D. Transverse Section, Inferior View

Key for C.

Pericardium

- Fibrous pericardium

Serous pericardium:

- Parietal layer of serous pericardium (lines fibrous pericardium)
- Visceral layer of serous pericardium (outermost layer of heart wall)

Thin film of fluid in pericardial cavity between visceral and parietal layers allows the heart to move freely within the pericardial sac.

Heart

- Epicardium (visceral layer of serous pericardium)
- Myocardium
- Endocardium

Pleurae

- Visceral pleura

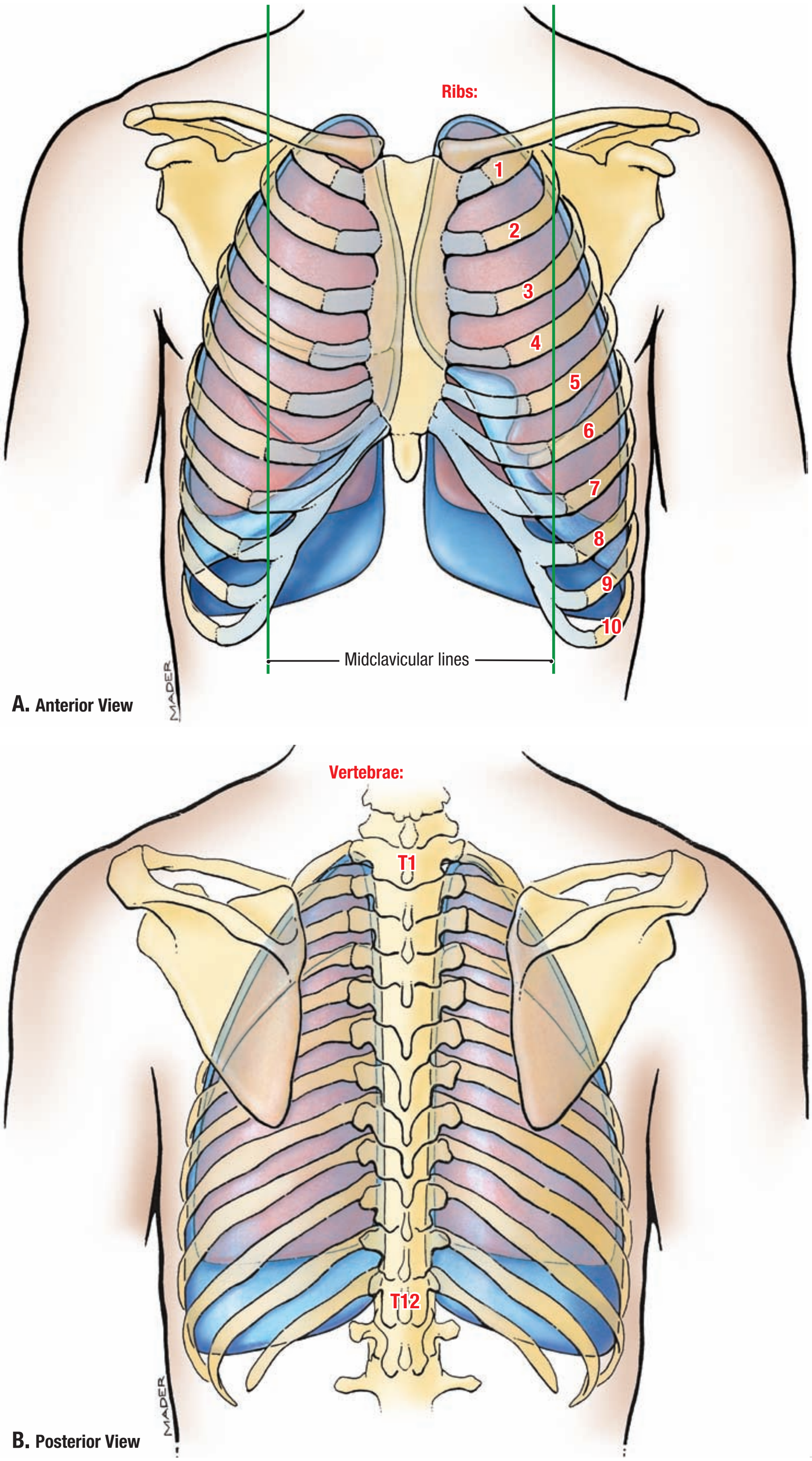
Parietal pleura:

- Mediastinal
- Costal

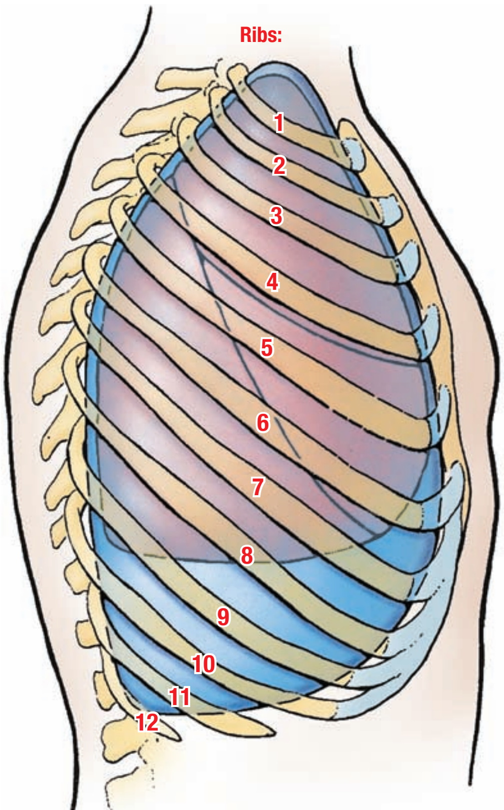
1.28 MEDIASTINUM AND PERICARDIUM

A. and B. Subdivisions of mediastinum. **C. and D.** Layers of pericardium and heart.

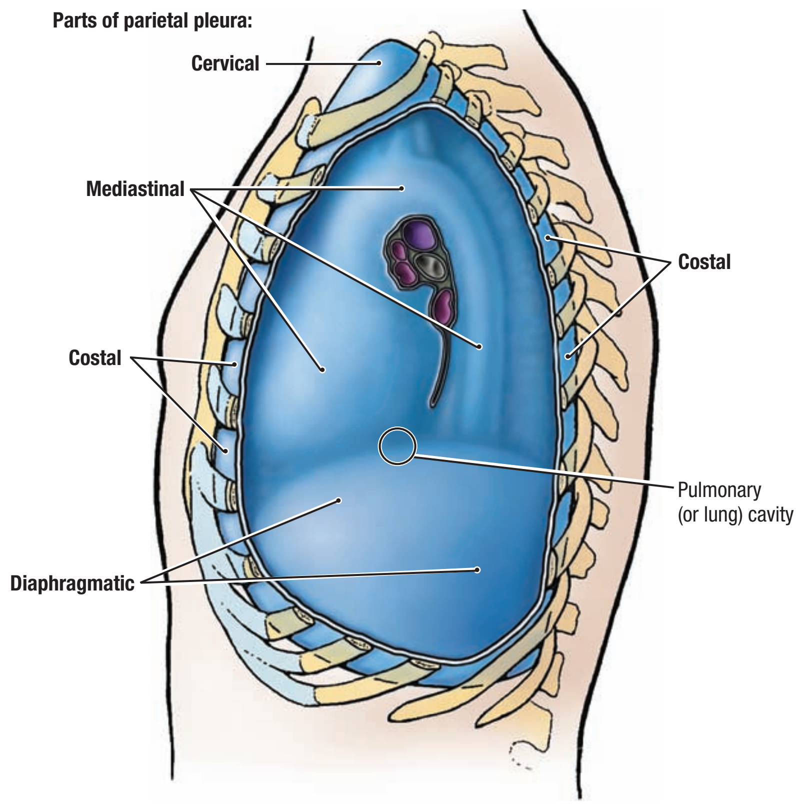
Cardiac tamponade (heart compression) is a potentially lethal condition because heart volume is increasingly compromised by the fluid outside the heart but inside the pericardial cavity. The heart is increasingly compressed and circulation fails. Blood in the pericardial cavity, **hemopericardium**, produces cardiac tamponade.



1.29 EXTENT OF PARIETAL PLEURA AND LUNGS



C. Right Lateral View



D. Left Lateral View (lung removed)

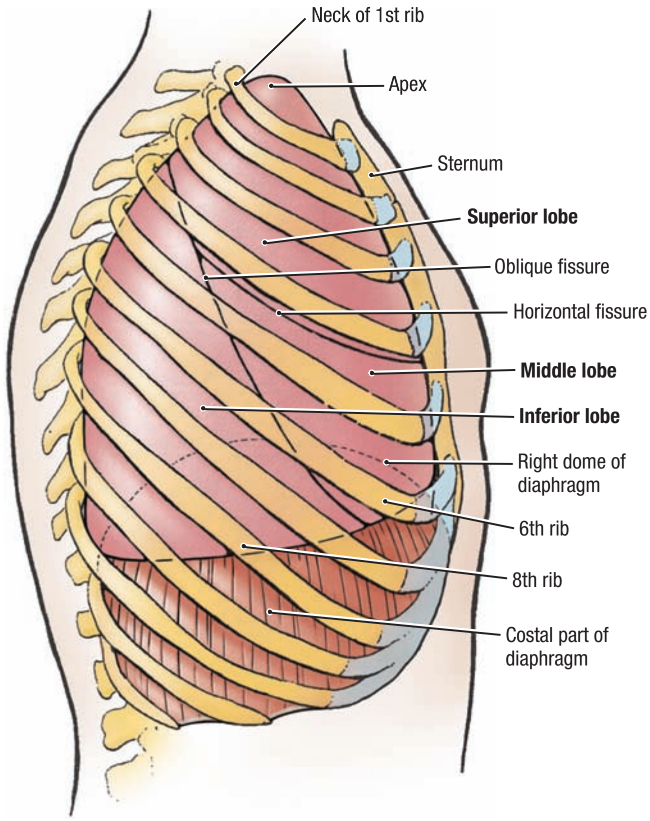
1.29 EXTENT OF PARIETAL PLEURA AND LUNGS (*CONTINUED*)

TABLE 1.3 SURFACE MARKINGS OF PARIETAL PLEURA (BLUE)

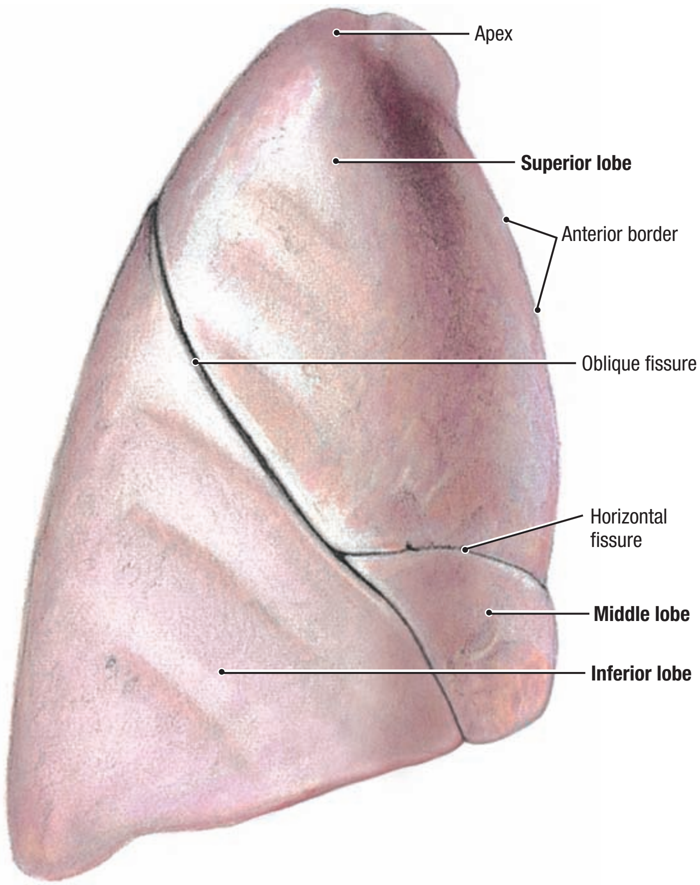
Level	Left Pleura	Right Pleura
Apex	About 4 cm superior to middle of clavicle	About 4 cm superior to middle of clavicle
4th costal cartilage	Midline (anteriorly)	Midline (anteriorly)
6th costal cartilage	Lateral margin of sternum	Midline (anteriorly)
8th costal cartilage	Midclavicular line	Midclavicular line
10th rib	Midaxillary line	Midaxillary line
11th rib	Line of inferior angle of scapula	Line of inferior angle of scapula
12th rib	Lateral border of erector spinae to T12 spinous process (slightly lower level than right pleura)	Lateral border of erector spinae to T12 spinous process

SURFACE MARKINGS OF LUNGS COVERED WITH VISCERAL PLEURA (PINK)

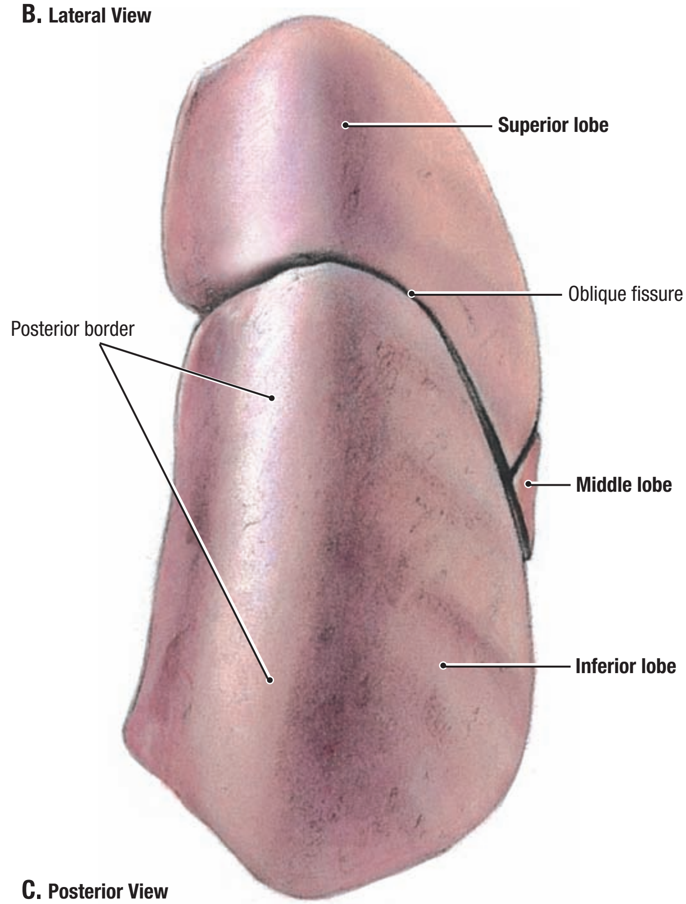
Level	Left Lung	Right Lung
Apex	About 4 cm superior to middle of clavicle	About 4 cm superior to middle of clavicle
2nd costal cartilage	Midline (anteriorly)	Midline (anteriorly)
4th costal cartilage	Lateral margin of sternum	Lateral margin of sternum
6th costal cartilage	Follows 4th costal cartilage, turns inferiorly to 6th costal cartilage in the midclavicular line (cardiac notch)	Midclavicular line
8th rib	Midaxillary line	Midaxillary line
10th rib	Line of inferior angle of scapula to T10 spinous process	Line of inferior angle of scapula to T10 spinous process



A. **Lateral View**



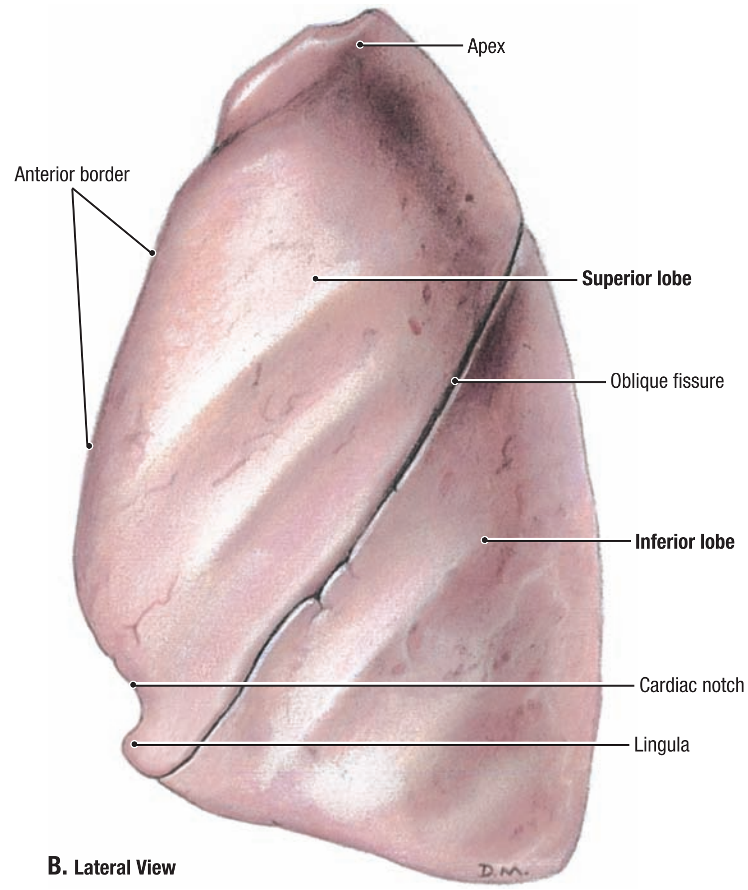
B. **Lateral View**



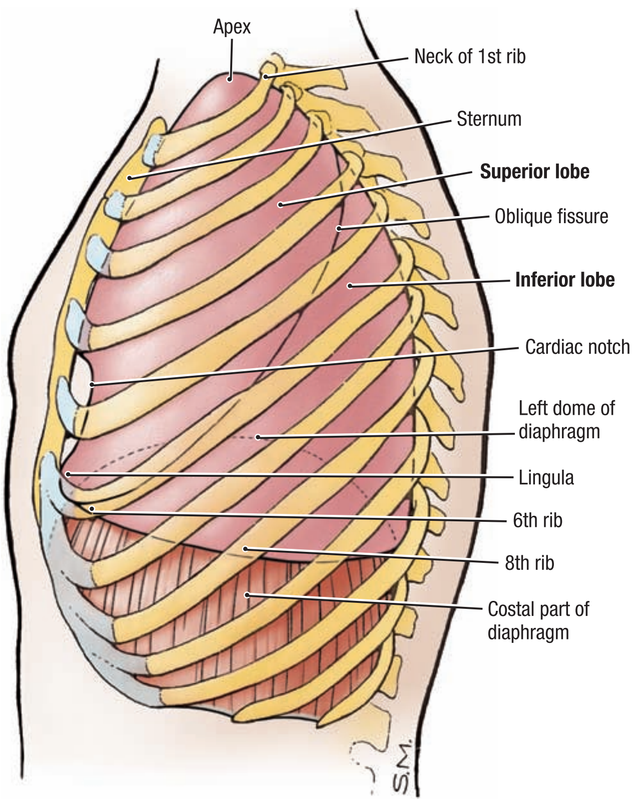
C. **Posterior View**

1.30 RIGHT LUNG

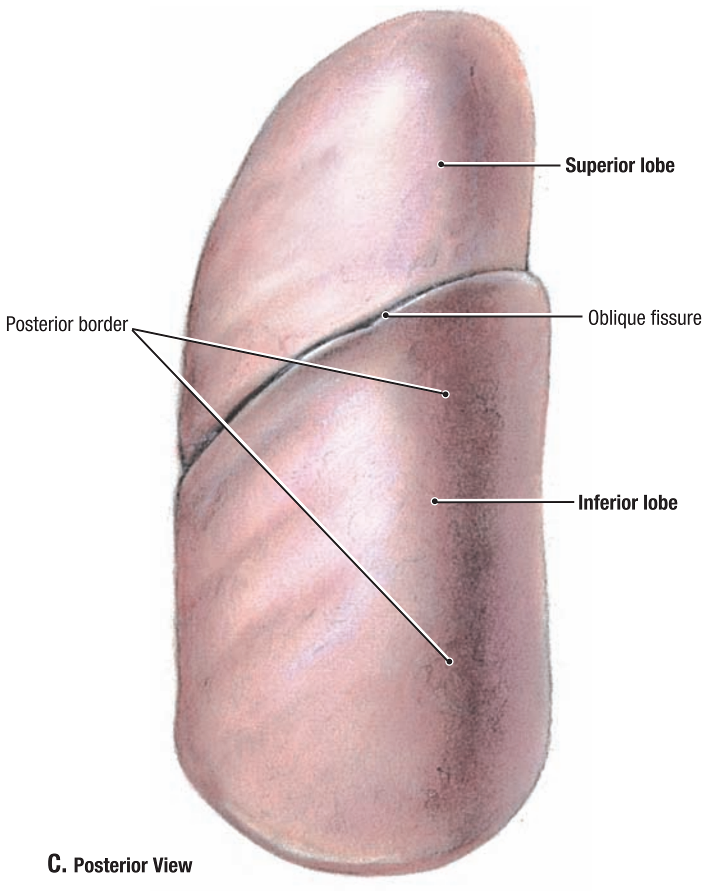
- The oblique and horizontal fissures divide the right lung into three lobes: superior, middle and inferior.
- The right lung is larger and heavier than the left, but is shorter and wider because the right dome of the diaphragm is higher and the heart bulges more to the left.
- Cadaveric lungs may be shrunken, firm and discolored, whereas healthy lungs in living people are normally soft, light and spongy.
- Each lung has an apex and base, three surfaces (costal, mediastinal and diaphragmatic) and three borders (anterior, inferior and posterior).



B. **Lateral View**



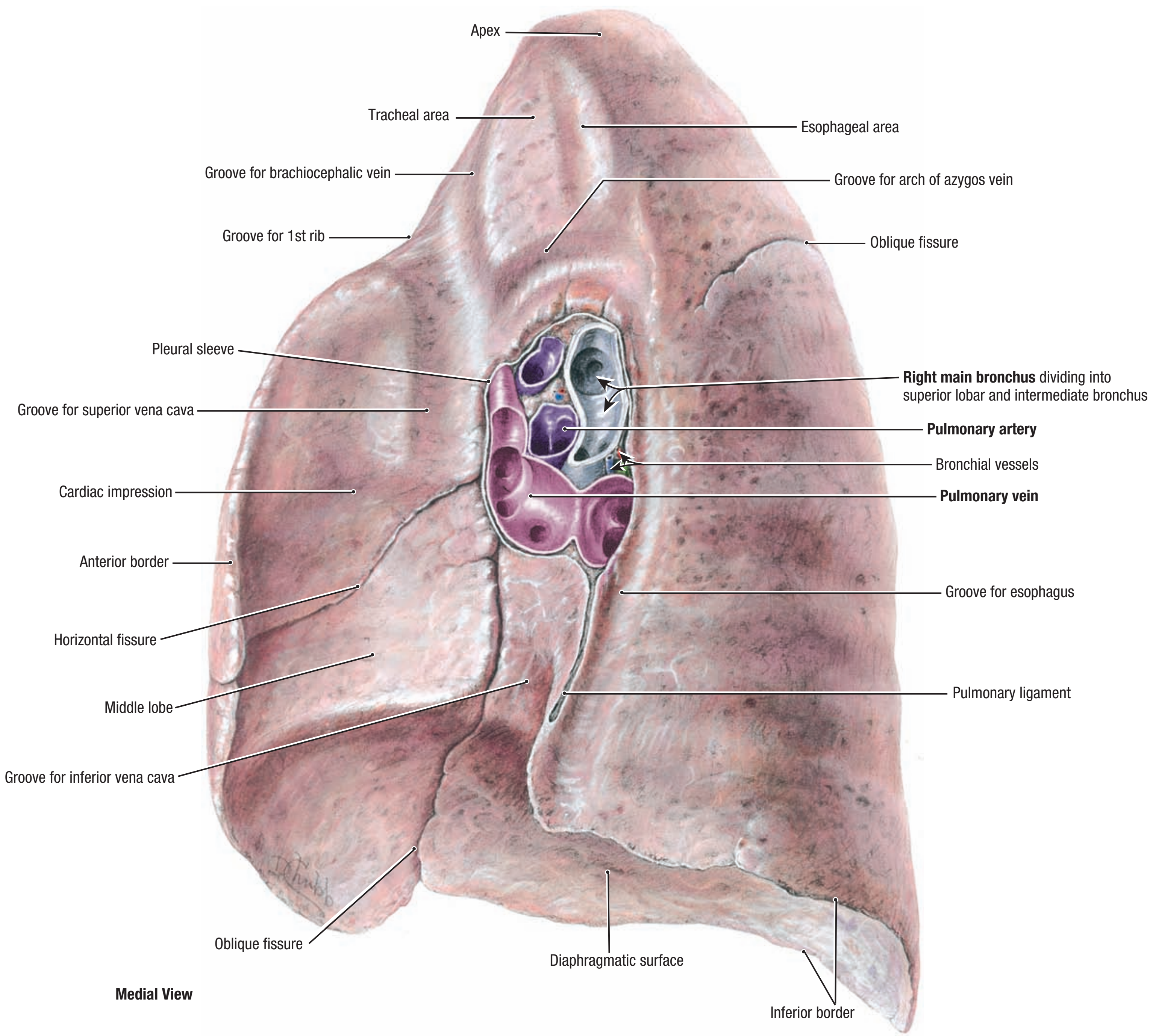
A. **Lateral View**



C. **Posterior View**

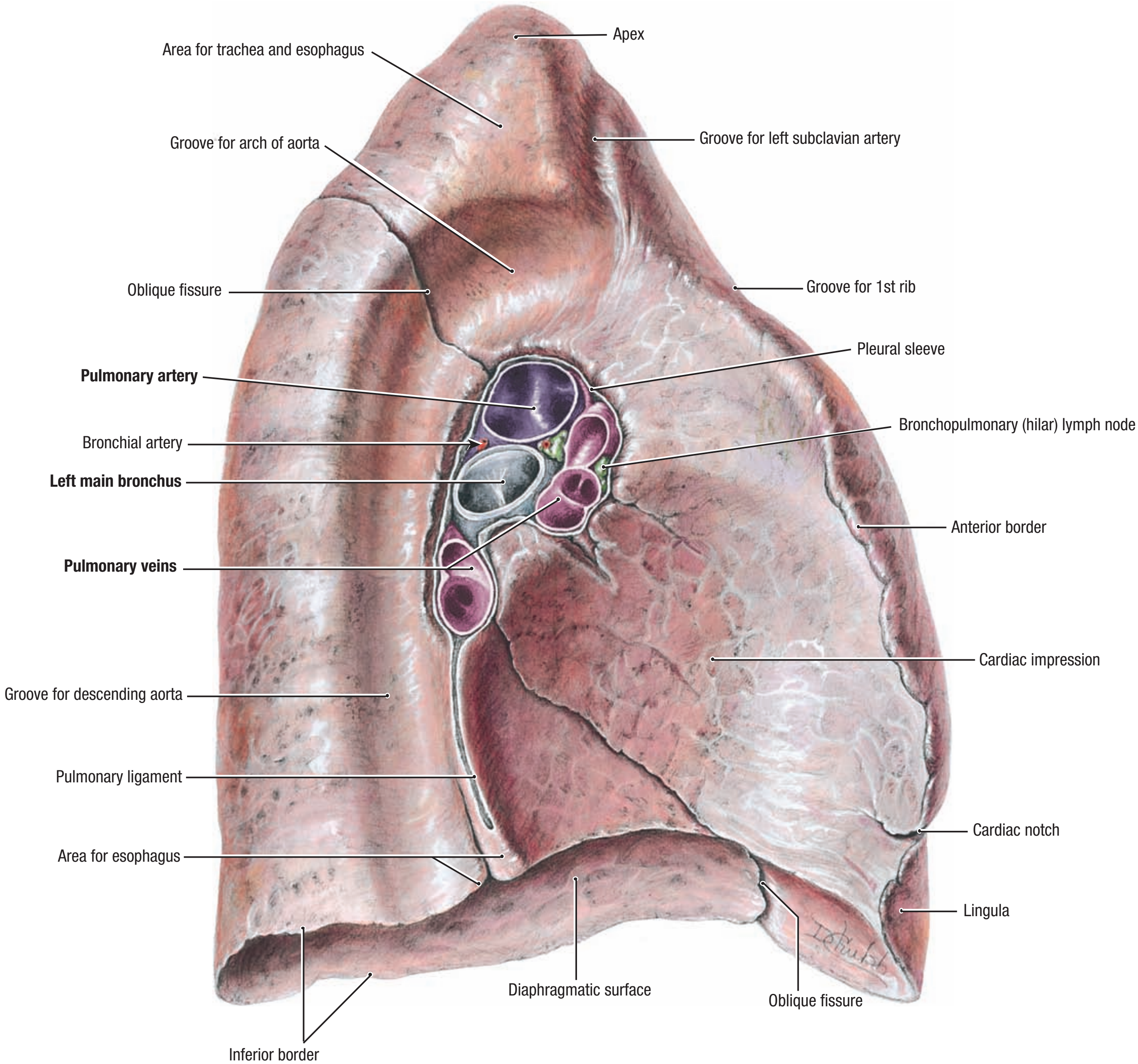
1.31 LEFT LUNG

- The left lung has two lobes, superior and inferior, separated by the oblique fissure.
- The anterior border has a deep cardiac notch that indents the antero-inferior aspect of the superior lobe.
- The lingula, a tonguelike process of the superior lobe, extends below the cardiac notch and slides in and out of the costomediastinal recess during inspiration and expiration.
- The lungs of an embalmed cadaver usually retain impressions of structures that lie adjacent to them, such as the ribs and heart.



1.32 MEDIASTINAL (MEDIAL) SURFACE AND HILUM OF RIGHT LUNG

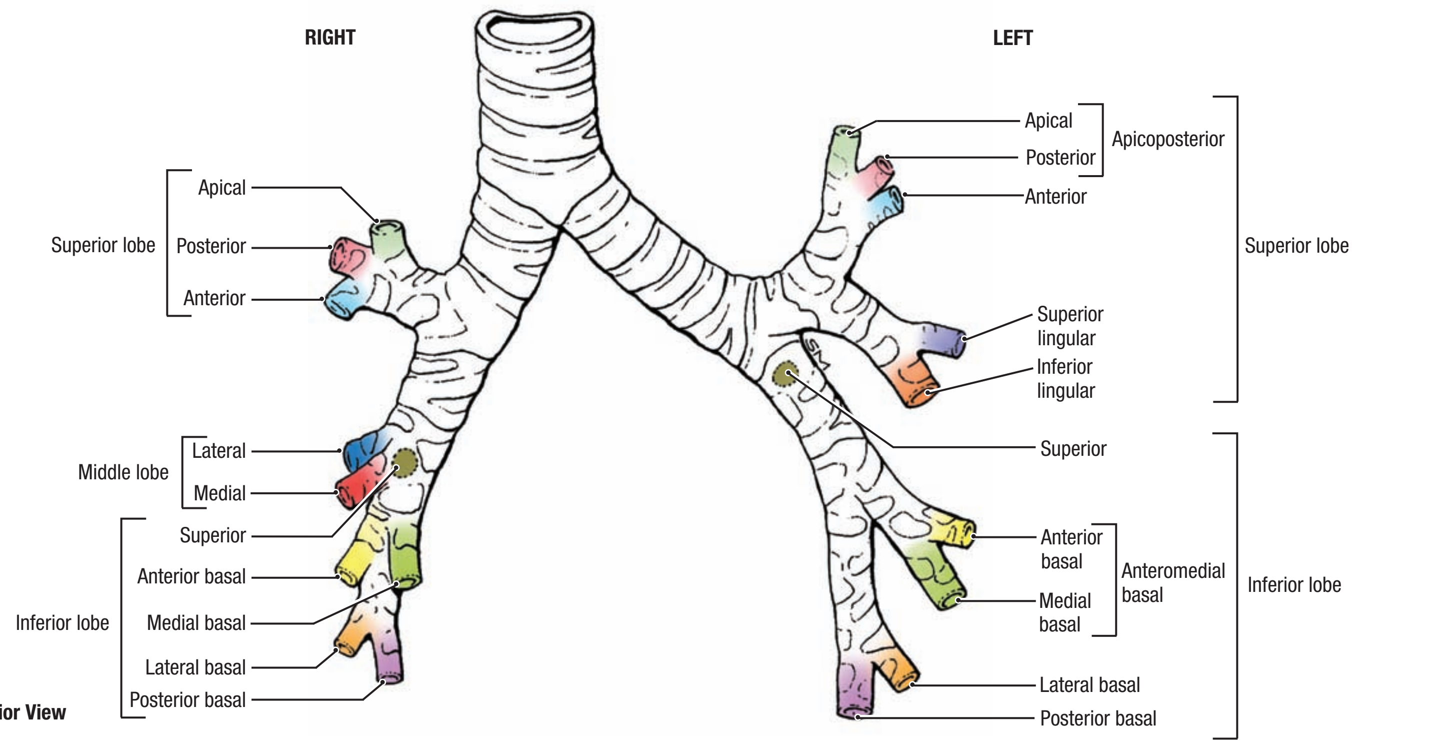
The embalmed lung shows impressions of the structures with which it comes into contact, clearly demarcated as surface features; the base is contoured by the domes of the diaphragm; the costal surface bears the impressions of the ribs; distended vessels leave their mark, but nerves do not. The oblique fissure is incomplete here.



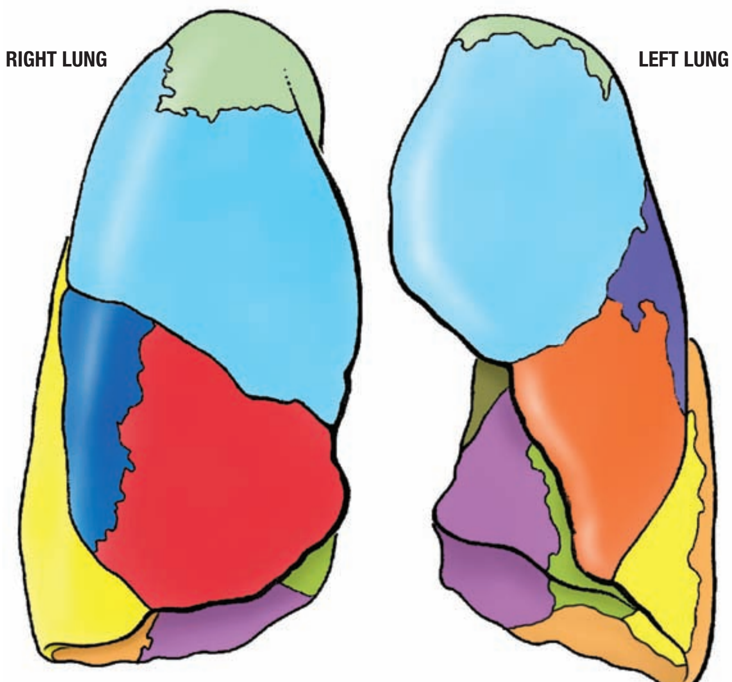
Medial View

1.33 MEDIASTINAL (MEDIAL) SURFACE AND HILUM OF LEFT LUNG

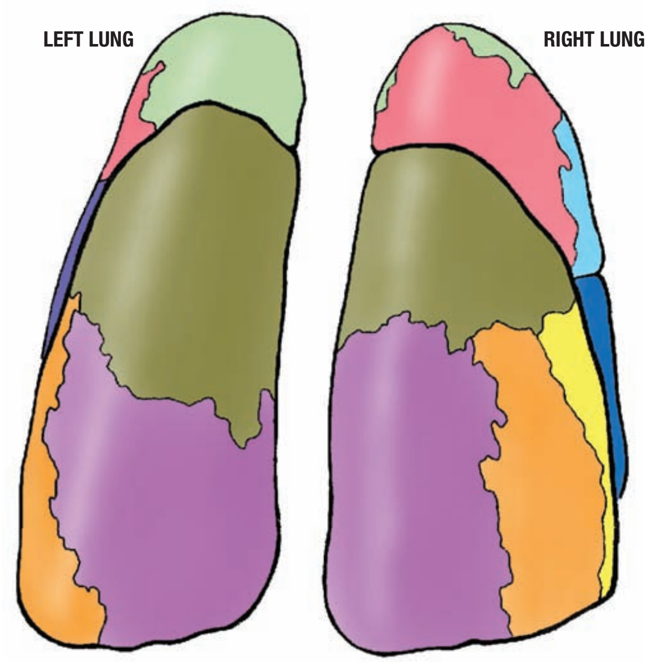
Note the site of contact with esophagus, between the descending aorta and the inferior end of the pulmonary ligament. In the right and left roots, the artery is superior, the bronchus is posterior, one vein is anterior, and the other is inferior; in the right root, the bronchus to the superior lobe (also called the *eparterial bronchus*) is the most superior structure.



A. Anterior View



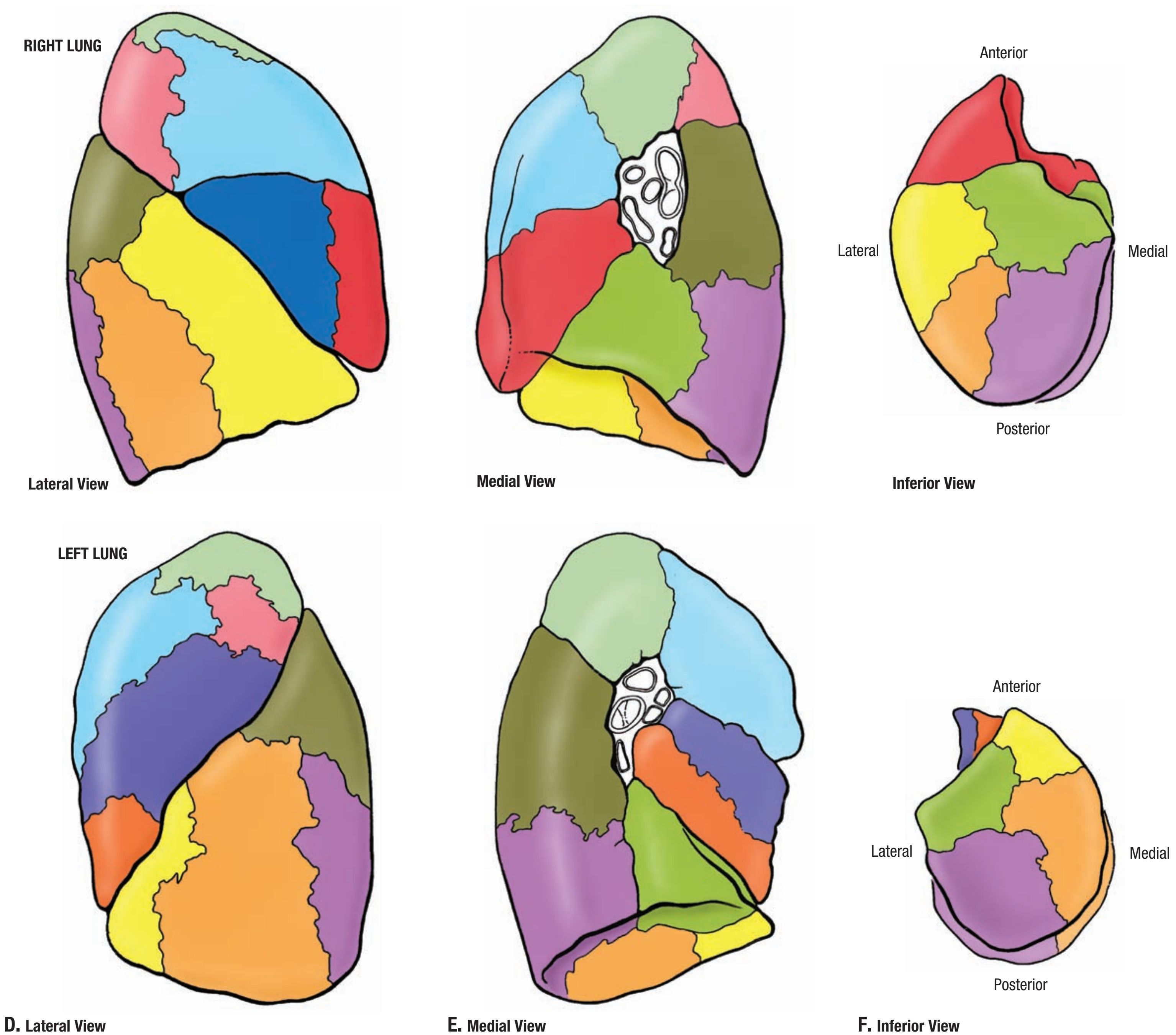
B. Anterior View



C. Posterior View

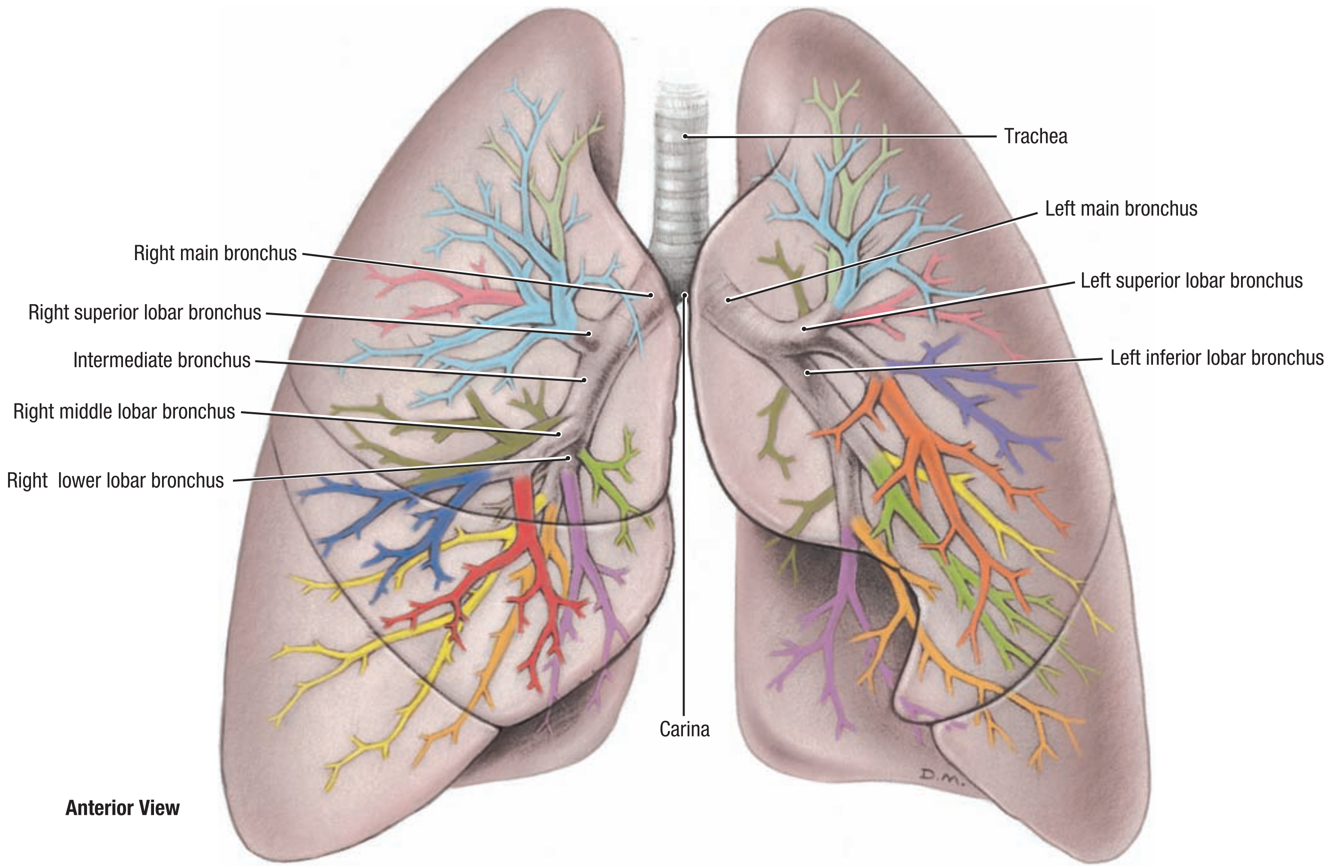
1.34 SEGMENTAL BRONCHI AND BRONCHOPULMONARY SEGMENTS

A. There are 10 tertiary or segmental bronchi on the right, and 8 on the left. Note that on the left, the apical and posterior bronchi arise from a single stem, as do the anterior basal and medial basal. **B.–F.** A bronchopulmonary segment consists of a tertiary bronchus, pulmonary vein and artery, and the portion of lung they serve. These structures are surgically separable to allow segmental resection of the lung. To prepare these specimens, the tertiary bronchi of fresh lungs were isolated within the hilum and injected with latex of various colors. Minor variations in the branching of the bronchi result in variations in the surface patterns.



1.34 SEGMENTAL BRONCHI AND BRONCHOPULMONARY SEGMENTS (*CONTINUED*)

Knowledge of the anatomy of the bronchopulmonary segments is essential for precise interpretations of diagnostic images of the lungs and for surgical resection (removal) of diseased segments. During the treatment of lung cancer, the surgeon may remove a whole lung (**pneumonectomy**), a lobe (**lobectomy**), or one or more bronchopulmonary segments (**segmentectomy**). Knowledge and understanding of the bronchopulmonary segments and their relationship to the bronchial tree are also essential for planning drainage and clearance techniques used in physical therapy for enhancing drainage from specific areas (e.g., in patients with pneumonia or cystic fibrosis).

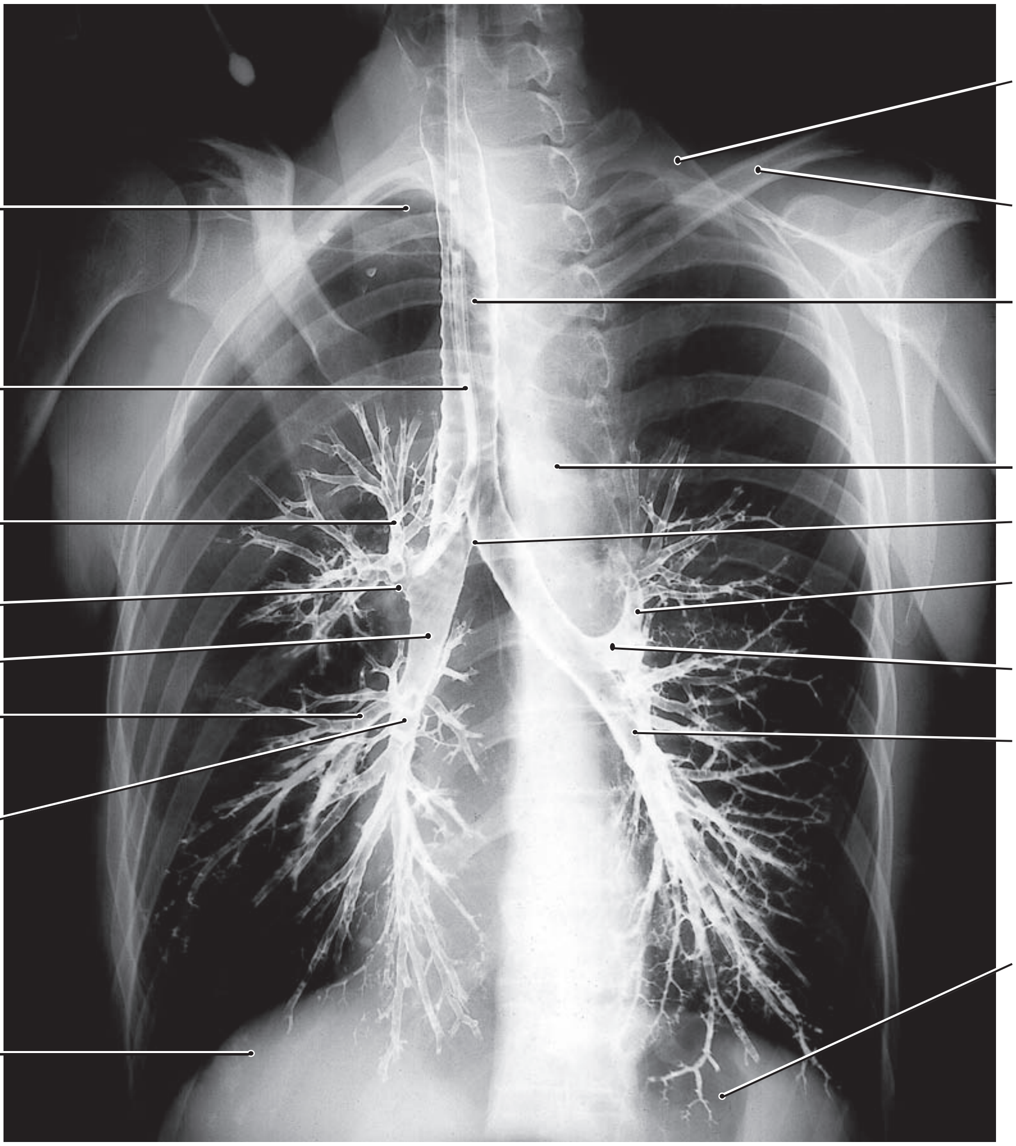


Segmental bronchi:

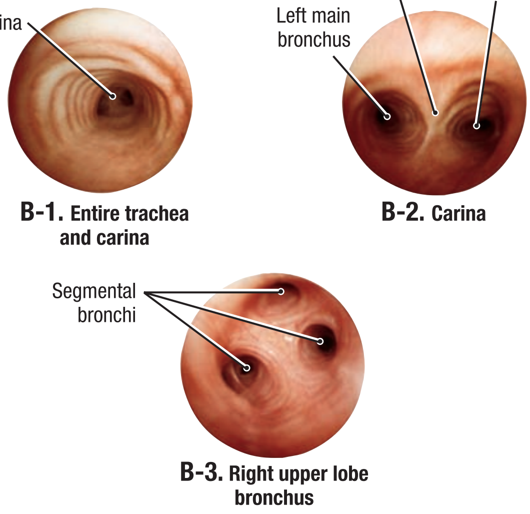
RIGHT LUNG	LEFT LUNG
Superior Lobe	**Superior Lobe**
Apical	Apical (Apicoposterior)
Posterior	Posterior (Apicoposterior)
Anterior	Anterior
	Superior lingular
	Inferior lingular
Middle Lobe	**Inferior Lobe**
Lateral	Superior
Medial	Anterior basal (Anteromedial basal)
Inferior Lobe	Medial basal (Anteromedial basal)
Superior	Lateral basal
Anterior basal	Posterior basal
Medial basal	
Lateral basal	
Posterior basal	

1.35 TRACHEA AND BRONCHI IN SITU

- The segmental (tertiary) bronchi are color coded.
- The trachea bifurcates into right and left main (primary) bronchi; the right main bronchus is shorter, wider, and more vertical than the left. Therefore, it is more likely that **aspirated foreign bodies** will enter and lodge in the right main bronchus or one of its descending branches.
- The right main bronchus gives off the right superior lobe bronchus (eparterial bronchus) before entering the hilum (hilus) of the lung; after entering the hilum, the continuing intermediate bronchus divides into the right middle and inferior lobar bronchi.
- The left main bronchus divides at the hilum into the left superior and left inferior lobar bronchi; the lobar bronchi further divide into segmental (tertiary) bronchi.



A. **Slightly Oblique Anteroposterior View**

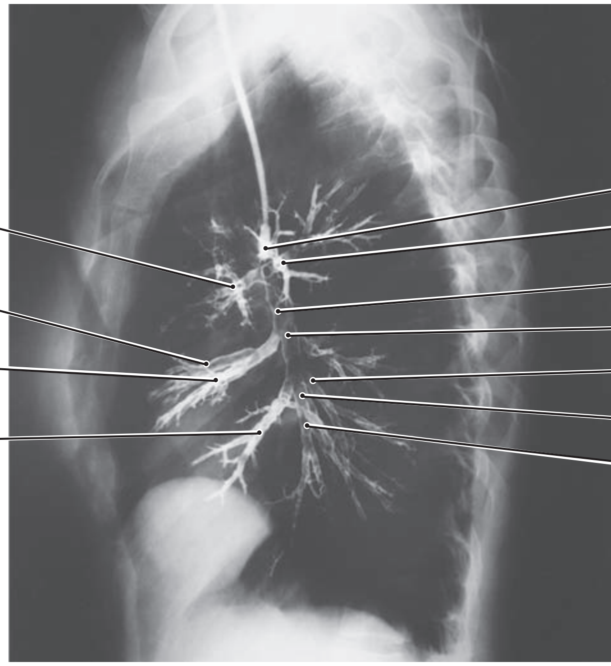


B. **Bronchoscopic Views**

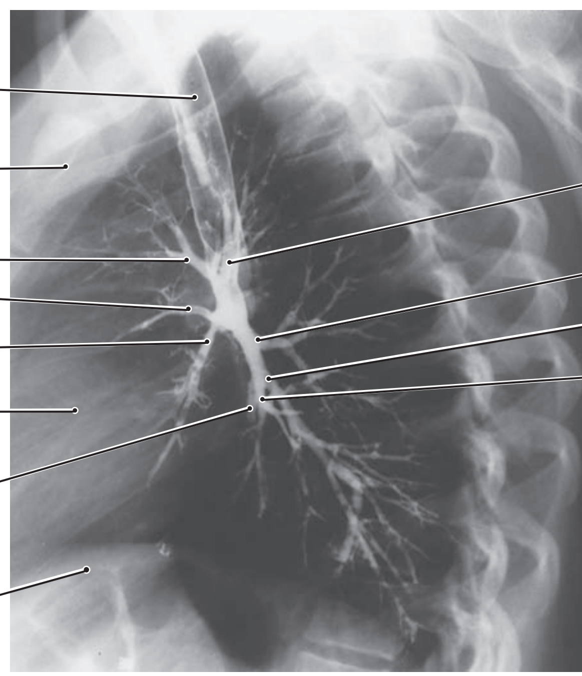
1.36 BRONCHOGRAMS

A. Bronchogram of tracheobronchial tree. **B.** Bronchoscopy.

When examining the bronchi with a *bronchoscope*—an endoscope for inspecting the interior of the tracheobronchial tree for diagnostic purposes—one can observe a ridge, the *carina*, between the orifices of the main bronchi. If the tracheobronchial lymph nodes in the angle between the main bronchi are enlarged because cancer cells have metastasized from a bronchogenic carcinoma, for example, the carina is distorted, widened posteriorly, and immobile.



C. **Right Segmental Bronchi, Right Lateral View**

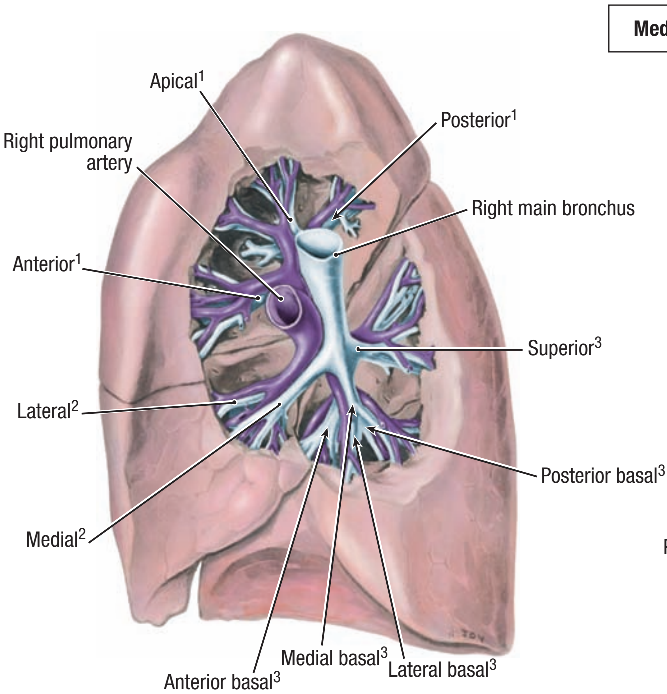


D. **Left Segmental Bronchi, Left Lateral View**

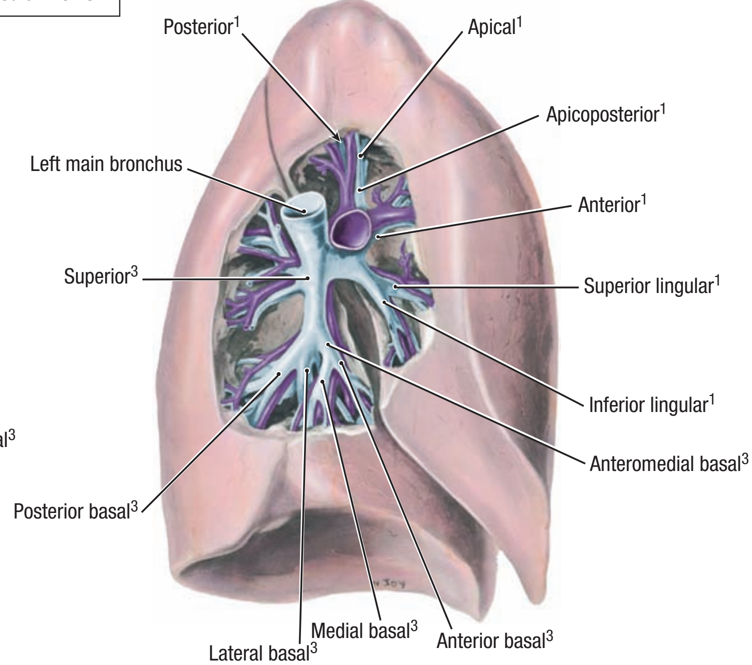
1.36 BRONCHOGRAMS (*CONTINUED*)

C. Right lateral bronchogram, showing segmental bronchi. **D.** Left lateral bronchogram, showing segmental bronchi.

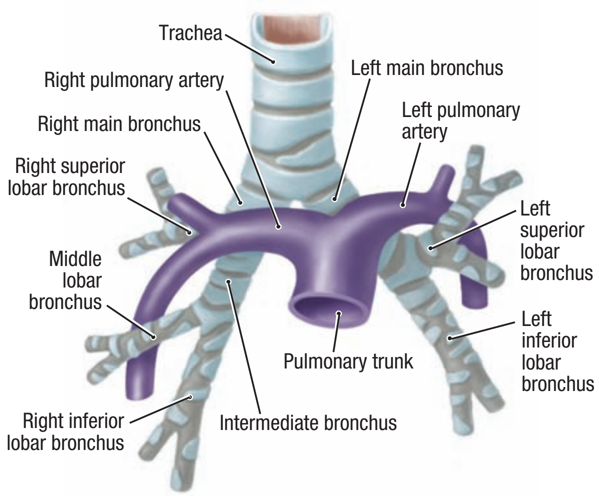
Medial views



A. **Right Lung**



B. **Left Lung**

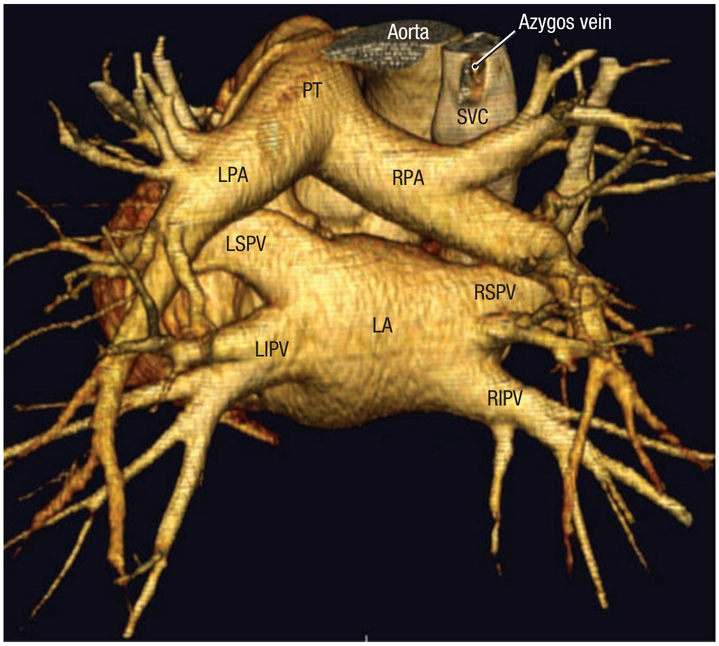


C. **Anterior View**

1.37 RELATIONSHIP OF BRONCHI AND PULMONARY ARTERIES

A. Right lung. **B.** Left lung. **C.** Pulmonary arteries and main bronchii. Superscripts indicate segmental bronchi to the [1]superior lobe, [2]middle lobe, and [3]inferior lobe. The pulmonary arteries of fresh lungs were filled with latex, the bronchi were inflated with air. The tissues surrounding the bronchi and vessels were removed.

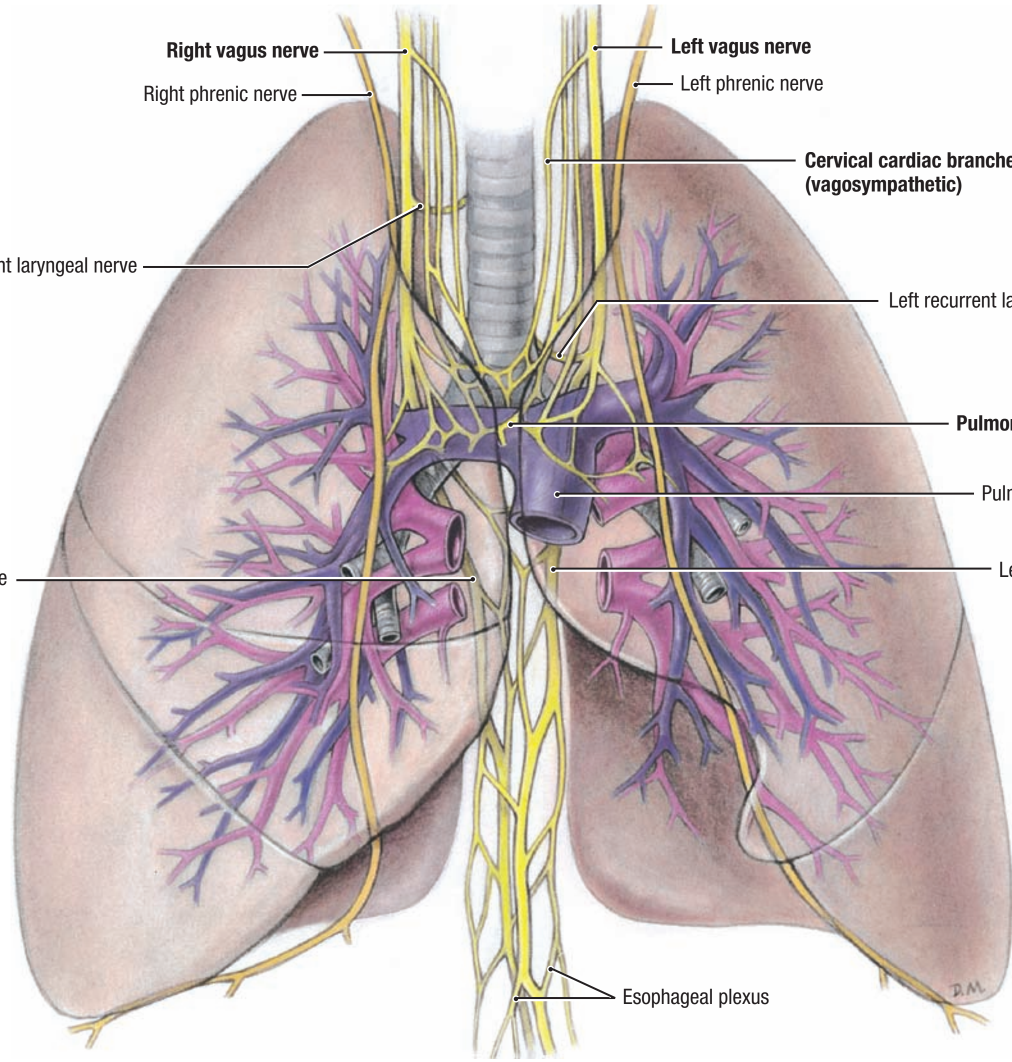
Obstruction of a pulmonary artery by a blood clot (**pulmonary embolism**) results in partial or complete obstruction of blood flow to the lung.



Posterior View

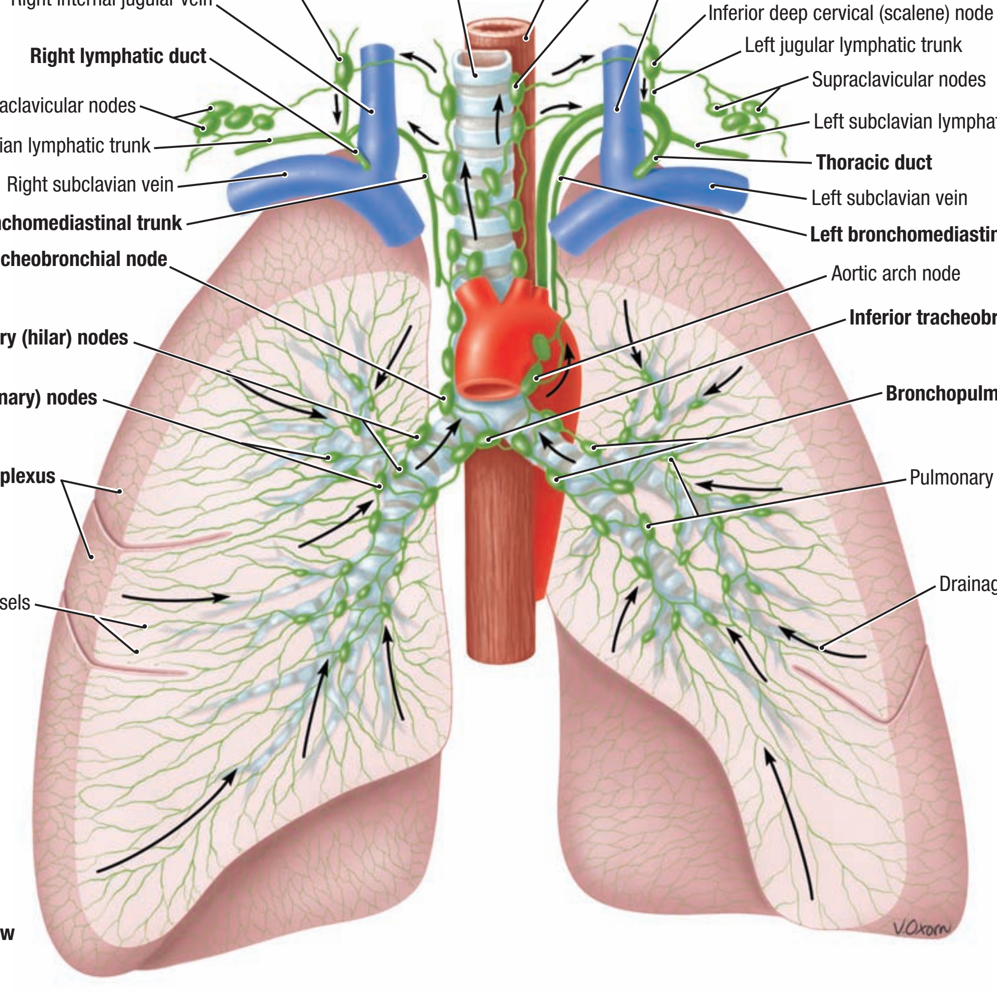
1.38 3D VOLUME RECONSTRUCTION (3DVR) OF PULMONARY ARTERIES AND VEINS AND LEFT ATRIUM

The pulmonary trunk (*PT*) divides into a longer right pulmonary artery (*RPA*) and shorter left pulmonary artery (*LPA*); the left superior (*LSPV*) and inferior (*LIPV*) and the right superior (*RSPV*) and inferior (*RIPV*) pulmonary veins drain into the left atrium (*LA*). Superior vena cava (*SVC*).



1.39 INNERVATION OF LUNGS

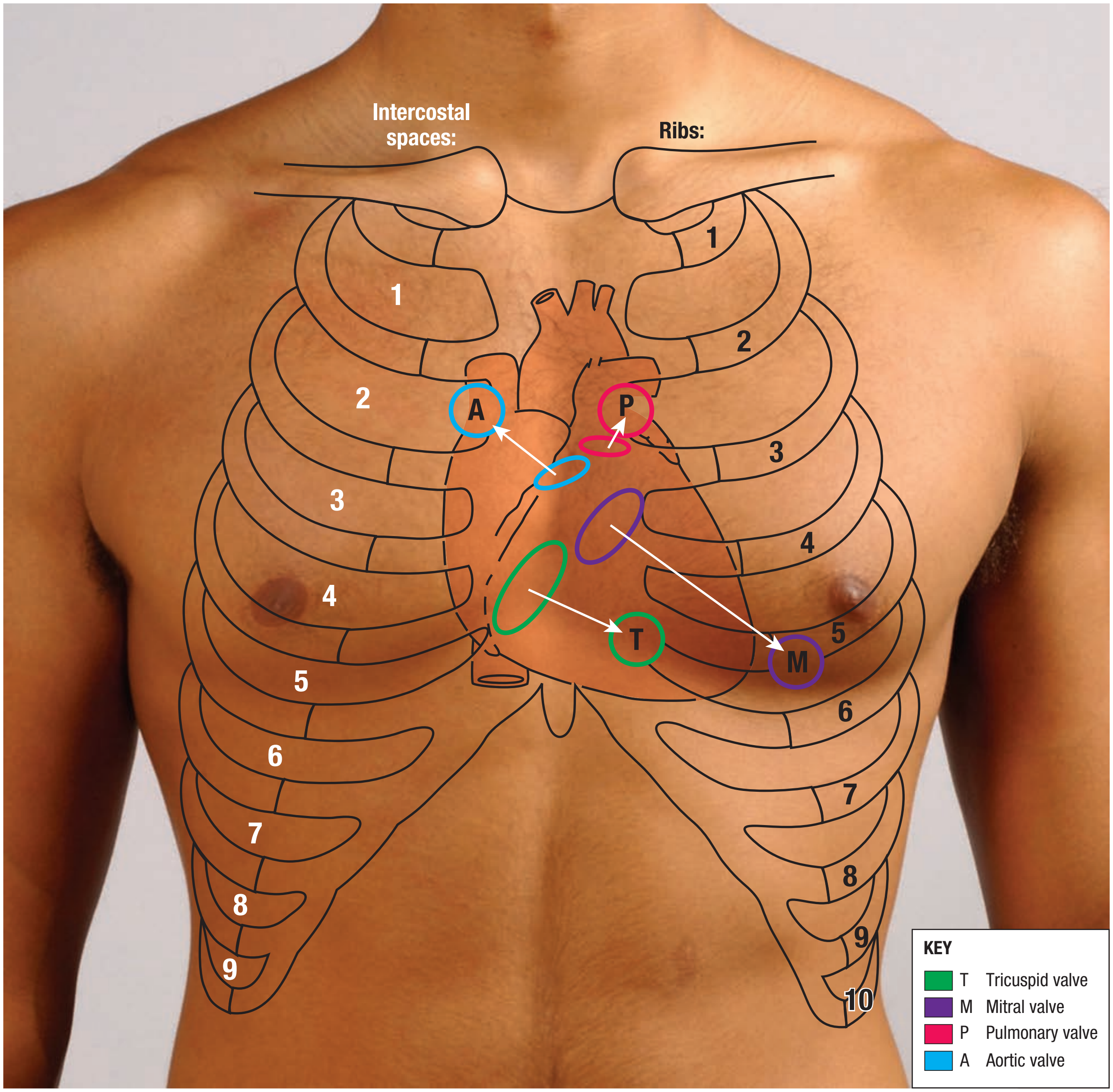
- The pulmonary plexuses, located anterior and posterior to the roots of the lungs, receive sympathetic contributions from the right and left sympathetic trunks (2nd to 5th thoracic ganglia, not shown) and parasympathetic contributions from the right and left vagus nerves; cell bodies of postsynaptic parasympathetic neurons are in the pulmonary plexuses and along the branches of the pulmonary tree.
- The right and left vagus nerves continue inferiorly from the posterior pulmonary plexus to contribute fibers to the esophageal plexus.
- The phrenic nerves pass anterior to the root of the lung on their way to the diaphragm.
- **Pleurisy/pleuritis.** The visceral pleura is insensitive to pain. The autonomic nerves reach the visceral pleura in company with the bronchial vessels. The visceral pleura receives no nerves of general sensation.
- The parietal pleura is sensitive to pain because it is richly supplied by branches of the somatic intercostal and phrenic nerves. Irritation of the parietal pleura produces local pain and referred pain to the areas sharing innervation by the same segments of the spinal cord.



1.40 LYMPHATIC DRAINAGE OF LUNGS

- Lymphatic vessels originate in the subpleural (superficial) and deep lymphatic plexuses.
- The subpleural lymphatic plexus is superficial, lying deep to the visceral pleura, and drains lymph from the surface of the lung to the bronchopulmonary (hilar) nodes.
- The deep lymphatic plexus is in the lung and follows the bronchi and pulmonary vessels to the pulmonary, and then bronchopulmonary, nodes located at the root of the lung.
- All lymph from the lungs enters the inferior (carinal) and superior tracheobronchial nodes and then continues to the right and left bronchomediastinal trunks to drain into the venous system via the right lymphatic and thoracic ducts; lymph from the left inferior lobe passes largely to the right side.
- Lymph from the parietal pleura drains into lymph nodes of the thoracic wall (Fig. 1.71).

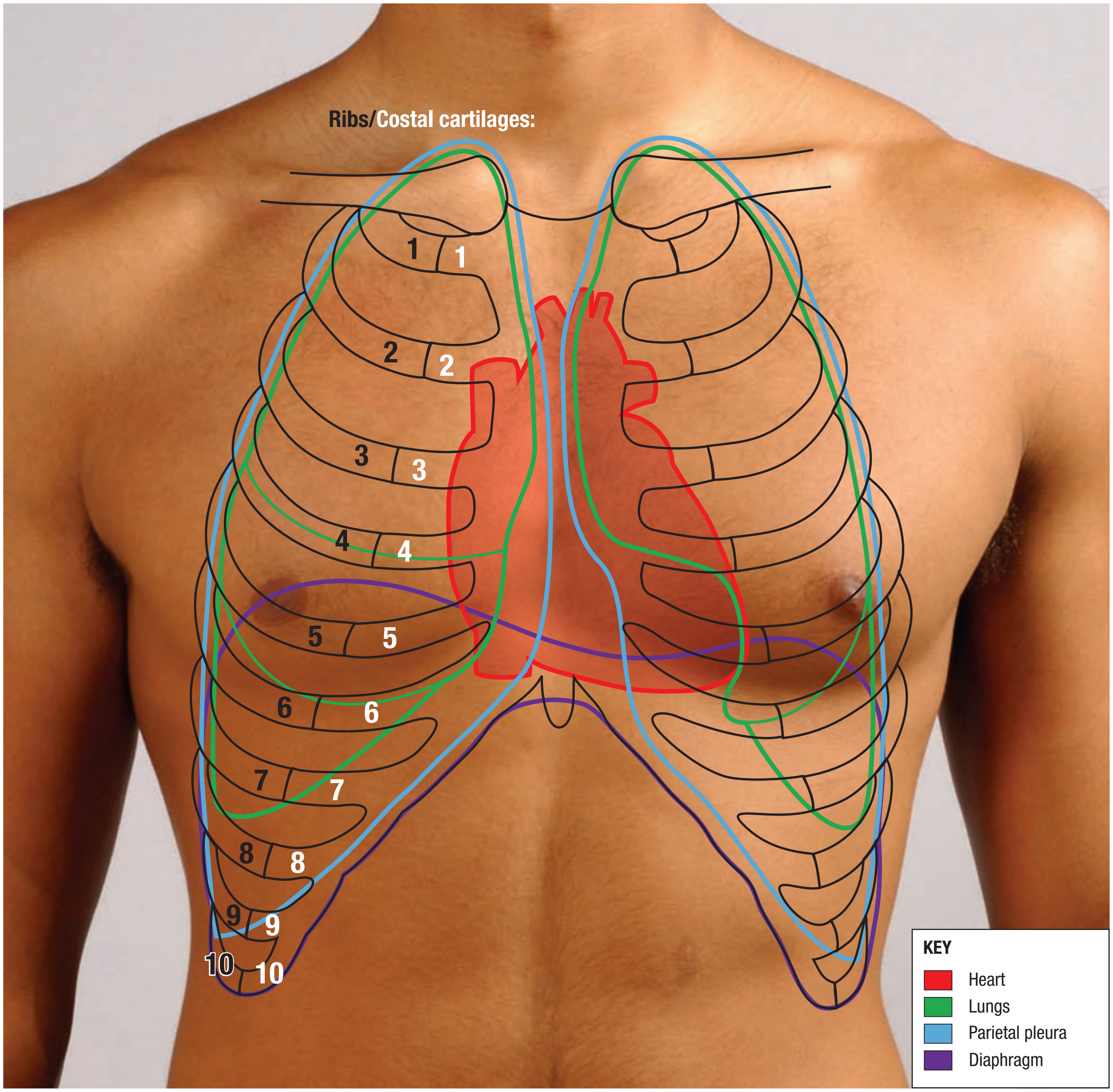
Lung cancer (carcinoma) metastasizes early to the bronchopulmonary lymph nodes and subsequently to the other thoracic lymph nodes. Common sites of **hematogenous metastases** (spreading through the blood) of cancer cells from a bronchogenic carcinoma are the brain, bones, lungs, and suprarenal glands. Often the lymph nodes superior to the clavicle—the supraclavicular lymph nodes—are enlarged when lung (bronchogenic) carcinoma develops owing to metastasis of cancer cells from the tumor. Consequently, the supraclavicular nodes were once referred to as sentinel lymph nodes. More recently, the term sentinel lymph node has been applied to a node or nodes that first receive lymph drainage from a cancer-containing area, regardless of location, following injection of blue dye containing radioactive tracer (technetium-99).



Anterior View

1.41 SURFACE MARKINGS OF THE HEART, HEART VALVES, AND THEIR AUSCULTATION AREAS

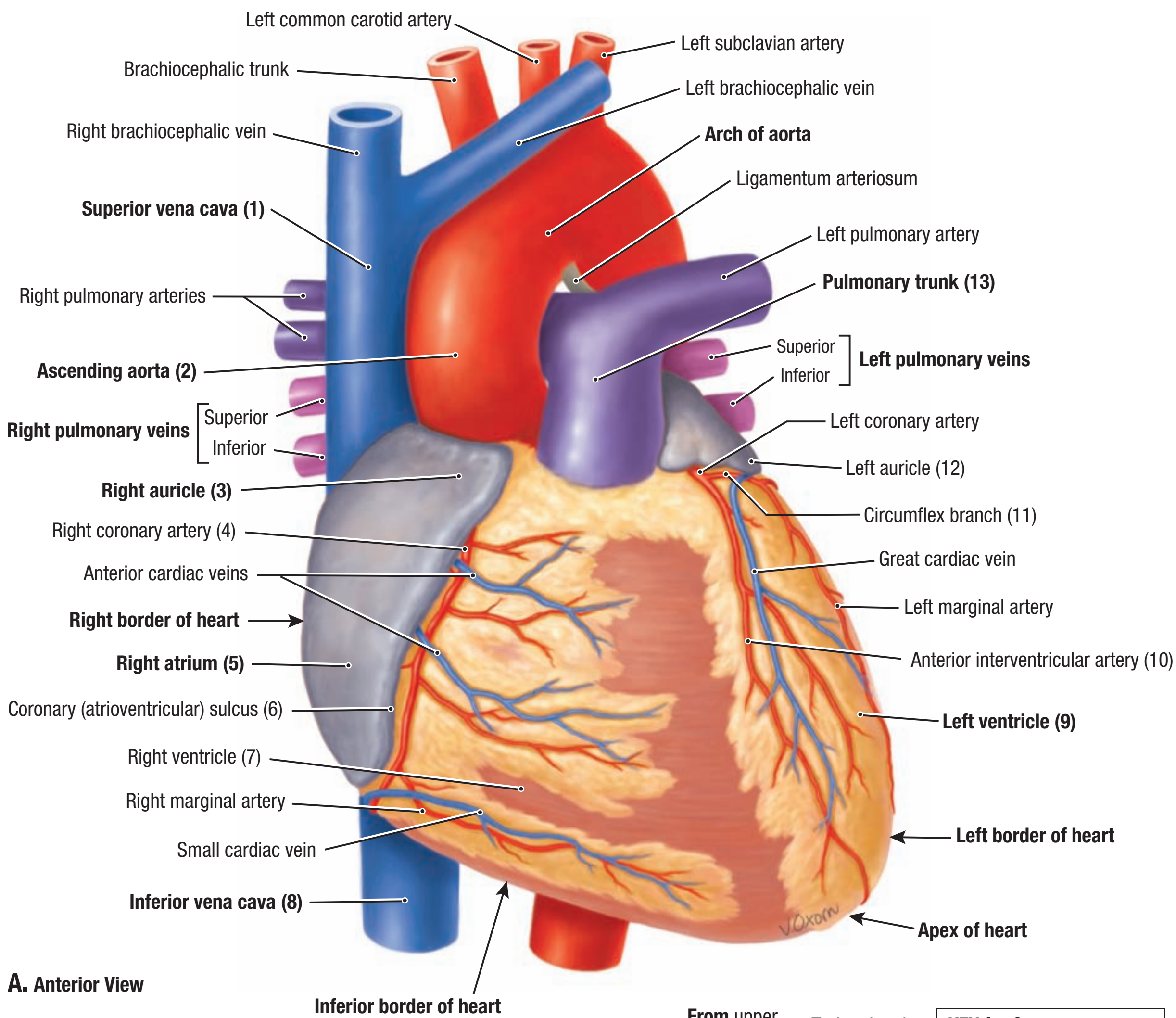
- The location of each heart valve in situ is indicated by a colored oval and the area of auscultation of the valve is indicated as a circle of the same color containing the first letter of the valve name.
- The auscultation areas are sites where the sounds of each of the heart's valves can be heard most distinctly through a stethoscope (*cardiac auscultation*).
- The aortic (*A*) and pulmonary (*P*) auscultation areas are in the 2nd intercostal space to the right and left of the sternal border; the tricuspid area (*T*) is near the left sternal border in the 5th or 6th intercostal space; the mitral valve (*M*) is heard best near the apex of the heart in the 5th intercostal space in the midclavicular line.



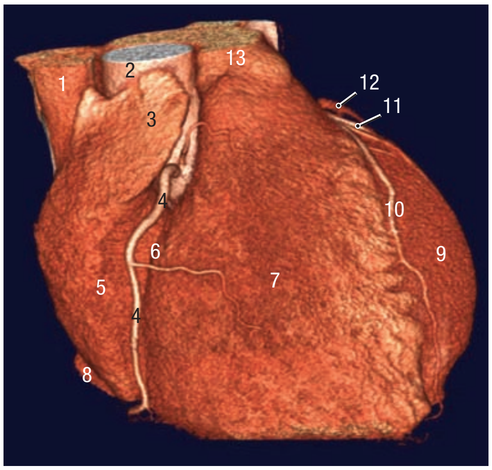
Anterior View

1.42 SURFACE MARKINGS OF THE HEART, LUNGS, AND DIAPHRAGM

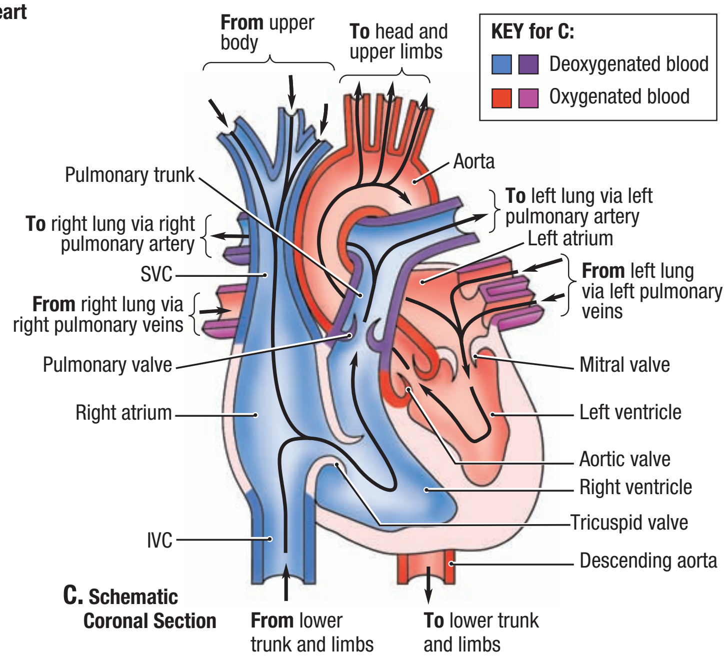
- The superior border of the heart is represented by a slightly oblique line joining the 3rd costal cartilages; the convex right side of the heart projects lateral to the sternum and inferiorly, lying at the 6th or 7th costochondral junction; the inferior border of the heart is lying superior to the central tendon of the diaphragm and sloping slightly inferiorly to the apex at the 5th interspace at the midclavicular line.
- The right dome of the diaphragm is higher than the left because of the large size of the liver inferior to the dome; during expiration the right dome reaches as high as the 5th rib and the left dome ascends to the 5th intercostal space.
- The left pleural cavity is smaller than the right because of the projection of the heart to the left side.



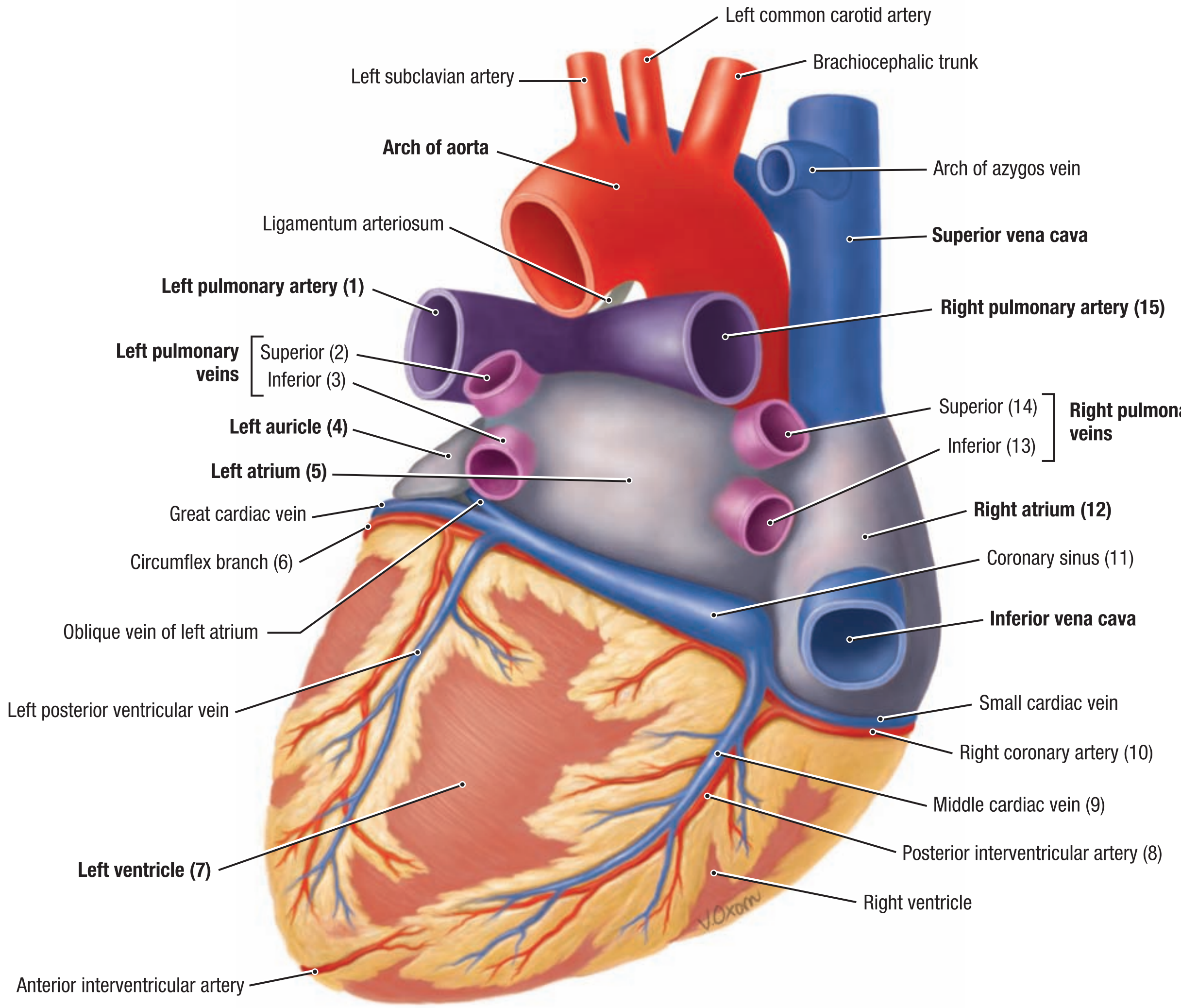
A. Anterior View



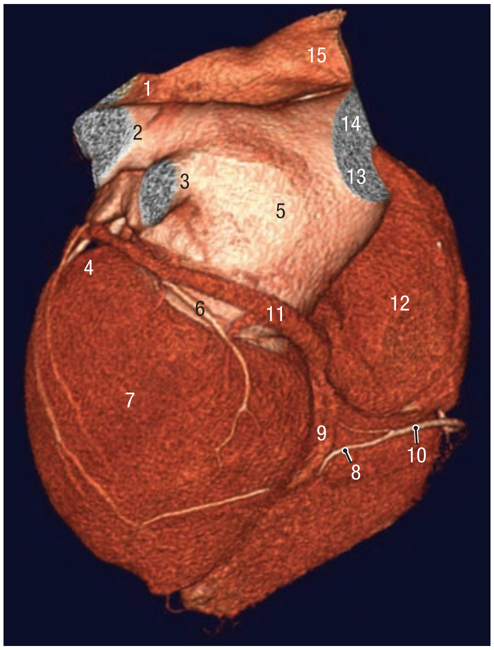
B. Anterior View



C. Schematic Coronal Section



D. Posteroinferior View



E. Posteroinferior View

1.43 HEART AND GREAT VESSELS (*CONTINUED*)

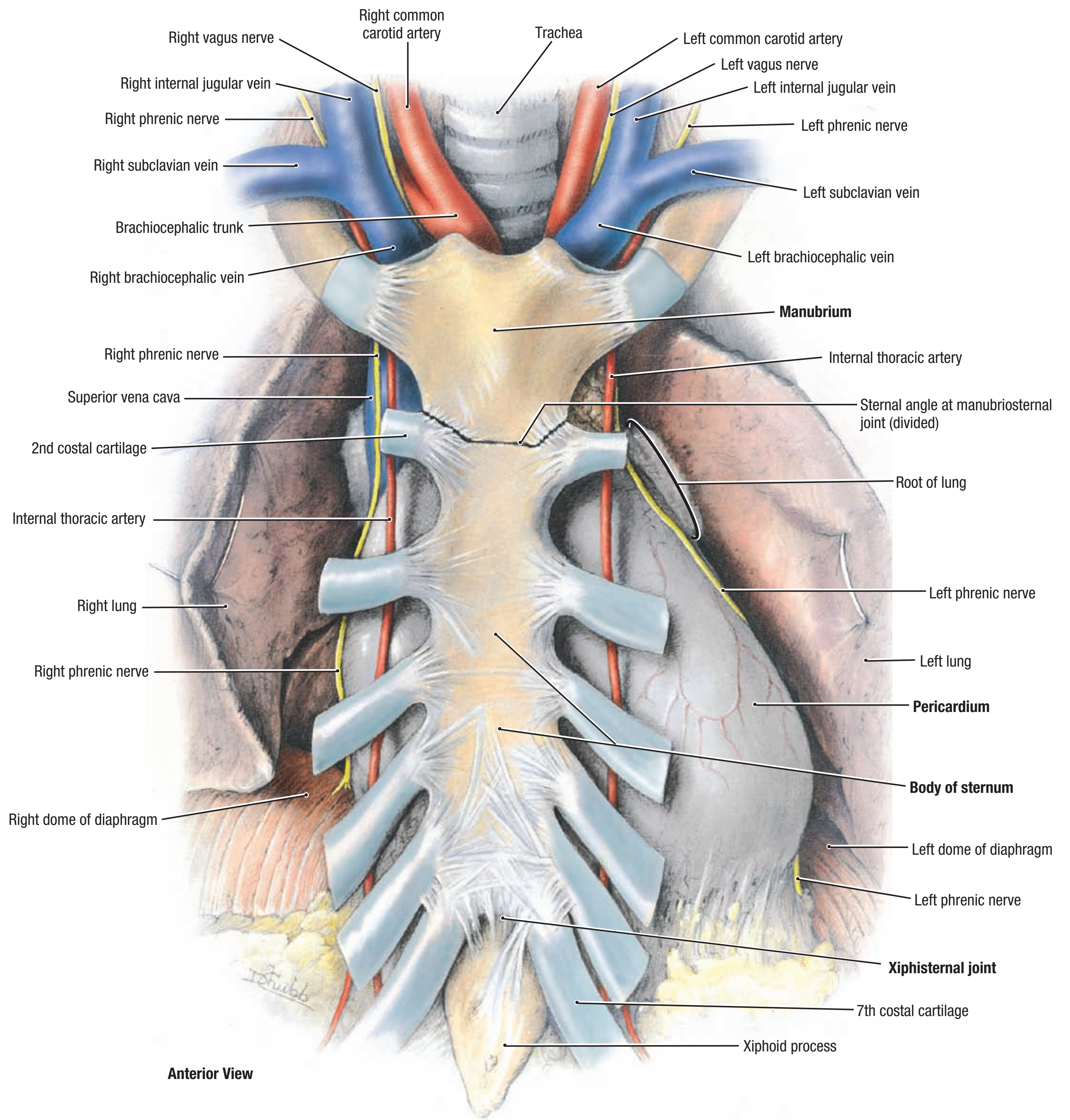
A. Anatomical specimen
- The right border of the heart, formed by the right atrium, is slightly convex and almost in line with the superior vena cava.
- The inferior border is formed primarily by the right ventricle and part of the left ventricle.
- The left border is formed primarily by the left ventricle and part of the left auricle.

B. 3D volume reconstruction from MRI of heart and coronary vessels (living patient). Numbers refer to structures in **A.**

C. Circulation of blood through the heart

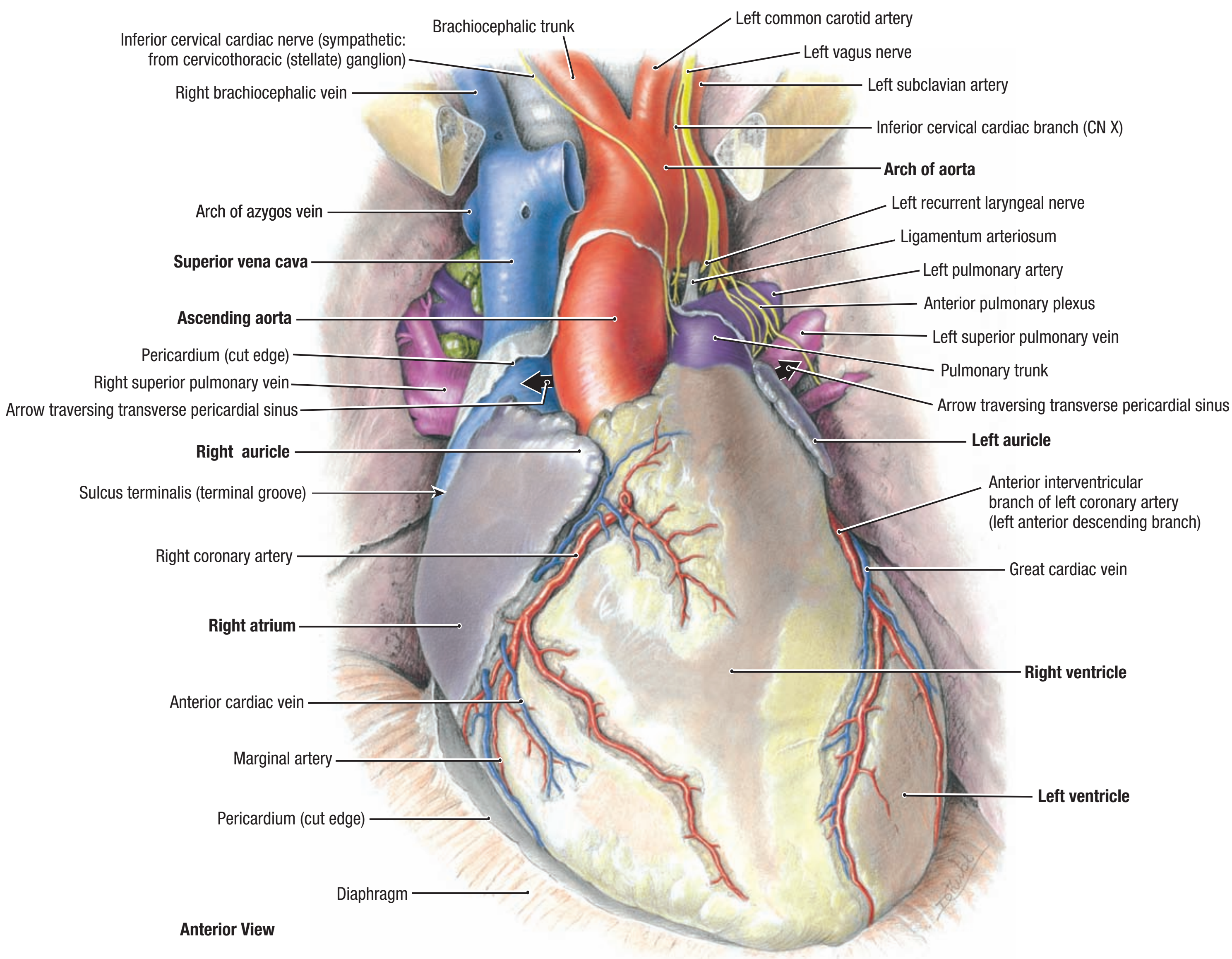
D. Anatomical specimen, posterior view.
- Most of the left atrium and left ventricle are visible in this posteroinferior view.
- The right and left pulmonary veins open into the left atrium.
- The arch of the aorta extends superiorly, posteriorly and to the left, in a nearly sagittal planes.

E. 3D volume reconstruction from MRI of heart and coronary vessels. Numbers refer to structures in **D.**



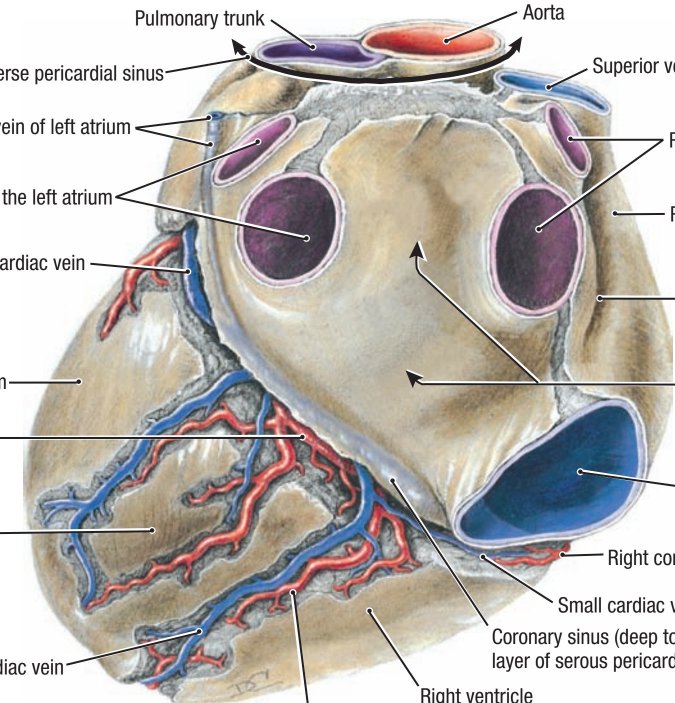
1.44 PERICARDIUM IN RELATION TO STERNUM

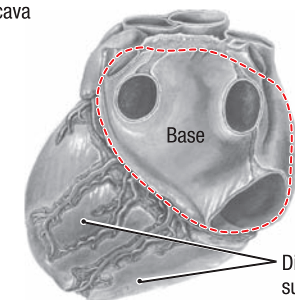
- The pericardium lies posterior to the body of the sternum, extending from just superior to the sternal angle to the level of the xiphisternal joint; approximately two thirds lies to the left of the median plane.
- The heart lies between the sternum and the anterior mediastinum anteriorly and the vertebral column and the posterior mediastinum posteriorly. In **cardiac compression**, the sternum is depressed 4 to 5 cm, forcing blood out of the heart and into the great vessels.
- Internal thoracic arteries arise from the subclavian arteries and descend posterior to the costal cartilages, running lateral to the sternum and anterior to the pleura.



1.45 STERNOCOSTAL (ANTERIOR) SURFACE OF HEART AND GREAT VESSELS IN SITU

- The right ventricle forms most of the sternocostal surface.
- The entire right auricle and much of the right atrium are visible anteriorly, but only a small portion of the left auricle is visible; the auricles, like a closing claw, grasp the origins of the pulmonary trunk and ascending aorta from a posterior approach.
- The ligamentum arteriosum passes from the origin of the left pulmonary artery to the arch of the aorta.
- The right coronary artery courses in the anterior atrioventricular groove, and the anterior interventricular branch of the left coronary artery (anterior descending branch) courses in or parallel to the anterior interventricular groove (see Fig. 1.43B).
- The left vagus nerve passes lateral to the arch of the aorta and then posterior to the root of the lung; the left recurrent laryngeal nerve passes inferior to the arch of the aorta posterior to the ligamentum arteriosum.
- The great cardiac vein ascends beside the anterior interventricular branch of the left coronary artery to drain into the coronary sinus posteriorly.

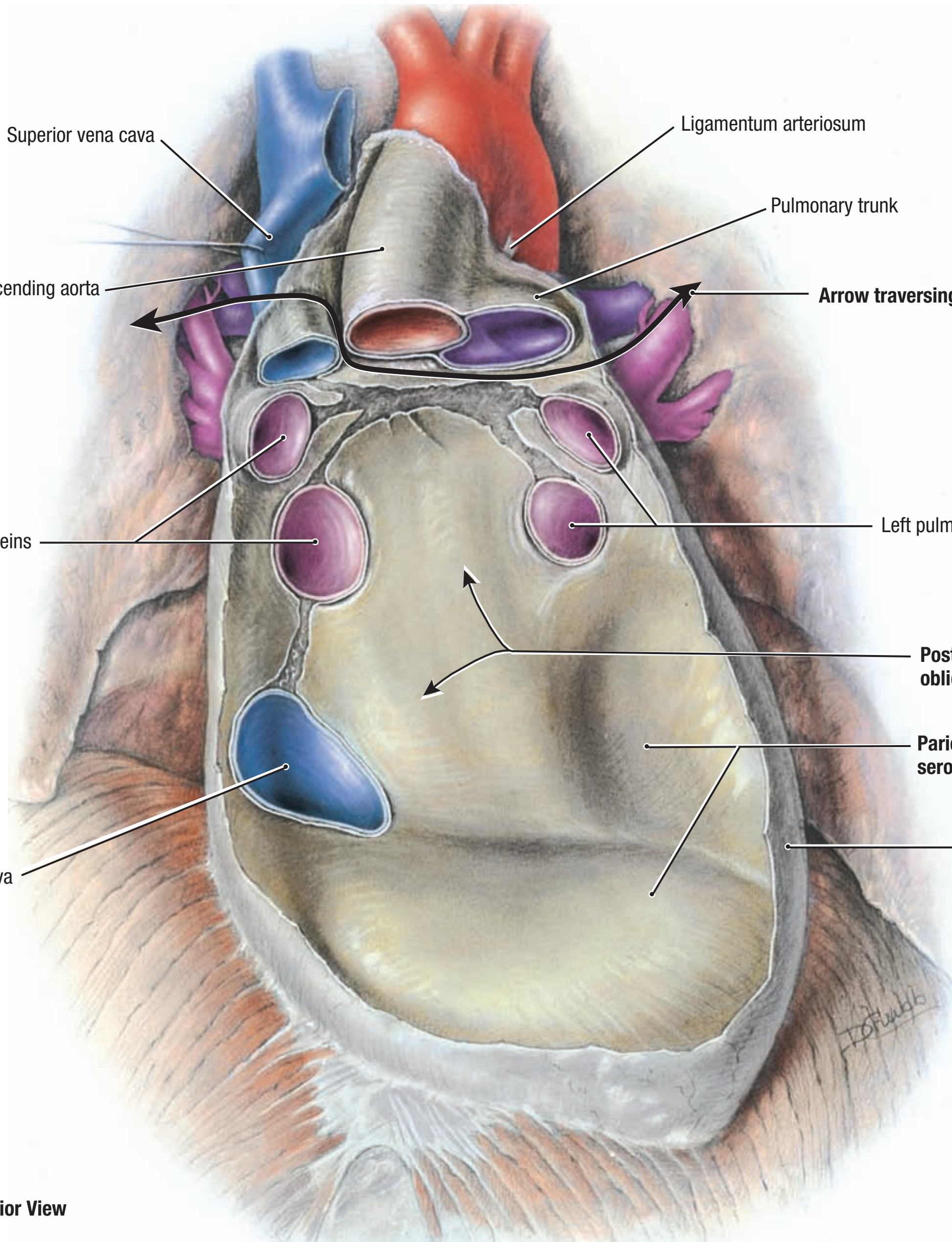




A. Posterior View

1.46 HEART AND PERICARDIUM

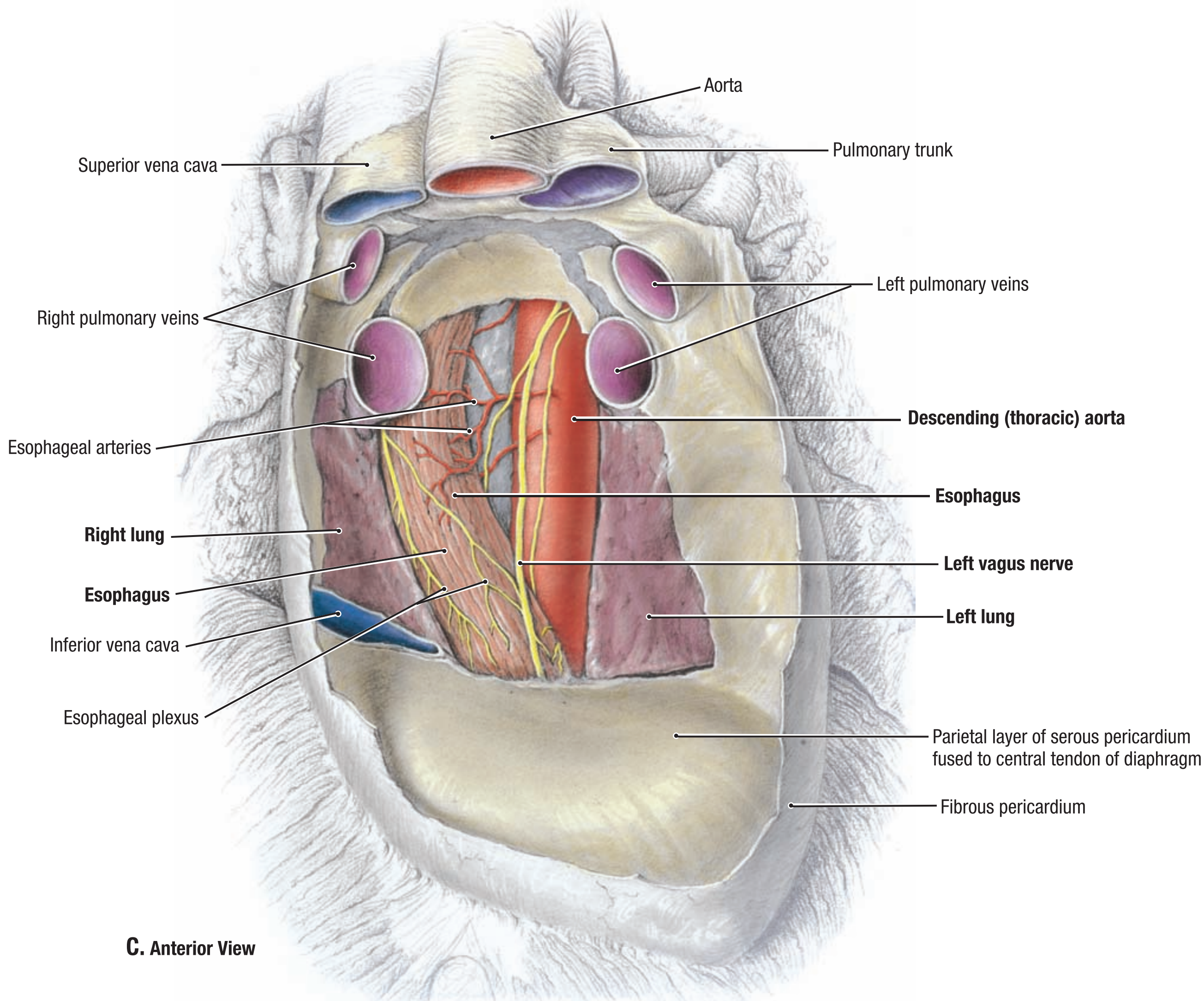
- This heart **(A)** was removed from the interior of the pericardial sac **(B).**
- The entire base, or posterior surface, and part of the diaphragmatic or inferior surface of the heart are in view.
- The superior vena cava and larger inferior vena cava join the superior and inferior aspects of the right atrium.
- The left atrium forms the greater part of the base (posterior surface) of the heart.
- The left coronary artery in this specimen is dominant, since it supplies the posterior interventricular branch.
- Most branches of cardiac veins cross branches of the coronary arteries superficially.
- The visceral layer of serous pericardium (epicardium) covers the surface of the heart and reflects onto the great vessels; from around the great vessels, the serous pericardium reflects to line the internal aspect of the fibrous pericardium as the parietal layer of serous pericardium. The fibrous pericardium and the parietal layer of serous pericardium form the pericardial sac that encases the heart.
- Note the cut edges of the reflections of serous pericardia around the arterial vessels (the pulmonary trunk and aorta) and venous vessels (the superior and inferior venae cavae and the pulmonary veins).
- **Surgical isolation of cardiac outflow.** The transverse pericardial sinus is especially important to cardiac surgeons. After the pericardial sac has been opened anteriorly, a finger can be passed through the transverse pericardial sinus posterior to the aorta and pulmonary trunk. By passing a surgical clamp or placing a ligature around these vessels, inserting the tubes of a coronary bypass machine, and then tightening the ligature, surgeons can stop or divert the circulation of blood in these large arteries while performing cardiac surgery.



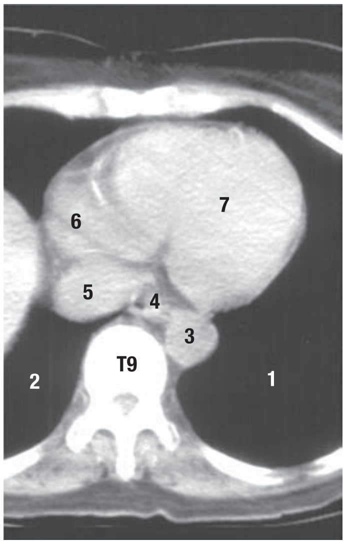
B. Anterior View

1.46 HEART AND PERICARDIUM (*CONTINUED*)

- Interior of pericardial sac. Eight vessels were severed to excise the heart: superior and inferior venae cavae, four pulmonary veins, and two pulmonary arteries.
- The oblique sinus is bounded anteriorly by the visceral layer of serous pericardium covering the left atrium **(A)**, posteriorly by the parietal layer of serous pericardium lining the fibrous pericardium, and superiorly and laterally by the reflection of serous pericardium around the four pulmonary veins and the superior and inferior venae cavae **(B)**.
- The transverse sinus is bounded anteriorly by the serous pericardium covering the posterior aspect of the pulmonary trunk and aorta, and posteriorly by the visceral pericardium reflecting from the atria **(A)** inferiorly and the superior vena cava superiorly on the right.
- Blood in the pericardial cavity, **hemopericardium**, produces *cardiac tamponade*. Hemopericardium may result from perforation of a weakened area of the heart muscle owing to a previous **myocardial infarction (MI)** or heart attack, from bleeding into the pericardial cavity after cardiac operations, or from stab wounds. Heart volume is increasingly compromised and circulation fails.



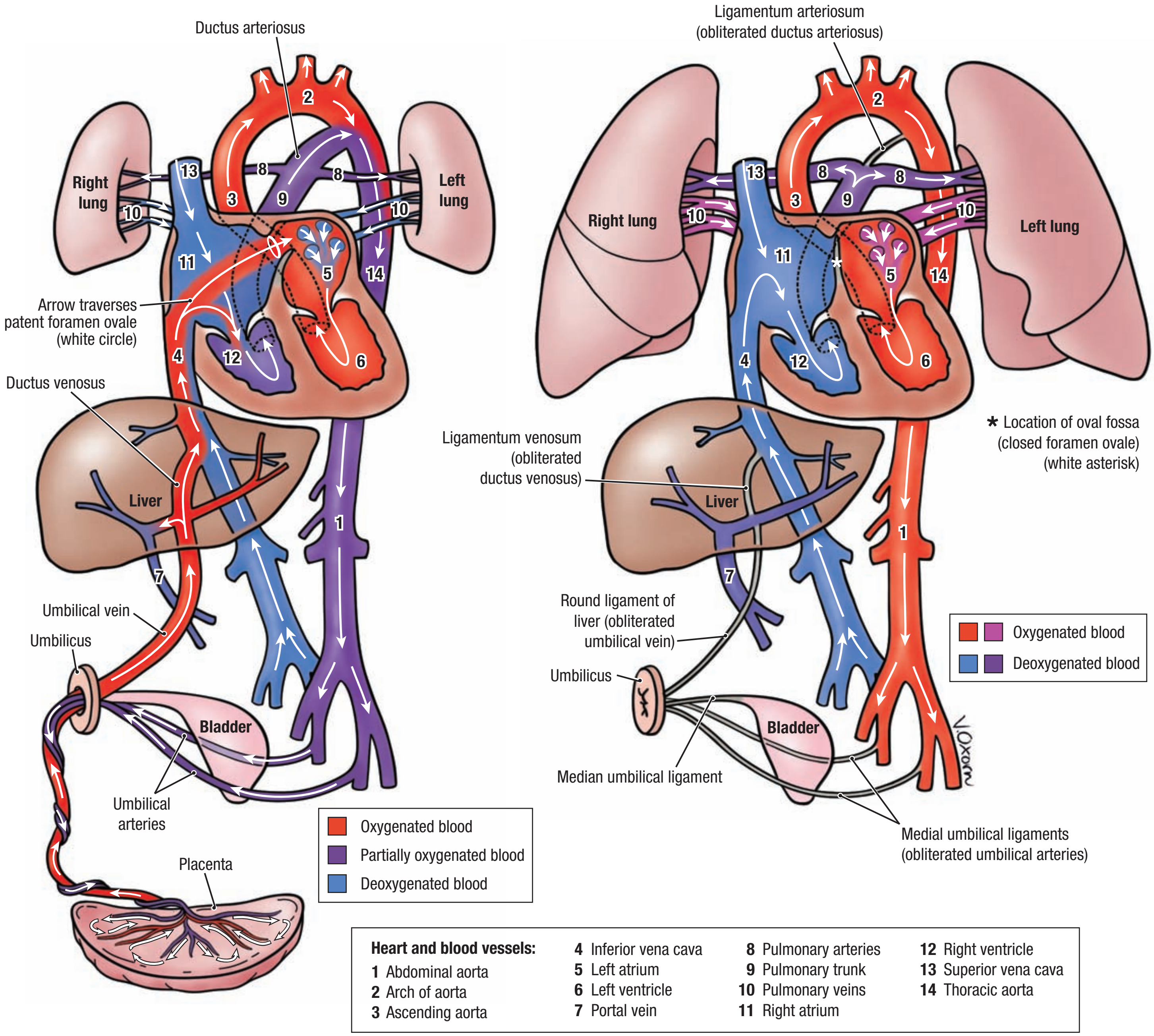
C. Anterior View



D. Axial CT Scan, Inferior View

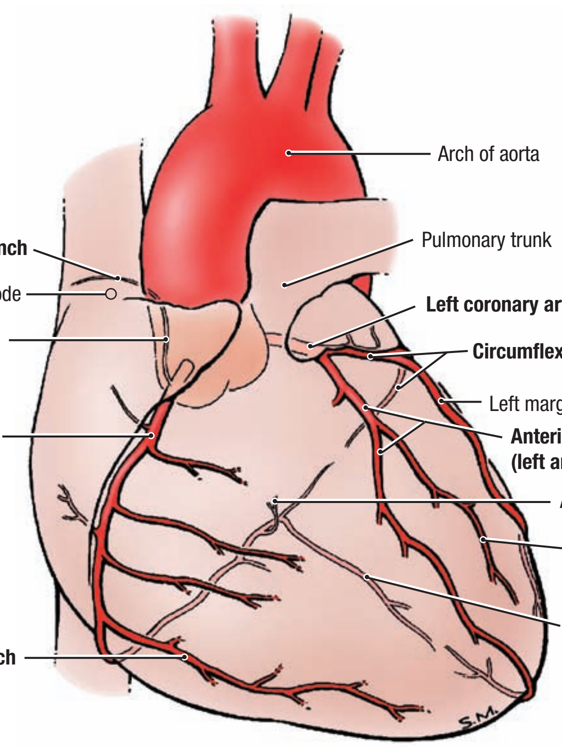
1.46 HEART AND PERICARDIUM (*CONTINUED*)

C. Posterior relationships; dissection. The fibrous and parietal layers of serous pericardium have been removed from posterior and lateral to the oblique sinus. The esophagus in this specimen is deflected to the right; it usually lies in contact with the aorta, forming primary posterior relationships of the heart. **D**. Posterior relationships of heart. Axial computed tomographic (CT) scan at level of T9 vertebra. *1*, left lung; *2*, right lung; *3*, descending aorta; *4*, esophagus; *5*, inferior vena cava; *6*, right atrium; *7*, left ventricle.



1.47 PRE- AND POSTNATAL CIRCULATION

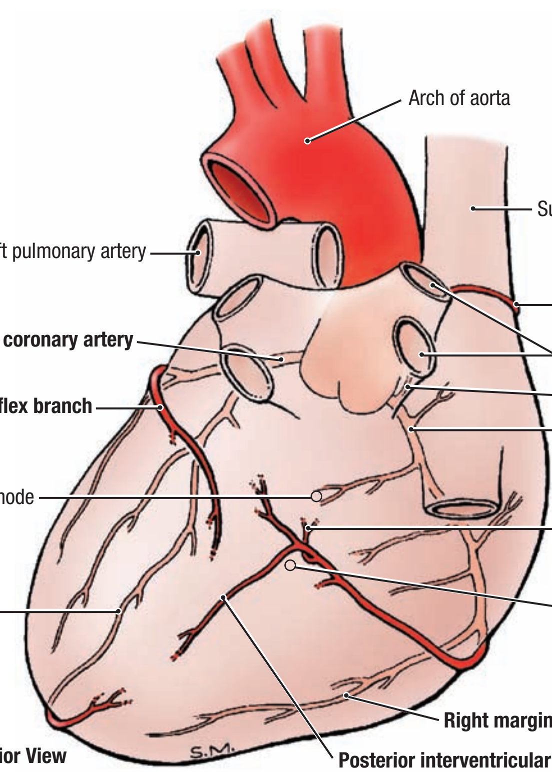
At birth two major changes take place: (1) pulmonary respiration starts and (2) after the umbilical cord is ligated, the umbilical arteries (except the most proximal part), umbilical vein, and ductus venosus are occluded and become ligaments.



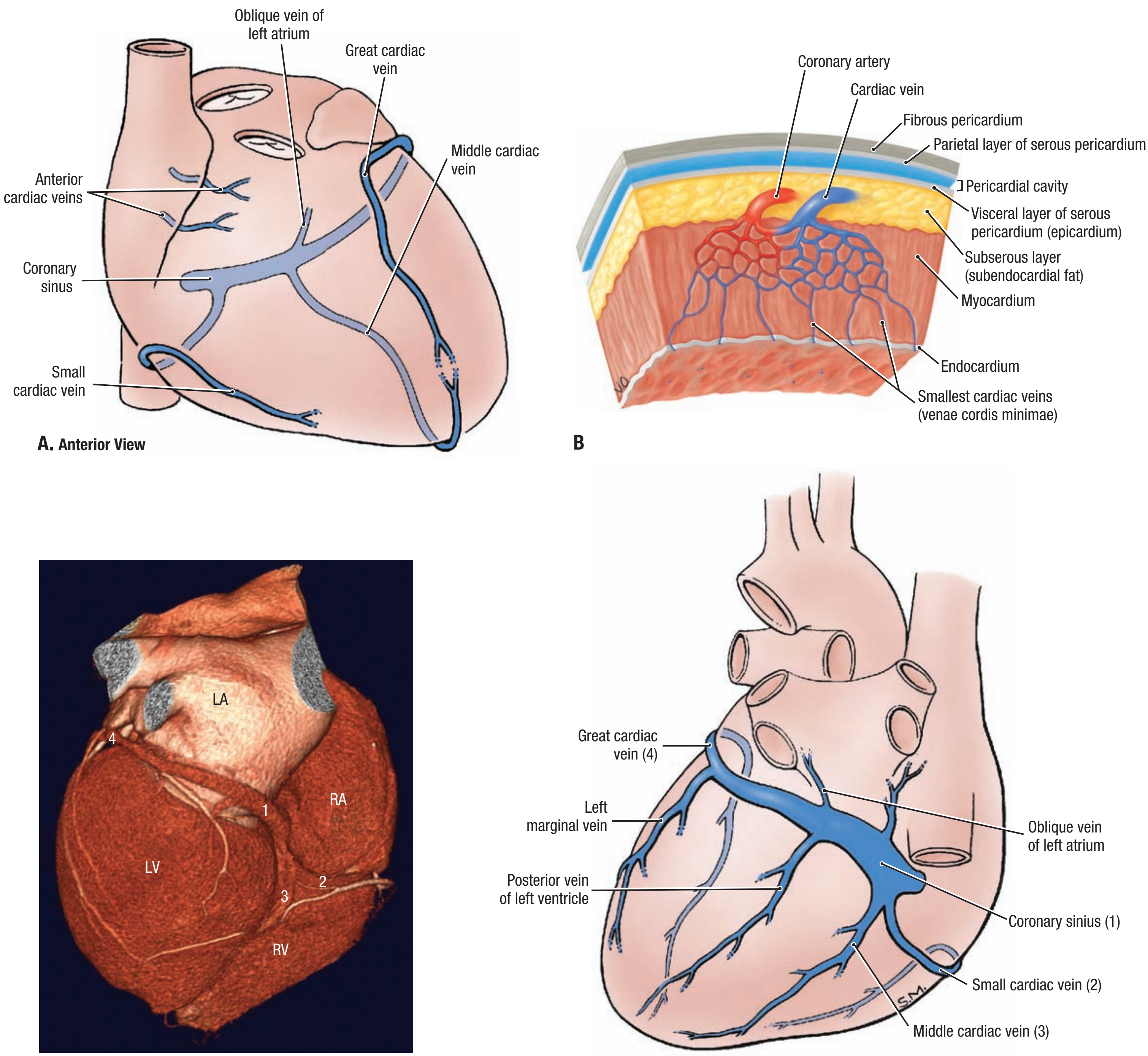
A. Anterior View

1.48 CORONARY ARTERIES

- In the most common pattern, the right coronary artery travels in the coronary sulcus to reach the posterior surface of the heart, where it anastomoses with the circumflex branch of the left coronary artery. Early in its course, it gives off the right atrial branch, which supplies the sinu-atrial (SA) node via its sinu-atrial nodal branch. Major branches are a marginal branch supplying much of the anterior wall of the right ventricle, an atrioventricular (AV) nodal branch given off near the posterior border of the interventricular septum, and a posterior interventricular branch in the interventricular groove that anastomoses with the anterior interventricular branch of the left coronary artery.
- The left coronary artery divides into a circumflex branch that passes posteriorly to anastomose with the right coronary artery on the posterior aspect of the heart and an anterior descending branch in the interventricular groove; the origin of the SA nodal branch is variable and may be a branch of the left coronary artery.
- The interventricular septum receives its blood supply from septal branches of the two interventricular (descending) branches: typically the anterior two thirds from the left coronary, and the posterior one third from the right (see Fig. 1.51A).



B. Posterior View



A. Anterior View

B

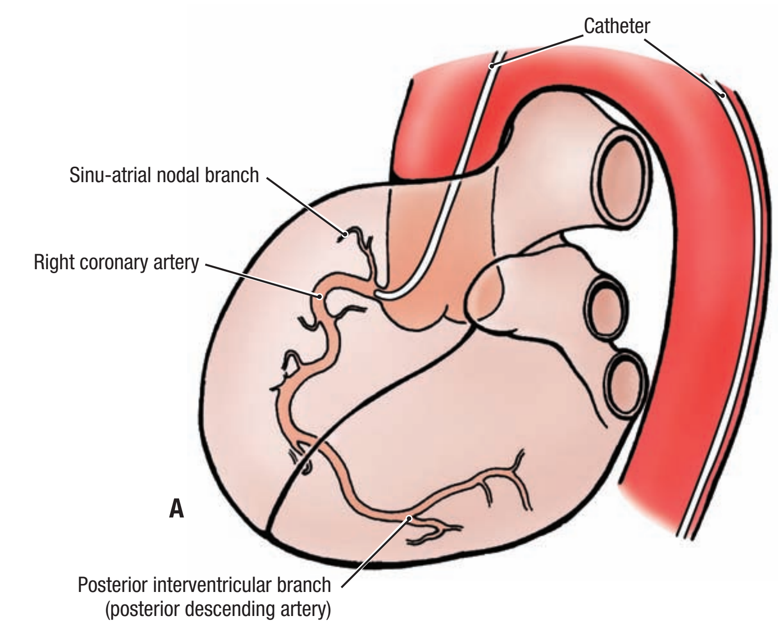
C. Posteroinferior View

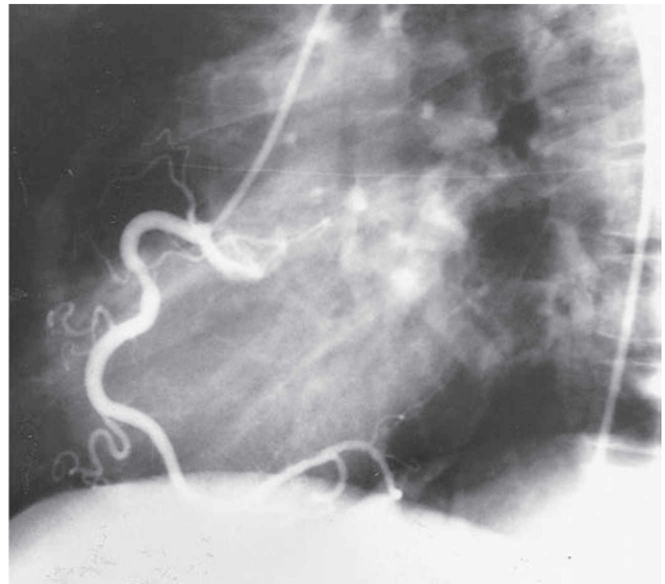
D. Posteroinferior View

1.49 CARDIAC VEINS

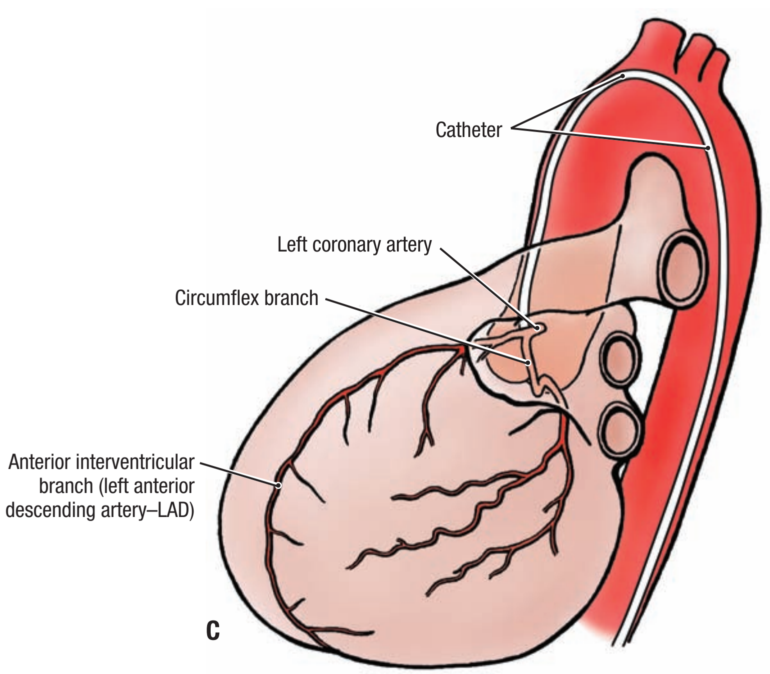
A. Anterior aspect. **B.** Smallest cardiac veins. **C.** 3D volume reconstruction. Numbers refer to veins in **D.** *LA*, left atrium; *RA*, right atrium; *LV*, left ventricle; *RV*, right ventricle. **D.** Posteroinferior aspect.

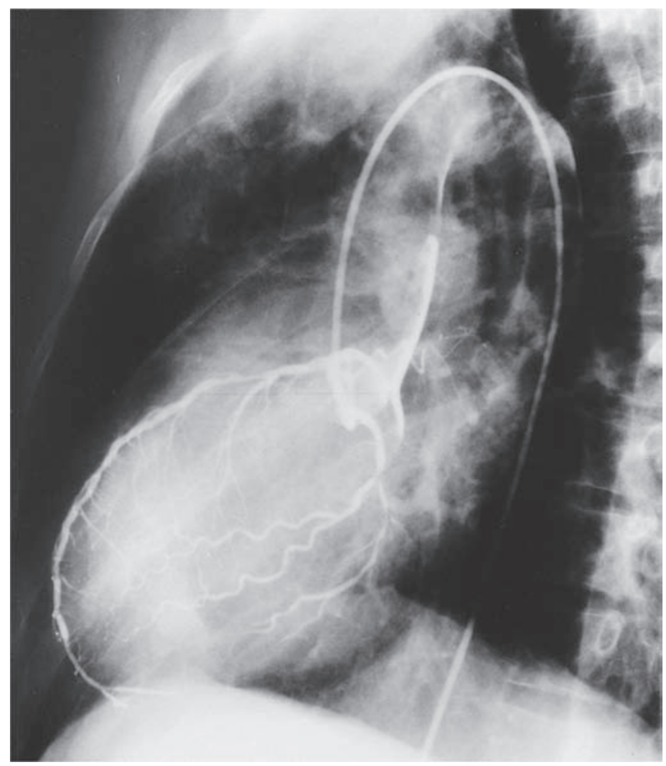
The coronary sinus is the major venous drainage vessel of the heart; it is located posteriorly in the atrioventricular (coronary) groove and drains into the right atrium. The great, middle, and small cardiac veins; the oblique vein of the left atrium; and the posterior vein of the left ventricle are the principal vessels draining into the coronary sinus. The anterior cardiac veins drain directly into the right atrium. The smallest cardiac veins (venae cordis minimae) drain the myocardium directly into the atria and ventricles **(B).** The cardiac veins accompany the coronary arteries and their branches.





B. **Left Anterior Oblique View**



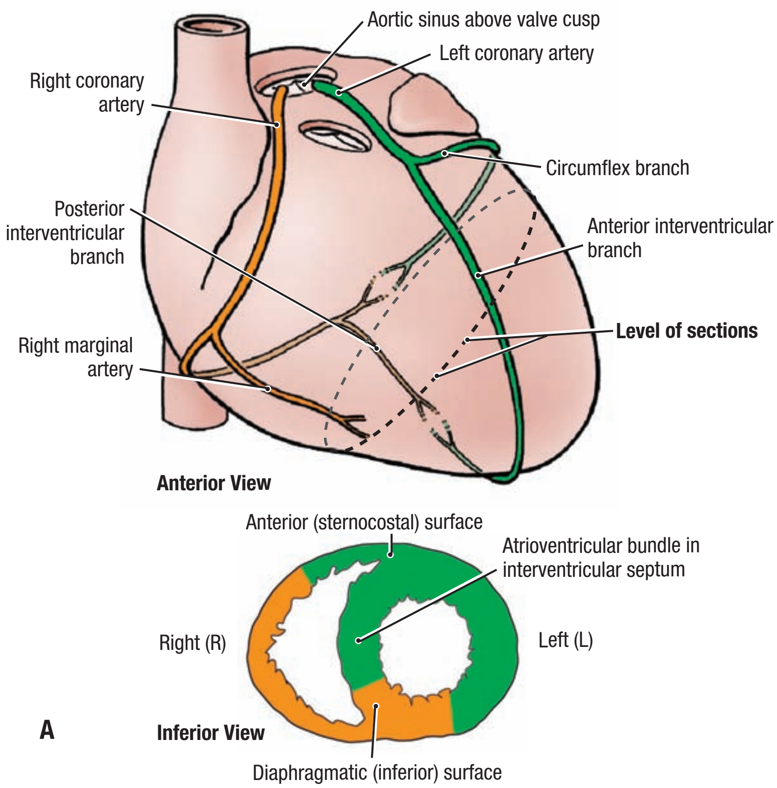


D. **Left Anterior Oblique View**

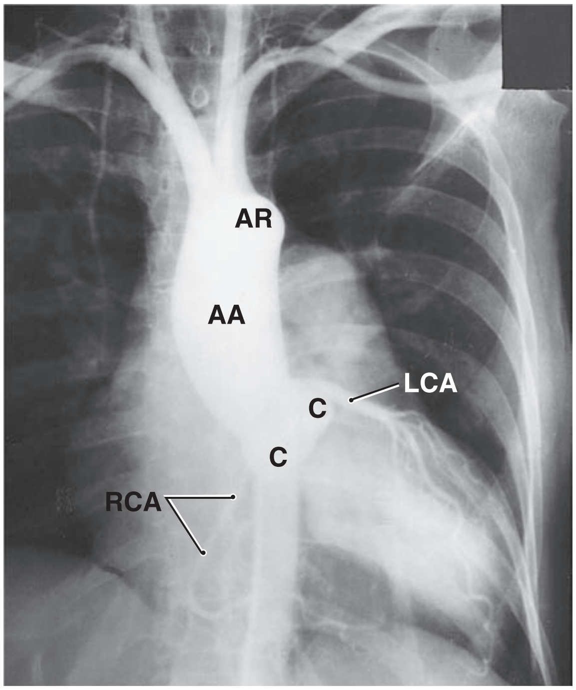
1.50 CORONARY ARTERIOGRAMS WITH ORIENTATION DRAWINGS

Right (**A** and **B**) and left (**C** and **D**) coronary arteriograms.

Coronary artery disease (CAD), one of the leading causes of death, results in a reduced blood supply to the vital myocardial tissue. The three most common sites of coronary artery occlusion and the approximate percentage of occlusions involving each artery are the (1) anterior interventricular (clinically referred to as LAD) branch of the left coronary artery (LCA) (40% to 50%); (2) right coronary artery (RCA), (30% to 40%); (3) circumflex branch of the LCA (15% to 20%).



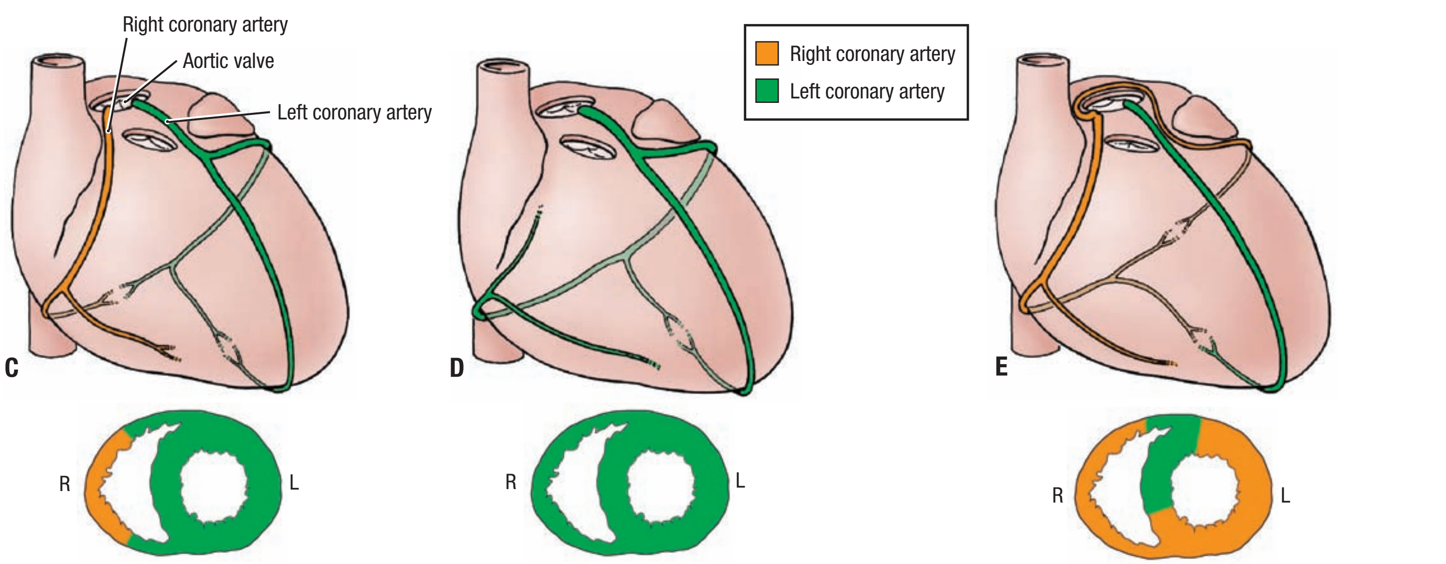
A. and B. **Most common pattern (67%). Right coronary artery is dominant, giving rise to the posterior interventricular branch.**



B. Coronary Angiogram, Anteroposterior View

KEY for B:

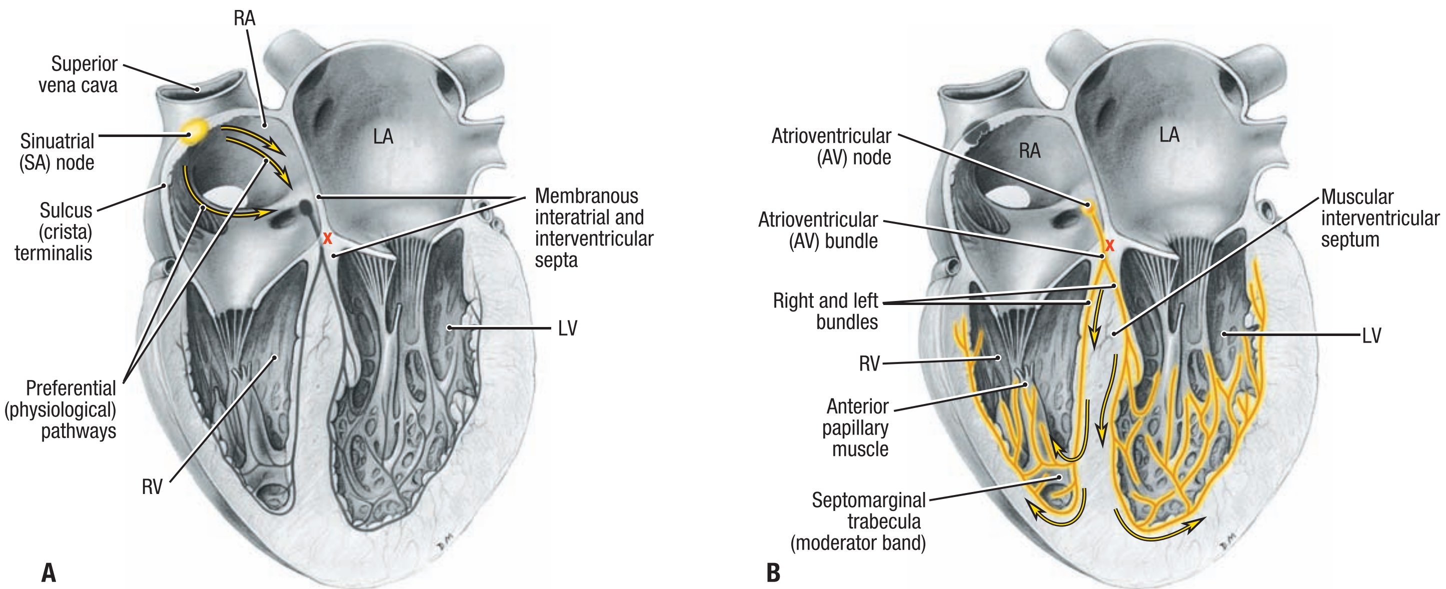
AA	Ascending aorta	LCA	Left coronary artery
AR	Arch of aorta	RCA	Right coronary artery
C	Cusp of aortic valve		



C. and D. **Left coronary artery gives rise to the posterior interventricular branch (15%).**

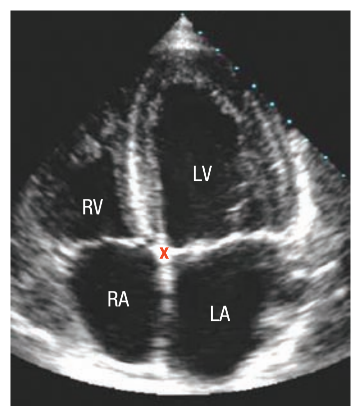
E. **Circumflex branch emerging from right coronary sinus.**

1.51 CORONARY CIRCULATION



Anterior Views

RV Right ventricle LV Left ventricle
x Crux of heart
RA Right atrium LA Left atrium

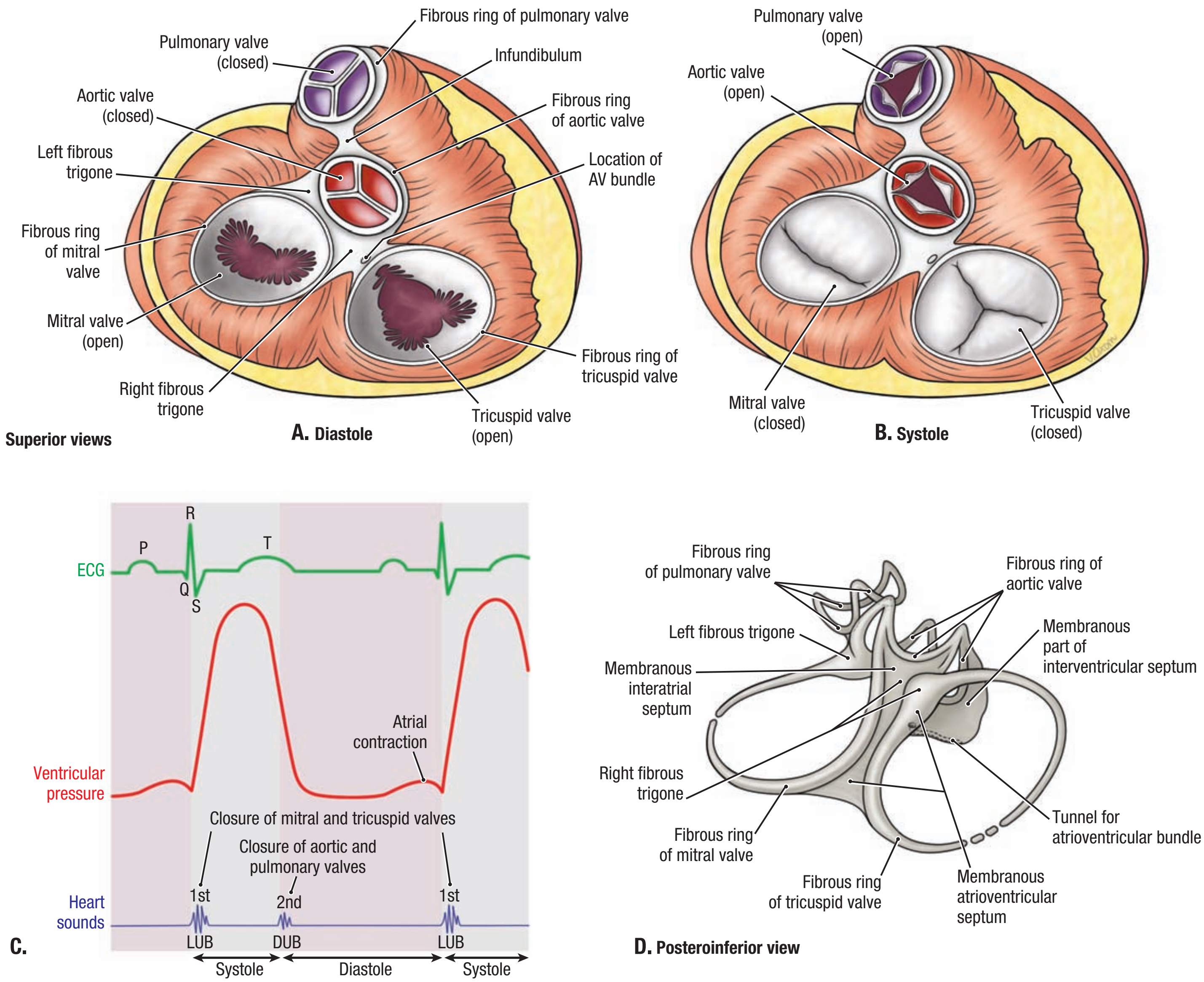


C

1.52 CONDUCTION SYSTEM OF HEART, CORONAL SECTION

A. Impulses (*arrows*) initiated at the sinu-atrial node. **B.** Atrioventricular (AV) node, AV bundle, and bundle branches. **C.** Echocardiogram, apical four-chamber view.

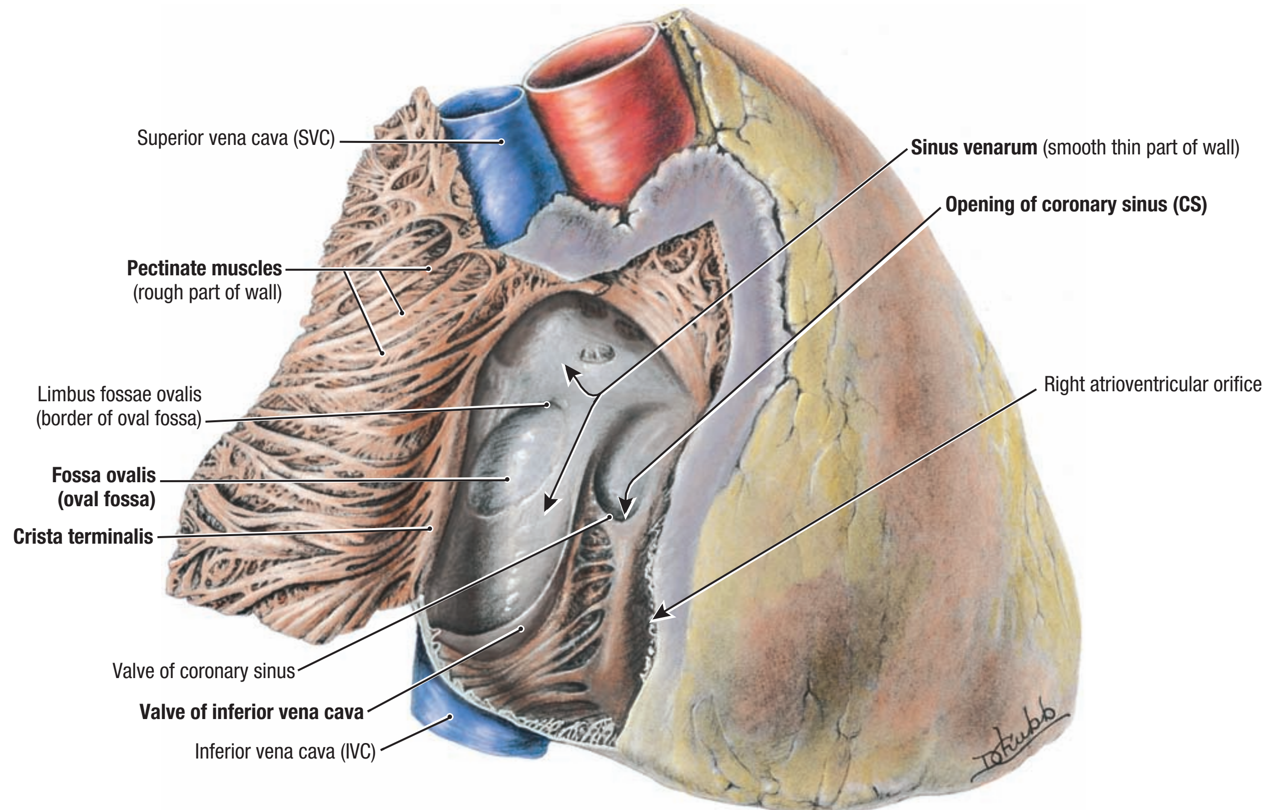
- The sinu-atrial (SA) node in the wall of the right atrium near the superior end of the sulcus terminalis (internally crista terminalis) extends over the opening of the superior vena cava. The SA node is the "pacemaker" of the heart because it initiates muscle contraction and determines the heart rate. It is supplied by the sinuatrial nodal artery, usually a branch of the right atrial branch of the right coronary artery, but it may arise from the left coronary artery.
- Contraction spreads through the atrial wall (myogenic induction) until it reaches the atrioventricular (AV) node in the interatrial septum superomedial to the opening of the coronary sinus. The AV node is supplied by the atrioventricular nodal artery, usually arising from the right coronary artery posteriorly at the inferior margin of the interatrial septum.
- The AV bundle, usually supplied by the right coronary artery, passes from the AV node in the membranous part of the interventricular septum, dividing into right and left bundle branches on either side of the muscular part of the interventricular septum.
- The right bundle branch travels inferiorly in the interventricular septum to the anterior wall of the ventricle, with part passing via the septomarginal trabecula to the anterior papillary muscle; excitation spreads throughout the right ventricular wall through a network of subendocardial branches from the right bundle (Purkinje fibers).
- The left bundle branch lies beneath the endocardium on the left side of the interventricular septum and branches to enter the anterior and posterior papillary muscles and the wall of the left ventricle; further branching into a plexus of subendocardial branches (Purkinje fibers) allows the impulses to be conveyed throughout the left ventricular wall. The bundle branches are mostly supplied by the left coronary artery except the posterior limb of the left bundle branch, which is supplied by both coronary arteries.
- **Damage to the cardiac conduction system** (often by compromised blood supply as in coronary artery disease) leads to disturbances of muscle contraction. Damage to the AV node results in "heart block" because the atrial excitation wave does not reach the ventricles, which begin to contract independently at their own slower rate. Damage to one of the bundle branches results in "bundle branch block," in which excitation goes down the unaffected branch to cause systole of that ventricle; the impulse then spreads to the other ventricle, producing later asynchronous contraction.



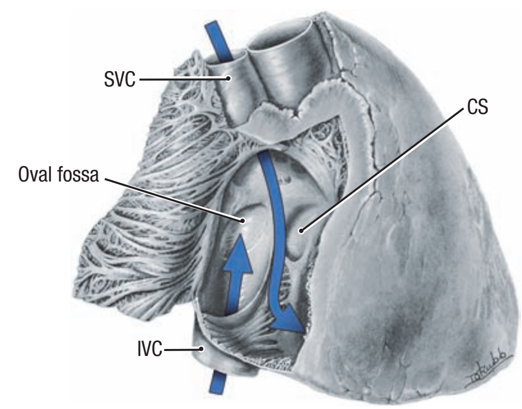
1.53 CARDIAC CYCLE AND CARDIAC SKELETON

A. Ventricular diastole. **B.** Ventricular systole. **C.** Correlation of ventricular pressure, electrocardiogram (ECG), and heart sounds. The cardiac cycle describes the complete movement of the heart or heartbeat and includes the period from the beginning of one heartbeat to the beginning of the next one. The cycle consists of diastole (ventricular relaxation and filling) and systole (ventricular contraction and emptying). The right heart is the pump for the pulmonary circuit; the left heart is the pump for the systemic circuit. (see Fig. 1.43C). **D.** Cardiac skeleton. The fibrous framework of dense collagen forms four fibrous rings, which provide attachment for the leaflets and cusps of the valves, and two fibrous trigones that connect the rings, and the membranous parts of the interatrial and interventricular septa. The fibrous skeleton keeps the orifices of the valves patent and separates the myenterically conducted impulses of the atria.

Disorders involving the valves of the heart disturb the pumping efficiency of the heart. **Valvular heart disease** produces either stenosis (narrowing) or insufficiency. **Valvular stenosis** is the failure of a valve to open fully, slowing blood flow from a chamber. **Valvular insufficiency**, or regurgitation, is the failure of the valve to close completely, usually owing to nodule formation on (or scarring and contraction of) the cusps so that the edges do not meet or align. This allows a variable amount of blood (depending on the severity) to flow back into the chamber it was just ejected from. Both stenosis and insufficiency result in an increased workload for the heart. Because valvular diseases are mechanical problems, damaged or defective cardiac valves are often replaced surgically in a procedure called **valvuloplasty**.



A. **Anterior View**

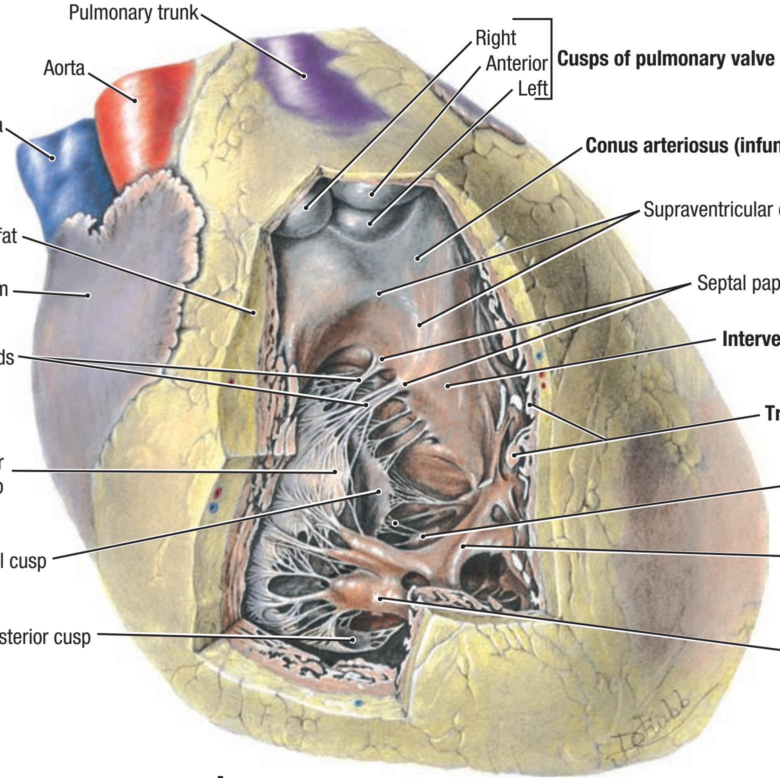


B. **Anterior View**

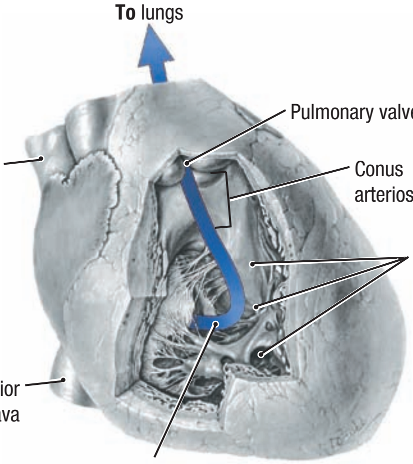
1.54 RIGHT ATRIUM

A. Interior of right atrium. The anterior wall of the right atrium is reflected. **B.** Blood flow into atrium from the superior and inferior vena cavae.

- The smooth part of the atrial wall is formed by the absorption of the right horn of the sinus venosus, and the rough part is formed from the primitive atrium.
- Crista terminalis, the valve of the inferior vena cava, and the valve of the coronary sinus separate the smooth part from the rough part.
- The pectinate muscle passes anteriorly from the crista terminalis; the crista underlies the sulcus terminalis (not shown), a groove visible externally on the posterolateral surface of the right atrium between the superior and inferior venae cavae.
- The superior and inferior venae cavae and the coronary sinus open onto the smooth part of the right atrium; the anterior cardiac veins and venae cordis minimae (not visible) also open into the atrium.
- The floor of the fossa is the remnant of the fetal septum primum; the crescent-shaped ridge (limbus fossae ovalis) partially surrounding the fossa is the remnant of the septum secundum.
- In **B,** the inflow from the superior vena cava is directed toward the tricuspid orifice, whereas blood from the inferior vena cava is directed toward the fossa ovalis.
- Congenital anomalies of the interatrial septum, most often incomplete closure of the oval foramen (patent foramen ovale), are **atrial septal defects (ASDs)**. A probe-size patency is present in the superior part of the oval fossa in 15% to 25% of adults (Moore and Persaud, 2008). These small openings, by themselves, cause no hemodynamic abnormalities. Large ASDs allow oxygenated blood from the lungs to be shunted from the left atrium through the ASD into the right atrium, causing enlargement of the right atrium and ventricle and dilation of the pulmonary trunk.



A. Anterior View

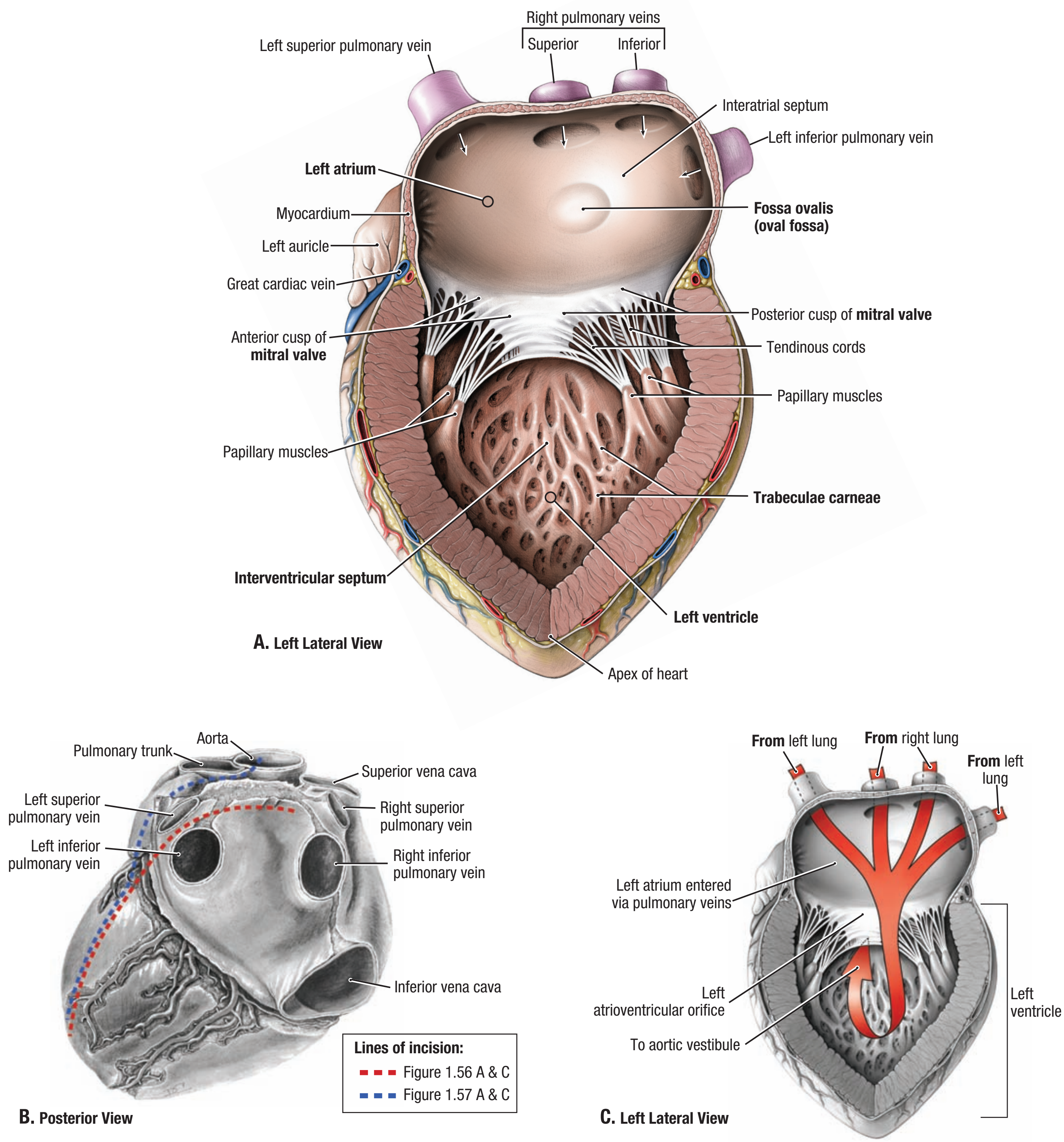


B. Anterior View

1.55 RIGHT VENTRICLE

A. Interior of right ventricle. **B.** Blood flow through right heart.

- The entrance to this chamber, the right atrioventricular or tricuspid orifice, is situated posteriorly; the exit, the orifice of the pulmonary trunk, is superior.
- The outflow portion of the chamber inferior to the pulmonary orifice (conus arteriosus or infundibulum) has a smooth, funnel-shaped wall; the remainder of the ventricle is rough with fleshy trabeculae.
- There are three types of trabeculae: mere ridges, bridges attached only at each end, and fingerlike projections called papillary muscles. The anterior papillary muscle rises from the anterior wall, the posterior (papillary muscle) from the posterior wall, and a series of small septal papillae from the septal wall.
- The septomarginal trabecula, here thick, extends from the septum to the base of the anterior papillary muscle.
- The membranous part of the interventricular septum develops separately from the muscular part and has a complex embryological origin (Moore and Persaud, 2008). Consequently, this part is the common site of *ventricular septal defects* (VSDs), although defects also occur in the muscular part. VSDs rank first on all lists of cardiac defects. The size of the defect varies from 1 to 25 mm. A VSD causes a left-to-right shunt of blood through the defect. A large shunt increases pulmonary blood flow, which causes severe pulmonary disease (*pulmonary hypertension*, or increased blood pressure) and may cause *cardiac failure*.



A. Left Lateral View

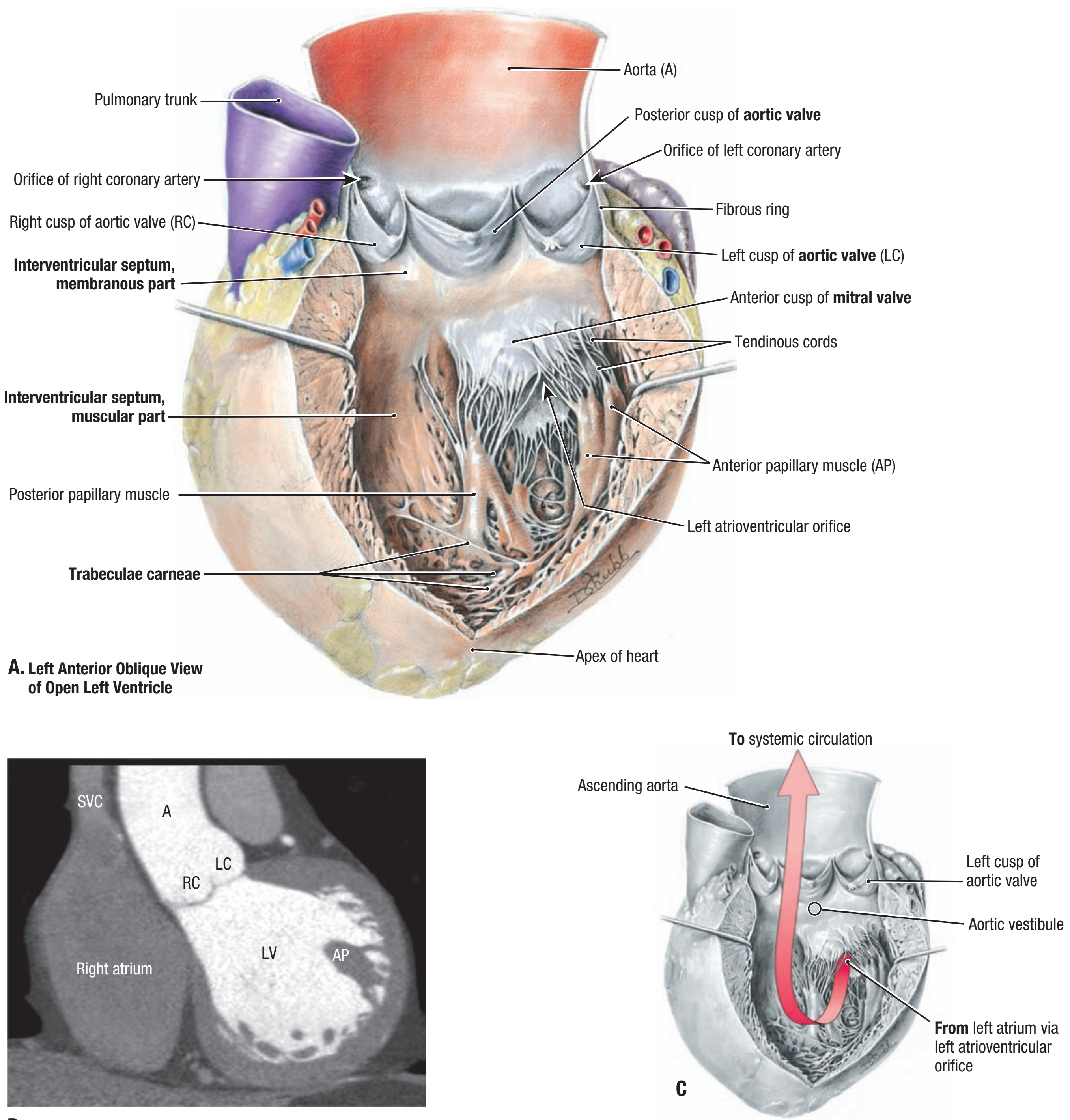
B. Posterior View

C. Left Lateral View

1.56 LEFT ATRIUM AND LEFT VENTRICLE

A. Interior of left heart. **B.** Blood flow through the left heart.

- A diagonal cut was made from the base of the heart to the apex, passing between the superior and inferior pulmonary veins and through the posterior cusp of the mitral valve, followed by retraction (spreading) of the left heart wall on each side of the incision.
- The entrances (pulmonary veins) to the left atrium are posterior, and the exit (left atrioventricular or mitral orifice) is anterior.
- The left side of the fossa ovalis is also seen on the left side of the interatrial septum, although the left side is not usually as distinct as the right side is within the right atrium.
- Except for that of the auricle, the atrial wall is smooth.



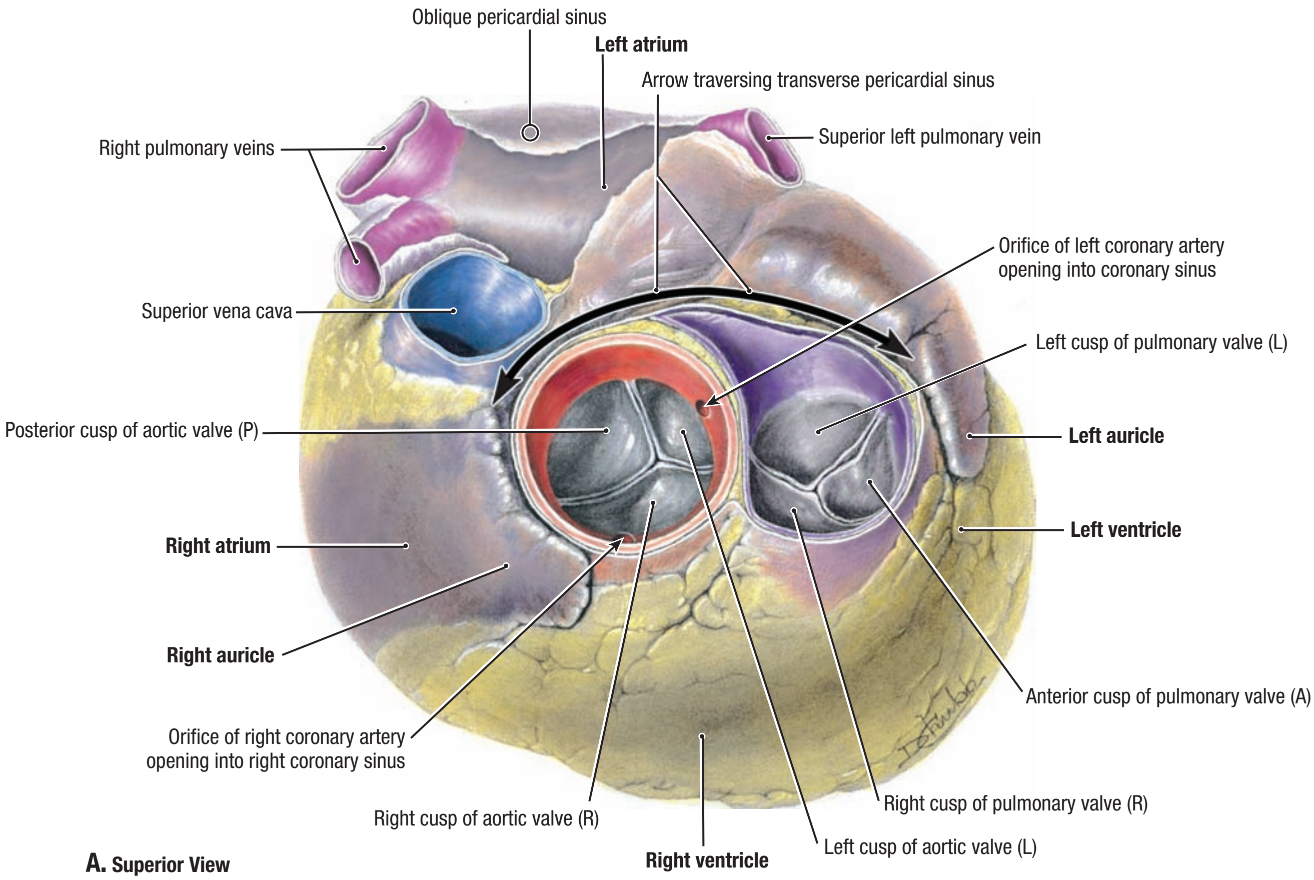
A. **Left Anterior Oblique View of Open Left Ventricle**

B. **Anterior View**

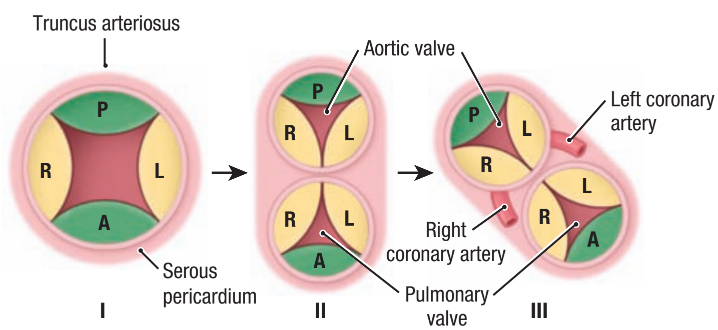
1.57 LEFT VENTRICLE

A. Interior of left ventricle. **B.** Coronal CT angiogram. Letters refer to structures in **A. C.** Blood flow through the left ventricle.

- A cut was made from the apex along the left margin of the heart, passing posterior to the pulmonary trunk, to open the aortic vestibule and ascending aorta.
- The chamber has a conical shape.
- The entrance (left atrioventricular, bicuspid, or mitral orifice) is situated posteriorly, and the exit (aortic orifice) is superior.
- The left ventricular wall is thin and muscular near the apex, thick and muscular superiorly, and thin and fibrous (nonelastic) at the aortic orifice.
- Two large papillary muscles, the anterior from the anterior wall and the posterior from the posterior wall, control the adjacent halves of two cusps of the mitral valve with tendinous cords (chordae tendineae).
- The anterior cusp of the mitral valve lies between the inlet (mitral orifice) and the outlet (aortic orifice).



A. **Superior View**



Semilunar valves:	
R Right	**A** Anterior
L Left	**P** Posterior

B

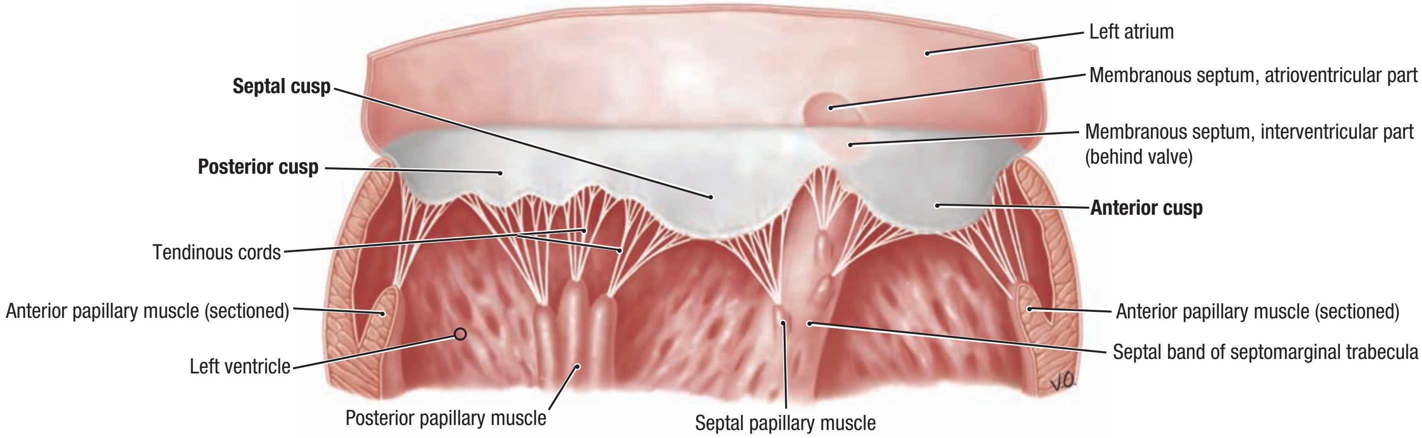
1.58 VALVES OF HEART

A. Excised heart.

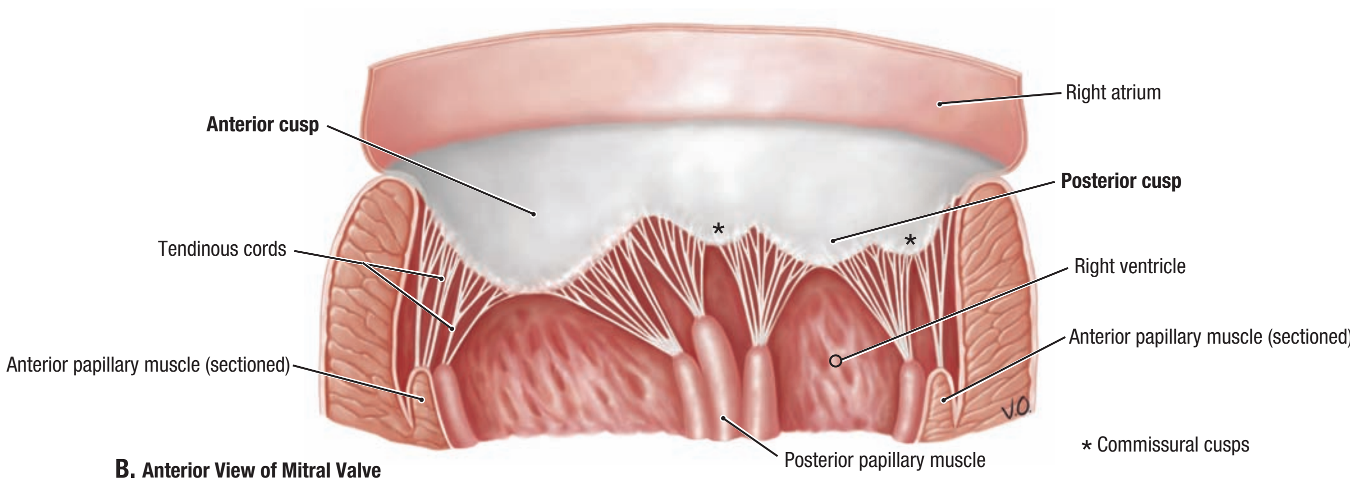
- The ventricles are positioned anteriorly and to the left, the atria posteriorly and to the right.
- The roots of the aorta and pulmonary artery, which conduct blood from the ventricles, are placed anterior to the atria and their incoming blood vessels (the superior and inferior vena cava and pulmonary veins).
- The aorta and pulmonary artery are enclosed within a common tube of serous pericardium and partly embraced by the auricles of the atria.
- The transverse pericardial sinus curves posterior to the enclosed stems of the aorta and pulmonary trunk and anterior to the superior vena cava and upper limits of the atria.
- The three cusps of the aortic and pulmonary valves. Immediately superior to each semilunar cusp, the walls of the origins of the pulmonary trunk and aorta are slightly dilated, forming a sinus. The aortic sinuses and sinuses of the pulmonary trunk (pulmonary sinuses) are the spaces at the origin of the pulmonary trunk and ascending aorta between the dilated wall of the vessel and each cusp of the semilunar valves.

B. Developmental basis for naming of pulmonary and aortic valve cusps.

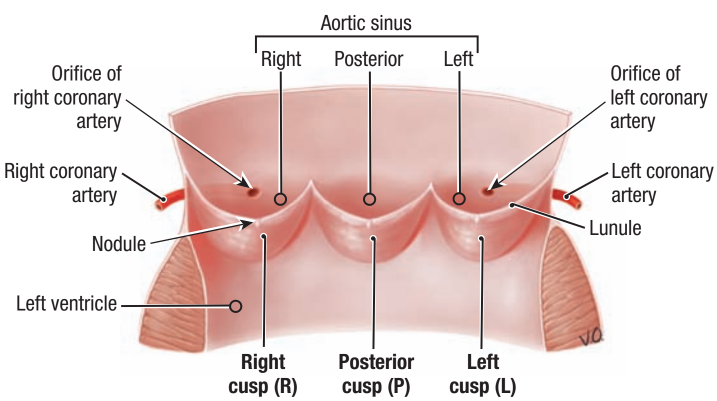
- The names of these cusps have a developmental origin (**B**) the truncus arteriosus with four cusps **(I)** splits to form two valves, each with three cusps **(II)**. The heart undergoes partial rotation to the left on its axis, resulting in the arrangement of cusps shown in **(III)** and in Figure 1.58B.



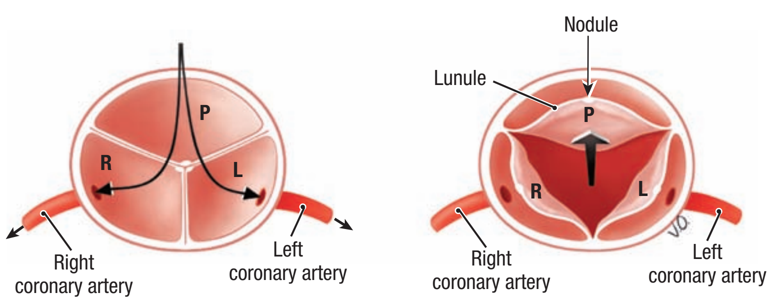
A. Anterior View of Tricuspid Valve



B. Anterior View of Mitral Valve



C. Left Posterior Oblique View of Aortic Valve

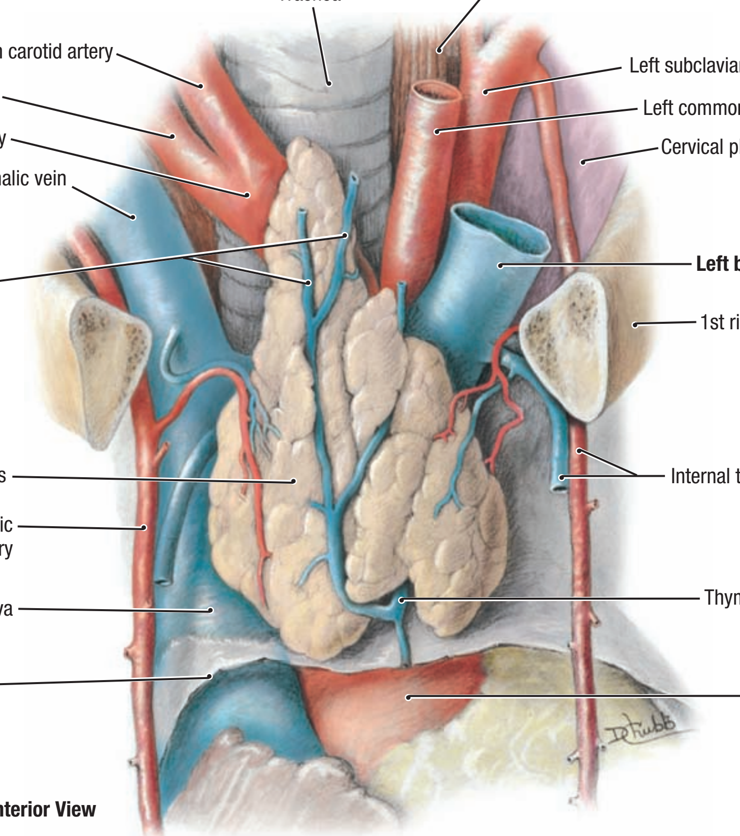


D. Superior Views of Aortic Valve (Arrows indicate direction of blood flow)

1.59 VALVES OF THE HEART

A. and B. Atrioventricular valves. **C. and D.** Semilunar valves.

Tendinous cords pass from the tips of the papillary muscles to the free margins and ventricular surfaces of the cusps of the tricuspid **(A)** and mitral **(B)** valves. Each papillary muscle or muscle group controls the adjacent sides of two cusps, resisting valve prolapse during systole. In **(C),** as in Figure 1.57A, the anulus of the aortic valve has been incised between the right and left cusps and spread open. Each cusp of the semilunar valves bears a nodule in the midpoint of its free edge, flanked by thin connective tissue areas (lunules). When the ventricles relax to fill (diastole), backflow of blood from aortic recoil or pulmonary resistance fills the sinus (space between cusp and dilated part of the aortic or pulmonary wall), causing the nodules and lunules to meet centrally, closing the valve **(D,** ***left*****).** Filling of the coronary arteries occurs during diastole (when ventricular walls are relaxed) as backflow "inflates" the cusps to close the valve.



A. Anterior View

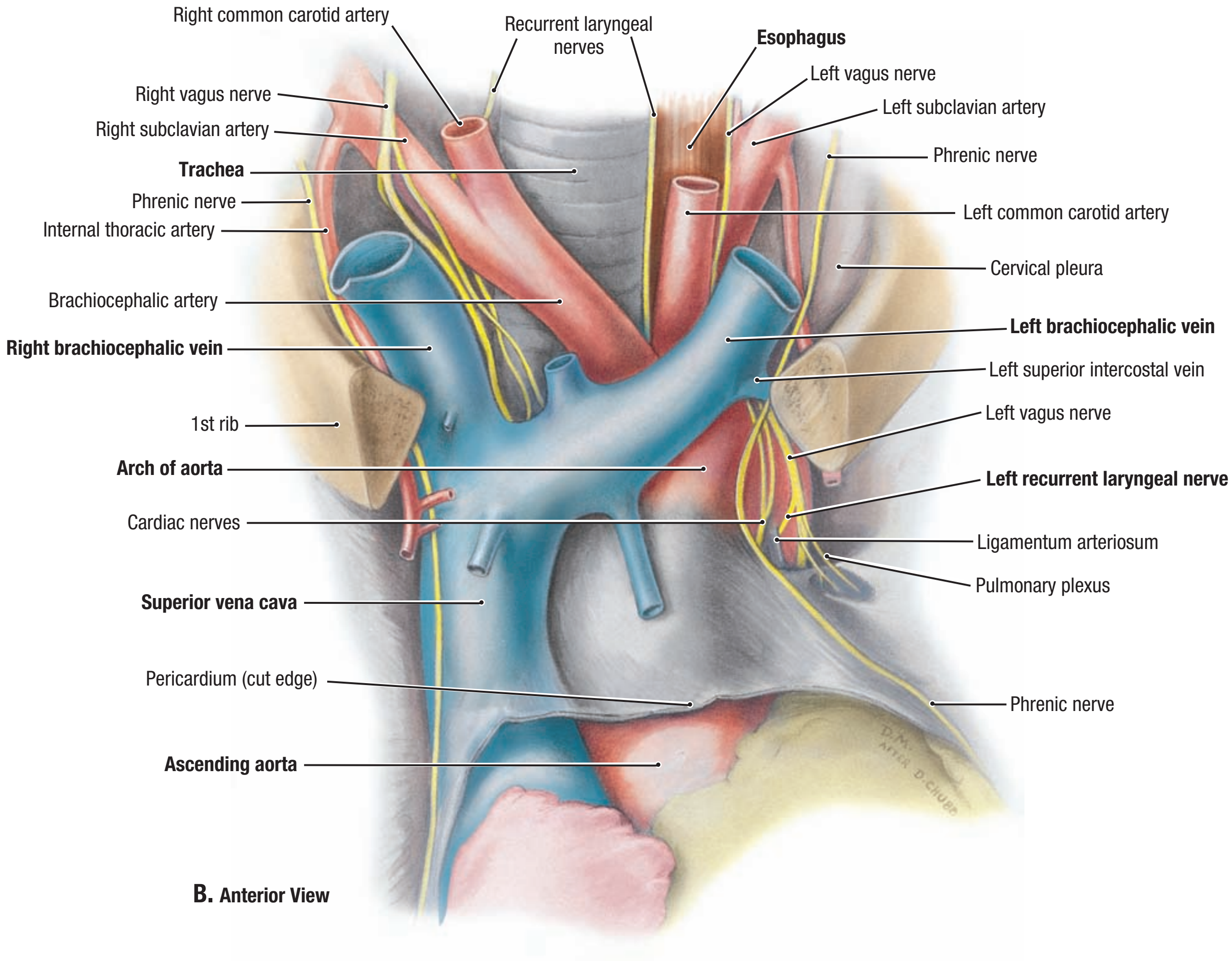
1.60 SUPERIOR MEDIASTINUM I AND II: SUPERFICIAL DISSECTIONS

A. Thymus in situ. The sternum and ribs have been excised and the pleurae removed. It is unusual in an adult to see such a discrete thymus, which is large during puberty but subsequently regresses and is for the most part replaced by fat and fibrous tissue. **B.** Thymus removed. **C.** Relationship of nerves and vessels. The right vagus nerve (CN X) crosses anterior to the right subclavian artery and gives off the right recurrent laryngeal nerve, which passes medially to reach the trachea and esophagus. The left recurrent laryngeal nerve passes inferior and then posterior to the arch of the aorta and ascends between the trachea and esophagus to the larynx.

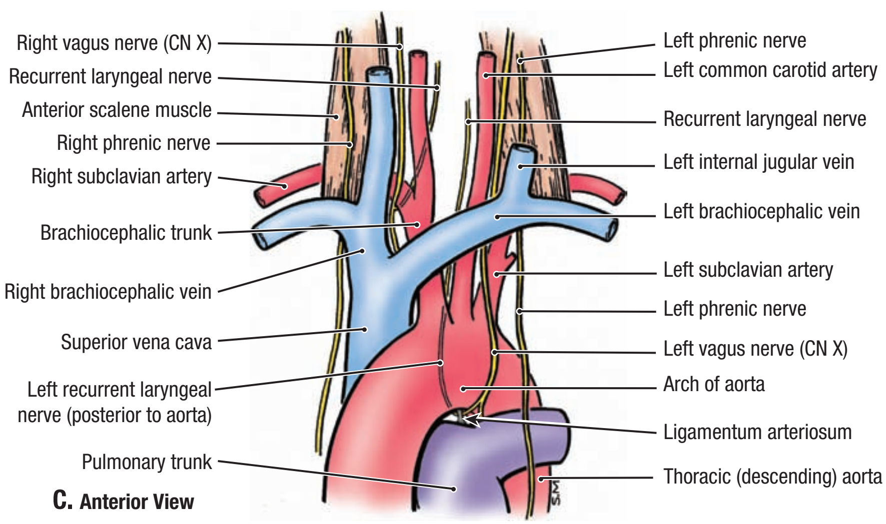
The distal part of the ascending aorta receives a strong thrust of blood when the left ventricle contracts. Because its wall is not reinforced by fibrous pericardium (the fibrous pericardium blends with the aortic adventitia at the beginning of the arch), an aneurysm may develop. An **aortic aneurysm** is evident on chest film (radiograph of the thorax) or a magnetic resonance angiogram as an enlarged area of the ascending aorta silhouette. Individuals with an aneurysm usually complain of chest pain that radiates to the back. The aneurysm may exert pressure on the trachea, esophagus, and recurrent laryngeal nerve, causing difficulty in breathing and swallowing.

The recurrent laryngeal nerves supply all the intrinsic muscles of the larynx, except the cricothyroid. Consequently, any investigative procedure or disease process in the superior mediastinum may involve these nerves and affect the voice. Because the left recurrent laryngeal nerve hooks around the arch of the aorta and ascends between the trachea and the esophagus, it may be involved when there is a bronchial or esophageal carcinoma, enlargement of mediastinal lymph nodes, or an aneurysm of the arch of the aorta.

The thymus is a prominent feature during infancy and childhood. In some infants, the thymus may compress the trachea. The thymus plays an important role in the development and maintenance of the immune system. As puberty is reached, the thymus begins to diminish in relative size. By adulthood, it is replaced by adipose tissue.

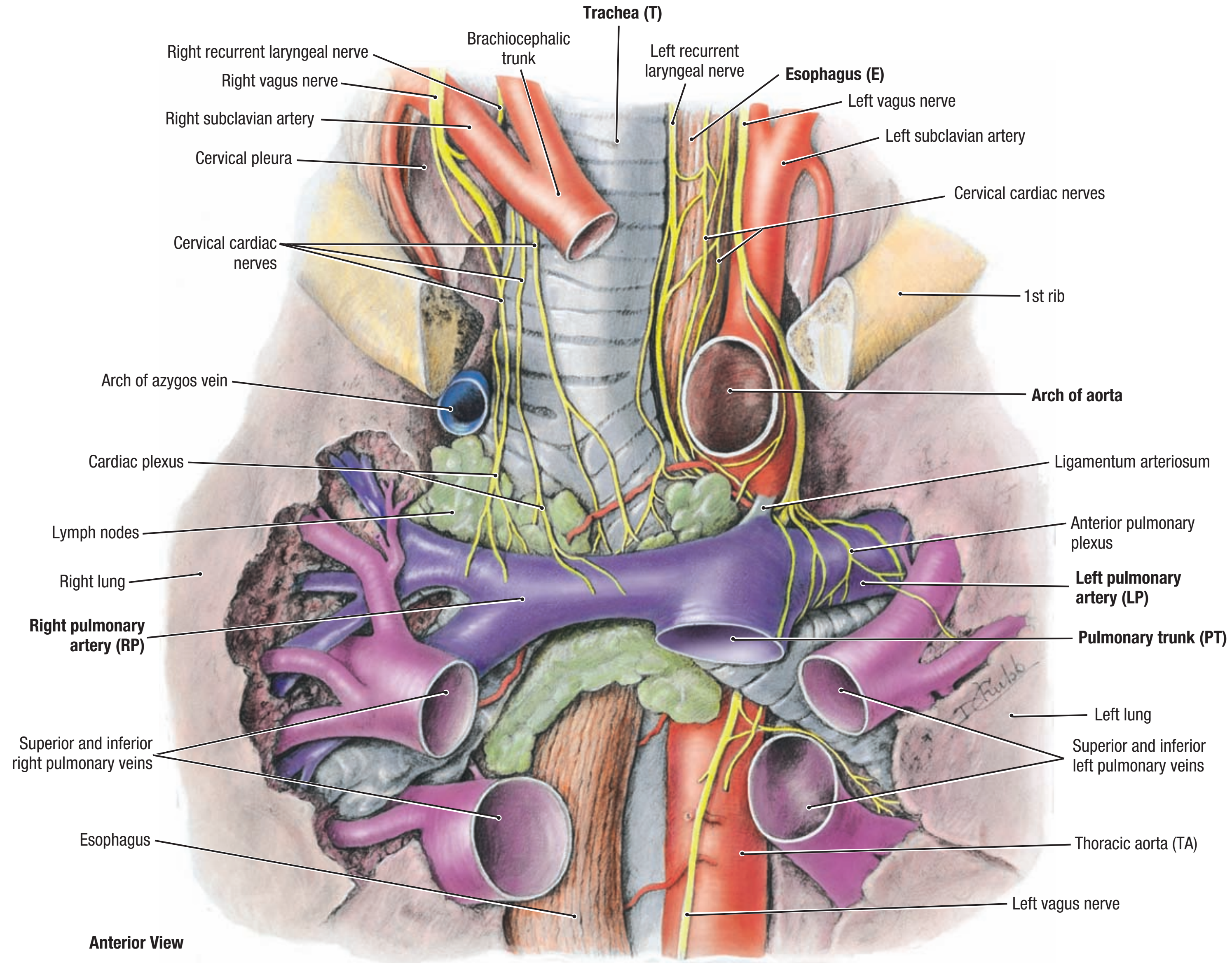


B. **Anterior View**

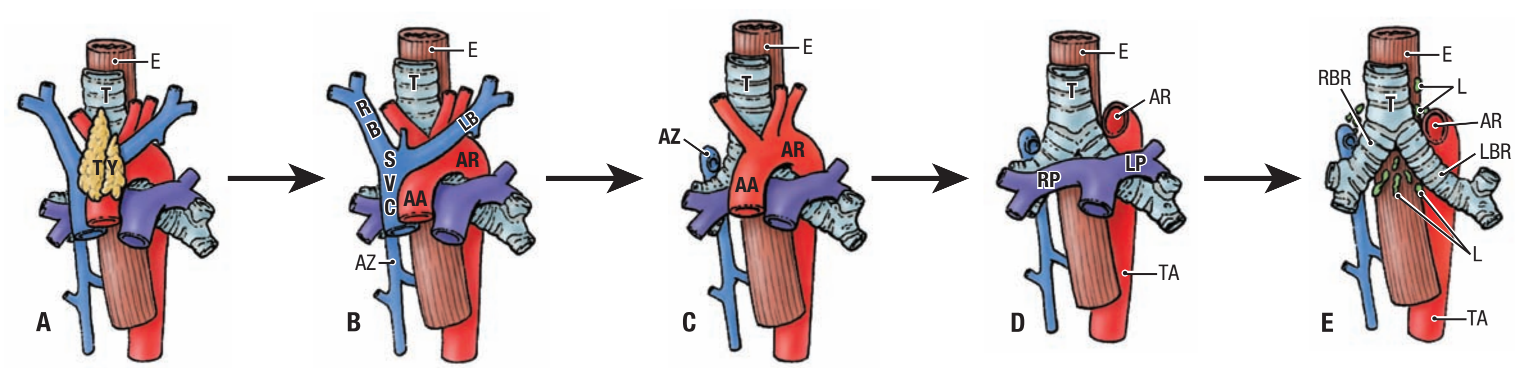


C. **Anterior View**

1.60 SUPERIOR MEDIASTINUM I AND II (*CONTINUED*)

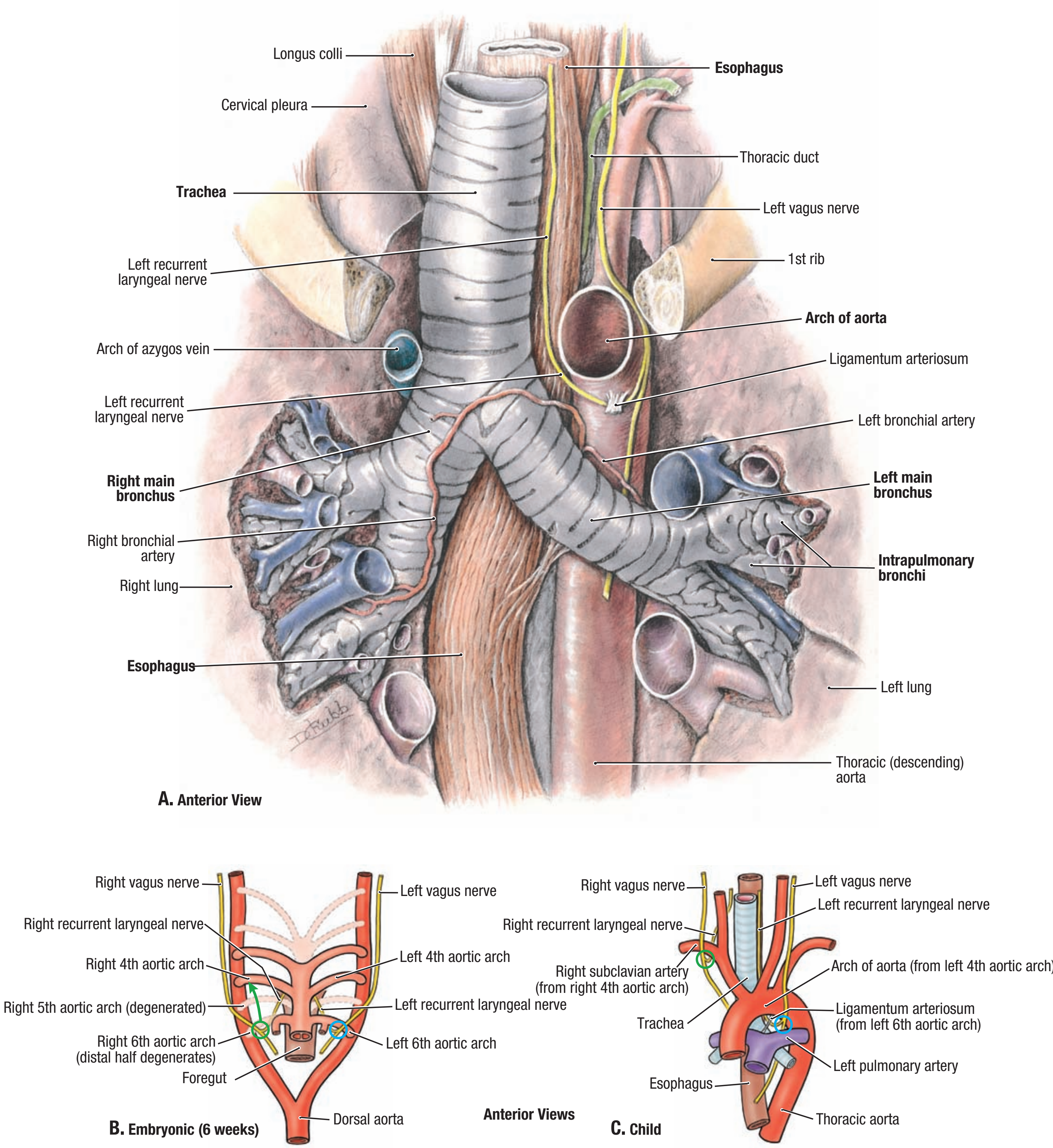


1.61 SUPERIOR MEDIASTINUM III: CARDIAC PLEXUS AND PULMONARY ARTERIES



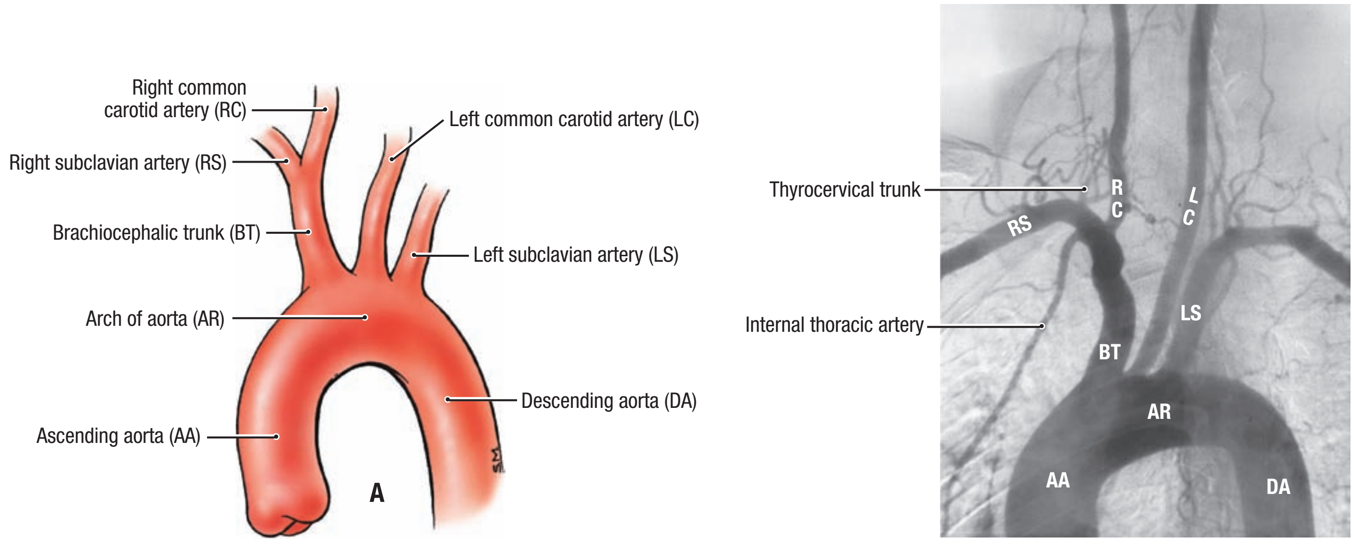
1.62 RELATIONS OF GREAT VESSELS AND TRACHEA

Observe, from superficial to deep: **(A)** Thymus (*TY*); **(B)** the right (*RB*) and left (*LB*) brachiocephalic veins form the superior vena cava (*SVC*) and receive the arch of the azygos vein (*AZ*) posteriorly; **(C)** the ascending aorta (*AA*) and arch of the aorta (*AR*) arch over the right pulmonary artery and left main bronchus; **(D)** the right and left pulmonary arteries (*RP* and *LP*); and **(E)** the tracheobronchial lymph nodes (*L*) at the tracheal bifurcation (*T*).



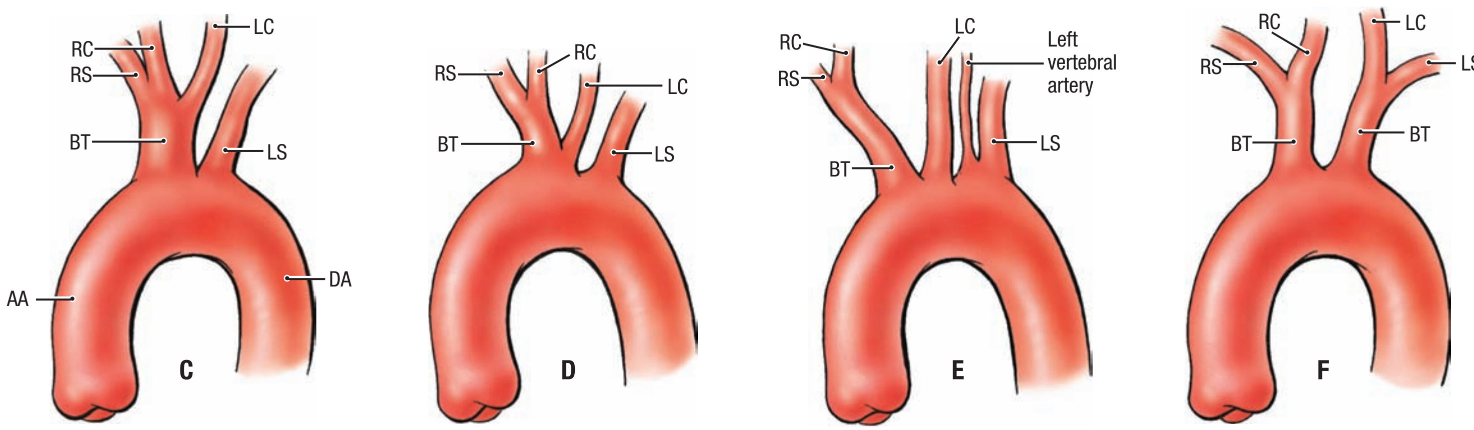
1.63 SUPERIOR MEDIASTINUM IV: TRACHEAL BIFURCATION AND BRONCHI

A. Dissection. **B.** Asymmetrical course of right and left recurrent laryngeal nerves. Arch VI disappears on the right, leaving the right recurrent laryngeal nerve to pass under arch IV, which becomes the right subclavian artery. Arch VI becomes part of the ductus arteriosus on the left side, and arch IV "descends" to become the arch of the aorta; thus the left recurrent laryngeal nerve is pulled into the thorax.



A. and B. Most common pattern (65%)

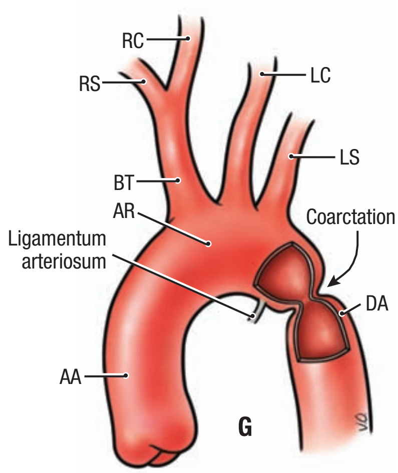
B. Aortic Angiogram, Left Anterior Oblique View



C. and D. Left common carotid artery originating from the brachiocephalic trunk (27%)

E. Four arteries originating independently from the arch of the aorta (2.5%)

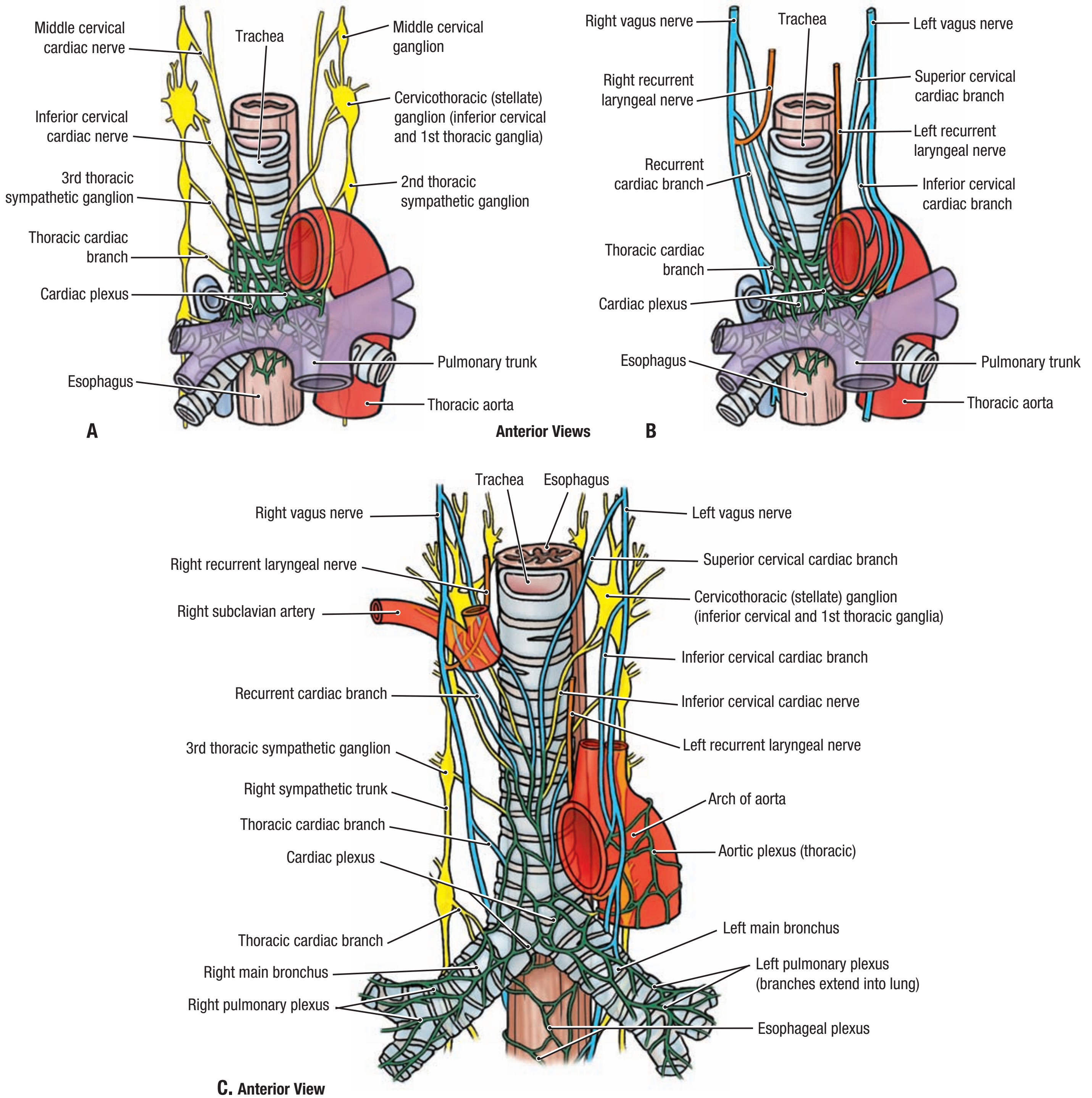
F. Right and left brachiocephalic trunks originating from the arch of the aorta (1.2%)



KEY
AA Ascending aorta
AR Arch of aorta
DA Descending aorta
BT Brachiocephalic trunk (artery)
LC Left common carotid artery
LS Left subclavian artery
RC Right common carotid artery
RS Right subclavian artery

1.64 BRANCHES OF AORTIC ARCH

A. and B. Most common pattern (65%). **C.–F.** Variations. **G.** In **coarctation of the aorta,** the arch or descending aorta has an abnormal narrowing (stenosis) that diminishes the caliber of the aortic lumen, producing an obstruction to blood flow. The most common site is near the ligamentum arteriosum. When the coarctation is inferior to this site (postductal coarctation), a good collateral circulation usually develops between the proximal and distal parts of the aorta through the intercostal and internal thoracic arteries.

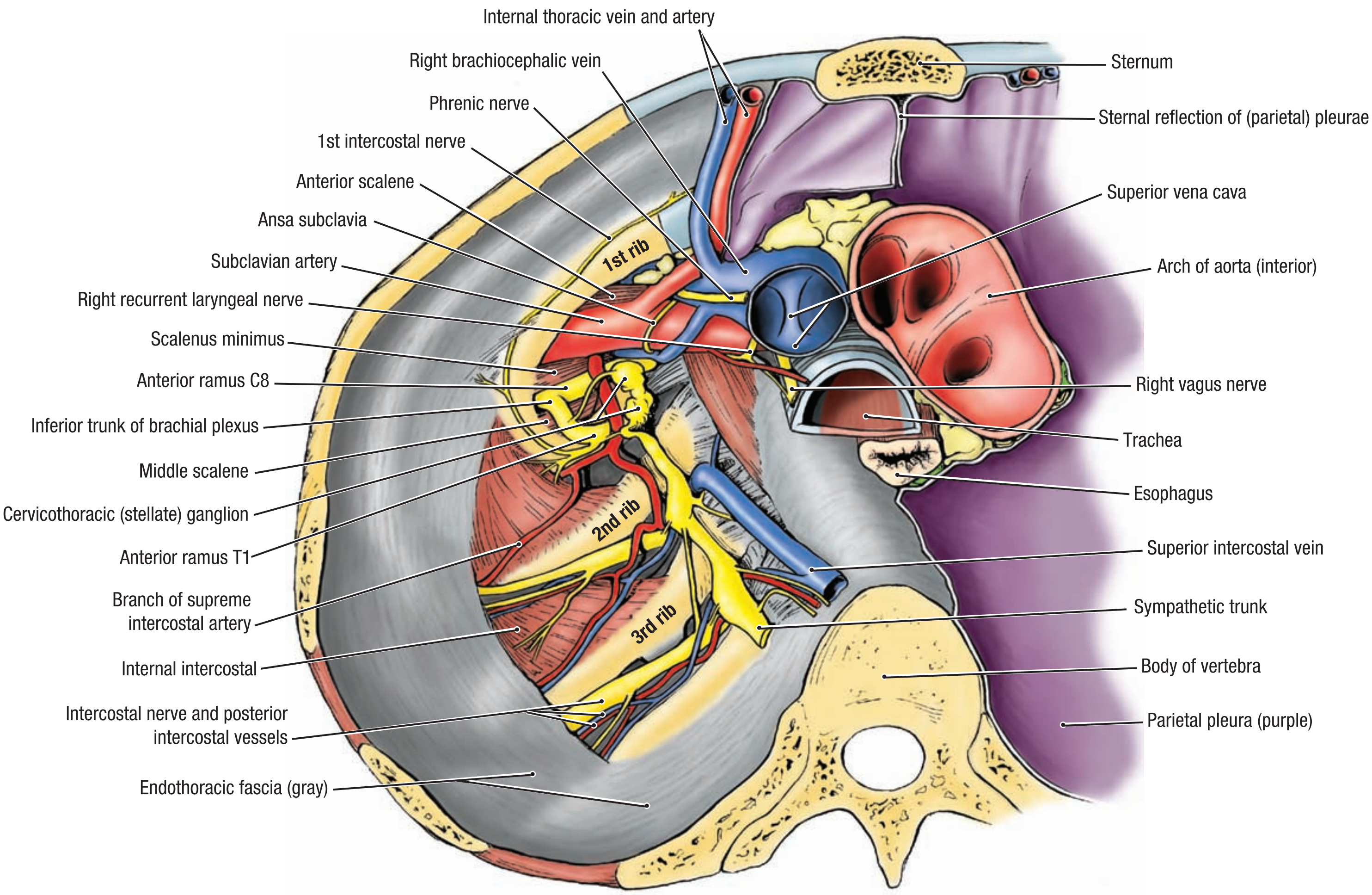


1.65 CARDIAC AND PULMONARY PLEXUSES

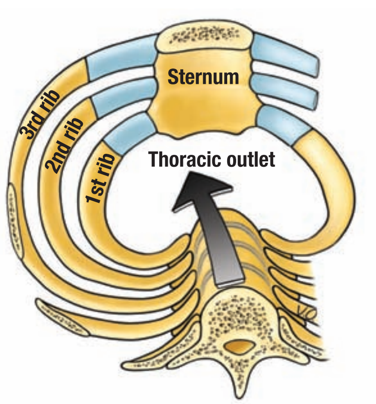
A. Sympathetic contribution. **B.** Parasympathetic contribution. **C.** Overview. *Yellow*, sympathetic; *blue*, parasympathetic; *green*, mixed sympathetic and parasympathetic nerves.

Heart: Sympathetic stimulation increases the heart's rate and the force of its contractions. Parasympathetic stimulation slows the heart rate, reduces the force of contraction, and constricts the coronary arteries, saving energy between periods of increased demand. While the cardiac plexus is shown in relation to the bifurcation of the trachea, note that it lies directly posterior to the superior margin of the heart (see Fig. 1.28C) and in close proximity to the nodal tissue and origins of the coronary arteries.

Lungs: Sympathetic fibers are inhibitory to the bronchial muscle (bronchodilator), motor to pulmonary vessels (vasoconstrictor) and inhibitory to the alveolar glands of the bronchial tree. Parasympathetic fibers from CN X are bronchoconstrictors, secretory to the glands of the bronchial tree (secretomotor).

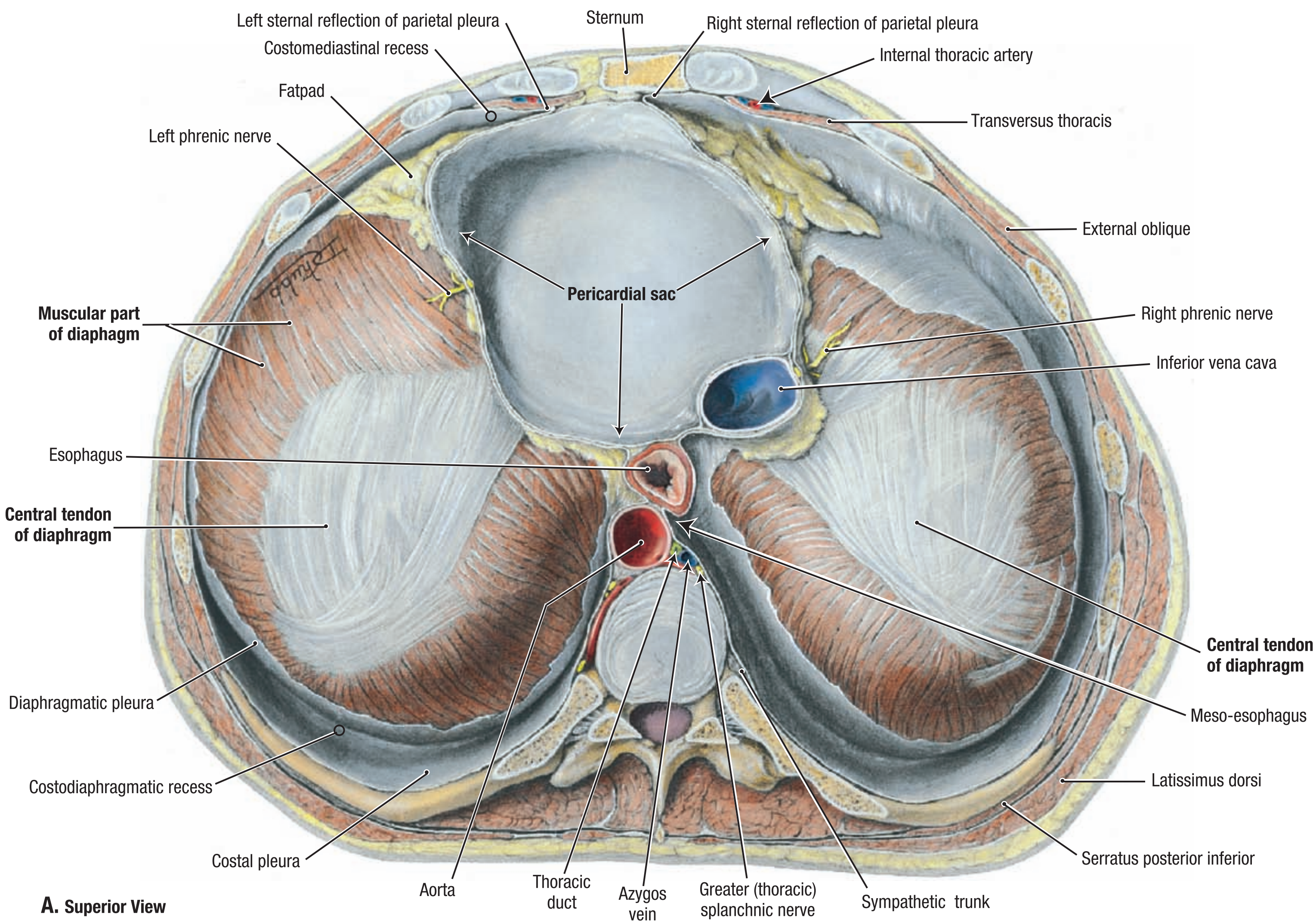


Inferior View



1.66 SUPERIOR MEDIASTINUM AND ROOF OF PLEURAL CAVITY

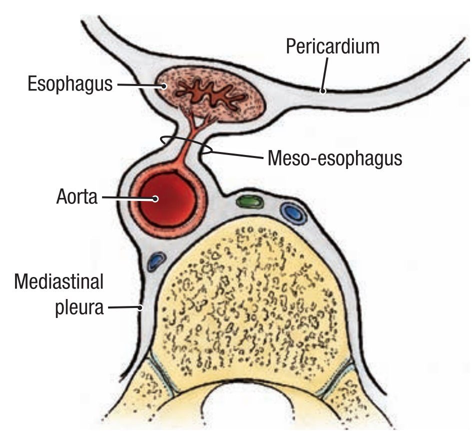
- The cervical, costal, and mediastinal parietal pleura (*purple*) and portions of the endothoracic fascia (*gray*) have been removed from the right side of the specimen to demonstrate structures traversing the superior thoracic aperture.
- The first part of the subclavian artery disappears as it crosses the first rib anterior to the anterior scalene muscle.
- The ansa subclavia from the sympathetic trunk and right recurrent laryngeal nerve from the vagus are seen looping inferior to the subclavian artery.
- The anterior rami of C8 and T1 merge to form the inferior trunk of the brachial plexus, which crosses the first rib posterior to the anterior scalene muscle.



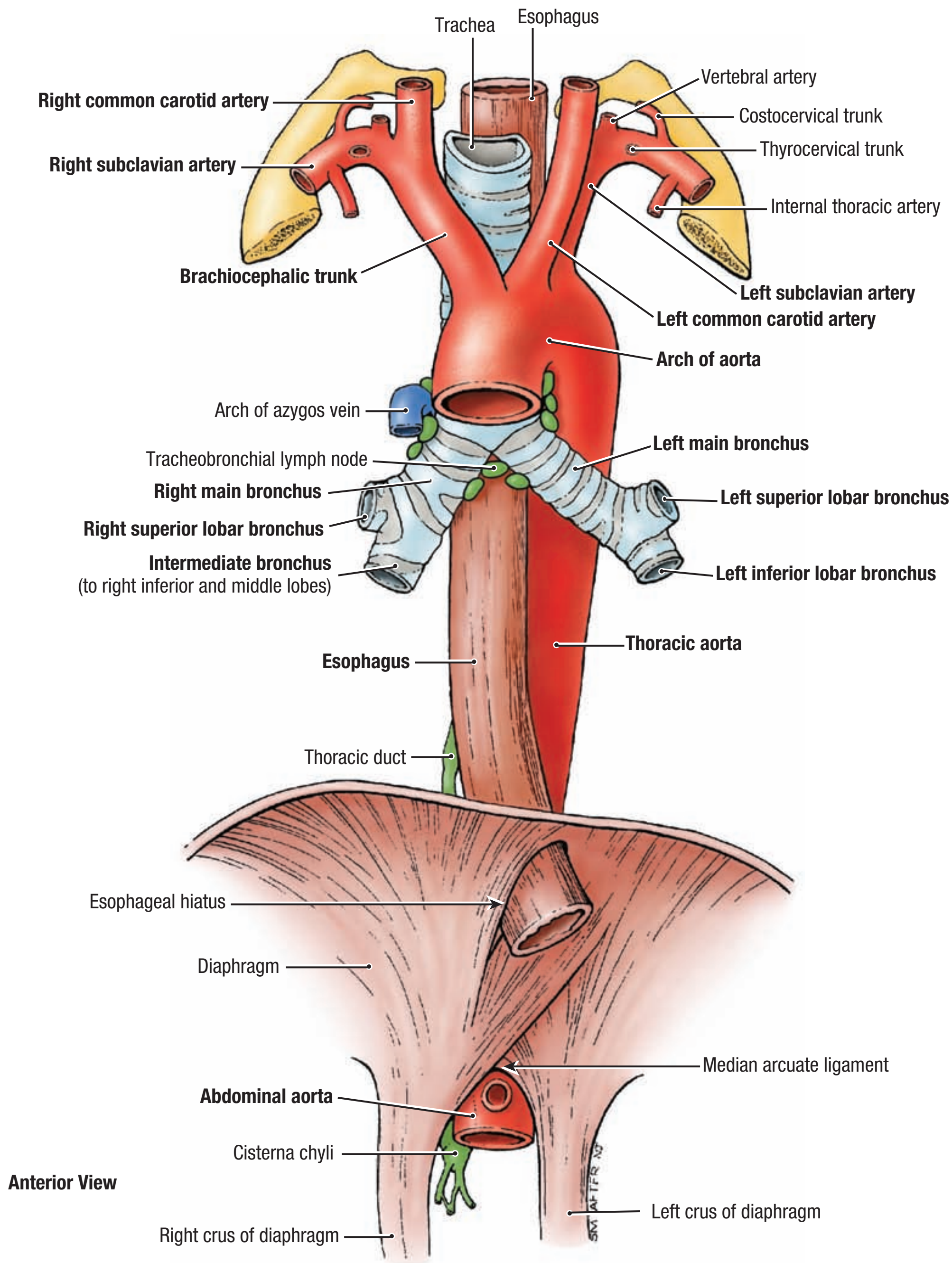
A. **Superior View**

1.67 DIAPHRAGM AND PERICARDIAL SAC

A. The diaphragmatic pleura is mostly removed. The pericardial sac is situated on the anterior half of the diaphragm; one third is to the right of the median plane, and two thirds to the left. Note also that anterior to the pericardium, the sternal reflection of the left pleural sac approaches but fails to meet that of the right sac in the median plane; and on reaching the vertebral column, the costal pleura becomes the mediastinal pleura. Irritation of the parietal pleura produces local pain and referred pain to the areas sharing innervation by the same segments of the spinal cord. Irritation of the costal and peripheral parts of the diaphragmatic pleura results in local pain and referred pain along the intercostal nerves to the thoracic and abdominal walls. Irritation of the mediastinal and central diaphragmatic areas of the parietal pleura results in pain that is referred to the root of the neck and over the shoulder (C3–C5 dermatomes). **B.** Between the inferior part of the esophagus and the aorta, the right and left layers of mediastinal pleura form a dorsal meso-esophagus, especially when the body is in the prone position.

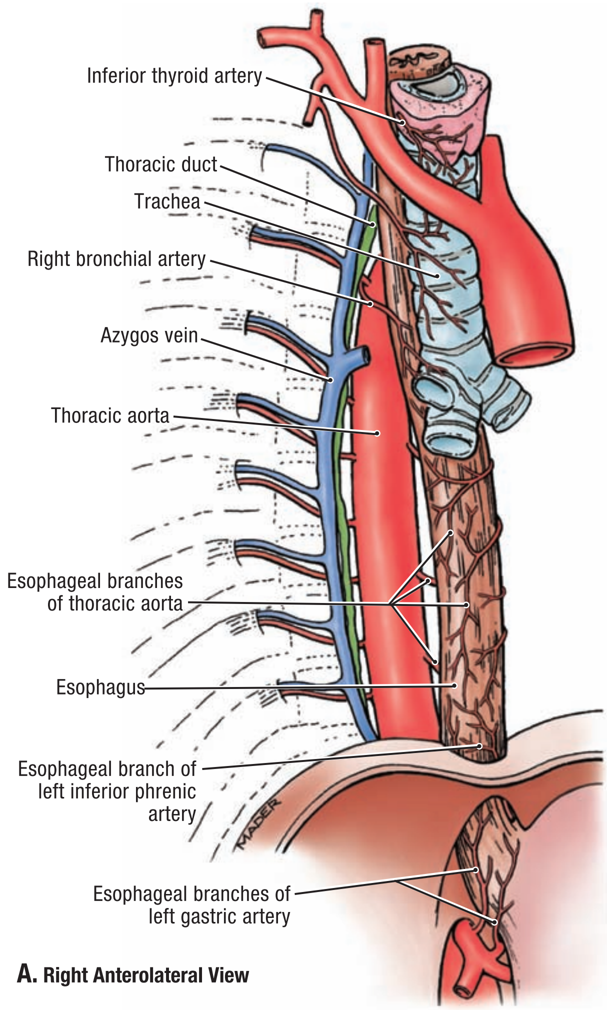


B. **Superior View**

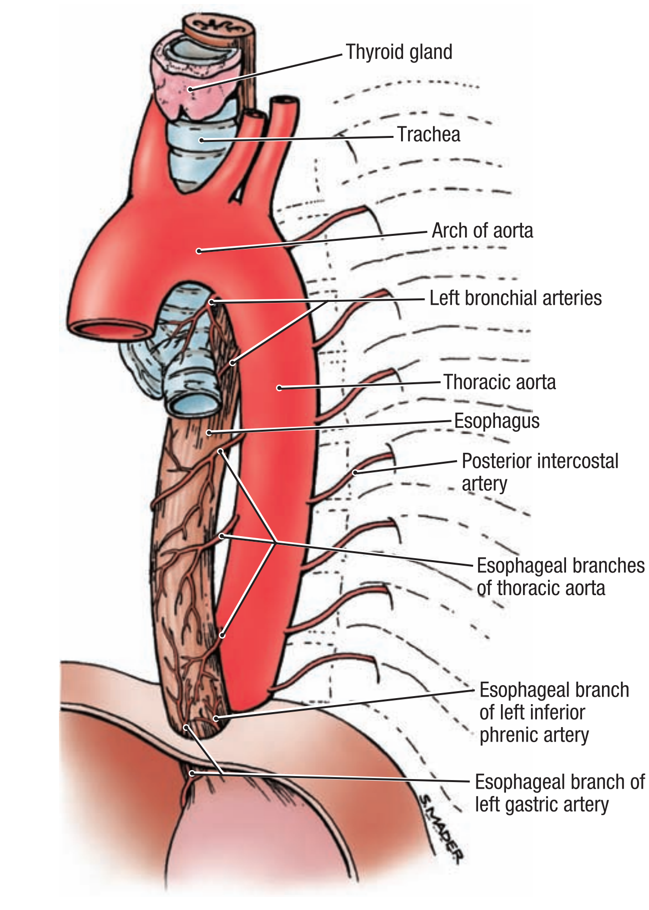


1.68 ESOPHAGUS, TRACHEA, AND AORTA

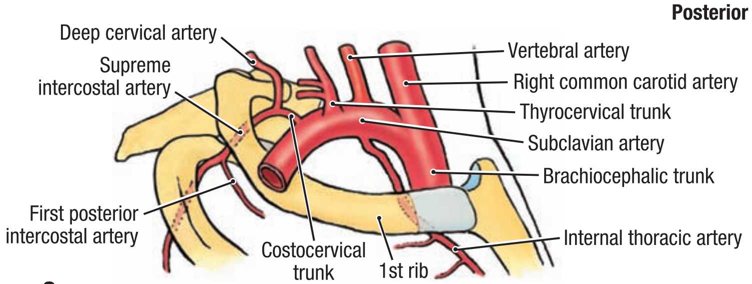
- The anterior relations of the thoracic part of the esophagus from superior to inferior are the trachea (from origin at cricoid cartilage to bifurcation), right and left bronchi, inferior tracheobronchial lymph nodes, pericardium (not shown) and, finally, the diaphragm.
- The arch of the aorta passes posterior to the left of these four structures as it arches over the left main bronchus; the arch of the azygos vein passes anterior to their right as it arches over the right main bronchus.
- The impressions produced in the esophagus by adjacent structures (aorta, left main bronchus, and esophageal hiatus) are of clinical interest because of the slower passage of substances at these sites. The impressions indicate where swallowed foreign objects are most likely to lodge and where a stricture may develop after the accidental drinking of a caustic liquid such as lye.



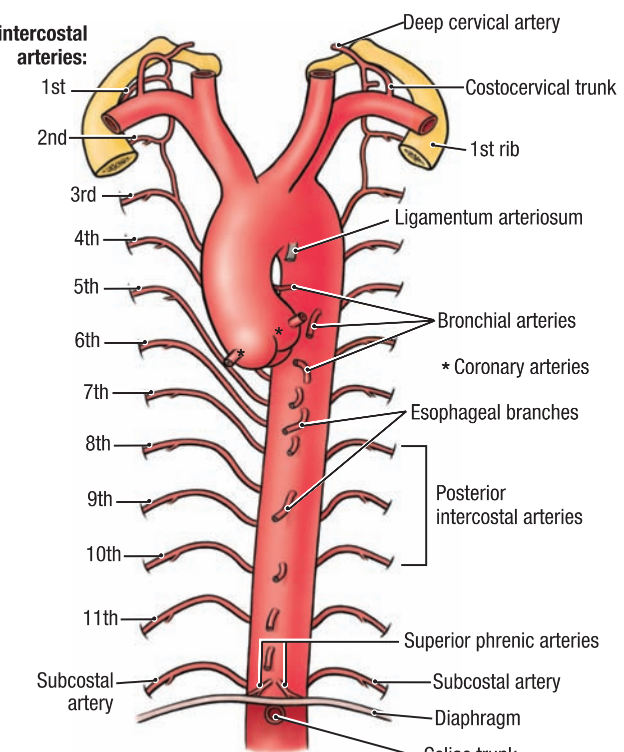
A. Right Anterolateral View



B. Left Anterolateral View



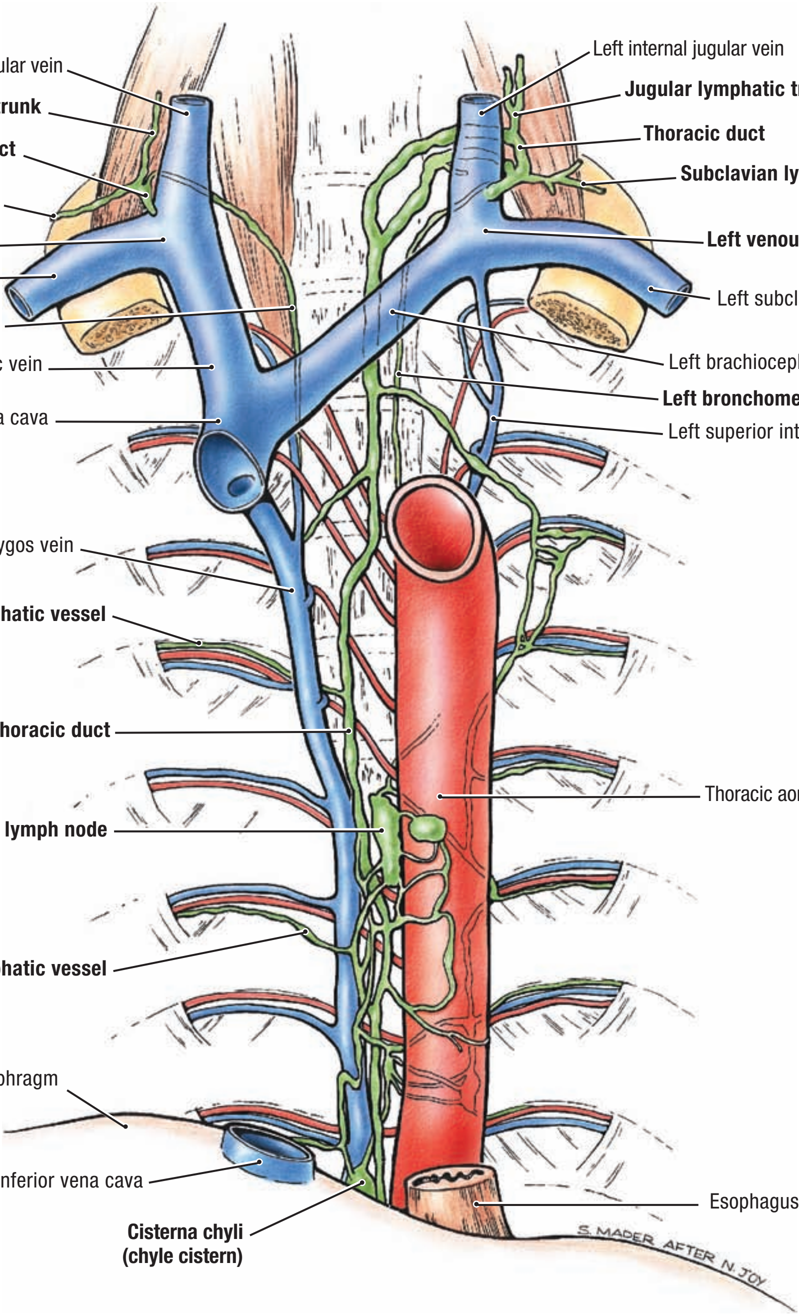
C. Lateral View



D. Anterior View

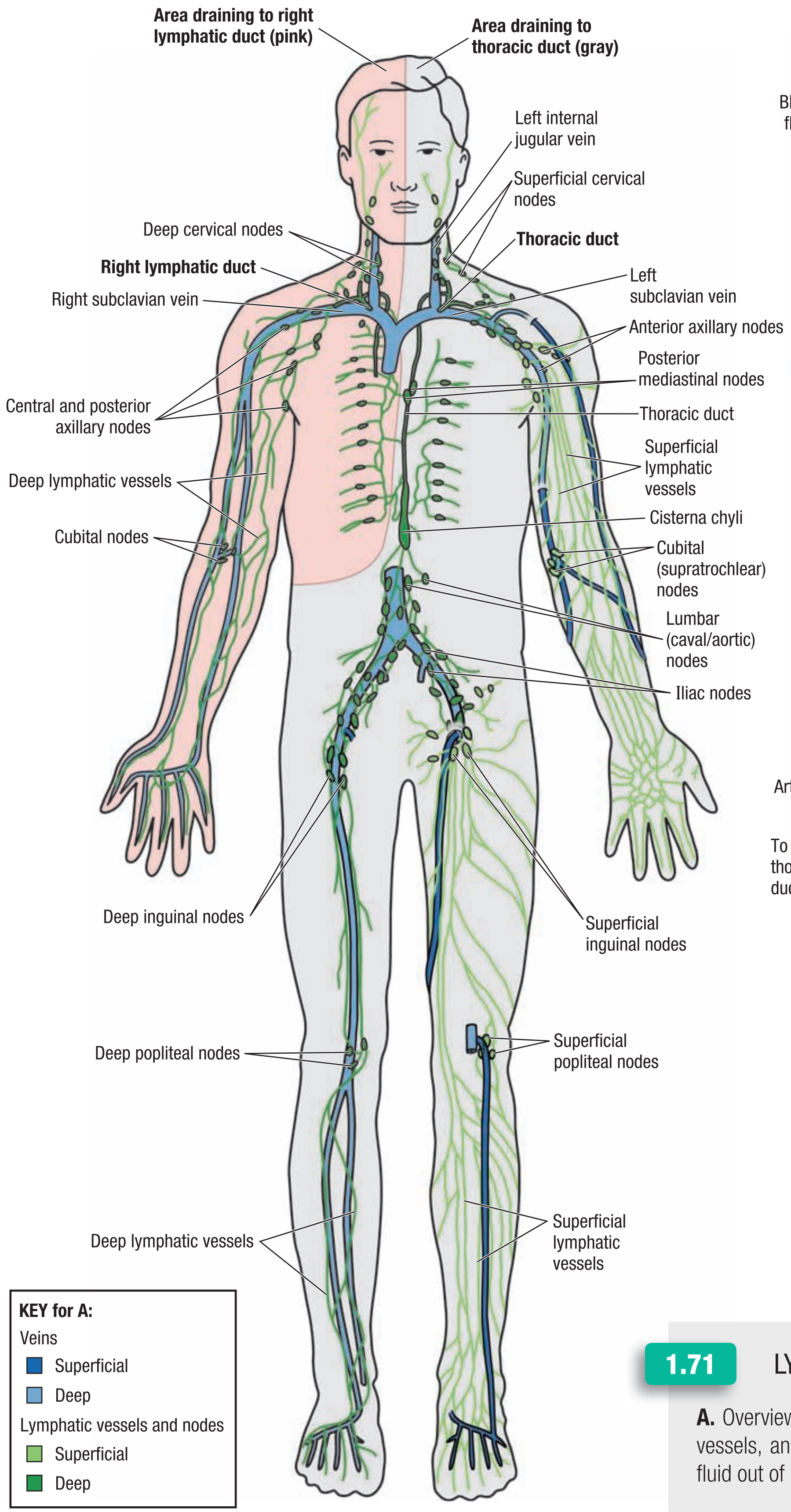
1.69 ARTERIAL SUPPLY TO TRACHEA AND ESOPHAGUS

A. and B. The continuous anastomotic chain of arteries on the esophagus is formed (1) by branches of the right and left inferior thyroid and right supreme intercostal arteries superiorly, (2) by the unpaired median aortic (bronchial and esophageal) branches, and (3) by branches of the left gastric and left inferior phrenic arteries inferiorly. The right bronchial artery usually arises from the superior left bronchial or 3rd right posterior intercostal artery (here the 5th) or from the aorta directly. The unpaired median aortic branches also supply the trachea and bronchi. **C.** Origin of supreme intercostal artery. **D.** Branches of the thoracic aorta.

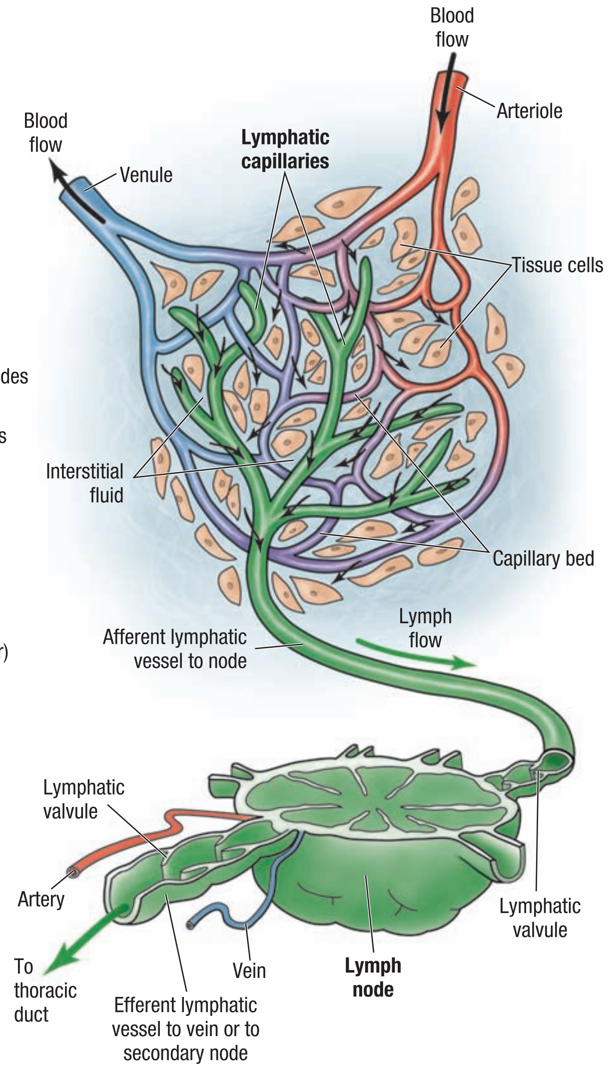


1.70 THORACIC DUCT

- The descending aorta is located to the left, and the azygos vein slightly to the right of the midline.
- The thoracic duct (1) originates from the cisterna chyli at the T12 vertebral level, (2) ascends on the vertebral column between the azygos vein and the descending aorta, (3) passes to the left at the junction of the posterior and superior mediastina, and continues its ascent to the neck, where (4) it arches laterally to enter the venous system near or at the angle of union of the left internal jugular and subclavian veins (left venous angle).
- The thoracic duct is commonly plexiform (resembling a network) in the posterior mediastinum.
- The termination of the thoracic duct typically receives the left jugular, subclavian, and bronchomediastinal trunks.
- The right lymph duct is short and formed by the union of the right jugular, subclavian, and bronchomediastinal trunks.
- Because the thoracic duct is thin walled and may be colorless, it may not be easily identified. Consequently, it is vulnerable to inadvertent injury during investigative and/or surgical procedures in the posterior mediastinum. **Laceration of the thoracic duct** results in chyle escaping into the thoracic cavity. Chyle may also enter the pleural cavity, producing chylothorax.



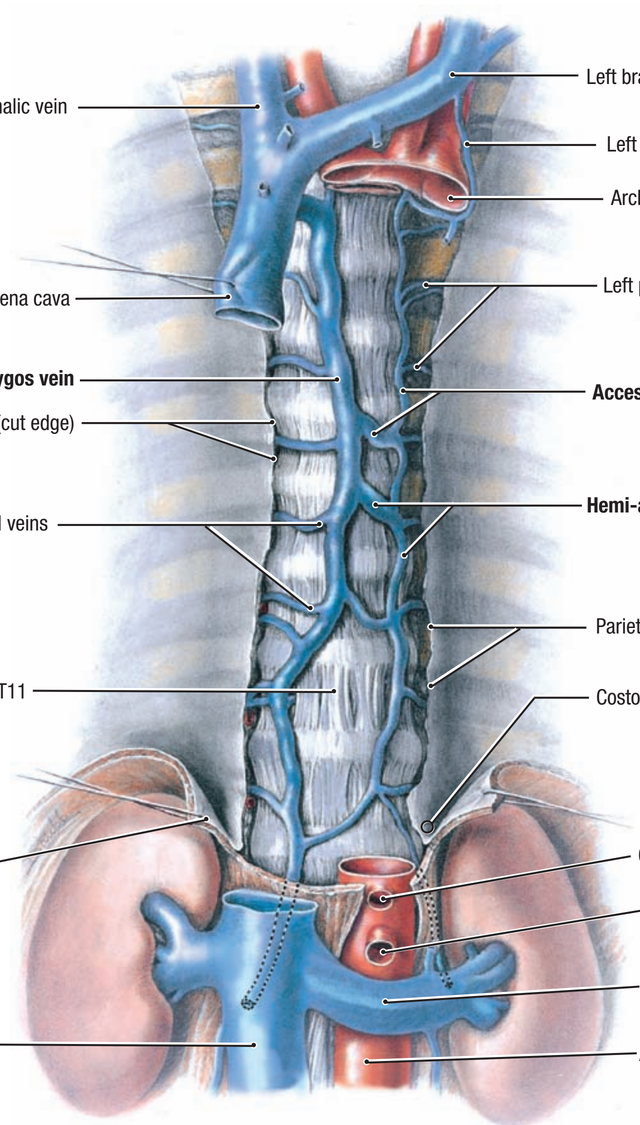
A. **Anterior View**



B. **Schematic Illustration**

1.71 LYMPHATIC SYSTEM

A. Overview of superficial and deep lymphatics. **B.** Lymphatic capillaries, vessels, and nodes. *Black arrows* indicate the flow (leaking of interstitial fluid out of blood vessels and absorption) into the lymphatic capillaries.

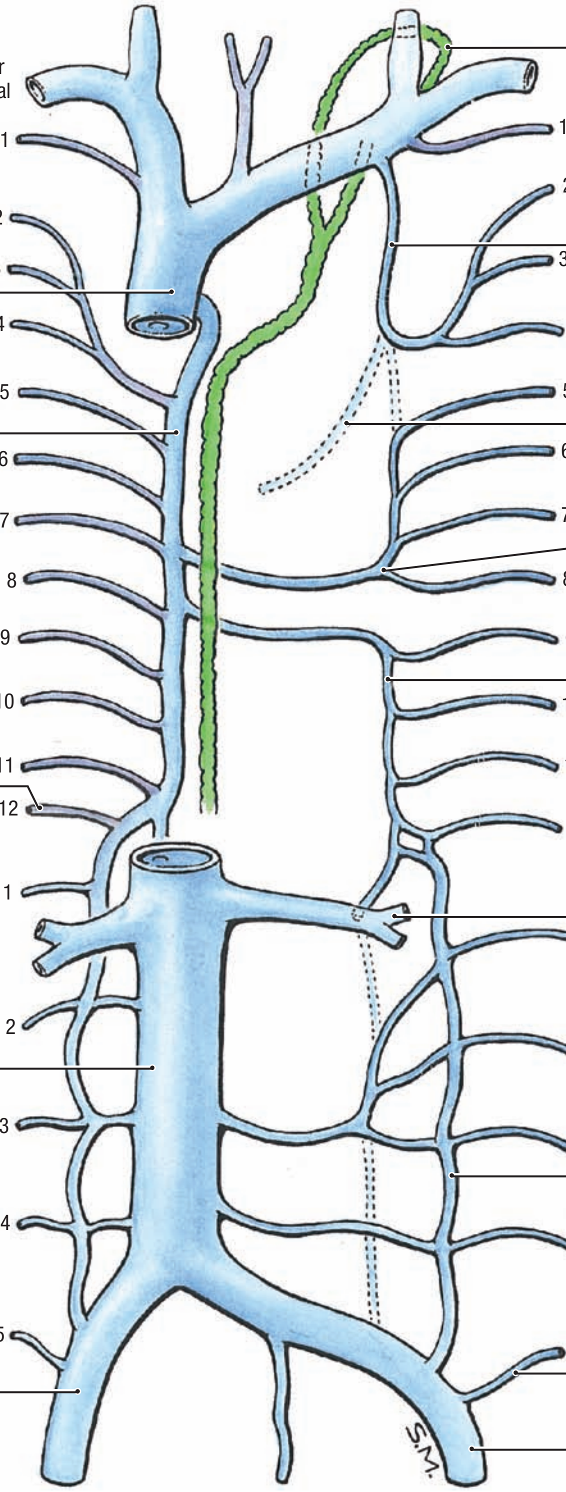


A. Anterior View

1.72 AZYGOS SYSTEM OF VEINS

The ascending lumbar veins connect the common iliac veins to the lumbar veins and join the subcostal veins to become the lateral roots of the azygos and hemi-azygos veins; the medial roots of the azygos and hemi-azygos veins are usually from the inferior vena cava and left renal vein, if present. Typically the upper four left posterior intercostal veins drain into the left brachiocephalic vein, directly and via the left superior intercostal veins.

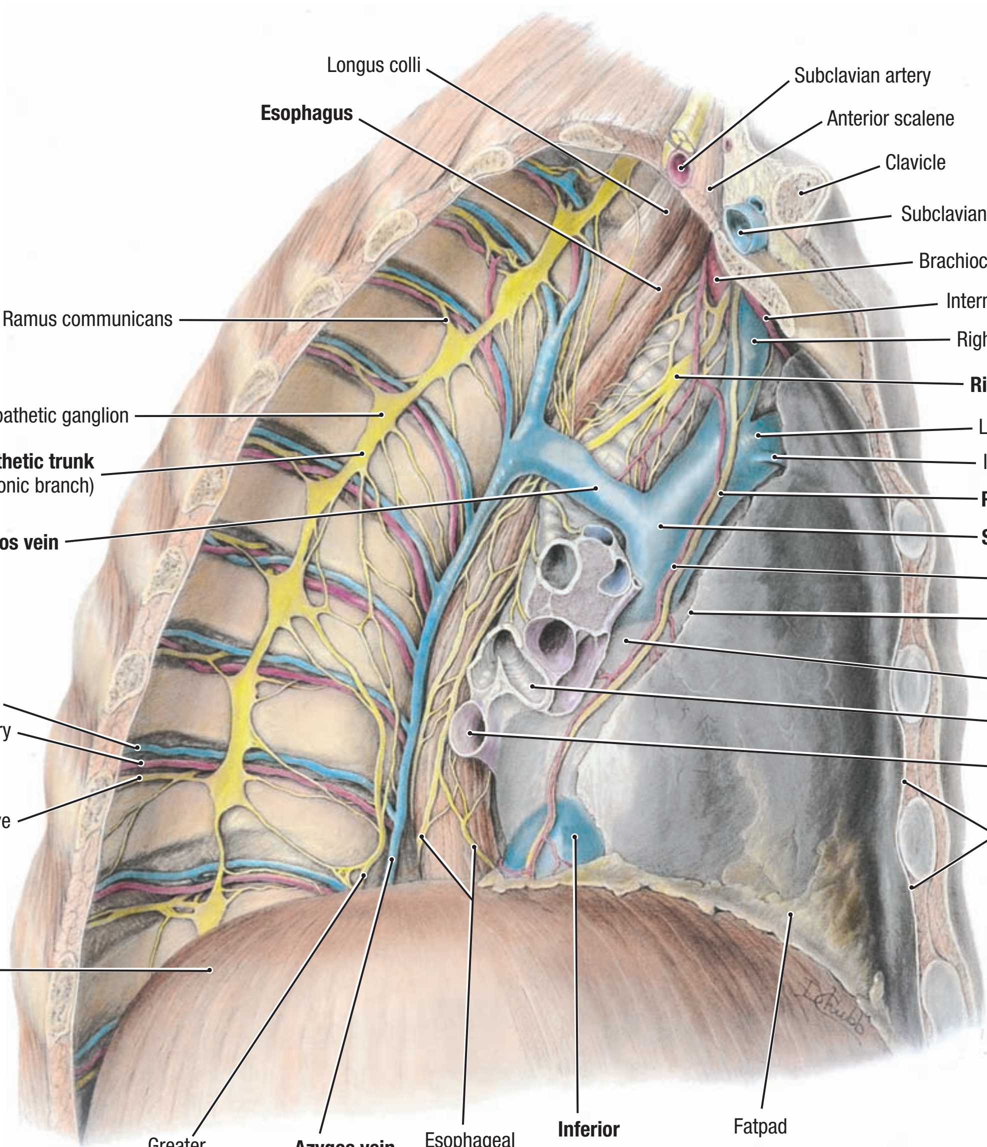
In **A,** the hemi-azygos, accessory hemi-azygos, and left superior intercostals veins are continuous here, but commonly they are discontinuous. The hemi-azygos vein crosses the vertebral column at approximately T9, and the accessory hemi-azygos vein crosses at T8, to enter the azygos vein. In **A,** there are four cross-connecting channels between the azygos and hemi-azygos systems. The azygos vein arches superior to the root of the right lung at T4 to drain into the superior vena cava.



B. **Anterior View**

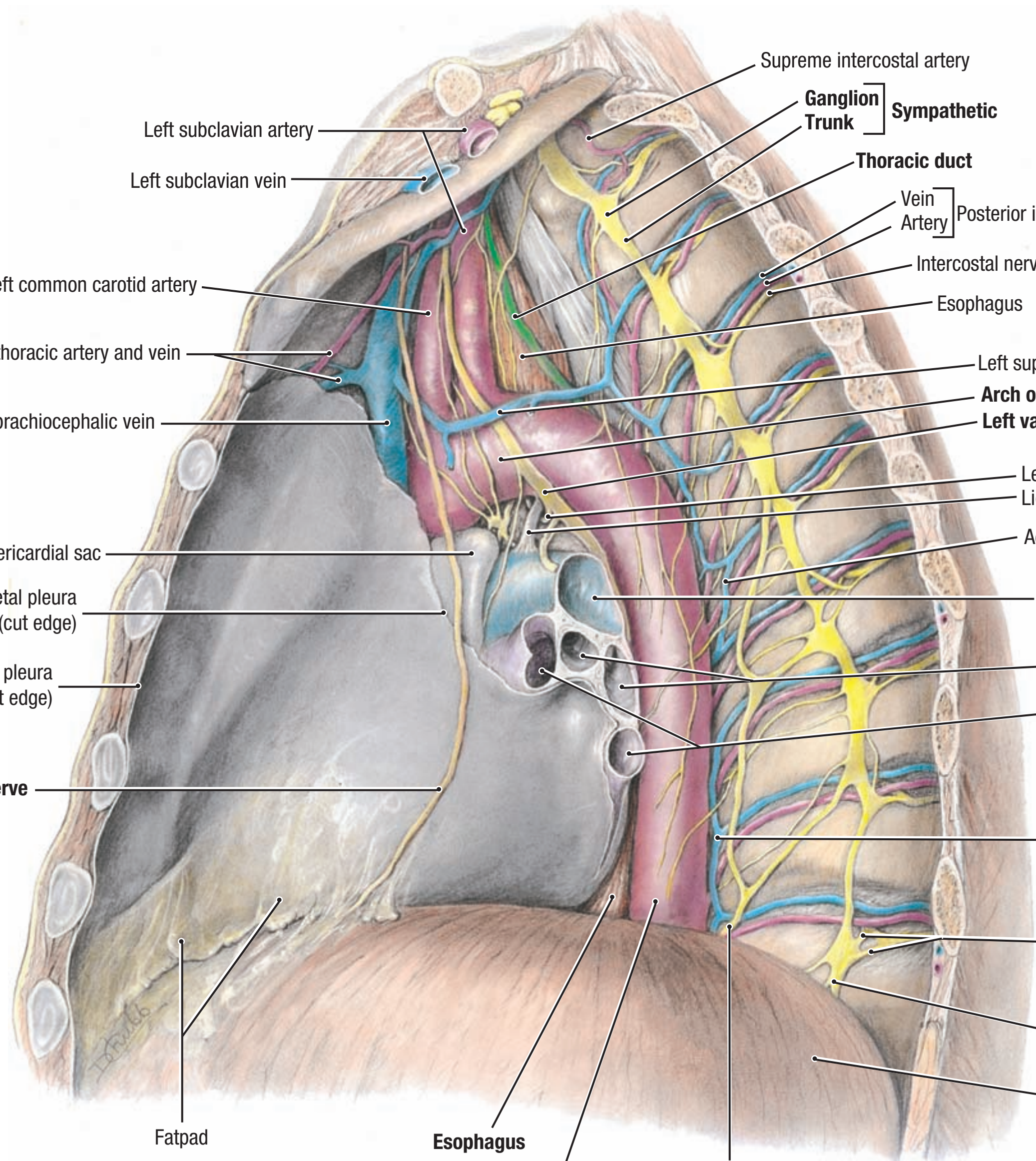
1.72 AZYGOS SYSTEM OF VEINS (*CONTINUED*)

The azygos, hemi-azygos, and accessory hemi-azygos veins offer alternate means of venous drainage from the thoracic, abdominal, and back regions when **obstruction of the IVC** occurs. In some people, an accessory azygos vein parallels the main azygos vein on the right side. Other people have no hemi-azygos system of veins. A clinically important variation, although uncommon, is when the azygos system receives all the blood from the IVC, except that from the liver. In these people, the azygos system drains nearly all the blood inferior to the diaphragm, except that from the digestive tract. When **obstruction of the SVC** occurs superior to the entrance of the azygos vein, blood can drain inferiorly into the veins of the abdominal wall and return to the right atrium through the IVC and azygos system of veins.



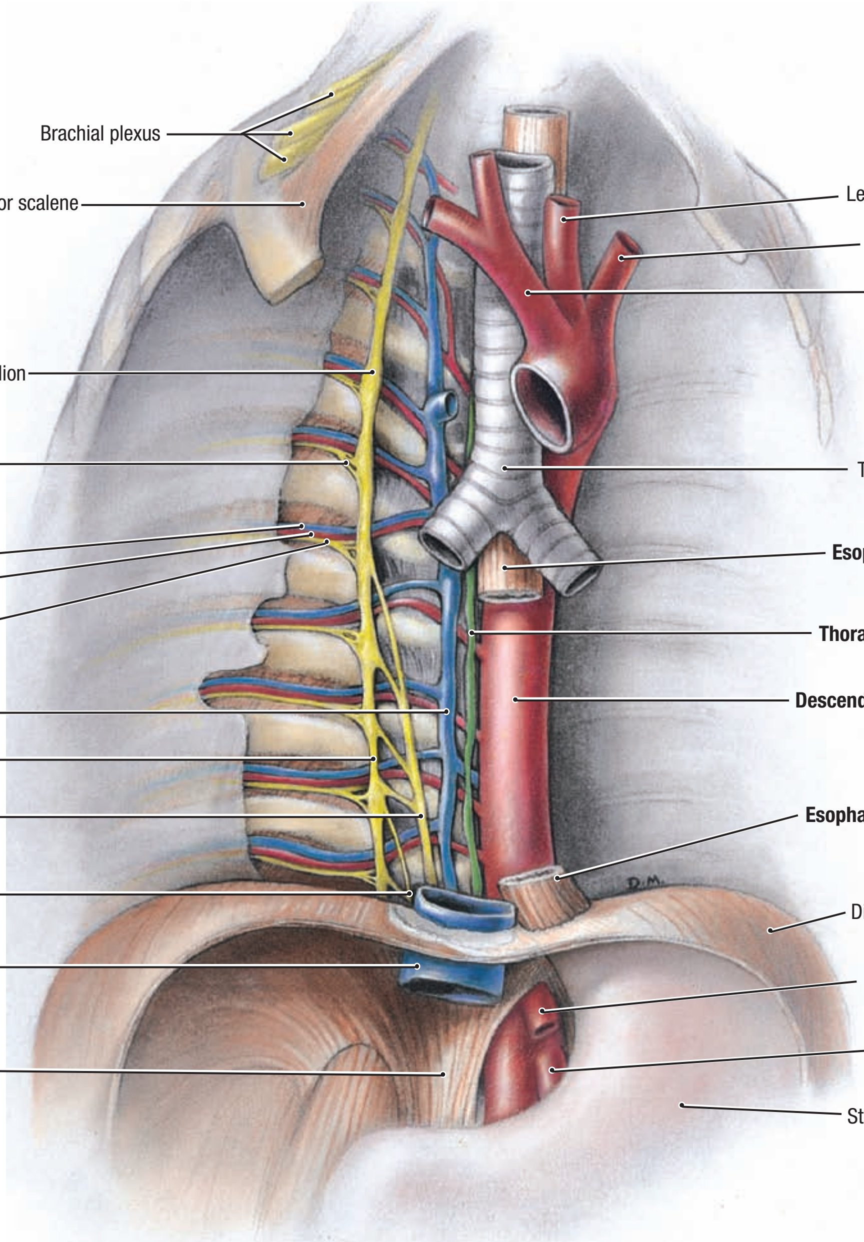
1.73 MEDIASTINUM, RIGHT SIDE

- The costal and mediastinal pleurae have mostly been removed, exposing the underlying structures. Compare with the mediastinal surface of the right lung in Figure 1.32.
- The right side of the mediastinum is the "blue side," dominated by the arch of the azygos vein and the superior vena cava.
- Both the trachea and the esophagus are visible from the right side.
- The right vagus nerve descends on the medial surface of the trachea, passes medial to the arch of the azygos vein, posterior to the root of the lung, and then enters the esophageal plexus.
- The right phrenic nerve passes anterior to the root of the lung lateral to both venae cavae.



1.74 MEDIASTINUM, LEFT SIDE

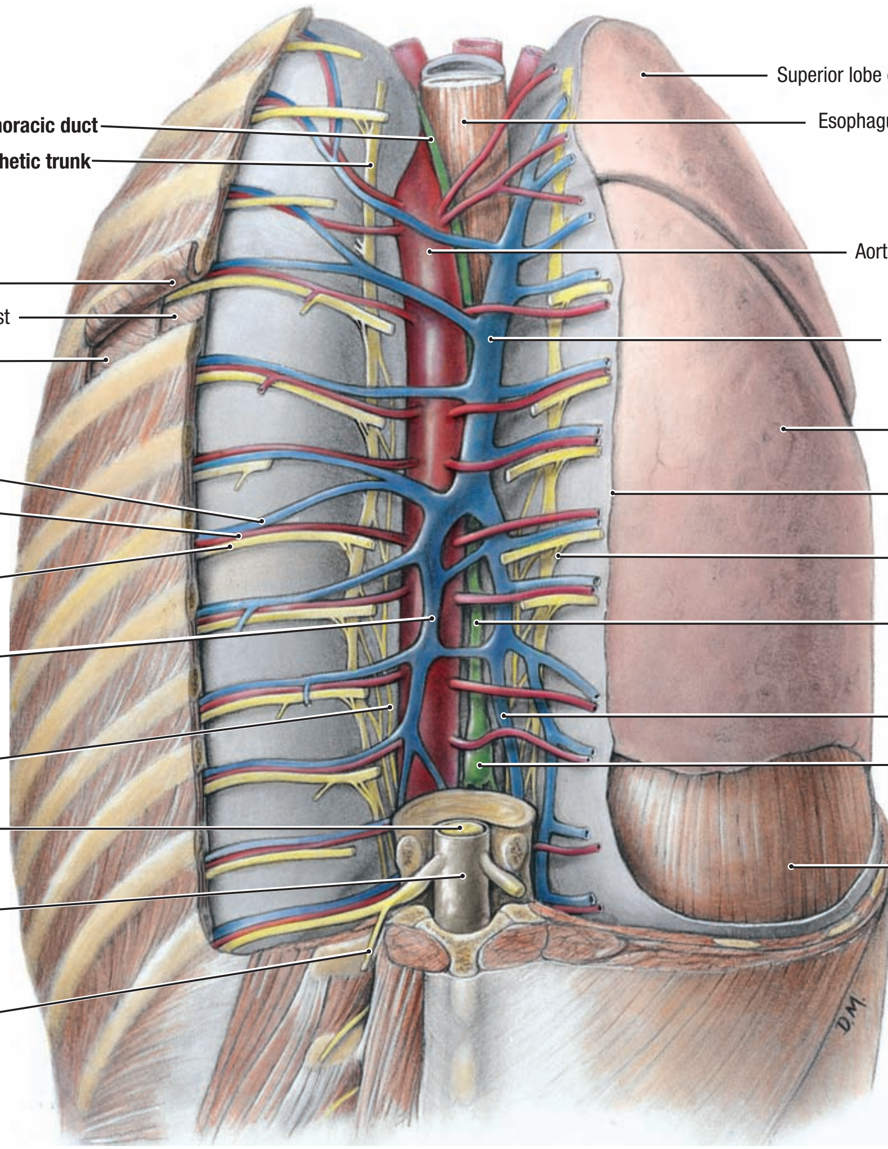
- Compare with the mediastinal surface of the left lung in Figure 1.33.
- The left side of the mediastinum is the "red side," dominated by the arch and descending portion of the aorta, the left common carotid and subclavian arteries; the latter obscure the trachea from view.
- The thoracic duct can be seen on the left side of the esophagus.
- The left vagus nerve passes posterior to the root of the lung, sending its recurrent laryngeal branch around the ligamentum arteriosum inferior and then medial to the aortic arch.
- The phrenic nerve passes anterior to the root of the lung and penetrates the diaphragm more anteriorly than on the right side.



Right Anterior Oblique View

1.75 STRUCTURES OF POSTERIOR MEDIASTINUM I

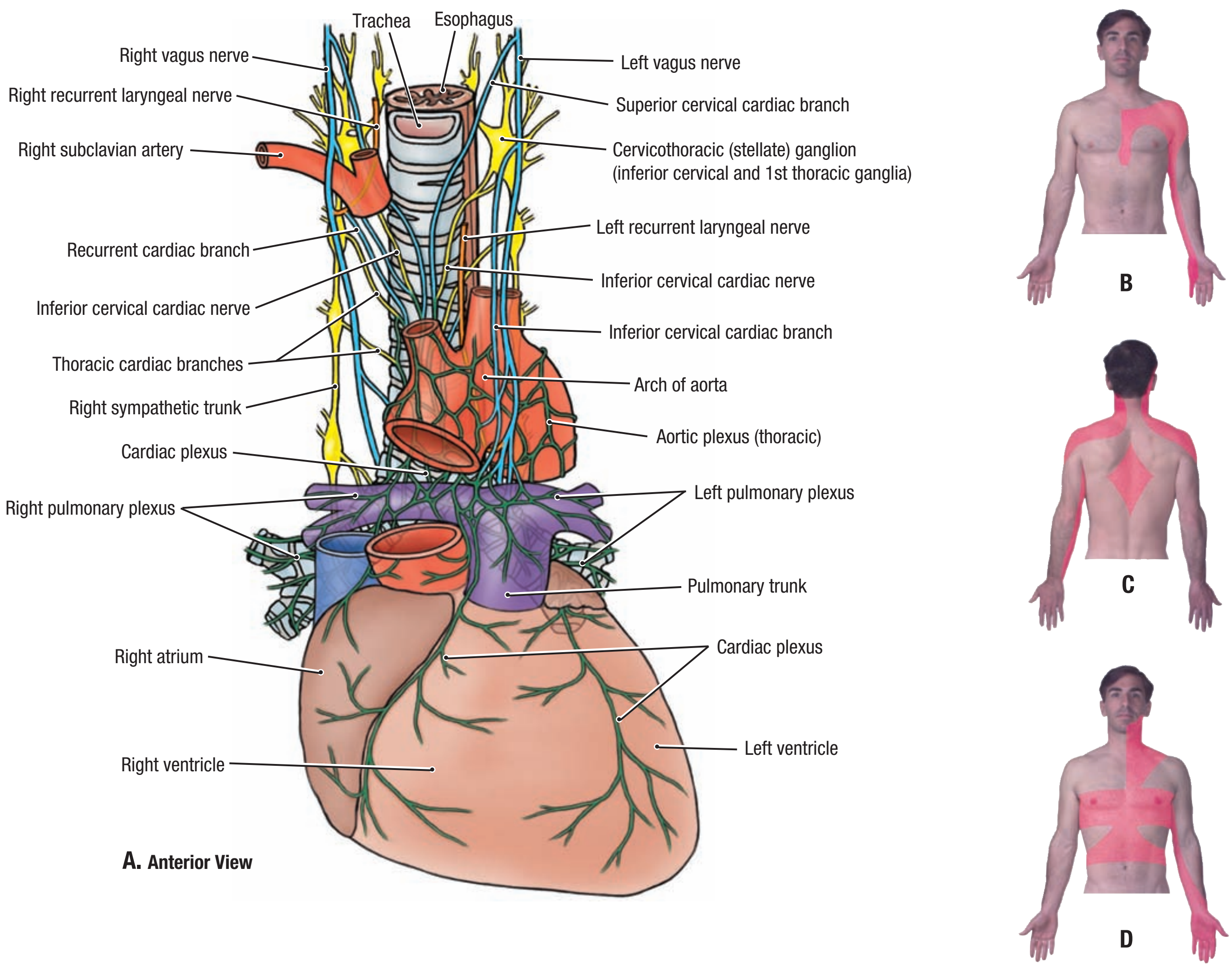
- In this specimen, the parietal pleura is intact on the left side and partially removed on the right side. A portion of the esophagus, between the bifurcation of the trachea and the diaphragm, is also removed.
- The thoracic sympathetic trunk is connected to each intercostal nerve by rami communicantes.
- The greater splanchnic nerve is formed by fibers from the 5th to 10th thoracic sympathetic ganglia, and the lesser splanchnic nerve receives fibers from the 10th and 11th thoracic ganglia. Both nerves contain presynaptic and visceral afferent fibers.
- The azygos vein ascends anterior to the intercostal vessels and to the right of the thoracic duct and aorta and drains into the superior vena cava.



Posterior View

1.76 STRUCTURES OF POSTERIOR MEDIASTINUM II

- The thoracic vertebral column and thoracic cage are removed on the right. On the left, the ribs and intercostal musculature are removed posteriorly as far laterally as the angles of the ribs. The parietal pleura is intact on the left side but partially removed on the right to reveal the visceral pleura covering the right lung.
- The azygos vein is on the right side, and the hemi-azygos vein is on the left, crossing the midline (usually at T9, but higher in this specimen) to join the azygos vein. The accessory hemi-azygos vein is absent in this specimen; instead, three most superior posterior intercostal veins drain directly into the azygos vein.



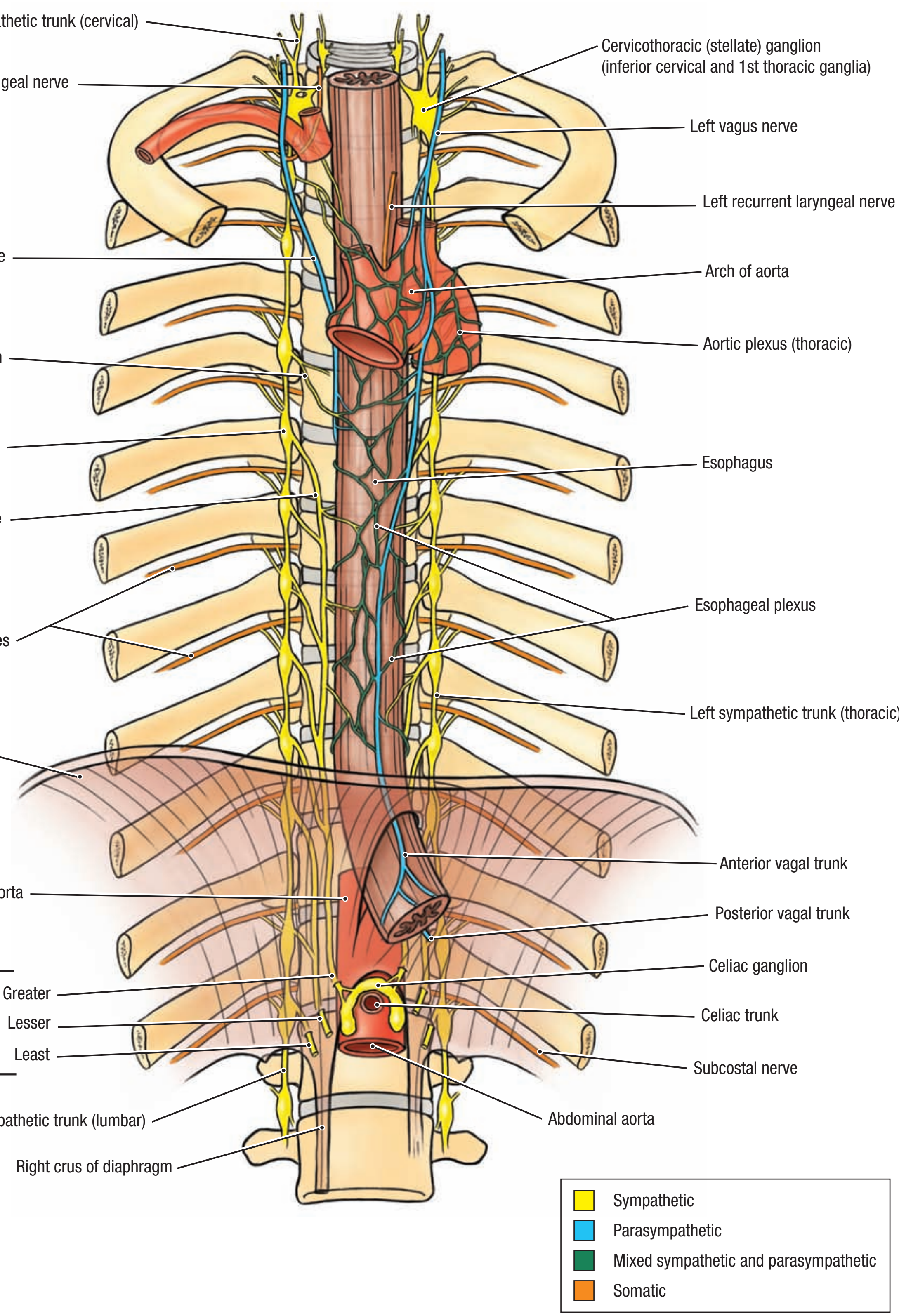
1.77 OVERVIEW OF AUTONOMIC AND VISCERAL AFFERENT INNERVATION OF THORAX

A. Innervation of heart. **B.–D.** Areas of cardiac referred pain (*red*). **E.** Innervation of posterior and superior mediastina.

The heart is insensitive to touch, cutting, cold, and heat; however, ischemia and the accumulation of metabolic products stimulate pain endings in the myocardium. The afferent pain fibers run centrally in the middle and inferior cervical branches and especially in the thoracic cardiac branches of the sympathetic trunk. The axons of these primary sensory neurons enter spinal cord segments T1 through T4 or T5, especially on the left side.

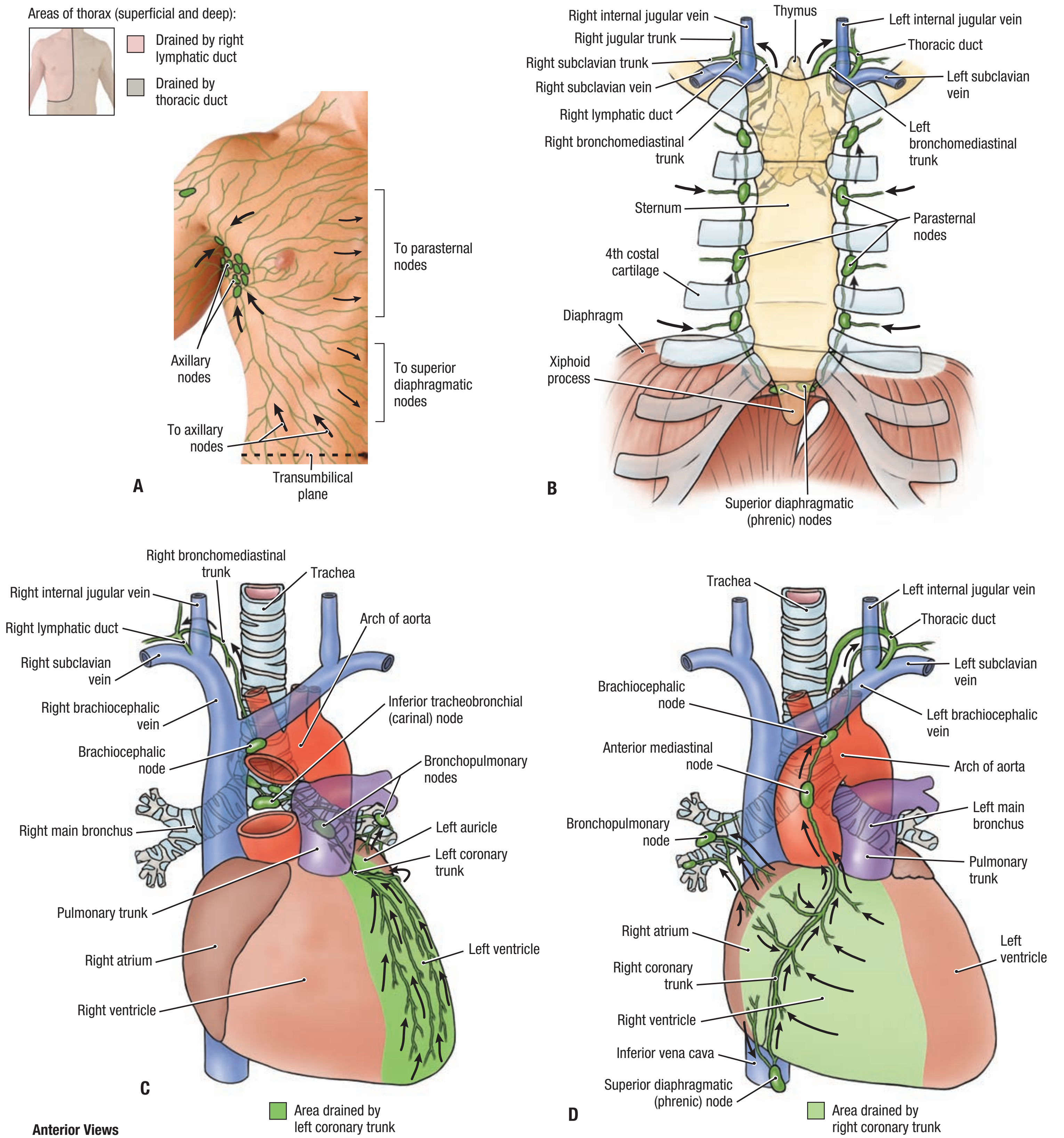
Cardiac referred pain is a phenomenon whereby noxious stimuli originating in the heart are perceived by a person as pain arising from a superficial part of the body—the skin on the left upper limb, for example. Visceral referred pain is transmitted by visceral afferent fibers accompanying sympathetic fibers and is typically referred to somatic structures or areas such as a limb having afferent fibers with cell bodies in the same spinal ganglion, and central processes that enter the spinal cord through the same posterior roots (Hardy and Naftel, 2001).

Anginal pain is commonly felt as radiating from the substernal and left pectoral regions to the left shoulder and the medial aspect of the left upper limb (**B**). This part of the limb is supplied by the medial cutaneous nerve of the arm. Often the lateral cutaneous branches of the 2nd and 3rd intercostal nerves (the intercostobrachial nerves) join or overlap in their distribution with the medial cutaneous nerve of the arm. Consequently, cardiac pain is referred to the upper limb because the spinal cord segments of these cutaneous nerves (T1–T3) are also common to the visceral afferent terminations for the coronary arteries. Synaptic contacts may also be made with commissural (connector) neurons, which conduct impulses to neurons on the right side of comparable areas of the spinal cord. This occurrence explains why pain of cardiac origin, although usually referred to the left side, may be referred to the right side, both sides, or the back (**C and D**).



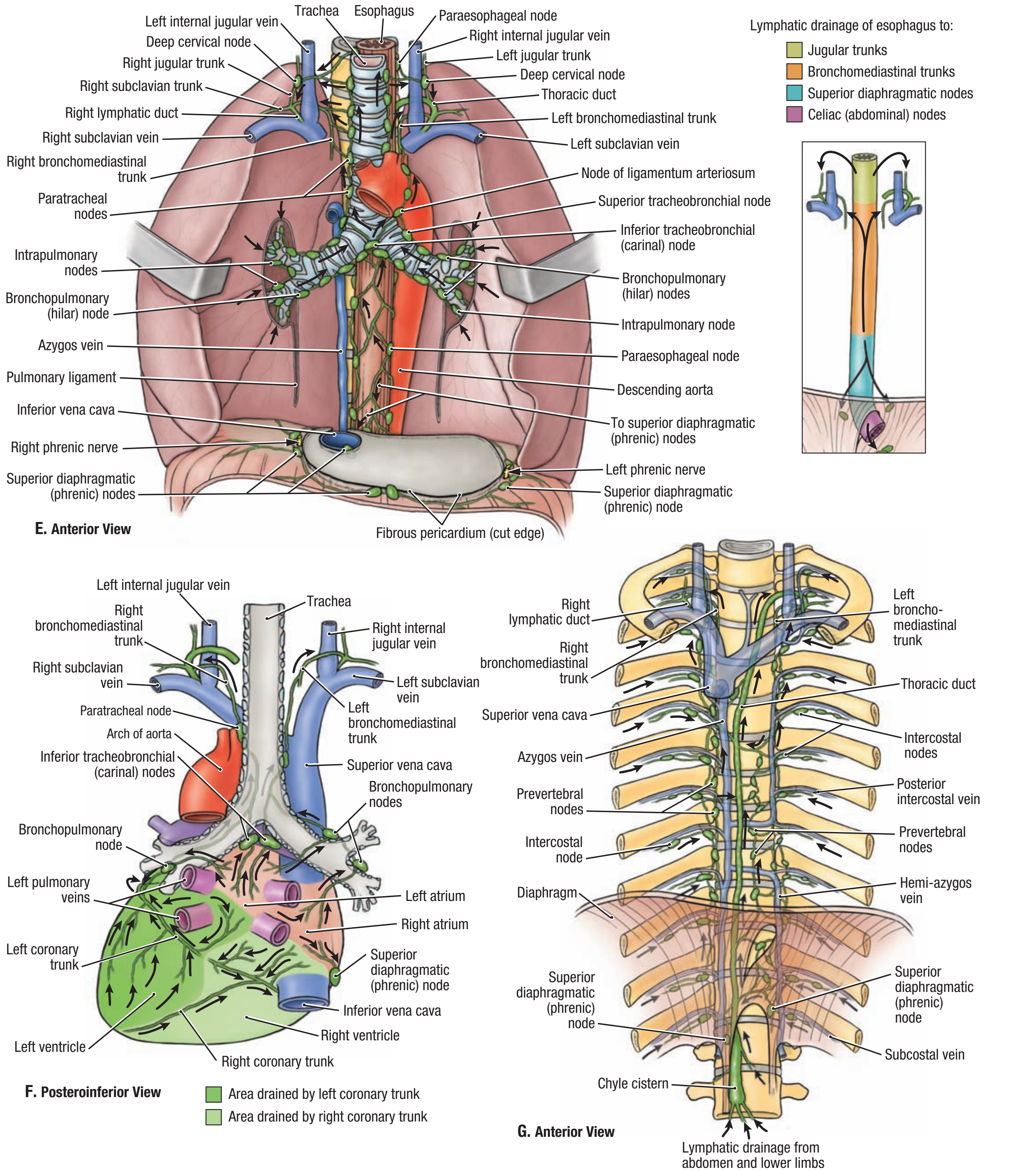
E. **Anterior View**

1.77 OVERVIEW OF AUTONOMIC INNERVATION OF THE THORAX (*CONTINUED*)



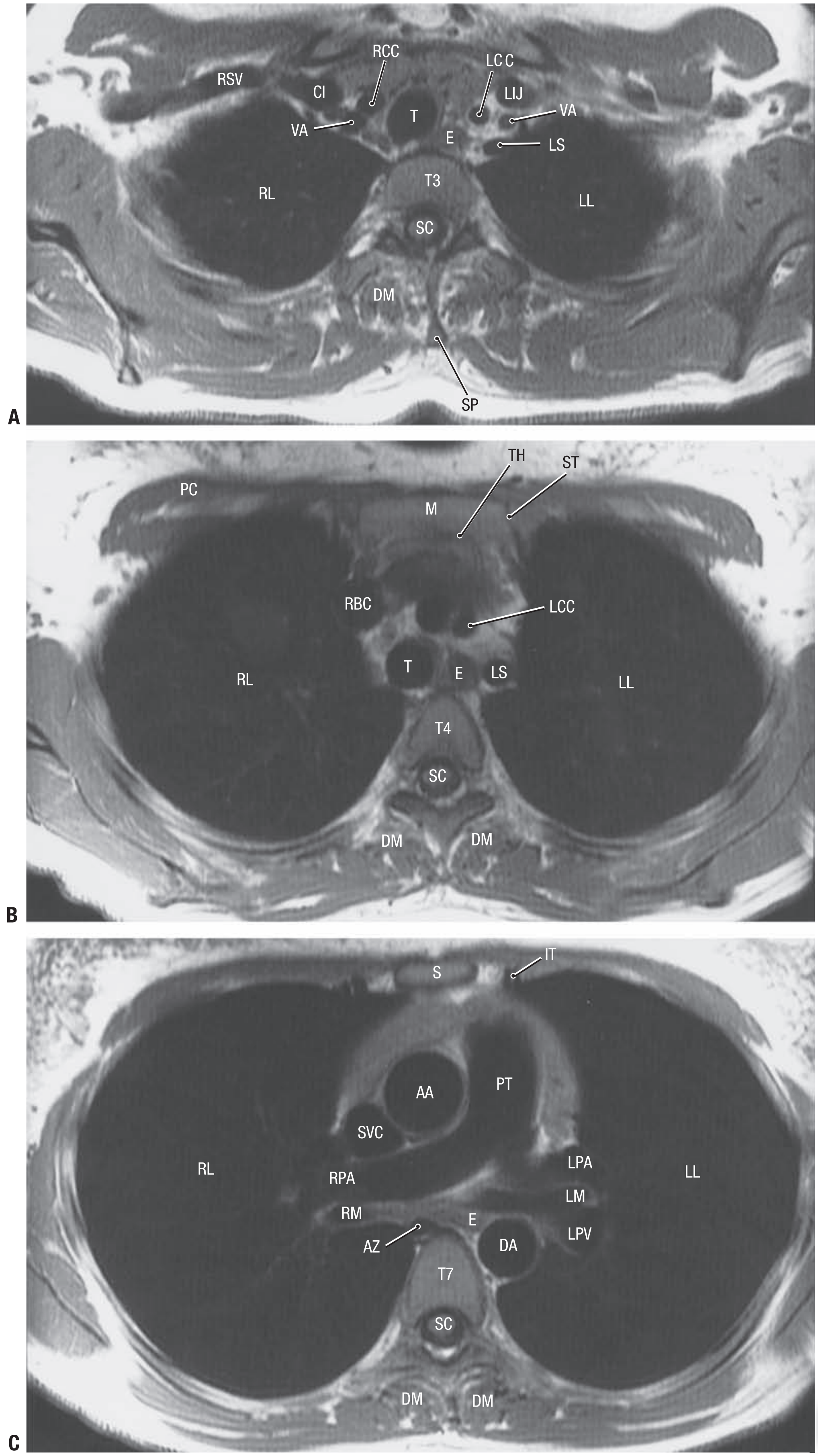
1.78 OVERVIEW OF LYMPHATIC DRAINAGE OF THORAX

A. Superficial lymphatic drainage. **B.** Deep lymphatic drainage of parasternal nodes. **C.** Lymphatic drainage of left side of heart. **D.** Lymphatic drainage of right side of heart.



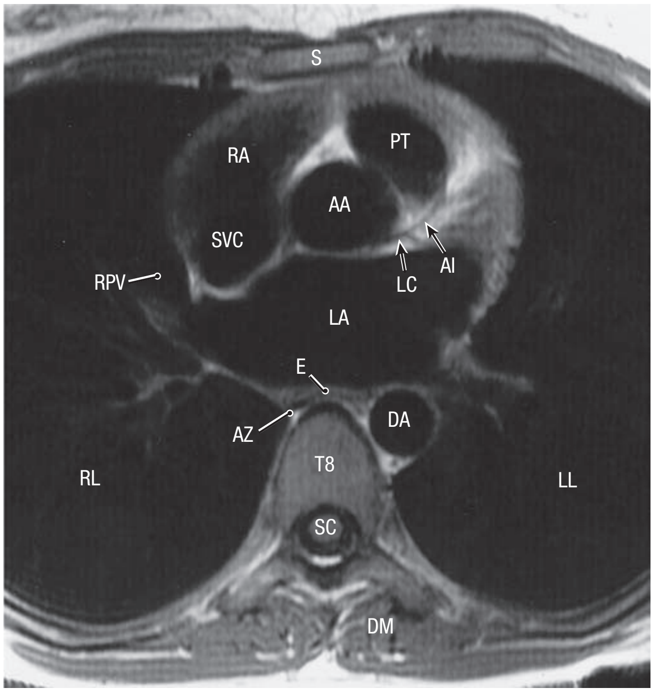
1.78 OVERVIEW OF LYMPHATIC DRAINAGE OF THORAX (*CONTINUED*)

E. Lymphatic drainage of lungs, esophagus, and superior surface of diaphragm. **F.** Lymphatic drainage of posterior and inferior surfaces of heart. **G.** Lymphatic drainage of posterior mediastinum.

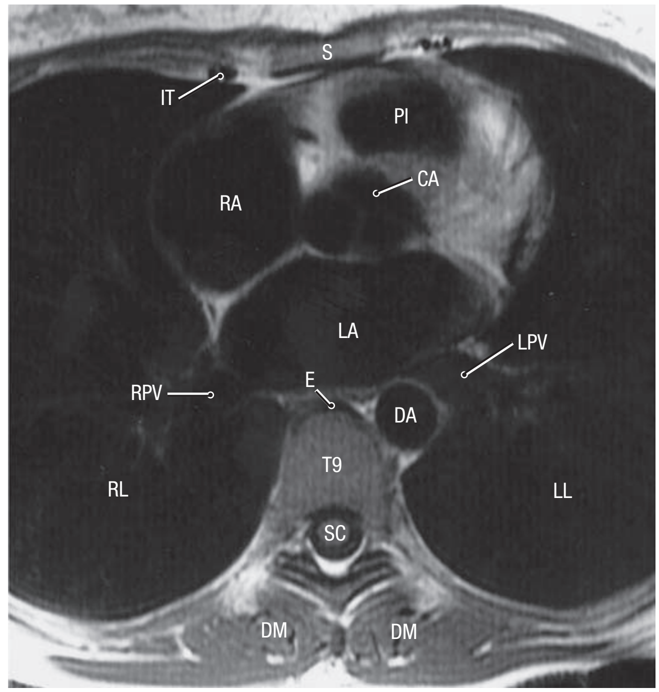


AA	Ascending aorta
AI	Anterior interventricular artery
AZ	Azygos vein
CA	Cusp of aortic valve
CI	Confluence of internal jugular vein
DA	Descending aorta
DM	Deep back muscles
E	Esophagus
HR	Head of rib
HZ	Hemi-azygos vein
IT	Internal thoracic vessels
IVS	Interventricular septum
LA	Left atrium
LC	Left coronary artery
LCC	Left common carotid artery
LIJ	Left internal jugular vein
LL	Left lung
LM	Left main bronchus
LPA	Left pulmonary artery
LPV	Left pulmonary vein
LS	Left subclavian artery
LV	Left vertebral artery
M	Manubrium
P	Pericardium
PC	Pectoralis major
PI	Pulmonary infundibulum
PM	Papillary muscle
PT	Pulmonary trunk
RA	Right atrium
RBC	Right brachiocephalic vein
RCC	Right common carotid artery
RL	Right lung
RM	Right middle lobar bronchus
RPA	Right pulmonary artery
RPV	Right pulmonary vein
RSV	Right subclavian vein
RV	Right vertebral artery
S	Sternum
SC	Spinal cord
SP	Spinous process
ST	Sternoclavicular joint
SVC	Superior vena cava
T3-T10	Vertebral body
T	Trachea
TH	Thymus
VA	Vertebral artery

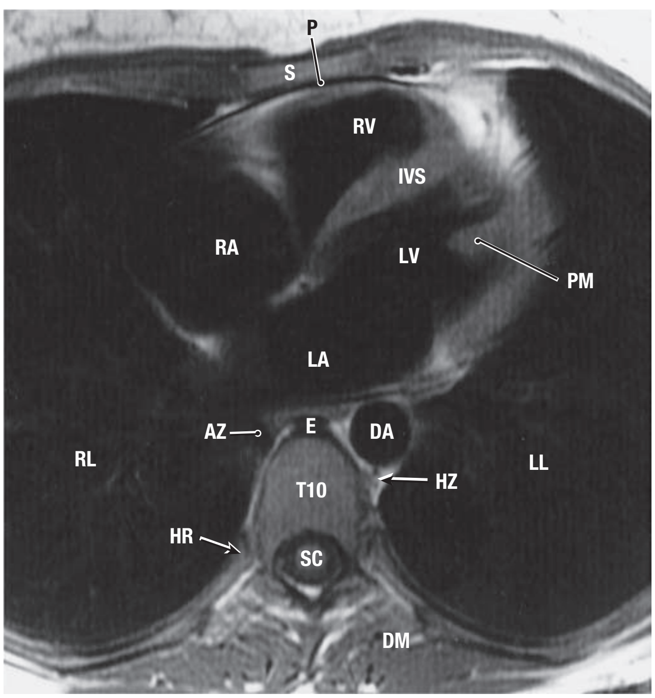
1.79 TRANSVERSE (AXIAL) MRIs OF THORAX (A–F)



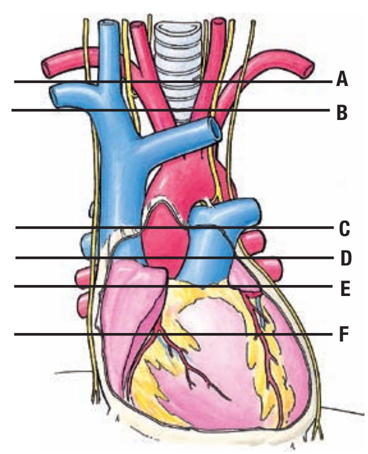
D



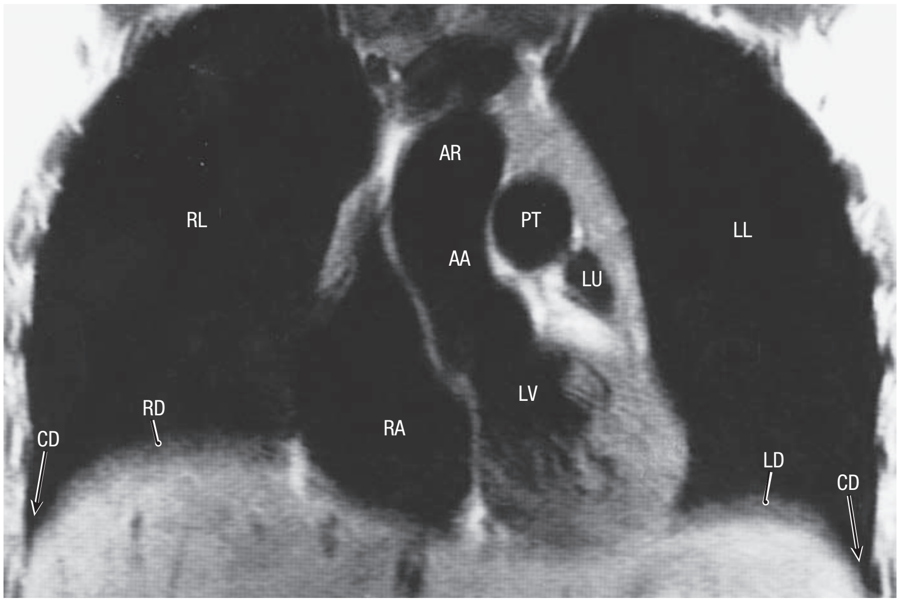
E



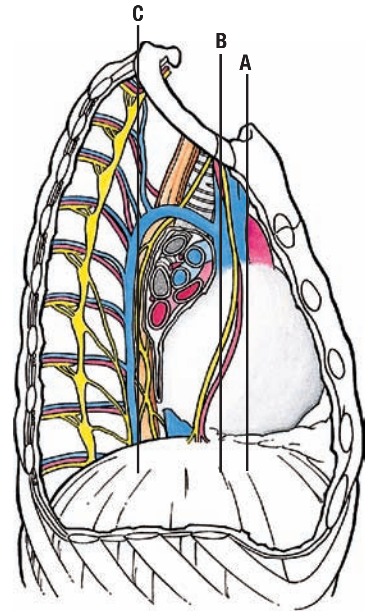
F

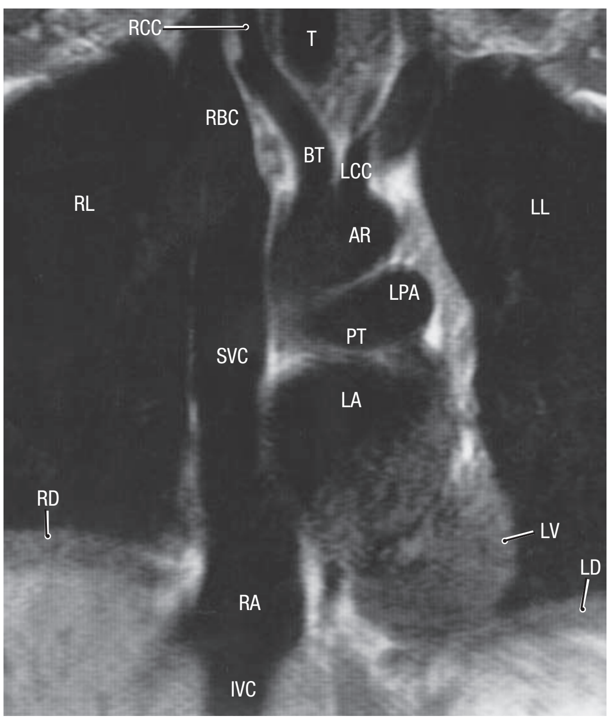


1.79 TRANSVERSE (AXIAL) MRIs OF THORAX (*CONTINUED*)

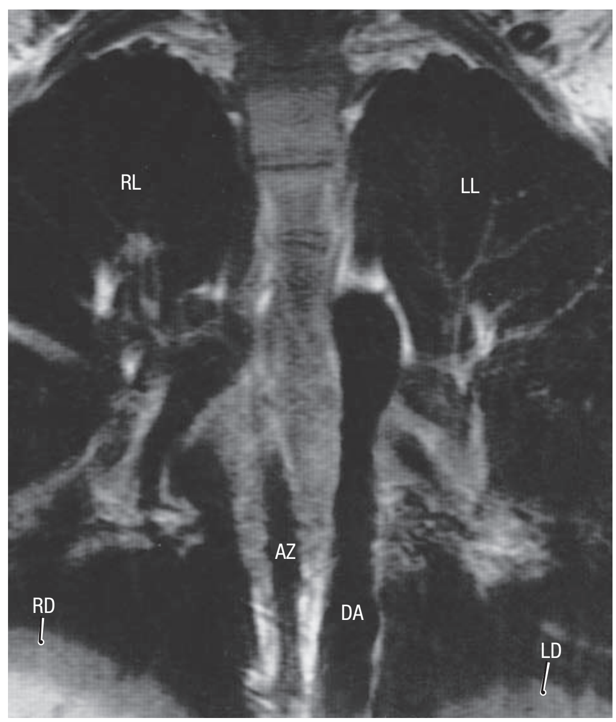


A





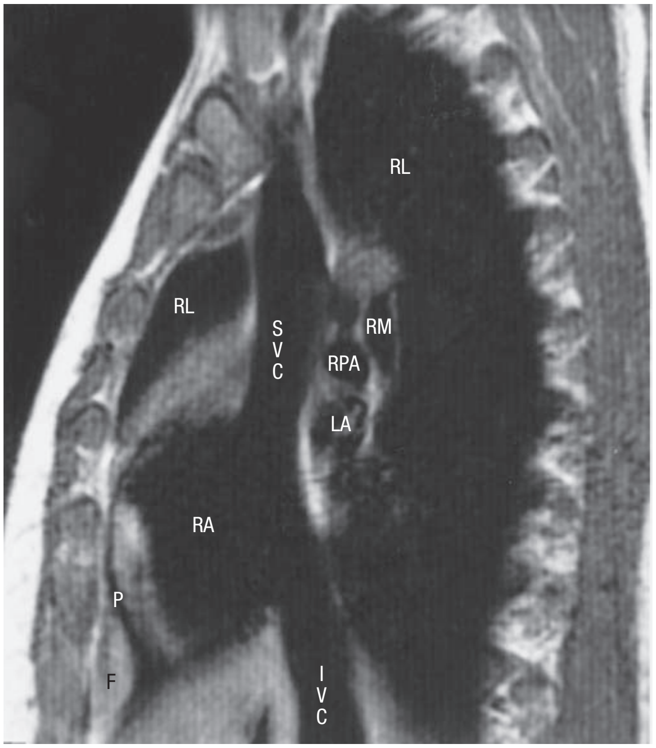
B



C

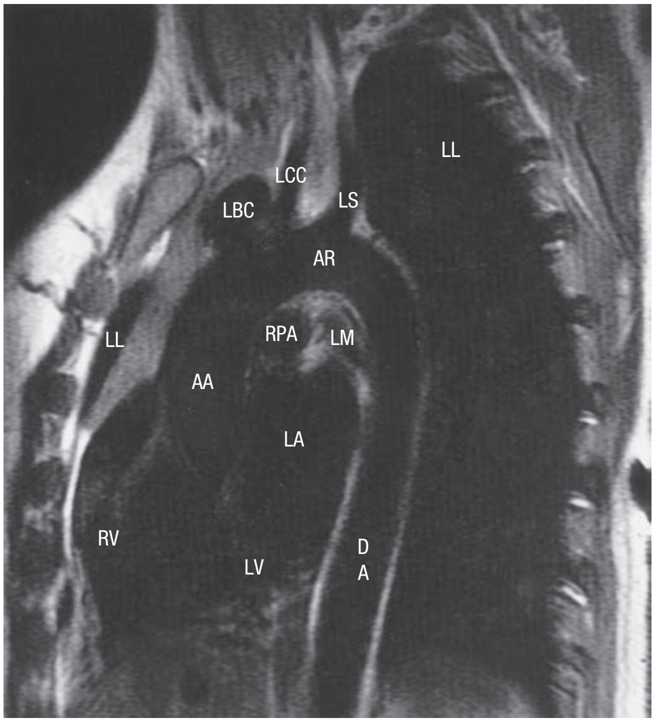
AA	Ascending aorta	IVC	Inferior vena cava	LU	Left auricle	RD	Right dome of diaphragm
AR	Arch of aorta	LA	Left atrium	LV	Left ventricle	RL	Right lung
AZ	Azygos vein	LCC	Left common carotid artery	PT	Pulmonary trunk	RV	Right ventricle
BT	Brachiocephalic trunk	LD	Left dome of diaphragm	RA	Right atrium	SVC	Superior vena cava
CD	Costodiaphragmatic recess	LL	Left lung	RBC	Right brachiocephalic vein	T	Trachea
DA	Descending aorta	LPA	Left pulmonary artery	RCC	Right common carotid artery	V	Vertebral body

1.80 CORONAL MRIs OF THORAX

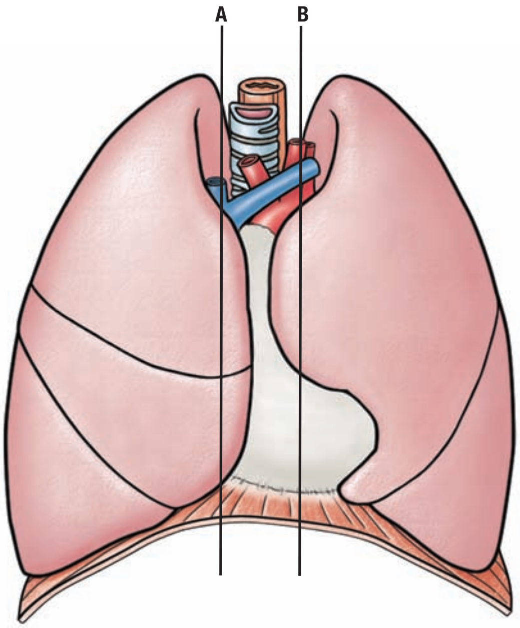


A

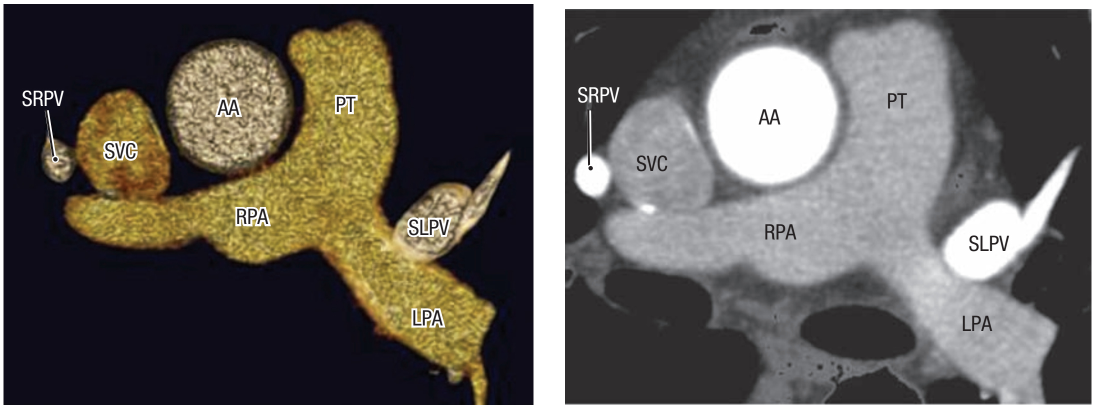
AR	Arch of aorta
AA	Ascending aorta
DA	Descending aorta
F	Fat
IVC	Inferior vena cava
LA	Left atrium
LBC	Left brachiocephalic vein
LCC	Left common carotid artery
LL	Left lung
LM	Left main bronchus
LS	Left subclavian artery
LV	Left ventricle
P	Pericardium
RA	Right atrium
RL	Right lung
RM	Right main bronchus
RPA	Right pulmonary artery
RV	Right ventricle
SVC	Superior vena cava



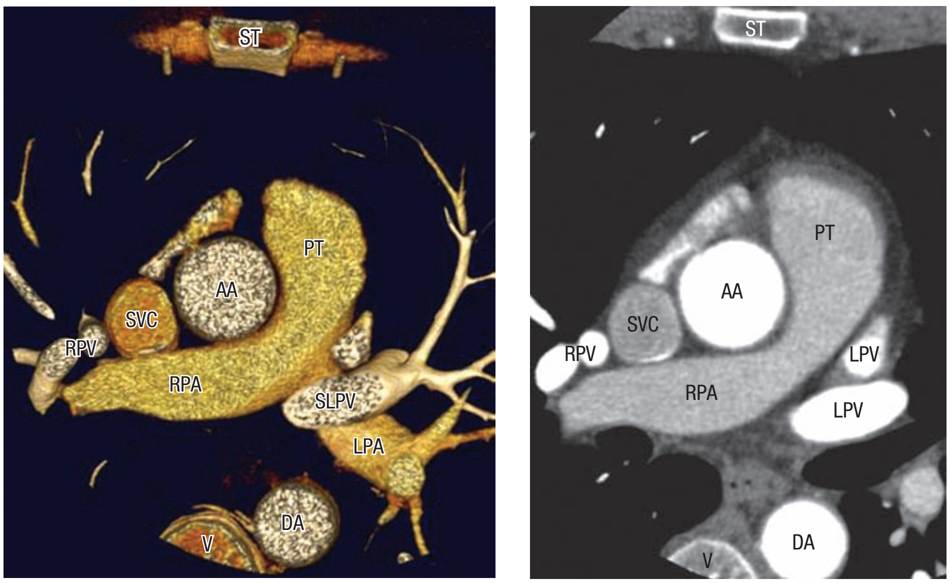
B



1.81 SAGITTAL MRIs OF THORAX

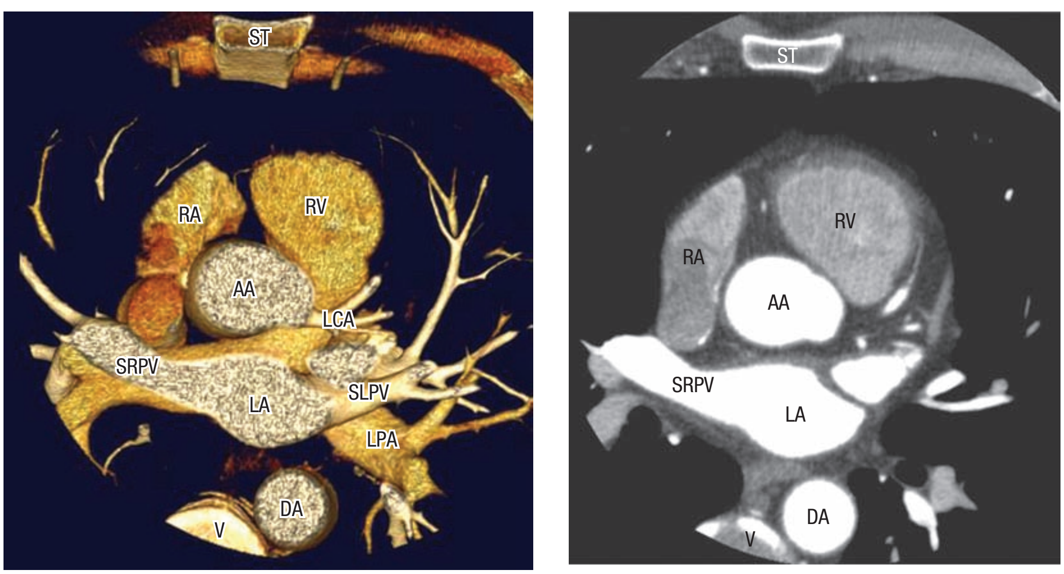


A



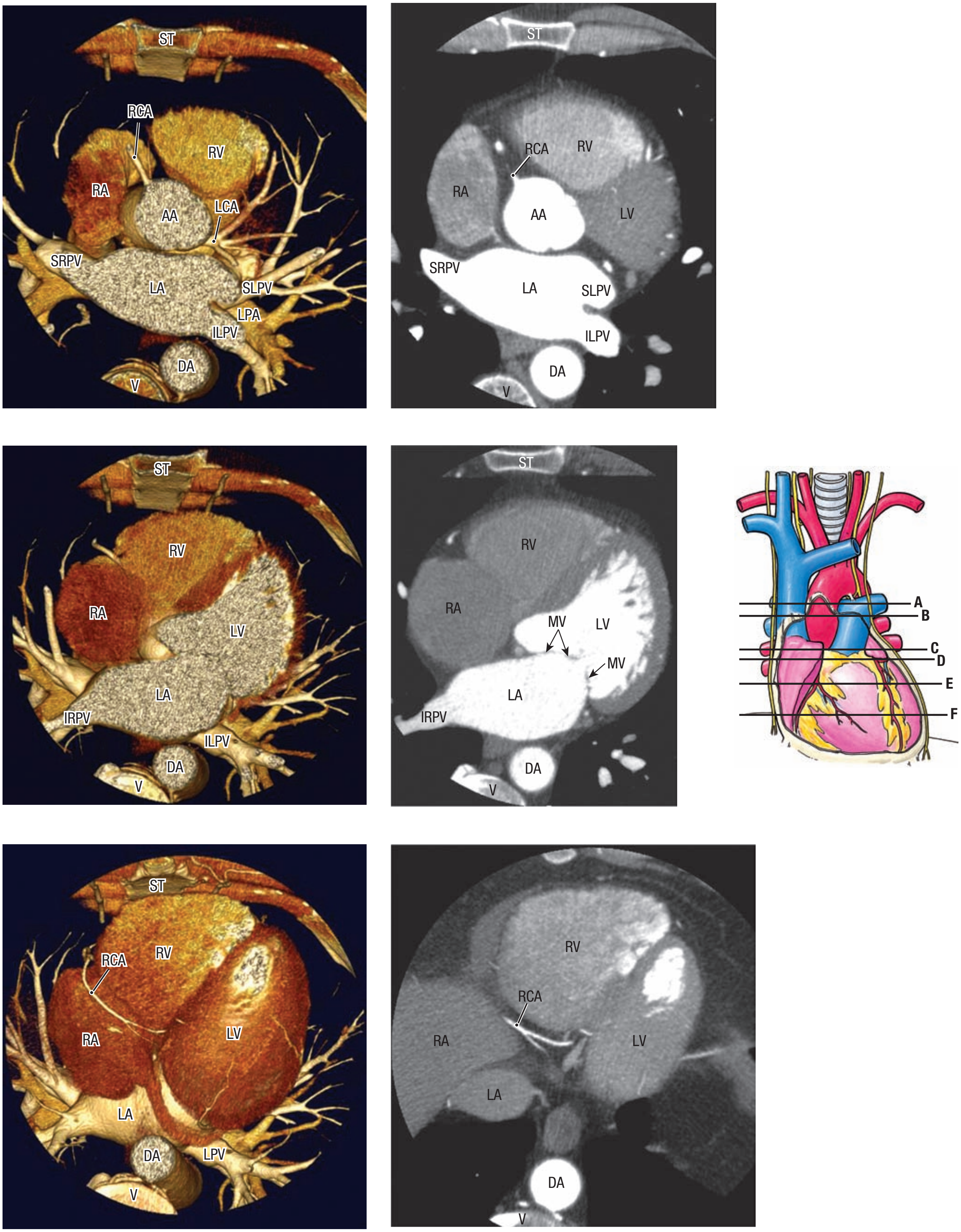
B

AA	Ascending aorta
AZ	Azygos vein
DA	Descending aorta
E	Esophagus
ILPV	Inferior left pulmonary vein
IRPV	Inferior right pulmonary vein
IS	Interventricular septum
LA	Left atrium
LCA	Left coronary artery
LPA	Left pulmonary artery
LPV	Left pulmonary vein
LV	Left ventricle
MV	Mitral valve
PT	Pulmonary trunk
RA	Right atrium
RCA	Right coronary artery
RPA	Right pulmonary artery
RPV	Right pulmonary vein
RV	Right ventricle
SLPV	Superior left pulmonary vein
SRPV	Superior right pulmonary vein
SVC	Superior vena cava
V	Vertebra
ST	Sternum



C

1.82 TRANSVERSE OR HORIZONTAL (AXIAL) 3D VOLUME RECONSTRUCTIONS (ON LEFT SIDE OF PAGE) AND CT ANGIOGRAMS OF THORAX (A–F)



D

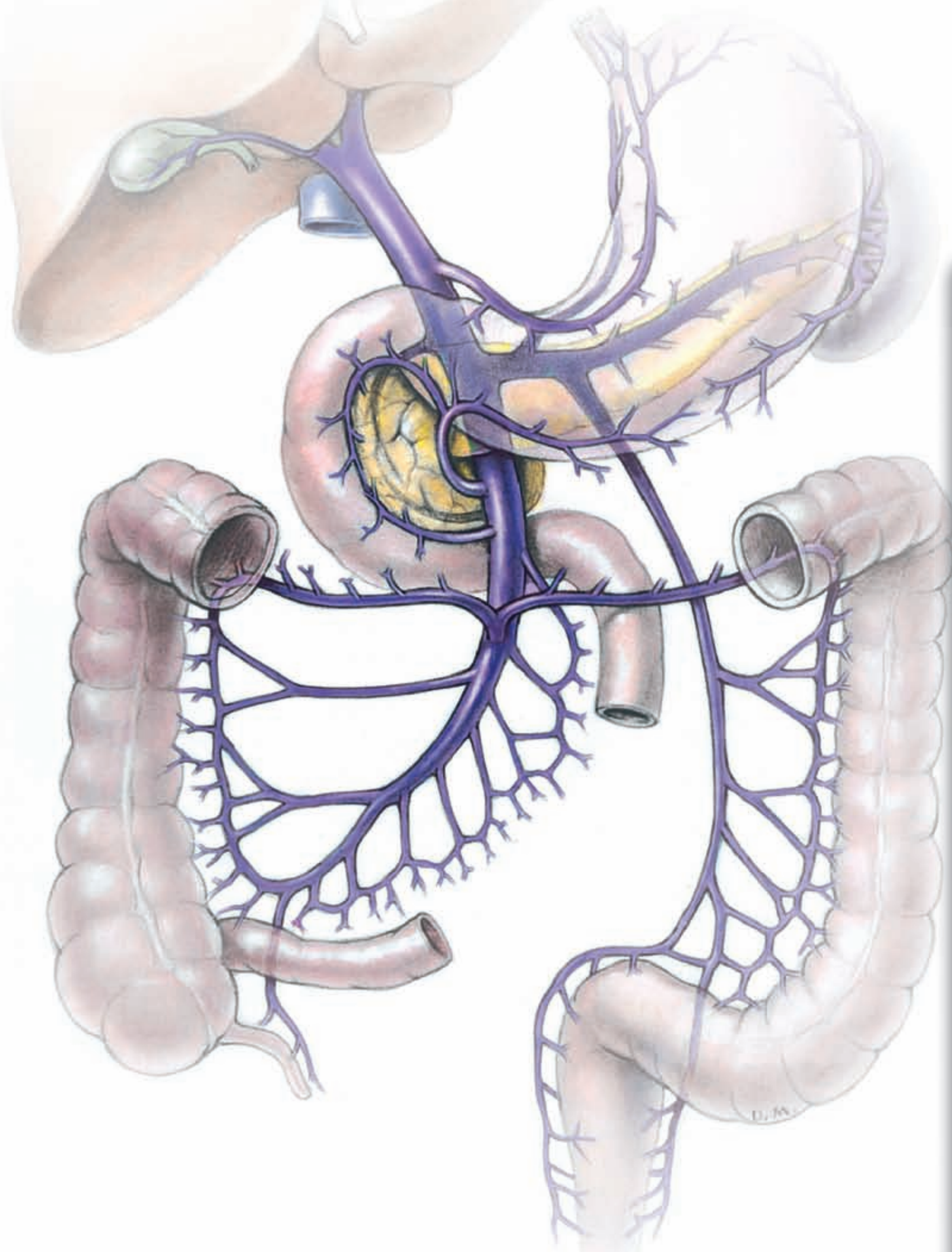
E

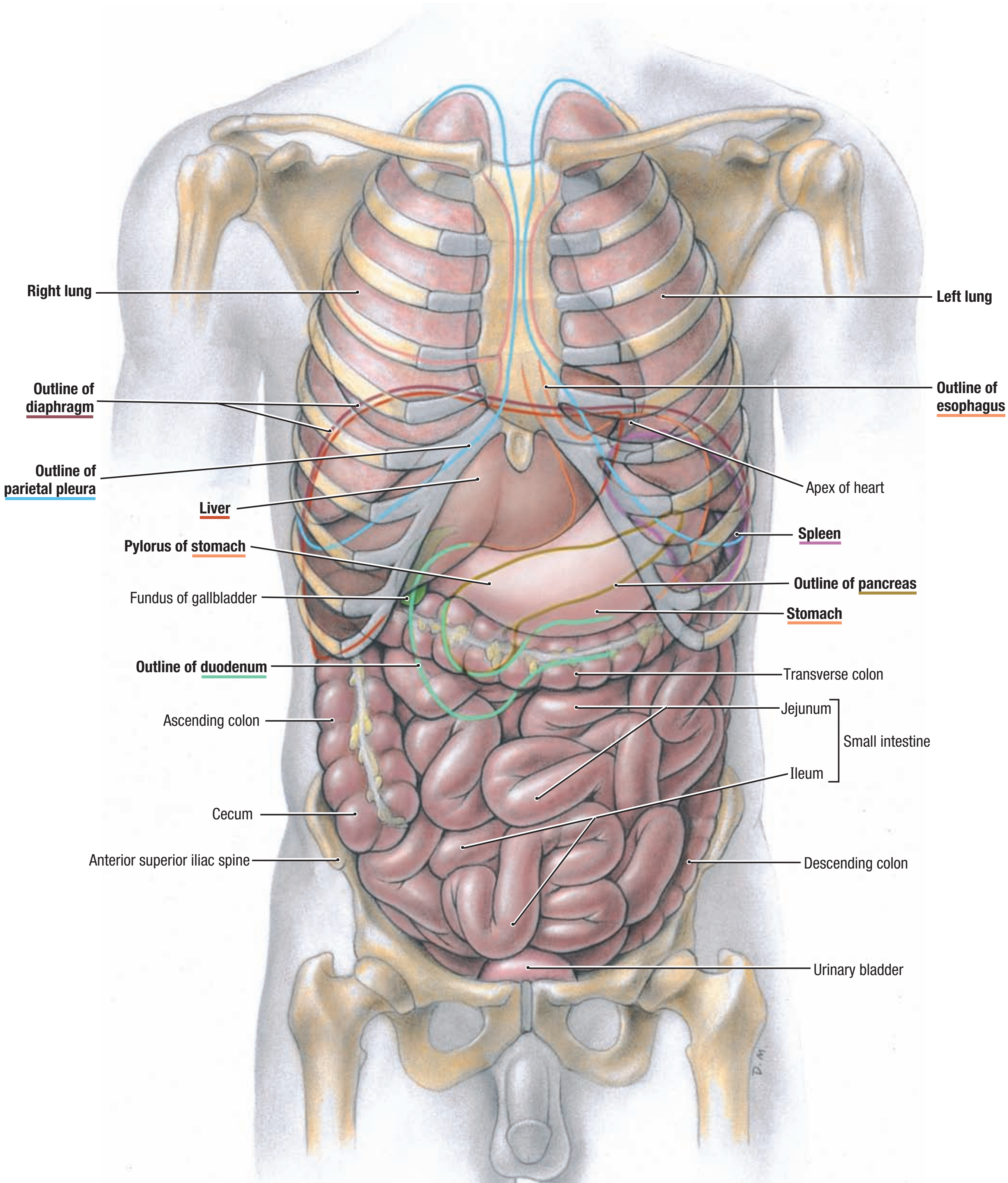
F

1.82 TRANSVERSE OR HORIZONTAL (AXIAL) 3D VOLUME RECONSTRUCTIONS (ON LEFT SIDE OF PAGE) AND CT ANGIOGRAMS OF THORAX (A–F) (*CONTINUED*)

CHAPTER 2

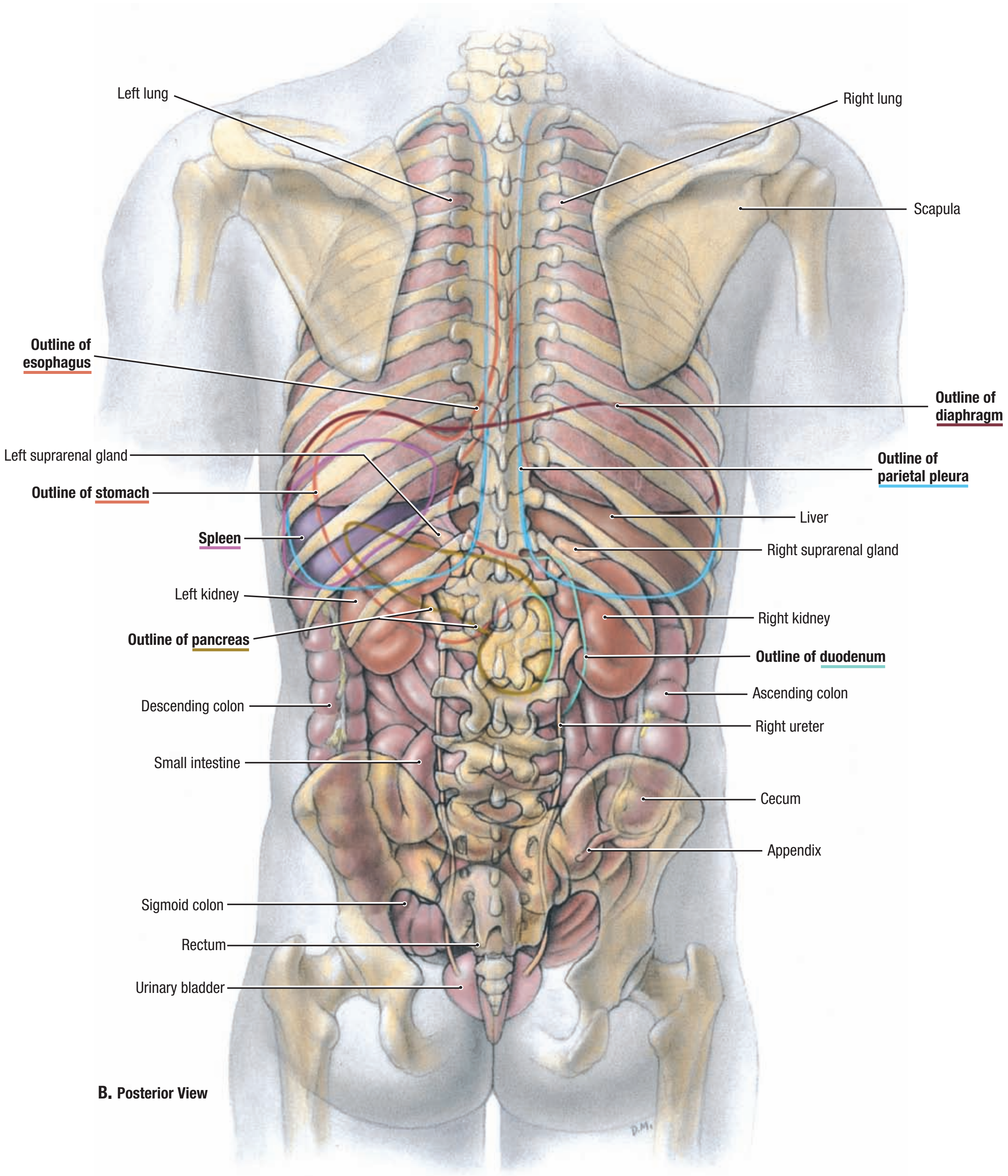
Abdomen





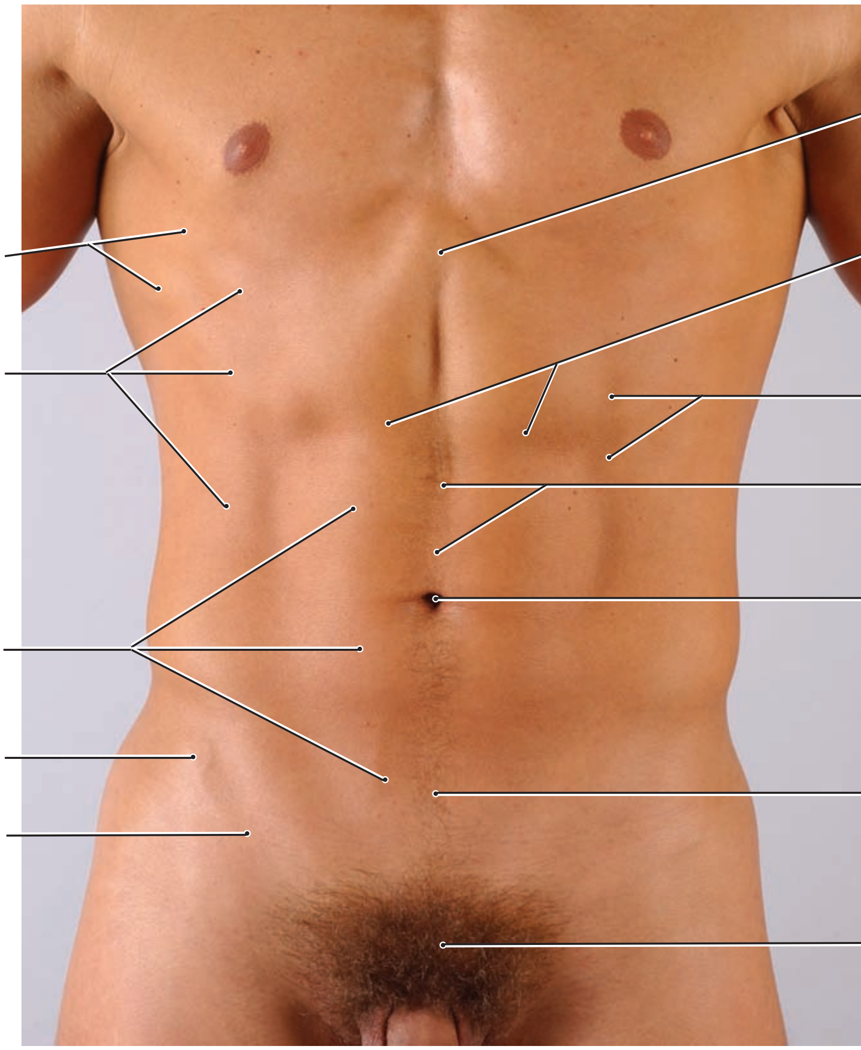
A. Anterior View

2.1 ABDOMINAL VISCERA IN SITU



B. **Posterior View**

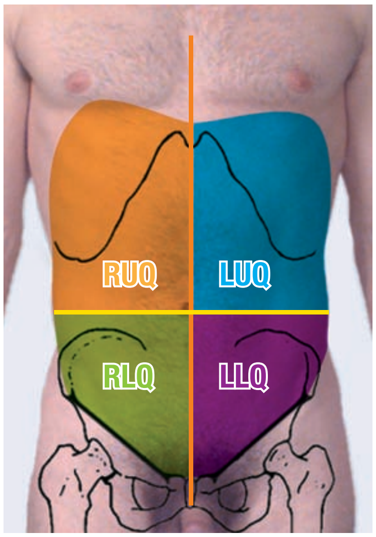
2.1 ABDOMINAL VISCERA IN SITU (*CONTINUED*)



2.2 SURFACE ANATOMY

A. Surface features.

- The umbilicus is where the umbilical cord entered the fetus and indicates the anterior level of the T10 dermatome, typically at the level of the IV disc between the L3 and L4 vertebrae.
- The linea alba is a fibrous band extending from the xiphoid process to the pubic symphysis that is demarcated superficially by a midline vertical skin groove as far inferiorly as the umbilicus.
- Curved skin grooves, the linea semilunaris, demarcate the lateral borders of the rectus abdominis muscle and rectus sheath.
- In lean individuals with good muscle development, three transverse skin grooves overlie the tendinous intersections of the rectus abdominis muscle.
- The site of the inguinal ligament is indicated by a skin crease, the inguinal groove, just inferior and parallel to the ligament, marking the division between the anterolateral abdominal wall and the thigh.



Abdominal Quadrants:

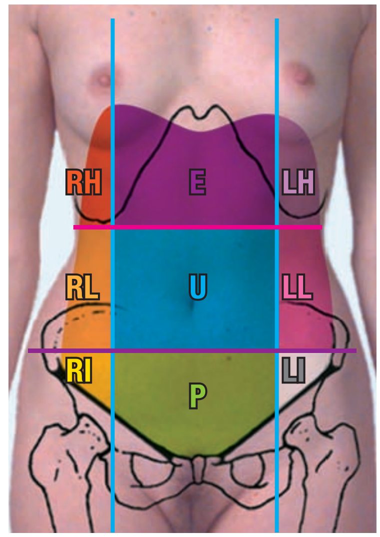
- RUQ Right upper quadrant
- LUQ Left upper quadrant
- RLQ Right lower quadrant
- LLQ Left lower quadrant
- Median plane
- Transumbilical plane

Right upper quadrant (RUQ)
Liver: right lobe Gallbladder Stomach: pylorus Duodenum: parts 1-3 Pancreas: head Right suprarenal gland Right kidney Right colic (hepatic) flexure Ascending colon: superior part Transverse colon: right half

Left upper quadrant (LUQ)
Liver: left lobe Spleen Stomach Jejunum and proximal ileum Pancreas: body and tail Left kidney Left suprarenal gland Left colic (splenic) flexure Transverse colon: left half Descending colon: superior part

Right lower quadrant (RLQ)
Cecum Appendix Most of ileum Ascending colon: inferior part Right ovary Right uterine tube Right ureter: abdominal part Right spermatic cord: abdominal part Uterus (if enlarged) Urinary bladder (if very full)

Left lower quadrant (LLQ)
Sigmoid colon Descending colon: inferior part Left ovary Left uterine tube Left ureter: abdominal part Left spermatic cord: abdominal part Uterus (if enlarged) Urinary bladder (if very full)



Abdominal Regions:

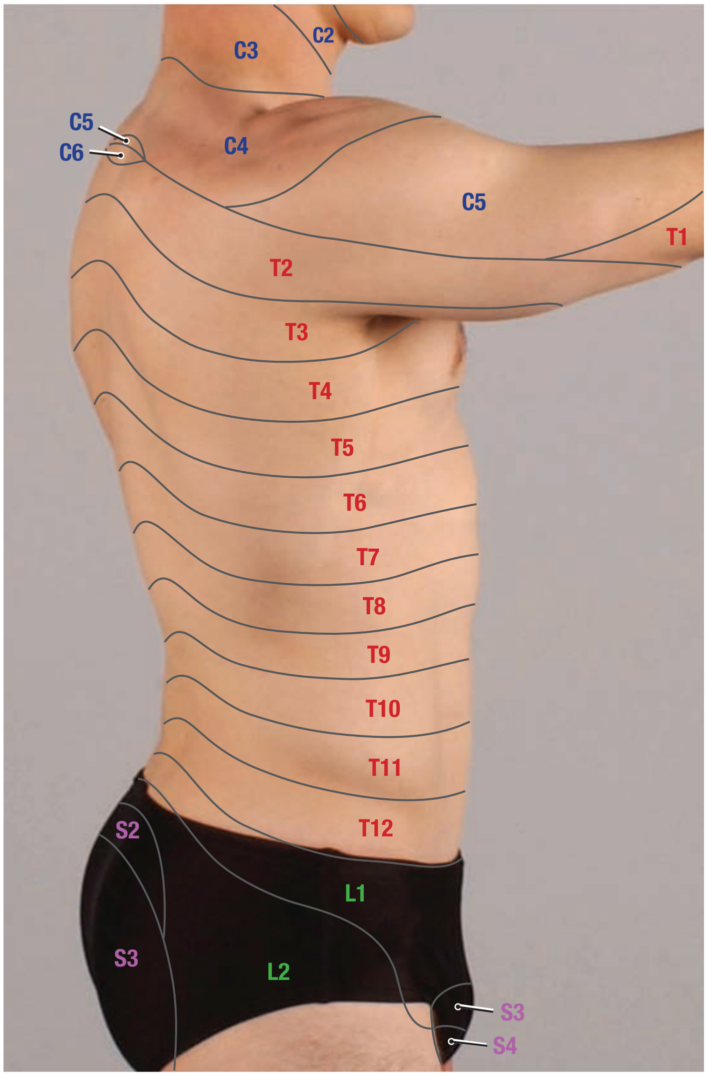
- RH Right hypochondrium
- RL Right flank (lateral region)
- RI Right inguinal (groin)
- LH Left hypochondrium
- LL Left flank (lateral region)
- LI Left inguinal (groin)
- E Epigastric
- U Umbilical
- P Pubic
- Midclavicular plane
- Transtubercular plane
- Subcostal plane

2.3 ABDOMINAL REGIONS AND QUADRANTS

A. Quadrants. **B.** Regions. It is important to know what organs are located in each abdominal region or quadrant so that one knows where to auscultate, percuss, and palpate them and to record the locations of findings during a physical exam.

The six common causes of **abdominal protrusion** begin with the letter F: food, fluid, fat, feces, flatus, and fetus. Eversion of the umbilicus may be a sign of increased intra-abdominal pressure, usually resulting from ascites (abdominal accumulation of serous fluid in the peritoneal cavity), or a large mass (e.g., a tumor, fetus, or enlarged organ such as the liver [hepatomegaly]).

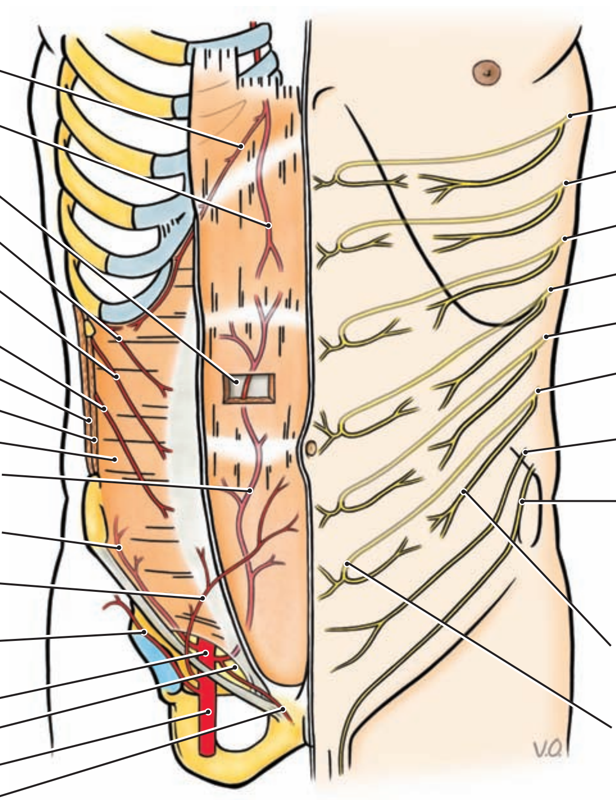
Warm hands are important when palpating the abdominal wall because cold hands make the anterolateral abdominal muscles tense, producing involuntary muscle spasms known as guarding. Intense guarding, boardlike reflexive muscular rigidity that cannot be willfully suppressed, occurs during palpation when an organ (such as the appendix) is inflamed and in itself constitutes a clinically significant sign of **acute abdomen.** The involuntary muscular spasms attempt to protect the viscera from pressure, which is painful when an abdominal infection is present. The common nerve supply of the skin and muscles of the wall explains why these spasms occur.



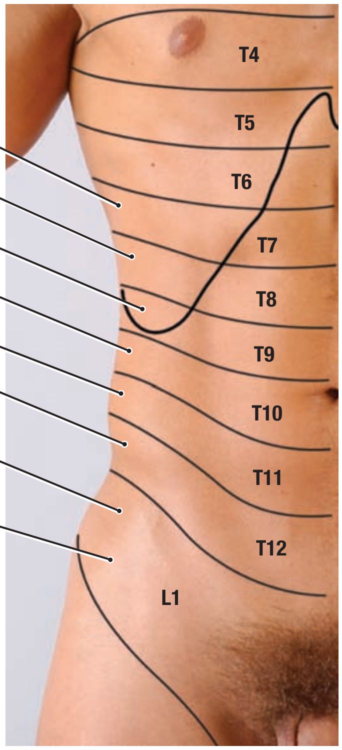
Lateral View

2.4 DERMATOMES

The thoraco-abdominal (T7–T11) nerves run between the external and internal oblique muscles to supply sensory innervation to the overlying skin. The T10 nerve supplies the region of the umbilicus. The subcostal nerve (T12) runs along the inferior border of the 12th rib to supply the skin over the anterior superior iliac spine and hip. The iliohypogastric nerve (L1) innervates the skin over the iliac crest and hypogastric region and the ilio-inguinal nerve (L1) the skin of the medial aspect of the thigh, the scrotum or labium majus, and mons pubis.



Anterior view



2.5 ARTERIES AND NERVES OF ANTEROLATERAL ABDOMINAL WALL

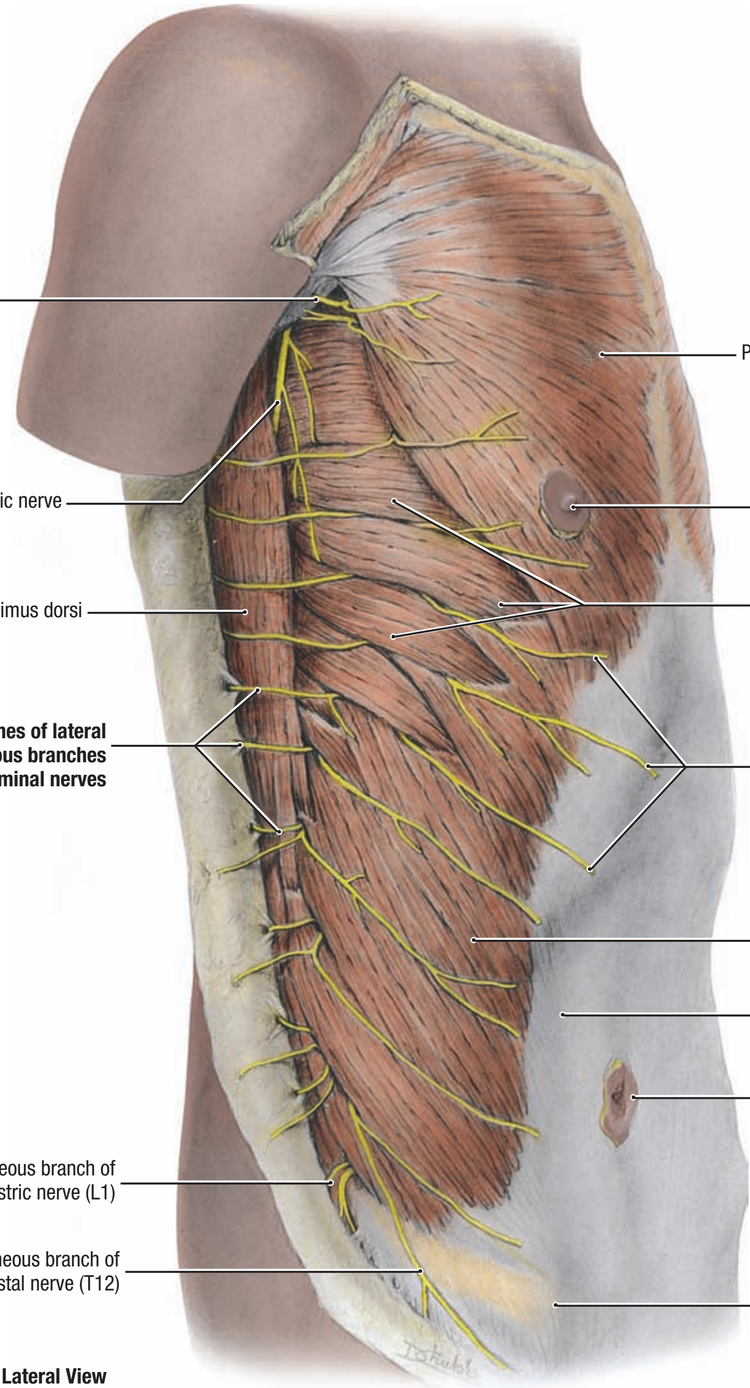
The skin and muscles of the anterolateral abdominal wall are supplied mainly by the:

- Thoraco-abdominal nerves: distal, abdominal parts of the anterior rami of the inferior six thoracic spinal nerves (T7–T11), which have muscular branches and anterior and lateral abdominal cutaneous branches. The anterior abdominal cutaneous branches pierce the rectus sheath a short distance from the median plane, after the rectus abdominis muscle has been supplied. Spinal nerves T7–T9 supply the skin superior to the umbilicus; T10 innervates the skin around the umbilicus.
- Subcostal nerve: large anterior ramus of spinal nerve T12.
- Iliohypogastric and ilio-inguinal nerves: terminal branches of the anterior ramus of spinal nerve L1.
- Spinal nerve T11, plus the cutaneous branches of the subcostal (T12), iliohypogastric, and ilio-inguinal (L1) nerves: supply the skin inferior to the umbilicus.

The blood vessels of the anterolateral abdominal wall are the:

- Superior epigastric vessels and branches of the musculophrenic vessels from the internal thoracic vessels.
- Inferior epigastric and deep circumflex iliac vessels from the external iliac vessels.
- Superficial circumflex iliac and superficial epigastric vessels from the femoral artery and great saphenous vein.
- Posterior intercostal vessels in the 11th intercostal space and anterior branches of subcostal vessels.

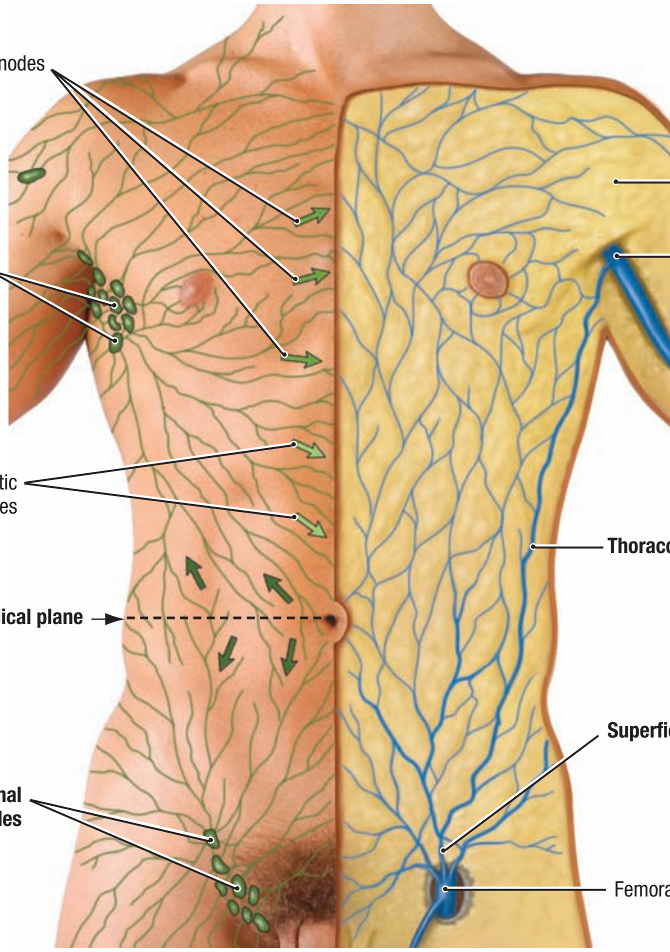
Incisional nerve injury. The inferior thoracic spinal nerves (T7–T12) and the iliohypogastric and ilio-inguinal nerves (L1) approach the abdominal musculature separately to provide the multisegmental innervation of the abdominal muscles. Thus they are distributed across the anterolateral abdominal wall, where they run oblique but mostly horizontal courses. They are susceptible to injury in surgical incisions or from trauma at any level of the abdominal wall. Injury to them may result in weakening of the muscles. In the inguinal region, such a weakness may predispose an individual to development of an inguinal hernia.



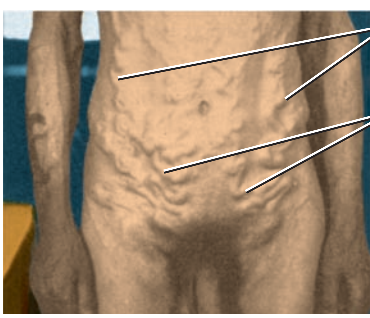
2.6 ANTEROLATERAL ABDOMINAL WALL, SUPERFICIAL DISSECTION

The muscular portion of the external oblique muscle interdigitates with slips of the serratus anterior muscle, and the aponeurotic portion contributes to the anterior wall of the rectus sheath. The anterior and posterior branches of the lateral abdominal cutaneous branches of the thoraco-abdominal nerves course superficially in the subcutaneous tissue.

- **Umbilical hernias** are usually small protrusions of extraperitoneal fat and/or peritoneum and omentum and sometimes bowel. They result from increased intra-abdominal pressure in the presence of weakness or incomplete closure of the anterior abdominal wall after ligation of the umbilical cord at birth, or may be acquired later, most commonly in women and obese people.
- The lines along which the fibers of the abdominal aponeurosis interlace (see Fig. 2.10A,B,D) are also potential sites of herniation. These gaps may be congenital, the result of the stresses of obesity and aging, or the consequence of surgical or traumatic wounds.



A. Anterior view



B
Anterior View

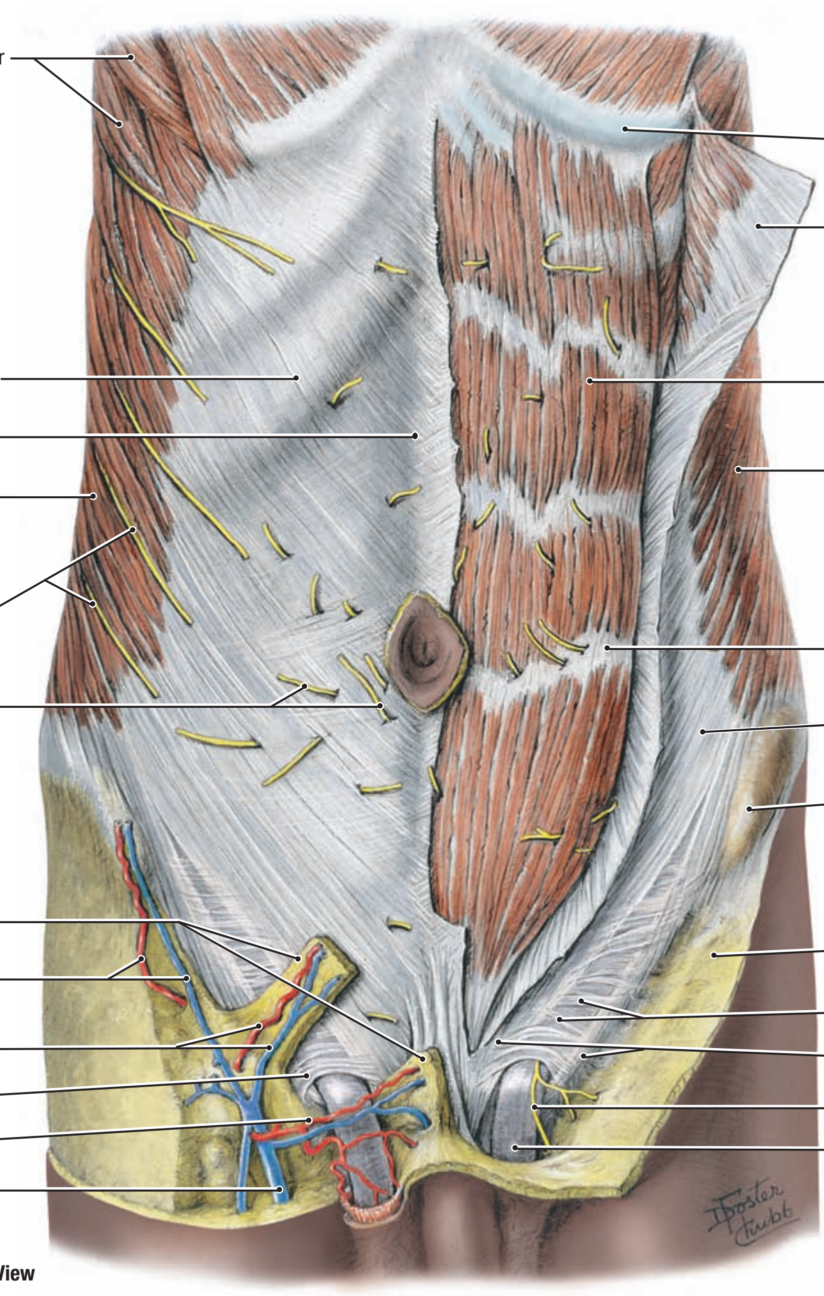
2.7 LYMPHATIC DRAINAGE AND SUBCUTANEOUS (SUPERFICIAL) VENOUS DRAINAGE OF ANTEROLATERAL ABDOMINAL WALL

A. Overview.

- The skin and subcutaneous tissue of the abdominal wall are served by an intricate subcutaneous venous plexus, draining superiorly to the internal thoracic vein medially and the lateral thoracic vein laterally and inferiorly to the superficial and inferior epigastric veins, tributaries of the femoral and external iliac veins, respectively.
- Superficial lymphatic vessels accompany the subcutaneous veins; those superior to the transumbilical plane drain mainly to the axillary lymph nodes; however, a few drain to the parasternal lymph nodes. Superficial lymphatic vessels inferior to the transumbilical plane drain to the superficial inguinal lymph nodes.

B. Enlargement of subcutaneous veins.

- **Liposuction** is a surgical method for removing unwanted subcutaneous fat using a percutaneously placed suction tube and high vacuum pressure. The tubes are inserted subdermally through small skin incisions.
- When flow in the superior or inferior vena cava is obstructed, anastomoses between the tributaries of these systemic veins, such as the thoraco-epigastric vein, may provide **collateral pathways** by which the obstruction may be bypassed, allowing blood to return to the heart. The veins become enlarged and tortuous **(B).**

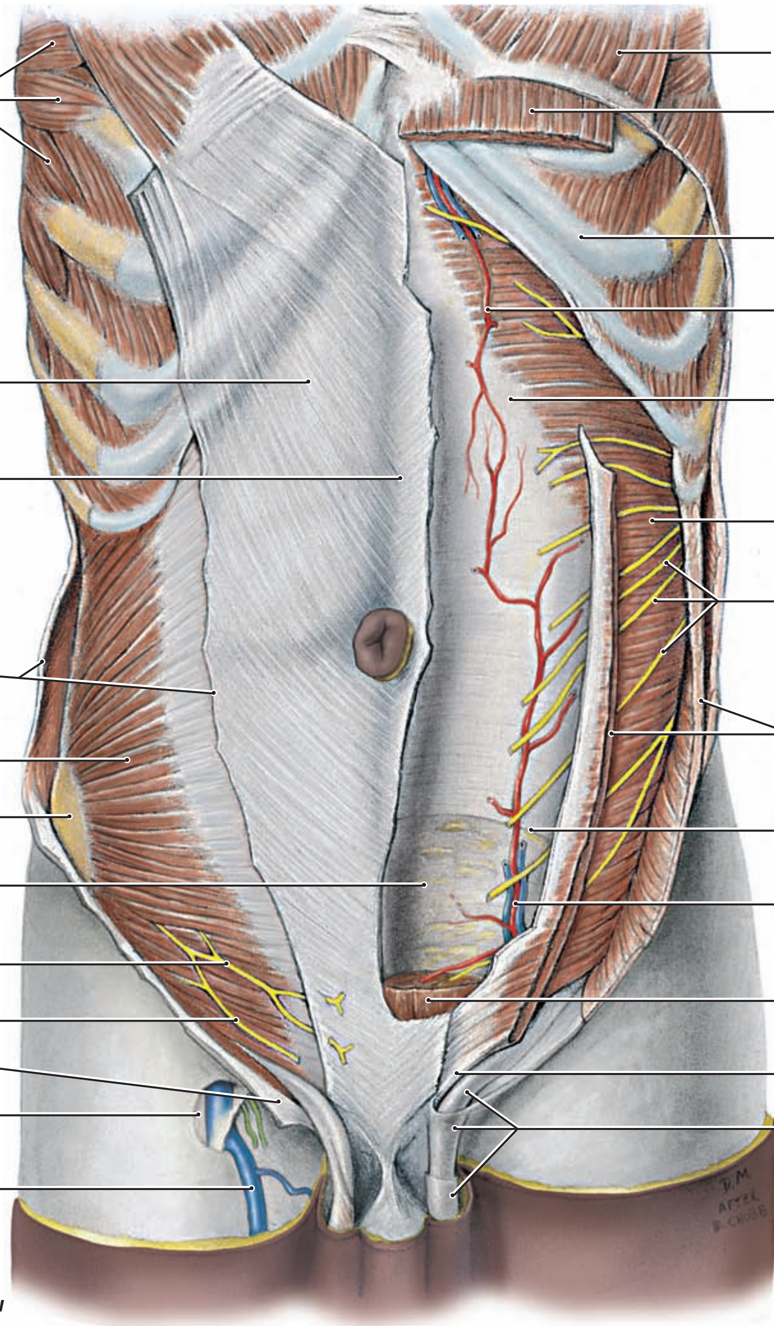


A. Anterior View

2.8 ANTERIOR ABDOMINAL WALL

A. Superficial dissection demonstrating the relationship of the cutaneous nerves and superficial vessels to the musculoaponeurotic structures. The anterior wall of the left rectus sheath is reflected, revealing the rectus abdominis muscle, segmented by tendinous intersections.

- After the T7 to T12 spinal nerves supply the muscles, their anterior abdominal cutaneous branches emerge from the rectus abdominis muscle and pierce the anterior wall of its sheath.
- The three superficial inguinal branches of the femoral artery (superficial circumflex iliac artery, superficial epigastric artery, and external pudendal artery) and the great saphenous vein lie in the fatty layer of subcutaneous tissue.
- The fibers of the external oblique aponeurosis separate into medial and lateral crura, which, with the intercrural fibers that unite them, form the superficial inguinal ring. The spermatic cord of the male (shown here), or round ligament of the female, exits the inguinal canal through the superficial inguinal ring along with the ilio-inguinal nerve.

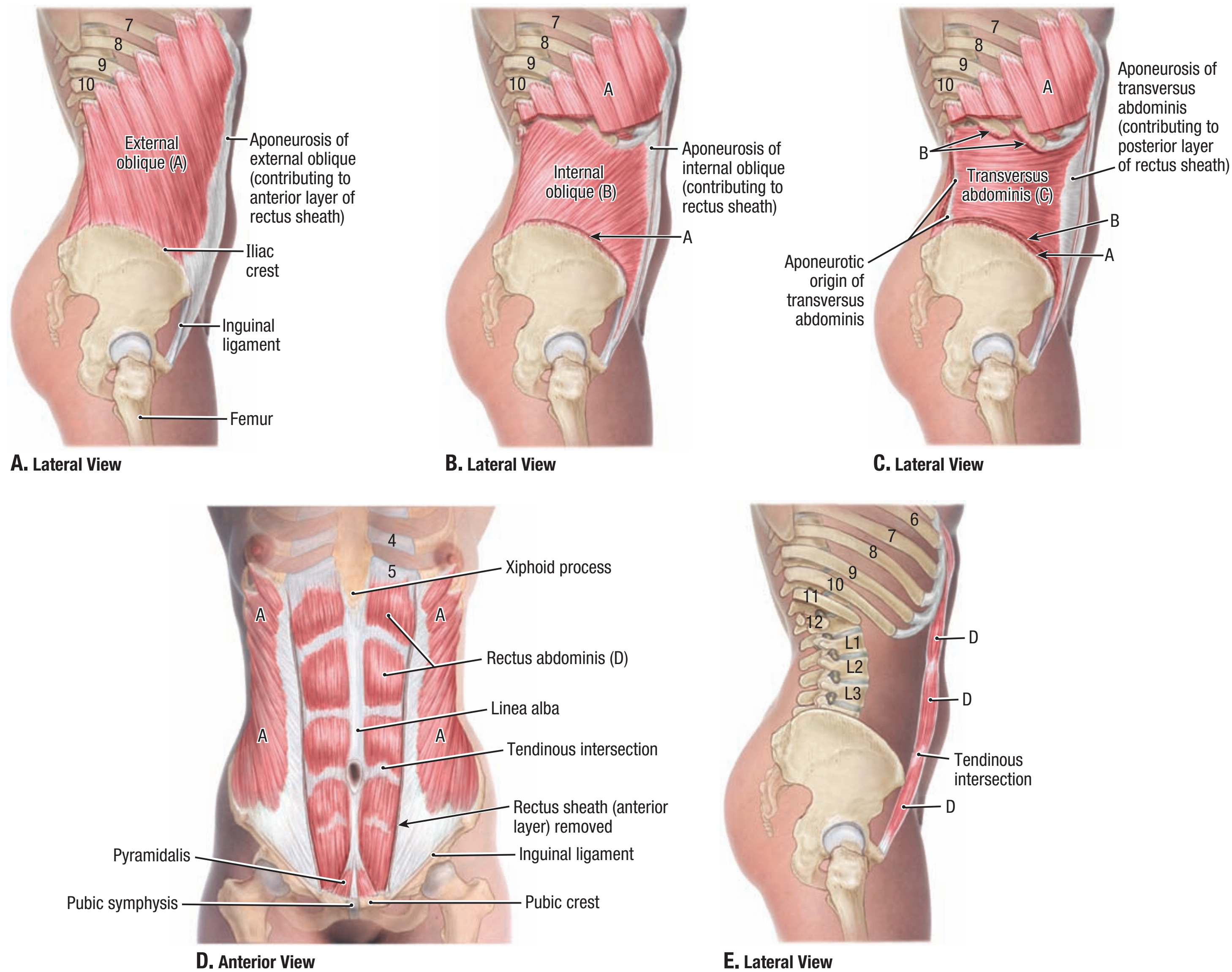


B. **Anterior View**

2.8 ANTERIOR ABDOMINAL WALL (*CONTINUED*)

B. Deep dissection. On the right side of the specimen, most of the external oblique muscle is excised. On the left, the internal oblique muscle is divided and the rectus abdominis muscle is excised, revealing the posterior wall of the rectus sheath.

- The fibers of the internal oblique muscle run horizontally at the level of the anterior superior iliac spine (ASIS), obliquely upward superior to the ASIS, and obliquely downward inferior to the ASIS.
- The arcuate line is at the level of the ASIS; inferior to the line, only transversalis fascia lies posterior to the rectus abdominis muscle.
- Initially, the anterior abdominal branches of the anterior rami course between the internal oblique and transversus abdominis muscles.
- The anastomosis between the superior and inferior epigastric arteries indirectly unites the subclavian artery of the upper limb to the external iliac arteries of the lower limb. The anastomosis can become functionally patent in response to **slowly developing occlusion of the aorta.**



2.9 MUSCLES OF ANTEROLATERAL ABDOMINAL WALL

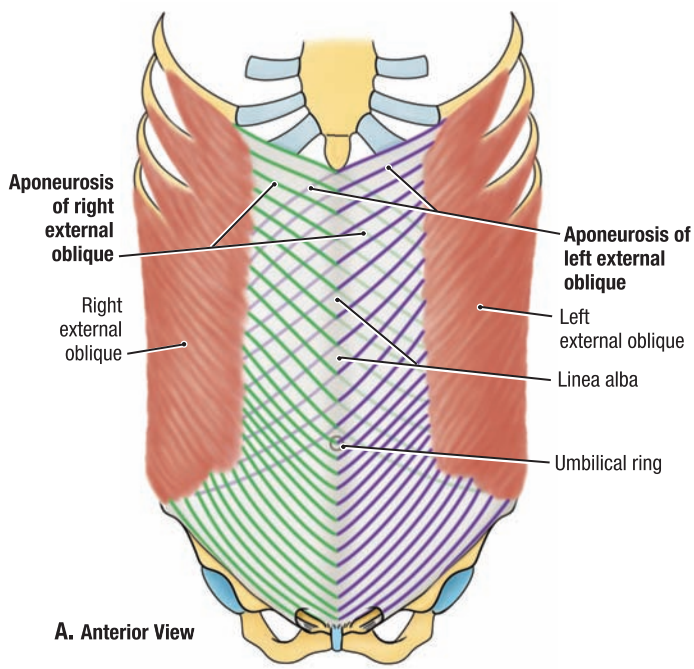
A. External oblique. **B.** Internal oblique. **C.** Transversus abdominis. **D. and E.** Rectus abdominis and pyramidalis.

TABLE 2.1 PRINCIPAL MUSCLES OF ANTEROLATERAL ABDOMINAL WALL

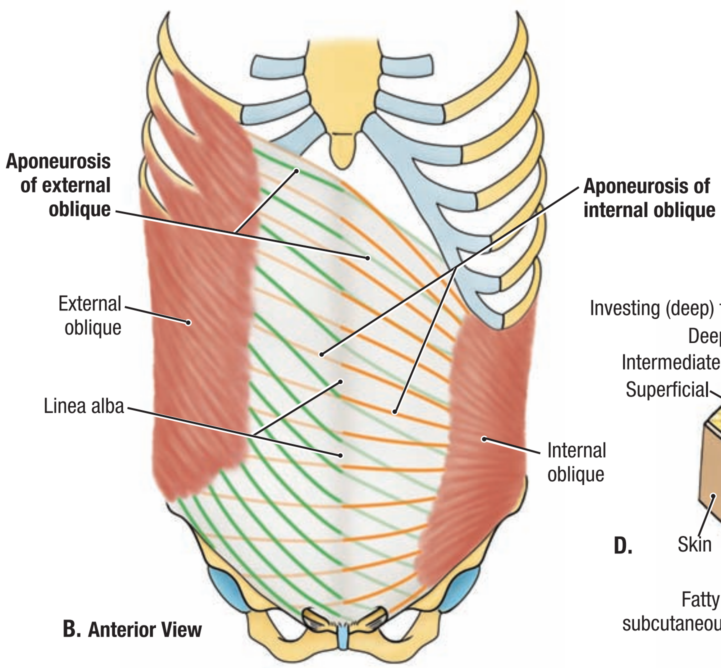
Muscles[a]	Origin	Insertion	Innervation	Action(s)
External oblique **(A)**	External surfaces of 5th–12th ribs	Linea alba, pubic tubercle, and anterior half of iliac crest	Thoraco-abdominal nerves (anterior rami of T7–T11) and subcostal nerve	Compresses and supports abdominal viscera; flexes and rotates trunk
Internal oblique **(B)**	Thoracolumbar fascia, anterior two thirds of iliac crest, and connective tissue deep to inguinal ligament	Inferior borders of 10th–12th ribs, linea alba, and pubis via conjoint tendon	Thoraco-abdominal nerves (anterior rami of T7–T11), subcostal nerve, and first lumbar nerve	
Transversus abdominis **(C)**	Internal surfaces of 7th–12th costal cartilages, thoracolumbar fascia, iliac crest, and connective tissue deep to inguinal ligament (iliopsoas fascia)	Linea alba with aponeurosis of internal oblique, pubic crest, and pectin pubis via conjoint tendon		Compresses and supports abdominal viscera (external oblique ipsilaterally, internal oblique contralaterally)
Rectus abdominis **(D)**	Pubic symphysis and pubic crest	Xiphoid process and 5th–7th costal cartilages	Thoraco-abdominal nerves (T7–T11) and subcostal nerve	Flexes trunk (lumbar vertebrae) and compresses abdominal viscera;[b] stabilizes and controls tilt of pelvis (antilordosis)

[a]Approximately 80% of people have a *pyramidalis muscle,* which is located in the rectus sheath anterior to the most inferior part of the rectus abdominis. It extends from the pubic crest of the hip bone to the linea alba. This small muscle tenses the linea alba.

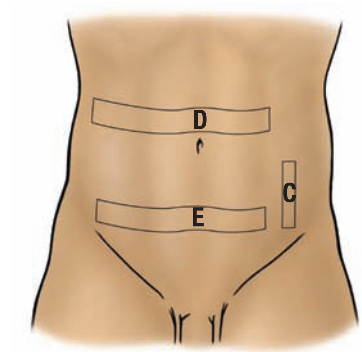
[b]In so doing, these muscles act as antagonists of the diaphragm to produce expiration.



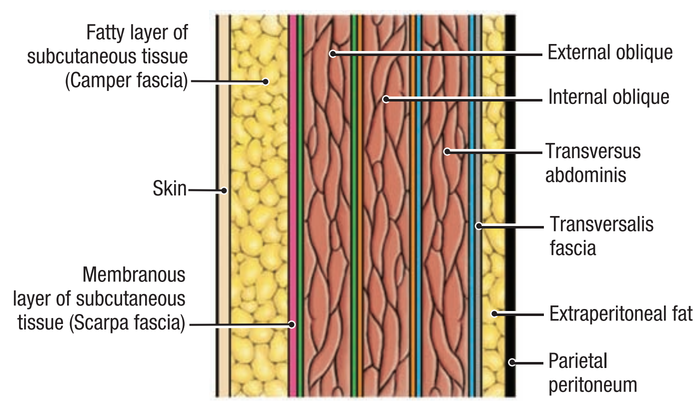
A. **Anterior View**



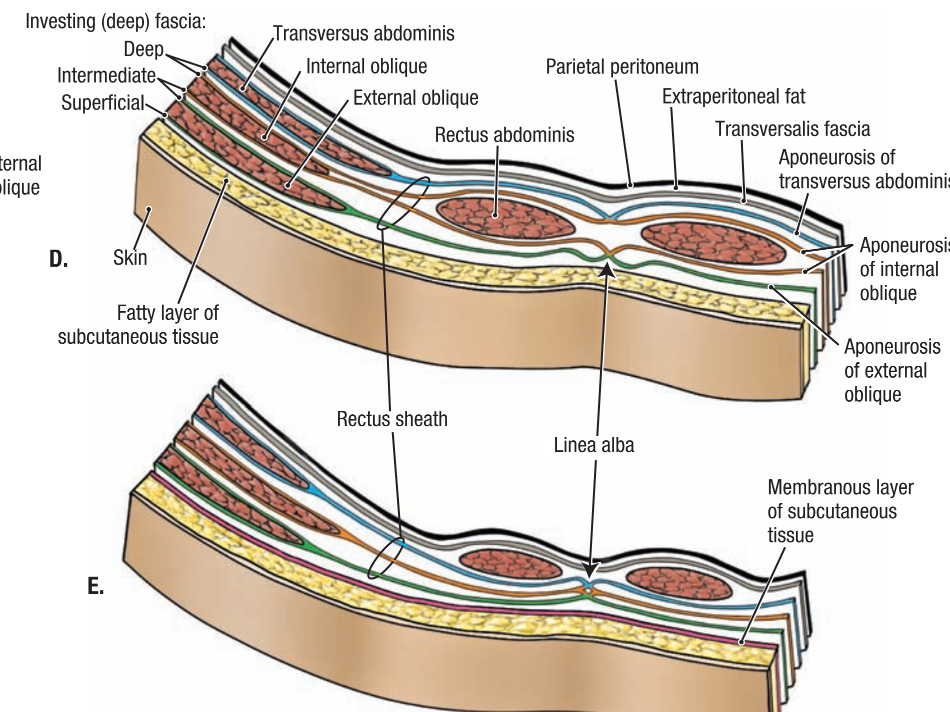
B. **Anterior View**



Anterior View Showing Location of Sections C-E



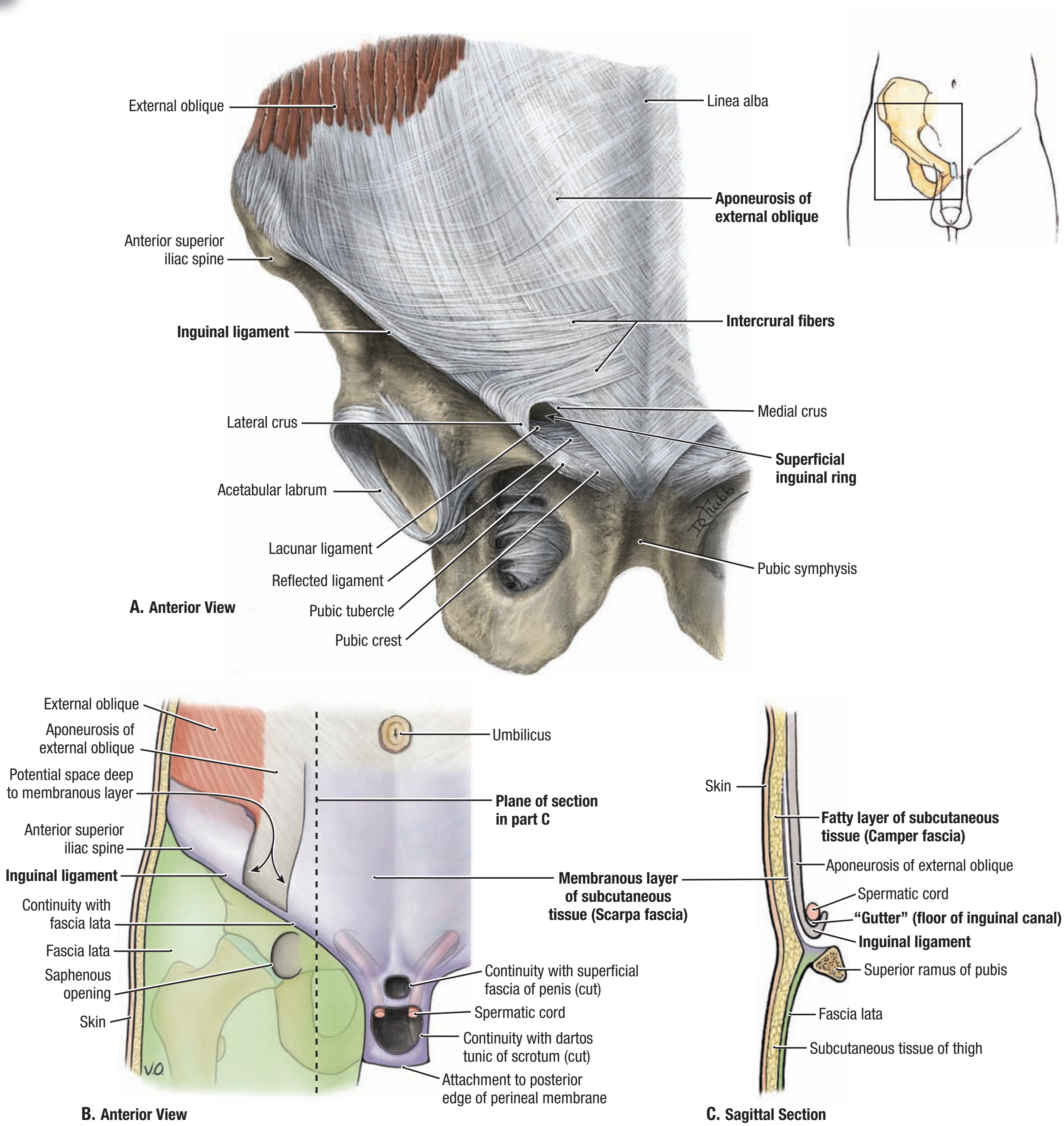
C. **Longitudinal Section**



Transverse Sections

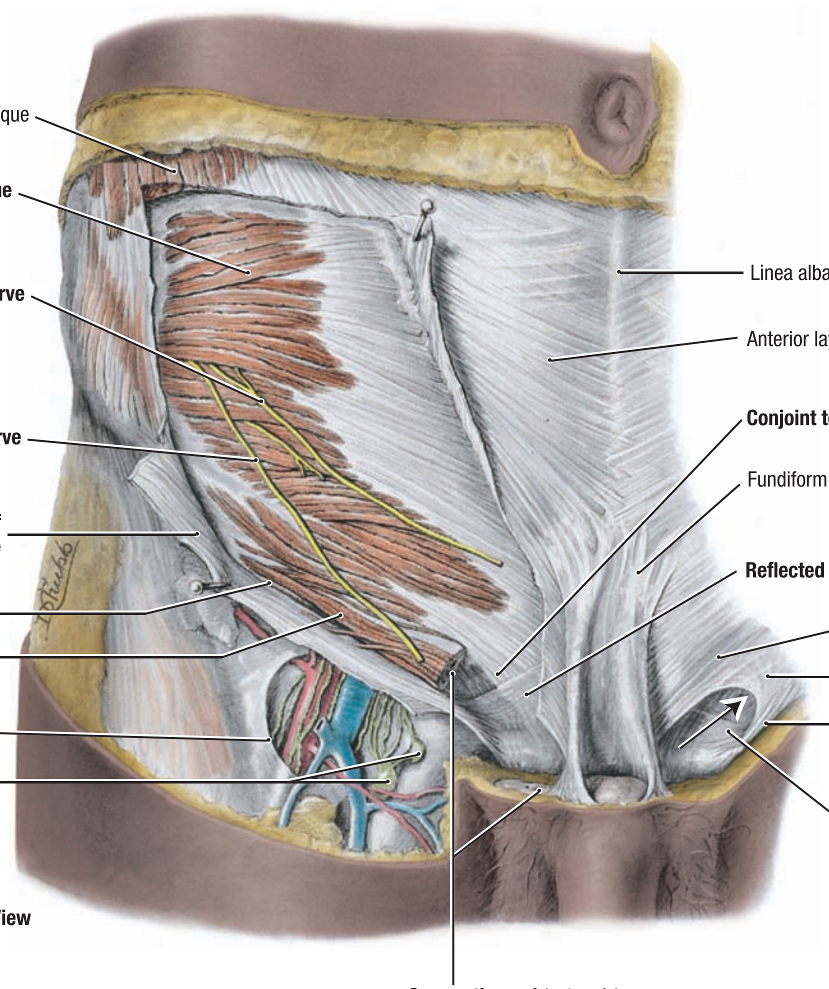
2.10 STRUCTURE OF ANTEROLATERAL ABDOMINAL WALL

A. Interdigitation of the aponeuroses of the right and left external oblique muscles. **B.** Interdigitation of the aponeuroses of the contralateral external and internal oblique muscles. **C.–E.** Layers of the abdominal wall and the rectus sheath.

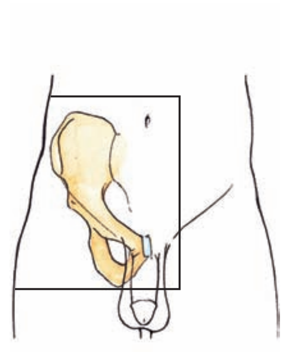


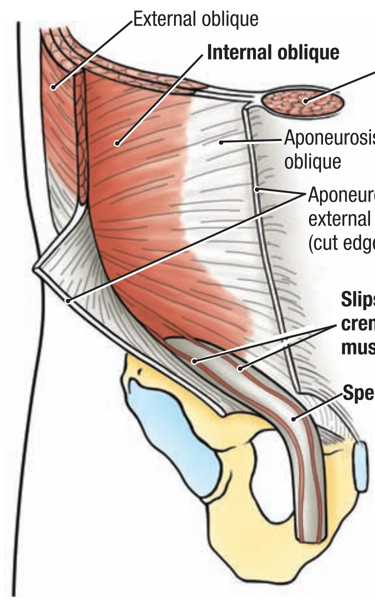
2.11 INGUINAL REGION OF MALE I

A. Formations of the aponeurosis of the external oblique muscle. **B. and C.** Membranous (deep) layer of subcutaneous tissue. Inferior to the umbilicus, the subcutaneous tissue is composed of two layers: a superficial fatty layer and a deep membranous layer. Laterally, the membranous layer fuses with the fascia lata of the thigh about a finger's breadth inferior to the inguinal ligament. Medially, it fuses with the linea alba and pubic symphysis in the midline, and inferiorly, it continues as the membranous layer of the subcutaneous tissue of the perineum and penis and the dartos fascia of the scrotum. The inferior margin of the external oblique aponeurosis is thickened and turned internally forming the inguinal ligament. The superior surface of the in-turning inguinal ligament forms a shallow trough or "gutter" that is the floor of the inguinal canal.



A. Anterior View



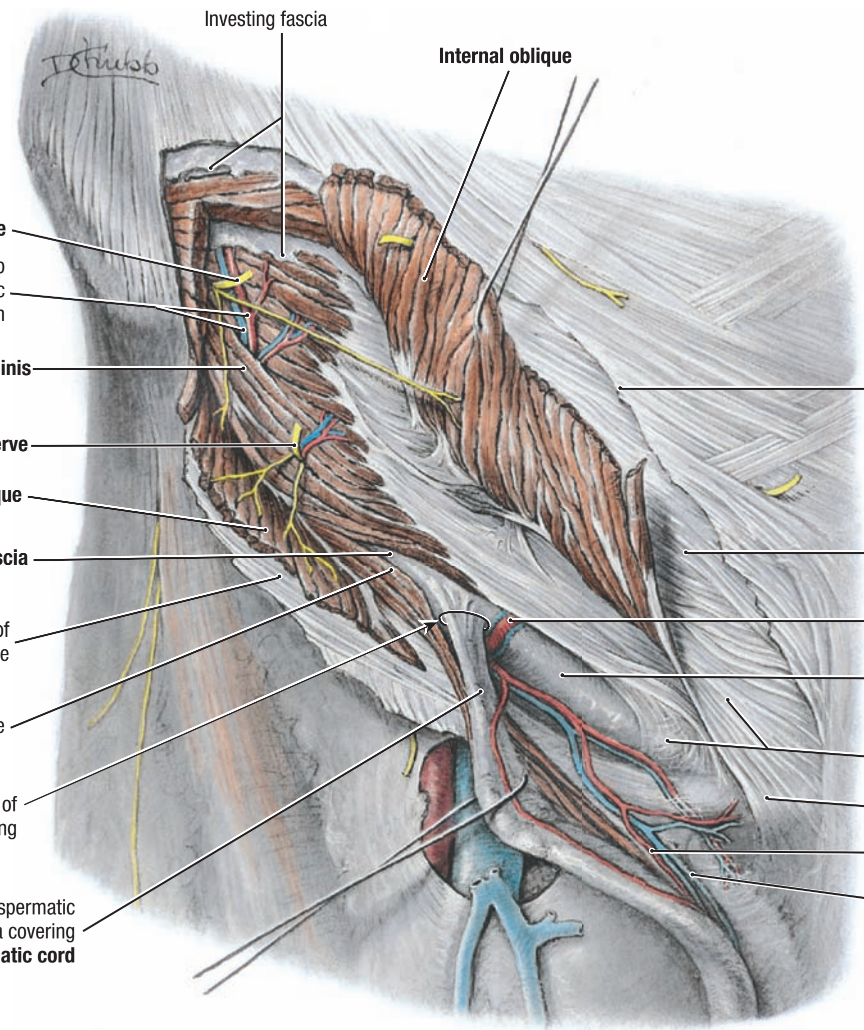


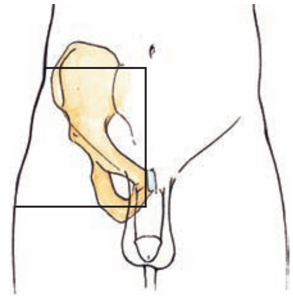
B. Anterior View

2.12 INGUINAL REGION OF MALE II

A. Internal oblique and cremaster muscle. Part of the aponeurosis of the external oblique muscle is cut away, and the spermatic cord is cut short. **B.** Schematic illustration.

- The cremaster muscle covers the spermatic cord.
- The reflected ligament is formed by aponeurotic fibers of the external oblique muscle and lies anterior to the conjoint tendon. The conjoint tendon is formed by the fusion of the aponeurosis of the internal oblique and transversus abdominis muscles.
- The cutaneous branches of the iliohypogastric and ilio-inguinal nerves (L1) course between the internal and external oblique muscles and must be avoided when an **appendectomy (gridiron) incision** is made in this region.





Anterior View

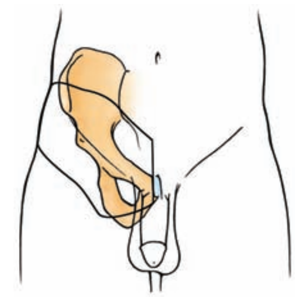
2.13 INGUINAL REGION OF MALE III

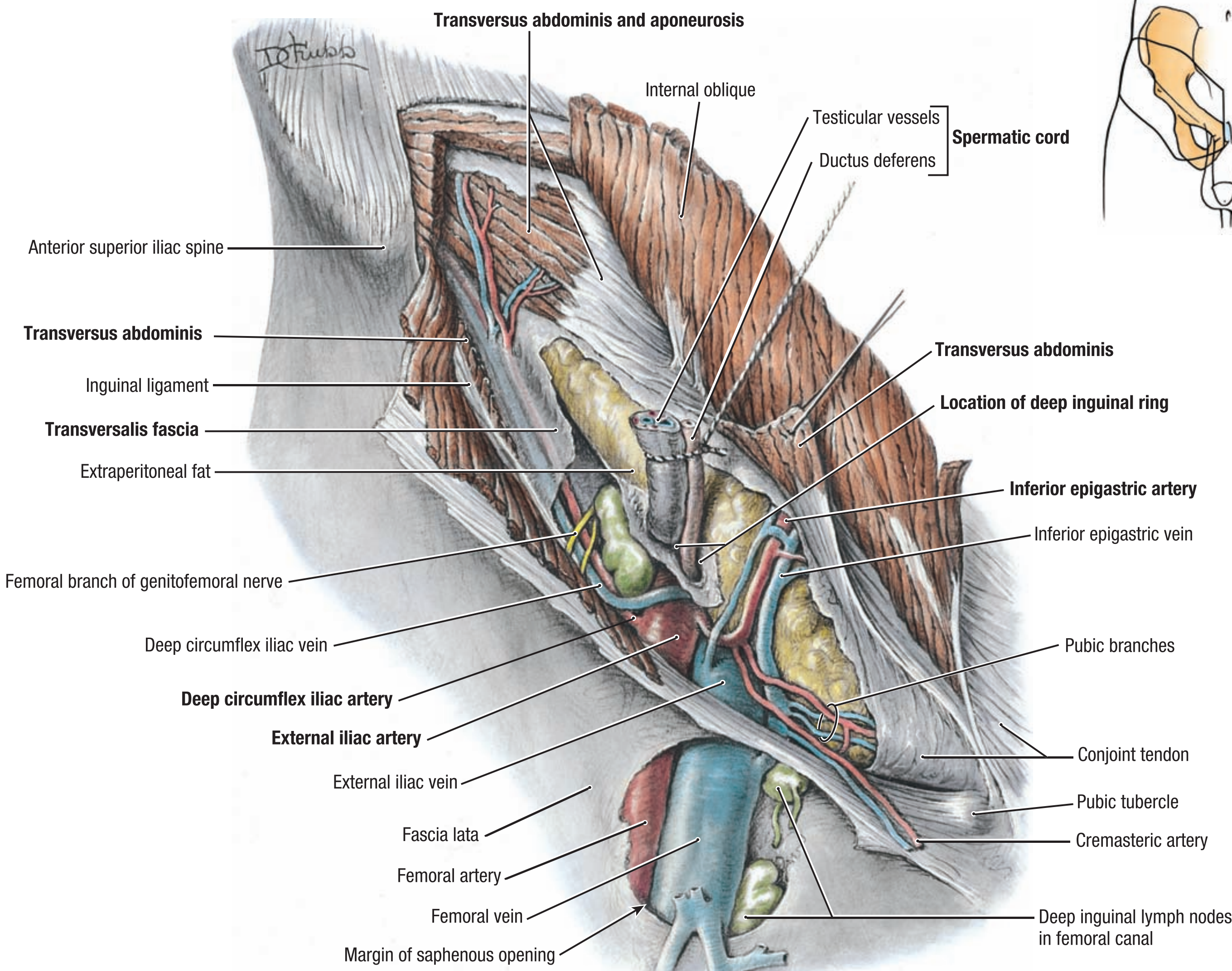
The internal oblique muscle is reflected, and the spermatic cord is retracted.

- The internal oblique muscle portion of the conjoint tendon is attached to the pubic crest, and the transversus abdominis portion to the pectineal line.
- The iliohypogastric and ilio-inguinal nerves (L1) supply the internal oblique and transversus abdominis muscles.
- The transversalis fascia is evaginated to form the tubular internal spermatic fascia. The mouth of the tube, called the deep inguinal ring, is situated lateral to the inferior epigastric vessels.

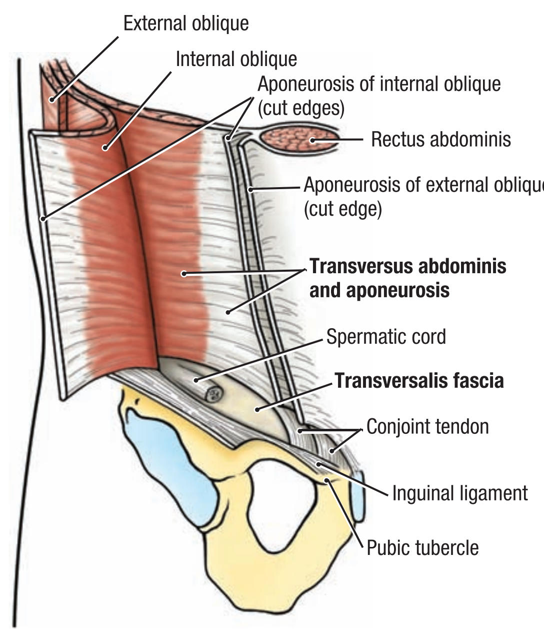
TABLE 2.2 BOUNDARIES OF INGUINAL CANAL

Boundary	Deep Ring/Lateral Third	Middle Third	Lateral Third/Superficial Ring
Posterior wall	Transversalis fascia	Transversalis fascia	Inguinal falx (conjoint tendon) plus reflected inguinal ligament
Anterior wall	Internal oblique plus lateral crus of aponeurosis of external oblique	Aponeurosis of external oblique (lateral crus and intercrural fibers)	Aponeurosis of external oblique (intercrural fibers), with fascia of external oblique continuing onto cord as external spermatic fascia
Roof	Transversalis fascia	Musculoa-poneurotic arches of internal oblique and transversus abdominis	Medial crus of aponeurosis of external oblique
Floor	Iliopubic tract	Inguinal ligament	Lacunar ligament





A. **Anterior View**

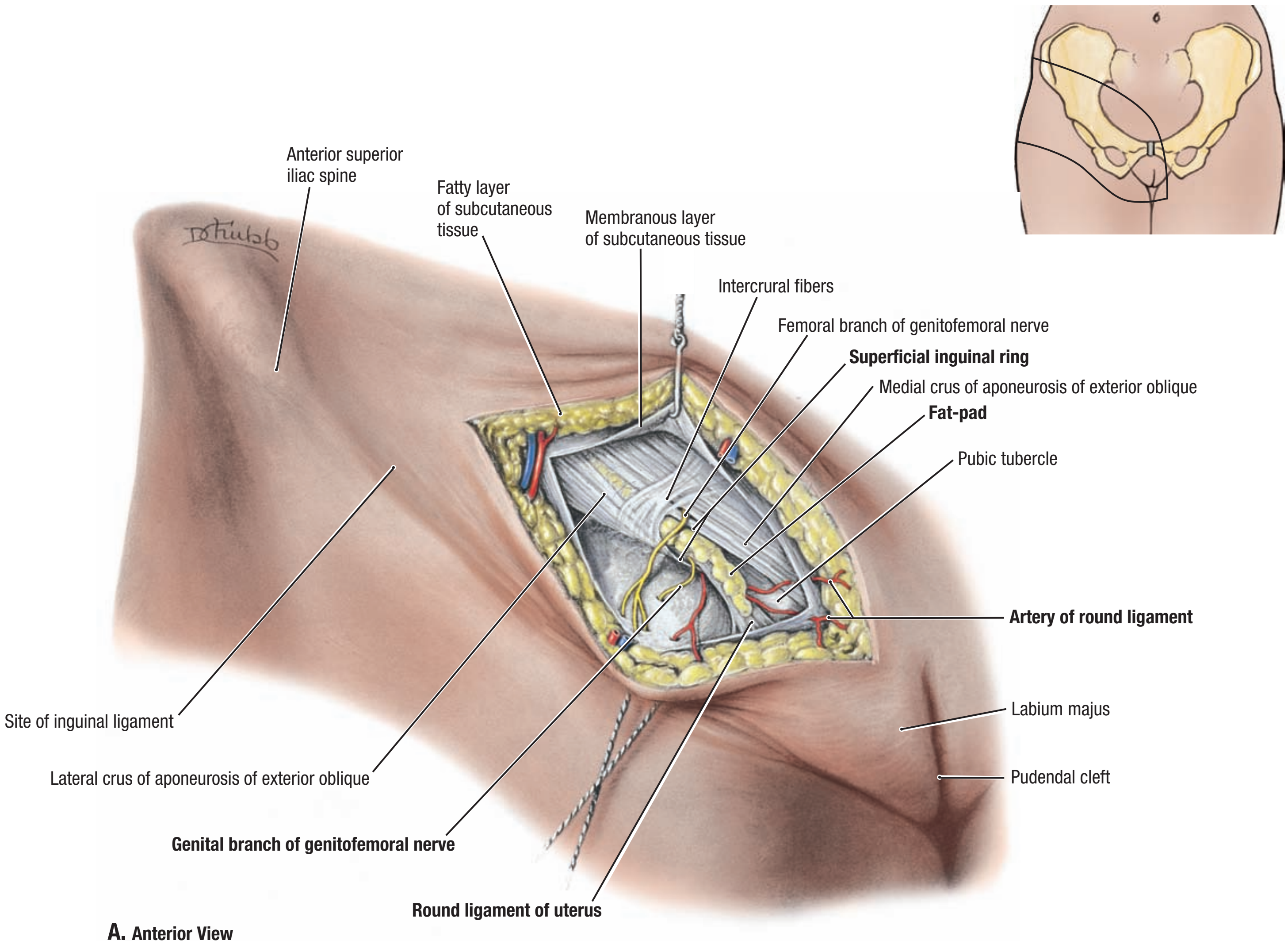


B. **Anterior View**

2.14 INGUINAL REGION OF MALE IV

A. The inguinal part of the transversus abdominis muscle and transversalis fascia is partially cut away, the spermatic cord is excised, and the ductus deferens is retracted. **B.** Schematic illustration.

- The deep inguinal ring is located superior to the inguinal ligament at the midpoint between the anterior superior iliac spine and pubic tubercle.
- The external iliac artery has two branches, the deep circumflex iliac and inferior epigastric arteries. Note also the cremasteric artery and pubic branch arising from the latter.

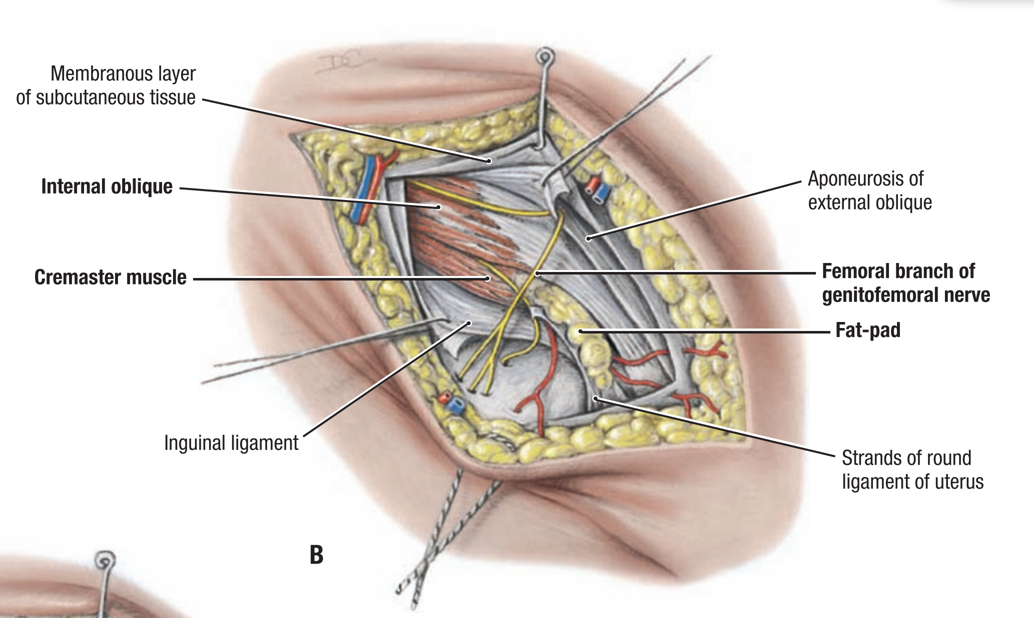


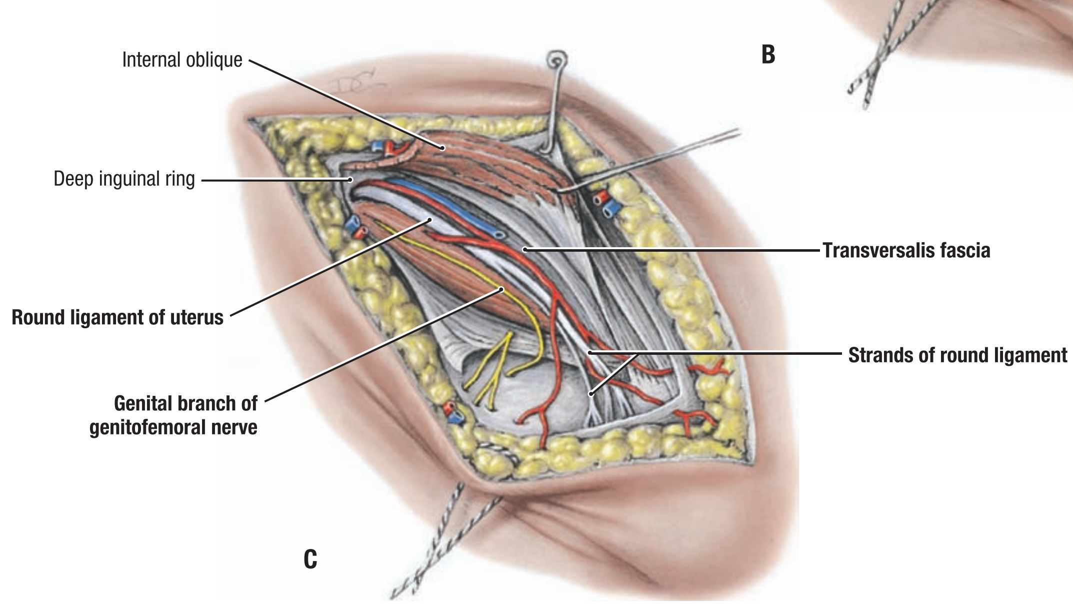
A. **Anterior View**

2.15 INGUINAL CANAL OF FEMALE

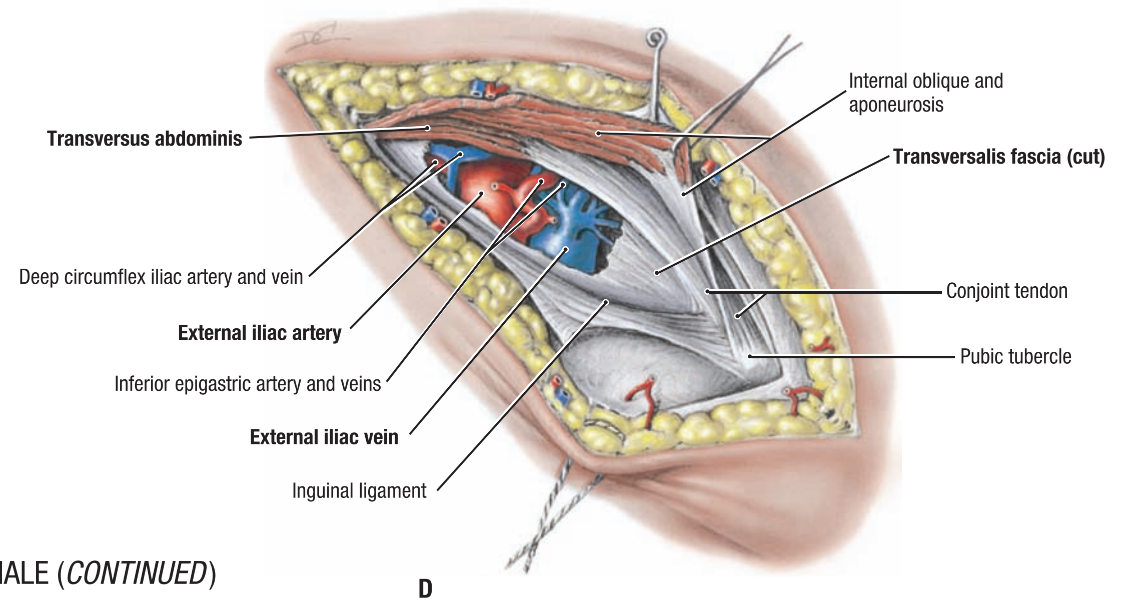
Progressive dissections of the female inguinal canal **(A.–D)**.

- In **A,** the superficial inguinal ring is small. Passing through the superficial inguinal ring are the round ligament of the uterus, a closely applied fat pad, the genital branch of the genitofemoral nerve, and the artery of the round ligament of the uterus. The ilio-inguinal nerve may also pass through the ring.
- The round ligament breaks up into strands as it leaves the inguinal canal and approaches the labium majus **(C).**
- The external iliac artery and vein are exposed deep to the inguinal canal by excising the transversalis fascia **(D).**

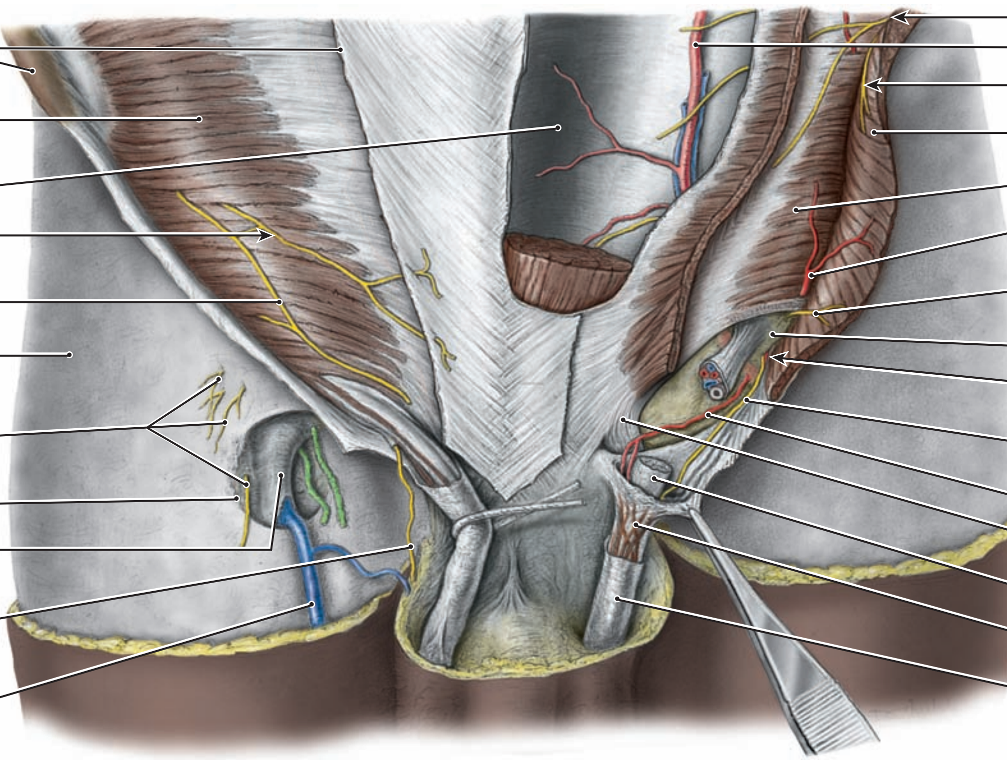




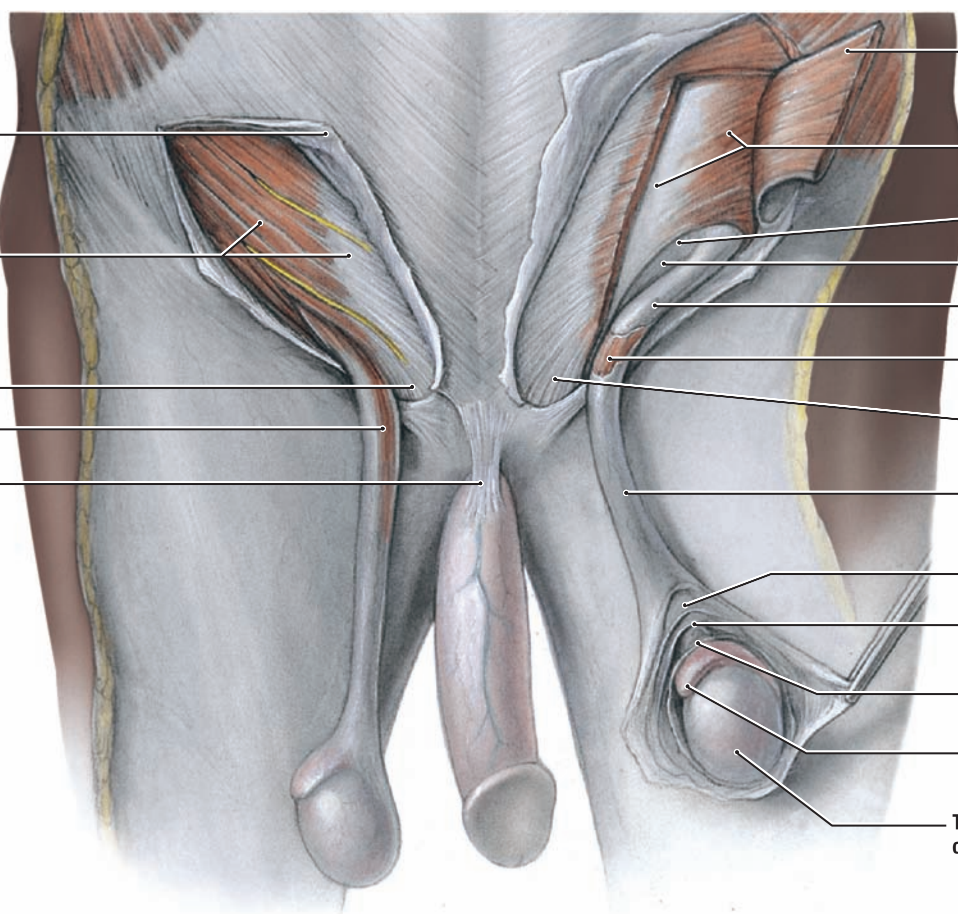
Anterior Views



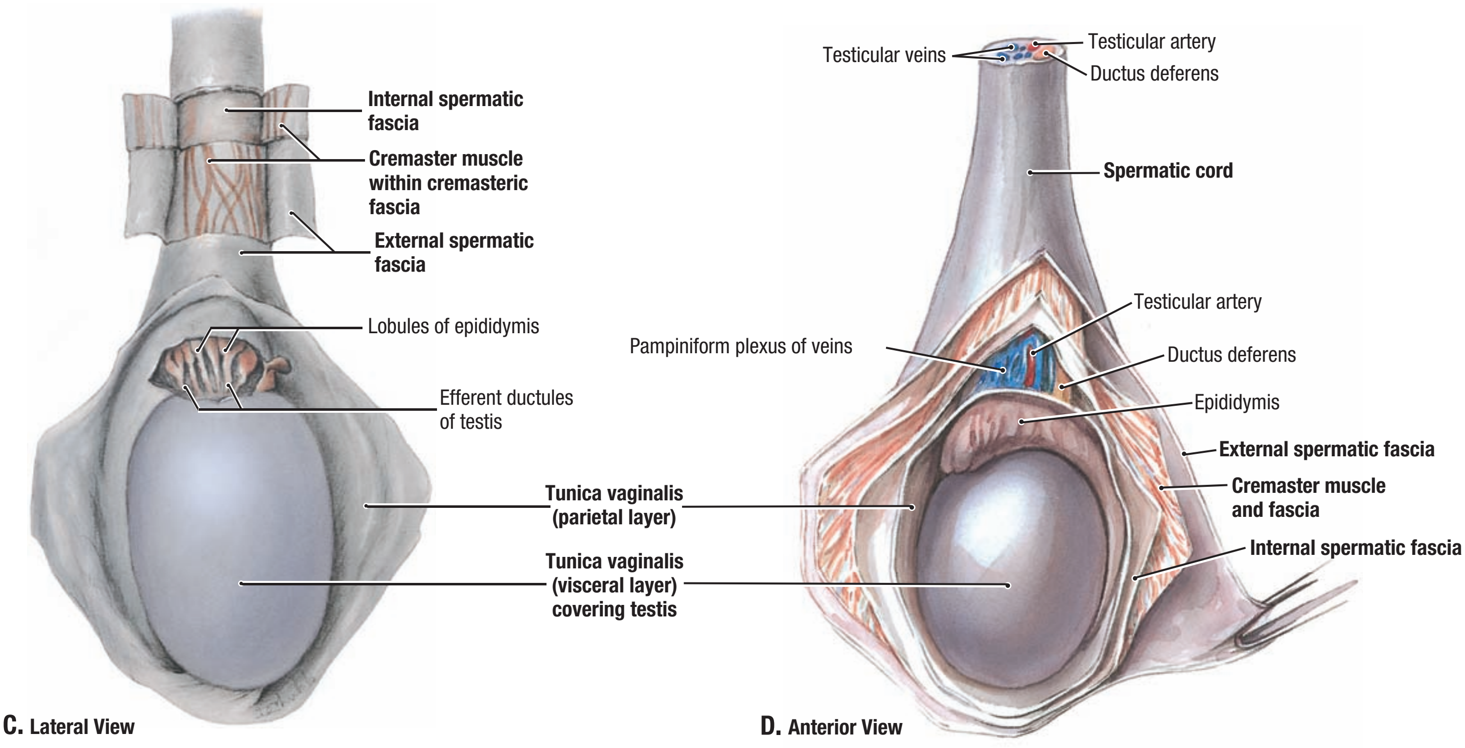
2.15 INGUINAL CANAL OF FEMALE (*CONTINUED*)



A. Anterior View



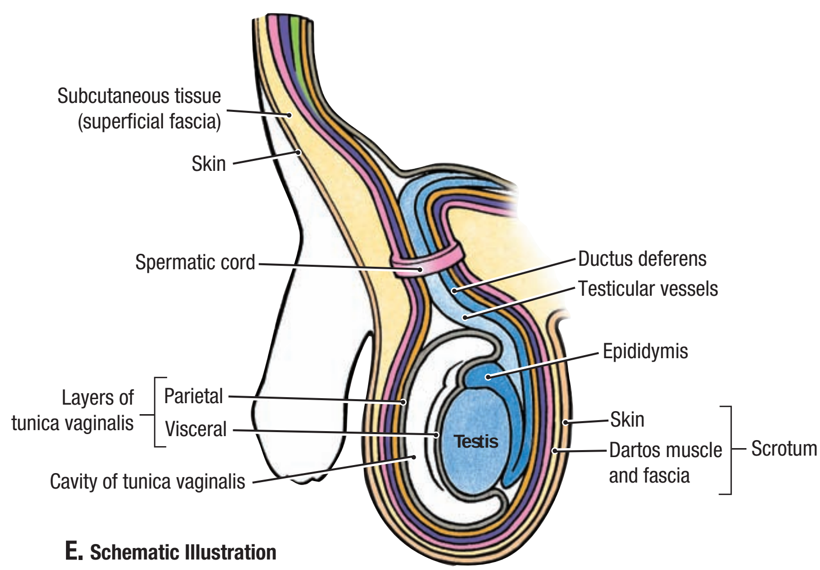
B. Anterior View



C. Lateral View

D. Anterior View

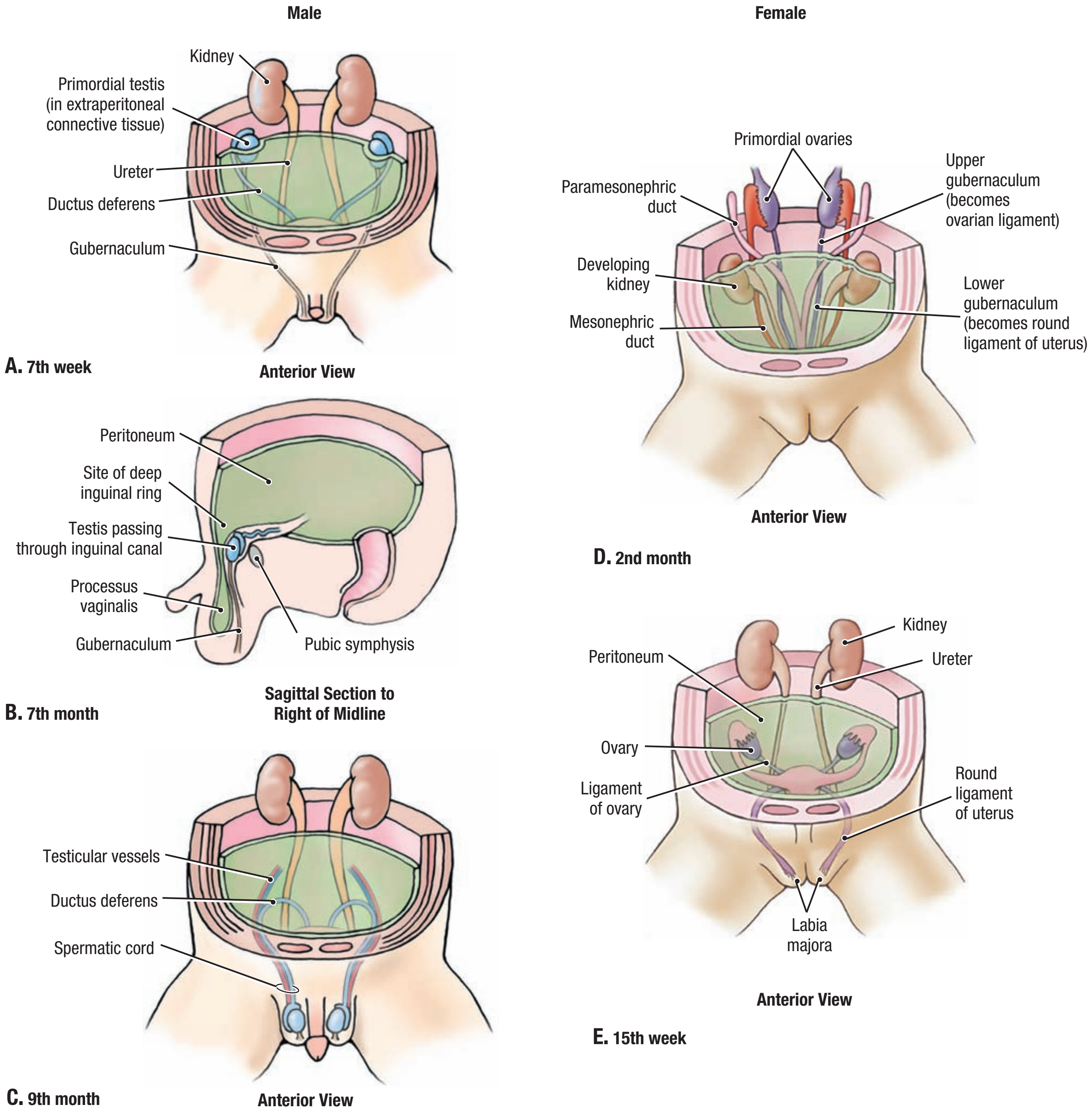
- External oblique / External spermatic fascia
- Internal oblique / Cremaster muscle & cremasteric fascia
- Transversus abdominis
- Transversalis fascia / Internal spermatic fascia
- Peritoneum / Tunica vaginalis (parietal and visceral layers)



E. Schematic Illustration

2.16 INGUINAL CANAL, SPERMATIC CORD, AND TESTIS (*CONTINUED*)

A. Dissection of inguinal canal. **B.** Dissection of inguinal region and coverings of the spermatic cord and testis. **C.–E.** Coverings of spermatic cord and testis.

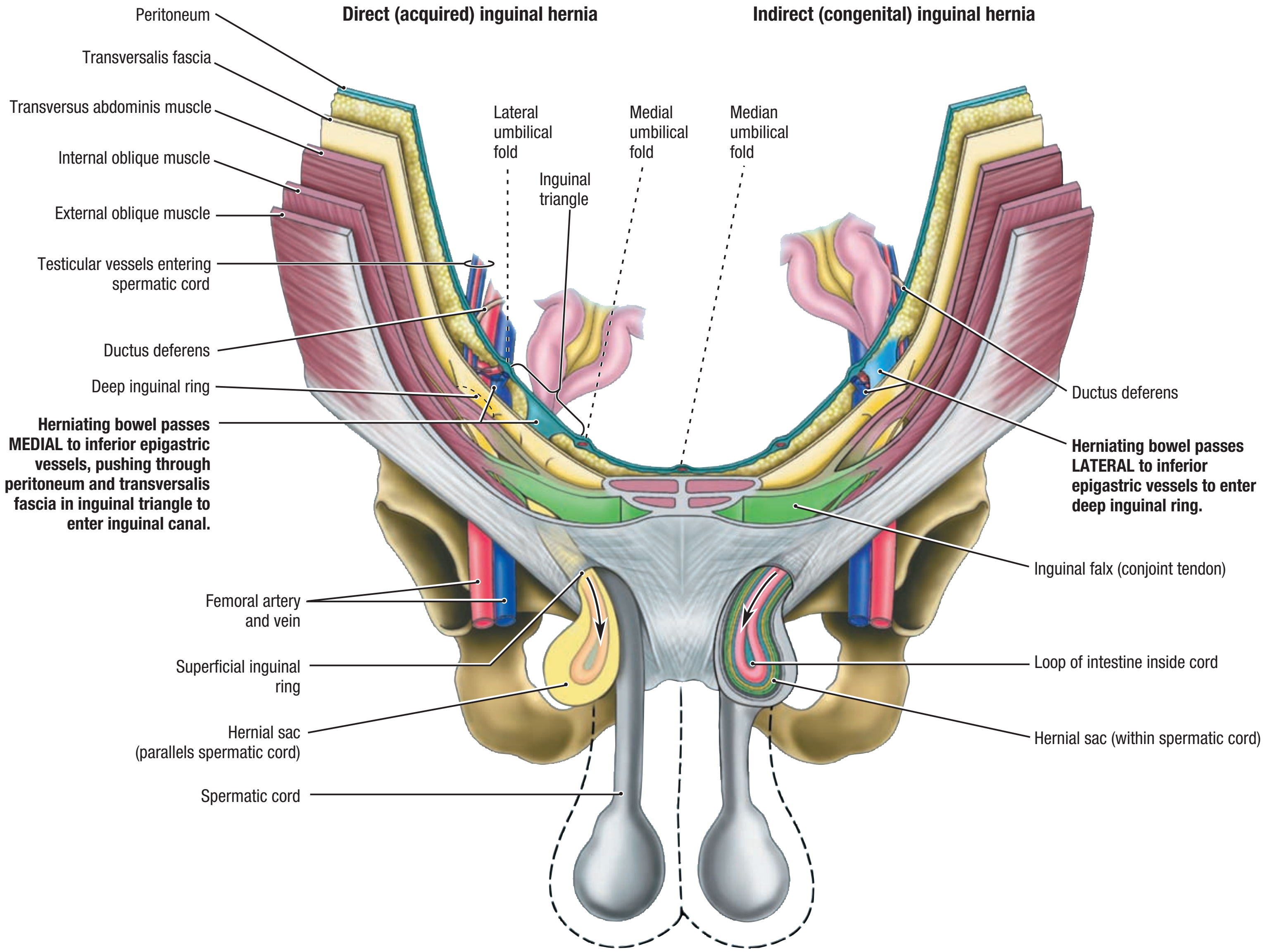


2.17 DESCENT OF GONADS

The inguinal canals in females are narrower than those in males, and the canals in infants of both sexes are shorter and much less oblique than in adults. For a complete description of the embryology of the inguinal region, see Moore and Persaud (2008).

The fetal testes descend from the dorsal abdominal wall in the superior lumbar region to the deep inguinal rings during the 9th to 12th fetal weeks. This movement probably results from the growth of the vertebral column and pelvis. The male gubernaculum, attached to the caudal pole of the testis and accompanied by an outpouching of peritoneum, the processus vaginalis, projects into the scrotum. The testis descends posterior to the processus vaginalis. The inferior remnant of the processus vaginalis forms the tunica vaginalis covering the testis. The ductus deferens, testicular vessels, nerves, and lymphatics accompany the testis. The final descent of the testis usually occurs before or shortly after birth.

The fetal ovaries also descend from the dorsal abdominal wall in the superior lumbar region during the 12th week but pass into the lesser pelvis. The female gubernaculum attaches to the caudal pole of the ovary and projects into the labia majora, attaching en route to the uterus; the part passing from the uterus to the ovary forms the ovarian ligament, and the remainder of it becomes the round ligament of the uterus. Because of the attachment of the ovarian ligaments to the uterus, the ovaries do not descend to the inguinal region; however, the round ligament passes through the inguinal canal and attaches to the subcutaneous tissue of the labium majus.



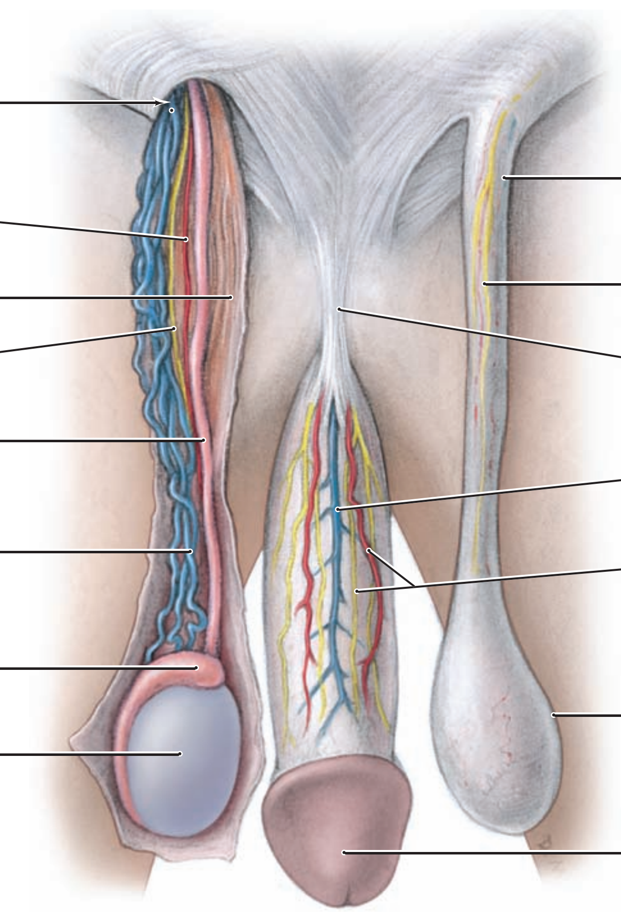
2.18 COURSE OF DIRECT AND INDIRECT INGUINAL HERNIAS

An **inguinal hernia** is a protrusion of parietal peritoneum and viscera, such as the small intestine, through the abdominal wall in the inguinal region. There are two major categories of inguinal hernia: indirect and direct. More than two thirds are indirect hernias, most commonly occurring in males.

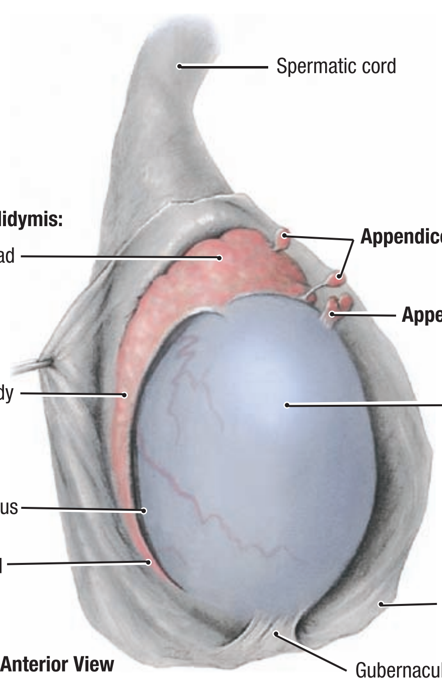
TABLE 2.3 CHARACTERISTICS OF INGUINAL HERNIAS

Characteristics[a]	Direct (Acquired)	Indirect (Congenital)
Predisposing factors	Weakness of anterior abdominal wall in inguinal triangle (e.g., owing to distended superficial ring, narrow conjoint tendon, or attenuation of aponeurosis in males >40 years of age)	Patency of processus vaginalis (complete or at least of superior part) in younger persons, the great majority of whom are males
Frequency	Less common (one third to one fourth of inguinal hernias)	More common (two third to three fourth of inguinal hernias)
Coverings at exit from abdominal cavity (**A** and **B**)	Peritoneum plus transversalis fascia (lies outside inner one or two fascial coverings of cord)	Peritoneum of persistent processus vaginalis plus all three fascial coverings of cord/round ligament
Course **(C)**	Usually traverses only medial third of inguinal canal, external and parallel to vestige of processus vaginalis	Traverses inguinal canal (entire canal if it is sufficient size) within processus vaginalis
Exit from anterior abdominal wall	Via superficial ring, lateral to cord; rarely enters scrotum	Via superficial ring inside cord, commonly passing into scrotum/labium majus

[a]Letters in parentheses refer to the figure parts.



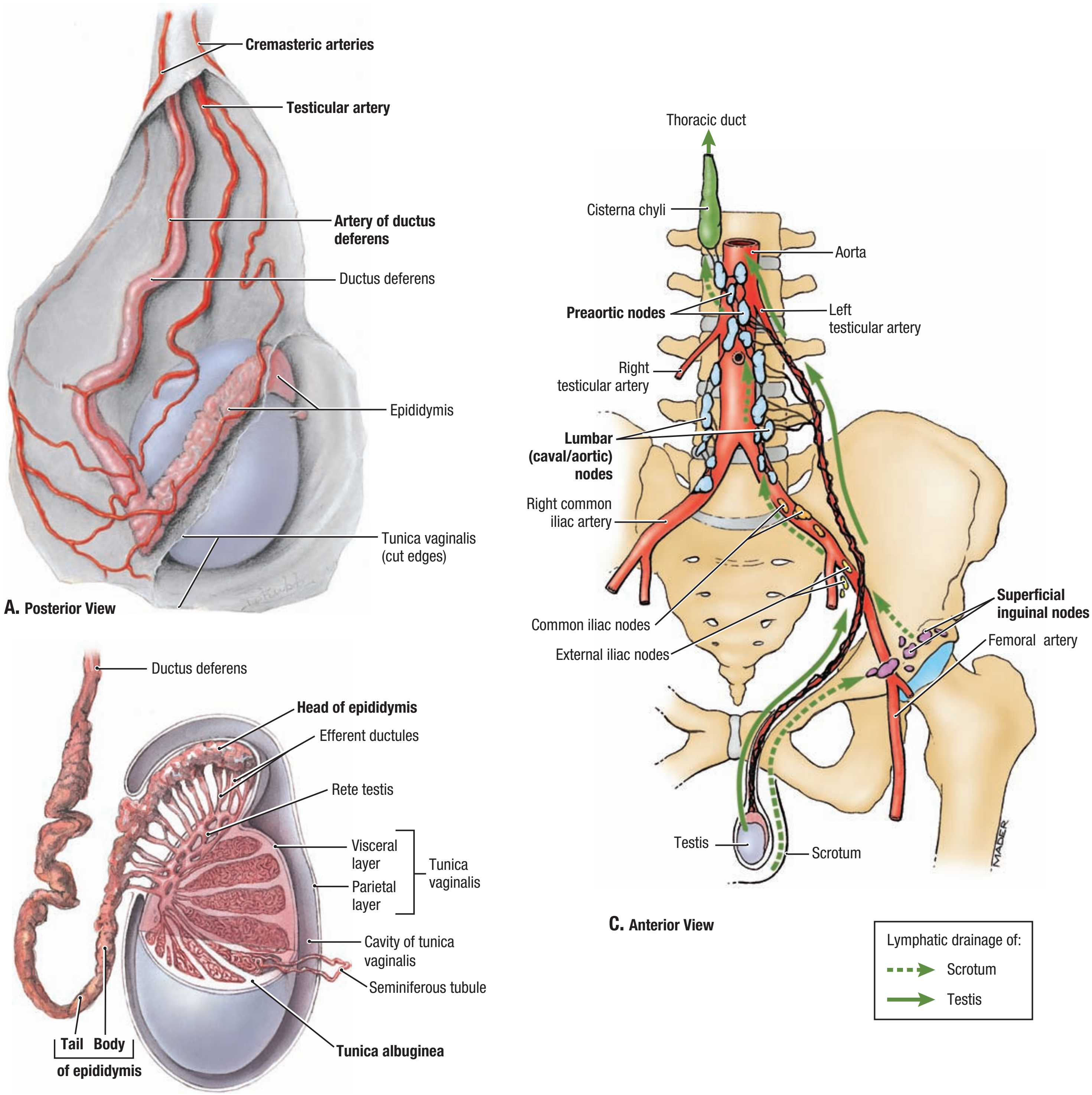
A. Anterior View



B. Anterior View

2.19 SPERMATIC CORD, TESTIS, AND EPIDIDYMIS

A. Dissection of spermatic cord. The subcutaneous tissue (dartos fascia) covering the penis has been removed and the deep fascia rendered transparent to demonstrate the median deep dorsal vein and the bilateral dorsal arteries and nerves of the penis. On the specimen's right, the coverings of the spermatic cord and testis are reflected, and the contents of the cord are separated. The testicular artery has been separated from the pampiniform plexus of veins that surrounds it as it courses parallel to the ductus deferens. Lymphatic vessels and autonomic nerve fibers (not shown) are also present. **B.** The tunica vaginalis has been incised longitudinally to expose its cavity, surrounding the testis anteriorly and laterally, and extending between the testis and epididymis at the sinus of the epididymis. The epididymis is located posterolateral to the left testis, that is, on the right side of the right testis and on the left side of the left testis. The appendices of the testis and epididymis may be observed in some specimens. These structures are small remnants of the embryonic genital (paramesonephric) duct.



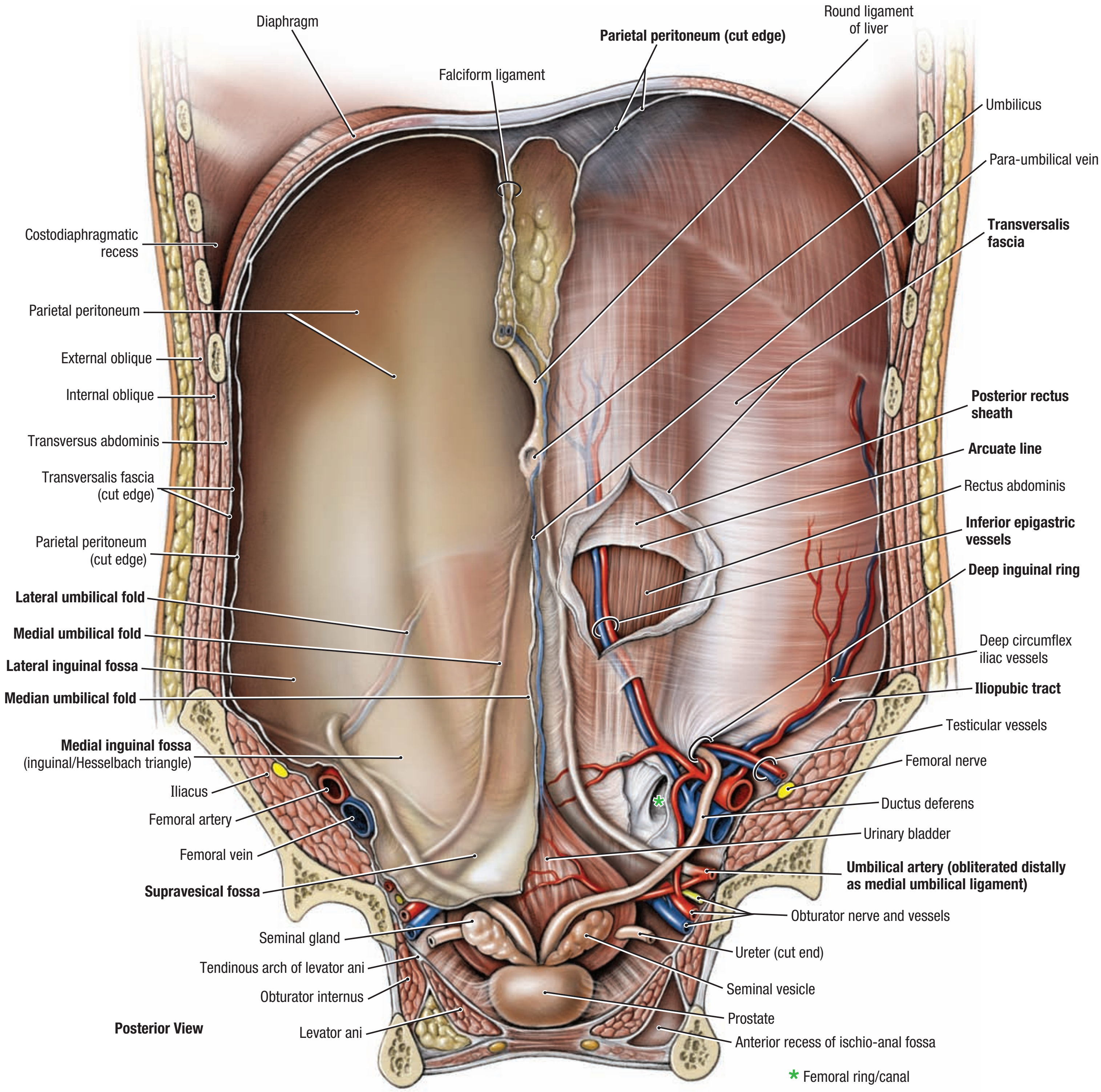
A. Posterior View

B. Longitinal Section of Tunica Vaginalis; Testis Sectioned in Sagittal and Transverse Planes

C. Anterior View

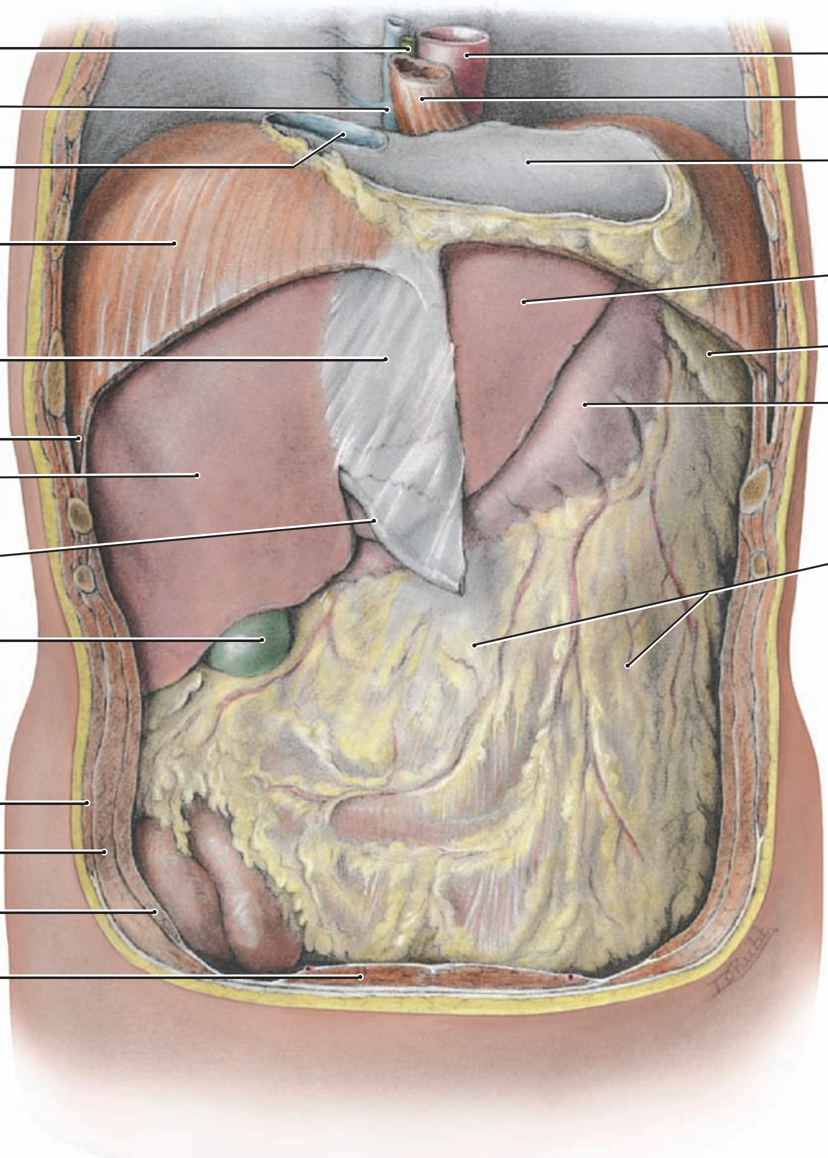
2.20 BLOOD SUPPLY AND LYMPHATIC DRAINAGE OF TESTIS

A. Blood supply. **B.** Internal structure. **C.** Lymphatic drainage. Because the testes descend from the posterior abdominal wall into the scrotum during fetal development, their lymphatic drainage differs from that of the scrotum, which is an outpouching of the abdominal skin. Consequently, **cancer of the testis** metastasizes initially to the lumbar lymph nodes, and **cancer of the scrotum** metastasizes initially to the superficial inguinal lymph nodes.



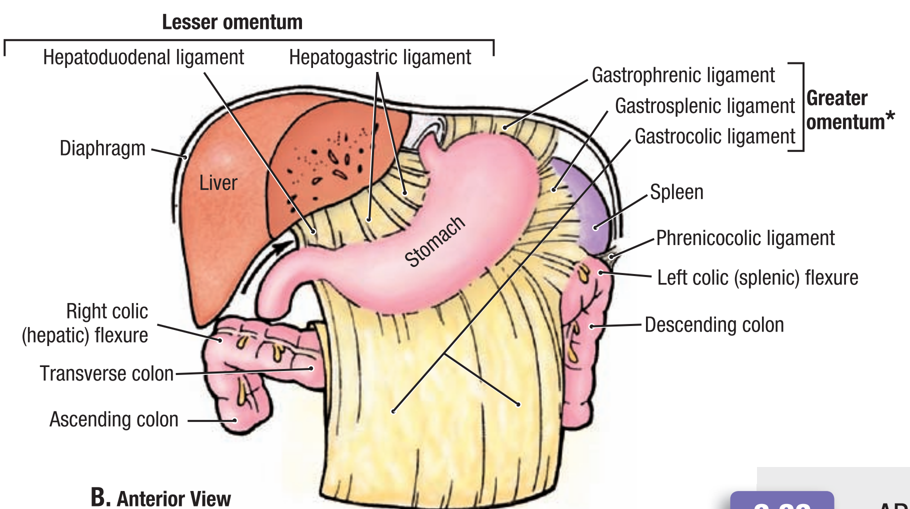
2.21 POSTERIOR ASPECT OF THE ANTEROLATERAL ABDOMINAL WALL

Umbilical folds (median, medial, and lateral) are reflections of the parietal peritoneum that are raised from the body wall by underlying structures. The median umbilical fold extends from the urinary bladder to the umbilicus and covers the median umbilical ligament (the remnant of the urachus). The two medial umbilical folds cover the medial umbilical ligaments (occluded remnants of the fetal umbilical arteries). Two lateral umbilical folds cover the inferior epigastric vessels. The supravesical fossae are between the median and medial umbilical folds, the medial inguinal fossae (inguinal triangles) are between the medial and lateral umbilical folds, and the lateral inguinal fossae and deep inguinal rings are lateral to the lateral umbilical folds.



A. **Anterior View**

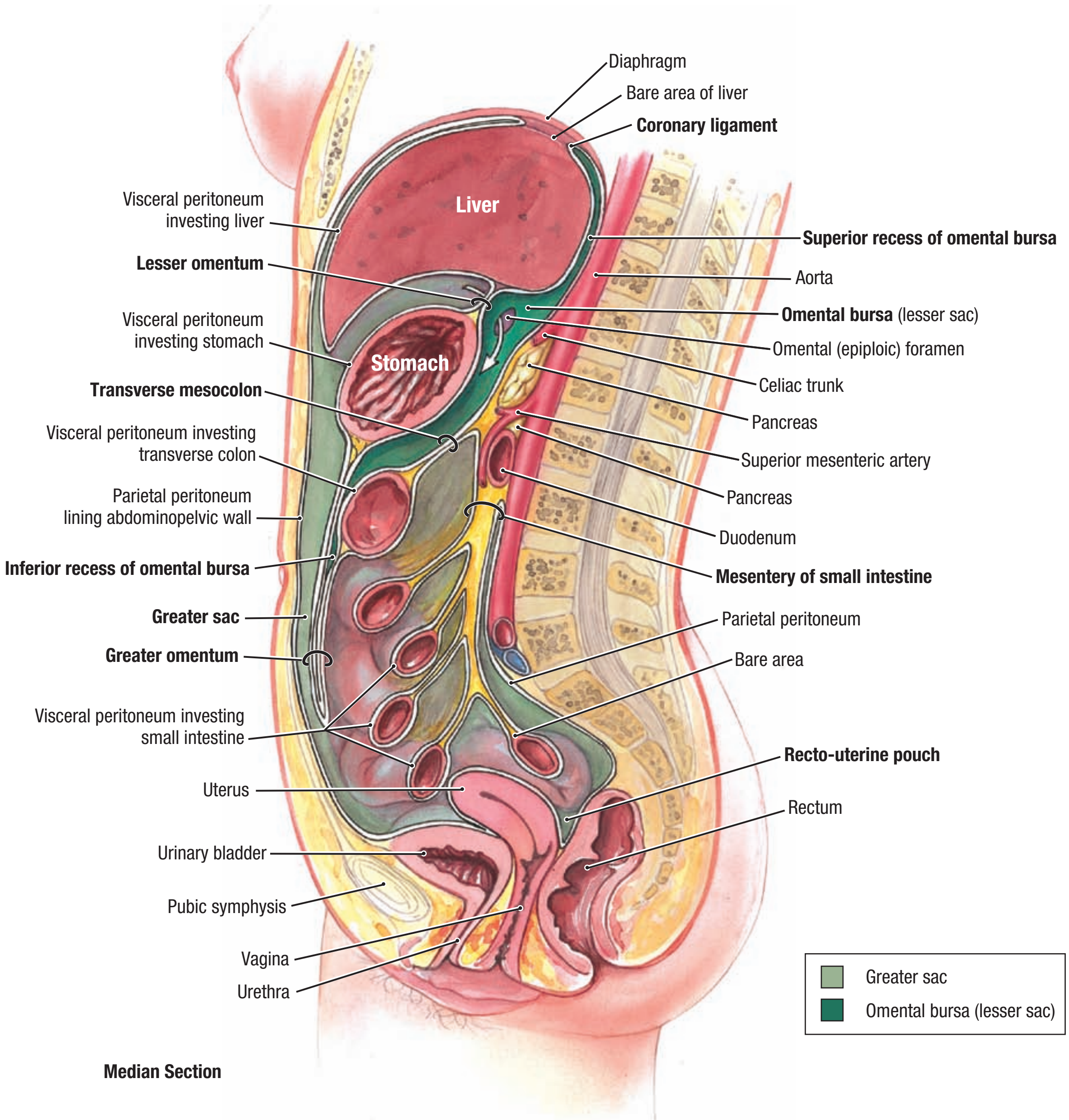
*The term greater omentum is often used as a synonym for the gastrocolic ligament, but it actually also includes the gastrosplenic and gastrosphrenic ligaments, all of which have a continuous attachment to the greater curvature of the stomach.



B. **Anterior View**

2.22 ABDOMINAL CONTENTS AND PERITONEUM

A. Dissection. **B.** Components of greater and lesser omentum. *Arrow*, site of omental (epiploic) foramen.

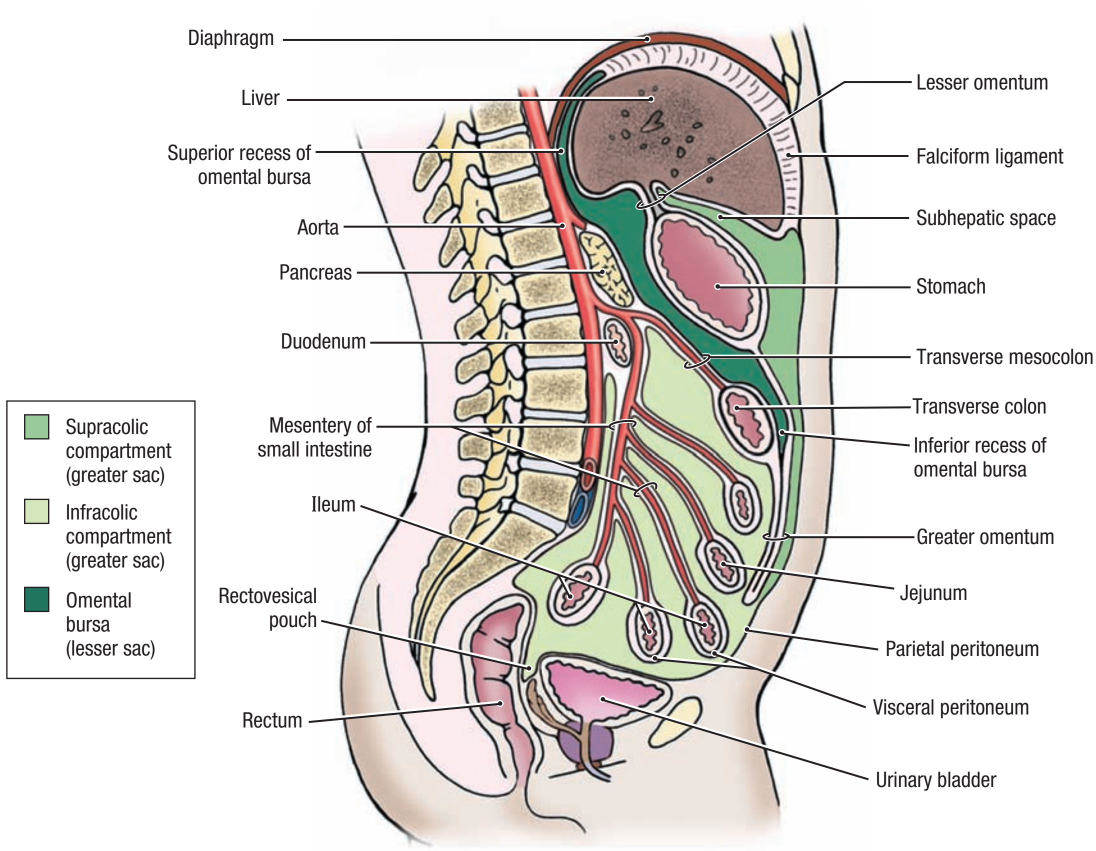


2.23 PERITONEAL FORMATIONS AND BARE AREAS

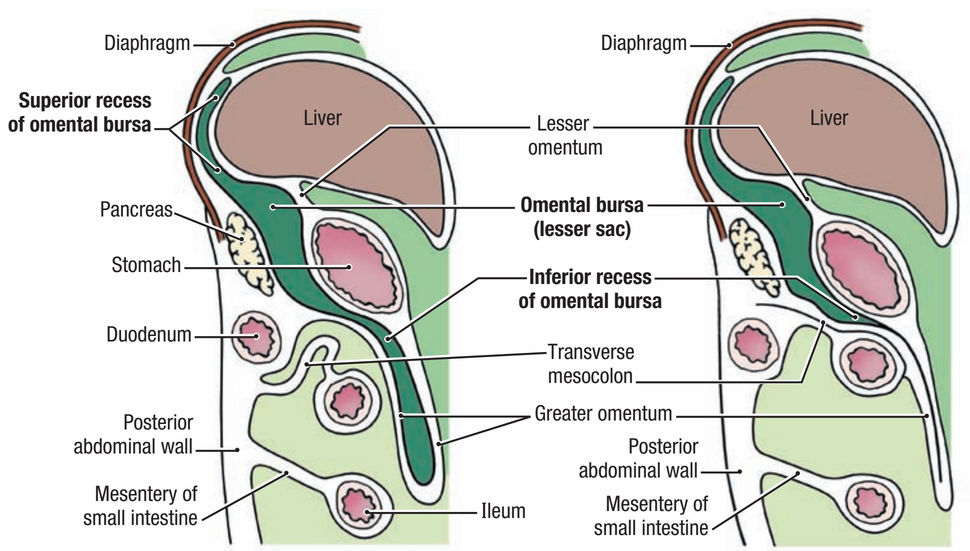
Various terms are used to describe the parts of the peritoneum that connect organs with other organs or to the abdominal wall and to describe the compartments and recesses that are formed as a consequence. The *arrow* passes through the omental (epiploic) foramen.

TABLE 2.4 TERMS USED TO DESCRIBE PARTS OF PERITONEUM

Term	Definition
Peritoneal ligament	Double layer of peritoneum that connects an organ with another organ or to the abdominal wall.
Mesentery	Double layer of peritoneum that occurs as a result of the invagination of the peritoneum by an organ and constitutes a continuity of the visceral and parietal peritoneum.
Omentum	Double-layered extension of peritoneum passing from the stomach and proximal part of the duodenum to adjacent organs. The greater omentum extends from the greater curvature of the stomach and the proximal duodenum; the lesser omentum from the lesser curvature.
Bare area	Every organ must have an area, the bare area, that is not covered with visceral peritoneum, to allow the entrance and exit of neurovascular structures. Bare areas are formed in relation to the attachments of mesenteries, omenta, and ligaments. Named bare areas, e.g., bare area of liver, are especially extensive in area.



A. **Right Lateral View**



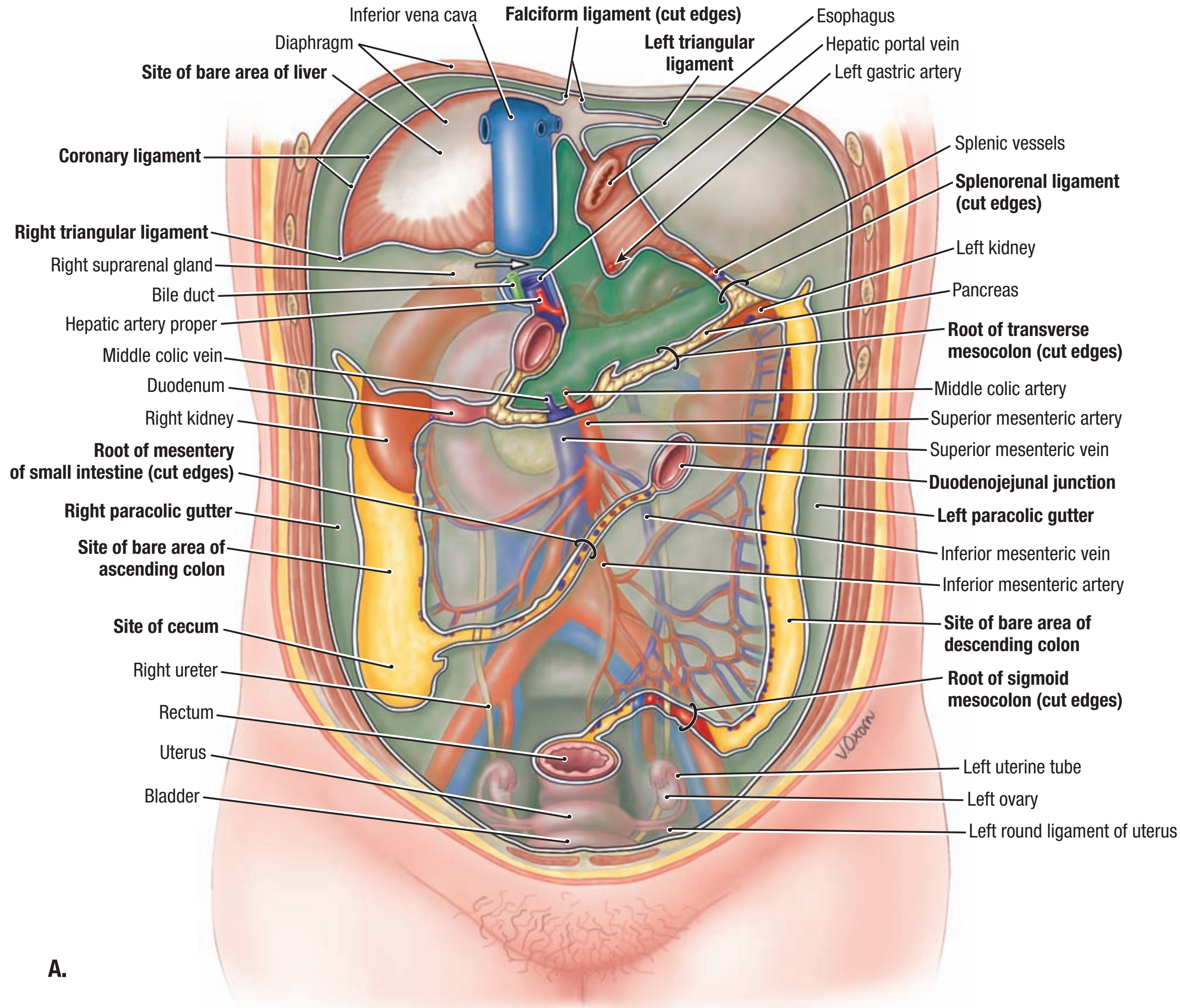
B. **Infant**

C. **Adult**

Schematic Sagittal Sections, Lateral View

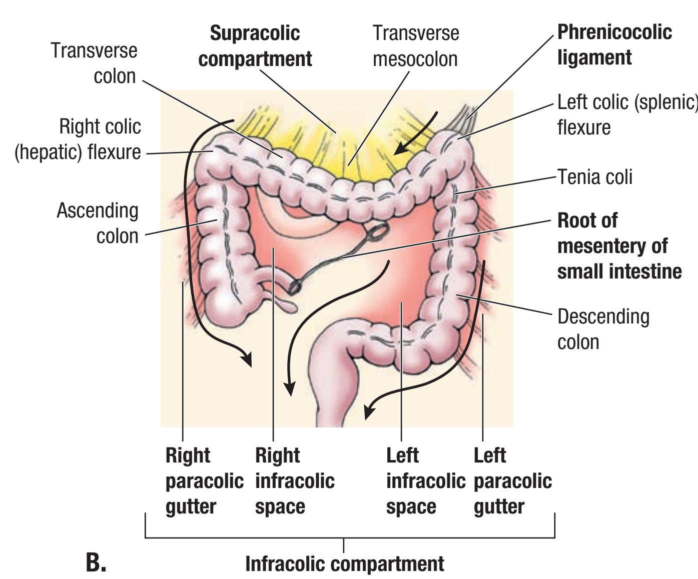
2.24 SUBDIVISIONS OF PERITONEAL CAVITY

A. Sagittal section. **B.** In an infant, the omental bursa (lesser sac) is an isolated part of the peritoneal cavity, lying dorsal to the stomach and extending superiorly to the liver and diaphragm (superior recess of the omental bursa) and inferiorly between the layers of the greater omentum (inferior recess of the omental bursa). **C.** In an adult, after fusion of the layers of the greater omentum, the inferior recess of the omental bursa now extends inferiorly only as far as the transverse colon. The *red arrows* pass from the greater sac through the omental (epiploic) foramen into the omental bursa.



A.

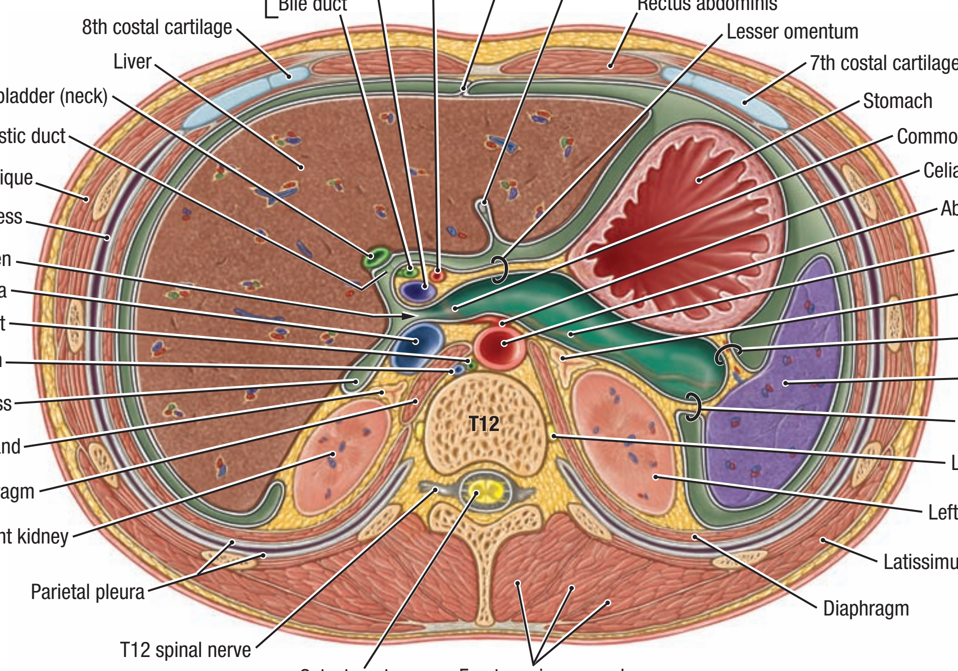
Anterior Views



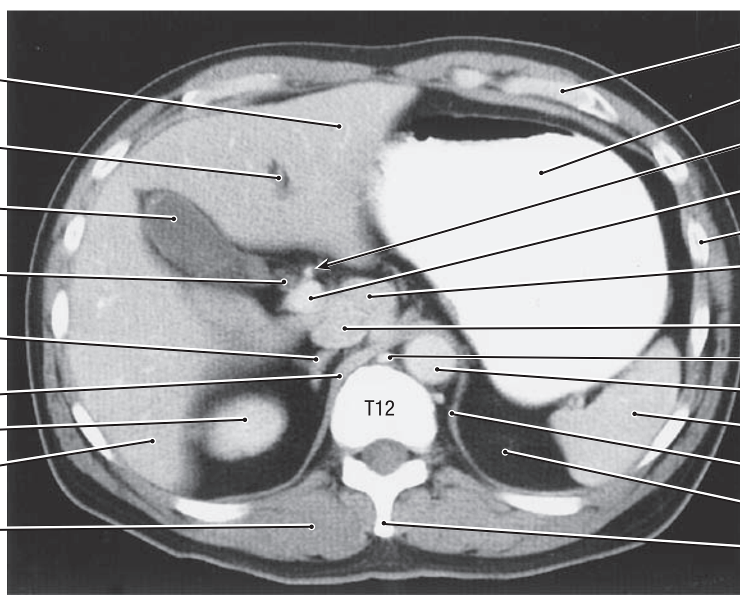
B.

2.25 POSTERIOR WALL OF PERITONEAL CAVITY

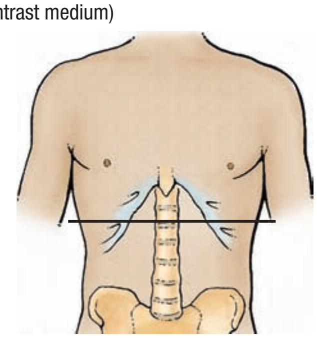
A. Roots of the peritoneal reflections. The peritoneal reflections from the posterior abdominal wall (mesenteries and reflections surrounding bare areas of liver and secondarily retroperitoneal organs) have been cut at their roots, and the intraperitoneal and secondarily retroperitoneal viscera have been removed. The *white arrow* passes through the omental (epiploic) foramen. **B.** Supracolic and infracolic compartments of the greater sac. The infracolic spaces and paracolic gutters are of clinical importance because they determine the paths (*black arrows*) for the **flow of ascitic fluid with changes in position**, and the spread of intraperitoneal infections.



A. **Inferior View**



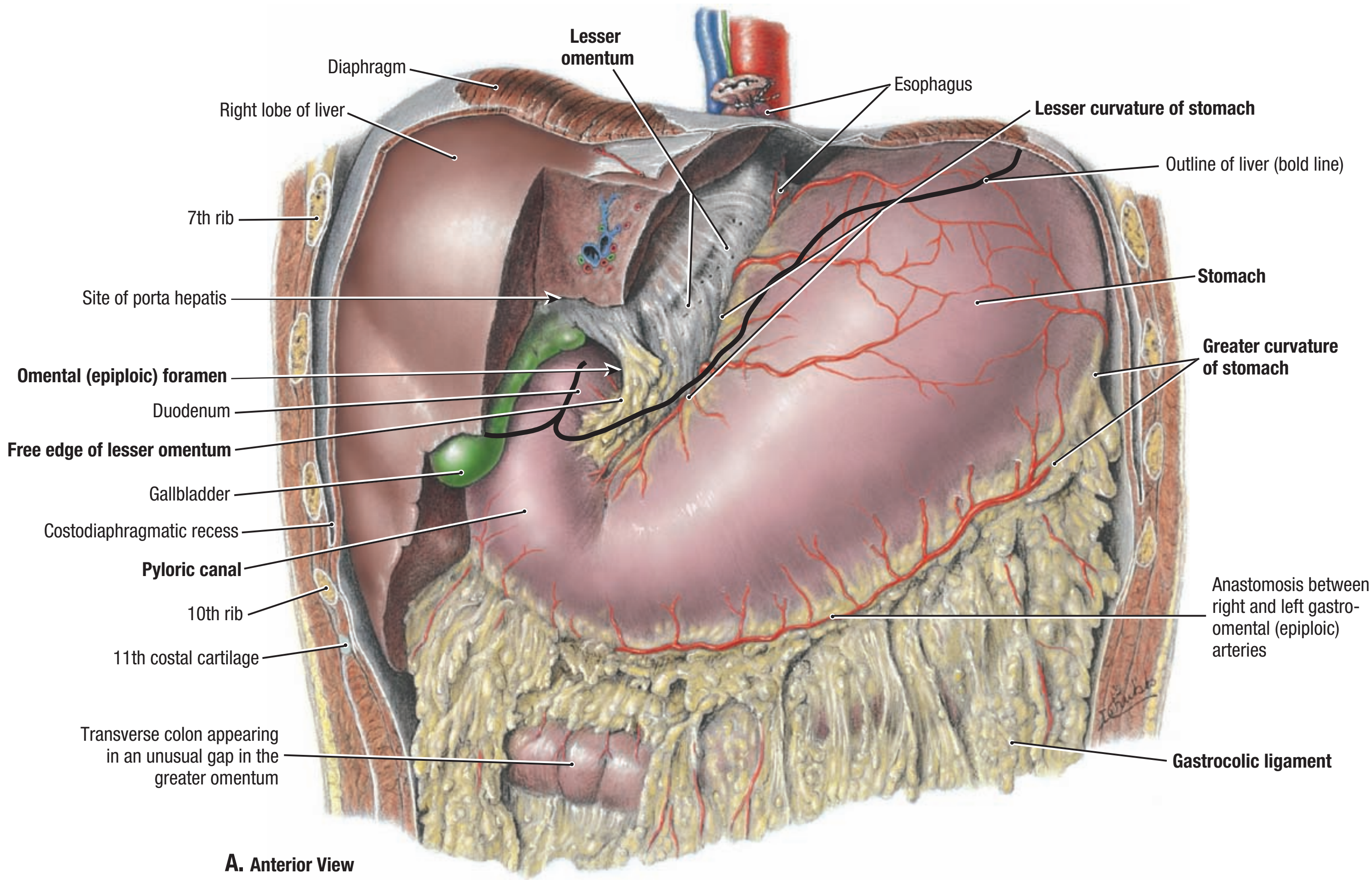
B. **CT Scan Inferior View**



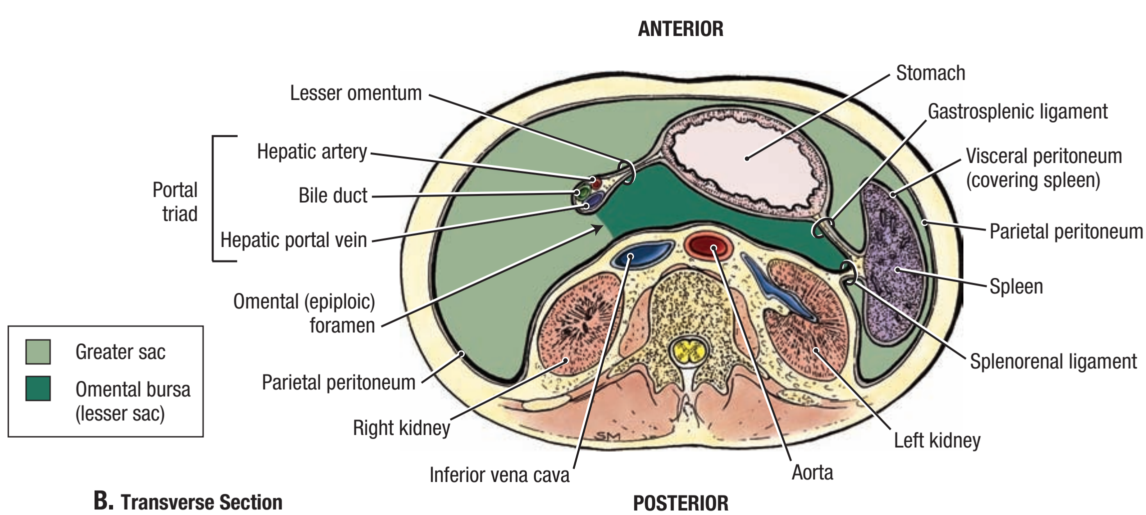
Plane of section (T12 vertebra) in A & B

2.26 TRANSVERSE SECTIONS THROUGH GREATER SAC AND OMENTAL BURSA

- When bacterial contamination occurs or when the gut is traumatically penetrated or ruptured as the result of infection and inflammation, gas, fecal matter, and bacteria enter the peritoneal cavity. The result is infection and inflammation of the peritoneum, called **peritonitis**.
- Under certain pathological conditions such as peritonitis, the peritoneal cavity may be distended with abnormal fluid, **ascites**. Widespread metastases (spread) of cancer cells to the abdominal viscera cause exudation (escape) of fluid that is often blood stained. Thus the peritoneal cavity may be distended with several liters of abnormal fluid. Surgical puncture of the peritoneal cavity for the aspiration of drainage of fluid is called **paracentesis**.



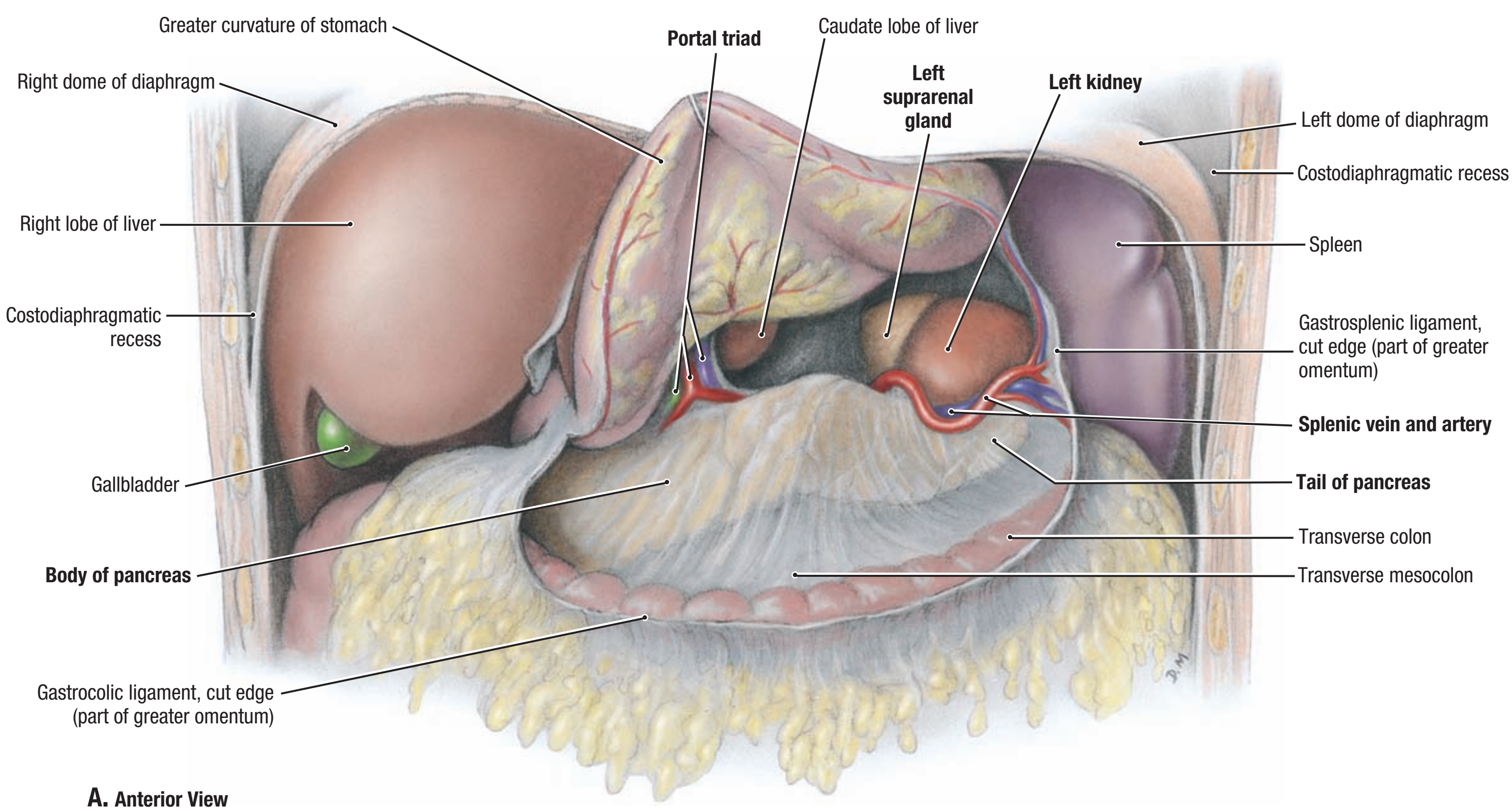
A. **Anterior View**



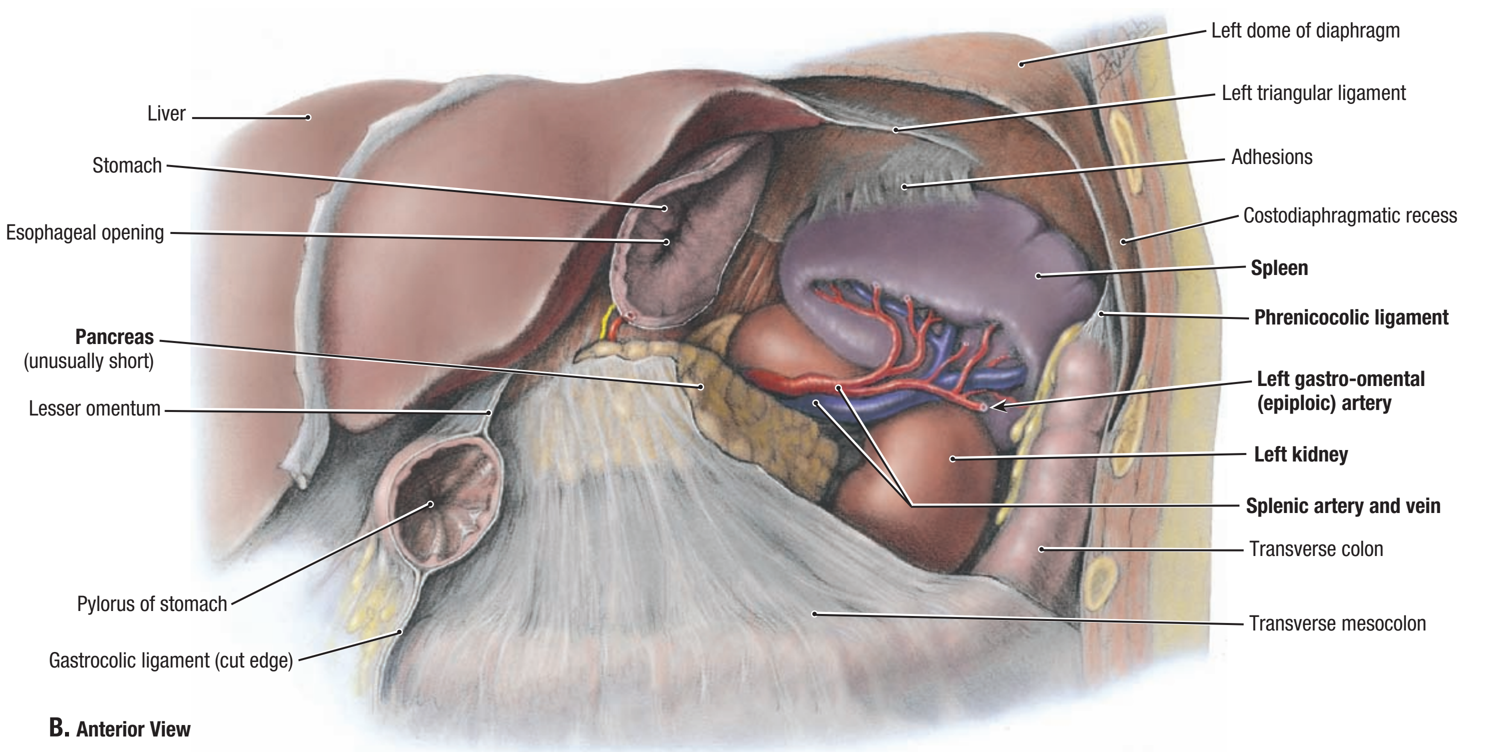
B. **Transverse Section**

2.27 STOMACH AND OMENTA

A. Lesser and greater omenta. The stomach is inflated with air, and the left part of the liver is cut away. The gallbladder, followed superiorly, leads to the free margin of the lesser omentum and serves as a guide to the omental (epiploic) foramen, which lies posterior to that free margin. **B.** Omental bursa (lesser sac), schematic transverse section.



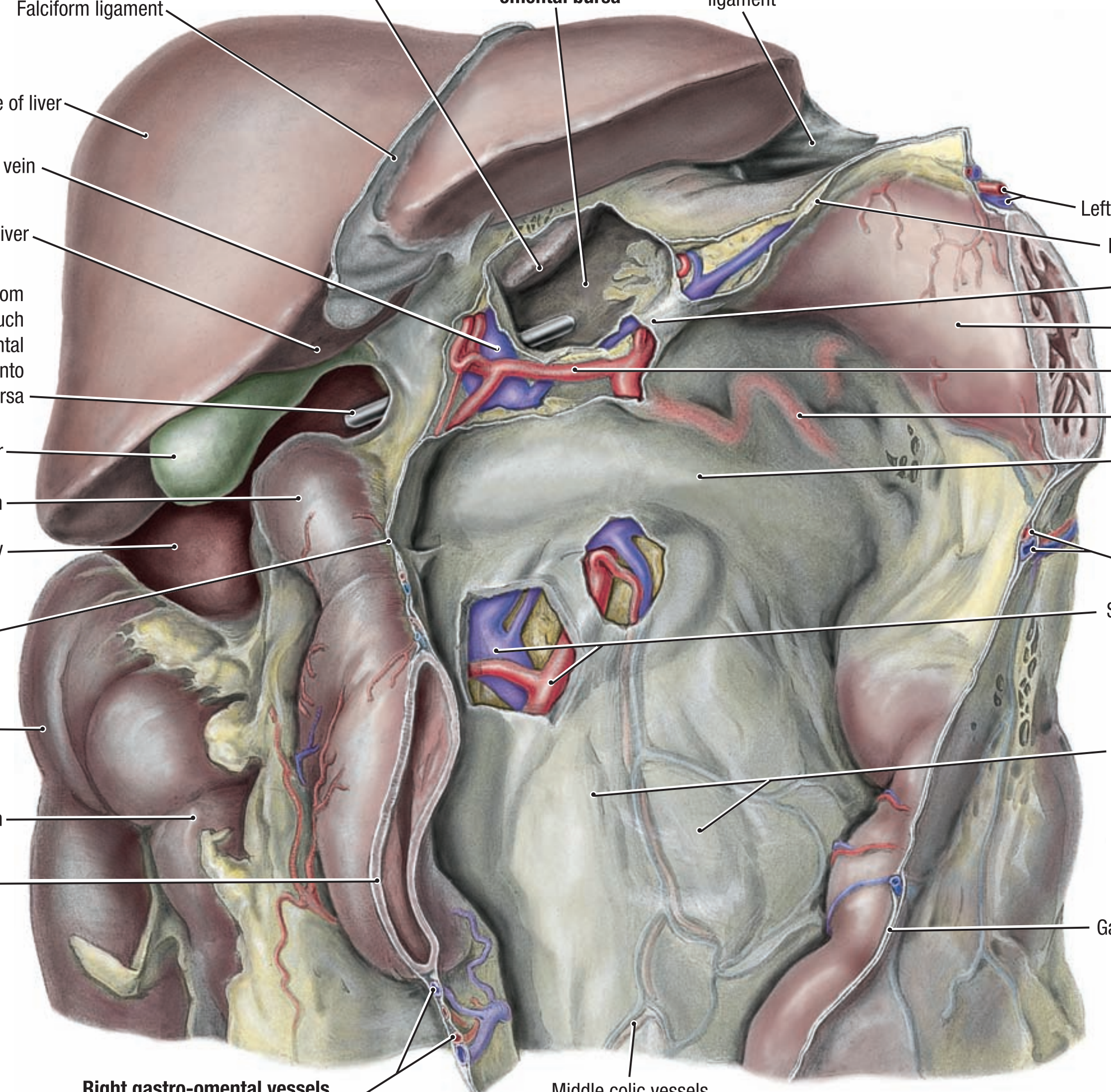
A. Anterior View



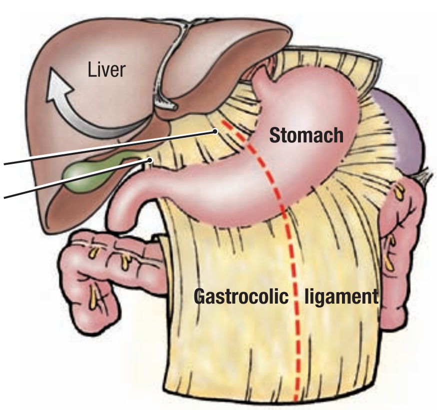
B. Anterior View

2.28 POSTERIOR RELATIONSHIPS OF OMENTAL BURSA (LESSER SAC)

A. Opened omental bursa. The greater omentum has been cut along the greater curvature of the stomach; the stomach is reflected superiorly. Peritoneum of the stomach bed is partially removed. **B.** Stomach bed. The stomach is excised. Peritoneum covering the stomach bed and inferior part of the kidney and pancreas is largely removed. **Adhesions** binding the spleen to the diaphragm are pathological, but not unusual.



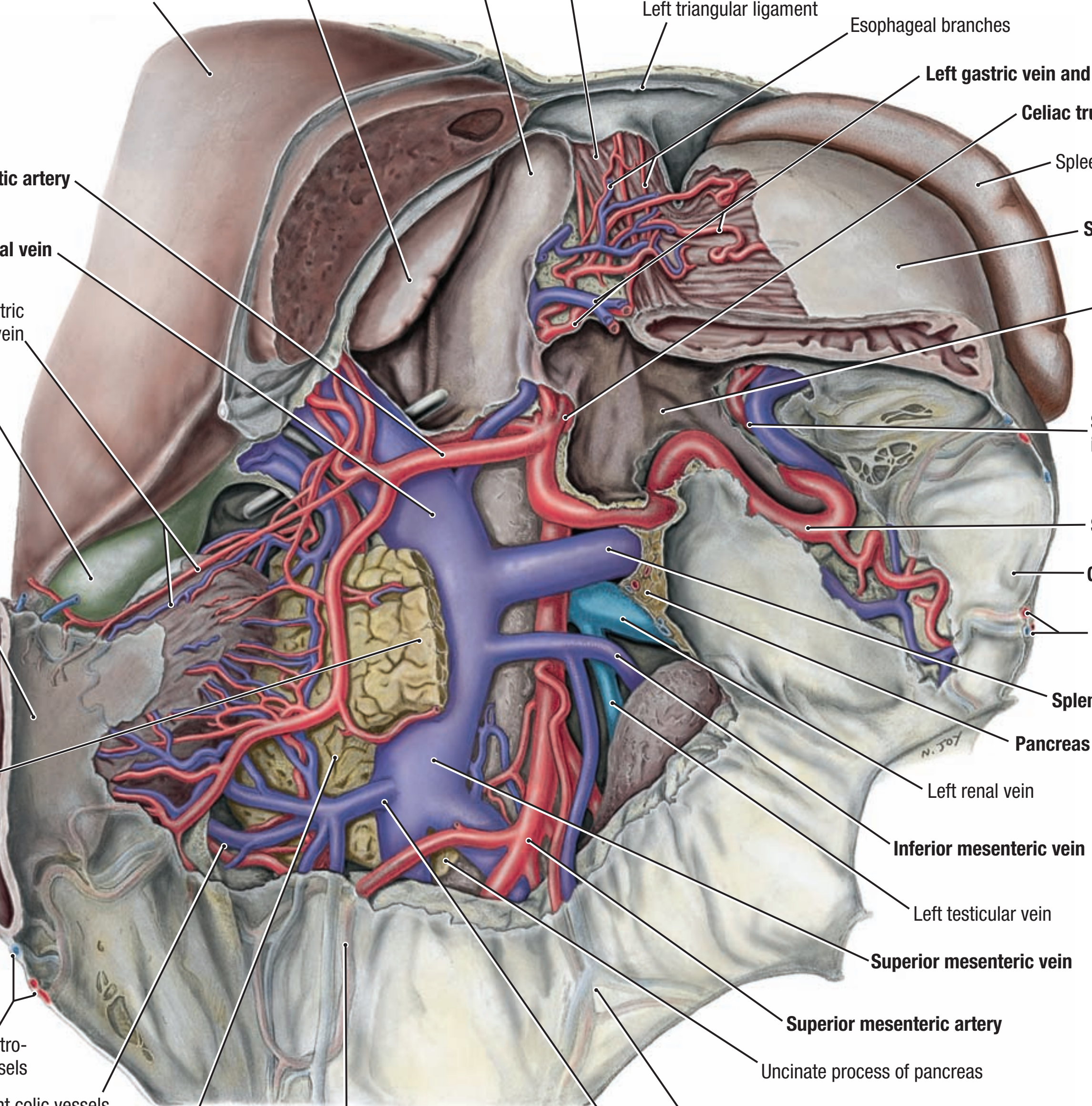
A. Anterior View



B. Anterior View

2.29 OMENTAL BURSA (LESSER SAC), OPENED

A. Dissection. **B.** Line of incision in **A.** The anterior wall of the omental bursa, consisting of the stomach, lesser omentum, anterior layer of the greater omentum, and vessels along the curvatures of the stomach, has been sectioned sagittally. The two halves have been retracted to the left and right: the body of the stomach on the left side, and the pyloric part of the stomach and first part of the duodenum on the right. The right kidney forms the posterior wall of the hepatorenal pouch (part of greater sac), and the pancreas lies horizontally on the posterior wall of the main compartment of the omental bursa (lesser sac). The gastrocolic ligament forms the anterior wall and the lower part of the posterior wall of the inferior recess of the omental bursa. The transverse mesocolon forms the upper part of the posterior wall of the inferior recess of the omental bursa.

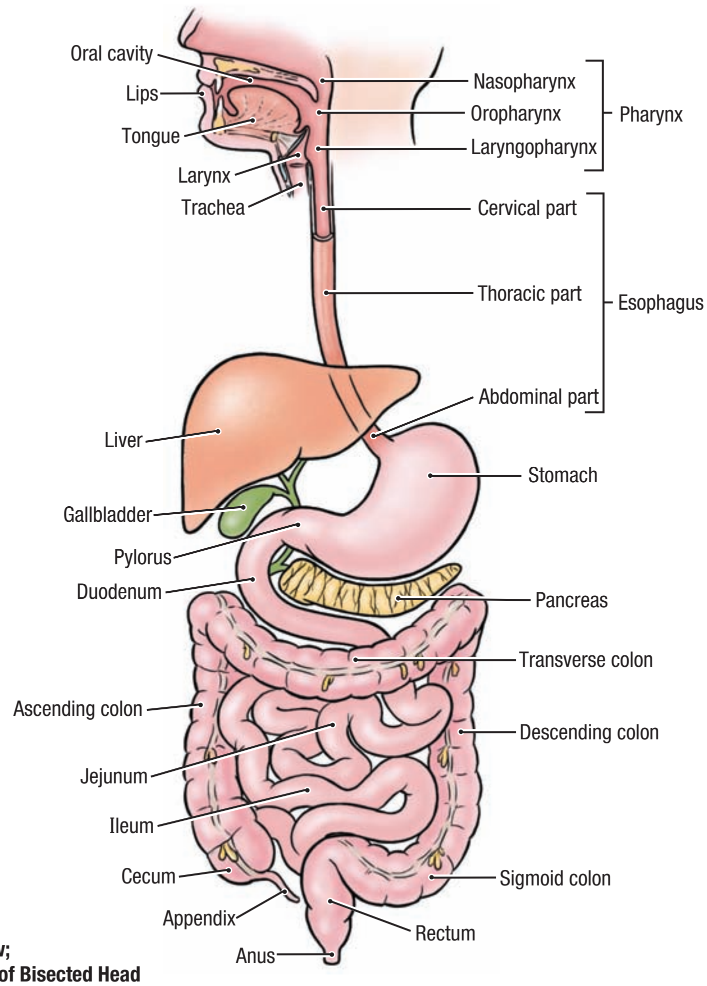


Anterior View

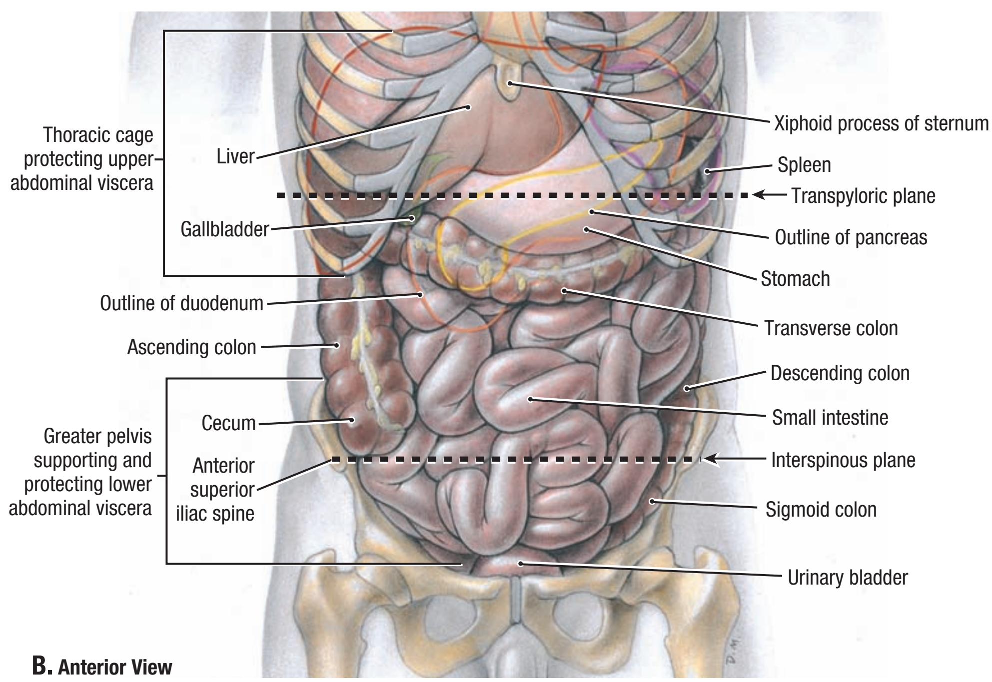
2.30 POSTERIOR WALL OF OMENTAL BURSA

The parietal peritoneum of the posterior wall of the omental bursa has been mostly removed, and a section of the pancreas has been excised. The rod passes through the omental foramen.

- The celiac trunk gives rise to the left gastric artery, the splenic artery that runs tortuously to the left, and the common hepatic artery that runs to the right, passing anterior to the hepatic portal vein.
- The hepatic portal vein is formed posterior to the neck of the pancreas by the union of the superior mesenteric and splenic veins, with the inferior mesenteric vein joining at or near the angle of union.
- The left testicular vein usually drains into the left renal vein. Both are systemic veins.
- **Inflammation of the parietal peritoneum** can occur due to an enlarged organ or by the escape of fluid from an organ. The area becomes inflamed and causes pain over the affected region.
- **Rebound tenderness** is a pain that is elicited after pressure over the inflamed area is released.



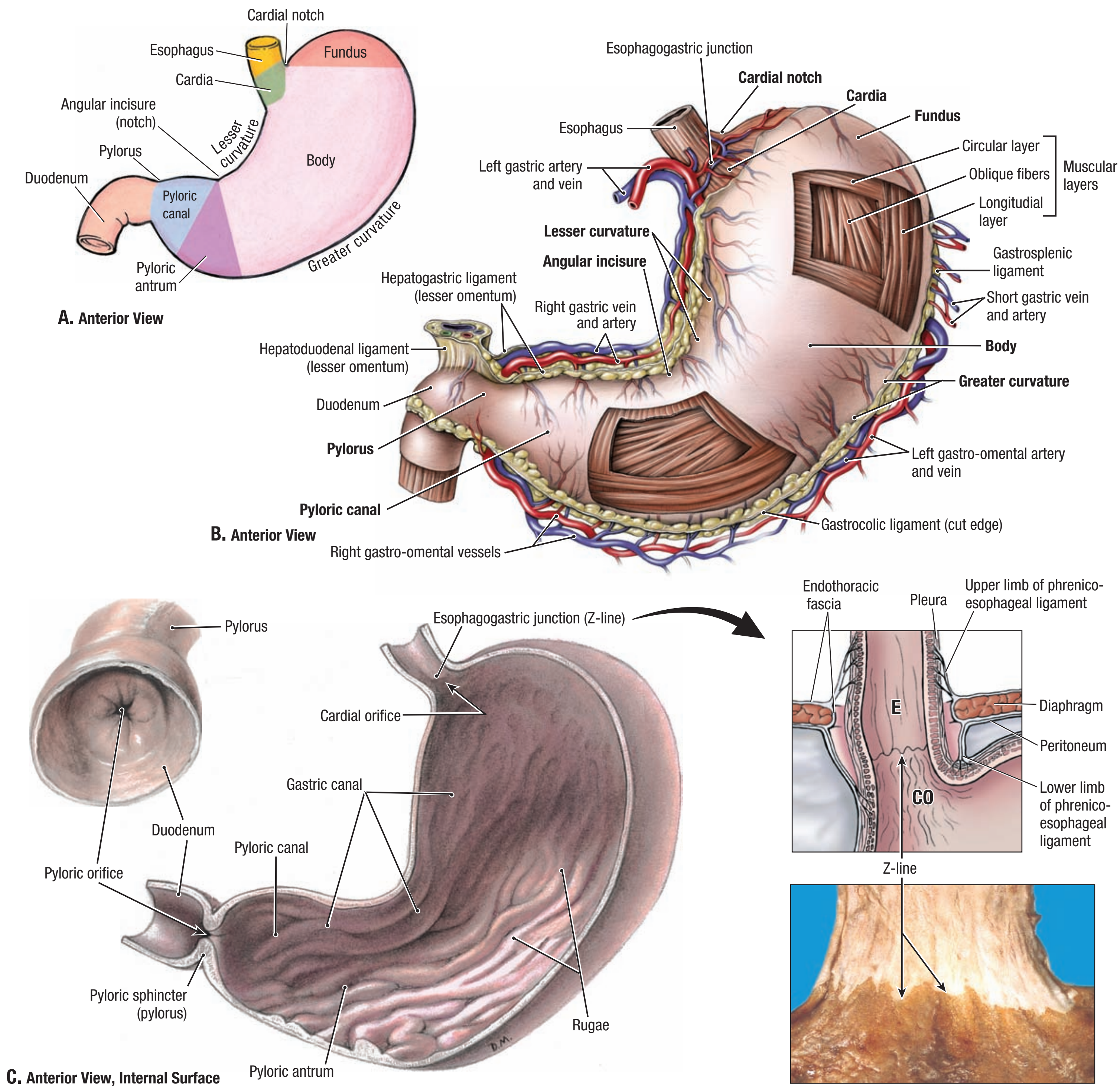
A. **Anterior View; Medial View of Bisected Head**



B. **Anterior View**

2.31 DIGESTIVE SYSTEM

A. Schematic illustration. **B.** Abdominal portion. The digestive system extends from the lips to the anus. Associated organs include the liver, gallbladder, and pancreas.



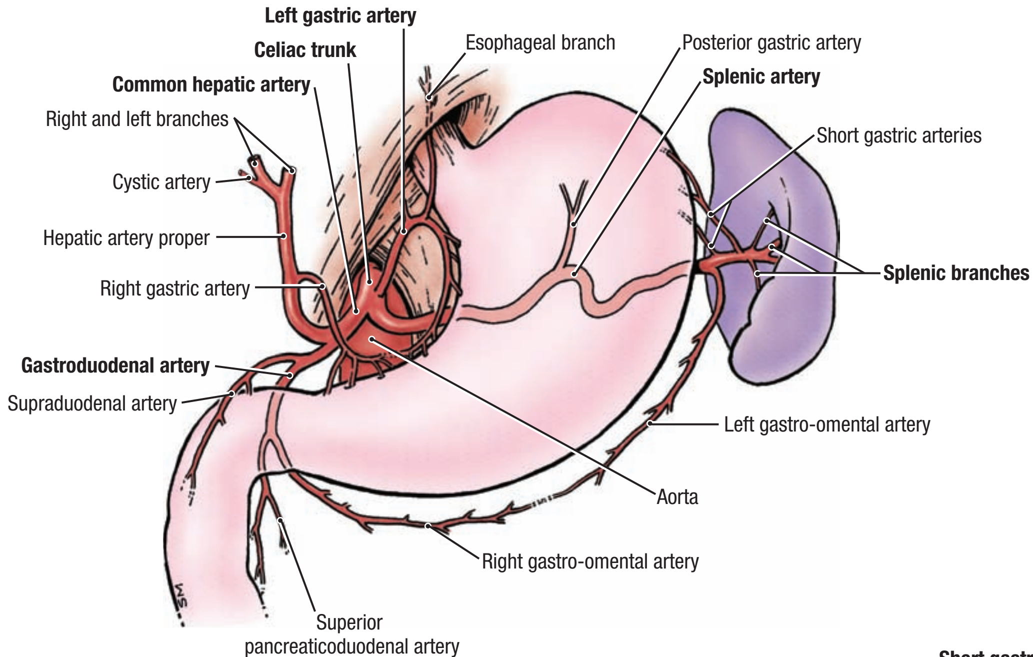
A. **Anterior View**

B. **Anterior View**

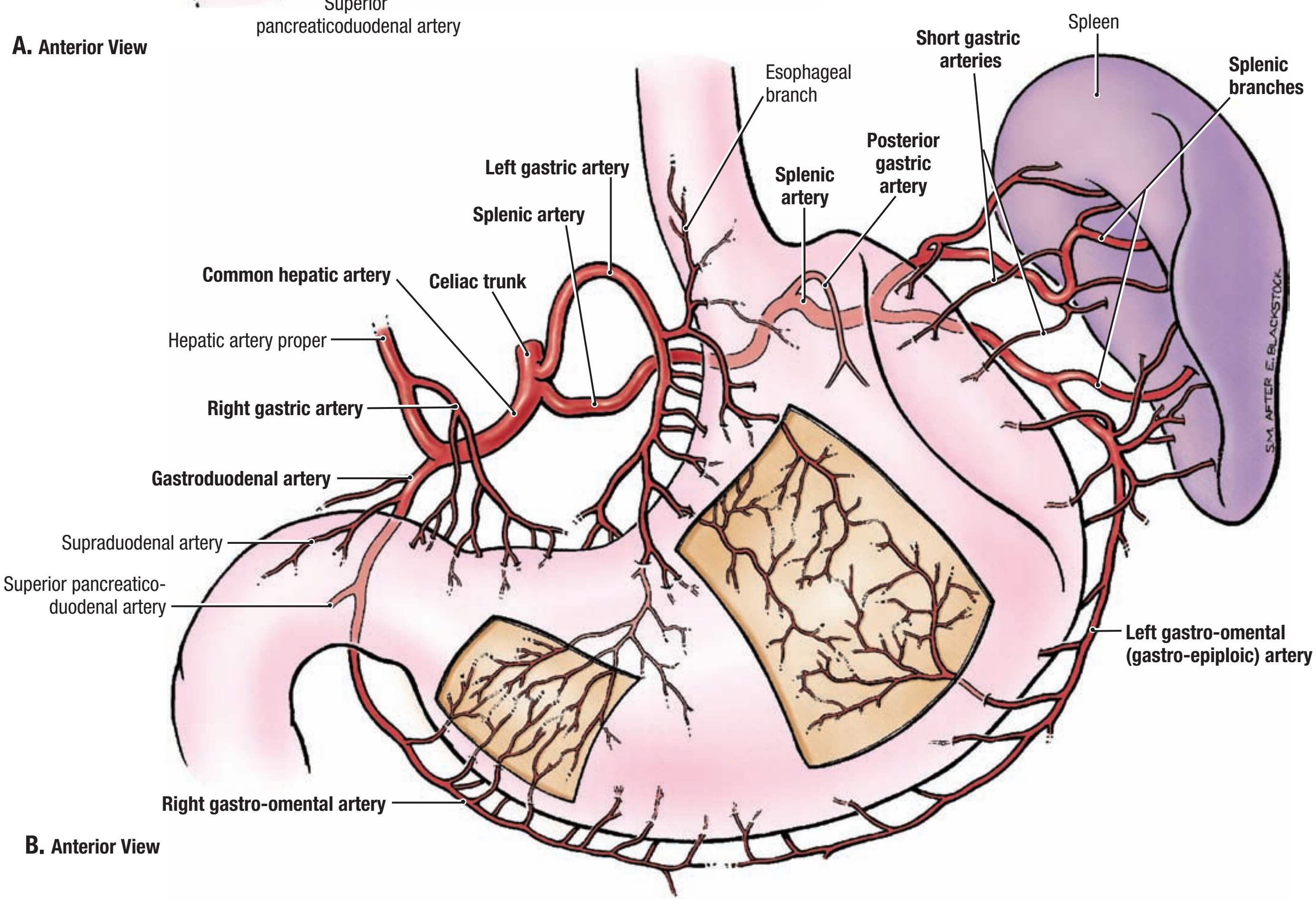
C. **Anterior View, Internal Surface**

2.32 STOMACH

A. Parts. **B.** External surface. **C.** Internal surface (mucous membrane), anterior wall removed. Insets: Left side of page—pylorus, viewed from the duodenum. Right side of page—details of the esophagogastric junction. The Z-line is where the stratified squamous epithelium of the esophagus (white portion in photograph) to the simple columnar epithelium of the stomach (dark portion).



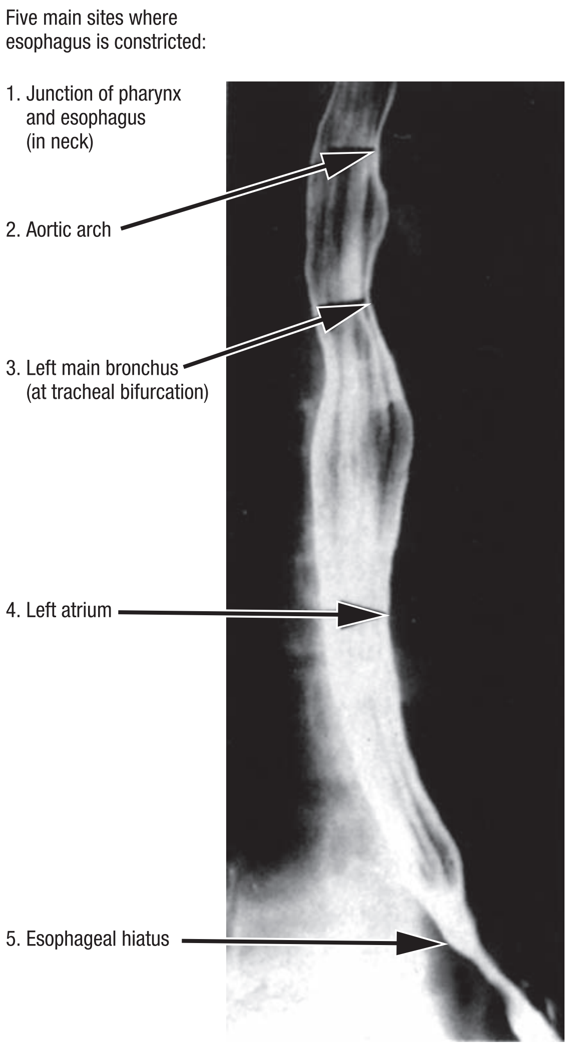
A. **Anterior View**



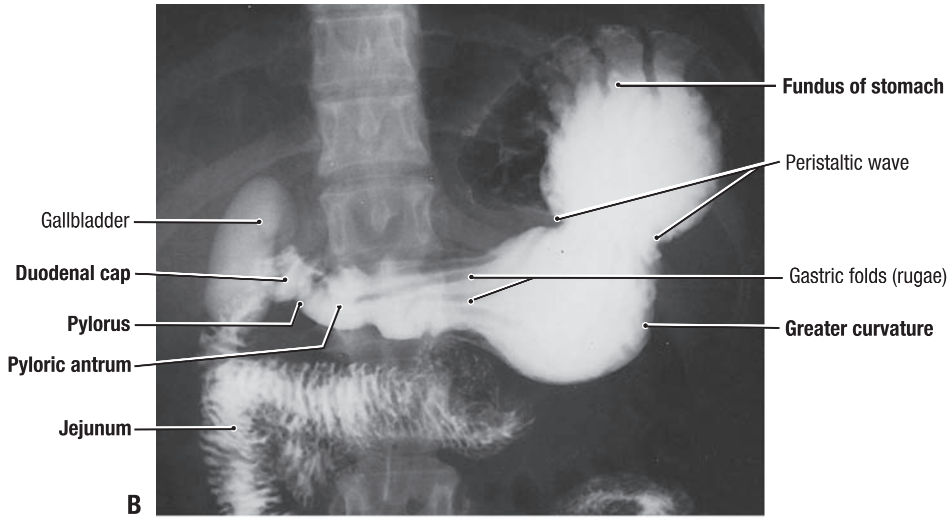
B. **Anterior View**

2.33 CELIAC ARTERY

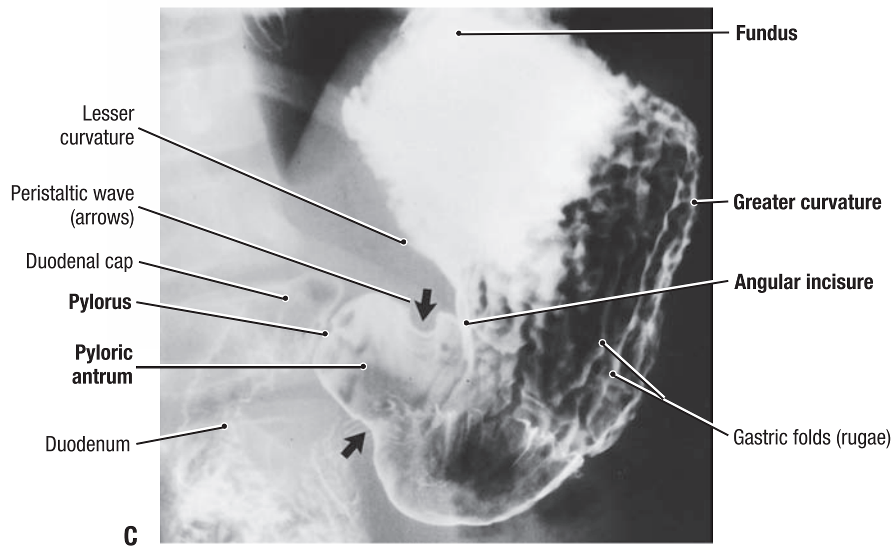
A. Branches of celiac trunk. The celiac trunk is a branch of the abdominal aorta, arising immediately inferior to the aortic hiatus of the diaphragm (T12 vertebral level). The vessel is usually 1 to 2 cm long and divides into the left gastric, common hepatic, and splenic arteries. The celiac trunk supplies the liver, gall bladder, inferior esophagus, stomach, pancreas, spleen, and duodenum. **B.** Arteries of stomach and spleen. The serous and muscular coats are removed from two areas of the stomach, revealing anastomotic networks in the submucous coat.



A. Lateral View



B



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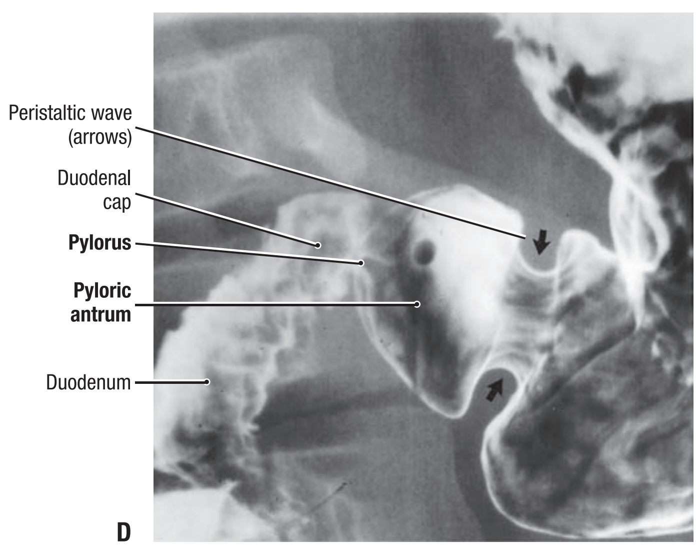


D

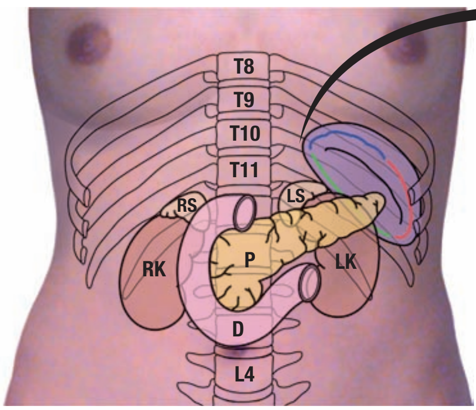
Anterior Views (B–D)

2.34 RADIOGRAPHS OF ESOPHAGUS, STOMACH, DUODENUM (BARIUM SWALLOW)

A. Five sites of normal esophageal constriction. **B.** Stomach, small intestine, and gallbladder. Note additional contrast medium in gallbladder. **C.** Stomach and duodenum. **D.** Pyloric antrum and duodenal cap.

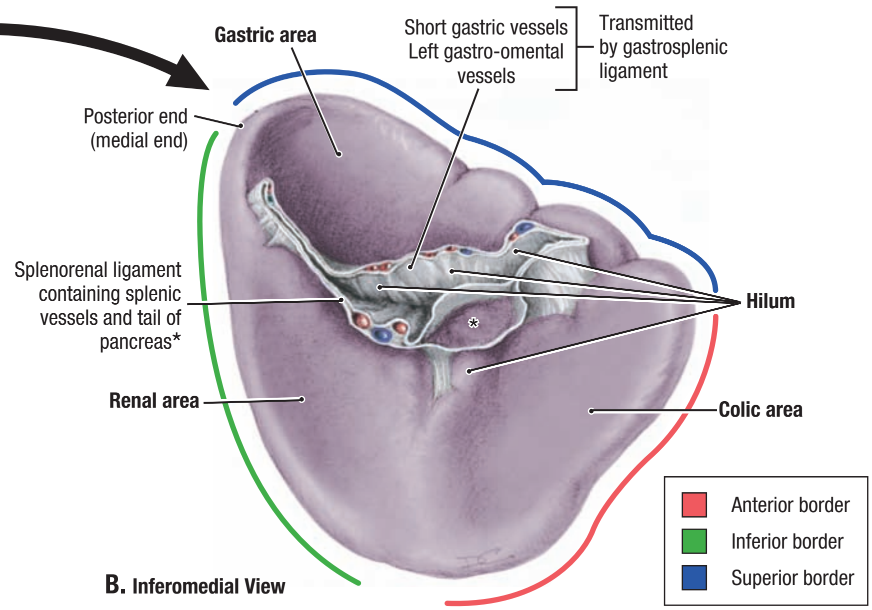
Blockage of esophagus. The impressions produced in the esophagus by adjacent structures are of clinical interest because of the slower passage of substances at these sites. The impressions indicate where swallowed foreign objects are most likely to lodge and where a stricture may develop, for example, after the accidental drinking of a caustic liquid, such as lye.

A **hiatal (hiatus) hernia** is a protrusion of a part of the stomach into the mediastinum through the esophageal hiatus of the diaphragm. The hernias occur most often in people after middle age, possibly because of weakening of the muscular part of the diaphragm and widening of the esophageal hiatus.



A. Anterior View

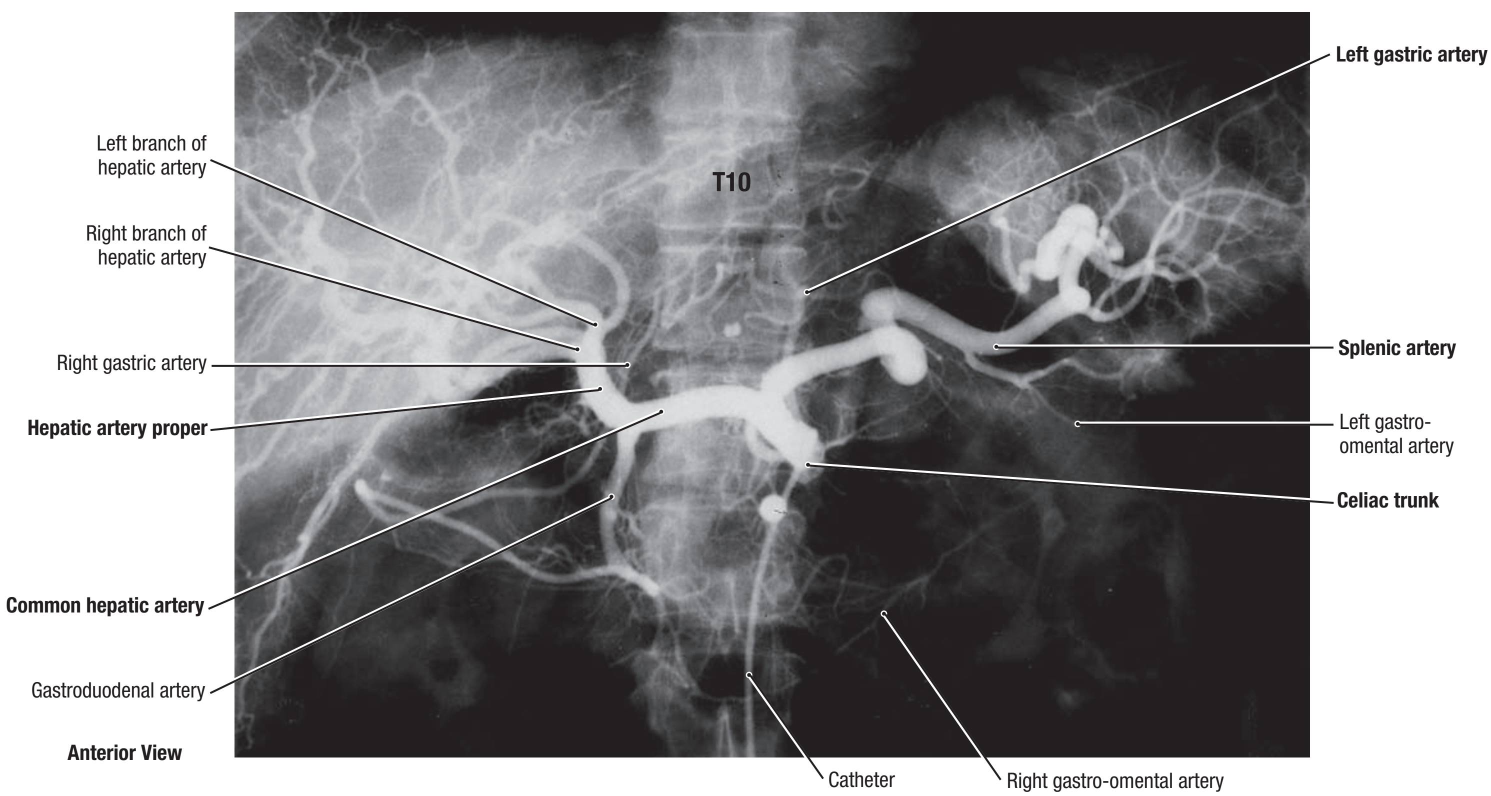
D	Duodenum	P	Pancreas
LK	Left kidney	RK	Right kidney
LS	Left suprarenal gland	RS	Right suprarenal gland



B. Inferomedial View

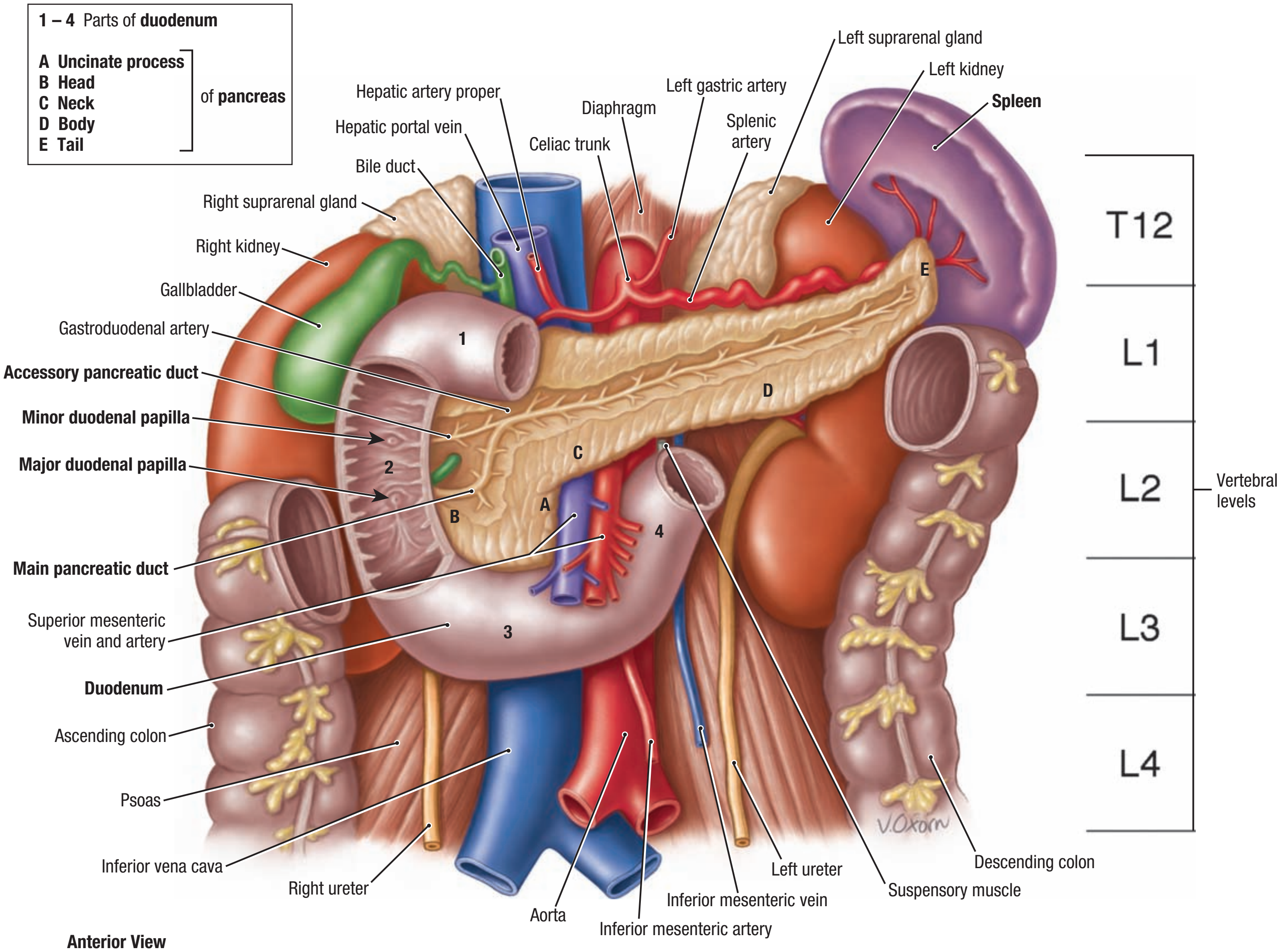
2.35 SPLEEN

A. The surface anatomy of the spleen. The spleen lies superficially in the left upper abdominal quadrant between the 9th and 11th ribs. **B.** Note the impressions (colic, renal, and gastric areas) made by structures in contact with its visceral surface. The superior border is notched.



Anterior View

2.36 CELIAC ARTERIOGRAM

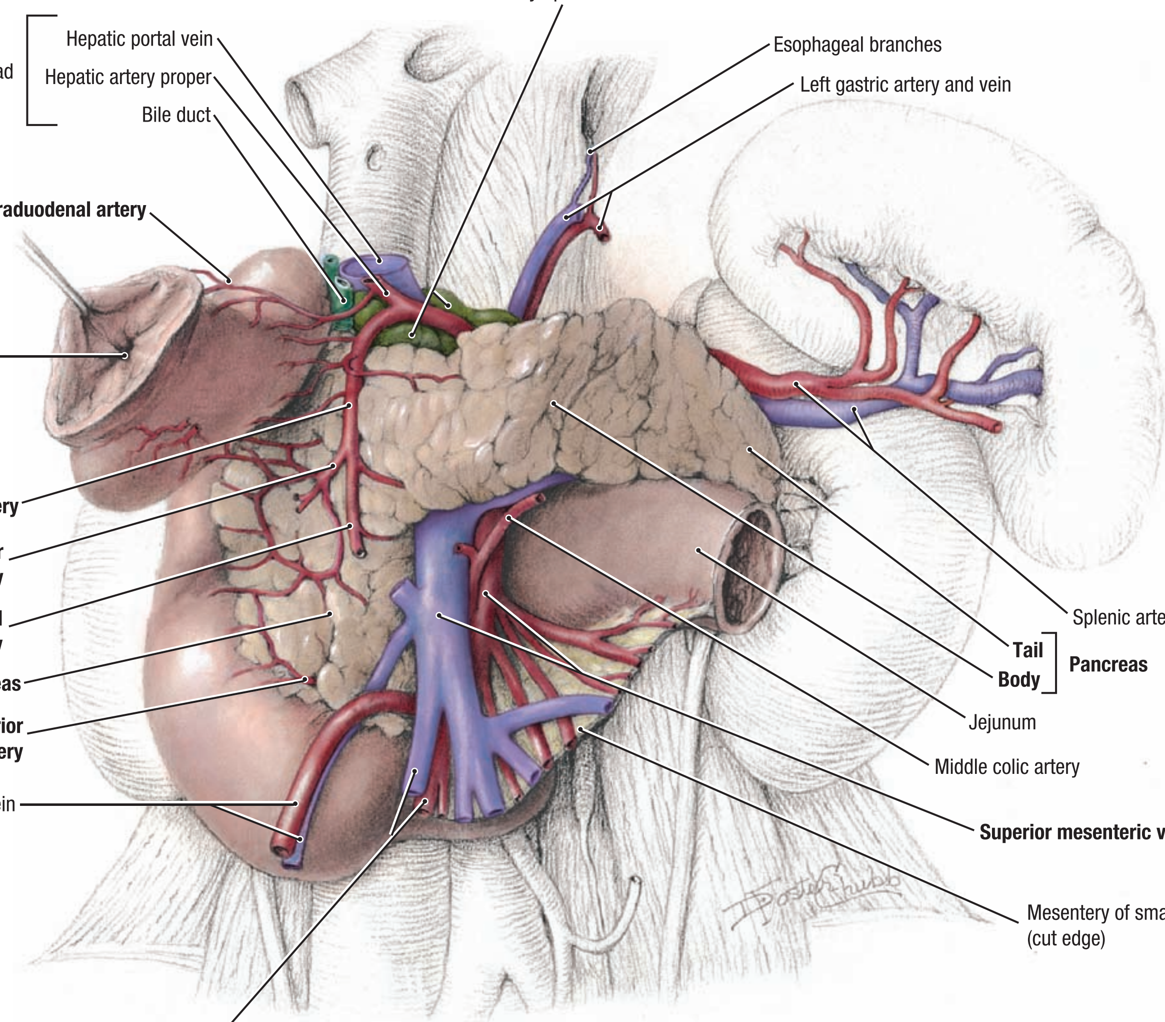


2.37 PARTS AND RELATIONSHIPS OF PANCREAS AND DUODENUM

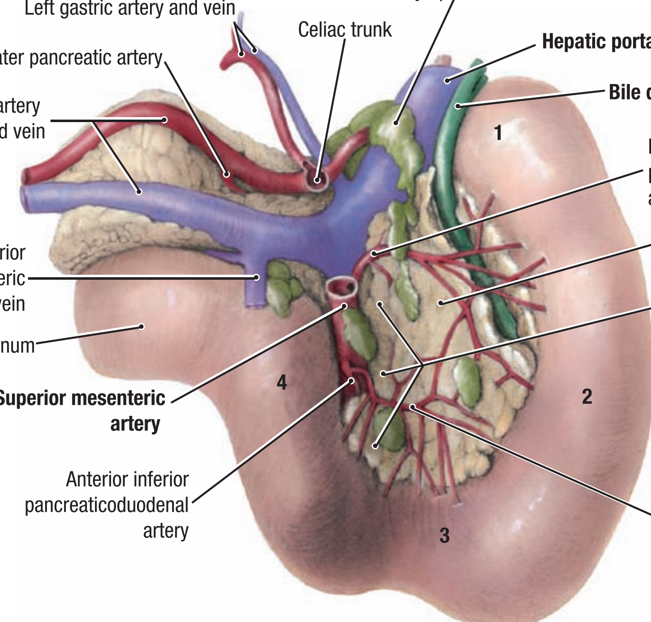
A. Pancreas and duodenum in situ.

TABLE 2.5 PARTS AND RELATIONSHIPS OF DUODENUM

Part of Duodenum	Anterior	Posterior	Medial	Superior	Inferior	Vertebral Level
Superior (**1**st part)	Peritoneum Gallbladder Quadrate lobe of liver	Bile duct Gastroduodenal artery Hepatic portal vein IVC		Neck of gallbladder	Neck of pancreas	Anterolateral to L1 vertebra
Descending (**2**nd part)	Transverse colon Transverse mesocolon Coils of small intestine	Hilum of right kidney Renal vessels Ureter Psoas major	Head of pancreas Pancreatic duct Bile duct			Right of L2–L3 vertebrae
Inferior (horizontal or **3**rd part)	Superior mesenteric artery Superior mesenteric vein Coils of small intestine	Right psoas major IVC Aorta Right ureter		Head and uncinate process of pancreas Superior mesenteric artery and vein		Anterior to L3 vertebra
Ascending (**4**th part)	Beginning of root of mesentery Coils of jejunum	Left psoas major Left margin of aorta	Superior mesenteric artery and vein	Body of pancreas		Left of L3 vertebra



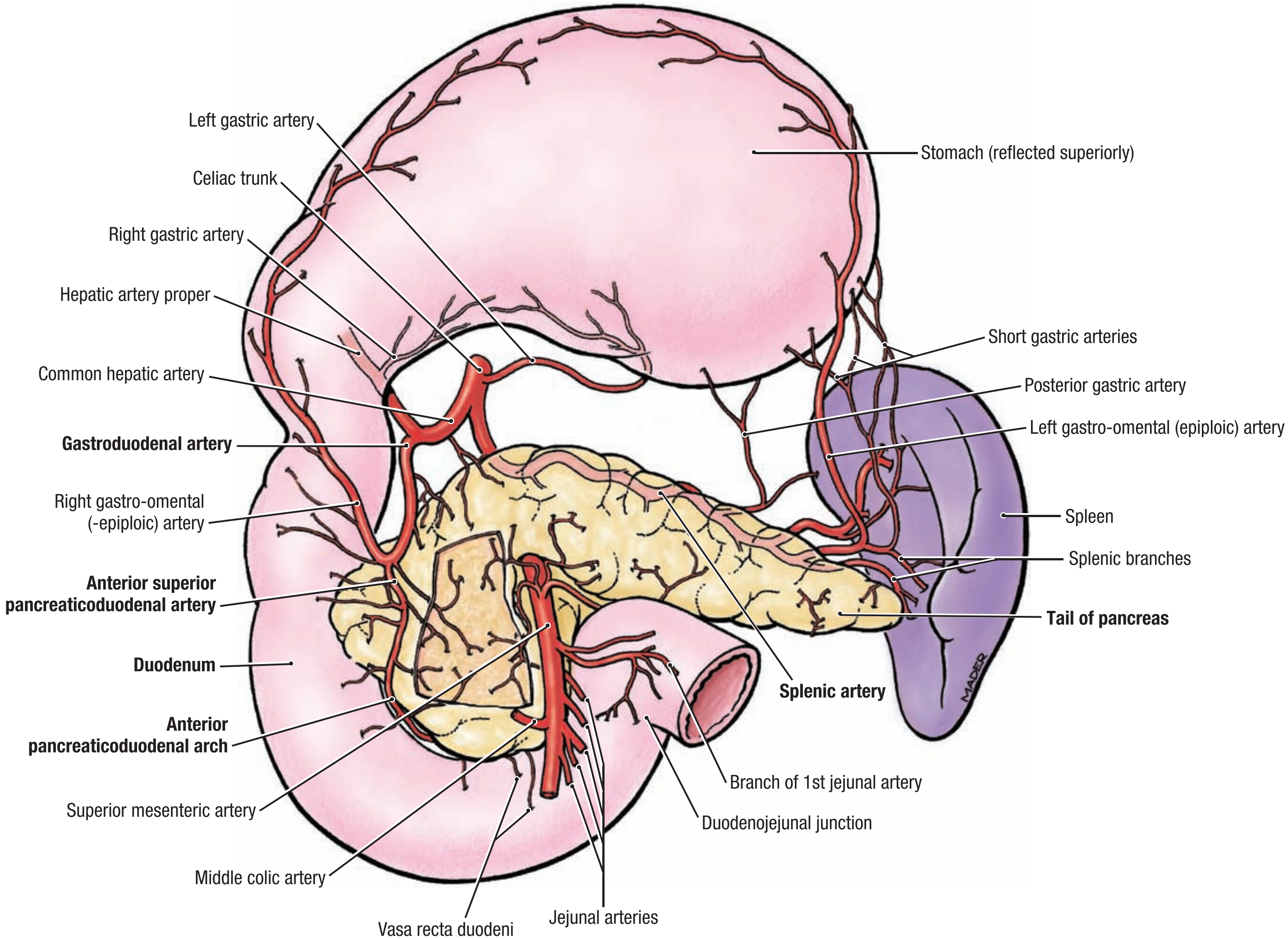
A. **Anterior View**



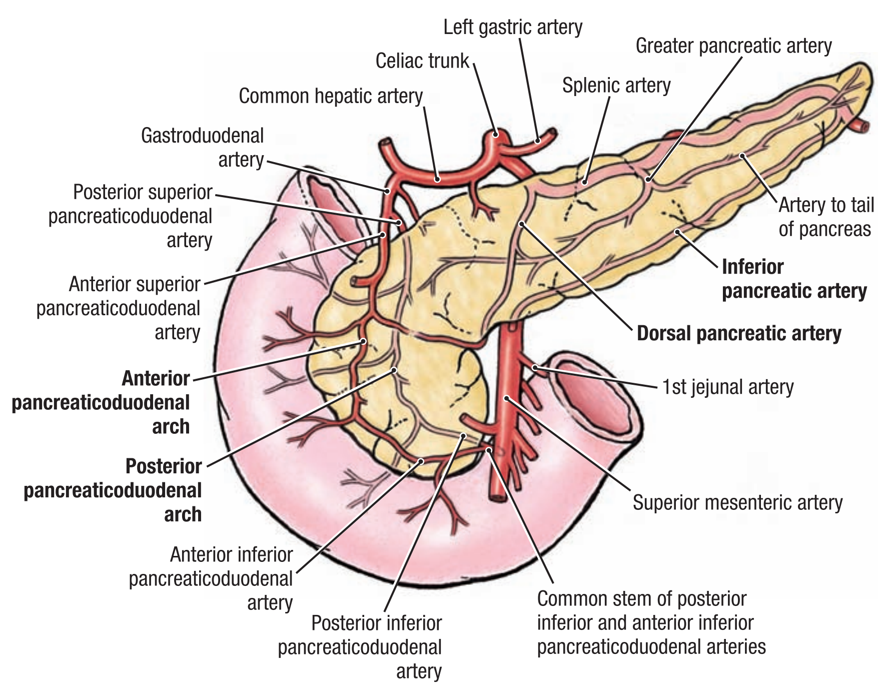
B. **Posterior View**

2.38 PARTS AND RELATIONSHIPS OF PANCREAS AND DUODENUM (*CONTINUED*)

B. Anterior relationships. The gastroduodenal artery descends anterior to the neck of the pancreas. **C.** Posterior relationships. The splenic artery and vein course on the posterior aspect of the pancreatic tail, which usually extends to the spleen. The pancreas "loops" around the right side of the superior mesenteric vessels so that its neck is anterior, its head is to the right, and its uncinate process is posterior to the vessels. The splenic and superior mesenteric veins unite posterior to the neck to form the hepatic portal vein. The bile duct descends in a fissure (opened up) in the posterior part of the head of the pancreas. Most inflammatory erosions of the duodenal wall, **duodenal (peptic) ulcers**, are in the posterior wall of the superior (1st) part of the duodenum within 3 cm of the pylorus.



A. **Anterior View, with Stomach Reflected Superiorly**

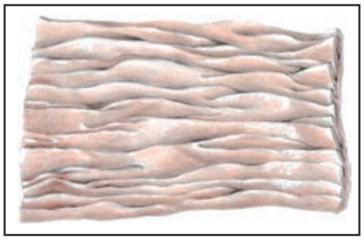


B. **Anterior View**

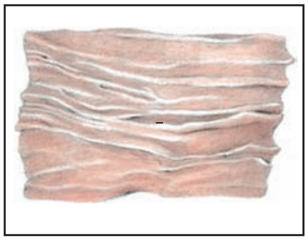
2.39 BLOOD SUPPLY TO THE PANCREAS, DUODENUM, AND SPLEEN

A. Celiac trunk and superior mesenteric artery. **B.** Pancreatic and pancreaticoduodenal arteries.

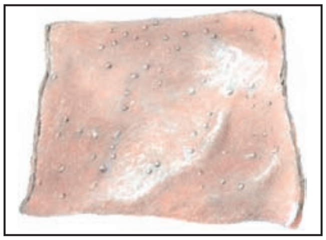
- The anterior superior pancreaticoduodenal artery from the gastroduodenal artery and the anterior inferior pancreaticoduodenal artery of the superior mesenteric artery form the anterior pancreaticoduodenal arch anterior to the head of the pancreas. The posterior superior and posterior inferior branches of the same two arteries form the posterior pancreaticoduodenal arch posterior to the pancreas. The anterior and posterior inferior arteries often arise from a common stem.
- Arteries supplying the pancreas are derived from the common hepatic artery, gastroduodenal artery, pancreaticoduodenal arches, splenic artery, and superior mesenteric artery.



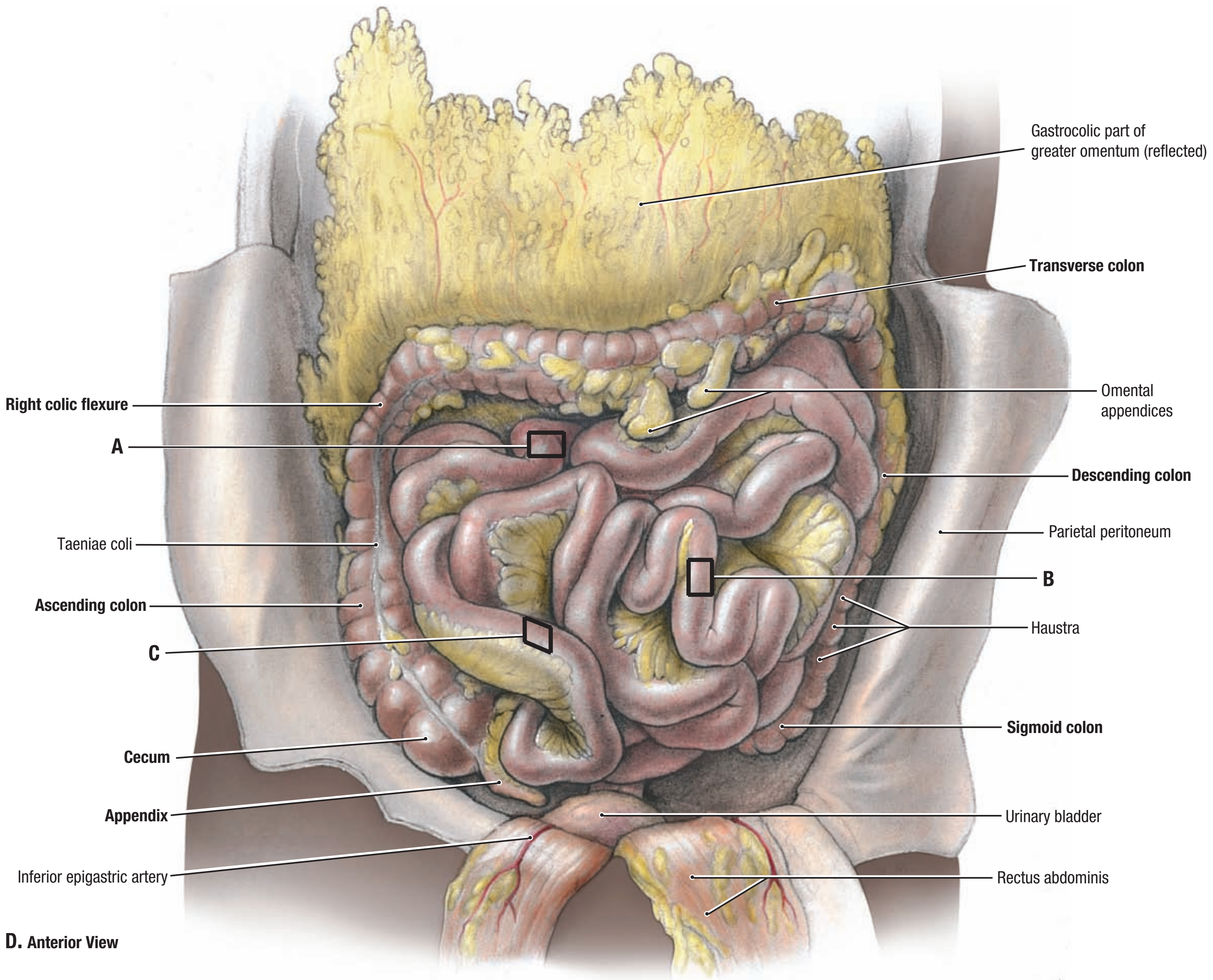
A. Proximal Jejunum



B. Proximal Ileum



C. Distal Ileum

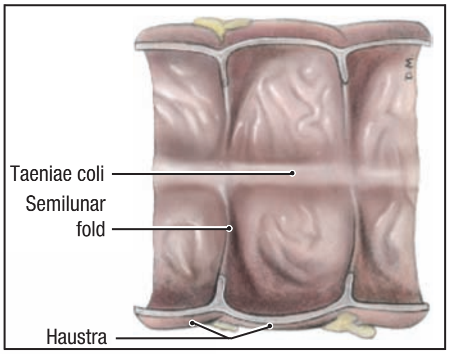


D. Anterior View

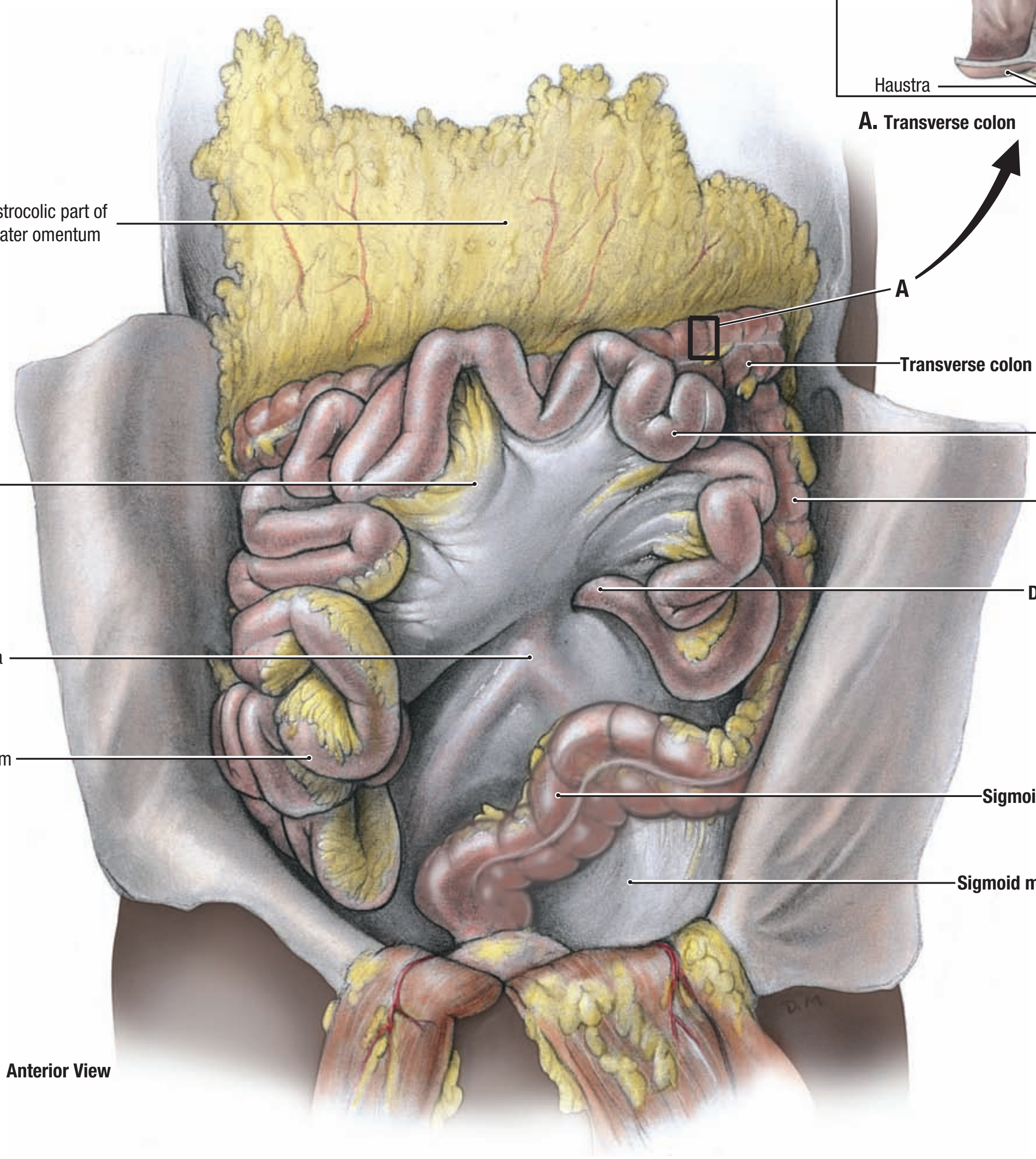
2.40 INTESTINES IN SITU, INTERIOR OF SMALL INTESTINE

A. Proximal jejunum. The circular folds are tall, closely packed, and commonly branched. **B.** Proximal ileum. The circular folds are low and becoming sparse. The caliber of the gut is reduced, and the wall is thinner. **C.** Distal ileum. Circular folds are absent, and solitary lymph nodules stud the wall.

D. Intestines in situ, greater omentum reflected. The ileum is reflected to expose the appendix. The appendix usually lies posterior to the cecum (retrocecal) or, as in this case, projects over the pelvic brim. The features of the large intestines are the taeniae coli, haustra, and omental appendices.



A. Transverse colon

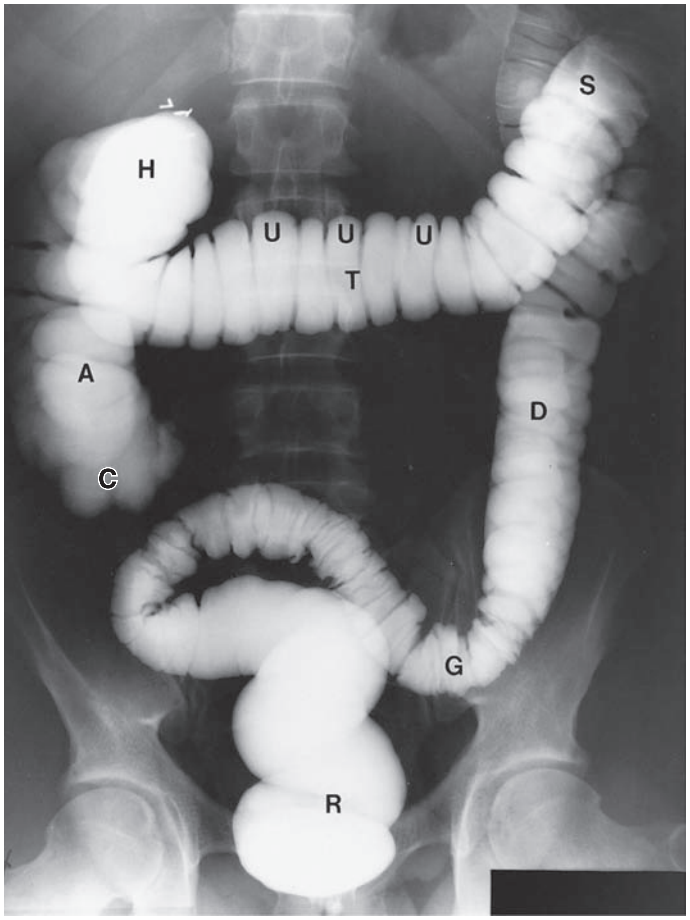


B. Anterior View

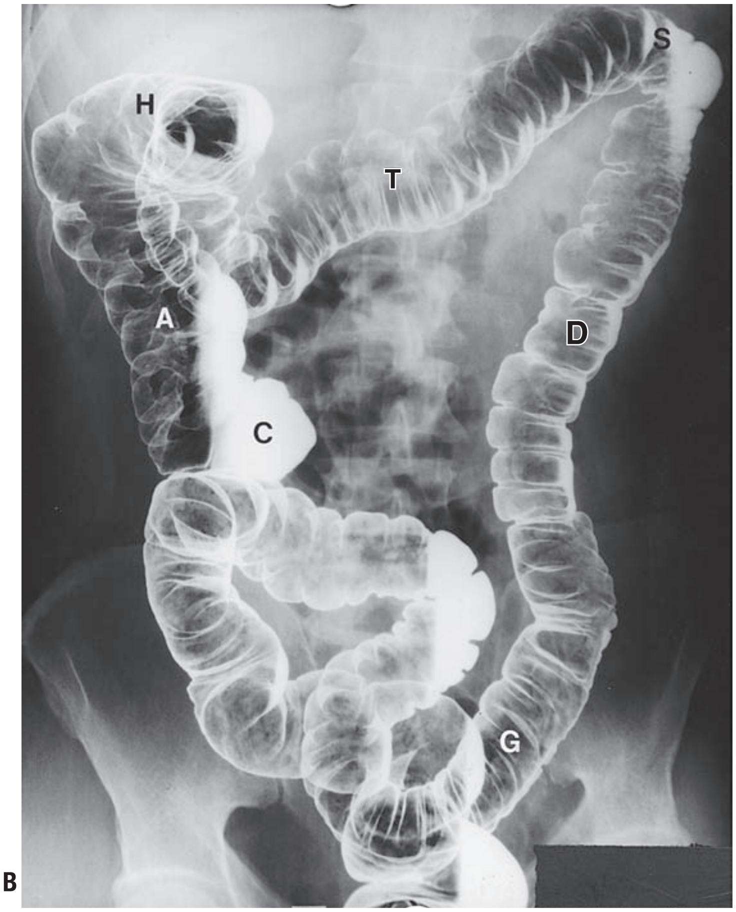
2.41 SIGMOID MESOCOLON AND MESENTERY OF SMALL INTESTINE, INTERIOR OF TRANSVERSE COLON

A. Transverse colon. The semilunar folds and taeniae coli form prominent features on the smooth-surfaced wall. **B.** Sigmoid mesocolon and mesentery of the small intestine.

- The duodenojejunal junction is situated to the left of the median plane.
- The mesentery of the small intestine fans out extensively from its short root to accommodate the length of jejunum and ileum (~6 m).
- The descending colon is the narrowest part of the large intestine and is retroperitoneal. The sigmoid colon has a mesentery, the sigmoid mesocolon; the sigmoid colon is continuous with the rectum at the point at which the sigmoid mesocolon ends.



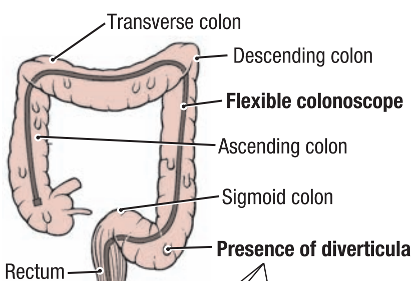
A



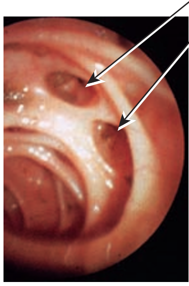
B

Postero-anterior Radiographs

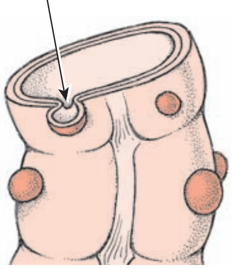
A	Ascending colon	G	Sigmoid colon	S	Splenic flexure
C	Cecum	H	Hepatic flexure	T	Transverse colon
D	Descending colon	R	Rectum	U	Haustra



C. Anterior View



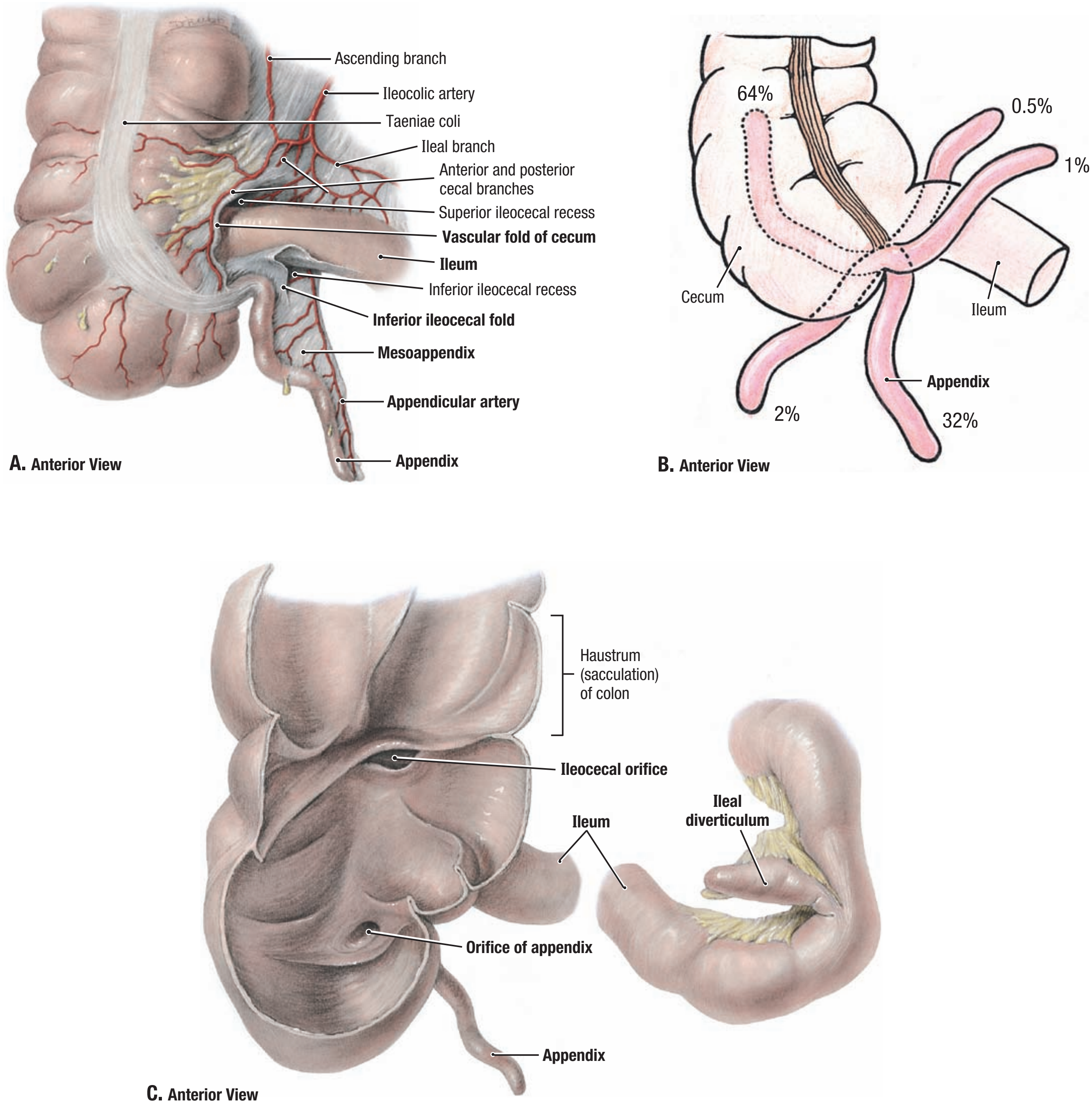
D. Colonoscopic View



E. Diverticulosis

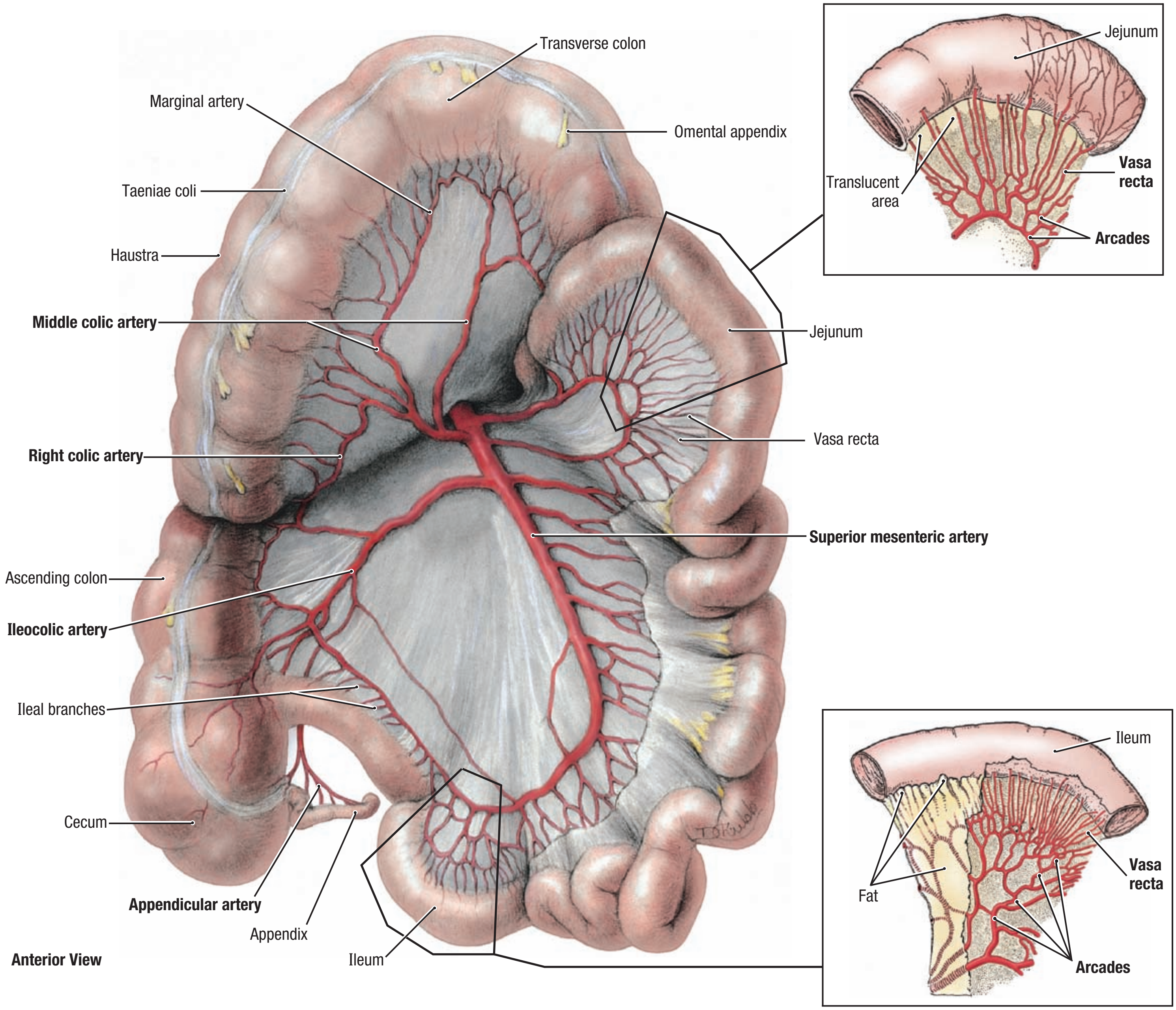
2.42 BARIUM ENEMA AND COLONOSCOPY OF COLON

A. Single-contrast study. A barium enema has filled the colon. **B. Double-contrast study.** Barium can be seen coating the walls of the colon, which is distended with air, providing a vivid view of the mucosal relief and haustra. C. The interior of the colon can be observed with an elongated endoscope, usually a fiberoptic **flexible colonoscope.** The endoscope is a tube that inserts into the colon through the anus and rectum. **D. Diverticulosis of the colon** can be photographed through a colonoscope. **E. Diverticulosis** is a disorder in which multiple false diverticula (external evaginations or outpocketings of the mucosa of the colon) develop along the intestine. It primarily affects middle-aged and elderly people. Diverticulosis is commonly (60%) found in the sigmoid colon. Diverticula are subject to infection and rupture, leading to **diverticulitis,** and they can distort and erode the nutrient arteries, leading to hemorrhage.



2.43 ILEOCECAL REGION AND APPENDIX

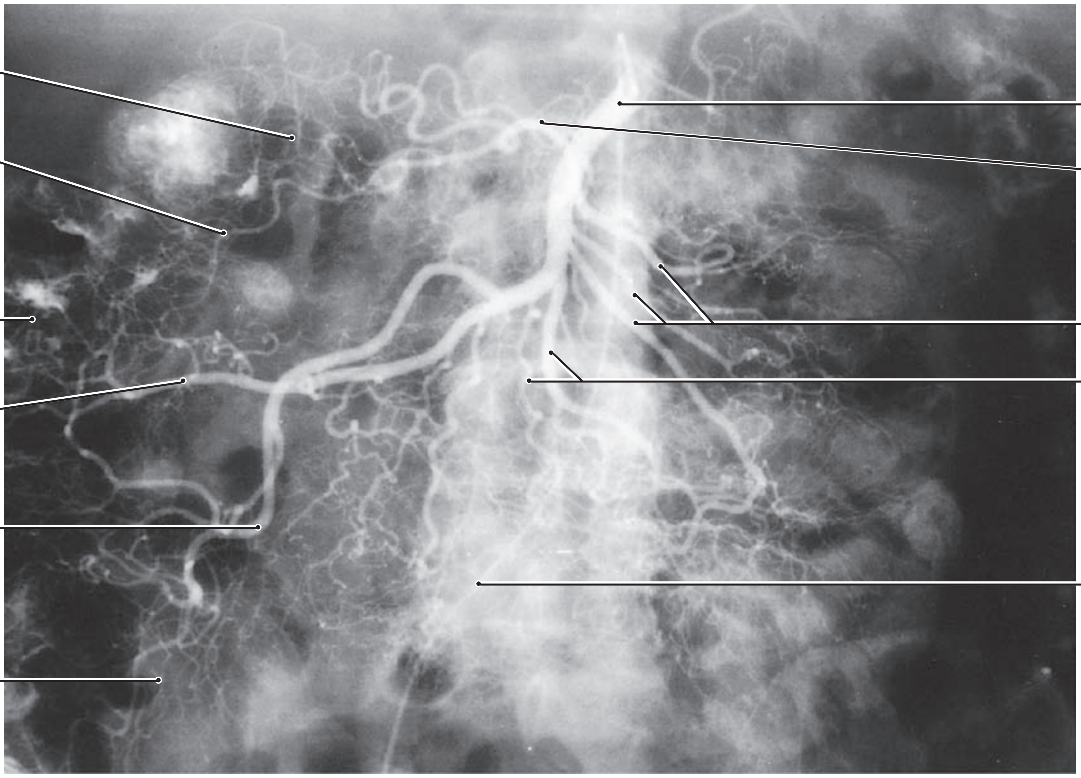
A. Blood supply. The appendicular artery is located in the free edge of the mesoappendix. The inferior ileocecal fold is bloodless, whereas the superior ileocecal fold is called the vascular fold of the cecum. **B.** The approximate incidence of various positions of the appendix. **C.** Interior of a dried cecum and ileal diverticulum (of Meckel). This cecum was filled with air until dry, opened, and varnished. **Ileal diverticulum** is a congenital anomaly that occurs in 1% to 2% of persons. It is a pouchlike remnant (3 to 6 cm long) of the proximal part of the yolk stalk, typically within 50 cm of the ileocecal junction. It sometimes becomes inflamed and produces pain that may mimic that produced by appendicitis.



2.44 SUPERIOR MESENTERIC ARTERY AND ARTERIAL ARCADES

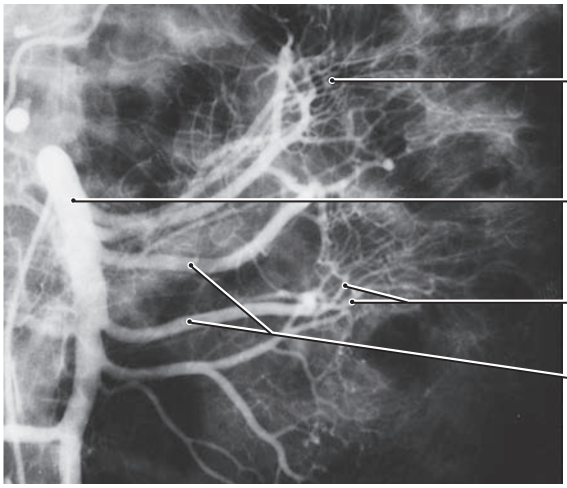
The peritoneum is partially stripped off.

- The superior mesenteric artery ends by anastomosing with one of its own branches, the ileal branch of the ileocolic artery.
- On the inset drawings of jejunum and ileum compare the diameter, thickness of wall, number of arterial arcades, long or short vasa recta, presence of translucent (fat-free) areas at the mesenteric border, and fat encroaching on the wall of the gut between the jejunum and ileum.
- **Acute inflammation of the appendix** is a common cause of an acute abdomen (severe abdominal pain arising suddenly). The pain of appendicitis usually commences as a vague pain in the periumbilical region because afferent pain fibers enter the spinal cord at the T10 level. Later, severe pain in the right lower quadrant results from irritation of the parietal peritoneum lining the posterior abdominal wall.



A

Anteroposterior Arteriograms

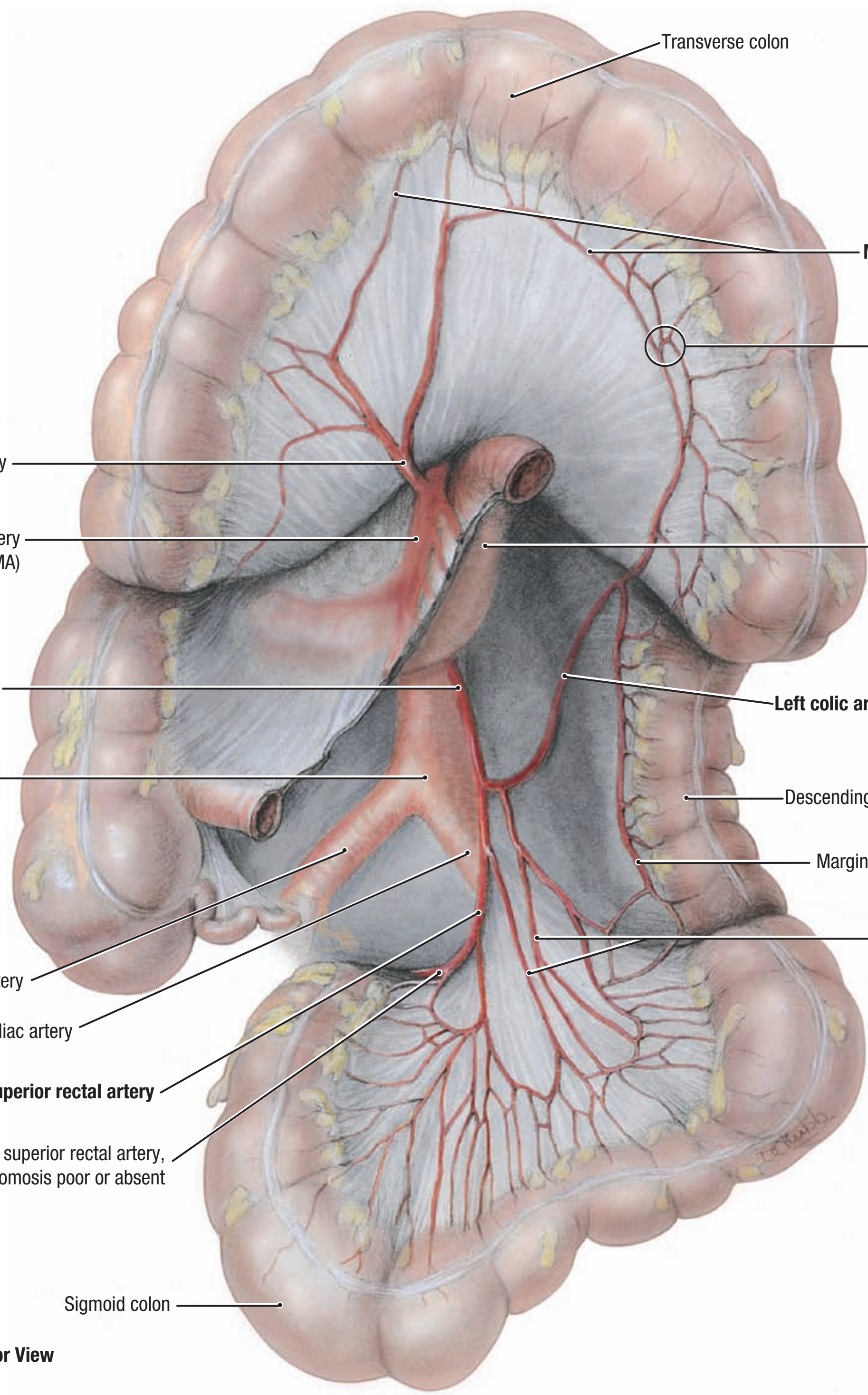


B

2.45 SUPERIOR MESENTERIC ARTERIOGRAMS

A. Branches of superior mesenteric artery. Consult Figure 2.44 to identify the branches. **B.** Enlargement to show the jejunal arteries, arterial arcades, and vasa recta.

- The branches of the superior mesenteric artery include, from its left side, 12 or more jejunal and ileal arteries that anastomose to form arcades from which vasa recta pass to the small intestine and, from its right side, the middle colic, ileocolic, and commonly (but not here) an independent right colic artery that anastomose to form a marginal artery that parallels the mesenteric border at the colon and from which vasa recta pass to the large intestine. **Occlusion of the vasa recta** by emboli results in ischemia of the part of the intestine concerned. If the ischemia is severe, necrosis of the involved segment results and **ileus** (obstruction of the intestine) of the paralytic type occurs. Ileus is accompanied by a severe colicky pain, along with abdominal distension, vomiting, and often fever and dehydration. If the condition is diagnosed early (e.g., using a superior mesenteric arteriogram), the obstructed part of the vessel may be cleared surgically.

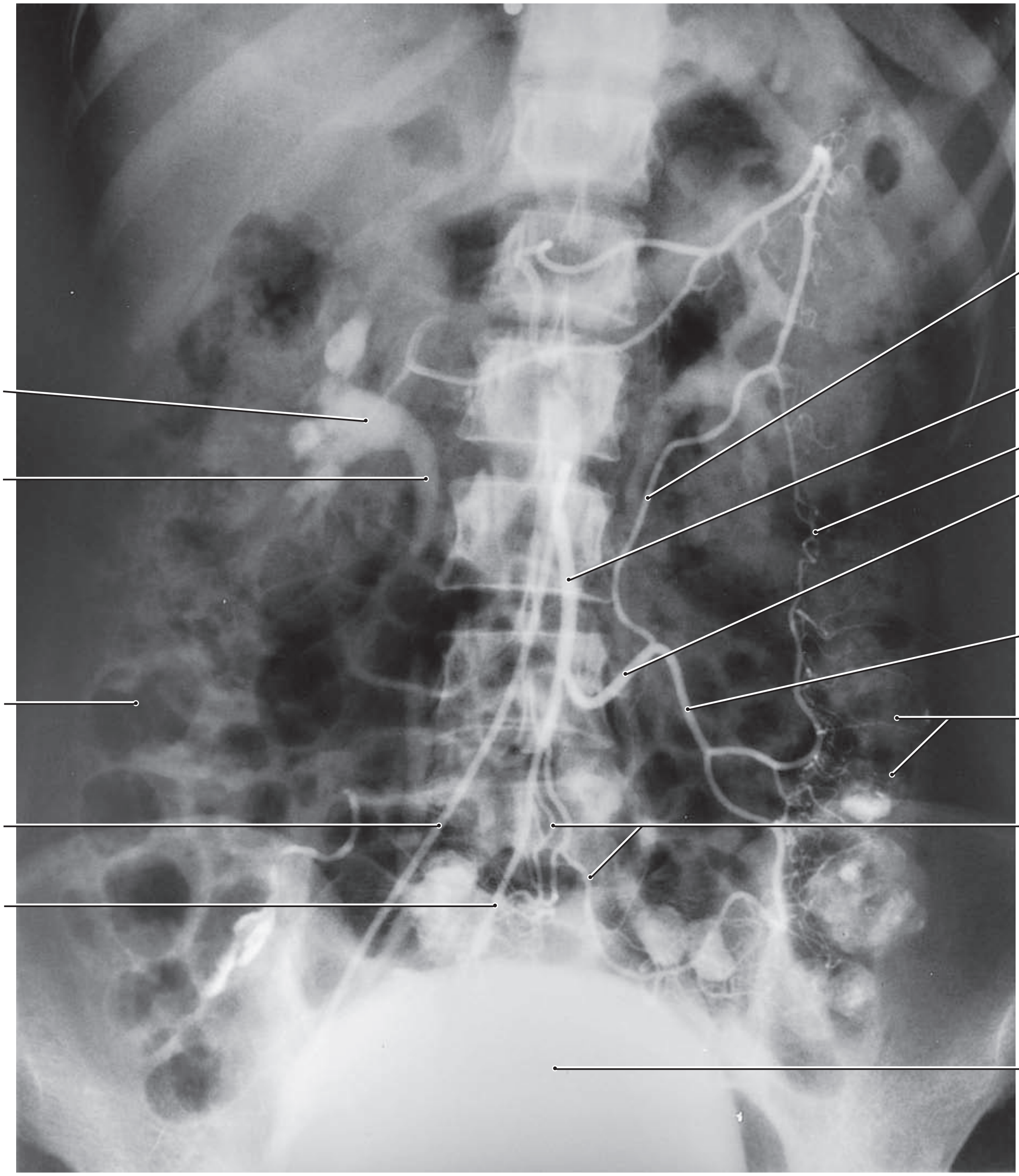


Anterior View

2.46 INFERIOR MESENTERIC ARTERY

The mesentery of the small intestine has been cut at its root.

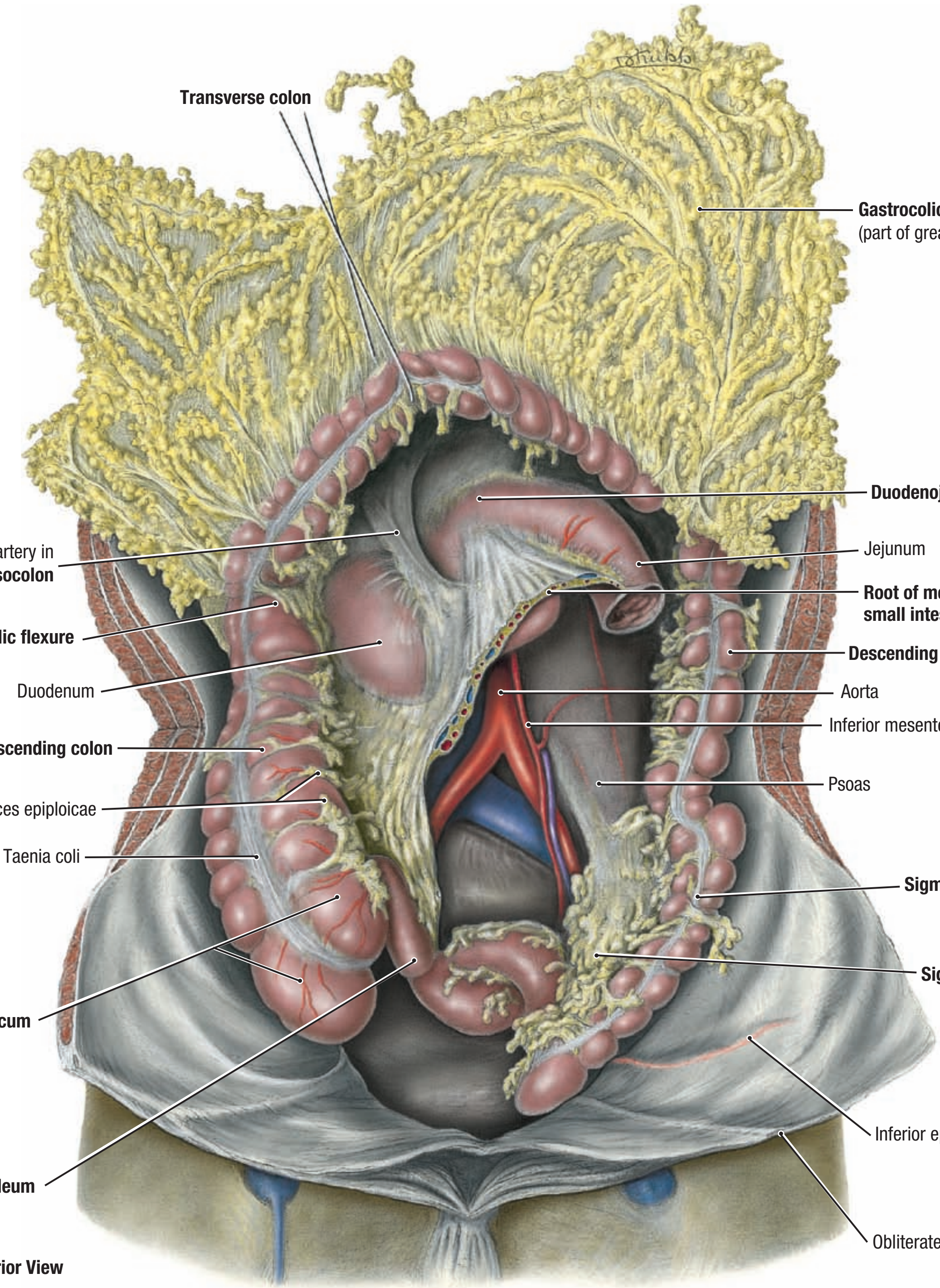
- The inferior mesenteric artery arises posterior to the ascending part of the duodenum, about 4 cm superior to the bifurcation of the aorta; on crossing the left common iliac artery, it becomes the superior rectal artery.
- The branches of the inferior mesenteric artery include the left colic artery and several sigmoid arteries; the inferior two sigmoid arteries branch from the superior rectal artery.
- The point at which the last artery to the colon branches from the superior rectal artery is known as the "critical point" of the superior rectal artery; distal to this point, there are poor or no anastomotic connections with the superior rectal artery.



Postero-anterior Arteriogram

2.47 INFERIOR MESENTERIC ARTERIOGRAM

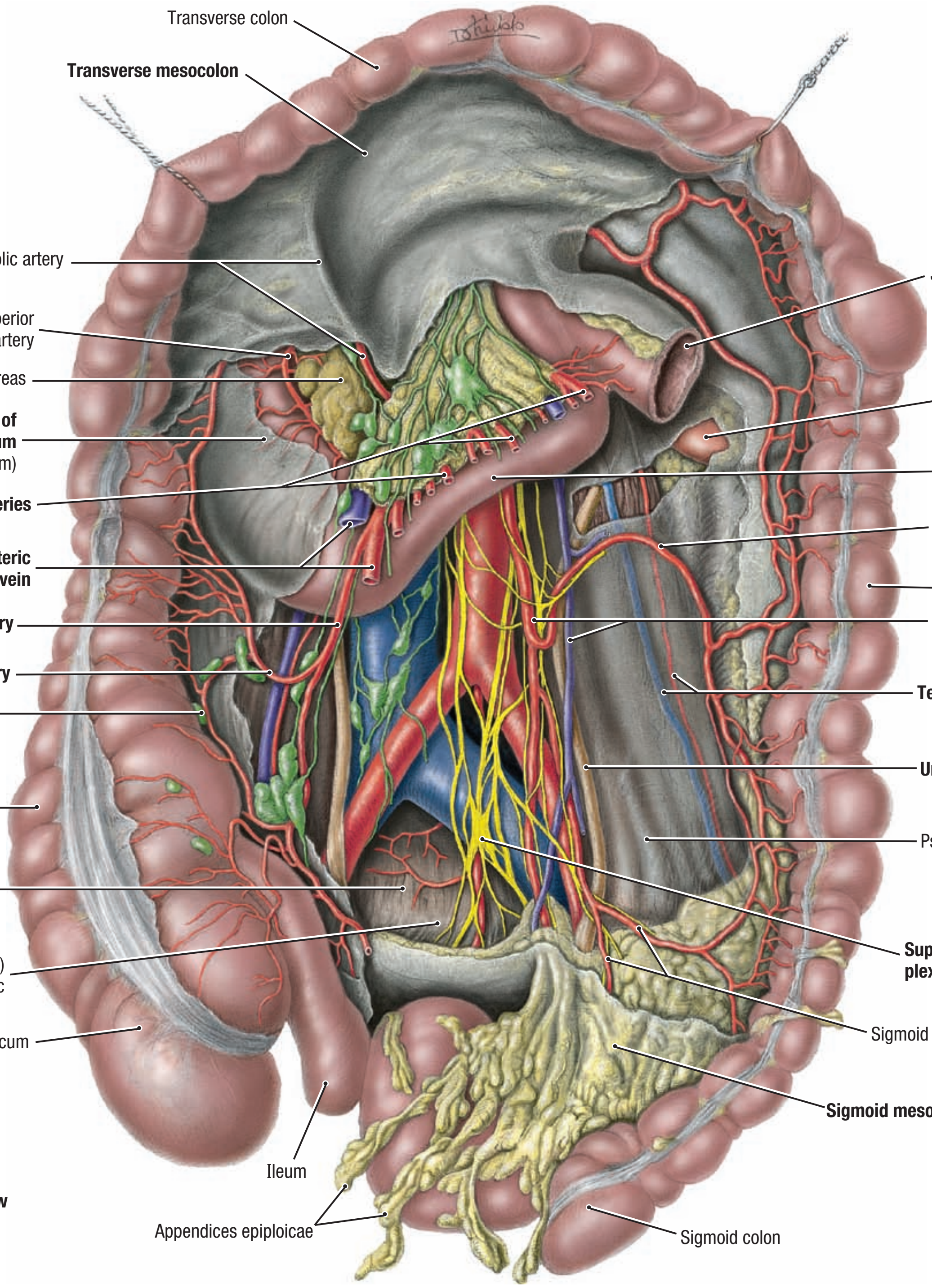
- The left colic artery courses to the left toward the descending colon and splits into ascending and descending branches.
- The sigmoid arteries, two to four in number, supply the sigmoid colon.
- The superior rectal artery, which is the continuation of the inferior mesenteric artery, supplies the rectum; the superior rectal anastomoses are formed by branches of the middle and inferior rectal arteries (from the internal iliac artery).



2.48 PERITONEUM OF POSTERIOR ABDOMINAL CAVITY

The gastrocolic ligament is retracted superiorly, along with the transverse colon and transverse mesocolon. The appendix had been surgically removed. This dissection is continued in Figure 2.49.

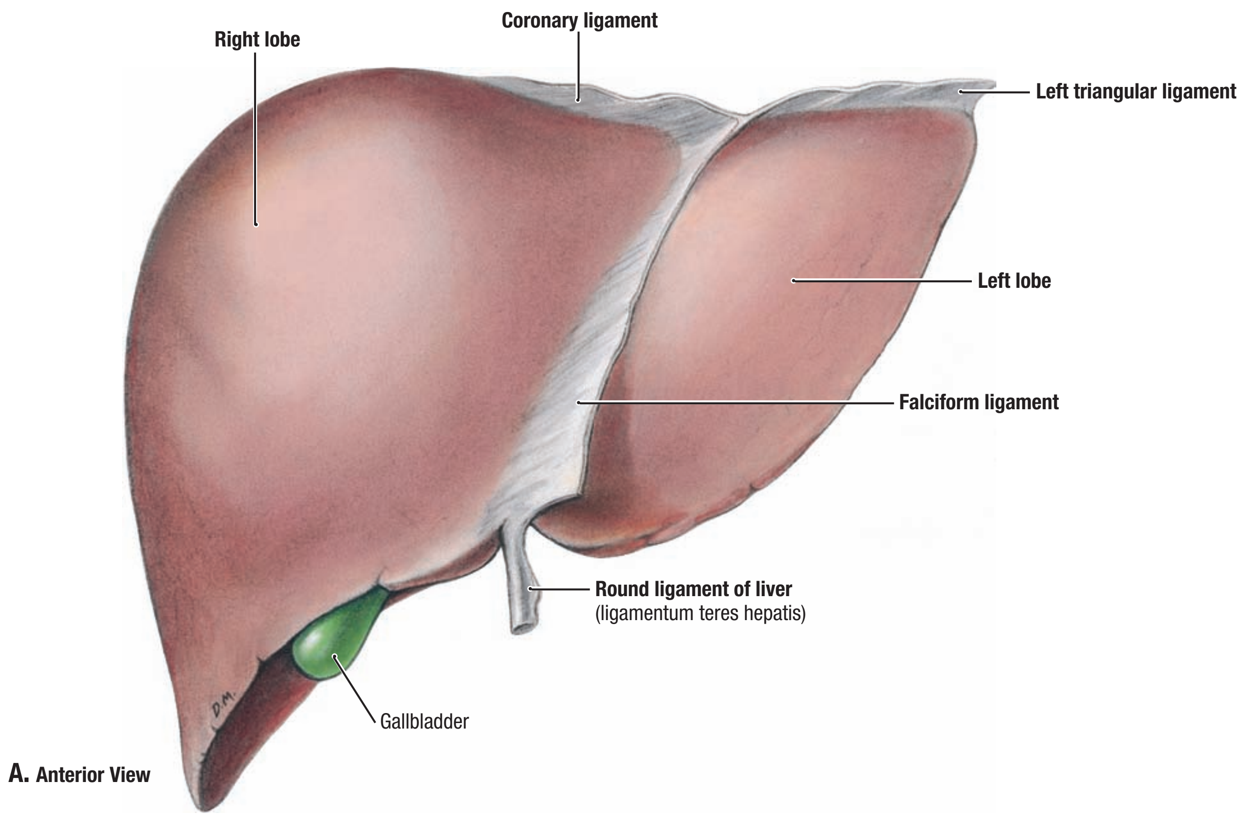
- The root of the mesentery of the small intestine, approximately 15 to 20 cm in length, extends between the duodenojejunal junction and ileocecal junction.
- The large intestine forms 3½ sides of a square around the jejunum and ileum. On the right are the cecum and ascending colon, superior is the transverse colon, on the left is the descending and sigmoid colon, and inferiorly is the sigmoid colon.
- **Chronic inflammation of the colon (ulcerative colitis, Crohn disease)** is characterized by severe inflammation and ulceration of the colon and rectum. In some patients, a colectomy is performed, during which the terminal ileum and colon as well as the rectum and anal canal are removed. An ileostomy is then constructed to establish an artificial cutaneous opening between the ileum and the skin of the anterolateral abdominal wall.

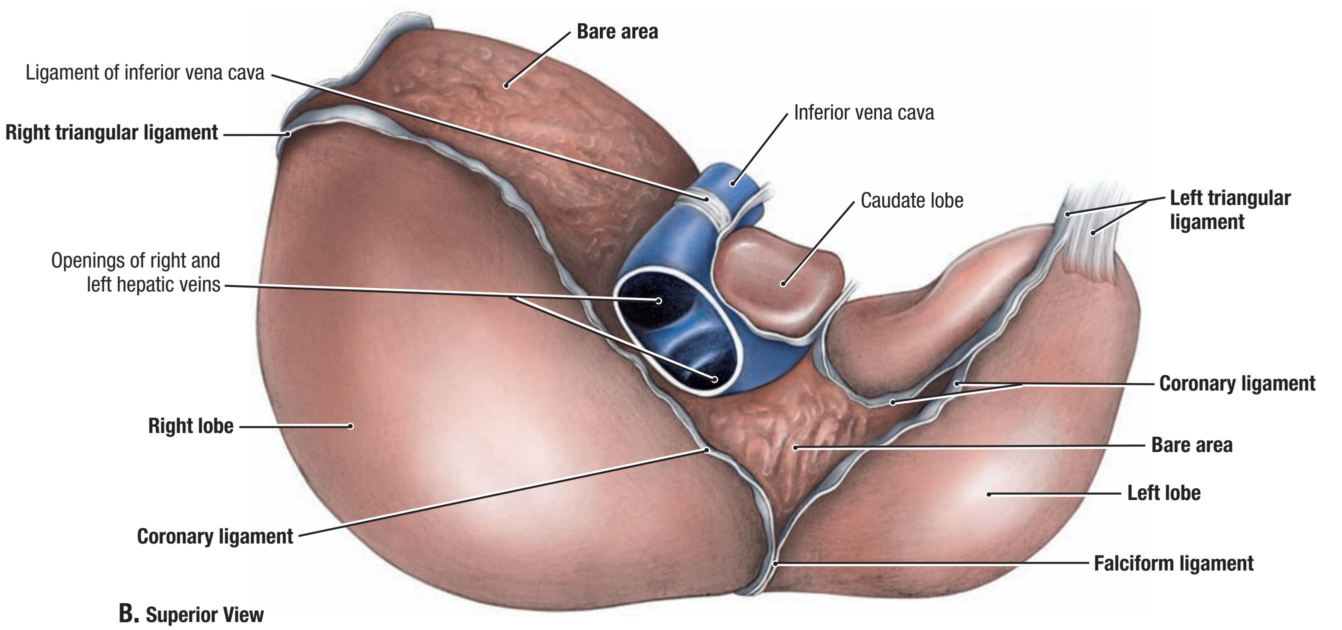


2.49 POSTERIOR ABDOMINAL CAVITY WITH PERITONEUM REMOVED

The jejunal and ileal branches (cut) pass from the left side of the superior mesenteric artery. The right colic artery here is a branch of the ileocolic artery. This is the same specimen as in Figure 2.48.

- The duodenum is large in diameter before crossing the superior mesenteric vessels and narrow afterward.
- On the right side, there are lymph nodes on the colon, paracolic nodes beside the colon, and nodes along the ileocolic artery, which drain into nodes anterior to the pancreas.
- The intestines and intestinal vessels lie on a resectable plane anterior to that of the testicular vessels; these in turn lie anterior to the plane of the kidney, its vessels, and the ureter.
- The superior hypogastric plexus lie inferior to the bifurcation of the aorta and anterior to the left common iliac vein, the body of the 5th lumbar vertebra, and the 5th intervertebral disc.

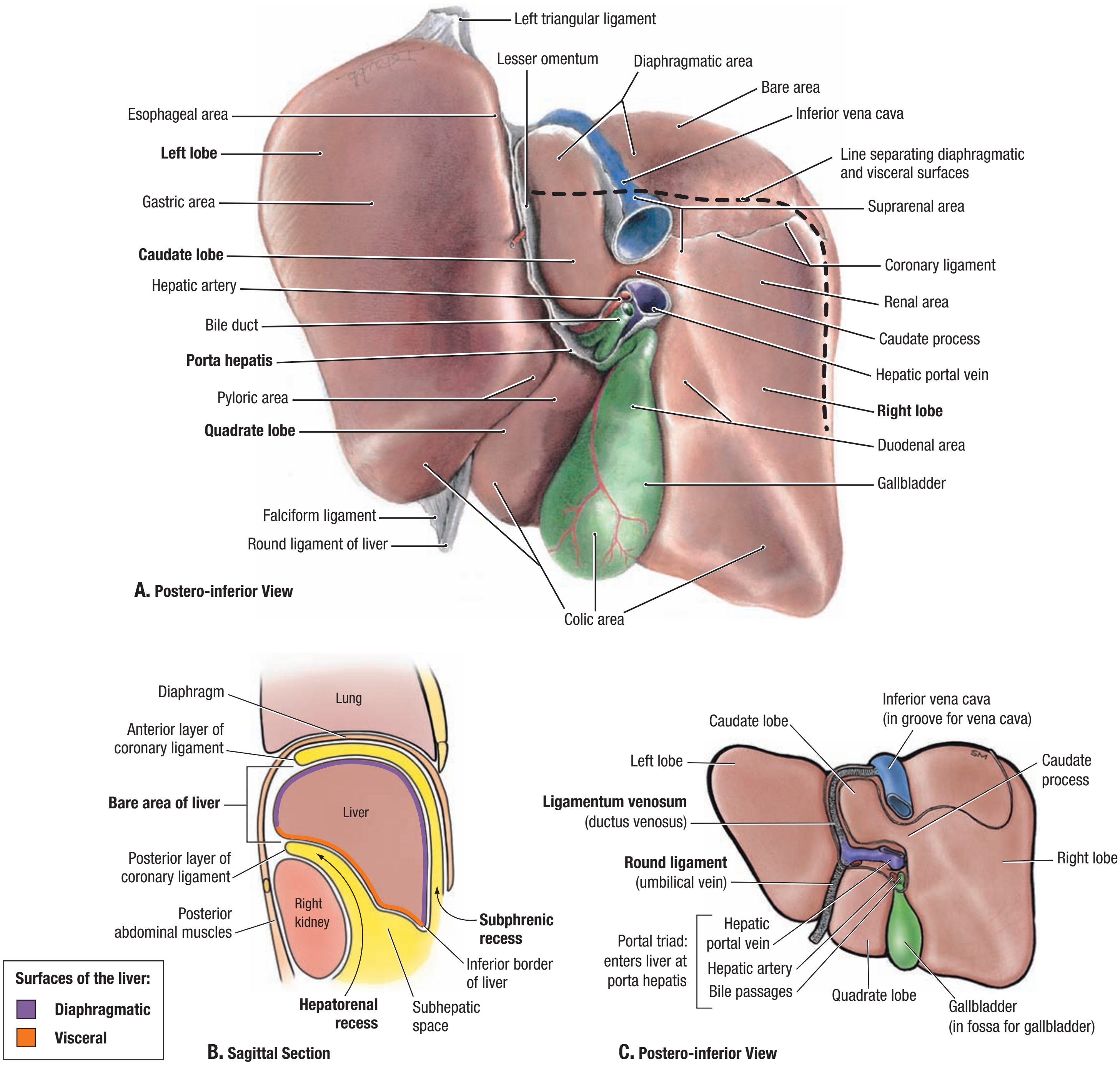




2.50 DIAPHRAGMATIC (ANTERIOR AND SUPERIOR) SURFACE OF LIVER

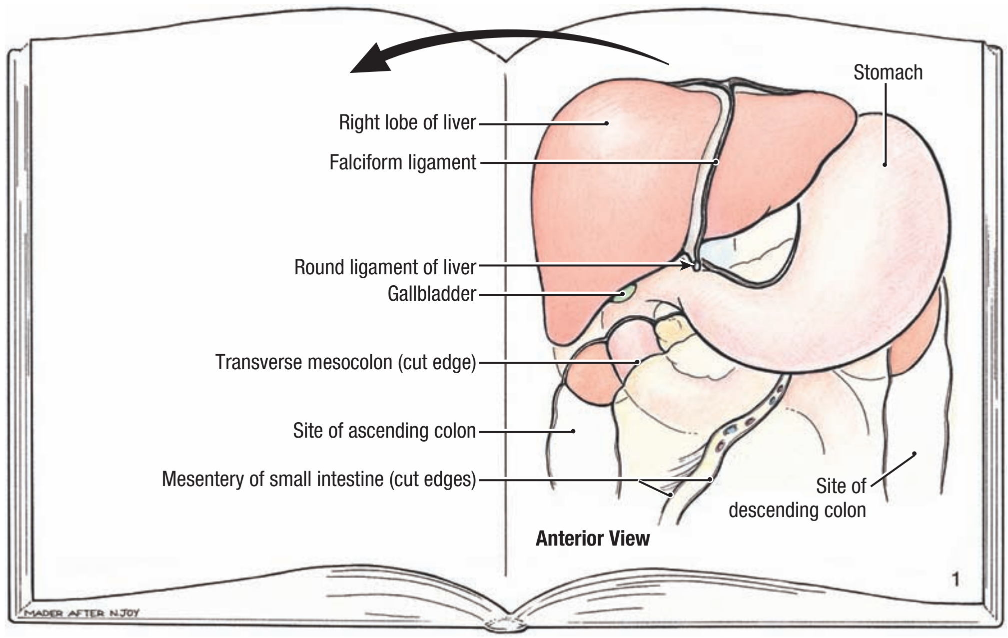
A. The falciform ligament has been severed close to its attachment to the diaphragm and anterior abdominal wall and demarcates the right and left lobes of the liver. The round ligament of the liver (ligamentum teres) lies within the free edge of the falciform ligament.

B. The two layers of peritoneum that form the falciform ligament separate over the superior aspect (surrounding the bare area) of the liver to form the superior layer of the coronary ligament and the right and left triangular ligaments.

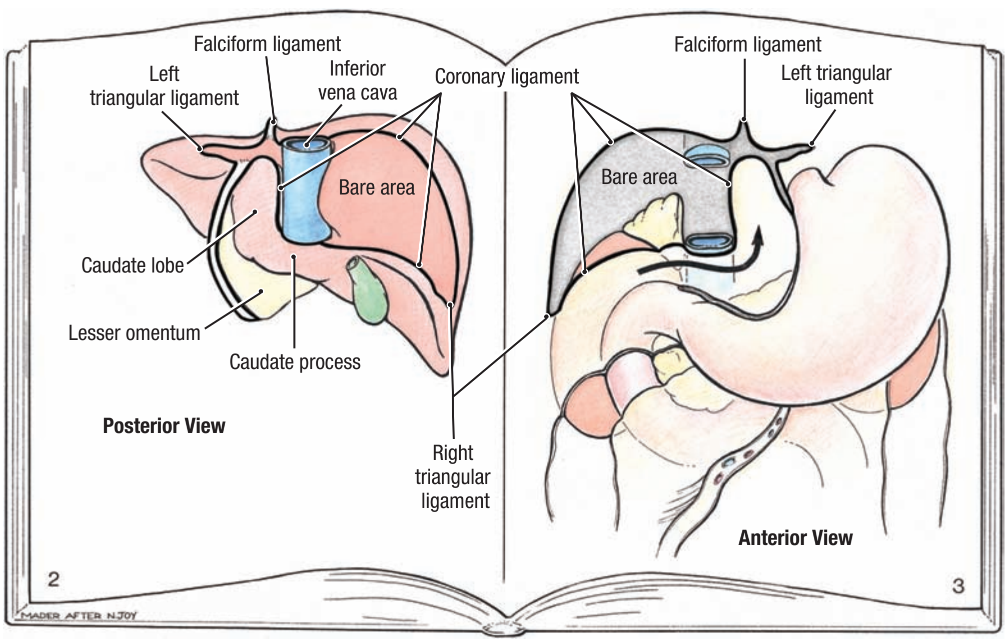


2.51 VISCERAL (POSTERO-INFERIOR) SURFACE OF LIVER

A. Isolated specimen demonstrating lobes, and impressions of adjacent viscera. **B.** Hepatic surfaces and peritoneal recesses. **C.** Round ligament of liver and ligamentum venosum. The round ligament of liver includes the obliterated remains of the umbilical vein that carried well-oxygenated blood from the placenta to the fetus. The ligamentum venosum is the fibrous remnant of the fetal ductus venosus that shunted blood from the umbilical vein to the inferior vena cava, short circuiting the liver. Hepatic tissue may be obtained for diagnostic purposes by **liver biopsy.** The needle puncture is commonly made through the right 10th intercostal space in the midaxillary line. Before the physician takes the biopsy, the person is asked to hold his or her breath in full expiration to reduce the costodiaphragmatic recess and to lessen the possibility of damaging the lung and contaminating the pleural cavity.



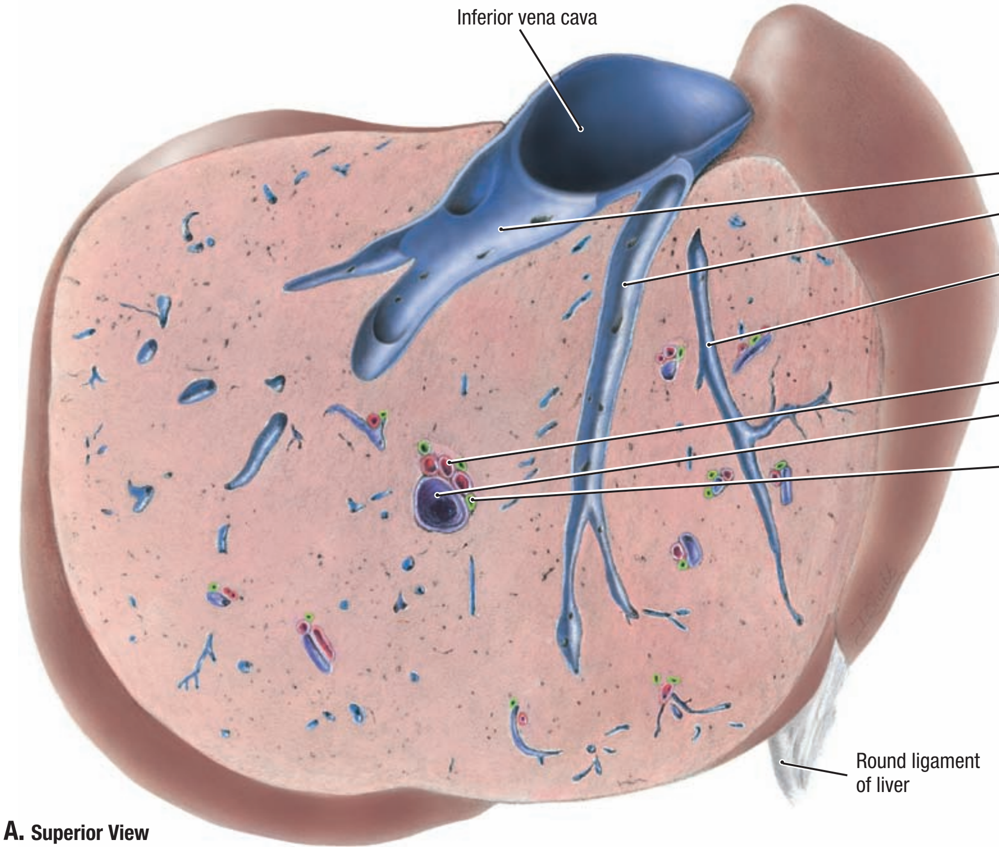
A



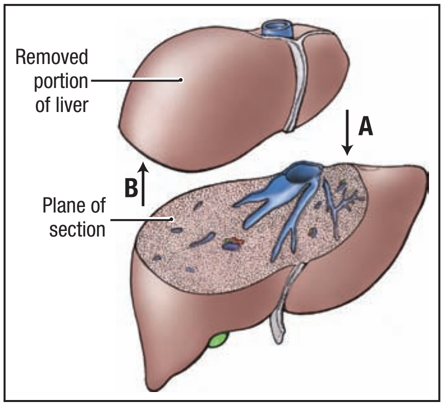
B

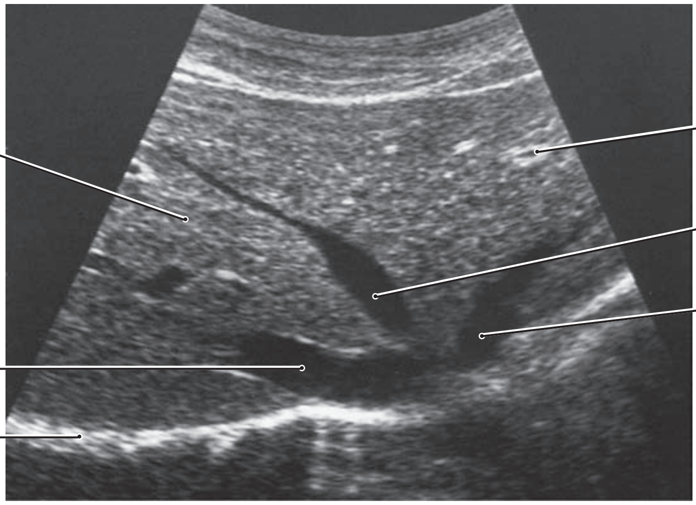
2.52 LIVER AND ITS POSTERIOR RELATIONS, SCHEMATIC ILLUSTRATION

A. Liver in situ. The jejunum, ileum, and the ascending, transverse, and descending colons have been removed. **B.** The liver is drawn schematically on a page in a book, so that as the page is turned (*arrow in A*), the liver is reflected to the right to reveal its posterior surface, and on the facing page, the posterior relations that compose the bed of the liver are viewed. The *arrow in B* traverses the omental (epiploic) foramen to enter the omental bursa and its superior recess (*arrowhead*). The bare area is triangular, hence the coronary ligament that surrounds it is three-sided; its left side, or base, is between the inferior vena cava and caudate lobe, and its apex is at the right triangular ligament, where the superior and inferior layers of the coronary ligament meet.



A. Superior View

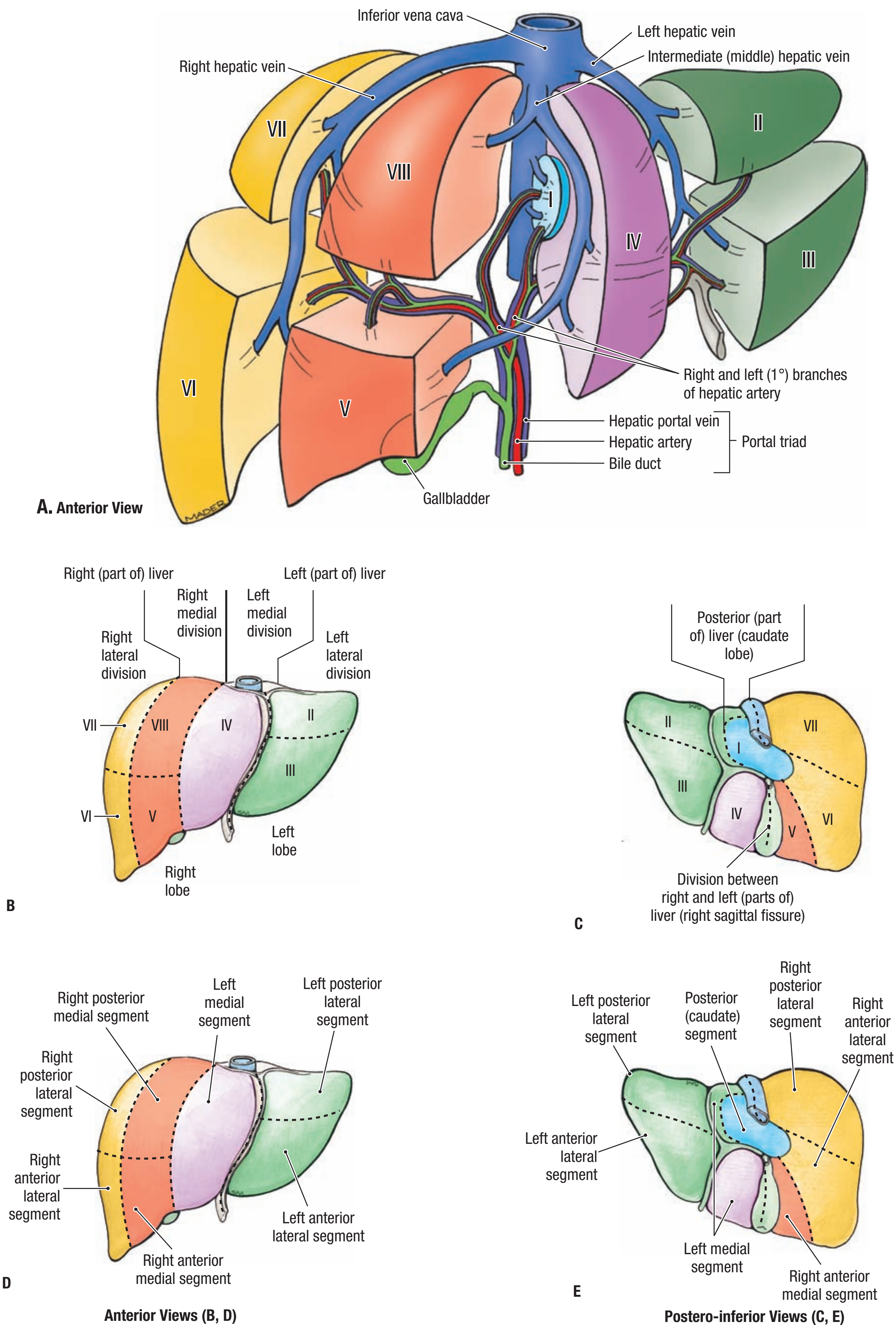




B. Inferior View

2.53 HEPATIC VEINS

A. Approximately horizontal section of liver with the posterior aspect at the top of page. Note the multiple perivascular fibrous capsules sectioned throughout the cut surface, each containing a portal triad (the hepatic portal vein, hepatic artery, bile ductules) plus lymph vessels. Interdigitating with these are branches of the three main hepatic veins (right, intermediate, and left), which, unaccompanied and lacking capsules, converge on the inferior vena cava. **B.** Ultrasound scan. The transducer was placed under the costal margin and directed posteriorly, producing an inverted image corresponding to **A.**



2.54 HEPATIC SEGMENTATION

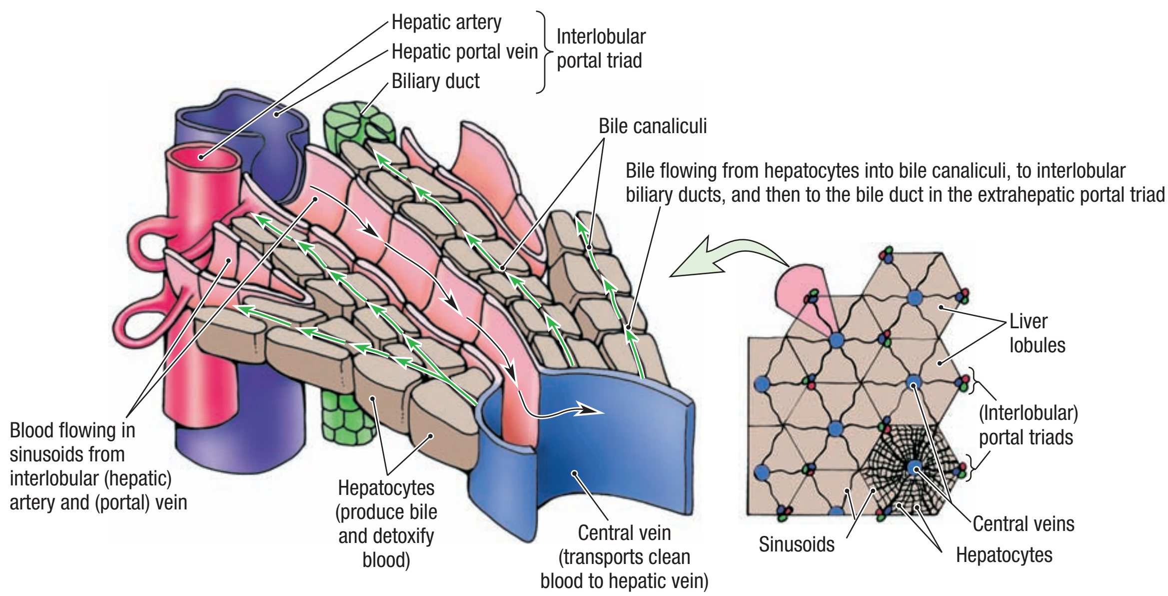
2.54 HEPATIC SEGMENTATION *(CONTINUED)*

Each segment is supplied by a secondary or tertiary branch of the hepatic artery, bile duct, and portal vein. The hepatic veins interdigitate between the structures of the portal triad and are intersegmental in that they drain adjacent segments. Since the right and left hepatic arteries and ducts and branches of the right and left portal veins do not communicate, it is possible to perform **hepatic lobectomies** (removal of the right or left part of the liver) and **segmentectomies.** Each segment can be identified numerically or by name (Table 2.6).

TABLE 2.6 SCHEMA OF TERMINOLOGY FOR SUBDIVISIONS OF THE LIVER

Anatomical Term	Right Lobe		Left Lobe		Caudate Lobe	
Functional/surgical term[a]	Right (part of) liver [Right portal lobe[b]]		Left (part of) liver [Left portal lobe[c]]		Posterior (part of) liver	
	Right lateral division	Right medial division	Left medial division	Left lateral division	[Right caudate lobe[b]]	[Left caudate lobe[c]]
	Posterior lateral segment **Segment VII** [Posterior superior area]	Posterior medial segment **Segment VIII** [Anterior superior area]	[Medial superior area] Left medial segment **Segment IV**	Lateral segment **Segment II** [Lateral superior area]	Posterior segment **Segment I**	
	Right anterior lateral segment **Segment VI** [Posterior inferior area]	Anterior medial segment **Segment V** [Anterior inferior area]	[Medial inferior area = quadrate lobe]	Left anterior lateral segment **Segment III** [Lateral inferior area]		

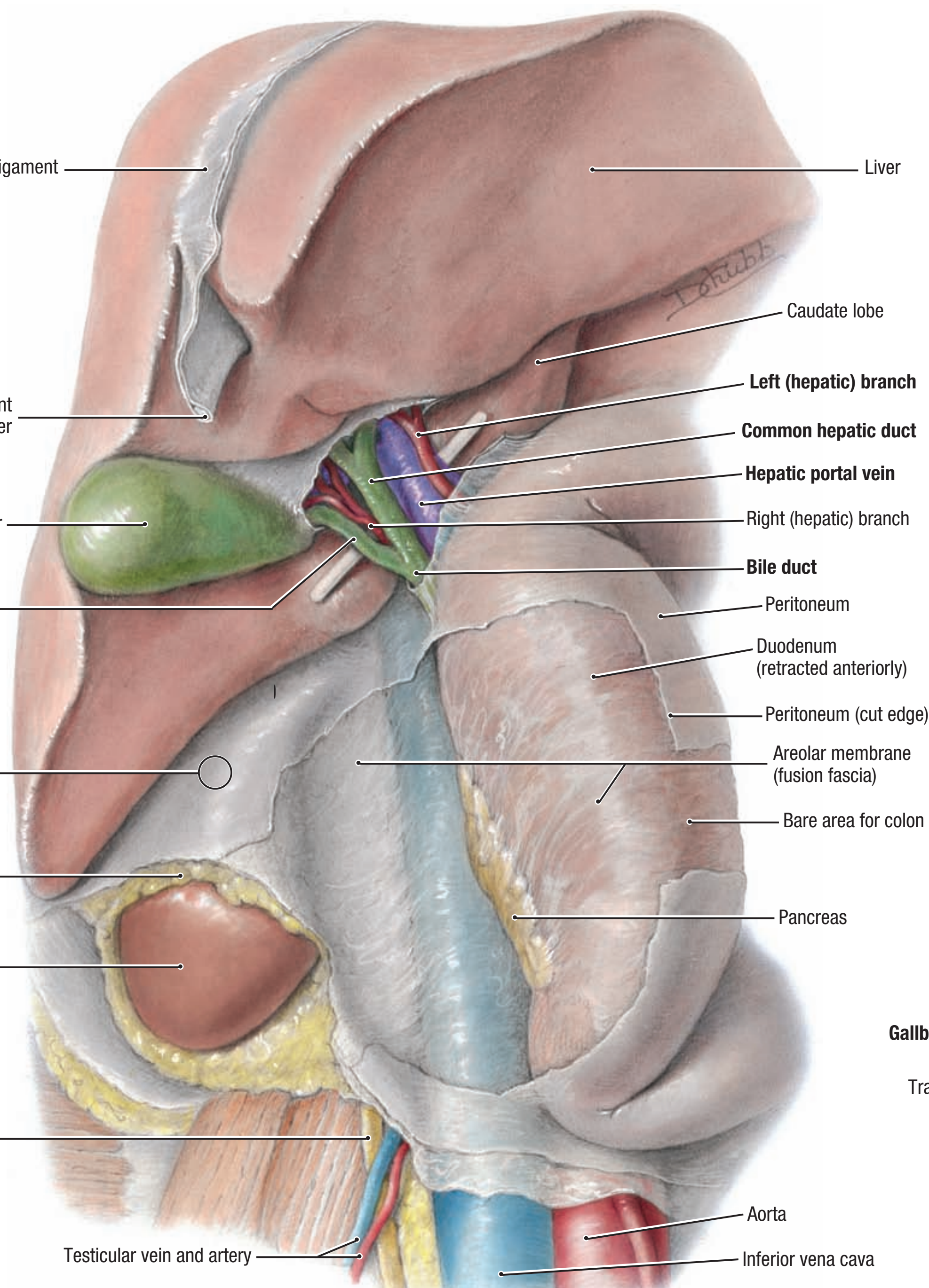
[a]The labels in the table and figure above reflect the Terminologia *Anatomica: International Anatomical Terminology*. Previous terminology is in brackets.
[b,c]Under the schema of the previous terminology, the caudate lobe was divided into right and left halves, and [b]the right half of the caudate lobe was considered a subdivision of the right portal lobe; [c]the left half of the caudate lobe was considered a subdivision of the left portal lobe.



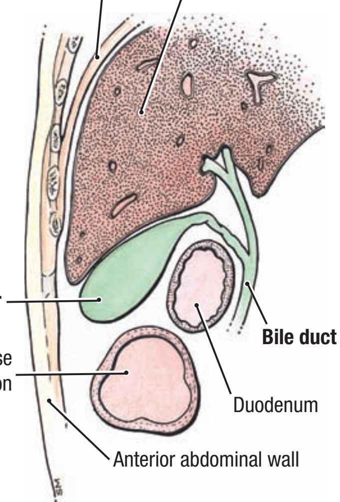
2.55 FLOW OF BLOOD AND BILE IN THE LIVER

This small part of a liver lobule shows the components of the interlobular portal triad and the positioning of the sinusoids and bile canaliculi. **Right.** The cut surface of the liver shows the hexagonal pattern of the lobules.

- With the exception of lipids, every substance absorbed by the alimentary tract is received first by the liver, via the hepatic portal vein. In addition to its many metabolic activities, the liver stores glycogen and secretes bile.
- There is progressive destruction of hepatocytes in **cirrhosis of the liver** and replacement of them by fibrous tissue. This tissue surrounds the intrahepatic blood vessels and biliary ducts, making the liver firm and impeding circulation of blood through it.



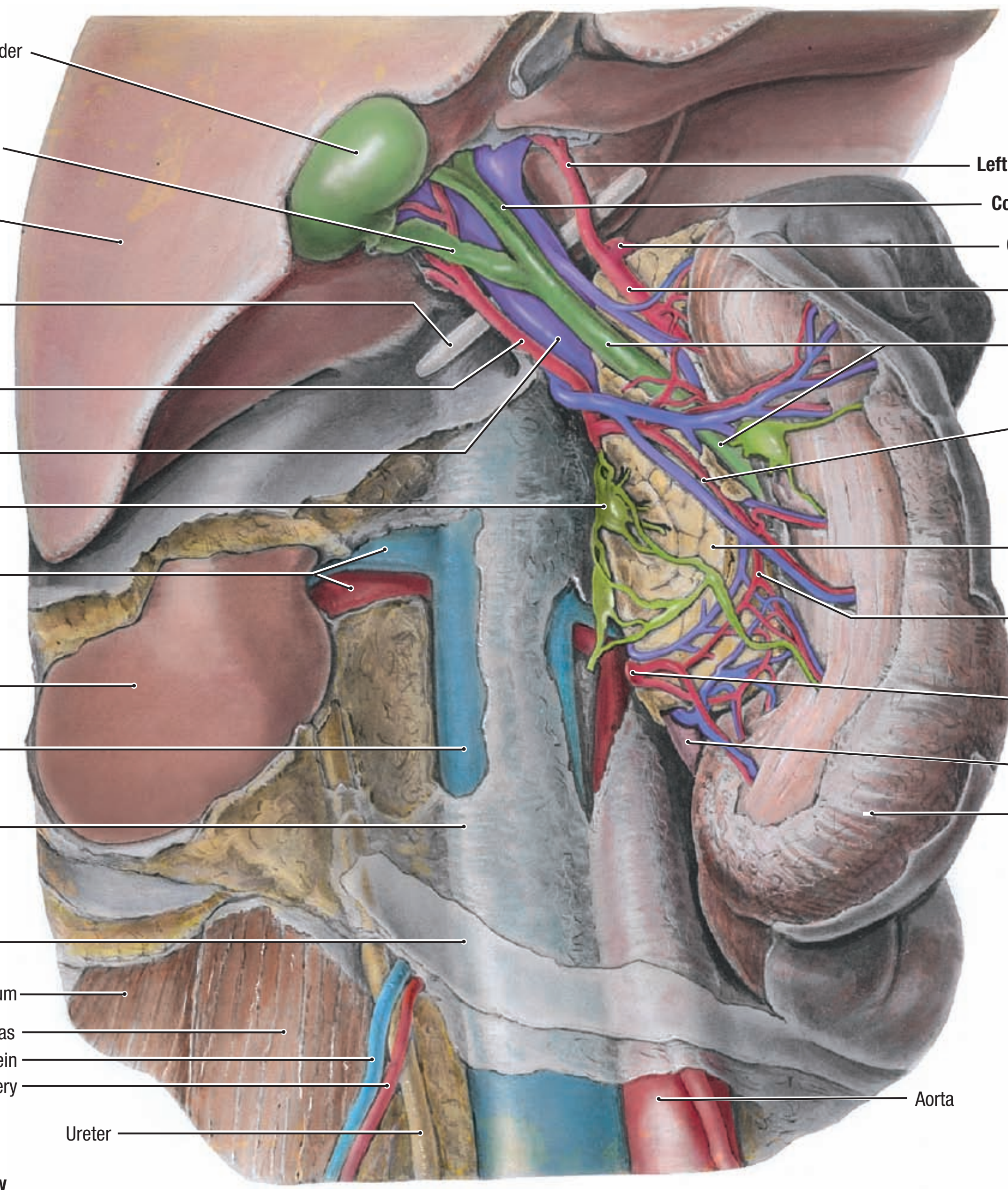
A. **Anterior View**



B. **Schematic Sagittal Section, in Right Midclavicular Plane**

2.56 EXPOSURE OF THE PORTAL TRIAD

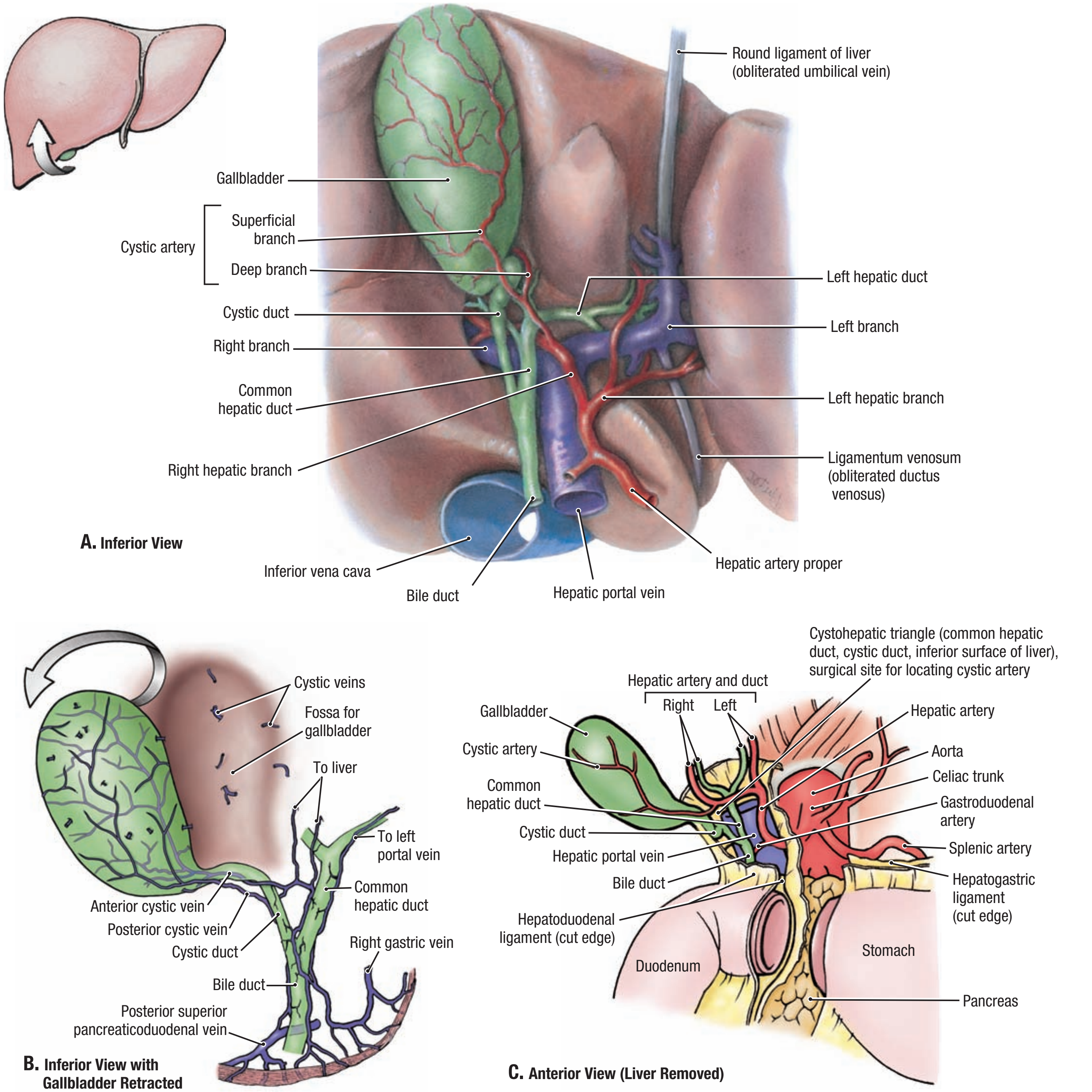
A. The portal triad typically consists of the hepatic portal vein (posteriorly), the hepatic artery proper (ascending from the left), and the bile passages (descending to the right). Here, the hepatic artery proper is replaced by a left hepatic branch, arising directly from the common hepatic artery, and a right hepatic branch, arising from the superior mesenteric artery (a common variation). A rod traverses the omental (epiploic) foramen. The lesser omentum and transverse colon are removed, and the peritoneum is cut along the right border of the duodenum; this part of the duodenum is retracted anteriorly. The space opened up reveals two smooth areolar membranes (fusion fascia) normally applied to each other that are vestiges of the embryonic peritoneum originally covering these surfaces. **B.** Typical relations of gallbladder, cystic duct, and bile duct to the duodenum.



C. Anterior View

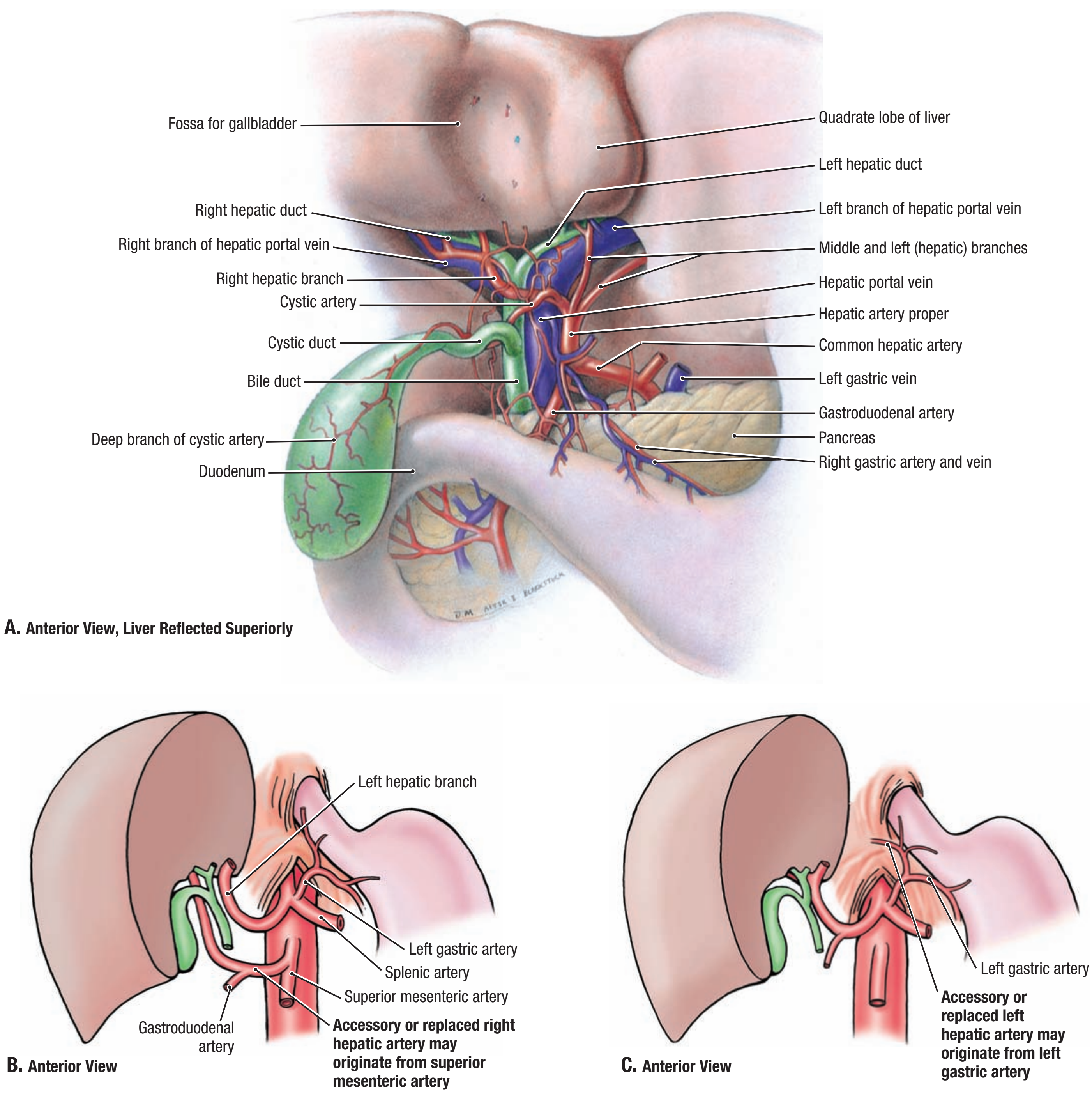
2.56 EXPOSURE OF THE PORTAL TRIAD (*CONTINUED*)

C. Continuing the dissection in **A**, the secondarily retroperitoneal viscera (duodenum and head of the pancreas) are retracted anteriorly and to the left. The areolar membrane (fusion fascia) covering the posterior aspect of the pancreas and duodenum is largely removed, and that covering the anterior aspect of the great vessels is partly removed. A common method for **reducing portal hypertension** is to divert blood from the portal venous system to the systemic venous system by creating a communication between the portal vein and the IVC. This **portacaval anastomosis or portosystemic shunt** may be created where these vessels lie close to each other posterior to the liver.



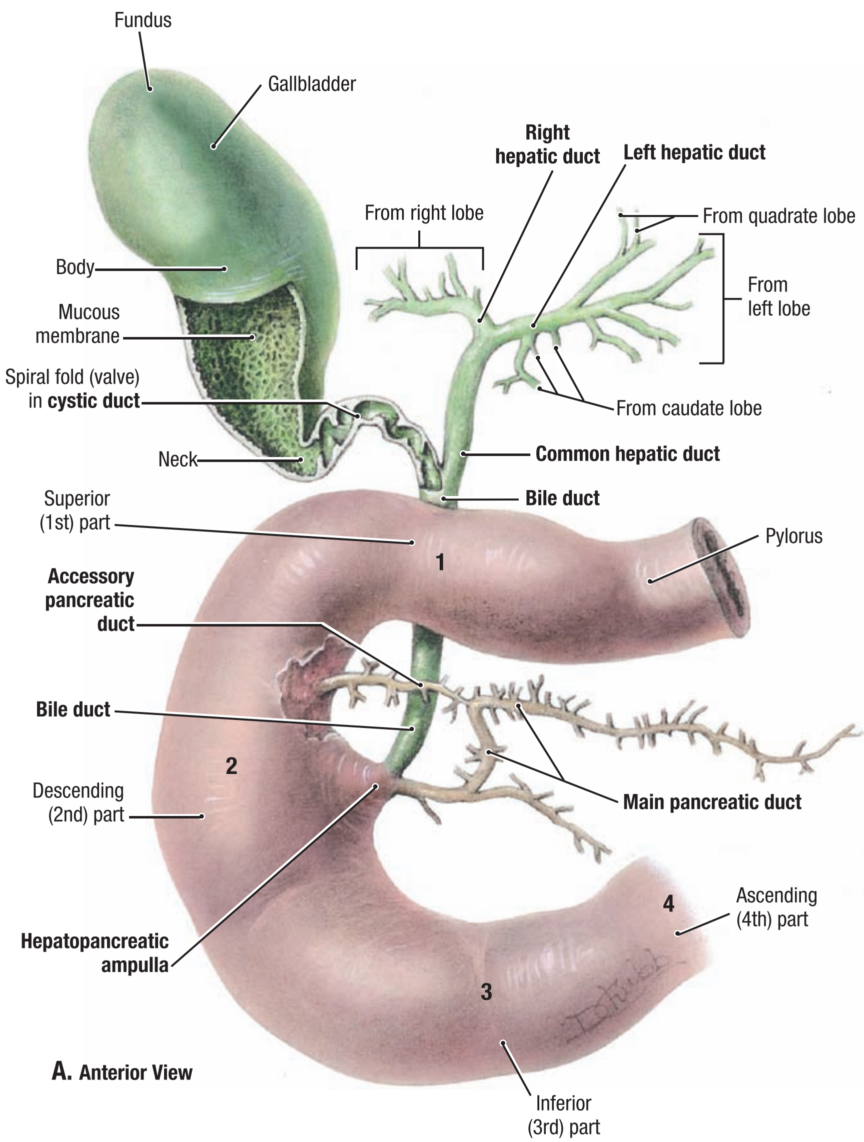
2.57 GALLBLADDER AND STRUCTURES OF PORTA HEPATIS

A. Gallbladder, cystic artery, and extrahepatic bile ducts. The inferior border of the liver is elevated to demonstrate its visceral surface (as in orientation figure). **B.** Venous drainage of the gall bladder and extrahepatic ducts. Most veins are tributaries of the hepatic portal vein, but some drain directly to the liver. **C.** Portal triad within the hepatoduodenal ligament (free edge of lesser omentum). **Gallstones** are concretions, in the gallbladder or extrahepatic biliary ducts. The cystohepatic (hepatobiliary) triangle (Calot), between the common hepatic duct, cystic duct, and liver, is an important endoscopic landmark for locating the cystic artery during **cholecystectomy.**

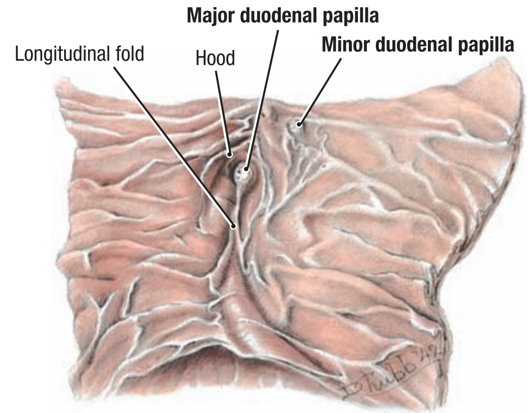


2.58 VESSELS IN PORTA HEPATIS

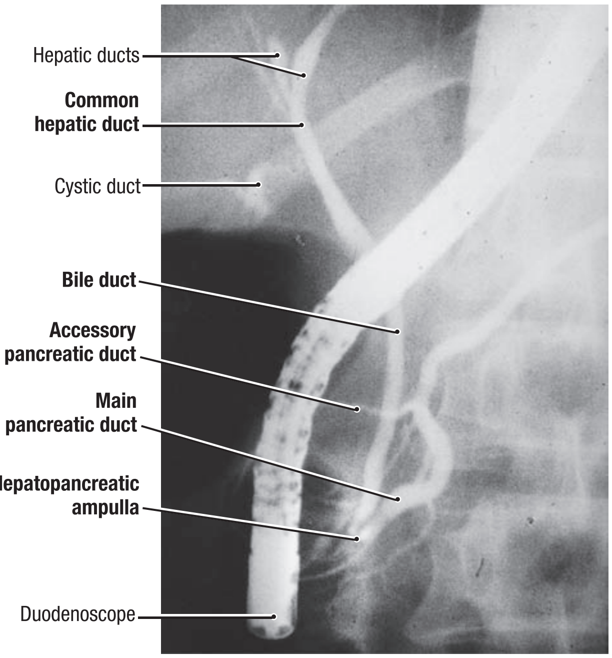
A. Hepatic and cystic vessels. The liver is reflected superiorly. The gallbladder, freed from its bed or fossa, has remained nearly in its anatomical position, pulled slightly to the right. The deep branch of the cystic artery on the deep, or attached, surface of the gallbladder anastomoses with branches of the superficial branch of the cystic artery and sends twigs into the bed of the gallbladder. Veins (not all shown) accompany most arteries. **B.** Aberrant (accessory or replaced) right hepatic artery. **C.** Aberrant left hepatic artery. Awareness of the variations in arteries and bile duct formation is important for surgeons when they ligate the cystic duct during **cholecystectomy** (removal of the gallbladder).



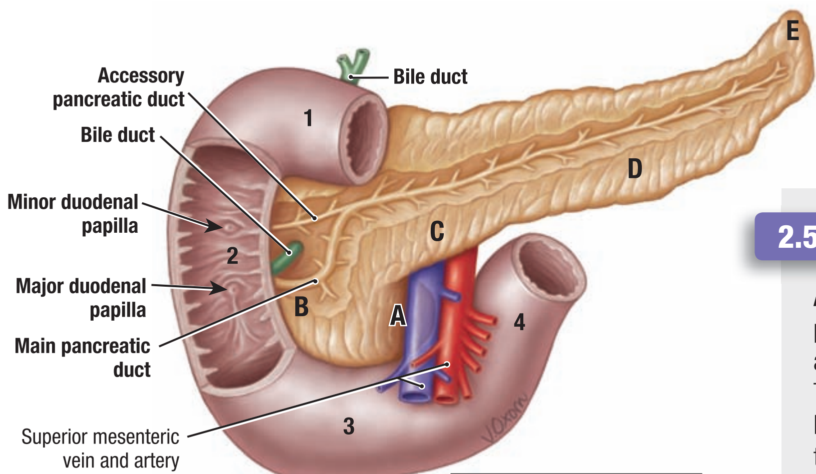
A. Anterior View



C. Internal View



D. Anterior View

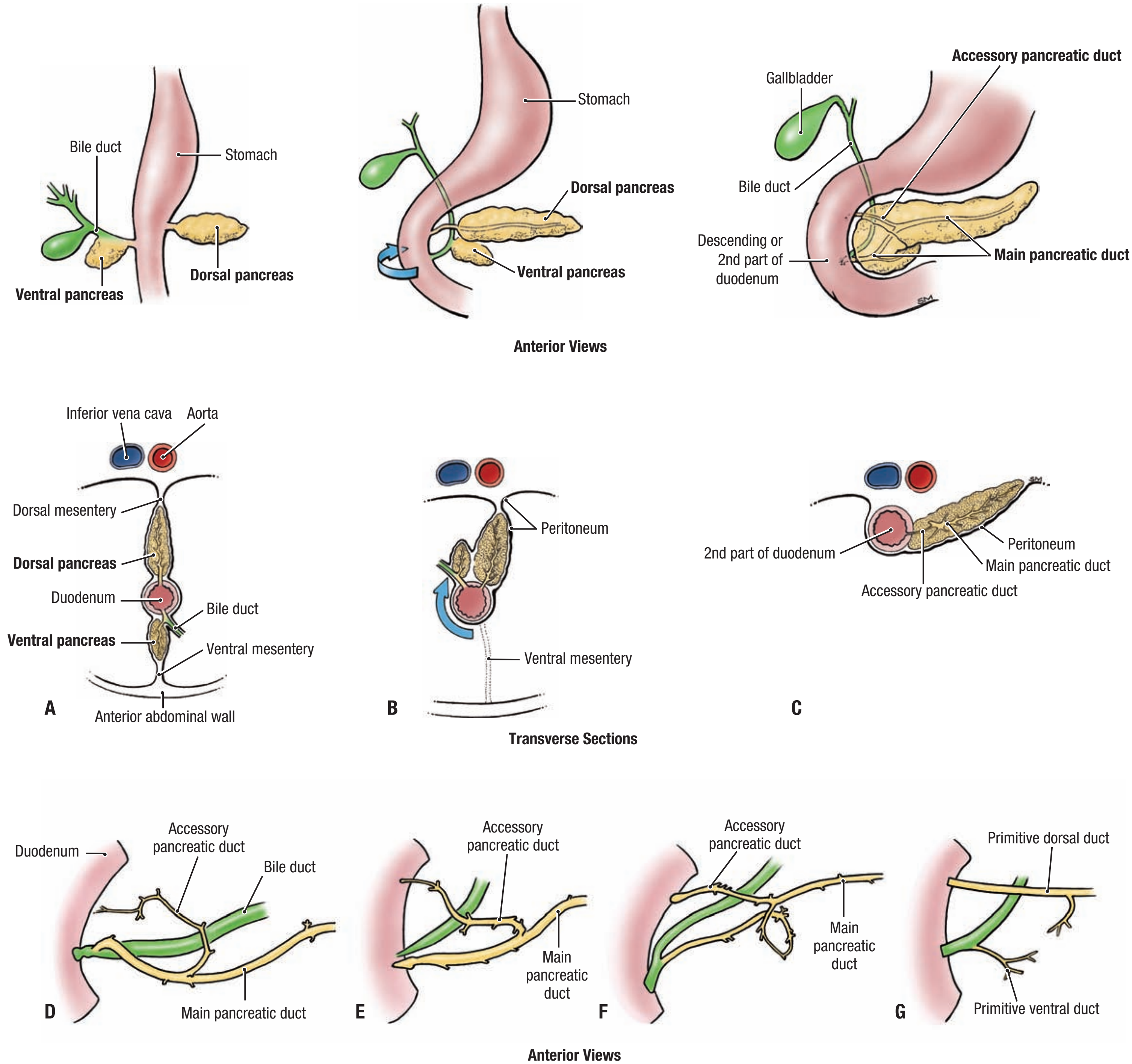


B. Anterior View

1 – 4 Parts of duodenum
Parts of pancreas:
A Uncinate process (extends posterior to superior mesenteric vein)
B Head **D** Body
C Neck **E** Tail

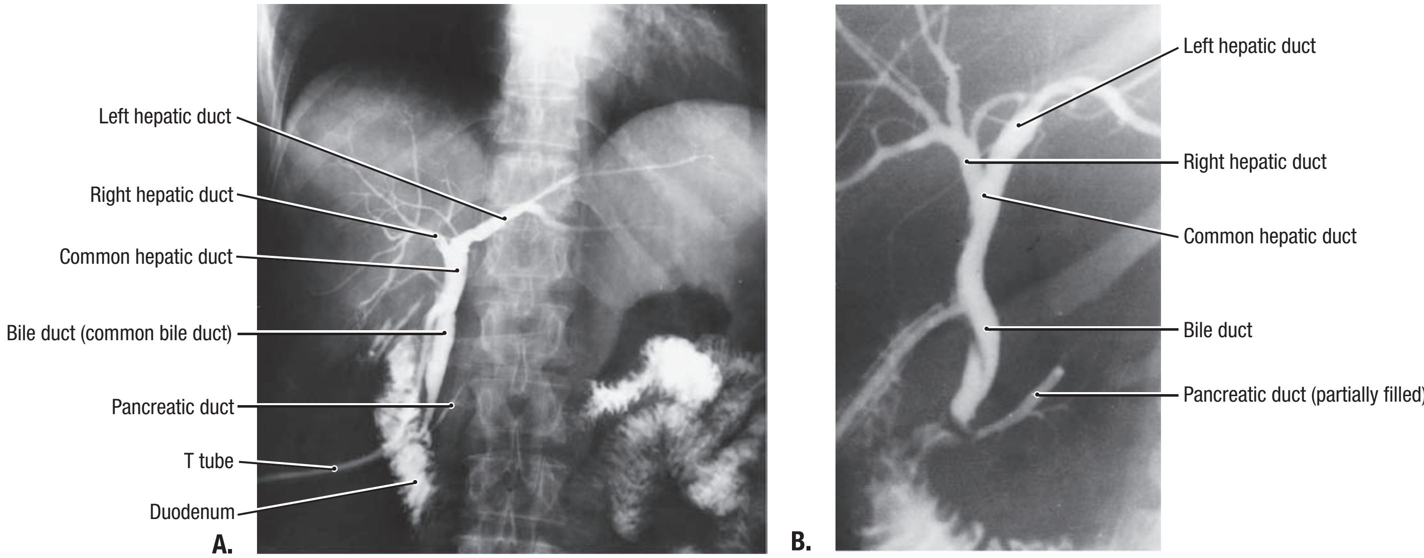
2.59 BILE AND PANCREATIC DUCTS

A. Extrahepatic bile passages and pancreatic ducts. **B.** Descending (2nd) part of the duodenum (interior). **C.** Endoscopic retrograde cholangiography and pancreatography (ERCP) demonstrating the bile and pancreatic ducts. The right and left hepatic ducts collect bile from the liver; the common hepatic duct unites with the cystic duct superior to the duodenum to form the bile duct, which descends posterior to the superior (1st) part of the duodenum. The bile duct joins the main pancreatic duct, forming the hepatopancreatic ampulla, which opens on the major duodenal papilla. This opening is the narrowest part of the biliary passages and is the common site for **impaction of a gallstone.** Gallstones may produce biliary colic (pain in the epigastric region). The accessory pancreatic duct opens on the minor duodenal papilla.



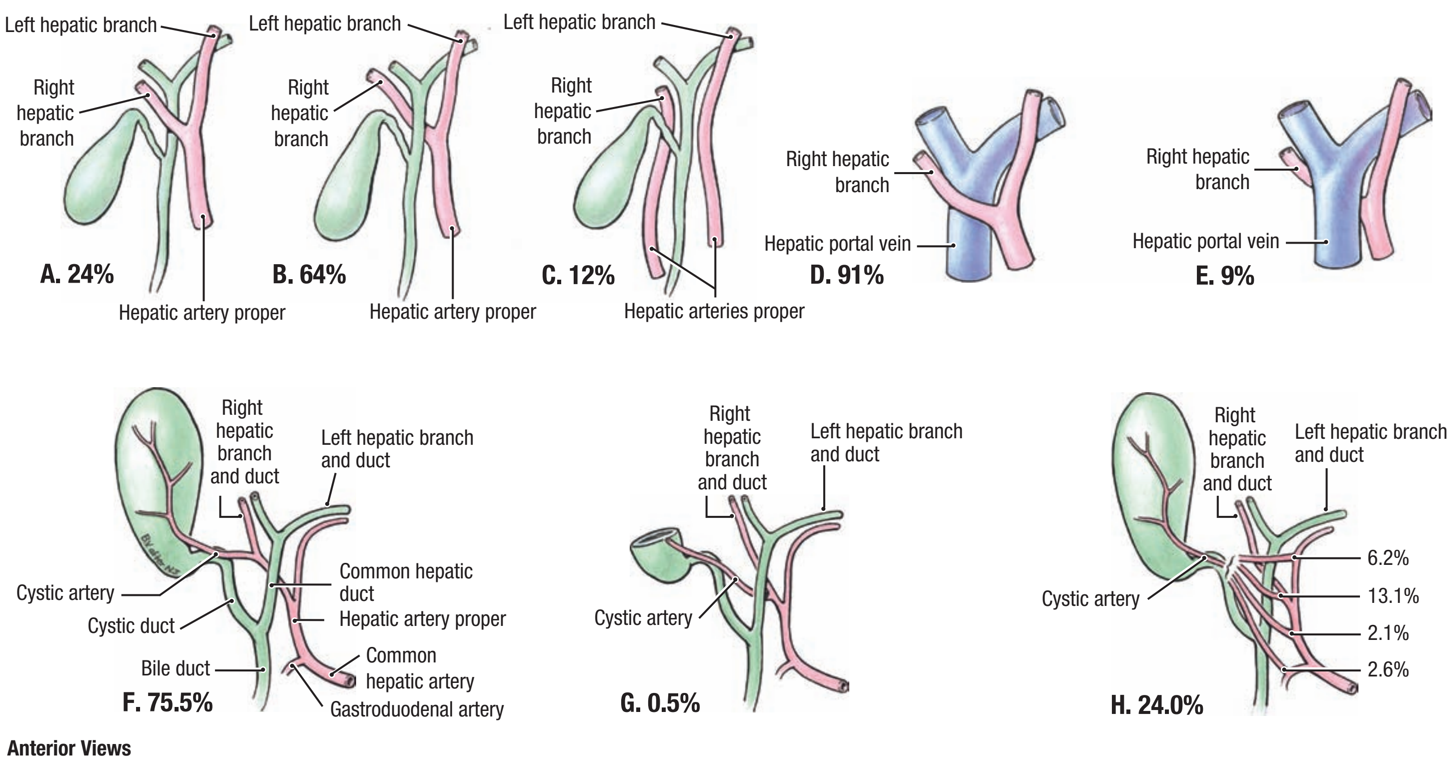
2.60 DEVELOPMENT AND VARIABILITY OF THE PANCREATIC DUCTS

A.–C. Anterior views (*top*) and transverse sections (*bottom*) of the stages in the development of the pancreas. **A.** The small, primitive ventral bud arises in common with the bile duct, and a larger, primitive dorsal bud arises independently from the duodenum. **B.** The 2nd, or descending, part of the duodenum rotates on its long axis, which brings the ventral bud and bile duct posterior to the dorsal bud. **C.** A connecting segment unites the dorsal duct to the ventral duct, whereupon the duodenal end of the dorsal duct atrophies, and the direction of flow within it is reversed. **D.–G.** Common variations of the pancreatic duct. **D.** An accessory duct that has lost its connection with the duodenum. **E.** An accessory duct that is large enough to relieve an obstructed main duct. **F.** An accessory duct that could probably substitute for the main duct. **G.** A persisting primitive dorsal duct unconnected to the primitive ventral duct.



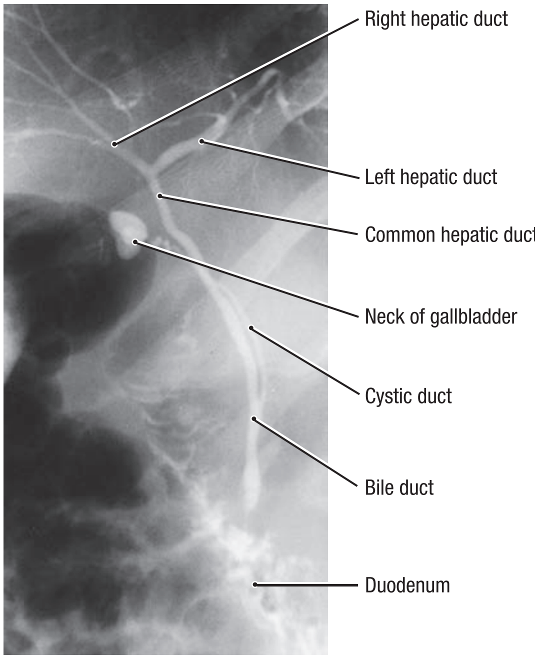
2.61 RADIOGRAPHS OF BILIARY PASSAGES

After a cholecystectomy (removal of the gallbladder), contrast medium was injected with a T tube inserted into the bile passages. The biliary passages are visualized in the superior abdomen in **A** and are more localized in **B.**

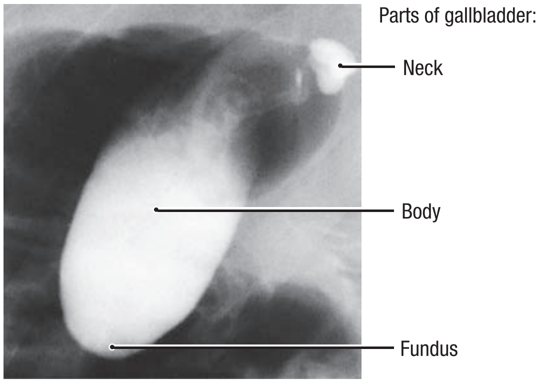


2.62 VARIATIONS IN HEPATIC AND CYSTIC ARTERIES

In a study of 165 cadavers in Dr. Grant's laboratory, five patterns were observed. **A.** Right hepatic artery crossing anterior to bile passages, 24%. **B.** Right hepatic artery crossing posterior to bile passages, 64%. **C.** Aberrant artery arising from the superior mesenteric artery, 12%. The artery crossed anterior **(D)** to the portal vein in 91% and posterior **(E)** in 9%. The cystic artery usually arises from the right hepatic artery in the angle between the common hepatic duct and cystic duct (see cystohepatic triangle, Fig. 2.57A), without crossing the common hepatic duct **(F. and G)**. However, when it arises on the left of the bile passages, it almost always crosses anterior to the passages **(H)**.



A. Anterior View

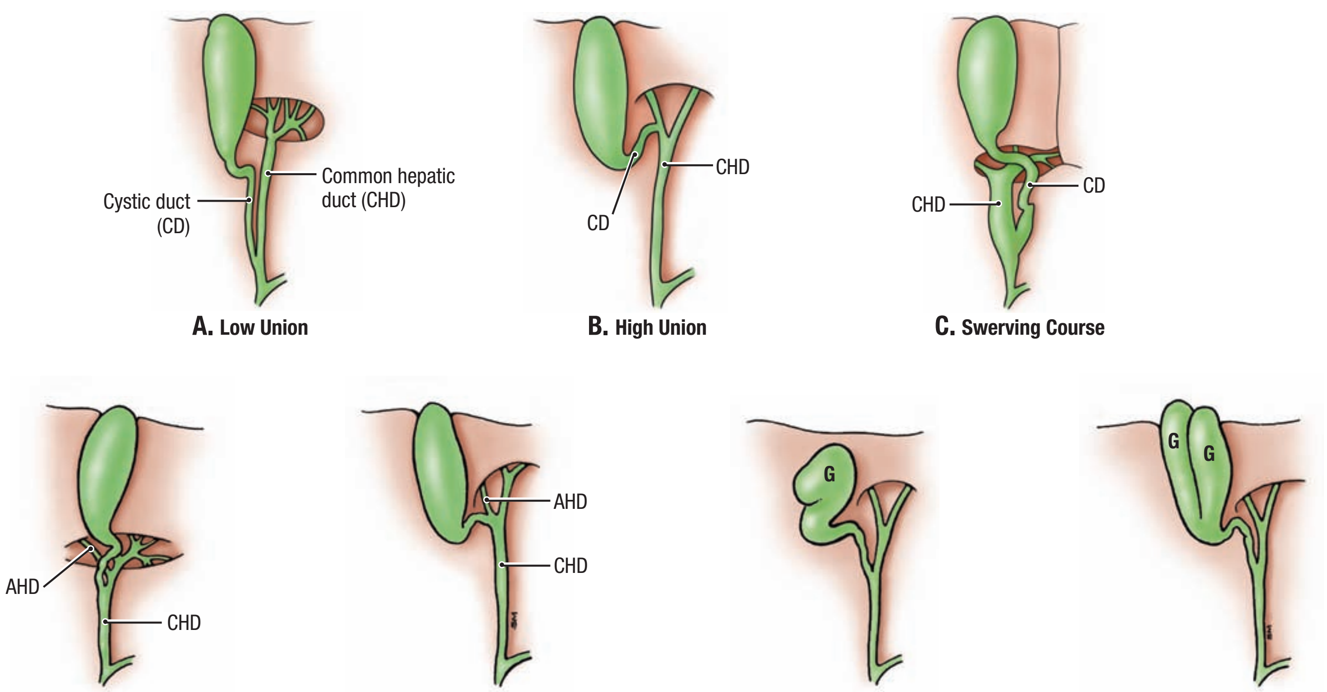


B. Anterior View

2.63 ENDOSCOPIC RETROGRADE CHOLANGIOGRAPHY OF GALLBLADDER AND BILIARY PASSAGES

A. Cystic duct. **B.** Parts of gallbladder.

Endoscopic retrograde cholangiography (ERCP) is done by first passing a fiberoptic endoscope through the mouth, esophagus, and stomach. Then the duodenum is entered, and a cannula is inserted into the major duodenal papilla and advanced under fluoroscopic control into the duct of choice (bile duct or pancreatic duct) for injection of radiographic contrast medium.



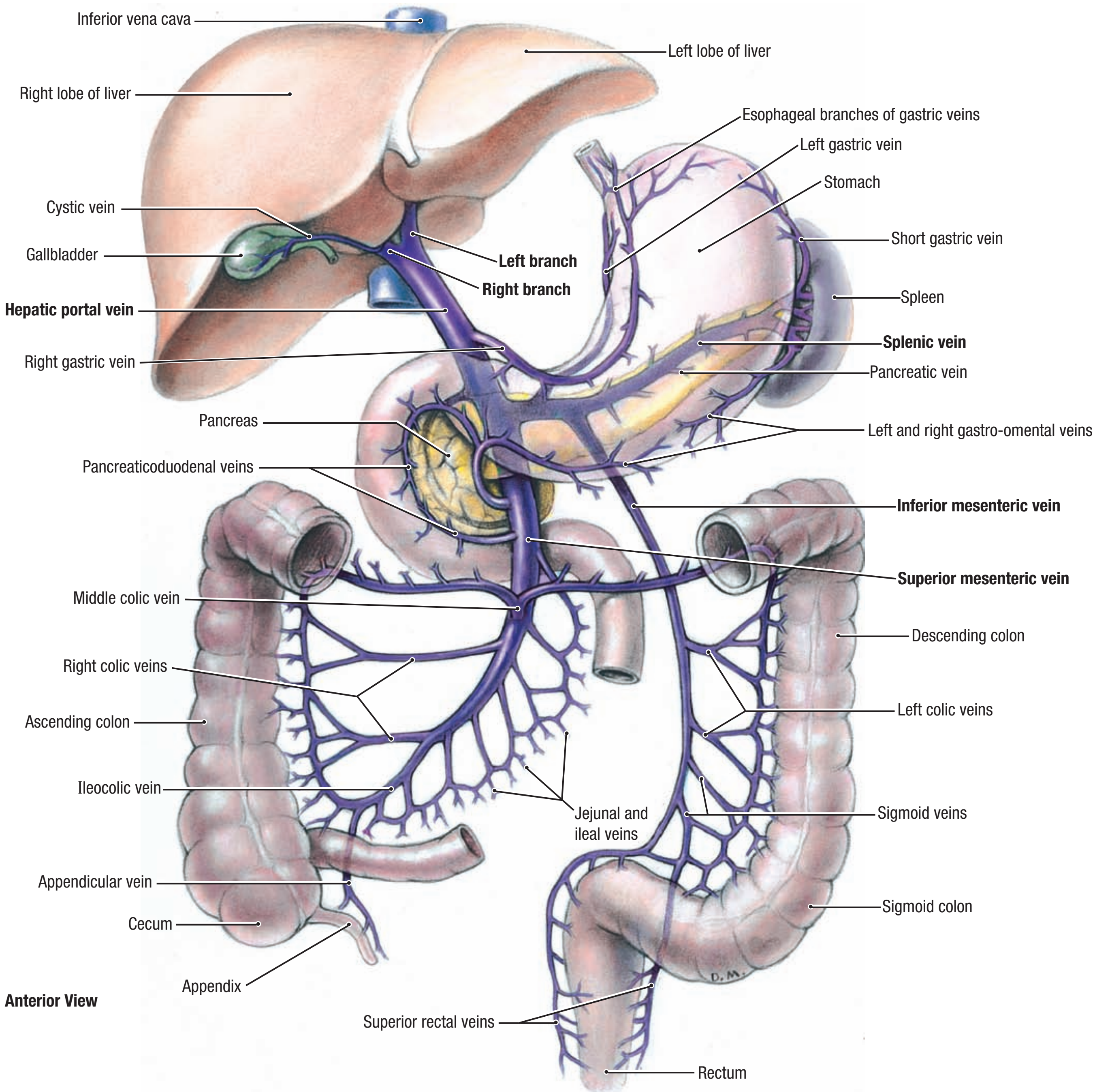
A. Low Union **B. High Union** **C. Swerving Course**

Inferior Views

D. Accessory Hepatic Duct (AHD) **E. Accessory Hepatic Duct (AHD)** **F. Folded Gallbladder (G)** **G. Double Gallbladder (G)**

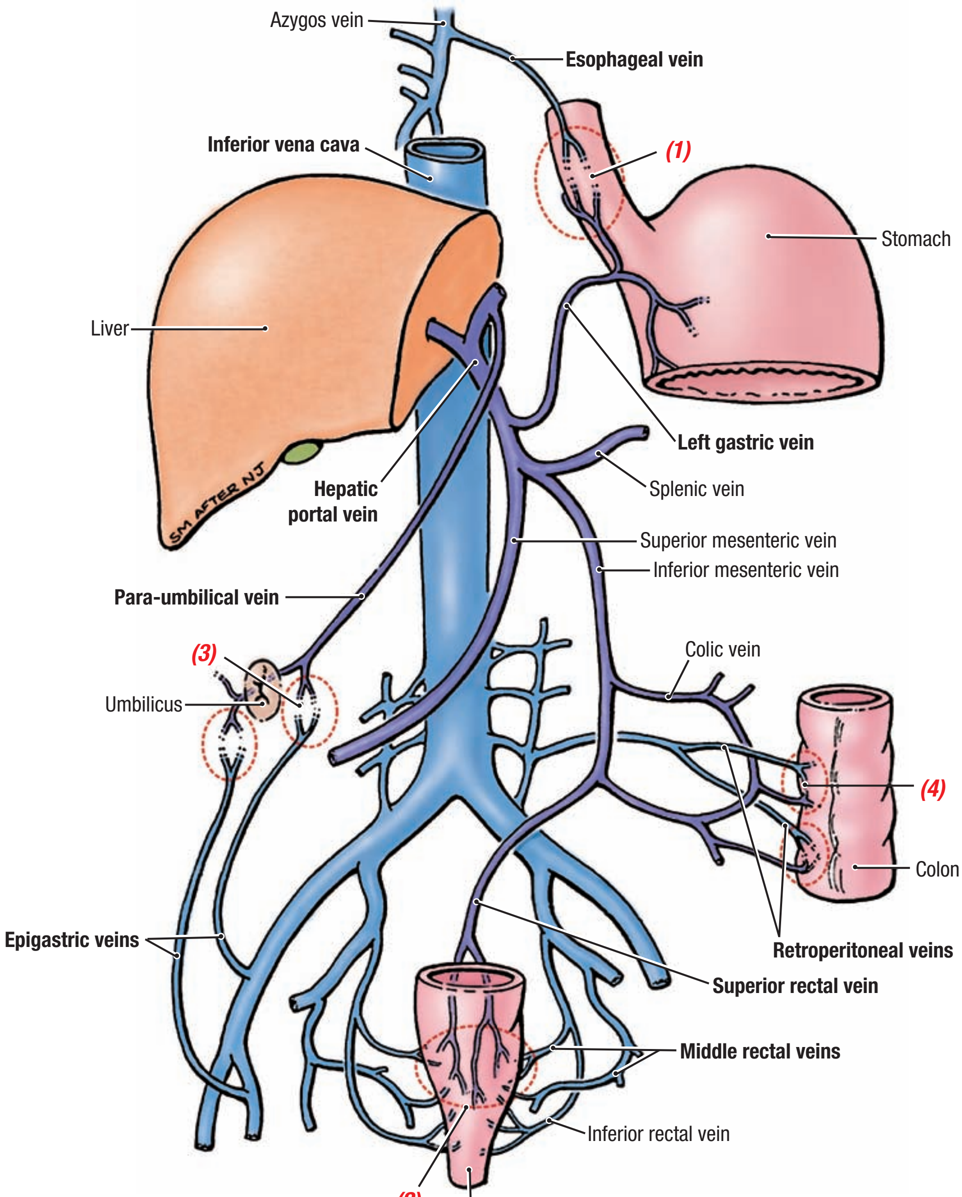
2.64 VARIATIONS OF CYSTIC AND HEPATIC DUCTS AND GALLBLADDER

The cystic duct usually lies on the right side of the common hepatic duct, joining it just above the superior (1st) part of the duodenum, but this varies as in **A.–C.** Of 95 gallbladders and bile passages studied in Dr. Grant's laboratory, 7 had accessory ducts. Of these, four joined the common hepatic duct near the cystic duct **(D),** two joined the cystic duct **(E)**, and one was an anastomosing duct connecting the cystic with the common hepatic duct. **F.** Folded gallbladder. **G.** Double gallbladder.

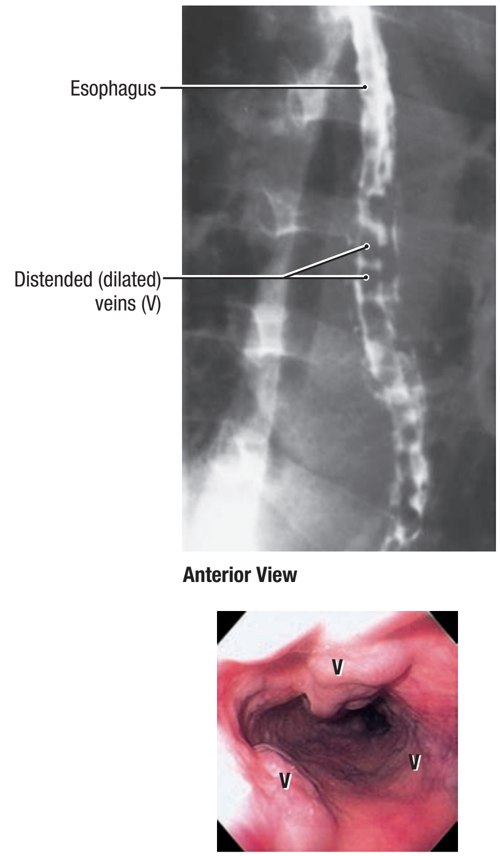


2.65 PORTAL VENOUS SYSTEM

- The hepatic portal vein drains venous blood from the gastrointestinal tract, spleen, pancreas, and gallbladder to the sinusoids of the liver; from here, the blood is conveyed to the systemic venous system by the hepatic veins that drain directly to the inferior vena cava.
- The hepatic portal vein forms posterior to the neck of the pancreas by the union of the superior mesenteric and splenic veins, with the inferior mesenteric vein joining at or near the angle of union.
- The splenic vein drains blood from the inferior mesenteric, left gastro-omental (epiploic), short gastric, and pancreatic veins.
- The right gastro-omental, pancreaticoduodenal, jejunal, ileal, right, and middle colic veins drain into the superior mesenteric vein.
- The inferior mesenteric vein commences in the rectal plexus as the superior rectal vein and, after crossing the common iliac vessels, becomes the inferior mesenteric vein; branches include the sigmoid and left colic veins.
- The hepatic portal vein divides into right and left branches at the porta hepatis. The left branch carries mainly, but not exclusively, blood from the inferior mesenteric, gastric, and splenic veins, and the right branch carries blood mainly from the superior mesenteric vein.



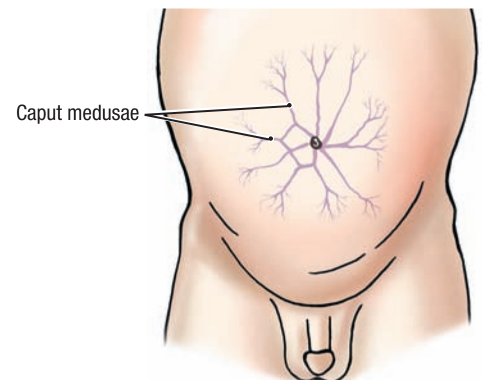
A. Anterior View



Anterior View

View through esophagoscope

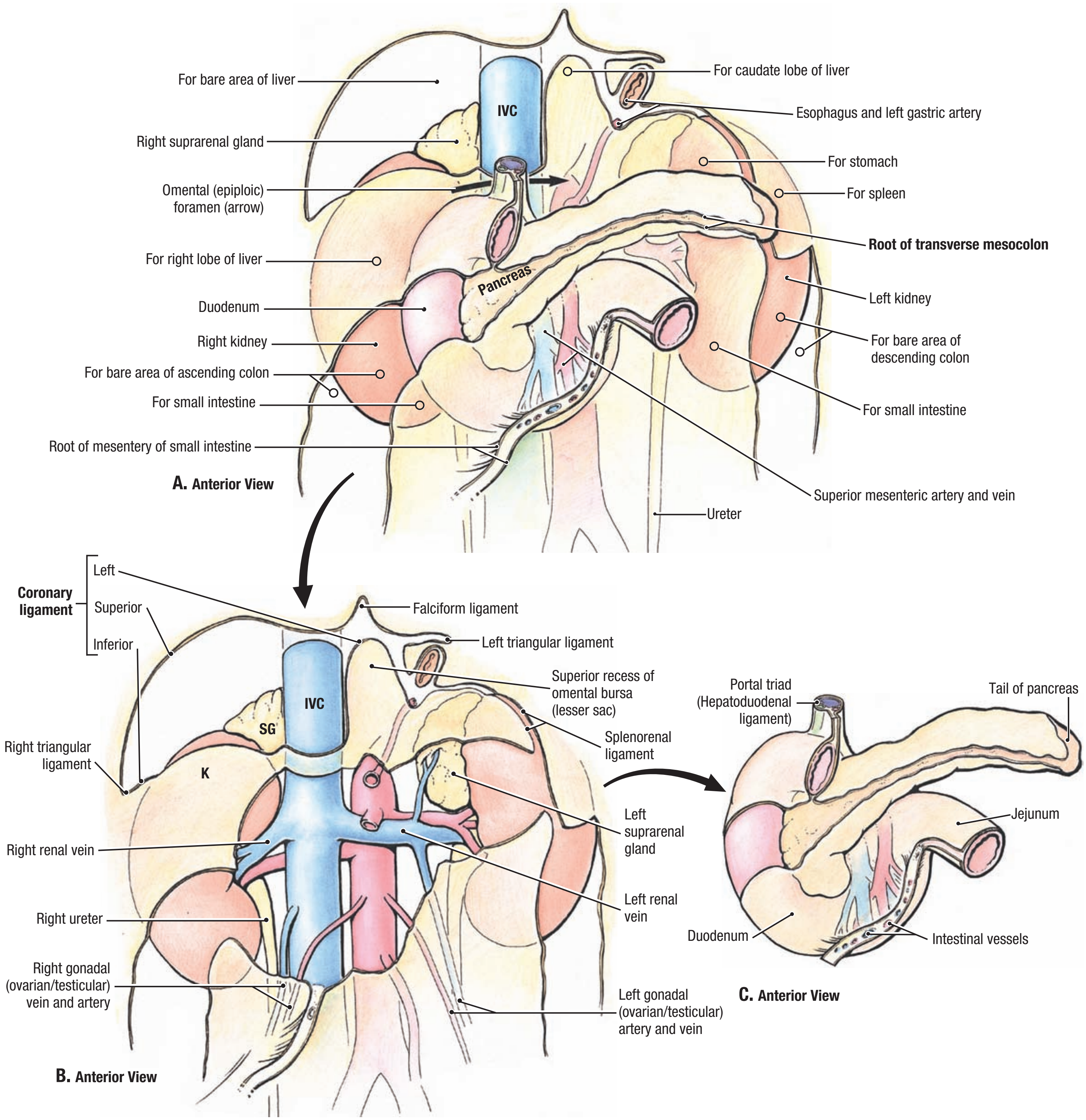
B. Esophageal Varices (V)



C. Anterior View

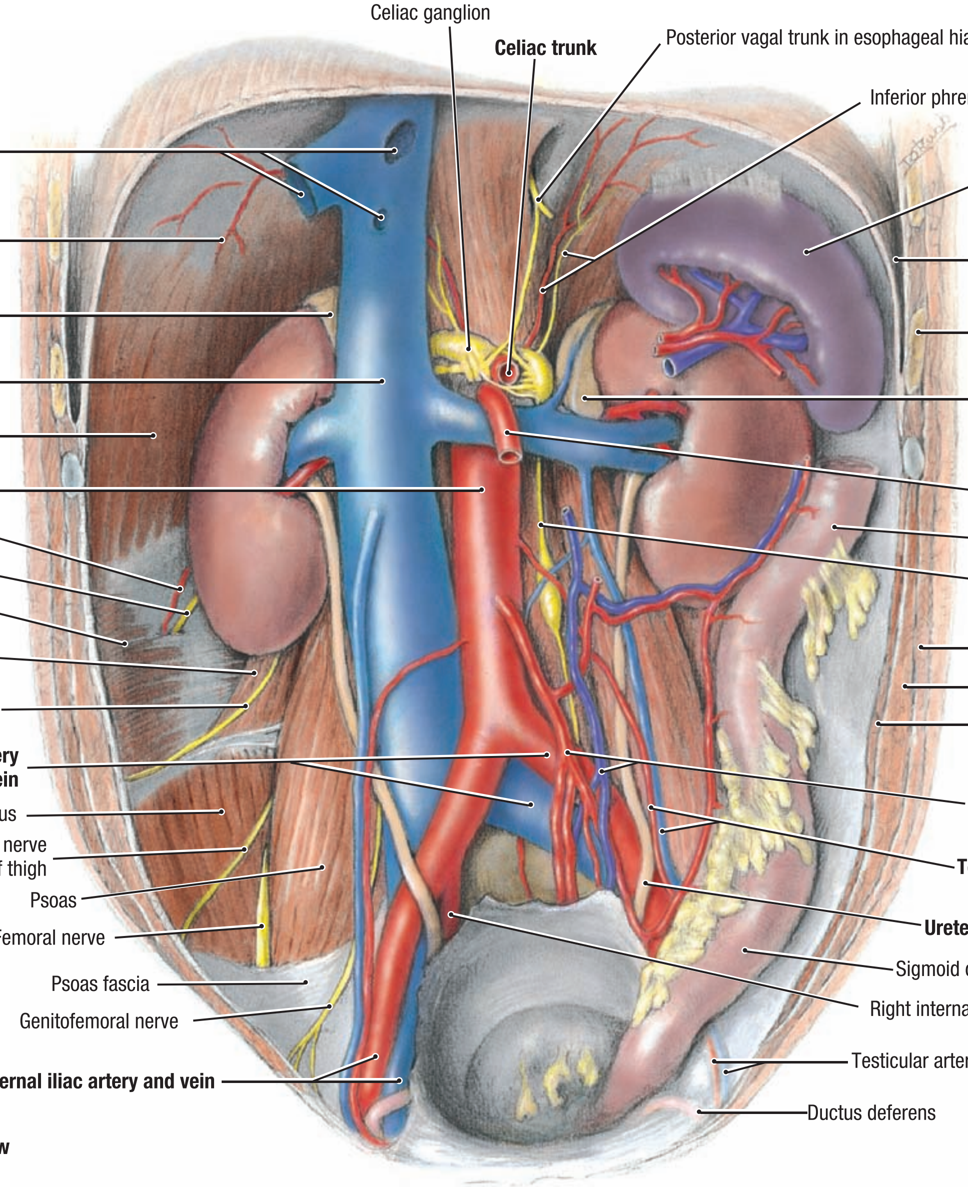
2.66 PORTACAVAL SYSTEM

A. Portacaval system. In this diagram, portal tributaries are *dark blue*, and systemic tributaries and communicating veins are *light blue*. In **portal hypertension** (as in hepatic cirrhosis), the portal blood cannot pass freely through the liver, and the portocaval anastomoses become engorged, dilated, or even varicose; as a consequence, these veins may rupture. The sites of the portocaval anastomosis shown are between *(1)* esophageal veins draining into the azygos vein (systemic) and left gastric vein (portal), which when dilated are esophageal varices; *(2)* the inferior and middle rectal veins, draining into the inferior vena cava (systemic) and the superior rectal vein continuing as the inferior mesenteric vein (portal) (hemorrhoids result if the vessels are dilated); *(3)* paraumbilical veins (portal) and small epigastric veins of the anterior abdominal wall (systemic), which when varicose form "caput medusae" (so named because of the resemblance of the radiating veins to the serpents on the head of Medusa, a character in Greek mythology); and *(4)* twigs of colic veins (portal) anastomosing with systemic retroperitoneal veins. **B.** Esophageal varices. **C.** Caput medusae.

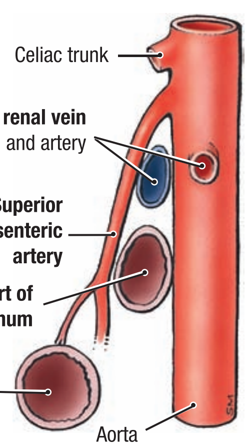


2.67 POSTERIOR ABDOMINAL VISCERA AND THEIR ANTERIOR RELATIONS

The peritoneal coverings are yellow. **A.** Duodenum and pancreas in situ. Note the line of attachment of the root of the transverse mesocolon is to the body and tail of the pancreas. The viscera contacting specific regions are indicated by the term "for." The omental (epiploic) foramen is traversed by an arrow. **B.** After removal of duodenum and pancreas. The three parts of the coronary ligament are attached to the diaphragm, except where the inferior vena cava (IVC), suprarenal gland (SG), and kidney (K) intervene. **C.** Pancreas and duodenum removed from **A.**



A. Anterior View

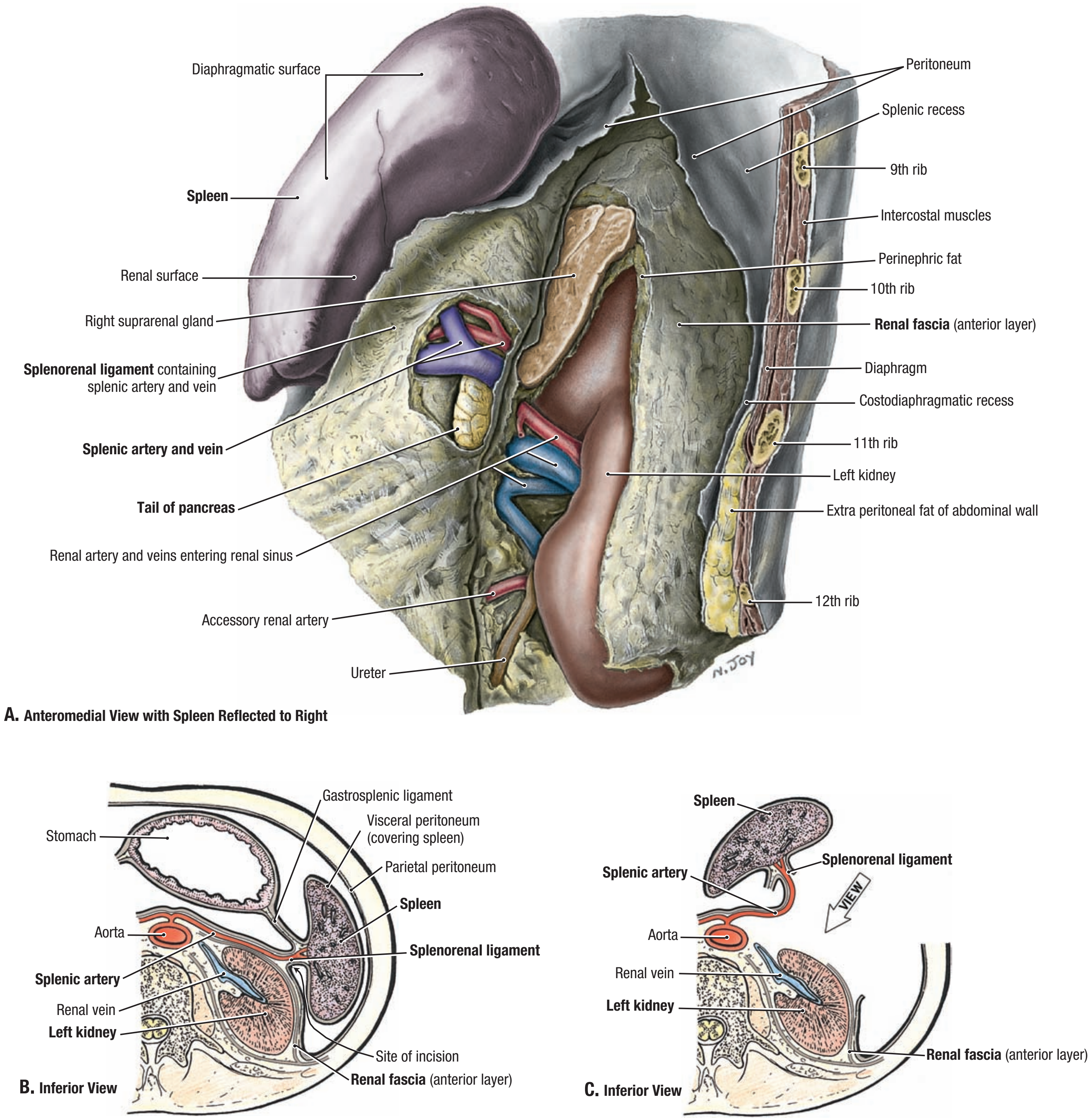


B. Lateral View (from left)

2.68 VISCERA AND VESSELS OF POSTERIOR ABDOMINAL WALL

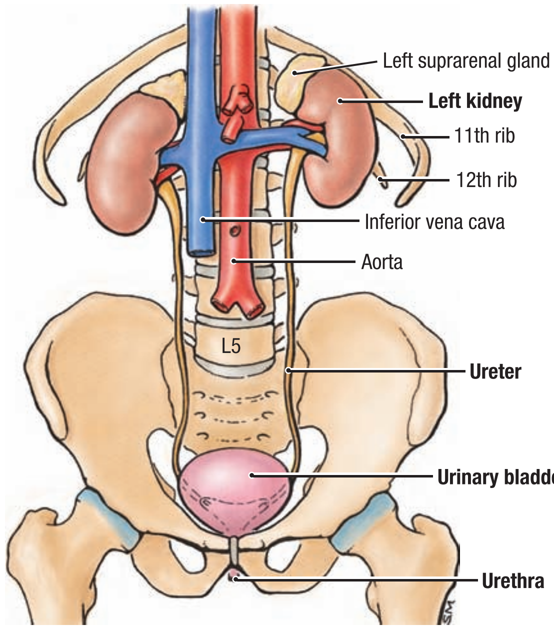
A. Great vessels, kidneys, and suprarenal glands. **B.** Relationships of left renal vein and inferior (3rd) part of duodenum to aorta and superior mesenteric artery.

- The abdominal aorta is shorter and smaller in caliber than the inferior vena cava.
- The inferior mesenteric artery arises about 4 cm superior to the aortic bifurcation and crosses the left common iliac vessels to become the superior rectal artery.
- The left renal vein drains the left testis, left suprarenal gland, and left kidney; the renal arteries are posterior to the renal veins.
- The ureter crosses the external iliac artery just beyond the common iliac bifurcation.
- The testicular vessels cross anterior to the ureter and join the ductus deferens at the deep inguinal ring.
- In **B**, the left renal vein and duodenum (and uncinate process of pancreas—not shown) pass between the aorta posteriorly and the superior mesenteric artery anteriorly; they may be compressed like nuts in a nutcracker.

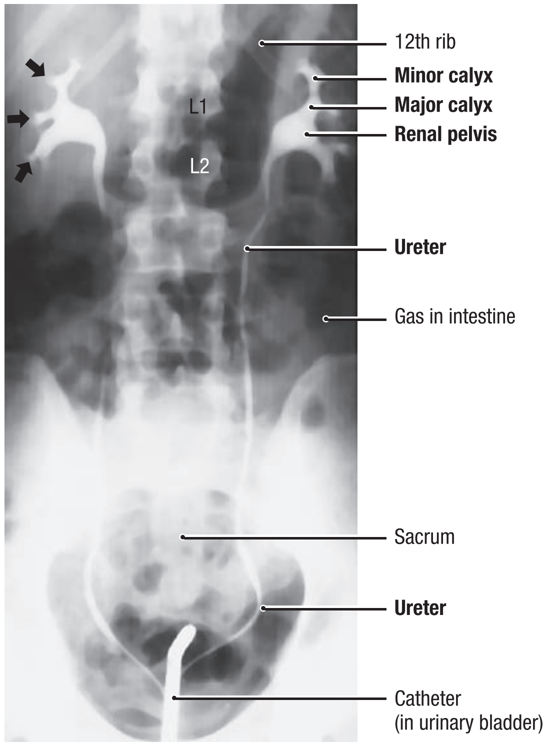


2.69 EXPOSURE OF THE LEFT KIDNEY AND SUPRARENAL GLAND

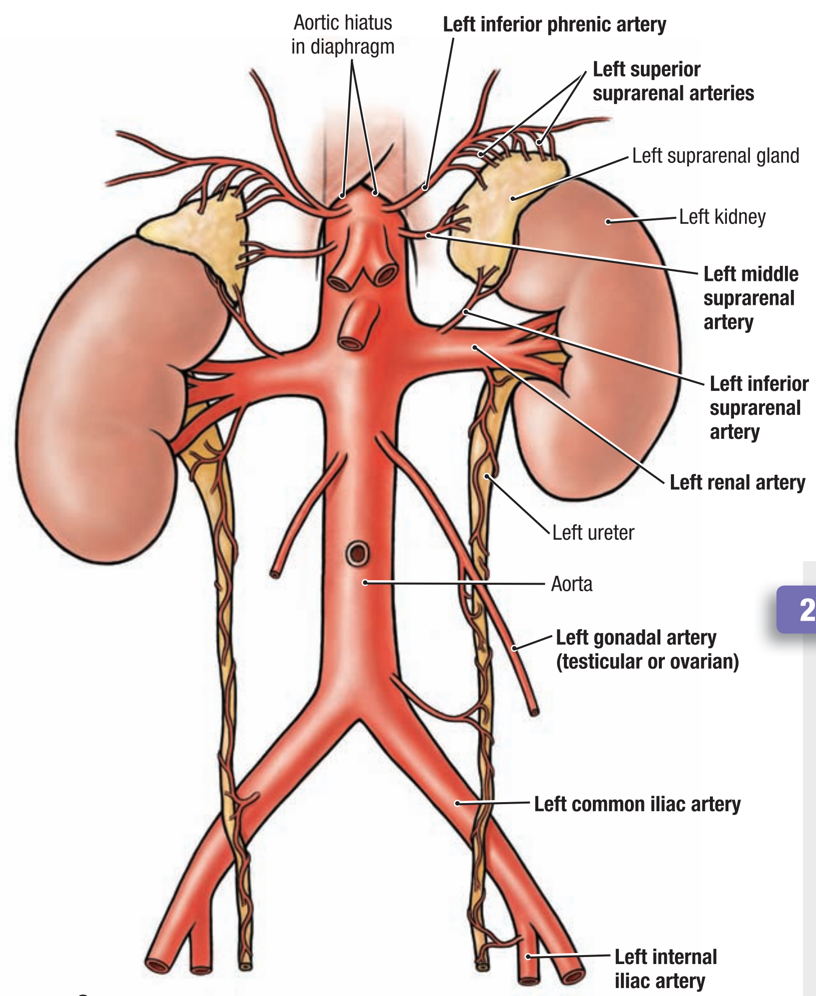
A. Dissection. **B.** Schematic section with spleen and splenorenal ligament intact. **C.** Procedure used in **A** to expose the kidney. The spleen and splenorenal ligament are reflected anteriorly, with the splenic vessels and tail of the pancreas. Part of the renal fascia of the kidney is removed. Note the proximity of the splenic vein and left renal vein, enabling a **splenorenal shunt** to be established surgically to relieve portal hypertension.



A. Anterior View



B. Anteroposterior Pyelogram

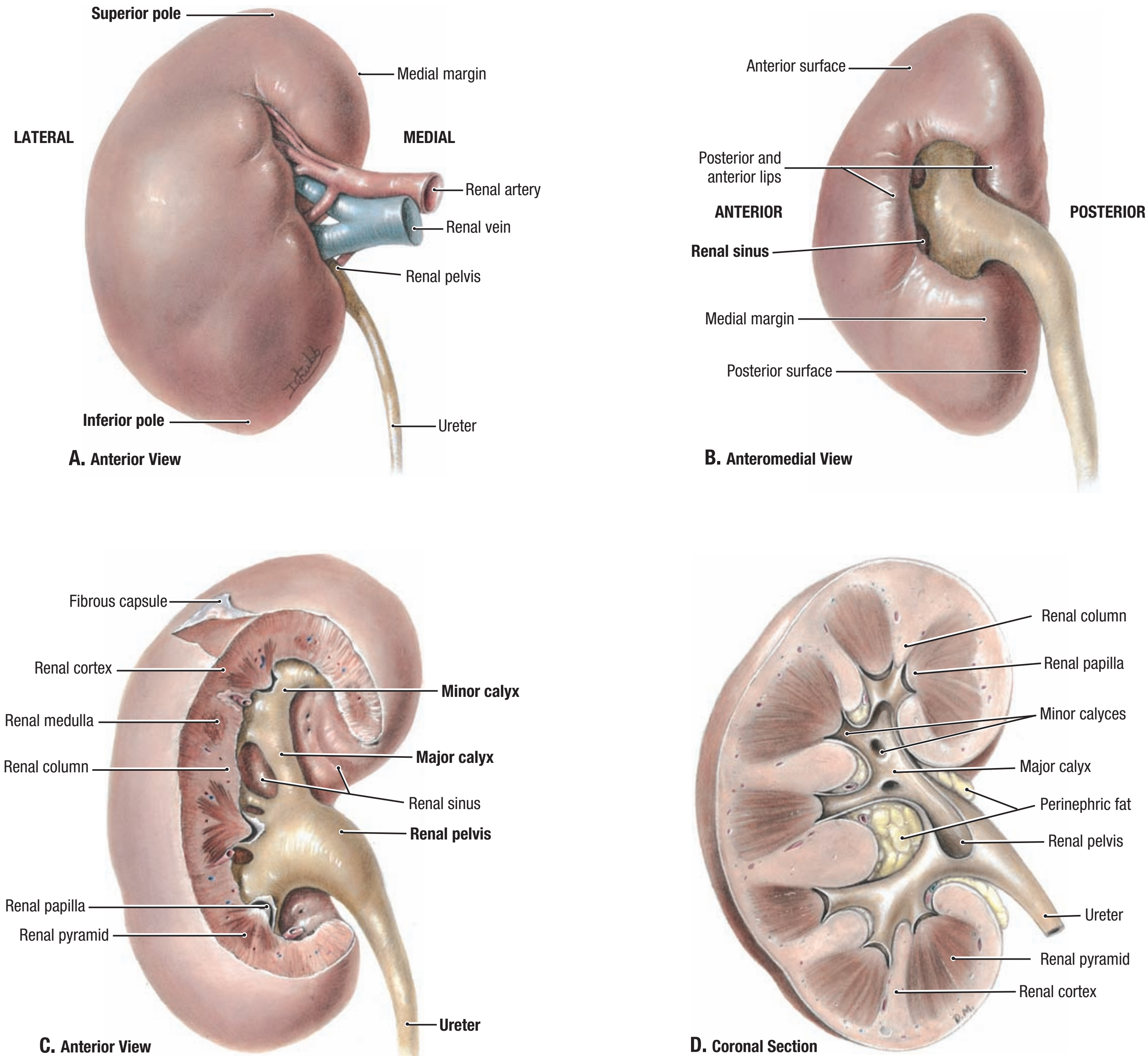


C. Anterior View

2.70 KIDNEYS AND SUPRARENAL GLANDS

A. Overview of urinary system. **B.** Pyelogram. Radiopaque material occupies the cavities that normally conduct urine. Note the papillae (indicated with *arrows*) bulging into the minor calices, which empty into a major calyx that opens, in turn, into the renal pelvis drained by the ureter. **C.** Arterial supply of the suprarenal glands, kidneys, and ureters.

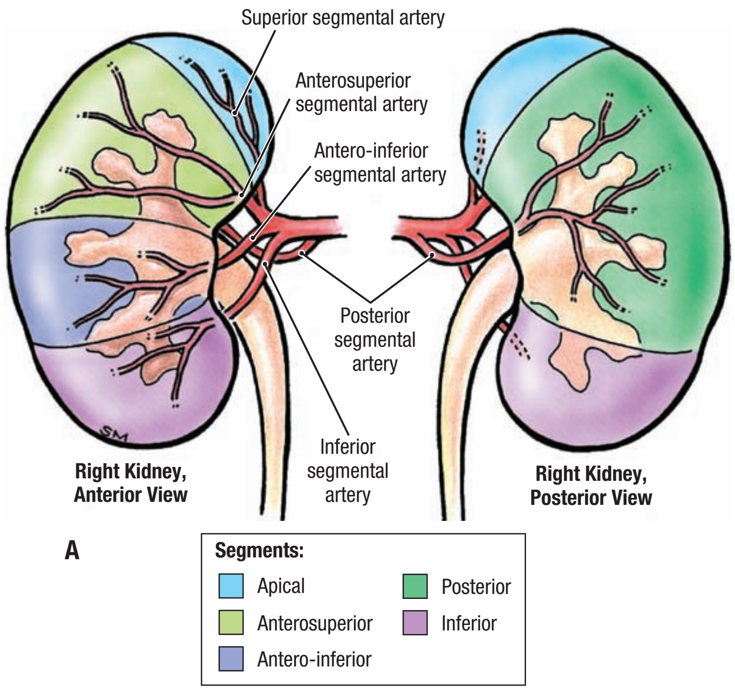
Renal transplantation is now an established operation for the treatment of selected cases of chronic renal failure. The kidney can be removed from the donor without damaging the suprarenal gland because of the weak septum of renal fascia that separates the kidney from this gland. The site for transplanting a kidney is in the iliac fossa of the greater pelvis. The renal artery and vein are joined to the external iliac artery and vein, respectively, and the ureter is sutured into the urinary bladder.



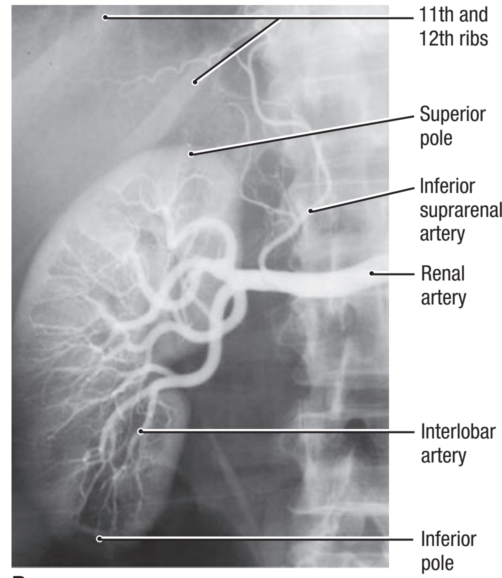
A. **Anterior View** **B.** **Anteromedial View** **C.** **Anterior View** **D.** **Coronal Section**

2.71 STRUCTURE OF KIDNEY

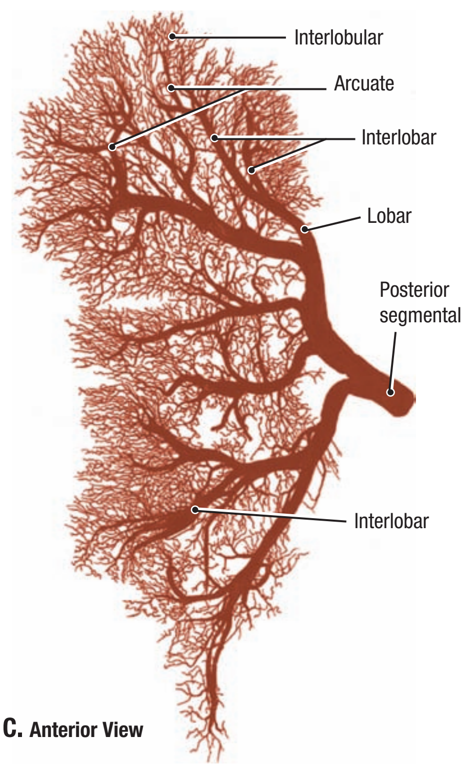
A. External features. The superior pole of the kidney is closer to the median plane than the inferior pole. Approximately 25% of kidneys may have a 2nd, 3rd, and even 4th accessory renal artery branching from the aorta. These multiple vessels enter through the renal sinus or at the superior or inferior pole. **B.** Renal sinus. The renal sinus is a vertical "pocket" opening on the medial side of the kidney. Tucked into the pocket are the renal pelvis and renal vessels in a matrix of perinephric fat. **C.** Renal calices. The anterior wall of the renal sinus has been cut away to expose the renal pelvis and the calices. **D.** Internal features. **Cysts in the kidney**, multiple or solitary, are common and usually benign findings during ultrasound examinations and dissection of cadavers. **Adult polycystic disease** of the kidneys, however, is an important cause of renal failure.



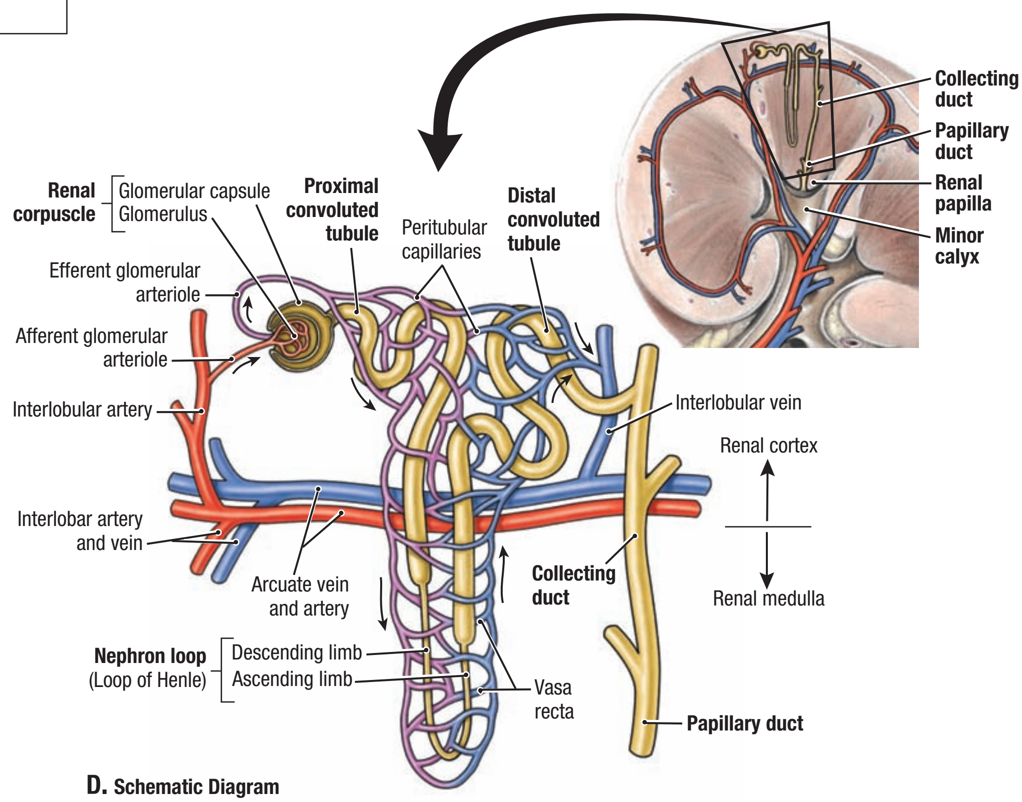
A



B. Anteroposterior Arteriogram



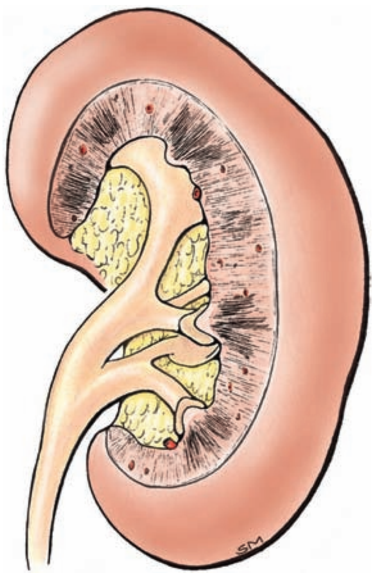
C. Anterior View



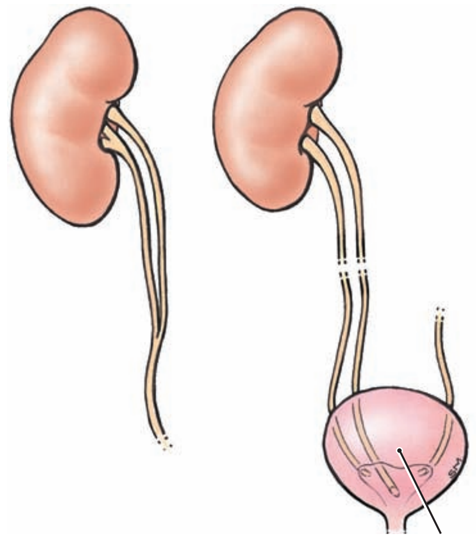
D. Schematic Diagram

2.72 SEGMENTS OF THE KIDNEYS

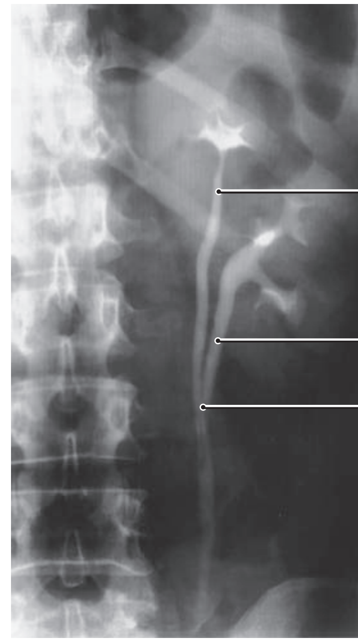
A. Segmental arteries. Segmental arteries do not anastomose significantly with other segmental arteries; they are end arteries. The area supplied by each segmented artery is an independent, surgically respectable unit or **renal segment.** **B.** Renal arteriogram. **C.** Corrosion cast of posterior segmental artery of kidney. **D.** The nephron is the functional unit of the kidney consisting of a renal corpuscle, proximal tubule, nephron loop, and distal tubule. Papillary ducts open onto renal papillae, emptying into minor calices.



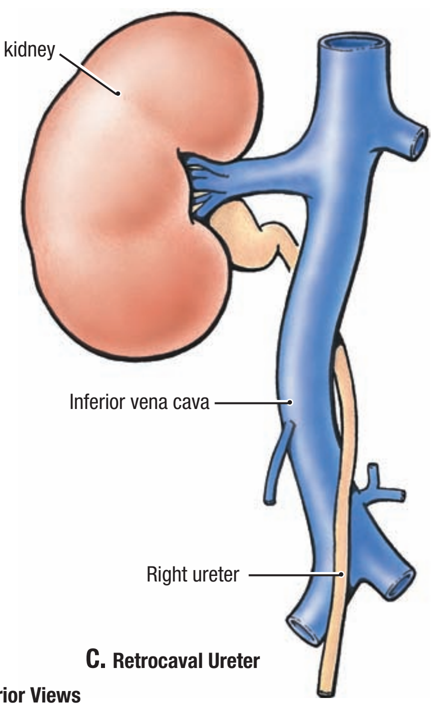
A. Bifid Pelves



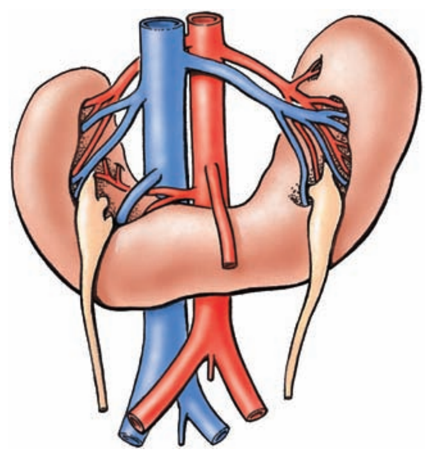
B. Bifid Ureter



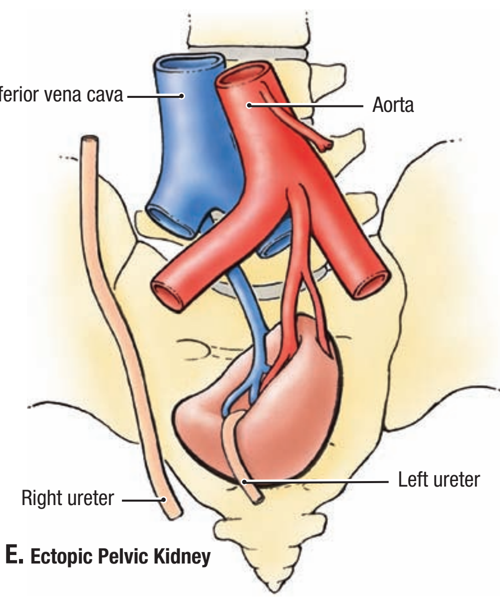
Anteroposterior Pyelogram



C. Retrocaval Ureter



D. Horseshoe Kidney

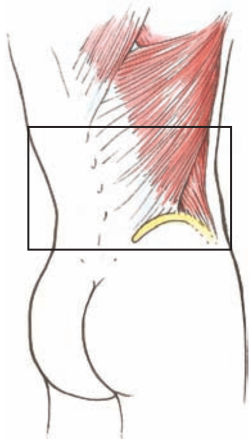


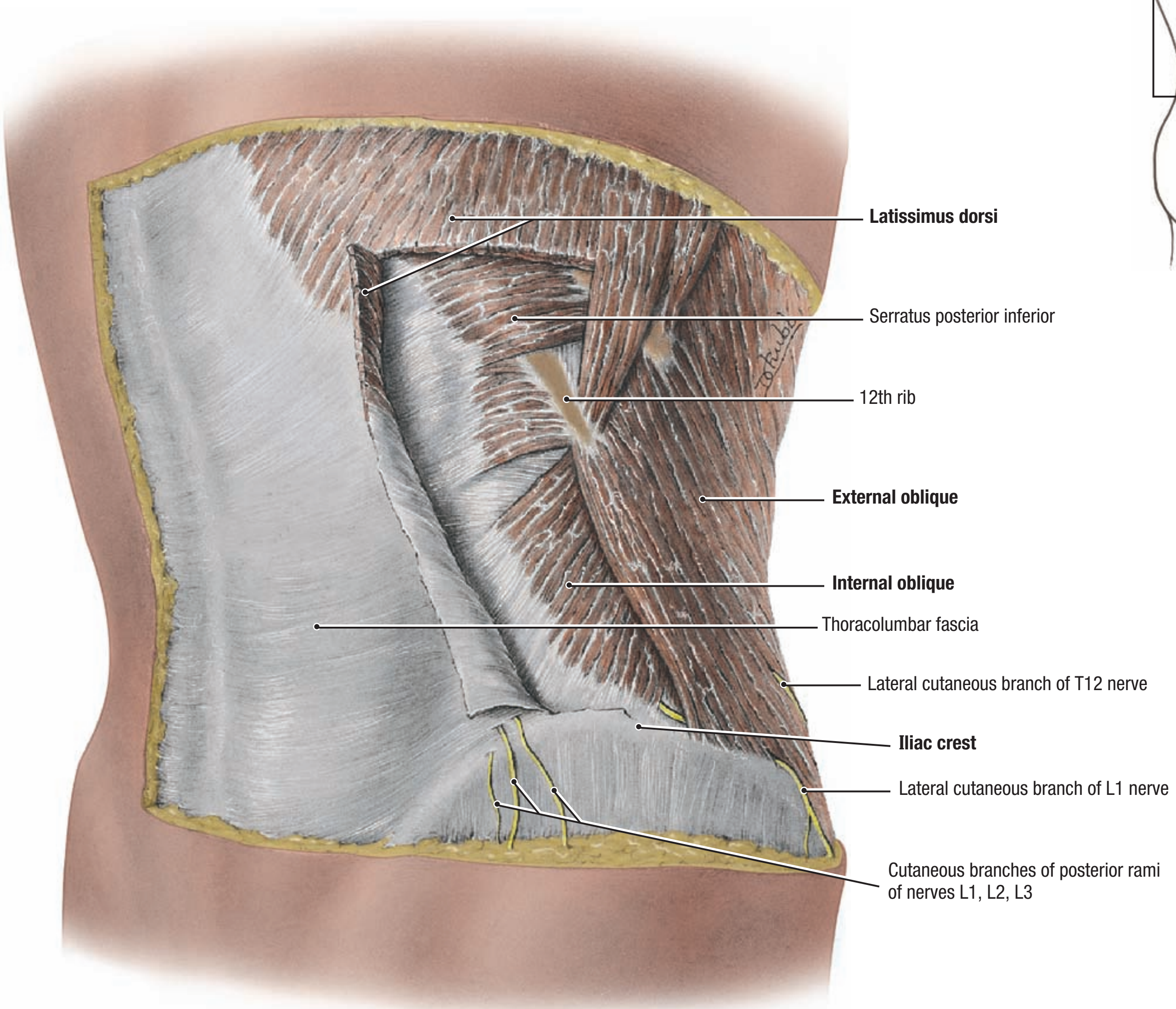
E. Ectopic Pelvic Kidney

Anterior Views

2.73 ANOMALIES OF KIDNEY AND URETER

A. Bifid pelves. The pelves are almost replaced by two long major calices, which extend outside the sinus. **B. Duplicated, or bifid, ureters**. These can be unilateral or bilateral and complete or incomplete. **C. Retrocaval ureter.** The ureter courses posterior and then anterior to the inferior vena cava. **D. Horseshoe kidney.** The right and left kidneys are fused in the midline. **E. Ectopic pelvic kidney.** Pelvic kidneys have no fatty capsule and can be unilateral or bilateral. During childbirth, they may cause obstruction and suffer injury.

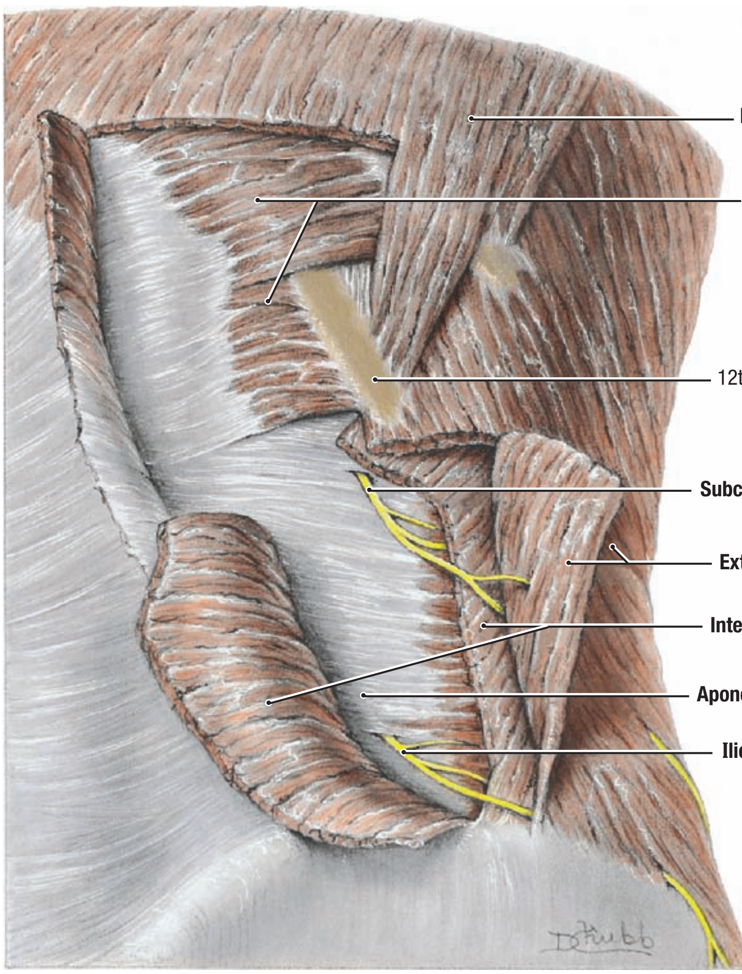


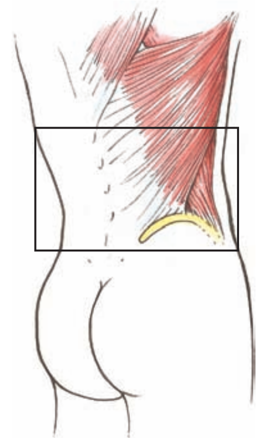


2.74 POSTEROLATERAL ABDOMINAL WALL: EXPOSURE OF KIDNEY I

The latissimus dorsi is partially reflected.

- The external oblique muscle has an oblique, free posterior border that extends from the tip of the 12th rib to the midpoint of the iliac crest.
- The internal oblique muscle extends posteriorly beyond the border of the external oblique muscle.



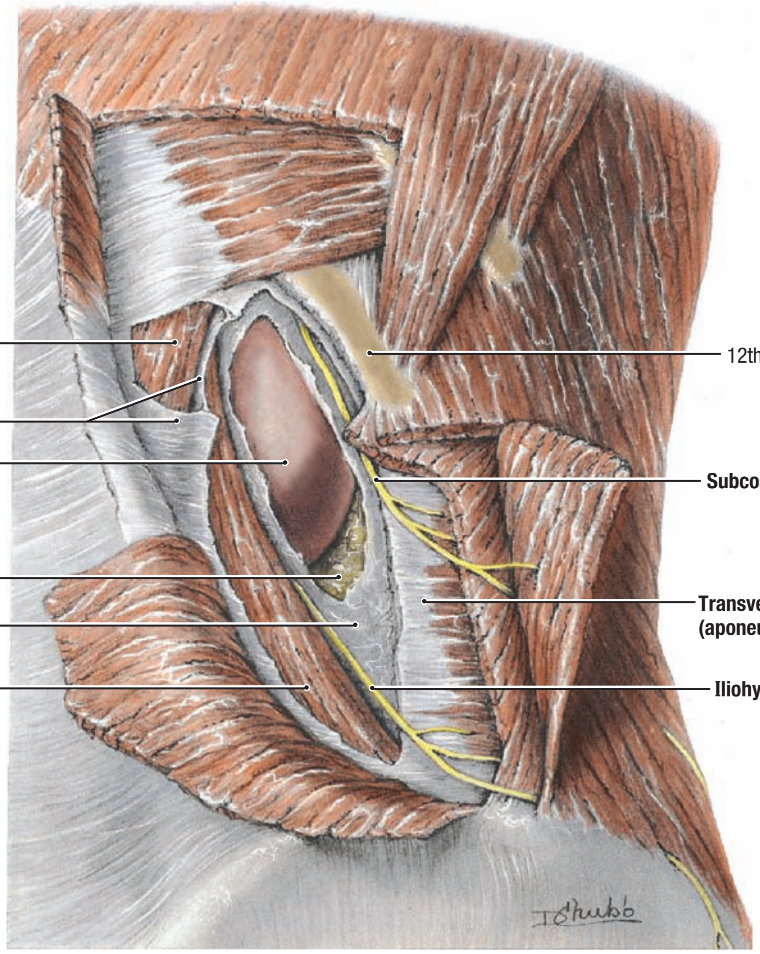


2.75 POSTEROLATERAL ABDOMINAL WALL: EXPOSURE OF KIDNEY II

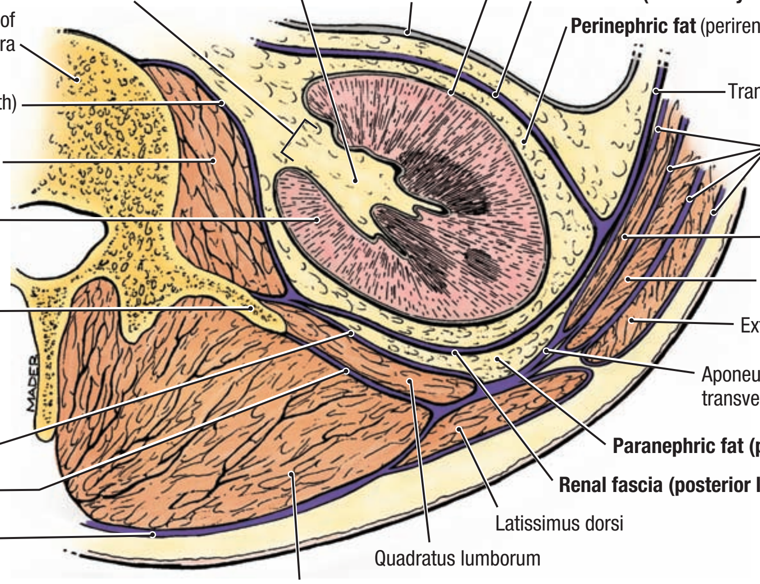
The external oblique muscle is incised and reflected laterally, and the internal oblique muscle is incised and reflected medially; the transversus abdominis muscle and its posterior aponeurosis are exposed where pierced by the subcostal (T12) and iliohypogastric (L1) nerves. These nerves give off motor twigs and lateral cutaneous branches and continue anteriorly between the internal oblique and transversus abdominis muscles.

2.76 POSTEROLATERAL ABDOMINAL WALL: EXPOSURE OF KIDNEY III AND RENAL FASCIA →

A. The posterior aponeurosis of the transversus abdominis muscle is divided between the subcostal and iliohypogastric nerves and lateral to the oblique lateral border of the quadratus lumborum muscle; the retroperitoneal fat surrounding the kidney is exposed. **B.** Renal fascia and retroperitoneal fat, schematic transverse section. The renal fascia is within this fat; the portion of fat internal to the renal fascia is termed perinephric fat (perirenal fat capsule), and the fat immediately external is paranephric fat (pararenal fat body).

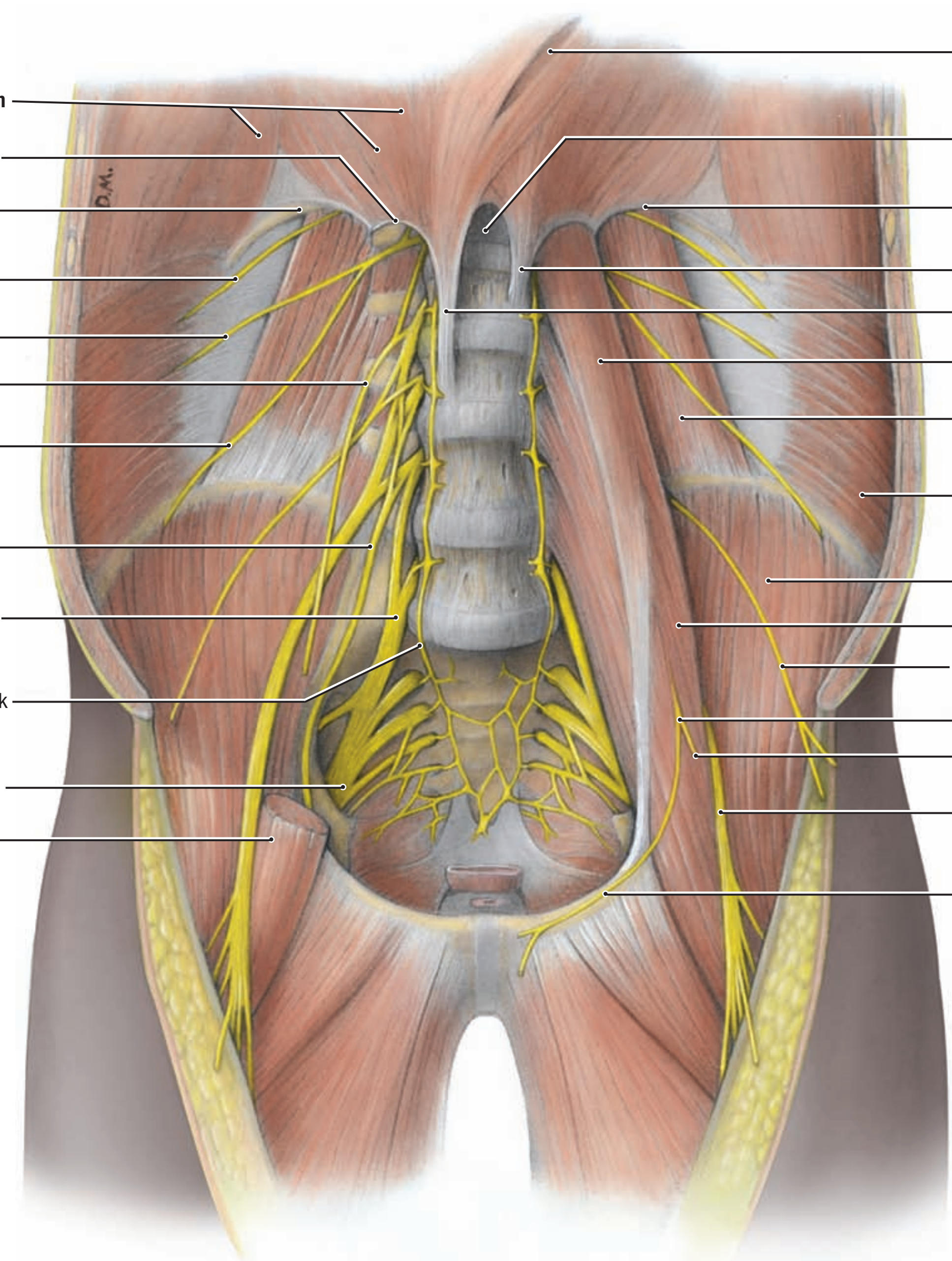


A. Posterolateral View



B. Transverse Section

 POSTEROLATERAL ABDOMINAL WALL: EXPOSURE OF KIDNEY III AND RENAL FASCIA (*CONTINUED*)

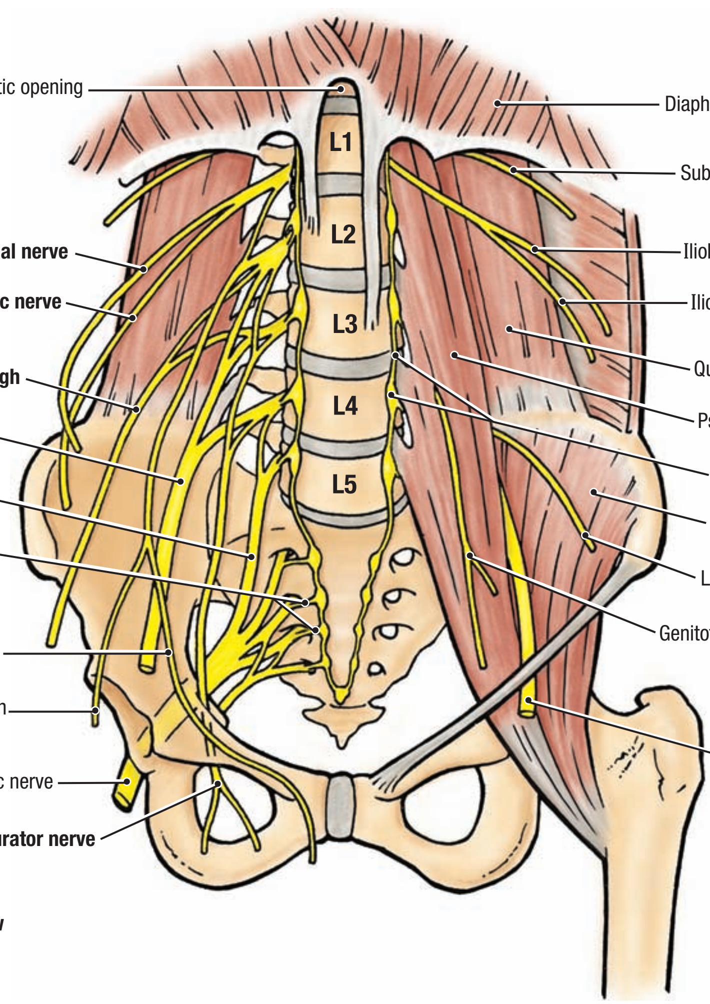


2.77 LUMBAR PLEXUS AND VERTEBRAL ATTACHMENT OF DIAPHRAGM

TABLE 2.7 PRINCIPAL MUSCLES OF POSTERIOR ABDOMINAL WALL

Muscle	Superior Attachments	Inferior Attachments	Innervation	Actions
Psoas major[a,b]	Transverse processes of lumbar vertebrae; sides of bodies of T12–L5 vertebrae and intervening intervertebral discs	By a strong tendon to lesser trochanter of femur	Anterior rami of lumbar nerves (**L1, L2**, L3)	Acting inferiorly with iliacus, it flexes thigh at hip; acting superiorly, it flexes vertebral column laterally; it is used to balance the trunk; during sitting it acts inferiorly with iliacus to flex trunk
Iliacus[a]	Superior two thirds of iliac fossa, ala of sacrum, and anterior sacro-iliac ligaments	Lesser trochanter of femur and shaft inferior to it, and to psoas major tendon	Femoral nerve (**L2**, L3, L4)	Flexes thigh and stabilizes hip joint; acts with psoas major
Quadratus lumborum	Medial half of inferior border of 12th rib and tips of lumbar transverse processes	Iliolumbar ligament and internal lip of iliac crest	Anterior rami of T12 and L1–L4 nerves	Extends and laterally flexes vertebral column; fixes 12th rib during inspiration

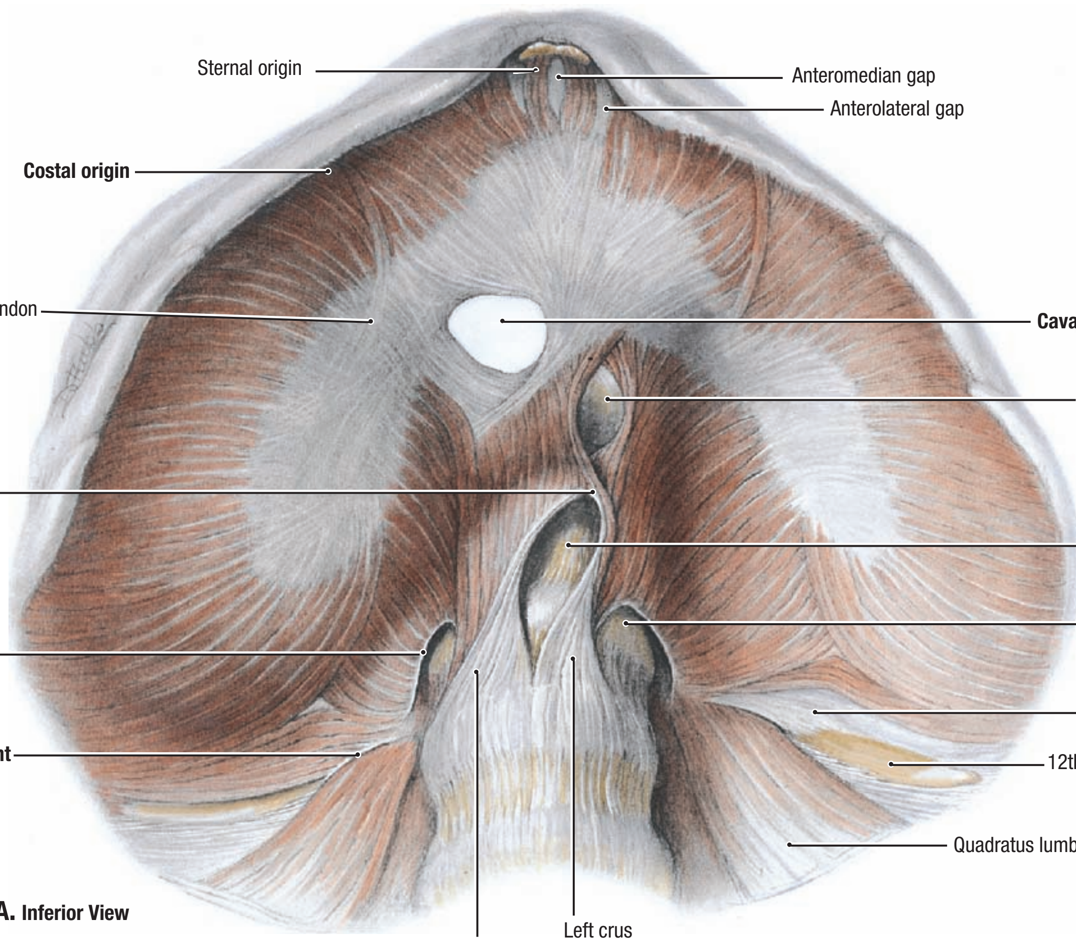
[a]Psoas major and iliacus muscles are often described together as the iliopsoas muscle when flexion of the thigh is discussed.
[b]Psoas minor attaches proximally to the sides of bodies of T12–L1 vertebrae and intervertebral disc and distally to the pectineal line and iliopectineal eminence via the iliopectineal arch; it does not cross the hip joint. It is used to balance the trunk, in conjunction with psoas major. Innervation is from the anterior rami of lumbar nerves (L1, L2).



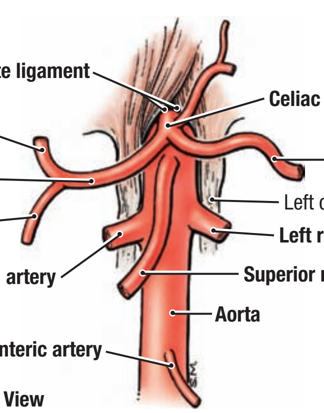
2.78 NERVES OF LUMBAR PLEXUS

The lumbar plexus of nerves is in the posterior part of the psoas major, anterior to the lumbar transverse processes. This nerve network is composed of the anterior rami of L1–L4 nerves. All rami receive gray rami communicates from the sympathetic trunks. The following nerves are branches of the lumbar plexus:

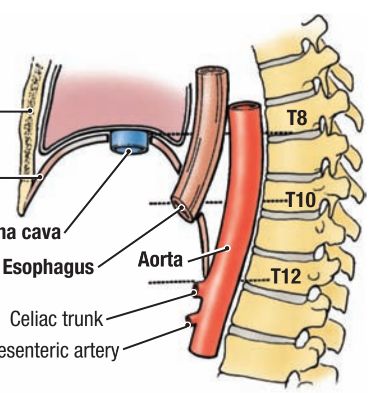
- Ilio-inguinal and iliohypogastric nerves (L1) arise from the anterior ramus of L1 and enter the abdomen posterior to the medial arcuate ligaments and pass inferolaterally, anterior to the quadratus lumborum muscle; they pierce the transversus abdominis muscle near the anterior superior iliac spine and pass through the internal and external oblique muscles to supply the skin of the suprapubic and inguinal regions.
- Lateral cutaneous nerve of thigh (L2, L3) runs inferolaterally on the iliacus muscle and enters the thigh posterior to the inguinal ligament, just medial to the anterior superior iliac spine; it supplies the skin on the anterolateral surface of the thigh.
- Femoral nerve (L2–L4) emerges from the lateral border of the psoas and innervates the iliacus muscle and the extensor muscles of the knee.
- Genitofemoral nerve (L1, L2) pierces the anterior surface of the psoas major muscle and runs inferiorly on it deep to the psoas fascia; it divides lateral to the common and external iliac arteries into femoral and genital branches.
- Obturator nerve (L2–L4) emerges from the medial border of the psoas to supply the adductor muscles of the thigh.
- Lumbosacral trunk (L4, L5) passes over the ala (wing) of the sacrum and descends into the pelvis to take part in the formation of the sacral plexus along with the anterior rami of S1–S4 nerves.



A. Inferior View



B. Anterior View

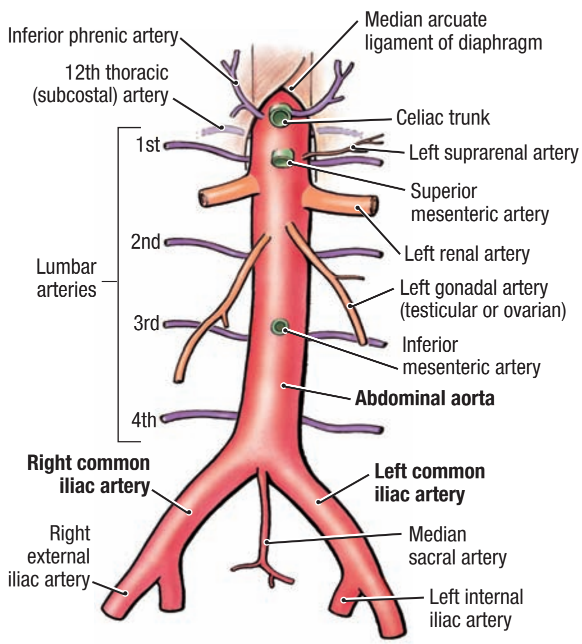


C. Lateral View, from Left

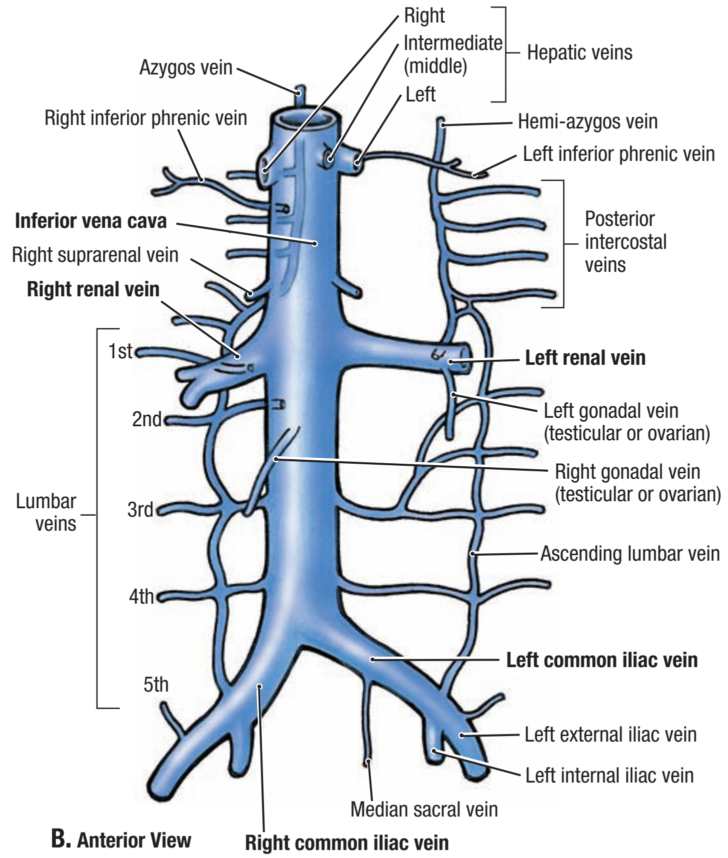
2.79 DIAPHRAGM

A. Dissection. The clover-shaped central tendon is the aponeurotic insertion of the muscle. **Diaphragmatic hernia.** The diaphragm in this specimen fails to arise from the left lateral arcuate ligament, leaving a potential opening, the lumbocostal triangle, through which abdominal contents may be herniated into the thoracic cavity following a sudden increase in intra-thoracic or intra-abdominal pressure. A **hiatal hernia** is a protrusion of part of the stomach into the thorax through the esophageal hiatus.

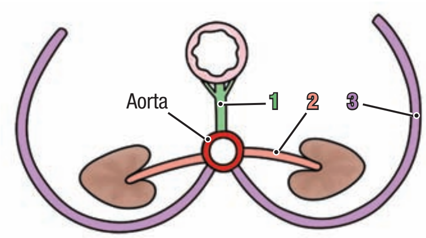
B. Median arcuate ligament and branches of the aorta. **C.** Openings of the diaphragm. There are three major openings: (1) the caval opening for the inferior vena cava, most anterior, at the T8 vertebral level to the right of the midline; (2) the esophageal hiatus, intermediate, at T10 level and to the left; and (3) the aortic hiatus, which allows the aorta to pass posterior to the vertebral attachment of the diaphragm in the midline at T12.



A. Anterior View

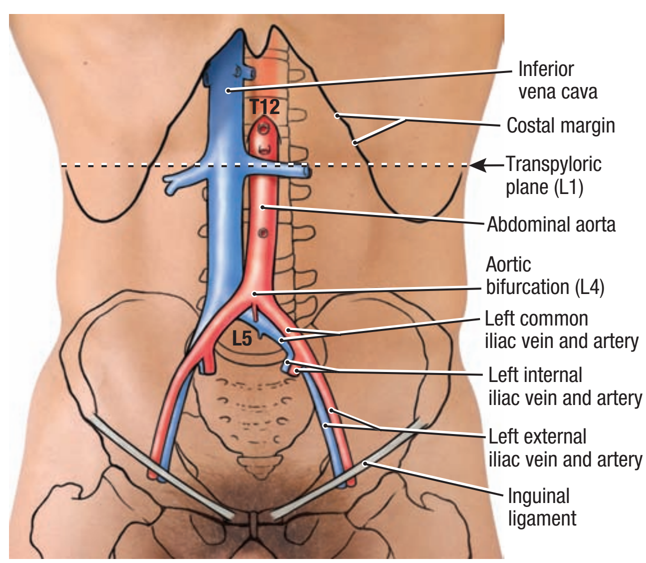


B. Anterior View



Three Vascular Planes

	Origin from Aorta	Class	Distribution	Abdominal Branches (Arteries)	Vertebral Level
1	Anterior midline	Unpaired visceral	Alimentary tract	Celiac	T12
				Superior mesenteric (SMA)	L1
				Inferior mesenteric (IMA)	L3
2	Lateral	Paired visceral	Urogenital and endocrine organs	Suprarenal	L1
				Renal	L1
				Gonadal (testicular or ovarian)	L2
3	Postero-lateral	Paired parietal (segmental)	Diaphragm Body Wall	Subcostal	T12
				Inferior phrenic	T12
				Lumbar	L1–L4

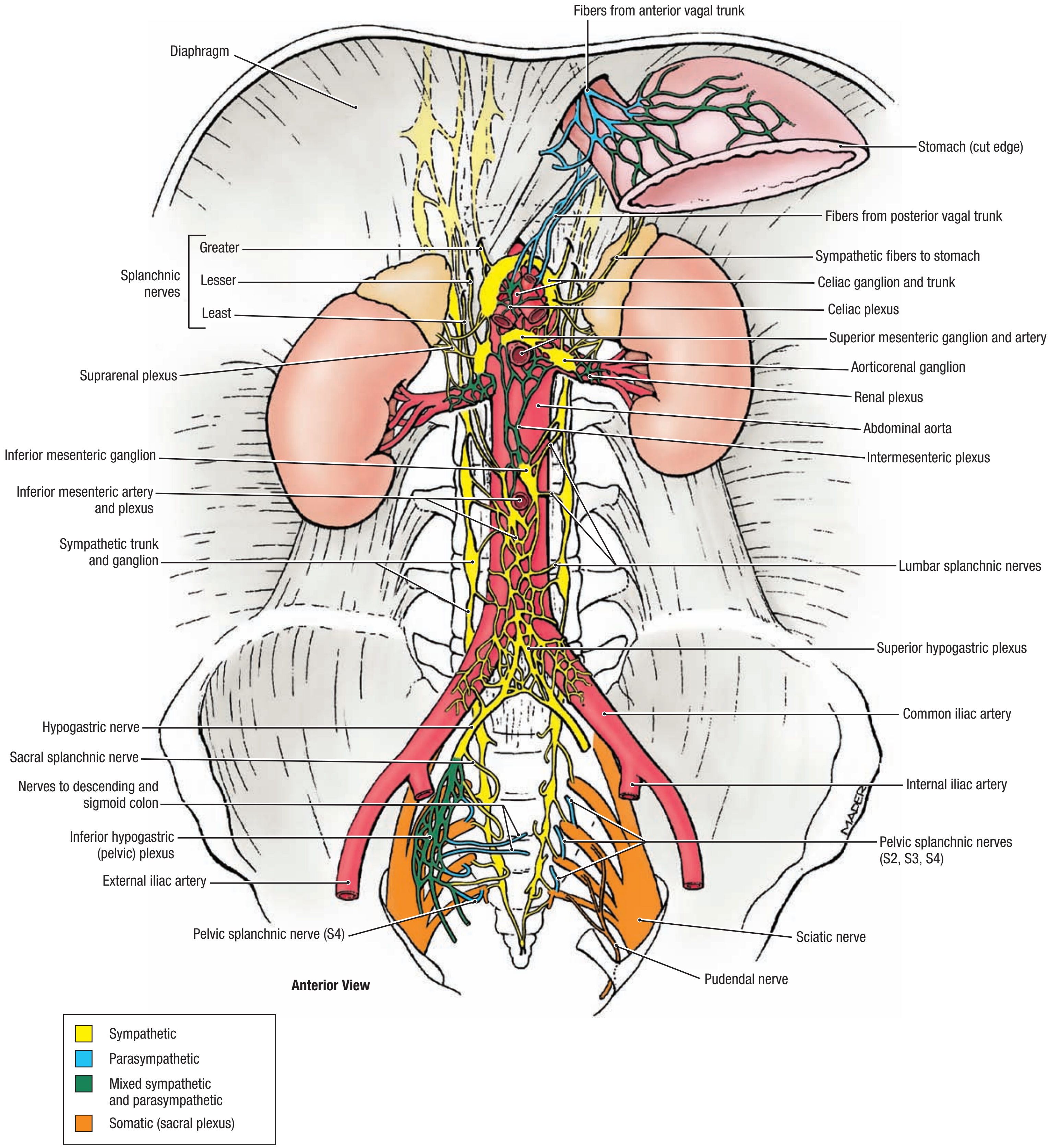


C. Anterior View

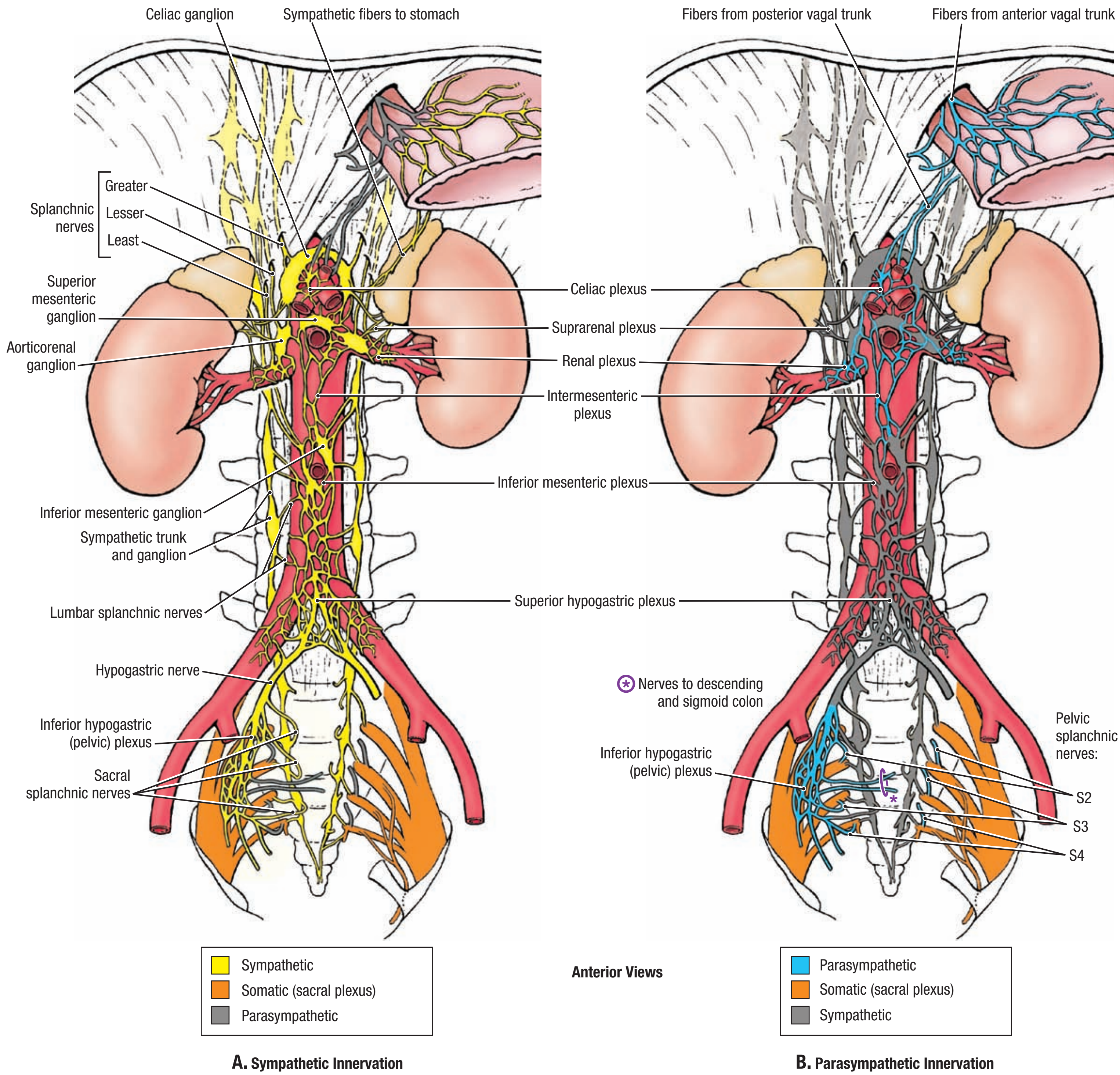
2.80 ABDOMINAL AORTA AND INFERIOR VENA CAVA AND THEIR BRANCHES

A. Branches of abdominal aorta. **B.** Tributaries of the inferior vena cava (IVC). **C.** Surface anatomy.

Rupture of an **aortic aneurysm** (localized enlargement of the abdominal aorta) causes severe pain in the abdomen or back. If unrecognized, a ruptured aneurysm has a mortality of nearly 90% because of heavy blood loss. Surgeons can repair an aneurysm by opening it, inserting a prosthetic graft (such as one made of Dacron), and sewing the wall of the aneurysmal aorta over the graft to protect it. Aneurysms may also be treated by endovascular catheterization procedures.

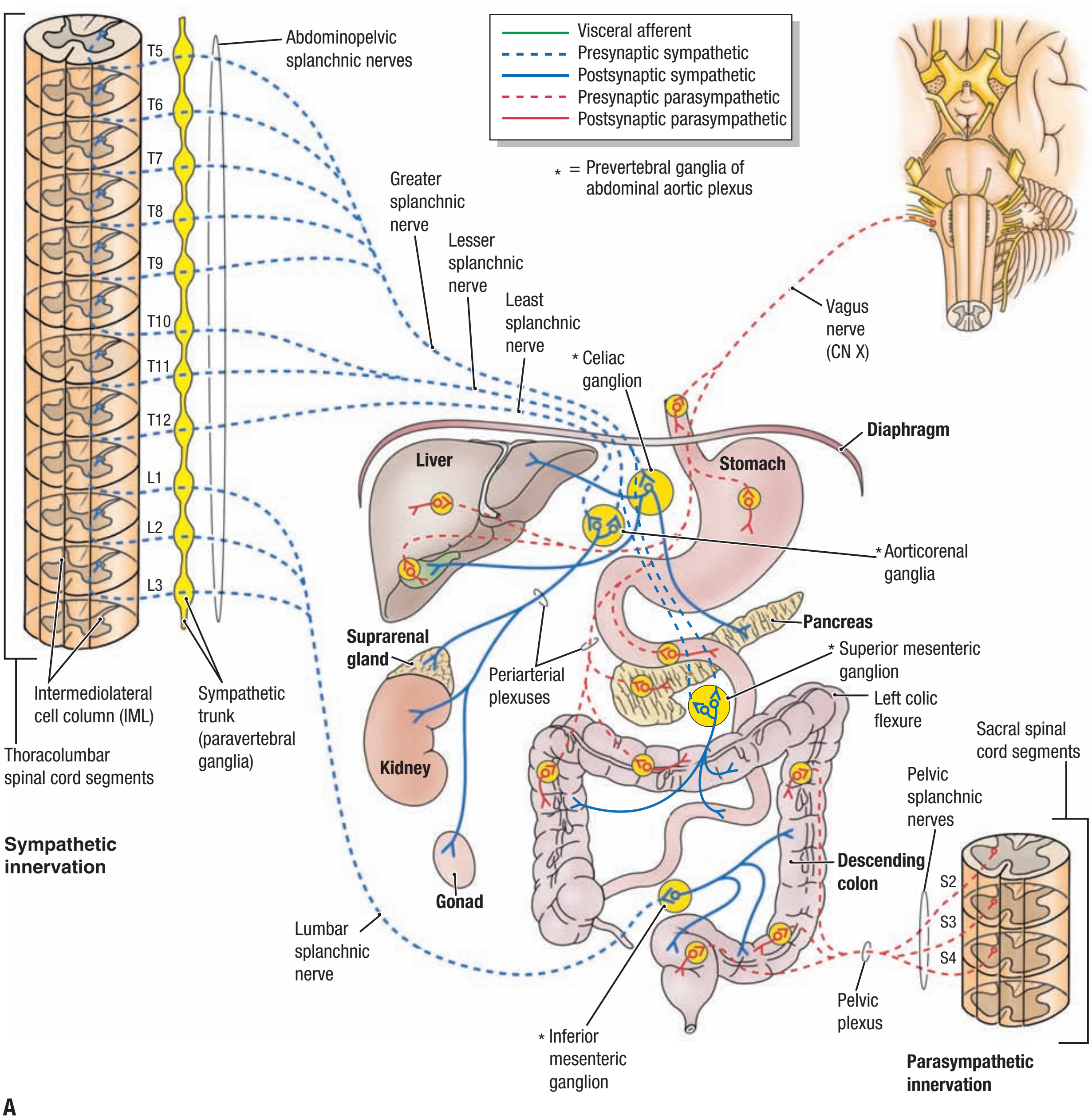


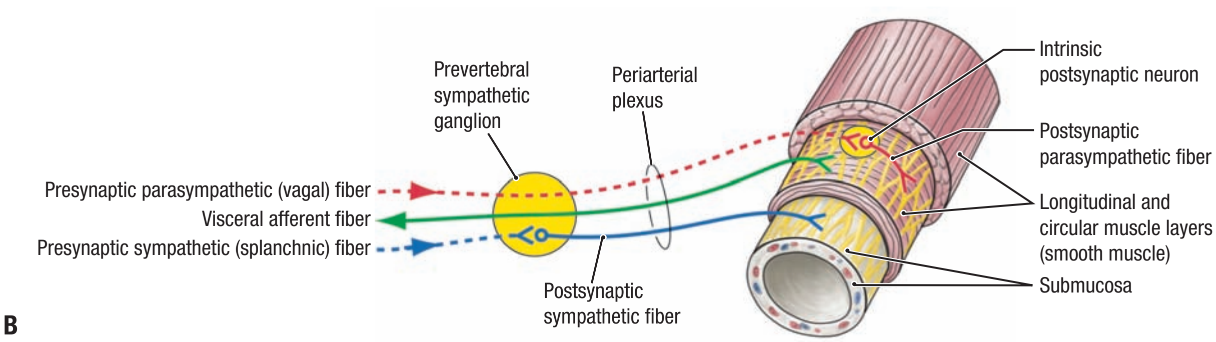
2.81 ABDOMINOPELVIC NERVE PLEXUSES AND GANGLIA



2.82 OVERVIEW OF AUTONOMIC NERVOUS SYSTEM

A. Sympathetic. **B.** Parasympathetic.





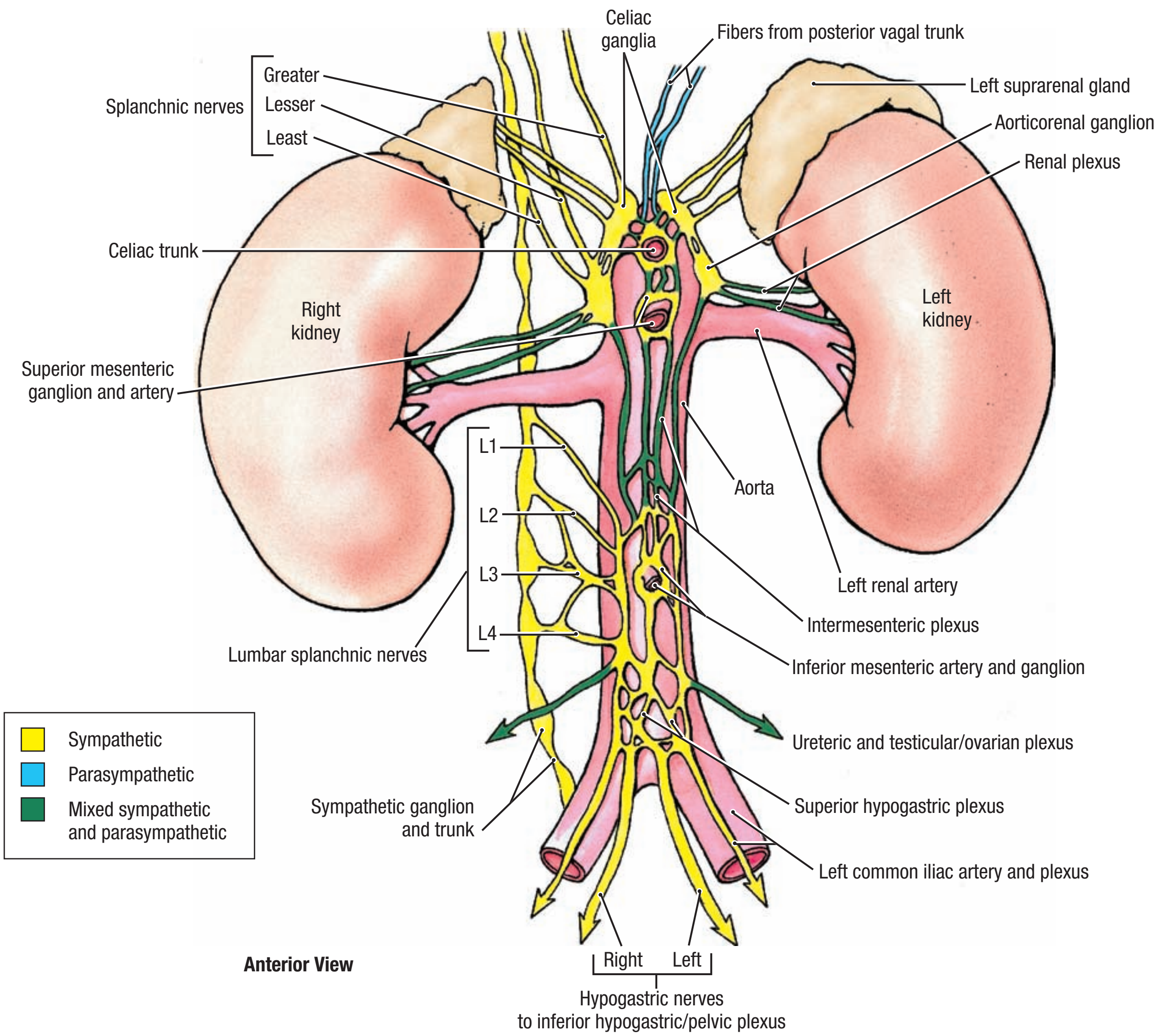
2.83 ORIGIN AND DISTRIBUTION OF PRESYNAPTIC AND POSTSYNAPTIC SYMPATHETIC AND PARASYMPATHETIC FIBERS, AND GANGLIA INVOLVED IN SUPPLYING ABDOMINAL VISCERA

A. Overview. **B.** Fibers supplying the intrinsic plexuses of abdominal viscera.

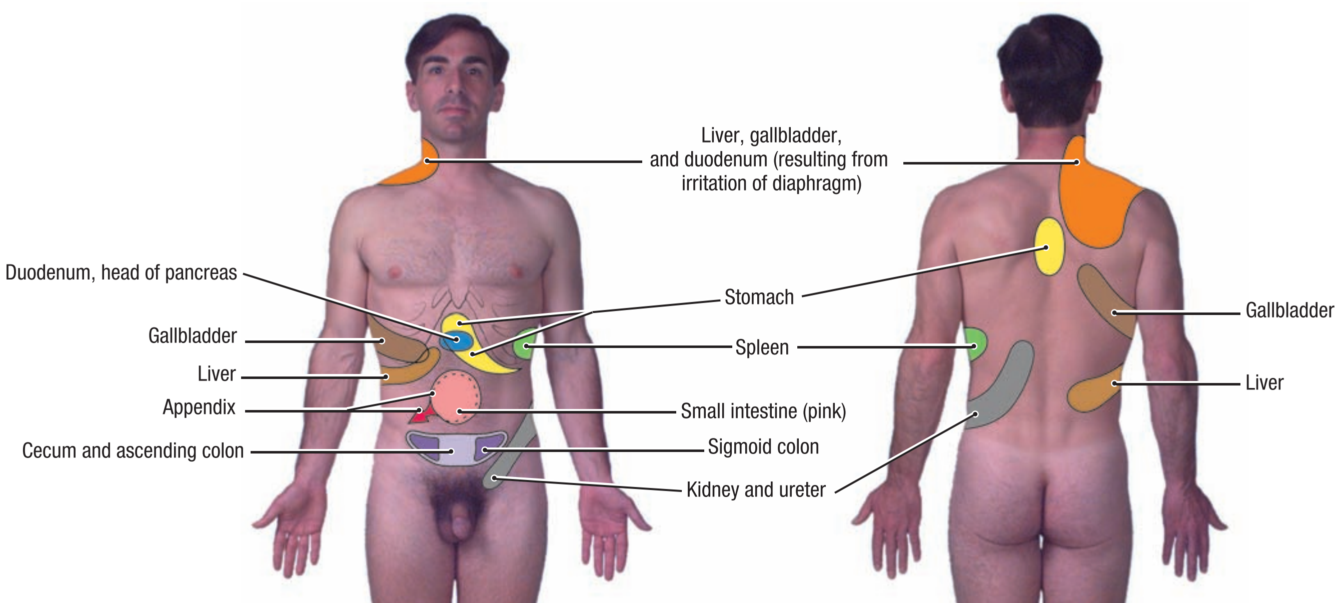
TABLE 2.8 AUTONOMIC INNERVATION OF ABDOMINAL VISCERA (SPLANCHNIC NERVES)

Splanchnic Nerves	Autonomic Fiber Type[a]	System	Origin	Destination
A. **Cardiopulmonary** (Cervical and upper thoracic)	Postsynaptic	Sympathetic	Cervical and upper thoracic sympathetic trunk	Thoracic cavity (viscera superior to the level of diaphragm)
B. **Abdominopelvic** 1. Lower thoracic a. Greater b. Lesser c. Least 2. Lumbar 3. Sacral	Presynaptic		Lower thoracic and abdominopelvic sympathetic trunk: 1. Thoracic sympathetic trunk: a. T5–T9 or T10 level b. T10–T11 level c. T12 level 2. Abdominal sympathetic trunk 3. Pelvic (sacral) sympathetic trunk	Abdominopelvic cavity (prevertebral ganglia serving viscera and suprarenal glands inferior to the level of diaphragm) 1. Abdominal prevertebral ganglia: a. Celiac ganglia b. Aorticorenal ganglia c. & 2. Other abdominal prevertebral ganglia (superior and inferior mesenteric and of intermesenteric/hypogastric plexuses) 3. Pelvic prevertebral ganglia
C. **Pelvic**	Presynaptic	Parasympathetic	Anterior rami of S2–S4 spinal nerves	Intrinsic ganglia of descending and sigmoid colon, rectum, and pelvic viscera

[a]Splanchnic nerves also convey visceral afferent fibers, which are not part of the autonomic nervous system.

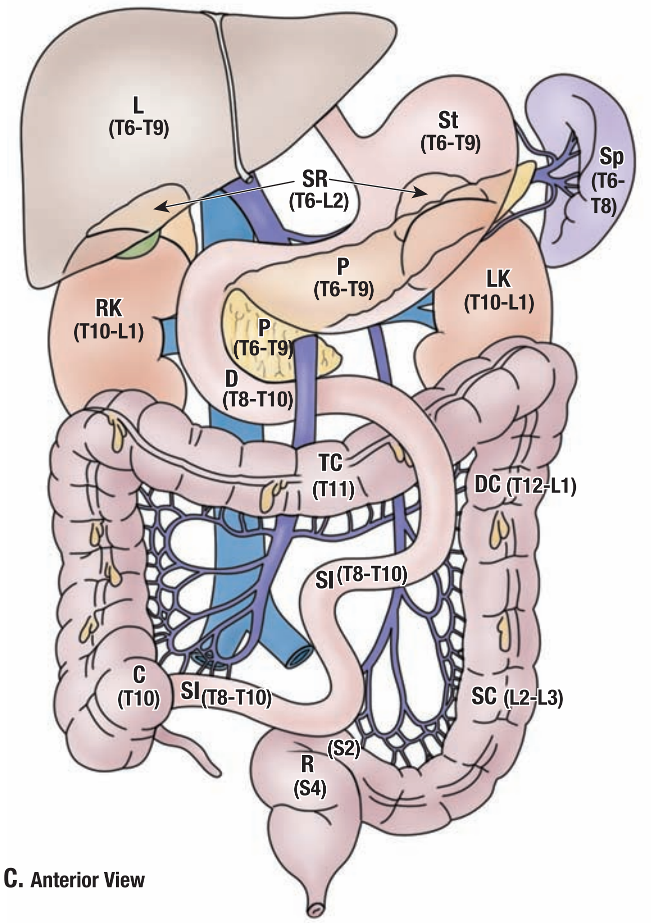


2.84 ABDOMINAL NERVE PLEXUSES AND GANGLIA



A. Anterior View

B. Posterior View



C. Anterior View

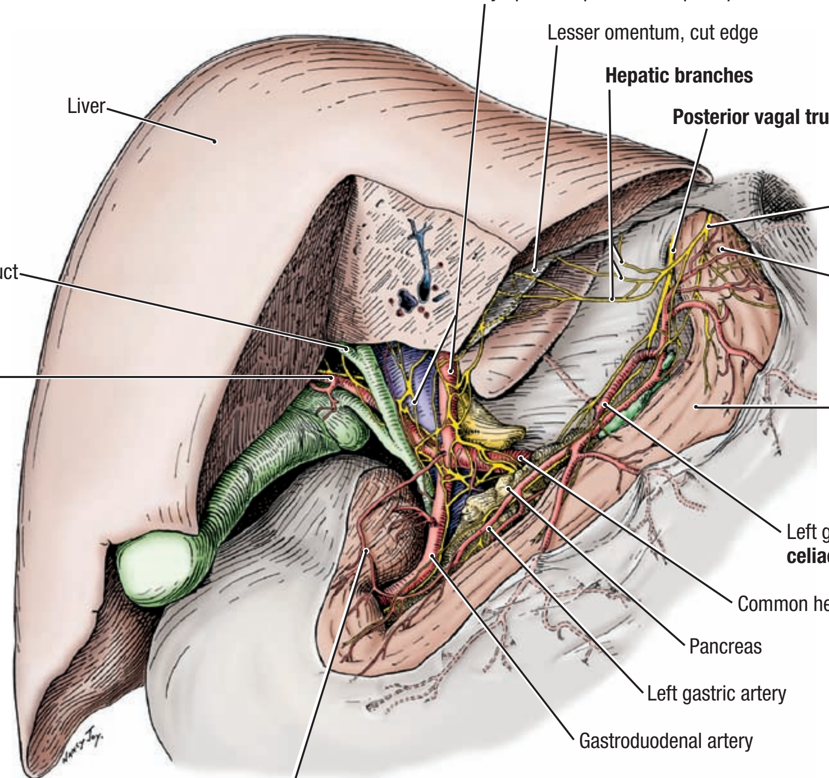
C	Cecum	P	Pancreas	Sp	Spleen
D	Duodenum	R	Rectum	SR	Suprarenal gands
DC	Descending colon	RK	Right kidney	St	Stomach
L	Liver	SC	Sigmoid colon	TC	Transverse colon
LK	Left kidney	SI	Small intestine		

2.85 SURFACE PROJECTIONS OF VISCERAL PAIN

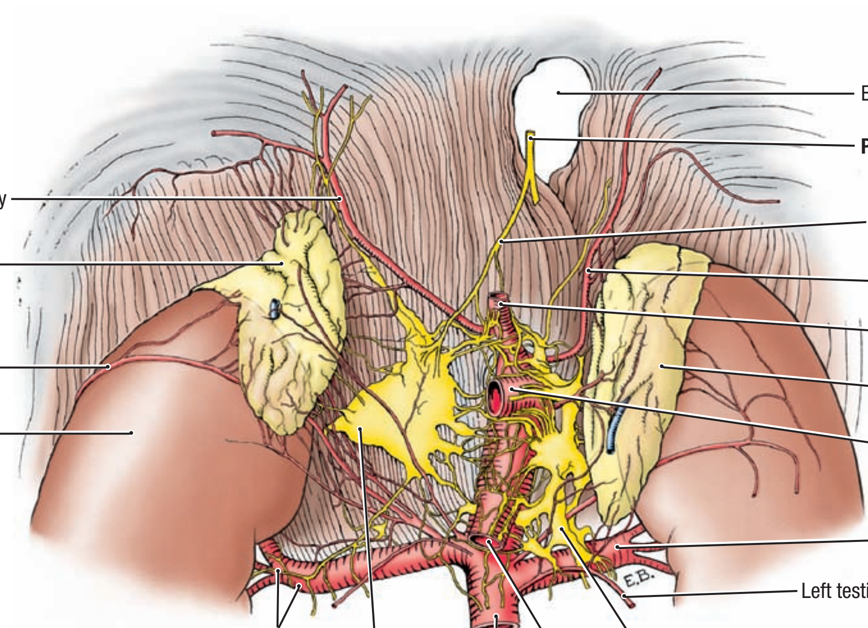
A. and B. Sites of visceral referred pain. **C.** Approximate spinal cord segments and spinal sensory ganglia involved in sympathetic and visceral afferent (pain) innervation of abdominal viscera.

Pain is an unpleasant sensation associated with actual or potential tissue damage, mediated by specific nerve fibers to the brain, where its conscious appreciation may be modified. Organic pain arising from an organ such as the stomach varies from dull to severe; however, the pain is poorly localized. It radiates to the dermatome level served by the corresponding sensory ganglion, which receives the visceral afferent fibers from the organ concerned. **Visceral referred pain** from a gastric ulcer, for example, is referred to the epigastric region because the stomach is supplied by pain afferents that reach the T7 and T8 spinal sensory ganglia and spinal cord segments through the greater splanchnic nerve. The brain interprets the pain as though the irritation occurred in the skin of the epigastric region, which is also supplied by the same sensory ganglia and spinal cord segments.

Pain arising from the parietal peritoneum is of the somatic type and is usually severe. The site of its origin can be localized. The anatomical basis for this localization of pain is that the parietal peritoneum is supplied by somatic sensory fibers through thoracic nerves, whereas a viscus such as the appendix is supplied by visceral afferent fibers in the lesser splanchnic nerve. Inflamed parietal peritoneum is extremely sensitive to stretching. When digital pressure is applied to the anterolateral abdominal wall over the site of inflammation, the parietal peritoneum is stretched. When the fingers are suddenly removed, extreme localized pain is usually felt, known as **rebound tenderness.**



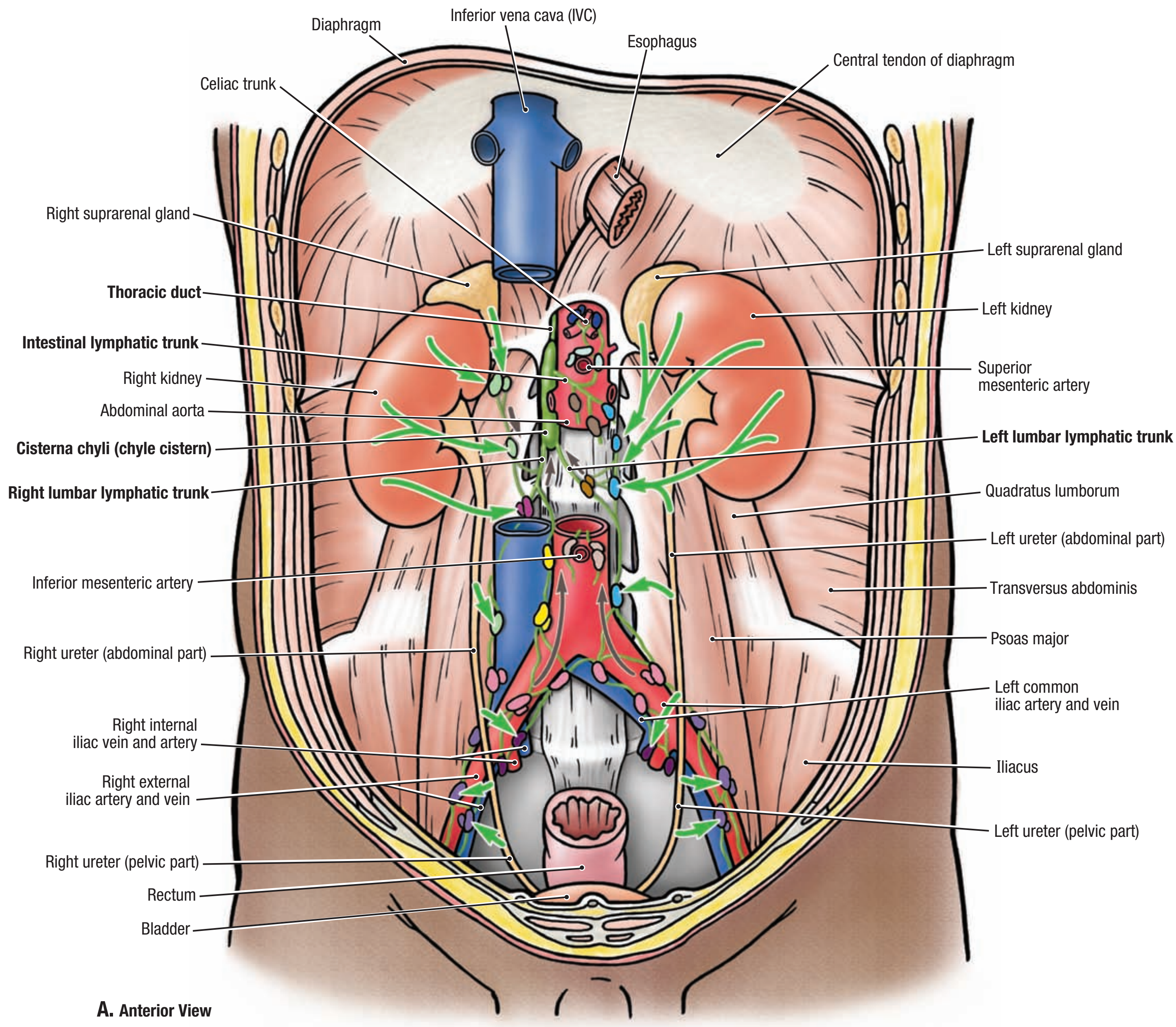
A. Anterior View



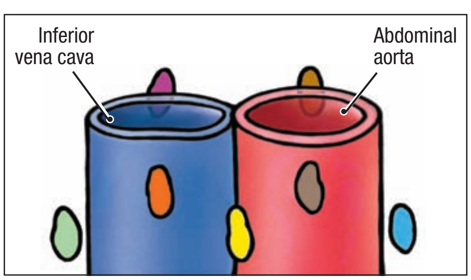
B. Antero-inferior View

2.86 VAGUS NERVES IN ABDOMEN

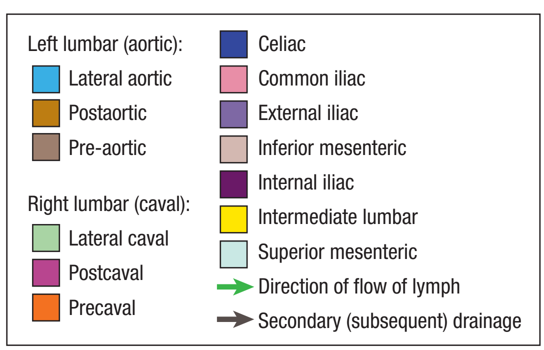
A. Anterior and posterior vagal trunks. **B.** Celiac plexus and ganglia and suprarenal glands.



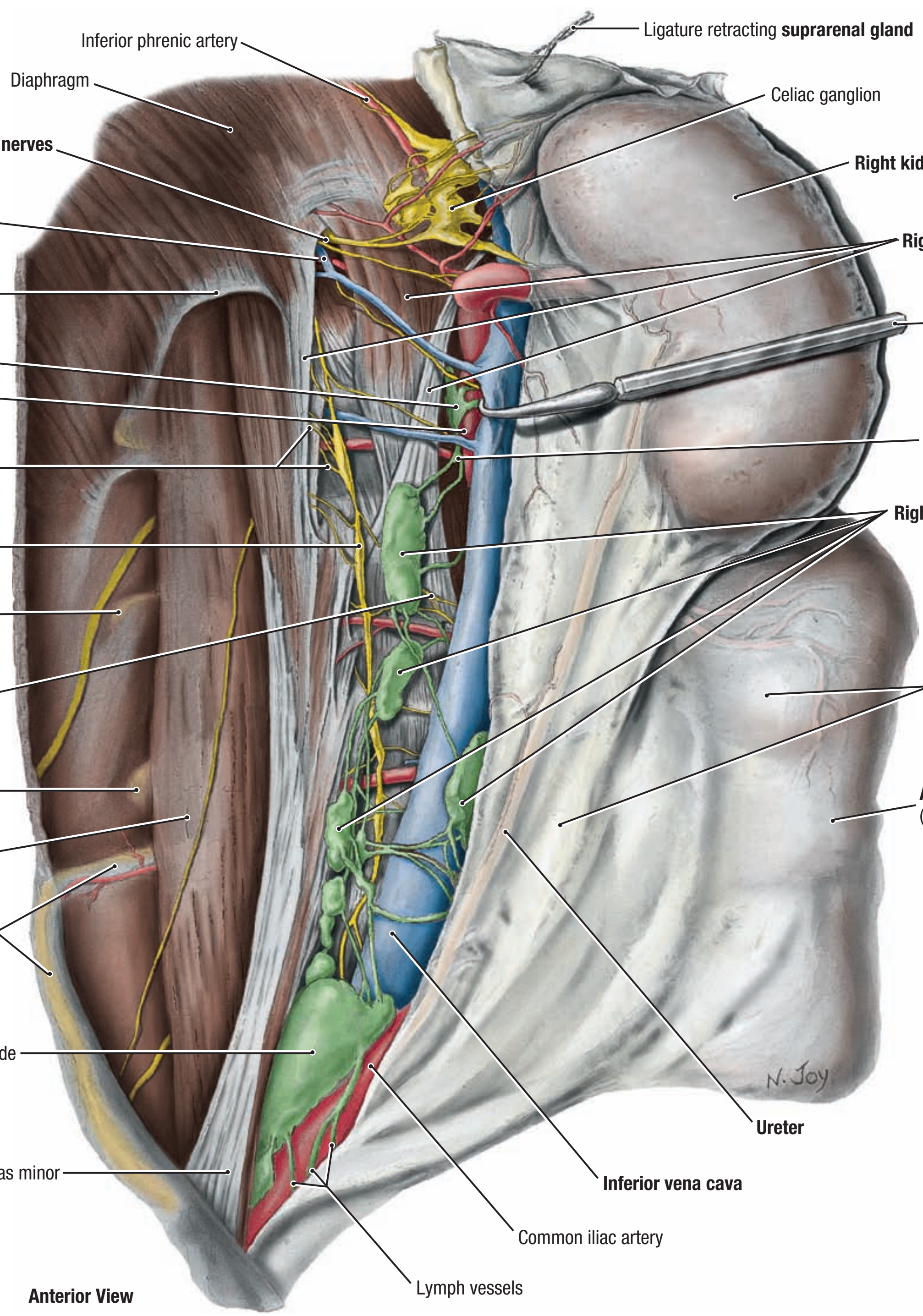
A. Anterior View



B. Anterior View

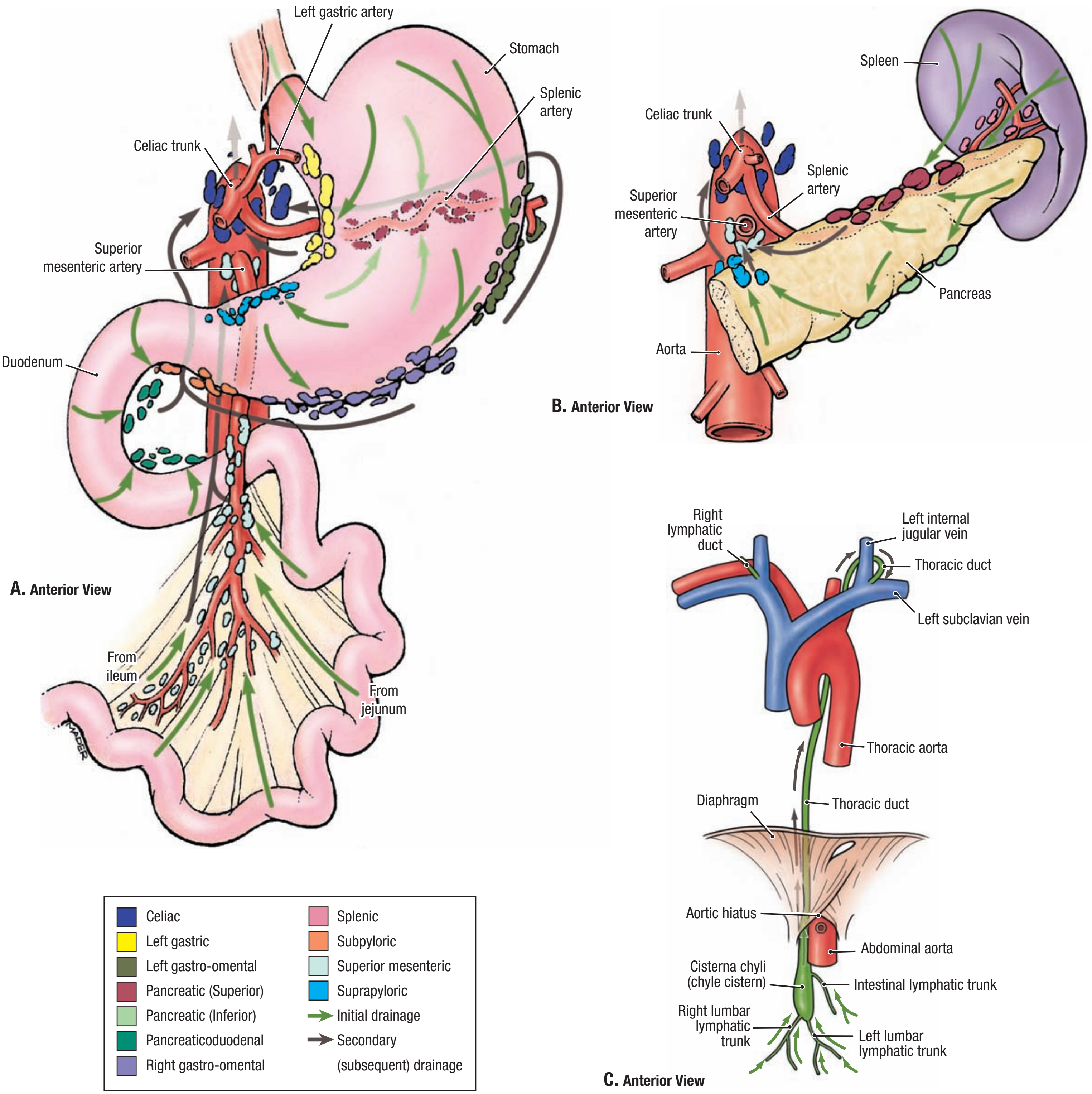


2.87 LYMPHATIC DRAINAGE OF SUPRARENAL GLANDS, KIDNEYS, AND URETERS



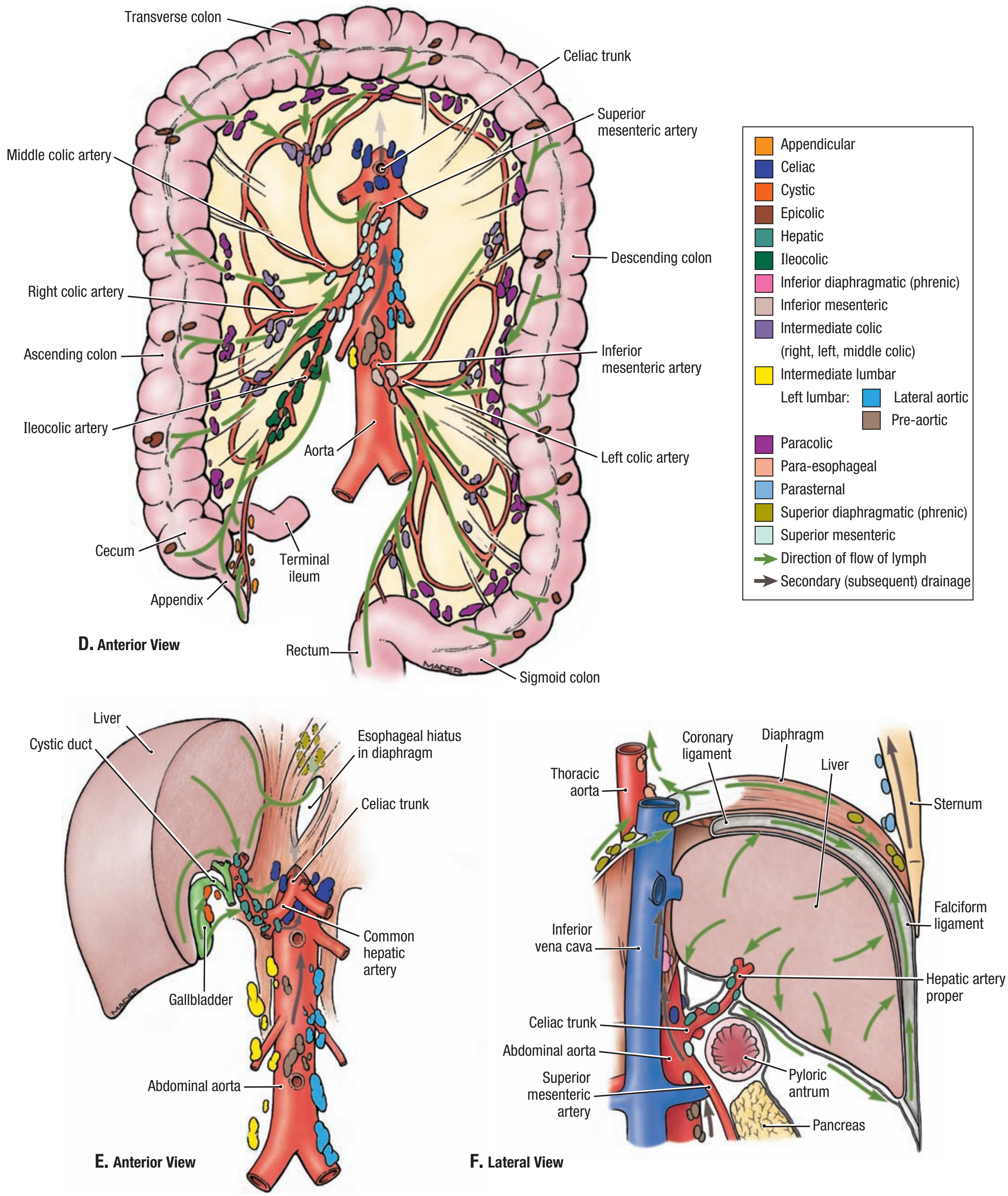
2.88 LUMBAR LYMPH NODES, SYMPATHETIC TRUNK, NERVES, AND GANGLIA

The right suprarenal gland, kidney, ureter, and colon are reflected to the left; the inferior vena cava is pulled medially, and the third and fourth lumbar veins are removed. In this specimen, the greater and lesser splanchnic nerves, the sympathetic trunk, and a communicating vein pass through an unusually wide cleft in the right crus. The splanchnic nerves convey preganglionic fibers arising from the cell bodies in the (thoracolumbar) sympathetic trunk. The greater splanchnic nerve is from thoracic ganglia 5 to 9, and the lesser from thoracic ganglia 10 to 11.



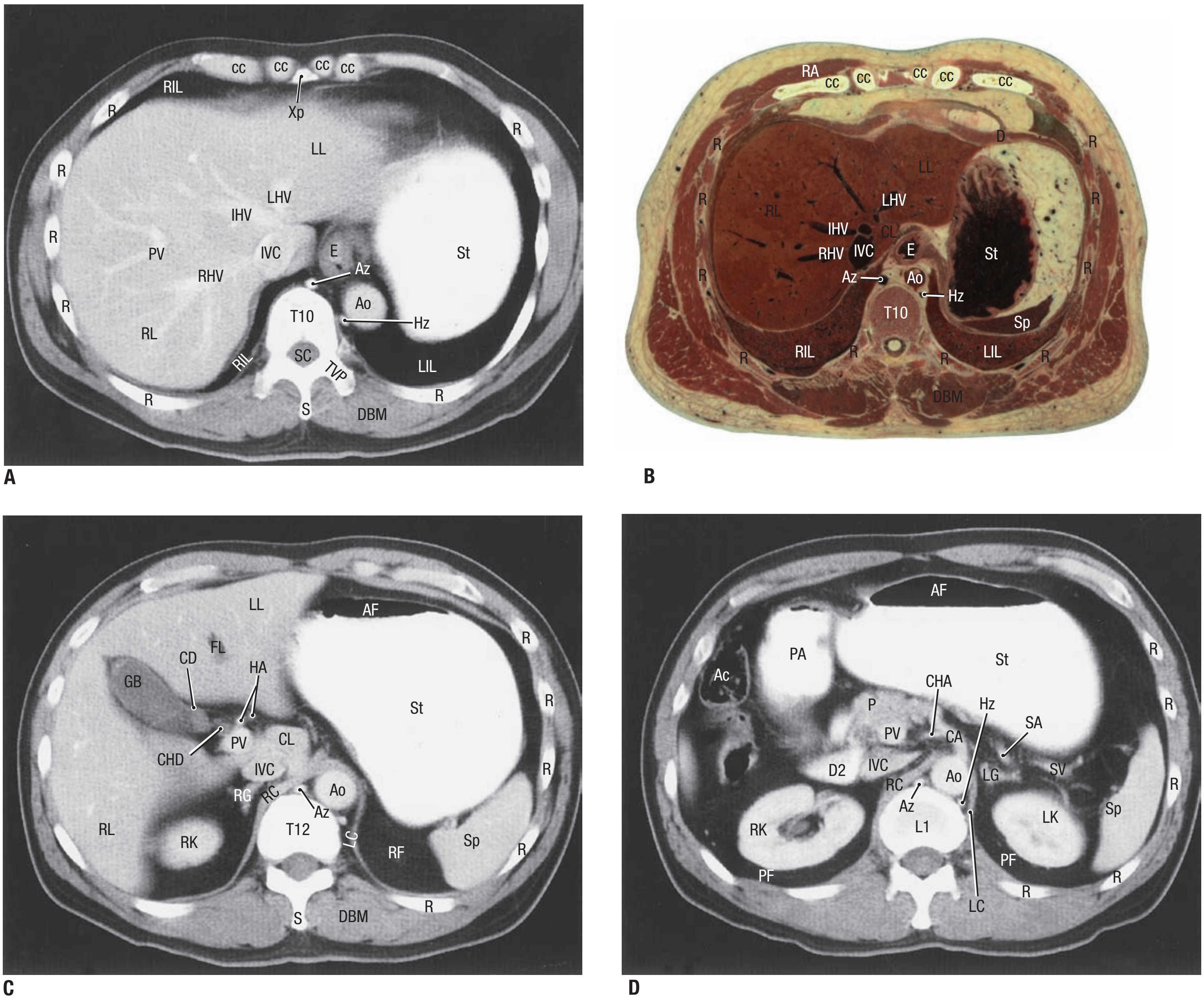
2.89 LYMPHATIC DRAINAGE

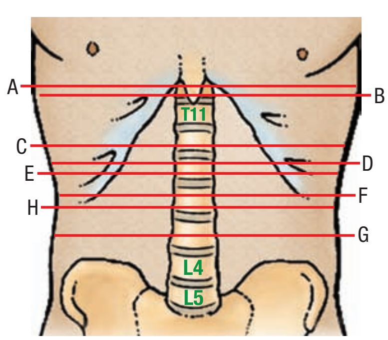
A. Stomach and small intestine. **B.** Spleen and pancreas. **C.** Drainage from lumbar and intestinal lymphatic trunks. The *arrows* indicate the direction of lymph flow; each group of lymph nodes is color coded. Lymph from the abdominal nodes drains into the cisterna chyli, origin of the inferior end of the thoracic duct. The thoracic duct receives all lymph that forms inferior to the diaphragm and left upper quadrant (thorax and left upper limb) and empties into the junction of the left subclavian and left internal jugular veins.



2.89 LYMPHATIC DRAINAGE (*CONTINUED*)

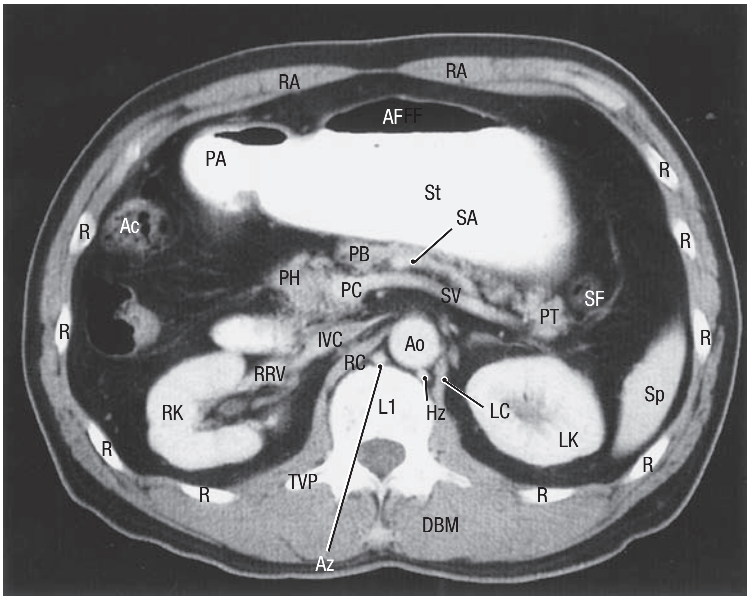
D. Large intestine. **E.** Liver and gallbladder. **F.** Liver.





Ac	Ascending colon	Dc	Descending colon	LG	Left suprarenal gland
AF	Air-fluid level of stomach	D2	Descending part of duodenum	LHV	Left hepatic vein
Ao	Aorta			LIL	Left inferior lobe of lung
Az	Azygos vein	D3	Inferior part of duodenum	LK	Left kidney
CA	Celiac artery	E	Esophagus	LL	Left lobe of liver
cc	Costal cartilage	FL	Falciform ligament	LRV	Left renal vein
CD	Cystic duct	GB	Gallbladder	LU	Left ureter
CHA	Common hepatic artery	HA	Hepatic artery	IHV	Intermediate hepatic vein
CHD	Common hepatic duct	Hz	Hemi-azygos vein	P	Pancreas
CL	Caudate lobe of liver	IMV	Inferior mesenteric vein	PA	Pyloric antrum of stomach
D	Diaphragm	IVC	Inferior vena cava	PB	Body of pancreas
DBM	Deep back muscles	LC	Left crus of diaphragm	PC	Portal confluence

2.90 TRANSVERSE OR HORIZONTAL (AXIAL) MRIs OF ABDOMEN



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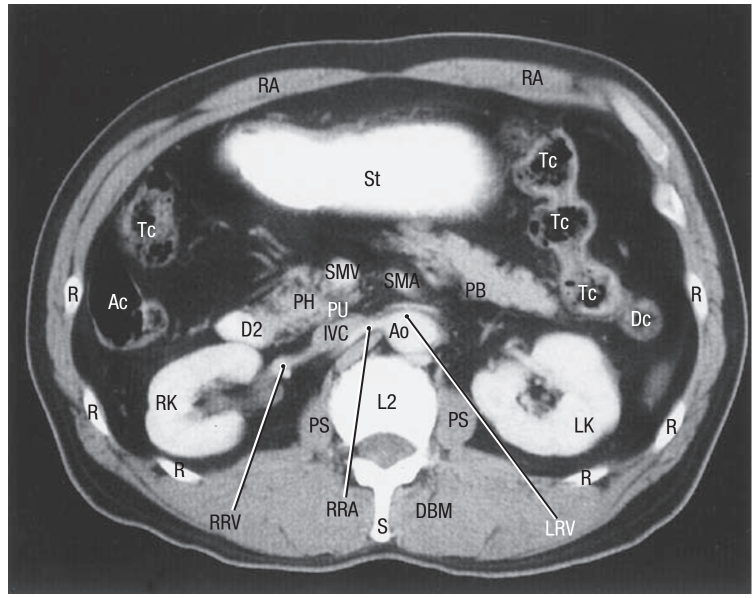

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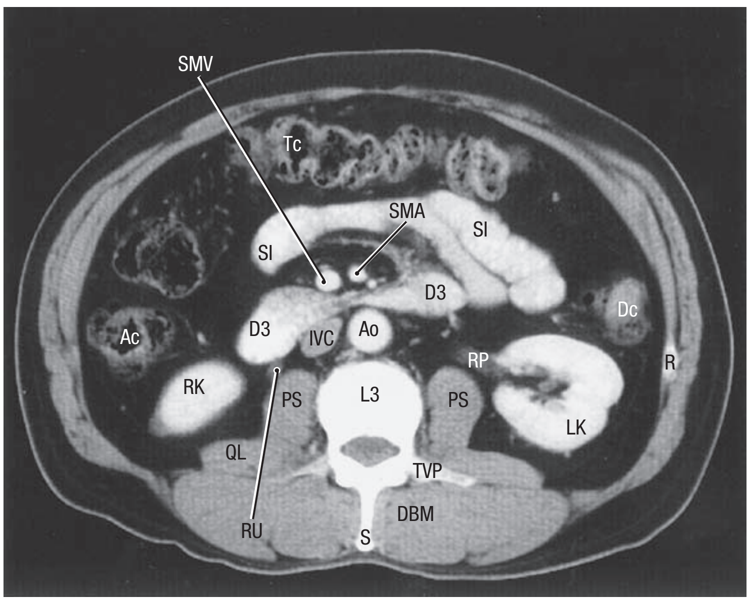

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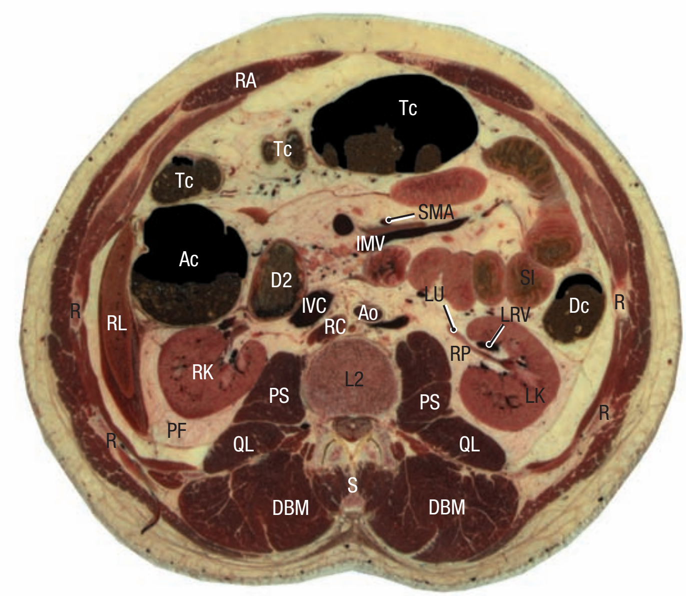
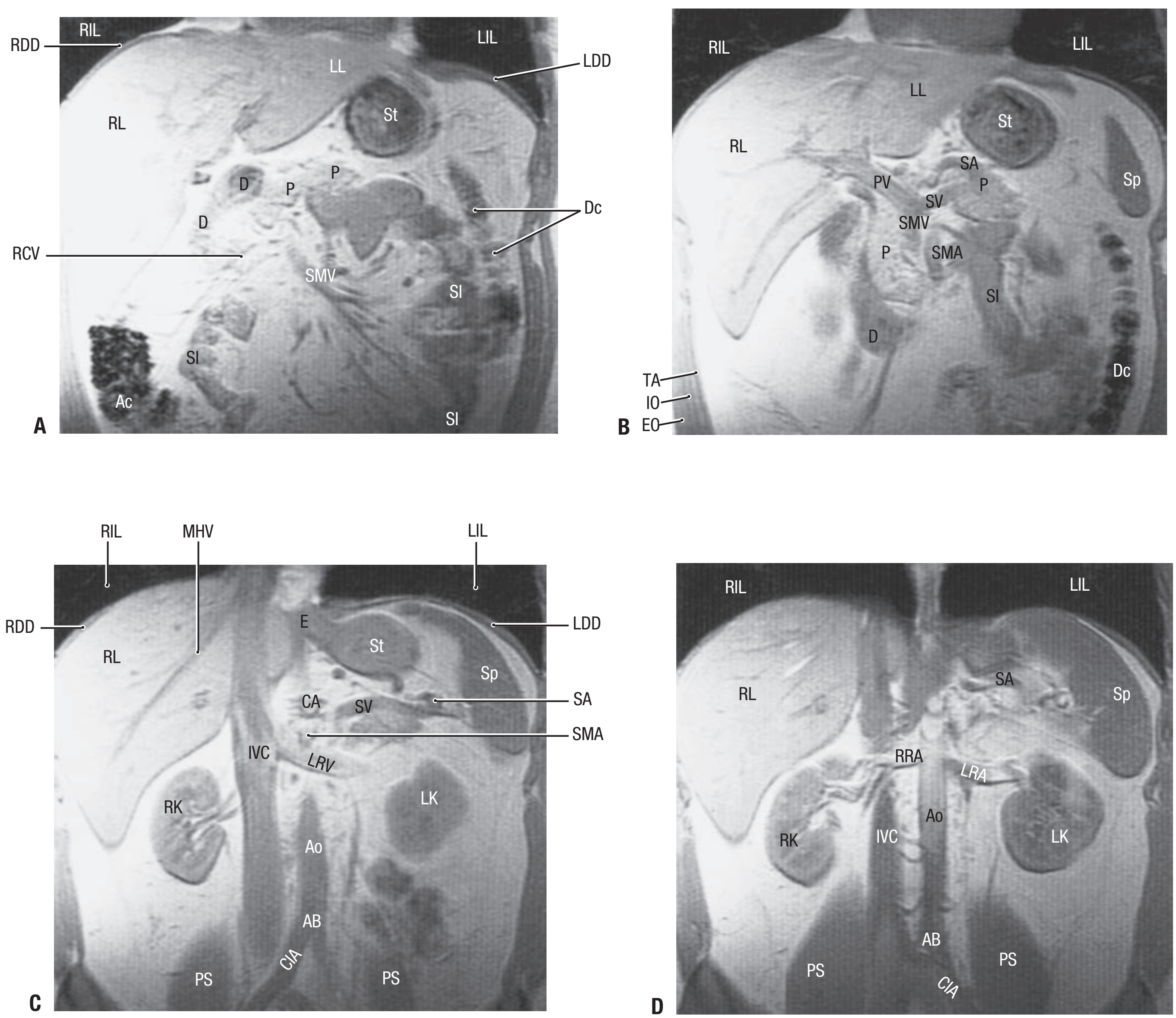


H

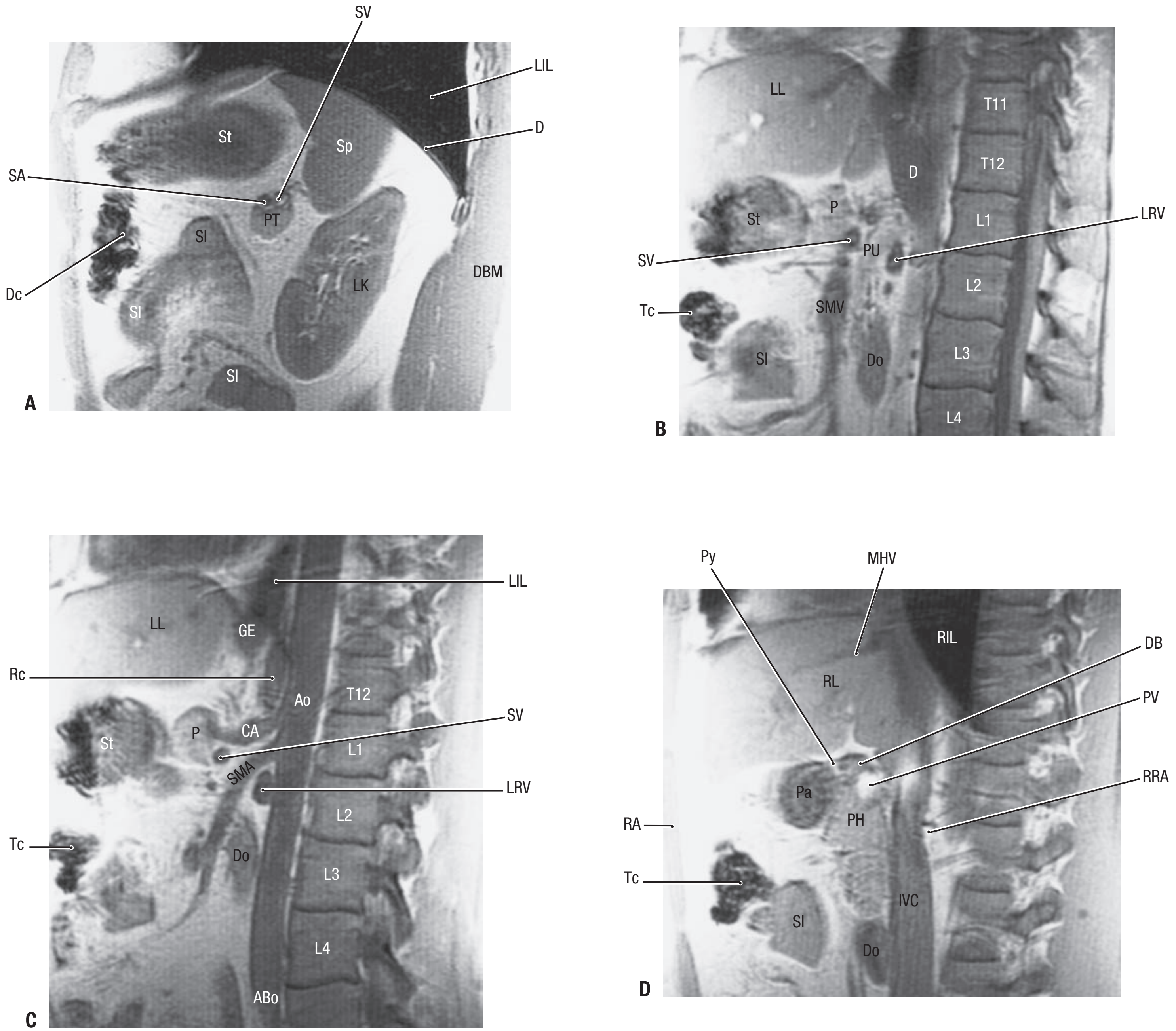
PF	Perinephric fat	RC	Right crus of diaphragm	RRV	Right renal vein	Sp	Spleen
PH	Head of pancreas	RF	Retroperitoneal fat	RU	Right ureter	St	Stomach
PS	Psoas muscle	RG	Right suprarenal gland	S	Spinous process	SV	Splenic vein
PT	Tail of pancreas	RHV	Right hepatic vein	SA	Splenic artery	Tc	Transverse colon
PU	Uncinate process of pancreas	RIL	Right inferior lobe of lung	SC	Spinal cord	TVP	Transverse process
PV	Hepatic portal vein	RK	Right kidney	SF	Splenic flexure	Xp	Xiphoid process
QL	Quadratus lumborum	RL	Right lobe of liver	SI	Small intestine		
R	Rib	RP	Renal pelvis	SMA	Superior mesenteric artery		
RA	Rectus abdominis	RRA	Right renal artery	SMV	Superior mesenteric vein		

2.90 TRANSVERSE OR HORIZONTAL (AXIAL) MRIs OF ABDOMEN (*CONTINUED*)



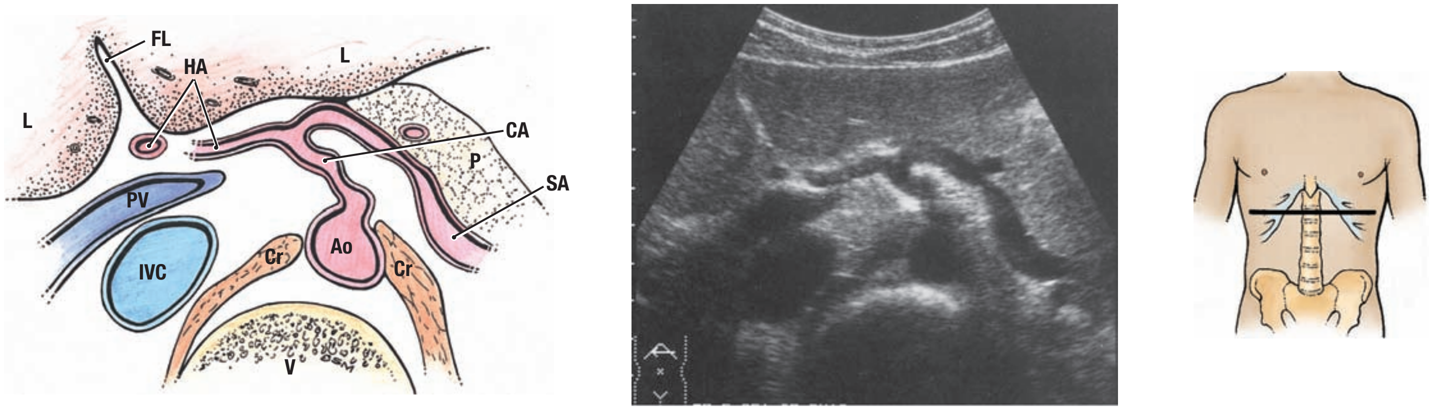
AB	Aortic bifurcation	IO	Internal oblique	P	Pancreas	SA	Splenic artery
Ac	Ascending colon	IVC	Inferior vena cava	PV	Portal vein	SI	Small intestine
Ao	Aorta	LDD	Left dome of diaphragm	PS	Psoas	SMA	Superior mesenteric artery
CA	Celiac artery	LIL	Left lung (inferior lobe)	RCV	Right colic vein	SMV	Superior mesenteric vein
CIA	Common iliac artery	LK	Left kidney	RDD	Right dome of diaphragm	Sp	Spleen
D	Duodenum	LL	Left lobe of liver	RIL	Right lung (inferior lobe)	St	Stomach
Dc	Descending colon	LRA	Left renal artery	RK	Right kidney	SV	Splenic vein
E	Esophagus	LRV	Left renal vein	RL	Right lobe of liver	TA	Transversus abdominis
EO	External oblique	MHV	Middle hepatic vein	RRA	Right renal artery		

2.91 CORONAL MRIs OF ABDOMEN

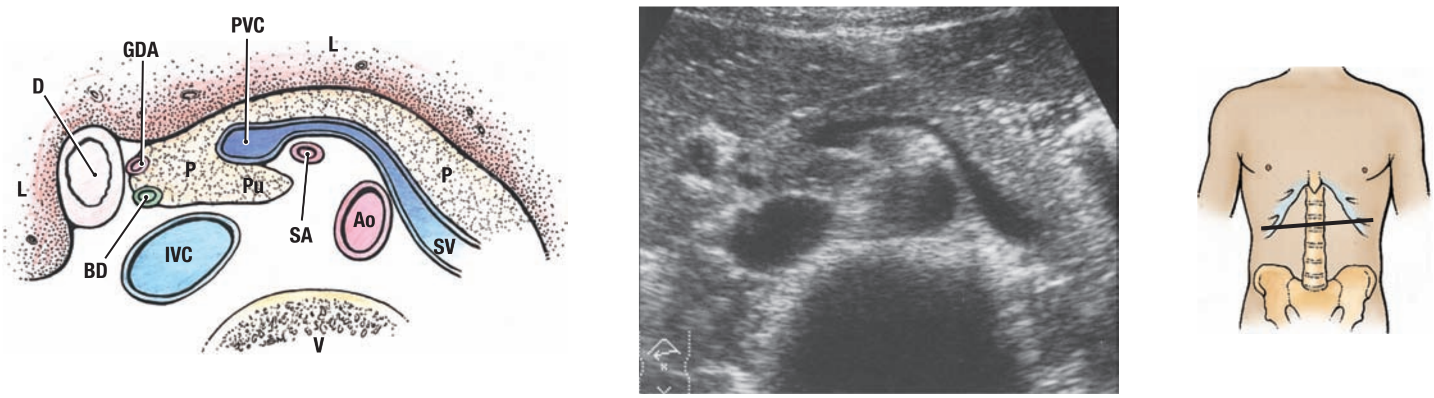


Ao	Aorta	IVC	Inferior vena cava	PH	Head of pancreas	RRA	Right renal artery
ABo	Bifurcation of aorta	LIL	Inferior lobe of left lung	PT	Tail of pancreas	SA	Splenic artery
CA	Celiac artery	LK	Left kidney	PV	Portal vein	SI	Small intestine
D	Diaphragm	LL	Left lobe of liver	PU	Uncinate process of pancreas	SMA	Superior mesenteric artery
DB	Bulb of duodenum	LRV	Left renal vein	Py	Pylorus of stomach	SMV	Superior mesenteric vein
Dc	Descending colon	MHV	Middle hepatic vein	RA	Rectus abdominus	Sp	Spleen
Do	Duodenum	P	Pancreas	RC	Right crus	St	Stomach
DBM	Deep back muscles	Pa	Pyloric antrum	RIL	Inferior lobe of right lung	SV	Splenic vein
GE	Gastroesophageal junction	PC	Portal confluence	RL	Right lobe of right liver	Tc	Transverse colon

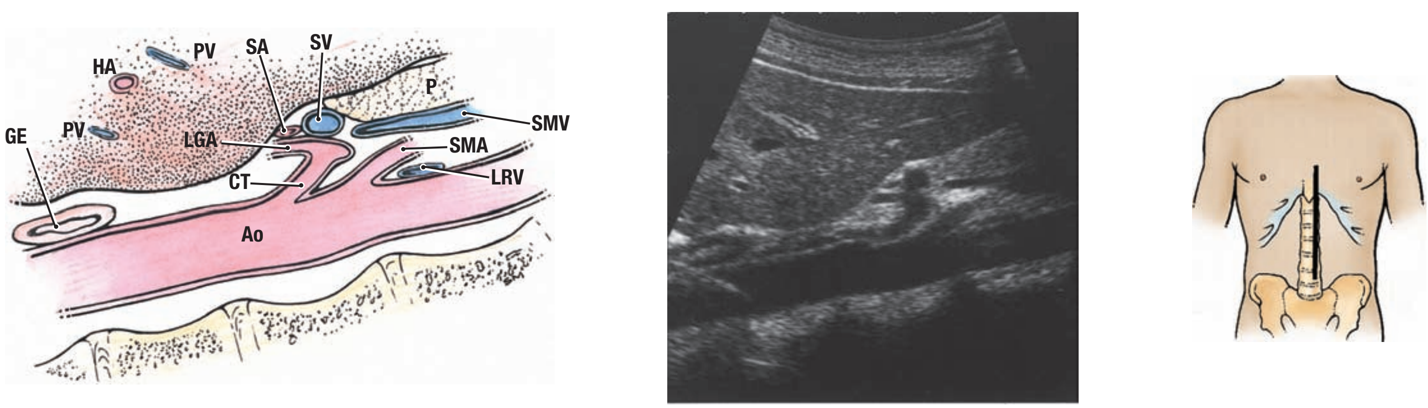
2.92 SAGITTAL MRIs OF ABDOMEN



A. Transverse Section, Inferior View



B. Transverse Section, Inferior View

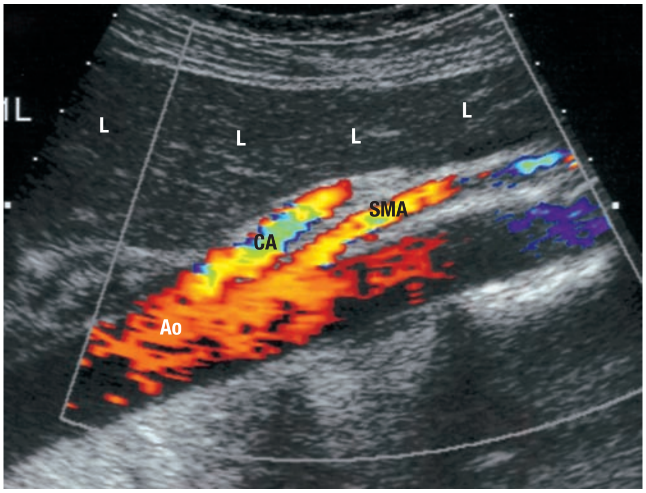


C. Median Section, Right Lateral View

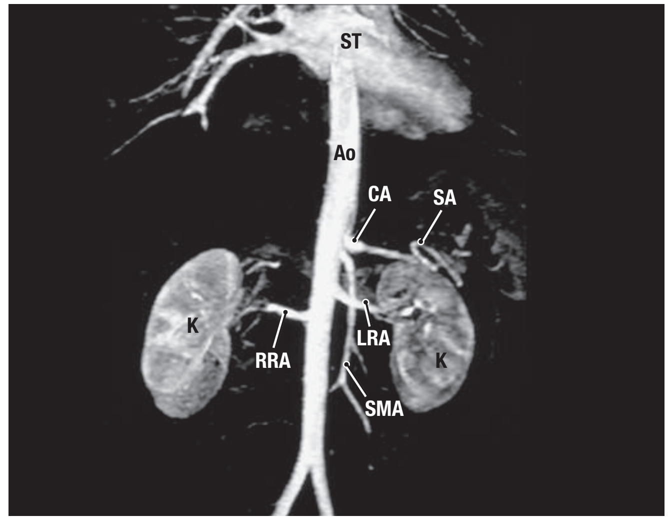
2.93 ULTRASOUND SCANS AND MR ANGIOGRAM OF ABDOMEN

A. Transverse ultrasound scan through celiac trunk. **B.** Transverse ultrasound scan through pancreas. **C. and D.** Sagittal ultrasound scans through the aorta, celiac trunk, and superior mesenteric artery. (**D.** with Doppler.) **E.** MR angiogram of abdominal aorta and branches. **F.** Transverse ultrasound scan at hilum of left kidney with the left renal artery and vein (with Doppler). **G.** Sagittal ultrasound scan of the right kidney.

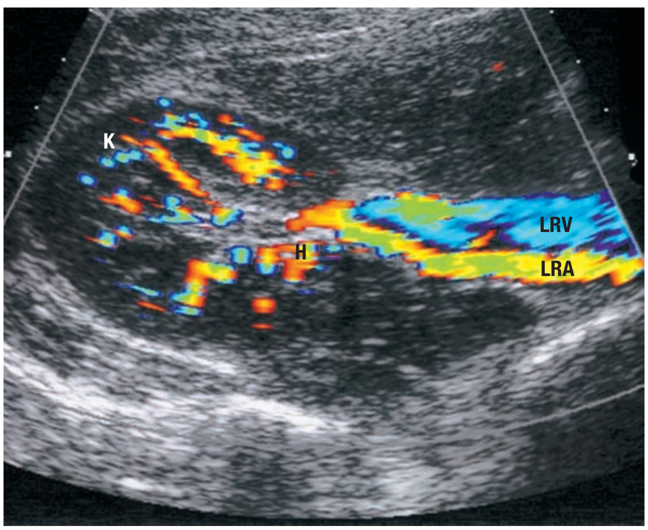
A major advantage of ultrasonography is its ability to produce real-time images, demonstrating motion of structures and flow within blood vessels. In Doppler ultrasonography (**D** and **F**) the shifts in frequency between emitted ultrasonic waves and their echoes are used to measure the velocities of moving objects. This technique is based on the principle of the Doppler effect. Blood flow through vessels is displayed in color, superimposed on the two-dimensional cross-sectional image (slow flow: *blue*, fast flow: *orange*).



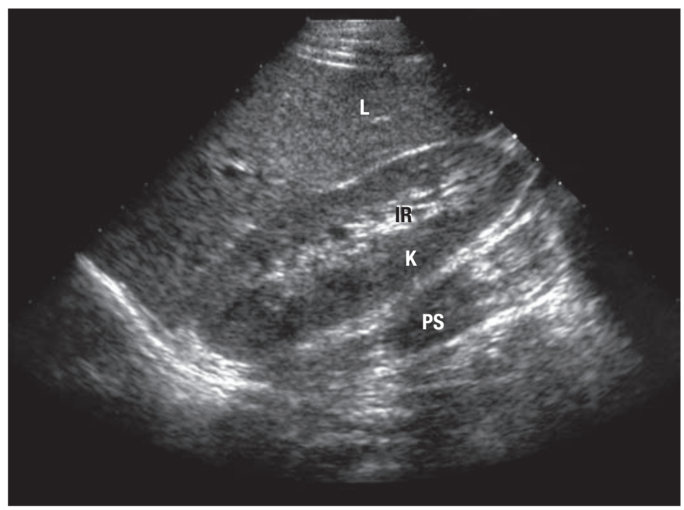
D. Median Section, Right Lateral View



E. Anterior View



F. Transverse Section



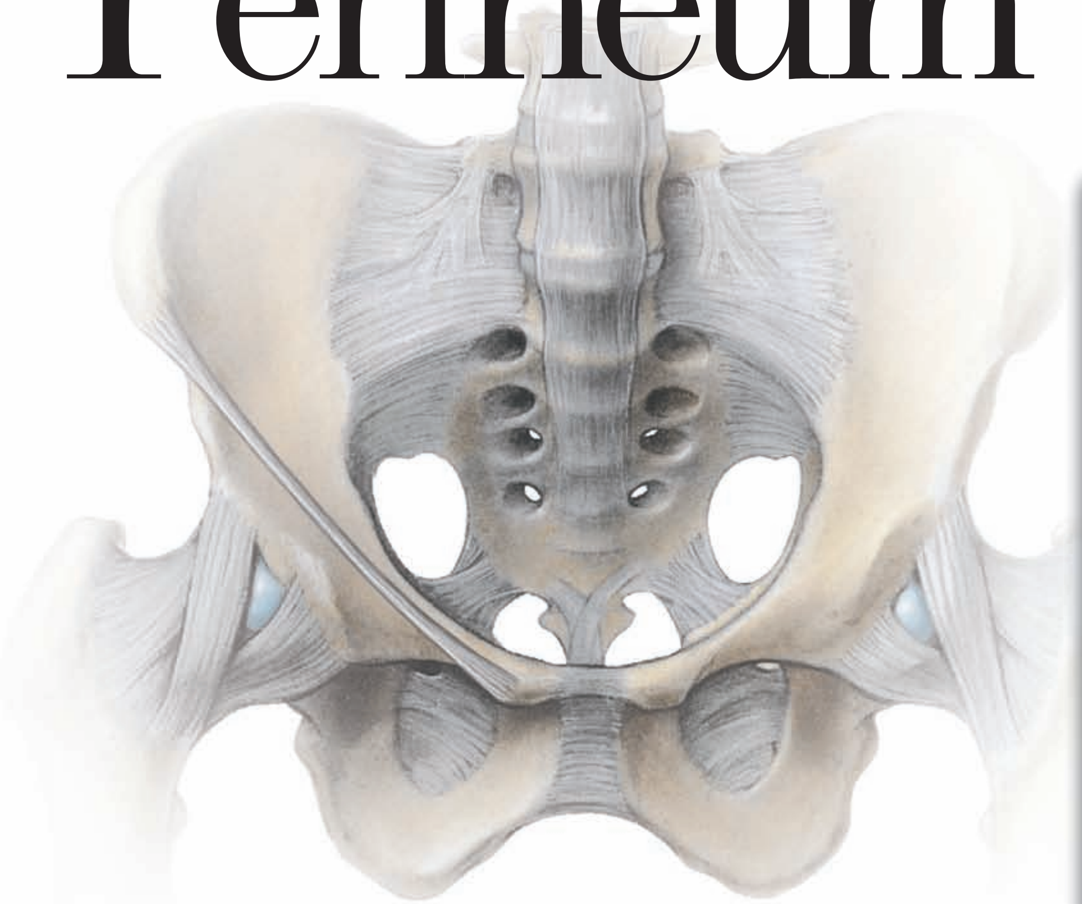
G. Sagittal Section, Right Lateral View

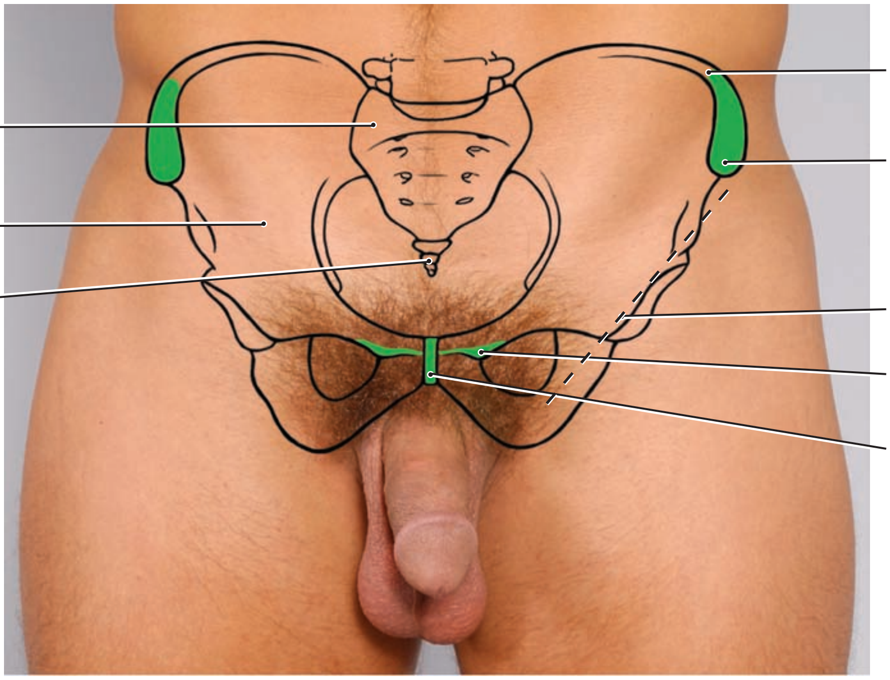
Ao	Aorta	H	Hilum of kidney	LRV	Left renal vein	SMA	Superior mesenteric artery
BD	Bile duct	HA	Hepatic artery	P	Pancreas	SMV	Superior mesenteric vein
CA	Celiac artery	IR	Perirenal fat in renal sinus	PS	Psoas	ST	Stomach
Cr	Crus of diaphragm	IVC	Inferior vena cava	Pu	Uncinate process of pancreas	SV	Splenic vein
D	Duodenum	K	Cortex of kidney	PV	Portal vein	V	Vertebra
FL	Falciform ligament	L	Liver	PVC	Portal venous confluence		
GDA	Gastroduodenal artery	LGA	Left gastric artery	RRA	Right renal artery		
GE	Gastro-esophageal junction	LRA	Left renal artery	SA	Splenic artery		

2.93 ULTRASOUND SCANS AND MR ANGIOGRAM OF ABDOMEN (*CONTINUED*)

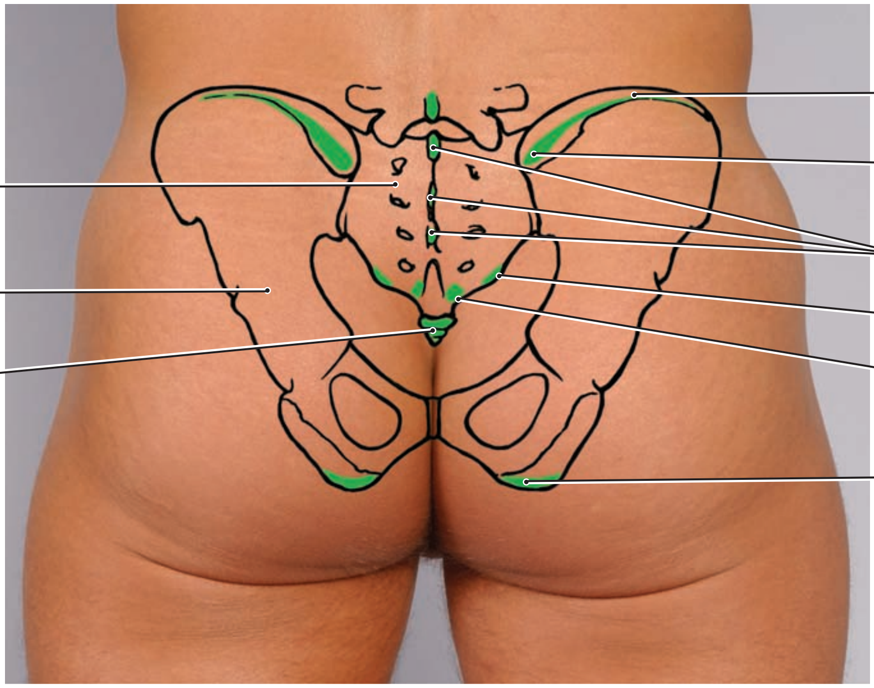
CHAPTER 3

Pelvis and Perineum





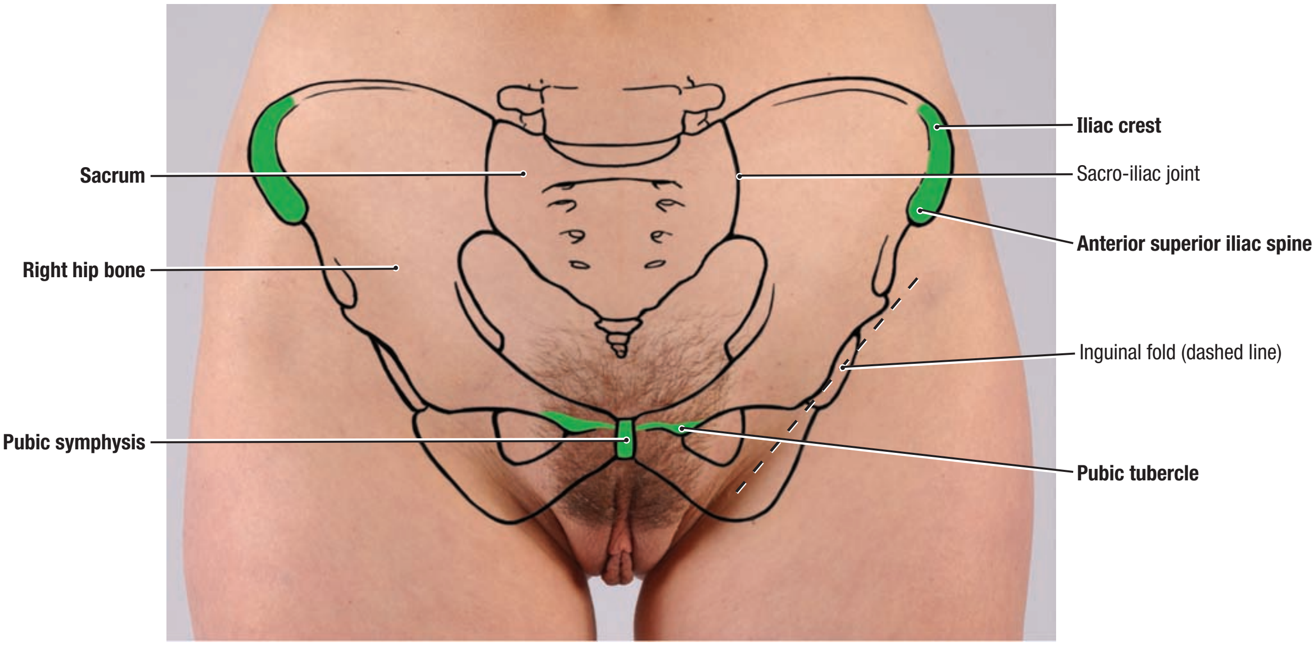
A. Anterior View



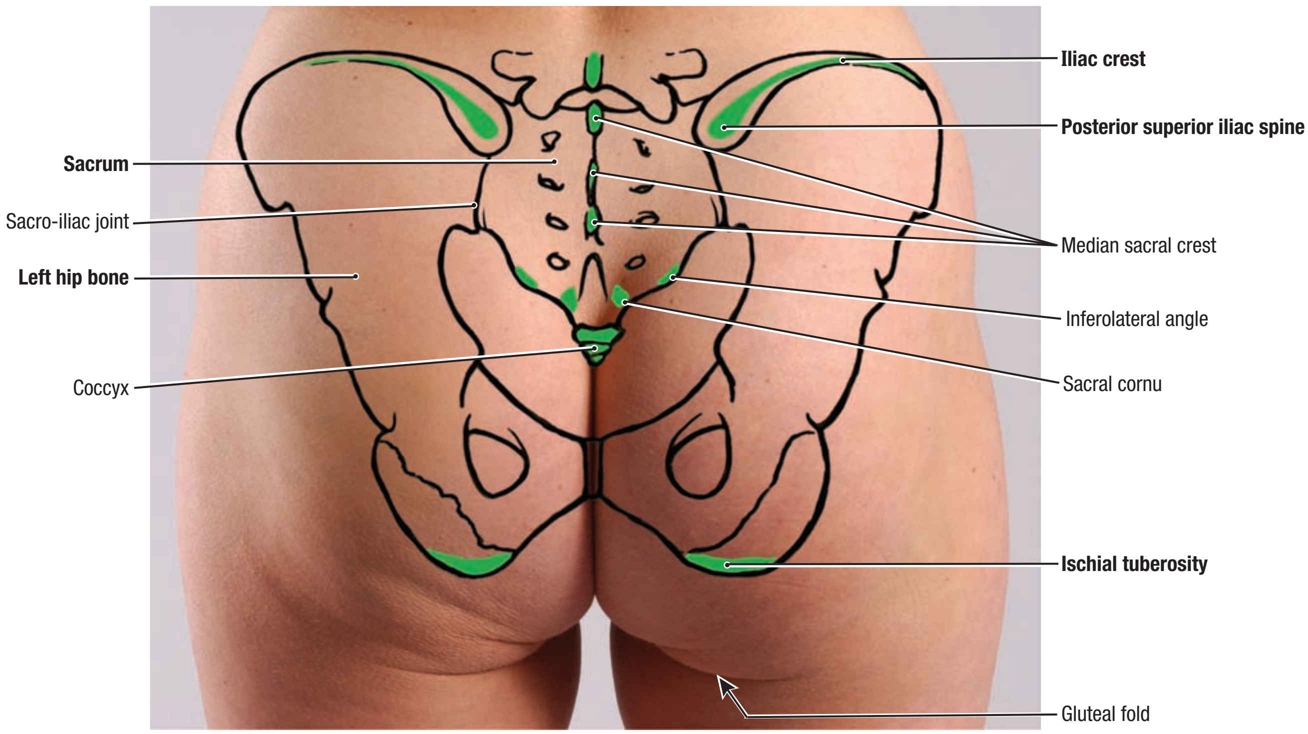
B. Posterior View

3.1 SURFACE ANATOMY OF MALE PELVIC GIRDLE

The pelvic girdle (bony pelvis) is a basin-shaped ring of three bones (right and left hip bones and sacrum) that connects the vertebral column to the femora. **Palpable features (green) should be symmetrical across the midline**. **A.** The anterior third of the iliac crests are subcutaneous and usually easily palpable. The remainder of the crests may also be palpable, depending on the thickness of the overlying subcutaneous tissue (fat). The inguinal ligament spans between the palpable anterior superior iliac spine (ASIS) and pubic tubercle, located superior to the lateral and medial ends of the inguinal fold. **B.** The posterior superior iliac spine (PSIS) is usually palpable and often lies deep to a visible dimple, indicating the S2 vertebral level. The ischial tuberosities may be palpated when the hip joint is flexed.



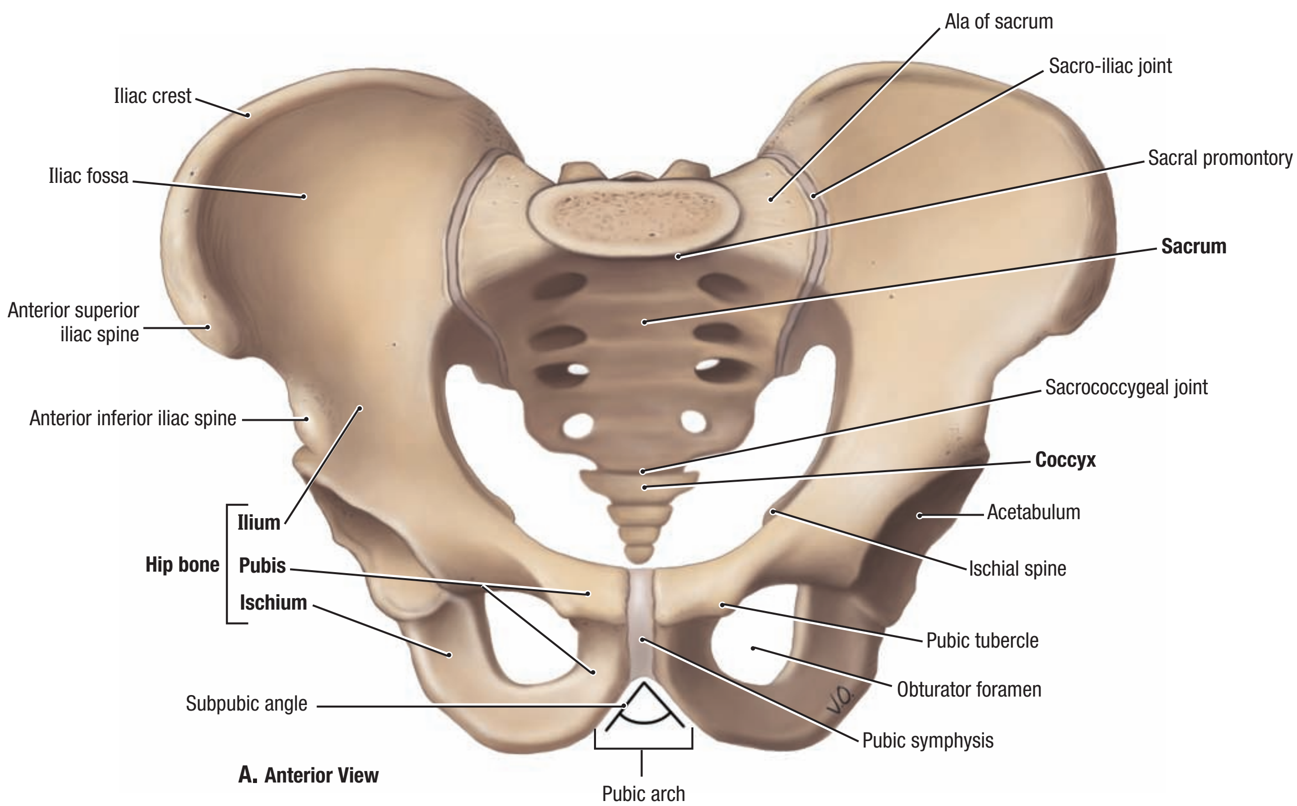
A. **Anterior View**



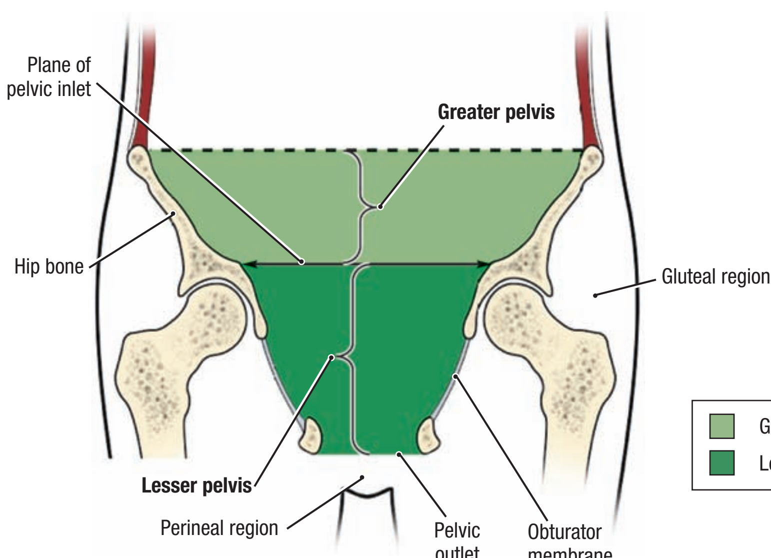
B. **Posterior View**

3.2 SURFACE ANATOMY OF FEMALE PELVIC GIRDLE

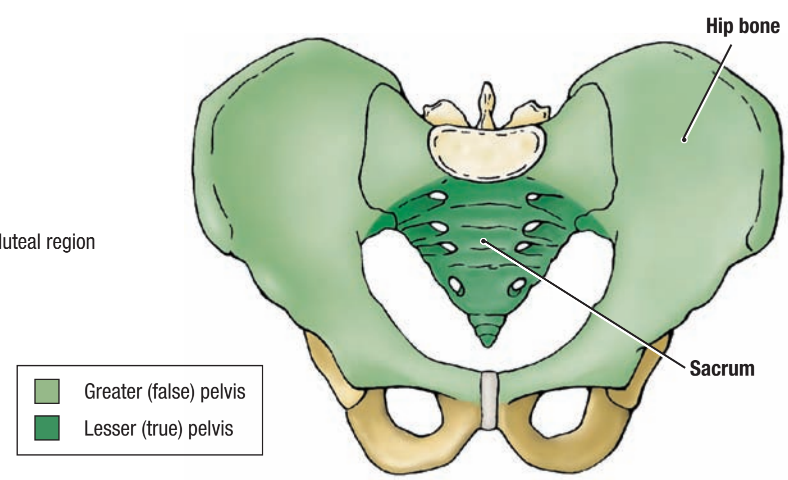
The female pelvic girdle is relatively wider and shallower than that of the male, related to its additional roles of bearing the weight of the gravid uterus in late **pregnancy** and allowing passage of the fetus through the pelvic outlet during childbirth **(parturition).** **A.** *Palpable features (green):* The hip bones are joined anteriorly at the pubic symphysis. The presence of a thick overlying pubic fat pad forming the mons pubis may interfere with palpation of the pubic tubercles and symphysis. **B.** Posteriorly the hip bones are joined to the sacrum at the sacro-iliac joints.



A. **Anterior View**



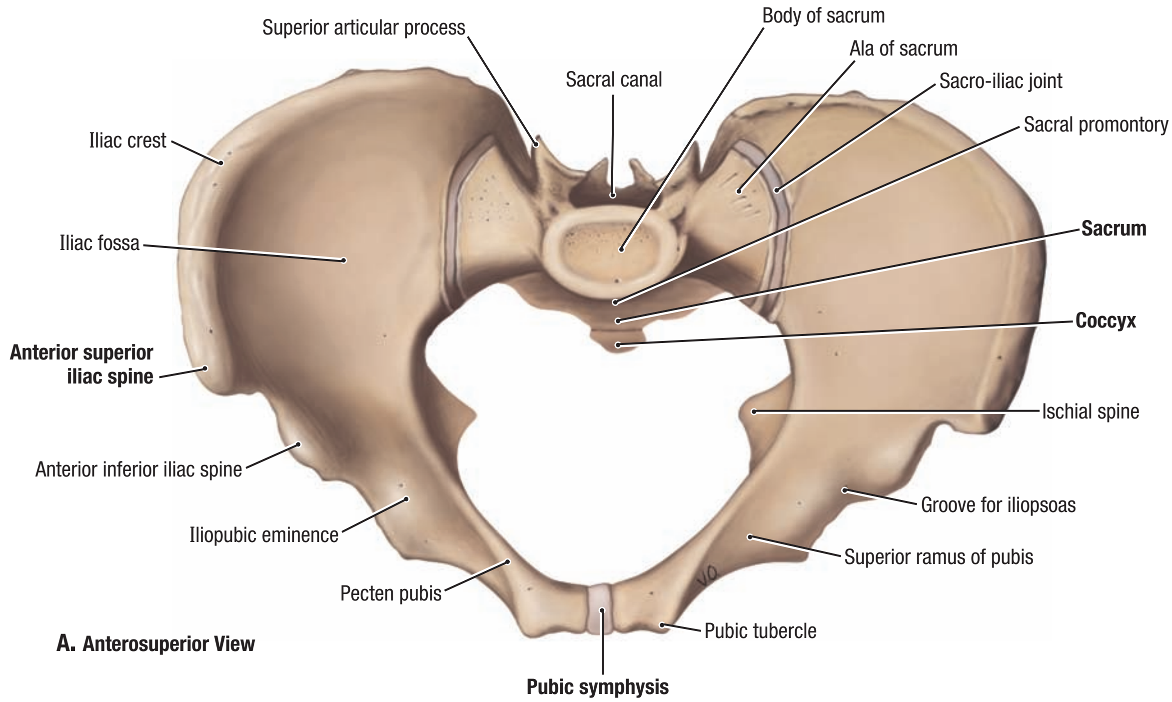
B. **Coronal section**



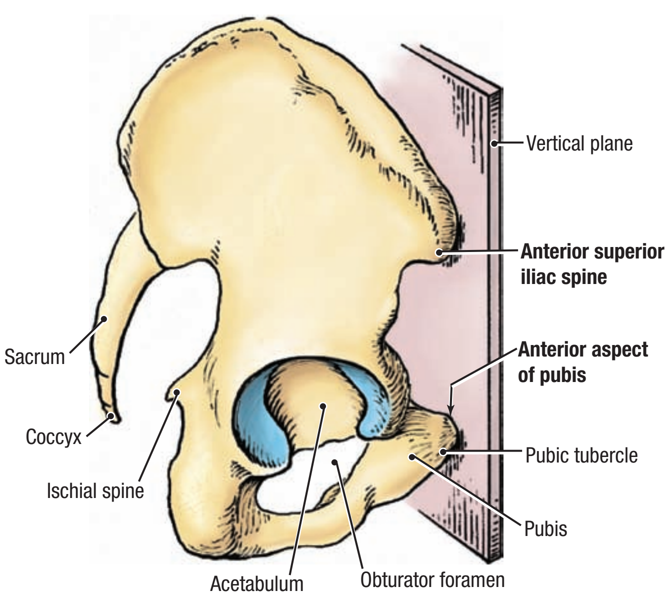
C. **Anterior View**

3.3 BONES AND DIVISIONS OF PELVIS

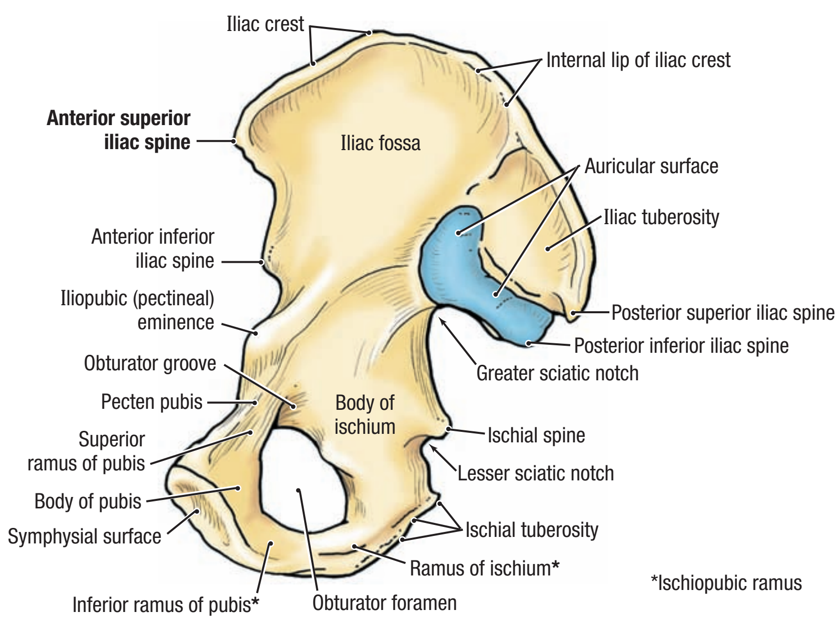
A. Bones of pelvis. The three bones composing the pelvis are the pubis, ischium, and ilium. **B. and C.** Lesser and greater pelvis, schematic illustrations. The plane of the pelvic inlet (*double-headed arrow* in *B*) separates the greater pelvis (part of the abdominal cavity) from the lesser pelvis (pelvic cavity).



A. Anterosuperior View



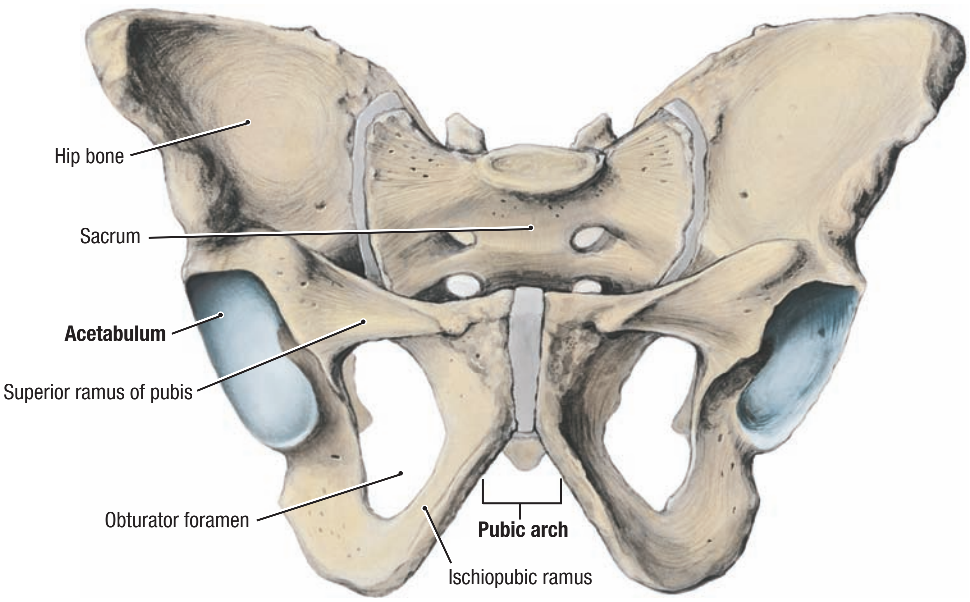
B. Lateral View



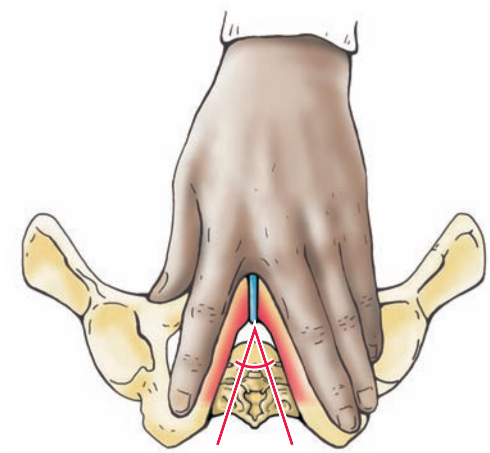
C. Medial Aspect

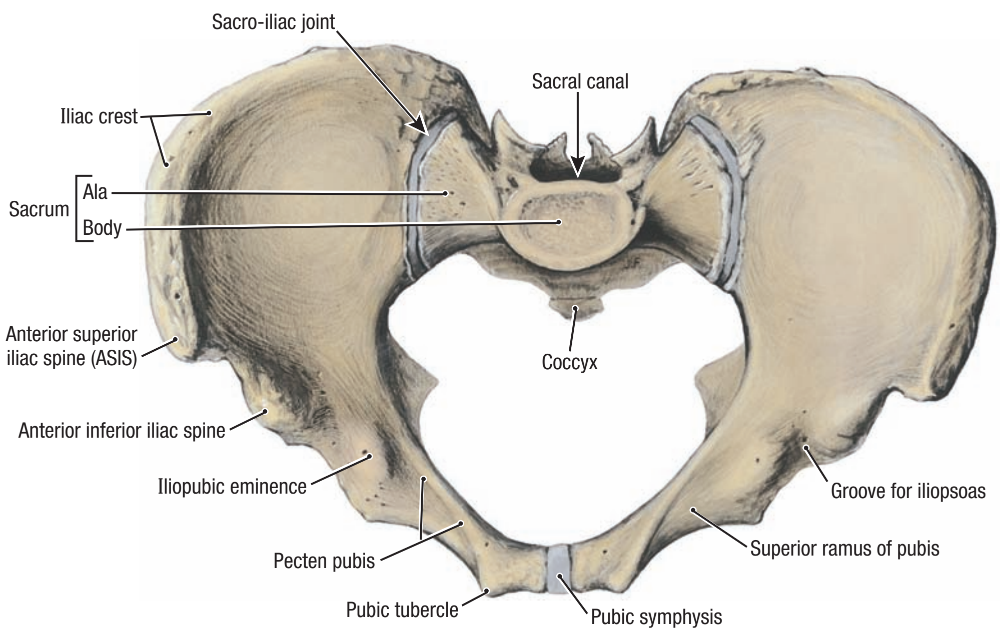
3.4 PELVIS, ANATOMICAL POSITION

A. Pelvic girdle. **B.** Placement of hip bone in anatomical position. In the anatomical position, (1) the anterior superior iliac spine and the anterior aspect of the pubis lie in the same vertical plane and (2) the sacrum is located superiorly, the coccyx posteriorly, and the pubic symphysis antero-inferiorly. **C.** Features of hip bone.



A. Anteroinferior View



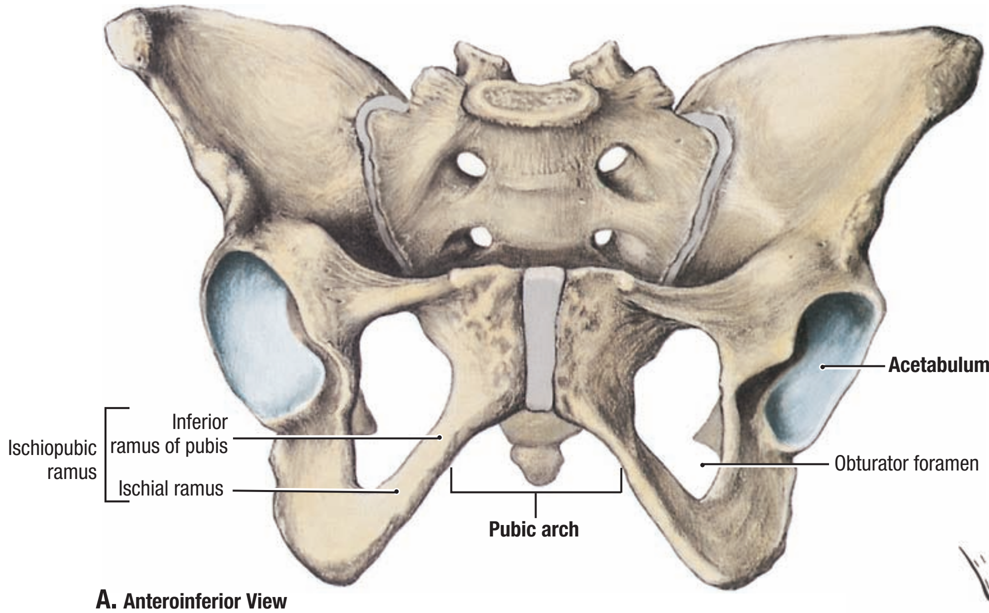


B. Anterosuperior View

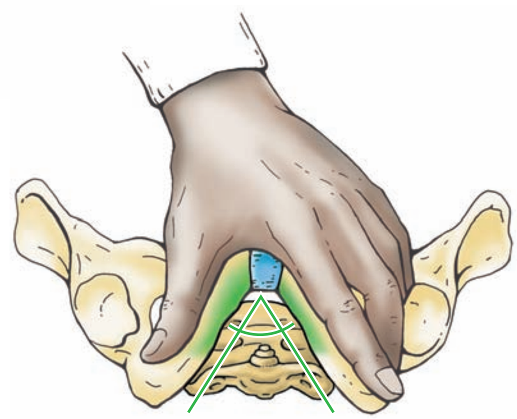
3.5 MALE PELVIC GIRDLE

TABLE 3.1 DIFFERENCES BETWEEN MALE AND FEMALE PELVES

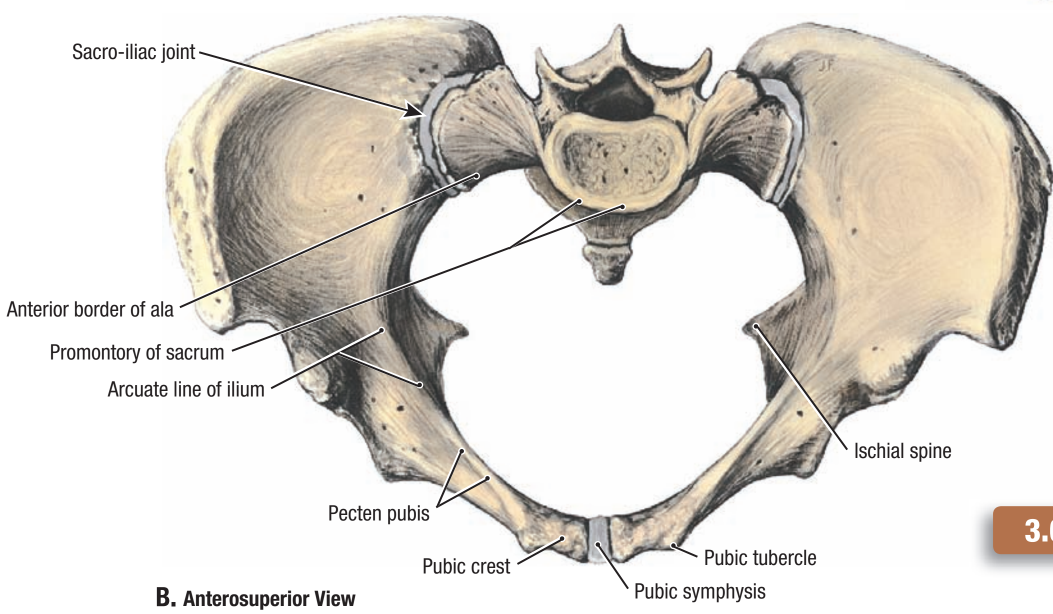
Bony Pelvis	Male	Female
General structure	Thicker and heavier	Thinner and lighter
Greater pelvis (pelvis major)	Deeper	Shallower
Lesser pelvis (pelvis minor)	Narrower and deeper, tapering	Wider and shallower, cylindrical
Pelvic inlet (superior pelvic aperture)	Heart shaped, narrower	More oval or rounded, wider



A. Anteroinferior View



C. Subpubic angle
"U" shaped

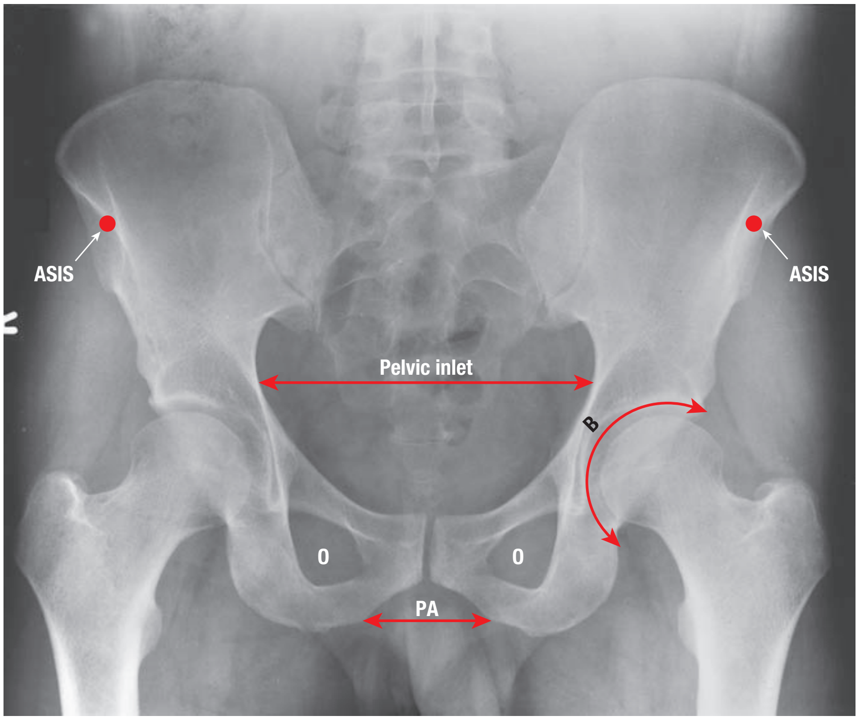


B. Anterosuperior View

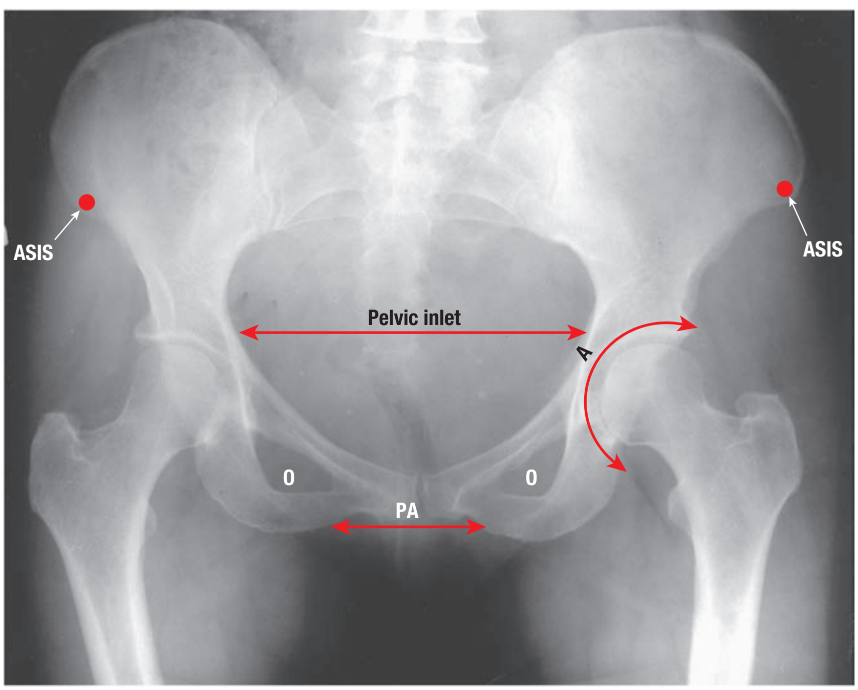
3.6 FEMALE PELVIC GIRDLE

TABLE 3.1 DIFFERENCES BETWEEN MALE AND FEMALE PELVES (CONTINUED)

Bony Pelvis	Male	Female
Sacrum/coccyx	More curved	Less curved
Pelvic outlet (inferior pelvic aperture)	Comparatively small	Comparatively large
Pubic arch and subpubic angle	Narrower	Wider
Obturator foramen	Round	Oval
Acetabulum	Large	Small



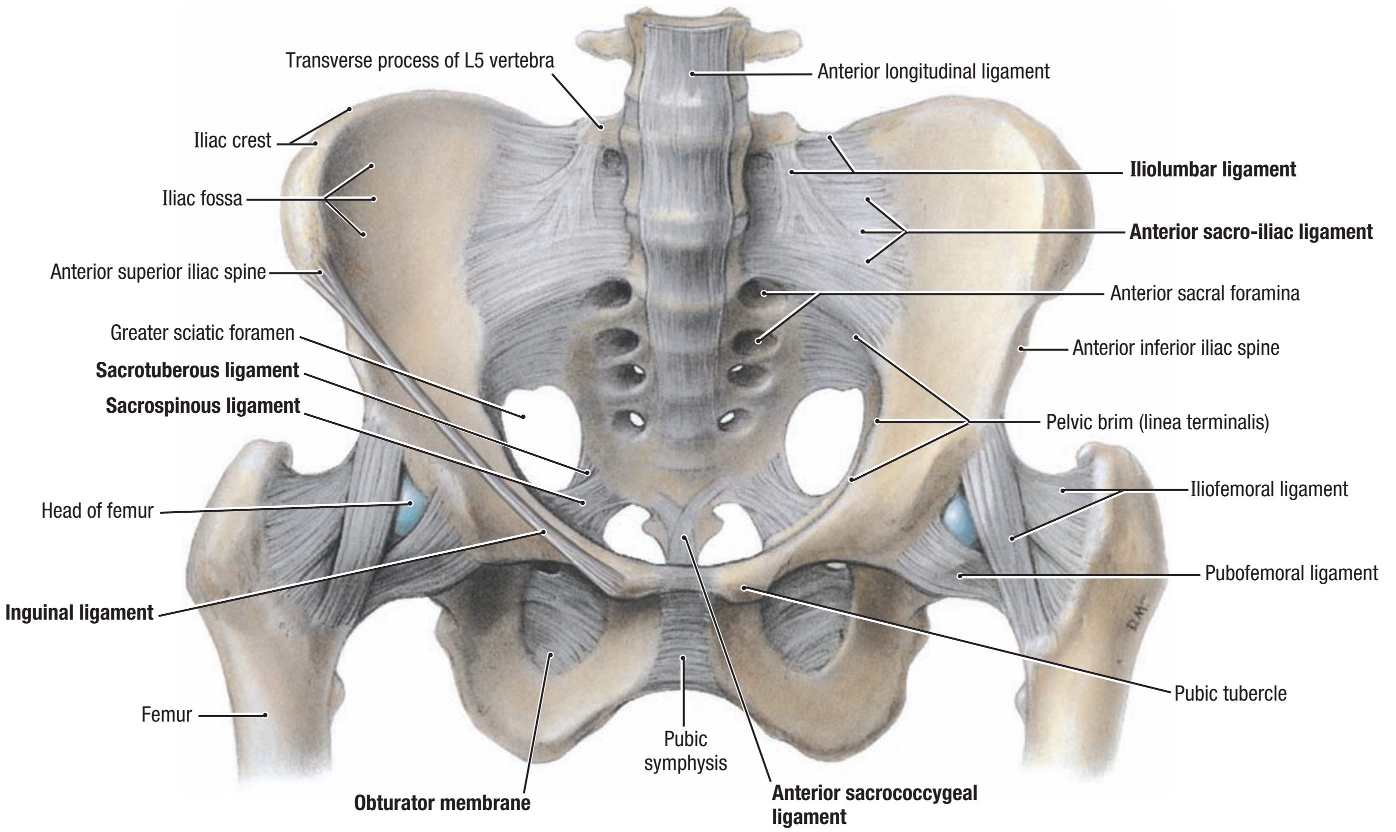
A. Anteroposterior View, Male Pelvis



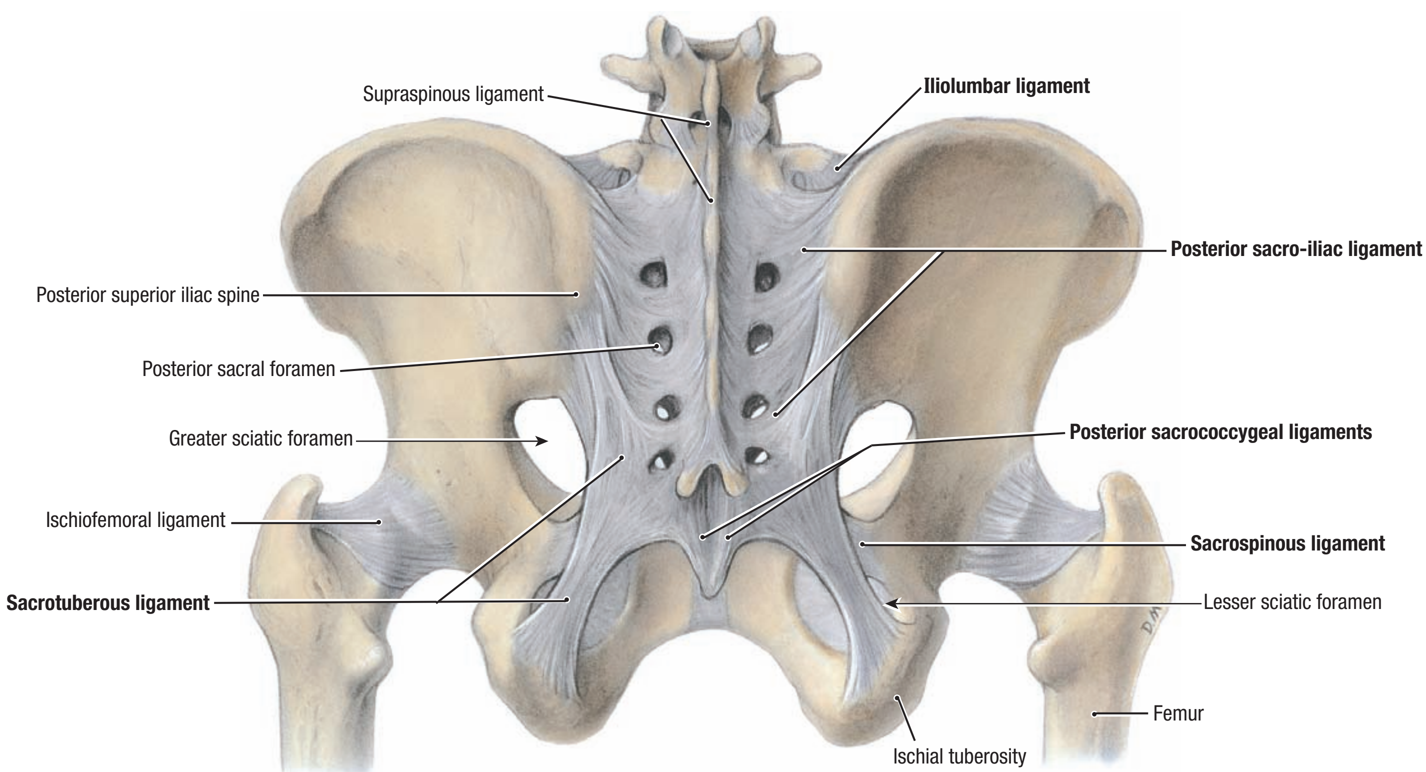
B. Anteroposterior View, Female Pelvis

3.7 RADIOGRAPHS OF PELVIS

A. Male. **B.** Female. Some of the main differences of male and female pelves are listed in Table 3.1. The radiographs highlight some of these differences. *A,* acetabulum; *ASIS,* anterior superior iliac spine; *O,* obturator foramen; *PA,* pubic arch.

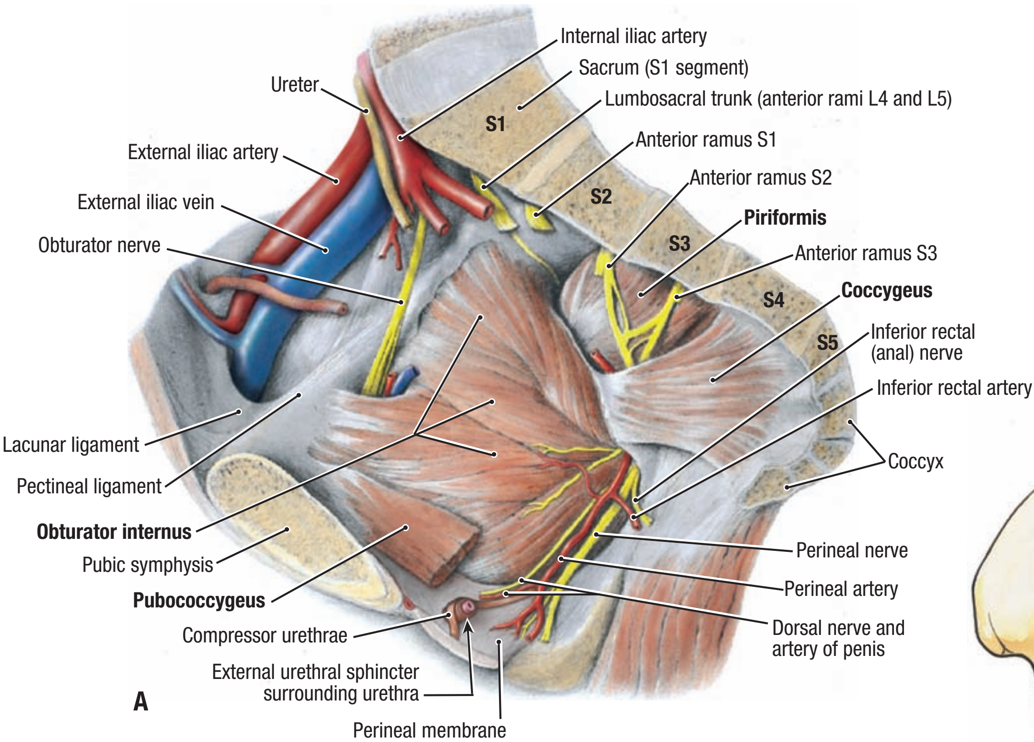


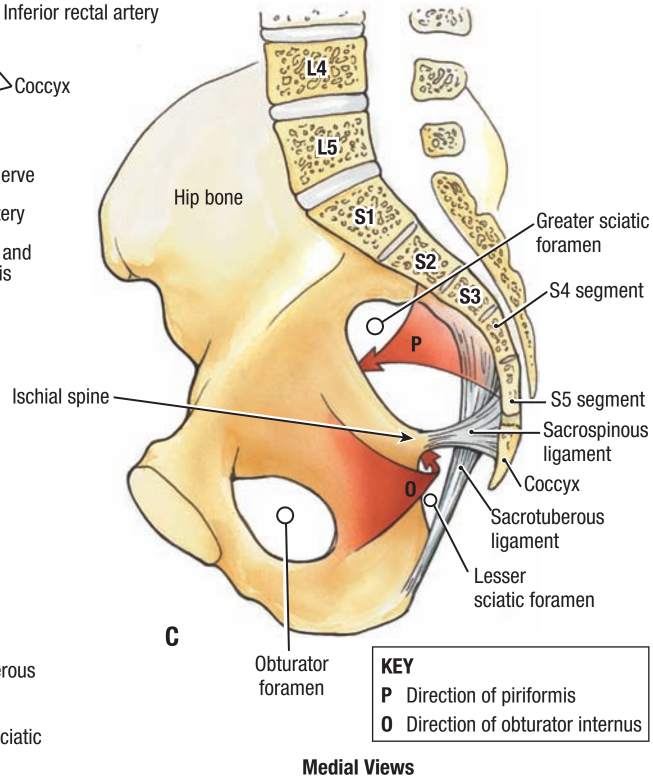
A. Anterior View

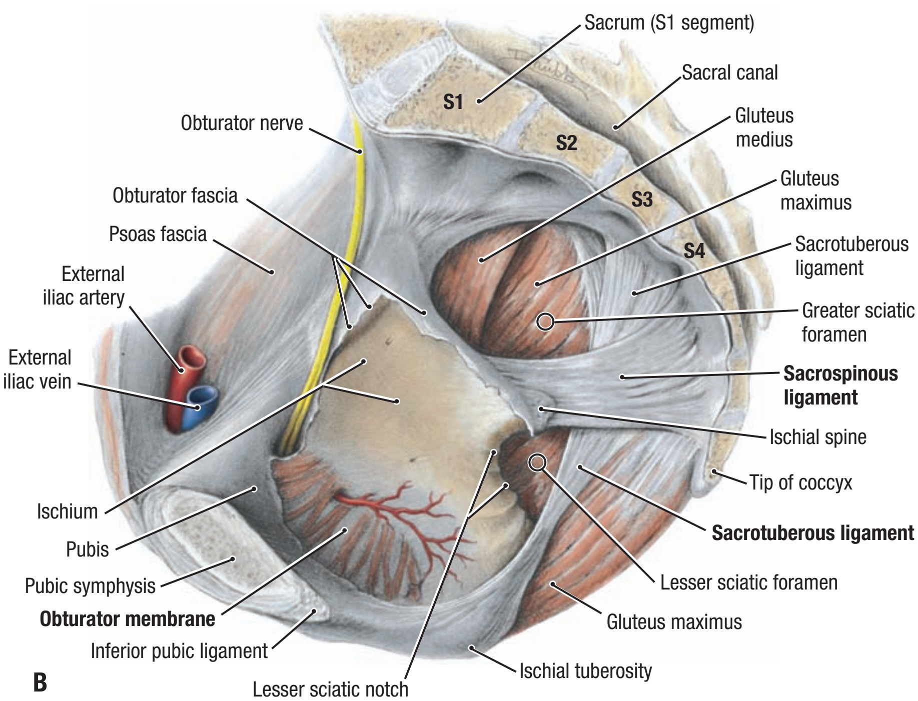


B. Posterior View

3.8 PELVIS AND PELVIC LIGAMENTS

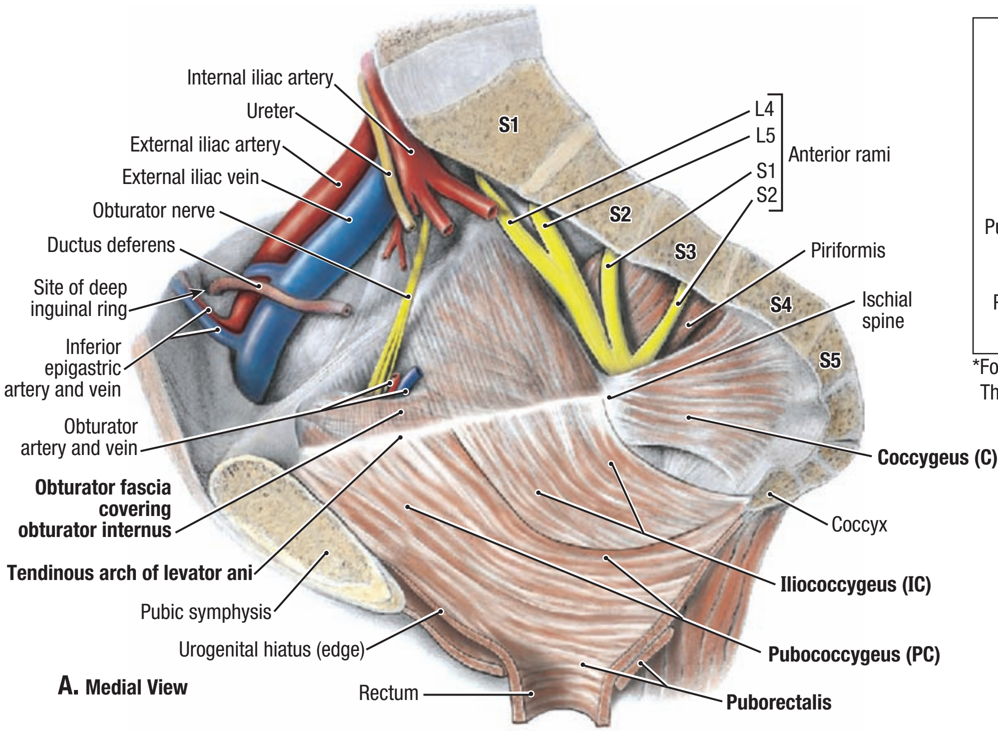






3.9 OBTURATOR INTERNUS AND PIRIFORMIS

- On the lateral pelvic wall, the obturator foramen is closed by the obturator membrane; the obturator internus muscle attaches to the obturator membrane and surrounding bone and exits the lesser pelvis through the lesser sciatic foramen; obturator fascia lies on the medial surface of the muscle.
- Piriformis lies on the posterolateral pelvic wall and leaves the lesser pelvis through the greater sciatic foramen.



A. Medial View

Muscles of floor of pelvis*:

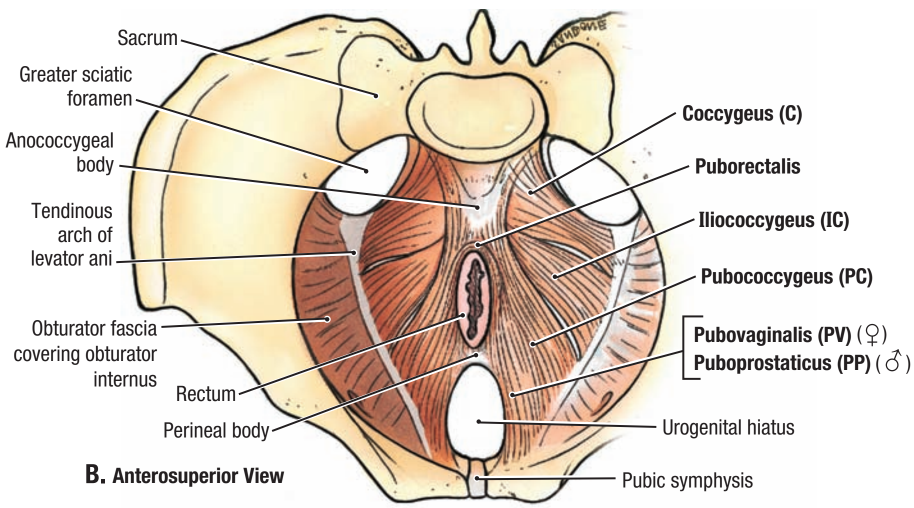
Pelvic diaphragm (PD) = Levator ani (LA) + Coccygeus (C)
(PD = LA + C)

Levator ani (LA) = Pubococcygeus (PC) + Iliococcygeus (IC)
(LA = PC + IC)

Pubococcygeus (PC ♀) = Puborectalis (PR) + Pubovaginalis (PV)
(PC = PR + PV ♀)

Pubococcygeus (PC ♂) = Puborectalis (PR) + Puboprostaticus (PP)
(PC = PR + PP ♂) (Levator prostatae)

*Formulas: Dr. Larry M. Ross.
The Univesity of Texas Medical School at Houston



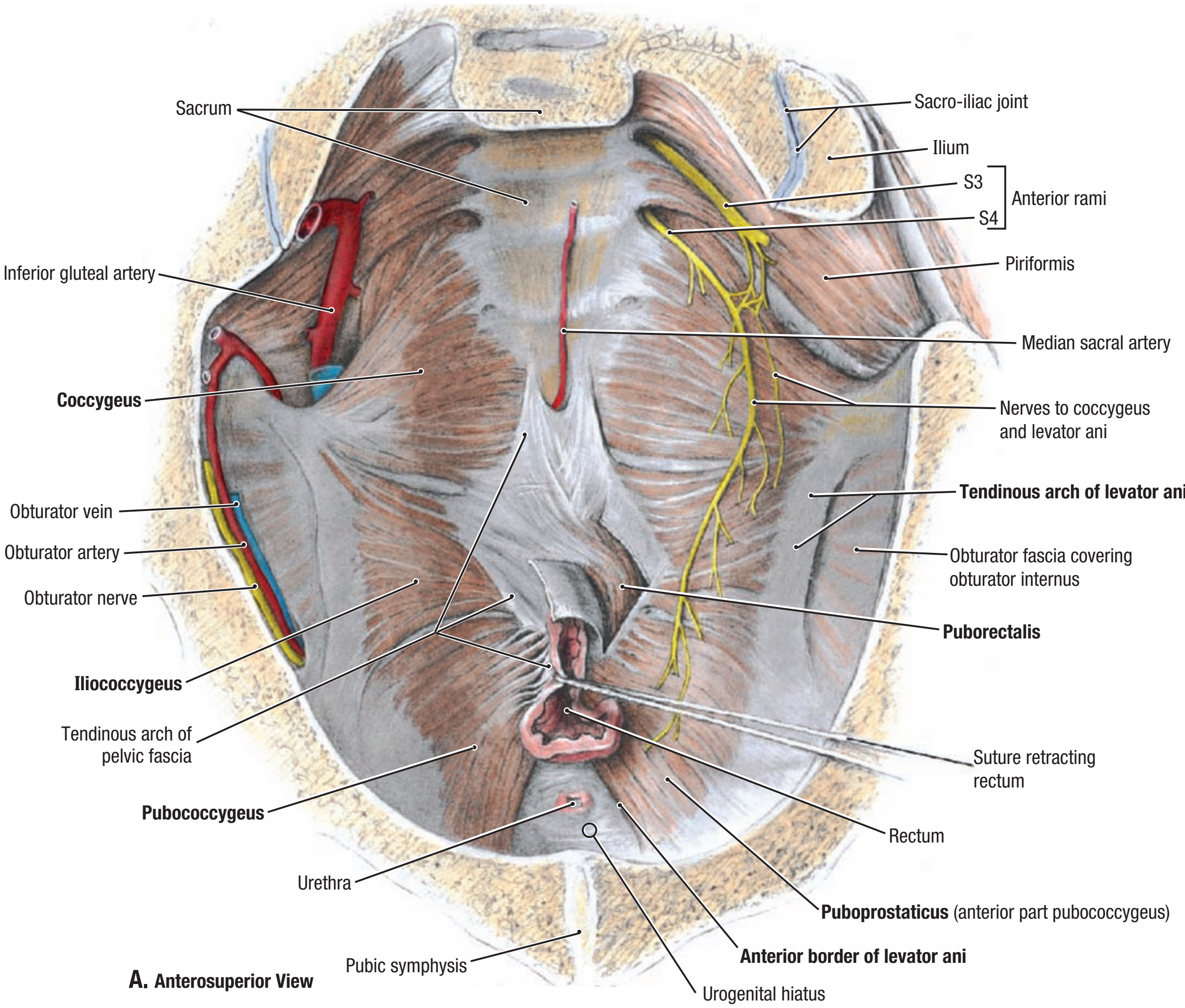
B. Anterosuperior View

3.10 MUSCLES OF PELVIC DIAPHRAGM

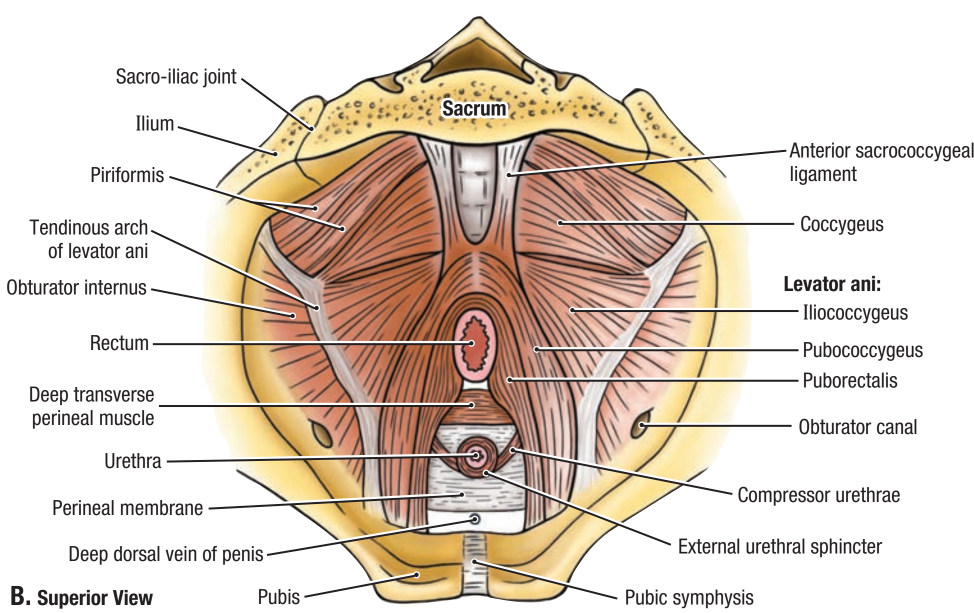
A. The pelvic floor is formed by the funnel- or bowl-shaped pelvic diaphragm. The funnel shape can be seen in a medial view of a median section. **B.** The bowl shape from a superior view.

TABLE 3.2 MUSCLES OF PELVIC WALLS AND FLOOR

Boundary	Muscle	Proximal Attachment	Distal Attachment	Innervation	Main Action
Lateral wall	Obturator internus	Pelvic surfaces of ilium and ischium, obturator membrane	Greater trochanter of femur	Nerve to obturator internus (L5, S1, S2)	Rotates hip joint laterally; assists in holding head of femur in acetabulum
Posterolateral wall	Piriformis	Pelvic surface of S2–S4 segments, superior margin of greater sciatic notch, sacrotuberous ligament		Anterior rami of S1 and S2	Rotates hip joint laterally; abducts hip joint; assists in holding head of femur in acetabulum
Floor	Levator ani (pubococcygeus, puborectalis, and iliococcygeus)	Body of pubis, tendinous arch of obturator fascia, ischial spine	Perineal body, coccyx, anococcygeal ligament, walls of prostate or vagina, rectum, and anal canal	Nerve to levator ani (branches of S4), inferior anal (rectal) nerve, and coccygeal plexus	Forms most of pelvic diaphragm that helps support pelvic viscera and resists increases in intra-abdominal pressure
	Coccygeus (ischiococcygeus)	Ischial spine	Inferior end of sacrum and coccyx	Branches of S4 and S5 spinal nerves	Forms small part of pelvic diaphragm that supports pelvic viscera; flexes sacrococcygeal joints

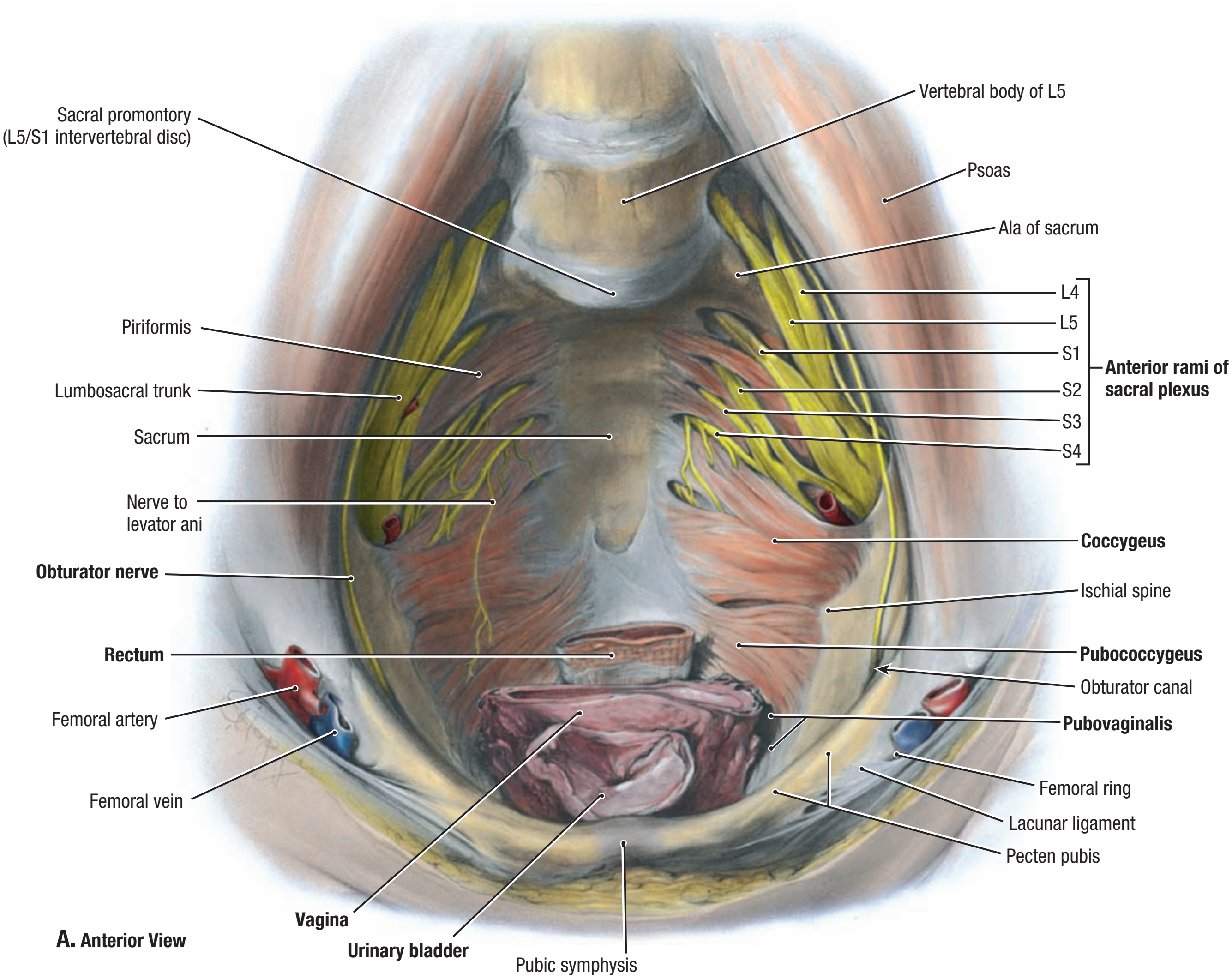


A. Anterosuperior View

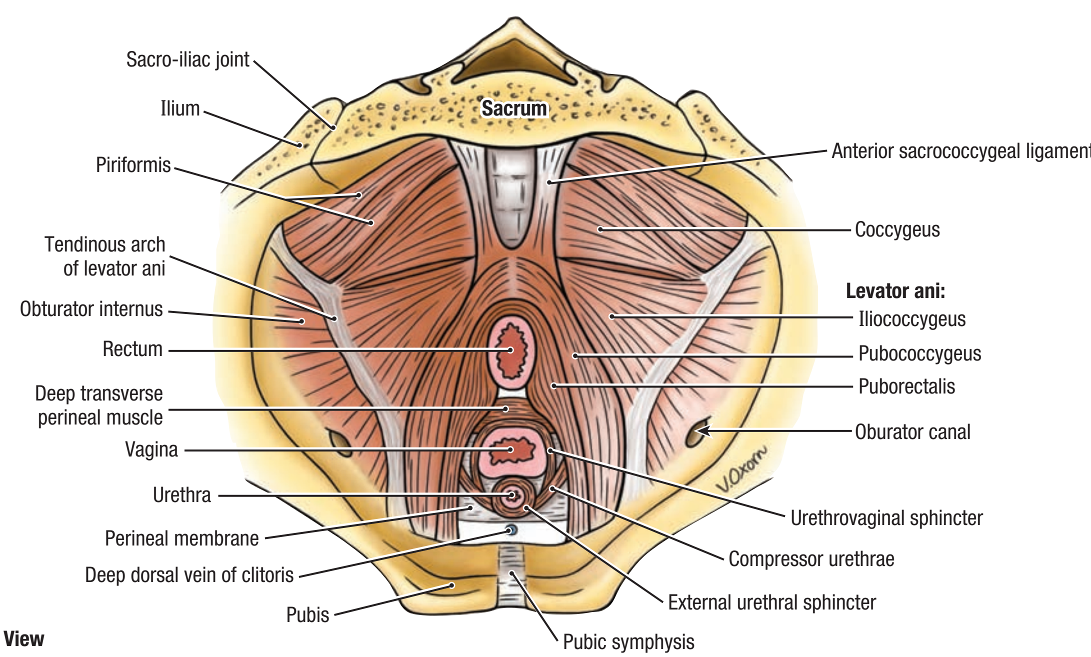


B. Superior View

3.11 FLOOR AND WALLS OF MALE PELVIS, PELVIC DIAPHRAGM

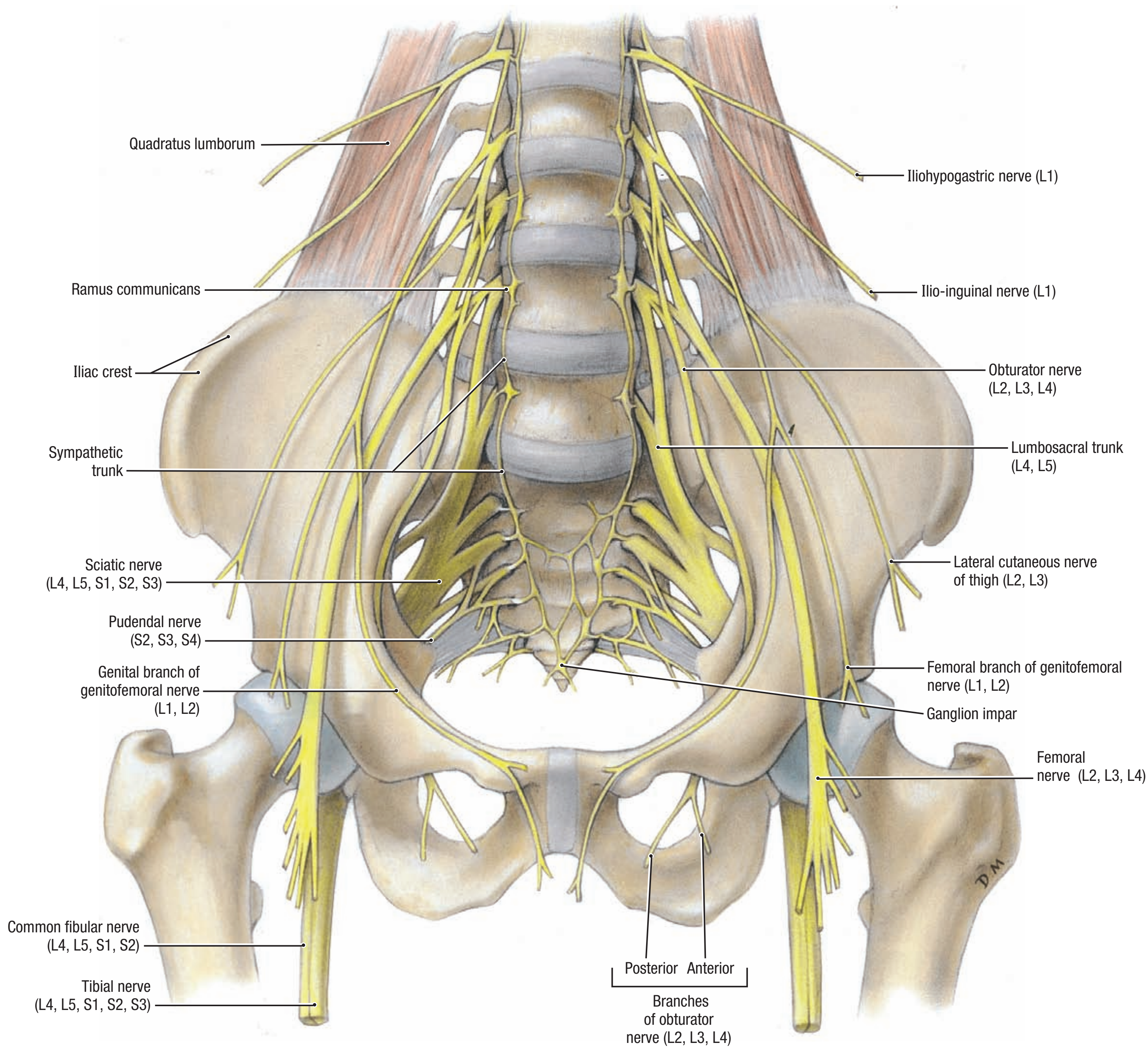


A. **Anterior View**



B. **Superior View**

3.12 FLOOR AND WALLS OF FEMALE PELVIS

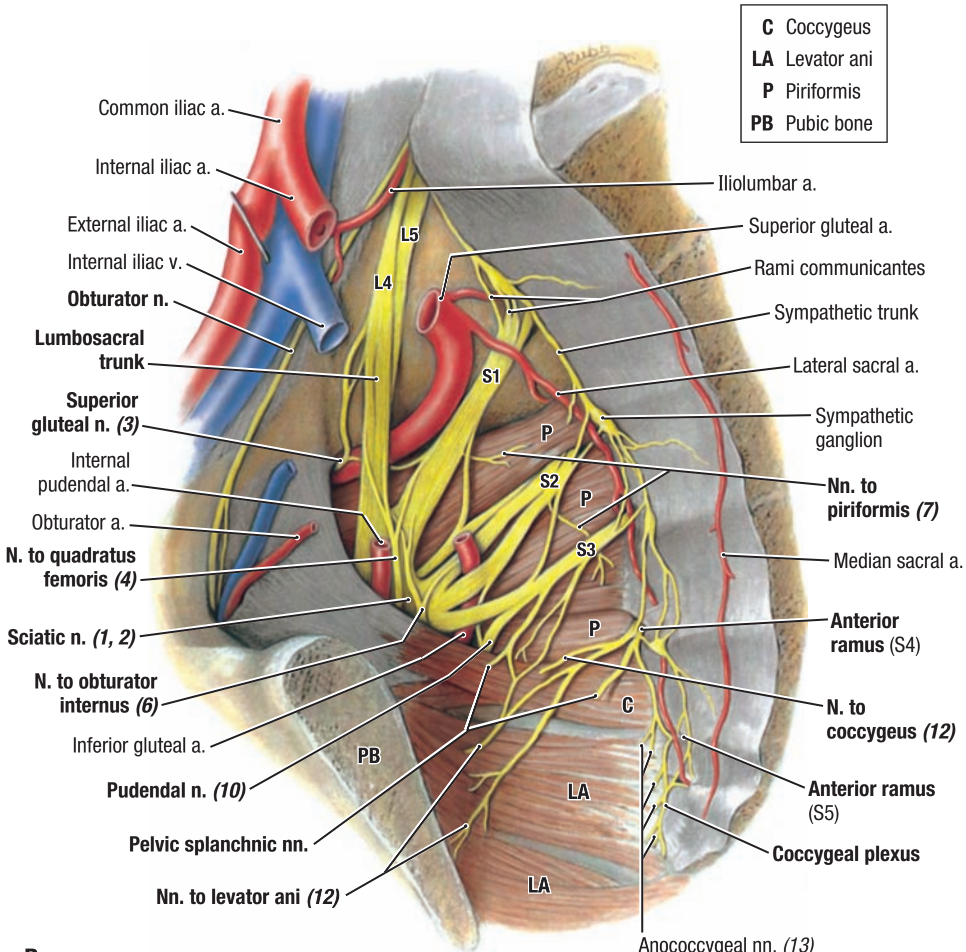


A. Anterior View

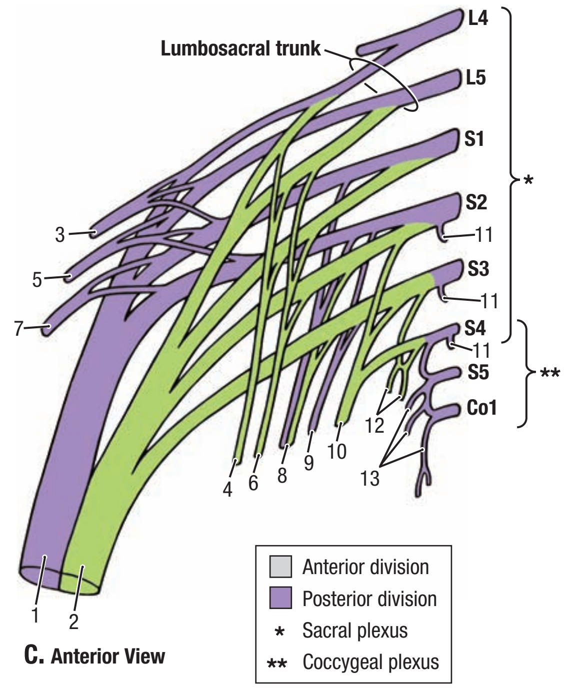
3.13 SACRAL AND COCCYGEAL NERVE PLEXUSES

A. Dissection

- The sympathetic trunk or its ganglia send rami communicantes to each sacral and coccygeal nerve.
- The anterior ramus from L4 joins that of L5 to form the lumbosacral trunk.



B. Medial View, right half of hemisected pelvis



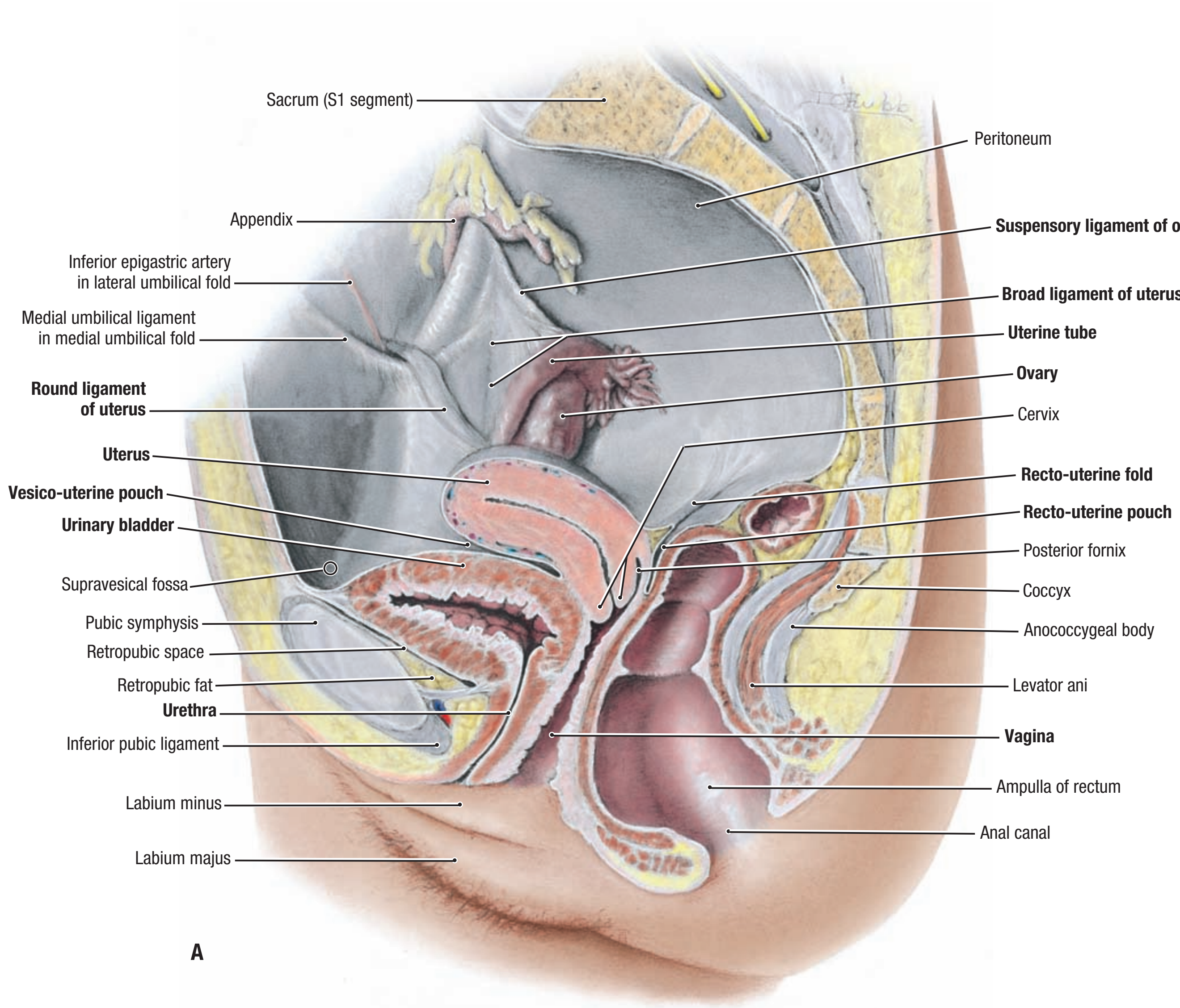
C. Anterior View

3.13 SACRAL AND COCCYGEAL NERVE PLEXUSES *(CONTINUED)*

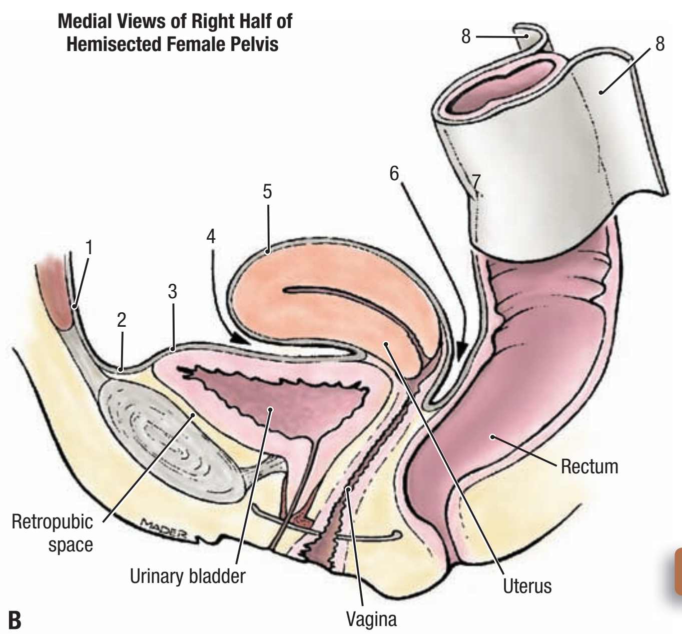
B. and C. Schematic illustrations.

TABLE 3.3 NERVES OF SACRAL AND COCCYGEAL PLEXUSES

Nerve	Origin	Distribution
Sciatic:		
1. Common fibular	L4, L5, S1, S2	Articular branches to hip joint and muscular branches to flexors of knee joint in thigh and all muscles in leg and foot
2. Tibial	L4, L5, S1, S2, S3	
3. Superior gluteal	L4, L5, S1	Gluteus medius and gluteus minimus muscles
4. Nerve to quadratus femoris and inferior gemellus	L4, L5, S1	Quadratus femoris and inferior gemellus muscles
5. Inferior gluteal	L5, S1, S2	Gluteus maximus muscle
6. Nerve to obturator internus and superior gemellus	L5, S1, S2	Obturator internus and superior gemellus muscles
7. Nerve to piriformis	S1, S2	Piriformis muscle
8. Posterior cutaneous nerve of thigh	S1, S2, S3	Cutaneous branches to buttock and uppermost medial and posterior surfaces of thigh
9. Perforating cutaneous	S2, S3	Cutaneous branches to medial part of buttock
10. Pudendal	S2, S3, S4	Structures in perineum, sensory to genitalia, muscular branches to perineal muscles, external urethral sphincter, and external anal sphincter
11. Pelvic splanchnic	S2, S3, S4	Pelvic viscera via inferior hypogastric and pelvic plexuses
12. Nerves to levator ani and coccygeus	S3, S4	Levator ani and coccygeus muscles
13. Anococcygeal nerves	S4, S5, Co1	Penetrate coccygeal attachments of sacrospinous/sacrotuberous ligaments to supply overlying skin



Medial Views of Right Half of Hemisected Female Pelvis



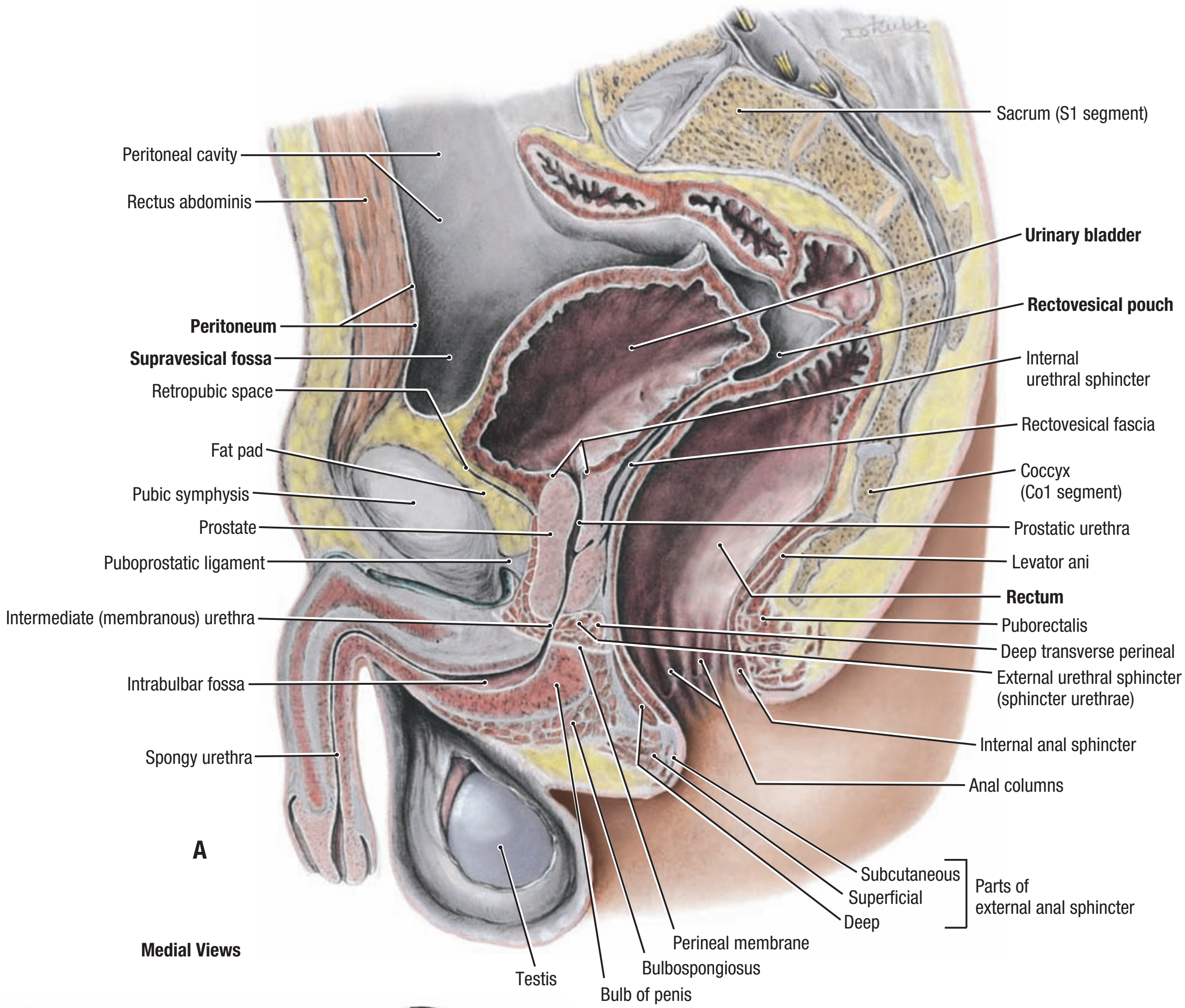
Female:

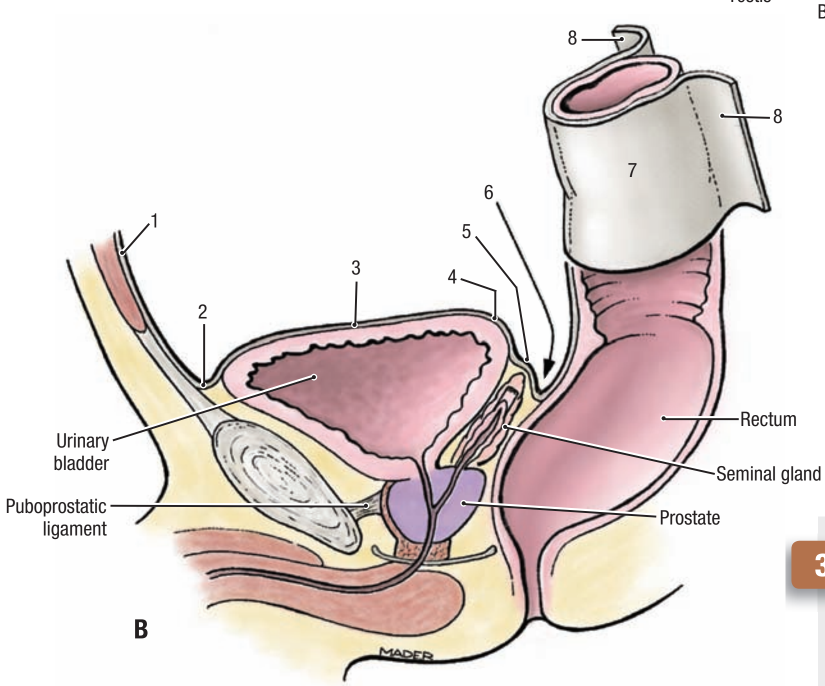
Peritoneum passes:

- From the anteiror abdominal wall *(1)*
- Superior to the pubic bone *(2)*, forming supravesical fossa
- On the superior surface of the urinary bladder *(3)*
- From the bladder to mid-uterus, forming the vesico-uterine pouch *(4)*
- On the fundus and body of the uterus, and posterior fornix of the vagina *(5)*
- Between the rectum and uterus, forming the recto-uterine pouch *(6)*
- On the anterior and lateral sides of the rectum *(7)*
- Posteriorly to become the sigmoid mesocolon *(8)*

3.14 PERITONEUM COVERING FEMALE PELVIC ORGANS

A. Organs in situ with peritoneal reflections. **B.** Schematic illustration. The level of the supravesical fossa changes with filling and emptying of bladder.



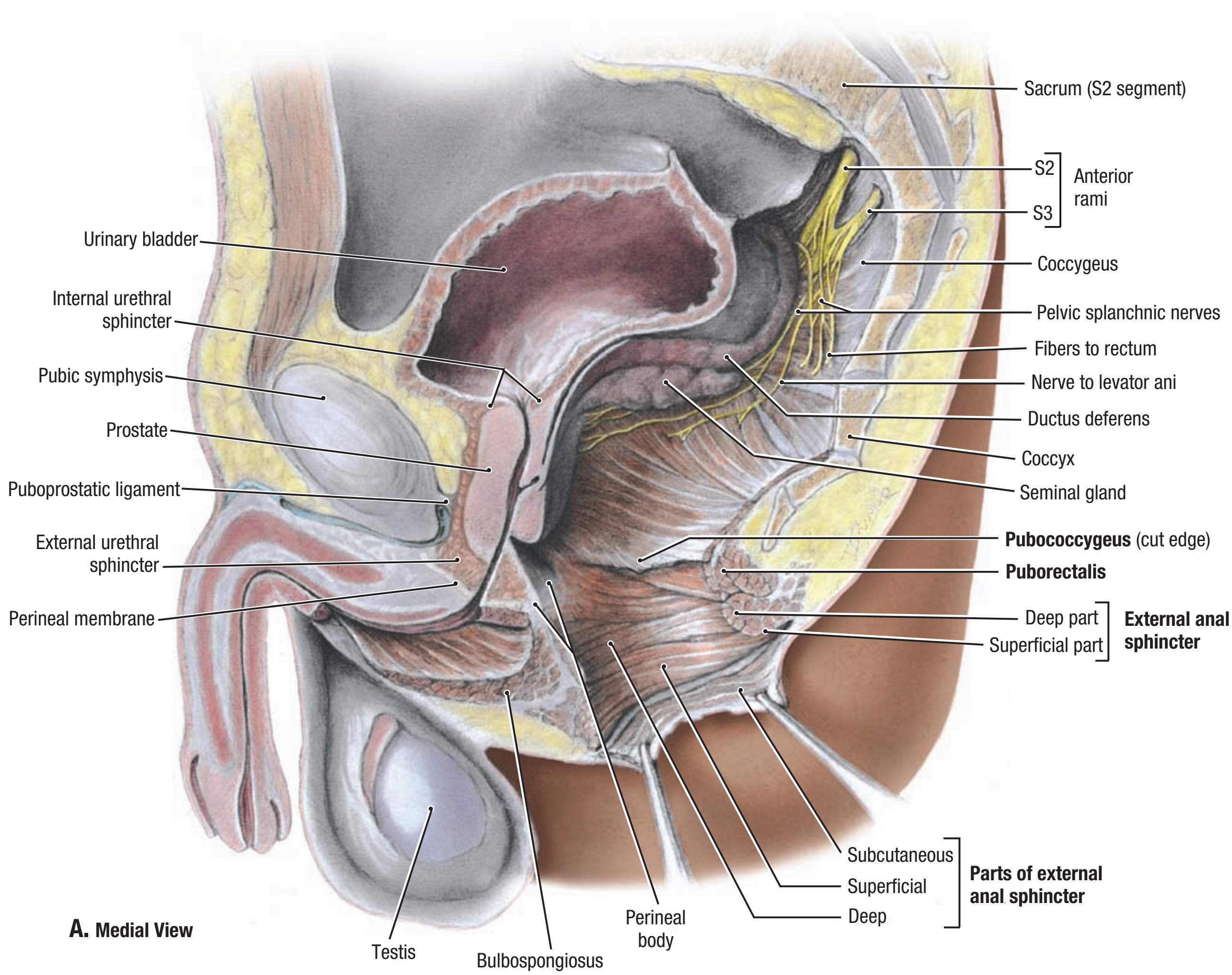


Male:
Peritoneum passes:

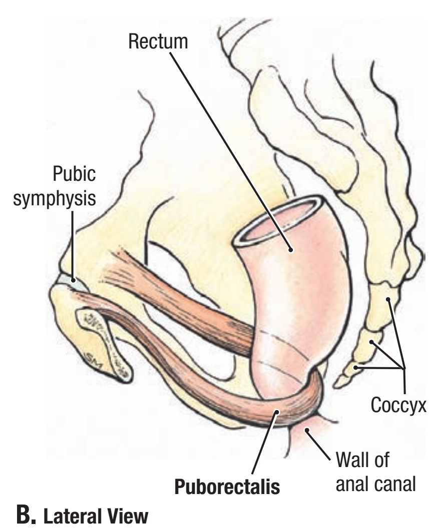
- From the anterior abdominal wall *(1)*
- Superior to the pubic bone *(2)*, forming supravesical fossa
- On the superior surface of the urinary bladder *(3)*
- 2 cm inferiorly on the posterior surface of the urinary bladder *(4)*
- On the superior ends of the seminal glands *(5)*
- Posteriorly to line the rectovesical pouch *(6)*
- To cover the rectum *(7)*
- Posteriorly to become the sigmoid mesocolon *(8)*

3.15 PERITONEUM COVERING MALE PELVIC ORGANS

A. Organs in situ. The urinary bladder is distended and displaced posteriorly in this specimen, not anteriorly as is usual, forming a broad and deep supravesical fossa even when the bladder is full. **B.** Peritoneum covering male pelvic organs. Typically, the location of supravesical fossa changes with filling and emptying of bladder.



A. Medial View



B. Lateral View

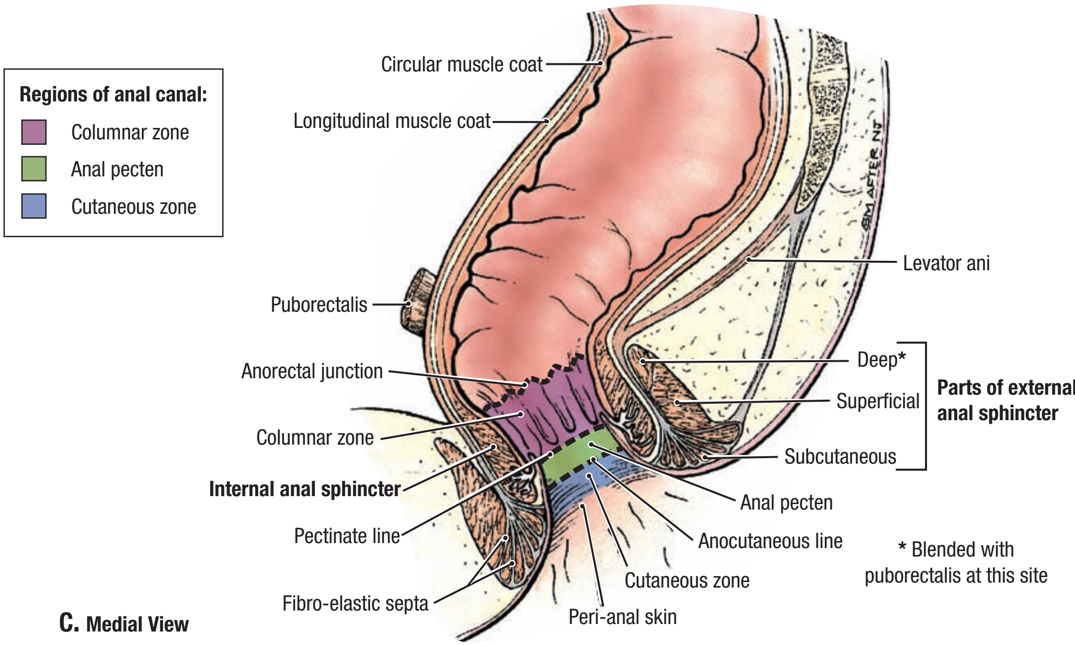
3.16 ANAL SPHINCTERS AND ANAL CANAL

A. Levator ani, in right half of hemisected pelvis.

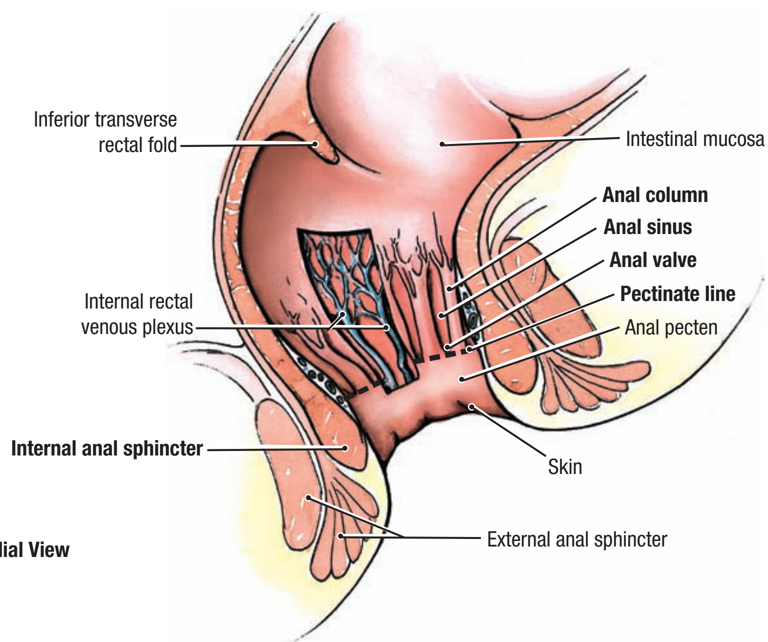
- The subcutaneous fibers of the external anal sphincter and overlying skin are reflected with forceps. The pubococcygeus muscle is cut to reveal the anal canal, to which it is, in part, attached.

B. Puborectalis.

- The innermost part of the pubococcygeus muscle, the puborectalis, forms a U-shaped muscular "sling" around the anorectal junction, which maintains the anorectal (perineal) flexure.



C. Medial View



D. Medial View

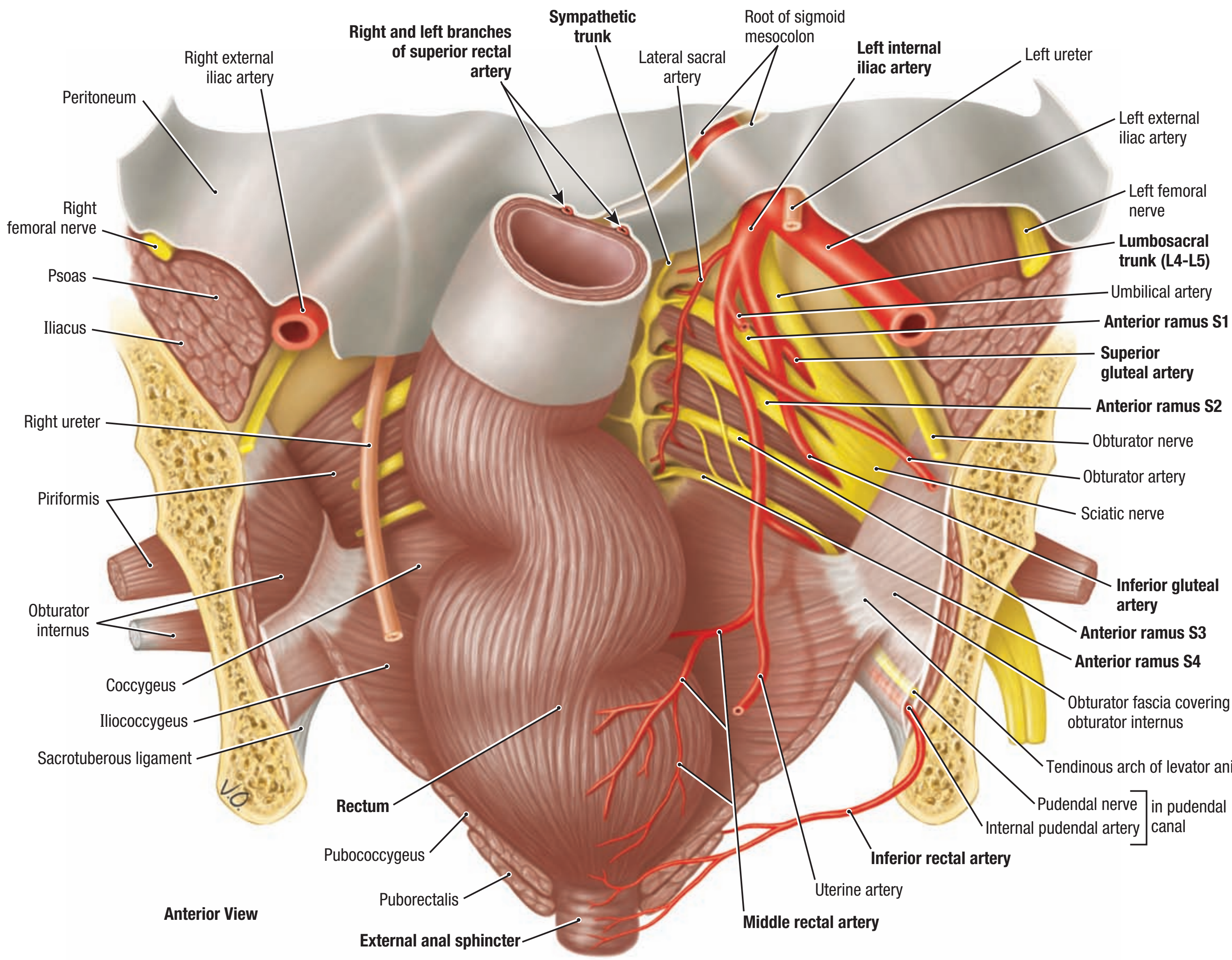
3.16 ANAL SPHINCTERS AND ANAL CANAL *(CONTINUED)*

C. External and internal anal sphincters.

- The internal anal sphincter is a thickening of the inner, circular muscular coat of the anal canal.
- The external anal sphincter has three often indistinct continuous zones: deep, superficial, and subcutaneous; the deep part intermingles with the puborectalis muscle posteriorly.
- The longitudinal muscle layer of the rectum separates the internal and external anal sphincters and terminates in the subcutaneous tissue and skin around the anus.

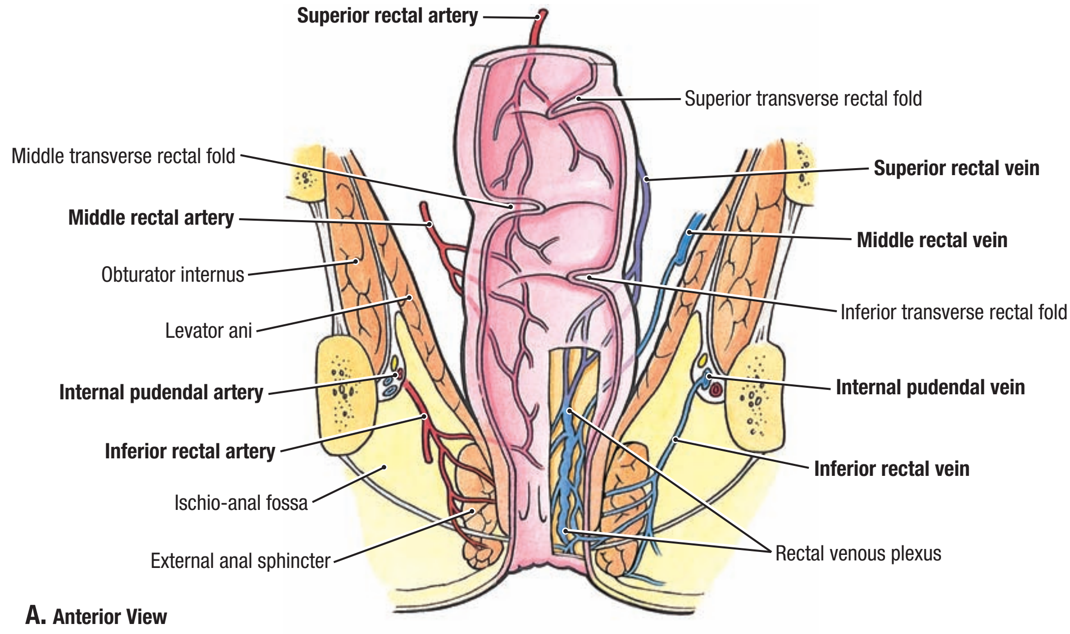
D. Features of the anal canal.

- The anal columns are 5 to 10 vertical folds of mucosa separated by anal sinuses and valves; they contain portions of the rectal venous plexus.
- The pecten is a smooth area of hairless stratified epithelium that lies between the anal valves superiorly and the inferior border of the internal anal sphincter inferiorly.
- The pectinate line is an irregular line at the base of the anal valves where the intestinal mucosa is continuous with the pecten; this indicates the junction of the superior part of the anal canal (derived from embryonic hindgut) and the inferior part of the anal canal (derived from the anal pit [proctodeum]). Innervation is visceral proximal to the line and somatic distally; lymphatic drainage is to the pararectal nodes proximally and to the superficial inguinal nodes distally.

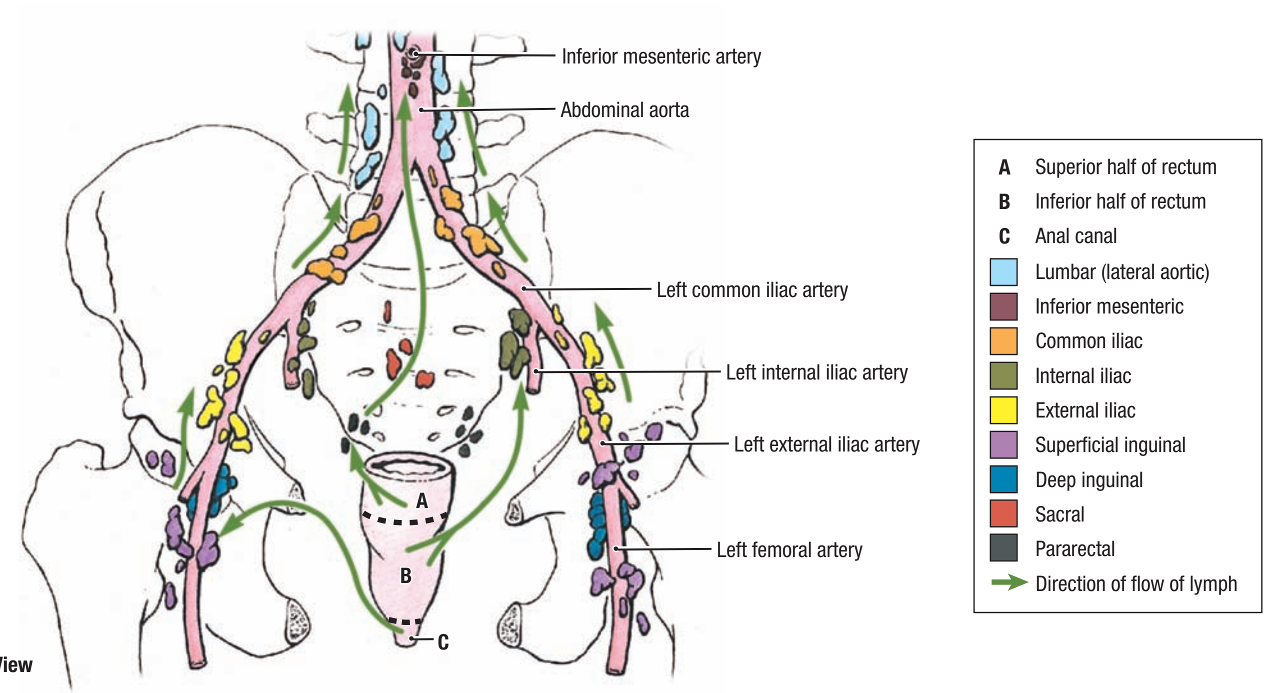


3.17 RECTUM, ANAL CANAL, AND NEUROVASCULAR STRUCTURES OF POSTERIOR PELVIS

The pelvis is coronally bisected anterior to the rectum and anal canal. The superior gluteal artery often passes posteriorly between the anterior rami of L5 and S1, and the inferior gluteal artery between S2 and S3.



A. **Anterior View**



B. **Anterior View**

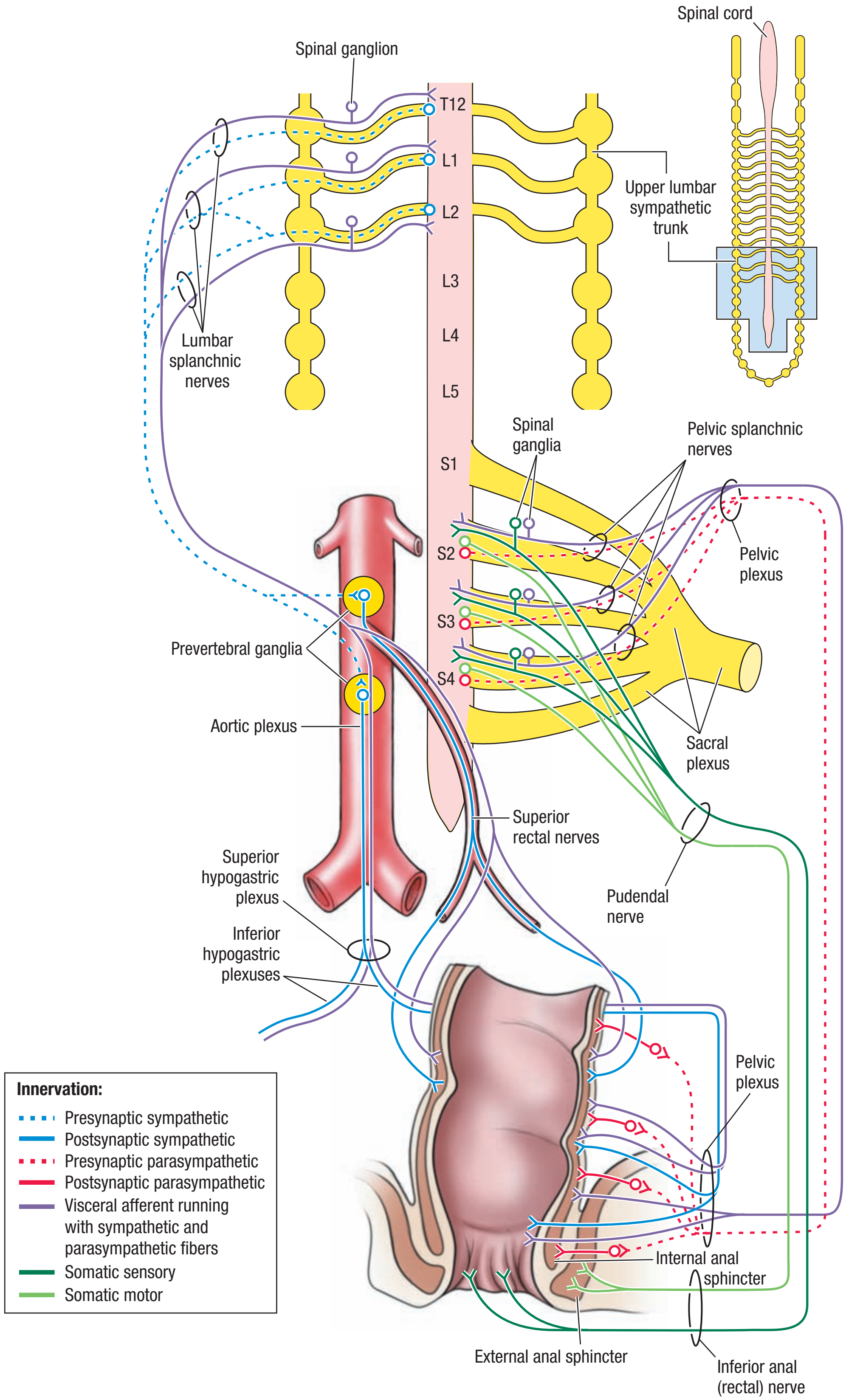
3.18 VASCULATURE OF RECTUM

A. Arterial and venous drainage.

- The continuation of the inferior mesenteric artery, the superior rectal artery, supplies the proximal part of rectum.
- Right and left middle rectal arteries, usually arising from the inferior vesical (male) or uterine (female) arteries, supply the middle and inferior parts of the rectum.
- Inferior rectal arteries, arising from the internal pudendal arteries, supply the anorectal junction and the anal canal.
- The rectal venous plexus surrounds the distal rectum and anal canal and consists of an internal rectal plexus deep to the epithelium of the anal canal and an external rectal plexus external to the muscular coats of the wall of the anal canal.
- The superior rectal vein drains into the portal system, and the middle and inferior veins drain into the systemic system; thus, this is an important area of **portacaval anastomosis** (see information on Hemorrhoids with Fig. 3.30).

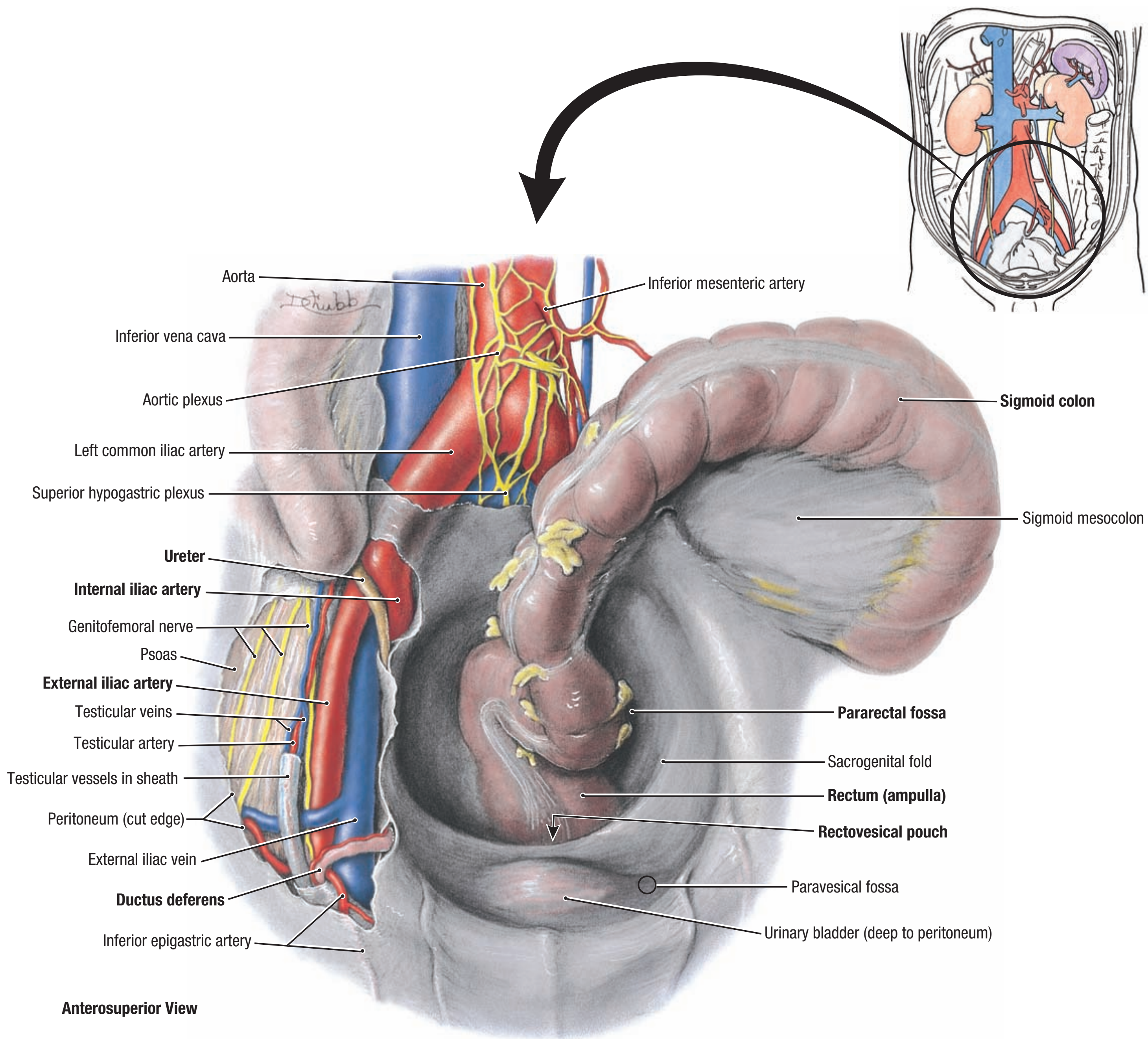
B. Lymphatic drainage.

- The superior, middle, and inferior rectal veins drain the rectum and anal canal; there are anastomoses between the plexuses formed by all three veins.



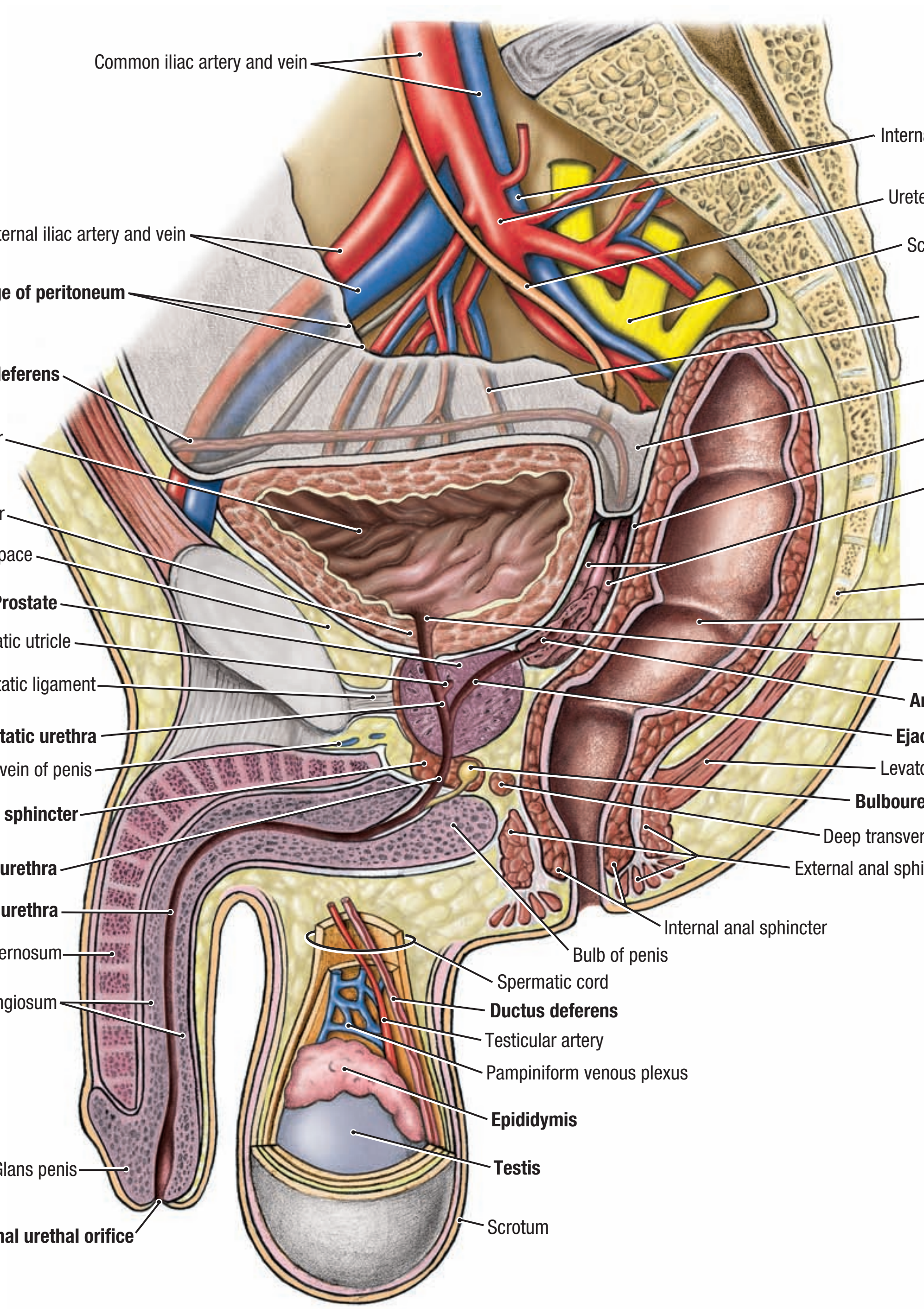
3.19 INNERVATION OF RECTUM AND ANAL CANAL

The lumbar and pelvic spinal nerves and hypogastric plexuses have been retracted laterally for clarity.



3.20 RECTUM IN SITU

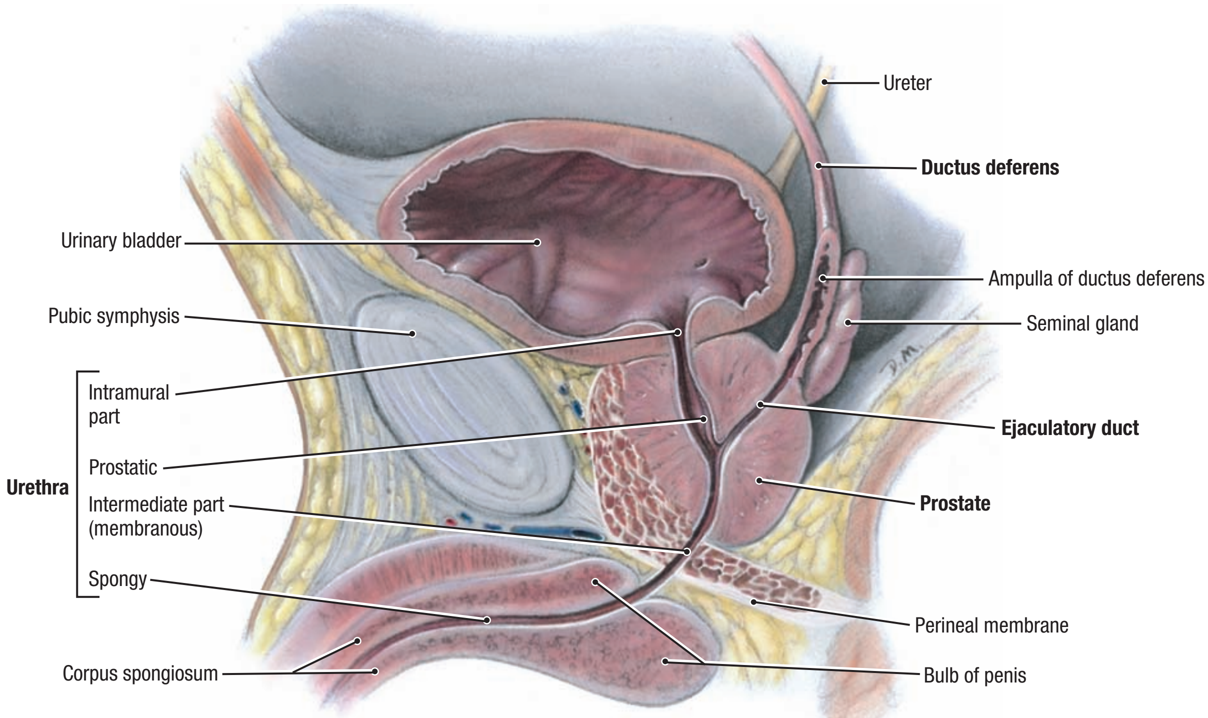
- The sigmoid colon begins at the left pelvic brim and becomes the rectum anterior to the third sacral segment in the midline.
- The superior hypogastric plexus lies inferior to the bifurcation of the aorta and anterior to the left common iliac vein.
- The ureter adheres to the external aspect of the peritoneum, crosses the external iliac vessels, and descends anterior to the internal iliac artery. The ductus deferens and its artery also adhere to the peritoneum, cross the external iliac vessels, and then hook around the inferior epigastric artery to join the other components of the spermatic cord.
- The genitofemoral nerve lies on the psoas.



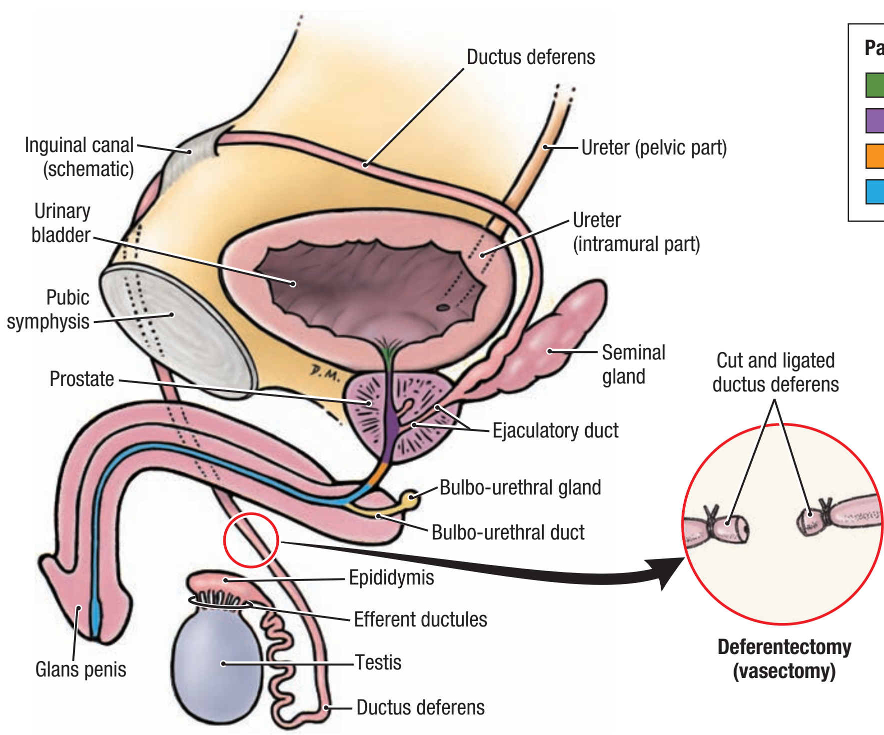
Median Section of Pelvis, Stepped Dissection of Testis

3.21 MALE PELVIC ORGANS AND EXTERNAL GENITALIA

- Pelvic viscera are subperitoneal, mostly embedded in a matrix of fatty endopelvic fascia.

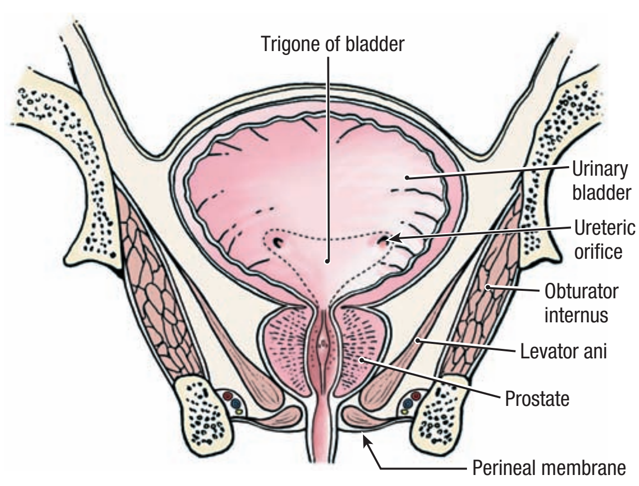


A. **Median Section**



Parts of male urethra in B:
- Intramural (preprostatic)
- Prostatic
- Intermediate (membranous)
- Spongy (penile)

B. **Schematic Median Section**

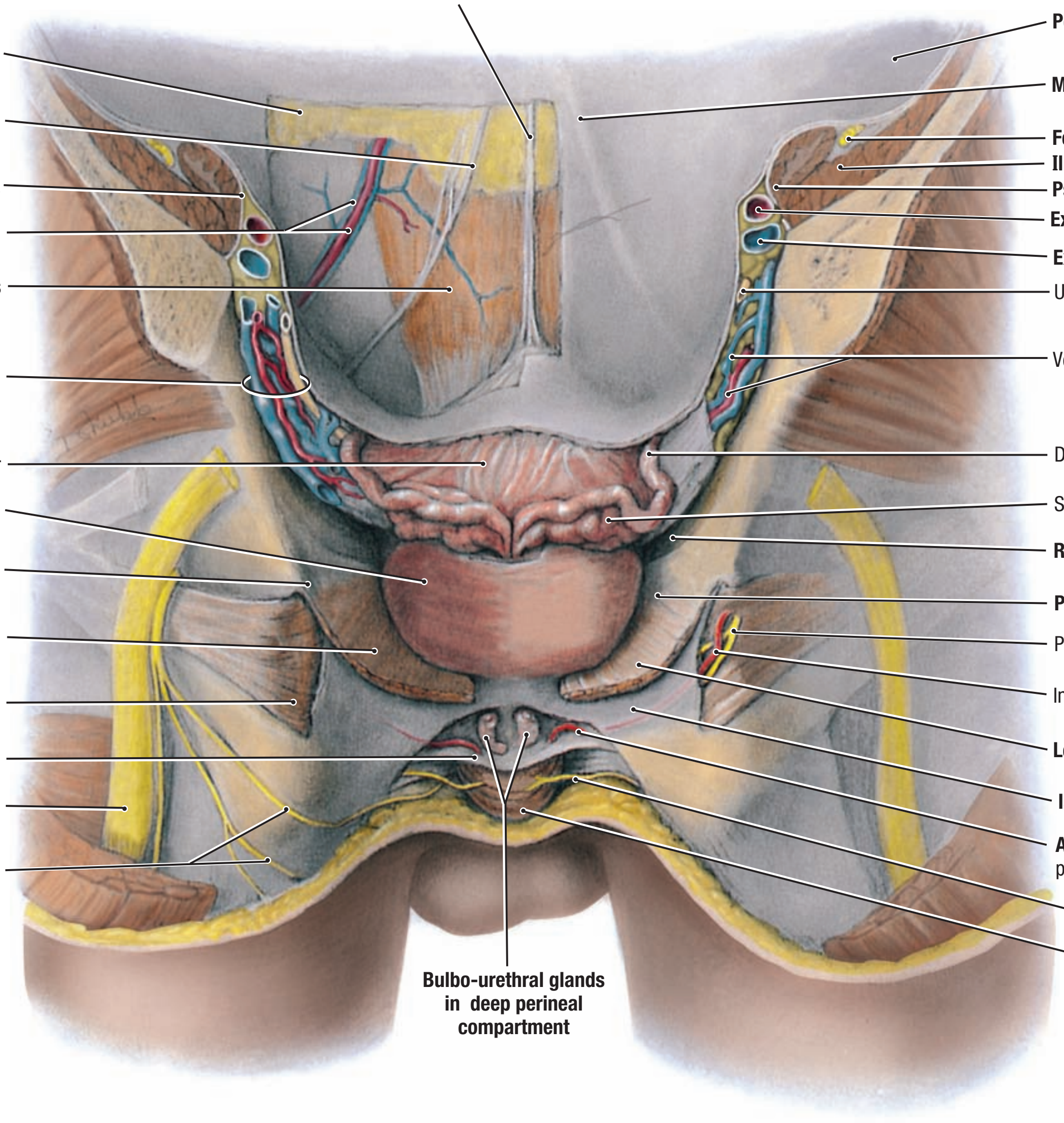


C. **Coronal Section**

3.22 URINARY BLADDER, PROSTATE, AND DUCTUS DEFERENS

A. Dissection. The ejaculatory duct (~2 cm in length) is formed by the union of the ductus deferens and duct of the seminal gland; it passes anteriorly and inferiorly through the substance of the prostate to enter the prostatic urethra on the seminal colliculus. **B.** Overview of urogenital system, schematic illustration. **C.** Coronal section through urinary bladder, prostate, and proximal urethra.

The common method of sterilizing males is a **deferentectomy**, popularly called **vasectomy**. During this procedure, part of the ductus deferens is ligated and/or excised through an incision in the superior part of the scrotum. Hence, the subsequent ejaculated fluid contains no sperms.

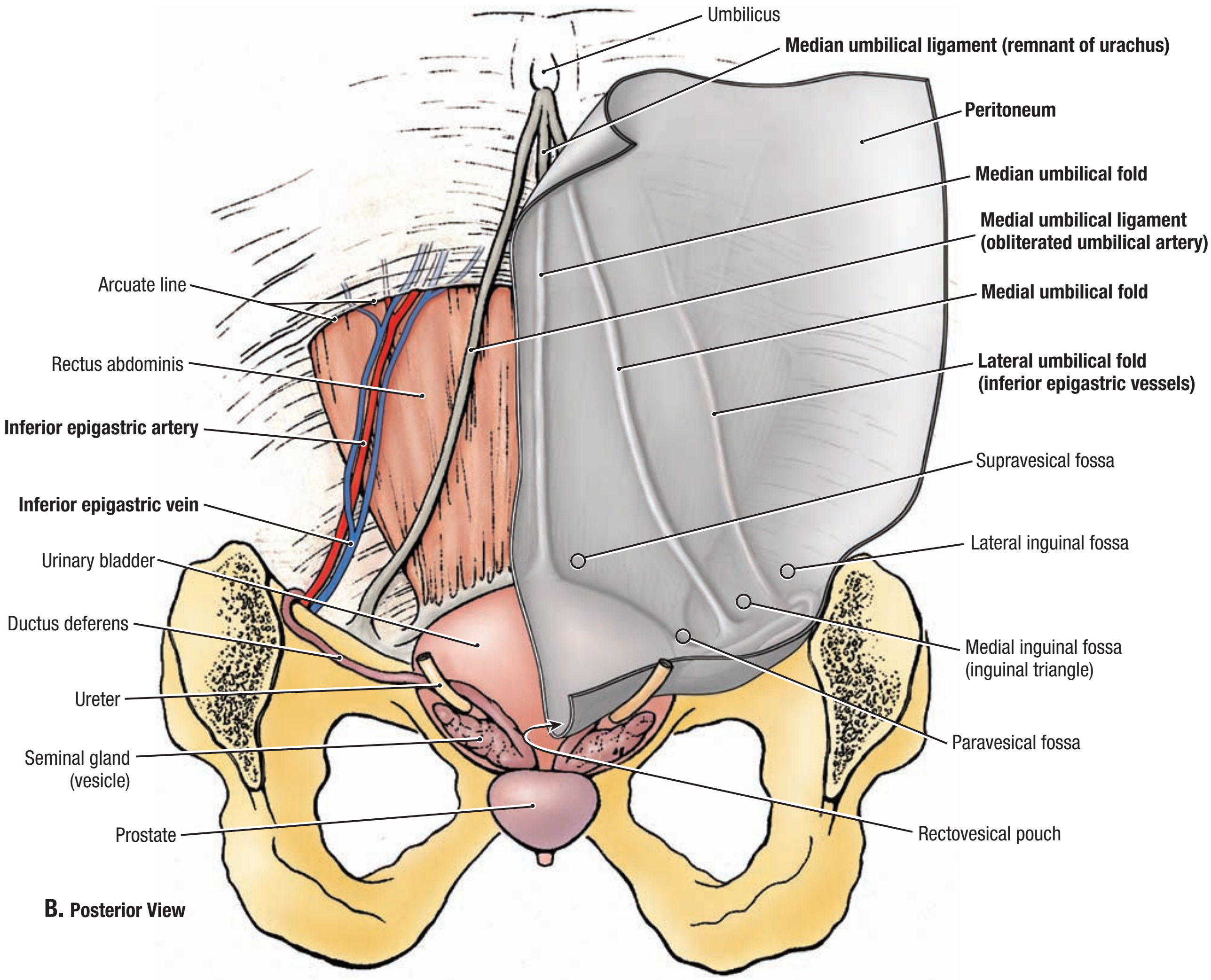


A. Posterior View

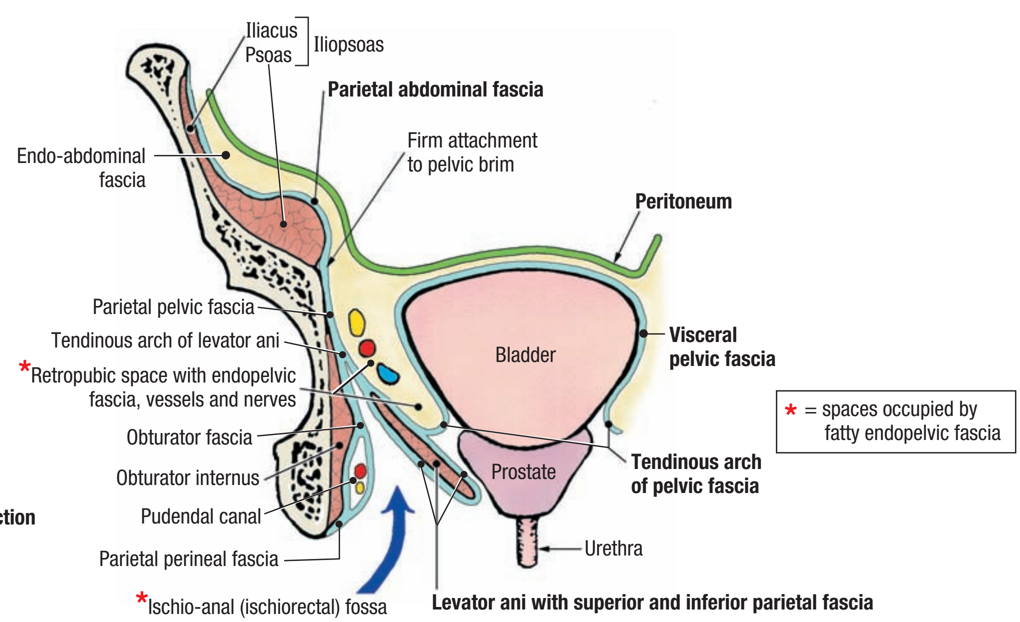
3.23 POSTERIOR APPROACH TO ANTERIOR PELVIC AND PERINEAL STRUCTURES AND SPACES

A. Dissection. The rectovesical septum and all pelvic and perineal structures posterior to it have been removed. **B.** Posterior surface of inferior part of anterior abdominal wall with umbilical folds and ligaments and anterior pelvic viscera. **C.** Schematic coronal section through the anterior pelvis (plane of urinary bladder and prostate) demonstrating pelvic fascia.

- In **A** and **B**, the inferior epigastric artery and accompanying veins enter the rectus sheath, covered posteriorly with peritoneum to form the lateral umbilical fold. The medial umbilical fold is formed by peritoneum overlying the medial umbilical ligament (obliterated umbilical artery), and the median umbilical fold is formed by the median umbilical ligament (urachus).
- In **A**, the femoral nerve lies between the psoas and iliacus muscles, covered on their internal aspects with psoas (membranous parietal) fascia; the external iliac artery and vein lie within the areolar extraperitoneal fascia.
- The pelvic genito-urinary organs are subperitoneal. Near the bladder, the ureter accompanies a “leash” of internal iliac vessels and derivatives within the fibro-areolar hypogastric sheath.
- The levator ani and its fascial coverings separate the retropubic and paravesical spaces of the pelvis from the ischio-anal fossae of the perineum. The fat that occupies these spaces has been removed.
- The bulbo-urethral glands and the initial part of the artery to the bulb lie superior to the perineal membrane in the deep perineal compartment.

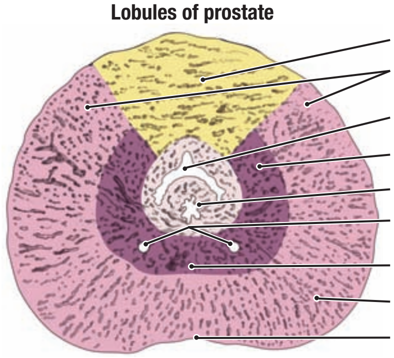


B. **Posterior View**

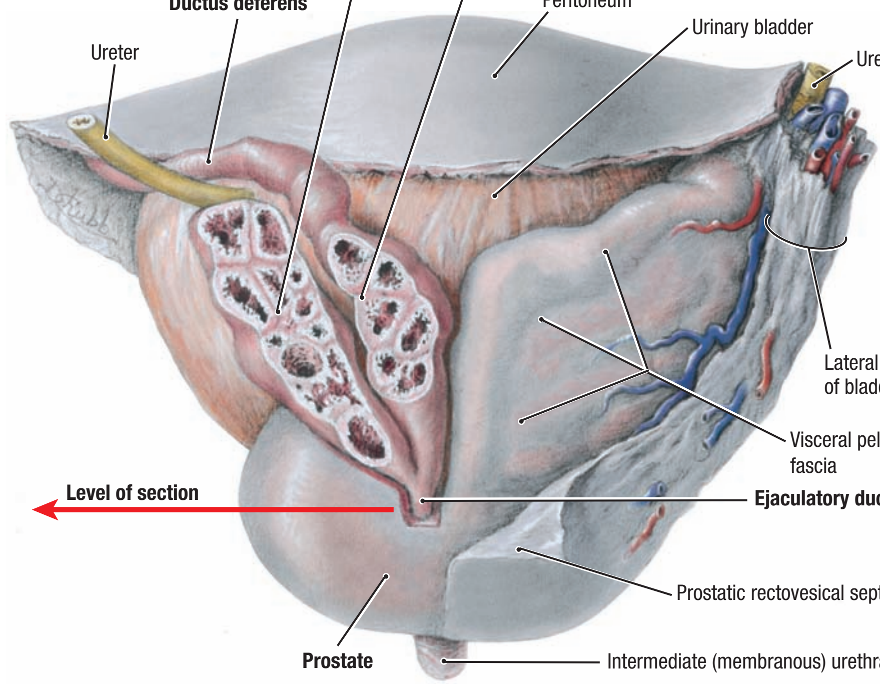


C. **Coronal Section**

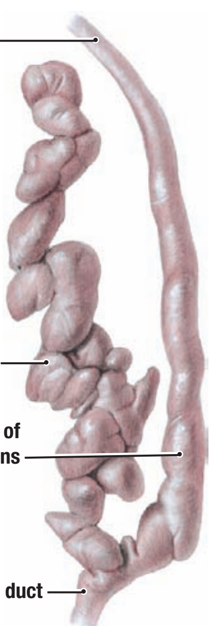
3.23 POSTERIOR APPROACH TO ANTERIOR PELVIC AND PERINEAL STRUCTURES AND SPACES *(CONTINUED)*



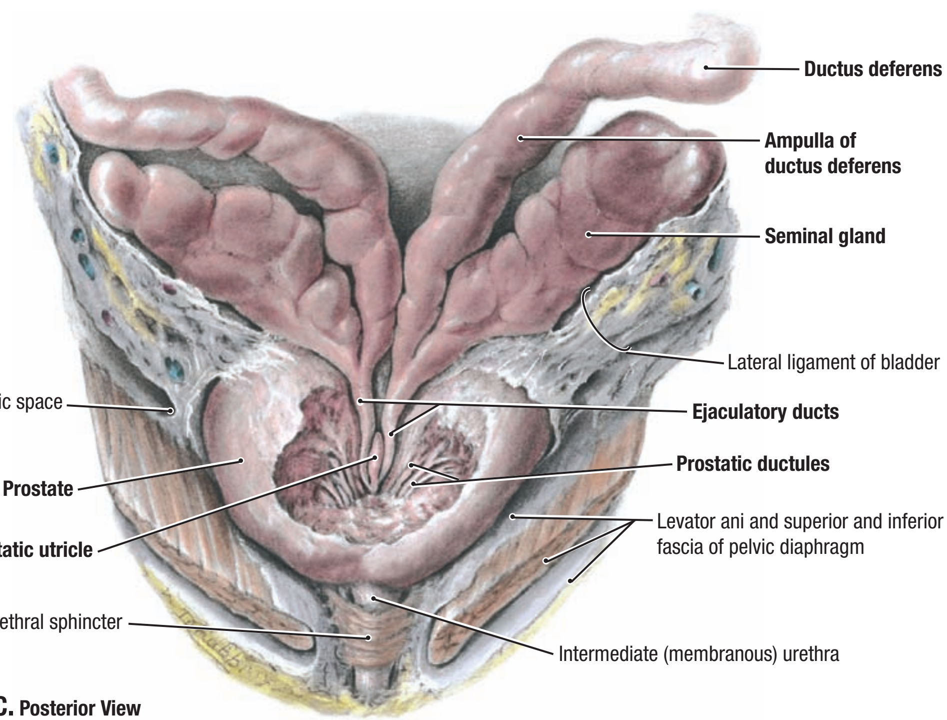
A. Transverse Section



Anterior View



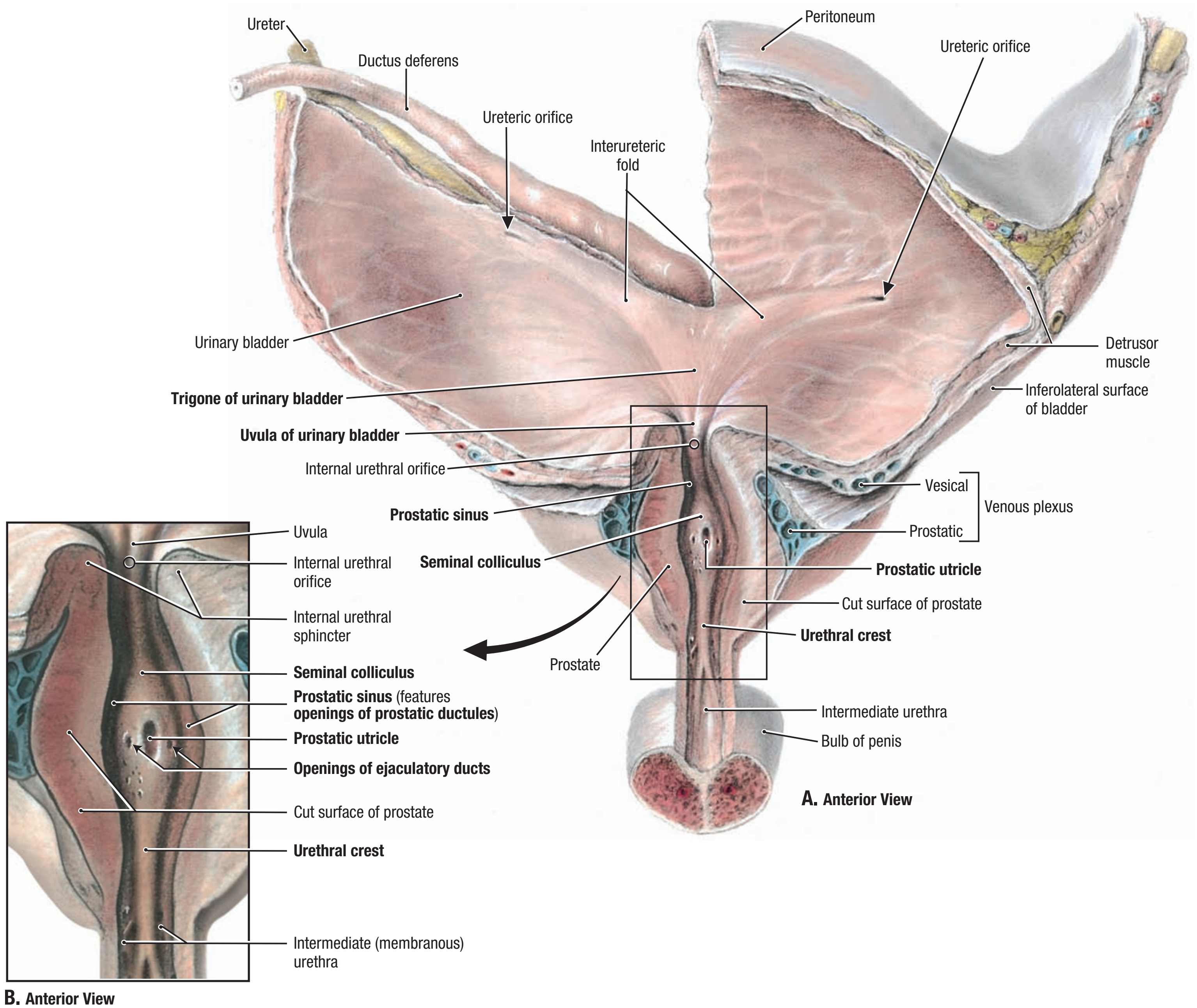
B. Unraveled Seminal Gland (vesicle)



C. Posterior View

3.24 SEMINAL GLANDS AND PROSTATE

A. Bladder, ductus deferens, seminal glands (vesicles), and lobules of prostate. The left seminal gland and ampulla of the ductus deferens are dissected and opened; part of the prostate is cut away to expose the ejaculatory duct. **B.** Seminal gland unraveled. The gland is a tortuous tube with numerous dilatations. The ampulla of the ductus deferens has similar dilatations. **C.** Prostate, dissected posteriorly. The ejaculatory duct (~2 cm in length) is formed by the union of the ductus deferens and the duct of the seminal gland; it passes anteriorly and inferiorly through the substance of the prostate to enter the prostatic urethra on the seminal colliculus. The prostatic utricle lies between the ends of the two ejaculatory ducts. The prostatic ductules mostly open onto the prostatic sinus.



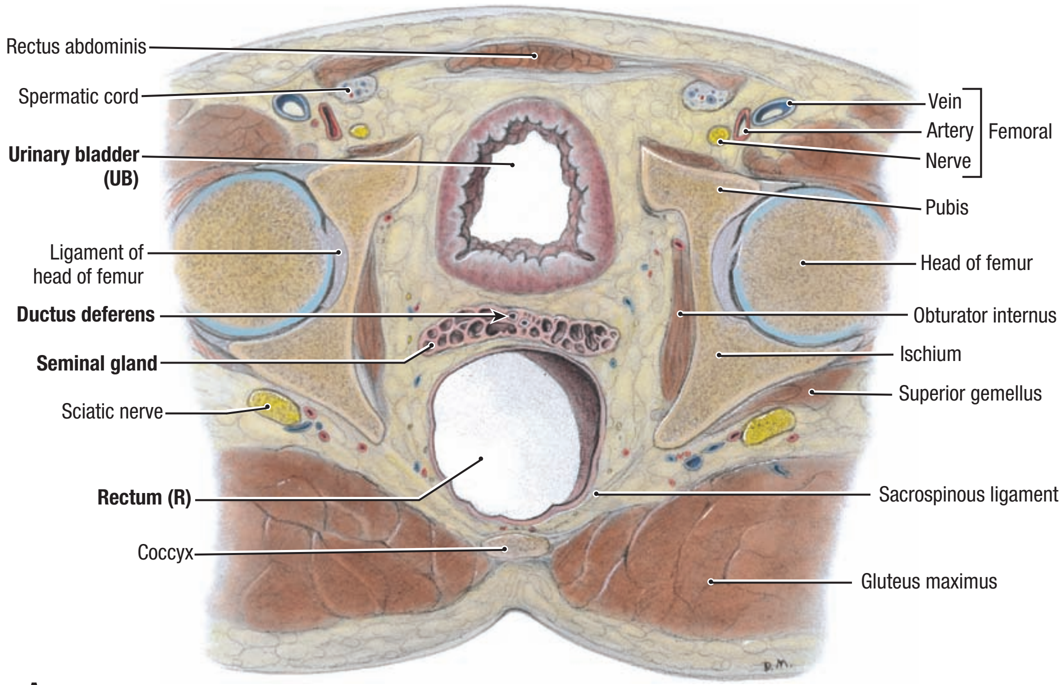
3.25 INTERIOR OF MALE URINARY BLADDER AND PROSTATIC URETHRA

A. Dissection. The anterior walls of the bladder, prostate, and urethra were cut away. **B.** Features of the prostatic urethra.

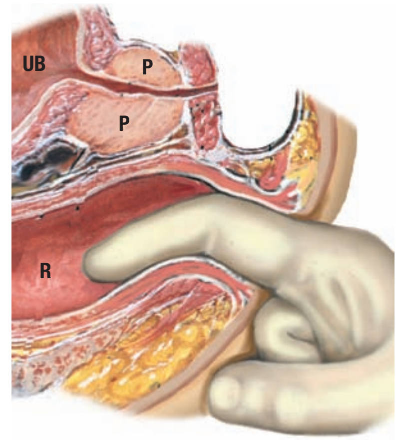
- The mucous membrane is smooth over the trigone of the urinary bladder (triangular region demarcated by ureteric and internal urethral orifices) but folded elsewhere, especially when the bladder is empty.
- The opening of the vestigial prostatic utricle is in the seminal colliculus on the urethral crest; there is an orifice of an ejaculatory duct on each side of the prostatic utricle. The prostatic fascia encloses a venous plexus.

The prostate is of considerable medical interest because enlargement or **benign hypertrophy of the prostate (BHP)** is common after middle age, affecting virtually every male who lives long enough. An enlarged prostate projects into the urinary bladder and impedes urination by distorting the prostatic urethra. The middle lobule usually enlarges the most and obstructs the internal urethral orifice. The more the person strains, the more the valvelike prostatic mass occludes the urethra.

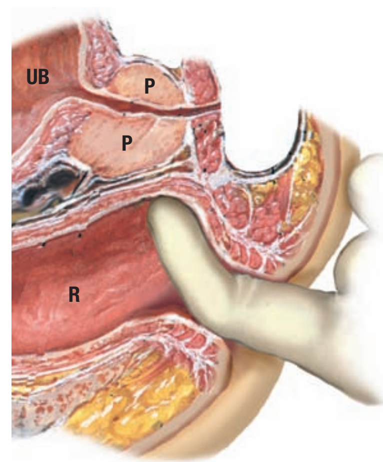
BHP is a common cause of urethral obstruction, leading to **nocturia** (needing to void during the night), **dysuria** (difficulty and/or pain during urination), and **urgency** (sudden desire to void). BHP also increases the risk of bladder infections (**cystitis**) as well as kidney damage.



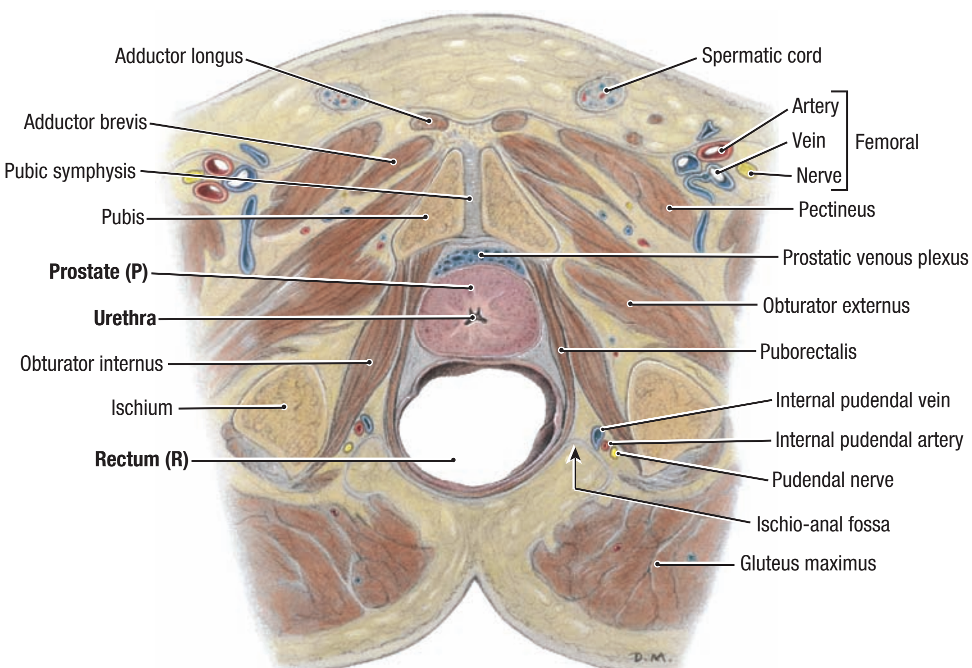
A. **Transverse Section**



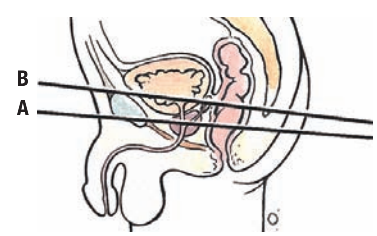
C. **Sagittal Section**



D. **Sagittal Section**

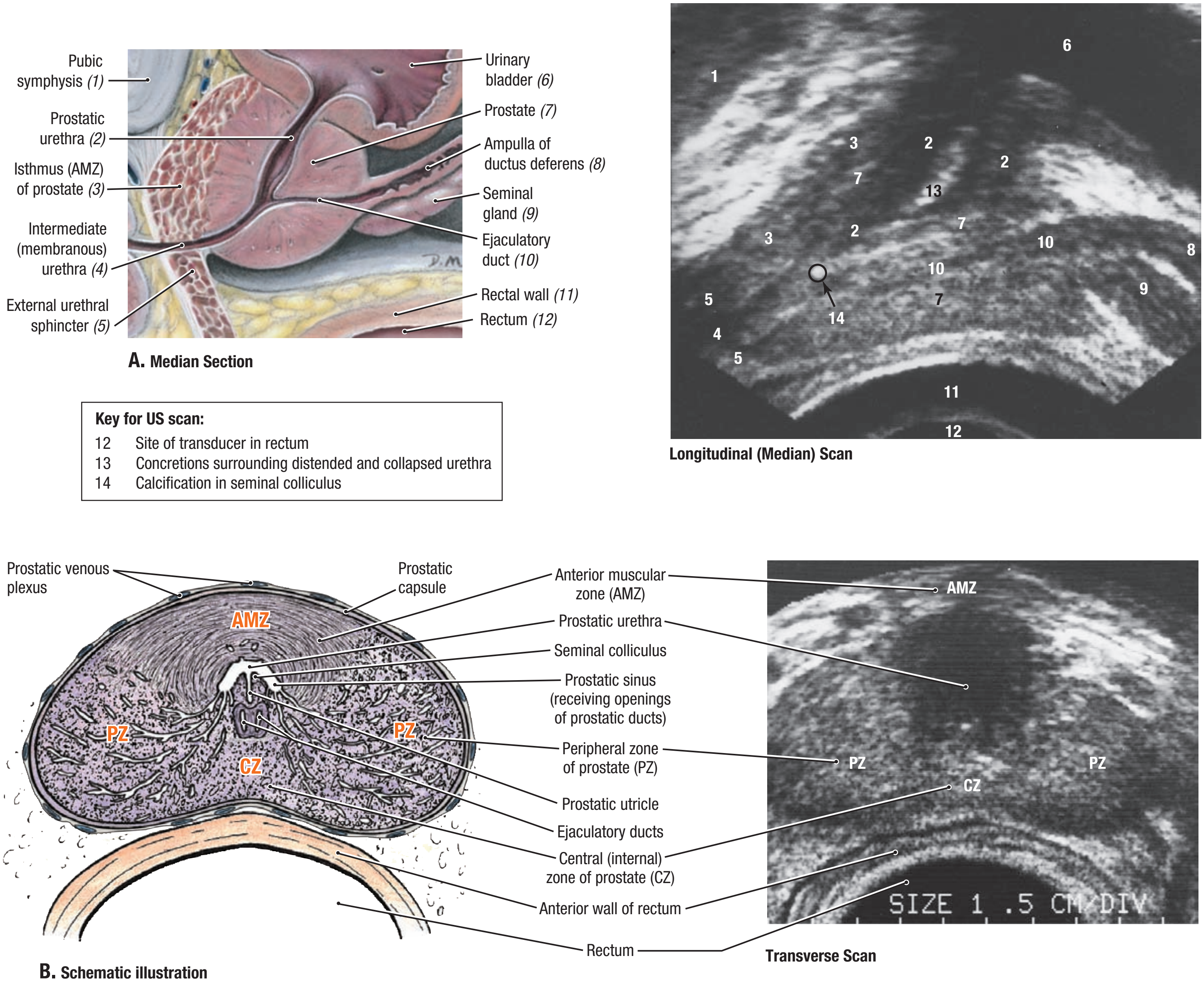


B. **Transverse Section**



3.26 MALE PELVIS, TRANSVERSE SECTIONS

A. Section through prostate and puborectalis. **B.** Section through urinary bladder and seminal gland. **C. and D.** The prostate *(P)* is examined for enlargement and tumors (focal masses or asymmetry) by **digital rectal examination**. A full bladder offers resistance, holding the gland in place and making it more readily palpable. The malignant prostate feels hard and often irregular. (*R*, *rectum)*.

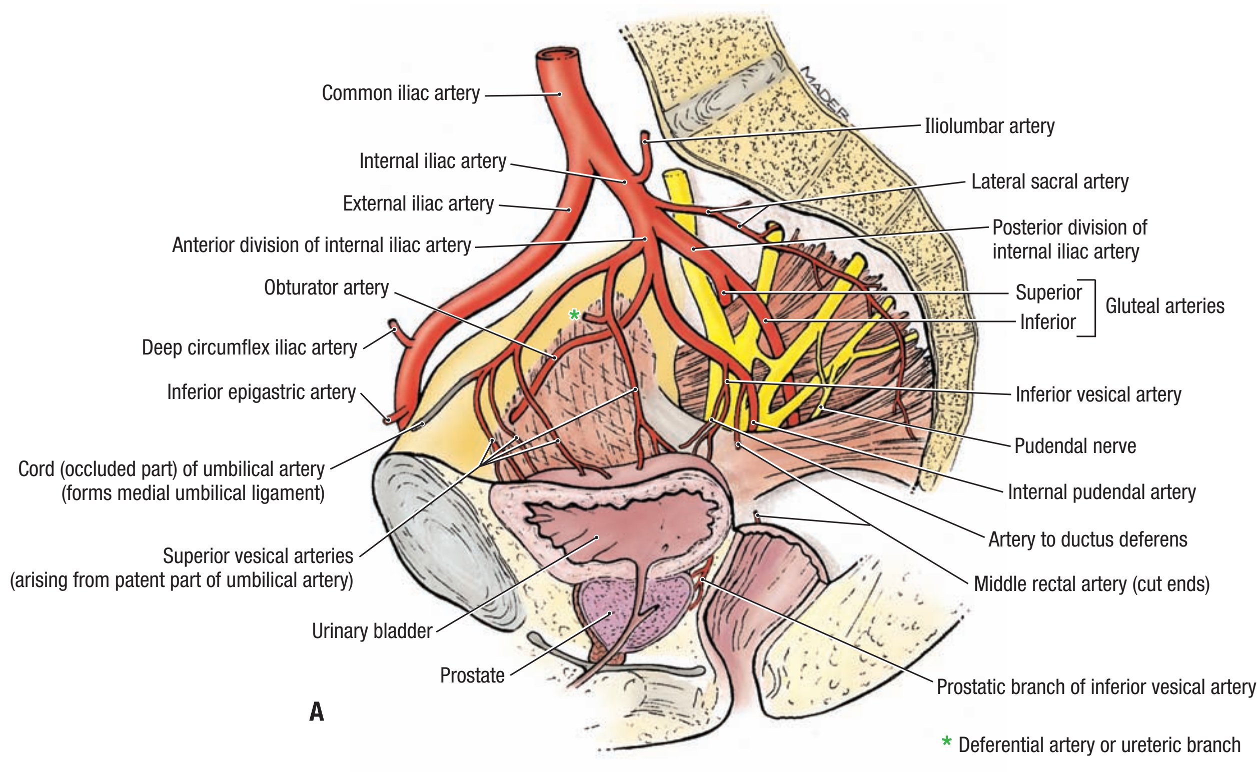


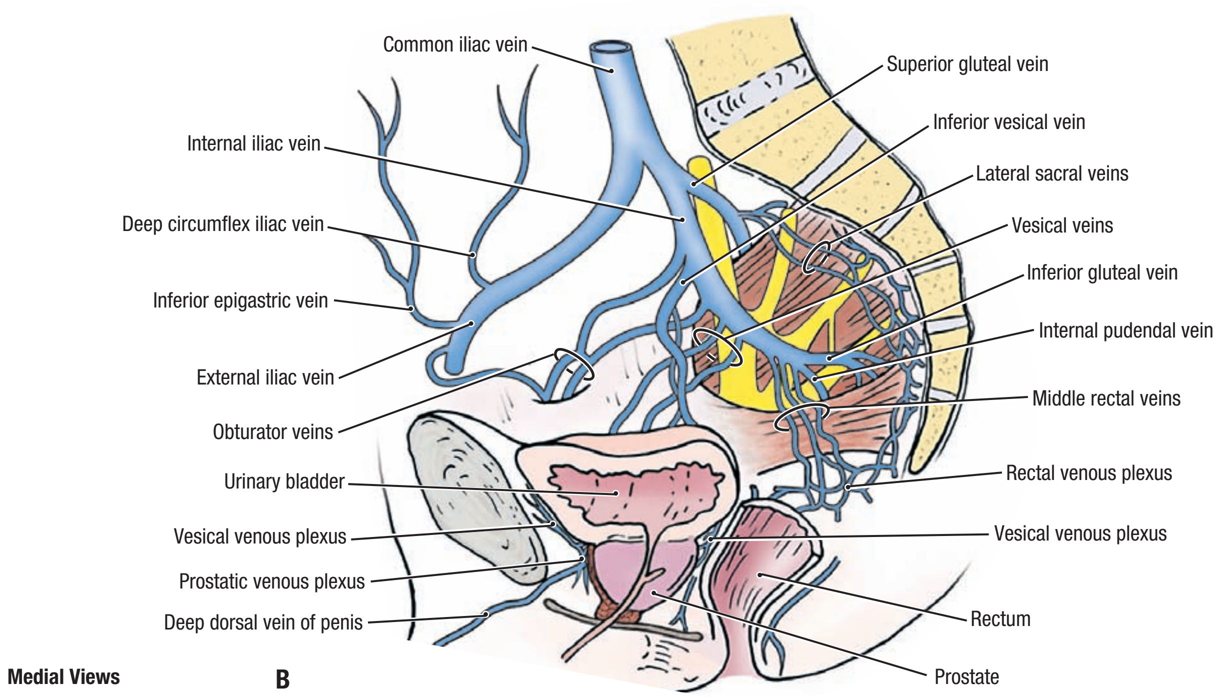
3.27 TRANSRECTAL ULTRASOUND SCANS OF MALE PELVIS

A. Longitudinal scan. **B.** Transverse scan. The probe was inserted into the rectum to scan the anteriorly located prostate. The ducts of the glands in the peripheral zone open into the prostatic sinuses, whereas the ducts of the glands in the central (internal) zone open into the prostatic sinuses and onto the seminal colliculus.

Because of the close relationship of the prostate to the prostatic urethra, obstructions of the urethra may be relieved endoscopically. The instrument is inserted transurethrally through the external urethral orifice and spongy urethra into the prostatic urethra. All or part of the prostate, or just the hypertrophied part, is removed by **transurethral resection of the prostate (TURP)**. In more serious cases, the entire prostate is removed along with the seminal glands, ejaculatory ducts, and terminal parts of the deferent ducts **(radical prostatectomy)**.

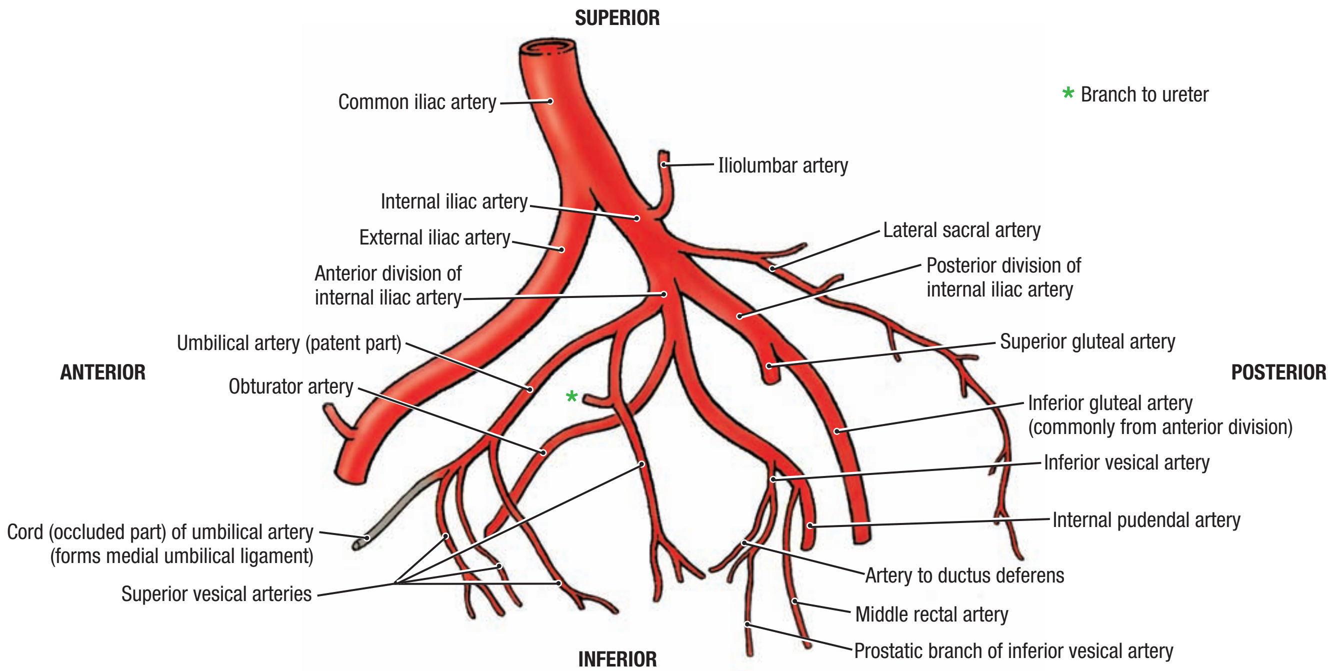
TURP and improved operative techniques (laparoscopic or robotic surgery) attempt to preserve the nerves and blood vessels associated with the capsule of the prostate and adjacent to the seminal vesicles as they pass to and from the penis, increasing the possibility for patients to retain sexual function after surgery, as well as restoring normal urinary control.





3.28 ARTERIES AND VEINS OF MALE PELVIS

A. Arteries. **B.** Pelvic veins and venous plexuses.



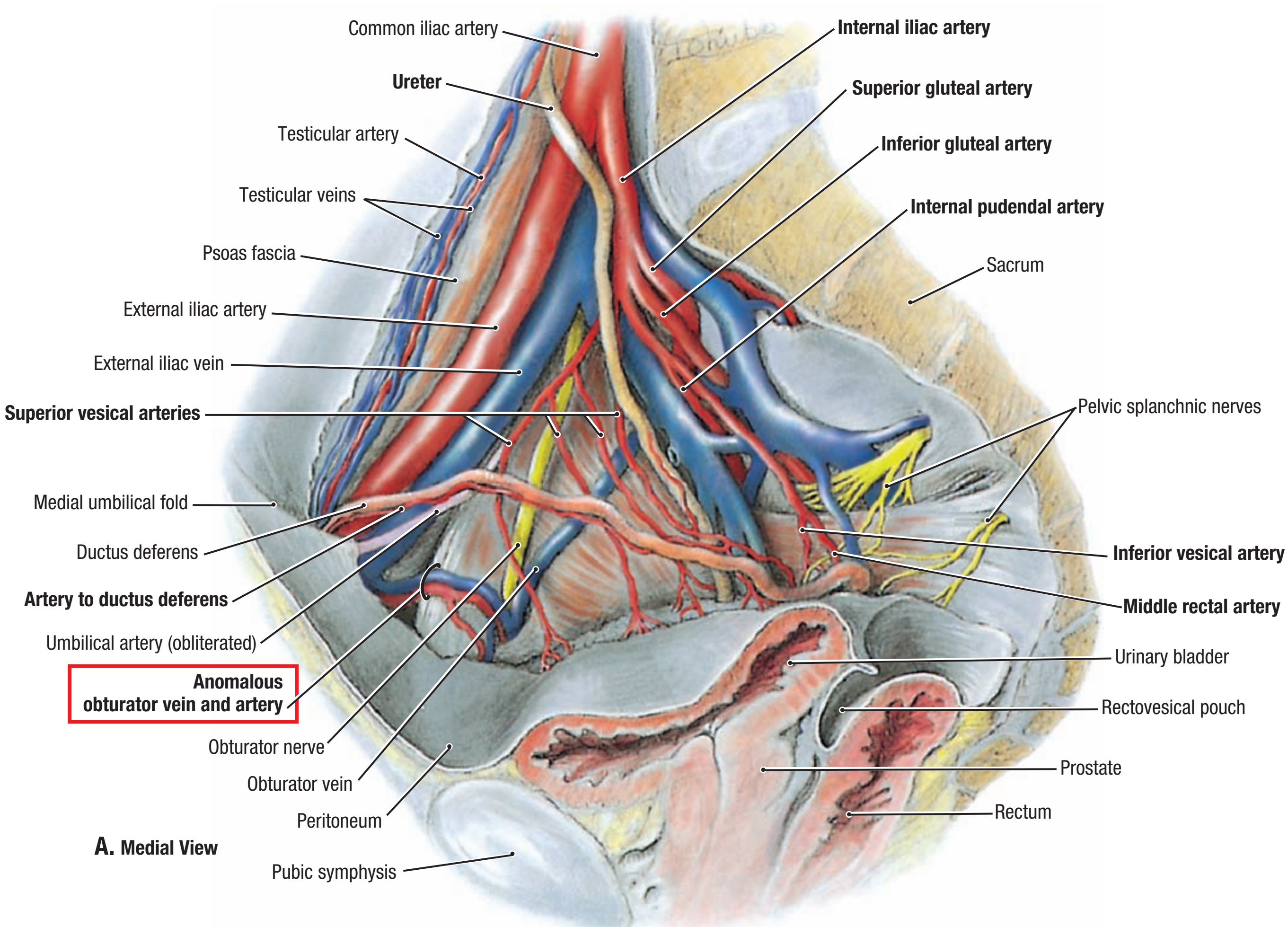
C. **Medial View**

3.28 ARTERIES AND VEINS OF MALE PELVIS *(CONTINUED)*

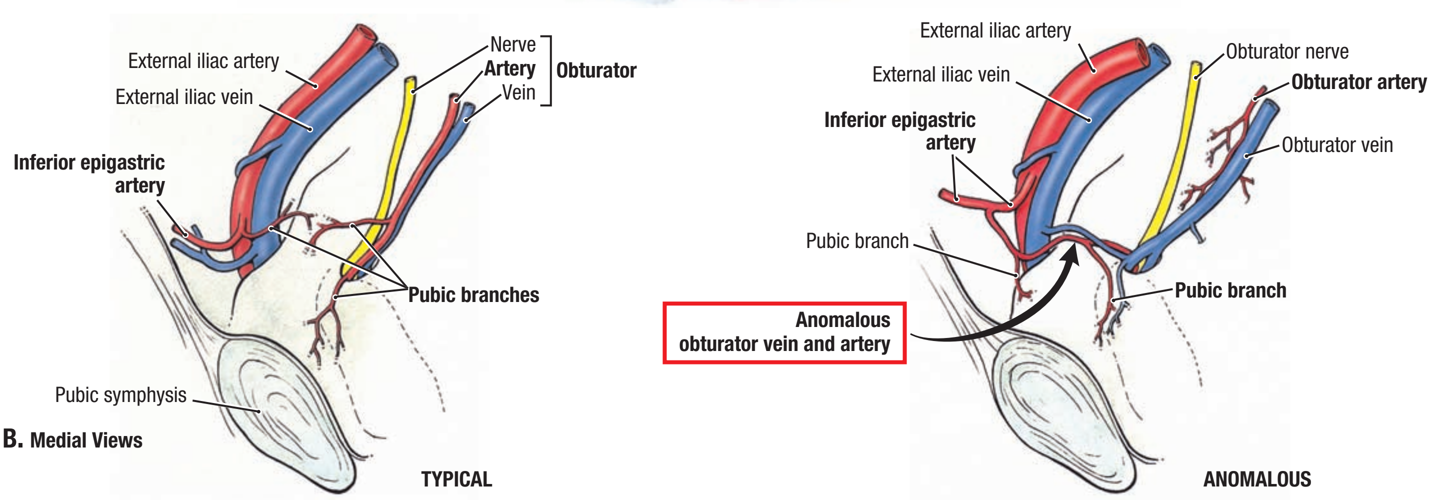
C. Arteries, isolated from **A.**

TABLE 3.4 ARTERIES OF MALE PELVIS

Artery	Origin	Course	Distribution
Internal iliac	Common iliac artery	Passes medially over pelvic brim and descends into pelvic cavity; often forms anterior and posterior divisions	Main blood supply to pelvic organs, gluteal muscles, and perineum
Anterior division of internal iliac artery	Internal iliac artery	Passes laterally along lateral wall of pelvis, dividing into visceral, obturator, and internal pudendal arteries	Pelvic viscera, perineum, and muscles of superior medial thigh
Umbilical	Anterior division of internal iliac artery	Short pelvic course; gives off superior vesical arteries, then obliterates, becoming medial umbilical ligament	Urinary bladder and, in some males, ductus deferens
Superior vesical	Patent part of umbilical artery	Usually multiple; pass to superior aspect of urinary bladder	Superior aspect of urinary bladder and distal ureter
Artery to ductus deferens	Superior or inferior vesical artery	Runs subperitoneally to ductus deferens	Ductus deferens
Obturator	Anterior division of internal iliac artery	Runs antero-inferiorly on lateral pelvic wall	Pelvic muscles, nutrient artery to head of femur and medial compartment of thigh
Inferior vesical		Passes subperitoneally giving rise to prostatic artery and occasionally the artery to the ductus deferens	Inferior aspect of urinary bladder, pelvic ureter, seminal glands, and prostate
Middle rectal		Descends in pelvis to rectum	Seminal glands, prostate, and inferior part of rectum
Internal pudendal		Exits pelvis through greater sciatic foramen and enters perineum via lesser sciatic foramen	Main artery to perineum, including muscles and skin of anal and urogenital triangles; erectile bodies
Posterior division of internal iliac artery	Internal iliac artery	Passes posteriorly and gives rise to parietal branches	Pelvic wall and gluteal region iliac artery
Iliolumbar	Posterior division of internal iliac artery	Ascends anterior to sacro-iliac joint and posterior to common iliac vessels and psoas major	Iliacus, psoas major, quadratus lumborum muscles, and cauda equina in vertebral canal
Lateral sacral (superior and inferior)		Run on anteromedial aspect of piriformis to send branches into pelvic sacral foramina	Piriformis muscle, structures in sacral canal and erector spinae muscles
Testicular (gonadal) [see Fig. 3.28A]	Abdominal aorta	Descends retroperitoneally; traverses inguinal canal and enters scrotum	Abdominal ureter, testis and epididymis



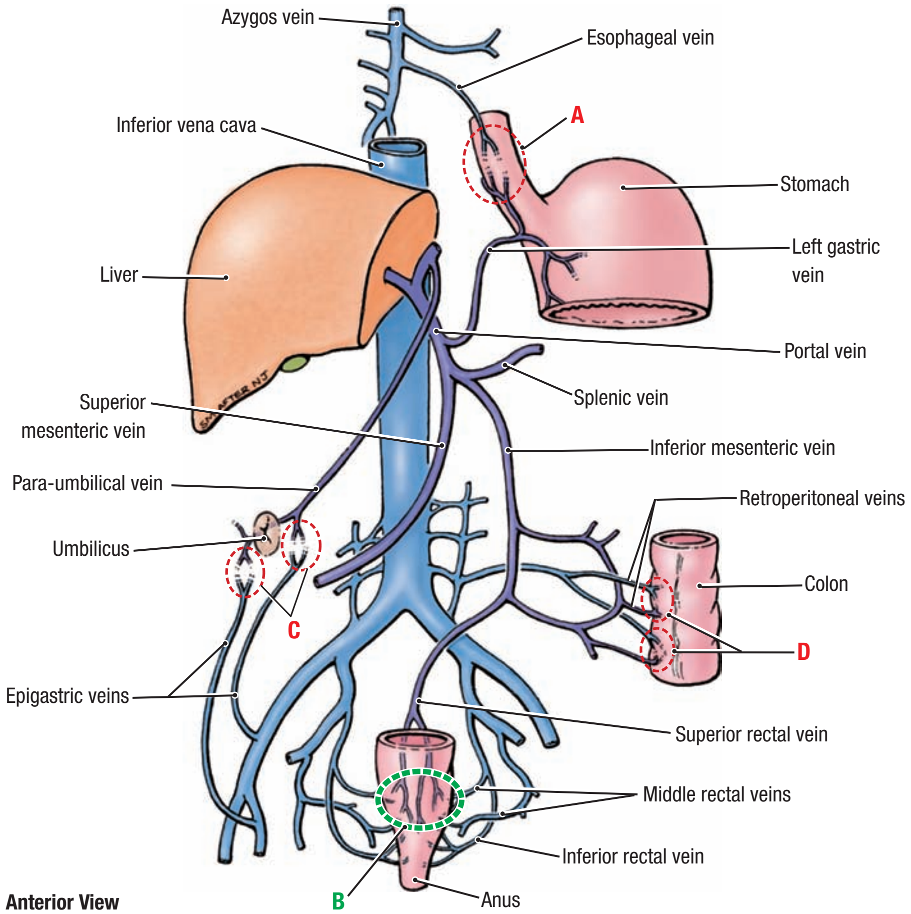
A. **Medial View**

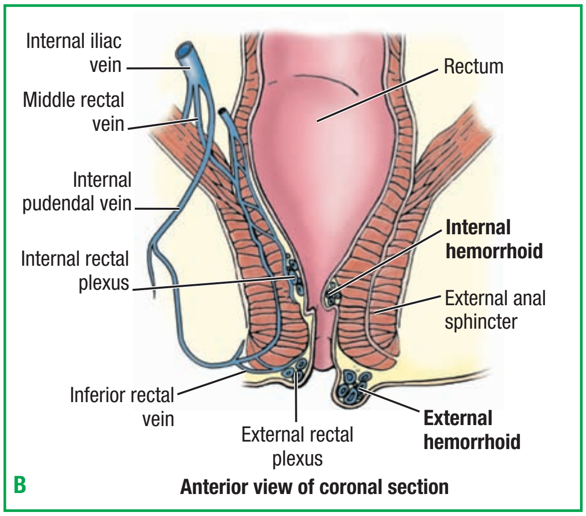


B. **Medial Views**

3.29 PELVIC VESSELS IN SITU; LATERAL PELVIC WALL

A. Dissection. The ureter crosses the external iliac artery at its origin (common iliac bifurcation), and the ductus deferens crosses the external iliac artery at its termination (deep inguinal ring). The ureter crosses the external iliac artery at its origin (common iliac bifurcation), and the ductus deferens crosses the external iliac artery at its termination (deep inguinal ring). In this speciman, an anomalous (replaced) obturator artery branches from the inferior epigastric artery. **B.** Typical and anomalous obturator arteries.





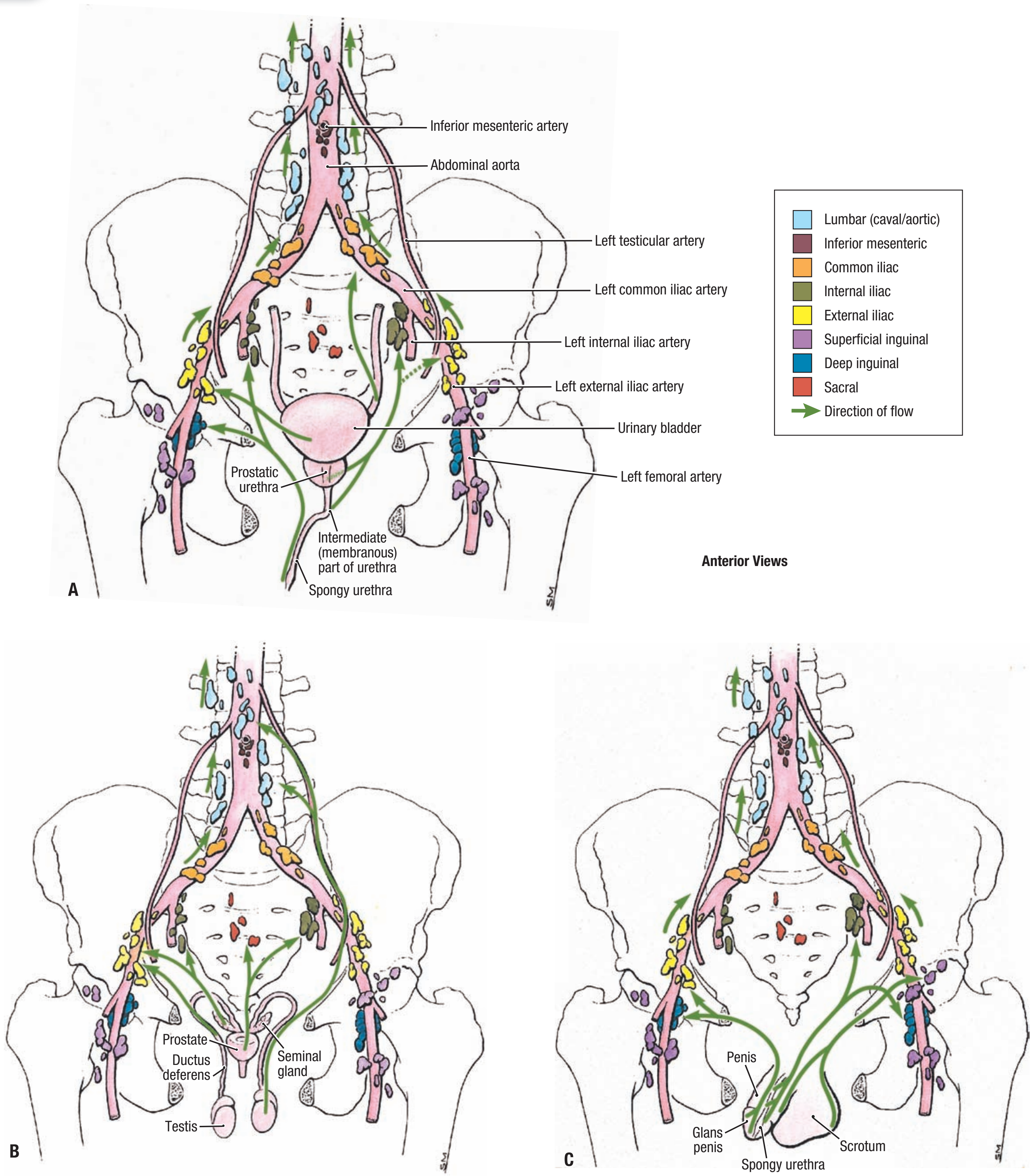
3.30 PORTAL–SYSTEMIC (PORTACAVAL) ANASTOMOSES

A. The portal tributaries are *purple,* and systemic tributaries are *blue. A–D* indicate sites of portal–systemic anastomoses. *A,* between portal and systemic esophageal veins; *B,* between portal and systemic rectal veins; *C,* para-umbilical veins (portal) anastomosing with small epigastric veins of the anterior abdominal wall (systemic); *D,* twigs of colic veins (portal) anastomosing with retroperitoneal veins (systemic).

B. Hemorrhoids. Internal hemorrhoids (piles) are prolapses of rectal mucosa containing the normally dilated veins of the internal rectal venous plexus. Internal hemorrhoids are thought to result from a breakdown of the muscularis mucosae, a smooth muscle layer deep to the mucosa. Internal hemorrhoids that prolapse through the anal canal are often compressed by the contracted sphincters, impeding blood flow. As a result, they tend to strangulate and ulcerate. Because of the presence of abundant arteriovenous anastomoses, bleeding from internal hemorrhoids is characteristically bright red. The current practice is to treat only prolapsed, ulcerated internal hemorrhoids.

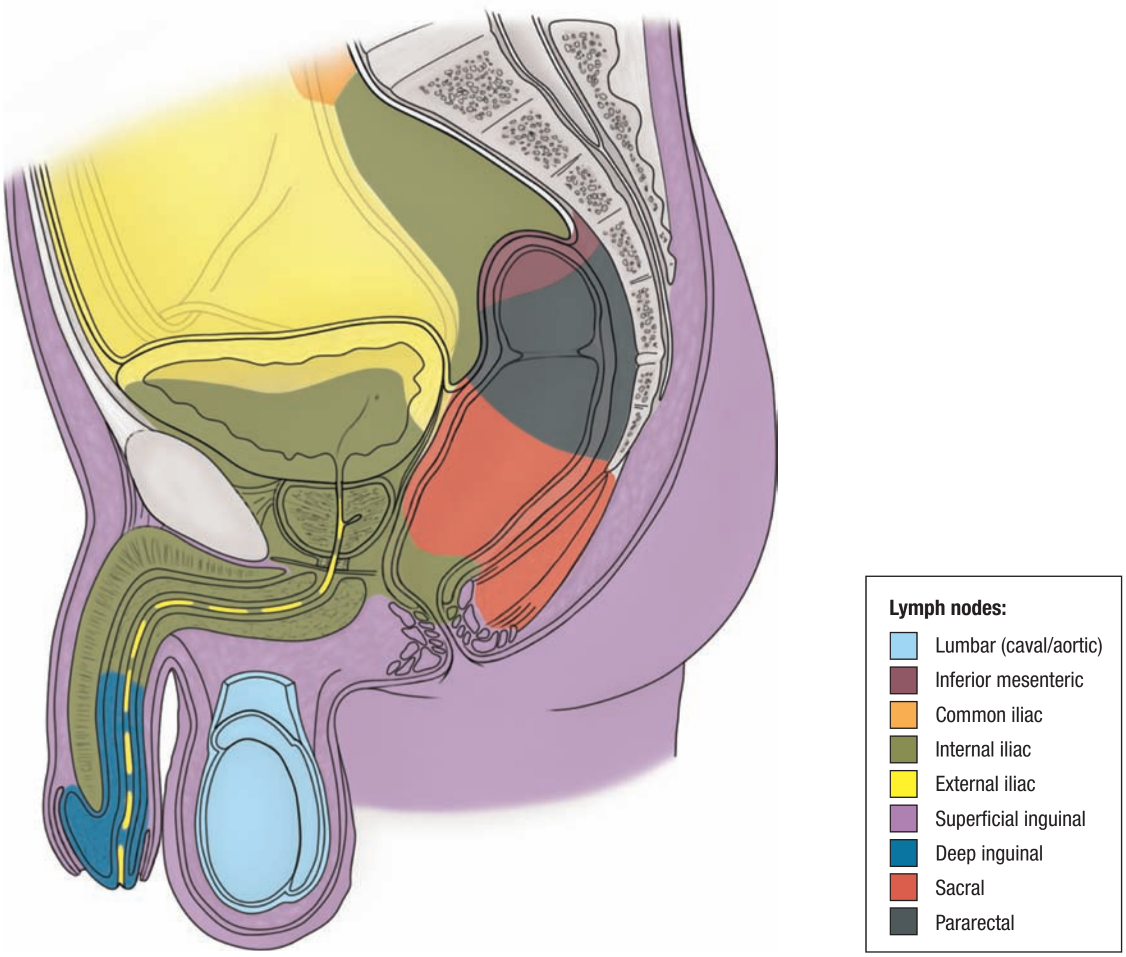
External hemorrhoids are thromboses (blood clots) in the veins of the external rectal venous plexus and are covered by skin. Predisposing factors for hemorrhoids include pregnancy, chronic constipation, and any disorder that impedes venous return including increased intra-abdominal pressure. The superior rectal vein drains into the inferior mesenteric vein, whereas the middle and inferior rectal veins drain through the systemic system into the inferior vena cava. Any abnormal increase in pressure in the valveless portal system or veins of the trunk may cause enlargement of the superior rectal veins, resulting in an increase in blood flow or stasis in the internal rectal venous plexus. In **portal hypertension** that occurs in relation to *hepatic cirrhosis,* the portacaval anastomosis (e.g., esophageal) may become varicose and rupture. It is important to note, however, that the veins of the rectal plexuses normally appear varicose (dilated and tortuous), even in newborns, and that internal hemorrhoids occur most commonly in the absence of portal hypertension.

Regarding pain from and the treatment of hemorrhoids, it is important to note that the anal canal superior to the pectinate line is visceral; thus, it is innervated by visceral afferent pain fibers, so that an incision or needle insertion into this region is painless. Internal hemorrhoids are not painful and can be treated without anesthesia. Inferior to the pectinate line, the anal canal is somatic, supplied by the inferior anal (rectal) nerves containing somatic sensory fibers. Therefore, it is sensitive to painful stimuli (e.g., to the prick of a hypodermic needle). External hemorrhoids can be painful, but often resolve in a few days.



3.31 LYMPHATIC DRAINAGE OF MALE PELVIS AND PERINEUM

A. Pelvic urinary system. **B.** Internal genital organs. **C.** Penis, spongy urethra, scrotum and testis.



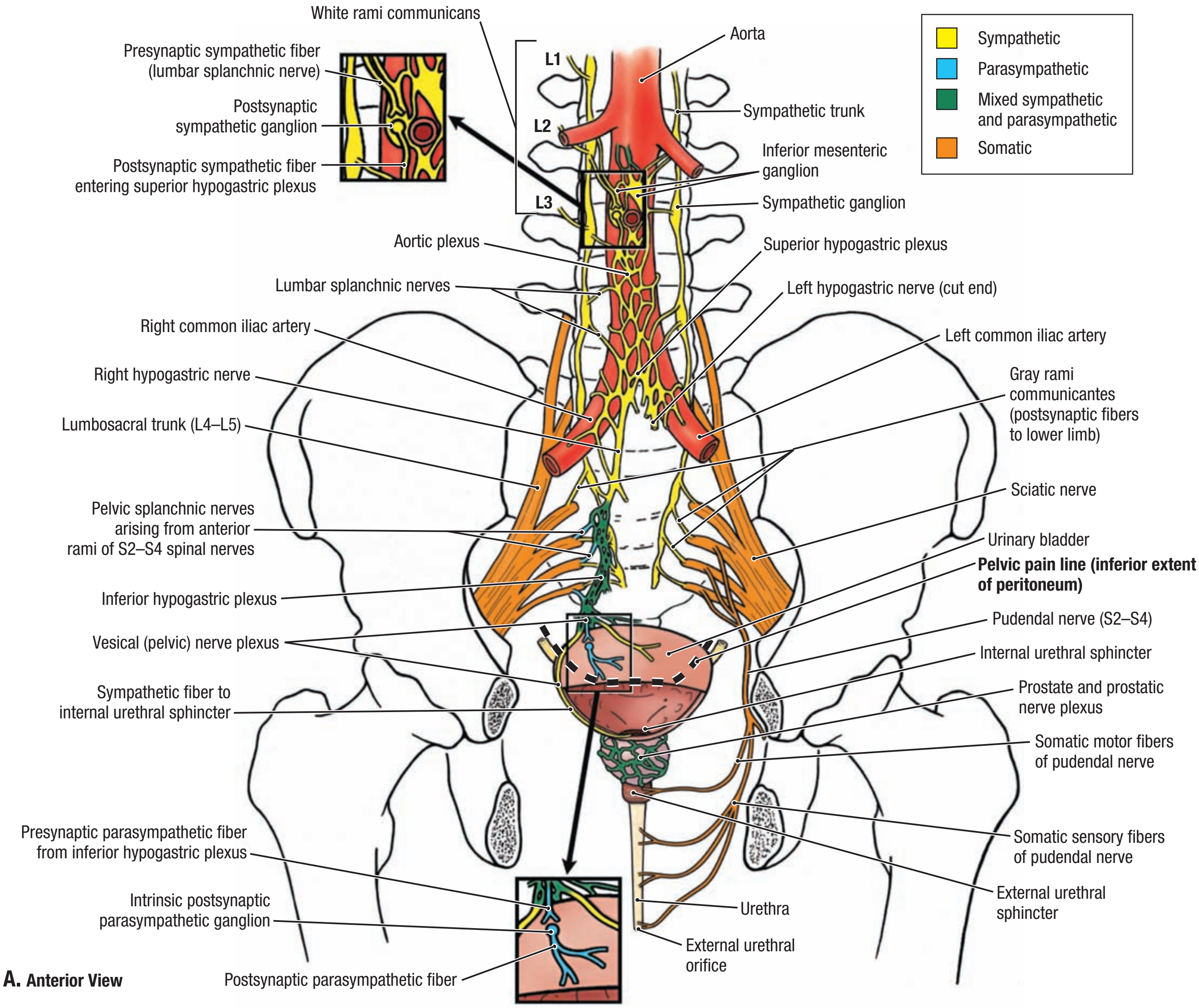
D. Medial View

3.31 LYMPHATIC DRAINAGE OF MALE PELVIS AND PERINEUM *(CONTINUED)*

D. Zones of pelvis and perineum initially draining into specific groups of lymph nodes.

TABLE 3.5 LYMPHATIC DRAINAGE OF MALE PELVIS AND PERINEUM

Lymph Node Group	Structures Typically Draining to Lymph Node Group
Lumbar	Gonads and associated structures (including testicular vessels), urethra, testis, epididymis, common iliac nodes
Inferior mesenteric nodes	Superiormost rectum, sigmoid colon, descending colon, pararectal nodes
Common iliac nodes	External and internal iliac lymph nodes
Internal iliac nodes	Inferior pelvic structures, deep perineal structures, sacral nodes, prostatic urethra, prostate, base of bladder, inferior part of pelvic ureter, inferior part of seminal glands, cavernous bodies, anal canal (above pectinate line), inferior rectum
External iliac nodes	Anterosuperior pelvic structures, deep inguinal nodes, superior aspect of bladder, superior part of pelvic ureter, upper part of seminal gland, pelvic part of ductus deferens, intermediate and spongy urethra
Superficial inguinal nodes	Lower limb, superficial drainage of inferolateral quadrant of trunk, including anterior abdominal wall inferior to umbilicus, gluteal region, superficial perineal structures, skin of perineum including skin and prepuce of penis, scrotum, perianal skin, anal canal inferior to pectinate line
Deep inguinal nodes	Glans of penis, distal spongy urethra, superficial inguinal nodes
Sacral nodes	Posteroinferior pelvic structures, inferior rectum
Pararectal nodes	Superior rectum



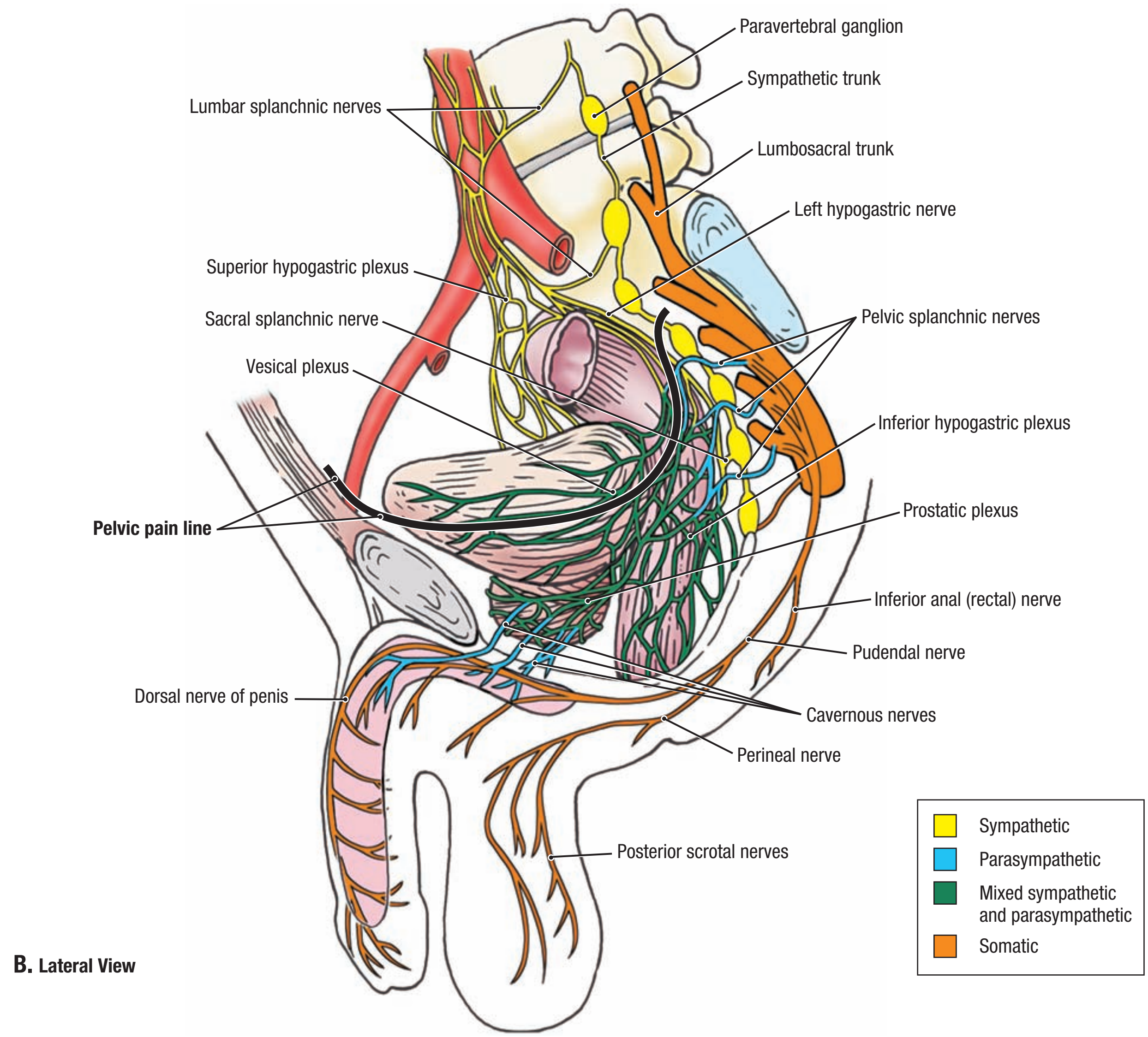
A. **Anterior View**

3.32 INNERVATION OF MALE PELVIS AND PERINEUM

TABLE 3.6 EFFECT OF SYMPATHETIC AND PARASYMPATHETIC STIMULATION ON URINARY TRACT, GENITAL SYSTEM, AND RECTUM

Organ, Tract, or System	Effect of Sympathetic Stimulation	Effect of Parasympathetic Stimulation
Urinary tract	Vasoconstriction of renal vessels slows urine formation; internal sphincter of male bladder contracted to prevent retrograde ejaculation and maintain urinary continence	Inhibits contraction of internal sphincter of bladder in males; contracts detrusor muscle of the bladder wall causing urination
Genital system	Causes ejaculation and vasoconstriction resulting in remission of erection	Produces engorgement (erection) of erectile tissues of the external genitals
Rectum	Maintains tonus of internal anal sphincter; inhibits peristalsis of rectum	Rectal contraction (peristalsis) for defecation; inhibition of contraction of internal anal sphincter

The parasympathetic system is restricted in its distribution to the head, neck, and body cavities (except for erectile tissues of genitalia); otherwise, parasympathetic fibers are never found in the body wall and limbs. Sympathetic fibers, by comparison, are distributed to all vascularized portions of the body.

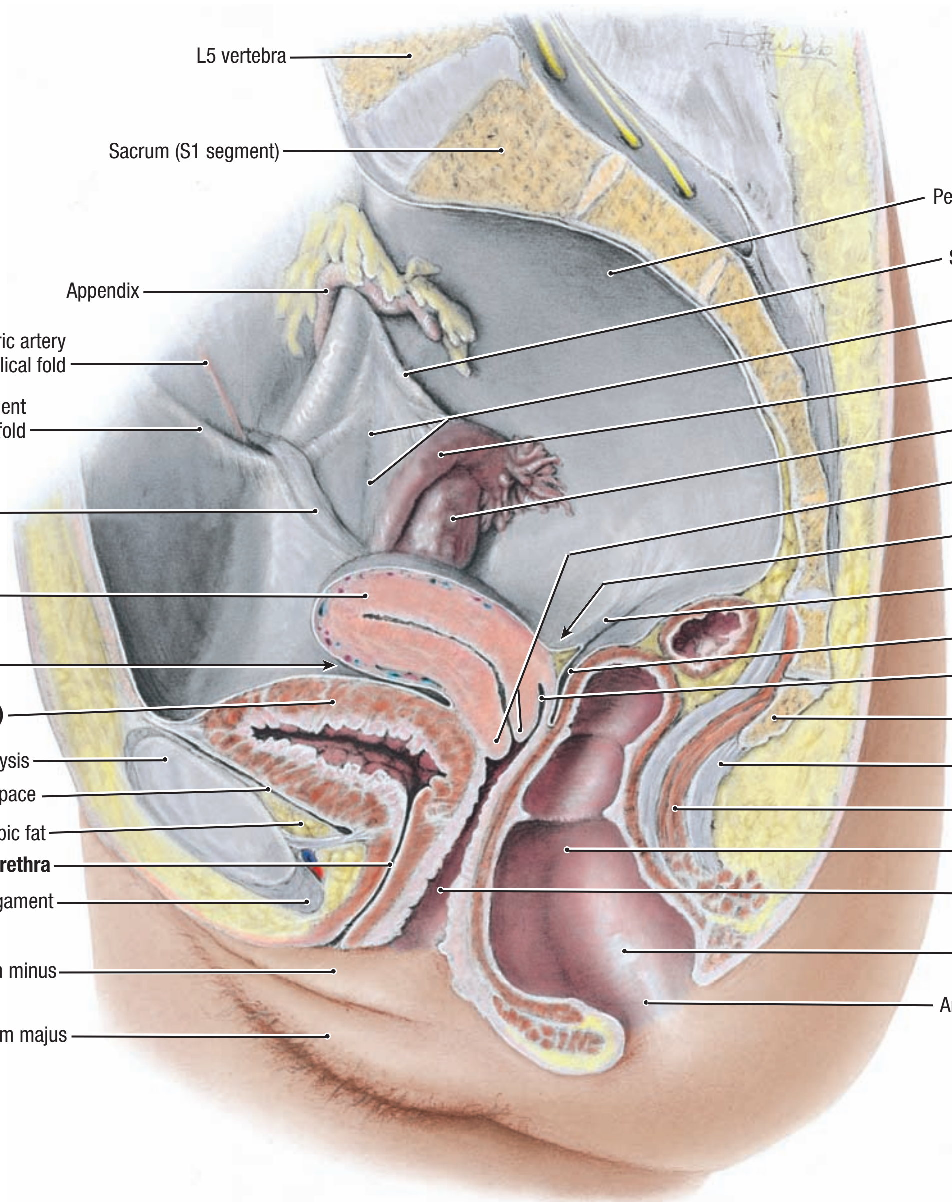


B. **Lateral View**

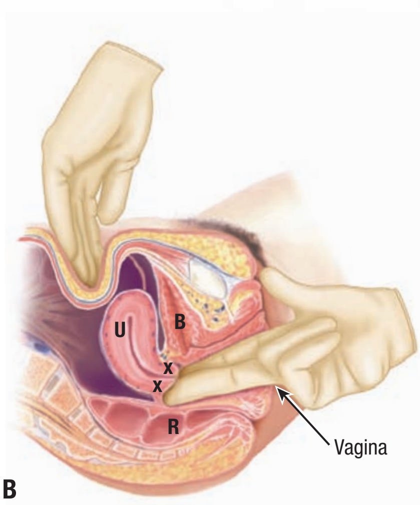
3.32 INNERVATION OF MALE PELVIS AND PERINEUM *(CONTINUED)*

A. Overview. **B.** Innervation of prostate and external genitalia.

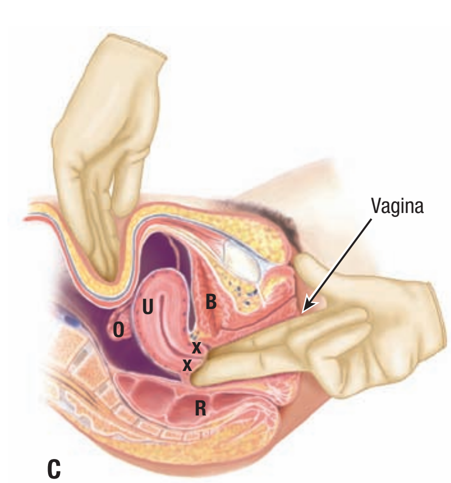
- The primary function of the sacral sympathetic trunks is to provide postsynaptic fibers to the sacral plexus for sympathetic innervation of the lower limb.
- The peri-arterial plexuses of the ovarian, superior rectal, and internal iliac arteries are minor routes by which sympathetic fibers enter the pelvis. Their primary function is vasomotion of the arteries they accompany.
- The hypogastric plexuses (superior and inferior) are networks of sympathetic and visceral afferent nerve fibers.
- The superior hypogastric plexus carries fibers conveyed to and from the aortic (intermesenteric) plexus by the L3 and L4 splanchnic nerves. The superior hypogastric plexus divides into right and left hypogastric nerves that merge with the parasympathetic pelvic splanchnic nerves to form the inferior hypogastric plexuses.
- The fibers of the inferior hypogastric plexuses continue to the pelvic viscera upon which they form pelvic plexuses, e.g., prostatic nerve plexus.
- The pelvic splanchnic nerves convey presynaptic parasympathetic fibers from the S2–S4 spinal cord segments, which make up the sacral outflow of the parasympathetic system.
- Visceral afferents conveying unconscious reflex sensation follow the course of the parasympathetic fibers retrogradely to the spinal sensory ganglia of S2–S4, as do those transmitting pain sensations from the viscera inferior to the pelvic pain line (structures that do not contact the peritoneum plus the distal sigmoid colon and rectum). Visceral afferent fibers conducting pain from structures superior to the pelvic pain line (structures in contact with the peritoneum, except for the distal sigmoid colon and rectum) follow the sympathetic fibers retrogradely to inferior thoracic and superior lumbar spinal ganglia.



A. Medial View

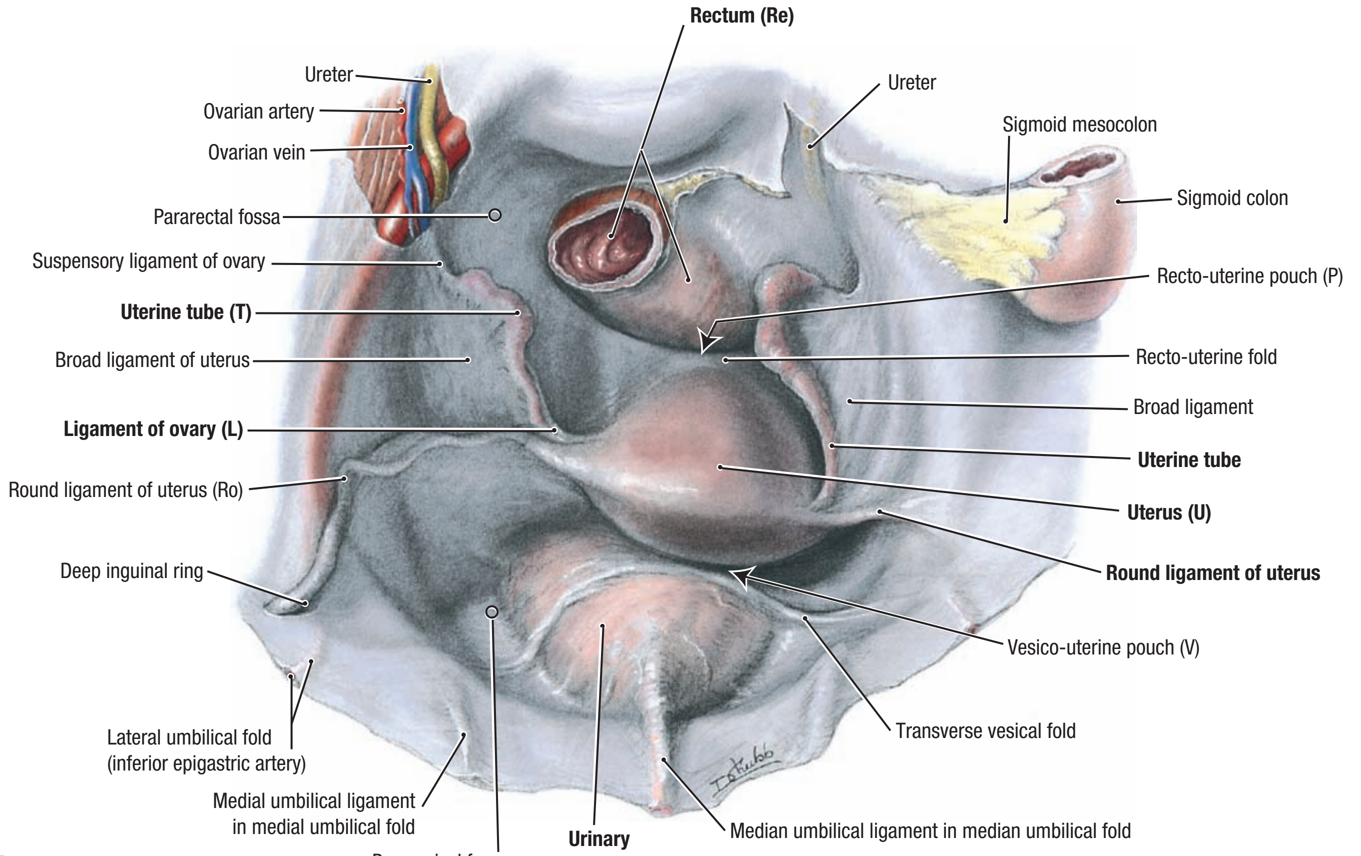


B

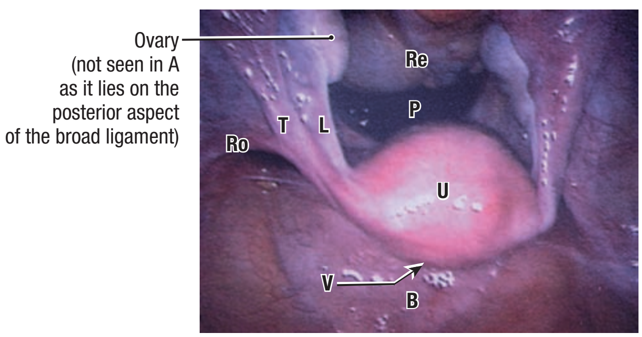


C

3.33 FEMALE PELVIC ORGANS IN SITU



D. Superior View

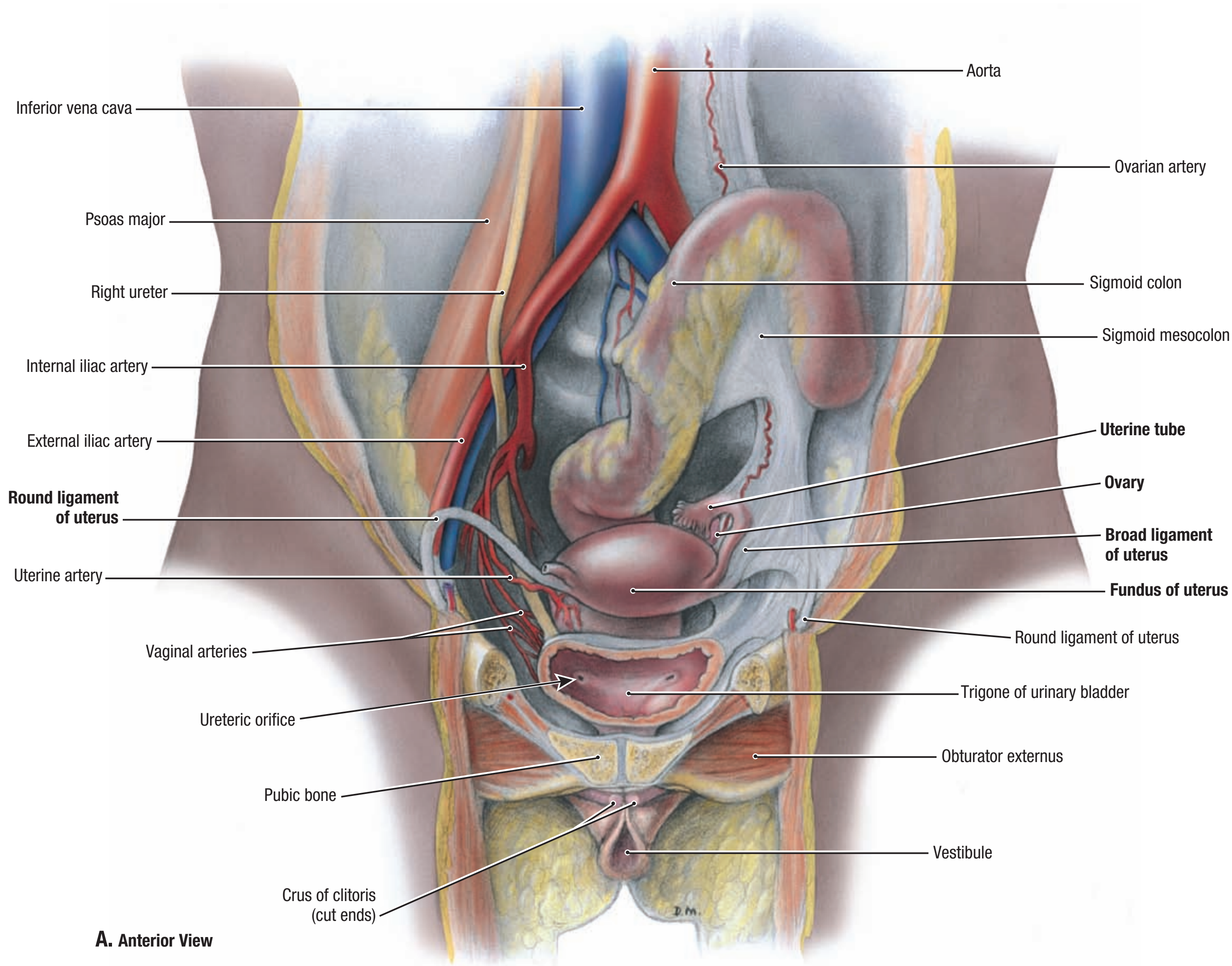


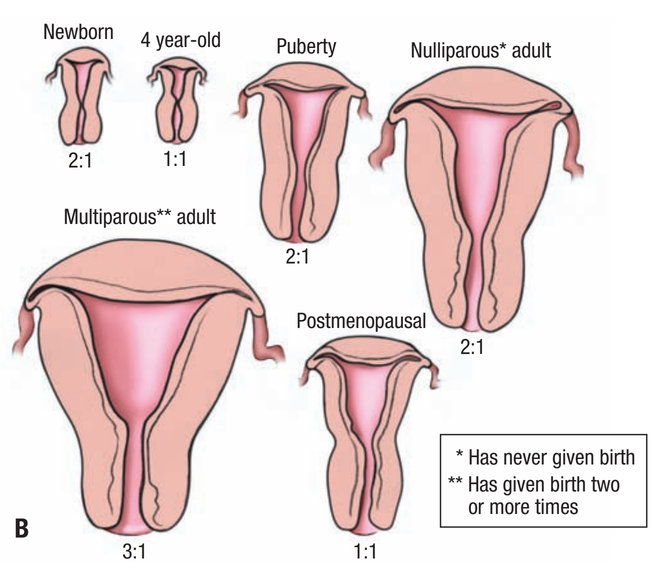
E. Laparoscopic View of Normal Female Pelvis

3.33 FEMALE PELVIC ORGANS IN SITU *(CONTINUED)*

A. Median section. The adult uterus is typically *anteverted* (tipped antereosuperiorly relative to the axis of the vagina) and *anteflexed* (flexed or bent anteriorly relative to the cervix, creating the *angle of flexion*) so that its mass lies over the bladder. The cervix, opening on the anterior wall of the vagina, has a short, round, anterior lip and a long, thin, posterior lip. **B. Bimanual palpation of uterus. C. Bimanual palpation of uterine adnexa** (e.g., ovaries). **D.** True pelvis with peritoneum intact, viewed from above. The uterus is usually asymmetrically placed. The round ligament of the female takes the same subperitoneal course as the ductus deferens of the male.

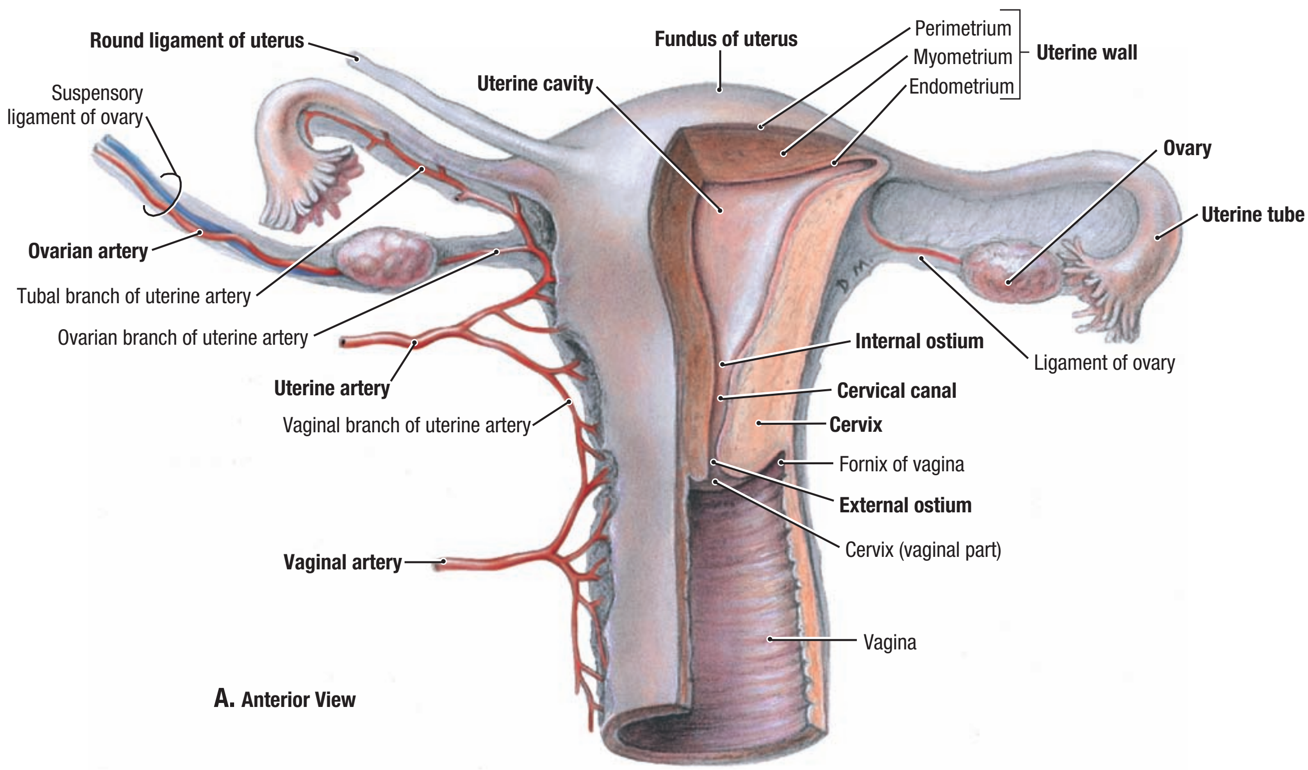
E. Laparoscopy involves inserting a laparoscope into the peritoneal cavity through a small incision below the umbilicus. Insufflation of inert gas creates a pneumoperitoneum to provide space to visualize the pelvic organs. Additional openings (ports) can be made to introduce other instruments for manipulation or to enable therapeutic procedures (e.g., ligation of the uterine tubes).



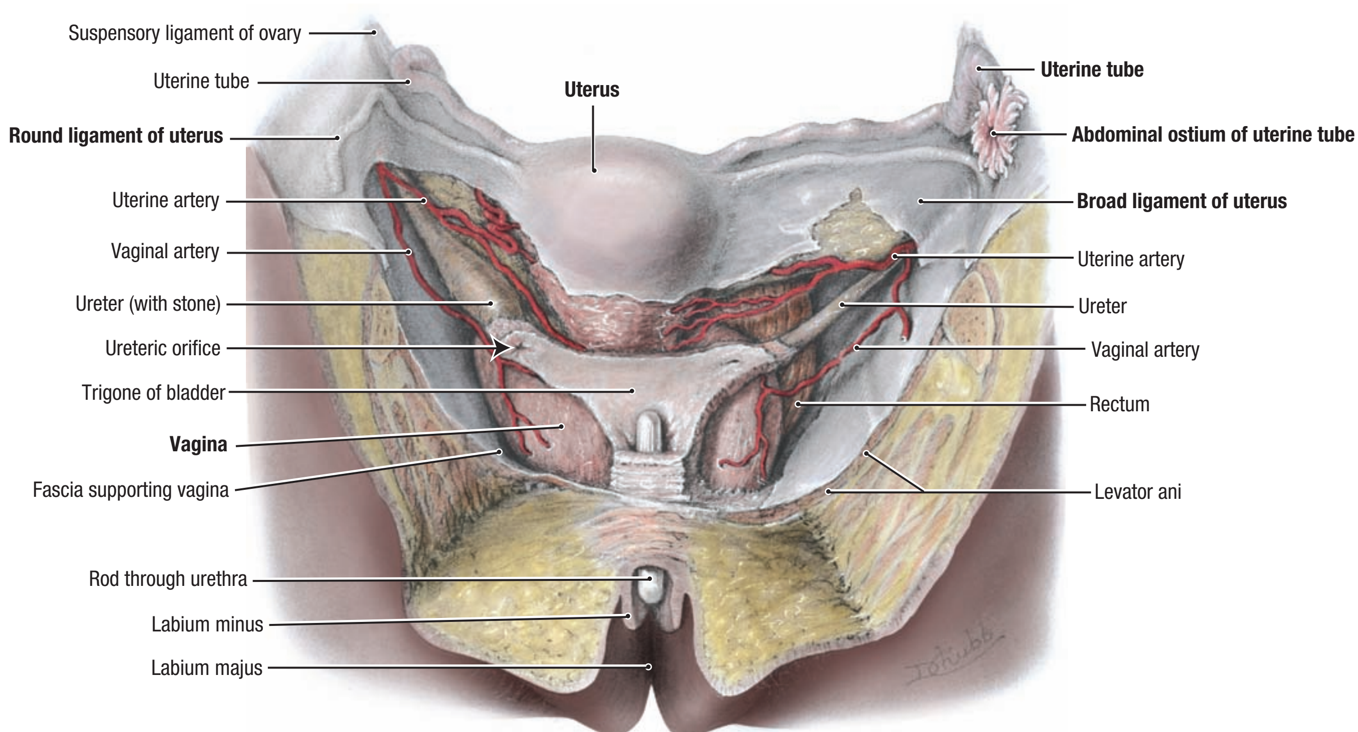


3.34 FEMALE GENITAL ORGANS

A. Dissection. Part of the pubic bones, the anterior aspect of the bladder, and—on the specimen's right side—the uterine tube, ovary, broad ligament, and peritoneum covering the lateral wall of the pelvis have been removed. **B. Lifetime changes in uterine size and proportion** (body to cervical ratio, e.g., 2:1). All these stages represent normal anatomy for the particular age and reproductive status of the woman.



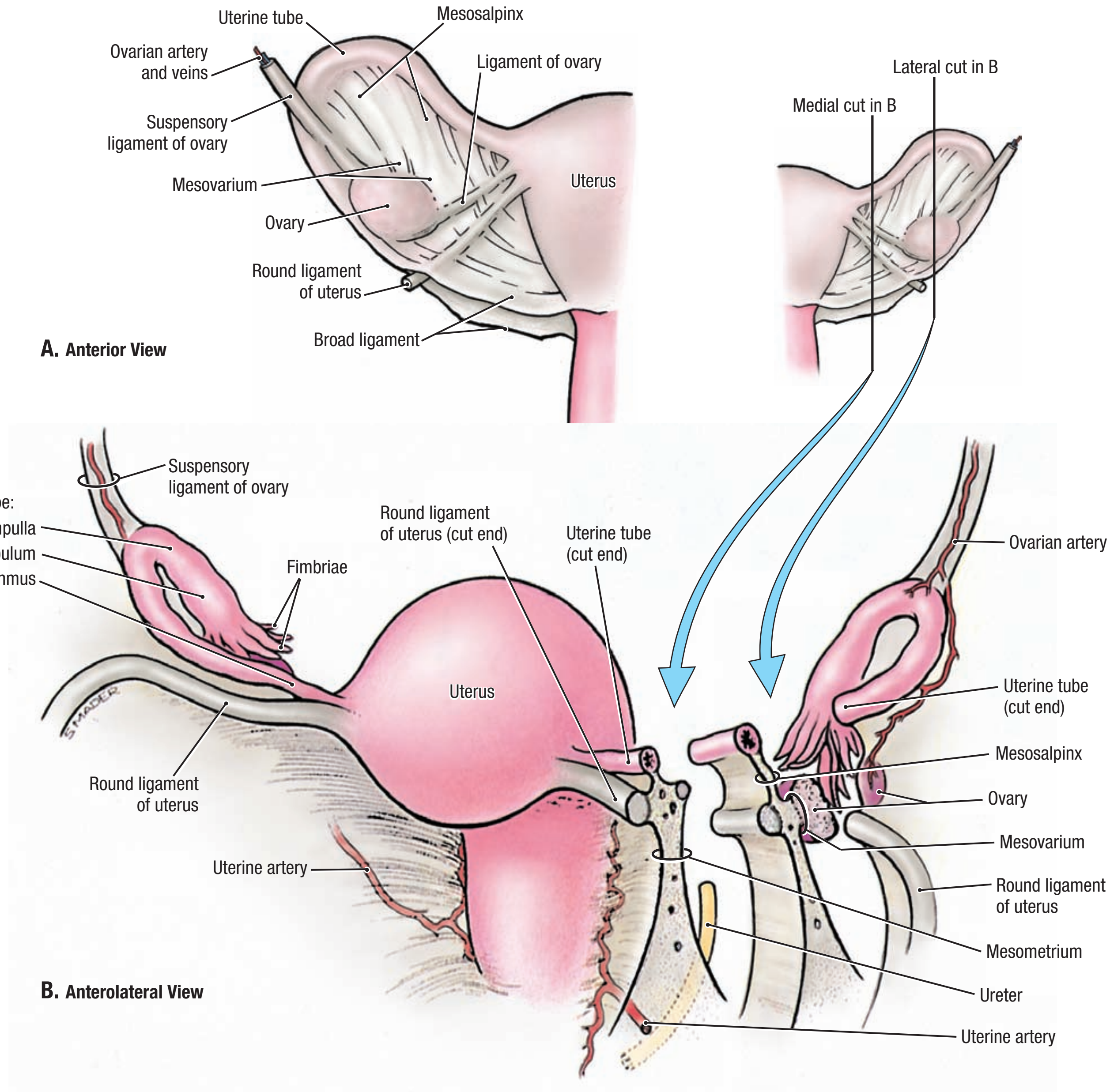
A. Anterior View



B. Anterior View

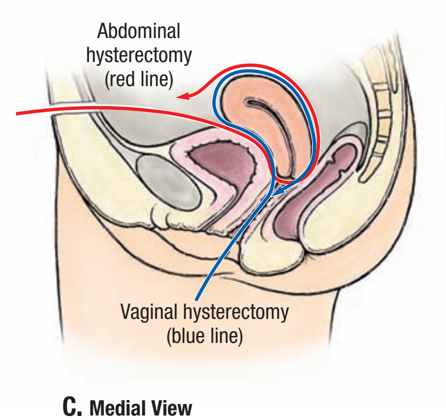
3.35 UTERUS AND ITS ADNEXA

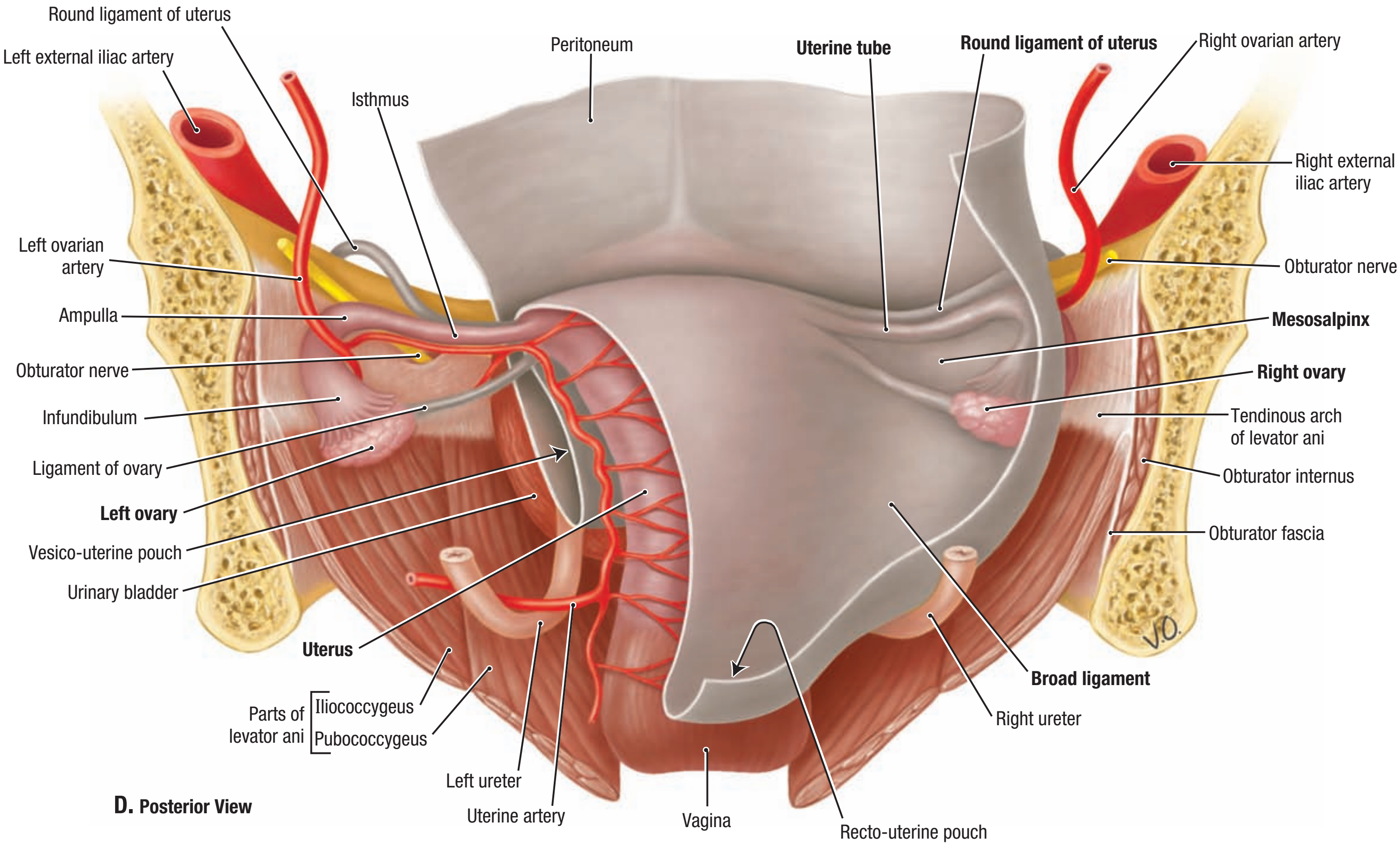
A. Blood supply. On the specimen's left side, part of the uterine wall with the round ligament and the vaginal wall have been cut away to expose the cervix, uterine cavity, and thick muscular wall of the uterus, the myometrium. On the specimen's right side, the ovarian artery (from the aorta) and uterine artery (from the internal iliac) supply the ovary, uterine tube, and uterus and anastomose in the broad ligament along the lateral aspect of the uterus. The uterine artery sends a uterine branch to supply the uterine body and fundus and a vaginal branch to supply the cervix and vagina. **B.** Uterus and broad ligament. The pubic bones and bladder, trigone excepted, are removed, as a continued dissection from Figure 3.34.



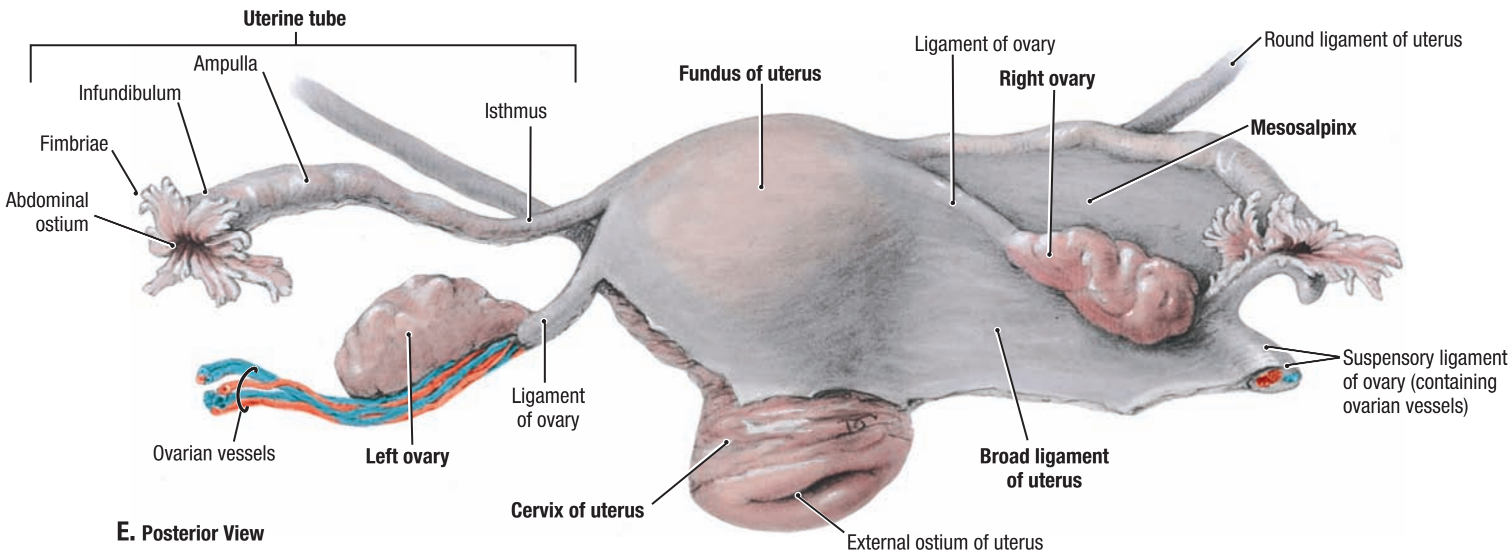
3.36 UTERUS AND BROAD LIGAMENT

A. and B. Two paramedian sections show "mesenteries" with the prefix meso-. "Salpinx" is the Greek word for trumpet or tube, "metro" for uterus. The mesentery of the uterus and uterine tube is called the broad ligament. The major part of the broad ligament, the *mesometrium*, is attached to the uterus. The ovary is attached to the broad ligament by a mesentery of its own, called the *mesovarium*; to the uterus by the ligament of the ovary; and near the pelvic brim, by the suspensory ligament of the ovary containing the ovarian vessels. The part of the broad ligament superior to the level of the mesovarium is called the *mesosalpinx*. **C. Hysterectomy** (excision of the uterus) is performed through the lower anterior abdominal wall or through the vagina. Because the uterine artery crosses superior to the ureter near the lateral fornix of the vagina, the ureter is in danger of being inadvertently clamped or severed when the uterine artery is tied off during a hysterectomy.





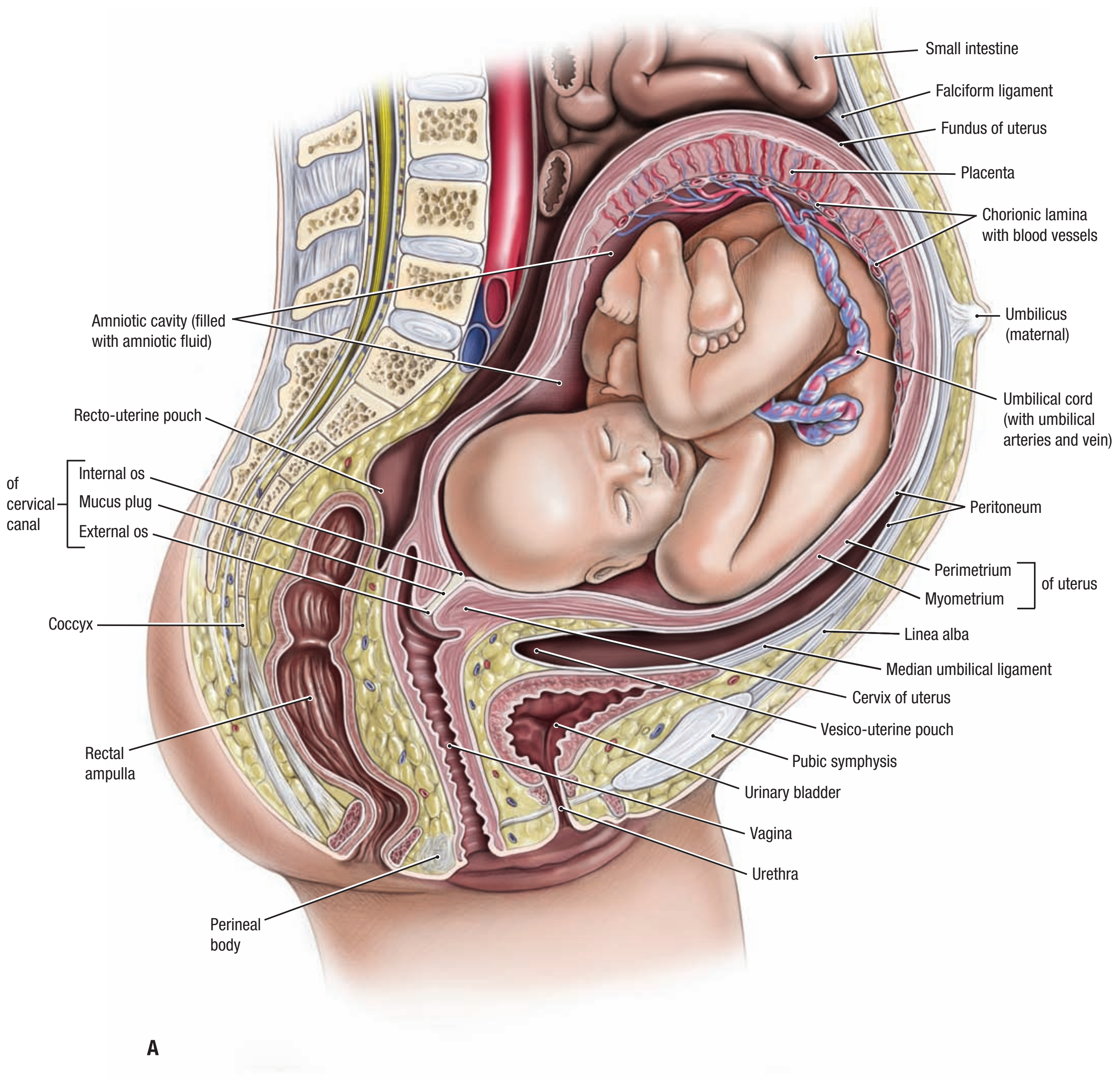
D. **Posterior View**



E. **Posterior View**

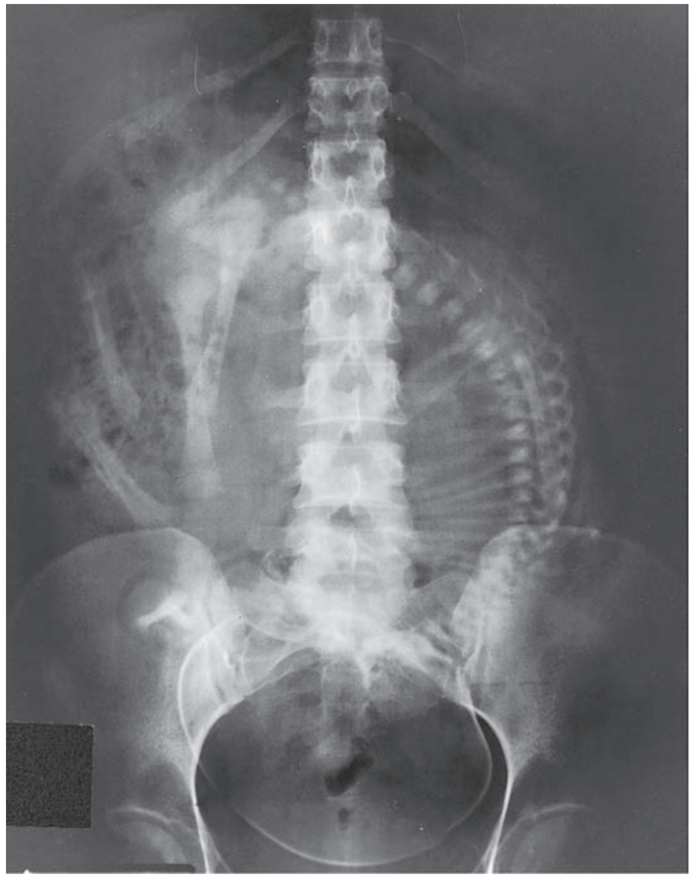
3.36 UTERUS AND BROAD LIGAMENT *(CONTINUED)*

D. Uterus in situ. **E.** Uterus and adnexa, removed from cadaver.

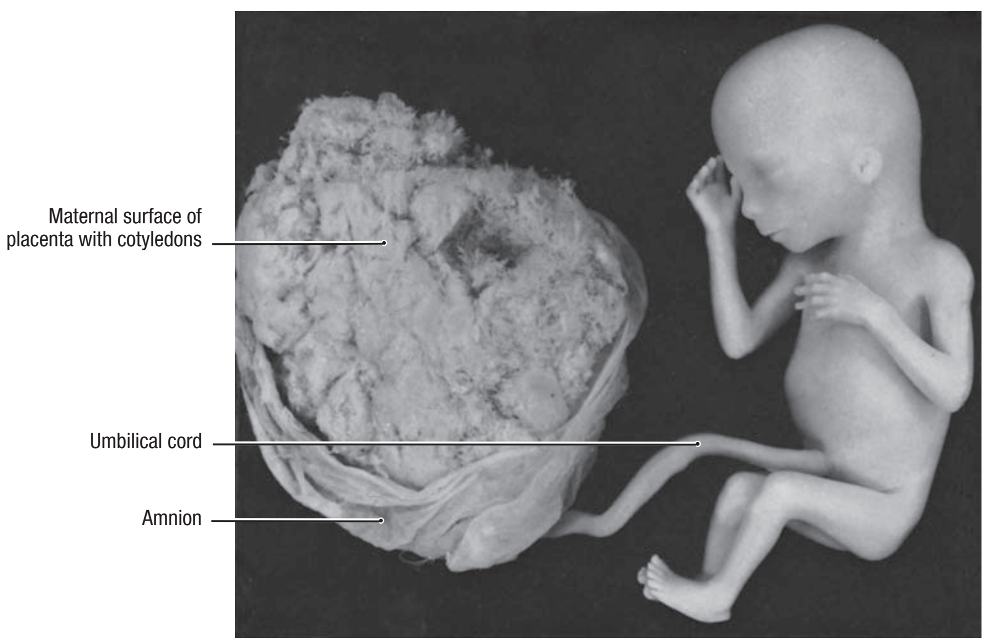


3.37 PREGNANT UTERUS

A. Median section; fetus is intact.



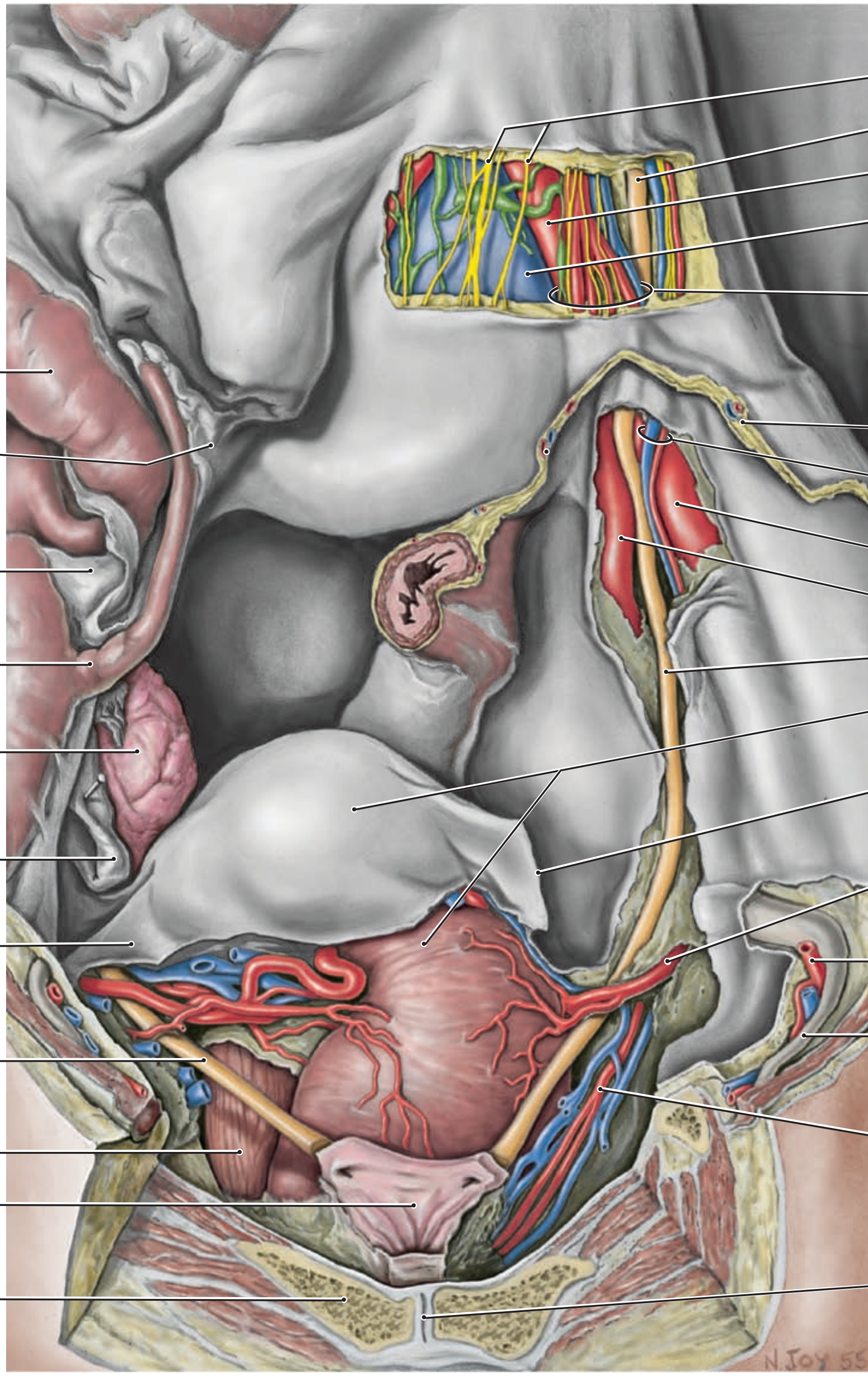
B. **Anteroposterior View**



C. **Maternal Surface of Placenta**

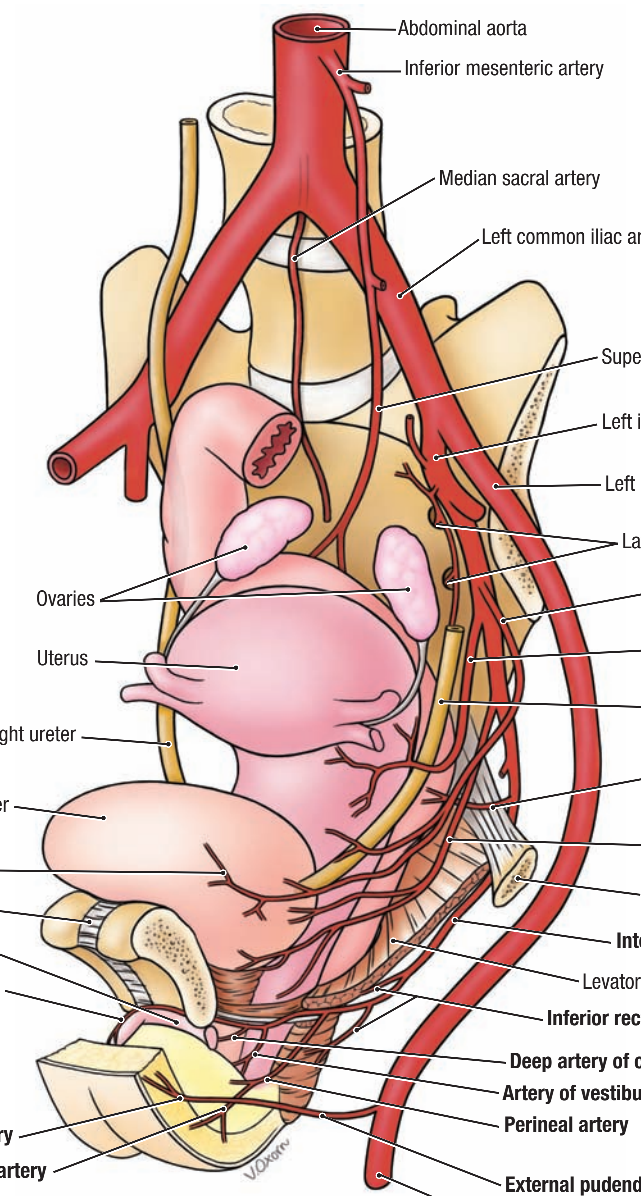
3.37 PREGNANT UTERUS *(CONTINUED)*

B. Radiograph of fetus. **C.** Photograph of an 18-week-old fetus connected to the placenta by the umbilical cord.



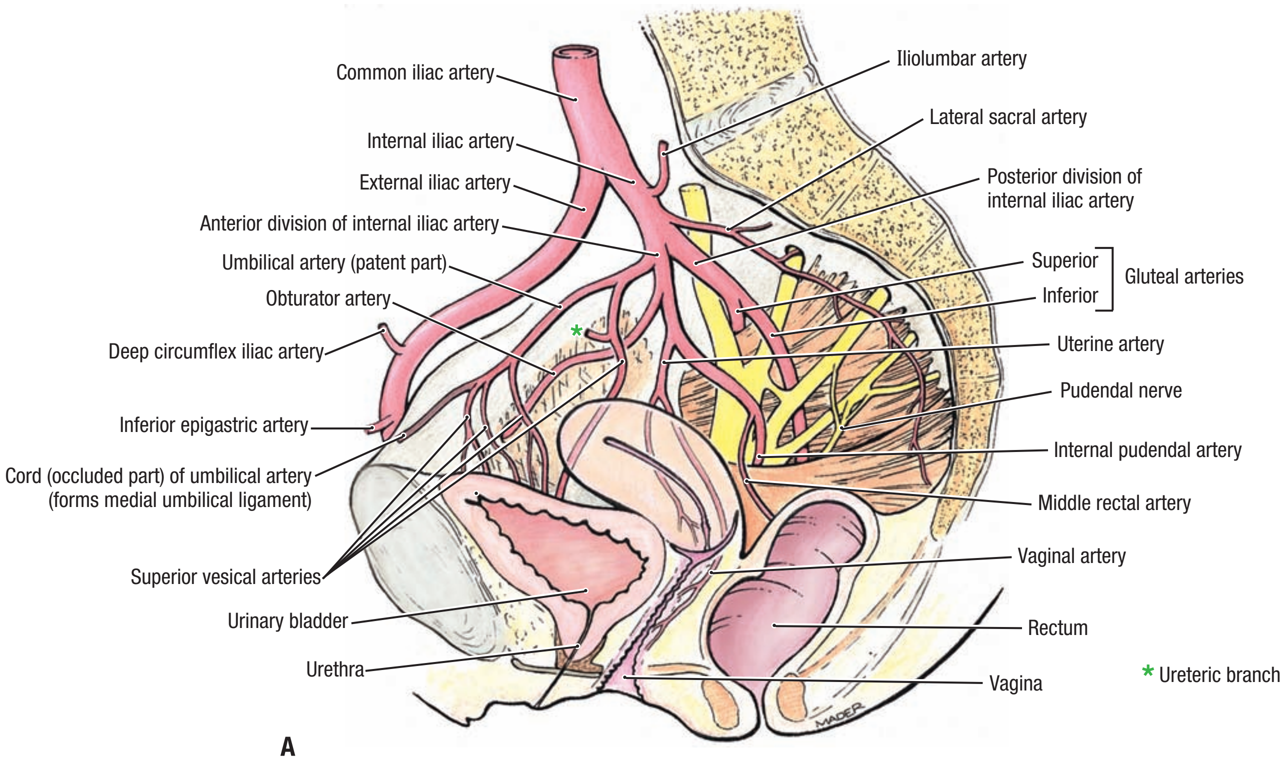
3.38 URETER AND RELATIONSHIP TO UTERINE ARTERY

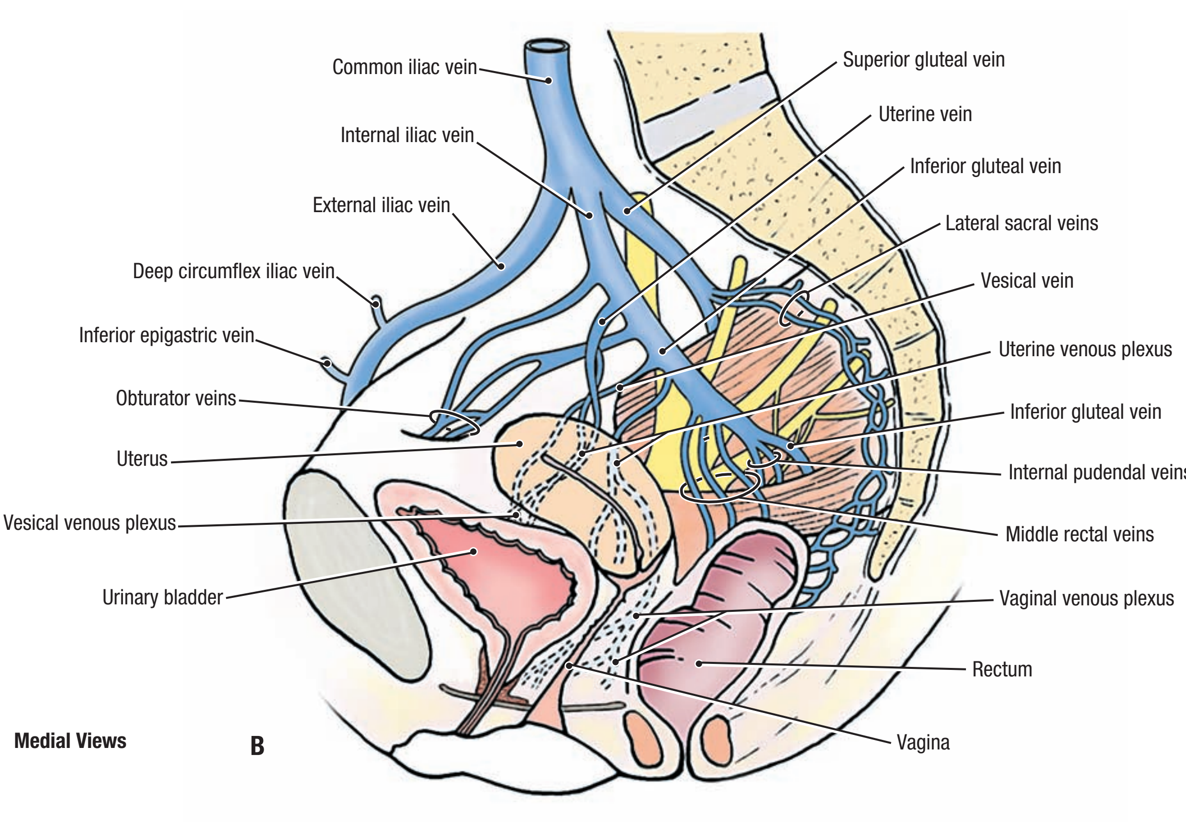
- Most of the pubic symphysis and most of the bladder (except the trigone) have been removed as in Figure 3.34B.
- The left ureter is crossed by the ovarian vessels and nerves; the apex of the inverted V-shaped root of the sigmoid mesocolon is situated anterior to the left ureter.
- The left ureter crosses the external iliac artery at the bifurcation of the common iliac artery and then descends anterior to the internal iliac artery; its course is subperitoneal from where it enters the pelvis to where it passes deep to the broad ligament and is crossed by the uterine artery. **Injury of the ureter** may occur in this region when the uterine artery is ligated and cut during hysterectomy.



3.39 ARTERIAL SUPPLY OF FEMALE PELVIS AND PERINEUM

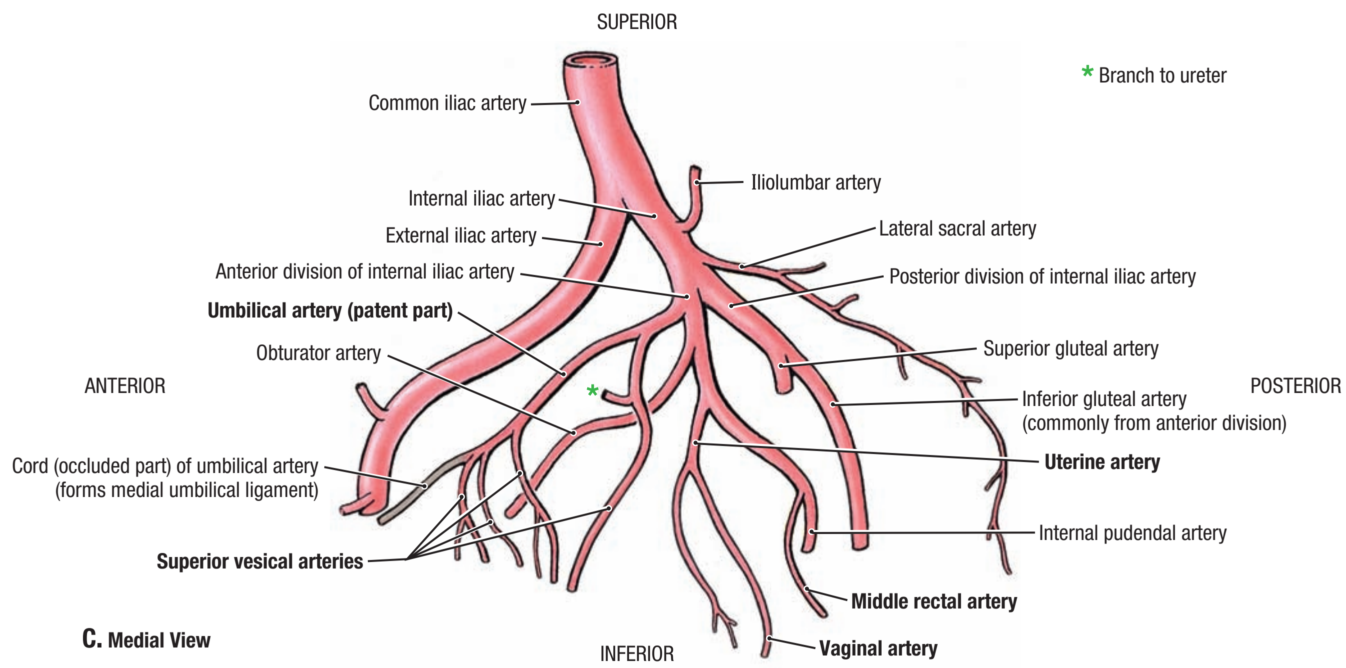
- The blood supply of the uterus is mainly from the *uterine arteries*, with potential collateral supply from the ovarian arteries.
- The arteries supplying the superior part of the vagina derive from the *uterine arteries*; the arteries supplying the middle and inferior parts of the vagina derive from the *vaginal* and *internal pudendal arteries*.
- The superior vesical arteries supply the anterosuperior parts of the bladder; the vaginal arteries supply the postero-inferior parts of the bladder.





3.40 ARTERIES AND VEINS OF FEMALE PELVIS

A. Arteries in situ. **B.** Pelvic veins and venous plexuses. **C.** Arteries isolated from **A**.

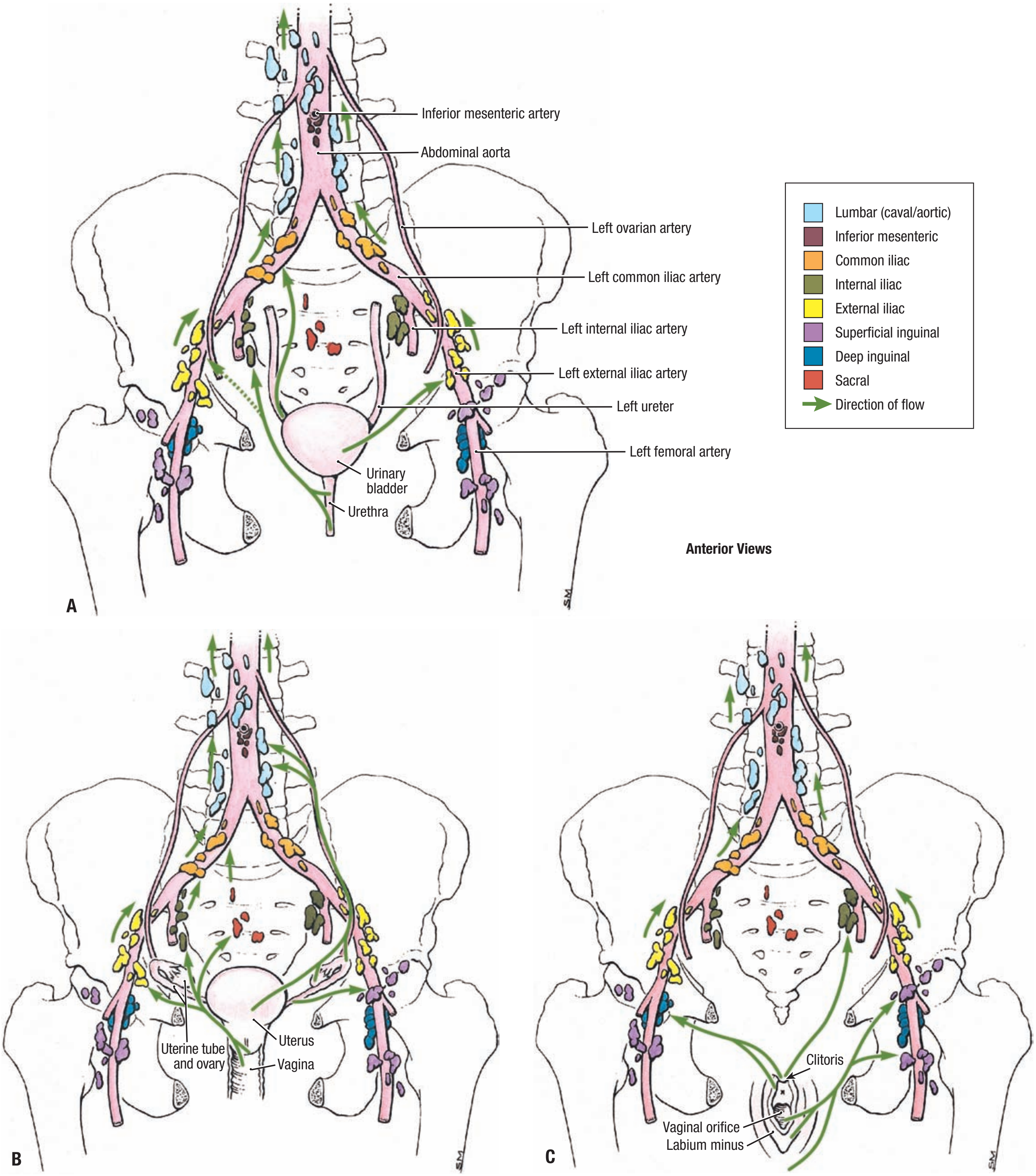


C. Medial View

3.40 ARTERIES AND VEINS OF FEMALE PELVIS *(CONTINUED)*

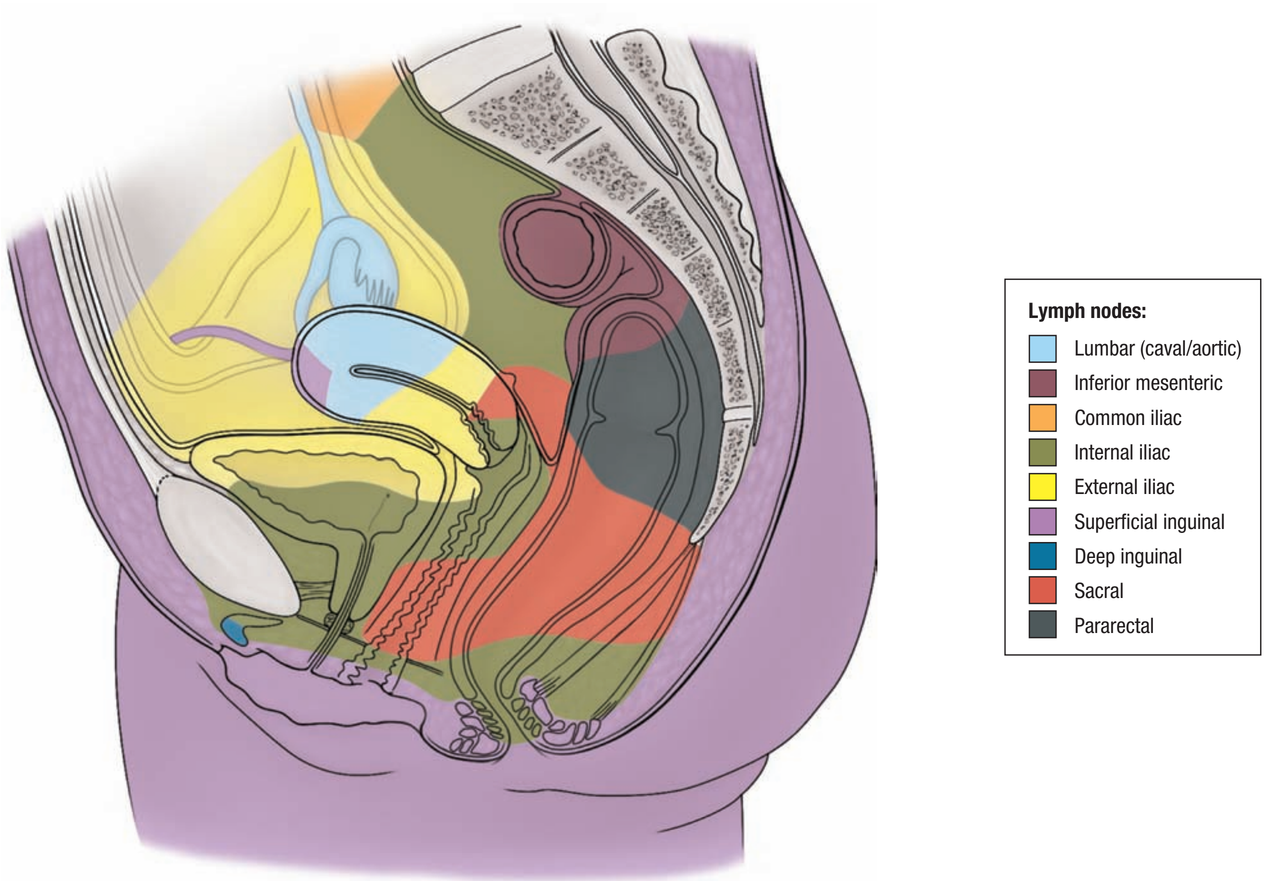
TABLE 3.7 ARTERIES OF FEMALE PELVIS

Artery	Origin	Course	Distribution
Internal iliac	Common iliac artery	Passes over pelvic brim and descends into pelvic cavity	Main blood supply to pelvic organs, gluteal muscles, and perineum
Anterior division of internal iliac artery	Internal iliac artery	Passes anteriorly along lateral wall of pelvis, dividing into visceral, obturator, and internal iliac arteries	Pelvic viscera and muscles of superior medial thigh and perineum
Umbilical	Anterior division of internal iliac artery	Short pelvic course, gives off superior vesical arteries	Superior aspect of urinary bladder
Superior vesical artery	Patent proximal part of umbilical artery	Usually multiple, pass to superior aspect of urinary bladder	Superior aspect of urinary bladder
Obturator	Anterior division of internal iliac artery	Runs antero-inferiorly on lateral pelvic wall	Pelvic muscles, nutrient artery to ilium, head of femur, and muscles of medial compartment of thigh
Uterine		Runs anteromedially in base of broad ligament/superior cardinal ligament; gives rise to vaginal branch, then crosses ureter superiorly to reach lateral aspect of uterine cervix	Uterus, ligaments of uterus, medial parts of uterine tube and ovary, and superior vagina
Vaginal		Divides into vaginal and inferior vesical branches	Vaginal branch: lower vagina, vestibular bulb, and adjacent rectum; inferior vesical branch: fundus of urinary bladder
Middle rectal		Descends in pelvis to inferior part of rectum	Inferior part of rectum
Internal pudendal		Exits pelvis via greater sciatic foramen and enters perineum (ischio-anal fossa) via lesser sciatic foramen	Main artery to perineum including muscles of anal canal and perineum, skin and urogenital triangle and erectile bodies
Posterior division of internal iliac artery	Internal iliac artery	Passes posteriorly and gives rise to parietal branches	Pelvic wall and gluteal region
Iliolumbar	Posterior division of internal iliac artery	Ascends anterior to sacro-iliac joint and posterior to common iliac vessels and psoas major	Iliacus, psoas major, quadratus lumborum muscles, and cauda equina in vertebral canal
Lateral sacral (superior and inferior)		Run on anteromedial aspect of piriformis	Piriformis muscle, structures in sacral canal, and erector spinae muscles
Ovarian	Abdominal aorta	Crosses pelvic brim and descends in suspensory ligament to ovary	Abdominal and/or pelvic ureter, ovary, and ampullary end of uterine tube



3.41 LYMPHATIC DRAINAGE OF FEMALE PELVIS AND PERINEUM

A. Pelvic urinary system. **B.** Internal genital organs. **C.** Vulva.



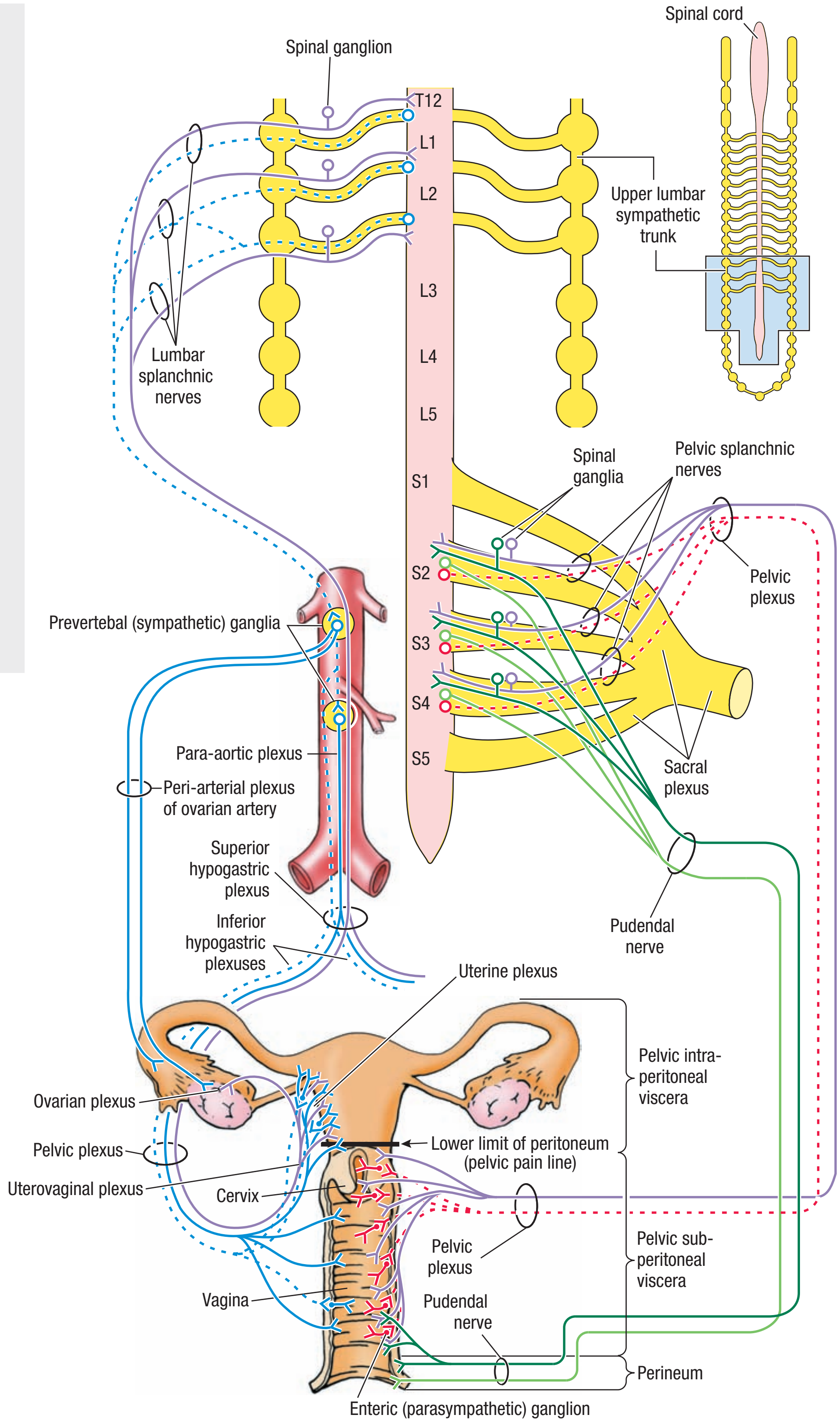
3.41 *LYMPHATIC DRAINAGE OF FEMALE PELVIS AND PERINEUM (CONTINUED)*

TABLE 3.8 LYMPHATIC DRAINAGE OF STRUCTURES OF FEMALE PELVIS AND PERINEUM

Lymph Node Group	Structures Typically Draining to Lymph Node Group
Lumbar	Gonads and associated structures (along ovarian vessels), ovary, uterine tube (except isthmus and intra-uterine parts), fundus of uterus, common iliac nodes
Inferior mesenteric	Superiormost rectum, sigmoid colon, descending colon, pararectal nodes
Common iliac	External and internal iliac lymph nodes
Internal iliac	Inferior pelvic structures, deep perineal structures, sacral nodes, base of bladder, inferior pelvic ureter, anal canal (above pectinate line), inferior rectum, middle and upper vagina, cervix, body of uterus, sacral nodes
External iliac	Anterosuperior pelvic structures, deep inguinal nodes, superior bladder, superior pelvic ureter, upper vagina, cervix, lower body of uterus
Superficial inguinal	Lower limb, superficial drainage of inferolateral quadrant of trunk, including anterior abdominal wall inferior to umbilicus, gluteal region, superolateral uterus (near attachment of round ligament), skin of perineum including vulva, ostium of vagina (inferior to hymen), prepuce of clitoris, peri-anal skin, anal canal inferior to pectinate line
Deep inguinal	Glans of clitoris, superficial inguinal nodes
Sacral	Postero-inferior pelvic structures, inferior rectum, inferior vagina
Pararectal	Superior rectum

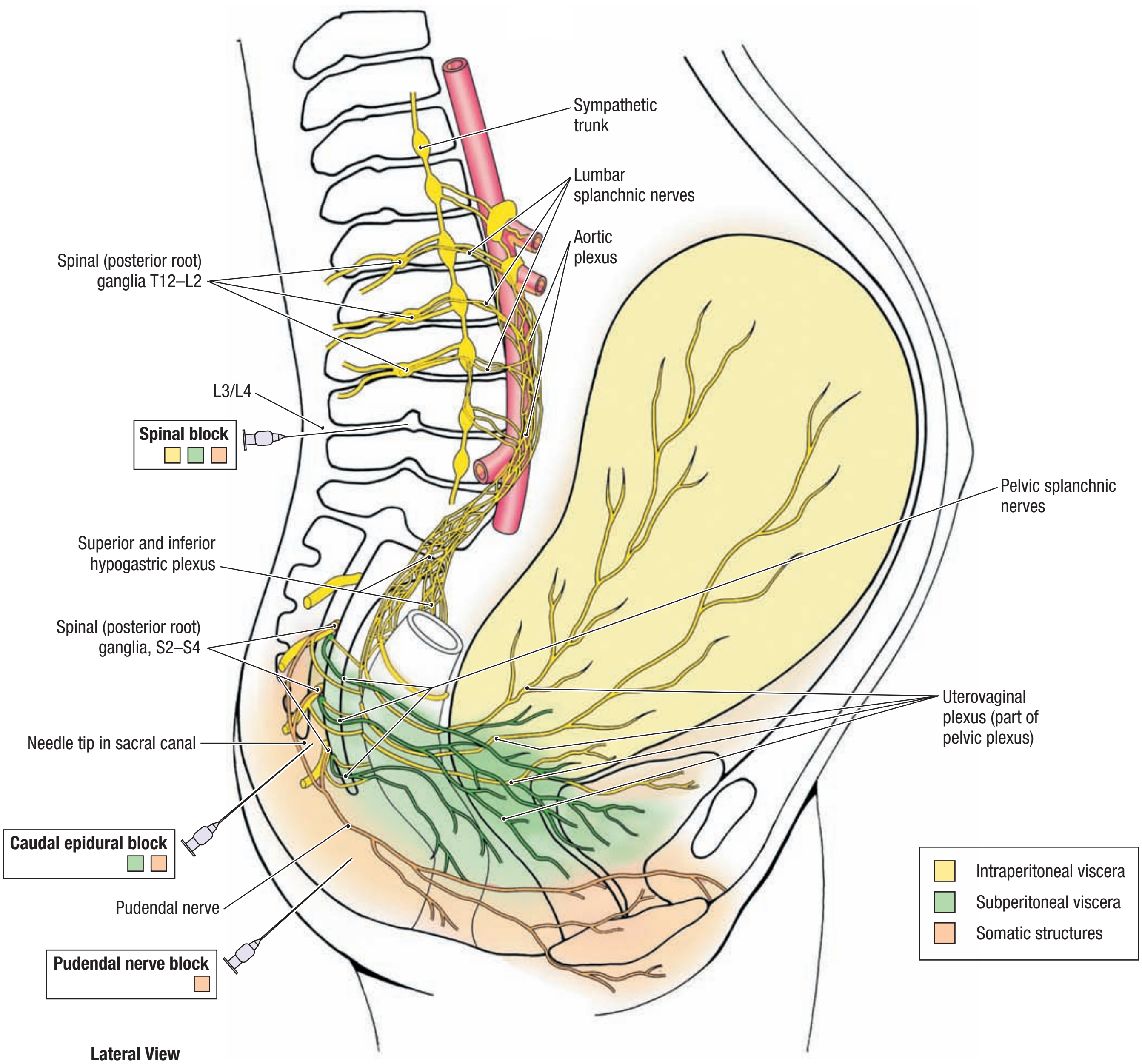
3.42 INNERVATION OF FEMALE PELVIC VISCERA

- Pelvic splanchnic nerves (S2–S4) supply parasympathetic motor fibers to the uterus and vagina (and vasodilator fibers to the erectile tissue of the clitoris and bulb of the vestibule; not shown).
- Presynaptic sympathetic fibers pass through the lumbar splanchnic nerves to synapse in prevertebral ganglia; the postsynaptic fibers travel through the superior and inferior hypogastric plexuses to reach the pelvic viscera.
- Visceral afferent fibers conducting pain from intraperitoneal viscera travel with the sympathetic fibers to the T12–L2 spinal ganglia. Visceral afferent fibers conducting pain from subperitoneal viscera travel with parasympathetic fibers to the S2–S4 spinal ganglia.
- Somatic sensation from the opening of the vagina also passes to the S2–S4 spinal ganglia via the pudendal nerve.
- Muscular contractions of the uterus are hormonally induced.



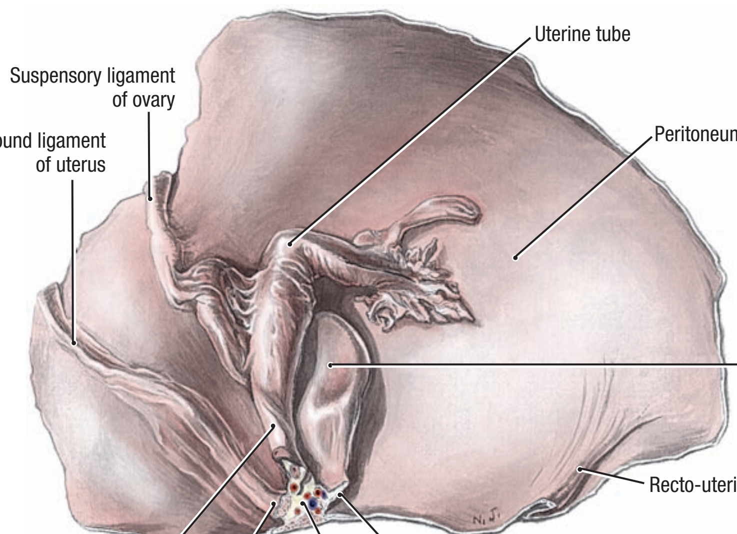
Innervation:
- Presynaptic sympathetic
- Postsynaptic sympathetic
- Presynaptic parasympathetic
- Postsynaptic parasympathetic
- Visceral afferent running with sympathetic and parasympathetic fibers
- Somatic sensory
- Somatic motor

Anterior View



3.43 INNERVATION OF PELVIC VISCERA DURING PREGNANCY; NERVE BLOCKS

- A **spinal block**, in which the anesthetic agent is introduced with a needle into the spinal subarachnoid space at the L3–L4 vertebral level produces complete anesthesia inferior to approximately the waist level. The perineum, pelvic floor, and birth canal are anesthetized, and motor and sensory functions of the entire lower limbs, as well as sensation of uterine contractions, are temporarily eliminated.
- With the **caudal epidural block**, the anesthetic agent is administered using an in-dwelling catheter in the sacral canal. The entire birth canal, pelvic floor, and most of the perineum are anesthetized, but the lower limbs are not usually affected. The mother is aware of her uterine contractions.
- A **pudendal nerve block** is a peripheral nerve block that provides local anesthesia over the S2–S4 dermatomes (most of the perineum) and the inferior quarter of the vagina. It does not block pain from the superior birth canal (uterine cervix and superior vagina), so the mother is able to feel uterine contractions.



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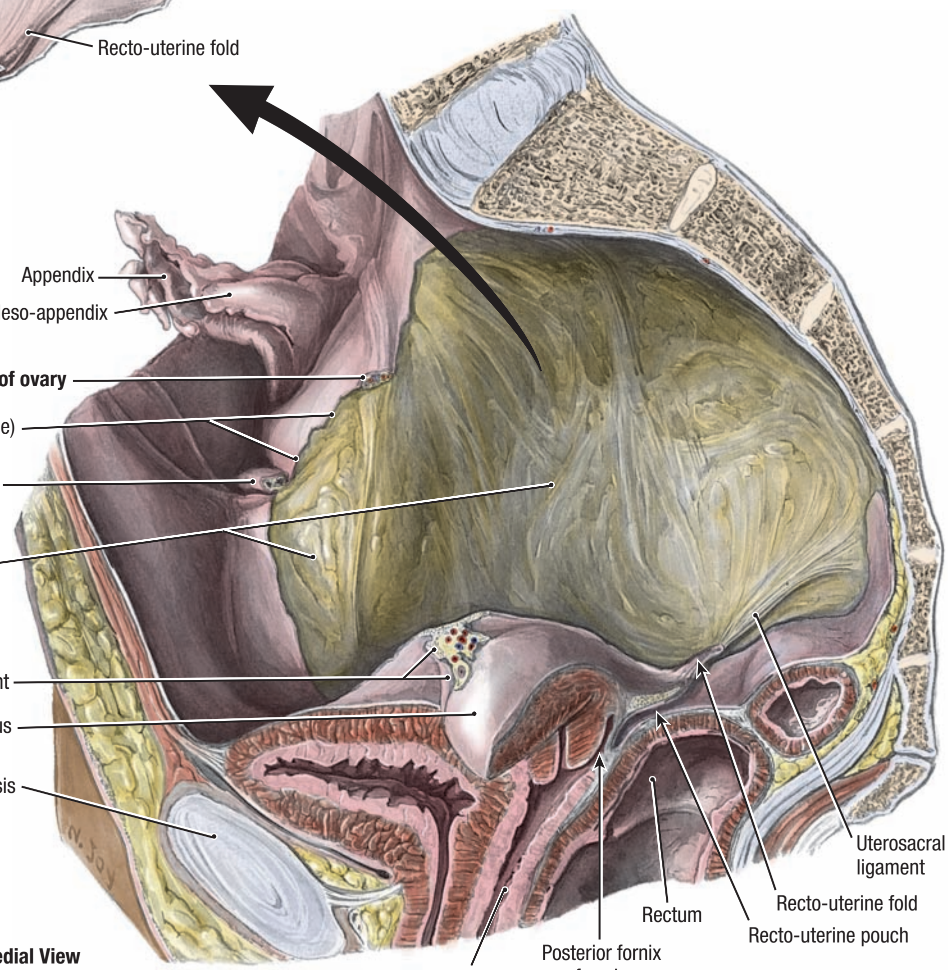
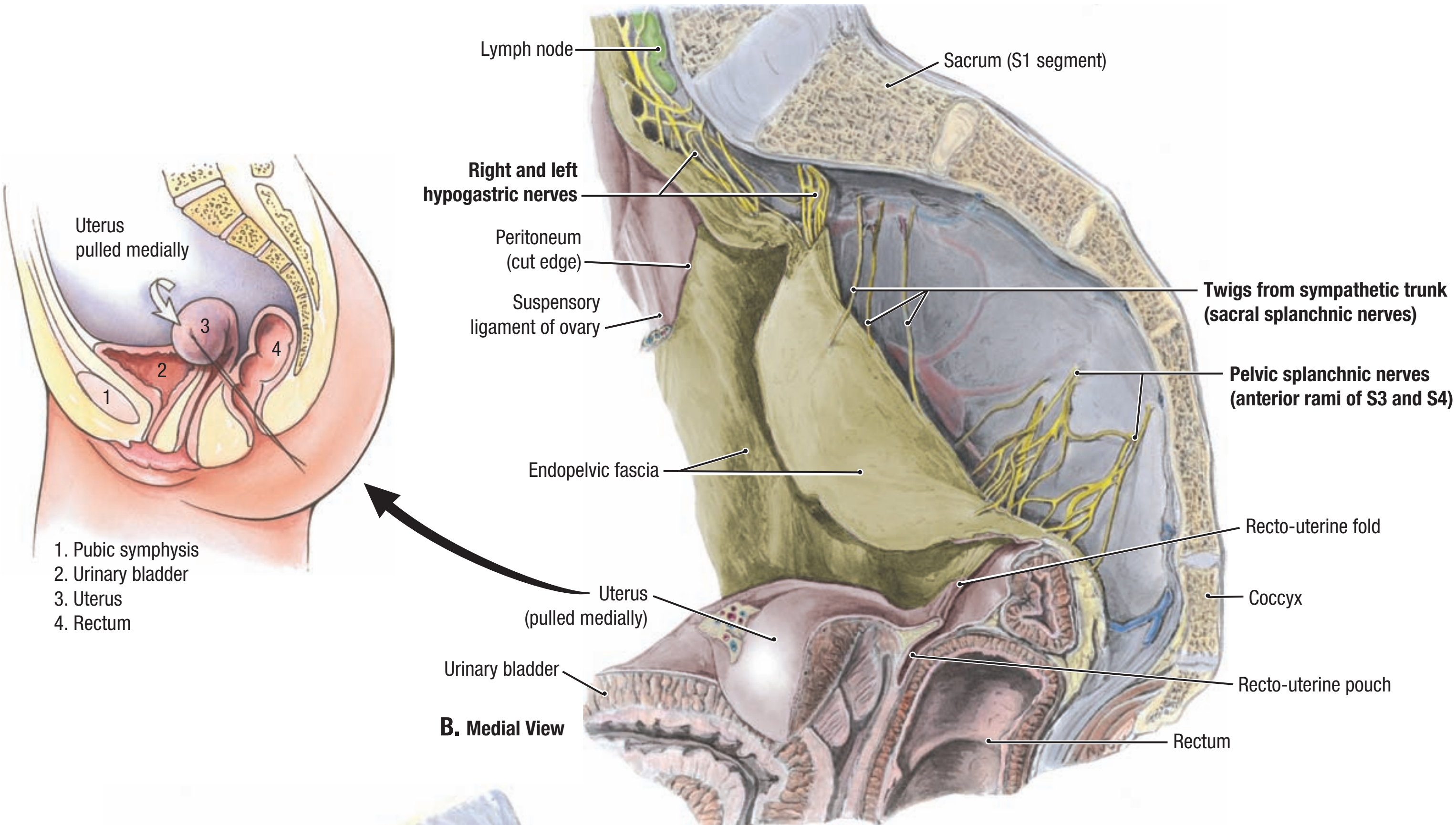


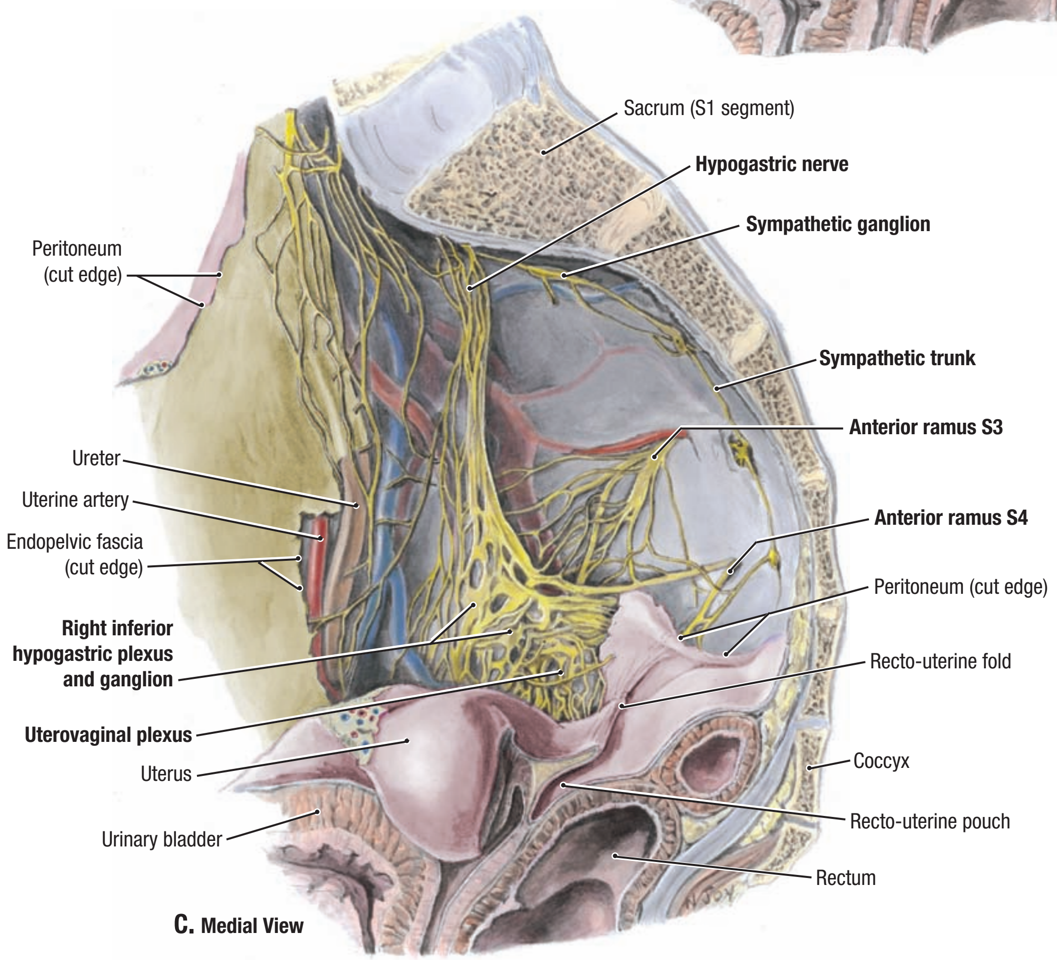
A. Medial View

3.44 SERIAL DISSECTION OF AUTONOMIC NERVES OF FEMALE PELVIS

A. Broad ligament and peritoneum of the lateral wall of the pelvic cavity have been removed to expose the endopelvic fascia.



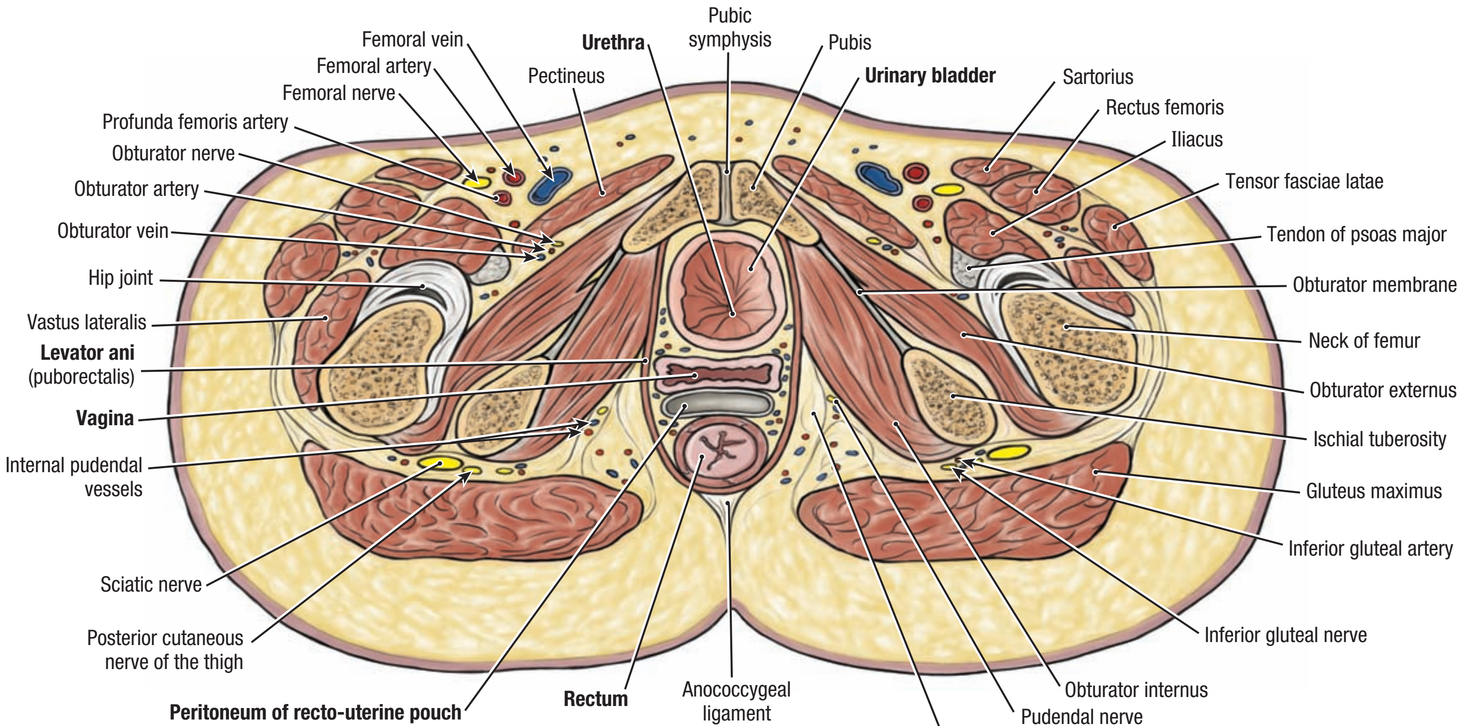
B. **Medial View**



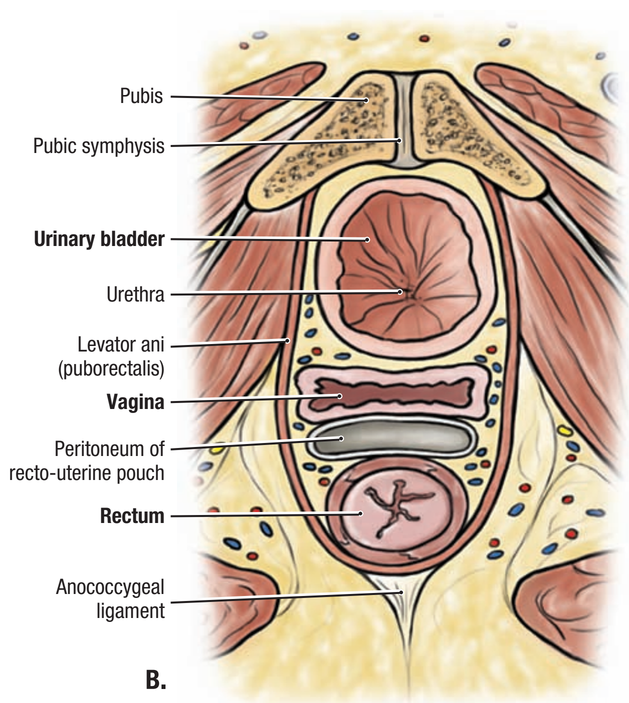
C. **Medial View**

3.44 SERIAL DISSECTION OF AUTONOMIC NERVES OF FEMALE PELVIS *(CONTINUED)*

B. The rectum and endopelvic fascia have been reflected anteriorly to expose the hypogastric nerves, sympathetic trunk, and pelvic splanchnic nerves (parasympathetic). **C.** The subperitoneal fatty-areolar tissue has been removed and the inferior hypogastric plexus exposed. The inferior hypogastric plexus continues as the uterovaginal plexus and supplies the uterus, uterine tubes, vagina, urethra, greater vestibular glands, erectile tissue of the clitoris, and bulb of the vestibule.



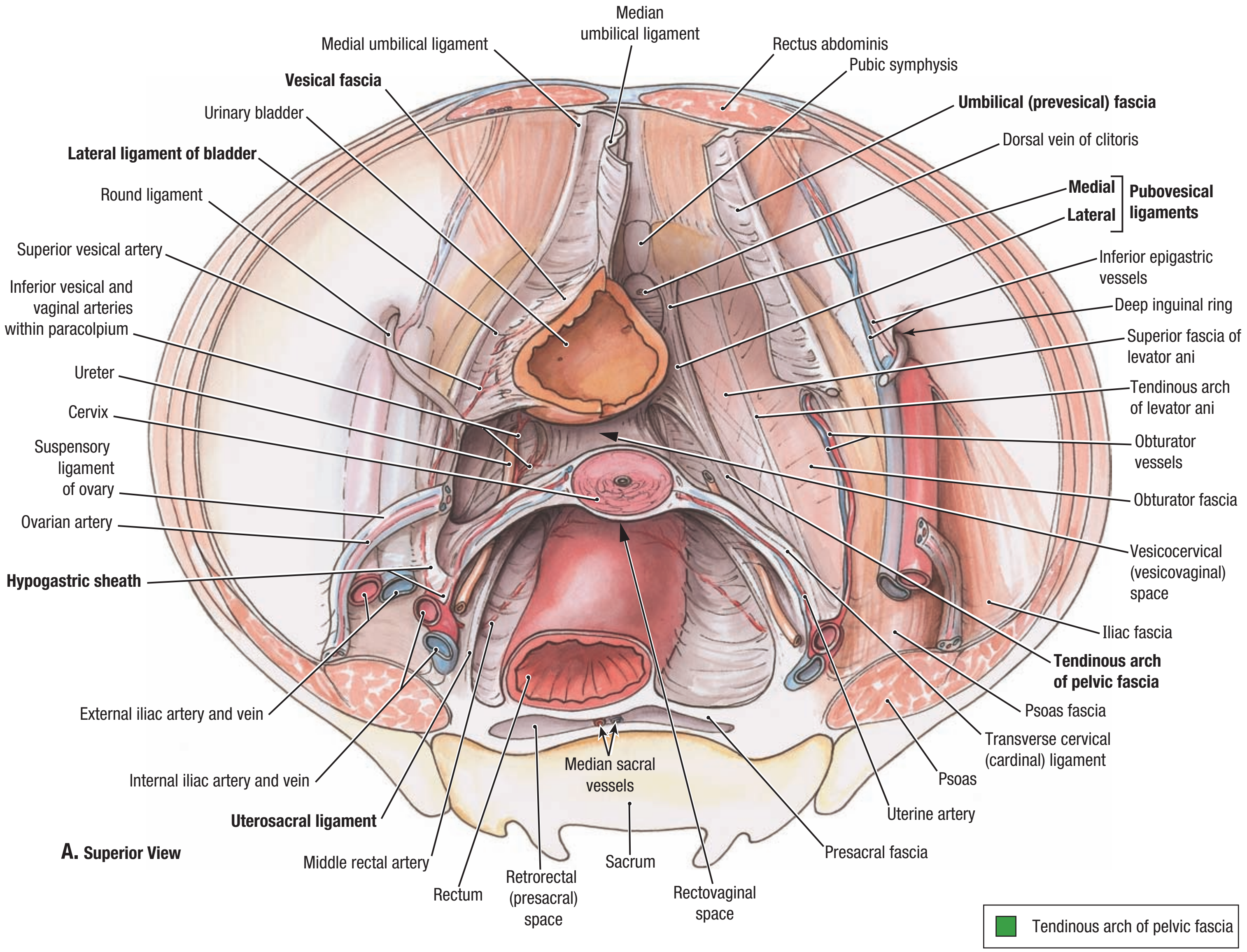
A. Transverse Section, Superior View



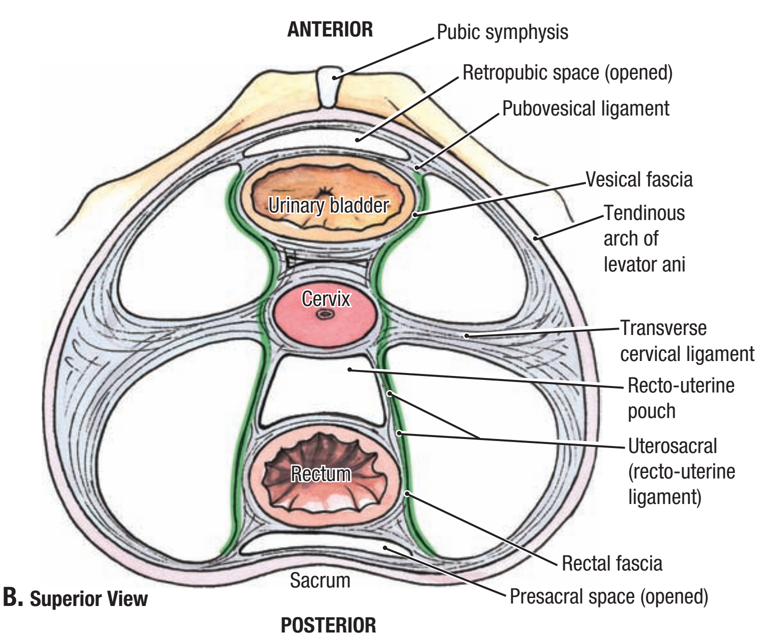
B.

3.45 TRANSVERSE SECTION THROUGH FEMALE PELVIS

A. Transverse section through the ischial tuberosities. **B.** Enlargement of central part of section including the bladder, vagina, rectum, and recto-uterine pouch.



A. **Superior View**

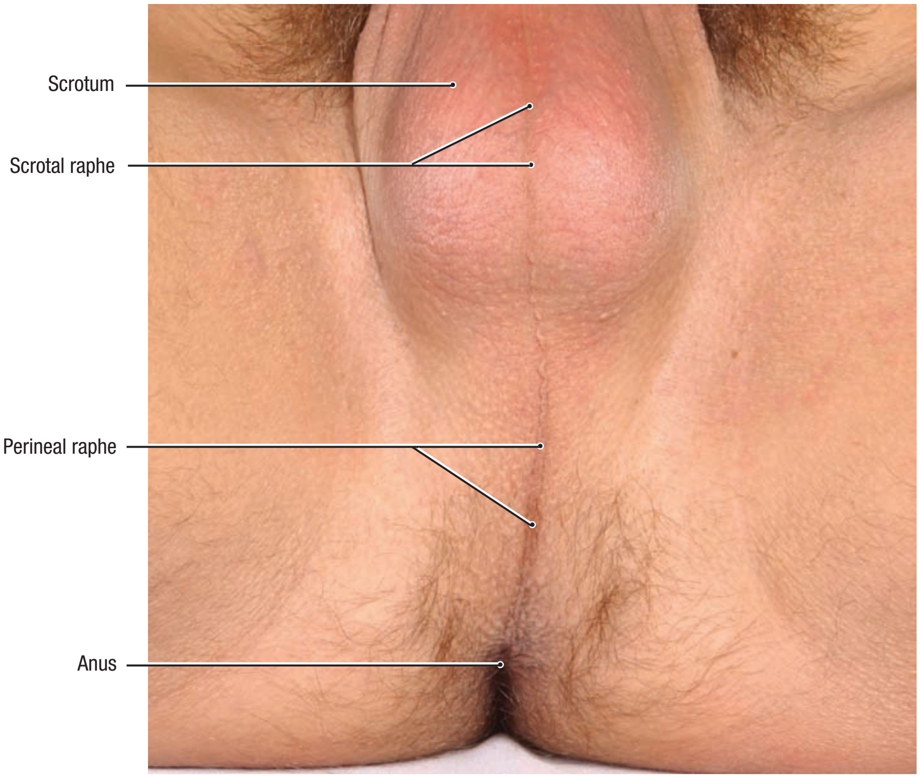


B. **Superior View**

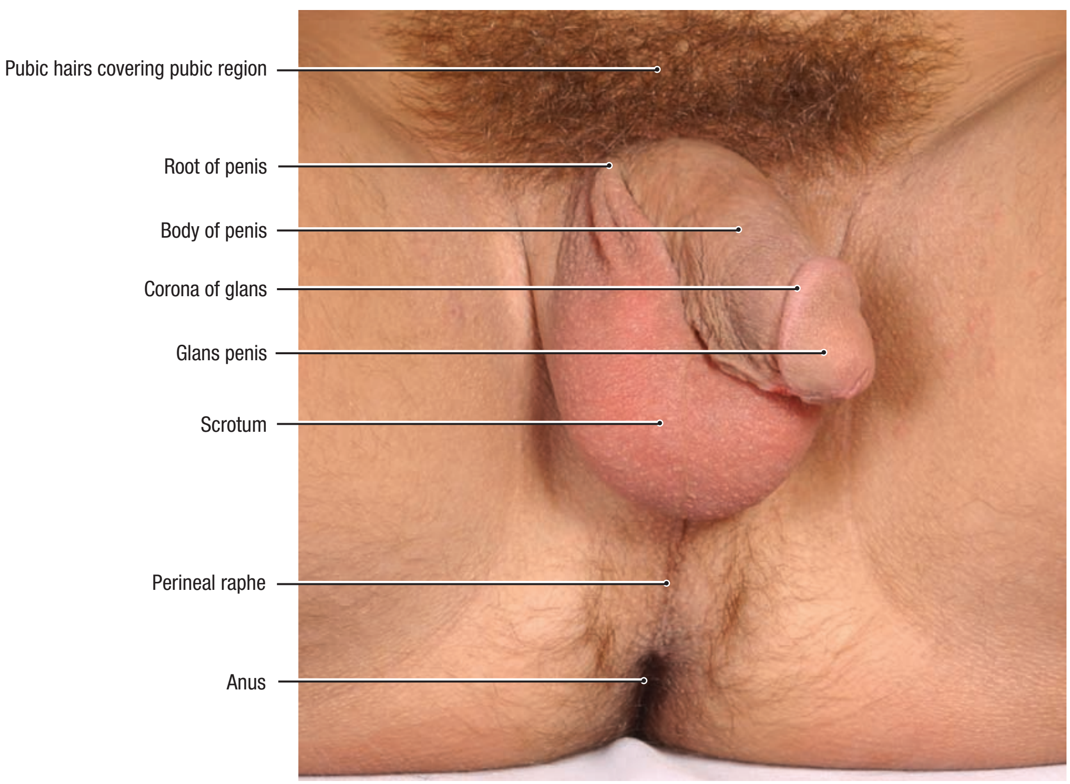
3.46 PELVIC FASCIA AND SUPPORTING MECHANISM OF CERVIX AND UPPER VAGINA

A. Greater and lesser pelvis demonstrating pelvic viscera and endopelvic fascia. **B.** Schematic illustration of fascial ligaments and areolar spaces at level of tendinous arch of pelvic fascia.

- Note the parietal pelvic fascia covering the obturator internus and levator ani muscles and the visceral pelvic fascia surrounding the pelvic organs. These membranous fasciae are continuous where the organs penetrate the pelvic floor, forming a tendinous arch of pelvic fascia bilaterally.
- The endopelvic fascia lies between, and is continuous with, both visceral and parietal layers of pelvic fascia. The loose, areolar portions of the endopelvic fascia have been removed; the fibrous, condensed portions remain. Note the condensation of this fascia into the hypogastric sheath, containing the vessels to the pelvic viscera, the ureters, and (in the male) the ductus deferens.
- Observe the ligamentous extensions of the hypogastric sheath: the lateral ligament of the urinary bladder, the transverse cervical ligament at the base of the broad ligament, and a less prominent lamina posteriorly containing the middle rectal vessels.



A. Inferior View

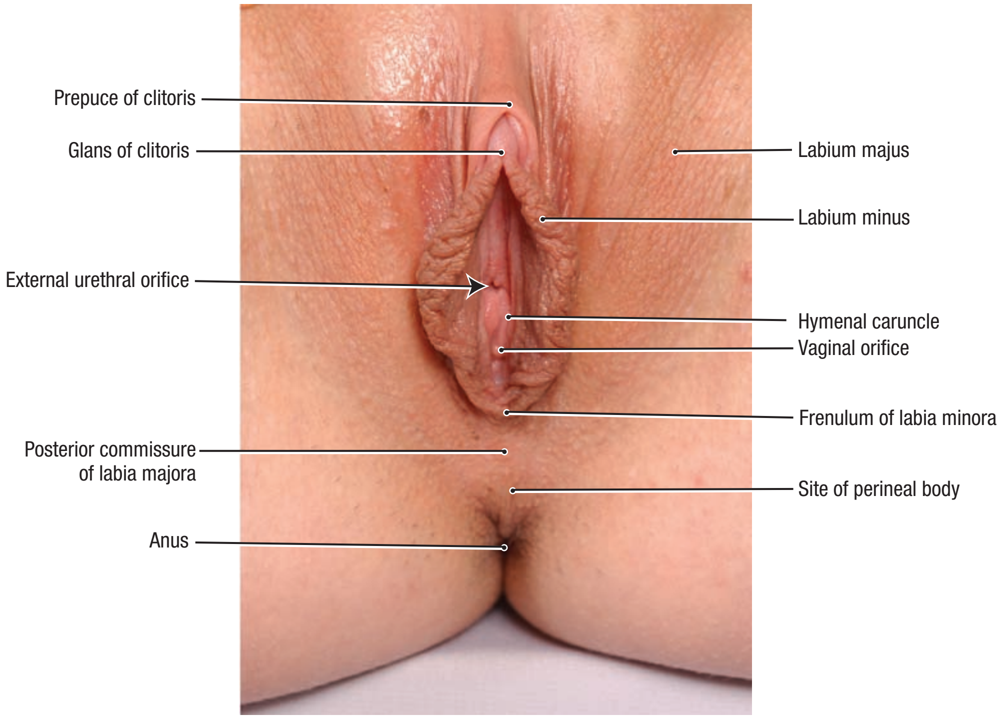


B. Inferior View

3.47 SURFACE ANATOMY OF MALE PERINEUM

A. Scrotum and anal region. **B.** Penis, scrotum, and anal region.

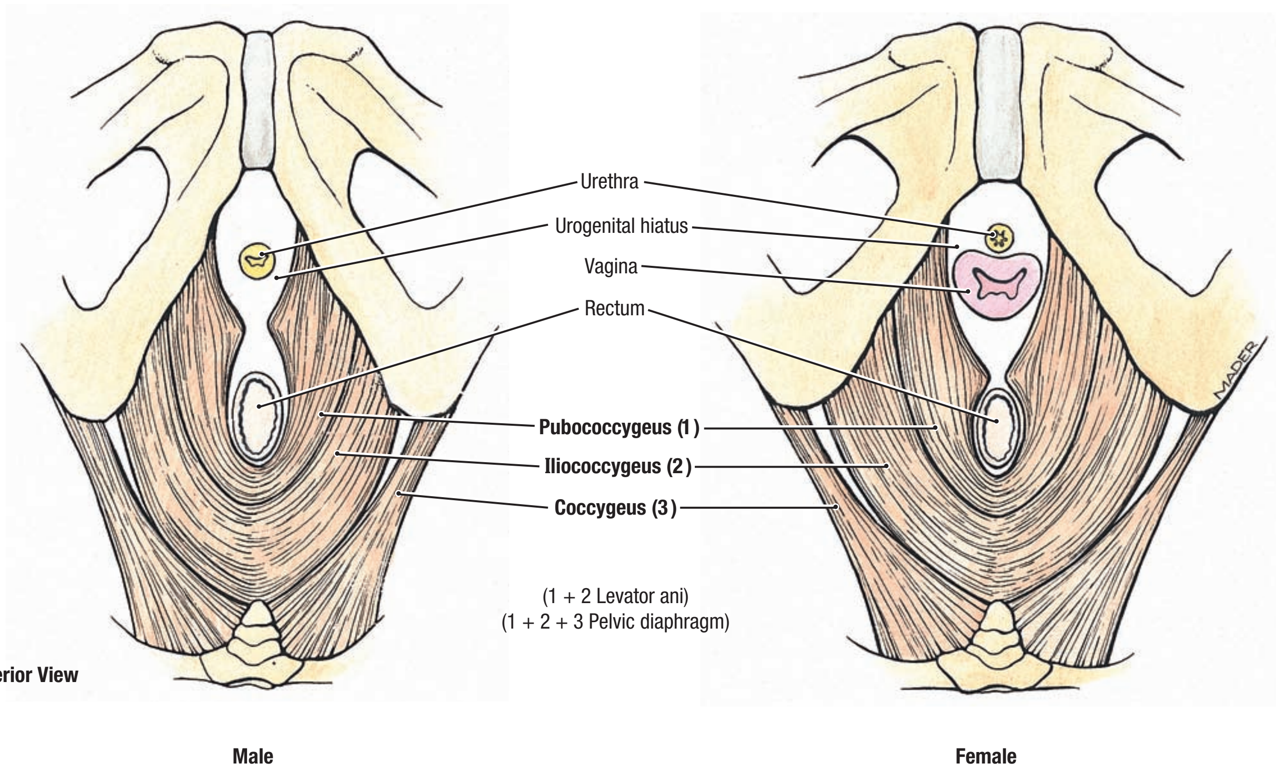
A. **Anterior View**



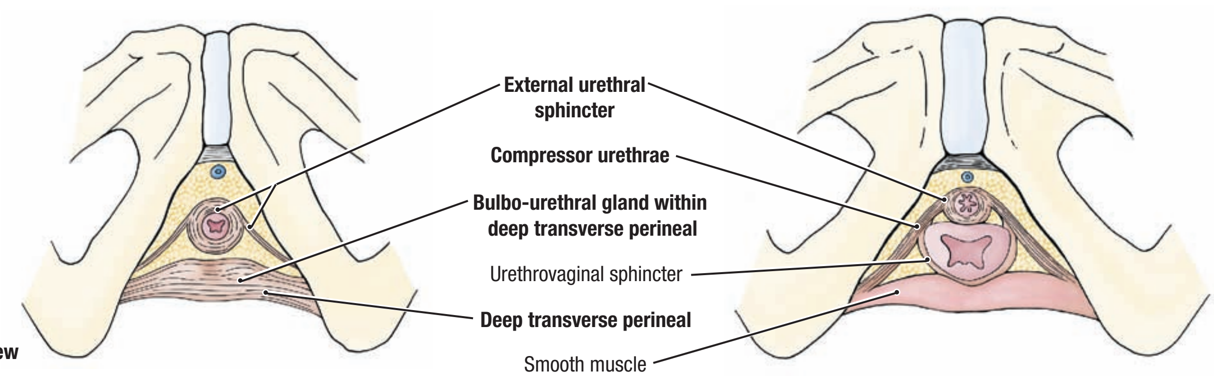
B. **Antero-inferior View (Lithotomy Position)**

3.48 SURFACE ANATOMY OF THE FEMALE PERINEUM

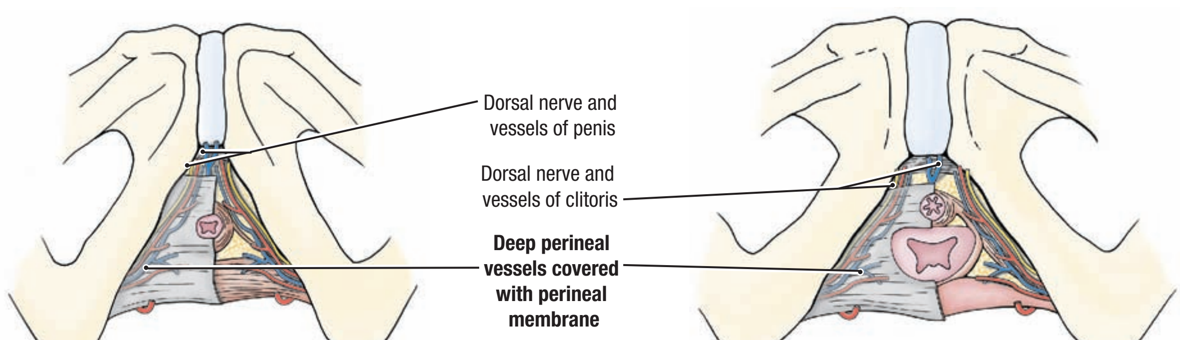
A. External genitalia (pudendum; vulva), standing position. **B.** Vestibule of vagina and the external urethral and vaginal orifices opening into it (recumbent position).



A. Inferior View



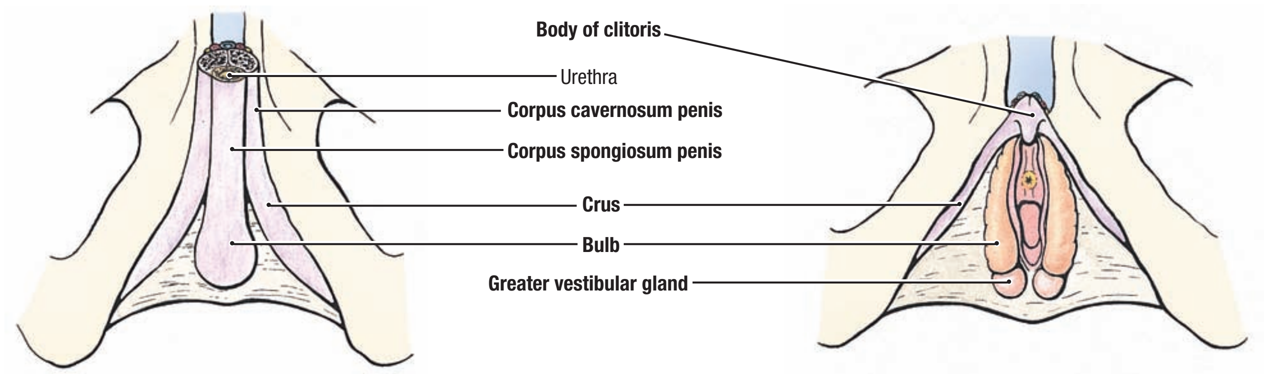
B. Inferior View



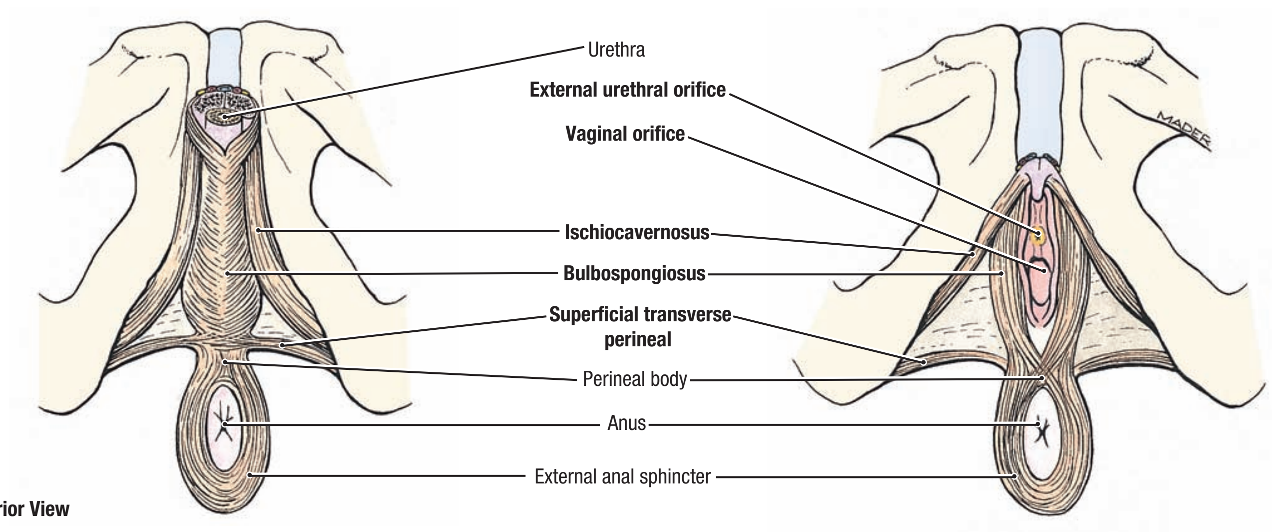
C. Inferior View

3.49 MALE AND FEMALE PERINEAL COMPARTMENTS

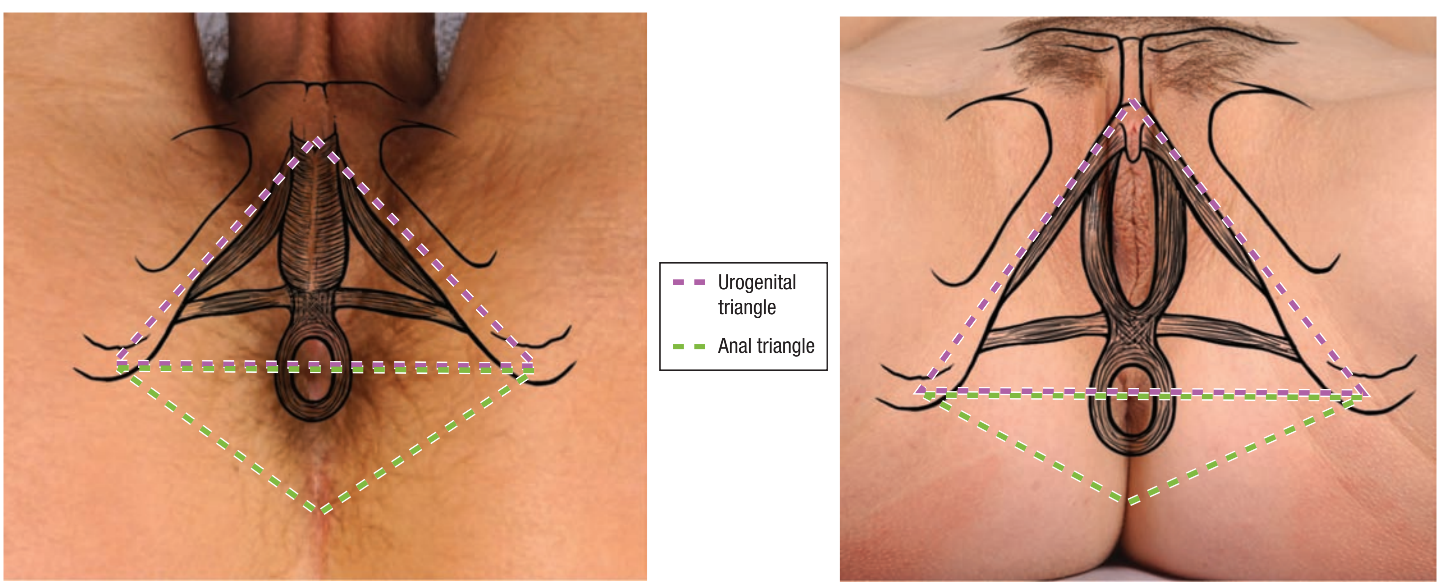
A.–F. Sequential demonstration of structures of the perineal compartments, from deep to superficial. **A.–C.** Deep perineal compartment (superior to perineal membrane). **A.** Pelvic diaphragm. **B.** Muscles of deep perineal compartment. **C.** Deep perineal vessels and nerves, covered by perineal membrane on right side.



D. Inferior View **Male** **Female**



E. Inferior View



F. Inferior View

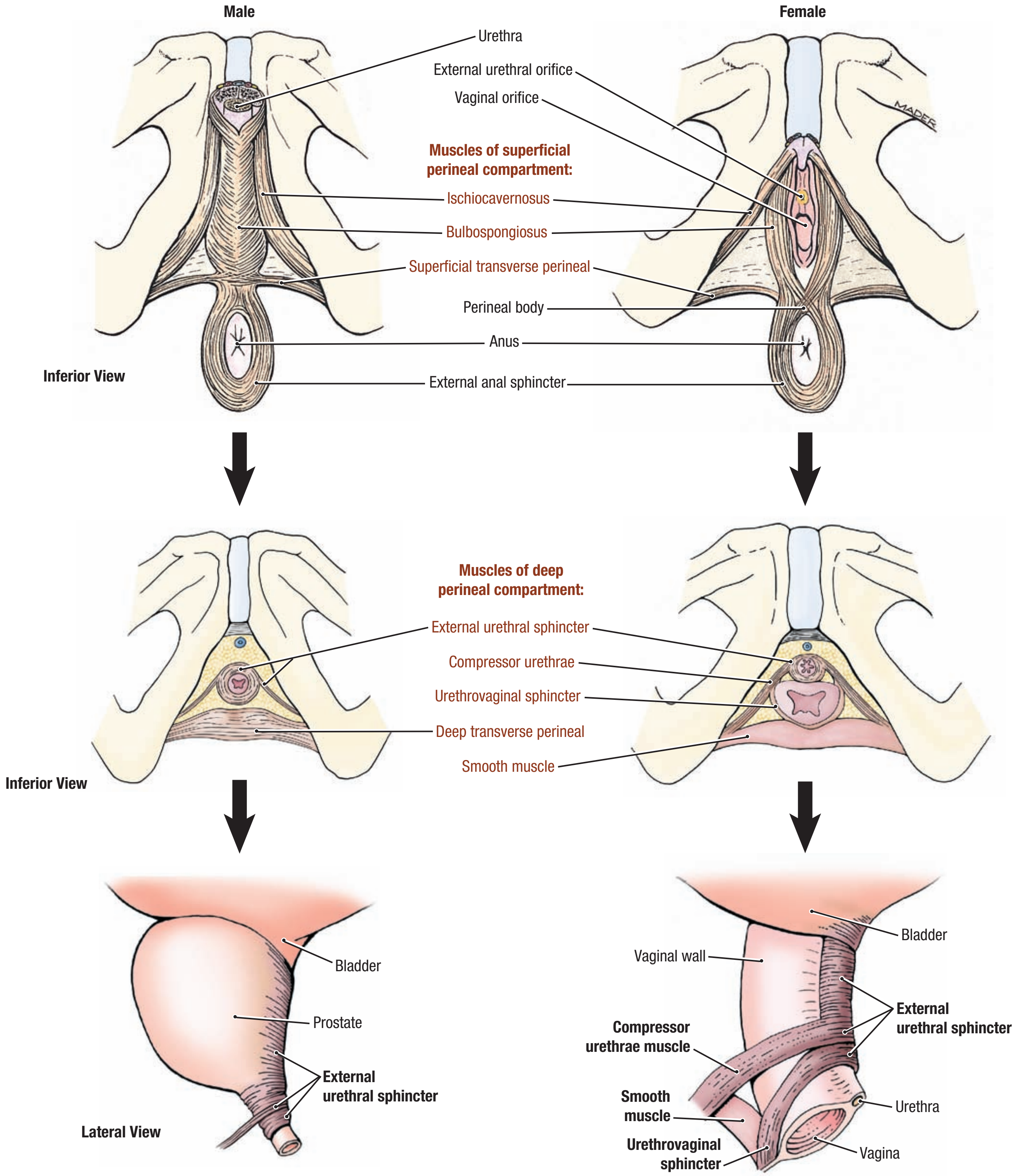
3.49 MALE AND FEMALE PERINEAL COMPARTMENTS *(CONTINUED)*

D.–F. Superficial perineal compartment (inferior to perineal membrane). **D.** Erectile bodies. **E.** Muscles of superficial perineal compartment. **F.** Superficial muscles imposed on surface anatomy of perineum.

TABLE 3.9 MUSCLES OF PERINEUM

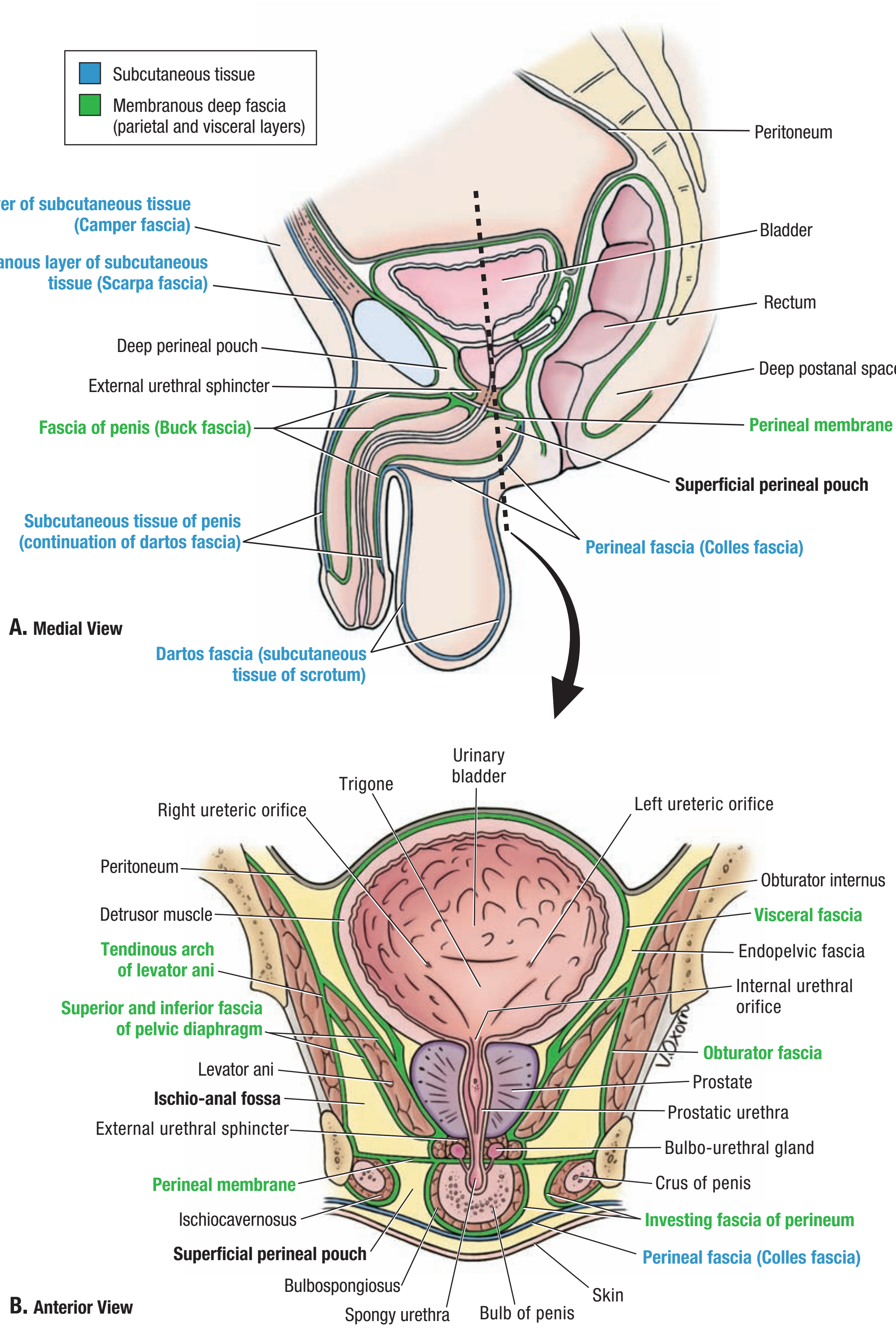
Muscle	Origin	Course and Insertion	Innervation	Main Action
External anal sphincter	Skin and fascia surrounding anus; coccyx via anococcygeal ligament	Passes around lateral aspects of anal canal; insertion into perineal body	Inferior anal (rectal) nerve, a branch of pudendal nerve (S2–S4)	Constricts anal canal during peristalsis, resisting defecation; supports and fixes perineal body and pelvic floor
Bulbospongiosus	*Male:* median raphe on ventral surface of bulb of penis; perineal body	*Male:* surrounds lateral aspects of bulb of penis and most proximal part of body of penis, inserting into perineal membrane, dorsal aspect of corpora spongiosum and cavernosa, and fascia of bulb of penis	Muscular (deep) branch of perineal nerve, a branch of the pudendal nerve (S2–S4)	*Male:* supports and fixes perineal body/pelvic floor; compresses bulb of penis to expel last drops of urine/semen; assists erection by compressing outflow via deep perineal vein and by pushing blood from bulb into body of penis
	Female: perineal body	*Female:* passes on each side of lower vagina, enclosing bulb and greater vestibular gland; inserts onto pubic arch and fascia of corpora cavernosa of clitoris		*Female:* supports and fixes perineal body/pelvic floor; "sphincter" of vagina; assists in erection of clitoris (and perhaps bulb of vestibule); compresses greater vestibular gland
Ischiocavernosus	Internal surface of ischiopubic ramus and ischial tuberosity	Embraces crus of penis or clitoris, inserting onto the inferior and medial aspects of the crus and to the perineal membrane medial to the crus		Maintains erection of penis or clitoris by compressing outflow veins and pushing blood from the root of penis or clitoris into the body of penis or clitoris
Superficial transverse perineal	Internal surface of ischiopubic ramus and ischial tuberosity	Passes along inferior aspect of posterior border of perineal membrane to perineal body		Supports and fixes perineal body (pelvic floor) to support abdominopelvic viscera and resist increased intra-abdominal pressure
Deep transverse perineal (male only)		Passes along superior aspect of posterior border of perineal membrane to perineal body, and external anal sphincter	Muscular (deep) branch of perineal nerve	
Smooth muscle (female only)	Ischiopubic rami	Passes to lateral wall of urethra and vagina	Autonomic nerves	Quantity of smooth muscle increases with age; function uncertain
External urethral sphincter		Surrounds urethra superior to perineal membrane; in males, also ascends anterior aspect of prostate	Dorsal nerve of penis or clitoris, terminal branch of pudendal nerve (S2–S4)	Compresses urethra to maintain urinary continence
Compressor urethrae (females only)	Internal surface of ischiopubic ramus	Continuous with external urethral sphincter		Compresses urethra; with pelvic diaphragm; assists in elongation of urethra
Urethrovaginal sphincter (females only)	Anterior side of urethra	Continuous with compressor urethrae; extends posteriorly on lateral wall of urethra and vagina to interdigitate with fibers from opposite side of perineal body		Compresses urethra and vagina

Oelrich TM. The urethral sphincter muscle in the male. *Am J Anat* 1980;158:229–246.
Oelrich TM. The striated urogenital sphincter muscle in the female. *Anat Rec* 1983;205:223–232.
Mirilas P, Skandalakis JE. Urogenital diaphragm: an erroneous concept casting its shadow over the sphincter urethrae and deep perineal space. *J Am Coll Surg* 2004;198:279–290.
DeLancey JO. Correlative study of paraurethral anatomy. *Obstet Gynecol* 1986;68:91–97.



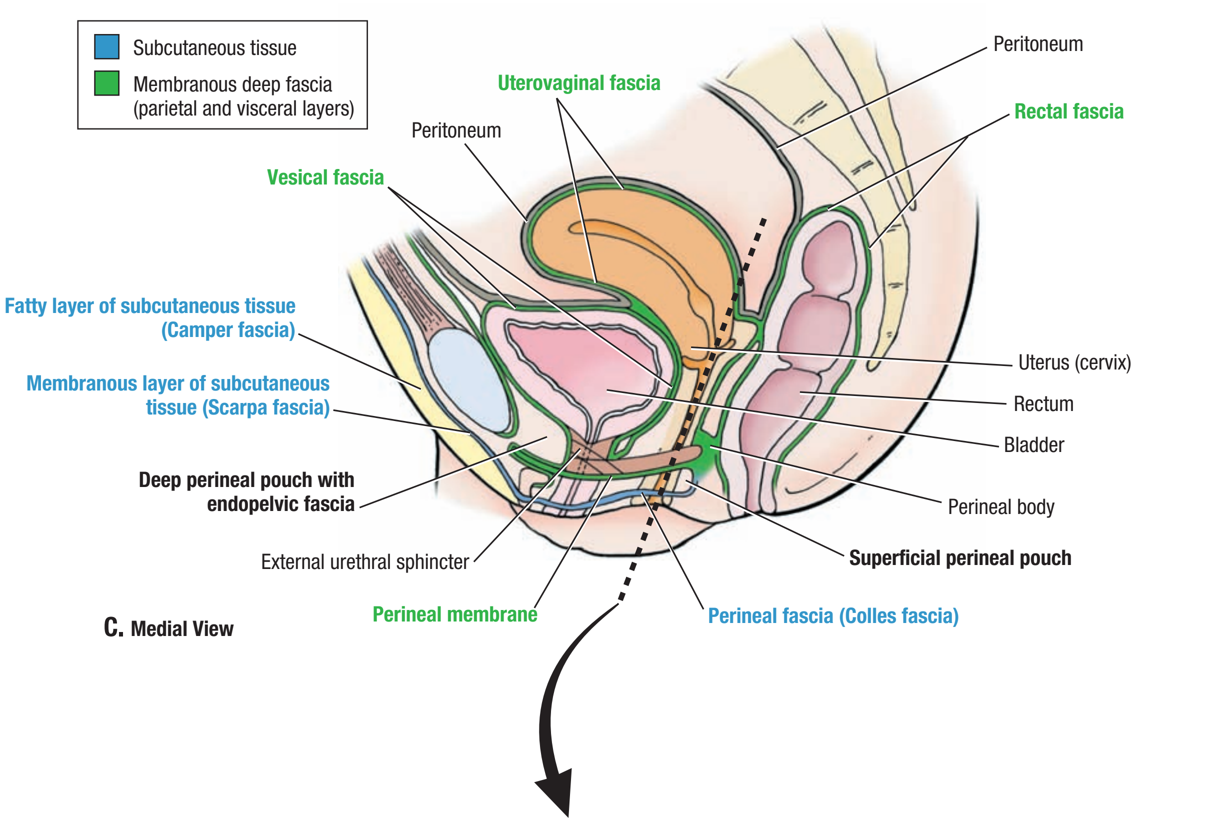
3.50 MUSCLES OF PERINEUM

A potential subcutaneous perineal space (pouch) lies between the membranous layer of the subcutaneous tissue of the perineum and the perineal fascia (investing fascia of the superficial perineal muscles). The superficial perineal compartment (pouch) is an enclosed compartment bounded inferiorly by the perineal fascia and superiorly by the perineal membrane. The deep compartment is bounded inferiorly by the perineal membrane and continues superiorly to the (inferior investing fascia of the) pelvic diaphragm (Oelich, 1980, 1983; DeLancy 1986; Mirilus, 2004).

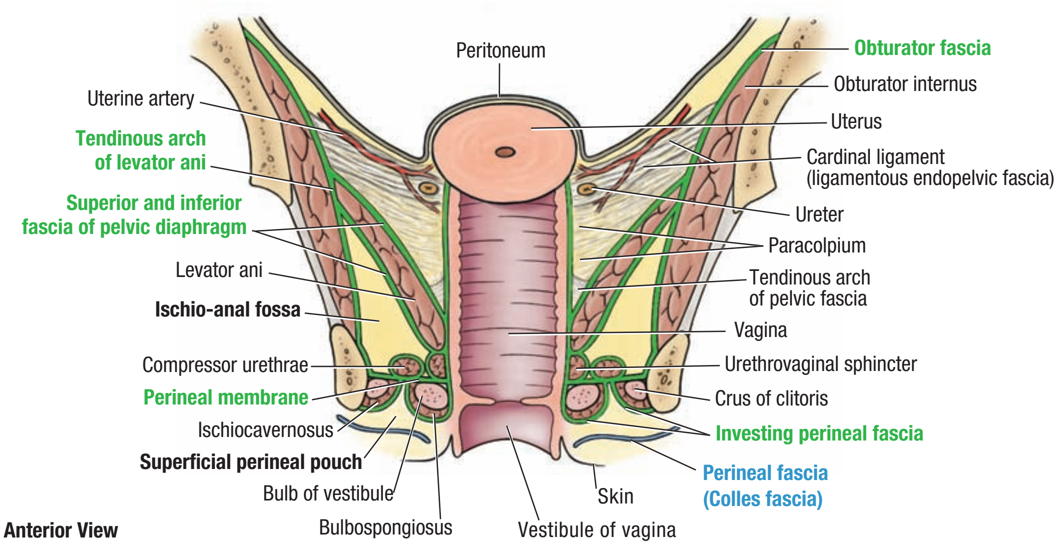


3.51 PERINEAL FASCIA AND PERINEAL COMPARTMENTS

A. Fascia of male perineum, median section. **B.** Compartments of male perineum, coronal section.



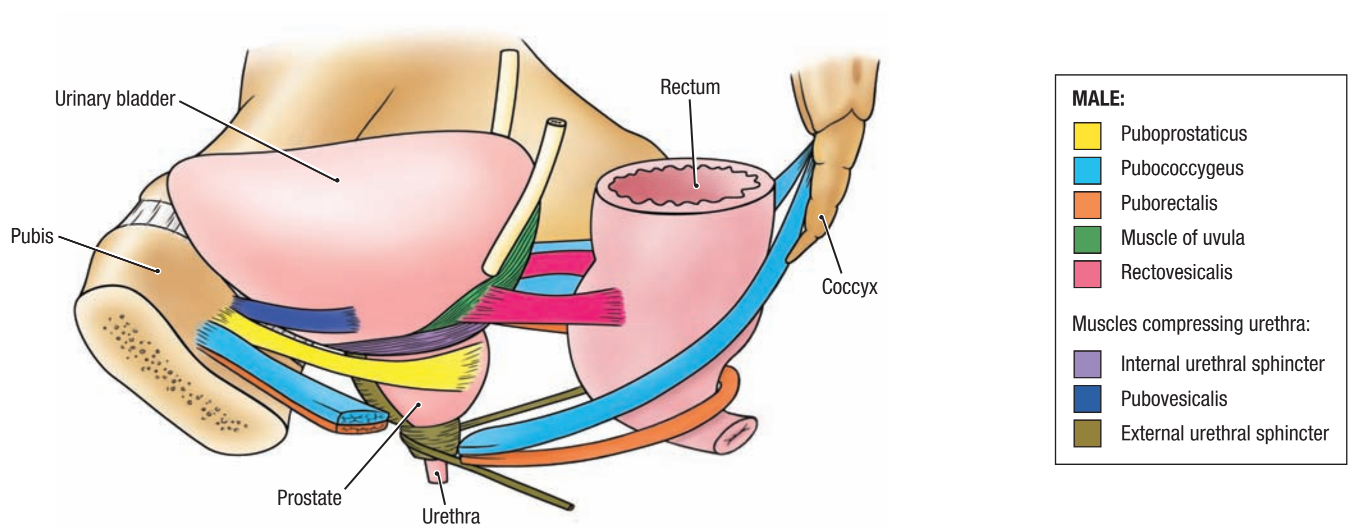
C. Medial View



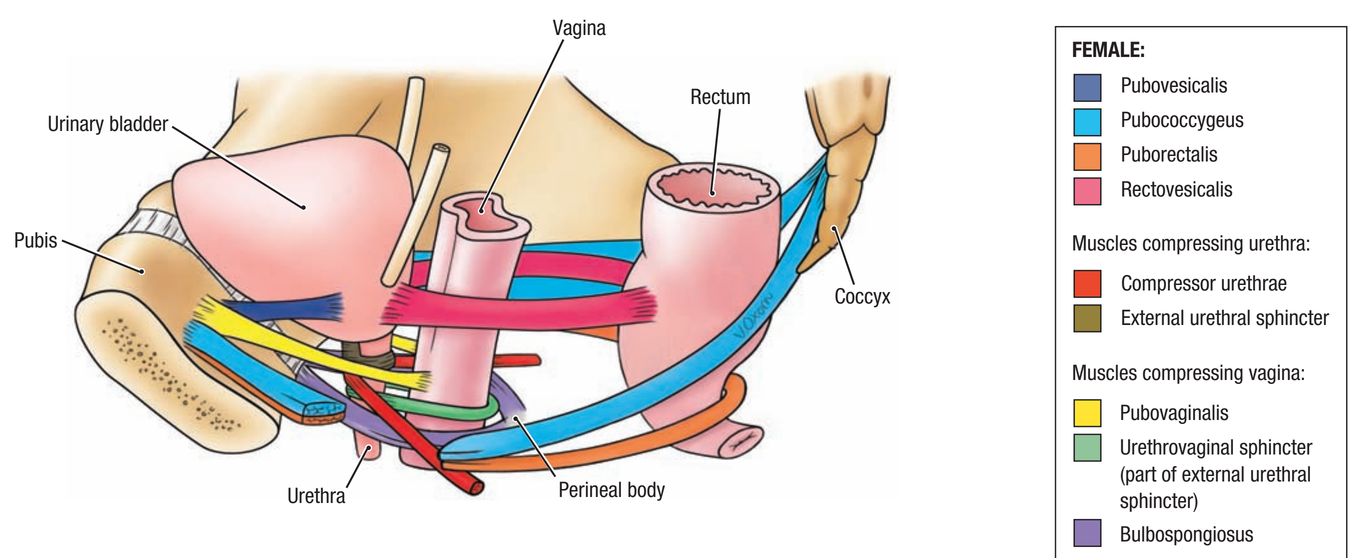
D. Anterior View

3.51 PERINEAL FASCIA AND PERINEAL COMPARTMENTS *(CONTINUED)*

C. Fascia of female perineum, median section. **D.** Compartments of female perineum, coronal section. Tendinous arch of levator ani = thickening of obturator fascia providing origin for levator ani; tendinous arch of pelvic fascia = thickening where somatic and parietal membranous pelvic fascias merge.



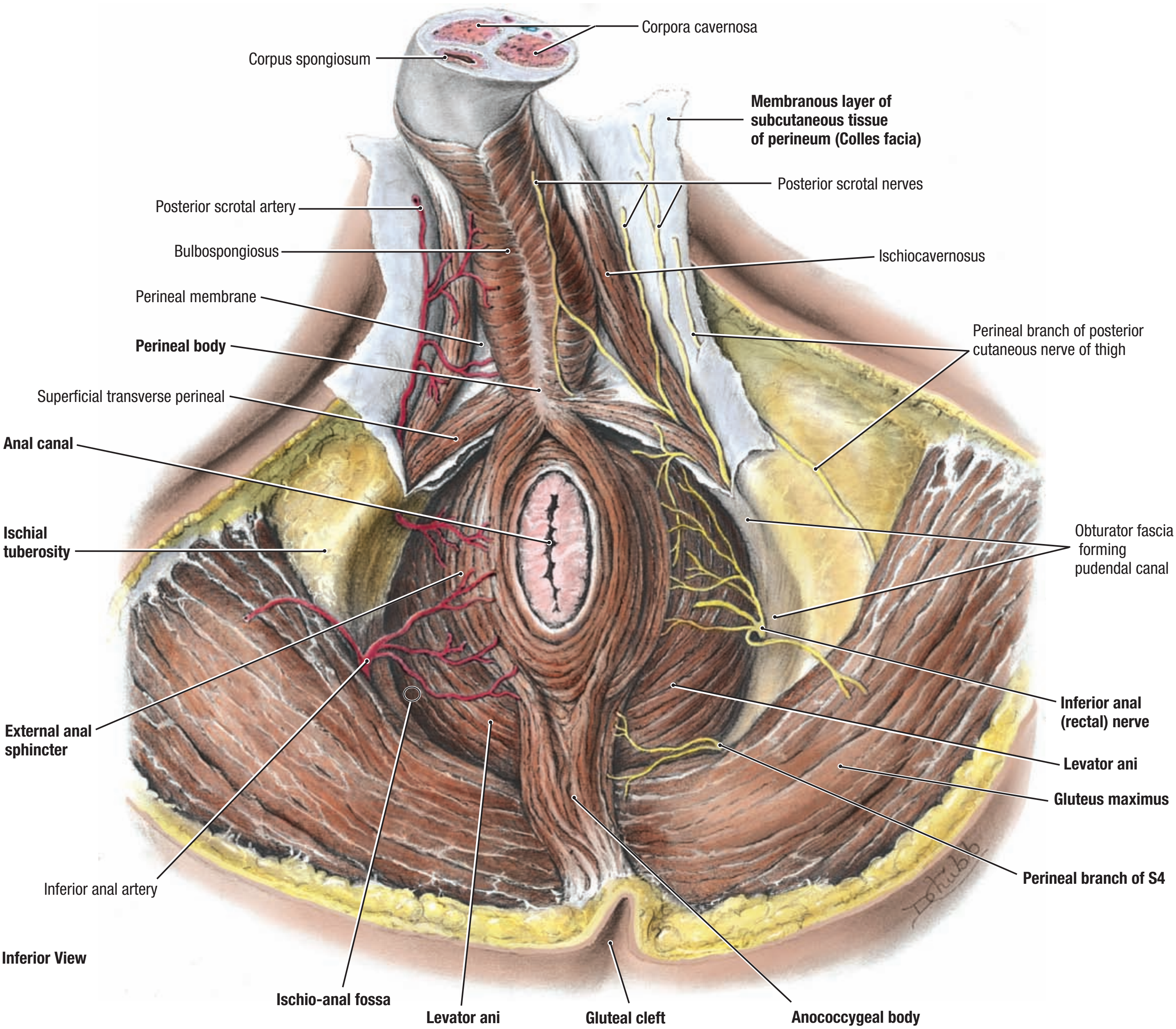
A. **Left Lateral View, Male**



B. **Left Lateral View, Female**

3.52 SUPPORTING AND COMPRESSOR/SPHINCTERIC MUSCLES OF PELVIS

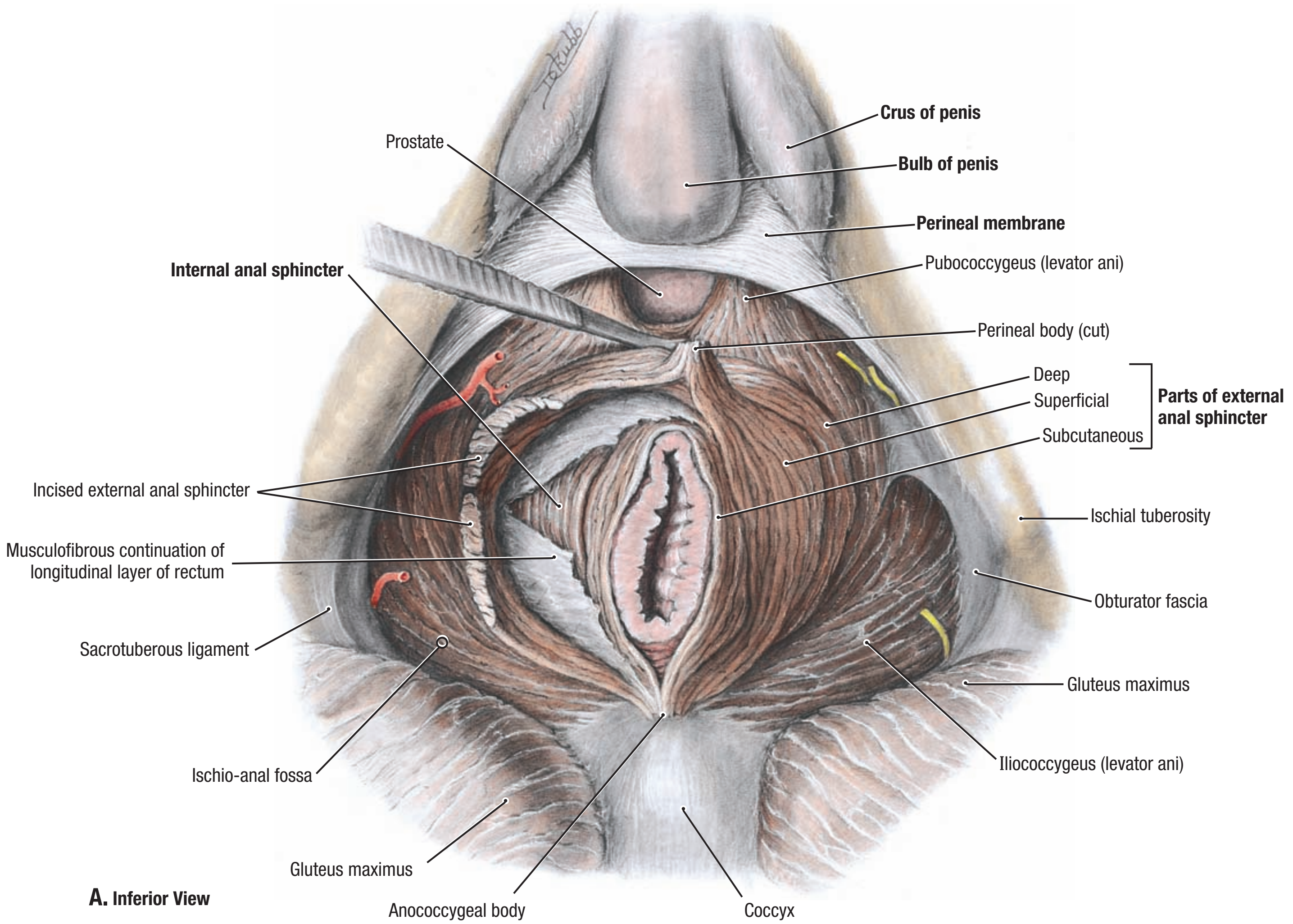
A. Male. **B.** Female.



3.53 DISSECTION OF MALE PERINEUM I

Superficial dissection.

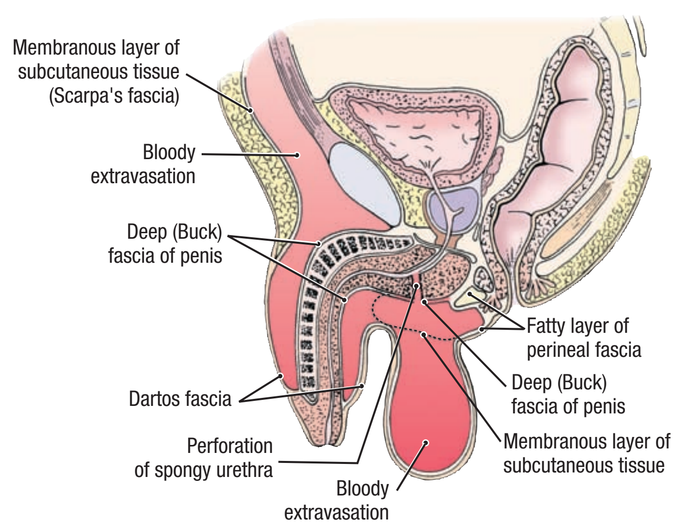
- The membranous layer of subcutaneous tissue of the perineum was incised and reflected, opening the subcutaneous perineal compartment (pouch) in which the cutaneous nerves course.
- The perineal membrane is exposed between the three paired muscles of the superficial compartment; although not evident here, the muscles are individually ensheathed with investing fascia.
- The anal canal is surrounded by the external anal sphincter. The superficial fibers of the sphincter anchor the anal canal anteriorly to the perineal body and posteriorly, via the anococcygeal body (ligament), to the coccyx and skin of the gluteal cleft.
- Ischio-anal (ischiorectal) fossae, from which fat bodies have been removed, lie on each side of the external anal sphincter. The fossae are also bound medially and superiorly by the levator ani, laterally by the ischial tuberosities and obturator internus fascia, and posteriorly by the gluteus maximus overlying the sacrotuberous ligaments. An anterior recess of each ischio-anal fossa extends superior to the perineal membrane.
- In the lateral wall of the fossa, the inferior anal (rectal) nerve emerges from the pudendal canal and, with the perineal branch of S4, supplies the voluntary external anal sphincter and perianal skin; most cutaneous twigs have been removed.



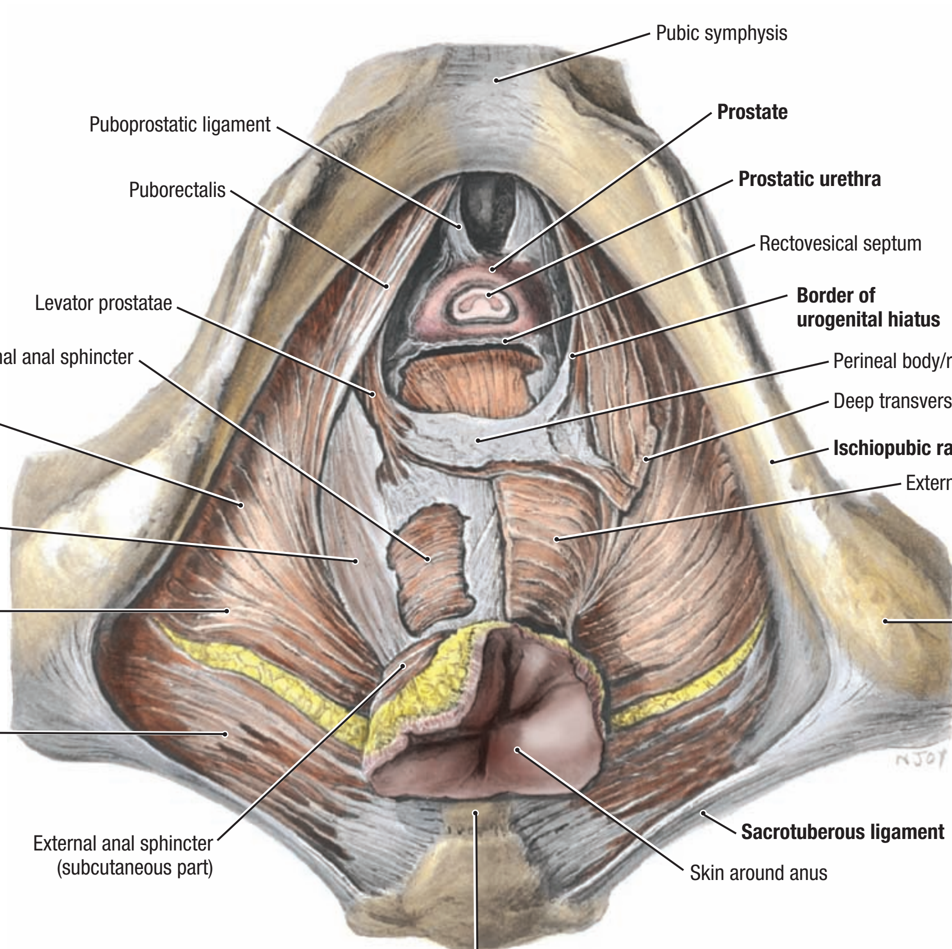
A. **Inferior View**

3.54 DISSECTION OF THE MALE PERINEUM II

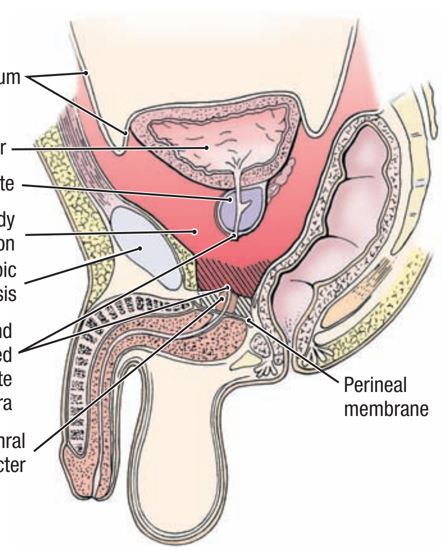
A. The superficial perineal muscles have been removed, revealing the roots of the erectile bodies (crura and bulb) of the penis, attached to the ischiopubic rami and perineal membrane. On the left side, the superficial and deep parts of the external anal sphincter were incised and reflected; the underlying musculofibrous continuation of the outer longitudinal layer of the muscular layer of the rectum is cut to reveal thickening of the inner circular layer that comprises the internal anal sphincter. **B. Rupture of the spongy urethra** in the bulb of the penis results in **extravasation** (abnormal passage) **of urine** into the subcutaneous perineal compartment. The attachments of the membranous layer of subcutaneous tissue determine the direction and restrictions of flow of the extravasated urine. Urine and blood may pass deep to the continuations of the membranous layer in the scrotum, penis, and inferior abdominal wall. The urine cannot pass laterally and inferiorly into the thighs because the membranous layer fuses with the fascia lata (deep fascia of the thigh), nor posteriorly into the anal triangle due to continuity with the perineal membrane and perineal body.



B. **Medial view (from left)**



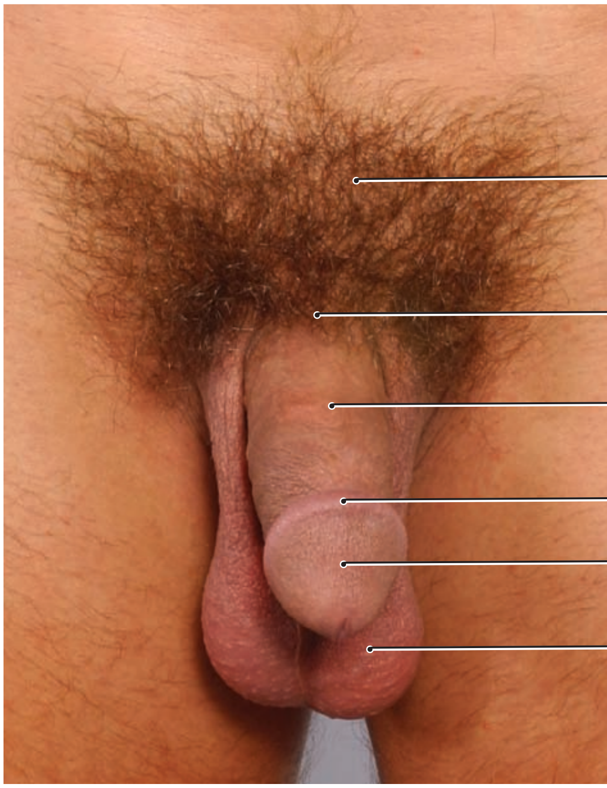
A. **Inferior View**

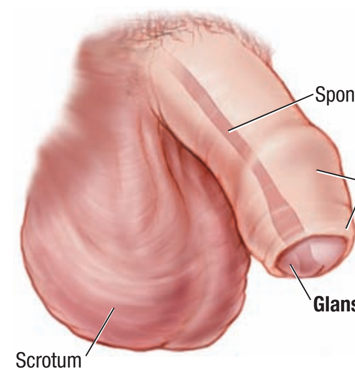


B. **Medial View (from left)**

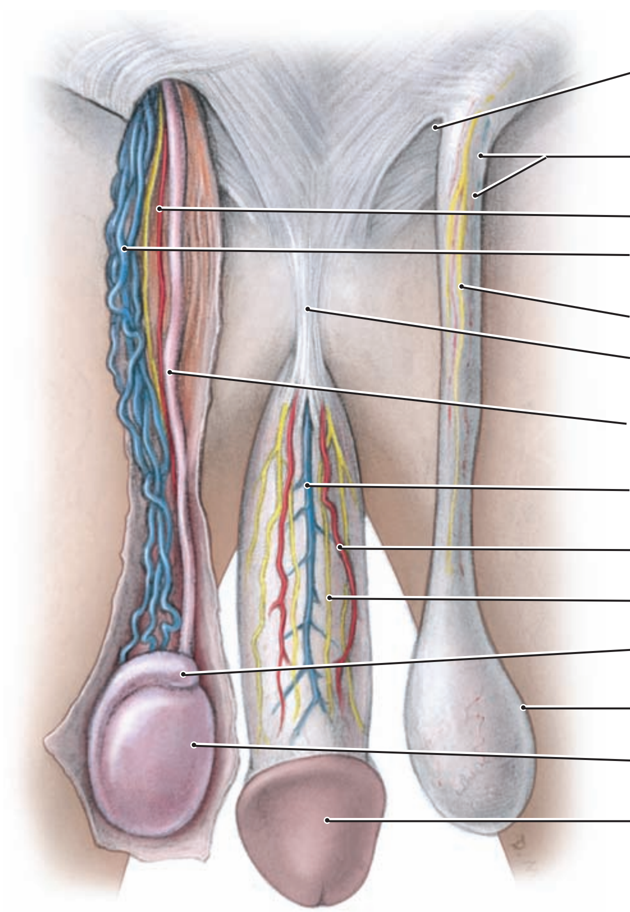
3.55 DISSECTION OF THE MALE PERINEUM III

A. The perineal membrane and structures superficial to it have been removed. The prostatic urethra, base of the prostate, and rectum are visible through the urogenital hiatus of the pelvic diaphragm. The osseofibrous boundaries are demonstrated. **B. Rupture of the intermediate part of the urethra** results in extravasation of urine and blood into the deep perineal compartment. The fluid may pass superiorly through the urogenital hiatus and distribute extraperitoneally around the prostate and bladder.





B. **Right Anterolateral View**



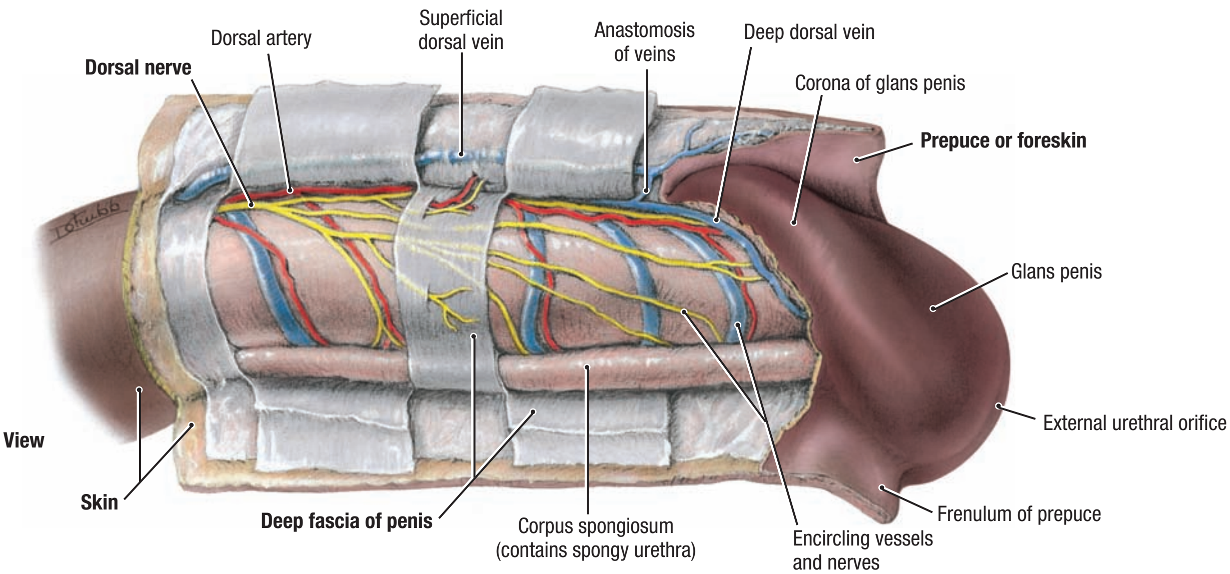
C. **Anterior View**

3.56 GLANS, PREPUCE, AND NEUROVASCULAR BUNDLE OF PENIS

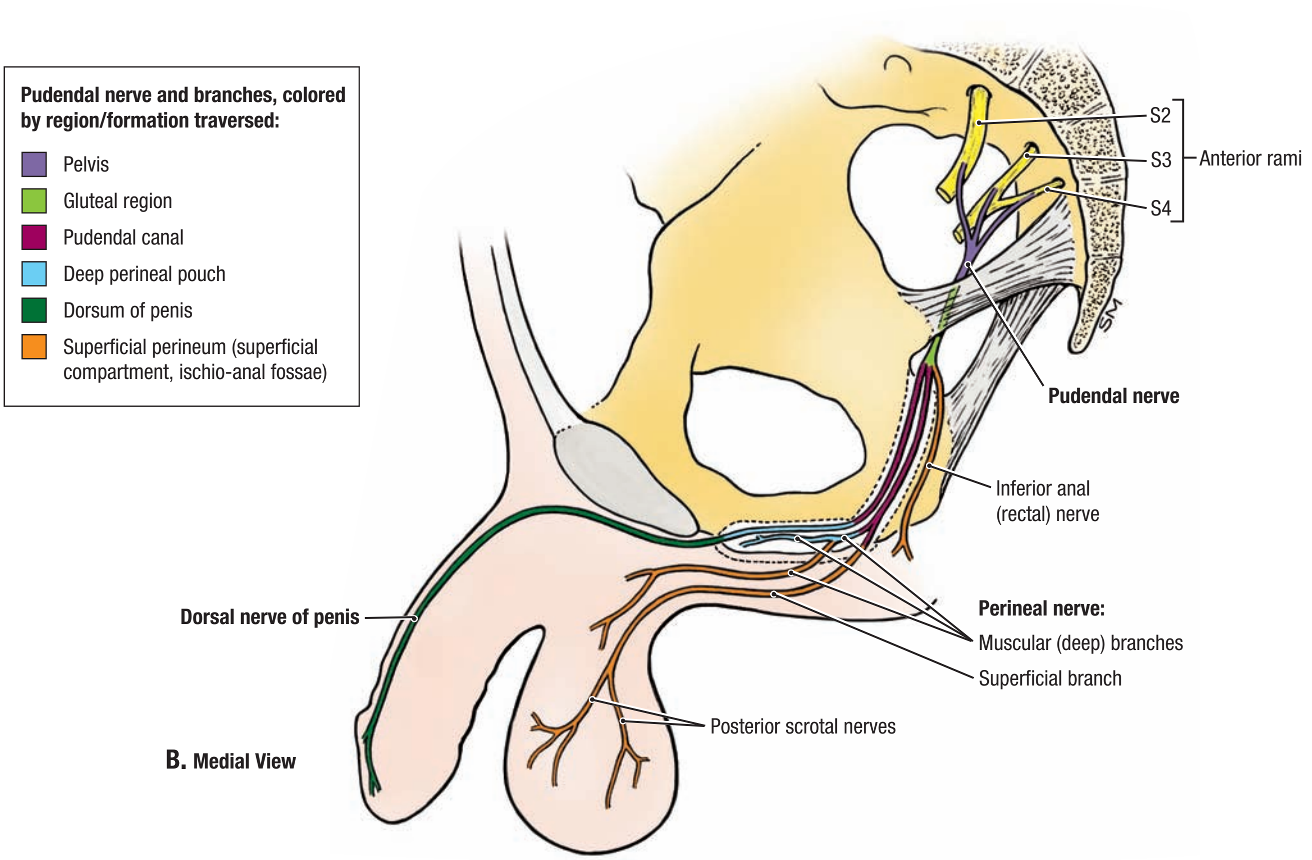
A. Surface anatomy, penis circumcised. **B.** Uncircumcised penis. **C.** Vessels and nerves of penis and contents of spermatic cord.

In **C:**

- The superficial and deep fasciae covering the penis are removed to expose the midline deep dorsal vein and the bilateral dorsal arteries and nerves of the penis. The triangular suspensory ligament of the penis attaches to the region of the pubic symphysis and blends with the deep fascia of the penis.
- On the specimen's left, the spermatic cord passes through the external inguinal ring and picks up a covering of external spermatic fascia from the margins of the superficial inguinal ring.
- On the specimen's right, the coverings of the spermatic cord and testis are incised and reflected, and the contents of the cord are separated.



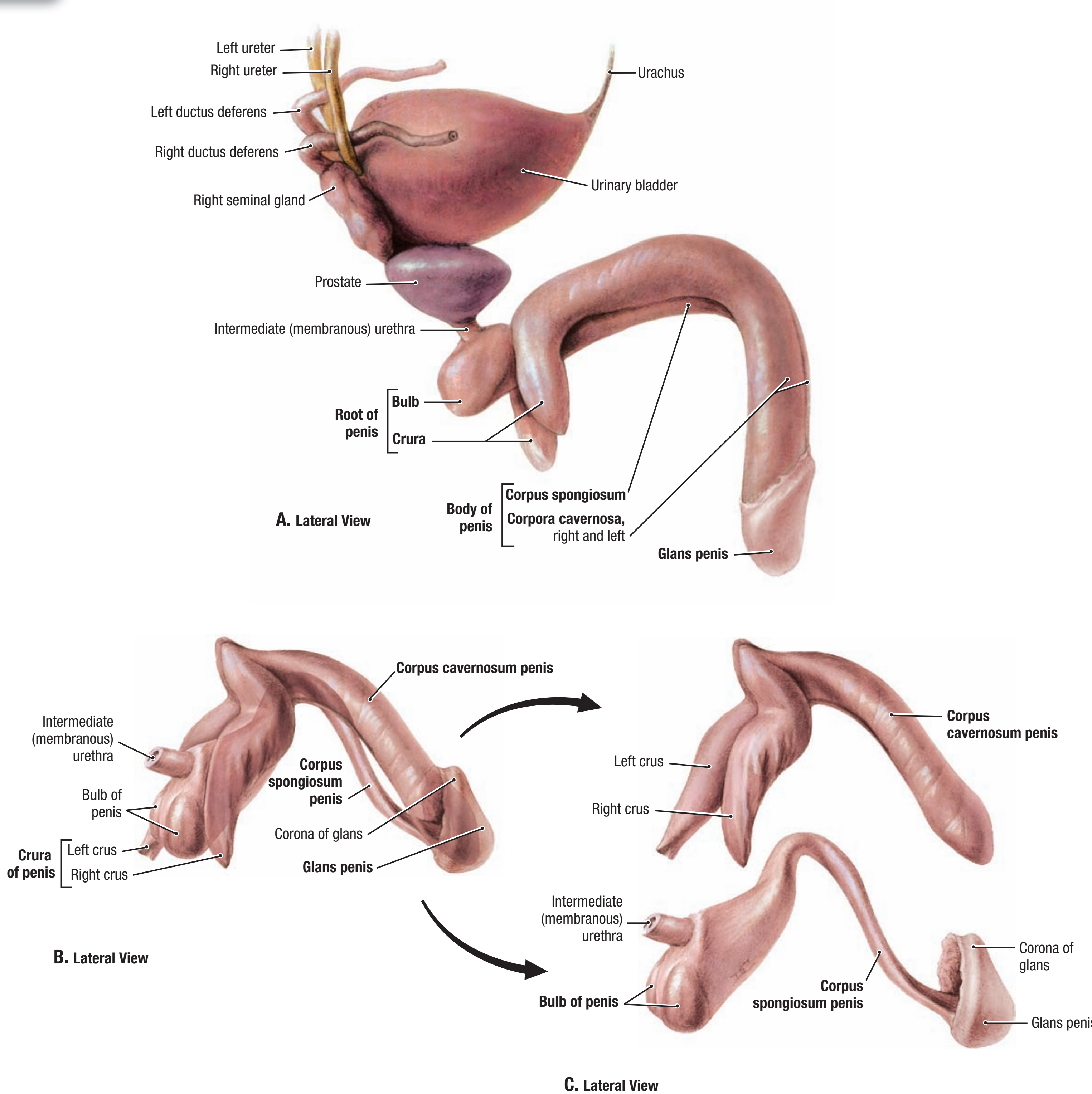
A. **Lateral View**



B. **Medial View**

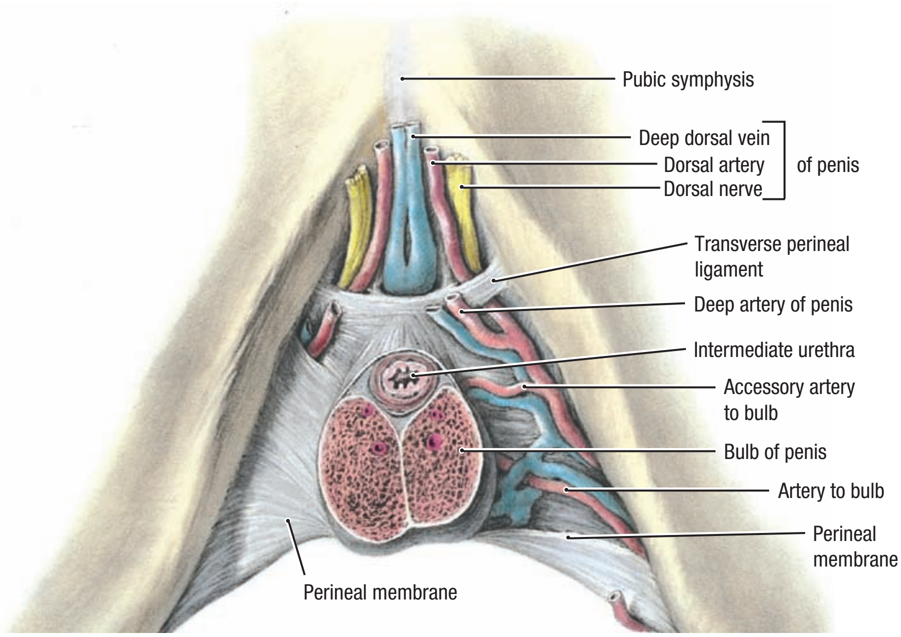
3.57 LAYERS AND NERVES OF PENIS

A. Dissection. The skin, subcutaneous tissue, and deep fascia of the penis and prepuce are reflected separately. **B.** Distribution of pudendal nerve, right hemipelvis. Five regions transversed by the nerve are demonstrated.

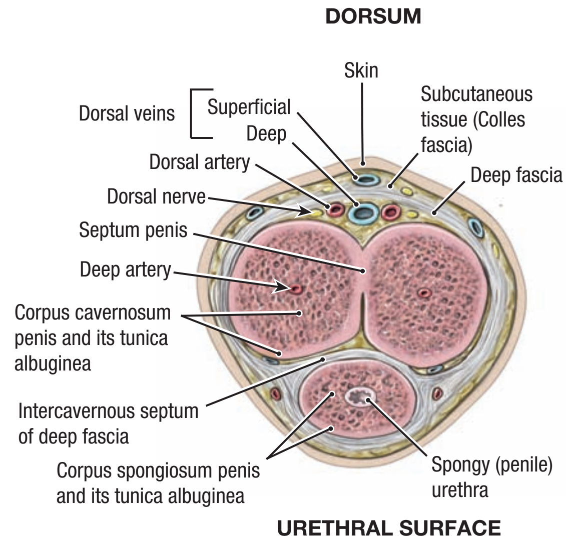


3.58 MALE UROGENITAL SYSTEM, ERECTILE BODIES

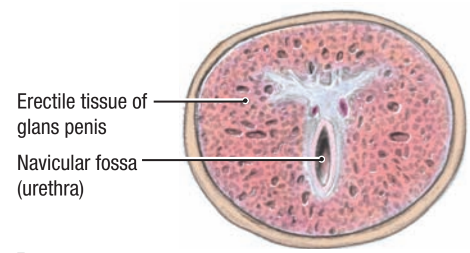
A. Pelvic components of genital and urinary tracts and erectile bodies of perineum. **B.** Dissection of male erectile bodies (corpora cavernosa and corpus spongiosum). **C.** Corpus spongiosum and corpora cavernosa, separated. The corpora cavernosa are bent where the penis is suspended by the suspensory ligament of the penis from the pubic symphysis. The corpus spongiosum extends posteriorly as the bulb of the penis and terminates anteriorly as the glans.



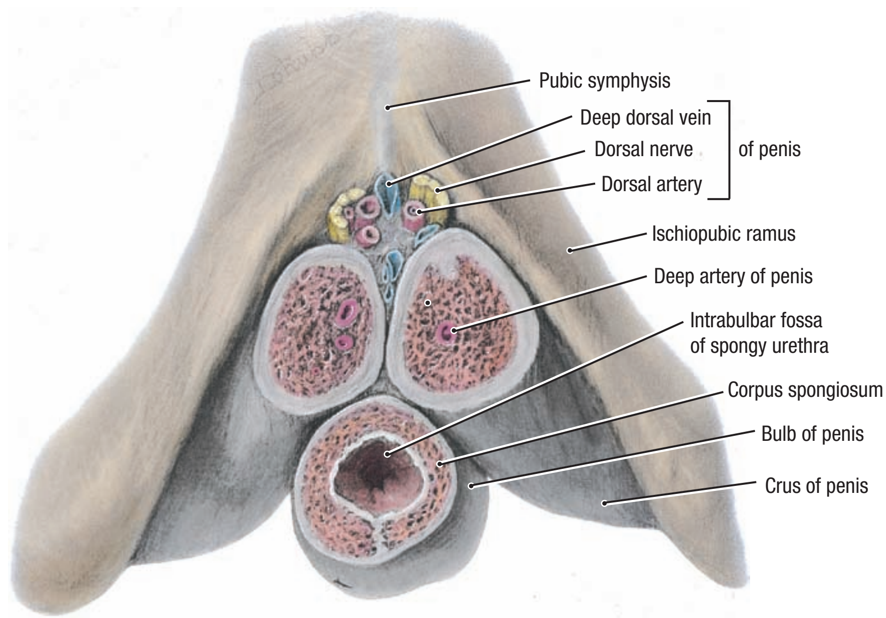
A. Anterior/Inferior View



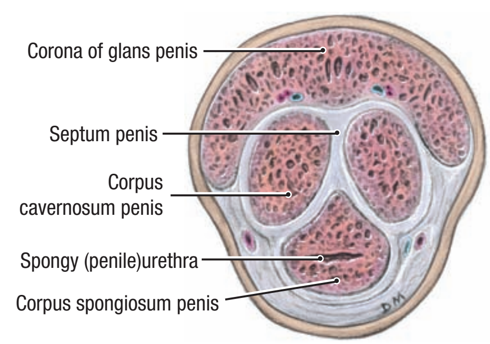
C. Transverse Section



D. Transverse Section



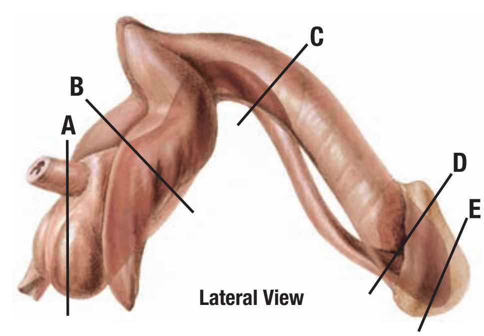
B. Anterior View

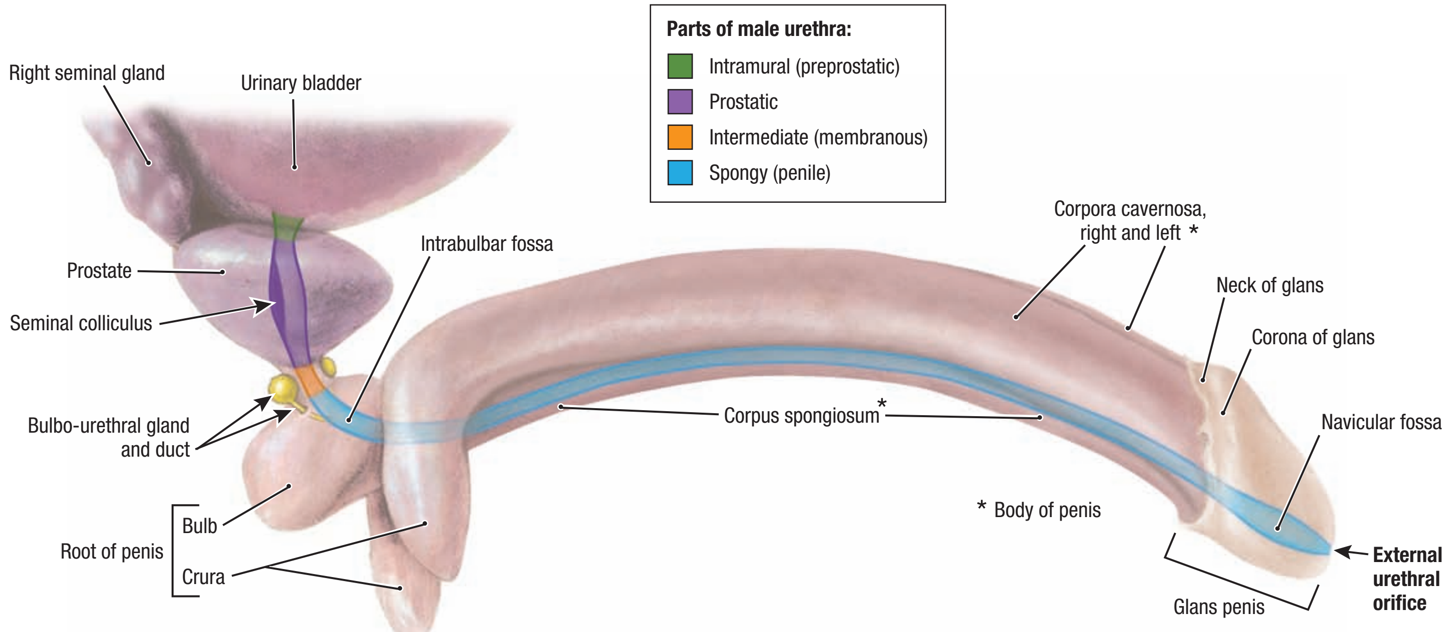


E. Transverse Section

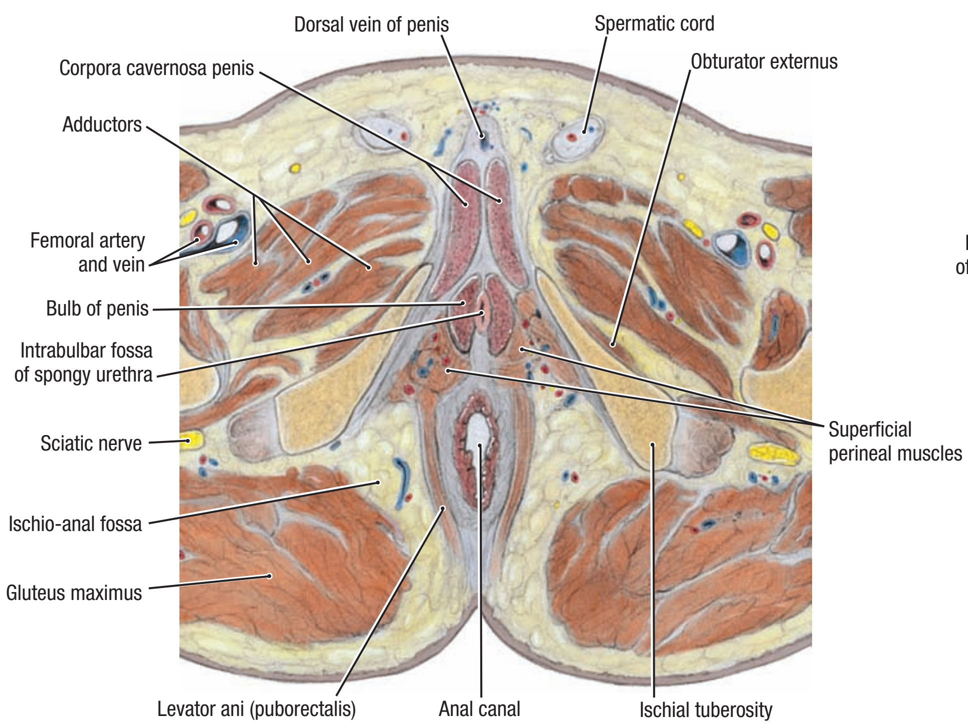
3.59 CROSS SECTIONS OF PENIS

A. Transverse section through bulb of penis with crura removed. The bulb is cut posterior to the entry of the intermediate urethra. On the left side, the perineal membrane is partially removed, opening the deep perineal compartment. **B.** The crura and bulb of penis have been sectioned obliquely. The spongy urethra is dilated within the bulb of the penis. **C.** Transverse section through body of penis. **D.** Transverse section through the proximal part of the glans penis. **E.** Transverse section through the distal part of the glans penis.

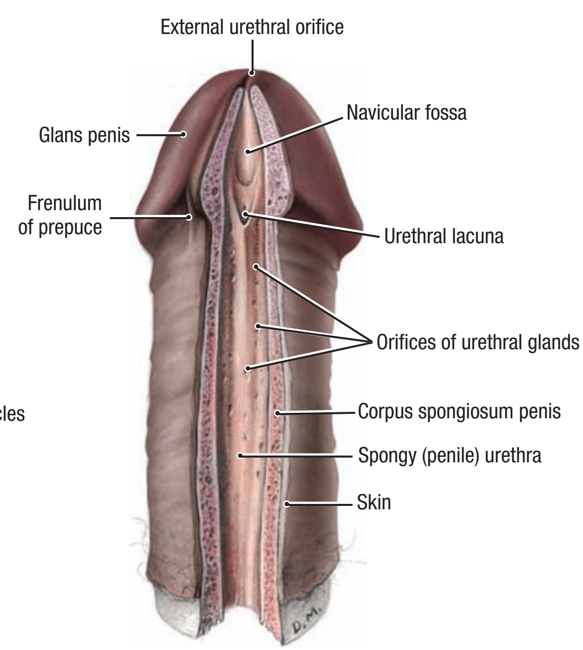




A. **Lateral View**



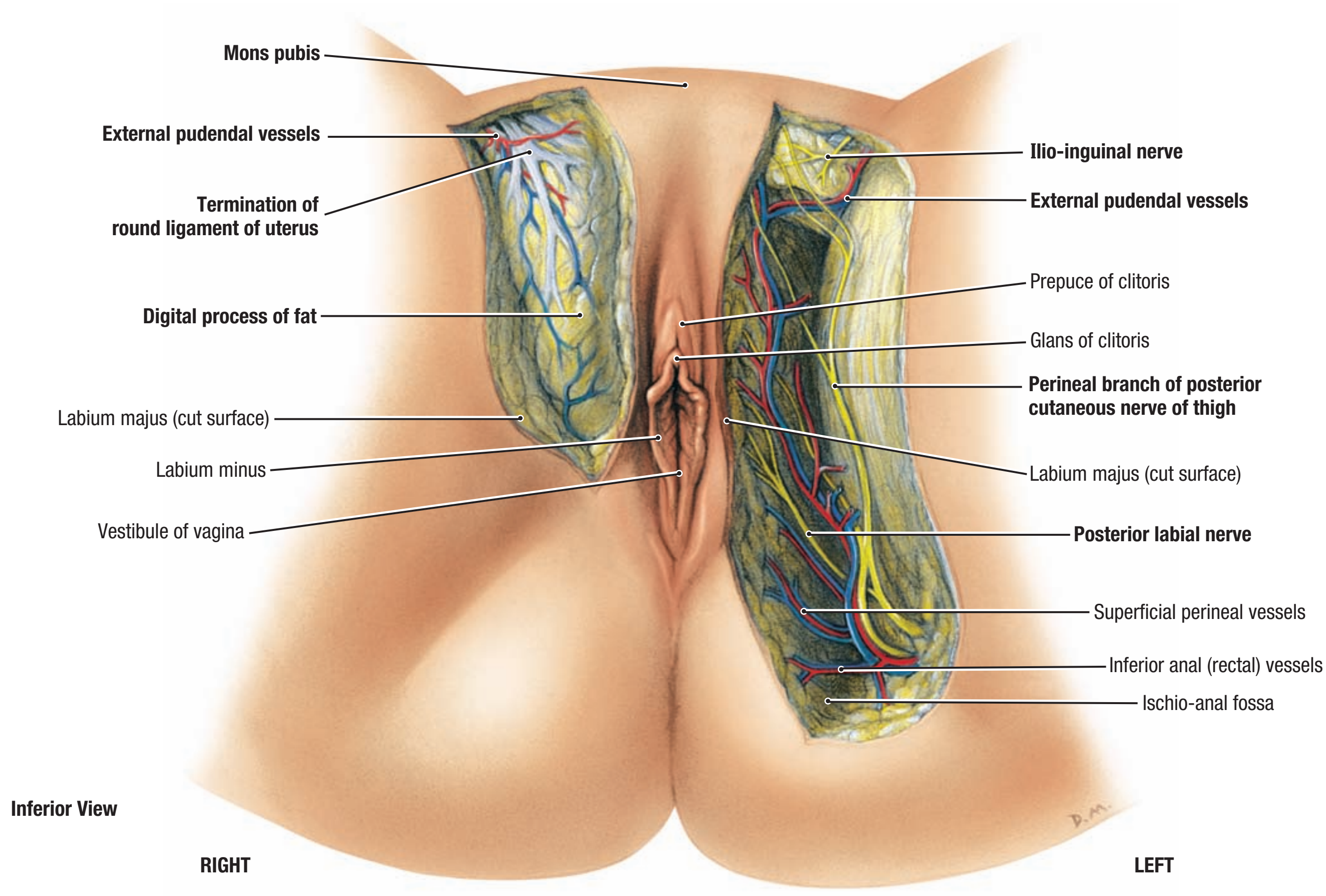
B. **Transverse Section, Inferior View**



C. **Urethal Aspect of Distal Penis**

3.60 URETHRA

A. Urethra and related structures. **B.** Transverse section of body passing through the bulb of the penis. **C.** Spongy urethra, interior. A longitudinal incision was made on the urethral surface of the penis and carried through the floor of the urethra, allowing a view of the dorsal surface of the interior of the urethra.



3.61 FEMALE PERINEUM I

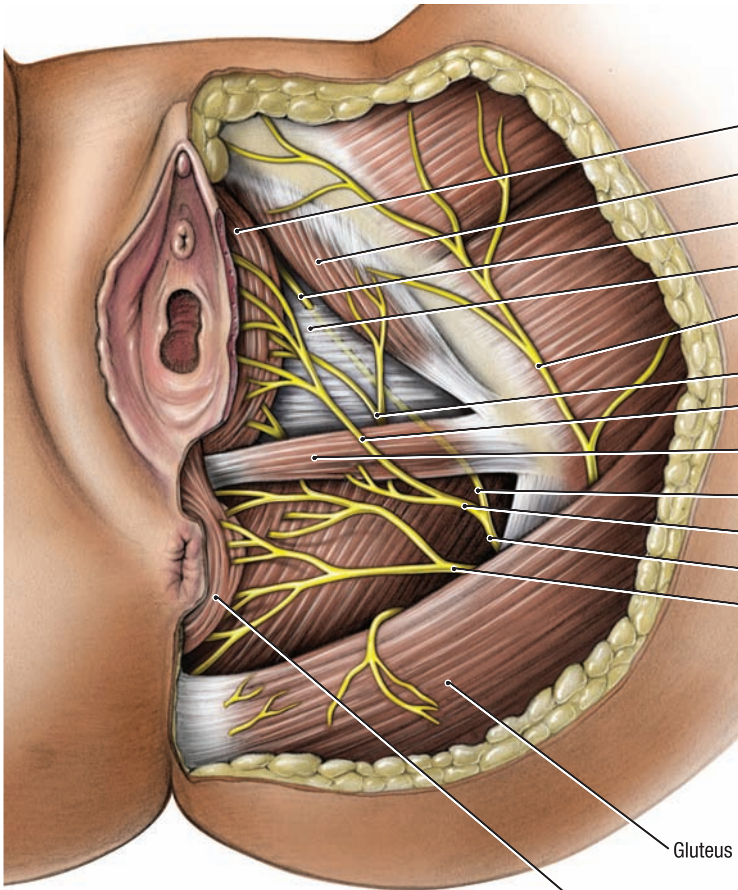
Superficial dissection.

On the right side of the specimen:

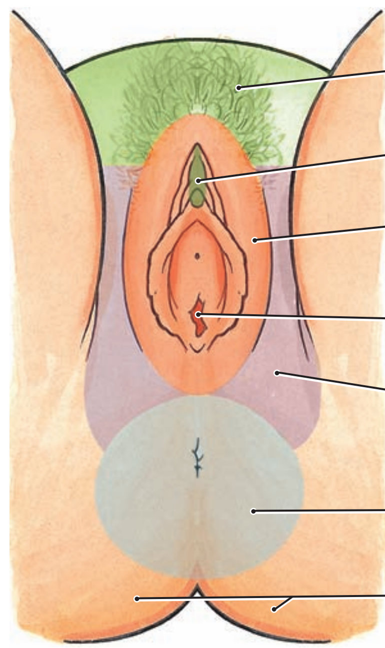
- A long digital process of fat lies deep to the fatty subcutaneous tissue and descends into the labium majus.
- The round ligament of the uterus ends as a branching band of fascia that spreads out superficial to the fatty digital process.

On the left side of the specimen:

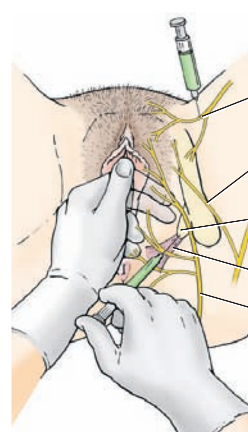
- Most of the fatty digital process is removed.
- The mons pubis is the rounded fatty prominence anterior to the pubic symphysis and bodies of the pubic bones.
- The posterior labial vessels and nerves (S2, S3) are joined by the perineal branch of the posterior cutaneous nerve of thigh (S1, S2, S3) and run anterior to the mons pubis. At the mons pubis, the vessels anastomose with the external pudendal vessels, and the nerves overlap in supply with the ilio-inguinal nerve (L1).



A. **Inferior View**



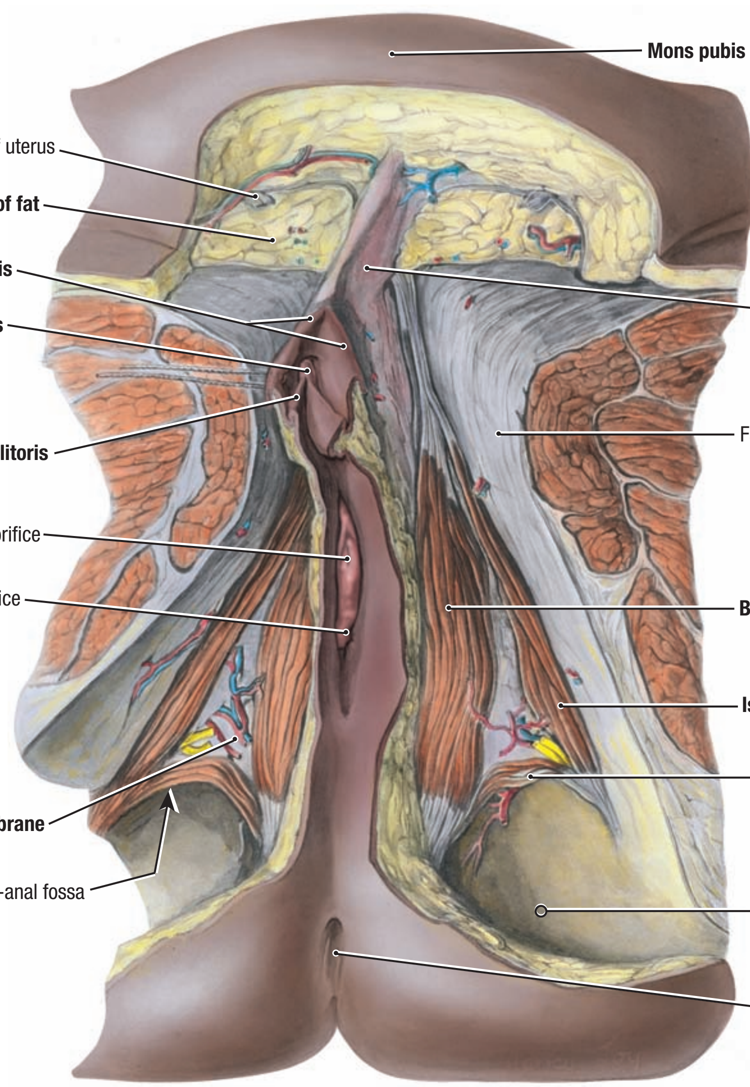
B. **Inferior View**



C. **Inferior View**

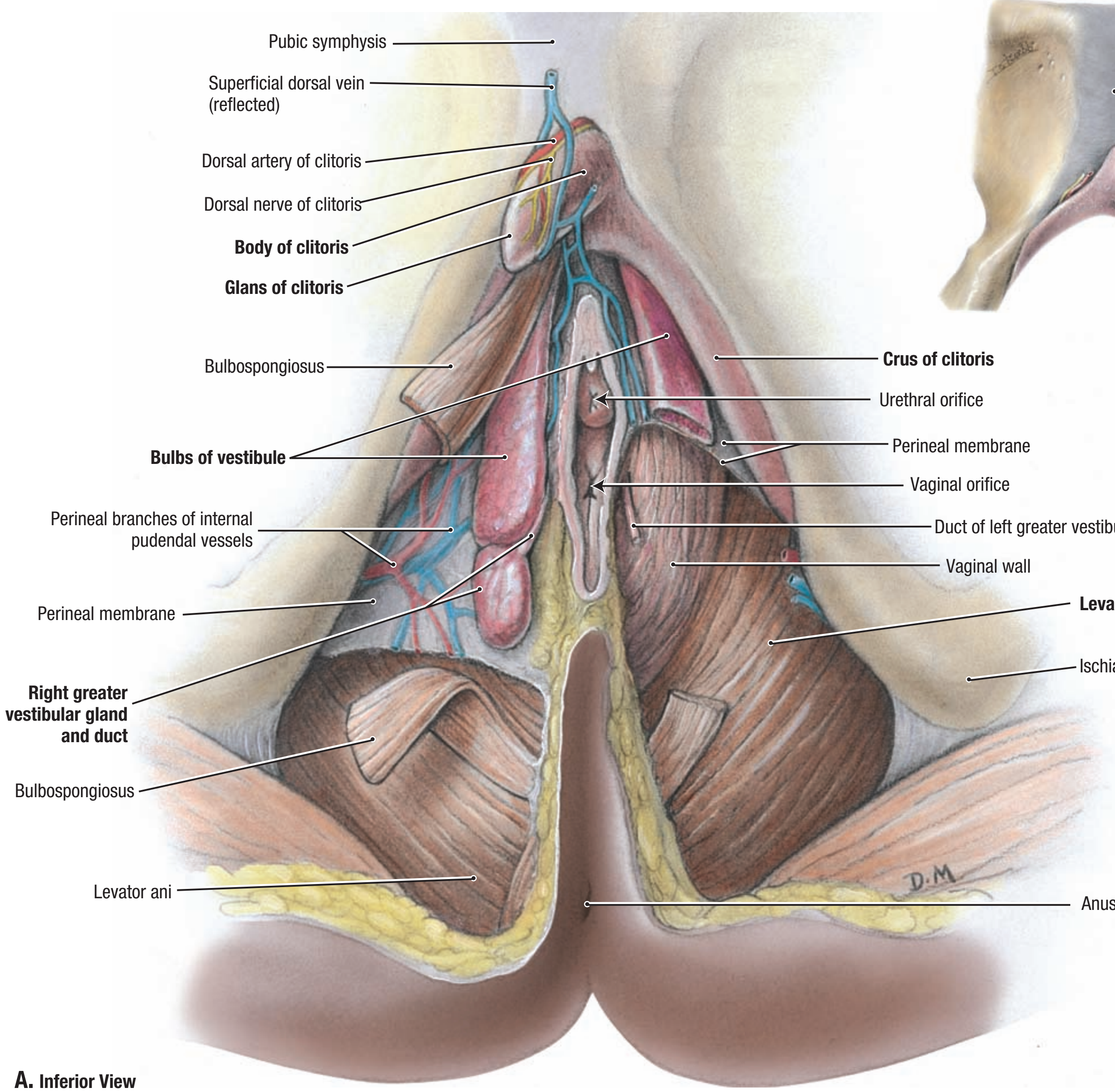
3.62 INNERVATION OF THE FEMALE PERINEUM

A. and B. The anterior aspect of the perineum is supplied by anterior labial nerves, derived from the ilio-inguinal nerve and genital branch of the genitofemoral nerve. The pudendal nerve is the main nerve of the perineum. Posterior labial nerves, derived from the superficial perineal nerve, supply most of the vulva. The deep perineal nerve supplies the orifice of the vagina and superficial perineal muscles; and the dorsal nerve of the clitoris supplies deep perineal muscles and sensations to the clitoris. The inferior anal (rectal) nerve, also from the pudendal nerve, innervates the external anal sphincter and the perianal skin. The lateral perineum is supplied by the perineal branch of the posterior cutaneous nerve of the thigh. **C.** To relieve the pain experienced during childbirth, **pudendal nerve block anesthesia** may be performed by injecting a local anesthetic agent into the tissue surrounding the pudendal nerve, near the ischial spine. A pudendal nerve block does not abolish sensations from the anterior and lateral parts of the perineum. Therefore, **an anesthetic block of the ilio-inguinal and/or perineal branch of the posterior cutaneous nerve of the thigh** may also need to be performed.

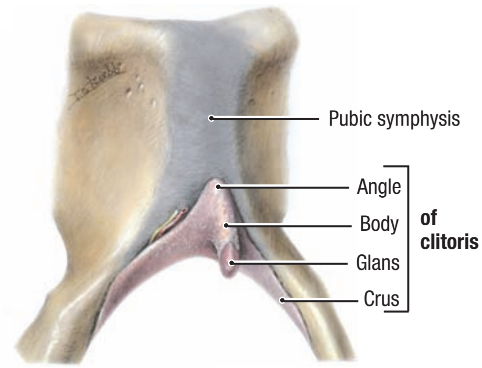


3.63 FEMALE PERINEUM II

- Note the thickness of the subcutaneous fatty tissue of the mons pubis and the encapsulated digital process of fat deep to this. The suspensory ligament of the clitoris descends from the linea alba.
- Anteriorly, each labium minus forms two laminae or folds: the lateral laminae of the labia pass on each side of the glans clitoris and unite, forming a hood that partially or completely covers the glans, the prepuce (foreskin) of the clitoris. The medial laminae of the labia merge posterior to the glans, forming the frenulum of the clitoris.
- There are three muscles on each side: bulbospongiosus, ischiocavernosus, and superficial transverse perineal; the perineal membrane is visible between them.
- The bulbospongiosus muscle overlies the bulb of the vestibule and the great vestibular gland. In the male, the muscles of the two sides are united by a median raphe; in the female, the orifice of the vagina separates the right from the left.



A. **Inferior View**



B

3.64 FEMALE PERINEUM III

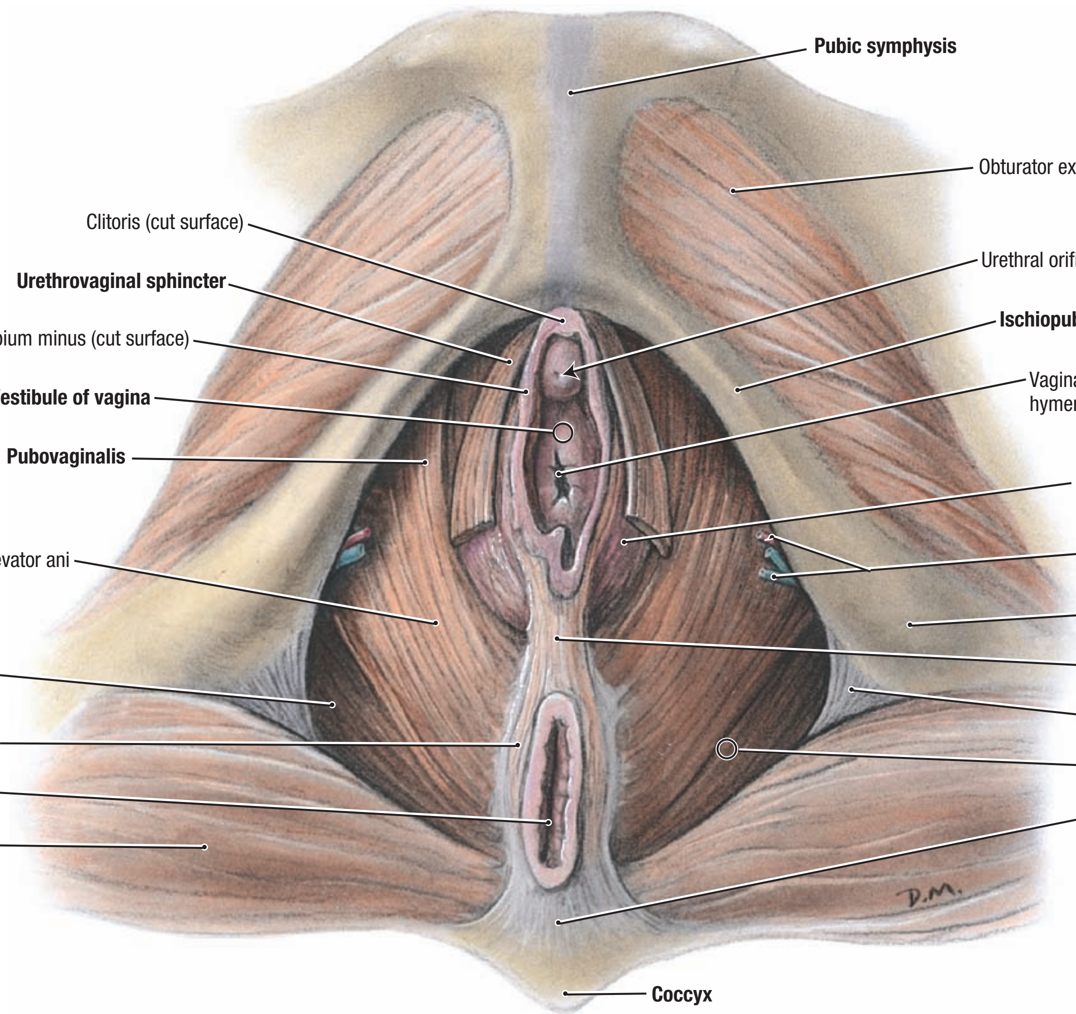
A. Deeper dissection. **B.** Clitoris.

In **A:**

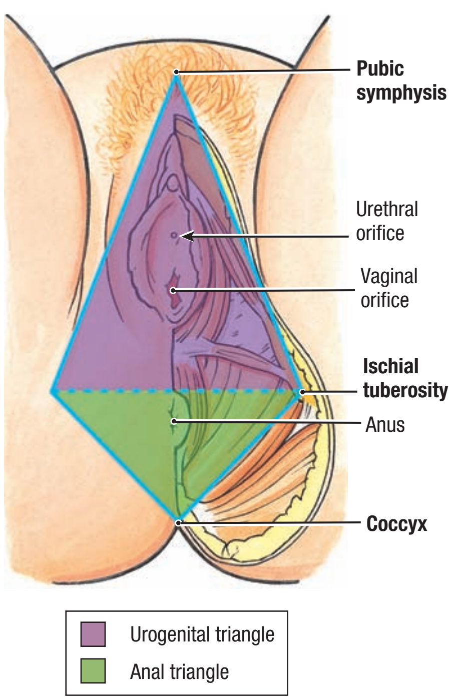
- The bulbospongiosus muscle is reflected on the right side and mostly removed on the left side; the posterior portion of the bulb of the vestibule and the greater vestibular gland have been removed on the left side.
- The glans and body of the clitoris is displaced to the right so that the distribution of the dorsal vessels and nerve of the clitoris can be seen.
- Homologues of the bulb of the penis, the bulbs of the vestibule exist as two masses of elongated erectile tissue that lie along the sides of the vaginal orifice; veins connect the bulbs of the vestibule to the glans of the clitoris.
- On the specimen's right side, the greater vestibular gland is situated at the posterior end of the bulb; both structures are covered by bulbospongiosus muscle.
- On the specimen's left side, the bulb, gland, and perineal membrane are cut away, thereby revealing the external aspect of the vaginal wall.

In **B:**

- The body of the clitoris, composed of two crura (corpora cavernosa), is capped by the glans.



A. Inferior View



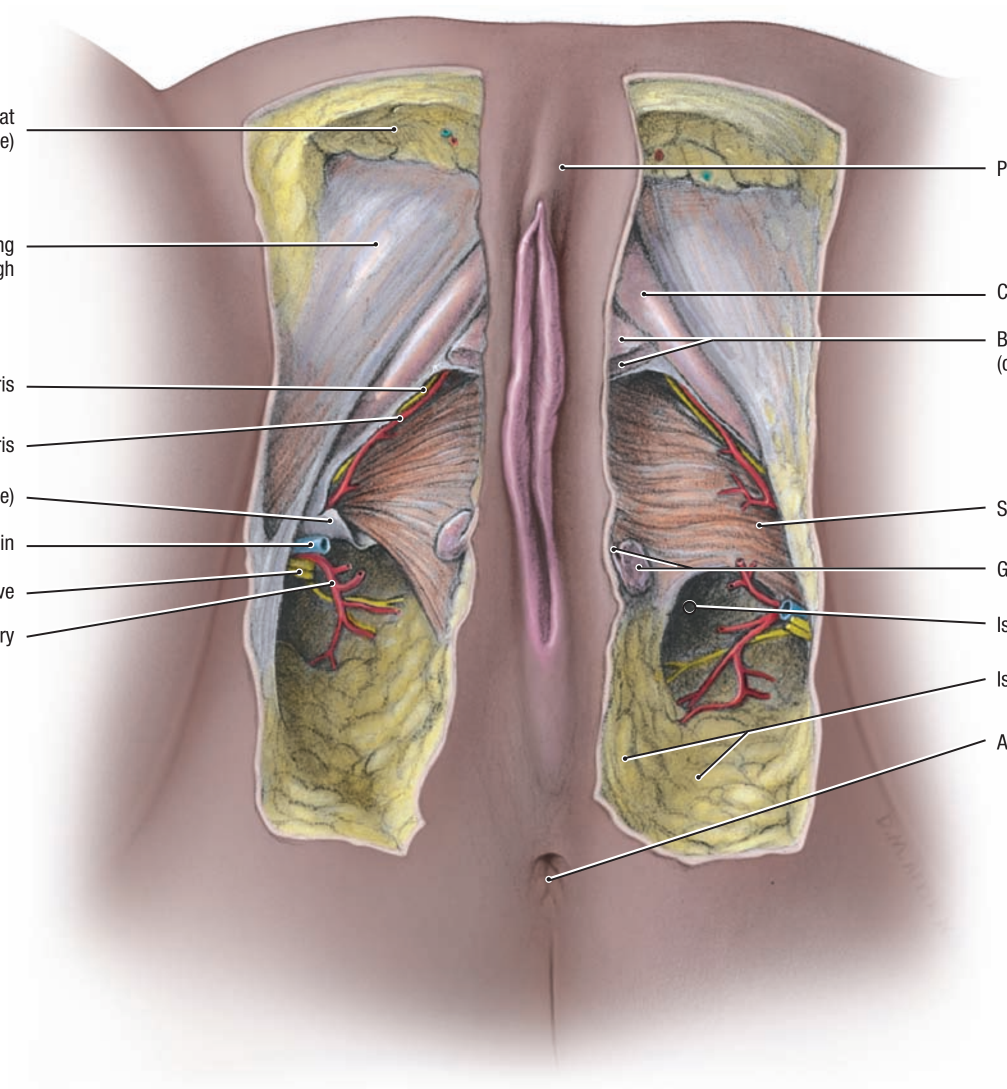
B. Inferior View

3.65 FEMALE PERINEUM IV

A. Deep perineal compartment. The perineal membrane and smooth muscle corresponding in position to the deep transverse perineal muscle in the male have been removed.

- The most anterior and medial part of the levator ani muscle, the pubovaginalis, passes posterior to the vaginal orifice.
- The urethrovaginal sphincter, part of the external urethral sphincter of the female, rests on the urethra and straddles the vagina.
- The labia minora (cut short here) bound the vestibule of the vagina.

A. and B. The osseoligamentous boundaries of the diamond-shaped perineum are the pubic symphysis, ischiopubic rami, ischial tuberosities, sacrotuberous ligaments, and coccyx. For descriptive purposes, a transverse line connecting the ischial tuberosities subdivides the diamond into urogenital and anal triangles.

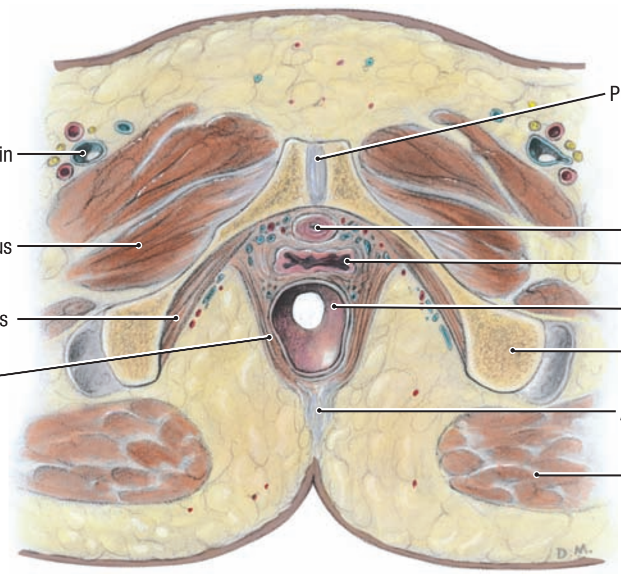


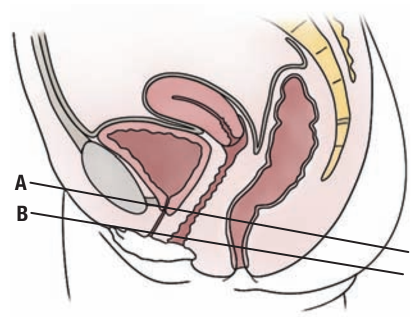
Inferior View

3.66 FEMALE PERINEUM V

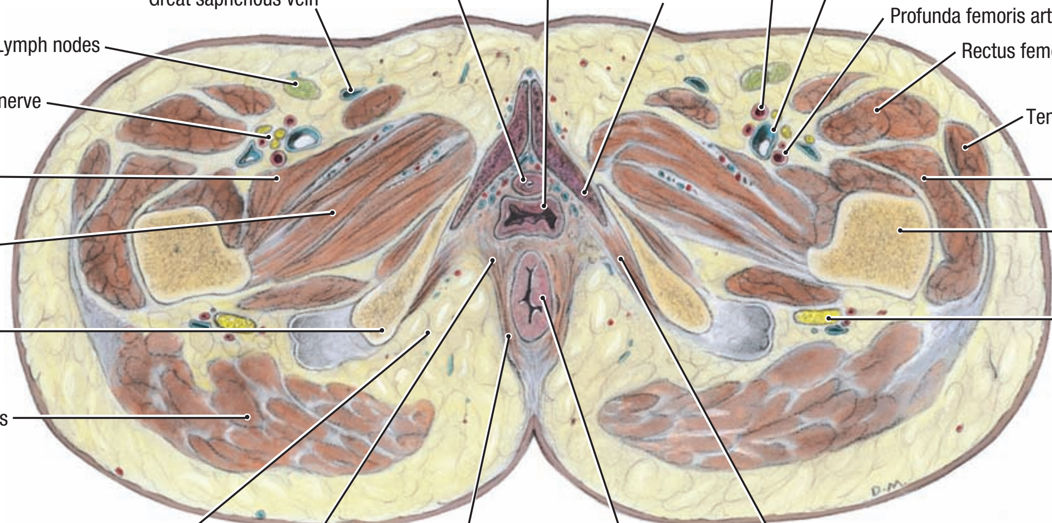
This is a different dissection than the previous series, with the vulva undissected centrally but the perineum dissected deeply on each side. Although most of the perineal membrane and bulbs of the vestibule have been removed, the greater vestibular glands (structures of the superficial perineal compartment) have been left in place. The development and extent of the smooth muscle layer corresponding in position to the voluntary deep transverse perineal muscles of the male are highly variable, being relatively extensive in this case, blending centrally with voluntary fibers of the external urethral sphincter and the perineal body.

The greater vestibular glands are usually not palpable, but are so when infected. Occlusion of the vestibular gland duct can predispose the individual to **infection of the vestibular gland.** The gland is the site or origin of most **vulvar adenocarcinomas** (cancers). **Bartholinitis**, inflammation of the greater vestibular (Bartholin) glands, may result from a number of pathogenic organisms. Infected glands may enlarge to a diameter of 4 to 5 cm and impinge on the wall of the rectum. Occlusion of the vestibular gland duct without infection can result in the accumulation of mucin (**Bartholin cyst**).





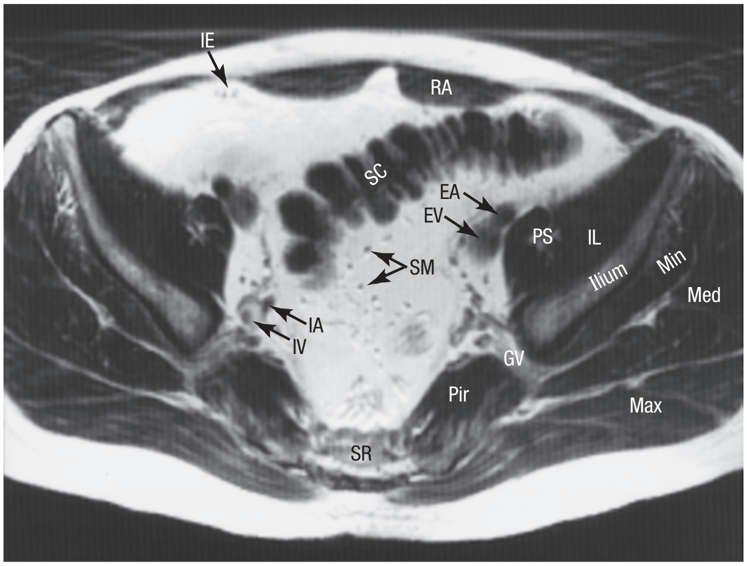
A. Transverse Section



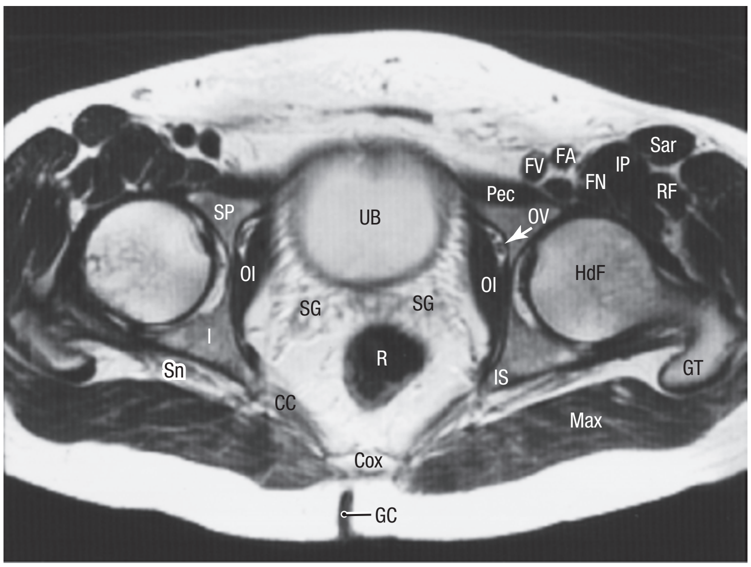
B. Transverse Section

3.67 FEMALE PERINEUM V

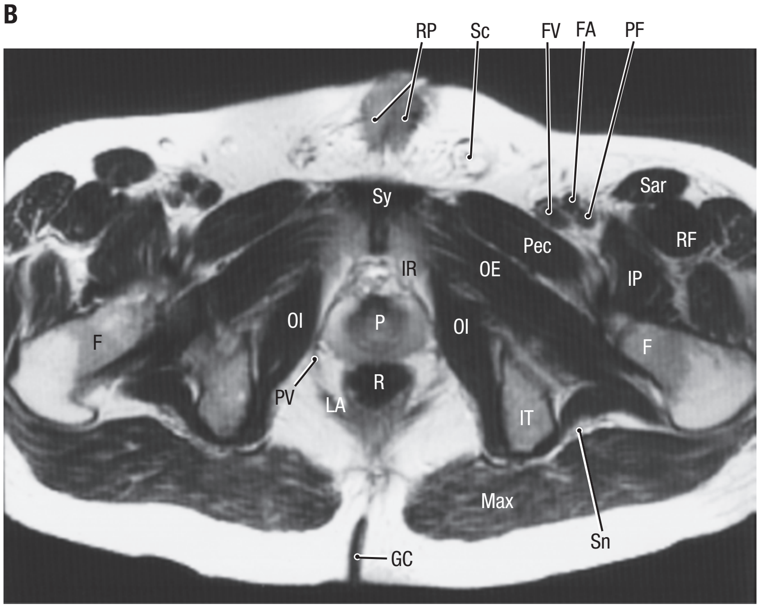
A. Section through vagina and urethra at base of urinary bladder. **B.** Section through vagina, urethra, and crura of clitoris.



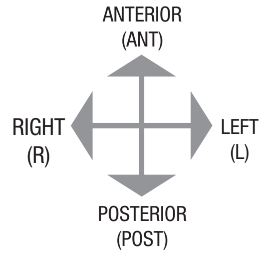
A



B

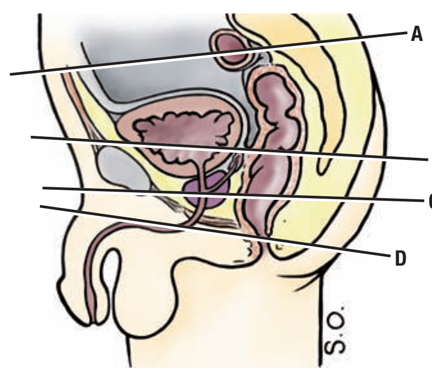


C



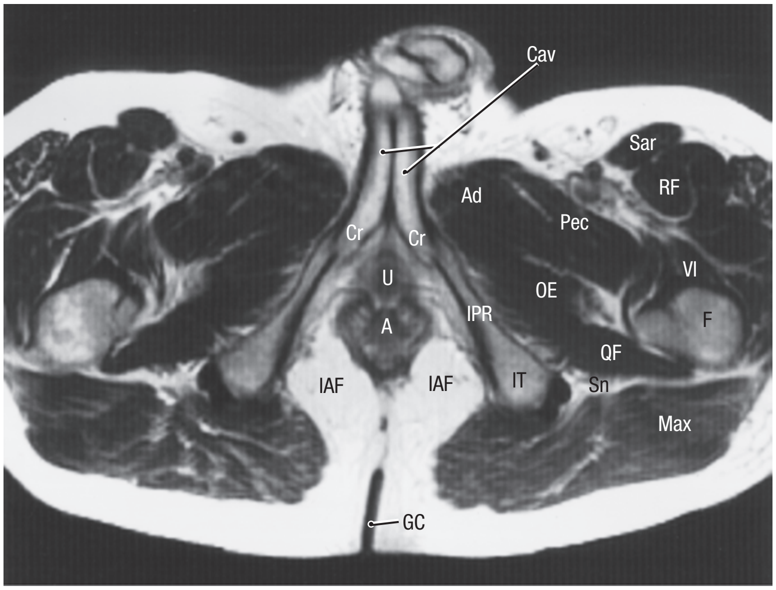
A	**Anus**	**LA**	**Levator ani**
Ad	Adductor muscles	Max	Gluteus maximus
Bi	Biceps femoris tendon	Med	Gluteus medius
Bu	**Bulb of penis**	Min	Gluteus minimus
Cav	**Corpus cavernosum penis**	OE	Obturator externus
CC	Coccygeus	OI	Obturator internus
Cox	Coccyx	OV	Obturator vessels and nerve
Cr	**Crus of penis**	**P**	**Prostate**
DD	Ductus deferens	**PB**	**Perineal body**
DVP	Dorsal vein of penis	Pec	Pectineus
EA	External iliac artery	PF	Profunda femoris artery
EAS	External anal sphincter	Pir	Piriformis
EV	External iliac vein	**PR**	**Puborectalis**
F	Femur	PS	Psoas
FA	Femoral artery	PV	Pudenal vessels and nerves
FN	Femoral nerve	QF	Quadratus femoris
FV	Femoral vein	**R**	**Rectum**
GC	Gluteal cleft	RA	Rectus abdominis
GSV	Great saphenous vein	RF	Rectus femoris
GT	Greater trochanter	**RP**	**Root of penis**
GV	Superior gluteal vein	Sar	Sartorius
HdF	Head of femur	Sc	Spermatic cord
I	Body of ischium	SC	Sigmoid colon
IA	Internal iliac artery	**SG**	**Seminal gland**
IAF	**Ischio-anal fossa (pararectal fat)**	SM	Sigmoidal vessels in mesentery of sigmoid colon
IC	**Ischiocavernosus**	Sn	Sciatic nerve
IE	Inferior epigastric vessels	SP	Superior ramus of pubis
IL	Iliacus	SR	Sacrum
IP	Iliopsoas	Sy	Pubic symphysis
IPR	Ischiopubic ramus	**U**	**Urethra**
IR	Inferior pubic ramus	**UB**	**Urinary bladder**
IS	Ischial spine	VI	Vastus intermedius
IT	Ischial tuberosity		
IV	Internal iliac vein		

(Organs/structures of male pelvis and perineum are in boldface)

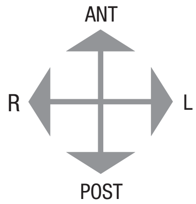


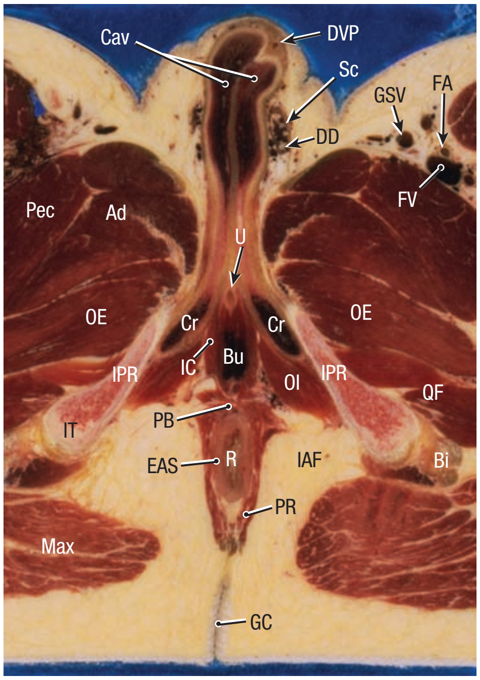
3.68 TRANSVERSE (AXIAL) MRIs AND SECTIONAL SPECIMEN OF MALE PELVIS AND PERINEUM, INFERIOR VIEWS

A.–D. MRIs. **E.** Anatomical section.



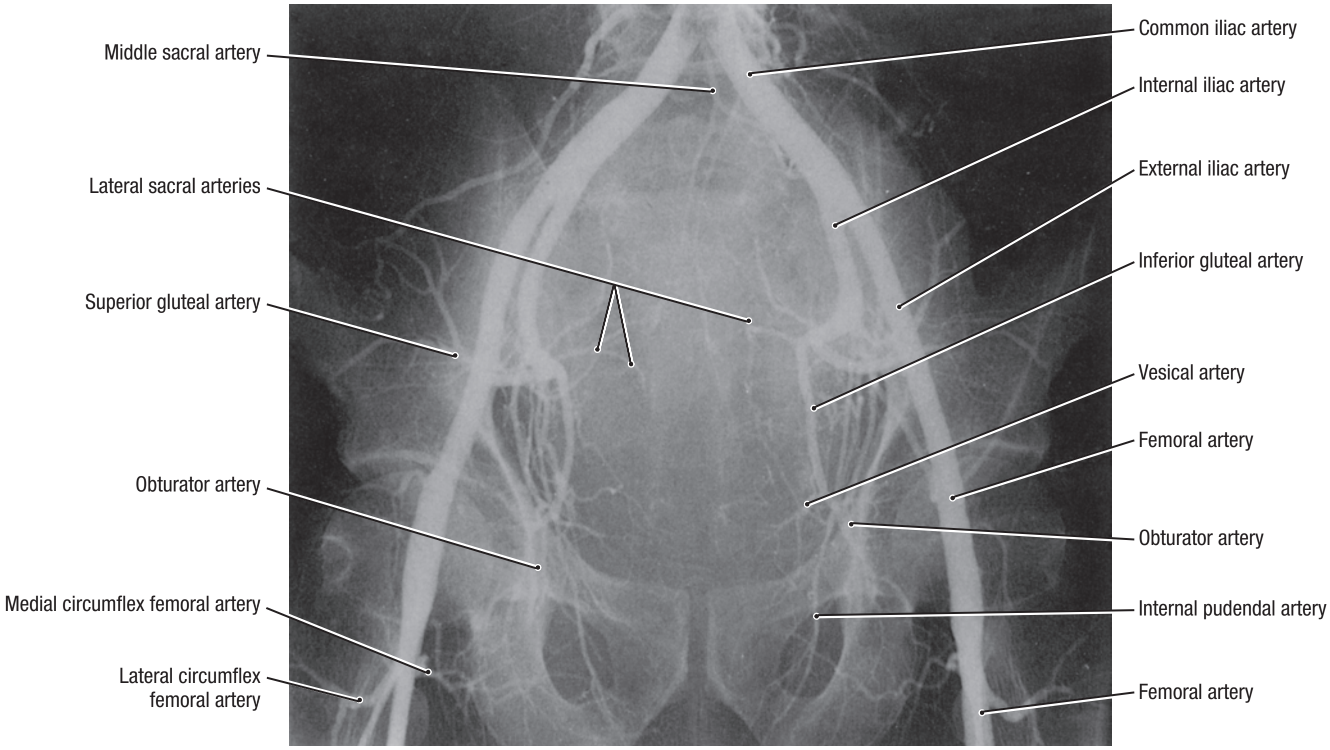
D



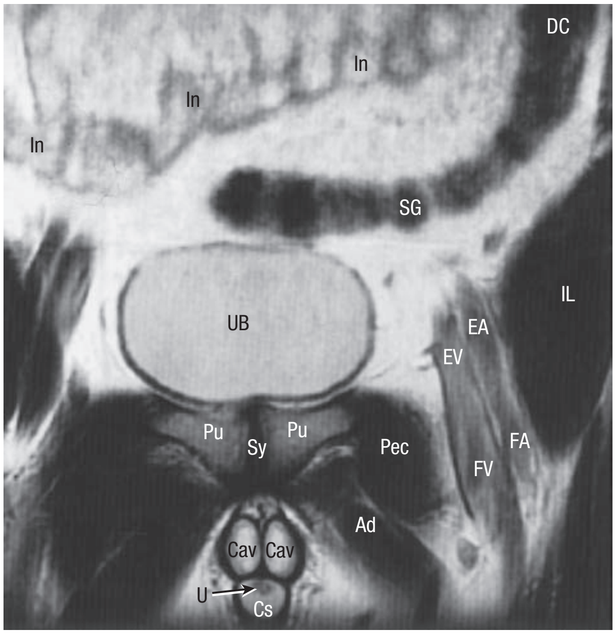


E

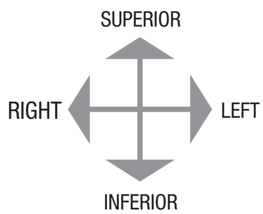
3.68 TRANSVERSE (AXIAL) MRIs AND SECTIONAL SPECIMEN OF MALE PELVIS AND PERINEUM, INFERIOR VIEWS *(CONTINUED)*

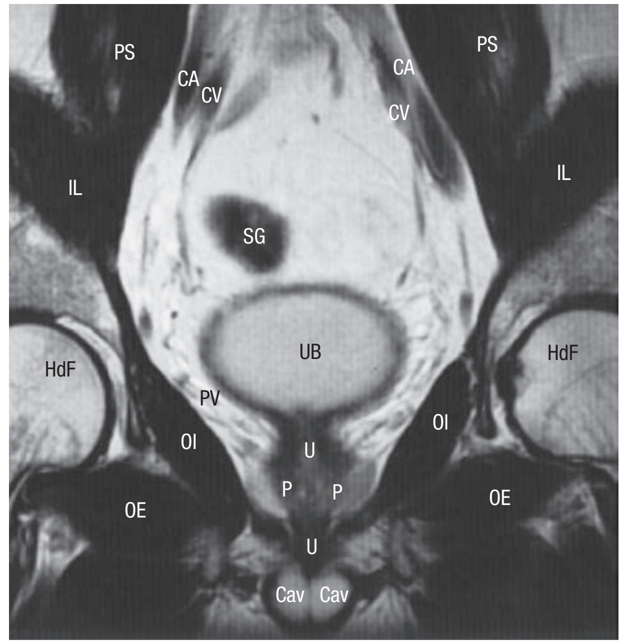


3.69 PELVIC ANGIOGRAPHY



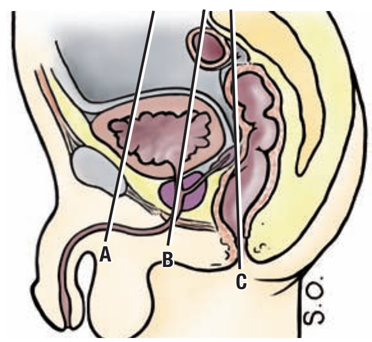
A





B

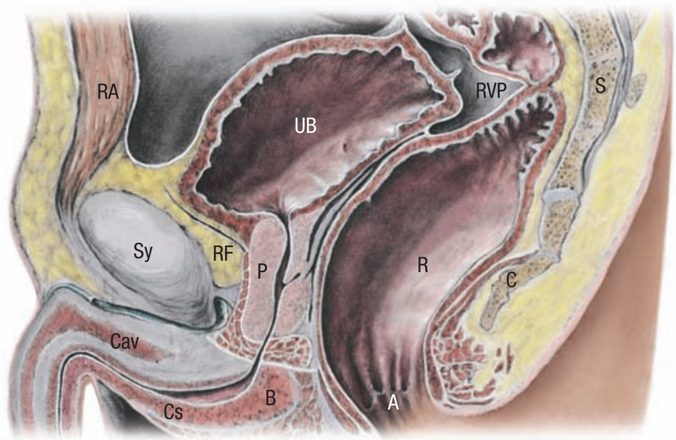
C



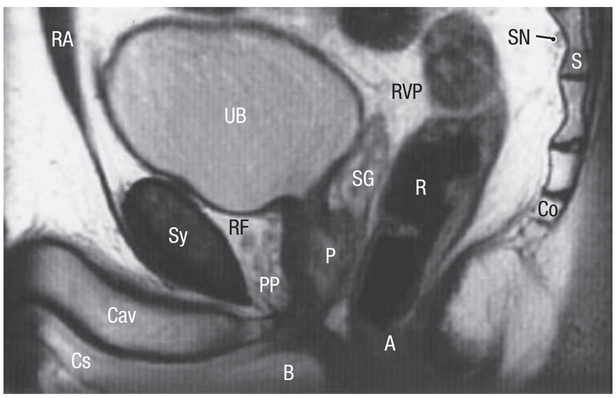
A	**Anus**	LS	Lumbosacral trunk
Ad	Adductors	OE	Obturator externus
CA	Common iliac artery	**OI**	**Obturator internus**
Cav	**Corpus cavernosum penis**	**P**	**Prostate**
Cs	**Corpus spongiosum penis**	Pec	Pectineus
CV	Common iliac vein	PS	Psoas
DC	Descending colon	Pu	Pubic bone
EA	External iliac artery	**PV**	**Pelvic vessels and nerves**
EV	External iliac vein	**R**	**Rectum**
FA	Femoral artery	**Sac**	**Sacrum**
FV	Femoral vein	SC	Sigmoid colon
HdF	Head of femur	**SG**	**Seminal gland**
IL	Iliacus	**Sy**	**Pubic symphysis**
In	Small intestine	**U**	**Urethra**
IR	**Inferior rectal nerve and vessels**	**UB**	**Urinary bladder**
LA	**Levator ani**		

3.70 CORONAL MRIs OF MALE PELVIS AND PERINEUM, ANTERIOR VIEWS

MALE

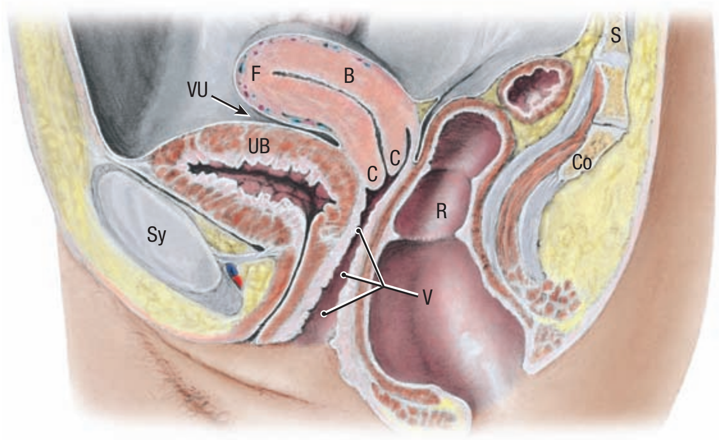


Median Section, Male

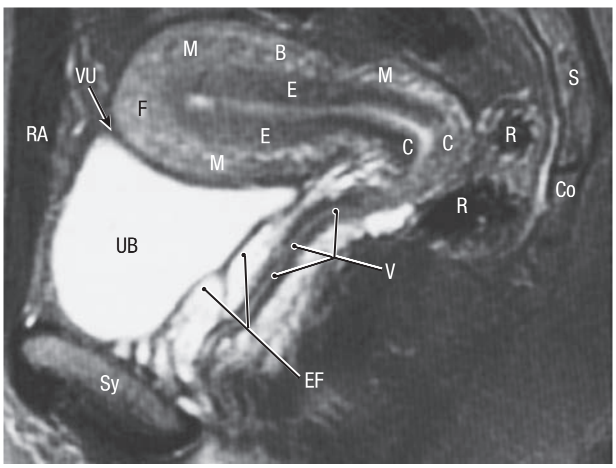


Median MRI Scan, Male

FEMALE



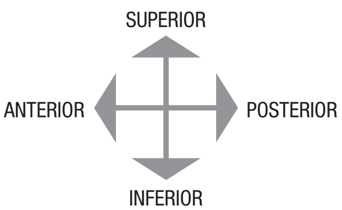
Median Section, Female



Median MRI Scan, Female

Male:

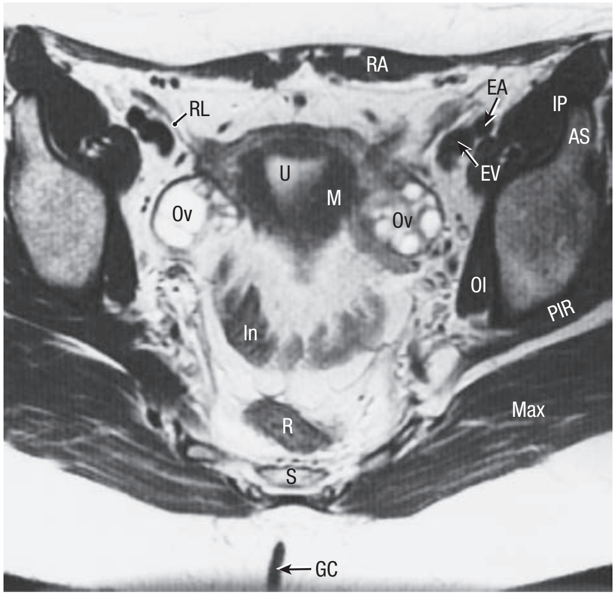
A	Anus
B	Bulb of penis
Co	Coccyx
Cav	Corpus cavernosum penis
Cs	Corpus spongiosum penis
P	Prostate
PP	Prostatic venous plexus
R	Rectum
RA	Rectus abdominis
RF	Retropubic fat
RVP	Rectovesical pouch
S	Sacrum
SG	Seminal gland
SN	Sacral nerves
Sy	Pubic symphysis
UB	Urinary bladder



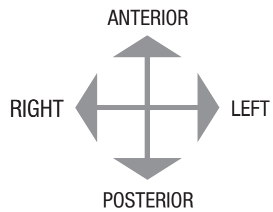
Female:

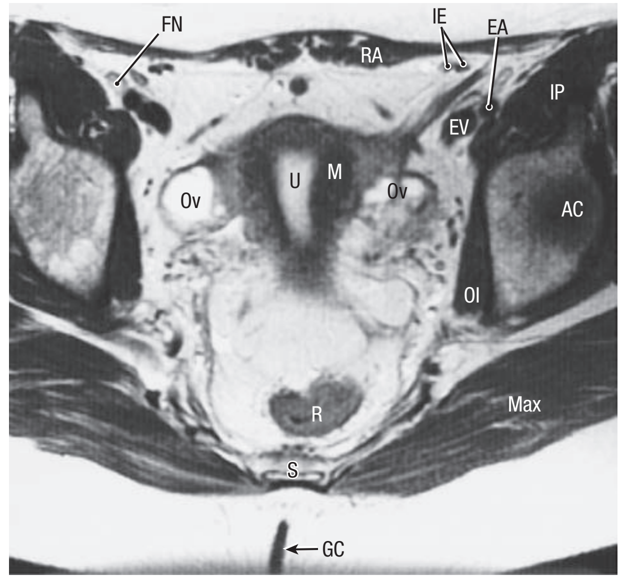
B	Body of uterus
C	Cervix of uterus
Co	Coccyx
E	Endometrium
EF	Endopelvic fascia
F	Fundus of uterus
M	Myometrium
R	Rectum
RA	Rectus abdominis
S	Sacrum
Sy	Pubic symphysis
UB	Urinary bladder
V	Vagina
VU	Vesico-uterine pouch

3.71 MEDIAN MRIs OF MALE AND FEMALE PELVIS AND PERINEUM

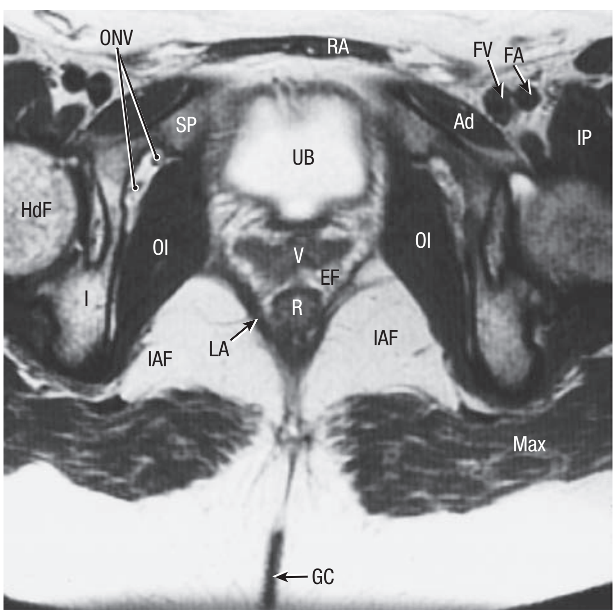


A



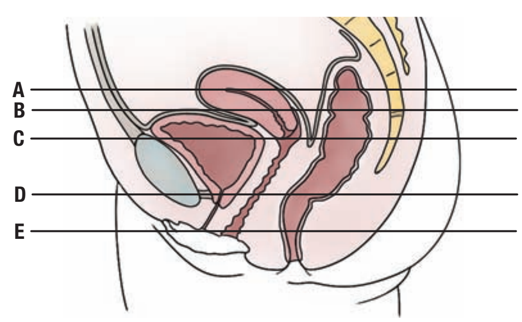


B



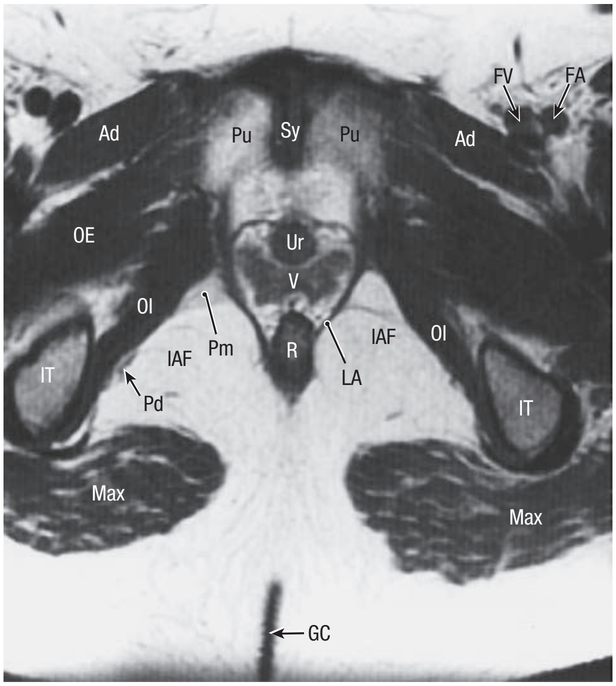
C

A	**Anus**	**M**	**Myometrium**
AC	Acetabulum	Max	Gluteus maximus
Ad	Adductor muscles	OE	Obturator externus
AS	Anterior superior iliac spine	**OI**	**Obturator internus**
BC	Body of clitoris	**Ov**	**Ovary**
CC	Crus of clitoris	ONV	Obturator nerve and vessels
EA	External iliac artery	Pd	Pudendal nerve and vessels
EF	Endopelvic fascia	Pec	Pectineus
EV	External iliac vein	PIR	Piriformis
FA	Femoral artery	**Pm**	**Perineal membrane**
FN	Femoral nerve	**Pu**	**Pubic bone**
FV	Femoral vein	QF	Quadratus femoris
GC	Gluteal cleft	**R**	**Rectum**
HdF	Head of femur	RA	Rectus abdominis
I	Ilium	**RF**	**Recto-uterine fold**
IAF	**Ischio-anal fossa**	**RL**	**Round ligament**
IE	Inferior epigastric vessels	**S**	**Sacrum**
In	Intestine	SP	Superior ramus of pubis
IP	Iliopsoas	Sy	Pubic symphysis
IPR	Ischiopubic ramus	**U**	**Uterus**
IT	Ischial tuberosity	**UB**	**Urinary bladder**
LA	**Levator ani**	**Ur**	**Urethra**
Lin	Linea alba	**V**	**Vagina**
LM	**Labia majus**	**Ve**	**Vestibule**

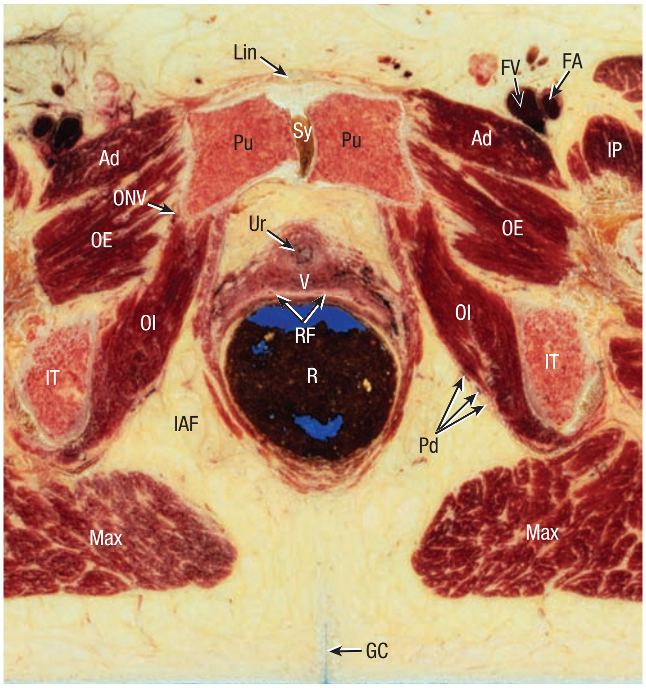


3.72 TRANSVERSE (AXIAL) MRIs AND SECTIONAL SPECIMENS OF FEMALE PELVIS AND PERINEUM, INFERIOR VIEWS

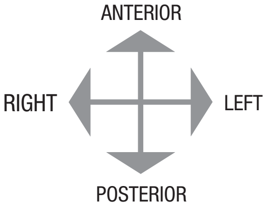
A.–C. MRIs.

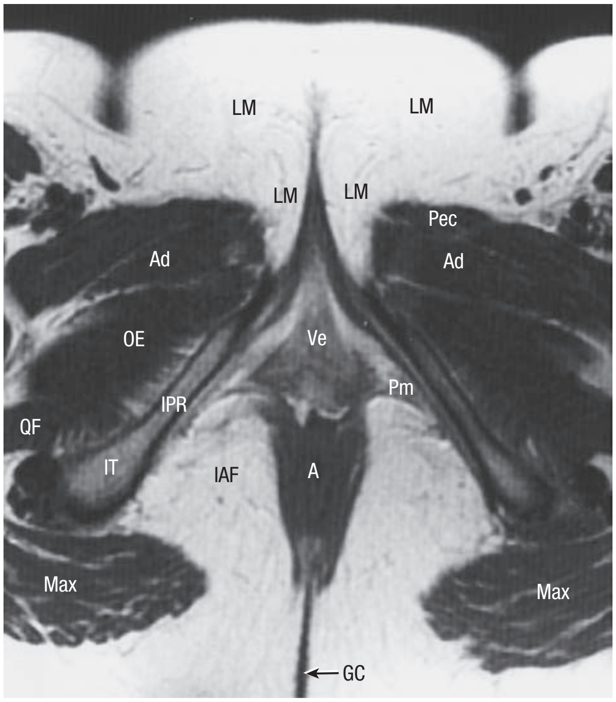


D

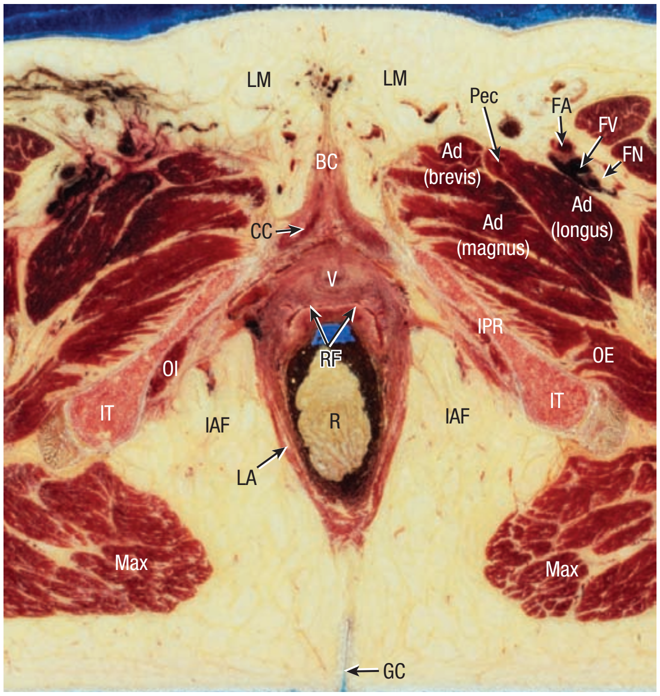


E





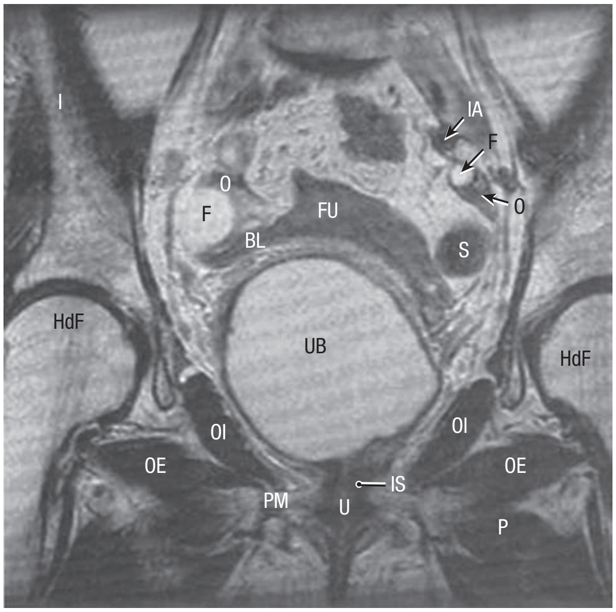
F



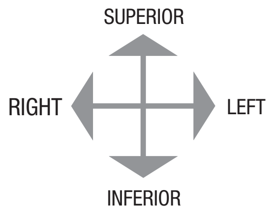
G

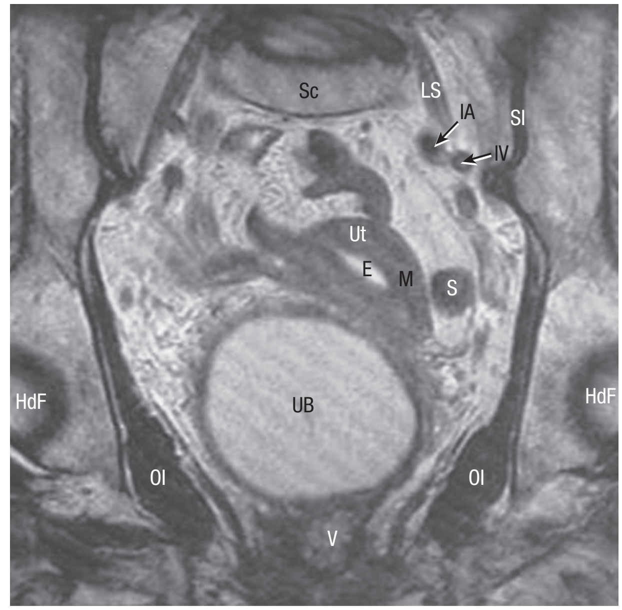
3.72 TRANSVERSE (AXIAL) MRIs AND SECTIONAL SPECIMENS OF FEMALE PELVIS AND PERINEUM, INFERIOR VIEWS *(CONTINUED)*

D. and F. MRIs. **E. and G.** Anatomical sections.



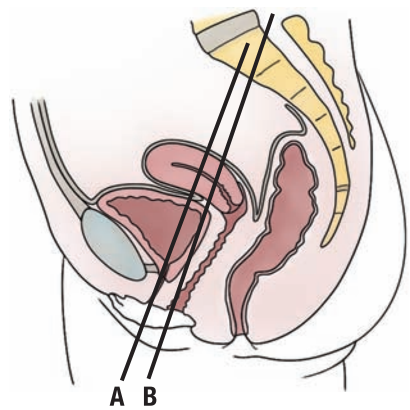
A



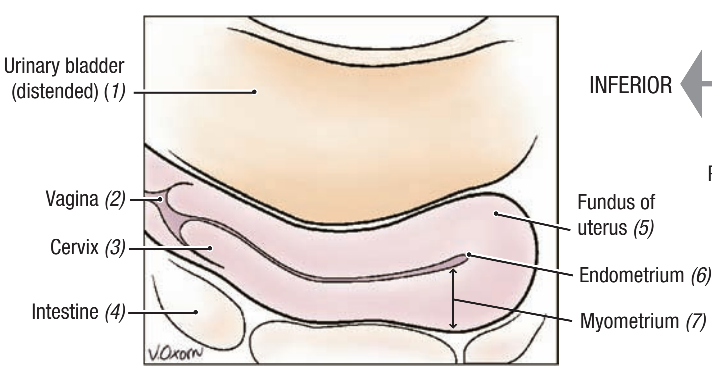


B

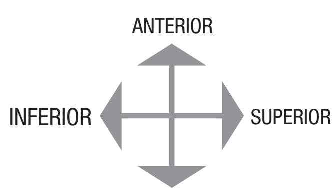
BL	**Broad ligament**	OE	Obturator externus
E	**Endometrium**	**OI**	**Obturator internus**
F	**Ovarian follicle**	P	Pectineus
FU	**Fundus of uterus**	**PM**	**Perineal membrane**
HdF	Head of femur	**S**	**Sigmoid colon**
I	Ilium	**Sc**	**Sacrum**
IA	Internal iliac artery	SI	Sacro-iliac joint
IV	Internal iliac vein	**U**	**Urethra**
IS	**Internal urethral sphincter**	**UB**	**Urinary bladder**
LS	Lumbosacral trunk	**Ut**	**Uterus**
M	**Myometrium**	**V**	**Vagina**
O	**Ovary**		

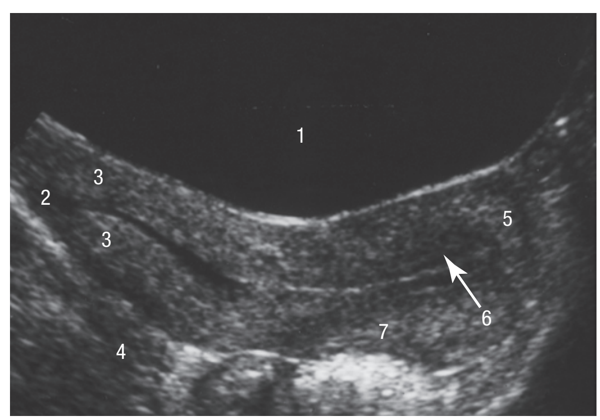


3.73 CORONAL MRIs OF FEMALE PELVIS AND PERINEUM, ANTERIOR VIEWS



A. **Longitudinal Section**

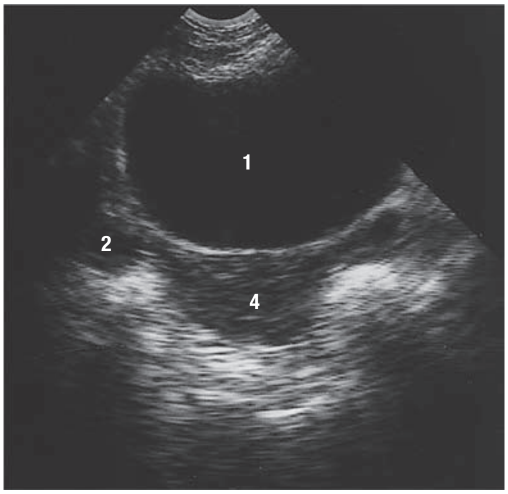




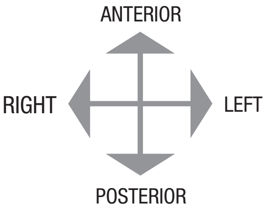
Longitudinal US Section

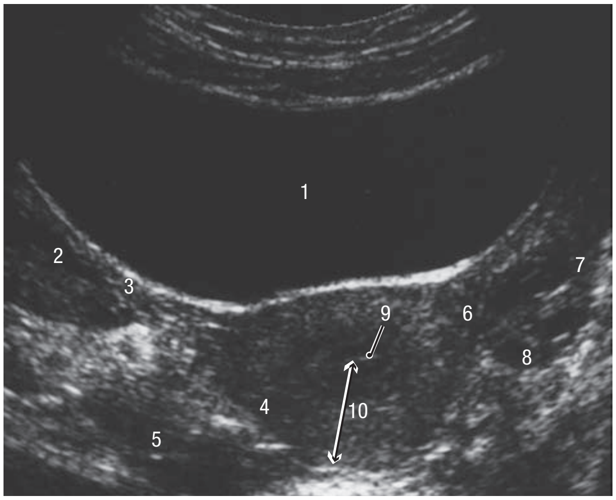
3.74 ULTRASOUND SCANS OF FEMALE PELVIS

A. Median (transabdominal) ultrasound scan and orientation drawing (numbers in parentheses correspond to labels on the ultrasound scan).

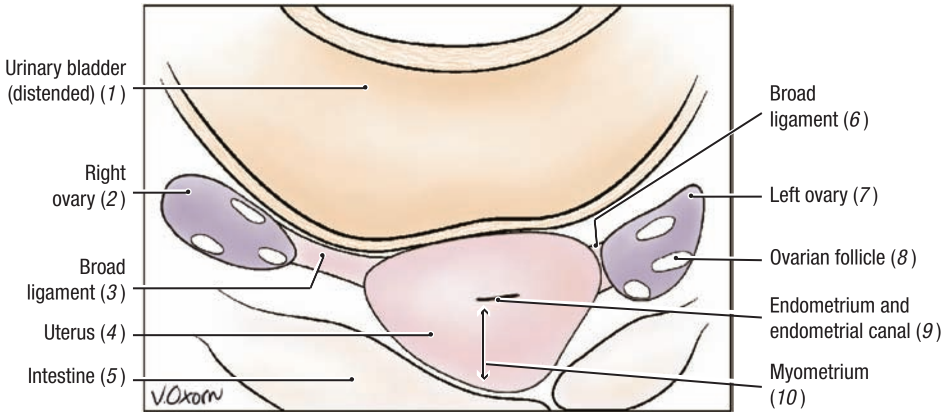


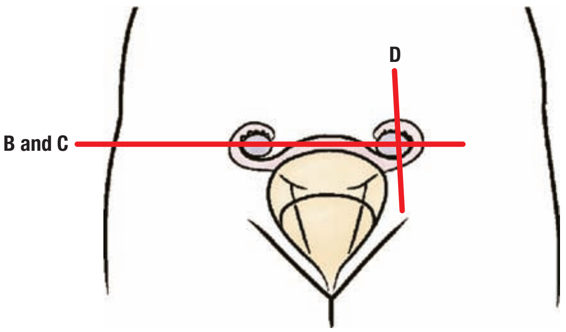
B. Transverse (Axial) Scan

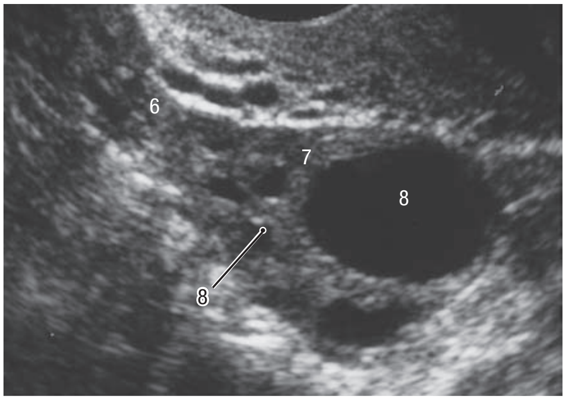




C. Transverse (Axial) Scan





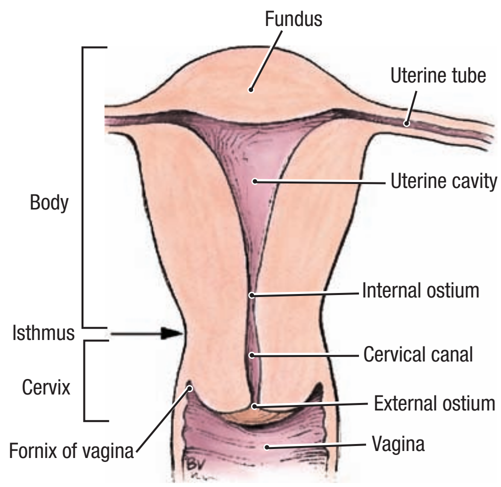


D. Sagittal Scan

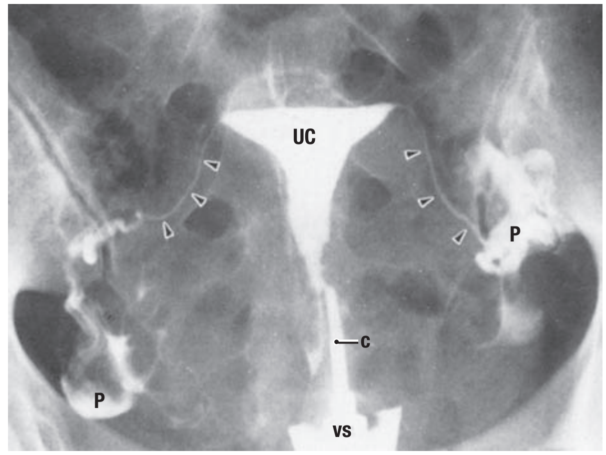
3.74 ULTRASOUND SCANS OF FEMALE PELVIS *(CONTINUED)*

B. and C. Transabdominal axial (transverse) scan through uterus and ovaries. **Transabdominal US scanning** requires a fully distended urinary bladder to displace the bowel loops from the pelvis and to provide an acoustical window through which to observe pelvic anatomy.

D. Transvaginal sagittal scan of left ovary (numbers in parentheses correspond to labels on the ultrasound scans). **Transvaginal and transrectal ultrasonography** enables the placing of the probe closer to the structures of interest, allowing increased resolution.

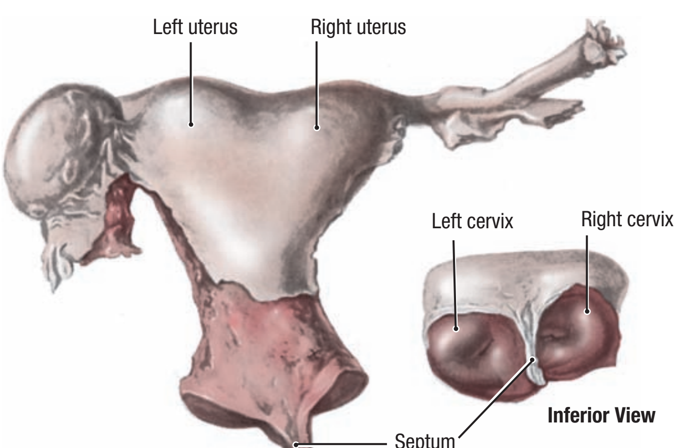


A. **Coronal Section**

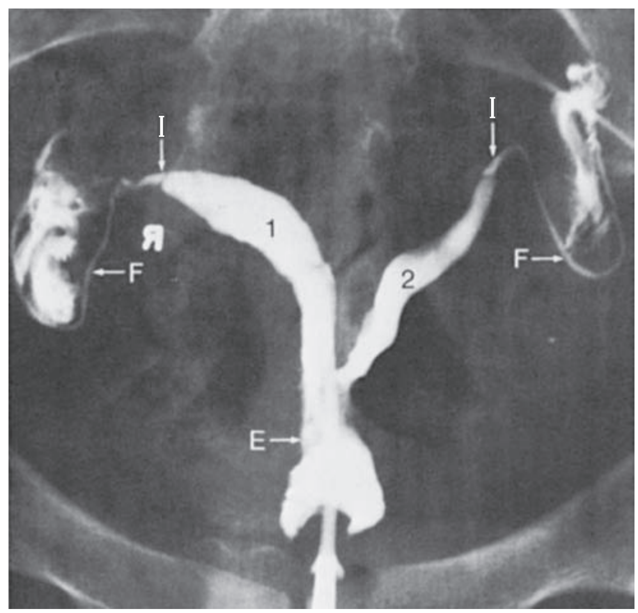


B. **Hysterosalpingogram of Normal Uterus, Anteroposterior View**

KEY for B:					
UC	Uterine cavity	P	Pararectal fossae	VS	Vaginal speculum
▲▲	Uterine tubes	C	Catheter in cervical canal		



C. **Posterior View**



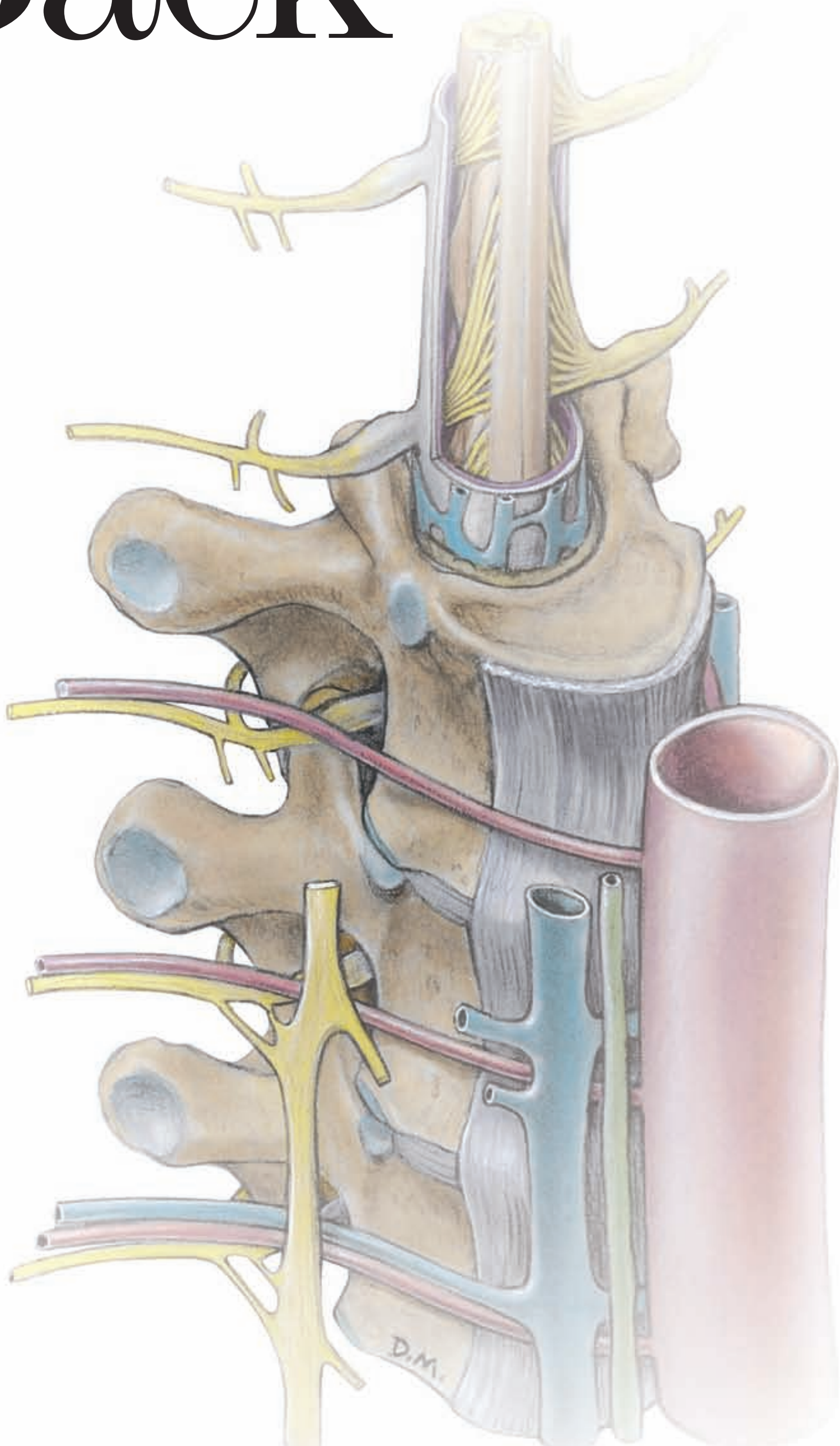
D. **Hysterosalpingogram of Bicornate Uterus, Anteroposterior View**

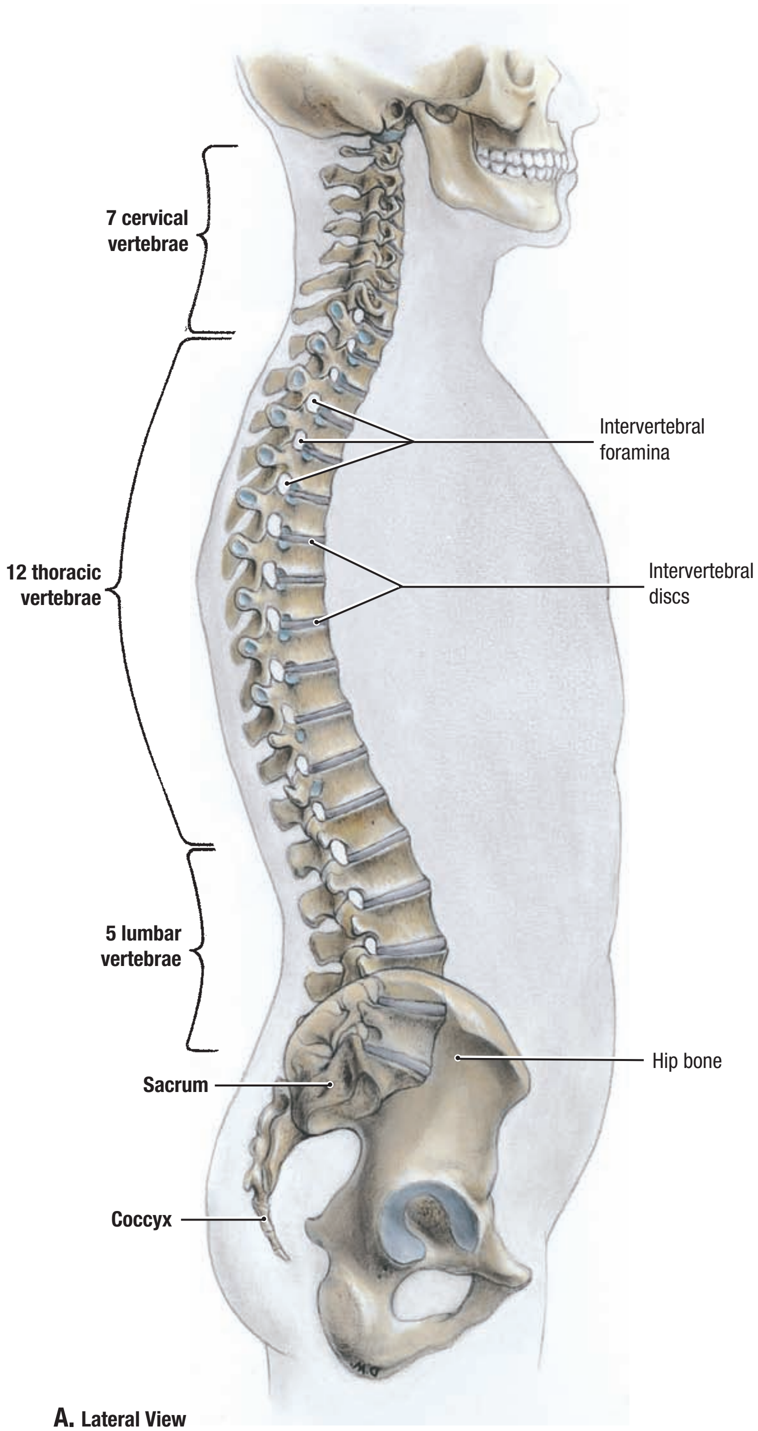
KEY for D:			
1 and 2	Uterine cavities	F	Uterine tubes
E	Cervical canal	I	Isthmus of uterine tubes

3.75 RADIOGRAPH OF UTERUS AND UTERINE TUBES (HYSTEROSALPINGOGRAM)

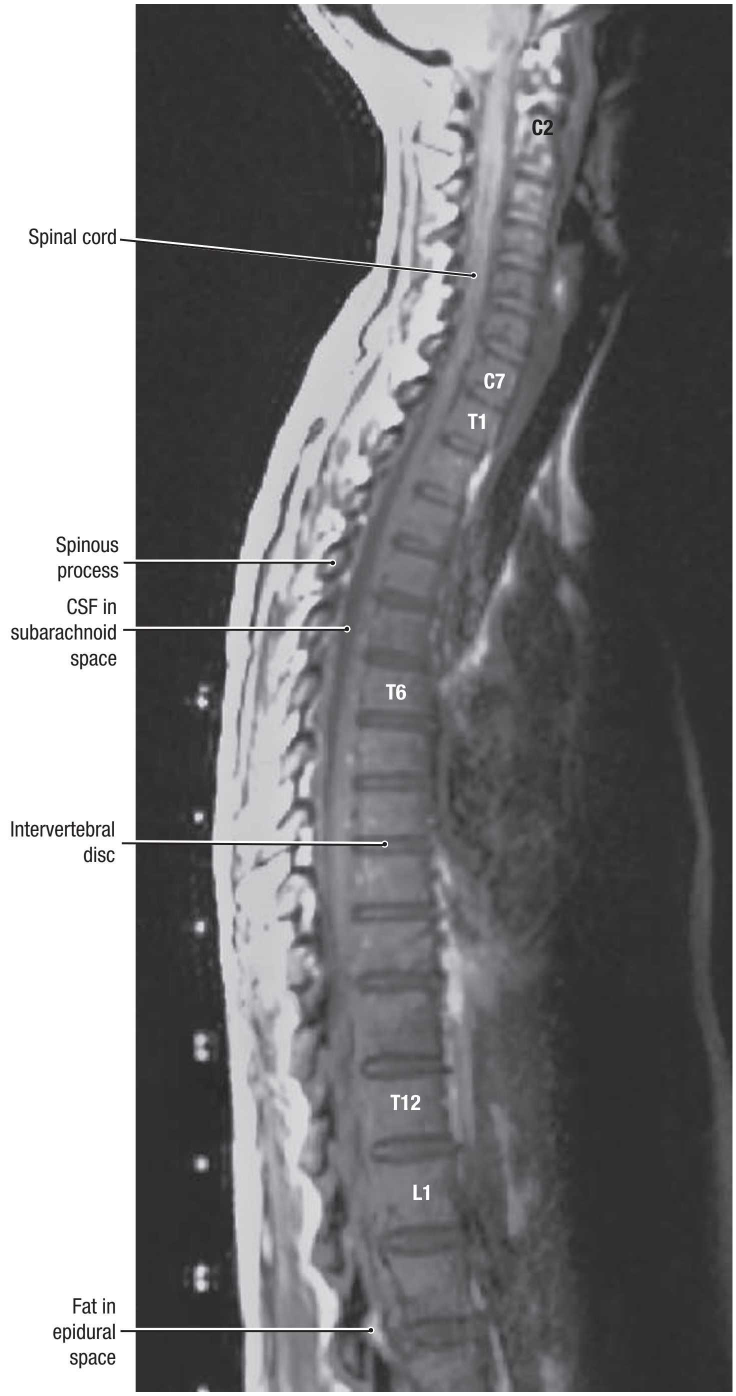
A. Coronal section of uterus. **B.** During *hysterosalpingography*, radiopaque material is injected into the uterus through external os of the uterus. If normal, contrast medium travels through the triangular uterine cavity (UC) and uterine tubes (*arrowheads*) and passes into the pararectal fossae *(P)* of the peritoneal cavity. The female genital tract is in direct communication with the peritoneal cavity and is, therefore, a potential pathway for the spread of an infection from the vagina and uterus. **C.** Illustration of duplicated uterus. **D.** Hysterosalpingogram of a bicornate ("two-horned") uterus.

Back





A. Lateral View

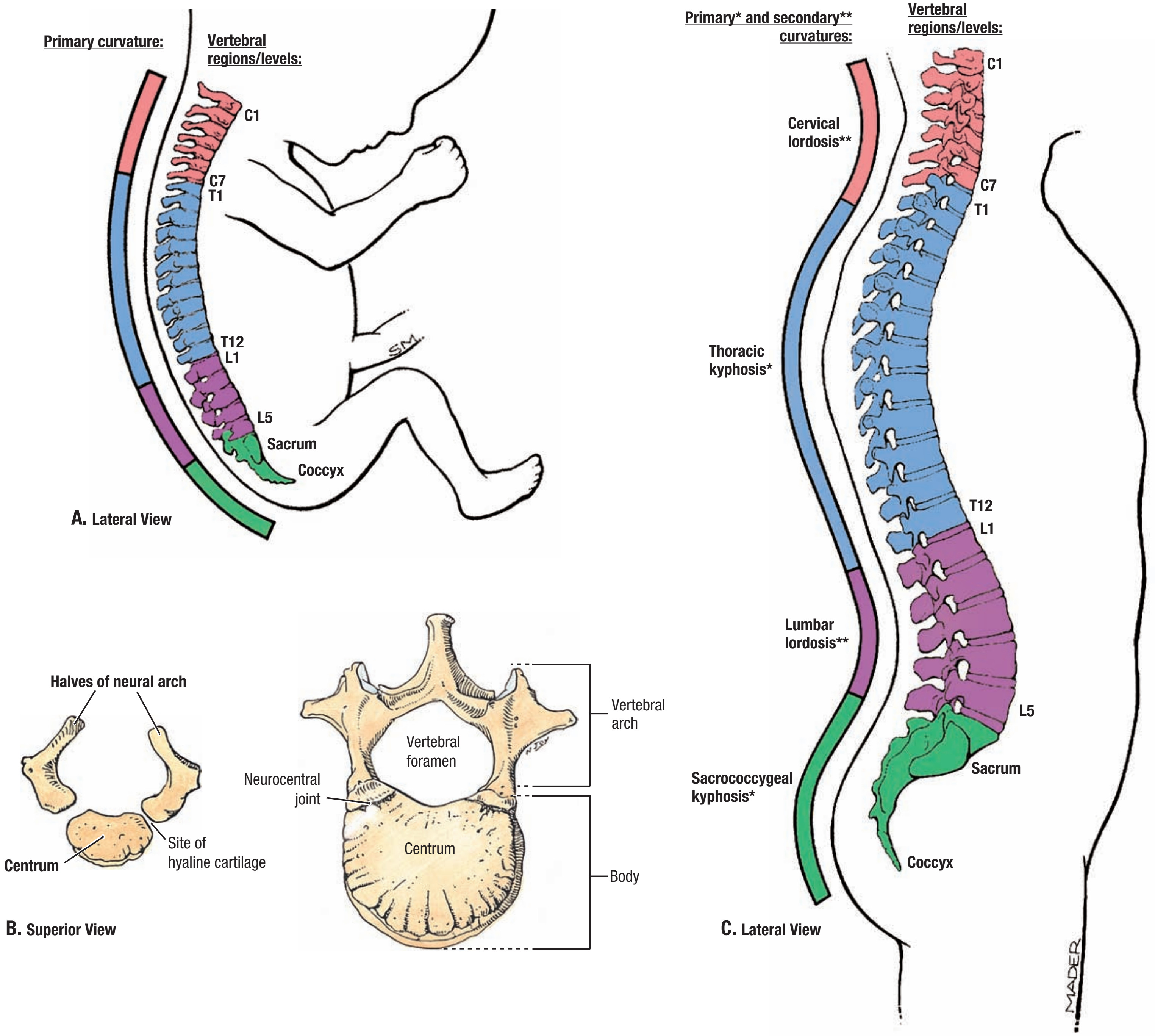


B. Sagittal MRI

4.1 OVERVIEW OF VERTEBRAL COLUMN

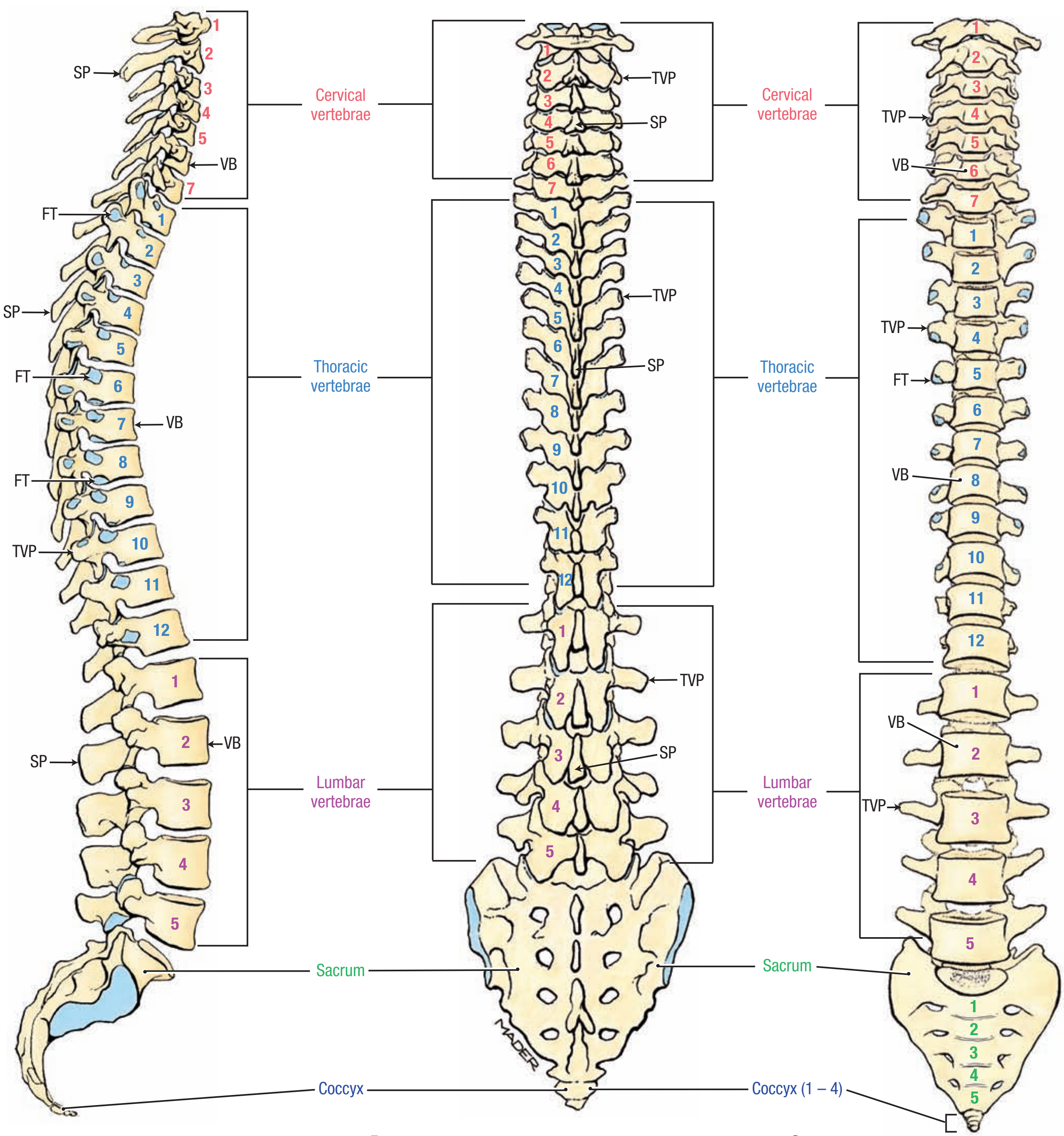
A. Vertebral column showing articulation with skull and hip bone. **B.** Sagittal MRI, lateral view.

- The vertebral column usually consists of 24 separate (presacral) vertebrae, 5 fused vertebrae in the sacrum, and variably 4 fused or separate coccygeal vertebrae. Of the 24 separate vertebrae, 12 support ribs (thoracic), 7 are in the neck (cervical), and 5 are in the lumbar region (lumbar).
- Vertebrae contributing to the posterior walls of the thoracic and pelvic cavities are concave anteriorly; elsewhere (in the cervical and lumbar regions) they are convex anteriorly.
- The spinal nerves exit the vertebral (spinal) canal via the intervertebral (IV) foramina. There are 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 to 2 coccygeal spinal nerves.
- Note the size and shape of the vertebral bodies, the direction of the spinous processes, cerebrospinal fluid (CSF) in the subarachnoid space, and the spinal cord in the vertebral canal (in **B**).



4.2 CURVATURES OF VERTEBRAL COLUMN

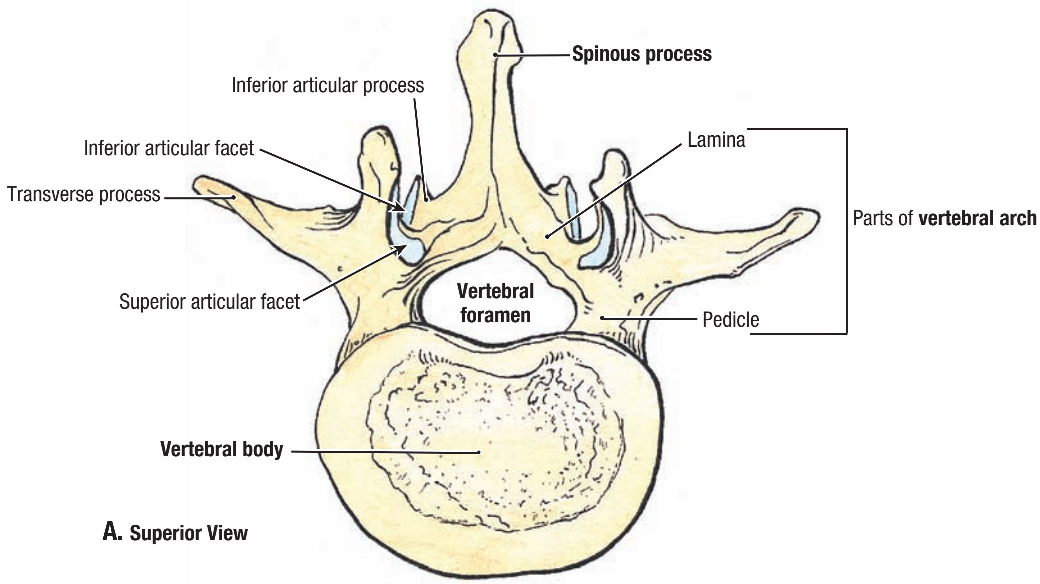
A. Fetus. Note the C-shaped curvature of the fetal spine, which is concave anteriorly over its entire length. **B.** Development of the vertebrae. At birth, a vertebra consists of three bony parts (two halves of the neural arch and the centrum) united by hyaline cartilage. At age 2, the halves of each neural arch begin to fuse, proceeding from the lumbar to the cervical region; at approximately age 7, the arches begin to fuse to the centrum, proceeding from the cervical to lumbar regions. **C.** Adult. The four curvatures of the adult vertebral column include the cervical lordosis, which is convex anteriorly and lies between vertebrae C1 and T2; the thoracic kyphosis, which is concave anteriorly, between vertebrae T2 and T12; the lumbar lordosis, convex anteriorly and lying between T12 and the lumbosacral joint; and the sacrococcygeal kyphosis, concave anteriorly and spanning from the lumbosacral joint to the tip of the coccyx. The anteriorly concave thoracic kyphosis and sacrococcygeal kyphosis are primary curves, and the anteriorly convex cervical lordosis and lumbar lordosis are secondary curves that develop after birth. The cervical lordosis develops when the child begins to hold the head up, and the lumbar kyphosis develops when the child begins to walk.



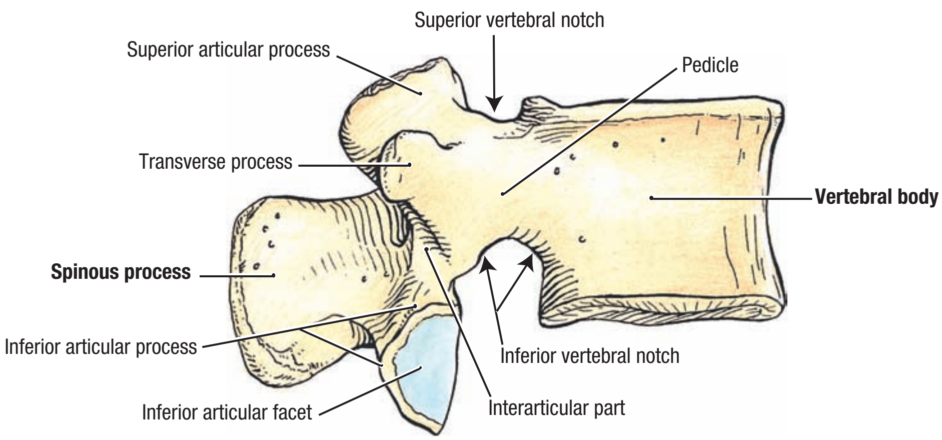
A. Lateral View **B.** Posterior View **C.** Anterior View

4.3 THREE VIEWS OF VERTEBRAL COLUMN

- The vertebral bodies (*VB*) vary in size and shape.
- Transverse processes (*TVP*) in the cervical region are directed laterally, inferiorly, and anteriorly. In the thoracic region, the vertebrae have facets for articulation with the ribs (FT); the TVPs are directed laterally, posteriorly, and superiorly; and are stout. In the lumbar region, the TVPs point laterally and are long and slender.
- Generally, spinous processes (*SP*) are bifid in Caucasians in the cervical region, long and spinelike in the thoracic region, and stout and oblong in the lumbar region. The cervical and thoracic SPs often overlap the adjacent, inferior vertebrae.



A. Superior View

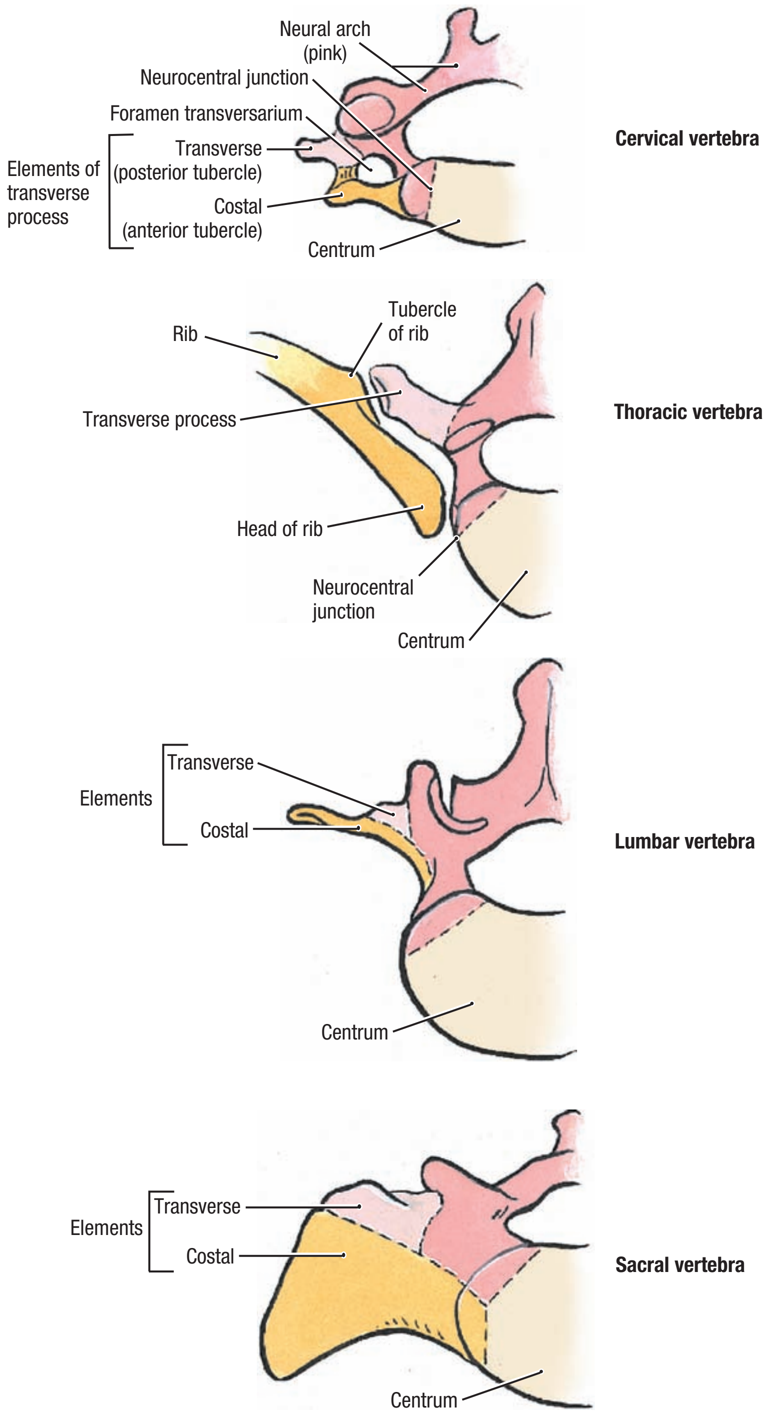


B. Lateral View

4.4 TYPICAL VERTEBRA

A typical vertebra (e.g., the 2nd lumbar vertebra) consists of the following parts:

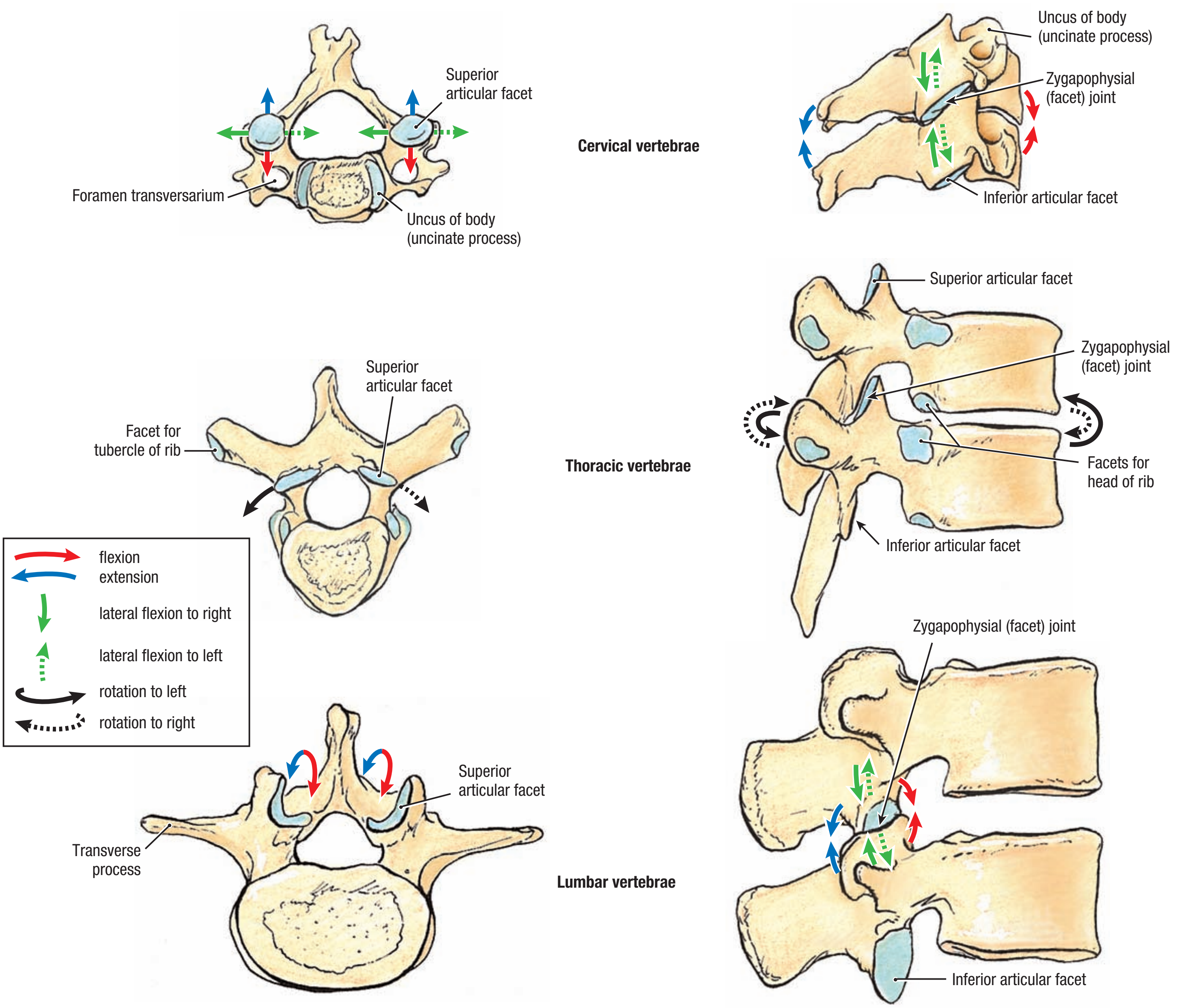
- A vertebral body, situated anteriorly, functions to support weight.
- The vertebral arch consists of two columnar pedicles, one on each side, which arise from the body, and two flat plates called laminae that unite posteriorly in the midline. The vertebral foramen is enclosed by the vertebral body and arch. Collectively, the vertebral foramina constitute the vertebral canal, in which the spinal cord lies. The function of a vertebral arch is to protect the spinal cord.
- Three processes, two transverse and one spinous, provide attachment for muscles and are the levers that help move the vertebrae.
- Four articular processes, two superior and two inferior, each have an articular facet. The articular processes project superiorly and inferiorly from the vertebral arch and come into apposition with the articular facet of the corresponding processes of the vertebrae above and below. The direction of the articular facets determines the nature of the movement between adjacent vertebrae.



Superior Views

4.5 HOMOLOGOUS PARTS OF VERTEBRAE

A rib is a free costal element in the thoracic region; in the cervical and lumbar regions, it is represented by the anterior part of a transverse process, and in the sacrum, by the anterior part of the lateral mass. The heads of the ribs (thoracic region) articulate with the sides of the vertebral bodies posterior to the neurocentral junction and the tubercles of the ribs articulate with the transverse processes of the vertebrae.



Superior Views - arrows indicate direction of movement of superior adjacent vertebra (not shown) relative to the inferior vertebra (shown here)

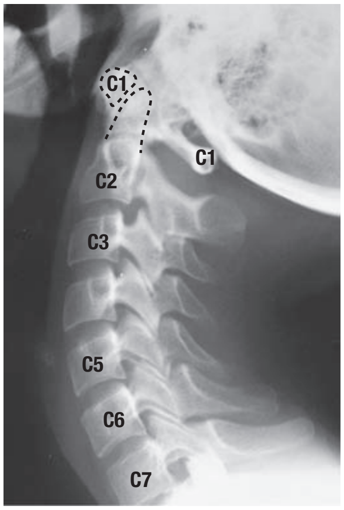
Lateral Views - arrows indicate direction of movement of the superior and inferior vertebra relative to each other

4.6 VERTEBRAL FEATURES AND MOVEMENTS

Direction of movement is indicated by *arrows*.

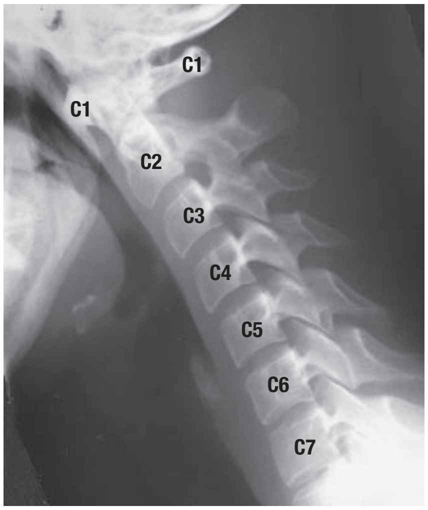
- In the thoracic and lumbar regions, the articular processes/facets lie posterior to the vertebral bodies and in the cervical region posterolateral to the bodies. Superior articular facets in the cervical region face mainly superiorly, in the thoracic region, mainly posteriorly, and in the lumbar region, mainly medially. The change in direction is gradual from cervical to thoracic but abrupt from thoracic to lumbar.
- Although movements between adjacent vertebrae are relatively small, especially in the thoracic region, the summation of all the small movements produces a considerable range of movement of the vertebral column as a whole.
- Movements of the vertebral column are freer (have greater range of motion) in the cervical and lumbar regions than in the thoracic region. Lateral bending is freest in the cervical and lumbar regions; flexion of the vertebral column is greatest in the cervical region; extension is most marked in the lumbar region, but the interlocking articular processes prevent rotation.
- The thoracic region is most stable because of the external support gained from the articulations of the ribs and costal cartilages with the sternum. The direction of the articular facets permits rotation, but flexion, extension, and lateral bending are severely restricted.

A. Lateral View

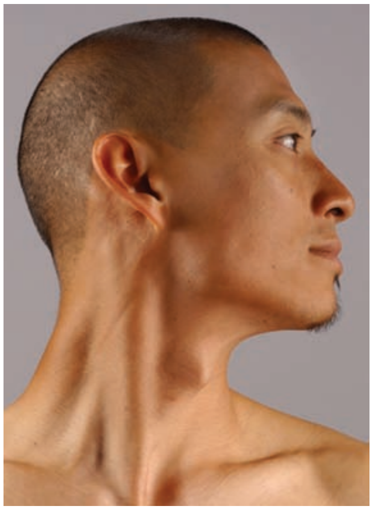


B. Lateral View

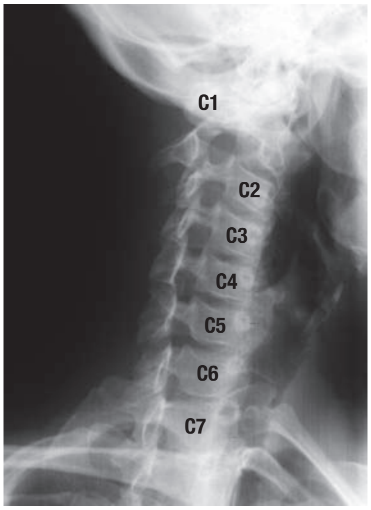
C. Lateral View



D. Lateral View



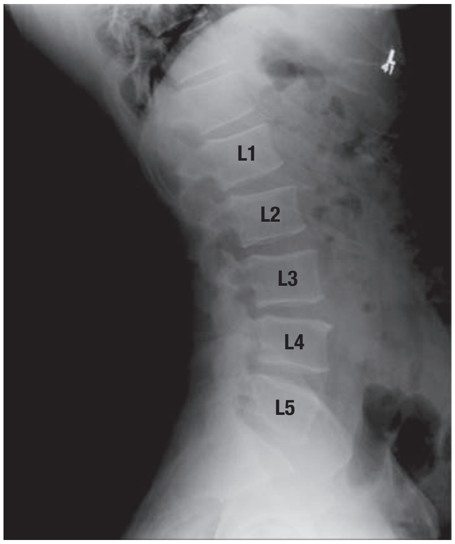
E. Anterior View



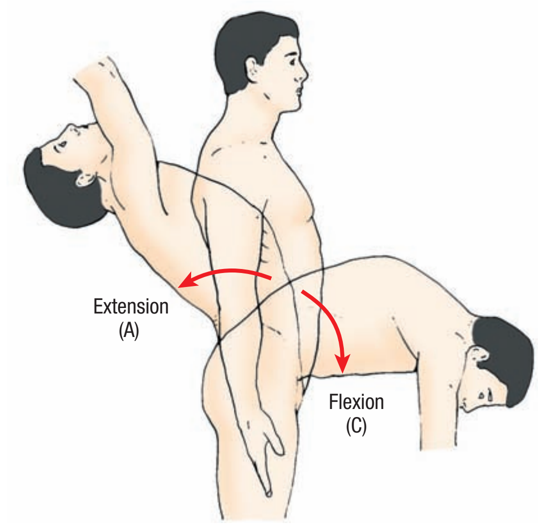
F. Oblique View

4.7 SURFACE ANATOMY WITH RADIOGRAPHIC CORRELATION OF SELECTED MOVEMENTS OF THE CERVICAL SPINE

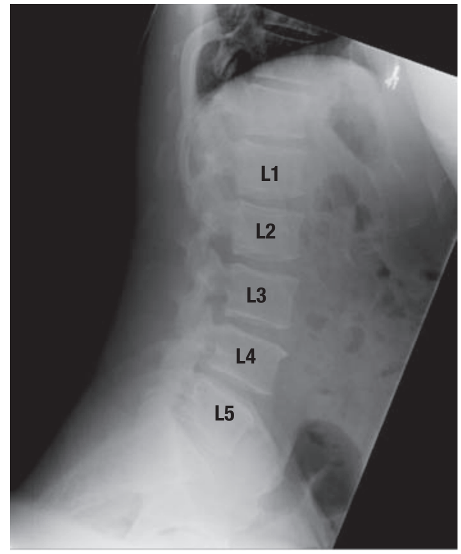
A. Extension of the neck. **B.** Radiograph of the extended cervical spine. **C.** Flexion of the neck. **D.** Radiograph of the flexed cervical spine. **E.** Head turned (rotated) to left. **F.** Radiograph of cervical spine rotated to left.



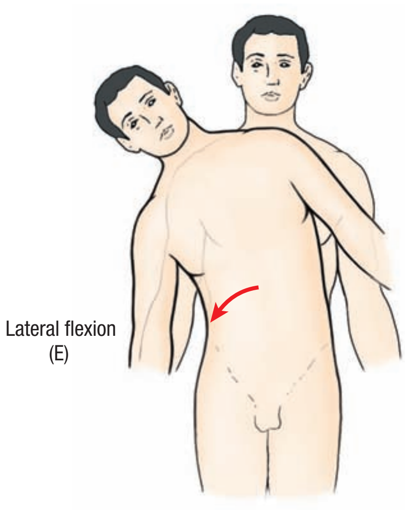
A. **Lateral View**



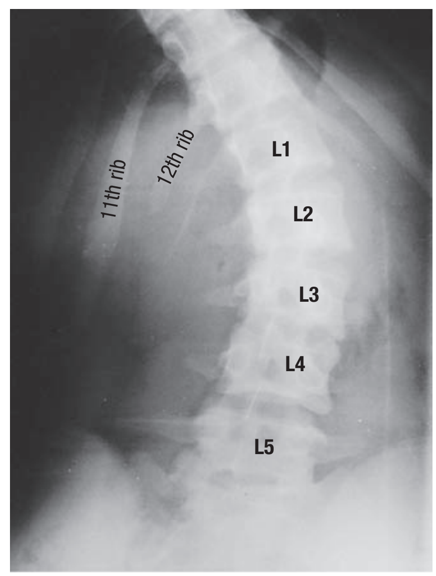
B. **Lateral View**



C. **Lateral View**



D. **Anterior View**

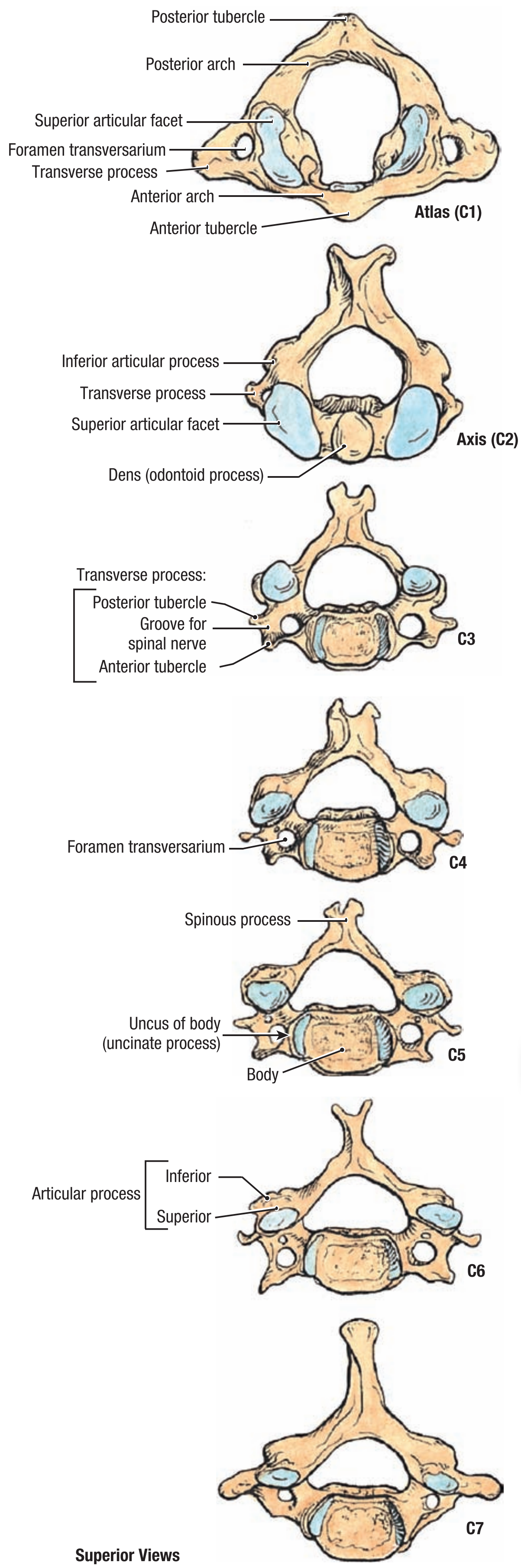


E. **Anteroposterior View**

4.8 SURFACE ANATOMY WITH RADIOGRAPHIC CORRELATION OF SELECTED MOVEMENTS OF THE LUMBAR SPINE

A. Radiograph of the extended lumbar spine. **B.** Flexion and extension of the trunk. **C.** Radiograph of the flexed lumbar spine. **D.** Lateral flexion (side flexion) of the trunk. **E.** Radiograph of the lumbar spine during lateral bending.

The range of movement of the vertebral column is limited by the thickness, elasticity, and compressibility of the IV discs; shape and orientation of the zygapophysial joints; tension of the joint capsules of the zygapophysial joints; resistance of the ligaments and back muscles; connection to thoracic (rib) cage and bulk of surrounding tissue.



Superior Views

TABLE 4.1 TYPICAL CERVICAL VERTEBRAE (C3–C7)a

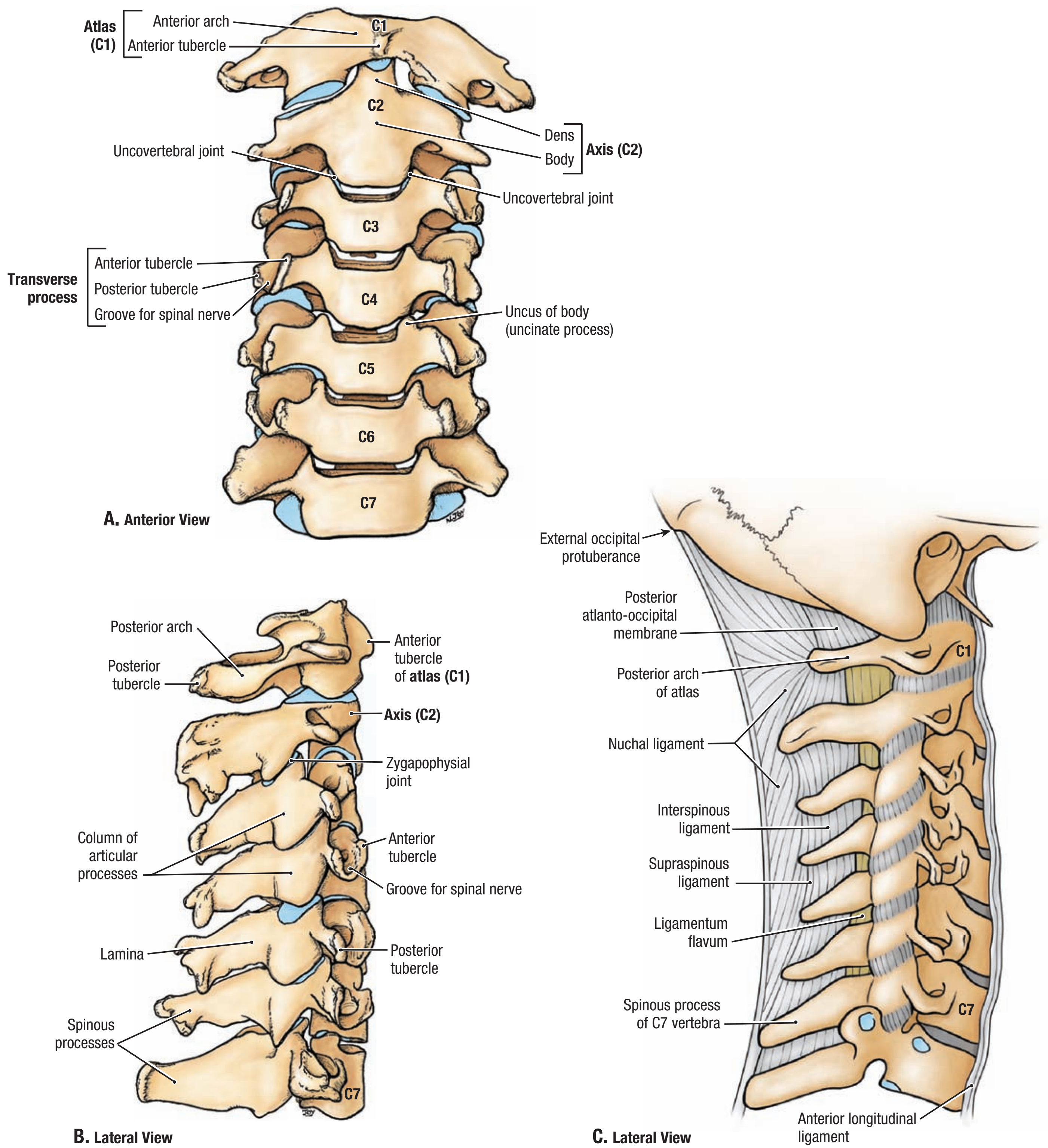
Part	Distinctive Characteristics
Body	Small and wider from side to side than anteroposteriorly; superior surface is concave with an uncus of body (uncinate process bilaterally); inferior surface is convex
Vertebral foramen	Large and triangular
Transverse processes	Foramina transversaria small or absent in vertebra C7; vertebral arteries and accompanying venous and sympathetic plexuses pass through foramina, except C7 foramina, which transmits only small accessory vertebral veins; anterior and posterior tubercles separated by groove for spinal nerve
Articular processes	Superior articular facets directed superoposteriorly; inferior articular facets directed infero-anteriorly; obliquely placed facets are most nearly horizontal in this region
Spinous process	Short (C3–C5) and bifid, only in Caucasians (C3–C5); process of C6 is long but that of C7 is longer; C7 is called "vertebra prominens"

[a]C1 and C2 vertebrae are atypical.

4.9 CERVICAL VERTEBRAE

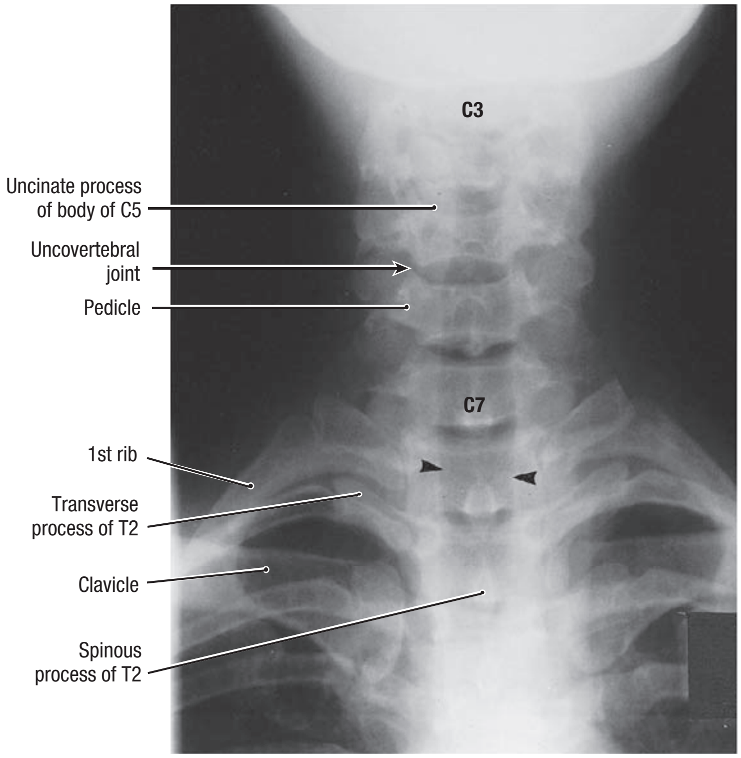
The bodies of the cervical vertebrae can be dislocated in neck injuries with less force than is required to fracture them. Because of the large vertebral canal in the cervical region, slight dislocation can occur without damaging the spinal cord. When a cervical vertebra is severely dislocated, it injures the spinal cord. If the dislocation does not result in "facet jumping" with locking of the displaced articular processes, the cervical vertebrae may self-reduce ("slip back into place") so that a radiograph may not indicate that the cord has been injured. MRI may reveal the resulting soft tissue damage.

Aging of the IV disc combined with the changing shape of the vertebrae results in an increase in compressive forces at the periphery of the vertebral bodies, where the disc attaches. In response **osteophytes** (bony spurs) commonly develop around the margins of the vertebral body, especially along the outer attachment of the IV disc. Similarly, as altered mechanics place greater stresses on the zygapophysial joints, osteophytes develop along the attachments of the joint capsules, especially those of the superior articular process.

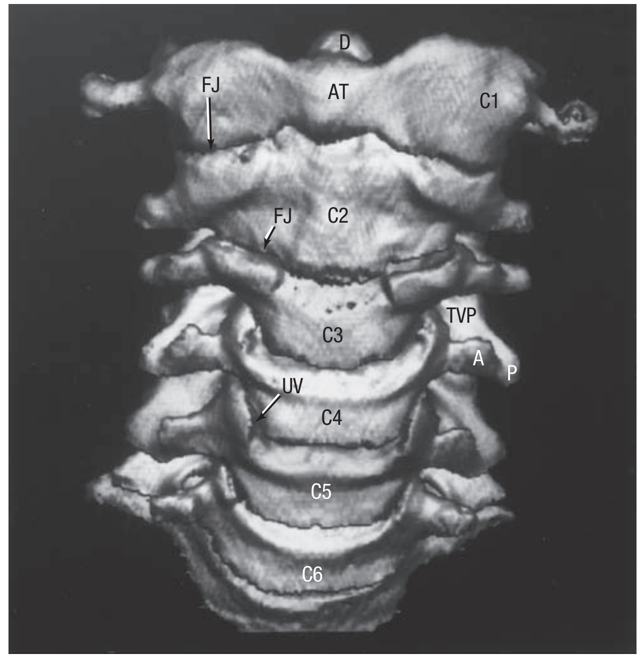


4.10 CERVICAL SPINE

A. and B. Articulated cervical vertebrae. **C.** Ligaments.

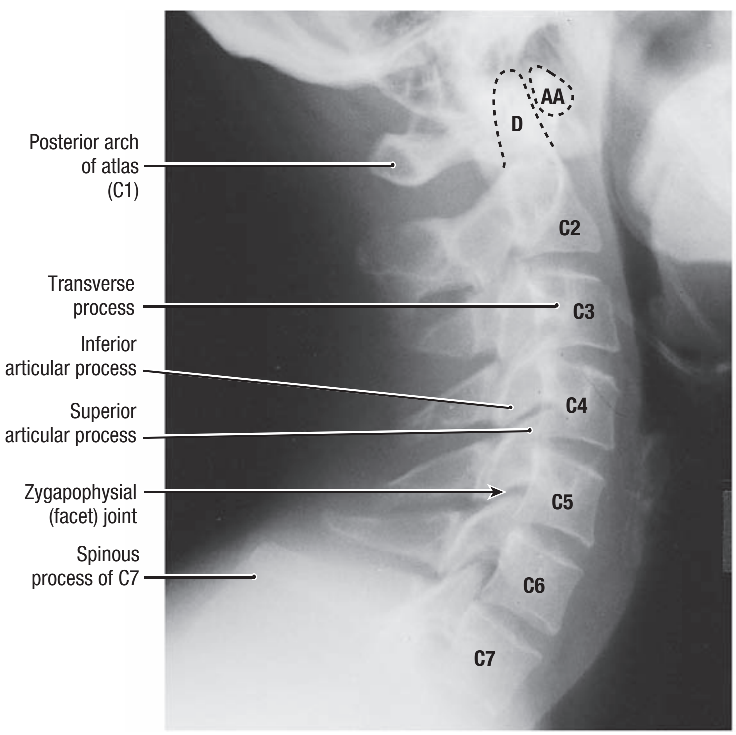


A. **Anteroposterior View**

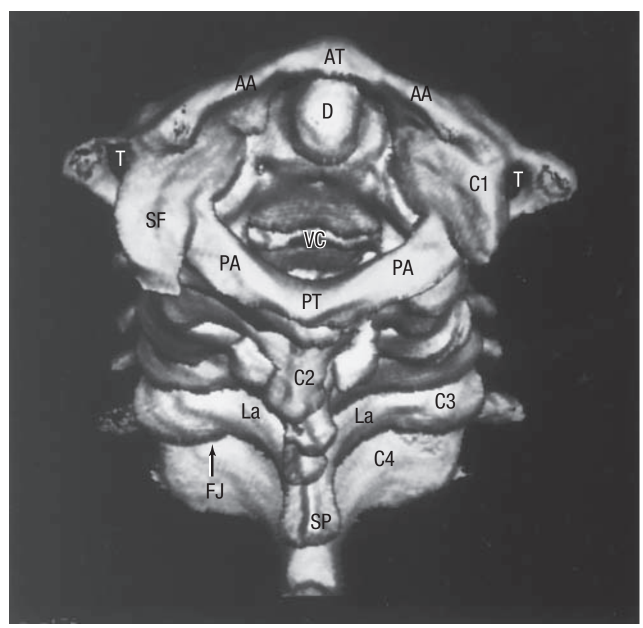


C. **Anterior View**

A	Anterior tubercle of transverse process	PA	Posterior arch of C1
AA	Anterior arch of C1	PT	Posterior tubercle of C1
AT	Anterior tubercle of C1	SF	Superior articular facet of C1
C1-C7	Vertebrae	SP	Spinous process
D	Dens (odontoid) process of C2	T	Foramen transversarium
FJ	Zygapophysial (facet) joint	TVP	Transverse process
La	Lamina	UV	Uncovertebral joint
P	Posterior tubercle of transverse process	VC	Vertebral canal



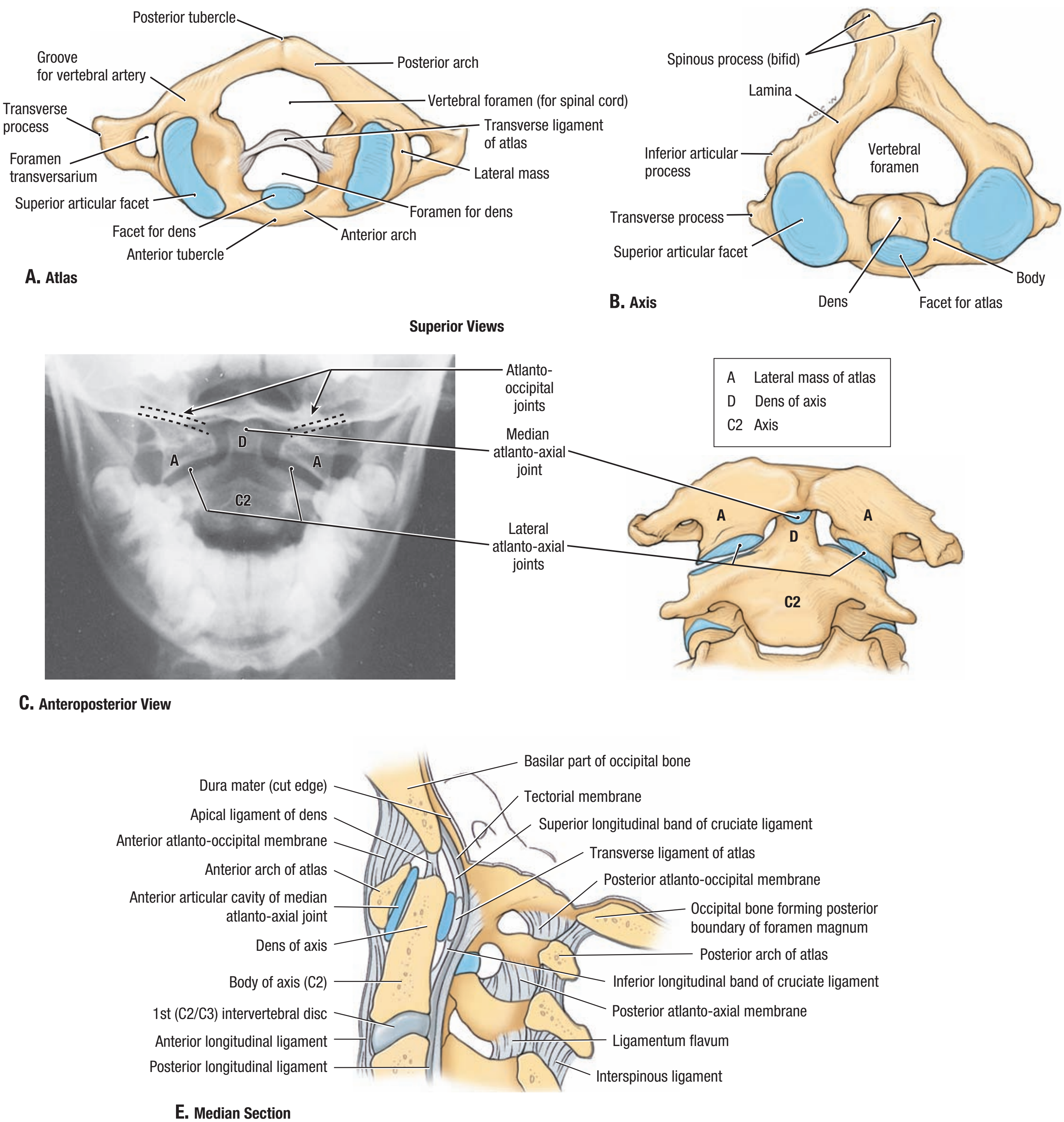
B. **Lateral View**



D. **Posterior View**

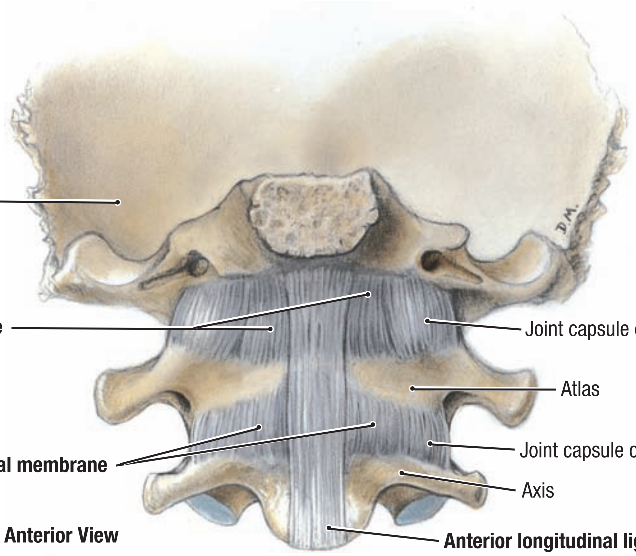
4.11 IMAGING OF THE CERVICAL SPINE

A. and B. Radiographs. The arrowheads demarcate the margins of the *(black)* column of air in the trachea.
C. and D. Three-dimensional (3D) reconstructed computed tomographic (CT) images.

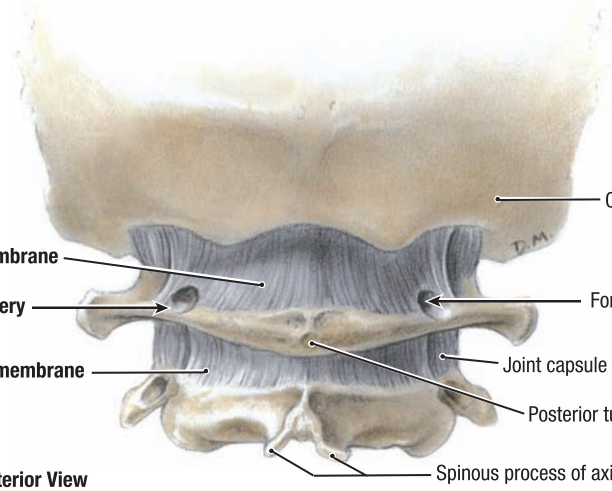


4.12 ATLAS AND AXIS AND THE ATLANTO-AXIAL JOINT

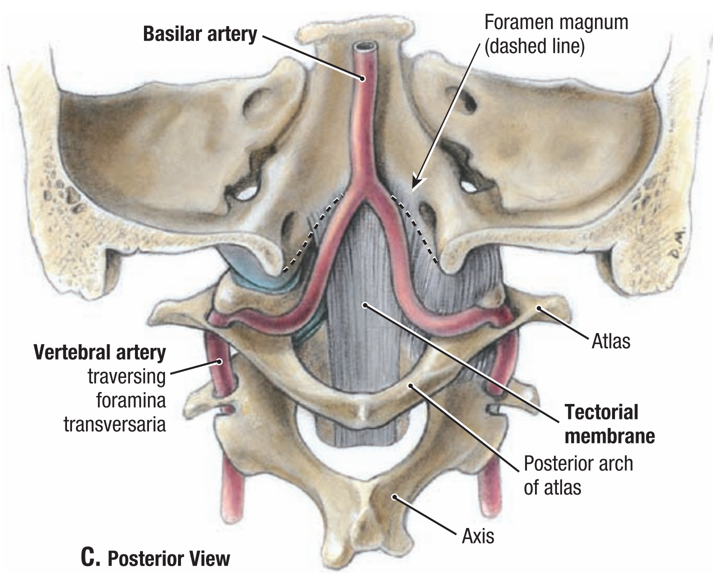
A. Atlas. **B.** Axis. **C.** Radiograph taken through the open mouth. **D.** Articulated atlas and axis. **E.** Median section with ligaments.



A. **Anterior View**



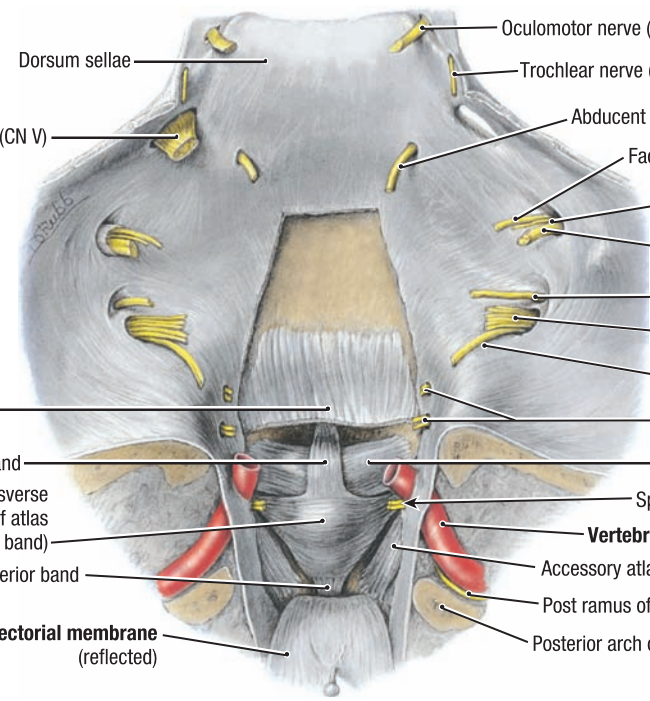
B. **Posterior View**



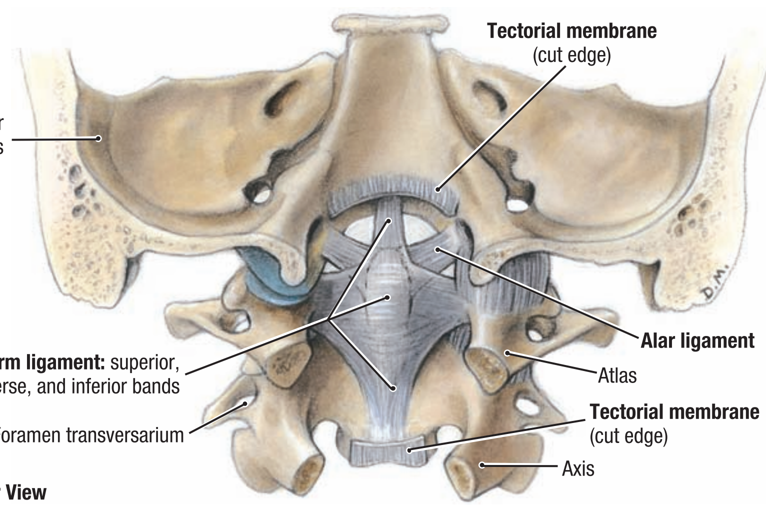
C. **Posterior View**

4.13 CRANIOVERTEBRAL JOINTS AND VERTEBRAL ARTERY

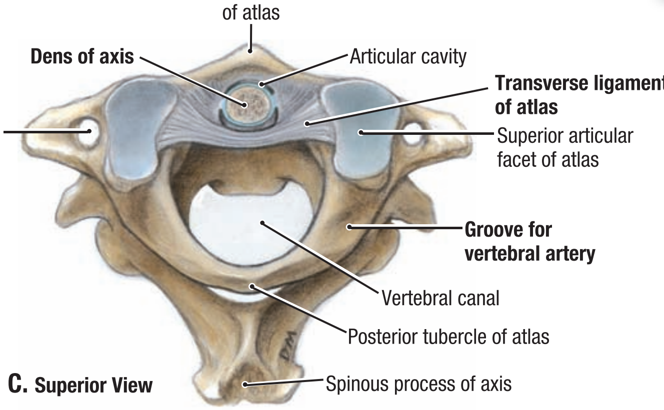
A. Anterior atlanto-axial and atlanto-occipital membranes. The anterior longitudinal ligament ascends to blend with, and form a central thickening in, the anterior atlanto-axial and atlanto-occipital membranes. **B.** Posterior atlanto-axial and atlanto-occipital membranes. Inferior to the axis (C2 vertebra), ligamenta flava occur in this position. **C.** Tectorial membrane and vertebral artery. The tectorial membrane is a superior continuation of the posterior longitudinal ligament superior to the body of the axis. After coursing through the foramina transversaria of vertebrae C6–C1, the vertebral arteries turn medially, grooving the superior aspect of the posterior arch of the atlas and piercing the posterior atlanto-occipital membrane (**B**). The right and left vertebral arteries traverse the foramen magnum and merge intracranially, forming the basilar artery.



A. **Posterior View**



B. **Posterior View (Coronal Section)**

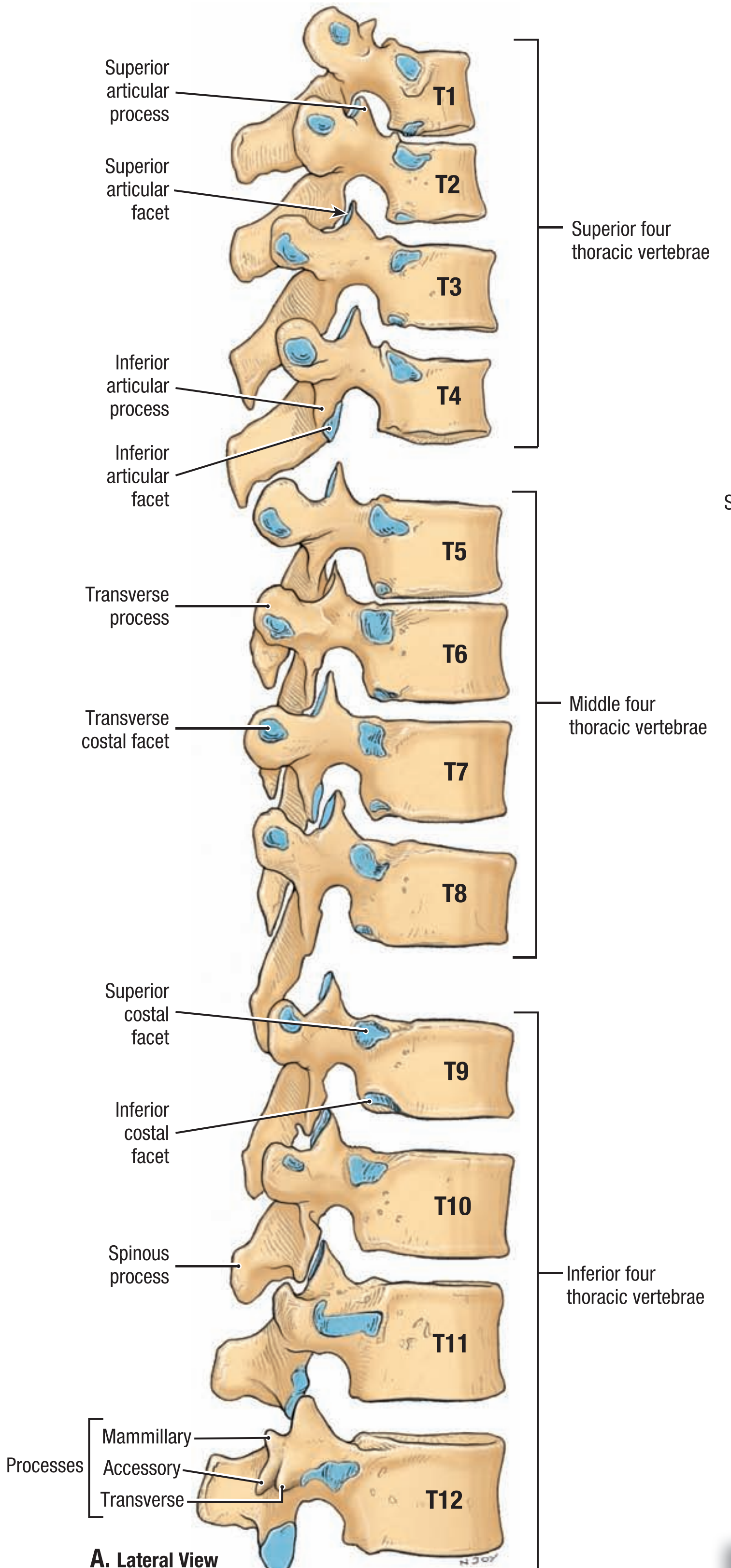


C. **Superior View**

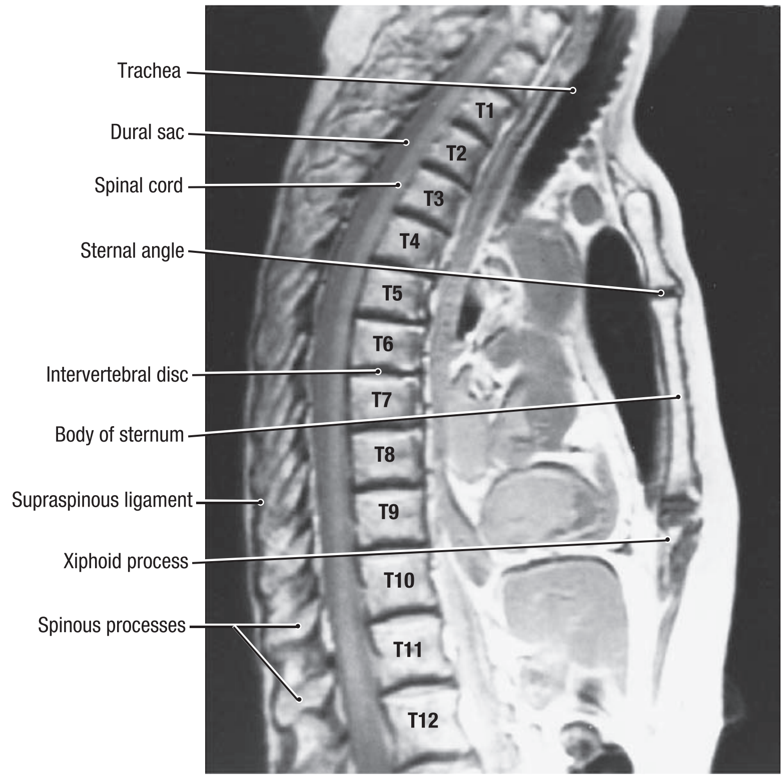
4.14 LIGAMENTS OF ATLANTO-OCCIPITAL AND ATLANTO-AXIAL JOINTS

A. Cranial nerves and dura mater of posterior cranial fossa with dura mater and tentorial membrane incised and removed to reveal the medial atlanto-axial joint. **B.** The alar ligaments serve as check ligaments for the rotary movements of the atlanto-axial joints. **B. and C.** The transverse ligament of the atlas, the transverse band of the cruciform ligament, provides the posterior wall of a socket that receives the dens of the axis, forming a pivot joint.

Fracture of atlas. The atlas is a bony ring, with two wedge-shaped lateral masses, connected by relatively thin anterior and posterior arches and the transverse ligament of the atlas (see Figs. 4.12A & C). Vertical forces (e.g., striking the head on bottom of pool) may force the lateral masses apart fracturing one or both of the anterior or posterior arches. If the force is sufficient, rupture of the transverse ligament of the atlas will also occur.



A. Lateral View



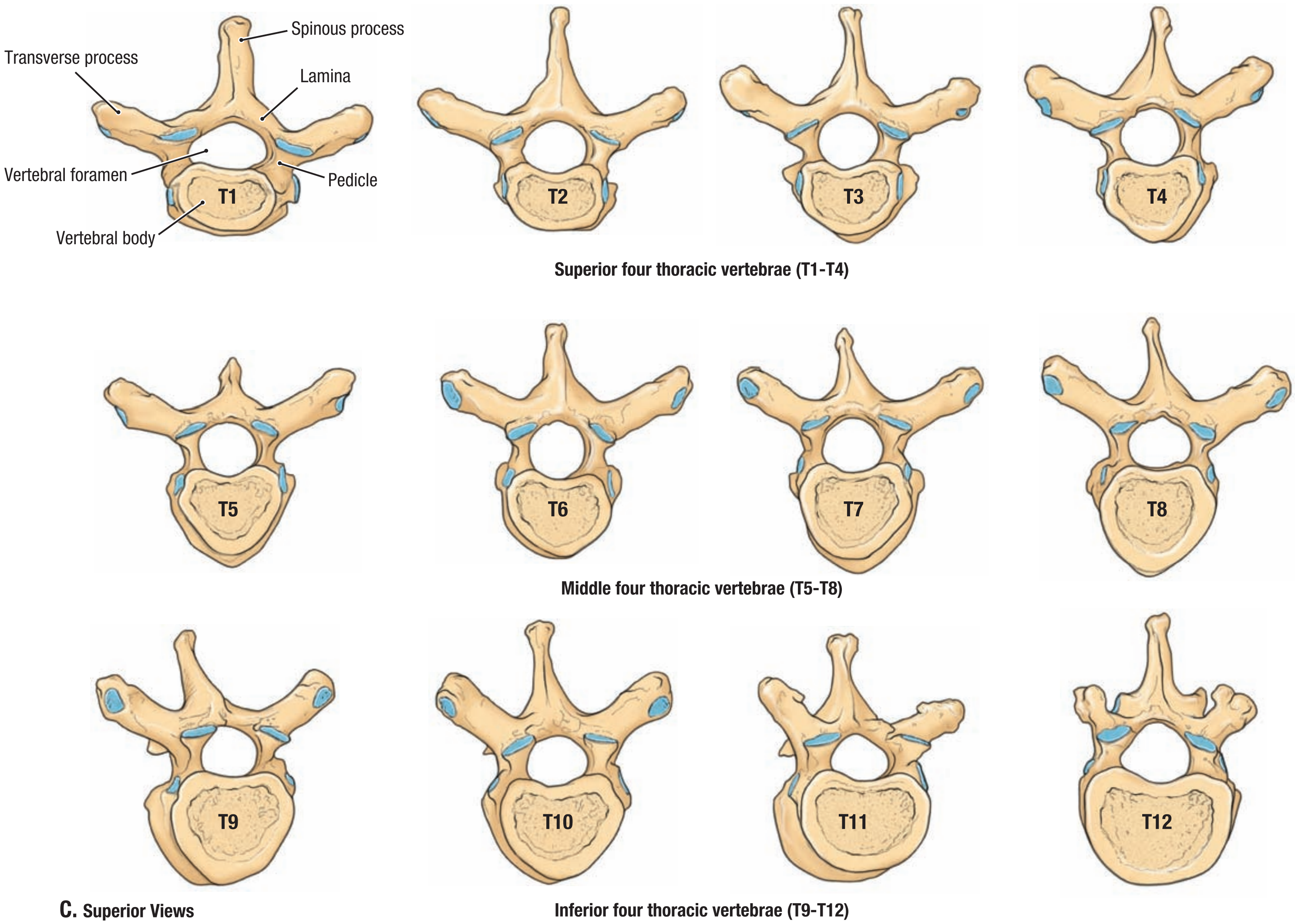
B. Median Section

TABLE 4.2 THORACIC VERTEBRAE

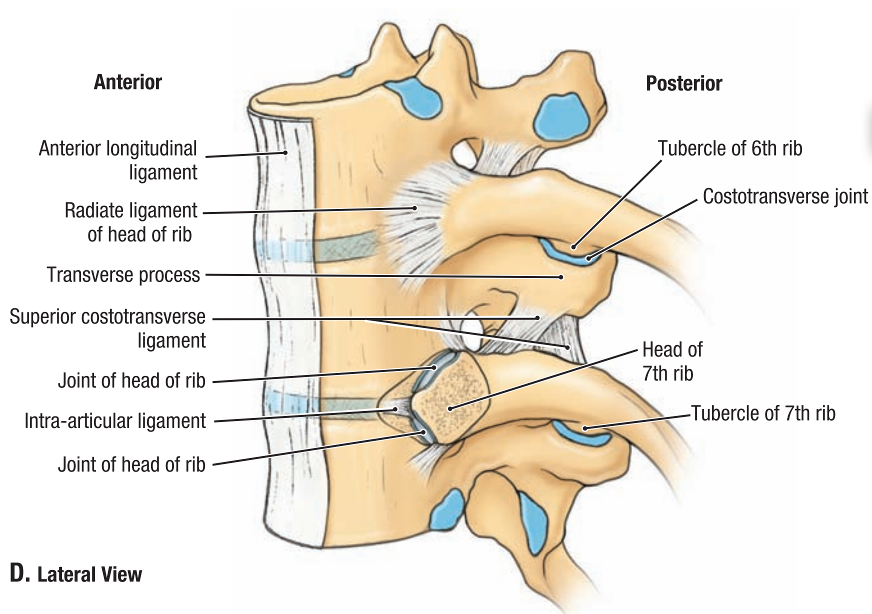
Part	Distinctive Characteristics
Body	Heart shaped; has one or two costal facets for articulation with head of rib
Vertebral foramen	Circular and smaller than those of cervical and lumbar vertebrae
Transverse processes	Long and extend posterolaterally; length diminishes from T1 to T12; T1–T10 have transverse costal facets for articulation with a tubercle of ribs 1–10 (ribs 11 and 12 have no tubercle and do not articulate with a transverse process)
Articular processes	Superior articular facets directed posteriorly and slightly laterally; inferior articular facets directed anteriorly and slightly medially
Spinous process	Long and slopes postero-inferiorly; tip extends to level of vertebral body below

4.15 THORACIC VERTEBRAE

A. Features. **B.** MRI scan of thoracic spine, median section.



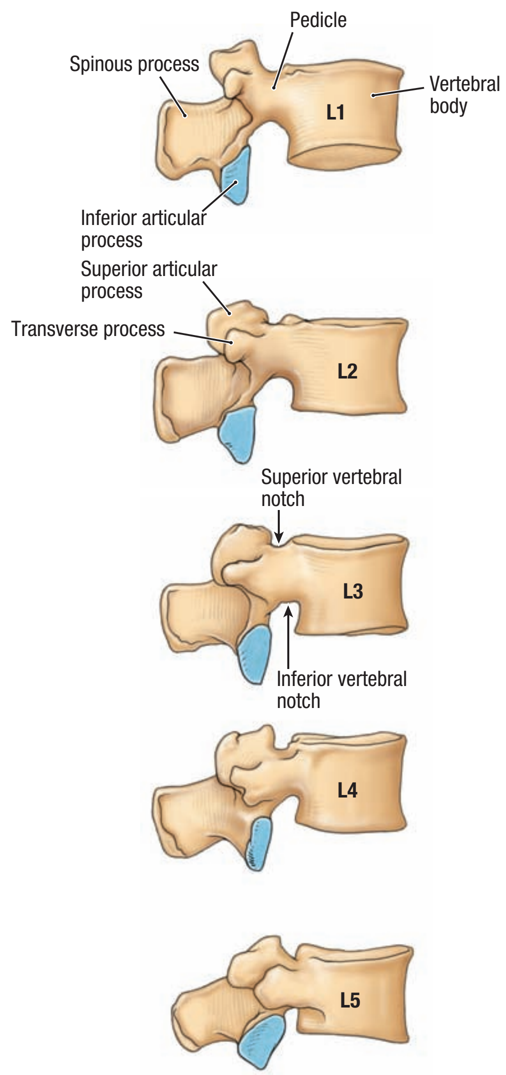
C. Superior Views



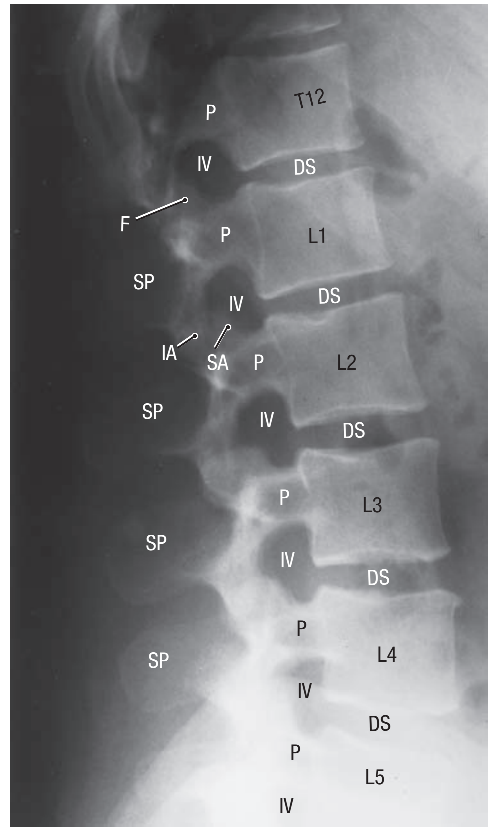
D. Lateral View

4.15 THORACIC VERTEBRAE (*CONTINUED*)

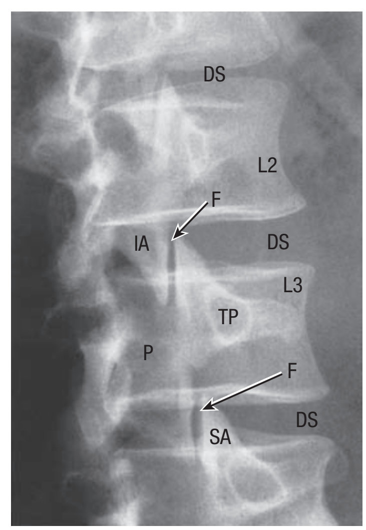
C. Comparative anatomy. The vertebral bodies increase in size as the vertebral column descends, each bearing an increasing amount of weight transferred by the vertebra above. **Fracture of thoracic vertebrae**. Although the characteristics of the superior aspect of vertebra T12 are distinctly thoracic, its inferior aspect has lumbar characteristics for articulation with vertebra L1. The abrupt transition allowing primarily rotational movements with vertebra T11 while disallowing rotational movements with vertebral L1 makes vertebra T12 especially susceptible to fracture. **D.** Intra- and extra-articular ligaments of the costovertebral articulations. Typically, the head of each rib articulates with the bodies of two adjacent vertebrae and the IV disc between them, and the tubercle of the rib articulates with the transverse process of the inferior vertebra.



A. **Lateral Views**



B. **Lateral View**



C. **Oblique View**

TABLE 4.3 LUMBAR VERTEBRAE

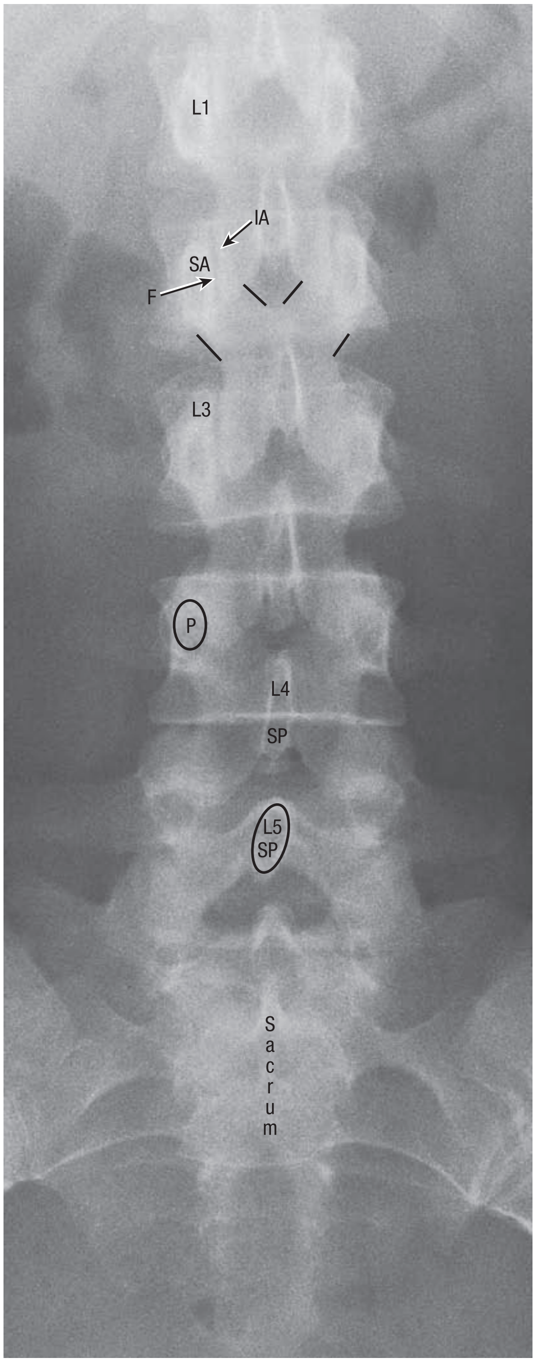
Part	Distinctive Characteristics
Body	Massive; kidney shaped when viewed superiorly
Vertebral	Triangular; larger than in thoracic vertebrae and foramen smaller than in cervical vertebrae
Transverse	Long and slender; accessory process on posterior surface of base of each transverse process
Articular processes	Superior articular facets directed posteromedially (or medially); inferior articular facets directed anterolaterally (or laterally); mammillary process on posterior surface of each superior articular process
Spinous process	Short and sturdy; thick, broad, and rectangular

Key for B, C and D

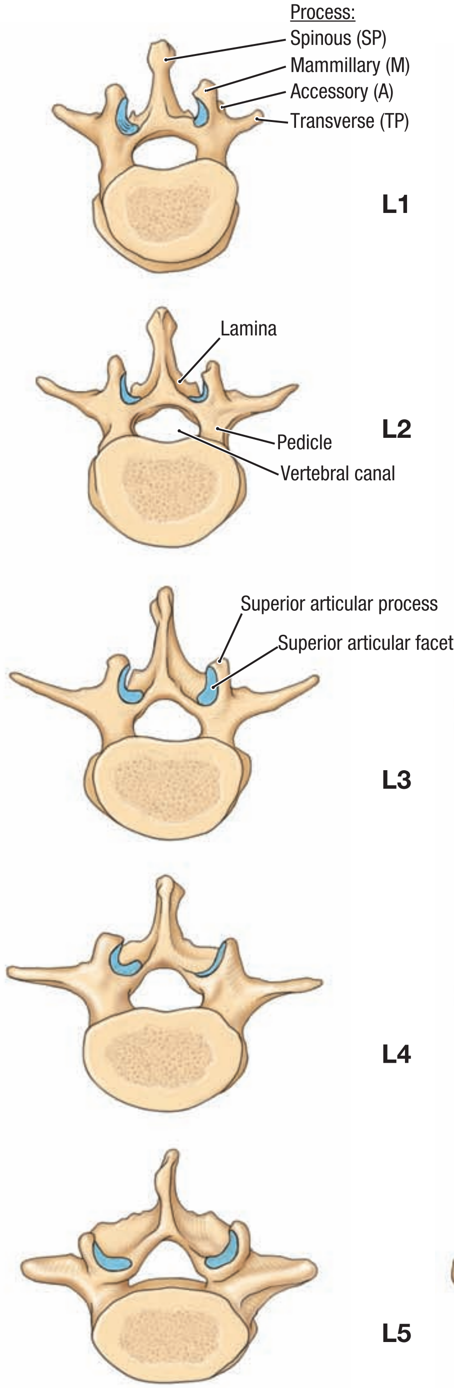
F	Zygapophysial (facet) joint	P	Pedicle
DS	Intervertebral disc space	SA	Superior articular process
IA	Inferior articular process	SP	Spinous process
IV	Intervertebral foramen	T12–L5	Vertebral bodies
L	Lamina	TP	Transverse process

4.16 LUMBAR VERTEBRAE

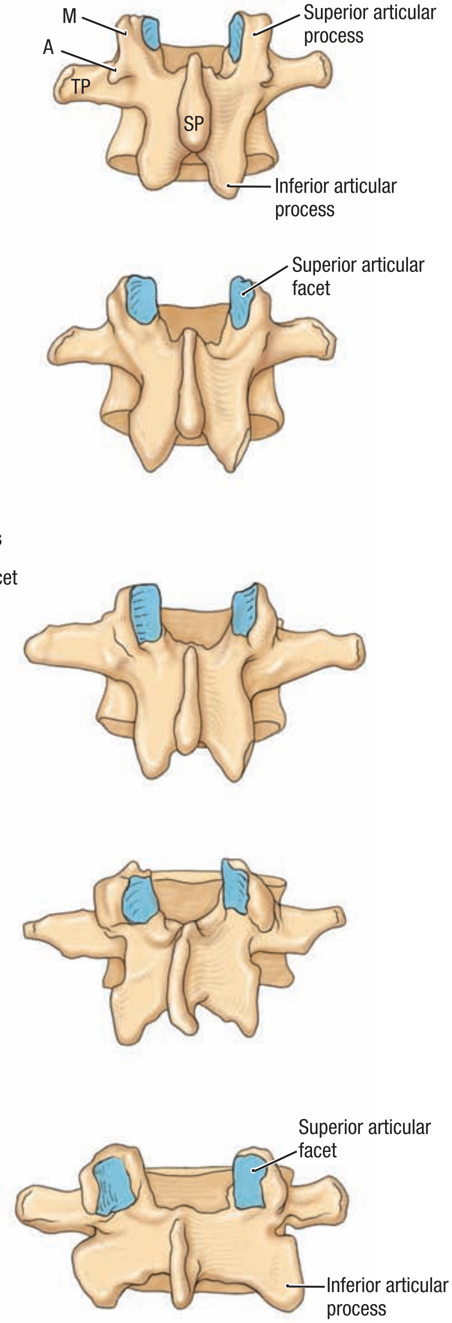
A, E, and F. Features. **B, C, and D.** Radiographs **G.** Laminectomy. A **laminectomy** is the surgical excision of one or more spinous processes and their supporting laminae in a particular region of the vertebral column (number 1 in **G.**). The term is also commonly used to denote the removal of most of the vertebral arch by transecting the pedicles (number 2 in **G.**). Laminectomies provide access to the vertebral canal to relieve pressure on the spinal cord or nerve roots, commonly caused by a tumor or herniated IV disc.



D. **Superior View**

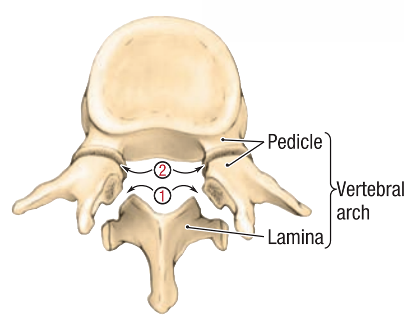


E. **Superior View**

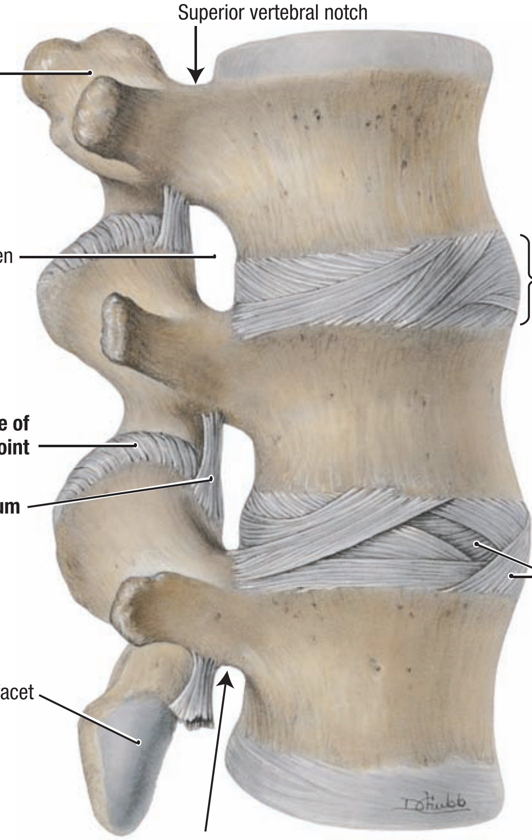


F. **Posterior View**

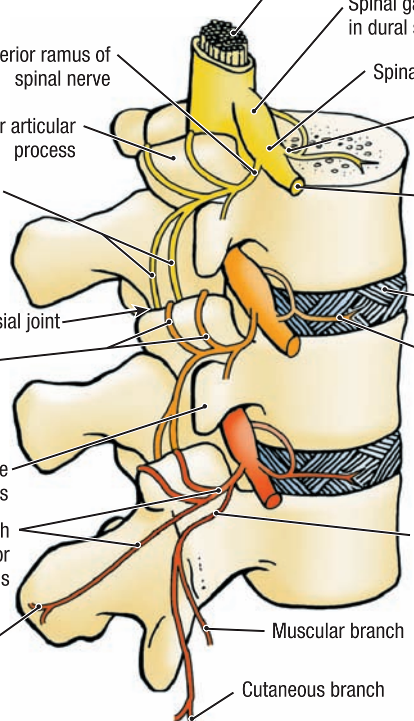
4.16 LUMBAR VERTEBRAE (*CONTINUED*)



G. **Superior View, Sites of Laminectomy (1 and 2)**



A. Lateral View

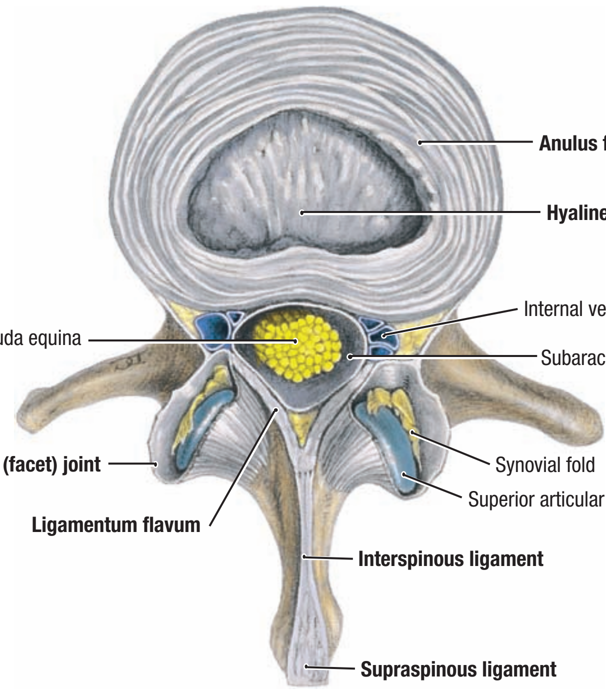


B. Left Posterolateral View

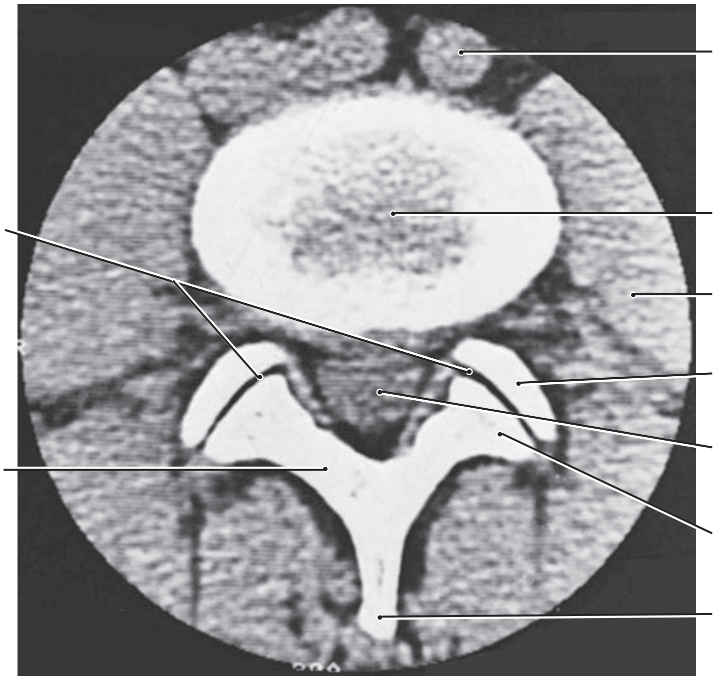
4.17 STRUCTURE AND INNERVATION OF INTERVERTEBRAL DISCS AND ZYGAPOPHYSIAL JOINTS

A. Intervertebral discs and intervertebral foramen. Sections have been removed from the superficial layers of the anulus fibrosus of the inferior IV disc to show the change in direction of the fibers in the concentric layers of the anulus. Note that the IV discs form the inferior half of the anterior boundary of the IV foramen. **B.** Innervation of zygapophysial joints and the anulus fibrosus of IV discs.

When the **zygapophysial joints are injured** or develop osteophytes during aging (osteoarthritis), the related spinal nerves are affected. This causes pain along the distribution pattern of the dermatomes and spasm in the muscles derived from the associated myotomes (a myotome consists of all the muscles or parts of muscles receiving innervation from one spinal nerve). Denervation of lumbar zygapophysial joints is a procedure that may be used for treatment of back pain caused by disease of these joints. The nerves are sectioned near the joints or are destroyed by radiofrequency percutaneous rhizolysis (root dissolution). The denervation process is directed at the articular branches of two adjacent posterior rami of the spinal nerves because each joint receives innervation from both the nerve exiting that level and the superjacent nerve.



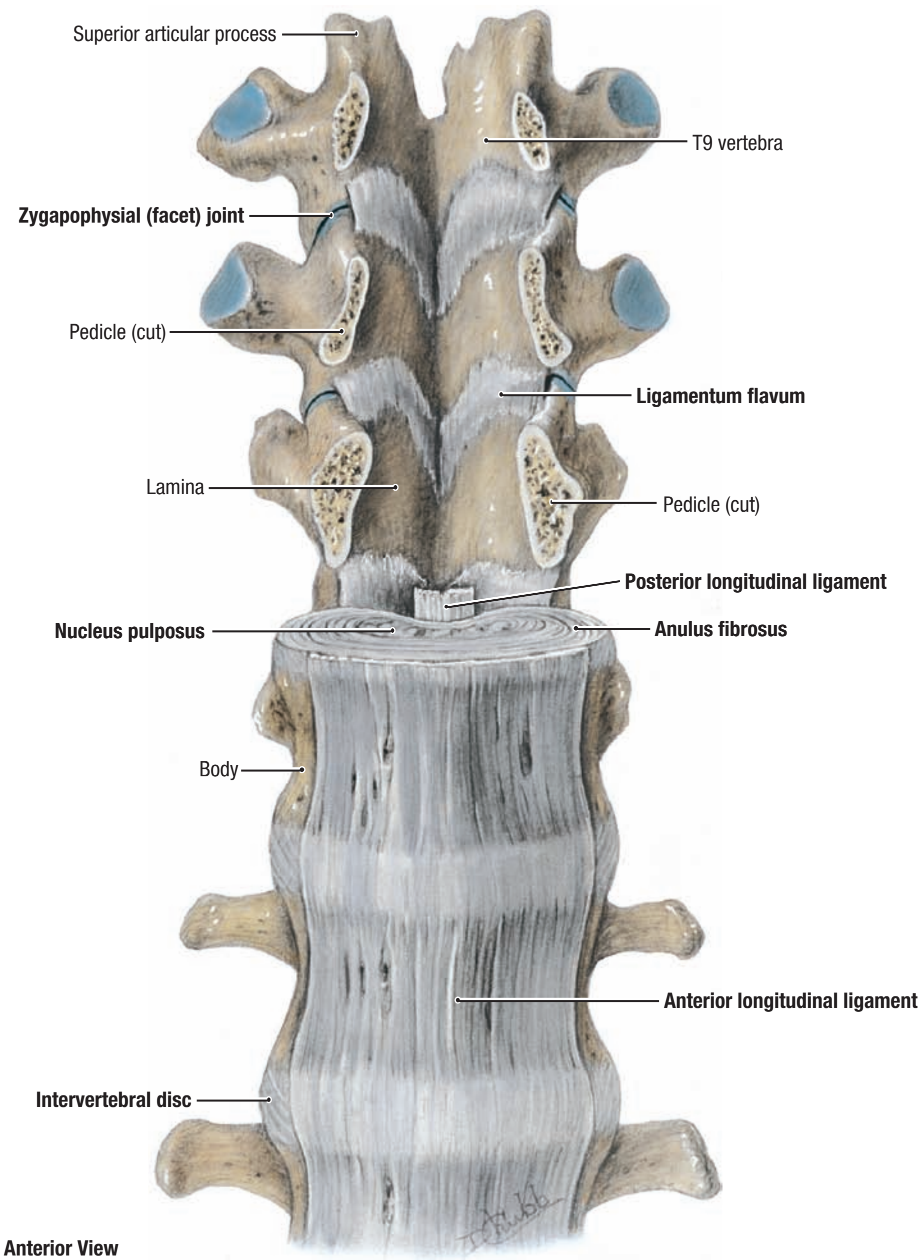
C. Transverse Section, Superior View



D. Transverse (Axial) CT Scan

4.17 STRUCTURE AND INNERVATION OF INTERVERTEBRAL DISCS AND ZYGAPOPHYSIAL JOINTS (*CONTINUED*)

C. Transverse section. The nucleus pulposus has been removed, and the cartilaginous epiphysial plate exposed. There are fewer rings of the anulus fibrosus posteriorly, and consequently, this portion of the annulus fibrosus is thinner. The ligamentum flavum, interspinous, and supraspinous ligaments are continuous. **D.** CT image of L4/L5 IV disc.



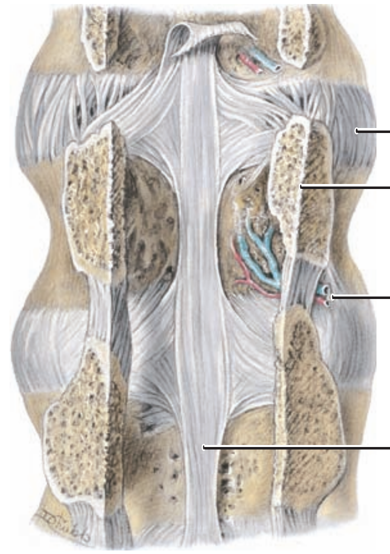
A. Anterior View

4.18 INTERVERTEBRAL DISCS: LIGAMENTS AND MOVEMENTS

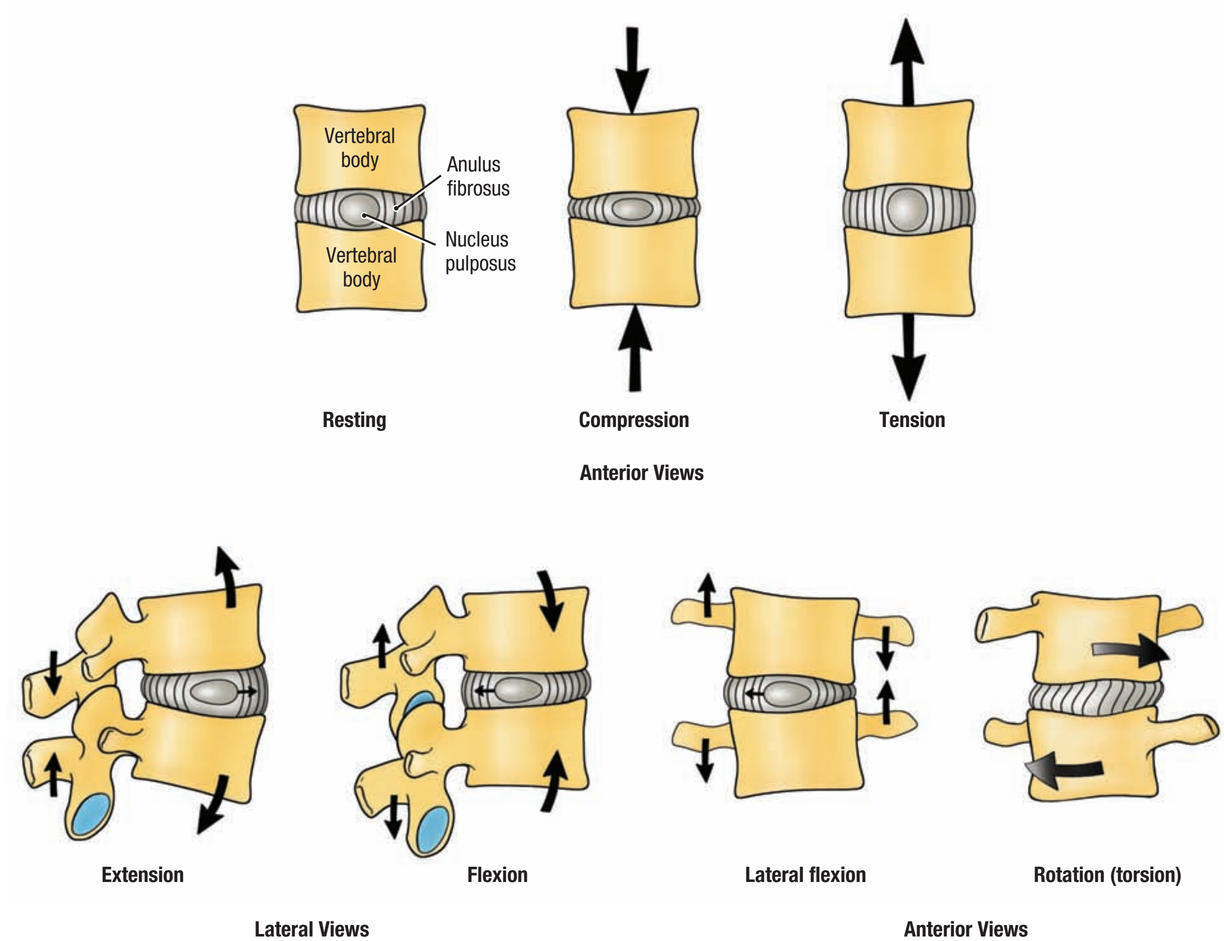
A. Anterior longitudinal ligament and ligamenta flava. The pedicles of vertebrae T9 to T11 were sawed through, and the posterior aspect of the bodies is shown in **B.**

B. Posterior longitudinal ligament. **C.** IV disc during loading and movement.

- The anterior and posterior longitudinal ligaments are ligaments of the vertebral bodies; the ligamenta flava are ligaments of the vertebral arches.
- The anterior longitudinal ligament consists of broad, strong, fibrous bands, thickened centrally, that are attached to the IV discs and vertebral bodies anteriorly and are perforated by the foramina for arteries and veins passing to and from the vertebral bodies.
- The ligamenta flava, composed of elastic fibers, extend between adjacent laminae; right and left ligaments converge in the median plane. They extend laterally to the articular processes, where they blend with the joint capsule of the zygapophysial joints.



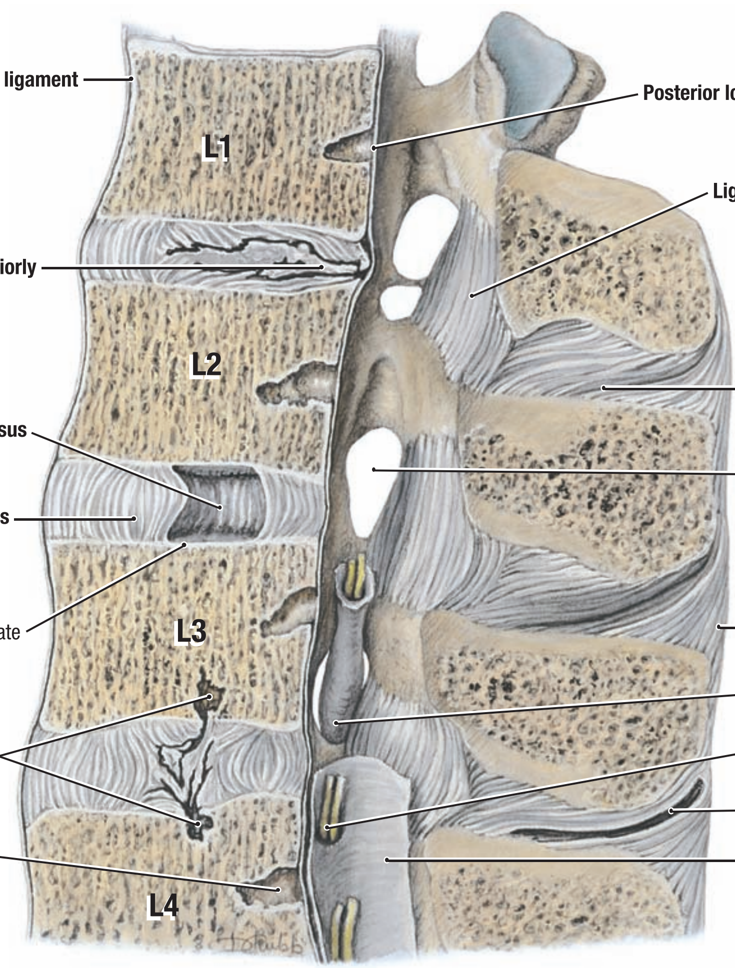
B. Posterior View



C.

4.18 INTERVERTEBRAL DISCS: LIGAMENTS AND MOVEMENTS (*CONTINUED*)

- The posterior longitudinal ligament is a narrow band passing from disc to disc, spanning the posterior surfaces of the vertebral bodies (in **B**). The ligament is diamond shaped posterior to each IV disc, where it exchanges fibers with the anulus fibrosus; the ligament extends to the sacrum inferiorly and becomes the tectorial membrane cranially.
- The movement or loading of the IV disc changes its shape and the position of the nucleus pulposus. Flexion and extension movements cause compression and tension simultaneously.

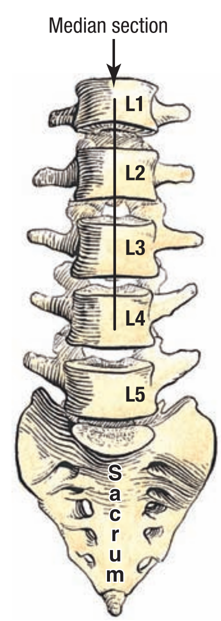


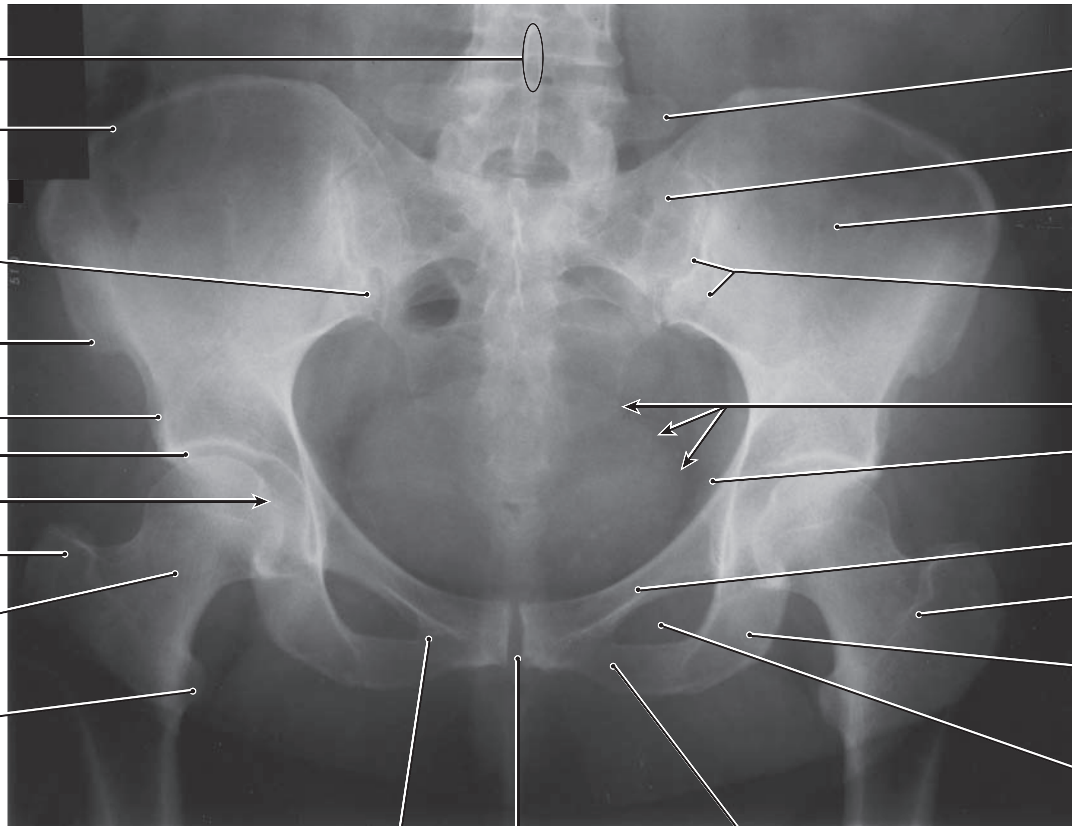
4.19 LUMBAR REGION OF VERTEBRAL COLUMN

The nucleus pulposus of the normal disc between vertebrae L2 and L3 has been removed from the enclosing anulus fibrosus.

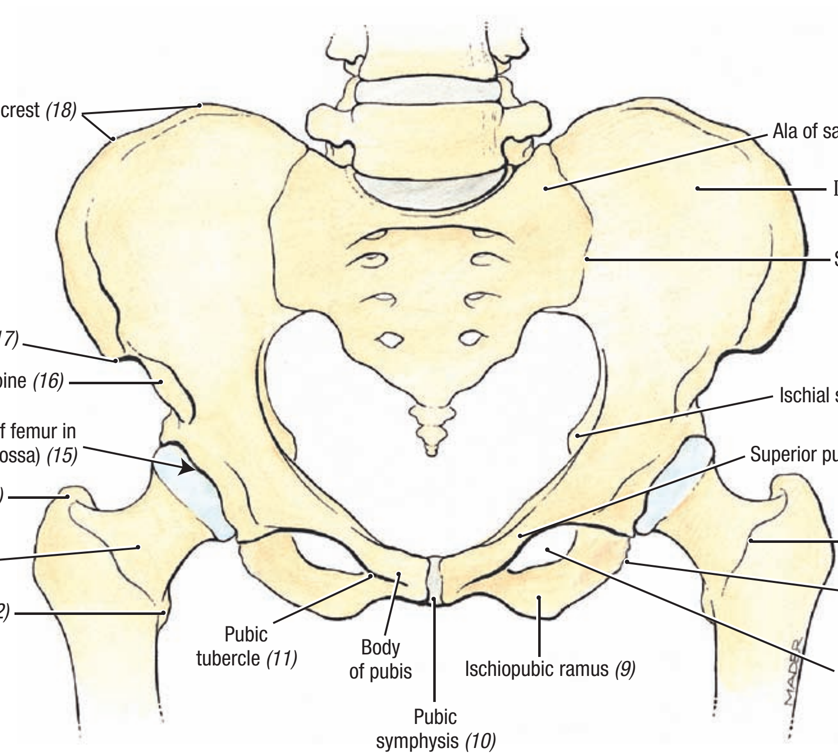
- The ligamentum flavum extends from the superior border and adjacent part of the posterior aspect of one lamina to the inferior border and adjacent part of the anterior aspect of the lamina above and extends laterally to become continuous with the fibrous capsule of the zygapophysial joint.
- The obliquely placed interspinous ligament unites the superior and inferior borders of two adjacent spines.
- The bursa between L3 and L4 spines is presumably the result of habitual hyperextension, which brings the lumbar spines into contact.

The nucleus pulposus of the disc between L1 and L2 has herniated posteriorly through the anulus. **Herniation** or **protrusion of the gelatinous nucleus pulposus** into or through the anulus fibrosus is a well-recognized cause of low back and lower limb pain. If degeneration of the posterior longitudinal ligament and wearing of the anulus fibrosus has occurred, the nucleus pulposus may herniate into the vertebral canal and compress the spinal cord or nerve roots of spinal nerves in the cauda equina. Herniations usually occur posterolaterally, where the anulus is relatively thin and does not receive support from either the posterior or anterior longitudinal ligaments.





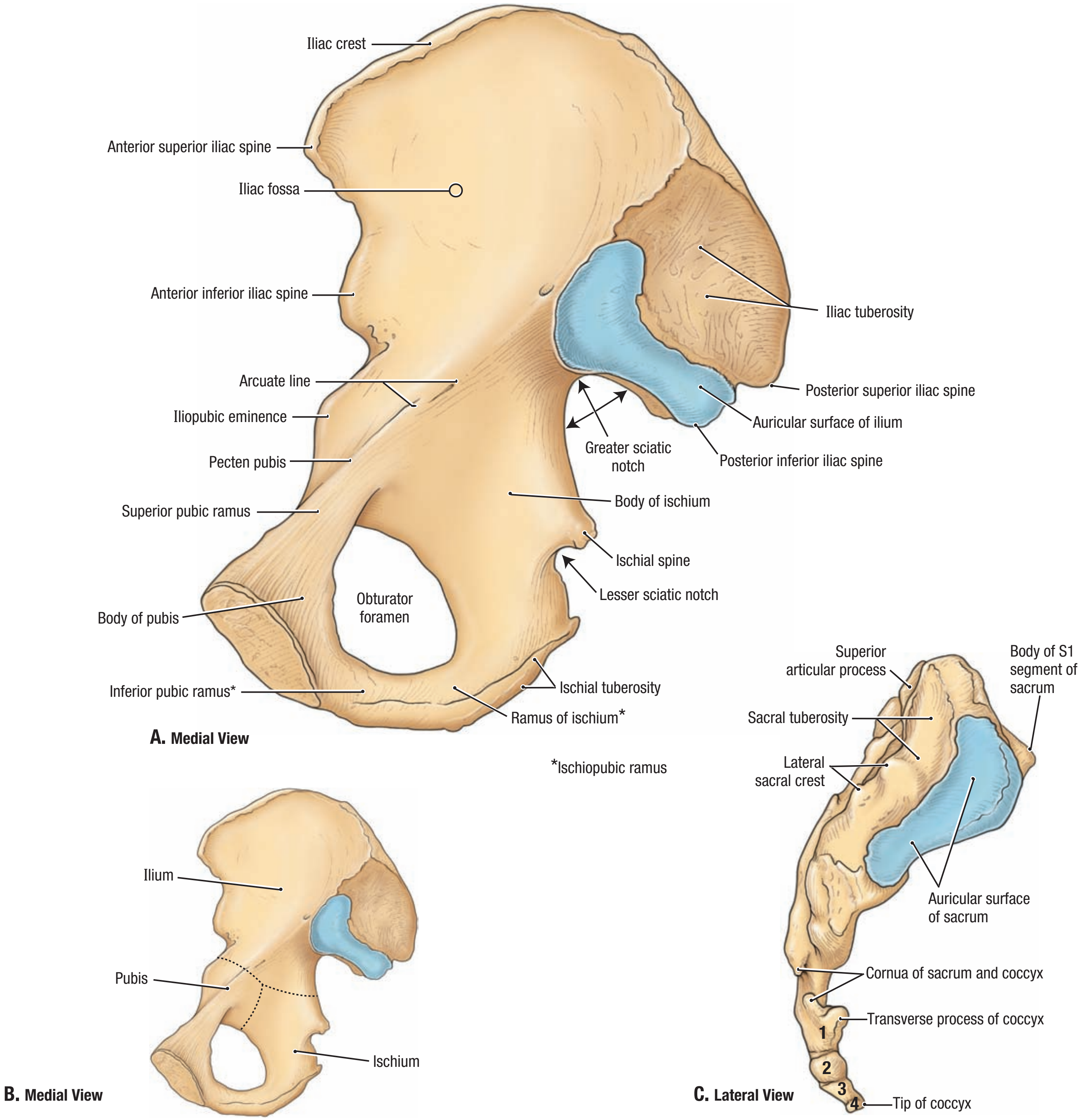
A. **Anteroposterior View**



B. **Anterior View**

4.20 PELVIS

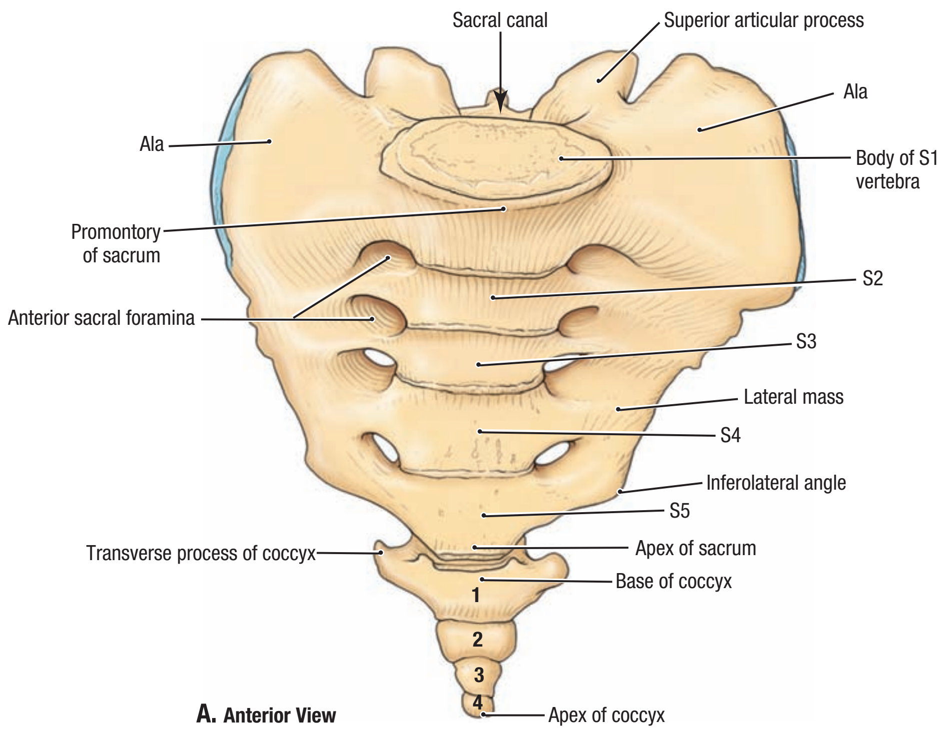
A. Radiograph of pelvis. **B.** Bony pelvis with articulated femora.



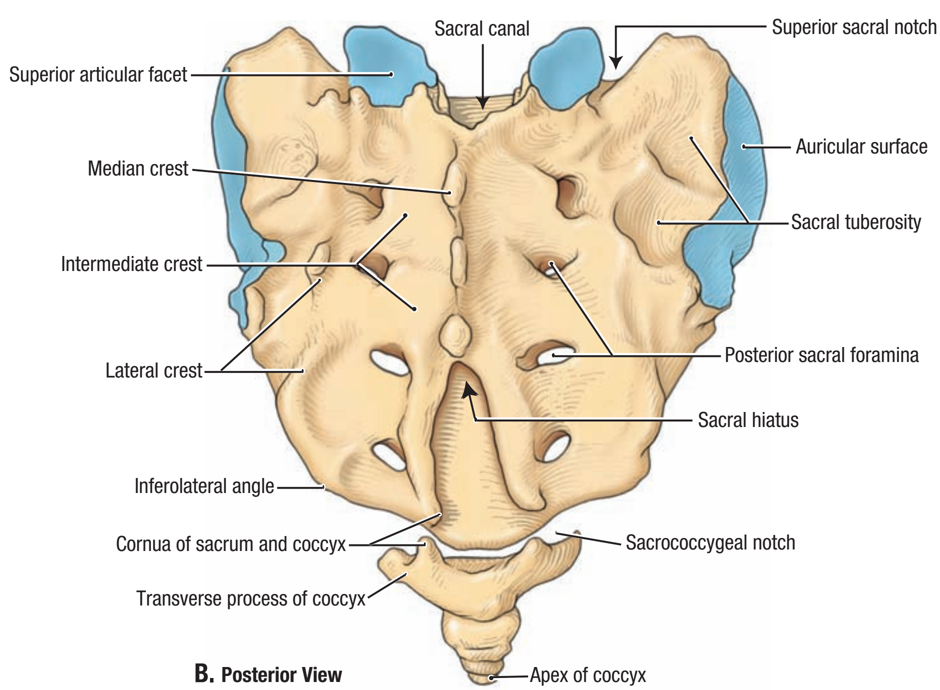
4.21 HIP BONE, SACRUM, AND COCCYX

A. Features of hip bone. **B.** Ilium, ischium, and pubis. **C.** Sacrum and coccyx. Vertebral column is fused to the sacrum.

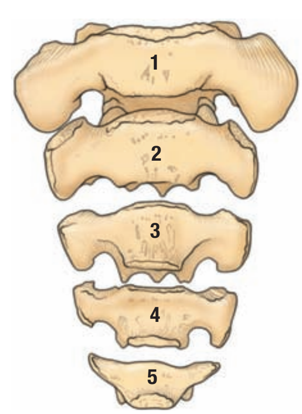
- Each hip bone consists of three bones: ilium, ischium, and pubis.
- Anterosuperiorly, the auricular, ear-shaped surface of the sacrum articulates with the auricular surface of the ilium; the sacral and iliac tuberosities are for the attachment of the posterior sacro-iliac and interosseous sacro-iliac ligaments.



A. Anterior View



B. Posterior View

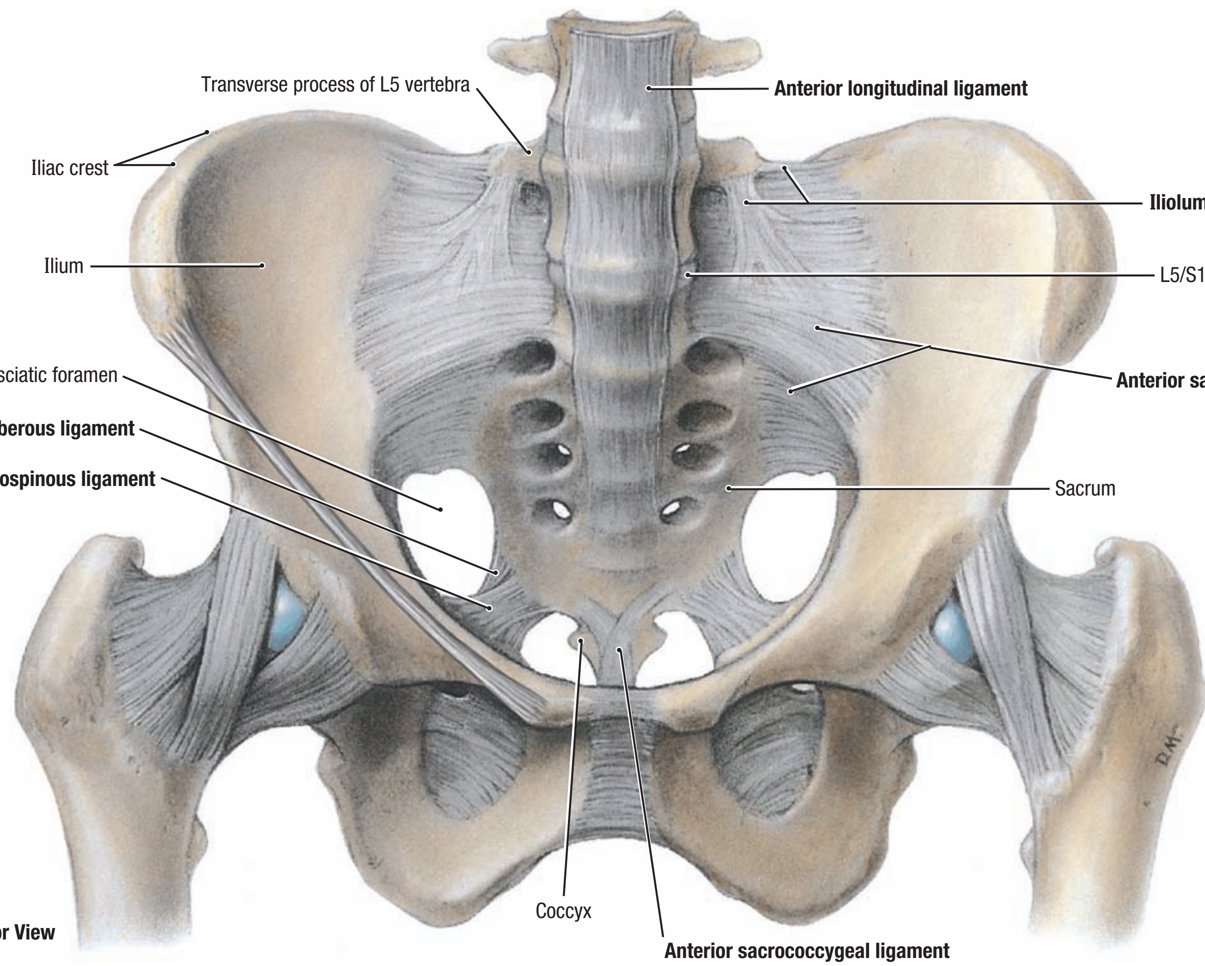


C. Anterior View

4.22 SACRUM AND COCCYX

A. Pelvic (anterior) surface. **B.** Dorsal (posterior surface). **C.** Sacrum in youth.

- In **A,** the bodies of the five sacral vertebrae are demarcated in the mature sacrum by four transverse lines ending laterally in four pairs of anterior sacral foramina. The coccyx has four vertebrae (segments)—the first having a pair of transverse processes and a pair of cornua (horns).
- The costal (lateral) elements of the coccygeal vertebrae begin to fuse around puberty. The bodies begin to fuse from inferior to superior at about the 17th to 18th year, with fusion usually completed by the 23rd year.

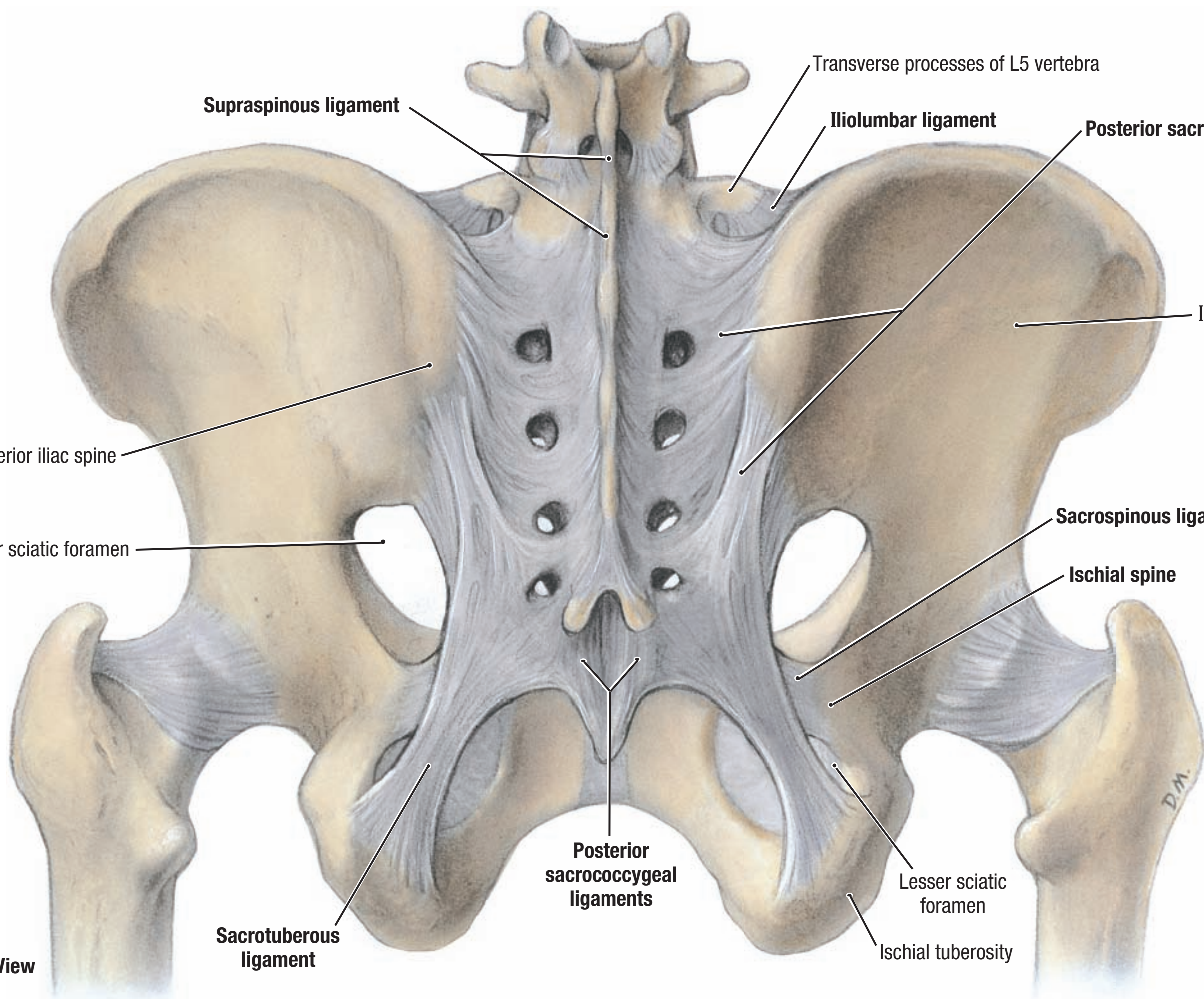


A. **Anterior View**

4.23 LUMBAR AND PELVIC LIGAMENTS

- The anterior sacro-iliac ligament is part of the fibrous capsule of the sacro-iliac joint anteriorly and spans between the lateral aspect of the sacrum and the ilium, anterior to the auricular surfaces.

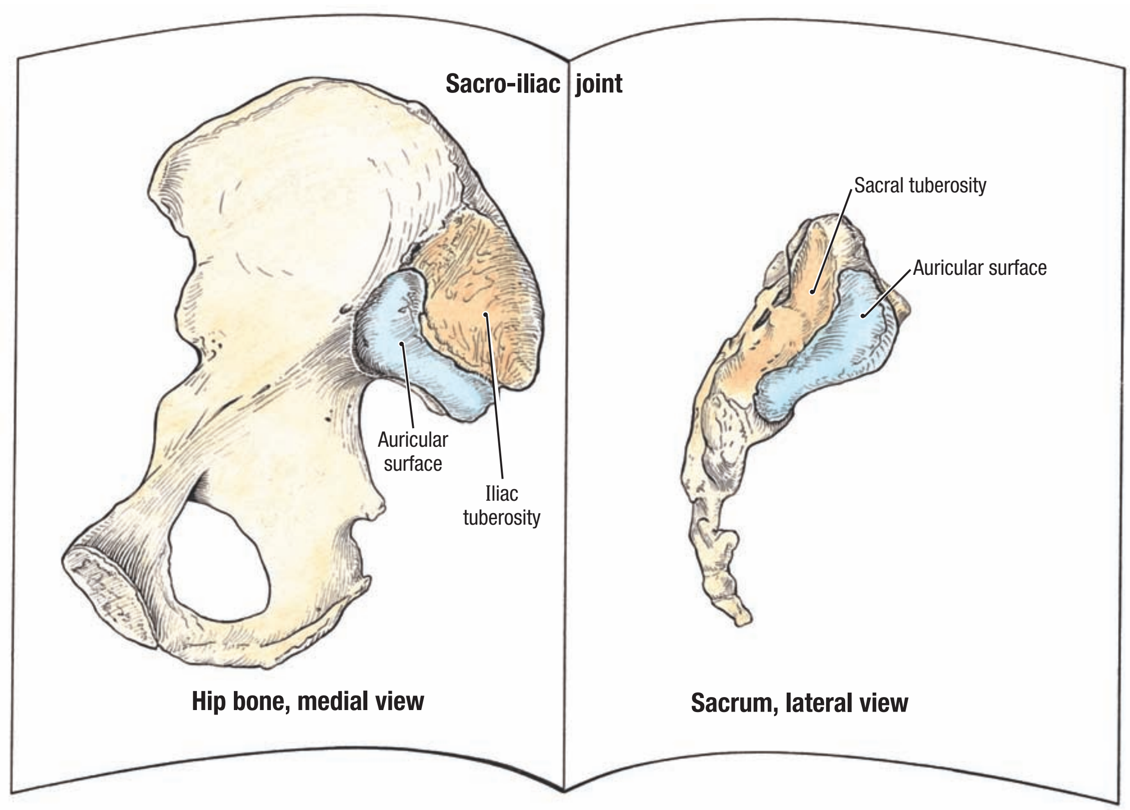
During **pregnancy,** the pelvic joints and ligaments relax**,** and pelvic movements increase. The sacro-iliac interlocking mechanism is less effective because the relaxation permits greater rotation of the pelvis and contributes to the lordotic posture often assumed during pregnancy with the change in the center of gravity. Relaxation of the sacro-iliac joints and pubic symphysis permits as much as 10% to 15% increase in diameters (mostly transverse), facilitating passage of the fetus through the pelvic canal. The coccyx is also allowed to move posteriorly.

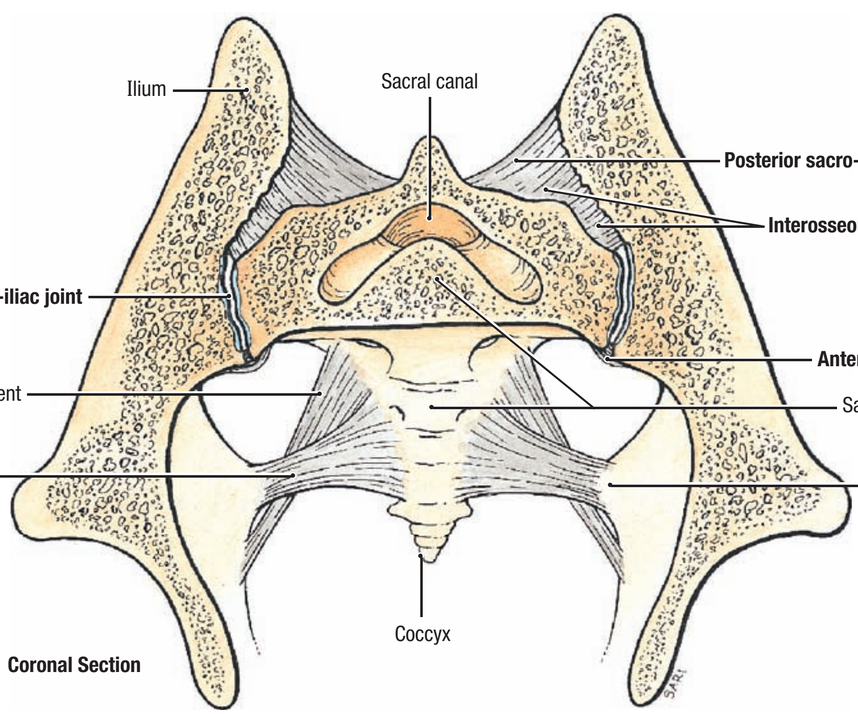


B. **Posterior View**

4.23 LUMBAR AND PELVIC LIGAMENTS (*CONTINUED*)

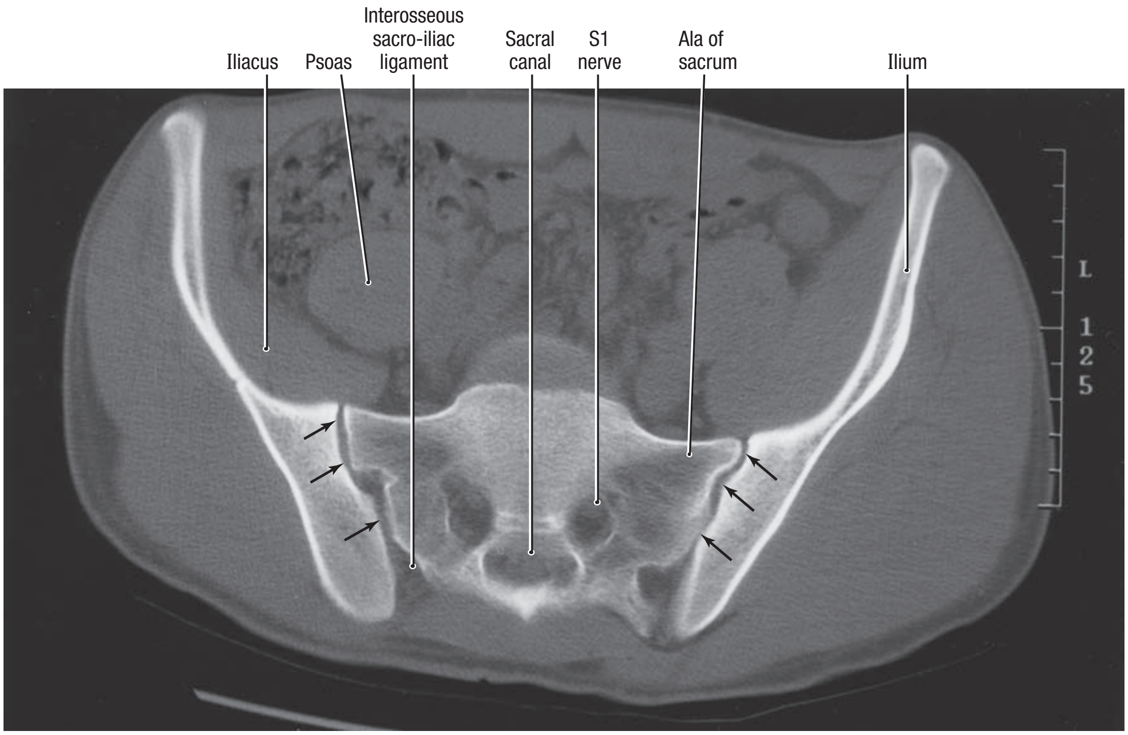
- The sacrotuberous ligaments attach the sacrum, ilium, and coccyx to the ischial tuberosity; the sacrospinous ligaments unite the sacrum and coccyx to the ischial spine. The sacrotuberous and sacrospinous ligaments convert the sciatic notches of the hip bones into greater and lesser sciatic foramina.
- The fibers of the posterior sacro-iliac ligament vary in obliquity; the superior fibers are shorter and lie between the ilium and superior part of the sacrum; the longer, obliquely oriented inferior fibers span between the posterior superior iliac spine and the inferior part of the sacrum, also blending with the sacrotuberous ligament.
- The interosseous sacro-iliac ligament lies deep to the posterior sacro-iliac ligament (see Fig. 4.24).
- The iliolumbar ligaments unite the ilia and transverse processes of L5; the lumbosacral portions of the ligaments descend to the alae of the sacrum and blend with the anterior sacro-iliac ligaments.



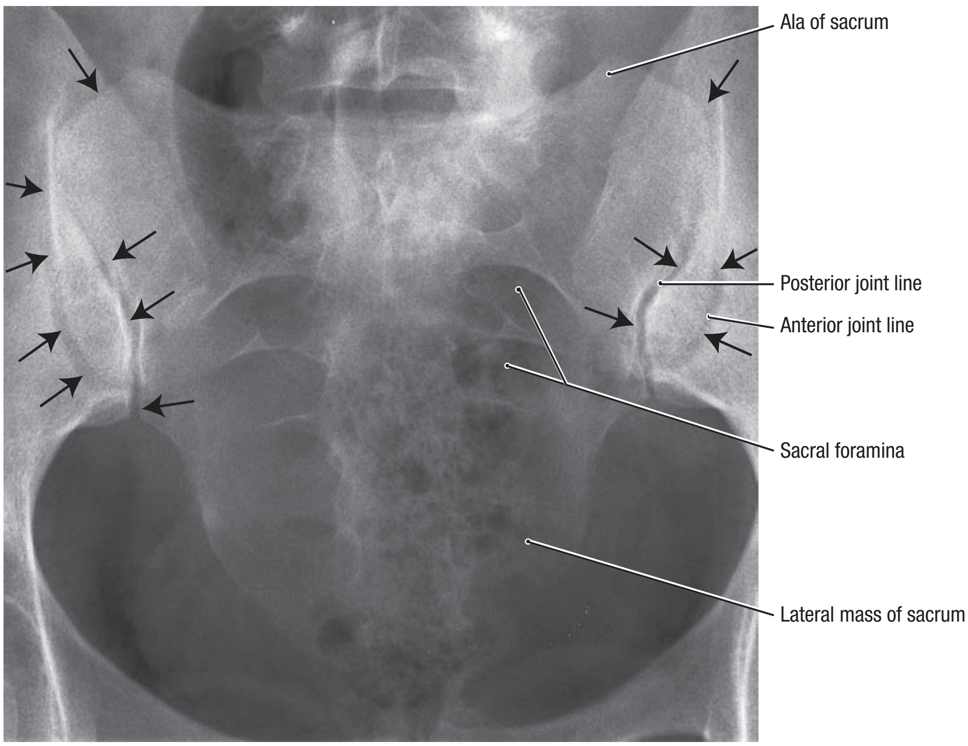


4.24 ARTICULAR SURFACES OF SACRO-ILIAC JOINT AND LIGAMENTS

A. Articular surfaces. Note the auricular surface (articular area, *blue*) of the sacrum and hip bone and the roughened areas superior and posterior to the auricular areas (*orange*) for the attachment of the interosseous sacro-iliac ligament. **B.** Sacro-iliac ligaments. Note the sacro-iliac joints and the strong interosseous sacro-iliac ligament that lies inferior and anterior to the posterior sacro-iliac ligament. The interosseous sacro-iliac ligament consists of short fibers connecting the sacral tuberosity to the iliac tuberosity. The sacrum is suspended from the ilia by the posterior and interosseous sacro-iliac ligaments.



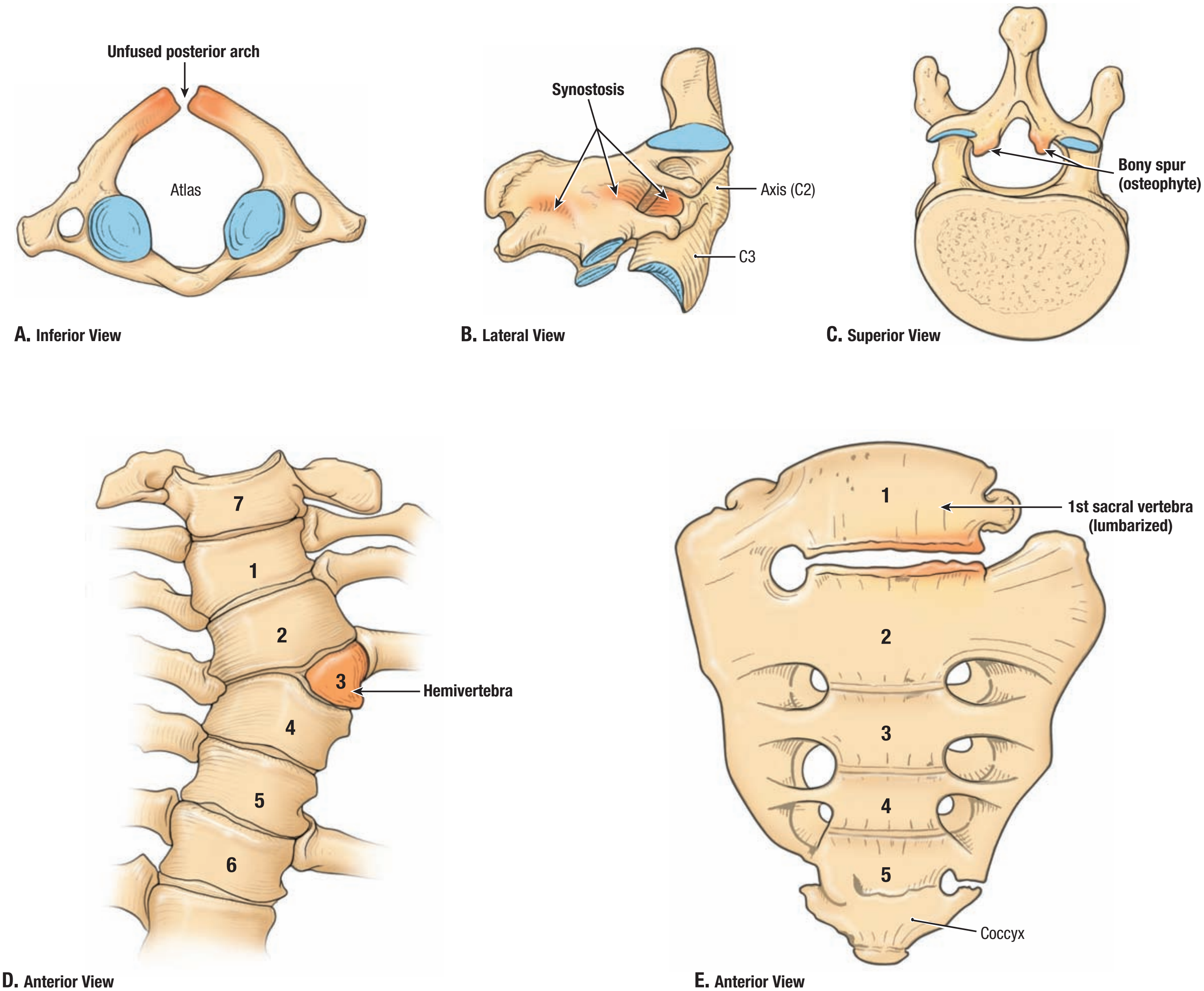
A. **Transverse (axial) CT Scan**



B. **Anteroposterior View**

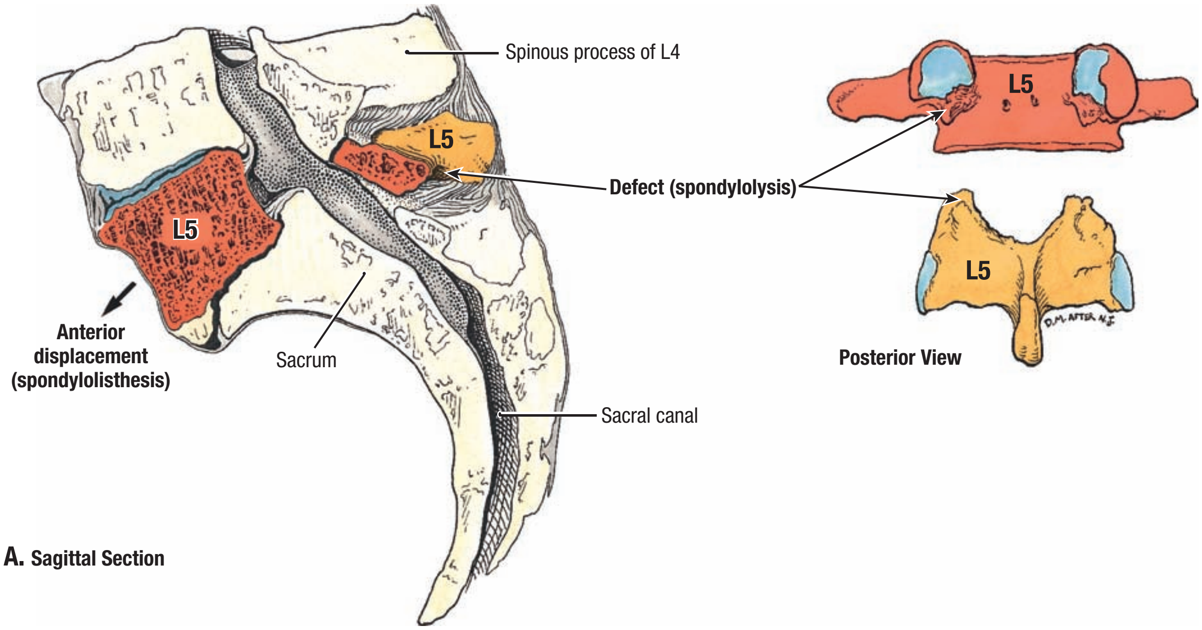
4.25 IMAGING OF SACRO-ILIAC JOINT

A. CT scan. The sacro-iliac joint is indicated by *arrows*. Note that the articular surfaces of the ilium and sacrum have irregular shapes that result in partial interlocking of the bones. The sacro-iliac joint is oblique, with the anterior aspect of the joint situated lateral to the posterior aspect of the joint. **B.** Radiograph. Due to the oblique placement of the sacro-iliac joints, the anterior and posterior joint lines appear separately.

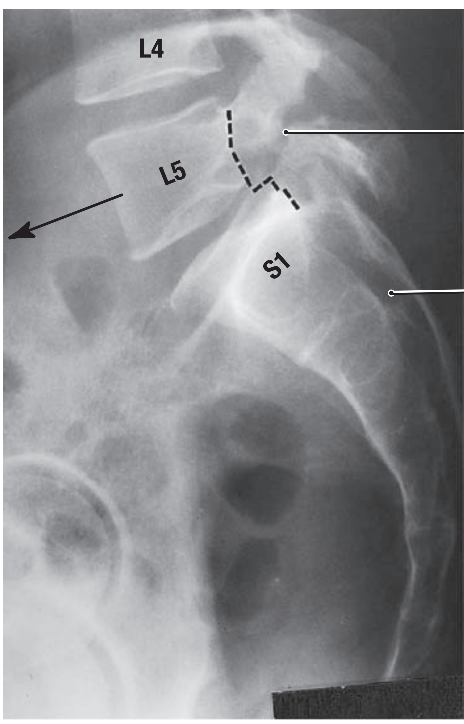


4.26 ANOMALIES OF VERTEBRAE

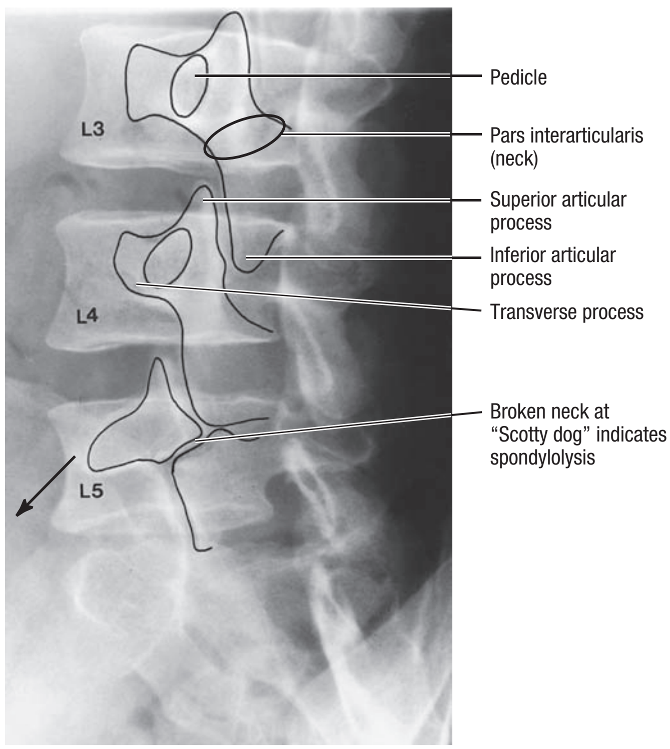
A. Unfused posterior arch of the atlas. The centrum fused to the right and left halves of the neural arch, but the arch did not fuse in the midline posteriorly. **B. Synostosis (fusion) of vertebrae C2 (axis) and C3. C. Bony spurs.** Sharp bony spurs may grow from the laminae inferiorly into the ligamenta flava, thereby reducing the lengths of the functional portions of these ligaments. When the vertebral column is flexed, the ligaments may be torn. **D. Hemivertebra.** The entire right half of vertebra T3 and the corresponding rib are absent. The left lamina and the spine are fused with those of T4, and the left IV foramen is reduced in size. Observe the associated scoliosis (lateral curvature of the spine). **E. Transitional lumbosacral vertebra.** Here, the 1st sacral vertebra is partly free (lumbarized). Not uncommonly, the 5th lumbar vertebra may be partly fused to the sacrum (sacralized).



A. Sagittal Section



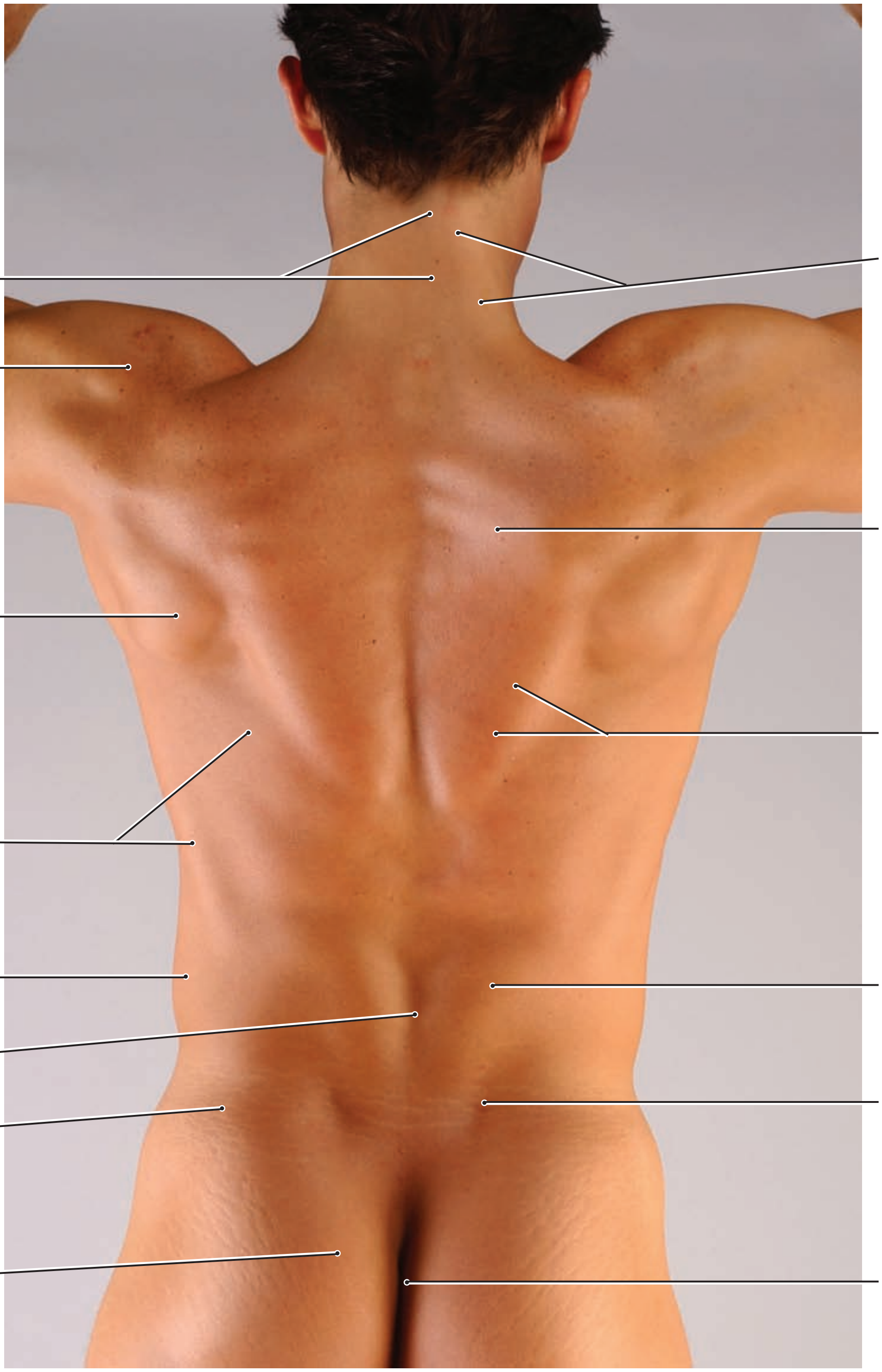
B. Lateral View



C. Oblique View

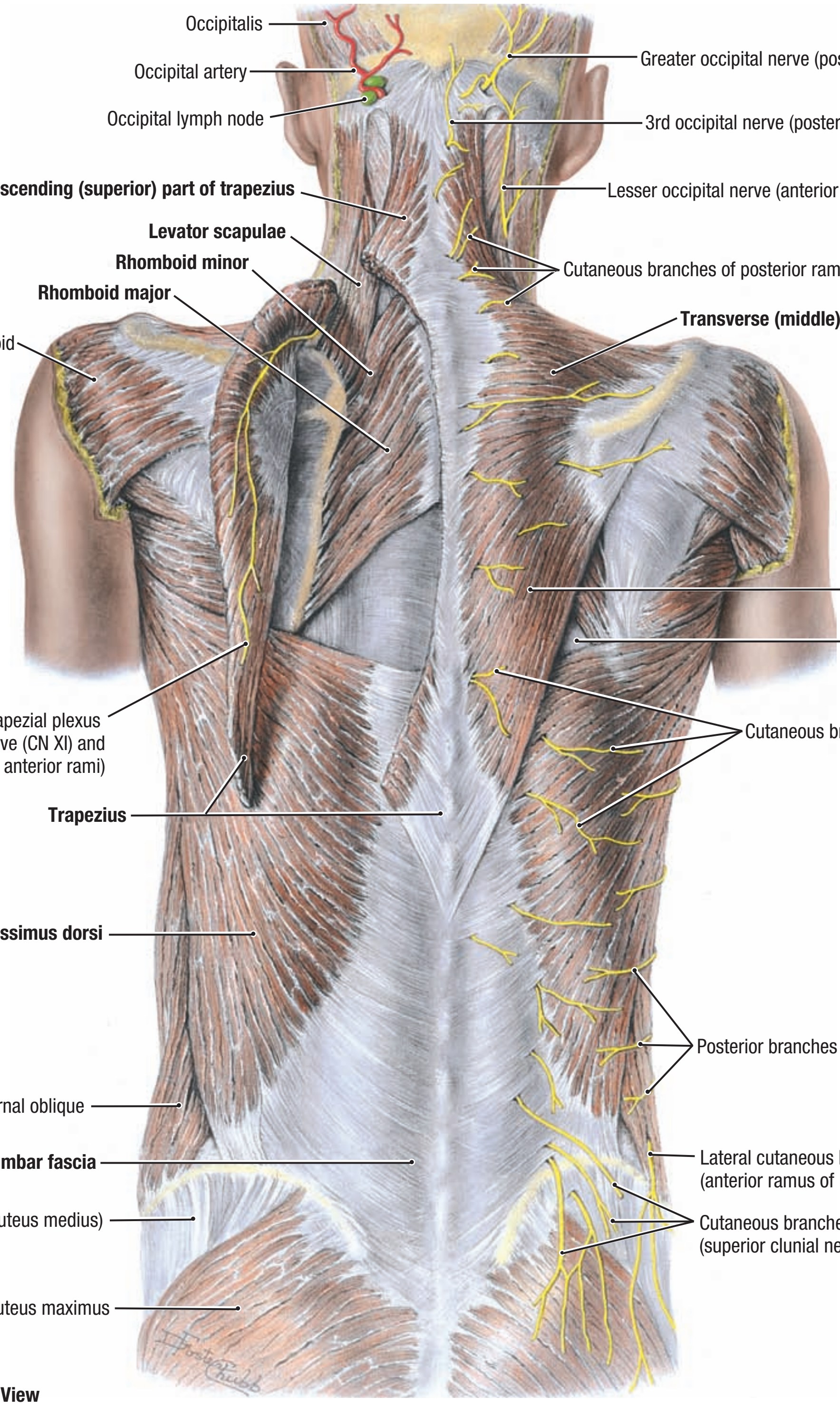
4.27 SPONDYLOLYSIS AND SPONDYLOLISTHESIS

A. Articulated and isolated spondylolytic L5 vertebra. The vertebra has an oblique defect (spondylolysis) through the interarticular part (pars interarticularis). The interarticular part is the region of the lamina of a lumbar vertebra between the superior and inferior articular processes. The defect may be traumatic or congenital in origin. Also, the vertebral body of L5 has slipped anteriorly (spondylolisthesis). **B and C.** Radiographs. In **B,** the *dotted line* following the posterior vertebral margins of L5 and the sacrum shows the anterior displacement of L5 (*arrow*)**.** In **C**, note the superimposed outline of a dog: the neck is the transverse process, the eye is the pedicle, and the ear is the superior articular process. The lucent (dark) cleft across the "neck" of the dog is the **spondylolysis**; the anterior displacement (*arrow*) is the **spondylolisthesis**.



4.28 SURFACE ANATOMY OF BACK

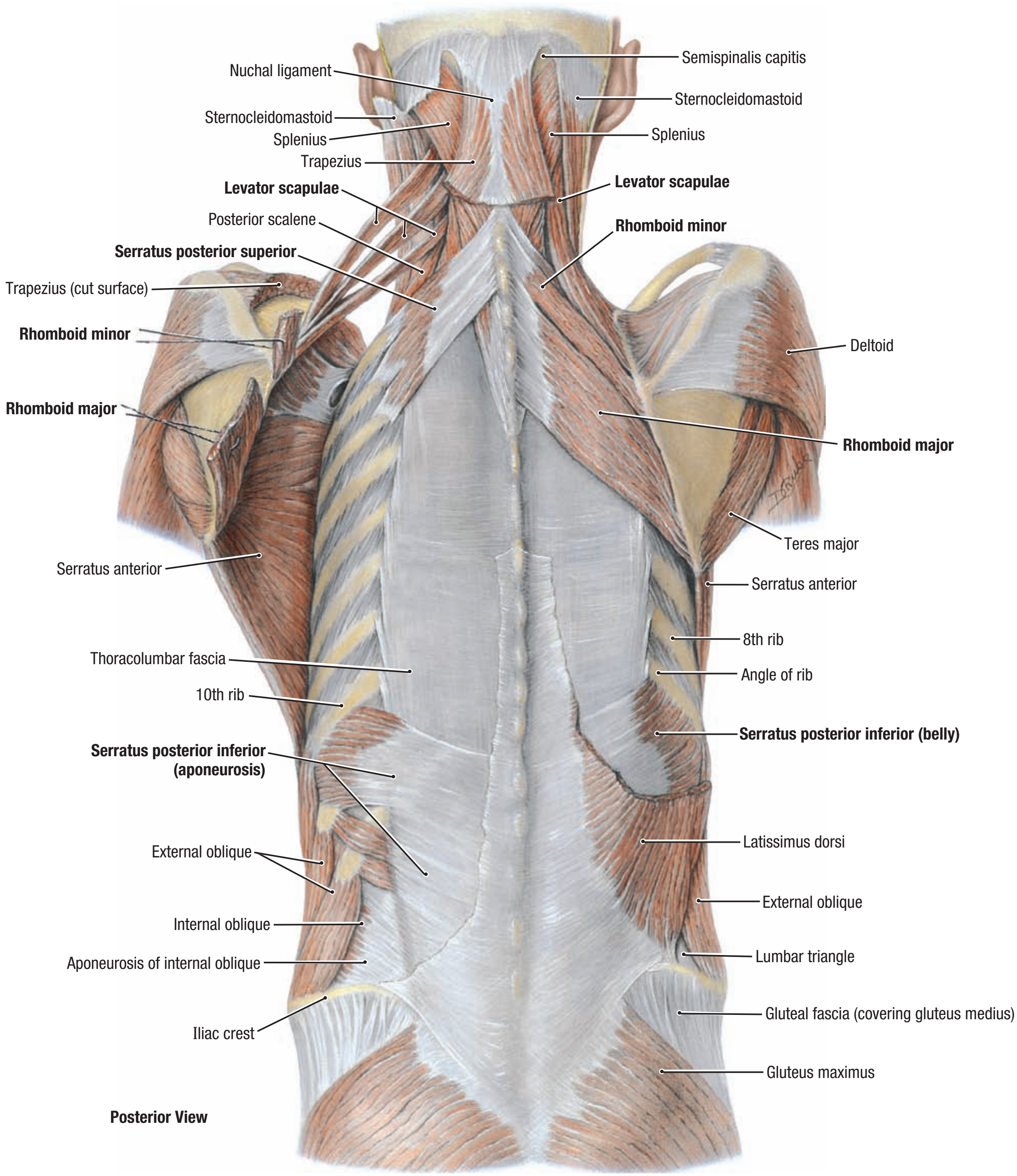
- The arms are abducted, so the scapulae have rotated superiorly on the thoracic wall.
- The latissimus dorsi and teres major muscles form the posterior axillary fold.
- The trapezius muscle has three parts: descending, transverse, and ascending.
- Note the deep median furrow that separates the longitudinal bulges formed by the contracted erector spinae group of muscles;
- Dimples (depressions) indicate the site of the posterior superior iliac spines, which usually lie at the level of the sacro-iliac joints.



Posterior View

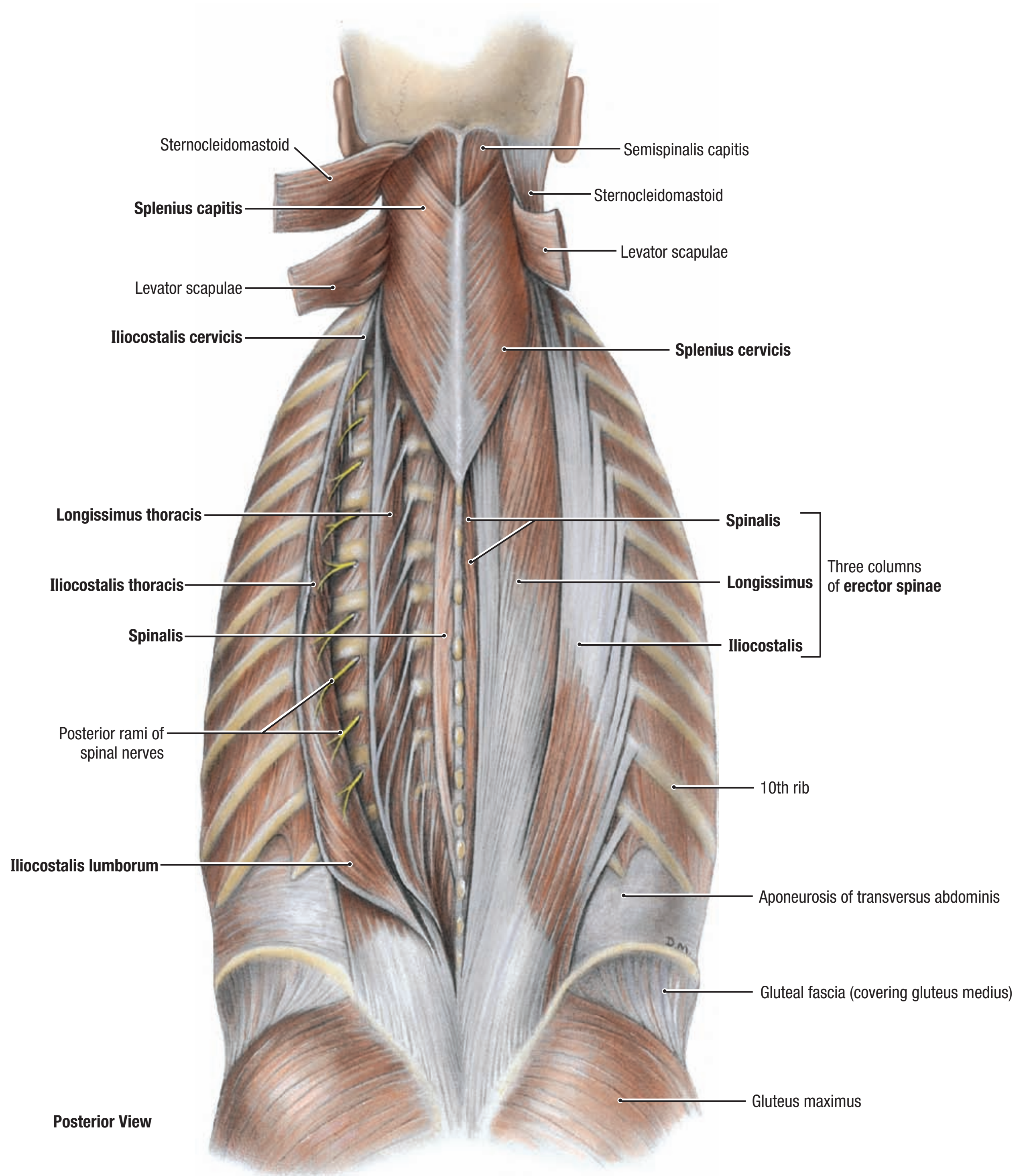
4.29 SUPERFICIAL MUSCLES OF BACK

On the *left,* the trapezius muscle is reflected. Observe two layers: the trapezius and latissimus dorsi muscles, and the levator scapulae and rhomboids minor and major. These axio-appendicular muscles help attach the upper limb to the trunk.



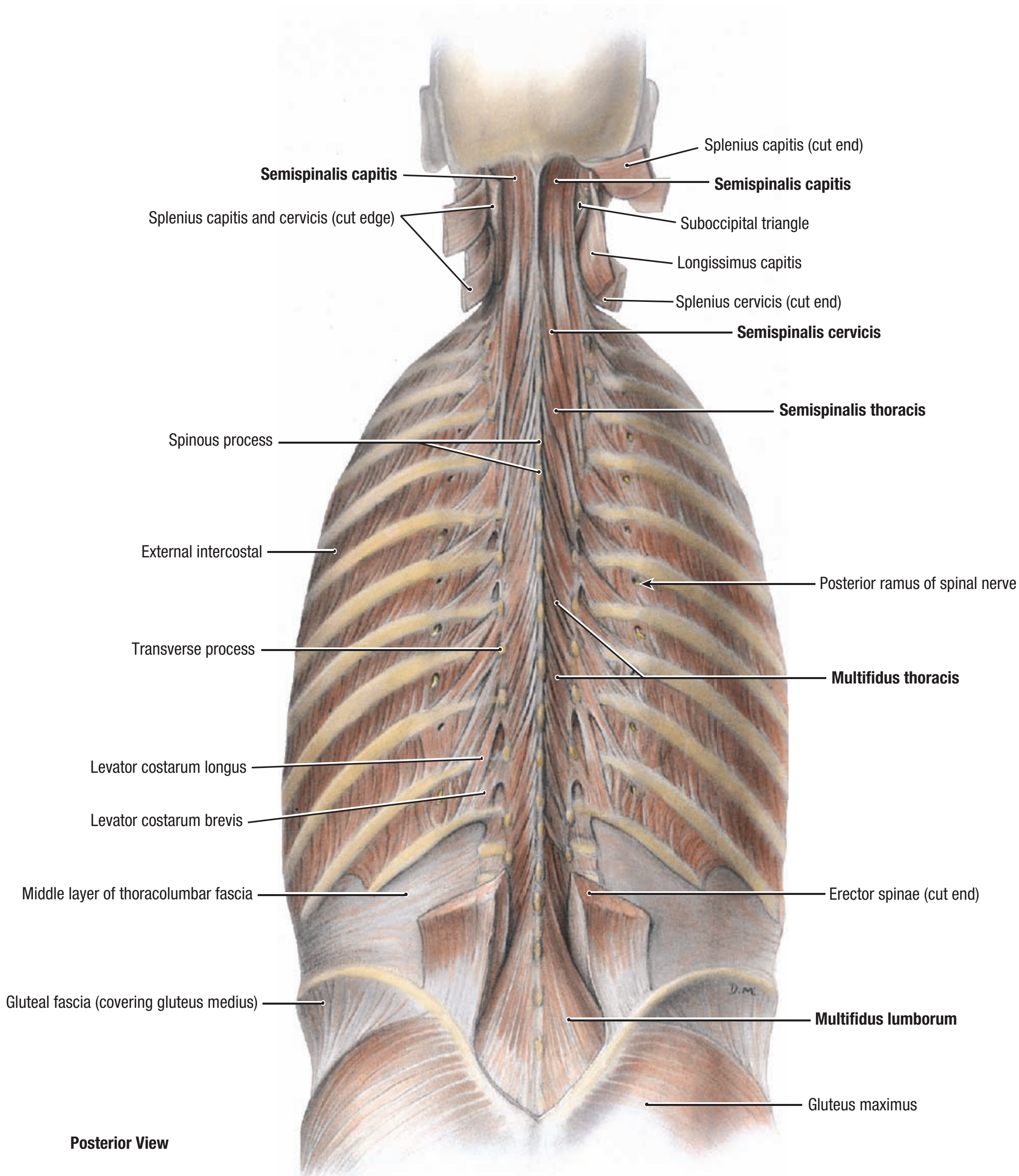
4.30 INTERMEDIATE MUSCLES OF BACK

The trapezius and latissimus dorsi muscles are largely cut away on both sides. On the *left,* the rhomboid muscles have been severed, allowing the vertebral border of the scapula to be raised from the thoracic wall. The serratus posterior superior and inferior form the intermediate layer of muscles, passing from the vertebral spines to the ribs; the two muscles slope in opposite directions and are muscles of respiration. The thoracolumbar fascia extends laterally to the angles of the ribs, becoming thin superiorly and passing deep to the serratus posterior superior muscle. The fascia gives attachment to the latissimus dorsi and serratus posterior inferior muscles (see Fig. 4.35).



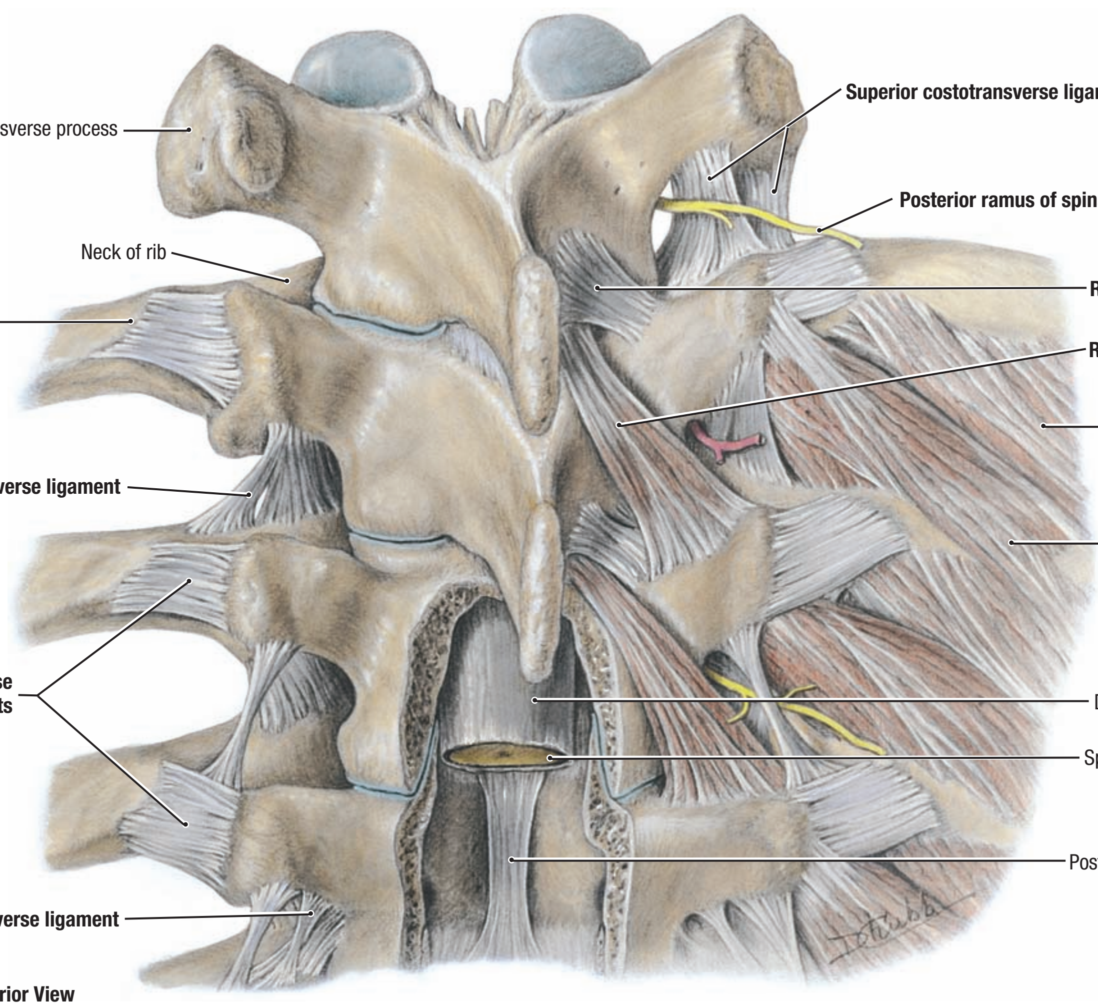
4.31 DEEP MUSCLES OF BACK: SPLENIUS AND ERECTOR SPINAE

On the *right* of the body, the erector spinae muscles are in situ, lying between the spinous processes medially and the angles of the ribs laterally. The erector spinae are split into three longitudinal columns: iliocostalis laterally, longissimus in the middle, and spinalis medially. On the *left,* the longissimus muscle is pulled laterally to show the insertion into the transverse processes and ribs; not shown here are its extensions to the neck and head, longissimus cervicis and capitis.



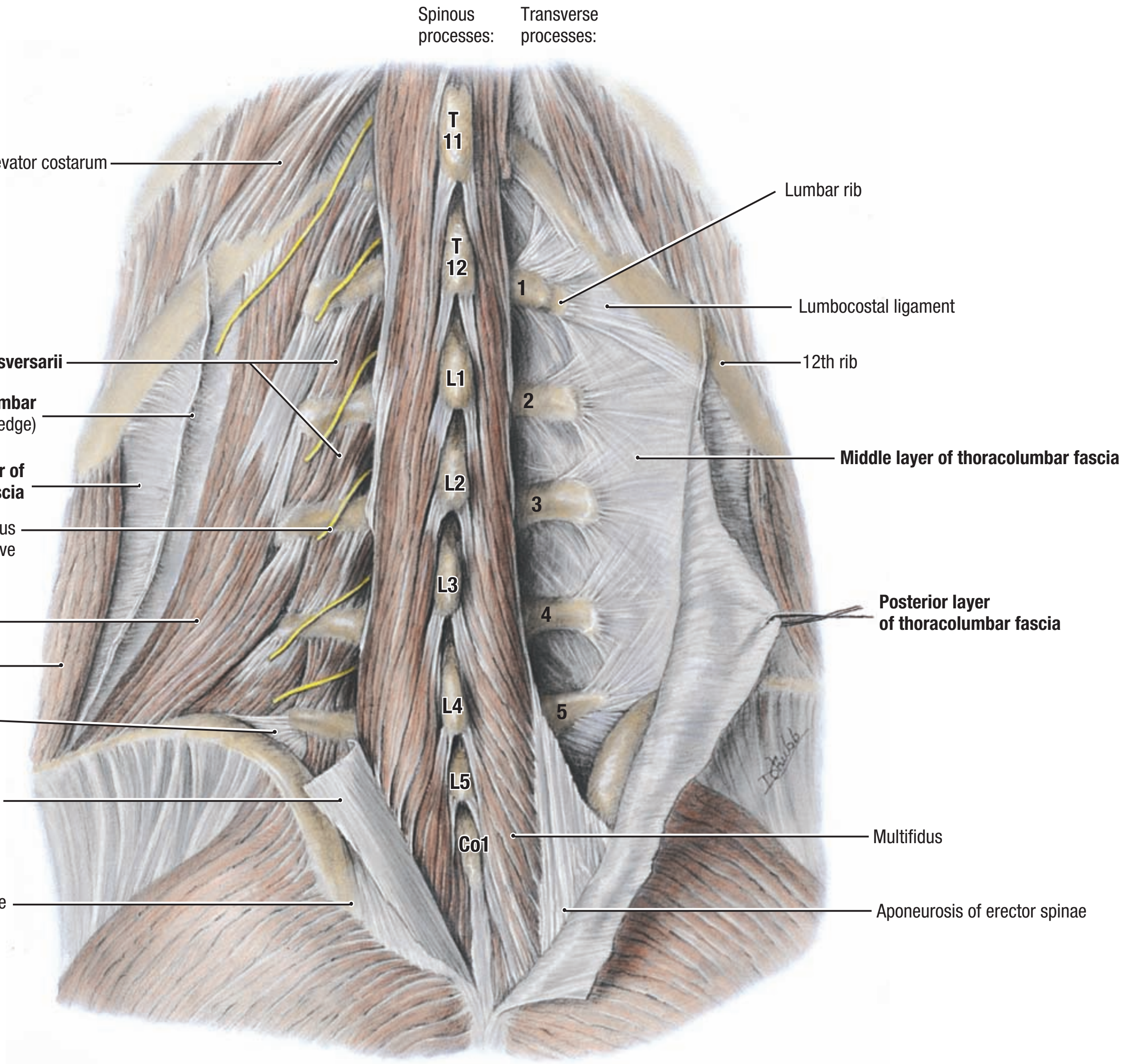
4.32 DEEP MUSCLES OF BACK: SEMISPINALIS AND MULTIFIDUS

- The semispinalis, multifidus, and rotatores muscles constitute the transverso spinalis group of deep muscles. In general, their bundles pass obliquely in a superomedial direction, from transverse processes to spinous processes in successively deeper layers. The bundles of semispinalis span approximately five interspaces, those of multifidus, approximately three, and those of rotatores, one or two.
- The semispinalis (thoracis, cervicis, and capitis) muscles span the lower thoracic region to the skull.
- The multifidus muscle extends from the sacrum to the spine of the axis. In the lumbosacral region it emerges from the aponeurosis of the erector spinae, and extends from the sacrum, and mammillary processes of the lumbar vertebrae, to insert into spinous processes approximately three segments higher.



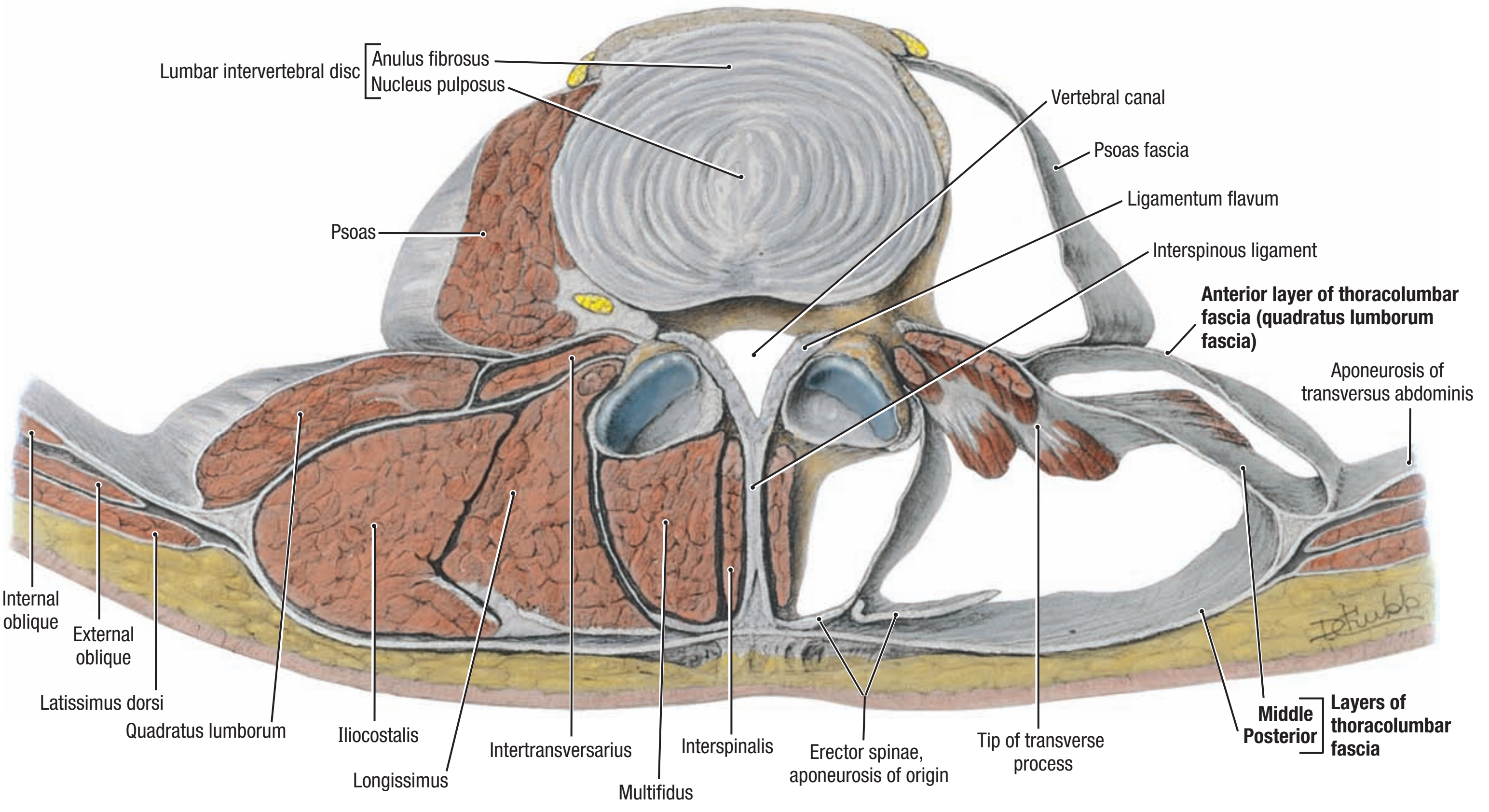
4.33 ROTATORES AND COSTOTRANSVERSE LIGAMENTS

- Of the three layers of transversospinalis, or oblique muscles of the back (semispinalis, multifidus, rotatores), the rotatores are the deepest and shortest. They pass from the root of one transverse process superomedially to the junction of the transverse process and lamina of the vertebra above. Rotatores longus span two vertebrae.
- The levatores costarum pass from the tip of one transverse process inferiorly to the rib below; some span two ribs.
- The superior costotransverse ligament splits laterally into two sheets, between which lie the levatores costarum and external intercostal muscles; the posterior ramus passes posterior to this ligament.
- The lateral costotransverse ligament is strong and joins the tubercle of the rib to the tip of the transverse process. It forms the posterior aspect of the joint capsule of the costotransverse joint.



4.34 BACK: MULTIFIDUS, QUADRATUS LUMBORUM, AND THORACOLUMBAR FASCIA

Right: After removal of erector spinae at the L1 level, the middle layer of thoracolumbar fascia extends from the tip of each lumbar transverse process in a fan-shaped manner. A short lumbar rib is present at the level of L1. *Left:* After removal of the posterior and middle layers of thoracolumbar fascia, the lateral border of the quadratus lumborum muscle is oblique, and the medial border is in continuity with the intertransversarii.

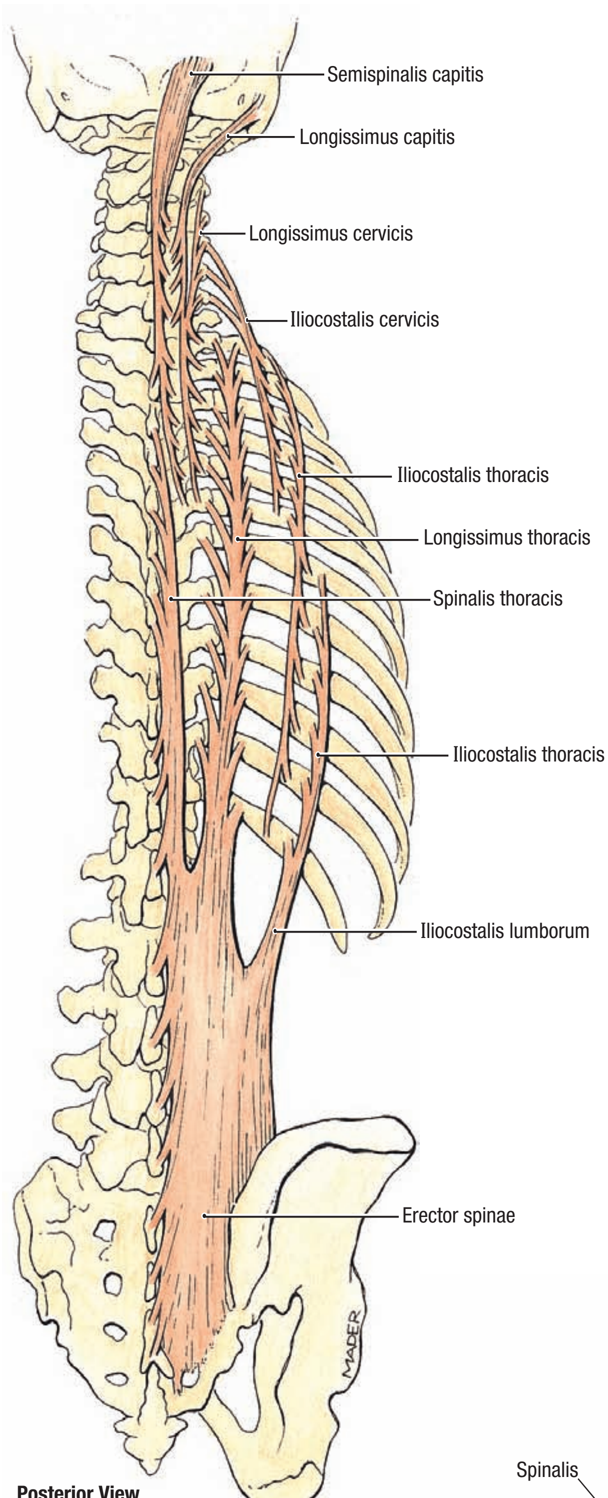


Transverse Section (Dissected), Superior View

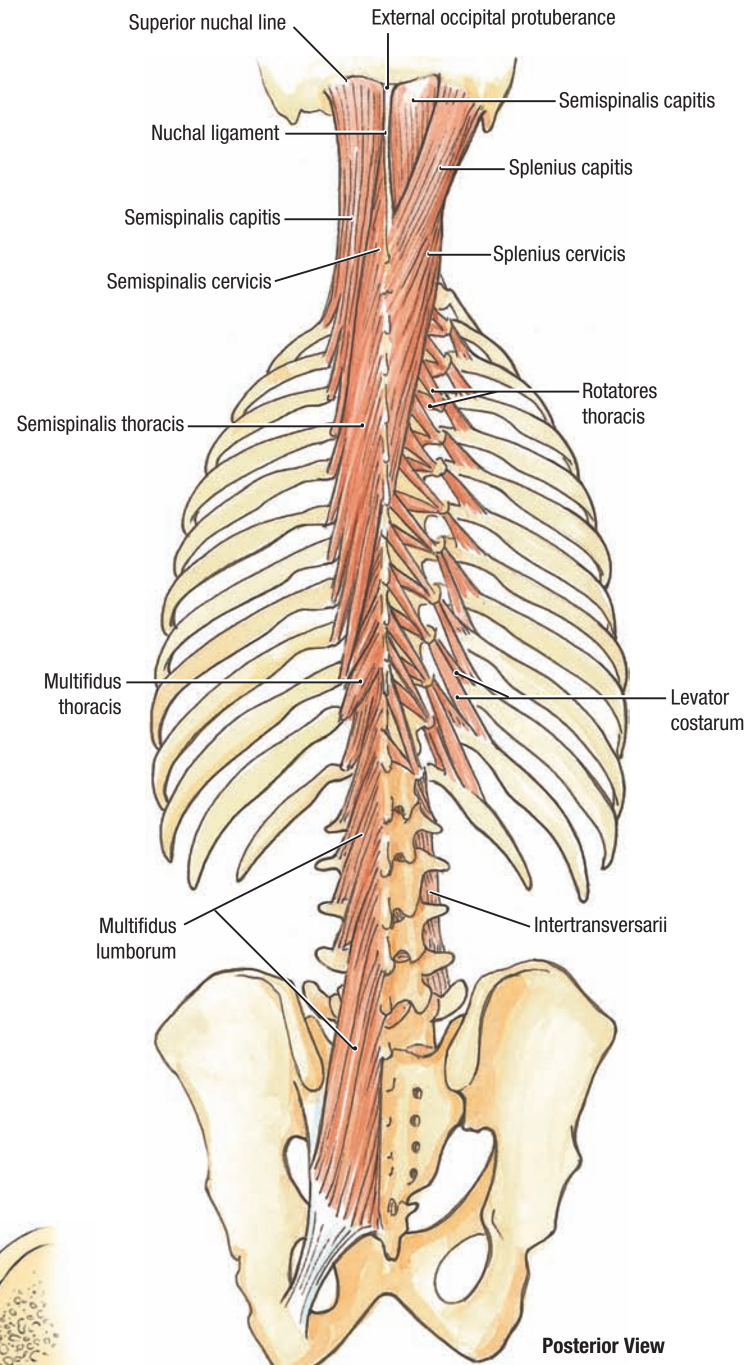
4.35 TRANSVERSE SECTION OF BACK MUSCLES AND THORACOLUMBAR FASCIA

- On the *left,* the muscles are seen in their fascial sheaths or compartments; on the *right,* the muscles have been removed from their sheaths.
- The deep back muscles extend from the pelvis to the cranium and are enclosed in fascia. This fascia attaches medially to the nuchal ligament, the tips of the spinous processes, the supraspinous ligament, and the median crest of the sacrum. The lateral attachment of the fascia is to the cervical transverse processes, the angles of the ribs, and the aponeurosis of transversus abdominis. The thoracic and lumbar parts of the fascia are named thoracolumbar fascia.
- The aponeurosis of transversus abdominis and posterior aponeurosis of internal oblique muscles split into two strong sheets, the middle and posterior layers of thoracolumbar fascia. The anterior layer of thoracolumbar fascia is the deep fascia of the quadratus lumborum (quadratus lumborum fascia). The posterior layer of the thoracolumbar fascia provides proximal attachment for the latissimus dorsi muscle and, at a higher level, the serratus posterior inferior muscle.

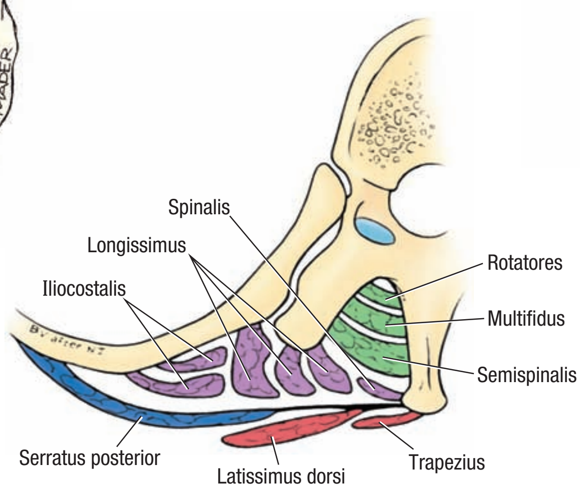
Back strain is a common back problem that usually results from extreme movements of the vertebral column, such as extension or rotation. Back strain refers to some stretching or microscopic tearing of muscle fibers and/or ligaments of the back. The muscles usually involved are those producing movements of the lumbar IV joints.



Posterior View



Posterior View



Transverse Section, Superior View

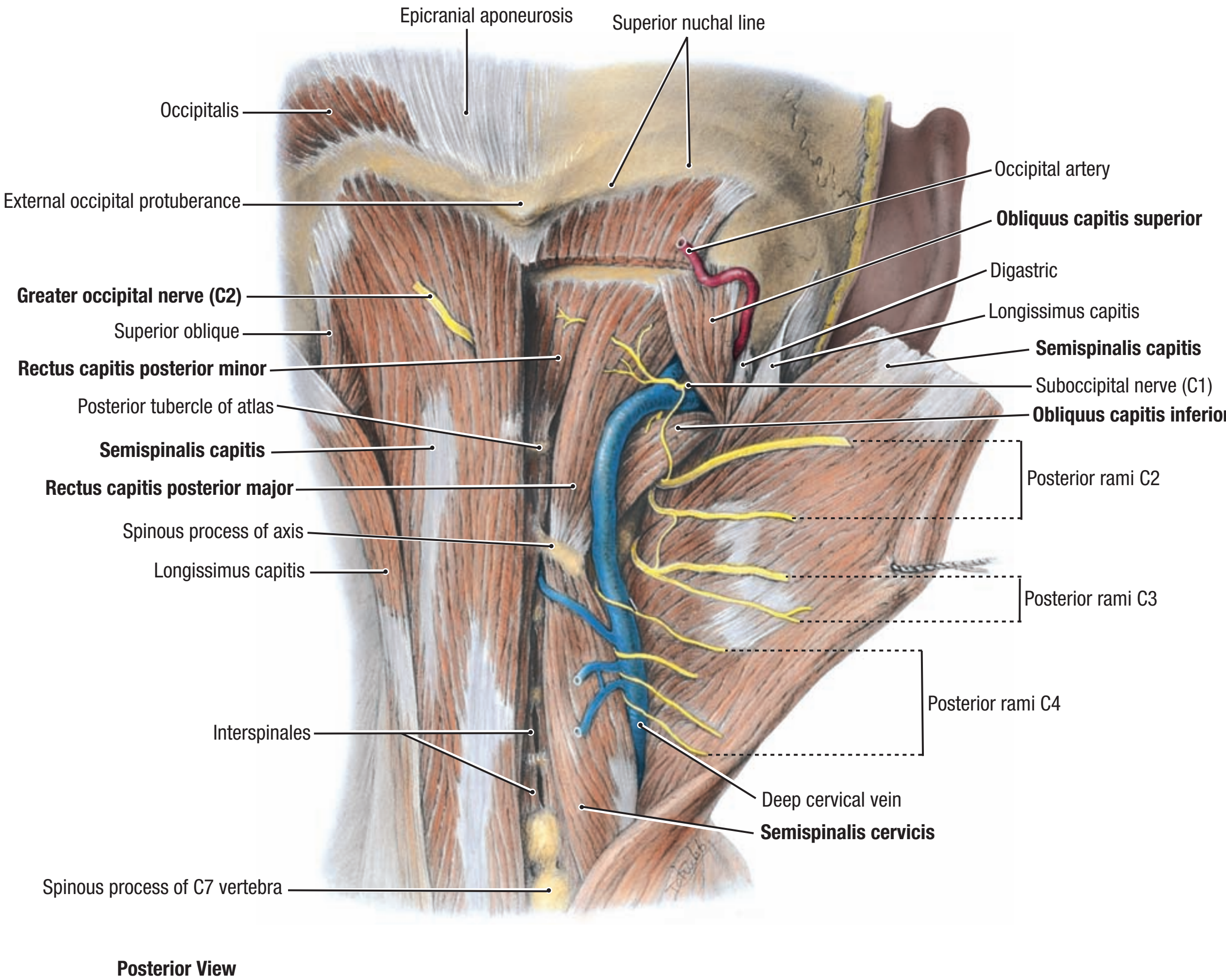
- Superficial extrinsic
- Intermediate extrinsic
- Erector spinae (intermediate intrinsic)
- Transversospinalis (deep intrinsic)

4.36 OVERVIEW OF DEEP BACK MUSCLES

TABLE 4.4 INTRINSIC BACK MUSCLES[a]

Muscles	Caudal (Inferior) Attachment	Rostral (Superior) Attachment	Nerve Supply[b]	Main Actions
Superficial layer Splenius	Nuchal ligament and spinous processes of C7–T6 vertebrae	*Splenius capitis:* fibers run superolaterally to mastoid process of temporal bone and lateral third of superior nuchal line of occipital bone *Splenius cervicis:* posterior tubercles of transverse processes of C1–C3/C4 vertebrae		*Acting unilaterally*: laterally flex neck and rotate head to side of active muscles; *Acting bilaterally*: extend head and neck
Intermediate layer Erector spinae	Arises by a broad tendon from posterior part of iliac crest, posterior surface of sacrum, sacral and inferior lumbar spinous processes, and supraspinous ligament	*Iliocostalis (lumborum, thoracis, and cervicis):* fibers run superiorly to angles of lower ribs and cervical transverse processes *Longissimus (thoracis, cervicis, and capitis):* fibers run superiorly to ribs between tubercles and angles to transverse processes in thoracic and cervical regions, and to mastoid process of temporal bone *Spinalis (thoracis, cervicis, and capitis):* fibers run superiorly to spinous processes in the upper thoracic region and to skull	Posterior rami of spinal nerves	*Acting unilaterally:* laterally bend vertebral column to side of active muscles *Acting bilaterally:* extend vertebral column and head; as back is flexed, control movement by gradually lengthening their fibers
Deep layer Transversospinalis	*Semispinalis:* arises from thoracic and cervical transverse processes *Multifidus:* arises from sacrum and ilium, transverse processes of T1–L5, and articular processes of C4–C7 *Rotatores:* arise from transverse processes of vertebrae; best developed in thoracic region	*Semispinalis: thoracis, cervicis, and capitis:* fibers run superomedially and attach to occipital bone and spinous processes in thoracic and cervical regions, spanning four to six segments *Multifidus (lumborum, thoracis, and cervicis):* fibers pass superomedially to spinous processes, spanning two to four segments *Rotatores (thoracis and cervicis):* Pass superomedially and attach to junction of lamina and transverse process of vertebra of origin or into spinous process above their origin, spanning one to two segments		**Extension** *Semispinalis:* extends head and thoracic and cervical regions of vertebral column and rotates them contralaterally *Multifidus:* stabilizes vertebrae during local movement of vertebral column *Rotatores:* Stabilize vertebrae and assist with local extension and rotary movements of vertebral column; may function as organ of proprioception
Minor deep layer Interspinales	Superior surfaces of spinous processes of cervical and lumbar vertebrae	Inferior surfaces of spinous processes of vertebrae superior to vertebrae of origin	Posterior rami of spinal nerves	Aid in extension and rotation of vertebral column
Intertransversarii	Transverse processes of cervical and lumbar vertebrae	Transverse processes of adjacent vertebrae	Posterior and anterior rami of spinal nerves	Aid in lateral flexion of vertebral column *Acting bilaterally:* stabilize vertebral column
Levatores costarum	**Medial attachment:** Tips of transverse processes of C7 and T1–T11 vertebrae	**Lateral attachment:** Pass inferolaterally and insert on rib between its tubercle and angle	Posterior rami of C8–T11 spinal nerves	Elevate ribs, assisting inspiration Assist with lateral flexion of vertebral column

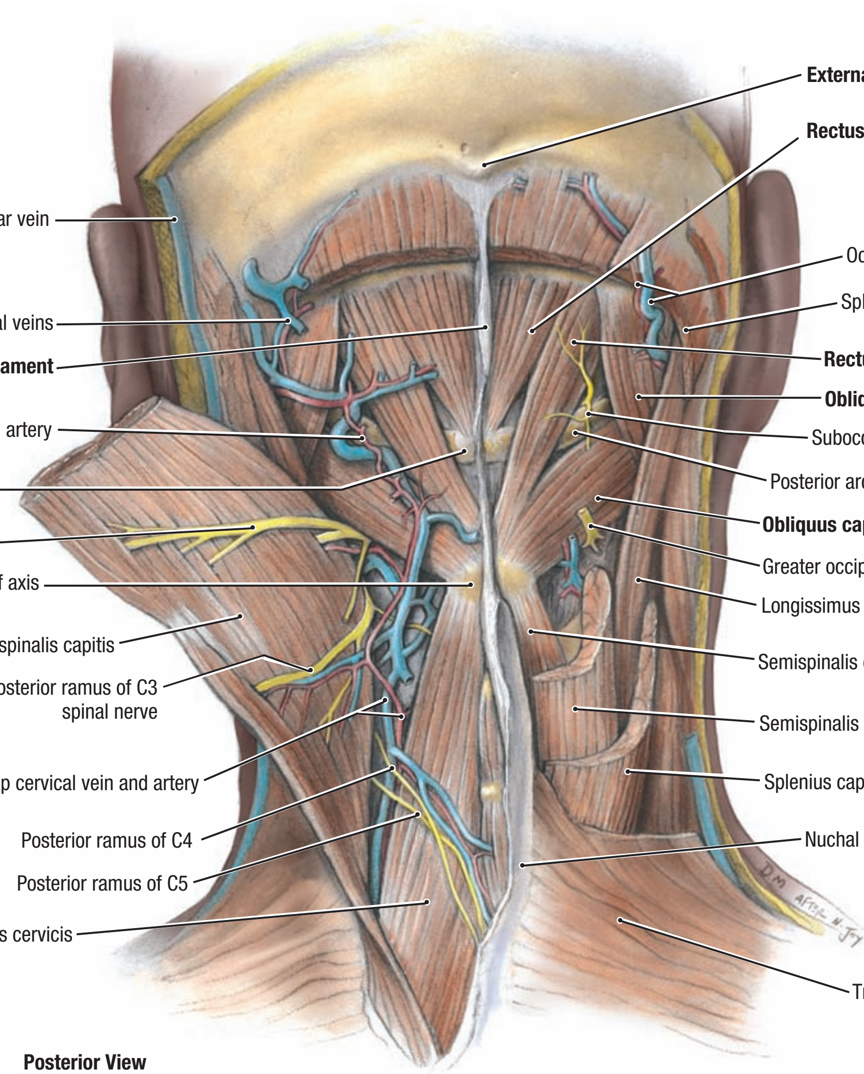
[a]See figures on opposite page.
[b]Most back muscles are innervated by posterior rami of spinal nerves, but a few are innervated by anterior rami. Intertransversarii of cervical region are supplied by anterior rami.



4.37 SUBOCCIPITAL REGION I

The trapezius, sternocleidomastoid, and splenius muscles are removed. The right semispinalis capitis muscle is cut and reflected laterally.

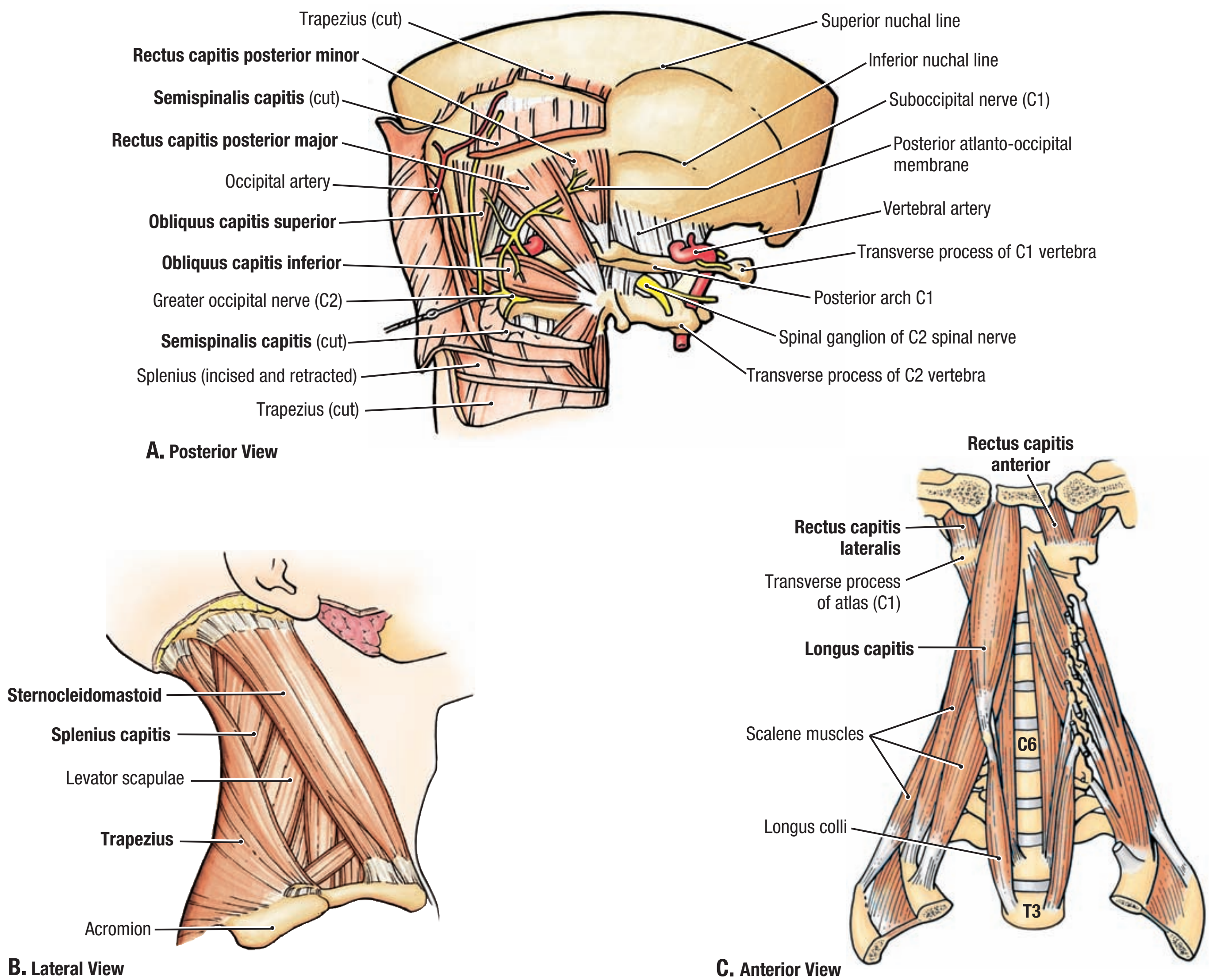
- The semispinalis capitis, the great extensor muscle of the head and neck, forms the posterior wall of the suboccipital region. It is pierced by the greater occipital nerve (posterior ramus of C2) and has free medial and lateral borders at this level.
- The greater occipital nerve, when followed caudally, leads to the inferior border of the obliquus capitis inferior muscle, around which it turns. Following the inferior border of the obliquus capitis inferior muscle medially from the nerve leads to the spinous process of the axis; followed laterally, this leads to the transverse process of the atlas.
- Five muscles (all paired) are attached to the spinous process of the axis: obliquus capitis inferior, rectus capitis posterior major, semispinalis cervicis, multifidus, and interspinalis; the latter two are largely concealed by the semispinalis cervicis.



4.38 SUBOCCIPITAL REGION II

The semispinalis capitis is reflected on the *left* and removed on the *right* side of the body; neck is flexed.

- The suboccipital region contains four pairs of structures: two straight muscles, the rectus capitis posterior major and minor; two oblique muscles, the obliquus capitis superior and obliquus capitis inferior; two nerves (posterior rami), C1 suboccipital (motor) and C2 greater occipital (sensory); and two arteries, the occipital and vertebral.
- The nuchal ligament, which represents the cervical part of the supraspinous ligament, is a median, thin, fibrous partition attached to the spinous processes of cervical vertebrae and the external occipital protuberance.
- The suboccipital triangle is bounded by three muscles: obliquus capitis superior and inferior and rectus capitis posterior major.
- The suboccipital nerve (posterior ramus of C1) supplies the three muscles bounding the suboccipital triangle and also the rectus capitis minor muscle and communicates with the greater occipital nerve.
- The occipital veins along with the suboccipital nerve (posterior ramus of C1) emerge through the suboccipital triangle to join the deep cervical vein.
- The posterior arch of the atlas forms the floor of the suboccipital triangle.



4.39 MUSCLES OF BASE OF SKULL

A. Suboccipital region. **B.** Lateral cervical region. **C.** Prevertebral muscles.

TABLE 4.5 MUSCLES OF ATLANTO-OCCIPITAL AND ATLANTO-AXIAL JOINTS

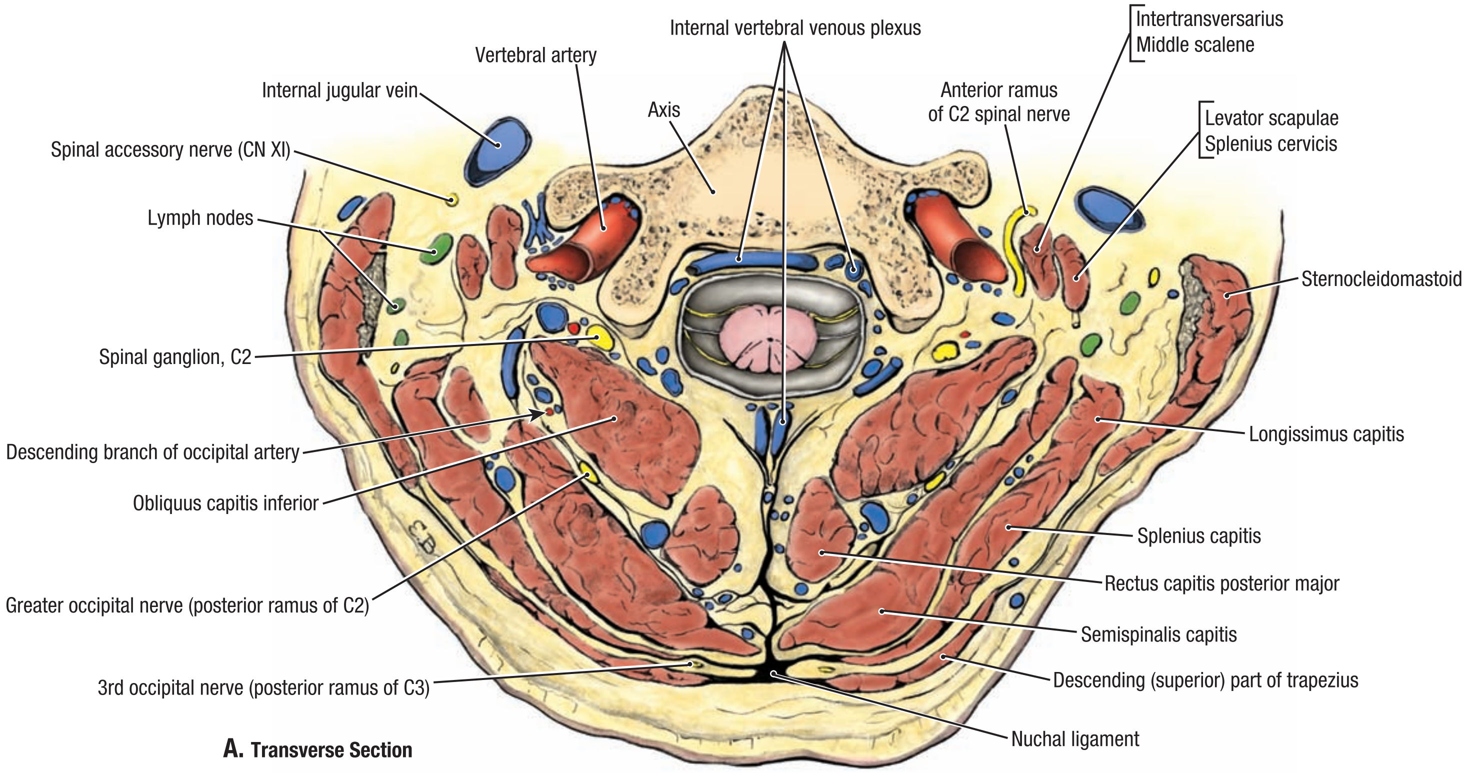
Movements of Atlanto-Occipital Joints

Flexion	Extension	Lateral Bending
Longus capitis Rectus capitis anterior Anterior fibers of sternocleidomastoid	Rectus capitis posterior major and minor Obliquus capitis superior Semispinalis capitis Splenius capitis Longissimus capitis Trapezius	Sternocleidomastoid Longissimus capitis Rectus capitis lateralis Splenius capitis

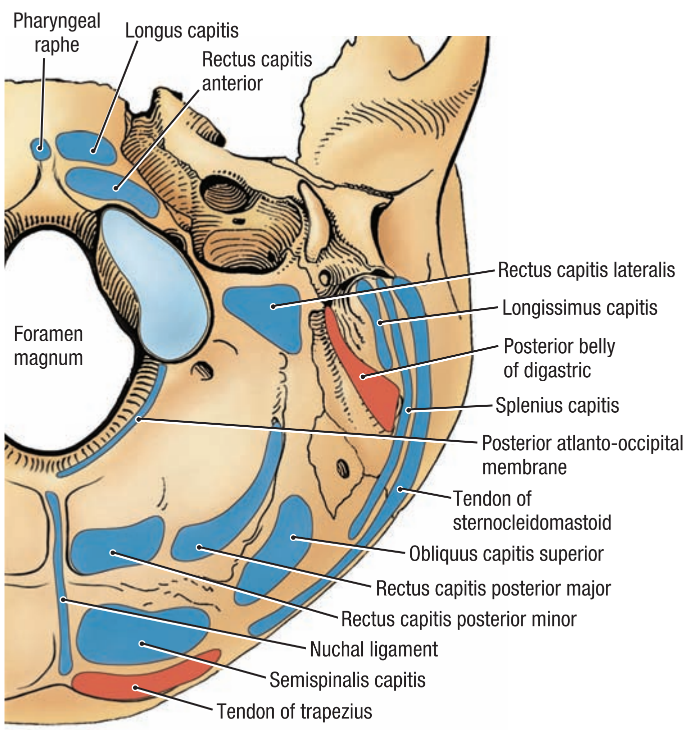
Rotation of Atlanto-Axial Joints[a]

Ipsilateral[b]	Contralateral
Obliquus capitis inferior Rectus capitis posterior, major and minor Longissimus capitis Splenius capitis	Sternocleidomastoid Semispinalis capitis

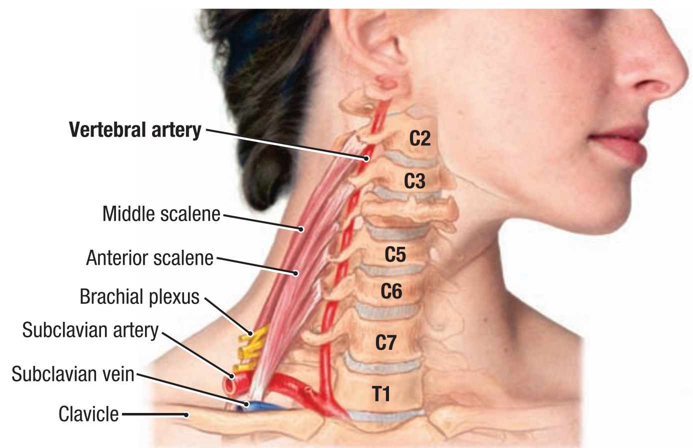
[a]Rotation is the specialized movement at these joints. Movement of one joint involves the other.
[b]Same side to which head is rotated.



A. **Transverse Section**



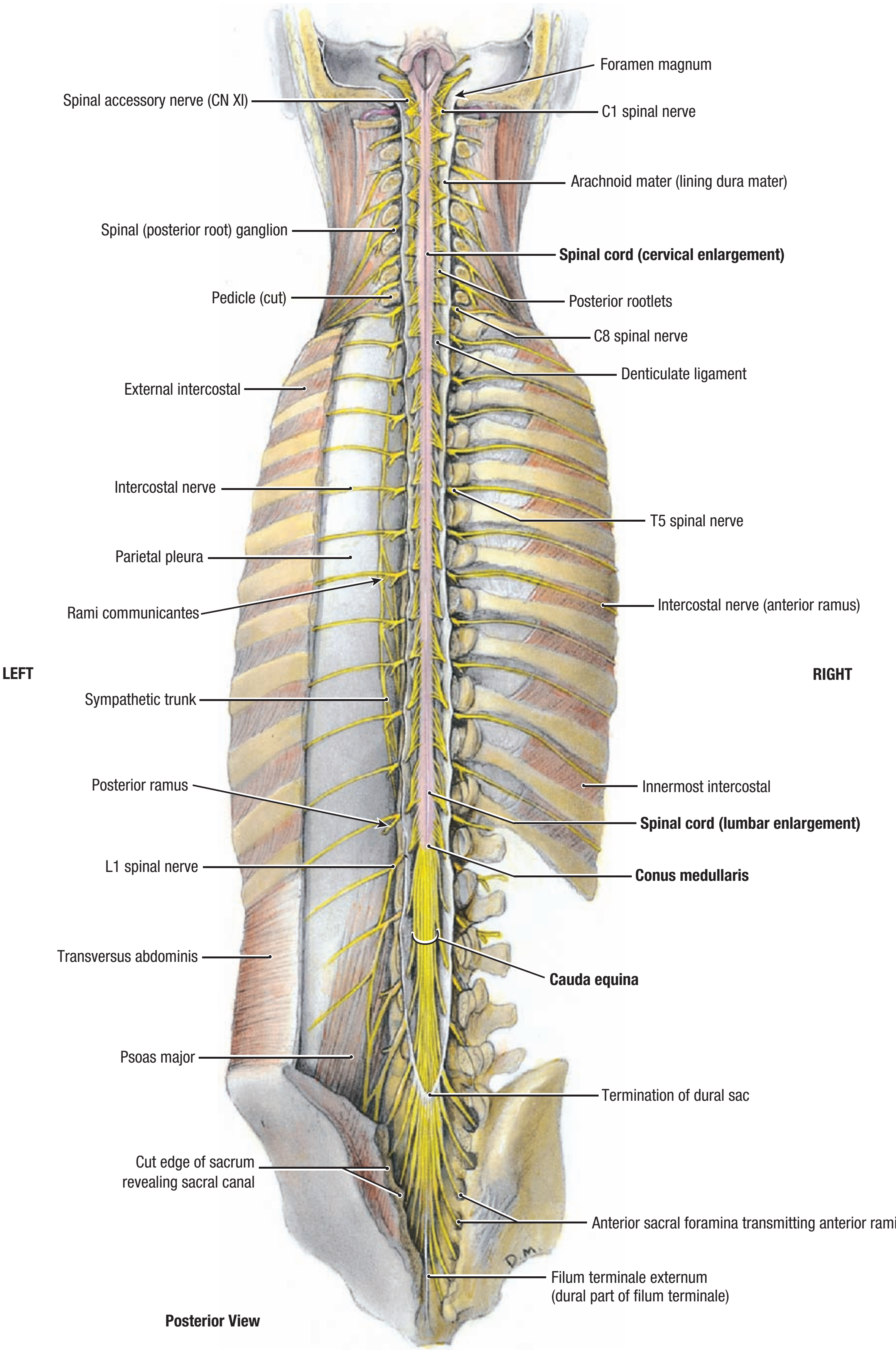
B. **Inferior View**



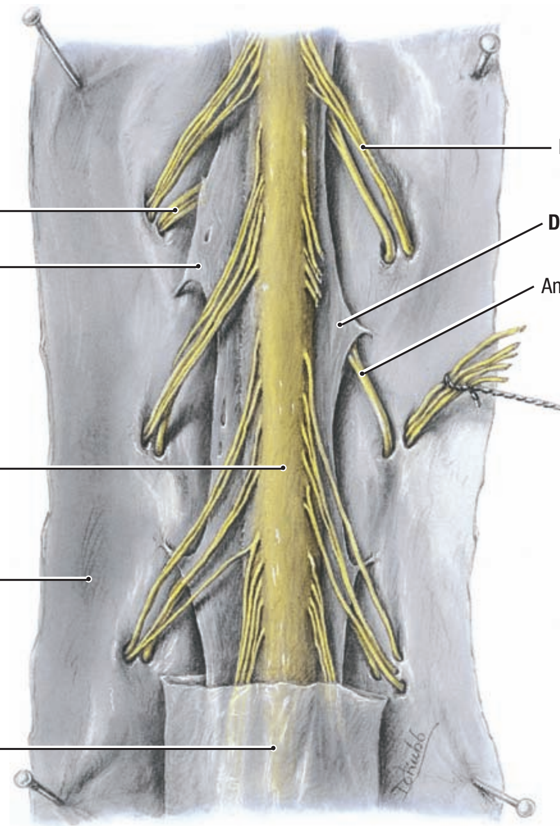
C. **Anterolateral View**

4.40 NUCHAL REGION

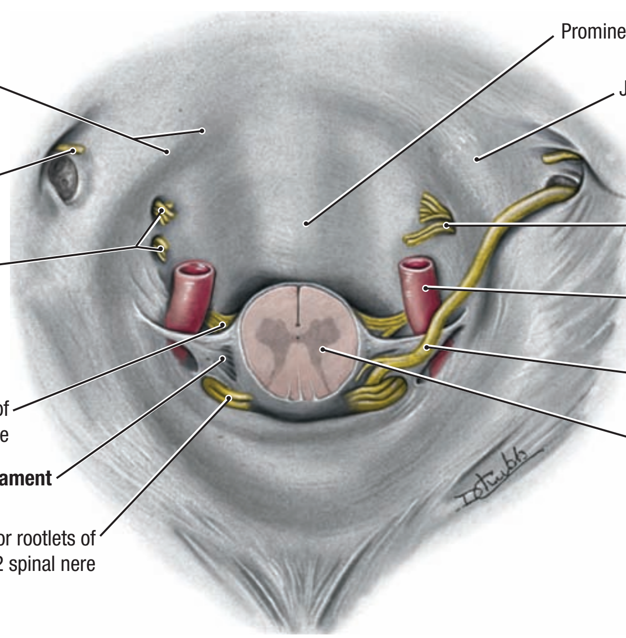
A. Transverse section at the level of the axis. **B.** Muscle attachments on the inferior aspect of the skull. **C.** Vertebral artery.



4.41 SPINAL CORD IN SITU



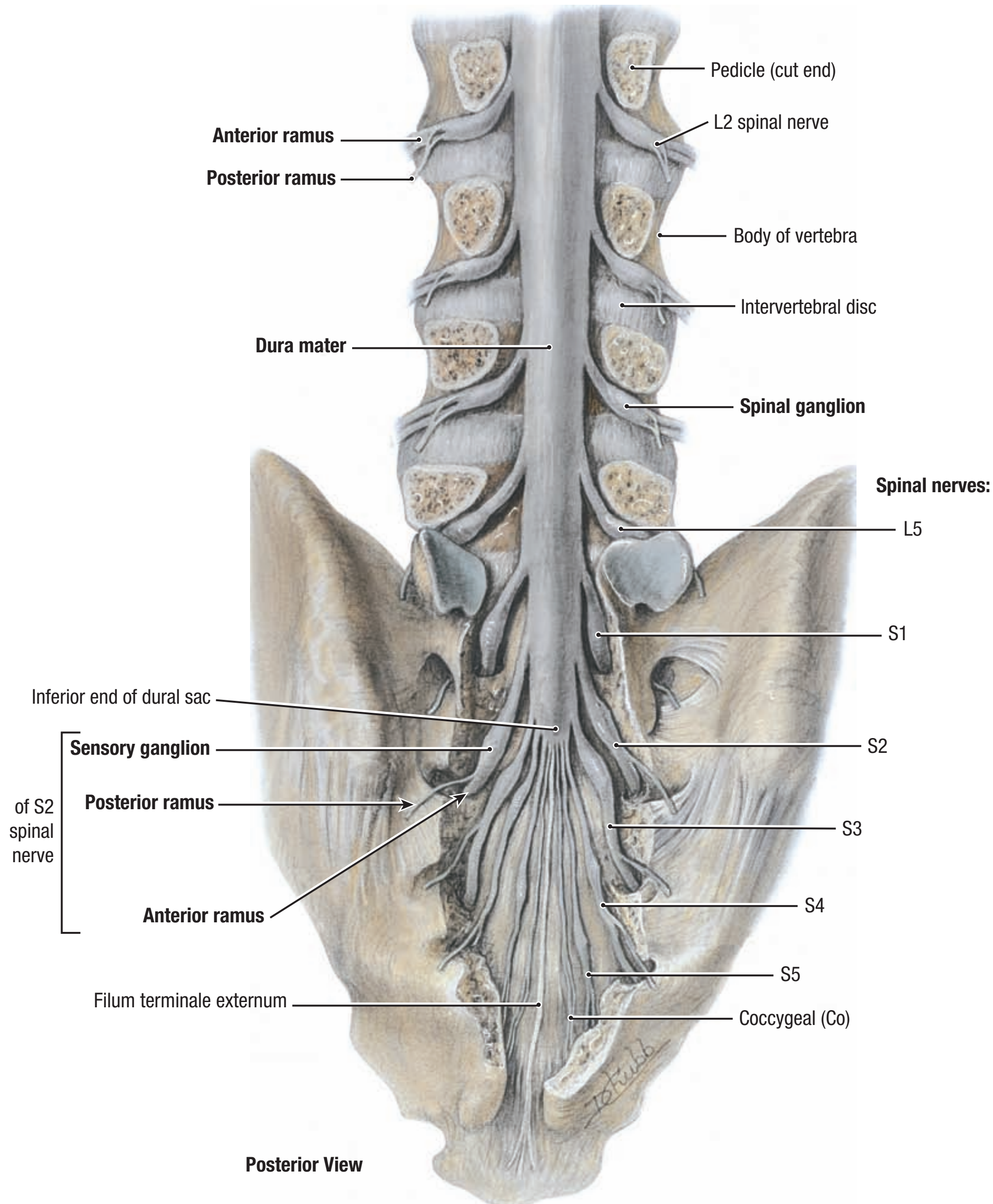
A. **Posterior View**



B. **Superior View**

4.42 SPINAL CORD AND MENINGES

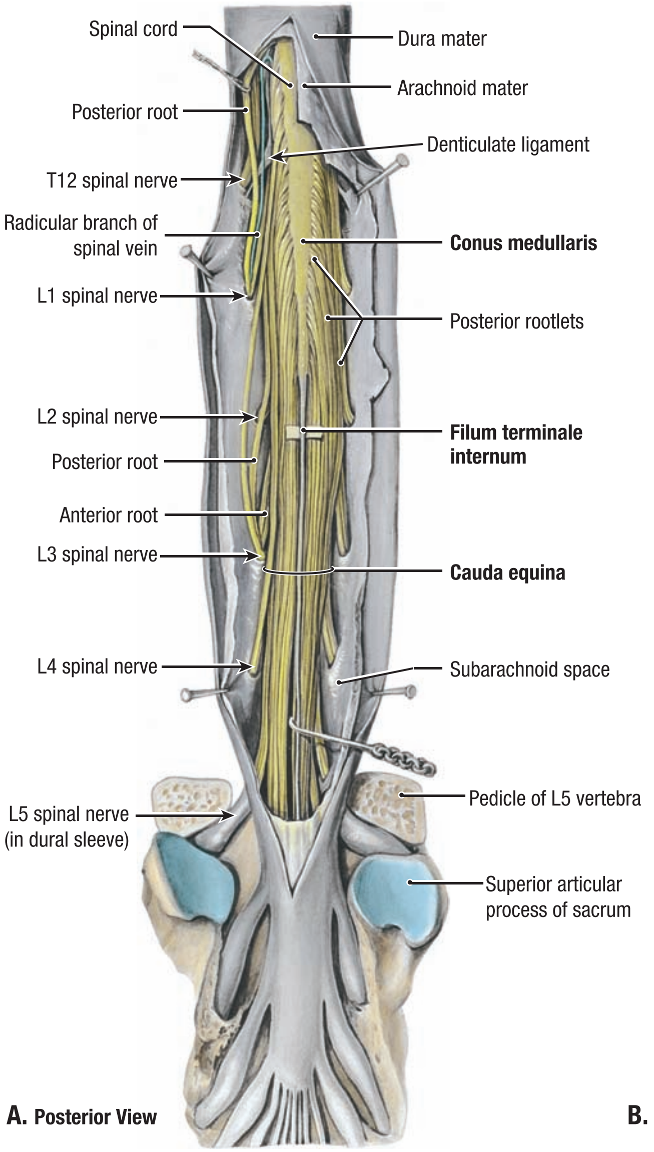
A. Dural sac cut open. The denticulate ligament anchors the cord to the dural sac between successive nerve roots by means of strong, toothlike processes. The anterior nerve roots (rootlets) lie anterior to the denticulate ligament, and the posterior nerve roots (rootlets) lie posterior to the ligament. **B.** Structures of vertebral canal seen through foramen magnum. The spinal cord, vertebral arteries, spinal accessory nerve (CN XI), and most superior part of the denticulate ligament pass through the foramen magnum within the meninges.



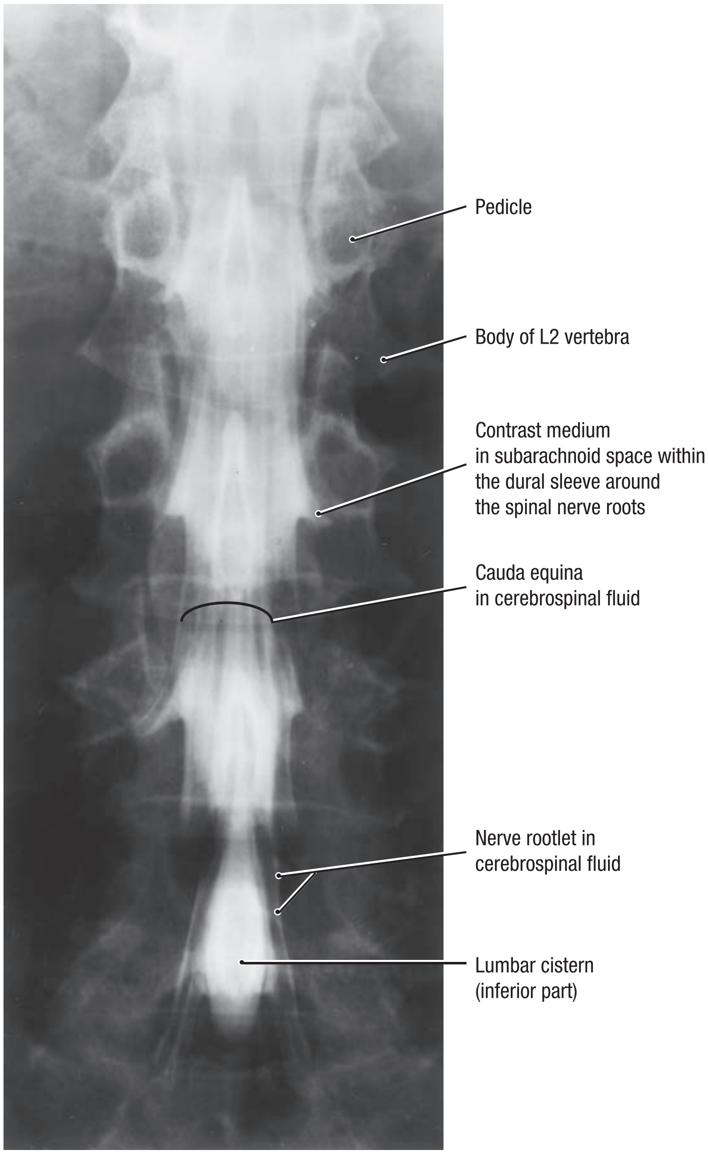
4.43 INFERIOR END OF DURAL SAC I

The posterior parts of the lumbar vertebrae and sacrum were removed.

- The inferior limit of the dural sac is at the level of the posterior superior iliac spine (body of 2nd sacral vertebra); the dura continues as the filum terminale externum.
- The lumbar spinal ganglia are in the IV foramina, and the sacral spinal ganglia are somewhat asymmetrically placed within the sacral canal.
- The posterior rami are smaller than the anterior rami.



A. Posterior View



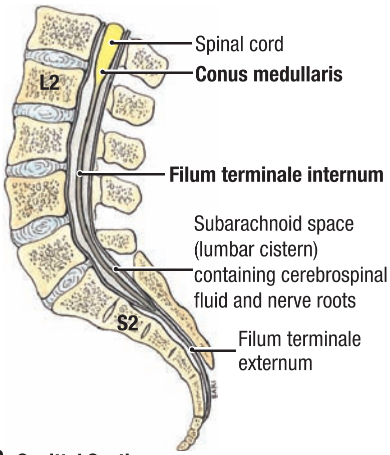
B. Myelogram

4.44 INFERIOR END OF DURAL SAC II

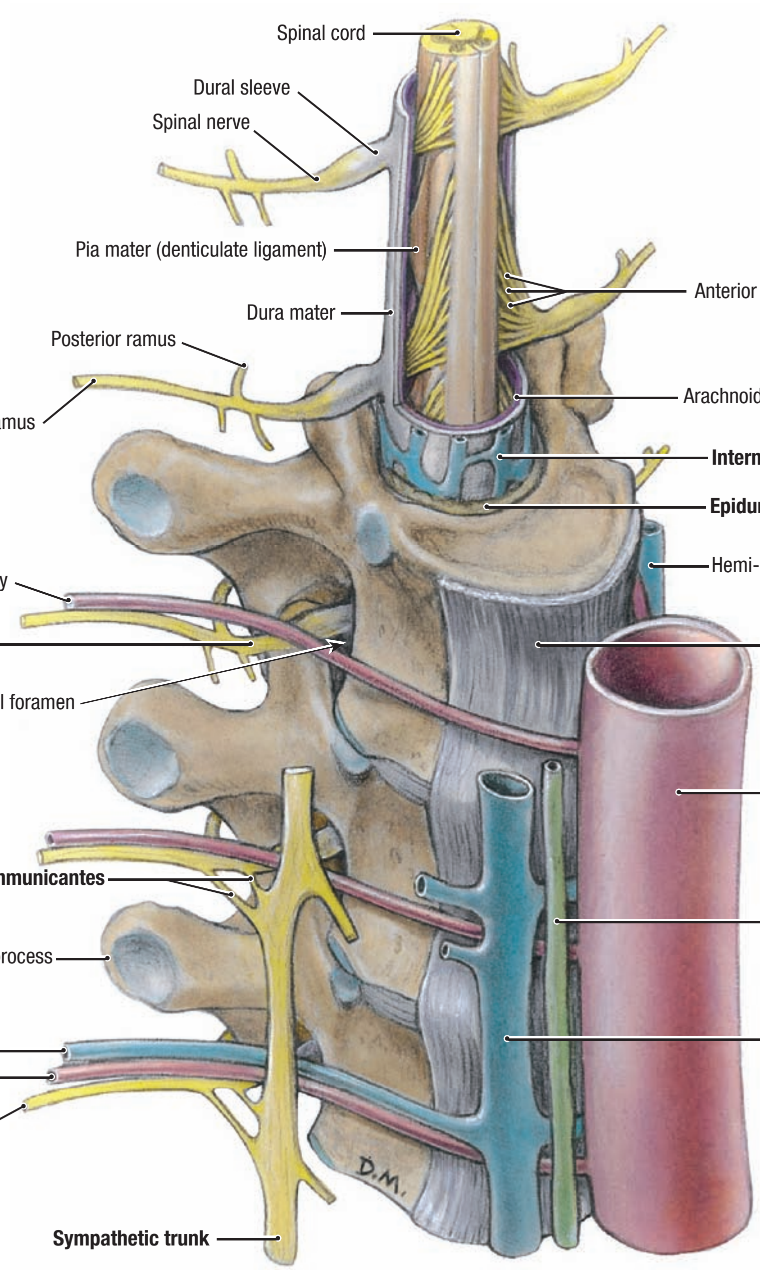
A. Inferior dural sac and lumbar cistern of subarachnoid space, opened. **B.** Myelogram of the lumbar region of the vertebral column. Contrast medium was injected into the subarachnoid space. **C.** Termination of spinal cord, in situ, sagittal section.

- The conus medullaris, or conical lower end of the spinal cord, continues as a glistening thread, the filum terminale internum, which descends with the posterior and anterior nerve roots; these constitute the cauda equina.
- In the adult, the spinal cord usually ends at the level of the disc between vertebrae L1 and L2. Variations: 95% of cords end within the limits of the bodies of L1 and L2, whereas 3% end posterior to the inferior half of T12, and 2% posterior to L3.
- The subarachnoid space usually ends at the level of the disc between S1 and S2, but it can be more inferior.

To obtain a **sample of CSF from the lumbar cistern**, a lumbar puncture needle, fitted with a stylet, is inserted into the subarachnoid space. Flexion of the vertebral column facilitates insertion of the needle by stretching the ligamenta flava and spreading the laminae and spinous processes apart. The needle is inserted in the midline between the spinous processes of the L3 and L4 (or the L4 and L5) vertebrae. At these levels in adults, there is little danger of damaging the spinal cord.



C. Sagittal Section

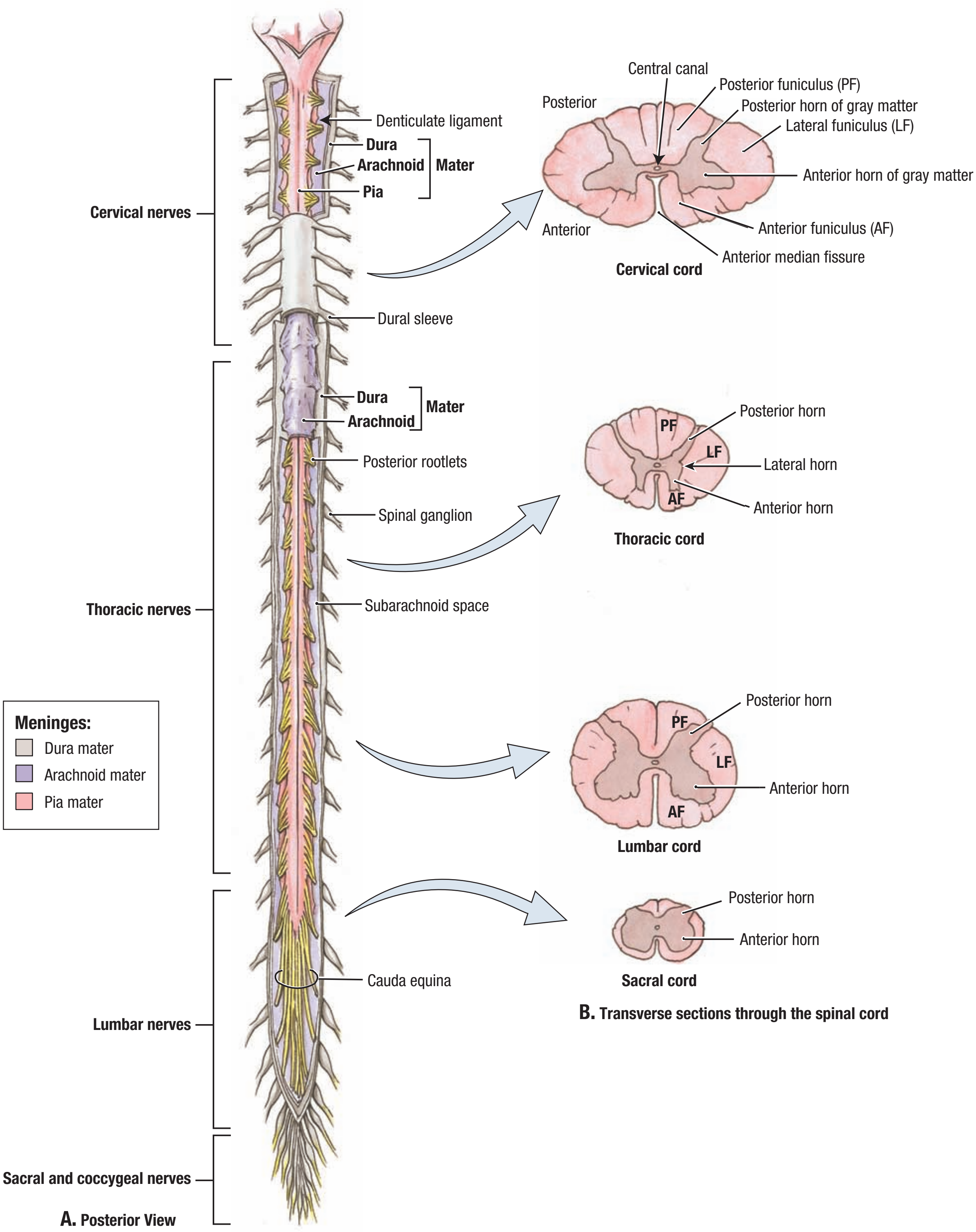


Right Anterolateral View

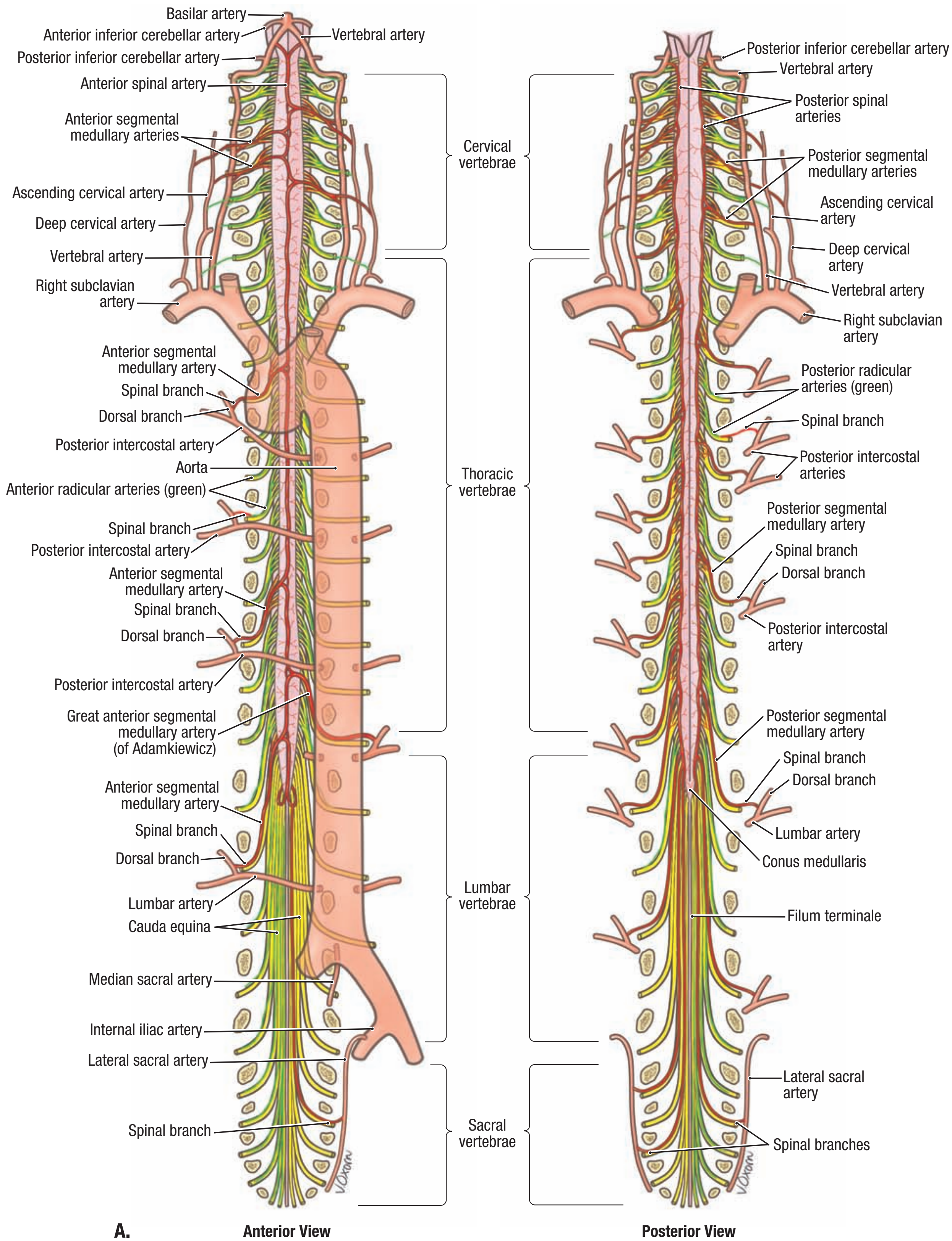
4.45 SPINAL CORD AND PREVERTEBRAL STRUCTURES

The vertebrae have been removed superiorly to expose the spinal cord and meninges.

- The aorta descends to the left of the midline, with the thoracic duct and azygos vein to its right.
- Typically, the azygos vein is on the right side of the vertebral bodies, and the hemi-azygos vein is on the left.
- The thoracic sympathetic trunk and ganglia lie lateral to the thoracic vertebrae; the rami communicantes connect the sympathetic ganglia with the spinal nerve.
- A sleeve of dura mater surrounds the spinal nerves and blends with the sheath (epineurium) of the spinal nerve.
- The dura mater is separated from the walls of the vertebral canal by epidural fat and the internal vertebral venous plexus.

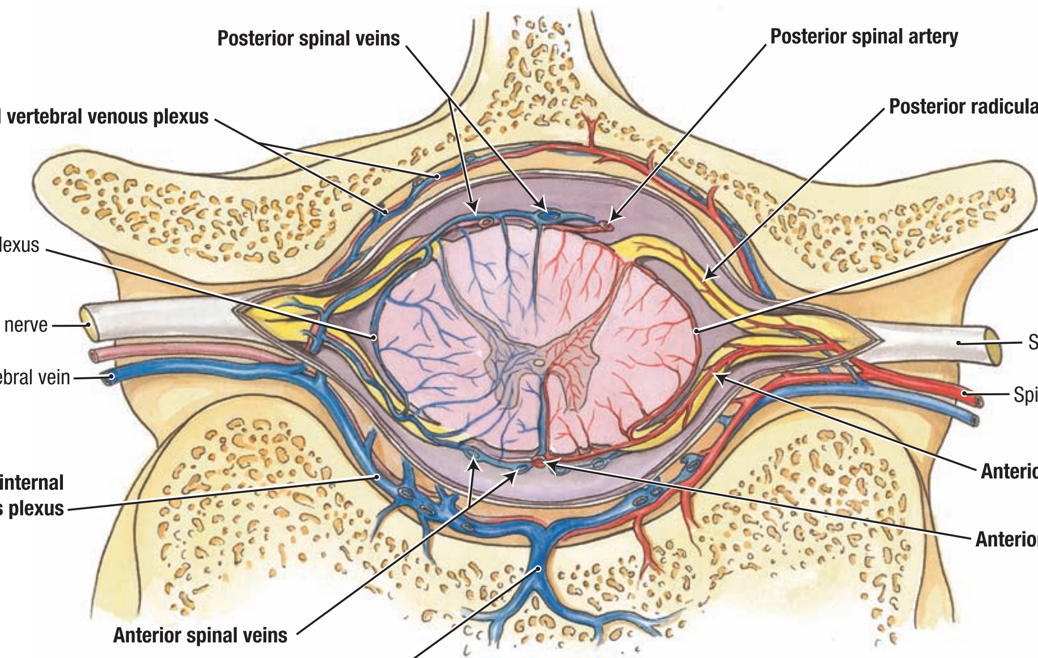


4.46 ISOLATED SPINAL CORD AND SPINAL NERVE ROOTS WITH COVERINGS AND REGIONAL SECTIONS

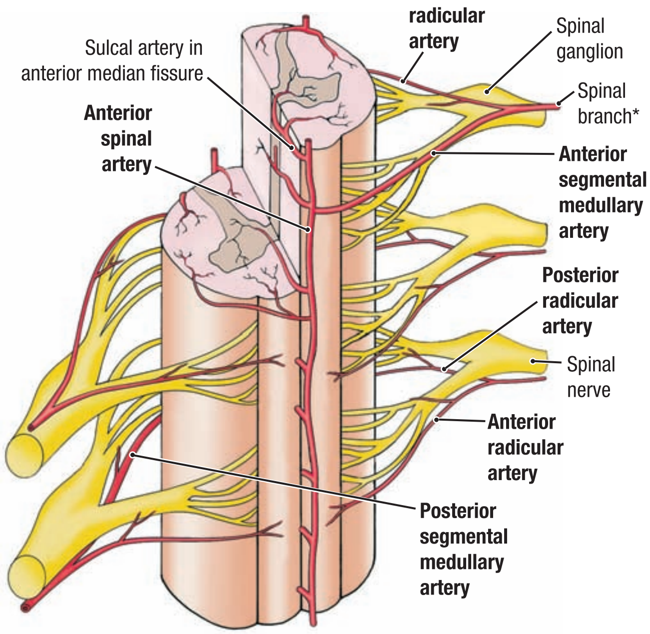


4.47 BLOOD SUPPLY OF SPINAL CORD

A. Arteries of spinal cord. The segmental reinforcements of blood supply from the segmental medullary arteries are important in supplying blood to the anterior and posterior spinal arteries. Fractures, dislocations, and fracture-dislocations may interfere with the blood supply to the spinal cord from the spinal and medullary arteries.



B. **Transverse Section**



* Spinal branches arise from the vertebral, intercostal, lumbar, or sacral artery, depending on level of spinal cord.

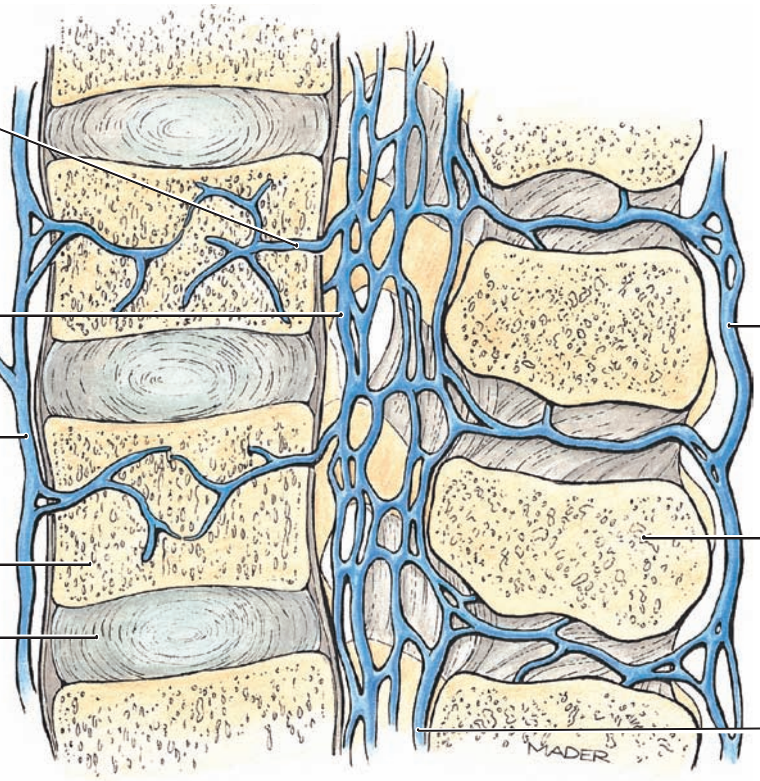
C. **Anterolateral View**

4.47 BLOOD SUPPLY OF SPINAL CORD (*CONTINUED*)

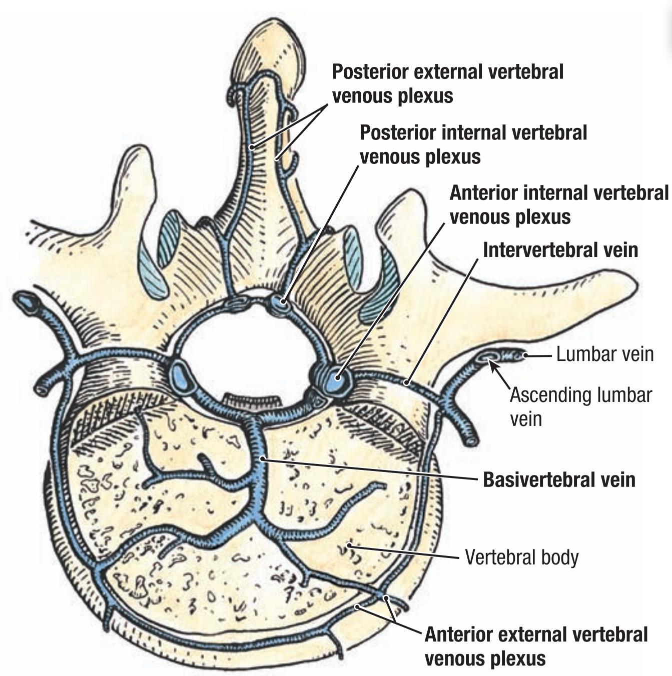
B. Arterial supply and venous drainage. **C.** Segmental medullary and radicular arteries. Three longitudinal arteries supply the spinal cord: an anterior spinal artery, formed by the union of branches of vertebral arteries, and paired posterior spinal arteries, each of which is a branch of either the vertebral artery or the posterior inferior cerebellar artery.

- The spinal arteries run longitudinally from the medulla oblongata of the brainstem to the conus medullaris of the spinal cord. By themselves, the anterior and posterior spinal arteries supply only the short superior part of the spinal cord. The circulation to much of the spinal cord depends on segmental medullary and radicular arteries.
- The anterior and posterior segmental medullary arteries enter the IV foramen to unite with the spinal arteries to supply blood to the spinal cord. The great anterior segmental medullary artery (Adamkiewicz artery) occurs on the left side in 65% of people. It reinforces the circulation to two thirds of the spinal cord.
- Posterior and anterior roots of the spinal nerves and their coverings are supplied by posterior and anterior radicular arteries, which run along the nerve roots. These vessels do not reach the posterior or anterior spinal arteries.
- The 3 anterior and 3 posterior spinal veins are arranged longitudinally; they communicate freely with each other and are drained by up to 12 anterior and posterior medullary and radicular veins. The veins draining the spinal cord join the internal vertebral plexus in the epidural space.

Ischemia. Deficiency of blood supply (ischemia) of the spinal cord affects its function and can lead to muscle weakness and paralysis. The spinal cord may also suffer circulatory impairment if the segmental medullary arteries, particularly the great anterior segmental medullary artery (of Adamkiewicz), are narrowed by obstructive arterial disease or aortic clamping during surgery.



A. **Median Section**

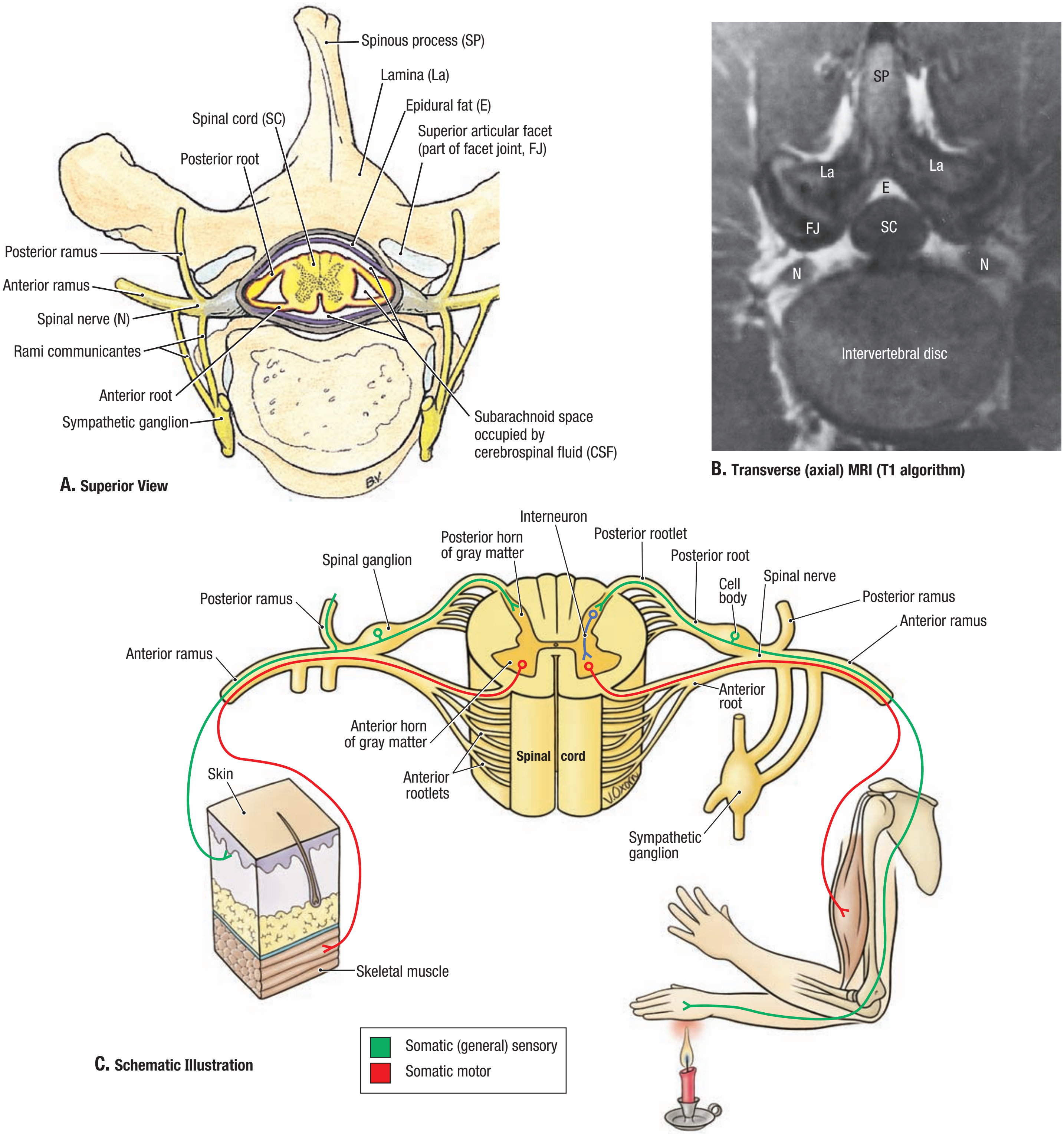


B. **Superior View**

4.48 VERTEBRAL VENOUS PLEXUSES

A. Median section of lumbar spine. **B.** Superior view of lumbar vertebra with the vertebral body sectioned transversely.

- There are internal and external vertebral venous plexuses, communicating with each other and with both systemic veins and the portal system. **Infection and tumors can spread** from the areas drained by the systemic and portal veins to the vertebral venous system and lodge in the vertebrae, spinal cord, brain, or skull.
- The internal vertebral venous plexus, located in the vertebral canal, consists of a plexus of thin-walled, valveless veins that surround the dura mater. Cranially, the internal venous plexus communicates through the foramen magnum with the occipital and basilar sinuses; at each spinal segment, the plexus receives veins from the spinal cord and a basivertebral vein from the vertebral body. The plexus is drained by IV veins that pass through the intervertebral and sacral foramina to the vertebral, intercostal, lumbar, and lateral sacral veins.
- The anterior external vertebral venous plexus is formed by veins that course through the body of each vertebra. Veins that pass through the ligamenta flava form the posterior external vertebral venous plexus. In the cervical region, these plexuses communicate with the occipital and deep cervical veins. In the thoracic, lumbar, and pelvic regions, the azygos (or hemi-azygos), ascending lumbar, and lateral sacral veins, respectively, further link segment to segment.



A. **Superior View**

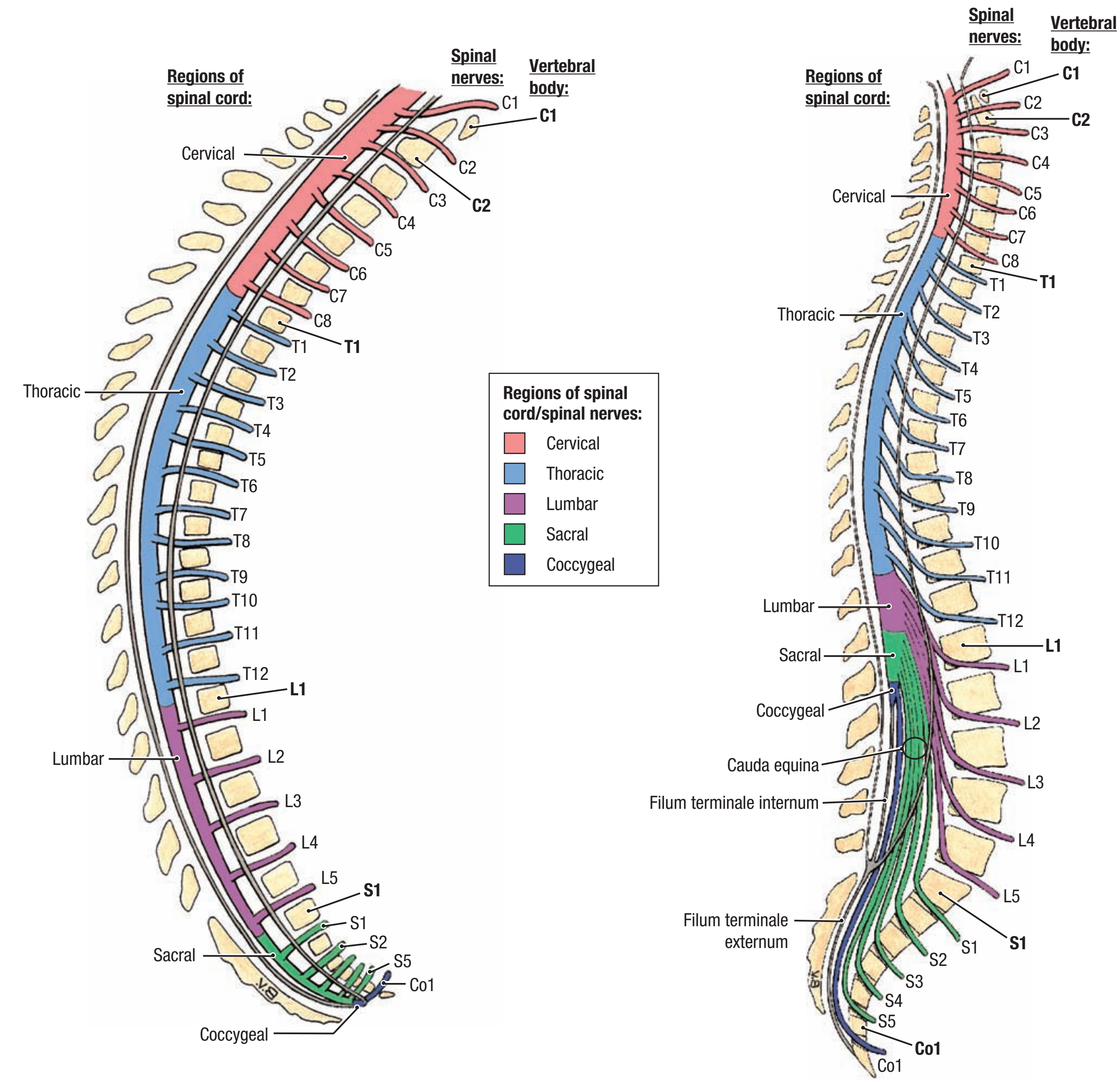
B. **Transverse (axial) MRI (T1 algorithm)**

C. **Schematic Illustration**

4.49 OVERVIEW OF SOMATIC NERVOUS SYSTEM

A. Spinal cord in situ in vertebral canal. **B.** Axial (transverse) MRI of lumbar spine. **C.** Components of typical spinal nerve. The somatic nervous system, or voluntary nervous system, composed of somatic parts of the CNS and PNS, provides general sensory and motor innervation to all parts of the body (G. *soma*), except the viscera in the body cavities, smooth muscle, and glands.

The somatic (general) sensory fibers transmit sensations of touch, pain, temperature, and position from sensory receptors. The somatic motor fibers permit voluntary and reflexive movement by causing contraction of skeletal muscles, such as occurs when one touches a candle flame.

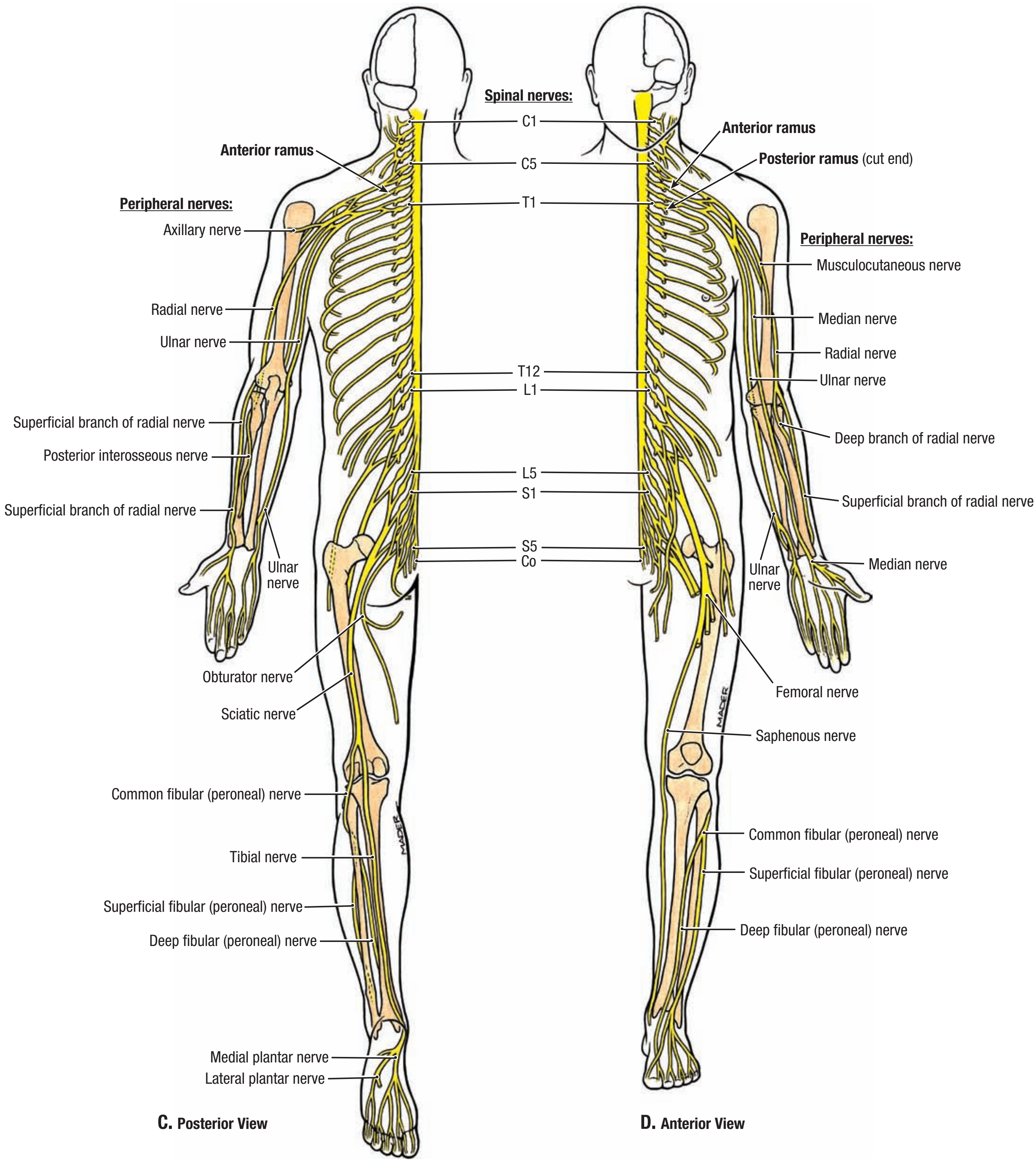


A. Sagittal Section **B.** Sagittal Section

4.50 SPINAL CORD AND SPINAL NERVES

A. Spinal cord at 12 weeks gestation. **B.** Spinal cord of an adult.

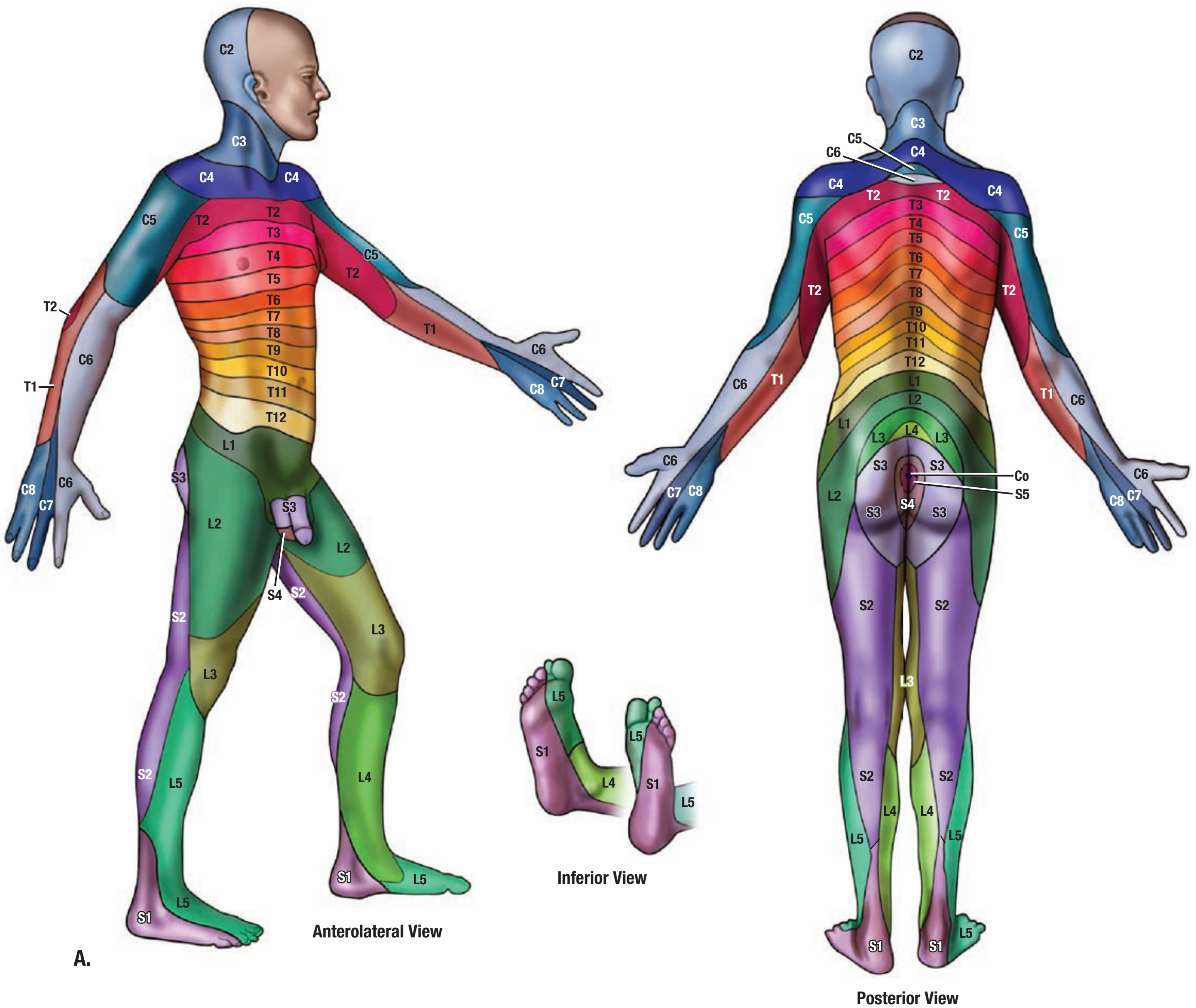
- Early in development, the spinal cord and vertebral (spinal) canal are nearly equal in length. The canal grows longer, so spinal nerves have an increasingly longer course to reach the IV foramen at the correct level for their exit. The spinal cord of adults terminates between vertebral bodies L1–L2. The remaining spinal nerves, seeking their IV foramen of exit, form the cauda equina.
- All 31 pairs of spinal nerves—8 cervical (C), 12 thoracic (T), 5 lumbar (L), 5 sacral (S), and 1 coccygeal (Co)—arise from the spinal cord and exit through the IV foramina in the vertebral column.



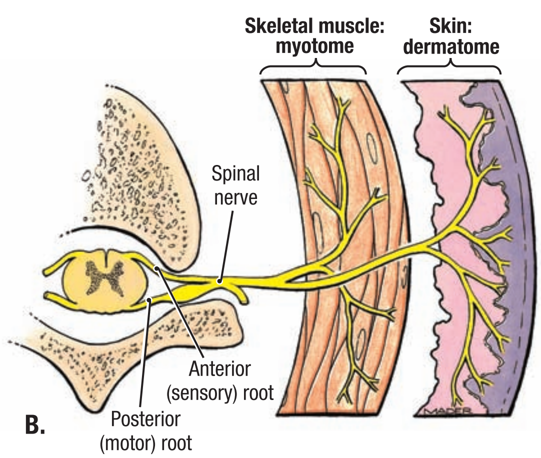
4.50 SPINAL CORD AND SPINAL NERVES (*CONTINUED*)

C. and D. Peripheral nerves.

- The anterior rami supply nerve fibers to the anterior and lateral regions of the trunk and upper and lower limbs.
- The posterior rami supply nerve fibers to synovial joints of the vertebral column, deep muscles of the back, and overlying skin.



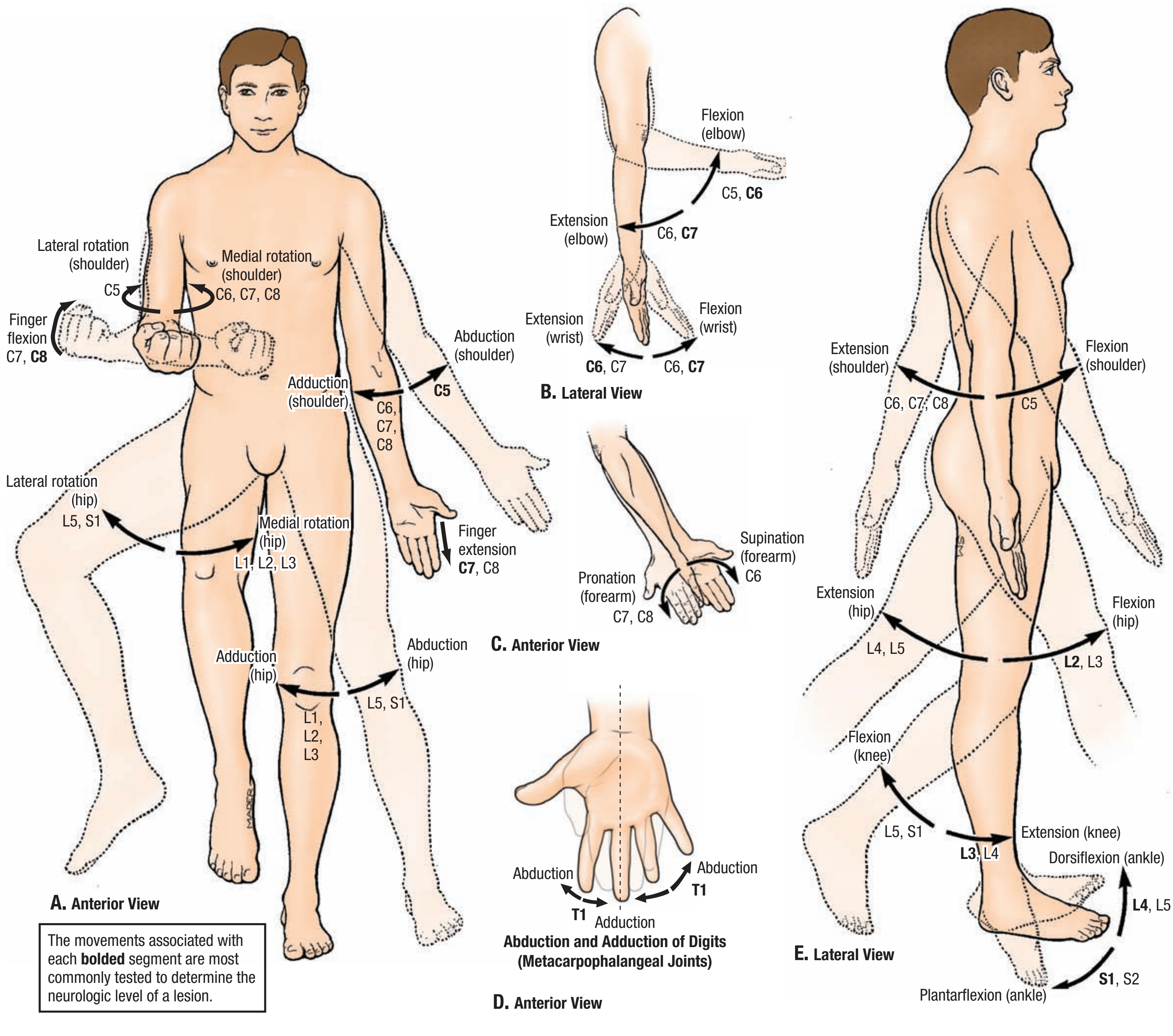
A.



B.

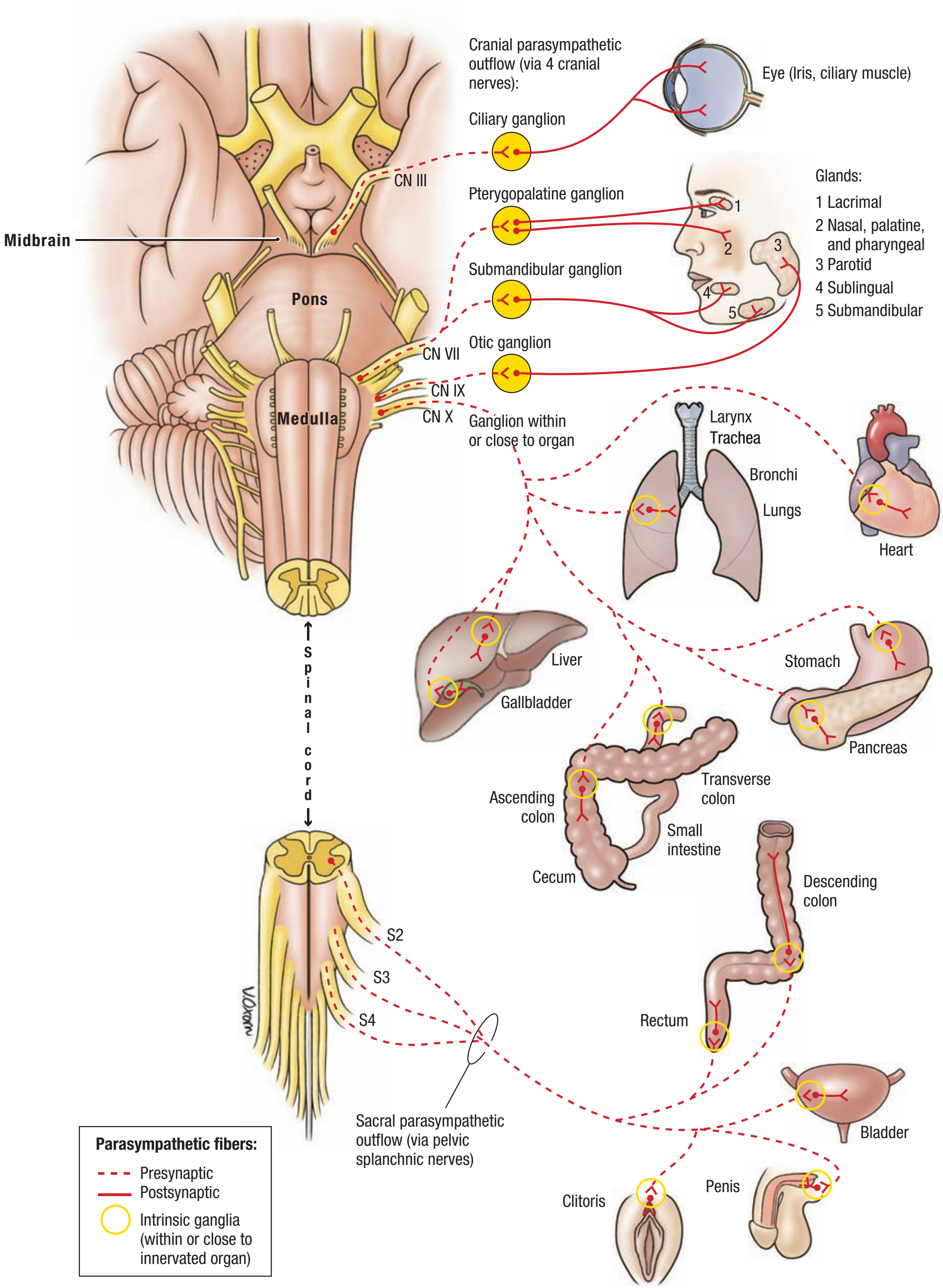
4.51 DERMATOMES

A.–C. Dermatome map (Foerster, 1933). The Keegan and Garrett (1948) dermatome map is not included here. The two schemes are similar in the trunk but differ in the limbs, where both are presented. **B.** Schematic illustration of a dermatome and myotome. The unilateral area of skin innervated by the general sensory fibers of a single spinal nerve is called a dermatome. From clinical studies of lesions in the posterior roots or spinal nerves, dermatome maps have been devised that indicate the typical patterns of innervation of the skin by specific spinal nerves.

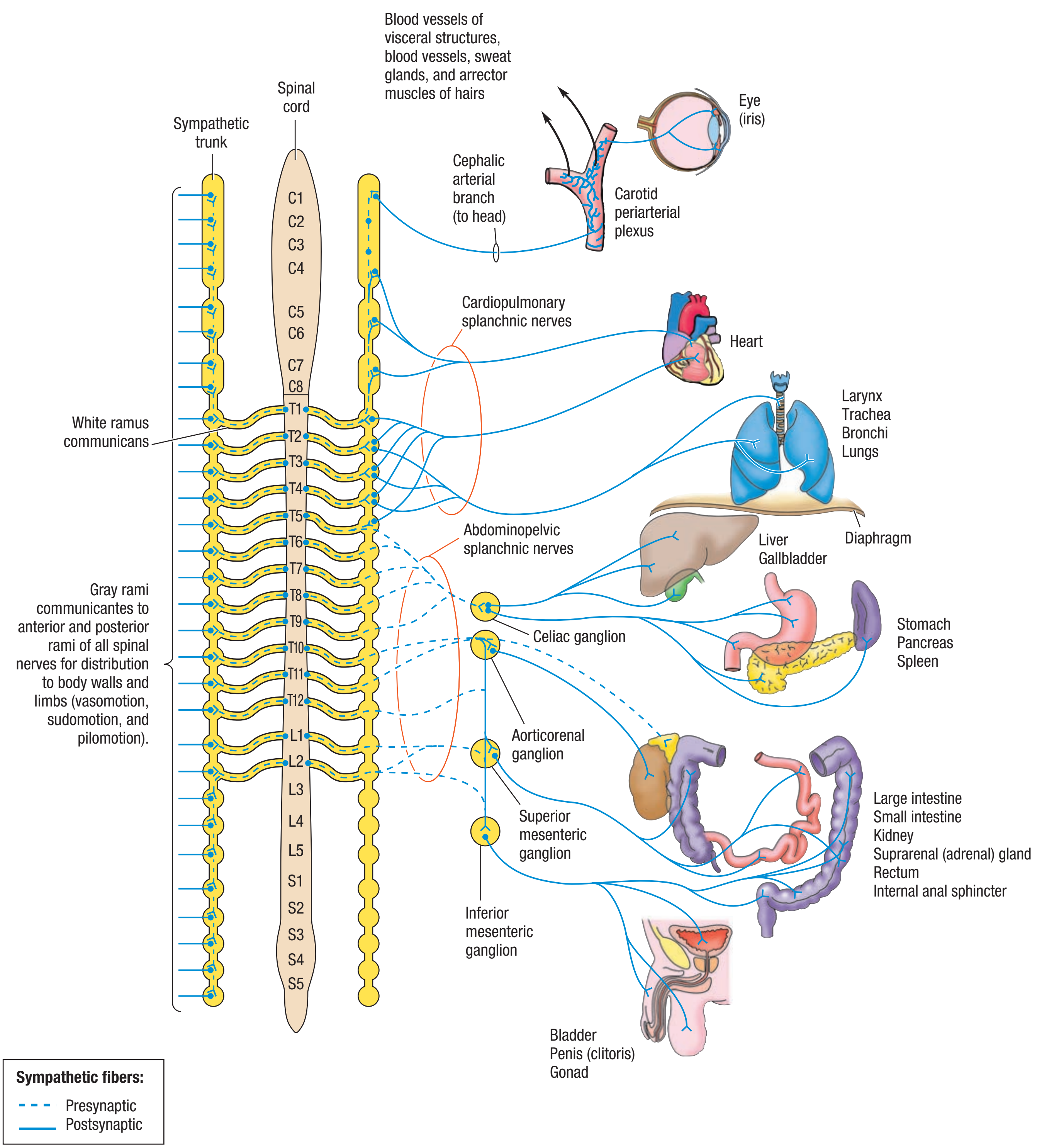


4.52 MYOTOMES

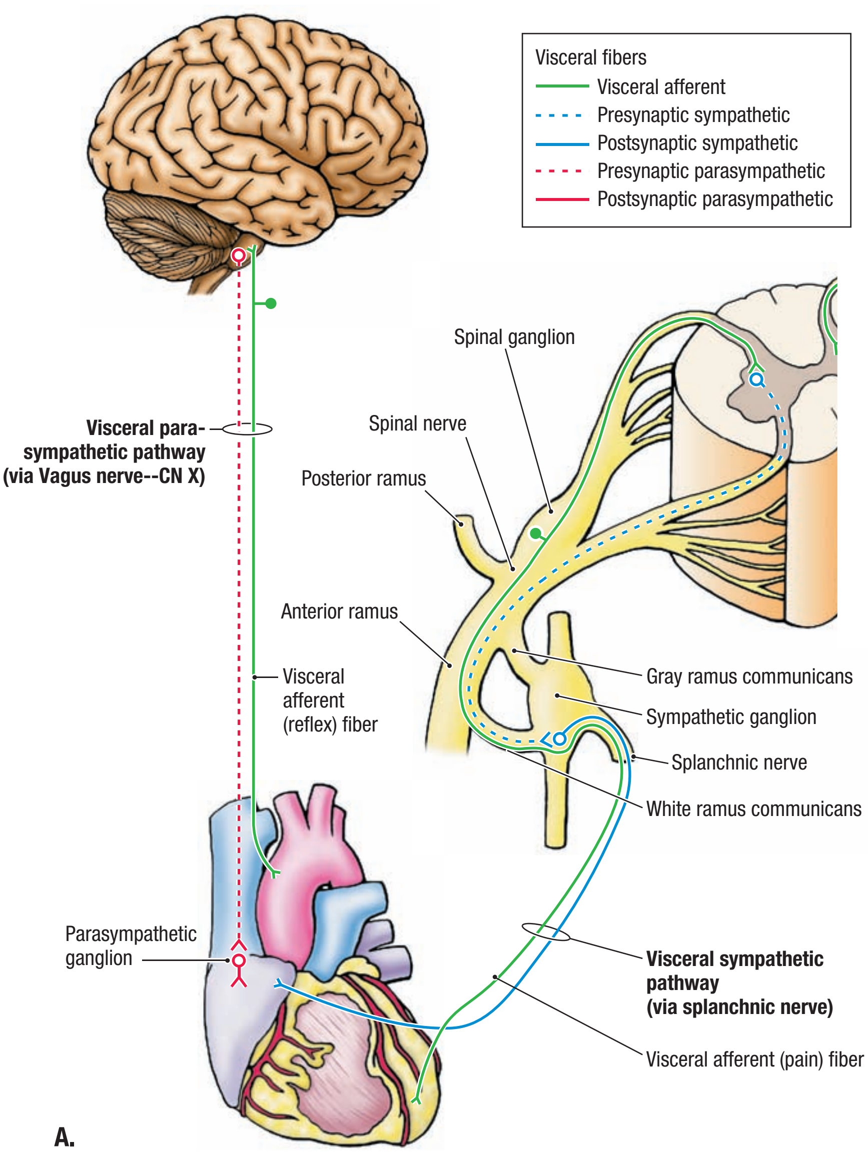
Somatic motor (general somatic efferent) fibers transmit impulses to skeletal (voluntary) muscles. The unilateral muscle mass receiving innervation from the somatic motor fibers conveyed by a single spinal nerve is a myotome. Each skeletal muscle is innervated by the somatic motor fibers of several spinal nerves; therefore, the muscle myotome will consist of several segments. The muscle myotomes have been grouped by joint movement to facilitate clinical testing. The intrinsic muscles of the hand constitute a single myotome—T1.



4.53 DISTRIBUTION OF PARASYMPATHETIC NERVE FIBERS



4.54 DISTRIBUTION OF SYMPATHETIC NERVE FIBERS



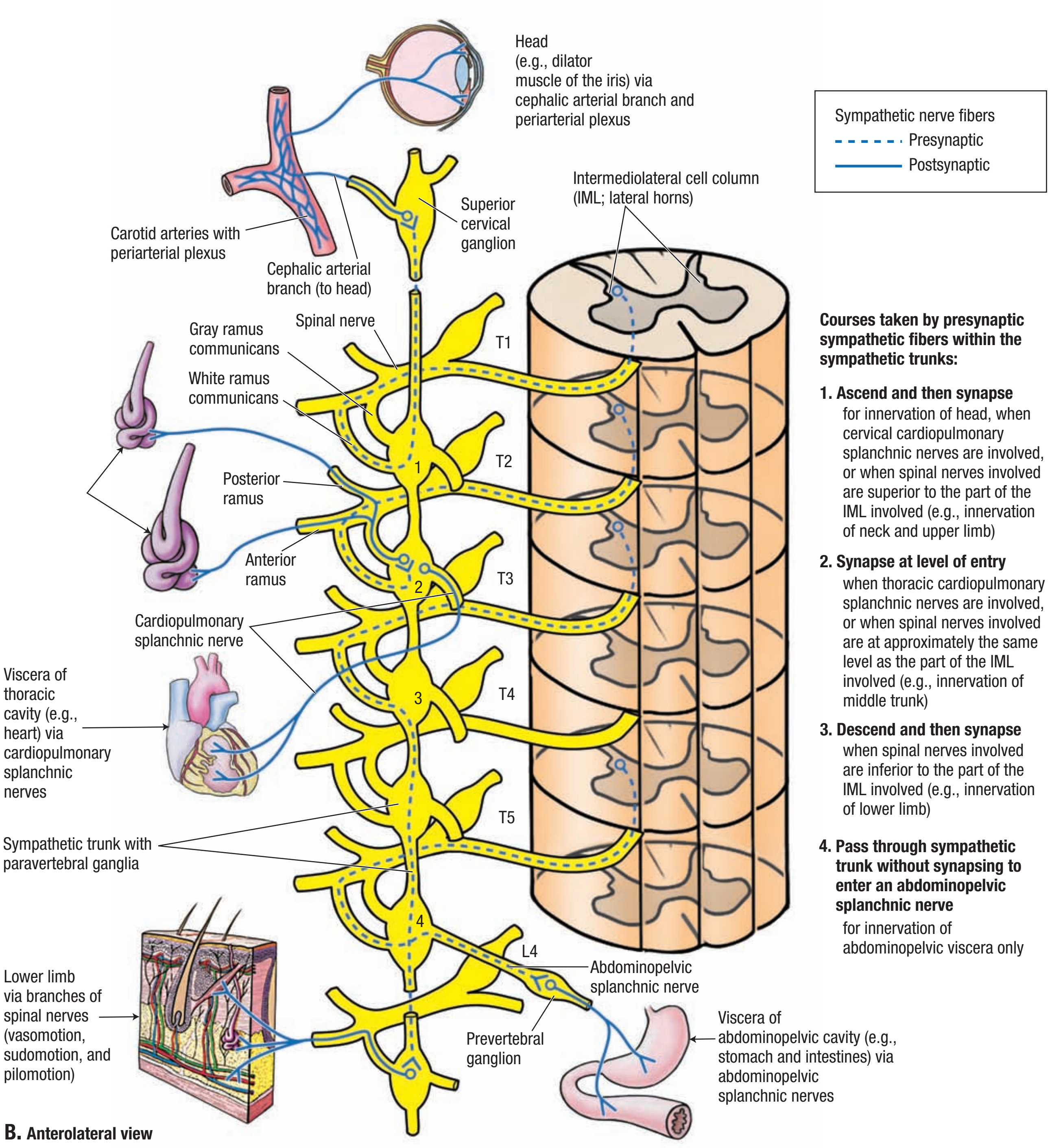
4.55 VISCERAL AFFERENT AND VISCERAL EFFERENT (MOTOR) INNERVATION

A. Schematic illustration. Visceral afferent fibers have important relationships to the CNS, both anatomically and functionally. We are usually unaware of the sensory input of these fibers, which provides information about the condition of the body's internal environment. This information is integrated in the CNS, often triggering visceral or somatic reflexes or both. Visceral reflexes regulate blood pressure and chemistry by altering such functions as heart and respiratory rates and vascular resistance. Visceral sensation that reaches a conscious level is generally categorized as pain that is usually poorly localized and may be perceived as hunger or nausea. However, adequate stimulation may elicit true pain. Most visceral/reflex (unconscious) sensation and some pain travel in visceral afferent fibers that accompany the parasympathetic fibers retrograde. Most visceral pain impulses (from the heart and most organs of the peritoneal cavity) travel along visceral afferent fibers accompanying sympathetic fibers.

Visceral efferent (motor) innervation. The efferent nerve fibers and ganglia of the ANS are organized into two systems or divisions.

1. Sympathetic (thoracolumbar) division. In general, the effects of sympathetic stimulation are catabolic (preparing the body for "flight or fight").
2. Parasympathetic (craniosacral) division. In general, the effects of parasympathetic stimulation are anabolic (promoting normal function and conserving energy).

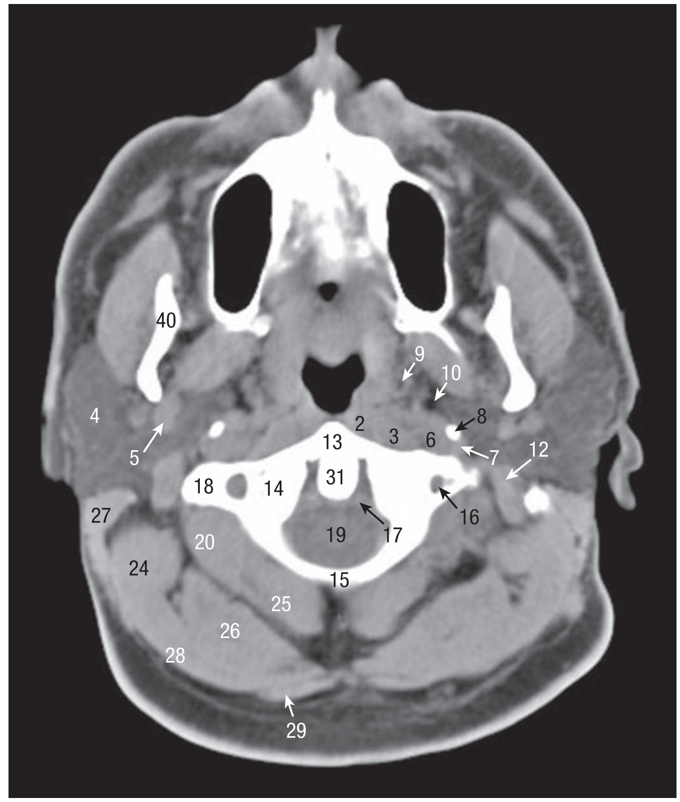
Conduction of impulses from the CNS to the effector organ involves a series of two neurons in both sympathetic and parasympathetic systems. The cell body of the presynaptic (preganglionic) neuron (first neuron) is located in the gray matter of the CNS. Its fiber (axon) synapses on the cell body of a postsynaptic (postganglionic) neuron, the second neuron in the series. The cell bodies of such second neurons are located in autonomic ganglia outside the CNS, and the postsynaptic fibers terminate on the effector organ (smooth muscle, modified cardiac muscle, or glands).



4.55 VISCERAL AFFERENT AND VISCERAL EFFERENT (MOTOR) INNERVATION (*CONTINUED*)

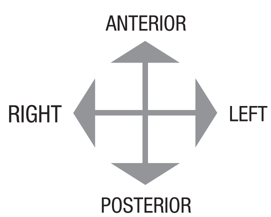
B. Courses taken by sympathetic motor fibers. Presynaptic fibers all follow the same course until they reach the sympathetic trunks. In the sympathetic trunks, they follow one of four possible courses. Fibers involved in providing sympathetic innervation to the body wall and limbs or viscera above the level of the diaphragm follow paths 1 to 3. They synapse in the paravertebral ganglia of the sympathetic trunks. Fibers involved in innervating abdominopelvic viscera follow path 4 to prevertebral ganglion via abdominopelvic splanchnic nerves. Postsynaptic fibers usually don't ascend or descend within the sympathetic trunks, exiting at the level of synapse.

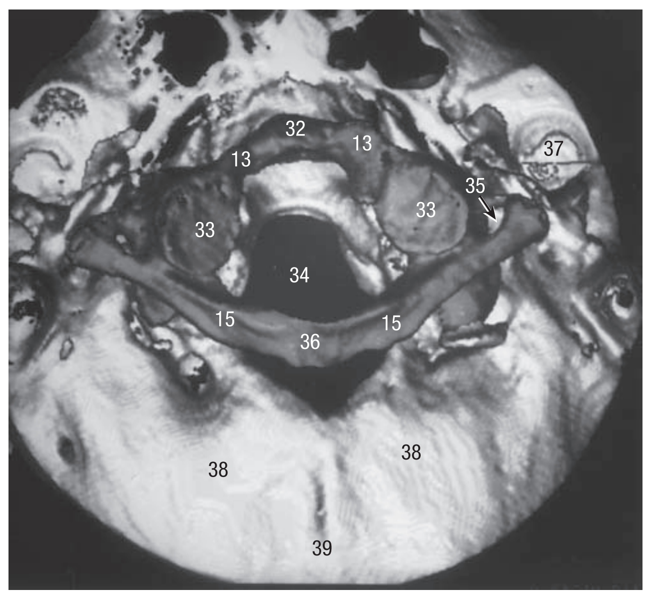
A. Inferior View



B. Inferior View

1 Site of retropharyngeal space
2 Longus colli
3 Longus capitis
4 Parotid gland
5 Retromandibular vein
6 Stylopharyngeus
7 Styloglossus
8 Stylohyoid muscle and ligament/process
9 Internal carotid artery
10 Internal jugular vein
11 Rectus capitis lateralis
12 Posterior belly of digastric
13 Anterior arch of atlas (C1 vertebra)
14 Lateral mass of atlas (C1)
15 Posterior arch of atlas (C1)
16 Vertebral artery
17 Transverse ligament of atlas (C1)
18 Transverse process of atlas (C1)
19 Spinal cord
20 Rectus capitis posterior major
21 Obliquus capitis inferior
22 Obliquus capitis superior
23 Spinous process of atlas (C1)
24 Longissimus capitis
25 Rectus capitis posterior minor
26 Semispinalis capitis
27 Sternocleidomastoid
28 Splenius capitis
29 Trapezius
30 Fatty mass
31 Dens of axis (C2 vertebra)
32 Anterior tubercle of atlas (C1)
33 Inferior articular facet of atlas (C1)
34 Foramen magnum
35 Foramen transversarium
36 Posterior tubercle of atlas (C1)
37 Mastoid process
38 Occipital bone of skull
39 External occipital protuberance
40 Ramus of mandible

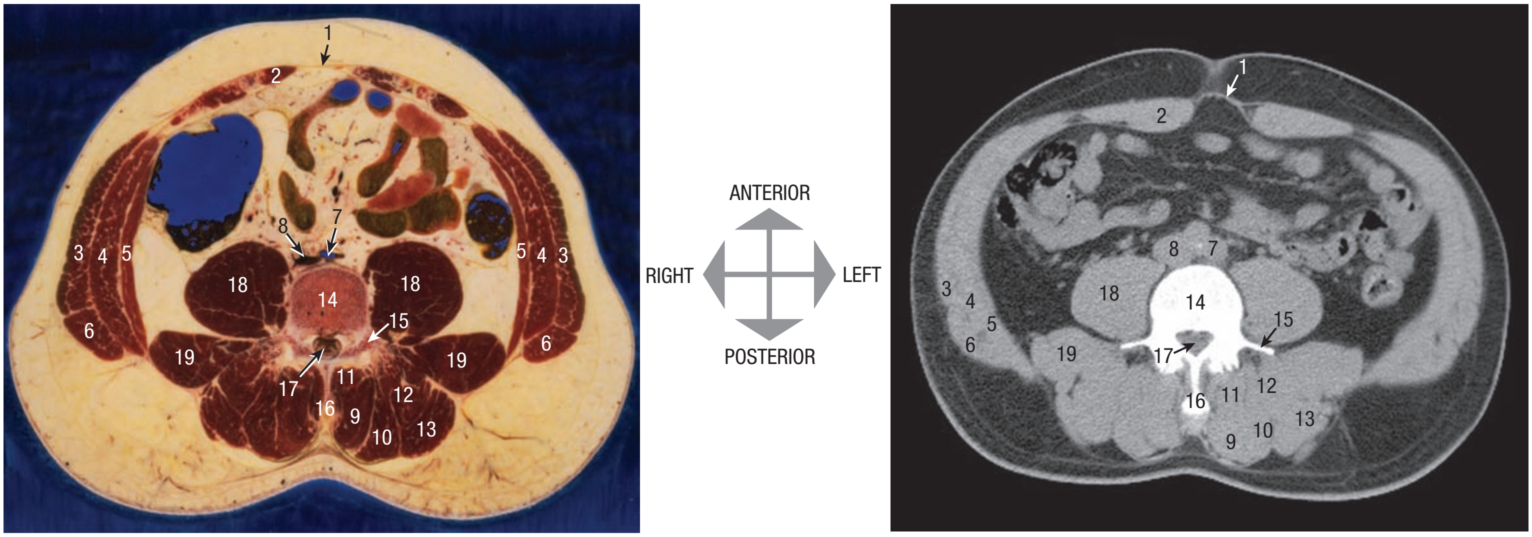




C. Postero-inferior View

4.56 IMAGING OF SUPERIOR NUCHAL REGION AT LEVEL OF ATLAS

A. Transverse section of specimen. **B.** Transverse computed tomographic (CT) scan. **C.** Three-dimensional (3D) CT of the base of the skull and atlas.



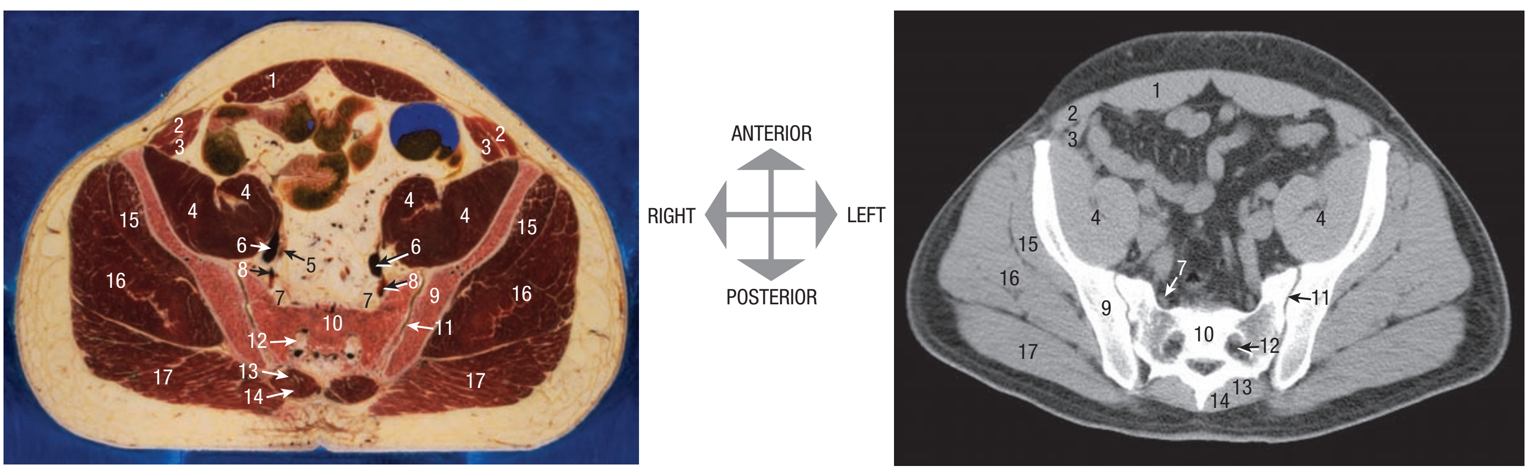
A. **Inferior View**

B. **Inferior View**

1	Linea alba	6	Latissimus dorsi	11	Multifidus	16	Spinous process
2	Rectus abdominis	7	Descending aorta	12	Rotatores	17	Cauda equina
3	External oblique	8	Inferior vena cava	13	Iliocostalis	18	Psoas major
4	Internal oblique	9	Spinalis	14	4th lumbar vertebra	19	Quadratus lumborum
5	Transversus abdominis	10	Longissimus	15	Transverse process		

4.57 IMAGING OF LUMBAR SPINE AT L4

A. Transverse section of specimen. **B.** Transverse computed tomographic (CT) scan.



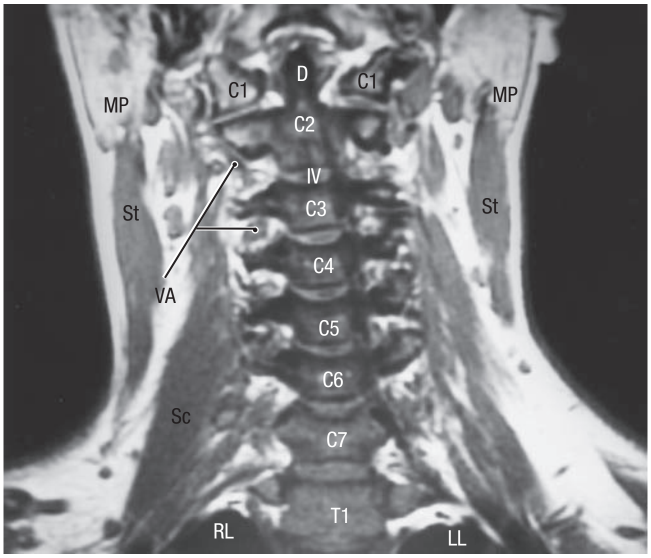
A. **Inferior View**

B. **Inferior View**

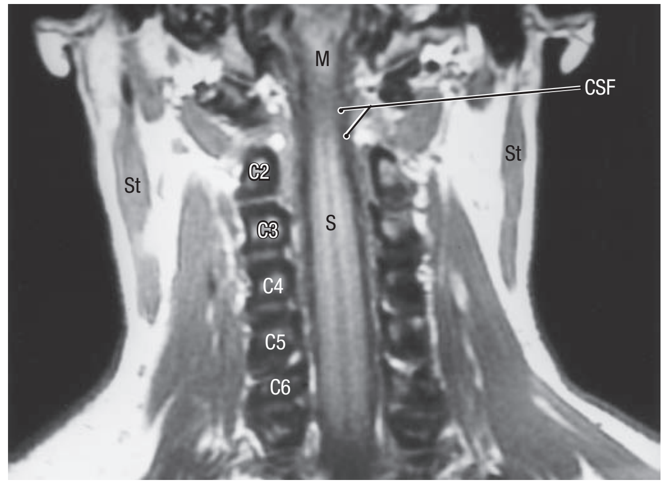
1	Rectus abdominis	6	Internal iliac vein	10	2nd sacral vertebra	14	Erector spinae
2	External oblique	7	Anterior rami	11	Sacro-iliac joint	15	Gluteus minimis
3	Internal oblique	8	Superior gluteal vessels	12	Sacral nerve root	16	Gluteus medius
4	Iliopsoas	9	Body of ilium	13	Multifidus	17	Gluteus maximus
5	Internal iliac artery						

4.58 IMAGING OF SACRO-ILIAC JOINT

A. Transverse section of specimen. **B.** Transverse computed tomographic (CT) scan.



A.



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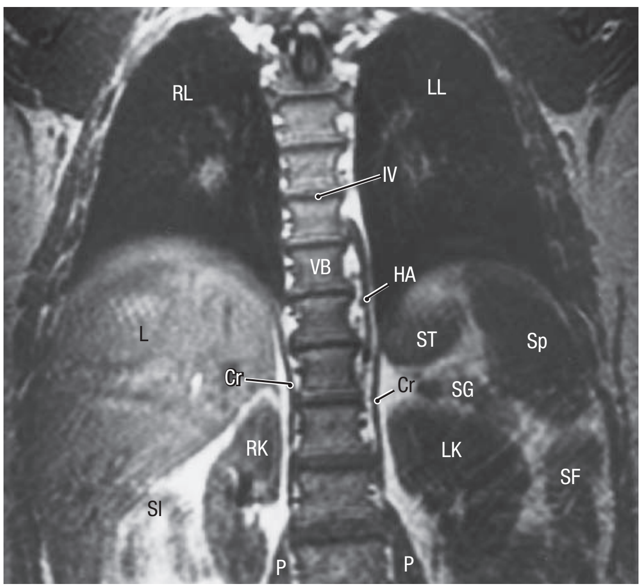

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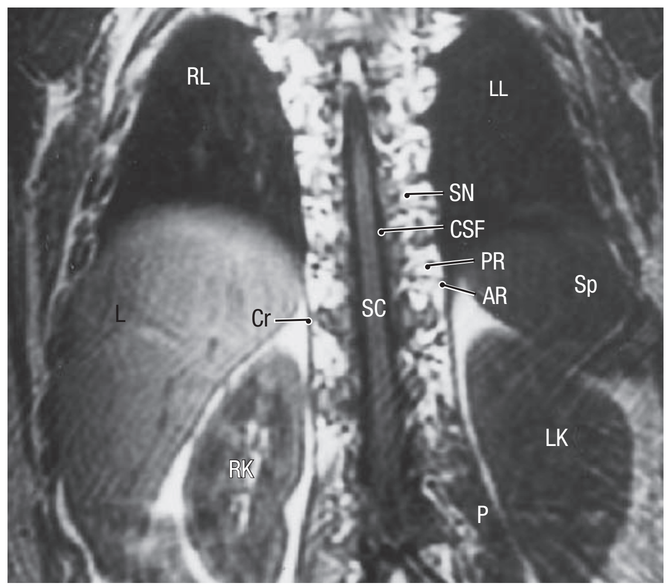


D.

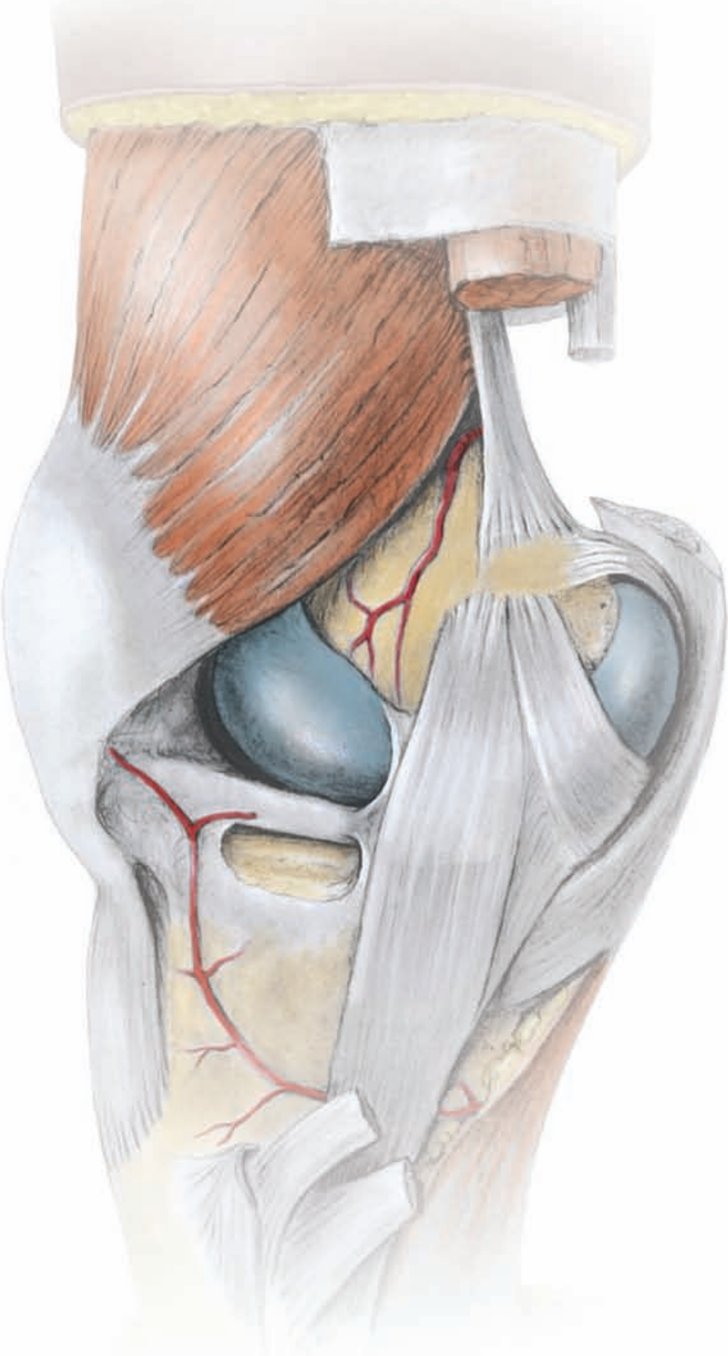
AR	Anterior ramus	LL	Left lung	SG	Suprarenal gland
C1-T1	Vertebrae	M	Medulla oblongata	SI	Small intestine
Cr	Crus of diaphragm	MP	Mastoid process	SN	Spinal nerve
CSF	Cerebrospinal fluid in subarachnoid space	P	Psoas muscle	Sp	Spleen
D	Dens (odontoid) process of C2	PR	Posterior ramus	St	Sternocleidomastoid
HA	Hemi-azygos vein	RK	Right kidney	ST	Stomach
IV	Intervertebral disc	RL	Right lung	VA	Vertebral artery
L	Liver	S	Spinal cord		
LK	Left kidney	SF	Splenic flexure		

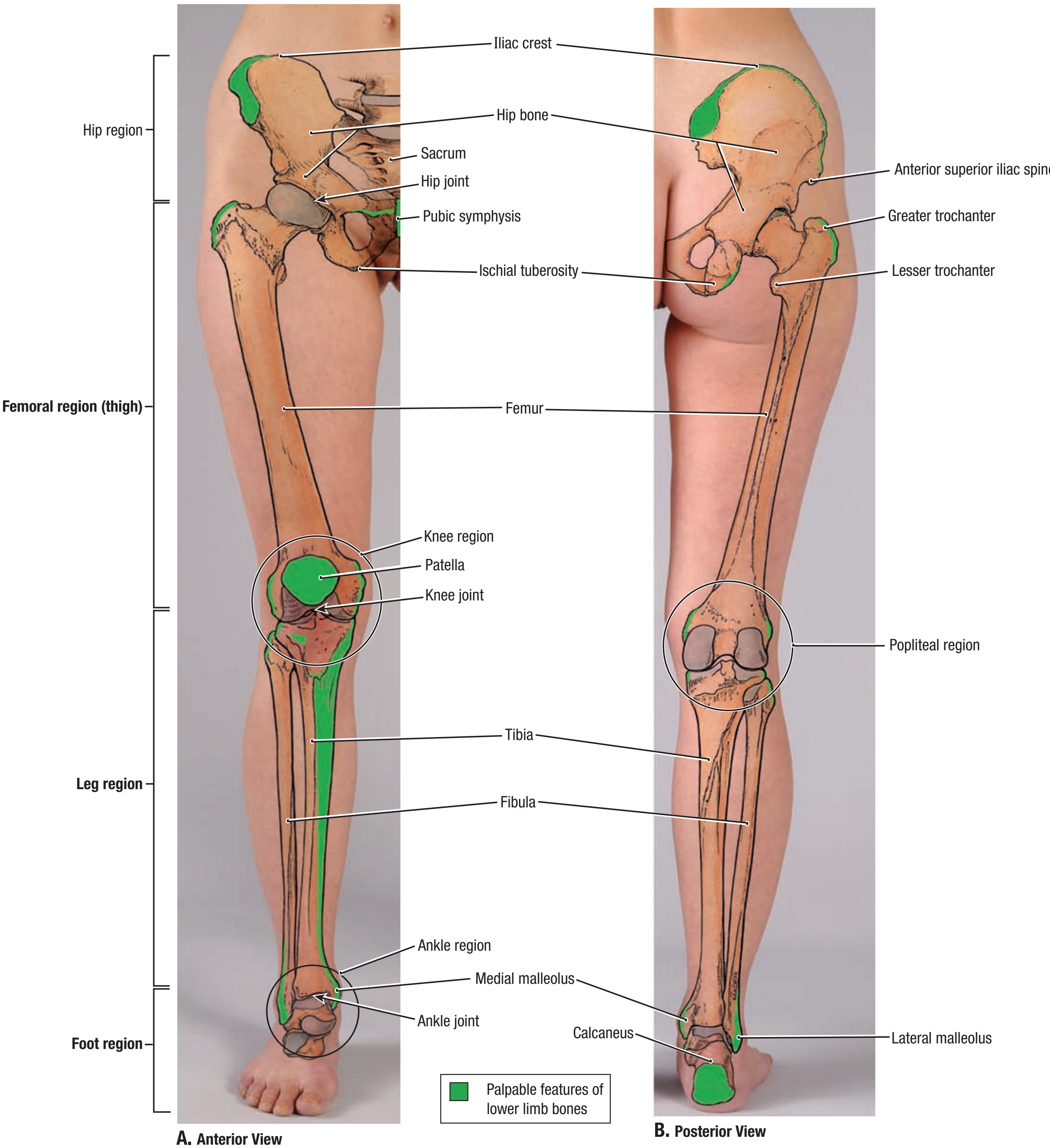
4.59 CORONAL MRI SCANS OF CERVICAL AND THORACIC SPINE

A. and **B.** Cervical spine. **C.** and **D.** Thoracic spine.

CHAPTER 5

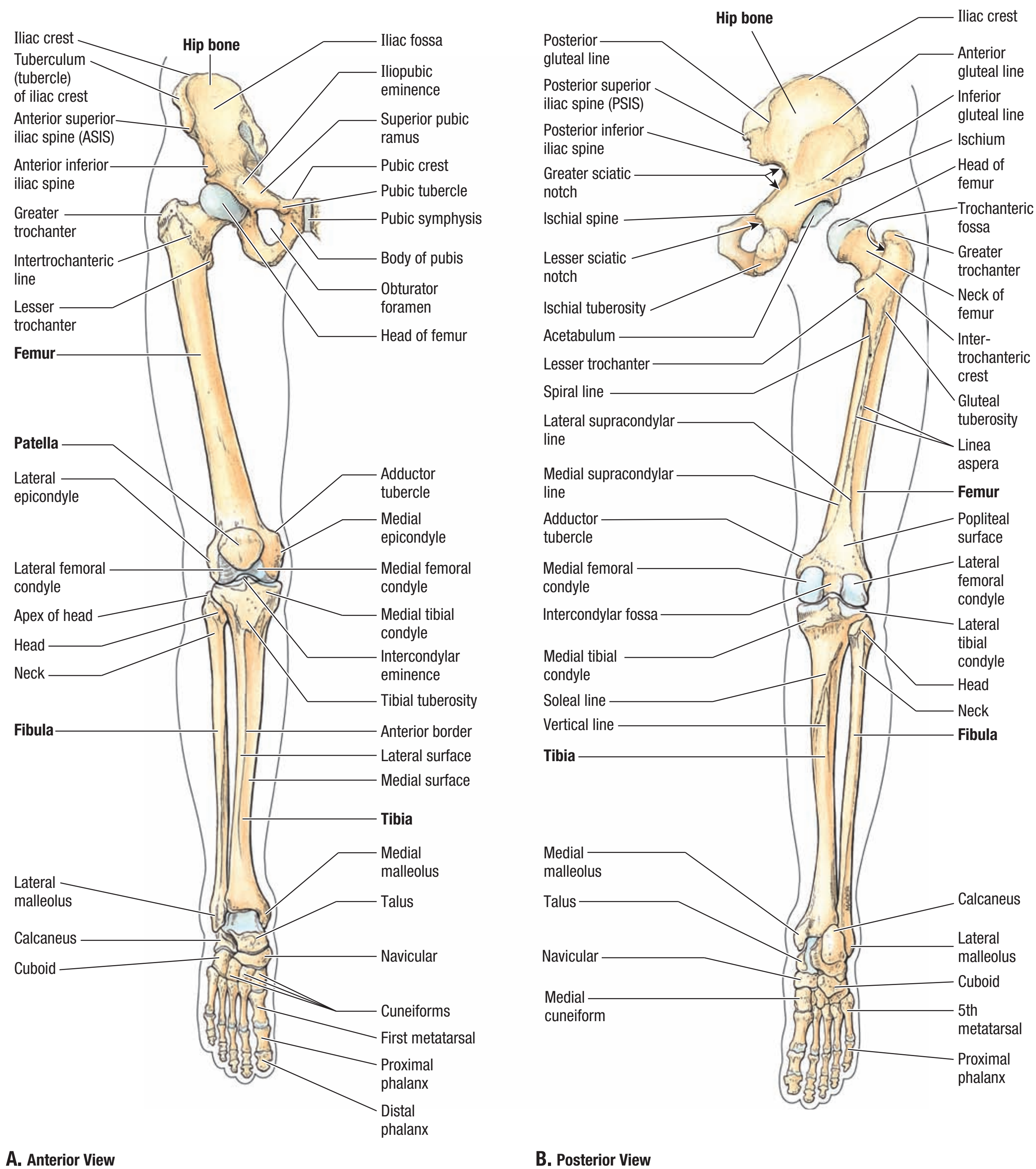
Lower Limb





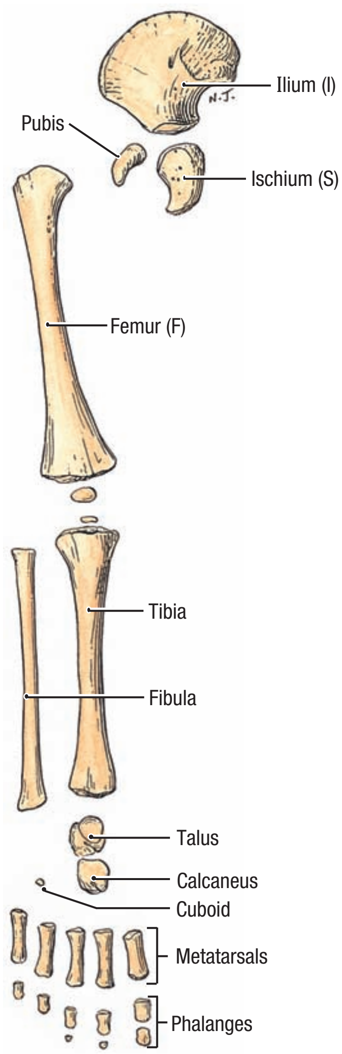
5.1 REGIONS, BONES, AND MAJOR JOINTS OF LOWER LIMB

The hip bones meet anteriorly at the pubic symphysis and articulate with the sacrum posteriorly. The femur articulates with the hip bone proximally and the tibia distally. The tibia and fibula are the bones of the leg that join the foot at the ankle.

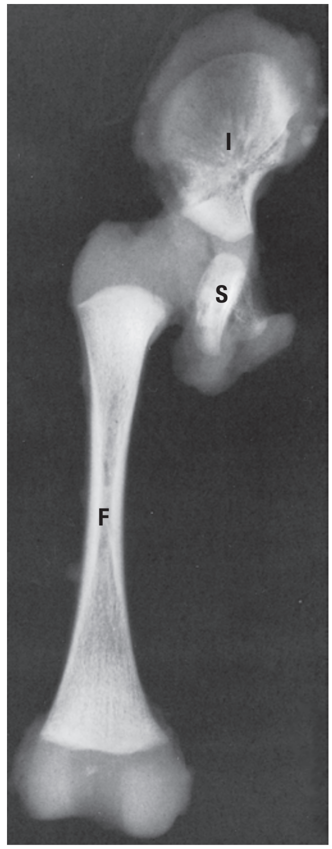


5.2 FEATURES OF BONES OF LOWER LIMB

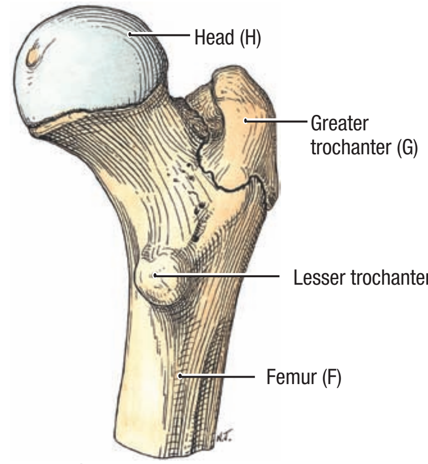
The foot is in full plantar flexion. The hip joint is disarticulated in **B** to demonstrate the acetabulum of the hip bone and the entire head of the femur.



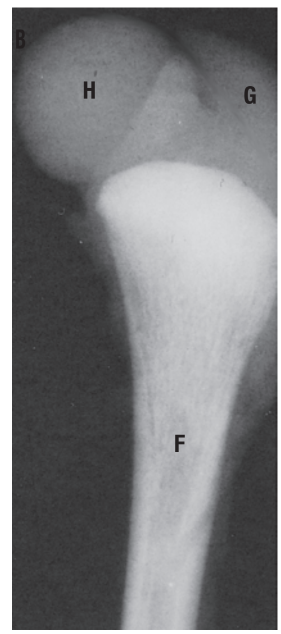
A. **Anterior View**



B. **Anteroposterior View**



C. **Posterior View**

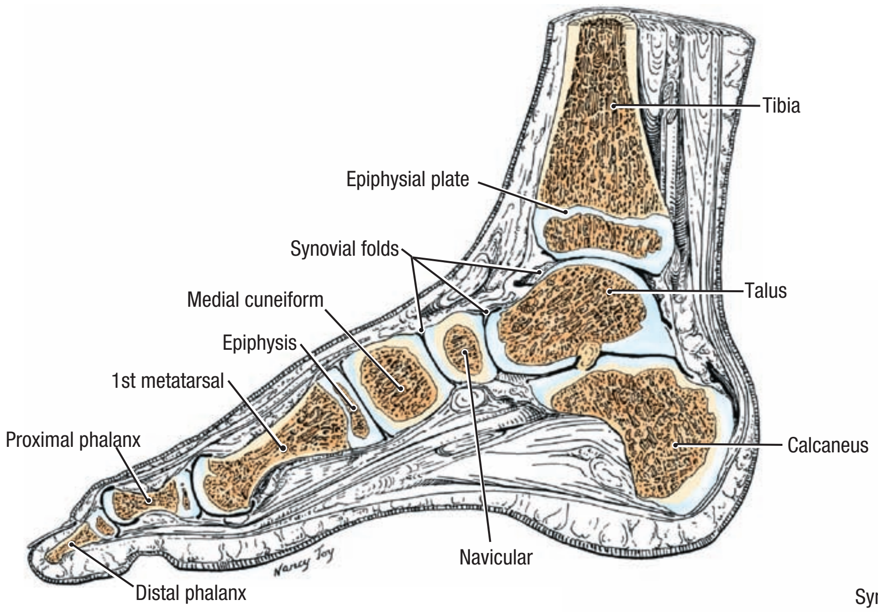


D. **Anteroposterior View**

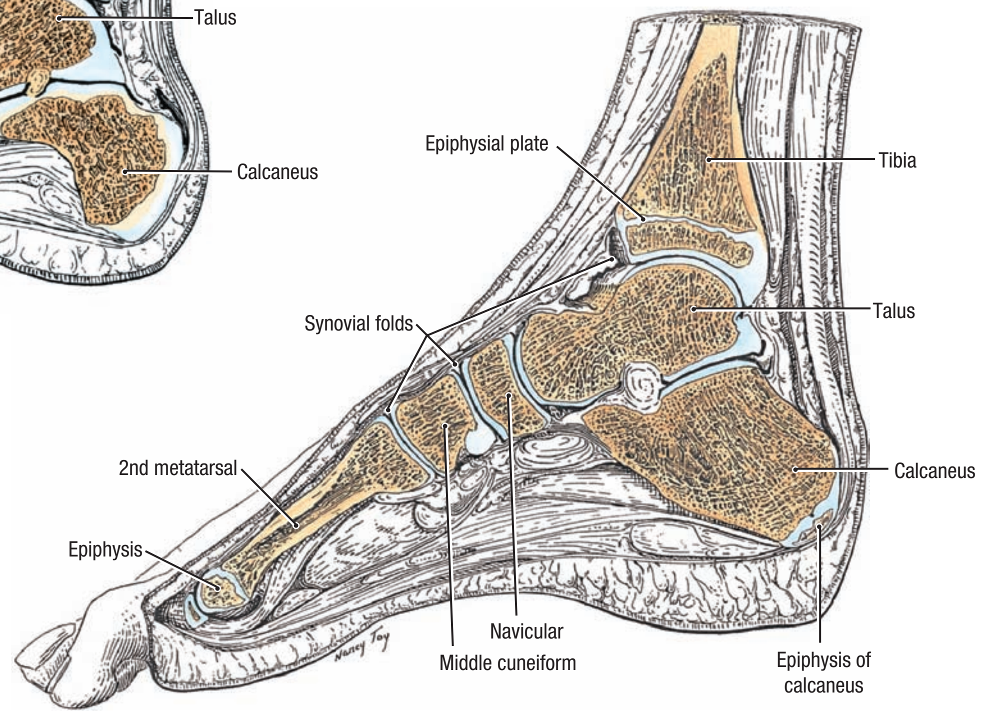
5.3 POSTNATAL LOWER LIMB DEVELOPMENT

A. Bones of lower limb at birth. The hip bone can be divided into three primary parts: ilium, ischium, and pubis. The diaphyses (bodies) of the long bones are well ossified. Some epiphyses (growth plates) and tarsal bones have begun to ossify, including the distal epiphysis of the femur and proximal epiphysis of the tibia, calcaneus, talus, and cuboid. **B. and D.** Anteroposterior radiographs of postmortem specimens of newborns show the bony (*white*) and cartilaginous *(gray)* components of the femur and hip bone. **C.** Epiphyses at proximal end of femur. The epiphysis of the head of the femur begins to ossify during the 1st year, that of the greater trochanter before the 5th year, and that of the lesser trochanter before the 14th year. These usually fuse completely with the body (shaft) before the end of the 18th year.

Dislocated epiphysis of femoral head. In older children and adolescents (10 to 17 years of age), the epiphysis of the femoral head may slip away from the femoral neck because of weakness of the epiphyseal plate. This injury may be caused by acute trauma or repetitive microtraumas that place increased shearing stress on the epiphysis, especially with abduction and lateral rotation.



E. Sagittal Section



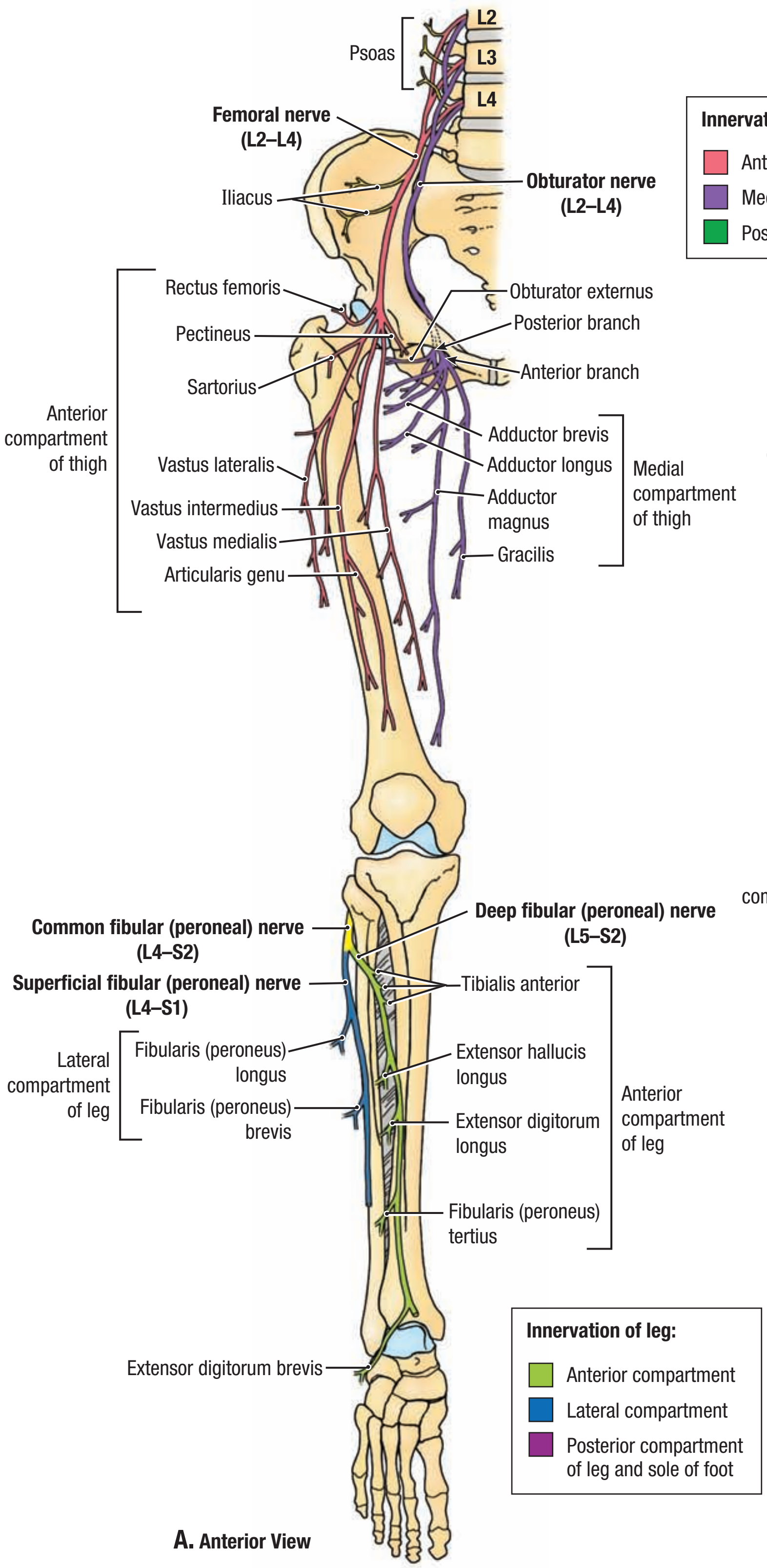
F. Sagittal Section

5.3 POSTNATAL LOWER LIMB DEVELOPMENT (*CONTINUED*)

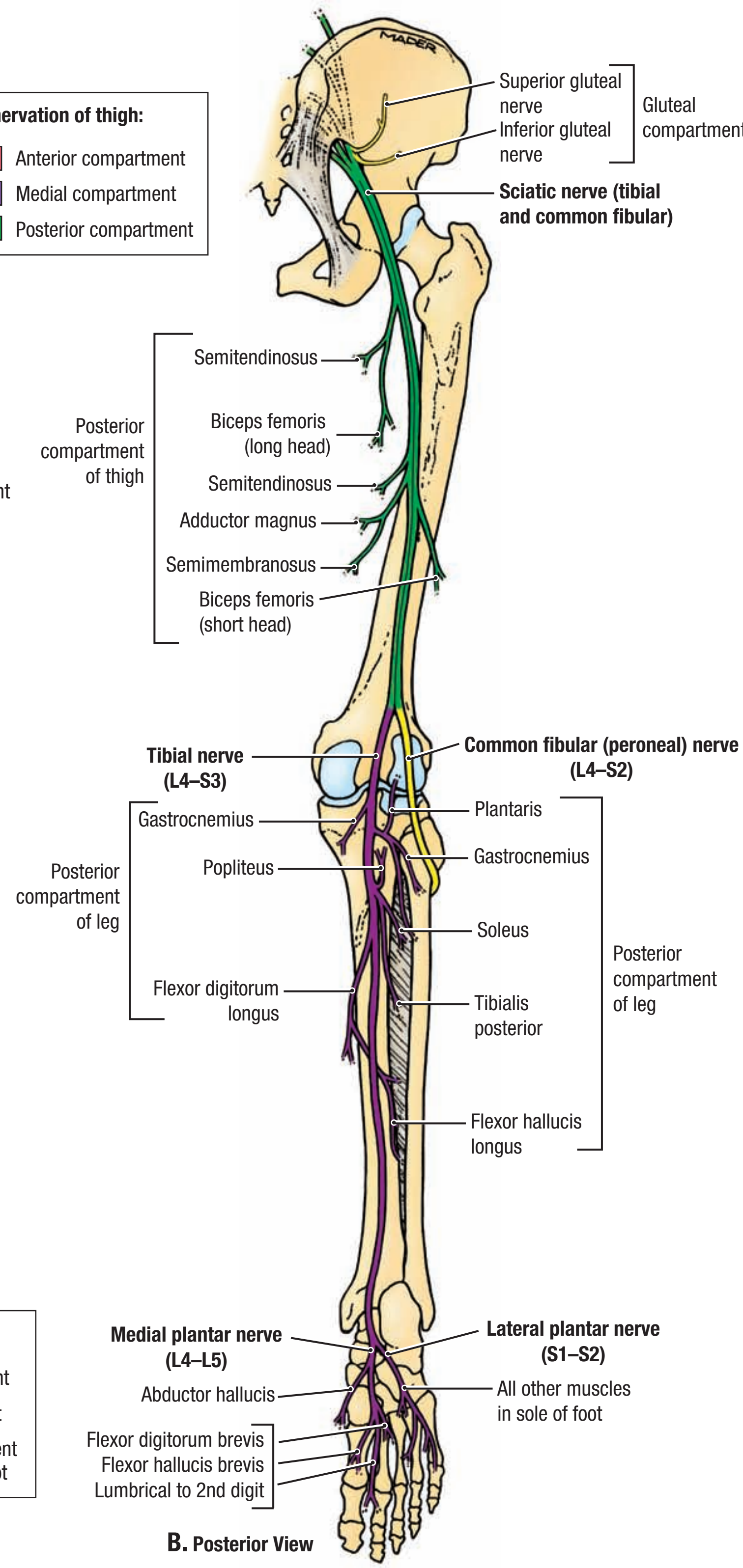
E. Foot of child age 4. **F.** Foot of child age 10.

- In the foot of the younger child **(E),** epiphyses of long bones (tibia, metatarsals, and phalanges) ossify like short bones, with the ossification centers being enveloped in cartilage. Ossification has already extended to the surface of the larger tarsal bones.
- In the foot of the older child **(F),** ossification has spread to the dorsal and plantar surfaces of all tarsal bones in view, and cartilage persists on the articular surfaces only.
- The traction epiphysis of the calcaneus for the calcaneal tendon and plantar aponeurosis begins to ossify from the ages of 6 to 10 years.
- The first metatarsal bone is similar to a phalanx in that its epiphysis is at the base instead of the head, as in the second and other metatarsal bones.
- The tuberosity of the calcaneus and the sesamoid bones of the first and the heads of the second to fifth metatarsals (here the second) support the longitudinal arch of the foot; the medial part of the longitudinal arch is higher and more mobile than the lateral.

Fractures involving epiphysial plates. The primary ossification center for the superior end of the tibia appears shortly after birth and joins the shaft of the tibia during adolescence (usually 16 to 18 years of age). Tibial fractures in children are more serious if they involve the epiphysial plates because continued normal growth of bone may be jeopardized. Disruption of the epiphysial plate at the tibial tuberosity may cause inflammation of the tuberosity and chronic recurring pain during adolescence (Osgood-Schlatter disease), especially in young athletes.



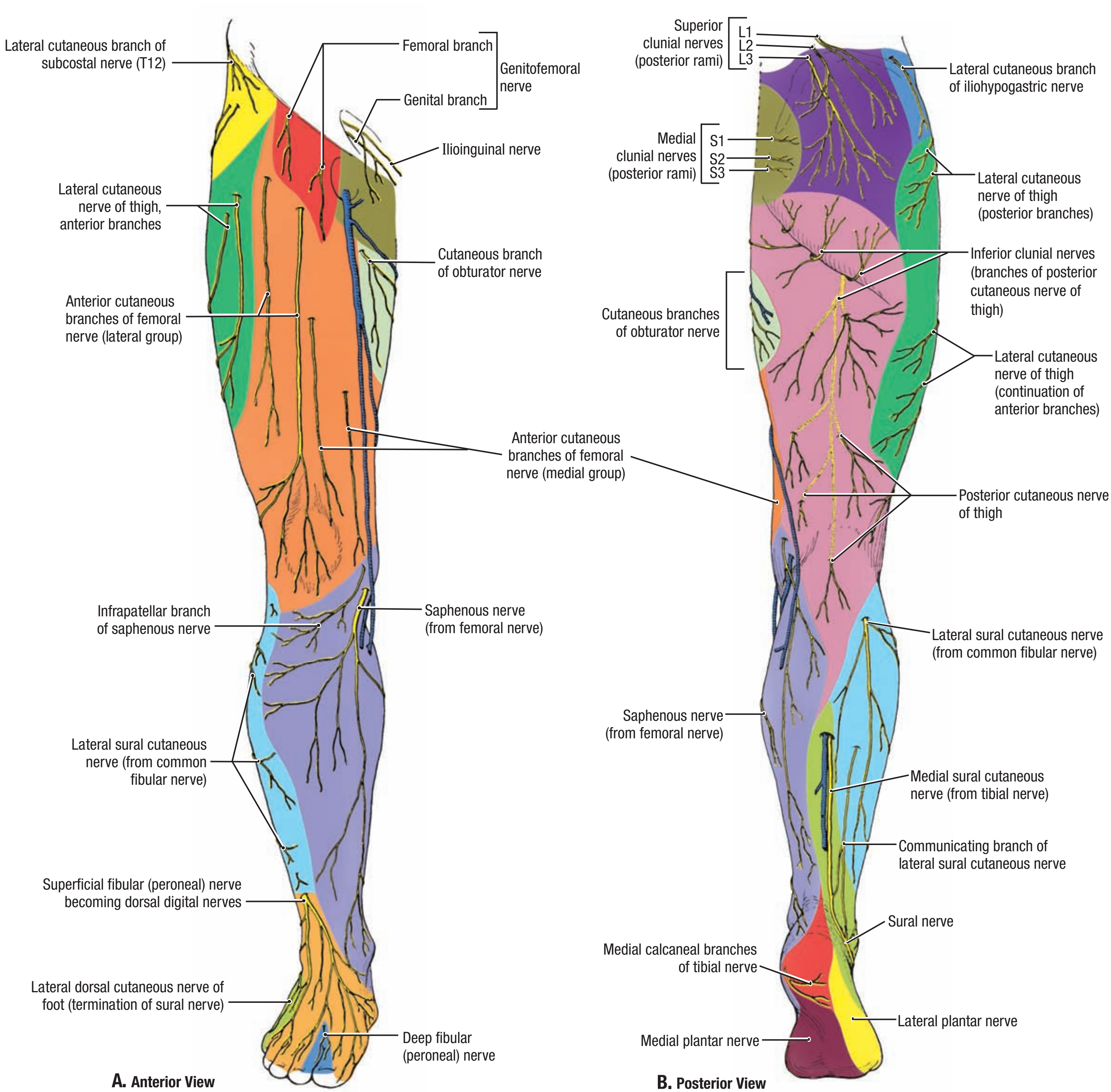
A. Anterior View



B. Posterior View

TABLE 5.1 MOTOR NERVES OF LOWER LIMB

Nerve	Origin	Course	Distribution
Femoral	Lumbar plexus (L2–L4)	Passes deep to midpoint of inguinal ligament, lateral to femoral vessels, dividing into muscular and cutaneous branches in femoral triangle	Anterior thigh muscles
Obturator		Traverses lesser pelvis to enter thigh via obturator foramen and then divides; its anterior branch descends between adductor longus and adductor brevis; its posterior branch descends between adductor brevis and adductor magnus	*Anterior branch:* adductor longus, adductor brevis, gracilis, and pectineus; *Posterior branch:* obturator externus and adductor magnus
Sciatic	Sacral plexus (L4–S3)	Enters gluteal region through greater sciatic foramen, usually passing inferior to piriformis, descends in posterior compartment of thigh, bifurcating at apex of popliteal fossa into tibial and common fibular (peroneal) nerves	Muscles of posterior thigh, leg and sole and dorsum of foot
Tibial	Sciatic nerve	Terminal branch of sciatic nerve arising at apex of popliteal fossa; descends through popliteal fossa with popliteal vessels, continuing in deep posterior compartment of leg with posterior tibial vessels; bifurcates into medial and lateral plantar nerves	Hamstring muscles of posterior compartment of thigh, muscles of posterior compartment of leg, and sole of foot
Common fibular (peroneal)		Terminal branch of sciatic nerve arising at apex of popliteal fossa; follows medial border of biceps femoris and its tendon to wind around neck of fibula deep to fibularis longus, where it bifurcates into superficial and deep fibular nerves	Short head of biceps femoris, muscles of anterior and lateral compartments of leg, and dorsum of foot
Superficial fibular (peroneal)	Common fibular nerve	Arises deep to fibularis longus on neck of fibula and descends in lateral compartment of the leg; pierces crural fascia in distal third of leg to become cutaneous	Muscles of lateral compartment of leg
Deep fibular (peroneal)		Arises deep to fibularis longus on neck of fibula; passes through extensor digitorum longus into anterior compartment, descending on interosseous membrane; crosses ankle joint and enters dorsum of foot	Muscles of anterior compartment of leg and dorsum of foot



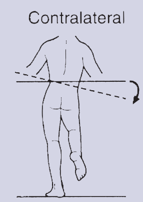
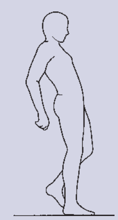
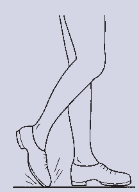
5.5 CUTANEOUS NERVES OF LOWER LIMB

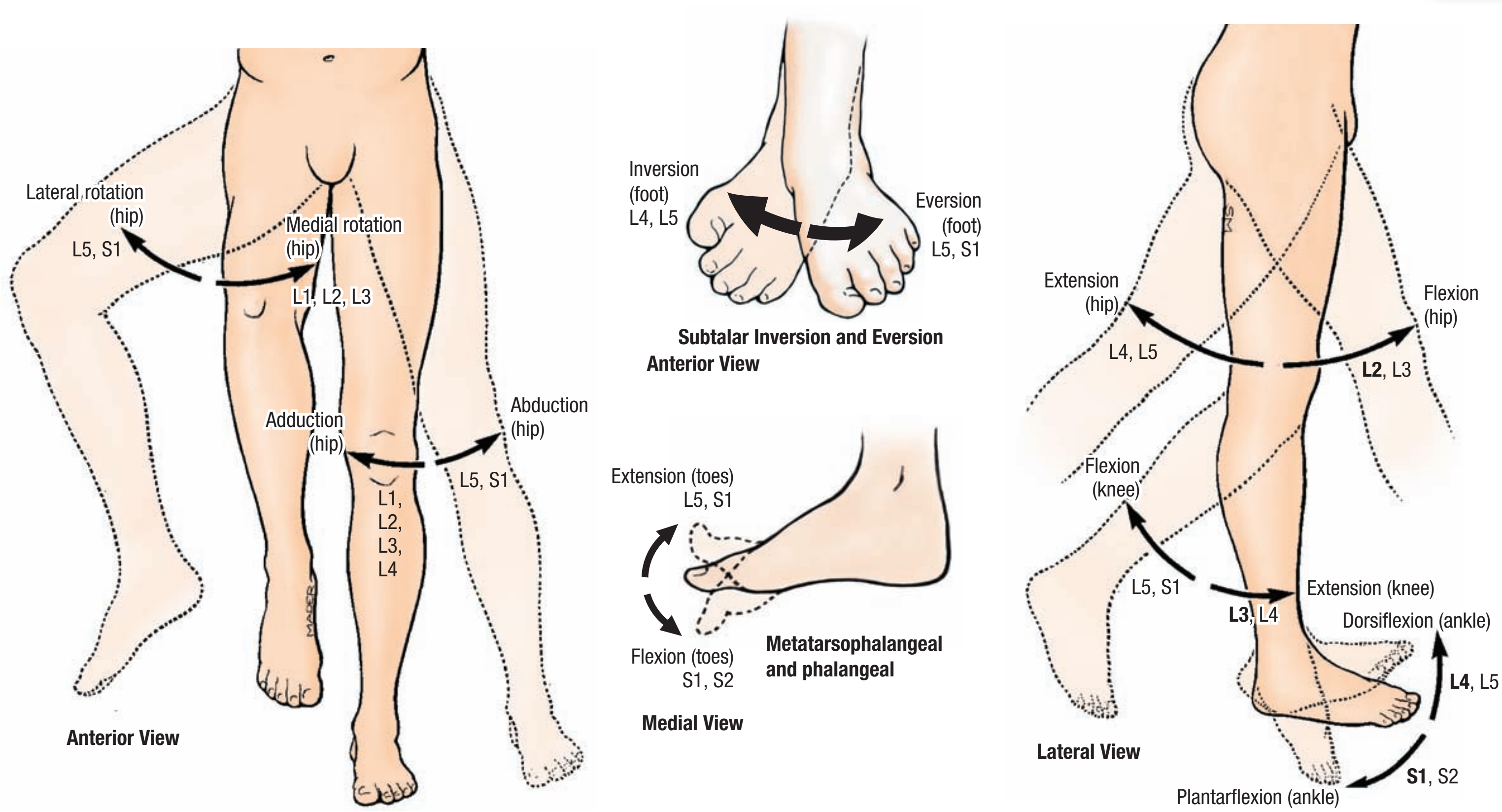
Cutaneous nerves in the subcutaneous tissue supply the skin of the lower limb. The cutaneous innervation of the lower limb reflects both the original segmental innervation of the skin via separate spinal nerves in its dermatomal pattern (Fig. 5.8) and the result of plexus formation of segmental peripheral nerves. In **B,** the medial sural cutaneous nerve (*sural* is Latin for calf) is joined between the popliteal fossa and posterior aspect of the ankle by a communicating branch of the lateral sural cutaneous nerve to form the sural nerve. The level of the junction is variable and is low in this specimen.

TABLE 5.2 CUTANEOUS NERVES OF LOWER LIMB

Nerve	Origin (Contributing Spinal Nerves)	Course	Distribution to Skin of Lower Limb
Subcostal (lateral cutaneous branch)	T12 anterior ramus	Descends over iliac crest	Hip region inferior to anterior part of iliac crest and anterior to greater trochanter
Iliohypogastric	Lumbar plexus (L1; occasionally T12)	Parallels iliac crest	Lateral cutaneous branch supplies superolateral quadrant of buttock
Ilio-inguinal	Lumbar plexus (L1; occasionally T12)	Passes through inguinal canal	Inguinal fold; femoral branch supplies skin over medial femoral triangle
Genitofemoral	Lumbar plexus (L1–L2)	Descends anterior surface of psoas major	Femoral branch supplies skin over lateral part of femoral triangle; genital branch supplies anterior scrotumor labia majora
Lateral cutaneous nerve of thigh	Lumbar plexus (L2–L3)	Passes deep to inguinal ligament, 2–3 cm medial to anterior superior iliac spine	Skin on anterior and lateral aspects of thigh
Anterior cutaneous branches	Lumbar plexus via femoral nerve (L2–L4)	Arise in femoral triangle; pierce fascia lata along the path of sartorius muscle	Skin of anterior and medial aspects of thigh
Cutaneous branch of obturator nerve	Lumbar plexus via obturator nerve (L2–L4)	Following its descent between adductors longus and brevis, obturator nerve pierces fascia lata to reach the skin of thigh	Skin of middle part of medial thigh
Posterior cutaneous nerve of thigh	Sacral plexus (S1–S3)	Enters gluteal region via greater sciatic foramen deep to gluteus maximus; then descends deep to fascia lata; terminal branches pierce fascia lata	Supply skin of posterior thigh and popliteal fossa
Saphenous nerve	Lumbar plexus via femoral nerve (L3–L4)	Traverses adductor canal but does not pass through adductor hiatus	Skin on medial side of leg and foot
Superficial fibular nerve	Common fibular nerve (L4–S1)	After supplying fibular muscles, perforates deep fascia of leg	Skin of anterolateral leg and dorsum of foot
Deep fibular nerve	Common fibular nerve (L5)	After supplying muscles on dorsum of foot, pierces deep fascia superior to heads of 1st and 2nd metatarsals	Skin of web between great and 2nd toes
Sural nerve	Tibial and common fibular nerves (S1–S2)	Medial sural cutaneous branch of tibial nerve and lateral sural cutaneous branch of common fibular nerve merge at varying levels on posterior leg	Skin of posterolateral leg and lateral margin of foot
Medial plantar nerve	Tibial nerve (L4–L5)	Passes between first and second layers of plantar muscles	Skin of medial side of sole, and plantar aspect, sides, and nail beds of medial 3½ toes
Lateral plantar nerve	Tibial nerve (S1–S2)	Passes between first and second layers of plantar muscles	Skin of lateral sole, and plantar aspect, sides, and nail beds of lateral 1½ toes
Calcaneal nerves	Tibial and sural nerves (S1–S2)	Branches over calcaneal tuberosity	Skin of heel
Superior clunial nerves	L1–L3 posterior rami	Course laterally/inferiorly in subcutaneous tissue	Skin overlying superior and central parts of buttock
Medial clunial nerves	S1–S3 posterior rami	From dorsal sacral foramina; enter overlying subcutaneous tissue	Skin of medial buttock and intergluteal cleft
Inferior clunial nerves	Posterior cutaneous nerve of thigh (S2-S3)	Arise deep to gluteus maximus; emerge from beneath inferior border of muscle	Skin of inferior buttock (overlying gluteal fold)

TABLE 5.3 NERVE LESIONS

Nerve Injury	Injury Description	Impairments	Clinical Aspects
Femoral nerve	Trauma at femoral triangle Pelvic fracture	Flexion of thigh is weakened Extension of leg is lost Sensory loss on anterior thigh and medial leg	Loss of knee jerk reflex Anesthesia on anterior thigh
Obturator nerve	Anterior hip dislocation Radical retropubic prostatectomy	Adduction of thigh is lost Sensory loss on medial thigh	
Superior gluteal nerve	Surgery Posterior hip dislocation Poliomyelitis	Gluteus medius and minimus function is lost Ability to pull contralateral pelvis up to level and abduction of thigh are lost	Gluteus medius limp or “waddling gait” Positive Trendelenburg sign 
Inferior gluteal nerve	Surgery Posterior hip dislocation	Gluteus maximus function is lost Ability to rise from a seated position, climb stairs or incline, or jump is lost	Patient will lean the body trunk backward at heel strike 
Common fibular nerve	Blow to lateral aspect of leg Fracture of neck of fibula	Eversion of foot is lost Dorsiflexion of foot is lost Extension of toes is lost Sensory loss on anterolateral leg and dorsum of foot	Patient will present with foot plantar flexed (“foot drop”) and inverted Patient cannot stand on heels “Foot slap” 
Tibial nerve at popliteal fossa	Trauma at popliteal fossa	Inversion of foot is weakened Plantar flexion of foot is lost Sensory loss on sole of foot	Patient will present with foot dorsiflexed and everted Patient cannot stand on toes



Myotatic (Deep Tendon) Reflex	Spinal Cord Segments
Quadriceps (knee joint)	L3/L4
Calcaneal (Achilles; ankle jerk)	S1/S2

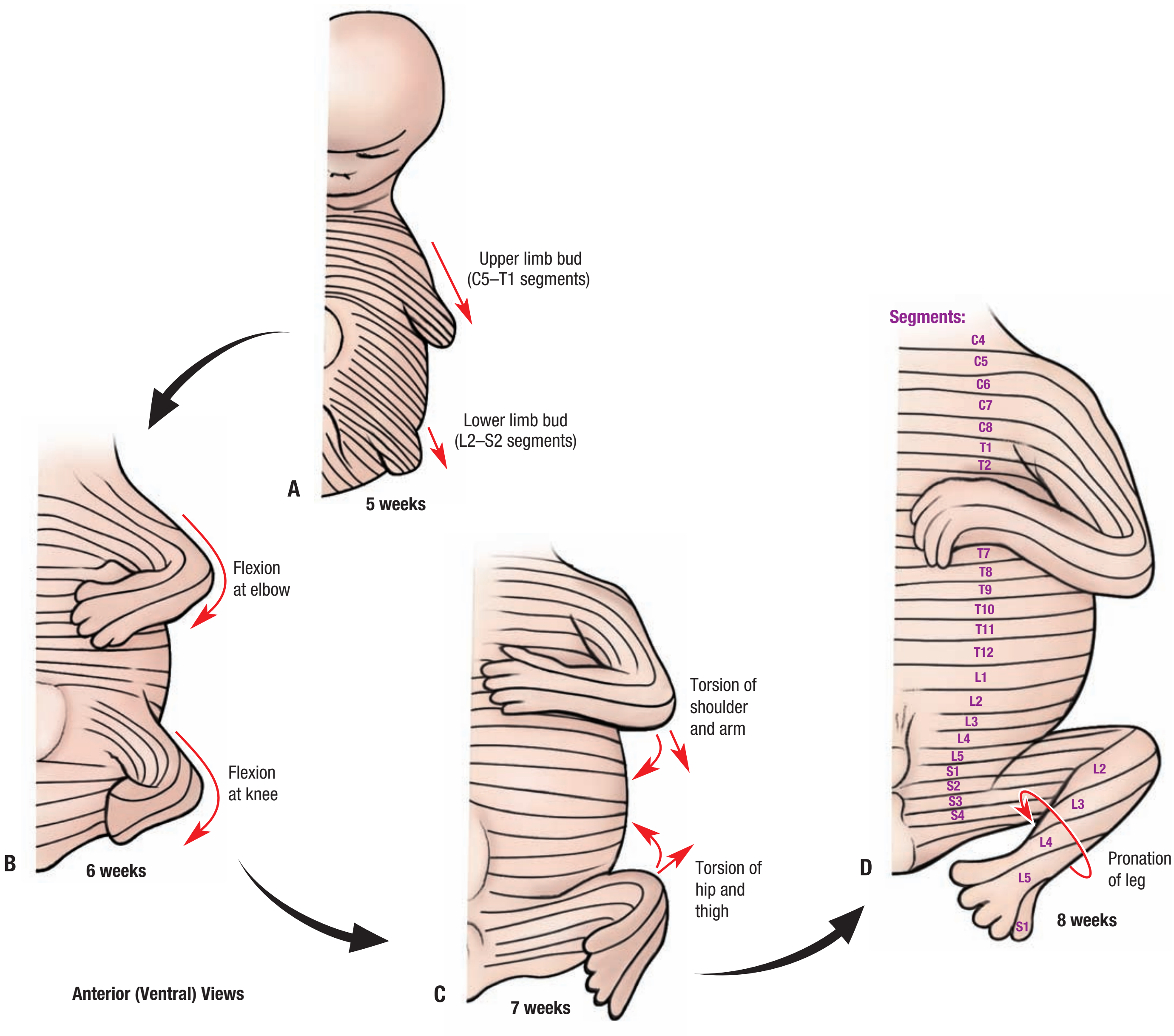
5.6 MYOTOMES AND DEEP TENDON REFLEXES

A. Myotomes. Somatic motor (general somatic efferent) fibers transmit impulses to skeletal (voluntary) muscles. The unilateral muscle mass receiving innervation from the somatic motor fibers conveyed by a single spinal nerve is a myotome. Each skeletal muscle is usually innervated by the somatic motor fibers of several spinal nerves; therefore, the muscle myotome will consist of several segments. The muscle myotomes have been grouped by joint movement to facilitate clinical testing.

B. Myotactic (deep tendon) reflexes. A myotatic (stretch) reflex is an involuntary contraction of a muscle in response to being stretched. Deep tendon reflexes (e.g., “knee jerk”) are monosynaptic stretch reflexes that are elicited by briskly tapping the tendon with a reflex hammer. Each tendon reflex is mediated by specific spinal nerves. Stretch reflexes control muscle tone (e.g., in antigravity, muscles that keep the body upright against gravity).

TABLE 5.4 NERVE ROOT (ANTERIOR RAMUS) LESIONS

Compressed Nerve Root	Dermatome Affected	Muscles Affected	Movement Weakness/Deficit	Nerve and Reflex Involved
L4	L4: medial surface of leg; big toe	Quadriceps	Extension of knee	Femoral nerve ↓ Knee jerk
L5	L5: lateral surface of leg; dorsum of foot	Tibialis anterior Extensor hallucis longus Extensor digitorum longus	Dorsiflexion of ankle (patient cannot stand on heels) Extension of toes	Common fibular nerve No reflex loss
S1	S1: posterior surface of lower limb; little toe	Gastrocnemius Soleus	Plantar flexion of ankle (patient cannot stand on toes) Flexion of toes	Tibial nerve ↓ Ankle jerk



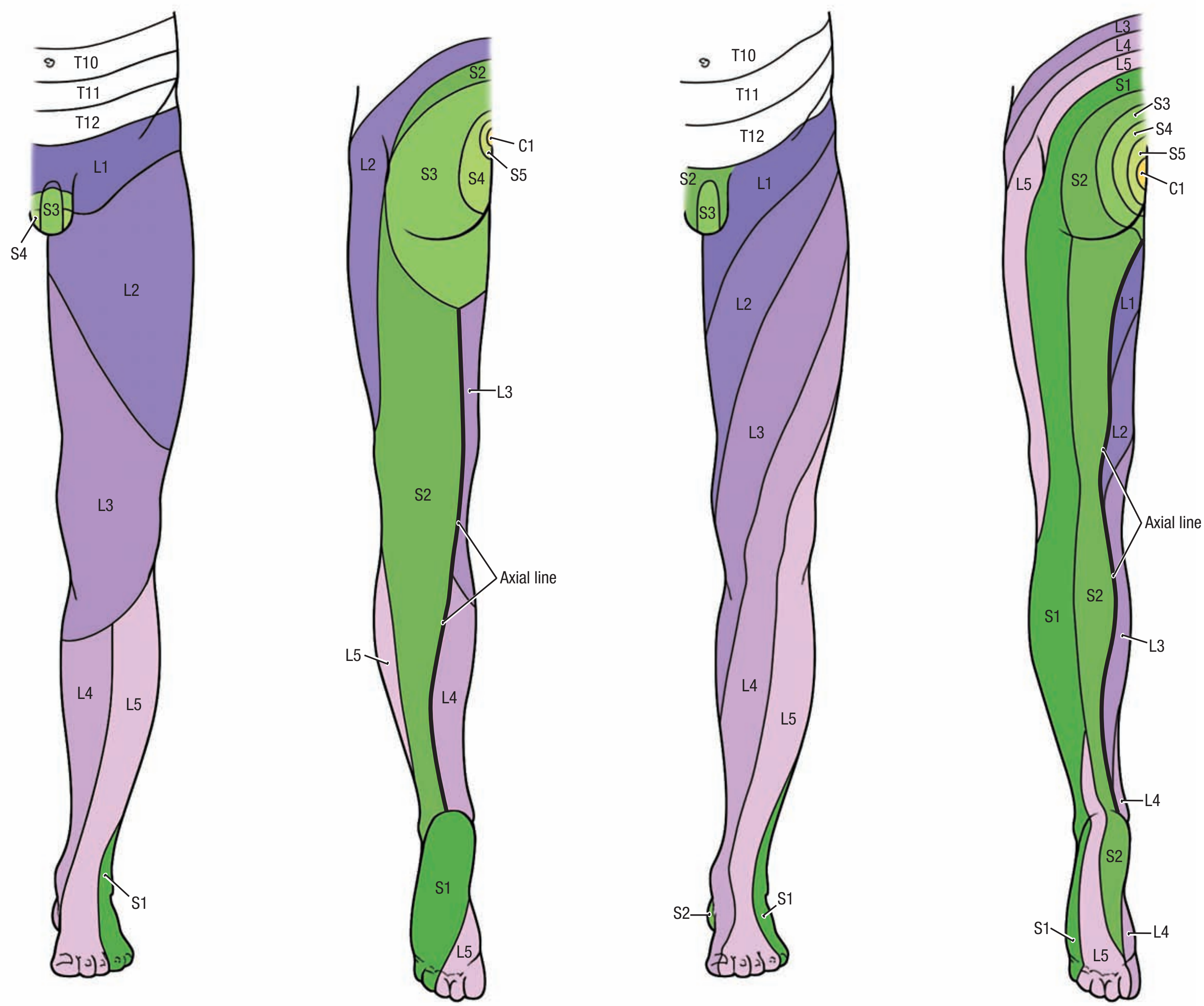
5.7 ROTATION OF LIMBS DURING DEVELOPMENT; EFFECT ON LOWER LIMB DERMATOME PATTERN

A. During early development, the trunk is divided into segments (metameres) that correspond to, and receive innervation from, the corresponding spinal cord segments. During the 4th week of development, the upper limb buds appear as elevations of the C5 to T1 segments of the ventrolateral body wall. Following the cranial-to-caudal pattern of development the lower limb buds appear about a week later (5th week). The lower limb buds grow laterally from broader bases formed by the L2 to S2 segments.

B. The distal ends of the limb buds flatten into paddlelike hand plates and foot plates that are elongated in the craniocaudal axis. Initially, both the thumb and the great toe are on the cranial sides of the developing hand and foot, directed superiorly, with the palms and soles directed anteriorly. Where gaps develop between the precursors of the long bones (future elbow and knee joints), flexures occur. At first, the limbs bend anteriorly, so that the elbow and knee are directed laterally, causing the palm and sole to be directed medially (toward the trunk).

C. By the end of the 7th week, the proximal parts of the upper and lower limbs undergo a 90-degree torsion around their long axes, but in opposite directions, so that the elbow becomes directed caudally and posteriorly and the knee cranially and anteriorly.

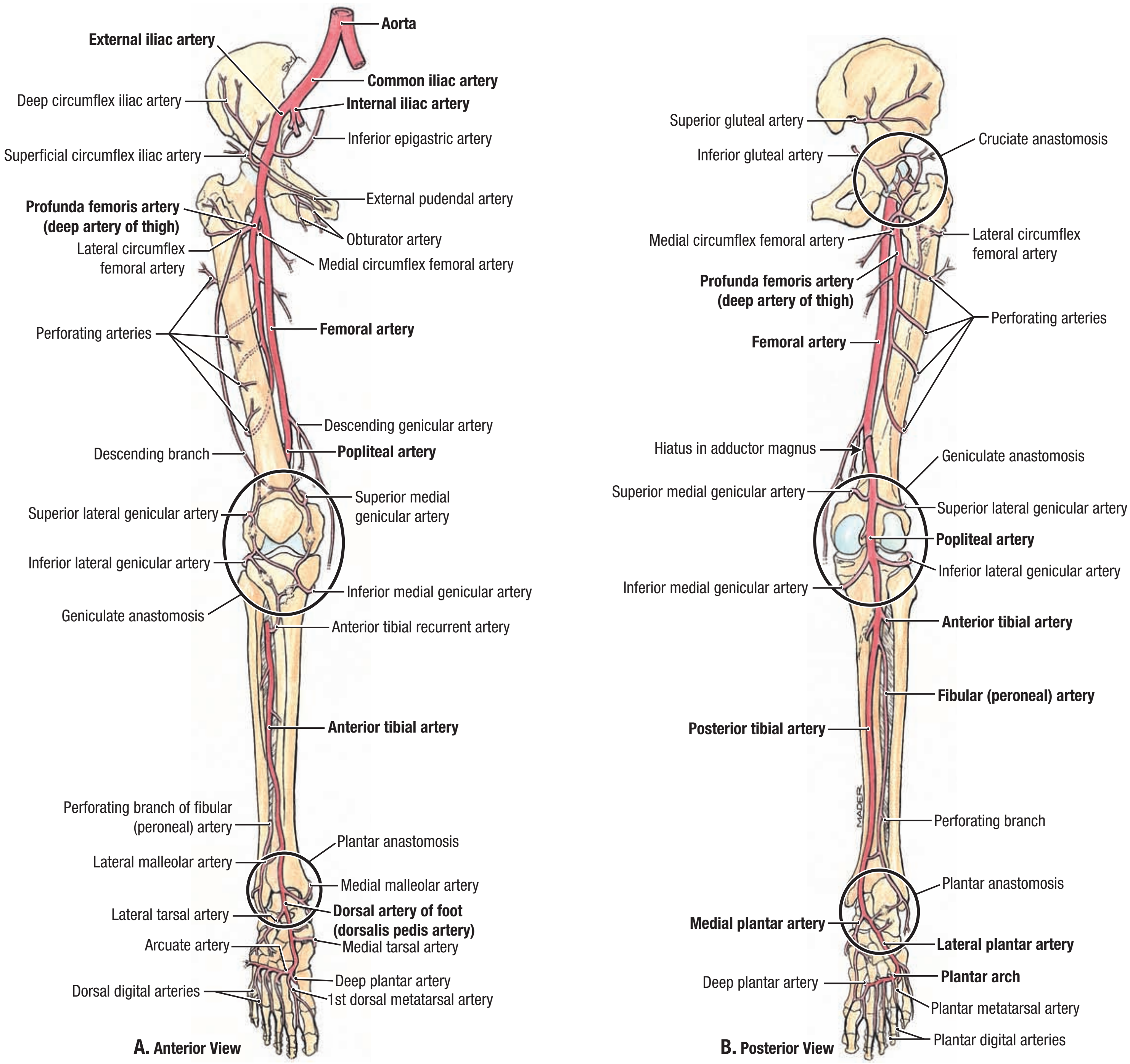
D. In the lower limb, the torsion of the proximal limb is accompanied by a permanent pronation (twisting) of the leg, so that the foot becomes oriented with the great toe on the medial side.



A. Anterior View **B.** Posterior View **C.** Anterior View **D.** Posterior View

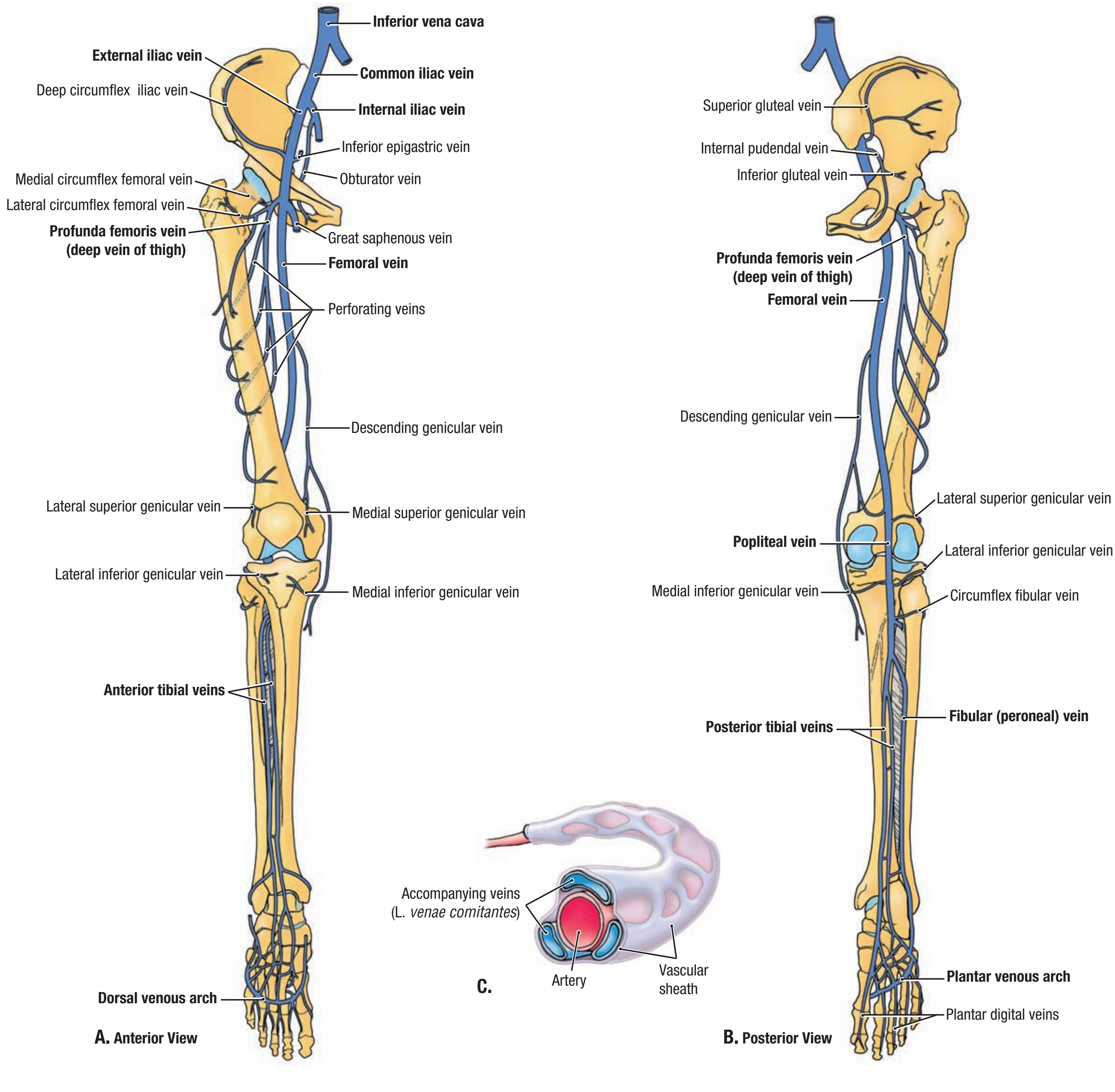
5.8 DERMATOMES OF LOWER LIMB

The dermatomal, or segmental, pattern of distribution of sensory nerve fibers persists despite the merging of spinal nerves in plexus formation during development. Two different dermatome maps are commonly used. **A. and B.** The dermatome pattern of the lower limb according to Foerster (1933) is preferred by many because of its correlation with clinical findings. **C. and D.** The dermatome pattern of the lower limb according to Keegan and Garrett (1948) is preferred by others for its aesthetic uniformity and obvious correlation with development. Although depicted as distinct zones, adjacent dermatomes overlap considerably, except along the axial line.



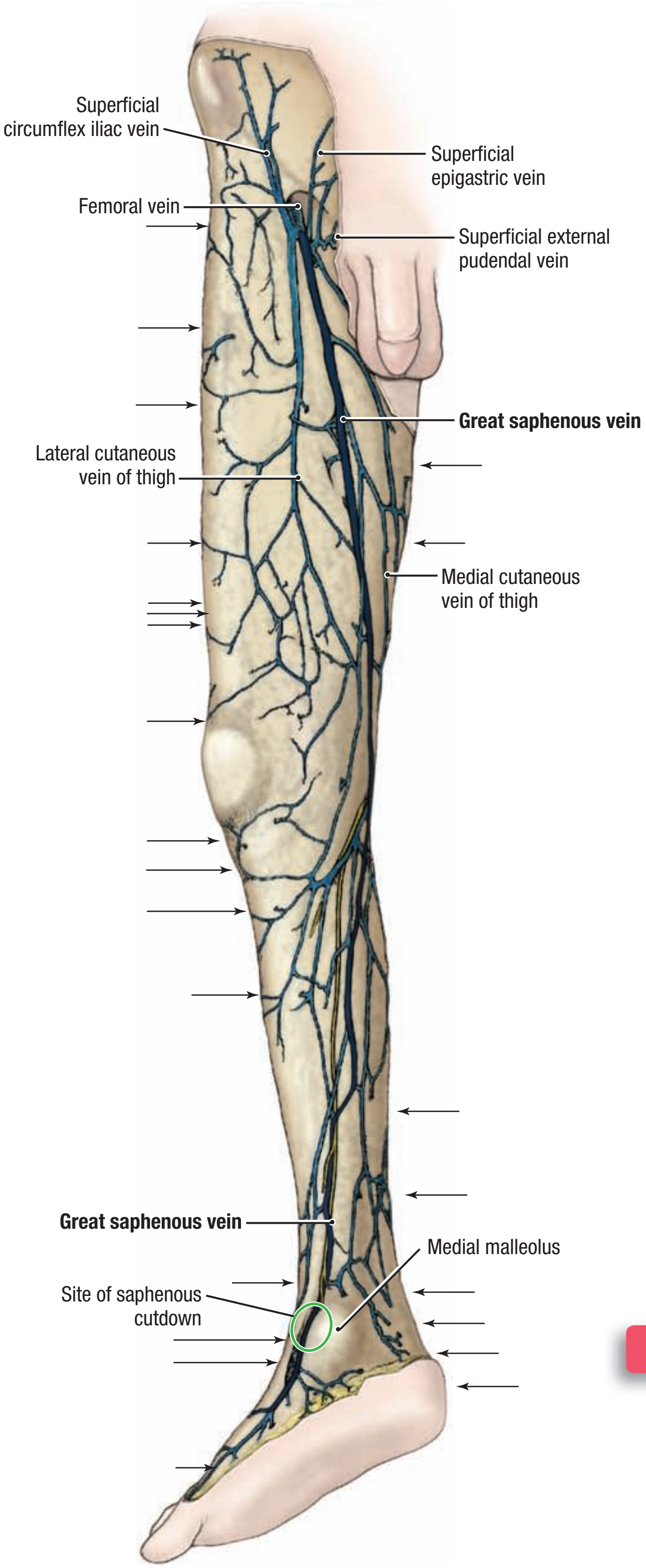
5.9 OVERVIEW OF ARTERIES OF LOWER LIMB

The arteries often anastomose or communicate to form networks to ensure blood supply distal to the joint throughout the range of movement (cruciate, geniculate and plantar anastomoses). If a main channel is slowly occluded, the smaller alternate channels can usually increase in size, providing a **collateral circulation** that ensures the blood supply to structures distal to the blockage.

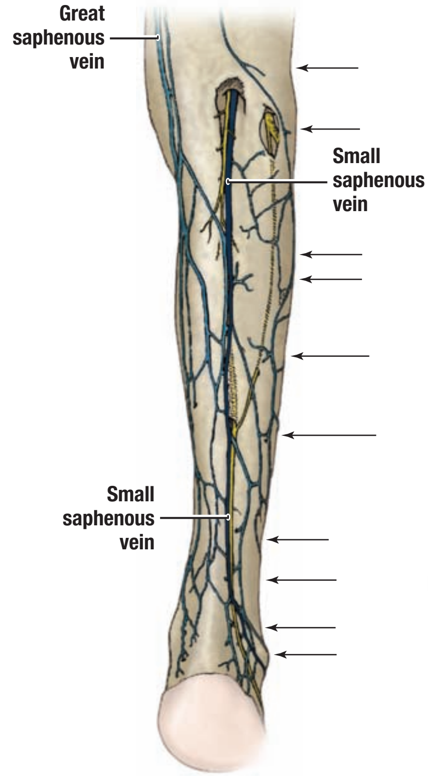


5.10 DEEP VEINS OF LOWER LIMB

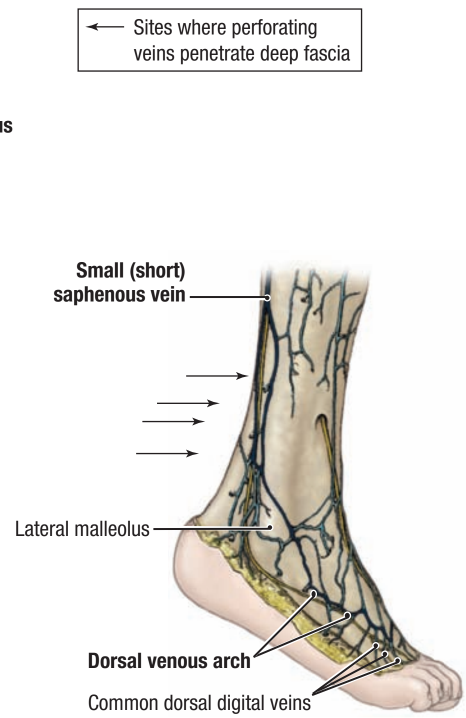
A. and B. Deep veins lie internal to the deep fascia. Although only the anterior and posterior tibial veins are depicted as paired structures in this schematic illustration, typically in the limbs deep veins occur as multiple, generally parallel, continually interanastomosing accompanying veins (L., venae comitantes) surrounding and sharing the name of the artery they accompany. **C.** Accompanying veins.



A. **Anteromedial View**



B. **Posterior View**

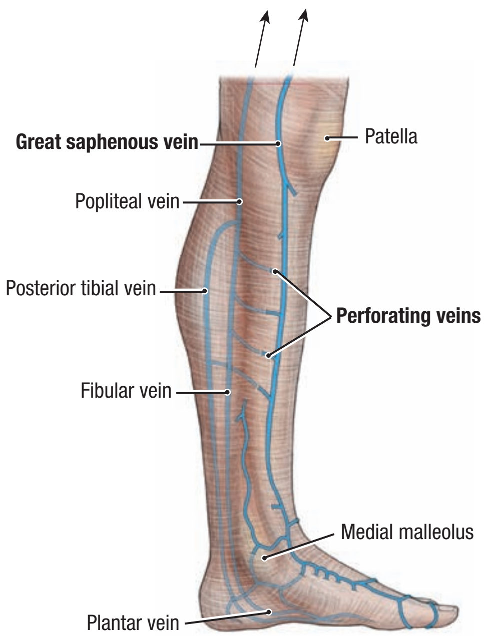


C. **Lateral View**

5.11 SUPERFICIAL VEINS OF LOWER LIMB

Blood is continuously shunted from the superficial veins in the subcutaneous tissue to deep veins via the perforating veins. **Vein grafts** obtained by surgically harvesting parts of the great saphenous vein are used to bypass obstructions in blood vessels (e.g., a coronary artery). When used as a bypass, the vein is reversed so that the valves do not obstruct blood flow. Because there are so many anastomosing leg veins, removal of the great saphenous vein rarely affects circulation seriously, provided the deep veins are intact.

Saphenous cut down. The great saphenous vein can be located by making a skin incision anterior to the medial malleolus. This procedure is used to insert a cannula for prolonged administration of blood, electrolytes, drugs etc.



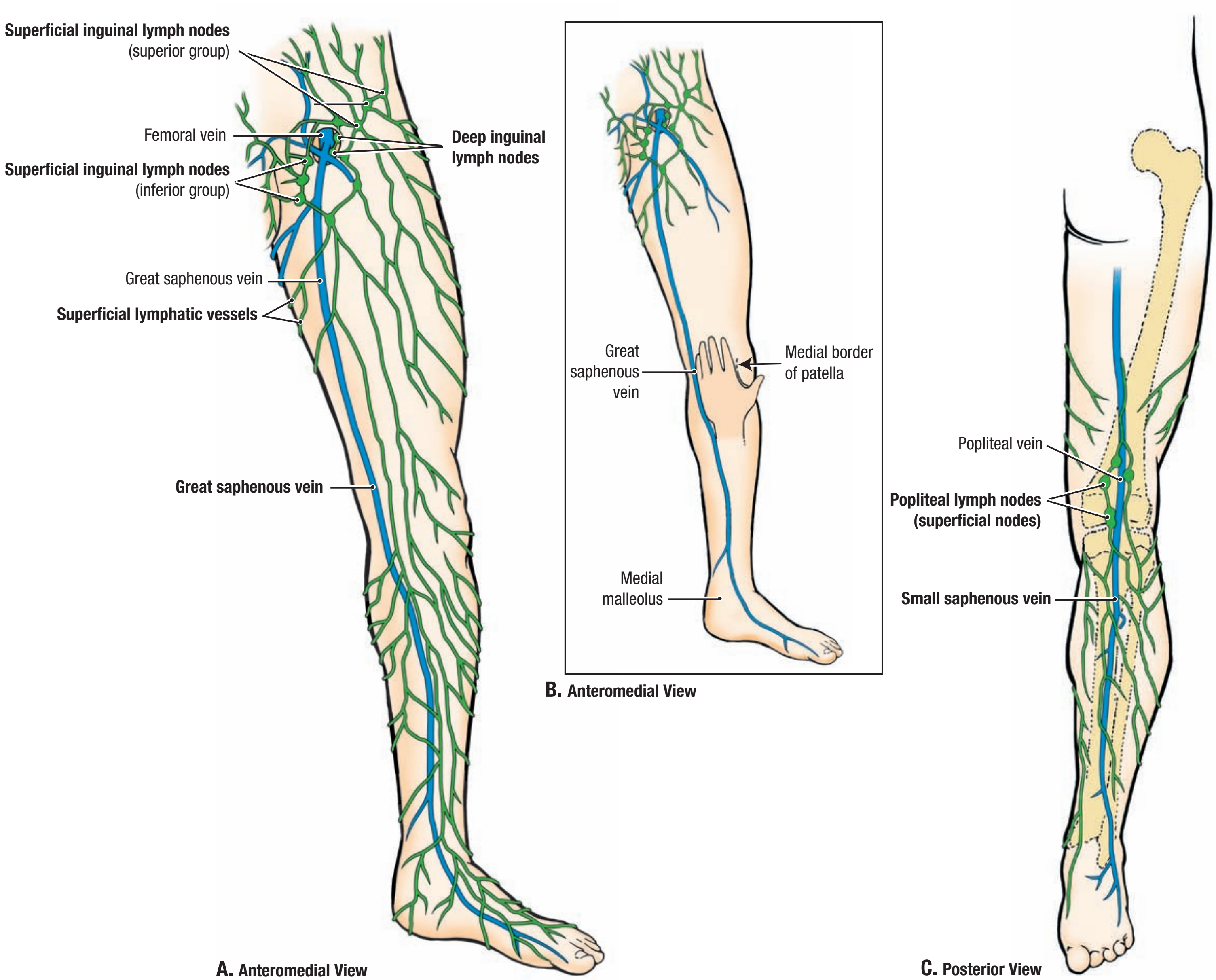
A. Medial View

B. Medial View, Varicose Veins

C. Anteromedial View, Normal Veins

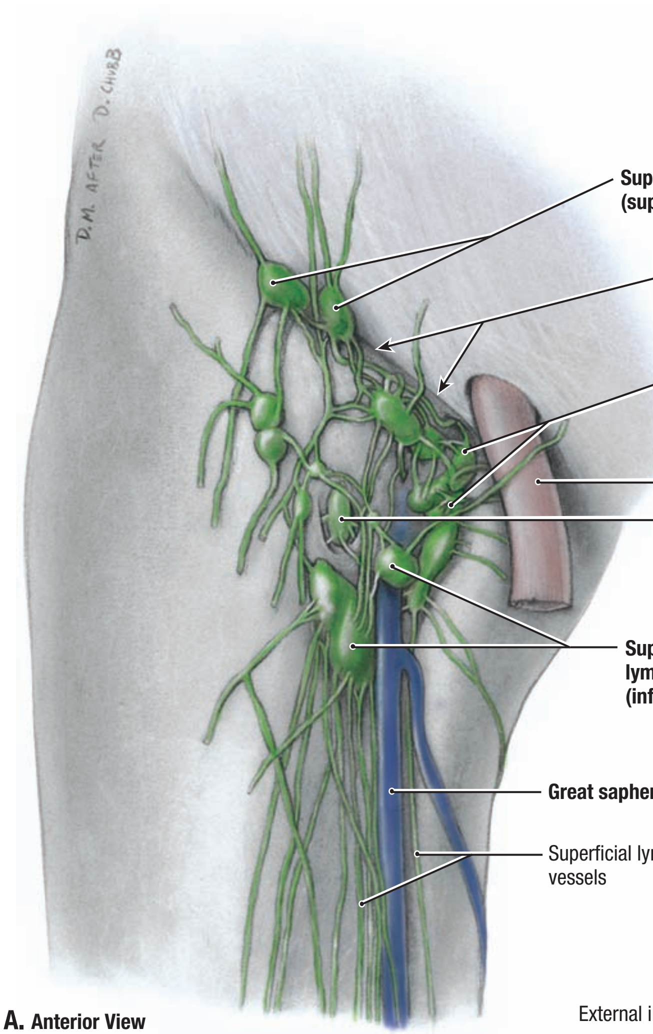
5.12 DRAINAGE AND SURFACE ANATOMY OF SUPERFICIAL VEINS OF LOWER LIMB

A. Schematic diagram of drainage of superficial veins. Blood is shunted from the superficial veins (e.g., great saphenous vein) to the deep veins (e.g., fibular and posterior tibial veins) via perforating veins that penetrate the deep fascia. Muscular compression of deep veins assists return of blood to the heart against gravity. **B. Varicose veins** form when either the deep fascia or the valves of the perforating veins are incompetent. This allows the muscular compression that normally propels blood toward the heart to push blood from the deep to the superficial veins. Consequently, superficial veins become enlarged and tortuous. **C.** Normal veins, distended following exercise.



5.13 SUPERFICIAL LYMPHATIC DRAINAGE OF LOWER LIMB

The superficial lymphatic vessels converge on and accompany the saphenous veins and their tributaries in the superficial fascia. The lymphatic vessels along the great saphenous vein drain into the superficial inguinal lymph nodes; those along the small saphenous vein drain into the popliteal lymph nodes. Lymph from the superficial inguinal nodes drains to the deep inguinal and external iliac nodes. Lymph from the popliteal nodes ascends through deep lymphatic vessels accompanying the deep blood vessels to the deep inguinal nodes. In **B,** note that the great saphenous vein lies anterior to the medial malleolus and a hand's breadth posterior to the medial border of the patella. **Lymph nodes enlarge** when diseased. Abrasions and minor sepsis, caused by pathogenic micro-organisms or their toxins in the blood or other tissues, may produce slight enlargement of the superficial inguinal nodes (lymphadenopathy) in otherwise healthy people. Malignancies (e.g., of the external genitalia and uterus) and perineal abscesses also result in enlargement of these nodes.



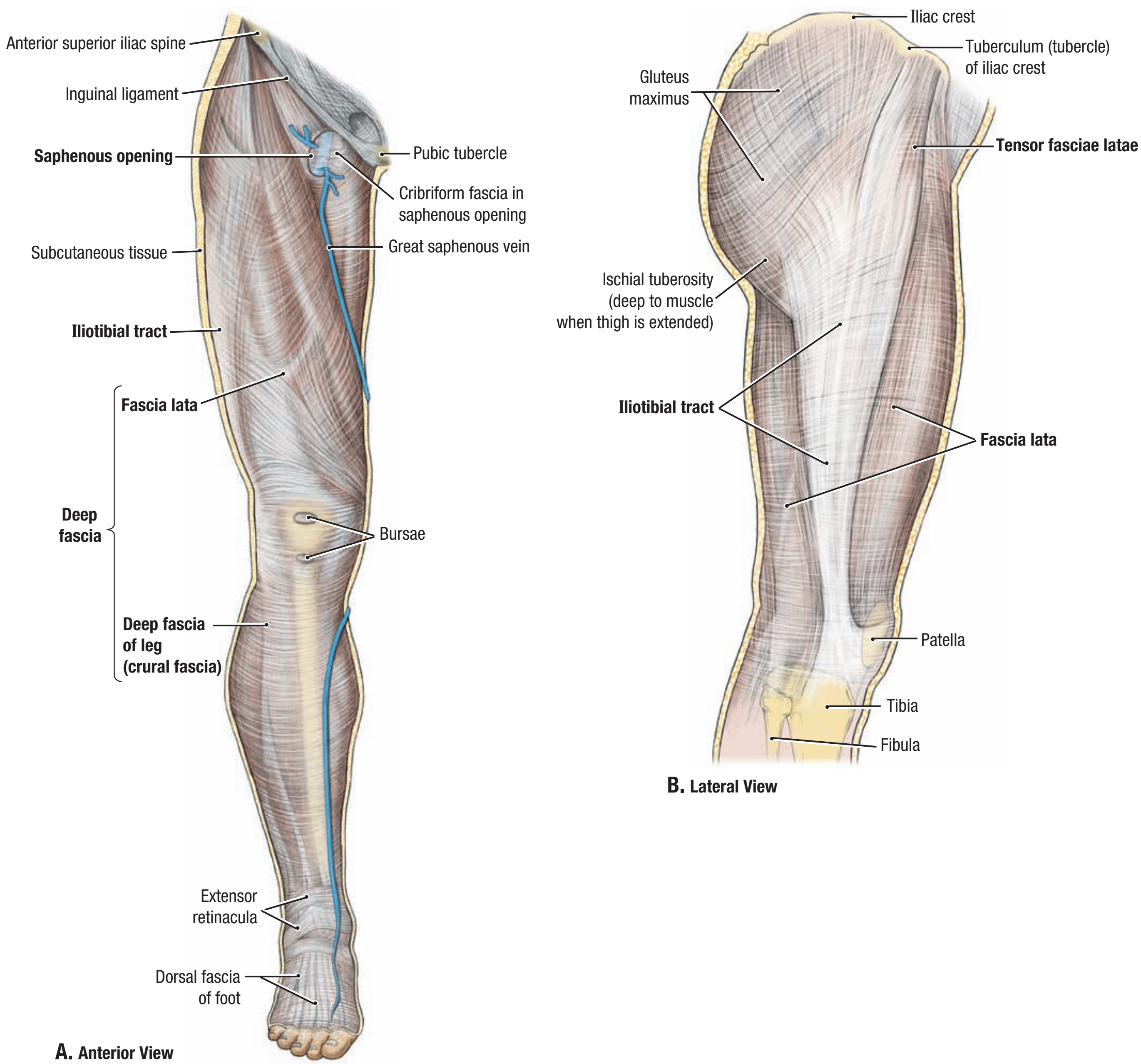
A. **Anterior View**

B. **Anteroposterior View**

5.14 INGUINAL LYMPH NODES

A. Dissection. **B.** Lymphangiogram.

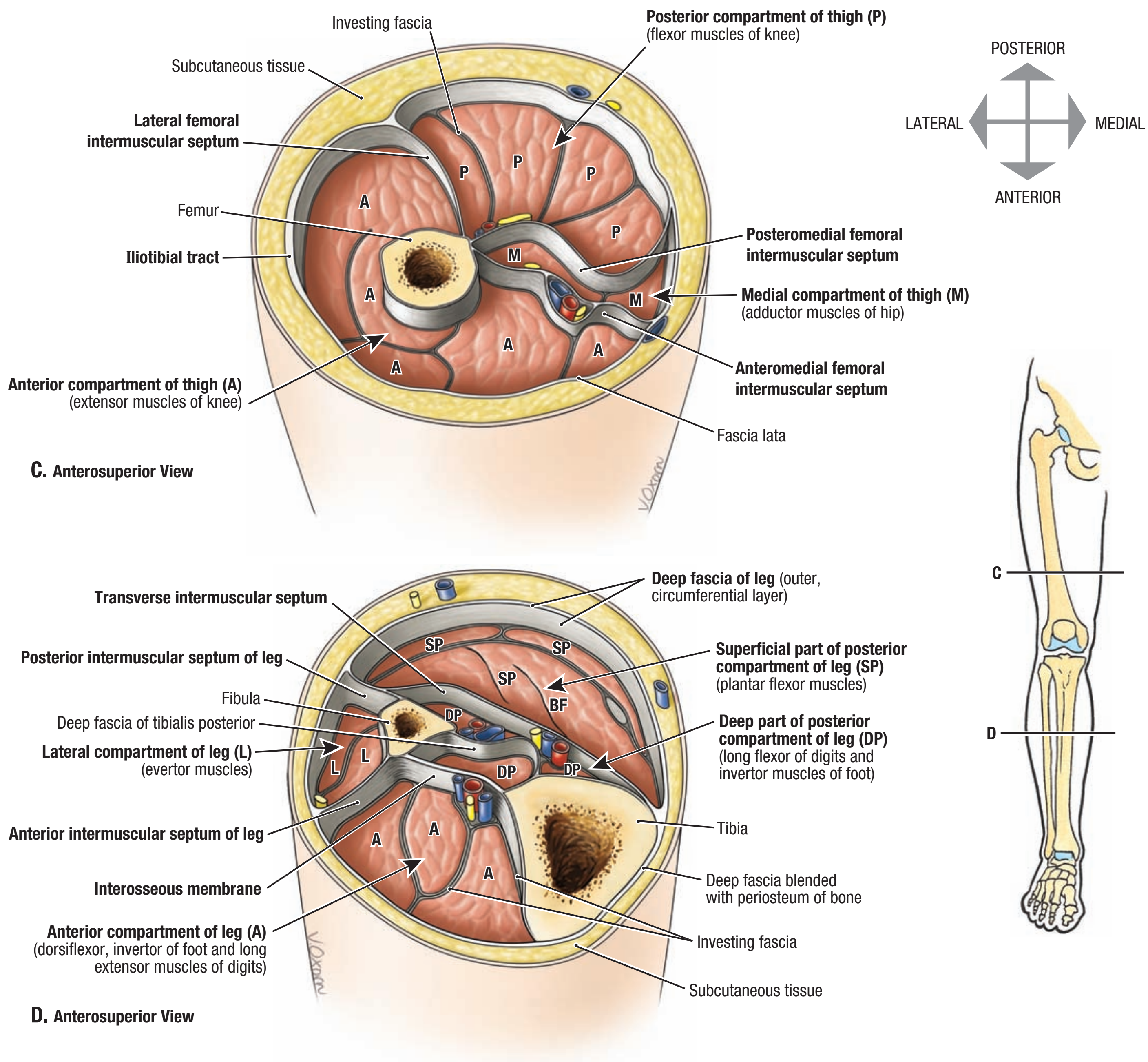
- Observe the arrangement of the nodes: a proximal chain parallel to the inguinal ligament (superolateral and superomedial superficial inguinal lymph nodes) and a distal chain on the sides of the great saphenous vein (inferior superficial inguinal lymph nodes). Efferent vessels leave these nodes and pass deep to the inguinal ligament to enter the deep inguinal and external iliac nodes. Some of the lymphatic vessels traverse the femoral canal, and others ascend alongside the femoral artery and vein, some inside the femoral sheath, and some outside it.
- Note the anastomosis between the lymph vessels.



5.15 FASCIA AND MUSCULOFASCIAL COMPARTMENTS OF LOWER LIMB

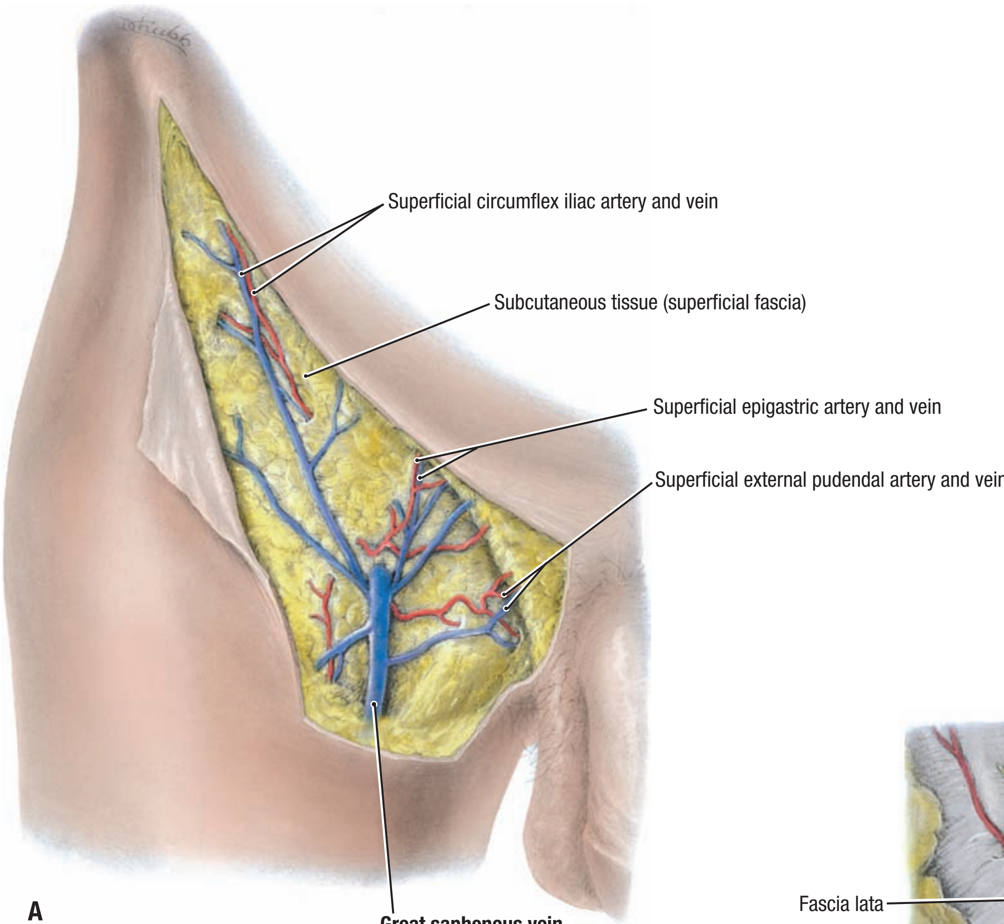
A. Anterior skin and subcutaneous tissue have been removed to reveal the deep fascia of the thigh (fascia lata) and leg (crural fascia). **B.** Lateral skin and subcutaneous tissue have been removed to reveal the fascia lata. The fascia lata is thick laterally and forms the iliotibial tract. The iliotibial tract serves as a common aponeurosis for the gluteus maximus and tensor fasciae latae muscles.

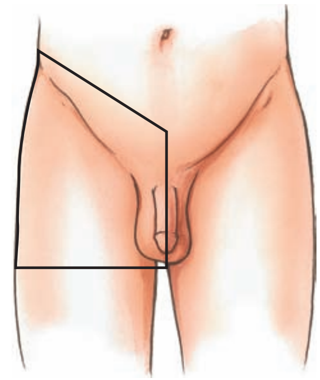
One of the most common causes of lateral knee pain in endurance athletes (e.g., runners, cyclers, hikers) is **iliotibial tract (band) syndrome (ITBS)**. Friction of the IT tract against the lateral epicondyle of the femur with flexion and extension of the knee (e.g., during running) may result in the inflammation of the IT tract over the lateral aspect of the knee or its attachment to the dorsolateral tubercle (Gerdy tubercle). ITBS may also occur in the hip region, especially in older individuals.

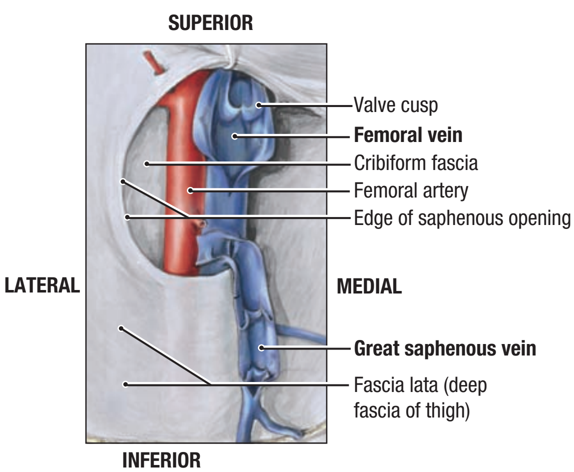


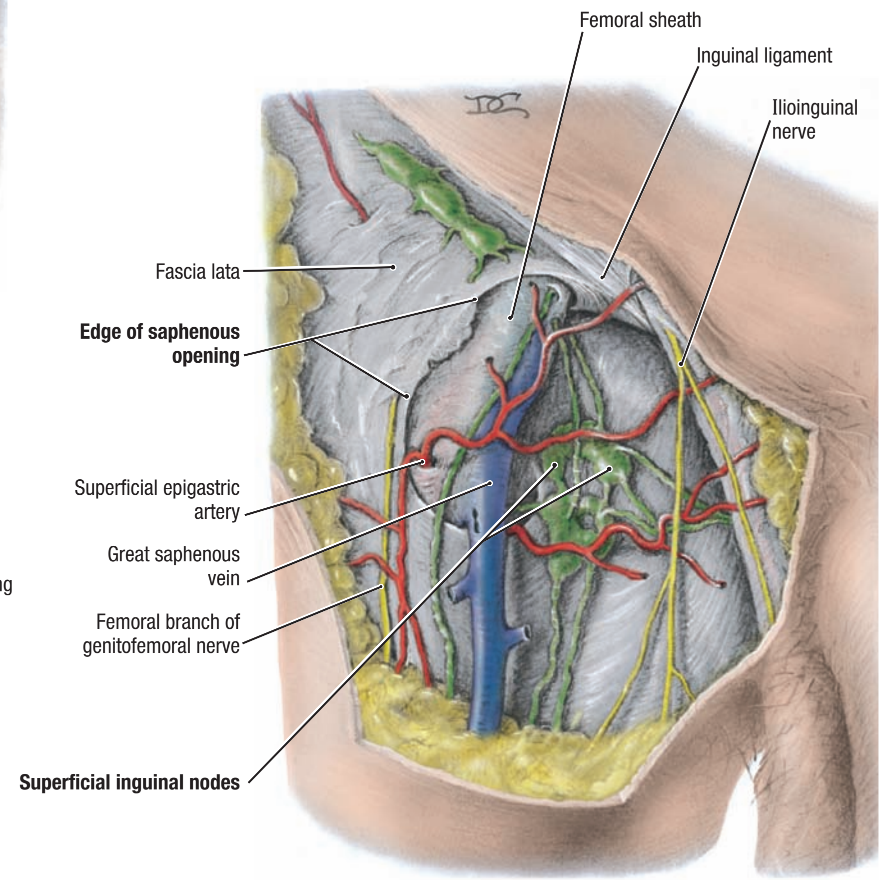
5.15 FASCIA AND MUSCULOFASCIAL COMPARTMENTS OF LOWER LIMB (*CONTINUED*)

C. and D. The fascial compartments of the thigh **(C)** and leg **(D)** are demonstrated in transverse section. The fascial compartments contain muscles that generally perform common functions and share common innervation, and contain the spread of infection. While both thigh and leg have anterior and posterior compartments, the thigh also includes a medial compartment and the leg a lateral compartment. Trauma to muscles and/or vessels in the compartments may produce hemorrhage, edema, and inflammation of the muscles. Because the septa, deep fascia, and bony attachments firmly bound the compartments, increased volume resulting from these processes raises intracompartmental pressure. In **compartment syndromes,** structures within or distal to the compressed area become ischemic and may become permanently injured (e.g., compression of capillary beds results in denervation and consequent paralysis of muscles). A **fasciotomy** (incision of bounding fascia or septum) may be performed to relieve the pressure in the compartment and restore circulation.



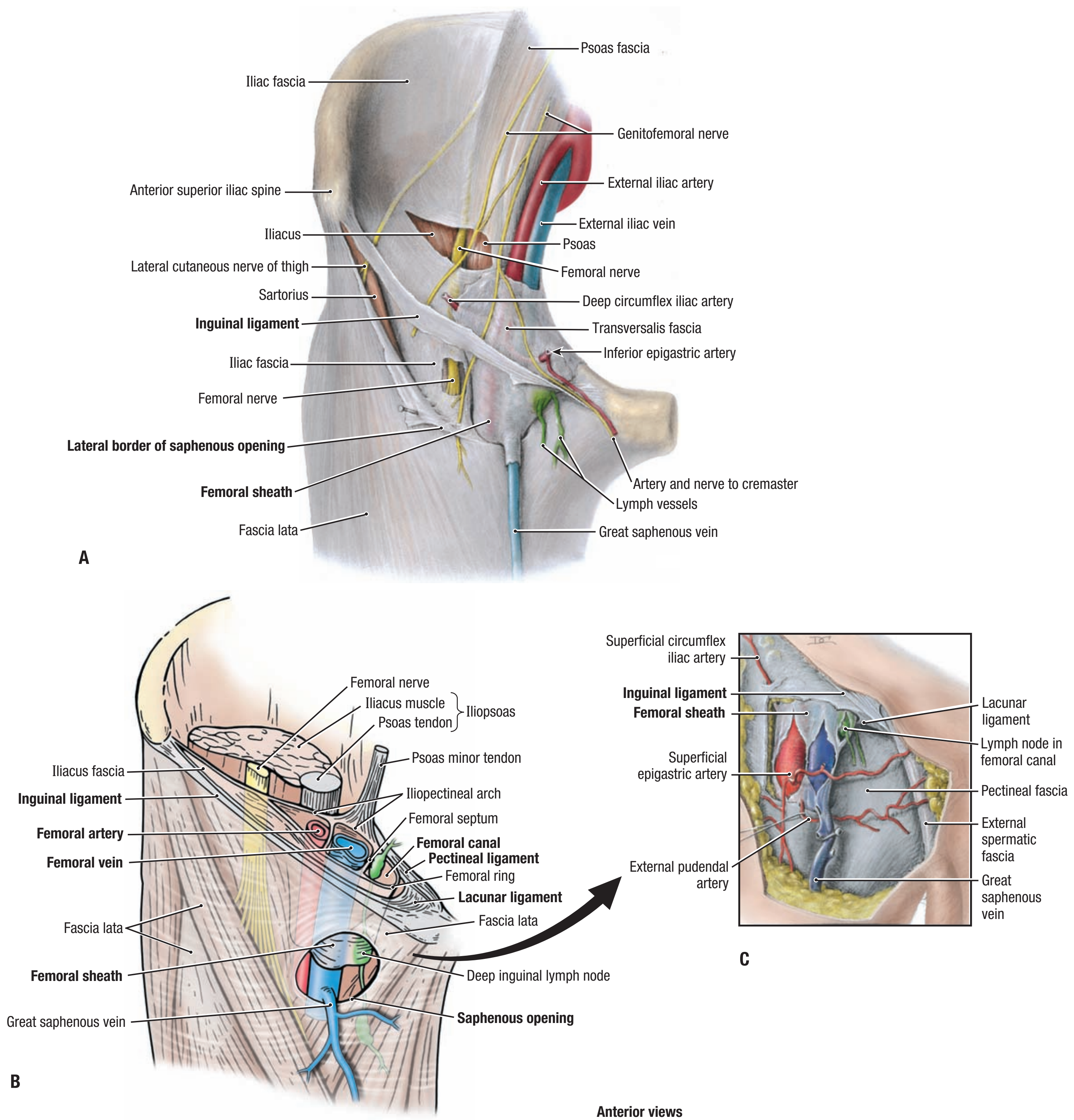






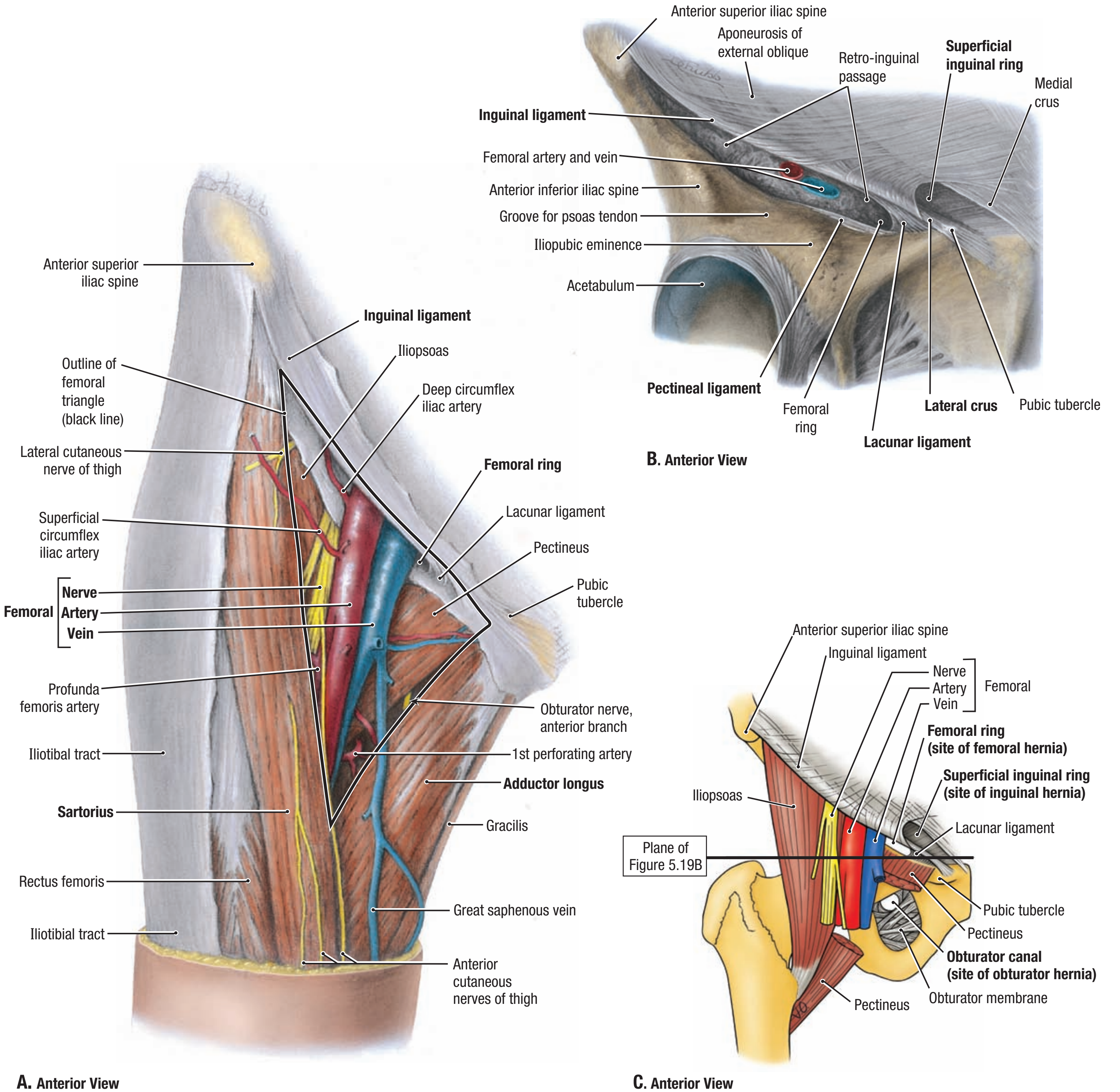
5.16 SUPERFICIAL INGUINAL VESSELS AND SAPHENOUS OPENING

A. Superficial inguinal vessels. The arteries are branches of the femoral artery, and the veins are tributaries of the great saphenous vein. **B.** Valves of the proximal part of femoral and great saphenous veins. **C.** Saphenous opening.



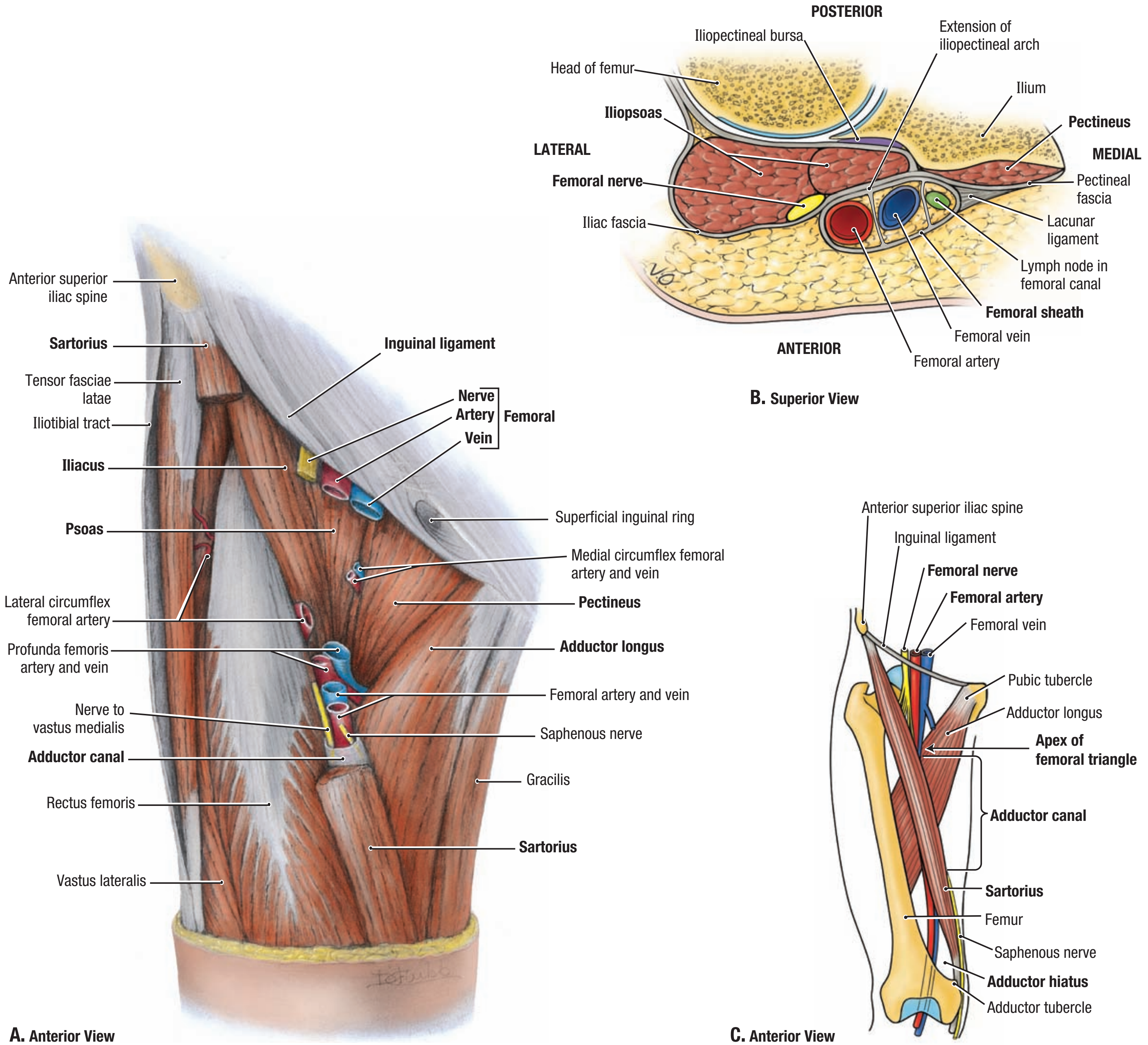
5.17 FEMORAL SHEATH AND INGUINAL LIGAMENT

A. Dissection. **B.** Schematic illustration. The femoral sheath contains the femoral artery, vein, and lymph vessels, but the femoral nerve, lying posterior to the iliacus fascia, is outside the femoral sheath. **C.** Femoral sheath and femoral ring. The three compartments of the femoral sheath are the lateral for the femoral artery; intermediate for the femoral vein; and medial for the femoral canal. The base of the femoral canal is formed by the small (about 1 cm wide) proximal opening at its abdominal end, the femoral ring. This opening is closed by extraperitoneal fatty tissue.



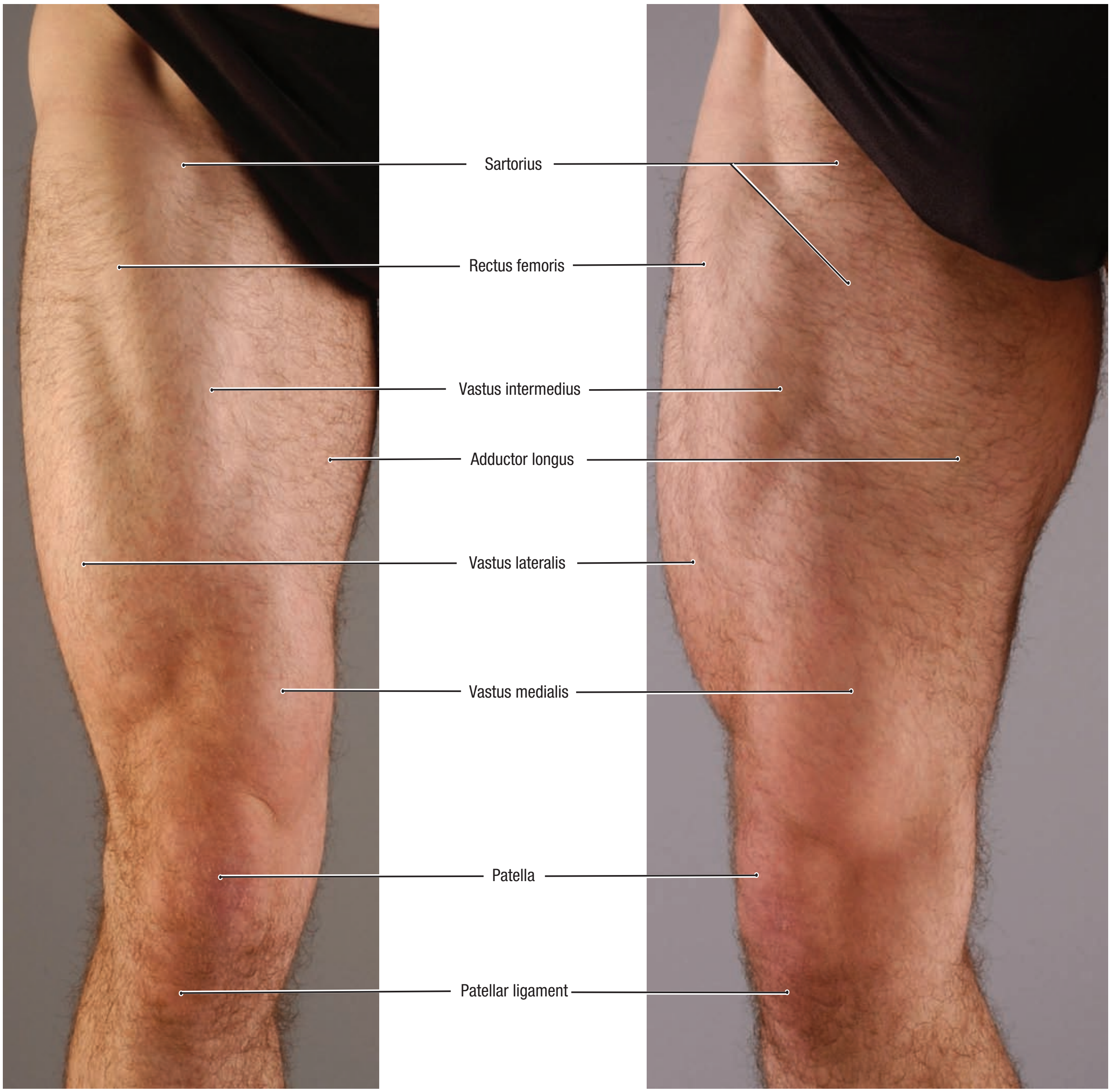
5.18 STRUCTURES PASSING TO/FROM FEMORAL TRIANGLE VIA RETRO-INGUINAL PASSAGE

A. Dissection. The boundaries of the femoral triangle are the inguinal ligament superiorly (base of triangle), the medial border of the sartorius (lateral side), and the lateral border of the adductor longus (medial side). The point at which the lateral and medial sides converge inferiorly forms the apex. The femoral triangle is bisected by the femoral vessels. **B.** Retro-inguinal passage between the inguinal ligament anteriorly and the bony pelvis posteriorly. **C.** The iliopsoas muscle, the femoral nerve, artery, and vein, and the lymphatic vessels draining the inguinal nodes pass deep to the inguinal ligament to enter the anterior thigh or return to the trunk. Three potential sites for **hernia formation** are indicated. **Pulsations of the femoral artery** can be felt distal to the inguinal ligament, midway between the anterior superior iliac spine and the pubic tubercle.



5.19 FLOOR OF FEMORAL CANAL AND RETRO-INGUINAL PASSAGE

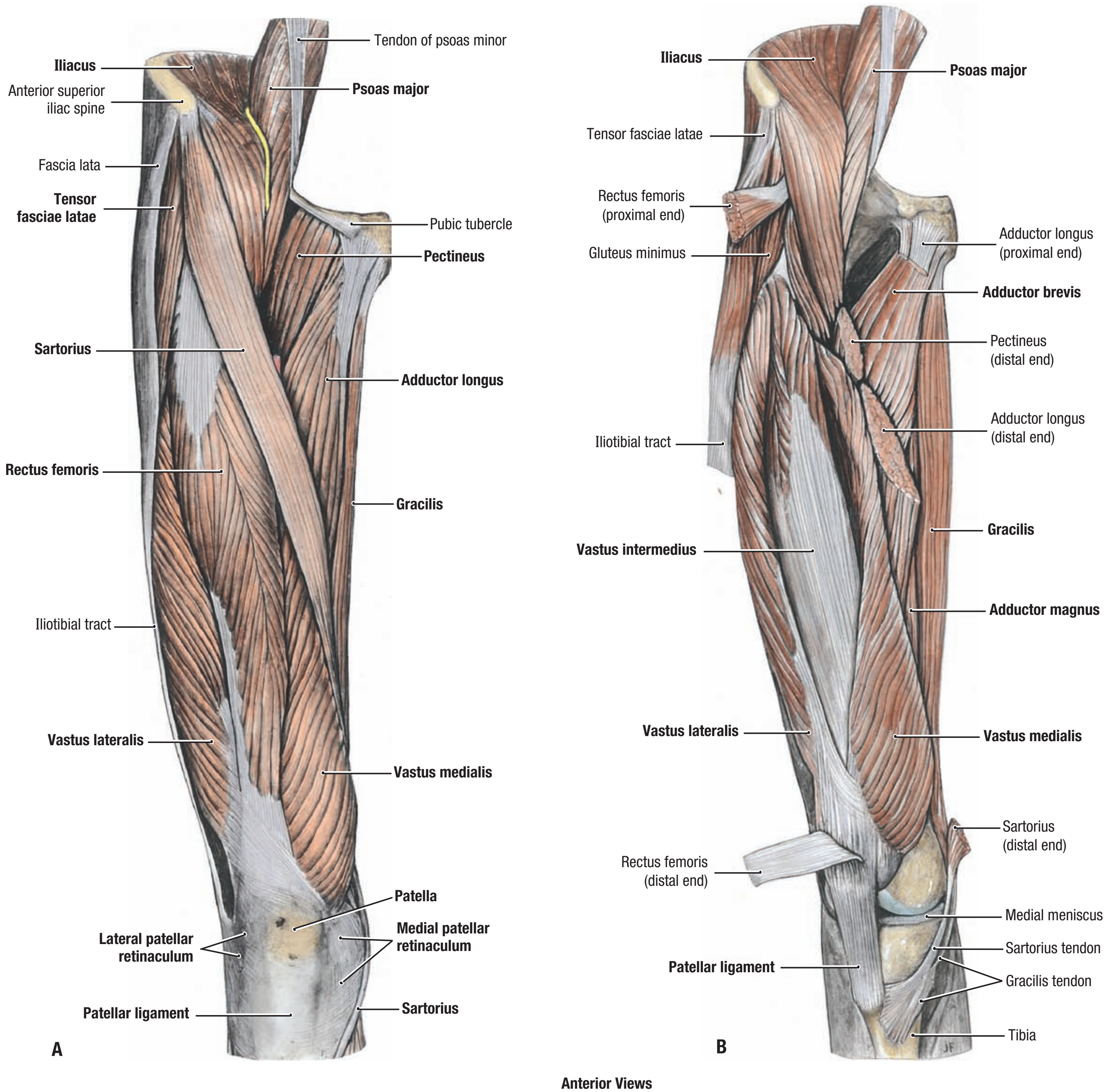
A. Dissection. Portions of the sartorius muscle, femoral vessels, and femoral nerve have been removed revealing the floor of the femoral triangle, formed by the iliopsoas laterally and the pectineus medially. At the apex of the triangle the femoral vessels, saphenous nerve, and the nerve to the vastus medialis pass deep to the sartorius into the adductor (subsartorial) canal. **B.** Transverse section of the femoral triangle at the level of head of femur. (Level of section is indicated in Fig. 5.18 **C**.) The iliopsoas and femoral nerve traverse the retro-inguinal passage and femoral triangle in a fascial sheath separate from the femoral vessels, which are contained within the femoral sheath. **C.** Schematic illustration of course of femoral vessels. The adductor canal extends from the apex of the femoral triangle to the adductor hiatus, by which the vessels enter and leave the popliteal fossa.



A. **Anterior View** **B.** **Anteromedial View**

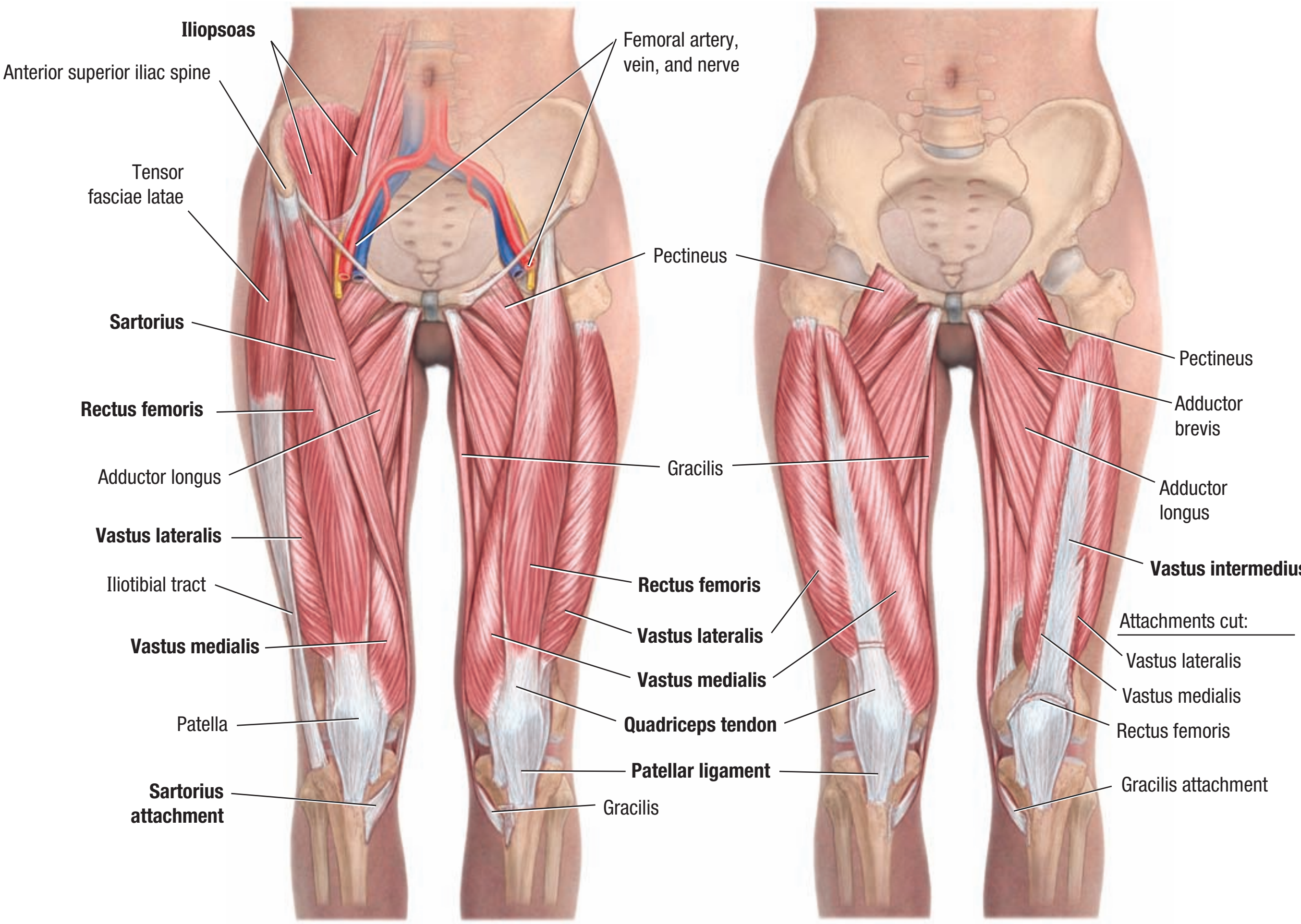
5.20 SURFACE ANATOMY OF ANTERIOR AND MEDIAL ASPECTS OF THIGH

Patellar tendinitis (jumper's knee) is caused by continuous overloading of the knee extensor mechanism, resulting in microtears of the tendon. The most vulnerable site is where the patellar ligament (tendon) attaches to the patella. This overuse injury can result in degeneration and tearing of the tendon.



5.21 ANTERIOR AND MEDIAL THIGH MUSCLES, SUPERFICIAL AND DEEP DISSECTIONS

A. Superficial dissection. **B.** Deep dissection. The central portions of the muscle bellies of the sartorius, rectus femoris, pectineus, and adductor longus muscles have been removed. **Weakness of the vastus medialis or vastus lateralis,** resulting from arthritis or trauma to the knee joint, for example, can result in abnormal patellar movement and loss of joint stability.

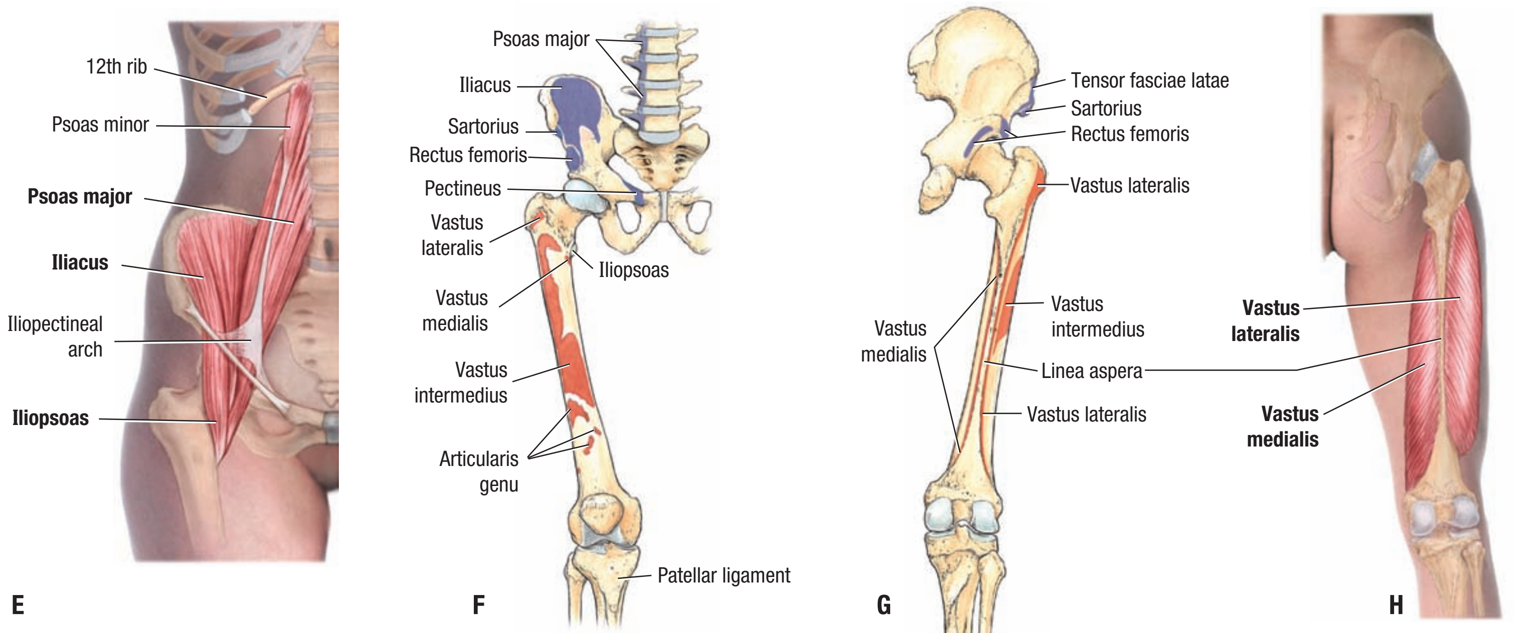


5.22 ANTERIOR AND MEDIAL THIGH MUSCLES, SCHEMATIC ILLUSTRATIONS

A.–D. Sequential views from superficial to deep.

A "hip pointer," which is a **contusion of the iliac crest,** usually occurs at its anterior part (e.g., where the sartorius attaches to the anterior superior iliac spine). This is one of the most common injuries to the hip region, usually occurring in association with collision sports. Contusions cause bleeding from ruptured capillaries and infiltration of blood into the muscles, tendons, and other soft tissues. The term hip pointer may also refer to avulsion of bony muscle attachments, for example, of the sartorius or rectus femoris from the anterior superior or inferior iliac spines or of the iliopsoas from the lesser trochanter of the femur. However, these injuries should be called **avulsion fractures.**

A person with a **paralyzed quadriceps** cannot extend the leg against resistance and usually presses on the distal end of the thigh during walking to prevent inadvertent flexion of the knee joint.



Anterior Views **Posterior Views**

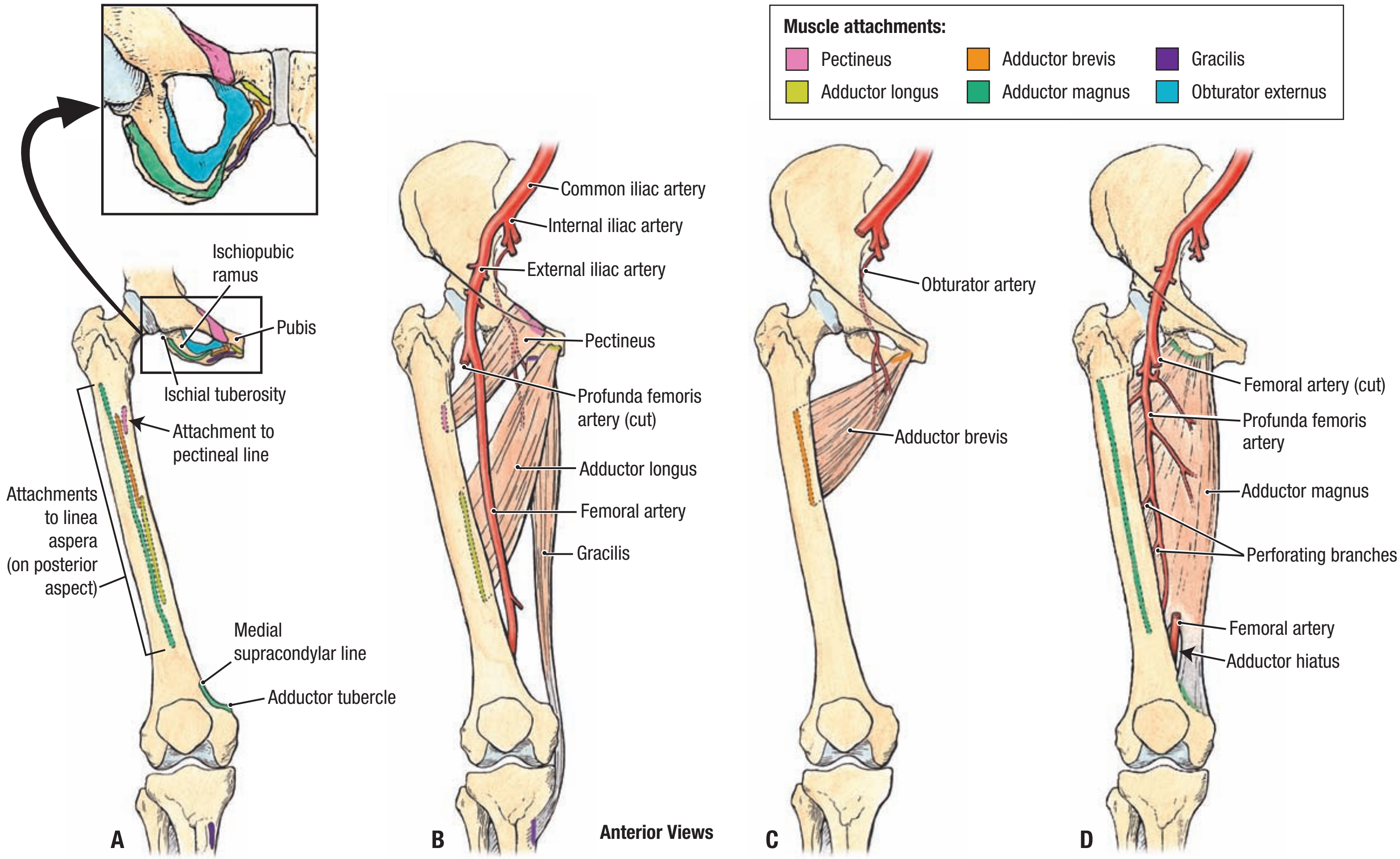
5.22 ANTERIOR AND MEDIAL THIGH MUSCLES, SCHEMATIC ILLUSTRATIONS (*CONTINUED)*

E. Iliopsoas. **F. and G.** Attachments of anterior muscles of thigh. **H.** Posterior attachment of vastus medialis and lateralis.

TABLE 5.5 MUSCLES OF ANTERIOR THIGH

Muscle	Proximal Attachment[a]	Distal Attachment[a]	Innervation[b]	Main Actions
Iliopsoas				
Psoas major	Lateral aspects of T12–L5 vertebrae and IV discs; transverse processes of all lumbar vertebrae	Lesser trochanter of femur	Anterior rami of lumbar nerves (**L1, L2,** and L3)	Flexes and stabilizes[c] hip joint
Iliacus	Iliac crest, iliac fossa, ala of sacrum and anterior sacro-iliac ligaments	Tendon of psoas major, lesser trochanter, and femur distal to it	Femoral nerve (L2 and L3)	
Tensor fasciae latae	Anterior superior iliac spine and anterior part of iliac crest	Iliotibial tract that attaches to lateral condyle of tibia	Superior gluteal (L4 and L5)	Abducts, medially rotates, and flexes hip joint; helps to keep knee extended; steadies trunk on thigh
Sartorius	Anterior superior iliac spine and superior part of notch inferior to it	Superior part of medial surface of tibia	Femoral nerve (L2 and L3)	Flexes, abducts, and laterally rotates hip joint; flexes knee joint[d]
Quadriceps femoris				
Rectus femoris	Anterior inferior iliac spine and ilium superior to acetabulum	Base of patella and by patellar ligament to tibial tuberosity; medial and lateral vasti also attach to tibia and patella via aponeuroses (medial and lateral patellar retinacula)	Femoral nerve (L2, **L3,** and **L4**)	Extends knee joint; rectus femoris also steadies hip joint and helps iliopsoas to flex hip joint
Vastus lateralis	Greater trochanter and lateral lip of linea aspera of femur			
Vastus medialis	Intertrochanteric line and medial lip of linea aspera of femur			
Vastus intermedius	Anterior and lateral surfaces of body of femur			

[a]See also Figure 5.22 for muscle attachments.
[b]Numbers indicate spinal cord segmental innervation of nerves (e.g., L1, L2, and L3 indicate that nerves supplying psoas major are derived from first three lumbar segments of the spinal cord; boldface type [**L1, L2**] indicates main segmental innervation). Damage to one or more of these spinal cord segments or to motor nerve roots arising from these segments results in paralysis of the muscles concerned.
[c]Psoas major is also a postural muscle that helps control deviation of trunk and is active during standing.
[d]Four actions of sartorius (L. sartor, tailor) produce the once-common cross-legged sitting position used by tailors—hence the name.



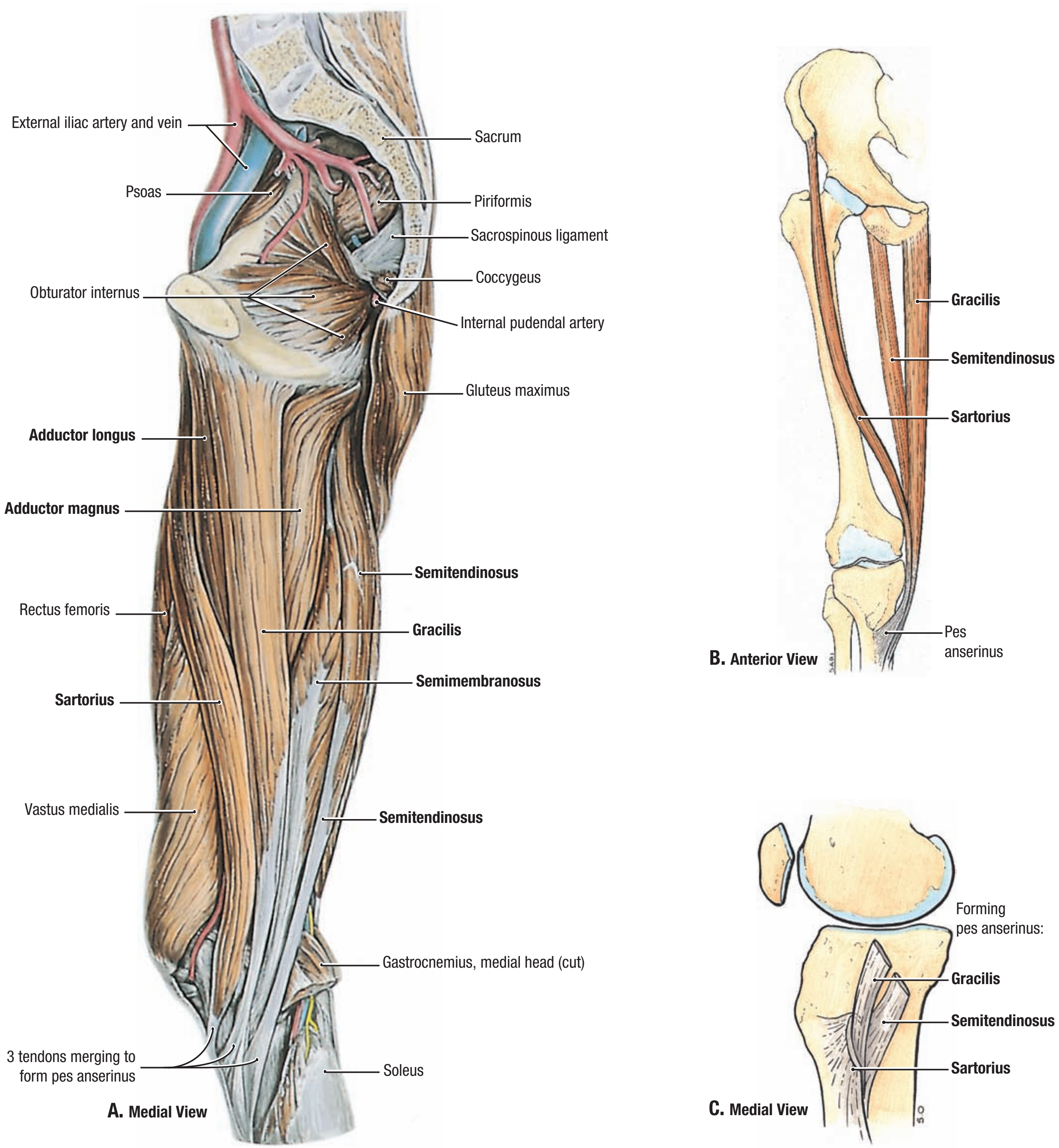
5.23 ATTACHMENTS OF MUSCLES OF MEDIAL ASPECT OF THIGH

A. Overview of attachments. **B.** Pectineus, adductor longus, and gracilis. **C.** Adductor brevis. **D.** Adductor magnus.

TABLE 5.6 MUSCLES OF MEDIAL THIGH

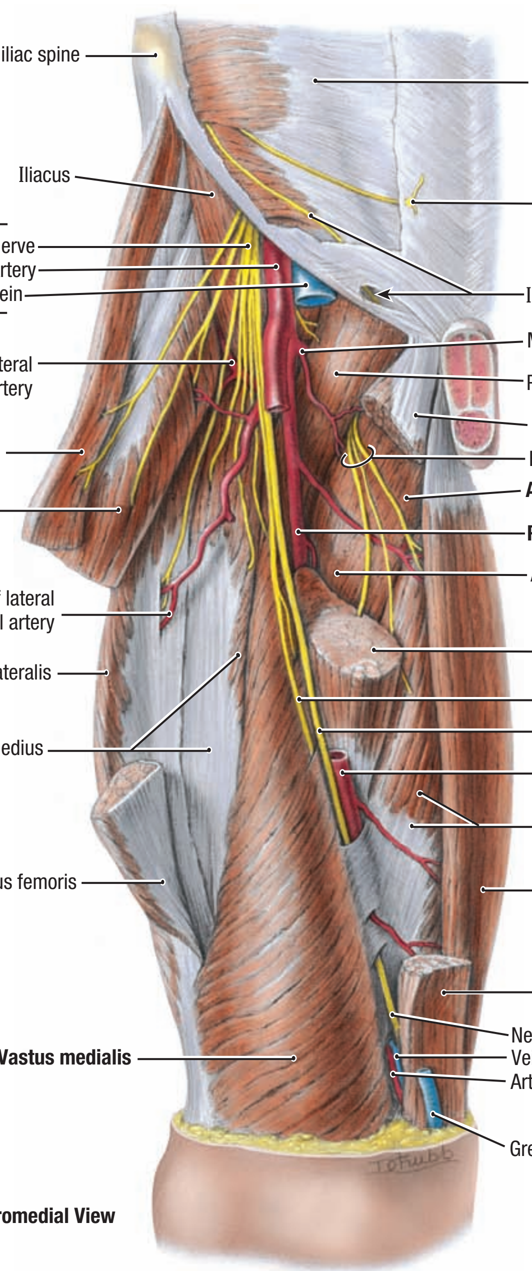
Muscle	Proximal Attachment	Distal Attachment[a]	Innervation[b]	Main Actions
Pectineus	Superior pubic ramus	Pectineal line of femur, just inferior to lesser trochanter	Femoral nerve (**L2** and L3) may receive a branch from obturator nerve	Adducts and flexes hip joint; assists with medial rotation of hip joint
Adductor longus	Body of pubis inferior to pubic crest	Middle third of linea aspera of femur	Obturator nerve, anterior branch (L2, **L3**, and L4)	Adducts hip joint
Adductor brevis	Body of pubis and inferior pubic ramus	Pectineal line and proximal part of linea aspera of femur	Obturator nerve (L2, **L3**, and L4)	Adducts hip joint and, to some extent, flexes it
Adductor magnus	Inferior pubic ramus, ramus of ischium (adductor part), and ischial tuberosity	Gluteal tuberosity, linea aspera, medial supracondylar line (adductor part), and adductor tubercle of femur (hamstring part)	*Adductor part:* obturator nerve (L2, **L3**, and **L4**) *Hamstring part:* tibial part of sciatic nerve **(L4)**	Adducts hip joint; its adductor part also flexes hip joint, and its hamstring part extends it
Gracilis	Body of pubis and inferior pubic ramus	Superior part of medial surface of tibia	Obturator nerve (**L2** and L3)	Adducts hip joint, flexes knee joint, and helps rotate it medially
Obturator externus	Margins of obturator foramen and obturator membrane	Trochanteric fossa of femur	Obturator nerve (L3 and **L4)**	Laterally rotates hip joint; steadies head of femur in acetabulum

Collectively, the first five muscles listed are the adductors of the thigh, but their actions are more complex (e.g., they act as flexors of the hip joint during flexion of the knee joint and are active during walking).
[a]See Figure 5.22 for muscle attachments.
[b]See Table 5.1 for explanation of segmental innervation.



5.24 MUSCLES OF MEDIAL ASPECT OF THIGH

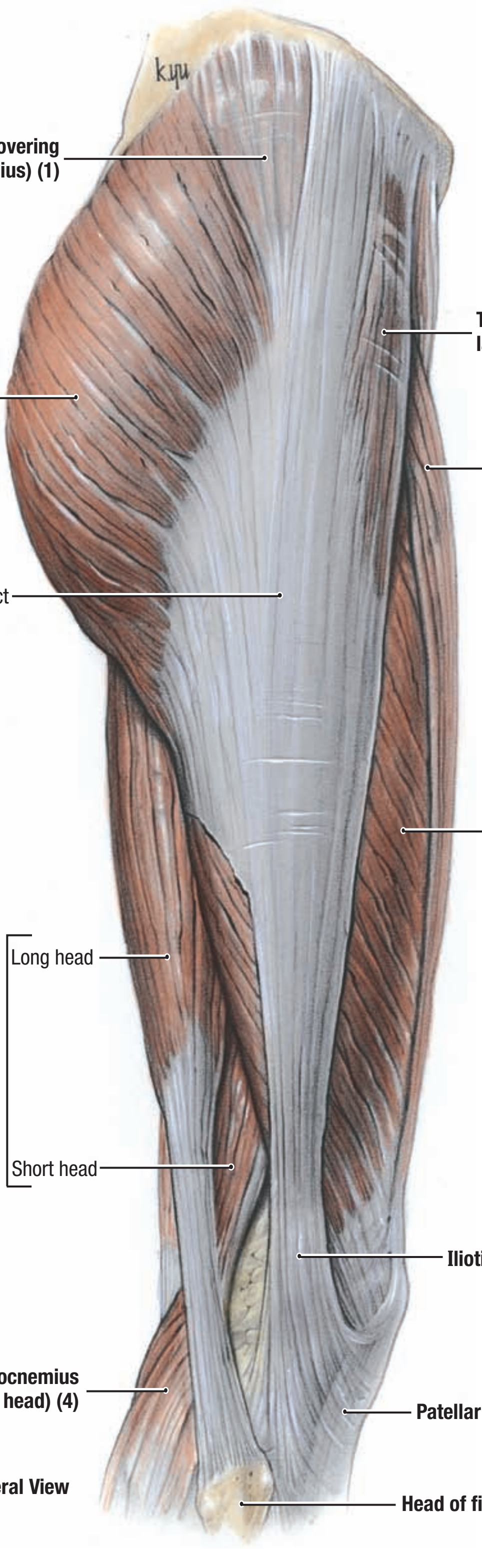
A. Dissection. **B.** Muscular tripod. The sartorius, gracilis, and semitendinosus muscles form an inverted tripod arising from three different components of the hip bone. These muscles course within three different compartments, perform three different functions, and are innervated by three different nerves yet share a common distal attachment. **C.** Distal attachment of sartorius, gracilis, and semitendinosus muscles. All three tendons become thin and aponeurotic and are collectively referred to as the pes anserinus. The gracilis is a relatively weak member of the adductor group and hence can be removed without noticeable loss of its actions on the leg. Surgeons often **transplant the gracilis**, or part of it, with its nerve and blood vessels to replace a damaged muscle in the hand, for example.



5.25 ANTEROMEDIAL ASPECT OF THIGH

- The limb is rotated laterally.
- The femoral nerve breaks up into several nerves on entering the thigh.
- The femoral artery lies between two motor territories: that of the obturator nerve, which is medial, and that of the femoral nerve, which is lateral. No motor nerve crosses anterior to the femoral artery, but the twig to the pectineus muscle crosses posterior to the femoral artery.
- The nerve to the vastus medialis muscle and the saphenous nerve accompany the femoral artery into the adductor canal. The saphenous nerve and artery and their anastomotic accompanying vein emerge from the canal distally between the sartorius and gracilis muscles.
- The profunda femoris artery (deep artery of thigh) is the largest branch of the femoral artery and the chief artery to the thigh. It arises from the femoral artery in the femoral triangle. In the middle third of the thigh, it is separated from the femoral artery and vein by the adductor longus. It gives off three or four perforating arteries that wrap around the posterior aspect of the femur and supply the adductor magnus, hamstring and vastus lateralis muscles.

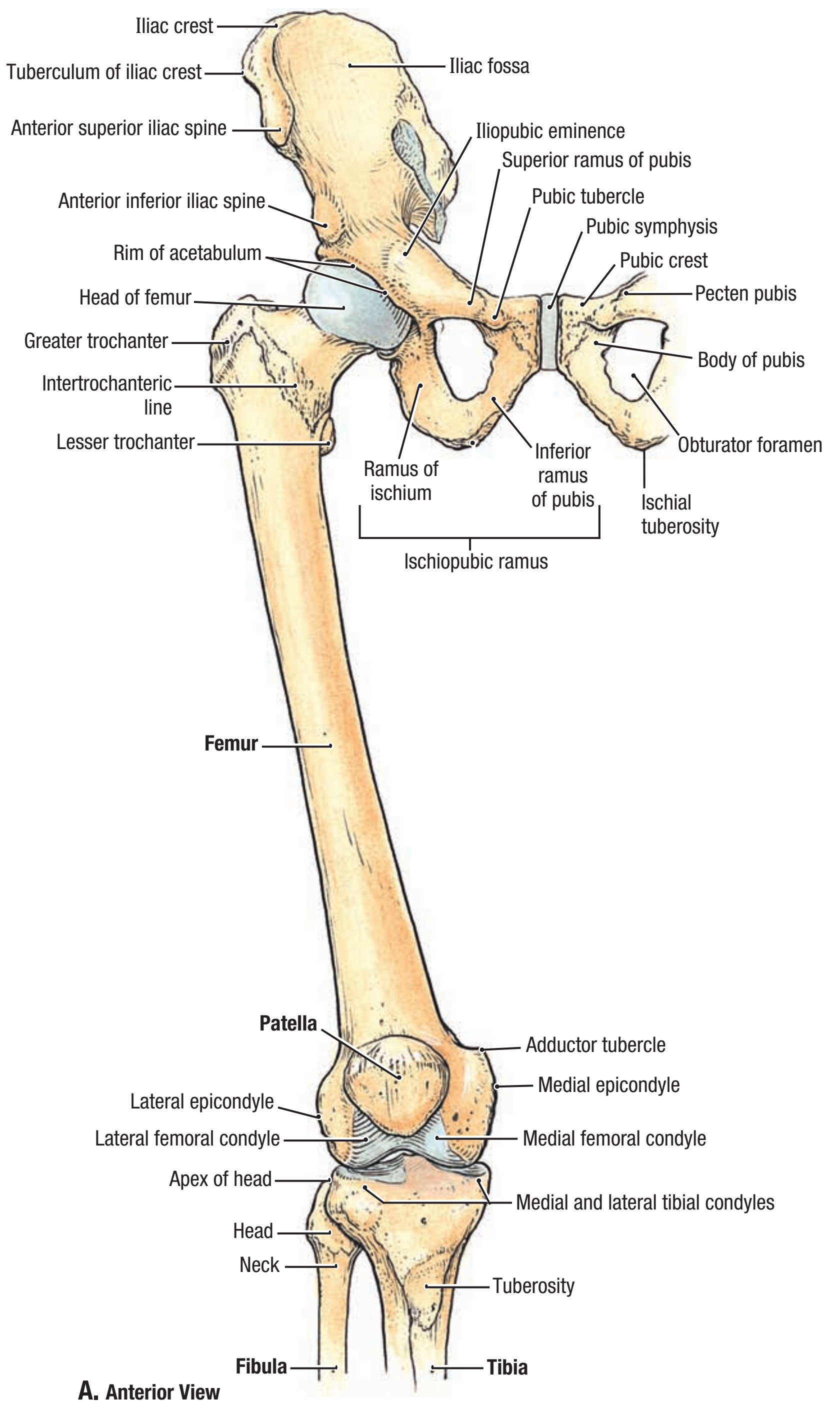
A. Lateral View

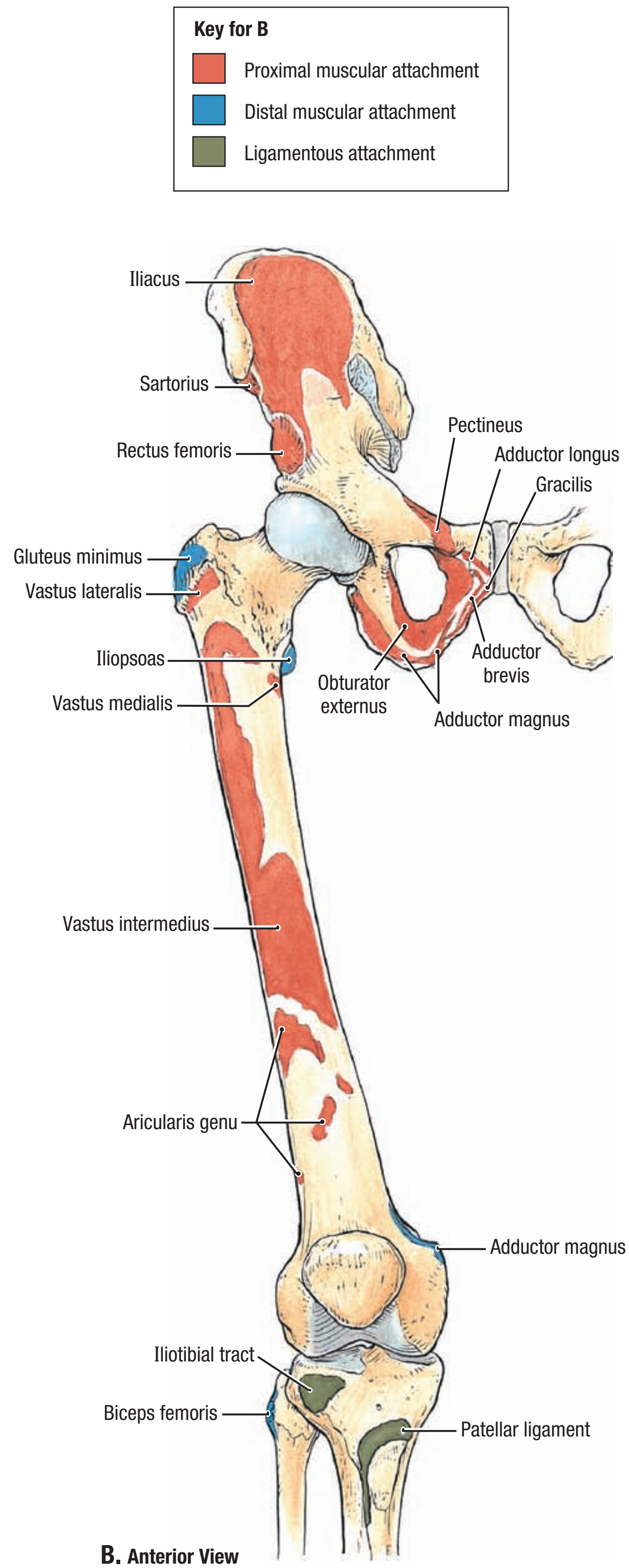


B. Lateral View

5.26 LATERAL ASPECT OF THIGH

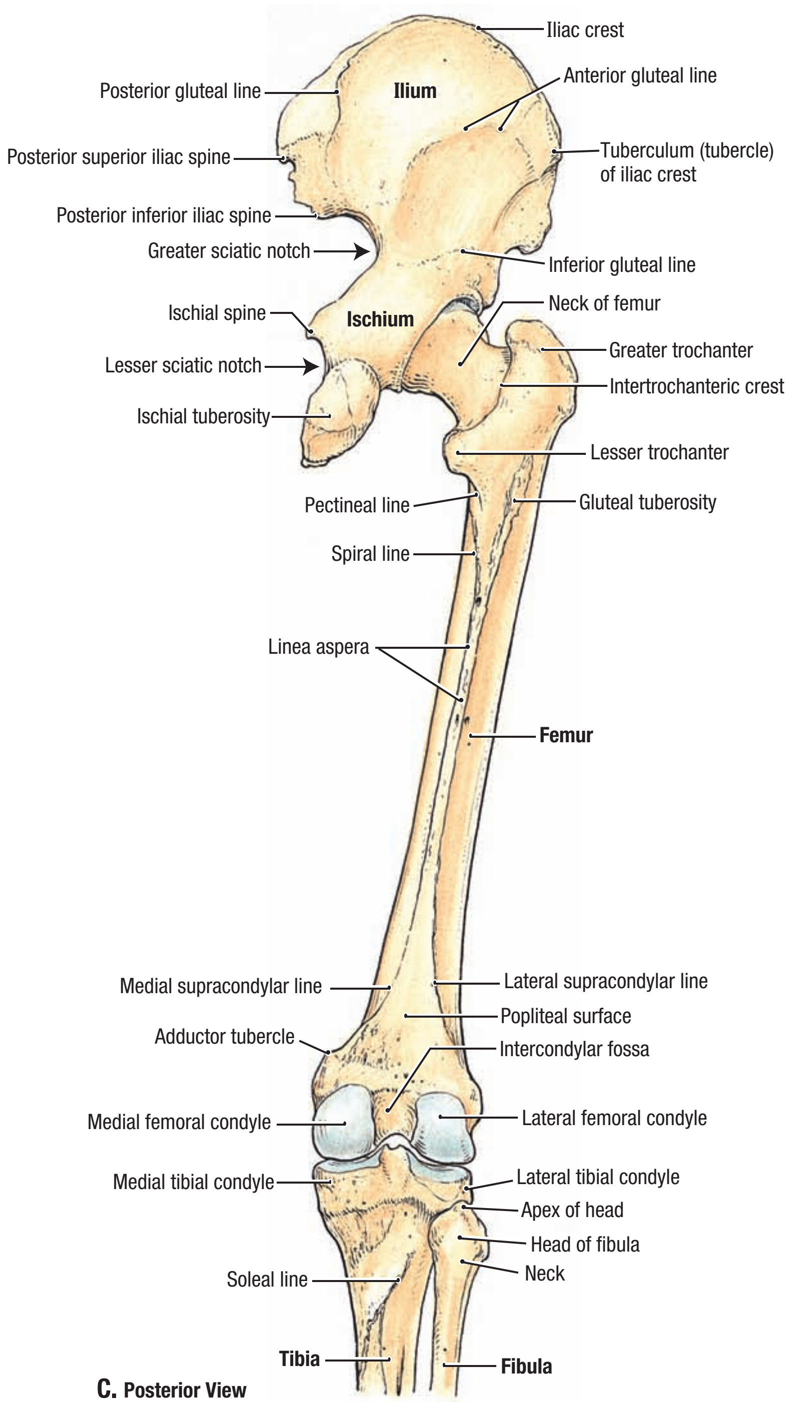
A. Surface anatomy (*numbers* refer to structures in **B**). **B.** Dissection showing the iliotibial tract, a thickening of the fascia lata, which serves as a tendon for the gluteus maximus and tensor fasciae latae. The iliotibial tract attaches to the anterolateral (Gerdy) tubercle of the lateral condyle of the tibia. The biceps femoris tendon attaches on the head of the fibula.



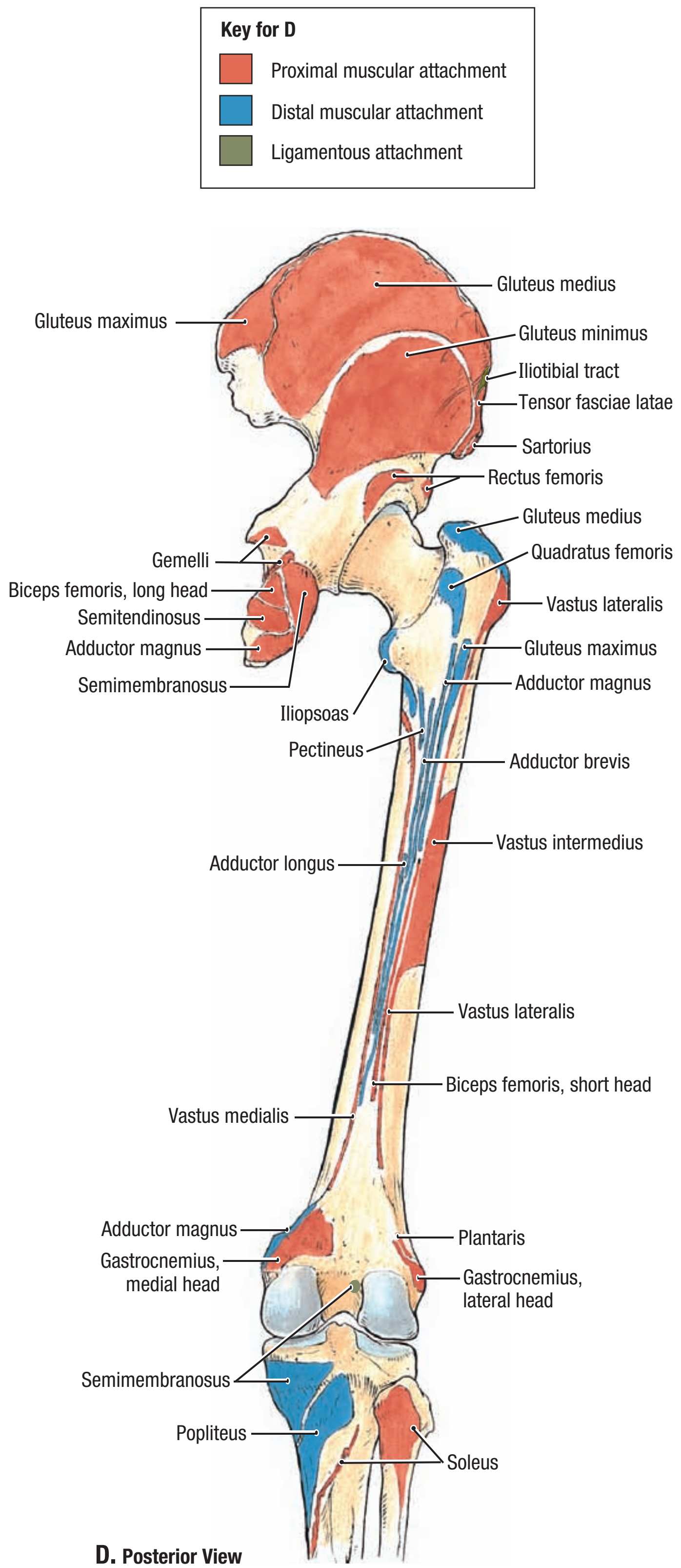


5.27 BONES OF THE THIGH AND PROXIMAL LEG

A. Bony features. **B.** Muscle attachment sites.



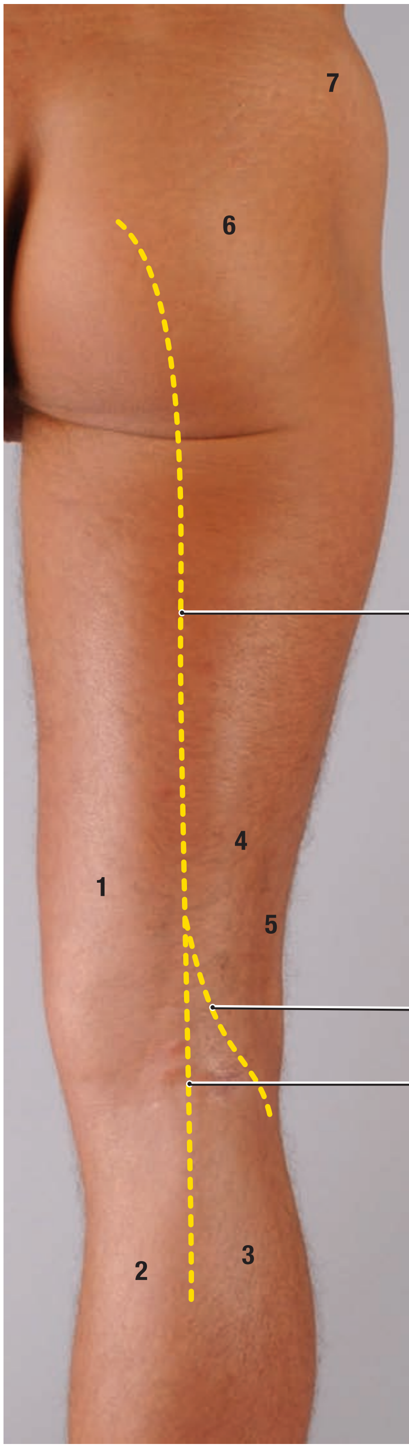
C. Posterior View



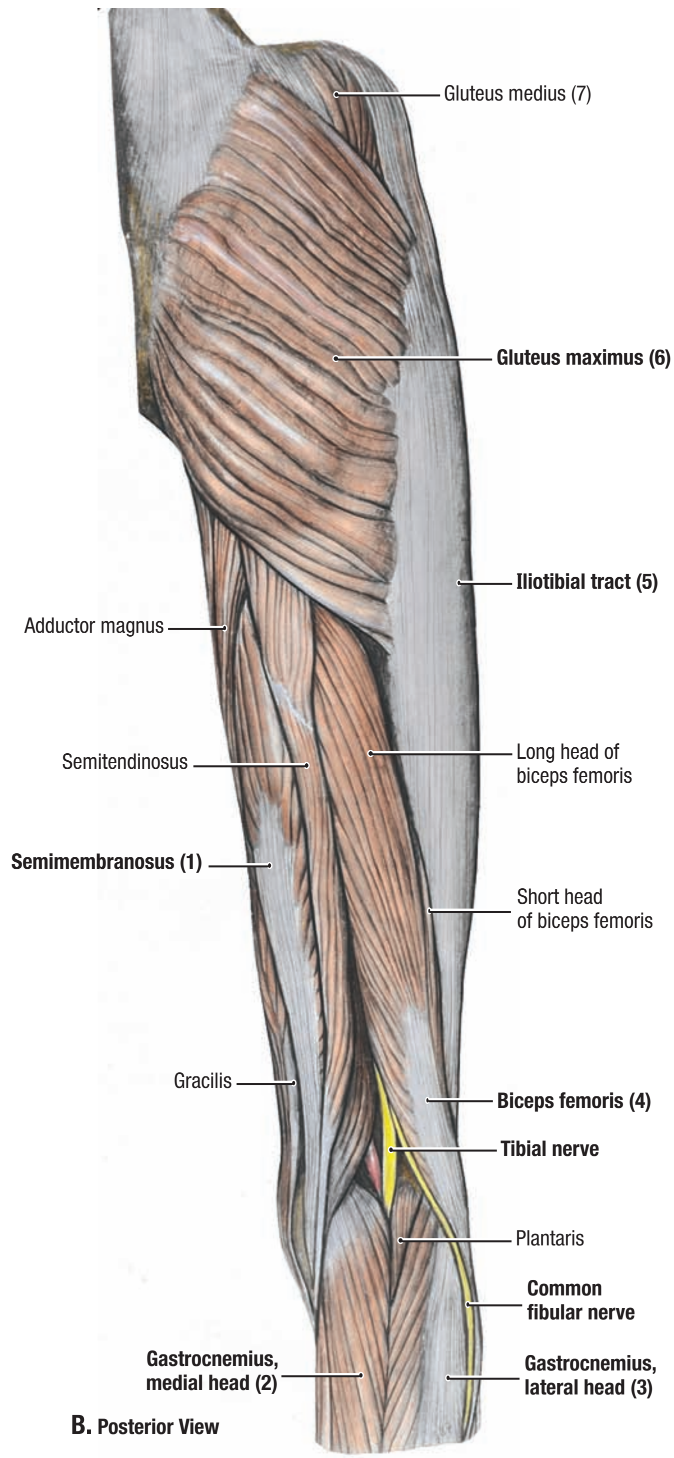
D. Posterior View

5.27 BONES OF THE THIGH AND PROXIMAL LEG (*CONTINUED*)

C. Bony features. **D.** Muscle attachment sites.



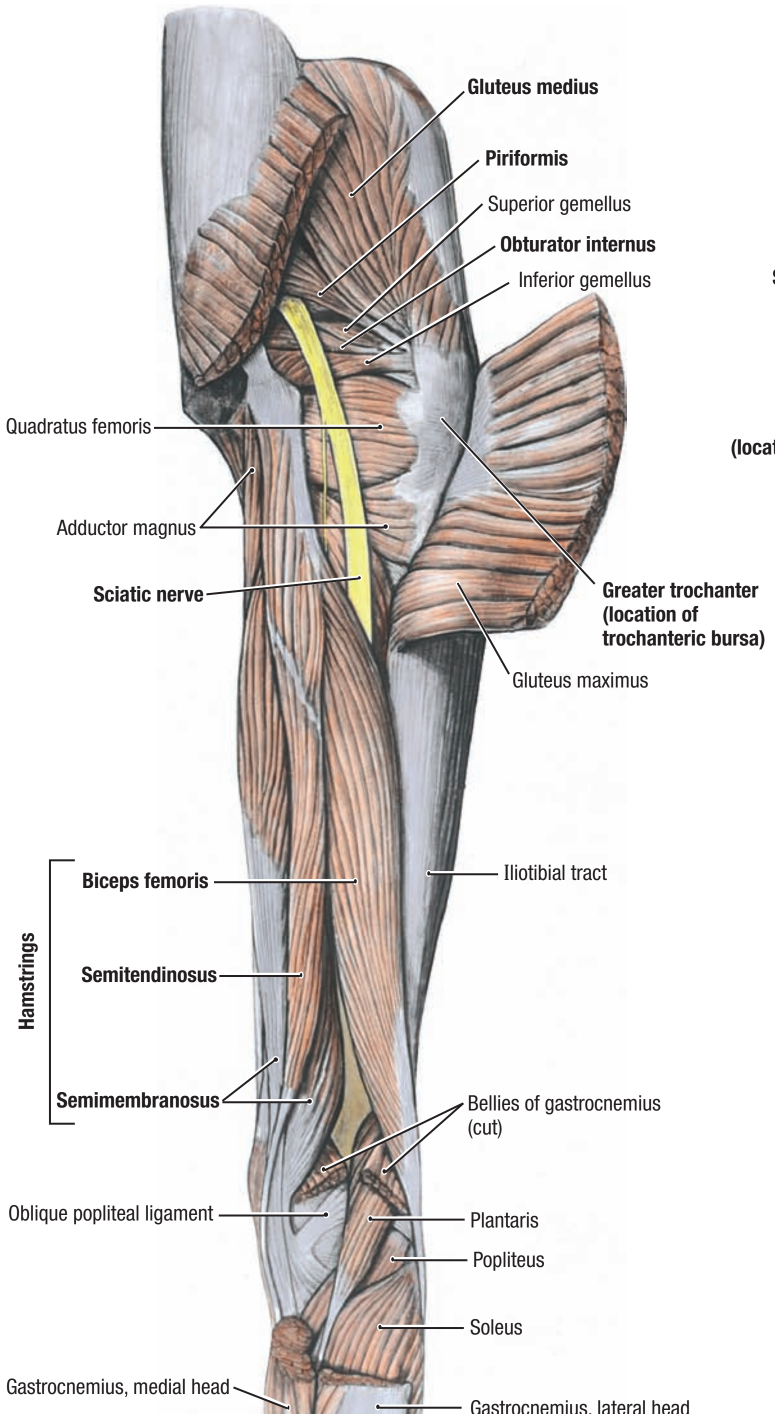
A. Posterior View



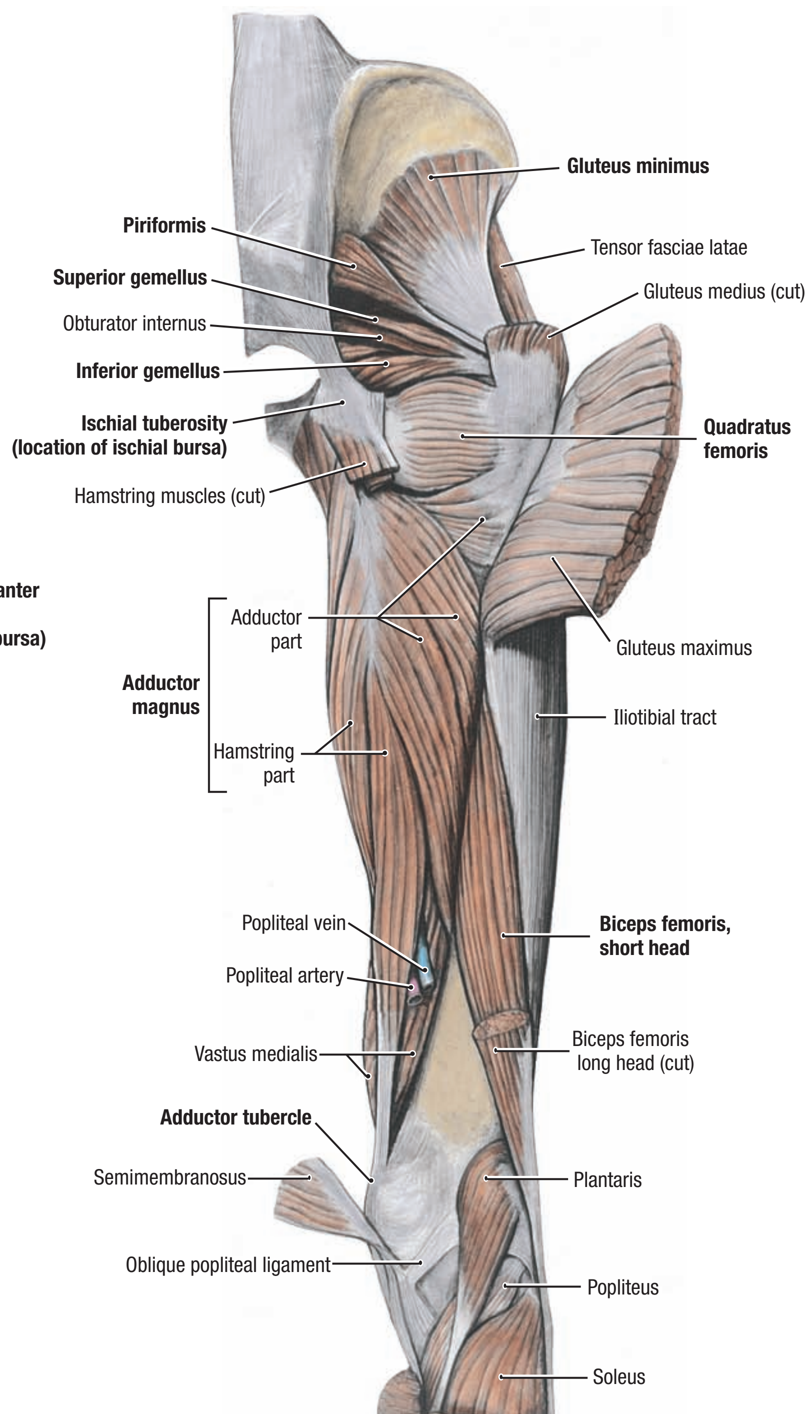
B. Posterior View

5.28 MUSCLES OF THE GLUTEAL REGION AND POSTERIOR THIGH I

A. Surface anatomy (*numbers* refer to structures in **B**). **B.** Superficial dissection of muscles of gluteal region and posterior thigh (hamstring muscles consisting of semimembranosus, semitendinosus, and biceps femoris). **Hamstring strains** (pulled and/or torn hamstrings) are common in running, jumping, and quick-start sports. The muscular exertion required to excel in these sports may tear part of the proximal attachments of the hamstrings from the ischial tuberosity.



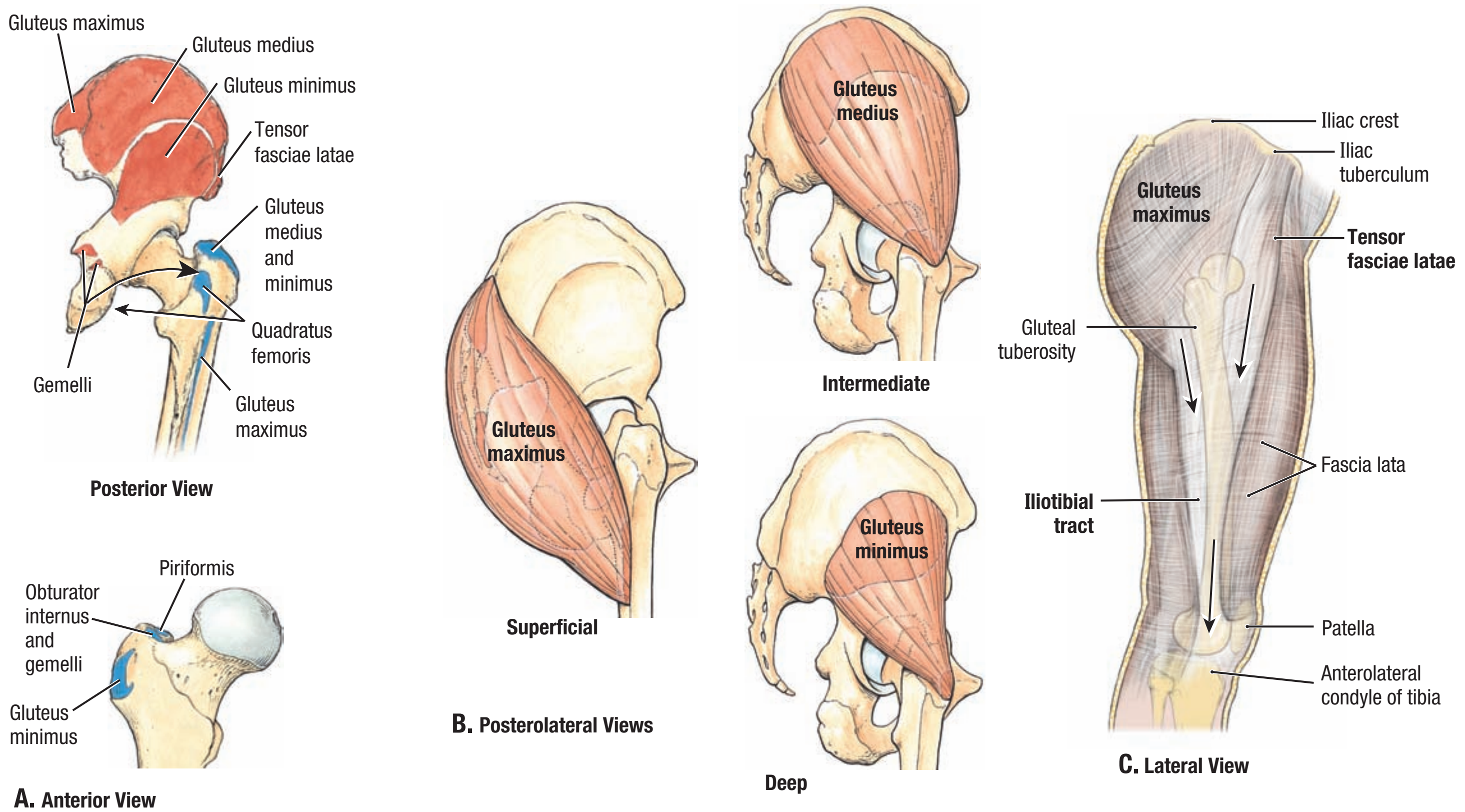
C. **Posterior View**



D. **Posterior View**

5.28 MUSCLES OF GLUTEAL REGION AND POSTERIOR THIGH (*CONTINUED*) II AND III

C. Muscles of gluteal region and posterior thigh with gluteus maximus reflected. **D.** Adductor magnus muscle. The adductor magnus has two parts: one belongs to the adductor group, innervated by the obturator nerve and the other to the hamstring group, innervated by the tibial portion of the sciatic nerve. The trochanteric bursa separates the superior fibers of the gluteus maximus from the greater trochanter of the femur and the ischial bursa separates the inferior part of the gluteus maximus from the ischial tuberosity. Diffuse deep pain in the lateral thigh region (e.g., during stair climbing) may be caused by **trochanteric bursitis.** It is characterized by point tenderness over the greater trochanter, with pain radiating along the iliotibial tract. **Ischial bursitis** results from excessive friction between the ischial bursae and ischial tuberosities (e.g., as from cycling).



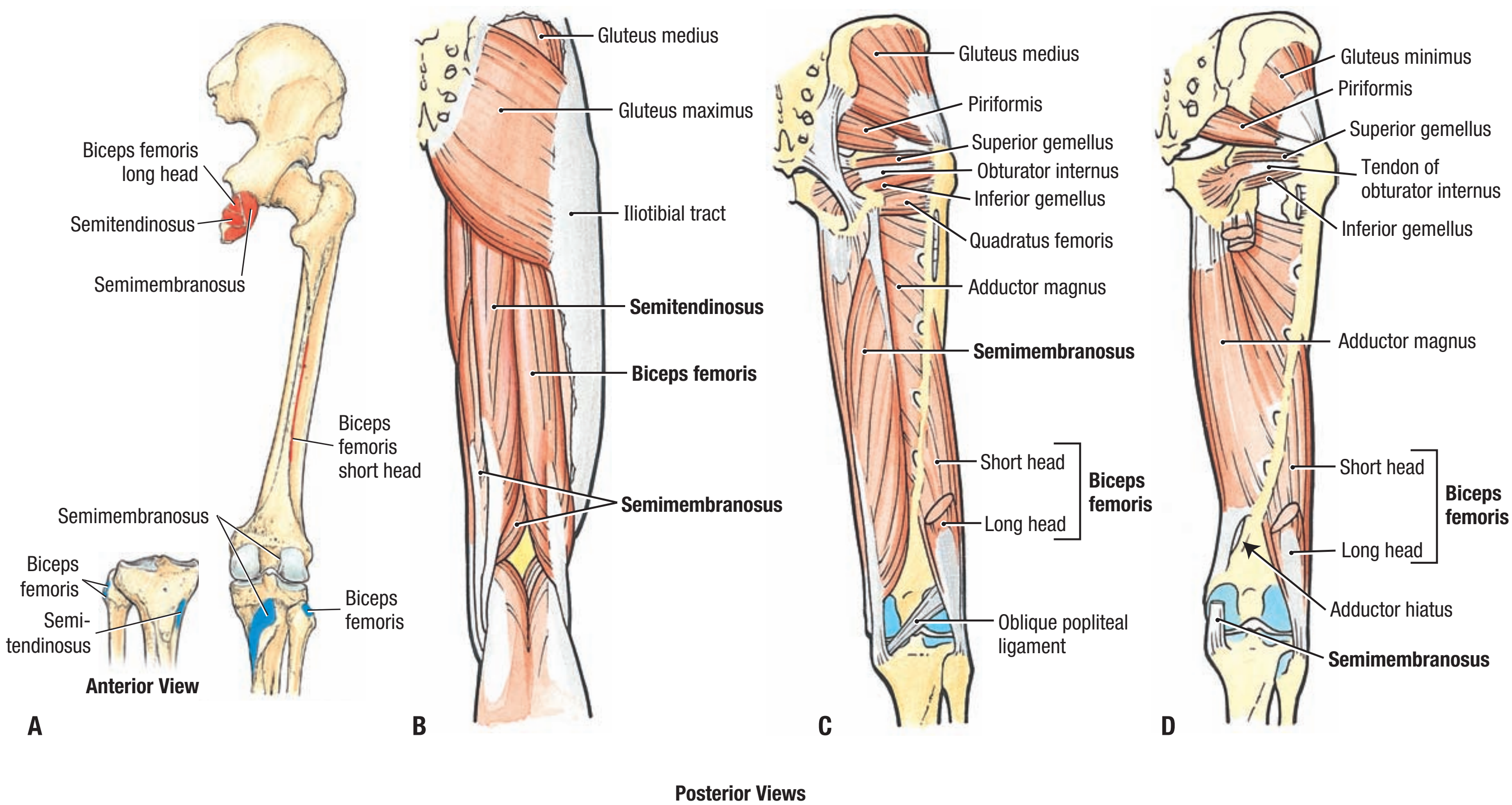
5.29 MUSCLES OF GLUTEAL REGION

A. Attachments. **B.** Relationship of gluteal muscles. **C.** Gluteus maximus and tensor fasciae latae.

TABLE 5.7 MUSCLES OF GLUTEAL REGION

Muscle	Proximal Attachment[a] (*Red*)	Distal Attachment[a] (*Blue*)	Innervation[b]	Main Actions
Gluteus maximus	Ilium posterior to posterior gluteal line, dorsal surface of sacrum and coccyx, sacrotuberous ligament	Iliotibial tract that inserts into lateral condyle of tibia; some fibers to gluteal tuberosity	Inferior gluteal nerve (L5, **S1, S2**)	Extends hip joint and assists in lateral rotation; steadies thigh and assists in raising trunk from flexed position
Gluteus medius	External surface of ilium between anterior and posterior gluteal lines; gluteal fascia	Lateral surface of greater trochanter of femur	Superior gluteal nerve (**L5,** S1)	Abducts and medially rotates hip joint[c]; keeps pelvis level when opposite leg is off ground and advances pelvis during swing phase of gait; TFL also contributes to stability of extended knee
Gluteus minimus	External surface of ilium between anterior and inferior gluteal lines	Anterior surface of greater trochanter of femur		
Tensor fasciae latae (TFL)	Anterior superior iliac spine and iliac crest	Iliotibial tract that attaches to lateral condyle (Gerdy tubercle) of tibia		
Piriformis	Anterior surface of sacrum and sacrotuberous ligament	Superior border of greater trochanter of femur	Anterior rami of S1 and S2	Laterally rotate extended hip joint and abduct flexed hip joint; steady femoral head in acetabulum
Obturator internus	Pelvic surface of obturator membrane and surrounding bones	Medial surface of greater trochanter of femur by common tendons	Nerve to obturator internus (L5, S1)	
Superior gemellus	Ischial spine			
Inferior gemellus	Ischial tuberosity			
Quadratus femoris	Lateral border of ischial tuberosity	Quadrate tubercle on intertrochanteric crest of femur	Nerve to quadratus femoris (L5, S1)	Laterally rotates hip joint,[d] steadies femoral head in acetabulum

[a]See Figure 5.22 for muscle attachments.
[b]See Table 5.1 for explanation of segmental innervation.
[c]Guteus medius and minimus: anterior fibers medially rotate hip joint and posterior fibers laterally rotate hip joint.
[d]There are six lateral rotators of the hip joint: piriformis, obturator internus, gemelli (superior and inferior), quadratus femoris, and obturator externus. These muscles also stabilize the hip joint.



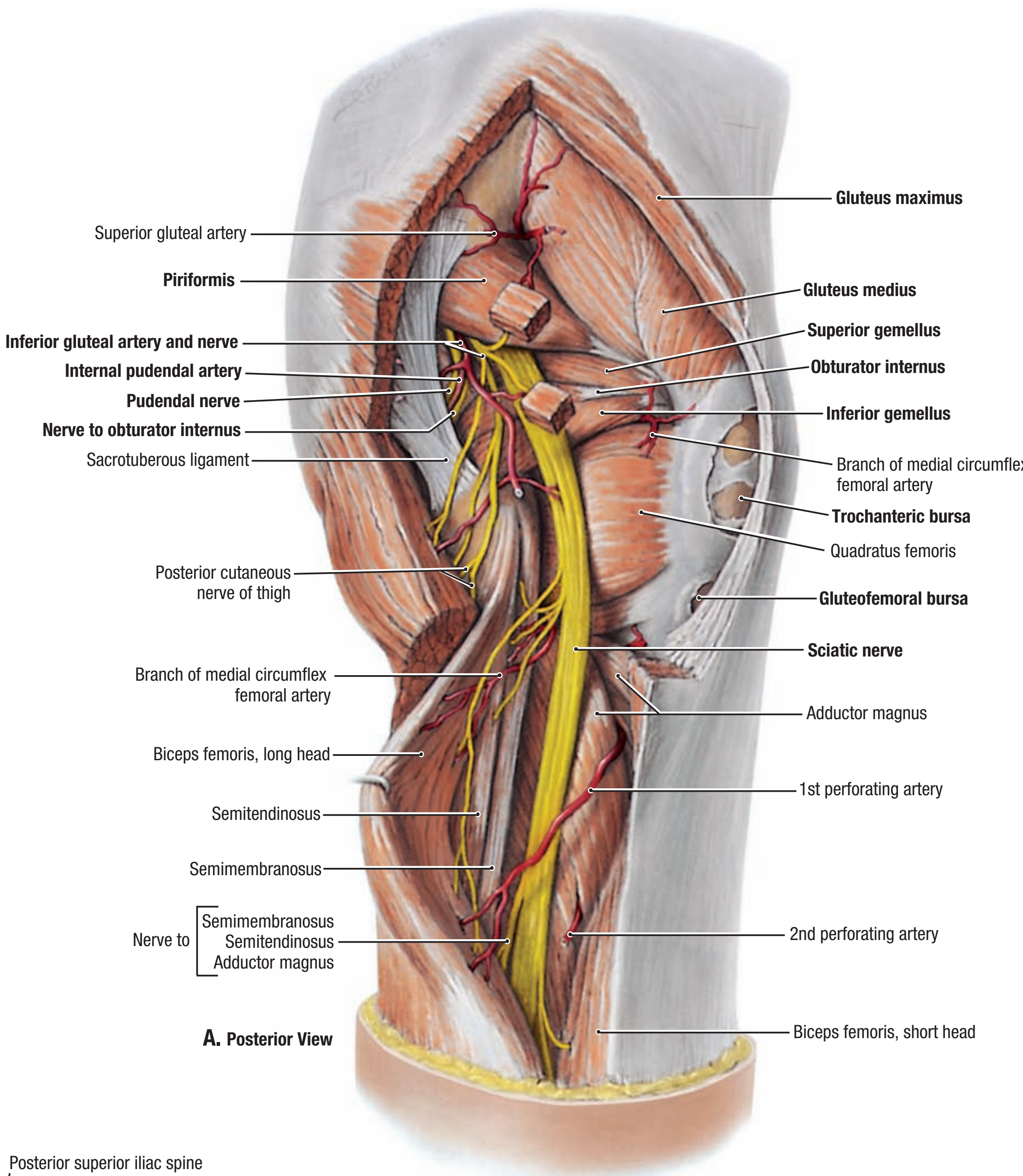
5.30 MUSCLES OF POSTERIOR THIGH

A. Attachments. **B.** Superficial layer. **C.** Intermediate layer. **D.** Deep layer.

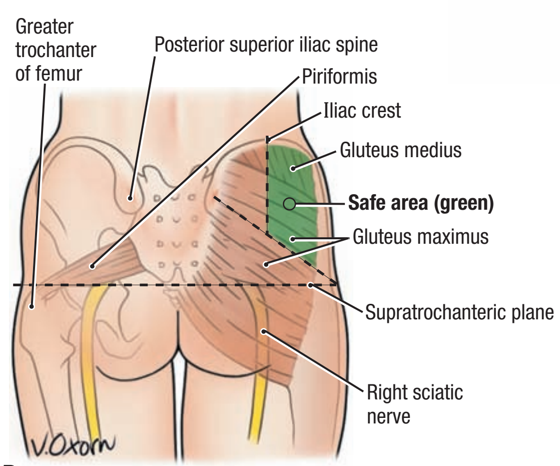
TABLE 5.8 MUSCLES OF POSTERIOR THIGH (HAMSTRING)

Muscle[a]	Proximal Attachment[a] (*Red*)	Distal Attachment[a] (*Blue*)	Innervation[b]	Main Actions
Semitendinosus	Ischial tuberosity	Medial surface of superior part of tibia	Tibial division of sciatic nerve (L5, S1, and S2)	Extend hip joint; flex knee joint and rotate it medially; when hip and knee joints are flexed, can extend trunk
Semimembranosus		Posterior part of medial condyle of tibia; reflected attachment forms oblique popliteal ligament to lateral femoral condyle		
Biceps femoris	*Long head:* ischial tuberosity; *Short head:* linea aspera and lateral supracondylar line of femur	Lateral side of head of fibula; tendon is split at this site by fibular collateral ligament of knee	*Long head:* tibial division of sciatic nerve (L5, S1, and S2); *Short head:* common fibular (peroneal) division of sciatic nerve (L5, S1, and S2)	Flexes knee joint and rotates it laterally; extends hip joint (e.g., when initiating a walking gait)

[a]See Figure 5.22 for muscle attachments.
[b]See Table 5.1 for explanation of segmental innervation.



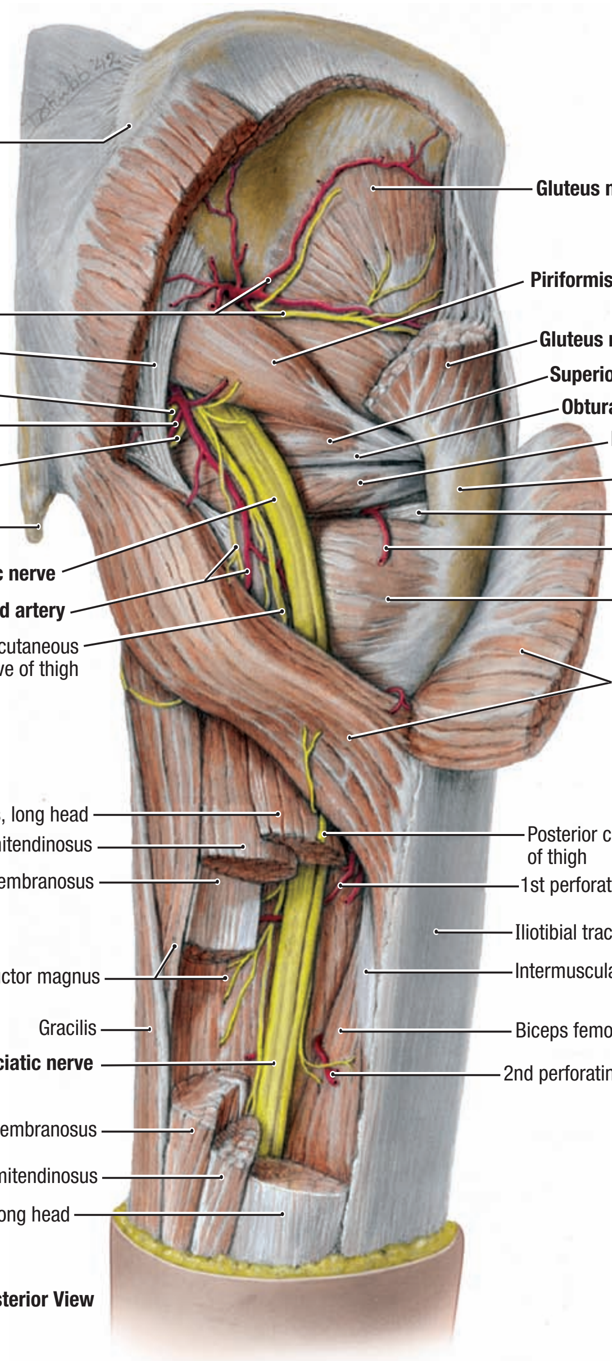
A. Posterior View



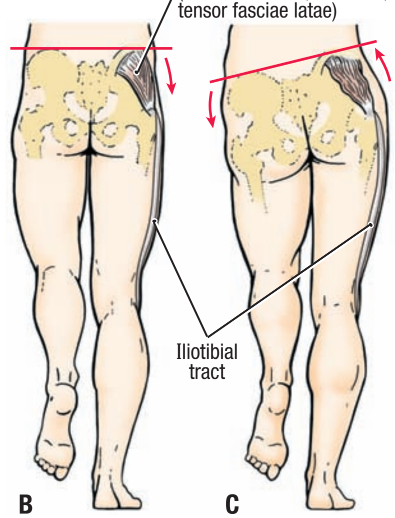
B. Posterior View, Intragluteal Injection

5.31 MUSCLES OF GLUTEAL REGION AND POSTERIOR THIGH IV

A. Dissection. The gluteus maximus muscle is split superiorly and inferiorly, and the middle part is excised; two cubes remain to identify its nerve. The gluteus maximus is the only muscle to cover the greater trochanter; it is aponeurotic and has underlying bursae where it glides on the trochanter (trochanteric bursa) and the aponeurosis of the vastus lateralis muscle (gluteofemoral bursa). **B. Intragluteal injection.** Injections can be made safely only into the superolateral part of the buttock to avoid injury to the sciatic and gluteal nerves. This site has a rich vascular network from the superior gluteal vessels that lie between the gluteus medius and minimus muscles.



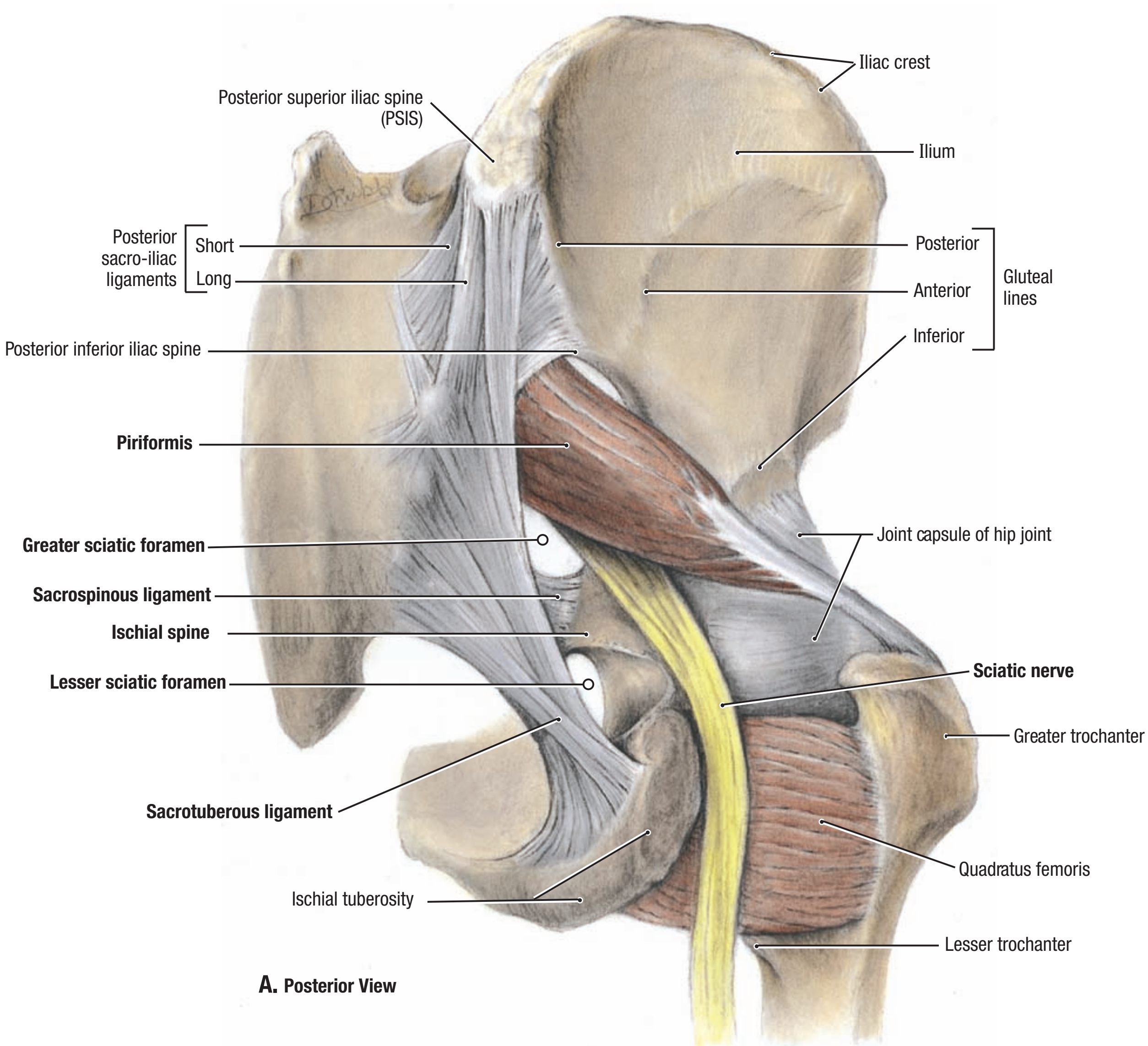
A. Posterior View



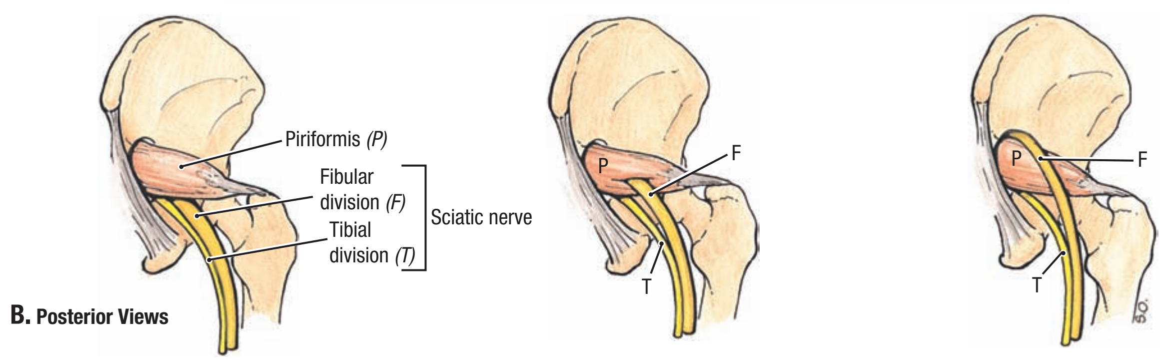
Posterior Views

5.32 MUSCLES OF GLUTEAL REGION AND POSTERIOR THIGH V

A. The proximal three quarters of the gluteus maximus muscle is reflected, and parts of the gluteus medius and the three hamstring muscles are excised. The superior gluteal vessels and nerves emerge superior to the piriformis muscle; all other vessels and nerves emerge inferior to it. **B.** When the weight is borne by one limb, the muscles on the supported side fix the pelvis so that it does not sag to the unsupported side, keeping the pelvis level. **C.** When the right **abductors are paralyzed,** owing to a lesion of the right superior gluteal nerve, fixation by these muscles is lost and the pelvis tilts to the unsupported left side (positive Trendelenburg sign).



A. Posterior View

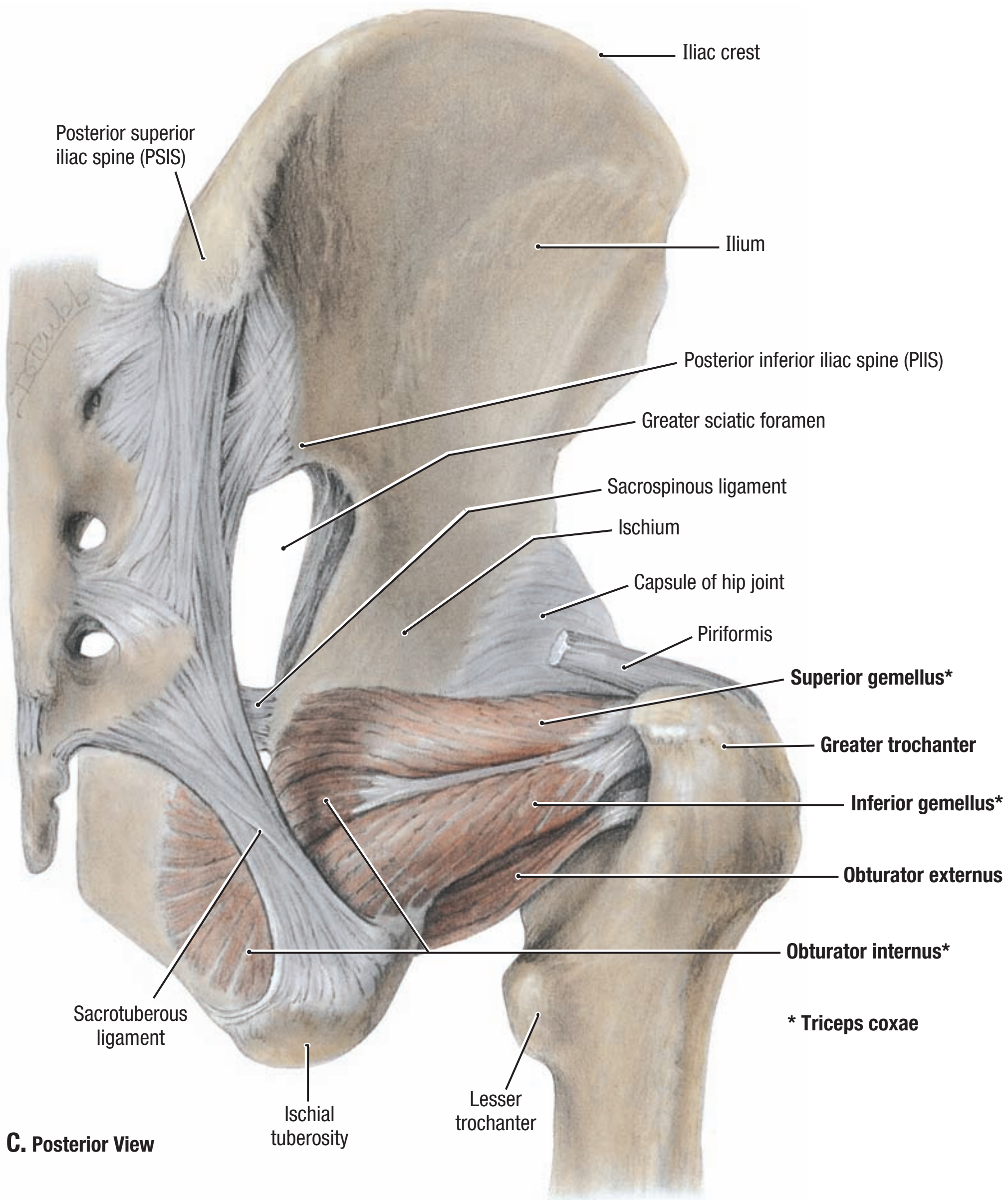


B. Posterior Views

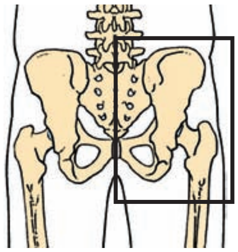
5.33 LATERAL ROTATORS OF HIP, SCIATIC NERVE, AND LIGAMENTS OF GLUTEAL REGION

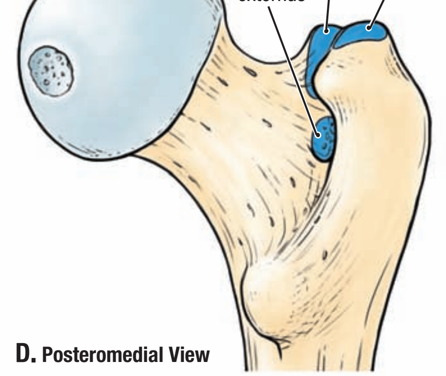
A. Piriformis and quadratus femoris. In the anatomical position the tip of the coccyx lies superior to the level of the ischial tuberosity and inferior to that of the ischial spine. The lateral border of the sciatic nerve lies midway between the lateral surface of the greater trochanter and the medial surface of the ischial tuberosity.

B. Relationship of sciatic nerve to piriformis muscle. Of 640 limbs studied in Dr. Grant's laboratory, in 87%, the tibial and fibular (peroneal) divisions passed inferior to the piriformis (*left*); in 12.2%, the fibular (peroneal) division passed through the piriformis (*center*); and in 0.5% the fibular (peroneal) division passed superior to the piriformis (*right*).



C. Posterior View





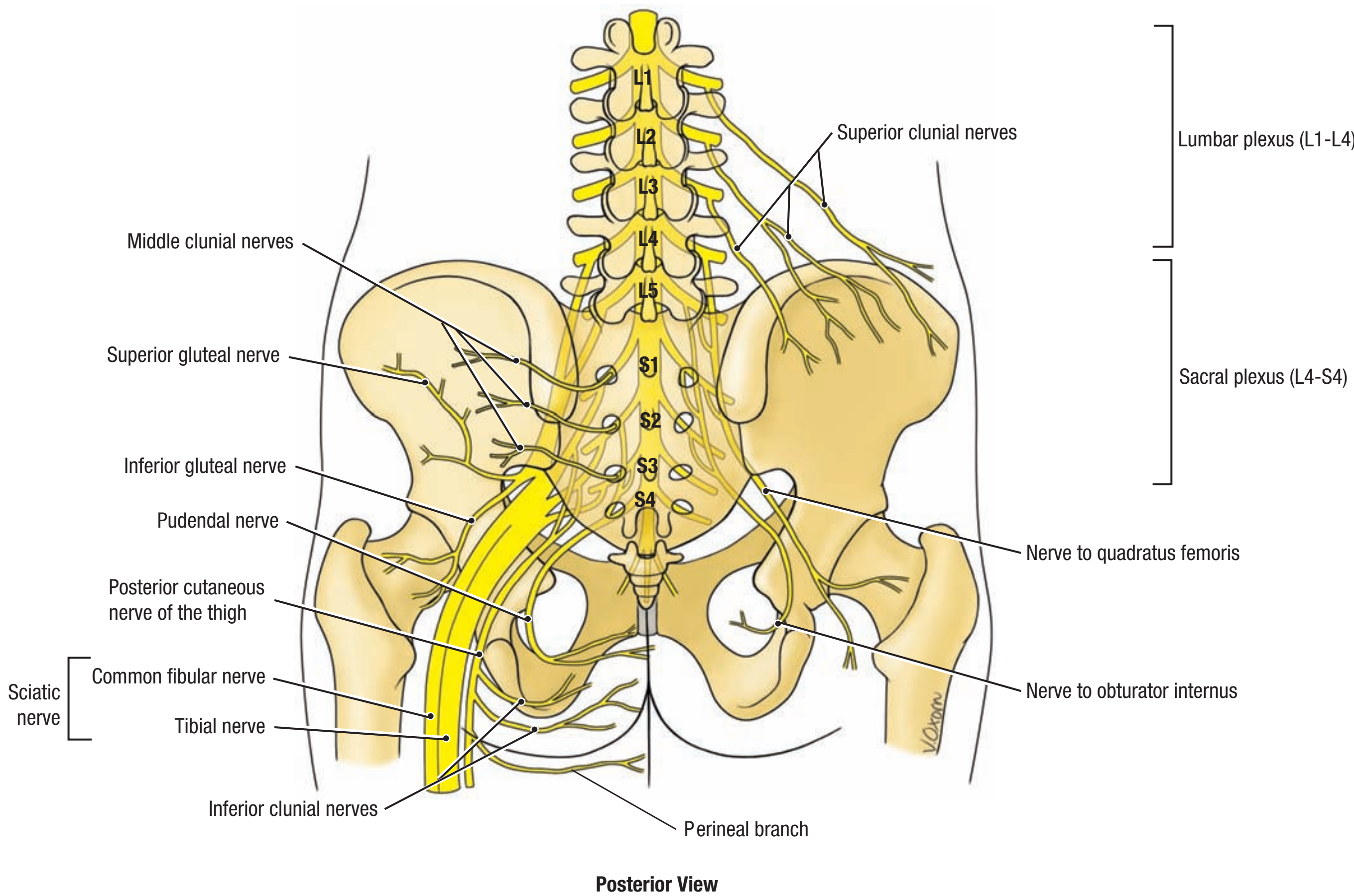
D. Posteromedial View

5.33 LATERAL ROTATORS OF HIP, SCIATIC NERVE, AND LIGAMENTS OF GLUTEAL REGION (*CONTINUED*)

C. Obturator internus, obturator externus, and superior and inferior gemelli.

- The obturator internus is located partly in the pelvis, where it covers most of the lateral wall of the lesser pelvis. It leaves the pelvis through the lesser sciatic foramen, makes a right-angle turn, becomes tendinous, and receives the distal attachments of the gemelli before attaching to the medial surface of the greater trochanter (trochanteric fossa).
- The obturator externus extends from the external surface of the obturator membrane and surrounding bone of the pelvis to the posterior aspect of the greater trochanter, passing directly under the acetabulum and neck of the femur.

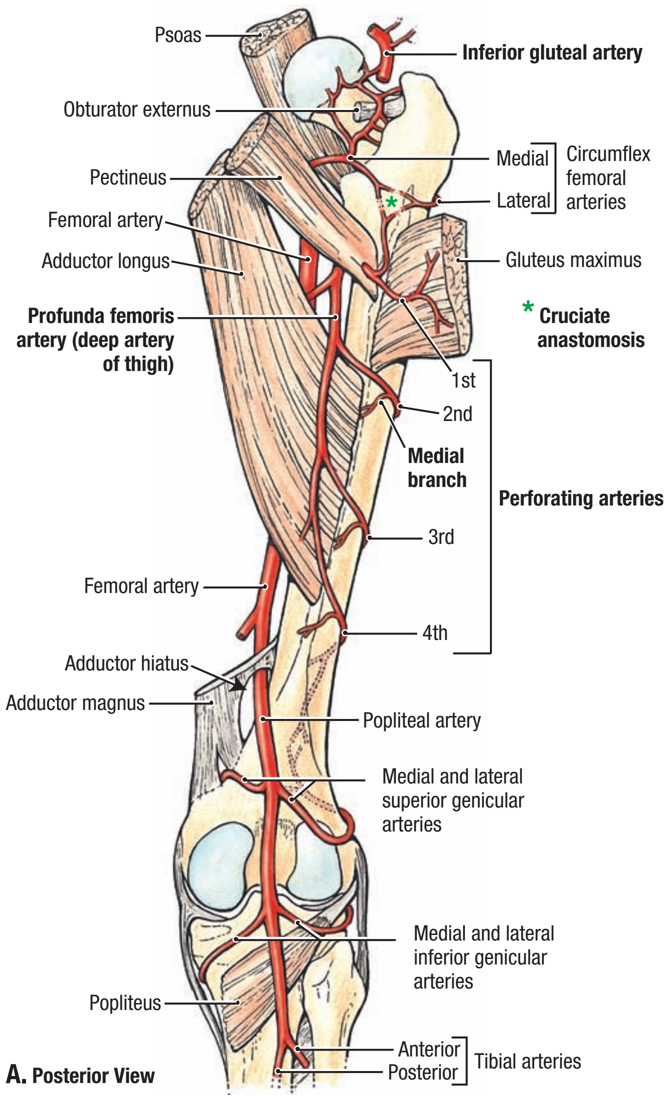
- **Sciatic nerve block.** Sensation conveyed by the sciatic nerve can be blocked by injecting an anesthetic agent a few centimeters inferior to the midpoint of the line joining the PSIS and the superior border of the greater trochanter. Paresthesia radiates to the foot because of anesthesia of the plantar nerves, which are terminal branches of the tibial nerve derived from the sciatic nerve.
- **Common fibular nerve compression at piriformis.** In the approximately 12% of people in whom the common fibular division of the sciatic nerve passes through the piriformis, this muscle may compress the nerve.

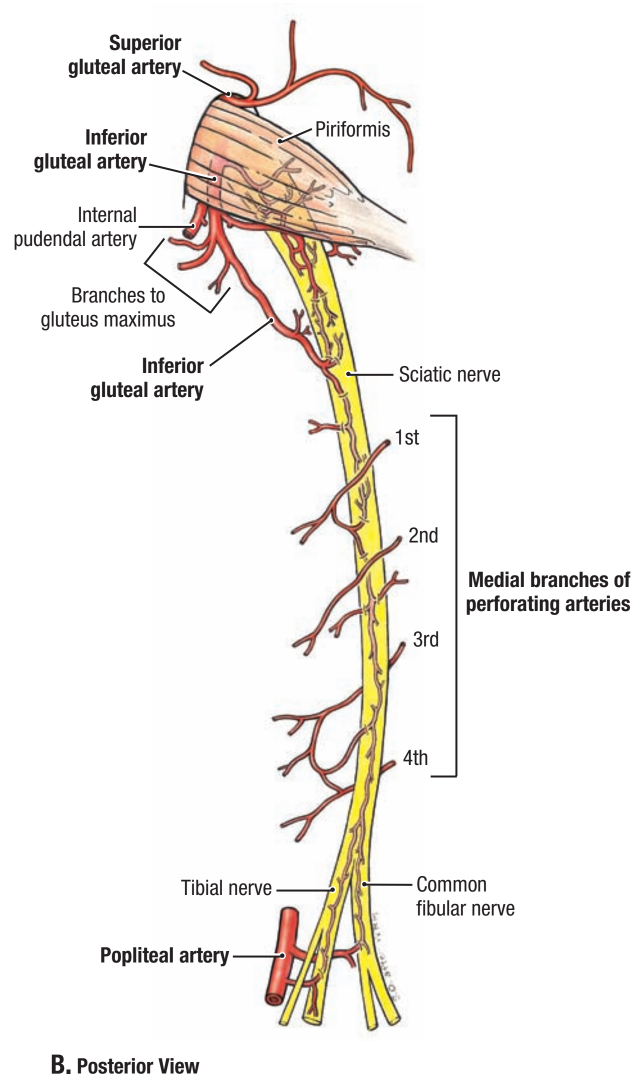


5.34 NERVES OF GLUTEAL REGION

TABLE 5.9 NERVES OF GLUTEAL REGION

Nerve	Origin	Course	Distribution in Gluteal Region
Clunial (superior, middle, and inferior)	*Superior:* posterior rami of L1–L3 nerves *Middle:* posterior rami of S1–S3 nerves *Inferior:* posterior cutaneous nerve of thigh	*Superior nerves* cross iliac crest; *middle nerves* exit through posterior sacral foramina and enter gluteal region; *inferior nerves* curve around inferior border of gluteus maximus	Gluteal region as far laterally as greater trochanter
Sciatic	Sacral plexus (L4–S3)	Exits pelvis via greater sciatic foramen inferior to piriformis to enter gluteal region	No muscles in gluteal region
Posterior cutaneous nerve of thigh	Sacral plexus (S1–S3)	Exits pelvis via greater sciatic foramen inferior to piriformis, emerges from inferior border of gluteus maximus coursing deep to fascia lata	Skin of buttock via inferior cluneal branches, skin over posterior thigh and popliteal fossa; skin of lateral perineum and upper medial thigh via perineal branch
Superior gluteal	Anterior rami of L4–S1 nerves	Exits pelvis via greater sciatic foramen superior to piriformis; courses between gluteus medius and minimus	Gluteus medius, gluteus minimus, and TFL
Inferior gluteal	Anterior rami of L5–S2 nerves	Exits pelvis via greater sciatic foramen inferior to piriformis, dividing into multiple branches	Gluteus maximus
Nerve to quadratus femoris	Anterior rami of L4–S1 nerves	Exits pelvis via greater sciatic foramen deep to sciatic nerve	Posterior hip joint, inferior gemellus, and quadratus femoris
Pudendal	Anterior rami of S2–S4 nerves	Exits pelvis via greater sciatic foramen inferior to piriformis; descends posterior to sacrospinous ligament; enters perineum (pudendal canal) through lesser sciatic foramen	No structures in gluteal region (supplies most of perineum)
Nerve to obturator internus	Anterior rami of L5–S2 nerves	Exits pelvis via greater sciatic foramen inferior to piriformis; descends posterior to ischial spine; enters lesser sciatic foramen and passes to obturator internus	Superior gemellus and obturator internus

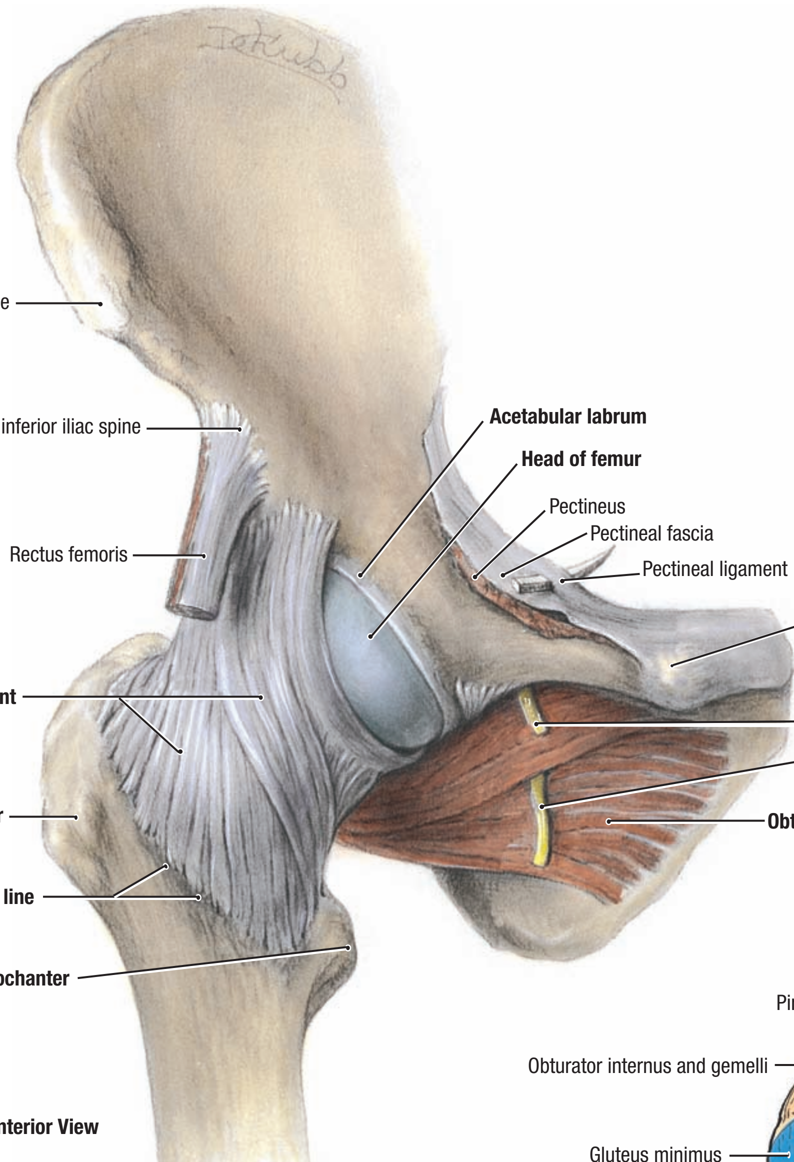




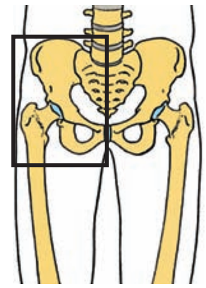
5.35 ARTERIES OF GLUTEAL REGION AND POSTERIOR THIGH

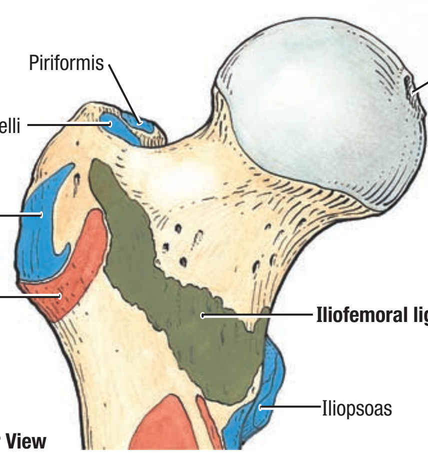
TABLE 5.10 ARTERIES OF GLUTEAL REGION AND POSTERIOR THIGH

Artery	Origin	Course	Distribution
Superior gluteal	Internal iliac	Enters gluteal region through greater sciatic foramen superior to piriformis; divides into superficial and deep branches; anastomoses with inferior gluteal and medial circumflex femoral arteries	*Superficial branch:* superior gluteus maximus *Deep branch:* runs between gluteus medius and minimus, supplying both and tensor fasciae latae
Inferior gluteal		Enters gluteal region through greater sciatic foramen inferior to piriformis; descends on medial side of sciatic nerve; anastomoses with superior gluteal artery and participates in cruciate anastomosis of thigh	Inferior gluteus maximus, obturator internus, quadratus femoris, and superior parts of ham-string muscles
Internal pudendal		Enters gluteal region through greater sciatic foramen; descends posterior to ischial spine; exits gluteal region via lesser sciatic fora-men to perineum	No structures in gluteal region (supplies external genitalia and muscles in perineal region)
Perforating arteries		Perforate aponeurotic portion of adductor magnus attachment and medial intermuscular septum to enter and supply muscular branches to posterior compartment; then pierce lateral intermuscular septum to enter posterolateral aspect of anterior compartment	Hamstring muscles in posterior compartment; posterior portion of vastus lateralis in anterior compartment; femur (via femoral nutrient arter-ies); reinforce arterial supply of sciatic nerve
Lateral circumflex femoral	Profunda femoris (may arise from femoral)	Passes laterally deep to sartorius and rectus femoris; enter gluteal region	Anterior part of gluteal region
Medial circumflex femoral		Passes medially and posteriorly between pectineus and iliopsoas; enters gluteal region	Supplies most blood to head and neck of femur; hip region



A. Anterior View





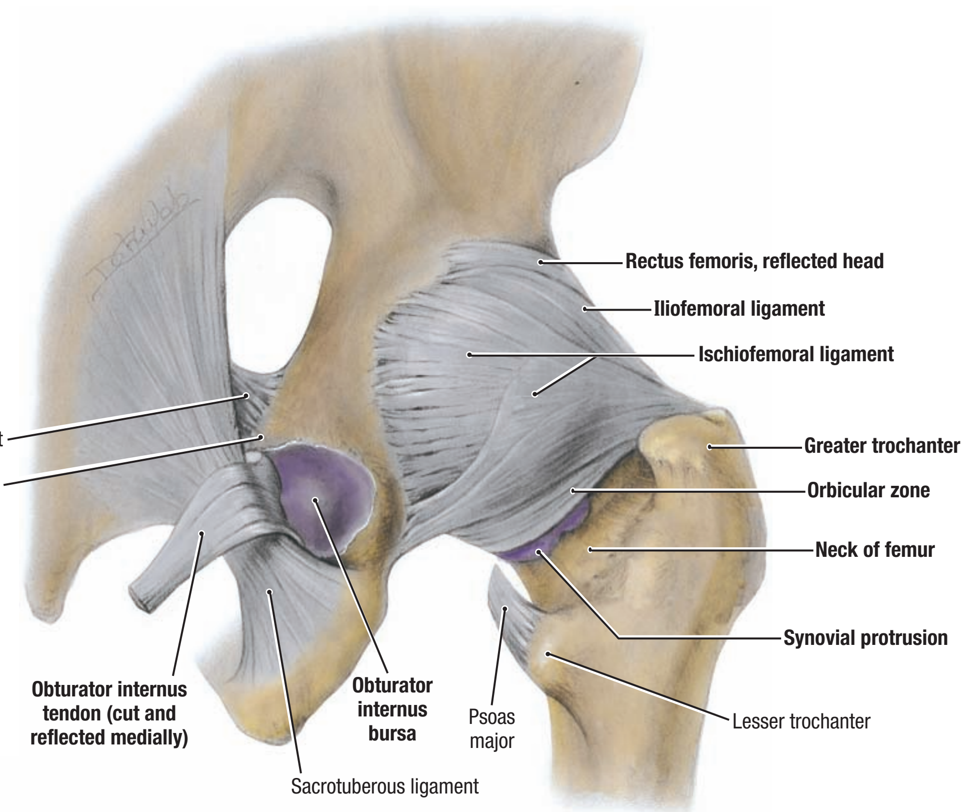
B. Anterior View

Key for B
- Proximal muscular attachment
- Distal muscular attachment
- Ligamentous attachment

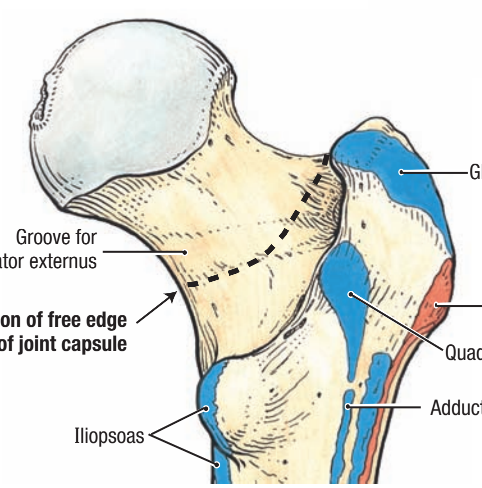
5.36 HIP JOINT

A. Iliofemoral ligament. **B.** Muscle attachments of anterior aspect of the proximal femur. In **A:**

- The head of the femur is exposed just medial to the iliofemoral ligament and faces superiorly, medially, and anteriorly. At the site of the subtendinous bursa of psoas, the capsule is weak or (as in this specimen) partially deficient, but it is guarded by the psoas tendon.
- The iliofemoral ligament, shaped like an inverted "Y." Superiorly it is attached deep to the rectus femoris muscle; the ligament becomes tight on medial rotation of the femur.
- The pectineus muscle is thin, and its fascia blends with the pectineal ligament.



C. **Posterior View**

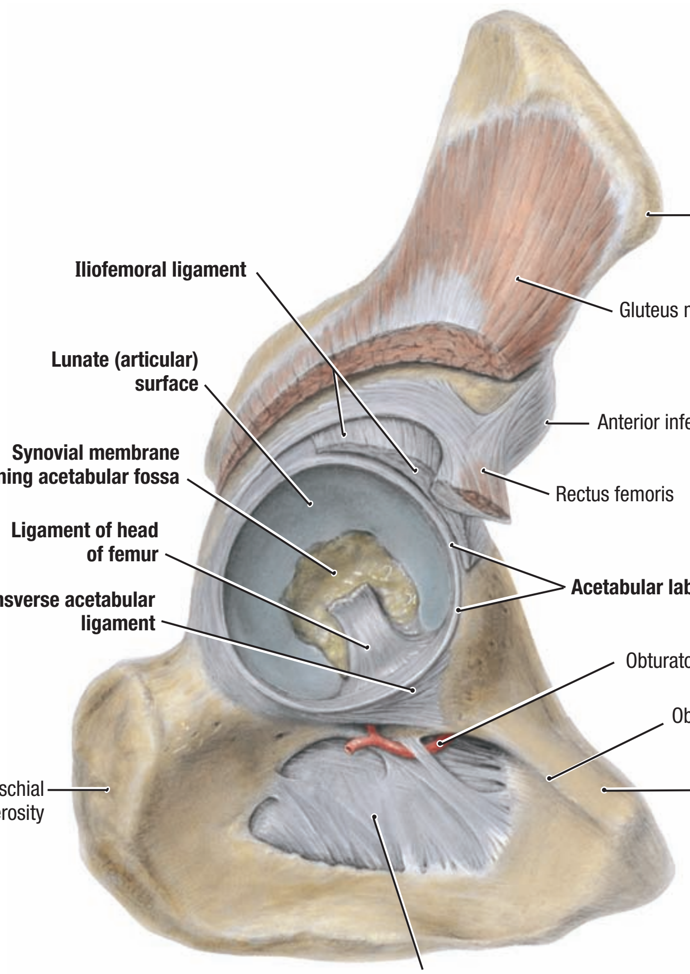


D. Posterior View

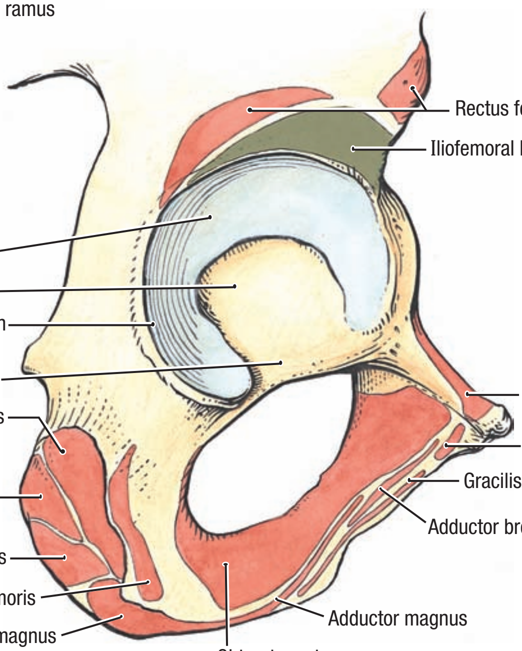
5.36 HIP JOINT (*CONTINUED*)

C. Ischiofemoral ligament. **D.** Muscle attachments onto the posterior aspect of proximal femur. In **C:**

- The fibers of the capsule spiral to become taut during extension and medial rotation of the femur.
- The synovial membrane protrudes inferior to the fibrous capsule and forms a bursa for the tendon of the obturator externus muscle. Note the large subtendinous bursa of the obturator internus at the lesser sciatic notch, where the tendon turns 90 degrees to attach to the greater trochanter.



A. **Anterolateral View**

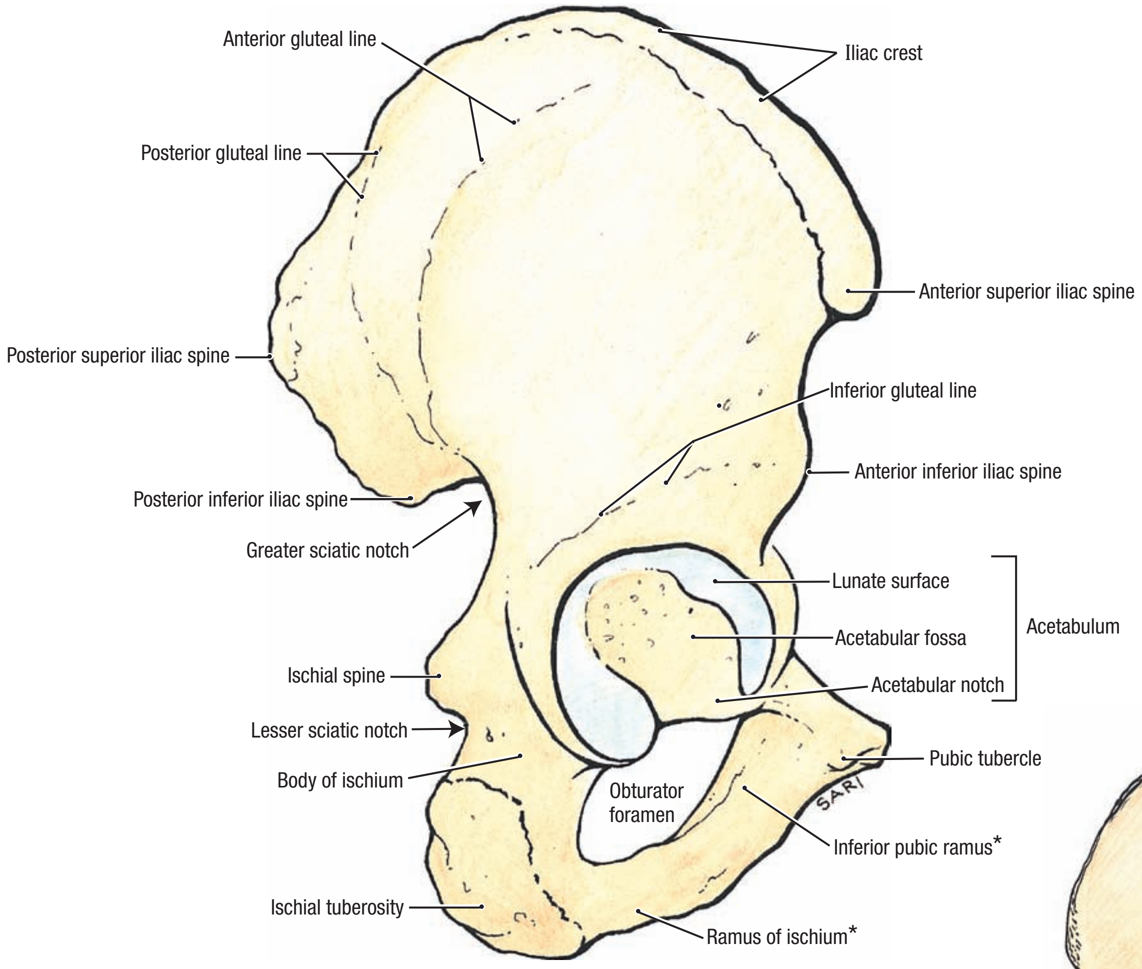


B. **Lateral View**

5.37 ACETABULAR REGION

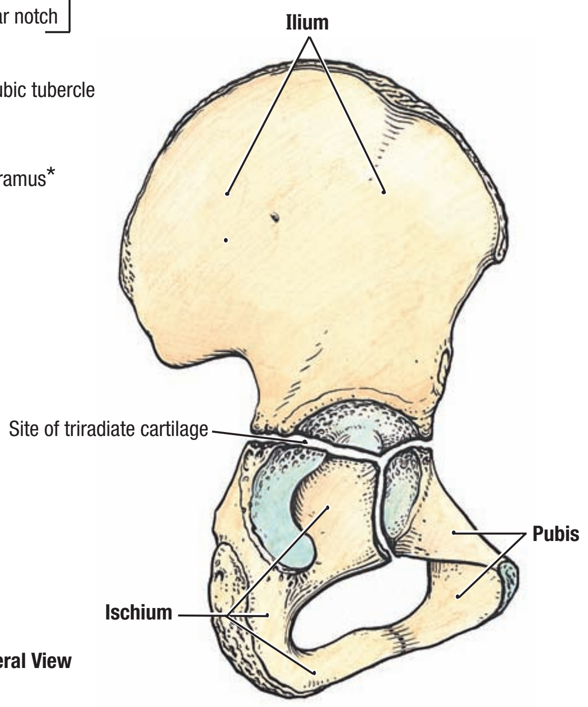
A. Dissection of acetabulum. **B.** Muscle attachments of acetabular region.
In **A:**

- The transverse acetabular ligament bridges the acetabular notch.
- The acetabular labrum is attached to the acetabular rim and transverse acetabular ligament and forms a complete ring around the head of the femur.
- The ligament of the head of the femur lies between the head of the femur and the acetabulum. These fibers are attached superiorly to the pit (fovea) on the head of the femur and inferiorly to the transverse acetabular ligament and the margins of the acetabular notch. The artery of the ligament of the head of the femur passes through the acetabular notch and into the ligament of the head of the femur.



A. Lateral View

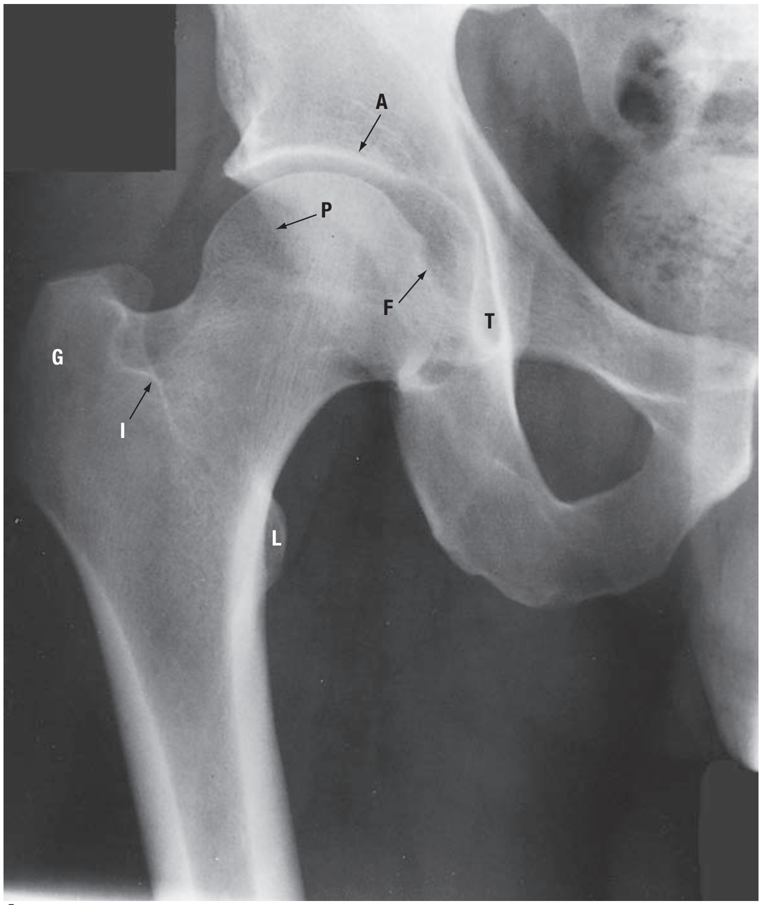
*Ischiopubic ramus



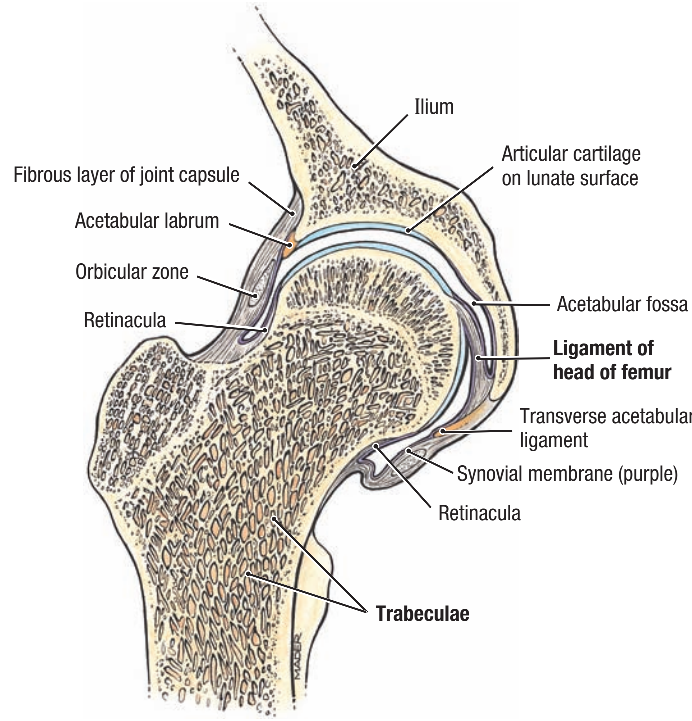
B. Lateral View

5.38 HIP BONE

A. Features of the lateral aspect. In the anatomical position, the anterior superior iliac spine and pubic tubercle are in the same coronal plane, and the ischial spine and superior end of the pubic symphysis are in the same horizontal plane; the internal aspect of the body of the pubis faces superiorly, and the acetabulum faces inferolaterally. **B.** Hip bone in youth. The three parts of the hip bone (ilium, ischium, and pubis) meet in the acetabulum at the triradiate synchondrosis. One or more primary centers of ossification appear in the triradiate cartilage at approximately the 12th year. Secondary centers of ossification appear along the length of the iliac crest, at the anterior inferior iliac spine, the ischial tuberosity, and the pubic symphysis at about puberty; fusion is usually complete by age 23.



A. **Anteroposterior View**

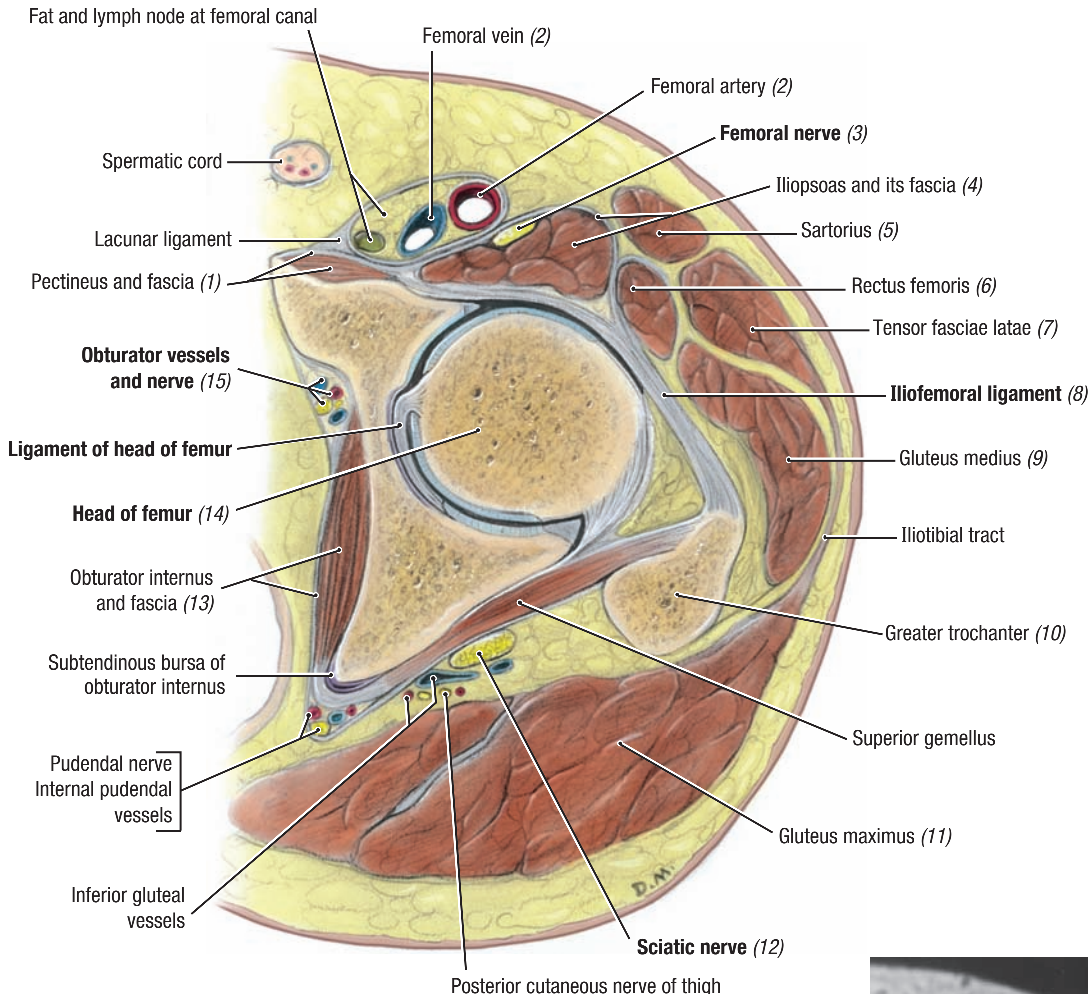


B. **Coronal Section**

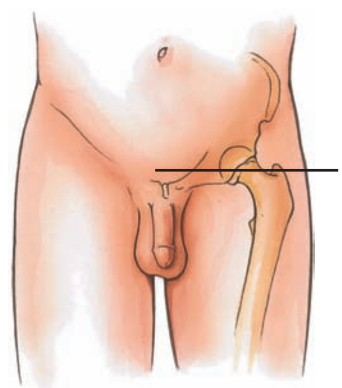
C. **Hip Prosthesis**

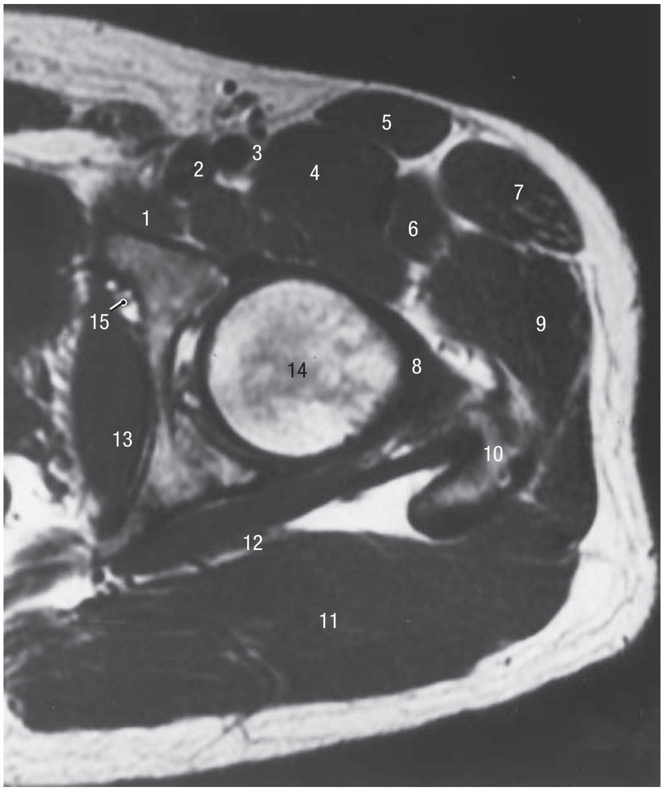
5.39 RADIOGRAPH AND CORONAL SECTION OF HIP JOINT

A. Radiograph. On the femur, note the greater (*G*) and lesser (*L*) trochanters, the intertrochanteric crest (*I*), and the pit or fovea (*F*) for the ligament of the head. On the pelvis, note the roof (*A*) and posterior rim (*P*) of the acetabulum and the "teardrop" appearance (*T*) caused by the superimposition of structures at the inferior margin of the acetabulum. **B.** Coronal section. Observe the bony trabeculae projecting into the head of the femur. The ligament of the head of the femur becomes taut during adduction of the hip joint, such as when crossing the legs. **C.** **Hip replacement.** The hip joint is subject to severe traumatic injury and degenerative disease. **Osteoarthritis of the hip joint**, characterized by pain, edema, limitation of motion, and erosion of articular cartilage, is a common cause of disability. During hip replacement, a metal prosthesis anchored to the femur by bone cement replaces the femoral head and neck. A plastic socket is cemented to the hip bone to replace the acetabulum. See Figure 5.41 clinical blue text.



A. Transverse Section, Inferior View



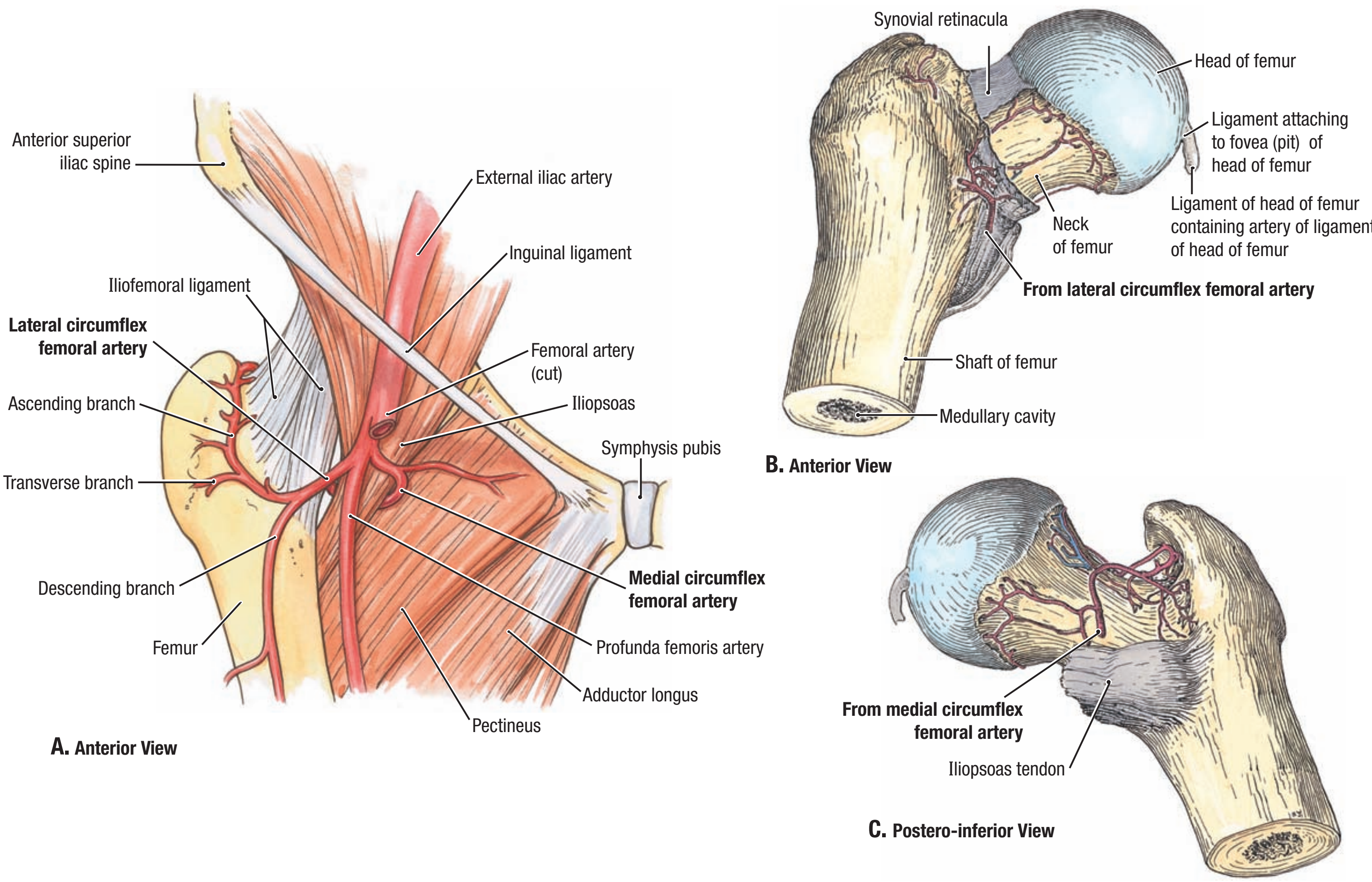


B. Transverse MRI

5.40 TRANSVERSE SECTION THROUGH THIGH AT LEVEL OF HIP JOINT

A. Transverse section. **B.** MRI (*numbers* refer to structures in **A**). In **A**:

- The fibrous capsule of the joint is thick where it forms the iliofemoral ligament and thin posterior to the subtendinous bursa of psoas and tendon.
- The femoral sheath, enclosing the femoral artery, vein, lymph node, lymph vessels, and fat, is free, except posteriorly where, between the psoas and pectineus muscles, it is attached to the capsule of the hip joint.
- The femoral vein is located at the interval between the psoas and pectineus muscles. The femoral nerve lies between the iliacus muscle and fascia.

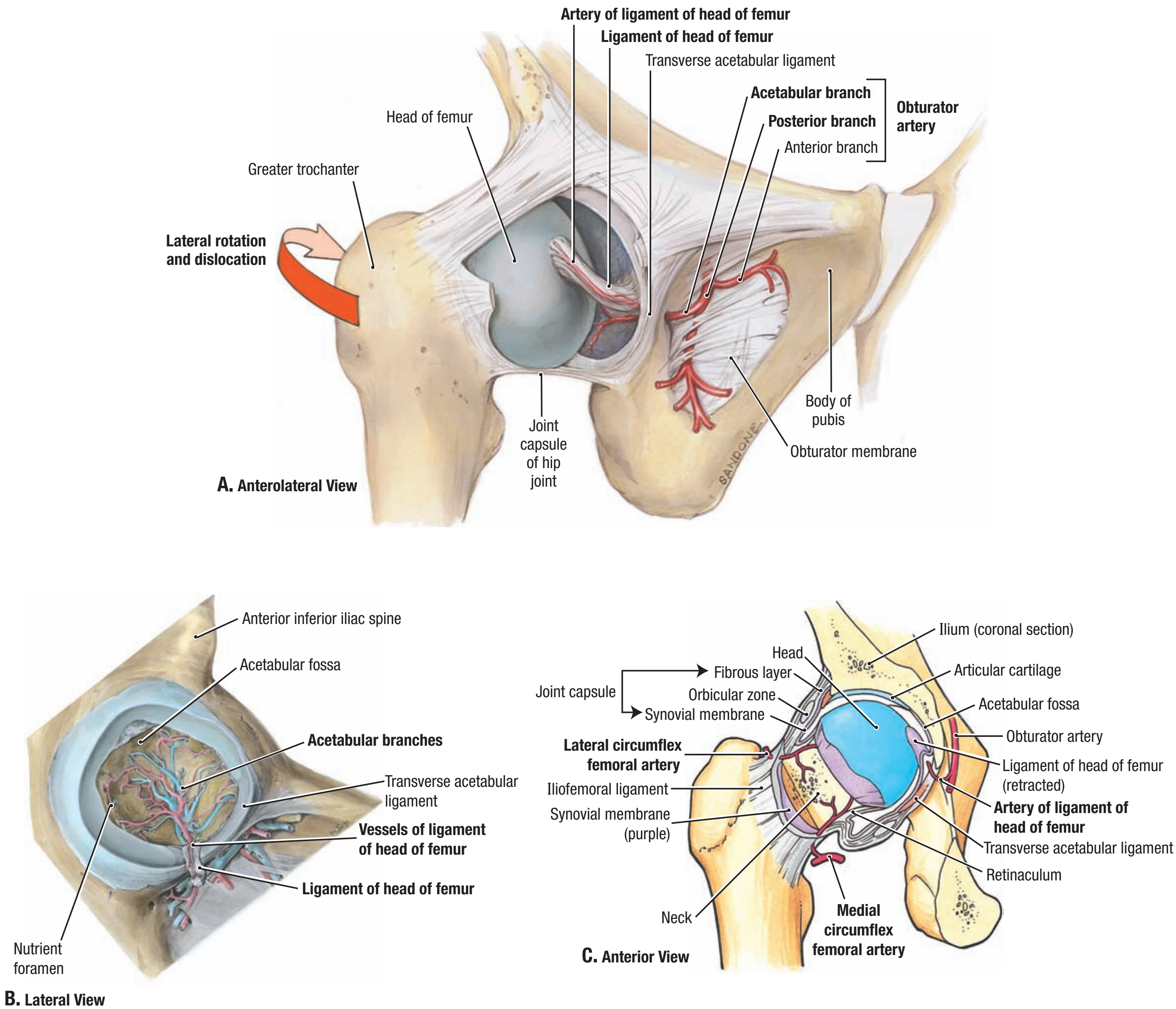


5.41 BLOOD SUPPLY TO HEAD OF FEMUR

A. Medial and lateral circumflex femoral arteries in femoral triangle. **B.** Branches of lateral circumflex femoral artery. **C.** Branches of medial circumflex femoral artery.

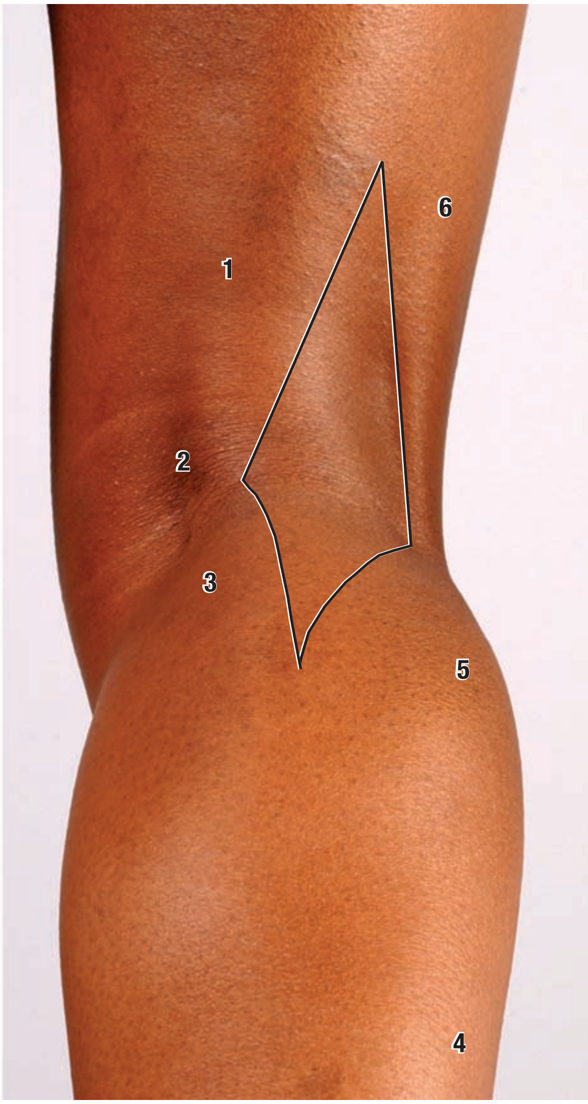
- Branches of the medial and lateral circumflex femoral arteries ascend on the posterosuperior and postero-inferior parts of the neck of the femur. The vessels ascend in synovial retinacula—reflections of synovial membrane along the neck of the femur. The retinacula (in **B** and **C**) have been mostly removed; thus, the vessels can be clearly visualized.
- The branches of the medial and lateral circumflex femoral arteries perforate the bone just distal to the head of the femur, where they anastomose with branches from the artery of the ligament of the head of the femur and with medullary branches located within the shaft of the femur.
- The ligament of the head of the femur usually contains the artery of the ligament of the head of the femur, a branch of the obturator artery. The artery enters the head of the femur only when the center of the ossification has extended to the pit (fovea) for the ligament of the head (12th to 14th year). When present, this anastomosis persists even in advanced age; however, in 20% of persons, it is never established.

Fractures of the femoral neck often disrupt the blood supply to the head of the femur. The medial circumflex femoral artery supplies most of the blood to the head and neck of the femur and is often torn when the femoral neck is fractured. In some cases, the blood supplied by the artery of the ligament of the head may be the only blood received by the proximal fragment of the femoral head, which may be inadequate. If the blood vessels are ruptured, the fragment of bone may receive no blood and undergo aseptic avascular necrosis.

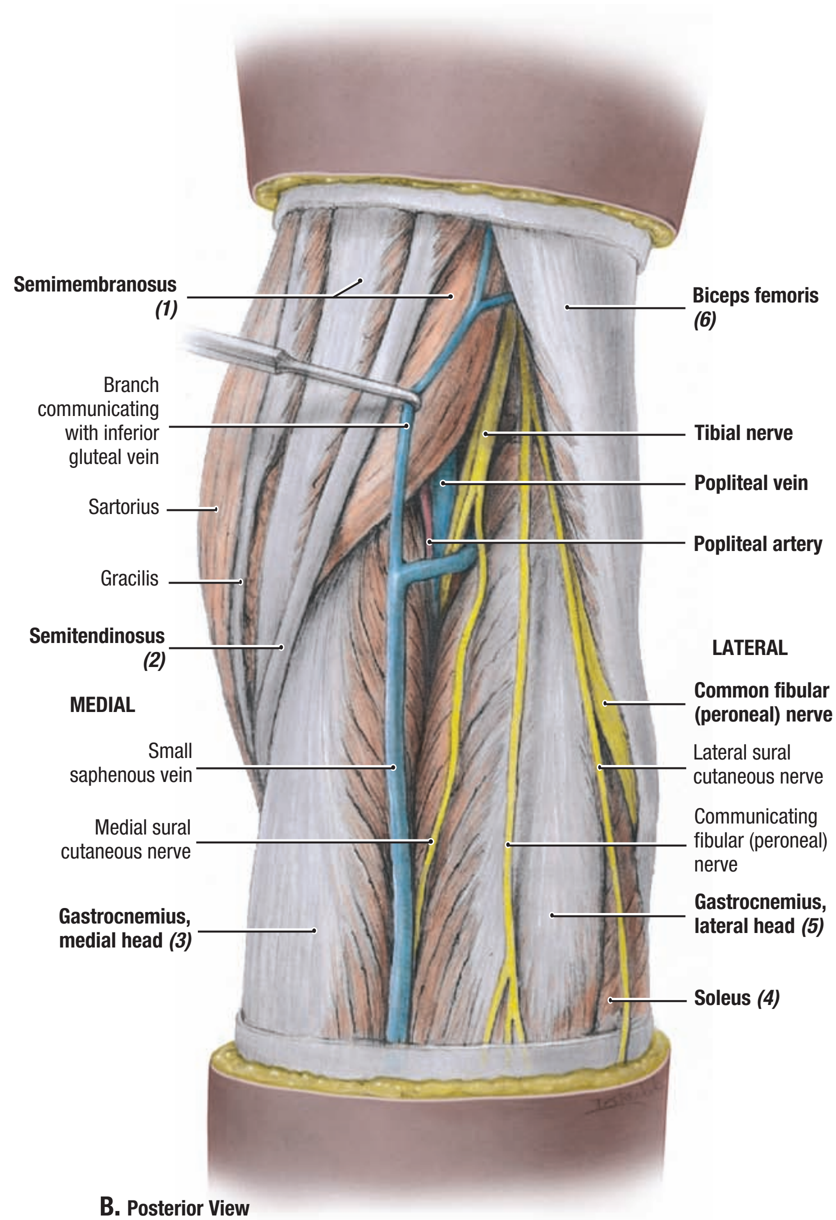


5.42 BLOOD VESSELS OF ACETABULAR FOSSA AND LIGAMENT OF HEAD OF FEMUR

A. Obturator artery. The hip joint has been dislocated to reveal the ligament of the head of the femur. The obturator artery divides into anterior and posterior branches, and the acetabular branch arises from the posterior branch. The artery of the ligament of the head of the femur is a branch of the acetabular artery and can be seen traveling in the ligament to the head of the femur. **B.** Acetabular artery and vein. The acetabular branches (artery and vein) pass through the acetabular foramen and enter the acetabular fossa, where they diverge in the fatty areolar tissue. The branches radiate to the margin of the fossa, where they enter nutrient foramina. **C.** Blood supply of the head and neck of the femur. A section of bone has been removed from the femoral neck.



A. Posterior View



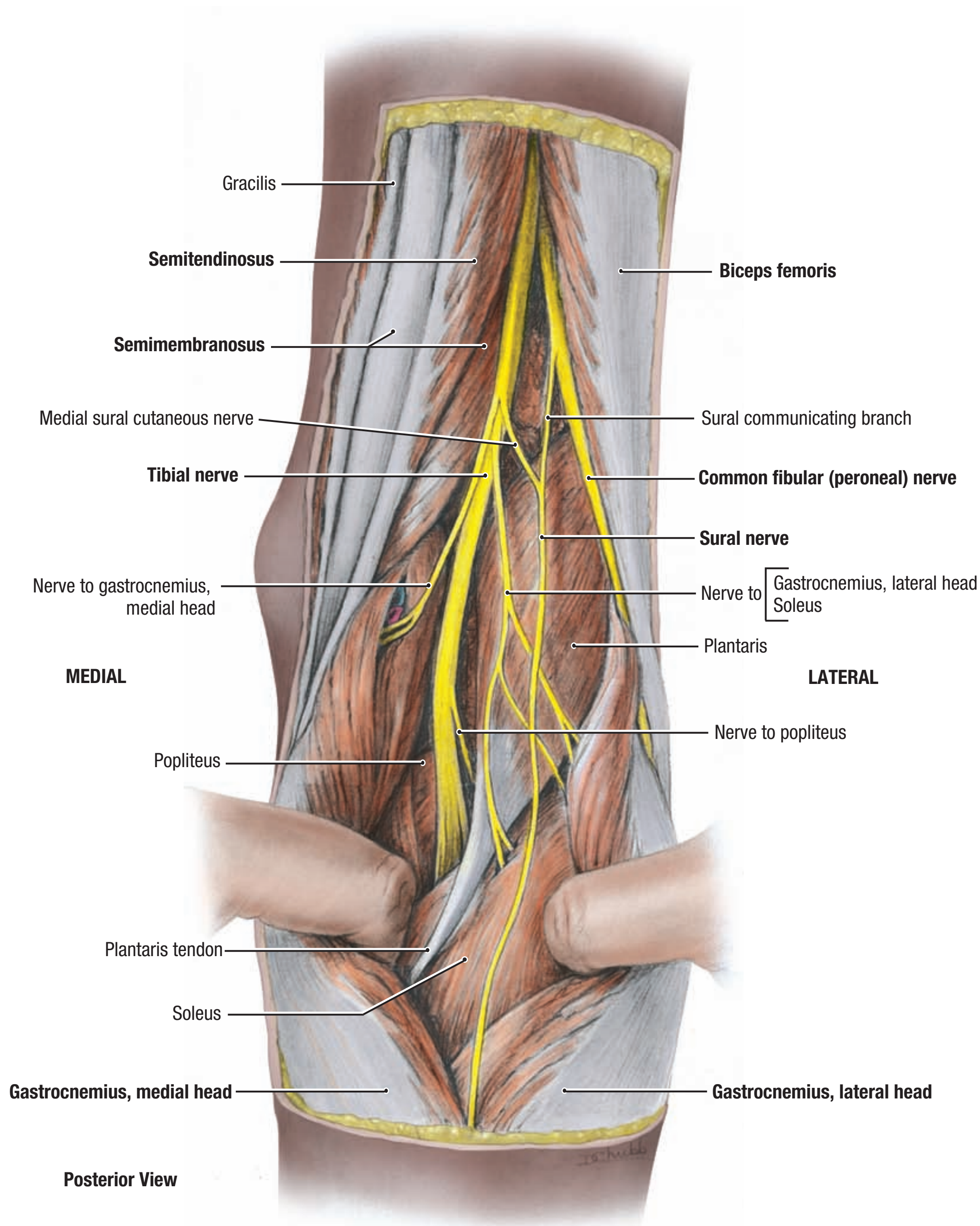
B. Posterior View

5.43 POPLITEAL FOSSA

A. Surface anatomy (*numbers* refer to structures in **B**). **B.** Superficial dissection.

- The two heads of the gastrocnemius muscle are embraced on the medial side by the semimembranosus muscle, which is overlaid by the semitendinosus muscle, and on the lateral side by the biceps femoris muscle.
- The small saphenous vein runs between the two heads of the gastrocnemius muscle. Deep to this vein is the medial sural cutaneous nerve, which, followed proximally, leads to the tibial nerve. The tibial nerve is superficial to the popliteal vein, which, in turn, is superficial to the popliteal artery.

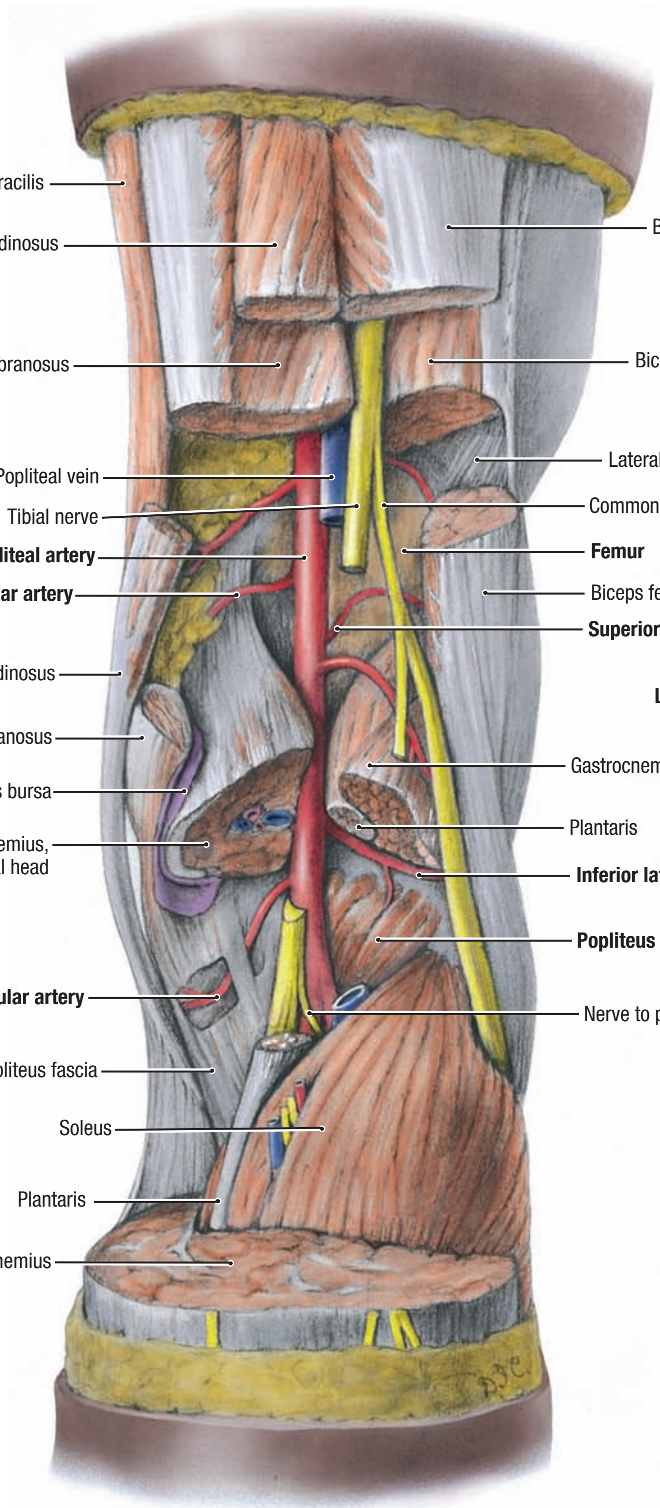
Because the popliteal artery is deep in the popliteal fossa, it may be difficult to feel the **popliteal pulse.** Palpation of this pulse is commonly performed by placing the person in the prone position with the knee flexed to relax the popliteal fascia and hamstrings. The pulsations are best felt in the inferior part of the fossa. Weakening or loss of the popliteal pulse is a sign of femoral artery obstruction.



5.44 NERVES OF POPLITEAL FOSSA

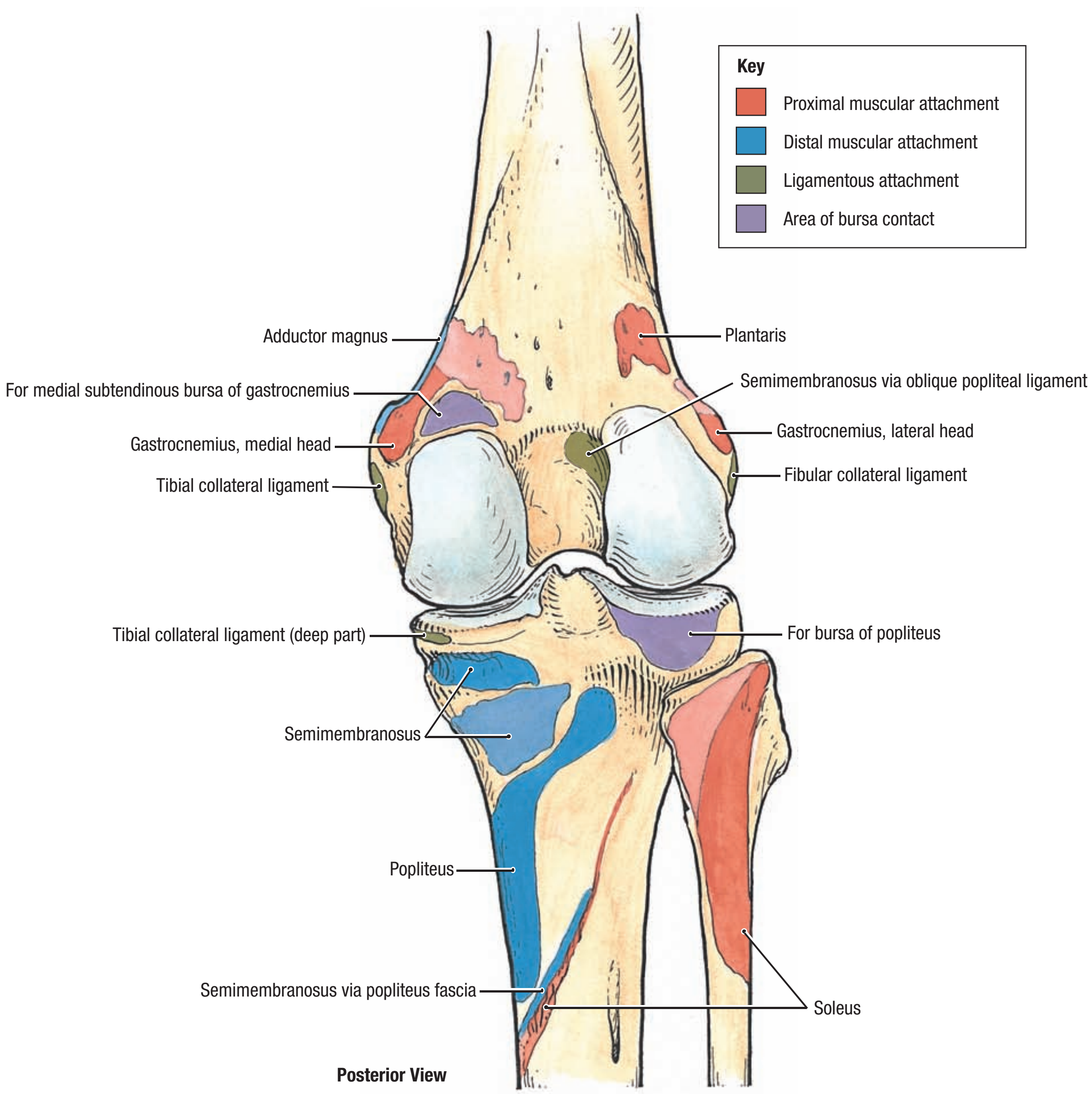
The two heads of the gastrocnemius muscle are separated. A cutaneous branch of the tibial nerve joins a cutaneous branch of the common fibular (peroneal) nerve to form the sural nerve. In this specimen, the junction is high; usually it is 5 to 8 cm proximal to the ankle.

All motor branches in this region emerge from the tibial nerve, one branch from its medial side and the others from its lateral side; hence, it is safer to dissect on the medial side.



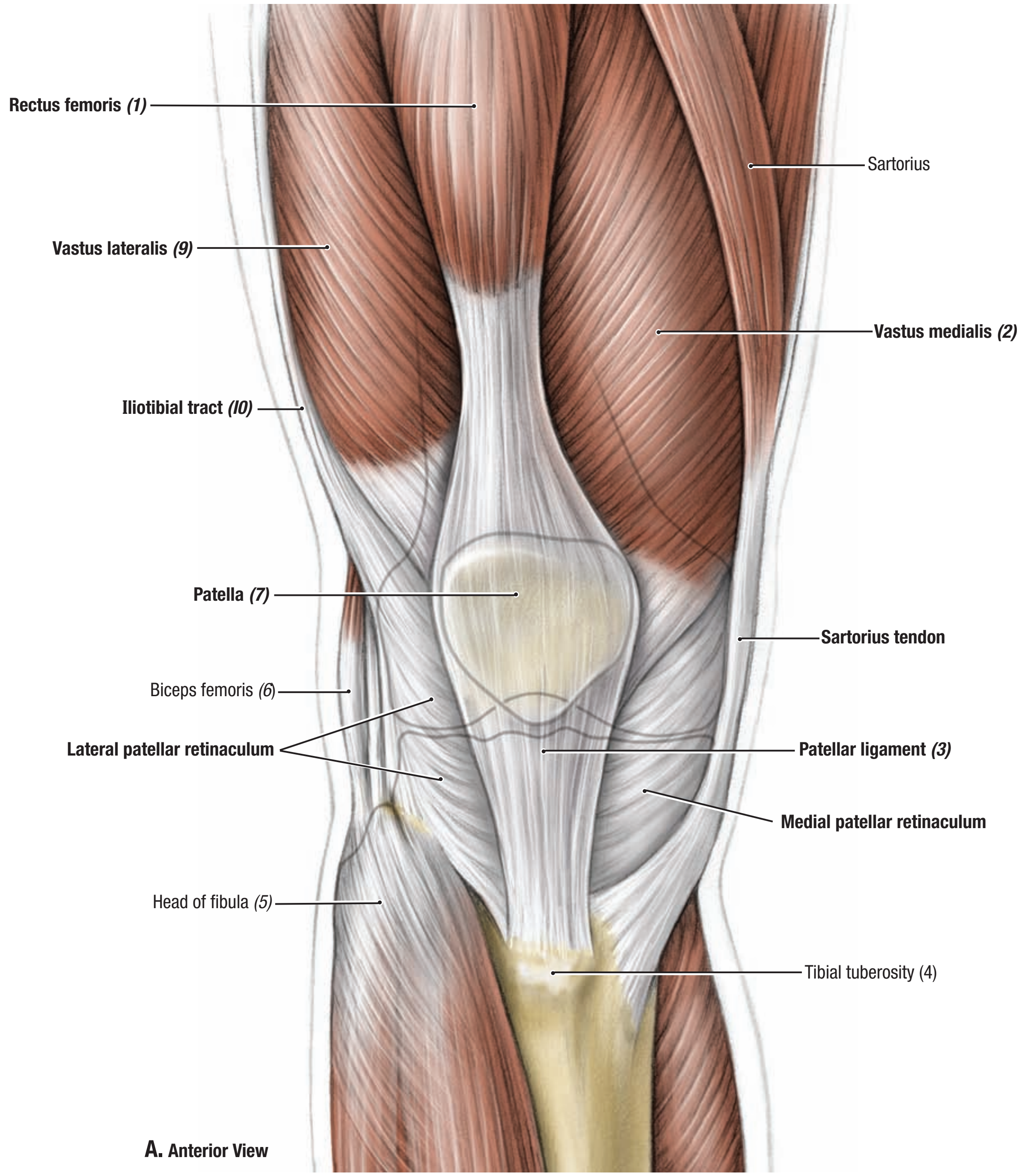
5.45 DEEP DISSECTION OF POPLITEAL FOSSA

The common fibular (peroneal) nerve follows the posterior border of the biceps femoris muscle and, in this specimen, gives off two cutaneous branches. The popliteal artery lies on the floor of the popliteal fossa. The floor is formed by the femur, capsule of the knee joint, and popliteus muscle and fascia. The popliteal artery gives off genicular branches that also lie on the floor of the fossa. A **popliteal aneurysm** (abnormal dilation of all or part of the popliteal artery) usually causes edema (swelling) and pain in the popliteal fossa. If the femoral artery has to be ligated, blood can bypass the occlusion through the genicular anastomosis and reach the popliteal artery distal to the ligation.



5.46 ATTACHMENT OF MUSCLES OF POPLITEAL REGION

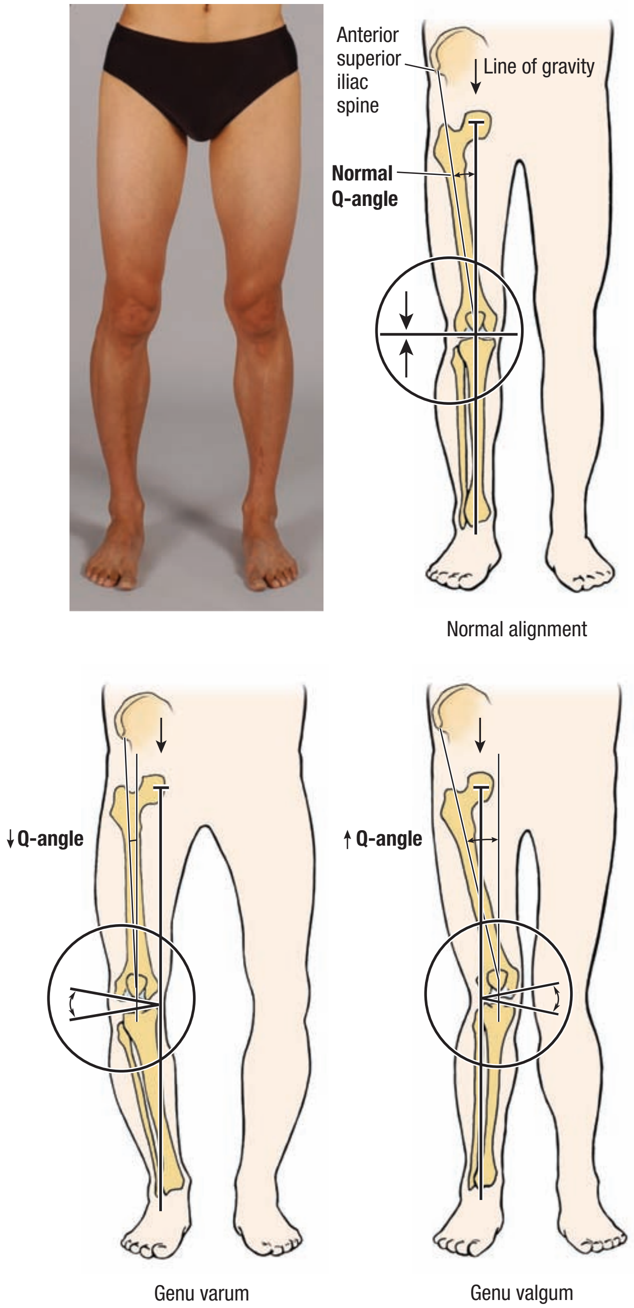
Lighter tones are secondary attachments.



5.47 ANTERIOR ASPECT OF KNEE

A. Distal thigh and knee regions. Note that the tendons of the four parts of the quadriceps unite to form the quadriceps tendon, a broad band that attaches to the patella. The patellar ligament, a continuation of the quadriceps tendon, attaches the patella to the tibial tuberosity. The lateral and medial patellar retinacula, formed largely by continuation of the iliotibial tract, and investing fascia of the vasti muscles, maintains alignment of the patella and patellar ligament. The retinacula also form the anterolateral and anteromedial portions of the fibrous layer of the joint capsule of the knee.

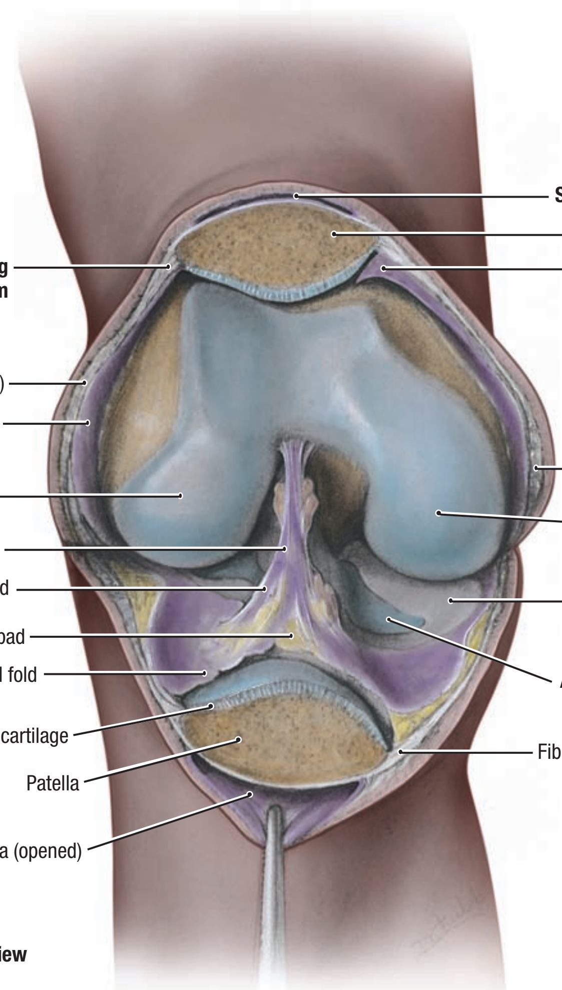
B. Anterior Views



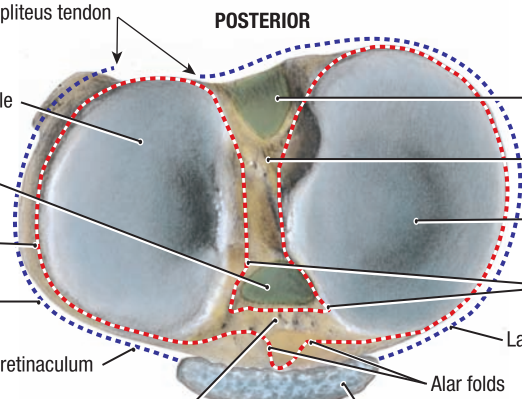
C. Anterior Views

5.47 ANTERIOR ASPECT OF KNEE (*CONTINUED*)

B. Surface anatomy (numbers refer to structures in **A**). The femur is placed diagonally within the thigh, whereas the tibia is almost vertical within the leg, creating an angle at the knee between the long axes of the bones. The angle between the two bones, referred to clinically as the **Q-angle,** is assessed by drawing a line from the anterior superior iliac spine to the middle of the patella and extrapolating a second (vertical) line passing through the middle of the patella and tibial tuberosity. The Q-angle is typically greater in adult females, owing to their wider pelves. **C. Genu valgum and genu varum.** A medial angulation of the leg in relation to the thigh, in which the femur is abnormally vertical and the Q-angle is small, is a deformity called genu varum (bowleg) that causes unequal weight bearing resulting in arthrosis (destruction of knee cartilages), and an overstressed fibular collateral ligament. A lateral angulation of the leg (large Q-angle, >17 degrees) in relation to the thigh is called genu valgum (knock-knee). This results in excess stress and degeneration of the lateral structures of the knee joint.



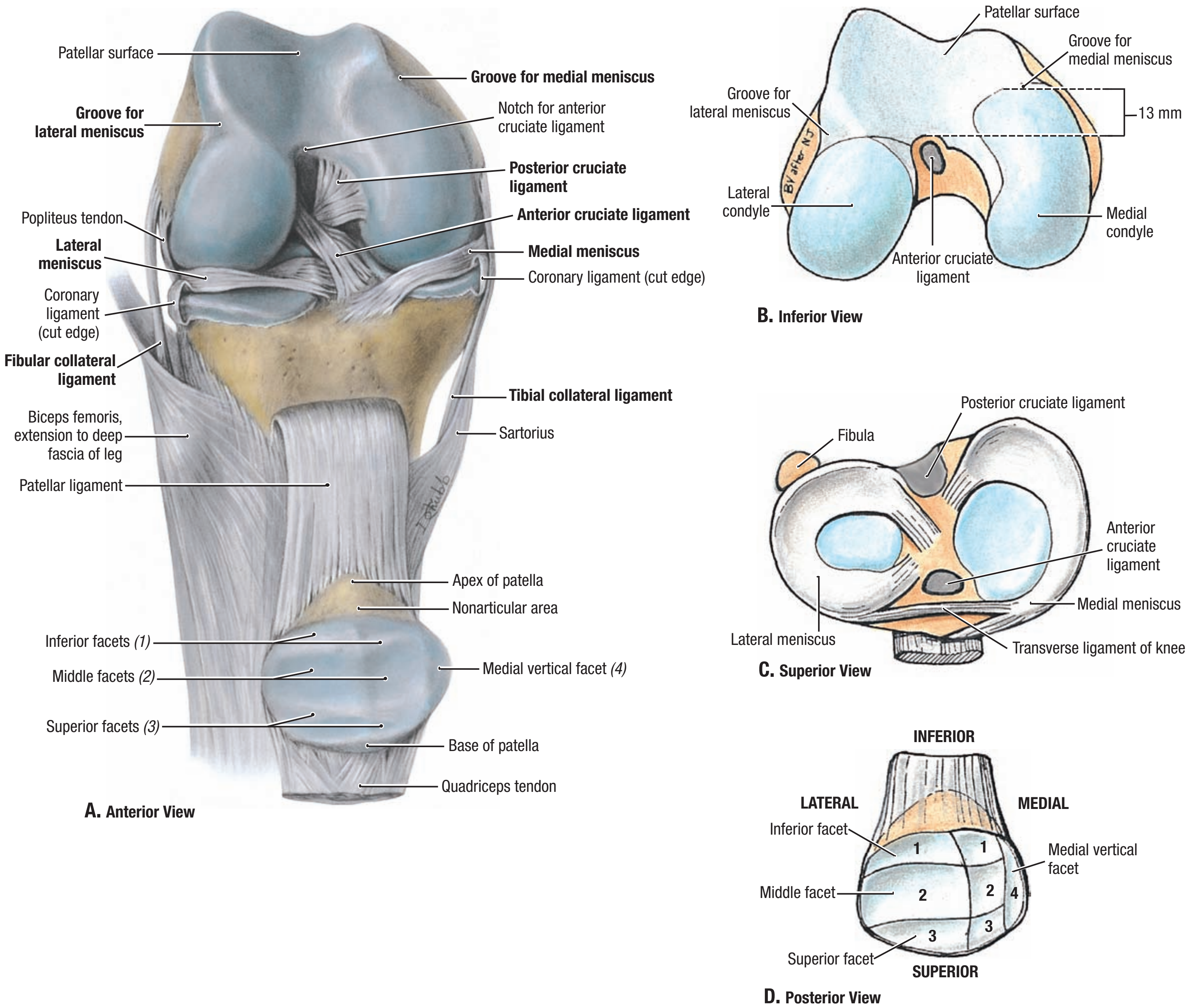
A. Anterior View



B. Superior View of Superior Articular Surface of Tibia (Tibial Plateau)

5.48 FIBROUS LAYER AND SYNOVIAL MEMBRANE OF JOINT CAPSULE

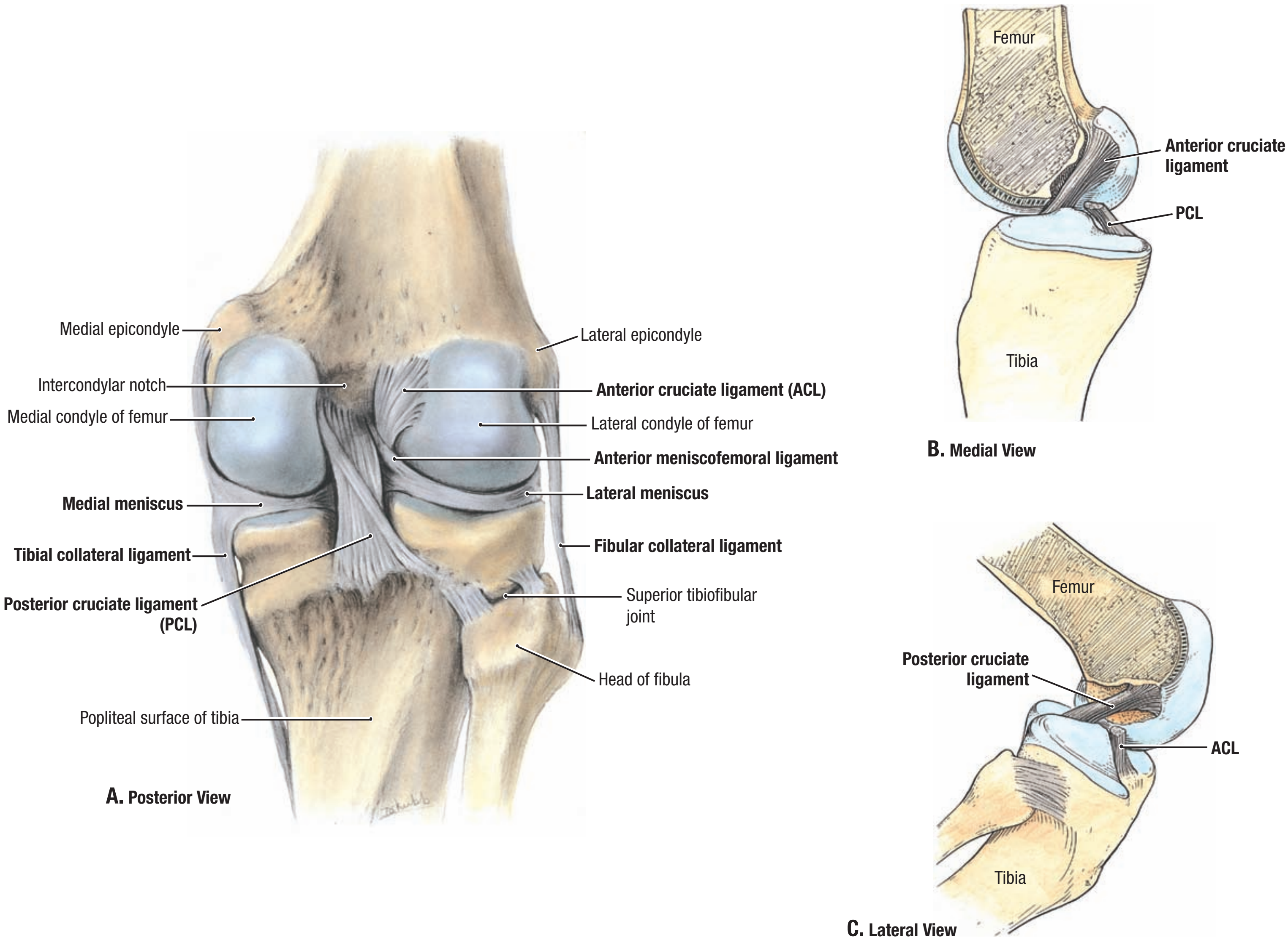
A. Dissection. **B.** Attachment of the layers of the joint capsule to the tibia. The fibrous layer (*blue dotted line*) and synovial membrane (*red dotted line*) are adjacent on each side, but they part company centrally to accommodate intercondylar and infrapatellar structures that are intracapsular (inside the fibrous layer) but extra-articular (excluded from the articular cavity by synovial membrane).



5.49 ARTICULAR SURFACES AND LIGAMENTS OF KNEE JOINT

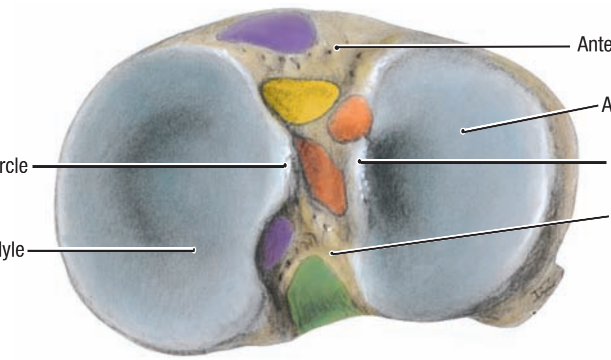
A. Flexed knee joint with patella reflected. There are indentations on the sides of the femoral condyles at the junction of the patellar and tibial articular areas. The lateral tibial articular area is shorter than the medial one. The notch at the anterolateral part of the intercondylar notch is for the anterior cruciate ligament on full extension. **B.** Distal femur. **C.** Tibial plateaus. **D.** Articular surfaces of patella. The three paired facets (superior, middle, and inferior) on the posterior surface of the patella articulate with the patellar surface of the femur successively during (*1*) extension, (*2*) slight flexion, (*3*) flexion, and the most medial vertical facet on the patella (*4*) articulates during full flexion with the crescentic facet on the medial margin of the intercondylar notch of the femur.

When the **patellar dislocation** occurs, it nearly always dislocates laterally. The tendency toward lateral dislocation is normally counterbalanced by the medial, more horizontal pull of the powerful vastus medialis. In addition, the more anterior projection of the lateral femoral condyle and deeper slope for the large lateral patellar facet provides a mechanical deterrent to lateral dislocation. An imbalance of the lateral pull and the mechanisms resisting it result in abnormal tracking of the patella within the patellar groove and chronic patellar pain, even if actual dislocation does not occur.

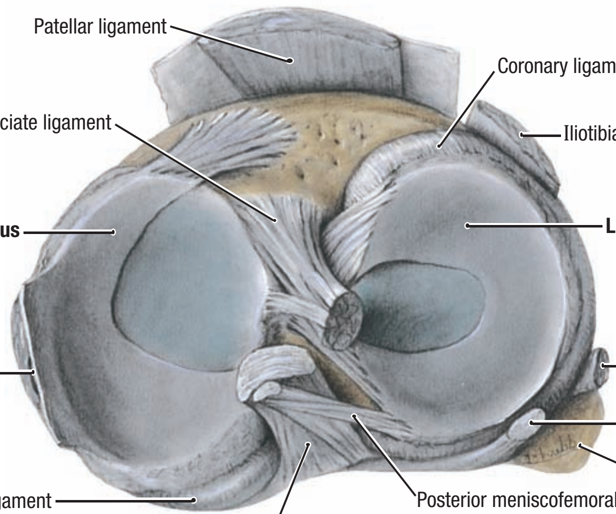


5.50 LIGAMENTS OF KNEE JOINT

A. Posterior aspect of joint. The bandlike tibial (medial) collateral ligament is attached to the medial meniscus, and the cordlike fibular (lateral) collateral ligament is separated from the lateral meniscus by the width of the popliteus tendon (removed). The posterior cruciate ligament is joined by a cord from the lateral meniscus called the anterior meniscofemoral ligament. The posterior meniscofemoral ligament attaches to the medial condyle of the femur just posterior to the attachment of the posterior cruciate ligament. **B.** Anterior cruciate ligament (ACL). **C.** Posterior cruciate ligament (PCL). In each illustration, half the femur is sagittally sectioned and removed with the proximal part of the corresponding cruciate ligament. Note that the posterior cruciate ligament prevents the femur from sliding anteriorly on the tibia, particularly when the knee is flexed. The anterior cruciate ligament prevents the femur from sliding posteriorly on the tibia, preventing hyperextension of the knee, and limits medial rotation of the femur when the foot is on the ground (i.e., when the leg is fixed). **Injury to the knee joint** is frequently caused by a blow to the lateral side of the extended knee or excessive lateral twisting of the flexed knee, which disrupts the tibial collateral ligament and concomitantly tears and/or detaches the medial meniscus from the joint capsule. This injury is common in athletes who twist their flexed knees while running (e.g., in football and soccer). The anterior cruciate ligament, which serves as a pivot for rotary movements of the knee, is taut during flexion and may also tear subsequent to the rupture of the tibial collateral ligament.



A. Superior View



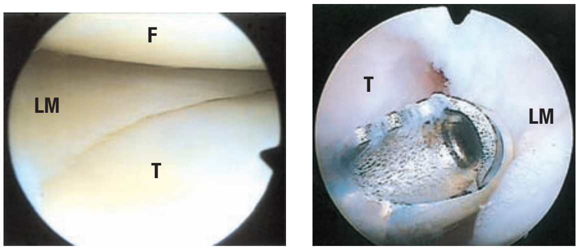
B. Superior View

5.51 CRUCIATE LIGAMENTS AND MENISCI

A. Attachments sites on tibia. **B.** Menisci in situ.

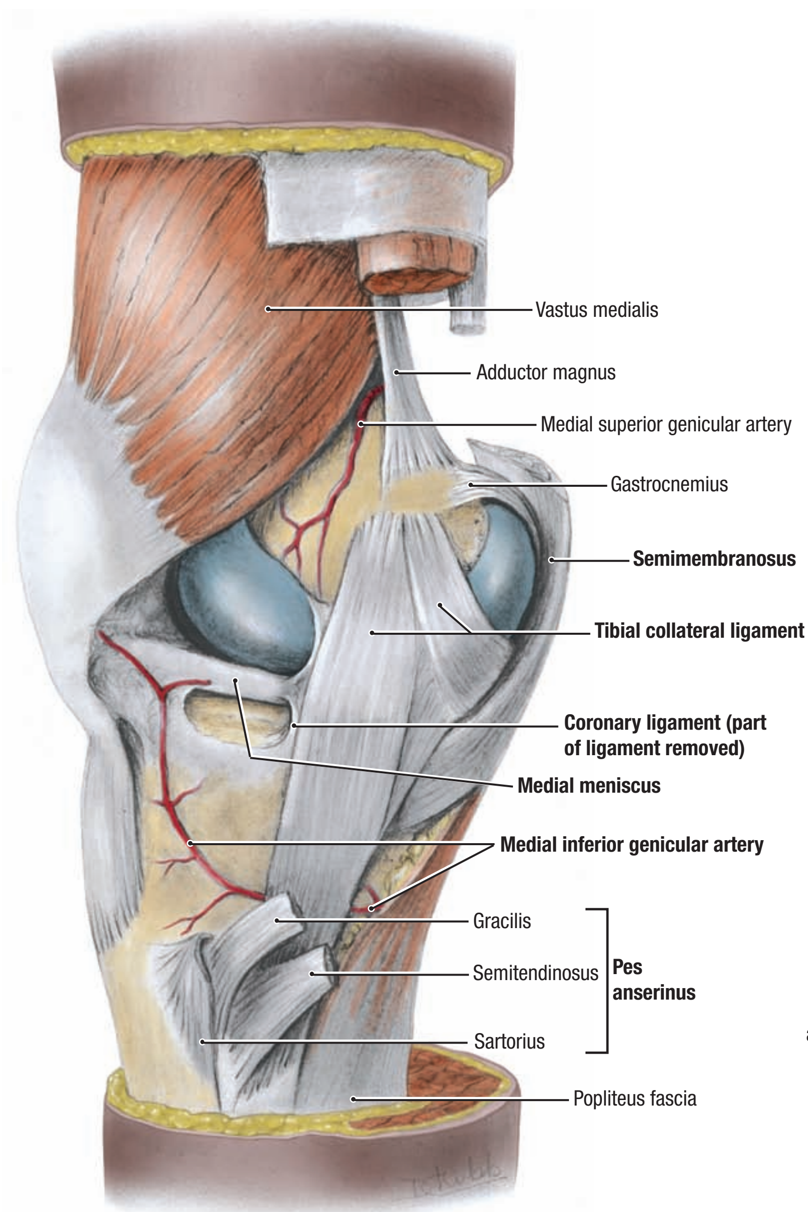
- The lateral tibial condyle is flatter, shorter from anterior to posterior, and more circular. The medial condyle is concave, longer from anterior to posterior, and more oval.
- The menisci conform to the shapes of the surfaces on which they rest. Because the horns of the lateral meniscus are attached close together and its coronary ligament is slack, this meniscus can slide anteriorly and posteriorly on the (flat) condyle; because the horns of the medial meniscus are attached further apart, its movements on the (concave) condyle are restricted.

Arthroscopy is an endoscopic examination that allows visualization of the interior of the knee joint cavity with minimal disruption of tissue. The arthroscope and one (or more) additional canula(e) are inserted through tiny incisions, known as portals. The second canula is for passage of specialized tools (e.g., manipulative probes or forceps) or equipment for trimming, shaping, or removing damaged tissue. This technique allows removal of torn menisci, loose bodies in the joint such as bone chips, and debridement (the excision of devitalized articular cartilaginous material in advanced cases of arthritis). Ligament repair or replacement may also be performed using an arthroscope.

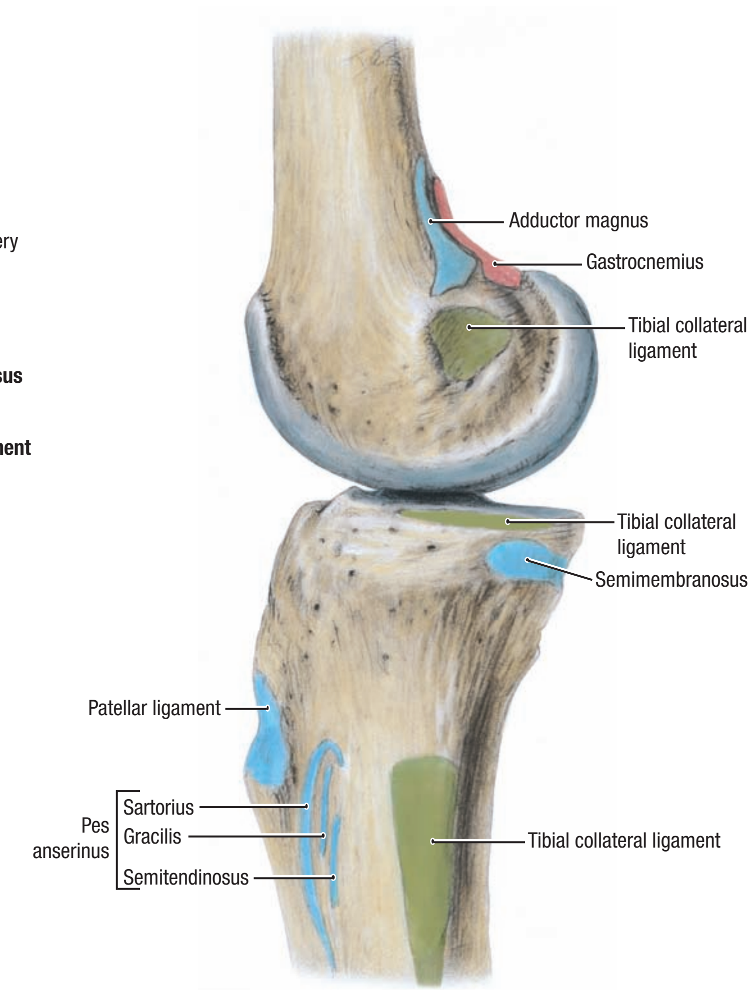


Normal lateral meniscus **Trimming torn lateral meniscus**

C. Femoral condyle (F), Tibial plateau (T), Lateral meniscus (LM)



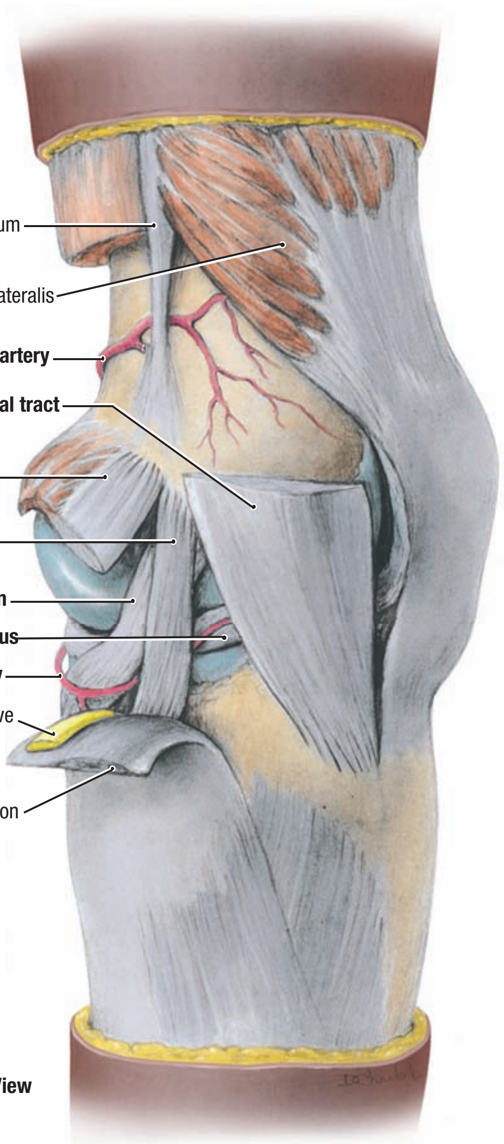
A. Medial View



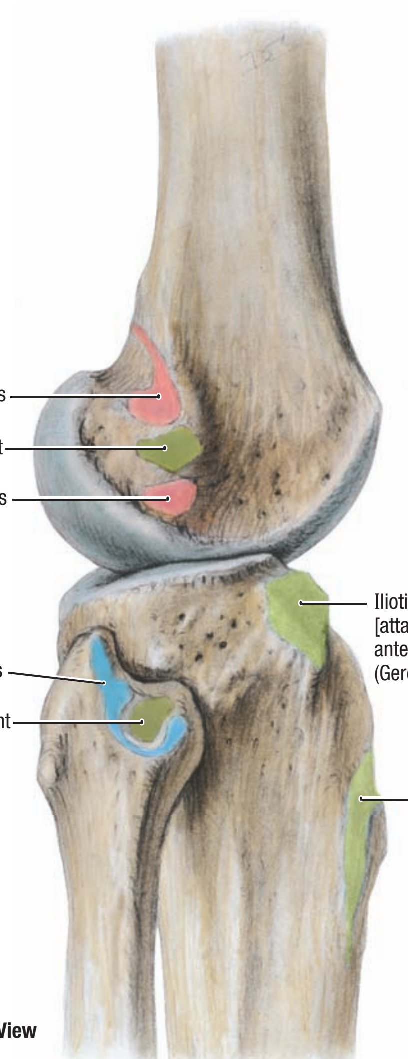
B. Medial View

5.52 MEDIAL ASPECT OF KNEE

A. Dissection. The bandlike part of the tibial collateral ligament attaches to the medial epicondyle of the femur, bridges superficial to the insertion of the semimembranosus muscle, and crosses the medial inferior genicular artery. Distally, the ligament is crossed by the three tendons forming the pes anserinus (sartorius, gracilis, and semitendinosus). **B.** Bones, showing muscle and ligament attachment sites.



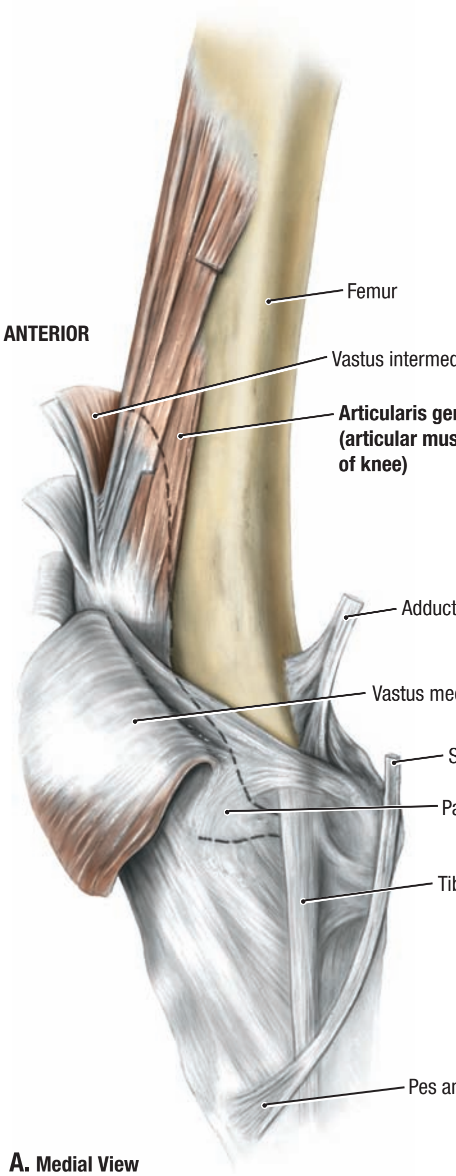
A. Lateral View



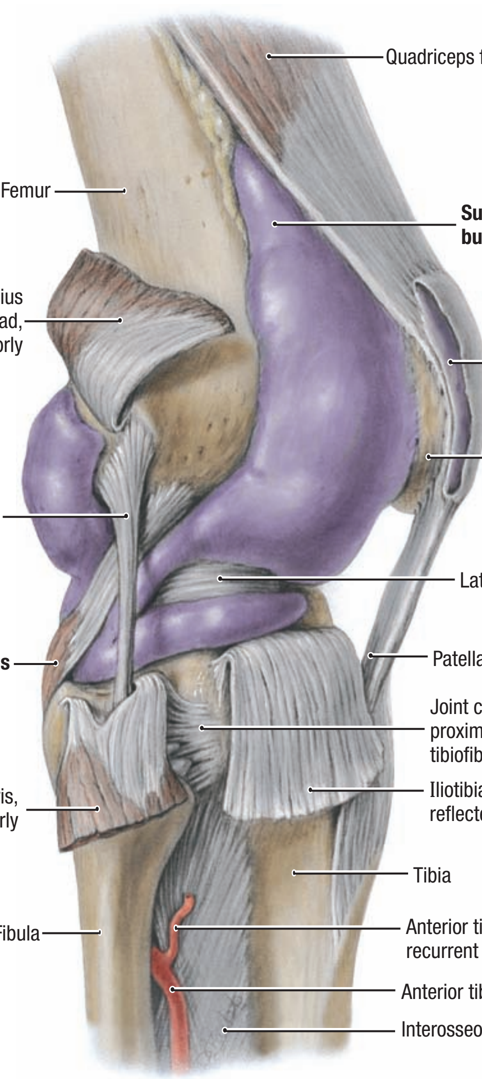
B. Lateral View

5.53 LATERAL ASPECT OF KNEE

A. Dissection. **B.** Bones, showing muscle and ligament attachments. Three structures arise from the lateral epicondyle and are uncovered by reflecting the biceps muscle: the gastrocnemius muscle is posterosuperior; the popliteus muscle is antero-inferior; and the fibular collateral ligament is in between, crossing superficial to the popliteus muscle. The lateral inferior genicular artery courses along the lateral meniscus.



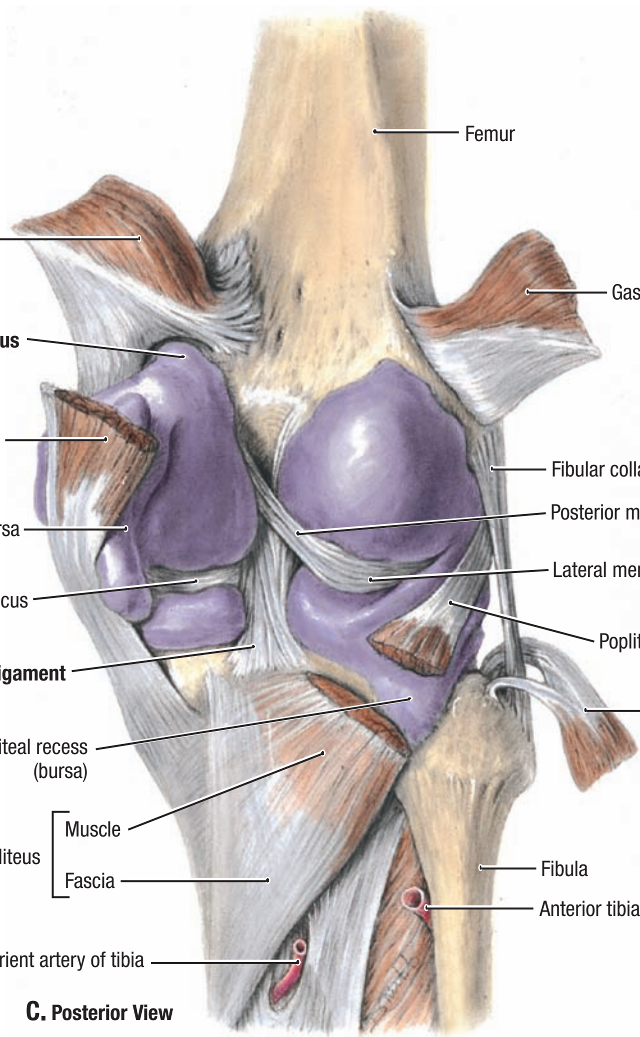
A. Medial View



B. Lateral View

5.54 ARTICULARIS GENU AND BURSAE OF KNEE REGION

A. Articularis genu (articular muscle of the knee). This muscle lies deep to the vastus intermedius muscle and consists of fibers arising from the anterior surface of the femur proximally and attaching into the synovial membrane distally. The articularis genu pulls the synovial membrane of the suprapatellar bursa (*dotted line*) superiorly during extension of the knee so that it will not be caught between the patella and femur within the knee joint. **B.** Lateral aspect of knee. Latex was injected into the articular cavity and fixed with acetic acid. The distended synovial membrane was exposed and cleaned. The gastrocnemius muscle was reflected proximally, and the biceps femoris muscle and the iliotibial tract were reflected distally. The extent of the synovial capsule: superiorly, it rises superior to the patella, where it rests on a layer of fat that allows it to glide freely with movements of the joint; this superior part is called the suprapatellar bursa; posteriorly, it rises as high as the origin of the gastrocnemius muscle; laterally, it curves inferior to the lateral femoral epicondyle, where the popliteus tendon and fibular collateral ligament are attached; and inferiorly, it bulges inferior to the lateral meniscus, overlapping the tibia (the coronary ligament is removed to show this). **Prepatellar bursitis** (housemaid's knee) is usually a friction bursitis caused by friction between the skin and the patella. The suprapatellar bursa communicates with the articular cavity of the knee joint; consequently, abrasions or penetrating wounds superior to the patella may result in **suprapatellar bursitis** caused by bacteria entering the bursa from the torn skin. The infection may spread to the knee joint. **C.** Posterior aspect of knee.

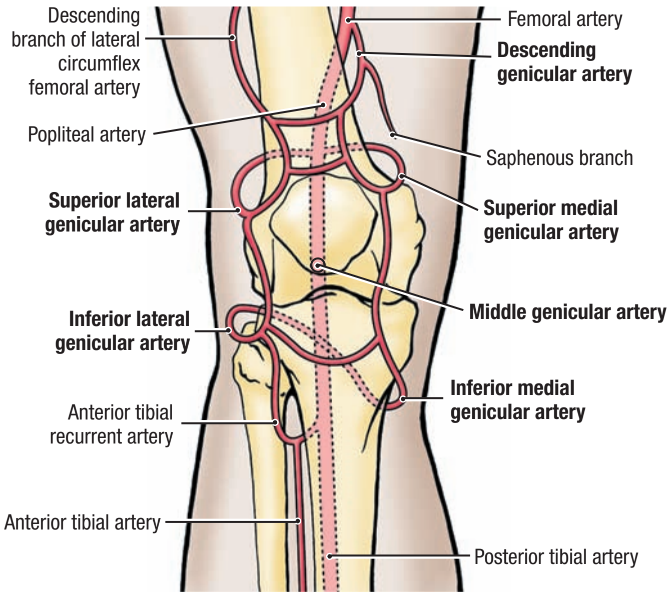


C. Posterior View

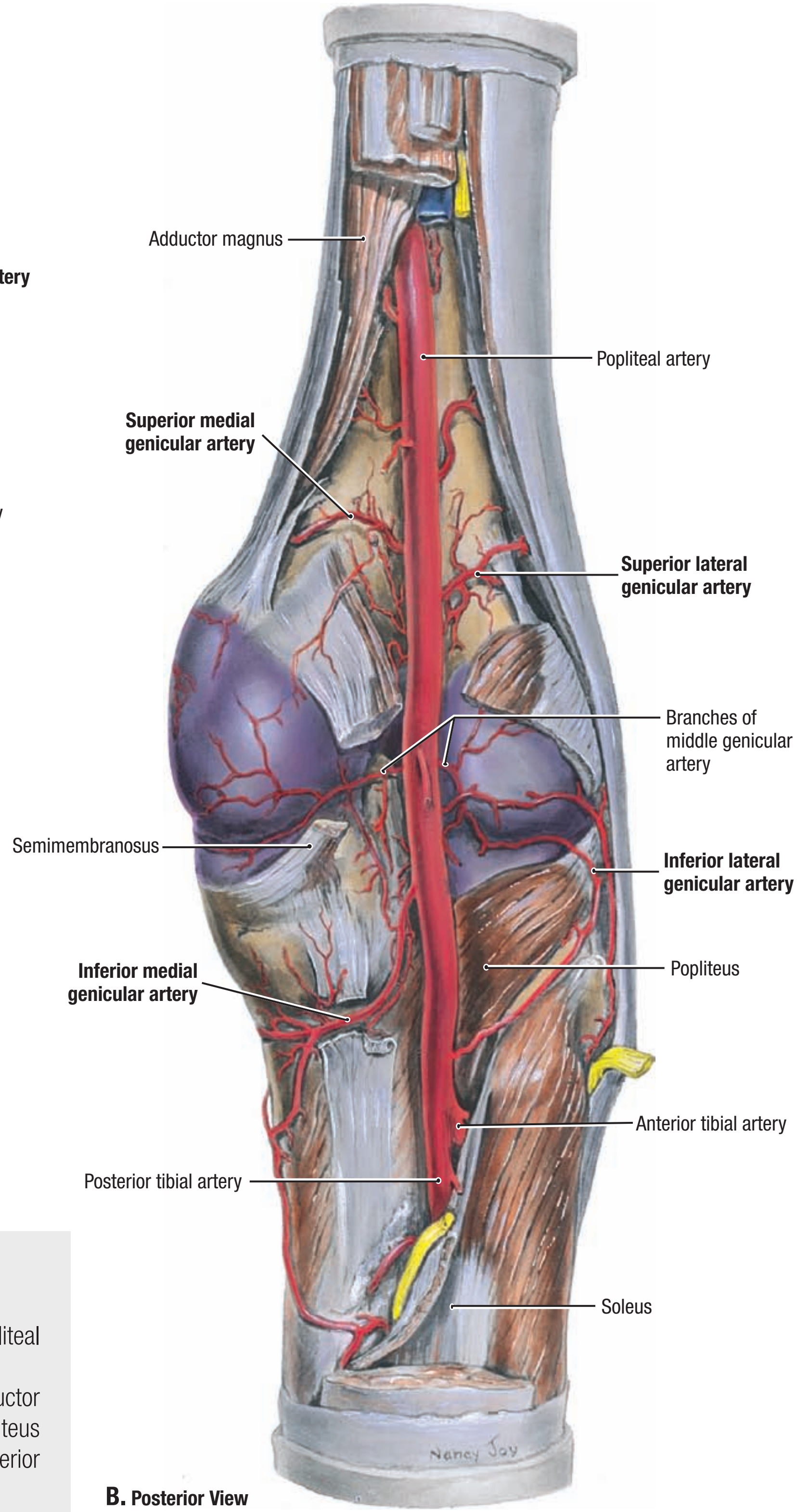
5.54 ARTICULARIS GENU AND BURSAE OF KNEE REGION (*CONTINUED*), DISTENDED KNEE JOINT

TABLE 5.11 BURSAE AROUND KNEE

Bursa	Location	Structural Features or Functions
Suprapatellar	Located between femur and tendon of quadriceps femoris	Held in position by articular muscle of knee; communicates freely with synovial cavity of knee joint
Popliteus	Located between tendon of popliteus and lateral condyle of tibia	Opens into synovial cavity of knee joint, inferior to lateral meniscus
Anserine	Separates tendons of sartorius, gracilis, and semitendinosus from tibia and tibial collateral ligament	Area where tendons of these muscles attach to tibia (pes anserinus) resembles the foot of a goose (L. *pes,* foot; L. *anser,* goose)
Medial subtendinous bursa of gastrocnemius	Lies deep to proximal attachment of tendon of medial head of gastrocnemius	Extension of synovial cavity of knee joint
Semimembranosus	Located between medial head of gastrocnemius and semimem-branosus tendon	Related to the distal attachment of semimembranosus
Subcutaneous prepatellar	Lies between skin and anterior surface of patella	Allows free movement of skin over patella during movements of leg
Subcutaneous infrapatellar	Located between skin and tibial tuberosity	Helps knee to withstand pressure when kneeling
Deep infrapatellar	Lies between patellar ligament and anterior surface of tibia	Separated from knee joint by infrapatellar fat pad



A. Anterior View

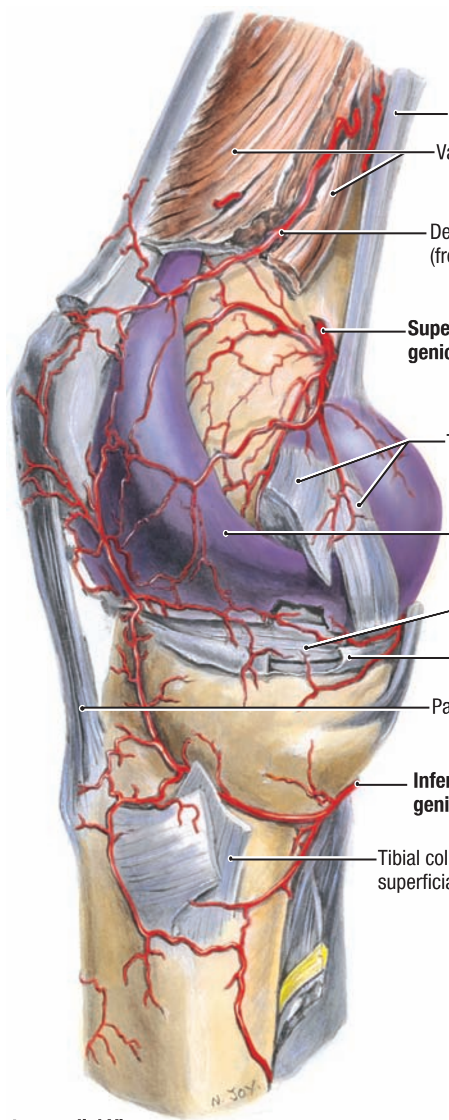


B. Posterior View

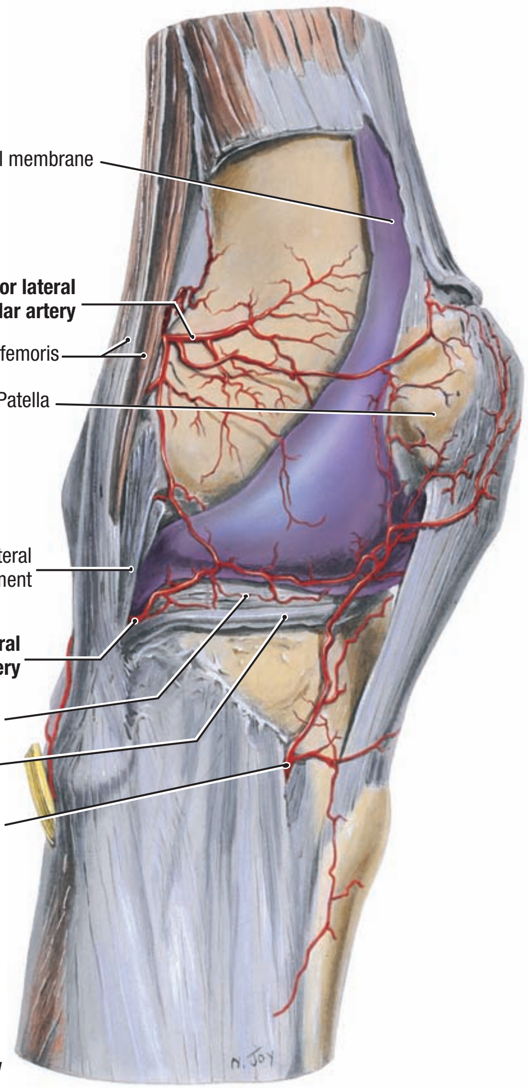
5.55 ANASTOMOSES AROUND KNEE

A. Genicular anastomosis on the anterior aspect of the knee. **B.** Popliteal artery in popliteal fossa.

- The popliteal artery runs from the adductor hiatus (in the adductor magnus muscle) proximally to the inferior border of the popliteus muscle distally, where it bifurcates into the anterior and posterior tibial arteries.
- The three anterior relations of the popliteal artery include the femur (fat intervening), the joint capsule of the knee; and the popliteus muscle.
- Five genicular branches of the popliteal artery supply the capsule and ligaments of the knee joint. The genicular arteries are the superior lateral, superior medial, middle, inferior lateral, and inferior medial genicular arteries.



C. Anteromedial View

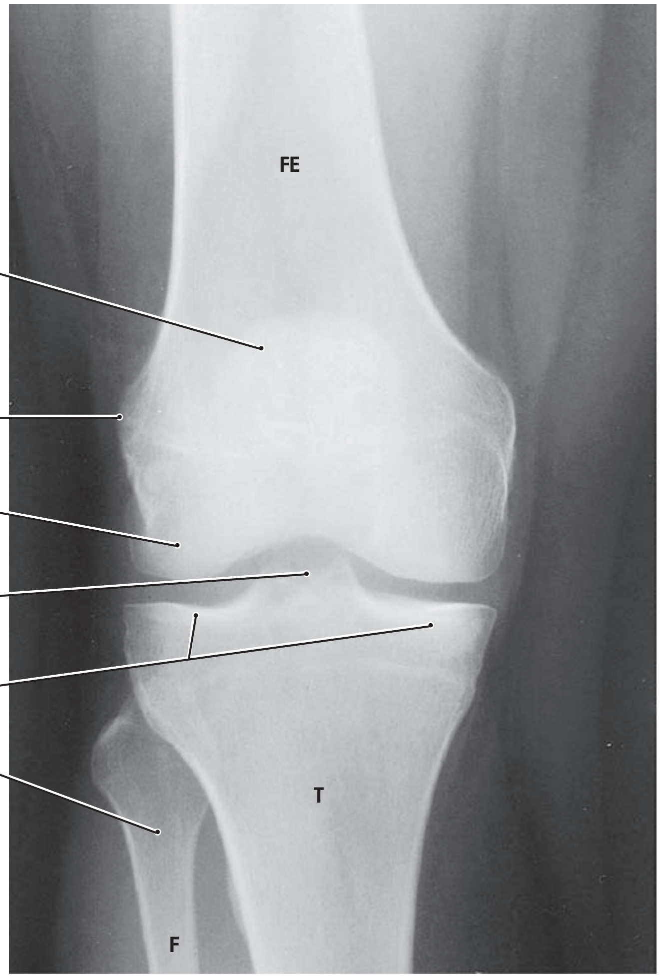


D. Anterolateral View

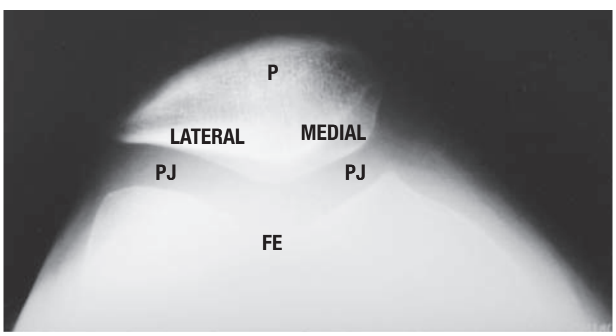
5.55 ANASTOMOSES AROUND KNEE (*CONTINUED*)

C. Medial aspect of the knee showing superior and inferior medial genicular arteries. **D.** Lateral aspect of the knee showing superior and inferior lateral genicular arteries.

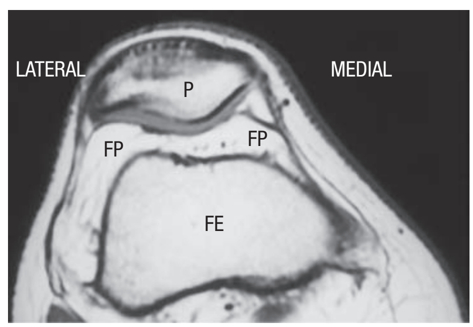
The genicular arteries participate in the formation of the periarticular genicular anastomosis, a network of vessels surrounding the knee that provides collateral circulation capable of maintaining blood supply to the leg during full knee flexion, which may kink the popliteal artery. Other contributors to this important anastomosis are the descending genicular artery, a branch of the femoral artery, superomedially; descending branch of the lateral circumflex femoral artery, superolaterally; and anterior tibial recurrent artery, a branch of the anterior tibial artery, inferolaterally.



A. Anteroposterior View



B. Skyline View (Knee in Flexion)

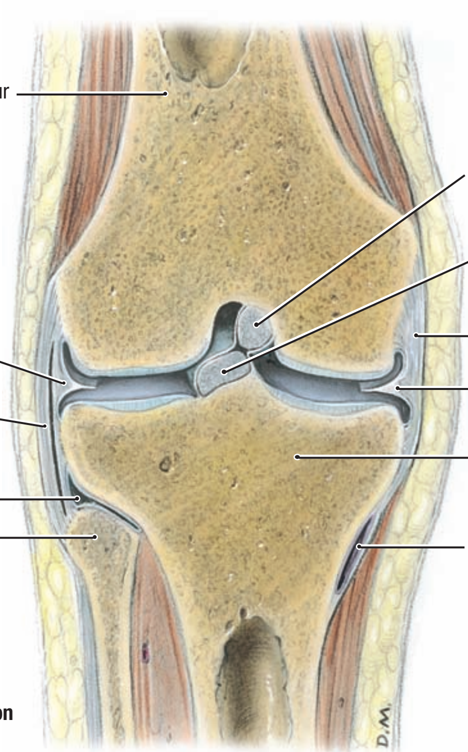


C. Transverse MRI

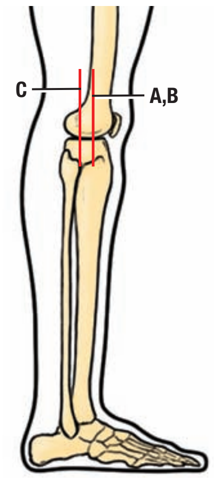
5.56 IMAGING OF THE KNEE AND PATELLOFEMORAL ARTICULATION

A. Anteroposterior radiograph of knee. **B.** Radiograph of patella (knee joint flexed). *FE*, femur; *FP*, fat pad; *P*, patella; *PJ*, patellofemoral joint. **C.** Transverse MRI showing the patellofemoral joint.

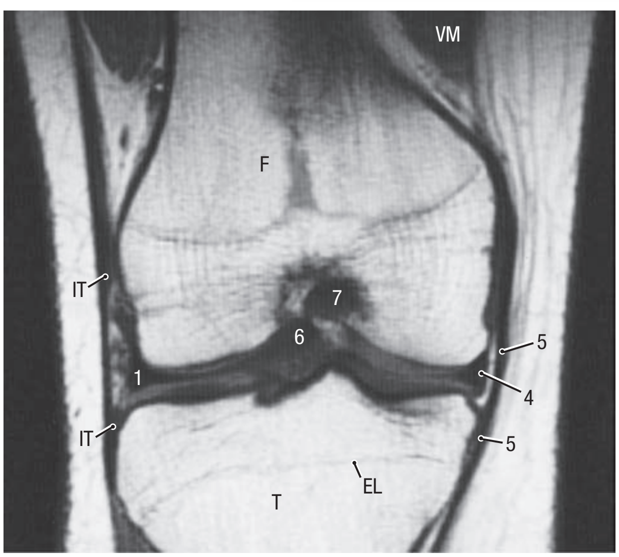
Pain deep to the patella often results from excessive running; hence, this type of pain is often called "runner's knee." The pain results from repetitive microtrauma caused by abnormal tracking of the patella relative to the patellar surface of the femur, a condition known as the **patellofemoral syndrome**. This syndrome may also result from a direct blow to the patella and from osteoarthritis of the patellofemoral compartment (degenerative wear and tear of articular cartilages). In some cases, strengthening of the vastus medialis corrects patellofemoral dysfunction. This muscle tends to prevent lateral dislocation of the patella resulting from the Q-angle because the vastus medialis attaches to and pulls on the medial border of the patella. Hence, weakness of the vastus medialis predisposes the individual to patellofemoral dysfunction and patellar dislocation.



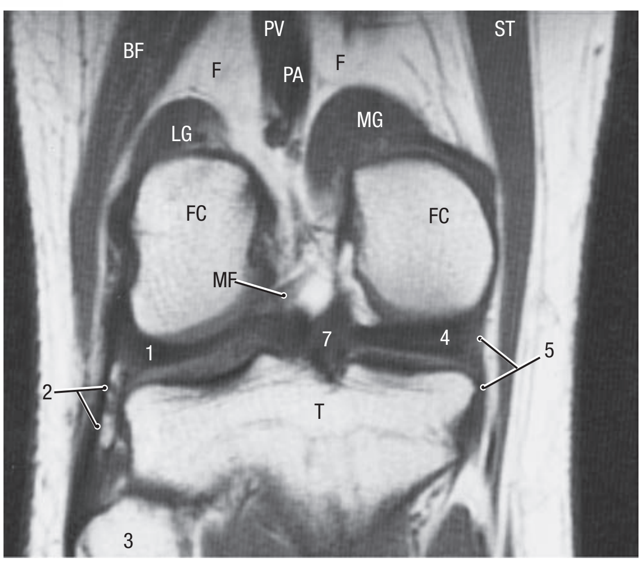
A. Coronal Section



Lateral View



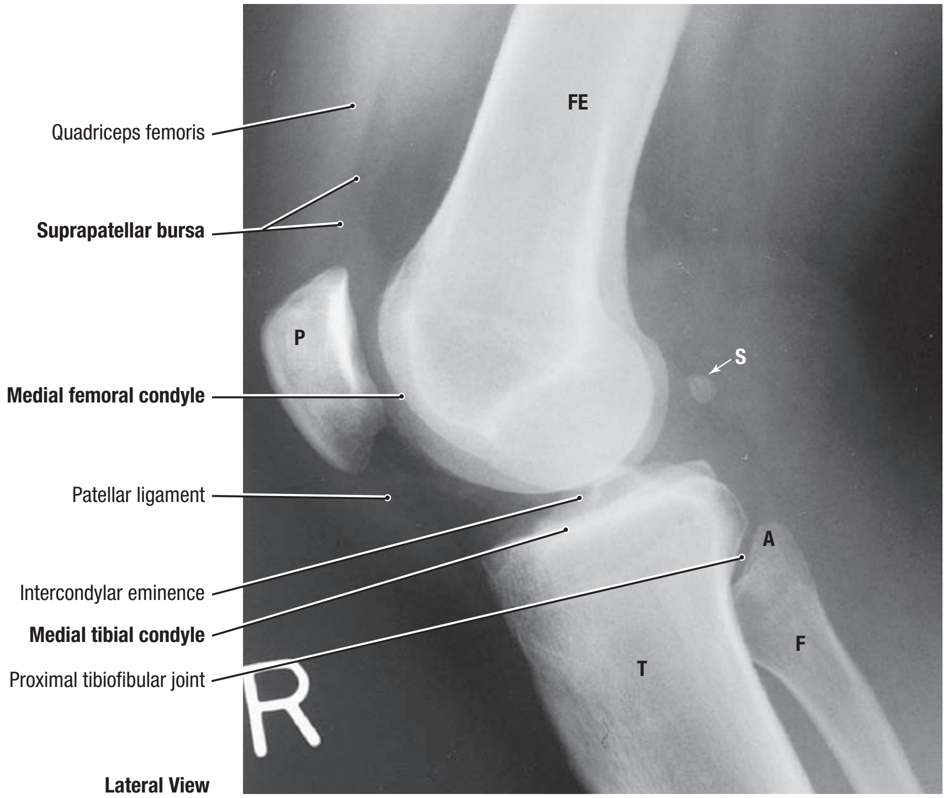
B. Coronal MRI



C. Coronal MRI

5.57 CORONAL SECTION AND MRIs OF KNEE

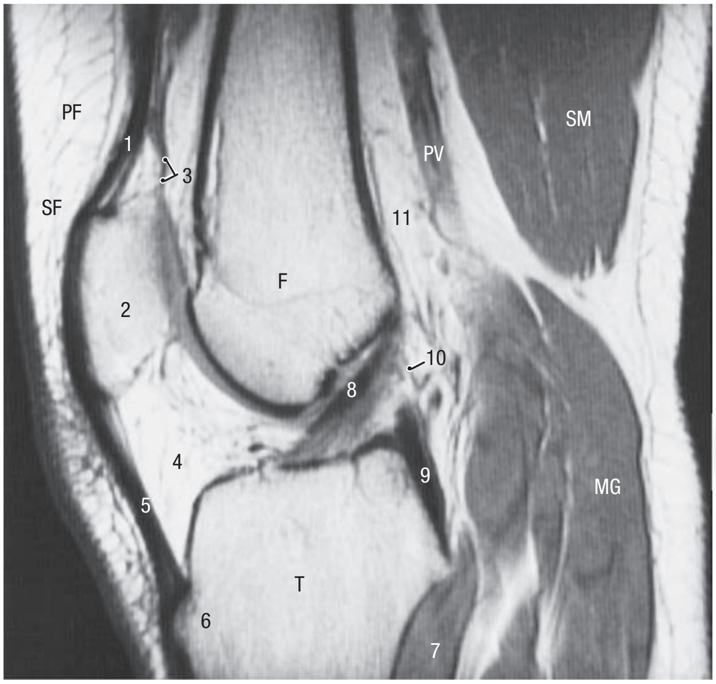
A. Section through intercondylar notch of femur, tibia, and fibula. **B.** MRI through intercondylar notch of femur and tibia. **C.** MRI through femoral condyles tibia and fibula. *Numbers* in MRIs refer to structures in **A.** *VM*, vastus medialis; *EL*, epiphyseal line; *IT*, iliotibial tract; *FC*, femoral condyle; *BF*, biceps femoris; *ST*, semitendinosus; *LG*, lateral head of gastrocnemius; *MG*, medial head of gastrocnemius; *PV*, popliteal vein; *PA*, popliteal artery; *F*, fat in popliteal fossa; *MF*, meniscofemoral ligament.



Lateral View

5.58 RADIOGRAPH OF KNEE

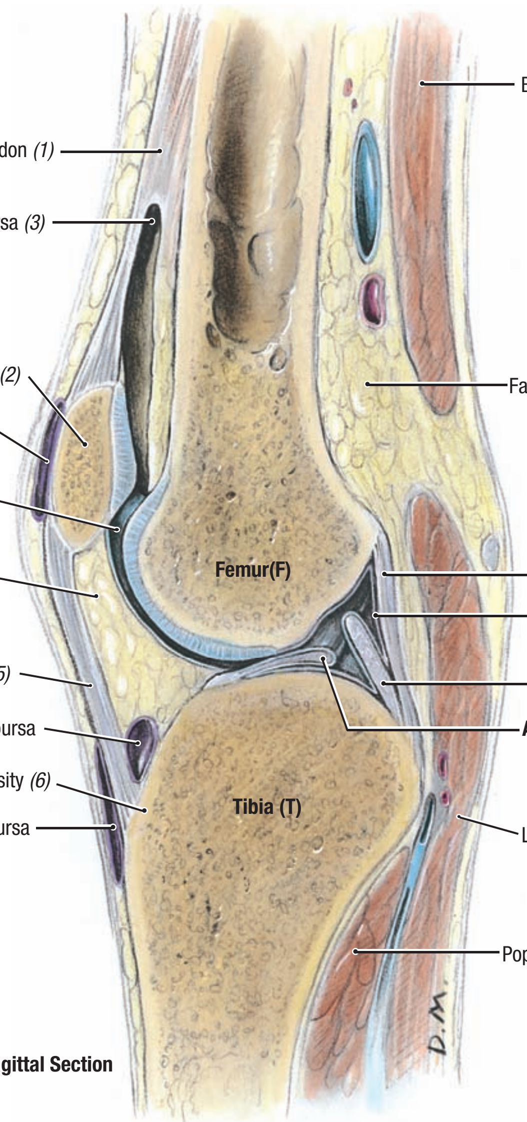
Lateral radiograph of flexed knee. *FE*, femur; *T*, tibia; *F*, fibula; *A*, apex of fibula; *S*, fabella; *P*, patella. The fabella is an inconsistent sesamoid bone in the lateral head of gastrocnemius muscle.



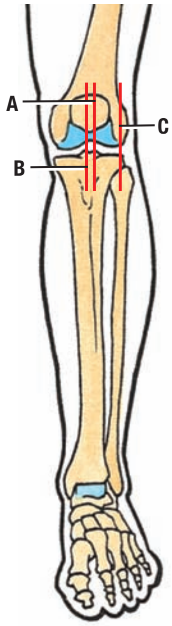
A. Sagittal MRI

5.59 SAGITTAL SECTION AND MRIs OF KNEE

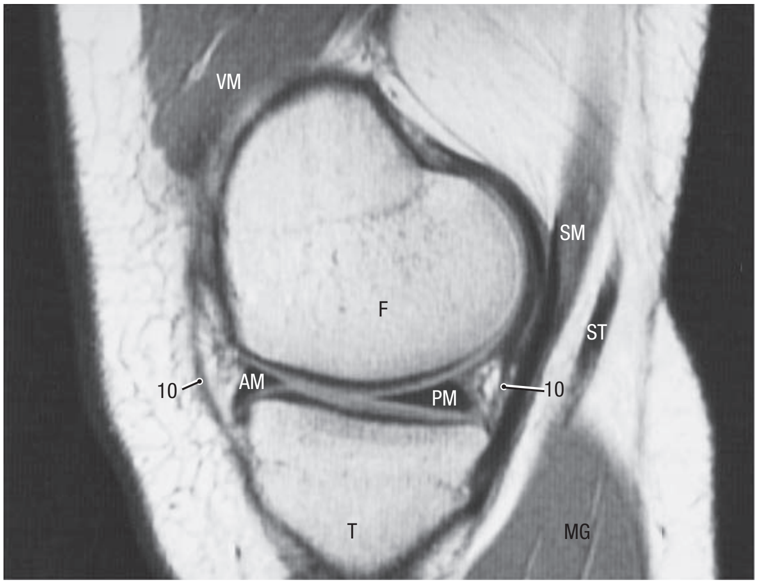
A. MRI through medial aspect of intercondylar notch of femur showing cruciate ligaments. **B.** Illustration of section through lateral aspect of intercondylar notch of femur. **C.** MRI through medial femoral and tibial condyles. *Numbers* in MRIs refer to structures in **A.** *SM*, semimembranosus; *ST*, semitendinosus; *MG*, medial head of gastrocnemius; *VM*, vastus medialis; *PF*, prefemoral fat; *SF*, suprapatellar fat; *AM*, anterior horn of medial meniscus; *PM*, posterior horn of medial meniscus; *PV*, popliteal vessels.



B. Sagittal Section



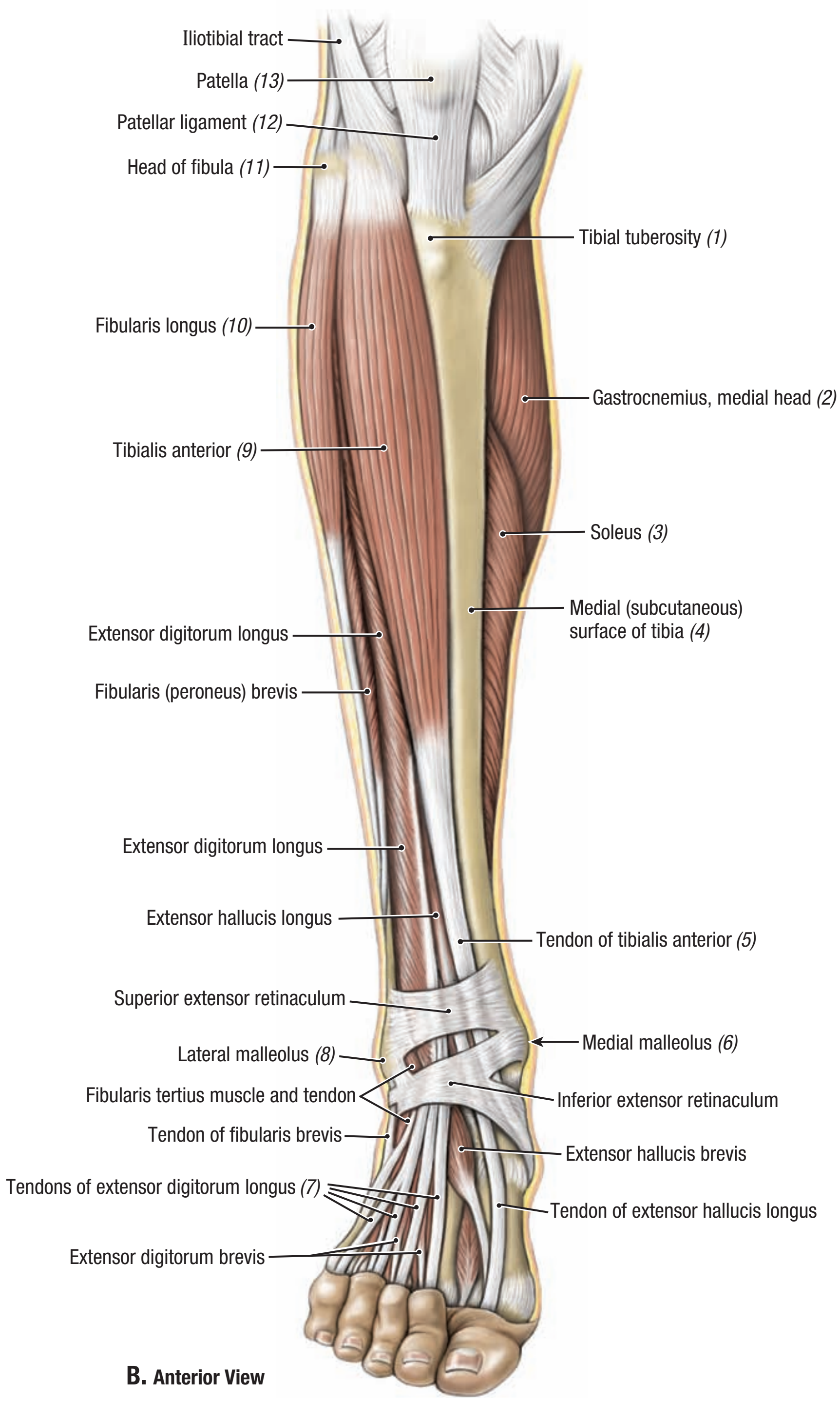
Anterior View



C. Sagittal MRI

 SAGITTAL SECTION AND MRIs OF KNEE (*CONTINUED*)

A. **Anterior View**

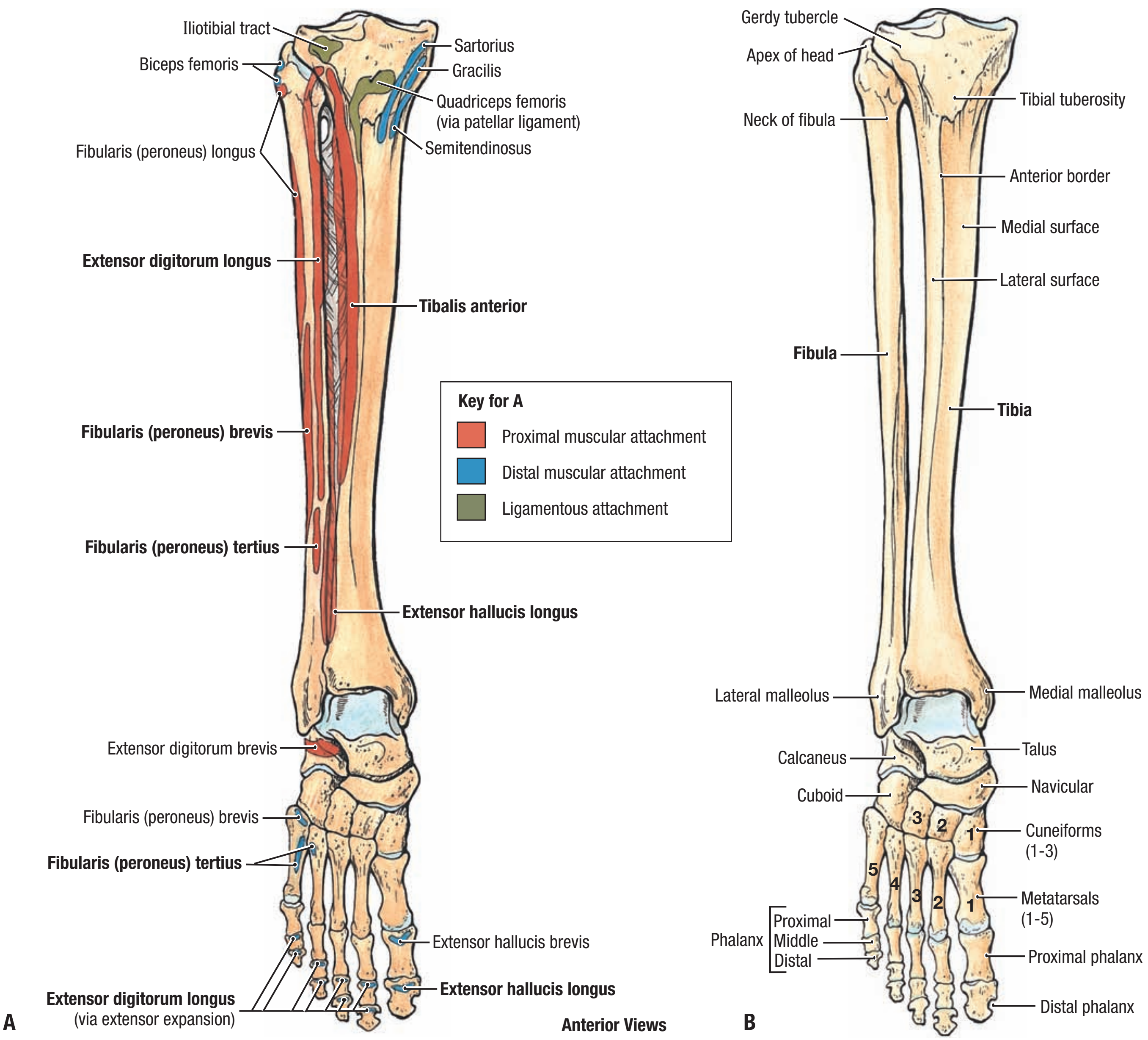


B. **Anterior View**

5.60 ANTERIOR LEG—SUPERFICIAL MUSCLES

A. Surface anatomy (*numbers* refer to structures labeled in **B**). **B.** Dissection. The muscles of the anterior compartment are ankle dorsiflexors/toe extensors. They are active in walking as they concentrically contract to raise the forefoot to clear the ground during the swing phase of the gait cycle and eccentrically contract to lower the forefoot to the ground after the heel strike of the stance phase.

Shin splints, edema, and pain in the area of the distal third of the tibia, result from repetitive microtrauma of the anterior compartment muscles, especially the tibialis anterior. This produces a mild form of **anterior compartment syndrome**. The pain commonly occurs during traumatic injury or athletic overexertion of the muscles. Edema and muscle-tendon inflammation causes swelling that reduces blood flow to the muscles. The swollen ischemic muscles are painful and tender to pressure.



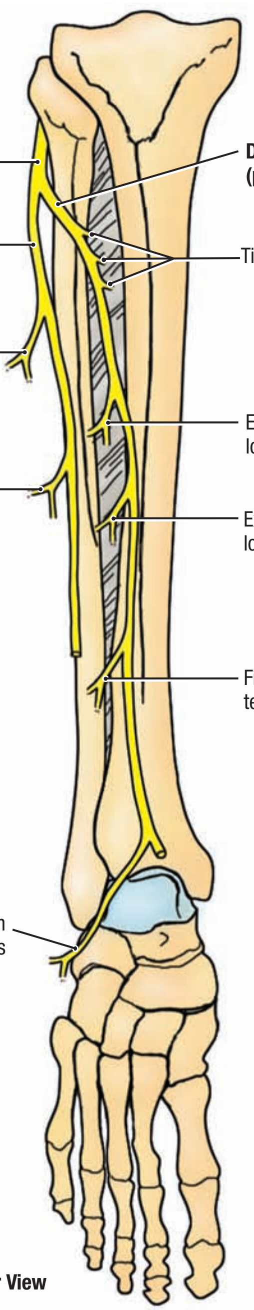
5.61 FEATURES OF BONES AND MUSCLE ATTACHMENTS: ANTERIOR LEG AND DORSUM OF FOOT

A. Attachments. **B.** Features of bones.

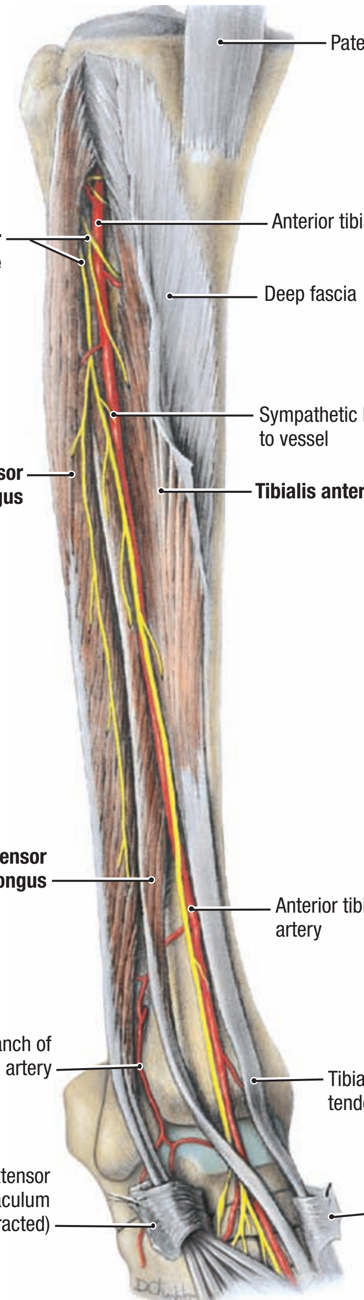
TABLE 5.12 MUSCLES OF ANTERIOR COMPARTMENT OF LEG

Muscle	Proximal Attachment	Distal Attachment	Innervation[a]	Main Actions
Tibialis anterior	Lateral condyle and superior half of lateral surface of tibia	Medial and inferior surfaces of medial cuneiform and base of first metatarsal	Deep fibular (peroneal) nerve (L4–L5)	Dorsiflexes ankle joint and inverts foot
Extensor hallucis longus	Middle part of anterior surface of fibula and interosseous membrane	Dorsal aspect of base of distal phalanx of great toe (hallux)		Extends great toe and dorsiflexes ankle joint
Extensor digitorum longus	Lateral condyle of tibia and superior three fourths of anterior surface of interosseous membrane	Middle and distal phalanges of lateral four digits	Deep fibular (peroneal) nerve (L5–S1)	Extends lateral four digits and dorsiflexes ankle joint
Fibularis (peroneus) tertius	Inferior third of anterior surface of fibula and interosseus membrane	Dorsum of base of fifth metatarsal		Dorsiflexes ankle joint and aids in eversion of foot

[a]See Table 5.1 for explanation of segmental innervation.



A. Anterior View

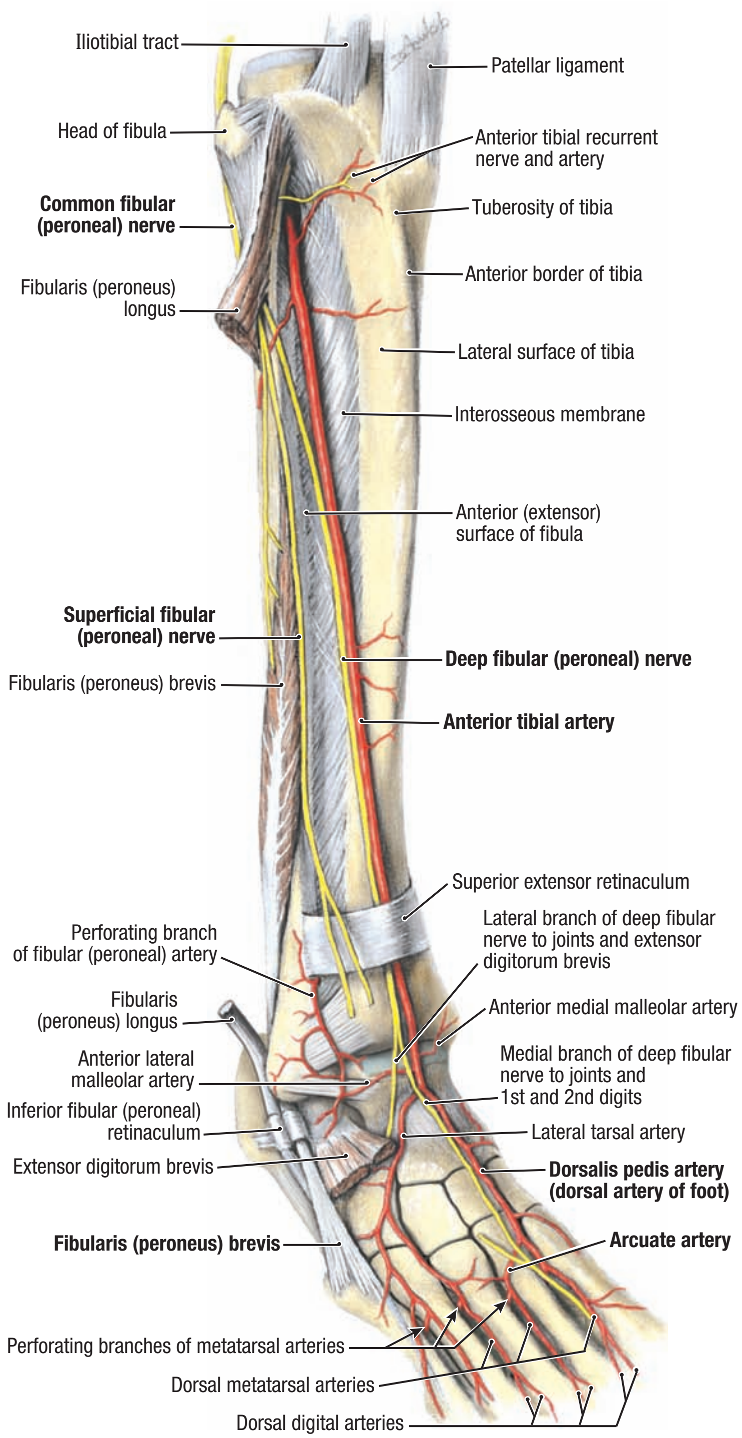


B. Anterolateral View

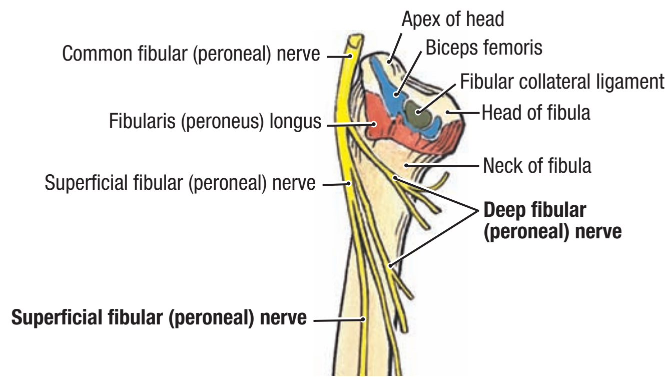
5.62 ANTERIOR LEG—DEEP MUSCLES, NERVES, AND VESSELS

TABLE 5.13 COMMON, SUPERFICIAL, AND DEEP FIBULAR (PERONEAL) NERVES

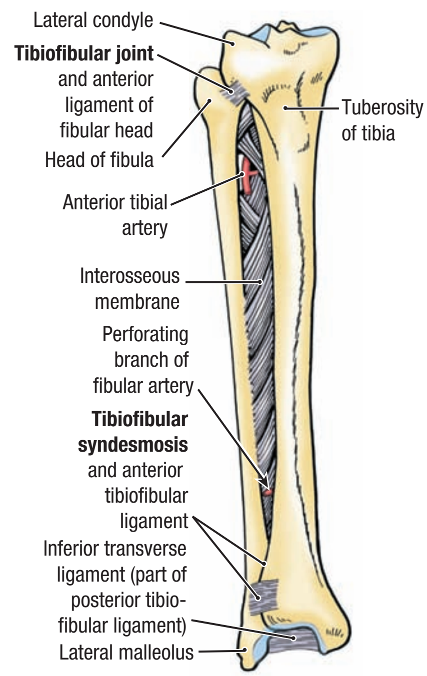
Nerve	Origin	Course	Distribution/Structure(S) Supplied
Common fibular	Sciatic nerve	Forms as sciatic nerve bifurcates at the apex of popliteal fossa and follows medial border of biceps femoris; winds around neck of fibula, dividing into superficial and deep fibular nerves	Skin on lateral part of posterior aspect of leg via the lateral sural cutaneous nerve; lateral aspect of knee joint via its articular branch
Superficial fibular	Common fibular nerve	Arises deep to fibularis longus and descends in lateral compartment of leg; pierces crural fascia at distal third of leg to become cutaneous	Fibularis longus and brevis and skin on distal third of anterolateral surface of leg and dorsum of foot
Deep fibular	Common fibular nerve	Arises deep to fibularis longus; passes through extensor digitorum longus, descends on interosseous membrane, and continues on dorsum of foot	Anterior muscles of leg, dorsum of foot, and skin of first interdigital cleft; dorsal aspect of joints crossed via articular branches



C. Anterolateral View



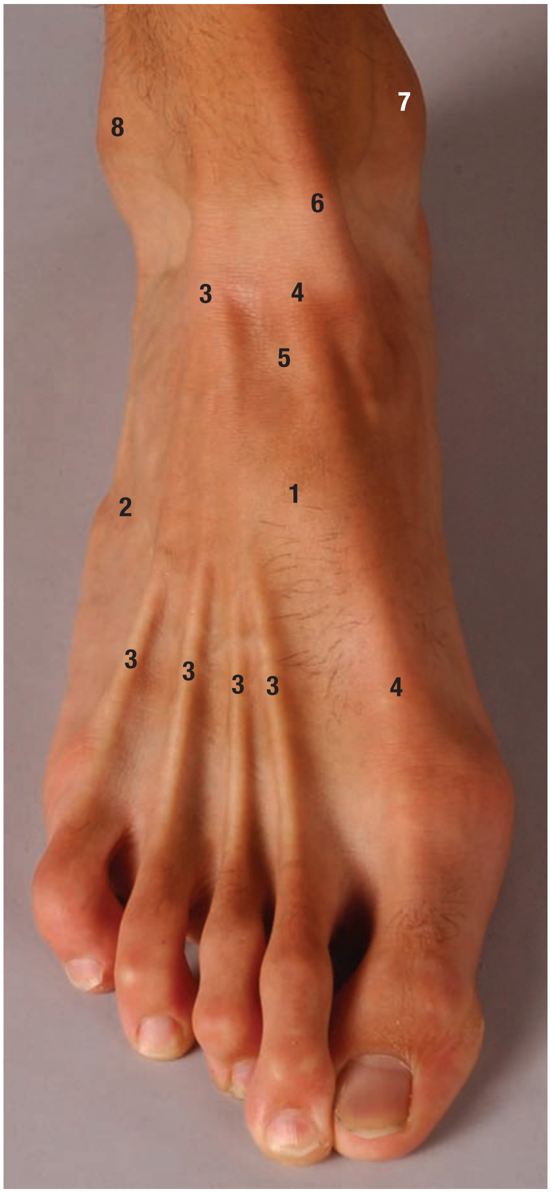
D. Lateral View



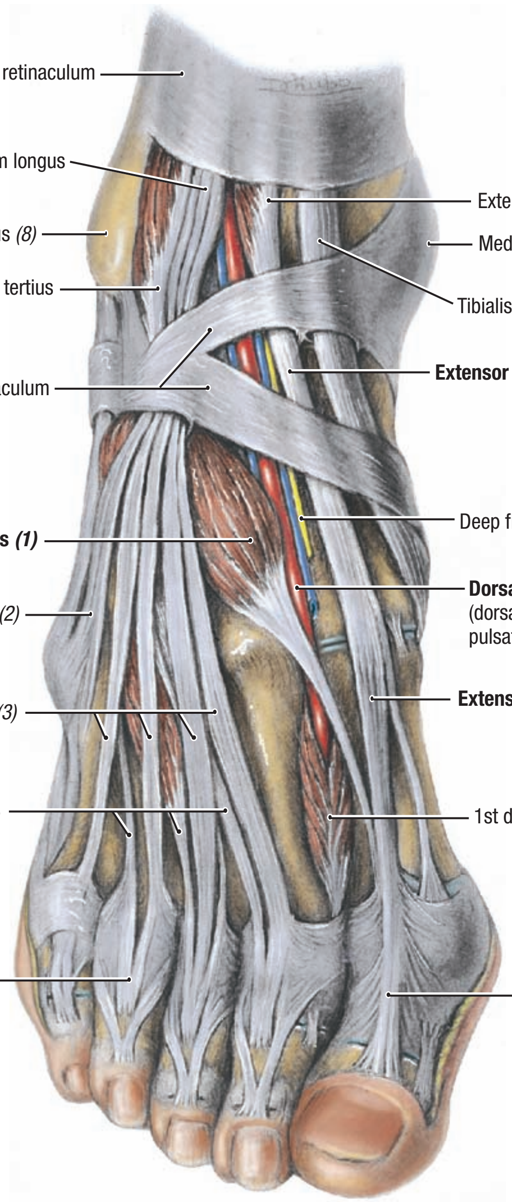
E. Anterior View

5.62 ANTERIOR LEG—DEEP MUSCLES, NERVES, AND VESSELS (*CONTINUED*)

A. Overview of motor innervation. **B.** Deep dissection of the anterior compartment of the leg. The muscles are separated to display the anterior tibial artery and deep fibular nerve. **C.** Neurovascular structures. **D.** Relations of common fibular nerve and branches to the proximal fibula. **E.** Interosseous membrane.



A. Superior View



B. Superior View

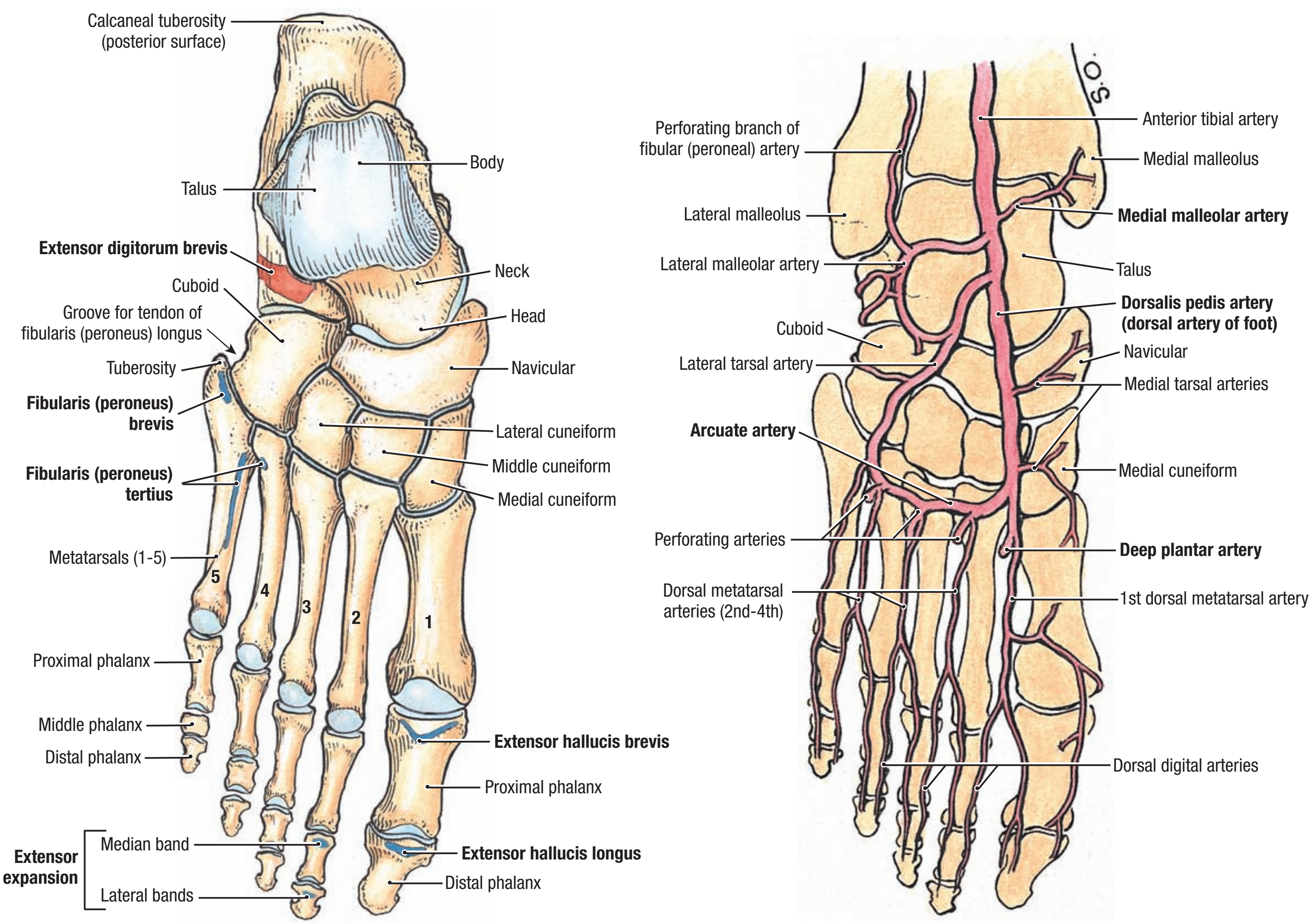
5.63 DORSUM OF FOOT

A. Surface anatomy (*numbers* refer to structures labeled in **B**). **B.** Dissection. The dorsal vein of foot and deep fibular nerve are cut.

At the ankle, the dorsalis pedis artery (dorsal artery of foot) and deep fibular nerve lie midway between the malleoli. On the dorsum of the foot, the dorsal artery of foot is crossed by the extensor hallucis brevis muscle and disappears between the two heads of the first dorsal interosseous muscle.

Clinically, knowing the location of the belly of the extensor digitorum brevis is important for distinguishing this muscle from abnormal edema. Contusion and tearing of the muscle fibers and associated blood vessels result in a **hematoma in extensor digitorum brevis**, producing edema anteromedial to the lateral malleolus. Most people who have not seen this inflamed muscle assume they have a severely sprained ankle.

The **dorsalis pedis pulse** may be palpated with the feet slightly dorsiflexed. The pulse is usually easy to palpate because the dorsal arteries of the foot are subcutaneous and pass along a line from the extensor retinaculum to a point just lateral to the extensor hallucis longus tendon. A diminished or absent dorsalis pedis pulse usually suggests vascular insufficiency resulting from arterial disease.



A. Superior View

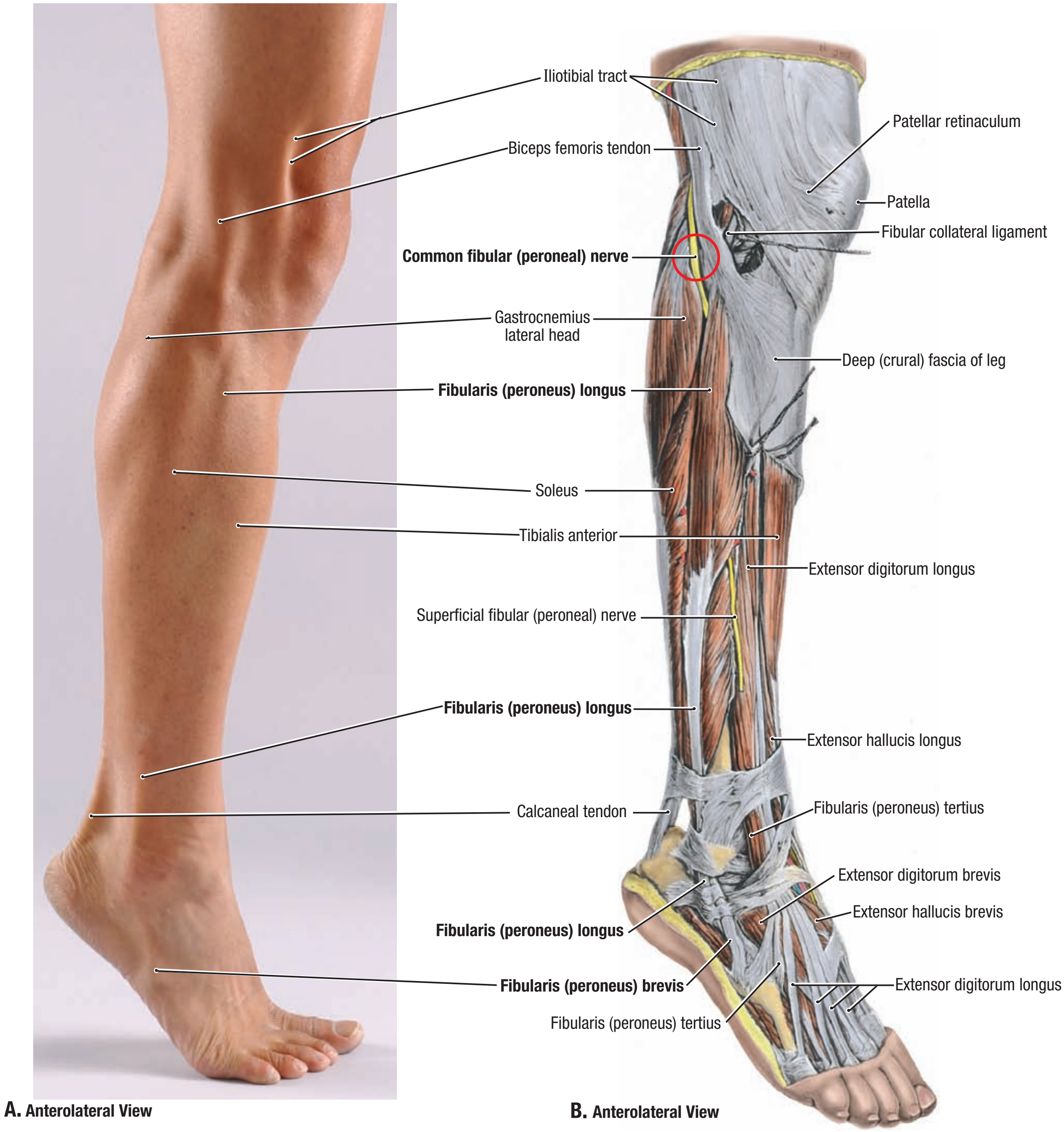
B. Superior View

5.64 ATTACHMENTS OF MUSCLES AND ARTERIES OF DORSUM OF FOOT

A. Attachments. **B.** Arterial supply.

TABLE 5.14 ARTERIAL SUPPLY TO DORSUM OF FOOT

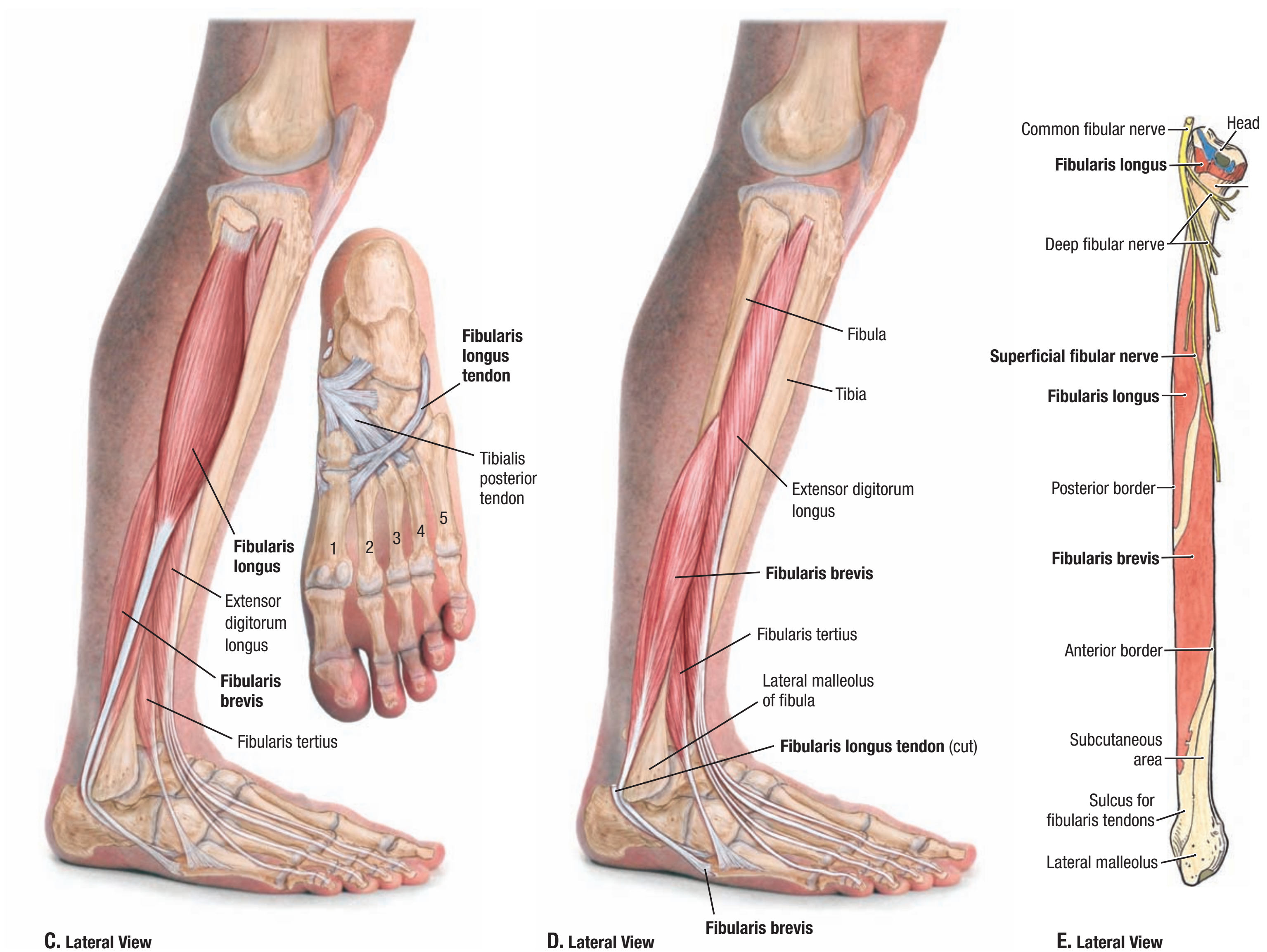
Artery	Origin	Course	Distribution
Dorsalis pedis (dorsal artery of foot)	Continuation of anterior tibial artery distal to talocrural joint	Descends anteromedially to 1st interosseous space and divides into deep plantar and arcuate arteries	Dorsal surface of foot
Lateral tarsal artery	From dorsalis pedis artery (dorsal artery of foot)	Runs an arched course laterally beneath extensor digitorum brevis to anastomose with branches of arcuate artery	
Arcuate artery		Runs laterally from 1st interosseous space across bases of lateral four metatarsals, deep to extensor tendons	
Deep plantar artery		Passes to sole of foot and joins plantar arch	Sole of foot
Metatarsal arteries 1st	From deep plantar artery	Run between metatarsals to clefts of toes where each vessel divides into two dorsal digital arteries.	Dorsal surface of foot
2nd to 4th	From arcuate artery	Perforating arteries connect to plantar arch and plantar metatarsal arteries.	
Dorsal digital arteries	From metatarsal arteries	Pass to sides of adjoining digits	Digits



5.65 MUSCLES OF LATERAL LEG AND FOOT

A. Surface anatomy. **B.** Dissection.

- The two fibular (peroneal) muscles both attach to two thirds of the fibula, the fibularis (peroneus) longus muscle to the proximal two thirds, and the fibularis (peroneus) brevis muscle to the distal two thirds. Where they overlap, the fibularis brevis muscle lies anteriorly.
- The fibularis (peroneus) longus muscle enters the foot by hooking around the cuboid and traveling medially to the base of the first metatarsal and medial cuneiform.
- **Common fibular (peroneal) nerve lesion.** The nerve lies in contact with the neck of the fibula deep to the fibularis longus muscle, where it is vulnerable to injury (**B,** *red circle*). This injury may have serious implications because the nerve supplies the extensor and everter muscle groups, with loss of function resulting in foot-drop (inability to dorsiflex the ankle) and difficulty in everting the foot.



5.65 MUSCLES OF LATERAL LEG AND FOOT (*CONTINUED*)

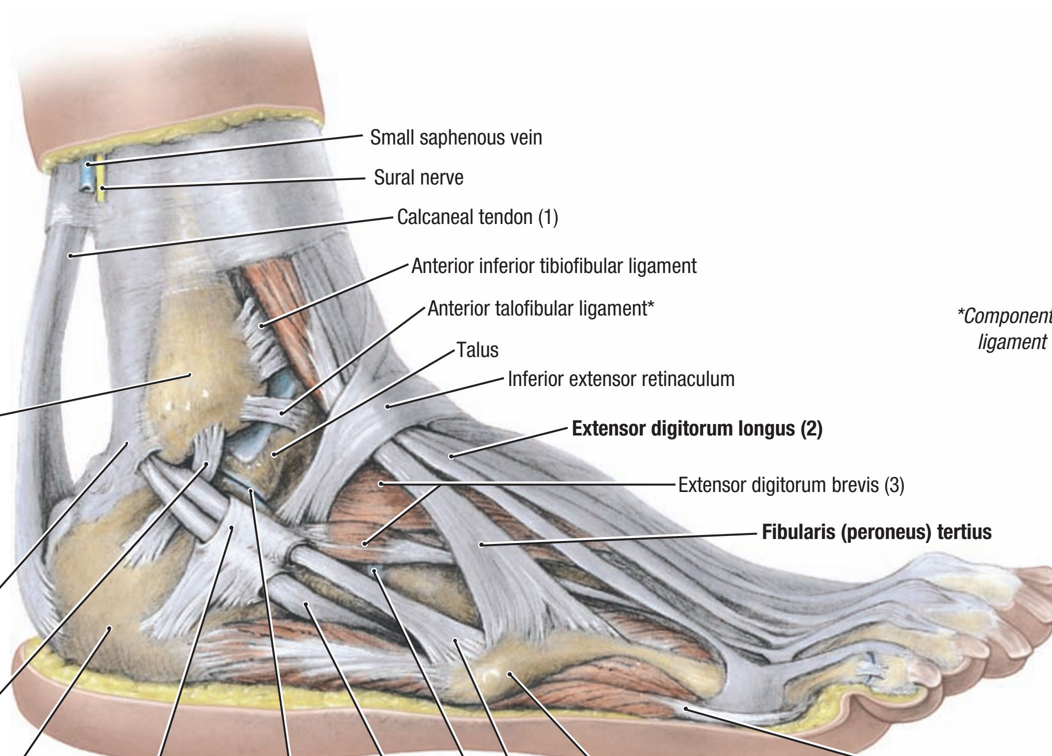
C. Fibularis (peroneus) longus. **D.** Fibularis (peroneus) brevis. **E.** Attachments sites on fibula.

TABLE 5.15 MUSCLES OF LATERAL COMPARTMENT OF LEG

Muscle	Proximal Attachment	Distal Attachment	Innervation[a]	Main Actions
Fibularis (peroneus) longus	Head and superior two thirds of lateral surface of fibula	Base of first metatarsal and medial cuneiform	Superficial fibular (peroneal) nerve (L5, S1, and S2)	Evert foot and weakly plantar flex ankle joint
Fibularis (peroneus) brevis	Inferior two thirds of lateral surface of fibula	Dorsal surface of tuberosity on lateral side of base of fifth metatarsal		

[a]See Table 5.1 for explanation of segmental innervation

A. **Lateral View**

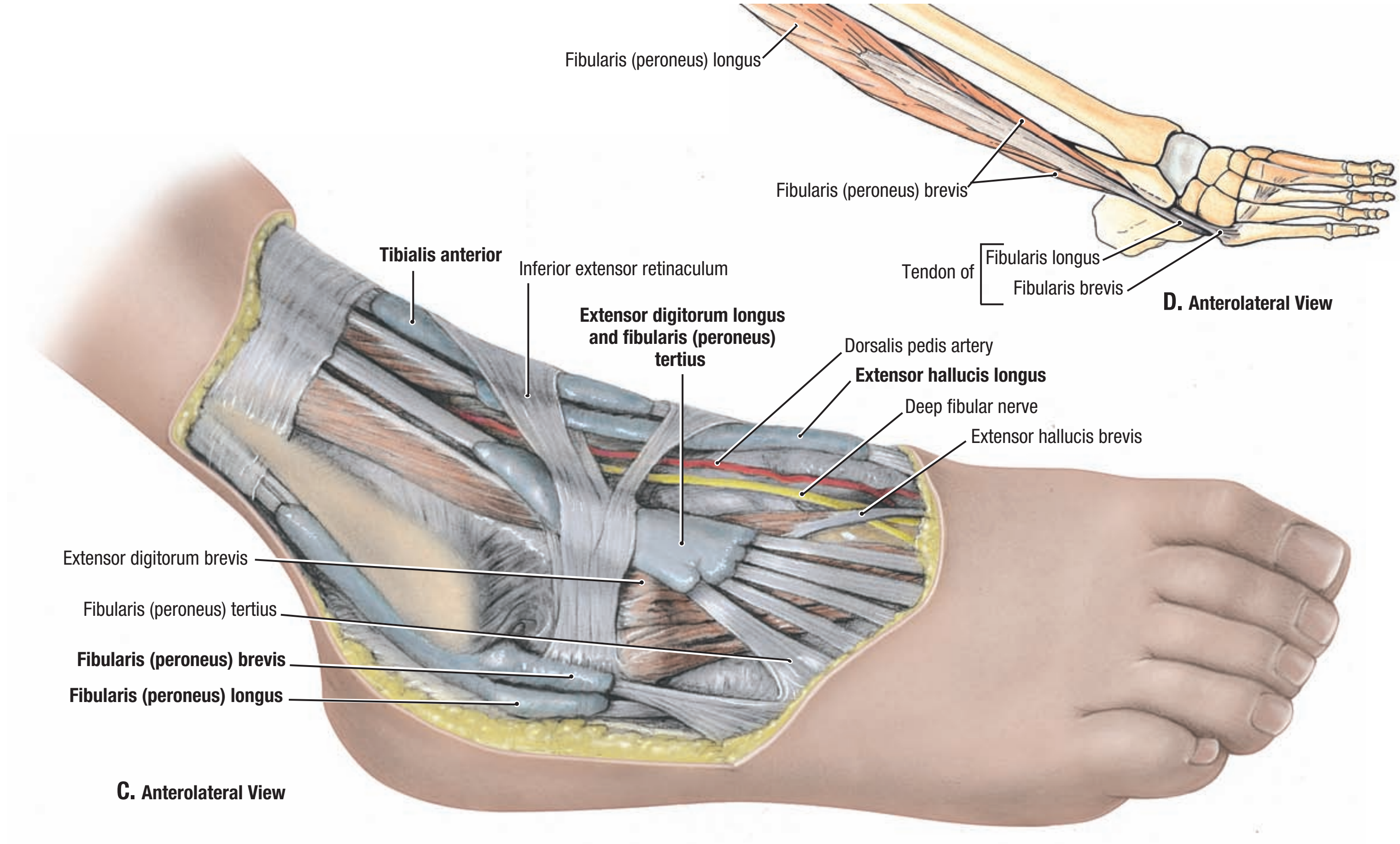


**Components of lateral ligament of ankle*

B. **Lateral View**

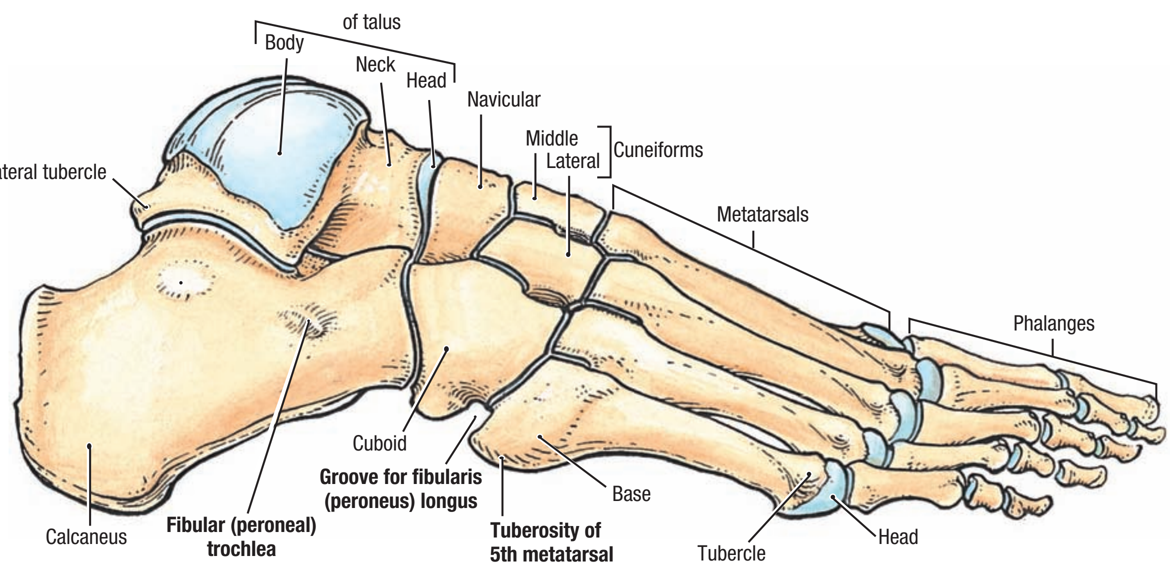
5.66 SYNOVIAL SHEATHS AND TENDONS AT ANKLE

A. Surface anatomy (*numbers* refer to structures labeled in **B**). **B.** Tendons at the lateral aspect of the ankle.



D. **Anterolateral View**

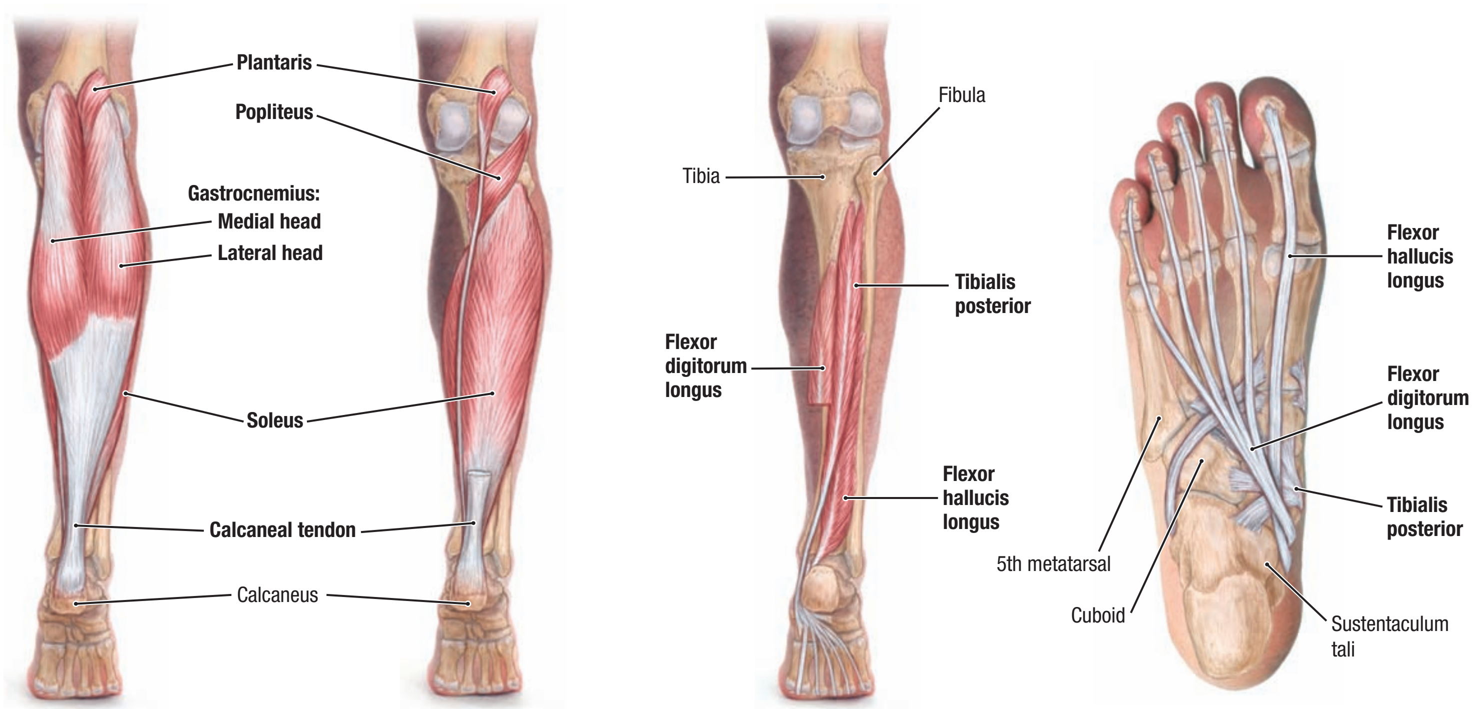
C. **Anterolateral View**



E. **Lateral View**

5.66 SYNOVIAL SHEATHS AND TENDONS AT ANKLE (*CONTINUED*)

C. Synovial sheaths of tendons on the anterolateral aspect of the ankle. The tendons of the fibularis (peroneus) longus and fibularis (peroneus) brevis muscles are enclosed in a common synovial sheath posterior to the lateral malleolus. This sheath splits into two, one for each tendon, posterior to the fibular (peroneal) trochlea. **D.** Schematic illustration of fibularis longus and brevis. **E.** Lateral aspect of bones of foot.



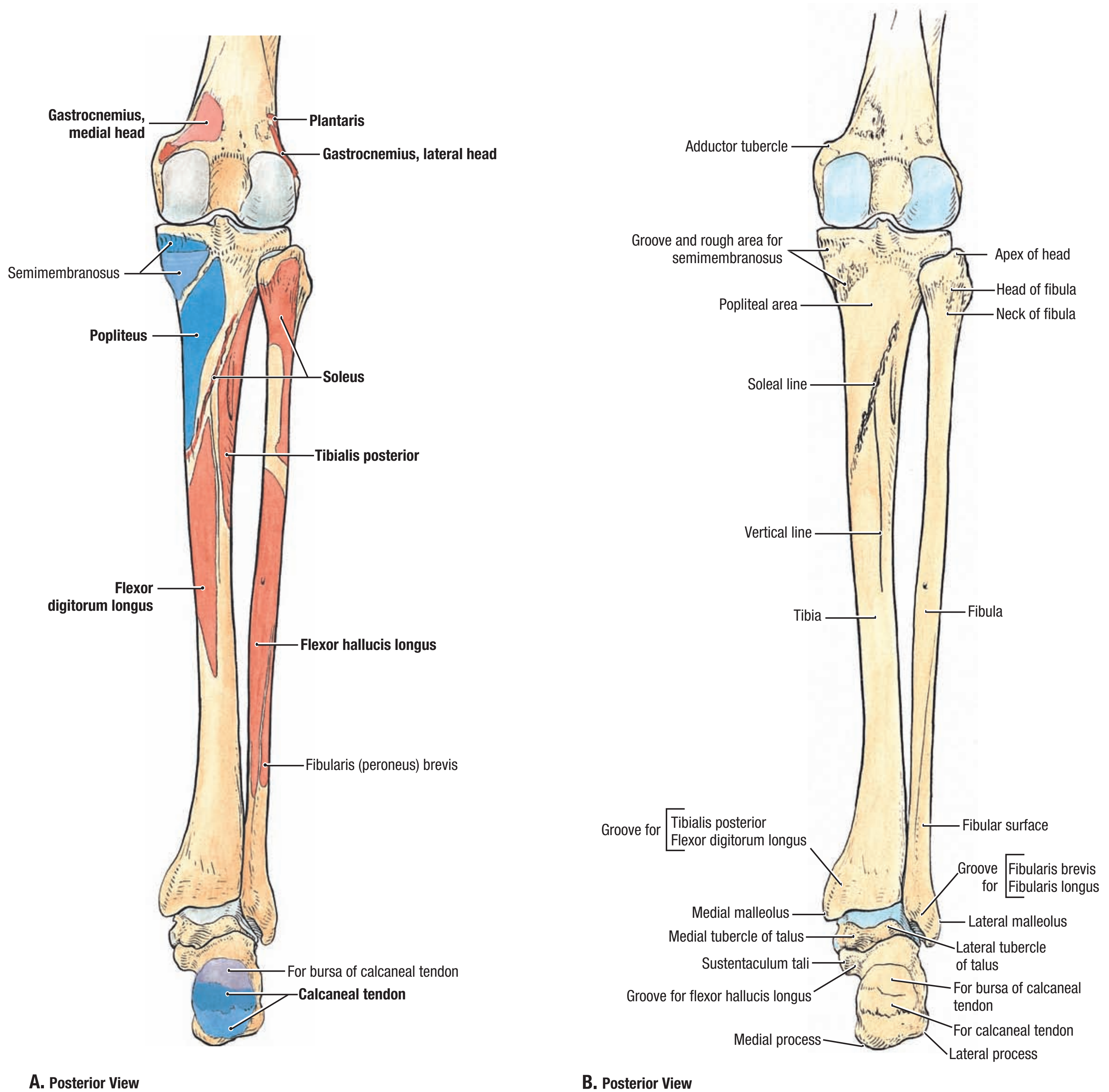
5.67 MUSCLES OF POSTERIOR LEG

A. and B. Muscles of superficial compartment. **C. and D.** Muscles of deep compartment.

TABLE 5.16 MUSCLES OF POSTERIOR COMPARTMENT OF LEG

Muscle	Proximal Attachment	Distal Attachment	Innervation[a]	Main Actions
Superficial muscles				
Gastrocnemius	*Lateral head:* lateral aspect of lateral condyle of femur	Posterior surface of calcaneus via calcaneal tendon (tendocalcaneus)	Tibial nerve (S1 and S2)	Plantar flexes ankle joint when knee joint is extended; raises heel during walking, and flexes knee joint
	Medial head: popliteal surface of femur, superior to medial condyle			
Soleus	Posterior aspect of head of fibula, superior fourth of posterior surface of fibula, soleal line and medial border of tibia			Plantar flexes ankle joint (independent of knee position) and steadies leg on foot
Plantaris	Inferior end of lateral supracondylar line of femur and oblique popliteal ligament			Weakly assists gastrocnemius in plantar flexing ankle joint and flexing knee joint
Deep muscles				
Popliteus	Lateral surface of lateral condyle of femur and lateral meniscus	Posterior surface of tibia, superior to soleal line	Tibial nerve (**L4,** L5, and S1)	Unlocks fully extended knee joint (laterally rotates femur 5 degrees on planted tibia); weakly flexes knee joint
Flexor hallucis longus	Inferior two thirds of posterior surface of fibula and inferior part of interosseous membrane	Base of distal phalanx of great toe (hallux)		Flexes great toe at all joints and plantar flexes ankle joint; supports medial longitudinal arch of foot
Flexor digitorum longus	Medial part of posterior surface of tibia inferior to soleal line, and by a broad tendon to fibula	Bases of distal phalanges of lateral four digits	Tibial nerve (**S2** and S3)	Flexes lateral four digits and plantar flexes ankle joint; supports longitudinal arches of foot
Tibialis posterior	Interosseous membrane, posterior surface of tibia inferior to soleal line and posterior surface of fibula	Tuberosity of navicular, cuneiform, and cuboid and bases of metatarsals 2–4	Tibial nerve (L4 and L5)	Plantar flexes ankle joint and inverts foot

[a]See Table 5.1 for explanation of segmental innervation.



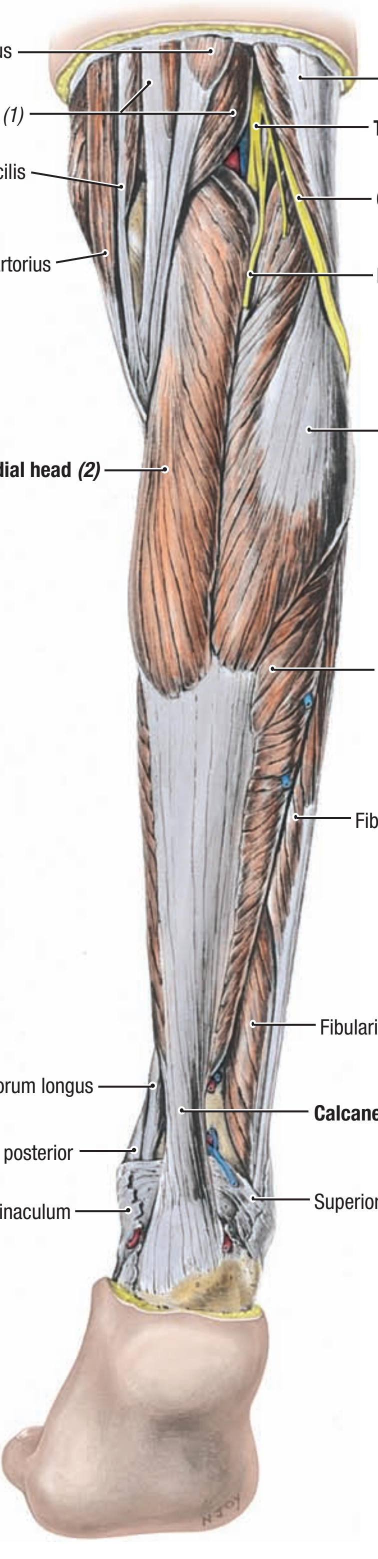
5.68 BONES OF THE POSTERIOR LEG

A. Muscle attachments. **B.** Features of bones.

Tibial fractures. The tibial shaft is narrowest at the junction of its middle and inferior thirds, which is the most frequent site of fracture. Unfortunately, this area of the bone also has the poorest blood supply.

Fibular fractures. These commonly occur 2 to 6 cm proximal to the distal end of the lateral malleolus and are often associated with fracture/dislocations of the ankle joint, which are combined with tibial fractures. When a person slips and the foot is forced into an excessively inverted position, the ankle ligaments tear, forcibly tilting the talus against the lateral malleolus and shearing it off.

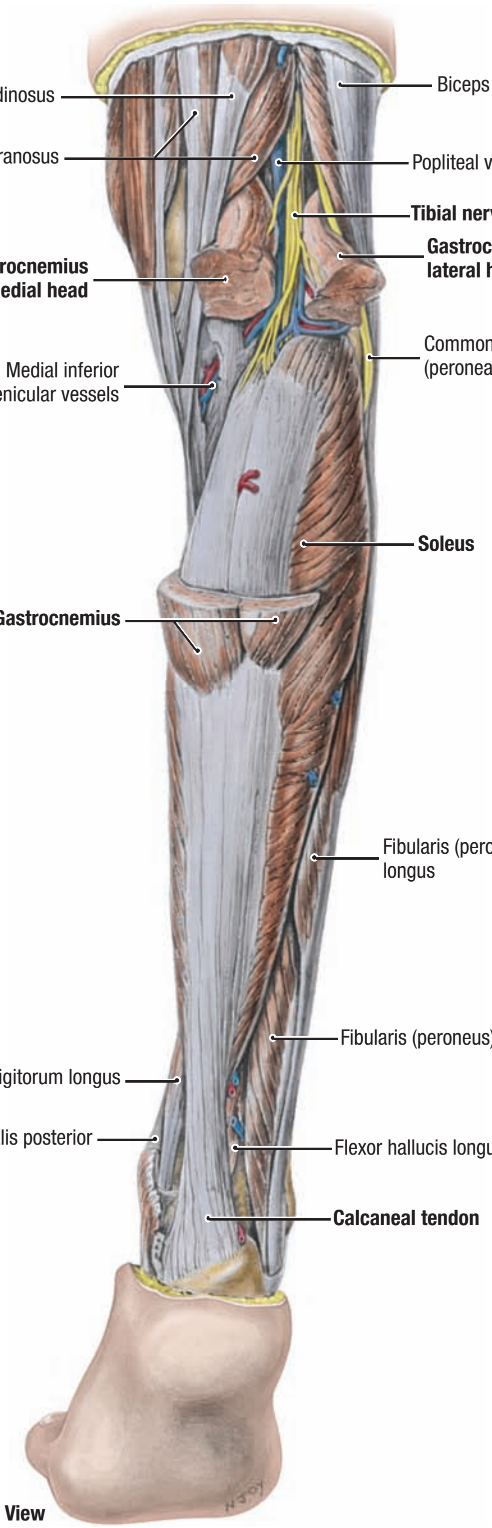
A. Posterior View



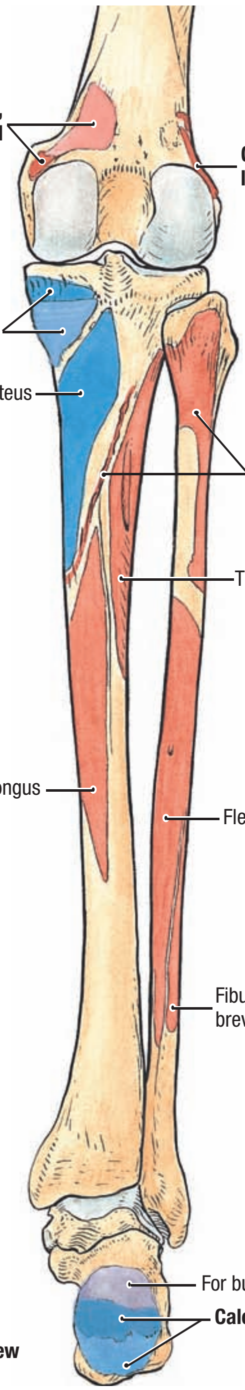
B. Posterior View

5.69 POSTERIOR LEG, SUPERFICIAL MUSCLES OF POSTERIOR COMPARTMENT

A. Surface anatomy (*numbers* refer to structures labeled in **B**). **B.** Dissection. **Gastrocnemius strain** (tennis leg) is a painful calf injury resulting from partial tearing of the medial belly of the muscle at or near its musculotendinous junction. It is caused by overstretching the muscle during simultaneous full extension of the knee joint and dorsiflexion of the ankle joint.



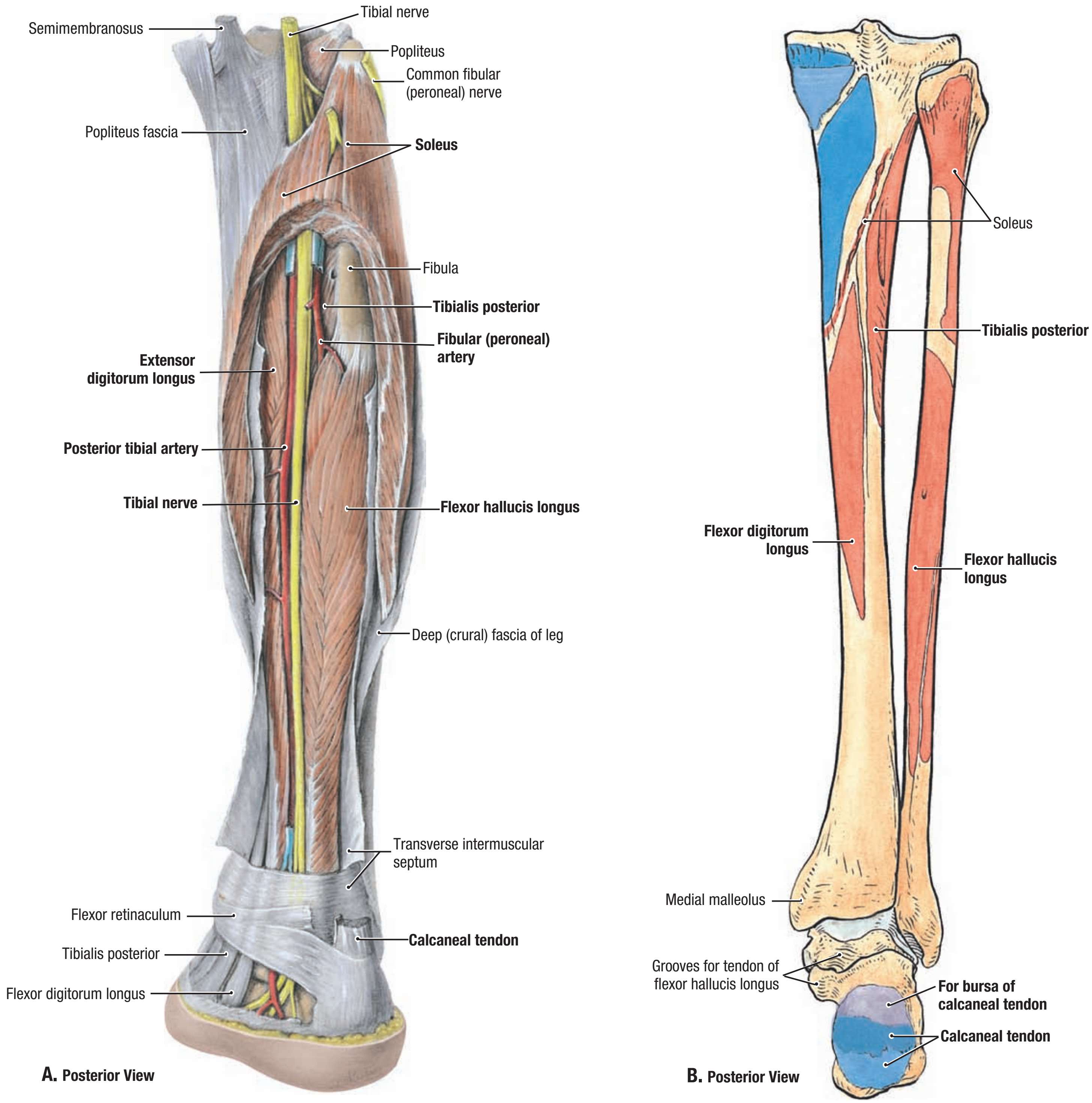
C. **Posterior View**



D. **Posterior View**

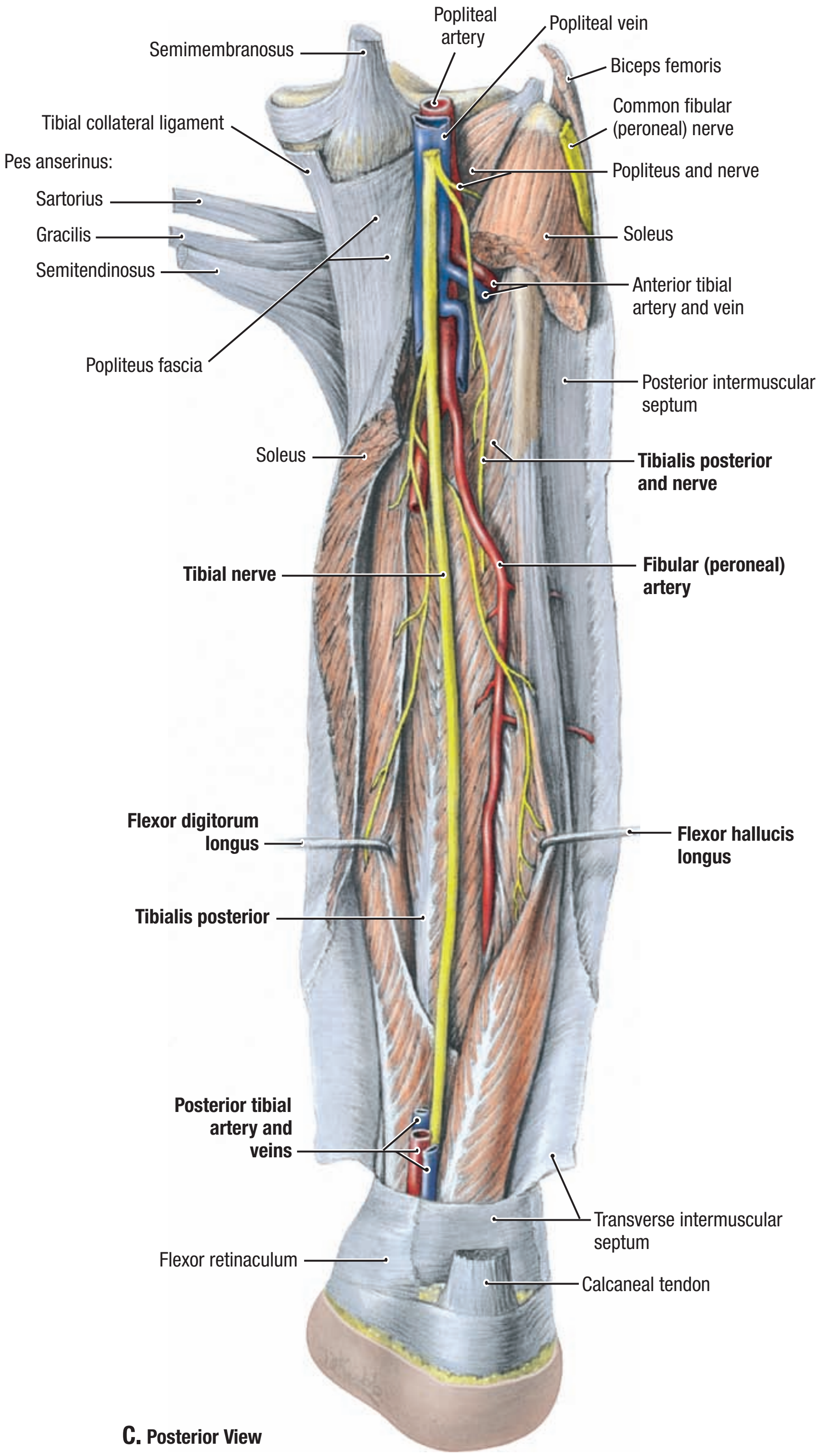
5.69 POSTERIOR LEG, SUPERFICIAL MUSCLES OF POSTERIOR COMPARTMENT (*CONTINUED*)

C. Dissection revealing soleus. **D.** Bones of leg showing muscle attachments. Inflammation of the calcaneal tendon due to microscopic tears of collagen fibers in the tendon, particularly just superior to its attachment to the calcaneus, results in **calcaneal tendinitis**, which causes pain during walking. **Calcaneal tendon rupture** is probably the most severe acute muscular problem of the leg. Following complete rupture of the tendon, passive dorsiflexion is excessive, and the person cannot plantar flex against resistance.

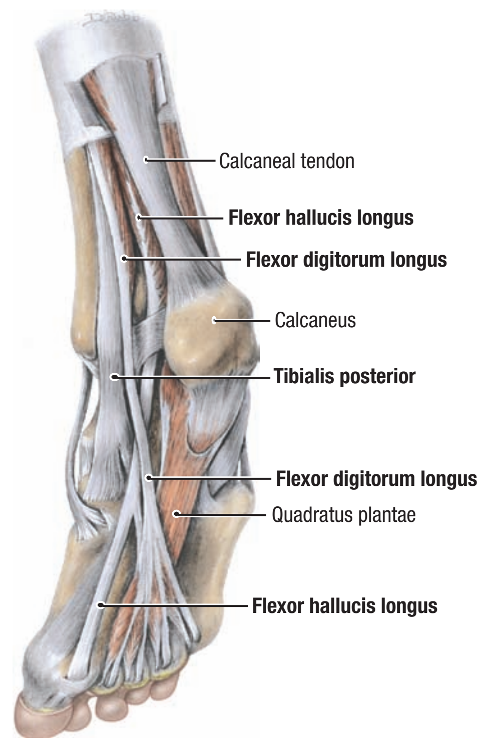


5.70 POSTERIOR LEG, DEEP MUSCLES OF POSTERIOR COMPARTMENT

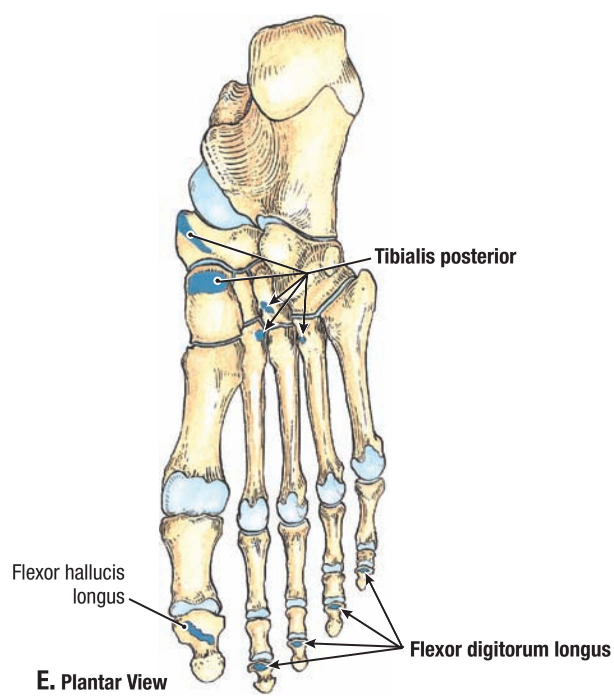
A. Superficial dissection. The calcaneal (Achilles) tendon is cut, the gastrocnemius muscle is removed, and only a horseshoe-shaped proximal part of the soleus muscle remains in place. **B.** Bones of leg showing muscle attachments. **Calcaneal bursitis** results from inflammation of the bursa of the calcaneal tendon located between the calcaneal tendon and the superior part of the posterior surface of the calcaneus. Calcaneal bursitis causes pain posterior to the heel and occurs commonly during long-distance running, basketball, and tennis. It is caused by excessive friction on the bursa as the calcaneal tendon continuously slides over it.



C. Posterior View



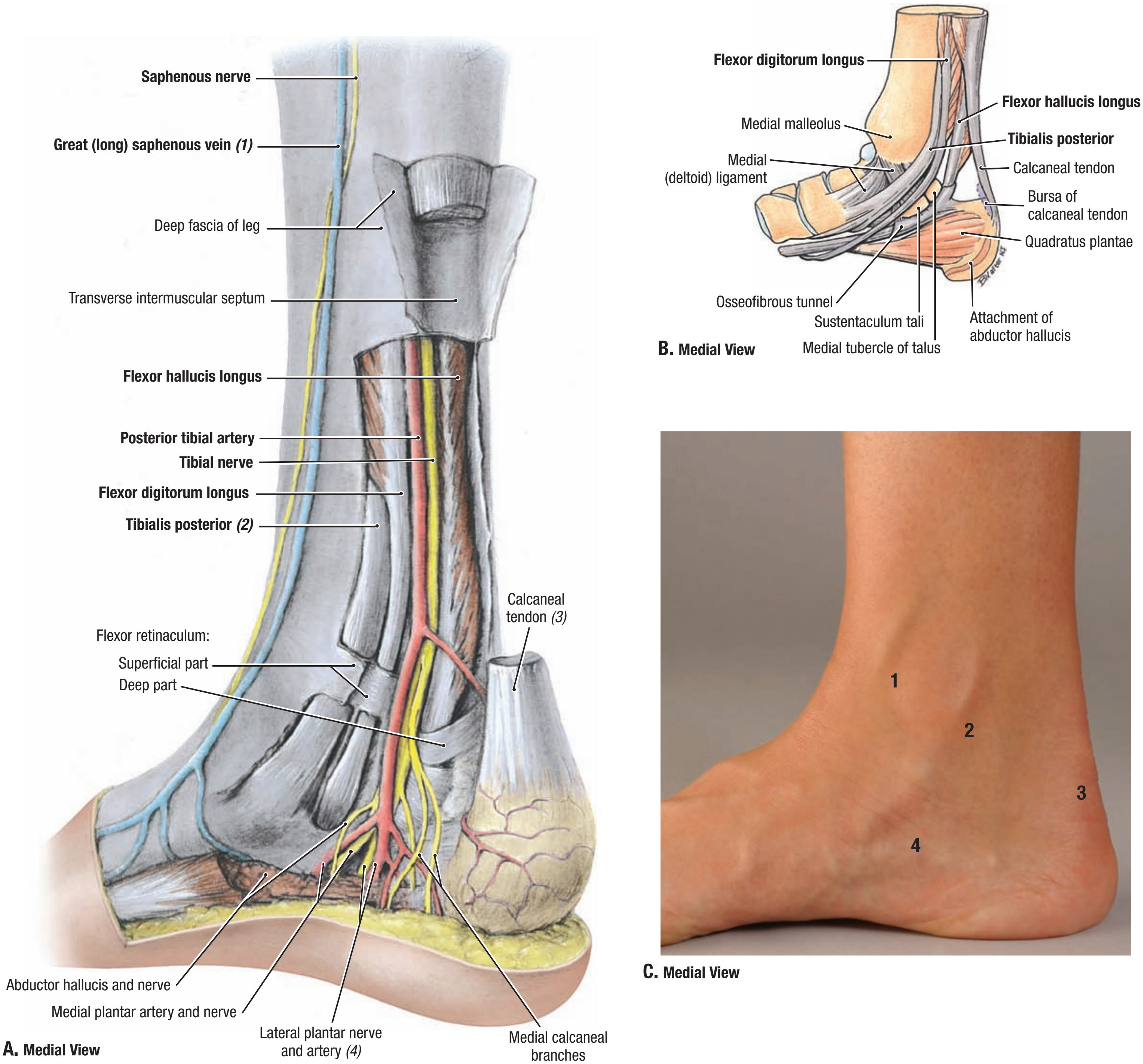
D. Anteromedial View



E. Plantar View

5.70 POSTERIOR LEG, DEEP MUSCLES OF POSTERIOR COMPARTMENT (*CONTINUED*)

C. Deeper dissection. The flexor hallucis longus and flexor digitorum longus are pulled apart, and the posterior tibial artery is partly excised. The tibialis posterior lies deep to the two long digital flexors. **D.** Crossing of muscles (tendons) of the deep compartment superoposterior to the medial malleolus and into the sole of the foot. **E.** Bones of foot showing muscle attachments.



A. Medial View

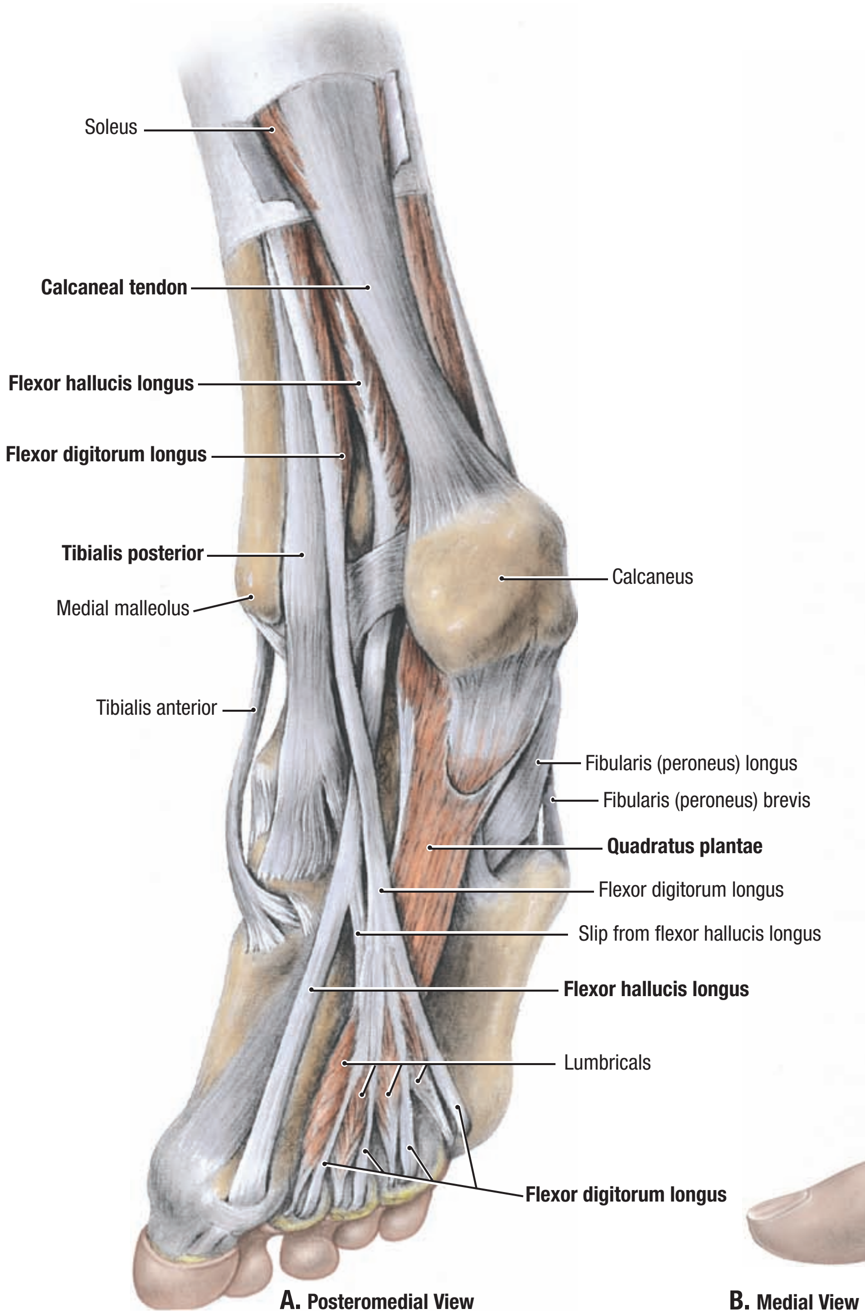
B. Medial View

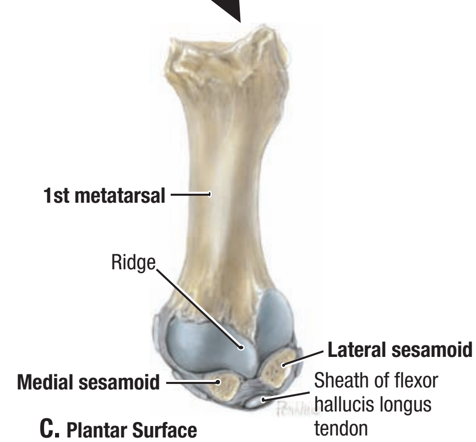
C. Medial View

5.71 MEDIAL ANKLE REGION

A. Dissection. The calcaneal tendon and posterior part of the abductor hallucis were excised. **B.** Schematic illustration of the tendons passing posterior to medial malleolus. **C.** Surface anatomy (*numbers* refer to structures labeled in **A**).

- The posterior tibial artery and the tibial nerve lie between the flexor digitorum longus and flexor hallucis longus muscles and divide into medial and lateral plantar branches.
- The tibialis posterior and flexor digitorum longus tendons occupy separate osseofibrous tunnels posterior to the medial malleolus.
- The **posterior tibial pulse** can usually be palpated between the posterior surface of the medial malleolus and the medial border of the calcaneal tendon.

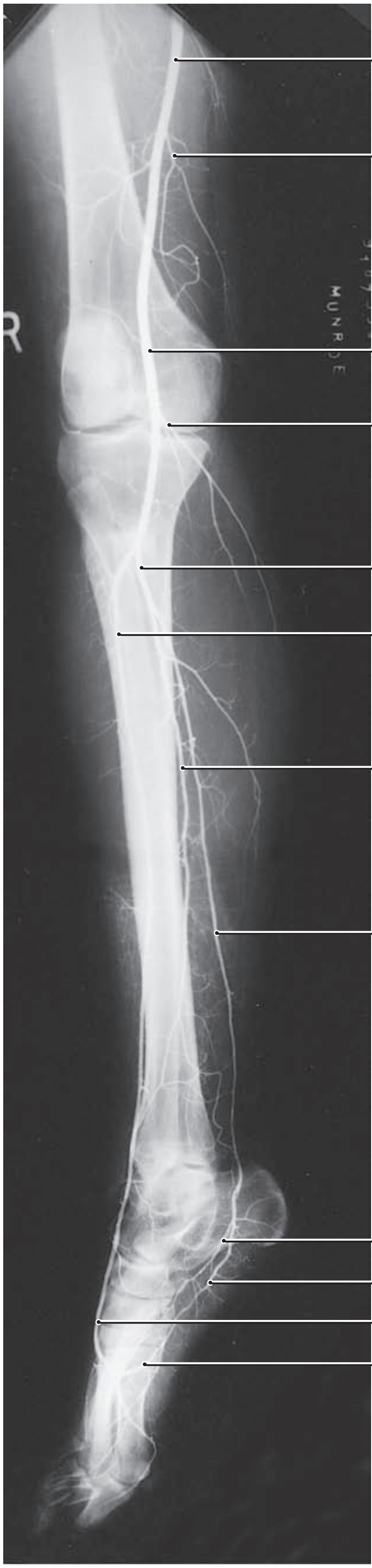




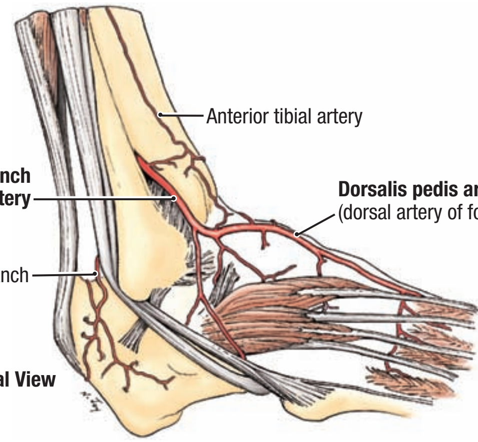
5.72 MEDIAL ANKLE AND FOOT

A. Tendons of deep compartment of the leg traced to their distal attachments in the sole of the foot. **B.** Foot raised as in walking and sesamoid bones of the great toe. The sesamoid bones of the great toe are located on each side of a bony ridge on the 1st metatarsal.

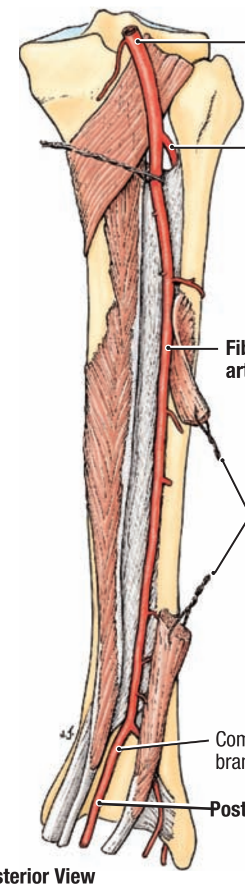
- The sesamoid bones are a "footstool" for the first metatarsal, giving it increased height.
- By inserting into the flexor digitorum longus muscle, the quadratus plantae muscle modifies the oblique pull of the flexor tendons.
- The flexor hallucis longus muscle uses three pulleys: a groove on the posterior aspect of the distal end of the tibia, a groove on the posterior aspect of the talus, and a groove inferior to the sustentaculum tali.
- The flexor digitorum longus muscle crosses superficial to the tibialis posterior, superoposterior to the medial malleolus.



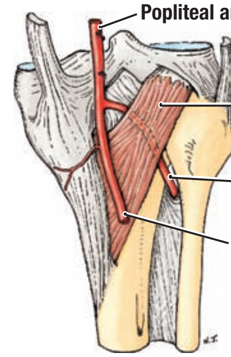
A. Medial View



B. Lateral View



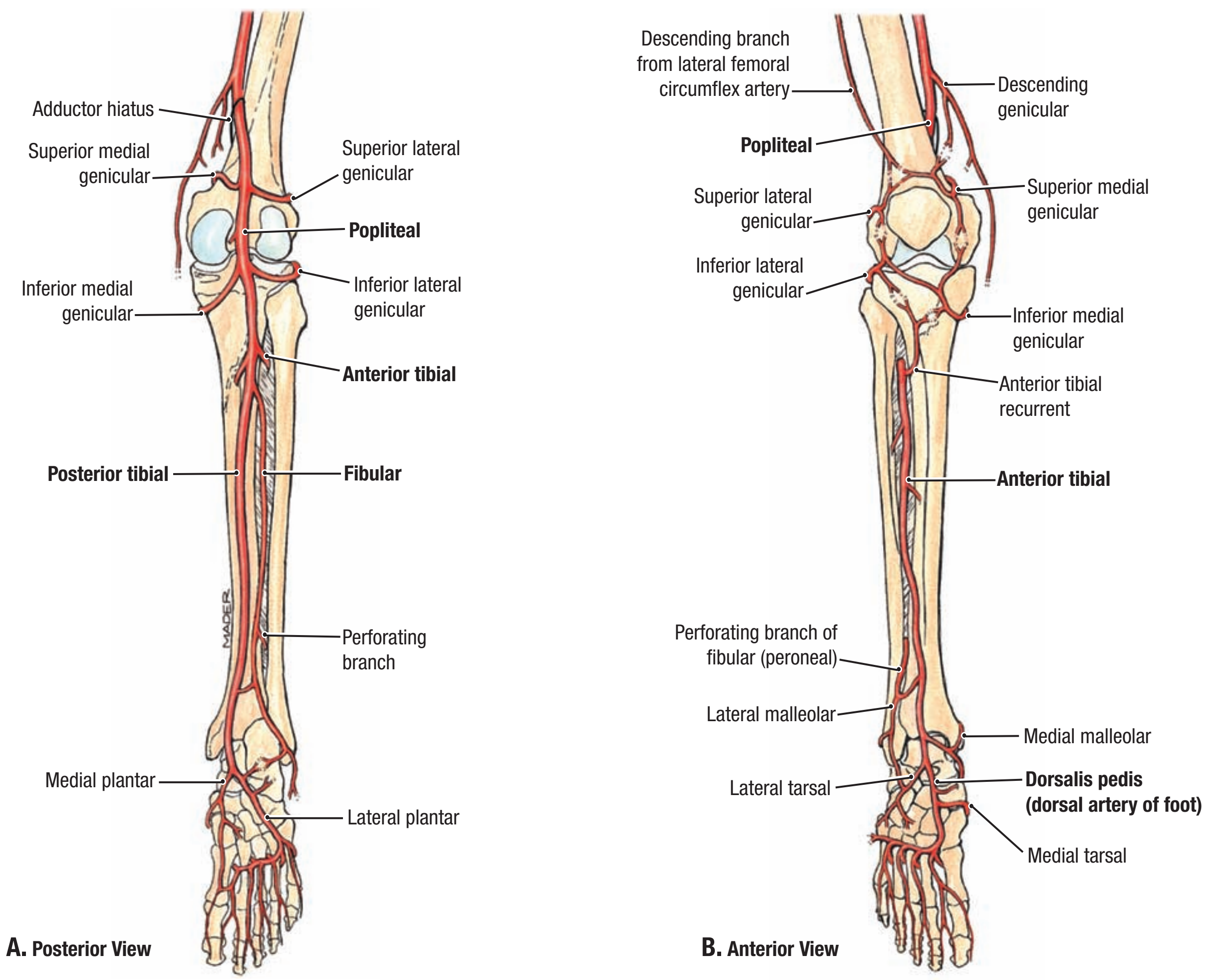
C. Posterior View



D. Posterior View

5.73 POPLITEAL ARTERIOGRAM AND ARTERIAL ANOMALIES

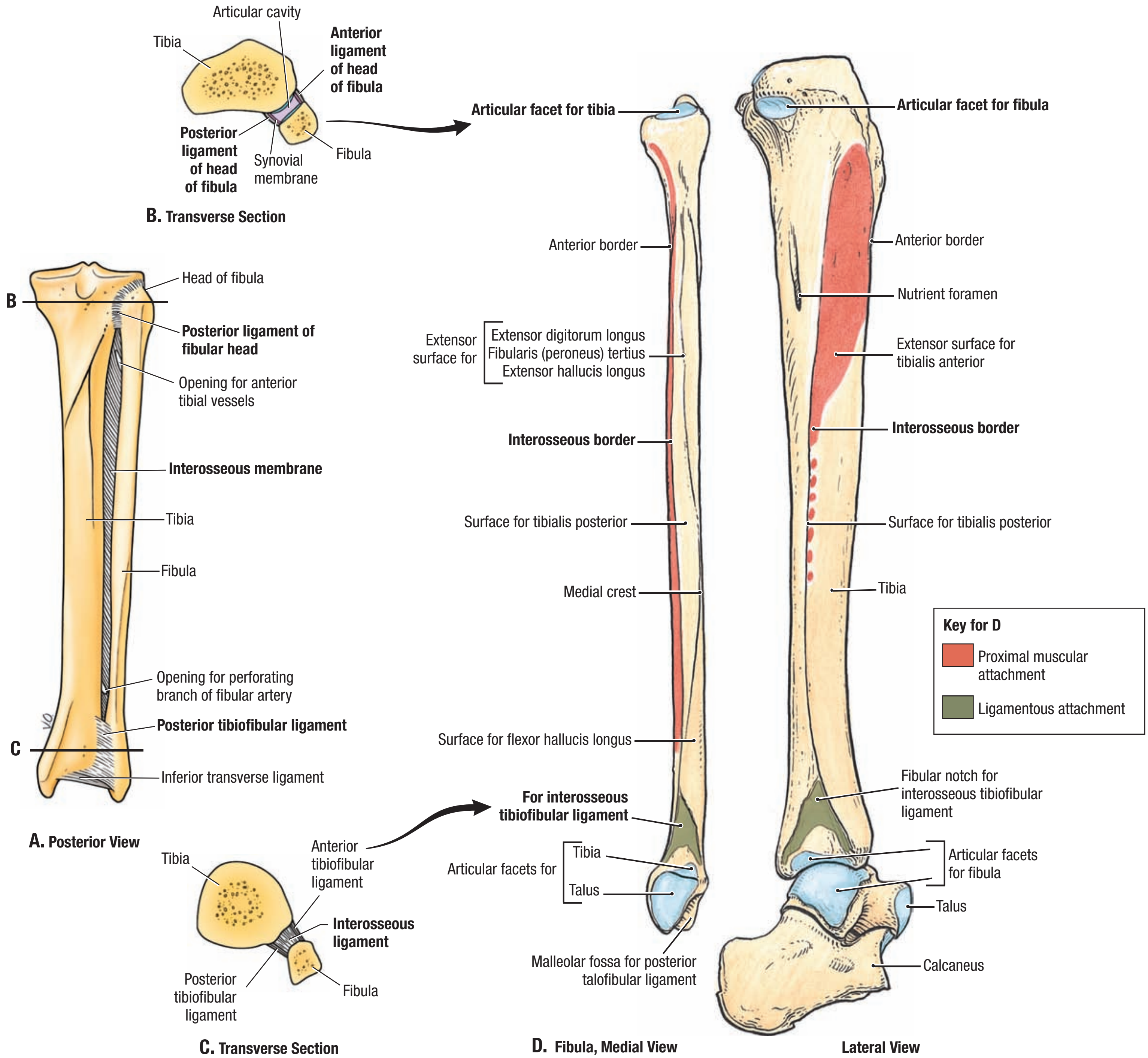
A. Popliteal arteriogram. The femoral artery becomes the popliteal artery at the adductor hiatus. The anterior tibial artery continues as the dorsalis pedis (dorsal artery of the foot). The posterior tibial artery terminates as the medial and lateral plantar arteries; its major branch is the fibular artery. **B. Anomalous dorsalis pedis artery**. The perforating branch of the fibular artery rarely continues as the dorsalis pedis artery, but when it does, the anterior tibial artery ends proximal to the ankle or is a slender vessel. **C. Absence of posterior tibial artery**. Compensatory enlargement of the fibular artery was found to occur in approximately 5% of limbs. **D. High division of popliteal artery**. Along with the anterior tibial artery descending anterior to the popliteus muscle; this anomaly was found to occur in approximately 2% of limbs.



5.74 ARTERIAL SUPPLY OF LEG AND FOOT

TABLE 5.17 ARTERIAL SUPPLY OF LEG AND FOOT

Artery	Origin	Course	Distribution in Leg
Popliteal	Continuation of femoral artery at adductor hiatus	Passes through popliteal fossa to leg; divides into anterior and posterior tibial arteries at lower border of popliteus	Lateral and medial aspects of knee via genicular arteries
Anterior tibial	From popliteal	Passes between tibia and fibula into anterior compartment through gap superior to interosseous membrane; descends between tibialis anterior and extensor digitorum longus muscles	Anterior compartment
Dorsalis pedis (dorsal artery of foot)	Continuation of anterior tibial artery distal to talocrural joint	Descends to first interosseous space; pierces first dorsal interosseous muscle as deep plantar artery; joins deep plantar arch	Muscles on dorsum of foot
Posterior tibial	From popliteal	Passes through posterior compartment; divides into medial and lateral plantar arteries posterior to medial malleolus	Posterior and lateral compartments, nutrient artery passes to tibia
Fibular (peroneal)		Descends in posterior compartment adjacent to posterior intermuscular septum	Posterior compartment: perforating branches supply lateral compartment
Medial plantar	From posterior tibial	In foot between abductor hallucis and flexor digitorum brevis muscles	Supplies mainly muscles of great toe and skin on medial side of sole of foot
Lateral plantar		Runs anterolaterally deep to abductor hallucis and flexor digitorum brevis, and then arches medially to form deep plantar arch	Supplies lateral aspect of sole of foot

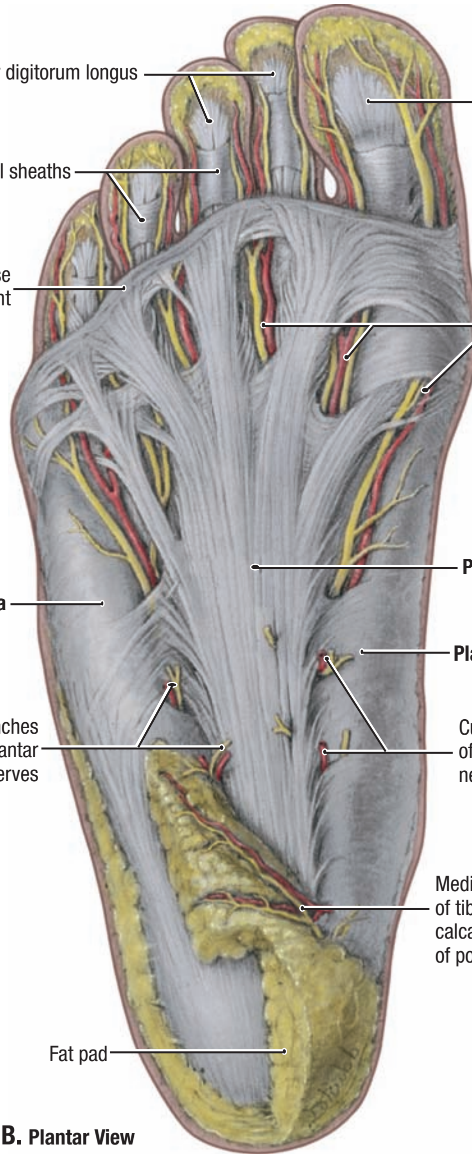


5.75 TIBIOFIBULAR JOINT AND TIBIOFIBULAR SYNDESMOSIS

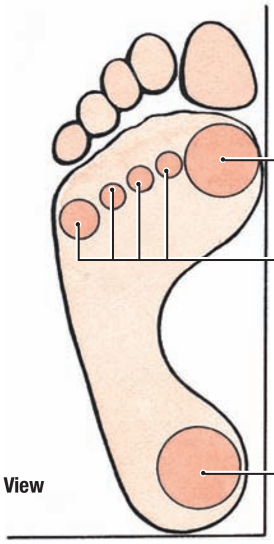
A. Overview. **B.** Tibiofibular joint. **C.** Tibiofibular syndesmosis. **D.** Tibia and fibula, disarticulated.

- The superior tibiofibular joint (proximal tibiofibular joint) is a plane type of synovial joint between the flat facet on the fibular head and a similar facet located posterolaterally on the lateral tibial condyle. The tense joint capsule surrounds the joint and attaches to the margins of the articular surfaces of the fibula and tibia.
- The tibiofibular syndesmosis is a fibrous joint. This articulation is essential for stability of the ankle joint because it keeps the lateral malleolus firmly against the lateral surface of the talus. The strong interosseous tibiofibular ligament is continuous superiorly with the interosseous membrane and forms the principal connection between the distal ends of the tibia and fibula.

A. Plantar View



B. Plantar View



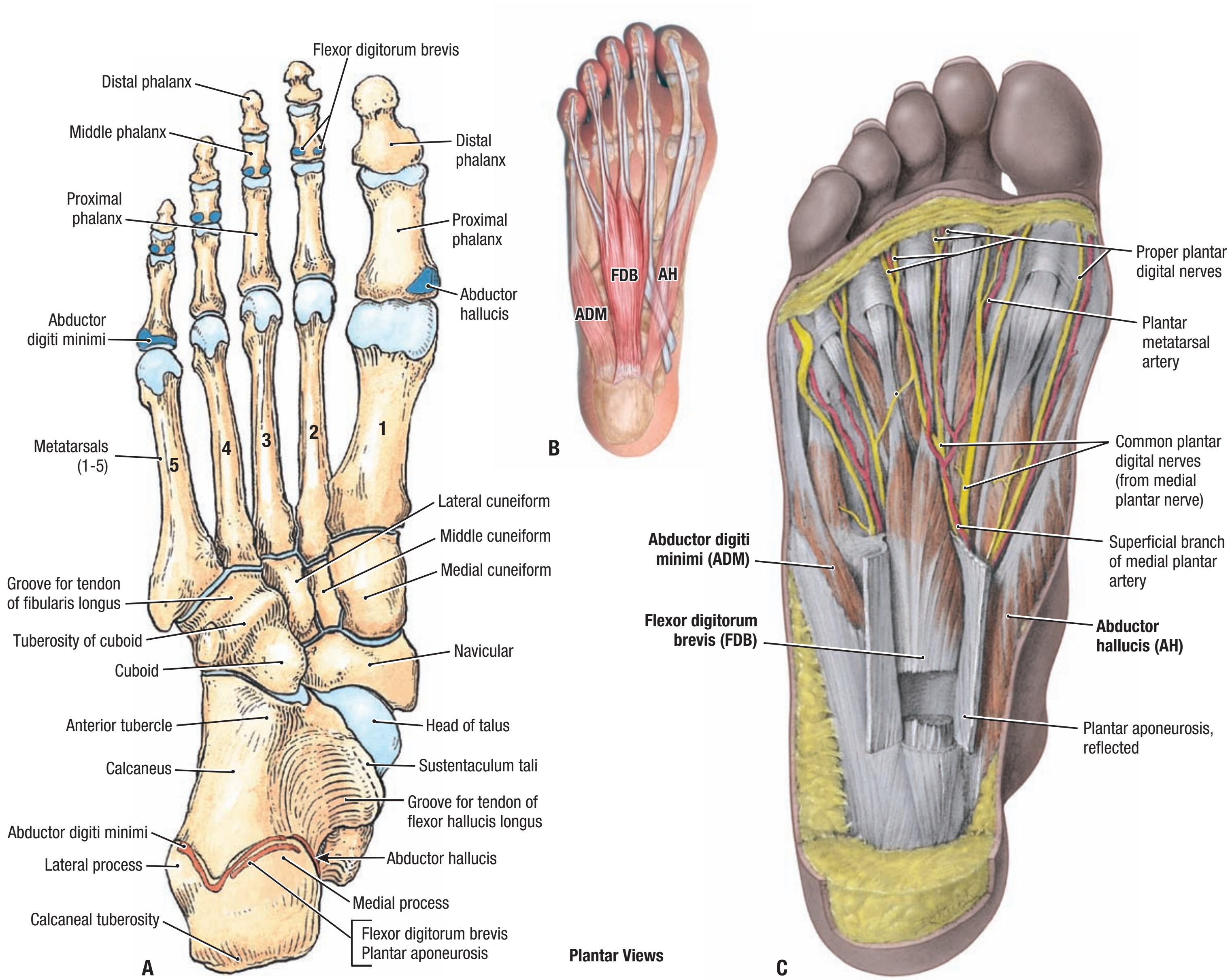
C. Plantar View

5.76 SOLE OF FOOT, SUPERFICIAL

A. Surface anatomy. **B.** Dissection. Plantar aponeurosis and fascia, with neurovascular structures. **C.** Weight-bearing areas.

- The weight of the body is transmitted to the talus from the tibia and fibula. It is then transmitted to the tuberosity of the calcaneus, the heads of the second to fifth metatarsals, and the sesamoid bones of the first digit.

Plantar fasciitis, strain and inflammation of the plantar aponeurosis, may result from running and high-impact aerobics, especially when inappropriate footwear is worn. It causes pain on the plantar surface of the heel and on the medial aspect of the foot. Point tenderness is located at the proximal attachment of the plantar aponeurosis to the medial tubercle of the calcaneus and on the medial surface of this bone. The pain increases with passive extension of the great toe and may be further exacerbated by dorsiflexion of the ankle and/or weight bearing.



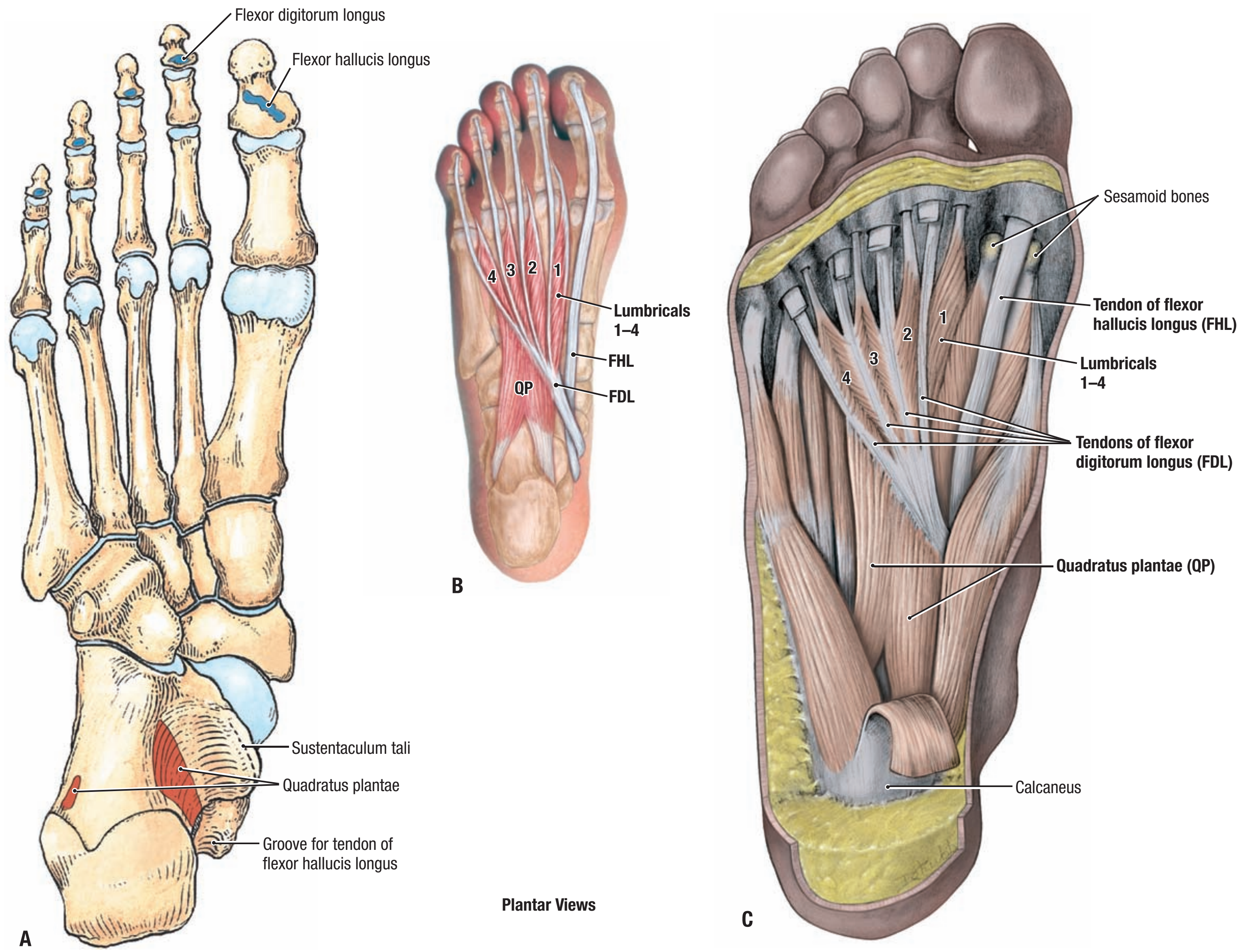
5.77 FIRST LAYER OF MUSCLES OF SOLE OF FOOT

A. Bones. **B.** Overview. **C.** Dissection. Muscles and neurovascular structures.

TABLE 5.18 MUSCLES IN SOLE OF FOOT—FIRST LAYER

Muscle	Proximal Attachment	Distal Attachment	Innervation	Actions[a]
Abductor hallucis	Medial process of tuberosity of calcaneus, flexor retinaculum, and plantar aponeurosis	Medial side of base of proximal phalanx of first digit	Medial plantar nerve (S2–S3)	Abducts and flexes first digit
Flexor digitorum brevis	Medial process of tuberosity of calcaneus, plantar aponeurosis, and intermuscular septa	Both sides of middle phalanges of lateral four digits		Flexes lateral four digits
Abductor digiti minimi	Medial and lateral processes of tuberosity of calca-neus, plantar aponeurosis, and intermuscular septa	Lateral side of base of proximal phalanx of fifth digit	Lateral plantar nerve (S2–S3)	Abducts and flexes fifth digit

[a]Although individual actions are described, the primary function of the intrinsic muscles of the foot is to act collectively to resist forces that stress (attempt to flatten) the arches of the foot.



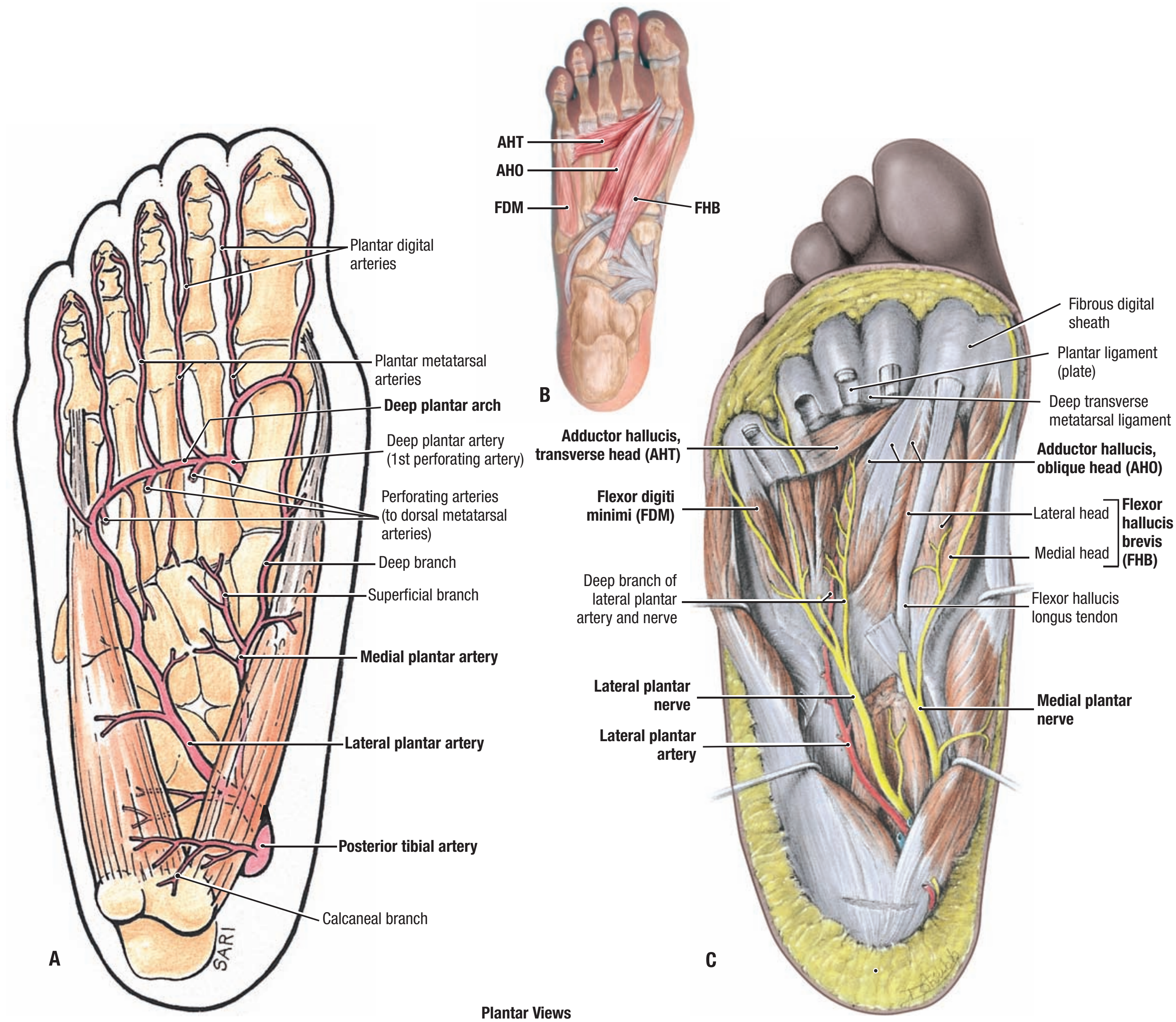
5.78 SECOND LAYER OF MUSCLES OF SOLE OF FOOT

A. Bony attachments. **B.** Overview. **C.** Dissection.

TABLE 5.19 MUSCLES IN SOLE OF FOOT—SECOND LAYER

Muscle	Proximal Attachment	Distal Attachment	Innervation	Actions[a]
Quadratus plantae	Medial surface and lateral margin of plantar surface of calcaneus	Posterolateral margin of tendon of flexor digitorum longus	Lateral plantar nerve (S2–S3)	Assists flexor digitorum longus in flexing lateral four digits
Lumbricals	Tendons of flexor digitorum longus	Medial aspect of extensor expansion over lateral four digits	*Medial one:* medial plantar nerve (S2–S3); *Lateral three:* lateral plantar nerve (S2–S3)	Flex proximal phalanges and extend middle and distal phalanges of lateral four digits

[a]Although individual actions are described, the primary function of the intrinsic muscles of the foot is to act collectively to resist forces that stress (attempt to flatten) the arches of the foot.



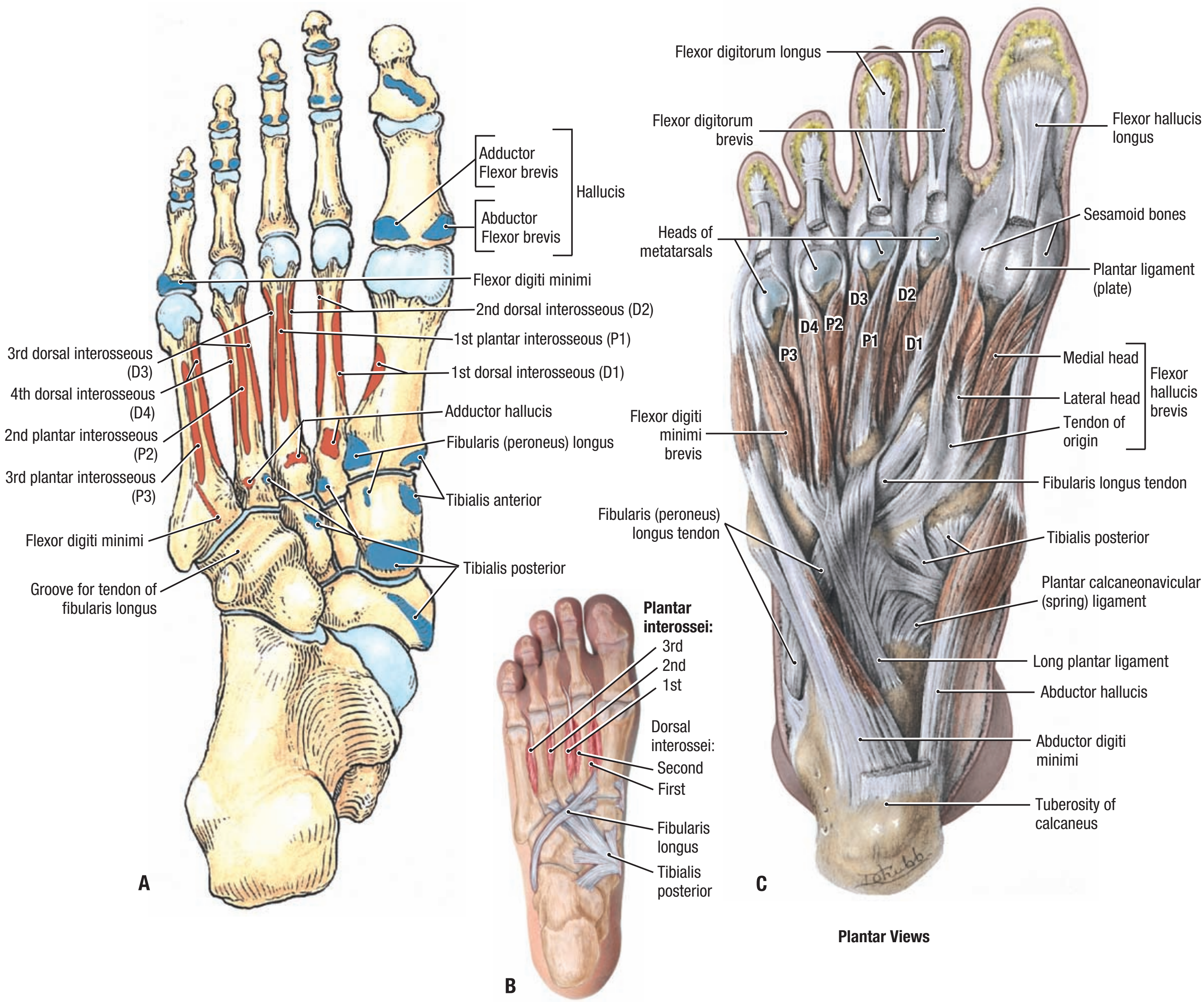
5.79 THIRD LAYER OF MUSCLES AND ARTERIAL SUPPLY OF SOLE OF FOOT

A. Arterial supply. **B.** Overview. **C.** Dissection. Muscles and neurovascular structures.

TABLE 5.20 MUSCLES IN SOLE OF FOOT—THIRD LAYER

Muscle	Proximal Attachment	Distal Attachment	Innervation	Actions[a]
Flexor hallucis brevis	Plantar surfaces of cuboid and lateral cuneiforms	Both sides of base of proximal phalanx of first digit	Medial plantar nerve (S2–S3)	Flexes proximal phalanx of first digit
Adductor hallucis	*Oblique head:* bases of metatarsals 2–4; *Transverse head:* plantar ligaments of metatarsophalangeal joints	Tendons of both heads attach to lateral side of base of proximal phalanx of first digit	Deep branch of lateral plantar nerve (S2–S3)	Adducts first digit; assists in maintaining transverse arch of foot
Flexor digiti minimi	Base of fifth metatarsal	Base of proximal phalanx of fifth digit	Superficial branch of lateral plantar nerve (S2–S3)	Flexes proximal phalanx of fifth digit, thereby assisting with its flexion

[a]Although individual actions are described, the primary function of the intrinsic muscles of the foot is to act collectively to resist forces that stress (attempt to flatten) the arches of the foot.



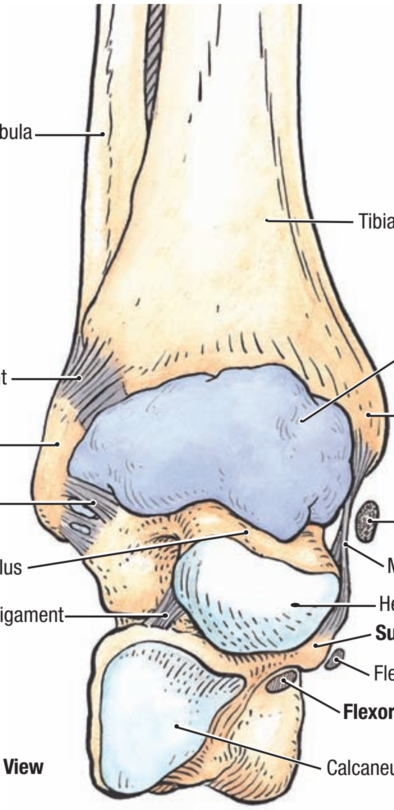
5.80 FOURTH LAYER OF MUSCLES OF SOLE OF FOOT

A. Bony attachments of muscles of third and fourth layers. **B.** Overview. **C.** Dissection. Muscles and ligaments.

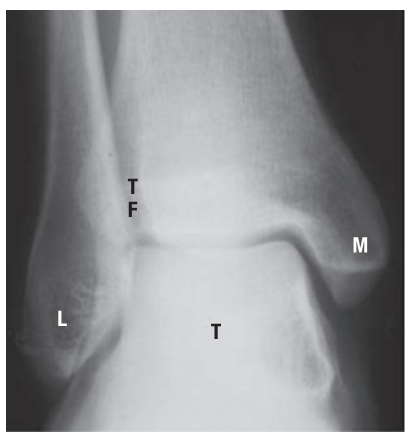
TABLE 5.21 MUSCLES IN SOLE OF FOOT—FOURTH LAYER

Muscle	Proximal Attachment	Distal Attachment	Innervation	Actions[a]
Plantar interossei (three muscles; P1–P3)	Plantar aspect of medial sides of shafts of metatarsals 3–5	Medial sides of bases of proximal phalanges of third to fifth digits	Lateral plantar nerve (S2–S3)	Adduct digits 3–5 and flex metatarsophalangeal joints
Dorsal interossei (four muscles; D1–D4)	Adjacent sides of shafts of metatarsals 1–5	First: medial side of proximal phalanx of second digit Second to fourth: lateral sides of second to fourth digits		Abduct digits 2–4 and flex metatarsophalangeal joints

[a]Although individual actions are described, the primary function of the intrinsic muscles of the foot is to act collectively to resist forces that stress (attempt to flatten) the arches of the foot.



A. **Anterior View**

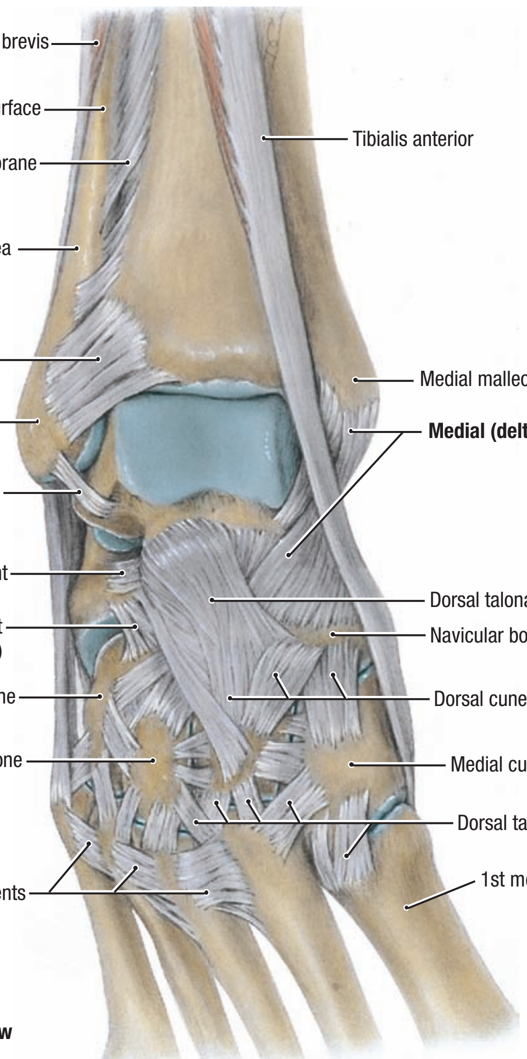


B. **Anteroposterior View**

5.81 JOINT CAVITY OF ANKLE JOINT

A. Ankle joint with joint cavity distended with injected latex. **B.** Radiograph of joints of ankle region. *L*, lateral malleolus; *M*, medial malleolus; *T*, talus; *TF*, tibiofibular syndesmosis.

- The anterior articular surfaces of the calcaneus and head of the talus are each convex from side to side; thus the foot can be inverted and everted at the transverse tarsal joint.
- Note the relations of the tendons to the sustentaculum tali: the flexor hallucis longus inferior to it, flexor digitorum longus along its medial aspect, and tibialis posterior superior to it and in contact with the medial (deltoid) ligament.

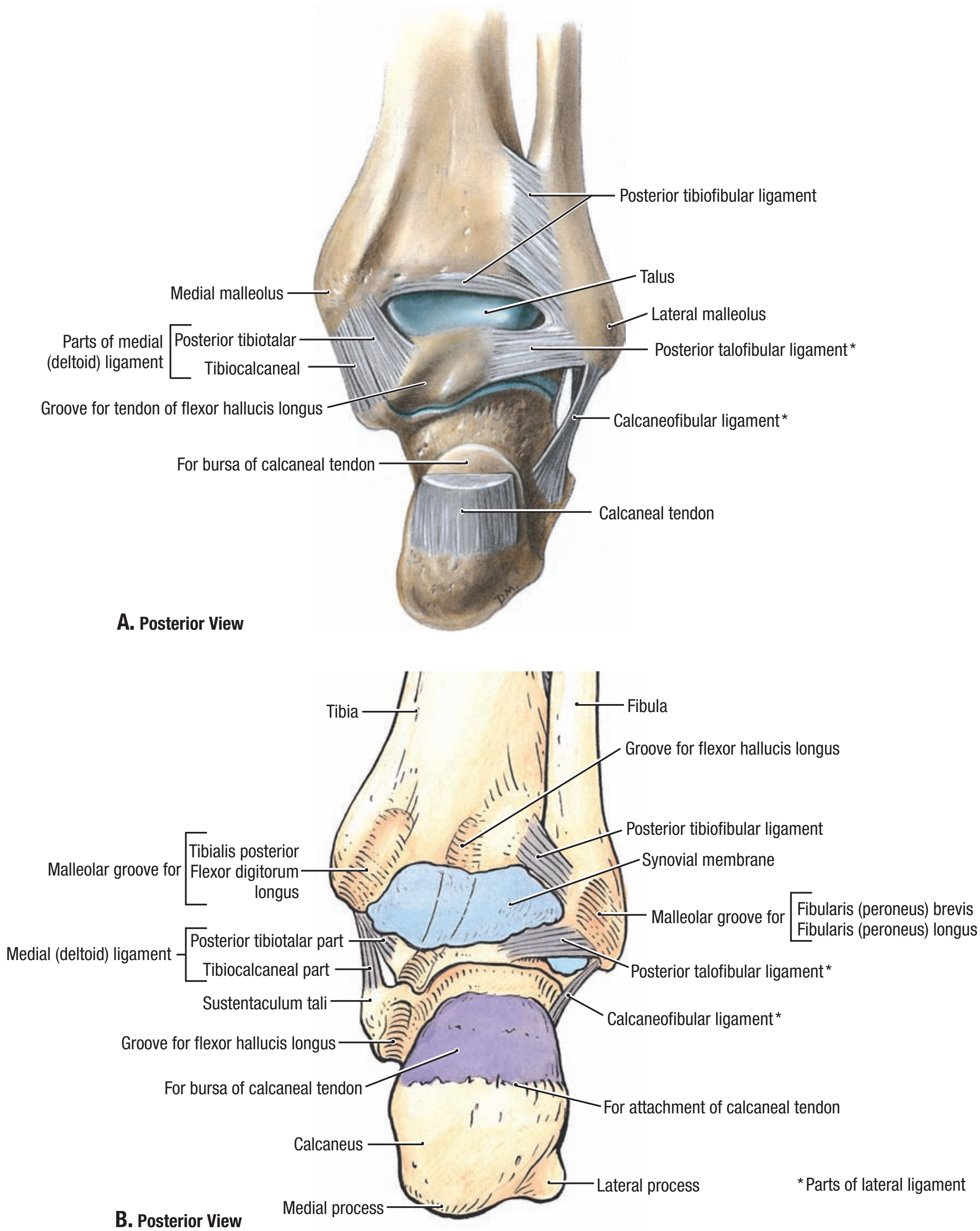


5.82 ANKLE JOINT AND LIGAMENTS OF DORSUM OF FOOT

Dissection. The ankle joint is plantar flexed, and its anterior capsular fibers are removed.

- All muscles attached to the fibula except the biceps femoris pull inferiorly on the bone during contraction. The oblique fibers of the interosseous membrane and ligaments uniting the fibula to the tibia resist this inferior pull but allow the fibula to be forced superiorly during full dorsiflexion of the ankle.
- The bifurcate ligament, a Y-shaped ligament consisting of calcaneocuboid and calcaneonavicular ligaments, and the talonavicular ligament are the primary dorsal ligaments of the transverse tarsal joint.

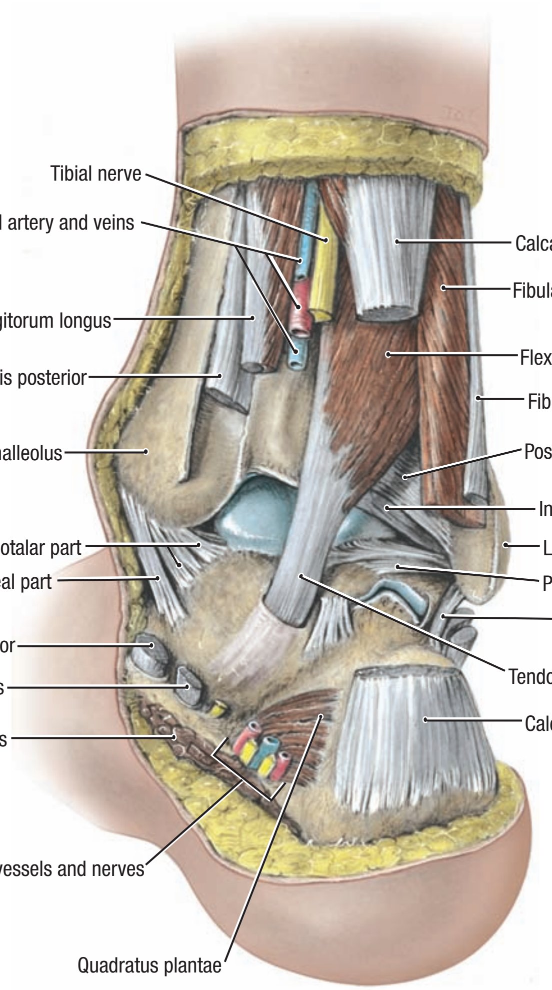
A **Pott fracture-dislocation of the ankle** occurs when the foot is forcibly everted. This action pulls on the extremely strong medial (deltoid) ligament, often avulsing the medial malleolus and compressing the lateral malleolus against the talus, shearing off the malleolus or, more often, fracturing the fibula superior to the tibiofibular syndesmosis.



5.83 POSTERIOR ASPECT OF ANKLE JOINT

A. Dissection. **B.** Ankle joint with joint cavity distended with latex. Observe the grooves for the flexor hallucis longus muscle, which crosses the middle of the ankle joint posteriorly, the two tendons posterior to the medial malleolus, and the two tendons posterior to the lateral malleolus.

- The posterior aspect of the ankle joint is strengthened by the transversely oriented posterior tibiofibular and posterior talofibular ligaments.
- The calcaneofibular ligament stabilizes the joint laterally, and the posterior tibiotalar and tibiocalcanean parts of the medial (deltoid) ligament stabilize it medially.
- The groove for the flexor hallucis tendon is between the medial and lateral tubercles of the talus and continues inferior to the sustentaculum tali.

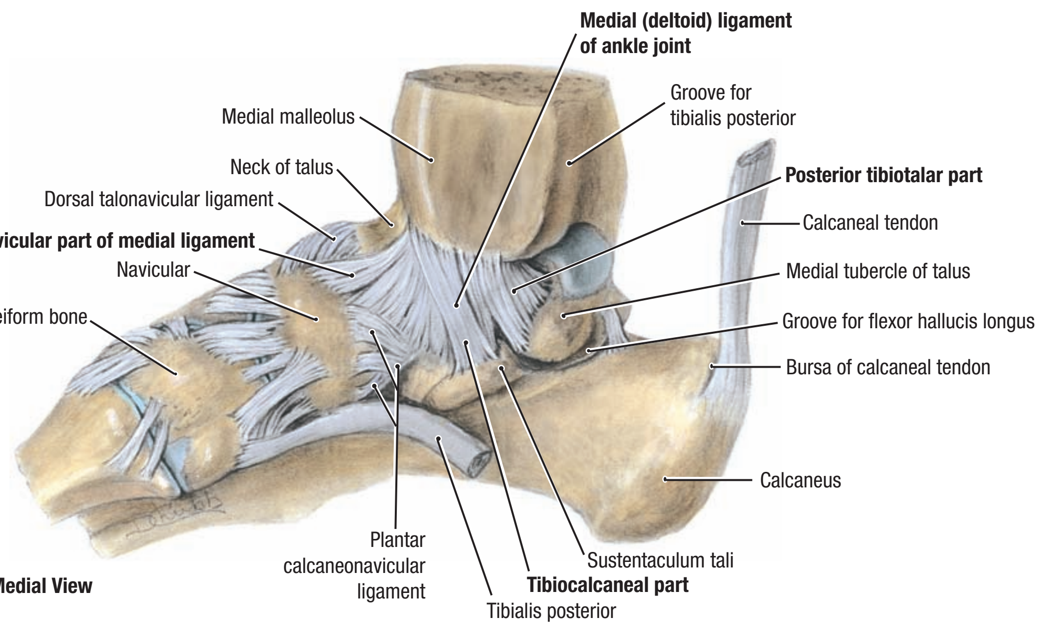


Posteromedial View

5.84 POSTEROMEDIAL ANKLE

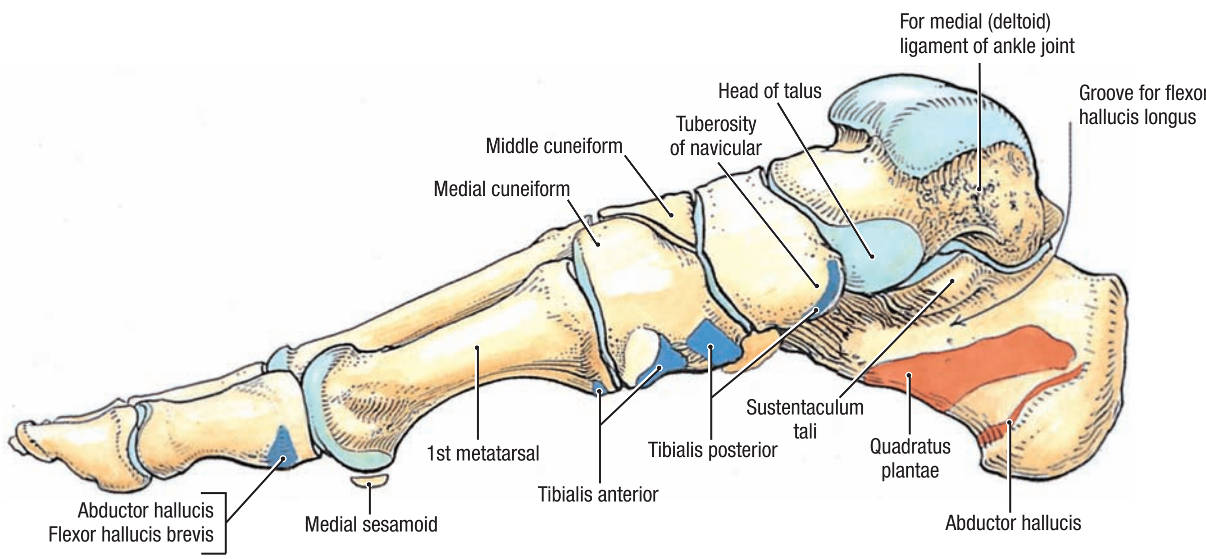
- The flexor hallucis longus muscle is midway between the medial and lateral malleoli; the tendons of the flexor digitorum and tibialis posterior are medial to it, and the tendons of the fibularis longus and brevis are lateral to it.
- The strongest parts of the ligaments of the ankle are those that prevent anterior displacement of the leg bones, namely, the posterior part of the medial ligament (posterior tibiotalar), the posterior talofibular, and calcaneofibular and tibiocalcaneal parts.

Tarsal tunnel syndrome, the entrapment and compression of the tibial nerve, occurs when there is edema and tightness in the ankle involving the synovial sheaths of the tendons of muscles in the posterior compartment of the leg. The area involved is from the medial malleolus to the calcaneus. The heel pain results from compression of the tibial nerve by the flexor retinaculum.



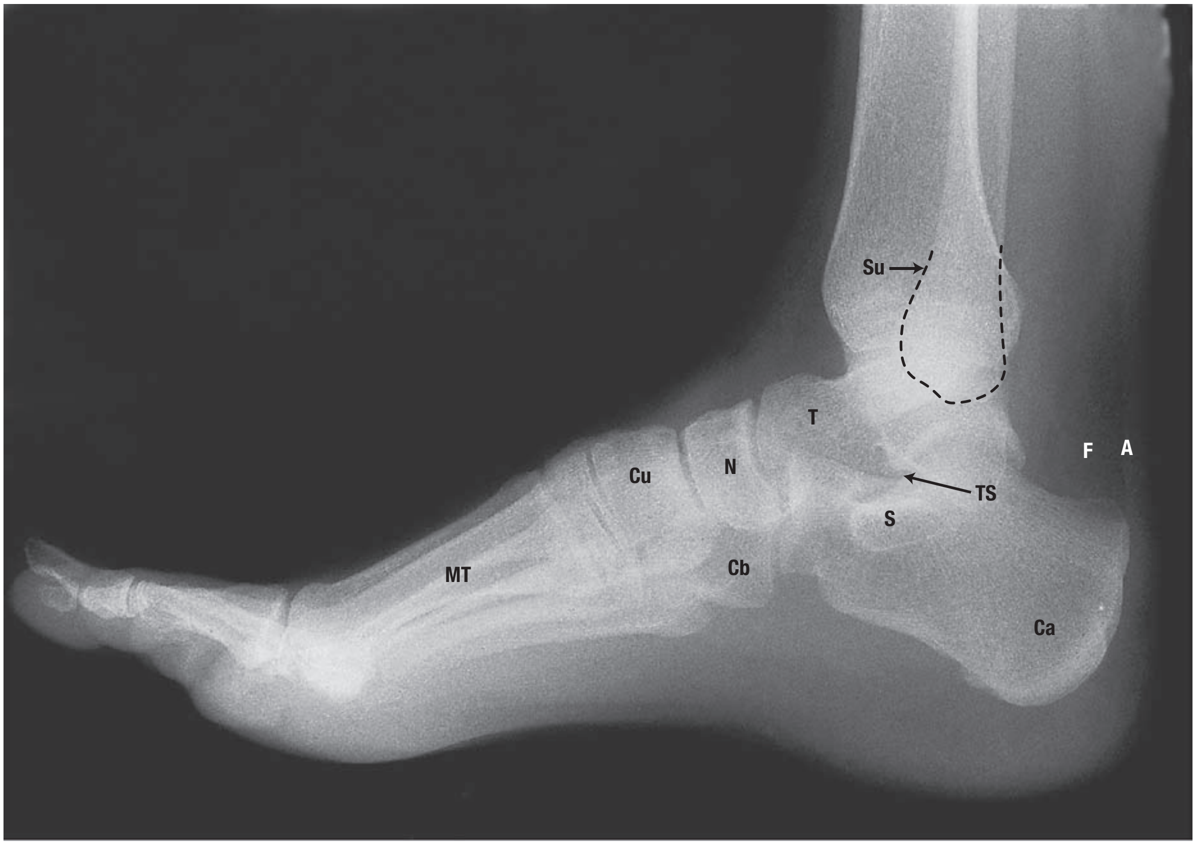
A. Medial View

B.



5.85 MEDIAL LIGAMENTS OF ANKLE REGION

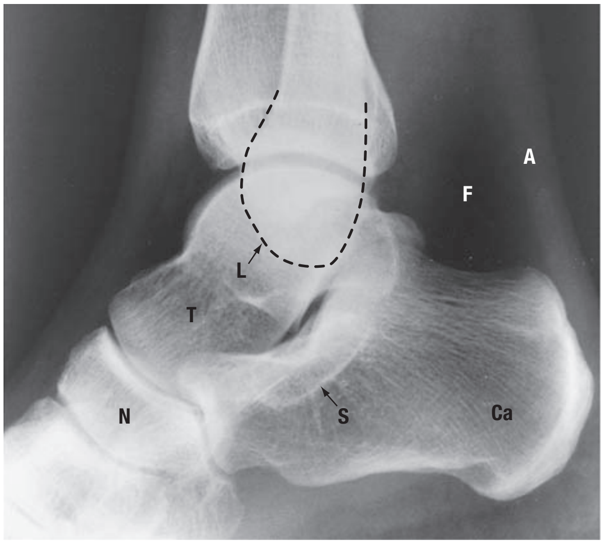
A. Dissection. **B.** Bones. The joint capsule of the ankle joint is reinforced medially by the large, strong medial (deltoid) ligament that attaches proximally to the medial malleolus and fans out from it to attach distally to the talus, calcaneus, and navicular via four adjacent and continuous parts: the tibionavicular part, the tibiocalcaneal part, and the anterior and posterior tibiotalar parts. The medial ligament stabilizes the ankle joint during eversion of the foot and prevents subluxation (partial dislocation) of the ankle joint.



A

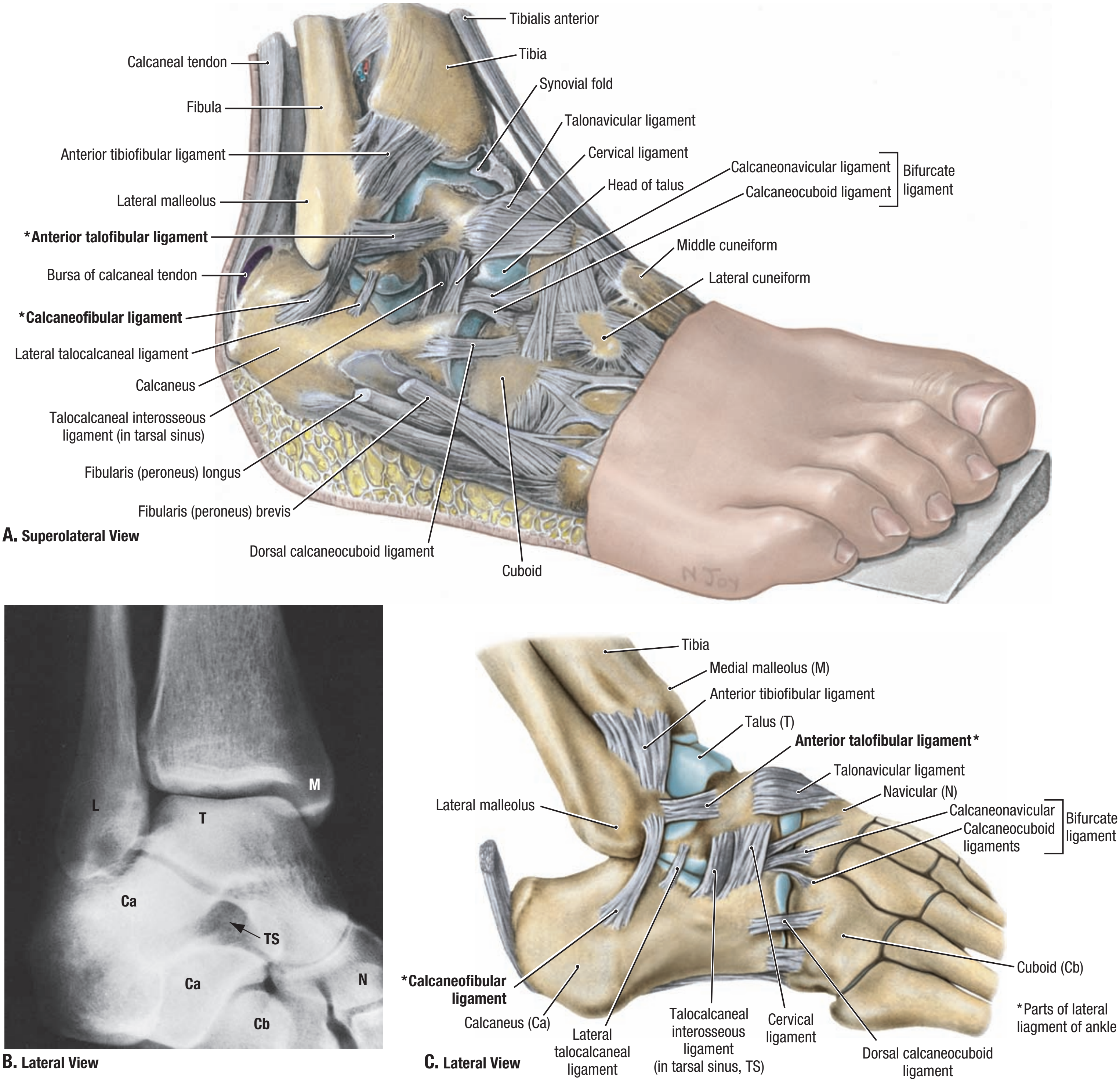
Medial Views

A	Calcaneal (Achilles) tendon
Ca	Calcaneus
Cb	Cuboid
Cu	Cuneiforms
F	Fat
L	Lateral malleolus
MT	Metatarsal
N	Navicular
S	Sustentaculum tali
Su	Superimposed tibia and fibula
T	Talus
TS	Tarsal sinus



B

5.86 RADIOGRAPHS OF ANKLE AND FOOT

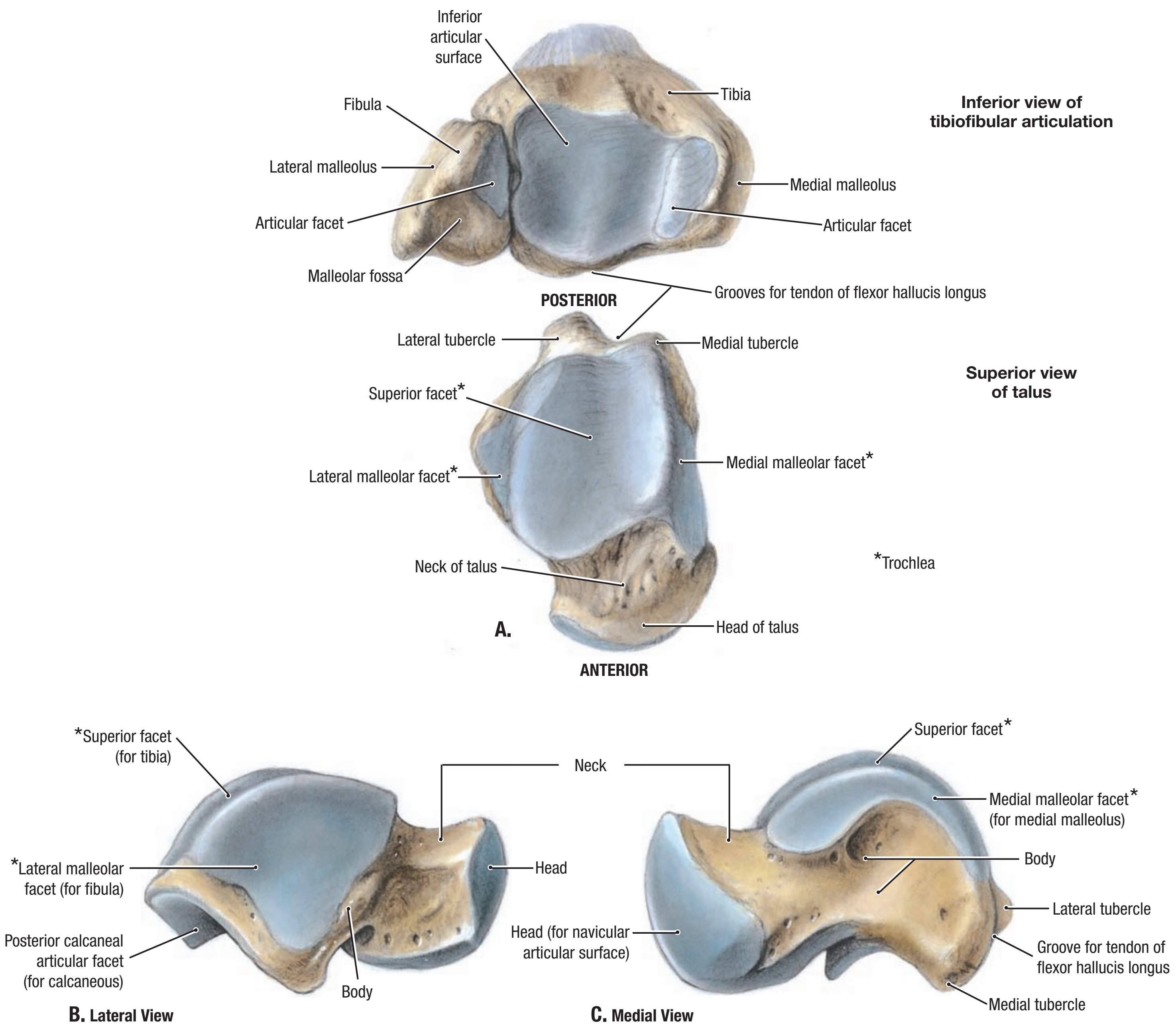


5.87 LATERAL LIGAMENTS OF ANKLE REGION

A. Dissection with foot inverted by underlying wedge. **B.** Lateral radiograph. **C.** Dissection. (Abbreviations refer to structures identified in **B.**)

The ankle joint is reinforced laterally by the lateral ligament of the ankle, which consists of three separate ligaments: (1) anterior talofibular ligament, a flat, weak band; (2) calcaneofibular ligament, a round cord directed postero-inferiorly; and (3) posterior talofibular ligament, a strong, medially directed horizontal ligament (see Fig. 5.83).

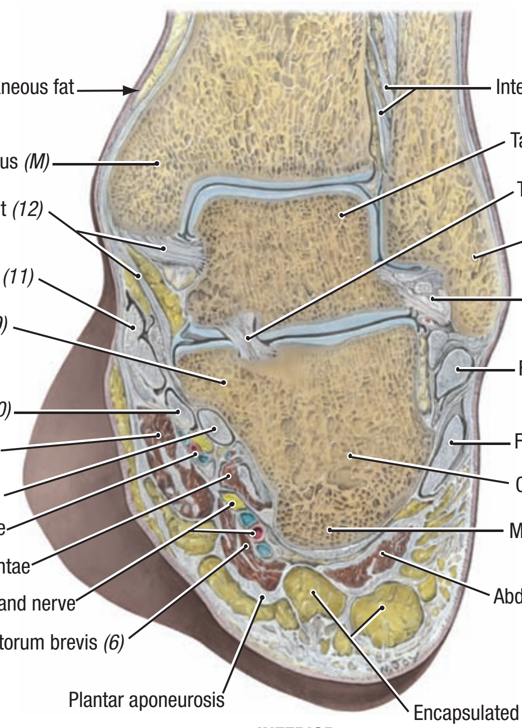
Ankle sprains (partial or fully torn ligaments) are common injuries. Ankle sprains nearly always result from forceful inversion of the weight-bearing plantar flexed foot. The anterior talofibular ligament is most commonly injured, resulting in instability of the ankle. The calcaneofibular is also often torn.



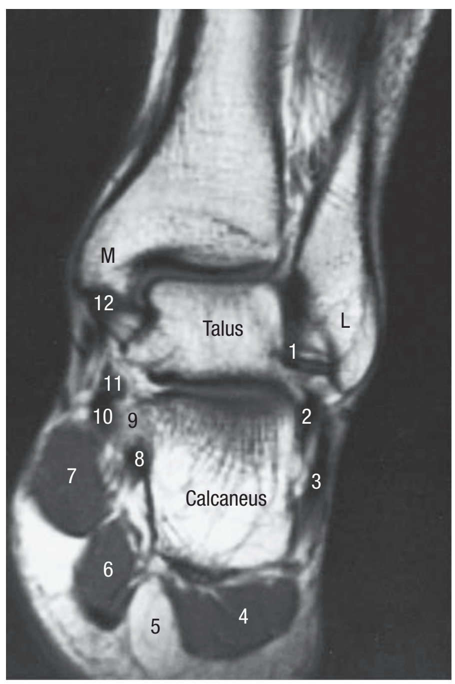
5.88 ARTICULAR SURFACES OF ANKLE JOINT

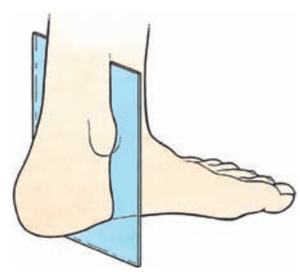
A. Superior aspect of talus separated from distal ends of tibia and fibula. The superior articular surface of the talus is broader anteriorly than posteriorly; hence the medial and lateral malleoli, which grasp the sides of the talus, tend to be forced apart in dorsiflexion. The fully dorsiflexed position is stable compared with the fully plantar flexed position. In plantar flexion, when the tibia and fibula articulate with the narrower posterior part of the superior articular surface of the talus, some side-to-side movement of the joint is allowed, accounting for the instability of the joint in this position. **B.** Lateral aspect of talus. The lateral, triangular articular area is for articulation with the lateral malleolus. **C.** Medial aspect of talus. The comma-shaped articular area is for articulation with the medial malleolus.

Fractures of the talar neck may occur during severe forceful dorsiflexion of the ankle, for example, from a motor vehicle accident. In some cases the body of the talus dislocates posteriorly.



A. **Coronal Section**



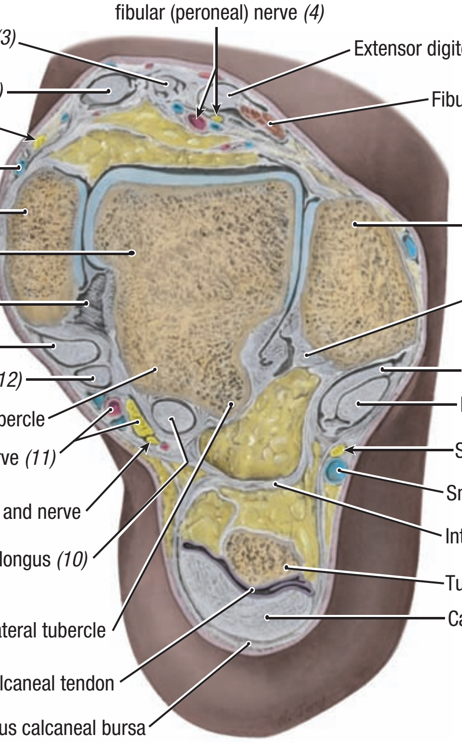


B. **Coronal MRI**

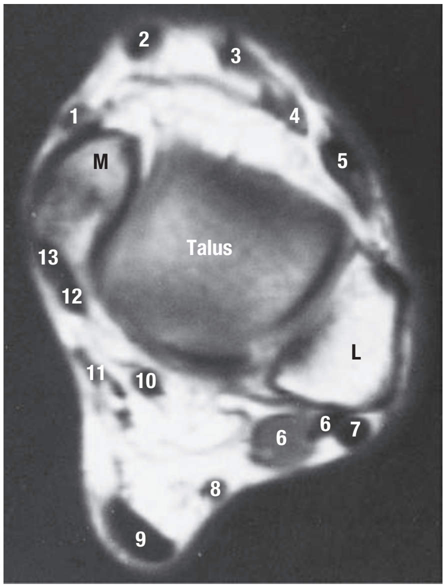
5.89 CORONAL SECTION AND MRI THROUGH ANKLE

A. Coronal section. **B.** Coronal MRI (*numbers* in **B** refer to structures labeled in **A**).

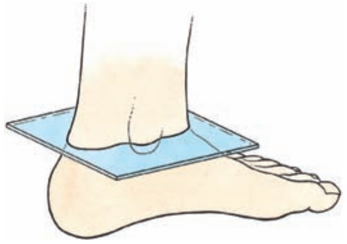
- The tibia rests on the talus, and the talus rests on the calcaneus; between the calcaneus and the skin are several encapsulated cushions of fat.
- The lateral malleolus descends farther inferiorly than the medial malleolus.
- The talocalcaneal (interosseous) ligament between the talus and calcaneus separates the subtalar, or posterior talocalcaneal joint from the talocalcaneonavicular joint.



A. Transverse Section Superior View



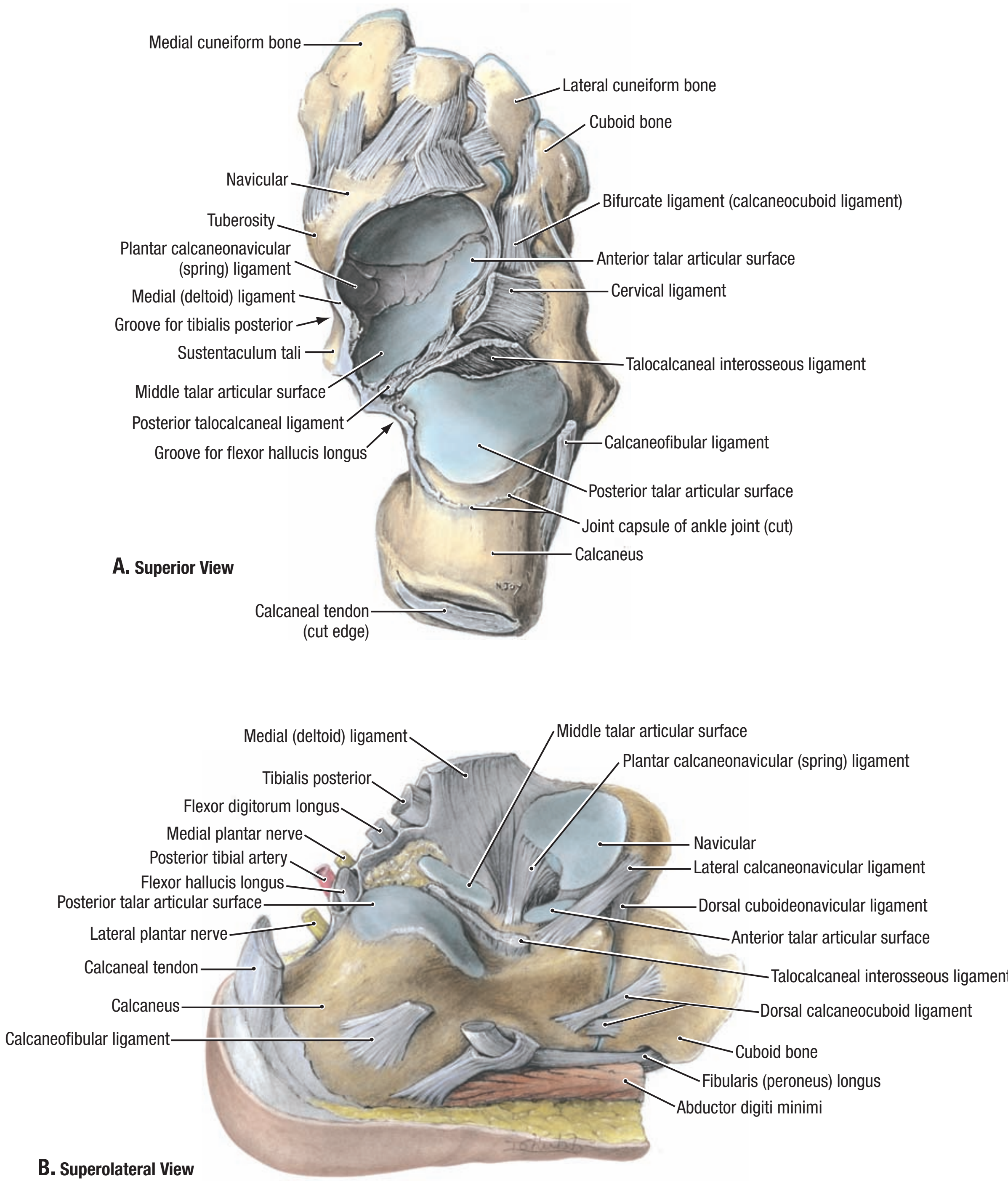
B. Transverse MRI



5.90 TRANSVERSE SECTION AND MRI THROUGH ANKLE

A. Transverse section. **B.** Transverse MRI (*numbers* in **B** refer to structures labeled in **A**).

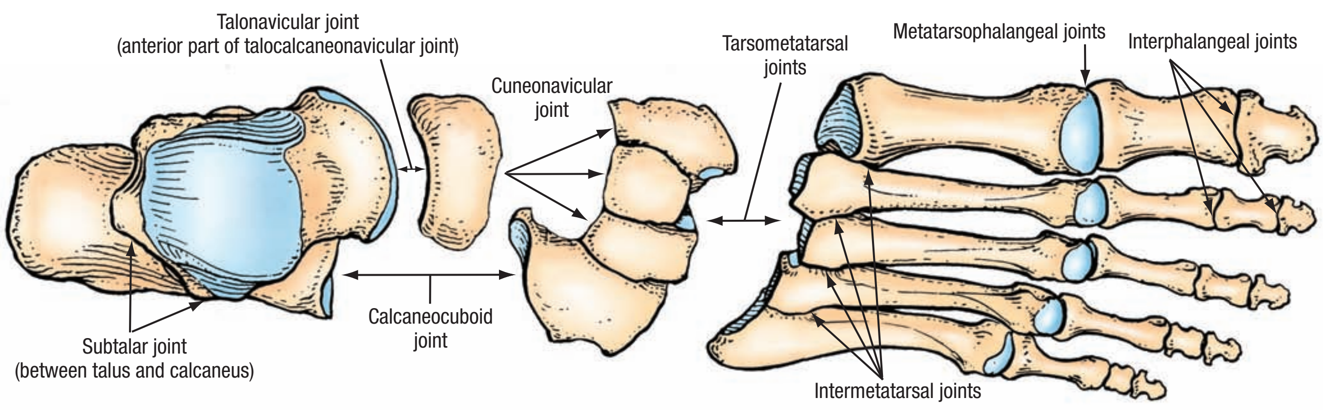
- The body of the talus is wedge shaped and positioned between the malleoli, which are bound to it by the medial (deltoid) and posterior talofibular ligaments.
- The flexor hallucis longus muscle lies within its osseofibrous sheath between the medial and lateral tubercles of the talus.
- There is a small, inconstant subcutaneous bursa superficial to the calcaneal tendon and a large, constant bursa of calcaneal tendon deep to it.



5.91 JOINTS OF INVERSION AND EVERSION

The joints of inversion and eversion are the subtalar (posterior talocalcaneal) joint, talocalcaneonavicular joint, and transverse tarsal (combined calcaneocuboid and talonavicular) joint. **A.** Posterior and middle parts of foot with talus removed. **B.** Posterior part of foot with talus removed. The convex posterior talar facet is separated from the concave middle, and anterior facets by the talocalcaneal (interosseous) ligament within the tarsal sinus.

Calcaneal fractures. A hard fall onto the heel, for example, from a ladder, may fracture the calcaneous into several pieces, resulting in a comminuted fracture. A calcaneal fracture is usually disabling because it disrupts the subtalar (talocalcaneal) joint.

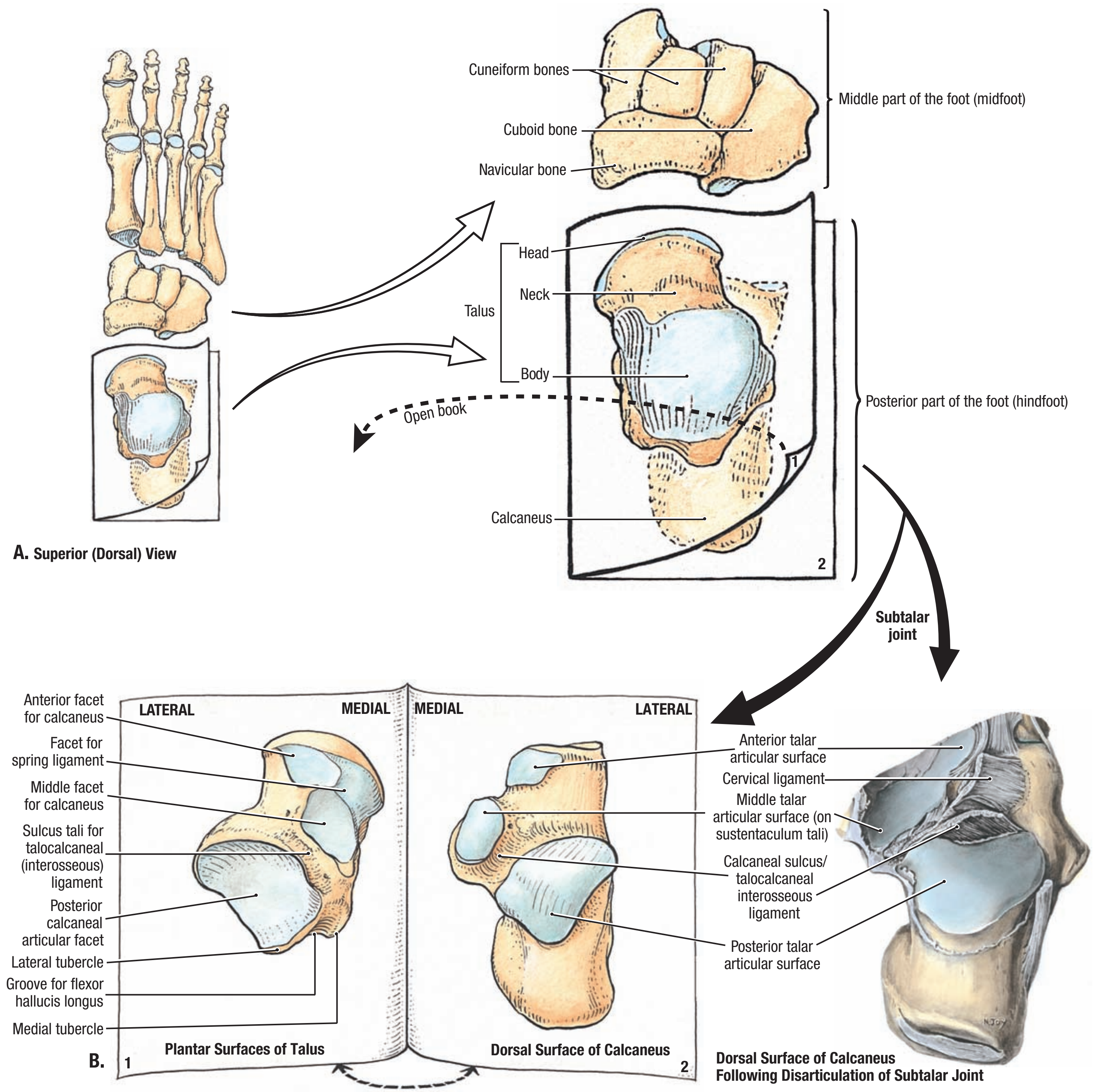


Superior View Talonavicular joint + Calcaneocuboid joint = Transverse tarsal joint

5.92 JOINTS OF FOOT

TABLE 5.22 JOINTS OF FOOT

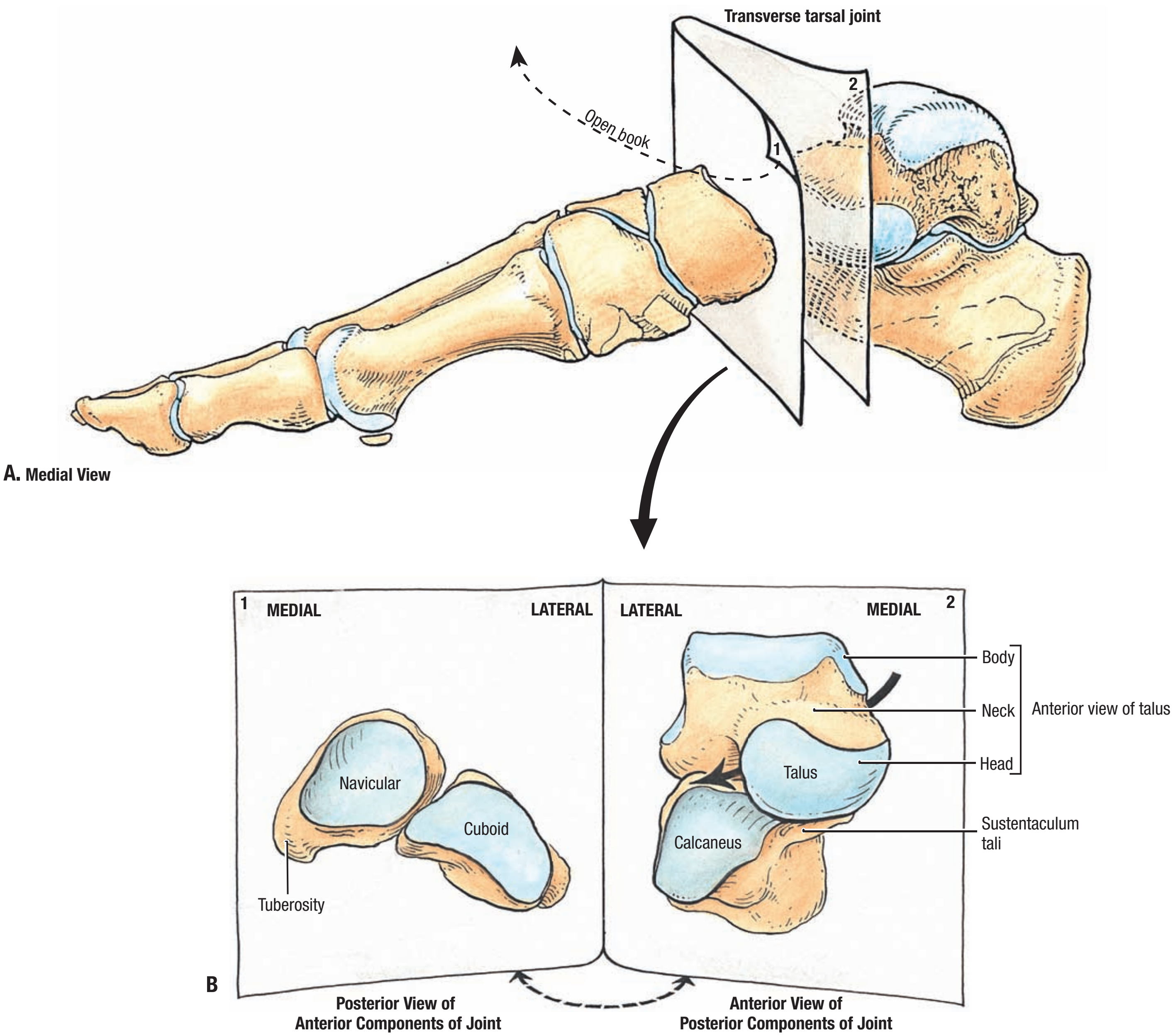
Joint	Type	Articular Surface	Joint Capsule	Ligaments	Movements
Subtalart	Synovial (plane) joint	Inferior surface of body of talus articulates with superior surface of calcaneus	Attached to margins of articular surfaces	Medial, lateral, and posterior talocalcaneal ligaments support capsule; talocalcaneal (interosseous) ligament binds bones together	Inversion and eversion of foot
Talocalcaneo-navicular	Synovial joint; talonavicular part is a pivot joint	Head of talus articulates with calcaneus and navicular bones	Incompletely encloses joint	Plantar calcaneonavicular ("spring") ligament supports head of talus	Gliding and rotary movements
Calcaneocuboid	Synovial (plane) joint	Anterior end of calcaneus articulates with posterior surface of cuboid	Encloses joint	Dorsal calcaneocuboid ligament, plantar calcaneocuboid ligament, and long plantar ligament support joint capsule	Inversion and eversion of foot
Cuneonavicular	Synovial (plane) joint	Anterior navicular articulates with posterior surface of cuneiforms	Common joint capsule	Dorsal and plantar ligaments	Limited gliding movement
Tarsometatarsal	Synovial (plane) joint	Anterior tarsal bones articulate with bases of metatarsal bones	Encloses joint	Dorsal, plantar, and interosseous ligaments	Gliding or sliding
Intermetatarsal	Synovial (plane) joint	Bases of metatarsal bones articulate with each other	Encloses each joint	Dorsal, plantar, and interosseous ligaments bind bones together	Little individual movement
Metatarsophalangeal	Synovial (condyloid) joint	Heads of metatarsal bones articulate with bases of proximal phalanges	Encloses each joint	Collateral ligaments support capsule on each side; plantar ligament supports plantar part of capsule	Flexion, extension, and some abduction, adduction and circumduction
Interphalangeal	Synovial (hinge) joint	Head of proximal or middle phalanx articulates with base of phalanx distal to it	Encloses each joint	Collateral and plantar ligaments support joints	Flexion and extension



5.93 TALOCALCANEAL JOINT

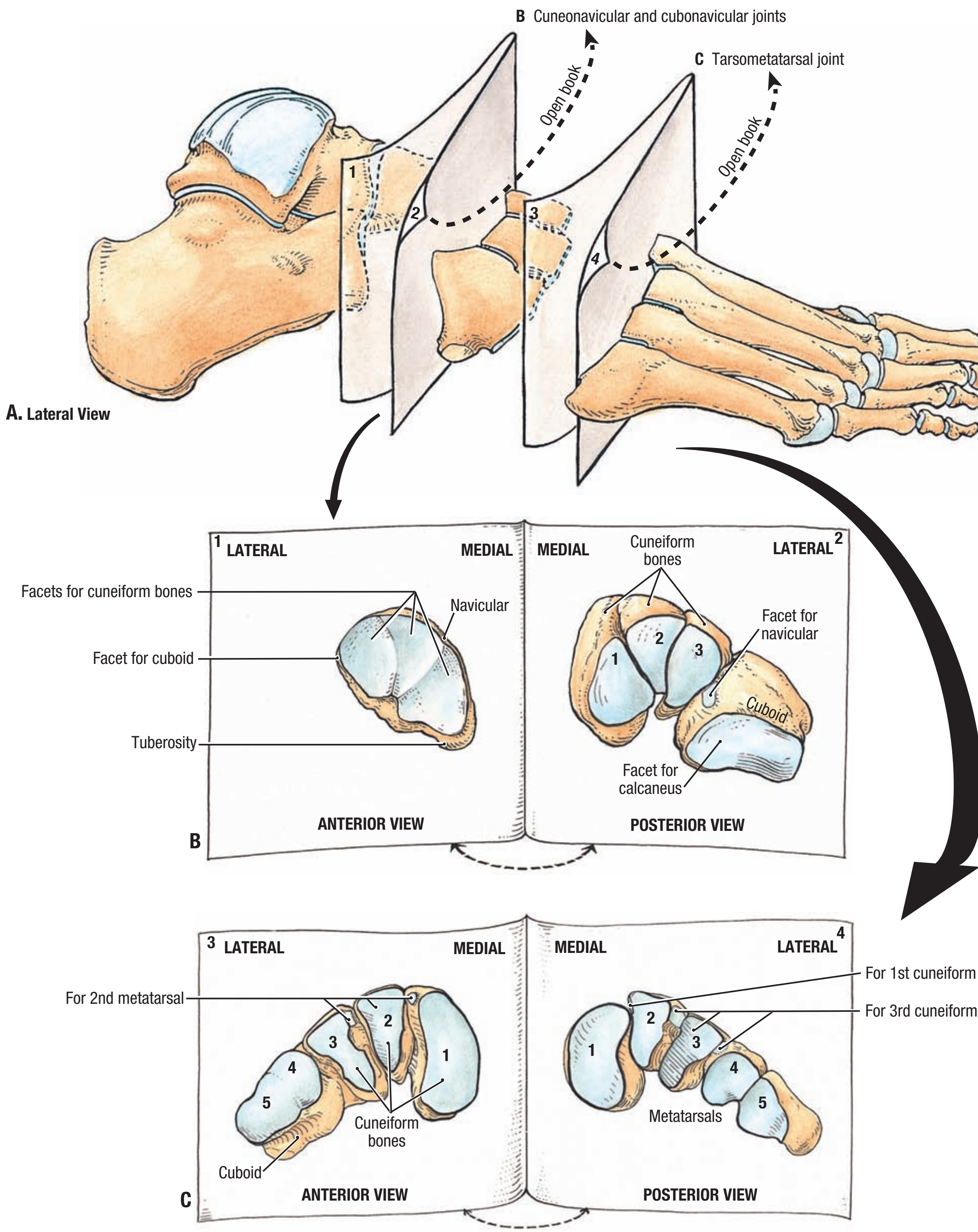
A. Bones of foot, with “closed book” inserted in joint plane of subtalar joint. **B.** “Open book” view of the bony surfaces of talocalcaneal joints. The plantar surface of the talus and dorsal surface of the calcaneus are displayed as pages in a book.

- The joints of inversion and eversion are the subtalar (posterior talocalcaneal) joint, talocalcaneonavicular joint, and transverse tarsal (combined calcaneocuboid and talonavicular) joint.
- The talus participates in the ankle joint, of the posterior and anterior talocalcaneal joints, and of the talonavicular joint.
- The posterior and anterior talocalcaneal joints are separated from each other by the sulcus tali and calcaneal sulcus, which, when the talus and calcaneus are in articulation, become the tarsal sinus.



5.94 TRANSVERSE TARSAL JOINT

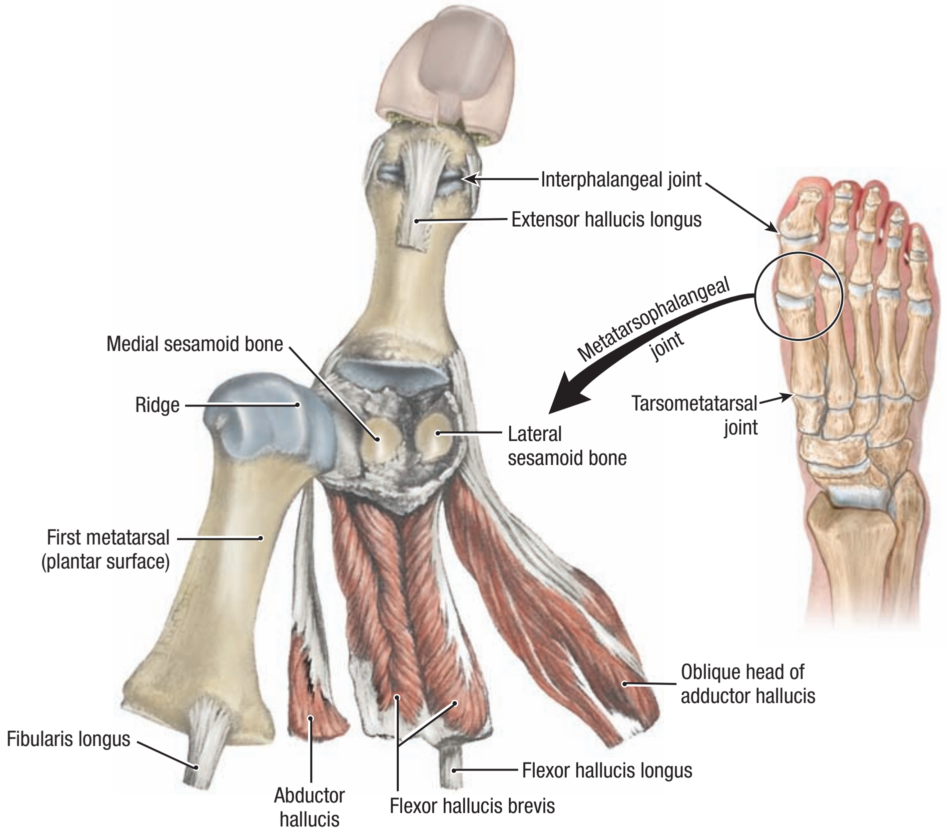
A. Bones of foot, with “closed book” inserted in joint plane of transverse tarsal joint. **B.** Articular surfaces of transverse tarsal joint. This compound joint includes the talonavicular and calcaneocuboid articulations. The posterior surfaces of the navicular and cuboid bones and the anterior surfaces of the talus and calcaneus are displayed as pages in an “open book”. The *black arrow* traverses the tarsal sinus, in which the talocalcaneal (interosseous) ligament is located.



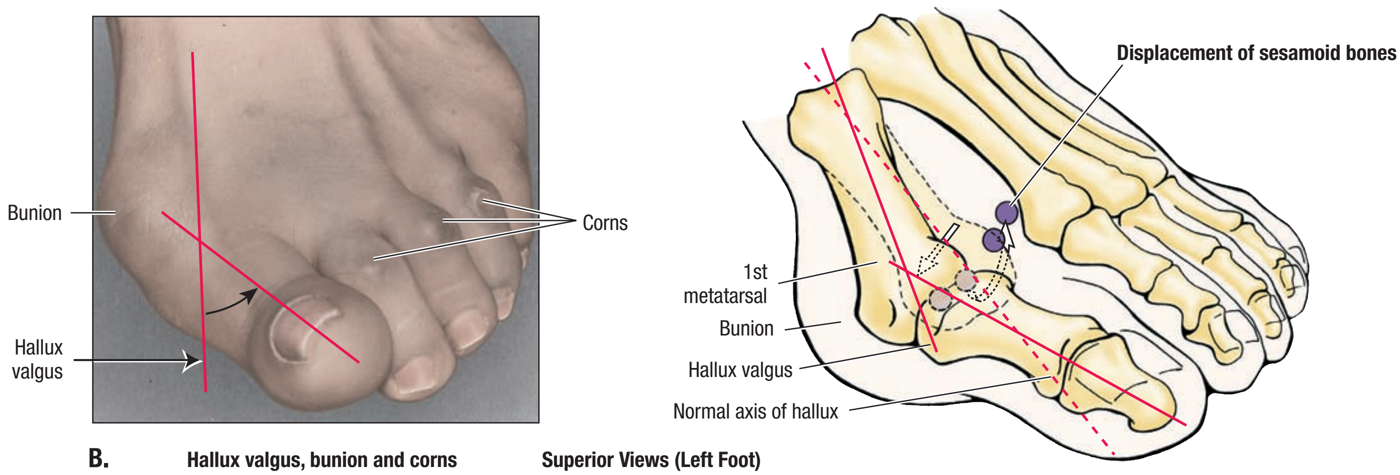
5.95 CUNEONAVICULAR, CUBONAVICULAR, AND TARSOMETATARSAL JOINTS

A. Bones of foot, with "closed book" inserted in indicated joint planes. **B.** "Open book" view of the bony surfaces of the cuneonavicular and cubonavicular joints. **C.** "Open book" view of the bony surfaces of the tarsometatarsal joints.

Metatarsal fractures (dancer's fracture) usually occur when the dancer loses balance, putting full body weight on the metatarsal. **Fatigue fractures of the metatarsals,** usually transverse, may result from prolonged walking with repeated stress on the metatarsals.



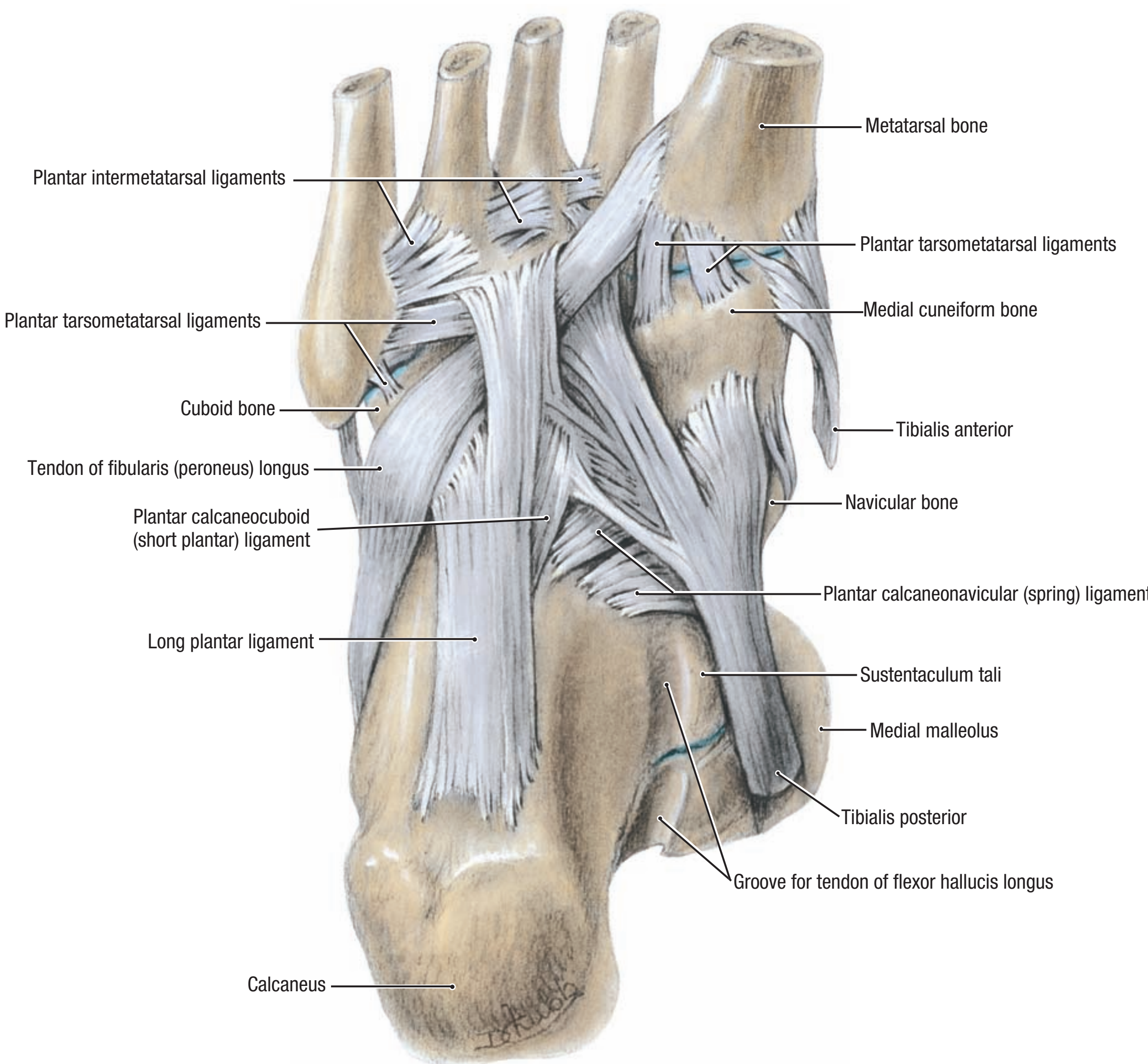
A. **Superior View of Phalanges and Nail, Right Great Toe, Medial View of First Metetarsal**



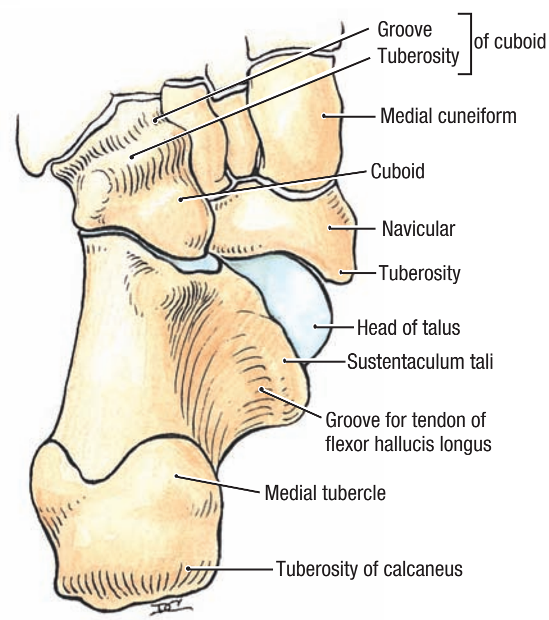
B. **Hallux valgus, bunion and corns** **Superior Views (Left Foot)**

5.96 METATARSOPHALANGEAL JOINT OF GREAT TOE

A. First metatarsal and sesamoid bones of the right great toe. The sesamoid bones of the great toe (hallux) are bound together and located on each side of a bony ridge on the first metatarsal. **B. Hallux valgus** is a foot deformity caused by pressure from footwear and degenerative joint disease. It is characterized by lateral deviation of the base of the first metatarsal and base of the proximal phalanx of the great toe (L. *hallux*). In some people, the deviation is so great that the 1st toe overlaps the 2nd toe. These individuals are unable to move their 1st digit away from their 2nd digit because the sesamoid bones under the head of the 1st metatarsal are displaced and lie in the space between the heads of the 1st and 2nd metatarsals. In addition, a subcutaneous bursa may form owing to pressure and friction against the shoe. When tender and inflamed, the bursa is called a **bunion.**



A. **Plantar View**

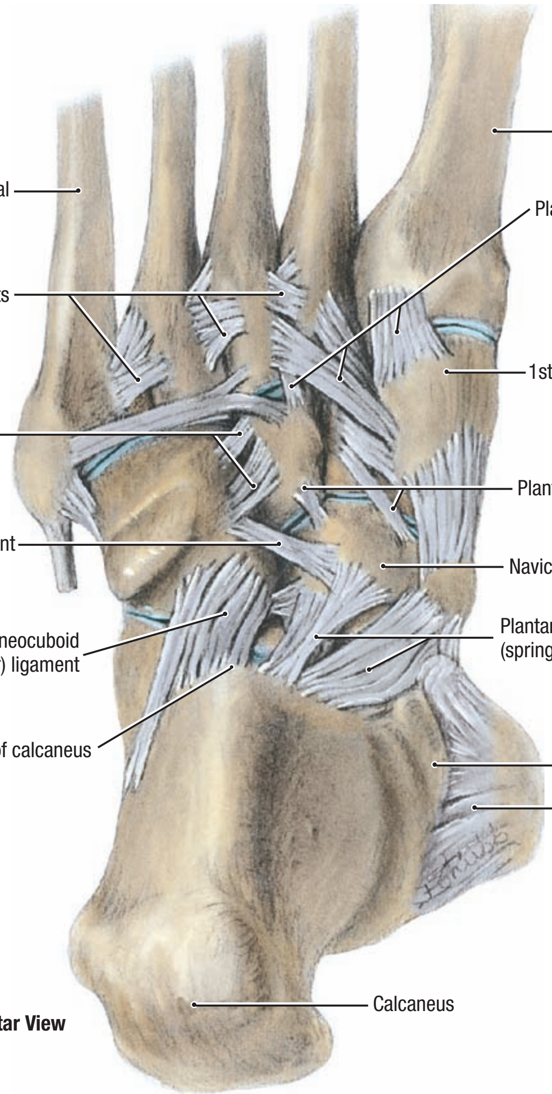


B. **Plantar View**

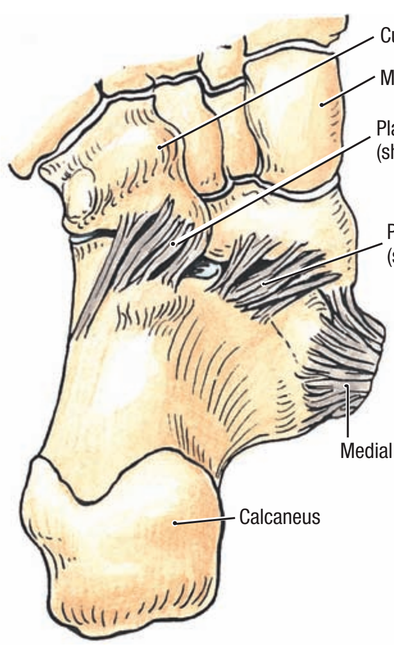
5.97 LIGAMENTS OF SOLE OF FOOT

A. Dissection of superficial ligaments. **B.** Bones lying deep to ligaments of **A**.
In **A**:

- The head of the talus is exposed between the sustentaculum tali of the calcaneus and the navicular.
- Note the insertions of three long tendons: fibularis (peroneus) longus, tibialis anterior, and tibialis posterior.
- The tendon of the fibularis (peroneus) longus muscle crosses the sole of the foot in the groove anterior to the ridge of the cuboid, is bridged by some fibers of the long plantar ligament, and inserts into the base of the first metatarsal.
- Observe the slips of the tibialis posterior tendon extending to the bones anterior to the transverse tarsal joint.



C. **Plantar View**

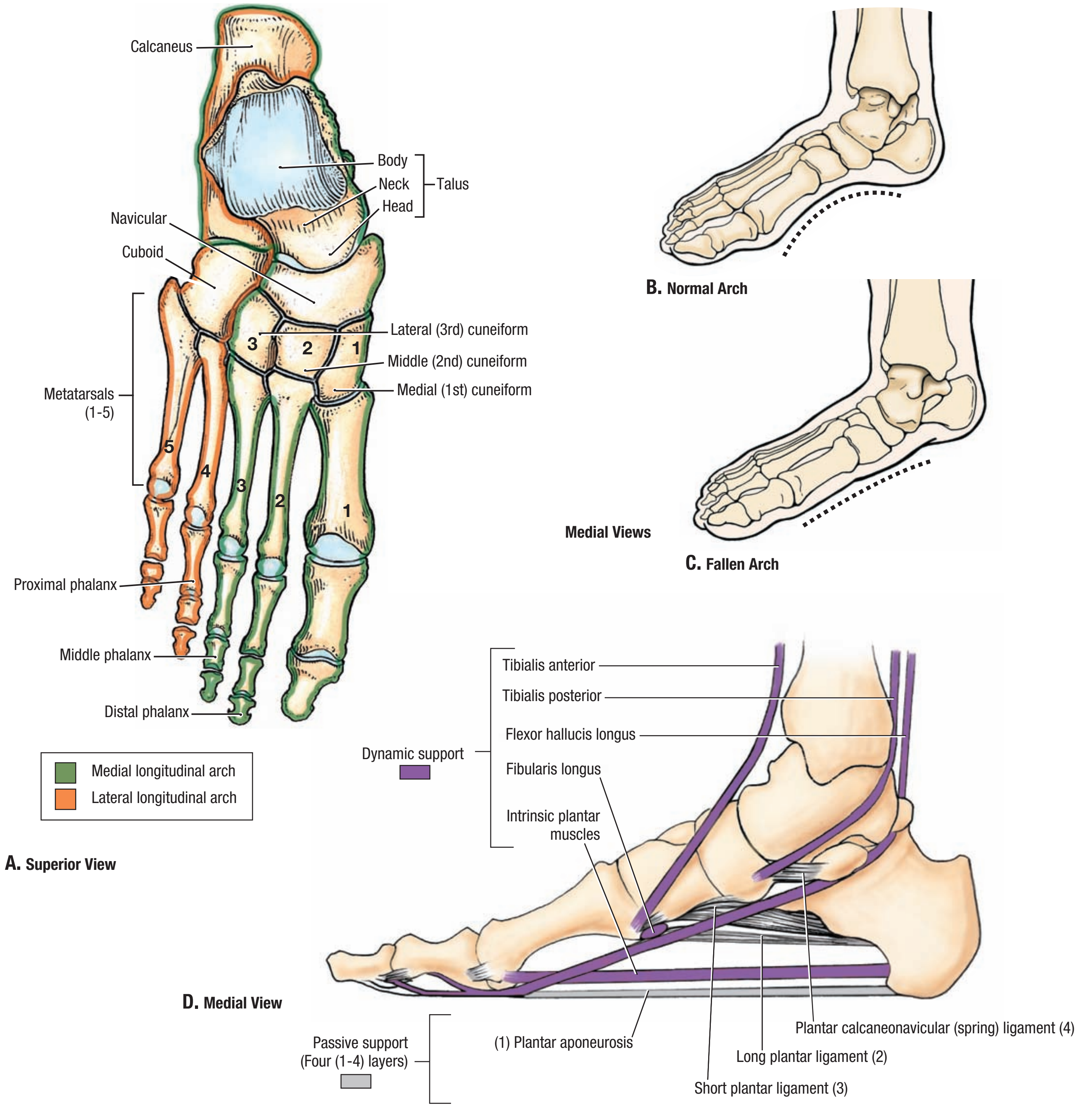


D. **Plantar View**

5.97 LIGAMENTS OF SOLE OF FOOT (*CONTINUED*)

C. Dissection of the deep ligaments. **D.** Support for head of talus. The head of the talus is supported by the plantar calcaneonavicular ligament (spring ligament) and the tendon of the tibialis posterior.

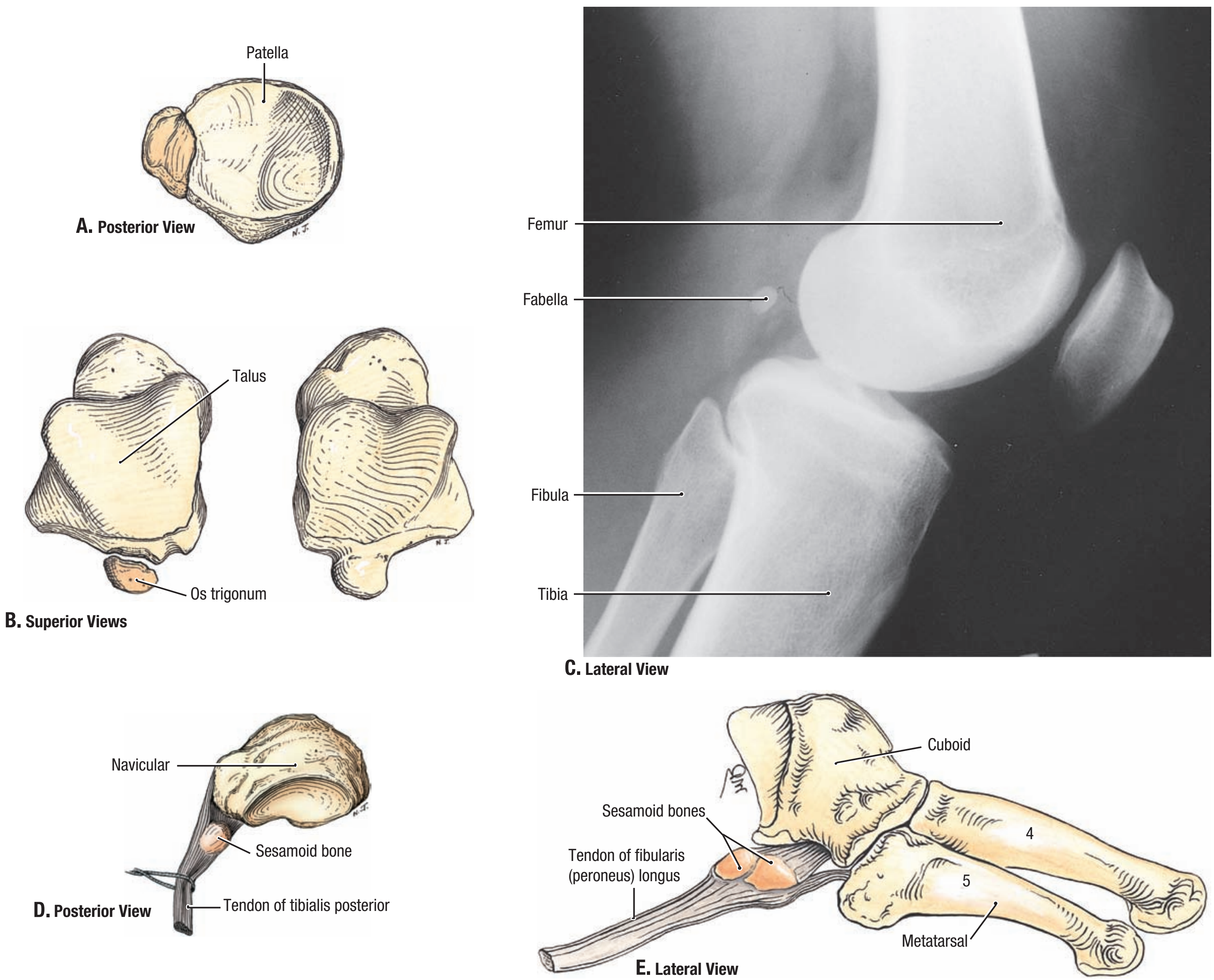
- The plantar calcaneocuboid (short plantar) and plantar calcaneonavicular (spring) ligaments are the primary plantar ligaments of the transverse tarsal joint.
- The ligaments of the anterior foot diverge laterally and posteriorly from each side of the long axis of the third metatarsal and third cuneiform; hence a posterior thrust received by the first metatarsal, as when rising on the big toe while in walking, is transmitted directly to the navicular and talus by the first cuneiform and indirectly by the second metatarsal, second cuneiform, third metatarsal, and third cuneiform.
- A posterior thrust received by the fourth and fifth metatarsals is transmitted directly to the cuboid and calcaneus.



5.98 ARCHES OF FOOT

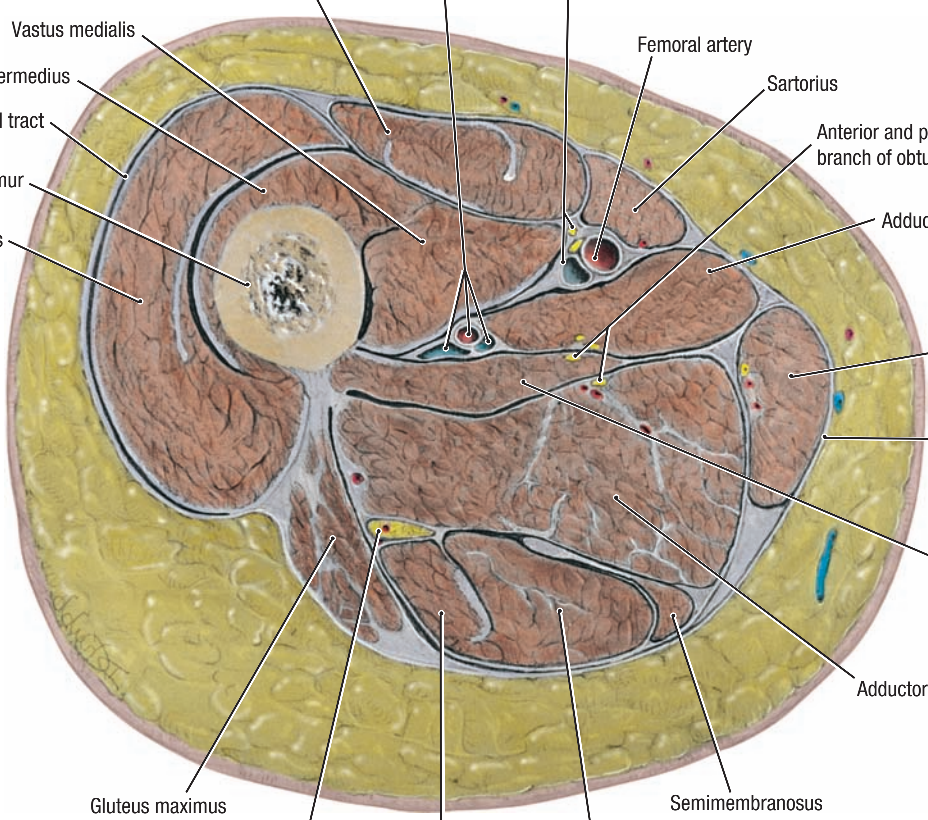
A. Medial and lateral longitudinal arches. **B.** Normal arch. **C.** Fallen arch. **D.** Supports of the longitudinal arches.

Pes planus (flatfeet). Acquired flatfeet ("fallen arches") are likely to be secondary to dysfunction of the tibialis posterior due to trauma, degeneration with age, or denervation. In the absence of normal passive or dynamic support, the plantar calcaneonavicular ligament fails to support the head of the talus. Consequently, the head of the talus displaces inferomedially. As a result flattening of the medial longitudinal arch occurs **(C)** along with lateral deviation of the forefoot. Flatfeet are common in older people, particularly if they undertake much unaccustomed standing or gain weight rapidly, adding stress on the muscles and increasing strain on the ligaments supporting the arches.

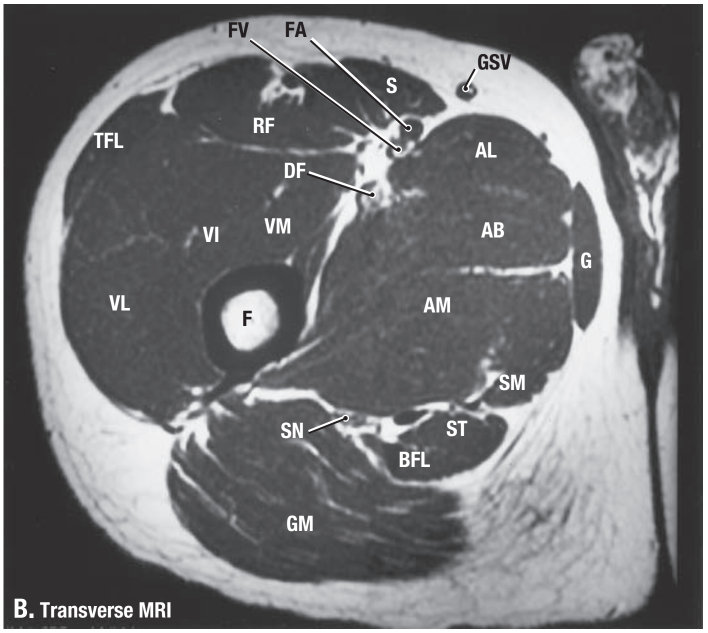


5.99 BONY ANOMALIES

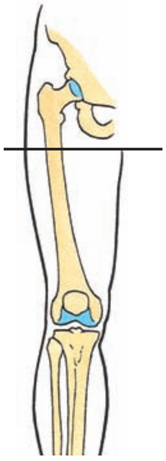
A. Bipartite patella. Occasionally, the superolateral angle of the patella ossifies independently and remains discrete. **B. Os trigonum.** The lateral (posterior) tubercle of the talus has a separate center of ossification that appears from the ages of 7 to 13 years; when this fails to fuse with the body of the talus, as in the left bone of this pair, it is called an os trigonum. It was found in Dr. Grant's lab in 7.7% of 558 adult feet; 22 were paired, and 21 were unpaired. **C. Fabella.** A sesamoid bone in the lateral head of the gastrocnemius muscle was present in 21.6% of 116 limbs. **D. Sesamoid bone in the tendon of tibialis posterior.** A sesamoid bone was found in 23% of 348 adults. **E. Sesamoid bone in the tendon of fibularis (peroneus) longus.** A sesamoid bone was found in 26% of 92 specimens. In this specimen, it is bipartite, and the fibularis (peroneus) longus muscle has an additional attachment to the 5th metatarsal bone.



A. Transverse Section



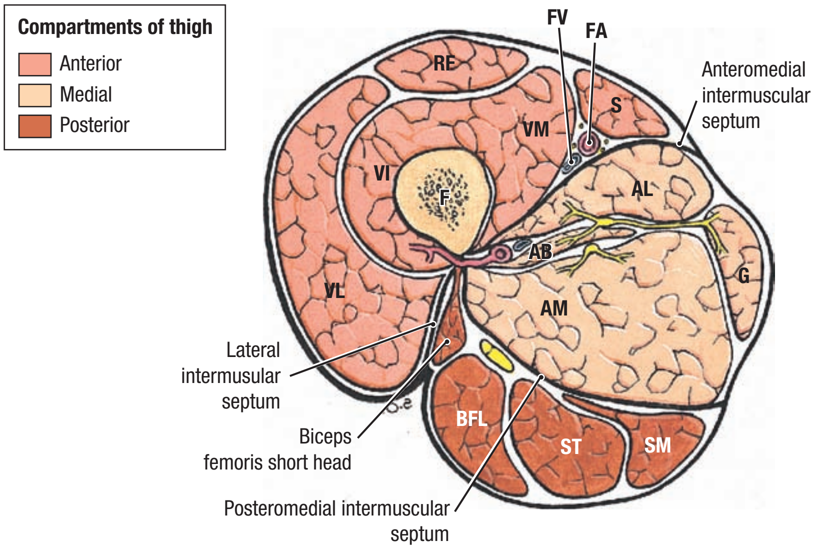
B. Transverse MRI



Level of Section

5.100 TRANSVERSE SECTIONS AND MRIs OF THIGH

A. Anatomical section of proximal thigh. **B.** Transverse MRI of proximal thigh.



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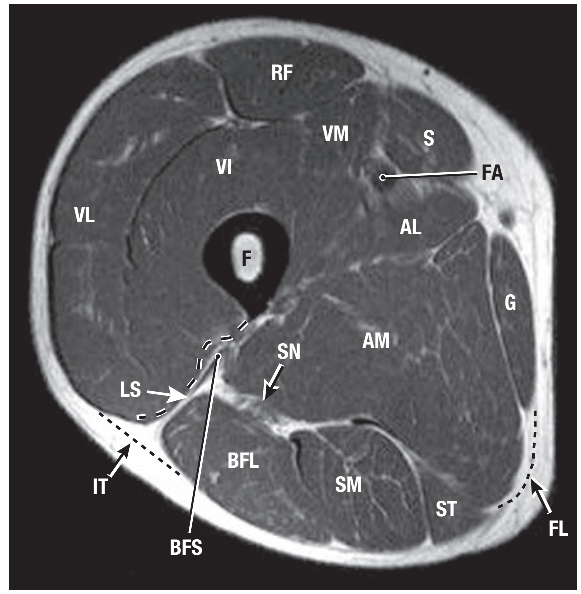
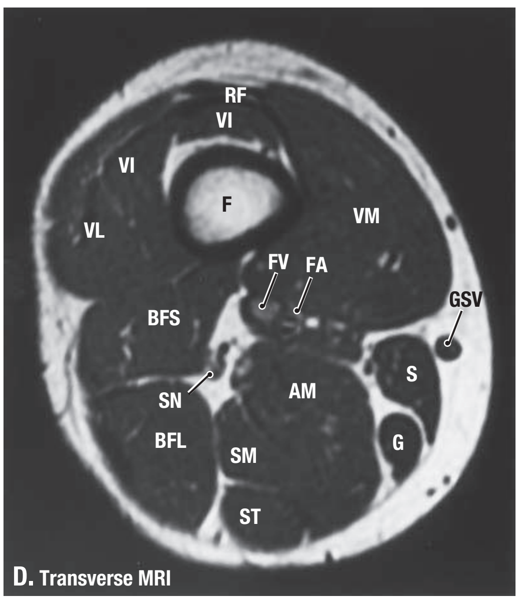
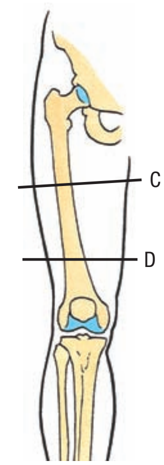


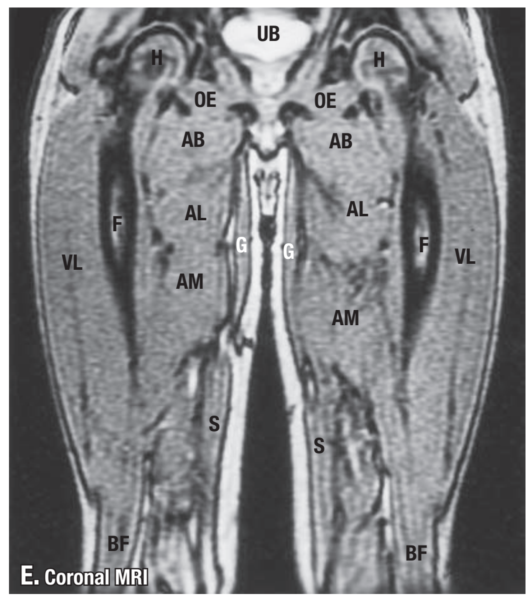
Transverse MRI



D. Transverse MRI



Level of Section



E. Coronal MRI

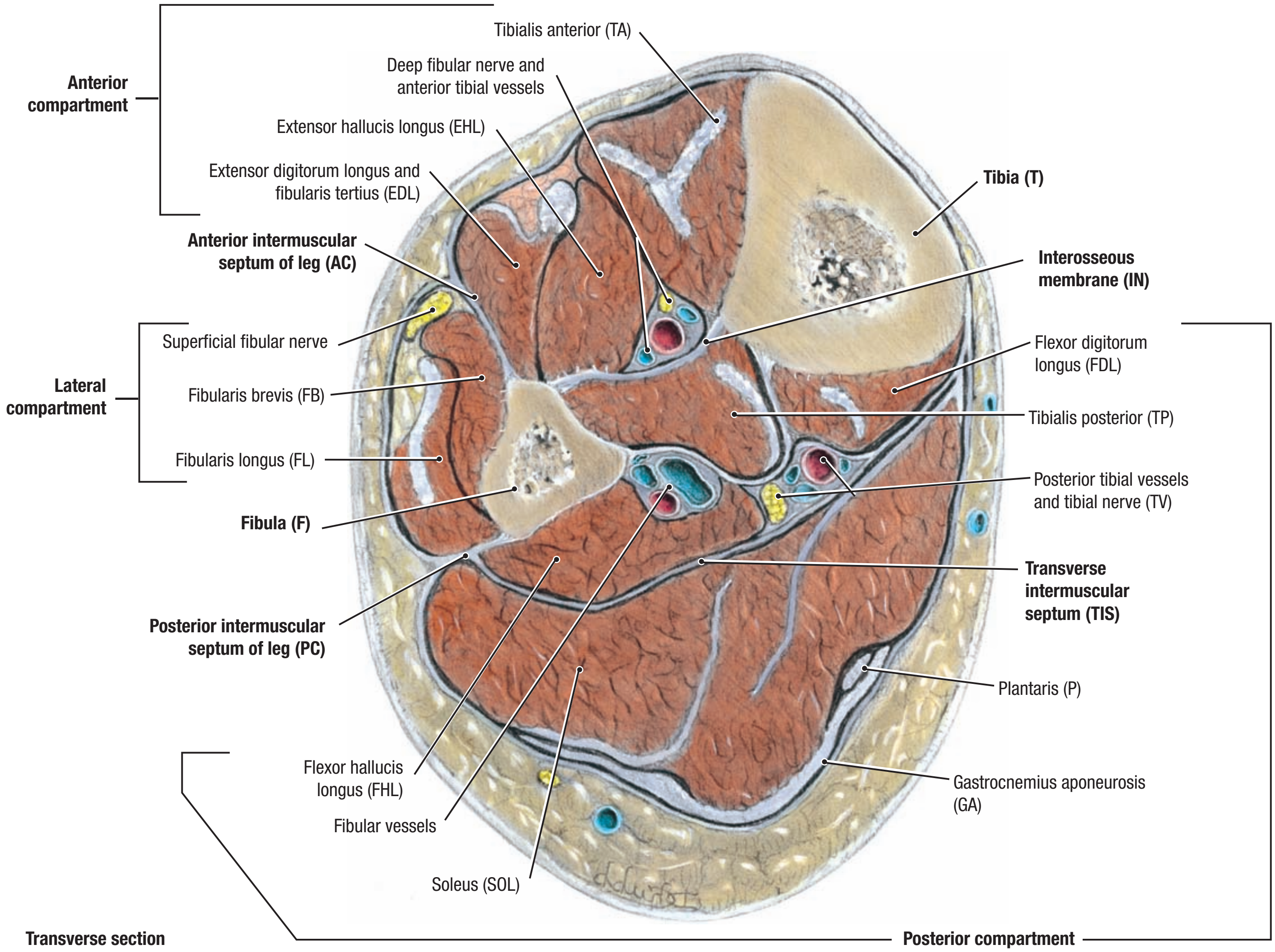
Key	
AB	Adductor brevis
AL	Adductor longus
AM	Adductor magnus
AS	Anteromedial intermuscular septum
BF	Biceps femoris
BFL	Long head of biceps femoris
BFS	Short head of biceps femoris
F	Femur
FA	Femoral artery
FL	Fascia lata
FV	Femoral vein
G	Gracilis
GM	Gluteus maximus
GSV	Great saphenous vein

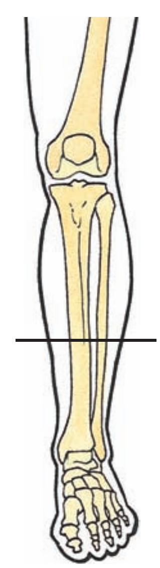
H	Head of femur
IT	Iliotibial tract
LS	Lateral intermuscular septum
OE	Obturator externus
PS	Posterior intermuscular septum
RF	Rectus femoris
S	Sartorius
SM	Semimembranosus
SN	Sciatic nerve
ST	Semitendinosus
TFL	Tensor fasciae latae
UB	Urinary bladder
VI	Vastus intermedius
VL	Vastus lateralis
VM	Vastus medialis

5.100 TRANSVERSE SECTIONS AND MRIs OF THIGH (*CONTINUED*)

C. Diagrammlatic anatomical section and transverse (axial) MRI of midthigh. **D.** Transverse (axial) MRI of distal thigh. **E.** Coronal MRI.

The thigh has three compartments, each with its own nerve supply and primary function: anterior group extends the knee and is supplied by the femoral nerve; medial group adducts the hip and is supplied by the obturator nerve; posterior group flexes the knee and is supplied by the sciatic nerve.

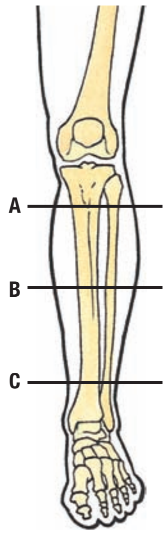


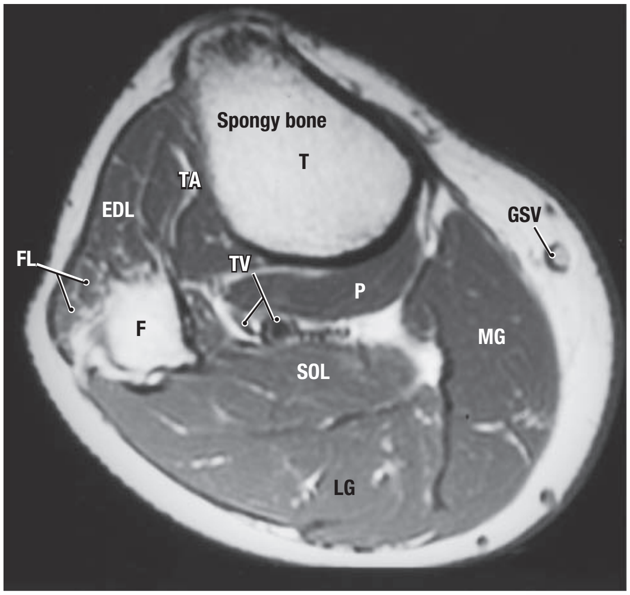


5.101 TRANSVERSE SECTION OF LEG

Boundaries of anterior, lateral, and posterior compartments of leg. Anterior compartment: tibia, interosseous membrane, fibula, anterior intermuscular septum, and crural fascia. Lateral compartment: fibula, anterior and posterior intermuscular septa, and the crural fascia. Posterior compartment: tibia, interosseous membrane, fibula, posterior intermuscular septum, and crural fascia. The posterior compartment is subdivided by the transverse intermuscular septum into superficial and deep subcompartments.

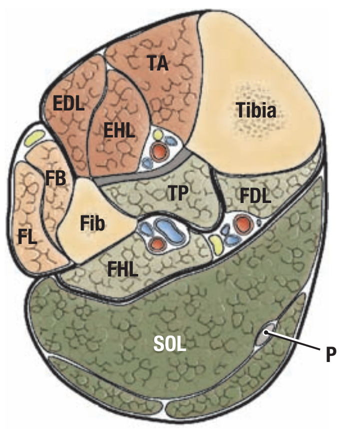
Compartmental infections in the leg. Because the septa and deep fascia forming the boundaries of the leg compartments are strong, the increased volume consequent to infection with suppuration (formation of pus) increases intracompartmental pressure. Inflammation within the anterior and posterior compartments spreads chiefly in a distal direction; however a purulent infection in the lateral compartment can ascend proximally into the popliteal fossa, presumably along the course of the fibular nerve. **Fasciotomy** may be necessary to relieve compartmental pressure and debride (remove by scraping) pockets of infection.

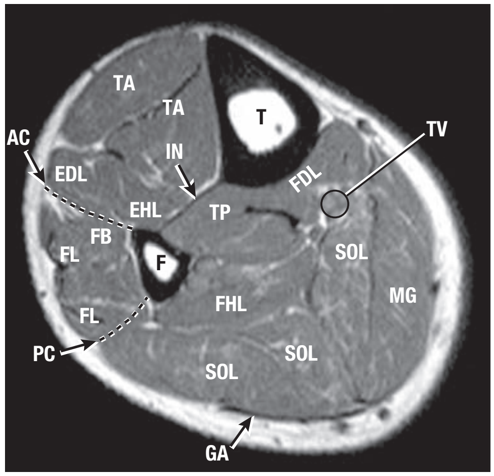




A. Transverse MRI

D. Coronal MRI

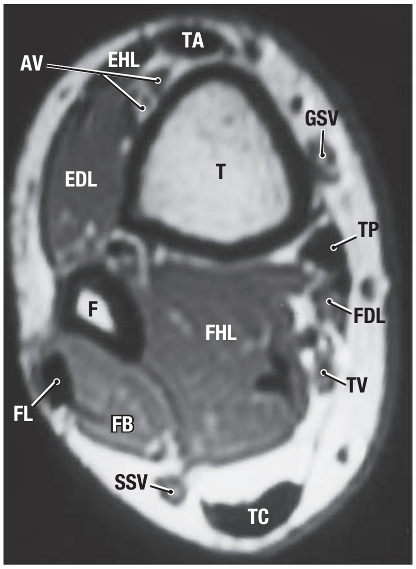




B. Transverse Section and MRI

Key for B

- Anterior compartment
- Lateral compartment
- Posterior compartment



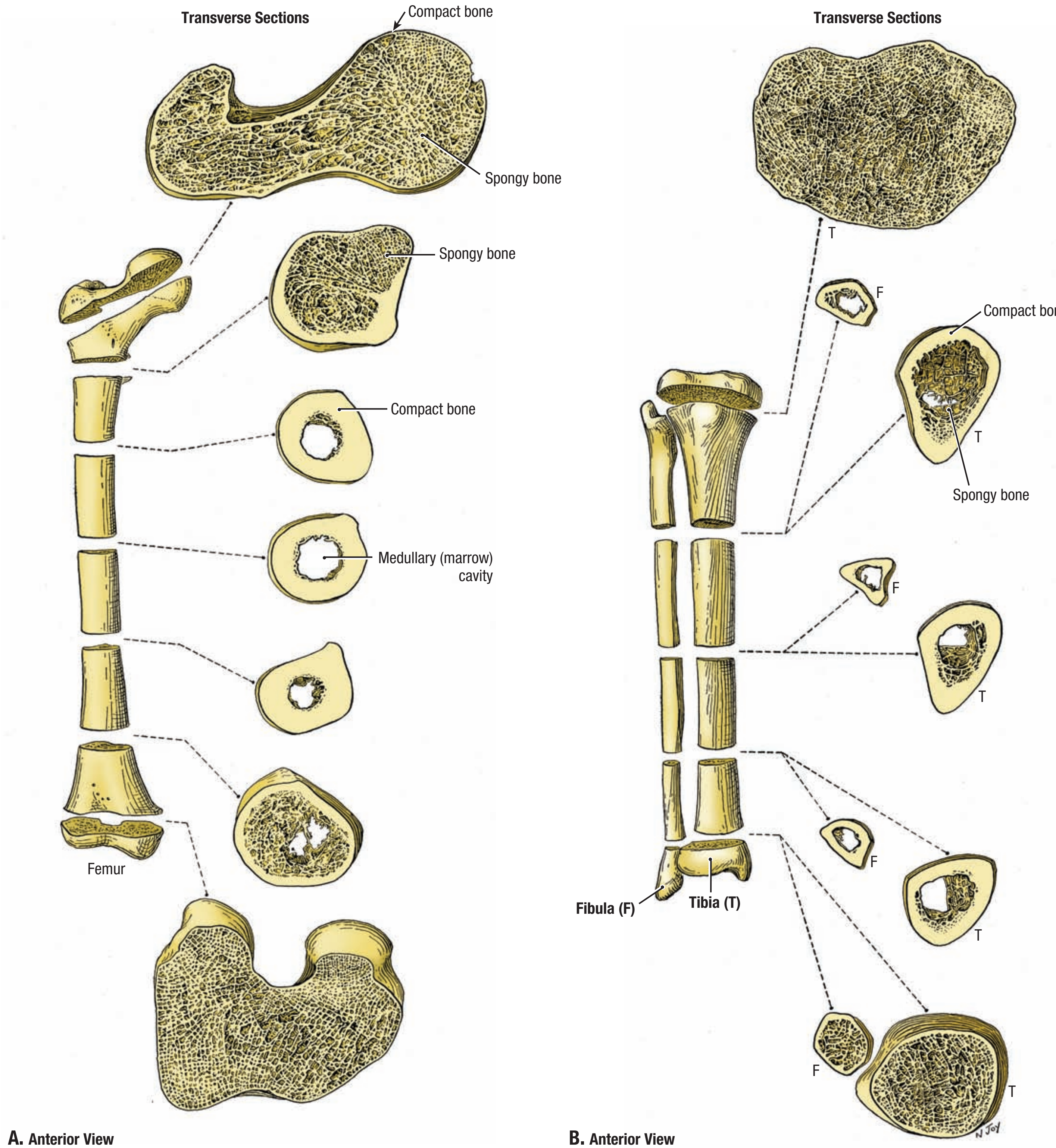
C. Transverse MRI

Key

AC	Anterior intermuscular septum
AV	Anterior tibial vessels and deep fibular nerve
EDL	Extensor digitorum longus
EHL	Extensor hallucis longus
F	Fibula
FB	Fibularis brevis
FDL	Flexor digitorum longus
FHL	Flexor hallucis longus
FL	Fibularis longus
GA	Gastrocnemius aponeurosis
G	Gracilis
GM	Gluteus maximus
GSV	Great saphenous vein
HF	Head of fibula
IN	Interosseous membrane
LG	Lateral head of gastrocnemius
MG	Medial head of gastrocnemius
MM	Medial malleolus
P	Popliteus
PC	Posterior intermuscular septum
SOL	Soleus
SSV	Small saphenous vein
T	Tibia
TA	Tibialis anterior
Ta	Talus
TC	Calcaneal tendon
TP	Tibialis posterior
TV	Tibial nerve and posterior tibial vessels

5.102 MRIs OF LEG

A., B. and C. Transverse (axial) MRIs. **D.** Coronal MRI.

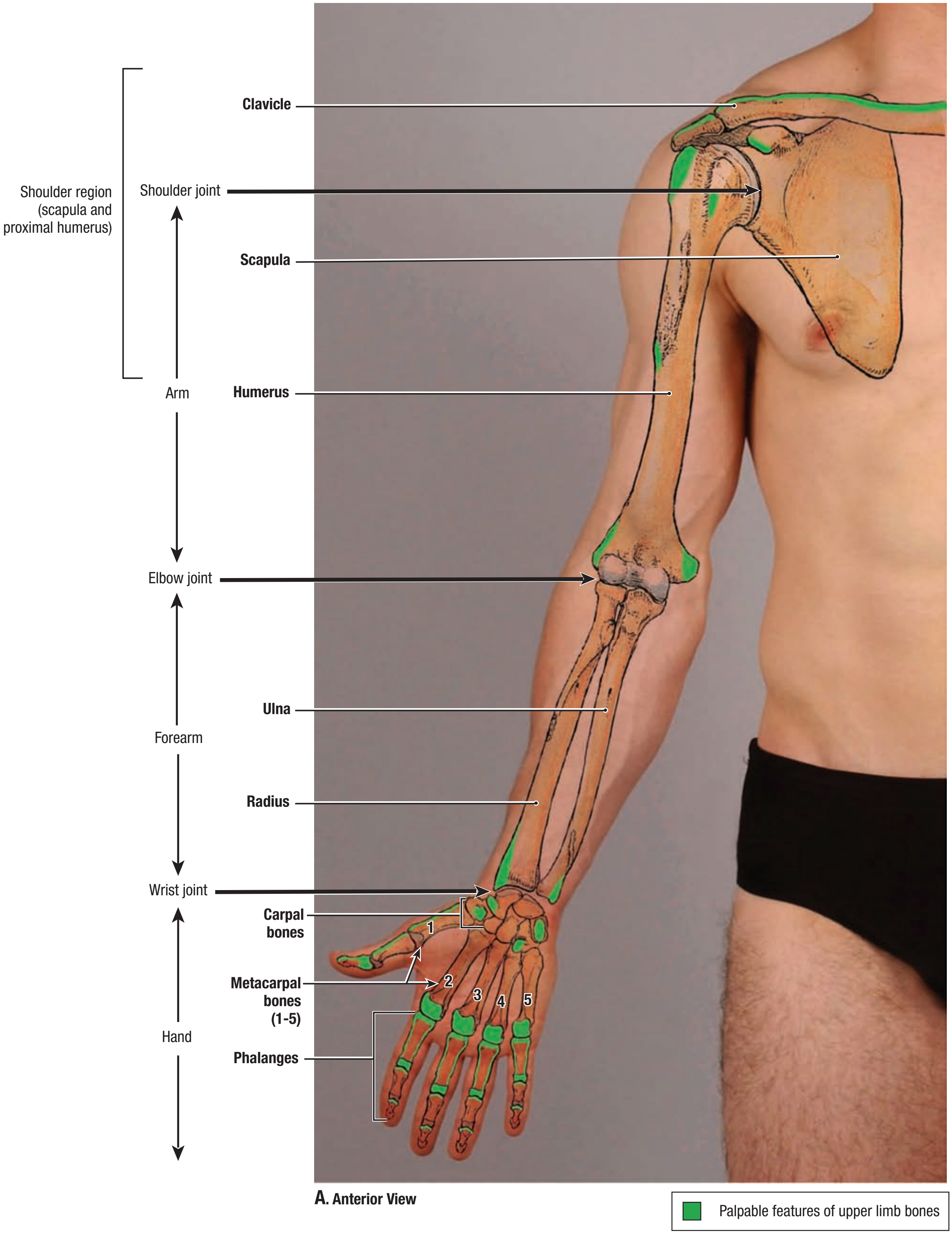


5.103 TRANSVERSE SECTIONS THROUGH FEMUR, TIBIA AND FIBULA

A. Femur. **B.** Tibia and fibula. Note the differences in thickness of the compact and spongy bone and in the width of the medullary (marrow) cavity. Compact and spongy bones are distinguished by the relative amount of solid matter and by the number and size of the spaces they contain. All bones have a superficial thin layer of compact bone around a central mass of spongy bone, except where the latter is replaced by the medullary (marrow) cavity. Within the medullary cavity of adult bones and between the spicules (trabeculae) of spongy bone, yellow (fatty) or red (blood cell and platelet forming) bone marrow or both are found.

CHAPTER 6

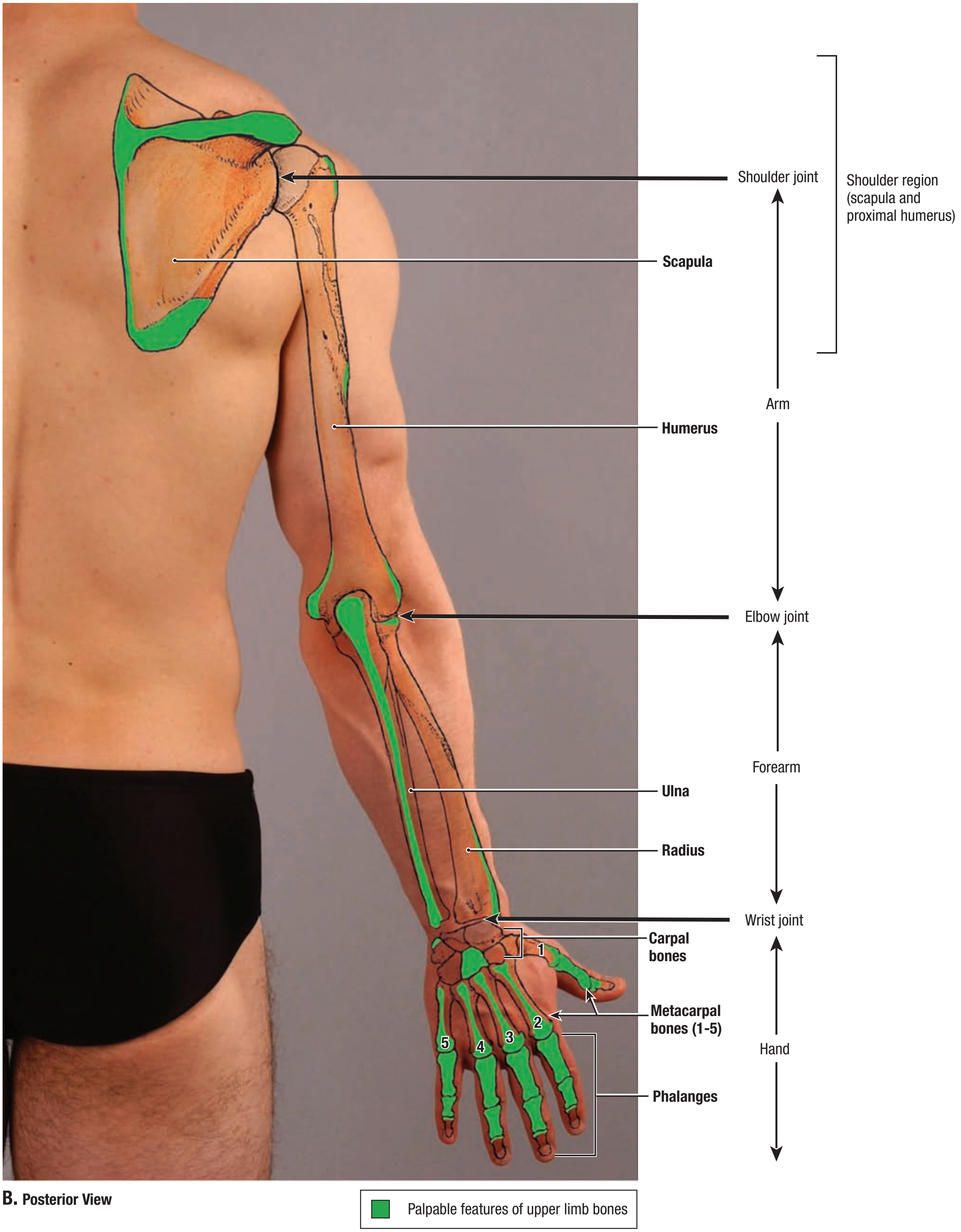
Upper Limb



A. Anterior View

6.1 REGIONS, BONES, AND MAJOR JOINTS OF UPPER LIMB

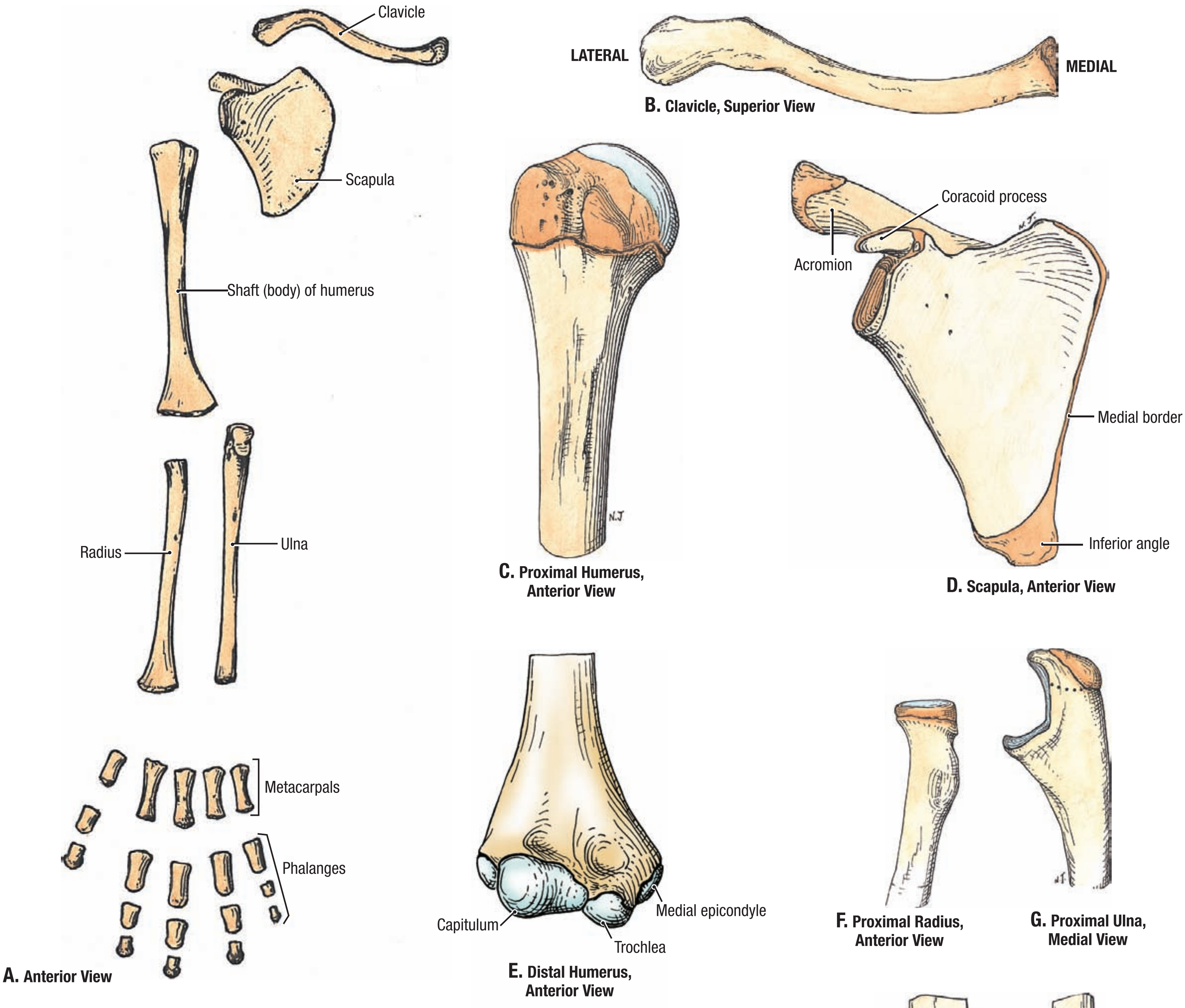
The joints divide the upper limb into four main regions: the shoulder, arm, forearm, and hand.

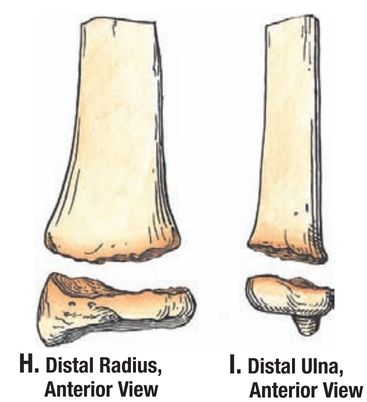


B. Posterior View

6.1 REGIONS, BONES, AND MAJOR JOINTS OF UPPER LIMB *(CONTINUED)*

The pectoral (shoulder) girdle is an incomplete ring of bones formed by the right and left scapulae and clavicles and is joined medially to the manubrium of the sternum.



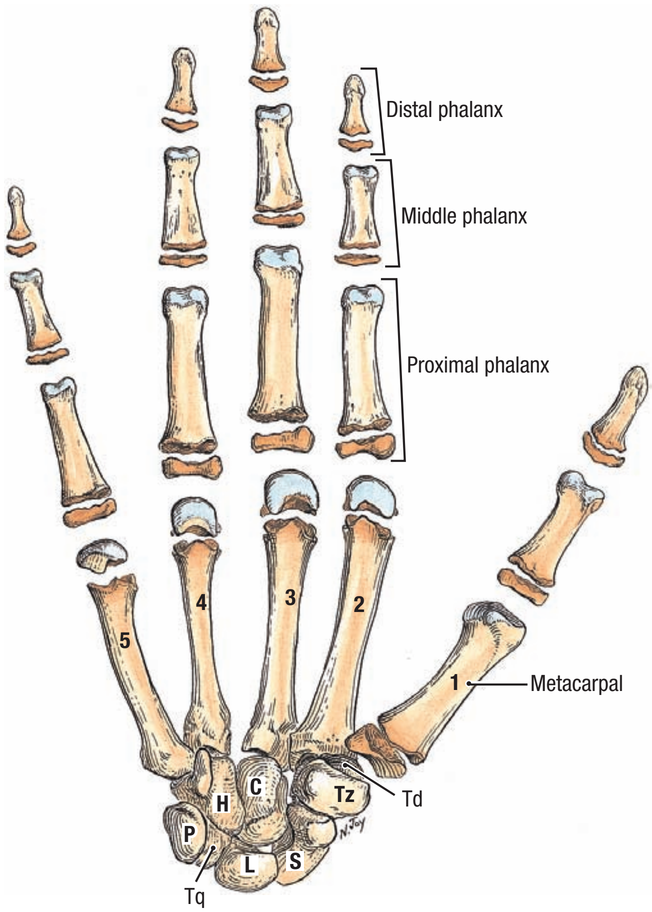


6.2 OSSIFICATION AND SITES OF EPIPHYSES OF BONES OF UPPER LIMB

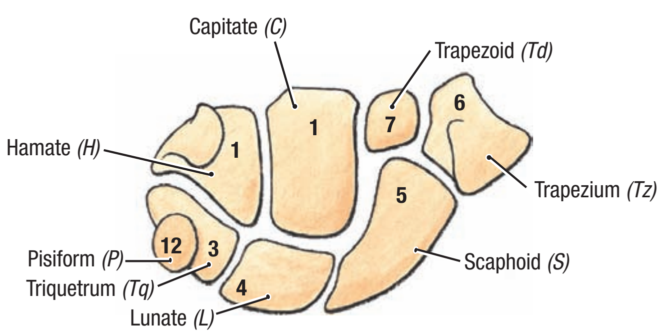
A. Upper limb bones at birth. Only the diaphyses of the long bones and scapula are ossified. The epiphyses, carpal bones, coracoid process, medial border of the scapula, and acromion are still cartilaginous. **B.–I.** Sites of epiphyses (*darker orange regions*).

- The ends of the long bones are ossified by the formation of one or more secondary centers of ossification; these epiphyses develop from birth to approximately 20 years of age in the clavicle, humerus, radius, ulna, metacarpals, and phalanges.

Epiphyses. Without knowledge of bone growth and the appearance of bones in radiographic and other diagnostic images at various ages, a displaced epiphysial plate could be mistaken for a fracture, and separation of an epiphysis could be interpreted as a displaced piece of fractured bone. Knowledge of the patient's age and the location of epiphyses can prevent these errors.

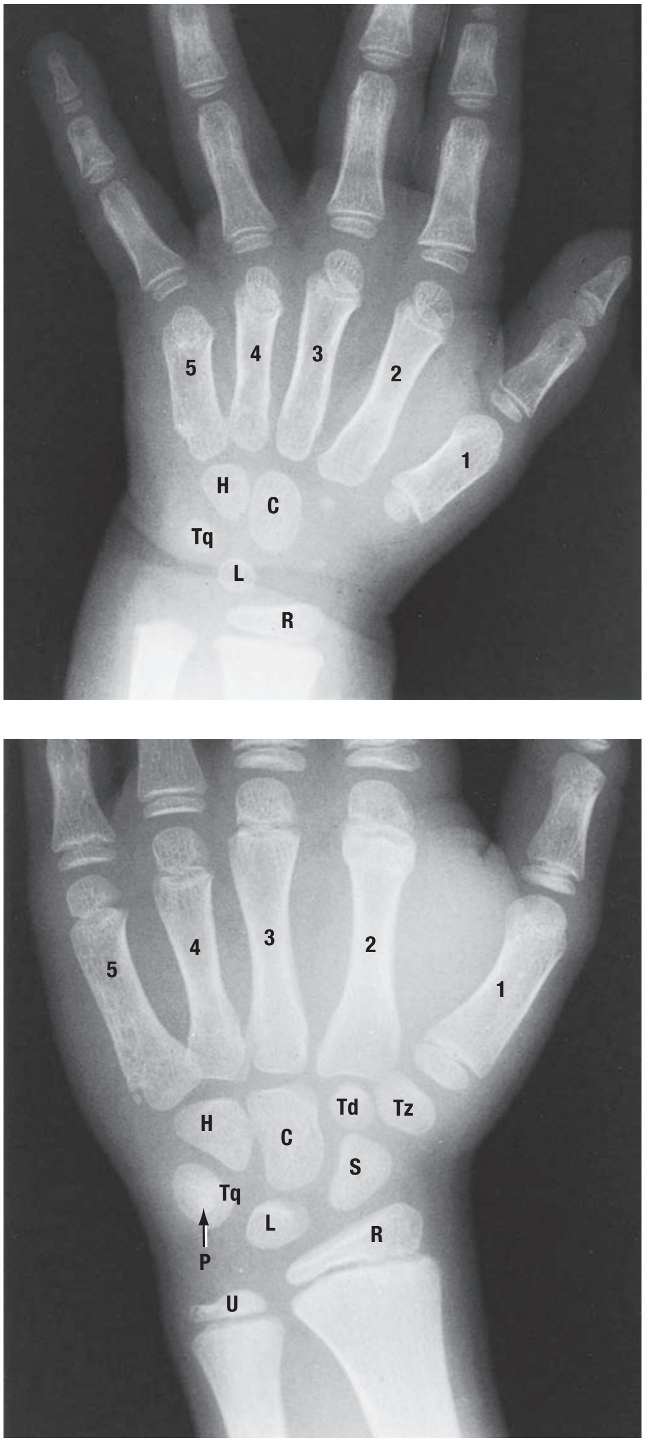


J. Anterior View (Right Hand)



Numbers: approximate age of ossification of carpal bones in years

K. Anterior View

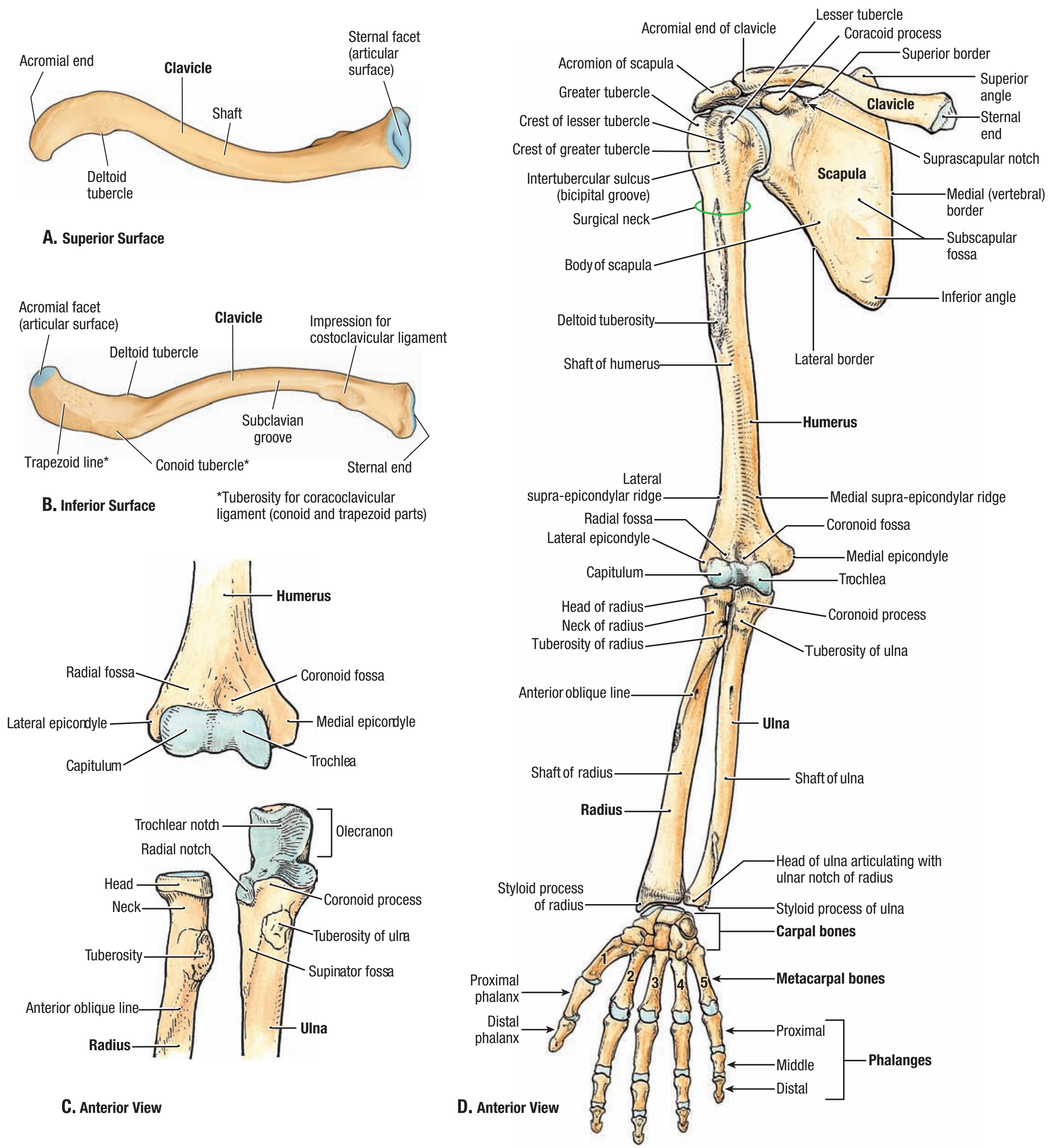


L. Antero-posterior View, Right Hand

Epiphyses in radiographs appear as radiolucent lines

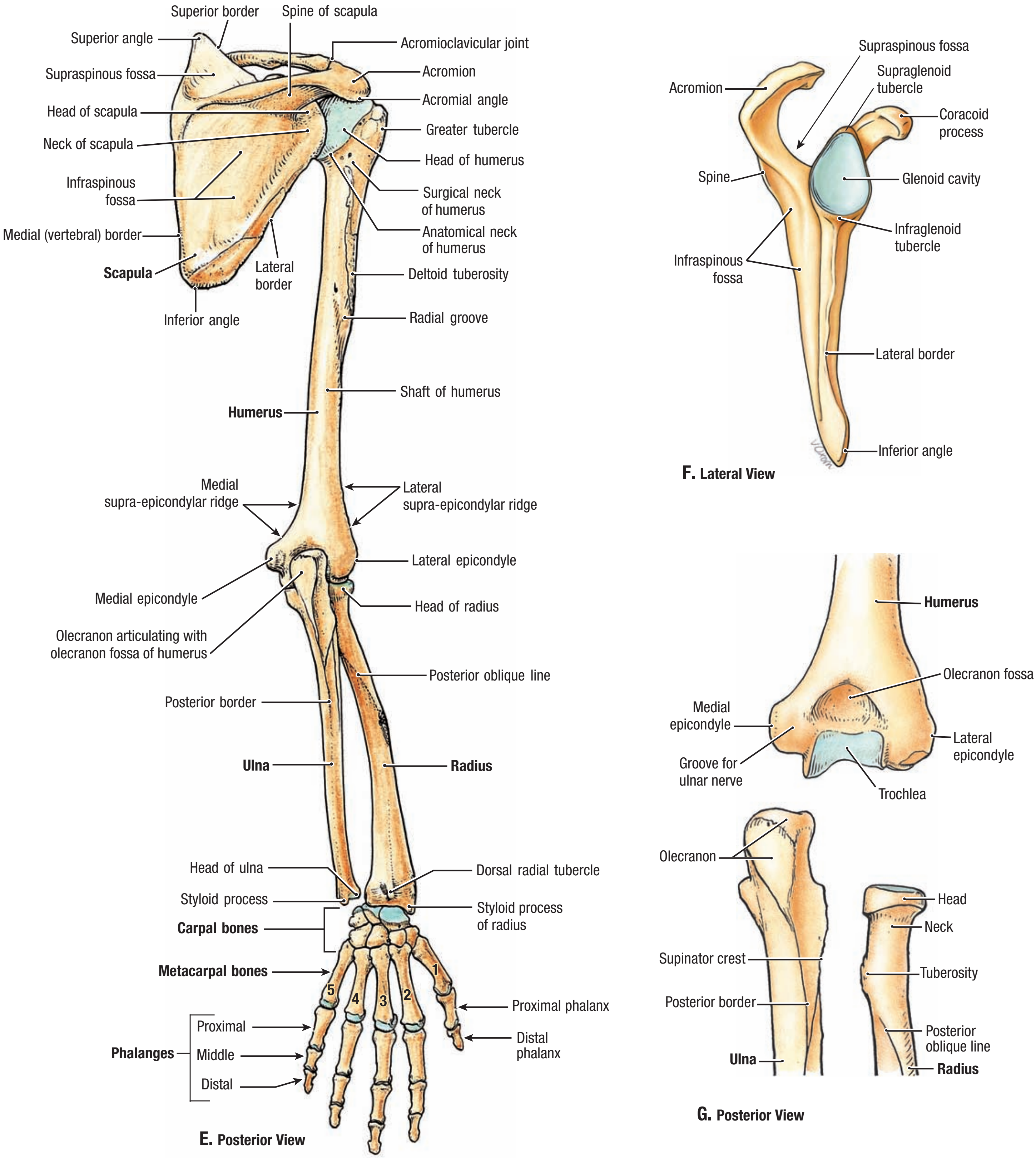
6.2 OSSIFICATION AND SITES OF EPIPHYSES OF BONES OF UPPER LIMB *(CONTINUED)*

J. Sequence of ossification of carpal bones. **K.** Ossification of bones of hand. Note the phalanges have a single proximal epiphysis and metacarpals 2, 3, 4, and 5 have single distal epiphyses. The 1st metacarpal behaves as a phalanx by having proximal epiphysis. Short-lived epiphyses may appear at the other ends of metacarpals 1 and/or 2. There are individual and gender differences in sequence and timing of ossification. **L.** Radiographs of stages of ossification of wrist and hand. *Top*, a $2^{1}/_{2}$-year-old child; the lunate is ossifying, and the distal radial epiphysis *(R)* is present (*C*, capitate; *H*, hamate; *Tq*, triquetrum; *L*, lunate). *Bottom*, an 11-year-old child. All carpal bones are ossified (*S*, scaphoid; *Td,* trapezoid; *Tz*, trapezium; *arrowhead*, pisiform), and the distal epiphysis of the ulna *(U)* has ossified.



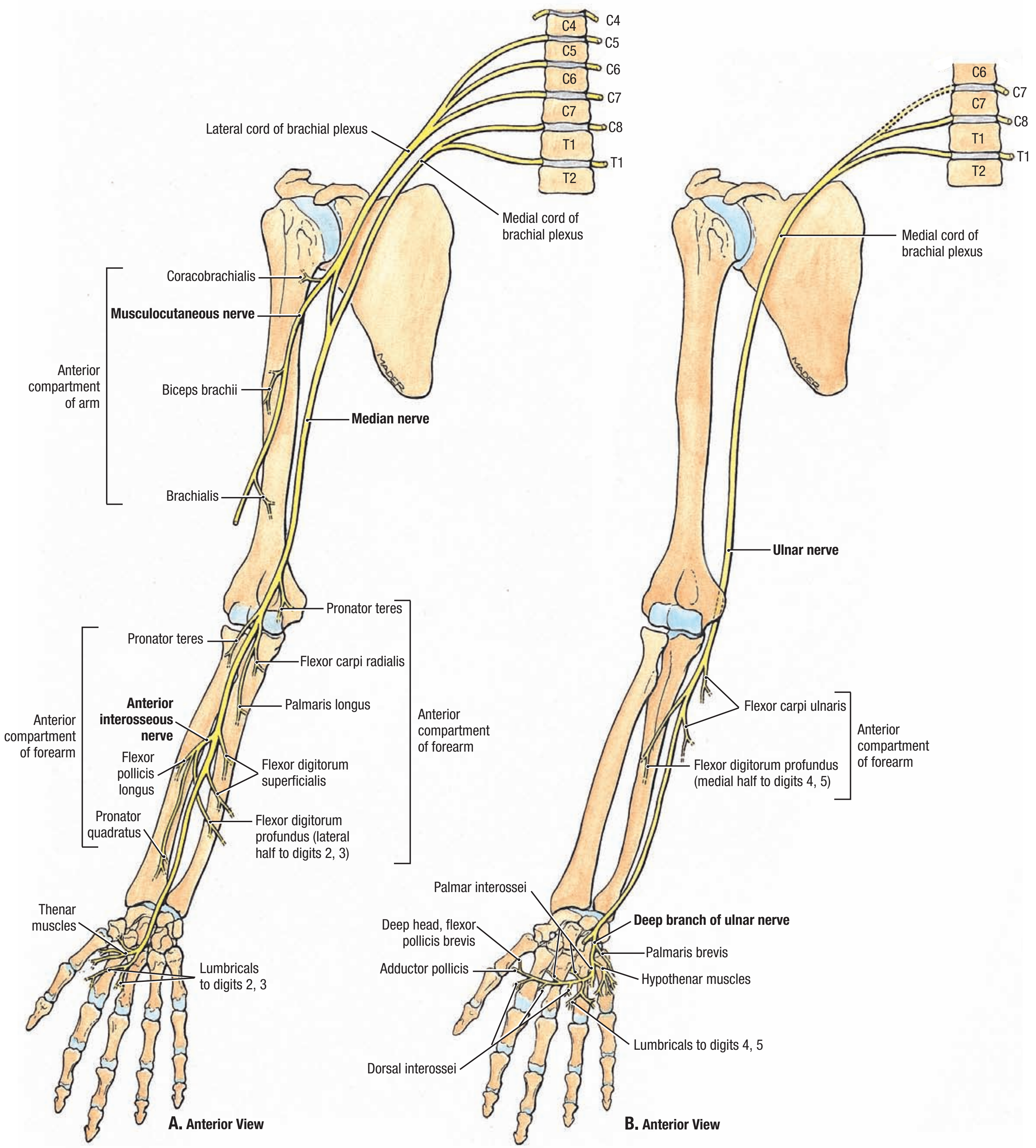
6.3 FEATURES OF BONES OF UPPER LIMB

A. and B. Clavicle. **C.** Anterior aspect of disarticulated distal end of humerus and proximal end of radius and ulna. **D.** Anterior aspect of articulated upper limb.

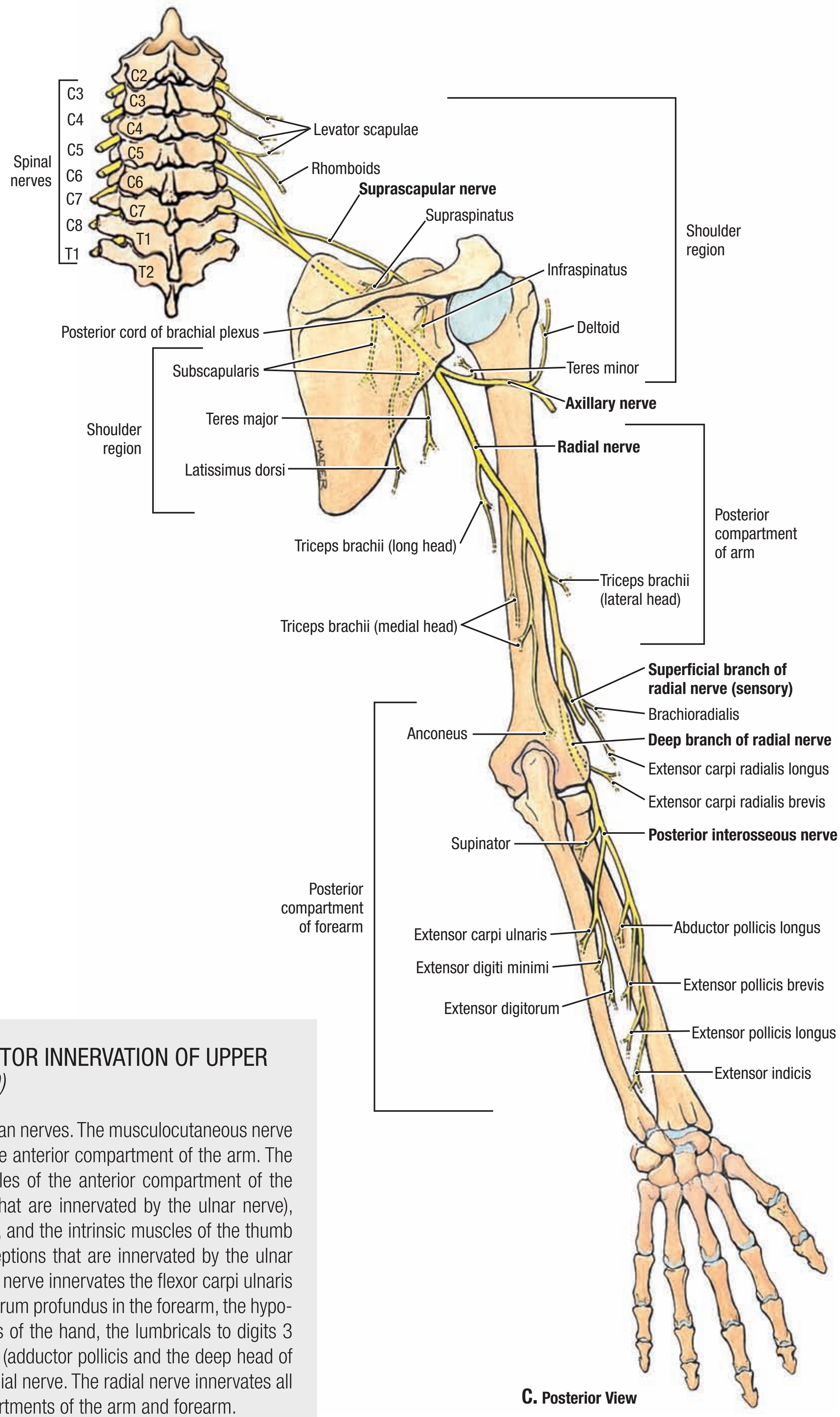


6.3 FEATURES OF BONES OF UPPER LIMB *(CONTINUED)*

E. Posterior aspect of articulated upper limb bones. **F.** Lateral aspect of scapula. **G.** Posterior aspect of disarticulated distal end of humerus and proximal ends of radius and ulna.



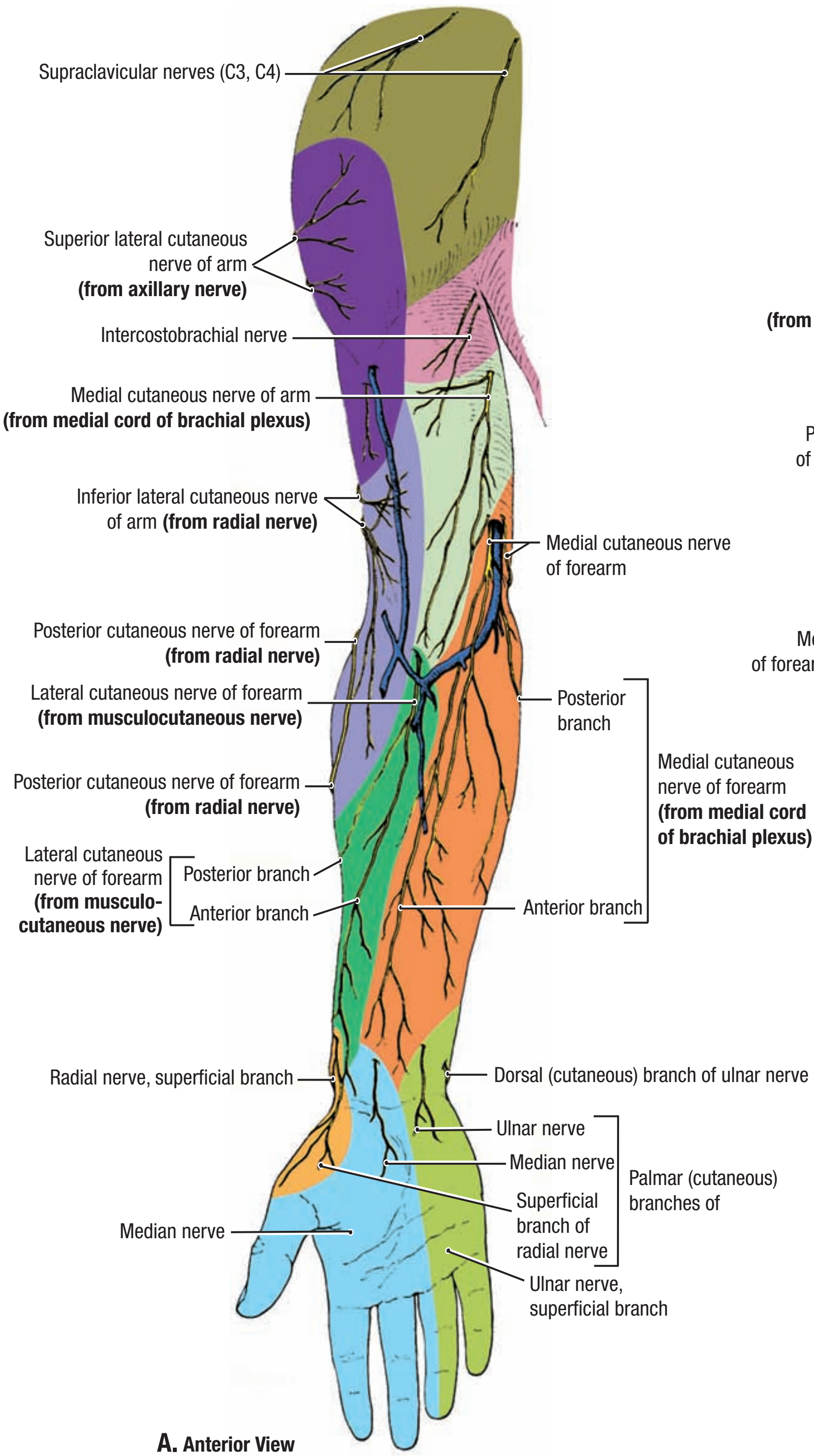
6.4 OVERVIEW OF MOTOR INNERVATION OF UPPER LIMB

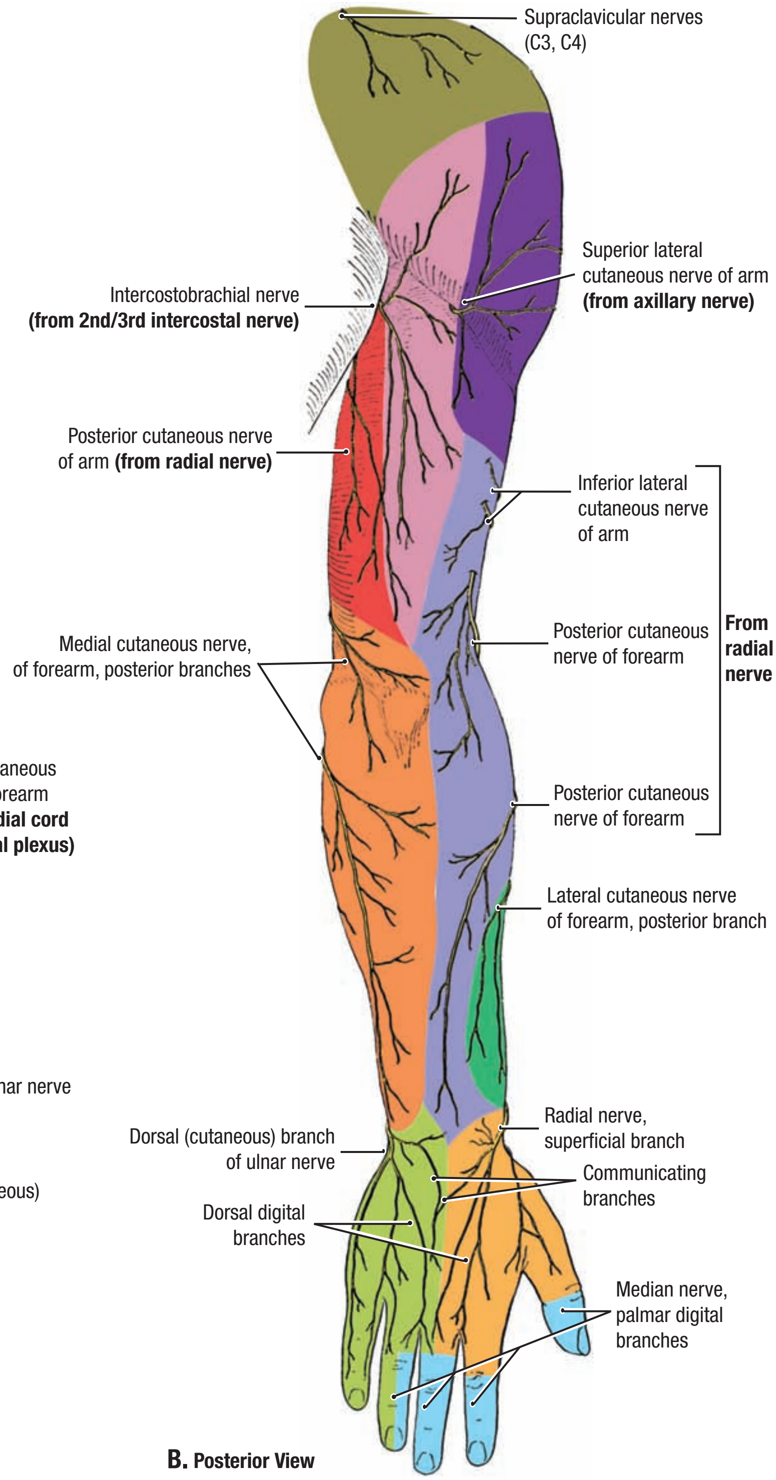


C. **Posterior View**

6.4 OVERVIEW OF MOTOR INNERVATION OF UPPER LIMB *(CONTINUED)*

A. Musculocutaneous and median nerves. The musculocutaneous nerve innervates all the muscles of the anterior compartment of the arm. The median nerve innervates muscles of the anterior compartment of the forearm (with $1^1/_2$ exceptions that are innervated by the ulnar nerve), the lumbricals to digits 2 and 3, and the intrinsic muscles of the thumb (thenar muscles) with $1^1/_2$ exceptions that are innervated by the ulnar nerve. **B.** Ulnar nerve. The ulnar nerve innervates the flexor carpi ulnaris and ulnar half of the flexor digitorum profundus in the forearm, the hypothenar and interosseus muscles of the hand, the lumbricals to digits 3 and 4, and $1^1/_2$ thenar muscles (adductor pollicis and the deep head of the flexor pollicis brevis). **C.** Radial nerve. The radial nerve innervates all muscles of the posterior compartments of the arm and forearm.



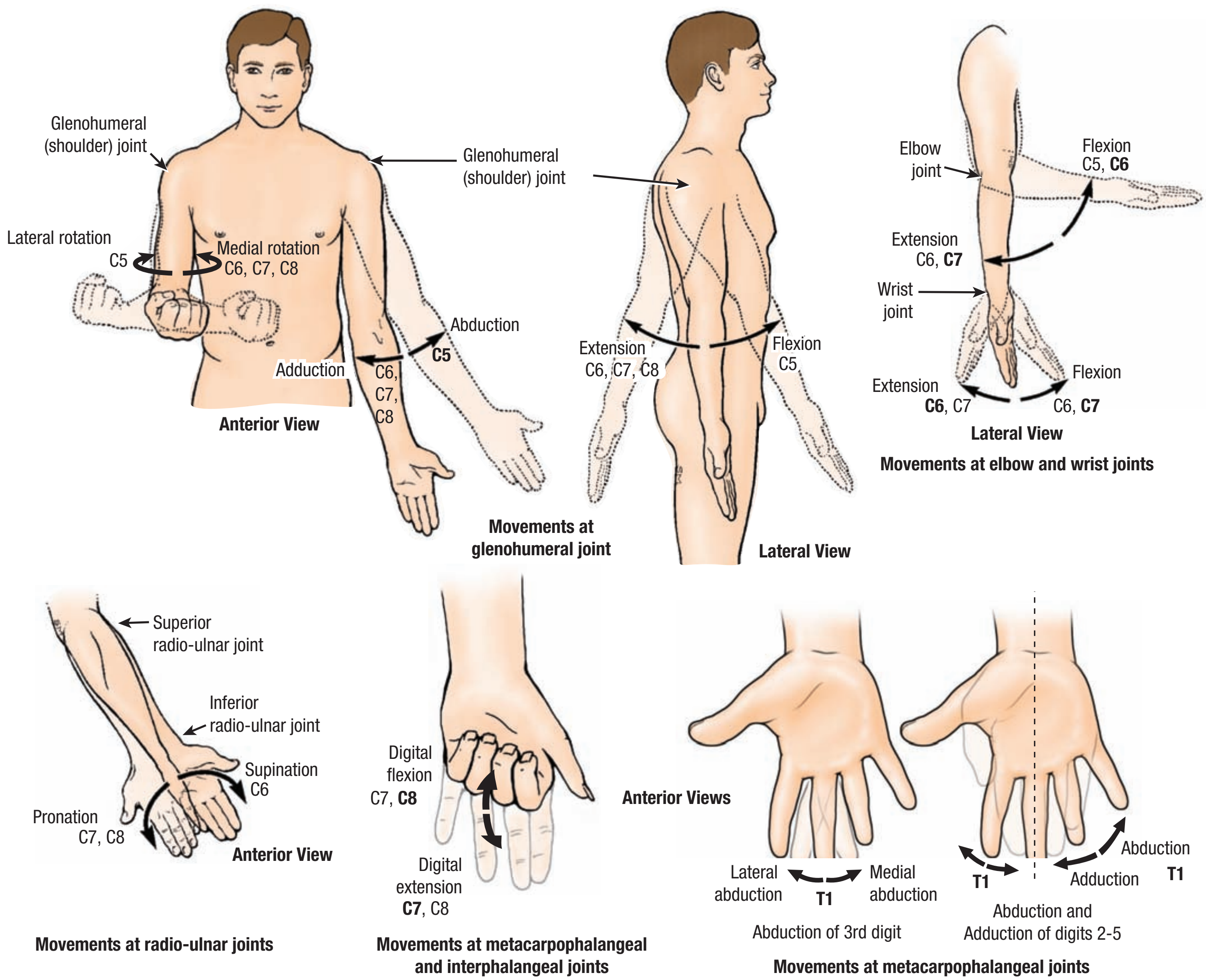


6.5 CUTANEOUS NERVES OF UPPER LIMB

TABLE 6.1 CUTANEOUS NERVES OF UPPER LIMB[a]

<table>
<tr><th>Nerve</th><th>Spinal Nerve components</th><th>Source</th><th>Course/Distribution</th></tr>
<tr><td>Supraclavicular nerves</td><td>C3–C4</td><td>Cervical plexus</td><td>Pass anterior to clavicle, immediately deep to platysma, and supply the skin over the clavicle and superolateral aspect of the pectoralis major muscle</td></tr>
<tr><td>Superior lateral cutaneous nerve of arm</td><td rowspan="2">C5–C6</td><td>Axillary nerve (posterior cord of brachial plexus)</td><td>Emerges from posterior margin of deltoid to supply skin over lower part of this muscle and the lateral side of the midarm</td></tr>
<tr><td>Inferior lateral cutaneous nerve of arm</td><td rowspan="4">Radial nerve (posterior cord of brachial plexus)</td><td>Arises with the posterior cutaneous nerve of forearm; pierces lateral head of triceps brachii to supply skin over the inferolateral aspect of the arm</td></tr>
<tr><td>Posterior cutaneous nerve of arm</td><td></td><td>Arises in axilla and supplies skin on posterior surface of the arm to olecranon</td></tr>
<tr><td>Posterior cutaneous nerve of forearm</td><td>C5–C8</td><td>Arises with the inferior lateral cutaneous nerve of the arm; pierces lateral head of triceps brachii to supply skin over the posterior aspect of the arm</td></tr>
<tr><td>Superficial branch of radial nerve</td><td rowspan="2">C6–C7</td><td>Arises in cubital fossa; supplies lateral (radial) half of the dorsal aspect of hand and thumb, and proximal portion of the dorsal aspects of digits 2 and 3, and the lateral (radial) half of dorsal aspect of digit 4</td></tr>
<tr><td>Lateral cutaneous nerve of forearm</td><td>Musculocutaneous nerve (lateral cord of brachial plexus)</td><td>Arises between biceps brachii and brachialis muscle as continuation of musculocutaneous nerve distal to branch to brachialis; emerges in cubital fossa lateral to biceps tendon and median cubital vein; supplies skin along radial (lateral) border of forearm to base of thenar eminence</td></tr>
<tr><td>Median nerve</td><td>C6–C7 (via lateral root); C8–T1 (via medial root)</td><td>Lateral and medial cords of brachial plexus</td><td>Courses with brachial artery in arm and deep to flexor digitorum superficialis in forearm; distal to origin of palmar cutaneous branch, traverses carpal tunnel to supply skin of palmar aspect of radial $3^1/_2$ digits and adjacent palm, plus distal dorsal aspects of same, including nail beds</td></tr>
<tr><td>Ulnar nerve</td><td>(C7), C8–T1</td><td rowspan="3">Medial cord of brachial plexus</td><td>Courses with brachial, superior ulnar collateral, and ulnar arteries; supplies skin of palmar and dorsal aspects of medial (ulnar) $1^1/_2$ digits and palm and dorsum of hand proximal to those digits</td></tr>
<tr><td>Medial cutaneous nerve of forearm</td><td>C8–T1</td><td>Pierces deep fascia with basilic vein in midarm; divides into anterior and posterior branches supplying skin over anterior and medial surfaces of forearm to wrist</td></tr>
<tr><td>Medial cutaneous nerve of arm</td><td>C8–T2</td><td>Smallest and most medial branch of brachial plexus; communicates with intercostobrachial nerve, then descends medial to brachial artery and basilic vein to innervate skin of distal medial arm</td></tr>
<tr><td>Intercostobrachial nerve</td><td>T2</td><td>Lateral cutaneous branch of 2nd intercostal nerve</td><td>Arises distal to angle of 2nd rib; supplies skin of axilla and proximal medial arm</td></tr>
</table>

[a]See Table 6.16 on Lesions of nerves of upper limb at end of chapter.



6.6 MYOTOMES AND MYOTATIC (DEEP TENDON STRETCH) REFLEXES

Myotomes. Somatic motor (general somatic efferent) fibers transmit impulses to skeletal (voluntary) muscles. The unilateral muscle mass receiving information from the somatic motor fibers conveyed by a single spinal nerve is a myotome. The movements associated with each bolded segment in Table 6.2 are most commonly tested to determine the neurologic level of a lesion.

Myotatic reflexes. A myotatic reflex (deep tendon or stretch reflex) is an involuntary contraction of a muscle in response to sudden stretching. Myotatic reflexes are elicited by briskly tapping the tendon with a reflex hammer. Each tendon reflex is mediated by specific spinal nerves. Stretch reflexes control muscle tone.

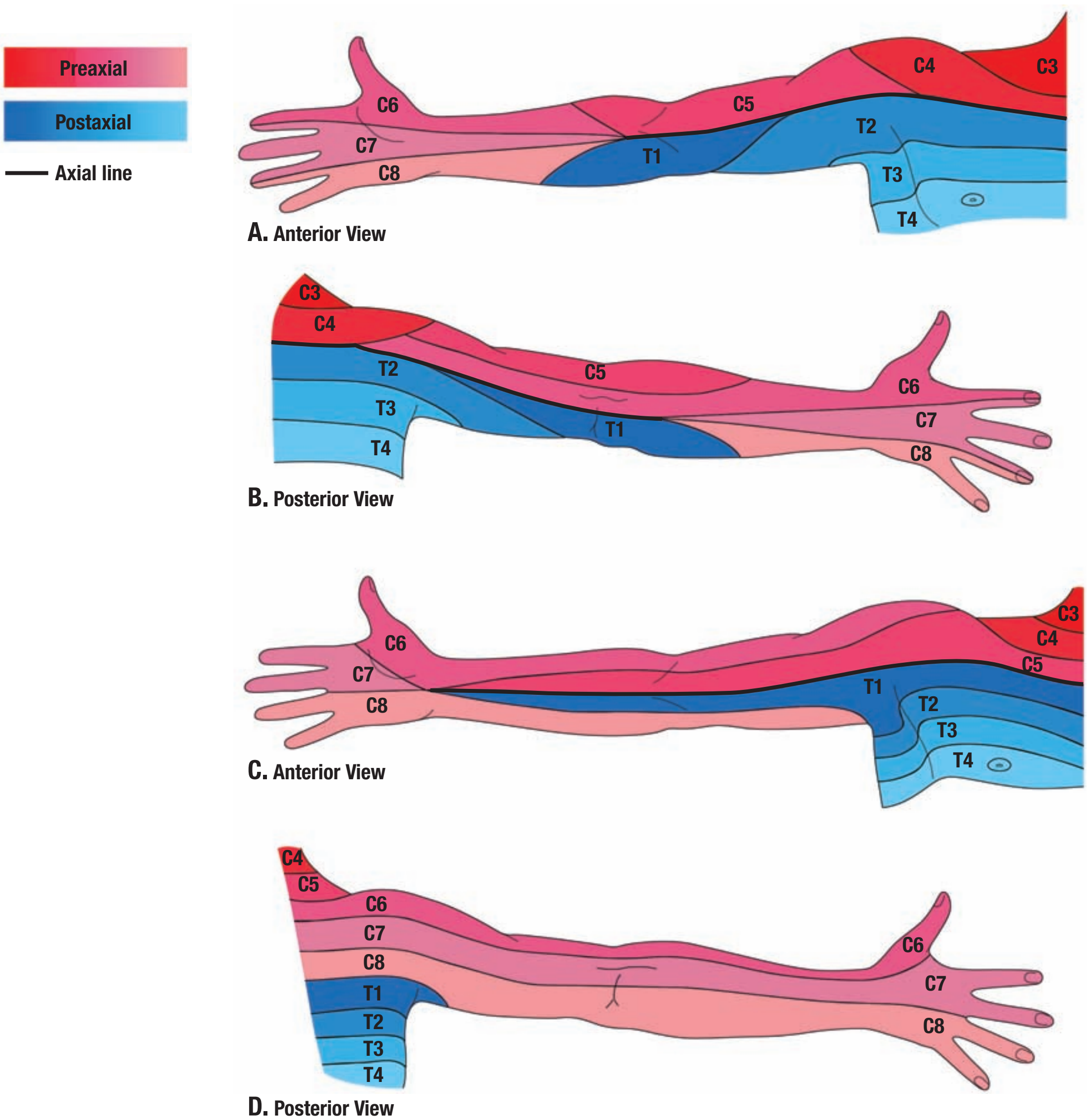
TABLE 6.2 CLINICAL MANIFESTATIONS OF NERVE ROOT COMPRESSION: UPPER LIMB (UL)

Herniated Disc Between	Compressed Nerve Roots	Dermatomes Affected	Muscles Affected	Movement Weakness	Nerve and Myotatic Reflex Involved
C4 and C5	**C5**	C5 Shoulder Lateral surface UL	Deltoid	Abduction of shoulder	Axillary nerve ↓ Biceps jerk
C5 and C6	**C6**	C6 Thumb	Biceps Brachialis Brachioradialis	Flexion of elbow Supination/pronation of forearm	Musculocutaneous nerve ↓ Biceps jerk ↓ Brachioradialis jerk
C6 and C7	**C7**	C7 Posterior surface UL Middle and index fingers	Triceps Wrist extensors	Extension of elbow Extension of wrist	Radial nerve ↓ Triceps reflex

TABLE 6.3 DERMATOMES OF UPPER LIMB

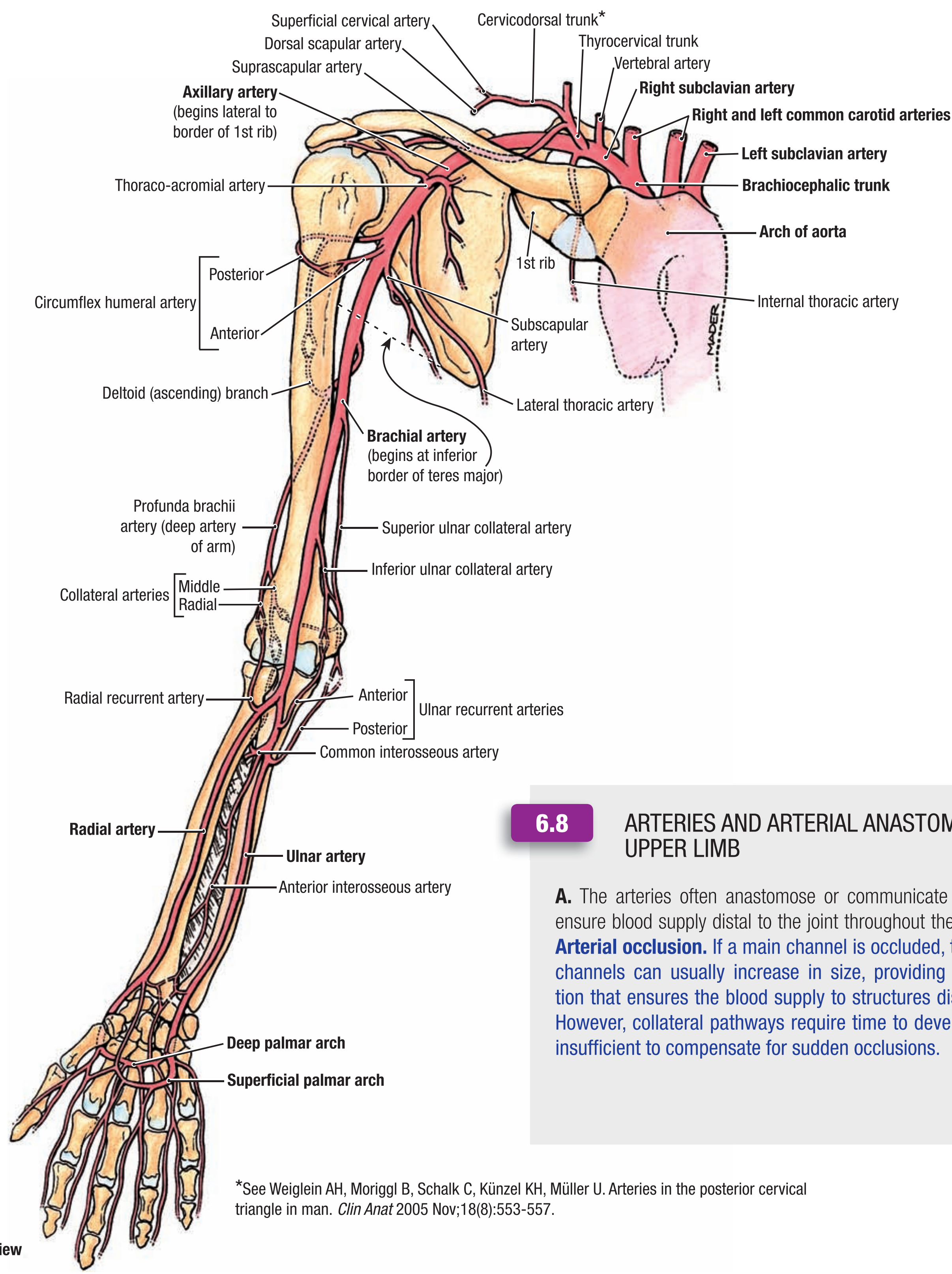
Spinal Segment/Nerve(s)	Description of Dermatome(s)
C3, C4	Region at base of neck extending laterally over shoulder
C5	Lateral aspect of arm (i.e., superior aspect of abducted arm)
C6	Lateral forearm and thumb
C7	Middle and ring fingers (or middle 3 fingers) and center of posterior aspect of forearm
C8	Little finger, medial side of hand and forearm (i.e., inferior aspect of abducted arm)
T1	Medial aspect of forearm and inferior arm
T2	Medial aspect of superior arm and skin of axilla[a]

[a]Not indicated on the Keegan and Garrett dermatome map. However, pain experienced during a heart attack, considered to be mediated by T1 and T2, is commonly described as "radiating down the medial side of the left arm").



6.7 DERMATOMES OF UPPER LIMB

The dermatomal or segmental pattern of distribution of sensory nerve fibers persists despite the merging of spinal nerves in plexus formation during development. Two different dermatome maps are commonly used. **A.** and **B.** The dermatome pattern of the upper limb according to Foerster (1933) is preferred by many because of its correlation with clinical findings. In the Foerster schema, dermatomes C6–T1 are displaced from the trunk to limbs. **C.** and **D.** The dermatome pattern of the upper limb according to Keegan and Garrett (1948) is preferred by others for its correlation with development. Although depicted as distinct zones, adjacent dermatomes overlap considerably except along the axial line.

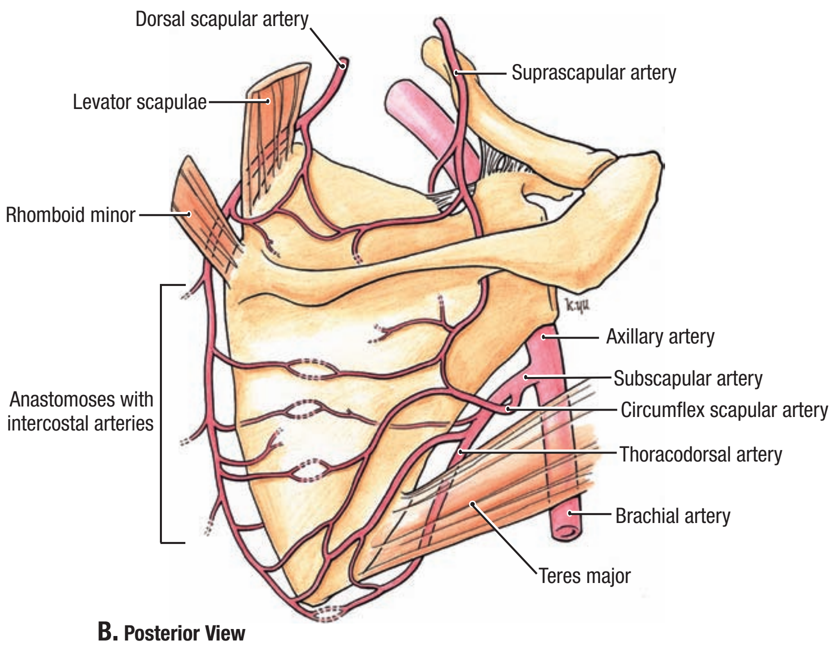


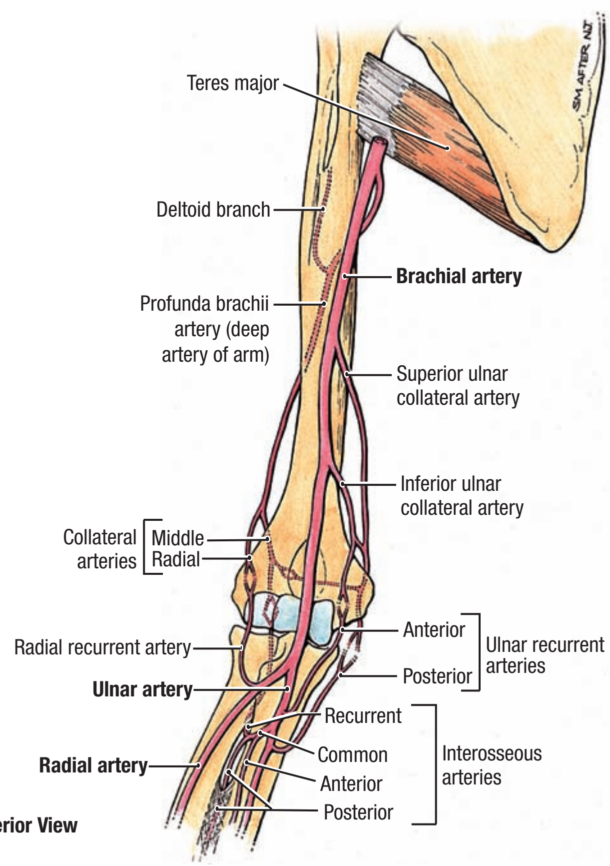
A. **Anterior View**

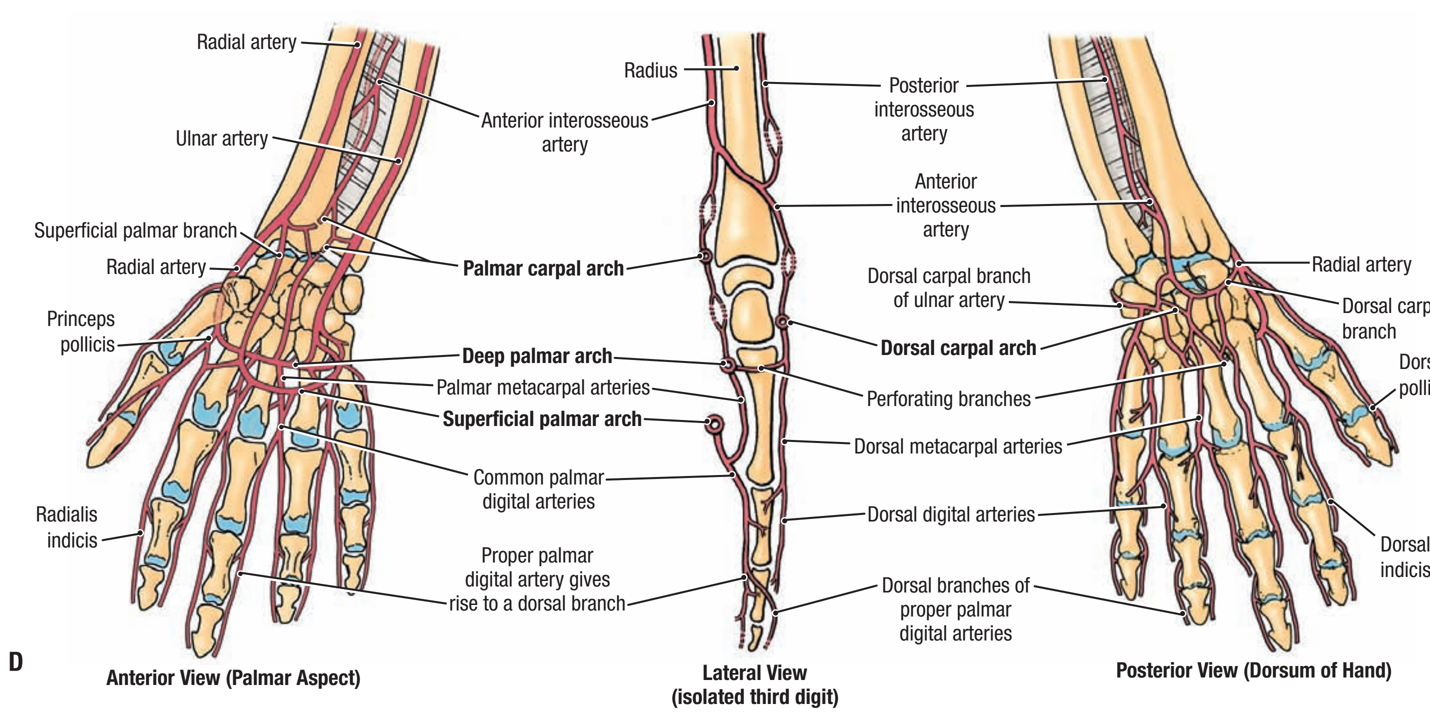
*See Weiglein AH, Moriggl B, Schalk C, Künzel KH, Müller U. Arteries in the posterior cervical triangle in man. *Clin Anat* 2005 Nov;18(8):553-557.

6.8 ARTERIES AND ARTERIAL ANASTOMOSES OF UPPER LIMB

A. The arteries often anastomose or communicate to form networks to ensure blood supply distal to the joint throughout the range of movement. **Arterial occlusion.** If a main channel is occluded, the smaller alternate channels can usually increase in size, providing a collateral circulation that ensures the blood supply to structures distal to the blockage. However, collateral pathways require time to develop; they are usually insufficient to compensate for sudden occlusions.

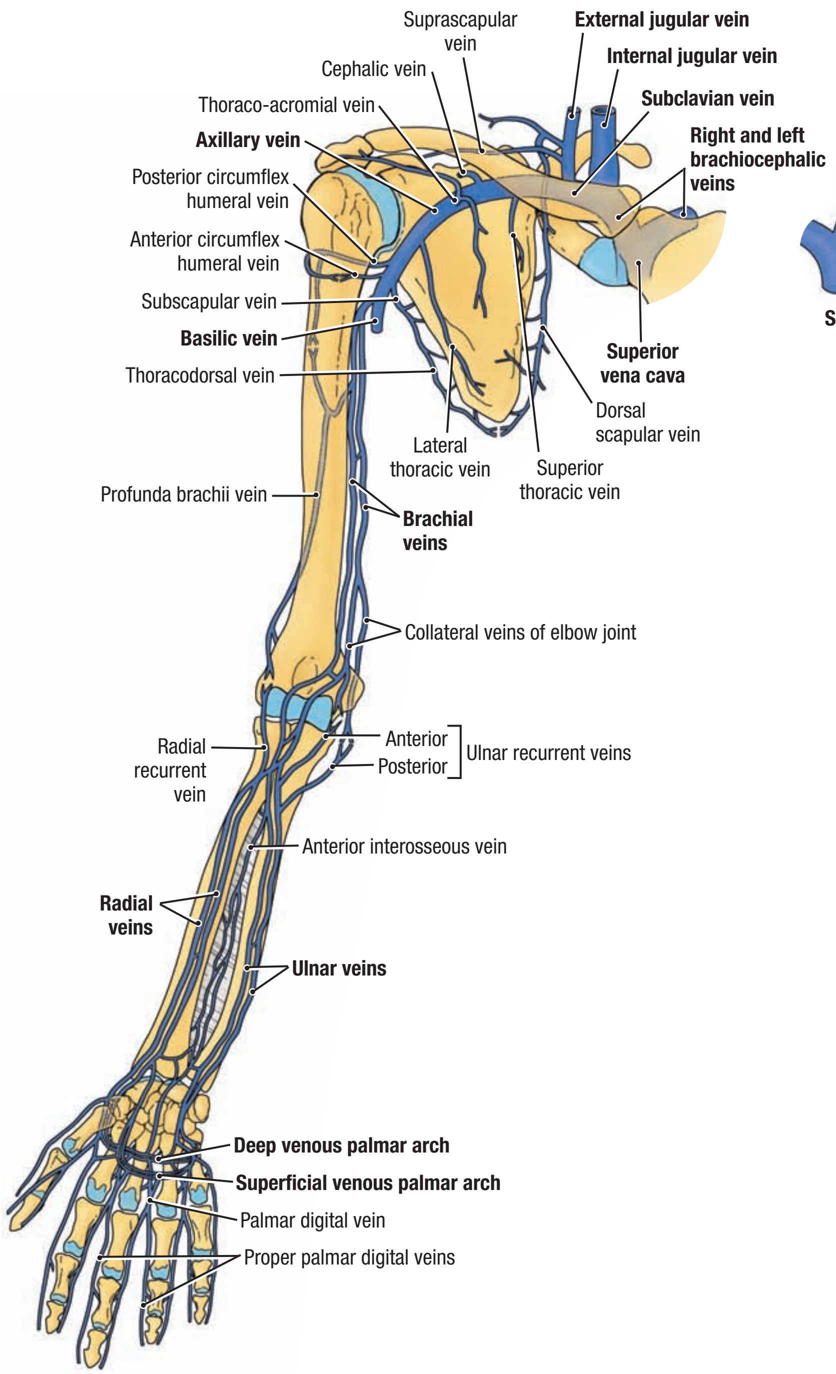




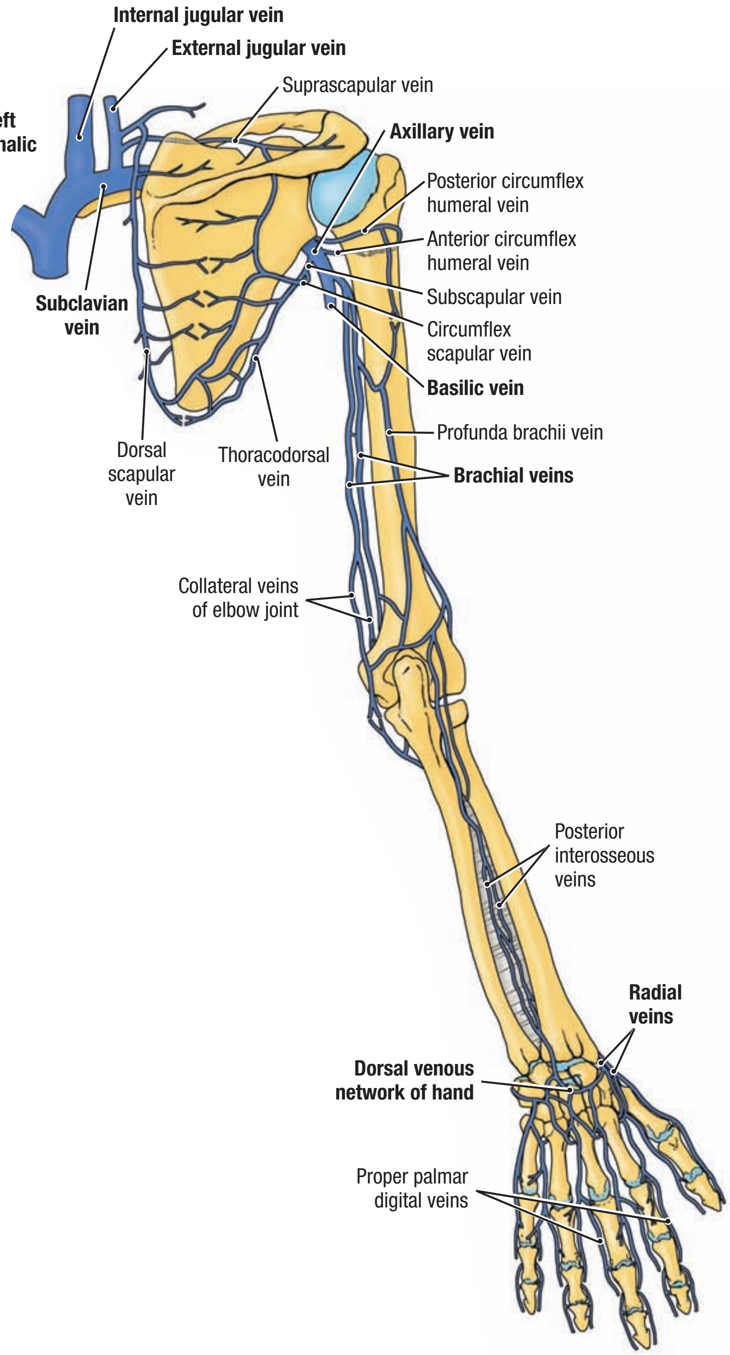


6.8 ARTERIES AND ARTERIAL ANASTOMOSES OF UPPER LIMB *(CONTINUED)*

B. Scapular anastomoses. **C.** Anastomoses of the elbow. **D.** Anastomoses of the hand. Joints receive blood from articular arteries that arise from vessels around joints.



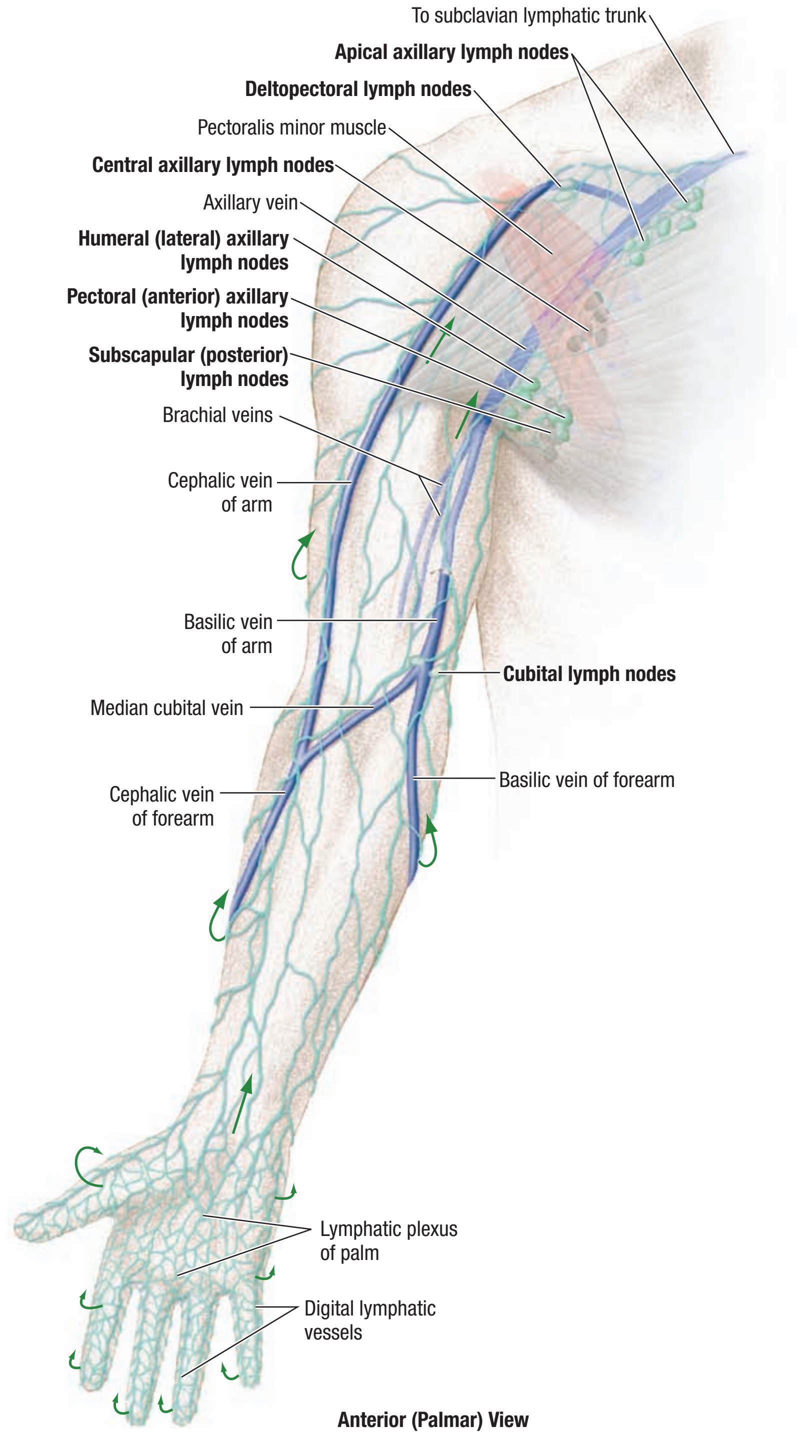
A. **Anterior View**



B. **Posterior View**

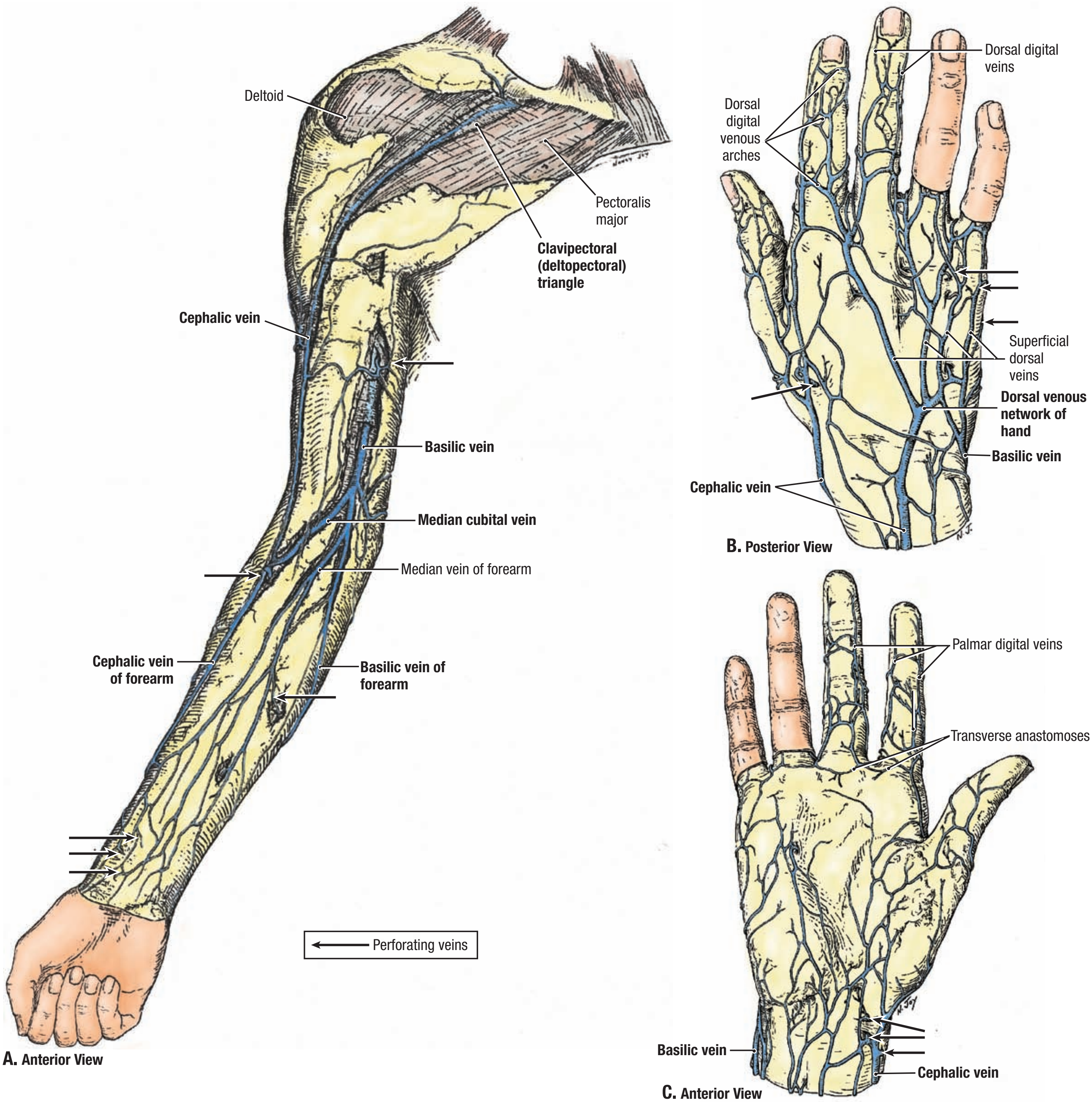
6.9 OVERVIEW OF DEEP VEINS OF UPPER LIMB

Deep veins lie internal to the deep fascia and occur as paired, continually interanastomosing “accompanying veins” (L., *venae comitantes*) surrounding and sharing the name of the artery they accompany.



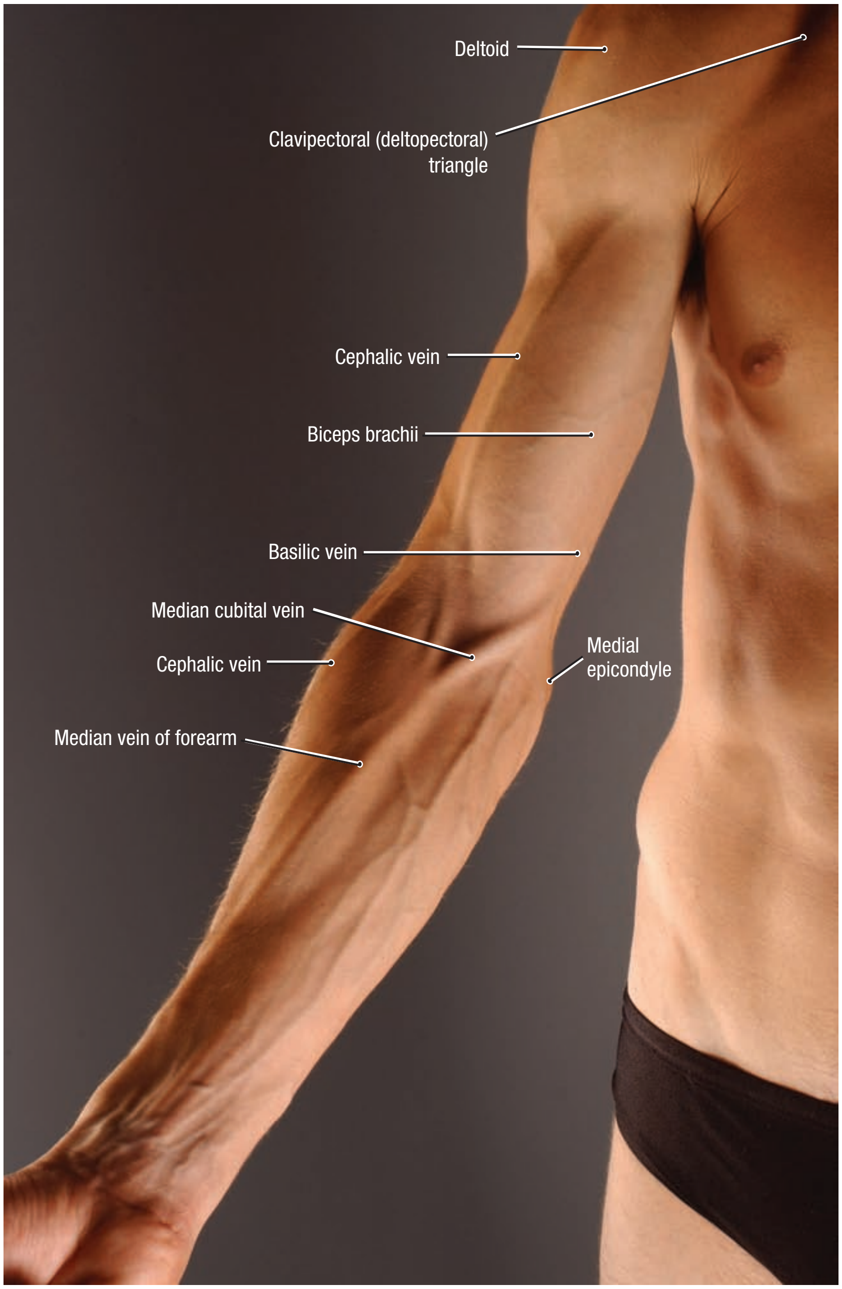
6.10 SUPERFICIAL VENOUS AND LYMPHATIC DRAINAGE OF UPPER LIMB

Superficial lymphatic vessels arise from lymphatic plexuses in the digits, palm, and dorsum of the hand and ascend with the superficial veins of the upper limb. The superficial lymphatic vessels ascend through the forearm and arm, converging toward the cephalic and especially to the basilic vein to reach the axillary lymph nodes. Some lymph passes through the cubital nodes at the elbow and the deltopectoral (infraclavicular) nodes at the shoulder. Deep lymphatic vessels accompany the neurovascular bundles of the upper limb and end primarily in the humeral (lateral) and central axillary lymph nodes.

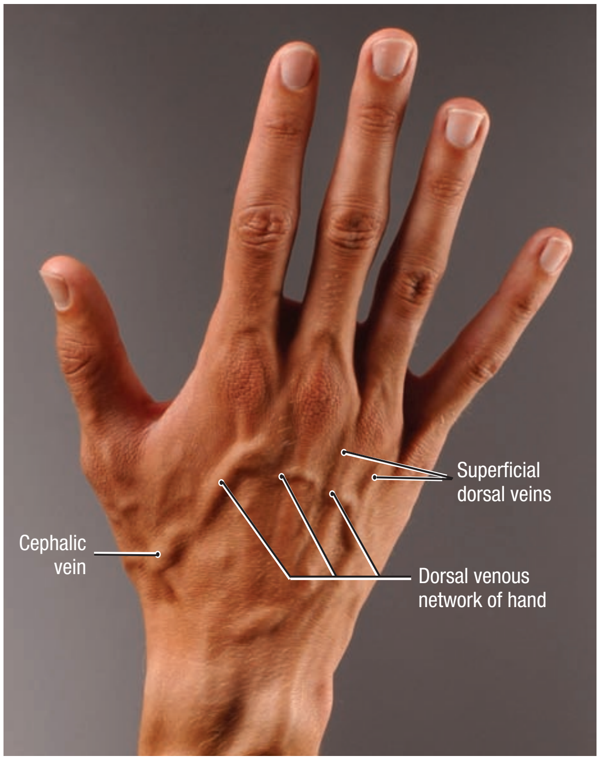


6.11 SUPERFICIAL VENOUS DRAINAGE OF UPPER LIMB

A. Forearm, arm, and pectoral region. **B.** Dorsal surface of hand. **C.** Palmar surface of hand. The *arrows* indicate where perforating veins penetrate the deep fascia. Blood is continuously shunted from these superficial veins in the subcutaneous tissue to deep veins via the perforating veins.



D. **Anterior View**

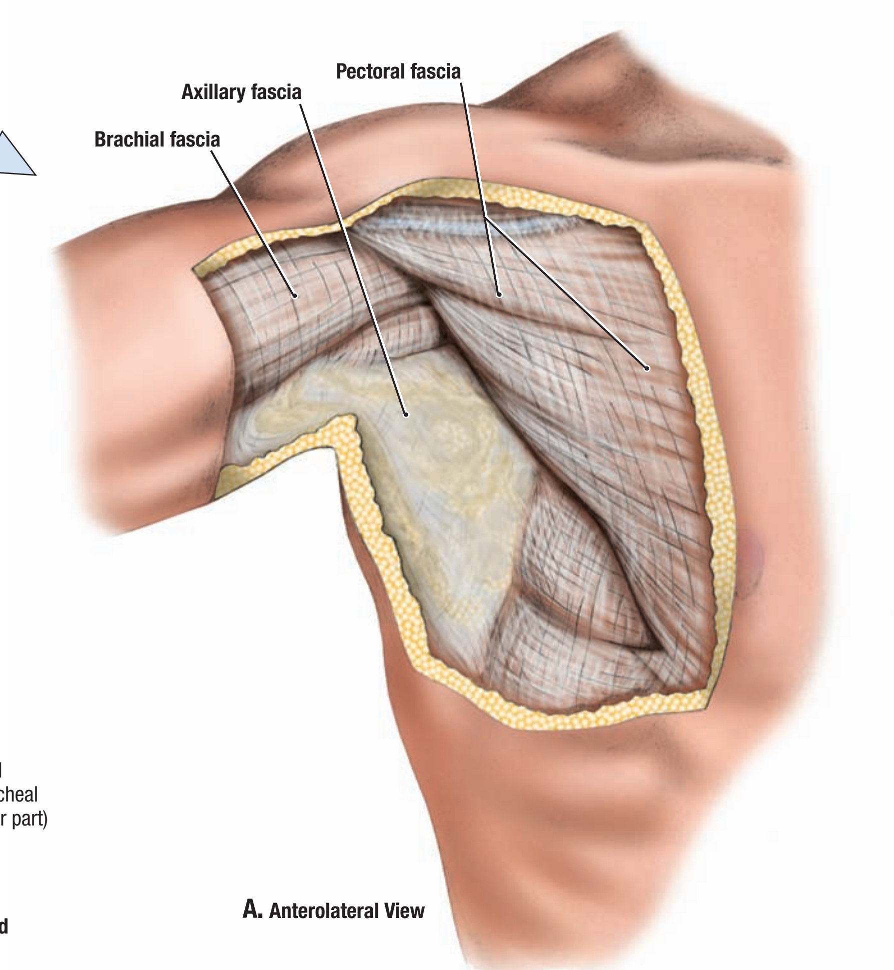


E. **Posterior View**

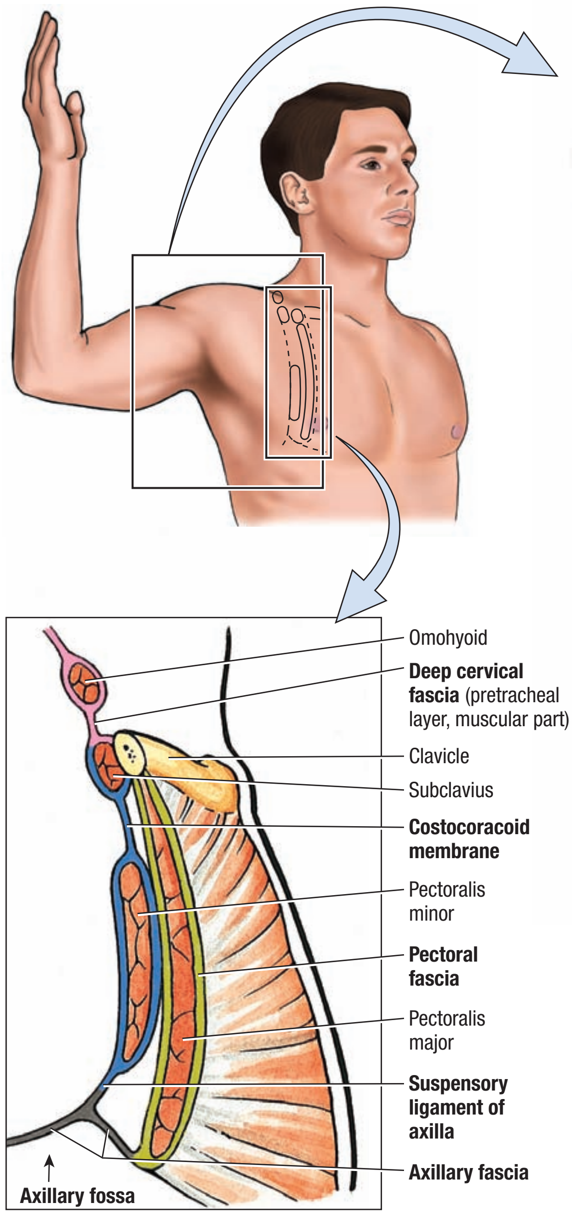
6.11 SUPERFICIAL VENOUS DRAINAGE OF UPPER LIMB *(CONTINUED)*

D. Surface anatomy of veins of forearm and arm. **E.** Surface anatomy of veins of the dorsal surface of hand.

Because of the prominence and accessibility of the superficial veins, they are commonly used for **venipuncture** (puncture of a vein to draw blood or inject a solution). By applying a tourniquet to the arm, the venous return is occluded, and the veins distend and usually are visible and/or palpable. Once a vein is punctured, the tourniquet is removed so that when the needle is removed the vein will not bleed extensively. The median cubital vein is commonly used for venipuncture. The veins forming the dorsal venous network of the hand and the cephalic and basilic veins arising from it are commonly used for long-term introduction of fluids **(intravenous feeding)**. The cubital veins are also a site for the **introduction of cardiac catheters** to secure blood samples from the great vessels and chambers of the heart.



A. Anterolateral View

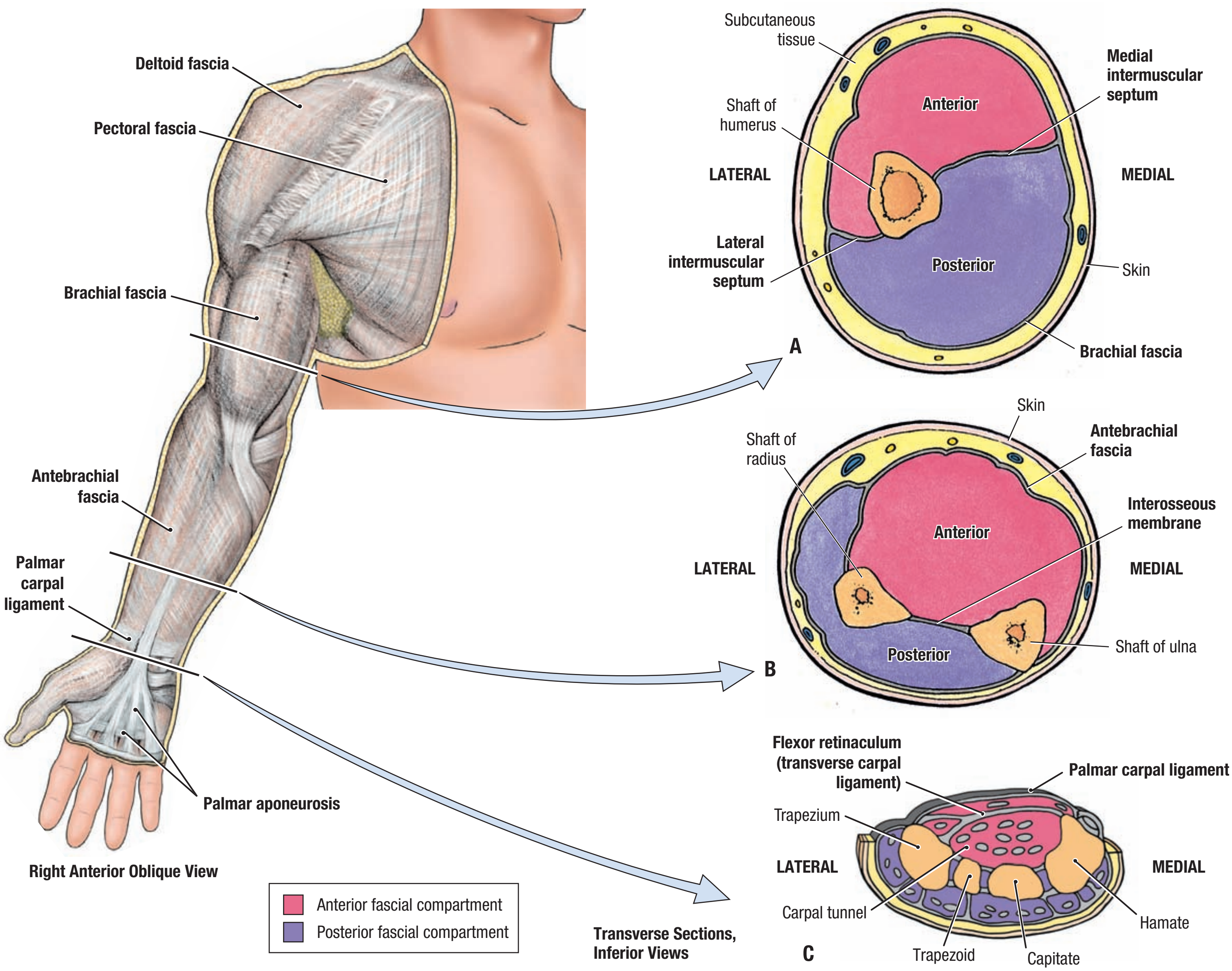


B. Sagittal Section

Fascia in B:
- Deep cervical
- Clavipectoral
- Pectoral
- Axillary

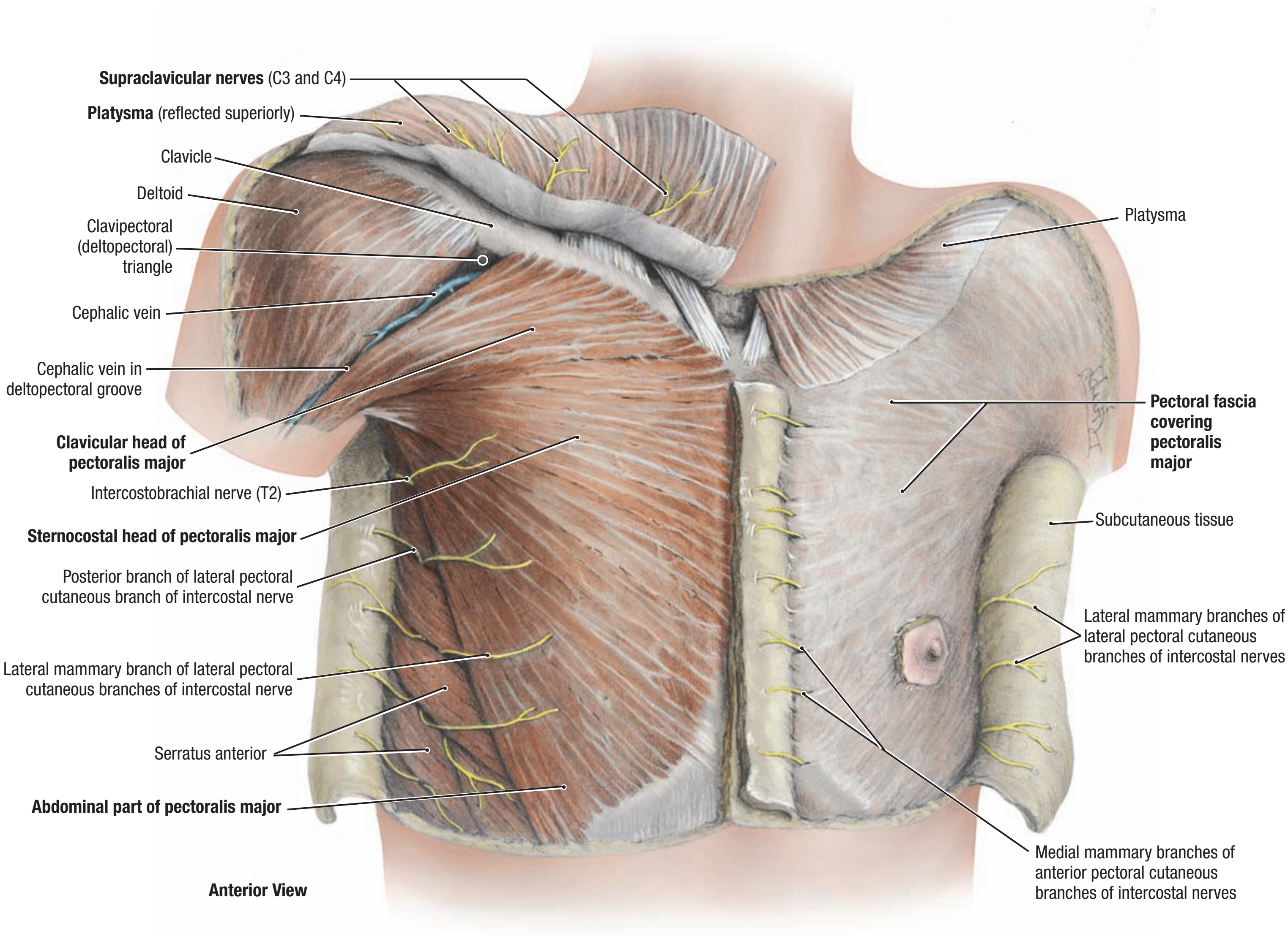
6.12 DEEP FASCIA OF UPPER LIMB—AXILLARY AND CLAVIPECTORAL FASCIA

A. Axillary fascia. The axillary fascia forms the floor of the axillary fossa and is continuous with the pectoral fascia covering the pectoralis major muscle and the brachial fascia of the arm. **B.** Clavipectoral fascia. The clavipectoral fascia extends from the axillary fascia to enclose the pectoralis minor and subclavius muscles and then attaches to the clavicle. The part of the clavipectoral fascia superior to the pectoralis minor is the costocoracoid membrane, and the part of the clavipectoral fascia inferior to the pectoralis minor is the suspensory ligament of the axilla. The suspensory ligament of the axilla, an extension of the axillary fascia, supports the axillary fascia and pulls the axillary fascia and the skin inferior to it superiorly when the arm is abducted, forming the axillary fossa or "armpit."



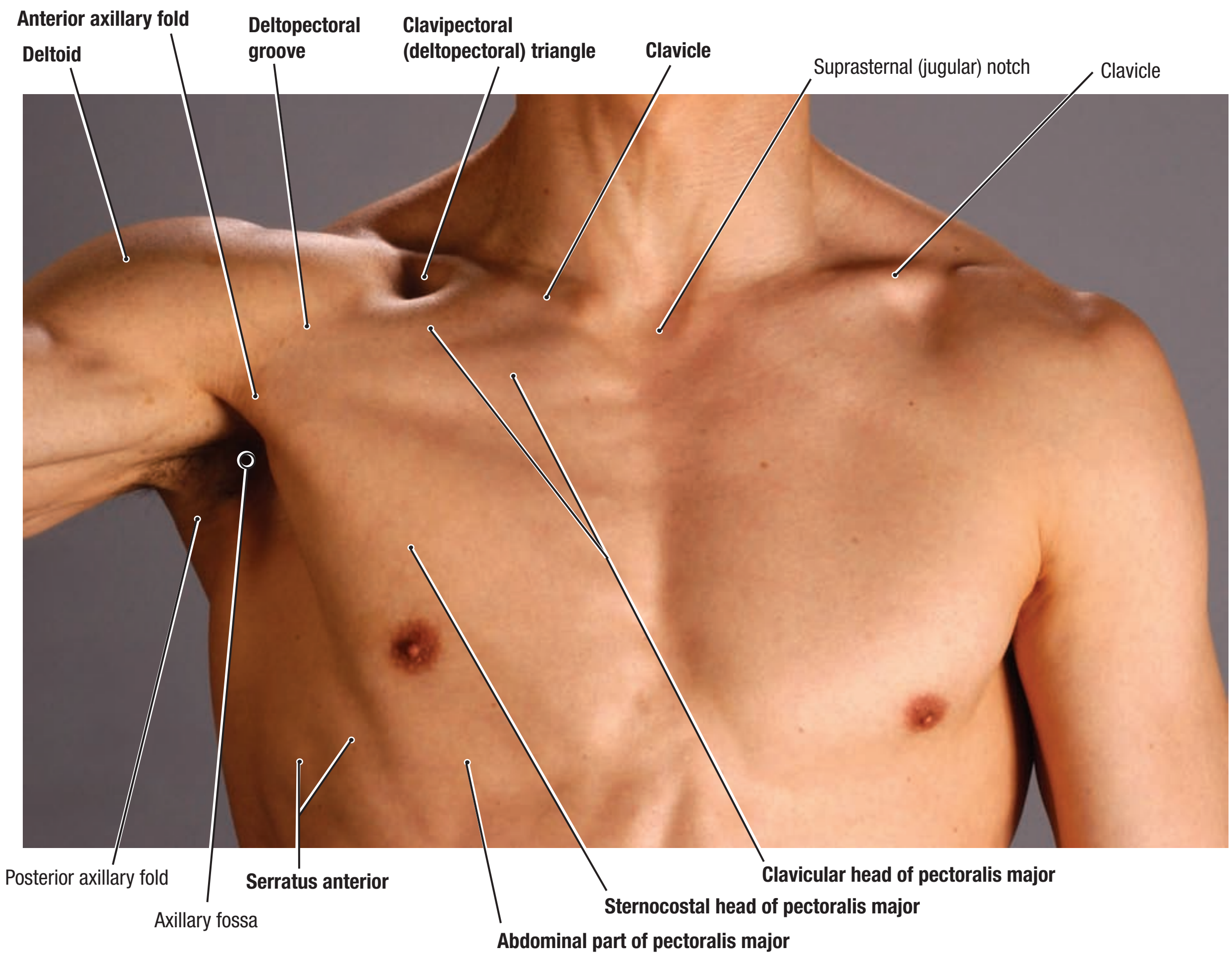
6.13 DEEP FASCIA OF UPPER LIMB, BRACHIAL AND ANTEBRACHIAL FASCIA

A. Brachial fascia. The brachial fascia is the deep fascia of the arm and is continuous superiorly with the pectoral and axillary layers of fascia. Medial and lateral intermuscular septa extend from the deep aspect of the brachial fascia to the humerus, dividing the arm into anterior and posterior musculofascial compartments. **B.** Antebrachial fascia. The antebrachial fascia surrounds the forearm and is continuous with the brachial fascia and deep fascia of the hand. The interosseous membrane separates the forearm into anterior and posterior musculofascial compartments. Distally the fascia thickens to form the palmar carpal ligament, which is continuous with the flexor retinaculum and dorsally with the extensor expansion. The deep fascia of the hand is continuous with the antebrachial fascia, and on the palmar surface of the hand it thickens to form the palmar aponeurosis. **C.** Flexor retinaculum (transverse carpal ligament). The flexor retinaculum extends between the medial and lateral carpal bones to form the carpal tunnel.



6.14 SUPERFICIAL DISSECTION, MALE PECTORAL REGION

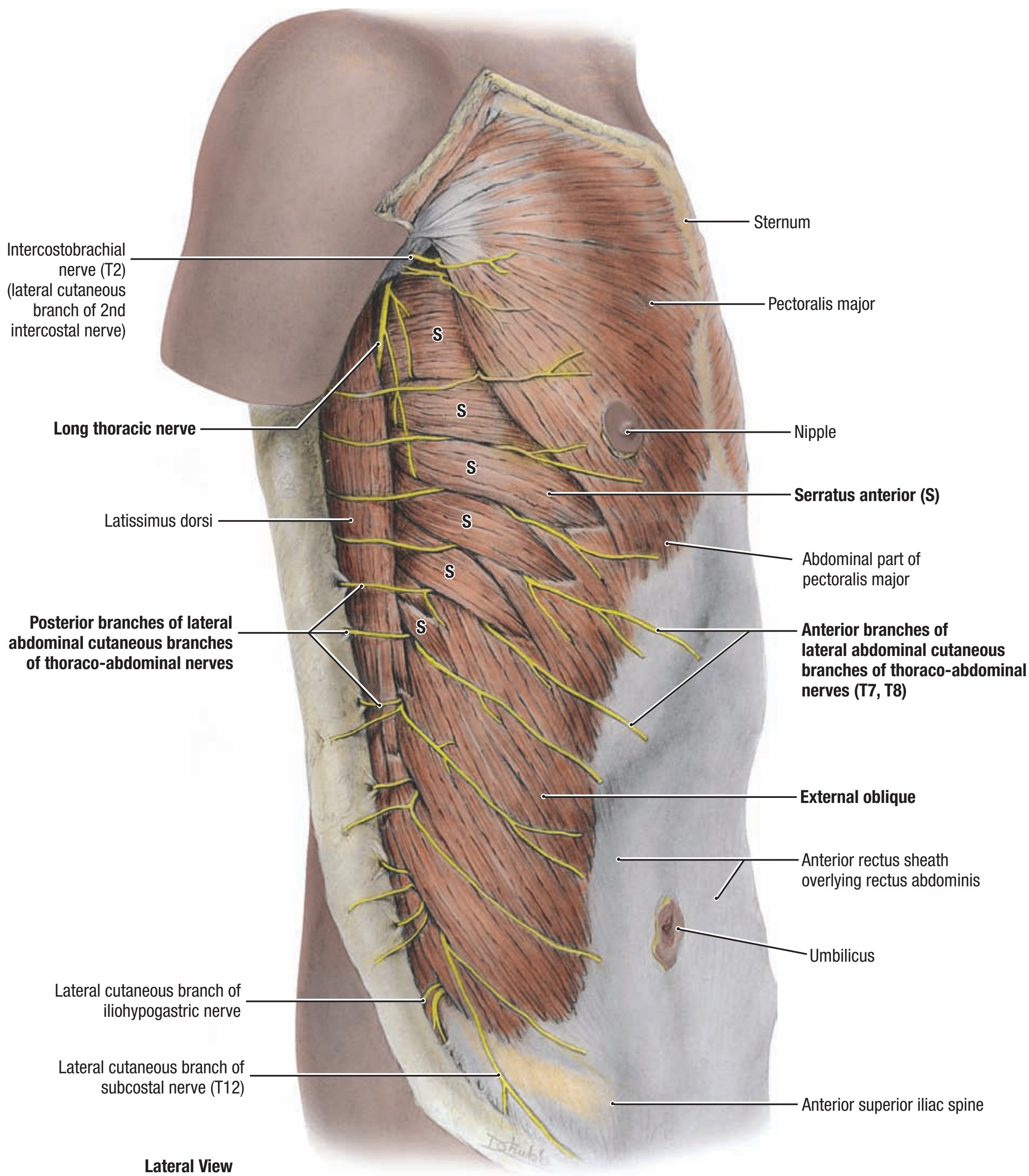
- The platysma muscle, which usually descends to the 2nd or 3rd rib, is cut short on the right side and, together with the supraclavicular nerves, is reflected on the left side.
- The exposed intermuscular bony strip of the clavicle is subcutaneous and subplatysmal.
- The cephalic vein passes deeply to join the axillary vein in the clavipectoral (deltopectoral) triangle.
- The cutaneous innervation of the pectoral region by the supraclavicular nerves (C3 and C4) and upper thoracic nerves (T2–T6); the brachial plexus (C5–T1) does not supply cutaneous branches to the pectoral region.



6.15 SURFACE ANATOMY, MALE PECTORAL REGION

The clavipectoral (deltopectoral) triangle is the depressed area just inferior to the lateral part of the clavicle, bounded by the clavicle superiorly, the deltoid laterally, and the clavicular head of pectoralis major medially. The clavipectoral triangle and the intermuscular deltopectoral groove extending from its inferior apex demarcate an "internervous plane" (plane not crossed by motor nerves) for an **anterior or deltopectoral surgical incision** to approach to the axilla, shoulder joint, or proximal humerus.

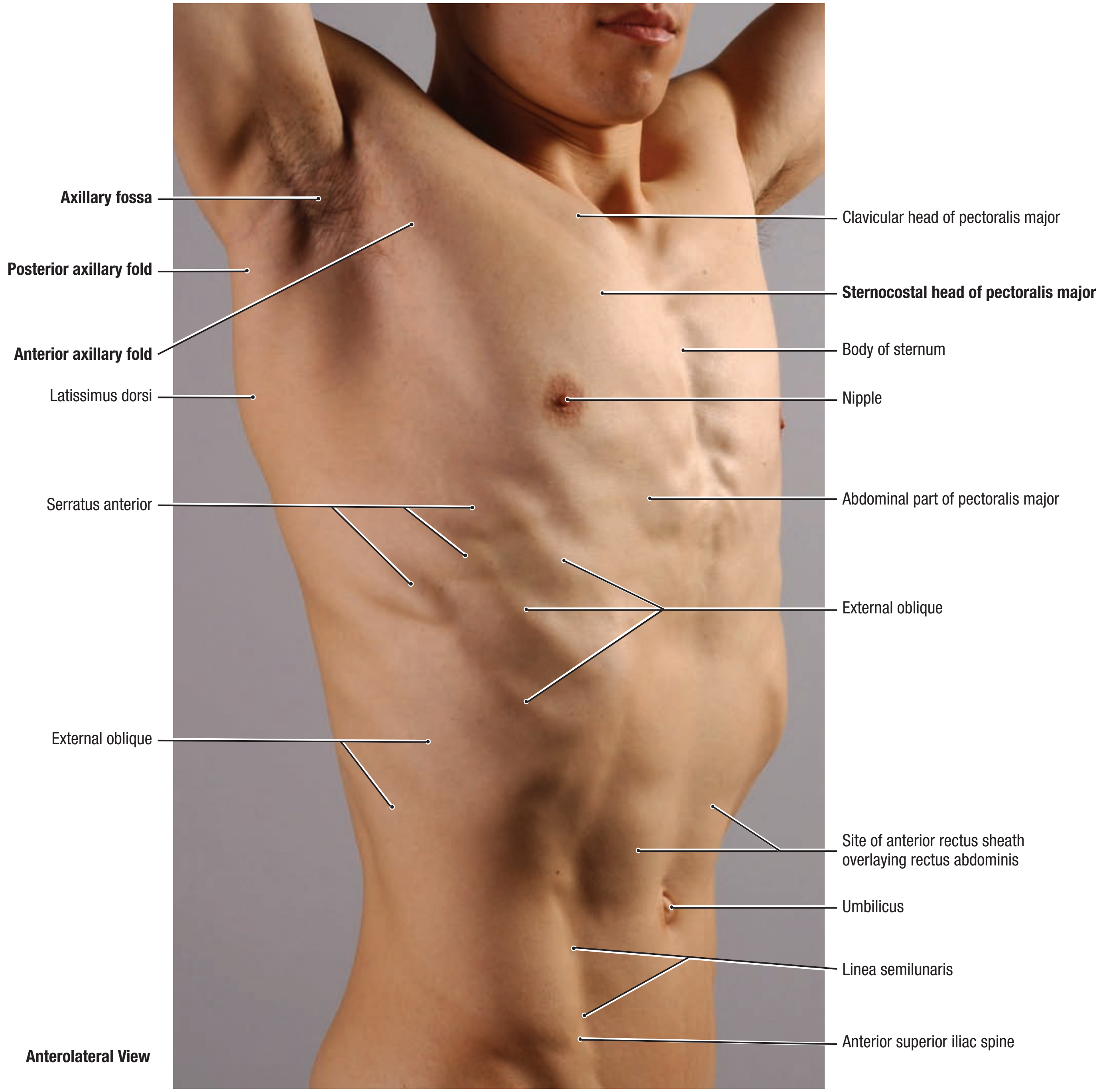
When the arm is abducted and then adducted against resistance, the two heads of the pectoralis major are visible and palpable. As this muscle extends from the thoracic wall to the arm, it forms the anterior axillary fold. Digitations of the serratus anterior appear inferolateral to the pectoralis major. The coracoid process of the scapula is covered by the anterior part of deltoid; however, the tip of the process can be felt on deep palpation in the clavipectoral triangle. The deltoid forms the contour of the shoulder.



Lateral View

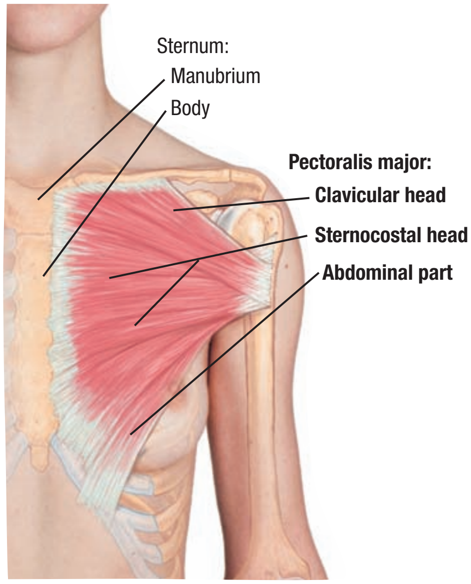
6.16 SUPERFICIAL DISSECTION OF TRUNK

- The slips of the serratus anterior interdigitate with the external oblique.
- The long thoracic nerve (nerve to serratus anterior) lies on the lateral (superficial) aspect of the serratus anterior; this nerve is vulnerable to damage from **stab wounds** and during surgery (e.g., radical mastectomy).
- The anterior and posterior branches of the lateral thoracic and abdominal cutaneous branches of intercostal and thoraco-abdominal nerves are dissected.

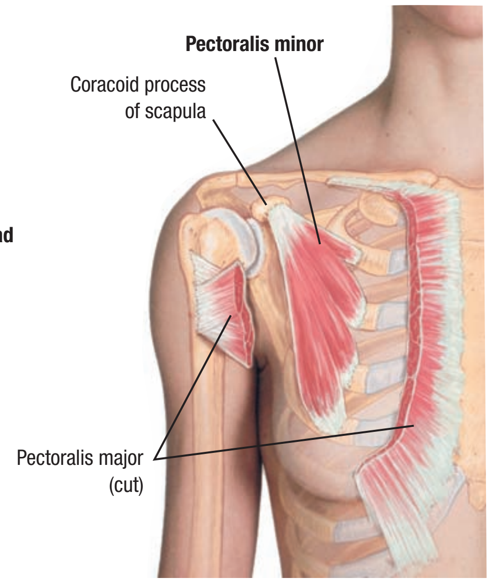


6.17 SURFACE ANATOMY OF ANTEROLATERAL ASPECT OF TRUNK

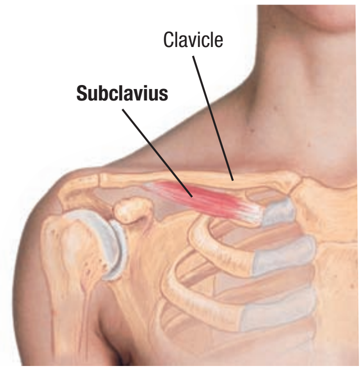
When the arm is abducted and then adducted against resistance, the sternocostal part of the pectoralis major can be seen and palpated. If the anterior axillary fold bounding the axilla is grasped between the fingers and thumb, the inferior border of the sternocostal head of the pectoralis major can be felt. Several digitations of the serratus anterior are visible inferior to the anterior axillary fold. The posterior axillary fold is composed of skin and muscular tissue (latissimus dorsi and teres major) bounding the axilla posteriorly.



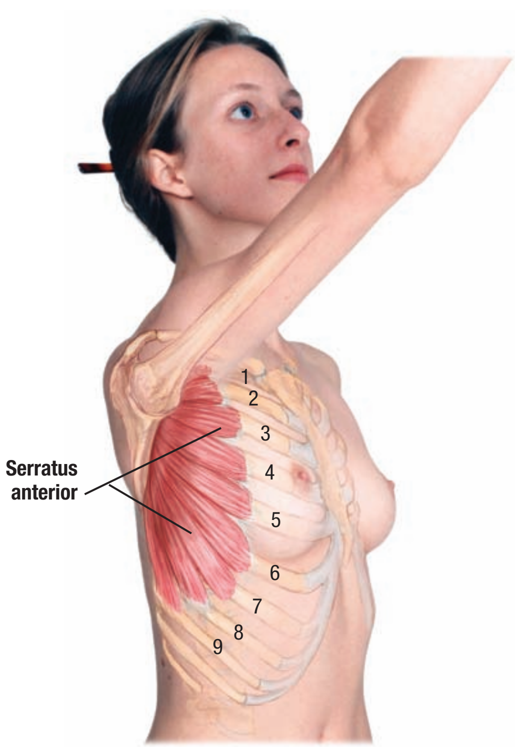
A. **Anterior View**



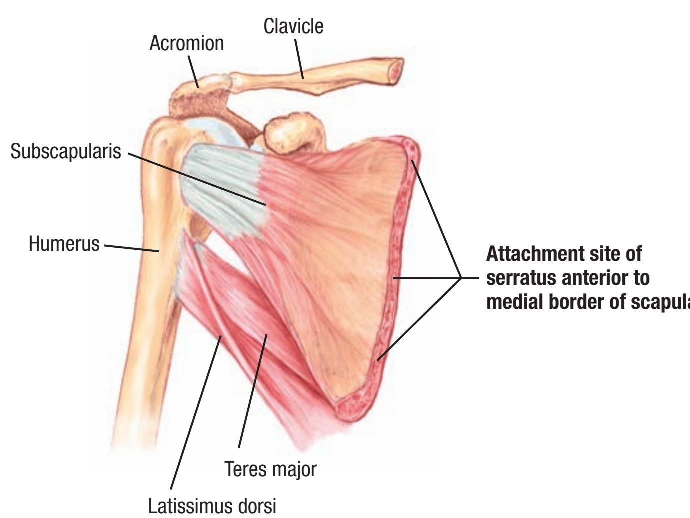
B. **Anterior View**



C. **Anterior View**



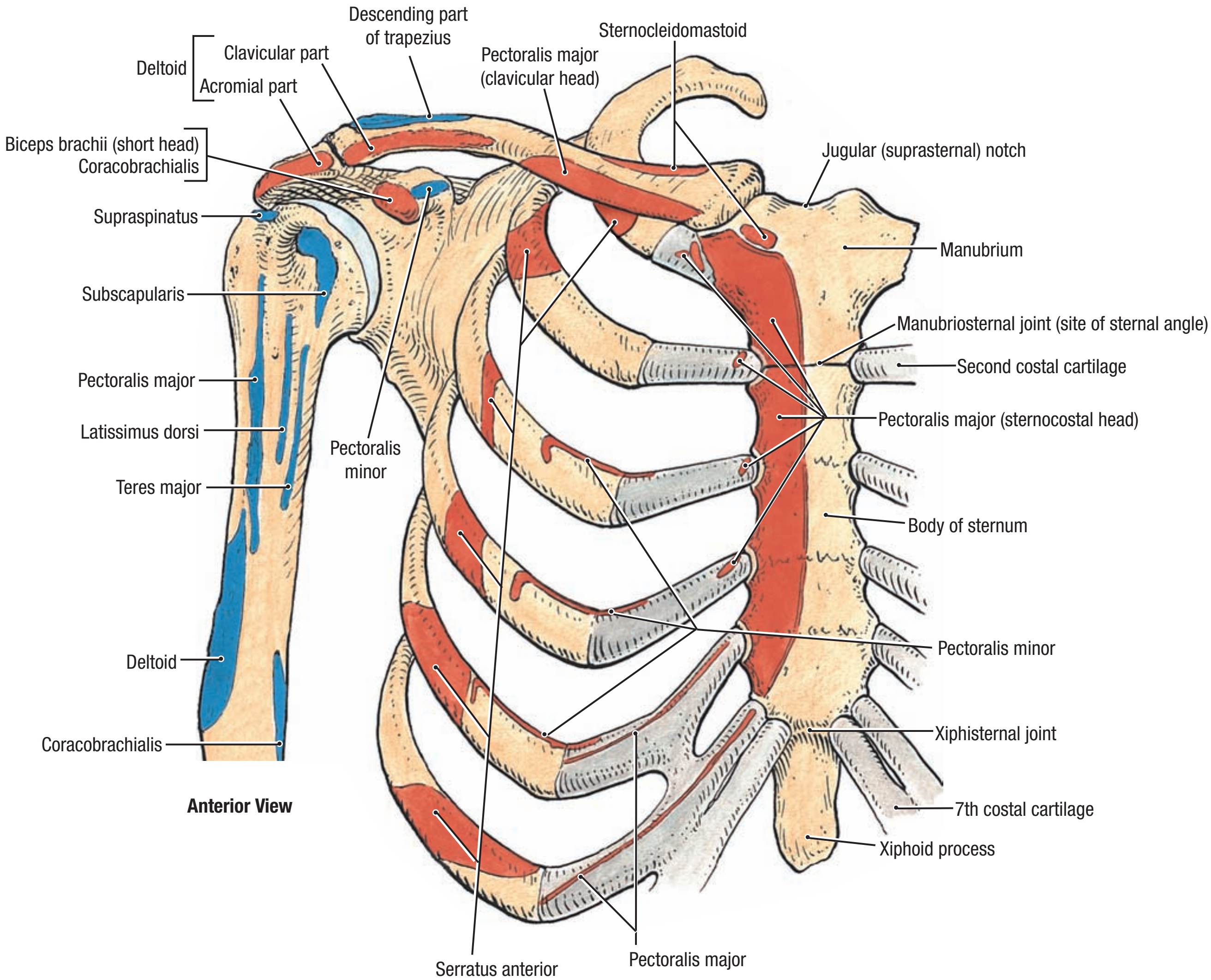
D. **Lateral View**



E. **Anterior View**

6.18 PECTORALIS MAJOR AND MINOR AND SERRATUS ANTERIOR

A. Pectoralis major. **B.** Pectoralis minor. **C.** Subclavius. **D. and E.** Serratus anterior and its scapular attachment.

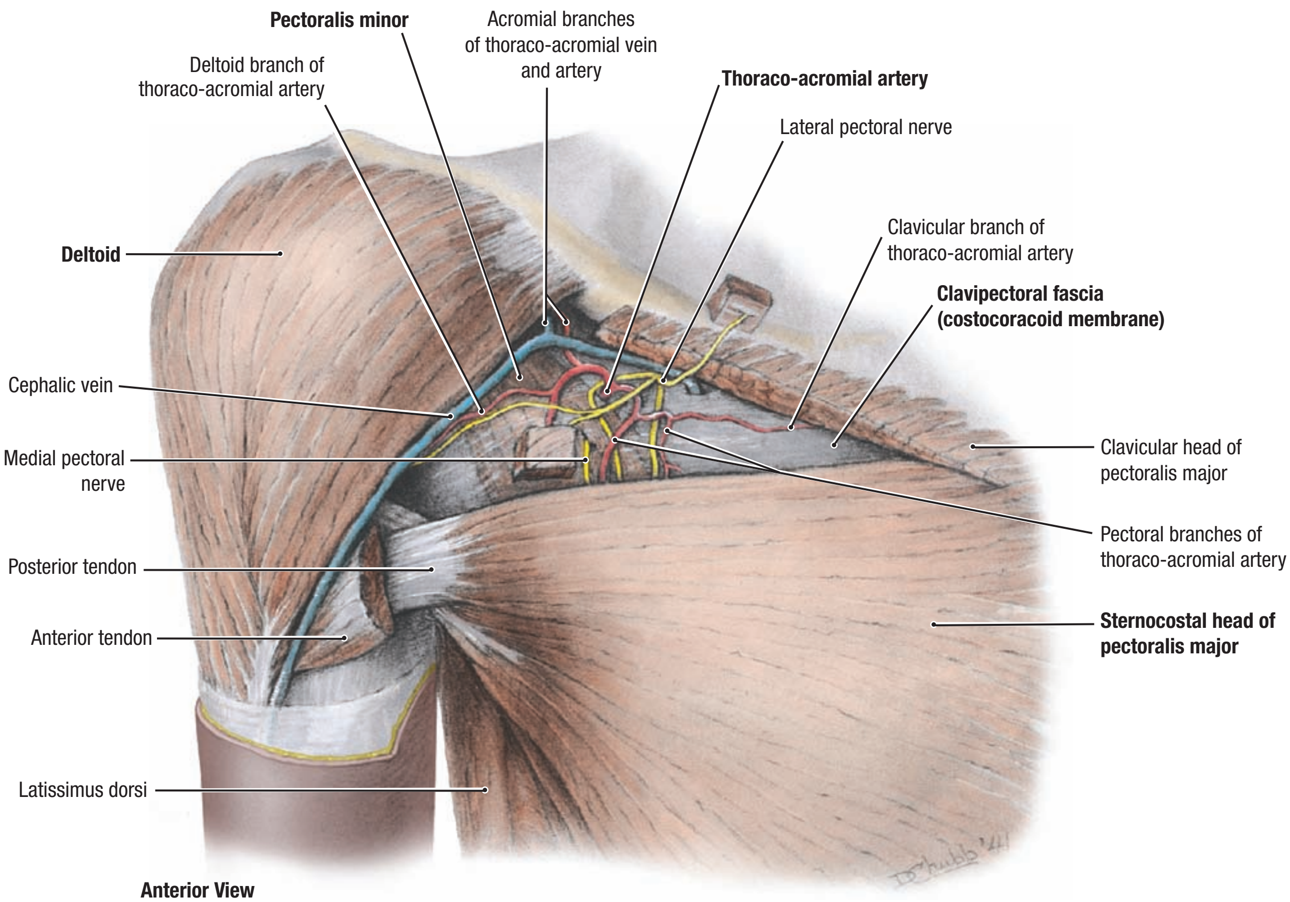


6.19 ANTERIOR ATTACHMENTS OF ANTERIOR AND POSTERIOR AXIO-APPENDICULAR AND SCAPULOHUMERAL MUSCLES

TABLE 6.4 ANTERIOR AXIO-APPENDICULAR MUSCLES

Muscle	Proximal Attachment (*red*)	Distal Attachment (*blue*)	Innervation[a]	Main Actions
Pectoralis major	*Clavicular head:* anterior surface of medial half of clavicle *Sternocostal head:* anterior surface of sternum, superior six costal cartilages *Abdominal part:* aponeurosis of external oblique muscle	Crest of greater tubercle of intertubercular sulcus (lateral lip of bicipital groove)	Lateral and medial pectoral nerves; clavicular head (C5 and **C6**), sternocostal head (**C7**, **C8**, and T1)	Adducts and medially rotates humerus at shoulder joint; draws scapula anteriorly and inferiorly Acting alone: clavicular head flexes shoulder joint, and sternocostal head extends it from the flexed position
Pectoralis minor	3rd to 5th ribs near their costal cartilages	Medial border and superior surface of coracoid process of scapula	Medial pectoral nerve (C8 and T1)	Stabilizes scapula by drawing it inferiorly and anteriorly against thoracic wall
Subclavius	Junction of 1st rib and its costal cartilage	Inferior surface of middle third of clavicle	Nerve to subclavius (**C5** and C6)	Anchors and depresses clavicle at sternoclavicular joint
Serratus anterior	External surfaces of lateral parts of 1st to 8th–9th ribs	Anterior surface of medial border of scapula (see Fig. 6.18E.)	Long thoracic nerve (C5, **C6**, and **C7**)	Protracts scapula and holds it against thoracic wall; rotates scapula

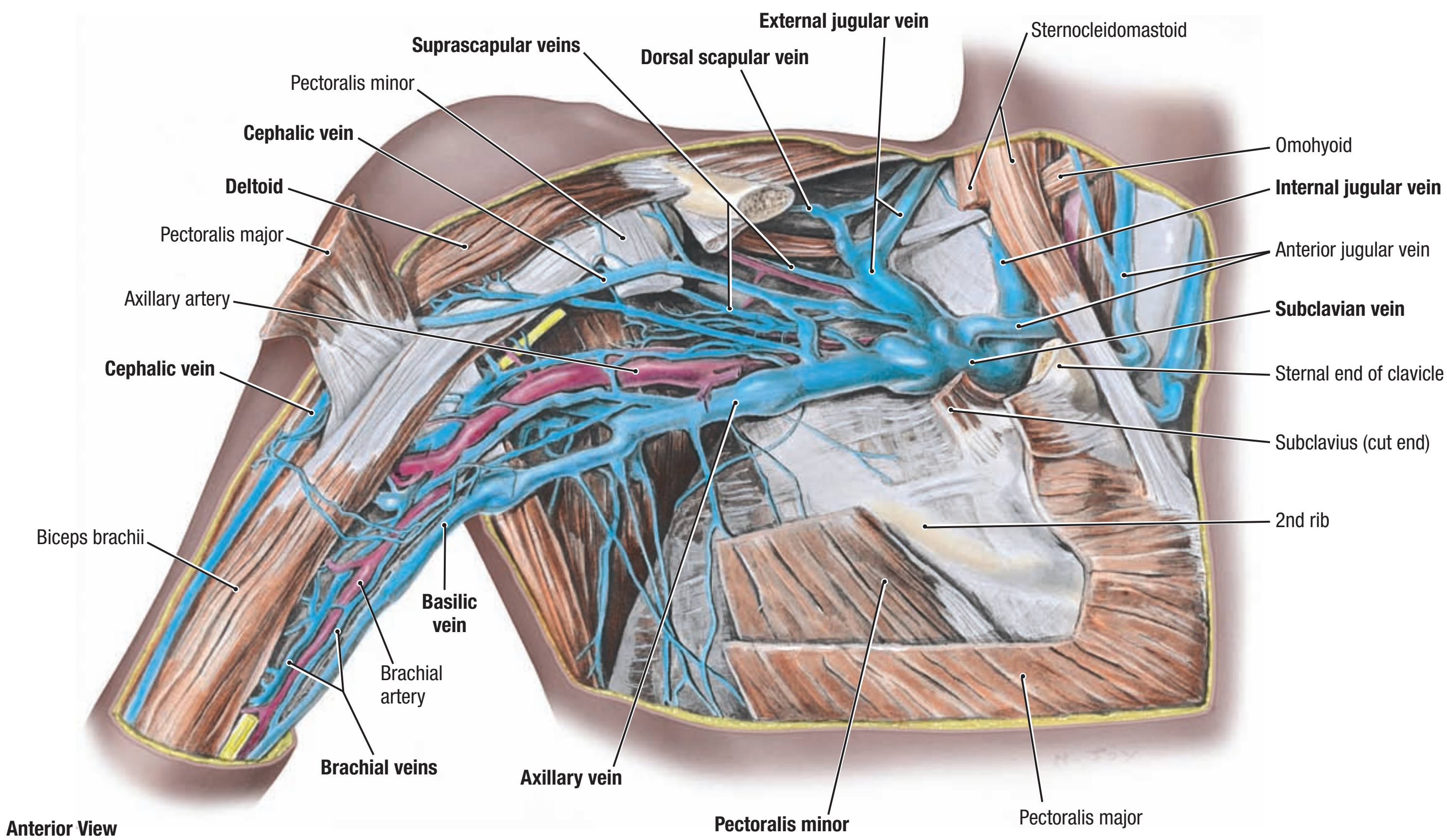
[a]Numbers indicate spinal cord segmental innervation (e.g., C5 and C6 indicate that nerves supplying the clavicular head of pectoralis major are derived from 5th and 6th cervical segments of spinal cord). Boldface numbers indicate the main segmental innervation. Damage to these segments or to motor nerve roots arising from them results in paralysis of the muscles concerned.



6.20 ANTERIOR WALL OF AXILLA AND CLAVIPECTORAL FASCIA

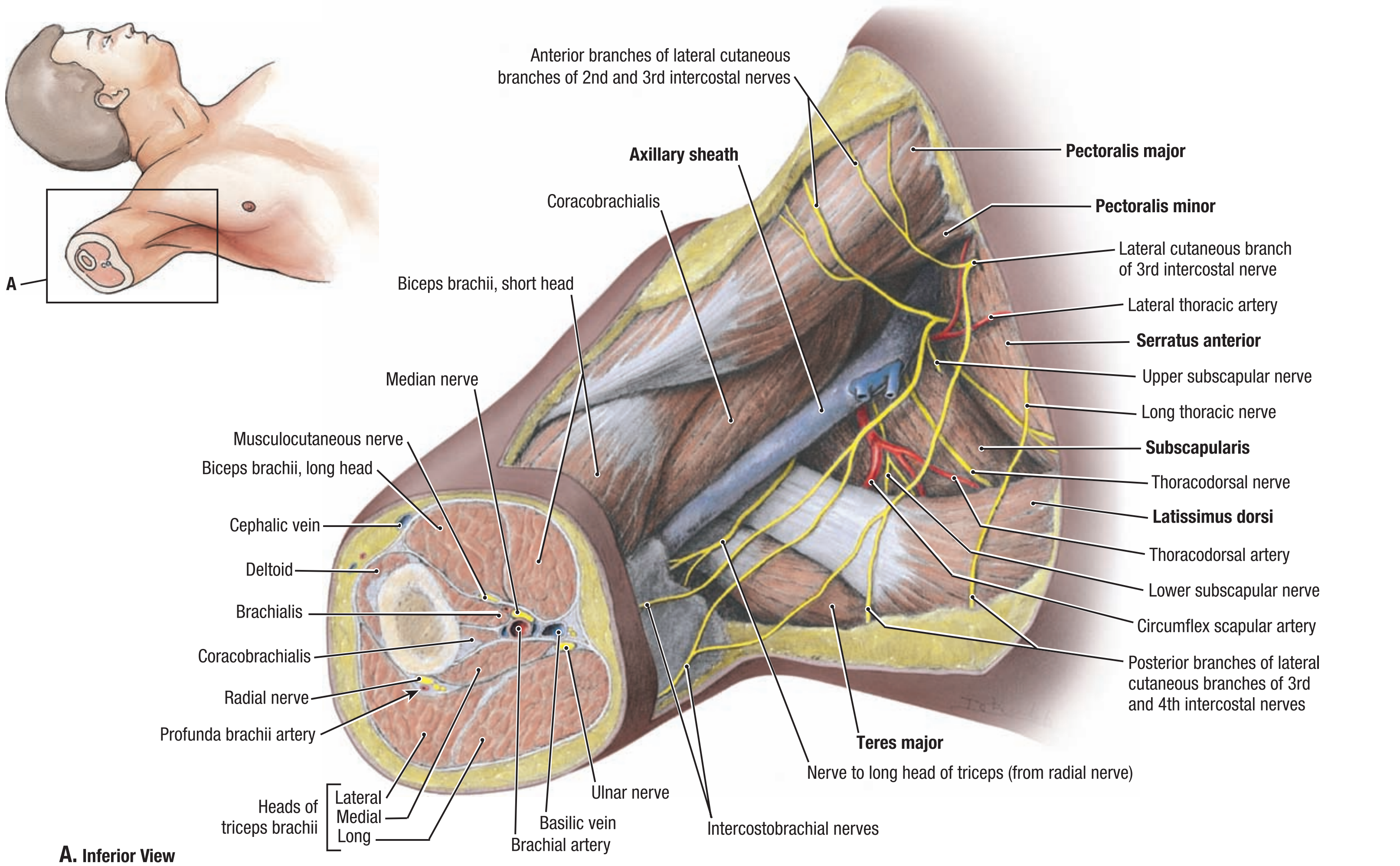
A. Anterior wall of axilla. The clavicular head of the pectoralis major is excised, except for two cubes of muscle that remain to identify the branches of the lateral pectoral nerve.

- The clavipectoral fascia superior to the pectoralis minor (costocoracoid membrane) is pierced by the cephalic vein, the lateral pectoral nerve, and the thoraco-acromial vessels.
- The pectoralis minor and clavipectoral fascia are pierced by the medial pectoral nerve.
- Observe the insertion of the pectoralis major from deep to superficial: inferior part of the sternocostal head, superior part of the sternocostal head (posterior tendon), and clavicular head (anterior tendon)

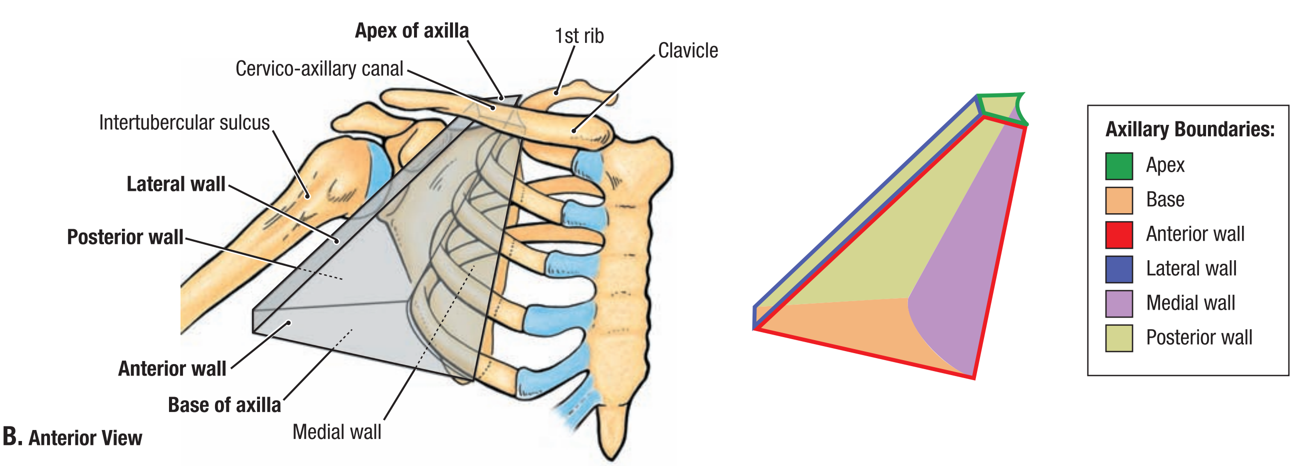


6.21 VEINS OF AXILLA

- The basilic vein joins the brachial veins to become the axillary vein near the inferior border of teres major, the axillary vein becomes the subclavian vein at the lateral border of the 1st rib, and the subclavian joins the internal jugular to become the brachiocephalic vein posterior to the sternal end of the clavicle.
- Numerous valves, enlargements in the vein, are shown.
- The cephalic vein in this specimen bifurcates to end in the axillary and external jugular veins.



A. Inferior View

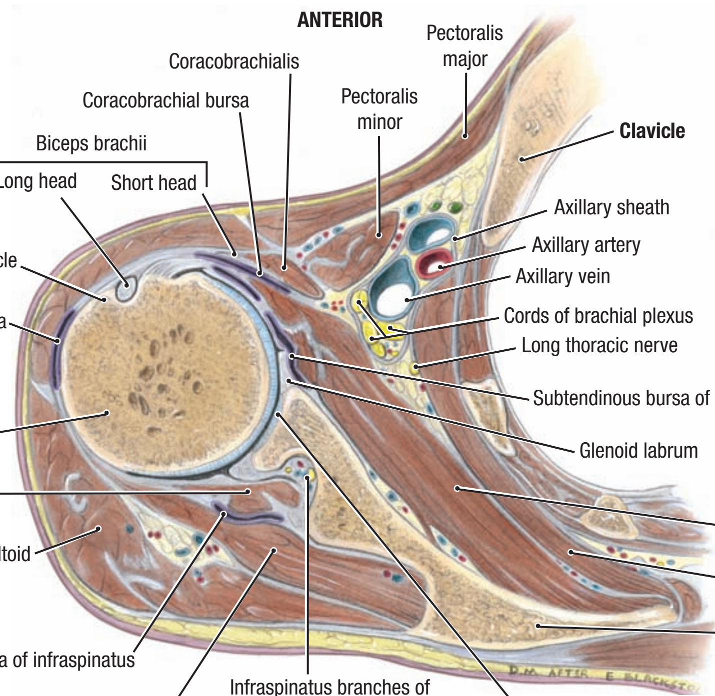


B. Anterior View

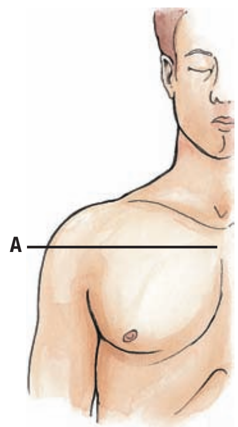
6.22 WALLS AND CONTENTS OF THE AXILLA

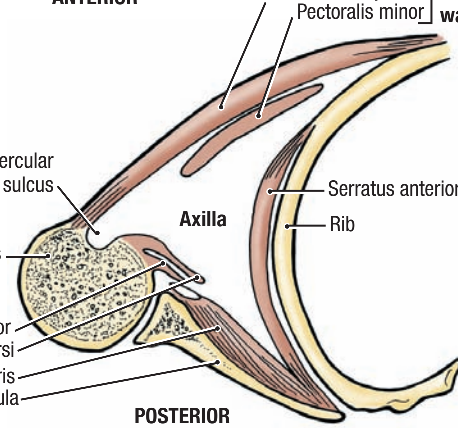
A. Dissection. **B.** Location and walls of axilla, schematic diagram.

- The walls of the axilla are anterior (formed by the pectoralis major, pectoralis minor, and subclavius muscles), posterior (formed by subscapularis, latissimus dorsi, and teres major muscles), medial (formed by the serratus anterior muscle), and lateral (formed by the intertubercular sulcus [bicipital groove] of the humerus [concealed by the biceps and coracobrachialis muscles]).
- The axillary sheath surrounds the nerves and vessels (neurovascular bundle) of the upper limb.

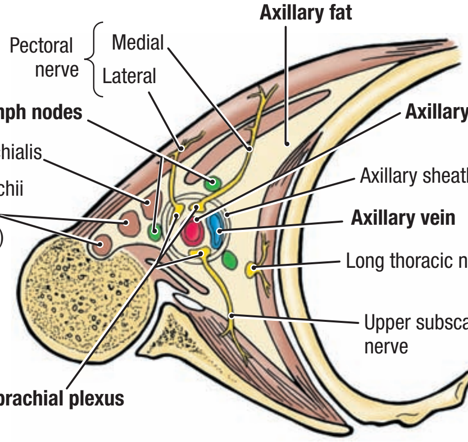


A. Transverse Section, Inferior View





B. Transverse Section, Inferior View

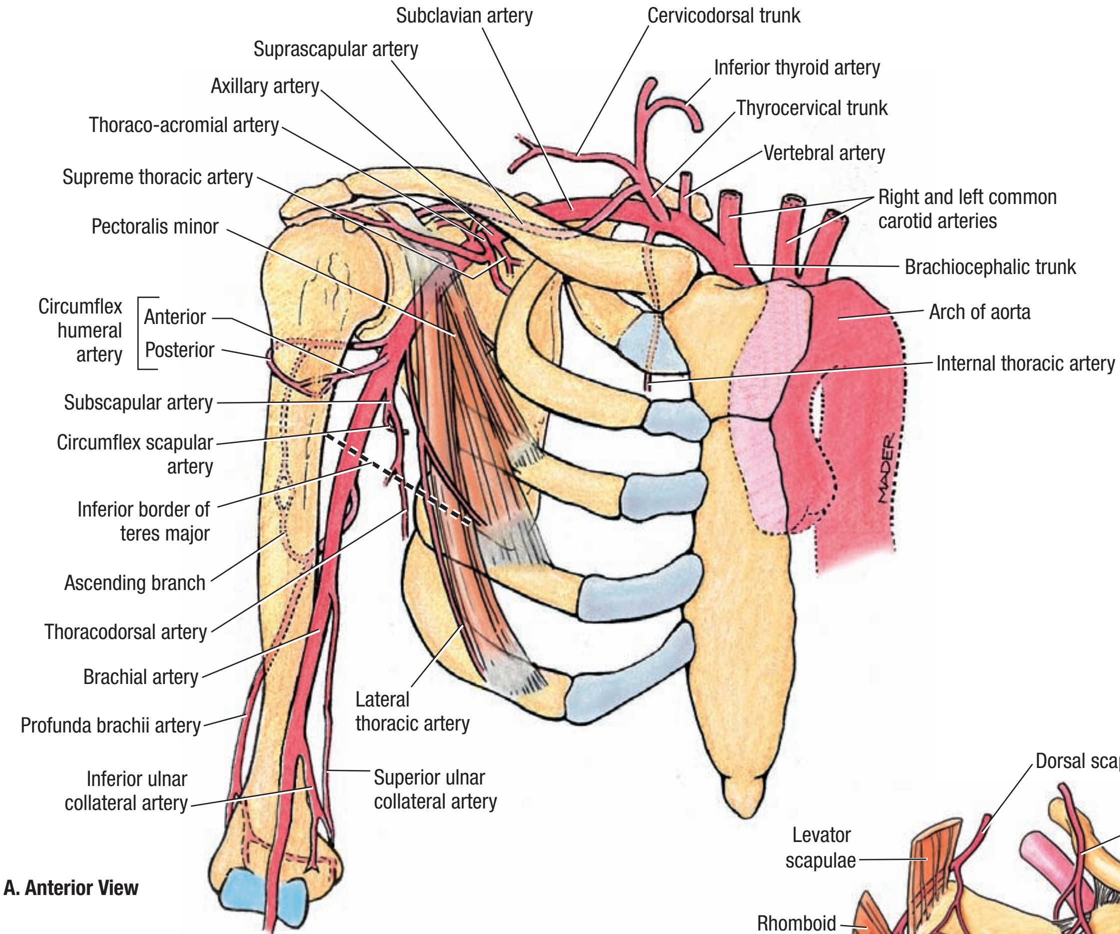


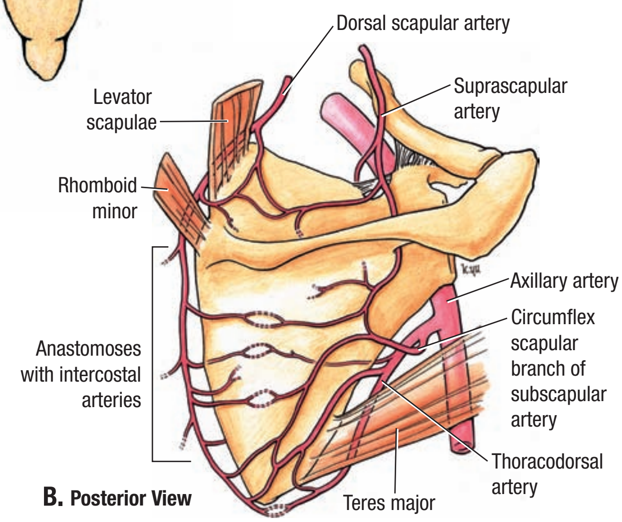
C. Transverse Section, Inferior View

6.23 TRANSVERSE SECTIONS THROUGH SHOULDER JOINT AND AXILLA

A. Anatomical section. **B.** Walls of axilla, schematic illustration. **C.** Walls and contents of axilla, schematic illustration.

- The intertubercular sulcus (bicipital groove) containing the tendon of the long head of the biceps brachii muscle is directed anteriorly; the short head of the biceps muscle and the coracobrachialis and pectoralis minor muscles are sectioned just inferior to their attachments to the coracoid process.
- The small glenoid cavity is deepened by the glenoid labrum.
- Bursae include the subdeltoid (subacromial) bursa, between the deltoid and greater tubercle; the subtendinous bursa of subscapularis, between the subscapularis tendon and scapula; and coracobrachial bursa, between the coracobrachialis and subscapularis.
- The axillary sheath encloses the axillary artery and vein and the three cords of the brachial plexus to form a neurovascular bundle, surrounded by axillary fat.





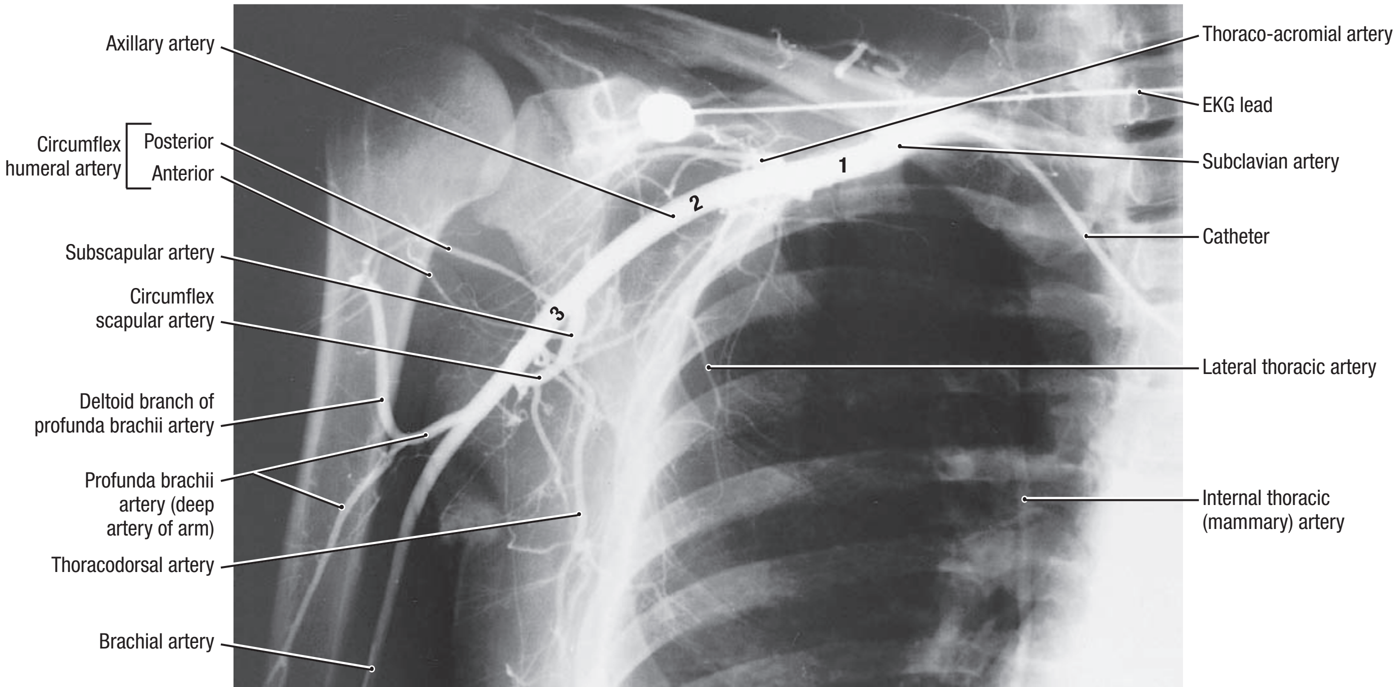
6.24 ARTERIES OF PROXIMAL UPPER LIMB

A. and B. Schematic illustrations. **C.** Axillary arteriogram.

TABLE 6.5 ARTERIES OF PROXIMAL UPPER LIMB (SHOULDER REGION AND ARM)

Artery	Origin	Course
Internal thoracic	Subclavian artery	Descends, inclining anteromedially, posterior to sternal end of clavicle and first costal cartilage; enters thorax to descend in parasternal plane; gives rise to perforating branches, anterior intercostal, musculophrenic, and superior epigastric arteries
Thyrocervical trunk		Ascends as a short, wide trunk, often giving rise to the suprascapular artery and/or cervicodorsal trunk and terminating by bifurcating into the ascending cervical and inferior thyroid arteries
Suprascapular	Cervicodorsal trunk from thyrocervical trunk (or as direct branch of subclavian artery[a])	Passes inferolaterally over anterior scalene muscle and phrenic nerve, subclavian artery and brachial plexus running laterally posterior and parallel to clavicle; next passes over transverse scapular ligament to supraspinous fossa, then lateral to scapular spine (deep to acromion) to infraspinous fossa

[a]See Weiglein AH, Moriggl B, Schalk C, et al. Arteries in the posterior cervical triangle. *Clinical Anatomy* 2005;18:533–537.

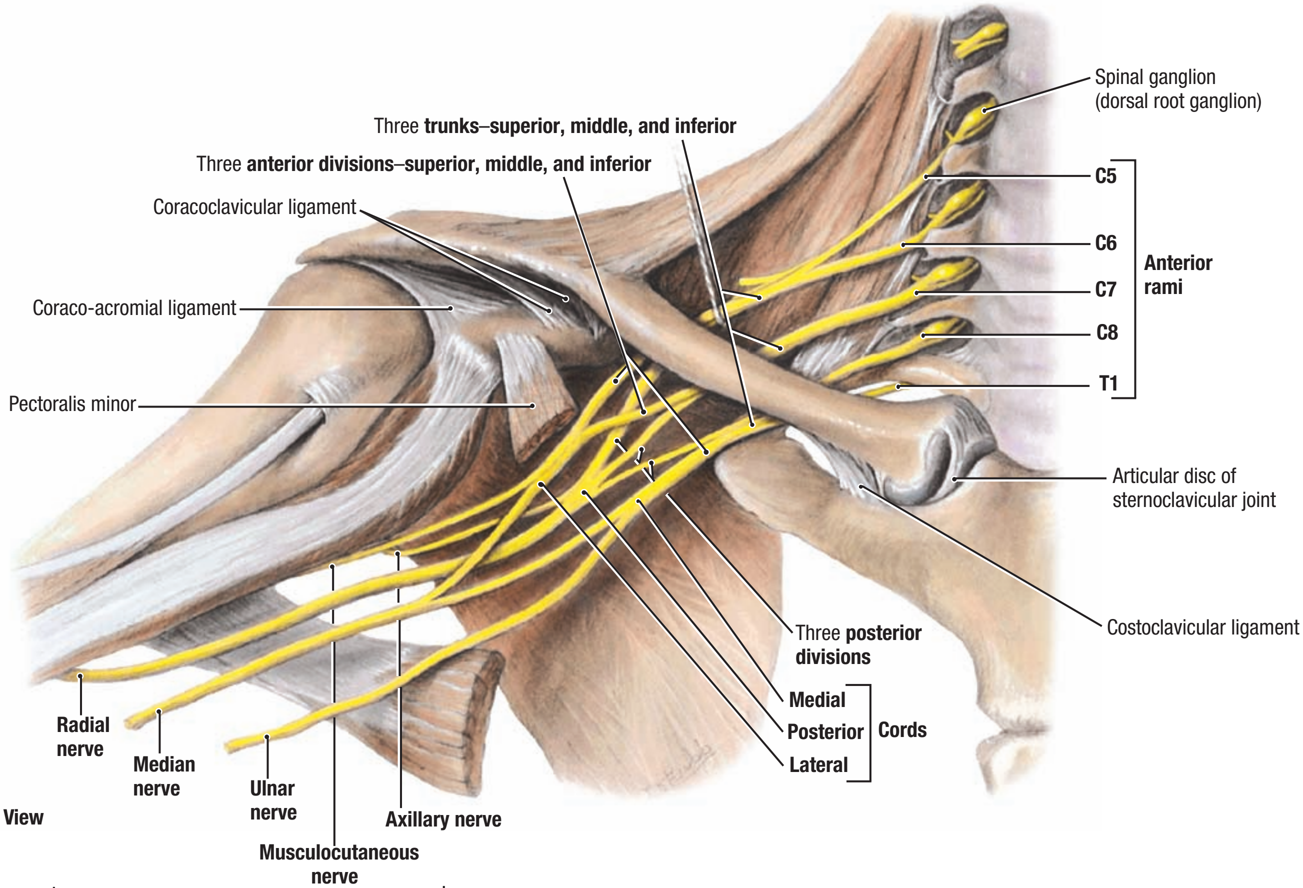


C. Anteroposterior View

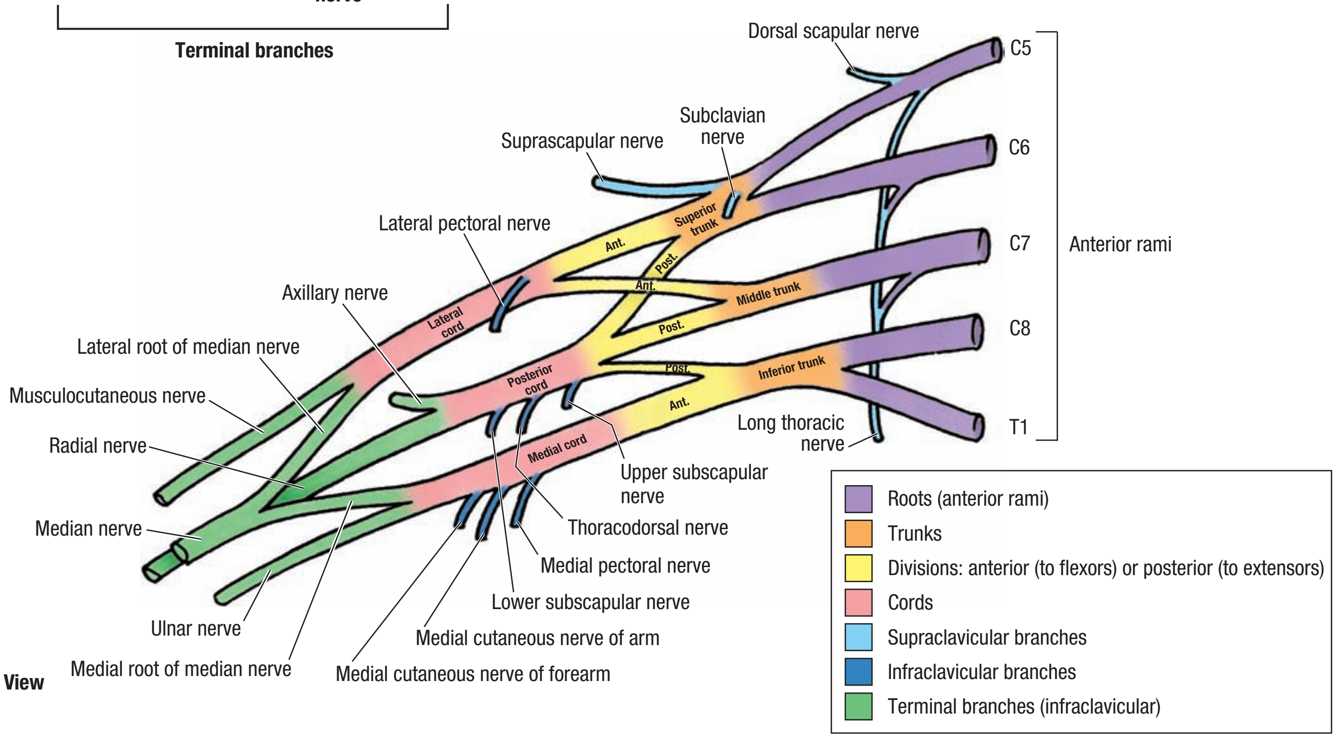
1: First part of the axillary artery is located between the lateral border of the 1st rib and the medial border of pectoralis minor.
2: Second part of the axillary artery lies posterior to pectoralis minor.
3: Third part of the axillary artery extends from the lateral border of pectoralis minor to the inferior border of teres major, where it becomes the brachial artery.

TABLE 6.5 ARTERIES OF PROXIMAL UPPER LIMB (SHOULDER REGION AND ARM) (CONTINUED)

Artery	Origin		Course
Supreme thoracic	1st part (as only branch)		Runs anteromedially along superior border of pectoralis minor; then passes between it and pectoralis major to thoracic wall; helps supply 1st and 2nd intercostal spaces and superior part of serratus anterior
Thoraco-acromial	2nd part (medial branch)	Axillary artery	Curls around superomedial border of pectoralis minor, pierces costocoracoid membrane (clavipectoral fascia), and divides into four branches: pectoral, deltoid, acromial, and clavicular
Lateral thoracic	2nd part (lateral branch)		Descends along axillary border of pectoralis minor; follows it onto thoracic wall, supplying lateral aspect of breast
Circumflex humeral (anterior and posterior)	3rd part (sometimes via a common trunk)		Encircle surgical neck of humerus, anastomosing with each other laterally; larger posterior branch traverses quadrangular space
Subscapular	3rd part (largest branch)		Descends from level of inferior border of subscapularis along lateral border of scapula, dividing within 2–3 cm into terminal branches, the circumflex scapular and thoracodorsal arteries
Circumflex scapular	Subscapular artery		Curves around lateral border of scapula to enter infraspinous fossa, anastomosing with subscapular artery
Thoracodorsal	Near its origin		Continuation of subscapular artery; accompanies thoracodorsal nerve to enter latissimus dorsi
Profunda brachii (deep brachial) artery	Near middle of arm	Brachial artery	Accompanies radial nerve through radial groove of humerus, supplying posterior compartment of arm and participating in peri-articular arterial anastomosis around elbow joint
Superior ulnar collateral	Inferior to teres major		Accompanies ulnar nerve to posterior aspect of elsbow; anastomoses with posterior ulnar recurrent artery
Inferior ulnar collateral	Superior to medial epicondyle of humerus		Passes anterior to medial epicondyle of humerus to anastomose with anterior ulnar collateral artery around elbow joint



A. Anterior View



B. Anterior View

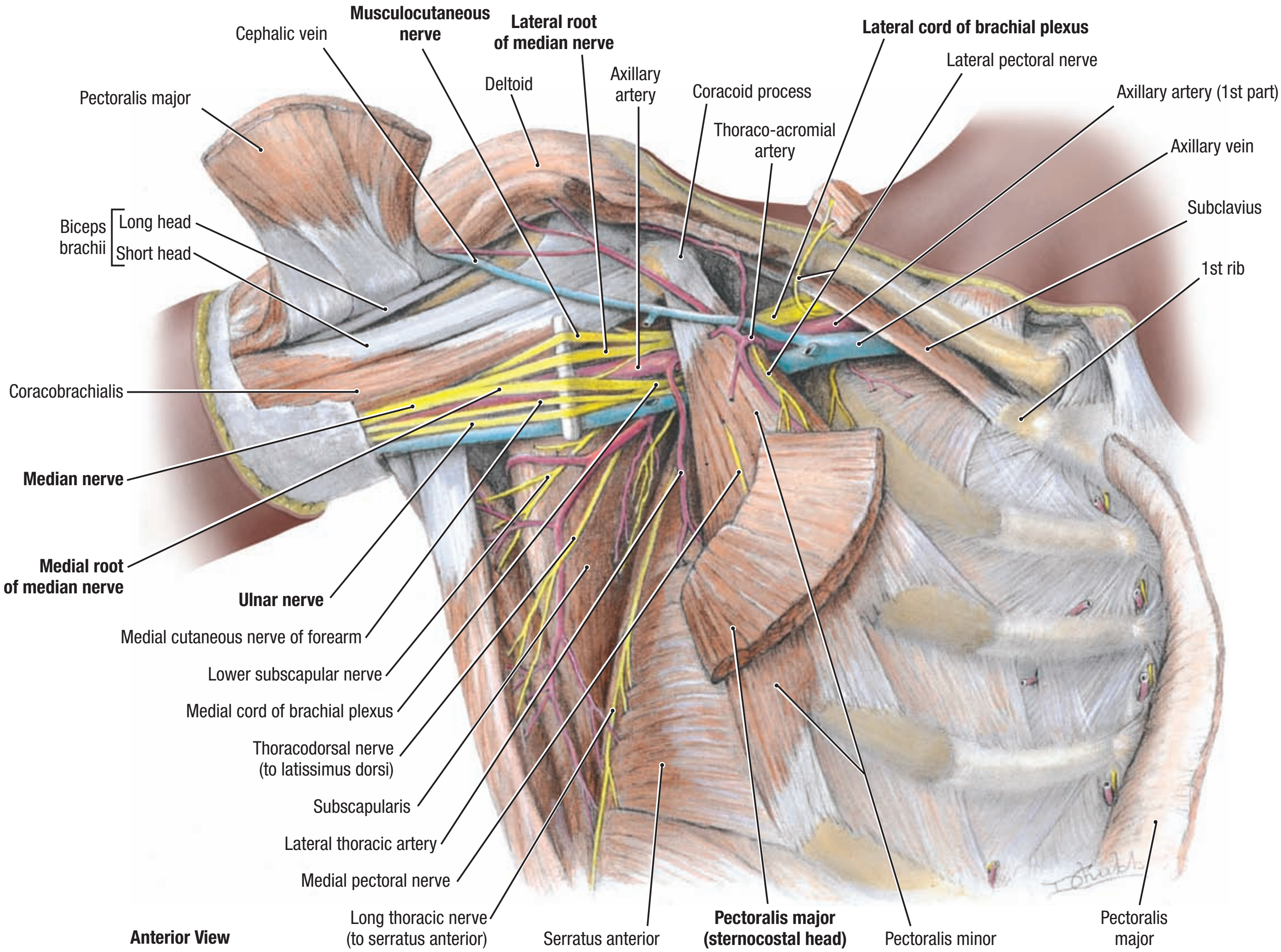
6.25 BRACHIAL PLEXUS

A. Dissection. **B.** Schematic illustration.

TABLE 6.6 *BRACHIAL PLEXUS*

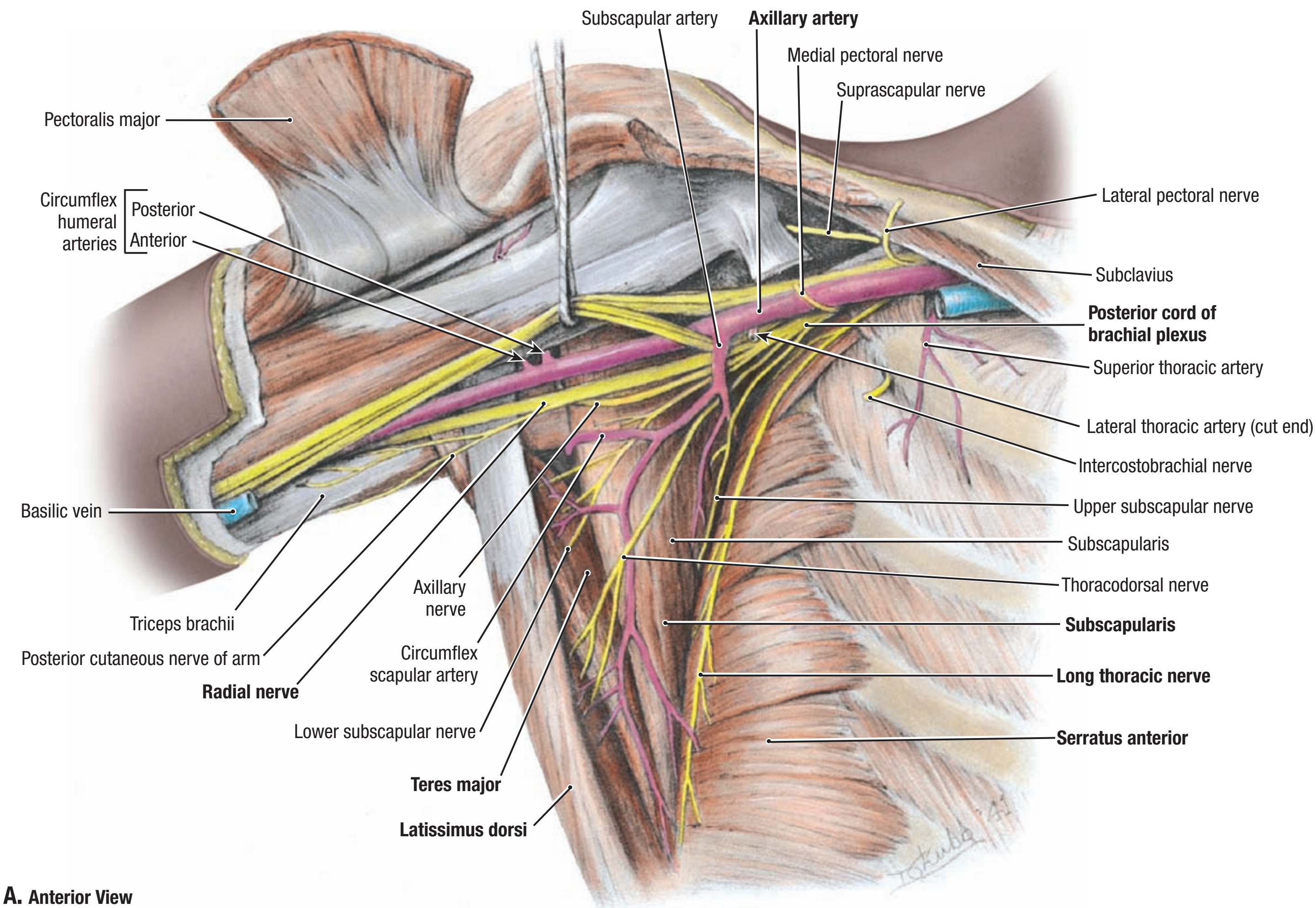
Nerve	Origin	Course	Distribution/Structure(s) Supplied
Supraclavicular Branches			
Dorsal scapular	Anterior ramus of C5 with a frequent contribution from C4	Pierces scalenus medius, descends on deep surface of rhomboids	Rhomboids and occasionally supplies levator scapulae
Long thoracic	Anterior rami of C5–C7	Descends posterior to C8 and T1 rami and passes distally on external surface of serratus anterior	Serratus anterior
Subclavian	Superior trunk receiving fibers from C5 and C6 and often C4	Descends posterior to clavicle and anterior to brachial plexus and subclavian artery	Subclavius and sternoclavicular joint
Suprascapular	Superior trunk receiving fibers from C5 and C6 and often C4	Passes laterally across posterior triangle of neck, through suprascapular notch deep to superior transverse scapular ligament	Supraspinatus, infraspinatus, and glenohumeral (shoulder) joint
Infraclavicular branches			
Lateral pectoral	Lateral cord receiving fibers from C5–C7	Pierces clavipectoral fascia to reach deep surface of pectoral muscles	Primarily pectoralis major but sends a loop to medial pectoral nerve that innervates pectoralis minor
Musculocutaneous	Lateral cord receiving fibers from C5–C7	Pierces coracobrachialis and descends between biceps brachii and brachialis	Coracobrachialis, biceps brachii, and brachialis; continues as lateral cutaneous nerve of forearm
Median	Lateral root of median nerve is a terminal branch of lateral cord (C6, C7); medial root of median nerve is a terminal branch of medial cord (C8, T1)	Lateral and medial roots merge to form median nerve lateral to axillary artery; crosses anterior to brachial artery to lie medial to artery in cubital fossa	Flexor muscles in forearm (except flexor carpi ulnaris, ulnar half of flexor digitorum profundus), 3½ thenar and lateral 2 lumbrical muscles in hand, and skin of palm and 3½ digits lateral to a line bisecting 4th digit and the dorsum of the distal halves of these digits
Medial pectoral	Medial cord receiving fibers from C8, T1	Passes between axillary artery and vein and enters deep surface of pectoralis minor	Pectoralis minor and part of pectoralis major
Medial cutaneous nerve of arm	Medial cord receiving fibers from C8, T1	Runs along the medial side of axillary vein and communicates with intercostobrachial nerve	Skin on medial side of arm
Medial cutaneous nerve of forearm	Medial cord receiving fibers from C8, T1	Runs between axillary artery and vein	Skin over medial side of forearm
Ulnar	Terminal branch of medial cord receiving fibers from C8, T1 and often C7	Passes down medial aspect of arm and runs posterior to medial epicondyle to enter forearm	Innervates 1½ flexor muscles in forearm (see Median nerve), 1½ thenar, 2 medial lumbricals, and all interossei muscles in hand, and skin of hand medial to a line bisecting 4th digit (ring finger) anteriorly and posteriorly
Upper subscapular	Branch of posterior cord receiving fibers from C5	Passes posteriorly and enters subscapularis	Superior portion of subscapularis
Thoracodorsal	Branch of posterior cord receiving fibers from C6 to C8	Arises between upper and lower subscapular nerves and runs inferolaterally to latissimus dorsi	Latissimus dorsi
Lower subscapular	Branch of posterior cord receiving fibers from C6	Passes inferolaterally, deep to subscapular artery and vein, to subscapularis and teres major	Inferior portion of subscapularis and teres major
Axillary	Terminal branch of posterior cord receiving fibers from C5 and C6	Passes to posterior aspect of arm through quadrangular space[a] with posterior circumflex humeral artery and then winds around surgical neck of humerus; gives rise to lateral cutaneous nerve of arm	Teres minor and deltoid, glenohumeral (shoulder) joint, and skin of superolateral arm
Radial	Terminal branch of posterior cord receiving fibers from C5 to T1	Descends posterior to axillary artery; enters radial groove to pass between long and medial heads of triceps brachii	Triceps brachii, anconeus, brachioradialis, and extensor muscles of forearm; supplies skin on posterior aspect of arm and forearm and dorsum of hand lateral to axial line of digit 4

[a]Quadrangular space is bounded superiorly by subscapularis and teres minor, inferiorly by teres major, medially by long head of triceps brachii, and laterally by humerus.

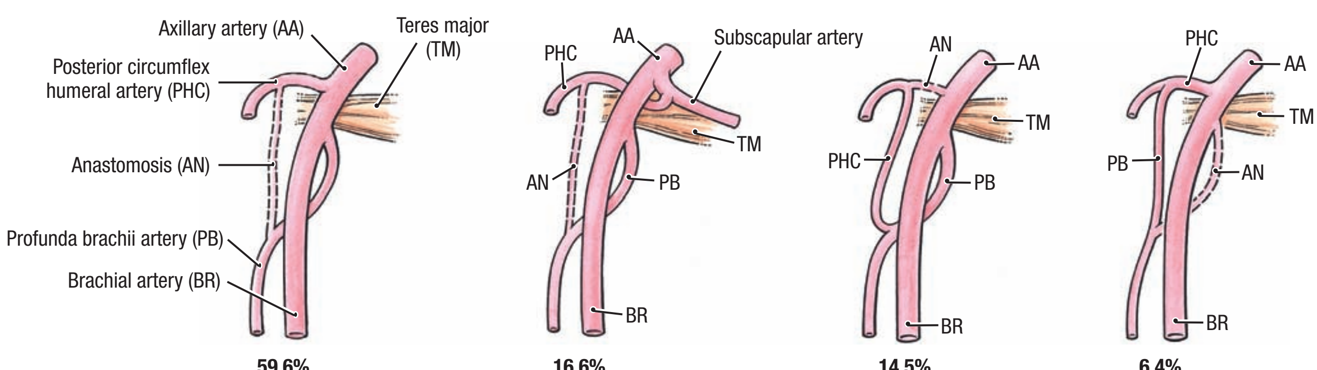


6.26 STRUCTURES OF AXILLA: DEEP DISSECTION I

- The pectoralis major muscle is reflected, and the clavipectoral fascia is removed; the cube of muscle superior to the clavicle is cut from the clavicular head of the pectoralis major muscle.
- The subclavius and pectoralis minor are the two deep muscles of the anterior wall.
- The 2nd part axillary artery passes posterior to the pectoralis minor muscle, a fingerbreadth from the tip of the coracoid process; the axillary vein lies anterior and then medial to the axillary artery.
- The median nerve, followed proximally, leads by its lateral root to the lateral cord and musculocutaneous nerve and by its medial root to the medial cord and ulnar nerve. These four nerves and the medial cutaneous nerve of the forearm are derived from the anterior divisions of the brachial plexus and are raised on a stick. The lateral root of the median nerve may occur as several strands.
- The musculocutaneous nerve enters the flexor compartment of the arm by piercing the coracobrachialis muscle.



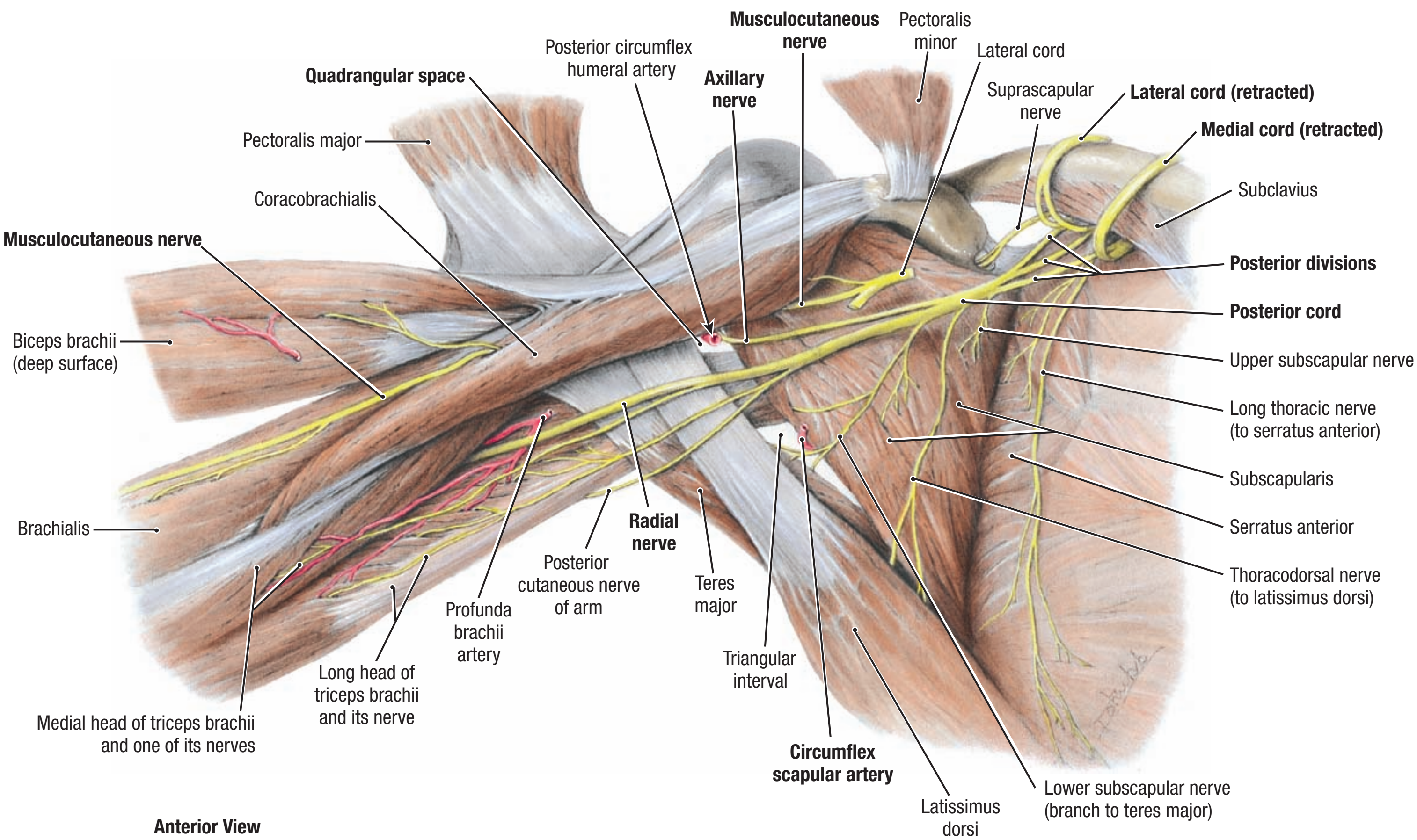
A. **Anterior View**



B. **Anterior Views**

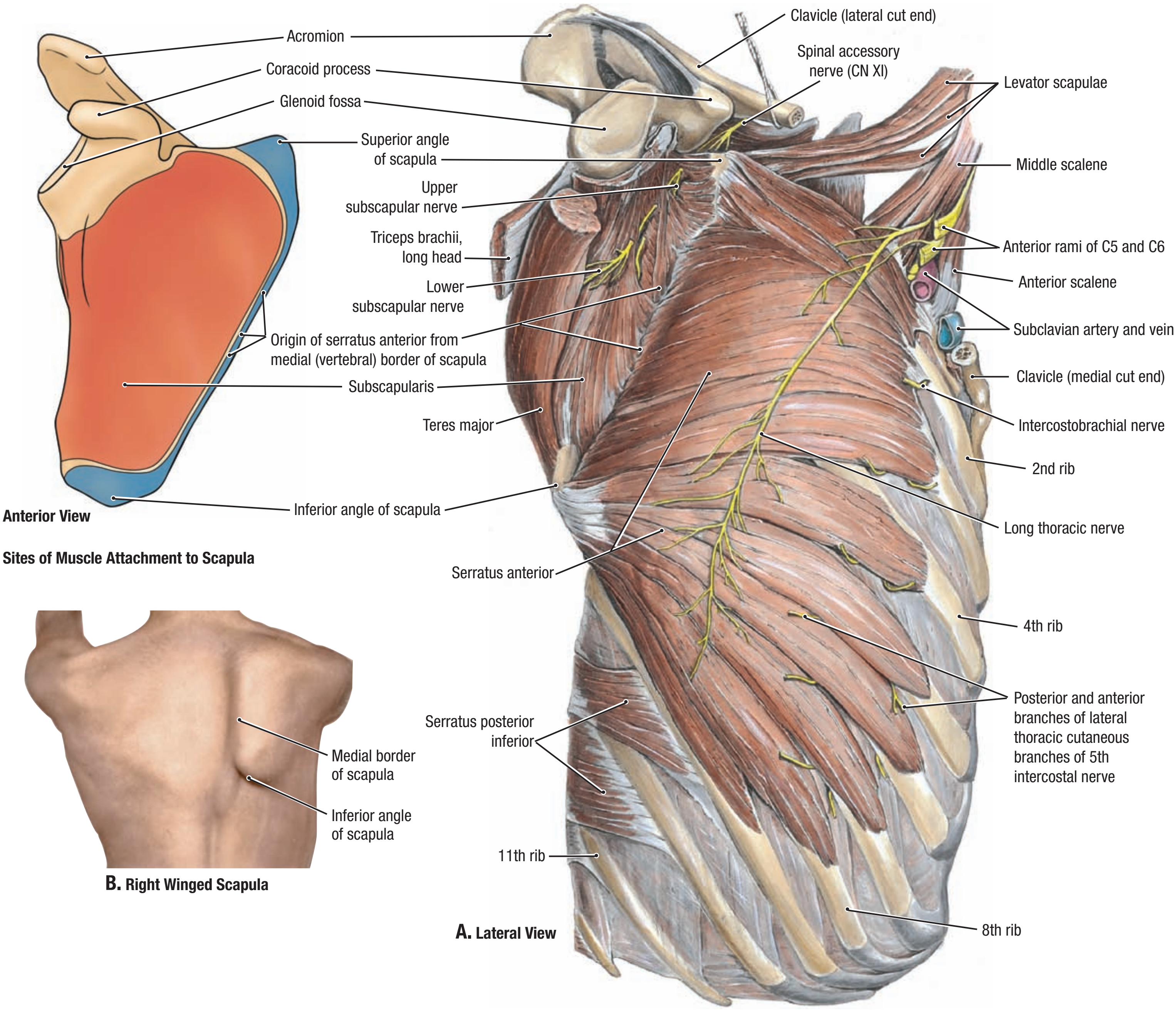
6.27 POSTERIOR AND MEDIAL WALLS OF AXILLA: DEEP DISSECTION II

A. Dissection. The pectoralis minor muscle is excised, the lateral and medial cords of the brachial plexus are retracted, and the axillary vein is removed. **B.** Variations of the posterior circumflex humeral artery and profunda brachii artery. Percentages are based on 235 specimens dissected in Dr. Grant's laboratory.



6.28 POSTERIOR WALL OF AXILLA, MUSCULOCUTANEOUS NERVE, AND POSTERIOR CORD: DEEP DISSECTION III

- The pectoralis major and minor muscles are reflected laterally, the lateral and medial cords of the brachial plexus are reflected superiorly, and the arteries, veins, and median and ulnar nerves are removed.
- Coracobrachialis arises with the short head of the biceps brachii muscle from the tip of the coracoid process and attaches halfway down the medial aspect of the humerus.
- The musculocutaneous nerve pierces the coracobrachialis muscle and supplies it, the biceps, and the brachialis before becoming the lateral cutaneous nerve of the forearm.
- The posterior cord of the plexus is formed by the union of the three posterior divisions; it supplies the three muscles of the posterior wall of the axilla and then bifurcates into the radial and axillary nerves.
- In the axilla, the radial nerve gives off the nerve to the long head of the triceps brachii muscle and a cutaneous branch; in this specimen, it also gives off a branch to the medial head of the triceps. It then enters the radial groove of the humerus with the profunda brachii (deep brachial) artery.
- The axillary nerve passes through the quadrangular space along with the posterior circumflex humeral artery. The borders of the quadrangular space are superiorly, the lateral border of the scapula; inferiorly, the teres major; laterally, the humerus (surgical neck); and medially, the long head of triceps brachii. The circumflex scapular artery traverses the triangular interval.



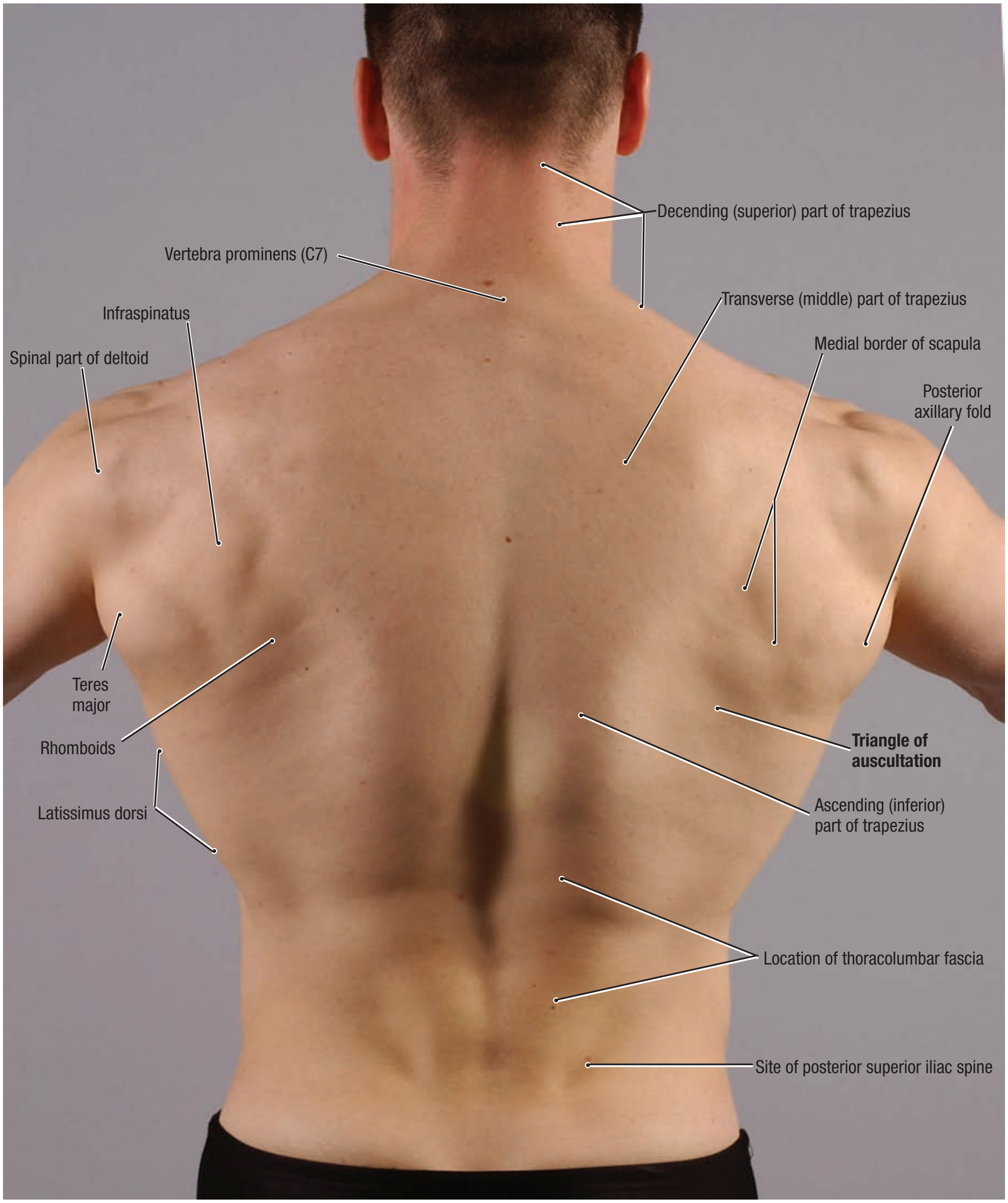
6.29 SERRATUS ANTERIOR AND SUBSCAPULARIS

A. The serratus anterior muscle, which forms the medial wall of the axilla, has a fleshy belly extending from the superior 8 or 9 ribs in the midclavicular line *(right)* to the medial border of the scapula *(left).*

- The fibers of the serratus anterior muscle from the 1st rib and the tendinous arch between the 1st and 2nd ribs (see Table 6.4) converge on the superior angle of the scapula; those from the 2nd and 3rd ribs diverge to spread thinly along the medial border; and the remainder (from the 4th to 9th ribs), which form the bulk of the muscle, converge on the inferior angle via a tendinous insertion.
- The long thoracic nerve to serratus anterior arises from spinal nerves C5, C6, and C7 and courses externally along most of the muscle's length.

Winged scapula (**B**). When the serratus anterior is paralyzed because of injury to the long thoracic nerve, the medial border of the scapula moves laterally and posteriorly, away from the thoracic wall. When the arm is abducted, the medial border and the inferior angle of the scapula pull away from the posterior thoracic wall, a deformation known as a winged scapula. In addition, the arm cannot be abducted above the horizontal position because the serratus anterior is unable to rotate the glenoid cavity superiorly.

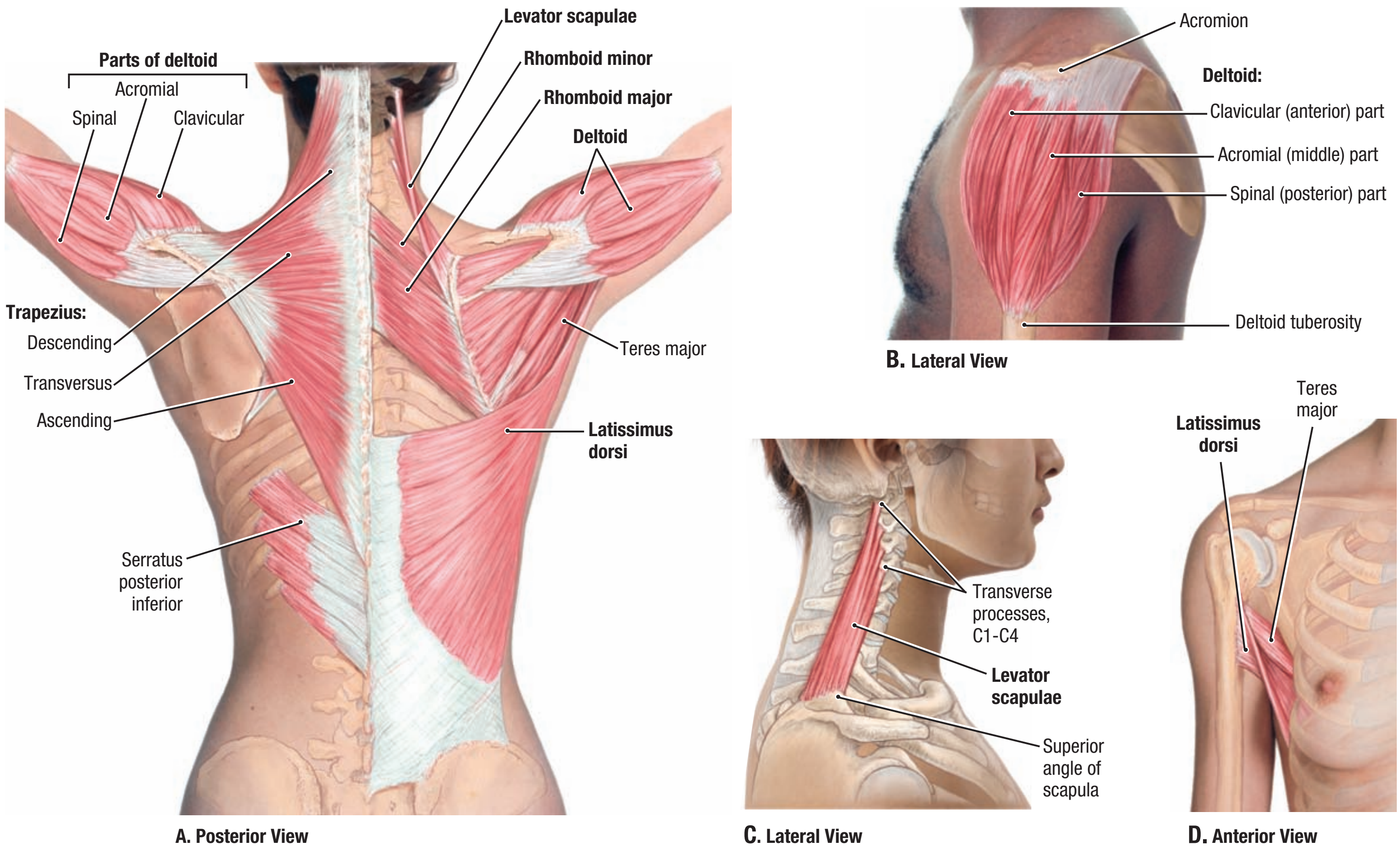
- The trunks of the brachial plexus and the subclavian artery emerge between the anterior and middle scalene muscles; the subclavian vein is separated from the artery by the anterior scalene muscle.



Posterior View

6.30 SURFACE ANATOMY OF SUPERFICIAL BACK

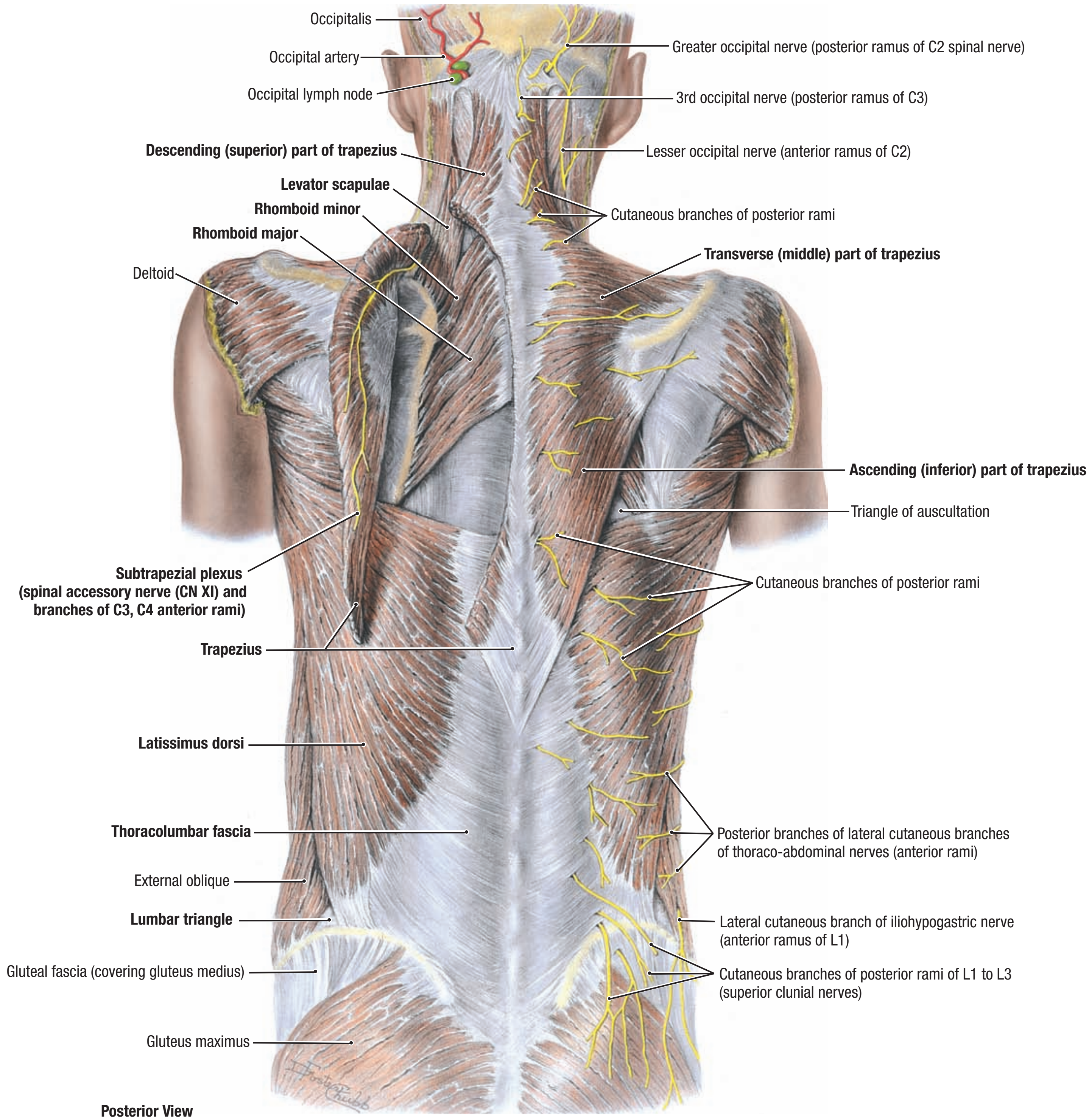
The superior border of the latissimus dorsi and a part of the rhomboid major are overlapped by the trapezius. The area formed by the superior border of latissimus dorsi, the medial border of the scapula, and the inferolateral border of the trapezius is called the **triangle of auscultation**. This gap in the thick back musculature is a good place to examine posterior segments of the lungs with a stethoscope. When the scapulae are drawn anteriorly by folding the arms across the thorax and the trunk is flexed, the auscultatory triangle enlarges. The teres major forms a raised oval area on the inferolateral third of the posterior aspect of the scapula when the arm is adducted against resistance. The posterior axillary fold is formed by the teres major and the tendon of the latissimus dorsi.



6.31 SUPERFICIAL BACK AND DELTOID MUSCLES

TABLE 6.7 SUPERFICIAL BACK (POSTERIOR AXIO-APPENDICULAR) AND DELTOID MUSCLES

Muscle	Proximal Attachment	Distal Attachment	Innervation	Main Actions
Trapezius	Medial third of superior nuchal line; external occipital protuberance, nuchal ligament, and spinous processes of C7–T12 vertebrae	Lateral third of clavicle, acromion, and spine of scapula	Spinal accessory nerve (CN XI—motor) and cervical nerves (C3–C4—sensory)	Elevates, retracts, and rotates scapula; *descending part* elevates, *transverse part* retracts, and *ascending part* depresses scapula; descending and ascending part act together in superior rotation of scapula
Latissimus dorsi	Spinous processes of inferior six thoracic vertebrae, thoracolumbar fascia, iliac crest, and inferior three or four ribs	Intertubercular sulcus (bicipital groove) of humerus	Thoracodorsal nerve (**C6**, **C7**, C8)	Extends, adducts, and medially rotates shoulder joint; elevates body toward arms during climbing
Levator scapulae	Posterior tubercles of transverse processes of C1–C4 vertebrae	Superior part of medial border of scapula	Dorsal scapular (C5) and cervical (C3–C4) nerves	Elevates scapula and tilts its glenoid cavity inferiorly by rotating scapula
Rhomboid minor and major	*Minor:* Inferior part of nuchal ligament and spinous processes of C7 and T1 vertebrae *Major:* spinous processes of T2–T5 vertebrae	Medial border of scapula from level of spine to inferior angle	Dorsal scapular nerve (C4–**C5**)	Retract scapula and rotate it to depress glenoid cavity; fix scapula to thoracic wall
Deltoid	Lateral third of clavicle *(clavicular part)*, acromion *(acromial part)*, and spine *(spinal part)* of scapula	Deltoid tuberosity of humerus	Axillary nerve (**C5**–C6)	*Clavicular (anterior) part:* flexes and medially rotates shoulder joint; *acromial (middle) part:* abducts shoulder joint; *spinal (posterior) part:* extends and laterally rotates shoulder joint

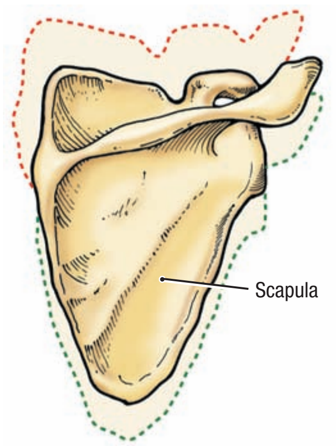


6.32 CUTANEOUS NERVES OF SUPERFICIAL BACK AND POSTERIOR AXIO-APPENDICULAR MUSCLES

The trapezius muscle is cut and reflected on the left side. A superficial or first muscle layer consists of the trapezius and latissimus dorsi muscles, and a second layer of the levator scapulae and rhomboids. Cutaneous branches of posterior rami penetrate but do not supply the superficial muscles.

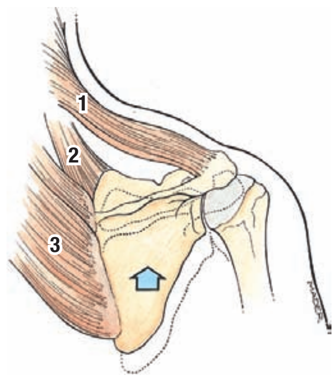
TABLE 6.8 MOVEMENTS OF SCAPULA

Boldface indicates prime movers. In the *middle* and *right columns* the *dotted outlines* represent the starting position for each movement.



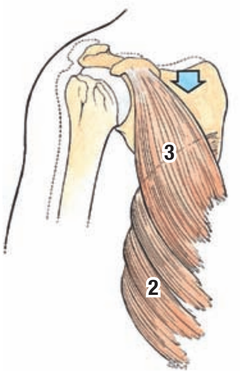
Posterior View

Elevation (red)
Depression (green)

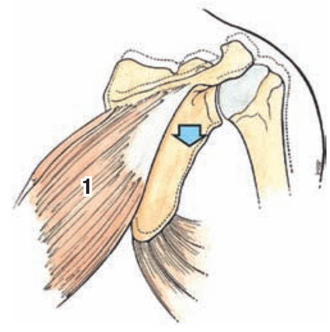


Posterior View

Elevation:
- **Trapezius, descending part** (1)
- Levator scapulae (2)
- Rhomboids (3)



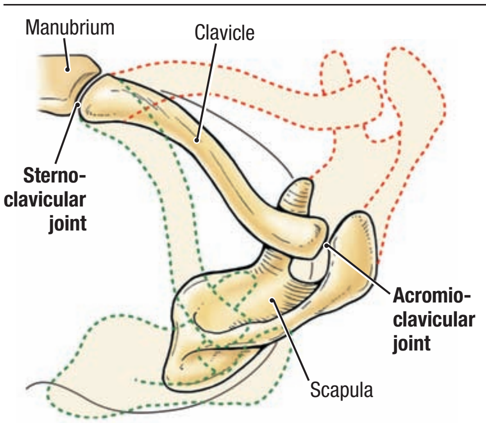
Anterior View



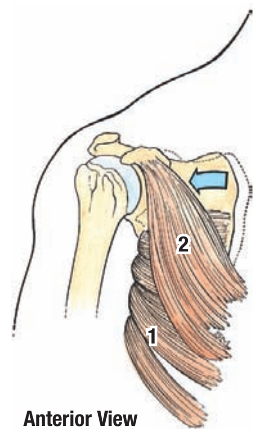
Posterior View

Depression:
- Trapezius, ascending part (1)
- Serratus anterior, inferior part (2)
- Pectoralis minor (3)

Also: Gravity, Latissimus dorsi, Inferior part of sternocostal head of pectoralis major



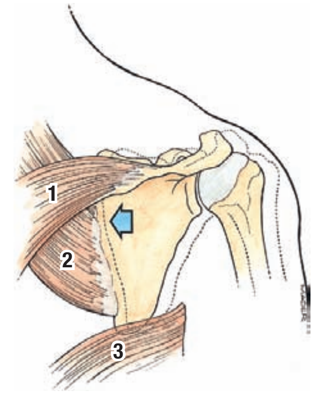
Protraction (red)
Retraction (green)



Anterior View

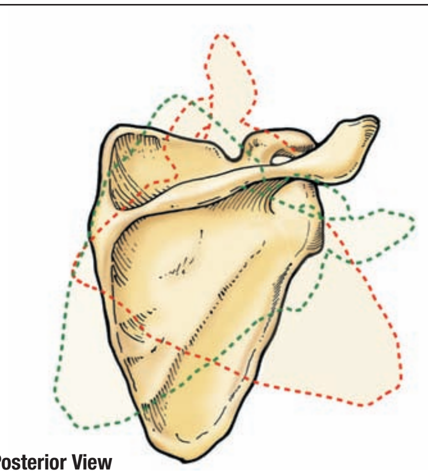
Protraction:
- **Serratus anterior** (1)
- Pectoralis minor (2)

Also: Pectoralis major



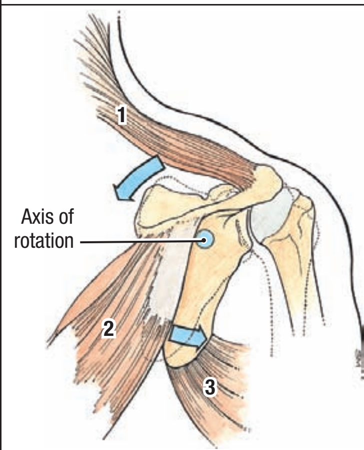
Posterior View

Retraction:
- **Trapezius, transverse part** (1)
- Rhomboids (2)
- Latissimus dorsi (3)



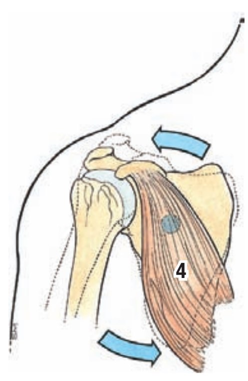
Posterior View

Upward rotation (red)
Downward rotation (green)

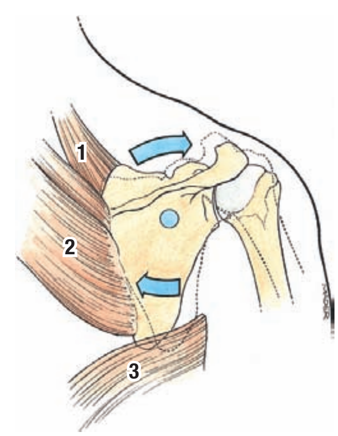


Posterior View

Upward rotation
- **Trapezius, descending part** (1)
- Trapezius, ascending part (2)
- **Serratus anterior, inferior part (3)**



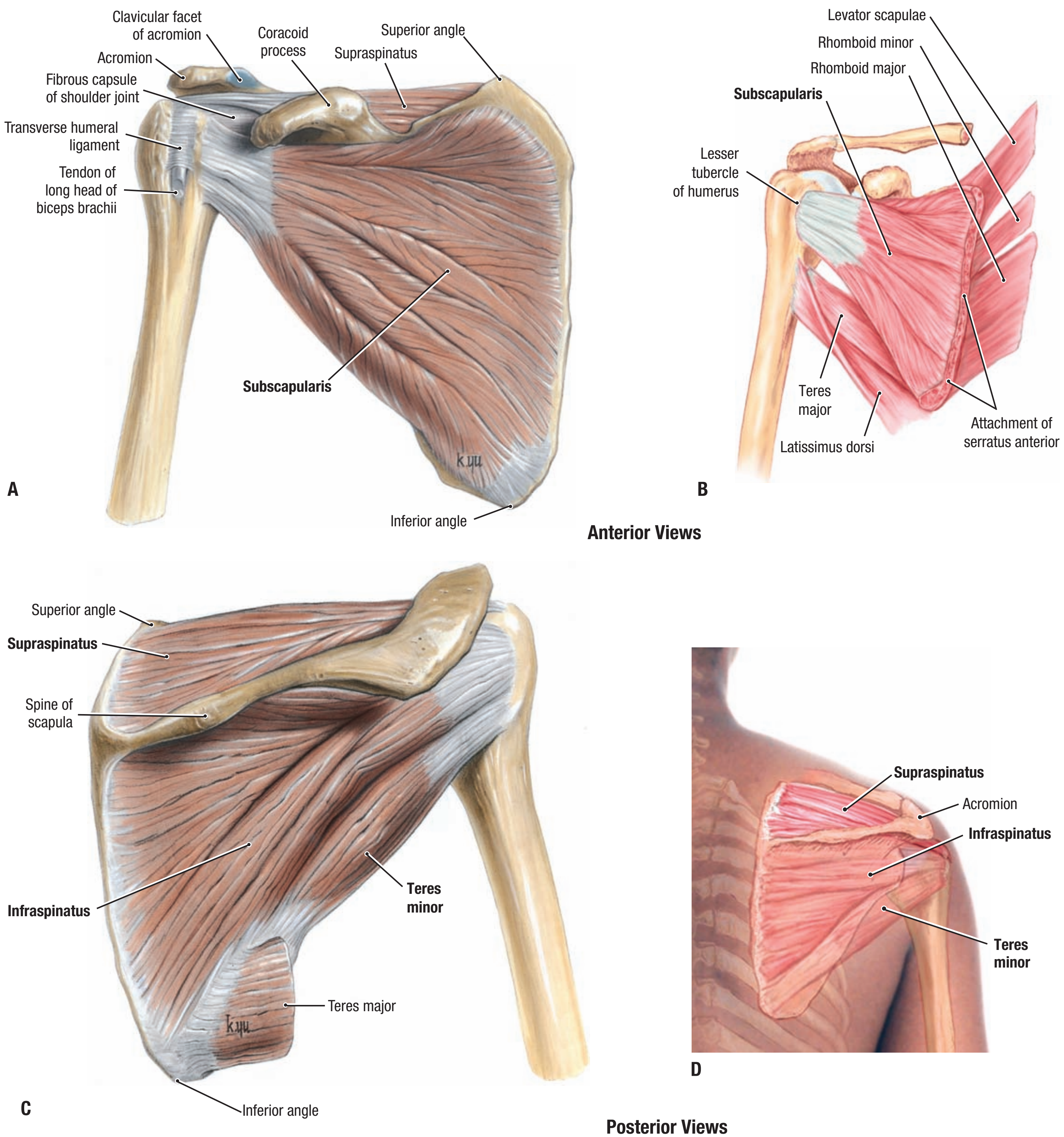
Anterior View



Posterior View

Downward rotation
- Levator scapulae (1)
- Rhomboids (2)
- **Latissimus dorsi (3)**
- Pectoralis minor (4)

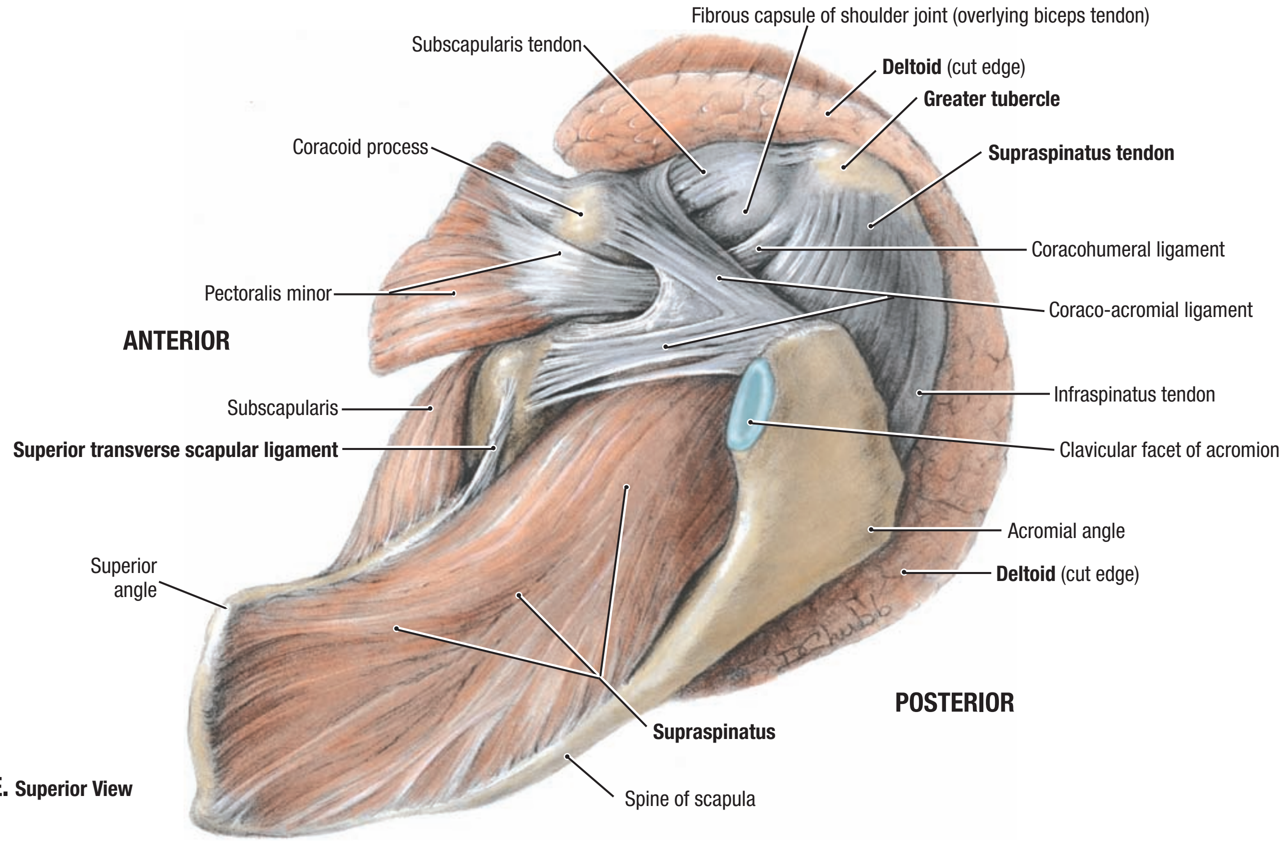
Also: Gravity, Inferior part of sternocostal head of pectoralis major



6.33 ROTATOR CUFF

A. and B. Subscapularis. **C. and D.** Supraspinatus, infraspinatus, and teres minor.

Four of the scapulohumeral muscles—supraspinatus, infraspinatus, teres minor, and subscapularis—are called rotator cuff muscles because they form a musculotendinous rotator cuff around the glenohumeral joint. All except the supraspinatus are rotators of the humerus.



E. **Superior View**

6.33 ROTATOR CUFF *(CONTINUED)*

E. Supraspinatus.

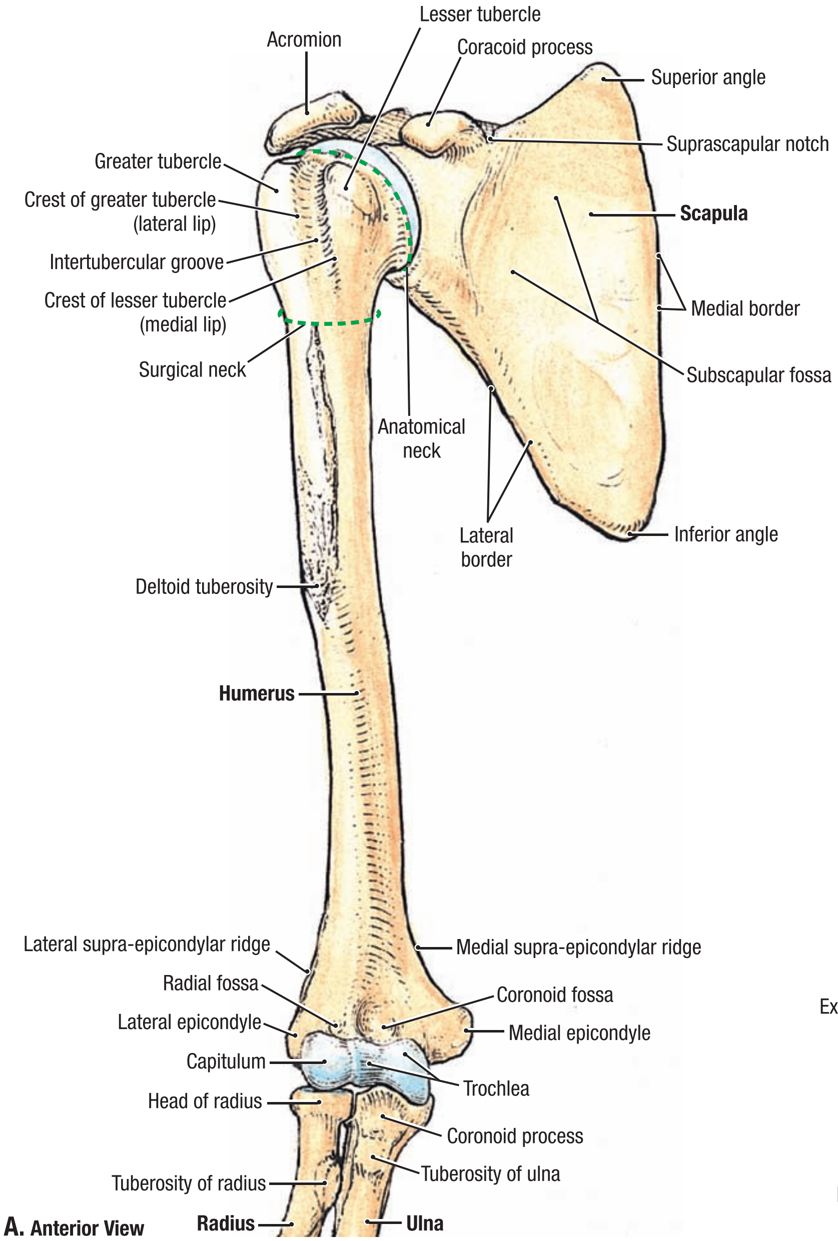
The supraspinatus, also part of the rotator cuff, initiates and assists the deltoid in abducting the shoulder joint. The tendons of the rotator cuff muscles blend with and reinforce the joint capsule of the glenohumeral joint, protecting the joint and giving it stability.

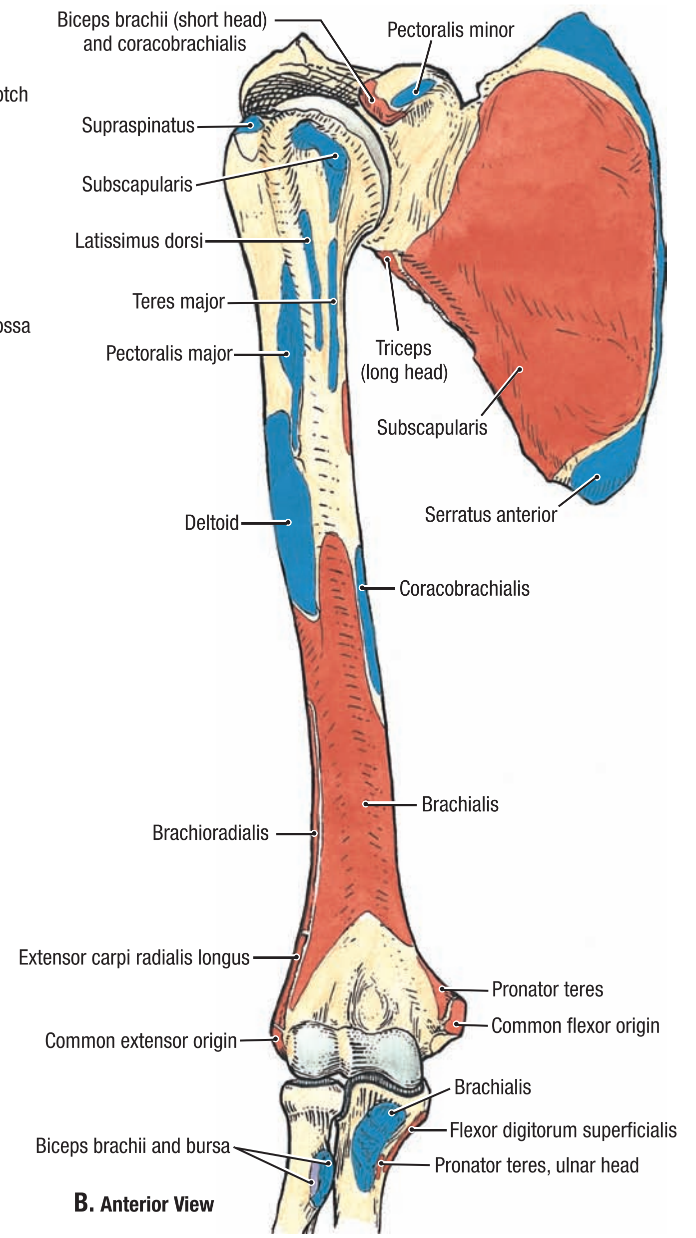
Injury or disease may damage the rotator cuff, producing instability of the glenohumeral joint. **Rupture or tear of the supraspinatus tendon** is the most common injury of the rotator cuff. **Degenerative tendinitis of the rotator cuff** is common, especially in older people.

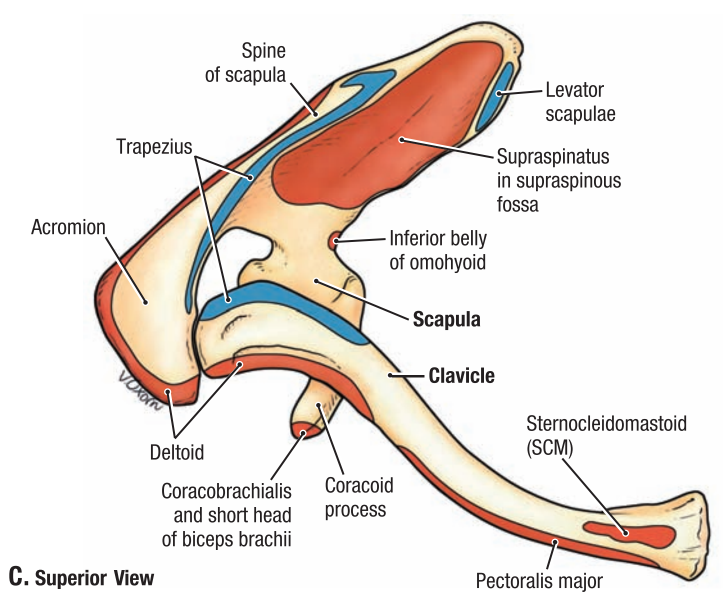
TABLE 6.9 SCAPULOHUMERAL MUSCLES

Muscle	Proximal Attachment	Distal Attachment	Innervation	Main Actions
Supraspinatus (S)	Supraspinous fossa of scapula	Superior facet on greater tubercle of humerus	Suprascapular nerve (C4, **C5**, and C6)	Initiates abduction at shoulder joint and acts with rotator cuff muscles[a]
Infraspinatus (I)	Infraspinous fossa of scapula	Middle facet on greater tubercle of humerus	Suprascapular nerve (**C5** and C6)	Laterally rotates shoulder joint; helps to hold humeral head in glenoid cavity of scapula
Teres minor (T)	Superior part of lateral border of scapula	Inferior facet on greater tubercle of humerus	Axillary nerve (**C5** and C6)	
Subscapularis(S)	Subscapular fossa	Lesser tubercle of humerus	Upper and lower subscapular nerves (C5, **C6**, and C7)	Medially rotates shoulder joint and adducts it; helps to hold humeral head in glenoid cavity
Teres major[b]	Posterior surface of inferior angle of scapula	Crest of lesser tubercle (medial lip of bicipital groove) of humerus	Lower subscapular nerve (**C6** and C7)	Adducts and medially rotates shoulder joint

[a]Collectively, the supraspinatus, infraspinatus, teres minor, and subscapularis muscles are referred to as the rotator cuff muscles or “SITS” muscles. They function together during all movements of the shoulder joint to hold the head of the humerus in the glenoid cavity of scapula.
[b]Not a rotator cuff muscle.

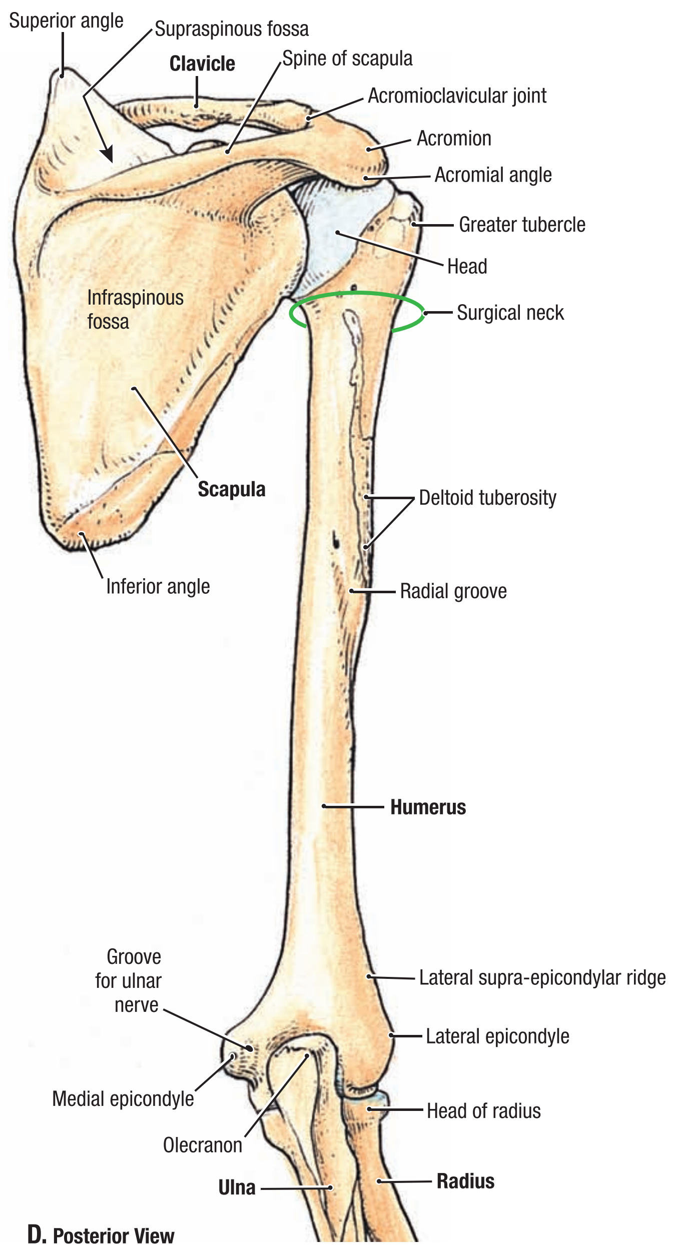




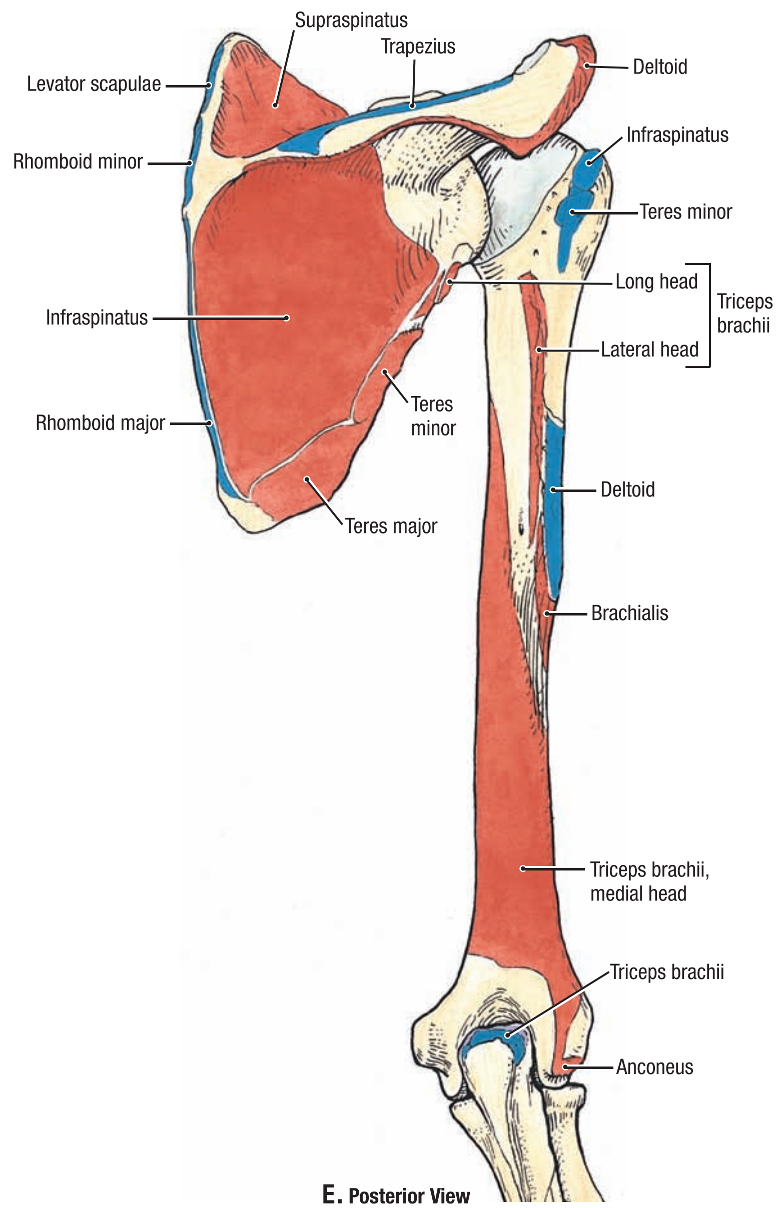


6.34 BONES OF PROXIMAL UPPER LIMB

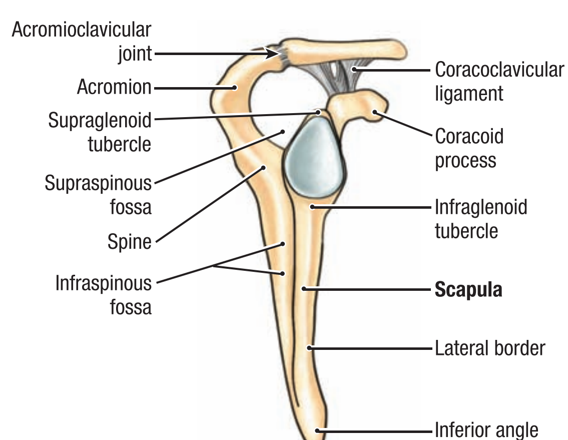
A. Bony features, anterior aspect. **B.** Muscle attachment sites, anterior aspect. **C.** Muscle attachment sites, clavicle and scapula. **Fractures of the clavicle** are common, often caused by indirect force transmitted from an outstretched hand through the bones of the forearm and arm to the shoulder during a fall. A fracture may also result from a fall directly on the shoulder. The weakest part of the clavicle is at the junction of its middle and lateral thirds.



D. Posterior View



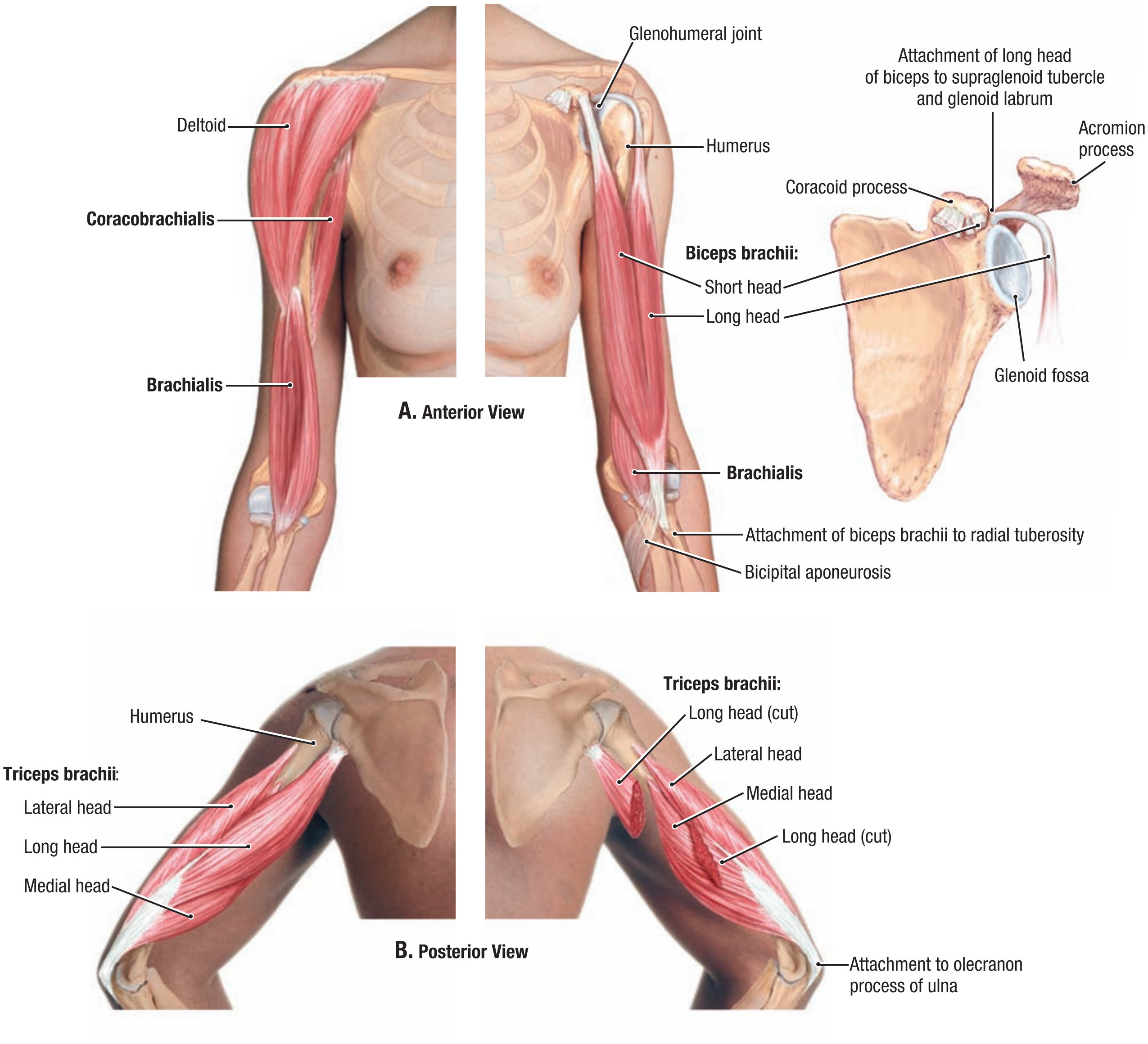
E. Posterior View



F. Lateral View

6.34 BONES OF PROXIMAL UPPER LIMB *(CONTINUED)*

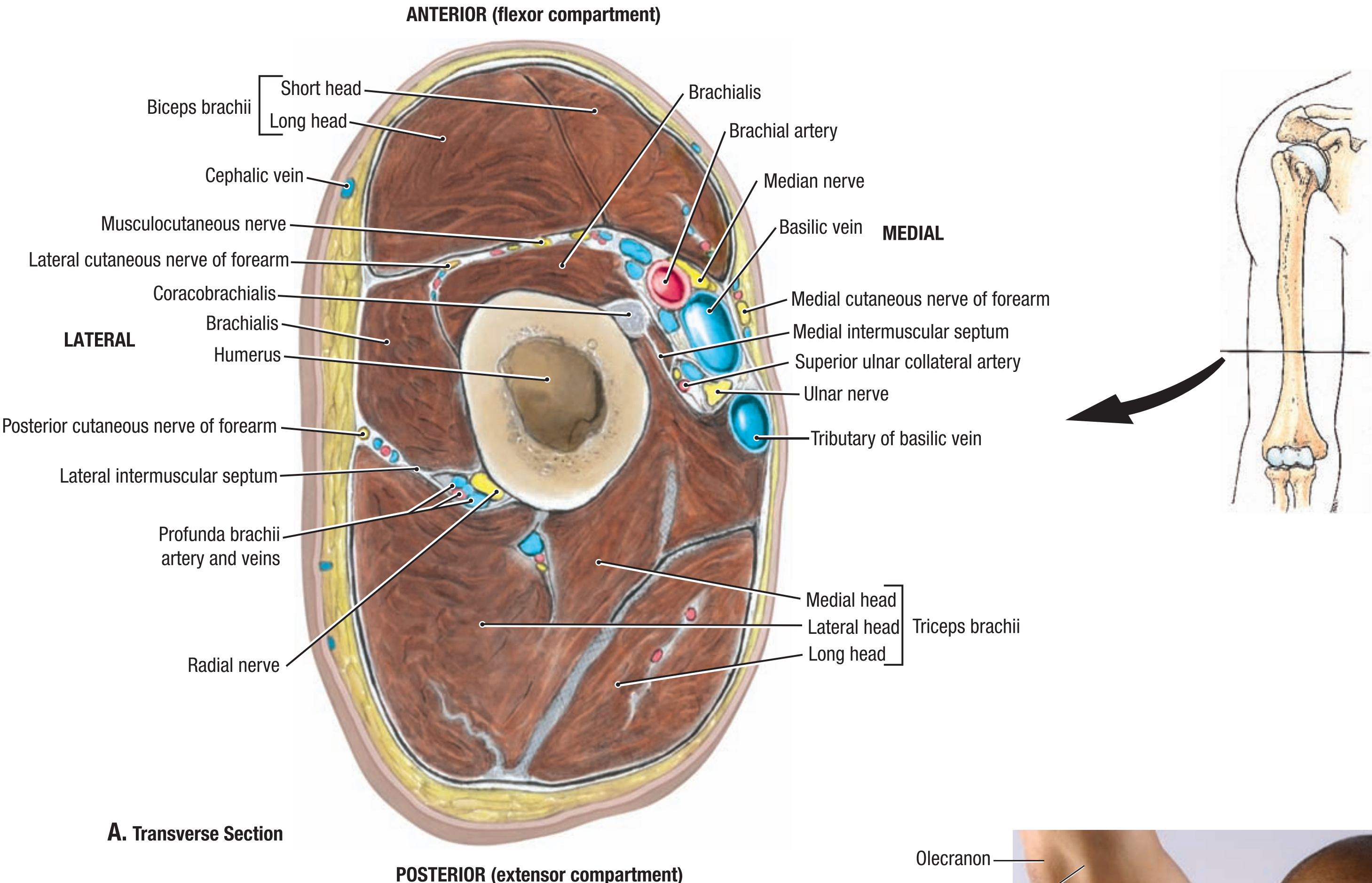
D. Bony features, posterior aspect. **E.** Muscle attachment sites, posterior aspect. **Fractures of the surgical neck of the humerus** are especially common in elderly people with **osteoporosis** (degeneration of bone). Even a low energy fall on the hand, with the force being transmitted up the forearm bones of the extended limb, may result in a fracture. **Transverse fractures of the shaft of humerus** frequently result from a direct blow to the arm. Fracture of the distal part of the humerus, near the supra-epicondylar ridges, is a **supra-epicondylar (supracondylar) fracture.**



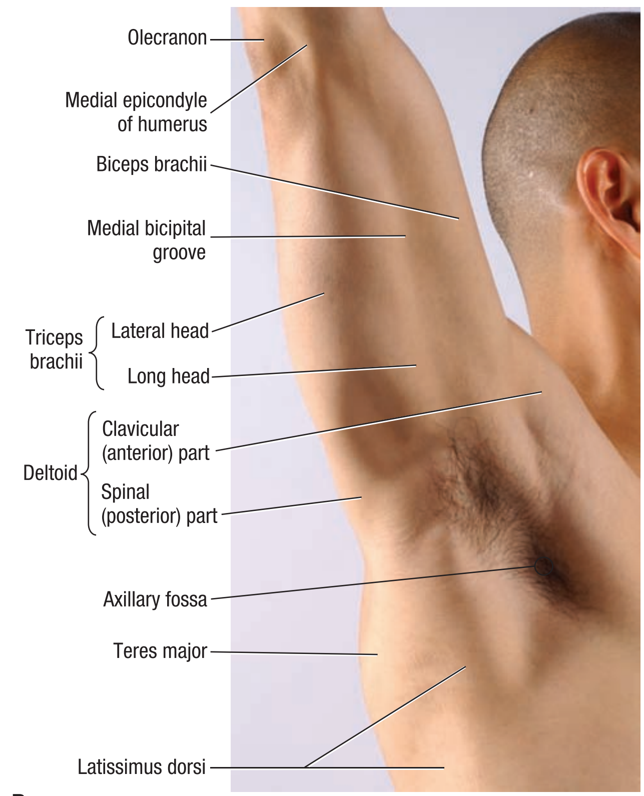
6.35 ARM MUSCLES

TABLE 6.10 ARM MUSCLES

Muscle	Proximal Attachment	Distal Attachment	Innervation	Main Actions
Biceps brachii	*Short head:* tip of coracoid process of scapula *Long head:* supraglenoid tubercle of scapula and glenoid labrum	Tuberosity of radius and fascia of forearm through bicipital aponeurosis	Musculocutaneous nerve (C5, **C6**, C7)	Supinates forearm and, when forearm is supine, flexes elbow joint; short head flexes shoulder joint; long head helps to stabilize should joint during abduction.
Brachialis	Distal half of anterior surface of humerus	Coronoid process and tuberosity of ulna	Musculocutaneous nerve (C5–C7) and radial (C5–C7)	Flexes elbow joint in all positions
Coracobrachialis	Tip of coracoid process of scapula	Middle third of medial surface of humerus	Musculocutaneous nerve (C5, **C6**, C7)	Assists with flexion and adduction of shoulder joint
Triceps brachii	*Long head:* infraglenoid tubercle of scapula *Lateral head:* posterior surface of humerus, superior to radial groove *Medial head:* posterior surface of humerus, inferior to radial groove	Proximal end of olecranon of ulna and fascia of forearm	Radial nerve (C6, **C7, C8**)	Extends the elbow joint; long head steadies head of humerus when shoulder joint is abducted
Anconeus	Lateral epicondyle of humerus	Lateral surface of olecranon and superior part of posterior surface of ulna	Radial nerve (C7–T1)	Assists triceps in extending elbow joint; stabilizes elbow joint; abducts ulna during pronation



A. Transverse Section

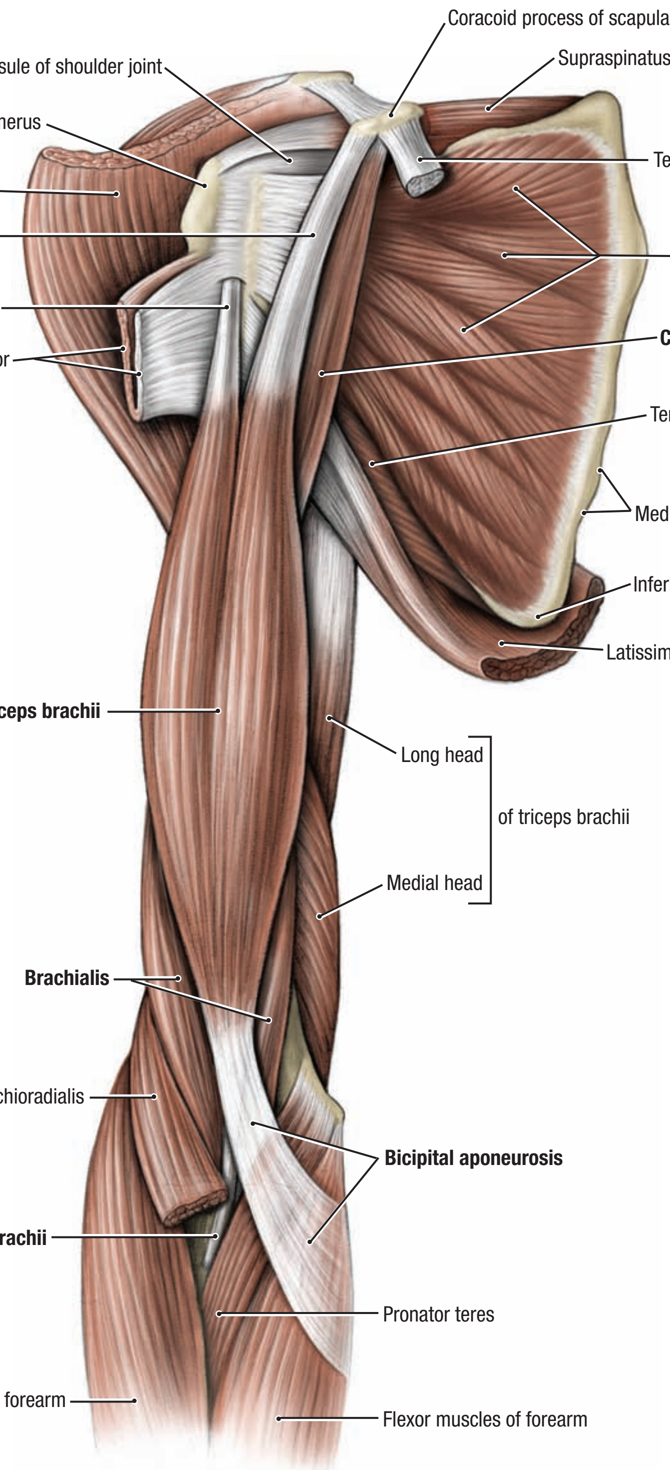


B. Anterolateral View

6.36 ANTERIOR AND POSTERIOR COMPARTMENTS OF ARM

A. Anatomical section. **B.** Surface anatomy.

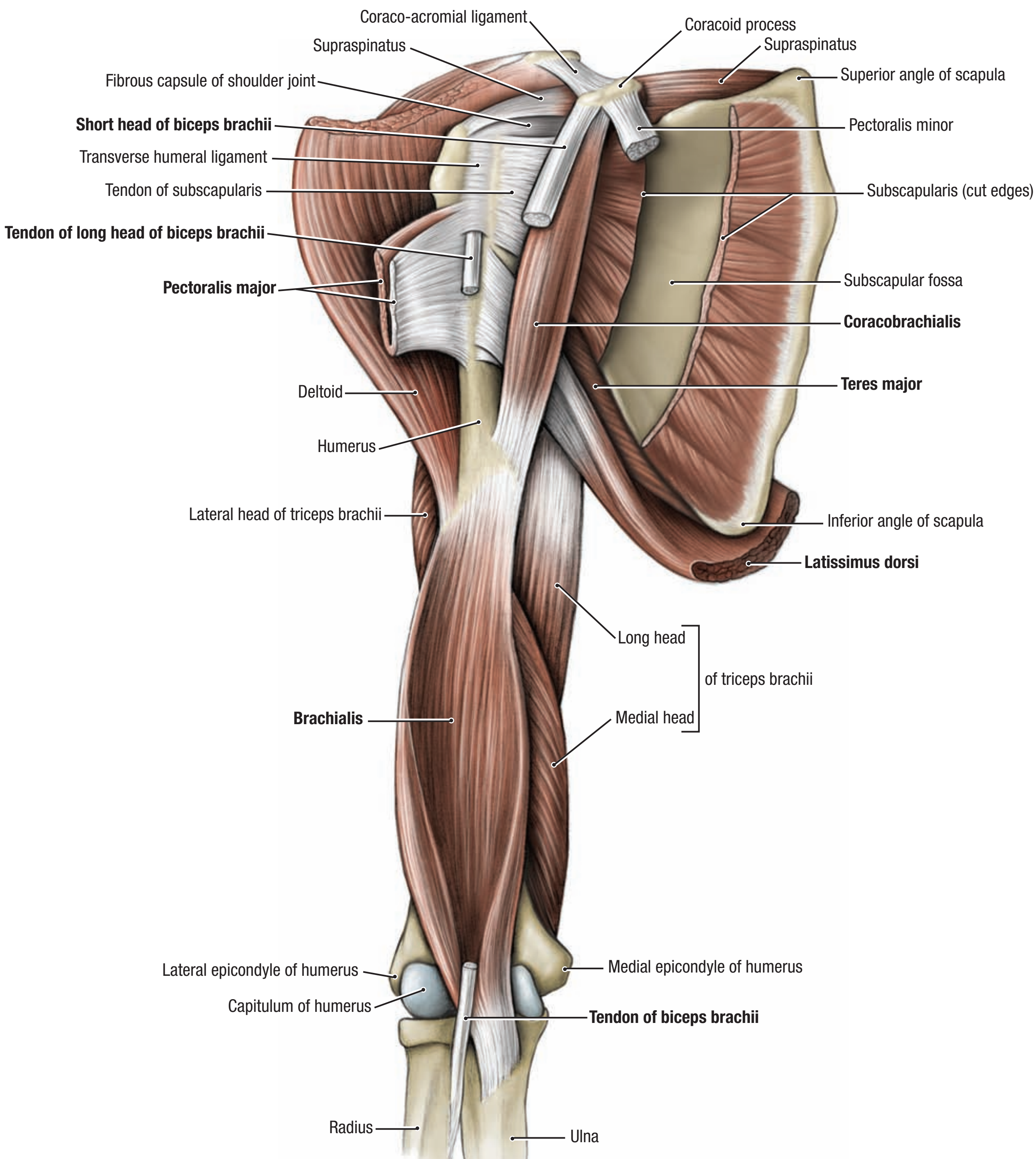
- Three muscles, the biceps, brachialis, and coracobrachialis, lie in the anterior compartment of the arm; the triceps brachii lies in the posterior compartment.
- The medial and lateral intermuscular septum separates these two muscle groups.
- The radial nerve and profunda brachii artery and veins serving the posterior compartment lie in contact with the radial groove of the humerus.
- The musculocutaneous nerve serving the anterior compartment lies in the plane between the biceps and the brachialis muscles.
- The median nerve crosses to the medial side of the brachial artery.
- The ulnar nerve passes posteriorly onto the medial side of the triceps muscle.
- The basilic vein (appearing here as two vessels) has pierced the deep fascia.



A. **Anterior View**

6.37 MUSCLES OF ANTERIOR ASPECT OF ARM I

- The biceps brachii has two heads: a long head and a short head.
- When the elbow joint is flexed approximately 90° the biceps is a flexor from the supinated position of the forearm but a very powerful supinator from the pronated position.
- A triangular membranous band, the bicipital aponeurosis, runs from the biceps tendon across the cubital fossa and merges with the antebrachial (deep) fascia covering the flexor muscles on the medial side of the forearm.

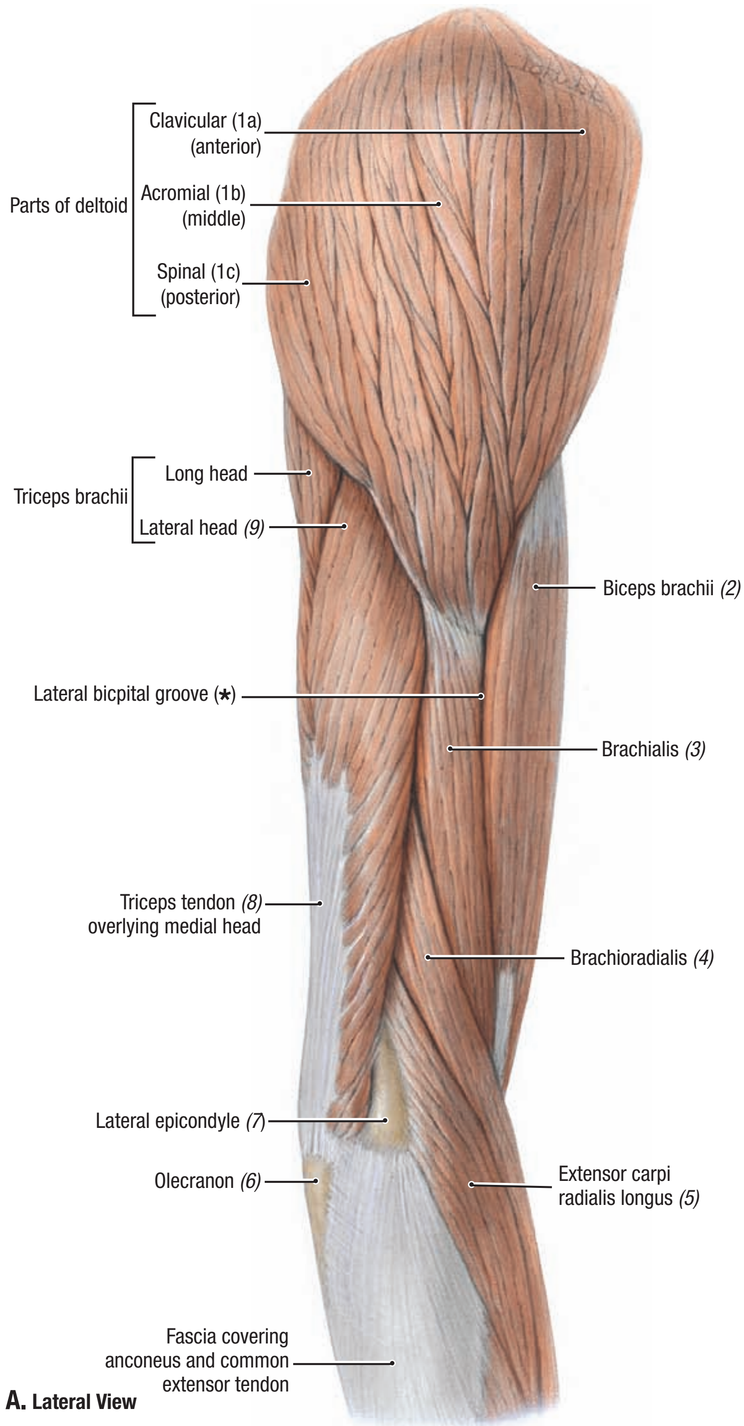


B. **Anterior View**

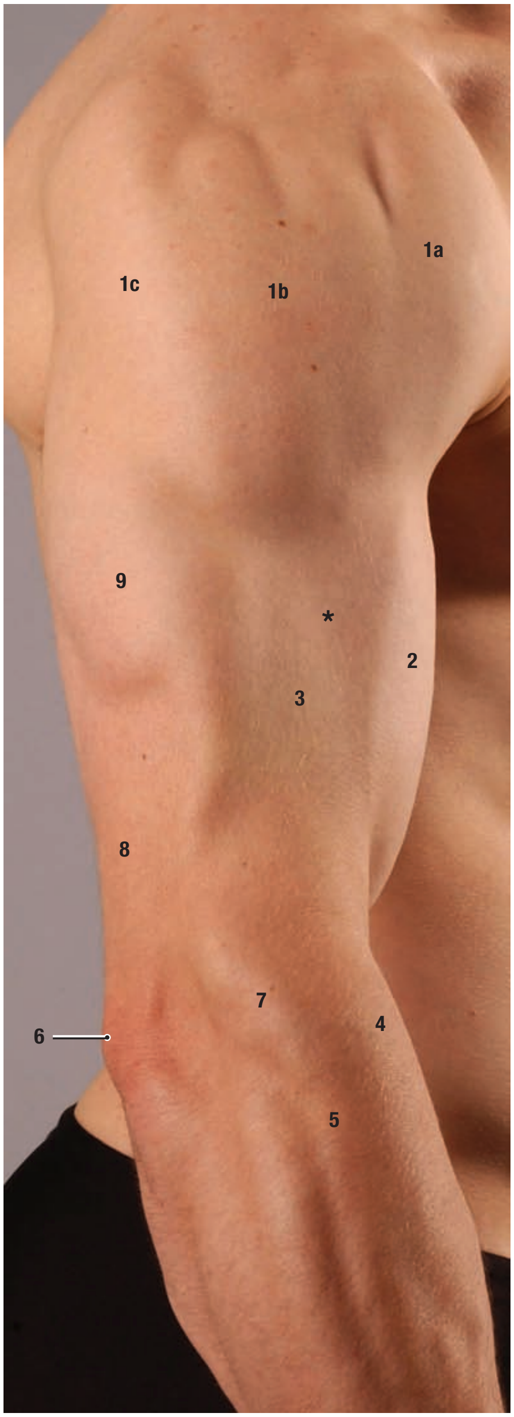
6.37 MUSCLES OF ANTERIOR ASPECT OF ARM II

- The brachialis, a flattened fusiform muscle, lies posterior (deep) to the biceps and produces the greatest amount of flexion force.
- The coracobrachialis, an elongated muscle in the superomedial part of the arm, is pierced by the musculocutaneous nerve. It helps flex and adduct the arm.

- **Rupture of the tendon of the long head of the biceps** usually results from wear and tear of an inflamed tendon **(biceps tendinitis)**. Normally, the tendon is torn from its attachment to the supraglenoid tubercle of the scapula. The detached muscle belly forms a ball near the center of the distal part of the anterior aspect of the arm.



A. Lateral View

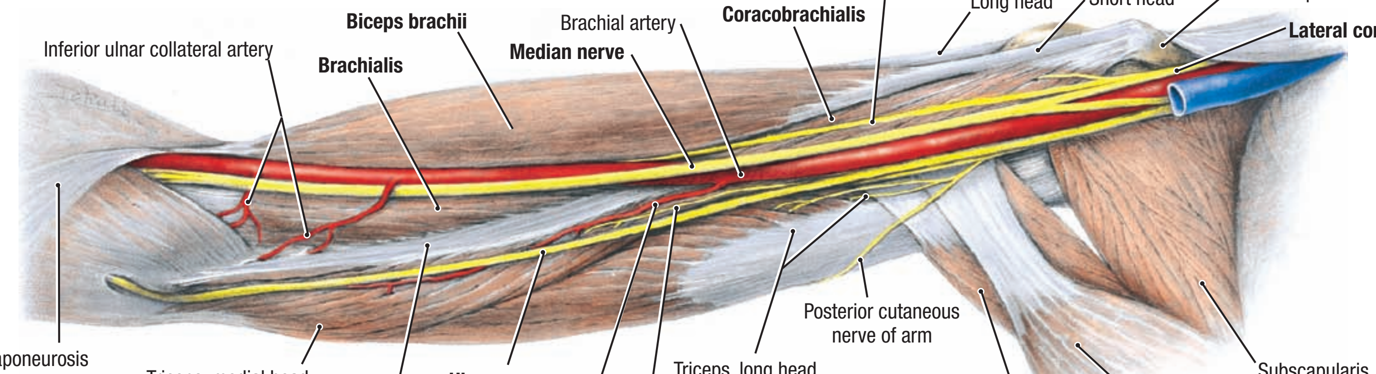


B. Lateral View

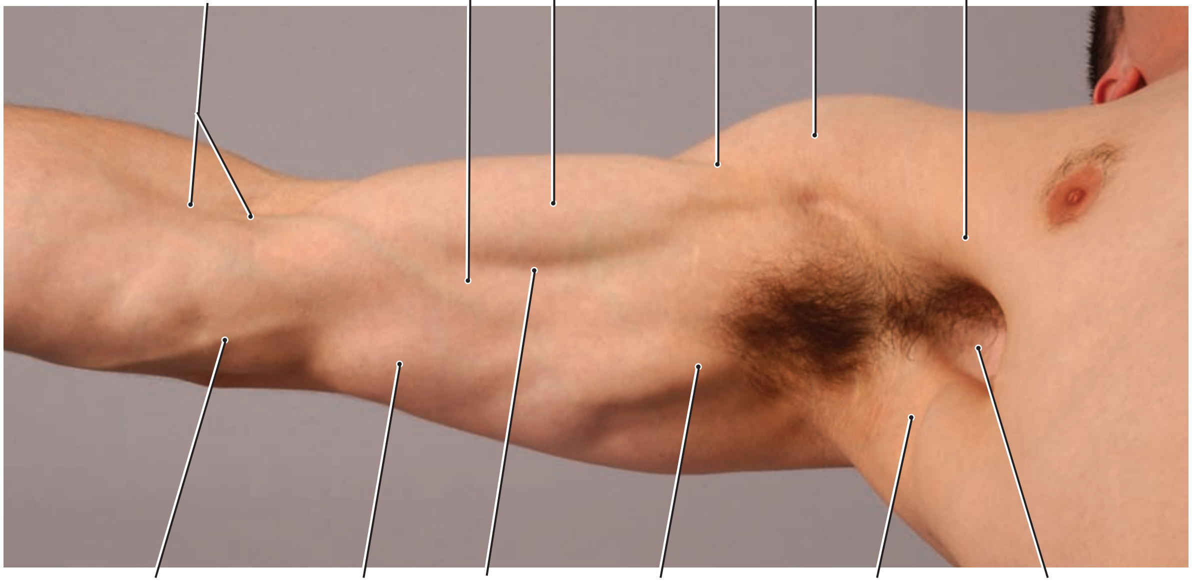
6.38 LATERAL ASPECT OF ARM

A. Dissection (*numbers* in parentheses refer to structures in **B**). **B.** Surface anatomy.

Atrophy of the deltoid occurs when the axillary nerve (C5 and C6) is severely damaged (e.g., as might occur when the surgical neck of the humerus is fractured). As the deltoid atrophies, the rounded contour of the shoulder disappears. This gives the shoulder a flattened appearance and produces a slight hollow inferior to the acromion. A loss of sensation may occur over the lateral side of the proximal part of the arm, the area supplied by the superior lateral cutaneous nerve of the arm. To test the deltoid (or the function of the axillary nerve) the shoulder joint is abducted against resistance, starting from approximately 15°. Supraspinatus initiates abduction at the shoulder joint.



A. **Medial View**

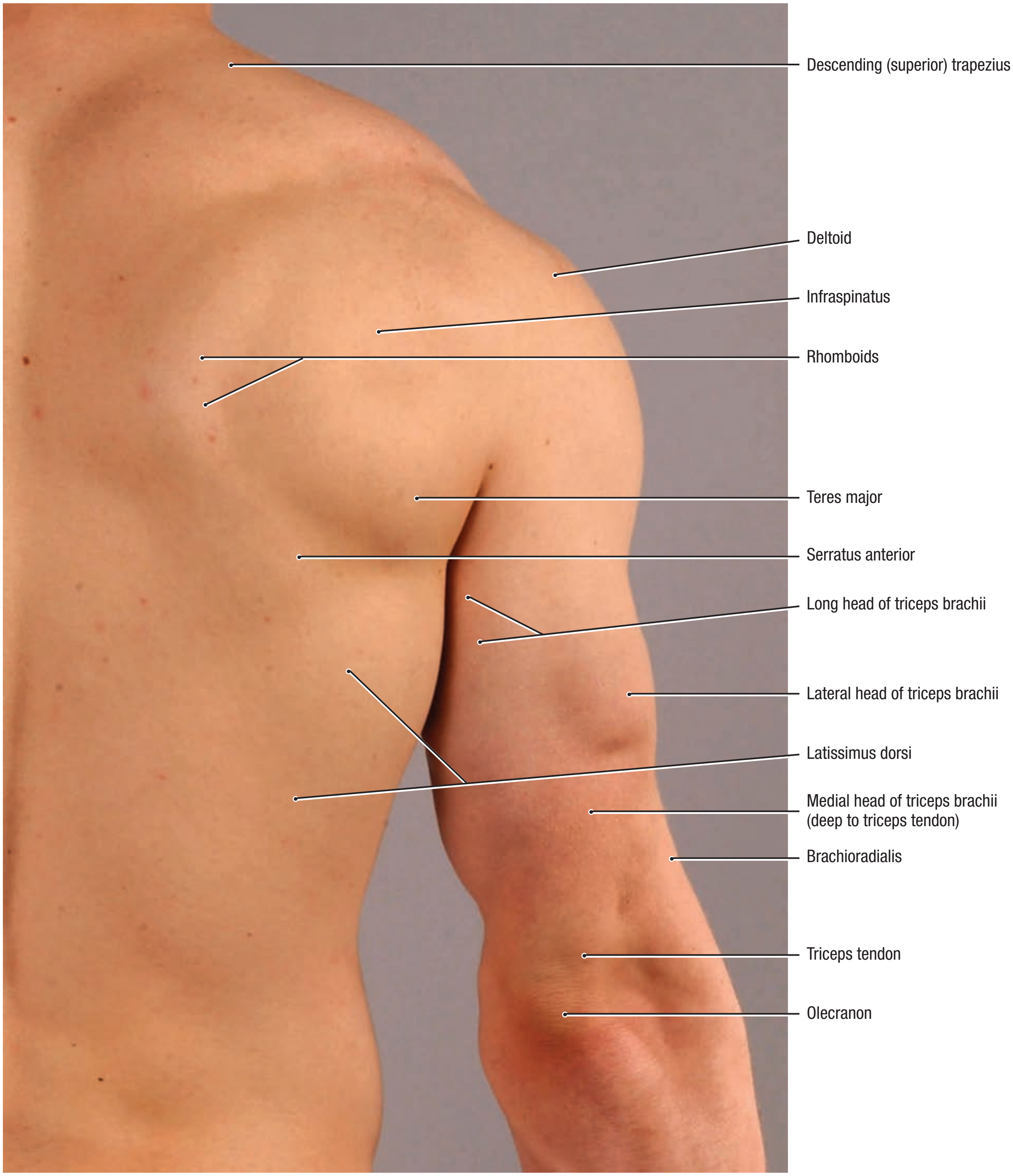


B. **Medial View**

6.39 MEDIAL ASPECT OF ARM

A. Dissection. **B.** Surface anatomy.

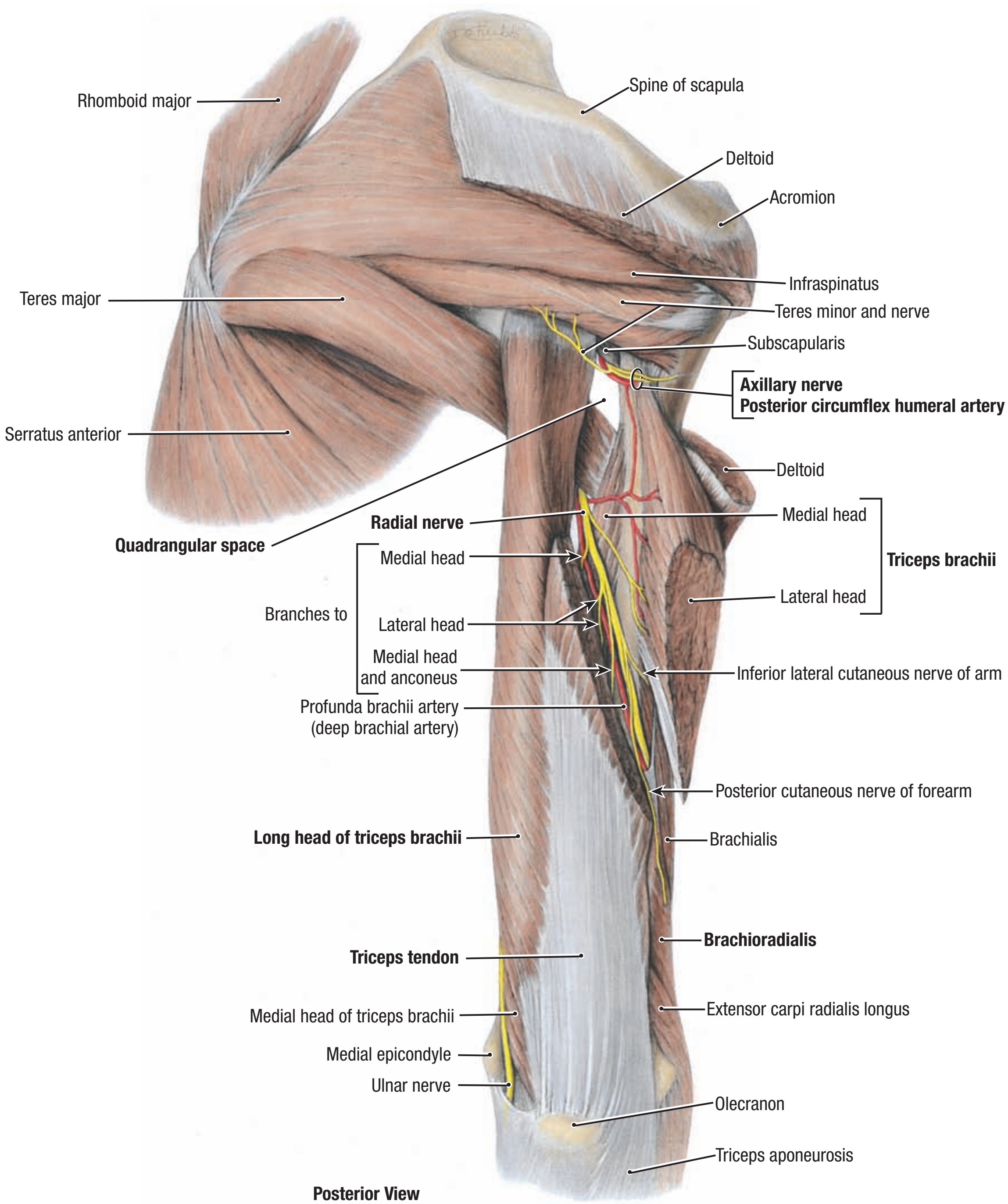
- The axillary artery passes just inferior to the tip of the coracoid process and courses posterior to the coracobrachialis. At the inferior border of the teres major, the axillary artery changes names to become the brachial artery and continues distally on the anterior aspect of the brachialis.
- Although collateral pathways confer some protection against gradual temporary and partial occlusion, sudden complete **occlusion or laceration of the brachial artery** creates a surgical emergency because paralysis of muscles results from ischemia within a few hours.
- The median nerve lies adjacent to the axillary and brachial arteries and then crosses the artery from lateral to medial.
- Proximally, the ulnar nerve is adjacent to the medial side of the artery, passes posterior to the medial intermuscular septum, and descends on the medial head of triceps to pass posterior to the medial epicondyle; here, the ulnar nerve is palpable.
- The superior ulnar collateral artery and ulnar collateral branch of the radial nerve (to medial head of the triceps) accompany the ulnar nerve in the arm.



Posterior View

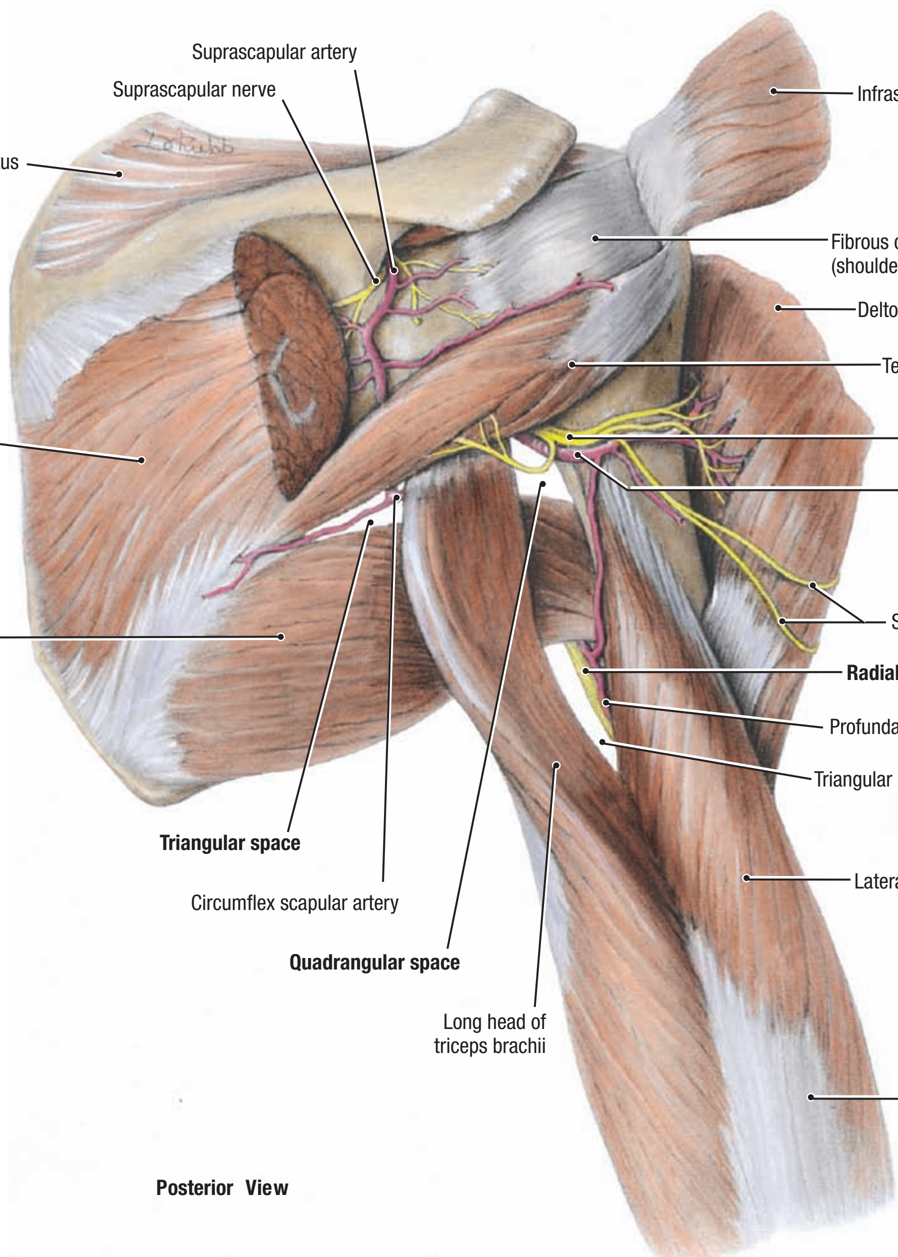
6.40 SURFACE ANATOMY OF SCAPULAR REGION AND POSTERIOR ASPECT OF ARM

The three heads of the triceps form a bulge on the posterior aspect of the arm and are identifiable in a lean individual when the elbow joint is extended from the flexed position against resistance.



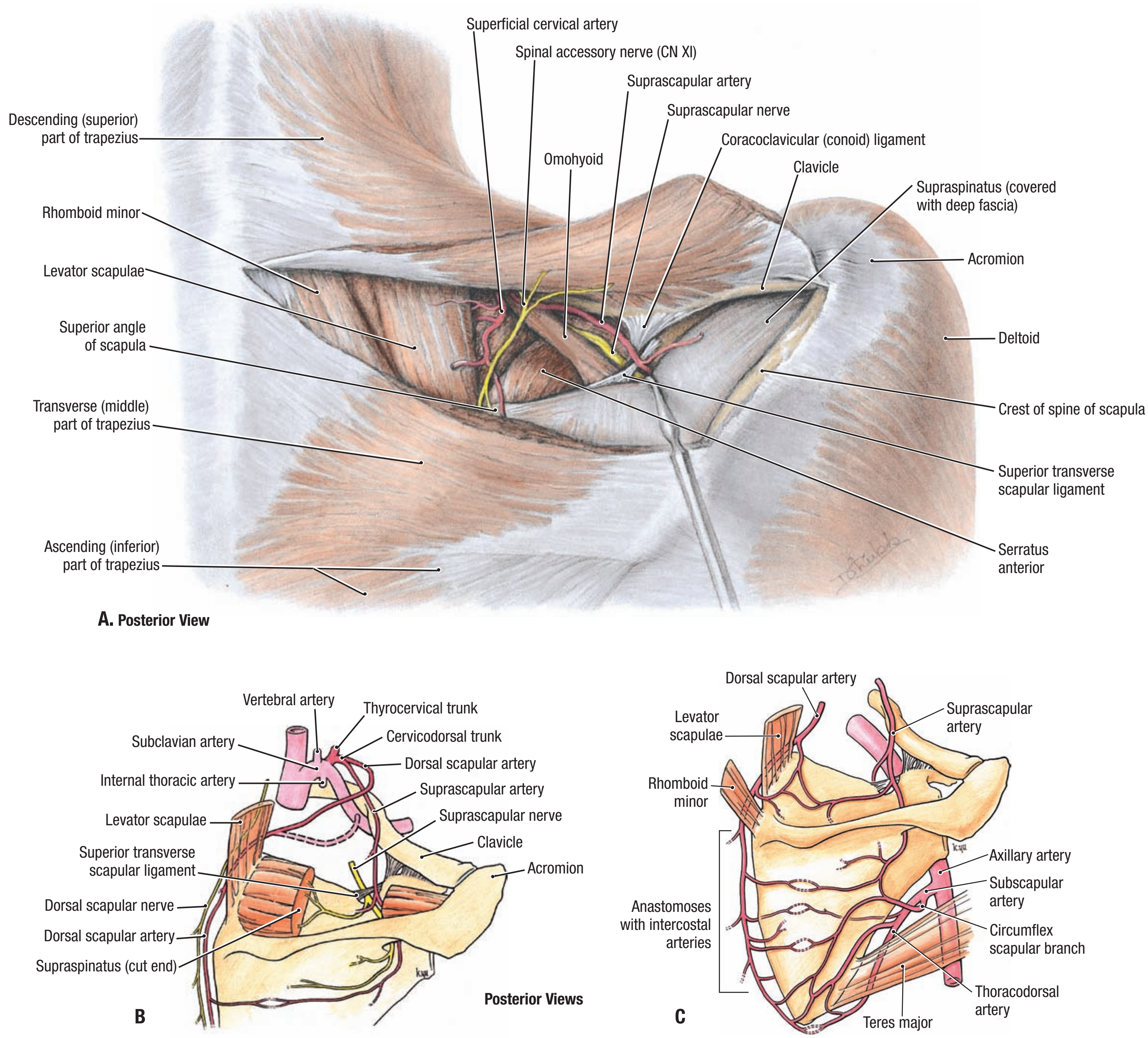
6.41 TRICEPS BRACHII AND RELATED NERVES

- The lateral head is reflected laterally, and the medial head is attached to the deep surface of the triceps tendon, which attaches to the olecranon.
- The radial nerve and deep brachial artery pass between the proximal attachments of the long and medial heads of the triceps brachii in the middle third of the arm, directly contacting the radial groove of the humerus.
- **Midarm fracture.** The middle third of the arm is a common site for fractures of the humerus, often with associated **radial nerve trauma.** When the radial nerve is injured in the radial groove, the triceps brachii muscle typically is only weakened because only the medial head is affected. However, the muscles in the posterior compartment of the forearm, supplied by more distal branches of the radial nerve, are paralyzed. The characteristic clinical sign of radial nerve injury is **wrist drop** (inability to extend the wrist joint and fingers at the metacarpophalangeal joints).
- The axillary nerve passes through the quadrangular space along with the posterior humeral circumflex artery.
- The ulnar nerve follows the medial border of the triceps then passes posterior to the medial epicondyle.



6.42 DORSAL SCAPULAR AND SUBDELTOID REGIONS

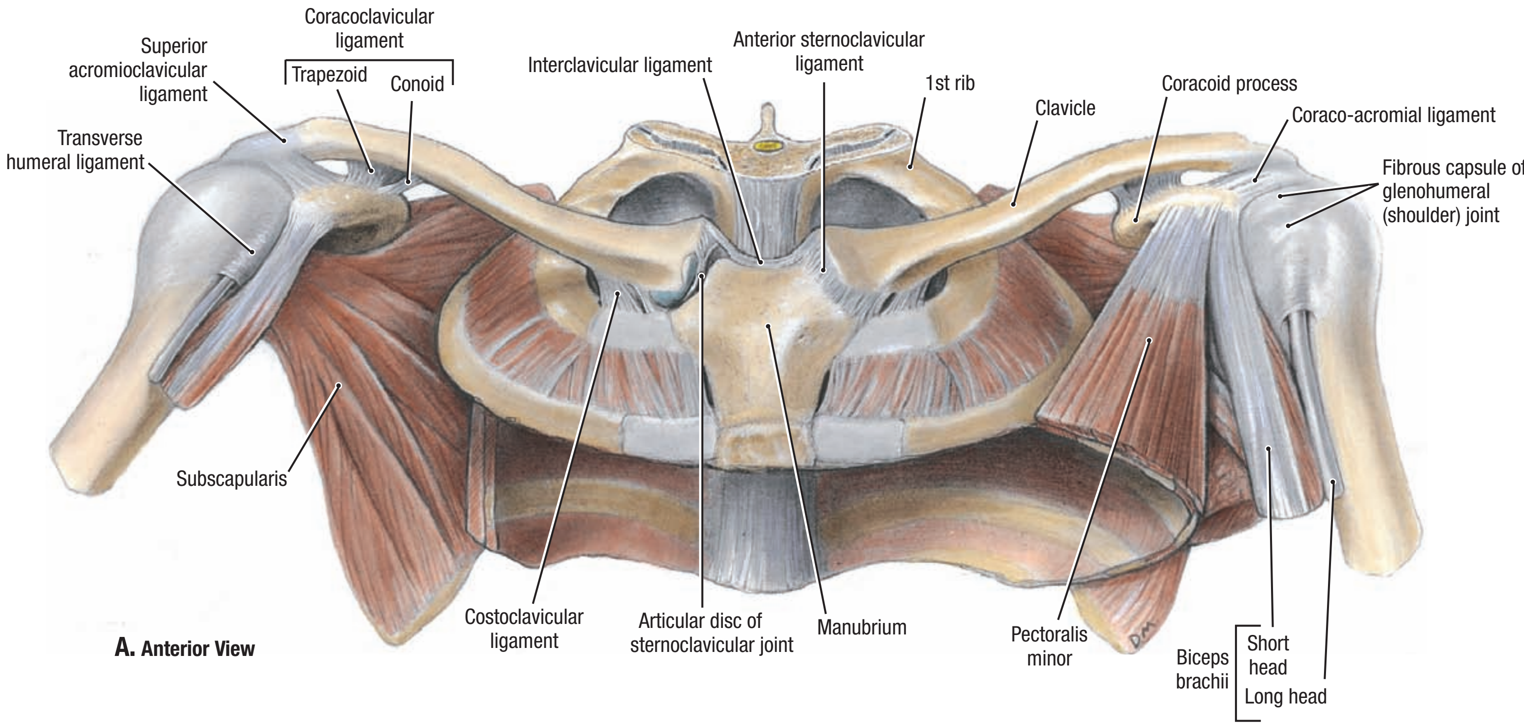
- The infraspinatus muscle, aided by the teres minor and spinal (posterior) fibers of the deltoid muscle, rotates the shoulder joint laterally.
- The long head of the triceps muscle passes between the teres minor (a lateral rotator) and teres major (a medial rotator).
- The long head of the triceps muscle separates the quadrangular space from the triangular interval.
- Regarding the distribution of the suprascapular and axillary nerves, each comes from C5 and C6; each supplies two muscles—the suprascapular nerve innervates the supraspinatus and infraspinatus, and the axillary nerve innervates the teres minor and deltoid muscles. Both nerves supply the shoulder joint, but only the axillary nerve has a cutaneous branch.
- **Axillary nerve injury** may occur when the glenohumeral (shoulder) joint dislocates because of its close relation to the inferior part of the joint capsule of this joint. The subglenoid displacement of the head of the humerus into the quadrangular space may damage the axillary nerve. Axillary nerve injury is indicated by paralysis of the deltoid and sensory loss over the lateral side of the proximal part of the arm.

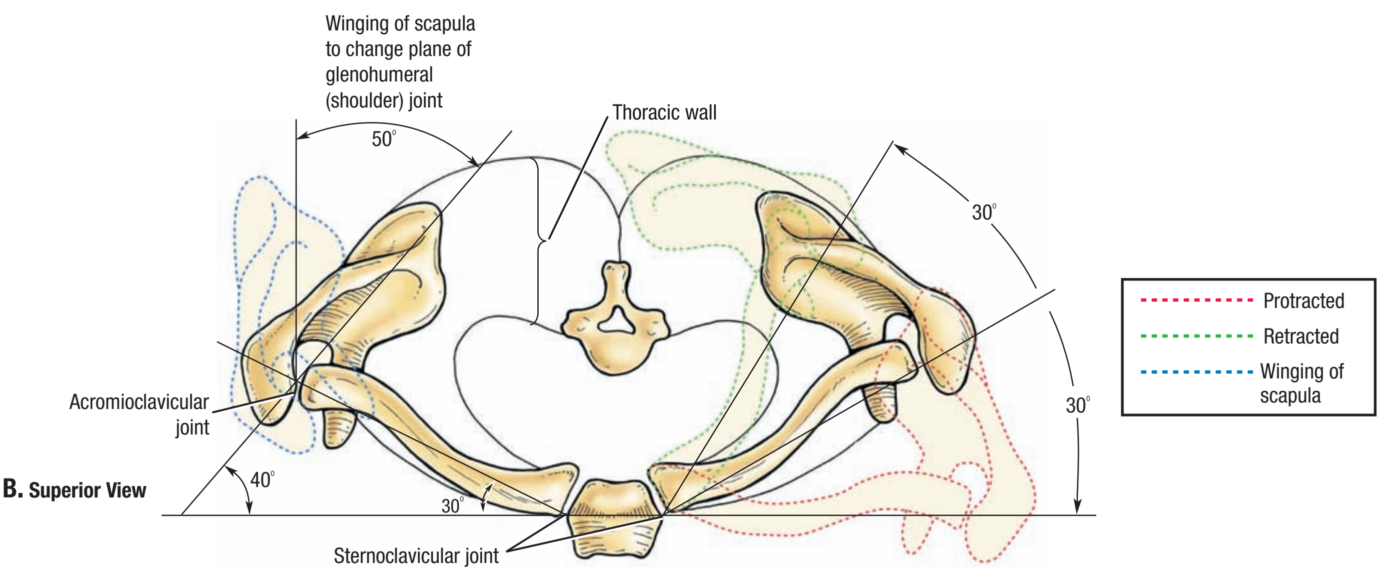


6.43 SUPRASCAPULAR REGION

A. Dissection. At the level of the superior angle of the scapula, the transverse part of the trapezius muscle is reflected. **B.** Suprascapular and dorsal scapular arteries. **C.** Scapular anastomosis.

Several arteries join to form anastomoses on the anterior and posterior surfaces of the scapula. The importance of the collateral circulation made possible by these anastomoses becomes apparent when **ligation of a lacerated subclavian or axillary artery** is necessary or there is occlusion of these vessels. The direction of blood flow in the subscapular artery is then reversed, enabling blood to reach the third part of the axillary artery. In contrast to a sudden occlusion, slow occlusion of an artery often enables sufficient lateral circulation to develop, preventing **ischemia** (deficiency of blood).



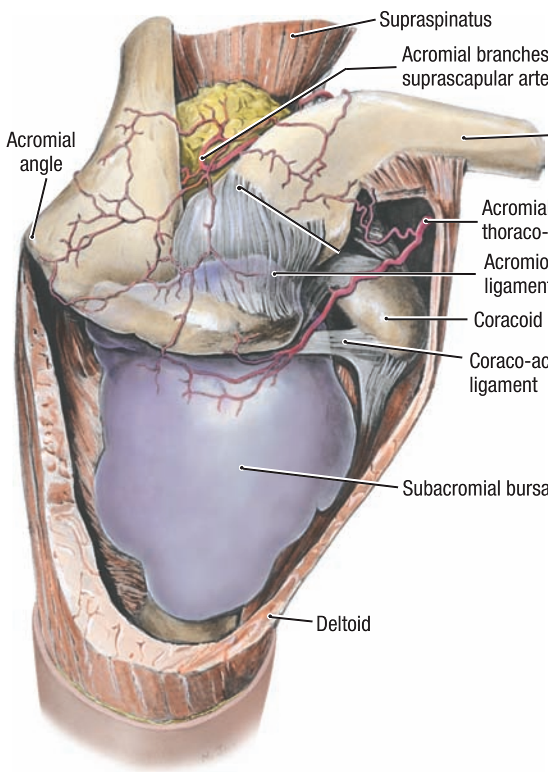


6.44 PECTORAL GIRDLE

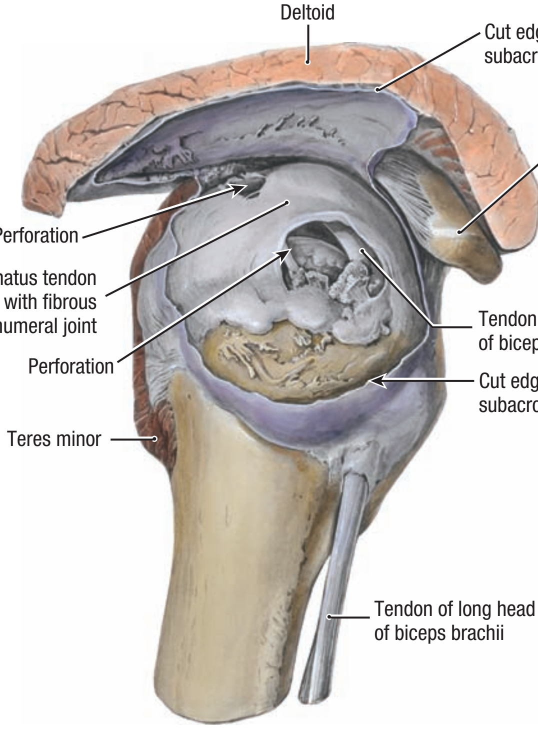
A. Dissection. **B.** Clavicular movements at the sternoclavicular and acromioclavicular joints during rotation, protraction, and retraction of the scapula on the thoracic wall *(left side)* and winging of the scapula *(right side).*

- The shoulder region includes the sternoclavicular, acromioclavicular, and shoulder (glenohumeral) joints; the mobility of the clavicle is essential to the movement of the upper limb.
- The sternoclavicular joint is the only joint connecting the upper limb (appendicular skeleton) to the trunk (axial skeleton). The articular disc of the sternoclavicular joint divides the joint cavity into two parts and attaches superiorly to the clavicle and inferiorly to the first costal cartilage; the disc resists superior and medial displacement of the clavicle.

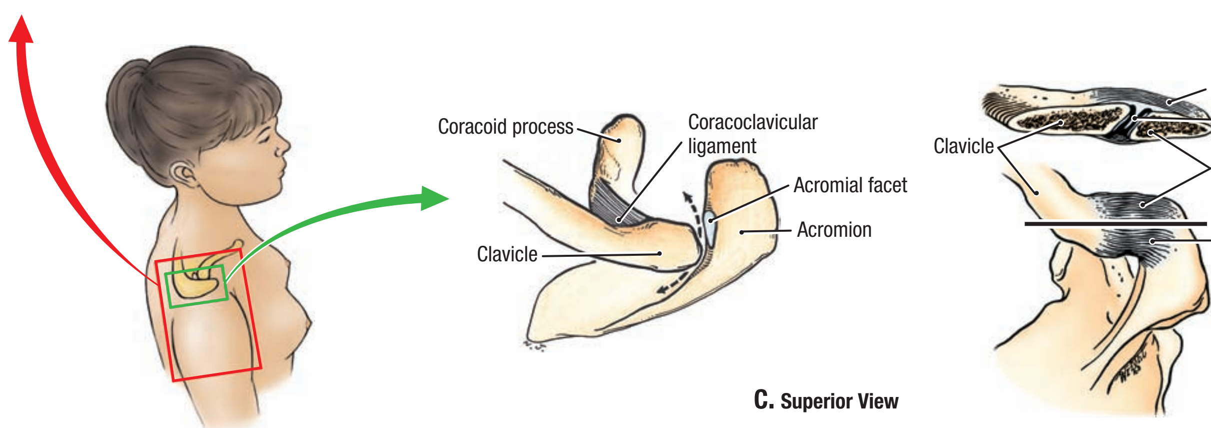
Paralysis of serratus anterior. In **B,** note that when the serratus anterior is paralyzed because of injury to the long thoracic nerve, the medial border of the scapula moves laterally and posteriorly away from the thoracic wall, giving the scapula the appearance of a wing **(winged scapula).** See Clinical Comment for Figure 6.29.



A. Superolateral View



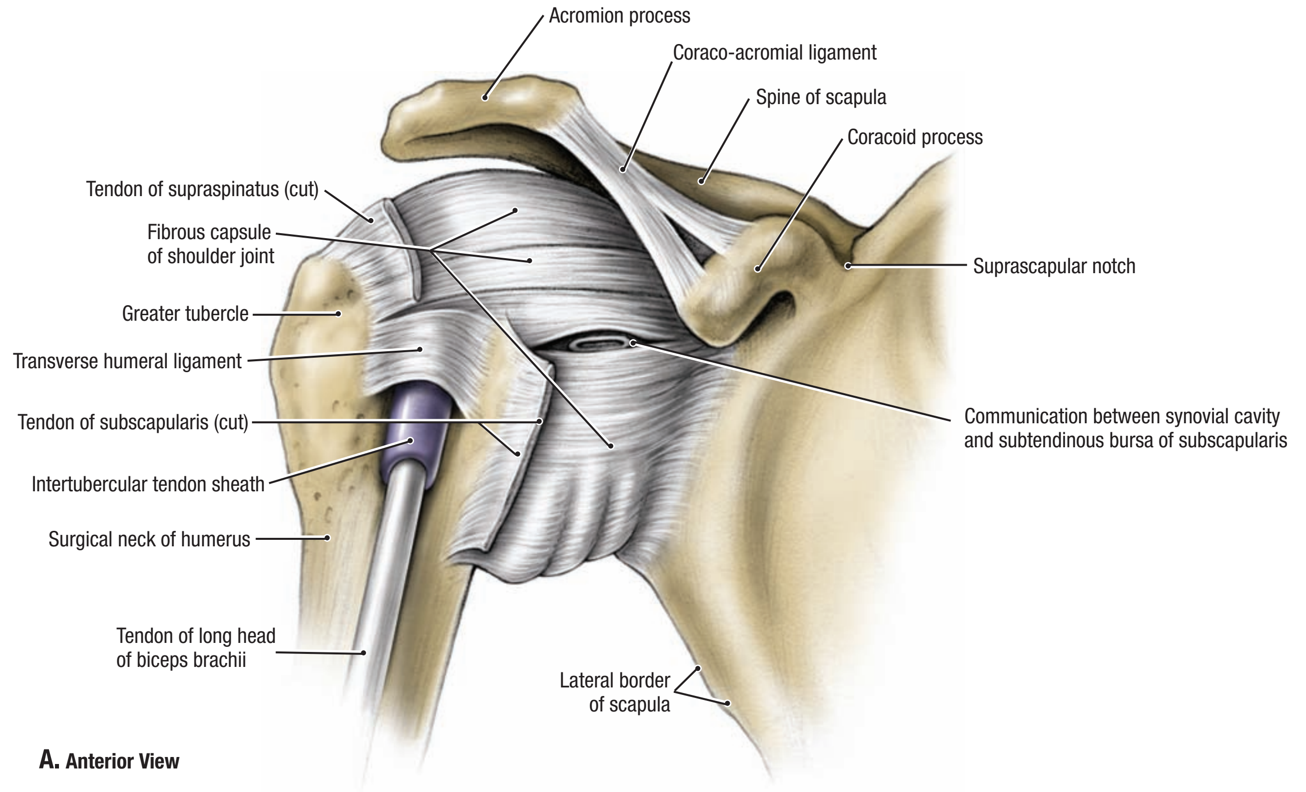
B. Lateral View



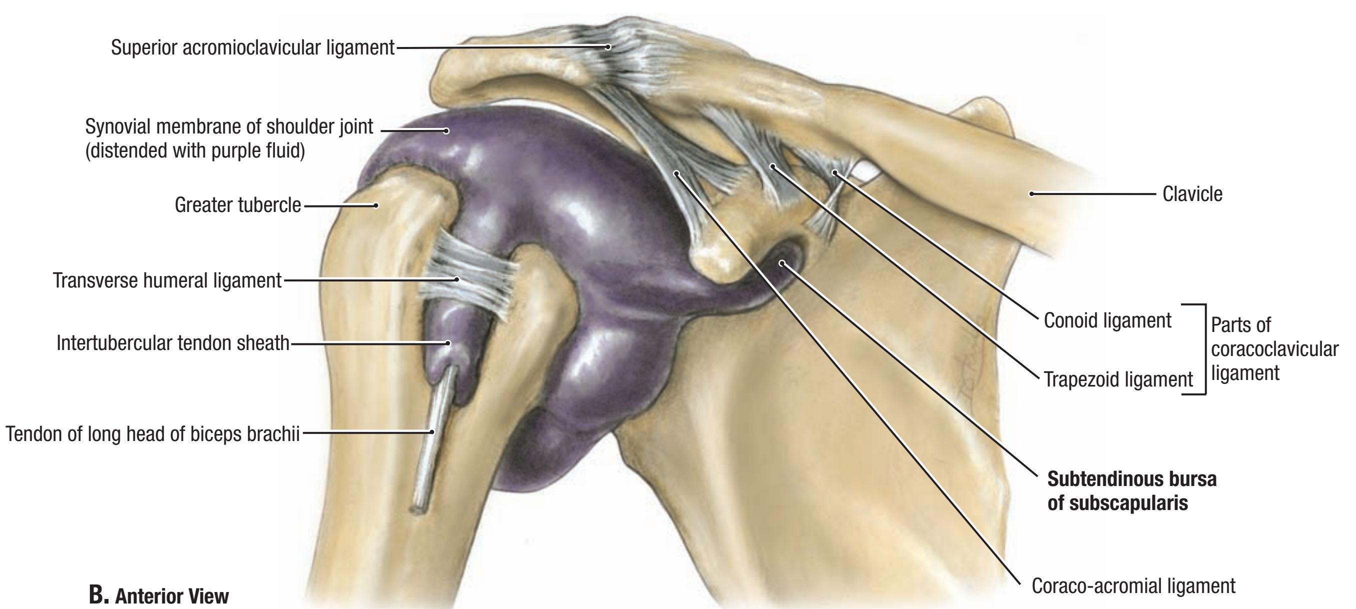
C. Superior View

6.45 SUBACROMIAL BURSA AND ACROMIOCLAVICULAR JOINT

A. Subacromial bursa. The bursa has been injected with purple latex. **B.** Acromioclavicular joint. **C. Attrition of supraspinatus tendon.** As a result of wearing away of the supraspinatus tendon and underlying capsule, the subacromial bursa and shoulder joint come into communication. The intracapsular part of the tendon of the long head of biceps muscle becomes frayed, leaving it adherent to the intertubercular groove. Of 95 dissecting room subjects in Dr. Grant's lab, none of the 18 younger than 50 years of age had a perforation, but 4 of the 19 who were 50 to 60 years and 23 of the 57 older than 60 years had perforations. The perforation was bilateral in 11 subjects and unilateral in 14.



A. Anterior View

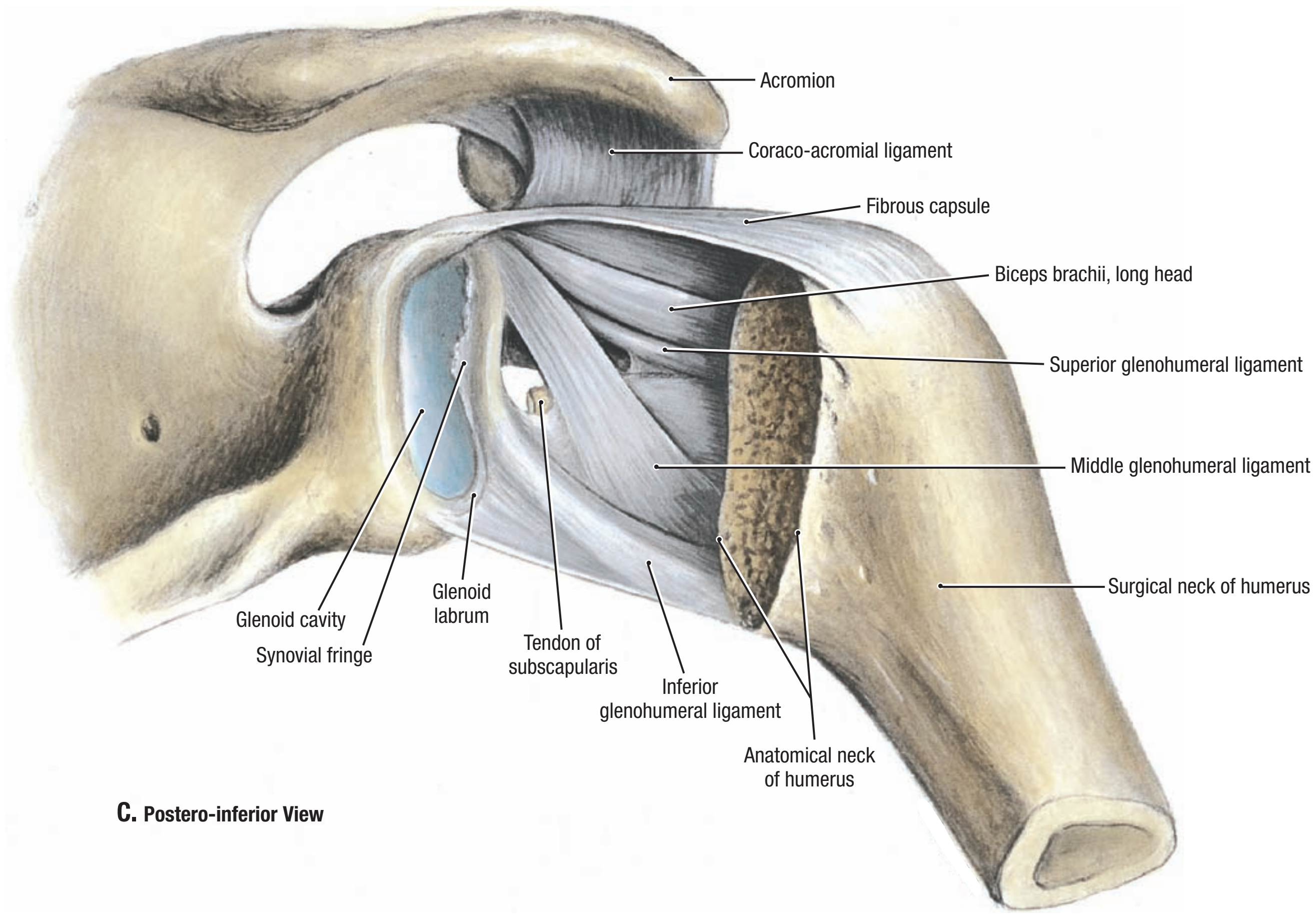


B. Anterior View

6.46 LIGAMENTS AND ARTICULAR CAPSULE OF GLENOHUMERAL (SHOULDER) JOINT

A. Fibrous capsule.

- The loose fibrous capsule is attached to the margin of the glenoid cavity and to the anatomical neck of the humerus.
- The strong coracoclavicular ligament provides stability to the acromioclavicular joint and prevents the scapula from being driven medially and the acromion from being driven inferior to the clavicle.
- The coraco-acromial ligament prevents superior displacement of the head of the humerus.



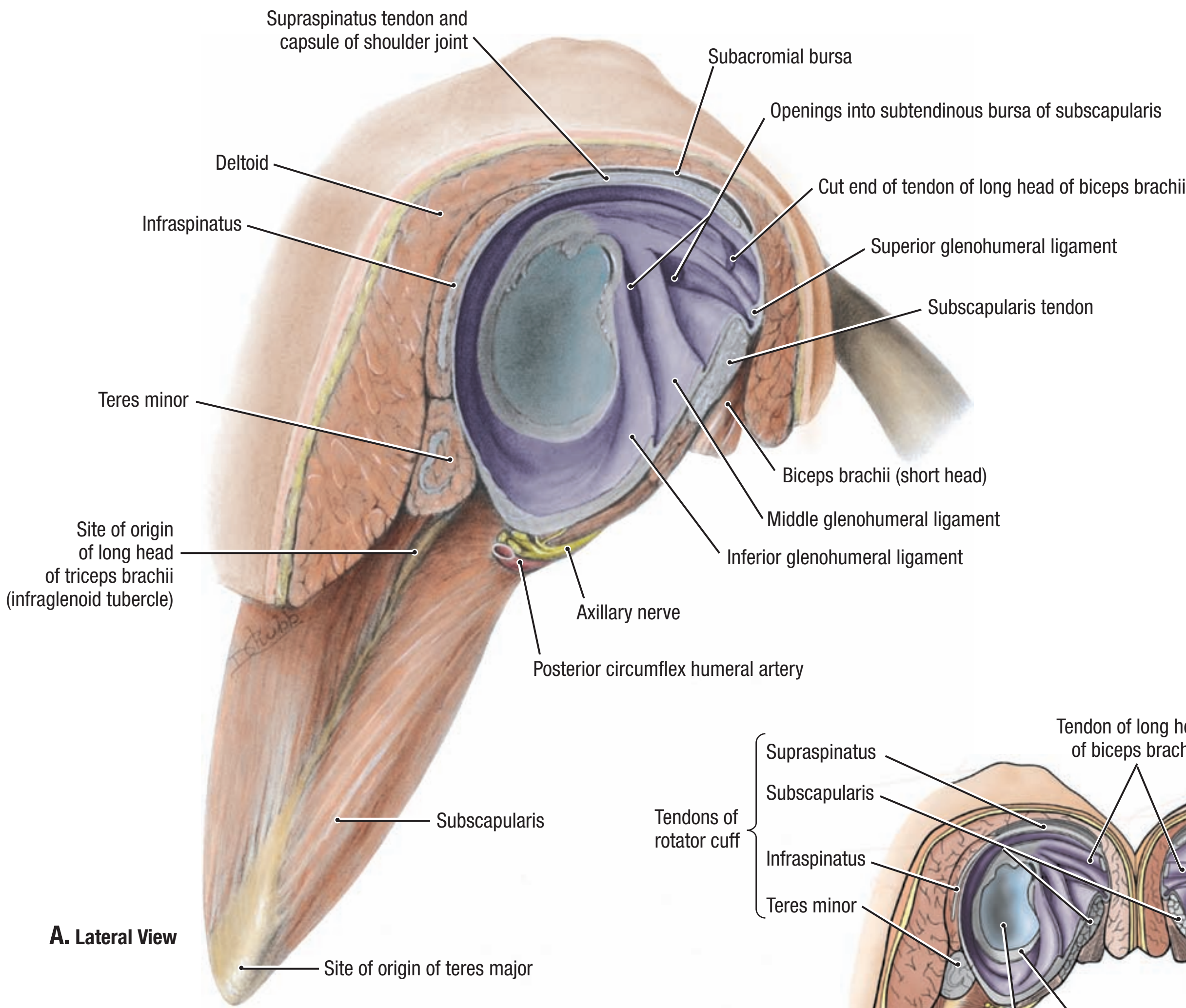
C. Postero-inferior View

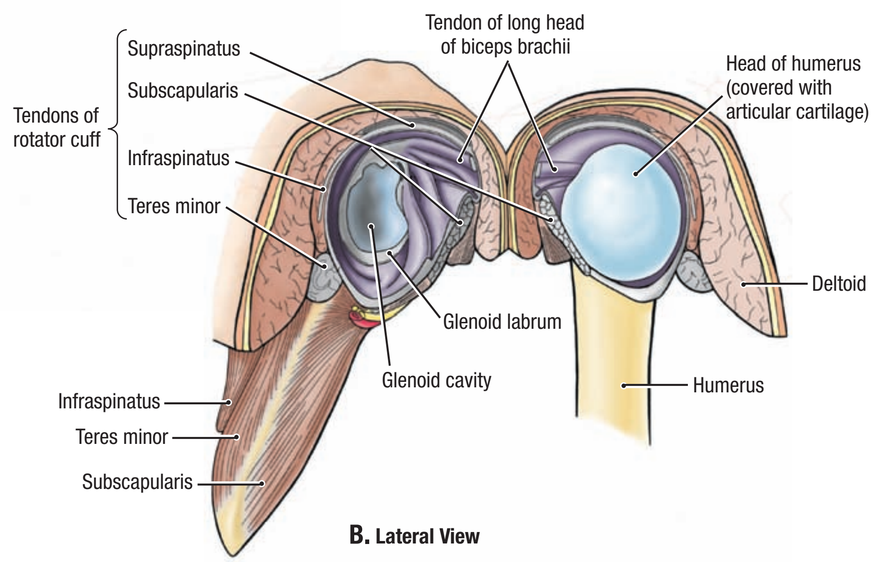
6.46 LIGAMENTS AND ARTICULAR CAPSULE OF GLENOHUMERAL (SHOULDER) JOINT *(CONTINUED)*

B. Synovial membrane of joint capsule. The synovial membrane lines the fibrous capsule and has two prolongations: (1) where it forms a synovial sheath for the tendon of the long head of the biceps muscle in its osseofibrous tunnel and (2) inferior to the coracoid process, where it forms a bursa between the subscapularis tendon and margin of the glenoid cavity—the subtendinous bursa of the subscapularis. **C.** Glenohumeral ligaments viewed from the interior of the shoulder joint.

- The joint is exposed from the posterior aspect by cutting away the thinner postero-inferior part of the capsule and sawing off the head of the humerus.
- The glenohumeral ligaments are visible from within the joint but are not easily seen externally.
- The glenohumeral ligaments and tendon of the long head of biceps brachii muscle converge on the supraglenoid tubercle.
- The slender superior glenohumeral ligament lies parallel to the tendon of the long head of biceps brachii. The middle ligament is free medially because the subtendinous bursa of subscapularis communicates with the joint cavity, usually there is only a single site of communication. In this individual there are openings on both sides of the ligament.

Because of its freedom of movement and instability, the glenohumeral joint is commonly dislocated by direct or indirect injury. Most **dislocations of the humeral head** occur in the downward (inferior) direction but are described clinically as anterior or (more rarely) posterior dislocations, indicating whether the humeral head has descended anterior or posterior to the infraglenoid tubercle and the long head of triceps. Anterior dislocation of the glenohumeral joint occurs most often in young adults, particularly athletes. It is usually caused by excessive extension and lateral rotation of the humerus.



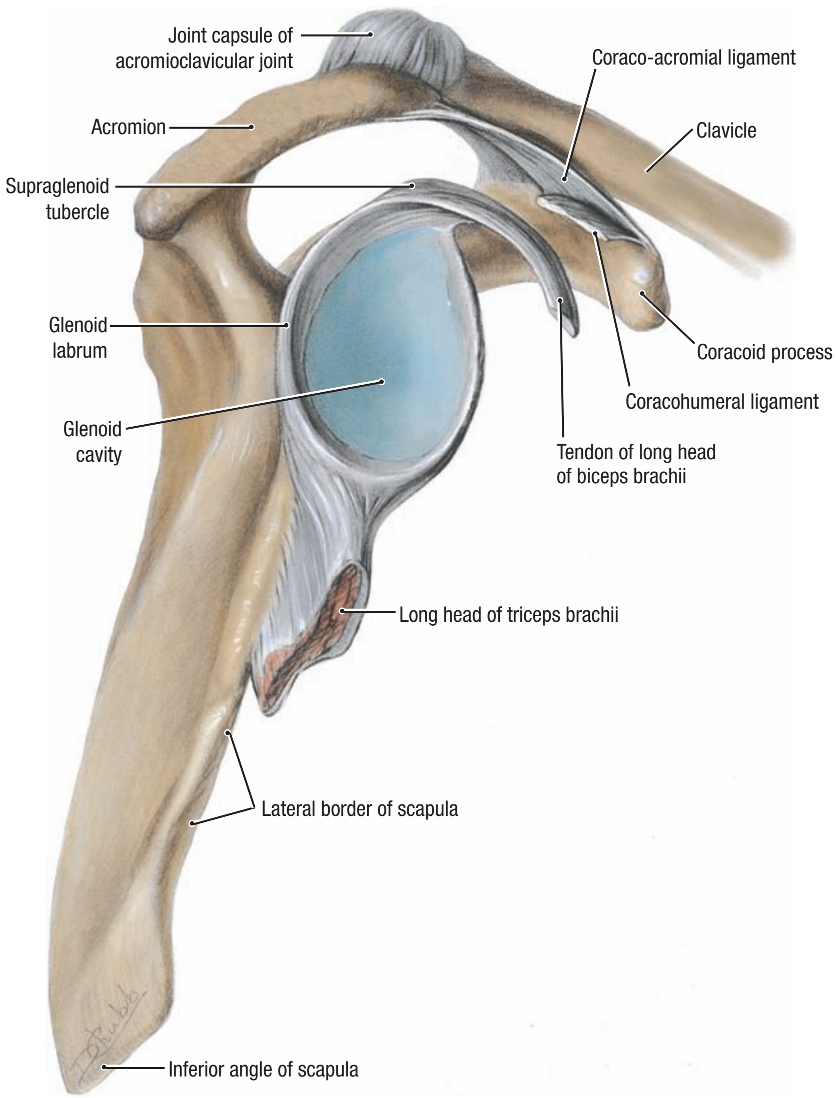


6.47 INTERIOR OF GLENOHUMERAL (SHOULDER) JOINT AND RELATIONSHIP OF ROTATOR CUFF

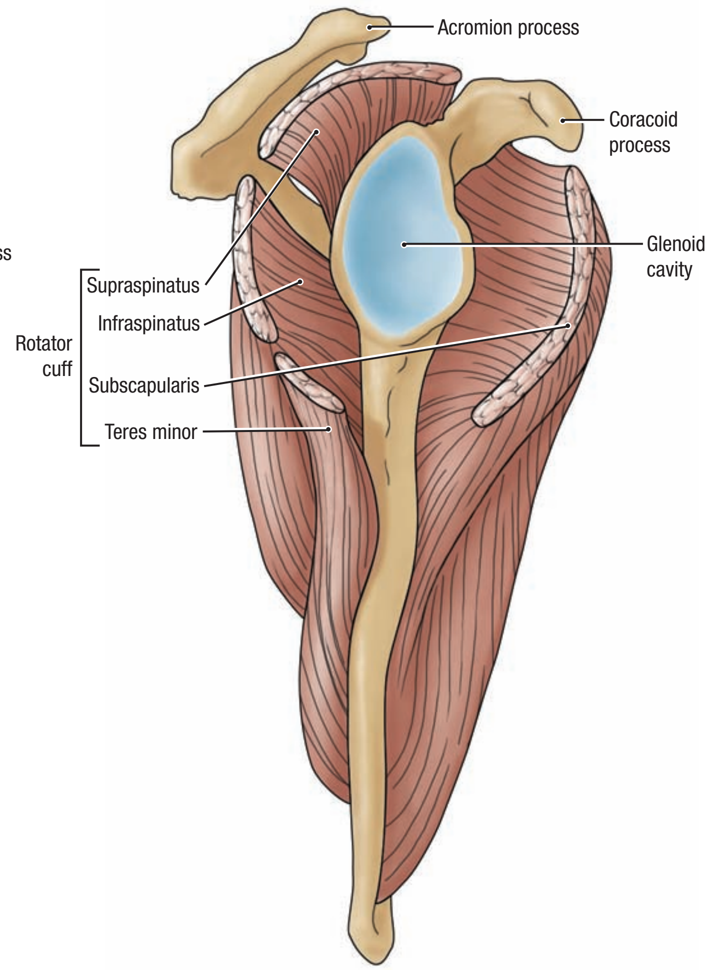
A. Dissection. **B.** Schematic illustration.

- The fibrous capsule of the joint is thickened anteriorly by the three glenohumeral ligaments.
- The subacromial bursa is between the acromion and deltoid superiorly and the tendon of supraspinatus inferiorly.
- The four short rotator cuff muscles (supraspinatus, infraspinatus, teres minor, and subscapularis) cross the joint and blend with the capsule.
- The axillary nerve and posterior circumflex humeral artery are in contact with the capsule inferiorly and may be injured when the glenohumeral joint dislocates.

- Inflammation and calcification of the subacromial bursa result in pain, tenderness, and limitation of movement of the glenohumeral joint. This condition is also known as **calcific scapulohumeral bursitis.** Deposition of calcium in the supraspinatus tendon may irritate the overlying subacromial bursa, producing an inflammatory reaction, **subacromial bursitis.**



C. **Lateral View**



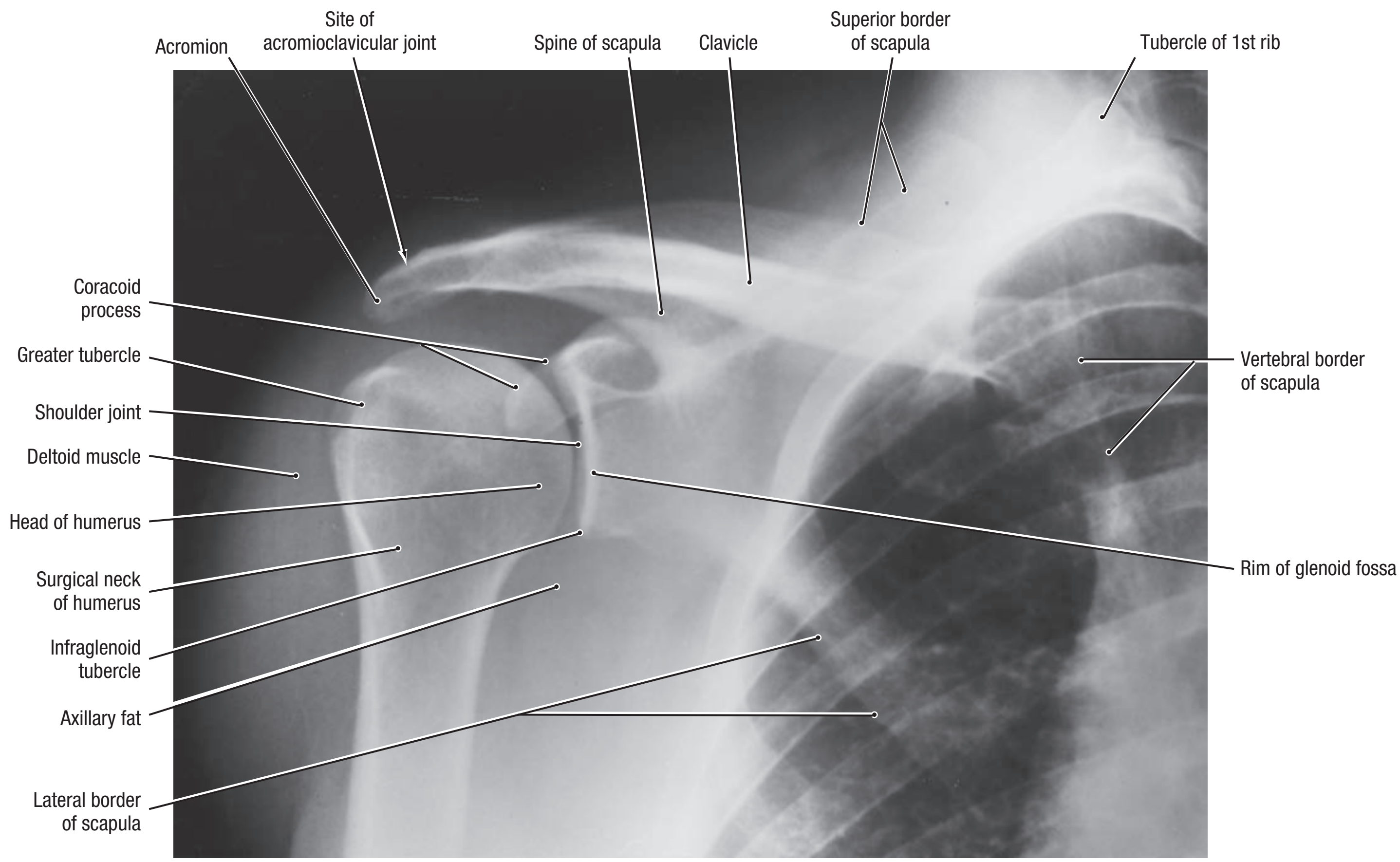
D. **Lateral View**

6.47 INTERIOR OF GLENOHUMERAL (SHOULDER) JOINT AND RELATIONSHIP OF ROTATOR CUFF *(CONTINUED)*

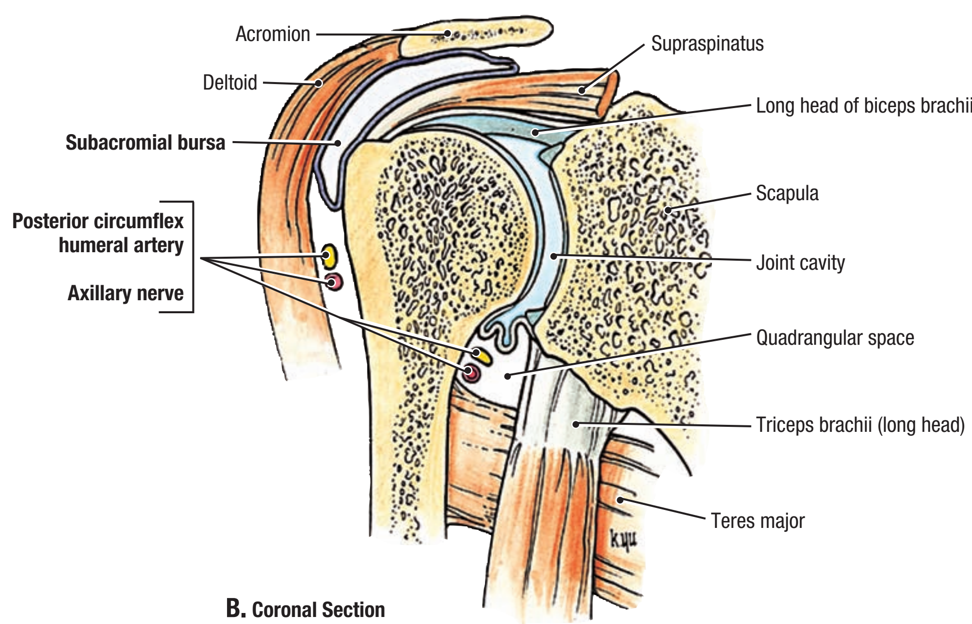
C. Dissection. **D.** Schematic illustration of the rotator cuff muscles and their relationship to the glenoid cavity.

- The coraco-acromial arch (coracoid process, coraco-acromial ligament, and acromion) prevents superior displacement of the head of the humerus.
- The long head of the triceps brachii muscle arises just inferior to the glenoid cavity; the long head of biceps just superior to it.
- The main function of the musculotendinous rotator cuff is to hold the large head of the humerus in the smaller and shallow glenoid cavity of the scapula, both during the relaxed state (by tonic contraction) and during active abduction.

Tearing of the fibrocartilaginous glenoid labrum commonly occurs in the athletes who throw (e.g., a baseball) and in those who have shoulder instability and subluxation (partial dislocation) of the glenohumeral joint. The tear often results from sudden contraction of the biceps or forceful subluxation of the humeral head over the glenoid labrum. Usually a tear occurs in the anterosuperior part of the labrum.



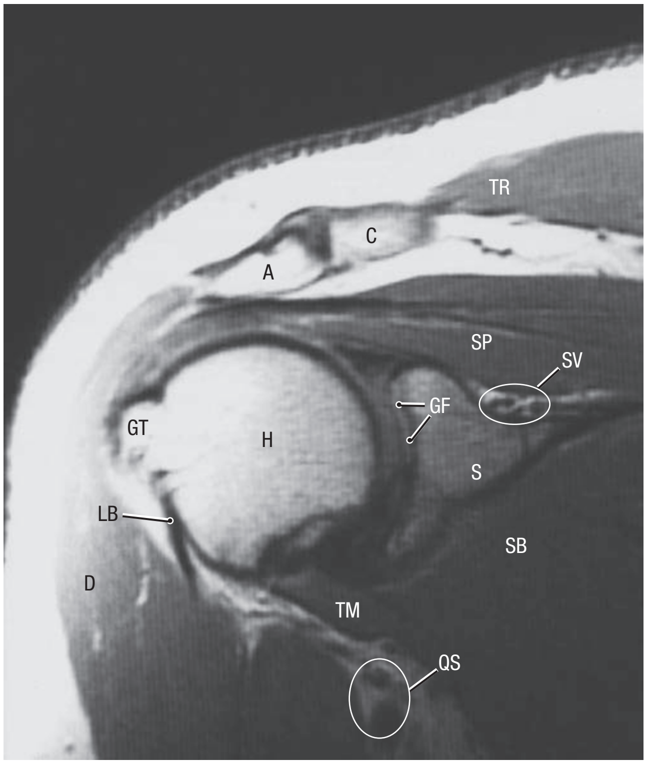
A. **Anteroposterior View**



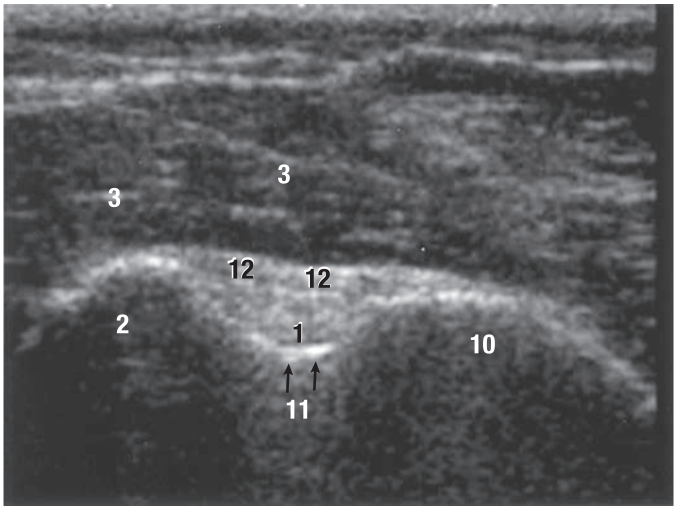
B. **Coronal Section**

6.48 IMAGING OF GLENOHUMERAL (SHOULDER) JOINT

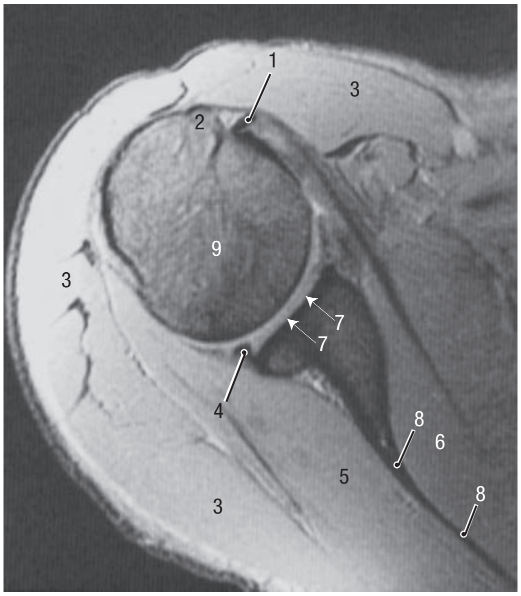
A. Radiograph. **B.** Sectioned joint to show location of subacromial bursa and joint cavity.



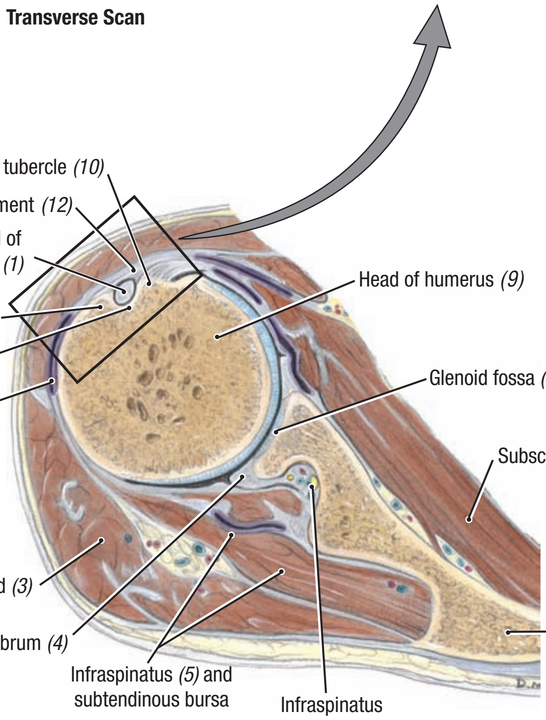
C. Coronal MRI



D. Transverse Scan



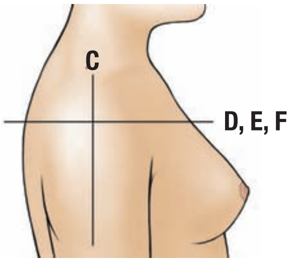
E. Transverse MRI

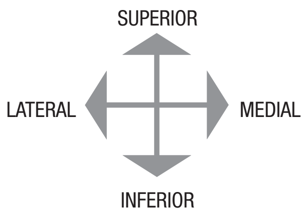


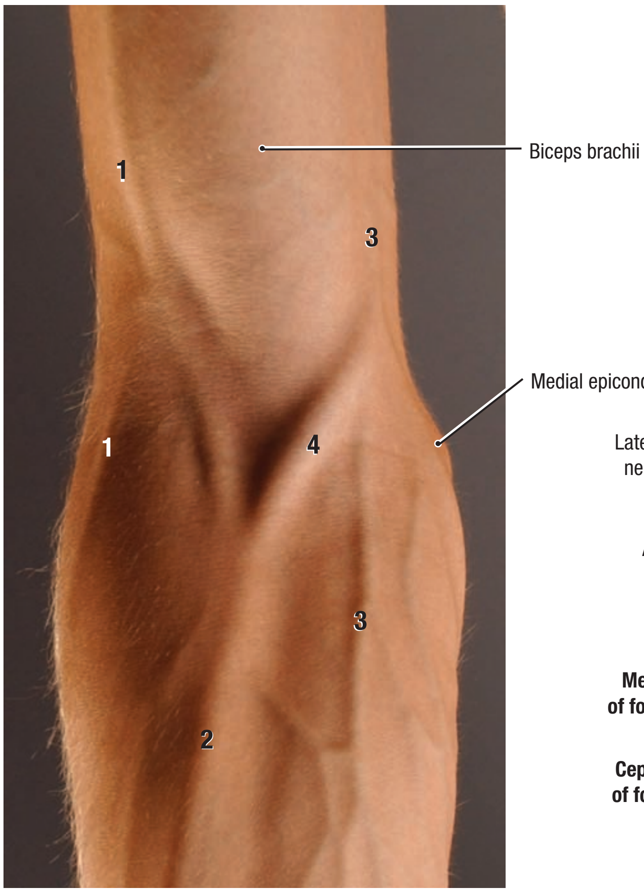
F. Transverse Section, Inferior View

6.48 IMAGING OF GLENOHUMERAL (SHOULDER) JOINT *(CONTINUED)*

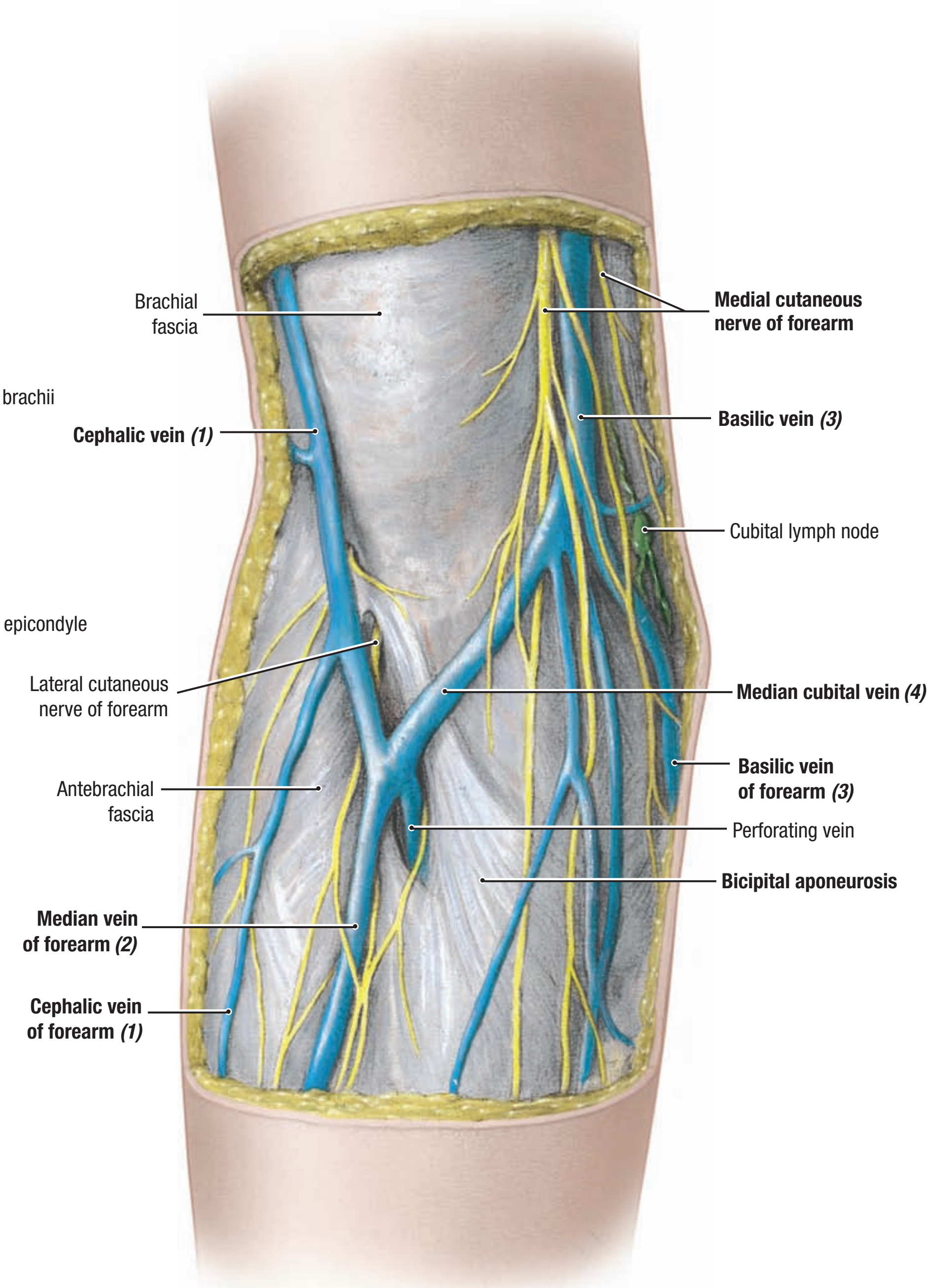
C. Coronal MRI. *A,* acromion; *C,* clavicle; *D,* deltoid; *GF,* glenoid cavity; *GT,* crest of greater tubercle; *H,* head of humerus; *LB,* long head of biceps brachii; *QS,* quadrangular space; *S,* scapula; *SB,* subscapularis; *SP,* supraspinatus; *SV,* suprascapular vessels and nerve; *TM,* teres minor; *TR,* trapezius. **D.** Transverse ultrasound scan of area indicated in **F. E.** Transverse MRI. **F.** Transverse section (*numbers* in **F** refer to structures labeled in **D** and **E**).







A. **Anterior View**

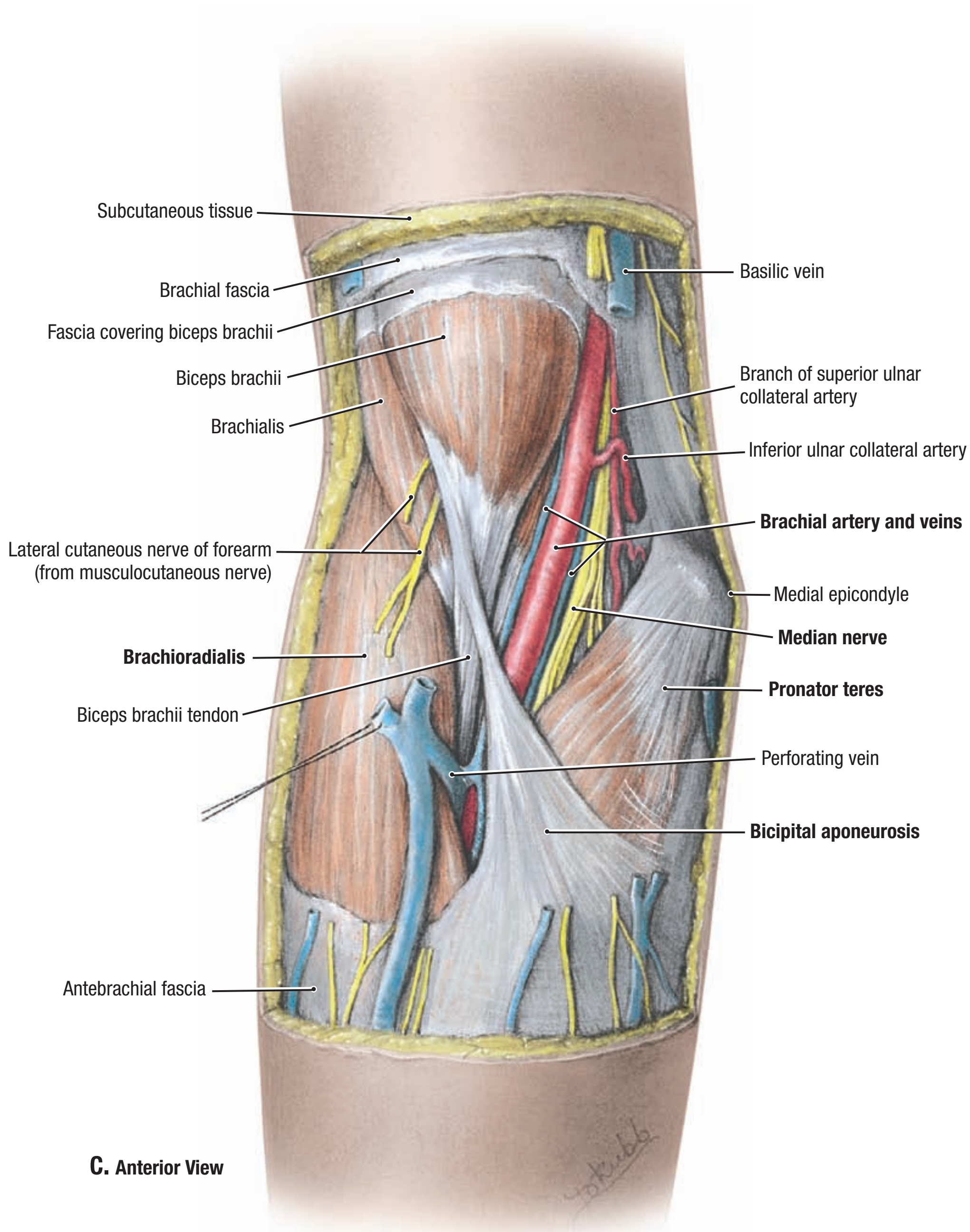


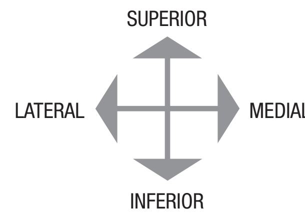
B. **Anterior View**

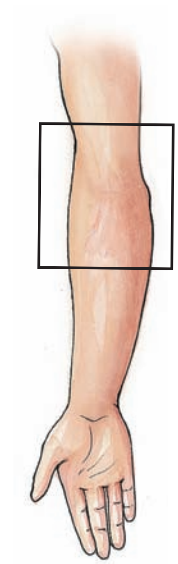
6.49 CUBITAL FOSSA: SURFACE ANATOMY AND SUPERFICIAL DISSECTION

A. Surface anatomy. **B.** Cutaneous nerves and superficial veins (*numbers* in parentheses refer to structures in **A**).

- The cubital fossa is a triangular space (compartment) inferior to the elbow crease, roofed by deep fascia.
- In the forearm, the superficial veins (cephalic, median, basilic, and their connecting veins) make a variable, M-shaped pattern.
- The cephalic and basilic veins occupy the bicipital grooves, one on each side of the biceps brachii. In the lateral bicipital groove, the lateral cutaneous nerve of the forearm appears just superior to the elbow crease; in the medial bicipital groove, the medial cutaneous nerve of the forearm becomes cutaneous at approximately the midpoint of the arm.
- The cubital fossa is the common site for **sampling and transfusion of blood and intravenous injections** because of the prominence and accessibility of veins. Usually, the median cubital vein or basilic vein is selected.





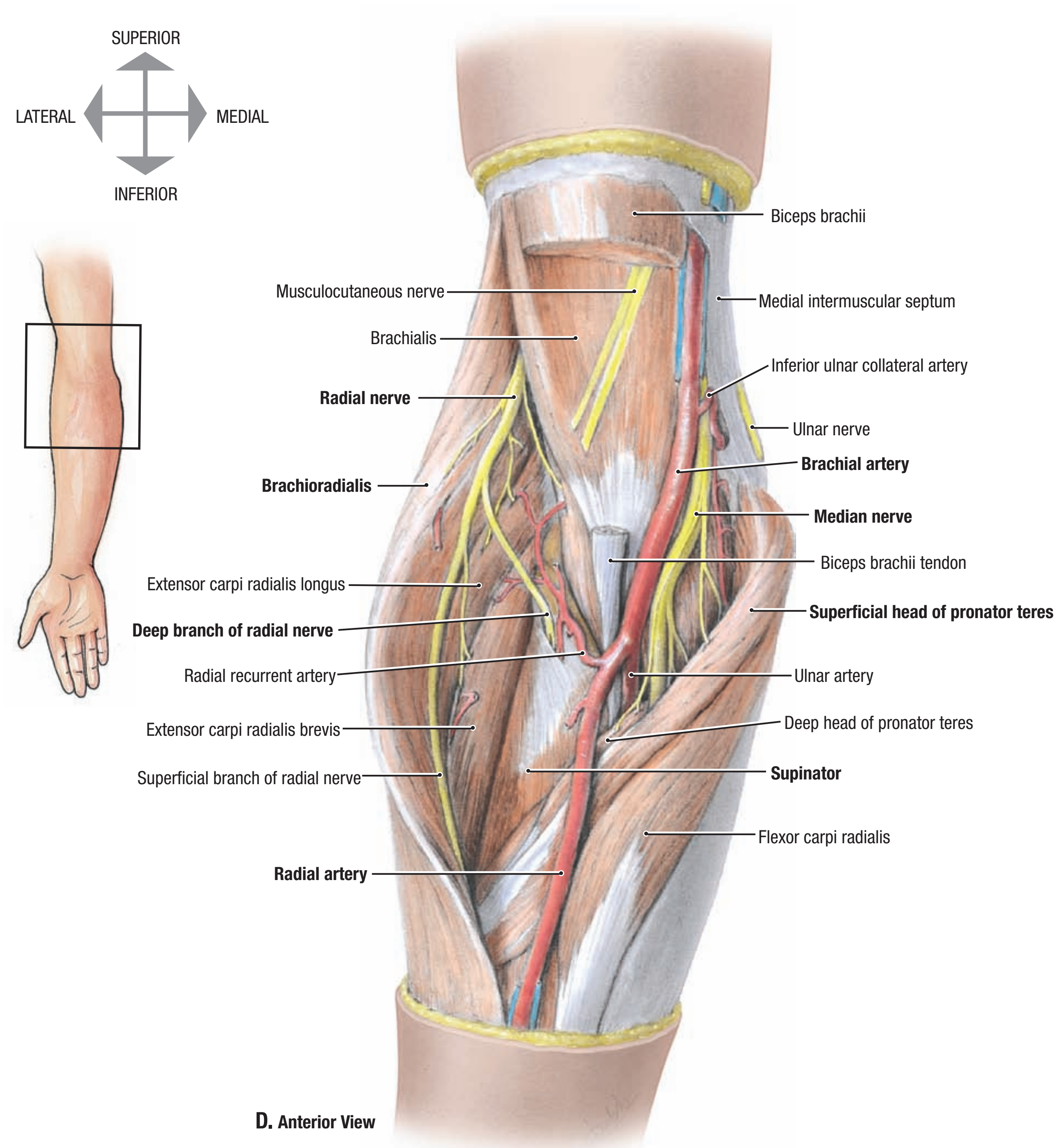


C. Anterior View

6.49 CUBITAL FOSSA: DEEP DISSECTION I

C. Boundaries and contents of the cubital fossa.

- The cubital fossa is bound laterally by the brachioradialis and medially by the pronator teres and superiorly by a line joining the medial and lateral epicondyles.
- The three chief contents of the cubital fossa are the biceps brachii tendon, brachial artery, and median nerve.
- The biceps brachii tendon, on approaching its insertion, rotates through 90°, and the bicipital aponeurosis extends medially from the proximal part of the tendon.
- A fracture of the distal part of the humerus, near the supra-epicondylar ridges, is called a **supra-epicondylar (supracondylar) fracture.** The distal bone fragment may be displaced anteriorly or posteriorly. Any of the nerves or branches of the brachial vessels related to the humerus may be injured by a displaced bone fragment.

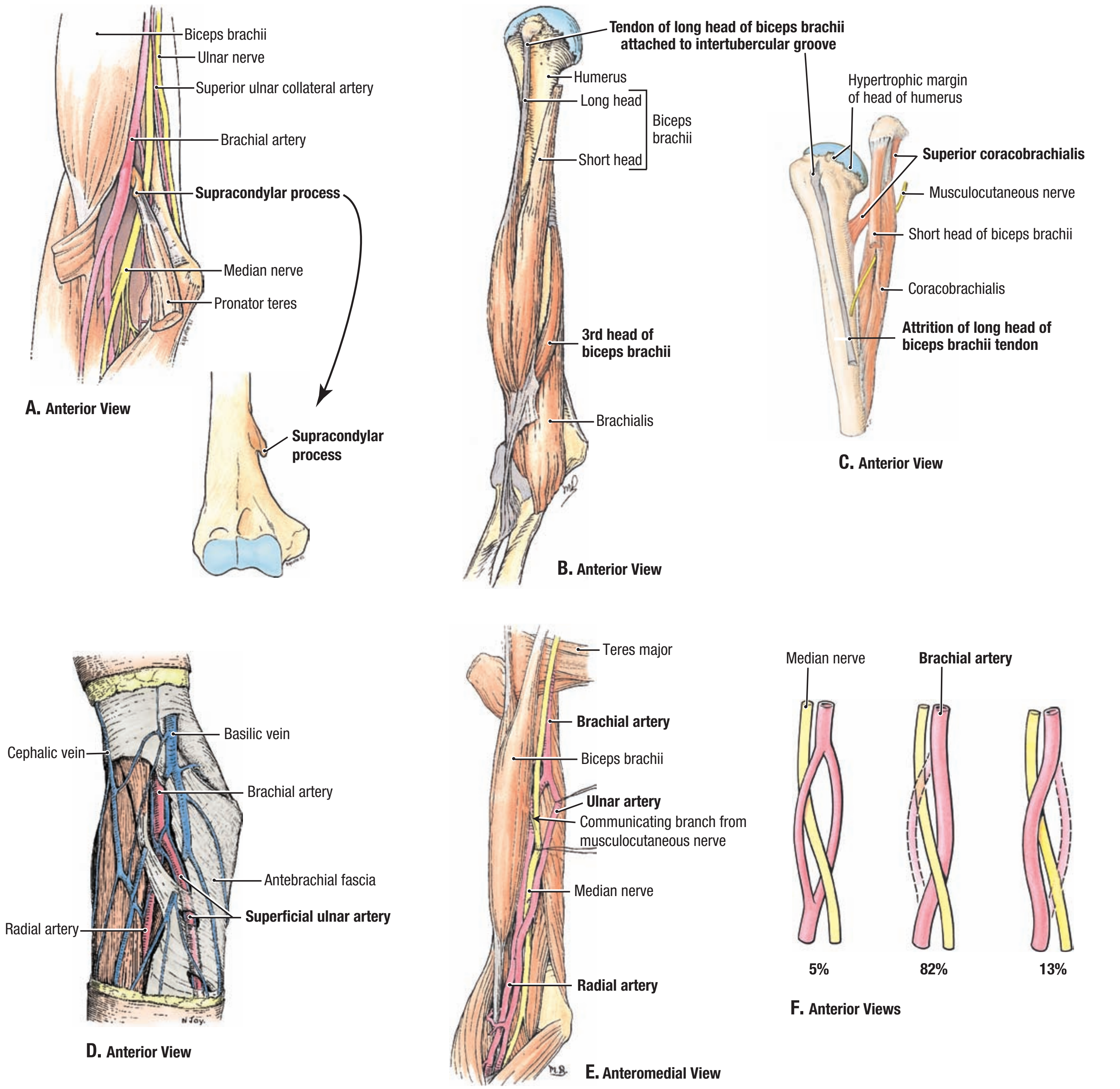


D. Anterior View

6.49 CUBITAL FOSSA: DEEP DISSECTION II

D. Floor of the cubital fossa.

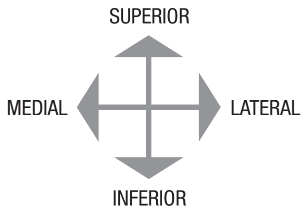
- Part of the biceps brachii muscle is excised, and the cubital fossa is opened widely, exposing the brachialis and supinator muscles in the floor of the fossa.
- The deep branch of the radial nerve pierces the supinator.
- The brachial artery lies between the biceps tendon and median nerve and divides into two branches, the ulnar and radial arteries.
- The median nerve supplies the flexor muscles. With the exception of the twig to the deep head of pronator teres, its motor branches arise from its medial side.
- The radial nerve supplies the extensor muscles. With the exception of the twig to brachioradialis, its motor branches arise from its lateral side. In this specimen, the radial nerve has been displaced laterally, so here its lateral branches appear to run medially.

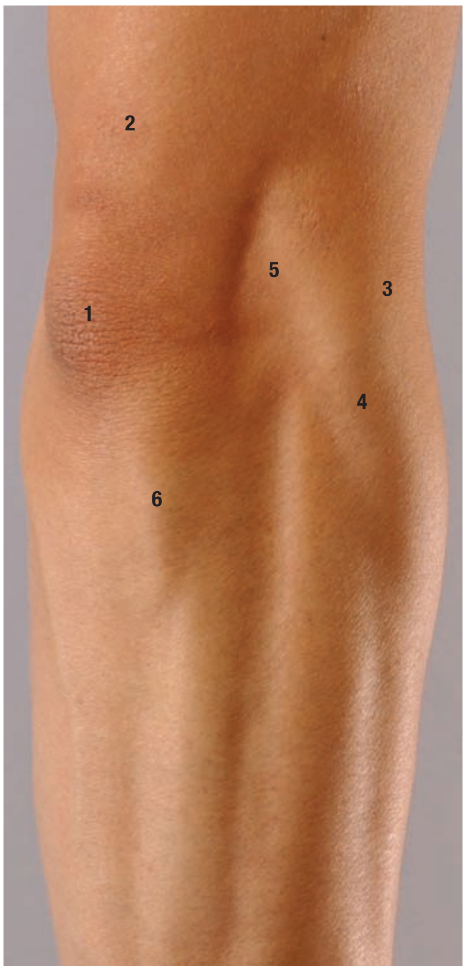


6.50 ANOMALIES

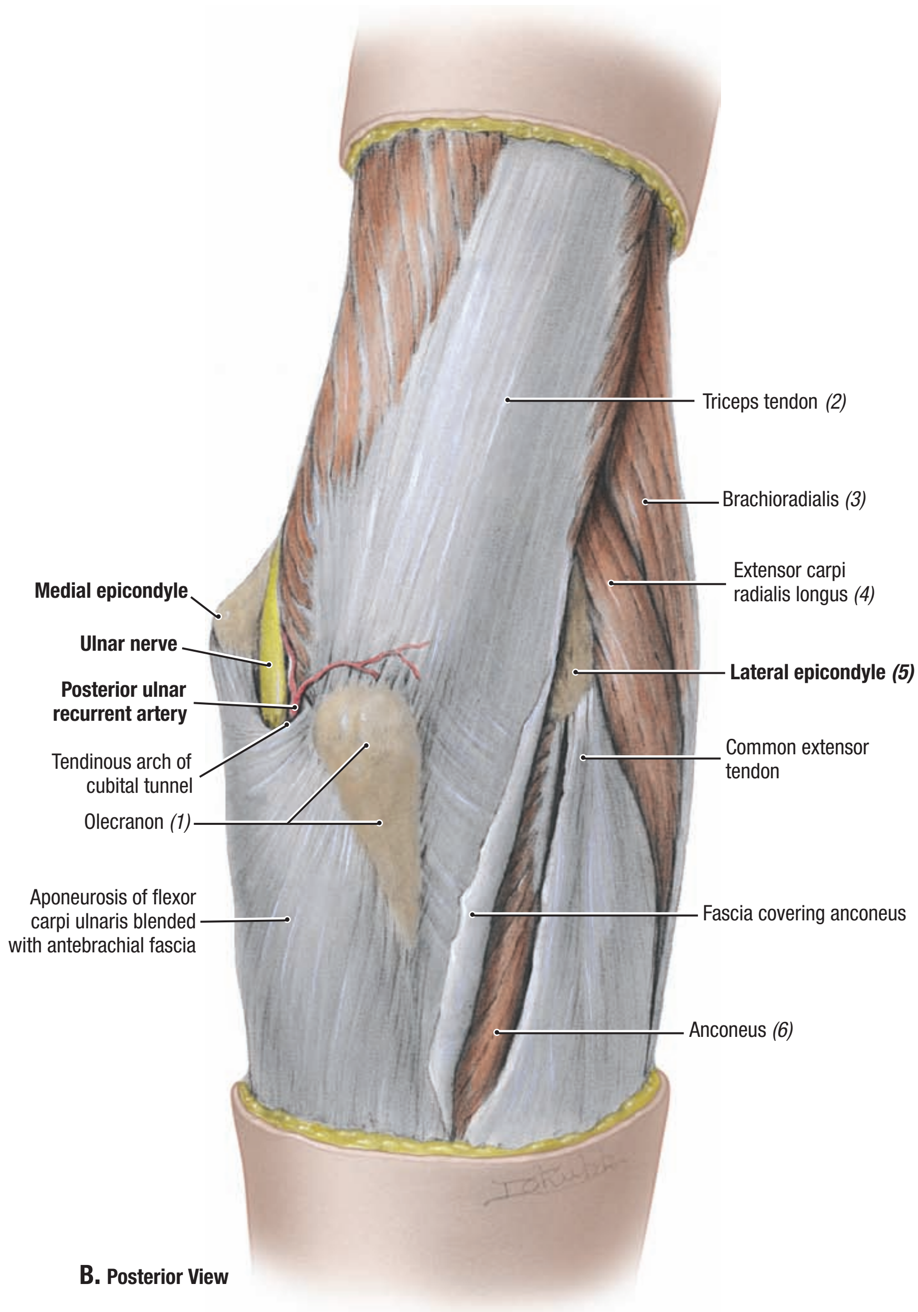
A. Supracondylar process of humerus. A fibrous band, from which the pronator teres muscle arises, joins this supra-epicondylar process to the medial epicondyle. The median nerve, often accompanied by the brachial artery, passes through the foramen formed by this band. This may be a cause of nerve entrapment. **B. Third head of biceps brachii.** In this case, there is also attrition of the biceps tendon. **C.** Attrition of the tendon of the long head of biceps brachii and presence of a coracobrachialis.

D. Superficial ulnar artery. E. Anomalous division of brachial artery. In this case, the median nerve passes between the radial and ulnar arteries, which arise high in the arm. **F. Relationship of median nerve and brachial artery.** The variable relationship of these two structures can be explained developmentally. In a study of 307 limbs in Dr. Grant's lab, portions of both primitive brachial arteries persisted in 5%, the posterior in 82%, and the anterior in 13%.





A. **Posterior View**

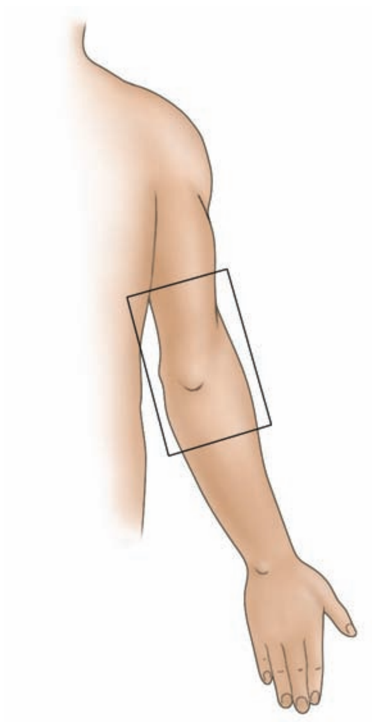


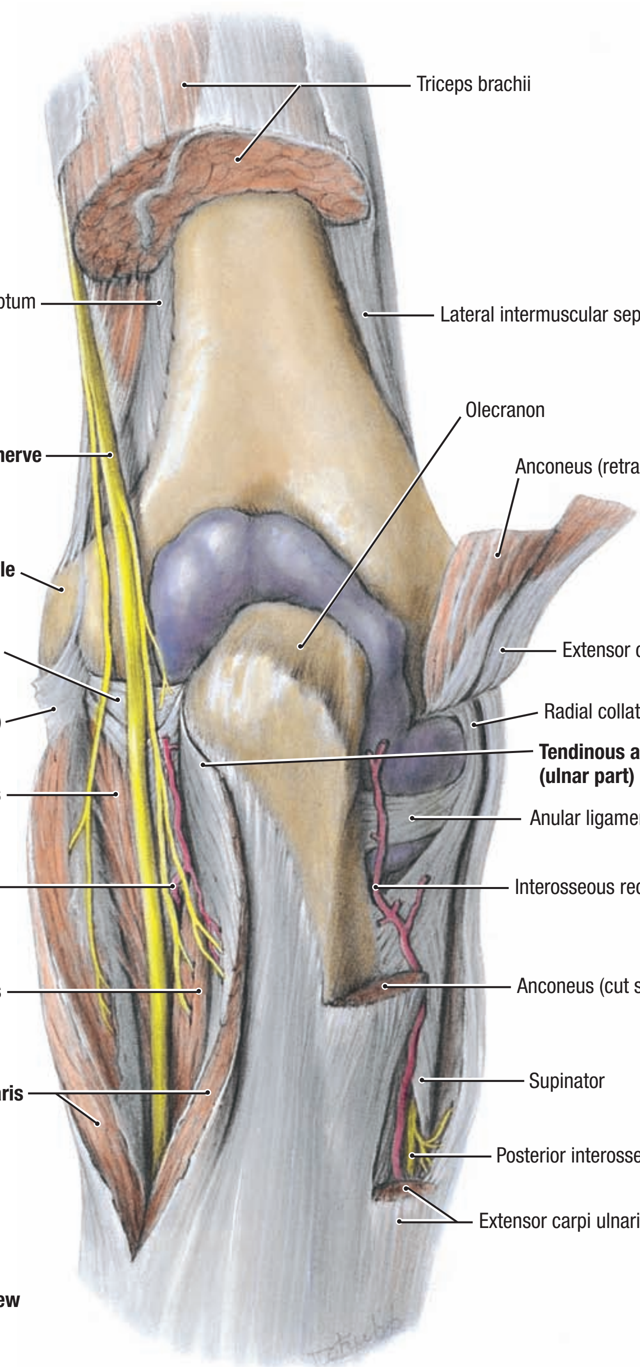
B. **Posterior View**

6.51 POSTERIOR ASPECT OF ELBOW I

A. Surface anatomy. **B.** Superficial dissection (*numbers* in parentheses refer to structures in **A**).

- The triceps brachii is attached distally to the superior surface of the olecranon and, through the deep fascia covering the anconeus, into the lateral border of olecranon.
- The posterior surfaces of the medial epicondyle, lateral epicondyle, and olecranon are subcutaneous and palpable.
- The ulnar nerve, also palpable, runs subfascially posterior to the medial epicondyle; distal to this point, it disappears deep to the two heads of the flexor carpi ulnaris.



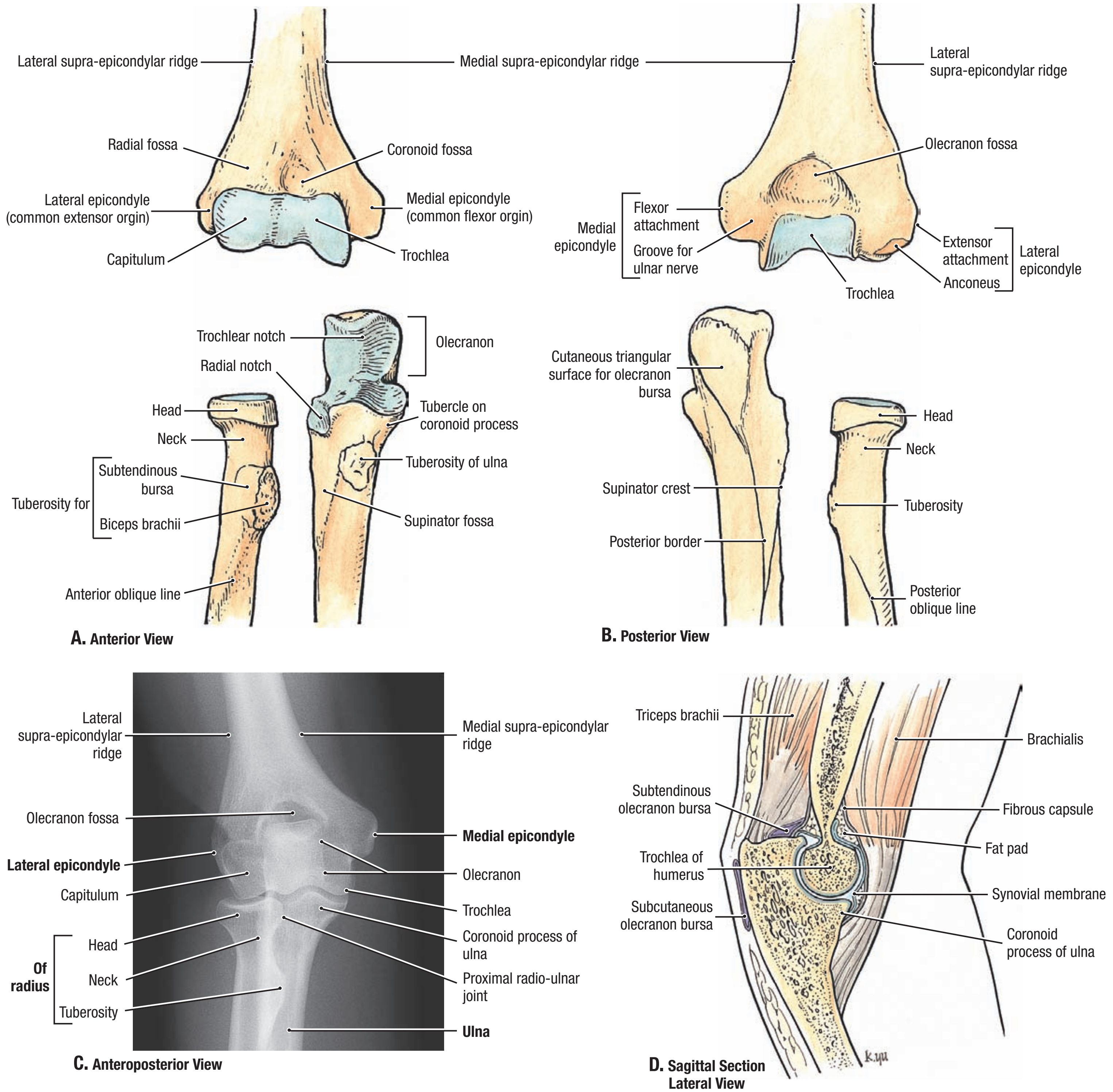


6.52 POSTERIOR ASPECT OF ELBOW II

Deep dissection. The distal portion of the triceps brachii muscle was removed.

- The ulnar nerve descends subfascially within the posterior compartment of the arm, passing posterior to the medial epicondyle in the groove for the ulnar nerve. Next it passes posterior to the ulnar collateral ligament of the elbow joint and then between the flexor carpi ulnaris and flexor digitorum profundus muscles.

Ulnar nerve injury occurs most commonly where the nerve passes posterior to the medial epicondyle of the humerus. The injury results when the medial part of the elbow hits a hard surface, fracturing the medial epicondyle. The ulnar nerve may be compressed in the cubital tunnel, resulting in **cubital tunnel syndrome.** The cubital tunnel is formed by the tendinous arch joining the humeral and ulnar heads of attachment of the flexor carpi ulnaris muscle. Ulnar nerve injury can result in extensive motor and sensory loss to the hand.

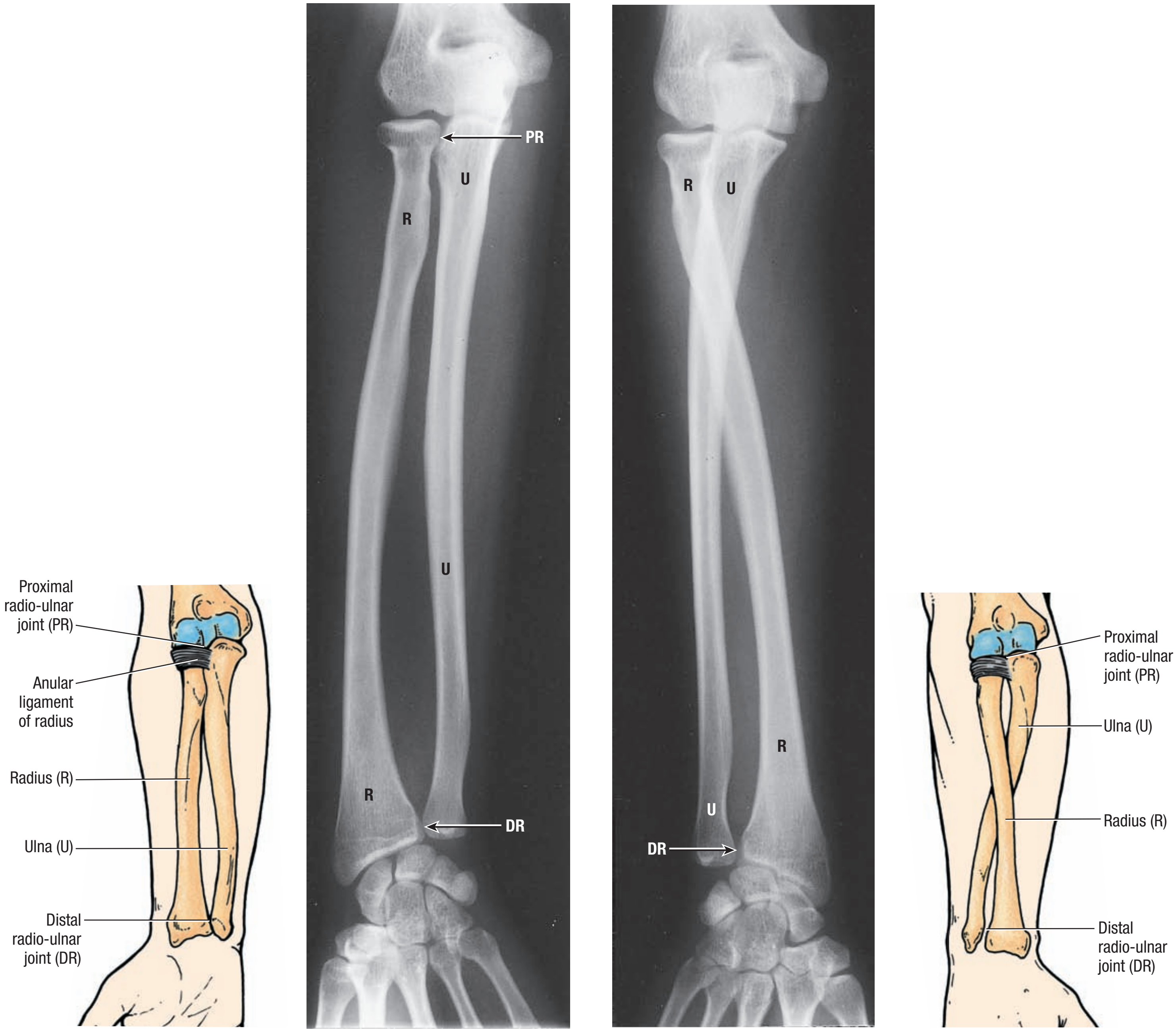


6.53 BONES AND IMAGING OF ELBOW REGION

A. Anterior bony features. **B.** Posterior bony features. **C.** Radiograph of elbow joint. **D.** Section of humero-ulnar joint.

The subcutaneous olecranon bursa is exposed to injury during falls on the elbow and to infection from abrasions of the skin covering the olecranon. Repeated excessive pressure and friction produces a friction **subcutaneous olecranon bursitis** (e.g., "student's elbow").

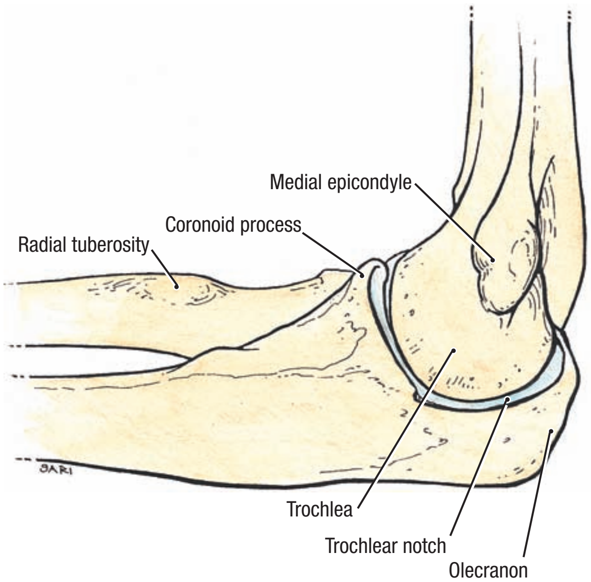
Subtendinous olecranon bursitis results from excessive friction between the triceps tendon and the olecranon. For example, it may occur due to repeated flexion-extension of the forearm during certain assembly-line jobs. The pain is severe during flexion of the forearm because of pressure exerted on the inflamed subtendinous olecranon bursa by the triceps tendon.



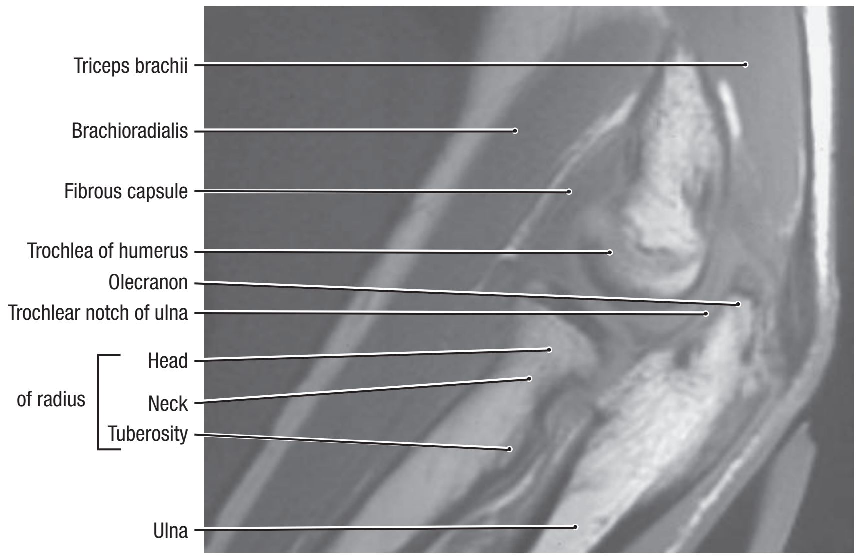
A. **Anterior View, Supination** **B.** **Anterior View, Pronation**

6.54 SUPINATION AND PRONATION AT SUPERIOR, MIDDLE, AND INFERIOR RADIO-ULNAR JOINTS

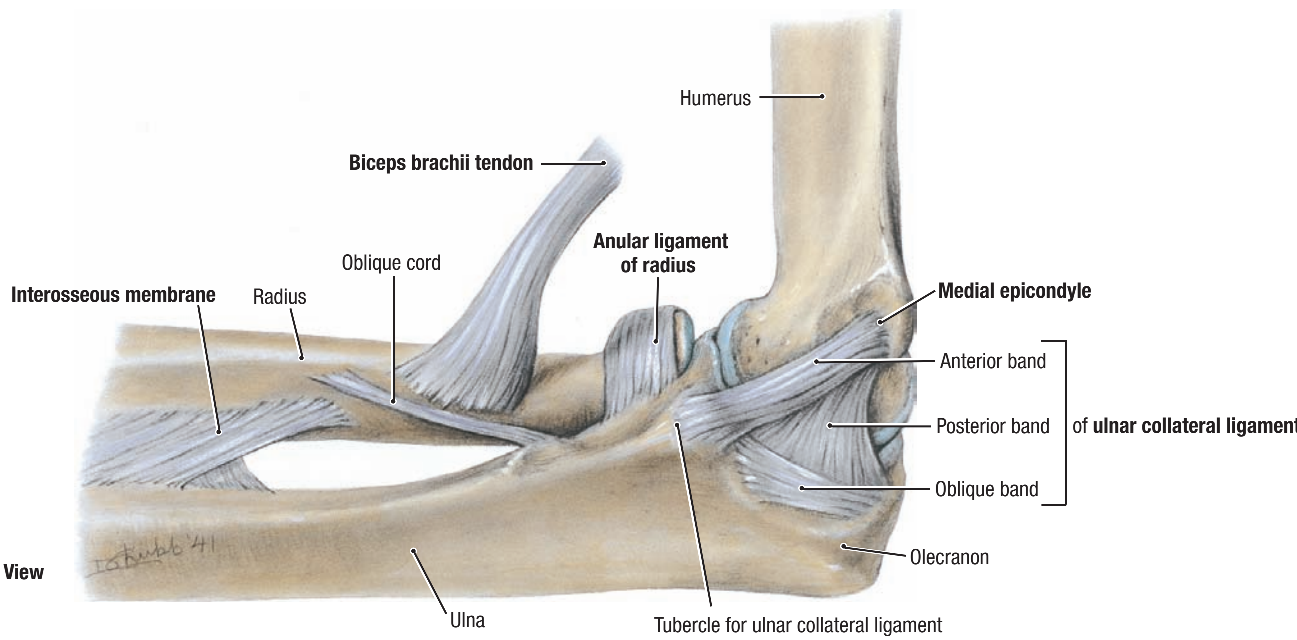
A. Radiograph of forearm in supination. **B.** Radiograph of forearm in pronation. The radius crosses the ulna when the forearm is pronated. The superior and inferior radio-ulnar joints are synovial joints; the middle radio-ulnar joint is a syndesmosis (fibrous joint) in which the interosseous ligament connects the forearm bones.



A. Medial View



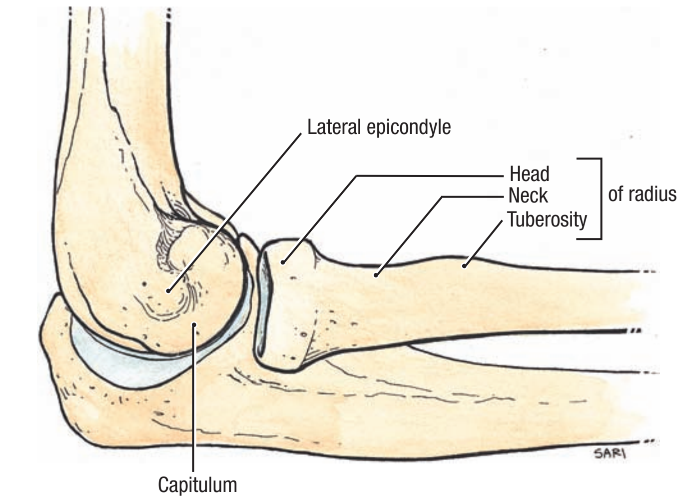
B. Sagittal MRI



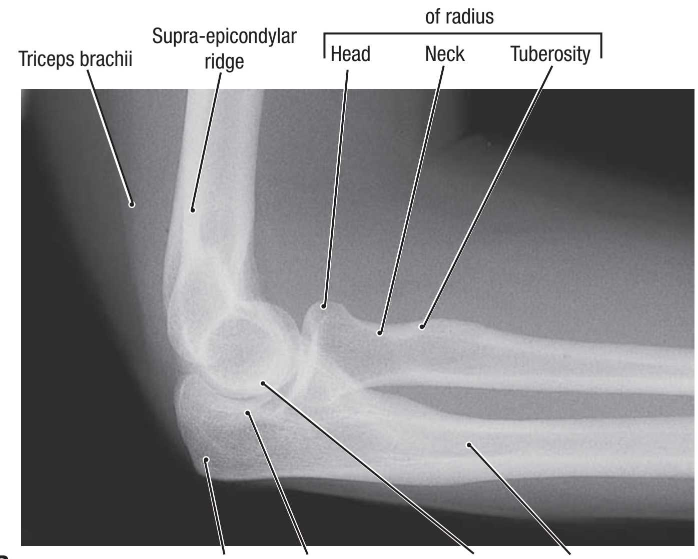
C. Medial View

6.55 MEDIAL ASPECT OF BONES AND LIGAMENTS OF ELBOW REGION

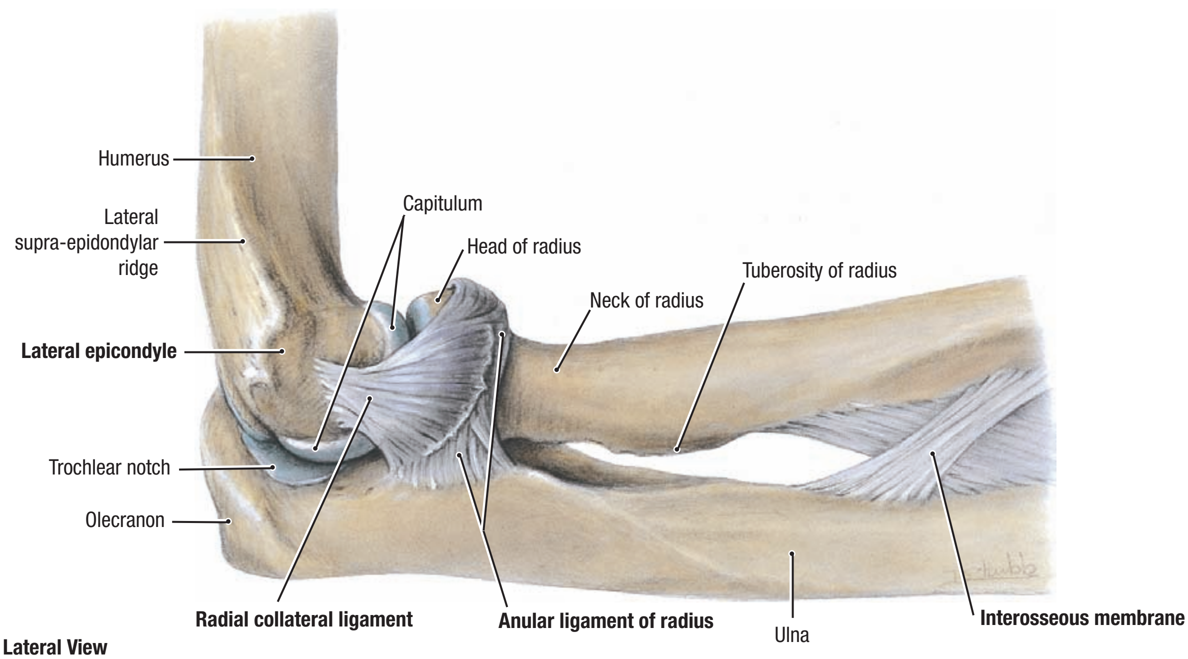
A. Bony features. **B.** MRI of elbow joint. **C.** Ligaments. The anterior band of the ulnar (medial) collateral ligament is a strong, round cord that is taut when the elbow joint is extended. The posterior band is a weak fan that is taut in flexion of the joint.



A. Lateral View



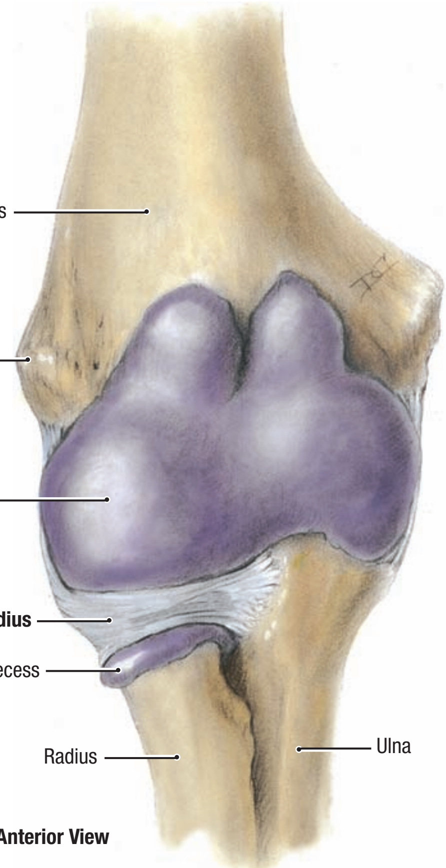
B. Lateral View



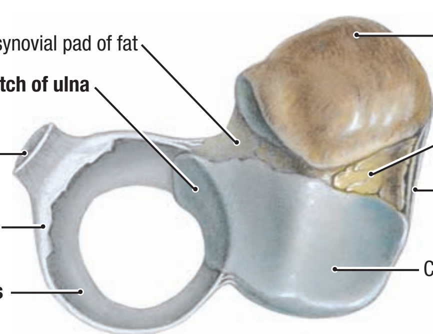
C. Lateral View

6.56 LATERAL ASPECT OF BONES AND LIGAMENTS OF ELBOW REGION

A. Bony features. **B.** Lateral radiograph. **C.** Ligaments. The fan-shaped radial (lateral) collateral ligament is primarily attached to the anular ligament of the radius; superficial fibers of the lateral ligament blend with the fibrous capsule and continue onto the radius.



A. **Anterior View**



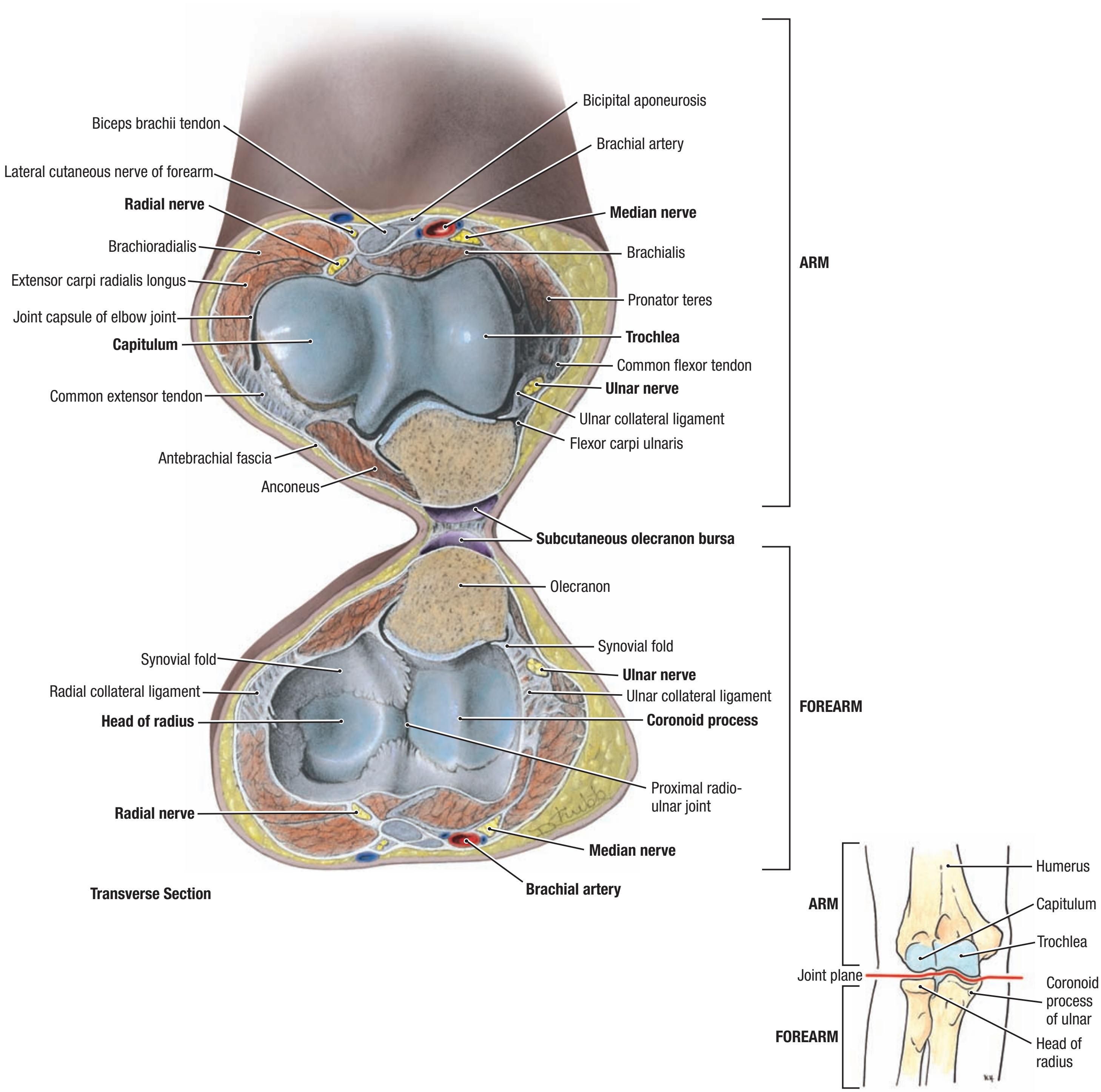
B. **Superior View**

6.57 SYNOVIAL CAPSULE OF ELBOW JOINT AND ANULAR LIGAMENT

A. Synovial capsule of elbow and proximal radio-ulnar joints. The cavity of the elbow was injected with purple fluid (wax). The fibrous capsule was removed, and the synovial membrane remains. **B.** Anular ligament.

- The anular ligament secures the head of the radius to the radial notch of the ulna and with it forms a tapering columnar socket (i.e., wide superiorly, narrow inferiorly).
- The anular ligament is bound to the humerus by the radial collateral ligament of the elbow.

A common childhood injury is **subluxation and dislocation of the head of the radius** after traction on a pronated forearm (e.g., when lifting a child onto a bus). The sudden pulling of the upper limb tears or stretches the distal attachment of the less tapering anular ligament of a child. The radial head then moves distally, partially out of the anular ligament. The proximal part of the torn ligament may become trapped between the head of the radius and the capitulum of the humerus. The source of pain is the pinched anular ligament.



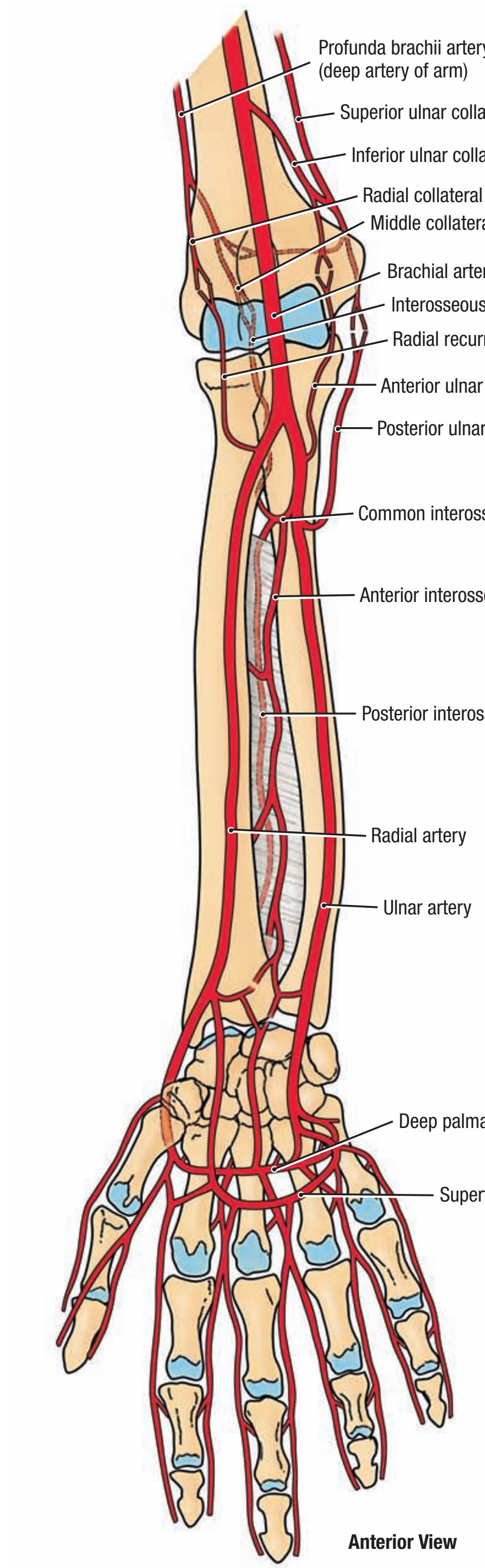
6.58 ARTICULAR SURFACES OF ELBOW JOINT

The tissue surrounding the condyles of the humerus has been sectioned in a transverse plane, followed by disarticulation of the elbow joint, revealing the articular surfaces. Compare the forearm (inferior) component with Figure 6.57B.

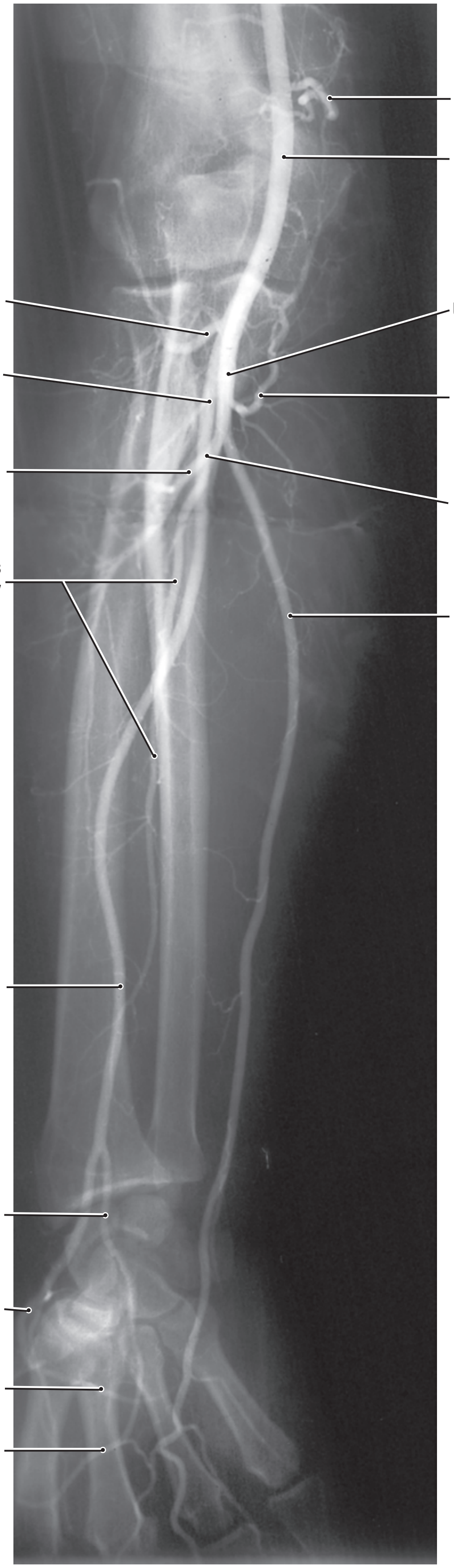
- Synovial folds containing fat overlie the periphery of the head of the radius and the nonarticular indentations on the trochlear notch of the ulna.
- The radial nerve is in contact with the joint capsule, the ulnar nerve is in contact with the ulnar collateral ligament, and the median nerve is separated from the joint capsule by the brachialis muscle.

TABLE 6.11 ARTERIES OF FOREARM

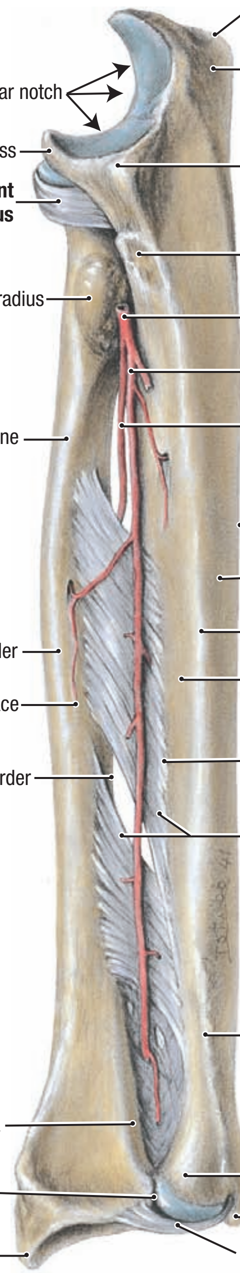
Radial artery	
Origin: In cubital fossa, as smaller terminal branch of brachial artery	
Course/Distribution: Runs distally under brachioradialis, lateral to flexor carpi radialis, defining boundary between the flexor and extensor compartments and supplying the radial aspect of both. Gives rise to a superficial palmar branch near the radiocarpal joint; it then transverses the anatomical snuff box to pass between the heads of the 1st dorsal interosseous muscle joining the deep branch of the ulnar artery to form the deep palmar arch	
Ulnar artery	
Origin: In cubital fossa, as larger terminal branch of brachial artery	
Course/Distribution: Passes distally between 2nd and 3rd layers of forearm flexor muscles, supplying ulnar aspect of flexor compartment; passes superficial to flexor retinaculum at wrist, continuing as the superficial palmar arch (with superficial branch of radial) after its deep palmar branch joins the deep palmar arch	
Radial recurrent artery	
Origin: In cubital fossa, as 1st (lateral) branch of radial artery	
Course/Distribution: Courses proximally, superficial to supinator, passing between brachioradialis and brachialis to anastomose with radial collateral artery	
Anterior and posterior ulnar recurrent arteries	
Origin: In and immediately distal to cubital fossa, as 1st and 2nd medial branches of ulnar artery	
Course/Distribution: Course proximally to anastomose with the inferior and superior ulnar collateral arteries, respectively, forming collateral pathways anterior and posterior to the medial epicondyle of the humerus	
Common interosseous artery	
Origin: Immediately distal to the cubital fossa, as 1st lateral branch of ulnar artery	
Course/Distribution: Terminates almost immediately, dividing into anterior and posterior interosseous arteries	
Anterior and posterior interosseous arteries	
Origin: Distal to radial tubercle, as terminal branches of common interosseous	
Course/Distribution: Pass to opposite sides of interosseous membrane; anterior artery runs on interosseous membrane; posterior artery runs between superficial and deep layers of extensor muscles as primary artery of compartment	
Interosseous recurrent artery	
Origin: Initial part of posterior interosseous artery	
Course/Distribution: Courses proximally between lateral epicondyle and olecranon, deep to anconeus, to anastomose with middle collateral artery	



6.59 ARTERIES OF FOREARM



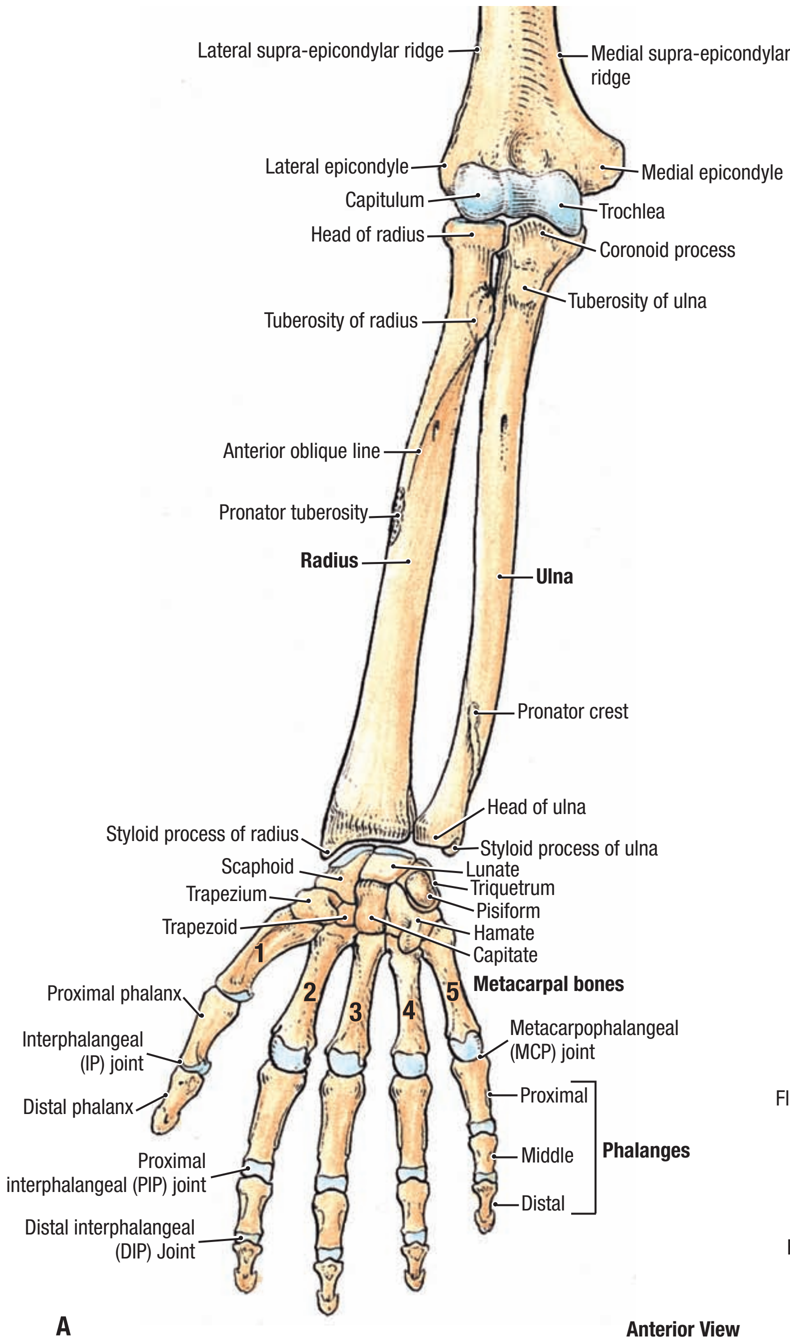
A. Anteroposterior View

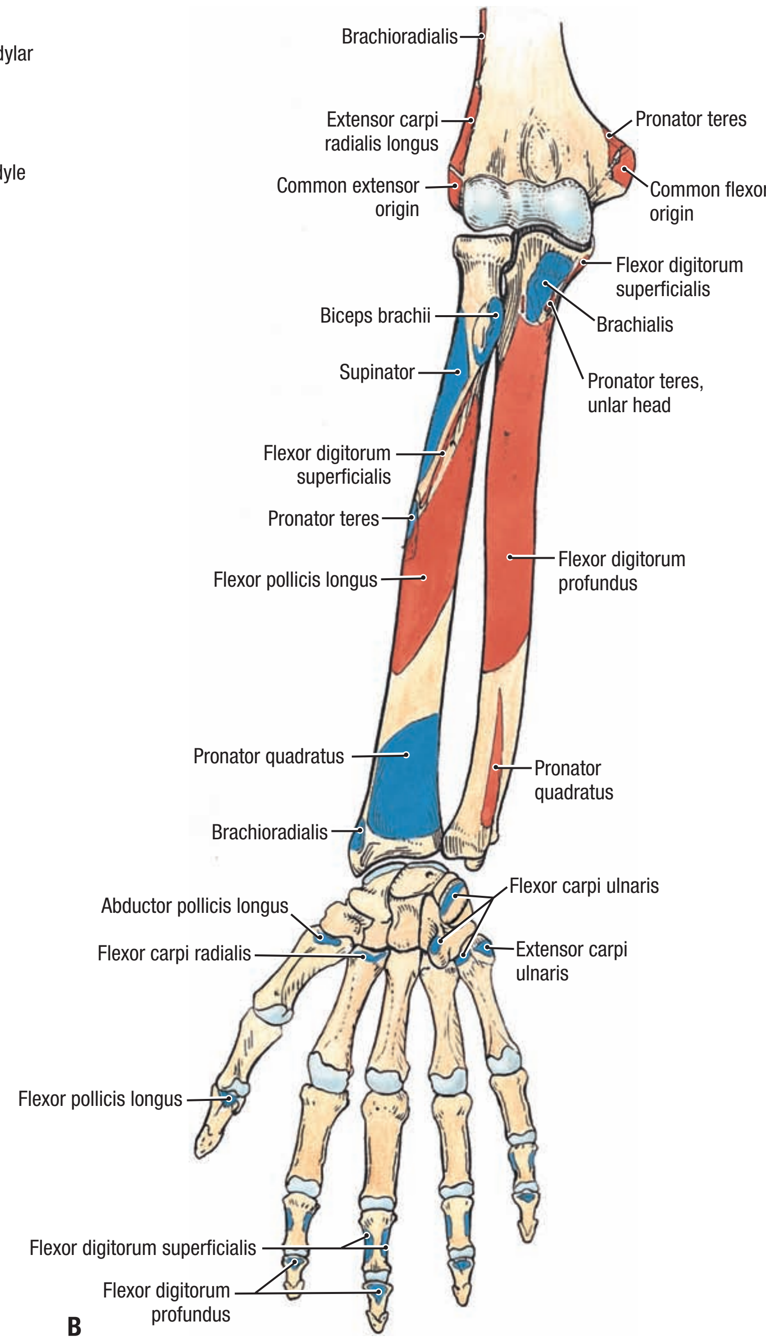


B. Anterior View

6.60 ARTERIES OF FOREARM AND LIGAMENTS OF RADIO-ULNAR JOINTS

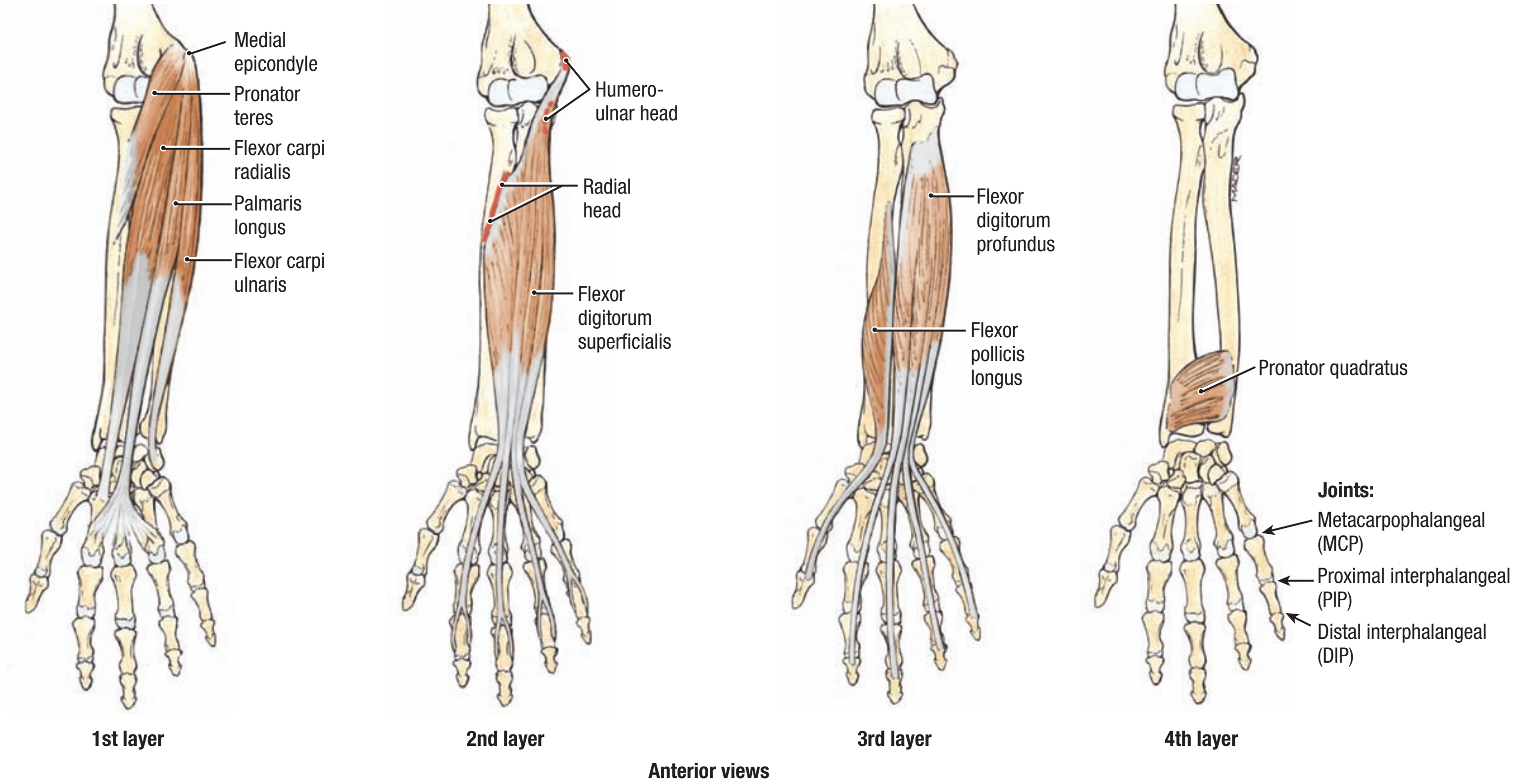
A. Brachial arteriogram. **B.** Radio-ulnar ligaments and interosseous arteries. The ligament maintaining the proximal radio-ulnar joint is the anular ligament, that for the distal joint is the articular disc, and that for the middle joint is the interosseous membrane. The interosseous membrane is attached to the interosseous borders of the radius and ulna, but it also spreads onto their surfaces.





6.61 BONES OF FOREARM AND HAND AND ATTACHMENTS OF FOREARM MUSCLES

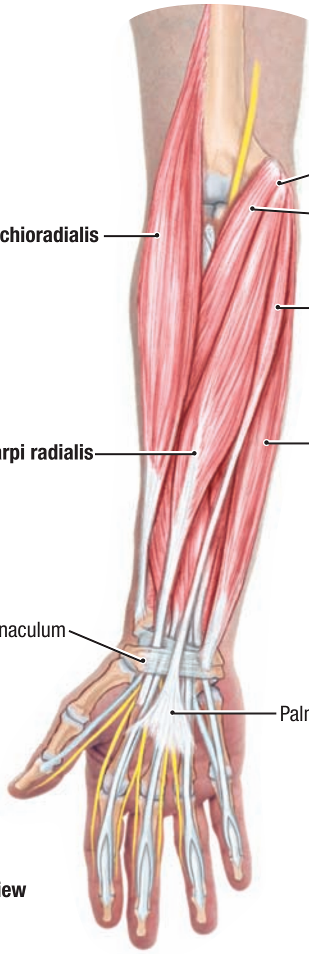
A. Bony features. **B.** Sites of muscle attachments.



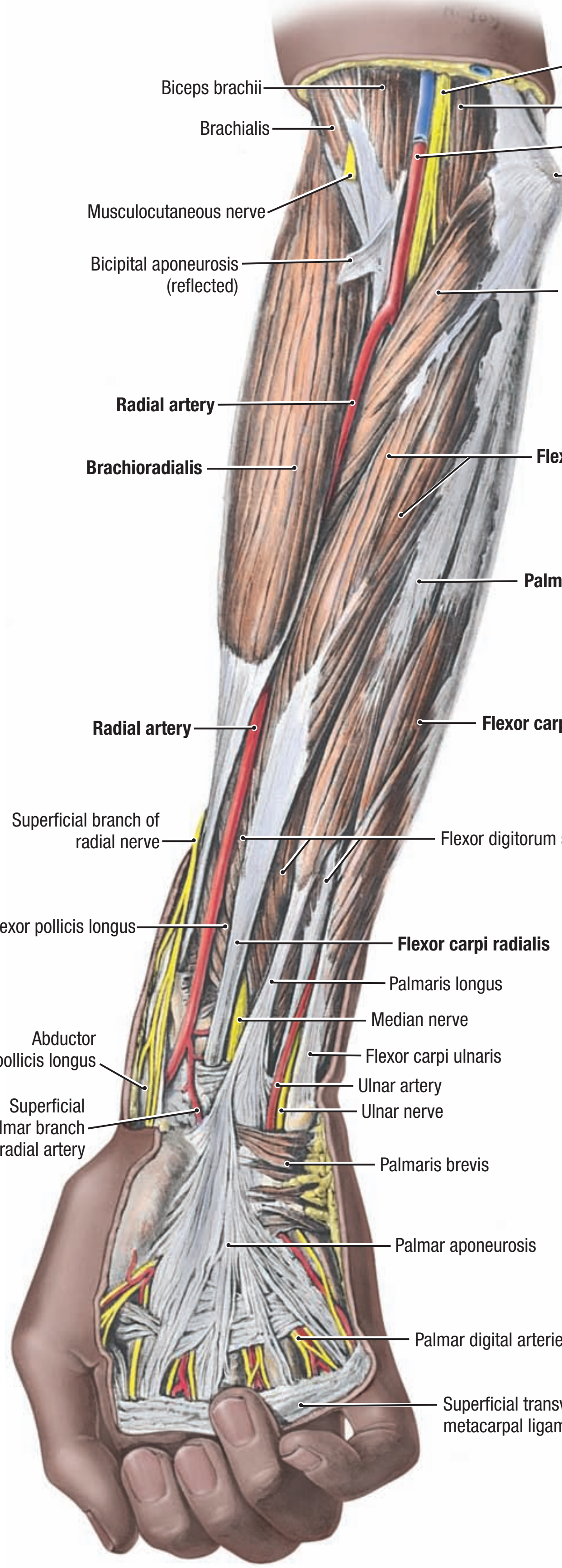
6.62 MUSCLES OF ANTERIOR ASPECT OF FOREARM

TABLE 6.12 MUSCLES OF ANTERIOR ASPECT OF FOREARM

Muscle	Proximal Attachment	Distal Attachment	Innervation	Main Actions
Pronator teres	Medial epicondyle of humerus and coronoid process of ulna	Middle of lateral surface of radius (pronator tuberosity)	Median nerve (C6–**C7**)	Pronates forearm and flexes elbow joint
Flexor carpi radialis	Medial epicondyle of humerus	Base of 2nd and 3rd metacarpals		Flexes and abducts wrist joint
Palmaris longus		Distal half of flexor retinaculum and palmar aponeurosis	Median nerve (C7–**C8**)	Flexes wrist joint and tightens palmar aponeurosis
Flexor carpi ulnaris	*Humeral head:* medial epicondyle of humerus; *Ulnar head:* olecranon and posterior border of ulna	Pisiform, hook of hamate, and 5th metacarpal	Ulnar nerve (C7–**C8**)	Flexes and adducts wrist joint
Flexor digitorum superficialis	*Humero-ulnar head:* medial epicondyle of humerus, ulnar collateral ligament, and coronoid process of ulna *Radial head:* superior half of anterior border of radius	Bodies of middle phalanges of medial four digits	Median nerve (C7, **C8**, and T1)	Flexes PIPs of medial four digits; acting more strongly, it flexes MCPs and wrist joint
Flexor digitorum profundus	Proximal three quarters of medial and anterior surfaces of ulna and interosseous membrane	Bases of distal phalanges of medial four digits	*Medial part:* ulnar nerve (**C8**–T1) *Lateral part:* median nerve (**C8**–T1)	Flexes DIPs of medial four digits; assists with flexion of wrist joint
Flexor pollicis longus	Anterior surface of radius and adjacent interosseous membrane	Base of distal phalanx of thumb	Anterior interosseous nerve from median (**C8**–T1)	Flexes IP joints of 1st digit (thumb) and assists flexion of wrist joint
Pronator quadratus	Distal fourth of anterior surface of ulna	Distal fourth of anterior surface of radius		Pronates forearm; deep fibers bind radius and ulna together



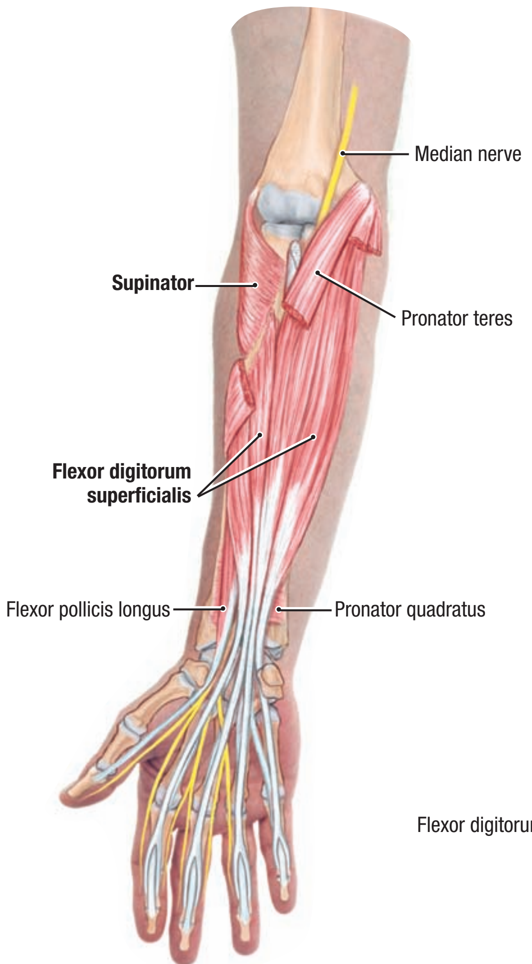
A. Anterior View



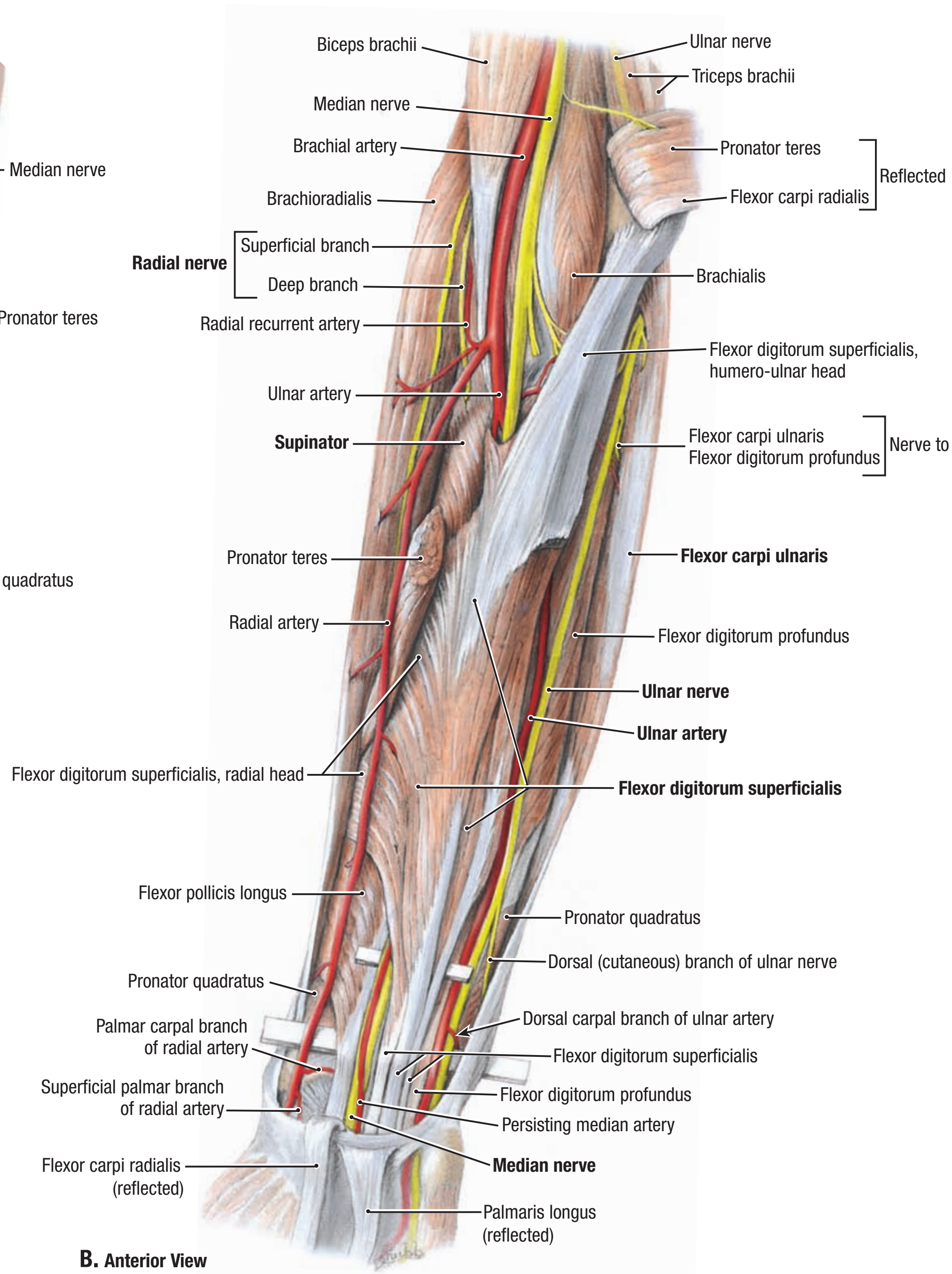
B. Anterior View

6.63 SUPERFICIAL MUSCLES OF FOREARM AND PALMAR APONEUROSIS

- At the elbow, the brachial artery lies between the biceps tendon and median nerve. It then bifurcates into the radial and ulnar arteries.
- At the wrist, the radial artery is lateral to the flexor carpi radialis tendon, and the ulnar artery is lateral to flexor carpi ulnaris tendon.
- In the forearm, the radial artery lies between the flexor and extensor compartments. The muscles lateral to the artery are supplied by the radial nerve, and those medial to it by the median and ulnar nerves; thus, no motor nerve crosses the radial artery.
- The brachioradialis muscle slightly overlaps the radial artery, which is otherwise superficial.
- The four superficial muscles all attach proximally to the medial epicondyle of the humerus (common flexor origin).
- The palmaris longus muscle, in this specimen, has an anomalous distal belly; this muscle usually has a small belly at the common flexor origin and a long tendon that is continued into the palm as the palmar aponeurosis. The palmaris longus is absent unilaterally or bilaterally in approximately 14% of limbs.



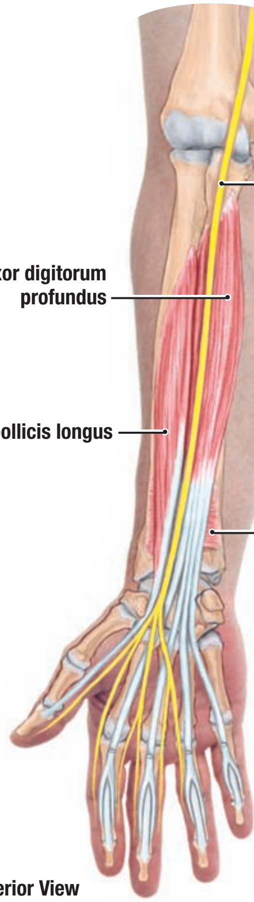
A. **Anterior View**



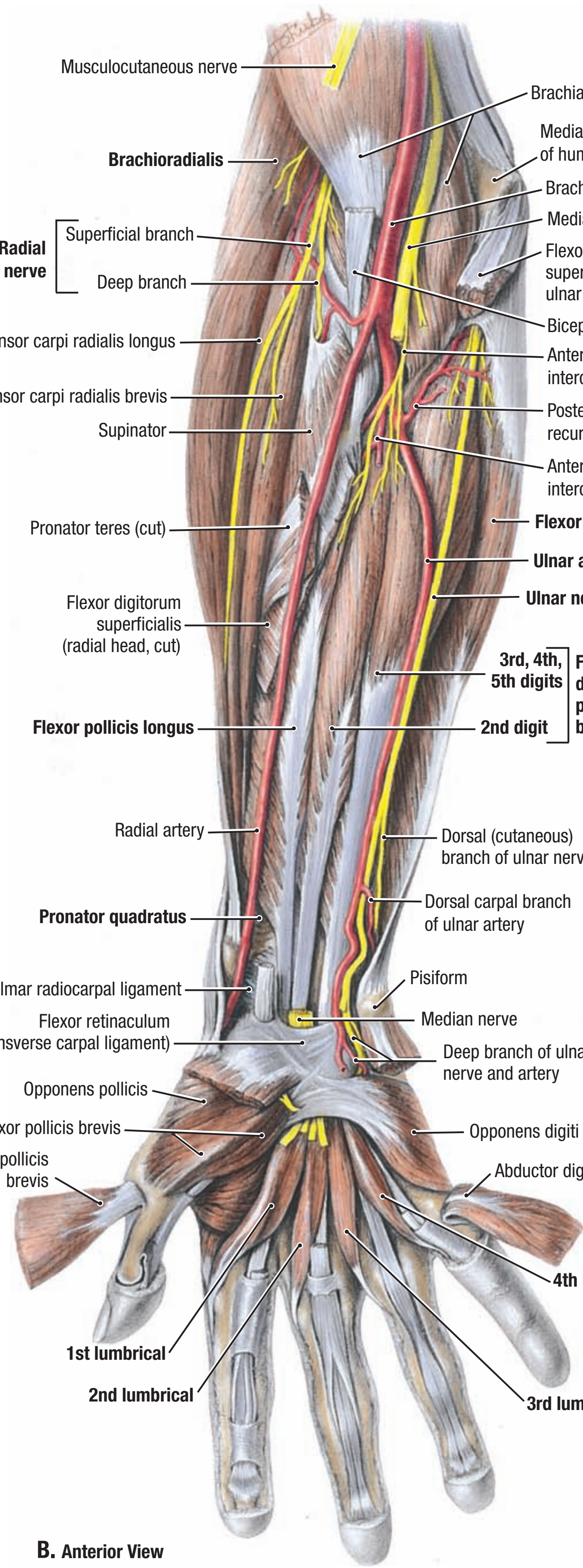
B. **Anterior View**

6.64 FLEXOR DIGITORUM SUPERFICIALIS AND RELATED STRUCTURES

- The flexor digitorum superficialis muscle is attached proximally to the humerus, ulna, and radius.
- The ulnar artery passes obliquely posterior to the flexor digitorum superficialis; at the medial border of the muscle, the ulnar artery joins the ulnar nerve.
- The ulnar nerve lies between the flexor digitorum profundus and flexor carpi ulnaris.
- The median nerve descends vertically posterior to the flexor digitorum superficialis and appears distally at its lateral border.
- The median artery of this specimen is a variation resulting from persistence of an embryologic vessel that usually disappears.



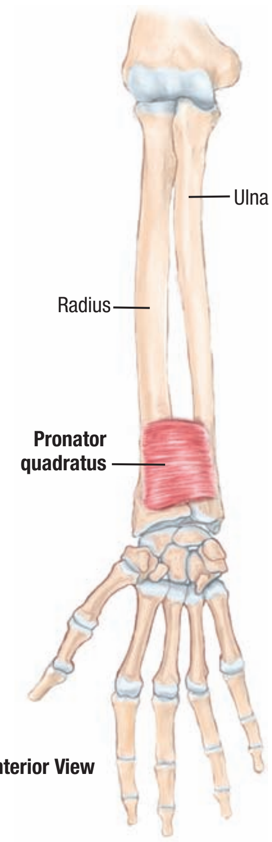
A. Anterior View



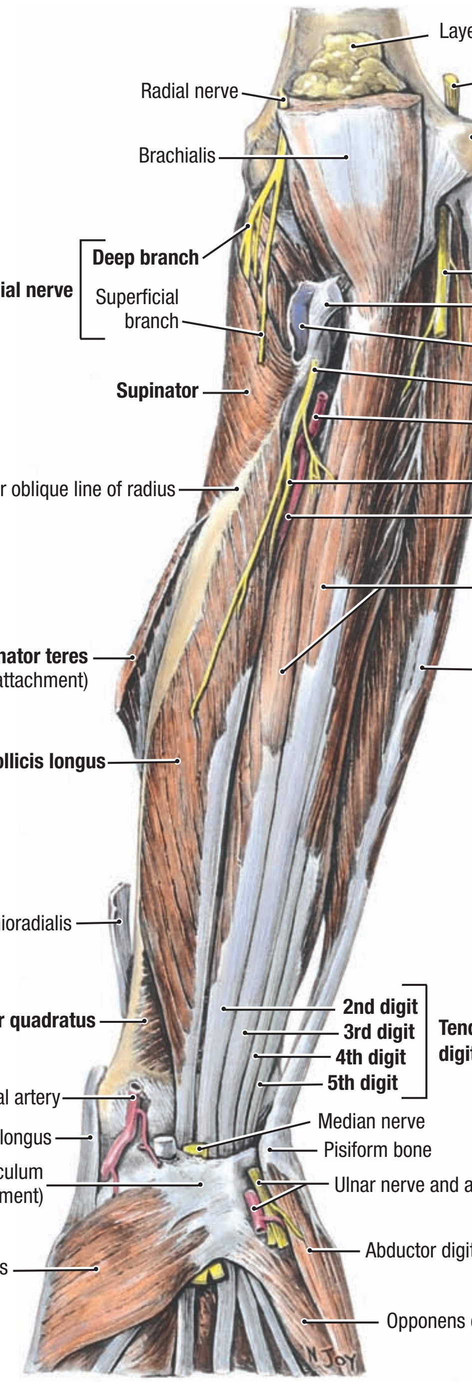
B. Anterior View

6.65 DEEP FLEXORS OF DIGITS AND RELATED STRUCTURES

- The ulnar nerve enters the forearm posterior to the medial epicondyle, then descends between the flexor digitorum profundus and flexor carpi ulnaris and is joined by the ulnar artery. At the wrist the ulnar nerve and artery pass anterior to the flexor retinaculum and lateral to the pisiform to enter the palm.
- At the elbow, the ulnar nerve supplies the flexor carpi ulnaris and the medial half of the flexor digitorum profundus muscles; proximal to the wrist, it gives off the dorsal (cutaneous) branch.
- The four lumbricals arise from the flexor digitorum profundus tendons.



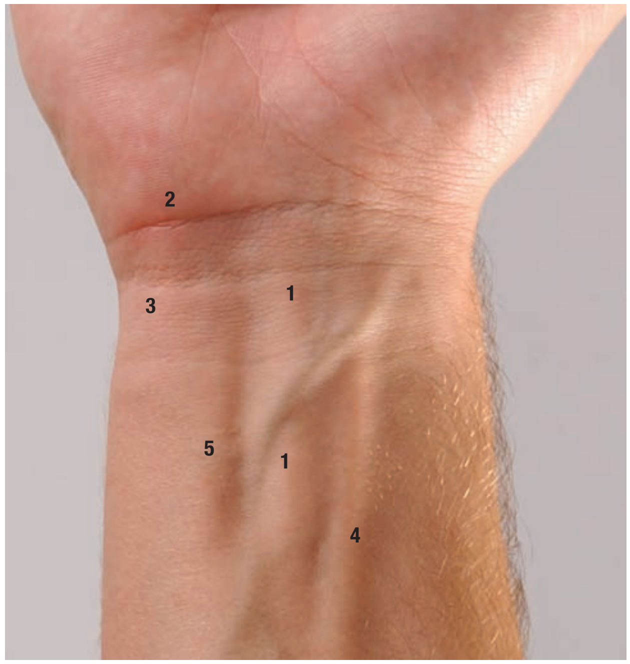
A. Anterior View



B. Anterior View

6.66 DEEP FLEXORS OF DIGITS AND SUPINATOR

- The five tendons of the deep digital flexors (flexor pollicis longus and flexor digitorum profundus) lie side by side as they enter the carpal tunnel.
- The deep branch of the radial nerve pierces and innervates the supinator muscle.
- The anterior interosseous nerve and artery pass deeply between the flexor pollicis longus and flexor digitorum profundus muscles to lie on the interosseous membrane.



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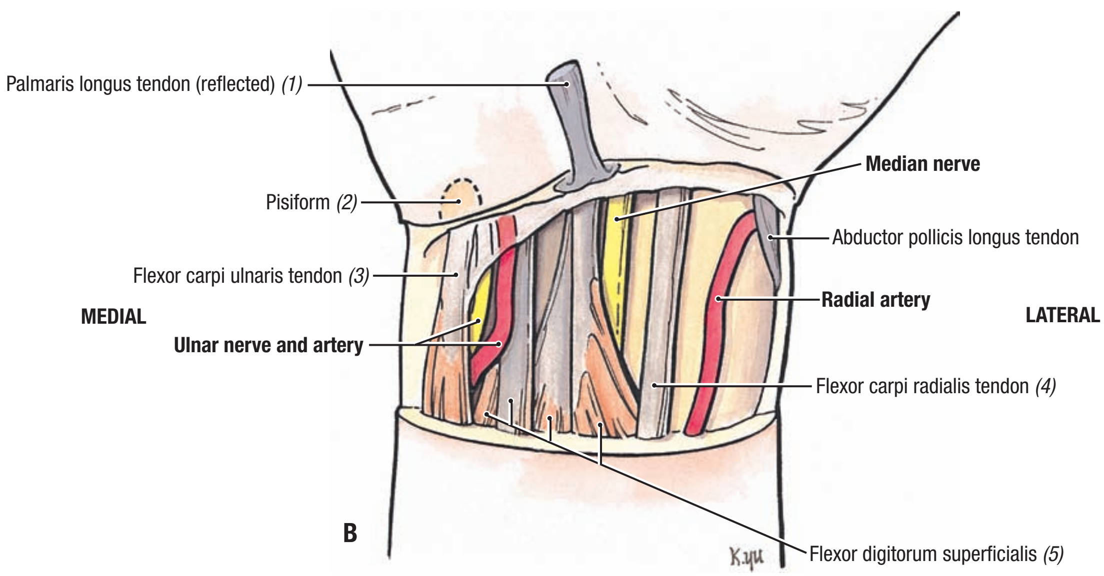


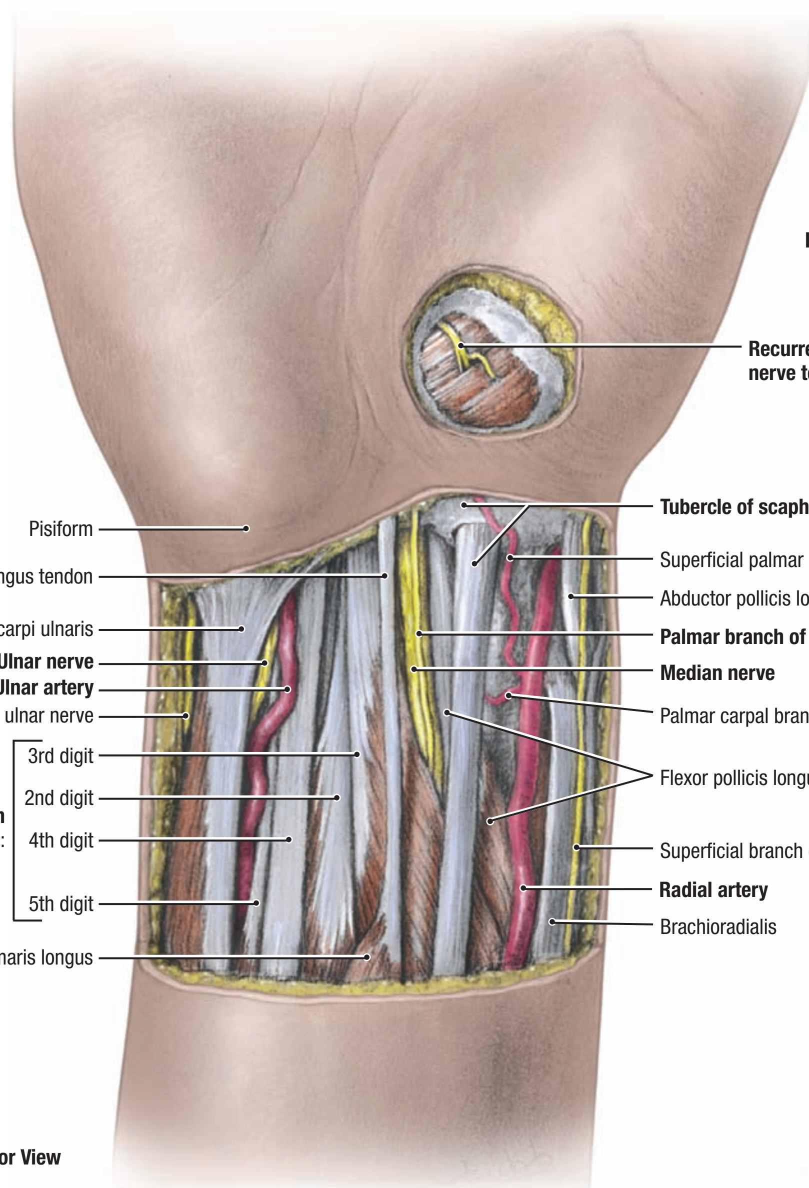
B

Anterior Views of Right Hand and Wrist

6.67 STRUCTURES OF ANTERIOR ASPECT OF WRIST

A. Surface anatomy. **B.** Schematic illustration. **C.** Dissection.

- The distal skin incision follows the transverse skin crease at the wrist. The incision crosses the pisiform, to which the flexor carpi ulnaris muscle attaches, and the tubercle of the scaphoid, to which the tendon of flexor carpi radialis muscle is a guide.
- The palmaris longus tendon bisects the transverse skin crease; deep to the lateral margin of the tendon is the median nerve.
- The radial artery passes deep to the tendon of the abductor pollicis longus muscle.
- The flexor digitorum superficialis tendons to the 3rd and 4th digits become anterior to those of the 2nd and 5th digits.
- The recurrent branch of the median nerve to the thenar muscles lies within a circle whose center is 2.5 to 4 cm distal to the tubercle of the scaphoid.

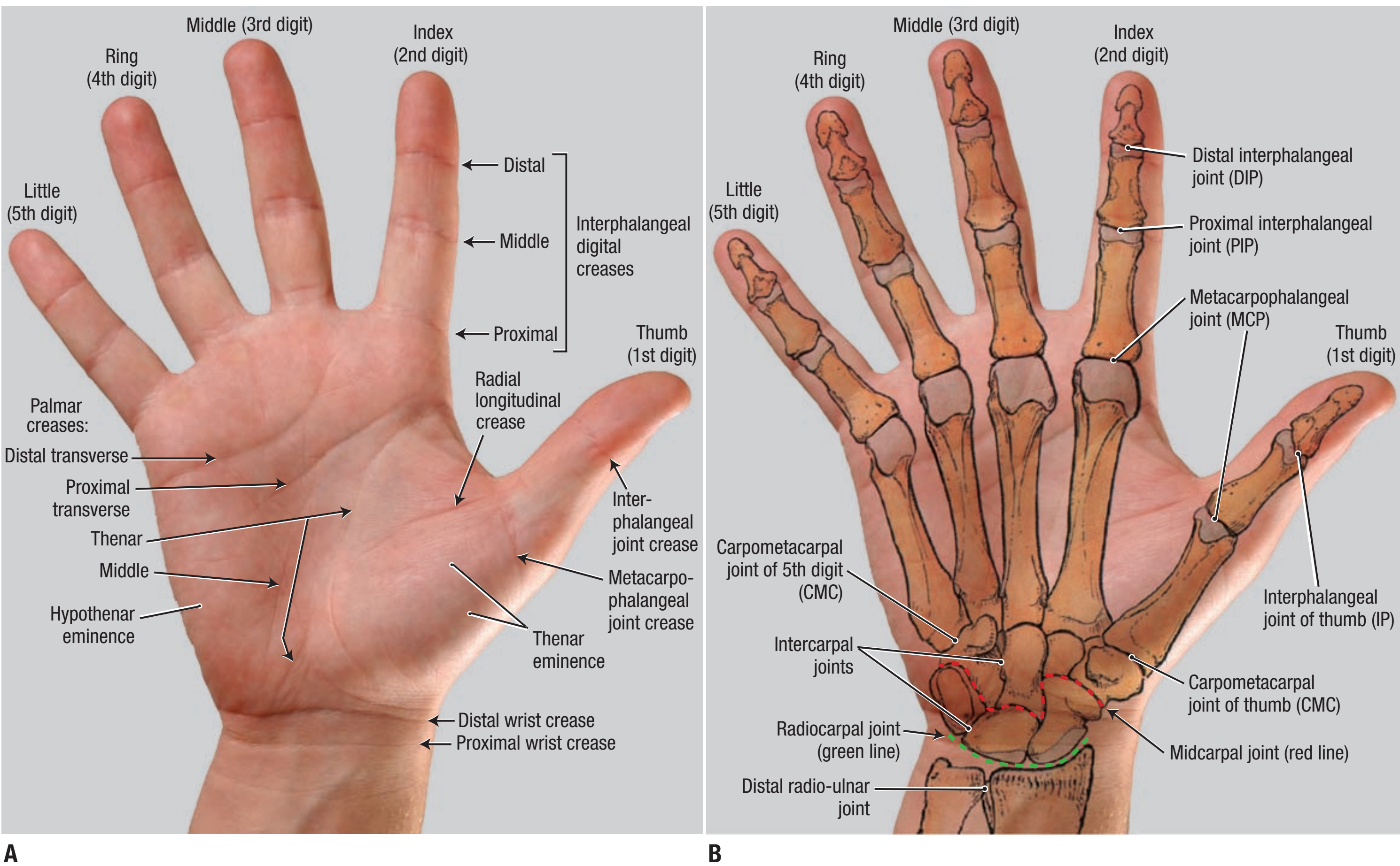


C. **Anterior View**

6.67 STRUCTURES OF ANTERIOR ASPECT OF WRIST *(CONTINUED)*

Lesions of the median nerve usually occur in two places: the forearm and wrist. The most common site is where the nerve passes though the carpal tunnel. Lacerations of the wrist often cause median nerve injury because this nerve is relatively close to the surface. This results in paralysis of the thenar muscles and the first two lumbricals. Hence opposition of the thumb is not possible and fine control movements of the 2nd and 3rd digits are impaired. Sensation is also lost over the thumb and adjacent two and a half digits.

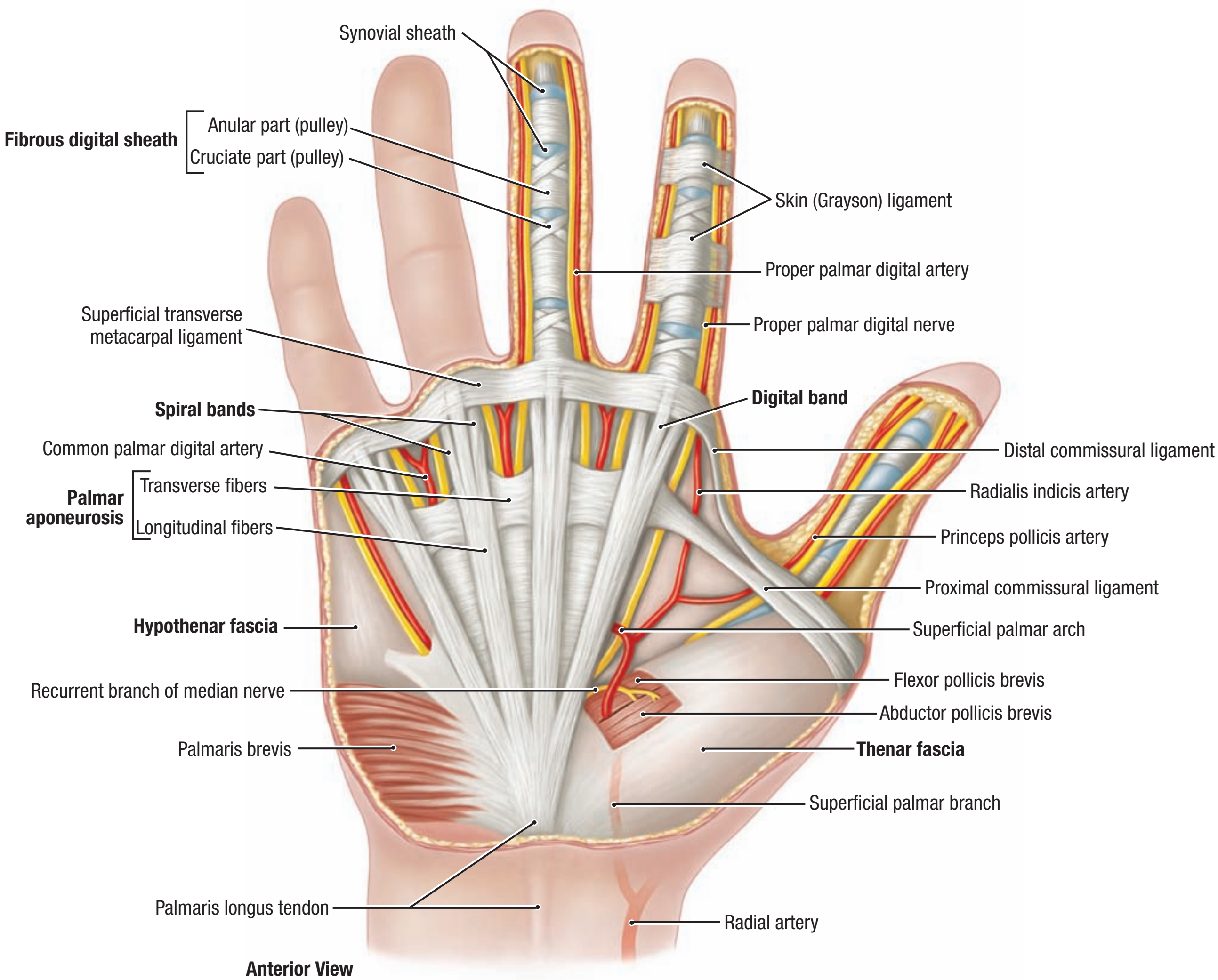
Median nerve injury resulting from a perforating wound in the elbow region results in loss of flexion of the proximal and distal interphalangeal joints of the 2nd and 3rd digits. The ability to flex the metacarpophalangeal joints of these digits is also affected because digital branches of the median nerve supply the 1st and 2nd lumbricals. The palmar cutaneous branch of the median nerve does not traverse the carpal tunnel. It supplies the skin of the central palm, which remains sensitive in carpal tunnel syndrome.



Anterior Views

6.68 SURFACE ANATOMY OF SKELETON OF HAND AND WRIST

A. Skin creases of wrist and hand. **B.** Surface projection of joints of wrist and hand. Note relationship of bones and joints to features of the hand.



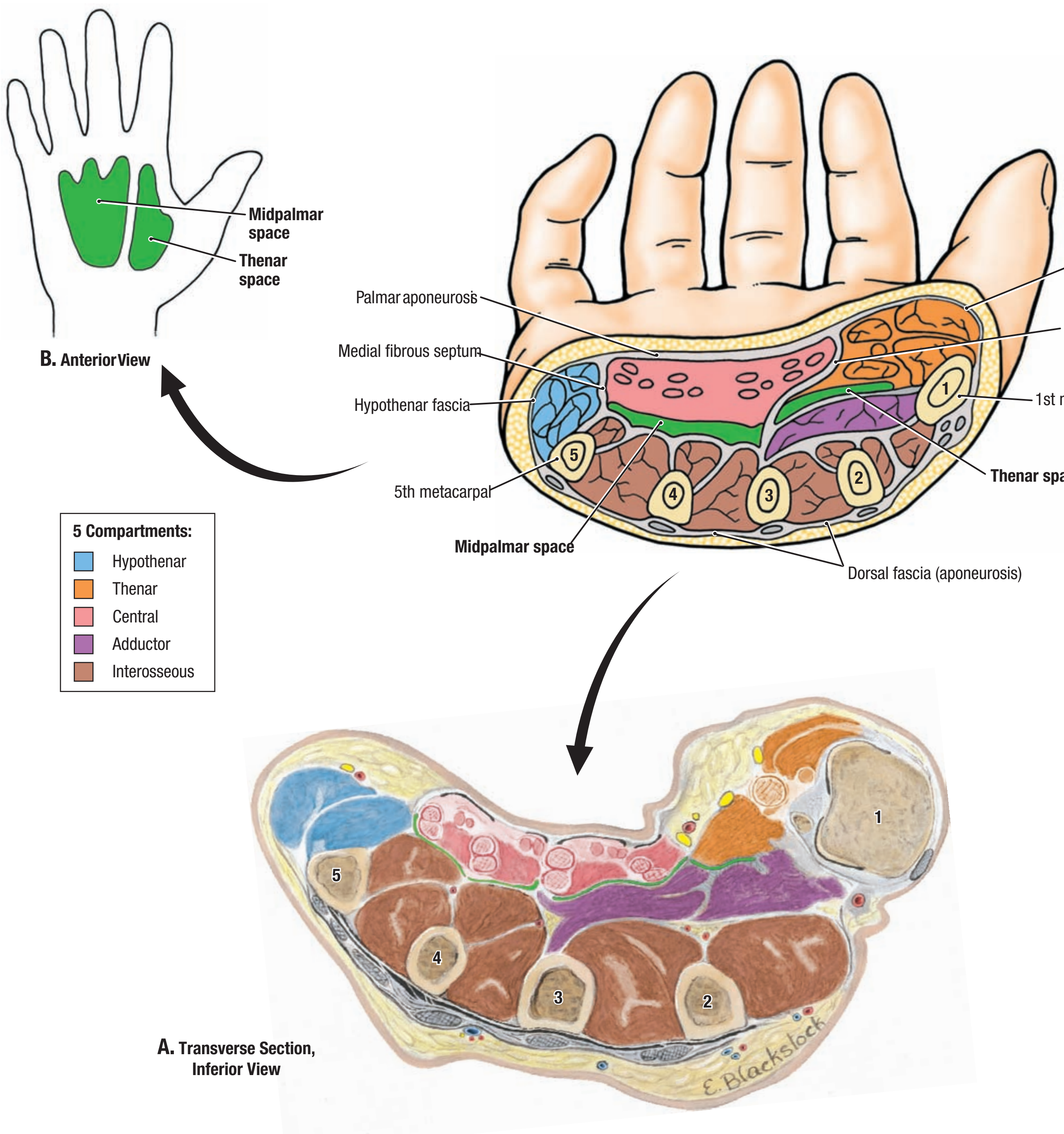
6.69 PALMAR (DEEP) FASCIA: PALMAR APONEUROSIS, THENAR AND HYPOTHENAR FASCIA

A. Anterior view.

- The palmar fascia is thin over the thenar and hypothenar eminences, but thick centrally, where it forms the palmar aponeurosis, and in the digits, where it forms the fibrous digital sheaths.
- At the distal end (base) of the palmar aponeurosis, four bundles of digital and spiral bands continue to the bases and fibrous digital sheaths of digits 2 to 5.

B. Dupuytren contracture is a disease of the palmar fascia resulting in progressive shortening, thickening, and fibrosis of the palmar fascia and palmar aponeurosis. The fibrous degeneration of the longitudinal digital bands of the aponeurosis on the medial side of the hand pulls the 4th and 5th fingers into partial flexion at the metacarpophalangeal and proximal interphalangeal joints. The contracture is frequently bilateral. Treatment of Dupuytren contracture usually involves surgical excision of all fibrotic parts of the palmar fascia to free the fingers.

B. Dupuytren contracture

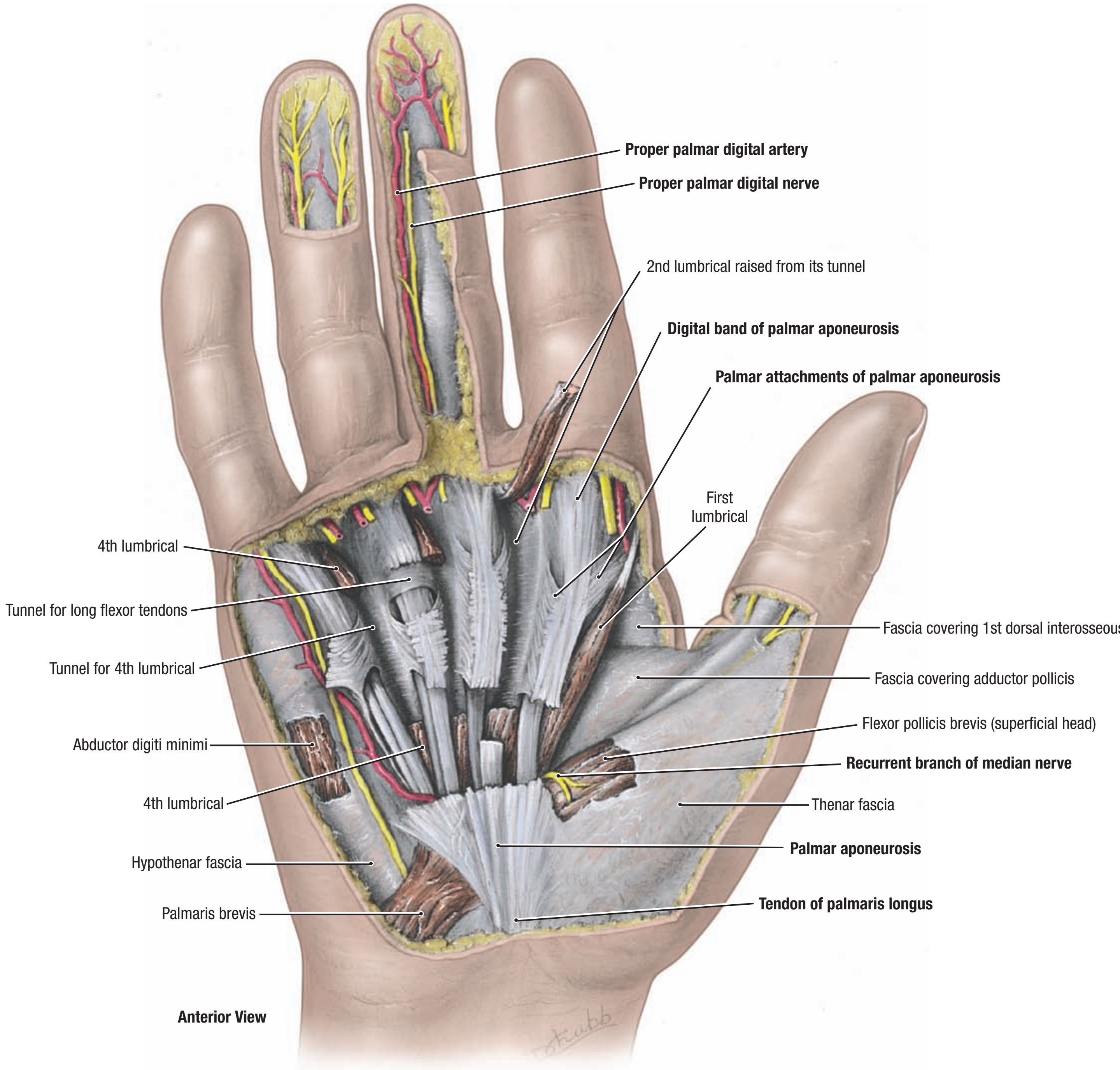


6.70 SYNOVIAL CAPSULE OF ELBOW JOINT AND ANULAR LIGAMENT

A. Transverse section through the middle of the palm showing the fascial compartments for the musculotendinous structures of the hand. **B.** Potential fascial spaces of palm.

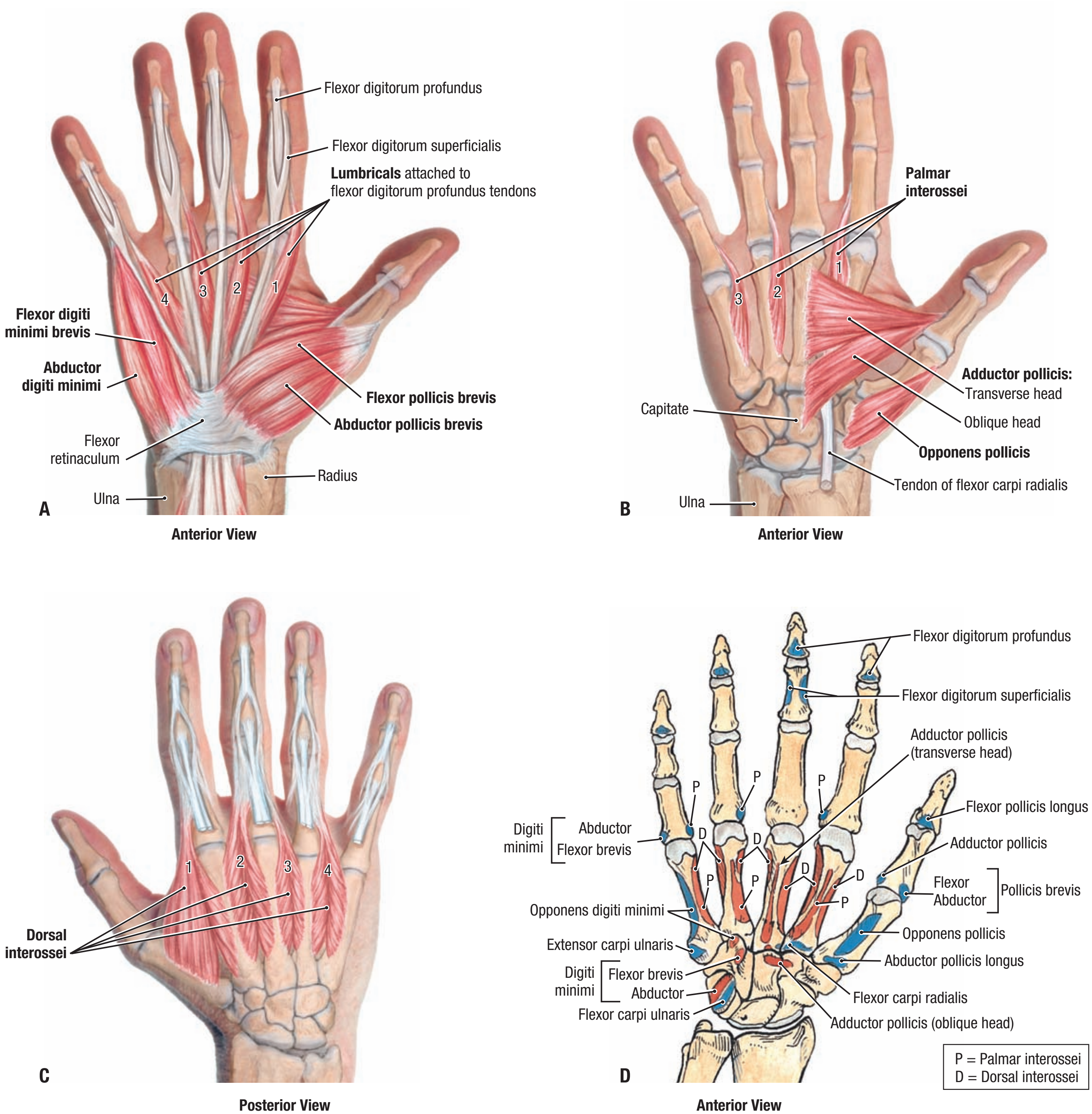
- The potential midpalmar space lies posterior to the central compartment, is bounded medially by the hypothenar compartment, and is related distally to the synovial sheath of the 3rd, 4th, and 5th digits.
- The potential thenar space lies posterior to the thenar compartment and is related distally to the synovial sheath of the index finger.
- The potential midpalmar and thenar spaces are separated by a septum that passes from the palmar aponeurosis to the third metacarpal.

Because the palmar fascia is thick and strong, **swellings resulting from hand infections** usually appear on the dorsum of the hand where the fascia is thinner. The potential fascial spaces of the palm are important because they may become infected. The fascial spaces determine the extent and direction of the spread of pus formed in the infected areas. Depending on the site of infection, pus will accumulate in the thenar, hypothenar, or adductor compartments. Antibiotic therapy has made infections that spread beyond one of these fascial compartments rare, but an untreated infection can spread proximally through the carpal tunnel into the forearm anterior to the pronator quadratus and its fascia.



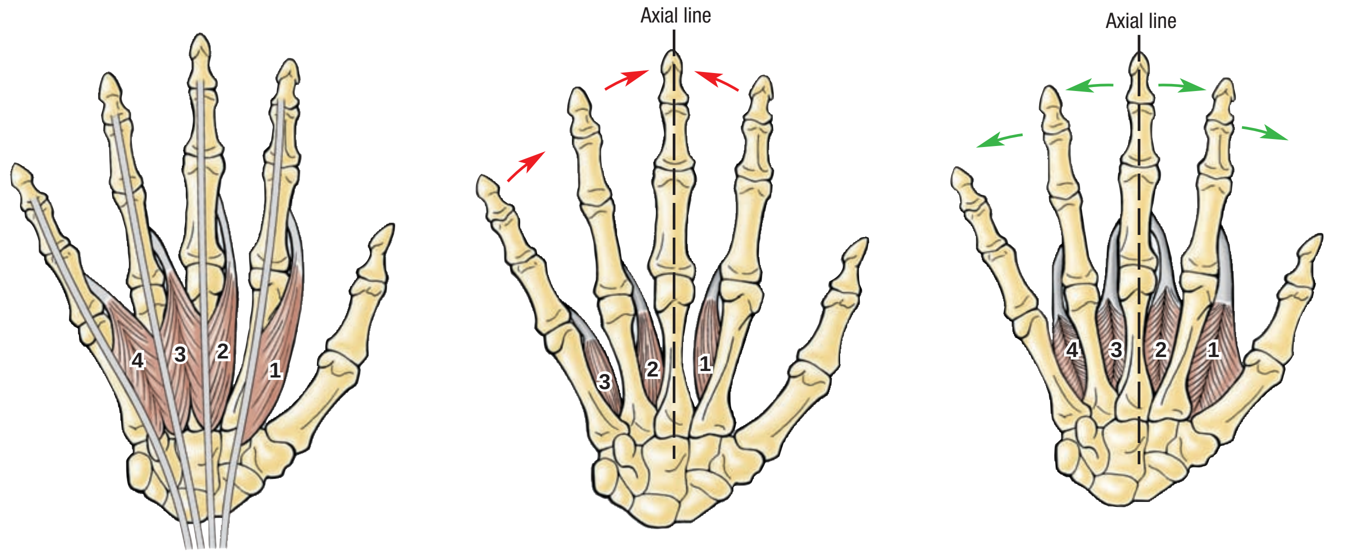
6.71 PALMAR APONEUROSIS

- From the palmar aponeurosis, four longitudinal digital bands enter the fingers; the other fibers form extensive fibro-areolar septa that pass posteriorly to the palmar ligaments (see Fig. 6.78) and, more proximally, to the fascia covering the interossei. Thus, two sets of tunnels exist in the distal half of the palm: (1) tunnels for long flexor tendons and (2) tunnels for lumbricals, digital vessels, and digital nerves.
- In the dissected middle finger, note the absence of fat deep to the skin creases of the fingers.



6.72 MUSCULAR LAYERS OF PALM

A. Lumbricals. **B.** Adductor pollicis. **C.** Dorsal (*D*) and palmar (*P*) interossei. **D.** Bony attachments.



Lumbricals (1–4)

Palmar interossei (Adduction)

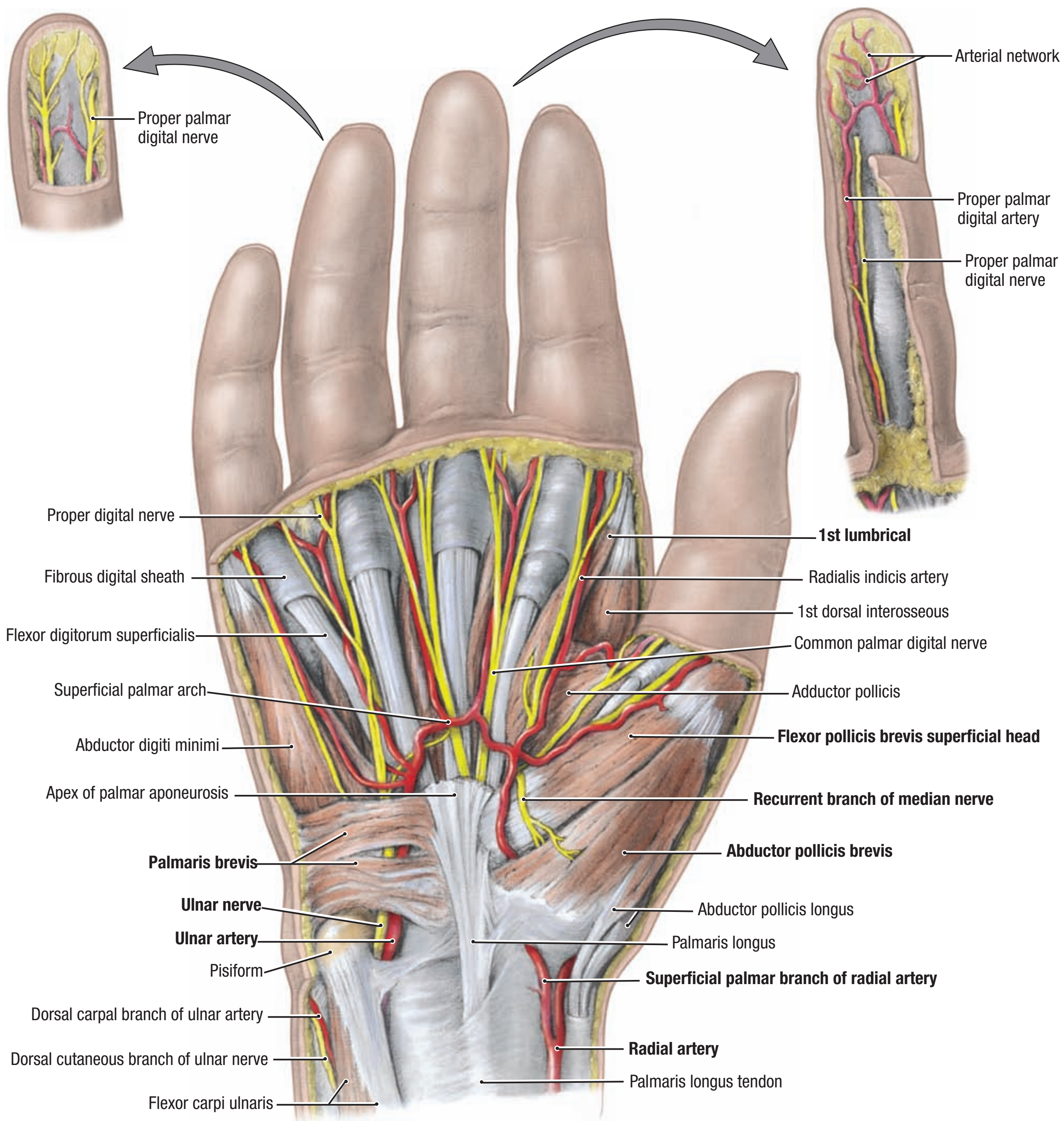
Dorsal interossei (Abduction)

Palmar Views

6.73 LUMBRICALS AND INTEROSSEI

TABLE 6.13 MUSCLES OF HAND

Muscle	Proximal Attachment	Distal Attachment	Innervation	Main Actions
Abductor pollicis brevis	Flexor retinaculum and tubercles of scaphoid and trapezium	Lateral side of base of proximal phalanx of thumb	Recurrent branch of median nerve (**C8** and T1)	Abducts thumb and helps oppose it
Flexor pollicis brevis	Flexor retinaculum (transverse carpal ligament) and tubercle of trapezium			Flexes thumb
Opponens pollicis		Lateral side of first metacarpal		Opposes thumb toward center of palm and rotates it medially
Adductor pollicis	*Oblique head:* bases of second and third metacarpals, capitate, and adjacent carpal bones *Transverse head:* anterior surface of shaft of third metacarpal	Medial side of base of proximal phalanx of thumb	Deep branch of ulnar nerve (C8 and **T1**)	Adducts thumb toward lateral border of palm
Abductor digiti minimi	Pisiform	Medial side of base of proximal phalanx of digit 5	Deep branch of ulnar nerve (C8 and T1)	Abducts digit 5, assists in flexion of its PIP joint
Flexor digiti minimi brevis	Hook of hamate and flexor retinaculum (transverse carpal ligament)	Medial border of fifth metacarpal		Flexes PIP joint of digit 5
Opponens digiti minimi				Draws fifth metacarpal anteriorly and rotates it, bringing digit 5 into opposition with thumb
Lumbricals 1 and 2	Lateral two tendons of flexor digitorum profundus	Lateral sides of extensor expansions of digits 2–5	Median nerve (C8 and **T1**)	Flex MCP joints and extend IP joints of digits 2–5
Lumbricals 3 and 4	Medial three tendons of flexor digitorum profundus		Deep branch of ulnar nerve (C8 and **T1**)	
Dorsal interossei 1–4	Adjacent sides of two metacarpals	Extensor expansions and bases of proximal phalanges of digits 2–4		Abduct 2–4 MCP joints; act with lumbricals to flex MCP and extend IP joints
Palmar interossei 1–3	Palmar surfaces of second, fourth, and fifth metacarpals	Extensor expansions of digits and bases of proximal phalanges of digits 2, 4, and 5		Adduct 2, 4, and 5 MCP joints; act with lumbricals to flex MCP and extend IP joints



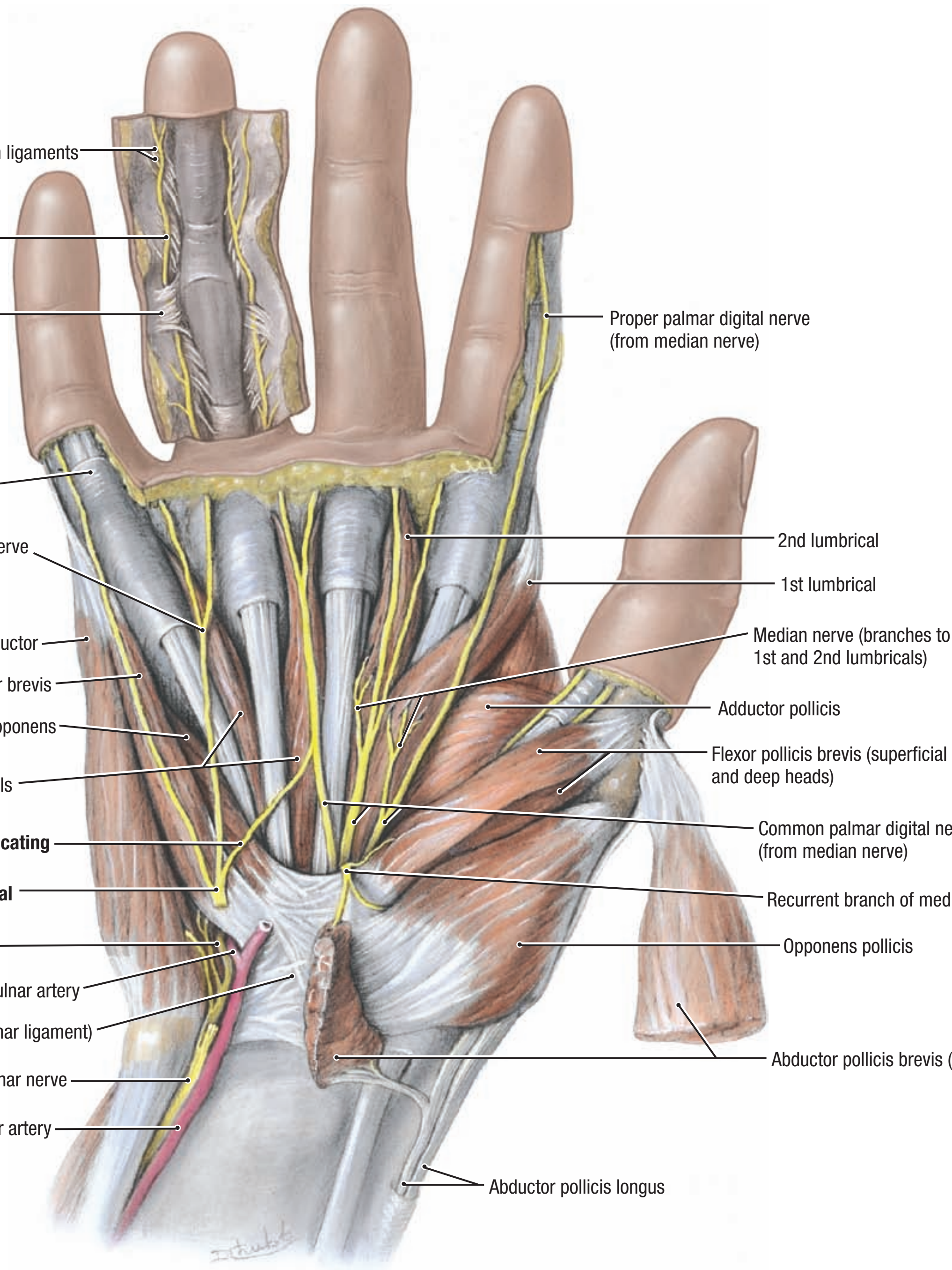
A. **Anterior View**

6.74 SUPERFICIAL DISSECTION OF PALM, ULNAR, AND MEDIAN NERVES

A. Superficial palmar arch and digital nerves and vessels.

- The skin, superficial fascia, palmar aponeurosis, and thenar and hypothenar fasciae have been removed.
- The superficial palmar arch is formed by the ulnar artery and completed by the superficial palmar branch of the radial artery.
- The four lumbricals lie posterior to the digital vessels and nerves. The lumbricals arise from the lateral sides of the flexor digitorum profundus tendons and are inserted into the lateral sides of the dorsal expansions of the corresponding digits. The medial two lumbricals are bipennate and also arise from the medial sides of adjacent flexor digitorum profundus tendons.
- In the digits, a proper palmar digital artery and nerve lie on each side of the fibrous digital sheath.
- Note the canal (Guyon) through which the ulnar vessels and nerve pass medial to the pisiform.

Laceration of palmar (arterial) arches. Bleeding is usually profuse when the palmar (arterial) arches are lacerated. It may not be sufficient to ligate (tie off) only one forearm artery when the arches are lacerated, because these vessels usually have numerous communications in the forearm and hand and thus bleed from both ends.

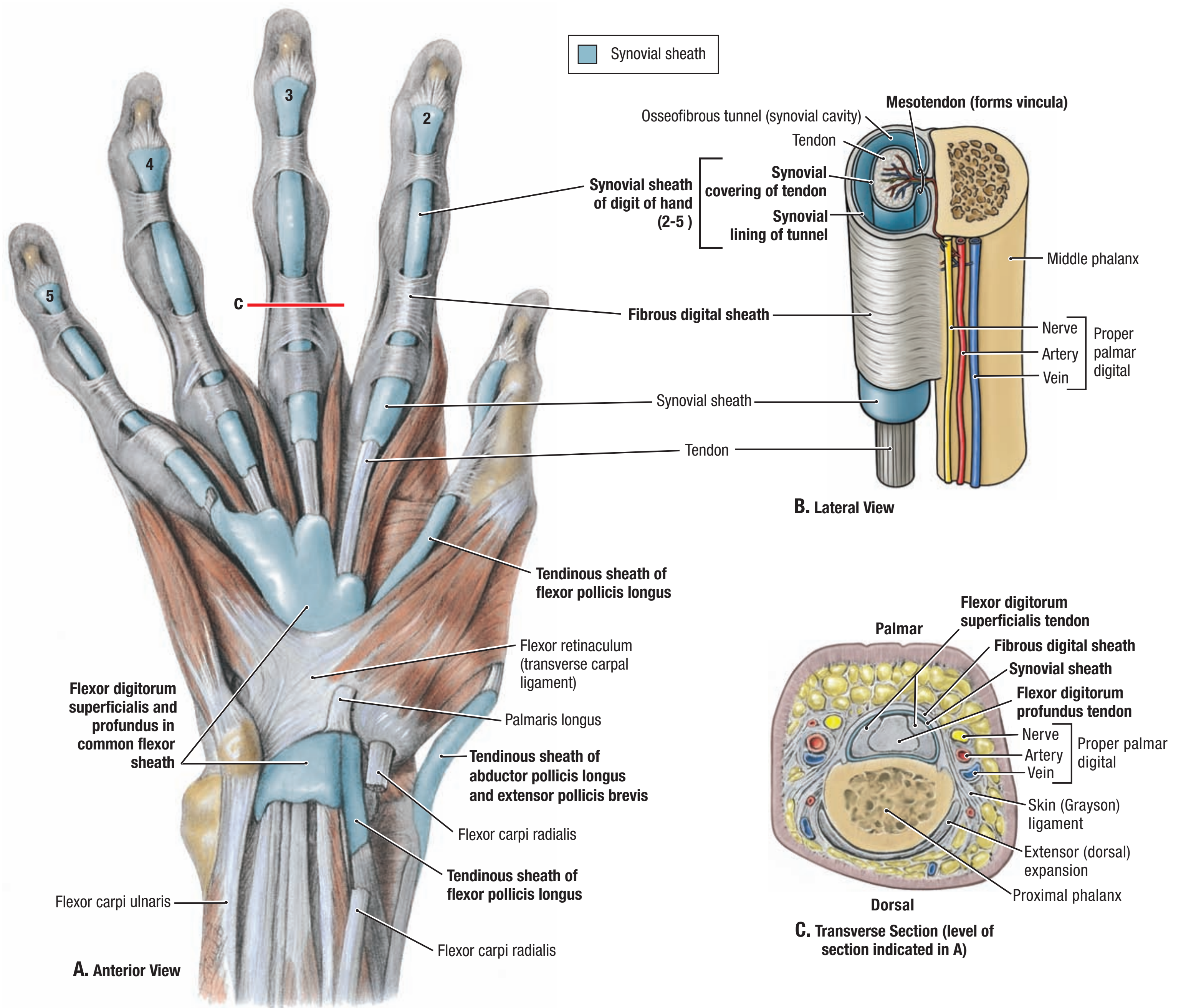


B. **Anterior View**

6.74 SUPERFICIAL DISSECTION OF PALM, ULNAR, AND MEDIAN NERVES *(CONTINUED)*

B. Ulnar and median nerves.

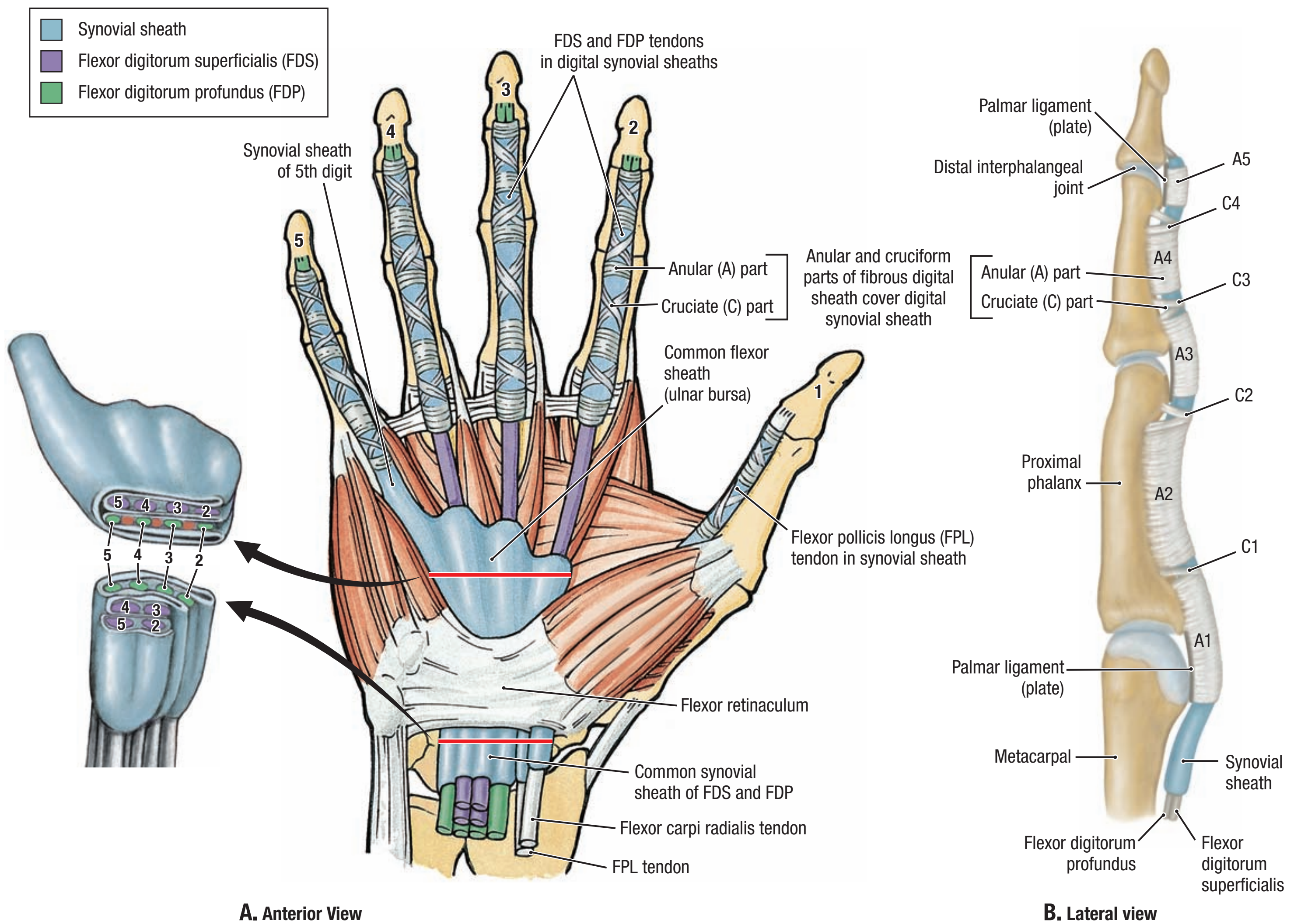
Carpal tunnel syndrome results from any lesion that significantly reduces the size of the carpal tunnel or, more commonly, increases the size of some of the structures (or their coverings) that pass though it (e.g., inflammation of the synovial sheaths). The median nerve is the most sensitive structure in the carpal tunnel. The median nerve has two terminal sensory branches that supply the skin of the hand; hence paresthesia (tingling), hypothesia (diminished sensation), or anesthesia (absence of tactile sensation) may occur in the lateral three and a half digits. Recall, however, that the palmar cutaneous branch of the median nerve arises proximal to and does not pass through the carpal tunnel; thus sensation in the central palm remains unaffected. This nerve also has one terminal motor branch, the recurrent branch, which innervates the three thenar muscles. Wasting of the thenar eminence and progressive loss of coordination and strength in the thumb may occur. To relieve the compression and resulting symptoms, partial or complete surgical division of the flexor retinaculum, a procedure called **carpal tunnel release,** may be necessary. The incision for carpal tunnel release is made toward the medial side of the wrist and flexor retinaculum to avoid possible injury to the recurrent branch of the median nerve.



6.75 SYNOVIAL SHEATHS OF PALM OF HAND

A. Tendinous (synovial) sheaths of long flexor tendons of the digits. **B.** Osseofibrous tunnel and tendinous (synovial) sheath. **C.** Transverse section through the proximal phalanx.

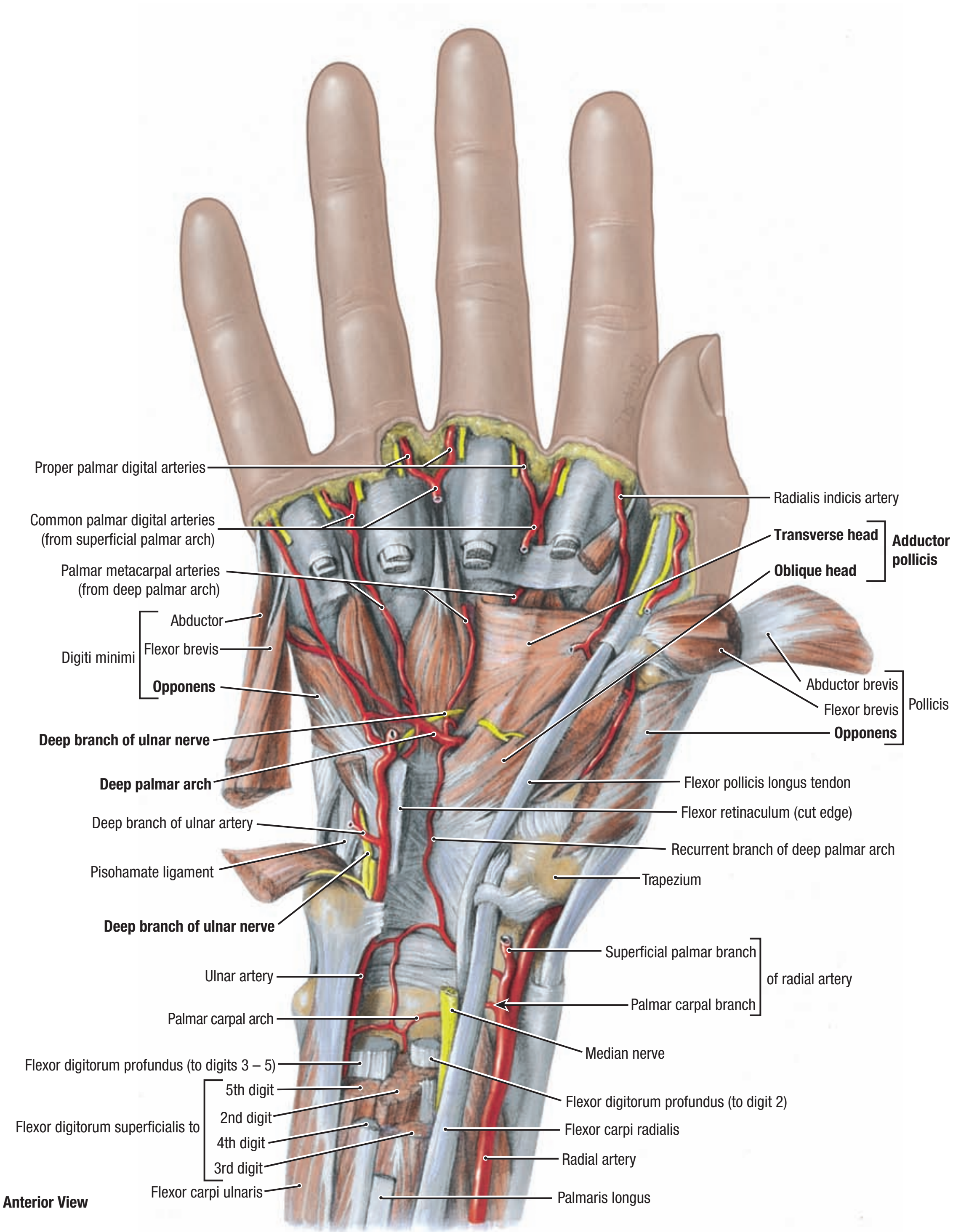
Injuries such as puncture of a finger by a rusty nail can cause **infection of the digital synovial sheaths.** When inflammation of the tendon and synovial sheath **(tenosynovitis)** occurs, the digit swells and movement becomes painful. Because the tendons of the 2nd to 4th digits nearly always have separate synovial sheaths, the infection usually is confined to the infected digits. If the infection is untreated, however, the proximal ends of these sheaths may rupture, allowing the infection to spread to the midpalmar space. Because the synovial sheath of the little finger is usually continuous with the common flexor sheath, tenosynovitis in this finger may spread to the common flexor sheath and thus through the palm and carpal tunnel to the anterior forearm. Likewise, tenosynovitis in the thumb may spread through the continuous tendinous sheath of flexor pollicis longus.



6.76 FIBROUS DIGITAL SHEATHS

A. Fibrous digital and synovial sheaths. **B.** Anular and cruciate parts (pulleys) of the fibrous digital sheath.

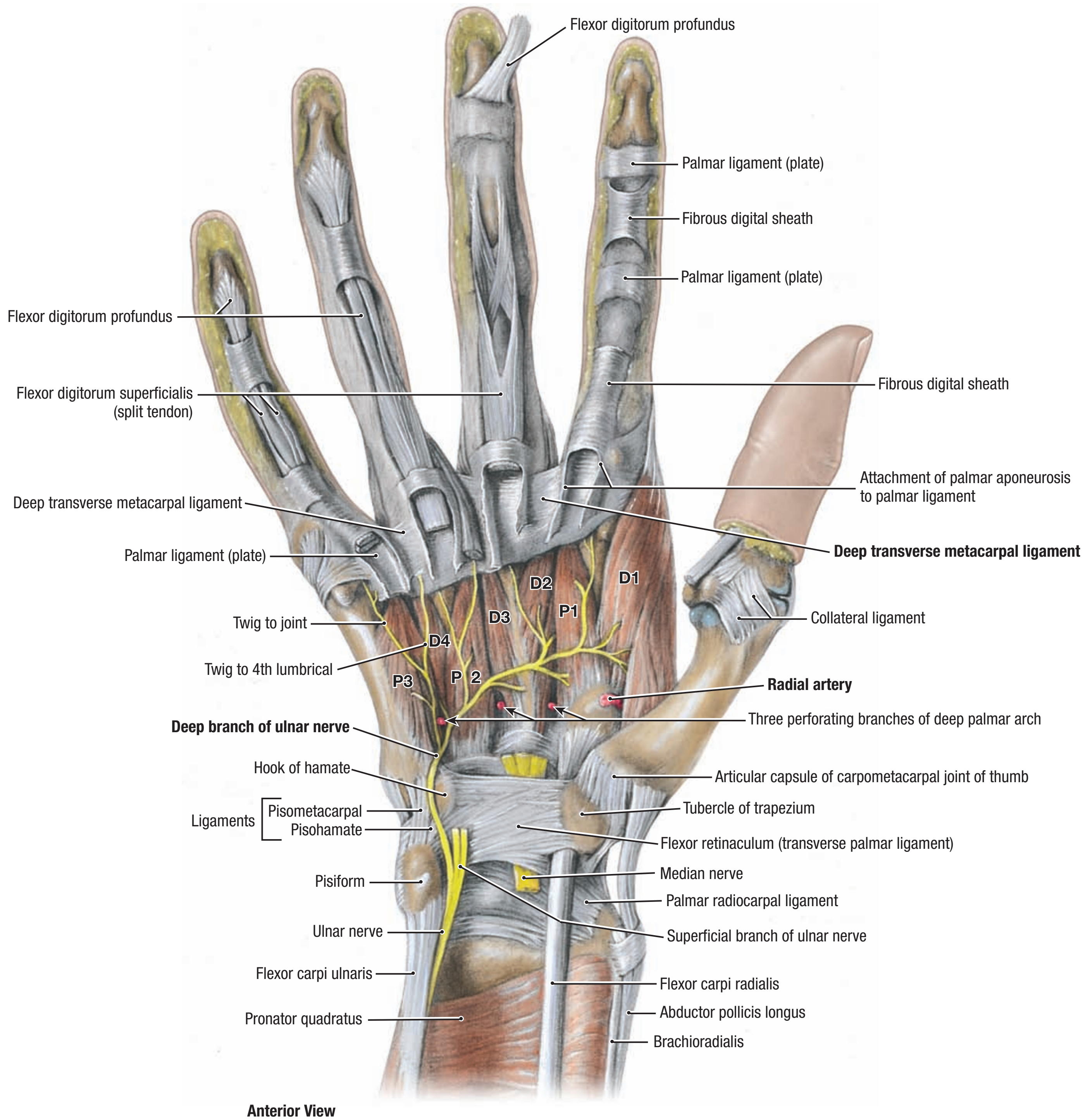
Fibrous digital sheaths are the strong ligamentous tunnels containing the flexor tendons and their synovial sheaths. The sheaths extend from the heads of the metacarpals to the bases of the distal phalanges. These sheaths prevent the tendons from pulling away from the digits (bowstringing). The fibrous digital sheaths combine with the bones to form osseofibrous tunnels through which the tendons pass to reach the digits. The anular and cruciform (cruciate) parts, often referred to clinically as “pulleys,” are thickened reinforcements of the fibrous digital sheaths.



6.77 DEEP DISSECTION OF PALM

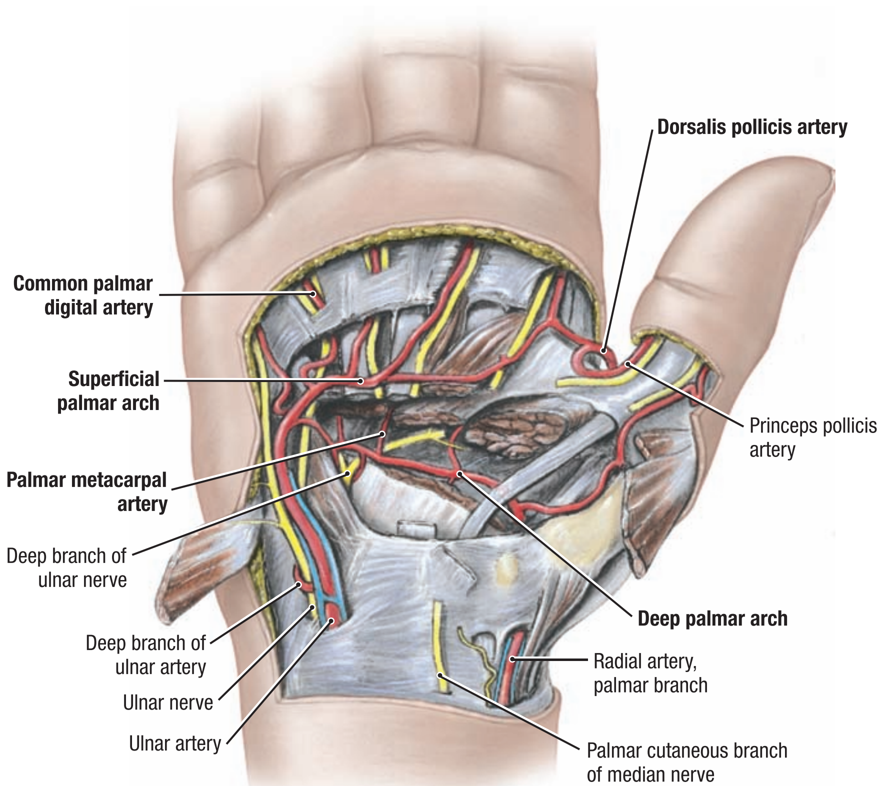
- The deep branch of the ulnar artery joins the radial artery to form the deep palmar arch.
- The pisohamate ligament is often considered a continuation of the tendon of flexor carpi ulnaris; thus making the pisiform a sesamoid bone.

Compression of the ulnar nerve may occur at the wrist where it passes between the pisiform and the hook of hamate. The depression between these bones is converted by the pisohamate ligament into an osseofibrous ulnar canal. **Ulnar canal syndrome** is manifest by hypoesthesia in the medial one and one half digits and weakness of the intrinsic hand muscles. Clawing of the 4th and 5th digits may occur, but in contrast to proximal nerve injury, their ability to flex is unaffected and there is no radial deviation of the wrist joint.

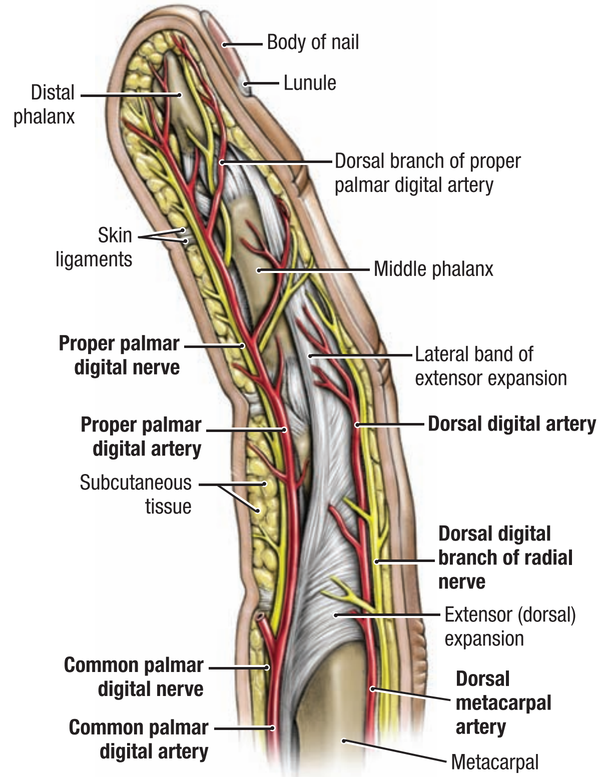


6.78 DEEP DISSECTION OF PALM AND DIGITS WITH DEEP BRANCH OF ULNAR NERVE

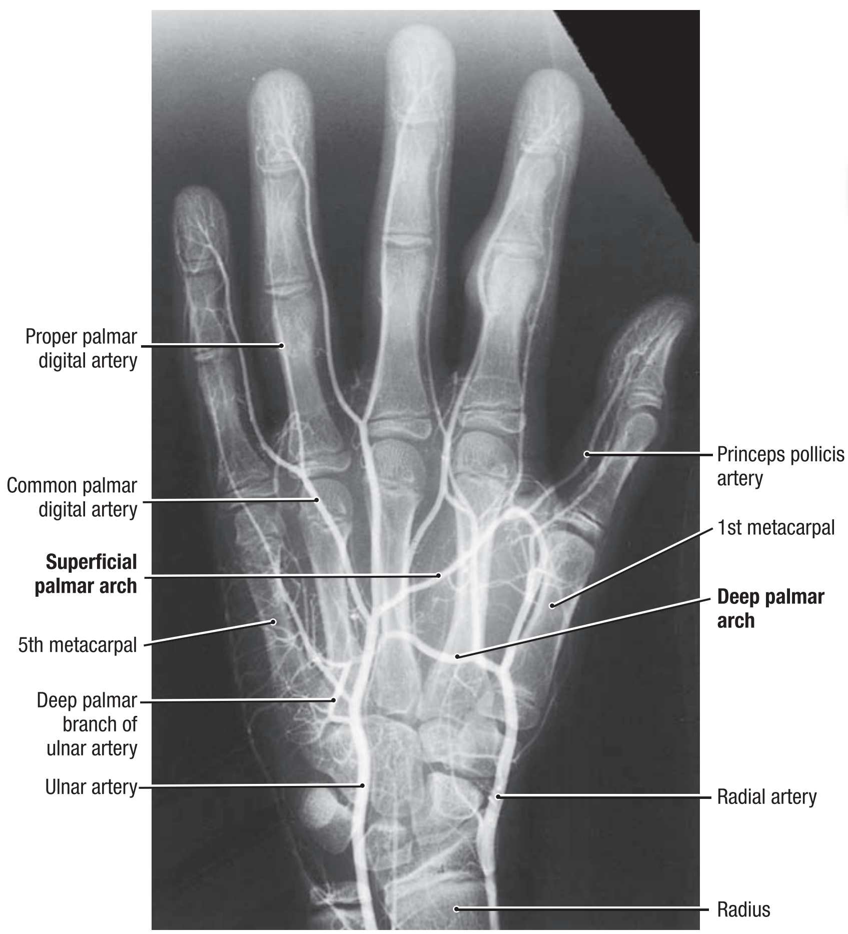
- Three unipennate palmar *(P1–P3)* and four bipennate dorsal *(D1–D4)* interosseous muscles are illustrated; the palmar interossei adduct the fingers, and the dorsal interossei abduct the fingers in relation to the axial line, an imaginary line drawn through the long axis of the 3rd digit (see Table 6.13).
- The deep transverse metacarpal ligaments unite the palmar ligaments; the lumbricals pass anterior to the deep transverse metacarpal ligament, and the interossei pass posterior to the ligament.
- Note the ulnar (Guyon) canal through which the ulnar vessels and nerve pass medial to the pisiform.
- The pisohamate and pisometacarpal ligaments form the distal attachment of flexor carpi ulnaris.



A. **Anterior View**



B. **Lateral View**



C. **Anteroposterior View**

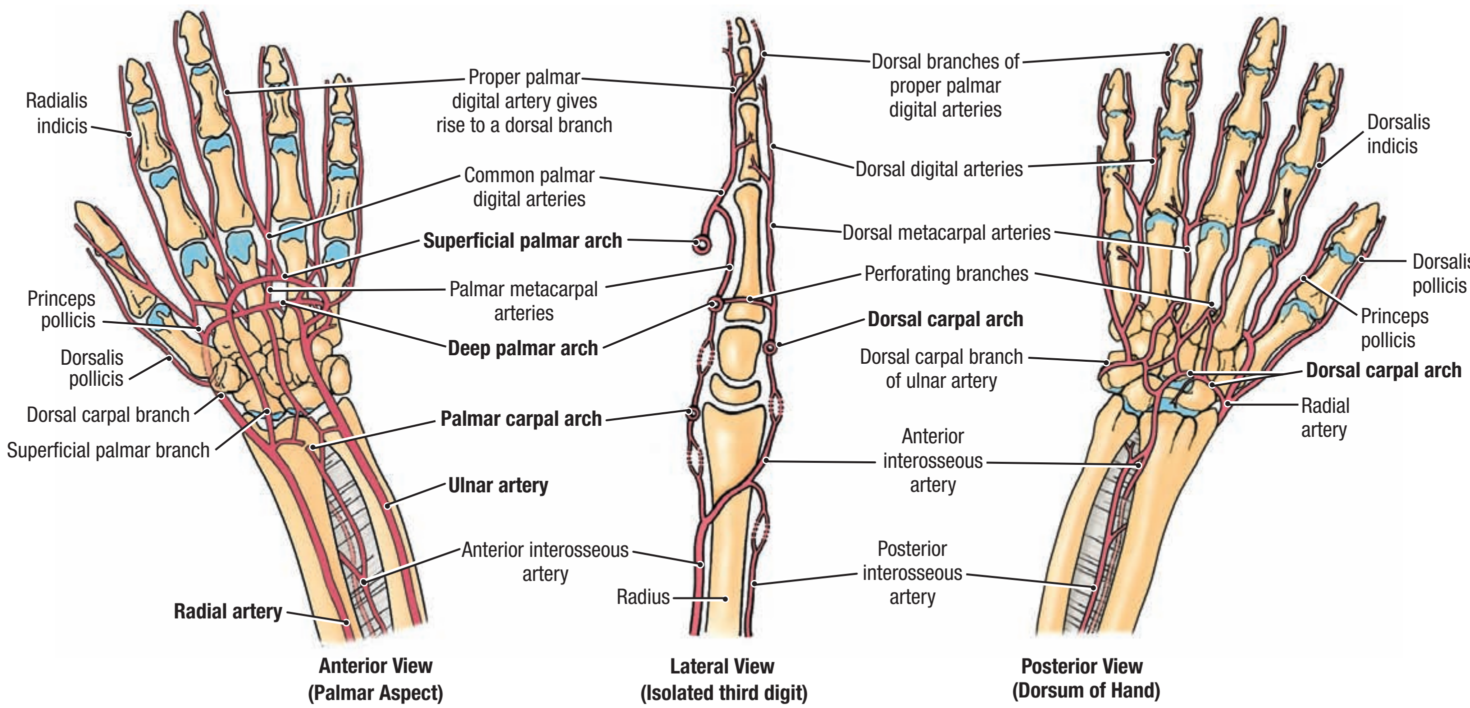
6.79 ARTERIAL SUPPLY OF HAND

A. Dissection of palmar arterial arches. **B.** Digital vessels and nerves. **C.** Arteriogram of the hand.

- The superficial palmar arch is usually completed by the superficial palmar branch of the radial artery, but in this specimen the dorsalis pollicis artery completes the arch.

The **superficial and deep palmar (arterial) arches** are not palpable, but their surface markings are visible. The superficial palmar arch occurs at the level of the distal border of the fully extended thumb. The deep palmar arch lies approximately 1 cm proximal to the superficial palmar arch. The location of these arches should be borne in mind in wounds of the palm and when palmar incisions are made.

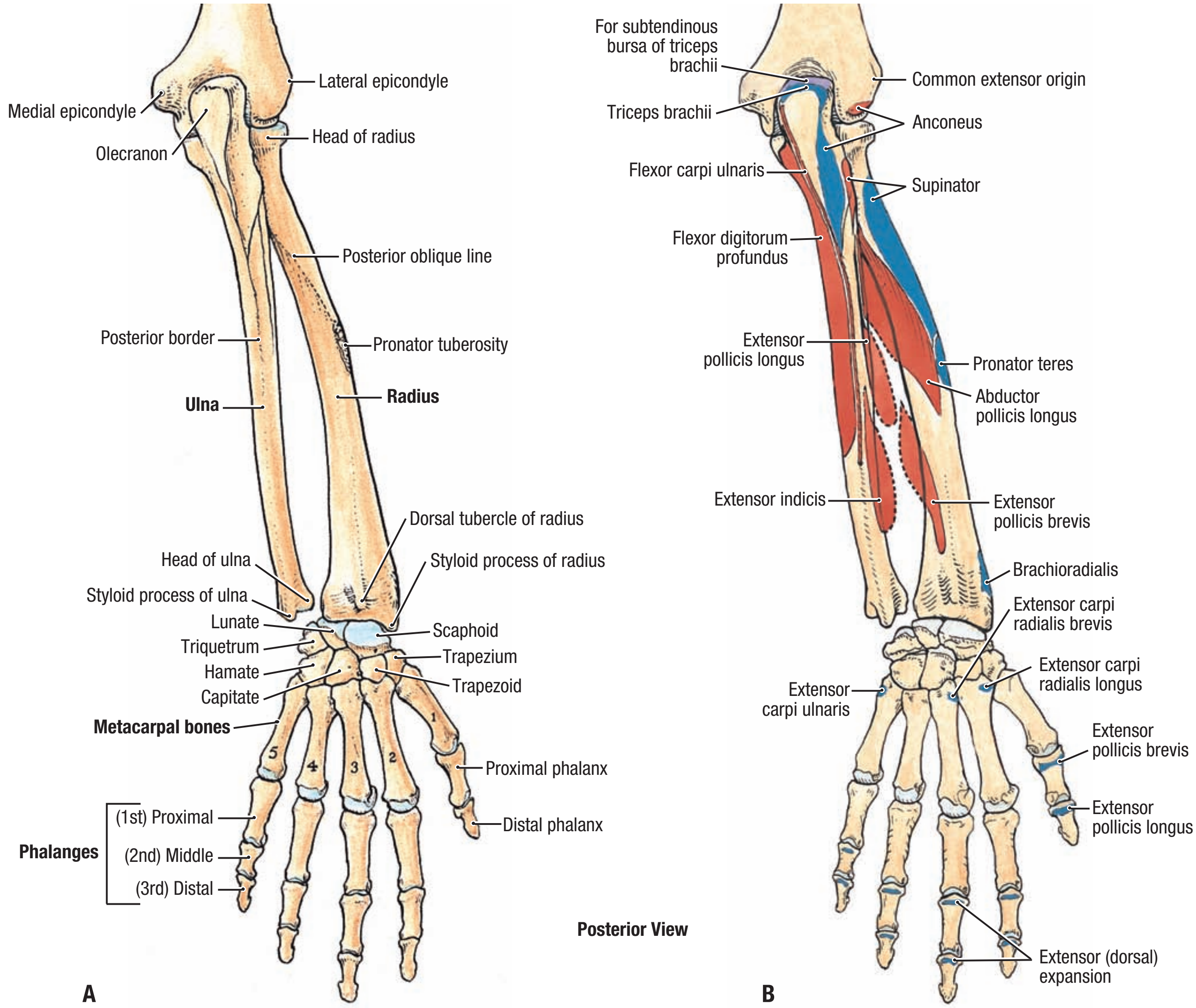
Intermittent bilateral attacks of **ischemia of the digits,** marked by cyanosis and often accompanied by paresthesia and pain, are characteristically brought on by cold and emotional stimuli. The condition may result from an anatomical abnormality or an underlying disease. When the cause of the condition is idiopathic (unknown) or primary, it is called **Raynaud syndrome** (disease). Since arteries receive innervation from postsynaptic fibers from the sympathetic ganglia, it may be necessary to perform a cervicodorsal presynaptic sympathectomy to dilate the digital arteries.



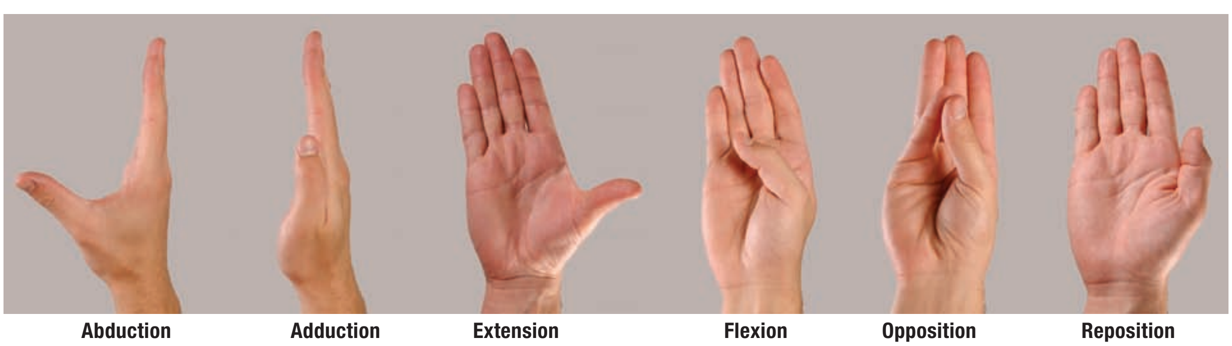
6.80 ARTERIES OF HAND

TABLE 6.14 ARTERIES OF HAND

Artery	Origin	Course
Superficial palmar arch	Direct continuation of ulnar artery; arch is completed on lateral side by superficial branch of radial artery or another of its branches	Curves laterally deep to palmar aponeurosis and superficial to long flexor tendons; curve of arch lies across palm at level of distal border of extended thumb
Deep palmar arch	Direct continuation of radial artery; arch is completed on medial side by deep branch of ulnar artery	Curves medially, deep to long flexor tendons and is in contact with bases of metacarpals
Common palmar digital	Superficial palmar arch	Pass directly on lumbricals to webbings of digits
Proper palmar digital	Common palmar digital arteries	Run along sides of digits 2–5
Princeps pollicis	Radial artery as it turns into palm	Descends on palmar aspect of first metacarpal and divides at the base of proximal phalanx into two branches that run along sides of thumb
Radialis indicis	Radial artery, but may arise from princeps pollicis artery	Passes along lateral side of index finger to its distal end
Dorsal carpal arch	Radial and ulnar arteries	Arches within fascia on dorsum of hand

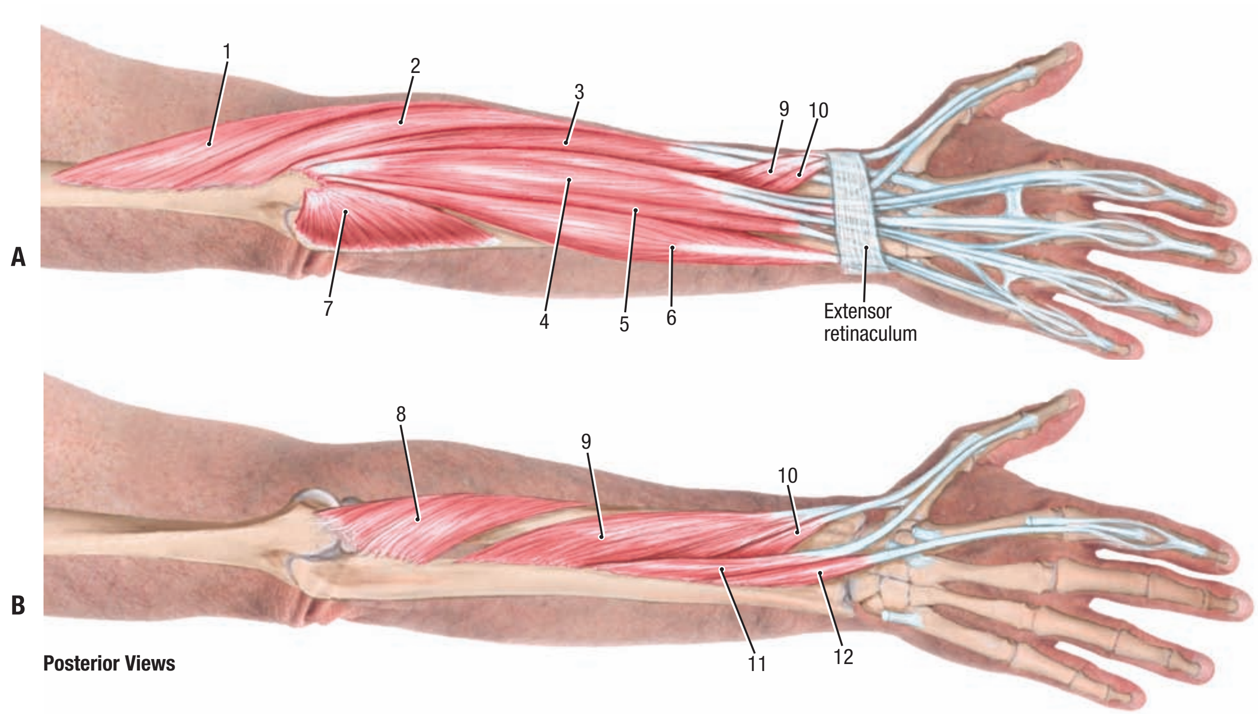


6.81 BONES AND MUSCLE ATTACHMENTS ON POSTERIOR ASPECT OF FOREARM AND HAND



6.82 MOVEMENTS OF THUMB

The thumb is rotated 90° compared to the other digits. Abduction and adduction at the MCP joint occur in a sagittal plane; flexion and extension at the MCP and IP joints occur in frontal planes, opposite to these movements at other joints.

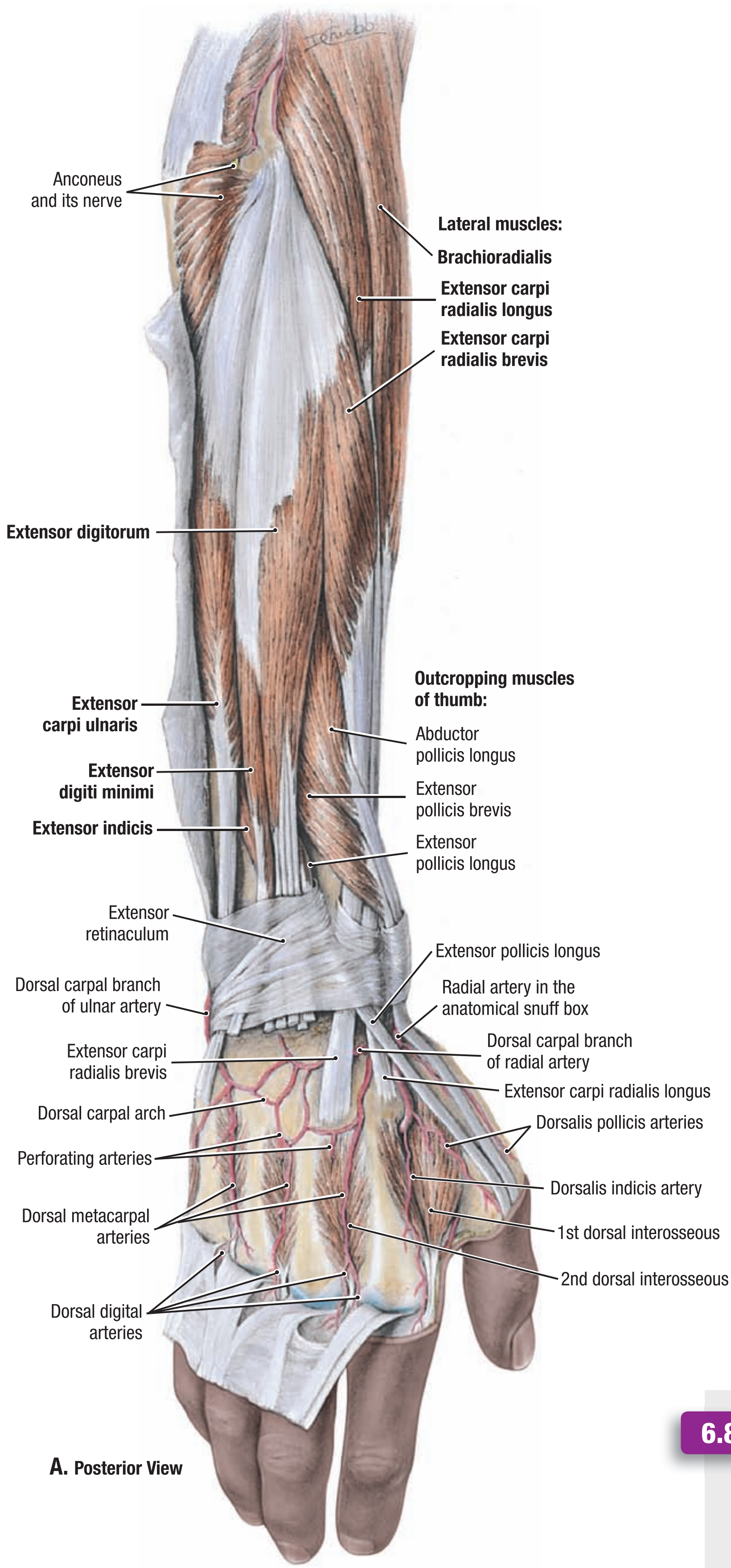


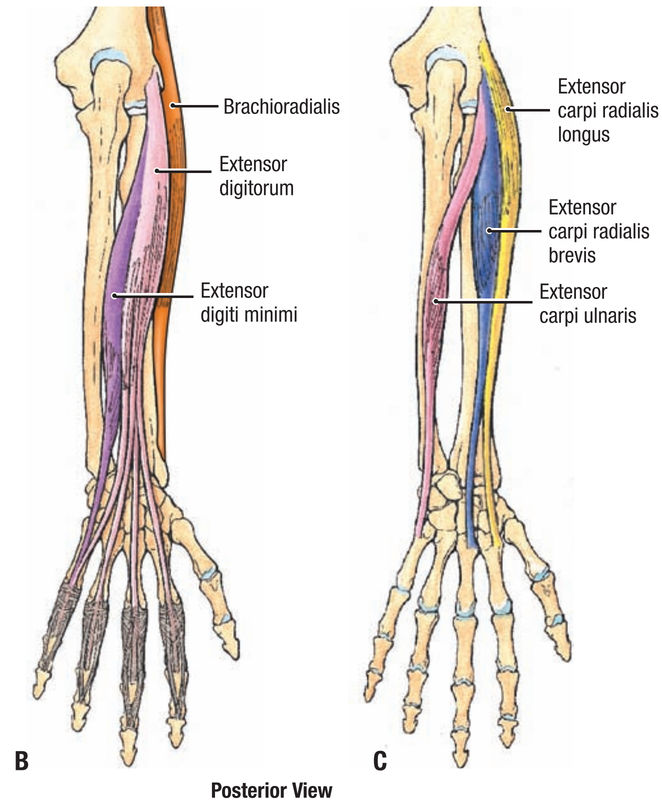
6.83 MUSCLES ON POSTERIOR ASPECT OF FOREARM

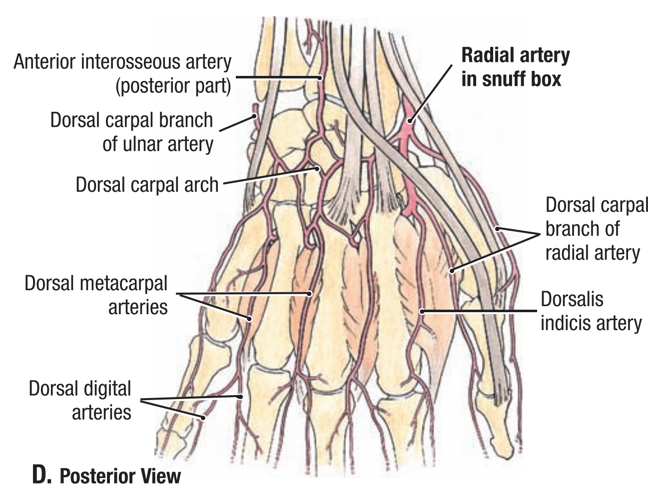
A. Superficial. **B.** Deep

TABLE 6.15 MUSCLES OF POSTERIOR SURFACE OF FOREARM

Muscle	Proximal Attachment	Distal Attachment	Innervation	Main Actions
Brachioradialis (1)	Proximal two thirds of lateral supra-epicondylar ridge of humerus	Lateral surface of distal end of radius	Radial nerve (C5, **C6**, and C7)	Flexes elbow joint
Extensor carpi radialis longus (2)	Lateral supra-epicondylar ridge of humerus	Base of second metacarpal bone	Radial nerve (C6 and C7)	Extend and abduct wrist joint
Extensor carpi radialis brevis (3)	Lateral epicondyle of humerus	Base of third metacarpal bone	Deep branch of radial nerve (**C7** and C8)	
Extensor digitorum (4)		Extensor expansions of medial four digits	Posterior interosseous nerve (C7 and C8), a branch of the radial nerve	Extends medial four metacarpophalangeal joints; extends wrist joint
Extensor digiti minimi (5)		Extensor expansion of fifth digit		Extends metacarpophalangeal and interphalangeal joints of 5th digit
Extensor carpi ulnaris (6)	Lateral epicondyle of humerus and posterior border of ulna	Base of fifth metacarpal bone		Extends and adducts wrist joint
Anconeus (7)	Lateral epicondyle of humerus	Lateral surface of olecranon and superior part of posterior surface of ulna	Radial nerve (C7, C8, and T1)	Assists triceps brachii in extending elbow joint; stabilizes elbow joint; abducts ulna during pronation
Supinator (8)	Lateral epicondyle of humerus, radial collateral and anular ligaments, supinator fossa, and crest of ulna	Lateral, posterior, and anterior surfaces of proximal third of radius	Deep branch of radial nerve (C5 and **C6**)	Supinates forearm
Abductor pollicis longus (9)	Posterior surface of ulna, radius, and interosseous membrane	Base of first metacarpal bone	Posterior interosseous nerve (C7 and **C8**)	Abducts and extends carpometacarpal joint of thumb
Extensor pollicis brevis (10)	Posterior surface of radius and interosseous membrane	Base of proximal phalanx of thumb		Extends metacarpophalangeal joint of thumb
Extensor pollicis longus (11)	Posterior surface of middle third of ulna and interosseous membrane	Base of distal phalanx of thumb		Extends metacarpophalangeal and interphalangeal joints of thumb
Extensor indicis (12)	Posterior surface of ulna and interosseous membrane	Extensor expansion of second digit		Extends MCP and IP joints of 2nd digit and helps to extend wrist joint

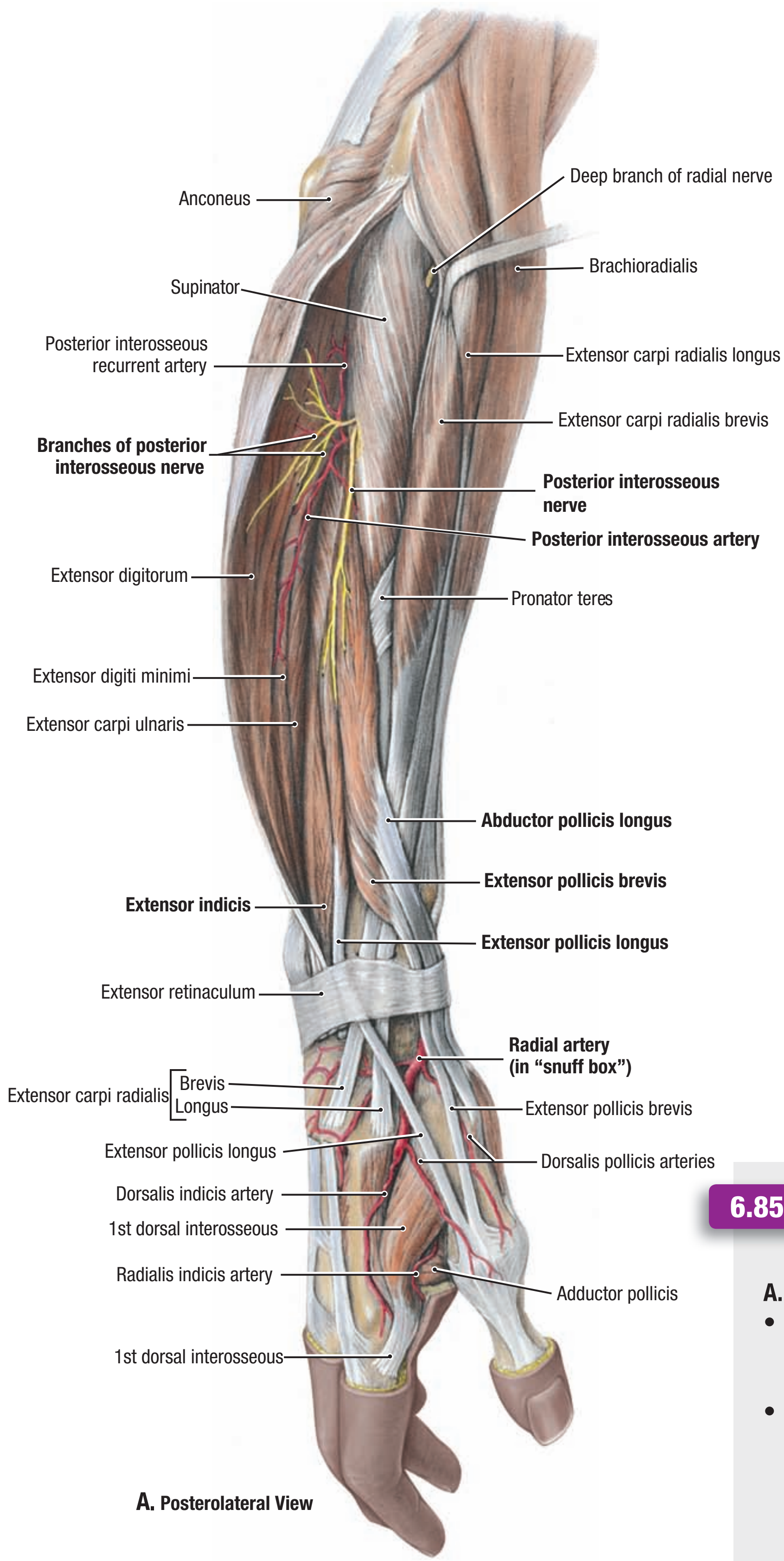




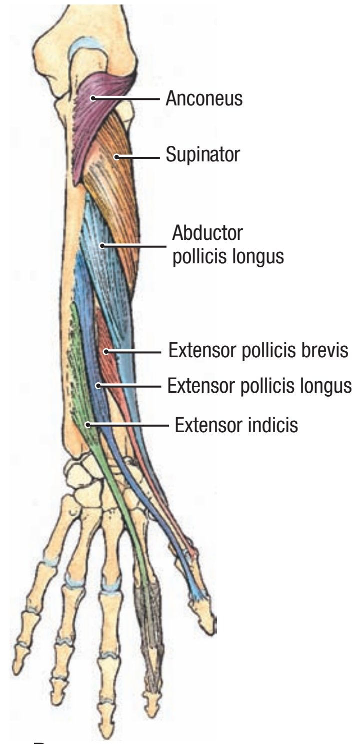


6.84 SUPERFICIAL MUSCLES OF EXTENSOR ASPECT OF FOREARM

A. Dissection. The digital extensor tendons have been reflected without disturbing the arteries because they lie on the skeletal plane. **B.** and **C.** Schematic illustrations of superficial extensor muscles. **D.** Arteries on dorsum of hand.



A. Posterolateral View



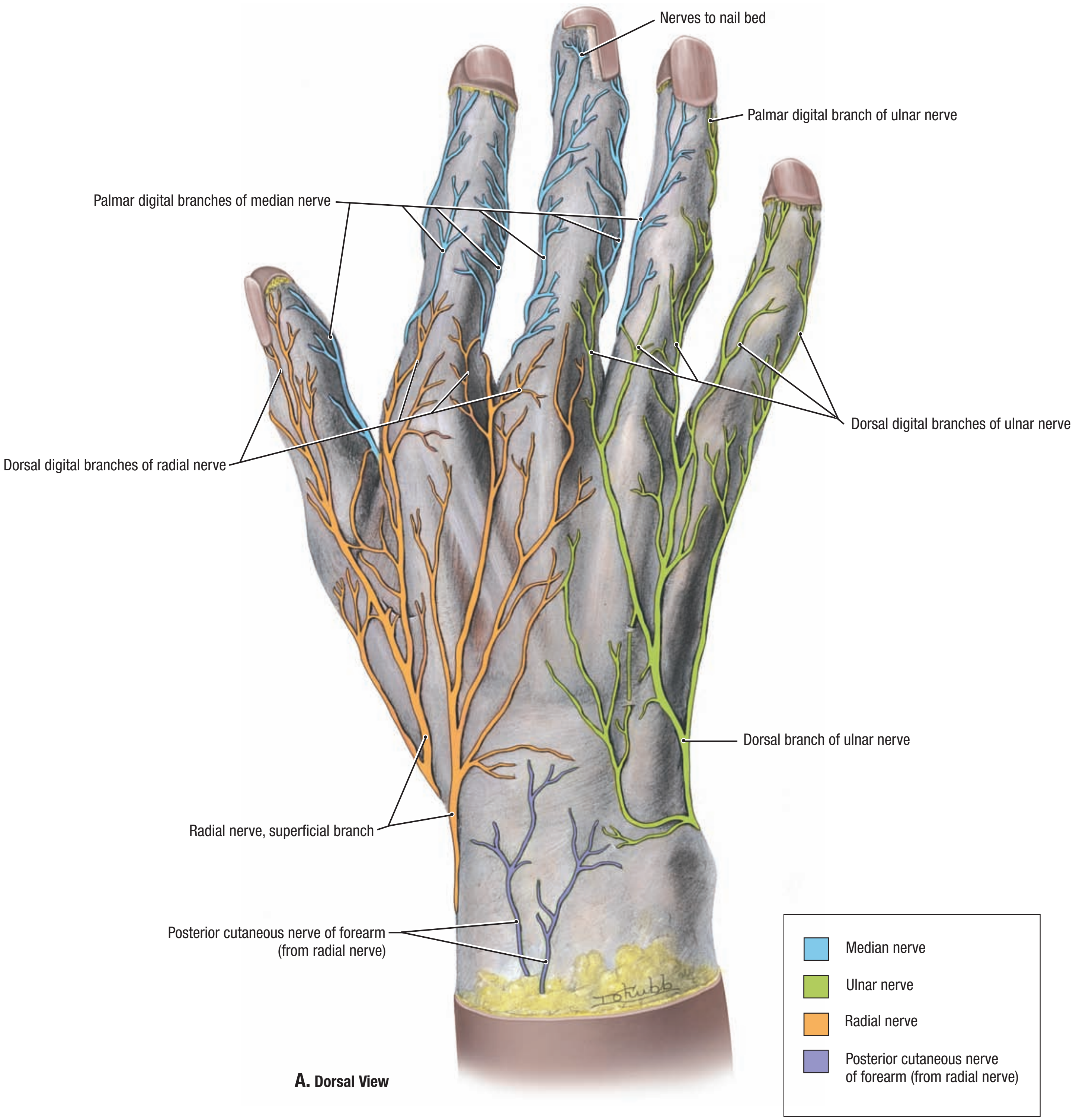
B. Posterior View

6.85 DEEP STRUCTURES ON EXTENSOR ASPECT OF FOREARM

A. Dissection. **B.** Schematic illustration of deep extensor muscles.

- Three "outcropping" muscles of the thumb (abductor pollicis longus, extensor pollicis brevis, and extensor pollicis longus) emerge between the extensor carpi radialis brevis and the extensor digitorum.
- The laterally retracted brachioradialis and extensor carpi radialis longus and brevis muscles and supinator muscle are innervated by the deep branch of the radial nerve; the other extensor muscles are supplied by the posterior interosseous nerve, which is a continuation of the deep branch of the radial nerve that pierced the supinator.

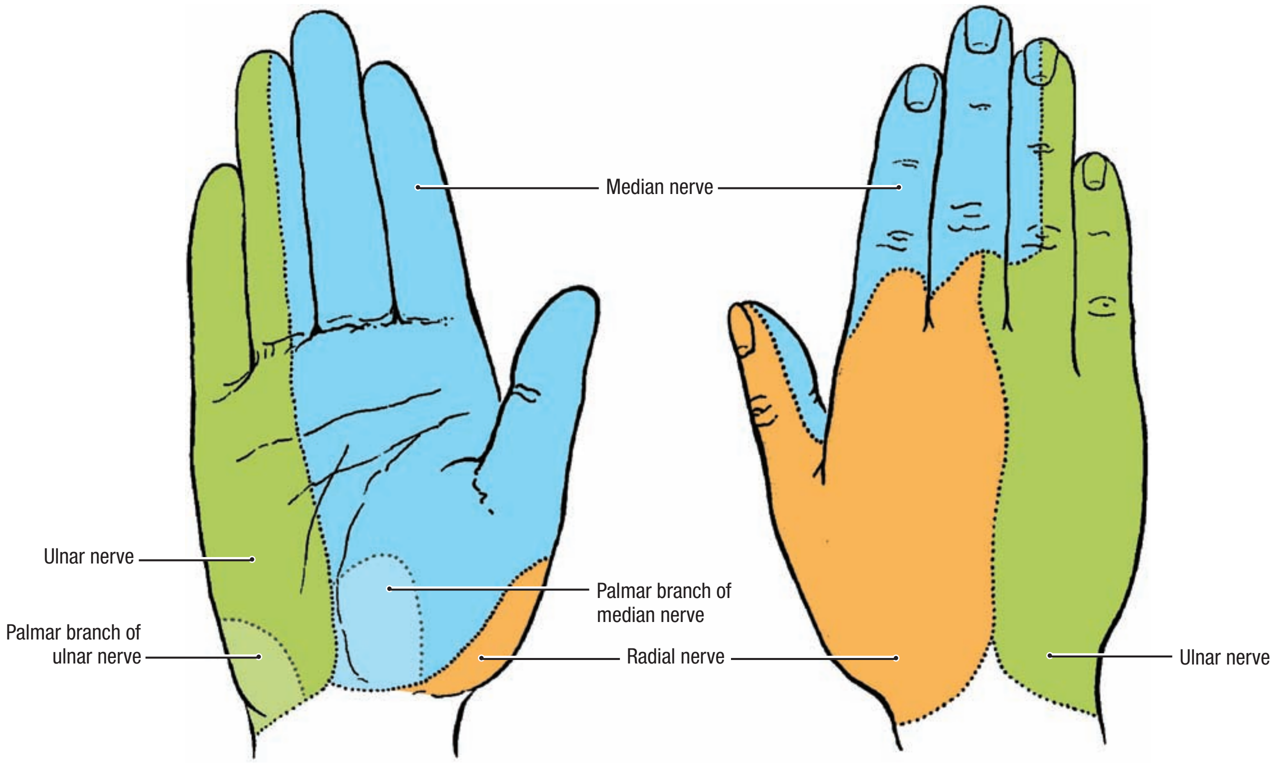
Severance of the deep branch of the radial nerve results in an inability to extend the thumb and the metacarpophalangeal joints of the other digits. Loss of sensation does not occur because the deep branch is entirely muscular and articular in distribution.



A. Dorsal View

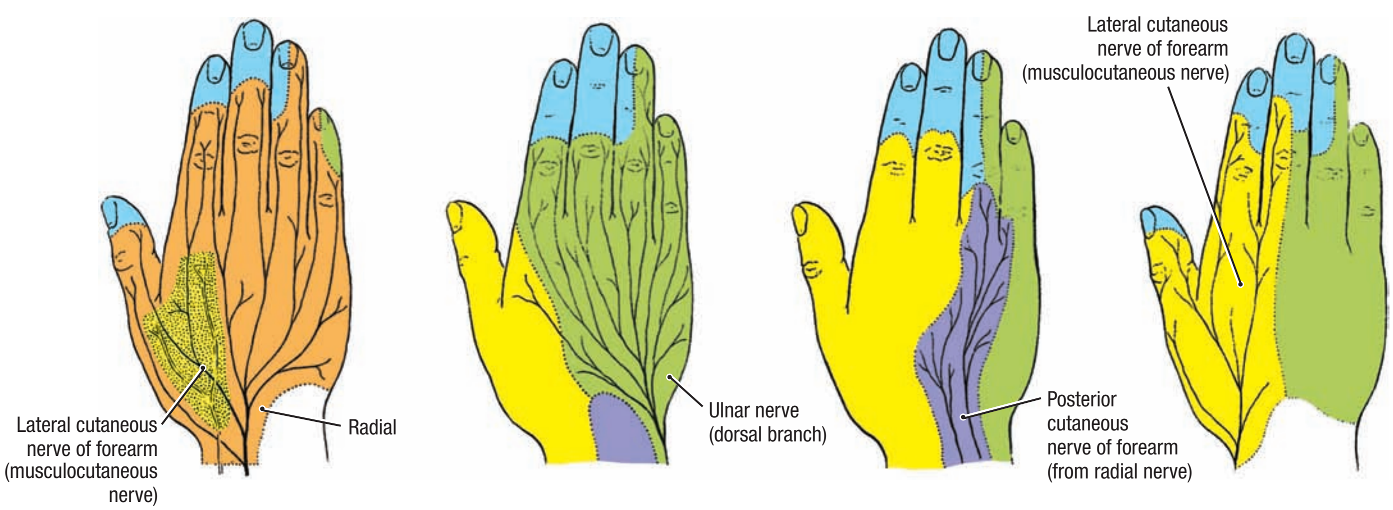
6.86 CUTANEOUS INNERVATION OF HAND

A. Dissection of nerves of dorsum of hand.



B **Anterior View** **Dorsal View**

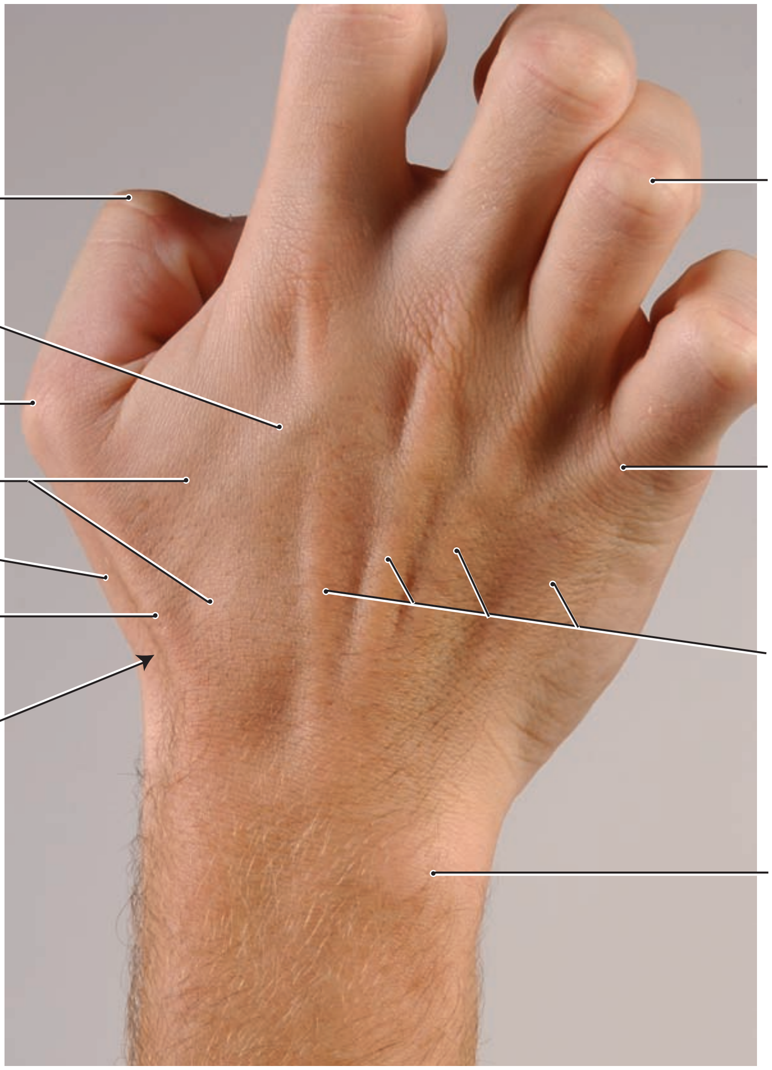
- Median nerve
- Ulnar nerve
- Radial nerve
- Posterior cutaneous nerve of forearm (from radial nerve)
- Lateral cutaneous nerve of forearm (musculocutaneous nerve)
- Dual innervation by lateral cutaneous nerve of forearm and radial nerves



C. Dorsal Views

6.86 CUTANEOUS INNERVATION OF HAND *(CONTINUED)*

B. Distribution of the cutaneous nerves to the palm and dorsum of the hand, schematic illustration. **C.** Variations in pattern of cutaneous nerves in dorsum of hand.



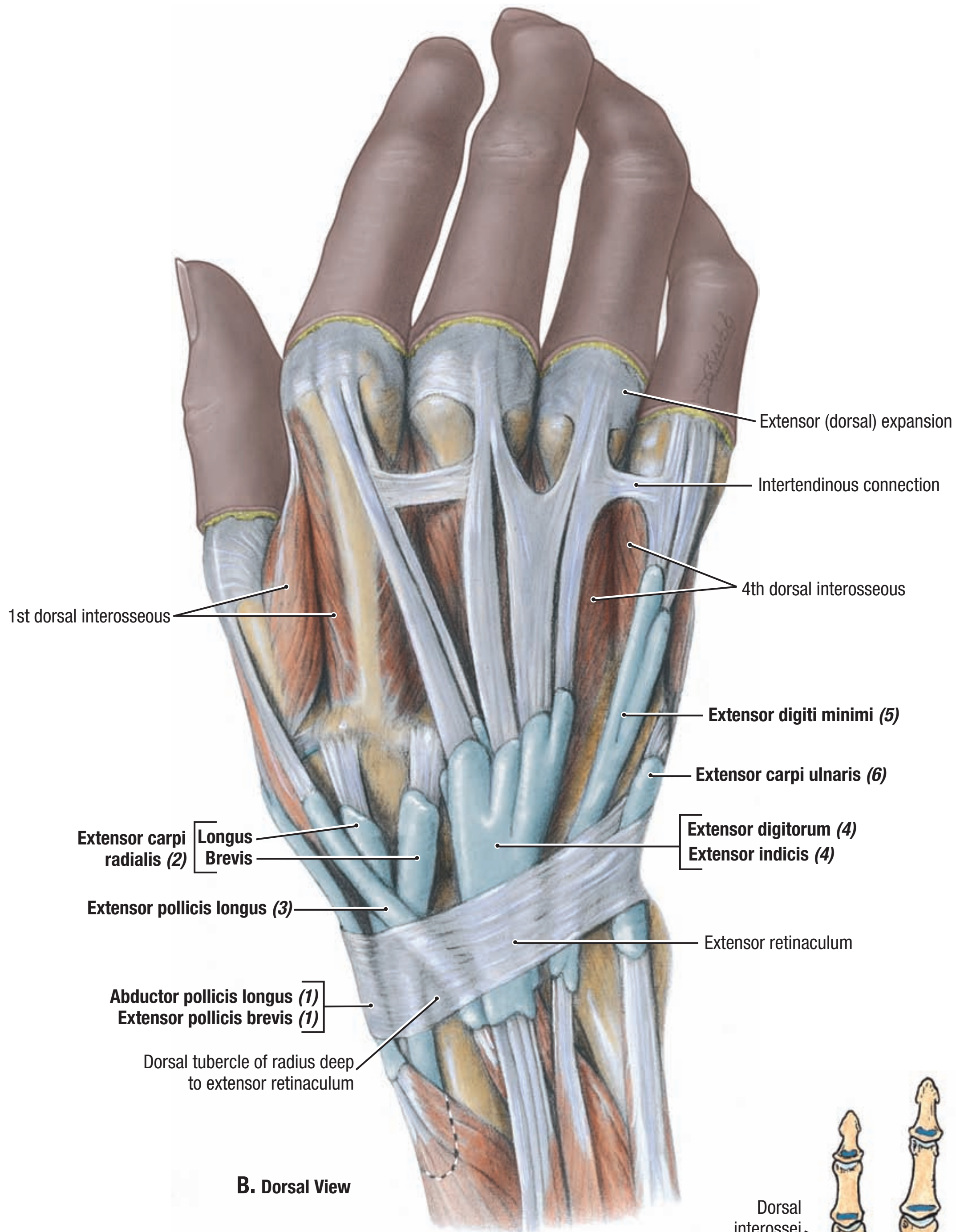
A. **Dorsal View**

6.87 DORSUM OF HAND

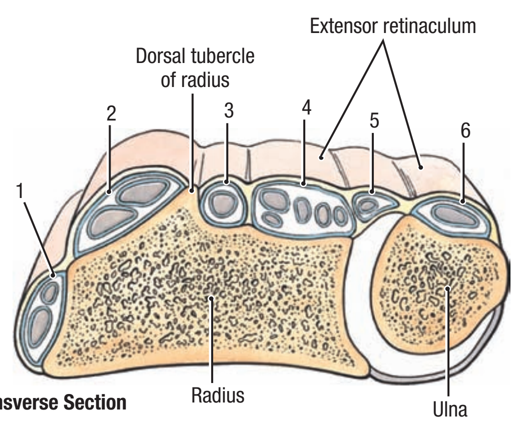
A. Surface anatomy. The interphalangeal joints are flexed, and the metacarpophalangeal joints are hyperextended to demonstrate the extensor digitorum tendons. **B.** Tendinous (synovial) sheaths distended with blue fluid. **C.** Transverse section of distal forearm (*numbers* refer to structures labeled in B). **D.** Sites of bony attachments.

- Six tendinous sheaths occupy the six osseofibrous tunnels deep to the extensor retinaculum. They contain nine tendons: tendons for the thumb in sheaths 1 and 3, tendons for the extensors of the wrist in sheaths 2 and 6, and tendons for the extensors of the wrist and fingers in sheaths 4 and 5.
- The tendon of the extensor pollicis longus hooks around the dorsal tubercle of radius to pass obliquely across the tendons of the extensor carpi radialis longus and brevis to the thumb.

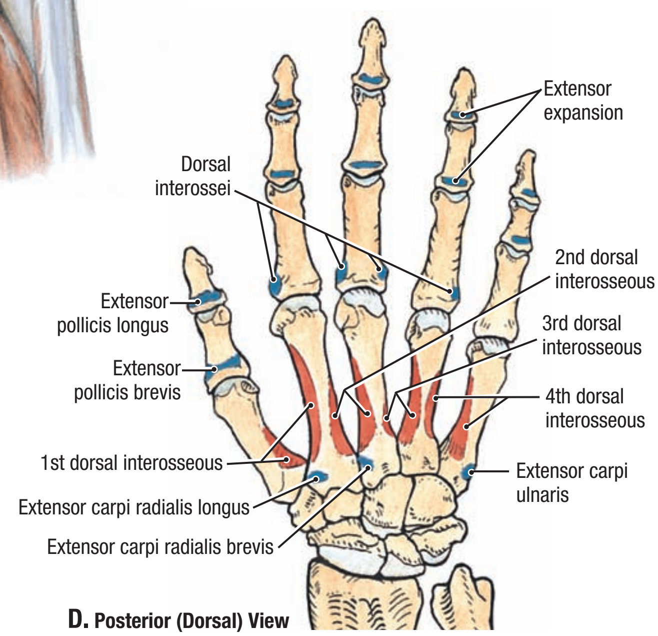
The tendons of the abductor pollicis longus and extensor pollicis brevis are in the same tendinous sheath on the dorsum of the wrist. Excessive friction of these tendons results in fibrous thickening of the sheath and stenosis of the osseofibrous tunnel, **Quervain tenovaginitis stenosans.** This condition causes pain in the wrist that radiates proximally to the forearm and distally to the thumb.



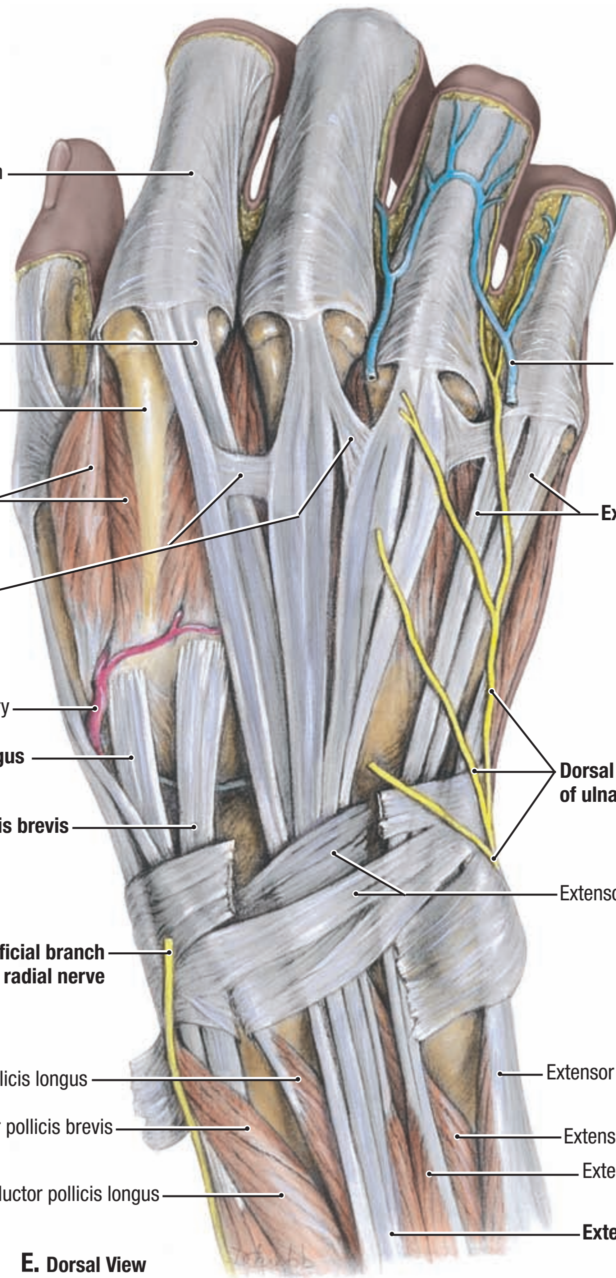
B. Dorsal View



C. Transverse Section



D. Posterior (Dorsal) View



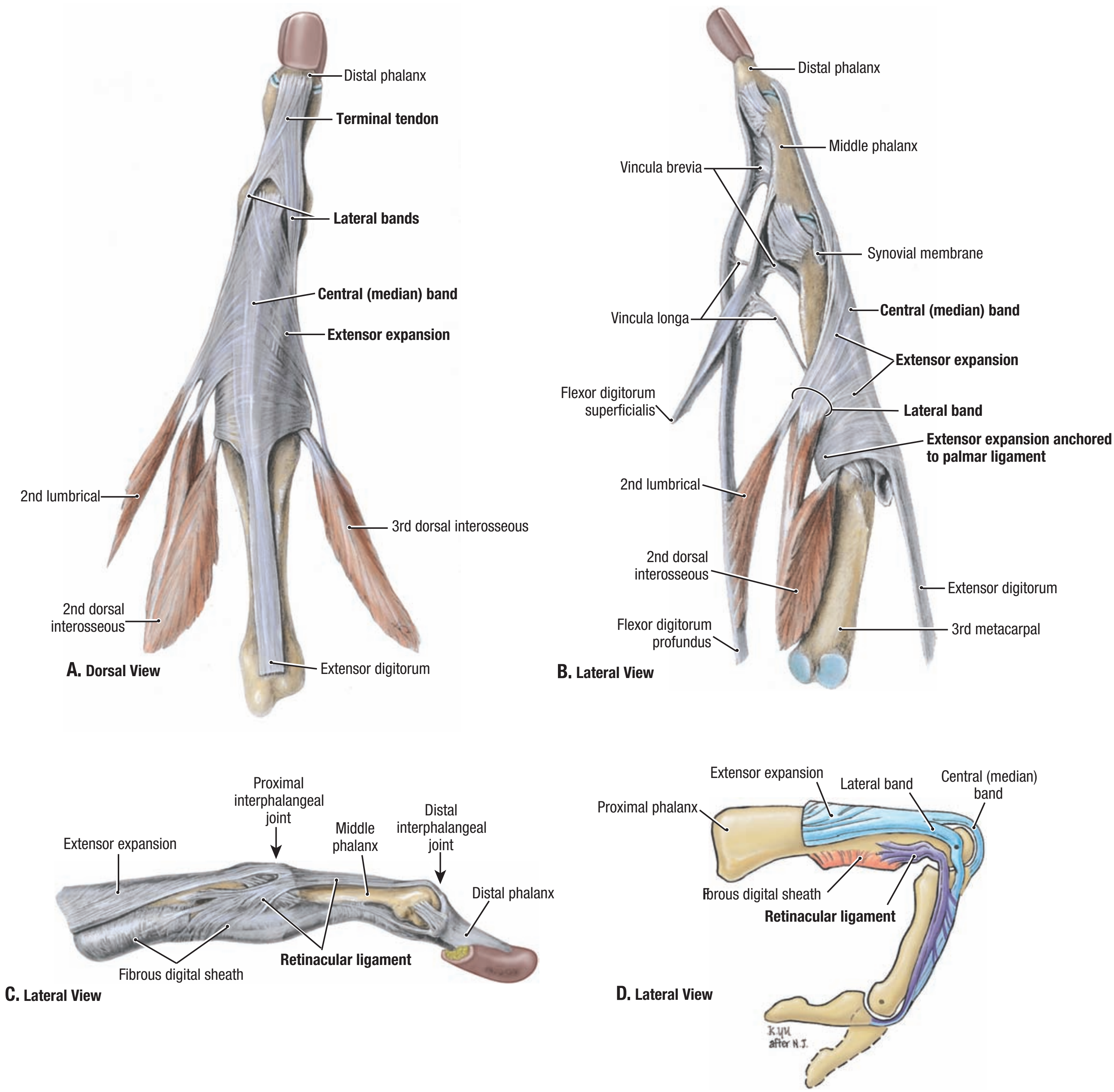
E. Dorsal View

6.87 DORSUM OF HAND *(CONTINUED)*

E. Tendons on dorsum of hand and extensor retinaculum.

- The deep fascia is thickened to form the extensor retinaculum.
- Proximal to the knuckles, intertendinous connections extend between the tendons of the digital extensors and, thereby, restrict the independent action of the fingers.

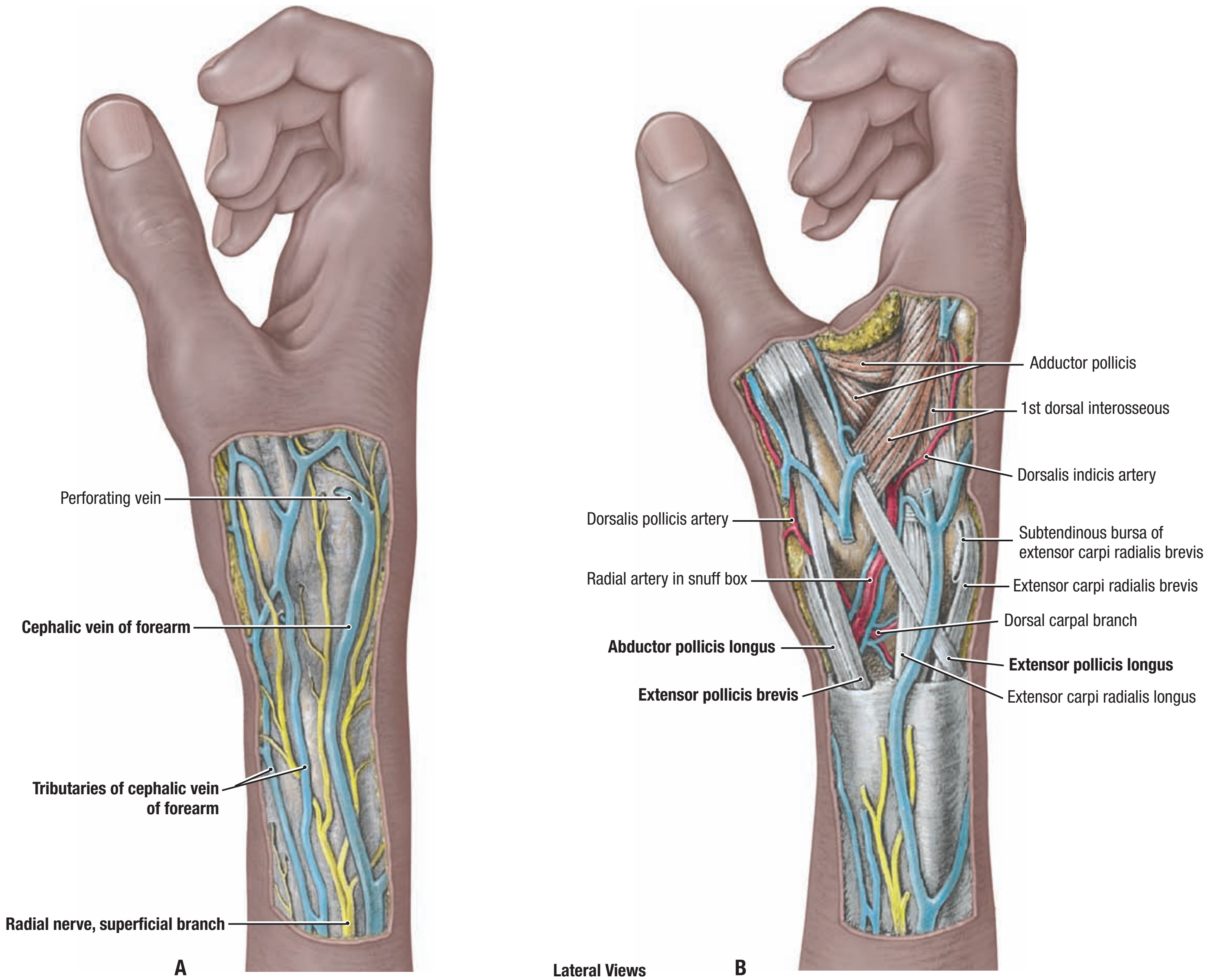
"Ganglion" cyst. Sometimes a nontender cystic swelling appears on the hand, most commonly on the dorsum of the wrist. The thin-walled cyst contains clear mucinous fluid. Clinically, this type of swelling is called a "ganglion" (G. swelling or knot). These synovial cysts are close to and often communicate with the synovial sheaths. The distal attachment of the extensor carpi radialis brevis tendon is a common site for such a cyst.



6.88 EXTENSOR (DORSAL) EXPANSION OF THIRD DIGIT

A. Dorsal aspect. **B.** Lateral aspect. **C.** Retinacular ligaments of extended digit. **D.** Retinacular ligaments of flexed digit.

- The hood covering the head of the metacarpal is attached to the palmar ligament.
- Contraction of the muscles attaching to the lateral band will produce flexion of the metacarpophalangeal joint and extension of the interphalangeal joints.
- The retinacular ligament is a fibrous band that runs from the proximal phalanx and fibrous digital sheath obliquely across the middle phalanx and two interphalangeal joints to join the extensor (dorsal) expansion, and then to the distal phalanx.
- On flexion of the distal interphalangeal joint, the retinacular ligament becomes taut and pulls the proximal joint into flexion; on extension of the proximal joint, the distal joint is pulled by the ligament into nearly complete extension.



6.89 LATERAL ASPECT OF WRIST AND HAND

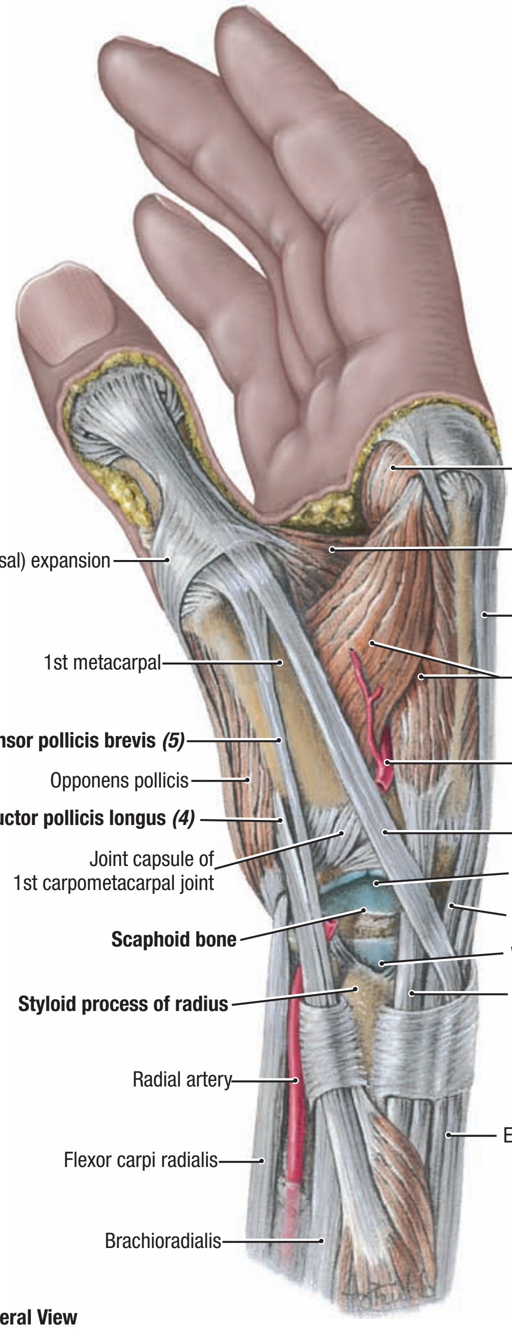
A. Anatomical snuff box—I. **B.** Anatomical snuff box—II.

In **A**:

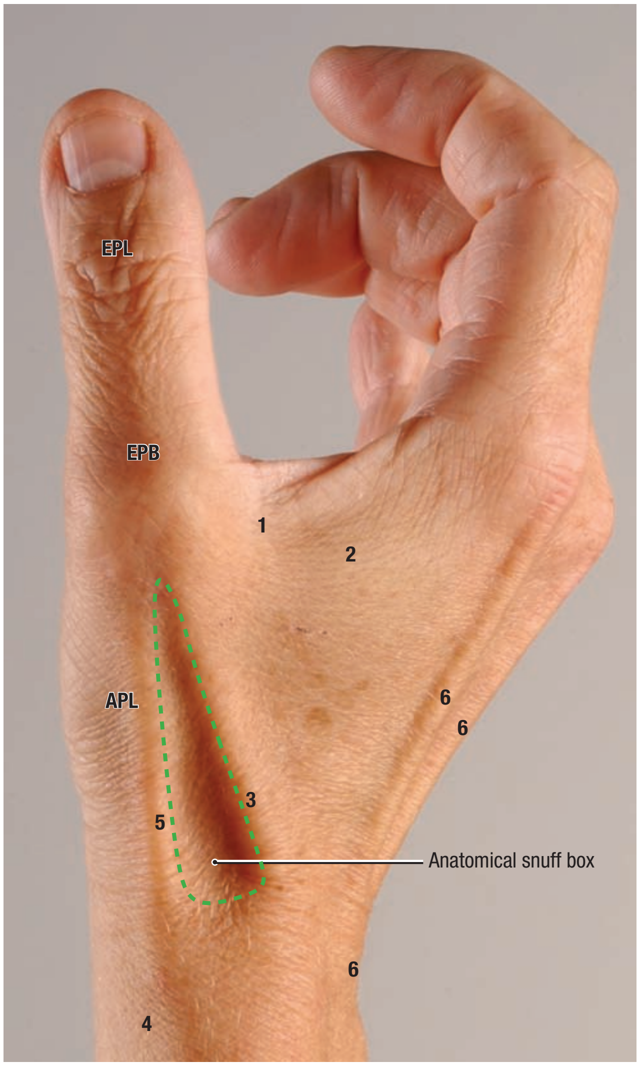
- The depression at the base of the thumb, the "anatomical snuff box," retains its name from an archaic habit.
- Note the superficial veins, including the cephalic vein of forearm and/or its tributaries, and cutaneous nerves crossing the snuff box.

In **B**:

- Three long tendons of the thumb form the boundaries of the snuff box; the extensor pollicis longus forms the medial boundary and the abductor pollicis longus and extensor pollicis brevis the lateral boundary.
- The radial artery crosses the floor of the snuff box and travels between the two heads of the 1st dorsal interosseous.
- The adductor pollicis and 1st dorsal interosseous are supplied by the ulnar nerve.



C. Lateral View



D. Lateral View

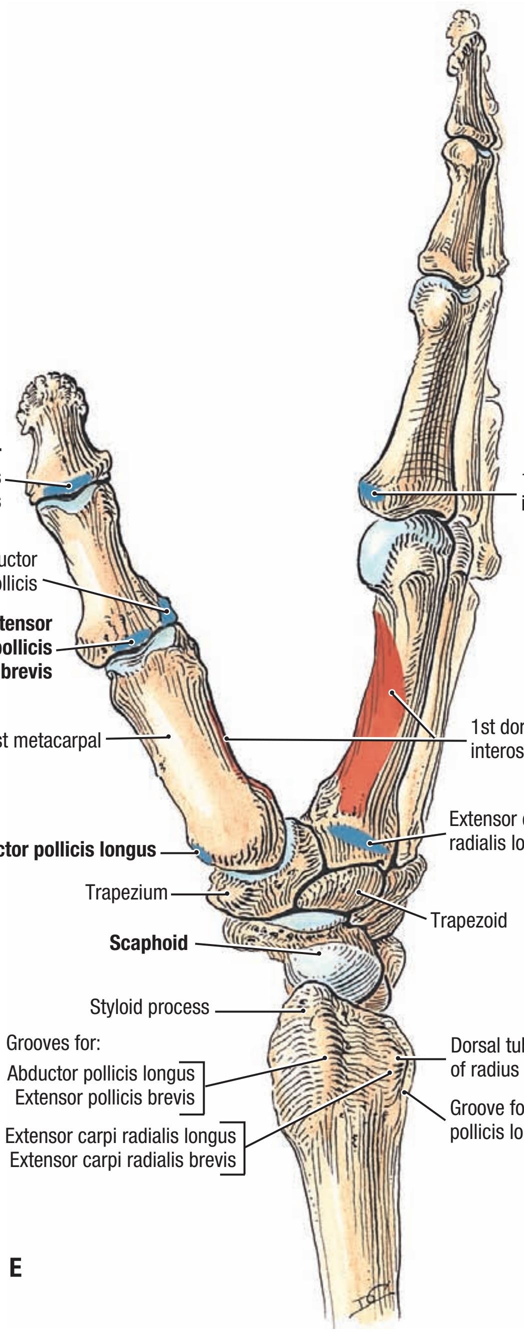
Distal Extents of:	
EPL	Extensor pollicis longus
EPB	Extensor pollicis brevis
APL	Abductor pollicis longus

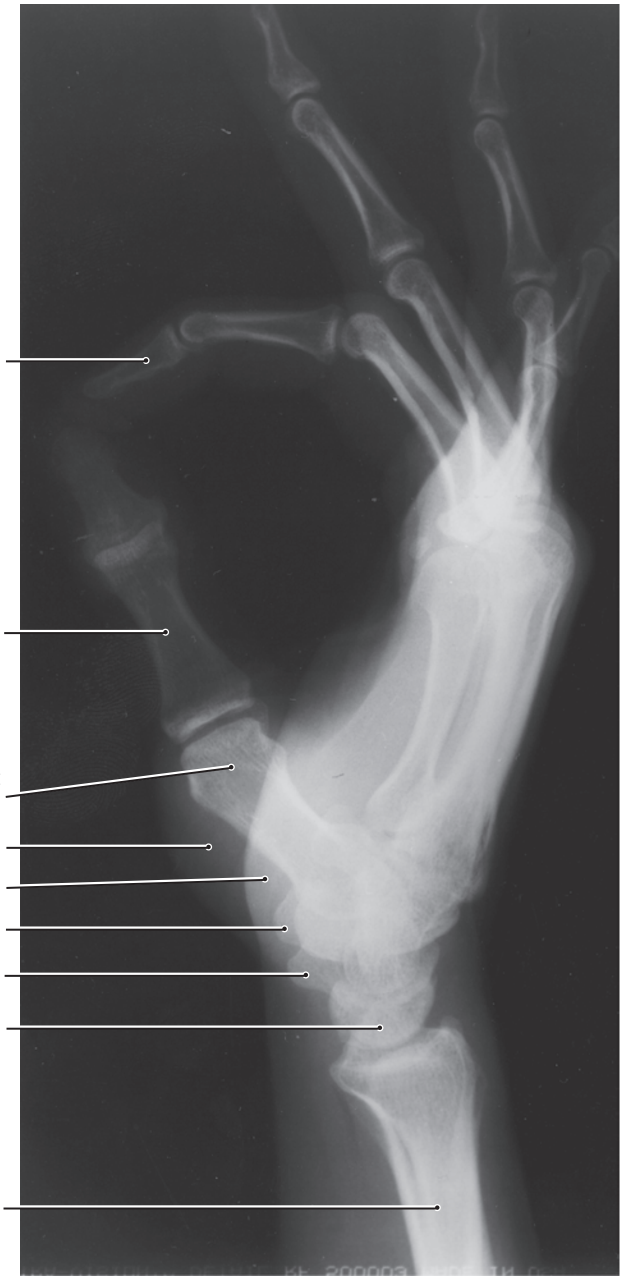
6.89 LATERAL ASPECT OF WRIST AND HAND *(CONTINUED)*

C. Anatomical snuff box—III. **D.** Surface anatomy.

In **C**: Note the scaphoid bone, the wrist joint proximal to the scaphoid, and the midcarpal joint distal to it.

Fracture of the scaphoid often results from a fall on the palm with the hand abducted. The fracture occurs across the narrow part ("waist") of the scaphoid. Pain occurs primarily on the lateral side of the wrist, especially during dorsiflexion and abduction of the hand. Initial radiographs of the wrist may not reveal a fracture, but radiographs taken 10 to 14 days later reveal a fracture because bone resorption has occurred. Owing to the poor blood supply to the proximal part of the scaphoid, union of the fractured parts may take several months. **Avascular necrosis of the proximal fragment of the scaphoid** (pathological death of bone resulting from poor blood supply) may occur and produce degenerative joint disease of the wrist.



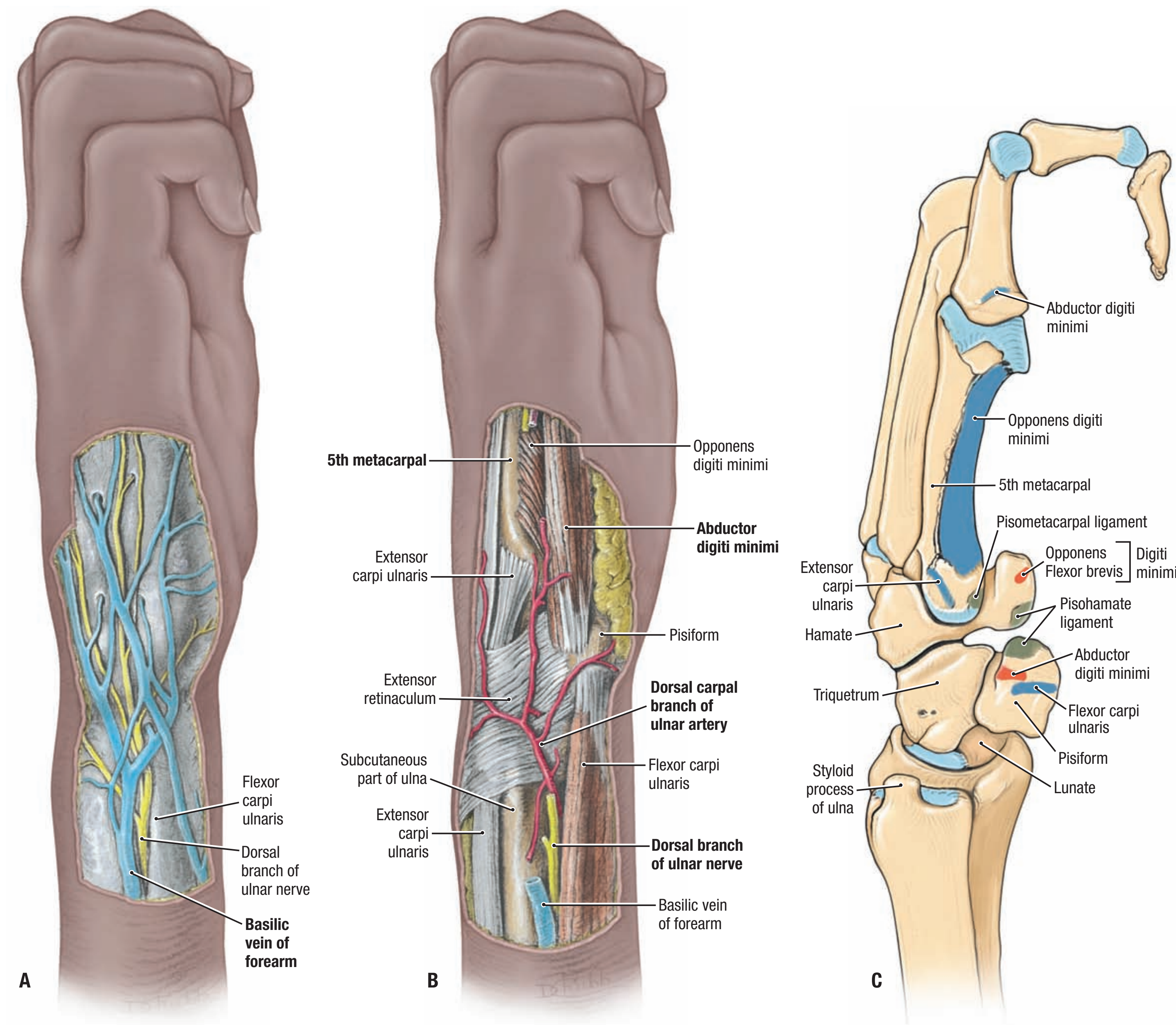


Lateral Views, Right Hand

6.89 LATERAL ASPECT OF WRIST AND HAND *(CONTINUED)*

E. Bony hand showing muscle attachments. **F.** Radiograph.

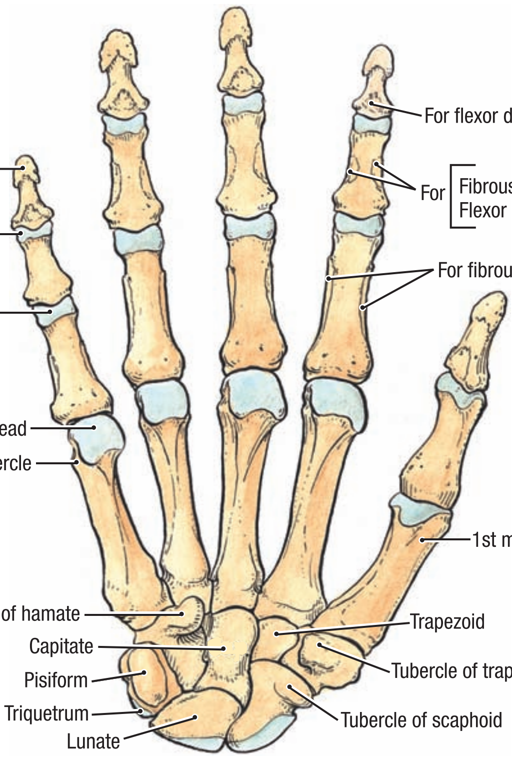
- The anatomical snuff box is limited proximally by the styloid process of the radius and distally by the base of the 1st metacarpal; aspects of the two lateral bones of the carpus (scaphoid and trapezium) form the floor of the snuff box.



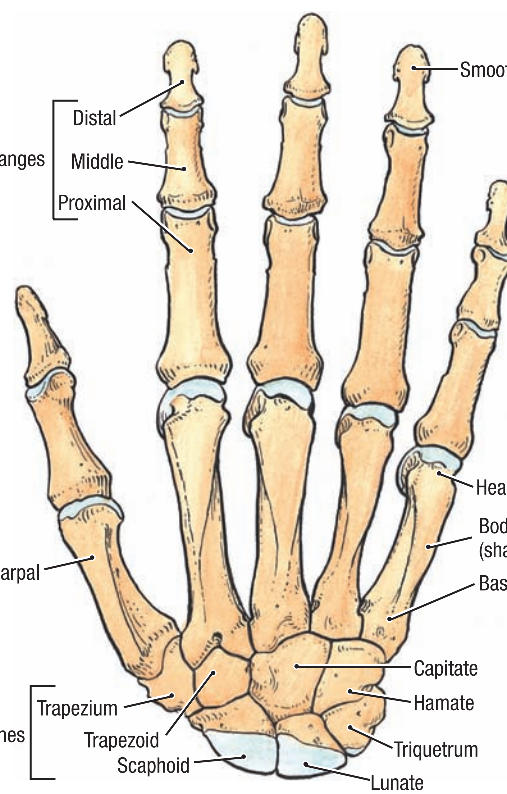
Medial Views

6.90 MEDIAL ASPECT OF WRIST AND HAND

A. Superficial dissection. **B.** Deep dissection. **C.** Bony hand showing sites of muscular and ligamentous attachments. The extensor carpi ulnaris is inserted directly into the base of the fifth metacarpal, but the flexor carpi ulnaris inserts indirectly to the base of the fifth metacarpal via the pisiform and pisohamate and pisometacarpal ligaments. These ligaments are often considered to be a part of the distal attachment of flexor carpi ulnaris.



A. Palmar View



B. Dorsal View

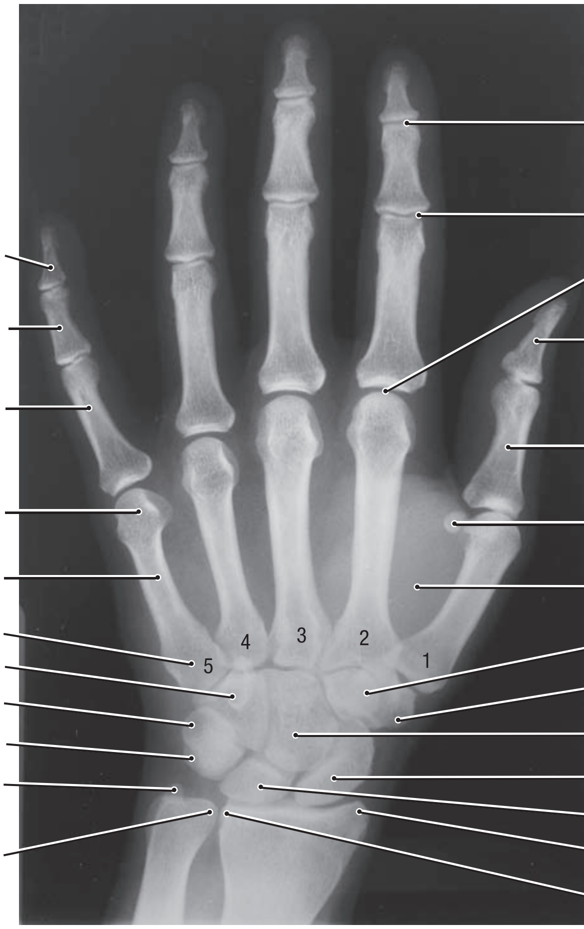
6.91 BONES OF HAND

A. Palmar view. **B.** Dorsal view.

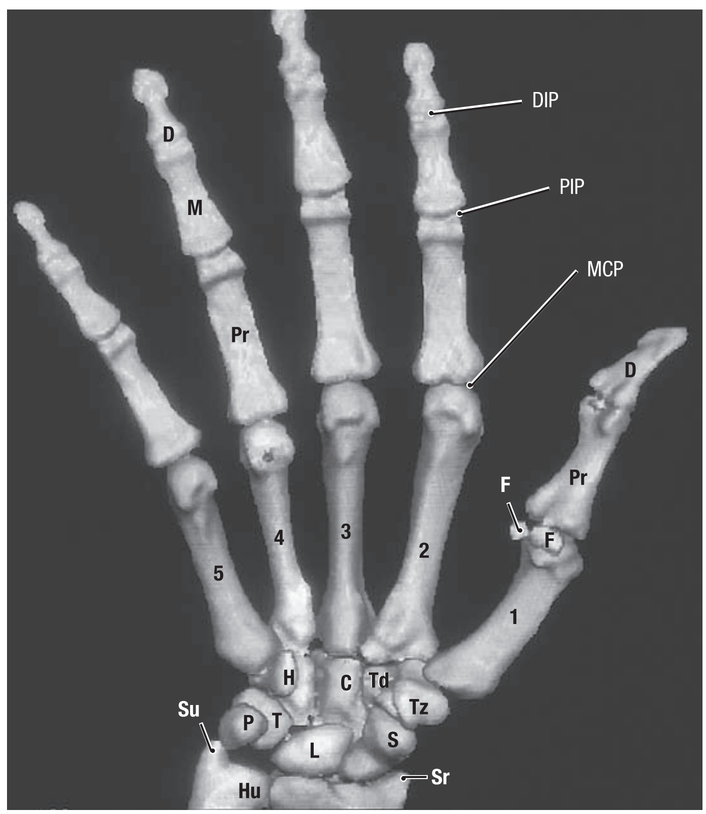
The eight carpal bones form two rows: in the distal row, the hamate, capitate, trapezoid, and trapezium, the trapezium forming a saddle-shaped joint with the 1st metacarpal, and in the proximal row, the scaphoid, lunate, and pisiform, the pisiform being superimposed on the triquetrum.

Severe **crushing injuries of the hand** may produce multiple metacarpal fractures, resulting in instability of the hand. Similar injuries of the distal phalanges are common (e.g., when a finger is caught in a car door).

A **fracture of a distal phalanx** is usually comminuted, and a painful **hematoma** (collection of blood) develops. **Fractures of the proximal and middle phalanges** are usually the result of crushing or hypertension injuries.



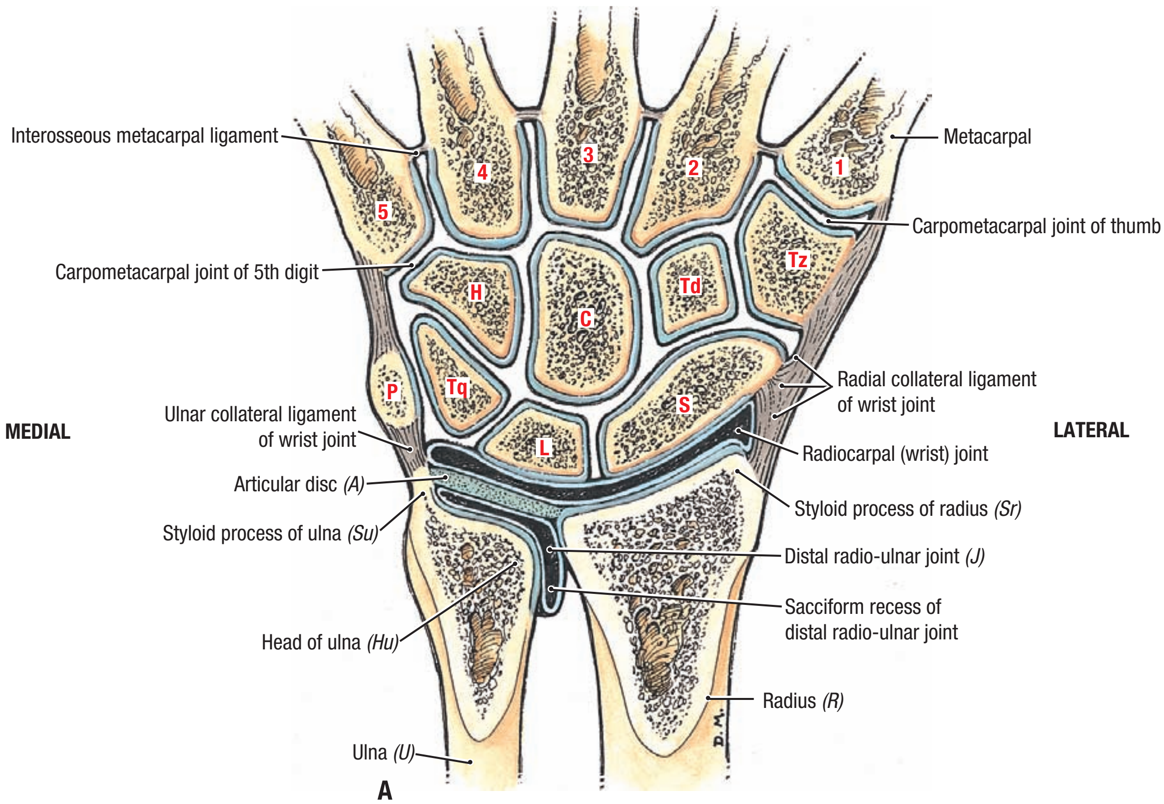
A. Anterior View

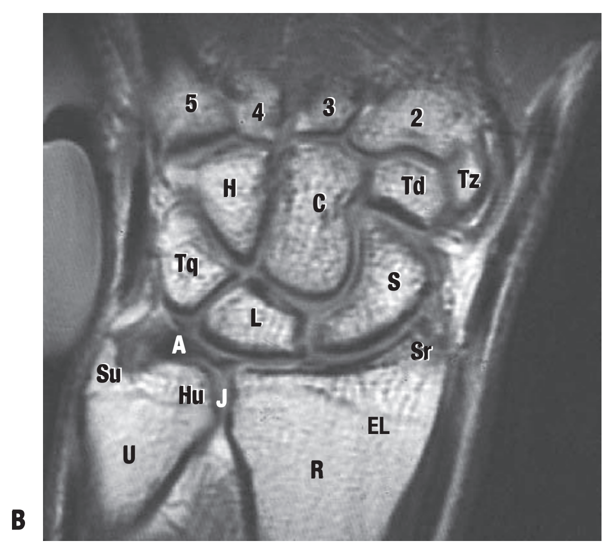


B. Anterior View

6.92 IMAGING OF BONES OF WRIST AND HAND

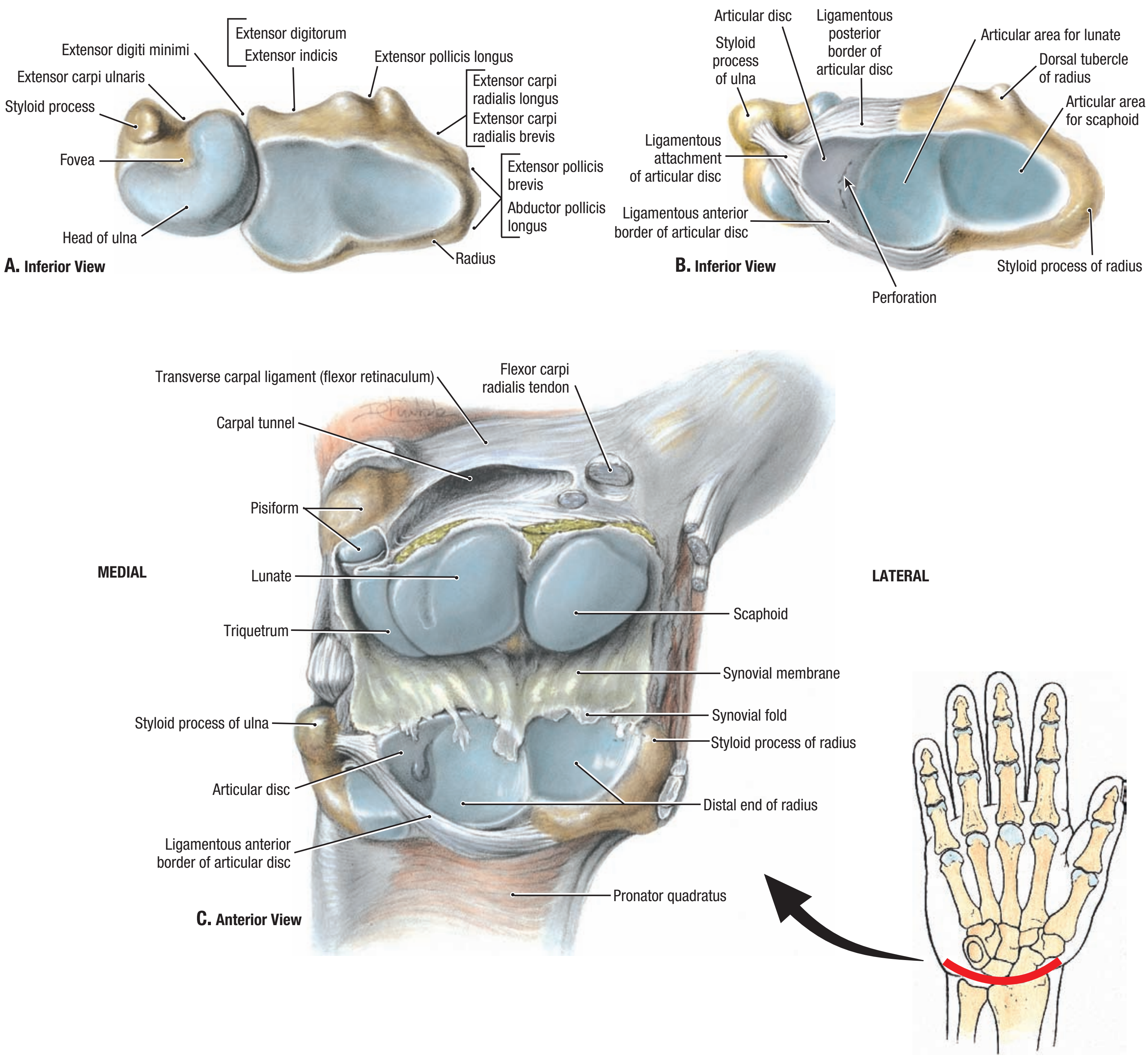
A. Radiograph. **B.** Three-dimensional computer-generated image of wrist and hand (letters correspond to structures labeled in **A**).





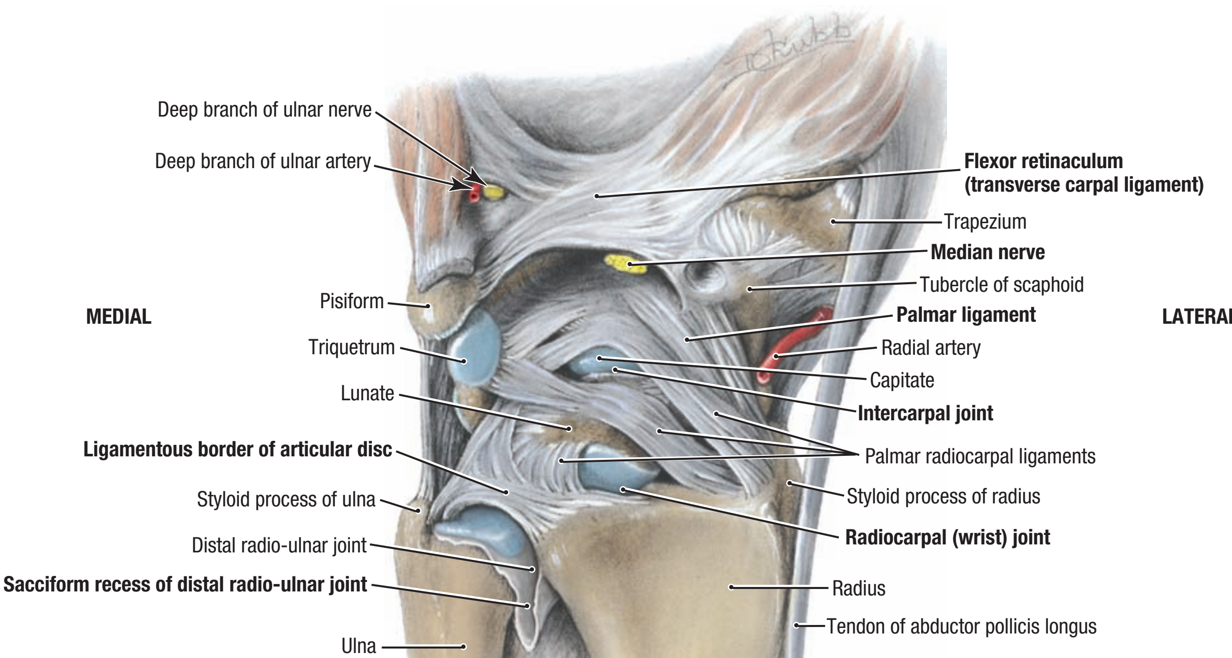
6.93 CORONAL SECTION OF WRIST

A. Schematic illustration. **B.** Coronal MRI. *EL,* epiphysial line; letters correspond to structures labeled in **A**.

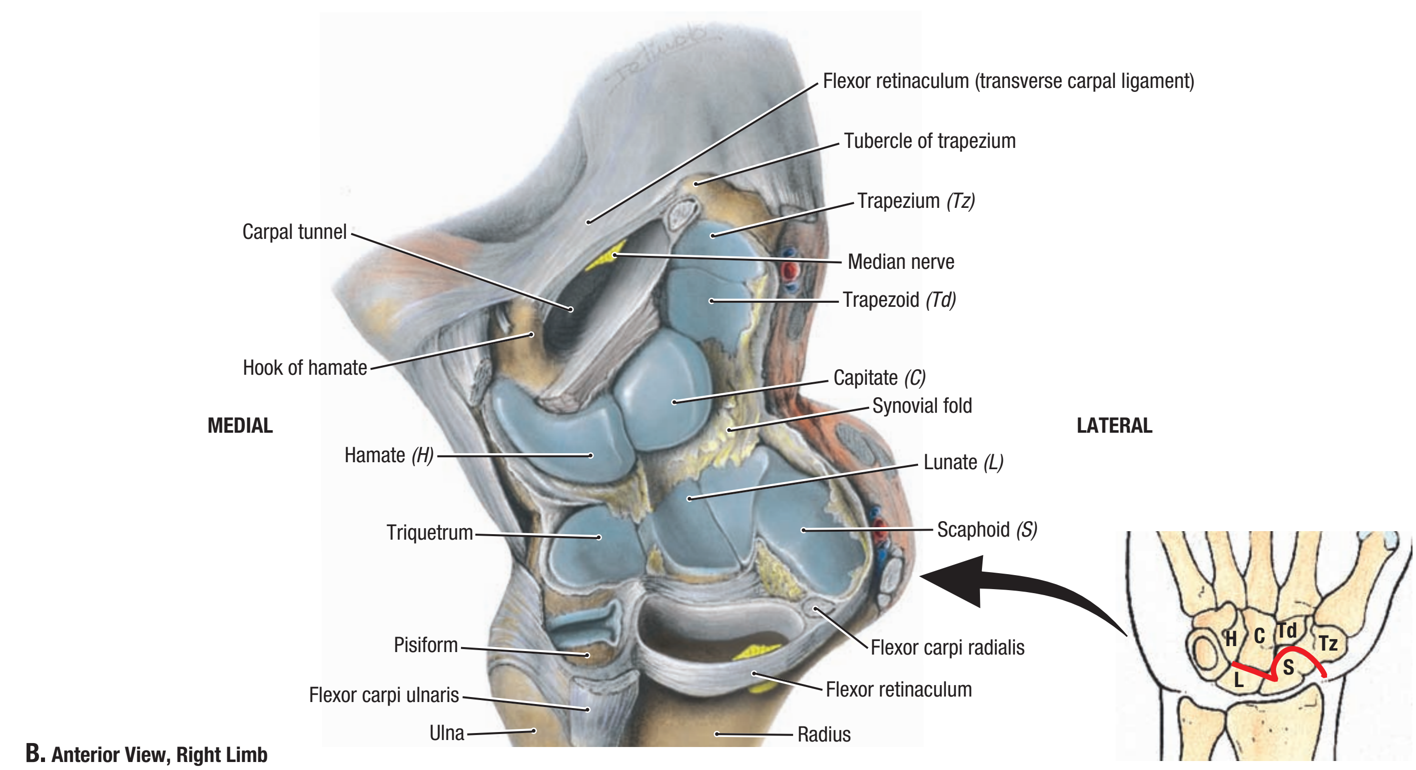


6.94 RADIOCARPAL (WRIST) JOINT

A. Distal ends of radius and ulna showing grooves for tendons on the posterior aspects. **B.** Articular disc. The articular disc unites the distal ends of the radius and ulna; it is fibrocartilaginous at the triangular area between the head of the ulna and the lunate bone, but ligamentous and pliable elsewhere. The cartilaginous part of the articular disc commonly has a fissure or perforation, as shown here, associated with a roughened surface of the lunate. **C.** Articular surface of the radiocarpal joint, which is opened anteriorly. The lunate articulates with the radius and articular disc; only during adduction of the wrist does the triquetrum come into articulation with the disc.



A. Anterior View

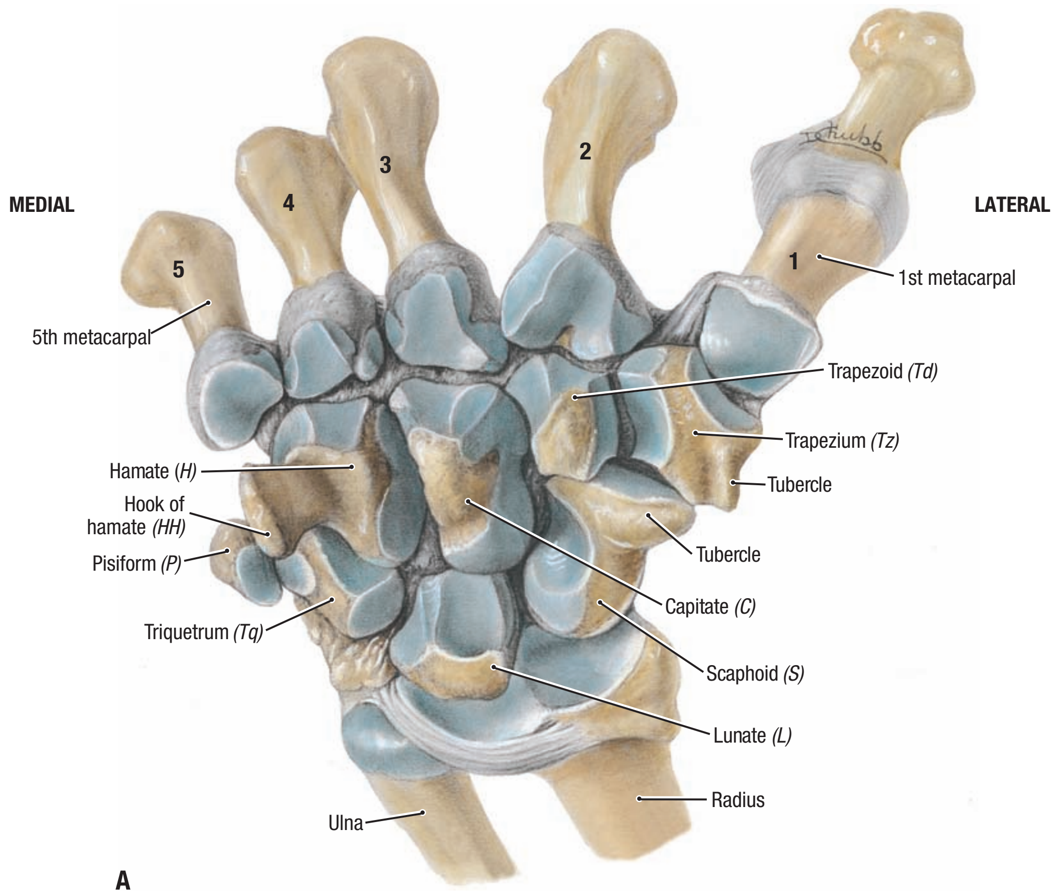


B. Anterior View, Right Limb

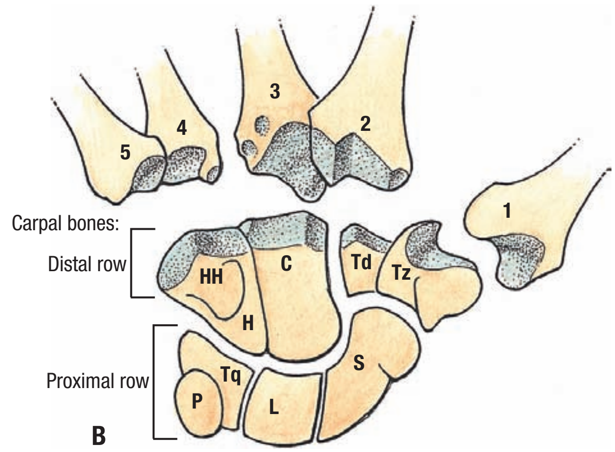
6.95 RADIOCARPAL (WRIST) AND MIDCARPAL (TRANSVERSE CARPAL) JOINT

A. Ligaments. The hand is forcibly extended. The palmar radiocarpal ligaments pass from the radius to the two rows of carpal bones; they are strong and directed so that the hand moves with the radius during supination. **B.** Articular surfaces of midcarpal (transverse carpal) joint, opened anteriorly.

- The flexor retinaculum (transverse carpal ligament) is cut; the proximal part of the ligament, which spans from the pisiform to the scaphoid, is relatively weak; the distal part, which passes from the hook of the hamate to the tubercle of the trapezium, is strong.
- The opposed bones have sinuous surfaces: the trapezium and trapezoid together form a concave, oval surface for the scaphoid, and the capitate and hamate together form a convex surface for the scaphoid, lunate, and triquetrum.



Anterior View, Right Limb

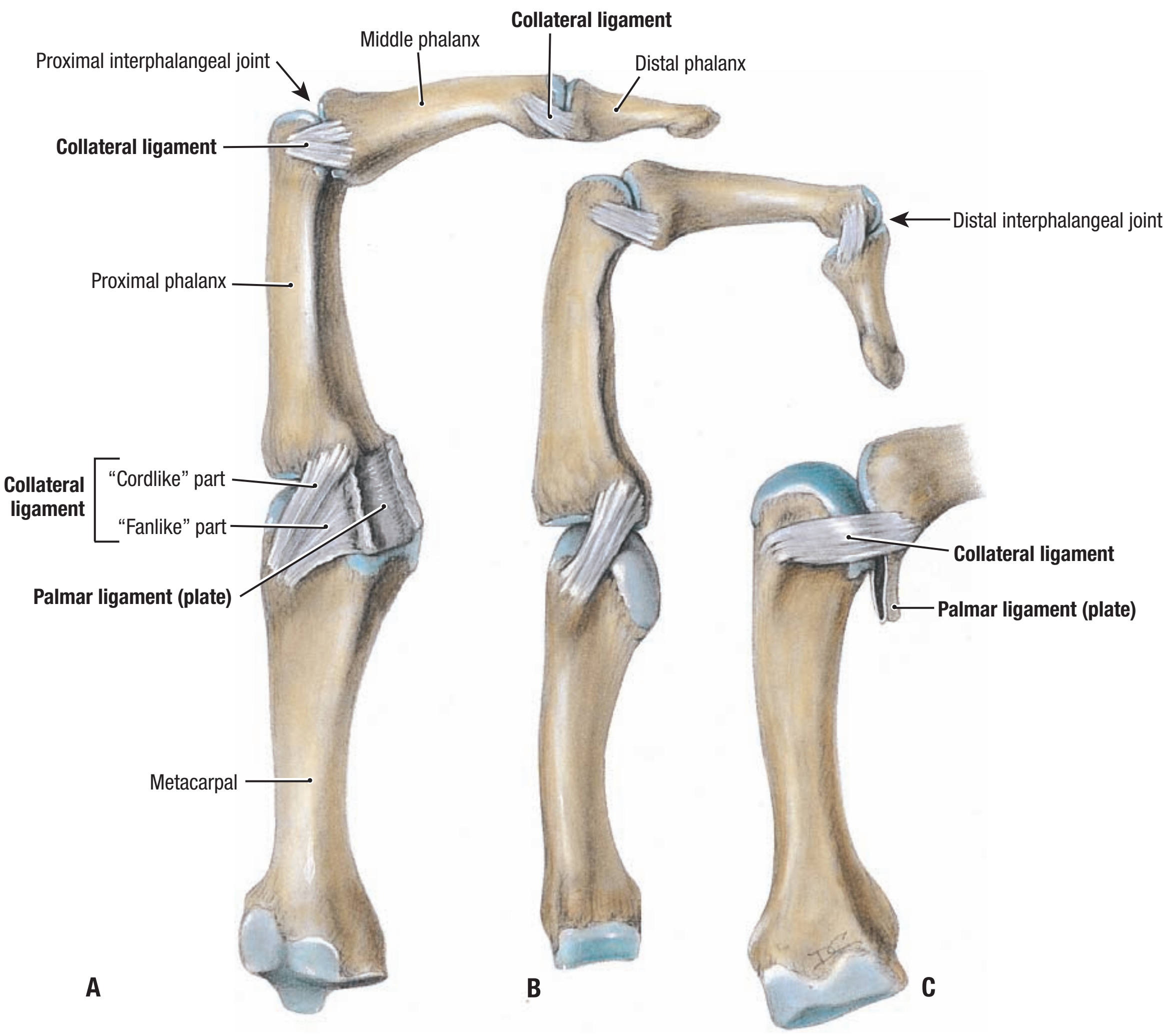


6.96 CARPAL BONES AND BASES OF METACARPALS

A. Open intercarpal and carpometacarpal (CMC) joints. The dorsal ligaments remain intact, and all the joints have been hyperextended, permitting study of articular facets. **B.** Diagram of the articular surfaces of the CMC joints (*letters* refer to structures labeled in **A**).

- The capitate articulates with three metacarpals (2nd, 3rd, and 4th).
- The 2nd metacarpal articulates with three carpals (trapezium, trapezoid, and capitate).
- The 1st CMC joint is saddle-shaped and especially mobile, allowing opposition of the thumb; the 2nd and 3rd CMC joints have interlocking surfaces and are practically immobile; and the 4th and 5th are hinge-shaped synovial joints with limited movement.

Anterior dislocation of the lunate is a serious injury that usually results from a fall on the extended wrist. The lunate is pushed to the palmar surface of the wrist and may compress the median nerve and lead to carpal tunnel syndrome. Because of poor blood supply, **avascular necrosis of the lunate** may occur.



Lateral Views of Right 3rd Digit

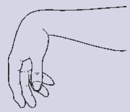
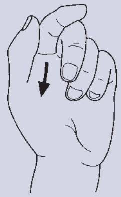
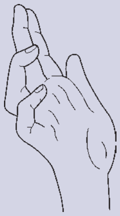
6.97 COLLATERAL LIGAMENTS OF METACARPOPHALANGEAL AND INTERPHALANGEAL JOINTS OF THIRD DIGIT

A. Extended metacarpophalangeal (MCP) and distal interphalangeal (IP) joints. **B.** Flexed interphalangeal joints. **C.** Flexed MCP joint.

- A fibrocartilaginous plate, the palmar ligament, hangs from the base of the proximal phalanx; is fixed to the head of the metacarpal by the weaker, fanlike part of the collateral ligament (**A**); and moves like a visor across the metacarpal head (**C**). The IP joints have similar palmar ligaments.
- The extremely strong, cordlike parts of the collateral ligaments of this joint (**A** and **B**) are eccentrically attached to the metacarpal heads; they are slack during extension and taut during flexion (**C**), so the fingers cannot be spread (abducted) unless the hand is open; the IP joints have similar collateral ligaments.

Skier's thumb refers to the rupture or chronic laxity of the collateral ligament of the 1st metacarpophalangeal joint. The injury results from hyperextension of the joint, which occurs when the thumb is held by the ski pole while the rest of the hand hits the ground or enters the snow.

TABLE 6.16 LESIONS OF NERVES OF UPPER LIMB

Nerve Injury	Injury Description	Impairments	Clinical Aspect
Long thoracic nerve	Stab wound Mastectomy	Abduction of shoulder joint and protraction of the scapula is compromised	Test: Pushing against a wall causes winging of scapula
Axillary nerve	Surgical neck fracture of humerus Anterior dislocation of shoulder joint	Abduction of shoulder joint to horizontal is compromised; sensory loss on lateral side of upper arm	Test: Abduct shoulder joint to horizontal and ask patient to hold position against a downward pull
Radial nerve	Midshaft fracture of humerus Badly fitted crutch Arm draped over a chair	Extension at wrist and joints of digits is lost; supination of forearm is compromised; sensory loss on posterior arm and forearm, and lateral aspect of dorsum of hand	Wrist drop 
Median nerve at elbow	Supra-epicondylar fracture of humerus	Flexion of wrist joint is weakened; hand will deviate to ulnar side during flexion of wrist joint; flexion of DIP, PIP and MP joints of index and middle digits is lost; abduction, opposition and flexion of thumb joints are lost; sensory loss on palmar and dorsal aspects of index, middle, and lateral half of ring fingers and palmar aspect of thumb	Absence of thumb opposition Hand of benediction 
Median nerve at wrist	Slashing of wrist Carpal tunnel syndrome	Weakened flexion of MP joints of index and middle fingers; opposition and abduction of CMC and MP joint of thumb lost; sensory loss same as for median nerve injury at elbow	Test: Make an "O" with thumb and index finger
Ulnar nerve at elbow	Fracture of medial epicondyle of humerus	Hand will deviate to radial side during flexion of wrist joint; flexion of DIP joints of ring and little finger lost; flexion at MP joint and extension at PIP and DIP joints of little and ring finger are lost; adduction and abduction of MP joints of digits 2–5 lost; adduction of thumb lost; sensory loss on palmar and dorsal aspects of little and medial half of ring fingers	Claw hand 
Ulnar nerve at wrist	Slashing of wrist	Flexion at MP joint and extension at PIP and DIP joints of little and ring fingers lost; adduction and abduction of MP joints of digits 2–5 lost; adduction of thumb lost; sensory loss same as for ulnar nerve injury at elbow	Test: Hold paper between middle and ring fingers

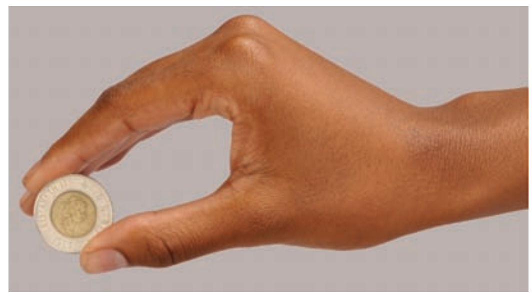
CMC, carpometacarpal joint; MP, metacarpophalangeal joint; PIP, proximal interphalangeal joint; DIP, distal interphalangeal joint.

A. Lateral view

B. Anterior view

C. Medial view

D. Medial view



E. Medial view

F. Medial view

I. Lateral view

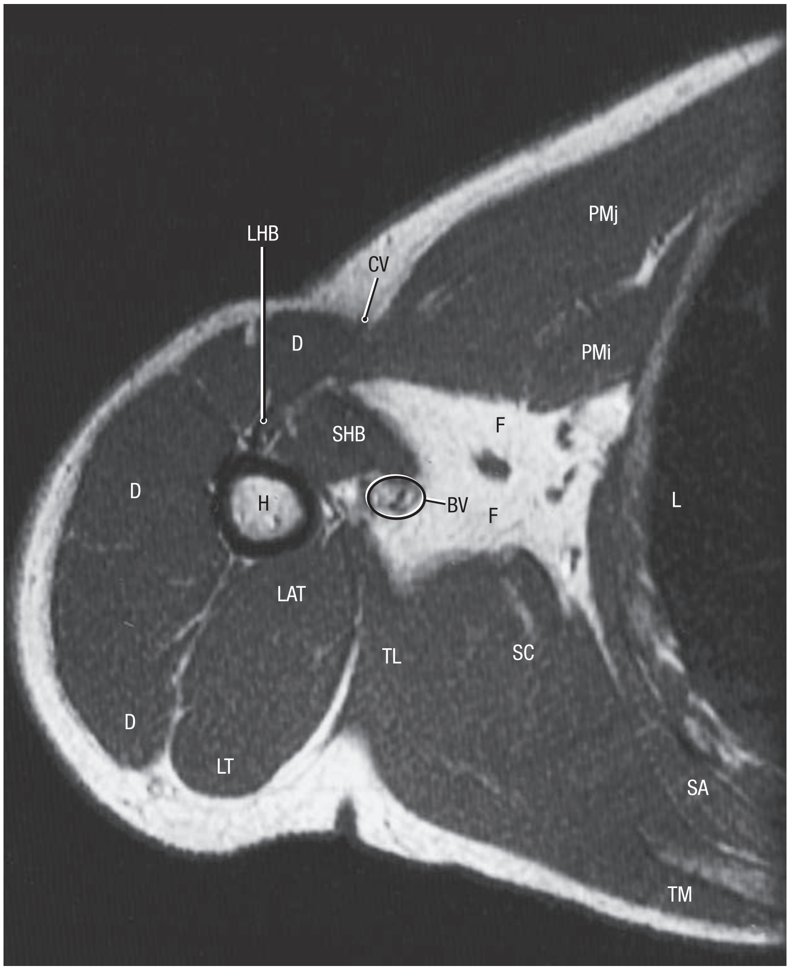
G. Anterior view

H. Anterior view

6.98 FUNCTIONAL POSITIONS OF HAND

A. Cylindrical (power) grasp. When grasping an object, the metacarpophalangeal and interphalangeal joints are flexed, but the radiocarpal joints are extended. Without wrist extension the grip is weak and insecure. **B.** Hook grasp. This grasp involves primarily the long flexors of the fingers, which are flexed to a varying degree depending on the size of the object. **C.** Tripod (three-jaw chuck) pinch. **D. and E.** Fingertip pinch. **F.** Rest position of hand. Casts for fractures are applied most often with the hand in this position. **G.** Loose cylindrical grasp. **H.** Firm cylindrical (power) grasp. **I.** Disc (power) grasp.

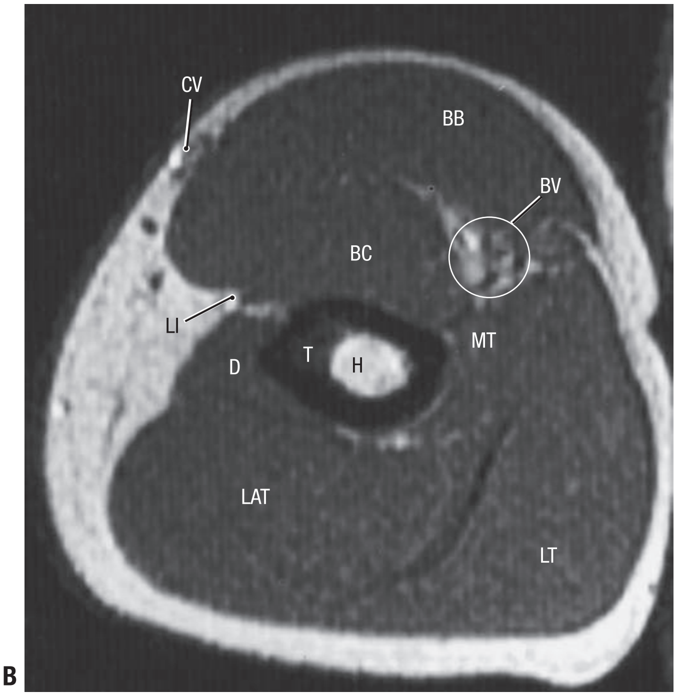
ANTERIOR



A

POSTERIOR

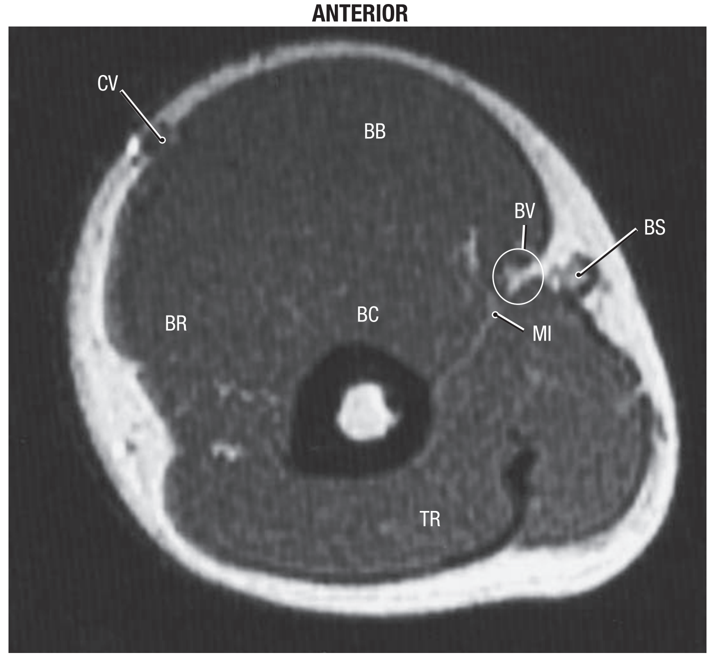
ANTERIOR



B

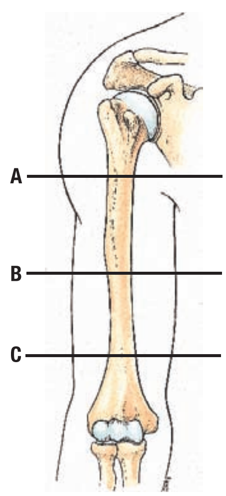
POSTERIOR

ANTERIOR



C

POSTERIOR

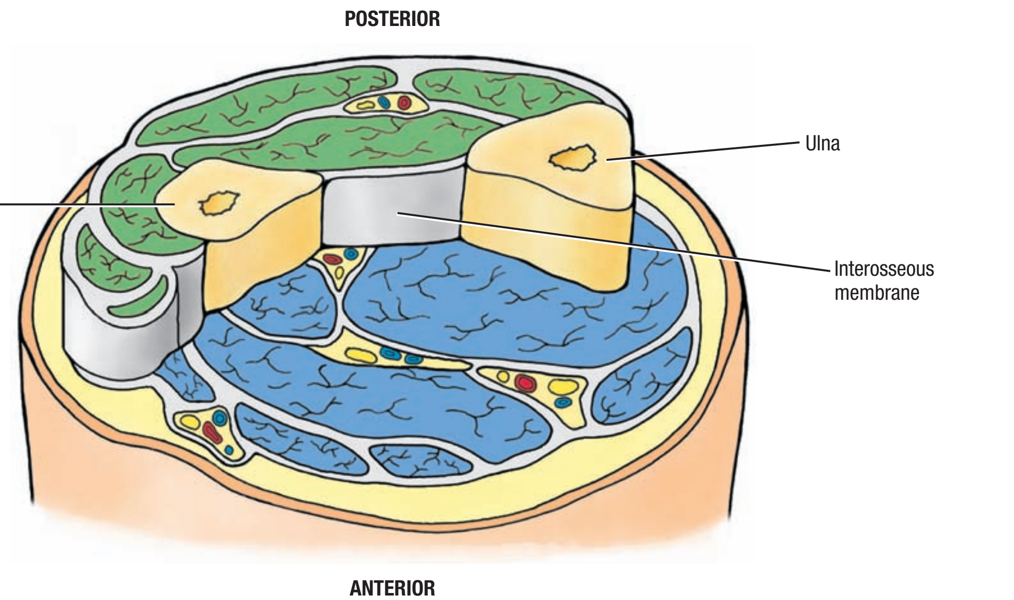


Key for A, B, and C:

BB	Biceps brachii
BC	Brachialis
BR	Brachioradialis
BS	Basilic Vein
BV	Brachial vessels and nerves
CV	Cephalic vein
D	Deltoid
F	Fat in axilla
H	Humerus
L	Lung
LAT	Lateral head of triceps brachii
LHB	Long head of biceps brachii
LI	Lateral intermuscular septum
LT	Long head of triceps brachii
MI	Medial intermuscular septum
MT	Medial head of triceps brachii
PMi	Pectoralis minor
PMj	Pectoralis major
SA	Serratus anterior
SC	Subscapularis
SHB	Short head of biceps brachii
T	Deltoid tuberosity
TL	Teres major and latissimus dorsi
TM	Teres minor
TR	Triceps brachii

6.99 TRANSVERSE (AXIAL) MRIs OF ARM

A. Transverse MRI through the proximal arm. **B.** Transverse MRI though the middle of the arm. **C.** Transverse MRI through the distal arm.



- Extensor–supinator compartment
- Flexor–pronator compartment

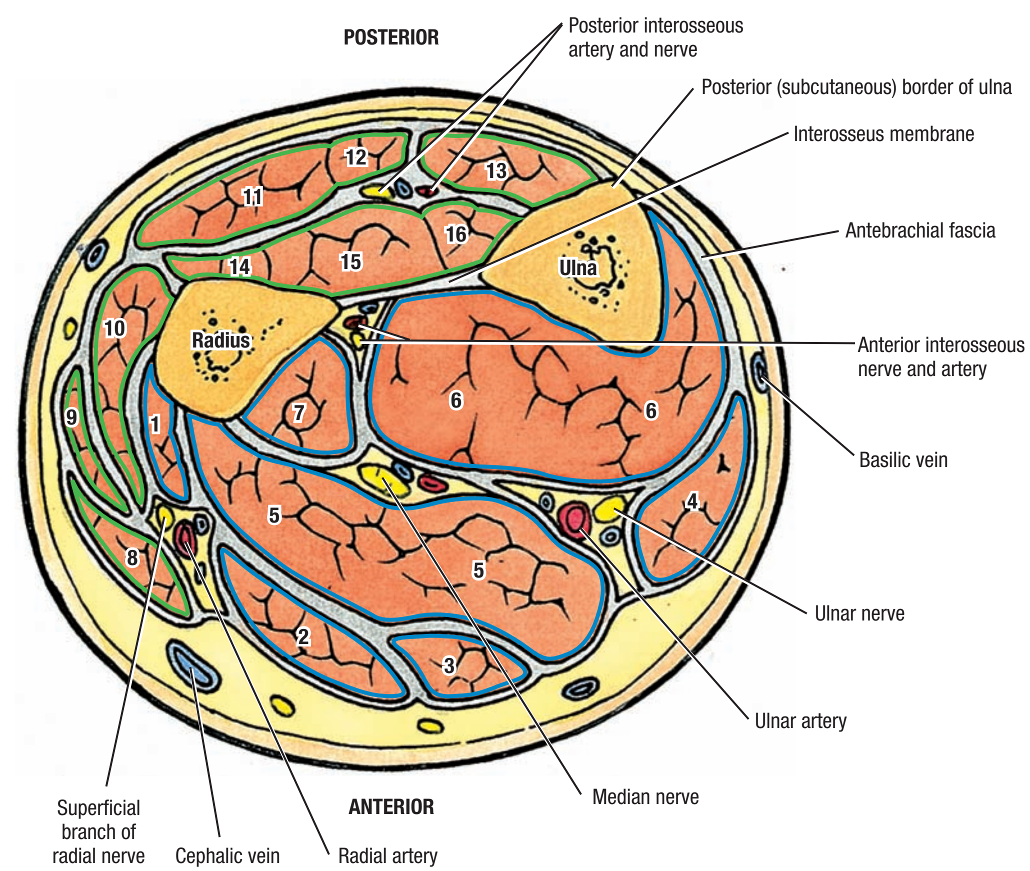
A. Anterosuperior View

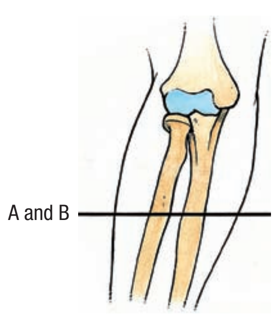
Flexors:

1. Pronator teres
2. Flexor carpi radialis
3. Palmaris longus
4. Flexor carpi ulnaris
5. Flexor digitorum superficialis
6. Flexor digitorum profundus
7. Flexor pollicis longus

Extensors:

8. Brachioradialis
9. Extensor carpi radialis longus
10. Extensor carpi radialis brevis
11. Extensor digitorum
12. Extensor digiti minimi
13. Extensor carpi ulnaris
14. Abductor pollicis longus
15. Extensor pollicis brevis
16. Extensor pollicis longus and extensor indicis





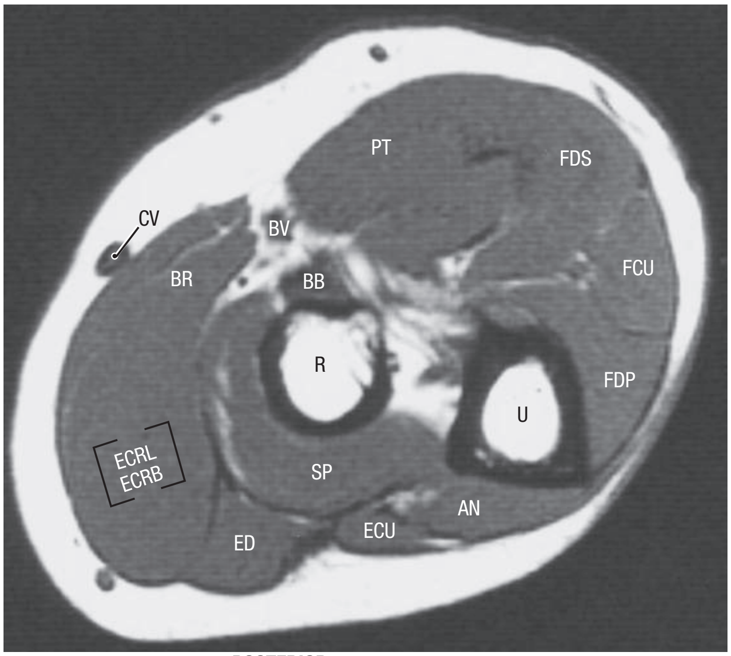
B. Transverse Section

6.100 TRANSVERSE SECTIONS AND TRANSVERSE (AXIAL) MRIs OF FOREARM

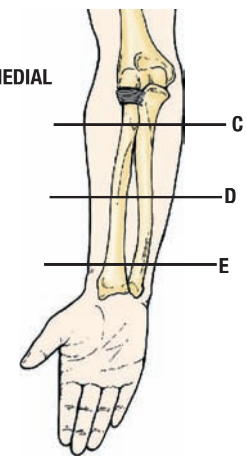
A. Stepped transverse sections of the anterior and posterior compartments. **B.** Contents of the anterior and posterior compartments.

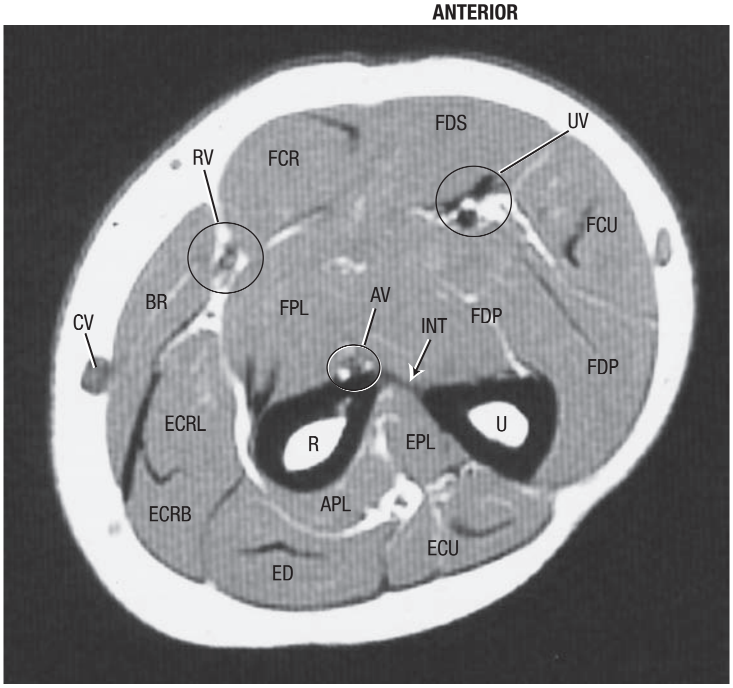
Key for C, D, and E:

AN	Anconeus
APL	Abductor pollicis longus
AV	Anterior interosseous vessels and nerve
BB	Biceps brachii
BR	Brachioradialis
BV	Brachial vessels
CV	Cephalic vein
ECRB	Extensor carpi radialis brevis
ECRL	Extensor carpi radialis longus
ECU	Extensor carpi ulnaris
ED	Extensor digitorum
EPB	Extensor pollicis brevis
EPL	Extensor pollicis longus
FCR	Flexor carpi radialis
FCU	Flexor carpi ulnaris
FDP	Flexor digitorum profundus
FDS	Flexor digitorum superficialis
FPL	Flexor pollicis longus
INT	Interosseous membrane
PQ	Pronator quadratus
PT	Pronator teres
R	Radius
RV	Radial vessels
SP	Supinator
U	Ulnar
UN	Ulnar vessels and nerve

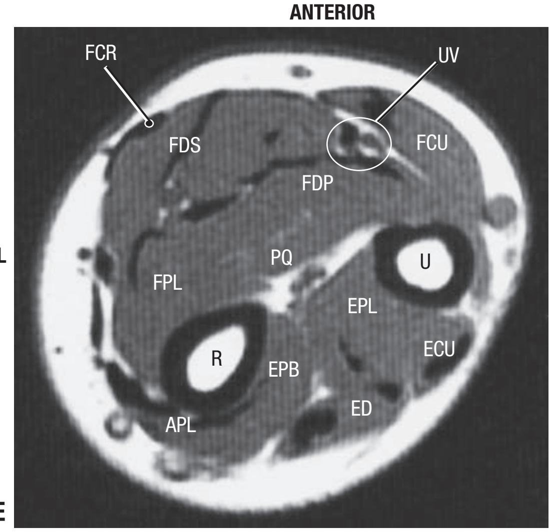


C





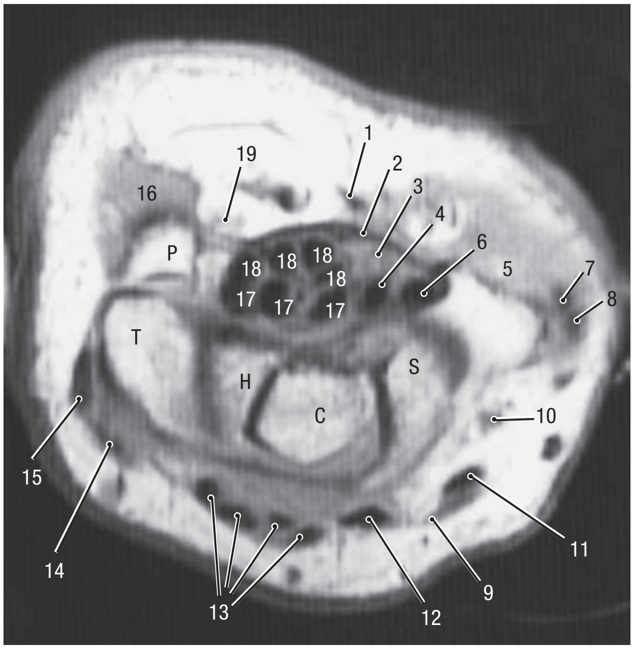
D

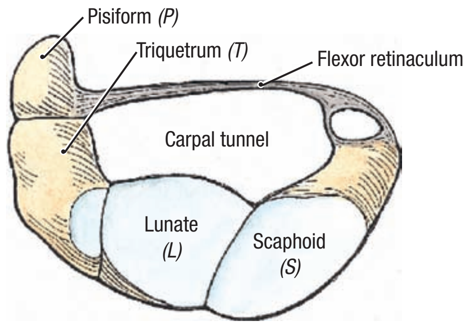


E

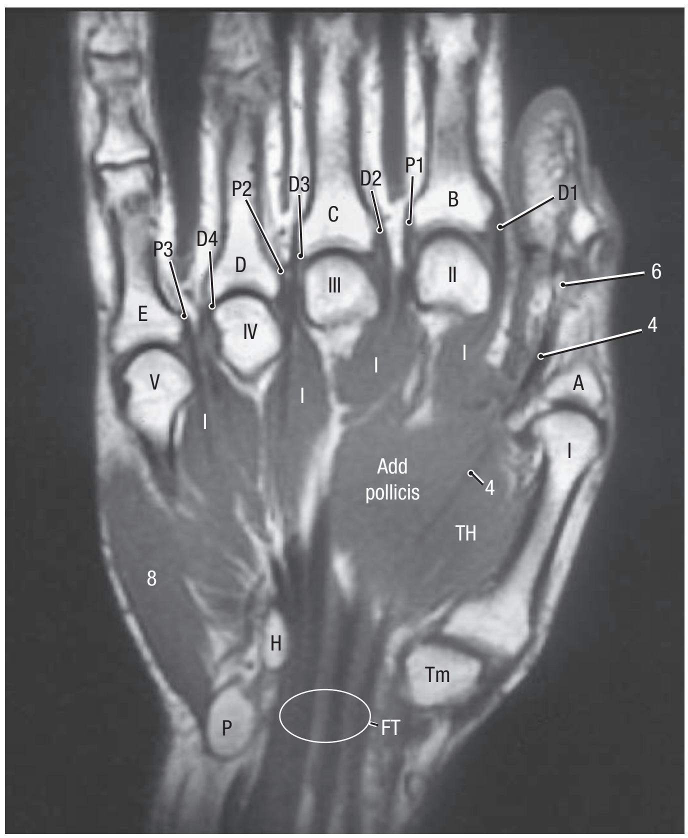
6.100 TRANSVERSE SECTIONS AND TRANSVERSE (AXIAL) MRIs OF FOREARM *(CONTINUED)*

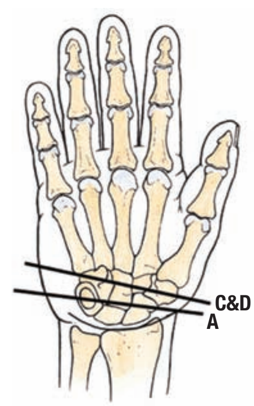
C. Transverse MRI through the proximal forearm. **D.** Transverse MRI through the middle forearm. **E.** Transverse MRI through the distal forearm.





A. Transverse MRI

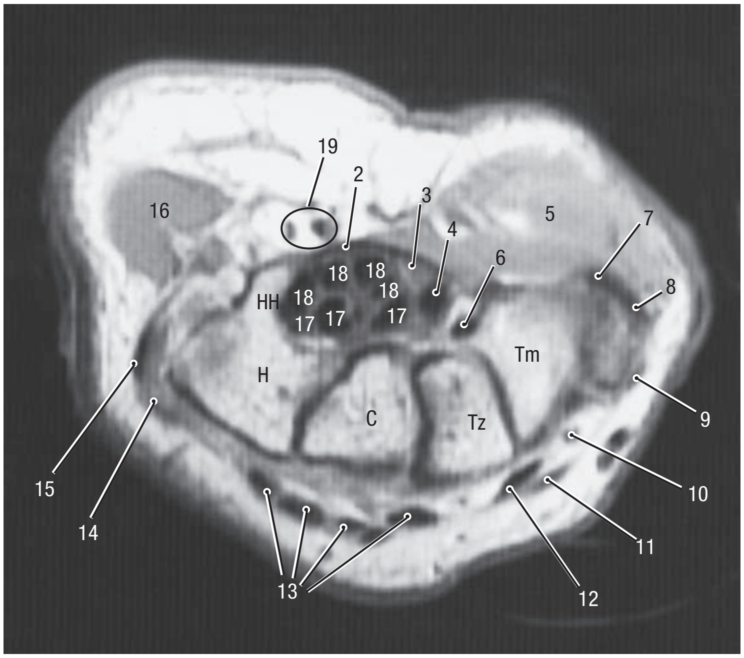




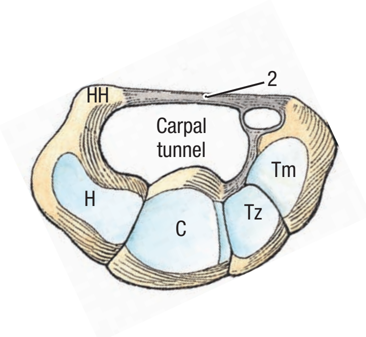
B. Coronal MRI

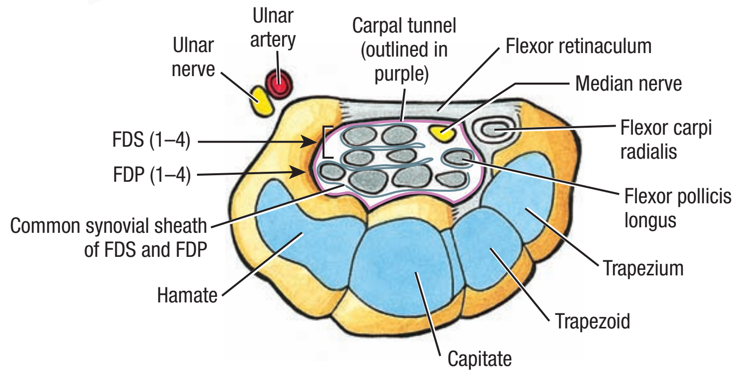
6.101 TRANSVERSE (AXIAL) SECTION AND MRIs THROUGH CARPAL TUNNEL

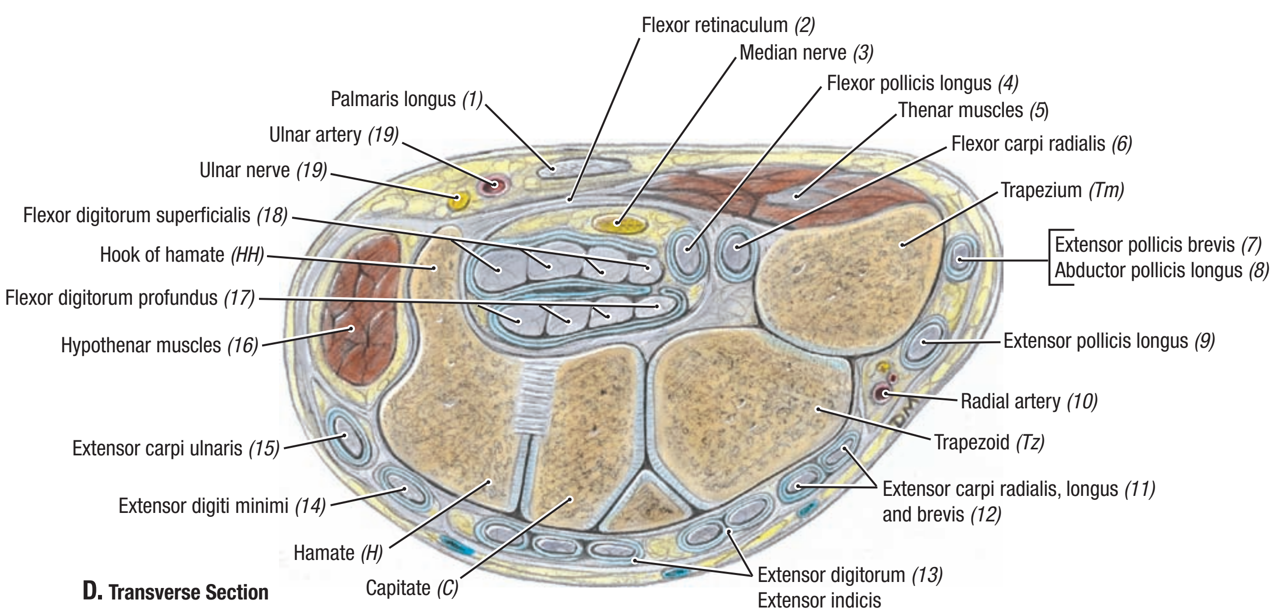
A. Transverse MRI through the proximal carpal tunnel (*numbers* and *letters* in MRIs refer to structures in **D**). **B.** Coronal MRI of wrist and hand showing the course of the long flexor tendons in the carpal tunnel (*numbers* and *letters* in MRIs refer to structures in **D**). *FT*, long flexor tendons in carpal tunnel; *TH*, thenar muscles; *P*, pisiform; *H*, hook of hamate; *Tm,* trapezium; *I*, interossei, *A–E,* proximal phalanges.



C. Transverse MRI



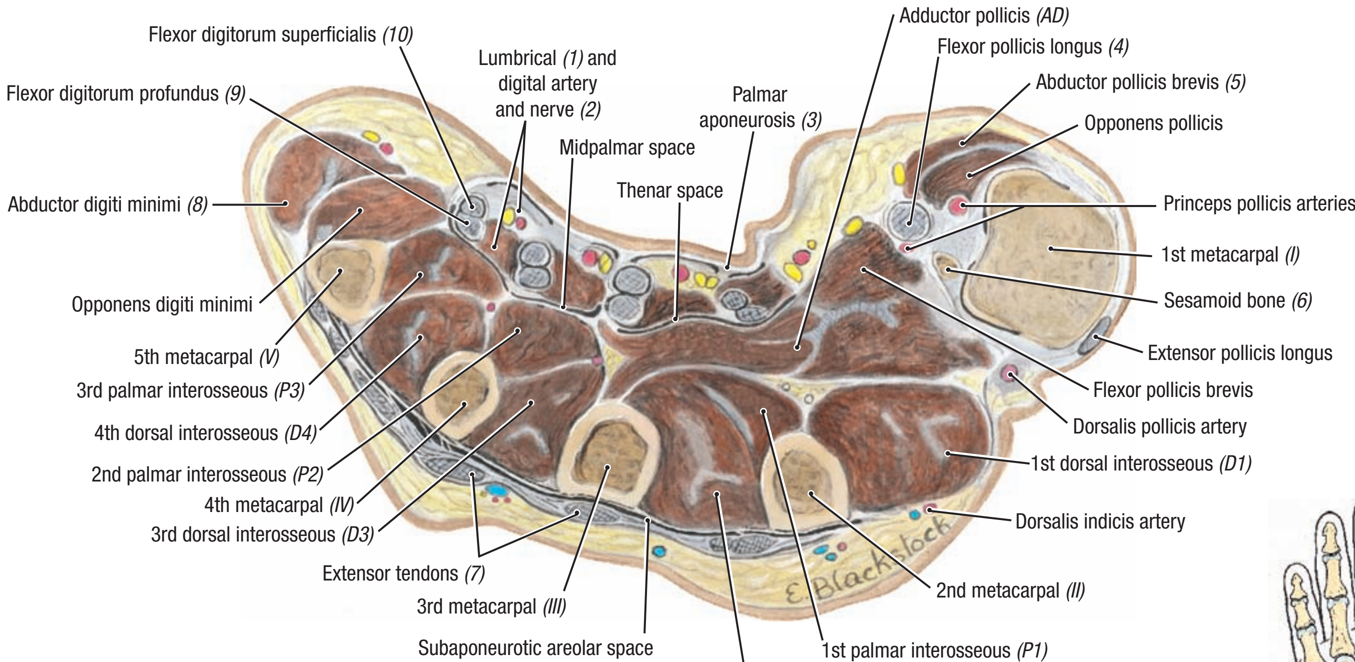




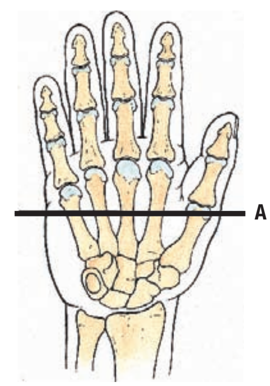
D. Transverse Section

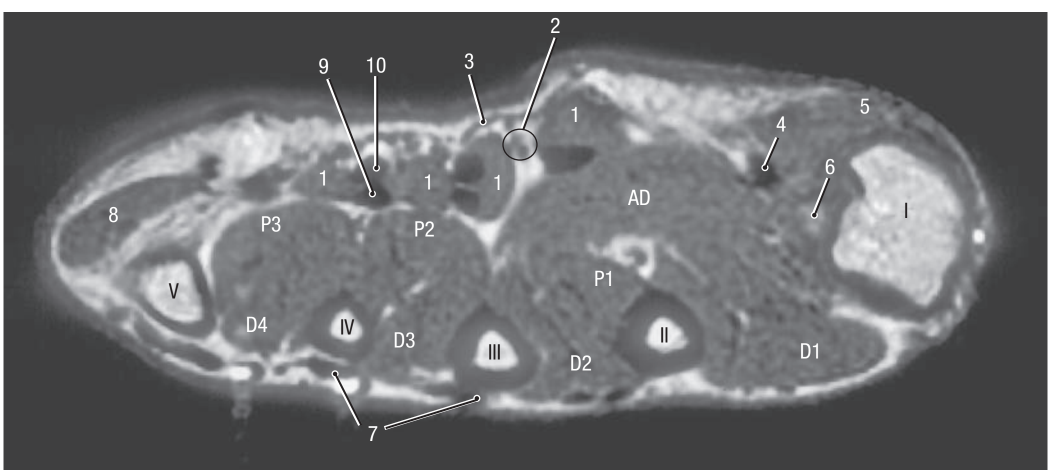
6.101 TRANSVERSE (AXIAL) SECTION AND MRIs THROUGH CARPAL TUNNEL *(CONTINUED)*

C. Transverse MRI through the distal carpal tunnel (*numbers* and *letters* in MRIs refer to structures in **D**).
D. Transverse section of carpal tunnel through the distal row of carpal bones.



A. Transverse Section



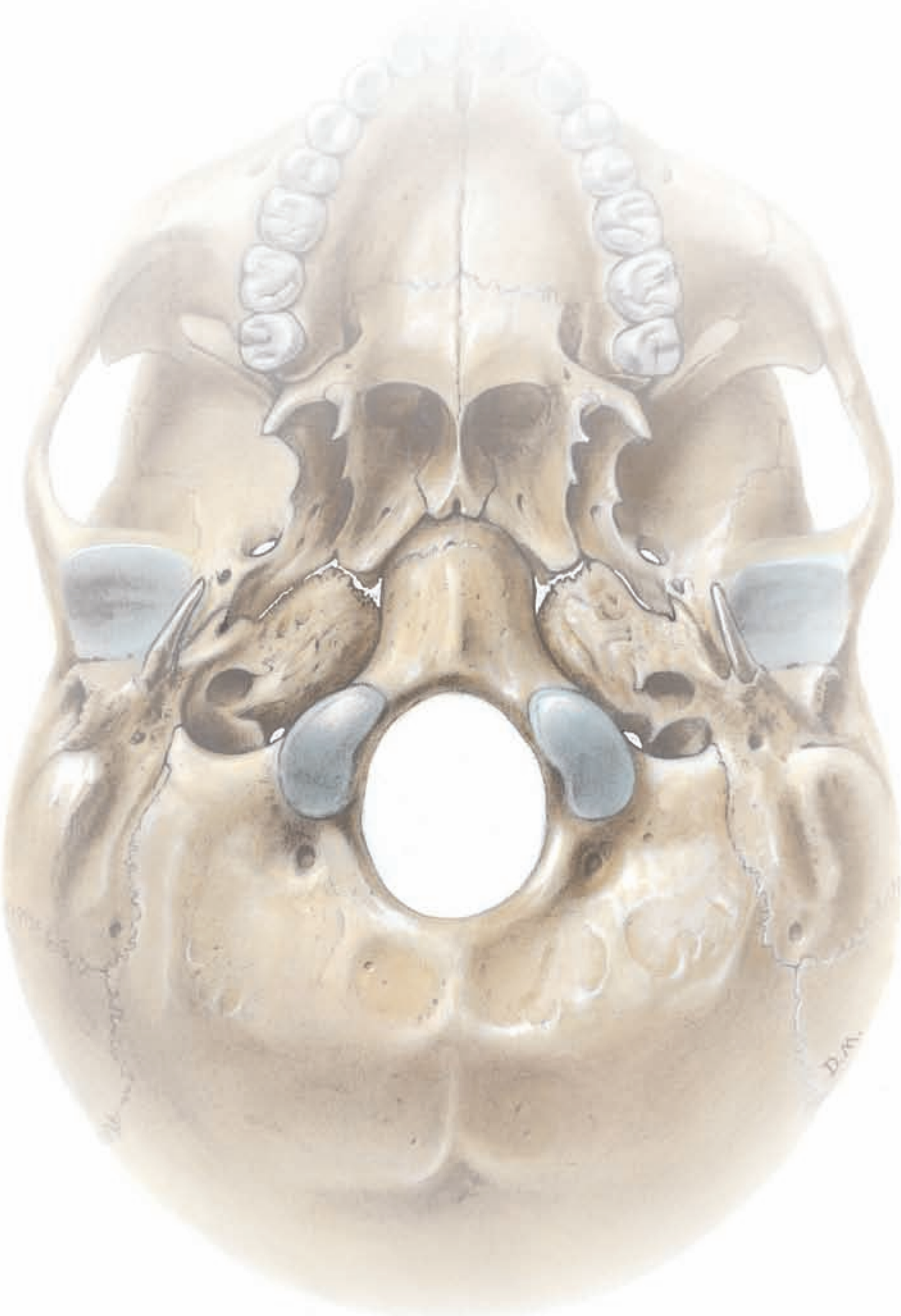


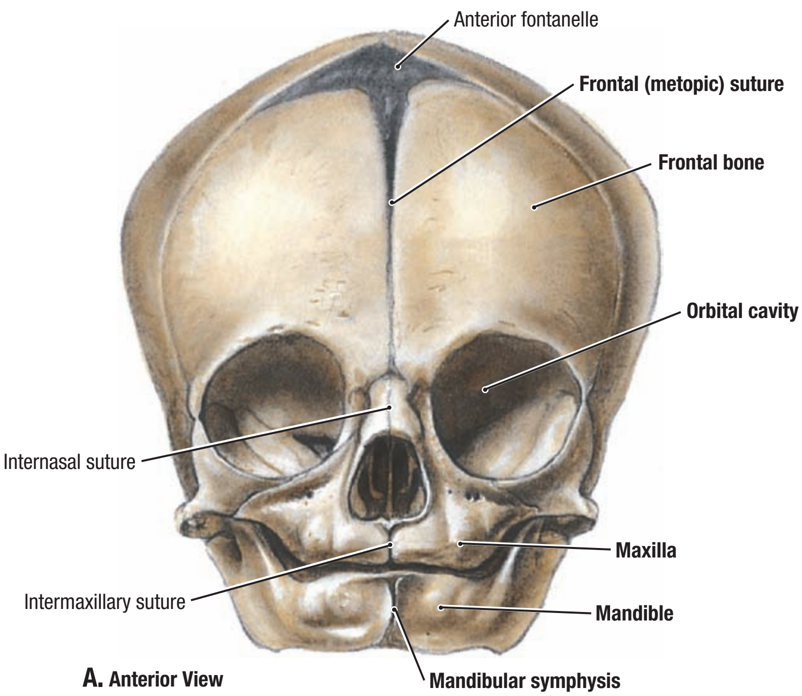
B. Transverse MRI

6.102 TRANSVERSE SECTION AND MRI THROUGH PALM (METACARPALS) AT LEVEL OF ADDUCTOR POLLICIS

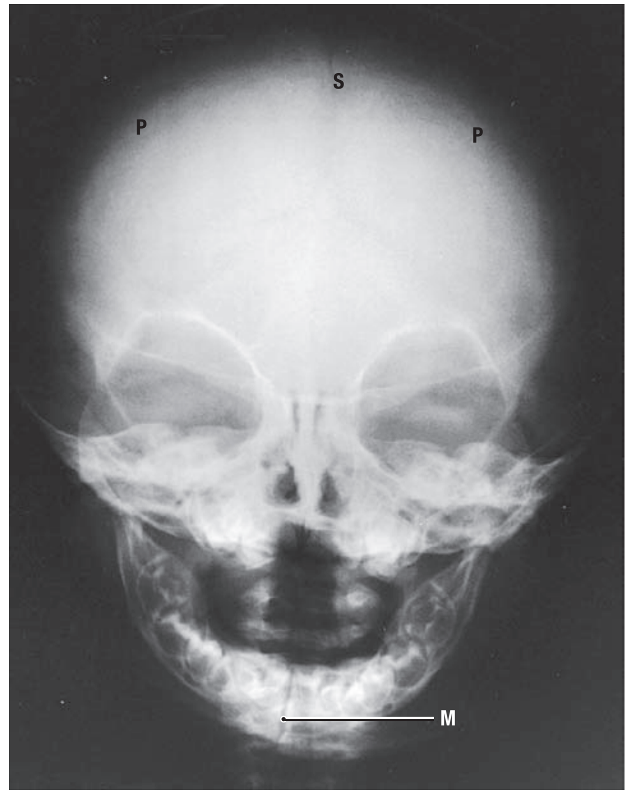
CHAPTER 7

Head

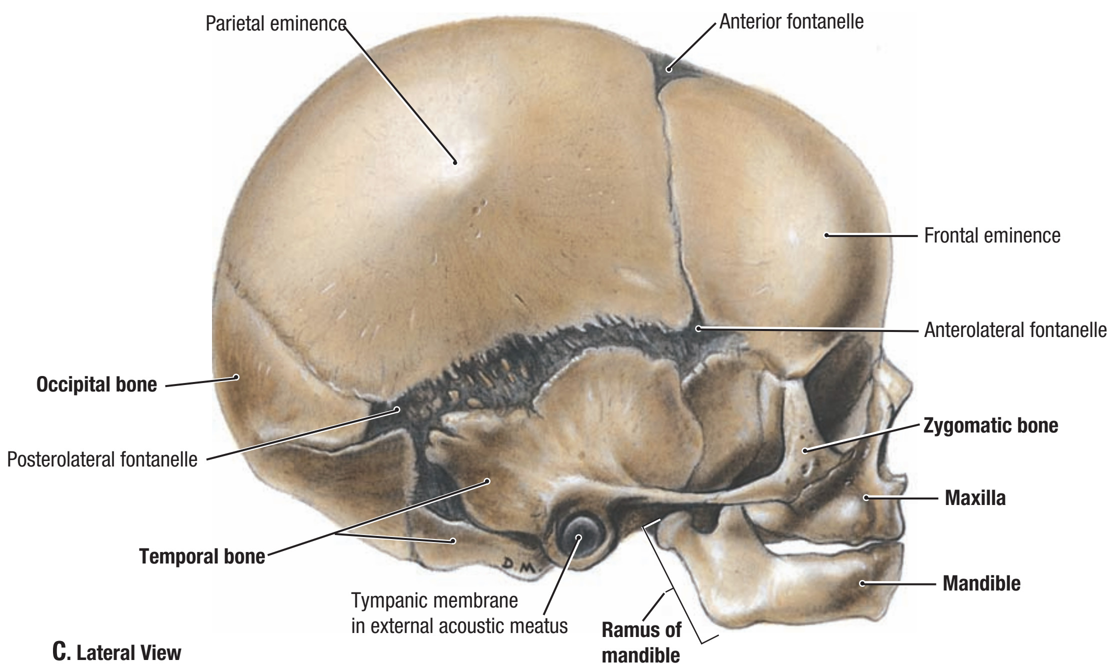




A. Anterior View



B. Anteroposterior View



C. Lateral View

7.1 CRANIUM AT BIRTH AND IN EARLY CHILDHOOD

A. Cranium at birth, anterior aspect. **B.** Radiograph of $6^1/_2$-month-old child. **C.** Cranium at birth, lateral aspect.

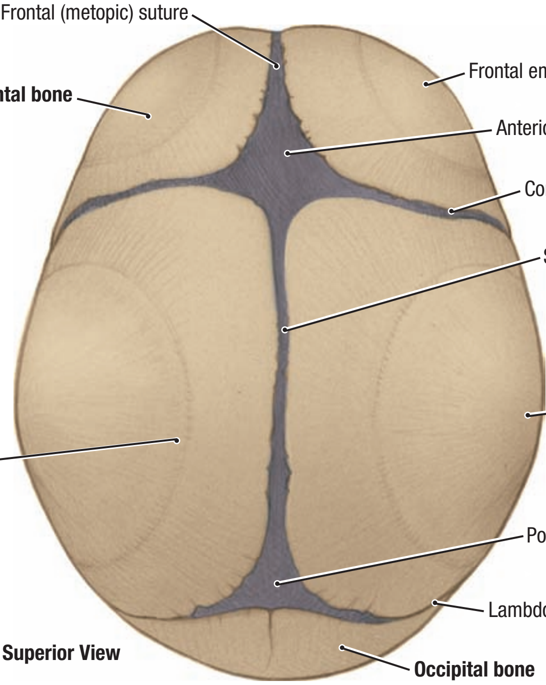
Compared with the adult skull (Figs. 7.2–7.4):

- The maxilla and mandible are proportionately small.
- The mandibular symphysis, which closes during the second year, and the frontal suture, which closes during the sixth year, are still open (unfused).
- The orbital cavities are proportionately large, but the face is small; the facial skeleton forming only one eighth of the whole cranium, while in the adult, it forms one third.

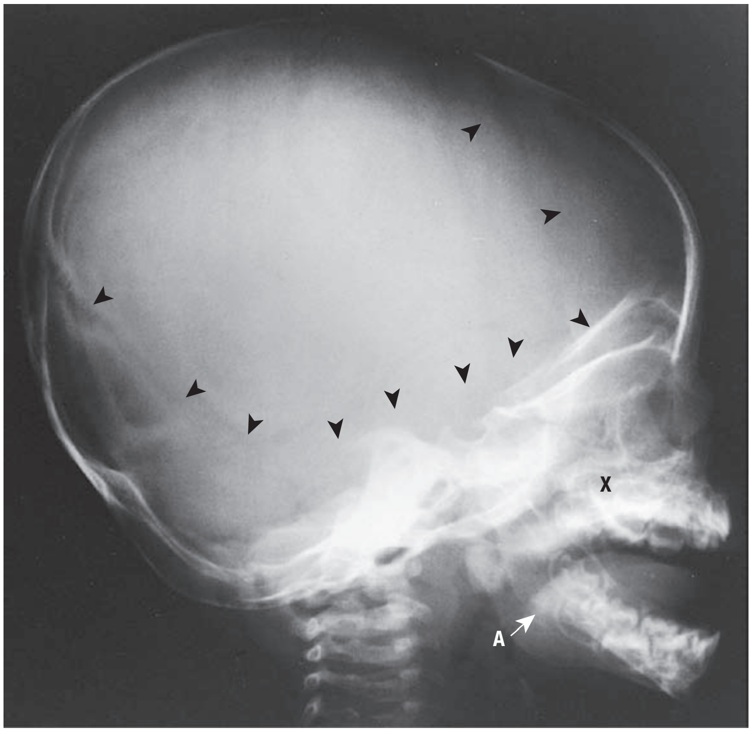
Key for B, E and F

A	Angle of mandible
B	Body of mandible
C	Coronal suture
F	Frontal bone
L	Lambdoid suture
M	Mandibular symphysis
O	Occipital bone
P	Parietal eminence
S	Sagittal suture
SP	Sphenoid
T	Temporal bone
X	Maxilla
Y	Mastoid process
Z	Zygomatic bone

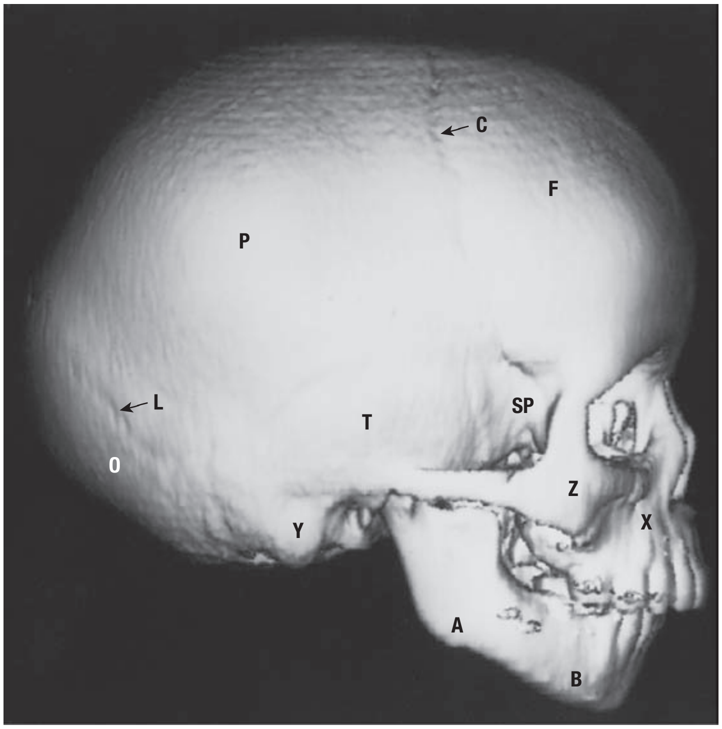
Arrowheads = Membranous outline of parietal bone



D. Superior View



E. Lateral View

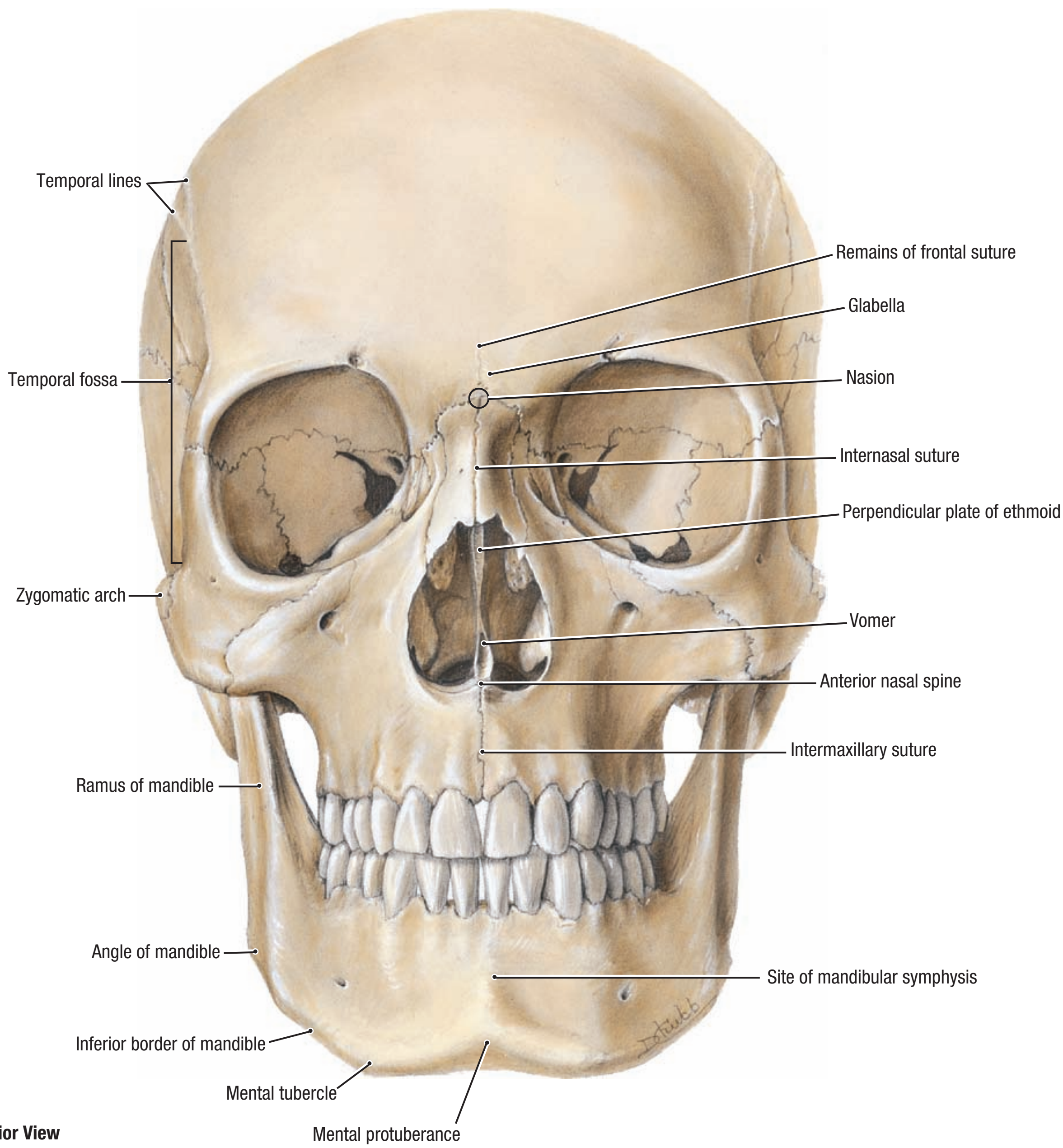


F. Lateral View

7.1 CRANIUM AT BIRTH AND IN EARLY CHILDHOOD *(CONTINUED)*

D. Cranium at birth, superior aspect. **E.** Radiograph of $6^1/_2$-month-old child. **F.** Three-dimensional computer-generated images of 3-year-old child's cranium.

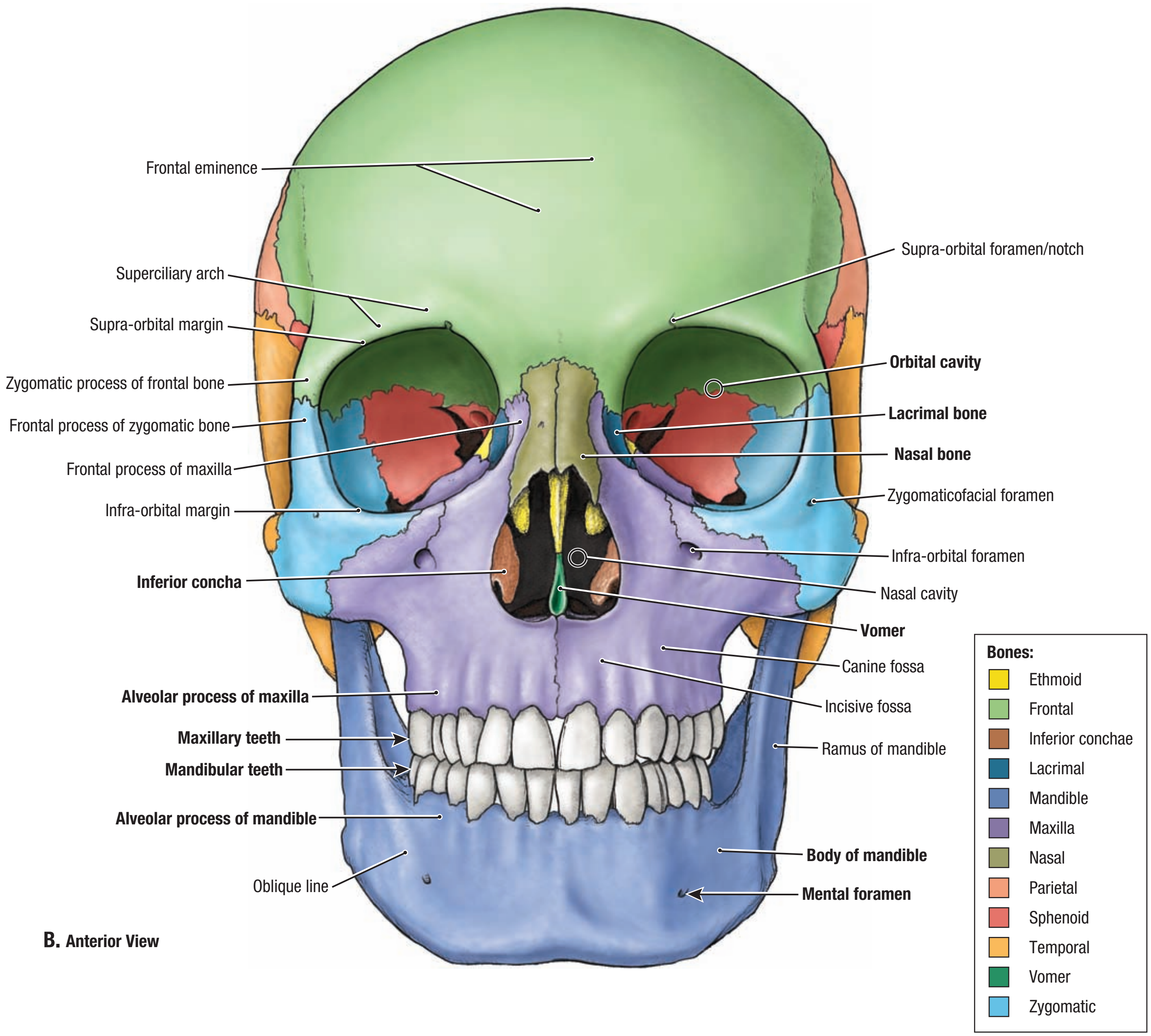
- The parietal eminence is a shallow, rounded cone. Ossification, which starts at the eminences, has not yet reached the ultimate four angles of the parietal bone; accordingly, these regions are membranous, and the membrane is blended with the pericranium externally and the dura mater internally to form the fontanelles. The fontanelles are usually closed by the second year. There is no mastoid process until the second year.



A. Anterior View

7.2 CRANIUM, FACIAL (FRONTAL) ASPECT

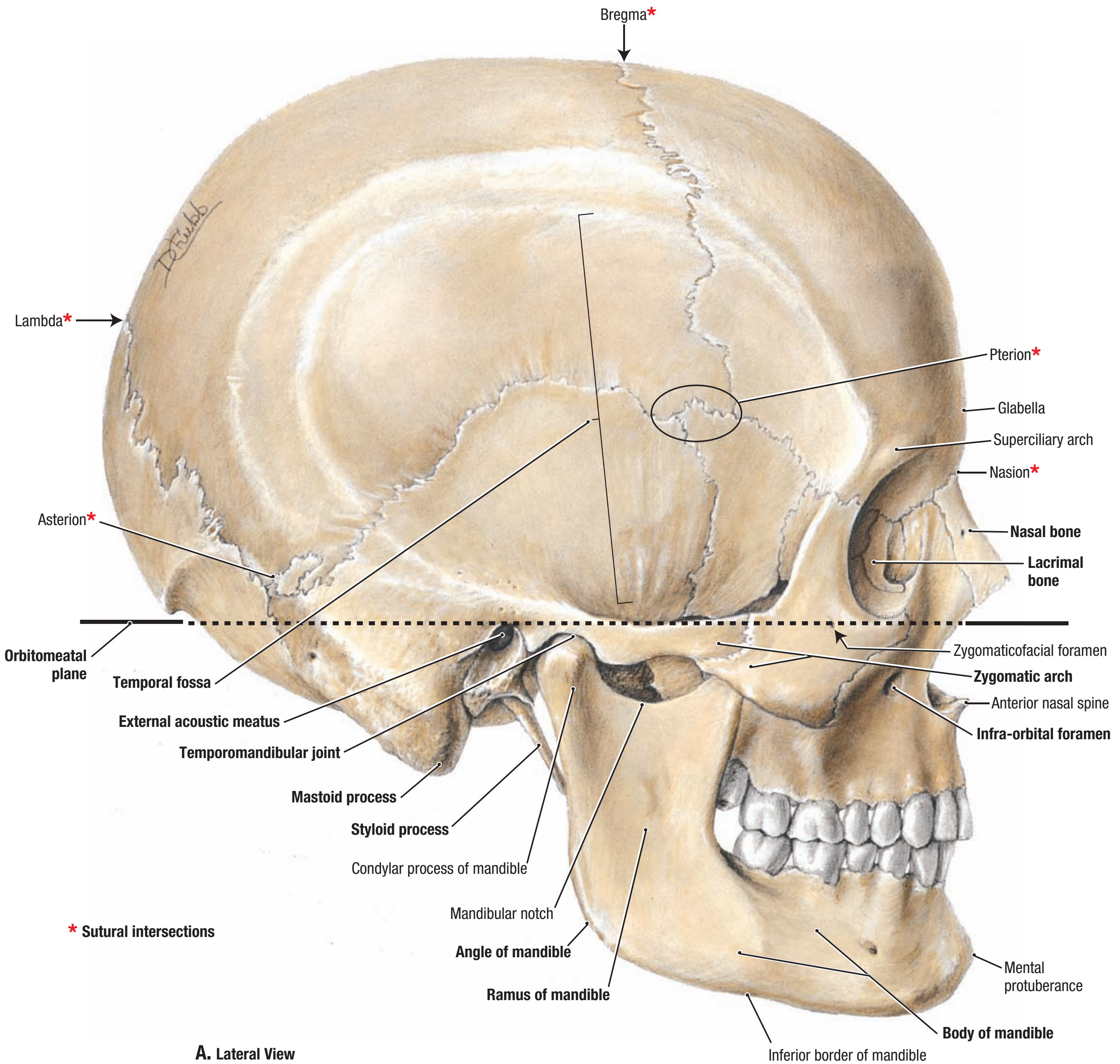
A. Formations of the bony cranium. **B.** Bones of cranium and their features. The individual bones forming the cranium are color coded. For the orbital cavity, see also Figure 7.36A.



B. Anterior View

7.2 CRANIUM, FACIAL (FRONTAL) ASPECT *(CONTINUED)*

Extraction of teeth causes the alveolar bone to resorb in the affected regions(s). Following complete loss or extraction of maxillary teeth, the sockets begin to fill in with bone, and the alveolar process begins to resorb. Similarly, extraction of mandibular teeth causes the bone of the alveolar process to resorb. The mental foramen may eventually lie near the superior border of the body of the mandible. In some cases, the mental foramina disappear, exposing the mental nerves to injury.

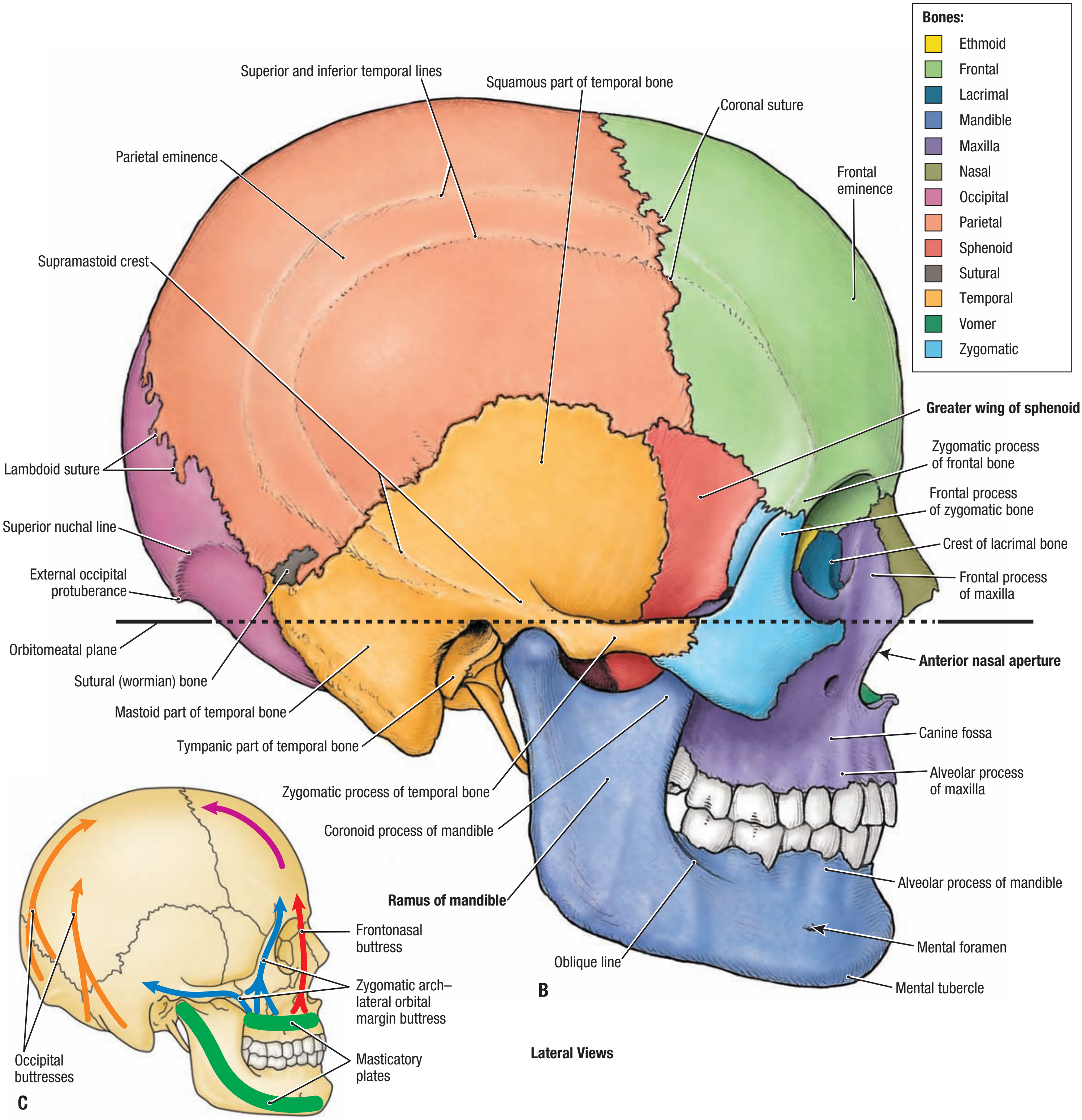


A. Lateral View

7.3 CRANIUM, LATERAL ASPECT

A. Bony cranium. **B.** Cranium with bones color coded. The cranium is in the anatomical position when the orbitomeatal plane is horizontal. **C.** Buttresses of cranium. The buttresses are thicker portions of cranial bones that transfer forces around the weaker regions of the orbits and nasal cavity.

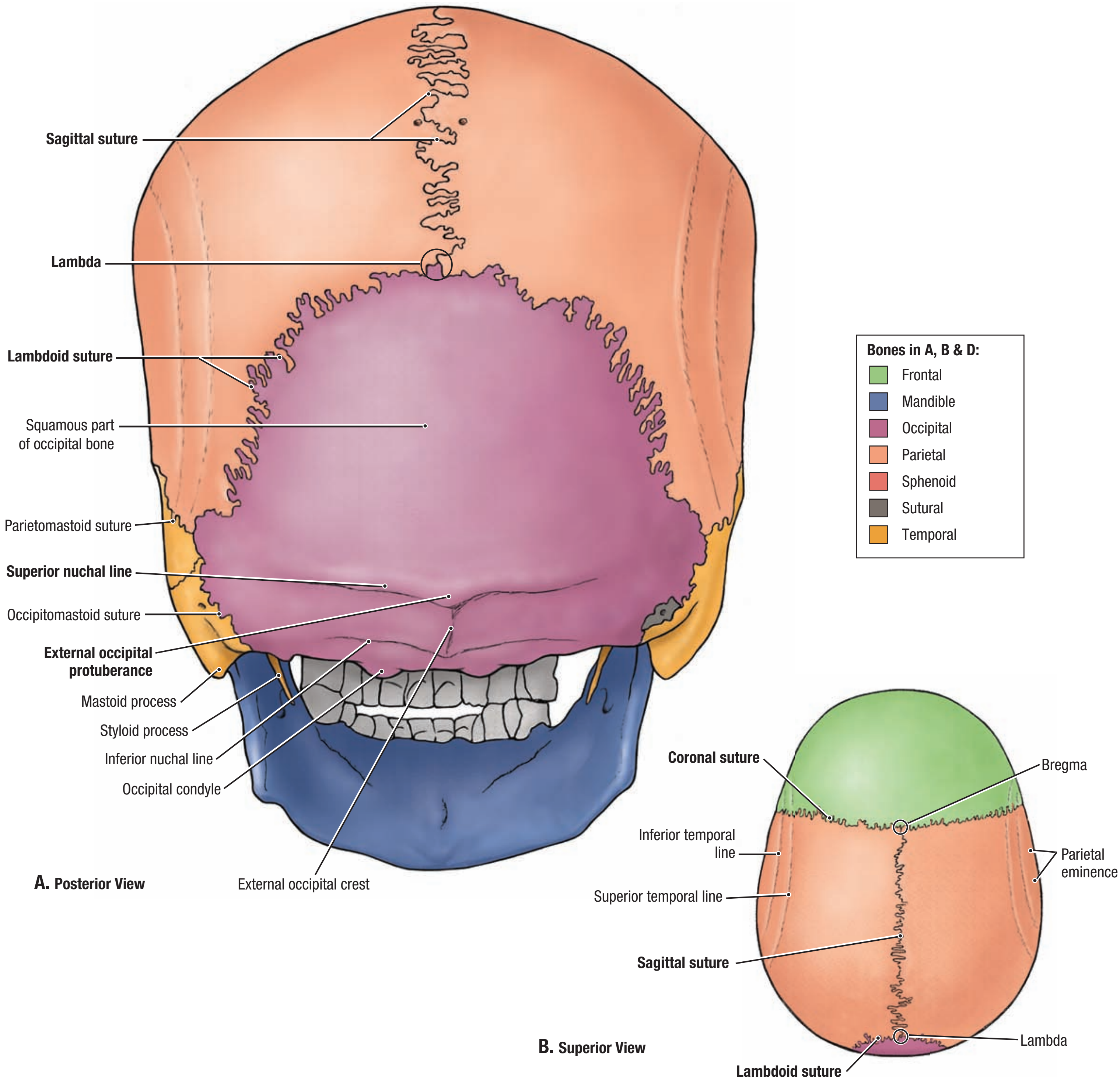
The convexity of the neurocranium (braincase) distributes and thereby minimizes the effects of a blow to it. However, hard blows to the head in thin areas of the cranium (e.g., in the temporal fossa) are likely to produce **depressed fractures**, in which a fragment of bone is depressed inward, compressing and/or injuring the brain. In **comminuted fractures**, the bone is broken into several pieces. **Linear fractures**, the most frequent type, usually occur at the point of impact, but fracture lines often radiate away from it in two or more directions.



Lateral Views

7.3 CRANIUM, LATERAL ASPECT *(CONTINUED)*

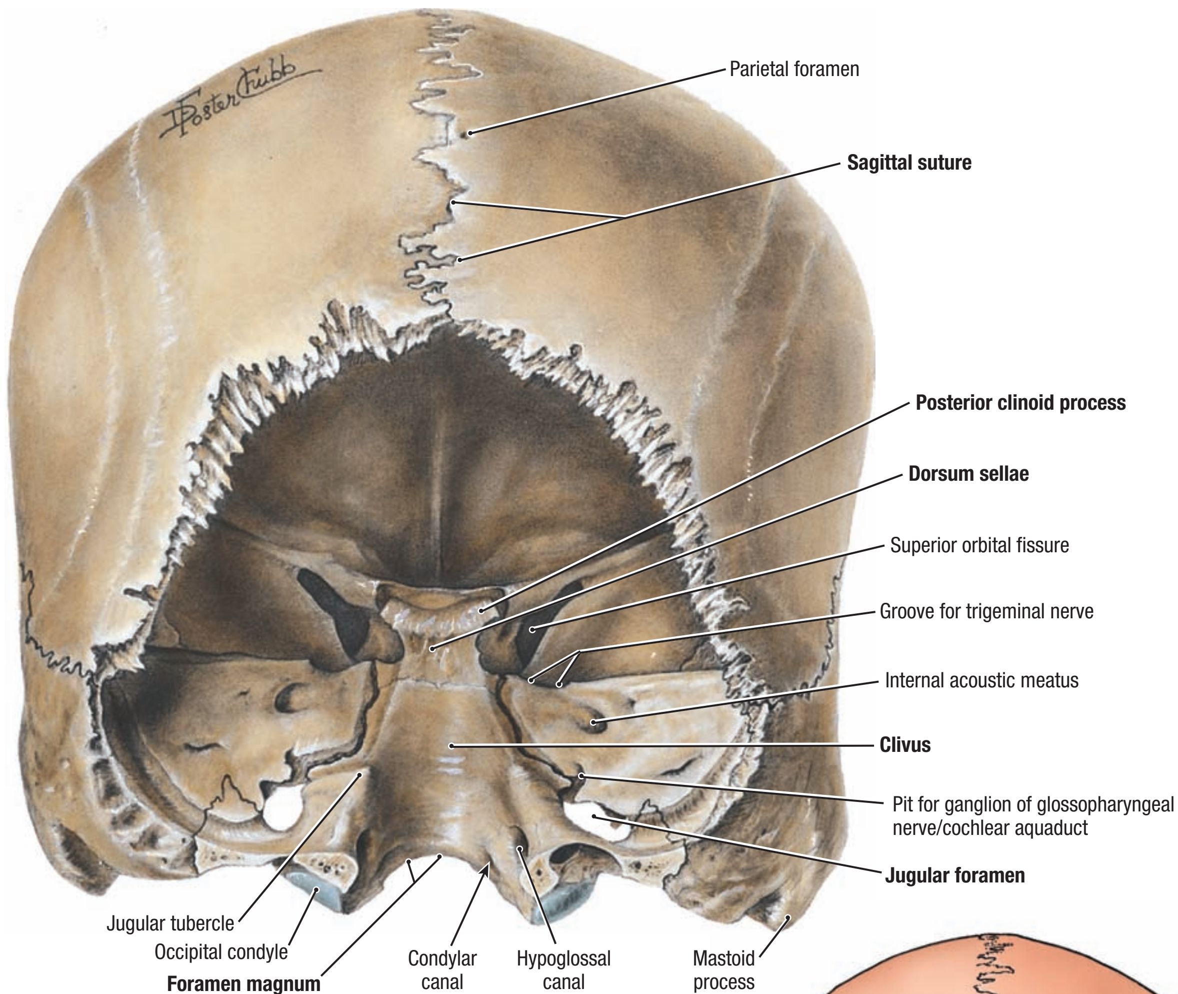
If the area of the neurocranium is thick at the site of impact, the bone usually bends inward without fracturing; however, a fracture may occur some distance from the site of direct trauma where the calvaria is thinner. In a **contrecoup (counterblow) fracture**, the fracture occurs on the opposite side of the cranium rather than at the point of impact. One or more sutural (accessory) bones may be located at the lambda or near the mastoid process.



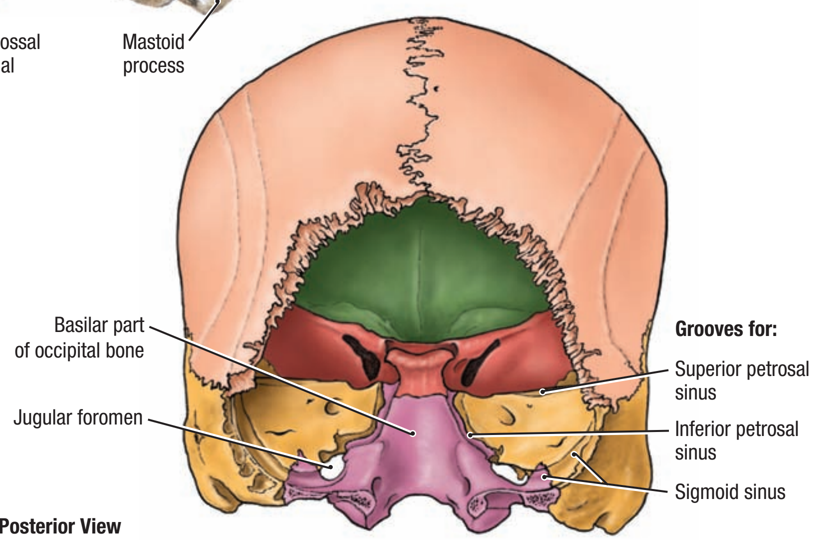
7.4 CRANIUM, OCCIPITAL ASPECT, CALVARIA, AND ANTERIOR PART OF POSTERIOR CRANIAL FOSSA

A. The lambda, near the center of this convex surface, is located at the junction of the sagittal and lambdoid sutures. **B.** The roof of the neurocranium, or calvaria (skullcap), is formed primarily by the paired parietal bones, the frontal bone, and the occipital bone.

Premature closure of the coronal suture results in a high, tower-like cranium, called **oxycephaly** or **turricephaly**. Premature closure of sutures usually does not affect brain development. When premature closure occurs on one side only, the cranium is asymmetrical, a condition known as **plagiocephaly**.



C. **Posterior View**



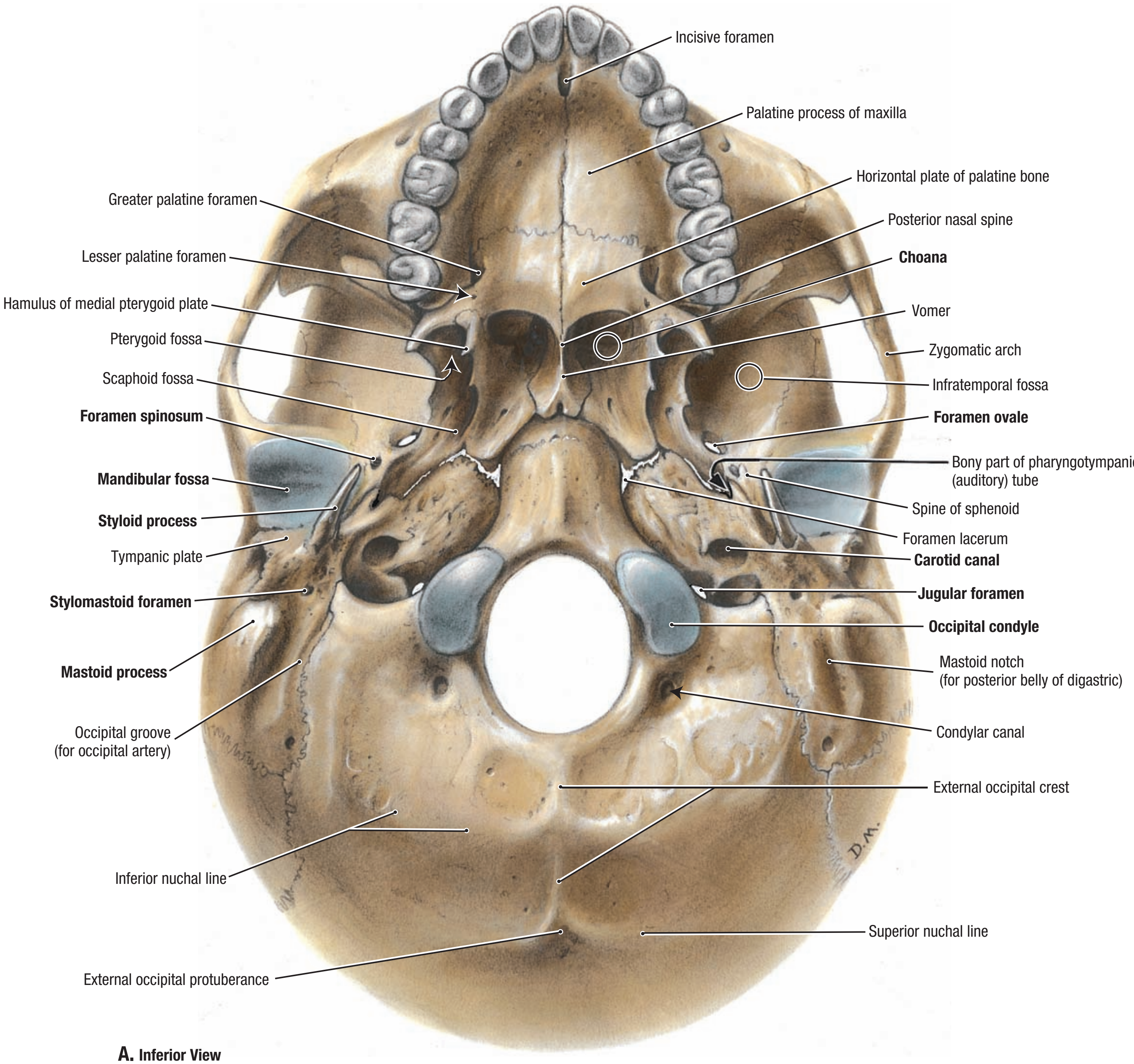
D. **Posterior View**

7.4 CRANIUM, OCCIPITAL ASPECT, CALVARIA, AND ANTERIOR PART OF POSTERIOR CRANIAL FOSSA *(CONTINUED)*

C. and D. Cranium after removal of squamous part of occipital bone.

- The dorsum sellae projects from the body of the sphenoid; the posterior clinoid processes form its superolateral corners.
- The clivus is the slope descending from the dorsum sellae to the foramen magnum.
- The grooves for the sigmoid sinus and inferior petrosal sinus lead inferiorly to the jugular foramen.

Premature closure of the sagittal suture, in which the anterior fontanelle is small or absent, results in a long, narrow, wedge-shaped cranium, a condition called **scaphocephaly**.



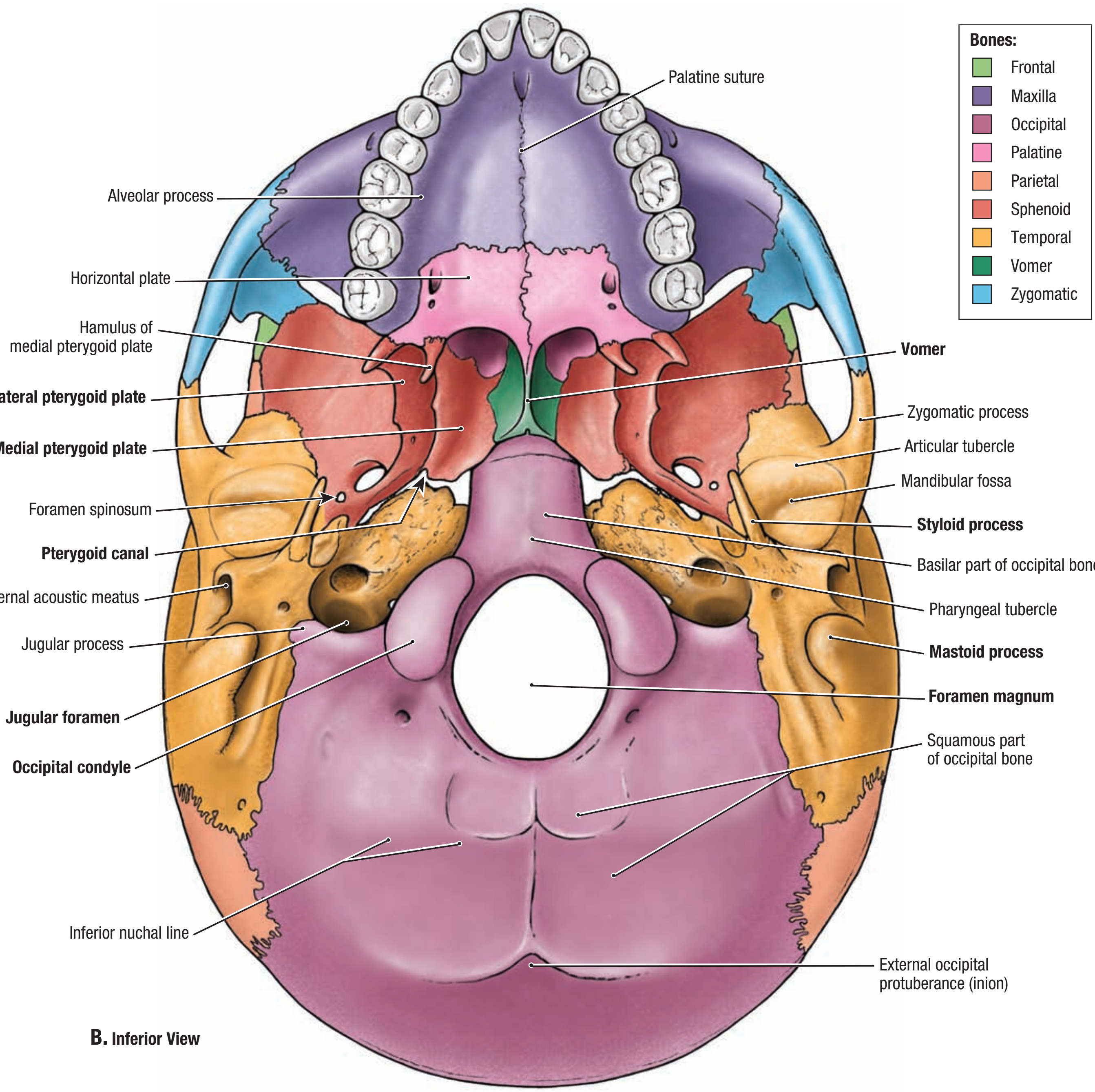
A. Inferior View

7.5 CRANIUM, INFERIOR ASPECT

A. Bony cranium. **B.** Diagram of cranium with bones color coded.

TABLE 7.1 FORAMINA AND OTHER APERTURES OF CRANIAL FOSSAE, AND CONTENTS (SEE FIGS. 7.2–7.6)

Foramen cecum: Nasal emissary vein (1% of population)	Optic canals: Optic nerve (CN II) and ophthalmic arteries
Cribriform plate: Olfactory nerves (CN I)	Superior orbital fissure: Ophthalmic veins; ophthalmic nerve (CN V_1); CN III, IV and VI; and sympathetic fibers
Anterior and posterior ethmoidal foramina: Vessels and nerves with same names	Foramen rotundum: Maxillary nerve (CN V_2)



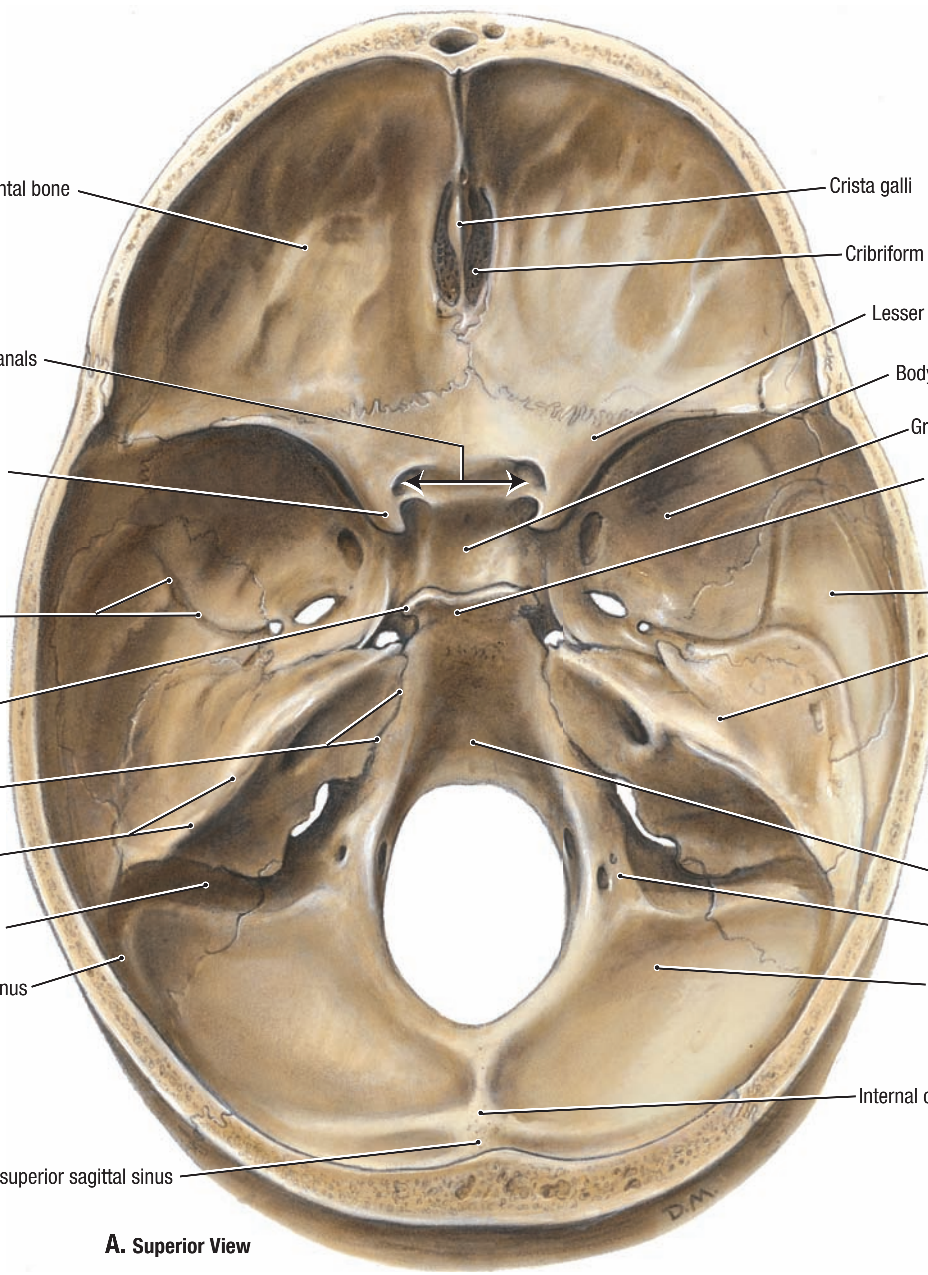
B. **Inferior View**

7.5 CRANIUM, INFERIOR ASPECT *(CONTINUED)*

TABLE 7.1 FORAMINA AND OTHER APERTURES OF CRANIAL FOSSAE, AND CONTENTS (SEE FIGS. 7.2–7.6) (CONTINUED)

Foramen ovale: Mandibular nerve (CN V_3) and accessory meningeal artery	Jugular foramen: CN IX, X, and XI; superior bulb of internal jugular vein; inferior petrosal and sigmoid sinuses; meningeal branches of ascending pharyngeal and occipital arteries.
Foramen spinosum: Middle meningeal artery/vein and meningeal branch of CN V_3	Hypoglossal canal: Hypoglossal nerve (CN XII)
Foramen lacerum[a]: Deep petrosal nerve, some meningeal arterial branches and small veins.	Foramen magnum: Spinal cord; spinal accessory nerve (CN XI); vertebral arteries; internal vertebral venous plexus.
Groove of greater petrosal nerve: Greater petrosal nerve and petrosal branch of middle meningeal artery	Condylar canal: Condyloid emissary vein (passes from sigmoid sinus to vertebral veins in neck)
Carotid canal: Internal carotid artery and accompanying sympathetic and venous plexuses	Stylomastoid foramen: Facial nerve (CN VII)
Internal acoustic meatus: Facial nerve/ intermediate nerve (CN VII); vestibulocochlear nerve (CN VIII); labyrinthine artery	Mastoid foramina: Mastoid emissary vein from sigmoid sinus and meningeal branch of occipital artery

[a]The internal carotid artery and its accompanying sympathetic and venous plexuses actually pass horizontally across (rather than vertically through) the area of the foramen lacerum, an artifact of dry crania, which is closed by cartilage in life.



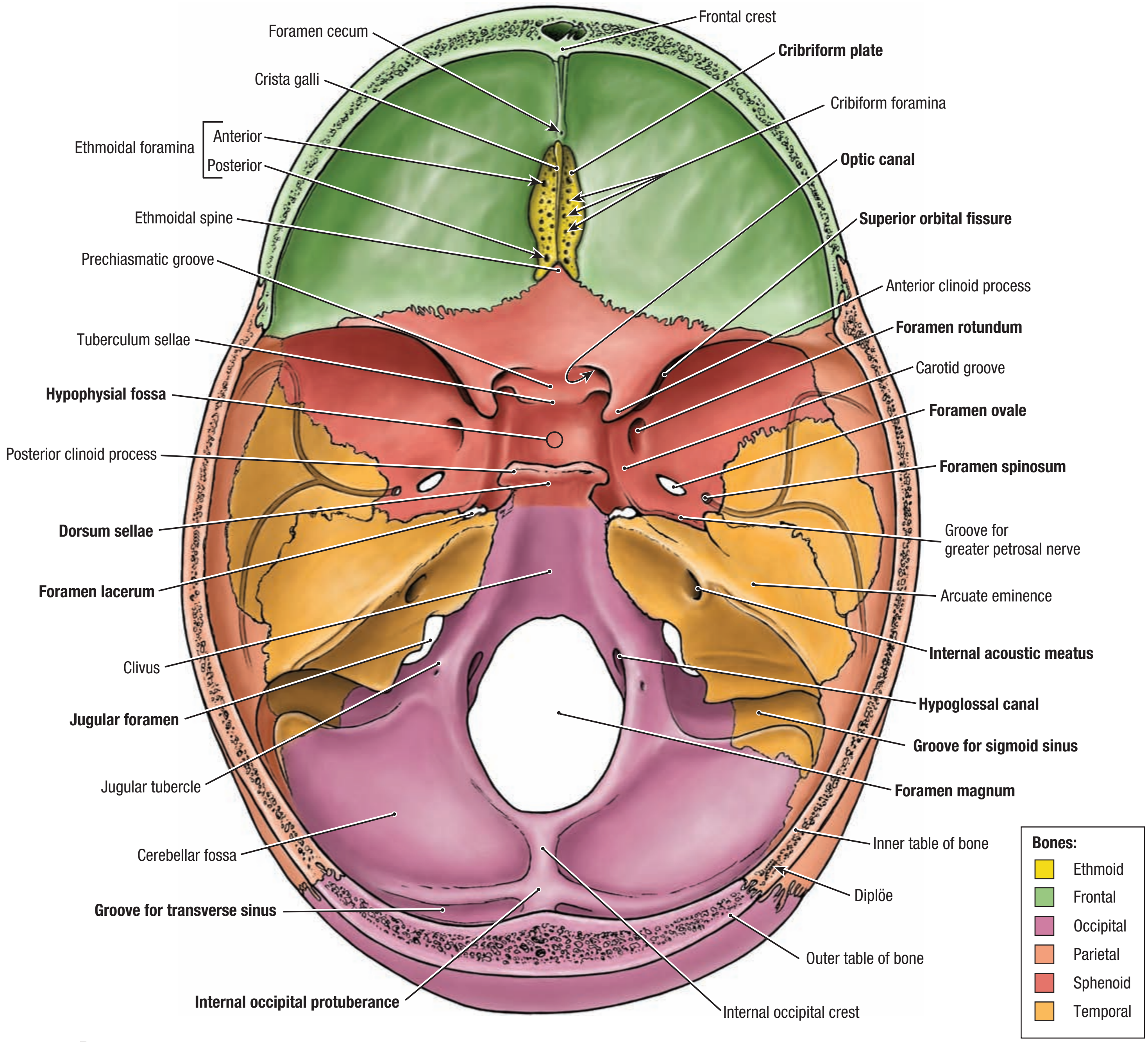
A. **Superior View**

7.6 INTERIOR OF THE CRANIAL BASE

A. Bony cranial base. **B.** Diagrammatic cranial base with bones color coded.

In **A:**

- Three bones contribute to the anterior cranial fossa: the orbital part of the frontal bone, the cribriform plate of the ethmoid, and the lesser wing of the sphenoid.
- The four parts of the occipital bone are the basilar, right and left lateral, and squamous.
- **Fractures in the floor of the anterior cranial fossa** may involve the cribriform plate of the ethmoid, resulting in leakage of CSF through the nose (CSF rhinorrhea). **CSF rhinorrhea** may be a primary indication of a cranial base fracture which increases the risk of meningitis, because an infection could spread to the meninges from the ear or nose.

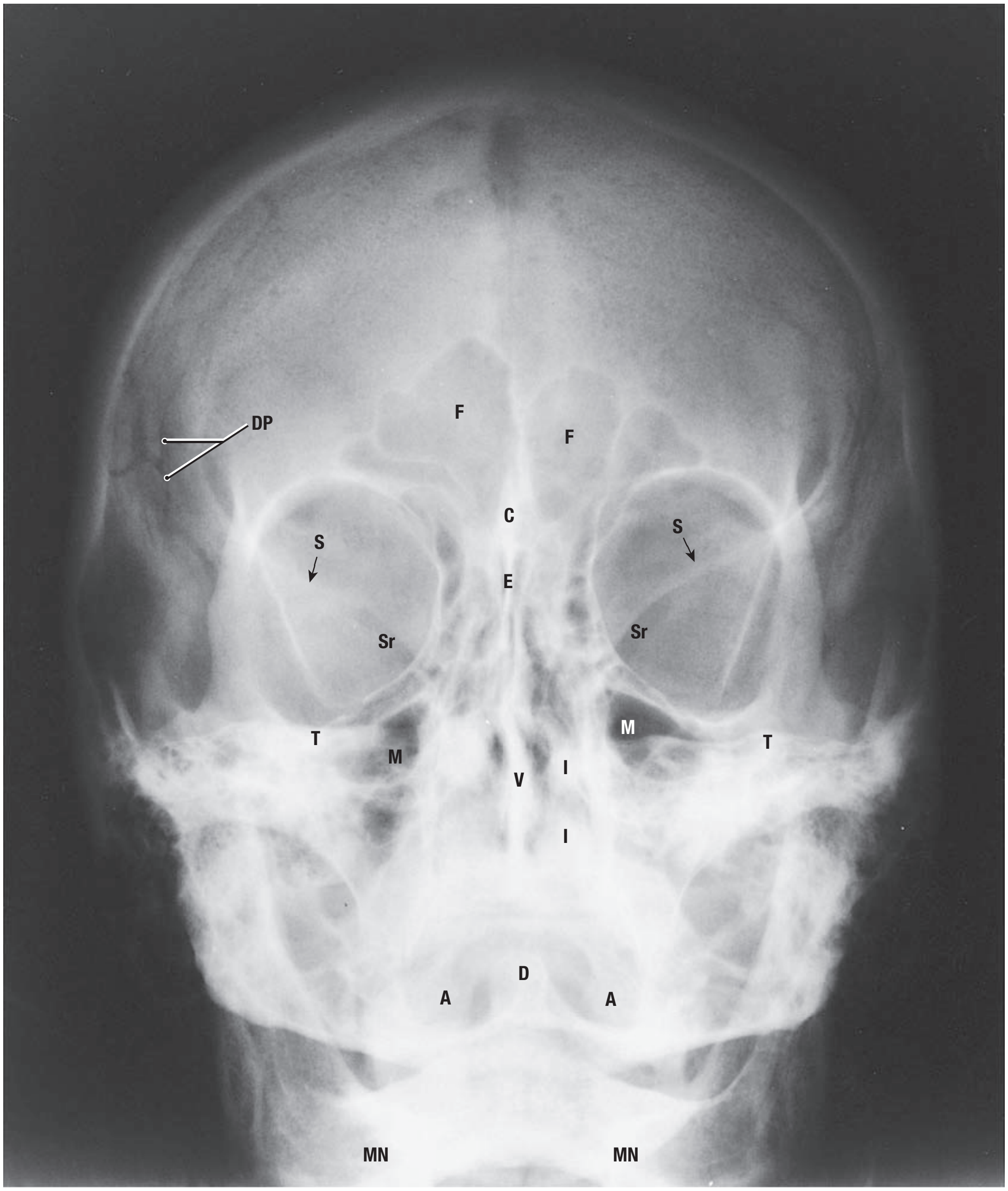


B. Superior View

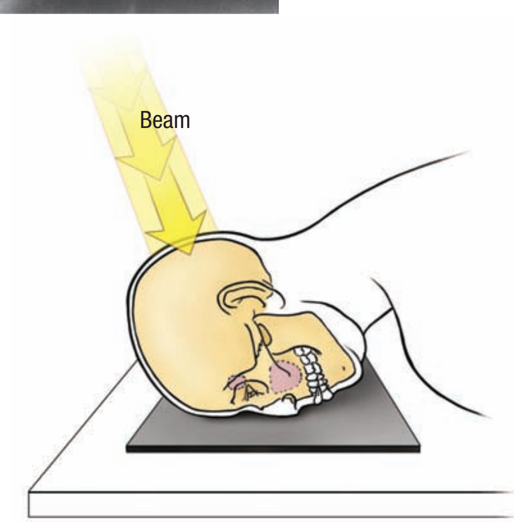
7.6 INTERIOR OF THE CRANIAL BASE *(CONTINUED)*

In **B,** note the following midline features:

- In the anterior cranial fossa, the frontal crest and crista galli for anterior attachment of the falx cerebri have between them the foramen cecum, which, during development, transmits a vein connecting the superior sagittal sinus with the veins of the frontal sinus and root of the nose.
- In the middle cranial fossa, the tuberculum sellae, hypophysial fossa, dorsum sellae, and posterior clinoid processes constitute the sella turcica (L. Turkish saddle).
- In the posterior cranial fossa, note the clivus, foramen magnum, internal occipital crest for attachment of the falx cerebelli, and the internal occipital protuberance, from which the grooves for the transverse sinuses course laterally.



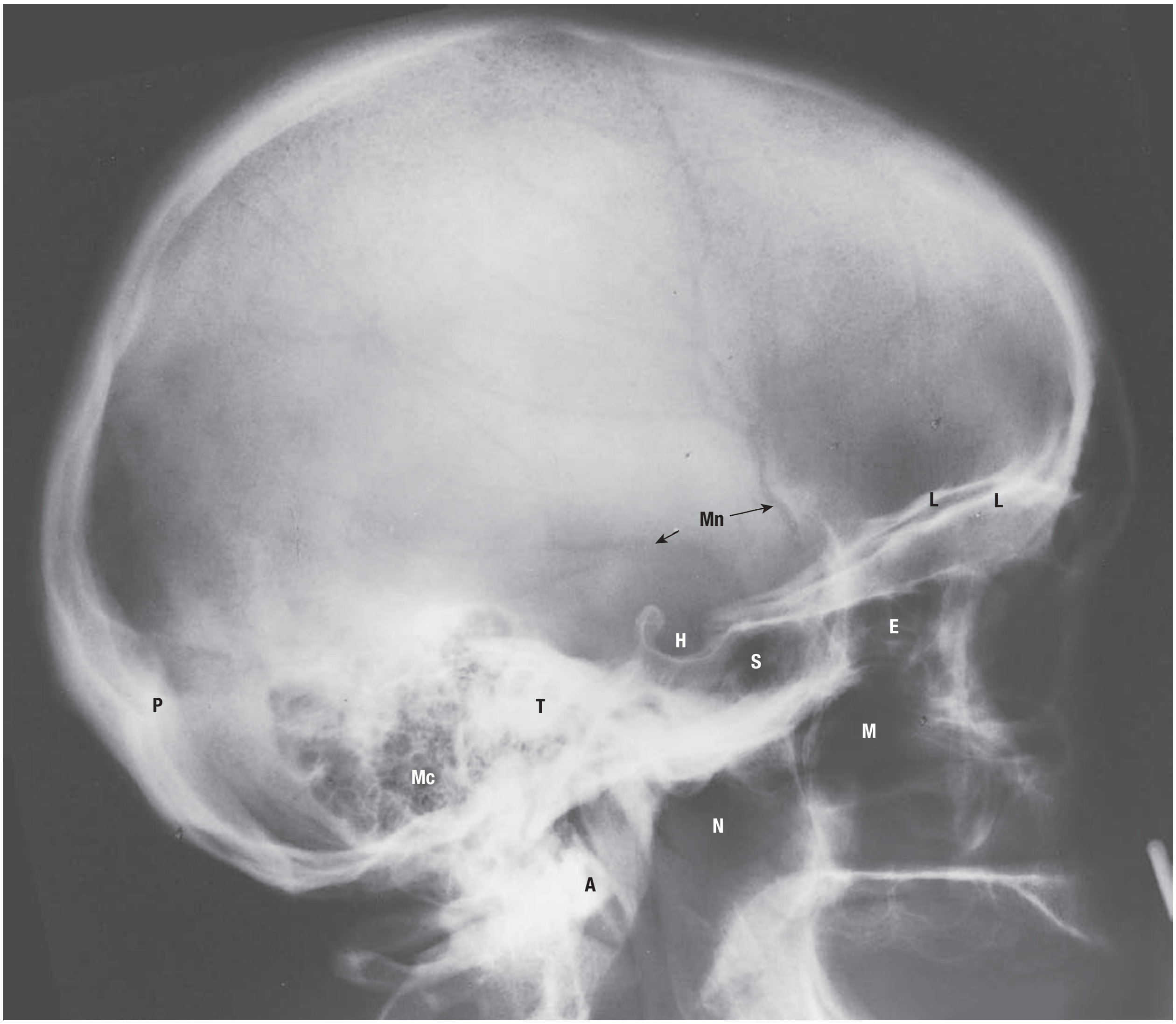
A. **Anteroposterior View**



7.7 RADIOGRAPHS OF THE CRANIUM

A. Postero-anterior (*Caldwell*) radiograph. This view places the orbits centrally in the head and is used to examine the orbits and paranasal sinuses. Observe in **A:**

- The labeled features include the superior orbital fissure *(Sr)*, lesser wing of the sphenoid *(S)*, superior surface of the petrous part of the temporal bone *(T)*, crista galli *(C)*, frontal sinus *(F)*, mandible *(MN)*, maxillary sinus *(M)*, and diploic veins *(DP)*.
- The nasal septum is formed by the perpendicular plate of the ethmoid (*E*) and the vomer (*V*); note the inferior and middle conchae (*I*) of the lateral wall of the nose.
- Superimposed on the facial skeleton are the dens (*D*) and lateral masses of the atlas (*A*).

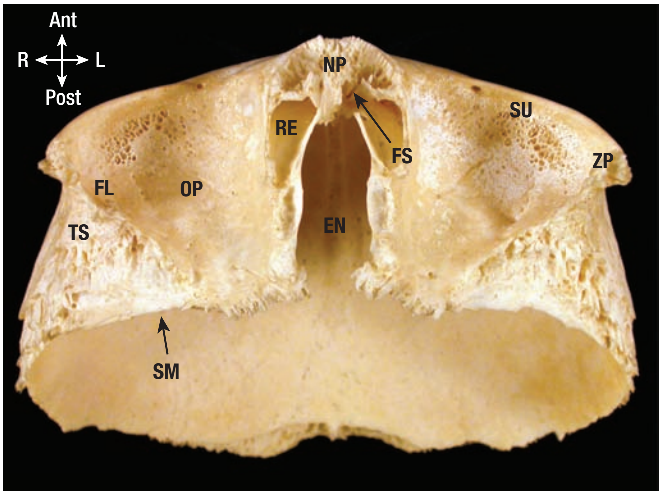


B. Lateral View

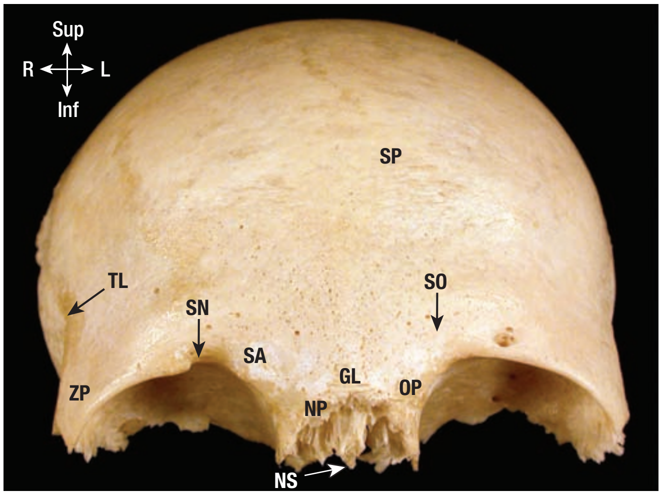
7.7 RADIOGRAPHS OF THE CRANIUM *(CONTINUED)*

B. Lateral radiograph of the cranium. Most of the relatively thin bone of the facial skeleton (viscerocranium) is radiolucent (appears *black*).

- The labeled features include the ethmoidal cells (*E*), sphenoidal (*S*) and maxillary (*M*) sinuses, the hypophysial fossa (*H*) for the pituitary gland, the petrous part of the temporal bone (*T*), mastoid cells (*Mc*), grooves for the branches of the middle meningeal vessels (*Mn*), anterior arch of the atlas (*A*), internal occipital protuberance (*P*), and the nasopharynx (*N*).
- The right and left orbital plates of the frontal bone are not superimposed; thus, the floor of the anterior cranial fossa appears as two lines (*L*).



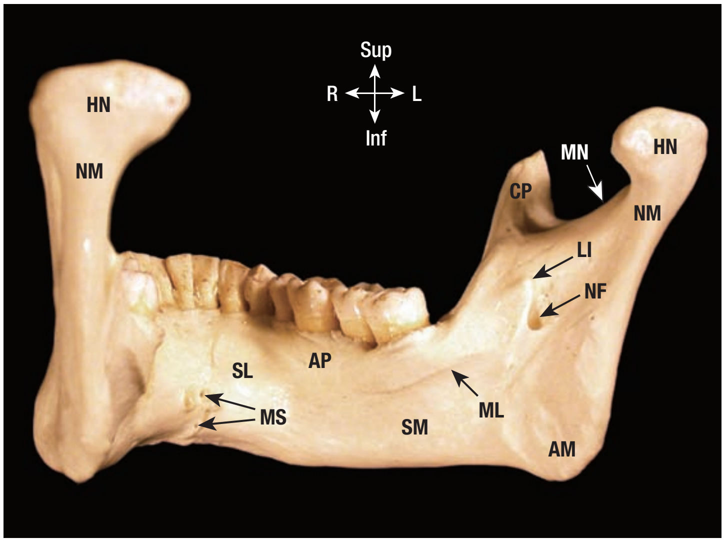
A. Inferior View



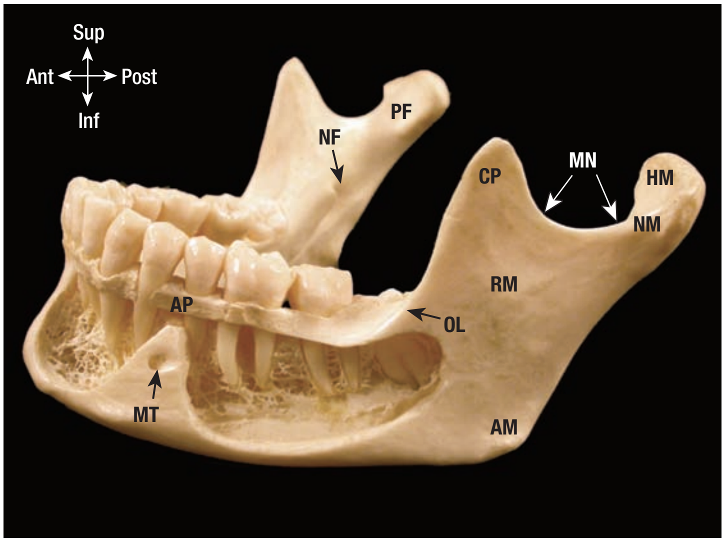
B. Anterior View

Key for A and B: Frontal Bone

EN	Ethmoidal notch	NP	Nasal part	SA	Superciliary arch	SU	Supra-orbital margin
FL	Fossa for lacrimal gland	NS	Nasal spine	SM	Sphenoidal margin	TL	Temporal line
FS	Opening of frontal sinus	OP	Orbital part	SN	Supra-orbital notch	TS	Temporal surface
GL	Glabella	RE	Root of ethmoid cells	SO	Supra-orbital foramen	ZP	Zygomatic process
				SP	Squamous part		



C. Posteromedial View



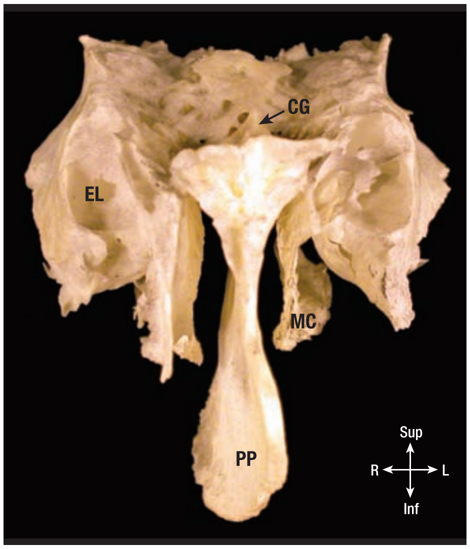
D. Lateral View

Key for C and D: Mandible

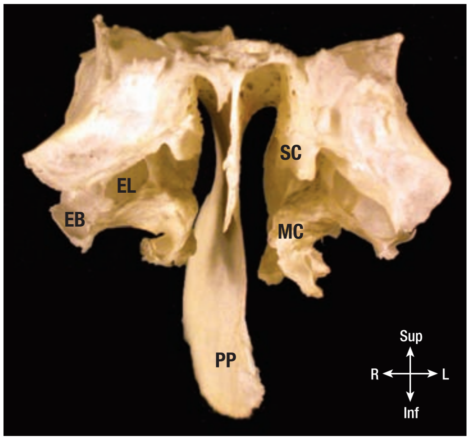
AM	Angle of mandible	ML	Mylohyoid groove	NM	Neck of mandible
AP	Alveolar part	MN	Mandibular notch	PF	Pterygoid fovea
CP	Coronoid process	MS	Mental (genial) spines	RM	Ramus of mandible
HM	Head of mandible	MT	Mental foramen	SL	Sublingual fossa
LI	Lingula	NF	Mandibular foramen	SM	Submandibular fossa

7.8 MANDIBLE, MAXILLA, FRONTAL, ETHMOID, AND LACRIMAL BONES

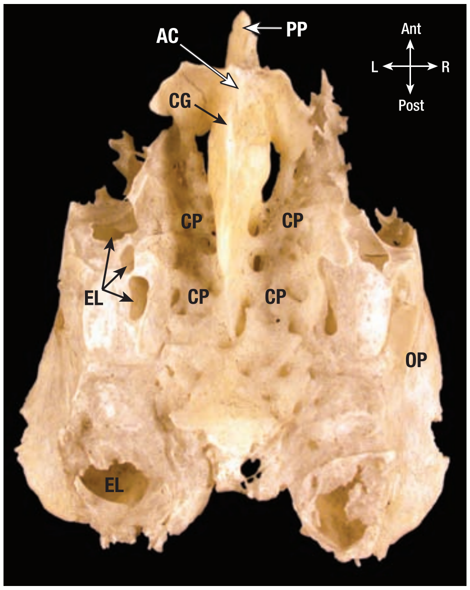
A. and B. Frontal bone. **C. and D.** Mandible.



E. Anterior View



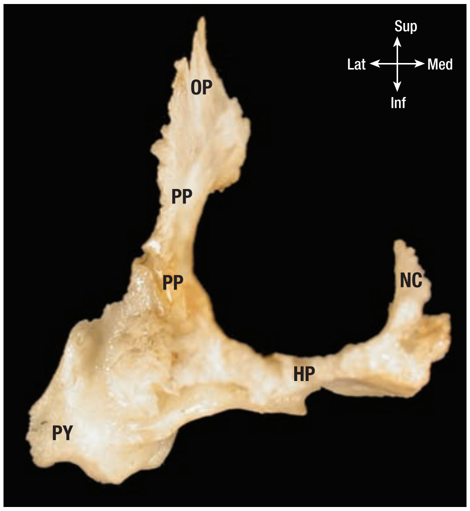
F. Posterior View



G. Superior View

Key for E-G: Ethmoid Bone

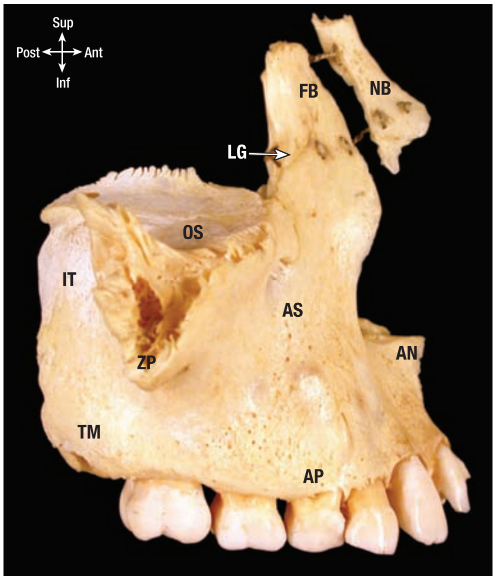
AC	Ala of crista galli	EB	Ethmoidal bulla	OP	Orbital plate
CG	Crista galli	EL	Ethmoidal labyrinth (cells)	PP	Perpendicular plate
CP	Cribriform plate	MC	Middle nasal concha	SC	Superior nasal concha



H. Anterior View

Key for H: Palatine Bone

HP	Horizontal plate	PP	Perpendicular plate
NC	Nasal crest	PY	Pyramidal process
OP	Orbital process		



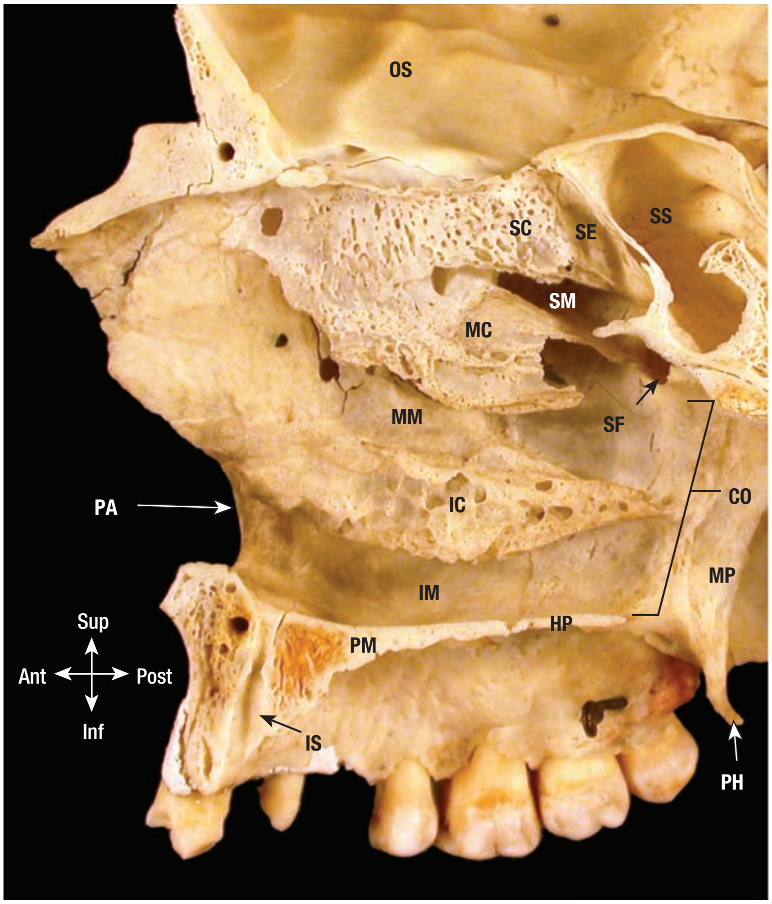
I. Lateral View

Key for I: Maxilla and Nasal Bone

AN	Anterior nasal spine	LG	Lacrimal groove
AP	Alveolar part	NB	Nasal bone
AS	Anterior surface	OS	Orbital surface
FP	Frontal process	TM	Tuberosity
IT	Infratemporal surface	ZP	Zygomatic process

7.8 MANDIBLE, MAXILLA, FRONTAL, ETHMOID, AND LACRIMAL BONES *(CONTINUED)*

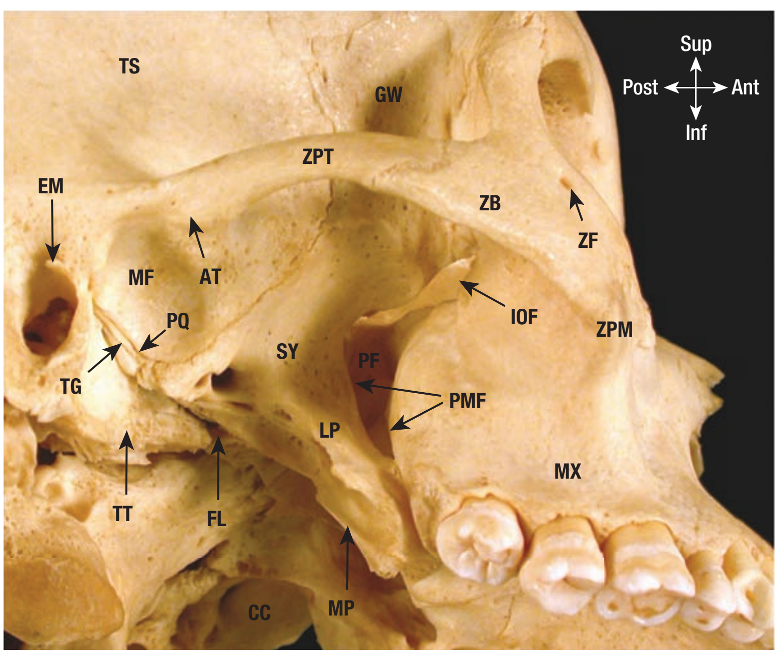
E.–G. Ethmoid bone. **H.** Lacrimal bone. **I.** Maxilla



A. Lateral Wall of Nose, Medial View

Key for A: Lateral Wall of Nose

CO	Choana (posterior nasal aperture)
HP	Horizontal plate of palatine bone
IC	Inferior nasal concha
IS	Incisive canal
IM	Inferior nasal meatus
MC	Middle nasal concha
MM	Middle nasal meatus
PH	Pterygoid hamulus
PM	Palatine process of maxilla
OS	Orbital surface of frontal bone
PA	Piriform aperture
PM	Palatine process of maxilla
SC	Superior nasal concha
SE	Spheno-ethmoidal recess
SF	Sphenopalatine foramen
SM	Superior nasal meatus
SS	Sphenoidal sinus



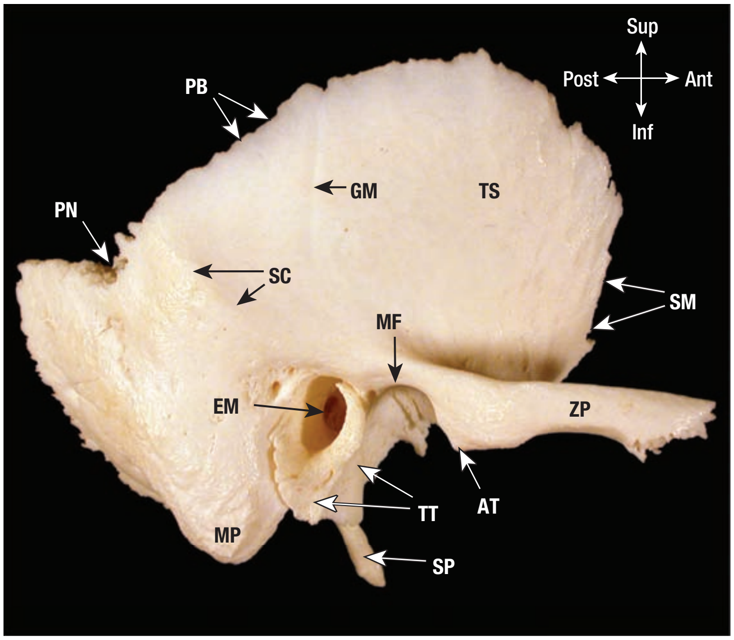
B. Infratemporal Region, Inferolateral View

Key for B: Infratemporal Region

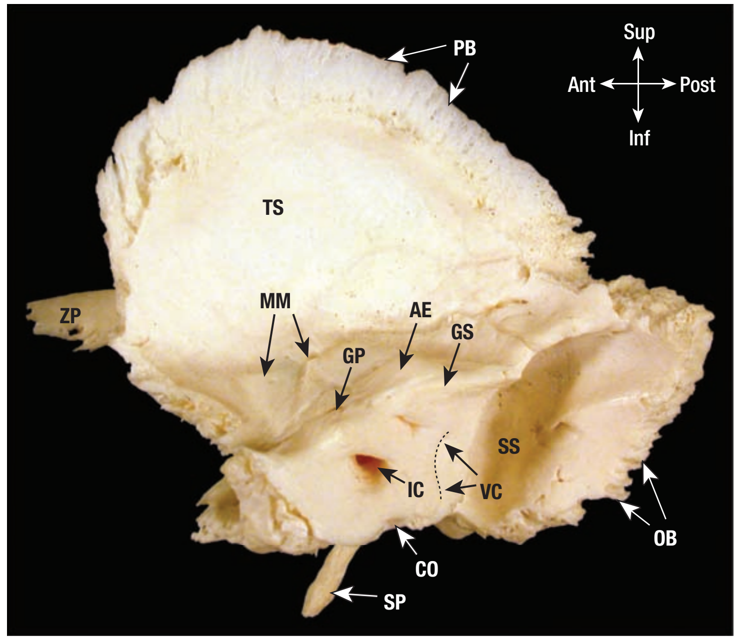
PF	Pterygopalatine fossa
MF	Mandibular fossa
AT	Articular tubercle
ZPT	Zygomatic process of temporal bone
CC	Carotid canal
FL	Foramen lacerum
ZF	Zygomaticofacial foramen
PQ	Petrosquamous fissure
TG	Tegmen tympani
TT	Temporal bone (tympanic part)
ZB	Zygomatic bone
MX	Maxilla
IOF	Inferior orbital fissure
PMF	Pterygomaxillary fissure
ZPM	Zygomatic process of maxilla
EM	External acoustic meatus
GW	Greater wing of sphenoid
LP	Lateral pterygoid plate
MP	Medial pterygoid plate
SY	Stylomastoid foramen

7.9 LATERAL WALL OF NOSE AND INFRATEMPORAL REGION

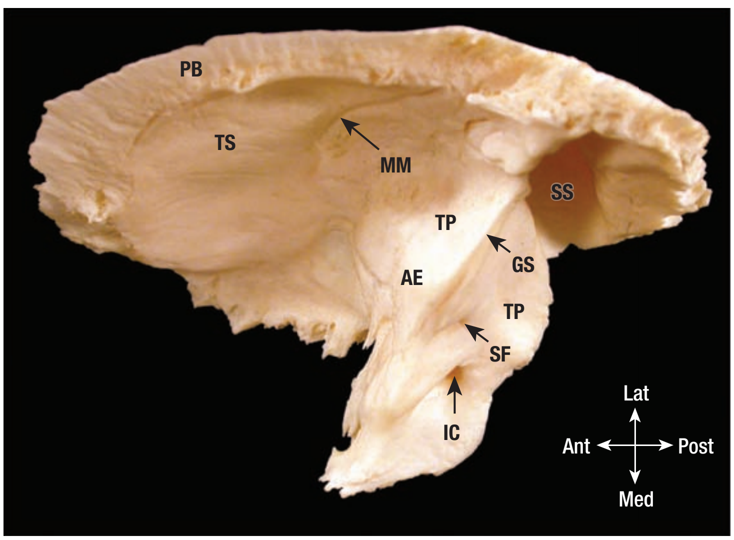
A. Lateral wall of nose. **B.** Infratemporal region.



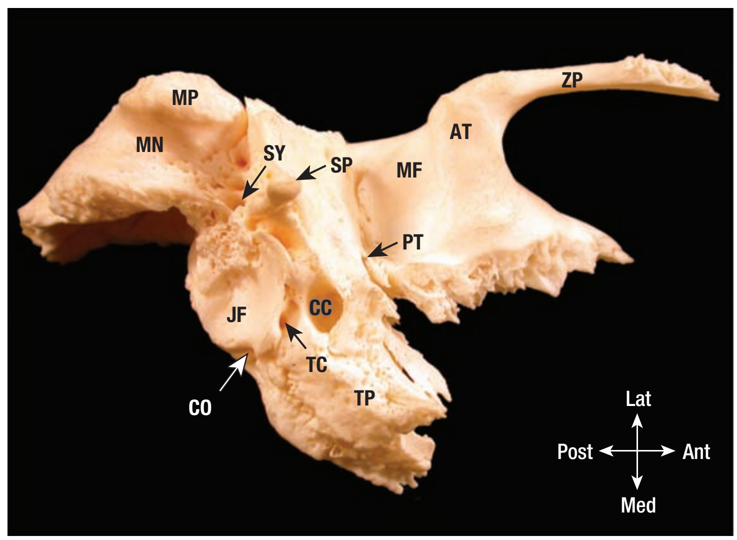
A. Lateral View



B. Medial View



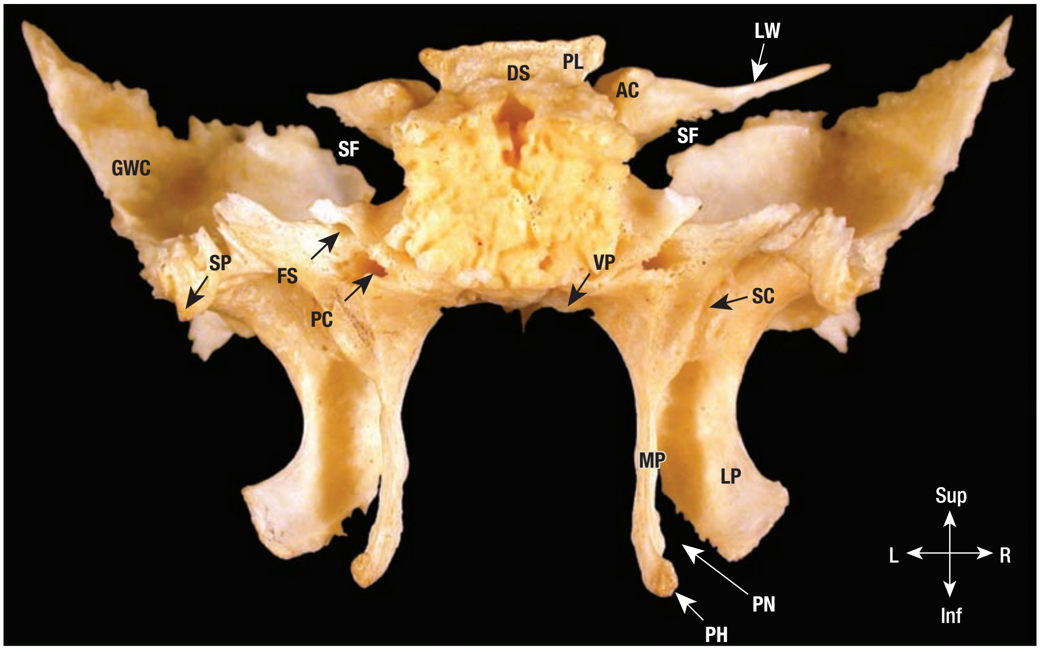
C. Superior View



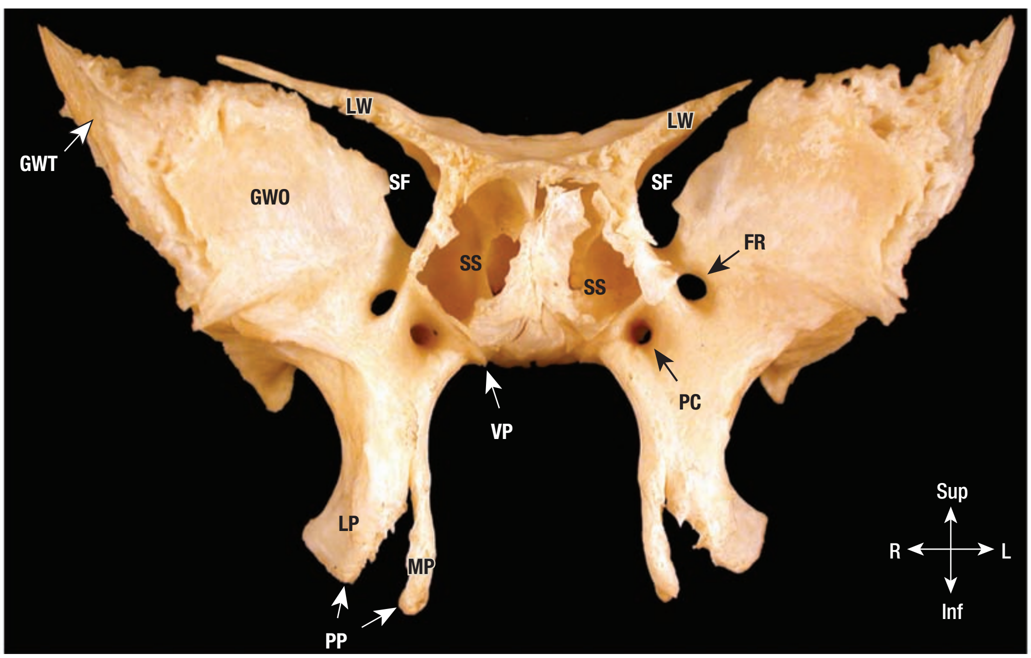
D. Inferior View

Key for A-D: Temporal Bone

AE	Arcuate eminence	MF	Mandibular fossa	SM	Sphenoid margin
AT	Articular tubercle	MM	Groove for middle meningeal artery	SP	Styloid process
CC	Carotid canal	MN	Mastoid notch	SS	Groove for sigmoid sinus
CO	Cochlear canaliculus	MP	Mastoid process	SY	Stylomastoid foramen
EM	External acoustic meatus	OB	Occipital border	TC	Tympanic canaliculus
GM	Groove for middle temporal artery	PB	Parietal border	TP	Temporal bone (petrous part)
GP	Hiatus for greater petrosal nerve	PN	Parietal notch	TS	Temporal bone (squamous part)
GS	Groove for superior petrosal sinus	PT	Petrotympanic fissure	TT	Temporal bone (tympanic part)
IC	Internal acoustic meatus	SC	Supramastoid crest	VC	Vestibular canaliculus
JF	Jugular fossa	SF	Subarcuate fossa	ZP	Zygomatic process



A. Posterior View

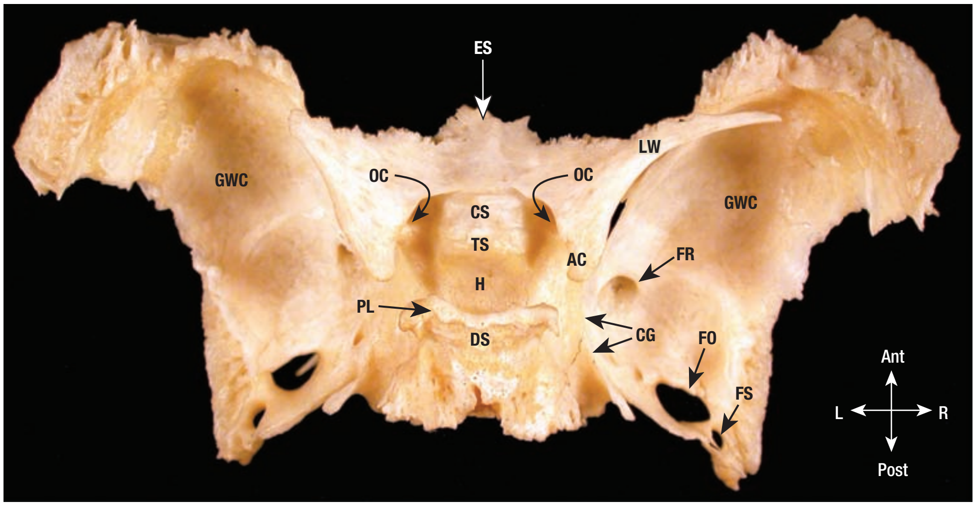


B. Anterior View

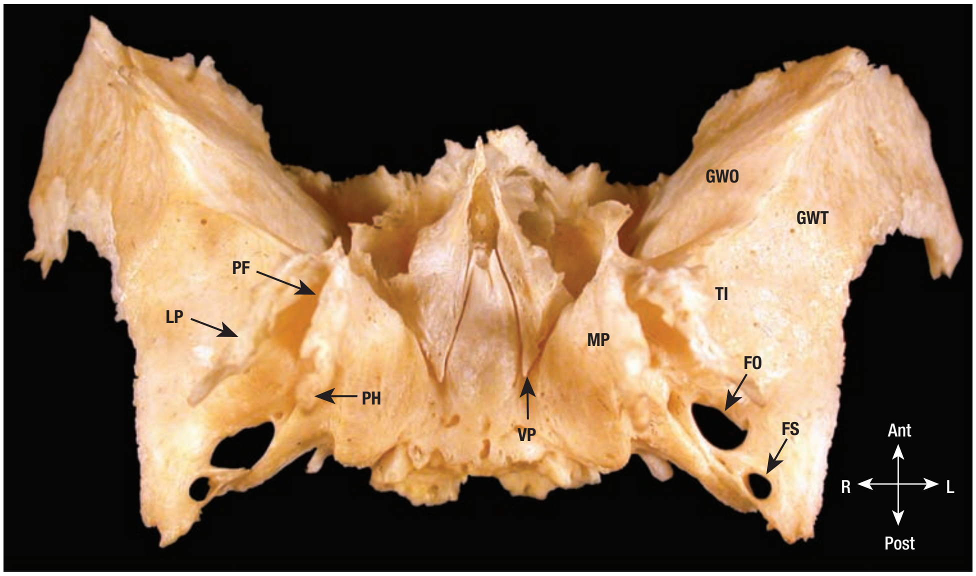
Key for A-D: Sphenoid Bone

AC	Anterior clinoid process	FO	Foramen ovale	GWO	Greater wing (orbital surface)
CG	Carotid sulcus	FR	Foramen rotundum	GWT	Greater wing (temporal surface)
CS	Prechiasmatic sulcus	FS	Foramen spinosum	H	Hypophysial fossa
DS	Dorsum sellae	GWC	Greater wing (cerebral surface)	LP	Lateral pterygoid plate
ES	Ethmoidal spine	GWI	Greater wing (infratemporal surface)	LW	Lesser wing

7.11 SPHENOID BONE



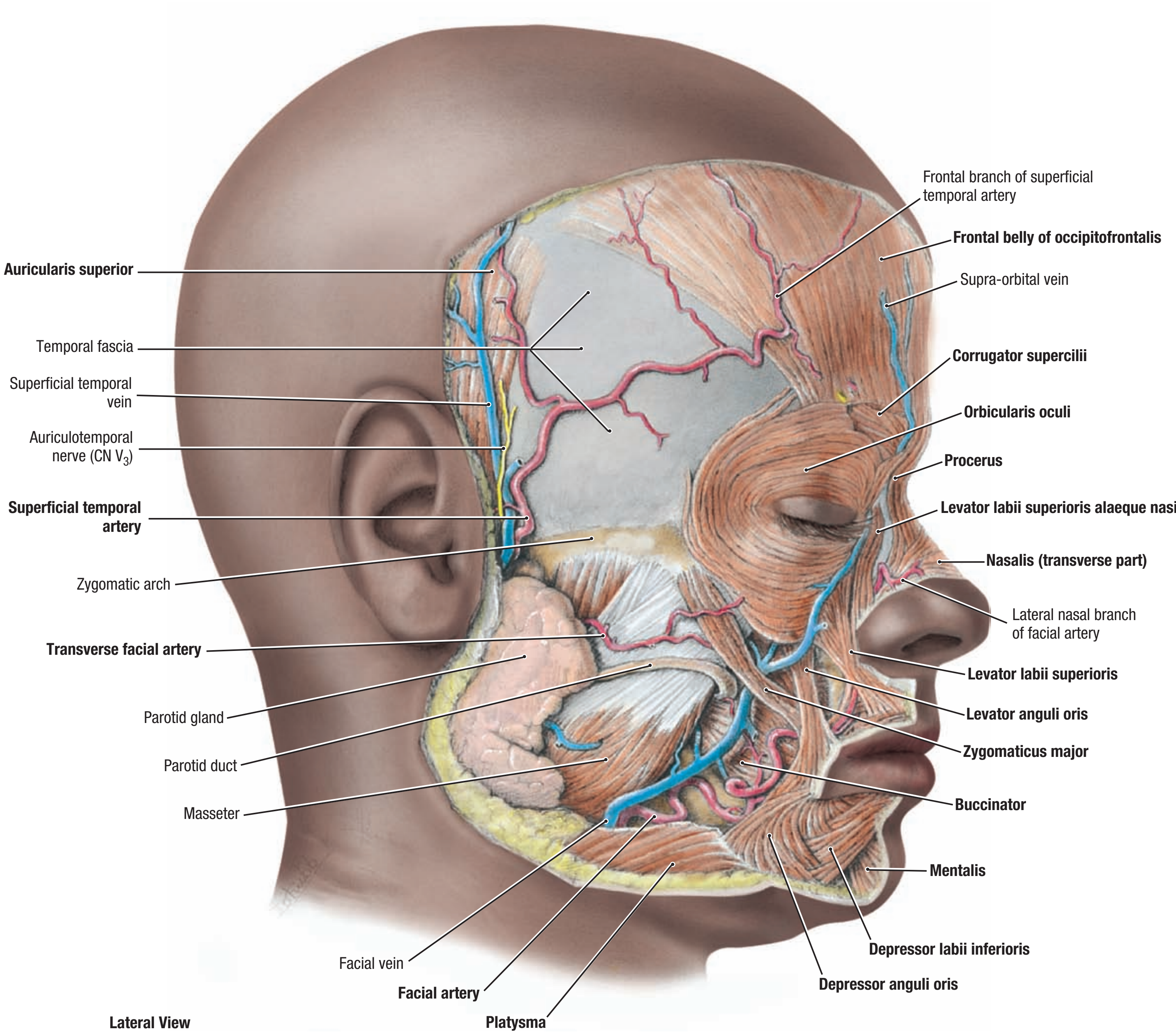
C. Superior View



D. Inferior View

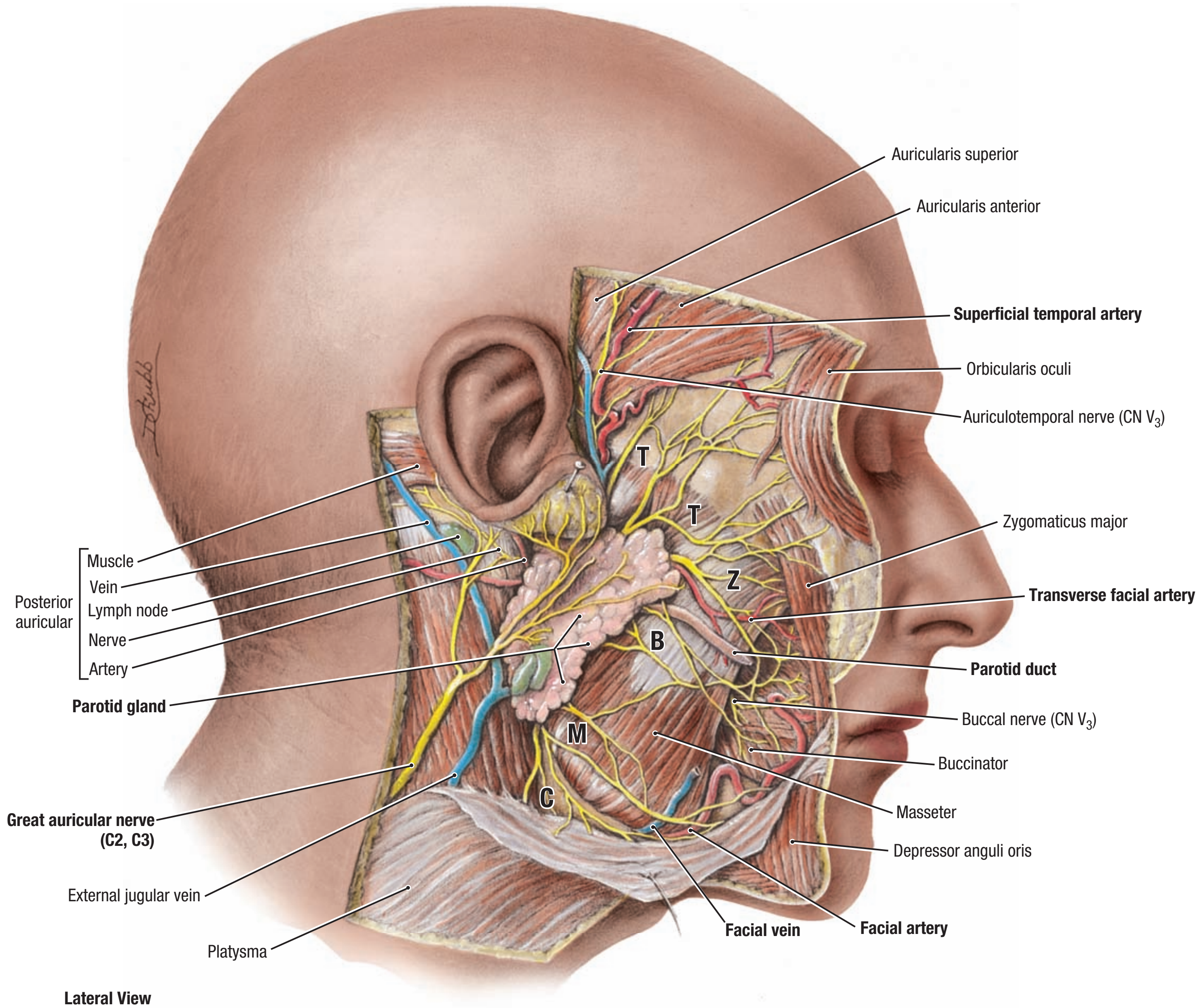
Key for A-D: Sphenoid Bone (Continued)					
MP	Medial pterygoid plate	PL	Posterior clinoid process	SP	Spine of sphenoid bone
OC	Optic canal	PN	Pterygoid notch	SS	Sphenoidal sinus (in body of sphenoid)
PC	Pterygoid canal	PP	Pterygoid process	TS	Tuberculum sellae
PF	Pterygoid fossa	SC	Scaphoid fossa	VP	Vaginal process
PH	Pterygoid hamulus	SF	Superior orbital fissure		

7.11 SPHENOID BONE *(CONTINUED)*



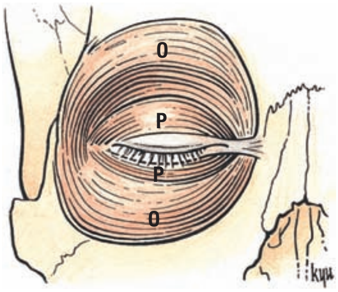
7.12 MUSCLES OF FACIAL EXPRESSION AND ARTERIES OF THE FACE

- The muscles of facial expression are the superficial sphincters and dilators of the openings of the head; all are supplied by the facial nerve (CN VII). The masseter and temporalis (the latter covered here by temporal fascia) are muscles of mastication that are innervated by the trigeminal nerve (CN V).
- **Superficial temporal and facial artery pulses.** Anesthesiologists, usually stationed at the head of the operating table, take these pulses. The superficial temporal pulse is palpated anterior to the auricle as the artery crosses the zygomatic arch. The facial pulse is palpated where the facial artery crosses the inferior border of the mandible immediately anterior to the masseter.



7.13 RELATIONSHIPS OF BRANCHES OF FACIAL NERVE AND VESSELS TO THE PAROTID GLAND AND DUCT

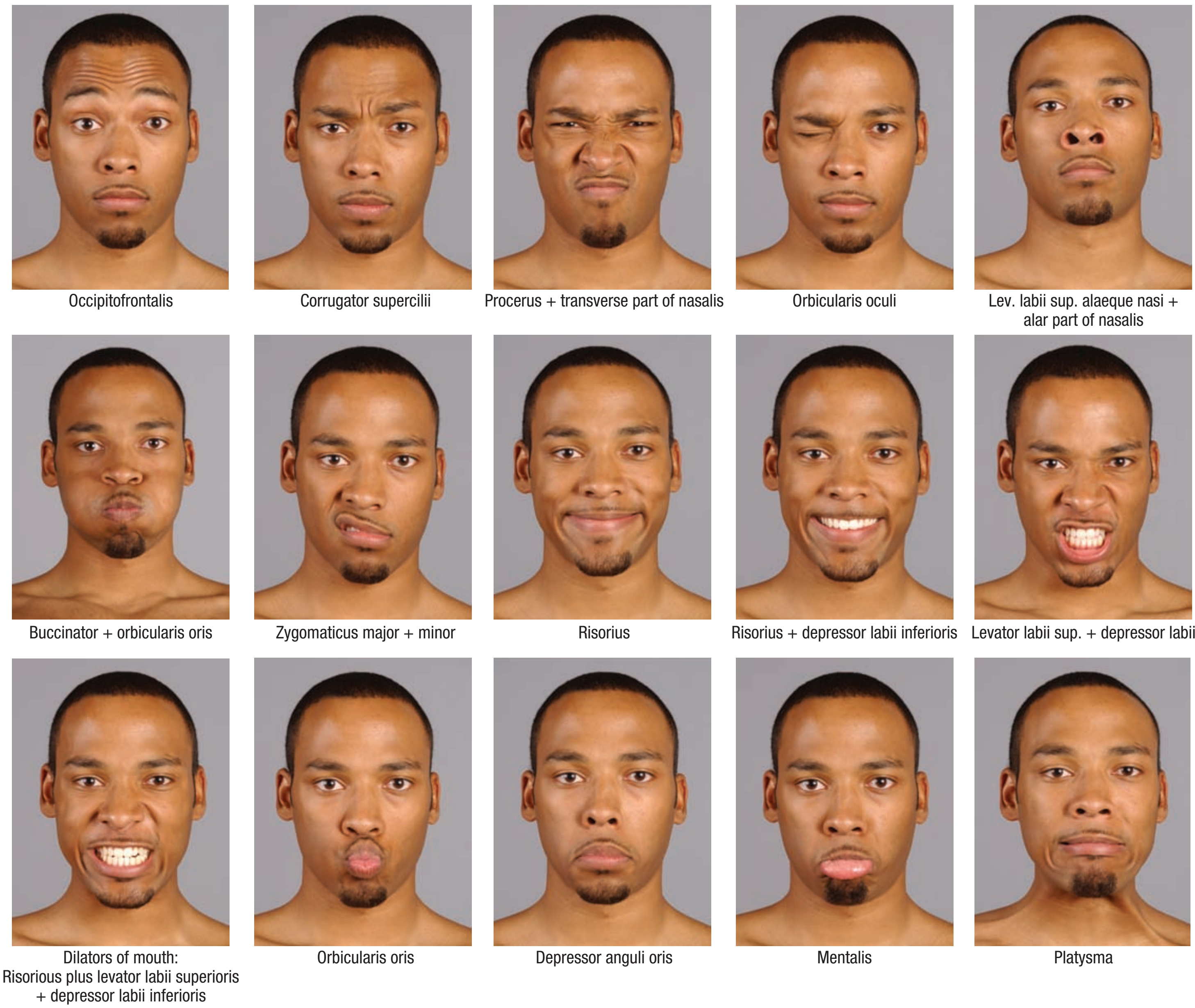
- The parotid duct extends across the masseter muscle just inferior to the zygomatic arch; the duct turns medially to pierce the buccinator and opens into the oral vestibule.
- The facial nerve (CN VII) innervates the muscles of facial expression. After emerging from the stylomastoid foramen, the main stem of the facial nerve has posterior auricular, digastric, and stylohyoid branches; the parotid plexus gives rise to temporal (T), zygomatic (Z), buccal (B), marginal mandibular (M), cervical (C), and posterior auricular branches. These branches form a plexus within the parotid gland, the branches of which radiate over the face, anastomosing with each other and the branches of the trigeminal nerve.
- During **parotidectomy** (surgical excision of the parotid gland), identification, dissection, and preservation of the branches of the facial nerve are critical.
- The parotid gland may become infected by infectious agents that pass through the bloodstream, as occurs in mumps, an acute communicable viral disease. Infection of the gland causes inflammation, **parotiditis**, and swelling of the gland. Severe pain occurs because the parotid sheath, innervated by the great auricular nerve, is distended by swelling.



A

B

C

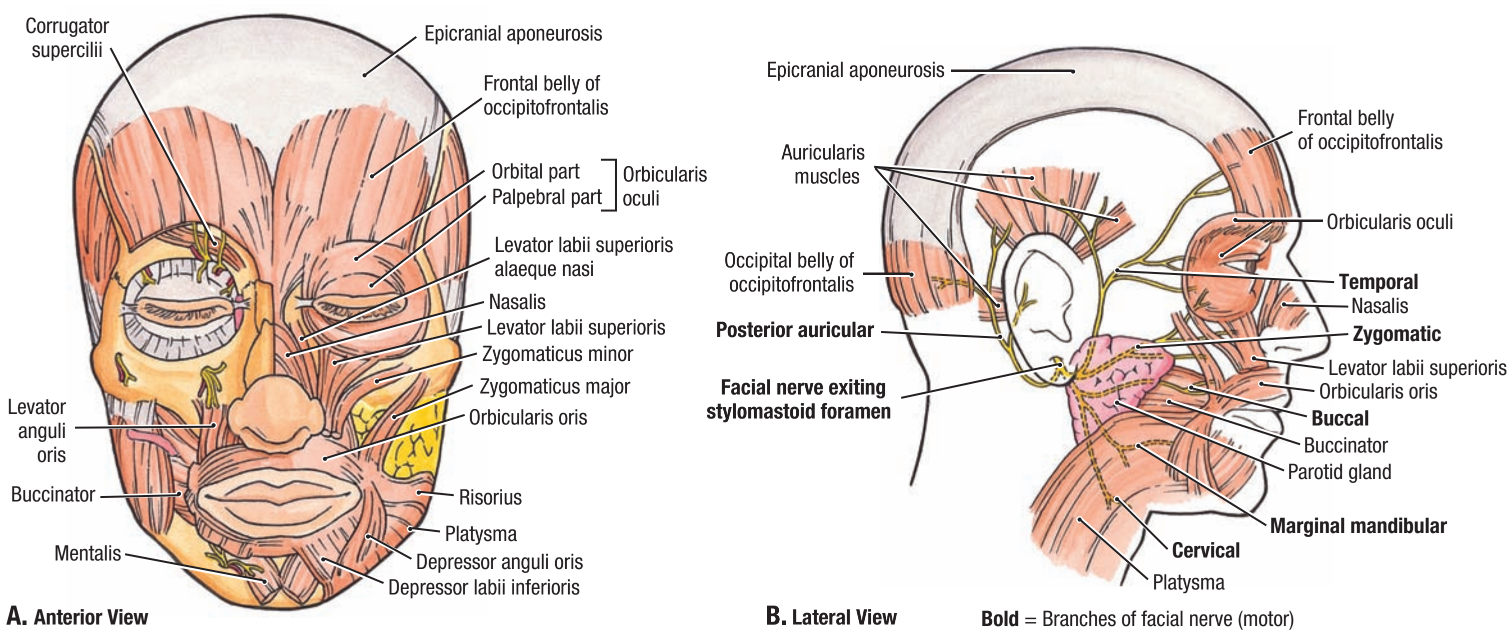


D

Anterior Views

7.14 MUSCLES OF FACIAL EXPRESSION

A. Orbicularis oculi: palpebral (P) and orbital (O) parts. Eyelids close lateral to medial washing lacrimal fluid across the cornea. **B.** Gentle closure of eyelid—palpebral part. **C.** Tight closure of eyelid—orbital part. **D.** Actions of selected muscles of facial expression.



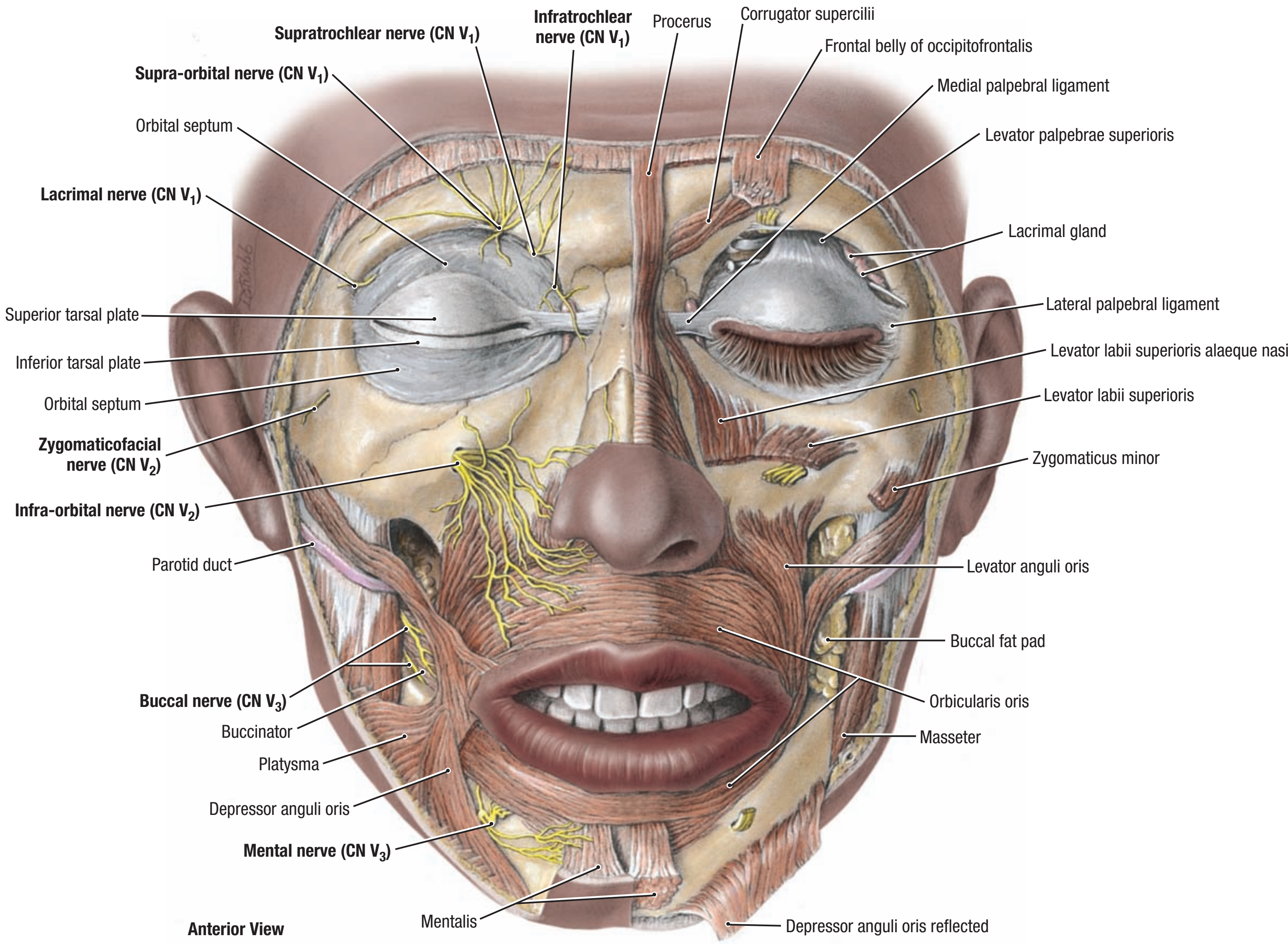
7.15 BRANCHES OF FACIAL NERVE AND MUSCLES OF FACIAL EXPRESSION

A. Muscles. **B.** Branches of facial nerve.

TABLE 7.2 MAIN MUSCLES OF FACIAL EXPRESSION [a]

Muscle[a]	Origin	Insertion	Action
Occipitofrontalis, frontal belly	Epicranial aponeurosis	Skin of and subcutaneous tissue of eyebrows and forehead	Elevates eyebrows and wrinkles skin of forehead; protracts scalp (indicating surprise or curiosity)
Occipitofrontalis, occipital belly	Lateral two-thirds of superior nuchal line	Epicranial aponeurosis	Retracts scalp; increasing effectiveness of frontal belly
Orbicularis oculi	Medial orbital margin, medial palpebral ligament; lacrimal bone	Skin around margin of orbit; superior and inferior tarsal plates	Closes eyelids; palpebral part does so gently; orbital part tightly (winking)
Orbicularis oris	Medial maxilla and mandible; deep surface of perioral skin; angle of mouth (modiolus)	Mucous membrane of lips	Tonus closes oral fissure; phasic contraction compresses and protrudes lips (kissing) or resists distension (when blowing)
Levator labii superioris	Infra-orbital margin (maxilla)	Skin of upper lip	Part of dilators of mouth; retract (elevate) and/or evert upper lip; deepen nasolabial sulcus (showing sadness)
Zygomaticus minor	Anterior aspect, zygomatic bone		
Buccinator	Mandible, alveolar processes of maxilla and mandible; pterygomandibular raphe	Angle of mouth (modiolus); orbicularis oris	Presses cheek against molar teeth; works with tongue to keep food between occlusal surfaces and out of oral vestibule; resists distension (when blowing)
Zygomaticus major	Lateral aspect of zygomatic bone	Angle of mouth (modiolus)	Part of dilators of mouth; elevate labial commissure—bilaterally to smile (happiness); unilaterally to sneer (disdain)
Rizorius	Parotid fascia and buccal skin (highly variable)		Part of dilators of mouth; widens oral fissure
Platysma	Subcutaneous tissue of infraclavicular and supraclavicular regions	Base of mandible; skin of cheek and lower lip; angle of mouth (modiolus); orbicularis oris	Depresses mandible (against resistance); tenses skin of inferior face and neck (conveying tension and stress)

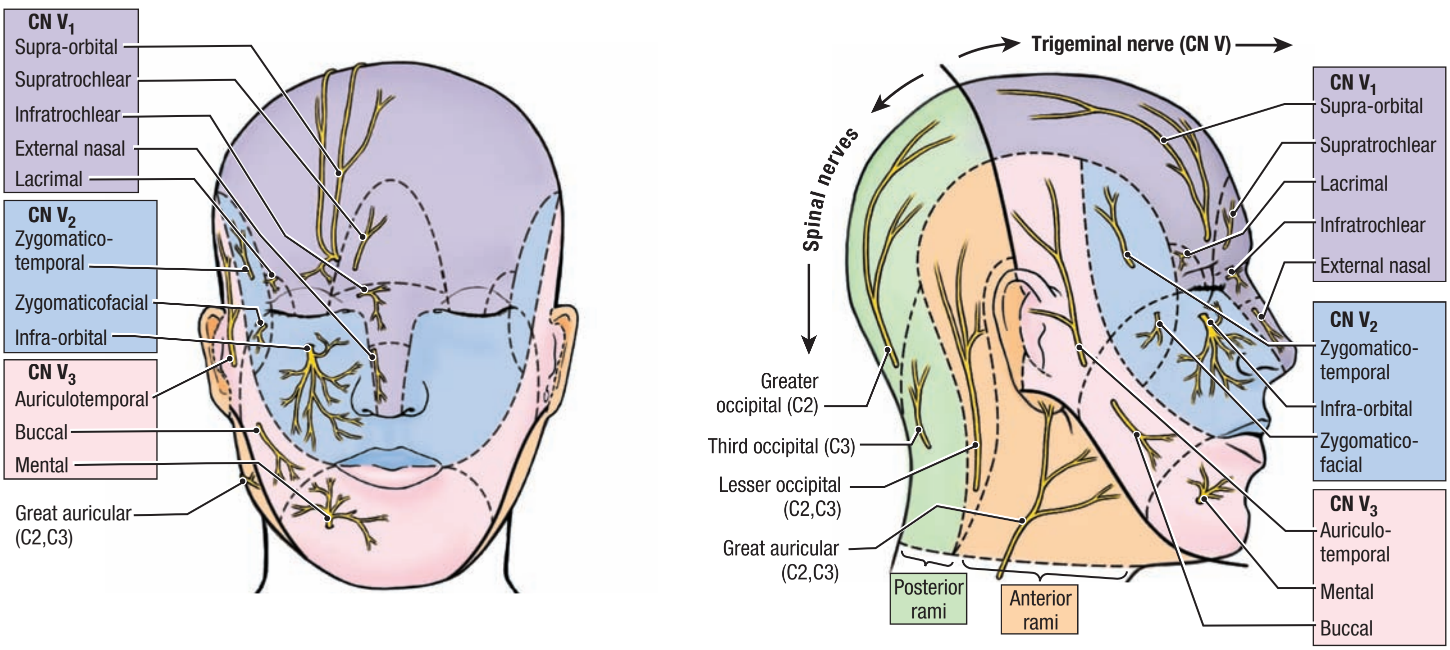
[a]All of these muscles are supplied by the facial nerve (CN VII).



7.16 CUTANEOUS BRANCHES OF TRIGEMINAL NERVE, MUSCLES OF FACIAL EXPRESSION, AND EYELID

Injury to the facial nerve (CN VII) or its branches produces paralysis of some or all of the facial muscles on the affected side (Bell palsy). The affected area sags, and facial expression is distorted. The loss of tonus of the orbicularis oculi causes the inferior lid to evert (fall away from the surface of the eyeball). As a result, the lacrimal fluid is not spread over the cornea, preventing adequate lubrication, hydration, and flushing of the cornea. This makes the cornea vulnerable to ulceration. If the injury weakens or paralyzes the buccinator and orbicularis oris, food will accumulate in the oral vestibule during chewing, usually requiring continual removal with a finger. When the sphincters or dilators of the mouth are affected, displacement of the mouth (drooping of the corner) is produced by gravity and contraction of unopposed contralateral facial muscles, resulting in food and saliva dribbling out of the side of the mouth. Weakened lip muscles affect speech. Affected people cannot whistle or blow a wind instrument effectively. They frequently dab their eyes and mouth with a handkerchief to wipe the fluid (tears and saliva) that runs from the drooping lid and mouth.

Because the face does not have a distinct layer of deep fascia and the subcutaneous tissue is loose between the attachments of facial muscles, **facial lacerations** tend to gap (part widely). Consequently, the skin must be sutured carefully to prevent scarring. The looseness of the subcutaneous tissue also enables fluid and blood to accumulate in the loose connective tissue after **bruising of the face**.



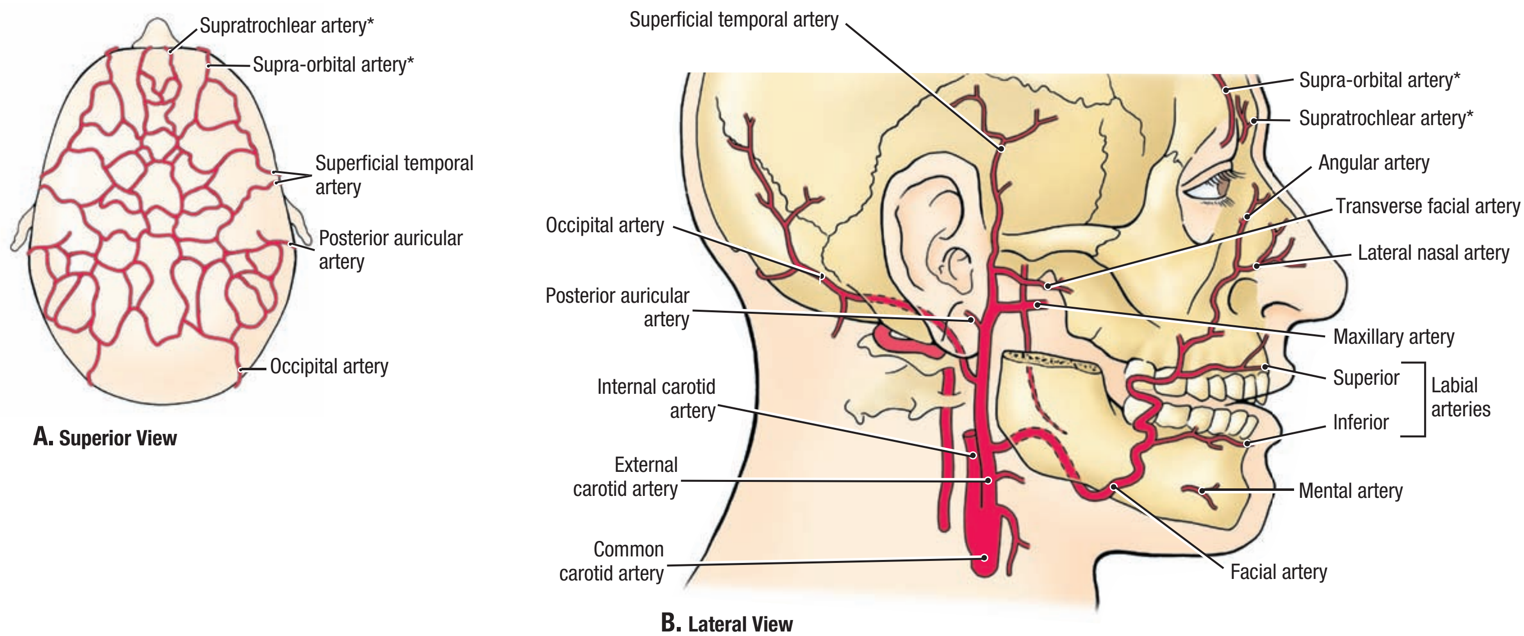
A. Anterior view

B. Lateral View (Cervical plexus)

7.17 NERVES OF FACE AND SCALP

TABLE 7.3 NERVES OF FACE AND SCALP

Nerve	Origin	Course	Distribution
Frontal	Ophthalmic nerve (CN V_1)	Crosses orbit on superior aspect of levator palpebrae superioris; divides into supra-orbital and supratrochlear branches	Skin of forehead, scalp, superior eyelid, and nose; conjunctiva of superior lid and mucosa of frontal sinus
Supra-orbital	Continuation of frontal nerve (CN V_1)	Emerges through supra-orbital notch, or foramen, and breaks up into small branches	Mucous membrane of frontal sinus and conjunctiva (lining) of superior eyelid; skin of forehead as far as vertex
Supratrochlear	Frontal nerve (CN V_1)	Continues anteromedially along roof of orbit, passing lateral to trochlea	Skin in middle of forehead to hairline
Infratrochlear	Nasociliary nerve (CN V_1)	Follows medial wall of orbit passing inferior to trochlea to superior eyelid	Skin and conjunctiva (lining) of superior eye lid
Lacrimal	Ophthalmic nerve (CN V_1)	Passes through palpebral fascia of superior eyelid near lateral angle (canthus) of eye	Lacrimal gland and small area of skin and conjunctiva of lateral part of superior eyelid
External nasal	Anterior ethmoidal nerve (CN V_1)	Runs in nasal cavity and emerges on face between nasal bone and lateral nasal cartilage	Skin on dorsum of nose, including tip of nose
Zygomatic	Maxillary nerve (CN V_2)	Arises in floor of orbit, divides into zygomaticofacial and zygomaticotemporal nerves, which traverse foramina of same name	Skin over zygomatic arch and anterior temporal region
Infra-orbital	Terminal branch of maxillary nerve (CN V_2)	Runs in floor of orbit and emerges at infra-orbital foramen	Skin of cheek, inferior lid, lateral side of nose and inferior septum and superior lip, upper premolar incisors and canine teeth; mucosa of maxillary sinus and superior lip
Auriculotemporal	Mandibular nerve (CN V_3)	From posterior division of CN V_3, it passes between neck of mandible and external acoustic meatus to accompany superficial temporal artery	Skin anterior to ear and posterior temporal region, tragus and part of helix of auricle, and roof of external acoustic meatus and upper tympanic membrane
Buccal	Mandibular nerve (CN V_3)	From the anterior division of CN V_3 in infratemporal fossa, it passes anteriorly to reach cheek	Skin and mucosa of cheek, buccal gingiva adjacent to 2nd and 3rd molar teeth
Mental	Terminal branch of inferior alveolar nerve (CN V_3)	Emerges from mandibular canal at mental foramen	Skin of chin and inferior lip and mucosa of lower lip

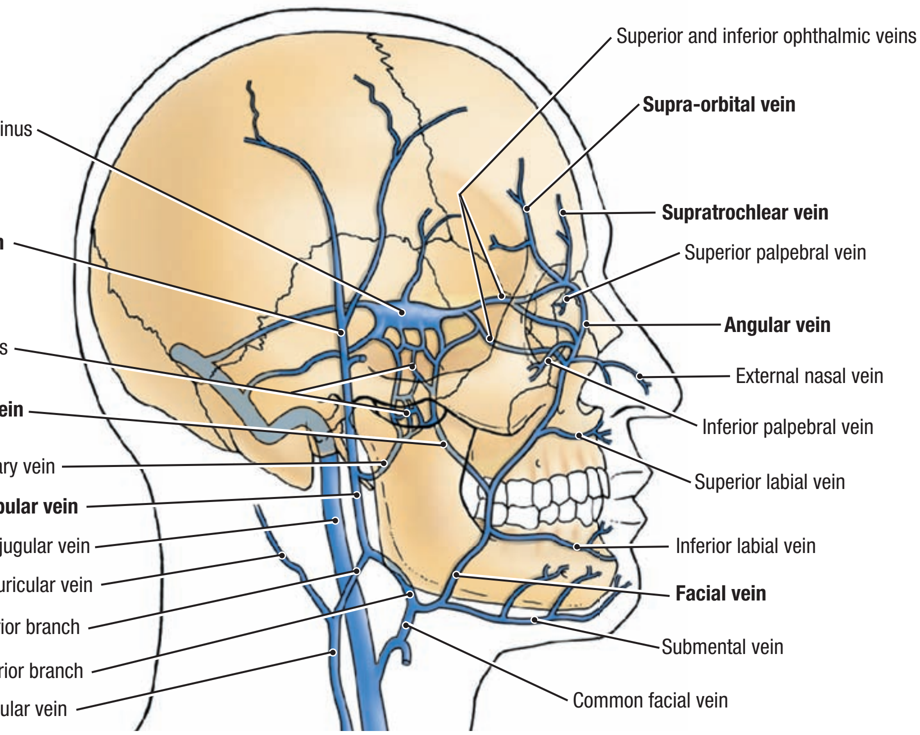


*Source= internal carotid artery (ophthalmic artery); all other labeled arteries are from external carotid

7.18 ARTERIES OF FACE AND SCALP

TABLE 7.4 ARTERIES OF SUPERFICIAL FACE AND SCALP

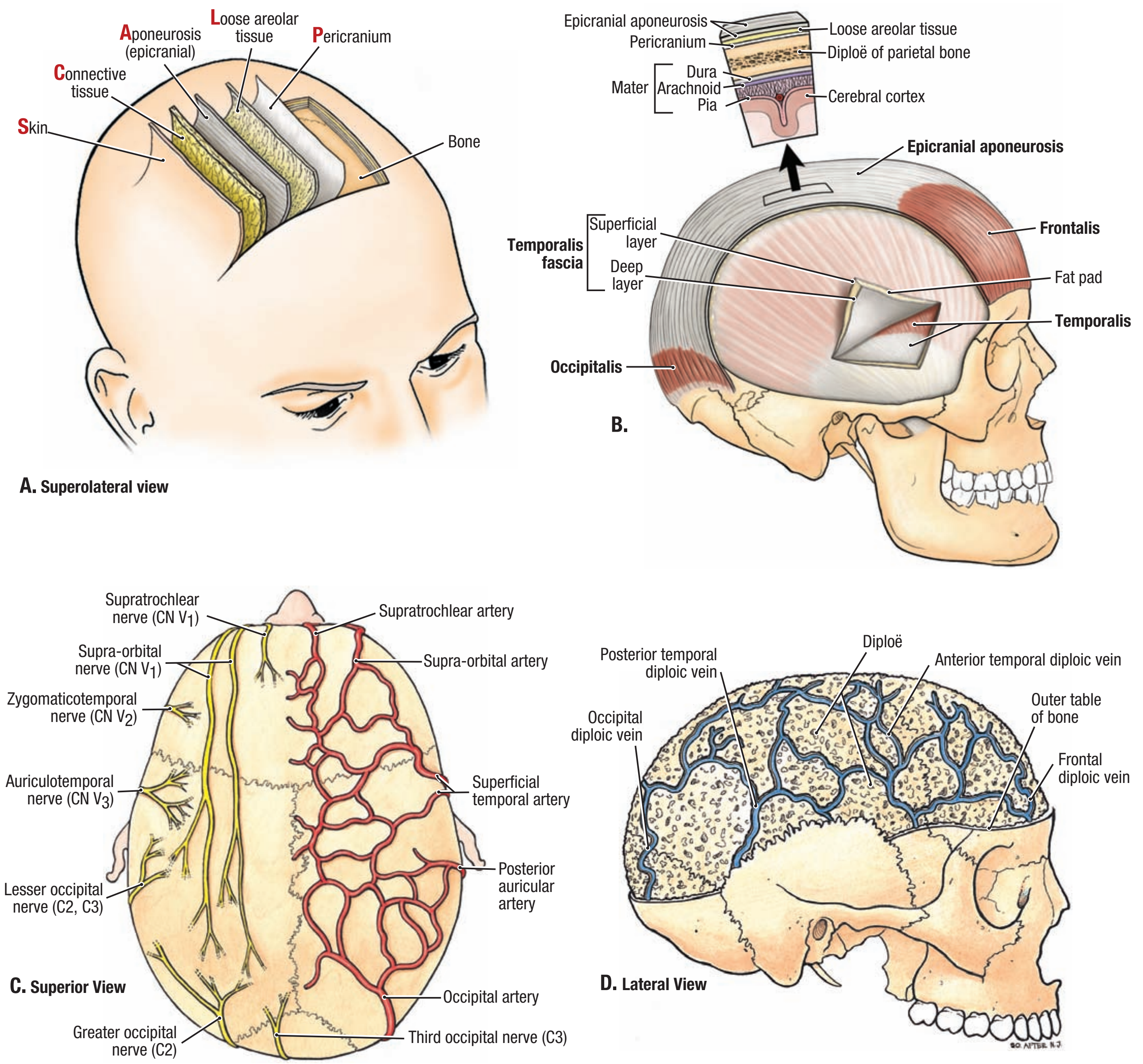
Artery	Origin	Course	Distribution
Facial	External carotid artery	Ascends deep to submandibular gland, winds around inferior border of mandible and enters face	Muscles of facial expression and face
Inferior labial	Facial artery near angle of mouth	Runs medially in lower lip	Lower lip and chin
Superior labial		Runs medially in upper lip	Upper lip and ala (side) and septum of nose
Lateral nasal	Facial artery as it ascends alongside nose	Passes to ala of nose	Skin on ala and dorsum of nose
Angular	Terminal branch of facial artery	Passes to medial angle (canthus) of eye	Superior part of cheek and lower eyelid
Occipital	External carotid artery	Passes medial to posterior belly of digastric and mastoid process; accompanies occipital nerve in occipital region	Scalp of back of head, as far as vertex
Posterior auricular		Passes posteriorly, deep to parotid, along styloid process between mastoid and ear	Scalp posterior to auricle and auricle
Superficial temporal	Smaller terminal branch of external carotid artery	Ascends anterior to ear to temporal region and ends in scalp	Facial muscles and skin of frontal and temporal regions
Transverse facial	Superficial temporal artery within parotid gland	Crosses face superficial to masseter and inferior to zygomatic arch	Parotid gland and duct, muscles and skin of face
Mental	Terminal branch of inferior alveolar artery	Emerges from mental foramen and passes to chin	Facial muscles and skin of chin
***Supra-orbital**	Terminal branch of ophthalmic artery, a branch of internal carotid	Passes superiorly from supra-orbital foramen	Muscles and skin of forehead and scalp
***Supratrochlear**		Passes superiorly from supratrochlear notch	Muscles and skin of scalp



7.19 VEINS OF FACE

TABLE 7.5 VEINS OF FACE

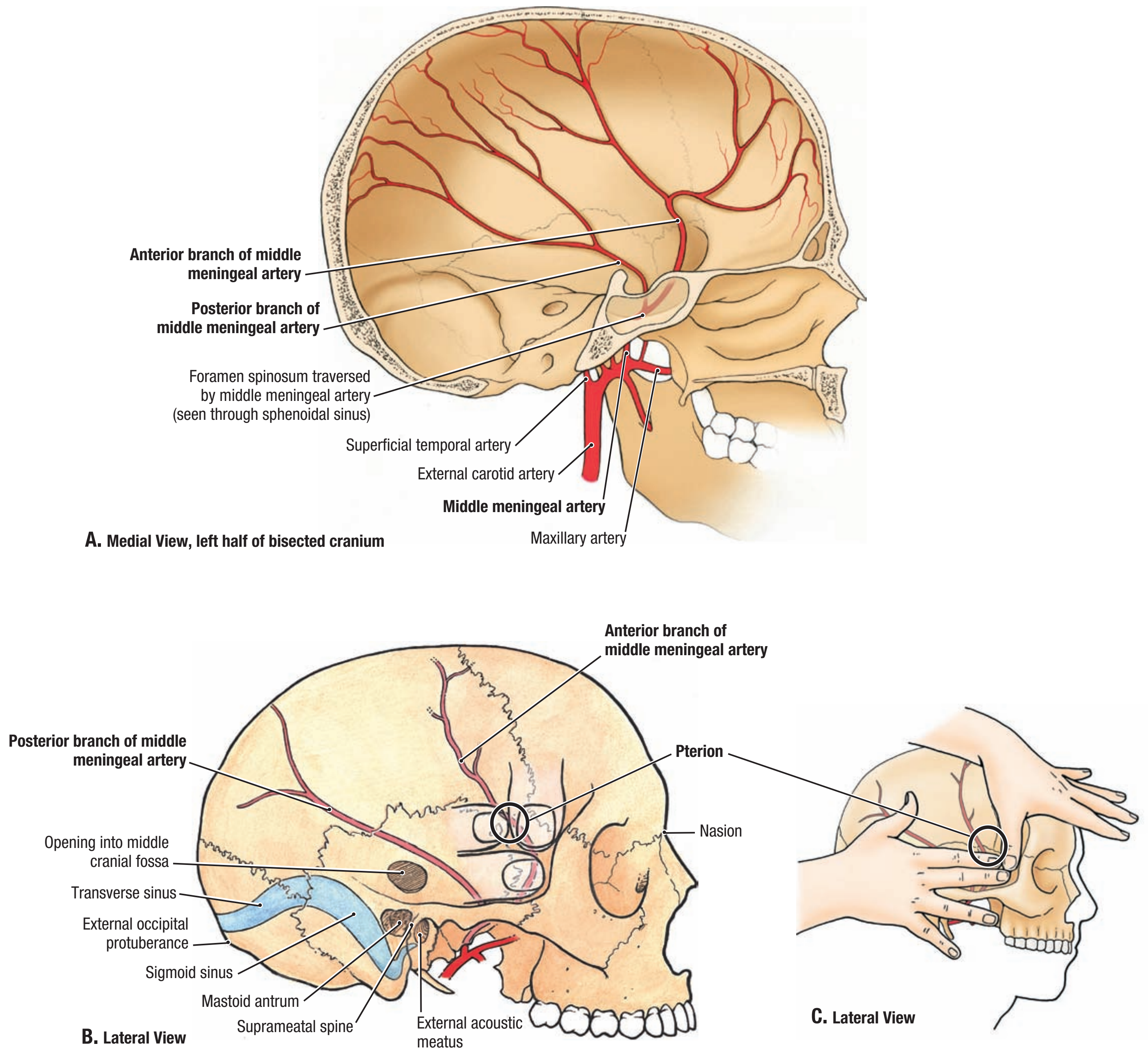
Vein	Origin	Course	Termination	Area Drained
Supratrochlear	Begins from a venous plexus on the forehead and scalp, through which it communicates with the frontal branch of the superficial temporal vein, its contralateral partner, and the supra-orbital vein	Descends near the midline of the forehead to the root of the nose where it joins the supra-orbital vein	Angular vein at the root of the nose	Anterior part of scalp and forehead
Supra-orbital	Begins in the forehead by anastomosing with a frontal tributary of the superficial temporal vein	Passes medially superior to the orbit and joins the supratrochlear vein; a branch passes through the supra-orbital notch and joins with the superior ophthalmic vein		
Angular	Begins at root of nose by union of supratrochlear and supra-orbital veins	Descends obliquely along the root and side of the nose to the inferior margin of the orbit	Becomes the facial vein at the inferior margin of the orbit	In addition to above, drains upper and lower lids and conjunctiva; may receive drainage from cavernous sinus
Facial	Continuation of angular vein past inferior margin of orbit	Descends along lateral border of the nose, receiving external nasal and inferior palpebral veins, then obliquely across face to mandible; receives anterior division of retromandibular vein, after which it is sometimes called the common facial vein	Internal jugular vein at or inferior to the level of the hyoid bone	Anterior scalp and forehead, eyelids, external nose, and anterior cheek, lips, chin, and submandibular gland
Deep facial	Pterygoid venous plexus	Runs anteriorly on maxilla above buccinator and deep to masseter, emerging medial to anterior border of masseter onto face	Enters posterior aspect of facial vein	Infratemporal fossa (most areas supplied by maxillary artery)
Superficial temporal	Begins from a widespread plexus of veins on the side of the scalp and along the zygomatic arch	Its frontal and parietal tributaries unite anterior to the auricle; it crosses the temporal root of the zygomatic arch to pass from the temporal region and enters the substance of the parotid gland	Joins the maxillary vein posterior to the neck of the mandible to form the retromandibular vein	Side of the scalp, superficial aspect of the temporal muscle, and external ear
Retromandibular	Formed anterior to the ear by the union of the superficial temporal and maxillary veins	Runs posterior and deep to the ramus of the mandible through the substance of the parotid gland; communicates at its inferior end with the facial vein	*Anterior branch* unites with facial vein to form common facial vein; *posterior branch* unites with the posterior auricular vein to form the external jugular vein	Parotid gland and masseter muscle



7.20 BRANCHES OF FACIAL NERVE, MUSCLES OF FACIAL EXPRESSION, AND SCALP

A. Layers of scalp. **B.** Occipitofrontalis and temporal muscles and fascia. **C.** Sensory nerves and arteries of the scalp. **D.** Diploic veins. The outer layer of the compact bone of the cranium has been filed away, exposing the channels for the diploic veins in the cancellous bone that composes the diploë (see Fig. 7.7).

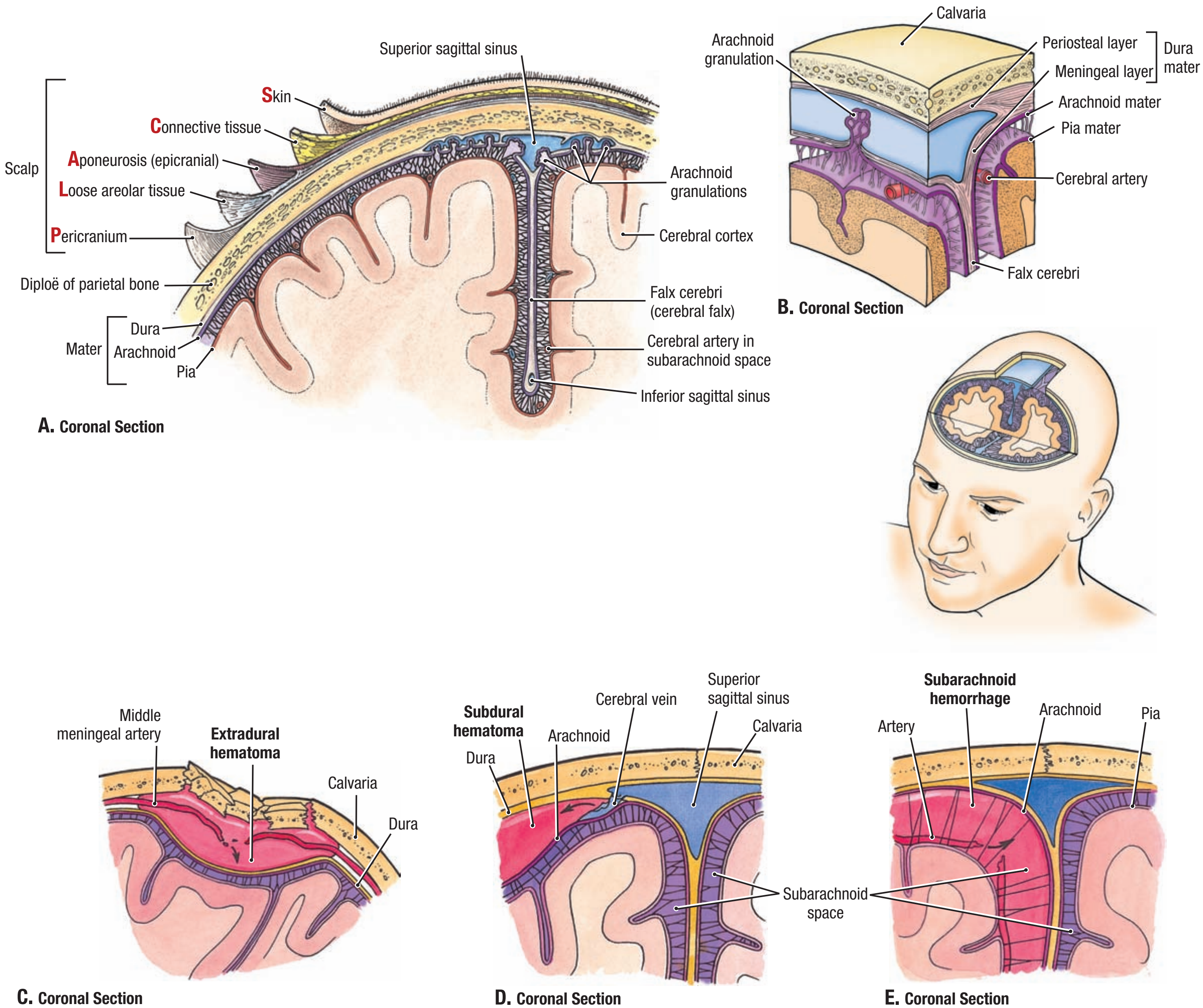
Scalp injuries and infections. The loose areolar tissue layer is the danger area of the scalp because pus or blood spreads easily in it. Infection in this layer can pass into the cranial cavity through emissary veins, which pass through parietal foramina in the calvaria and reach intracranial structures such as the meninges. An infection cannot pass into the neck because the occipital belly of the occipitofrontalis attaches to the occipital bone and mastoid parts of the temporal bones. Neither can a scalp infection spread laterally beyond the zygomatic arches because the epicranial aponeurosis is continuous with the temporalis fascia that attaches to these arches. An infection or fluid (e.g., pus or blood) can enter the eyelids and the root of the nose because the frontal belly of the occipitofrontalis inserts into the skin and dense subcutaneous tissue and does not attach to the bone. **Ecchymoses**, or purple patches, develop as a result of extravasation of blood into the subcutaneous tissue and skin of the eyelids and surrounding regions.



7.21 MIDDLE MENINGEAL ARTERY AND PTERION

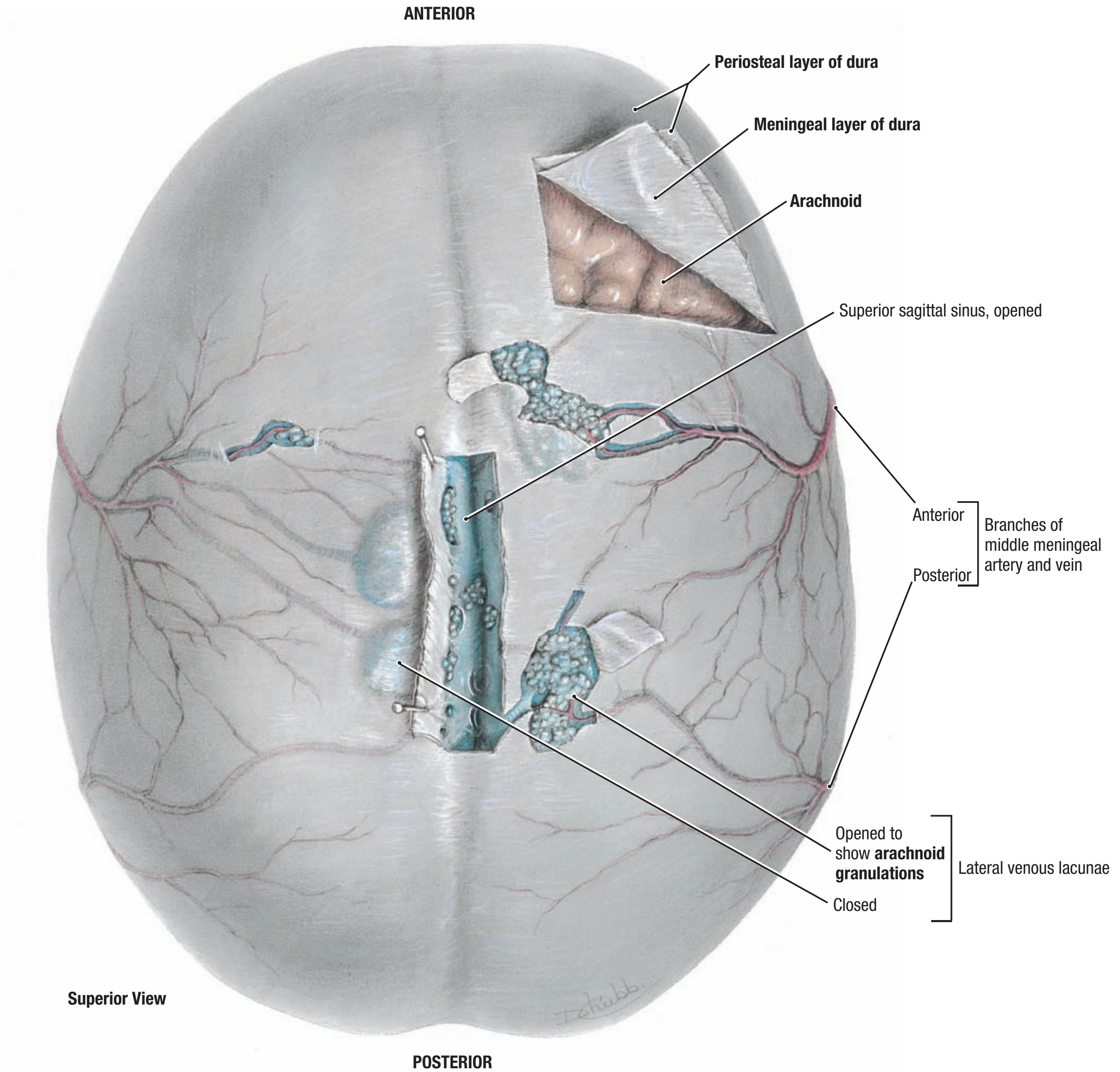
A. Course of the middle meningeal artery in the cranium. **B.** Surface projections of internal features of the neurocranium. **C.** Locating the pterion. The pterion is located two fingers breadth superior to the zygomatic arch and one thumb breadth posterior to the frontal process of the zygomatic bone (approximately 4 cm superior to the midpoint of the zygomatic arch); the anterior branch of the middle meningeal artery crosses the pterion.

A hard blow to the side of the head may fracture the thin bones forming the pterion, rupturing the anterior branch of the middle meningeal artery crossing the pterion. The resulting **extradural (epidural) hematoma** exerts pressure on the underlying cerebral cortex. Untreated middle meningeal artery hemorrhage may cause death in a few hours.



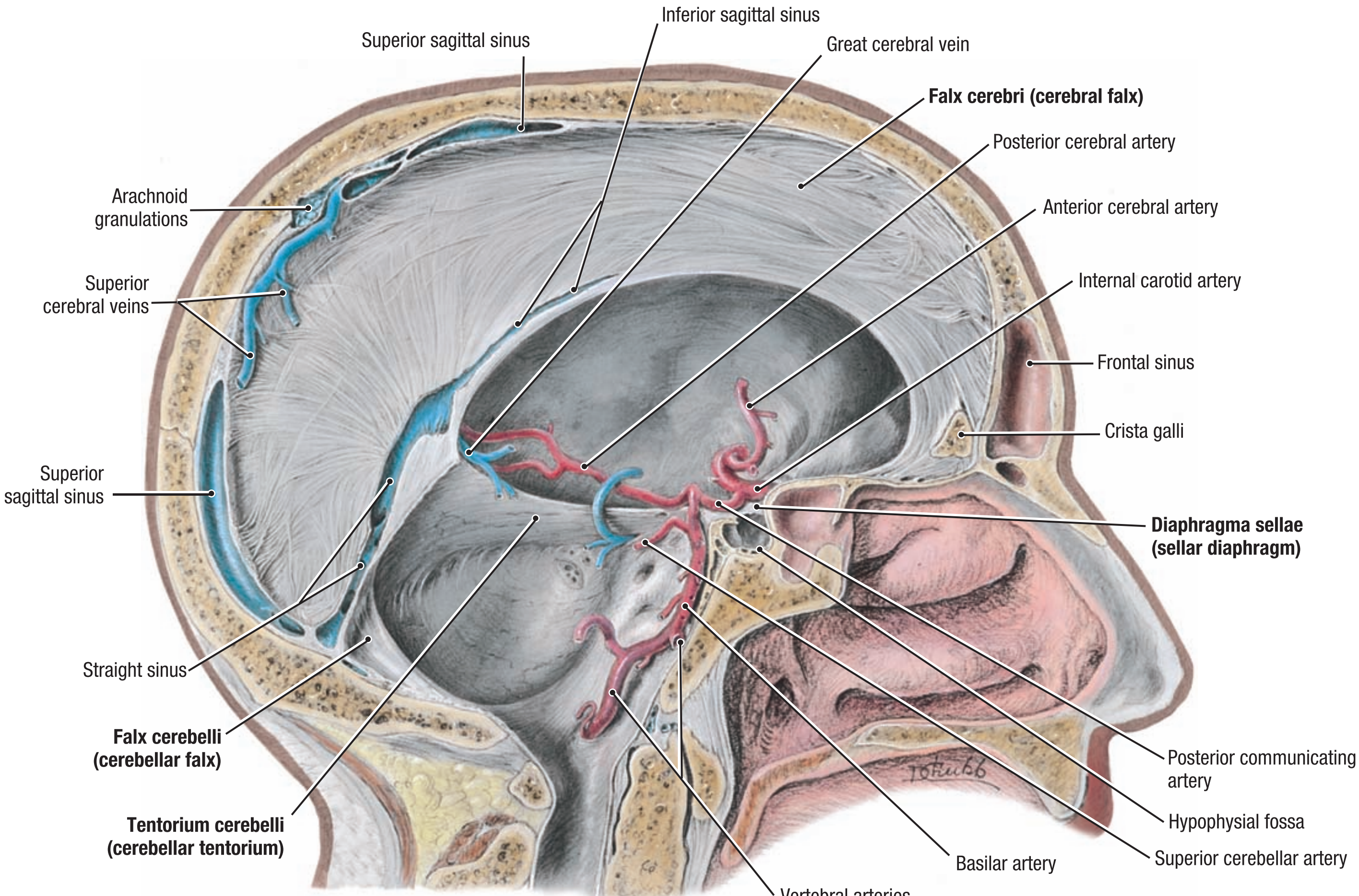
7.22 LAYERS OF THE SCALP AND MENINGES

A. Scalp, cranium, and meninges. **B.** Meninges and their relationship to the calvaria. The three meningeal spaces include the extradural (epidural) space between the cranial bones and dura, which is a potential space normally (it becomes a real space pathologically if blood accumulates in it); the similarly potential subdural space between the dura and arachnoid; and the subarachnoid space, the normal realized space between the arachnoid and pia, which contains cerebrospinal fluid (CSF). **C. Extradural (epidural) hematomas** result from bleeding from a torn middle meningeal artery. **D. Subdural hematomas** commonly result from tearing of a cerebral vein as it enters the superior sagittal sinus. **E. Subarachnoid hemorrhage** results from bleeding within the subarachnoid space, e.g., from rupture of an aneurysm.

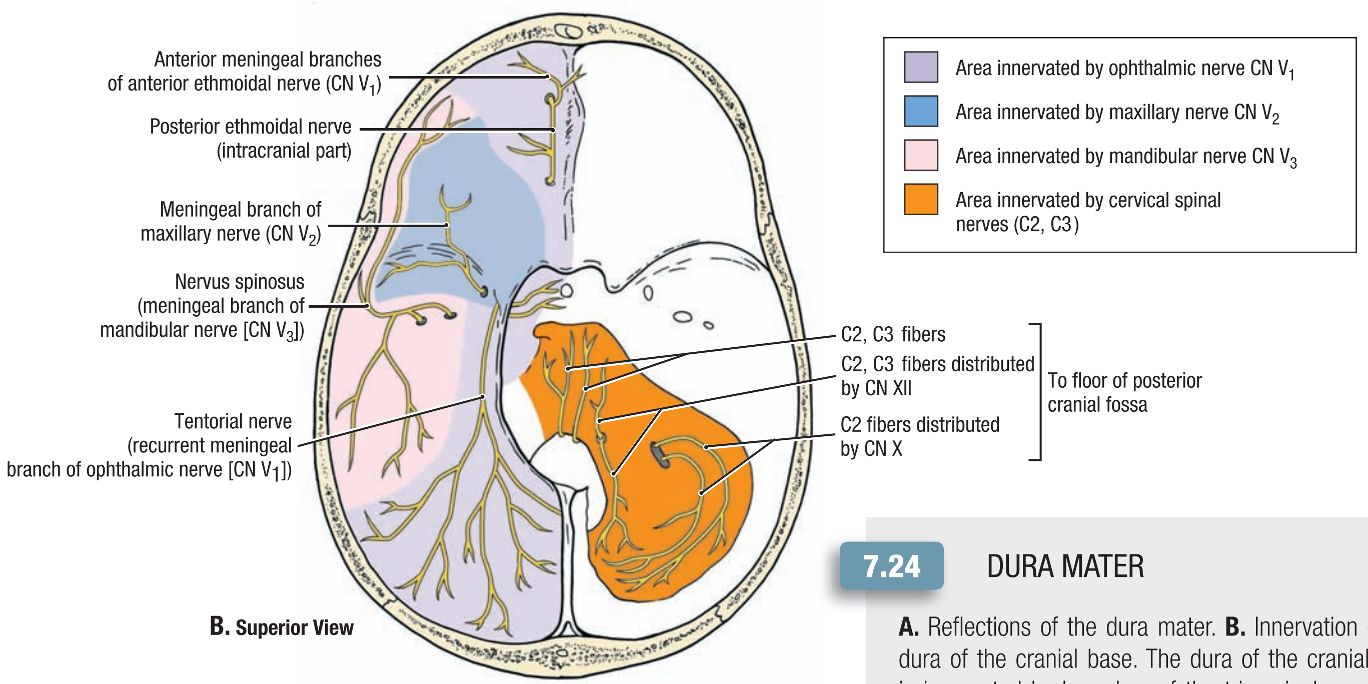


7.23 DURA MATER AND ARACHNOID GRANULATIONS

- The calvaria is removed. In the median plane, the thick roof of the superior sagittal sinus is partly pinned aside, and laterally, the thin roofs of two lateral lacunae are reflected.
- The middle meningeal artery lies in a venous channel (middle meningeal vein), which enlarges superiorly into a lateral lacunae. Other channels drain the lateral lacunae into the superior sagittal sinus.
- Arachnoid granulations in the lacunae are responsible for absorption of CSF from the subarachnoid space into the venous system.
- The dura is sensitive to pain, especially where it is related to the dural venous sinuses and meningeal arteries. Although the causes of **headache** are numerous, distention of the scalp or meningeal vessels (or both) is believed to be one cause of headache. Many headaches appear to be dural in origin, such as the headache occurring after a lumbar spinal puncture for removal of CSF. These headaches are thought to result from stimulation of sensory nerve endings in the dura.



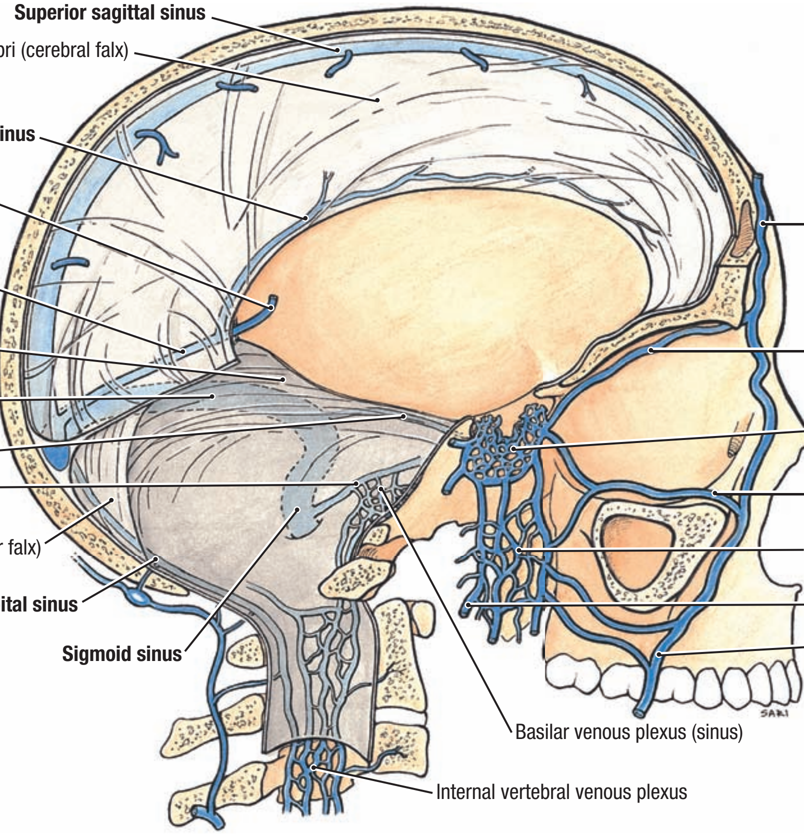
A. Sagittal Section



B. Superior View

7.24 DURA MATER

A. Reflections of the dura mater. **B.** Innervation of the dura of the cranial base. The dura of the cranial base is innervated by branches of the trigeminal nerve and sensory fibers of cervical spinal nerves (C2, C3) passing directly from those nerves or via meningeal branches of the vagus (CN X) and hypoglossal (CN XII) nerves.

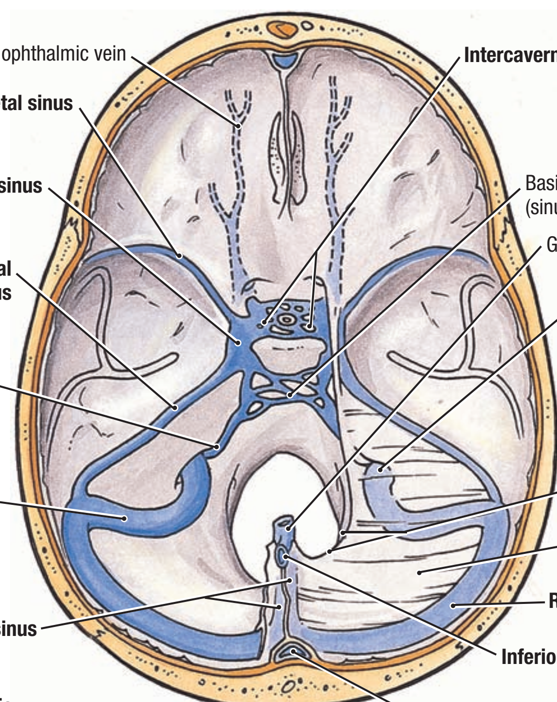


A. Medial View

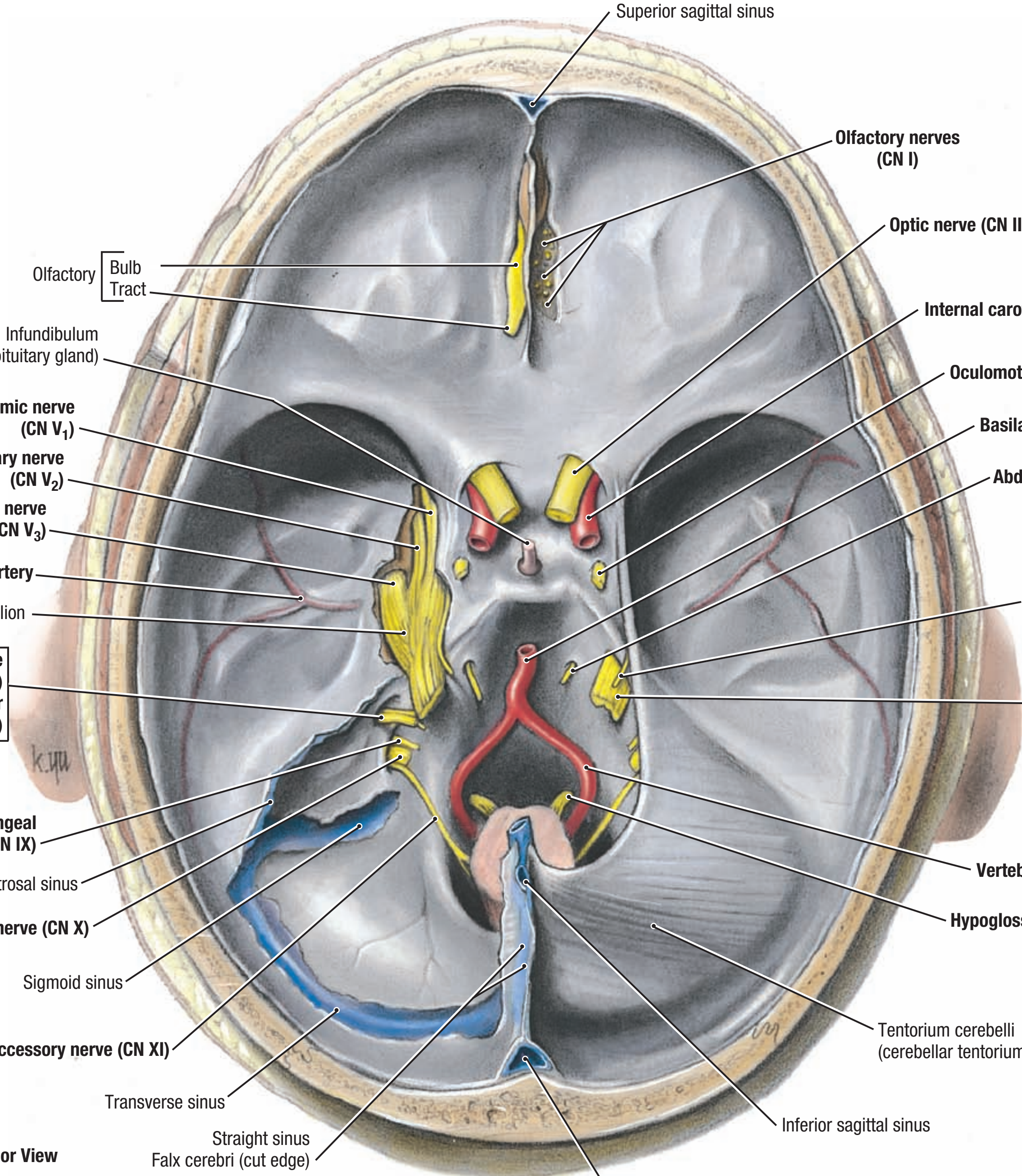
7.25 VENOUS SINUSES OF DURA MATER

A. Schematic of left half of cranial cavity and right facial skeleton. **B.** Venous sinuses of the cranial base.

- The superior sagittal sinus is at the superior border of the falx cerebri, and the inferior sagittal sinus is in its free border. The great cerebral vein joins the inferior sagittal sinus to form the straight sinus.
- The superior sagittal sinus usually becomes the right transverse sinus, which drains into the right sigmoid sinus, and next into the right internal jugular vein; the straight sinus similarly drains through the left transverse sinus, left sigmoid sinus, and left internal jugular vein.
- The cavernous sinus communicates with the veins of the face through the ophthalmic veins and pterygoid plexus of veins and with the sigmoid sinus through the superior and inferior petrosal sinuses.
- **Metastasis of tumor cells to dural sinuses.** The basilar and occipital sinuses communicate through the foramen magnum with the internal vertebral venous plexuses. Because these venous channels are valveless, increased intra-abdominopelvic or intrathoracic pressure, as occurs during heavy coughing and straining, may force venous blood from these regions into the internal vertebral venous system and from it into the dural venous sinuses. As a result, pus in abscesses and tumor cells in these regions may spread to the vertebrae and brain.

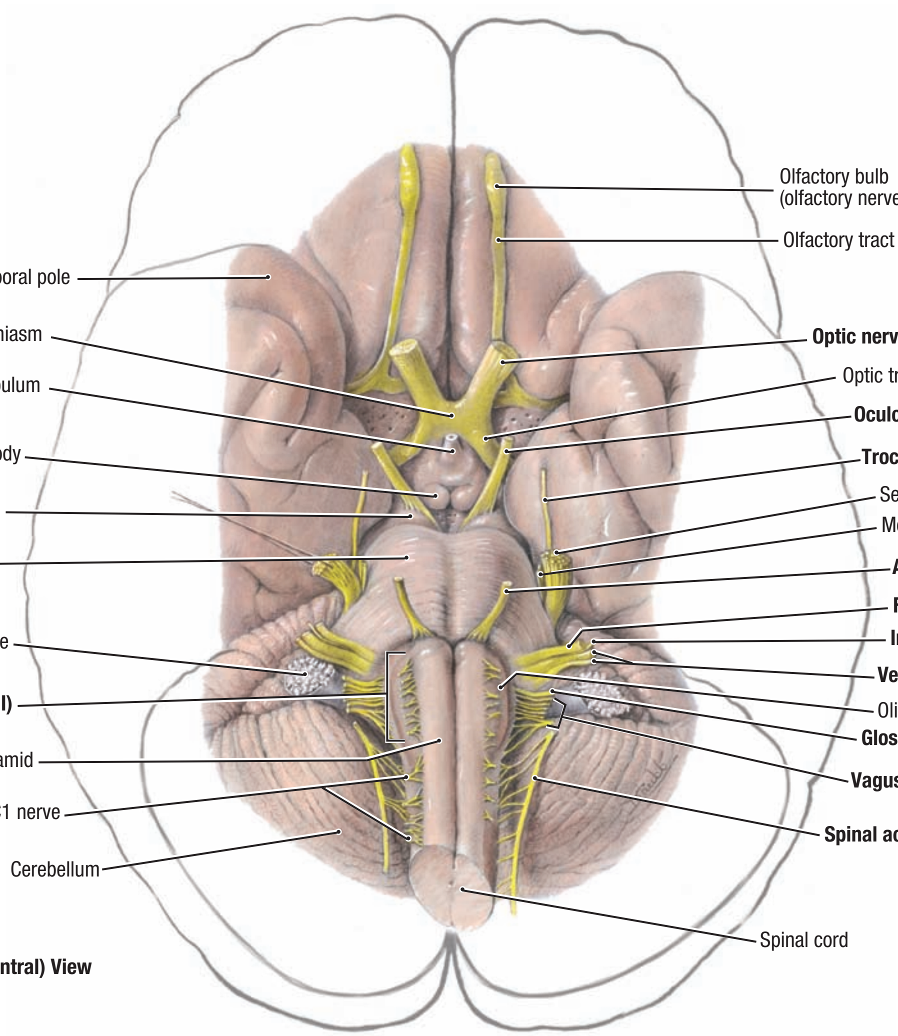


B. Superior View



7.26 NERVES AND VESSELS OF THE INTERIOR OF THE BASE OF CRANIUM

- On the left of the specimen, the dura mater forming the roof of the trigeminal cave is cut away to expose the trigeminal ganglion and its three branches. The tentorium cerebelli is removed to reveal the transverse and superior petrosal sinuses.
- The frontal lobes of the cerebrum are located in the anterior cranial fossa, the temporal lobes in the middle cranial fossa, and the brainstem and cerebellum in the posterior cranial fossa; the occipital lobes rest on the tentorium cerebelli.
- The sites where the 12 cranial nerves and the internal carotid, vertebral, basilar, and middle meningeal arteries penetrate the dura mater are shown.

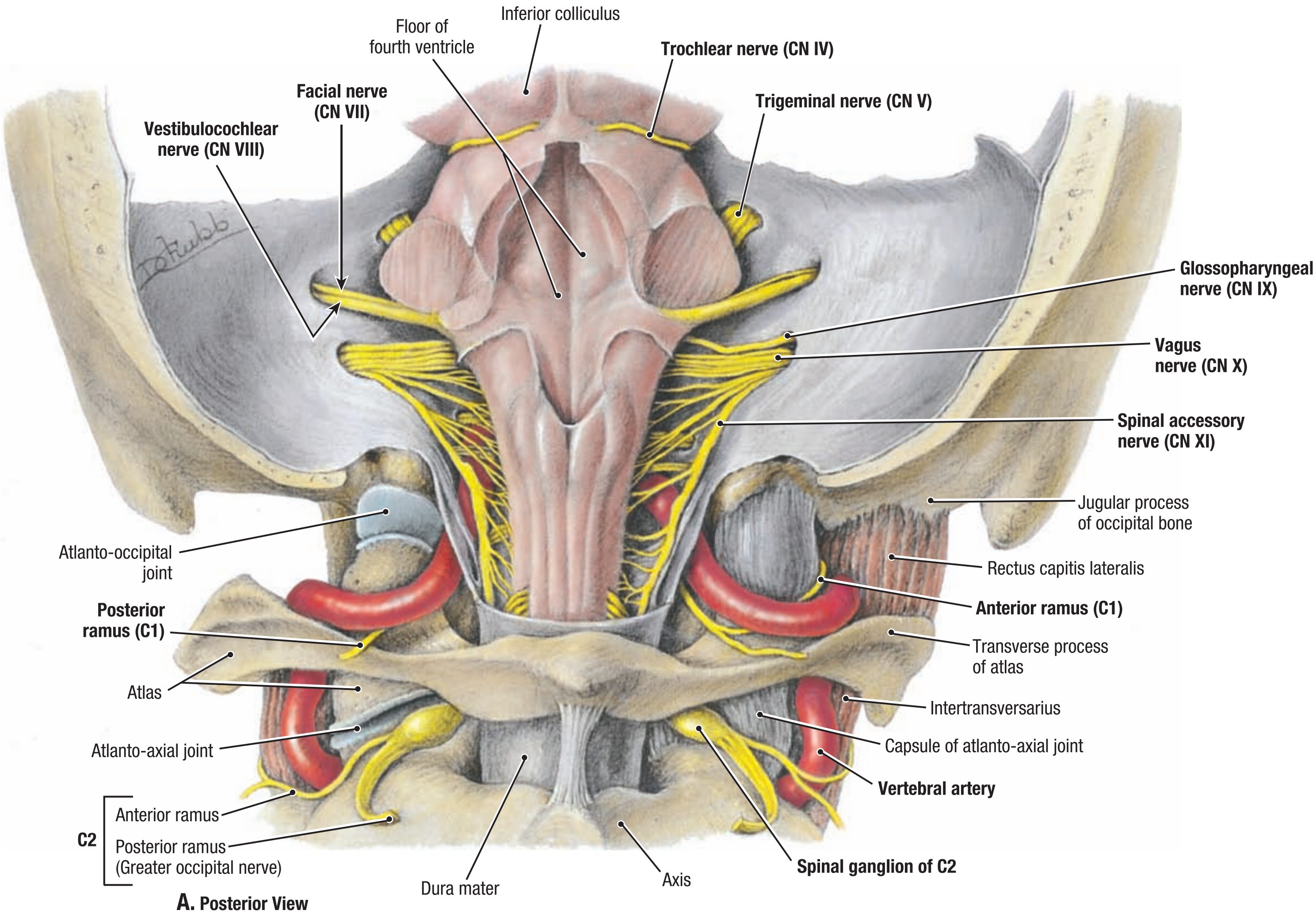


7.27 BASE OF BRAIN AND SUPERFICIAL ORIGINS OF CRANIAL NERVES

Foramina of skull and their associated cranial nerve(s) are listed below.

TABLE 7.6 OPENINGS BY WHICH CRANIAL NERVES EXIT CRANIAL CAVITY

Foramina/Apertures	Cranial nerve
Anterior cranial fossa	
Cribriform foramina in cribriform plate	Axons of olfactory cells in olfactory epithelium form olfactory nerves (CN I)
Middle cranial fossa	
Optic canal	Optic nerve (CN II)
Superior orbital fissure	Ophthalmic nerve (CN V_1), oculomotor nerve (CN III), trochlear nerve (CN IV), abducent nerve (CN VI) and branches of ophthalmic nerve (CN V_1)
Foramen rotundum	Maxillary nerve (CN V_2)
Foramen ovale	Mandibular nerve (CN V_3)
Posterior cranial fossa	
Foramen magnum	Spinal accessory nerve (CN XI)
Jugular foramen	Glossopharyngeal nerve (CN IX), vagus nerve (CN X), and spinal accessory nerve (CN XI)
Hypoglossal canal	Hypoglossal nerve (CN XII)

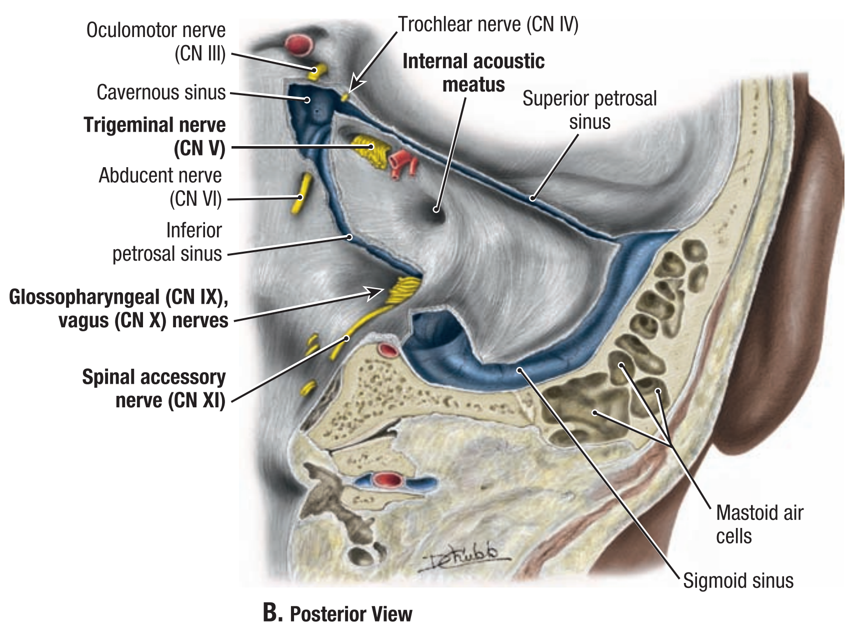


A. Posterior View

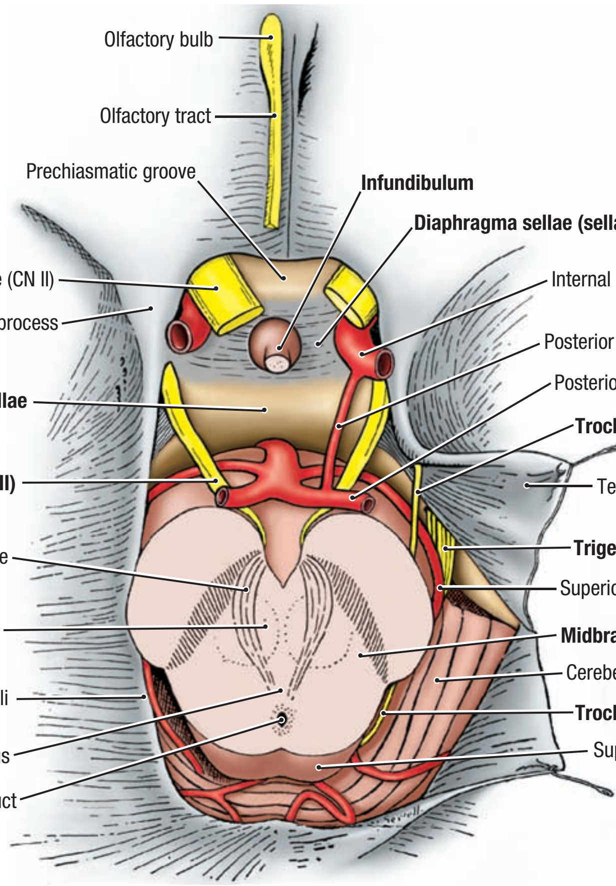
7.28 POSTERIOR EXPOSURES OF CRANIAL NERVES

A. and B. Squamous part of occipital bone has been removed posterior to foramen magnum to reveal posterior cranial fossa. **A.** Brainstem in situ. **B.** Right side, with brainstem removed. The trochlear nerves (CN IV) arise from the dorsal aspect of the midbrain, just inferior to the inferior colliculi.

- The sensory and motor roots of the trigeminal nerves (CN V) pass anterolaterally to enter the mouth of the trigeminal cave.
- The facial (CN VII) and vestibulocochlear (CN VIII) nerves course laterally to enter the internal acoustic meatus.
- The glossopharyngeal nerve (CN IX) pierces the dura mater separately but passes with the vagus (CN X) and spinal accessory (CN XI) nerves through the jugular foramen.
- An **acoustic neuroma** (neurofibroma) is a slow-growing benign tumor of the neurolemma (Schwann) cells. The tumor begins in the vestibulocochlear nerve (CN VIII) while it is in the internal acoustic meatus. The early symptom of an acoustic neuroma is usually loss of hearing. Dysequilibrium and tinnitus also may occur.



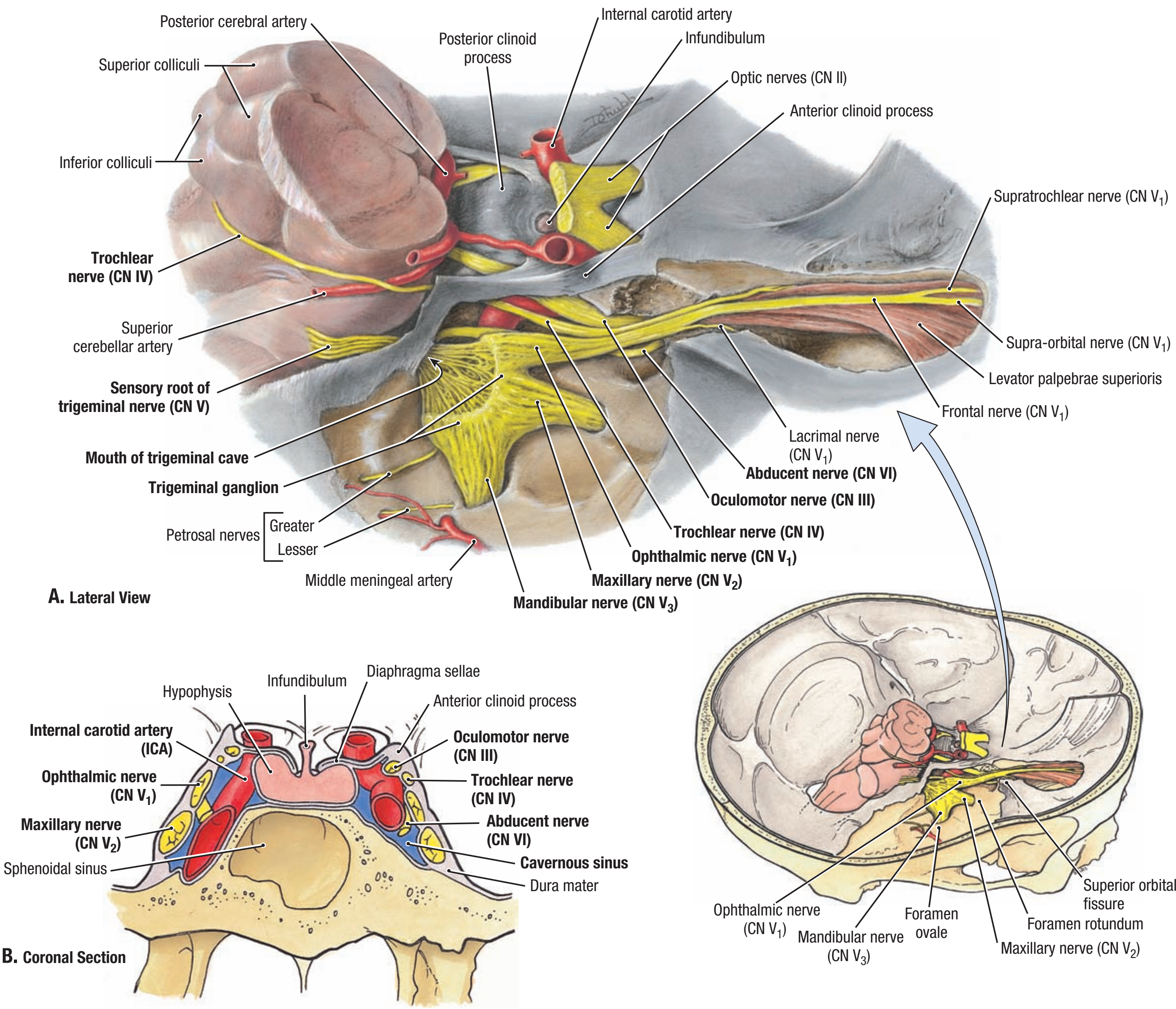
B. Posterior View



Superior View

7.29 TENTORIAL NOTCH

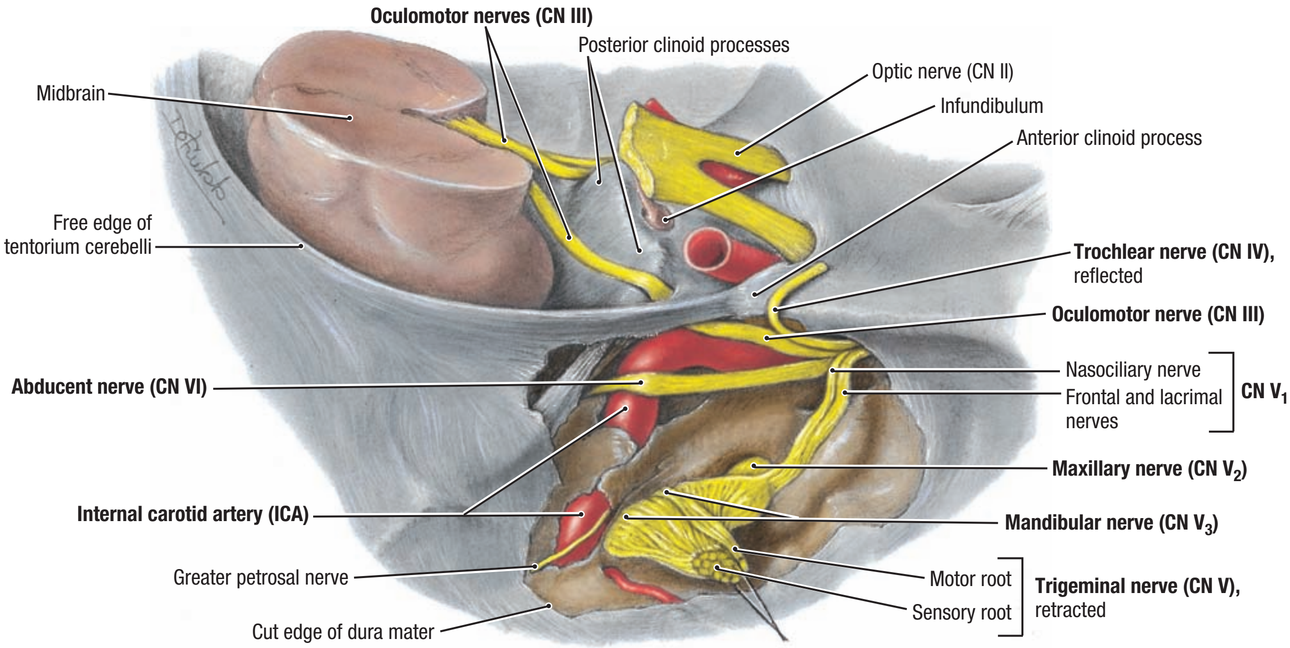
- The brain has been removed by cutting through the midbrain, revealing the tentorial notch through which the brainstem extends from the posterior into the middle cranial fossa.
- On the right side of the specimen, the tentorium cerebelli is divided and reflected. The trochlear nerve (CN IV) passes around the midbrain under the free edge of the tentorium cerebelli; the roots of the trigeminal nerve (CN V) enter the mouth of the trigeminal cave.
- There is a circular opening in the diaphragma sellae for the infundibulum, the stalk of the pituitary gland.
- The oculomotor nerve (CN III) passes between the posterior cerebral and superior cerebellar arteries and then laterally around the posterior clinoid process.
- The tentorial notch is the opening in the tentorium cerebelli for the brainstem, which is slightly larger than is necessary to accommodate the midbrain. Hence, space-occupying lesions, such as tumors in the supratentorial compartment, produce increased intracranial pressure that may cause part of the adjacent temporal lobe of the brain to herniate through the tentorial notch. During **tentorial herniation**, the temporal lobe may be lacerated by the tough tentorium cerebelli, and the oculomotor nerve (CN III) may be stretched, compressed, or both. Oculomotor lesions may produce paralysis of the extrinsic eye muscles supplied by CN III.



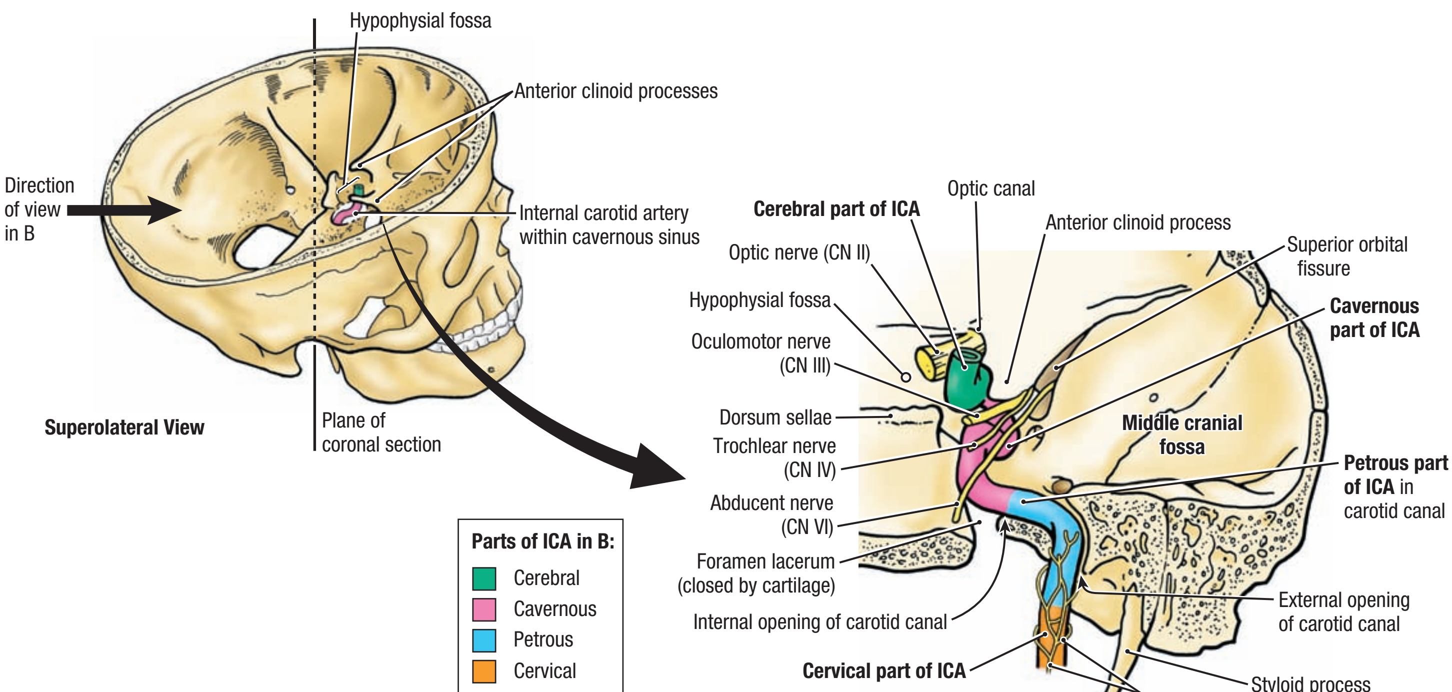
7.30 NERVES AND VESSELS OF MIDDLE CRANIAL FOSSA I

A. Superficial dissection. The tentorium cerebelli is cut away. The dura mater is largely removed from the middle cranial fossa. The roof of the orbit is partly removed. **B.** Coronal section through the cavernous sinus.

In **fractures of the cranial base**, the internal carotid artery may be torn, producing an arteriovenous fistula within the cavernous sinus. Arterial blood rushes into the sinus, enlarging it and forcing retrograde blood flow into its venous tributaries, especially the ophthalmic veins. As a result, the eyeball protrudes (**exophthalmos**) and the conjunctiva becomes engorged (**chemosis**). Because CN III, CN IV, CN VI, CN V_1, and CN V_2 lie in or close to the lateral wall of the cavernous sinus, these nerves may also be affected.



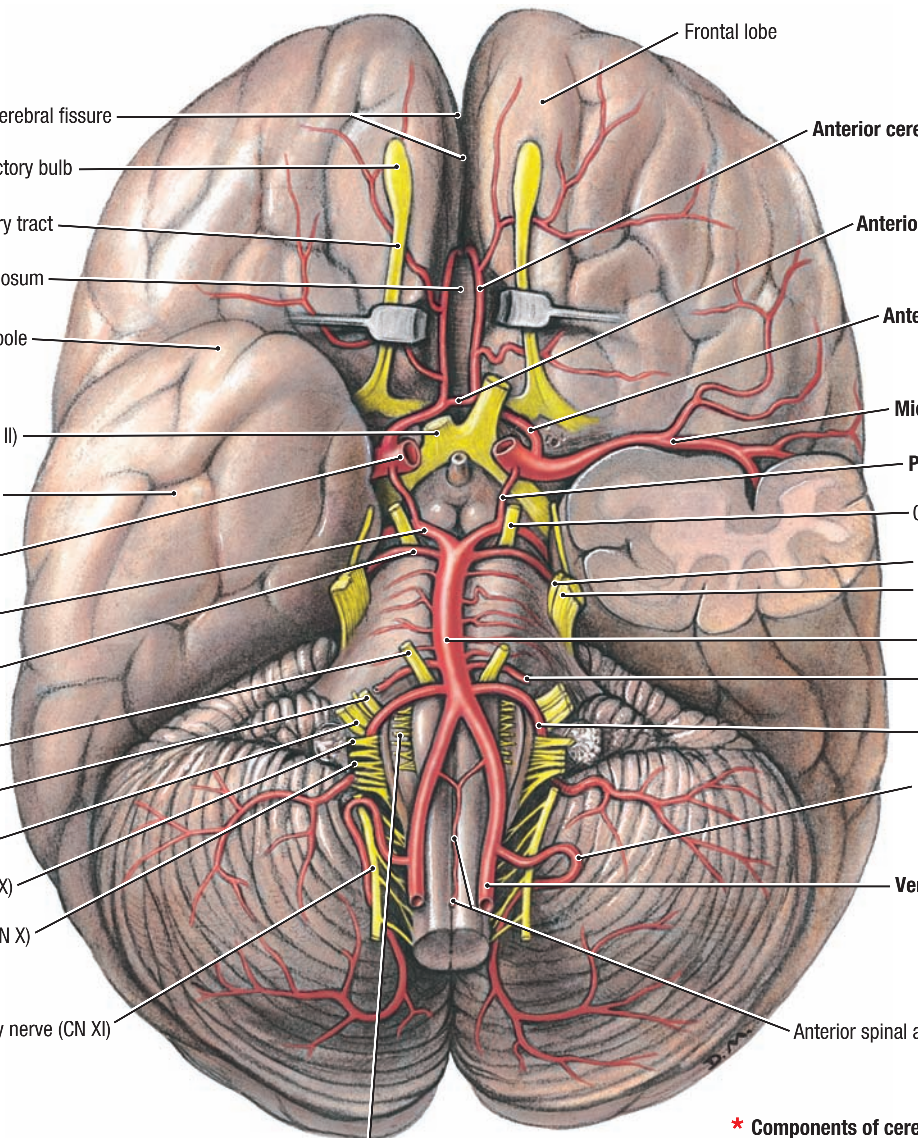
A. **Lateral View**



B. **Posterior View (of anterior part following bisection in coronal plane)**

7.31 NERVES AND VESSELS OF MIDDLE CRANIAL FOSSA II

A. Deep dissection. The roots of the trigeminal nerve are divided, withdrawn from the mouth of the trigeminal cave, and turned anteriorly. The trochlear nerve is reflected anteriorly. **B.** Course of the internal carotid artery.

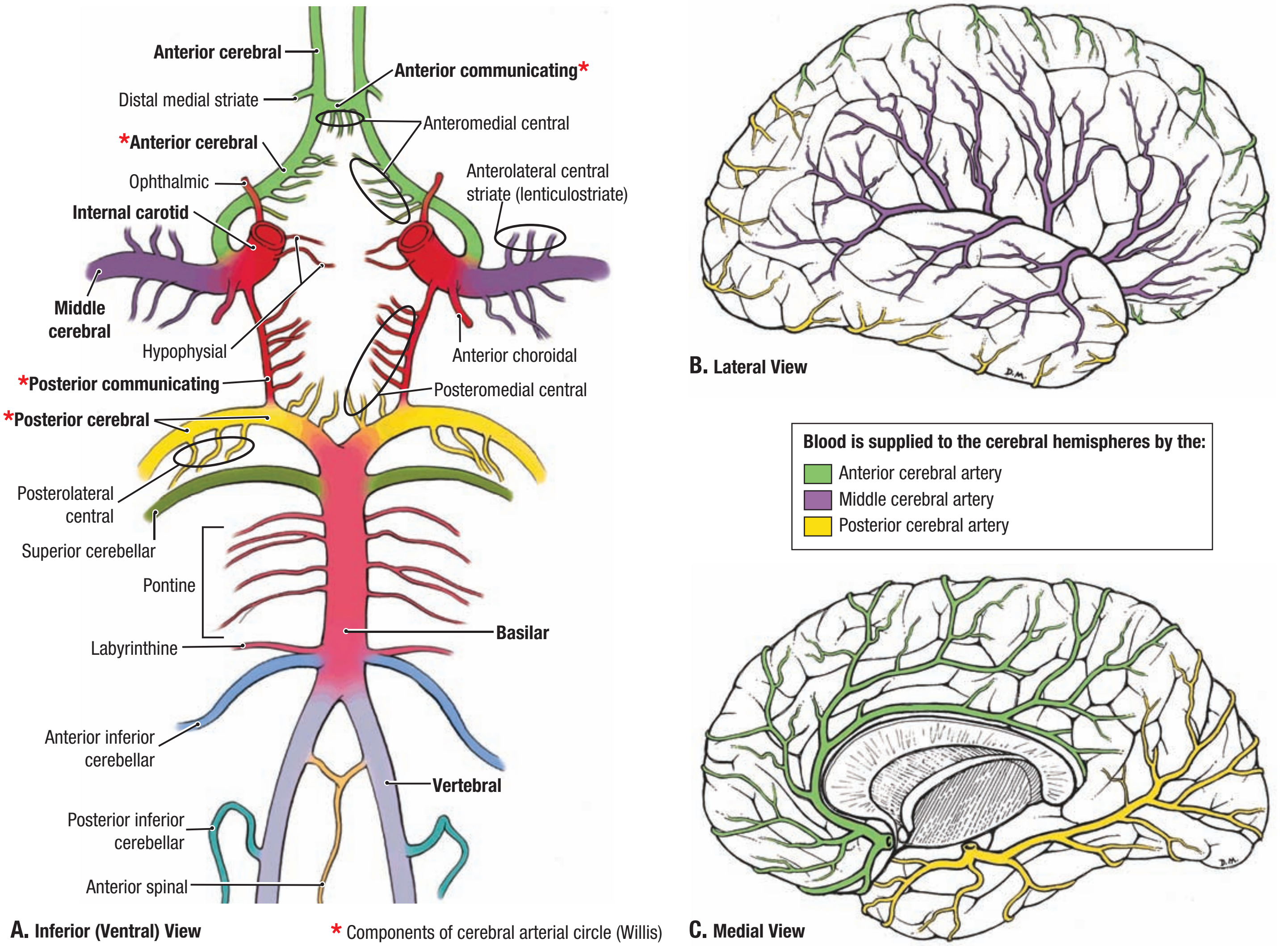


7.32 BASE OF BRAIN AND CEREBRAL ARTERIAL CIRCLE

The anterior part of the left temporal lobe is removed to enable visualization of the middle cerebral artery in the lateral fissure. The frontal lobes are separated to expose the anterior cerebral arteries and corpus callosum.

An **ischemic stroke** denotes the sudden development of neurological deficits that are consequences of impaired cerebral blood flow. The most common causes of strokes are spontaneous cerebrovascular accidents such as cerebral embolism, cerebral thrombosis, cerebral hemorrhage, and subarachnoid hemorrhage (Rowland, 2000). The cerebral arterial circle is an important means of collateral circulation in the event of gradual obstruction of one of the major arteries forming the circle. Sudden occlusion, even if only partial, results in neurological deficits. In elderly persons, the anastomoses are often inadequate when a large artery (e.g., internal carotid) is occluded, even if the occlusion is gradual. In such cases function is impaired at least to some degree.

Hemorrhagic stroke follows the rupture of an artery or a saccular aneurysm, a saclike dilation on a weak part of the arterial wall. The most common type of saccular aneurysm is a berry aneurysm, occurring in the vessels of or near the cerebral arterial circle. In time, especially in people with hypertension (high blood pressure), the weak part of the arterial wall expands and may rupture, allowing blood to enter the subarachnoid space.

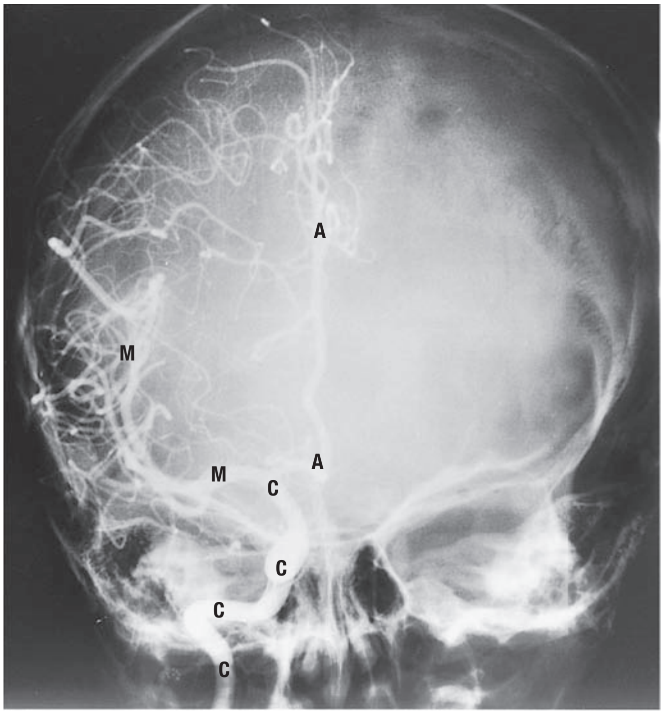


7.33 ARTERIES OF BRAIN

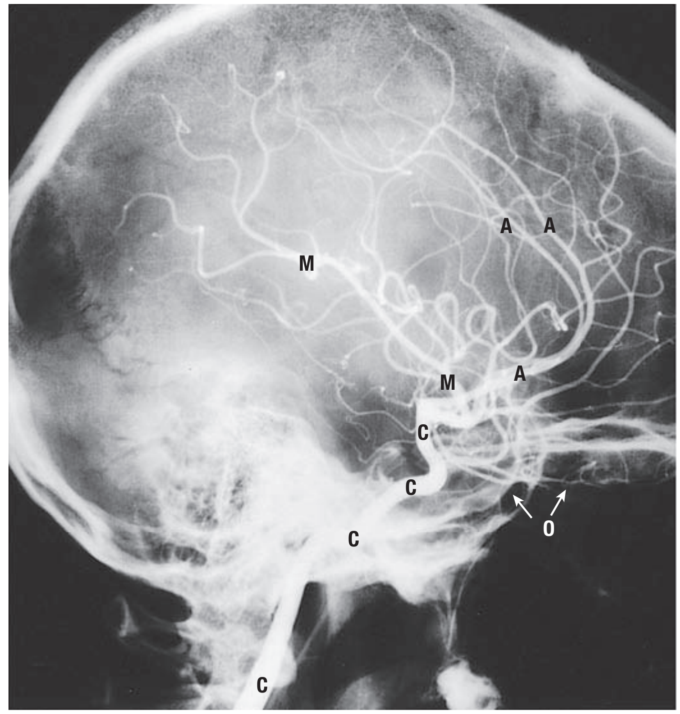
A. Schematic overview. **B and C.** Distribution of cerebral arteries.

TABLE 7.7 ARTERIAL SUPPLY TO BRAIN

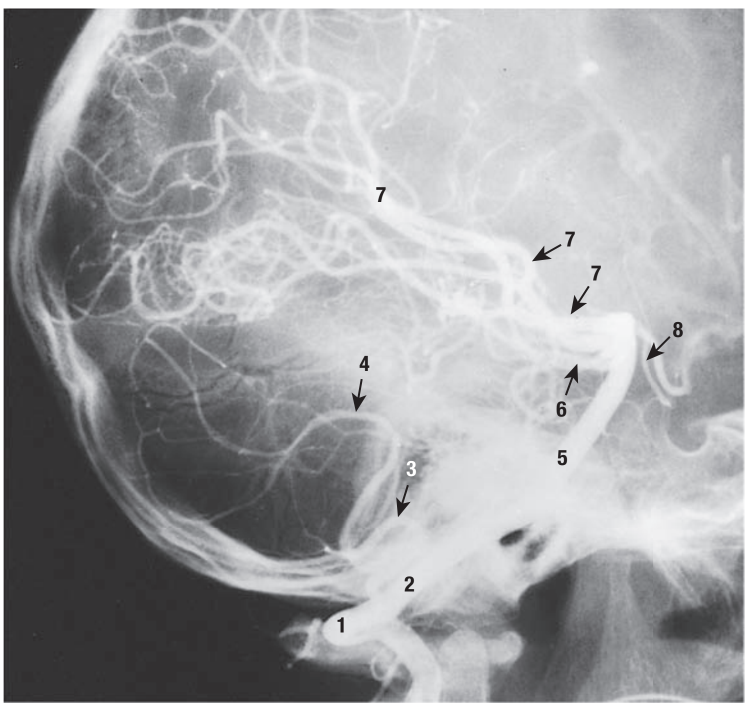
Artery	Origin	Distribution
Vertebral	Subclavian artery	Cranial meninges and cerebellum
Posterior inferior cerebellar	Vertebral artery	Postero-inferior aspect of cerebellum
Basilar	Formed by junction of vertebral arteries	Brainstem, cerebellum, and cerebrum
Pontine		Numerous branches to brainstem
Anterior inferior cerebellar	Basilar artery	Inferior aspect of cerebellum
Superior cerebellar		Superior aspect of cerebellum
Internal carotid	Common carotid artery at superior border of thyroid cartilage	Gives branches in cavernous sinus and provides supply to brain
Anterior cerebral	Internal carotid artery	Cerebral hemispheres, except for occipital lobes
Middle cerebral	Continuation of the internal carotid artery distal to anterior cerebral artery	Most of lateral surface of cerebral hemispheres
Posterior cerebral	Terminal branch of basilar artery	Inferior aspect of cerebral hemisphere and occipital lobe
Anterior communicating	Anterior cerebral artery	Cerebral arterial circle
Posterior communicating	Internal carotid artery	



A. **Postero-anterior View**



B. **Lateral View**



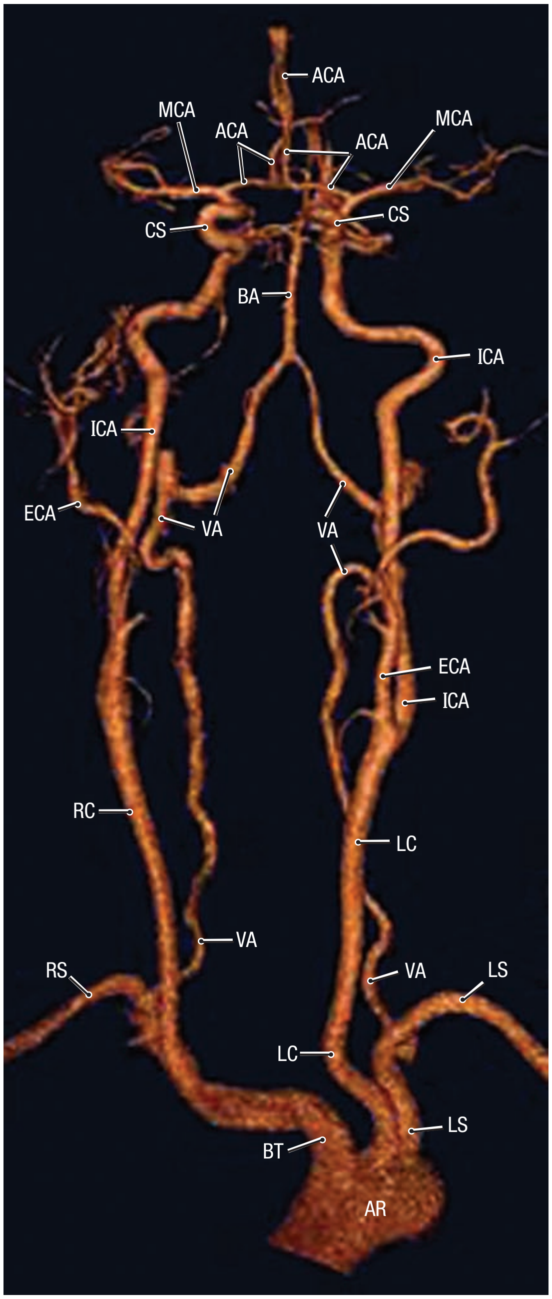
C. **Lateral View**

Key for A, B and C:

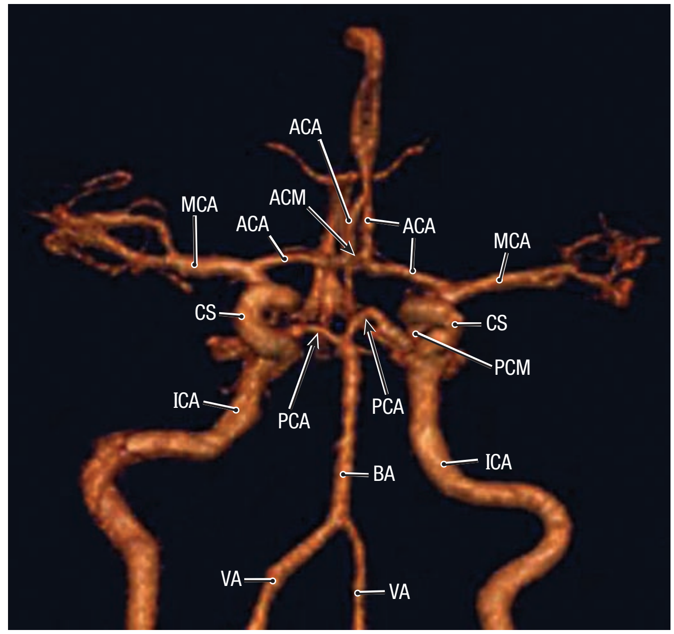
A	Anterior cerebral artery
M	Middle cerebral artery
C	Internal carotid artery
O	Ophthalmic artery
1	Vertebral artery on posterior arch of atlas
2	Vertebral artery entering skull through foramen magnum
3	Posterior inferior cerebellar artery
4	Anterior inferior cerebellar artery
5	Basilar artery
6	Superior cerebellar artery
7	Posterior cerebellar artery
8	Posterior communicating artery

7.34 ARTERIOGRAMS

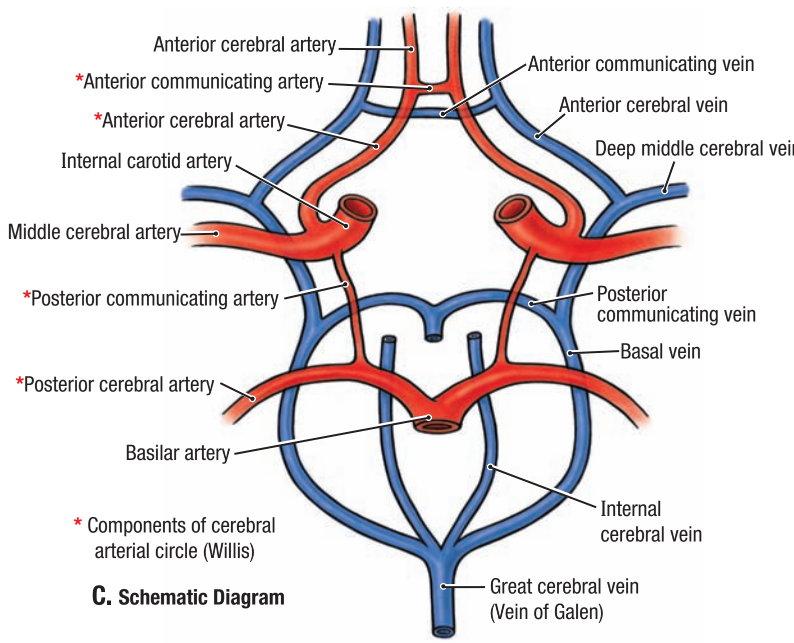
A. and B. Carotid arteriogram. The four *C*s indicate the parts of the internal carotid artery: cervical, before entering the cranium; petrous, within the temporal bone; cavernous, within the sinus; and cerebral, within the cranial subarachnoid space. **C.** Vertebral arteriogram. **Transient ischemic attacks (TIAs)** refer to neurological symptoms resulting from ischemia (deficient blood supply) of the brain. The symptoms of a TIA may be ambiguous: staggering, dizziness, light-headedness, fainting, and paresthesias (e.g., tingling in a limb). Most TIAs last a few minutes, but some persist longer. Individuals with TIAs are at increased risk for myocardial infarction and *ischemic stroke* (Brust, 2000).



A. **Anterior View**



B. **Anterior View**



* Components of cerebral arterial circle (Willis)

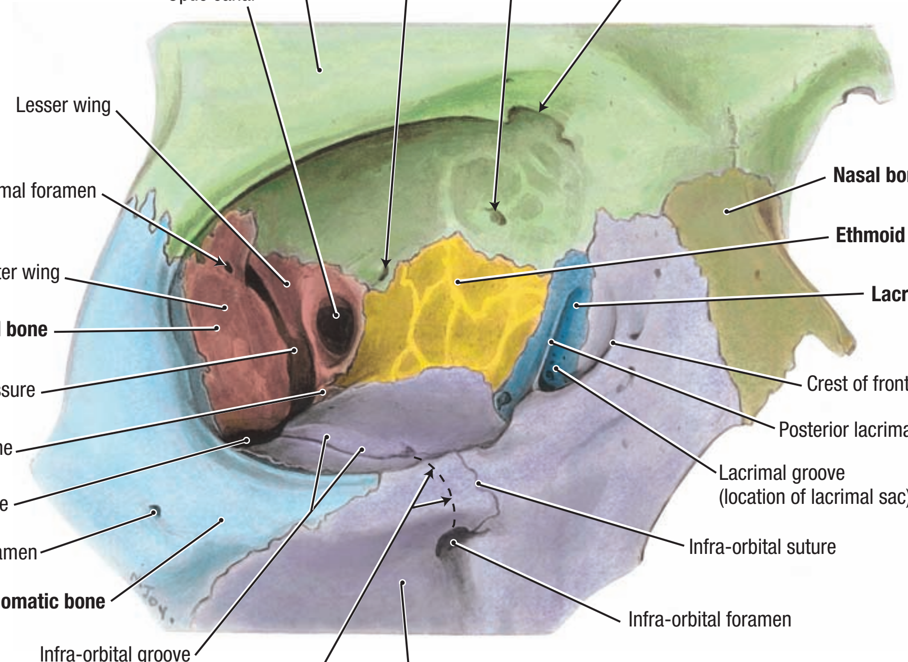
C. **Schematic Diagram**

Key for A and B:

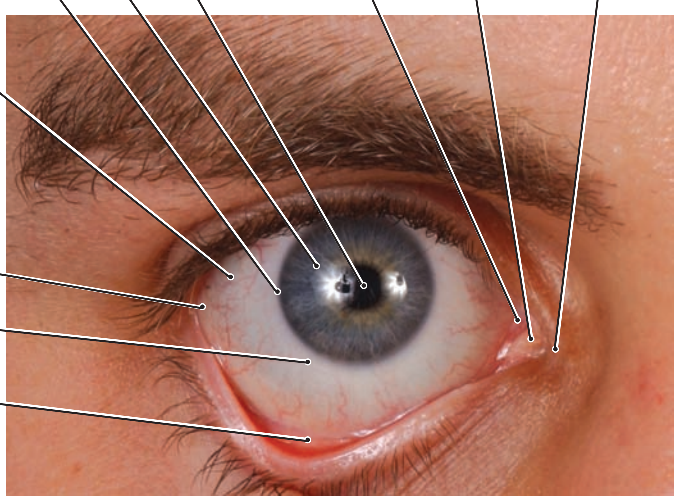
ACM	Anterior communicating artery	BT	Brachiocephalic trunk	LC	Left common carotid artery	PCM	Posterior communicating artery
ACA	Anterior cerebral artery	CS	Carotid siphon	LS	Left subclavian artery	RC	Right common carotid artery
AR	Arch of aorta	ECA	External carotid artery	MCA	Middle cerebral artery	RS	Right subclavian artery
BA	Basilar artery	ICA	Internal carotid artery	PCA	Posterior cerebral artery	VA	Vertebral artery

7.35 BLOOD SUPPLY OF HEAD AND NECK

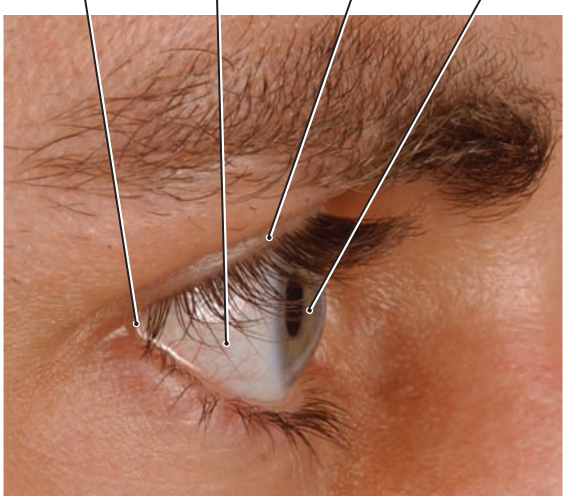
A. CT angiogram of arteries of head and neck. **B.** CT angiogram of cerebral arterial circle (circle of Willis). **C.** Schematic diagram of cerebral arterial circle and veins of cerebral base.



A. **Anterior View**



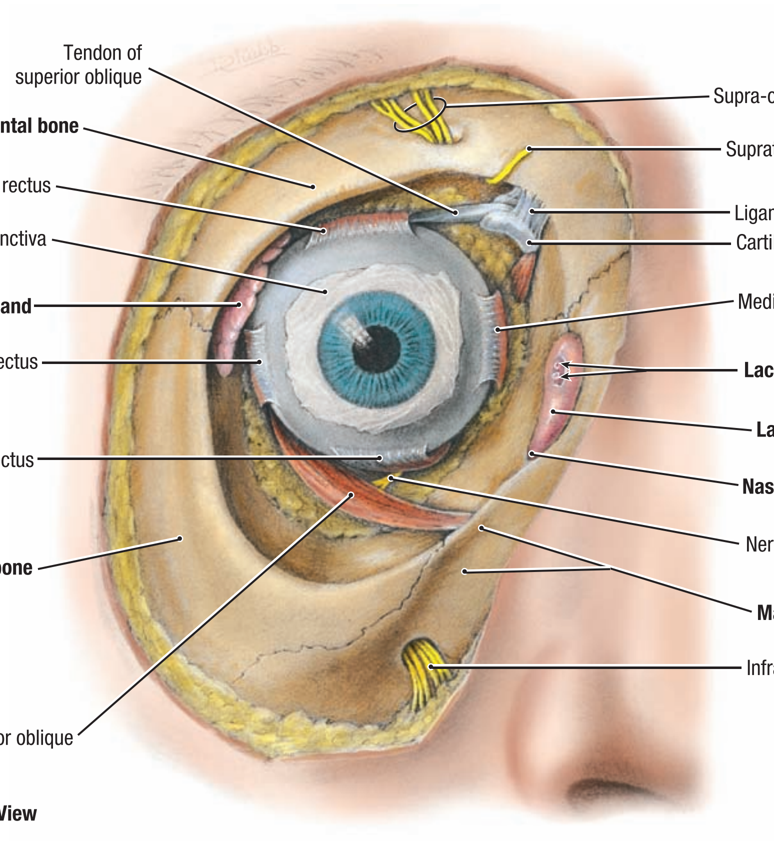
B. **Anterior View**



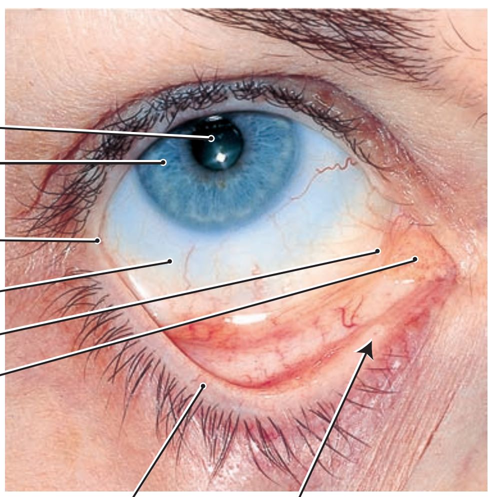
C. **Lateral View**

7.36 ORBITAL CAVITY AND SURFACE ANATOMY OF THE EYE

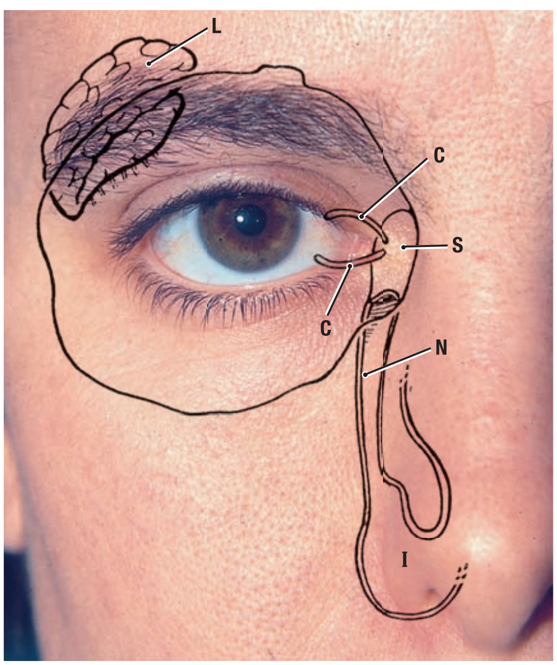
A. Bones and features of the orbital cavity. **B. and C.** Surface anatomy of the eye. In **B,** the inferior eyelid is everted to demonstrate the palpebral conjunctiva. When powerful blows impact directly on the bony rim of the orbit, the resulting **orbital fractures** usually occur at the sutures between the bones forming the orbital margin. Fractures of the medial wall may involve the ethmoidal and sphenoidal sinuses, whereas fractures in the inferior wall may involve the maxillary sinus. Although the superior wall is stronger than the medial and inferior walls, it is thin enough to be translucent and may be readily penetrated. Thus, a sharp object may pass through it into the frontal lobe of the brain. Orbital fractures often result in intraorbital bleeding, which exerts pressure on the eyeball, causing **exophthalmos** (protrusion of the eyeball).



A. Anterior View



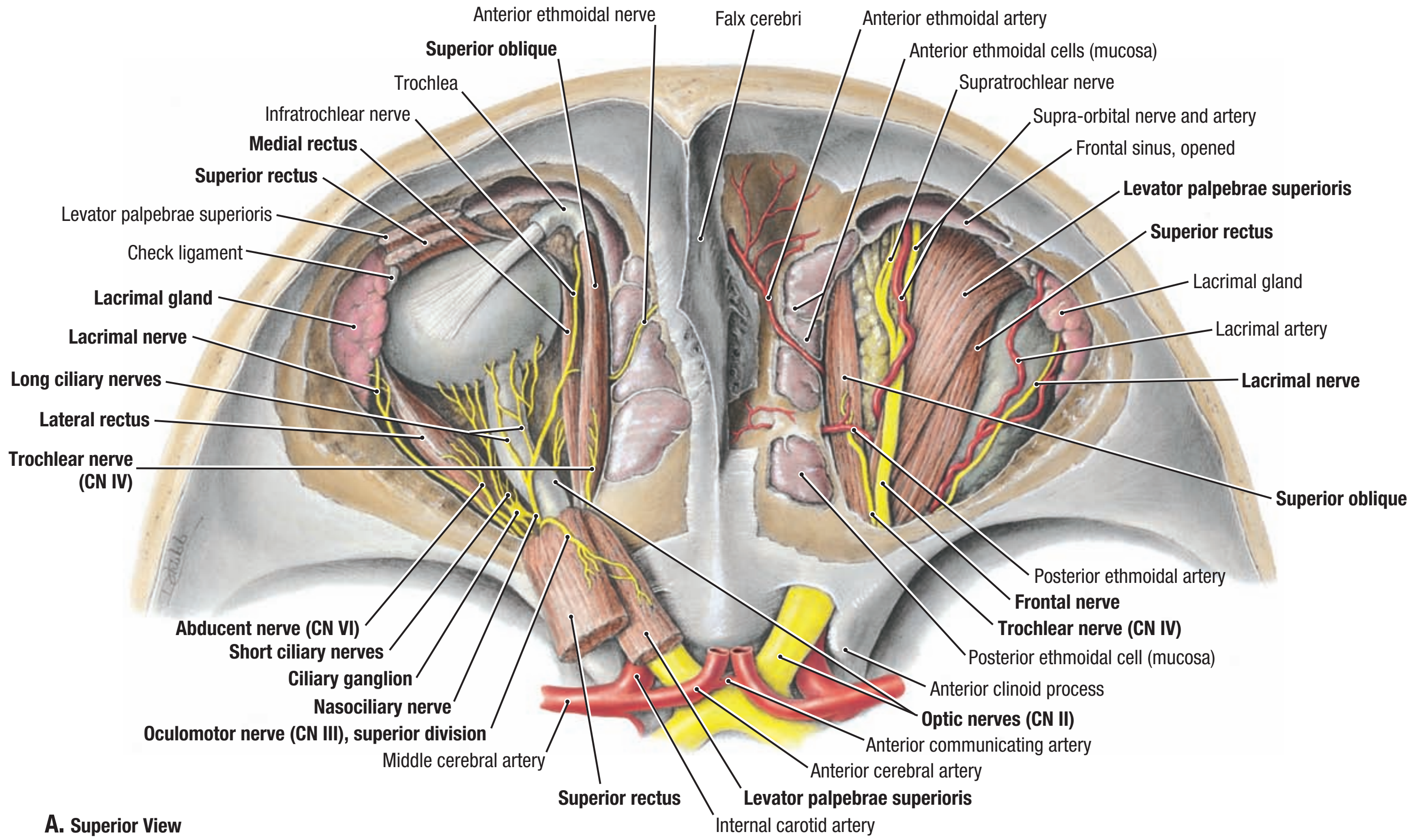
B. Anterior View



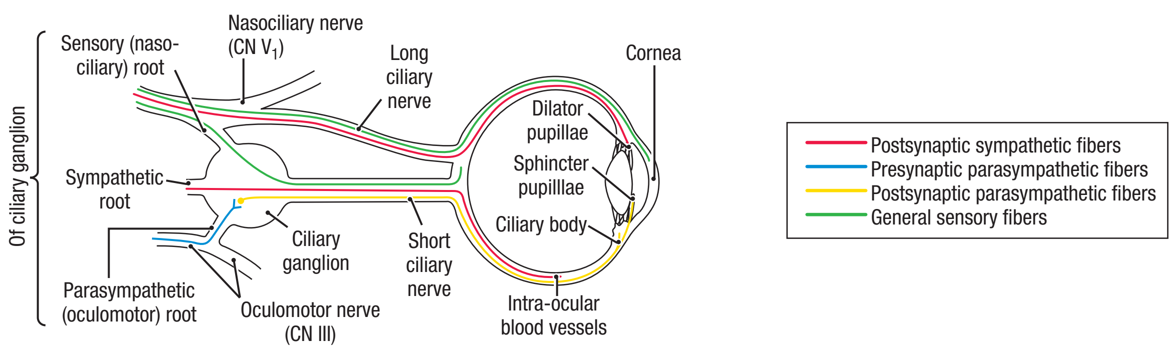
C. Anterior View

7.37 EYE AND LACRIMAL APPARATUS

A. Anterior dissection of orbital cavity. The eyelids, orbital septum, levator palpebrae superioris, and some fat are removed. **B.** Surface features, with the inferior eyelid everted. **C.** Surface projection of lacrimal apparatus. Tears, secreted by the lacrimal gland *(L)* in the superolateral angle of the bony orbit, pass across the eyeball and enter the lacus lacrimalis (lacrimal lake) at the medial angle of the eye; from here they drain through the lacrimal puncta and lacrimal canaliculi *(C)* to the lacrimal sac *(S)*. The lacrimal sac drains into the nasolacrimal duct *(N)*, which empties into the inferior meatus *(I)* of the nose.



A. **Superior View**



B

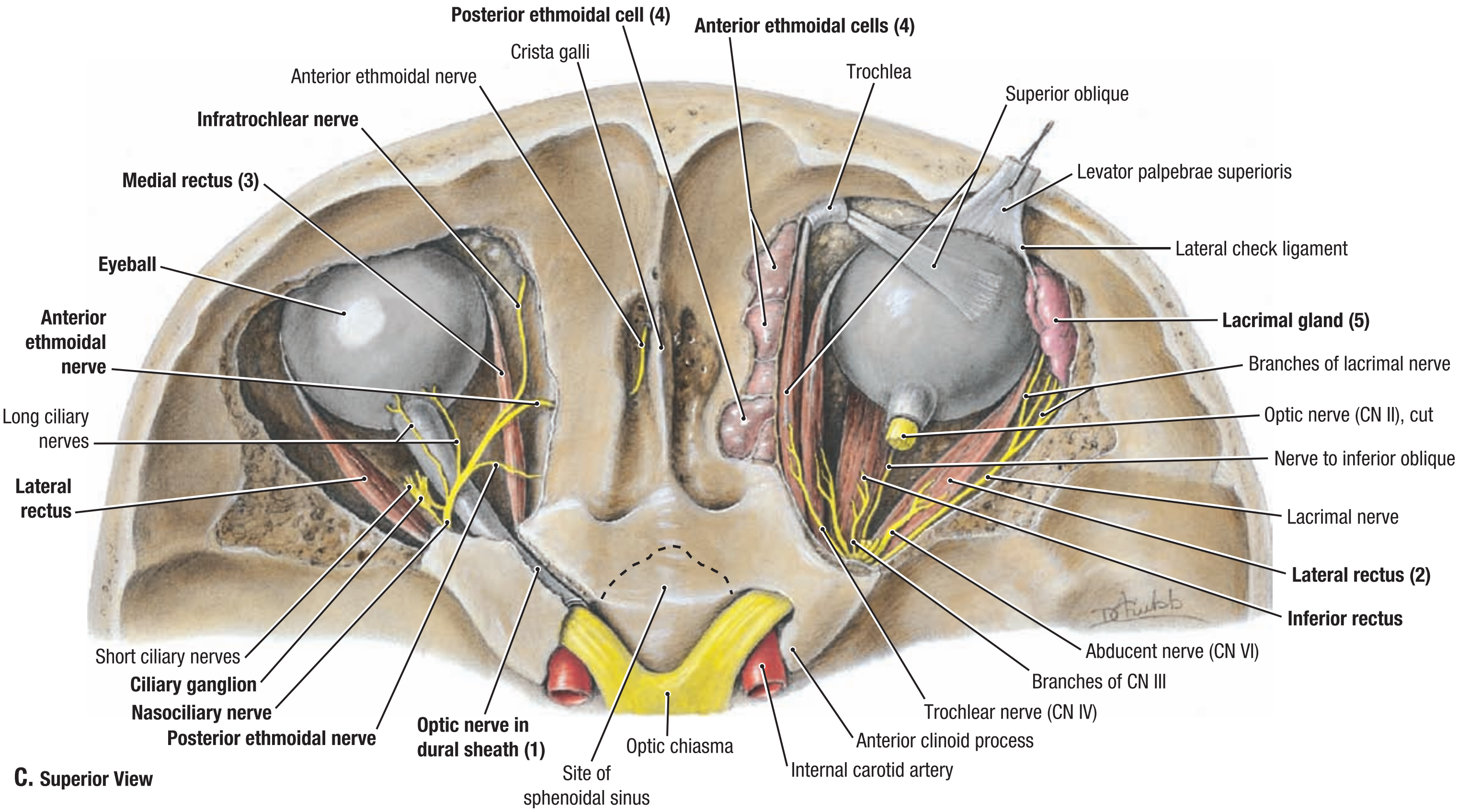
7.38 ORBITAL CAVITY, SUPERIOR APPROACH

A. Superficial dissection. On the right side of figure **A,** the orbital plate of the frontal bone is removed. On the left side of figure **A,** the levator palpebrae and superior rectus muscles are reflected.

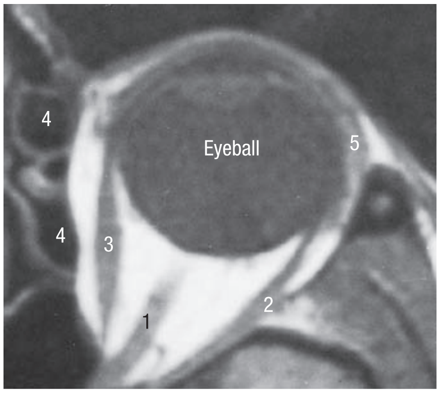
- The trochlear nerve (CN IV) lies on the medial side of the superior oblique muscle, and the abducent nerve (CN VI) on the medial side of the lateral rectus muscle.
- The lacrimal nerve runs superior to the lateral rectus muscle supplying sensory fibers to the conjunctiva and skin of the superior eyelid; it receives a communicating branch of the zygomaticotemporal nerve carrying secretory motor fibers from the pterygopalatine ganglion to the lacrimal gland.
- The parasympathetic ciliary ganglion, placed between the lateral rectus muscle and the optic nerve (CN II), gives rise to many short ciliary nerves; the nasociliary nerve gives rise to two long ciliary nerves that anastomose with each other and the short ciliary nerves.

B. Distribution of nerve fibers to ciliary ganglion and eyeball.

Horner syndrome results from interruption of a cervical sympathetic trunk and is manifest by the absence of sympathetically stimulated functions on the ipsilateral side of the head. The syndrome includes the following signs: constriction of the pupil *(miosis),* drooping of the superior eyelid (**ptosis**), redness and increased temperature of the skin (**vasodilatation**), and absence of sweating (**anhydrosis**).



C. Superior View



D. Axial MRI

7.38 ORBITAL CAVITY, SUPERIOR APPROACH *(CONTINUED)*

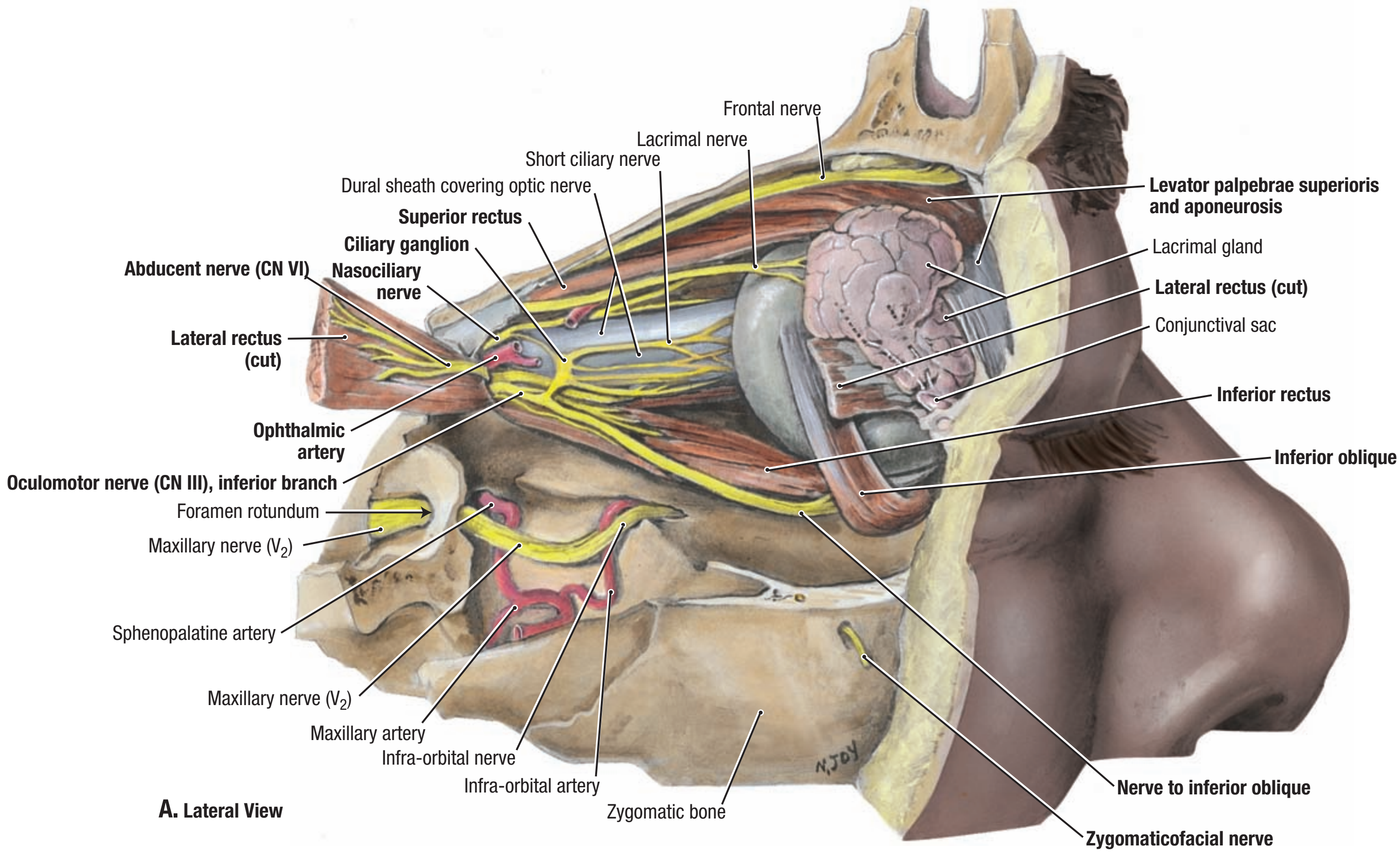
C. Deep dissection before *(left side of specimen)* and after *(right side of specimen)* section of the optic nerve (CN II). **D.** Transverse (axial) MRI of orbital cavity. (The *numbers* refer to structures labeled in **C**).

Observe on the right side of figure **C:**

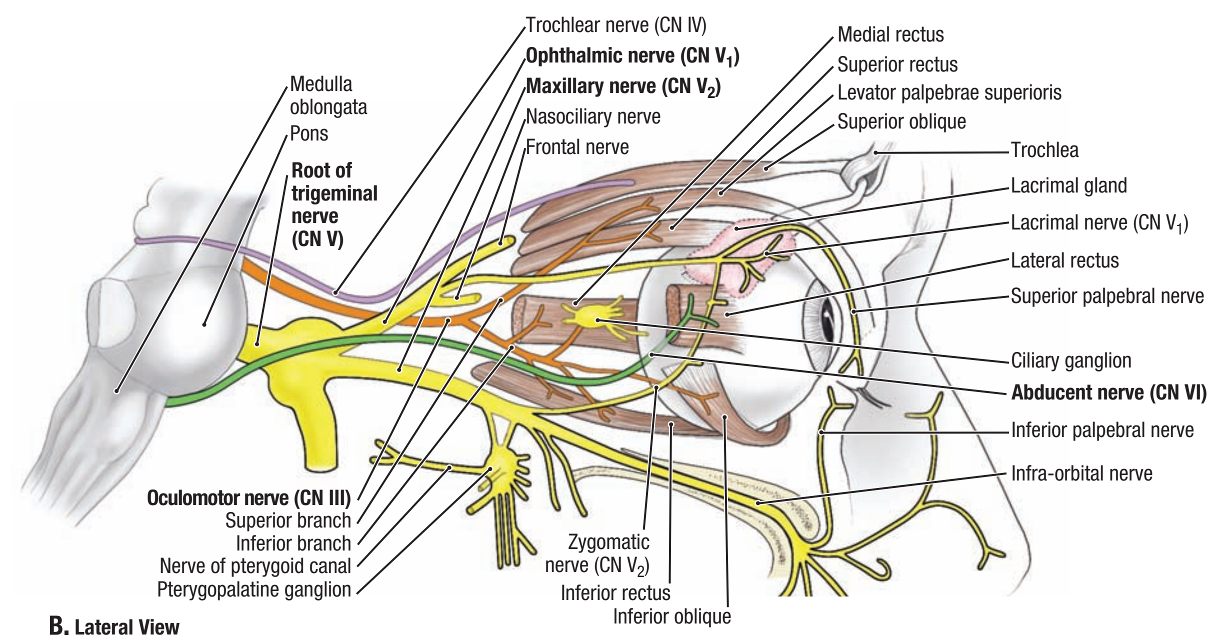
- The eyeball occupies the anterior half of the orbital cavity.

Observe on the left of figure **C:**

- The parasympathetic ciliary ganglion lies posteriorly between the lateral rectus muscle and the sheath of the optic nerve.
- The nasociliary nerve (CN V_1) sends a branch to the ciliary ganglion and crosses the optic nerve (CN II), where it gives off two long ciliary nerves (sensory to the eyeball and cornea) and the posterior ethmoidal nerve (to the sphenoidal sinus and posterior ethmoidal cells). The nasociliary nerve then divides into the anterior ethmoidal and infratrochlear nerves.
- The ciliary ganglion receives sensory fibers from the nasociliary branches of CN VI, postsynaptic sympathetic fibers from the continuation of the internal carotid plexus extending along the ophthalmic artery, and presynaptic parasympathetic fibers from the inferior branch of the oculomotor nerve; only the latter synapse in the ganglion.
- Complete **oculomotor nerve palsy** affects most of the ocular muscles, the levator palpebrae superioris, and the sphincter pupillae. The superior eyelid droops (**ptosis**) and cannot be raised voluntarily because of the unopposed activity of the orbicularis oculi (supplied by the facial nerve). The pupil is also fully dilated and nonreactive because of the unopposed dilator pupillae. The pupil is fully abducted and depressed ("down and out") because of the unopposed activity of the lateral rectus and superior oblique, respectively.
- A **lesion of the abducent nerve** results in loss of lateral gaze to the ipsilateral side because of paralysis of the lateral rectus muscle. On forward gaze, the eye is diverted medially because of the lack of normal resting tone in the lateral rectus, resulting in diplopia (double vision).



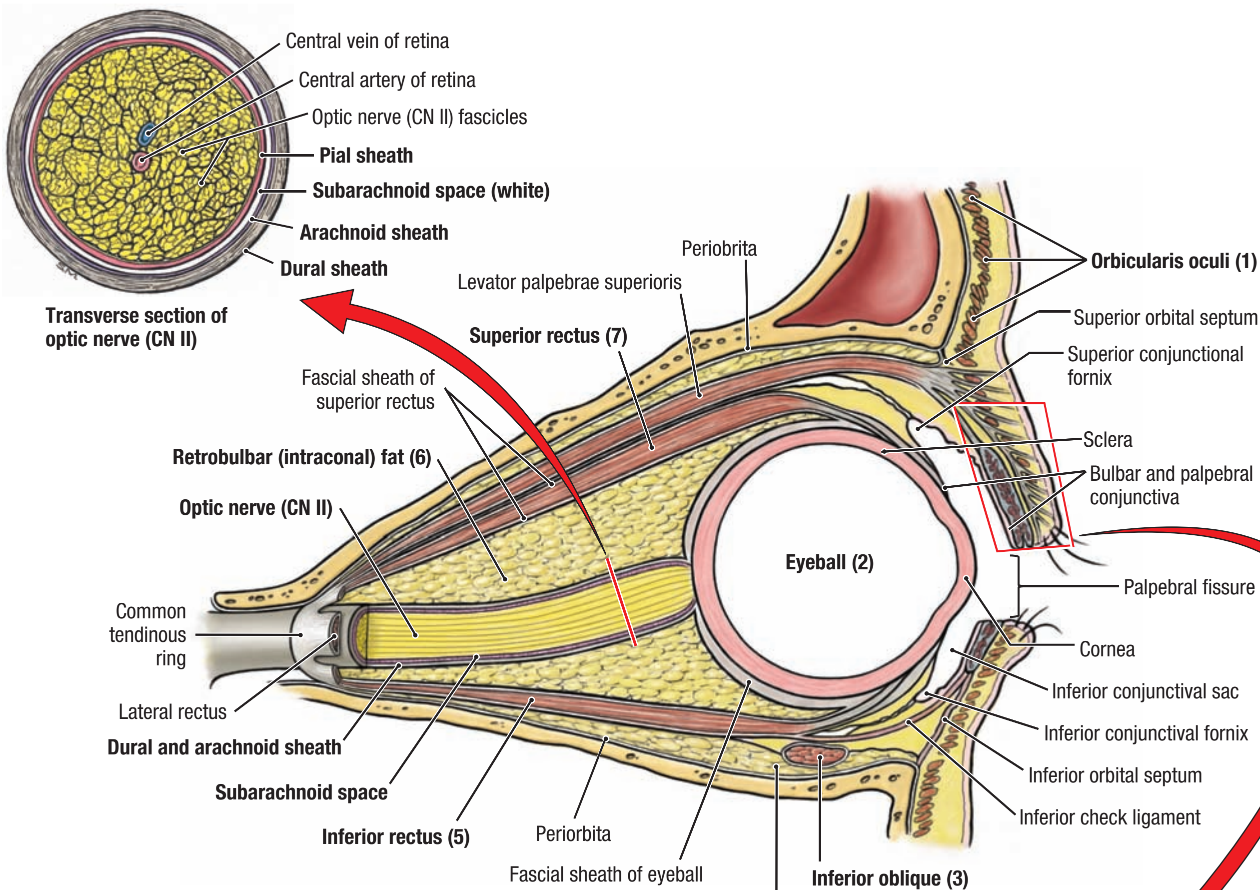
A. Lateral View



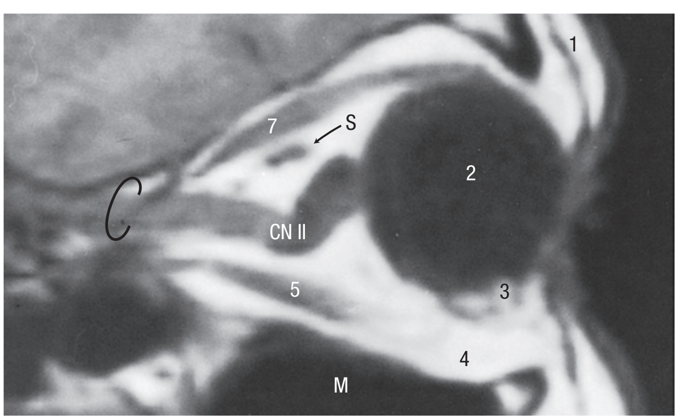
B. Lateral View

7.39 LATERAL ASPECT OF THE ORBIT AND STRUCTURE OF THE EYELID

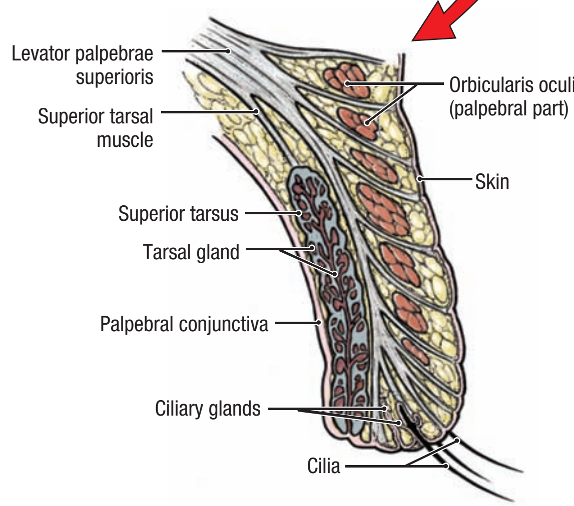
A. Dissection. **B.** Nerves. **C.** Sagittal and cross section through optic nerve. The subarachnoid space around the optic nerve is continuous with the subarachnoid space around the brain. **D.** Sagittal MRI. The *numbers* refer to structures labeled in *C; S,* superior ophthalmic vein; *M,* maxillary sinus; *circled,* optic foramen. **E.** Structure of eyelid.



C. Sagittal Section, Lateral View



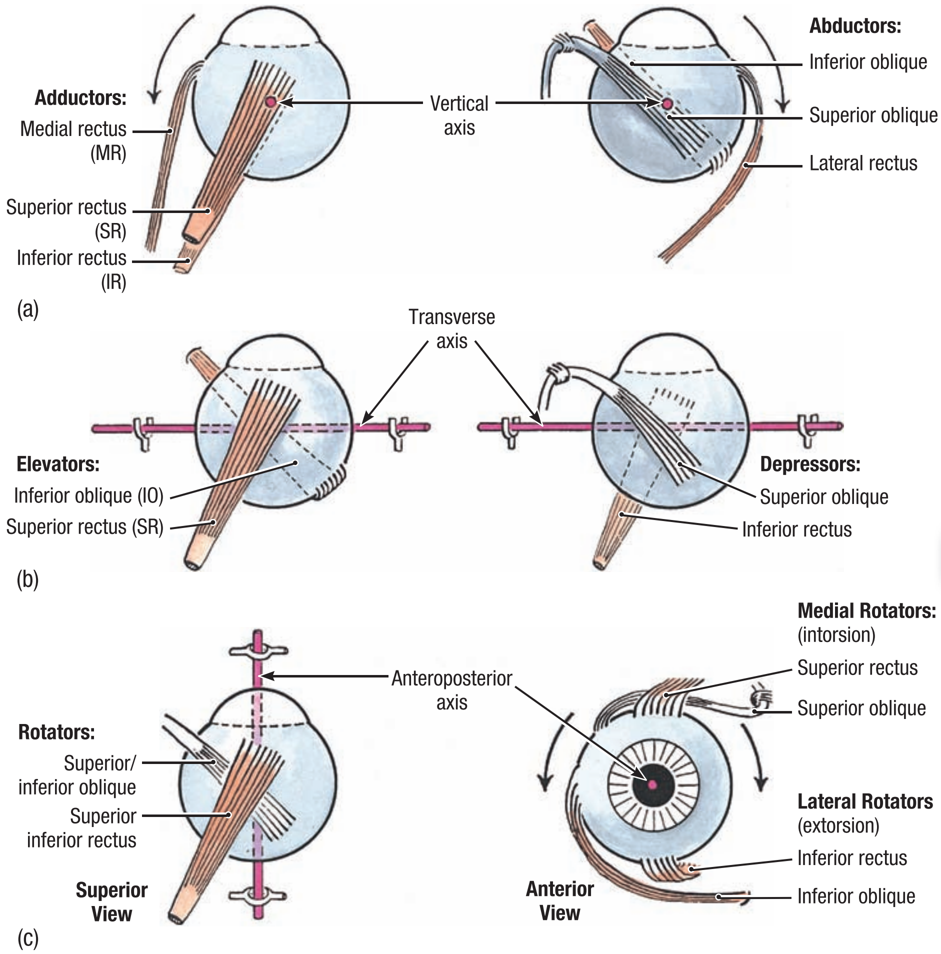
D. Sagittal MRI Section, Lateral View



E. Sagittal Section , Medial View

7.39 LATERAL ASPECT OF THE ORBIT AND STRUCTURE OF THE EYELID *(CONTINUED)*

- Foreign objects, such as sand or metal filings, produce **corneal abrasions** that cause sudden, stabbing eye pain and tears. Opening and closing the eyelids is also painful. **Corneal lacerations** are caused by sharp objects such as fingernails or the corner of a page of a book.
- Any of the glands in the eyelid may become inflamed and swollen from infection or obstruction of their ducts. If the ducts of the ciliary glands are obstructed, a painful red suppurative (pus-producing) swelling, a sty (hordeolum), develops on the eyelid. **Obstruction of a tarsal gland** produces inflammation, a tarsal chalazion, that protrudes toward the eyeball and rubs against it as the eyelids blink.



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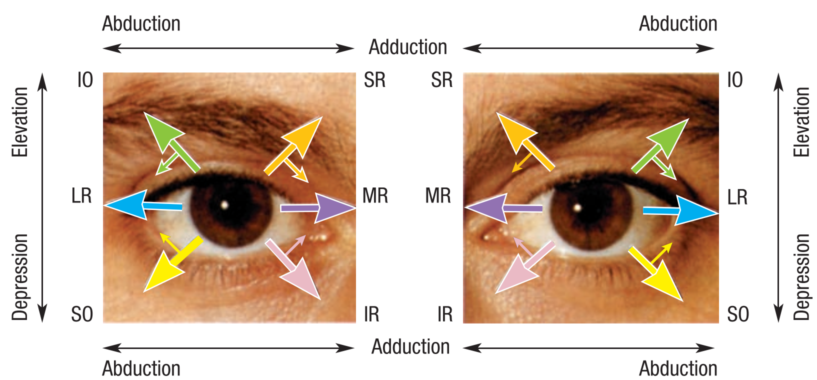


B. Anterior View of Right and Left Eyes

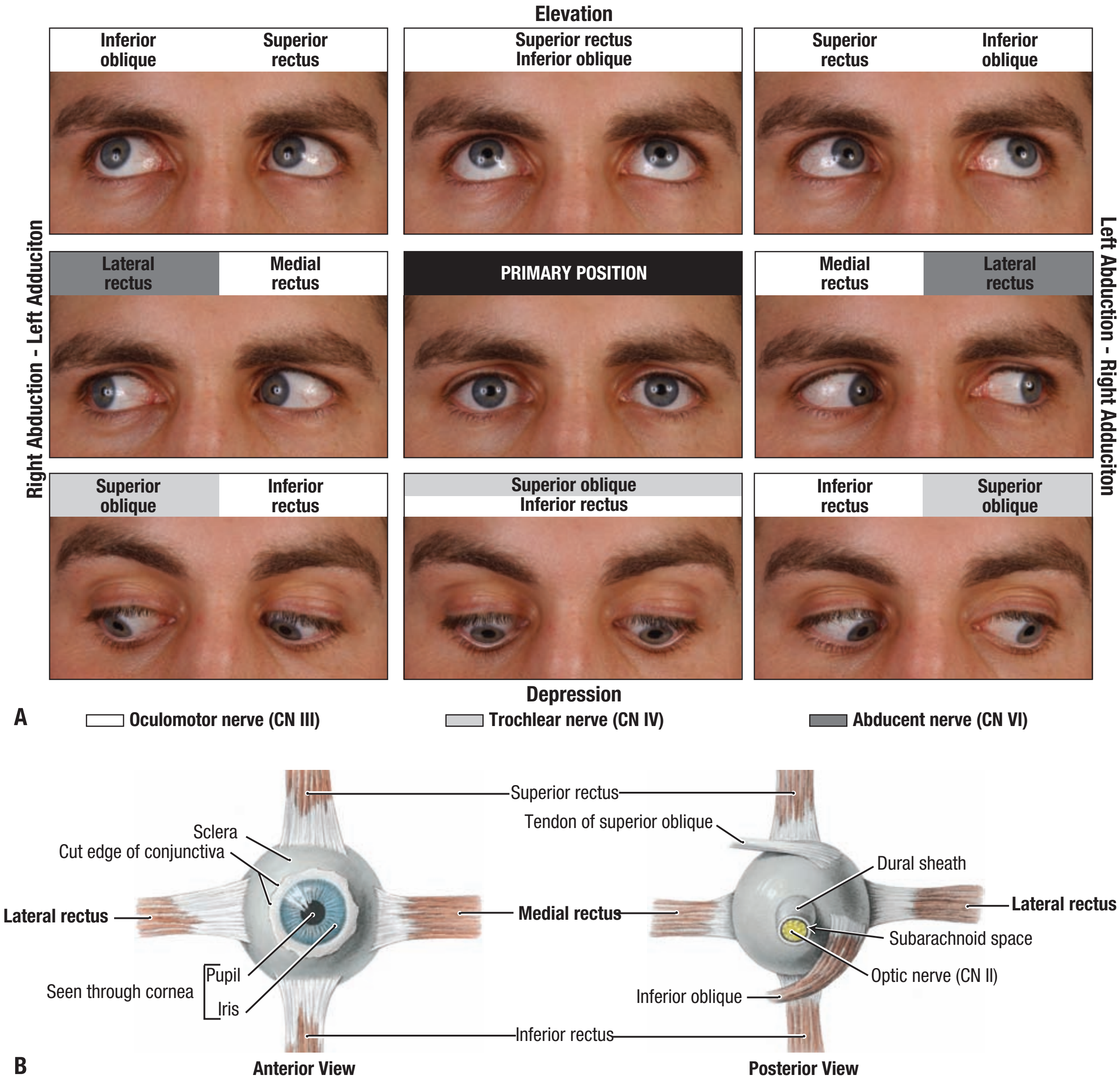
TABLE 7.8 ACTIONS OF MUSCLES OF ORBIT STARTING FROM PRIMARY POSITION[a]

Muscle	Main Action		
	Vertical Axis (A)	**Horizontal Axis (B)**	**Anteroposterior Axis (C)**
Superior rectus (SR)	Elevates	Adducts	Rotates medially (intorsion)
Inferior rectus (IR)	Depresses	Adducts	Rotates laterally (extorsion)
Superior oblique (SO)	Depresses	Abducts	Rotates medially (intorsion)
Inferior oblique (IO)	Elevates	Abducts	Rotates laterally (extorsion)
Medial rectus (MR)	N/A	Adducts	N/A
Lateral rectus (LR)	N/A	Abducts	N/A

[a]Primary position, gaze directed anteriorly.

7.40 EXTRA-OCULAR MUSCLES AND THEIR MOVEMENTS

A. The line of pull of the muscles relative to the eyeball and the axes around which movements occur. The orientation of the orbit is important in understanding the actions of the extra-ocular muscles. The common tendinous ring (origin of the recti), the origin of the inferior oblique, and the trochlea of the superior oblique all lie medial to the eyeball and to the A-P and vertical axes **(a)** The medial and lateral recti are the primary adductors and abductors of the eyeball. However, when movements begin from the primary position (gaze directed anteriorly along the A-P axis): (1) the line of pull of the superior and inferior rectus muscles passes medial and anterior to the vertical axis, resulting in secondary actions of adduction; and (2) the line of pull of the superior and inferior oblique muscles passes medial and posterior to the vertical axis, resulting in secondary actions of abduction. **(b)** Pulling in opposite directions relative to the transverse axis, the superior rectus and inferior oblique muscles are synergistic elevators, and the inferior rectus and superior oblique are synergistic depressors. **(c)** Medial pull produced by the muscles attaching to the superior eyeball (superior rectus and oblique) produces secondary actions of medial rotation (intorsion), and that produced by muscles attaching to the inferior eyeball (inferior rectus and oblique) produces lateral rotation (extorsion). **B.** Movements produced by isolated contraction of the four rectus and two oblique muscles, starting from the primary position. Large arrows indicate prime movers for the six cardinal movements. Movements in directions between large arrows (e.g., vertical elevation or depression) require synergistic actions of adjacent muscles. Contralaterally-paired muscles that work synergistically to direct parallel binocular gaze are called yoke muscles. For example, the right LR and left MR act as yoke muscles in directing gaze to the right.



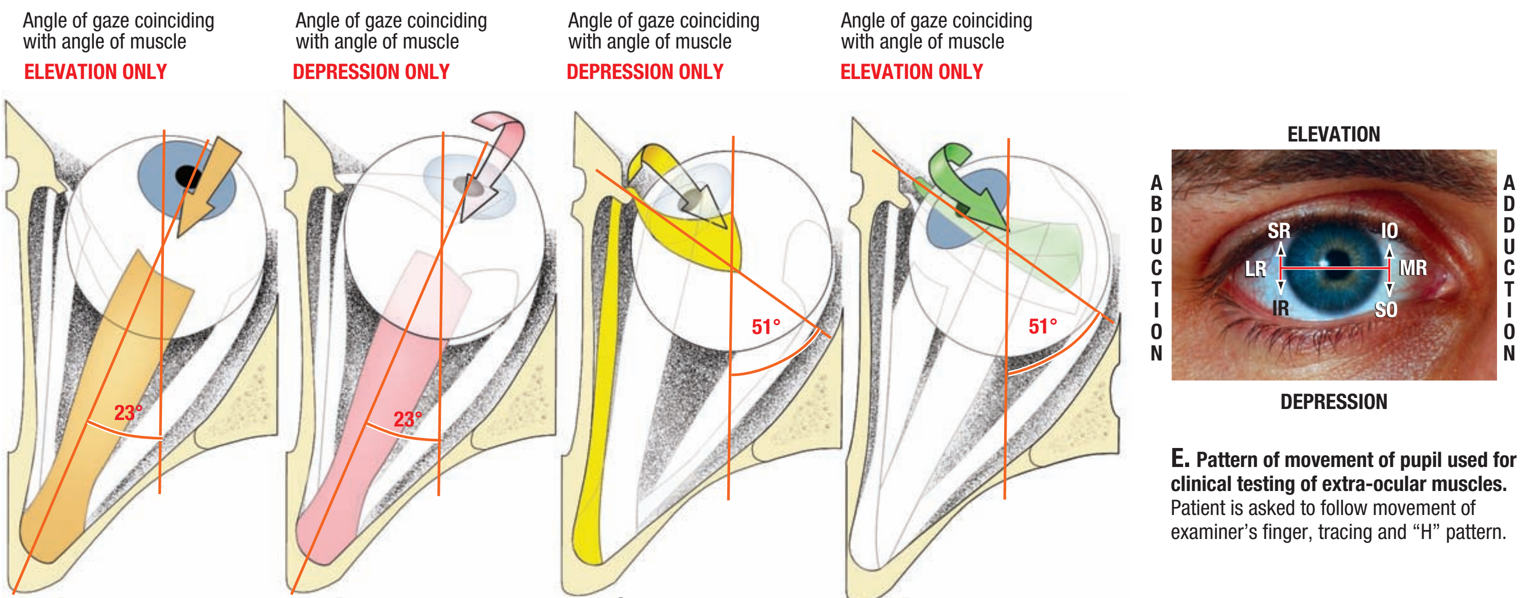
7.41 EXTRA-OCULAR MUSCLES AND THEIR MOVEMENTS *(CONTINUED)*

A. Binocular movements of eyeball from primary position, and muscles and nerves producing them. **B.** Muscles of eyeball.

TABLE 7.9 MUSCLES OF ORBIT

Muscle	Origin	Insertion	Innervation	Main Action(s)[a]
Levator palpebrae superioris	Lesser wing of sphenoid bone, superior and anterior to optic canal	Superior tarsus and skin of superior eyelid	Oculomotor nerve; deep layer (superior tarsal muscle) supplied by sympathetic fibers	Elevates superior eyelid
Superior oblique (SO)	Body of sphenoid bone	Tendon passes through trochlea to insert into sclera, deep to SR	Trochlear nerve (CN IV)	Abducts, depresses, and rotates eyeball medially (intorsion)
Inferior oblique (IO)	Anterior part of floor of orbit	Sclera deep to lateral rectus muscle	Oculomotor nerve (CN III)	Abducts, elevates, and rotates eyeball laterally (extorsion)
Superior rectus (SR)	Common tendinous ring	Sclera just posterior to corneoscleral junction		Elevates, adducts, and (SR) rotates eyeball medially (intorsion)
Inferior rectus (IR)				Depresses, adducts, and rotates eyeball laterally (extorsion)
Medial rectus (MR)				Adducts eyeball
Lateral rectus (LR)			Abducent nerve (CN VI)	Abducts eyeball

[a]It is essential to appreciate that all muscles are continuously involved in eyeball movements; thus the individual actions are not usually tested clinically.

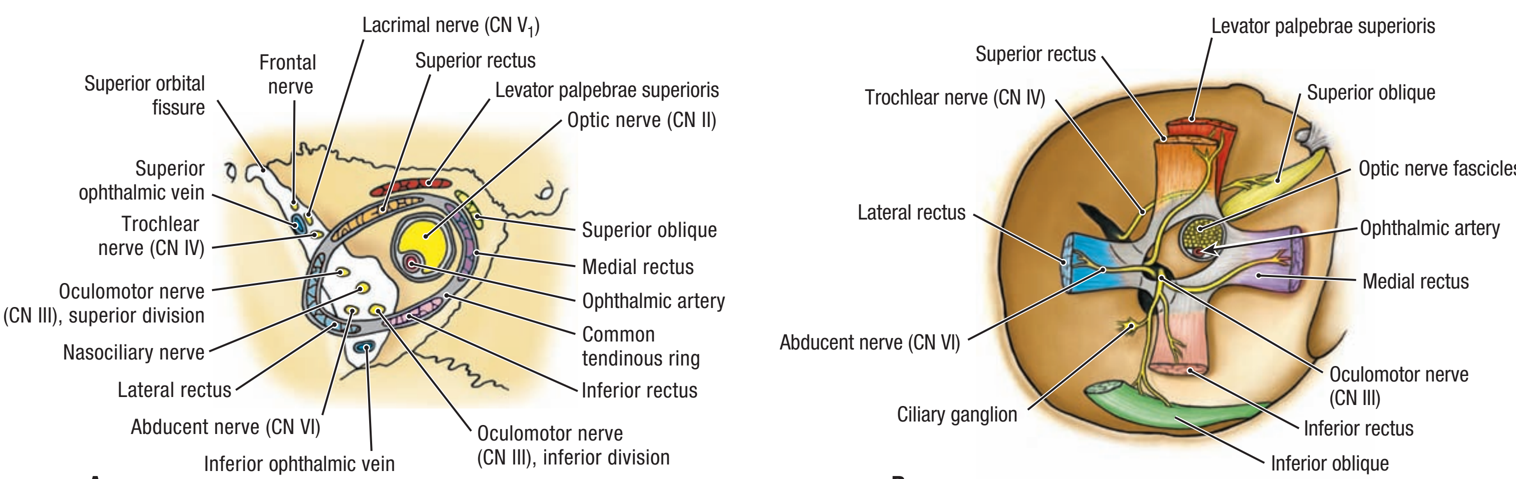


A. **Superior Rectus** **B.** **Inferior Rectus** **C.** **Superior Oblique** **D.** **Inferior Oblique**

E. Pattern of movement of pupil used for clinical testing of extra-ocular muscles. Patient is asked to follow movement of examiner's finger, tracing and "H" pattern.

7.42 CLINICAL TESTING OF EXTRA-OCULAR MUSCLES AND MOTOR NERVES (CN III, IV, AND VI)

Most movements from the primary position involve synergists. When testing muscles (usually to determine the integrity of the involved motor nerve), it is desirable to isolate muscle activity. If the pupil is first adducted (MR—CN III) so that the direction of gaze coincides with the line of pull of the oblique muscles, only the SO (CN IV) can depress and only the IO (CN III) can elevate the pupil. If the pupil is first abducted (LR—CN VI) so that the direction of gaze coincides with the line of pull of the superior and inferior recti, only these muscles can elevate and depress the pupil (superior and inferior divisions of CN III)

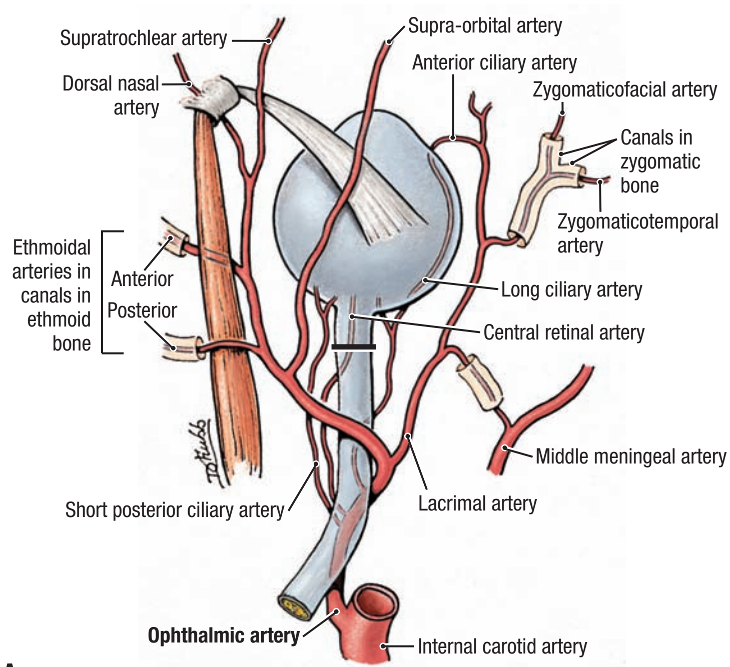


A. **Anterior View** **B.** **Anterior View**

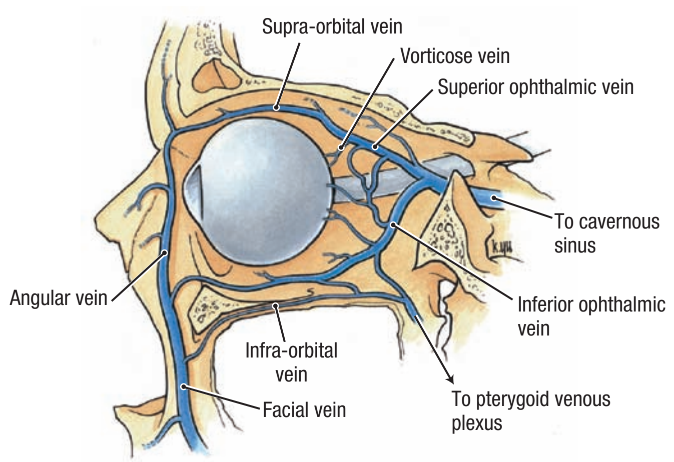
7.43 NERVES OF ORBIT

A. Overview. **B.** Relationships at apex of orbit. **C.** Common tendinous ring, structural relationships.

Orbital tumors. Because of the closeness of the optic nerve to the sphenoidal and posterior ethmoidal sinuses, a malignant tumor in these sinuses may erode the thin bony walls of the orbit and compress the optic nerve and orbital contents. Tumors in the orbit produce **exophthalmos** (protrusion of eyeball). Tumors in the middle cranial fossa enter the orbital cavity through the superior orbital fissure. Tumors in the temporal or infratemporal fossae enter the orbit through the inferior orbital fissure.



A. Superior View



B. Lateral View

7.44 ARTERIES AND VEINS OF ORBIT

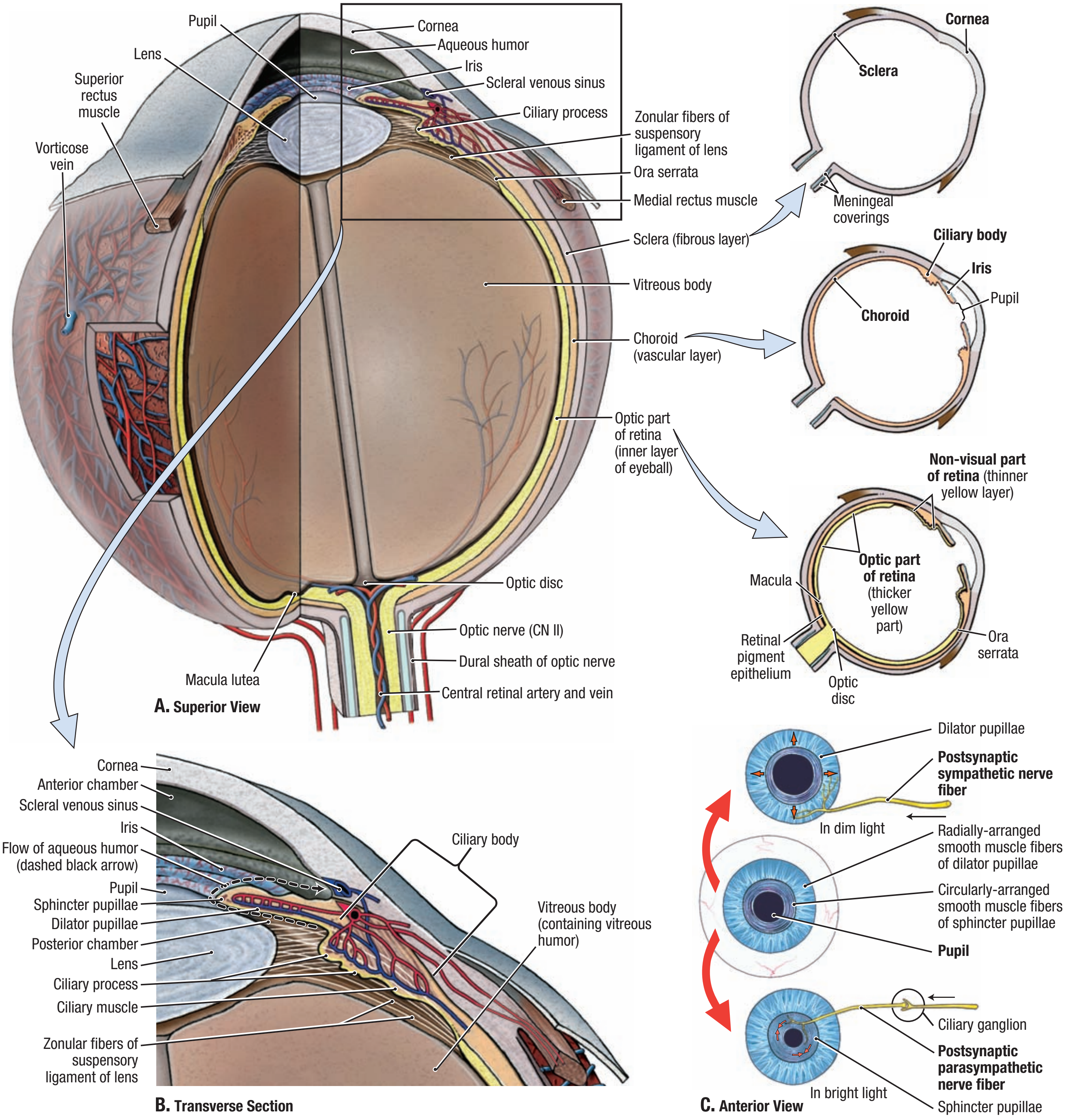
A. Arteries.

Blockage of central retinal artery. The terminal branches of the central retinal artery are end arteries. Obstruction of the artery by an embolus results in instant and total blindness. Blockage of the artery is usually unilateral and occurs in older people. **B.** Veins. The superior and inferior ophthalmic veins receive the vorticose veins from the eyeball and drain into the cavernous sinus posteriorly and the pterygoid plexus inferiorly. They communicate with the facial and supra-orbital veins anteriorly.

- The facial veins make clinically important connections with the cavernous sinus through the superior ophthalmic veins. **Cavernous sinus thrombosis** usually results from infections in the orbit, nasal sinuses, and superior part of the face (the danger triangle). In persons with thrombophlebitis of the facial vein, pieces of an infected thrombus may extend into the cavernous sinus, producing **thrombophlebitis of the cavernous sinus.** The infection usually involves only one sinus initially but may spread to the opposite side through the intercavernous sinuses.
- **Blockade of central retinal vein.** The central retinal vein enters the cavernous sinus. Thrombophlebitis of this sinus may result in passage of a thrombus to the central retinal vein and produce a blockage in one of the small retinal veins. Occlusion of a branch of the central vein of the retina usually results in slow, painless loss of vision.

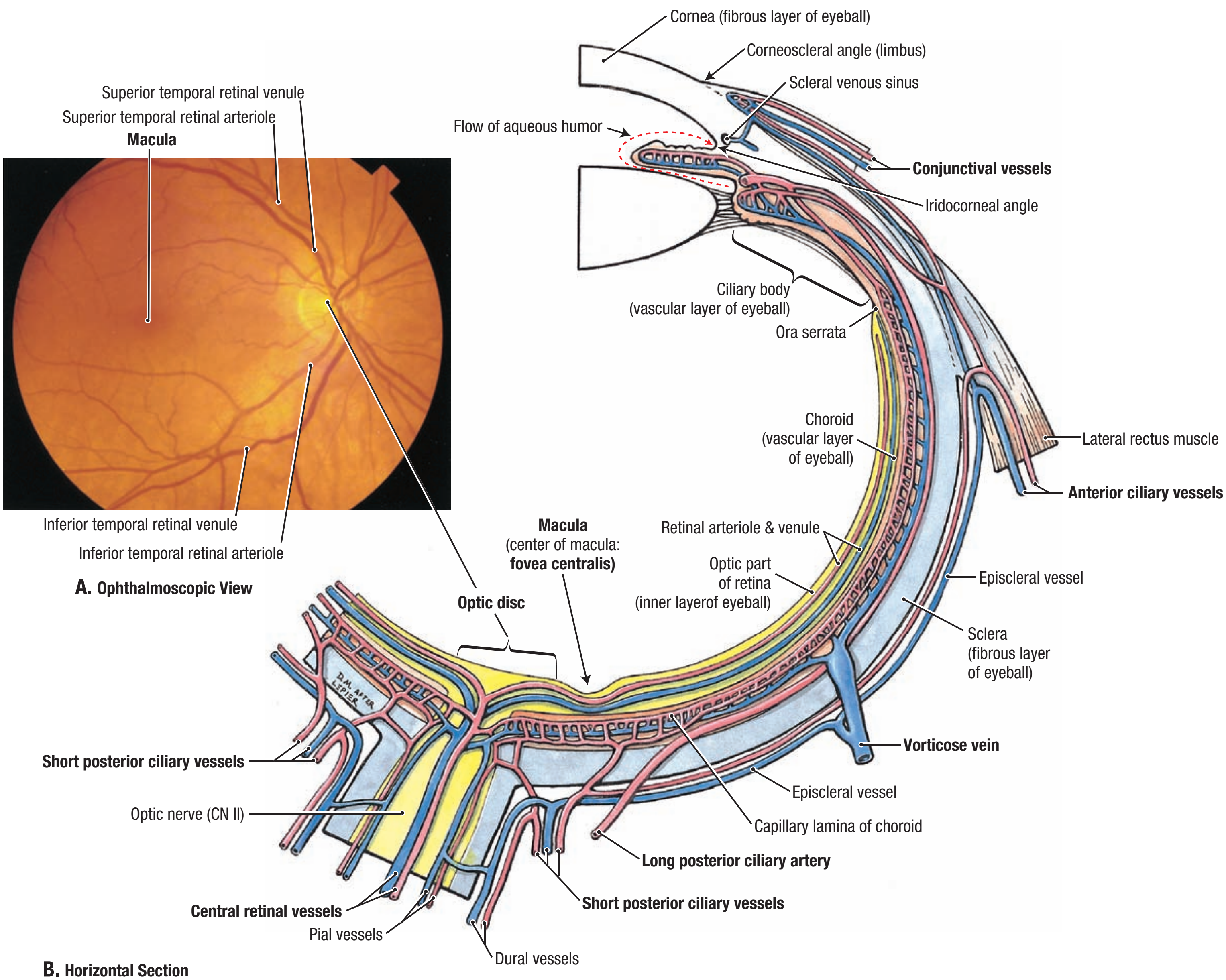
TABLE 7.10 ARTERIES OF ORBIT

Artery	Origin	Course and Distribution
Ophthalmic	Internal carotid artery	Traverses optic foramen to reach orbital cavity
Central retinal	Ophthalmic artery	Runs in dural sheath of optic nerve, entering nerve near eyeball; appears at center of optic disc; supplies optic retina (except cones and rods)
Supra-orbital		Passes superiorly and posteriorly from supra-orbital foramen to supply forehead and scalp
Supratrochlear		Passes from supra-orbital margin to forehead and scalp
Lacrimal		Passes along superior border of lateral rectus muscle to supply lacrimal gland, conjunctiva, and eyelids
Dorsal nasal		Courses along dorsal aspect of nose and supplies its surface
Short posterior ciliary		Pierces sclera at periphery of optic nerve to supply choroid, which, in turn, supplies cones and rods of optic retina
Long posterior ciliary		Pierces sclera to supply ciliary body and iris
Posterior ethmoidal		Passes through posterior ethmoidal foramen to posterior ethmoidal cells
Anterior ethmoidal		Passes through anterior ethmoidal foramen to anterior cranial fossa; supplies anterior and middle ethmoidal cells, frontal sinus, nasal cavity, and skin on dorsum of nose
Anterior ciliary	Muscular rami of the opthalmic and infra-orbital arteries	Pierces sclera at attachments of rectus muscles and forms network in iris and ciliary body
Infra-orbital	Third part of maxillary artery	Passes along infra-orbital groove and exits through infra-orbital foramen to face



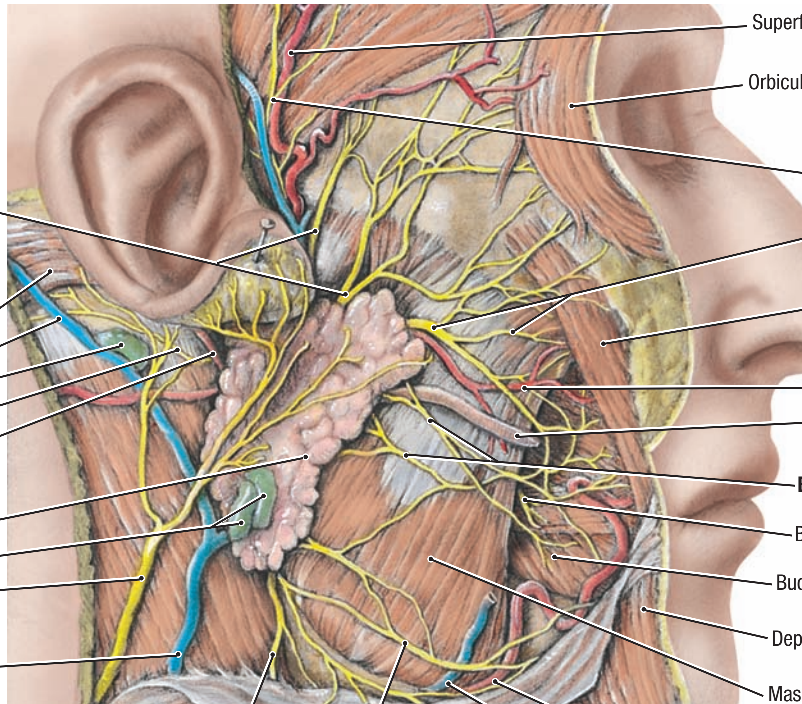
7.45 ILLUSTRATION OF A DISSECTED EYEBALL

A. Parts of the eyeball. **B.** Ciliary region. **C.** Structure and function of iris. The aqueous humor is produced by the ciliary processes and provides nutrients for the avascular cornea and lens; the aqueous humor drains into the scleral venous sinus (also called the sinus venosus sclerae or canal of Schlemm). **Glaucoma.** If drainage of the aqueous humor is reduced significantly, pressure builds up in the chambers of the eye (glaucoma). Blindness can result from compression of the inner layer of the retina and retinal arteries if aqueous humor production is not reduced to maintain normal intraocular pressure.

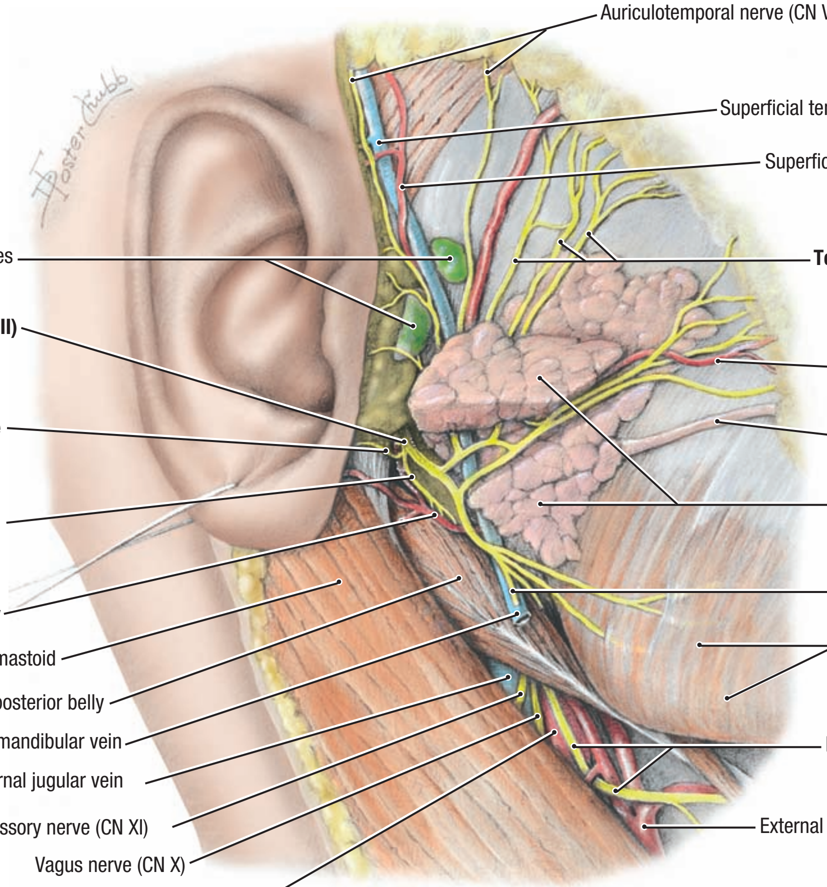


7.46 OCULAR FUNDUS AND BLOOD SUPPLY TO THE EYEBALL

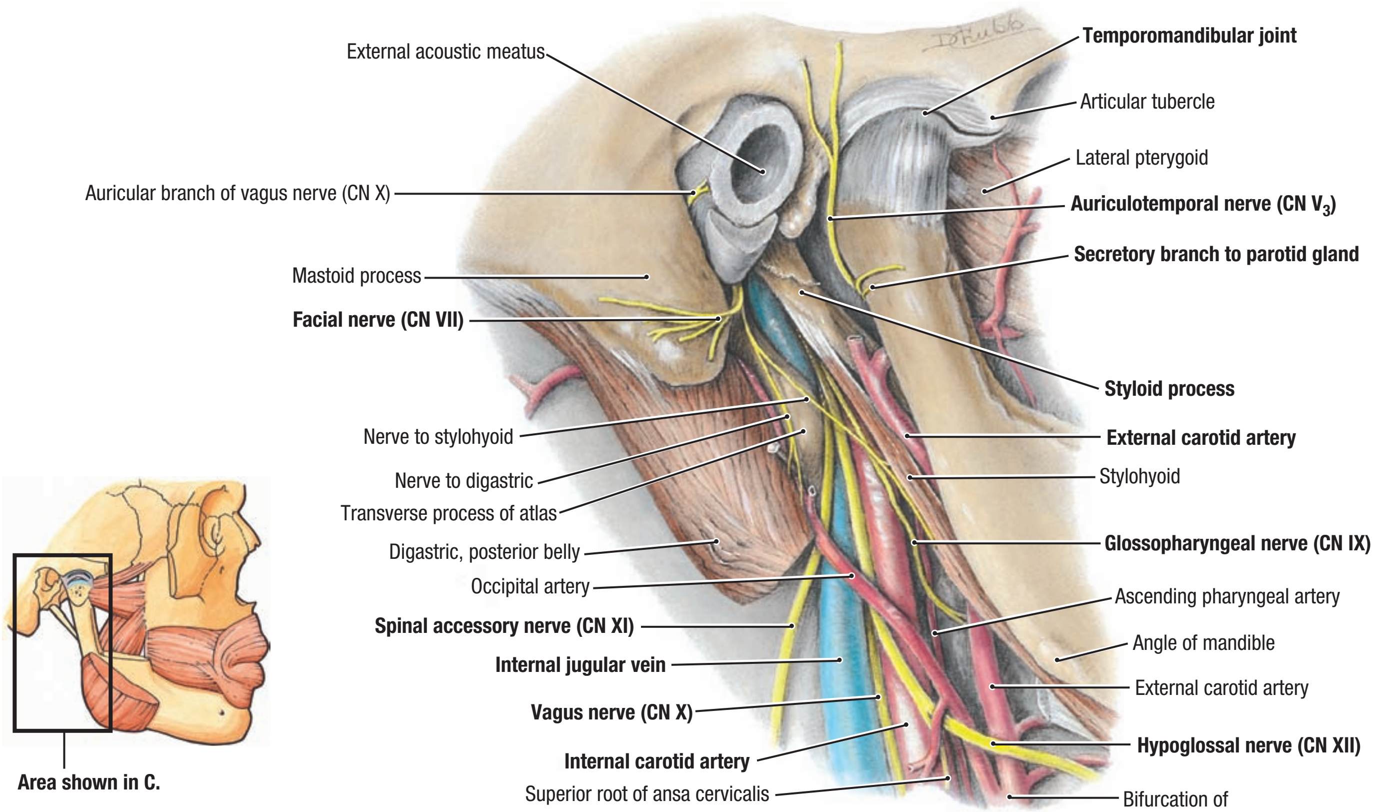
A. Right ocular fundus, ophthalmoscopic view. Retinal venules (wider) and retinal arterioles (narrower) radiate from the center of the oval optic disc, formed in relation to the entry of the optic nerve into the eyeball. The round, dark area lateral to the disc is the macula; branches of vessels extend to this area, but do not reach its center, the fovea centralis, a depressed spot that is the area of most acute vision. It is avascular but, like the rest of the outermost (cones and rods) layer of the retina, is nourished by the adjacent choriocapillaris. Increased intracranial pressure is transmitted through the CSF in the subarachnoid space surrounding the optic nerve, causing the optic disc to protrude. The protrusion, called **papilledema,** is apparent during ophthalmoscopy. **B.** Blood supply to eyeball. The eyeball has three layers: (1) the external, fibrous layer is the sclera and cornea; (2) the middle, vascular layer is the choroid, ciliary body, and iris; and (3) the internal, neural layer or retina consists of a pigment cell layer and a neural layer. The central artery of the retina, a branch of the ophthalmic artery, is an end artery. Of the eight posterior ciliary arteries, six are short posterior ciliary arteries and supply the choroid, which in turn nourishes the outer, nonvascular layer of the retina. Two long posterior ciliary arteries, one on each side of the eyeball, run between the sclera and choroid to anastomose with the anterior ciliary arteries, which are derived from muscular branches. The choroid is drained by posterior ciliary veins, and four to five vorticose veins drain into the ophthalmic veins.



A. **Lateral View**



B. **Lateral View**

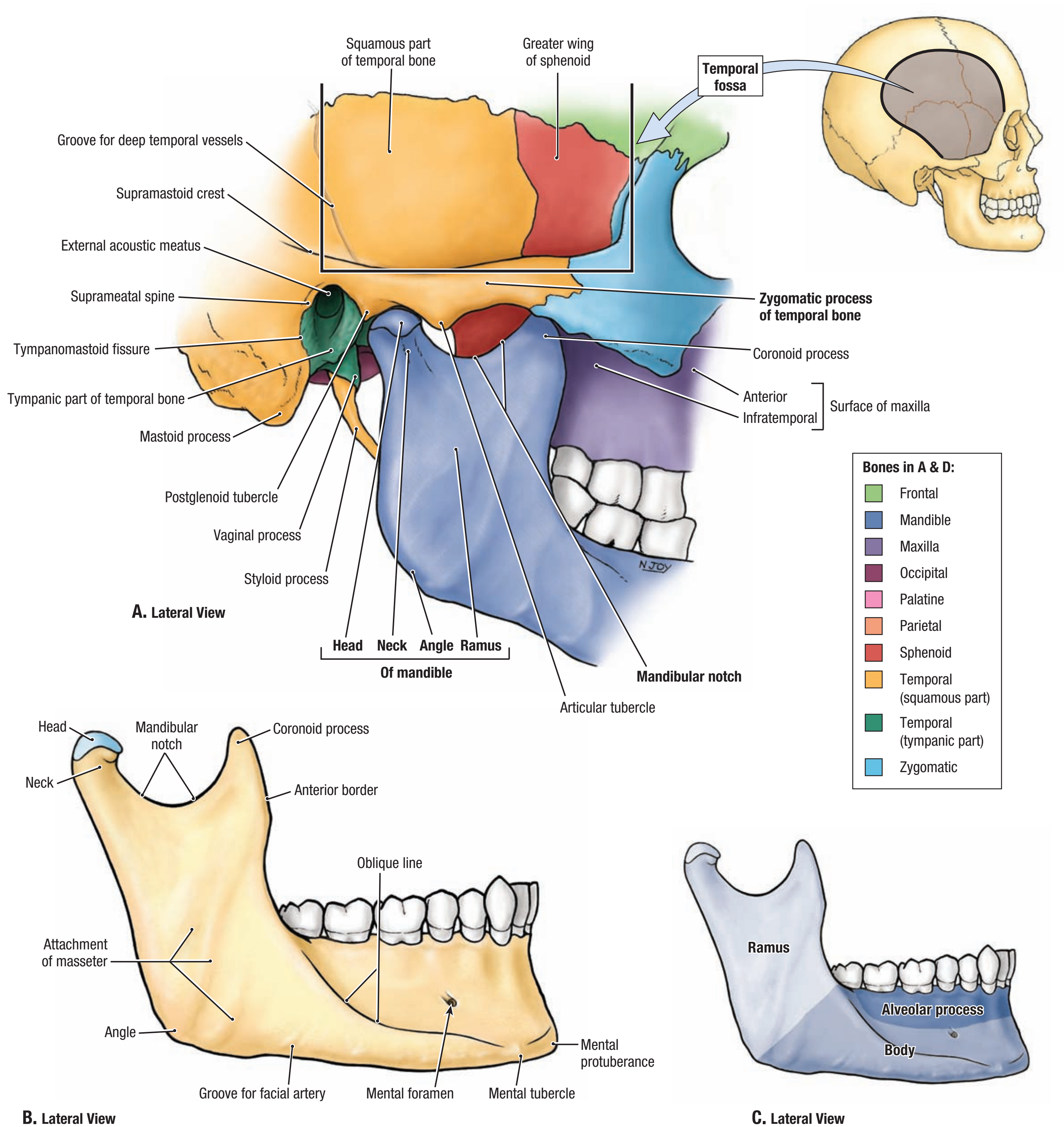


C. Lateral View

7.47 PAROTID REGION

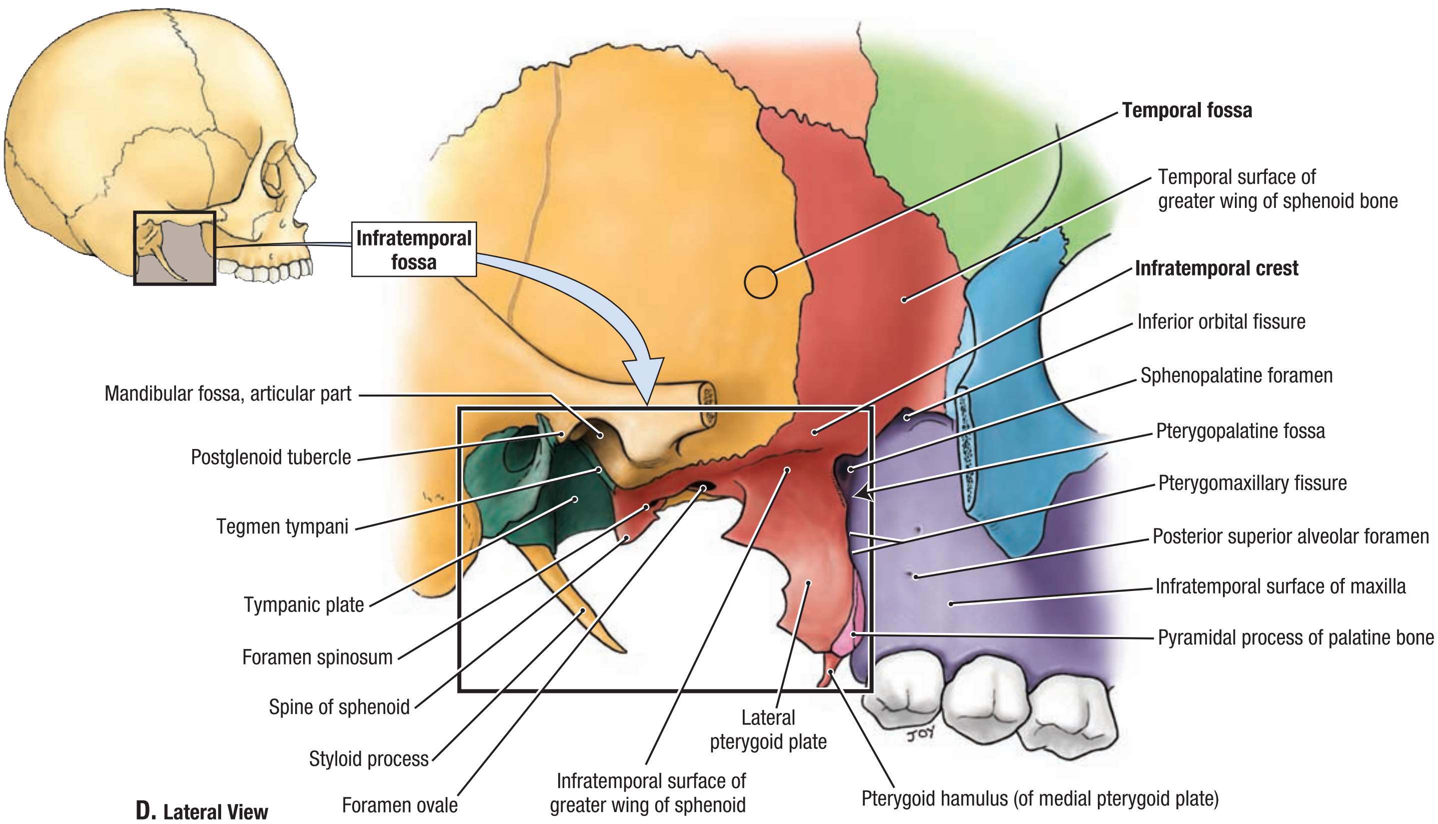
A. Superficial dissection. **B.** Deep dissection with part of the gland removed. During **parotidectomy** (surgical excision of the parotid gland), identification, dissection, and preservation of the facial nerve are critical. The parotid gland has superficial and deep parts. In parotidectomy the superficial part is removed, then the plexus may be retracted to remove the deep part. **C.** Deep dissection following removal of the parotid gland. The facial nerve, posterior belly of the digastric muscle, and its nerve are retracted; the external carotid artery, stylohyoid muscle, and the nerve to the stylohyoid remain in situ. The internal jugular vein, internal carotid artery, and glossopharyngeal (CN IX), vagus (CN X), accessory (CN XI), and hypoglossal (CN XII) nerves cross anterior to the transverse process of the atlas and deep to the styloid process.

Trauma, such as a **fractured mandible,** may injure the hypoglossal nerve (CN XII), resulting in paralysis and eventual atrophy of one side of the tongue. The tongue deviates to the paralyzed side during protrusion.

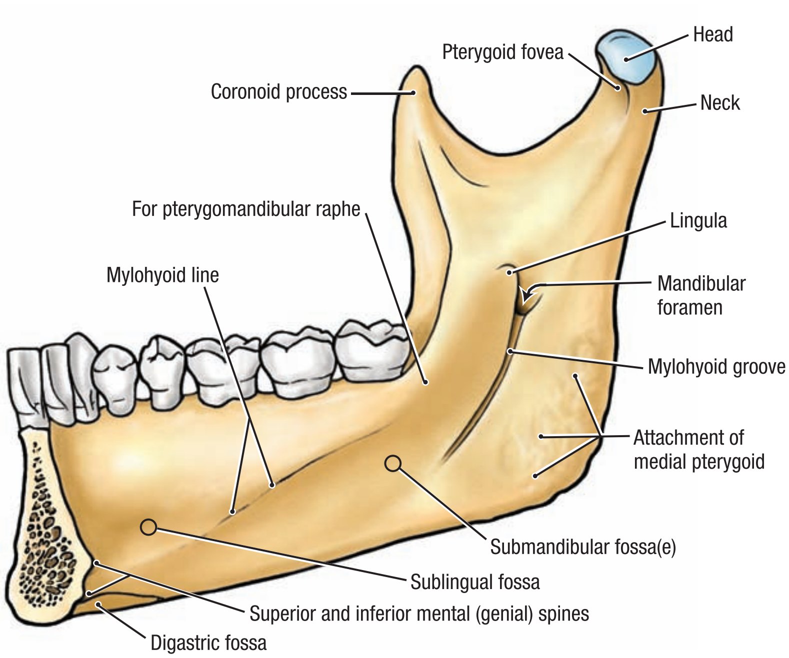


7.48 TEMPORAL AND INFRATEMPORAL FOSSAE AND MANDIBLE

A. Bones and bony features. Note that superficially the zygomatic process of the temporal bone is the boundary between the temporal fossa superiorly and the infratemporal fossa inferiorly. **B.** External surface of the mandible. **C.** Parts of mandible.



D. **Lateral View**

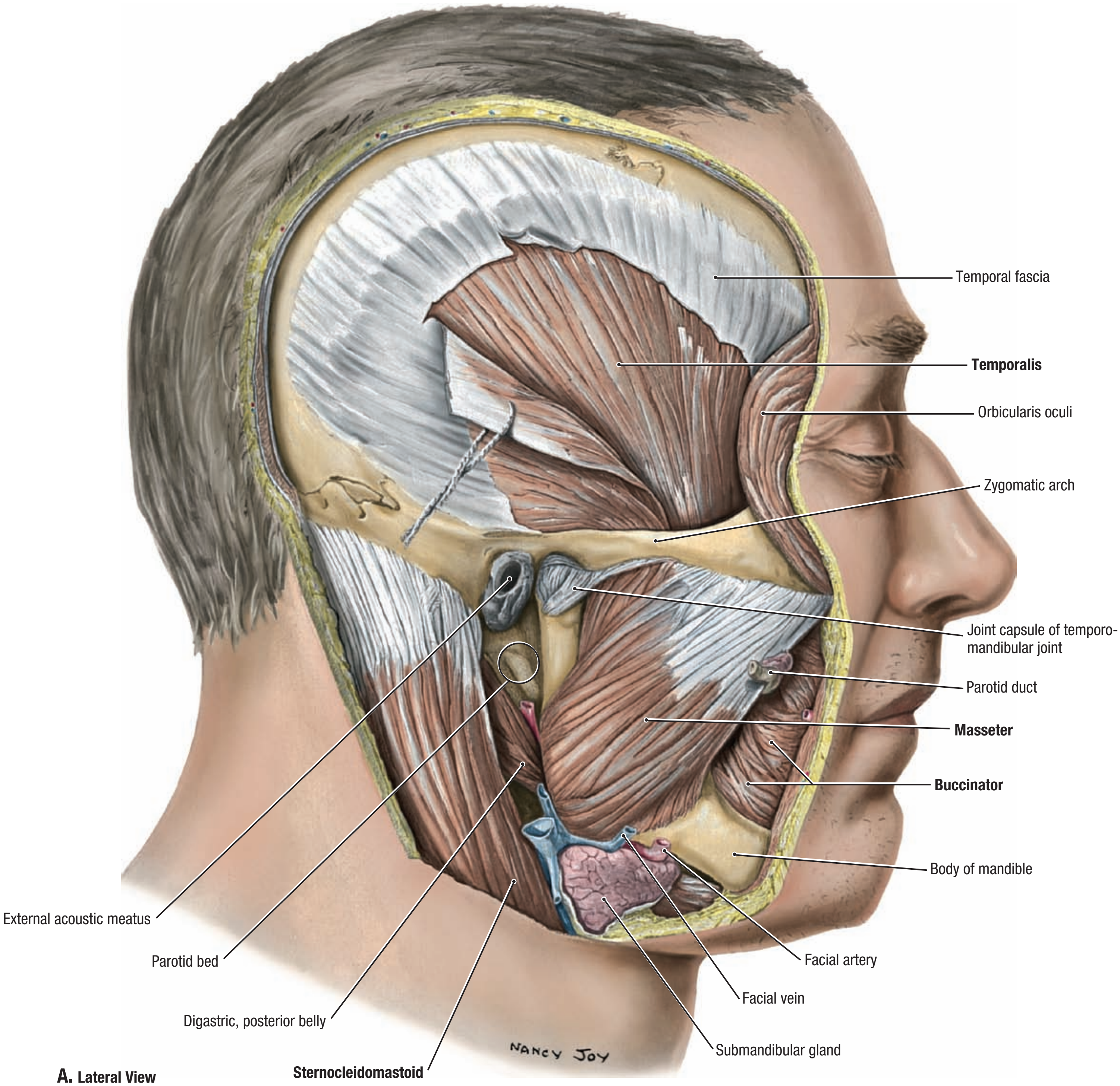


E. **Medial View**

7.48 TEMPORAL AND INFRATEMPORAL FOSSAE AND MANDIBLE *(CONTINUED)*

D. Bones and bony features of the infratemporal fossa. The mandible and part of the zygomatic arch have been removed. Deeply, the infratemporal crest separates the temporal and infratemporal fossae. **E.** Internal surface of the mandible.

- The temporal region is the region of the head that includes the lateral area of the scalp and the deeper soft tissues overlying the temporal fossa of the cranium, superior to the zygomatic arch. The temporal fossa, occupied primarily by the upper portion of the temporalis muscle, is bounded by the inferior temporal lines (see Fig. 7.3B).
- The infratemporal fossa is an irregularly shaped space deep and inferior to the zygomatic arch, deep to the ramus of the mandible and posterior to the maxilla. It communicates with the temporal fossa through the interval between the zygomatic arch and the cranial bones.

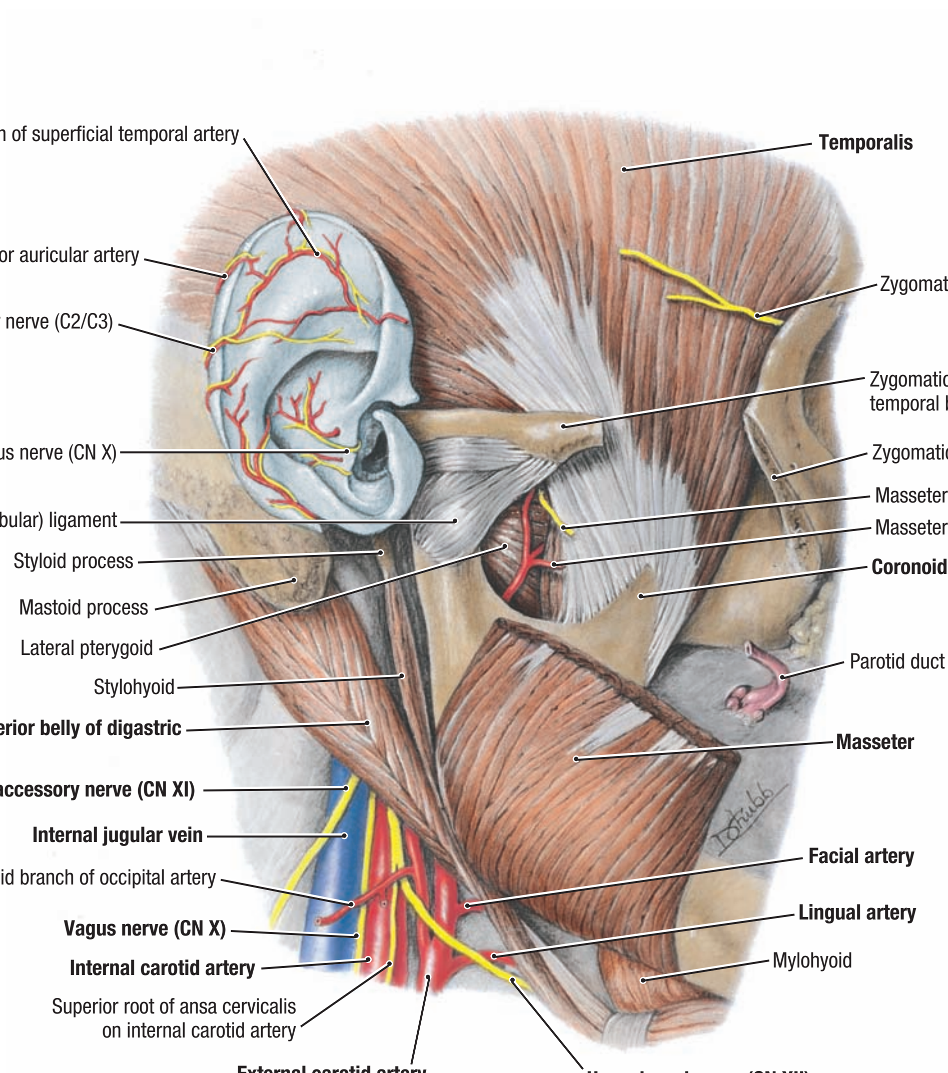


A. **Lateral View**

7.49 TEMPORALIS AND MASSETER

A. Superficial dissection.

- The temporalis and masseter muscles are supplied by the trigeminal nerve (CN V), and both elevate the mandible. The buccinator muscle, supplied by the facial nerve (CN VII), functions during chewing to keep food between the teeth but does not act on the mandible.
- The sternocleidomastoid muscle, supplied by the spinal accessory nerve (CN XI), is the chief flexor of the head and neck; it forms the lateral part of the posterior boundary of the parotid region/parotid bed.

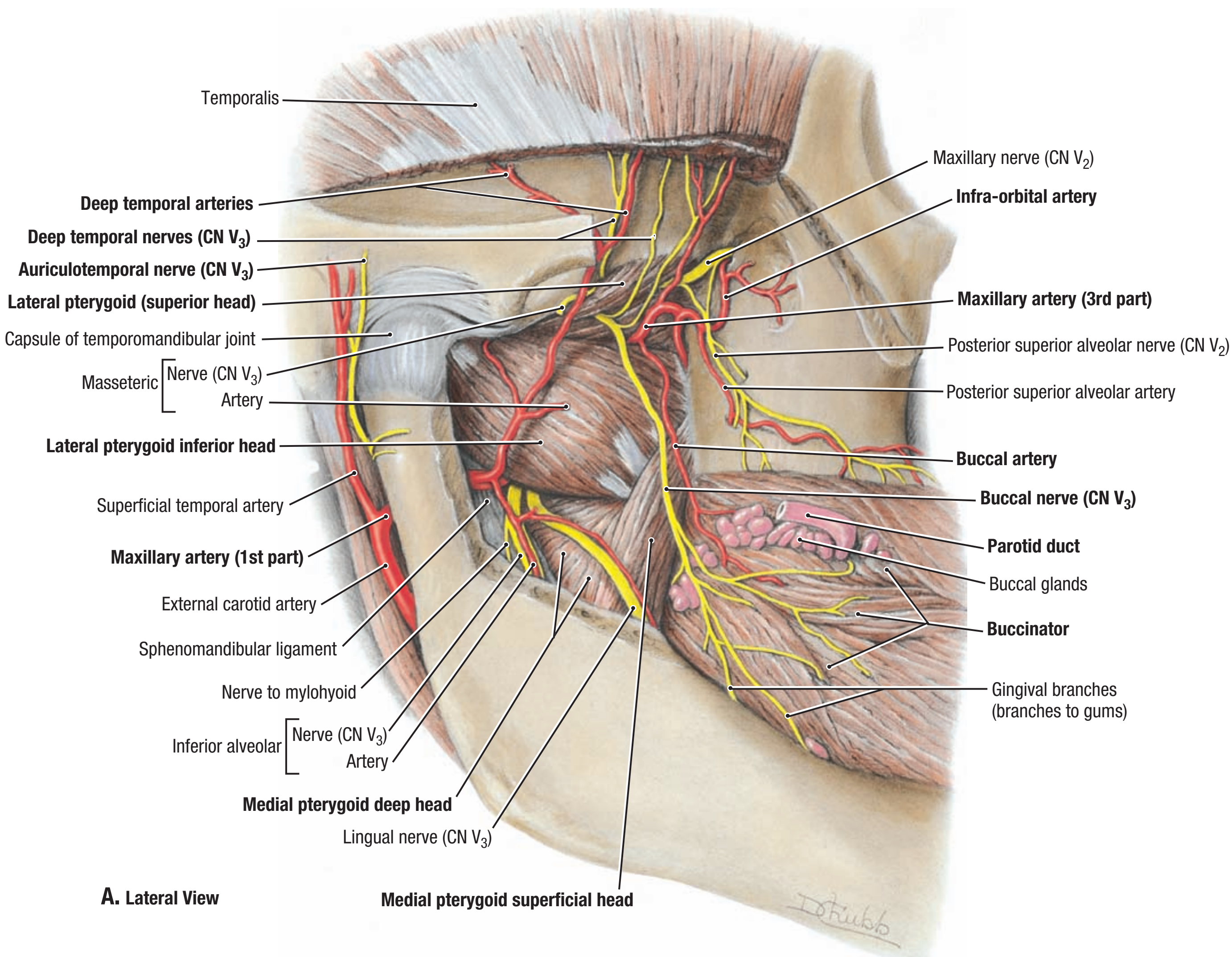


B. Lateral View

7.49 TEMPORALIS AND MASSETER *(CONTINUED)*

B. Deep dissection.

- Parts of the zygomatic arch and the attached masseter muscle have been removed to expose the attachment of the temporalis muscle to the coronoid process of the mandible.
- The carotid sheath surrounding the internal jugular vein, internal carotid artery, and the vagus nerve (CN X) has been removed. The external carotid artery and its lingual, facial, and occipital branches, and the spinal accessory (CN XI) and hypoglossal (CN XII) nerves pass deep to the posterior belly of the digastric muscle.

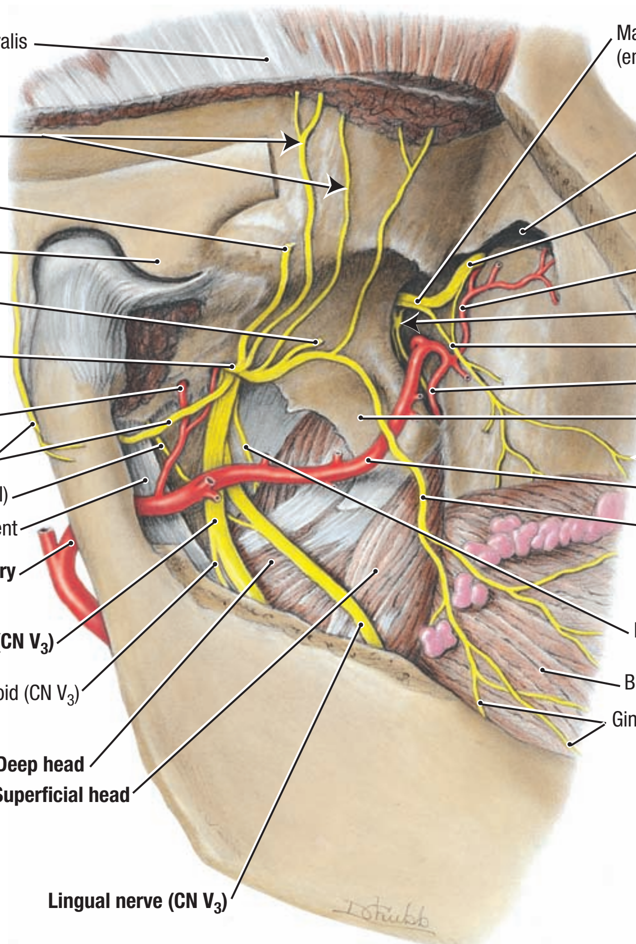


A. Lateral View

7.50 INFRATEMPORAL REGION

A. Superficial dissection.

- The maxillary artery, the larger of two terminal branches of the external carotid, is divided into three parts relative to the lateral pterygoid muscle.
- The buccinator is pierced by the parotid duct, the ducts of the buccal glands, and sensory branches of the buccal nerve.
- The lateral pterygoid muscle arises by two heads (parts), one head from the roof, and the other head from the medial wall of the infratemporal fossa; both heads insert in relation to the temporomandibular joint—the superior head attaching primarily to the articular disc of the joint and the inferior head primarily to the anterior aspect of the neck of the mandible (pterygoid fovea).
- Because of the close relationship of the facial and auriculotemporal nerves to the temporomandibular joint (TMJ), care must be taken during **surgical procedures on the temporomandibular joint** to preserve both the branches of the facial nerve overlying it and the articular branches of the auriculotemporal nerve that enter the posterior part of the joint. Injury to articular branches of the auriculotemporal nerve supplying the TMJ—associated with traumatic dislocation and rupture of the joint capsule and lateral ligament—leads to laxity and instability of the TMJ.

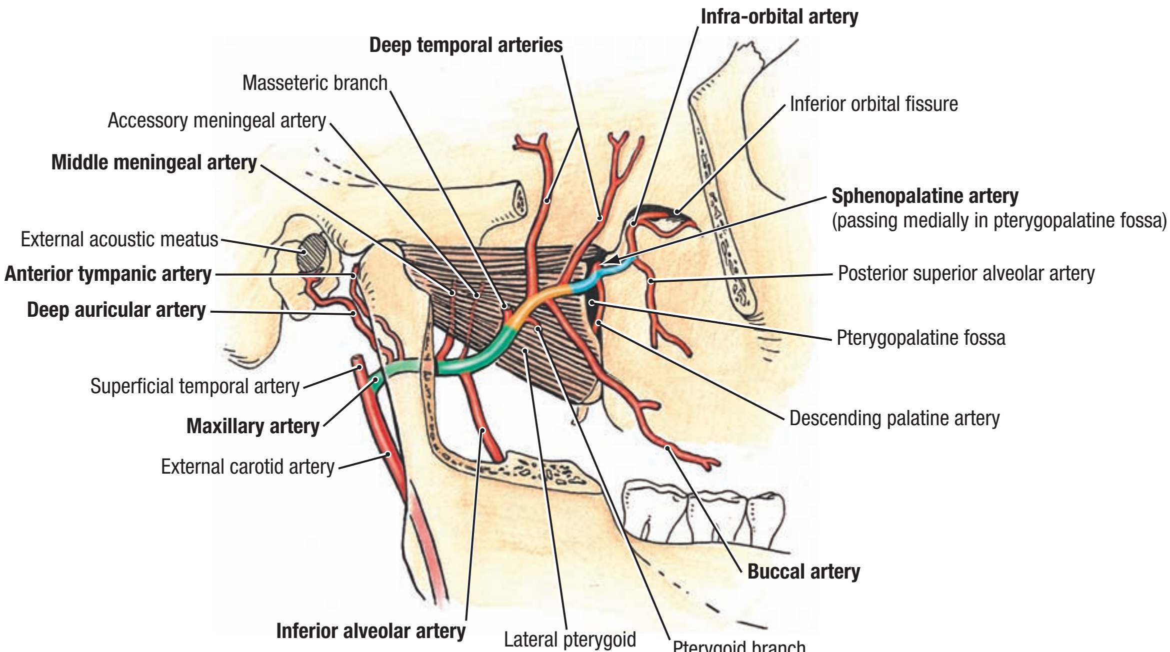


B. Lateral View

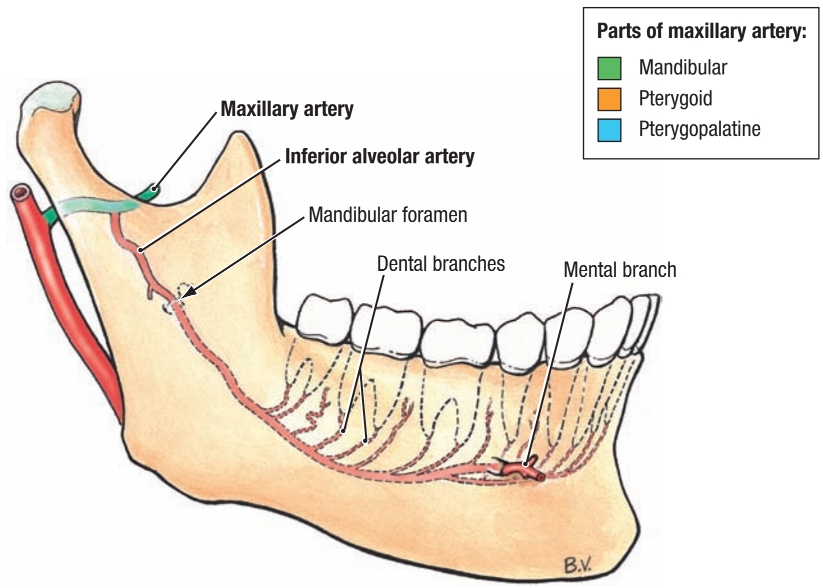
7.50 INFRATEMPORAL REGION *(CONTINUED)*

B. Deeper dissection.

- The lateral pterygoid muscle and most of the branches of the maxillary artery have been removed to expose the mandibular nerve (CN V_3) entering the infratemporal fossa through the foramen ovale and the middle meningeal artery passing through the foramen spinosum.
- The deep head of the medial pterygoid muscle arises from the medial surface of the lateral pterygoid plate and the pyramidal process of the palatine bone. It has a small, superficial head that arises from the tuberosity of the maxilla.
- The inferior alveolar and lingual nerves descend on the medial pterygoid muscle. The inferior alveolar nerve gives off the nerve to mylohyoid and nerve to anterior belly of the digastric muscle, and the lingual nerve receives the chorda tympani, which carries secretory parasympathetic fibers and fibers of taste.
- Motor nerves arising from CN V_3 supply the four muscles of mastication: the masseter, temporalis, and lateral and medial pterygoids. The buccal nerve from the mandibular nerve is sensory; the buccal branch of the facial nerve is the motor supply to the buccinator muscle.
- To perform a **mandibular nerve block,** an anesthetic agent is injected near the mandibular nerve where it enters the infratemporal fossa. This block usually anesthetizes the auriculotemporal, inferior alveolar, lingual, and buccal branches of the mandibular nerve.



A. Lateral View

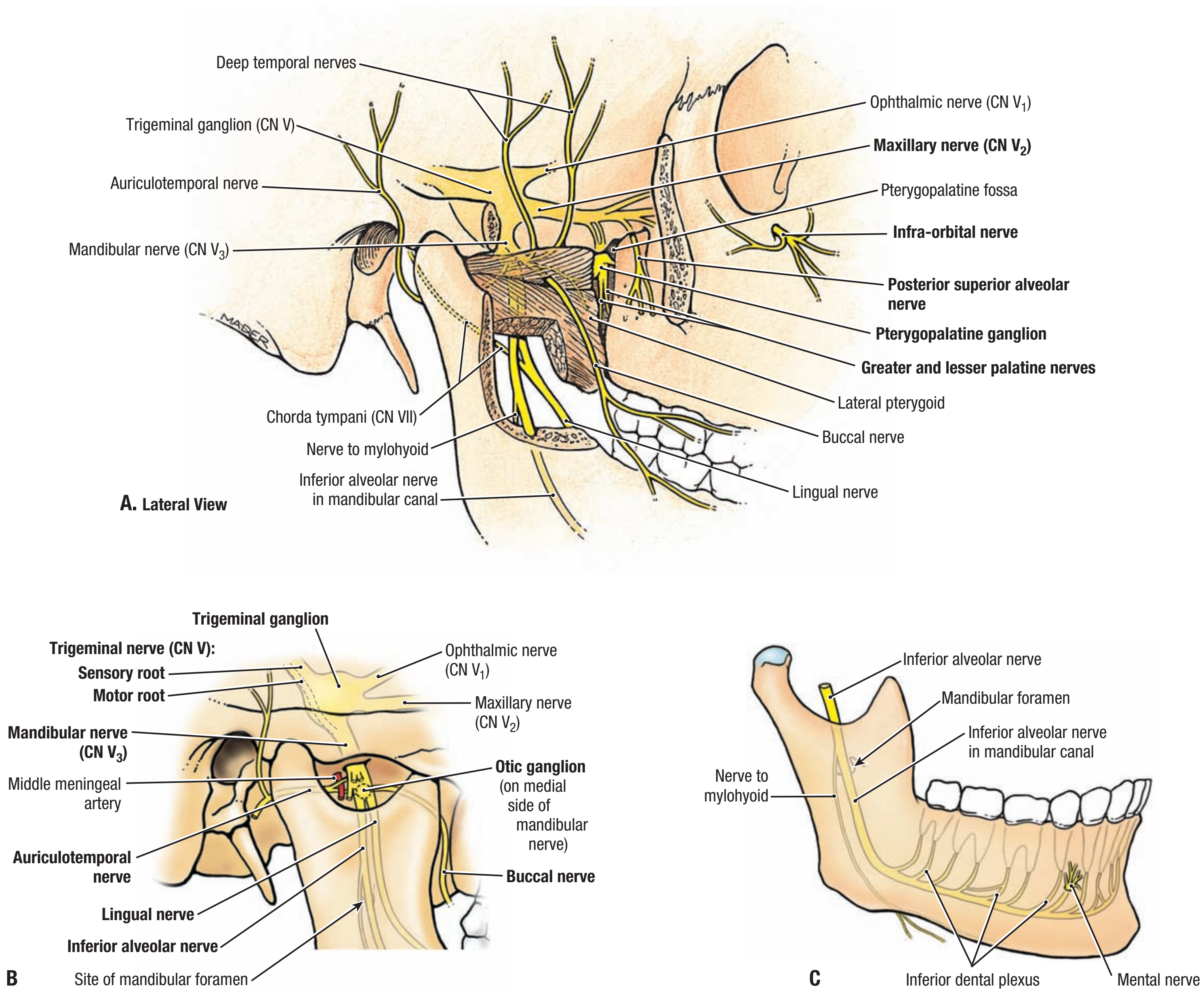


B. Lateral View

7.51 BRANCHES OF MAXILLARY ARTERY

A. Infratemporal region. **B.** Mandible.

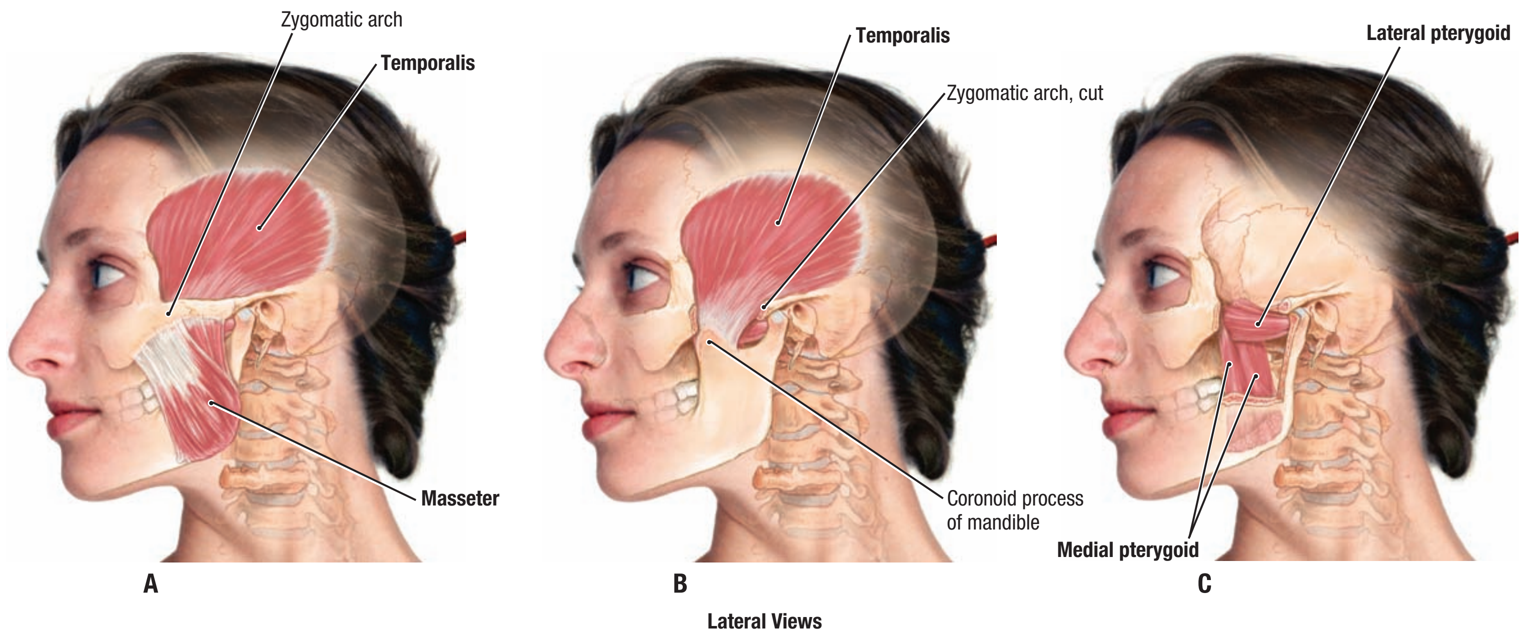
- The maxillary artery arises at the neck of the mandible and is divided into three parts (mandibular, pterygoid, and pterygopalatine) by the lateral pterygoid; it can pass medial or lateral to the lateral pterygoid.
- The branches of the *first (mandibular) part* pass through foramina or canals: the deep auricular to the external acoustic meatus, the anterior tympanic to the tympanic cavity, the middle and accessory meningeal to the cranial cavity, and the inferior alveolar to the mandible and teeth.
- The branches of the *second (pterygoid) part*, directly related to the lateral pterygoid, supply muscles via the masseteric, deep temporal, pterygoid, and buccal branches.
- The branches of the *third (pterygopalatine) part* (posterior superior alveolar, infra-orbital, descending palatine, and sphenopalatine arteries) arise immediately proximal to and within the pterygopalatine fossa.



7.52 BRANCHES OF MAXILLARY AND MANDIBULAR NERVES

A. Infratemporal region and pterygopalatine fossa. Branches of the maxillary (CN V_2) and mandibular (CN V_3) nerves accompany branches from the three parts of the maxillary artery. **B.** Nerves of infratemporal fossa and otic ganglion. **C.** Mandible and inferior alveolar nerve.

An **alveolar nerve block**—commonly used by dentists when repairing mandibular teeth—anesthetizes the inferior alveolar nerve, a branch of CN V_3. The anesthetic agent is injected around the mandibular foramen, the opening into the mandibular canal on the medial aspect of the ramus of the mandible. This canal gives passage to the inferior alveolar nerve, artery, and vein. When this nerve block is successful, all mandibular teeth are anesthetized to the median plane. The skin and mucous membrane of the lower lip, the labial alveolar mucosa and gingiva, and the skin of the chin are also anesthetized because they are supplied by the mental branch of this nerve.



7.53 MUSCLES OF MASTICATION

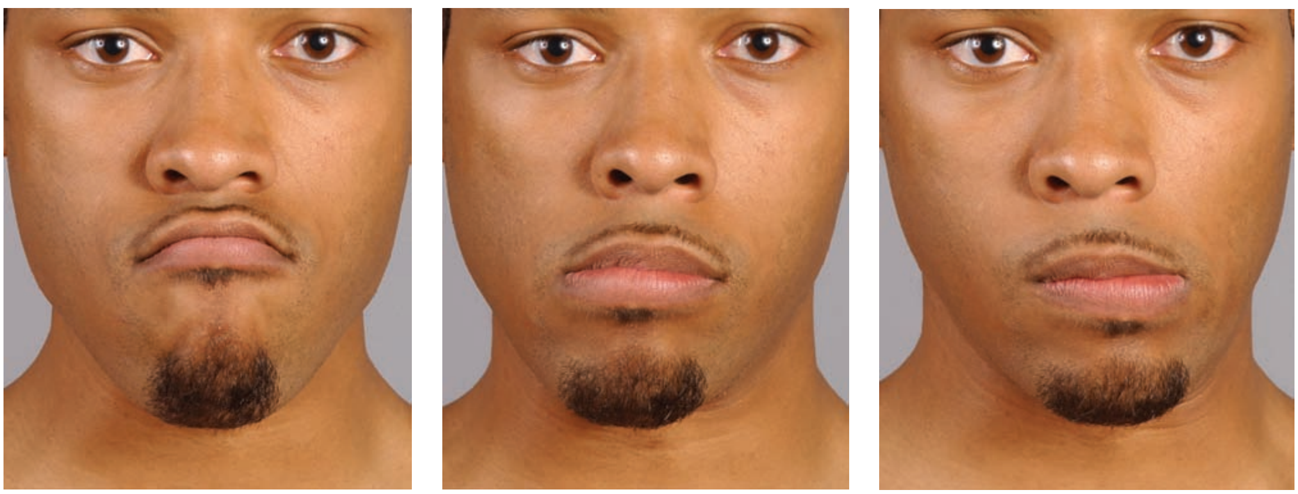
A. Temporalis and masseter. **B.** Temporalis. Zygomatic arch has been removed. **C.** Medial and lateral pterygoid.

TABLE 7.11 MUSCLES OF MASTICATION (ACTING ON TEMPOROMANDIBULAR JOINT)

Muscle	Origin	Insertion	Innervation	Main Action
Temporalis	Floor of temporal fossa and deep surface of temporal fascia	Tip and medial surface of coronoid process and anterior border of ramus of mandible	Deep temporal branches of mandibular nerve (CN V_3)	Elevates mandible, closing jaws; posterior fibers retrude mandible after protrusion
Masseter	Inferior border and medial surface of zygomatic arch	Lateral surface of ramus of mandible and coronoid process	Mandibular nerve (CN V_3) through masseteric nerve that enters deep surface of the muscle	Elevates and protrudes mandible, thus closing jaws; deep fibers retrude it
Lateral pterygoid	*Superior head:* infratemporal surface and infratemporal crest of greater wing of sphenoid bone *Inferior head:* lateral surface of lateral pterygoid plate	Neck of mandible, articular disc, and capsule of temporomandibular joint	Mandibular nerve (CN V_3) through lateral pterygoid nerve which enters its deep surface	*Acting bilaterally,* protrude mandible and depress chin; *Acting unilaterally* alternately, they produce side-to-side movements of mandible
Medial pterygoid	*Deep head:* medial surface of lateral pterygoid plate and pyramidal process of palatine bone *Superficial head:* tuberosity of maxilla	Medial surface of ramus of mandible, inferior to mandibular foramen	Mandibular nerve (CN V_3) through medial pterygoid nerve	Helps elevate mandible, closing jaws; *acting bilaterally* protrude mandible; *acting unilaterally,* protrudes side of jaw; acting alternately, they produce a grinding motion

A. Elevation of mandible **B.** Depression of mandible **C.** Retrusion **D.** Protrusion

Lateral Views



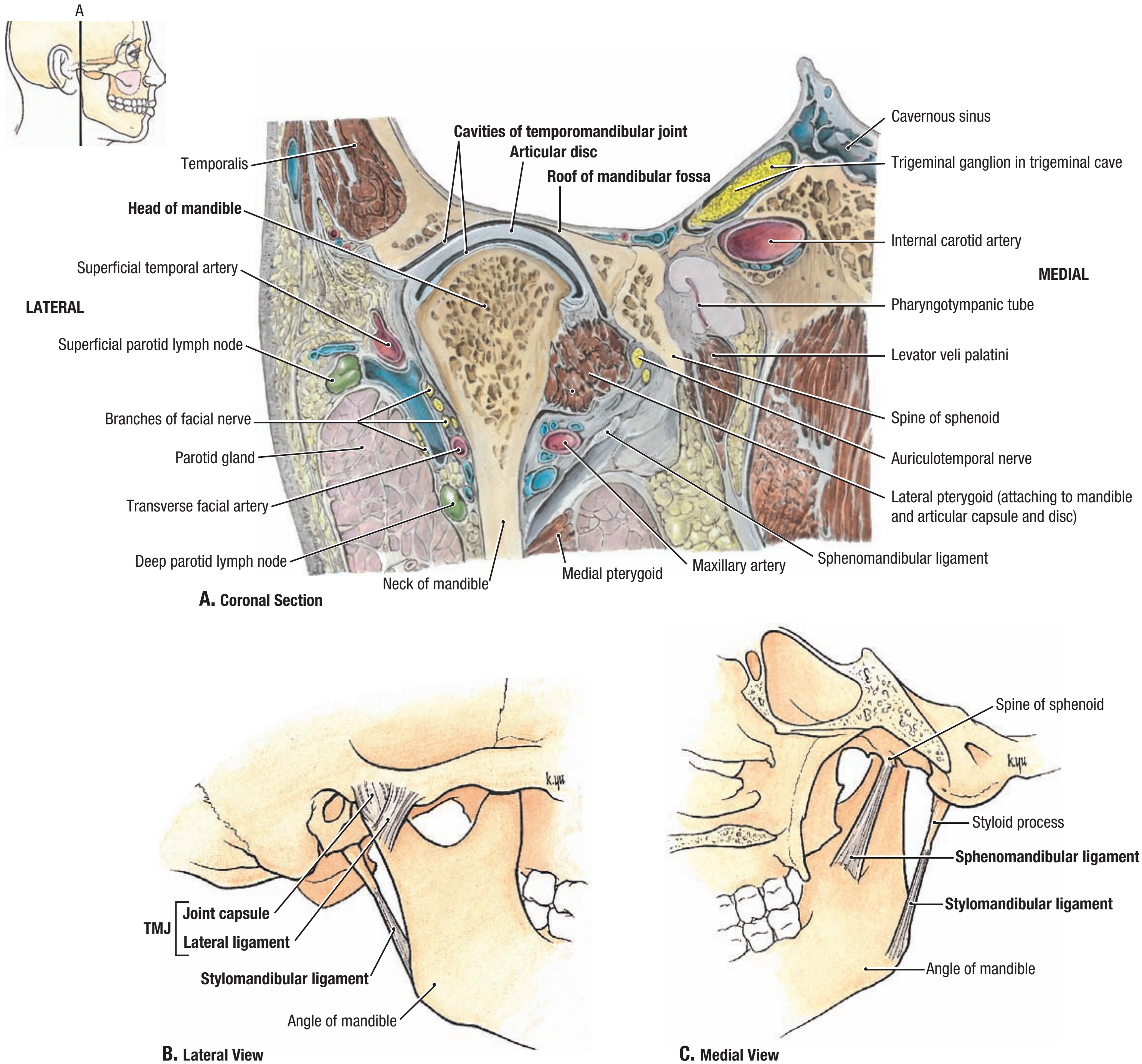
E. Protrusion **F.** Lateral movement to right side **G.** Lateral movement to left side

Anterior Views

7.54 MOVEMENTS OF TEMPOROMANDIBULAR JOINT

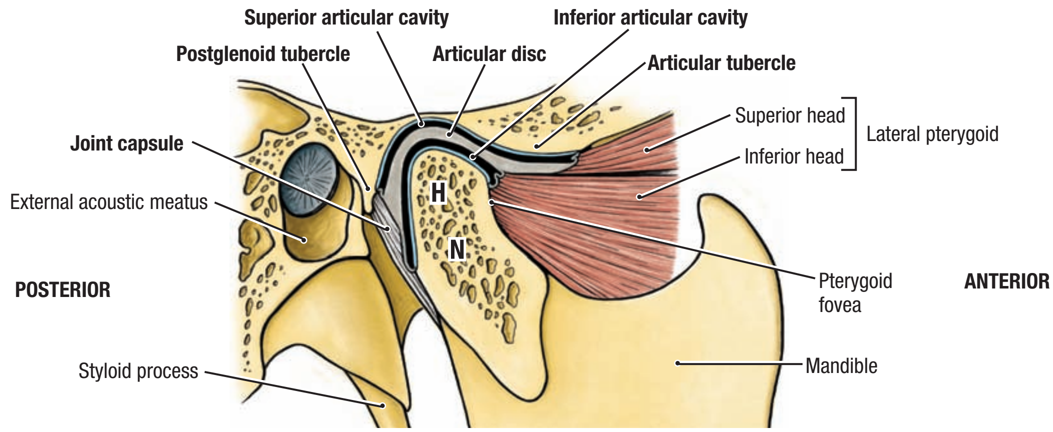
TABLE 7.12 MOVEMENTS OF TEMPOROMANDIBULAR JOINT

Movements	Muscles
Elevation (close mouth) (A)	Temporalis, masseter, and medial pterygoid
Depression (open mouth) (B)	Lateral pterygoid; suprahyoid and infrahyoid muscles; gravity
Retrusion (retrude chin) (C)	Temporalis (posterior oblique and near horizontal fibers) and masseter
Protrusion (protrude chin) (D and E)	Lateral pterygoid, masseter, and medial pterygoid
Lateral movements (grinding and chewing) (F and G)	Temporalis of same side, pterygoids of opposite side, and masseter

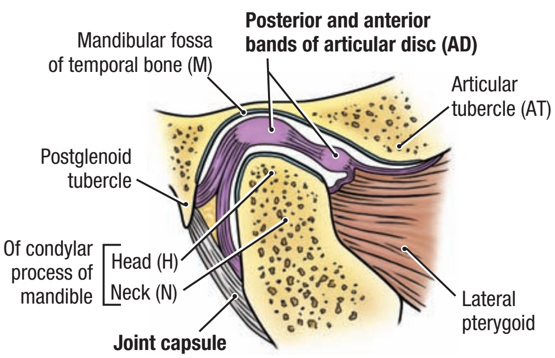


7.55 TEMPOROMANDIBULAR JOINT

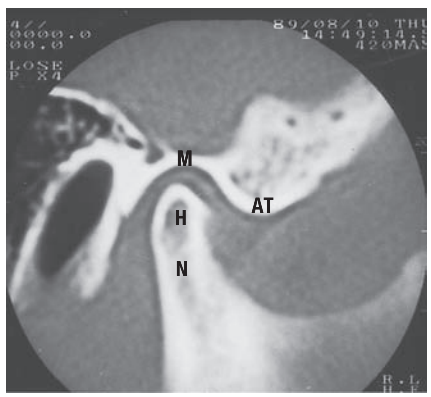
A. Coronal section. **B.** Temporomandibular joint and stylomandibular ligament. The joint capsule of the temporomandibular joint attaches to the margins of the mandibular fossa and articular tubercle of the temporal bone and around the neck of the mandible; the lateral (temporomandibular) ligament strengthens the lateral aspect of the joint. **C.** Stylomandibular and sphenomandibular ligaments. The strong sphenomandibular ligament descends from near the spine of the sphenoid to the lingula of the mandible and is the "swinging hinge" by which the mandible is suspended; the weaker stylomandibular ligament is a thickened part of the parotid sheath that joins the styloid process to the angle of the mandible.



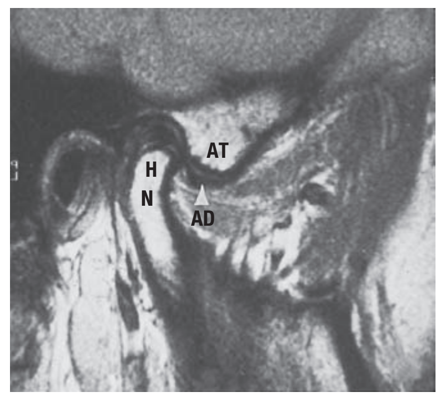
A. Sagittal Section



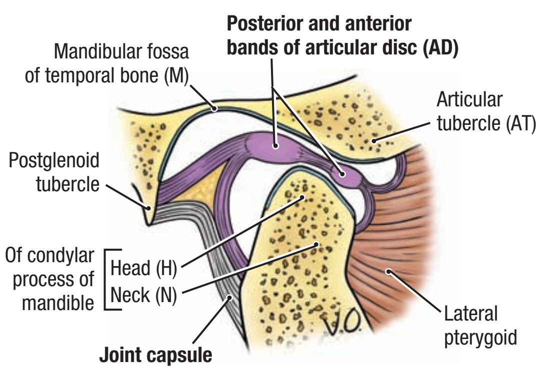
B. Closed Mouth, Sagittal Section



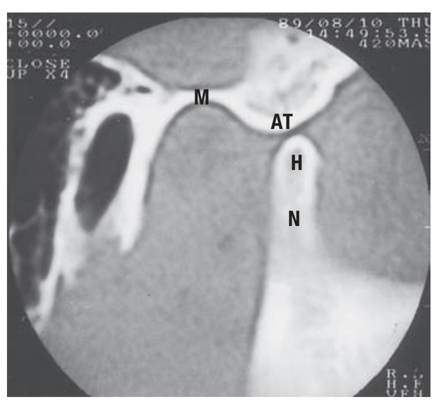
Sagittal CT



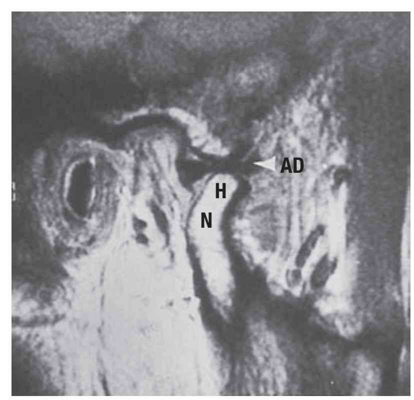
Sagittal MRI



C. Open Mouth, Sagittal Section



Sagittal CT

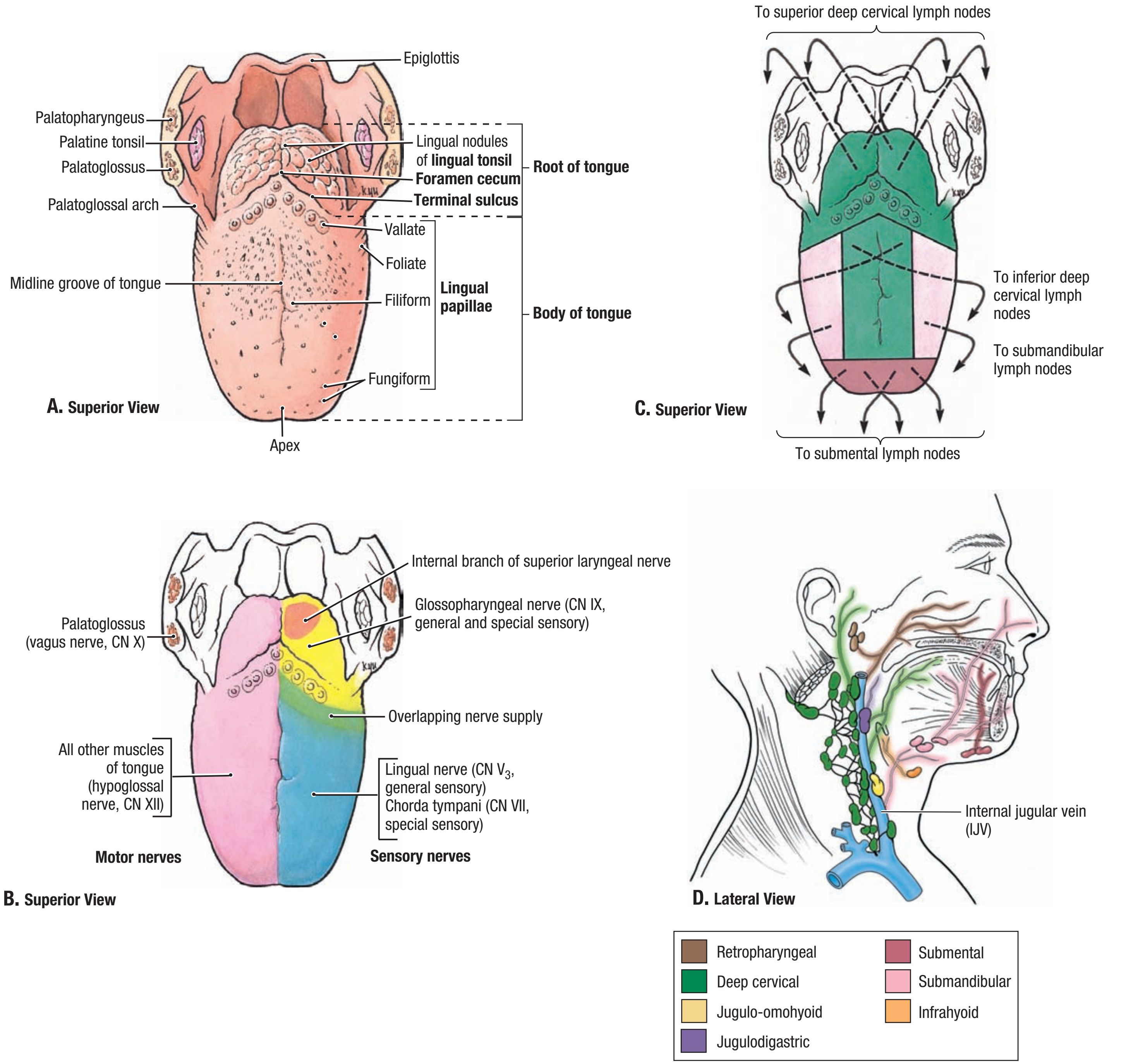


Sagittal MRI

7.56 SECTIONAL ANATOMY OF TEMPOROMANDIBULAR JOINT

A. TMJ and related structures, sagittal section. **B.** Sagittal orientation figure, CT, and MRI—mouth closed. **C.** Sagittal orientation figure, CT, and MRI—mouth opened widely. The articular disc divides the articular cavity into superior and inferior compartments, each lined by a separate synovial membrane.

Dislocation of mandible. During yawning or taking large bites, excessive contraction of the lateral pterygoids can cause the head of the mandible to dislocate (pass anterior to the articular tubercle). In this position, the mouth remains wide open, and the person cannot close it without manual distraction.

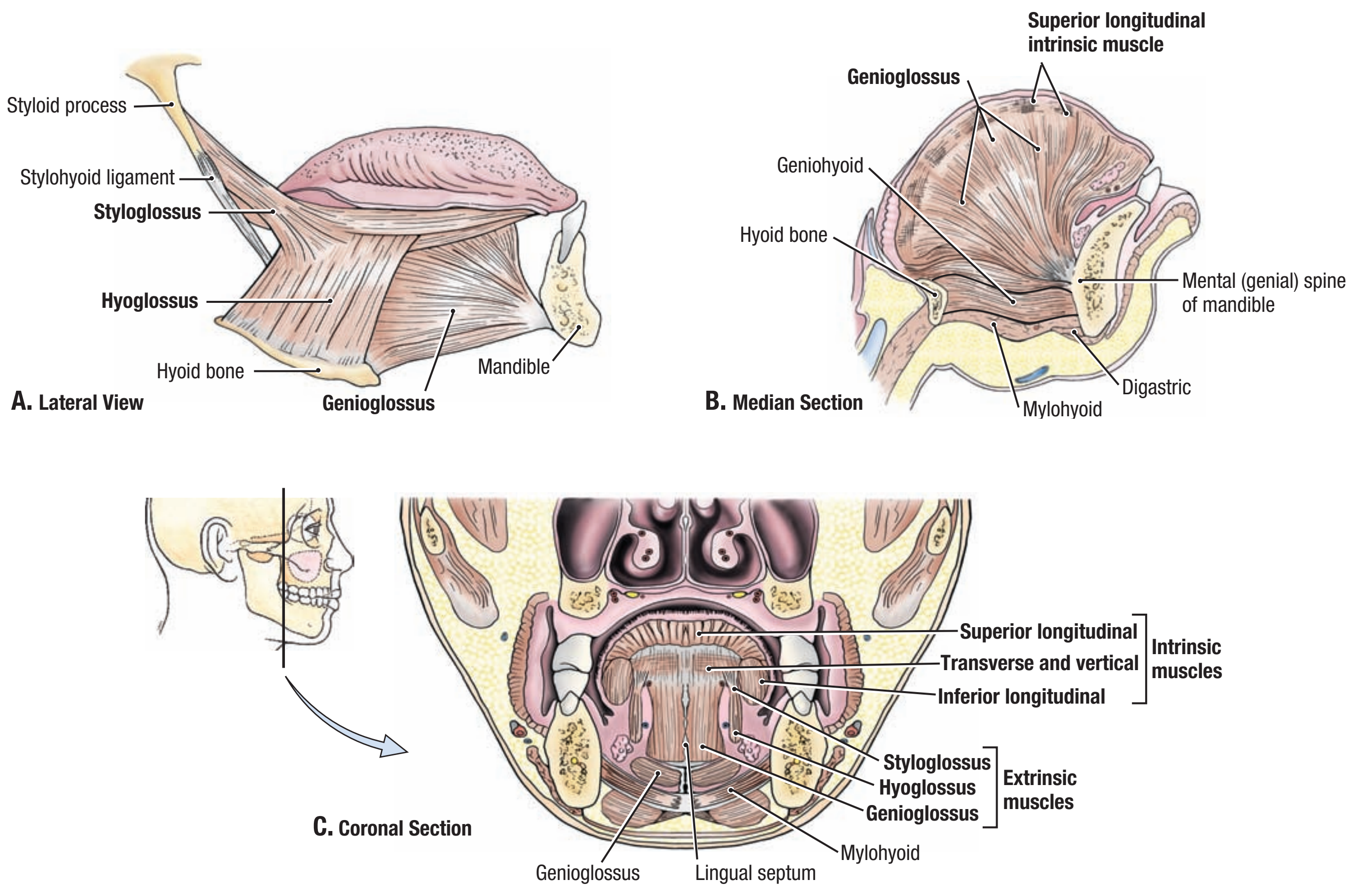


7.57 TONGUE

A. Features of dorsum of the tongue. The foramen cecum is the upper end of the primitive thyroglossal duct; the arms of the V-shaped terminal sulcus diverge from the foramen, demarcating the posterior third of the tongue from the anterior two thirds. **B.** General sensory, special sensory (taste), and motor innervation of tongue. **C.** Lymphatic drainage of dorsum of tongue. **D.** Lymphatic drainage of tongue, mouth, nasal cavity, and nose.

Carcinoma of tongue. Malignant tumors in the posterior part of the tongue metastasize to the superior deep cervical lymph nodes on both sides. In contrast, tumors in the apex and anterolateral parts usually do not metastasize to the inferior deep cervical nodes until late in the disease. Because the deep nodes are closely related to the internal jugular vein, metastases from the carcinoma may spread to the submental and submandibular regions and along the IJV into the neck.

Gag reflex. One may touch the anterior part of the tongue without feeling discomfort; however, when the posterior part is touched, one usually gags. CN IX and CN X are responsible for the muscular contraction of each side of the pharynx. Glossopharyngeal branches (CN IX) provide the afferent limb of the gag reflex.



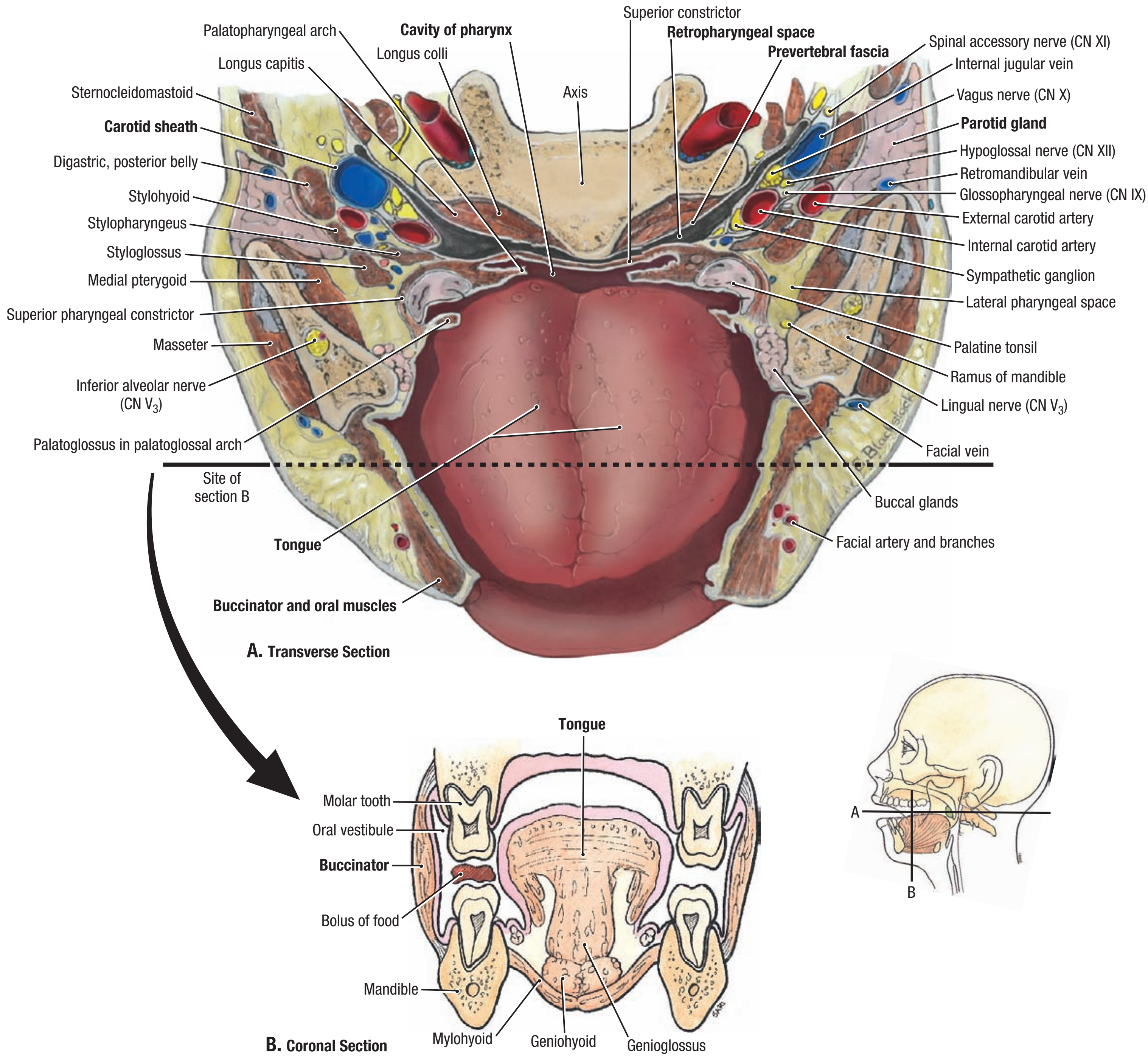
7.58 MUSCLES OF TONGUE

The extrinsic muscles of the tongue originate outside the tongue and attach to it, whereas the intrinsic muscles have their attachments entirely within the tongue and are not attached to bone.

TABLE 7.13 MUSCLES OF TONGUE

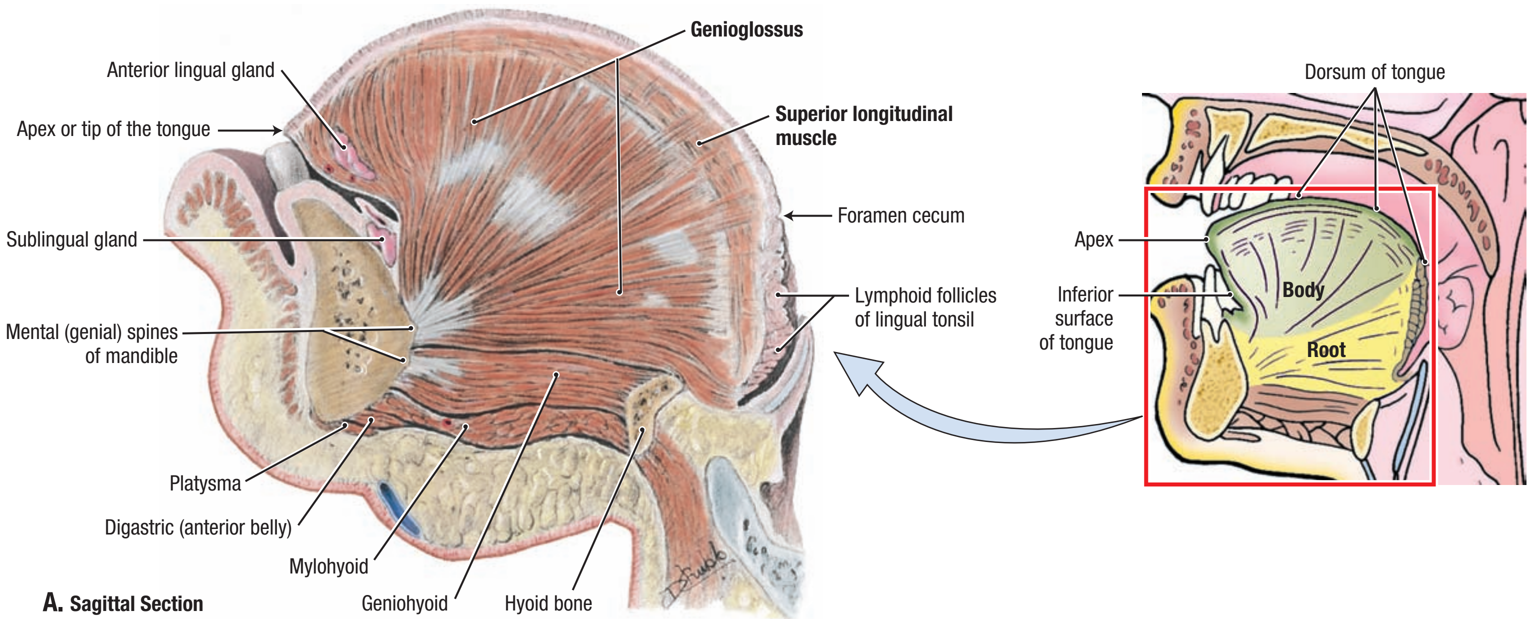
Muscle	Origin	Insertion	Innervation	Main Action
Extrinsic Muscles				
Genioglossus	Superior part of mental spine of mandible	Dorsum of tongue and body of hyoid bone		Depresses tongue; its posterior part pulls tonguew anteriorly for protrusion[a]
Hyoglossus	Body and greater horn of hyoid bone	Side and inferior aspect of tongue	Hypoglossal nerve (CN XII)	Depresses and retracts tongue
Styloglossus	Styloid process of temporal bone and stylohyoid ligament	Side and inferior aspect of tongue		Retracts tongue and draws it up to create a trough for swallowing
Palatoglossus	Palatine aponeurosis of soft palate	Side of tongue	CN X and pharyngeal plexus	Elevates posterior part of tongue plexus
Intrinsic Muscles				
Muscle	**Origin**	**Insertion**	**Innervation**	**Main Action**
Superior longitudinal	Submucous fibrous layer and lingual septum	Margins and mucous membrane of tongue		Curls tip and sides of tongue superiorly and shortens tongue
Inferior longitudinal	Root of tongue and body of hyoid bone	Apex of tongue	Hypoglossal nerve (CN XII)	Curls tip of tongue inferiorly and shortens tongue
Transverse	Lingual septum	Fibrous tissue at margins of tongue		Narrows and elongates the tongue[a]
Vertical	Superior surface of borders of tongue	Inferior surface of borders of tongue		Flattens and broadens the tongue[a]

[a]Acts simultaneously to protrude tongue.

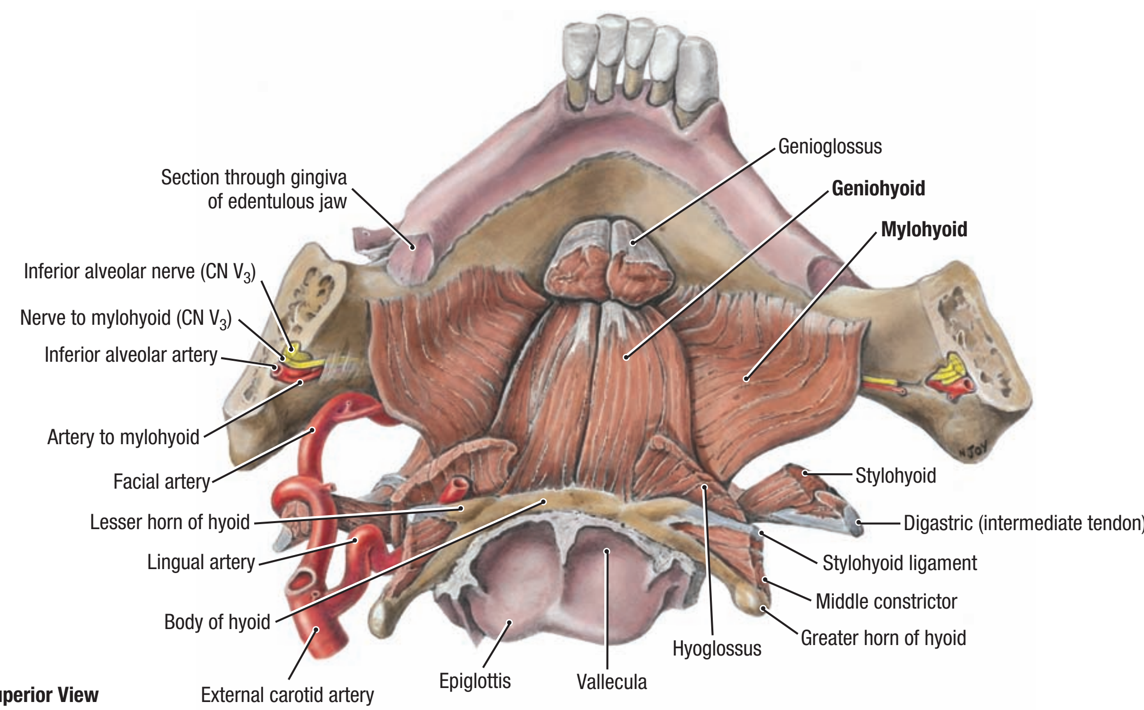


7.59 SECTIONS THROUGH MOUTH

A. The viscerocranium has been sectioned at the C1 vertebral level, the plane of section passing through the oral fissure anteriorly. The retropharyngeal space (opened up in this specimen) allows the pharynx to contract and relax during swallowing; the retropharyngeal space is closed laterally at the carotid sheath and limited posteriorly by the prevertebral fascia. The beds of the parotid glands are also demonstrated. **B.** Schematic coronal section demonstrating how the tongue and buccinator (or, anteriorly, the orbicularis oris) work together to retain food between the teeth when chewing. The buccinator and superior part of the orbicularis oris are innervated by the buccal branch of the facial nerve (CN VII).



A. Sagittal Section

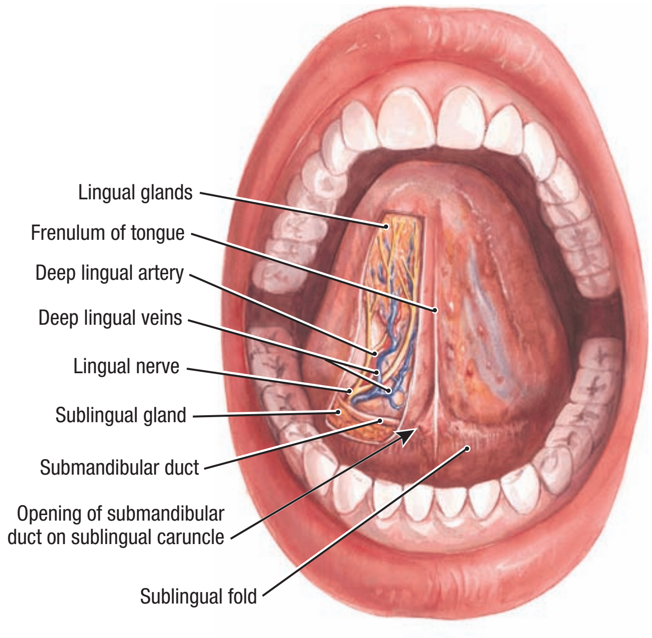


B. Posterosuperior View

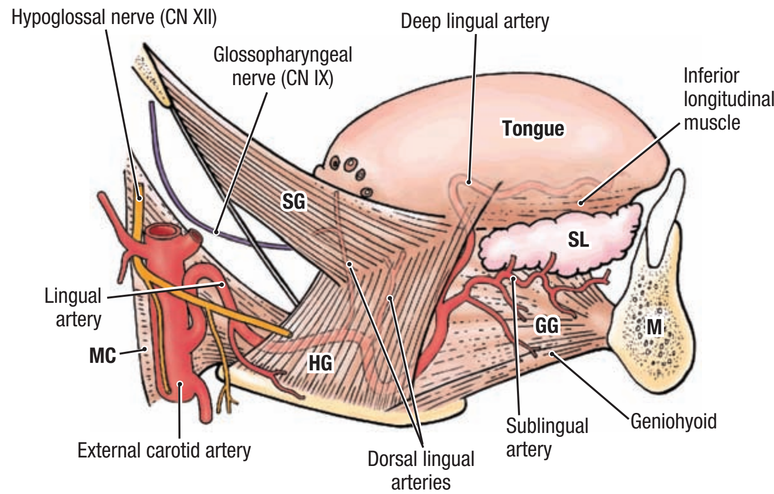
7.60 TONGUE AND FLOOR OF MOUTH

A. Median section though the tongue and lower jaw. The tongue is composed mainly of muscle; extrinsic muscles alter the position of the tongue, and intrinsic muscles alter its shape. The genioglossus is the extrinsic muscle apparent in this plane, and the superior longitudinal muscle is the intrinsic muscle. **B.** Muscles of the floor of the mouth viewed posterosuperiorly. The mylohyoid muscle extends between the two mylohyoid lines of the mandible. It has a thick, free posterior border and becomes thinner anteriorly.

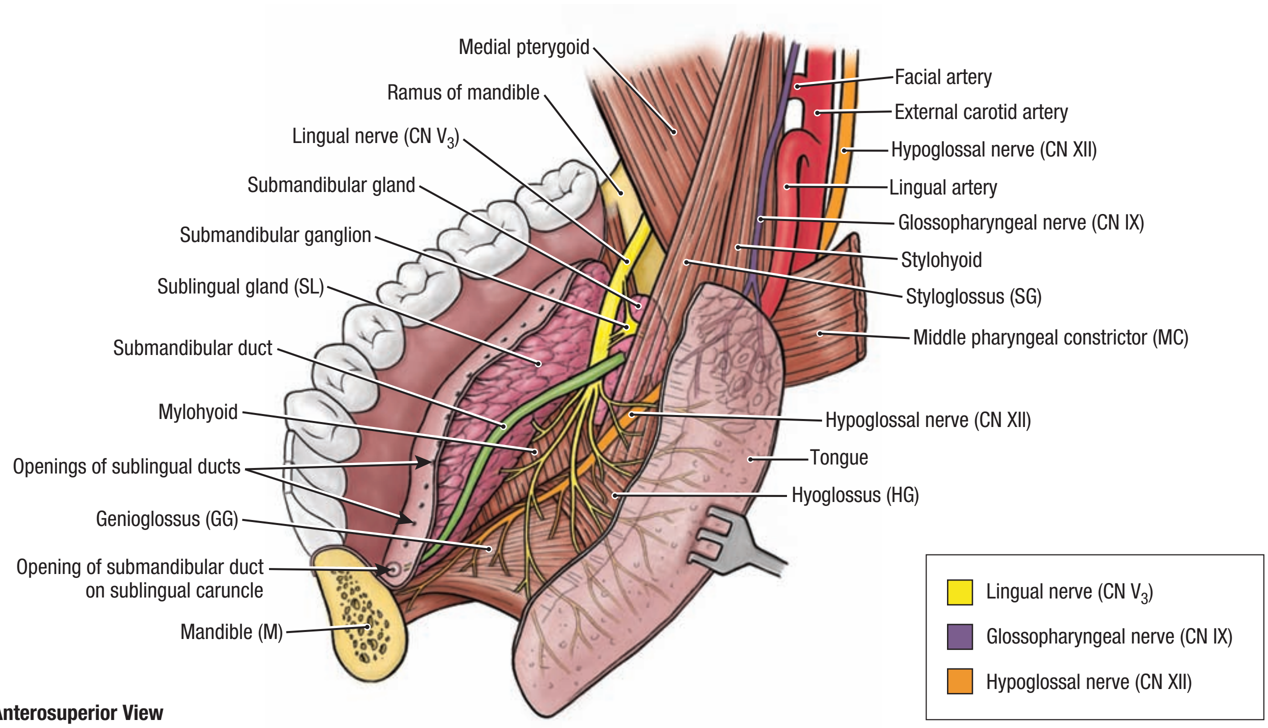
Genioglossus paralysis. When the genioglossus is paralyzed, the tongue mass has a tendency to shift posteriorly, obstructing the airway and presenting the risk of suffocation. Total relaxation of the genioglossus muscles occurs during general anesthesia; therefore, the tongue of an anesthetized patient must be prevented from relapsing by inserting an airway.



A. **Anterior View**



B. **Lateral View**

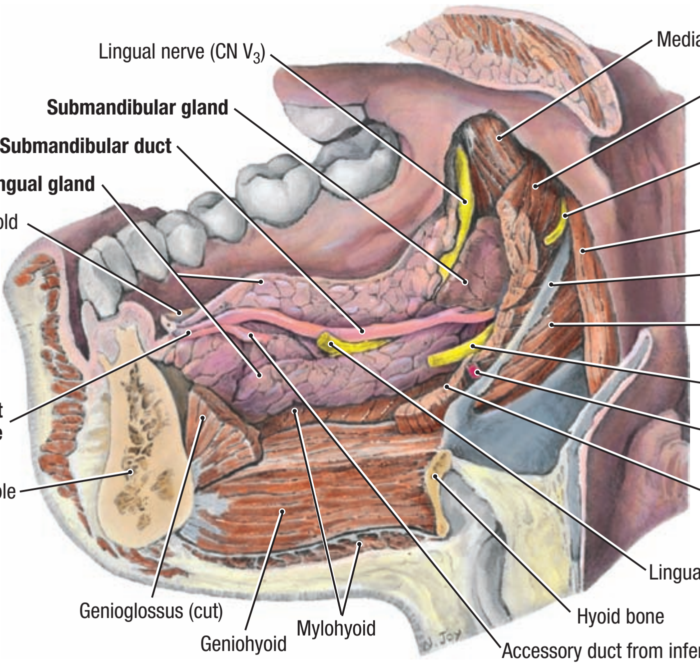


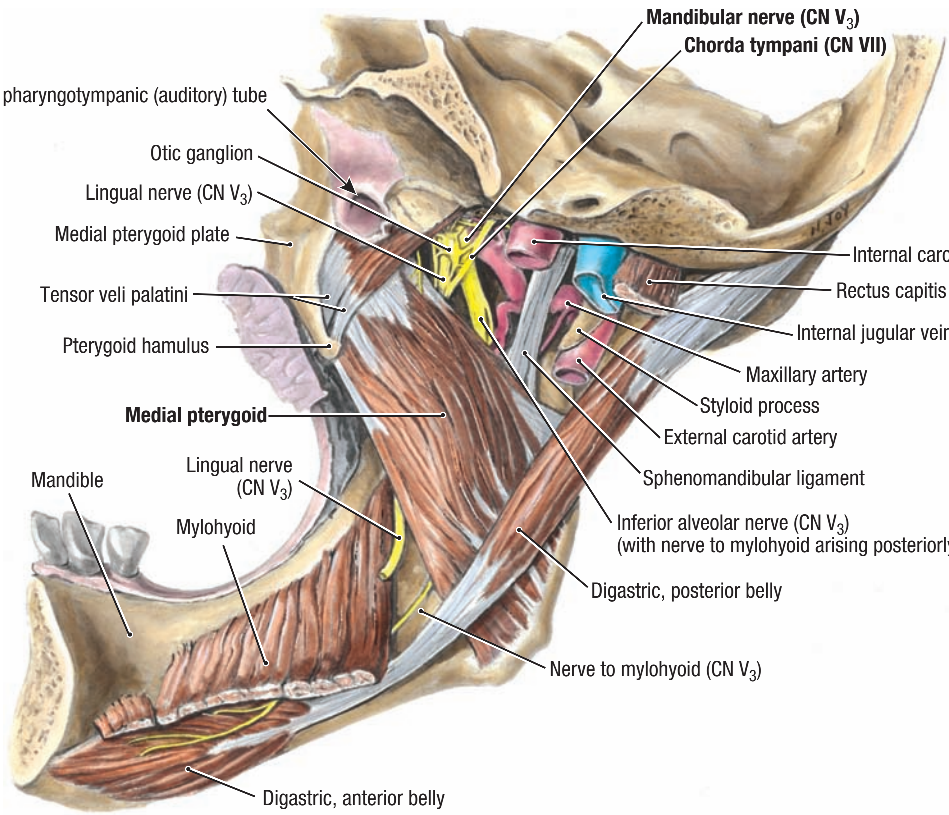
C. **Anterosuperior View**

7.61 ARTERIES AND NERVES OF THE TONGUE

A. Inferior surface of the tongue and floor of the mouth. The thin sublingual mucosa has been removed on the left side. **B.** Course and distribution of the lingual artery. **C.** Dissection of right side of floor of mouth. Letters in parentheses refer to **B**.

Sialography. The parotid and submandibular salivary glands may be examined radiographically after the injection of a contrast medium into their ducts. This special type of radiograph (sialogram) demonstrates the salivary ducts and some secretory units. Because of the small size and number of sublingual ducts of the sublingual glands, one cannot usually inject contrast medium into them.

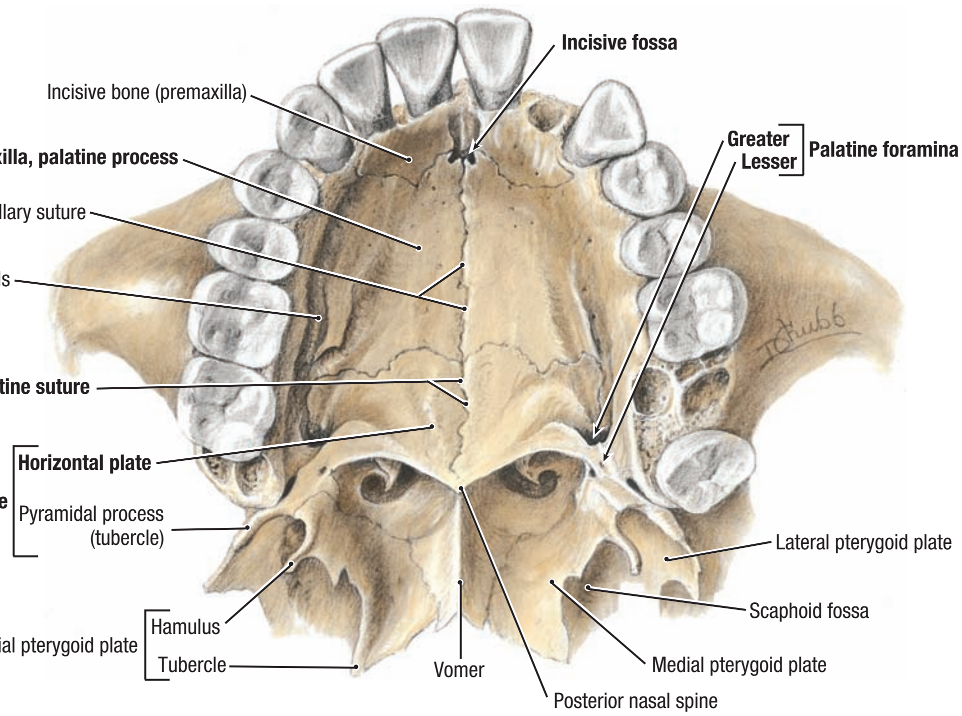




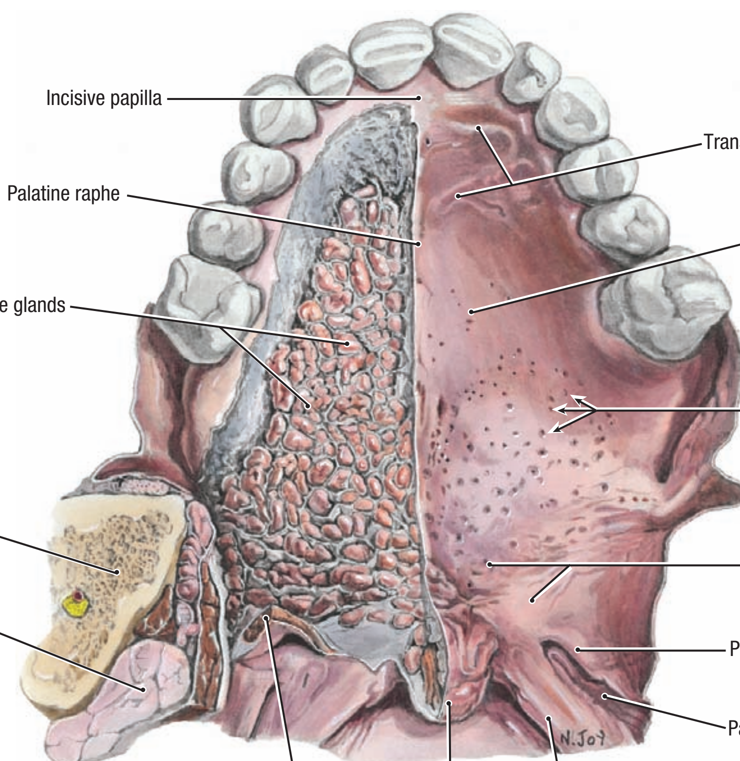
Medial Views

7.62 MUSCLES, GLANDS, AND VESSELS OF FLOOR OF MOUTH AND MEDIAL ASPECT OF MANDIBLE

A. Sublingual and submandibular glands. The tongue has been excised. **B.** Structures related to the medial surface of the mandible. The otic ganglion lies medial to the mandibular nerve (CN V_3) and between the foramen ovale superiorly and the medial pterygoid muscle inferiorly.



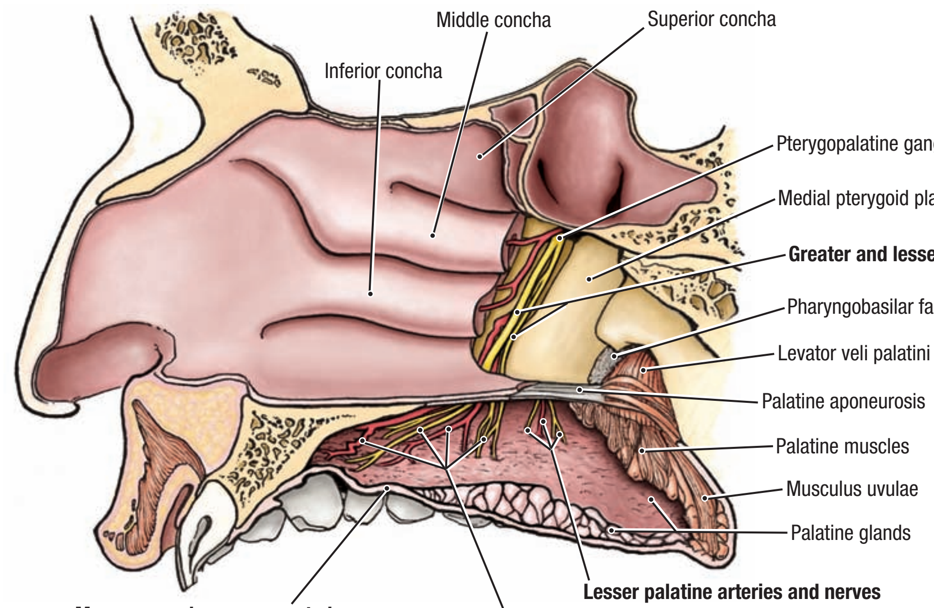
A. Inferior View



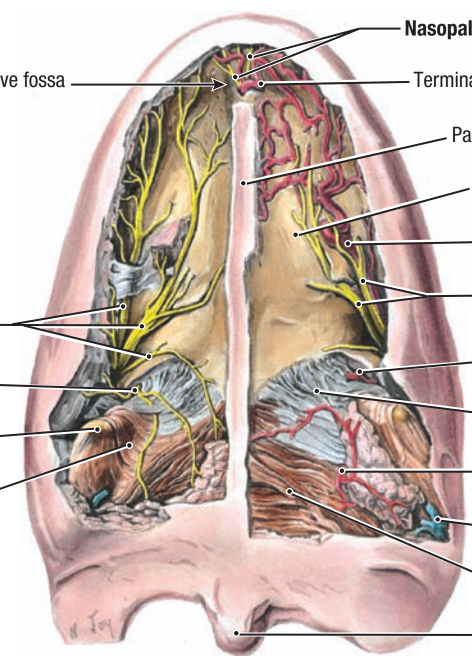
B. Inferior View

7.63 PALATE

A. Bones of the hard palate. The palatine aponeurosis, which forms the fibrous "skeleton" of the soft palate, stretches between the hamuli of the medial pterygoid plates. **B.** Mucous membrane and glands of palate.



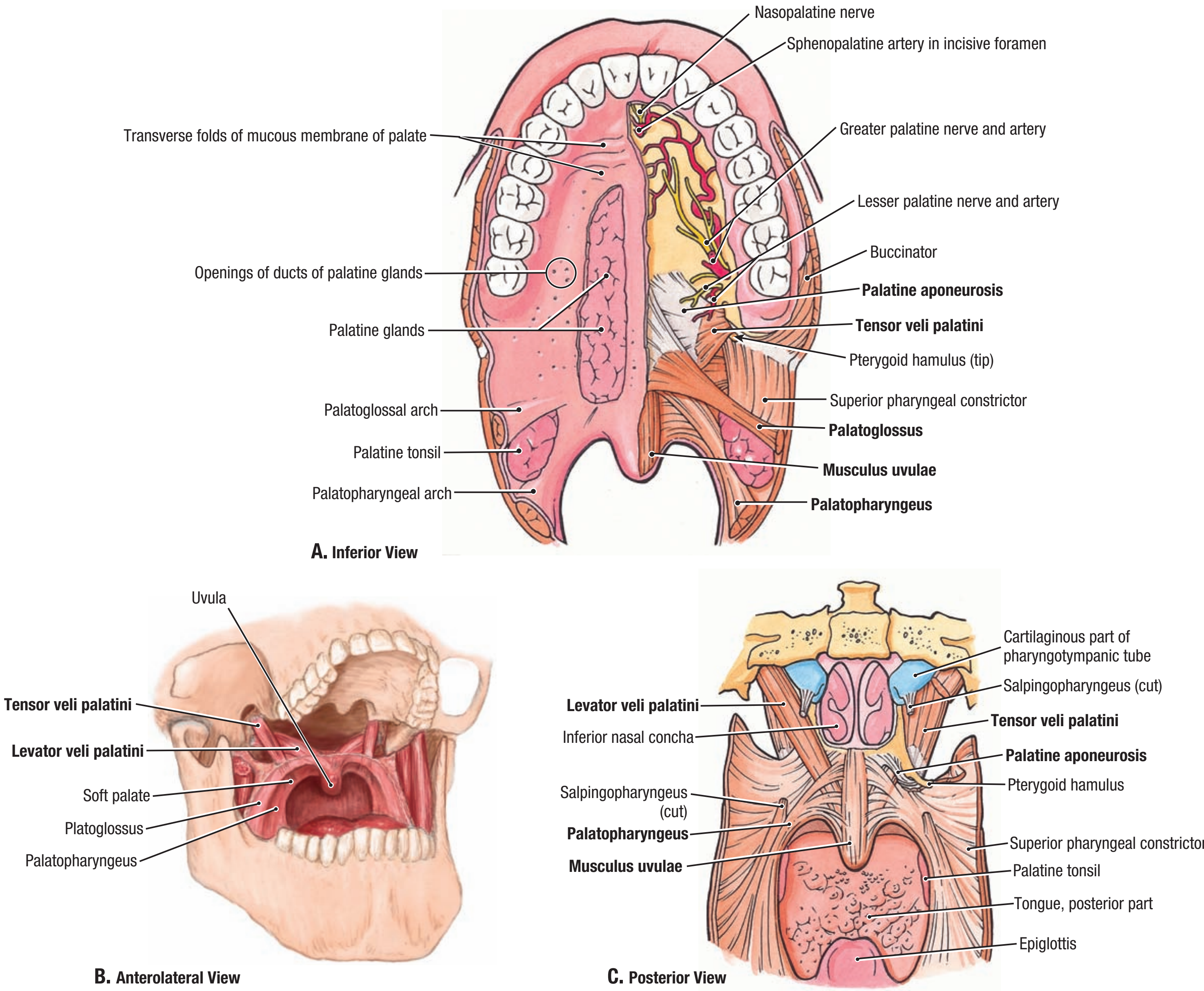
C. Lateral View



D. Inferior View

7.63 PALATE *(CONTINUED)*

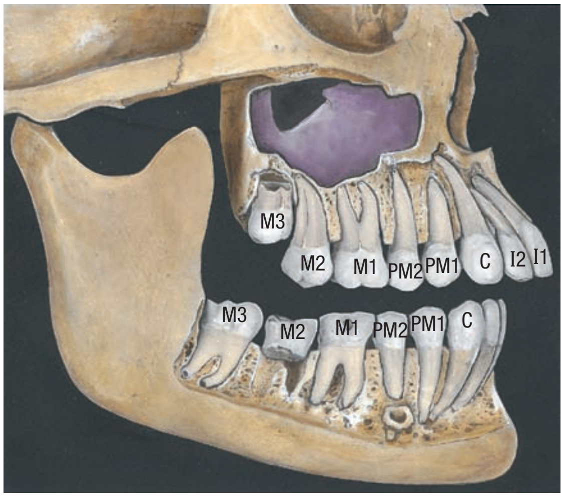
C. Nerves and vessels of palatine canal. The lateral wall of the nasal cavity is shown. The posterior ends of the middle and inferior conchae are excised along with the mucoperiosteum; the thin, perpendicular plate of the palatine bone is removed to expose the palatine nerves and arteries. **D.** Dissection of an edentulous palate. The greater palatine nerve supplies the gingivae and hard palate, the nasopalatine nerve the incisive region, and the lesser palatine nerves the soft palate. **Anesthesia of palatine nerves.** The nasopalatine nerves can be anesthetized by injecting anesthetic into the mouth of the incisive fossa in the hard palate. The anesthetized tissues are the palatal mucosa, the lingual gingivae, the six anterior maxillary teeth, and associated alveolar bone. The greater palatine nerve can be anesthetized by injecting anesthetic into the greater palatine foramen. The nerve emerges between the second and third maxillary molar teeth. This nerve block anesthetizes the palatal mucosa and lingual gingivae posterior to the maxillary canine teeth, and the underlying bone of the palate.



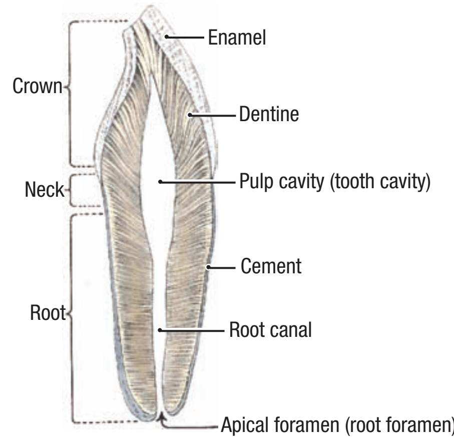
7.64 MUSCLES OF SOFT PALATE

TABLE 7.14 MUSCLES OF SOFT PALATE

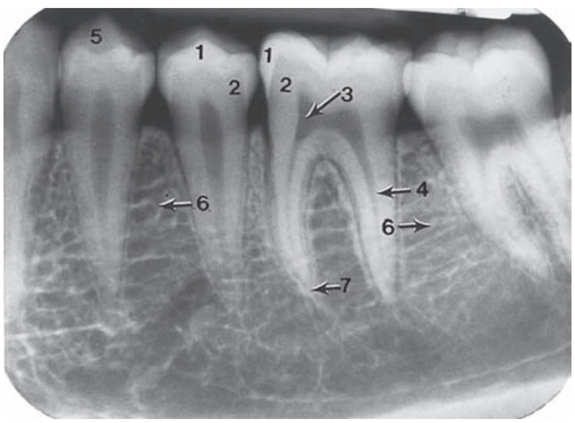
Muscle	Superior Attachment	Inferior Attachment	Innervation	Main Action(s)
Levator veli palatini	Cartilage of pharyngotympanic tube and petrous part of temporal bone	Palatine aponeurosis	Pharyngeal branch of vagus nerve through pharyngeal plexus	Elevates soft palate during swallowing and yawning
Tensor veli palatini	Scaphoid fossa of medial pterygoid plate, spine of sphenoid bone, and cartilage of pharyngotympanic tube		Medial pterygoid nerve (CN V_3) through otic ganglion	Tenses soft palate and opens mouth of pharyngotympanic tube during swallowing and yawning
Palatoglossus	Palatine aponeurosis	Side of tongue	Pharyngeal branch of vagus nerve (CN X) via pharyngeal plexus	Elevates posterior part of tongue and draws soft palate onto tongue
Palatopharyngeus	Hard palate and palatine aponeurosis	Lateral wall of pharynx		Tenses soft palate and pulls walls of pharynx superiorly, anteriorly, and medially during swallowing
Musculus uvulae	Posterior nasal spine and palatine aponeurosis	Mucosa of uvula		Shortens uvula and pulls it superiorly



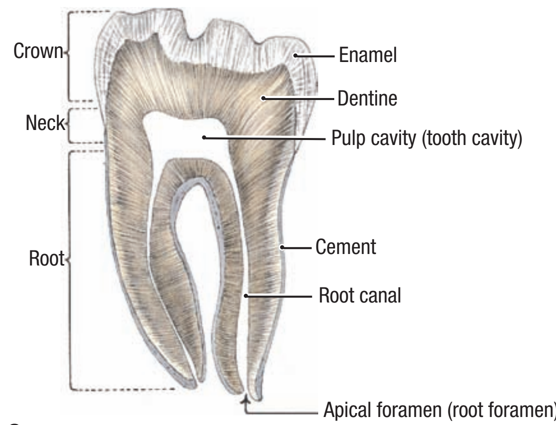
A. **Lateral View**



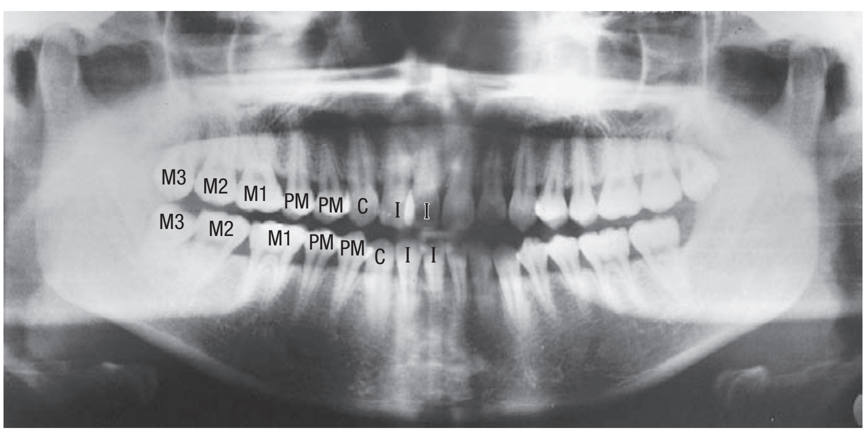
Incisor Tooth, Longitudinal Section



B. **Lateral Radiograph**



C. **Molar Tooth, Longitudinal Section**

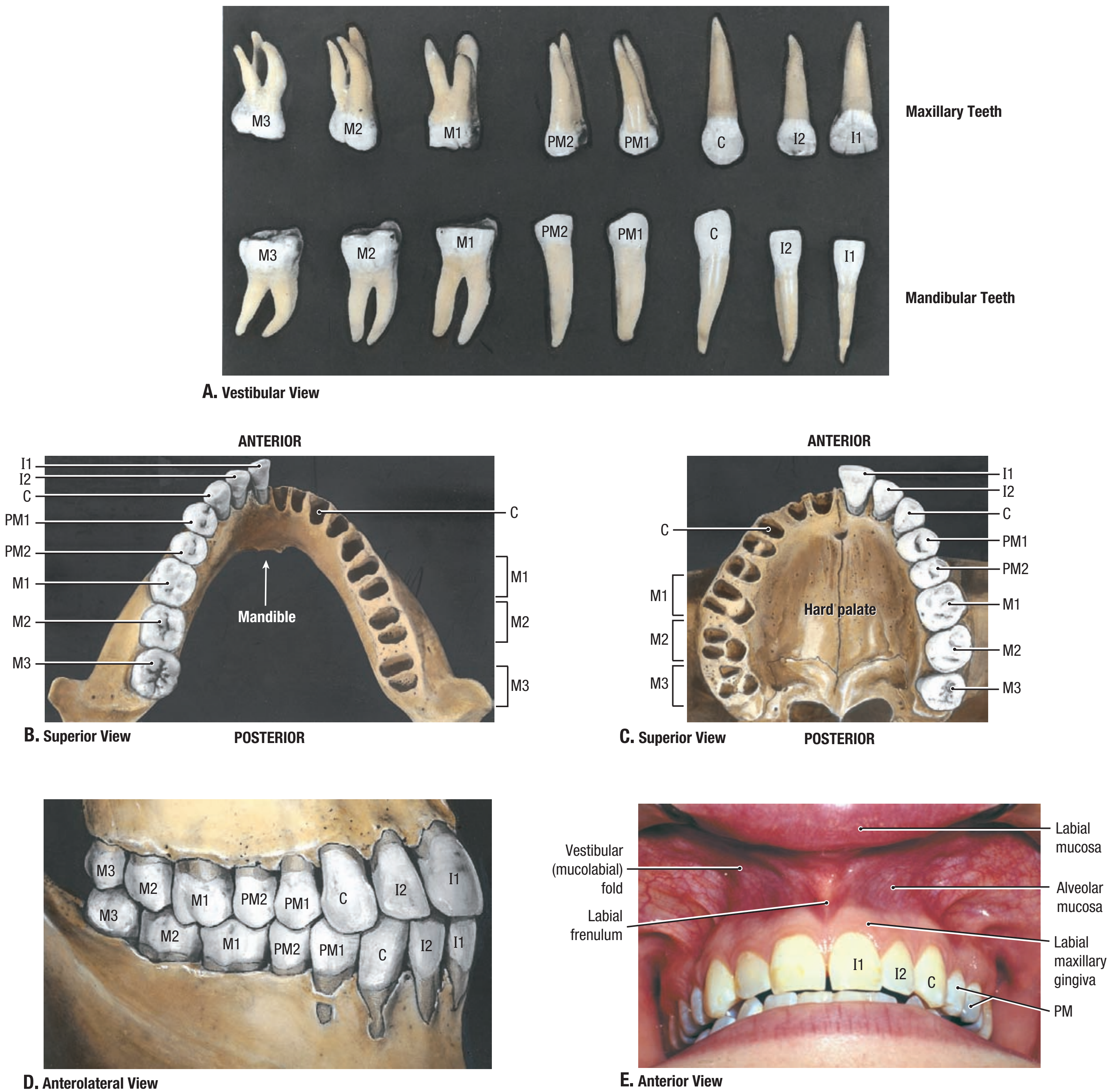


D. **Pantomographic Radiograph**

7.65 PERMANENT TEETH I

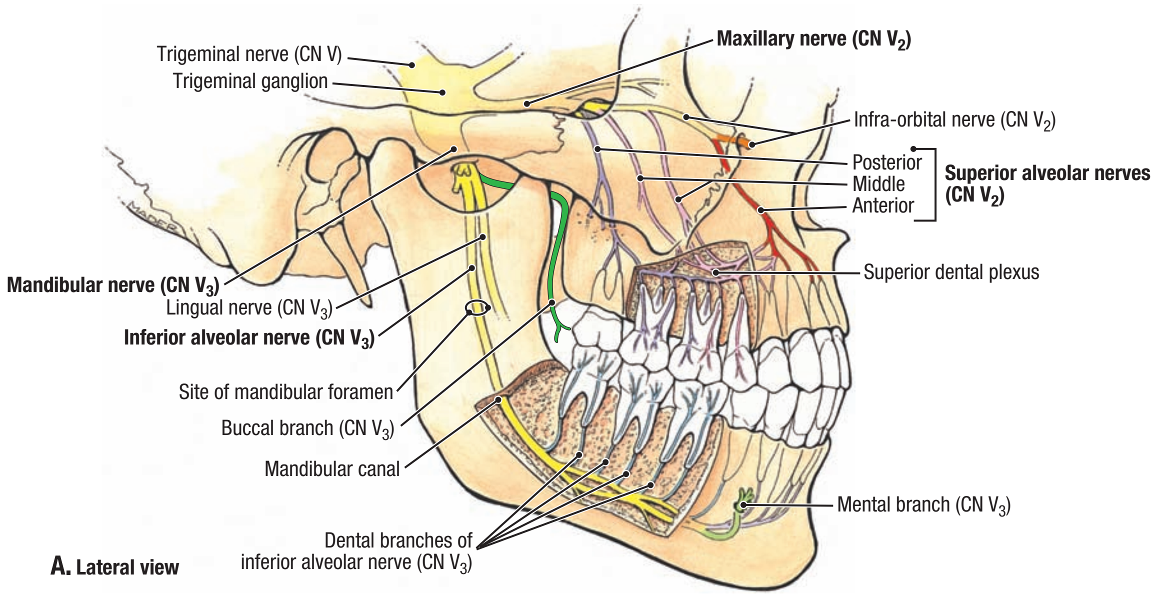
A. Teeth in situ with roots exposed. Incisors *(I1, I2)*, canine *(C1)*, premolars *(PM1, PM2)*, and molars *(M1, M2, M3)*. The roots of the 2nd lower molar have been removed. **B.** Lateral radiograph. *(1)* enamel, *(2)* dentin, *(3)* pulp chamber, *(4)* pulp canal, *(5)* buccal cusp, (*6)* alveolar bone, and *(7)* root apex. **C.** Longitudinal sections of an incisor and a molar tooth. **D.** Pantomographic radiograph of mandible and maxilla. The left lower third molar is not present.

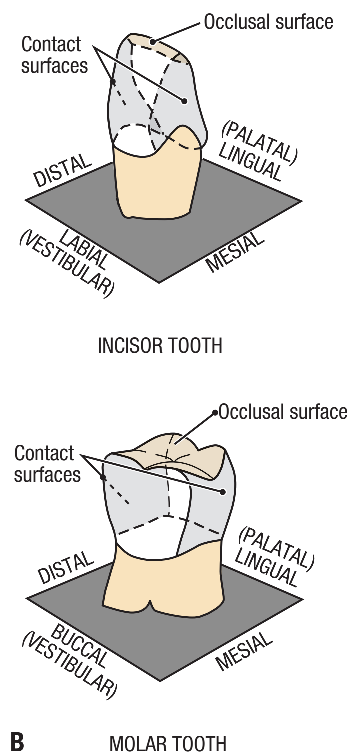
Decay of the hard tissues of a tooth results in the formation of **dental caries** (cavities). Invasion of the pulp of the tooth by a carious lesion (cavity) results in infection and irritation of the tissues in the pulp cavity. This condition causes an inflammatory process (pulpitis). Because the pulp cavity is a rigid space, the swollen pulpal tissues cause pain (toothache).

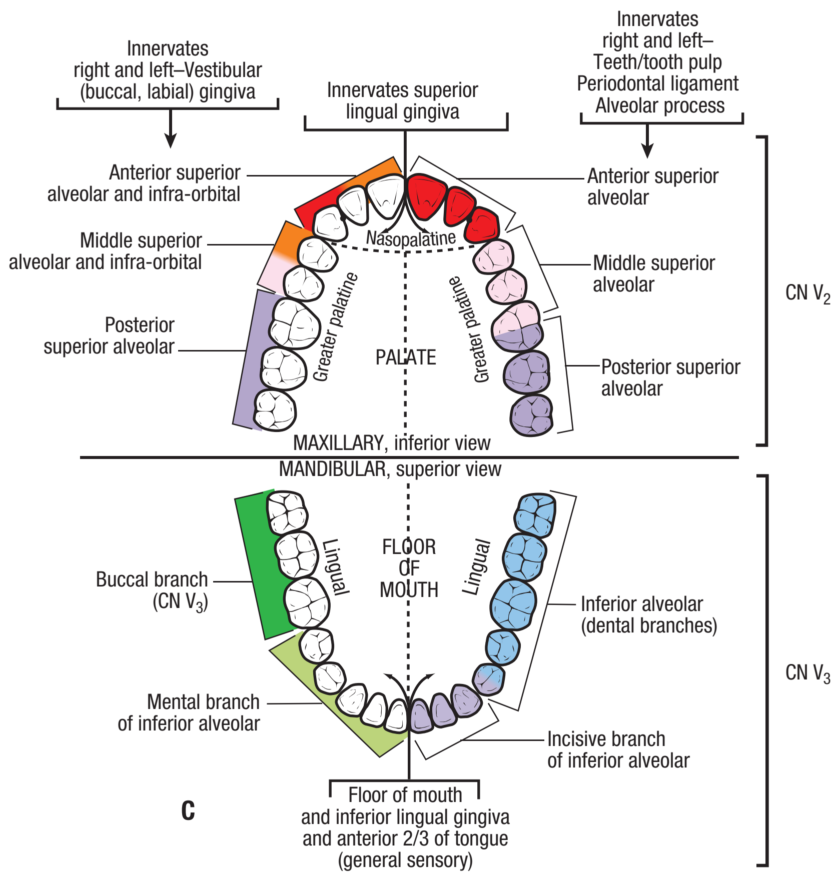


7.66 PERMANENT TEETH II

A. Removed teeth, displaying roots. There are 32 permanent teeth; 8 are on each side of each dental arch on the top (maxillary teeth) and bottom (mandibular teeth): 2 incisors *(I1–2)*, 1 canine *(C)*, 2 premolars *(PM1–2)*, and 3 molars *(M1–3)*. **B.** Permanent mandibular teeth and their sockets. **C.** Permanent maxillary teeth and their sockets. **D.** Teeth in occlusion. **E.** Vestibule and gingivae of the maxilla



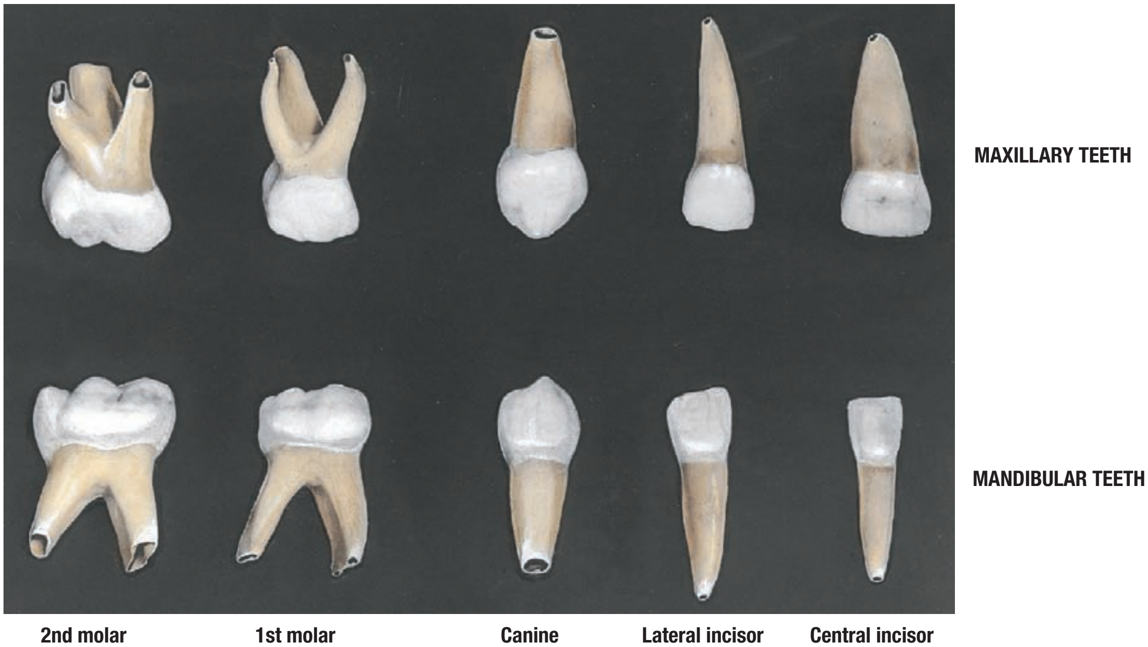




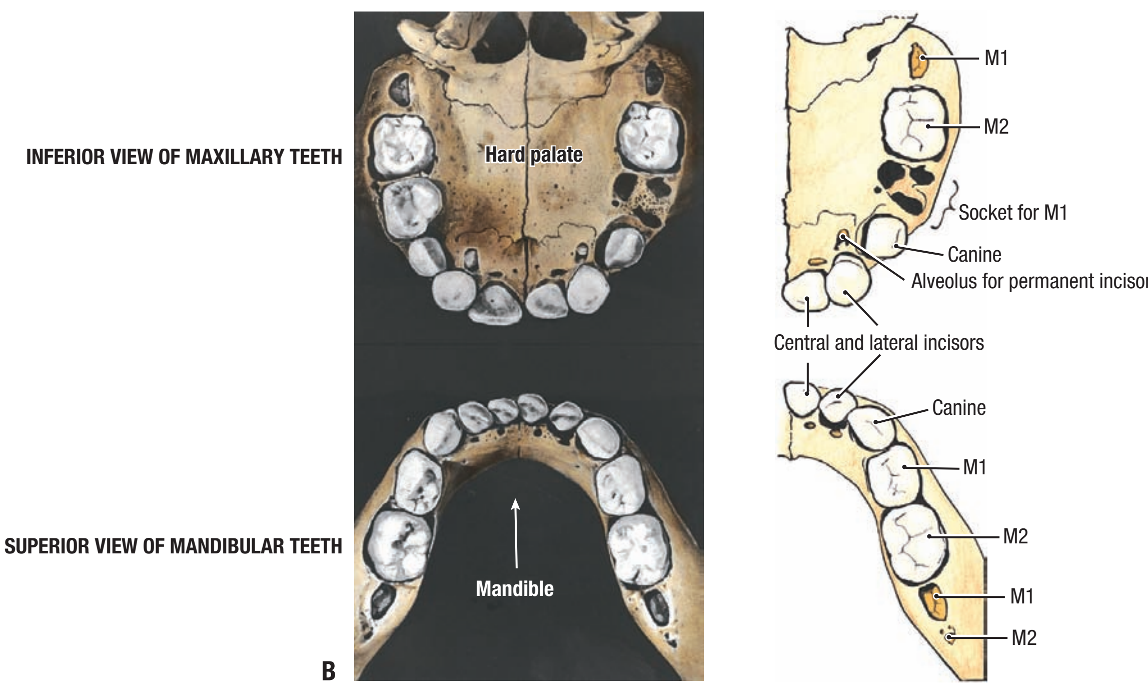
7.67 INNERVATION OF TEETH

A. Superior and inferior alveolar nerves. **B.** Surfaces of an incisor and molar tooth. **C.** Innervation of the mouth and teeth.

Improper oral hygiene results in food deposits in tooth and gingival crevices, which may cause inflammation of the gingivae, **gingivitis**. If untreated, the disease spreads to other supporting structures (including the alveolar bone), producing **periodontitis**. Periodontitis results in inflammation of the gingivae and may result in absorption of alveolar bone and gingival recession. Gingival recession exposes the sensitive cement of the teeth.



A. Vestibular View



B

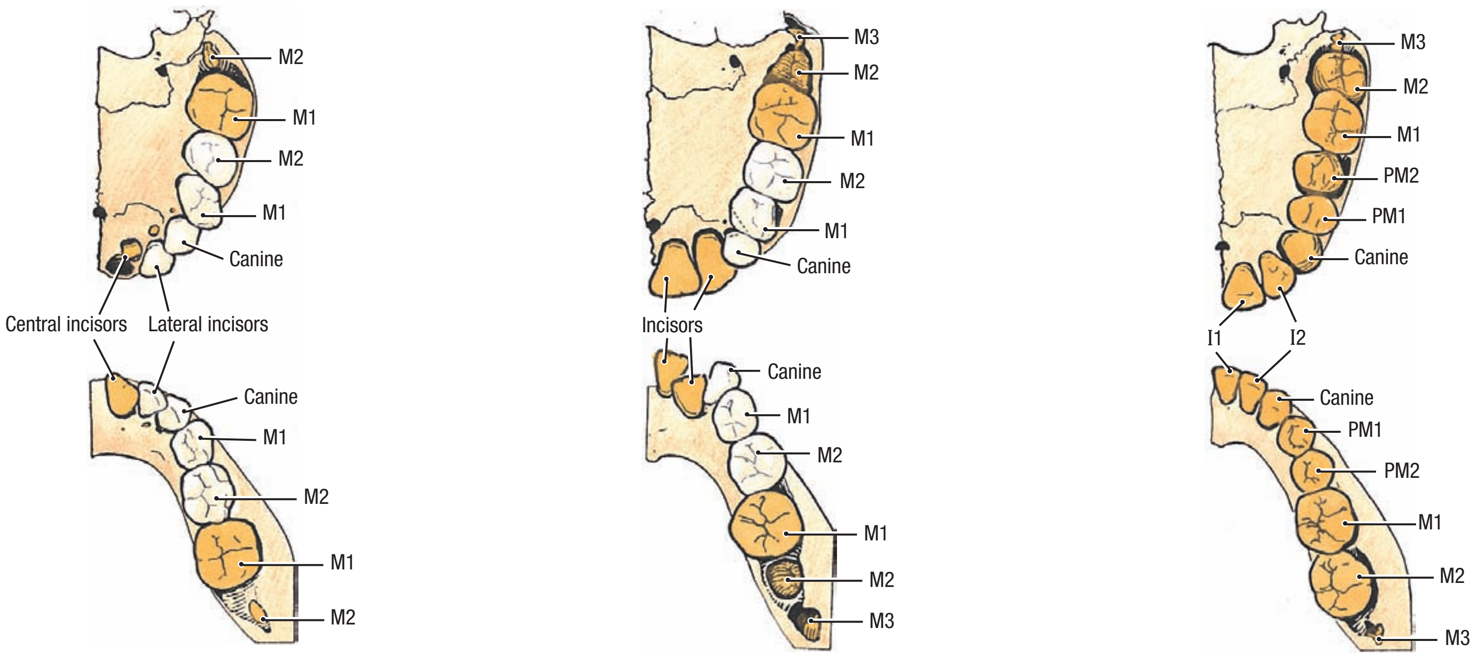
7.68 PRIMARY TEETH

A. Removed teeth. There are 20 primary (deciduous) teeth, 5 in each half of the mandible and 5 in each maxilla. They are named central incisor, lateral incisor, canine, 1st molar *(M1)*, and 2nd molar *(M2)*. Primary teeth differ from permanent teeth in that the primary teeth are smaller and whiter; the molars also have more bulbous crowns and more divergent roots. **B.** Teeth in situ, younger than 2 years of age. Permanent teeth are colored orange; the crowns of the unerupted first and second permanent molars are partly visible.

TABLE 7.15 PRIMARY AND SECONDARY DENTITION

Deciduous Teeth	Central Incisor	Lateral Incisor	Canine	First Molar	Second Molar
Eruption (months)[a]	6–8	8–10	16–20	12–16	20–24
Shedding (years)	6–7	7–8	10–12	9–11	10–12

[a]In some normal infants, the first teeth (medial incisors) may not erupt until 12 to 13 months of age



Age: 6–7 years

The 1st molars (6-year molars) have fully erupted, the primary central incisor has been shed, the lower central incisor is almost fully erupted, and the upper central incisor is descending into the vacated socket.

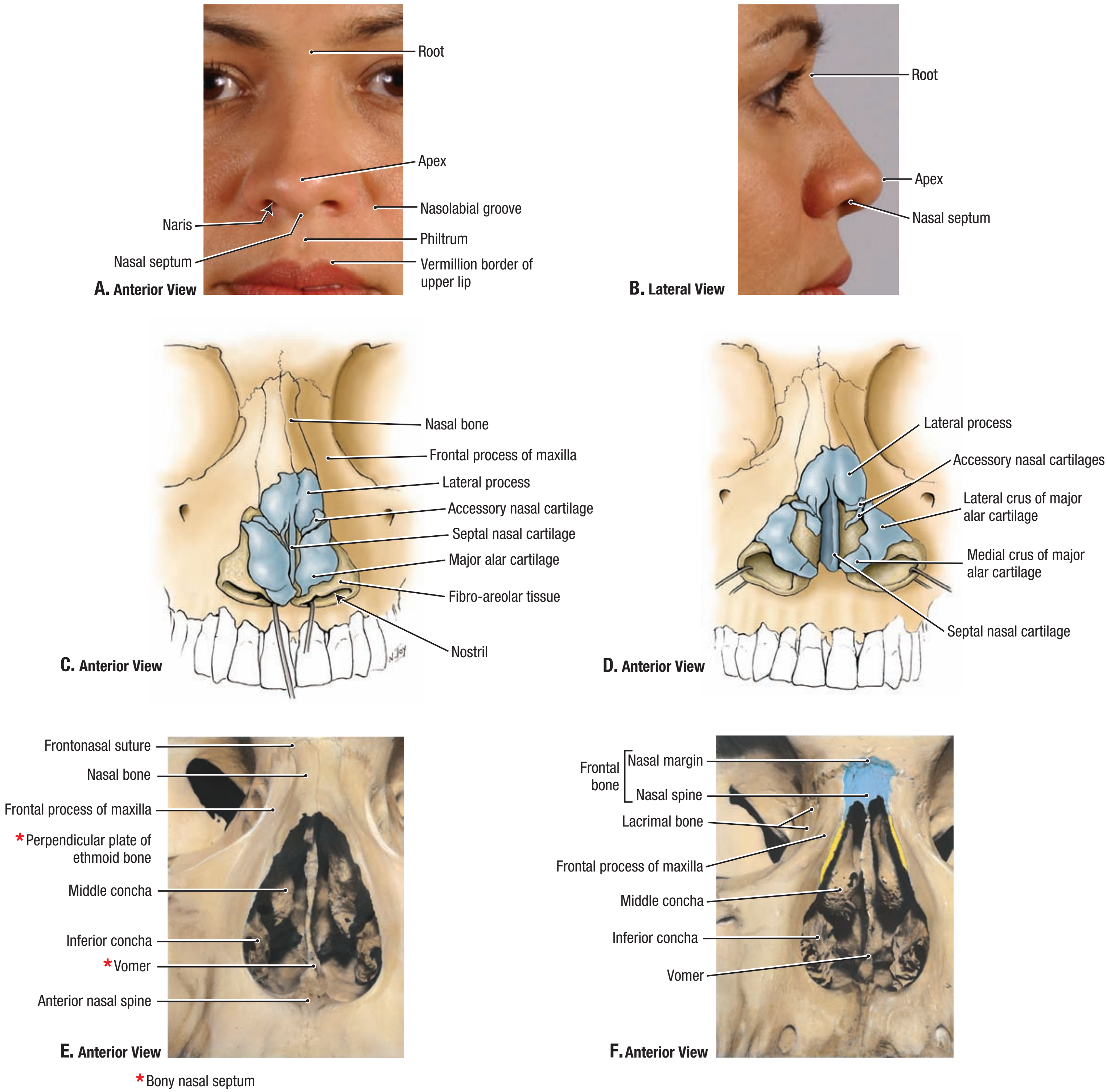
Age: 8 years

All of the permanent incisors have erupted; however, the lower lateral incisor is only partially erupted.

Age: 12 years

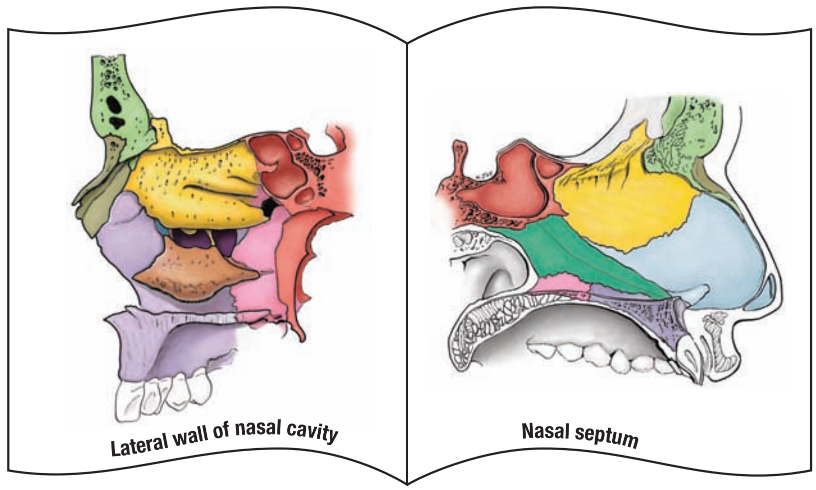
The primary teeth have been replaced by 20 permanent teeth, and the 1st and 2nd molars (12-year molars) have erupted; the canines, 2nd premolars, and 2nd molars (especially those in the upper jaw) have not erupted fully, nor have their bony sockets closed around them. By age 12, 28 permanent teeth are in evidence; the last 4 teeth, the 3rd molars, may erupt any time after this, or never.

Permanent Teeth	Central Incisor	Lateral Incisor	Canine	First Premolar	Second Premolar	First Molar	Second Molar	Third Molar
Eruption (years)	7–8	8–9	10–12	10–11	11–12	6–7	12	13–25

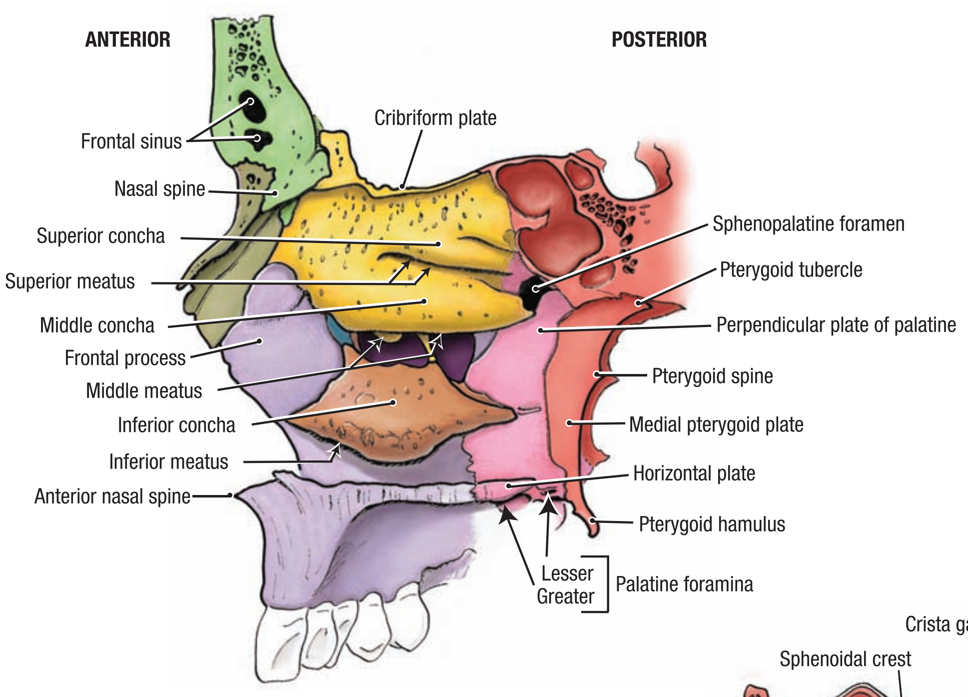


7.69 SURFACE ANATOMY, CARTILAGES, AND BONES OF NOSE

A. Surface features of anterior aspect of nose. **B.** Surface features of lateral aspect of nose. **C.** Nasal cartilages, with the septum pulled inferiorly. **D.** Nasal cartilages, separated and retracted laterally. **E.** Lower conchae and bony septum seen through the piriform aperture. The margin of the piriform aperture is sharp and formed by the maxillae and nasal bones. **F.** Nasal bones removed. The areas of the frontal processes of the maxillae *(yellow)* and of the frontal bone *(blue)* that articulate with the nasal bones can be seen.



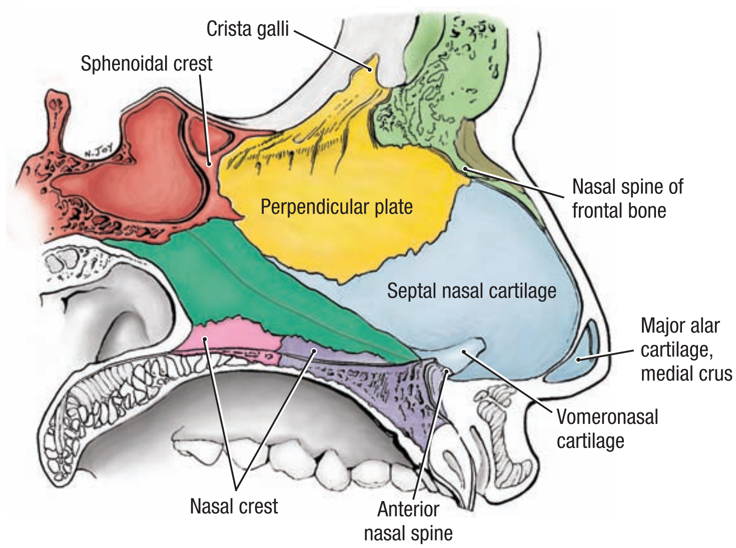
Right Nasal Cavity



A. Medial View of Lateral Wall

Bones:
- Ethmoid
- Frontal
- Inferior concha
- Lacrimal
- Maxilla
- Nasal
- Palatine
- Sphenoid
- Vomer

Other tissue:
- Lateral wall of maxillary sinus
- Nasal cartilage

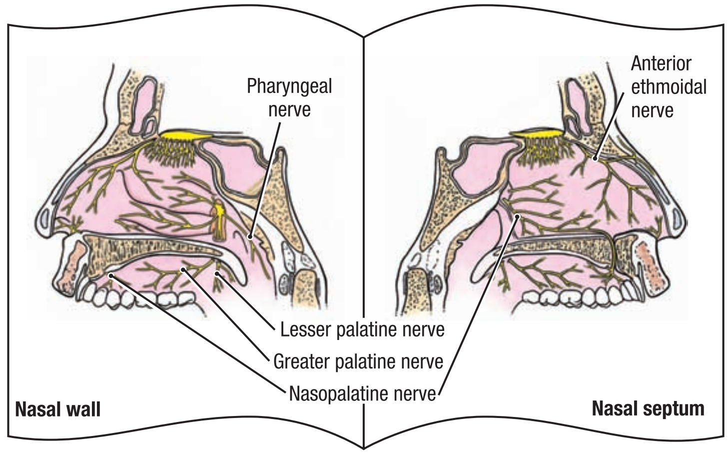


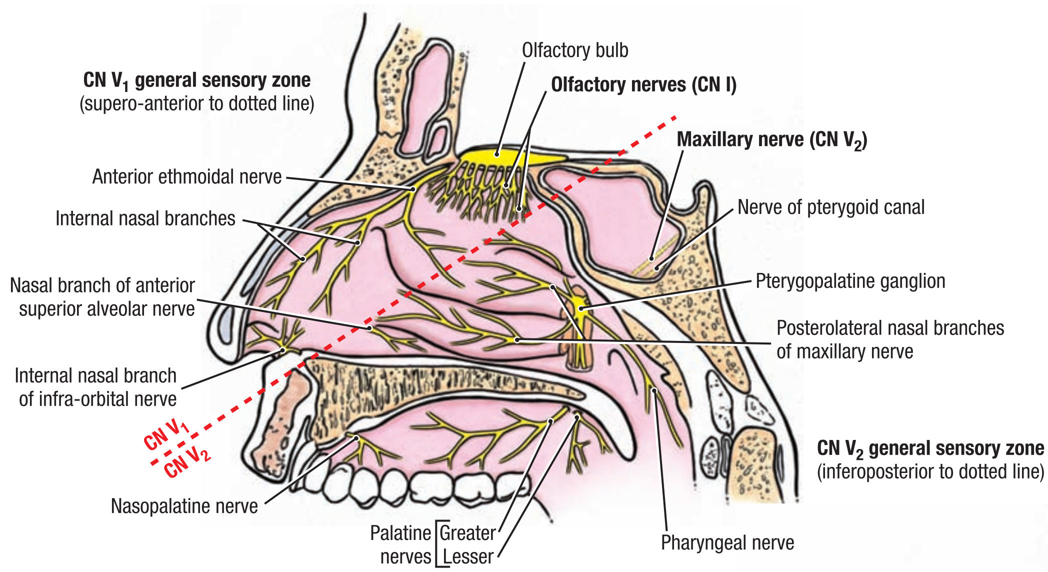
B. Lateral View of Nasal Septum

7.70 BONES OF THE NASAL WALL AND SEPTUM

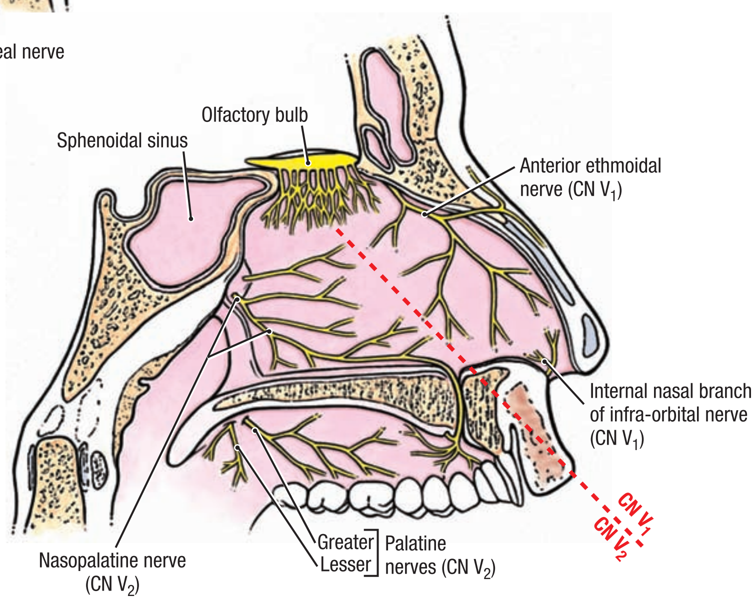
A. Lateral wall of nose. The superior and middle conchae are parts of the ethmoid bone, whereas the inferior concha is itself a bone. **B.** Nasal septum.

Deformity of the external nose usually is present with a fracture, particularly when a lateral force is applied by someone's elbow, for example. When the injury results from a direct blow (e.g., from a hockey stick), the cribriform plate of the ethmoid bone may fracture, resulting in CSF rhinorrhea.





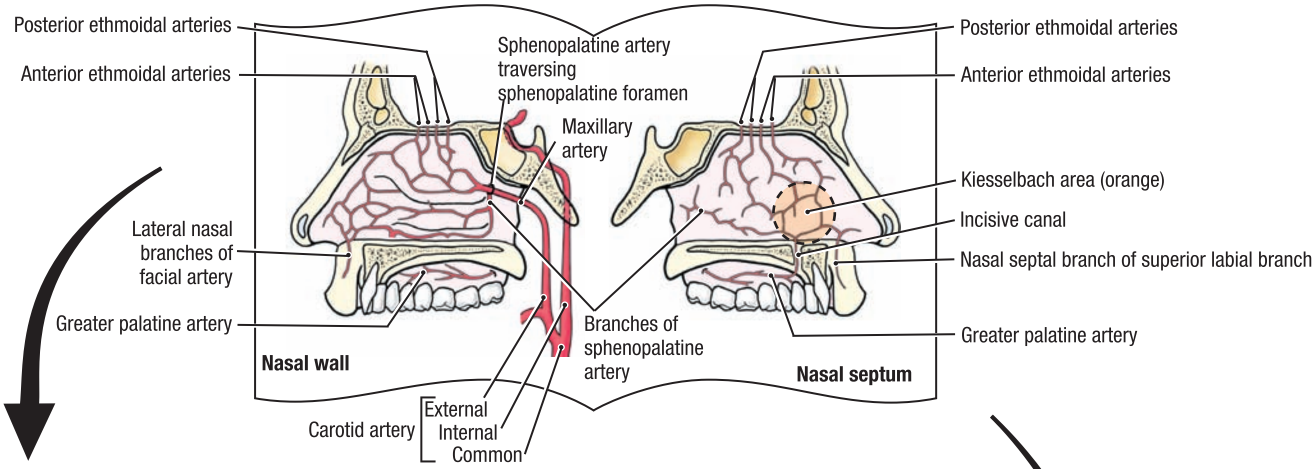
A. **Medial view of nasal wall**

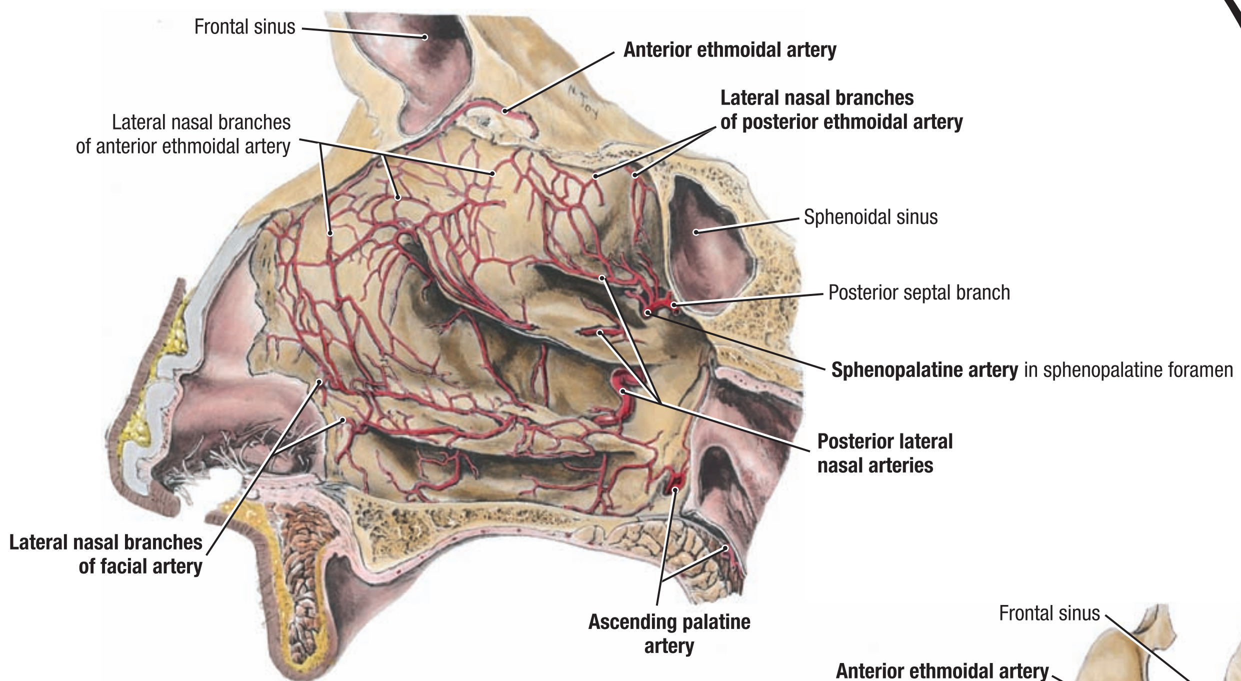


B. **Lateral view of nasal septum**

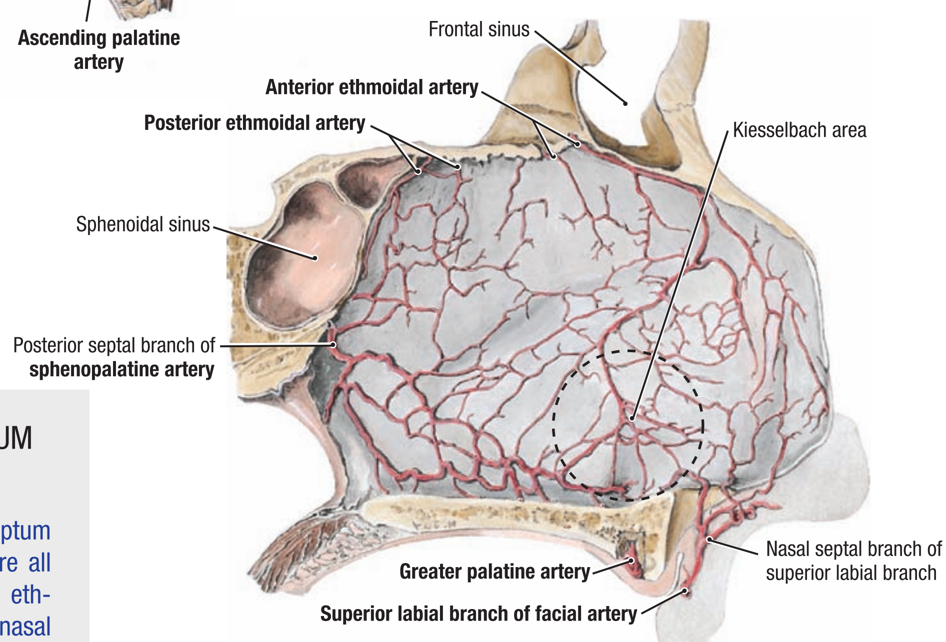
7.71 INNERVATION OF NASAL WALL AND SEPTUM

A. Lateral wall of nose. *Dashed diagonal lines* demarcate CN V_1 and CN V_2 general sensory zones. The olfactory neuroepithelium is in the superior part of the lateral and septal walls of the nasal cavity. The central processes of the olfactory neurosensory cells of each side form approximately 20 bundles that together form an olfactory nerve (CN I). **B.** Nasal septum. The nasopalatine nerve from the pterygopalatine ganglion supplies the posteroinferior septum, and the anterior ethmoidal nerve (branch of V_1) supplies the anterosuperior septum.





A. **Medial View of nasal wall**

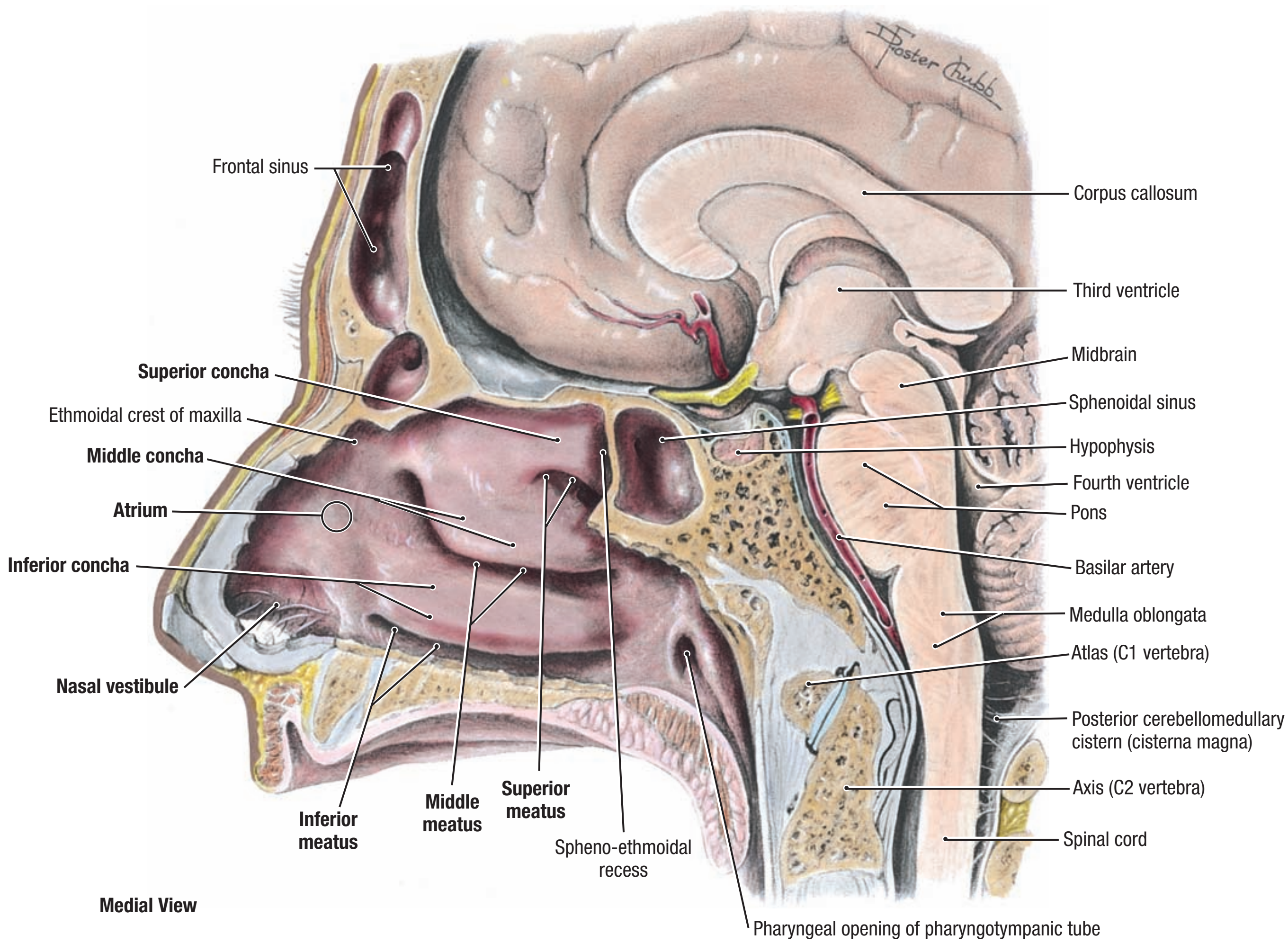


B. **Lateral View of Nasal Septum**

7.72 ARTERIES OF NASAL WALL AND SEPTUM

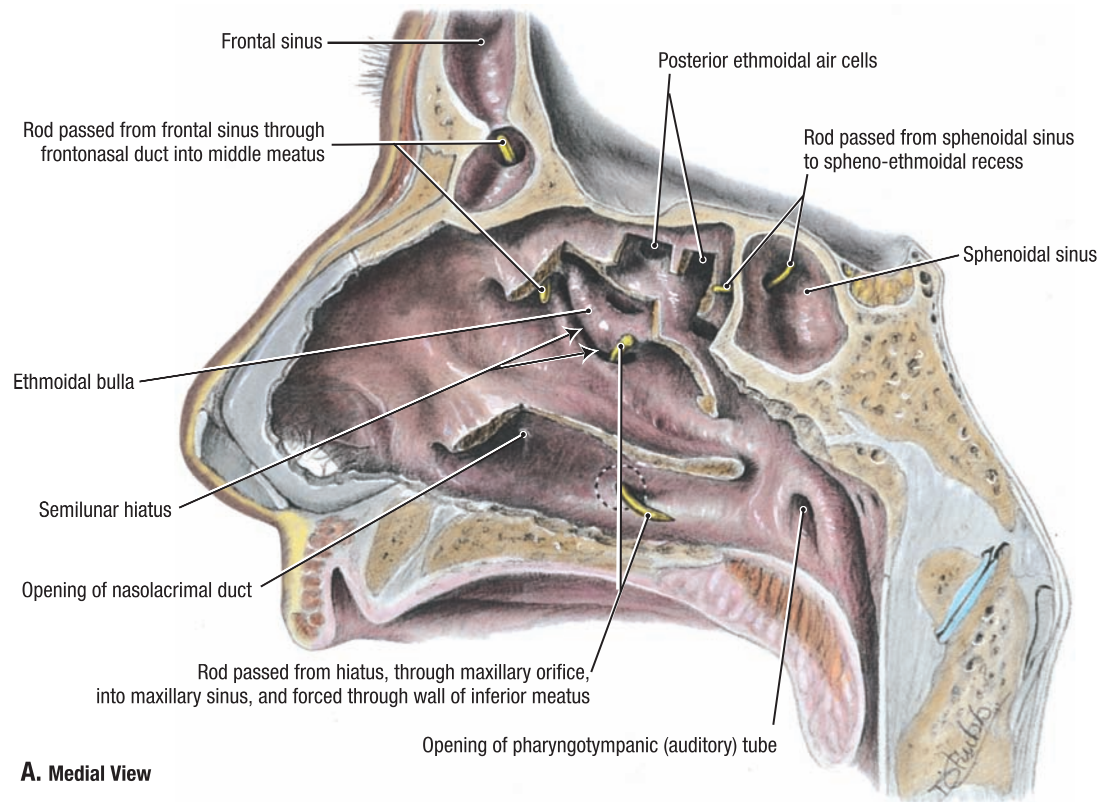
A. Lateral wall of nose. **B.** Nasal septum.

Epistaxis. On the anterior part of the nasal septum is an area rich in capillaries (Kiesselbach area) where all five arteries (sphenopalatine, anterior and posterior ethmoidal, greater palatine and superior labial and lateral nasal branches of the facial artery) supplying the nasal septum anastomose. This area is often where profuse bleeding from the nose (epistaxis) occurs.

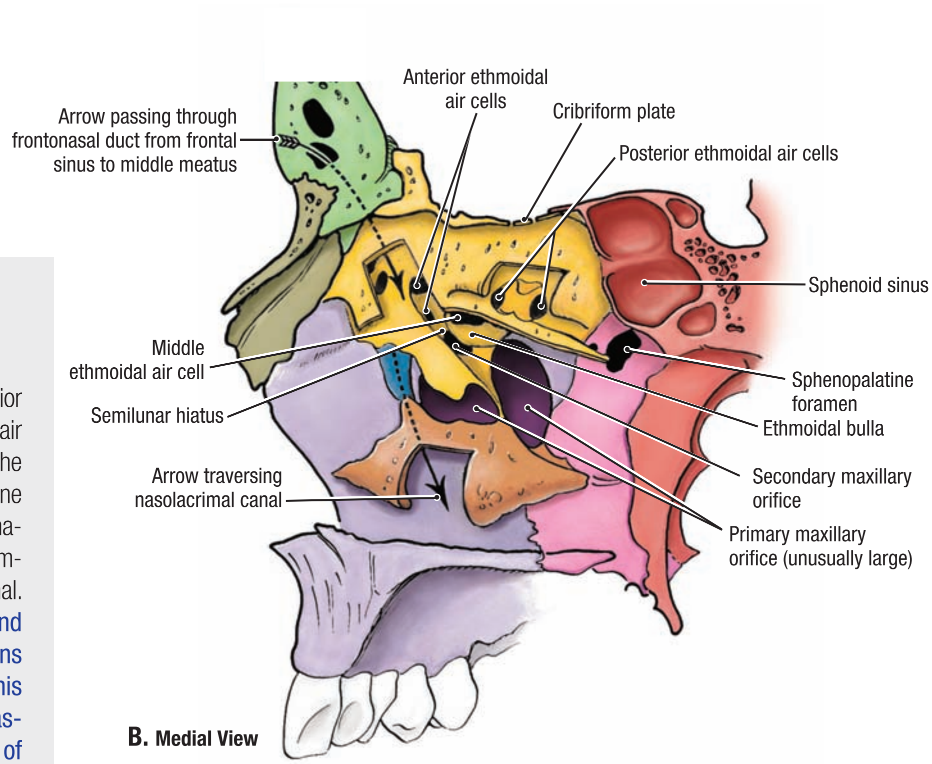


7.73 RIGHT HALF OF HEMISECTED HEAD DEMONSTRATING UPPER RESPIRATORY TRACT

- The vestibule is superior to the nostril and anterior to the inferior meatus; hairs grow from its skin-lined surface. The atrium is superior to the vestibule and anterior to the middle meatus.
- The inferior and middle conchae curve inferiorly and medially from the lateral wall, dividing it into three nearly equal parts and covering the inferior and middle meatuses, respectively. The middle concha ends inferior to the sphenoidal sinus, and the inferior concha ends inferior to the middle concha, just anterior to the orifice of the auditory tube. The superior concha is small and anterior to the sphenoidal sinus.
- The roof comprises an anterior sloping part corresponding to the bridge of the nose; an intermediate horizontal part; a perpendicular part anterior to the sphenoidal sinus; and a curved part, inferior to the sinus, that is continuous with the roof of the nasopharynx.



A. Medial View

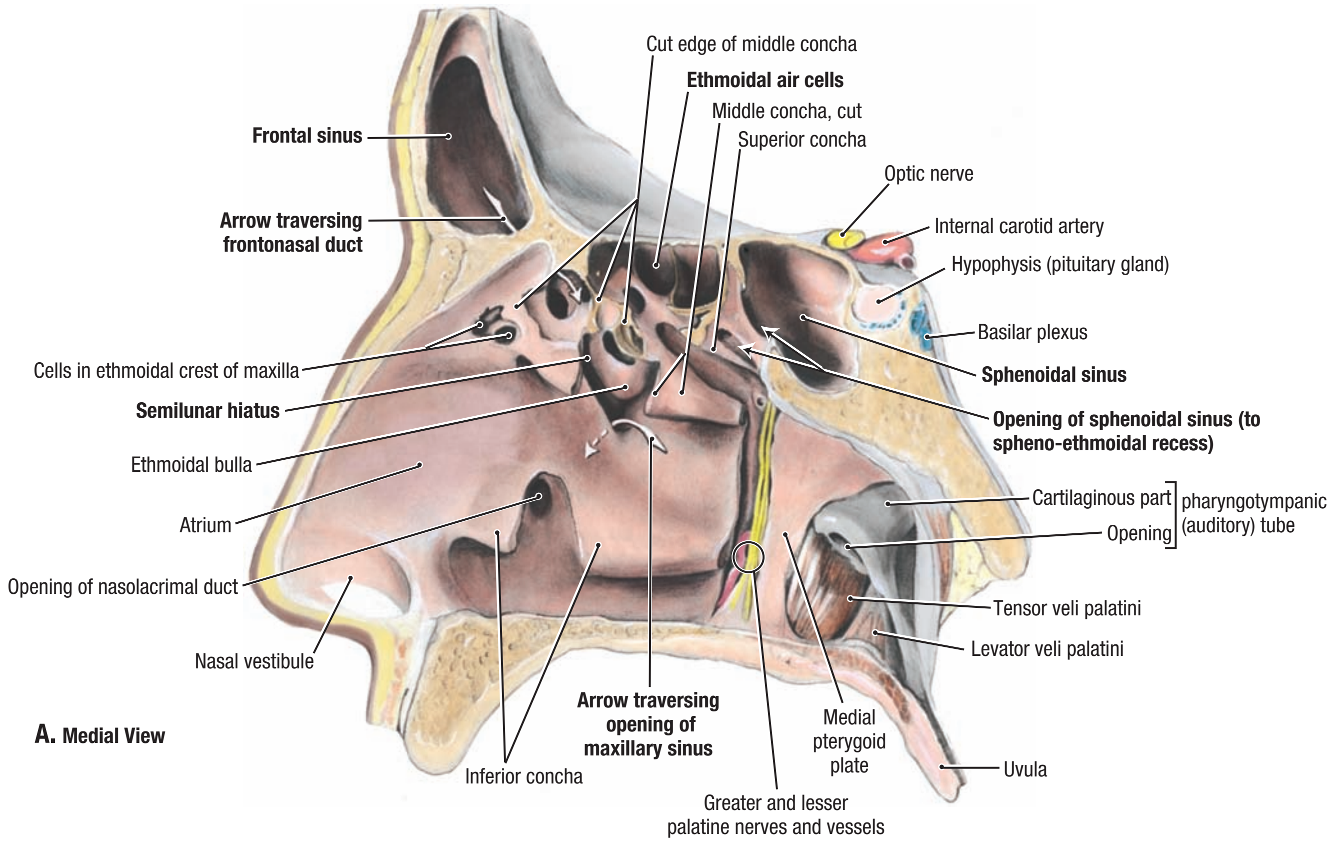


B. Medial View

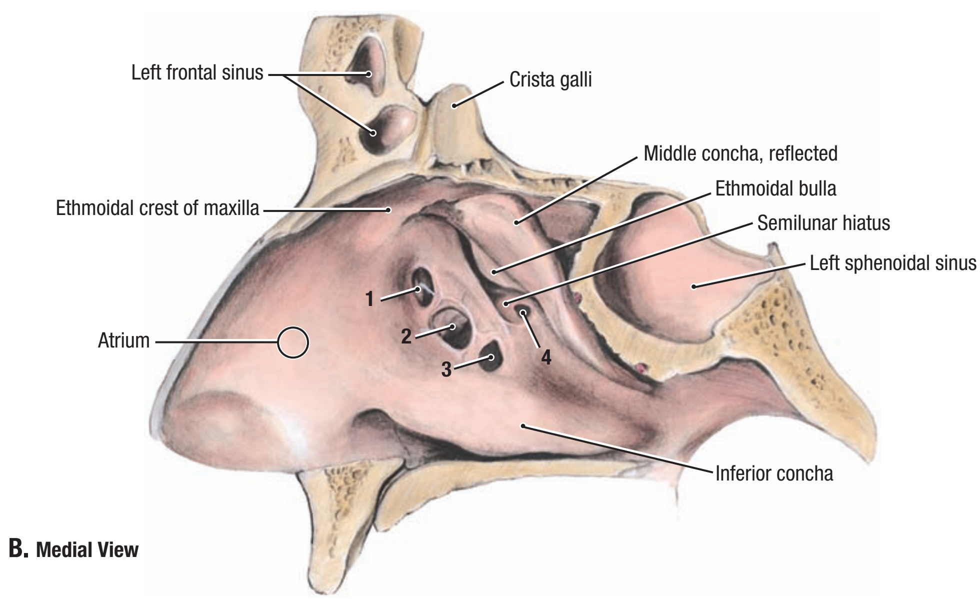
7.74 COMMUNICATIONS THROUGH NASAL WALL

A. Dissection. Parts of the superior, middle, and inferior conchae are cut away to reveal the openings of the air sinuses. **B.** Diagrams of the bones and openings of the lateral wall of nasal cavity following dissection. Note one *arrow* passing from the frontal sinus through the frontonasal duct into the middle meatus and another *arrow* coming from the anteromedial orbit via the nasolacrimal canal.

Rhinits. The nasal mucosa becomes swollen and inflamed (rhinitis) during upper respiratory infections and allergic reactions (e.g., hay fever). Swelling of this mucous membrane occurs readily because of its vascularity and abundant mucosal glands. Infections of the nasal cavities may spread to the anterior cranial fossa through the cribriform plate, nasopharynx and retropharyngeal soft tissues, middle ear through the pharyngotympanic (auditory) tube, paranasal sinuses, lacrimal apparatus, and conjunctiva.



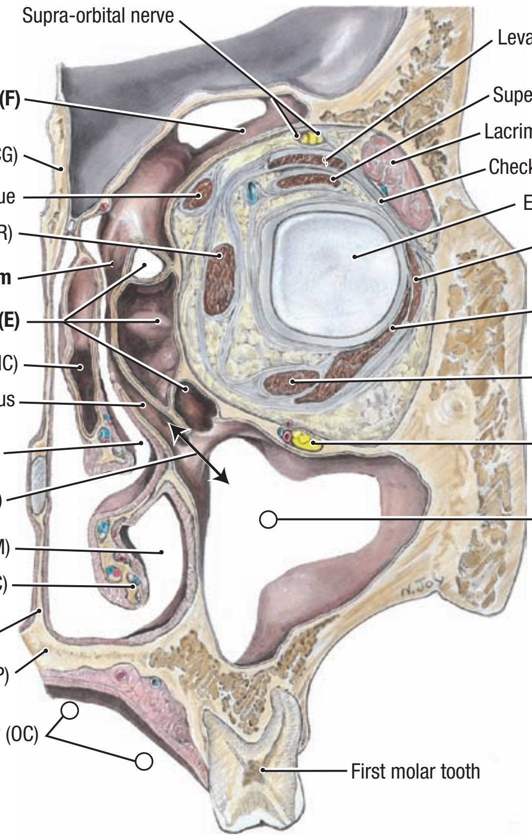
A. **Medial View**

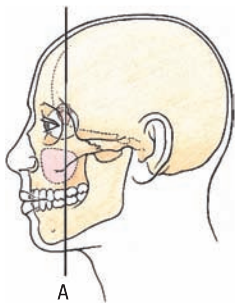


B. **Medial View**

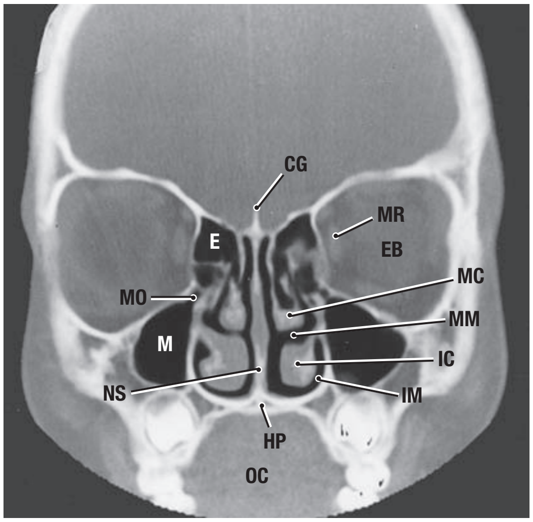
7.75 PARANASAL SINUSES, OPENINGS, AND PALATINE MUSCLES IN NASAL WALL

A. Dissection. Parts of the middle and inferior conchae and lateral wall of the nasal cavity are cut away to expose the nerves and vessels in the palatine canal and the extrinsic palatine muscles. **B.** Accessory maxillary orifices. In addition to the primary, or normal, ostium (not shown), there are four secondary, or acquired, ostia (numbered 1 to 4).

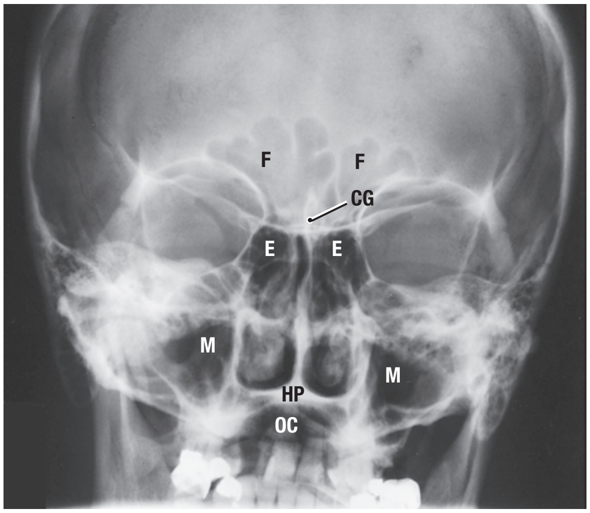




A. **Posterior View**



B. **Posterior View**



C. **Anteroposterior View**

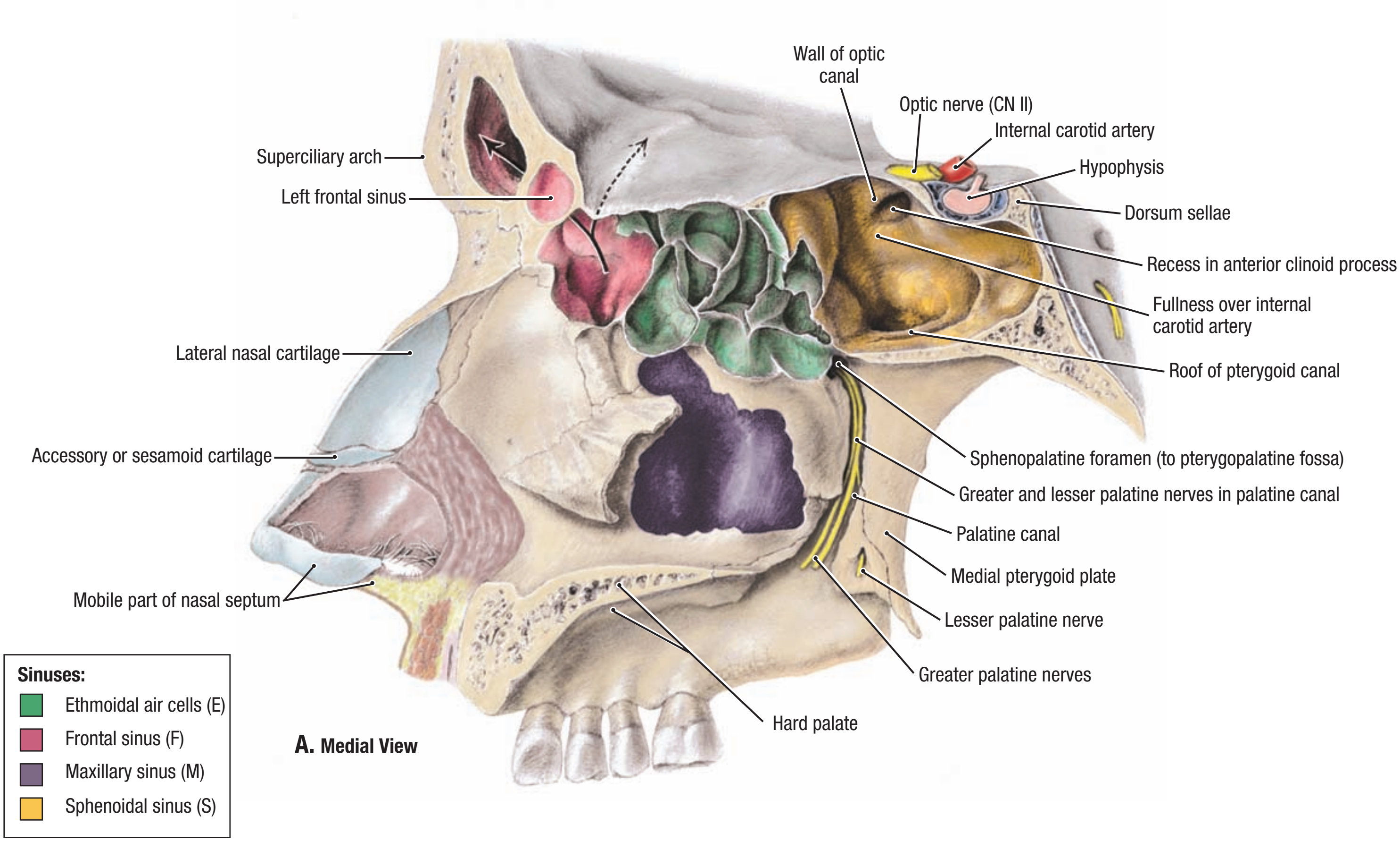
7.76 PARANASAL SINUSES AND NASAL CAVITY

A. Coronal section of right side of the head. **B.** CT scan. **C.** Radiograph of cranium. Letters in **B** and **C** refer to structures labeled in **A.**

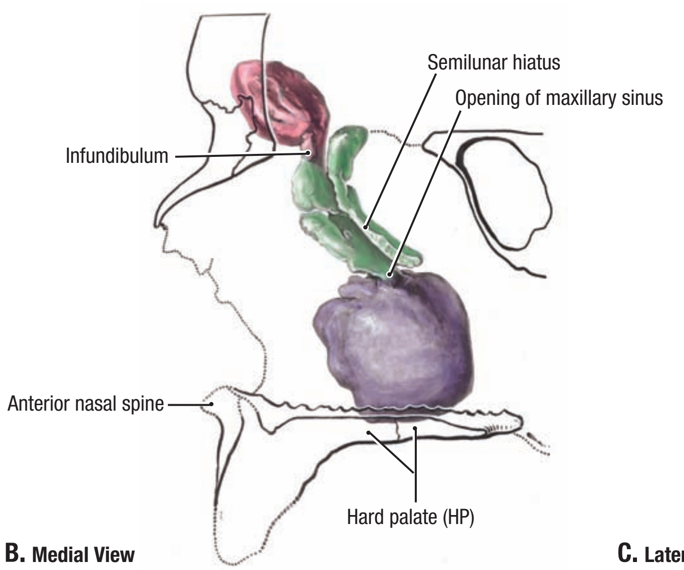
If nasal drainage is blocked, **infections of the ethmoidal cells** of the ethmoidal sinuses may break through the fragile medial wall of the orbit. Severe infections from this source may cause blindness but could also affect the dural sheath of the optic nerve, causing **optic neuritis**.

During **removal of a maxillary molar tooth,** a fracture of a root may occur. If proper retrieval methods are not used, a piece of the root may be driven superiorly into the maxillary sinus.

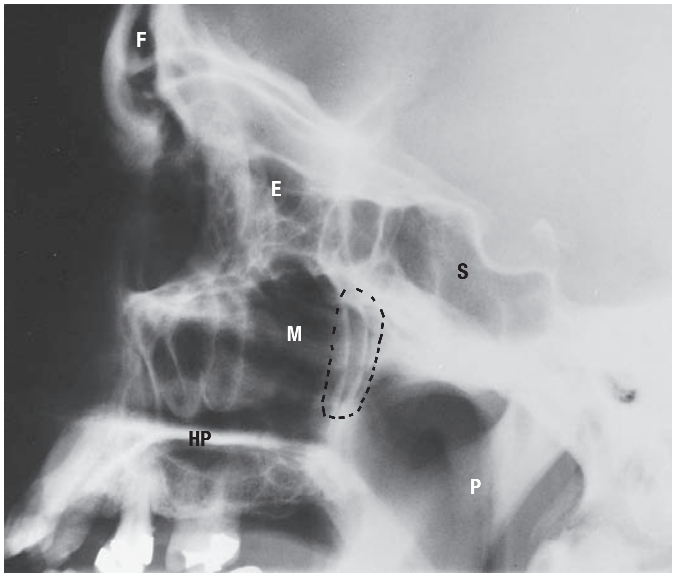
Radiographs/CT scans of the frontal sinuses may be used for forensic identification of unknown individuals. The frontal sinuses are unique to each person, much like fingerprints.



A. Medial View



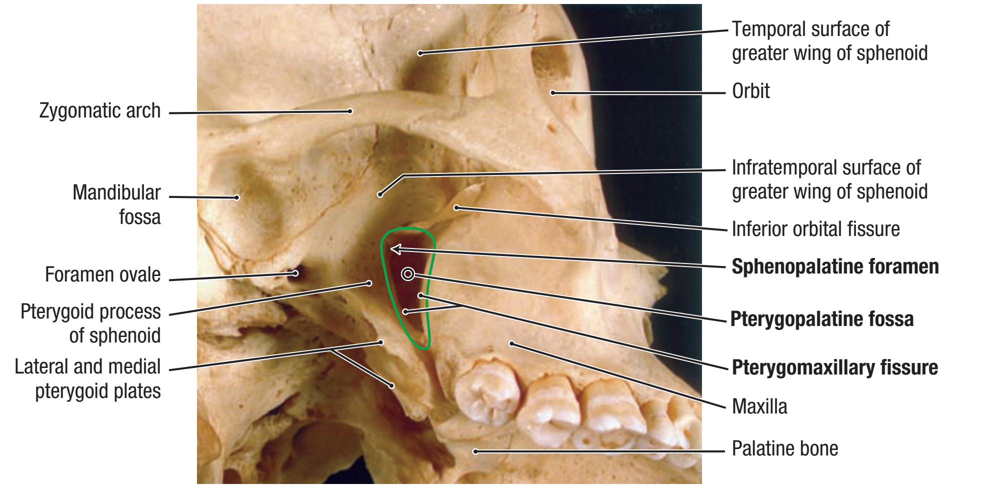
B. Medial View



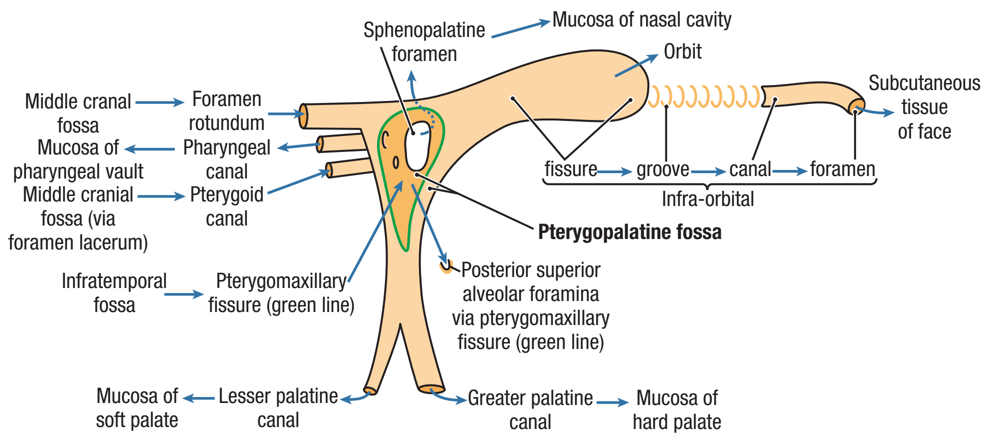
C. Lateral View

7.77 PARANASAL SINUSES

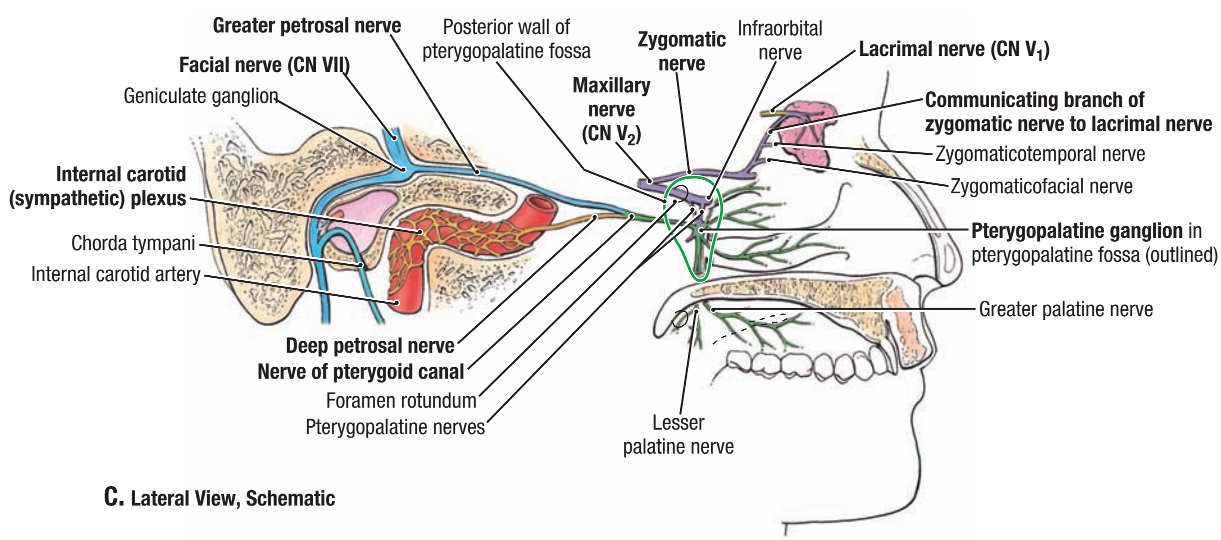
A. Opened sinuses, color coded. **B.** Cast of frontal and maxillary sinuses. **C.** Radiograph of cranium. *P,* pharynx; *dotted lines*, pterygopalatine fossa. Letters refer to structures labeled in **B.** **Maxillary sinusitis.** The maxillary sinuses are the most commonly infected, probably because their ostia are small and located high on their superomedial walls, a poor location for natural drainage of the sinus. When the mucous membrane of the sinus is congested, the maxillary ostia often are obstructed. The maxillary sinus can be cannulated and drained by passing a canula from the nares through the maxillary ostium into the sinus.



A. **Inferolateral and slightly posterior view, looking into infratemporal and pterygopalatine fossae**



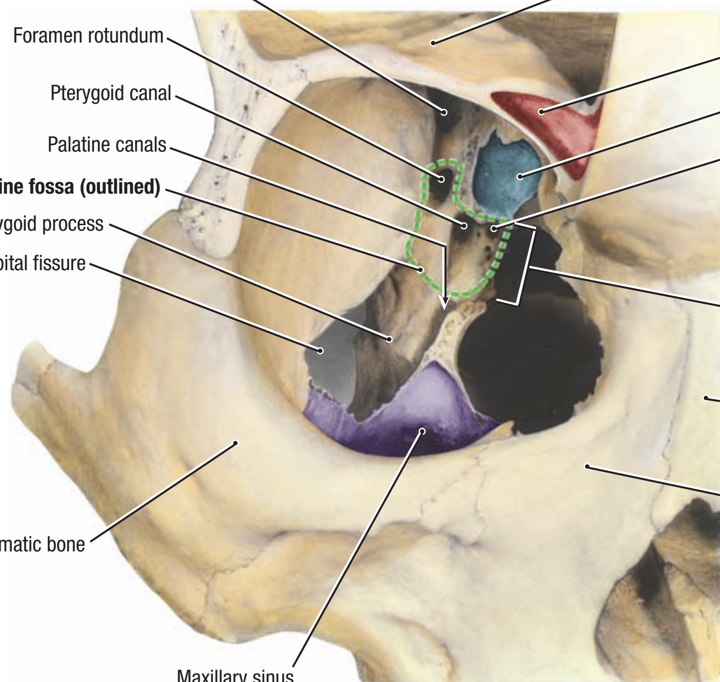
B



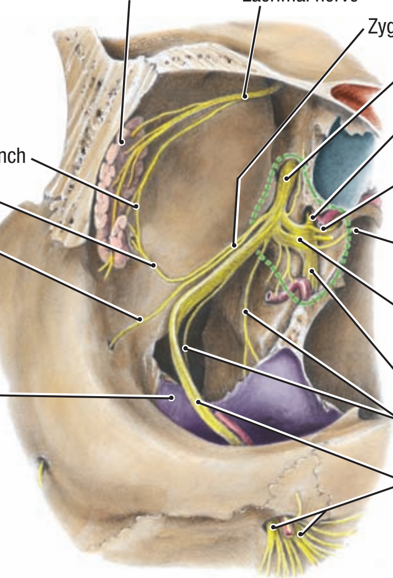
C. **Lateral View, Schematic**

7.78 PTERYGOPALATINE FOSSA

A. Bony relationships. The pterygopalatine fossa is a small pyramidal space inferior to the apex of the orbit. It lies between the pterygoid process of the sphenoid and the posterior aspect of the maxilla anteriorly. **B.** Communications. **C.** Pterygopalatine ganglion and related nerves.



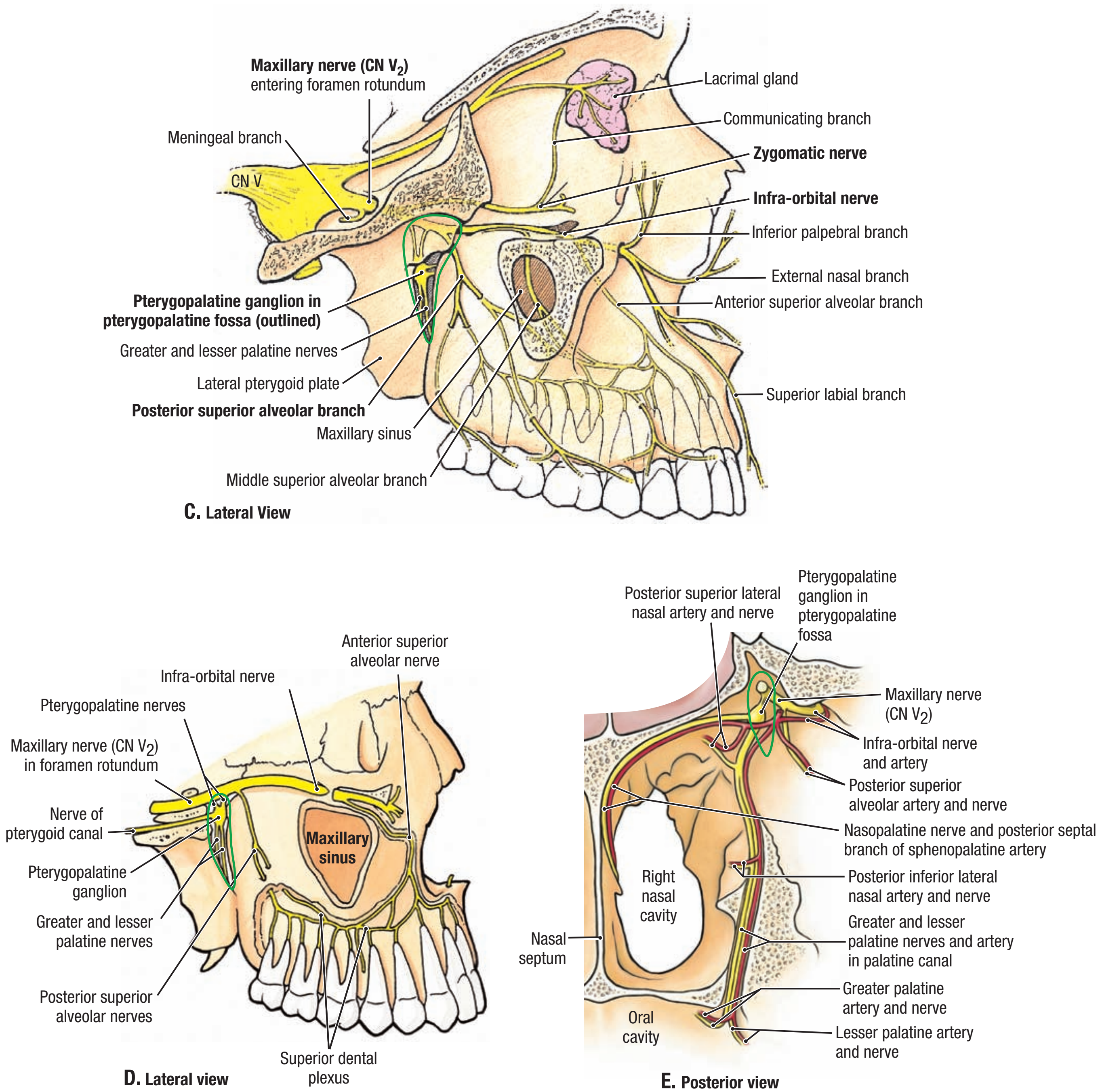
A. **Anterior View**



B. **Anterior View**

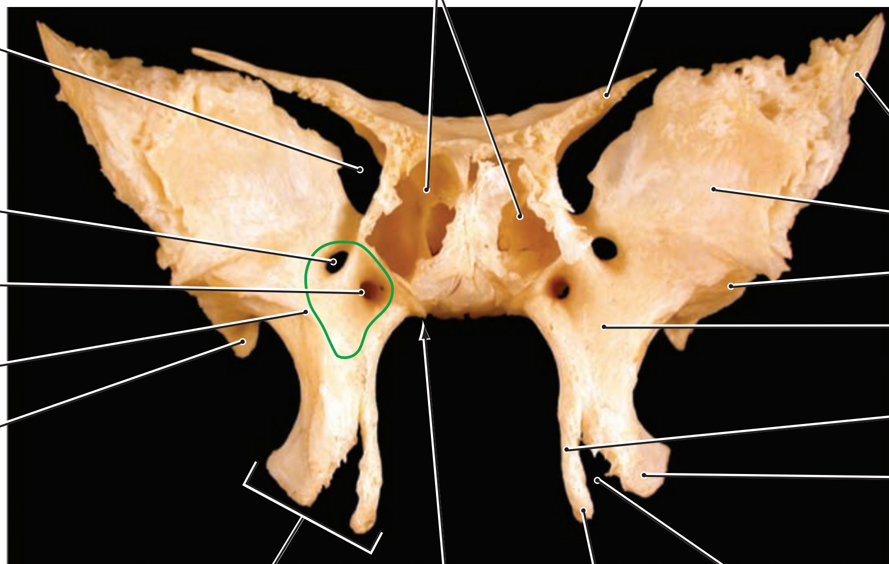
7.79 NERVES OF THE PTERYGOPALATINE FOSSA

A. Bones and foramina, orbital approach. **B.** Vessels and nerves, orbital approach. In **A** and **B,** the pterygopalatine fossa has been exposed through the floor of the orbit and maxillary sinus.

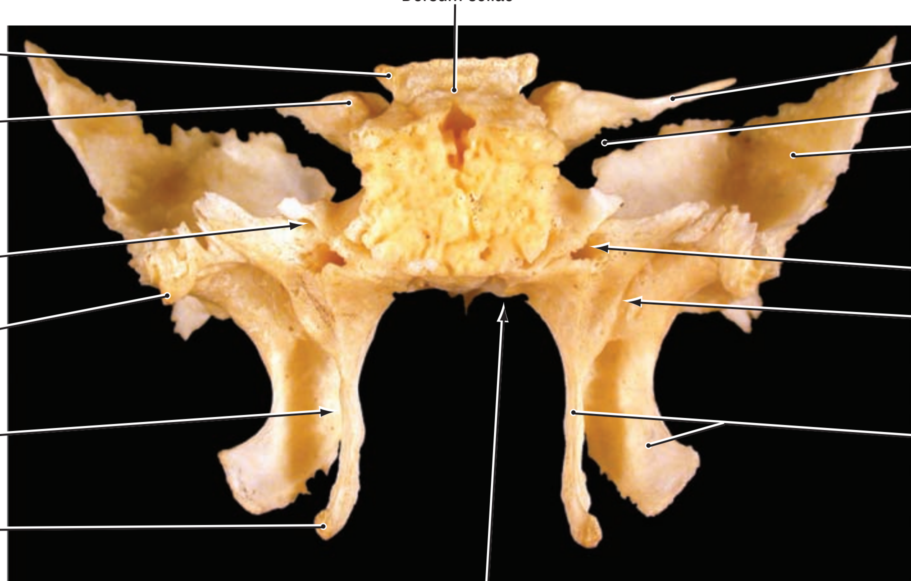


7.79 NERVES OF THE PTERYGOPALATINE FOSSA *(CONTINUED)*

C. Maxillary nerve (CN V_2) and branches. **D.** The fossa is viewed laterally. Part of the wall of the maxillary sinus has been removed. **E.** Nasopalatine and greater and lesser palatine nerves.



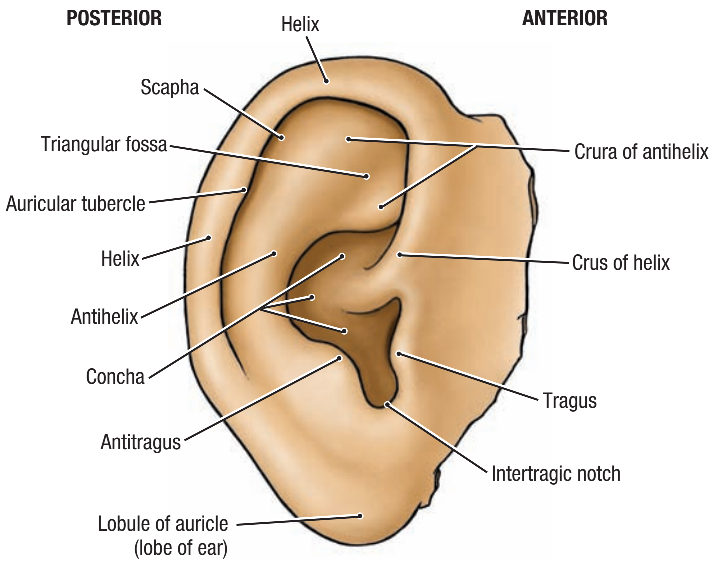
A. Anterior View



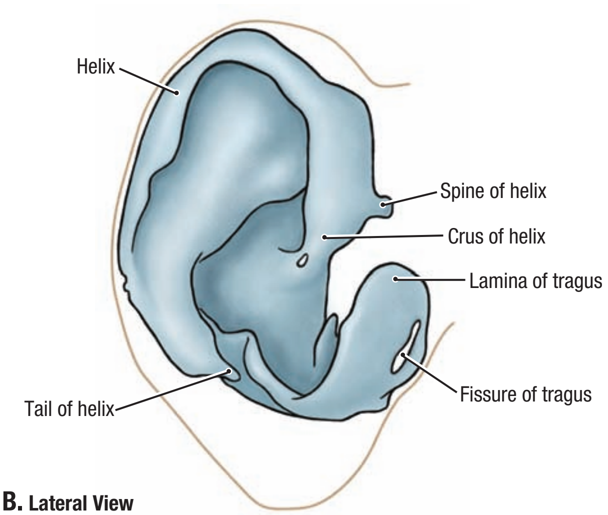
B. Posterior View

7.80 SPHENOID BONE: FEATURES AND RELATIONSHIP TO PTERYGOPALATINE FOSSA

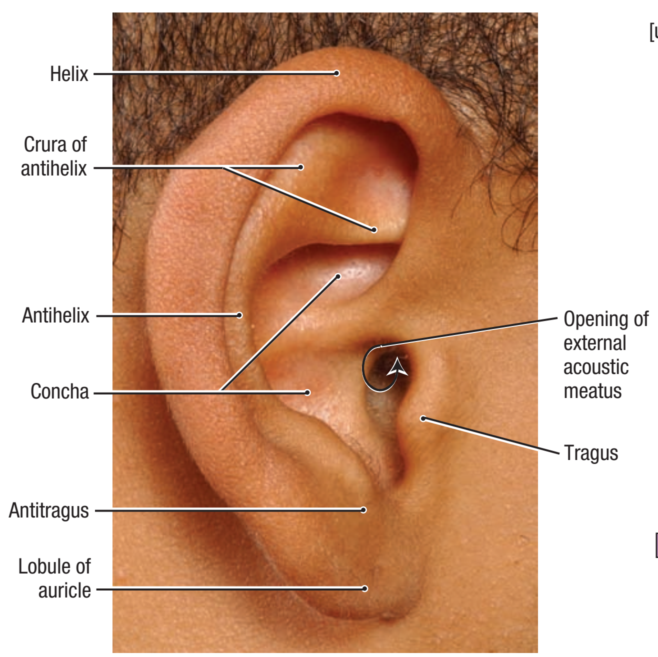
A. The pterygopalatine fossa communicates posterosuperiorly with the middle cranial fossa through the foramen rotundum and pterygoid canal. **B.** Bony features and tensor veli palatini.



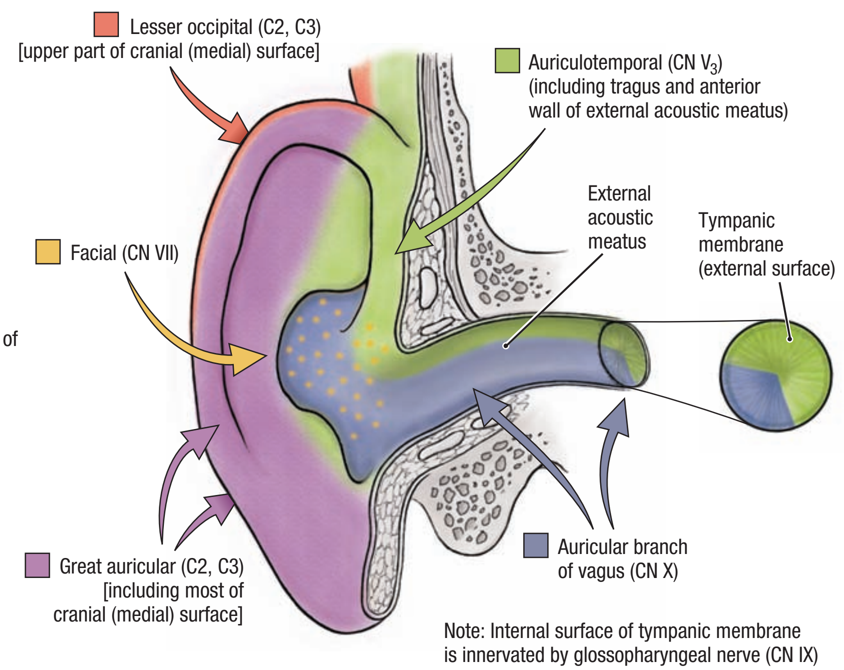
A. Lateral View



B. Lateral View



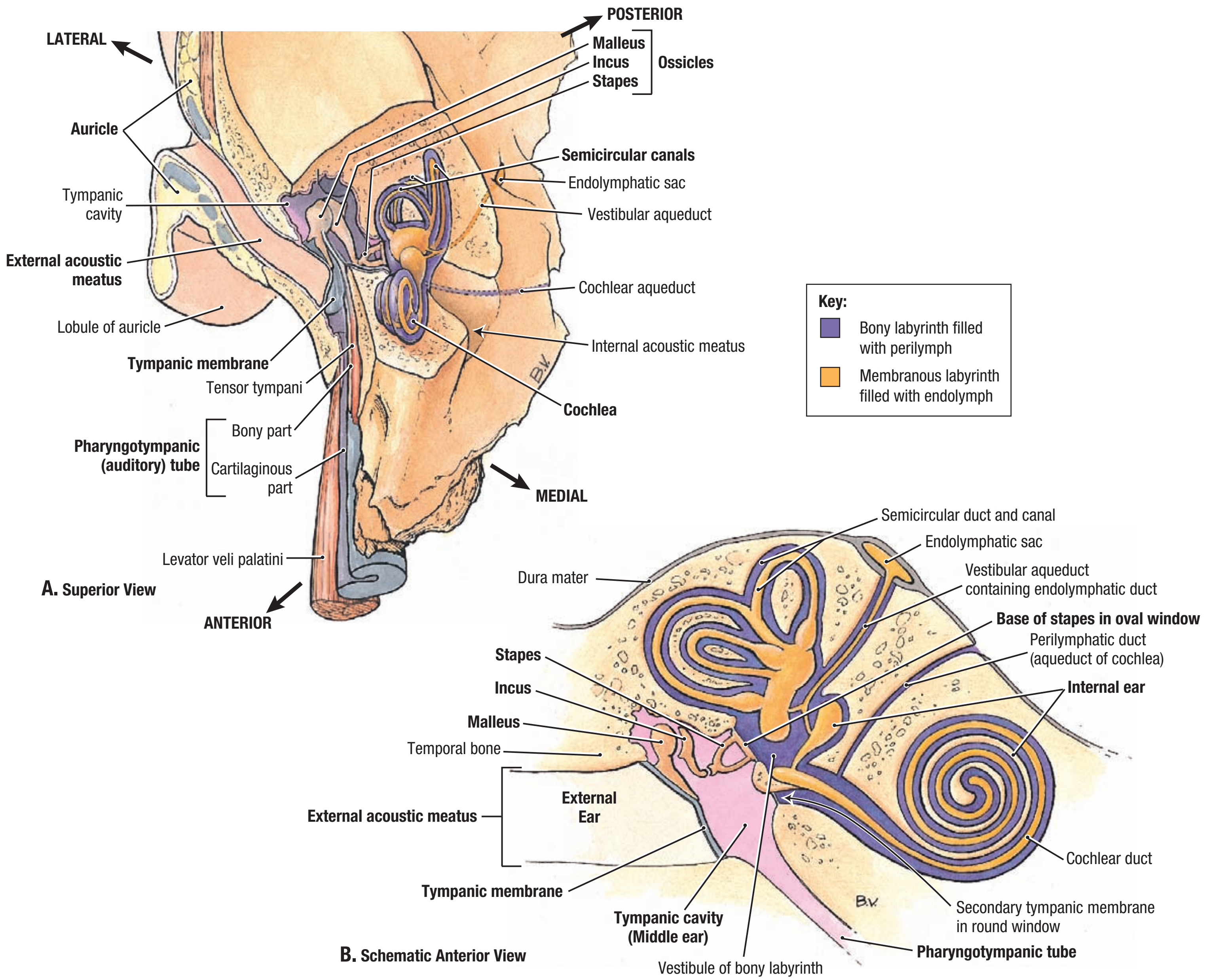
C. Lateral View



D. Schematic Section

7.81 AURICLE

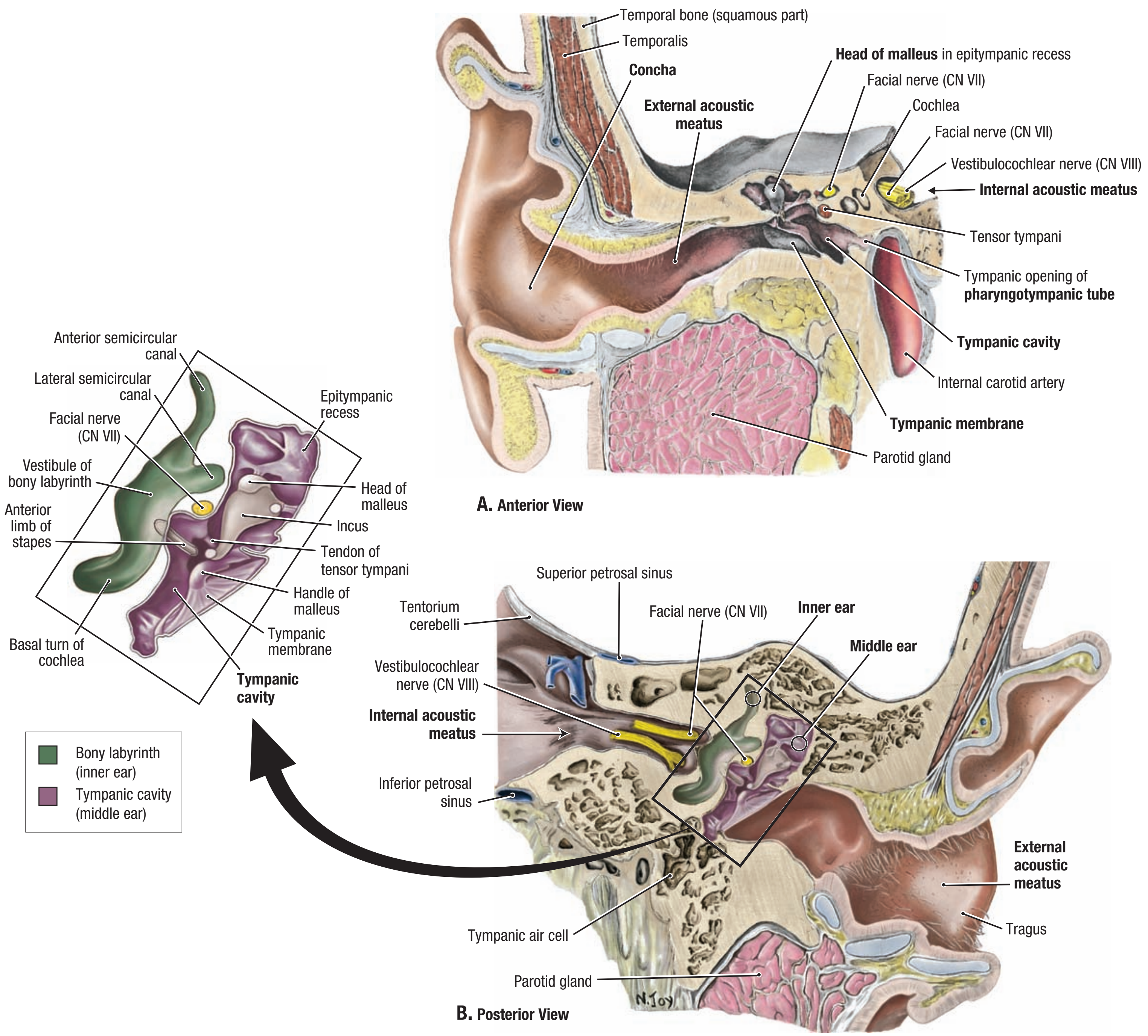
A. Features of auricle. **B.** Cartilage of auricle. **C.** Surface anatomy of auricle. **D.** Sensory innervation.



7.82 EXTERNAL, MIDDLE, AND INTERNAL EAR I: OVERVIEWS

A. Right temporal bone and auricle, sectioned in planes of (1) externa acoustic meatus and (2) pharyngotympanic tube. **B.** Schematic section of petrous temporal bone.

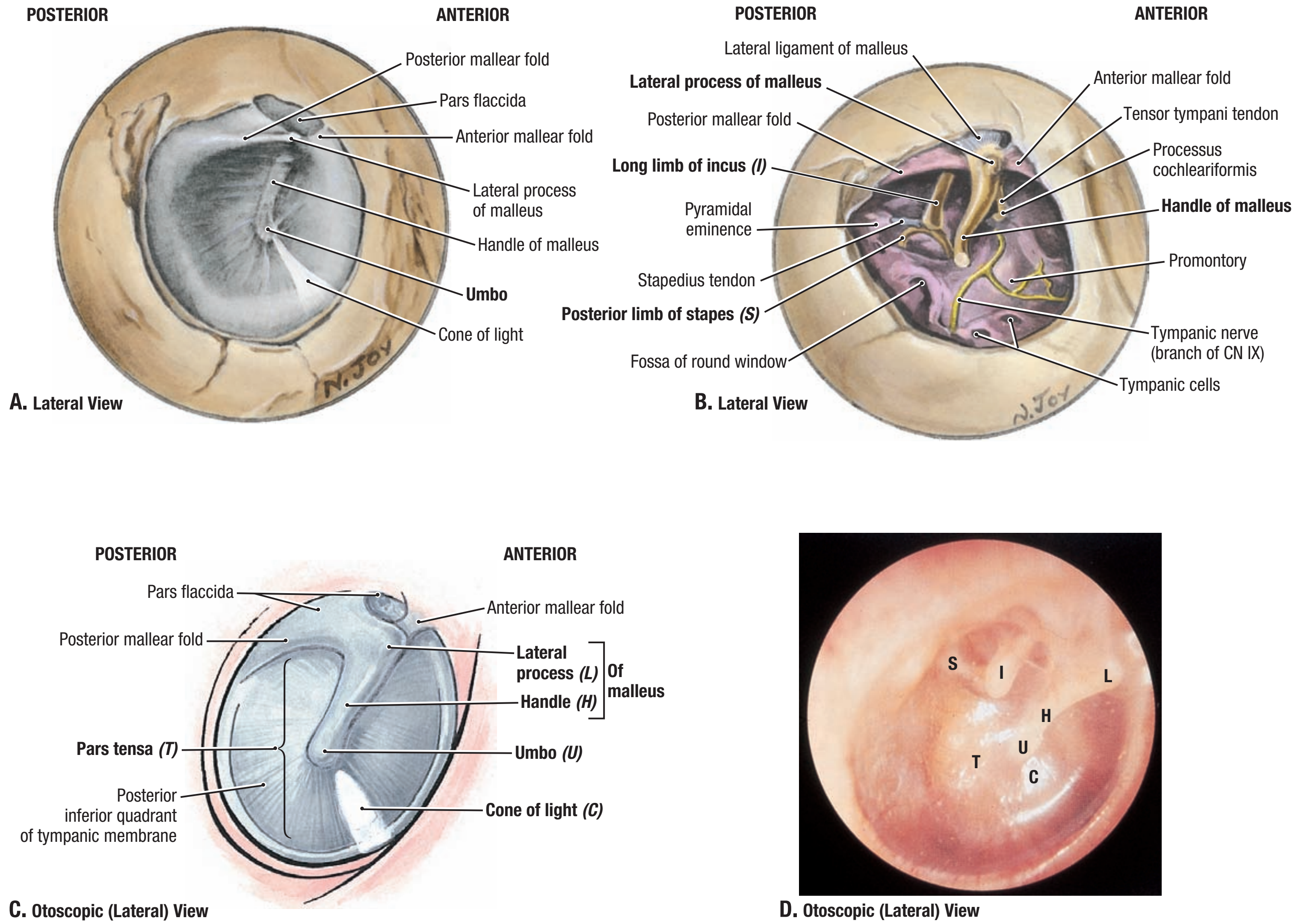
- The external ear comprises the auricle and external acoustic (auditory) meatus.
- The middle ear (tympanum) lies between the tympanic membrane and internal ear. Three ossicles extend from the lateral to the medial walls of the tympanum. Of these, the malleus is attached to the tympanic membrane. The stapes is attached by the anular ligament to the oval window, and the incus connects to the malleus and stapes. The pharyngotympanic tube, extending from the nasopharynx, opens into the anterior wall of the tympanic cavity.
- The membranous labyrinth comprises a closed system of membranous tubes and bulbs filled with fluid, endolymph (*orange* in **A** and **B**) and bathed in surrounding fluid, called perilymph *(purple* in **A** and **B**); both membranous labyrinth and perilymph are contained within the bony labyrinth.



7.83 EXTERNAL, MIDDLE, AND INTERNAL EAR II: CORONALLY SECTIONED

A. Anterior portion. **B.** Posterior portion. The inset *(outlined by the box)* is an enlargement of the structures of the middle and internal ear as they appear in **B.**

- The external acoustic meatus is about 3 cm long; half is cartilaginous and half is bony. It is narrowest at the isthmus, near the junction of the cartilaginous and bony parts.
- The external acoustic meatus is innervated by the auriculotemporal branch of the mandibular nerve (CN V_3) and the auricular branches of the vagus nerve (CN X); the middle ear is innervated by the glossopharyngeal nerve (CN IX).
- The cartilaginous part of the external acoustic meatus is lined with thick skin; the bony part is lined with thin skin that adheres to the periosteum and forms the outermost layer of the tympanic membrane.

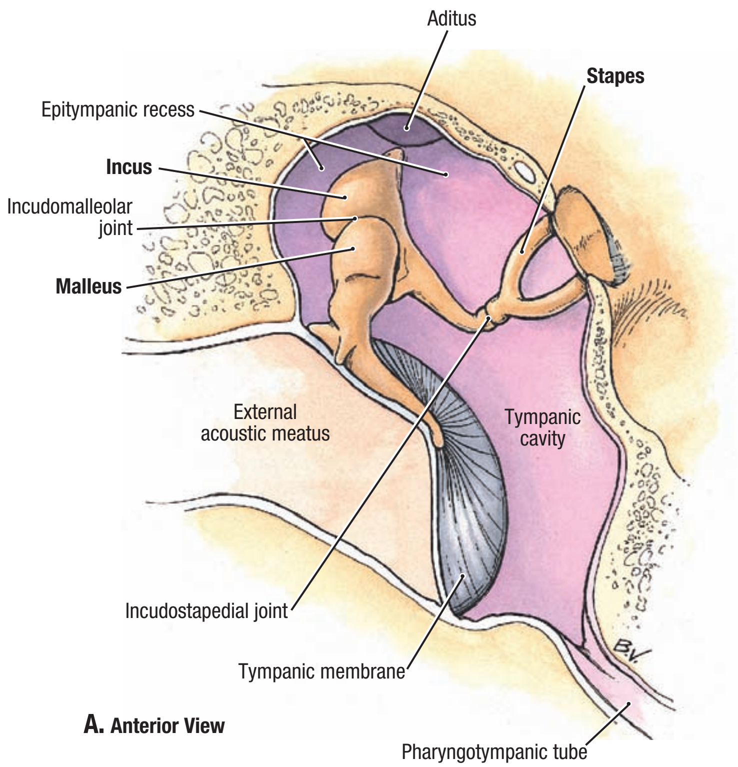


7.84 TYMPANIC MEMBRANE

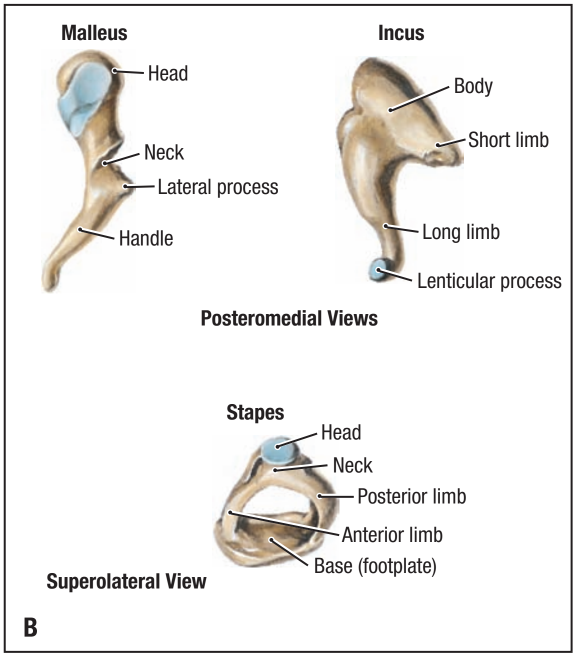
A. External (lateral) surface of tympanic membrane. **B.** Tympanic membrane removed, demonstrating structures that lie medially. **C.** Diagram of otoscopic view of tympanic membrane. **D.** Otoscopic view of tympanic membrane. Letter labels are identified in **C**.

- The oval tympanic membrane is a shallow cone deepest at the central apex, the umbo, where the membrane is attached to the tip of the handle of the malleus. The handle of the malleus is attached to the membrane along its entire length as it extends anterosuperiorly toward the periphery of the membrane.
- Superior to the lateral process of the malleus, the membrane is thin (pars flaccida); the flaccid part lacks the radial and circular fibers present in the remainder of the membrane (pars tensa). The junction between the two parts is marked by anterior and posterior mallear folds.
- The lateral surface of the tympanic membrane is innervated by the auricular branch of the auriculotemporal nerve (CN V_3) and the auricular branch of the vagus nerve (CN X); the medial surface is innervated by tympanic branches of CN IX.

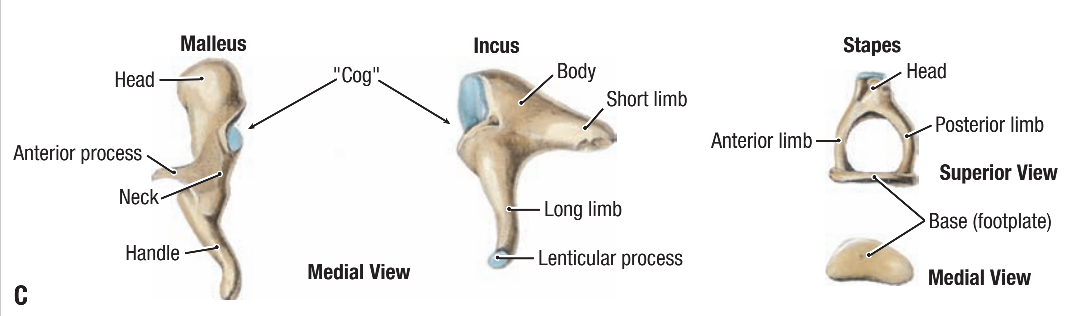
Examination of the external acoustic meatus and tympanic membrane begins by straightening the meatus. In adults, the helix is grasped and pulled posterosuperiorly (up, out, and back). These movements reduce the curvature of the external acoustic meatus, facilitating insertion of the otoscope. The external acoustic meatus is relatively short in infants; therefore, extra care must be taken to prevent damage to the tympanic membrane.



A. Anterior View



B



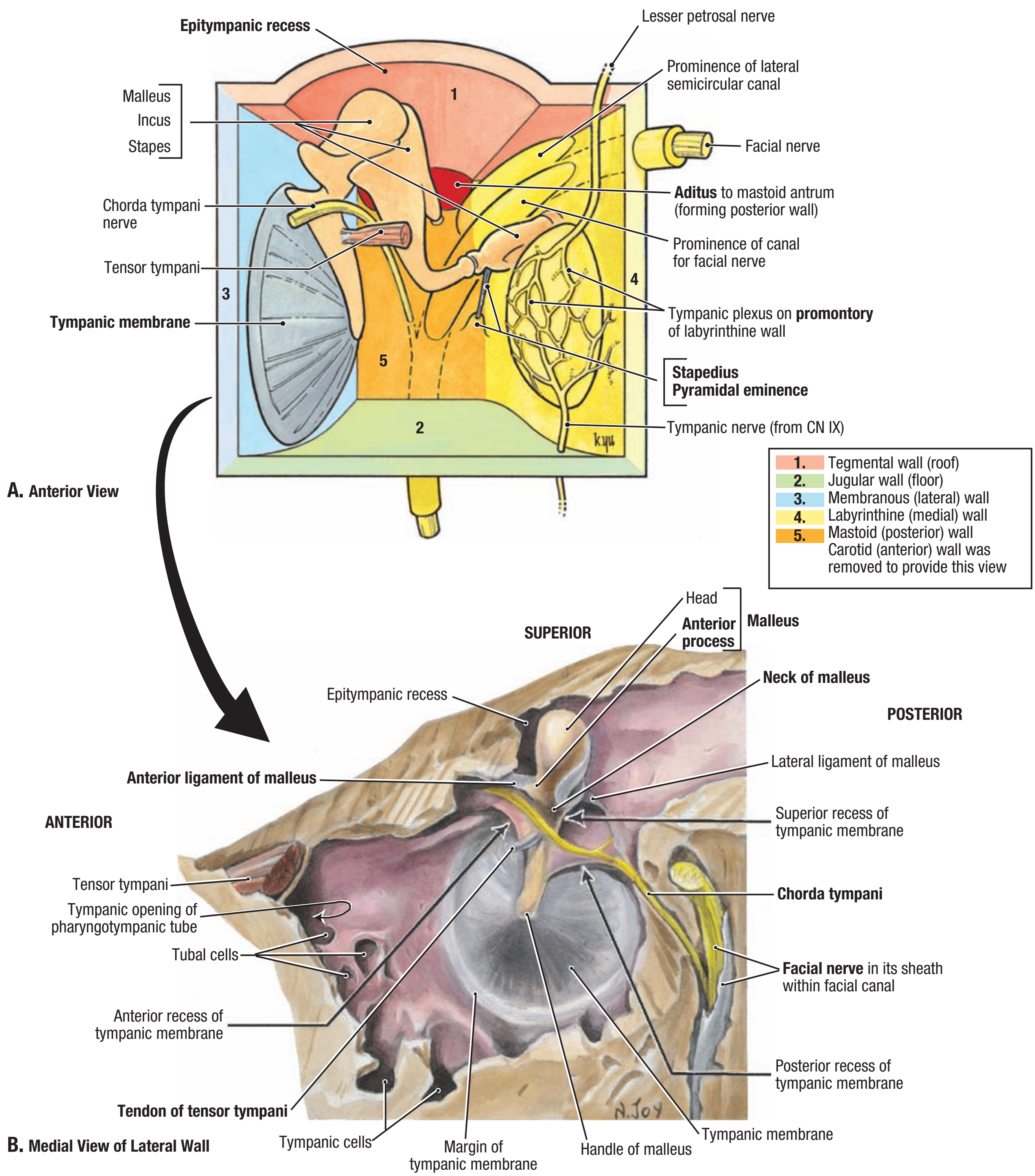
C

7.85 OSSICLES OF THE MIDDLE EAR

A. Ossicles in situ, as revealed by a coronal section of the temporal bone. **B. and C.** Isolated ossicles.

- The head of the malleus and body and short process of the incus lie in the epitympanic recess, and the handle of the malleus is embedded in the tympanic membrane.
- The saddle-shaped articular surface of the head of the malleus and the reciprocally shaped articular surface of the body of the incus form the incudomalleolar synovial joint.
- A convex articular facet at the end of the long process of the incus articulates with the head of the stapes to compose the incudostapedial synovial joint.

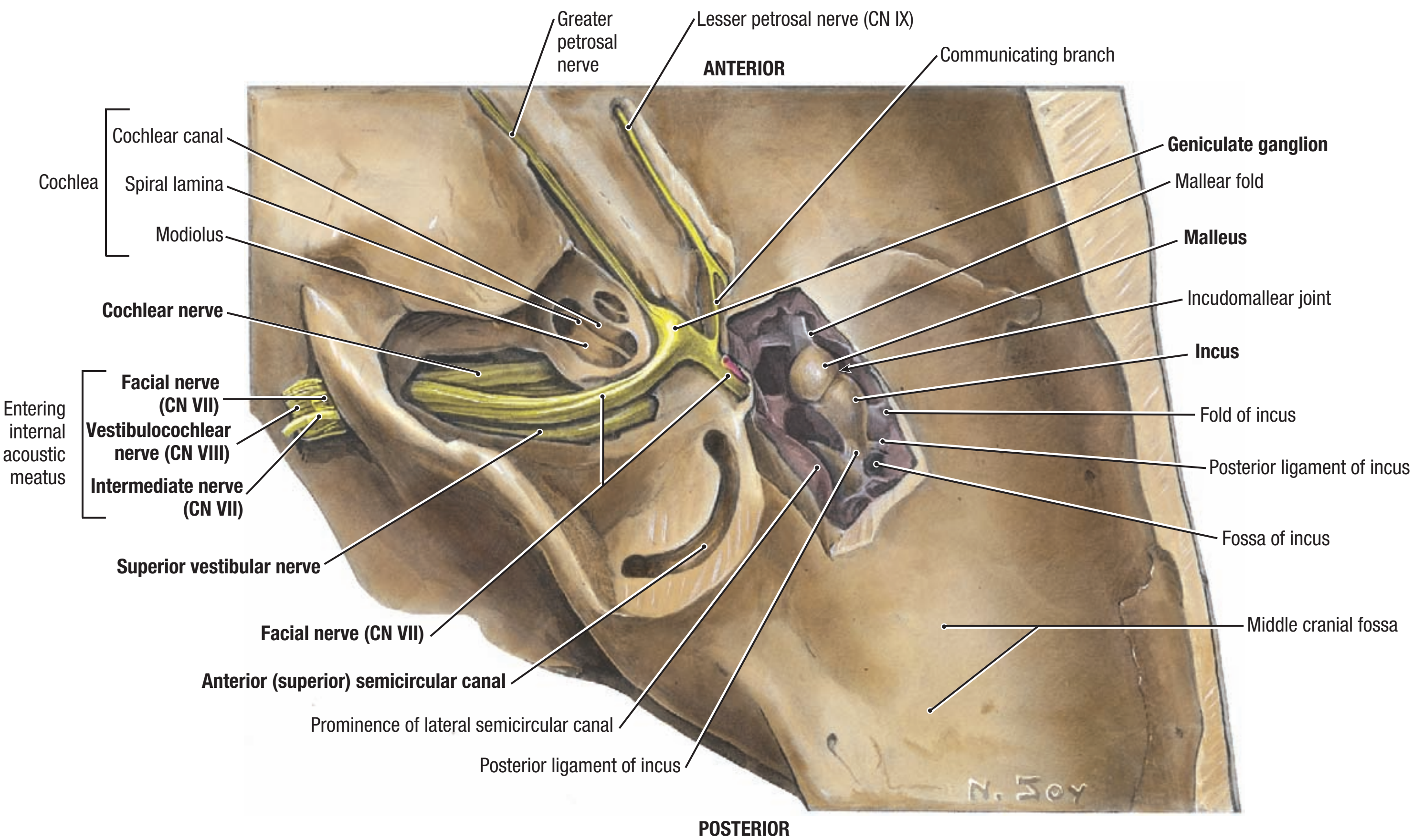
- An earache and bulging red tympanic membrane may indicate pus or fluid in the middle ear, a sign of **otitis media.** Infection of the middle ear often is secondary to upper respiratory infections. Inflammation and swelling of the mucous membrane lining the tympanic cavity may cause partial or complete blockage of the pharyngotympanic tube. The tympanic membrane becomes red and bulges, and the person may complain of “ear popping.” If untreated, otitis media may produce impaired hearing as the result of scarring of the auditory ossicles, limiting the ability of these bones to move in response to sound.



7.86 TRUCTURES OF THE TYMPANIC CAVITY

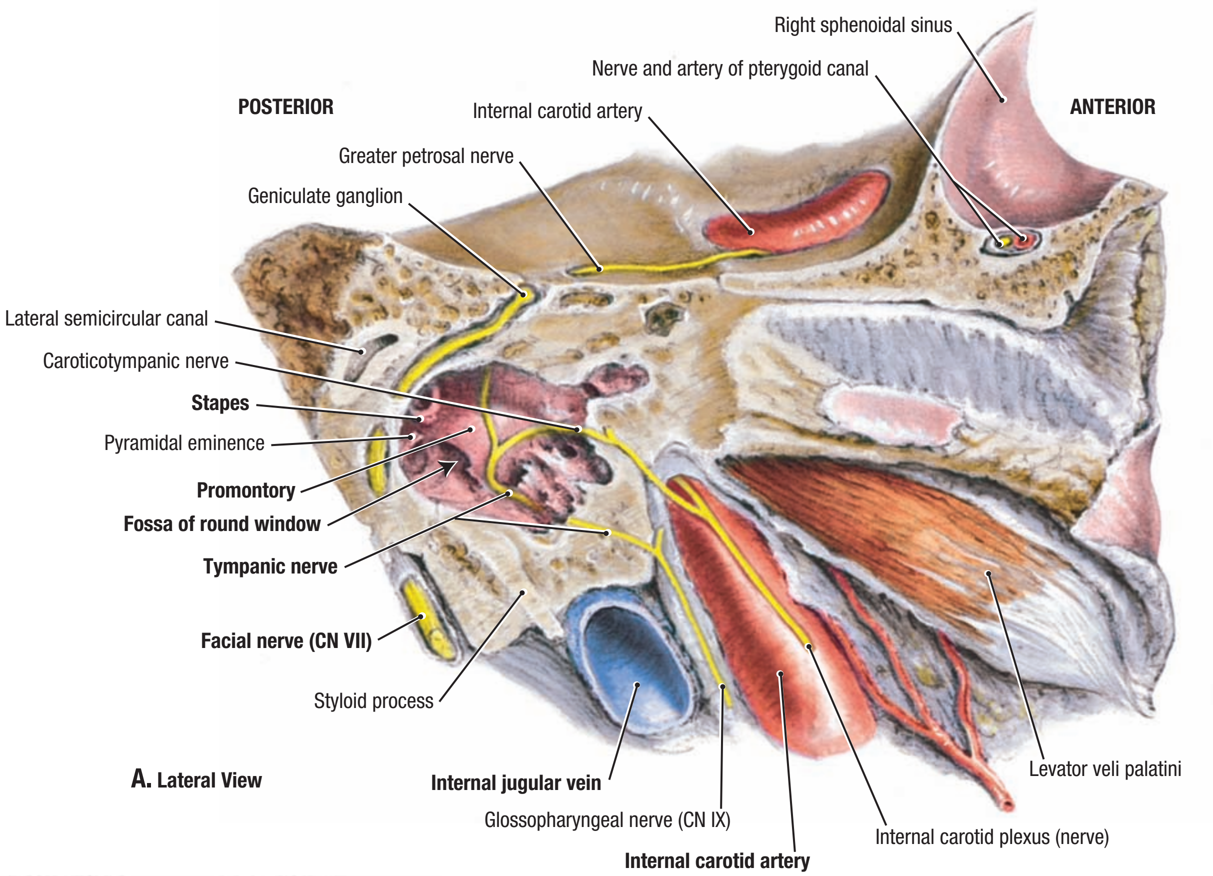
A. Schematic illustration of the tympanic cavity with the anterior wall removed. **B.** Lateral wall of the tympanic cavity. The facial nerve lies within the facial canal surrounded by a tough periosteal tube; the chorda tympani leaves the facial nerve and lies within two crescentic folds of mucous membrane, crossing the neck of the malleus superior to the tendon of tensor tympani.

Perforation of the tympanic membrane (ruptured eardrum) may result from otitis media. Perforation may also result from foreign bodies in the external acoustic meatus, trauma, or excessive pressure. Because the superior half of the tympanic membrane is much more vascular than the inferior half, incisions are made posteroinferiorly through the membrane. This incision also avoids injury to the chorda tympani nerve and auditory ossicles.

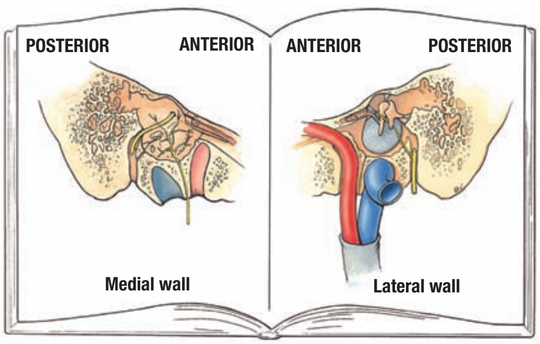


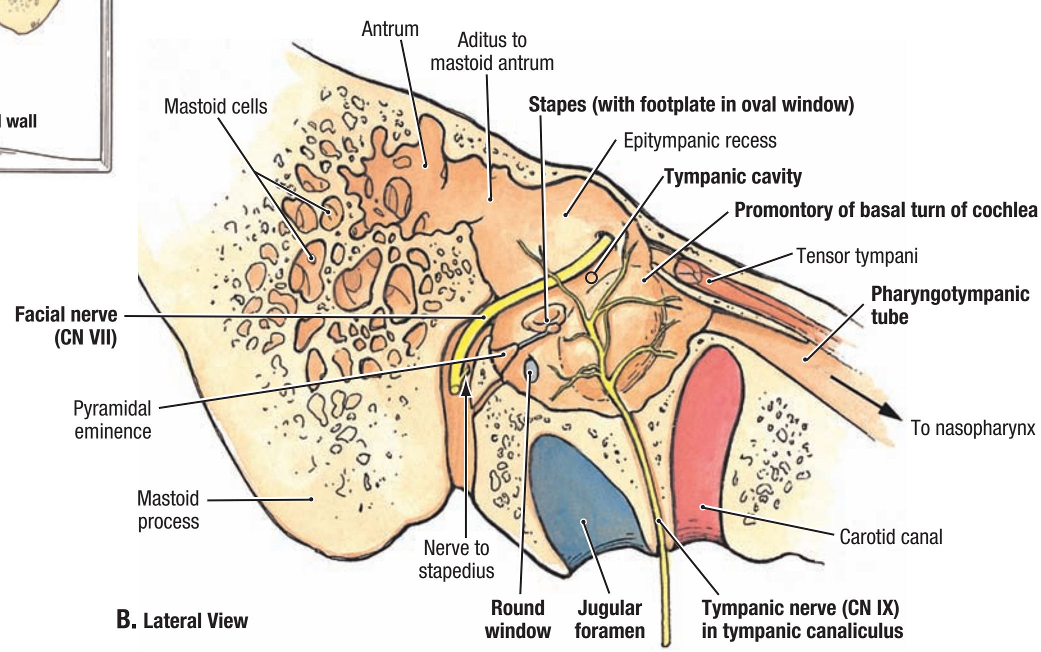
7.87 MIDDLE AND INNER EAR IN SITU

The tegmen tympani has been removed to expose the middle ear, the arcuate eminence has been removed to expose the anterior semicircular canal, and the course of the facial and vestibulocochlear nerves through the internal acoustic meatus and internal ear is demonstrated. At the geniculate ganglion, the facial nerve executes a sharp bend, called the genu, and then curves posteroinferiorly within the bony facial canal; the thin lateral wall of the facial canal separates the facial nerve from the tympanic cavity of the middle ear.



A. Lateral View

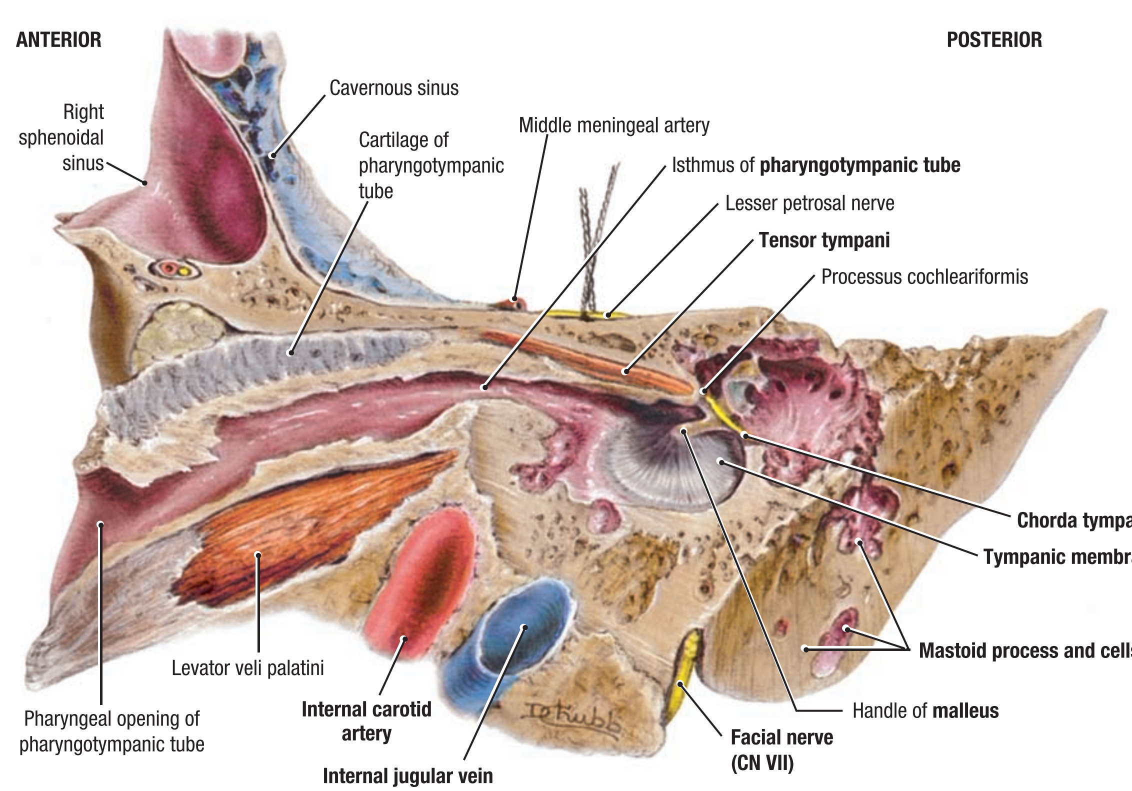




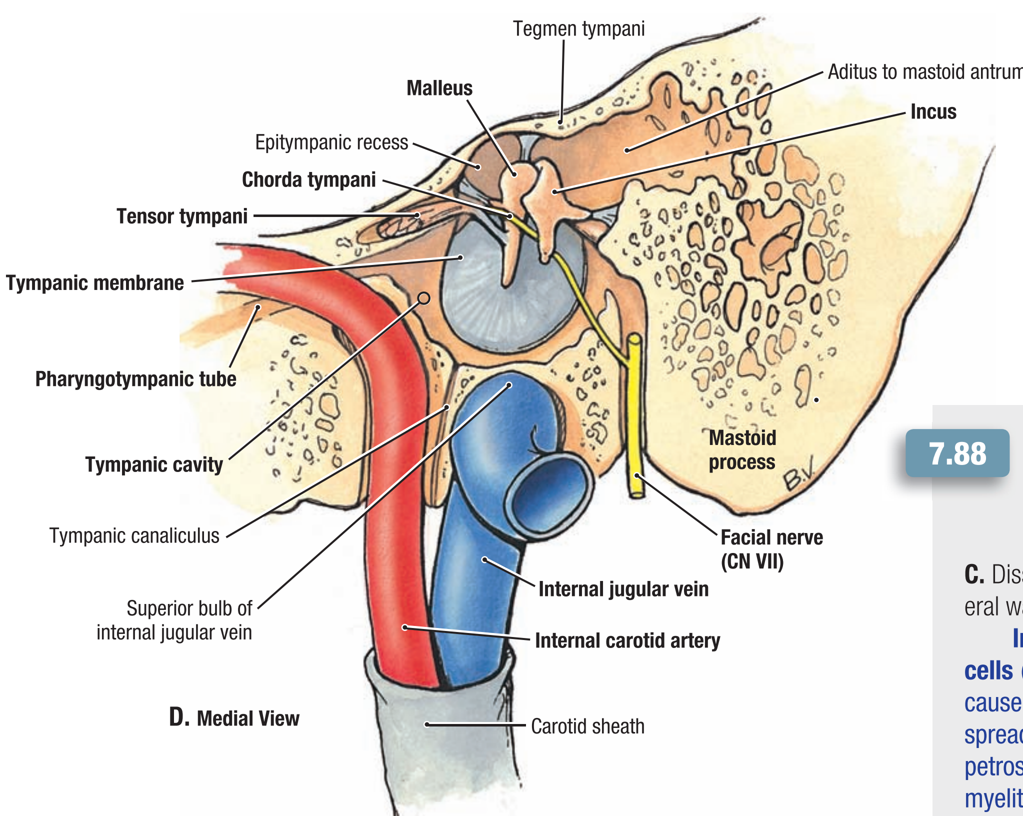
B. Lateral View

7.88 RIGHT TYMPANIC CAVITY AND PHARYNGOTYMPANIC TUBE

The cut surfaces of this longitudinally sectioned specimen are displayed as pages in a book. **A.** Dissection of medial wall. **B.** Schematic illustration of medial wall.



C. Medial View

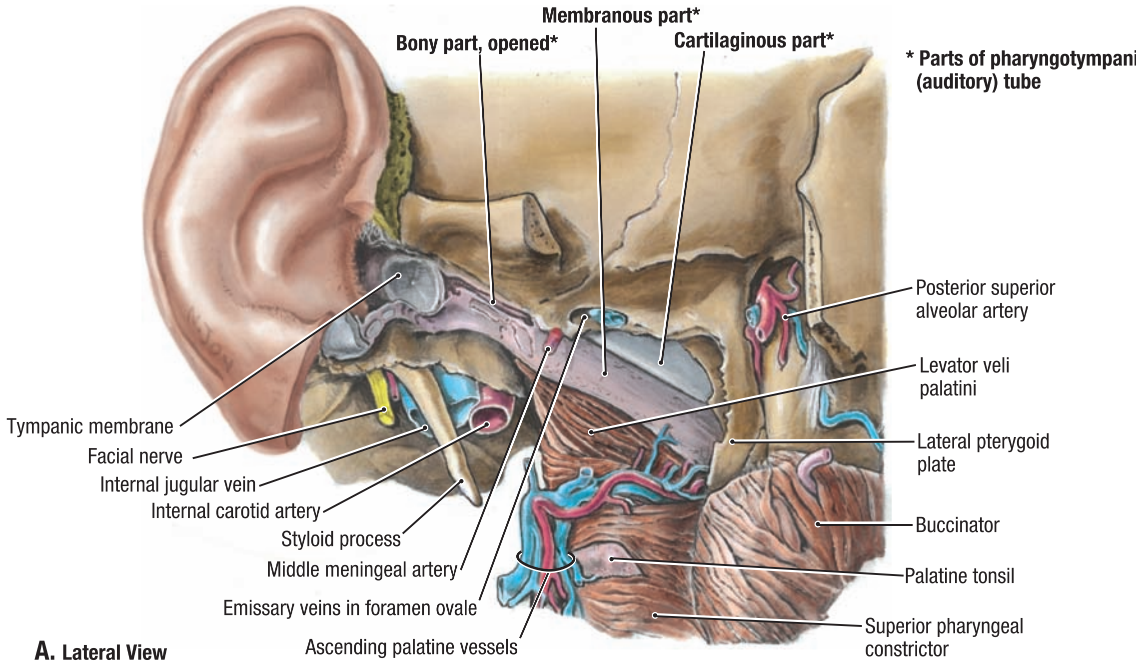


D. Medial View

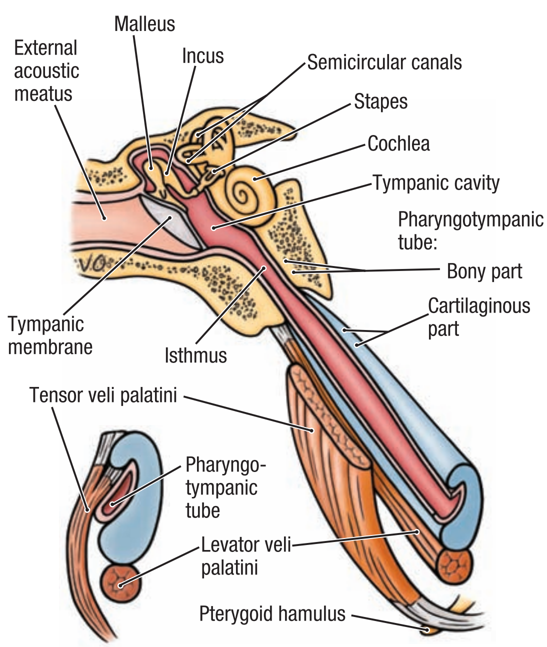
7.88 RIGHT TYMPANIC CAVITY AND PHARYNGOTYMPANIC TUBE *(CONTINUED)*

C. Dissection of lateral wall. **D.** Schematic illustration of lateral wall.

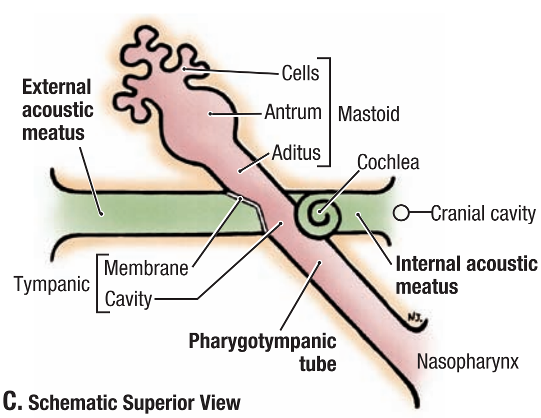
Infections of the mastoid antrum and mastoid cells (mastoiditis) result from middle ear infections that cause inflammation of the mastoid process. Infections may spread superiorly into the middle cranial fossa through the petrosquamous fissure in children or may cause osteomyelitis (bone infection) of the tegmen tympani. Since the advent of antibiotics, mastoiditis is uncommon.



A. Lateral View



B. Anterior view



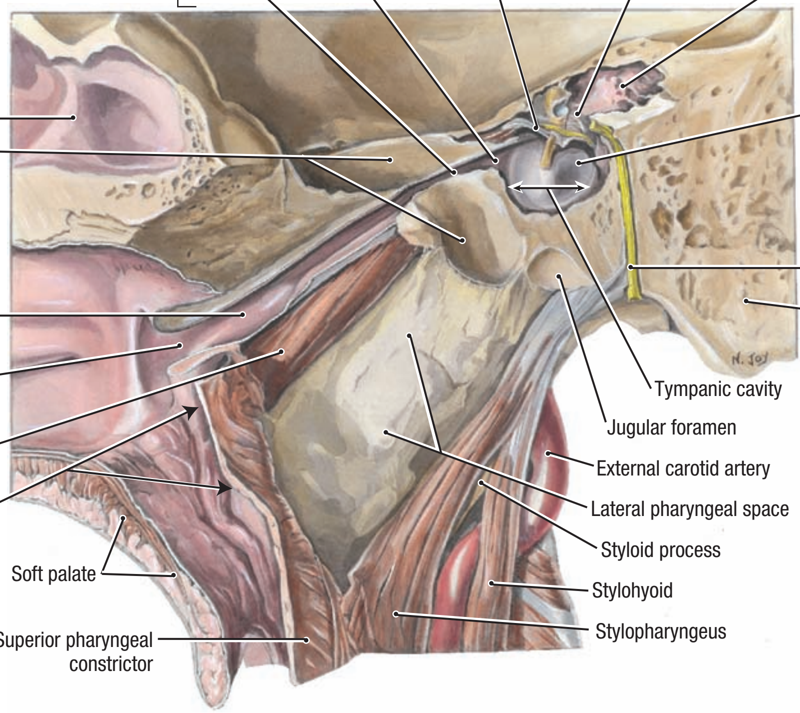
C. Schematic Superior View

7.89 RIGHT TYMPANIC CAVITY AND PHARYNGOTYMPANIC TUBE

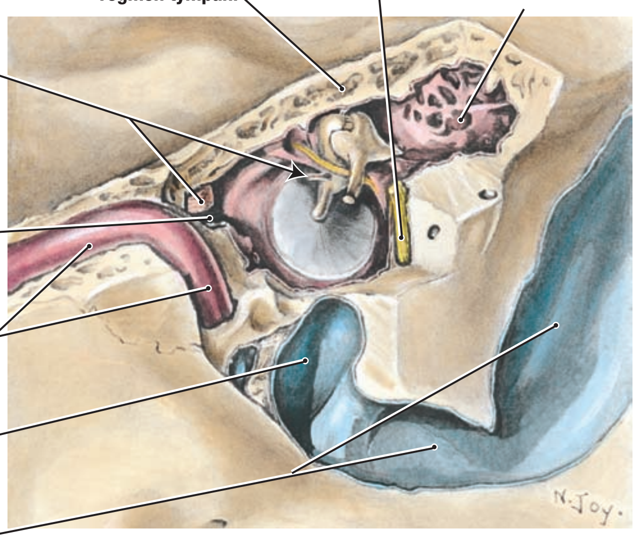
A. Dissection demonstrating lateral aspect of pharyngotympanic tube and structures located medially. **B.** Right pharyngotympanic tube. **C.** Schematic illustration demonstrating relationship between internal and external acoustic meatuses.

- The general direction of the pharyngotympanic tube is superior, posterior, and lateral from the nasopharynx to the tympanic cavity.
- The cartilaginous part of the tube rests throughout its length on the levator veli palatini muscle.
- The line of the meatuses and the line of the airway, from nasopharynx to mastoid cells, intersect at the tympanic cavity.
- The tegmen tympani forms the roof of the tympanic cavity and mastoid antrum.

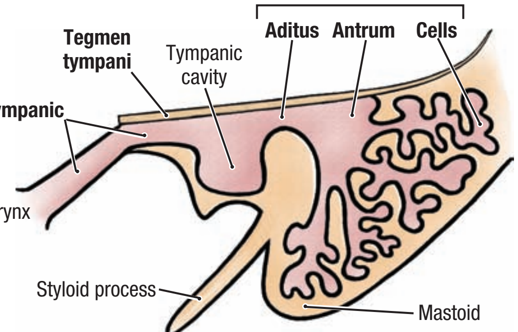
The **function of the pharyngotympanic tube** is to equalize pressure in the middle ear with the atmospheric pressure, thereby allowing free movement of the tympanic membrane. By allowing air to enter and leave the tympanic cavity, this tube balances the pressure on both sides of the membrane. Because the walls of the cartilaginous part of the tube are normally in apposition, the tube must be actively opened. The tube is opened by the expanding girth of the belly of the levator veli palatini as it contracts longitudinally, pushing against one wall while the tensor veli palatini pulls on the other. Because these are muscles of the soft palate, equalizing pressure (popping the eardrums) is commonly associated with activities such as yawning and swallowing.



D. Medial View



E. Medial View

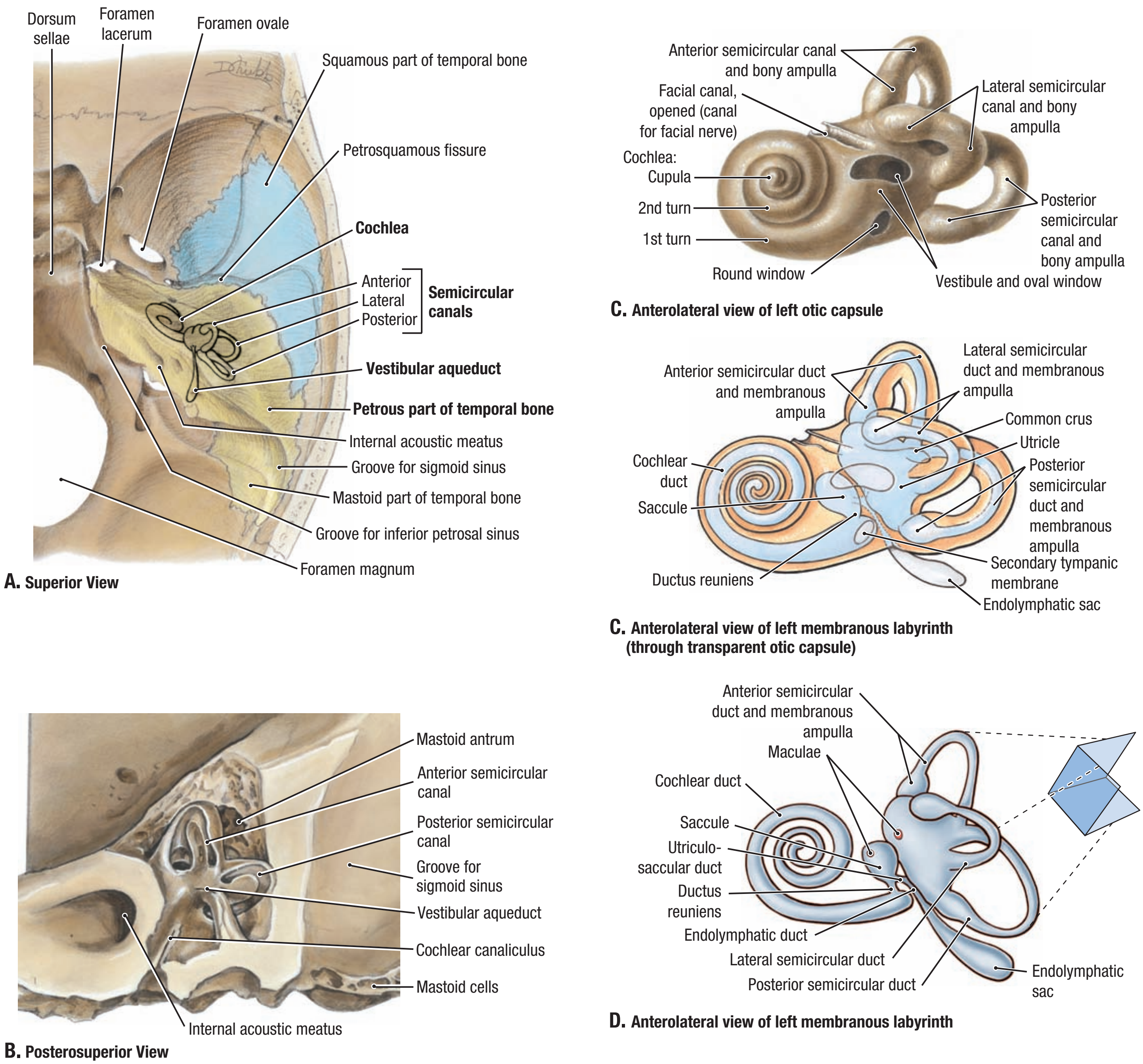


F. Schematic illustration

7.89 RIGHT TYMPANIC CAVITY AND PHARYNGOTYMPANIC TUBE *(CONTINUED)*

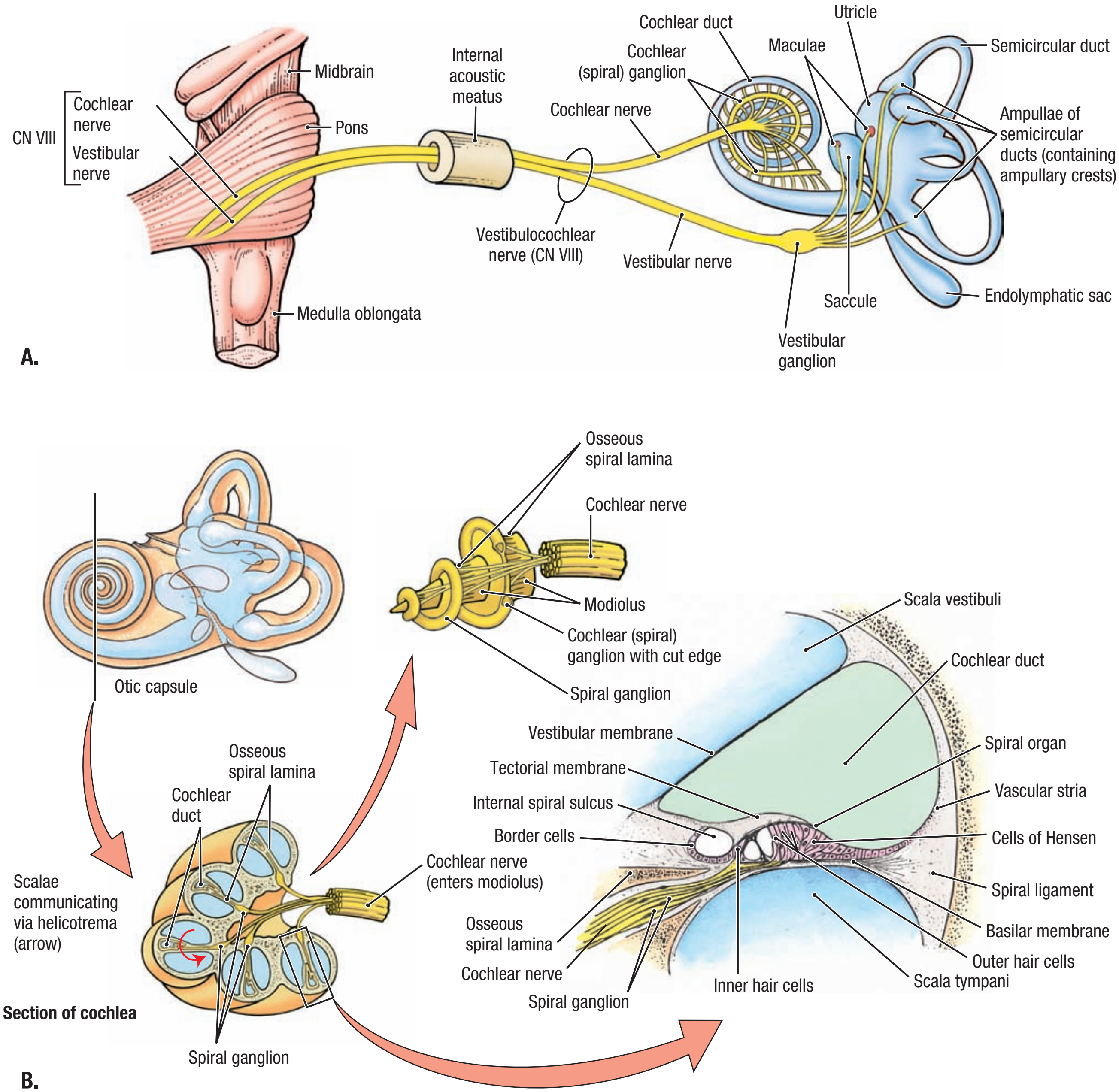
D. Spaces of tympanic bone. **E.** Relationship of tympanic cavity to internal carotid artery, sigmoid sinus, and middle cranial fossa. **F.** Diagram of tegmen tympani.

- The internal carotid artery is the primary relationship of the anterior wall, the internal jugular vein is the primary relationship of the floor, and the facial nerve is the primary relationship of the posterior wall.



7.90 BONY AND MEMBRANOUS LABYRINTHS

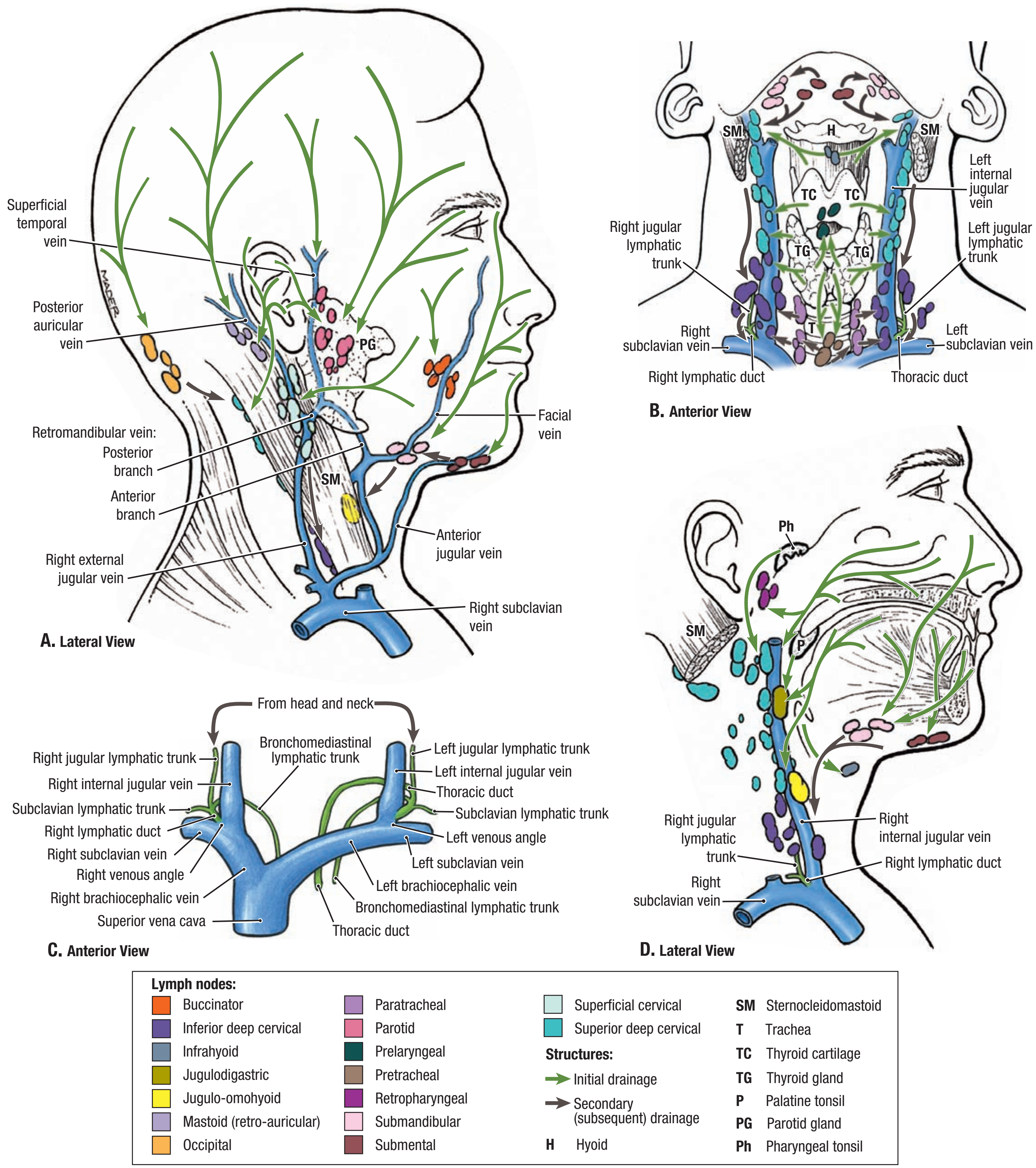
A. Location and orientation of bony labyrinth within petrous temporal bone. **B.** Semicircular canals and aqueducts *in situ*. The tegmen tympani has been excised, and the softer bone surrounding the harder bone of the otic capsule has been drilled away. **C.** Walls of left bony labyrinth (otic capsule). The bony labyrinth is the fluid-filled space contained within this formation. **D.** Membranous labyrinth as it lies within the surrounding bony labyrinth. **E.** Isolated left membranous labyrinth.



7.91 VESTIBULOCOCHLEAR NERVE (CN VIII) AND STRUCTURE OF COCHLEA

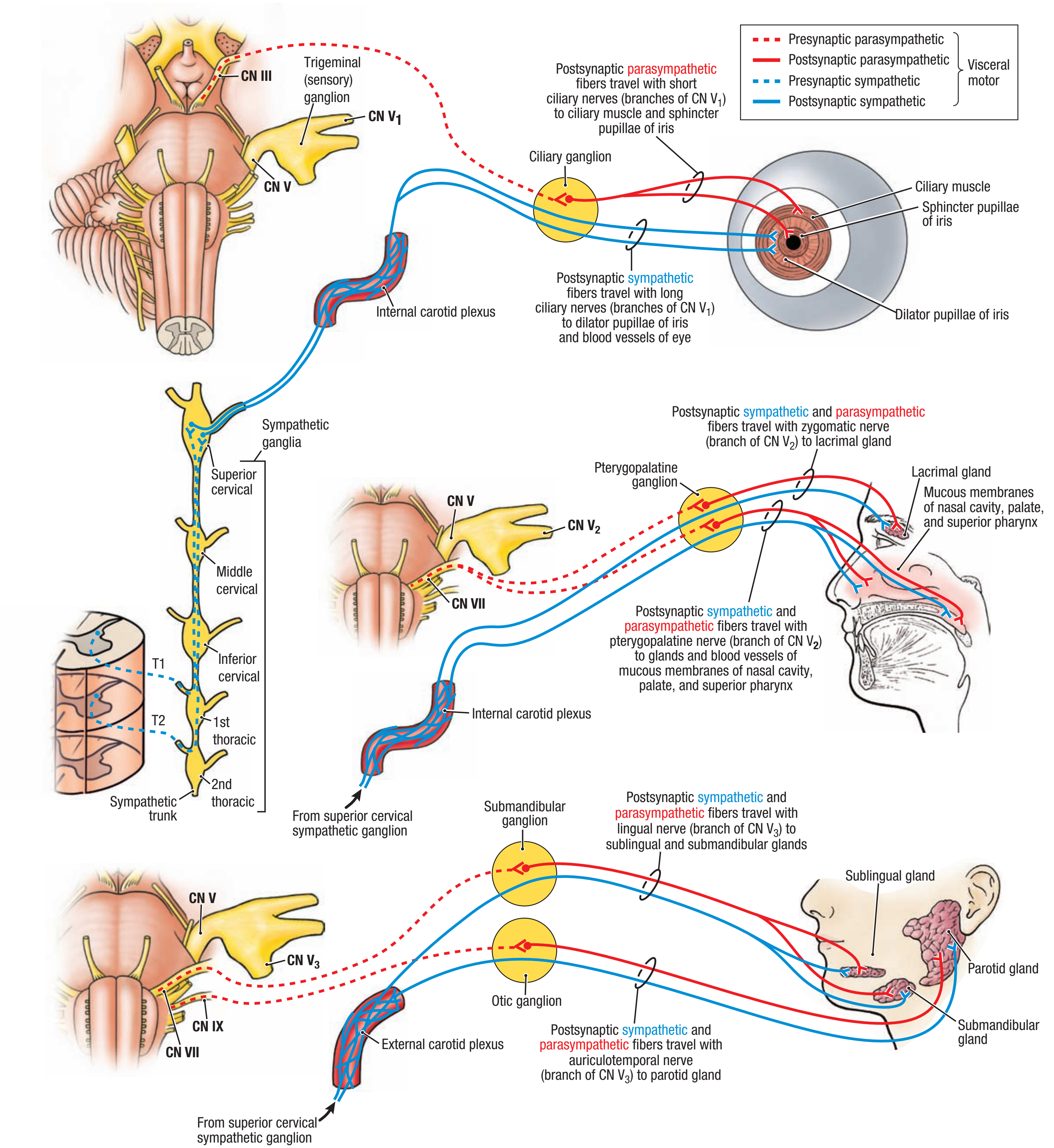
A. Distribution of vestibulocochlear nerve (schematic). **B.** Structure of cochlea. The cochlea has been sectioned along the bony core of the cochlea (modiolus), the axis about which the cochlea winds. An isolated modiolus is shown after the turns of the cochlea are removed, leaving only the spiral lamina winding around it. The *large drawing* shows the details of the *area enclosed in the rectangle,* including a cross section of the cochlear duct of the membranous labyrinth.

- The maculae of the membranous labyrinth are primarily static organs, which have small dense particles (otoliths) embedded among the hair cells. Under the influence of gravity, the otoliths cause bending of the hair cells, which stimulate the vestibular nerve and provide awareness of the position of the head in space; the hairs also respond to quick tilting movements and to linear acceleration and deceleration. **Motion sickness** results mainly from discordance between vestibular and visual stimuli.
- Persistent exposure to excessively loud sound causes degenerative changes in the spiral organ, resulting in **high-tone deafness.** This type of hearing loss commonly occurs in workers who are exposed to loud noises and do not wear protective earmuffs.

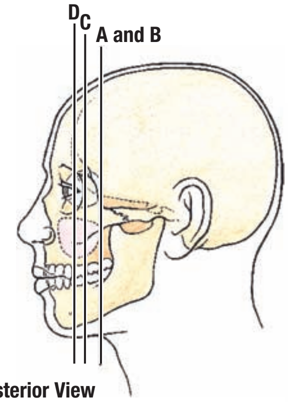


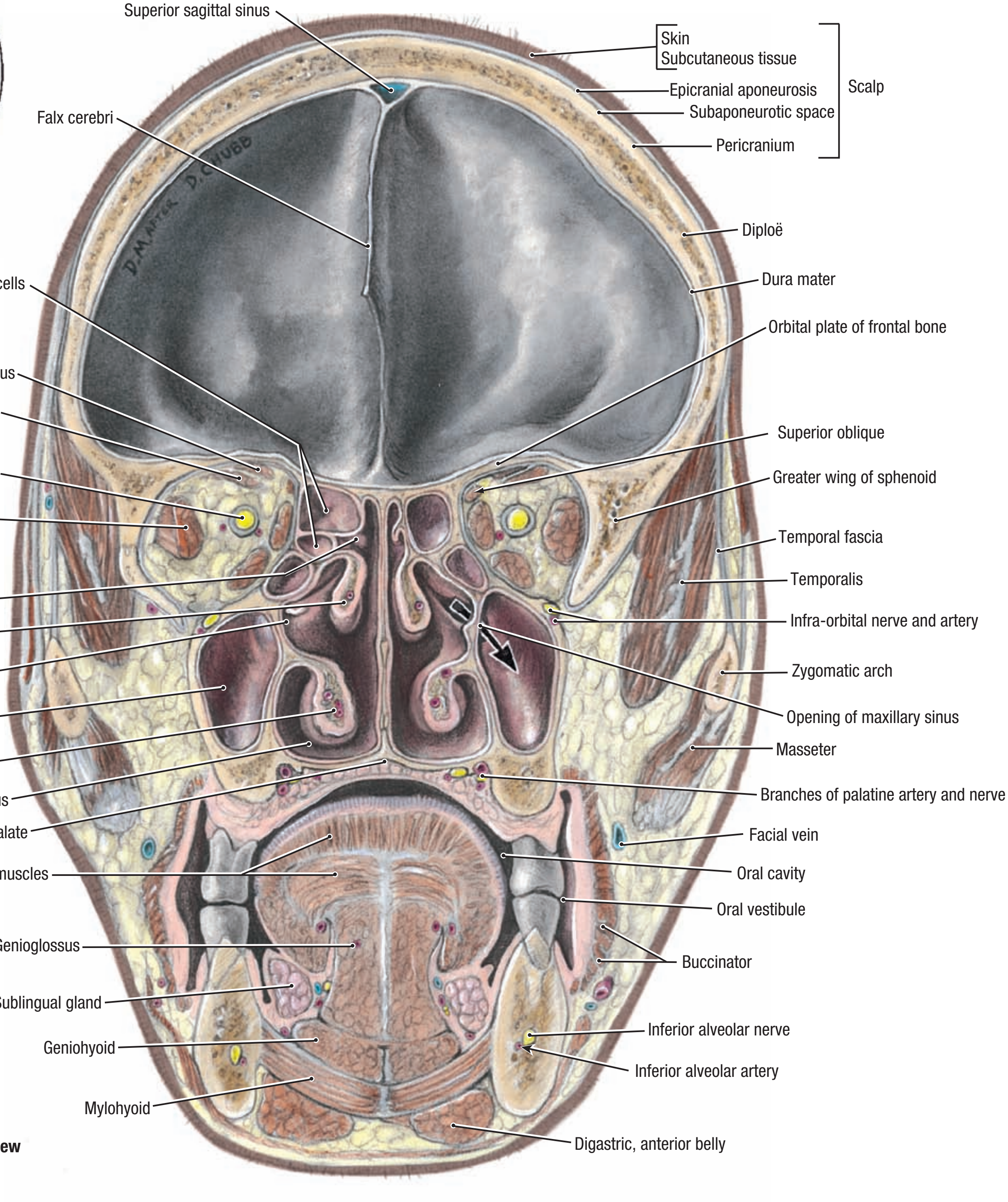
7.92 LYMPHATIC AND VENOUS DRAINAGE OF HEAD AND NECK

A. Superficial drainage. **B.** Drainage of the trachea, thyroid gland, larynx, and floor of mouth. **C.** Termination of right and left jugular lymphatic trunks. **D.** Deep drainage.



7.93 AUTONOMIC INNERVATION OF HEAD

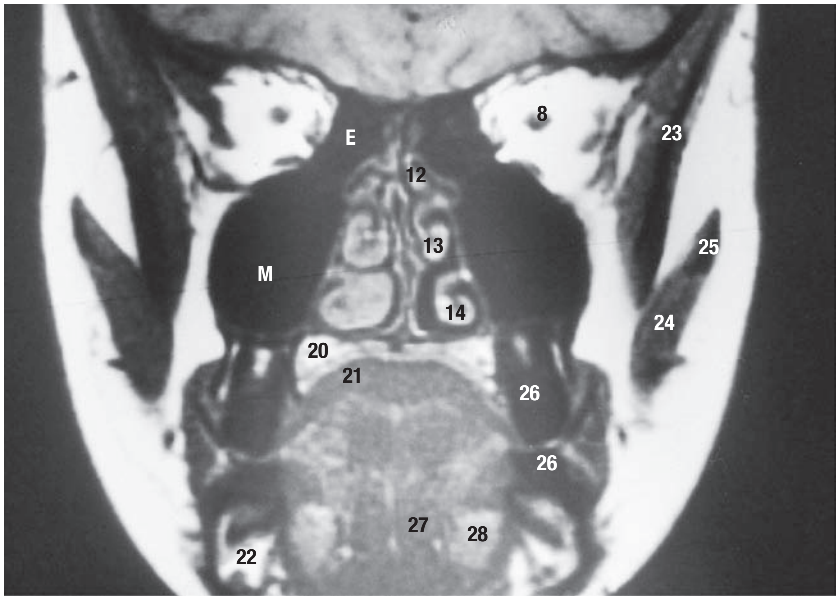




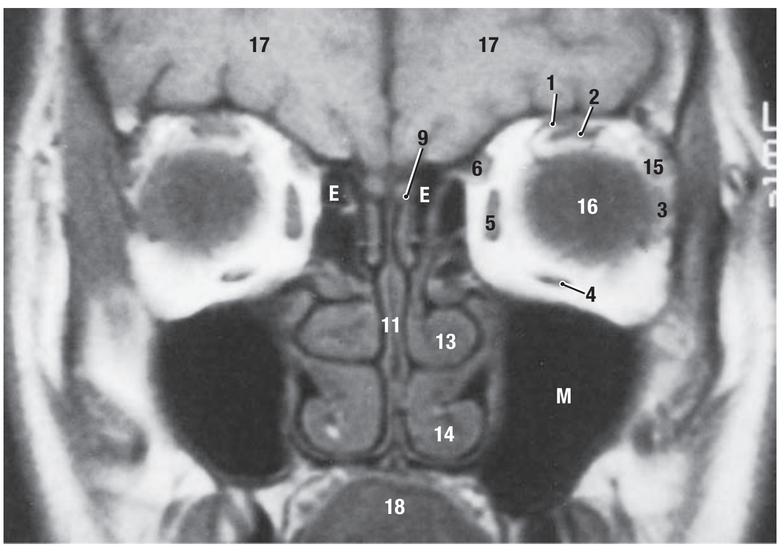
A. Coronal Section, Posterior View

7.94 CORONAL SECTION AND MRI IMAGING OF NASOPHARYNX AND ORAL CAVITY

A. Coronal section. **B.–D.** Coronal MRIs.

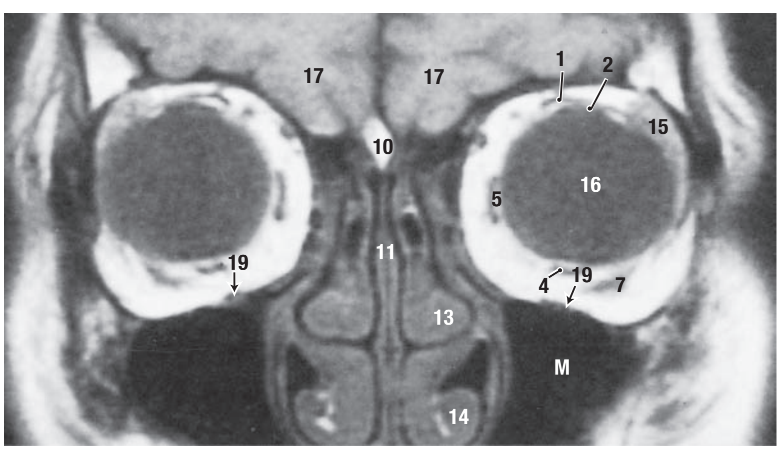


B



C

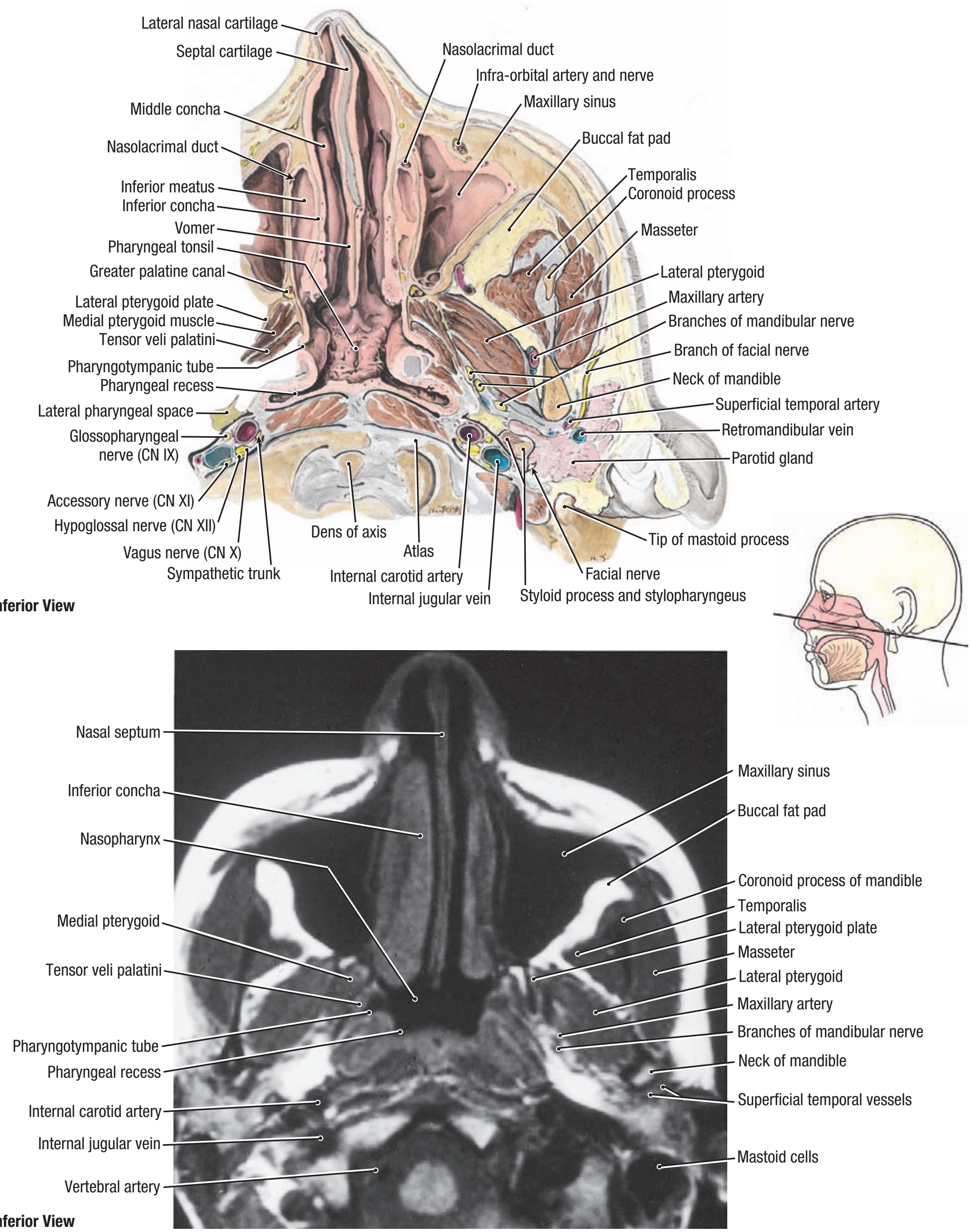
1 Levator palpebrae superioris
2 Superior rectus
3 Lateral rectus
4 Inferior rectus
5 Medial rectus
6 Superior oblique
7 Inferior oblique
8 Optic nerve
9 Olfactory bulb
10 Crista galli
11 Nasal septum
12 Superior concha
13 Middle concha
14 Inferior concha
15 Lacrimal gland
16 Eyeball
17 Frontal lobe
18 Tongue
19 Infra-orbital vessels and nerve
20 Hard palate
21 Intrinsic muscles of tongue
22 Mandible
23 Temporalis
24 Masseter
25 Zygomatic arch
26 Molar teeth
27 Genioglossus
28 Sublingual gland
M Maxillary sinus
E Ethmoidal air cell



Posterior Views

D

7.94 CORONAL SECTION AND MRI IMAGING OF NASOPHARYNX AND ORAL CAVITY *(CONTINUED)*

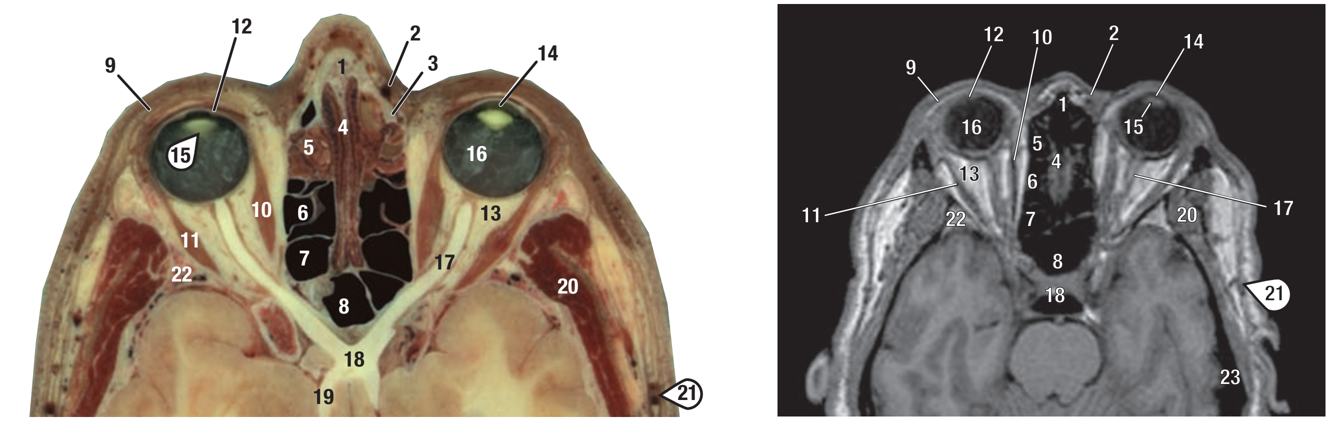


A. **Inferior View**

B. **Inferior View**

7.95 TRANSVERSE SECTION AND MRI IMAGE OF NASAL CAVITY AND NASOPHARYNX

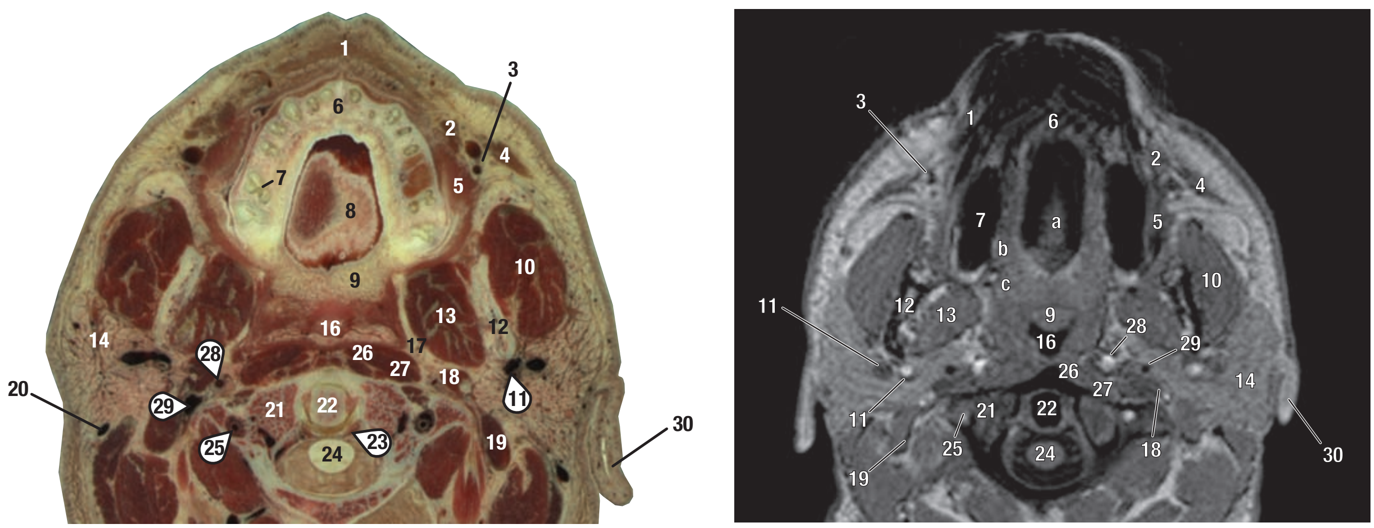
A. Transverse section of left side of head. **B.** Transverse (axial) MRI scan.



A. Transverse Section and Transverse (axial) MRI Scan

Key

1 Nasal bones
2 Angular artery
3 Frontal process of maxilla
4 Nasal septum
5 Anterior ethmoidal cell
6 Middle ethmoidal cell
7 Posterior ethmoidal air cell
8 Sphenoid sinus
9 Orbicularis oculi muscle
10 Medial rectus muscle
11 Lateral rectus muscle
12 Cornea
13 Retrobulbar fat
14 Anterior chamber
15 Lens
16 Vitreous body
17 Optic nerve
18 Optic chiasm
19 Optic tract
20 Temporalis muscle
21 Superficial temporal vessels
22 Greater wing of sphenoid
23 Squamous part of temporal bone



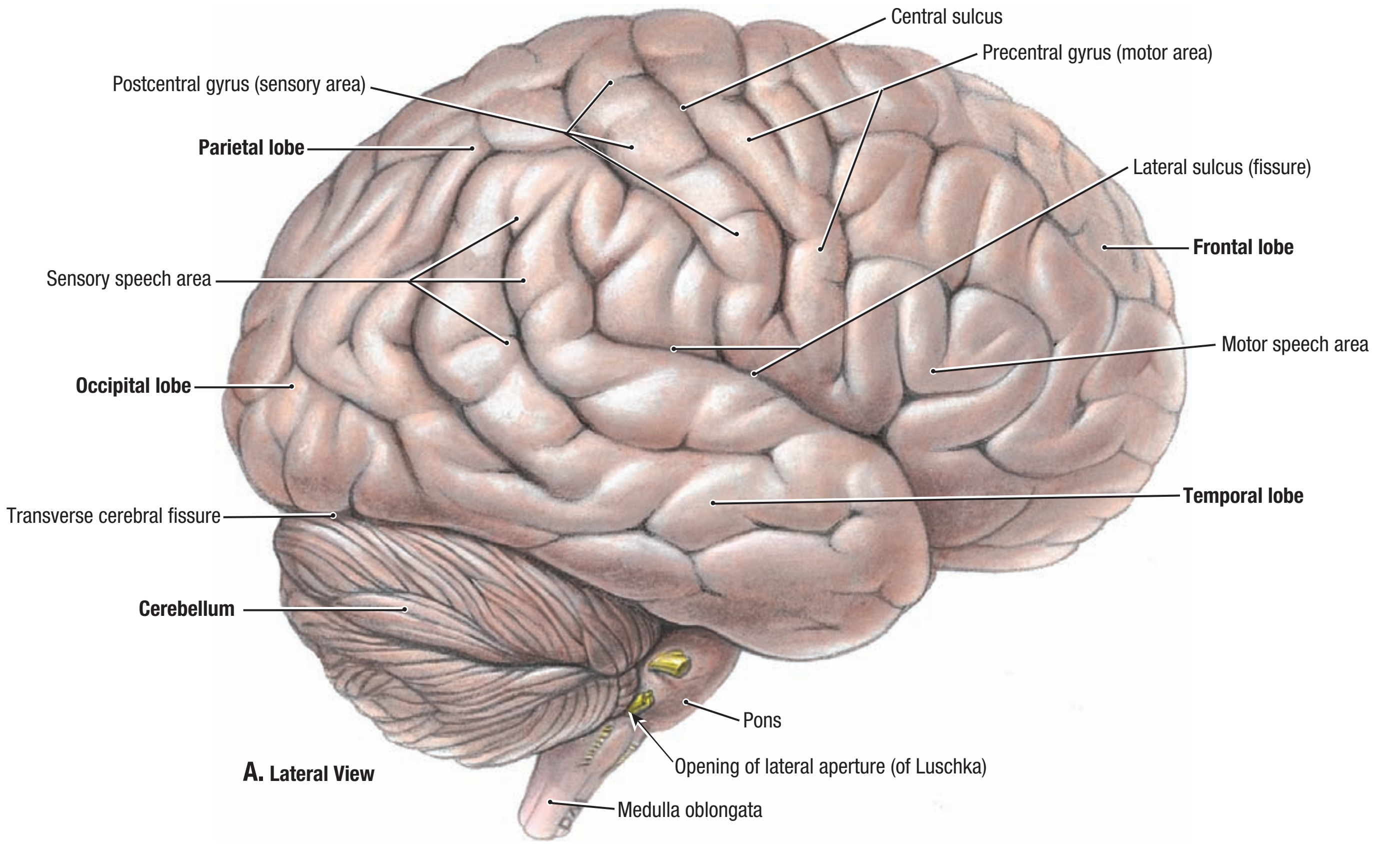
B. Transverse Section and Transverse (axial) MRI Scan

Key

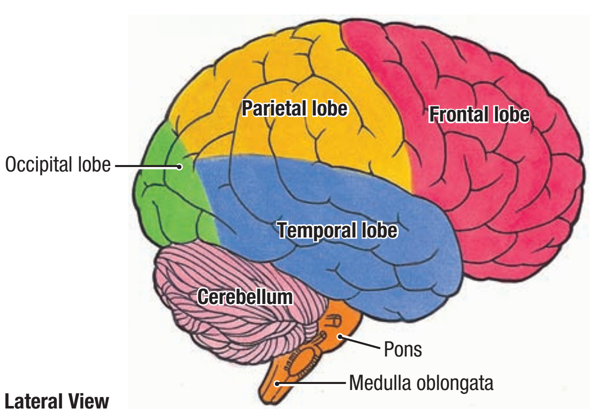
1 Orbicularis oris muscle
2 Levator anguli oris muscle
3 Facial artery and vein
4 Zygomaticus major muscle
5 Buccinator muscle
6 Maxilla
7 Alveolar process of maxilla
8 Dorsum of tongue
9 Soft palate (uvula apparent in image)
10 Masseter muscle
11 Retromandibular vein
12 Ramus of mandible
13 Lateral pterygoid muscle
14 Parotid gland
15 Superficial temporal vessels
16 Region of pharyngeal tubercle
17 Sphenoid bone
18 Stylohyoid ligament and muscle
19 Posterior belly of digastric muscle
20 Occipital artery
21 First cervical vertebrae (atlas)
22 Dens (axis)
23 Transverse ligament of atlas
24 Spinal cord
25 Vertebral artery in foramina transversaria
26 Longus colli muscle
27 Longus capitis muscle
28 Internal carotid artery
29 Internal jugular vein
30 Inferior portion of helix of auricle
a Hard palate
b Palatoglossus muscle
c Palatopharyngeus muscle

7.96 IMAGING OF ORBIT AND ORAL CAVITY/MAXILLARY REGION

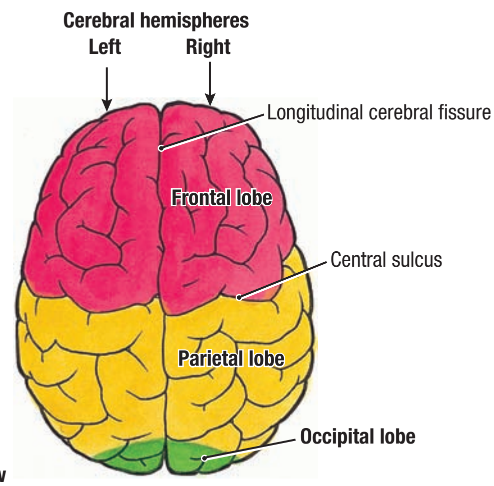
A. Transverse section and MRI through in plane of optic nerve. **B.** Transverse section and MRI at level of atlas/dens.



A. Lateral View



B. Lateral View

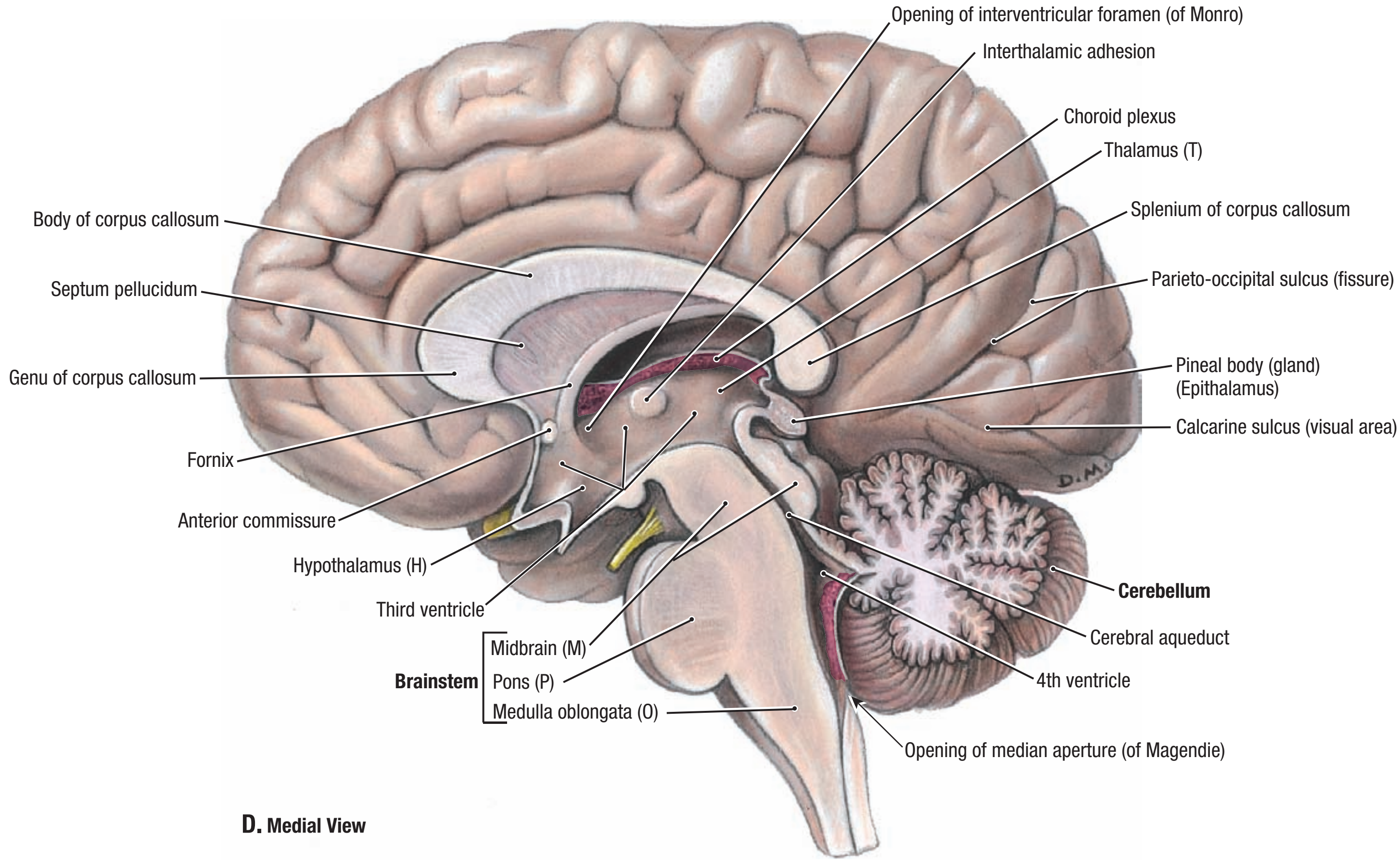


C. Superior View

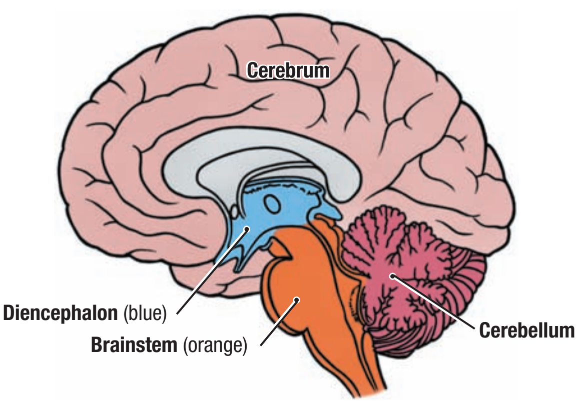
7.97 BRAIN

A. Cerebrum, cerebellum, and brainstem, lateral aspect. **B.** Lobes of the cerebral hemispheres, lateral aspect. **C.** Lobes of the cerebral hemispheres, superior aspect.

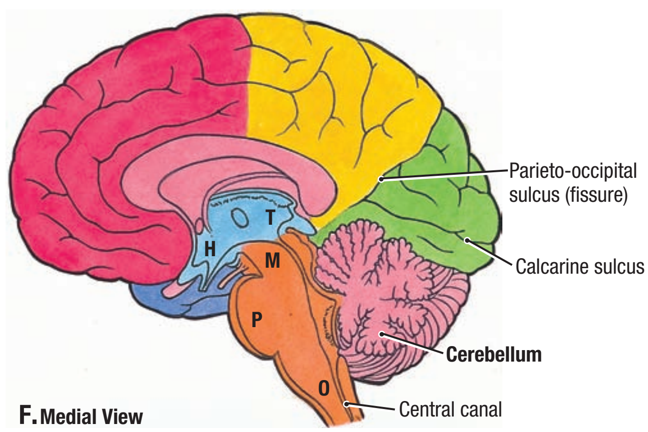
Cerebral contusion (bruising) results from brain trauma in which the pia is stripped from the injured surface of the brain and may be torn, allowing blood to enter the subarachnoid space. The bruising results from the sudden impact of the moving brain against the stationary cranium or from the suddenly moving cranium against the stationary brain. Cerebral contusion may result in an extended loss of consciousness.



D. Medial View



E. Medial View

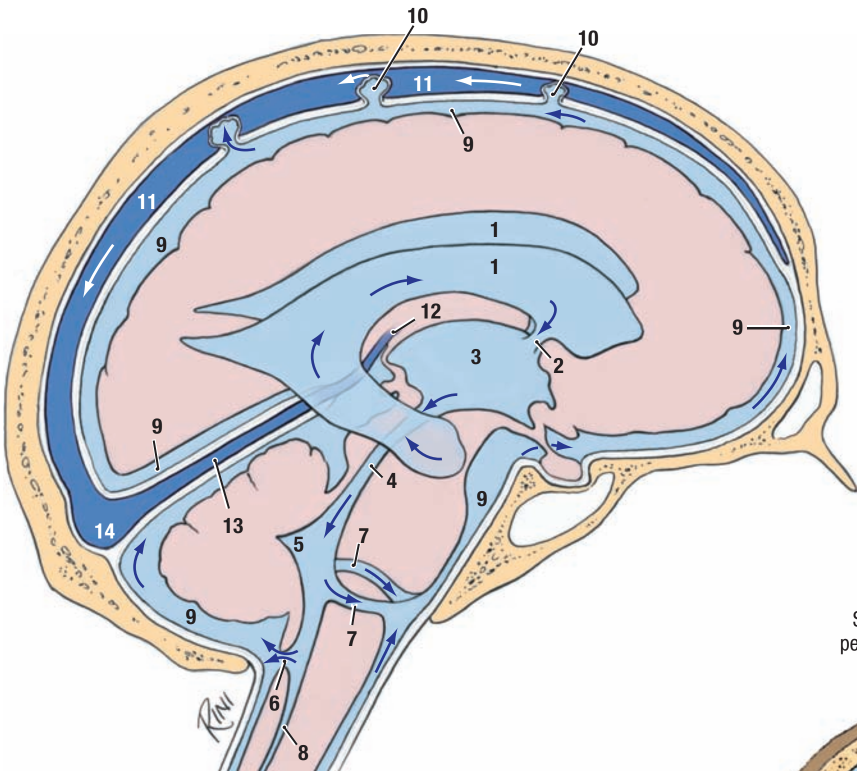


F. Medial View

7.97 BRAIN *(CONTINUED)*

D. Cerebrum, cerebellum, and brainstem, median section. **E.** Parts of the brain, median section. **F.** Lobes of the cerebral hemisphere, median section. See **D** for labeling key.

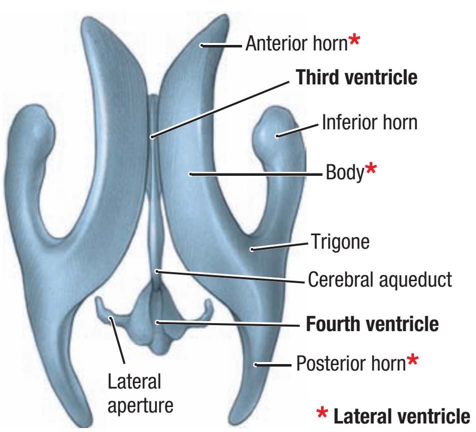
Cerebral compression may be produced by intracranial collections of blood, obstruction of CSF circulation or absorption, intracranial tumors or abscesses, and brain swelling caused by brain edema, an increase in brain volume resulting from an increase in water and sodium content.



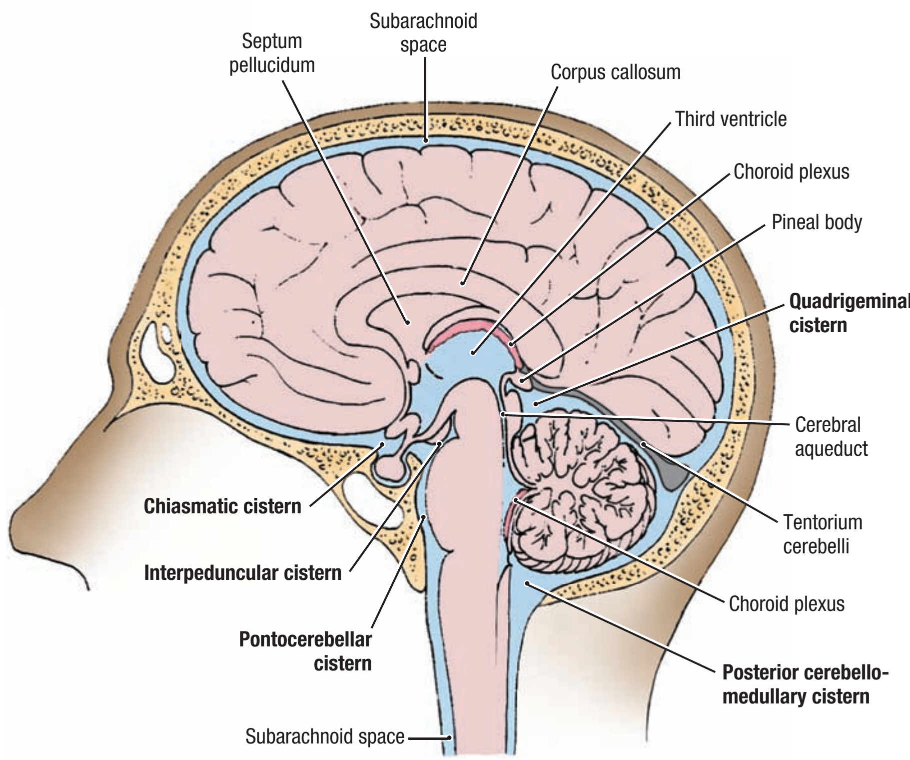
A. Lateral View, Schematic

KEY for A:

1	Right and left lateral ventricles
2	Interventricular foramen
3	Third ventricle
4	Cerebral aqueduct
5	Fourth ventricle
6	Median aperture
7	Lateral apertures
8	Central canal
9	Subarachnoid space
10	Arachnoid granulations
11	Superior sagittal sinus
12	Great cerebral vein
13	Straight sinus
14	Confluence of sinuses



B. Superior View

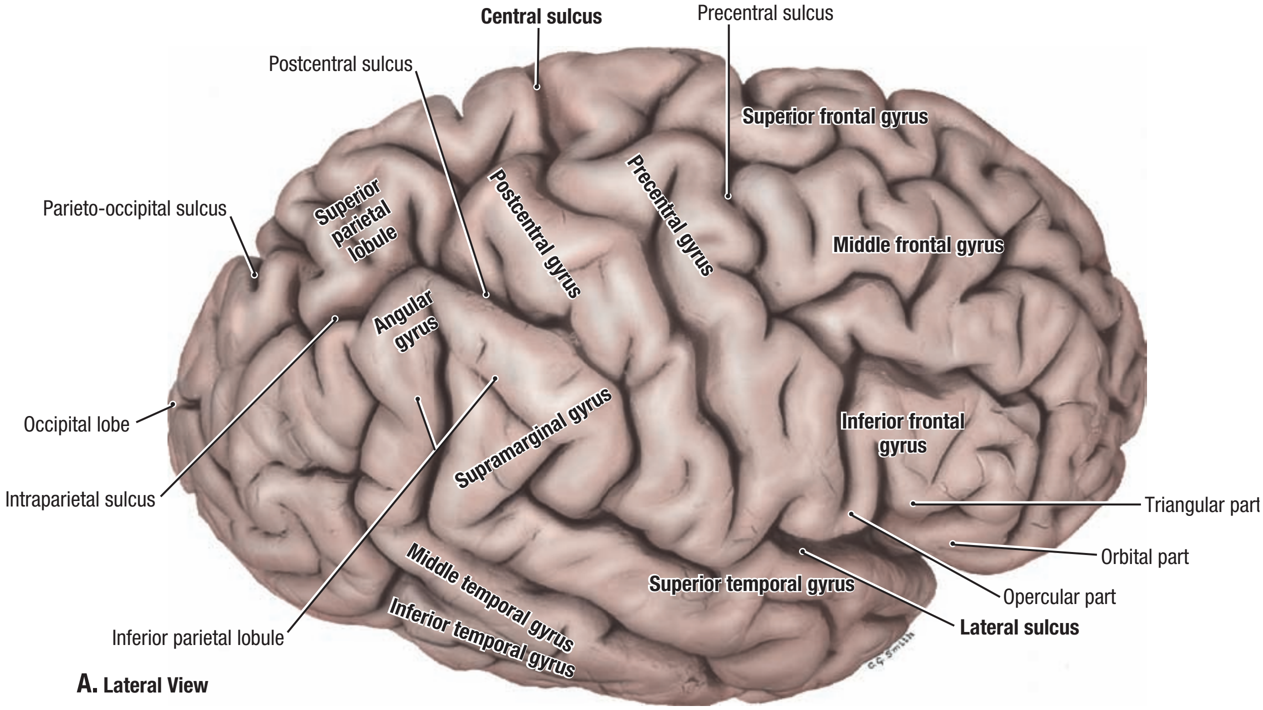


C. Medial View

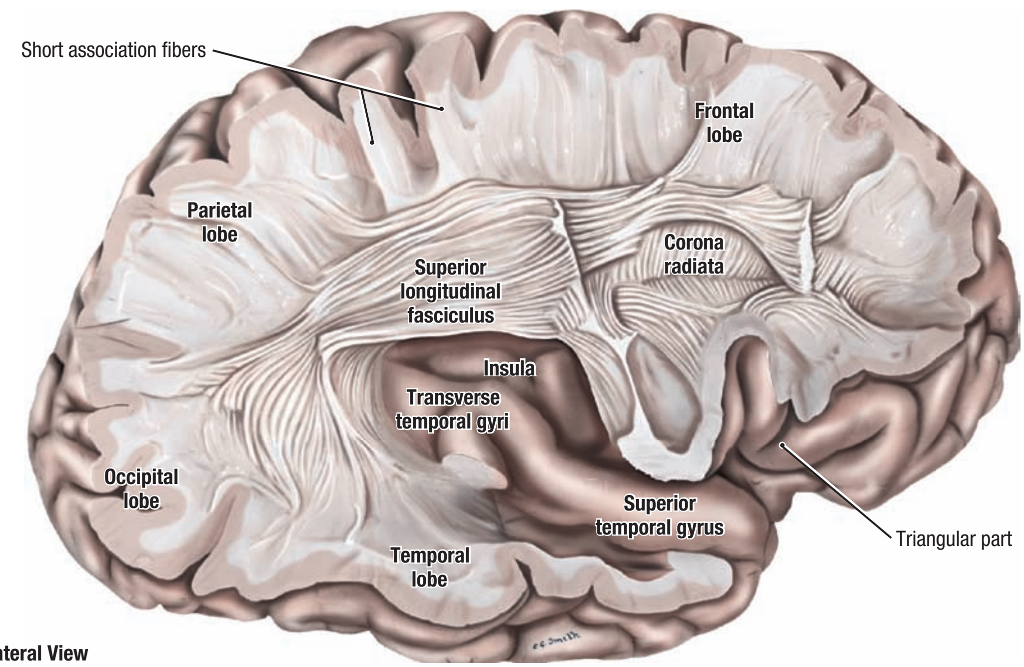
7.98 VENTRICULAR SYSTEM

A. Circulation of cerebrospinal fluid (CSF). **B.** Ventricles: lateral, third, and fourth.

- The ventricular system consists of two lateral ventricles located in the cerebral hemispheres, a third ventricle located between the right and left halves of the diencephalon, and a fourth ventricle located in the posterior parts of the pons and medulla.
- CSF secreted by choroid plexus in the ventricles drains via the interventricular foramen from the lateral to the third ventricle, via the cerebral aqueduct from the third to the fourth ventricle, and via median and lateral apertures into the subarachnoid space. CSF is absorbed by arachnoid granulations into the venous sinuses (especially the superior sagittal sinus).
- **Hydrocephalus.** Overproduction of CSF, obstruction of its flow, or interference with its absorption results in an excess of CSF in the ventricles and enlargement of the head, a condition known as hydrocephalus. Excess CSF dilates the ventricles; thins the brain; and, in infants, separates the bones of the calvaria because the sutures and fontanelles are still open.



A. Lateral View

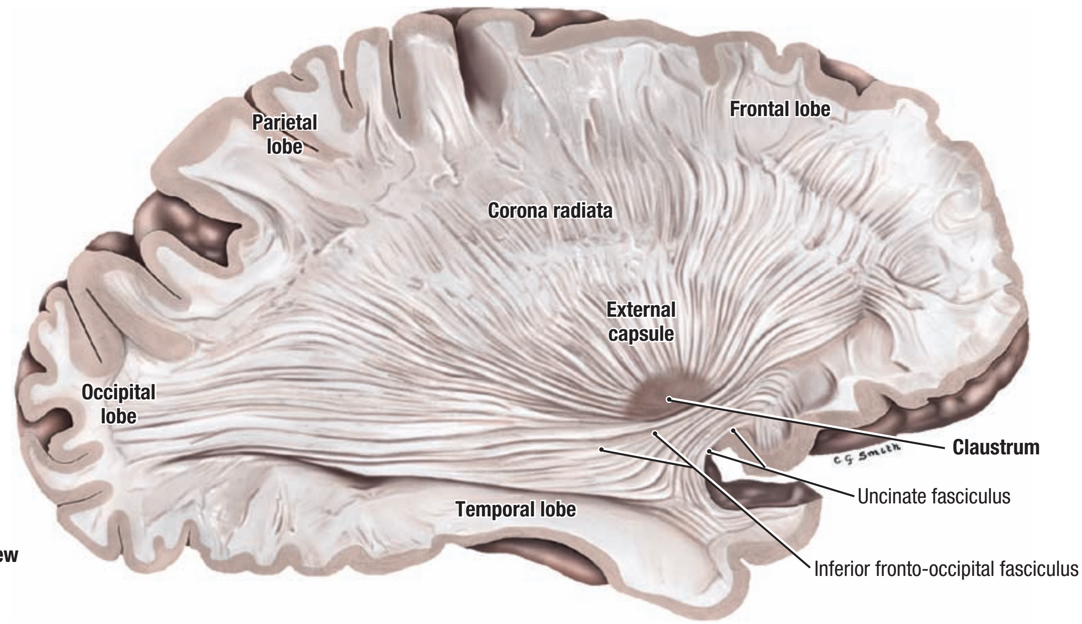


B. Lateral View

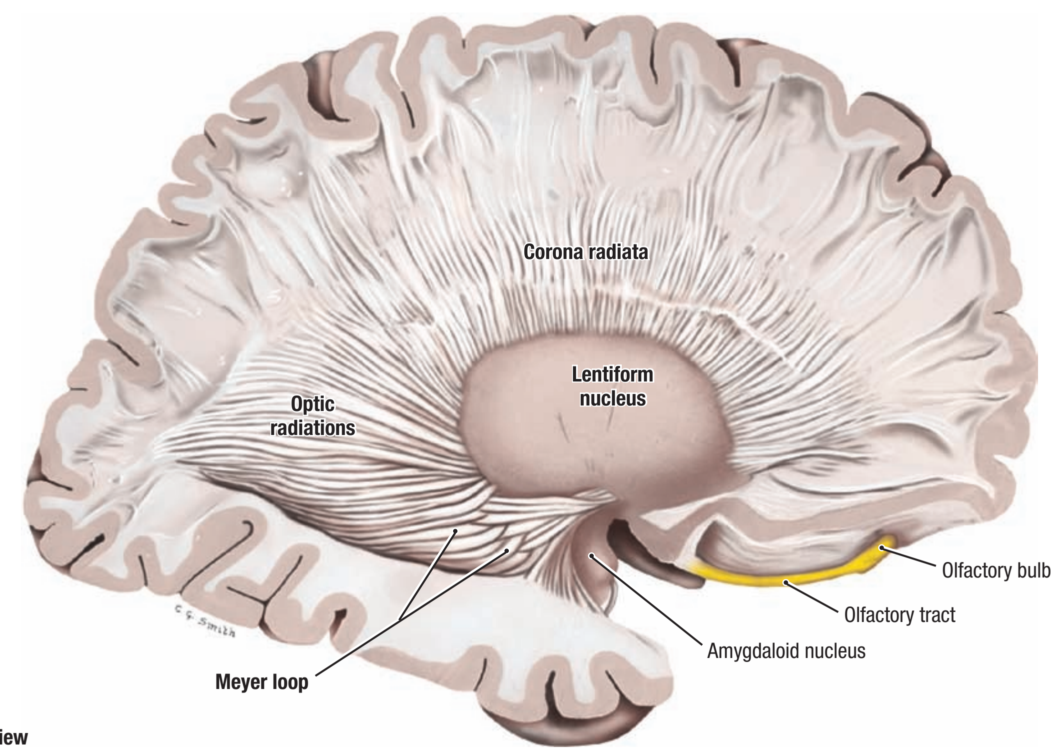
7.99 SERIAL DISSECTIONS OF LATERAL ASPECT OF CEREBRAL HEMISPHERE

The dissections begin from the lateral surface of the cerebral hemisphere **(A)** and proceed sequentially medially **(B.–F).**

A. Sulci and gyri of the lateral surface of one cerebral hemisphere. Each gyrus is a fold of cerebral cortex with a core of white matter. The furrows are called *sulci*. The pattern of sulci and gyri, formed shortly before birth, is recognizable in some adult brains, as shown in this specimen. Usually the expanding cortex acquires secondary foldings, which make identification of this basic pattern more difficult. **B.** Superior longitudinal fasciculus, transverse temporal gyri, and insula. The cortex and short association fiber bundles around the lateral fissure have been removed.



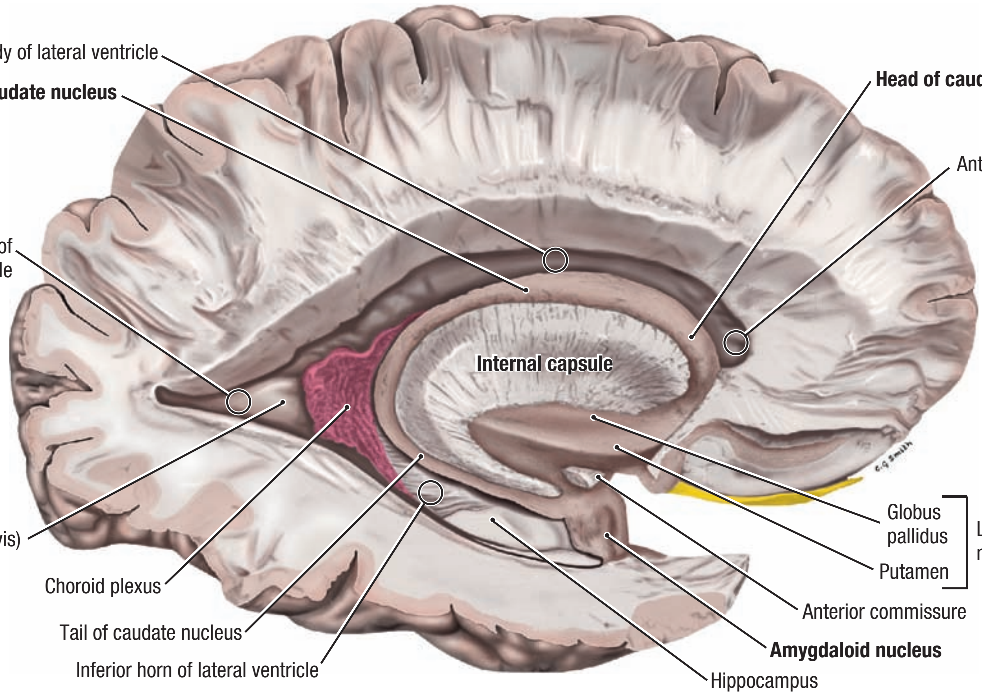
C. Lateral View



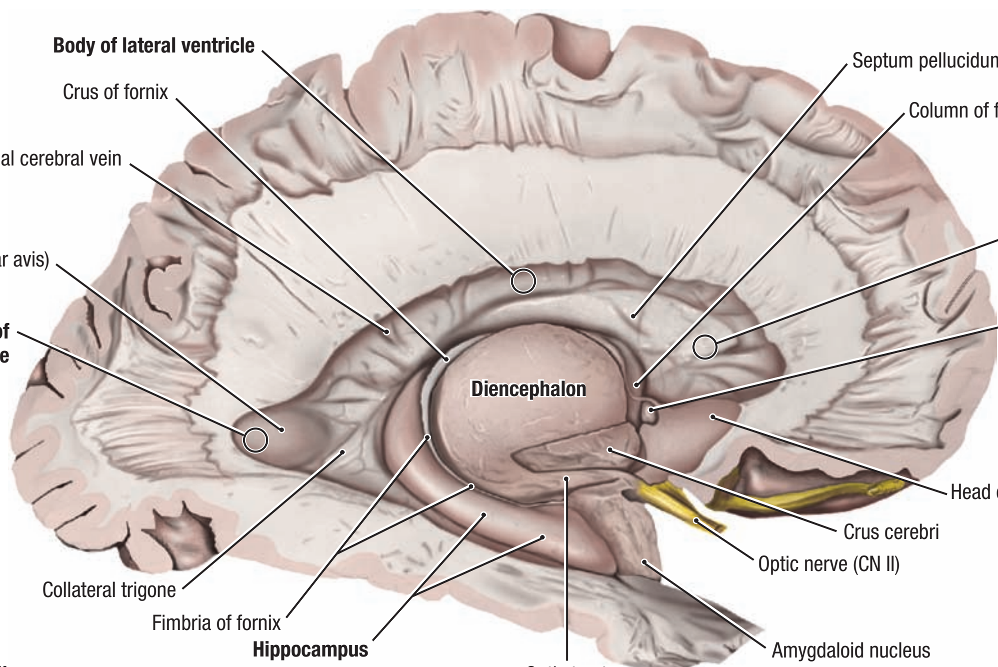
D. Lateral View

7.99 SERIAL DISSECTIONS OF LATERAL ASPECT OF CEREBRAL HEMISPHERE *(CONTINUED)*

C. Uncinate and inferior fronto-occipital fasciculi and external capsule. The external capsule consists of projection fibers that pass between the claustrum laterally and the lentiform nucleus medially. **D.** Lentiform nucleus and corona radiata. The inferior longitudinal and uncinate fasciculi, claustrum, and external capsule have been removed. The fibers of the optic radiations convey impulses from the right half of the retina of each eye; the fibers extending closest to the temporal pole (Meyer's loop) carry impulses from the lower portion of each retina.



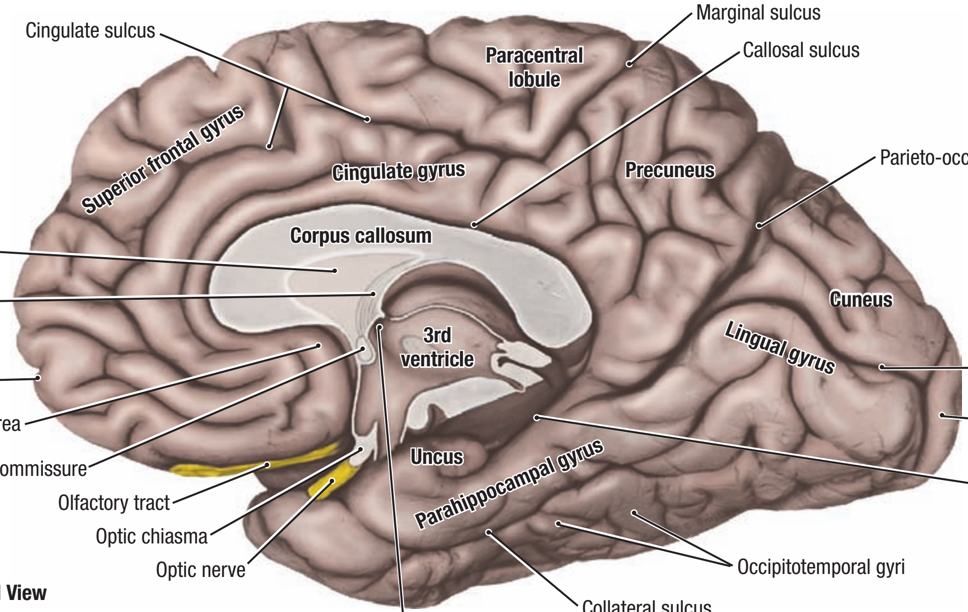
E. **Lateral View**



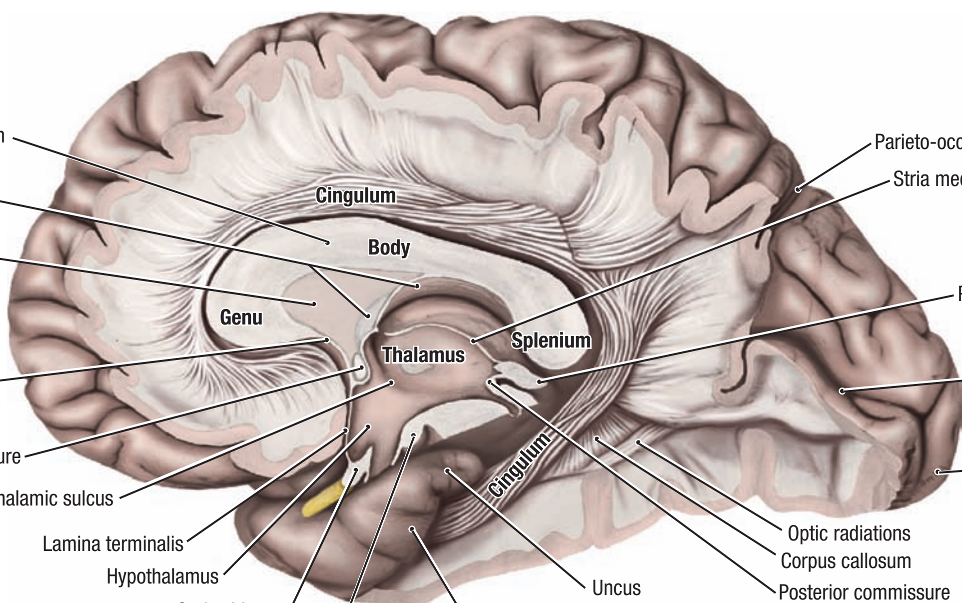
F. **Lateral View**

7.99 SERIAL DISSECTIONS OF LATERAL ASPECT OF CEREBRAL HEMISPHERE *(CONTINUED)*

E. Caudate and amygdaloid nuclei and internal capsule. The lateral wall of the lateral ventricle, the marginal part of the internal capsule, the anterior commissure, and the superior part of the lentiform nucleus have been removed. **F.** Lateral ventricle, hippocampus, and diencephalon. The inferior parts of the lentiform nucleus, internal capsule, and caudate nucleus have been removed.



A. Medial View

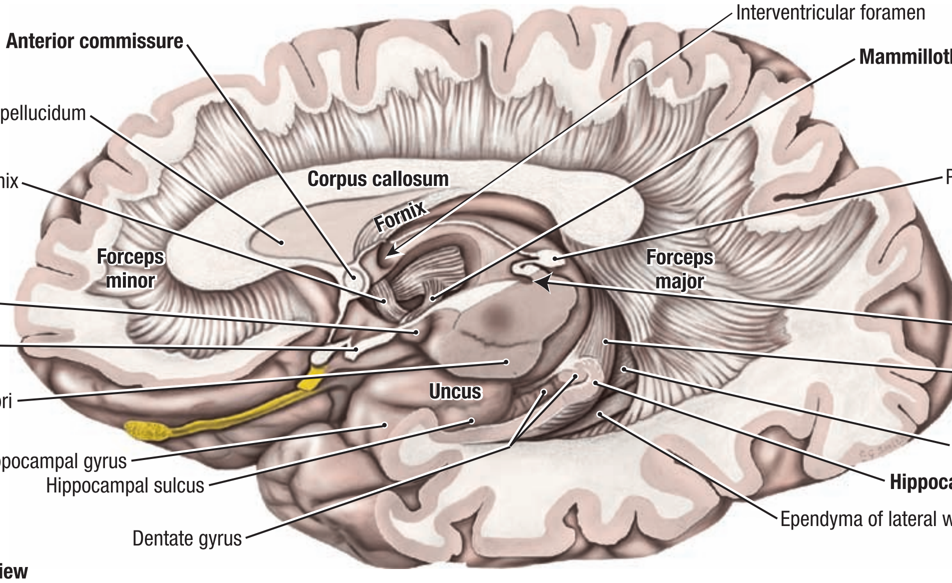


B. Medial View

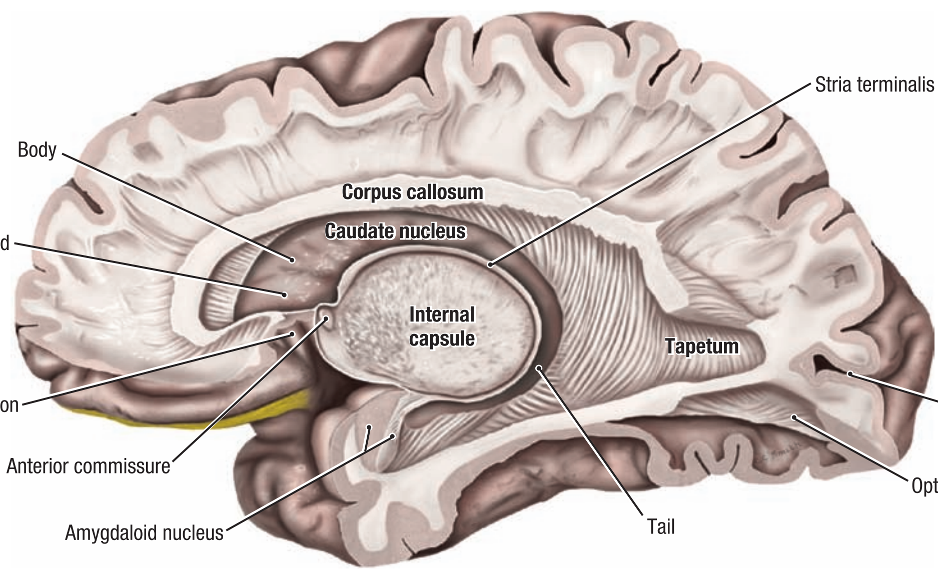
7.100 SERIAL DISSECTIONS OF MEDIAL ASPECT OF CEREBRAL HEMISPHERE

The dissections begin from the medial surface of the cerebral hemisphere **(A)** and proceed sequentially laterally **(B.–D)**.

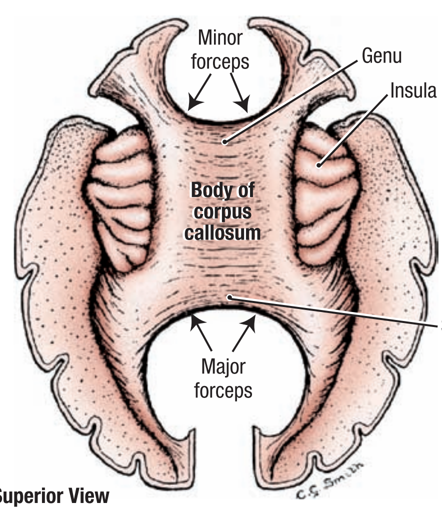
A. Sulci and gyri of medial surface of cerebral hemisphere. The corpus callosum consists of the rostrum, genu, body, and splenium; the cingulate and parahippocampal gyri from the limbic lobe. **B.** Cingulum. The cortex and short association fibers were removed from the medial aspect of the hemisphere. The cingulum is a long association fiber bundle that lies in the core of the cingulate and parahippocampal gyri.



C. Median View



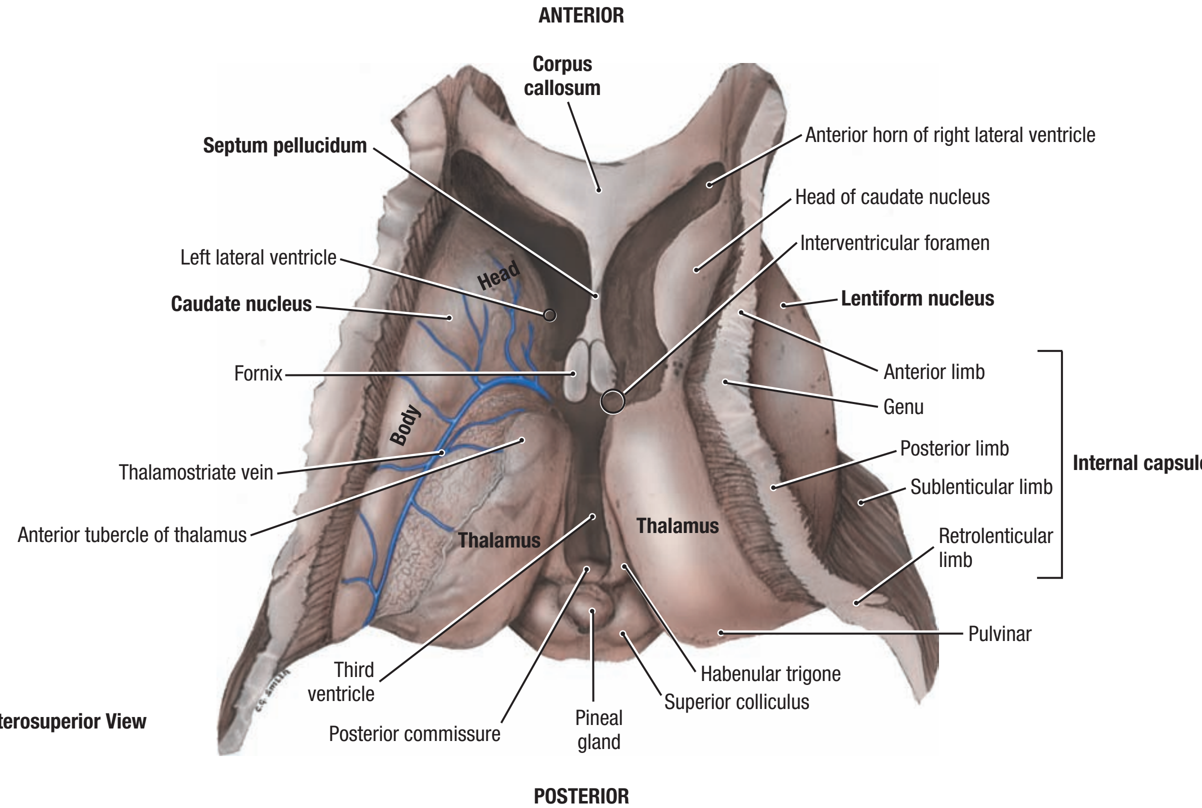
D. Median View



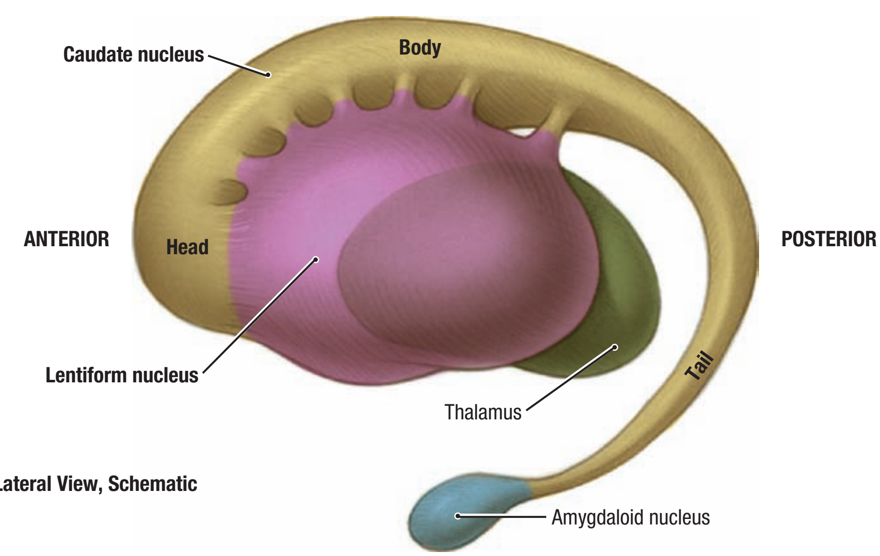
E. Superior View

7.100 SERIAL DISSECTIONS OF THE MEDIAL ASPECT OF CEREBRAL HEMISPHERE *(CONTINUED)*

C. Fornix, mammillothalamic fasciculus, and forceps major and minor. The cingulum and a portion of the wall of the third ventricle have been removed. The fornix begins at the hippocampus and terminates in the mammillary body by passing anterior to the interventricular foramen and posterior to the anterior commissure. The mammillothalamic fasciculus emerges from the mammillary body and terminates in the anterior nucleus of the thalamus. **D.** Caudate nucleus and internal capsule. The diencephalon was removed, along with the ependyma of the lateral ventricle, except where it covers the caudate and amygdaloid nuclei. **E.** Corpus callosum. The body of the corpus callosum connects the two cerebral hemispheres; the minor (frontal) forceps (at the genu of corpus callosum) connects the frontal lobes, and the major (occipital) forceps (at splenium) connects the occipital lobes.



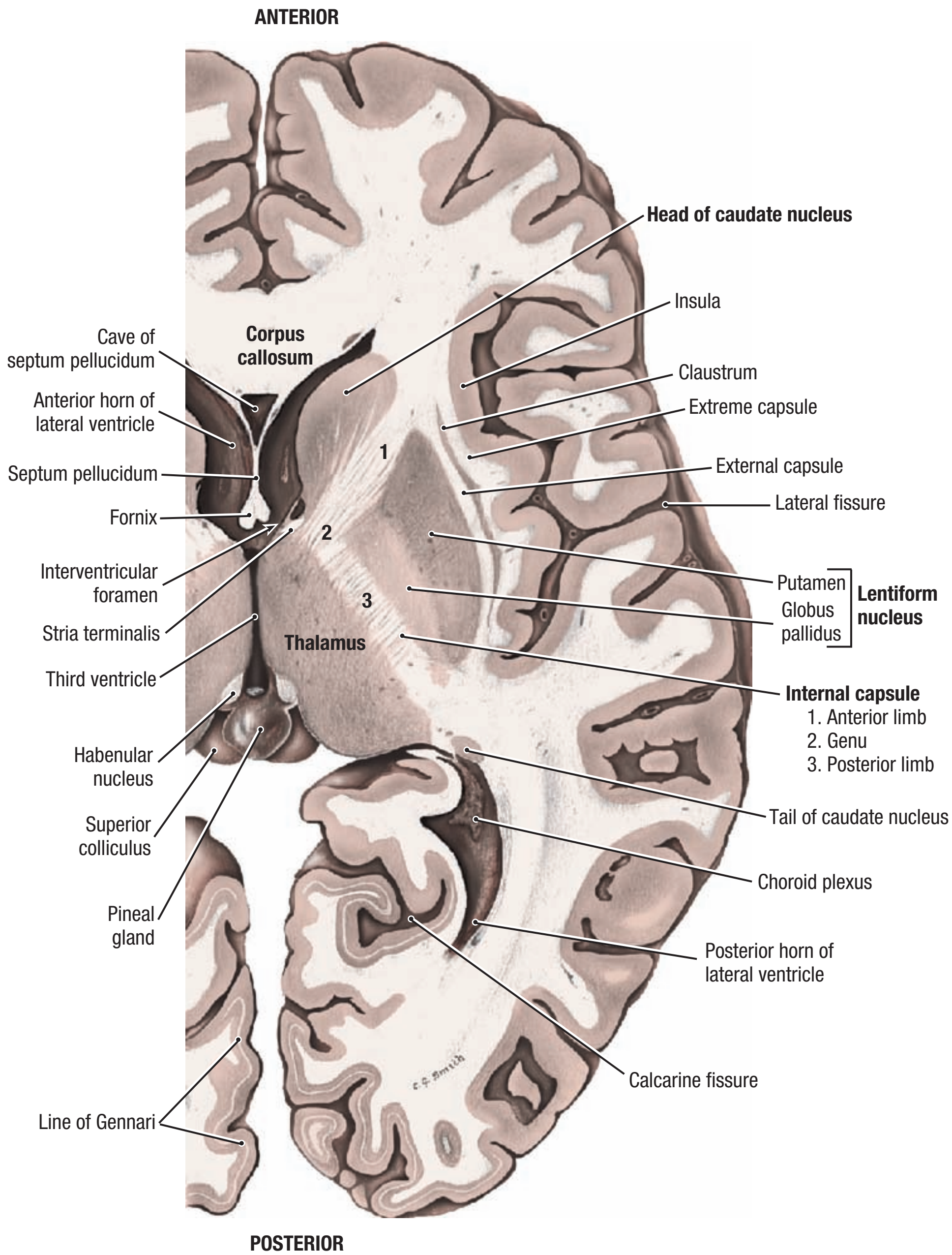
A. Posterosuperior View



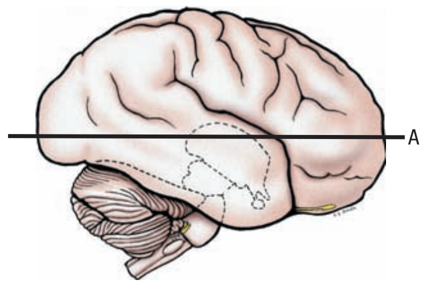
B. Lateral View, Schematic

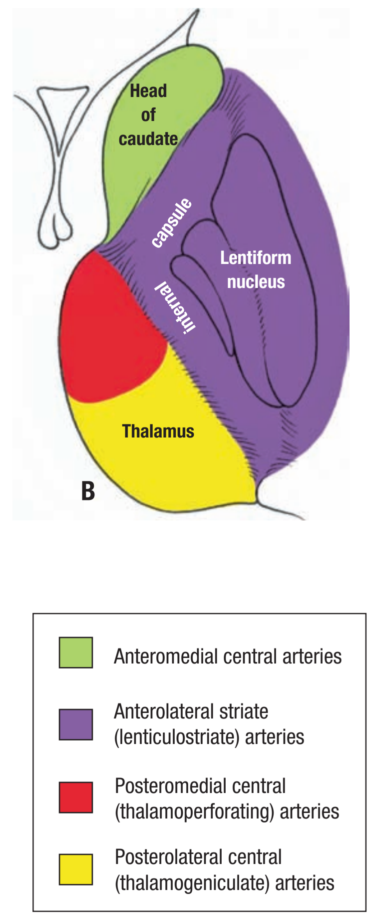
7.101 CAUDATE AND LENTIFORM NUCLEI

A. Relationship to the lateral ventricles and internal capsule. The dorsal surface of the diencephalon has been exposed by dissecting away the two cerebral hemispheres, except the anterior part of the corpus callosum, the inferior part of the septum pellucidum, the internal capsule, and the caudate and lentiform nuclei. On the right side of the specimen, the thalamus, caudate, and lentiform nuclei have been cut horizontally at the level of the interventricular foramen. The parts of the internal capsule include the anterior, posterior, retrolenticular sublenticular limbs, and genu. **B.** Schematic illustration of nuclei.



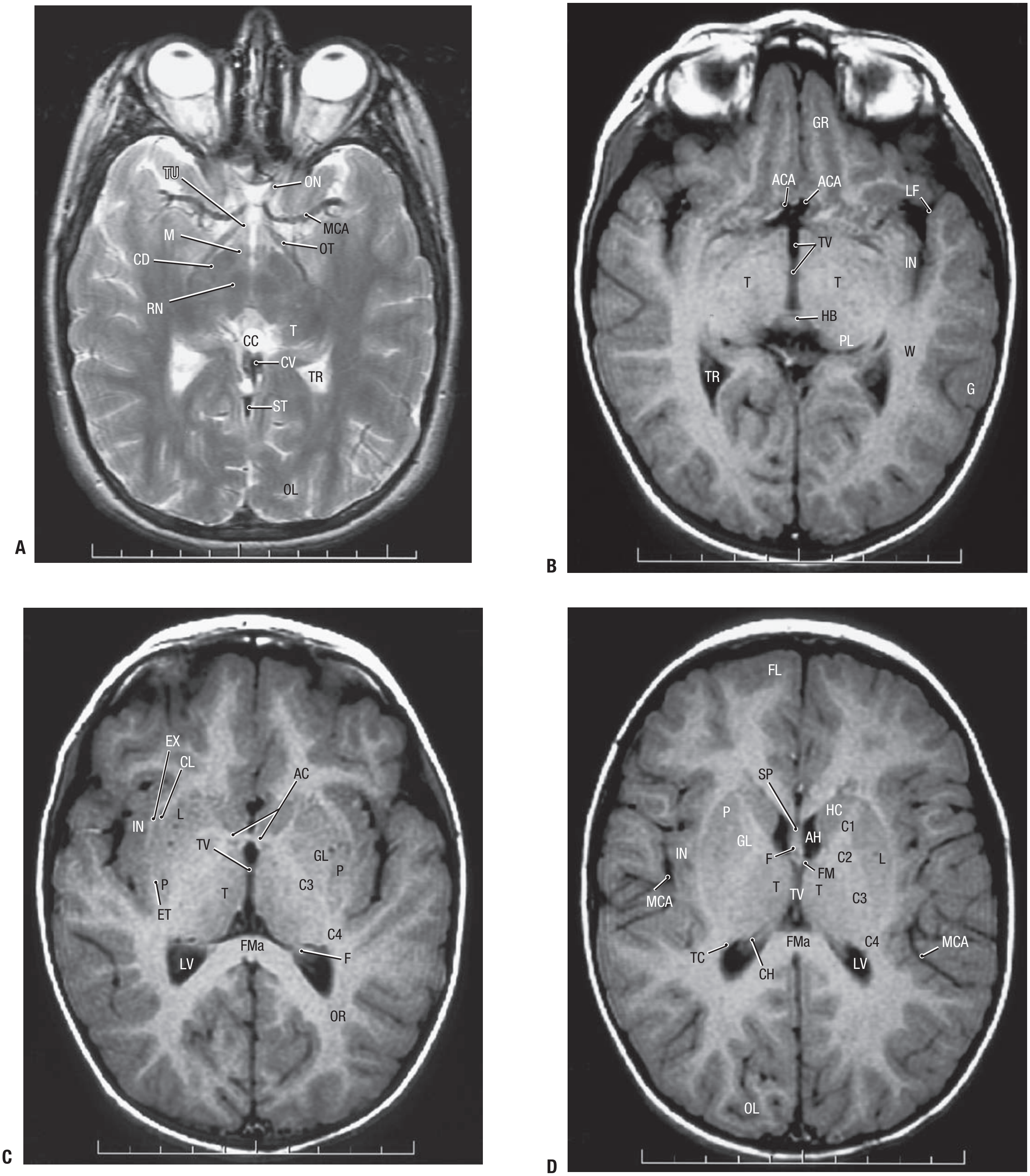
A. Transverse Section





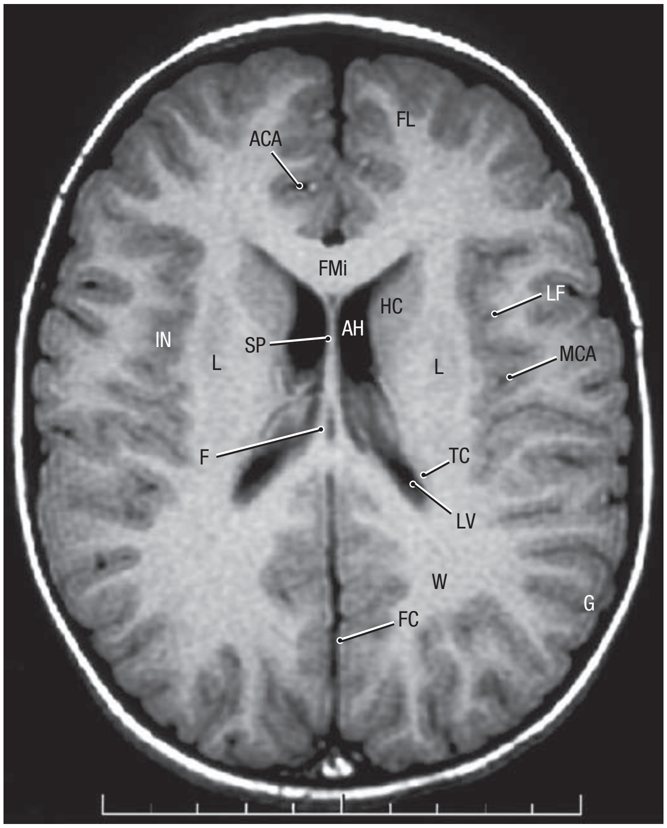
7.102 AXIAL SECTIONS THROUGH THALAMUS, CAUDATE NUCLEUS, AND LENTIFORM NUCLEUS

A. Relationships of the internal capsule. **B.** Blood supply of region.



7.103 AXIAL (TRANSVERSE) MRIs THROUGH CEREBRAL HEMISPHERES

See orientation drawing for sites of scans **A.–F.** **A** is T2 weighted, and **B.–F.** are T1 weighted.



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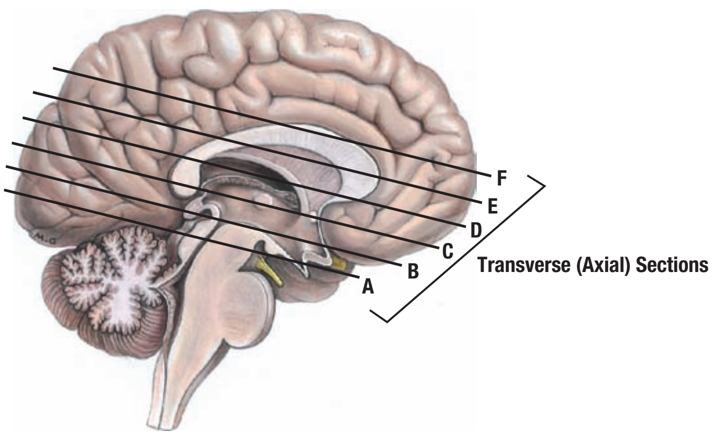
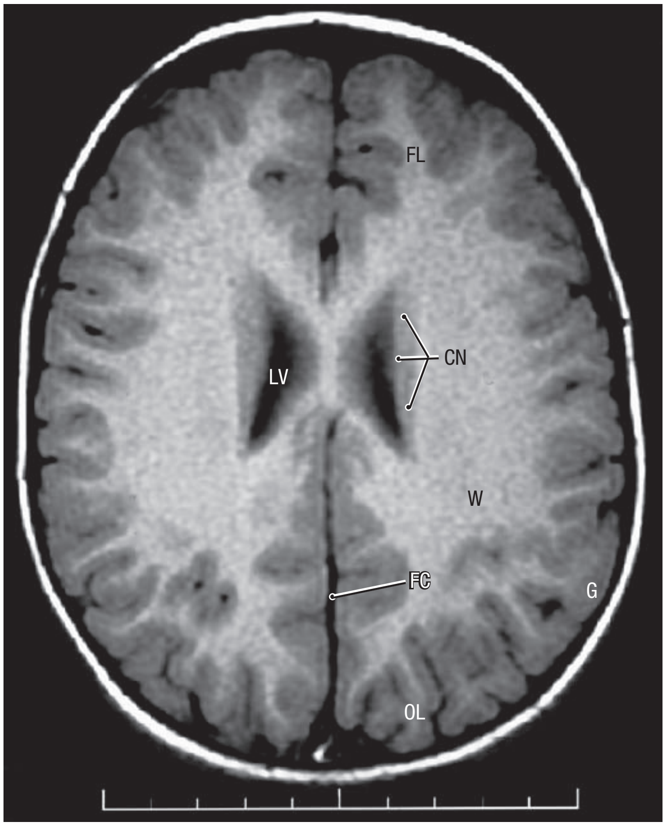
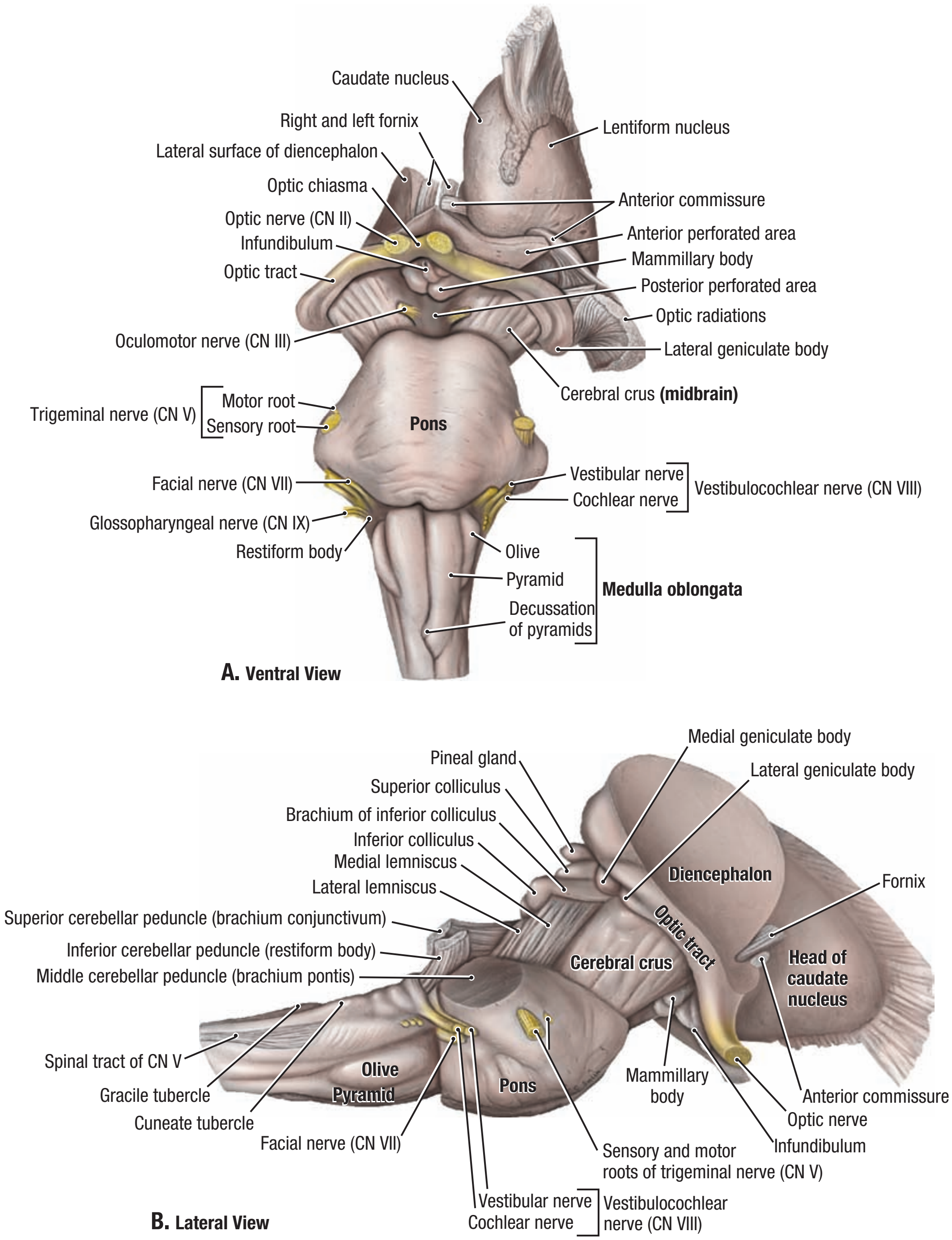




F

AC	Anterior commissure	GL	Globus pallidus
ACA	Anterior cerebral artery	GR	Gyrus rectus
AH	Anterior horn of lateral ventricle	HB	Habenular commissure
		HC	Head of caudate nucleus
C1	Anterior limb of internal capsule	IN	Insular cortex
		L	Lentiform nucleus
C2	Genu of internal capsule	LF	Lateral fissure
C3	Posterior limb of internal capsule	LV	Lateral ventricle
		M	Mammillary body
C4	Retrolenticular limb of internal capsule	MCA	Middle cerebral artery
		OL	Occipital lobe
CC	Collicular cistern	ON	Optic nerve
CD	Cerebral peduncle	OR	Optic radiations
CH	Choroid plexus	OT	Optic tract
CL	Claustrum	P	Putamen
CN	Caudate nucleus	PL	Pulvinar
CV	Great cerebral vein	RN	Red nucleus
ET	External capsule	SP	Septum pellucidum
EX	Extreme capsule	ST	Straight sinus
F	Fornix	T	Thalamus
FC	Falx cerebri	TC	Tail of caudate nucleus
FL	Frontal lobe	TR	Trigone of lateral ventricle
FM	Interventricular foramen	TU	Tuber cinereum
FMa	Forceps major	TV	Third ventricle
FMi	Forceps minor	W	White matter
G	Gray matter		

7.103 AXIAL (TRANSVERSE) MRIs THROUGH CEREBRAL HEMISPHERES *(CONTINUED)*



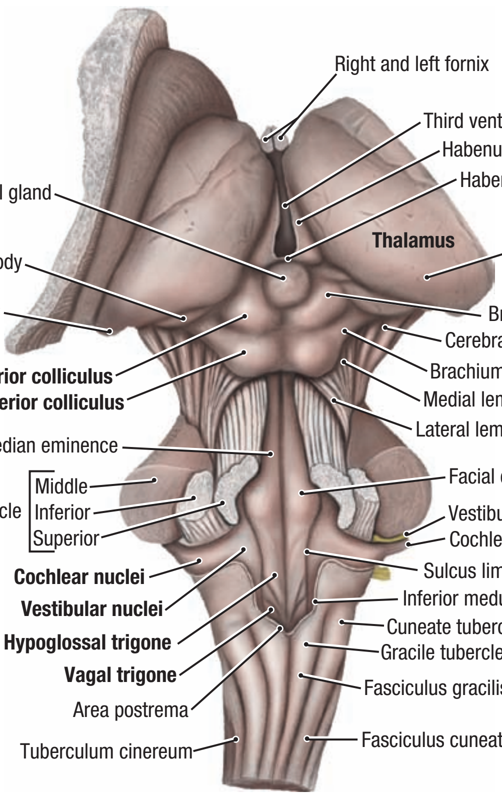
7.104 BRAINSTEM

The brainstem has been exposed by removing the cerebellum, all of the right cerebral hemisphere, and the major portion of the left hemisphere. **A.** Ventral aspect.

- The brainstem consists of the medulla oblongata, pons, and midbrain.
- The pyramid is on the ventral surface of the medulla; the decussation of the pyramids is formed by the decussating (crossing) lateral corticospinal tract.
- The trigeminal nerve (CN V) emerges as sensory and motor roots.
- The crus cerebri are part of the midbrain.
- The oculomotor nerve emerges from the interpeduncular fossa.

B. Lateral aspect.

- The vestibulocochlear nerve (CN VIII) consists of two nerves, the vestibular and cochlear nerves.
- The spinal tract of the trigeminal nerve is exposed where it comes to the surface of the medulla to form the tuber cinereum.
- The three are cerebellar peduncles: superior, middle, and inferior.
- The medial and lateral lemnisci on the lateral aspect of the midbrain

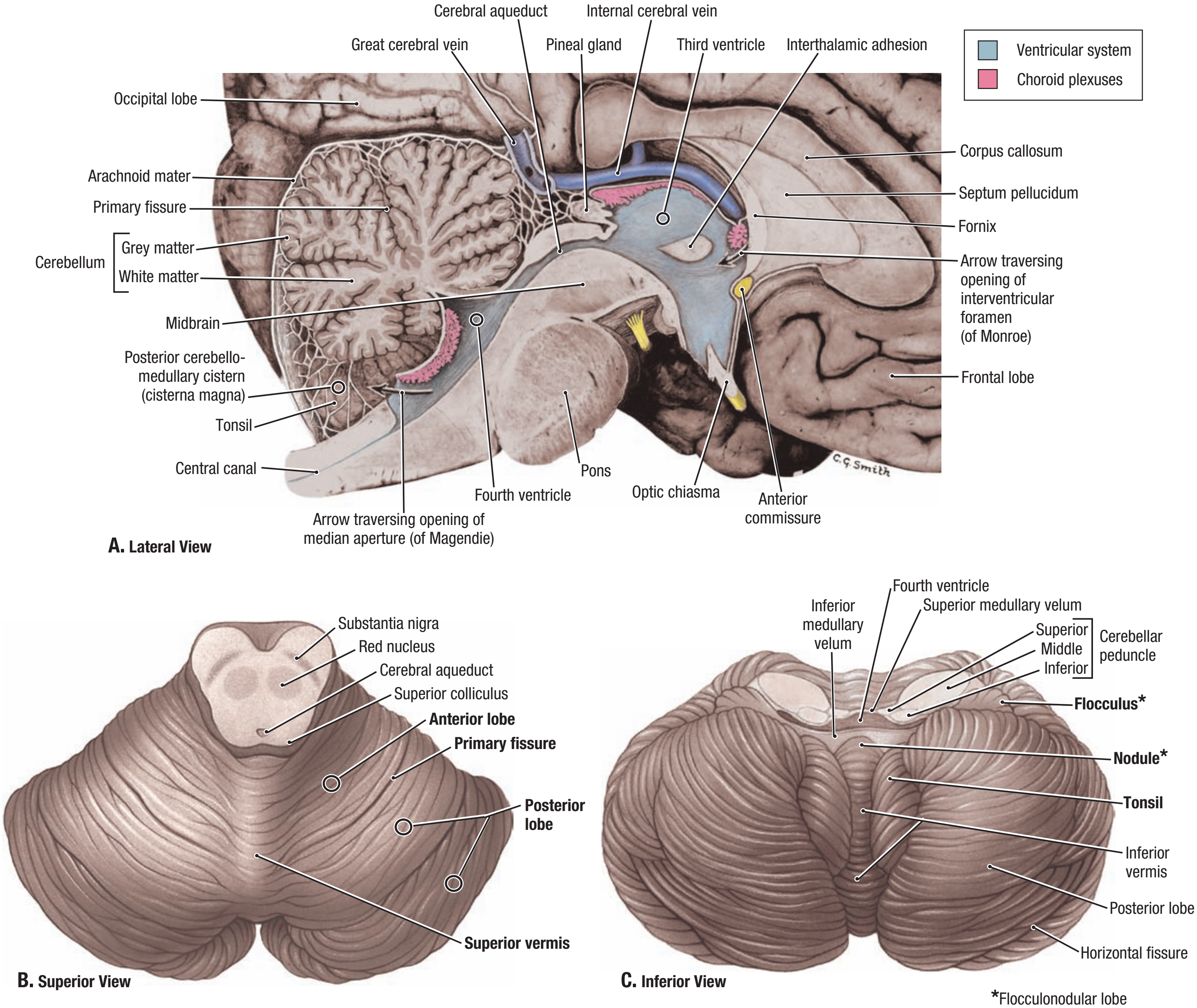


C. Posterior View

7.104 BRAINSTEM *(CONTINUED)*

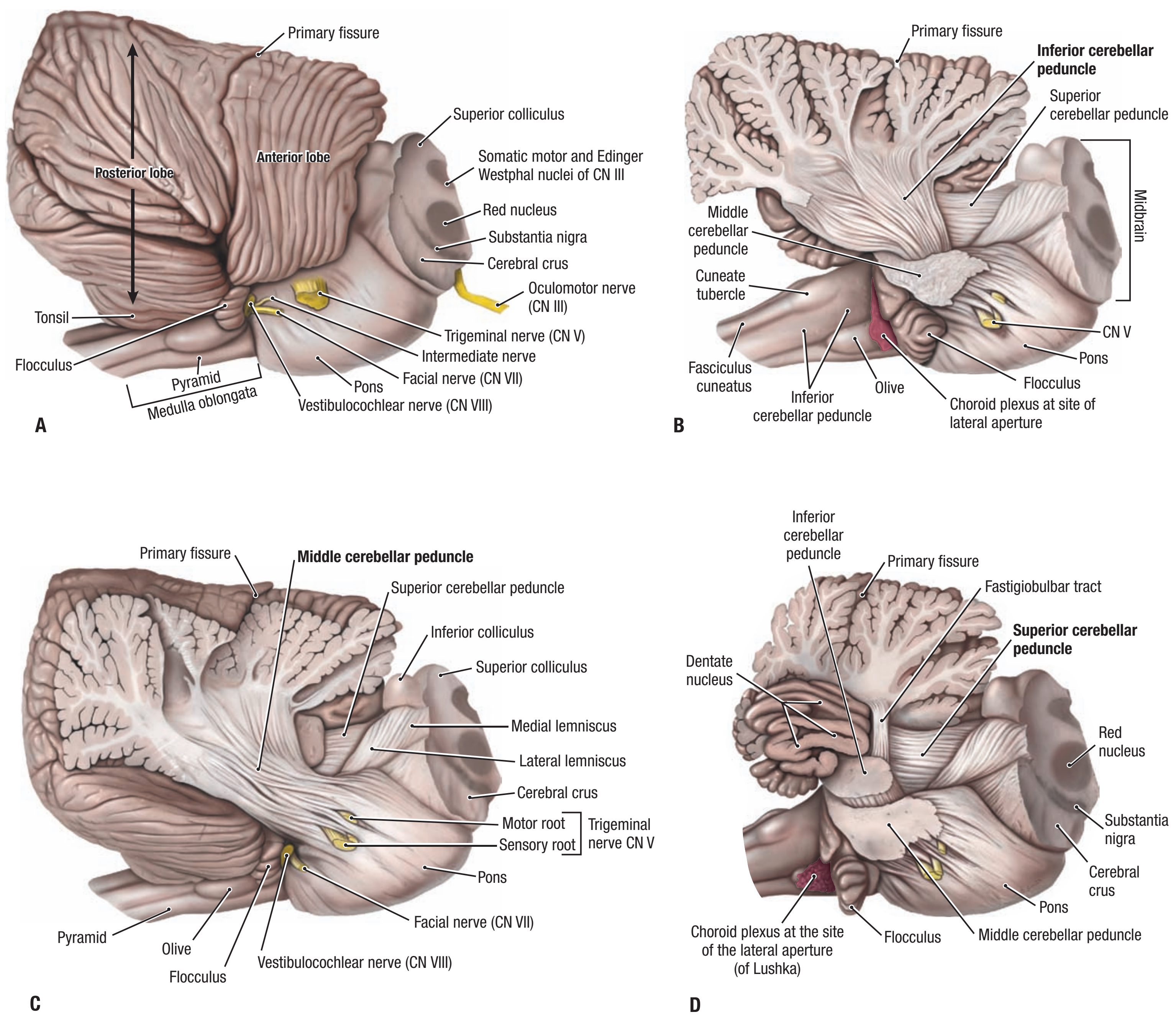
C. Dorsal aspect.

- Ridges are formed by the fasciculus gracilis and cuneatus.
- The gracile and cuneate tubercles are the sites of the nucleus gracilis and nucleus cuneatus.
- The diamond-shaped floor of the fourth ventricle; lateral to the sulcus limitans are the vestibular and cochlear nuclei and medially are the hypoglossal and vagal trigones and the facial colliculus.
- The superior and inferior colliculi form the dorsal surface of the midbrain.



7.105 CEREBELLUM

A. Median section. The arachnoid mater was removed except where it covered the cerebellum and the occipital lobe. **Cisternal puncture.** CSF may be obtained, for diagnostic purposes, from the posterior cerebellomedullary cistern, using a procedure known as cisternal puncture. The subarachnoid space or the ventricular system may also be entered for measuring or monitoring CSF pressure, injecting antibiotics, or administering contrast media for radiography. **B.** Superior view of the cerebellum. The right and left cerebellar hemispheres are united by the superior vermis; the anterior and posterior lobes are separated by the primary fissure. **C.** Inferior view of cerebellum. The flocculonodular lobe, the oldest part of the cerebellum, consists of the flocculus and nodule; the cerebellar tonsils typically extend into the foramen magnum.

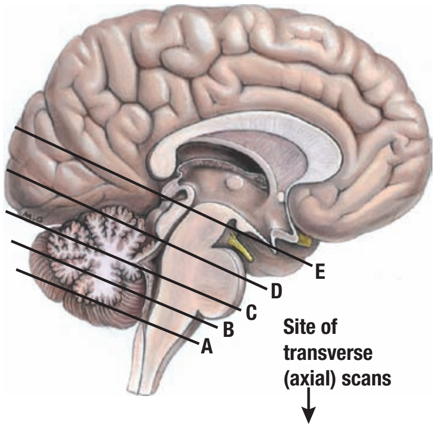


Lateral Views

7.106 SERIAL DISSECTIONS OF THE CEREBELLUM

The series begins with the lateral surface of the cerebellar hemispheres **(A)** and proceeds medially in sequence **(B–D)**.

A. Cerebellum and brainstem. **B.** Inferior cerebellar peduncle. The fibers of the middle cerebellar peduncle were cut dorsal to the trigeminal nerve and peeled away to expose the fibers of the inferior cerebellar peduncle. **C.** Middle cerebellar peduncle. The fibers of the middle cerebellar peduncle were exposed by peeling away the lateral portion of the lobules of the cerebellar hemisphere. **D.** Superior cerebellar peduncle and dentate nucleus. The fibers of the inferior cerebellar peduncle were cut just dorsal to the previously sectioned middle cerebellar peduncle and peeled away until the gray matter of the dentate nucleus could be seen.

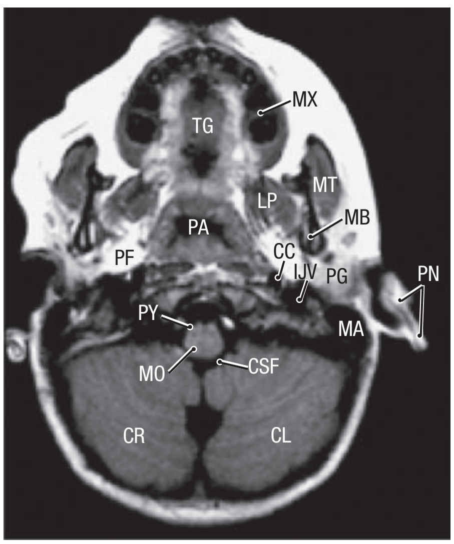


Blood Supply:

- Posterior cerebral
- Superior cerebellar
- Anterior inferior cerebellar
- Posterior inferior cerebellar
- Vertebral
- Anterior spinal
- Posterior spinal
- Basilar:
  - Long circumferential branches
  - Short circumferential branches
  - Paramedian branches

AICA	Anterior inferior cerebellar artery
AM	Internal acoustic meatus
BA	Basilar artery
C	Cerebral crus
CA	Cerebral aqueduct
CB	Ciliary body
CC	Common carotid artery
CI	Colliculi
CL	Left cerebellar hemisphere
CP	Cochlear perilymph
CR	Right cerebellar hemisphere
CSF	CSF in subarachnoid space
DS	Dorsum sellae
EB	Eyeball
F	CN VII and CN VIII
FC	Facial colliculus
FI	Fat in infratemporal fossa
FL	Flocculus
FV	Fourth ventricle
G	Gray matter
HF	Hypophysial fossa
HP	Hippocampus
IN	Infundibulum
IC	Interpeduncular cistern
ICA	Internal carotid artery
ICP	Inferior cerebellar peduncle
IF	Inferior concha
IH	Inferior horn (lateral ventricle)
IJV	Internal jugular vein
IP	Interpeduncular fossa
IV	Inferior vermis
L	Lens
LP	Lateral pterygoid
MA	Mastoid air cells
MB	Mandible
MC	Middle concha
MCP	Middle cerebellar peduncle
MD	Midbrain
MO	Medulla oblongata
MS	Maxillary sinus
MT	Masseter
MX	Maxilla
ND	Nodule of cerebellum
NS	Nasal septum
OB	Occipital bone
OC	Optic chiasm

ANTERIOR

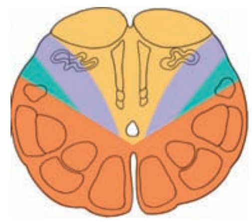


A

POSTERIOR

ANTERIOR

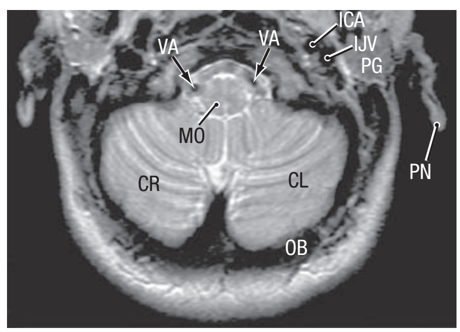
RIGHT



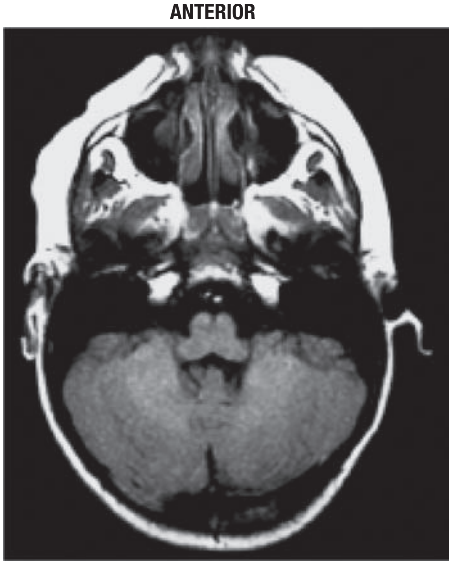
LEFT

POSTERIOR

Transverse section through lower medulla oblongata (Part A)



ANTERIOR

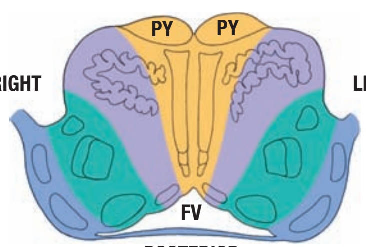


B

POSTERIOR

ANTERIOR

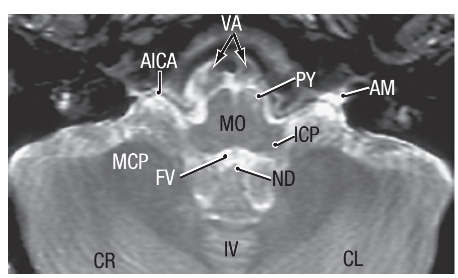
RIGHT



LEFT

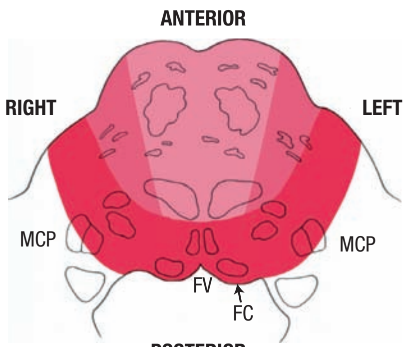
POSTERIOR

Transverse section through upper medulla oblongata (Part B)

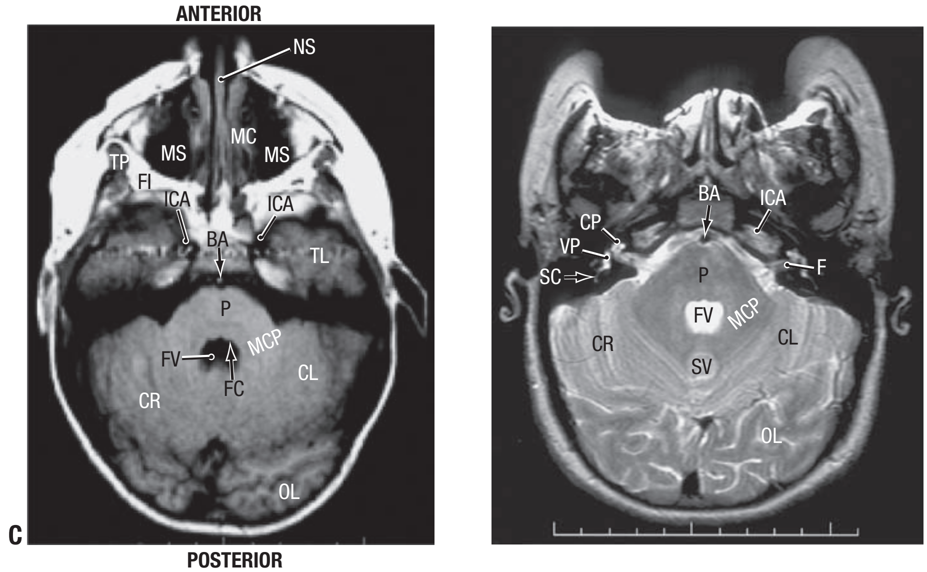


7.107 AXIAL (TRANSVERSE) MRIs THROUGH BRAINSTEM, INFERIOR VIEWS

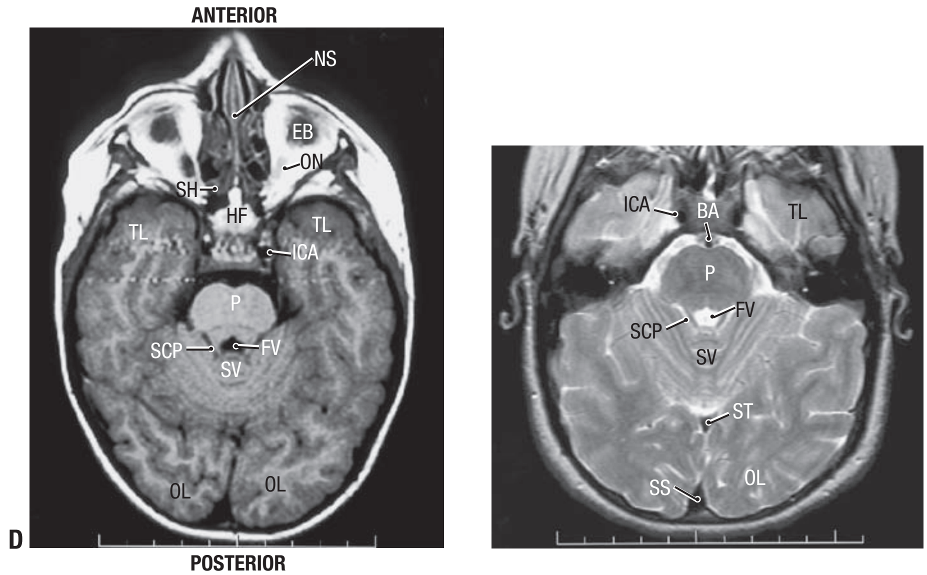
Images on left side of the page are T1 weighted, and images on the right side are T2 weighted.

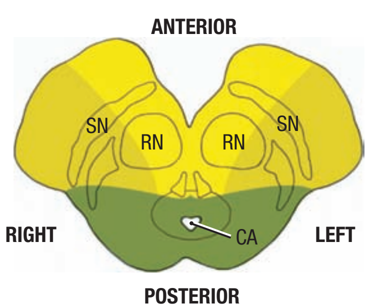


Transverse section through pons (Parts C & D)

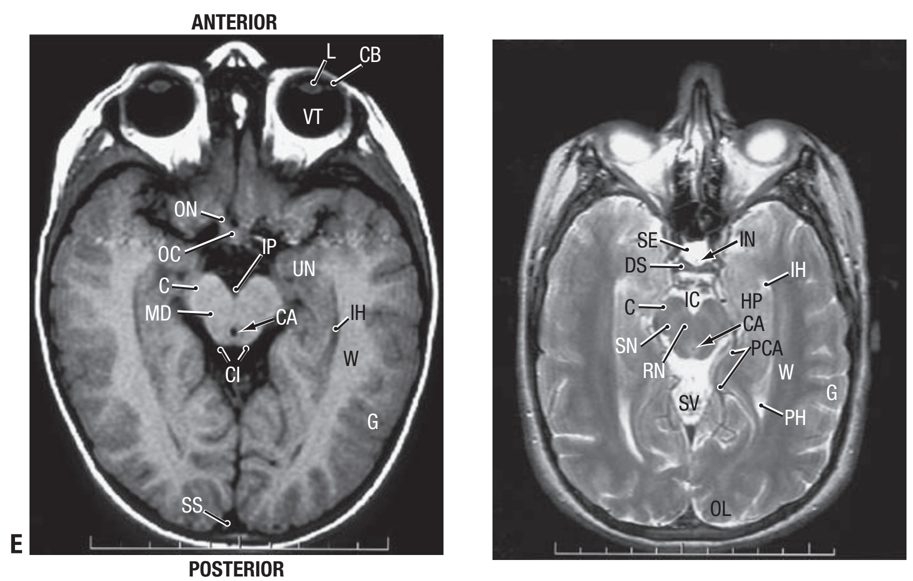


OL	Occipital lobe
ON	Optic nerve (CN II)
P	Pons
PA	Pharynx
PCA	Posterior cerebral artery
PF	Parapharyngeal fat
PG	Parotid gland
PH	Posterior horn (lateral ventricle)
PN	Pinna
PY	Pyramid
RN	Red nucleus
SC	Semicircular canal
SCP	Superior cerebellar peduncle
SE	Suprasellar cistern
SH	Superior concha
SN	Substantia nigra
SS	Superior sagittal sinus
ST	Straight sinus
SV	Superior vermis
TG	Tongue
TL	Temporal lobe
TP	Temporalis
UN	Uncus
VA	Vertebral artery
VP	Vestibular perilymph
VT	Vitreous body
W	White matter

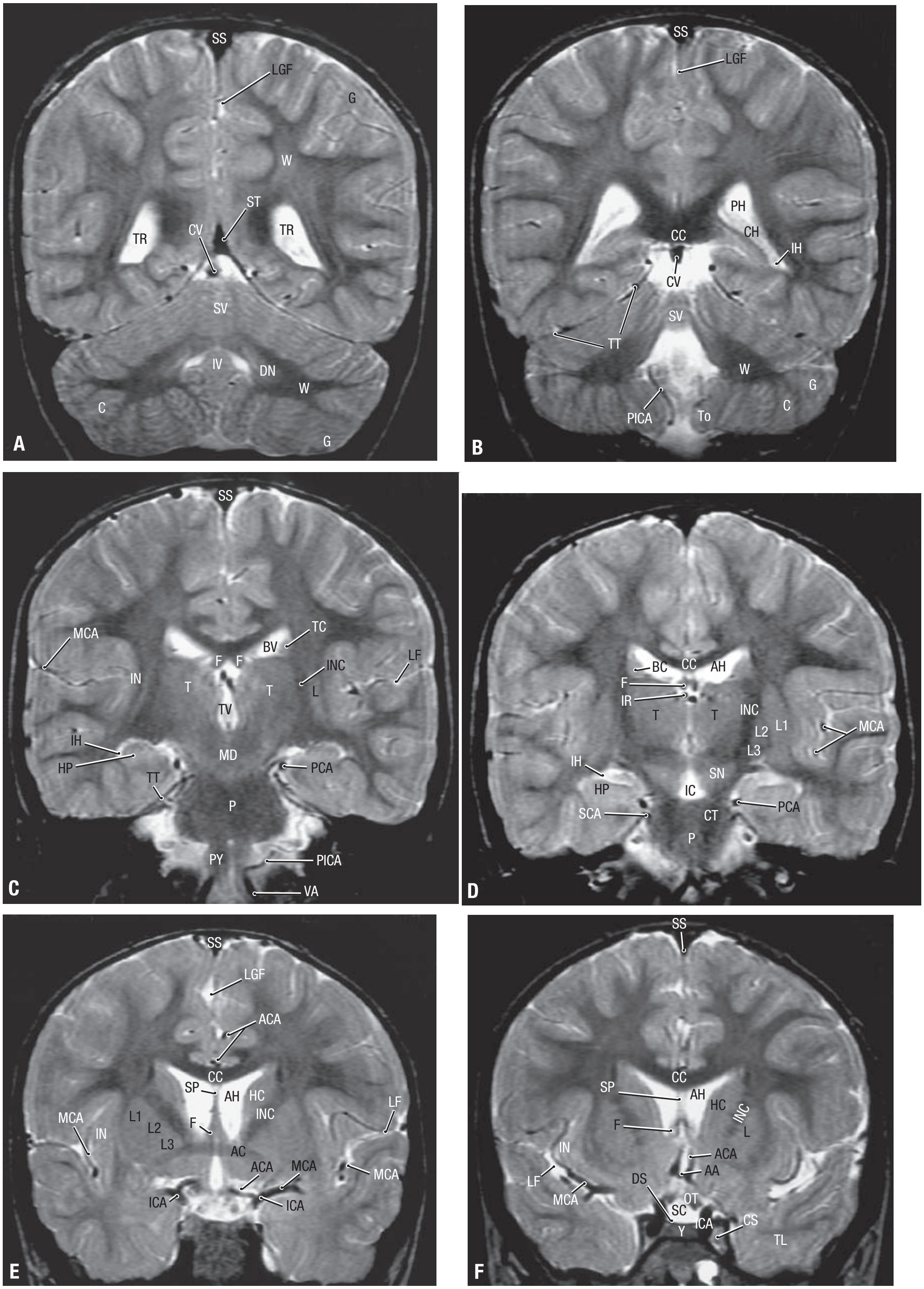




Transverse section through midbrain (Part E)



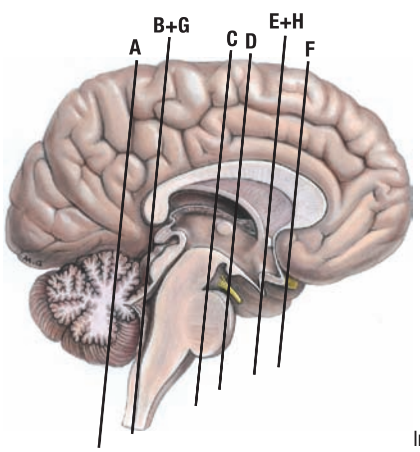
7.107 AXIAL (TRANSVERSE) MRIs THROUGH BRAINSTEM, INFERIOR VIEWS *(CONTINUED)*



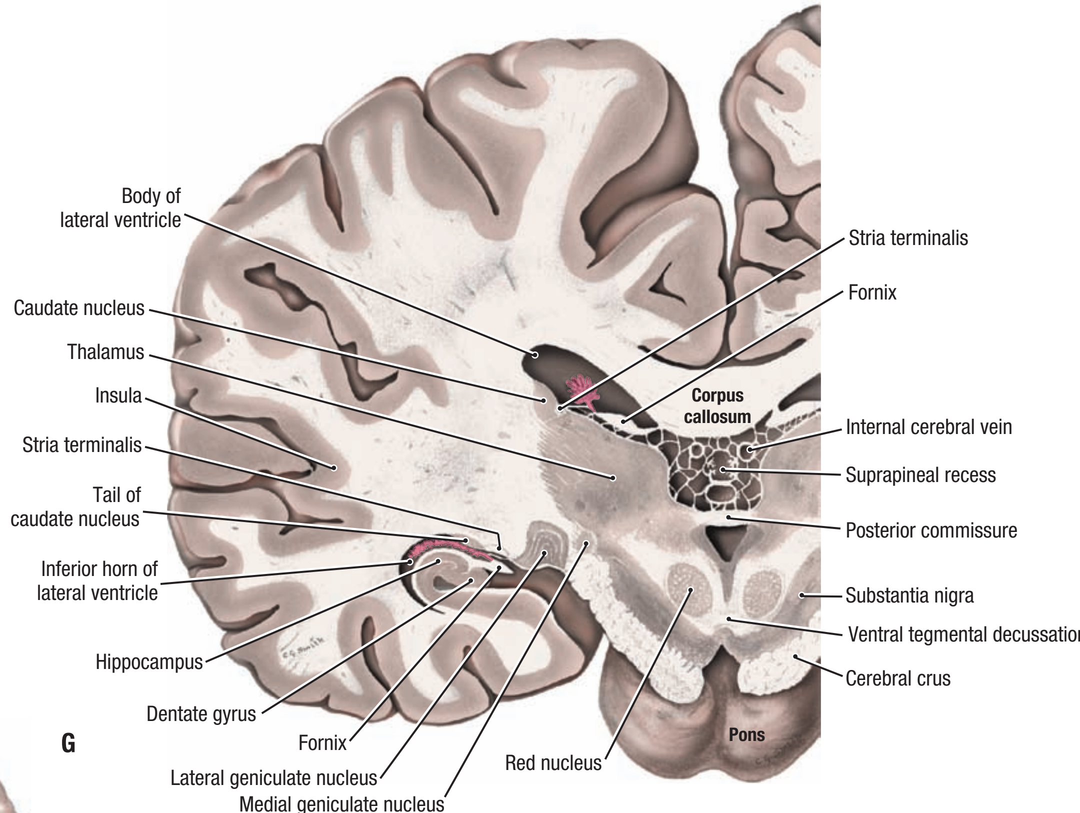
AA Anterior communicating artery
AC Anterior commissure
ACA Anterior cerebral artery
AH Anterior horn of lateral ventricle
BC Body of caudate nucleus
BV Body of lateral ventricle
C Cerebellum
CC Corpus callosum
CH Choroid plexus
CS Cavernous sinus
CT Corticospinal tract
CV Great cerebral vein
DN Dentate nucleus
DS Diaphragma sellae
F Fornix
FV Fourth ventricle
G Gray matter
HC Head of caudate nucleus
HP Hippocampus
IC Interpeduncular cistern
ICA Internal carotid artery
IH Interior horn of lateral ventricle
IN Insular cortex
INC Internal capsule
IR Intervertebral vein
IV Inferior vermis
L Lentiform nucleus
L1 Putamen
L2 External (lateral) segment of globus pallidus
L3 Internal (medial) segment of globus pallidus
LF Lateral fissure
LGF Longitudinal fissure
MCA Middle cerebral artery
MD Midbrain
OT Optic tract
P Pons
PCA Posterior cerebral artery
PH Posterior horn of lateral ventricle
PICA Posterior inferior cerebellar artery
PY Pyramid
S Carotid siphon
SC Supracellebellar cistern
SCA Superior cerebellar artery
SN Substantia nigra
SP Septum pellucidum
SS Superior sagittal sinus
ST Straight sinus
SV Superior vermis
T Thalamus
TC Tail of caudate nucleus
TL Temporal lobe
To Cerebellar tonsil
TR Trigone of lateral ventricle
TT Tentorium cerebelli
TV Third ventricle
VA Vertebral artery
W White matter
Y Hypophysis

7.108 CORONAL MRIs (T2 WEIGHTED) AND SECTIONS OF BRAIN

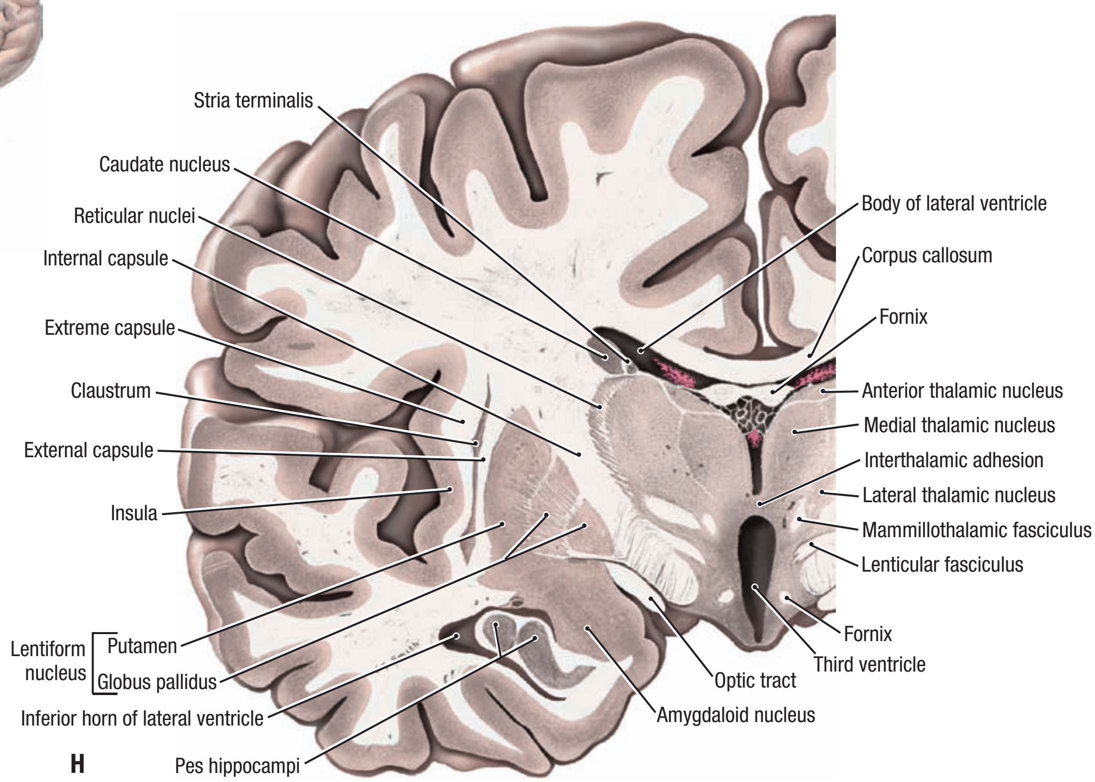
A.–F. Coronal MRIs. **G.–H.** Coronal sections, posterior views.



Site of coronal scans and sections

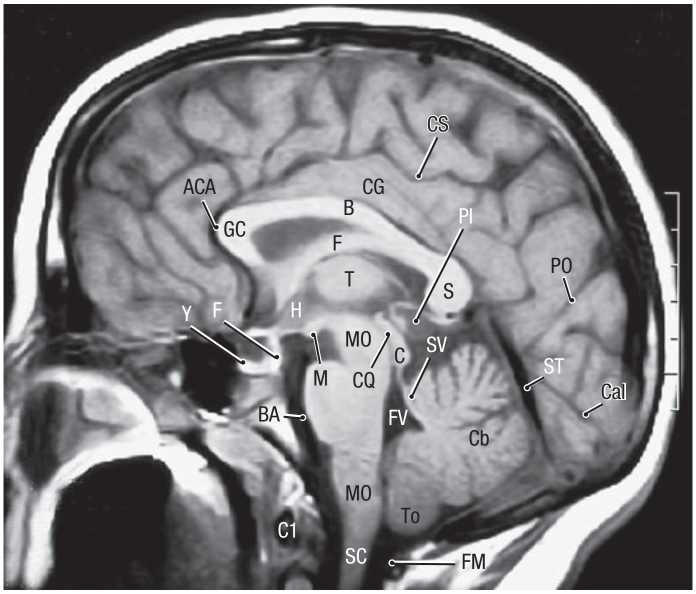


G

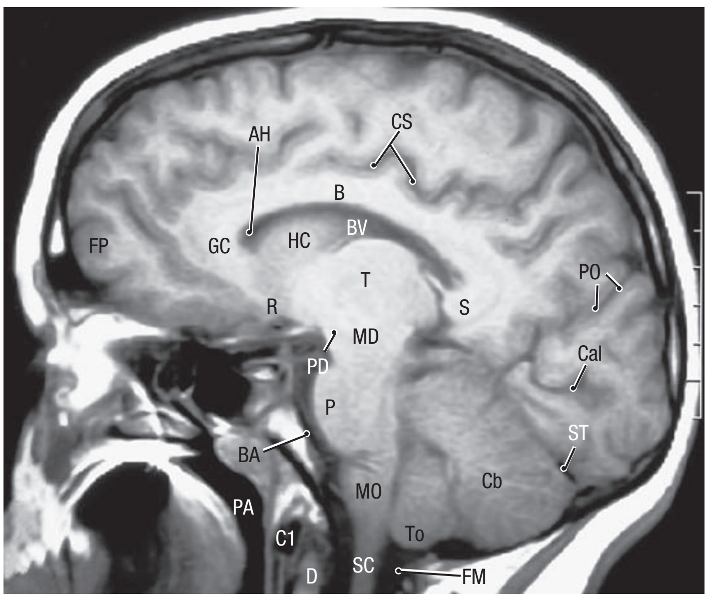


H

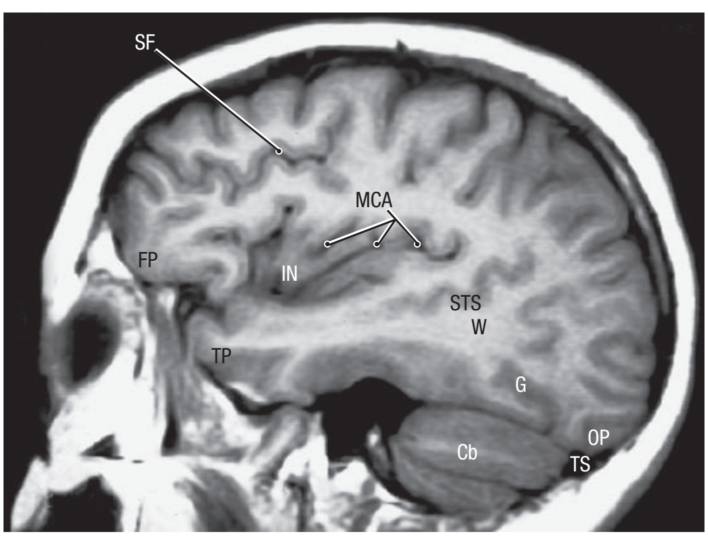
7.108 CORONAL MRIs (T2 WEIGHTED) AND SECTIONS OF BRAIN *(CONTINUED)*



A

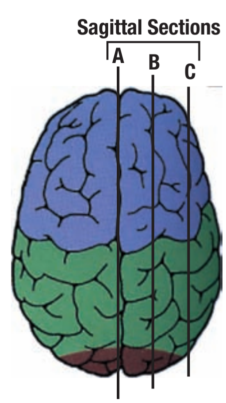


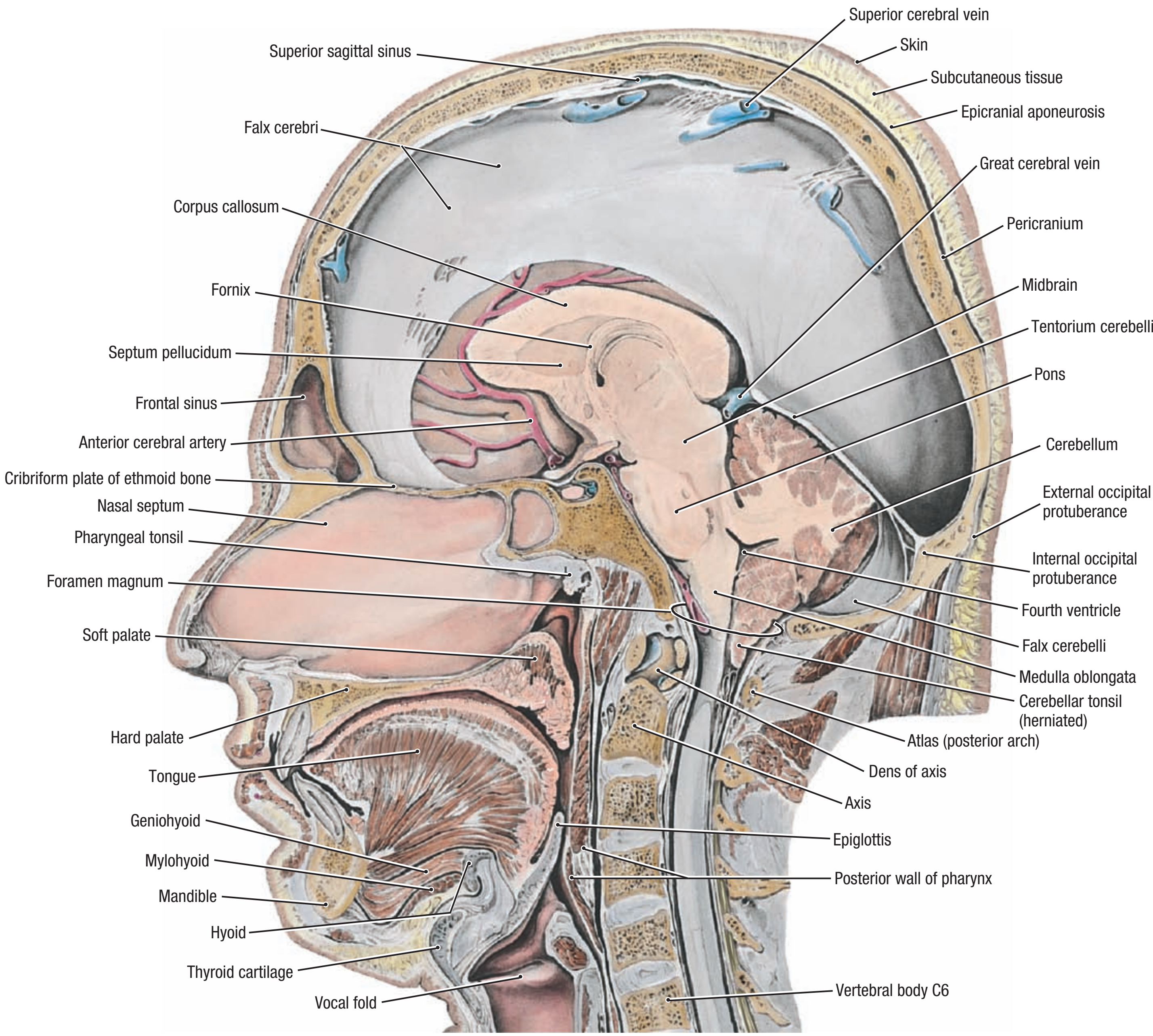
B



C

ACA	Anterior cerebral artery
AH	Anterior horn of lateral ventricle
B	Body of corpus callosum
BA	Basilar artery
BV	Body of lateral ventricle
C	Colliculi
C1	Anterior tubercle of atlas
Cal	Calcarine sulcus
Cb	Cerebellum
CG	Cingulate nucleus
CQ	Cerebral aqueduct
CS	Cingulate sulcus
D	Dens (odontoid process)
F	Fornix
FM	Foramen magnum
FP	Frontal pole
FV	Fourth ventricle
G	Cerebral cortex (gray matter)
GC	Genus of corpus callosum
H	Hypothalamus
HC	Head of caudate nucleus
I	Infundibulum
IN	Insular cortex
M	Mammillary body
MCA	Middle cerebral artery
MD	Midbrain
OP	Occipital pole
P	Pons
PA	Pharynx
PD	Cerebral peduncle
PI	Pineal
PO	Parieto-occipital fissure
R	Rostrum of corpus callosum
S	Splenium of corpus callosum
SC	Spinal cord
SF	Superior frontal sulcus
ST	Straight sinus
STS	Superior temporal sulcus
SV	Superior medullary vellum
T	Thalamus
To	Cerebellar tonsil
TP	Temporal pole
TS	Transverse sinus
W	White matter
Y	Hypophysis





D. **Median Section**

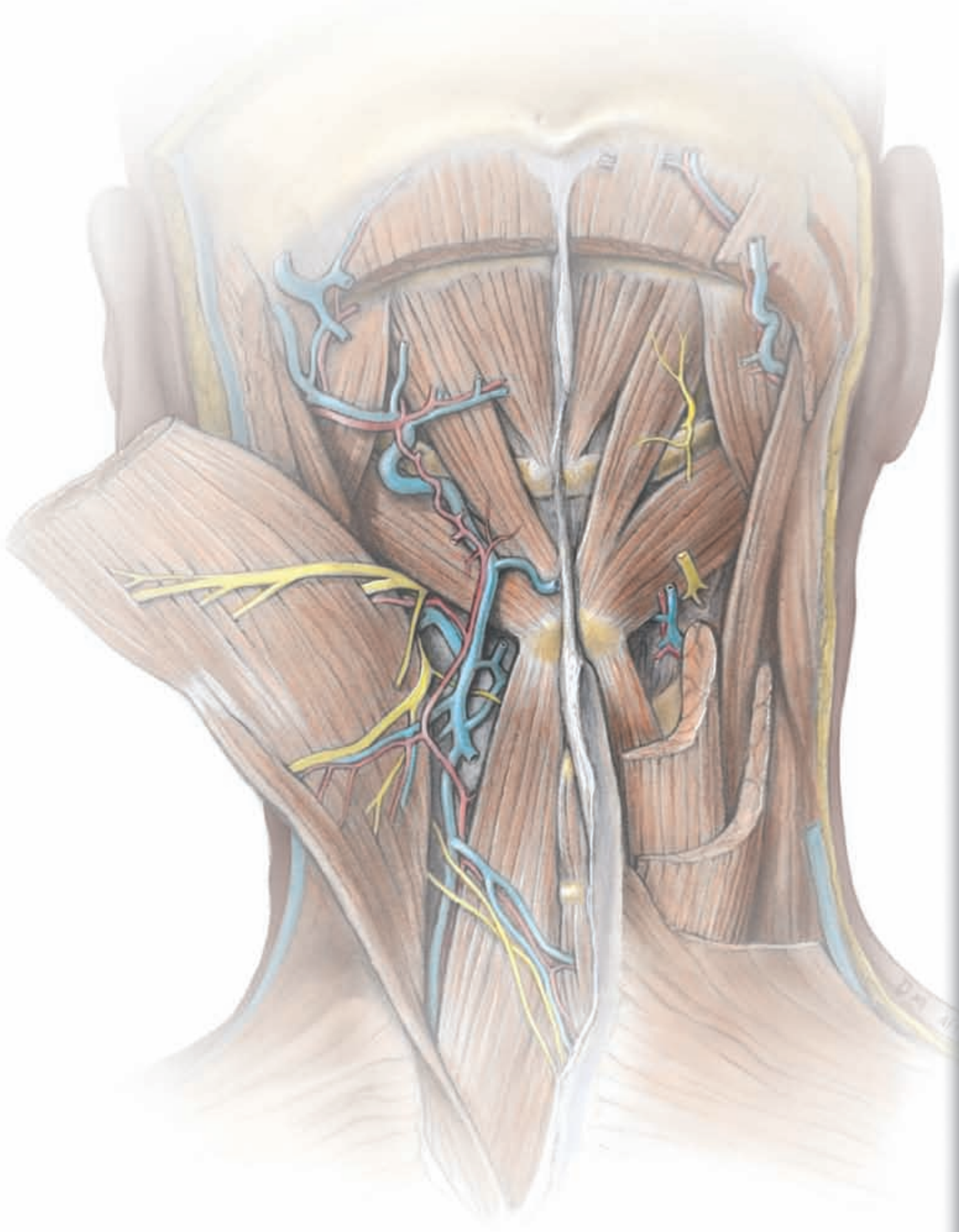
7.109 SAGITTAL MRIs (T1 WEIGHTED) AND MEDIAN SECTION OF BRAIN

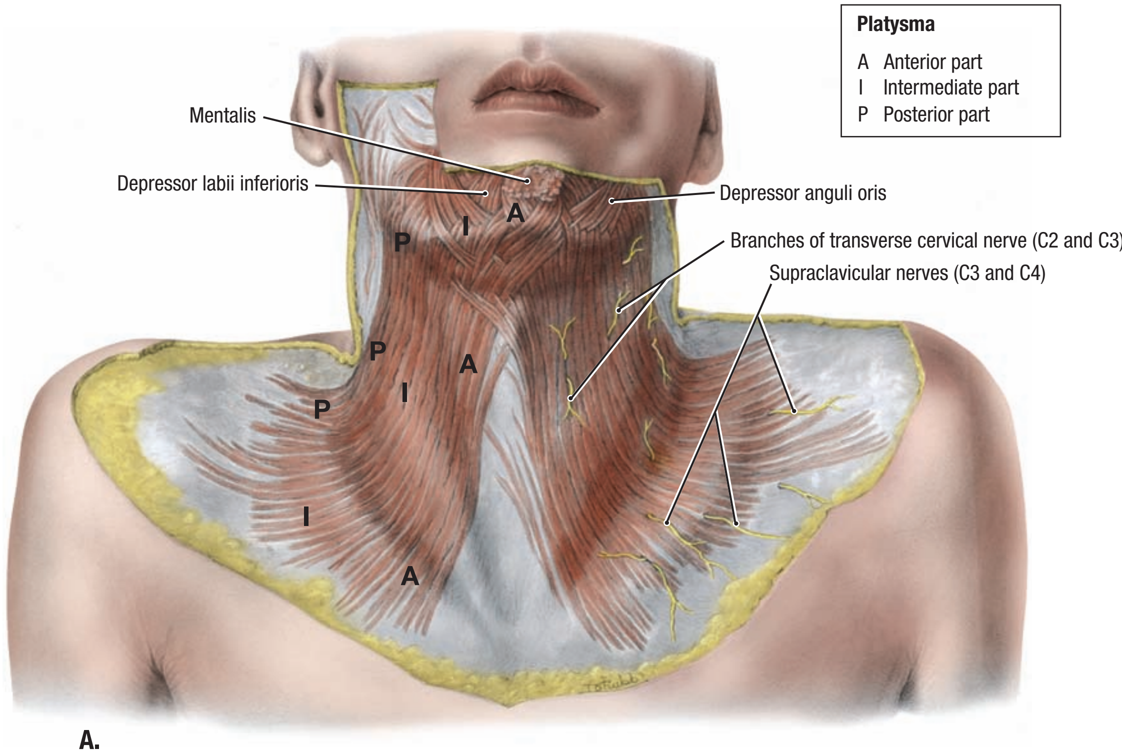
See orientation drawing for sites of scans **A.–C.**

Increased intracranial pressure (e.g., due to a tumor) may cause displacement of the cerebellar tonsils through the foramen magnum, resulting in a foraminal (tonsillar) herniation. Compression of the brainstem, if severe, may result in respiratory and cardiac arrest.

CHAPTER 8

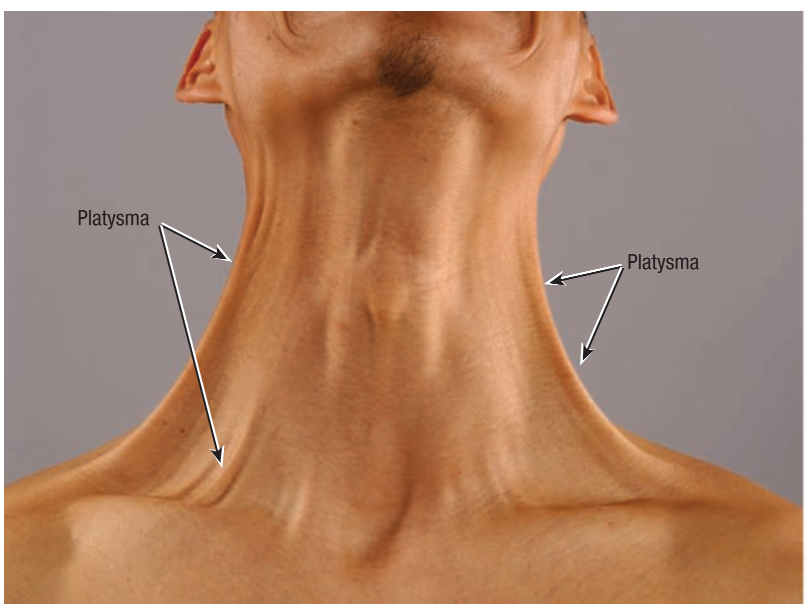
Neck





A.

Anterior Views



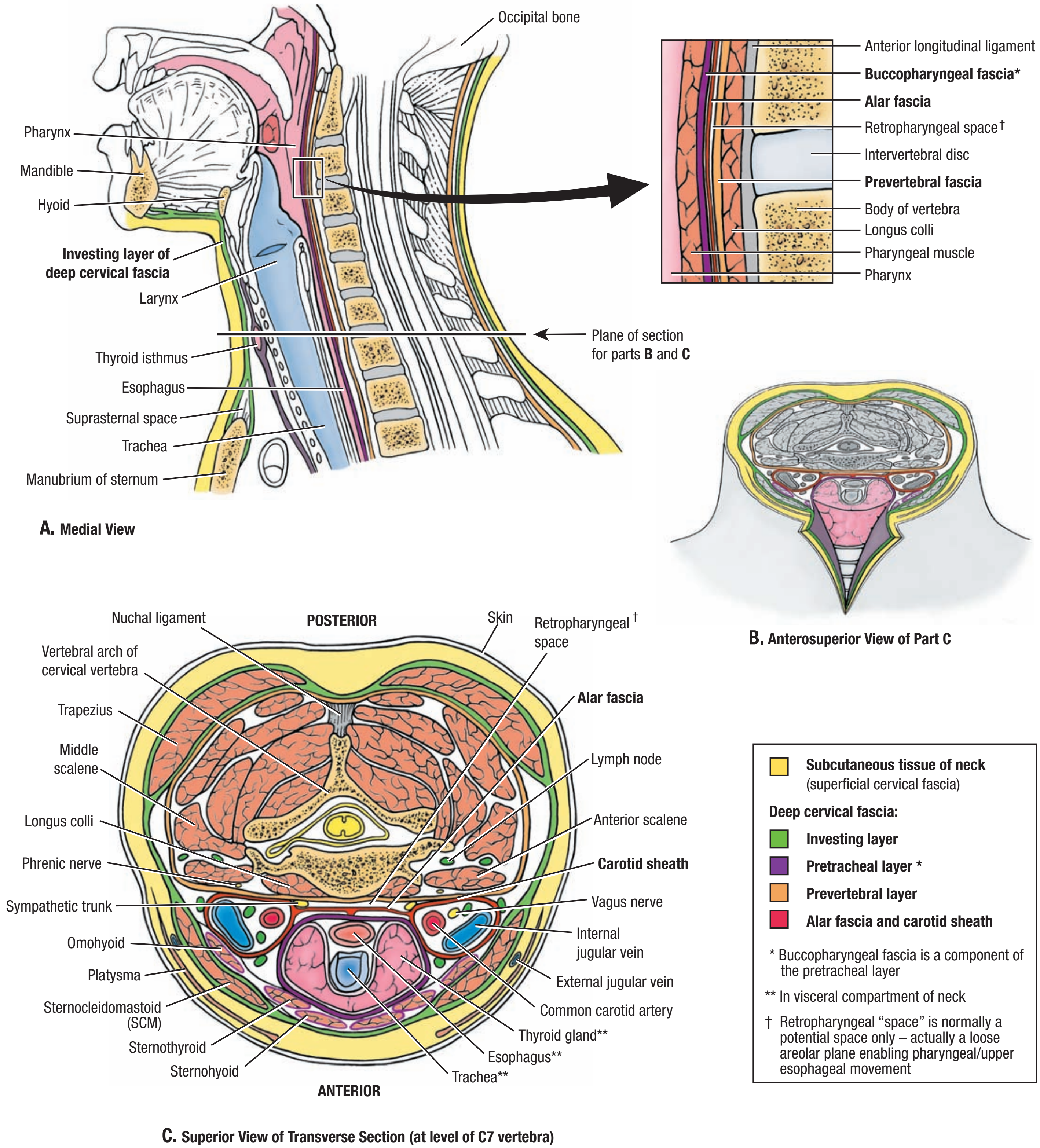
B.

8.1 PLATYSMA

A. Parts of platysma. **B.** Surface anatomy.

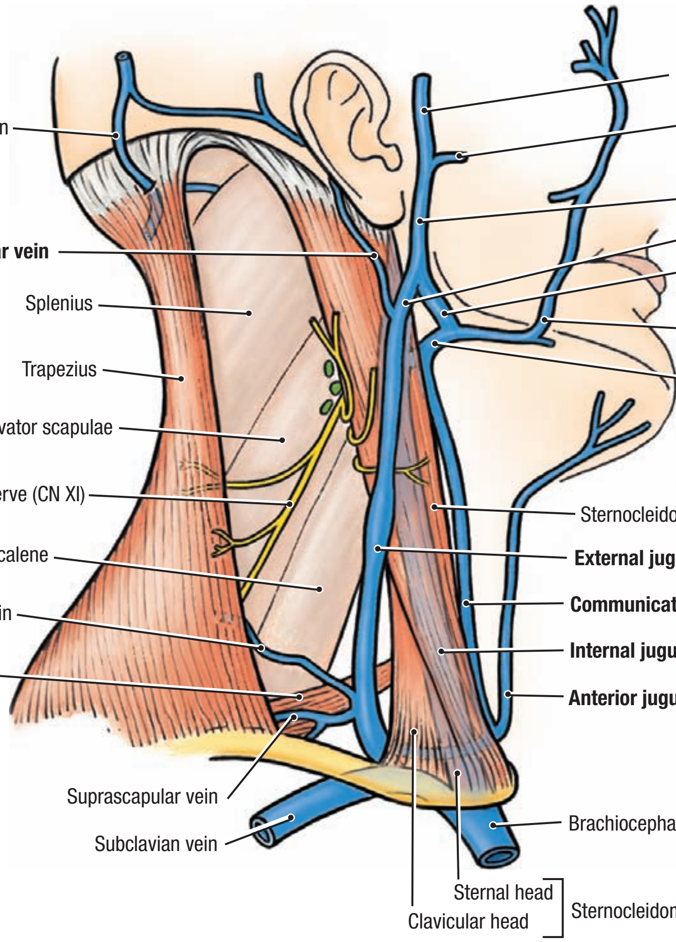
TABLE 8.1 PLATYSMA

Muscle	Superior Attachment	Inferior Attachment	Innervation	Main Action
Platysma	*Anterior part:* Fibers interlace with contralateral muscle *Intermediate part:* Fibers pass deep to depressors anguli oris and labii inferioris to attach to inferior border of mandible *Posterior part:* Skin/subcutaneous tissue of lower face lateral to mouth	Subcutaneous tissue overlying superior parts of pectoralis major and sometimes deltoid muscles	Cervical branch of facial nerve (CN VII)	Draws corner of mouth inferiorly and widens it as in expressions of sadness and fright; draws the skin of the neck superiorly, forming tense vertical and oblique ridges over the anterior neck

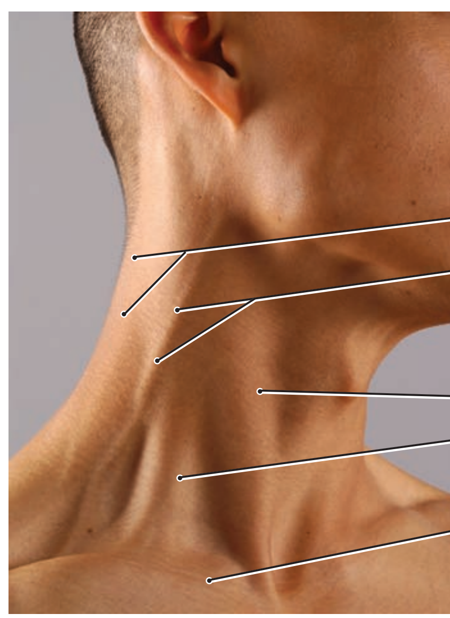


8.2 SUBCUTANEOUS TISSUE AND DEEP FASCIA OF NECK

Sectional demonstrations of the fasciae of the neck. **A.** Fasciae of the neck are continuous inferiorly and superiorly with thoracic and cranial fasciae. The *inset* illustrates the fascia of the retropharyngeal region. **B.** Relationship of the main layers of deep cervical fascia and the carotid sheath. Midline access to the cervical viscera is possible with minimal disruption of tissues. **C.** The concentric layers of fascia are apparent in this transverse section of neck at the level indicated in **A.**



A. Lateral View

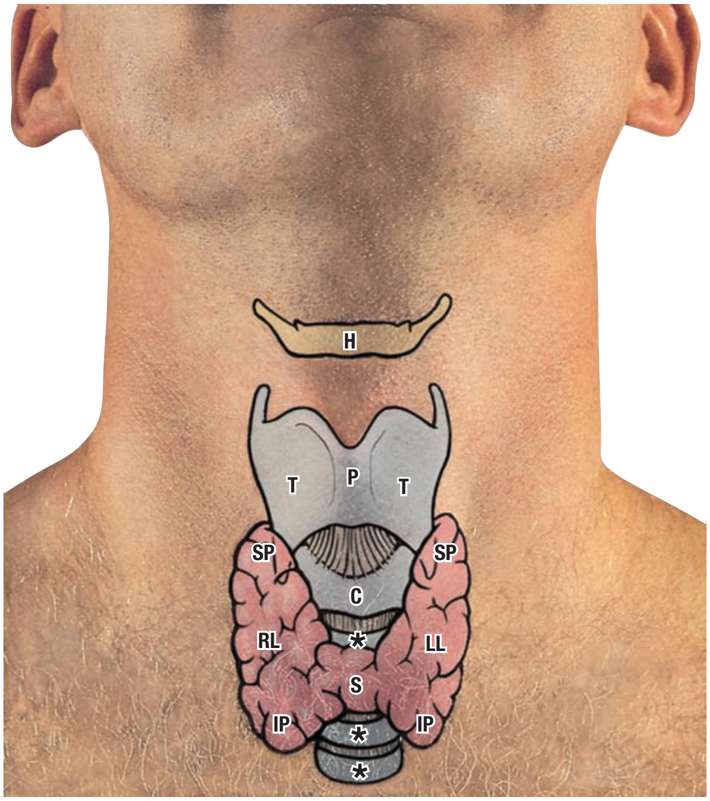


B. Right Anterolateral View

8.3 SUPERFICIAL VEINS OF NECK

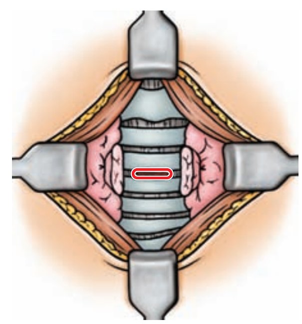
A. Schematic illustration of superficial veins of the neck. The superficial temporal and maxillary veins merge to form the retromandibular vein. The posterior division of the retromandibular vein unites with the posterior auricular vein to form the external jugular vein (EJV). The facial vein receives the anterior division of the retromandibular vein, forming the common facial vein that empties into the internal jugular vein. Variations are common. **B.** Surface anatomy of the external jugular vein and the muscles bounding the lateral cervical region (posterior triangle) of the neck.

External jugular vein (EJV). The EJV may serve as an "internal barometer." When venous pressure is in the normal range, the EJV is usually visible superior to the clavicle for only a short distance. However, when venous pressure rises (e.g., as in heart failure) the vein is prominent throughout its course along the side of the neck. Consequently, routine observation for distention of the EJVs during physical examinations may reveal diagnostic signs of heart failure, obstruction of the superior vena cava, enlarged supraclavicular lymph nodes, or increased intrathoracic pressure.

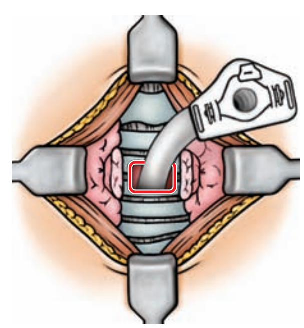


A. **Anterior View**

C	Cricoid cartilage
H	Hyoid bone
IP	Inferior pole of thyroid gland
LL	Left lobe of thyroid gland
P	Laryngeal prominence
RL	Right lobe of thyroid gland
S	Isthmus
SP	Superior pole of thyroid gland
T	Thyroid cartilage
*	Tracheal rings



Incision in trachea after retracting infrahyoid muscles and incising isthmus of thyroid gland



Tracheostomy tube inserted in tracheal opening

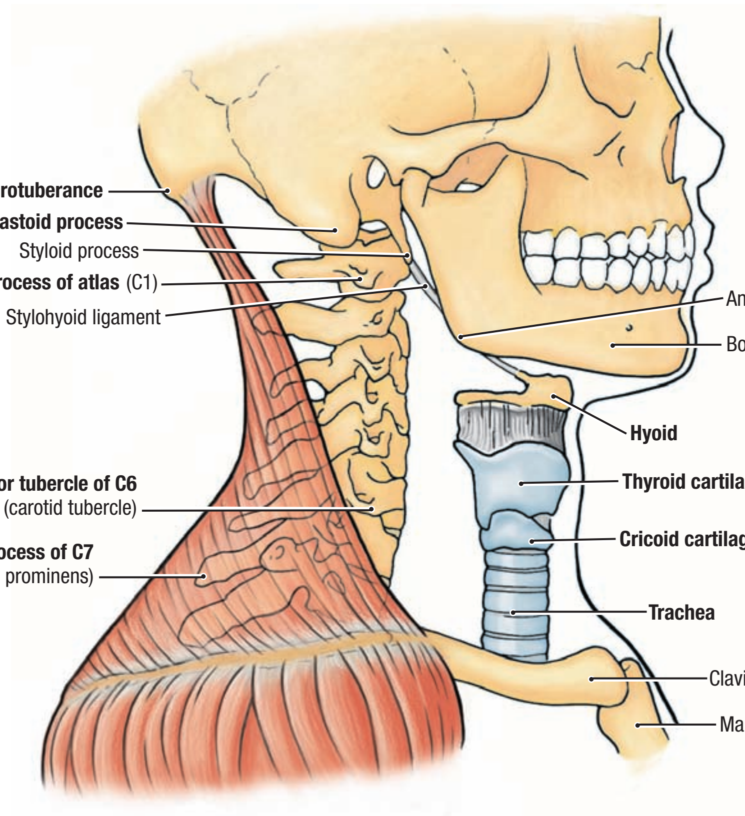
B. **Tracheostomy**

8.4 SURFACE ANATOMY OF HYOID AND CARTILAGES OF ANTERIOR NECK

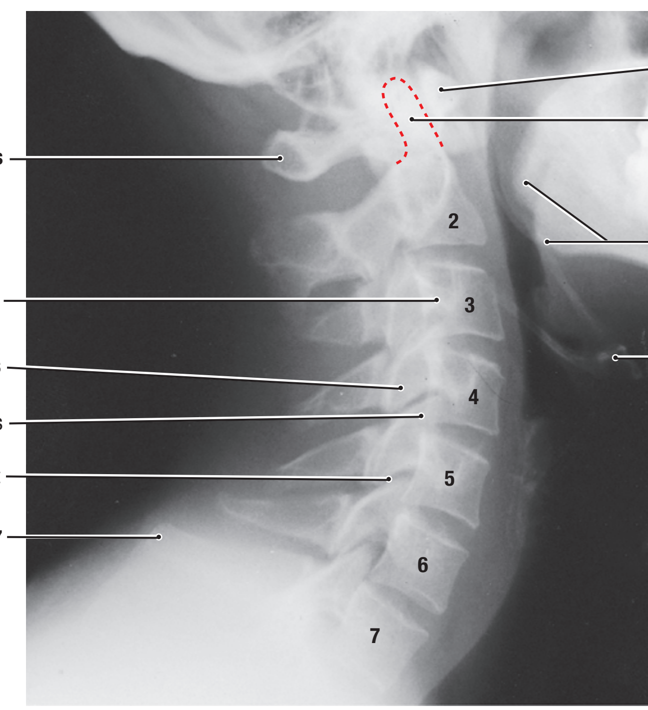
A. Surface anatomy. **B.** Tracheostomy. The U-shaped hyoid bone lies superior to the thyroid cartilage at the level of the C4 and C5 vertebrae. The laryngeal prominence is produced by the fused laminae of the thyroid cartilage, which meet in the median plane. The cricoid cartilage can be felt inferior to the laryngeal prominence. It lies at the level of the C6 vertebra. The cartilaginous tracheal rings are palpable in the inferior part of the neck. The 2nd to 4th rings cannot be felt because the isthmus of the thyroid, connecting its right and left lobes, covers them. The first tracheal ring is just superior to the isthmus.

Tracheostomy. A transverse incision through the skin of the neck and anterior wall of the trachea (*tracheostomy*) establishes an airway in patients with upper airway obstruction or respiratory failure. The infrahyoid muscles are retracted laterally, and the isthmus of the thyroid gland is either divided or retracted superiorly. An opening is made in the trachea between the 1st and 2nd tracheal rings or through the 2nd through 4th rings. A *tracheostomy tube* is then inserted into the trachea and secured. To avoid complications during a tracheostomy, the following anatomical relationships are important:

- The inferior thyroid veins arise from a venous plexus on the thyroid gland and descend anterior to the trachea (see Fig. 8.10).
- A small thyroid ima artery is present in approximately 10% of people; it ascends from the brachiocephalic trunk or the arch of the aorta to the isthmus of the thyroid gland (see Fig. 8.21).
- The left brachiocephalic vein, jugular venous arch, and pleurae may be encountered, particularly in infants and children.
- The thymus covers the inferior part of the trachea in infants and children.
- The trachea is small, mobile, and soft in infants, making it easy to cut through its posterior wall and damage the esophagus.



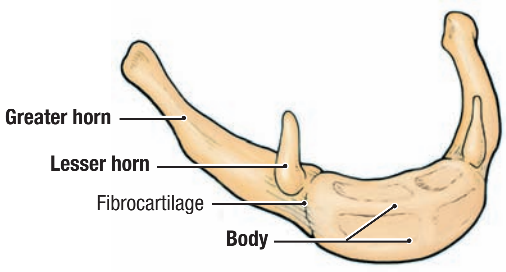
A. Lateral View



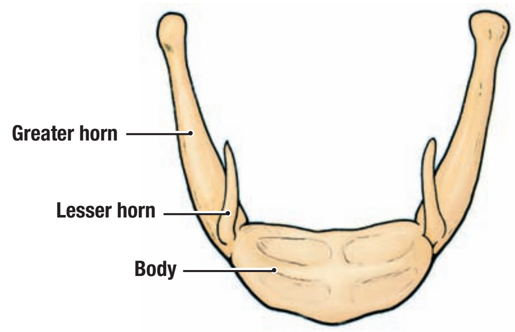
B. Lateral View

8.5 BONES AND CARTILAGES OF NECK

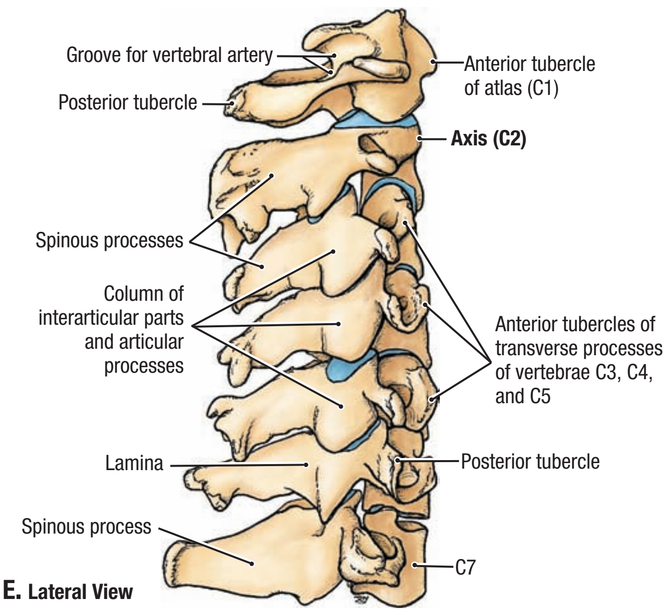
A. Bony and cartilaginous landmarks of the neck. **B.** Radiograph of hyoid bone and cervical vertebrae. Because the upper cervical vertebrae lie posterior to the upper and lower jaws and teeth, they are best seen radiographically in lateral views.



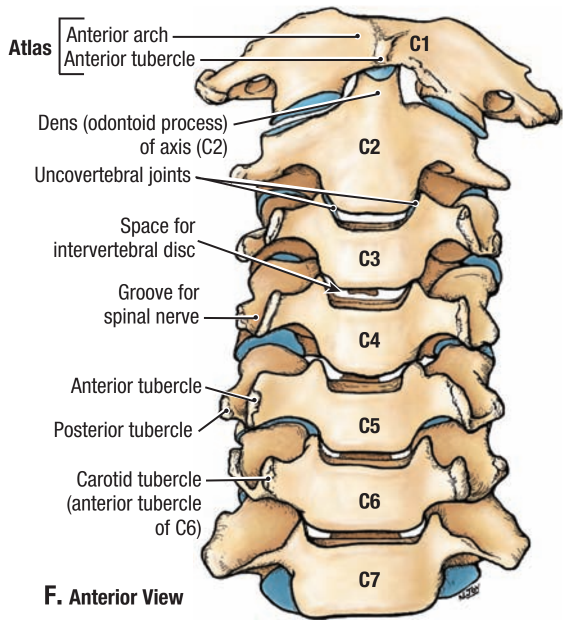
C. Right Anterolateral View of Hyoid



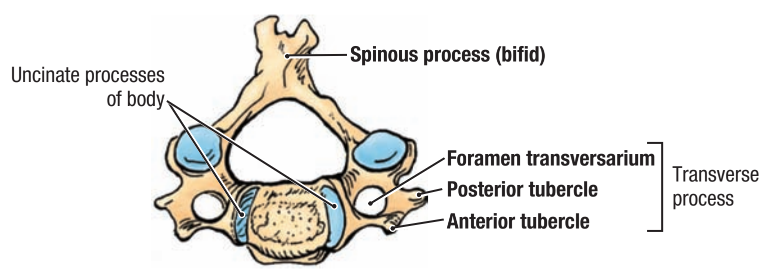
D. Anterosuperior View of Hyoid



E. Lateral View



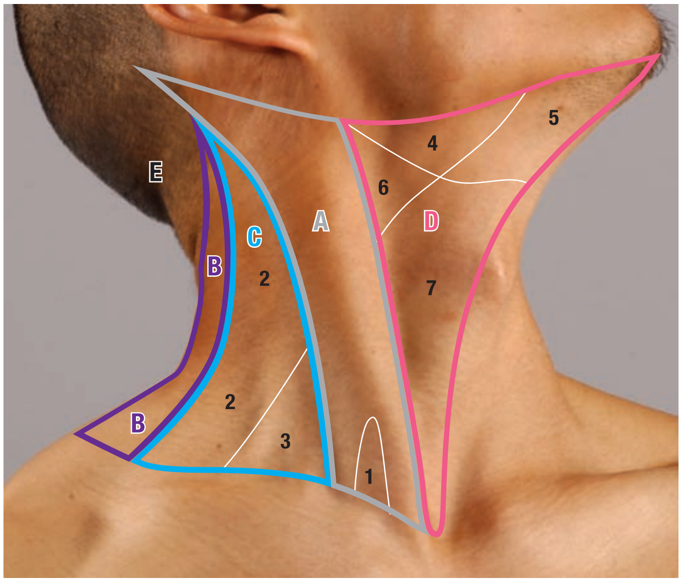
F. Anterior View



G. Superior View of Typical Cervical Vertebra (e.g., C4)

8.5 BONES AND CARTILAGES OF NECK *(CONTINUED)*

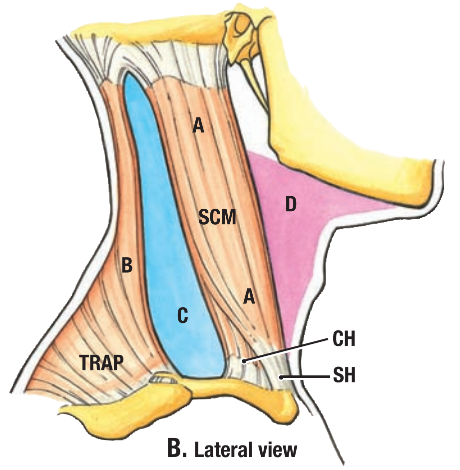
C. and D. Features of hyoid bone. **E. and F.** Articulated cervical vertebrae. **G.** Features of typical cervical vertebrae.



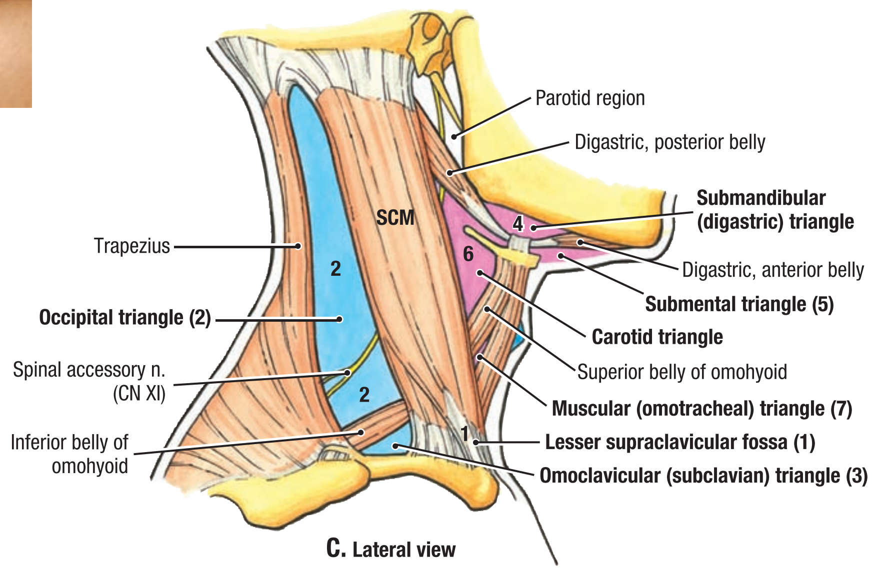
A. Anterolateral view

KEY for A and B:

A	Sternocleidomastoid region
B	Posterior cervical region
C	Lateral cervical region
D	Anterior cervical region
E	Suboccipital region
SCM	Sternocleidomastoid
CH	Clavicular head
SH	Sternal head
TRAP	Trapezius



B. Lateral view



C. Lateral view

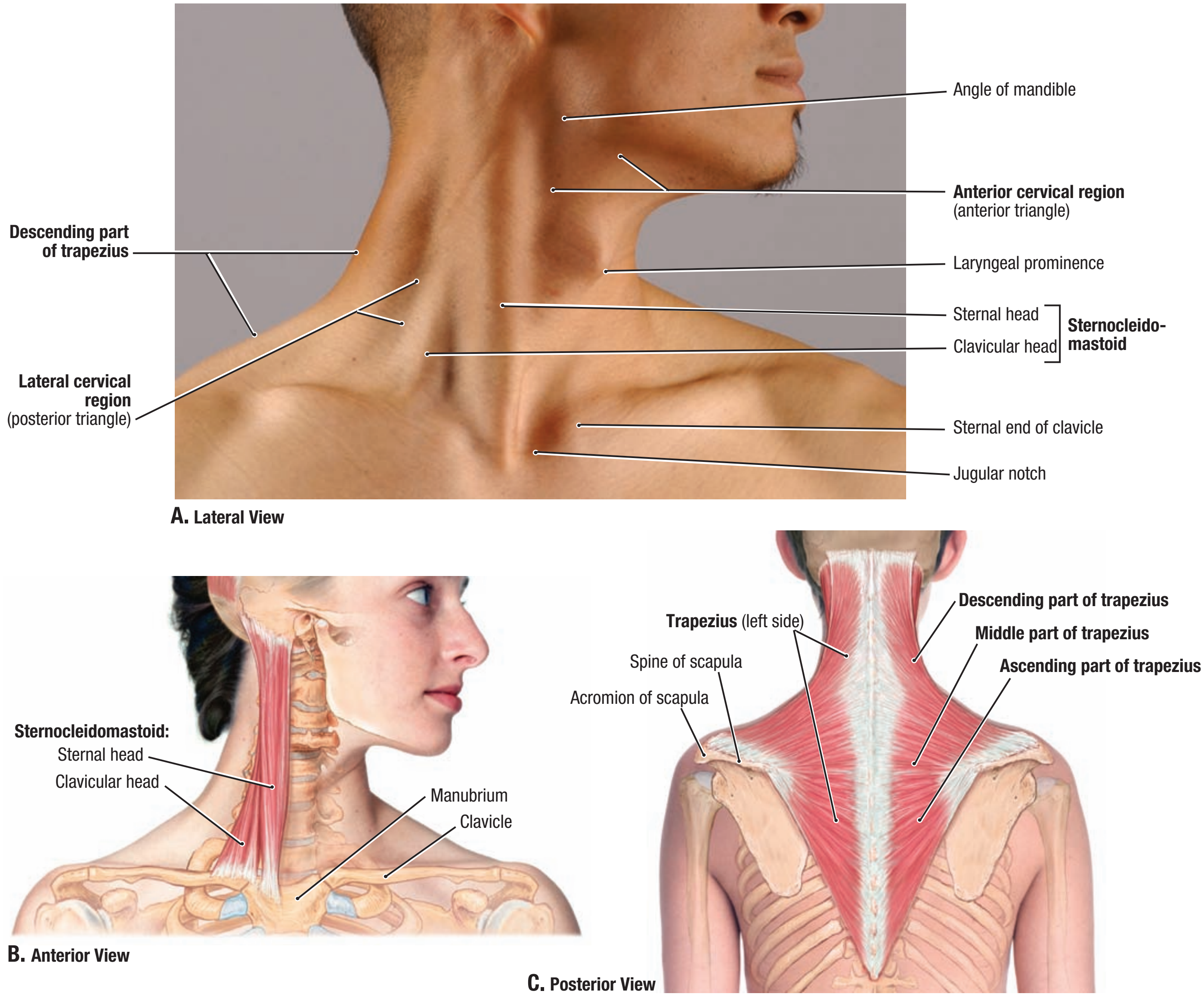
8.6 CERVICAL REGIONS

A. Surface anatomy. **B. and C.** Regions and triangles of neck.

TABLE 8.2 CERVICAL REGIONS AND CONTENTS[a]

Region	Main Contents and Underlying Structures
Sternocleidomastoid region *(A)*	Sternocleidomastoid (SCM) muscle; superior part of the external jugular vein; greater auricular nerve; transverse cervical nerve
Lesser supraclavicular fossa *(1)*	Inferior part of internal jugular vein
Posterior cervical region *(B)*	Trapezius muscle; cutaneous branches of posterior rami of cervical spinal nerves; suboccipital region (E) lies deep to superior part of this region
Lateral cervical region (posterior triangle) *(C)* Occipital triangle *(2)*	Part of external jugular vein; posterior branches of cervical plexus of nerves; spinal accessory nerve; trunks of brachial plexus; transverse cervical artery; cervical lymph nodes
Omoclavicular triangle *(3)*	Subclavian artery; part of subclavian vein (variable); suprascapular artery; supraclavicular lymph nodes
Anterior cervical region (anterior triangle) *(D)* Submandibular (digastric) triangle *(4)*	Submandibular gland almost fills triangle; submandibular lymph nodes; hypoglossal nerve; mylohyoid nerve; parts of facial artery and vein
Submental triangle *(5)*	Submental lymph nodes and small veins that unite to form anterior jugular vein
Carotid triangle *(6)*	Common carotid artery and its branches; internal jugular vein and its tributaries; vagus nerve; external carotid artery and some of its branches; hypoglossal nerve and superior root of ansa cervicalis; spinal accessory nerve; thyroid gland, larynx, and pharynx; deep cervical lymph nodes; branches of cervical plexus
Muscular (omotracheal) triangle (7)	Sternothyroid and sternohyoid muscles; thyroid and parathyroid glands

[a]Letters and numbers in parentheses refer to Figures A, B and C.

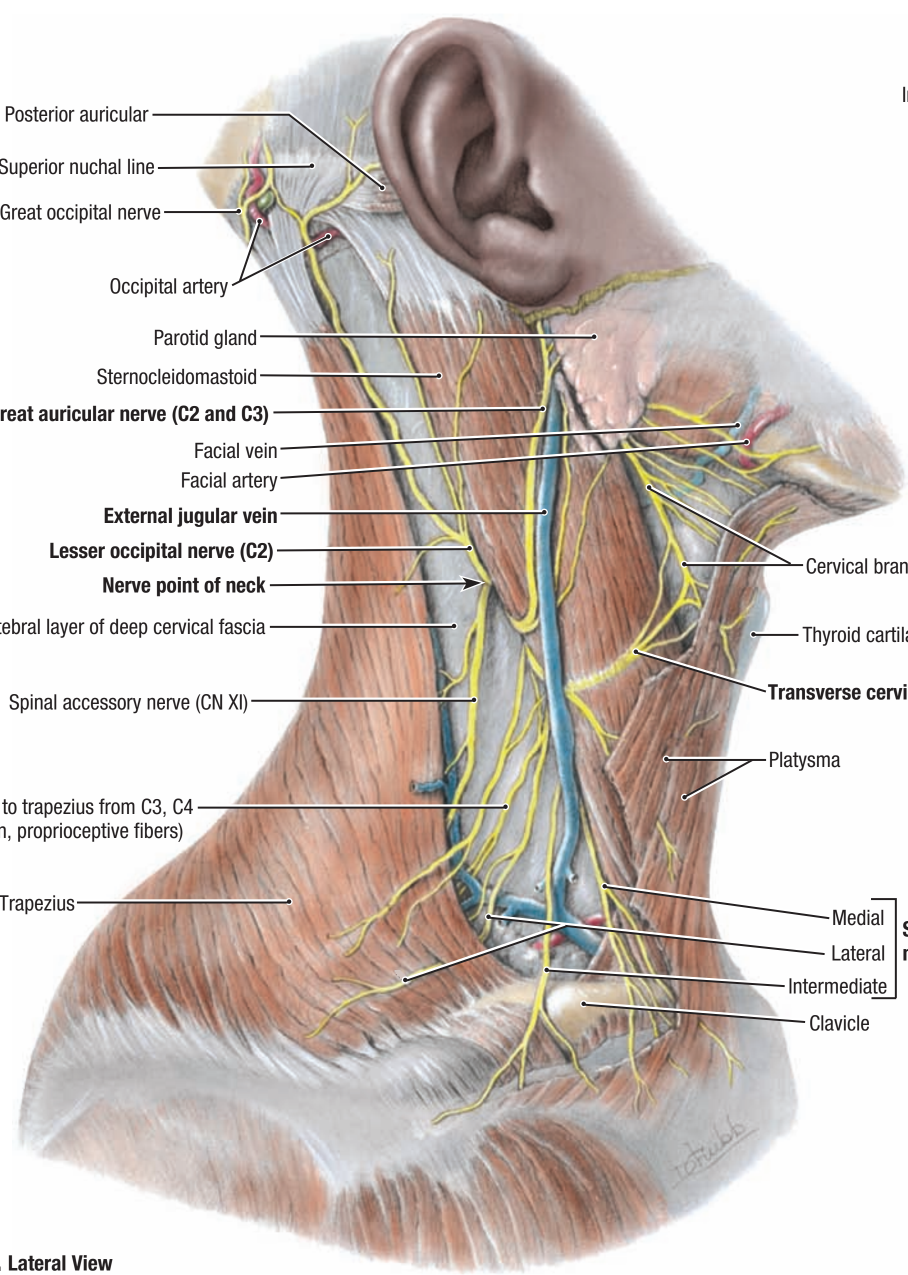


8.7 STERNOCLEIDOMASTOID AND TRAPEZIUS.

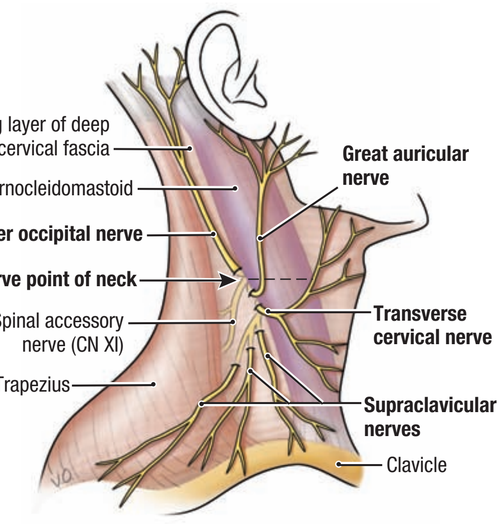
A. Surface anatomy. **B.** Sternocleidomastoid. **C.** Trapezius.

TABLE 8.3 STERNOCLEIDOMASTOID AND TRAPEZIUS

Muscle	Superior Attachment	Inferior Attachment	Innervation	Main Action
Sternocleidomastoid	Lateral surface of mastoid process of temporal bone; lateral half of superior nuchal line	*Sternal head:* anterior surface of manubrium of sternum *Clavicular head:* superior surface of medial third of clavicle	Spinal accessory nerve (CN XI) [motor] and C2 and C3 nerves (pain and proprioception)	*Unilateral contraction:* laterally flexes neck; rotates neck so face is turned superiorly toward opposite side; *Bilateral contraction:* (1) extends neck at atlanto-occipital joints, (2) flexes cervical vertebrae so that chin approaches manubrium, or (3) extends superior cervical vertebrae while flexing inferior vertebrae, so chin is thrust forward with head kept level; with cervical vertebrae fixed, may elevate manubrium and medial end of clavicles, assisting deep respiration.
Trapezius	Medial third of superior nuchal line, external occipital protuberance, nuchal ligament, spinous processes of C7–T12 vertebrae, lumbar and sacral spinous processes	Lateral third of clavicle, acromion, spine of scapula	Spinal accessory nerve (CN XI) [motor] and C2 and C3 nerves (pain and proprioception)	*Descending fibers* elevate pectoral girdle, maintain level of shoulders against gravity or resistance; *middle fibers* retract scapula; and *ascending fibers* depress shoulders; *superior* and *inferior fibers* work together to rotate scapula upward; *when shoulders are fixed*, bilateral contraction extends neck; unilateral contraction produces lateral flexion to same side



A. Lateral View



B. Lateral View

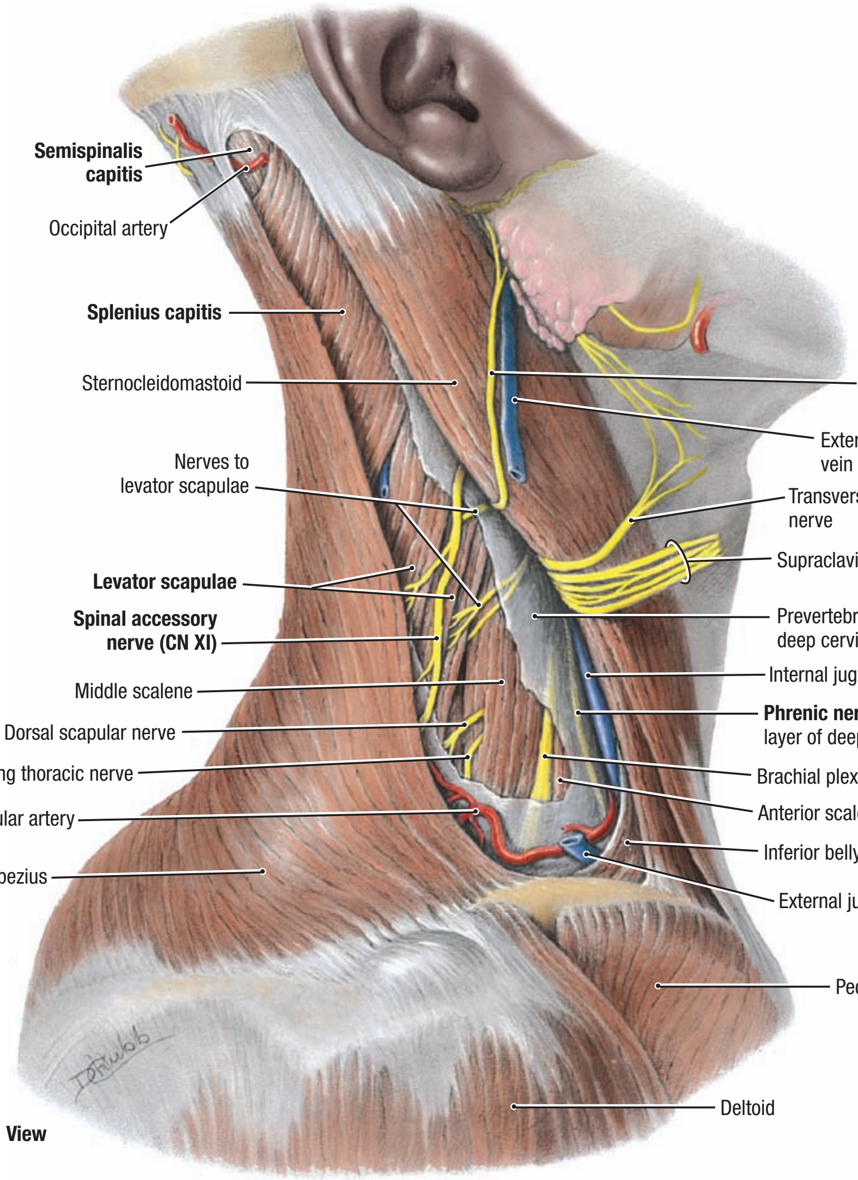
8.8 SERIAL DISSECTIONS OF LATERAL CERVICAL REGION (POSTERIOR TRIANGLE OF NECK)

A. External jugular vein and cutaneous branches of cervical plexus. Subcutaneous fat, the part of the plasma overlying the inferior part of the lateral cervical region, and the investing layer of deep cervical fascia have all been removed. The external jugular vein descends vertically across the sternocleidomastoid and pierces the prevertebral layer of deep cervical fascia superior to the clavicle.

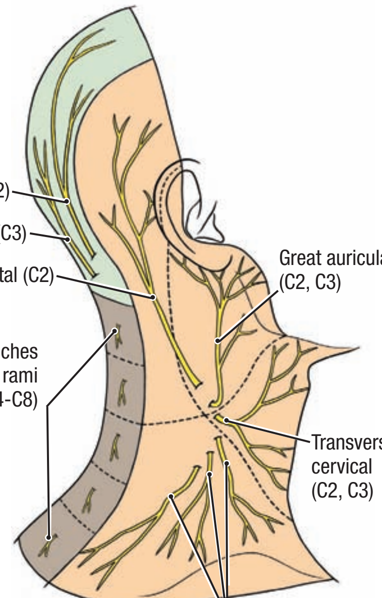
B. and C. Branches of the cervical plexus.

- Branches arising from the nerve loop between the anterior rami of C2 and C3 are the lesser occipital, great auricular, and transverse cervical nerves.
- Branches arising from the loop formed between the anterior rami of C3 and C4 are the supraclavicular nerves, which emerge as a common trunk under cover of the SCM.

Regional anesthesia is often used for surgical procedures in the neck region or upper limb. In a **cervical plexus block,** an anesthetic agent is injected at several points along the posterior border of the SCM, mainly at its midpoint, the nerve point of the neck.



D. Lateral View



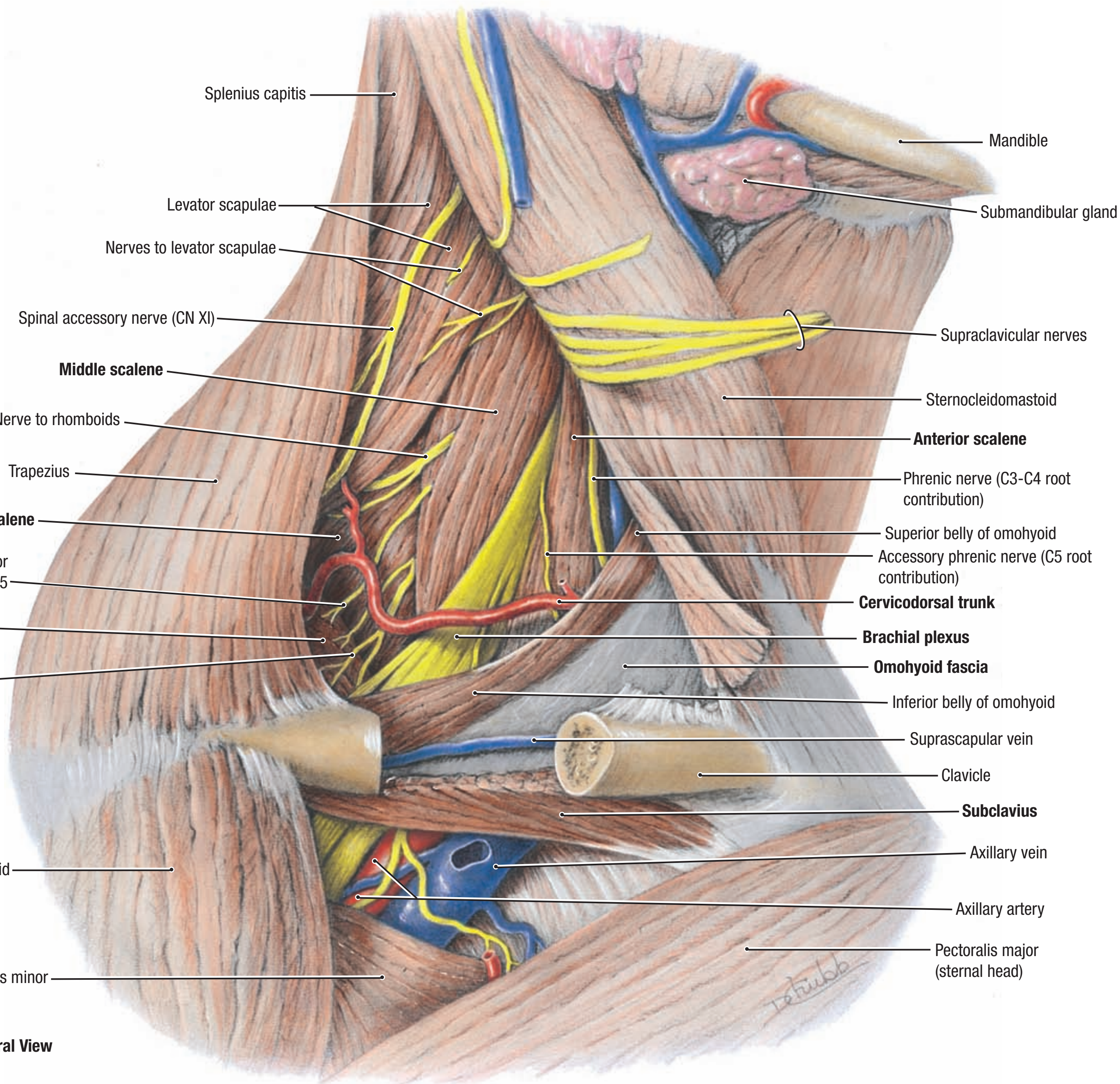
C. Lateral View

8.8 SERIAL DISSECTIONS OF LATERAL CERVICAL REGION *(CONTINUED)*

D. Muscles forming the floor of the lateral cervical region. The prevertebral layer of deep cervical fascia has been partially removed, and the motor nerves and most of the floor of the region are exposed.

- The spinal accessory nerve (CN XI) supplies the SCM and trapezius muscles; between them, it courses along the levator scapulae muscle but is separated from it by the prevertebral layer of deep cervical fascia.
- The phrenic nerve (C3, C4, C5) supplies the diaphragm and is located deep to the prevertebral layer of deep cervical fascia on the anterior surface of the anterior scalene muscle.

Severance of a phrenic nerve results in an ipsilateral paralysis of the diaphragm. A phrenic nerve block produces a short period of paralysis of the diaphragm on one side (e.g., for a lung operation). The anesthetic agent is injected around the nerve where it lies on the anterior surface of the anterior scalene muscle.



E. **Lateral View**

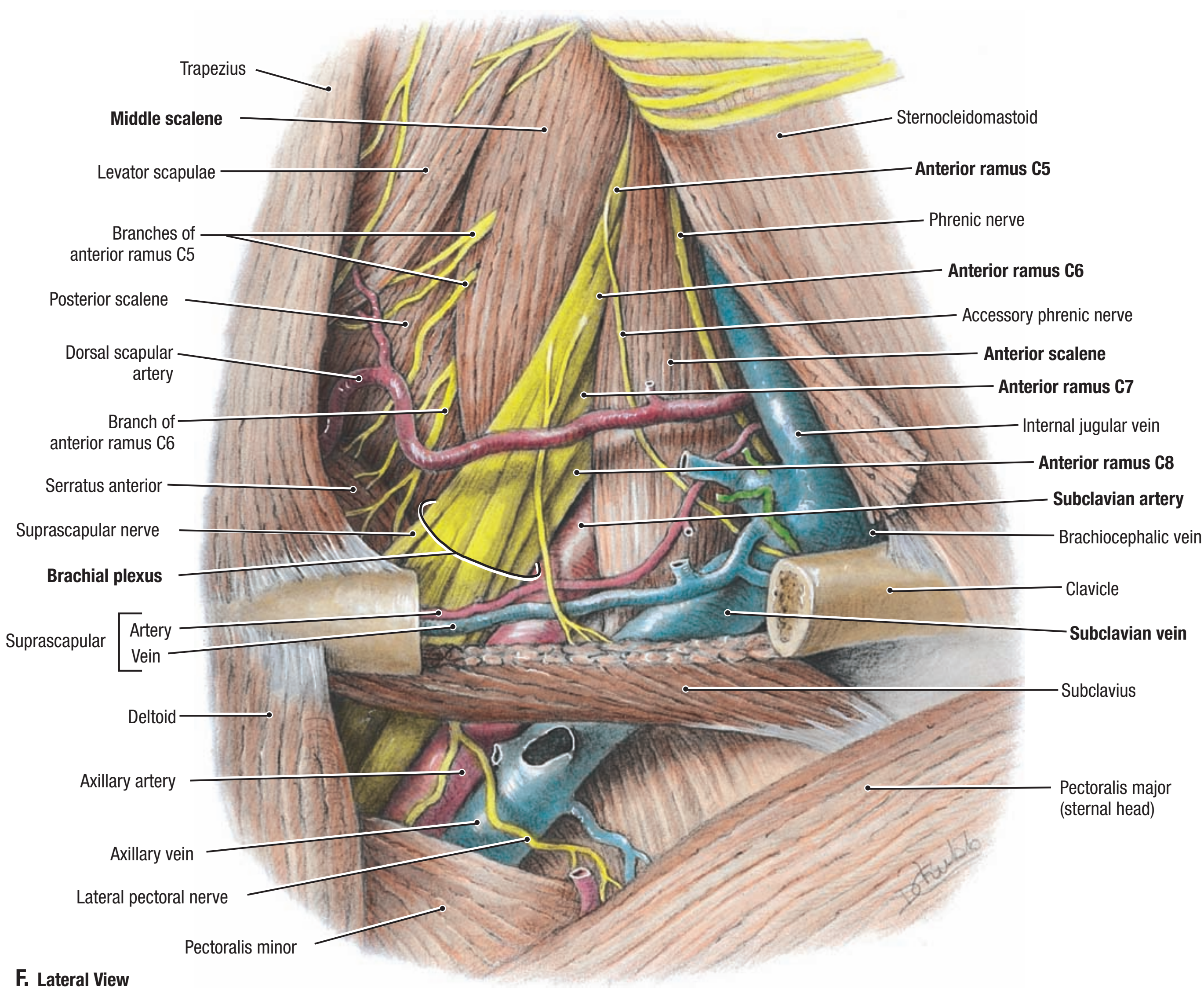
8.8 SERIAL DISSECTIONS OF LATERAL CERVICAL REGION *(CONTINUED)*

E. Vessels and motor nerves of the lateral cervical region. The clavicular head of the pectoralis major muscle and part of the clavicle have been removed.

The muscles that form the floor of the region are the semispinalis capitis, splenius capitis and levator scapulae superiorly and the anterior, middle and posterior scalenes and serratus anterior inferiorly.

- The brachial plexus emerges between the anterior and middle scalene muscles.

A **supraclavicular brachial plexus block** may be utilized for anesthesia of the upper limb. The anesthetic agent is injected around the supraclavicular part of the brachial plexus. The main injection site is superior to the midpoint of the clavicle.



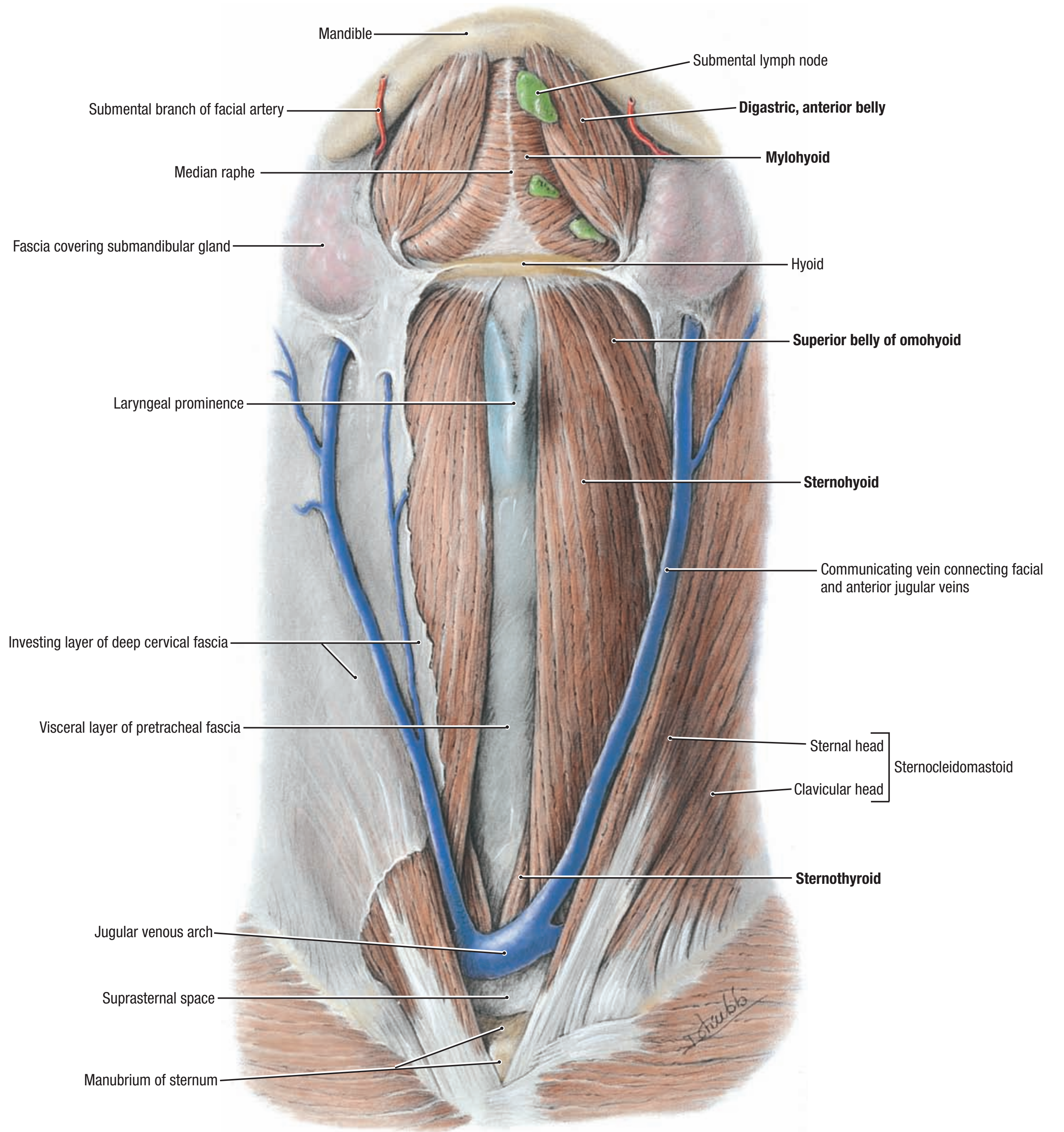
F. Lateral View

8.8 SERIAL DISSECTIONS OF LATERAL CERVICAL REGION *(CONTINUED)*

F. Structures of the omoclavicular (subclavian) triangle. The omohyoid muscle and fascia have been removed, exposing the brachial plexus and subclavian vessels.

- The anterior rami of C5–T1 form the brachial plexus; the anterior ramus of T1 lies posterior to the subclavian artery.
- The brachial plexus and subclavian artery emerge between the middle and anterior scalene muscles.
- The anterior scalene muscle lies between the subclavian artery and vein.

The right or left subclavian vein is often the site of **placement for a central venous catheter**, used to insert intravenous tubes ("central venous lines") for the administration of parenteral nutritional fluids or medications, for testing blood chemistry or central venous pressure, or inserting electrode wires for heart pacemaker devices. The relationships of the subclavian vein to the sternocleidomastoid muscle, clavicle, sternoclavicular joint and 1st rib are of clinical importance in line placement, and there is danger of puncture of the pleura or subclavian artery if the procedure is not performed correctly.

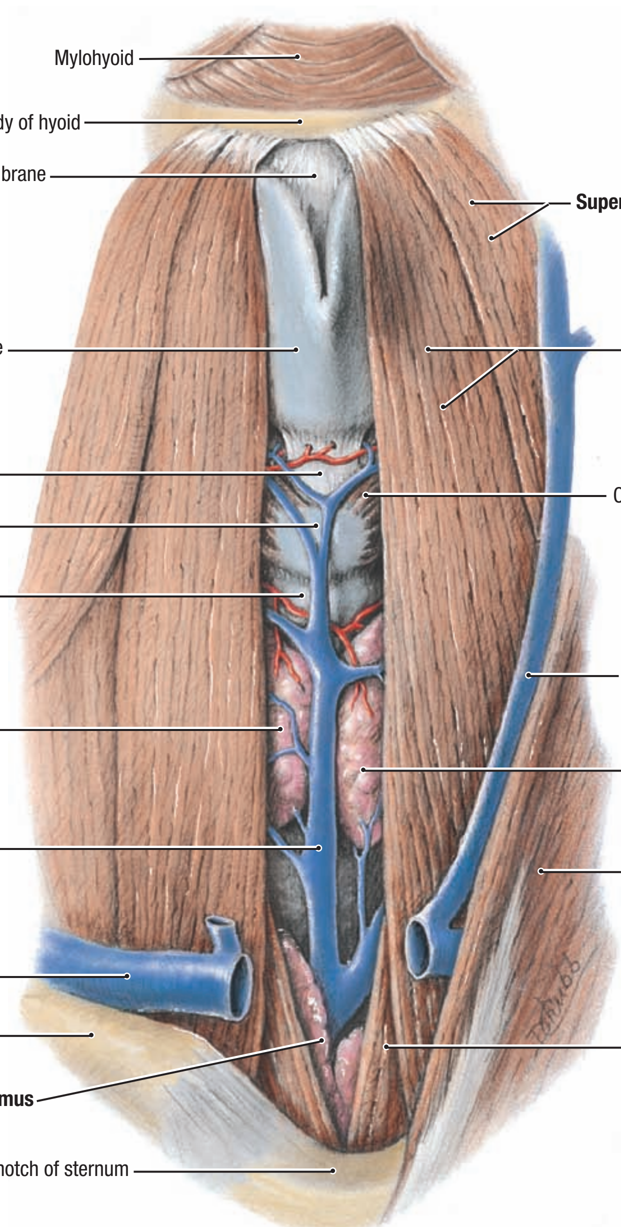


Anterior View

8.9 SUPRAHYOID AND INFRAHYOID MUSCLES

Much of the investing layer of deep cervical fascia has been removed.

- The anterior bellies of the digastric muscles form the sides of the suprahyoid part of the anterior cervical region, or submental triangle (floor of mouth). The hyoid bone forms the triangle's base, and the mylohyoid muscles are its floor.
- The infrahyoid part of the anterior cervical region is shaped like an elongated diamond bounded by the sternohyoid muscle superiorly and sternothyroid muscle inferiorly.



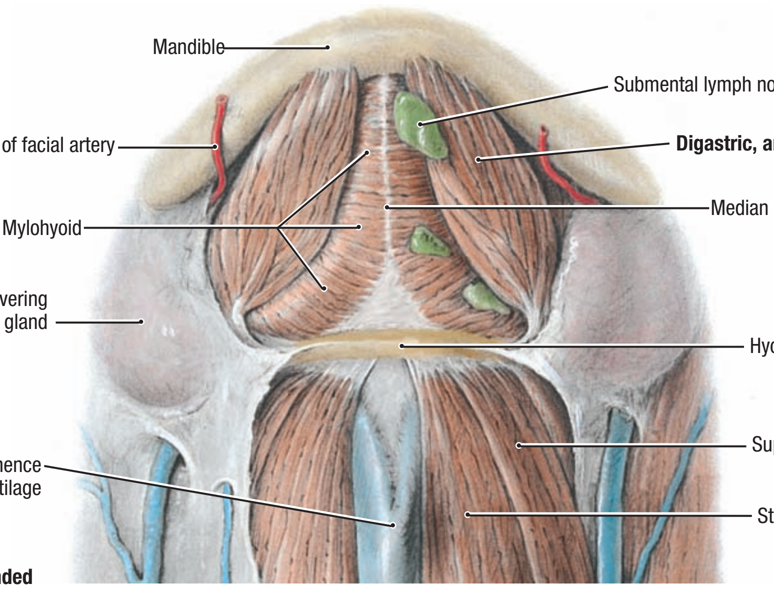
Anterior View

8.10 INFRAHYOID REGION, SUPERFICIAL MUSCULAR LAYER

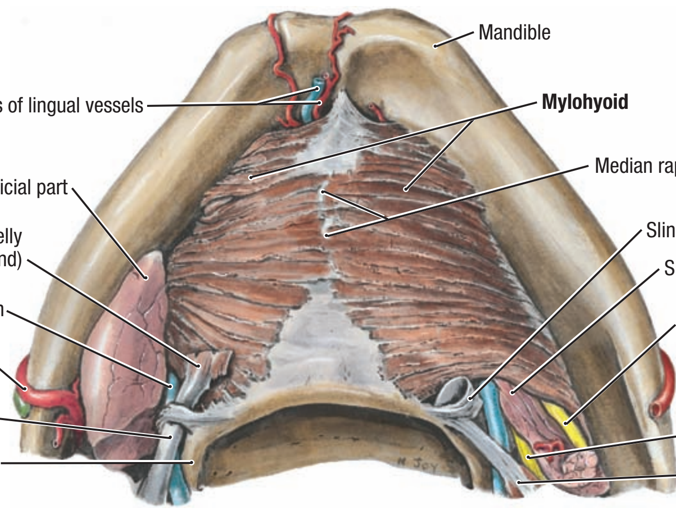
A. Muscular attachments onto the hyoid bone. **B.** The pretracheal fascia, right anterior jugular vein, and jugular venous arch have been removed.

- A persistent thymus projects superiorly from the thorax.
- The two superficial depressors of the larynx ("strap muscles") are the omohyoid (only the superior belly of which is seen here) and sternohyoid.

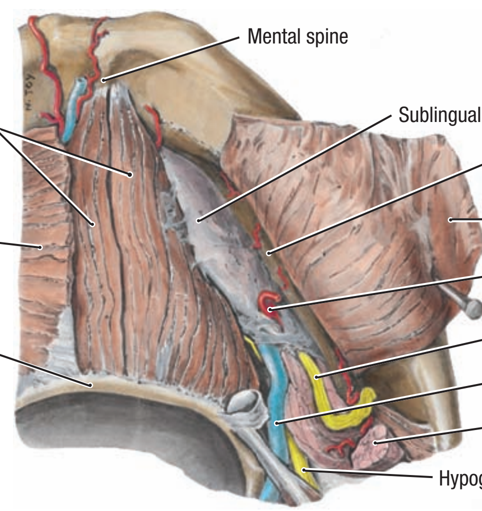
Fracture of the hyoid. This results in depression of the body of the hyoid onto the thyroid cartilage. Inability to elevate the hyoid and move it anteriorly beneath the tongue makes swallowing and maintenance of the separation of the alimentary and respiratory tracts difficult and may result in **aspiration pneumonia.**



A. Anterior View, Head Extended



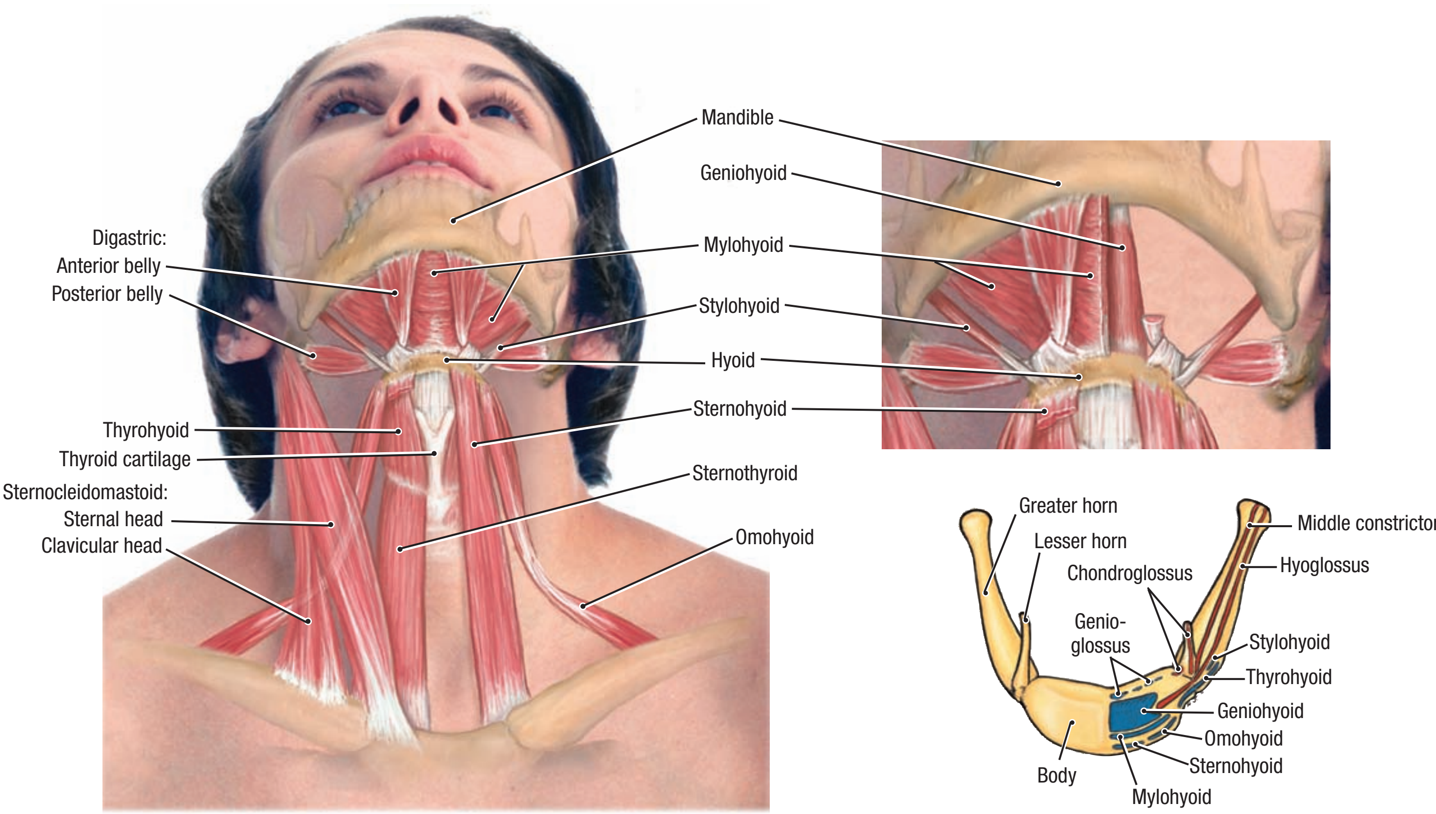
B. Inferior View



C. Inferior View

8.11 SUPRAHYOID REGION (SUBMENTAL TRIANGLE)

A. Superficial layer—anterior belly of digastric. **B.** Intermediate layer—mylohyoid muscles. **C.** Deep layer—geniohyoid muscles.



A. **Anterior View, Head and Neck Extended**

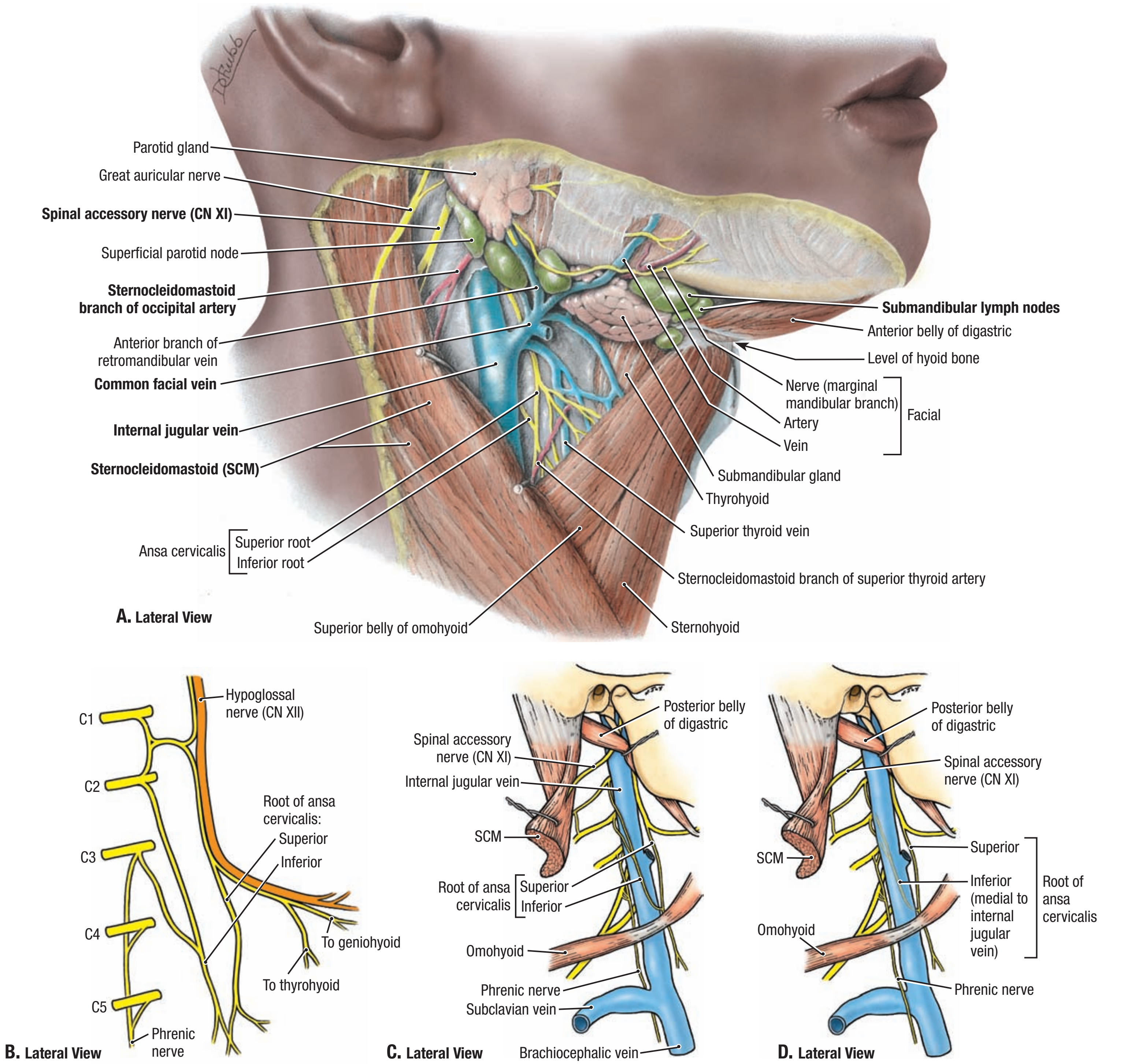
B. **Superior View of Hyoid**

8.12 SUPRAHYOID AND INFRAHYOID MUSCLES

A. Overview. **B.** Muscular attachments onto the hyoid bone.

TABLE 8.4 SUPRAHYOID AND INFRAHYOID MUSCLES

Muscle	Superior Attachment	Inferior Attachment	Innervation	Main Action
Suprahyoid muscles				
Mylohyoid	Mylohyoid line of mandible	Raphe and body of hyoid bone	Nerve to mylohyoid, a branch of inferior alveolar nerve (CN V^3)	Elevates hyoid bone, floor of mouth and tongue during swallowing and speaking
Digastric	*Anterior belly:* digastric fossa of mandible *Posterior belly:* mastoid notch of temporal bone	Intermediate tendon to body and greater horn of hyoid bone	*Anterior belly:* nerve to mylohyoid, a branch of inferior alveolar nerve (CN V^3) *Posterior belly:* facial nerve (CN VII)	Elevates hyoid bone and steadies it during swallowing and speaking; depresses mandible against resistance
Geniohyoid	Inferior mental spine of mandible	Body of hyoid bone	C1 via the hypoglossal nerve (CN XII)	Pulls hyoid bone anterosuperiorly, shortens floor of mouth, and widens pharynx
Stylohyoid	Styloid process of temporal bone		Cervical branch of facial nerve (CN VII)	Elevates and retracts hyoid bone, thereby elongating floor of mouth
Infrahyoid muscles				
Sternohyoid	Body of hyoid bone	Manubrium of sternum and medial end of clavicle	C1–C3 by a branch of ansa cervicalis	Depresses hyoid bone after it has been elevated during swallowing
Omohyoid	Inferior border of hyoid bone	Superior border of scapula near suprascapular notch		Depresses, retracts, and steadies hyoid bone
Sternothyroid	Oblique line of thyroid cartilage	Posterior surface of manubrium of sternum	C2 and C3 by a branch of ansa cervicalis	Depresses hyoid bone and larynx
Thyrohyoid	Inferior border of body and greater horn of hyoid bone	Oblique line of thyroid cartilage	C1 via hypoglossal nerve(CN XII)	Depresses hyoid bone and elevates larynx

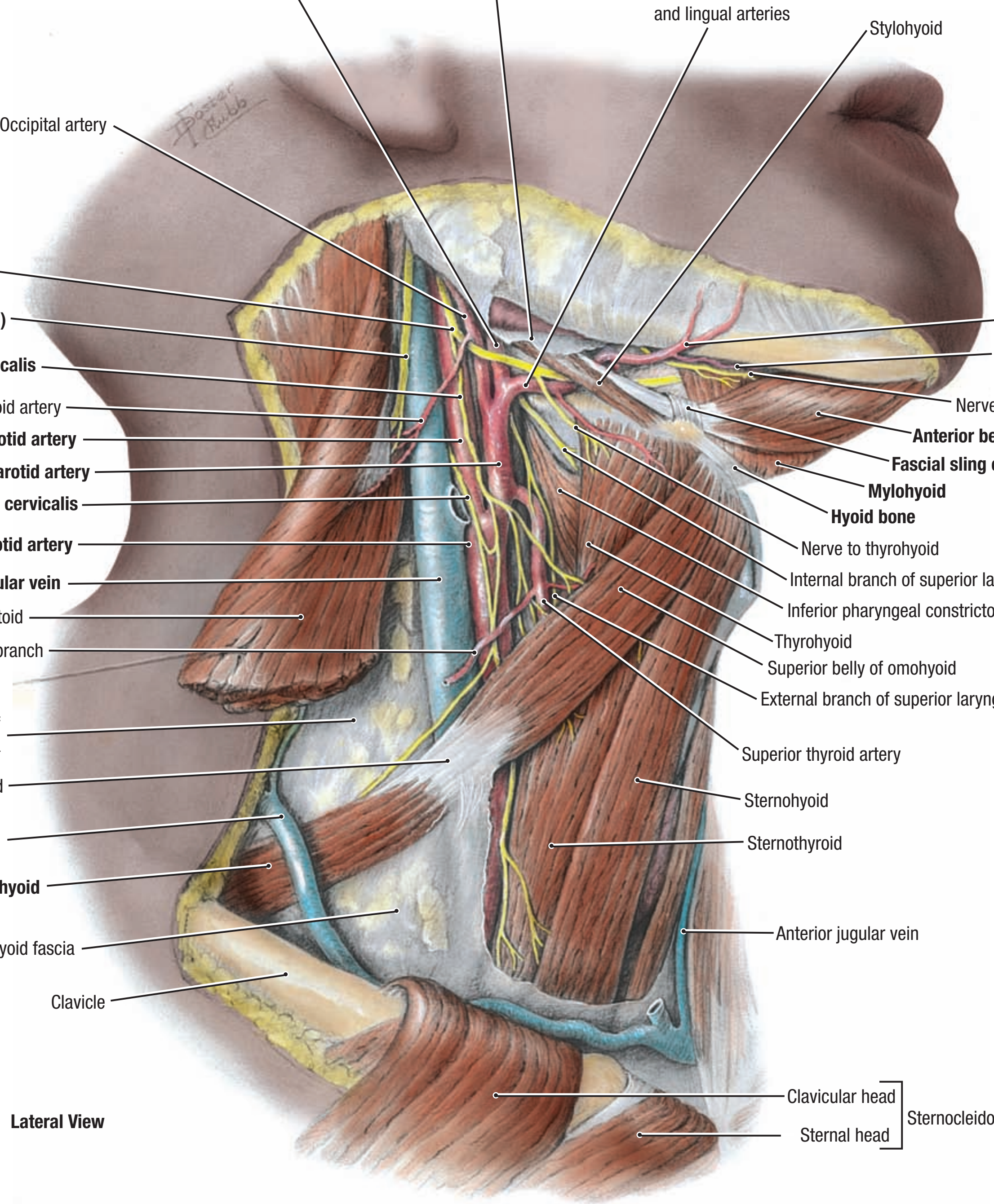


8.13 SUPERFICIAL DISSECTION OF CAROTID TRIANGLE

A. The skin, subcutaneous tissue (with platysma), and the investing layer of deep cervical fascia, including the sheaths of the parotid and submandibular glands, have been removed.

- The spinal accessory nerve (CN XI) enters the deep surface of the sternocleidomastoid muscle and is joined along its anterior border by the sternocleidomastoid branch of the occipital artery.
- The (common) facial vein joins the internal jugular vein near the level of the hyoid bone; here, the facial vein is joined by several other veins.
- The submandibular lymph nodes lie deep to the investing layer of deep cervical fascia in the submandibular triangle; some of the nodes lie deep in the submandibular gland.

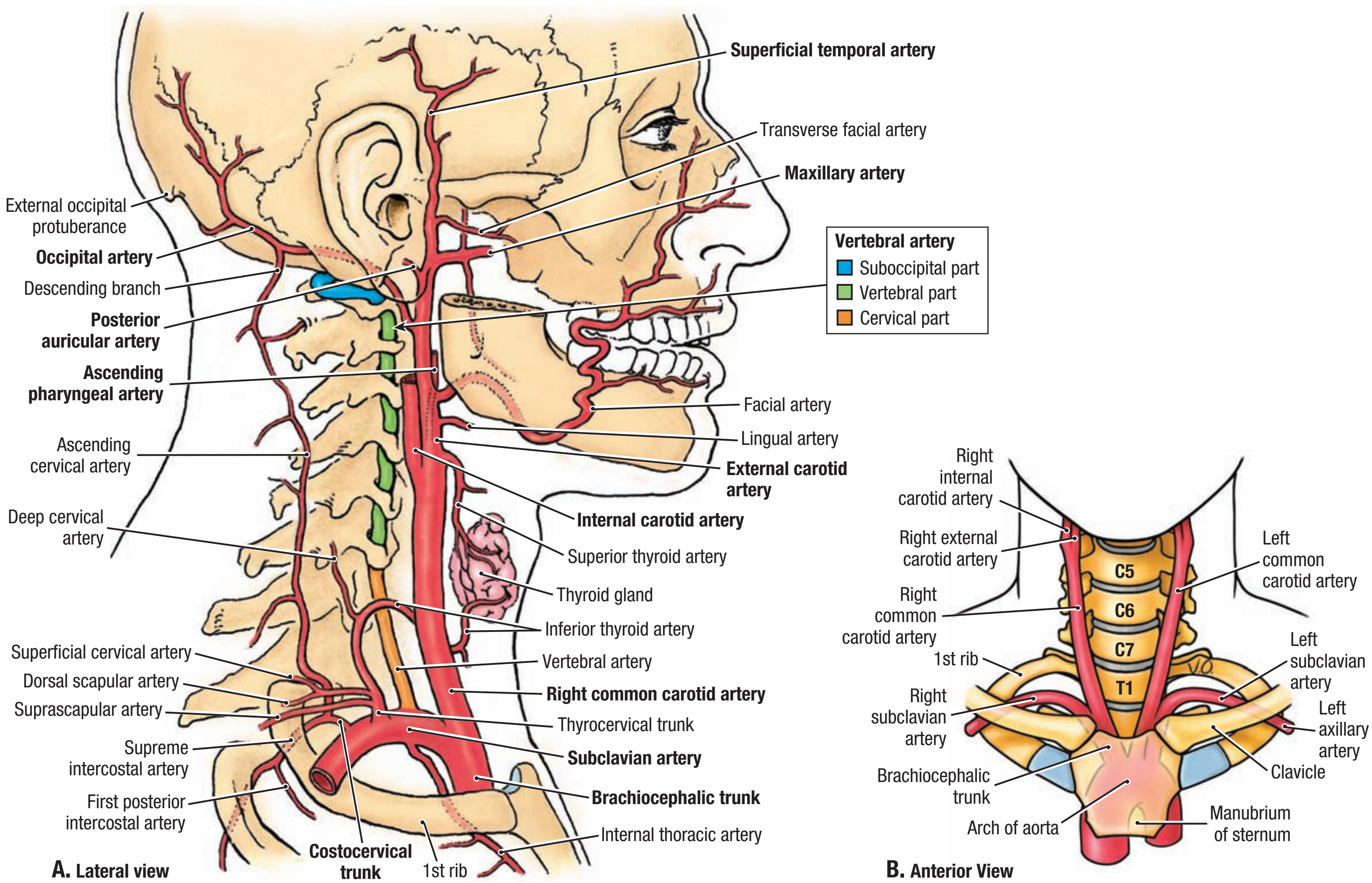
B. Diagram of the motor branches of cervical plexus. **C.** Typical relationships of ansa cervicalis, spinal accessory nerve (CN XI), and phrenic nerve to the internal jugular and subclavian veins. **D.** Atypical relationships.



8.14 DEEP DISSECTION OF CAROTID TRIANGLE

The sternocleidomastoid muscle has been severed; the inferior portion reflected inferiorly and superior portion posteriorly.

- The tendon of the digastric muscle is connected to the hyoid bone by a fascial sling derived from the muscular part of the pretracheal layer of deep cervical fascia; the tendon of the omohyoid muscle is similarly tethered to the clavicle.
- In this specimen, the facial and lingual arteries arise from a common trunk and pass deep to the stylohyoid and digastric muscles.
- The hypoglossal nerve (CN XII) crosses the internal and external carotid arteries and gives off two branches, the superior root of the ansa cervicalis and the nerve to the thyrohyoid, before passing anteriorly deep to the mylohyoid muscle. In this specimen, the inferior root of the ansa cervicalis lies deep to the internal jugular vein and emerges at its medial aspect.

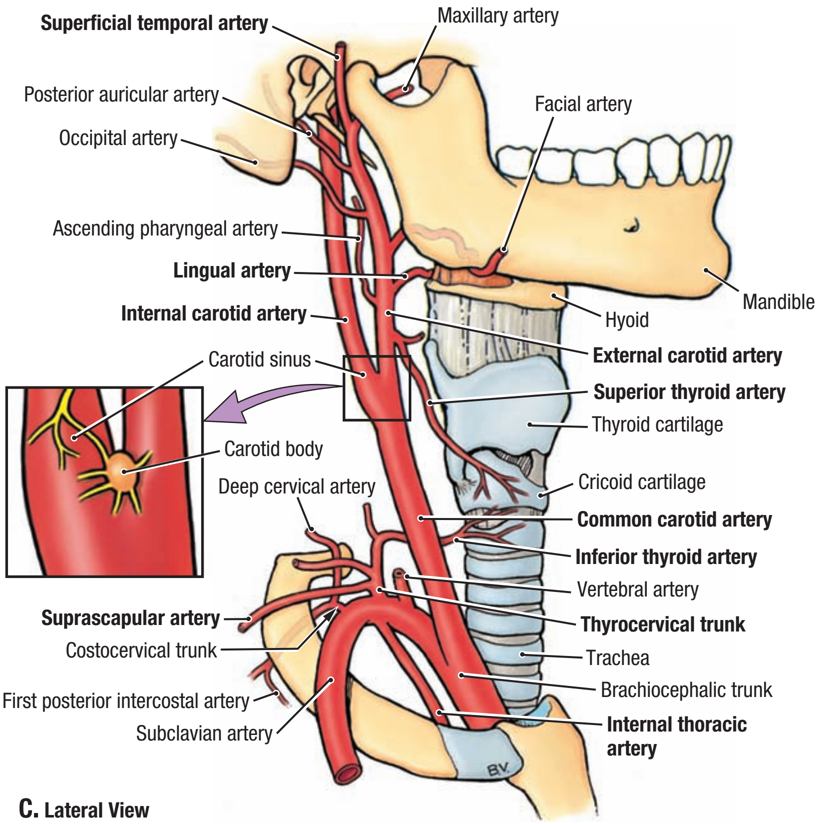


8.15 ARTERIES OF NECK

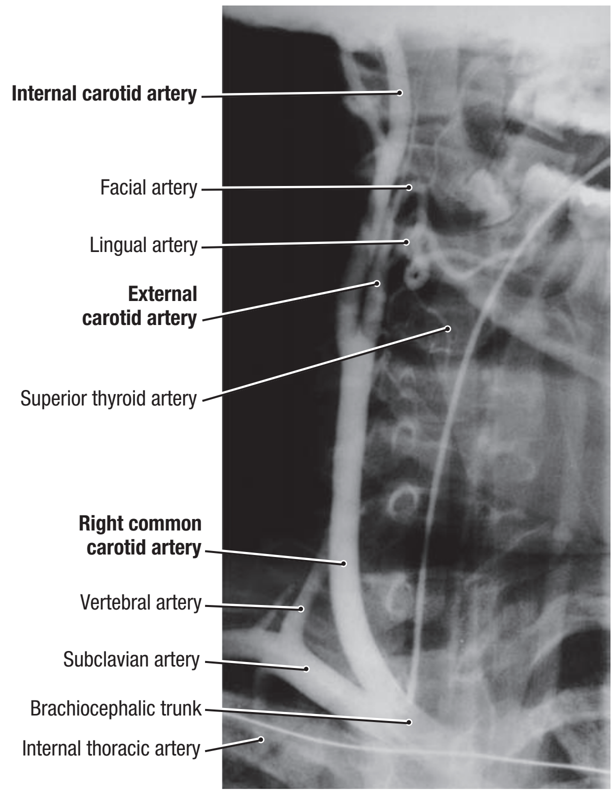
A. Overview. **B.** Common carotid and subclavian arteries.

TABLE 8.5 ARTERIES OF NECK

Artery	Origin	Course and Distribution
Right common carotid	Bifurcation of brachiocephalic trunk	Ascends in neck within carotid sheath with the internal jugular vein and vagus nerve (CN X). Terminates at superior border of thyroid cartilage (C4 vertebral level) by dividing into internal and external carotid arteries
Left common carotid	Arch of aorta	
Right and left internal carotid	Right and left common carotid	No branches in the neck. Enters cranium via carotid canal to supply brain and orbits. Proximal part location of carotid sinus, a baroreceptor that reacts to change in arterial blood pressure. The carotid body, a chemoreceptor that monitors oxygen level in blood, is located in bifurcation of common carotid
Right and left external carotid		Supplies most structures external to cranium; the orbit, part of forehead, and scalp are major exceptions (supplied by ophthalmic artery from intra-cranial internal carotid artery)
Ascending pharyngeal	External carotid	Ascends on pharynx to supply pharynx, prevertebral muscles, middle ear, and cranial meninges
Occipital		Passes posteriorly, medial and parallel to the posterior belly of digastric, ending in the posterior scalp
Posterior auricular		Ascends posteriorly between external acoustic meatus and mastoid process to supply adjacent muscles, parotid gland, facial nerve, auricle, and scalp



C. Lateral View



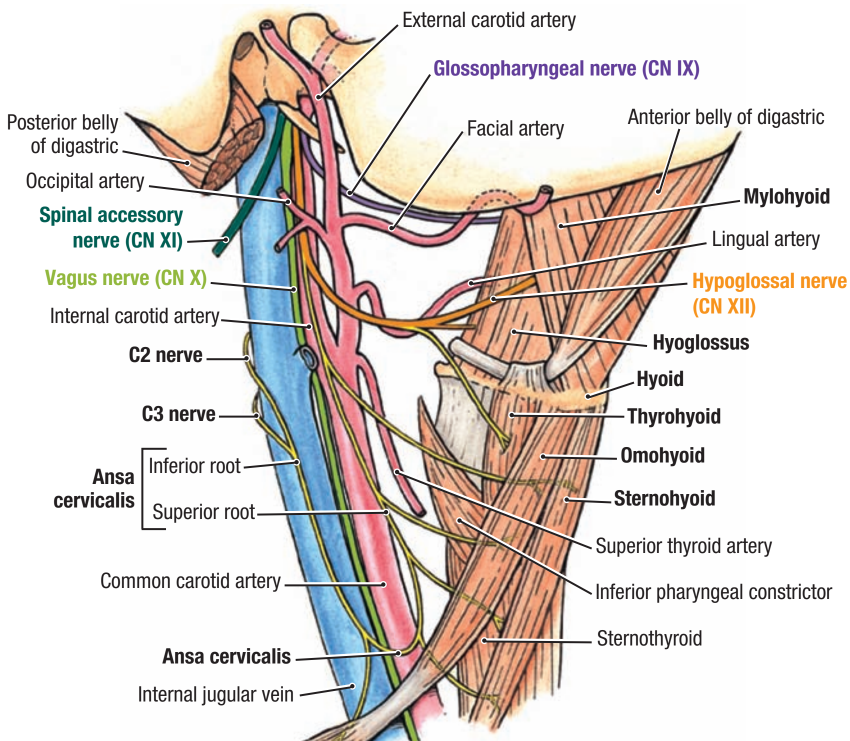
D. Carotid Arteriogram, Oblique View

8.15 ARTERIES OF NECK *(CONTINUED)*

C. Branches of external carotid and subclavian arteries. The carotid sinus is a baroreceptor that reacts to changes in arterial blood pressure and is located in the dilatation of the proximal part of the internal carotid artery. The carotid body is an ovoid mass of tissue that lies at the bifurcation of the common carotid artery. It is a chemoreceptor that monitors the level of oxygen in the blood.

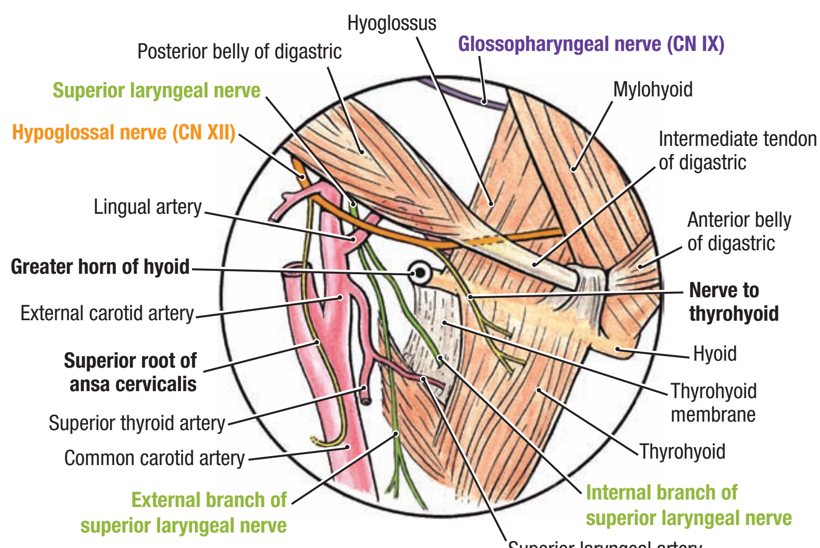
TABLE 8.5 ARTERIES OF NECK (CONTINUED)

Artery	Origin	Course and Distribution
Superior thyroid	External carotid	Runs antero-inferiorly deep to infrahyoid muscles to reach thyroid gland. Supplies thyroid gland, infrahyoid muscles, SCM, and larynx via *superior laryngeal artery*
Lingual		Lies on middle constrictor muscle of pharynx; arches supero-anteriorly and passes deep to CN XII, stylohyoid muscle, and posterior belly of digastric then passes deep to hyoglossus, giving branches to the posterior tongue and bifurcating into *deep lingual* and *sublingual arteries*
Facial		After giving rise to *ascending palatine artery* and a tonsillar branch, it passes superiorly under cover of the angle of the mandible. It then loops anteriorly to supply the submandibular gland and give rise to the *submental artery* to the floor of the mouth before entering the face
Maxillary	Terminal branches of external carotid	Passes posterior to neck of mandible, enters infratemporal fossa then pterygopalatine fossa to supply teeth, nose, ear, and face
Superficial temporal		Ascends anterior to auricle to temporal region and ends in scalp
Vertebral	Subclavian	Passes through the foramina transversaria of the transverse processes of vertebrae C1–C6, runs in a groove on the posterior arch of the atlas, and enters the cranial cavity through the foramen magnum
Internal thoracic		No branches in neck; enters thorax
Thyrocervical trunk		Has two branches: the *inferior thyroid artery*, the main visceral artery of the neck; the cervicodorsal trunk sending branches to the lateral cervical region, trapezius, and medial scapular arteries
Costocervical trunk		Trunk passes posterosuperiorly and divides into *superior intercostal* and *deep cervical arteries* to supply the 1st and 2nd intercostal spaces and posterior deep cervical muscles, respectively

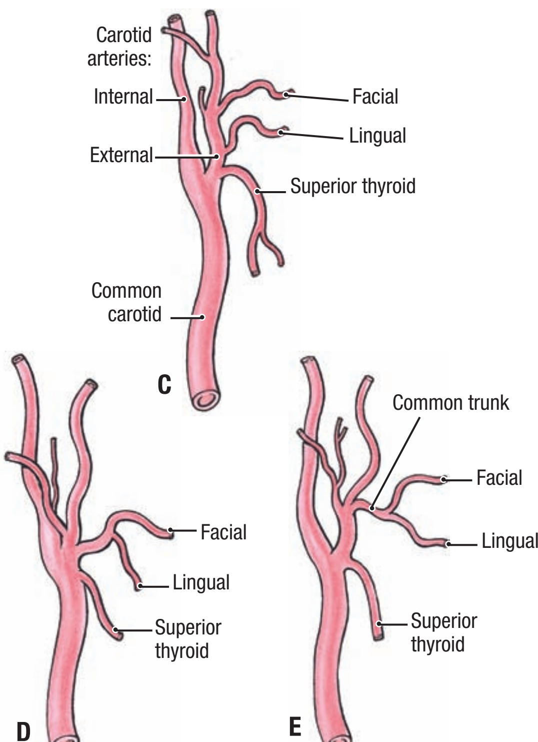


A. Lateral View

Glossopharyngeal—CN IX	Vagus—CN X
Motor: stylopharyngeus, parotid gland **Sensory:** taste: posterior third of tongue; general sensation: pharynx, tonsillar sinus, pharyngotympanic tube, middle ear cavity	**Motor:** palate, pharynx, larynx, trachea, bronchial tree, heart, GI tract to left colic flexure **Sensory:** pharynx, larynx; reflex sensory from tracheo-bronchial tree, lungs, heart, GI tract to left colic flexure
Spinal accessory—CN XI	**Hypoglossal—CN XII**
Motor: sternocleidomastoid and trapezius	**Motor:** all intrinsic and extrinsic muscles of tongue (excluding palatoglossus—a palatine muscle)



B. Lateral View

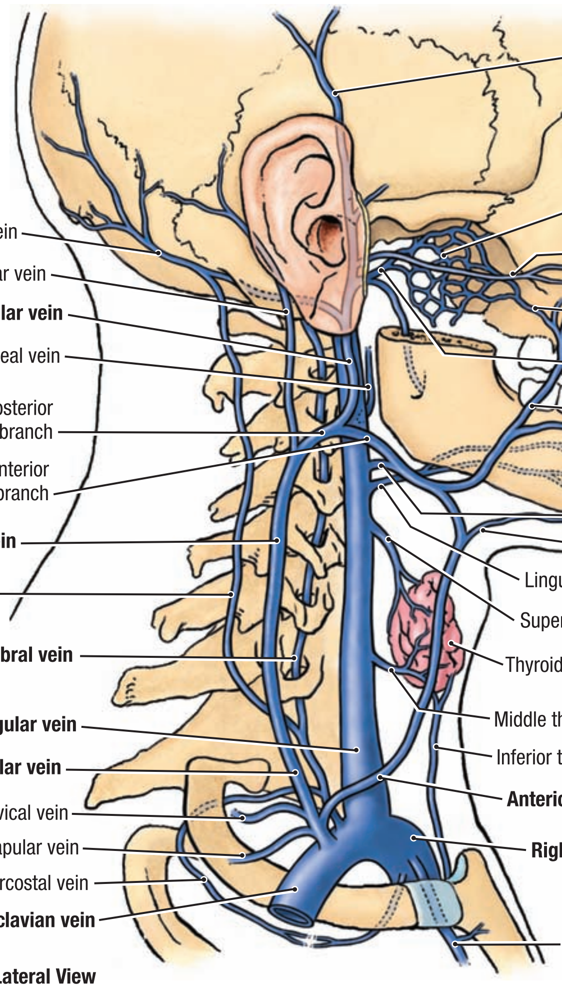


Lateral Views

8.16 RELATIONSHIPS OF NERVES AND VESSELS IN CAROTID TRIANGLE OF NECK

A. Ansa cervicalis and the strap muscles. **B.** Hypoglossal nerve (CN XII) and internal and external branches of superior laryngeal nerve (CN X). The tip of the greater hyoid bone, indicated with a *circle* is the reference point for many structures. **C.–E.** Variation in the origin of the lingual artery as studied by Dr. Grant in 211 specimens. In 80%, the superior thyroid, lingual, and facial arteries arose separately **(C)**; in 20%, the lingual and facial arteries arose from a common stem inferiorly **(D)** or high on the external carotid artery **(E)**. In one specimen, the superior thyroid and lingual arteries arose from a common stem.

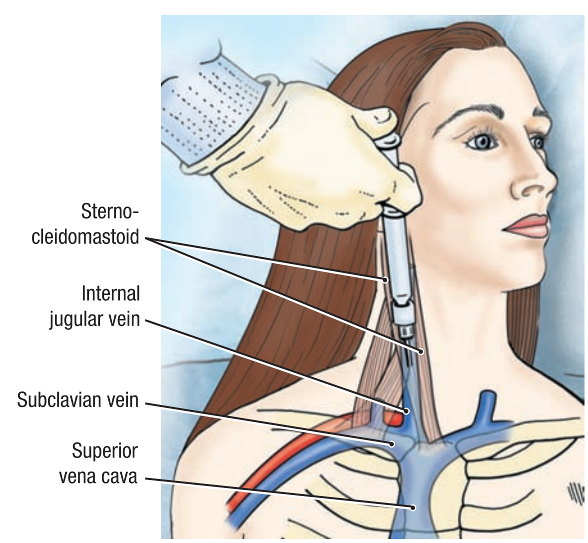
Carotid occlusion, causing stenosis (narrowing), can be relieved by opening the artery at its origin and stripping off the atherosclerotic plaque with the artery's lining (intima). This procedure is called carotid endarterectomy. Because of the relationships of the internal carotid artery, there is a risk of cranial nerve injury during the procedure involving one or more of the following nerves: CN IX, CN X (or its branch, the superior laryngeal nerve), CN XI, or CN XII.



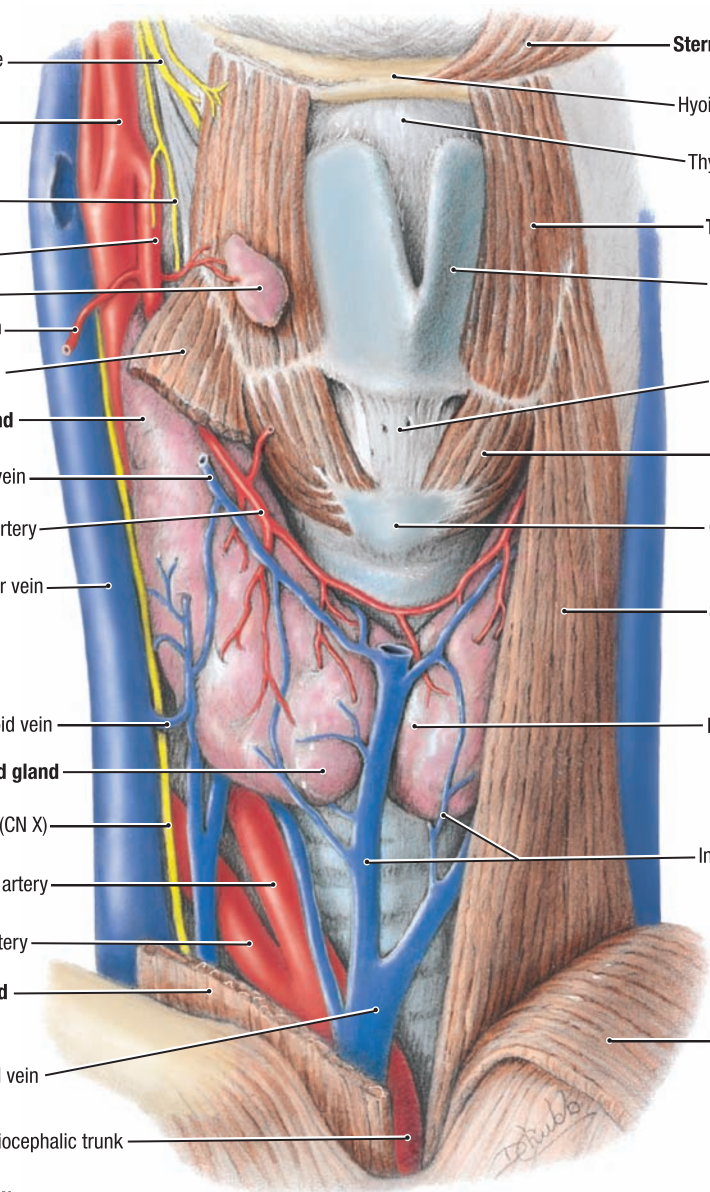
A. Lateral View

8.17 DEEP VEINS OF NECK

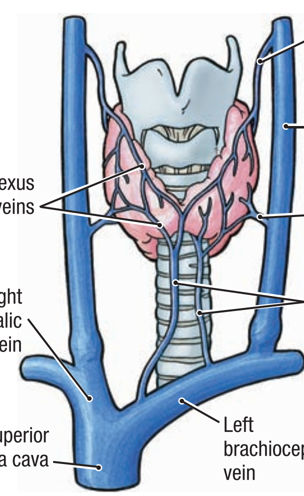
A. Overview. The IJV begins at the jugular foramen as the continuation of the sigmoid sinus. From a dilated origin, the superior bulb of the IJV, the vein runs inferiorly through the neck in the carotid sheath. Posterior to the sternal end of the clavicle the vein merges perpendicularly with the subclavian vein, forming the "venous angle" that marks the origin of the brachiocephalic vein. The inferior end of the IJV dilates superior to its terminal valve, forming the inferior bulb of the IJV. The valve permits blood to flow toward the heart while preventing backflow into the IJV. The external jugular vein drains blood from the occipital region and posterior neck to the subclavian vein, and the anterior jugular vein the anterior aspect of the neck. **B. Internal jugular vein puncture**. A needle and catheter may be inserted into the IJV, using ultrasonic guidance, for diagnostic or therapeutic purposes. The right internal jugular vein is preferable to the left because it is usually larger and straighter. During this procedure, the clinician palpates the common carotid artery and inserts the needle into the IJV just lateral to it at a 30° angle, aiming at the apex of the triangle between the sternal and clavicular heads of the SCM. The needle is then directed inferolaterally toward the ipsilateral nipple.



B. Internal jugular vein puncture



A. Anterior View

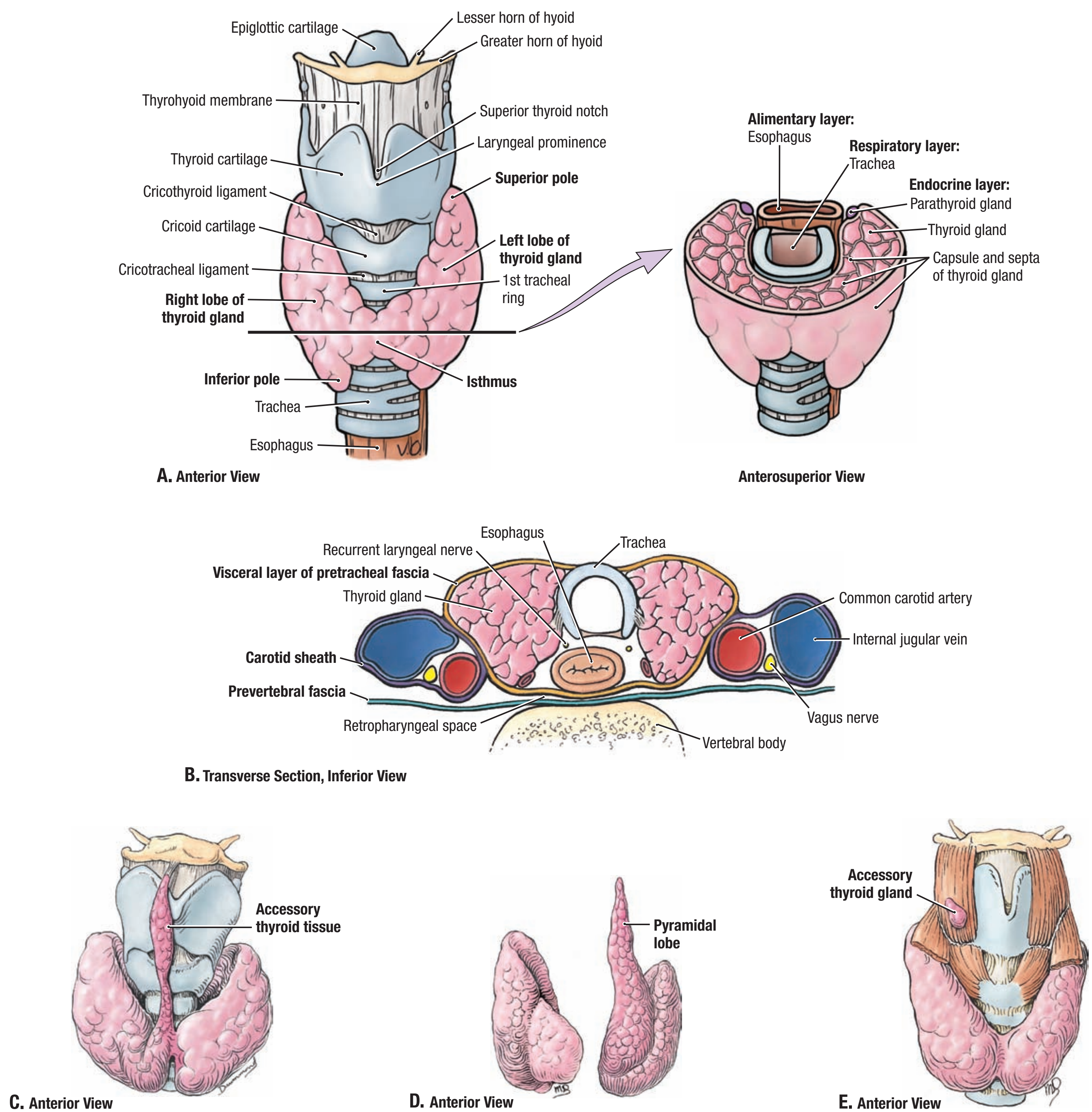


B. Anterior View

8.18 ENDOCRINE LAYER OF VISCERAL COMPARTMENT I

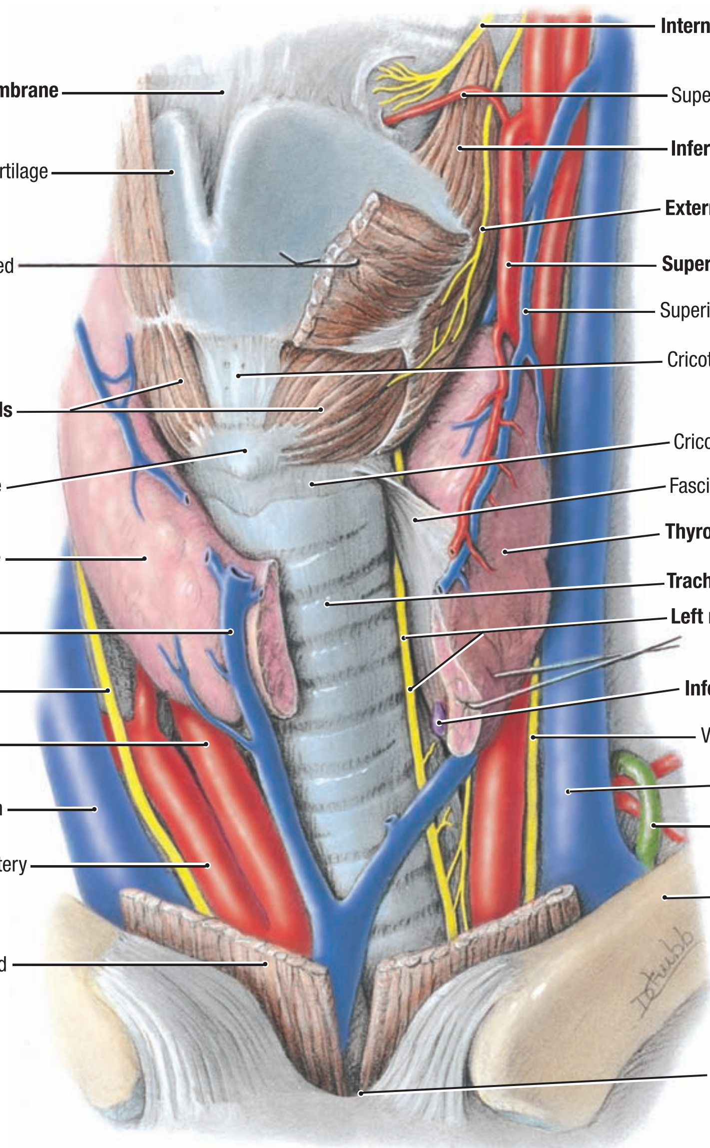
A. On the left side of the specimen, the sternohyoid and omohyoid muscles are reflected, exposing the sternothyroid and the thyrohyoid muscles; on the right side of the specimen, the sternothyroid muscle is largely excised. **B.** Schematic illustration of the venous drainage of the thyroid gland. Except for the superior thyroid veins, the thyroid veins are not paired with arteries of corresponding names.

The **carotid pulse (neck pulse)** is easily felt by palpating the common carotid artery in the side of the neck, where it lies in a groove between the trachea and the infrahyoid muscles. It is usually easily palpated just deep to the anterior border of the SCM at the level of the superior border of the thyroid cartilage. It is routinely checked during cardiopulmonary resuscitation (CPR). Absence of a carotid pulse indicates cardiac arrest.

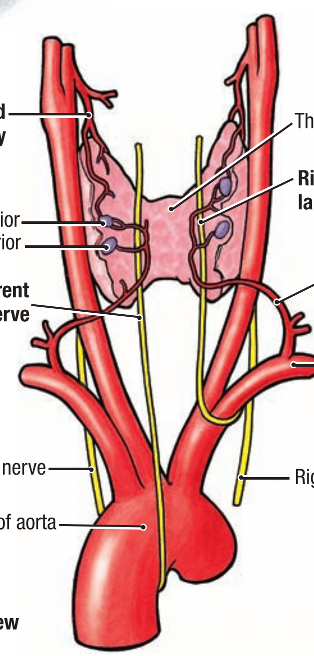


8.19 ENDOCRINE LAYER OF VISCERAL COMPARTMENT II

A. Relations of thyroid gland with transverse section showing alimentary, respiratory, and endocrine layers of visceral compartment. **B.** Fascia. **C.** Accessory thyroid tissue along the course of the thyroglossal duct, which was the path of migration of thyroid tissue from its embryonic site of development. **D.** Approximately 50% of glands have a pyramidal lobe that extends from near the isthmus to or toward the hyoid bone; the isthmus is occasionally absent, in which case the gland is in two parts. **E.** An accessory thyroid gland can occur between the suprahyoid region and arch of the aorta (see Fig. 8.18A).



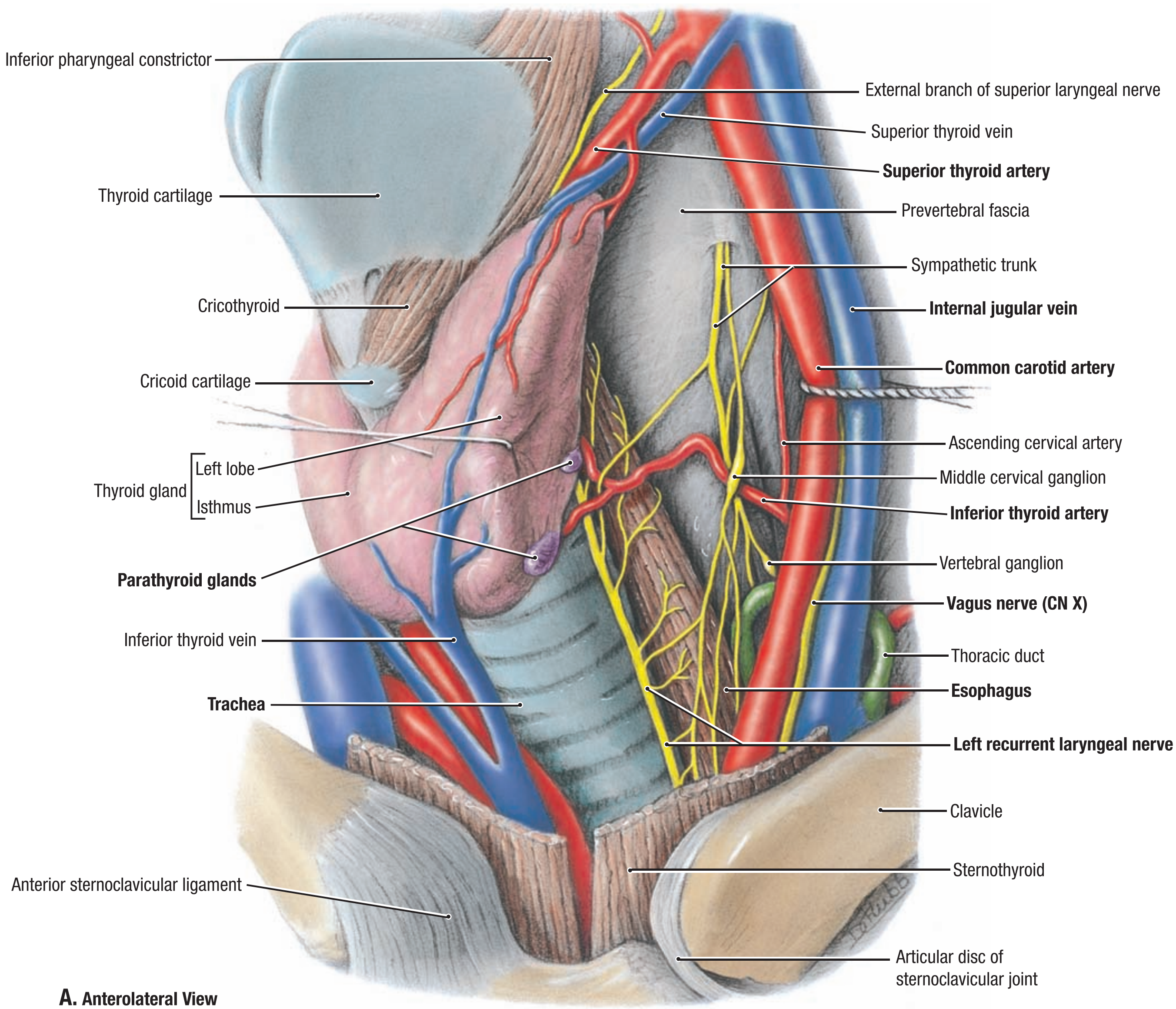
A. **Anterolateral View**



B. **Posterior View**

8.20 RESPIRATORY LAYER OF VISCERAL COMPARTMENT

A. The isthmus of the thyroid gland is divided, and the left lobe is retracted. The left recurrent laryngeal nerve ascends on the lateral aspect of the trachea between the trachea and esophagus. The internal branch of the superior laryngeal nerve runs along the superior border of the inferior pharyngeal constrictor muscle and pierces the thyrohyoid membrane. The external branch of the superior laryngeal nerve lies adjacent to the inferior pharyngeal constrictor muscle and supplies its lower portion; it continues to run along the anterior border of the superior thyroid artery, passing deep to the superior attachment of the sternothyroid muscle, and then supplies the cricothyroid muscle. **B.** Blood supply of the parathyroid glands and courses of the left and right recurrent laryngeal nerves.

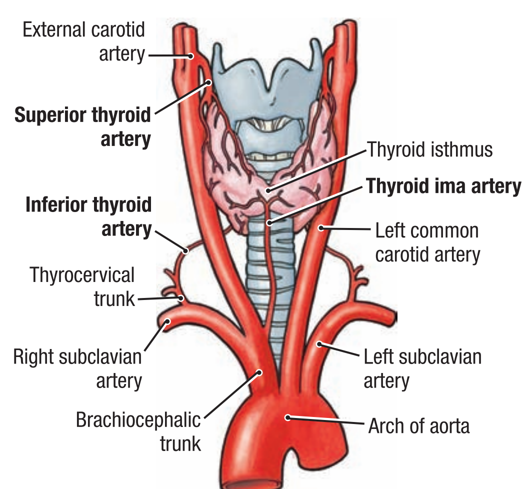


A. Anterolateral View

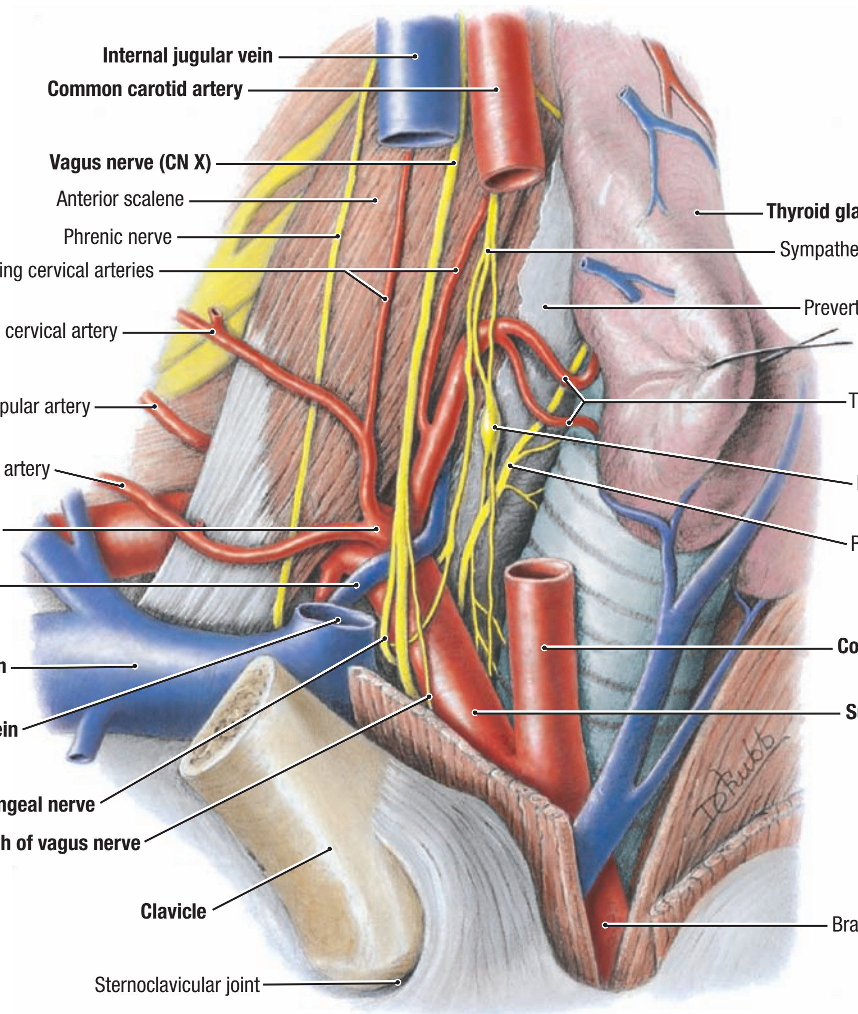
8.21 ALIMENTARY LAYER OF VISCERAL COMPARTMENT

A. Dissection of the left side of the root of the neck. The three structures contained in the carotid sheath (internal jugular vein, common carotid artery, and vagus nerve) are retracted. The left recurrent laryngeal nerve ascends on the lateral aspect of the trachea, just anterior to the recess between the trachea and esophagus. **B.** Arterial supply of thyroid gland. The thyroid ima artery is infrequent (10%) and variable in its origin.

During a **total thyroidectomy** (e.g., excision of a malignant thyroid gland), the parathyroid glands are in danger of being inadvertently damaged or removed. These glands are safe during **subtotal thyroidectomy** because the most posterior part of the thyroid gland usually is preserved. Variability in the position of the parathyroid glands, especially the inferior ones, puts them in danger of being removed during surgery on the thyroid gland. If the parathyroid glands are inadvertently removed during surgery, the patient suffers from **tetany,** a severe convulsive disorder. The generalized convulsive muscle spasms result from a fall in blood calcium levels.



B. Anterior View

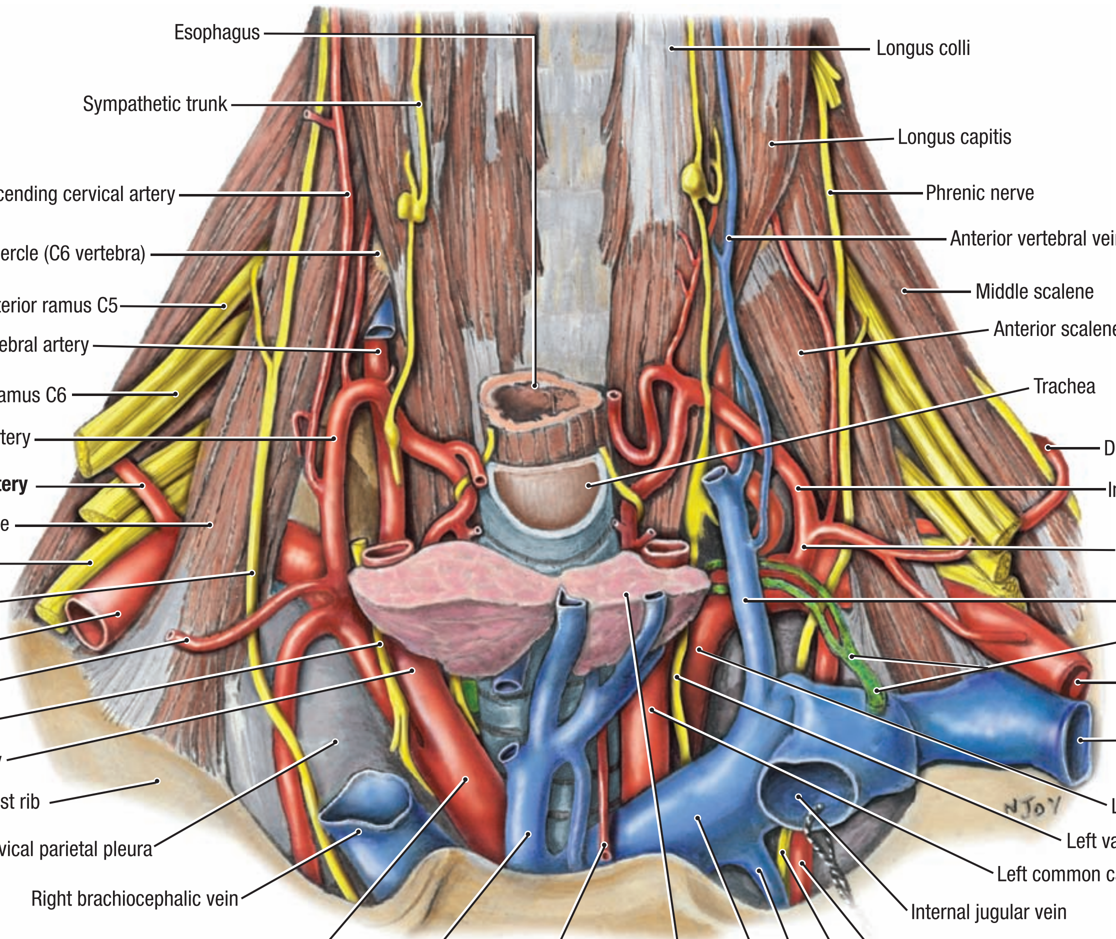


A. **Anterolateral View**

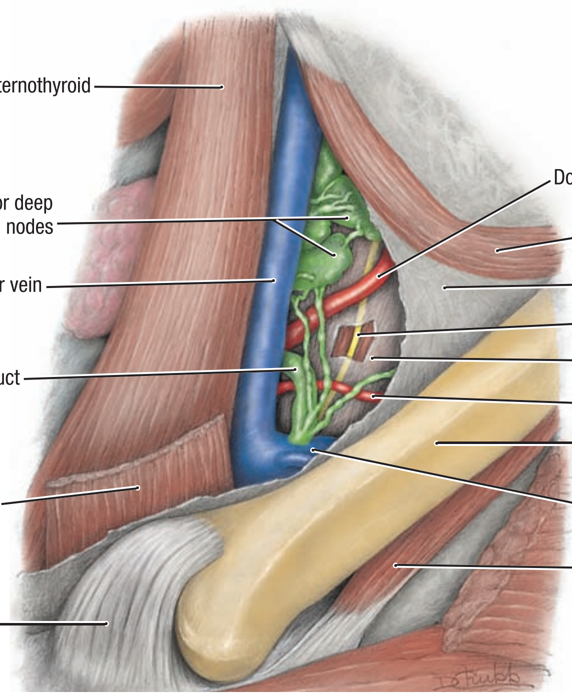
8.22 ROOT OF NECK

A. Dissection of the right side of the root of the neck. The clavicle is cut, sections of the common carotid artery and internal jugular vein are removed, and the right lobe of the thyroid gland is retracted. The right vagus nerve crosses the first part of the subclavian artery and gives off an inferior cardiac branch and the right recurrent laryngeal nerve. The right recurrent laryngeal nerve loops inferior to the subclavian artery and passes posterior to the common carotid artery on its way to the posterolateral aspect of the trachea.

- The **recurrent laryngeal nerves are vulnerable to injury** during thyroidectomy and other surgeries in the anterior cervical region of the neck. Because the terminal branch of this nerve, the inferior laryngeal nerve, innervates the muscles moving the vocal folds, injury to the nerve results in **paralysis of the vocal folds.**
- A non-neoplastic and noninflammatory enlargement of the thyroid gland, other than the variable enlargement that may occur during menstruation and pregnancy, is called a goiter. A **goiter** results from a lack of iodine. It is common in certain parts of the world where the soil and water are deficient in iodine and iodized salt is unavailable. The enlarged gland causes a swelling in the neck that may compress the trachea, esophagus, and recurrent laryngeal nerves. When the gland enlarges, it may do so anteriorly, posteriorly, inferiorly, or laterally. It cannot move superiorly because of the superior attachments of the sternothyroid and sternohyoid muscles. Substernal extension of a goiter is also common.



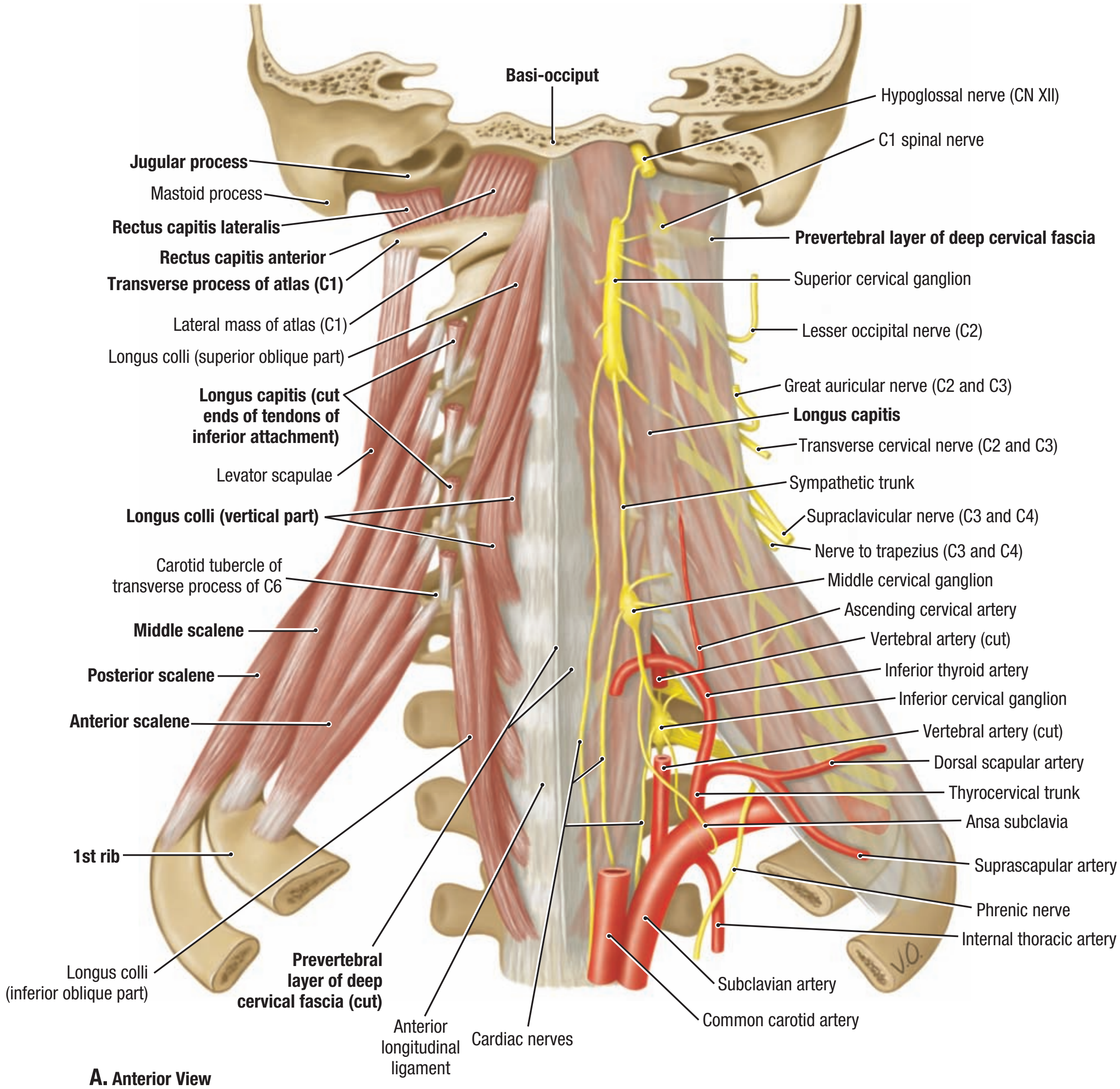
B. Anterior View



C. Anterolateral View

8.22 ROOT OF NECK *(CONTINUED)*

B. Deep anterior dissection. Note that the right dorsal scapular artery arises directly from the subclavian artery, a common variation. **C.** Dissection of termination of the thoracic duct. The sternocleidomastoid muscle is removed, the sternohyoid muscle is resected, and the omohyoid portion of the pretracheal fascia is partially removed. The thoracic duct arches laterally in the neck, passing posterior to the carotid sheath and anterior to the vertebral artery, thyrocervical trunk, and subclavian arteries; it enters the angle formed by the junction of the left subclavian and internal jugular veins to form the left brachiocephalic vein (the left venous angle).



A. Anterior View

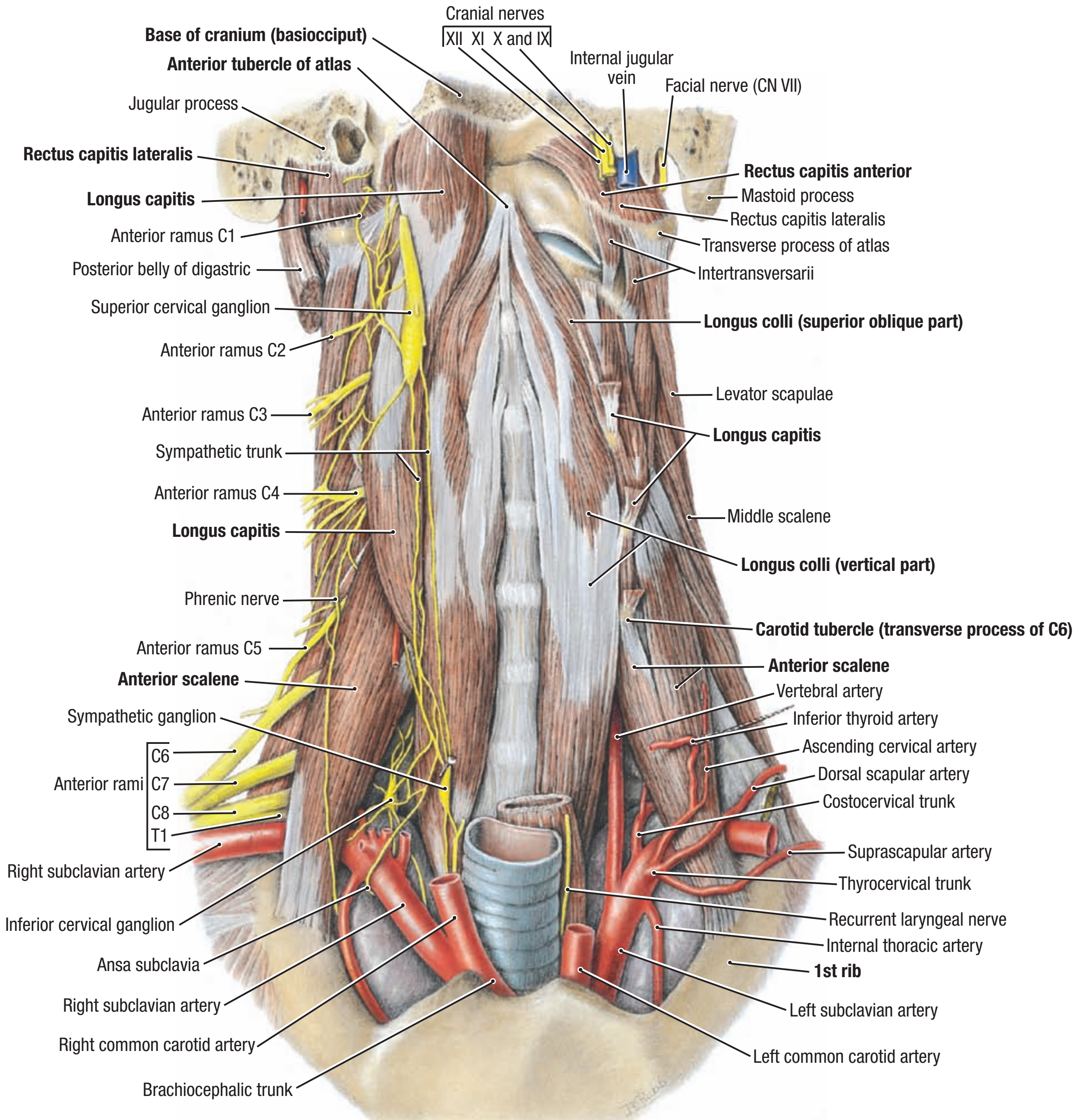
8.23 PREVERTEBRAL REGION

A. and B. Overview of muscles, nerves and vessels.

TABLE 8.6 PREVERTEBRAL AND SCALENE MUSCLES

Muscle	Superior Attachment	Inferior Attachment	Innervation	Main Action
Longus colli			Anterior rami of C2–C6 spinal nerves (cervical plexus)	Rotation of cervical spine to opposite side (acting unilaterally)
Superior oblique part	Anterior tubercle of atlas (C1)	Anterior tubercles of TVP C3–C5		
Vertical part	Vertebral bodies of C2–C4	Vertebral bodies C5–T3		
Inferior oblique part	Anterior tubercles of TVP C5–C6	Vertebral bodies T1–T3		Flexion of cervical spine (acting bilaterally)
Longus capitis	Basilar part of occipital bone	Anterior tubercles of TVP C3–C6	Anterior rami of C1–C3 spinal nerves (cervical plexus)	Flexion of head (atlanto-occipital joints)

TVP, transverse process



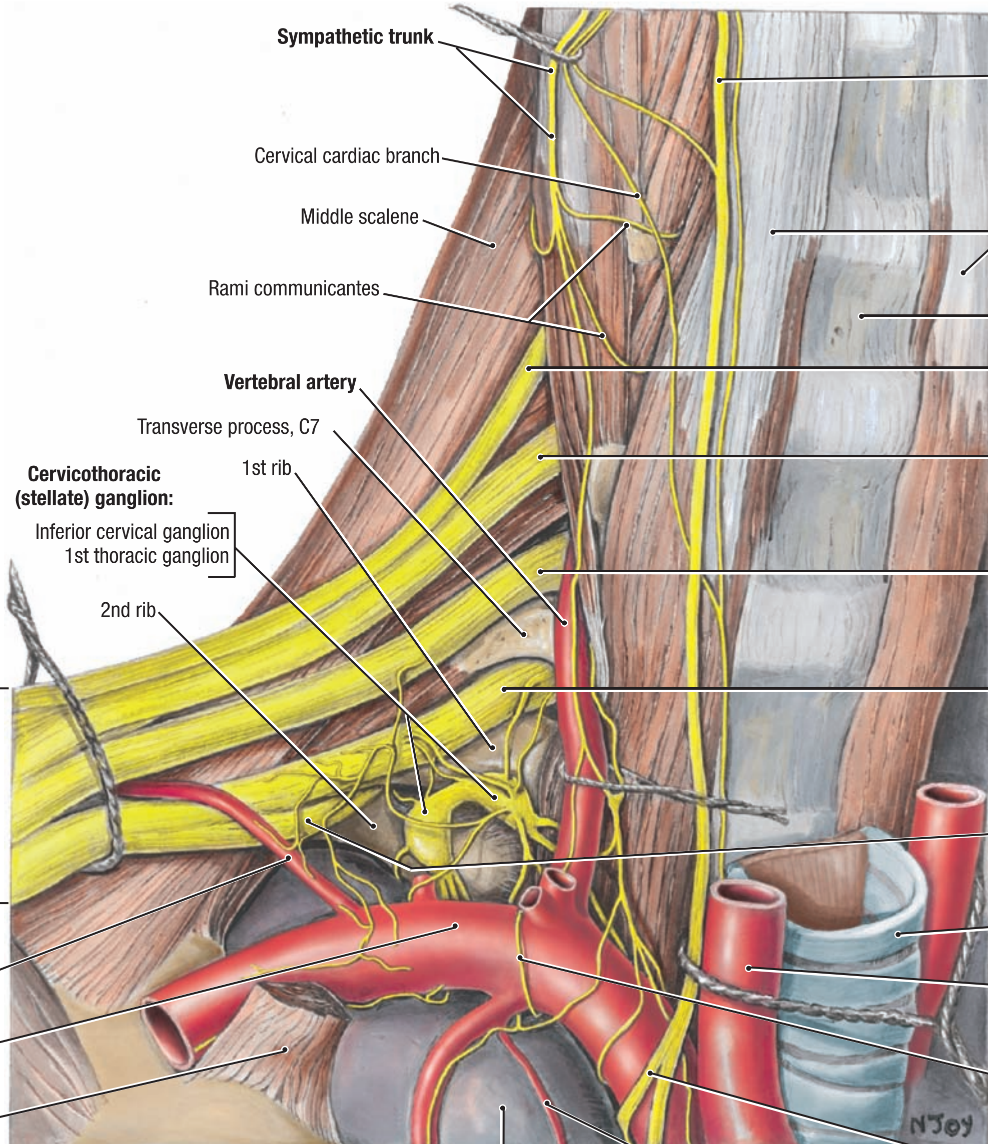
B. Anterior View

8.23 PREVERTEBRAL REGION *(CONTINUED)*

TABLE 8.6 PREVERTEBRAL AND SCALENE MUSCLES

Muscle	Superior Attachment	Inferior Attachment	Innervation	Main Action
Rectus capitis anterior	Base of cranium, just anterior to occipital condyle	Anterior surface of lateral mass of atlas (C1)	Branches from loop between C1 and C2 spinal nerves	Lateral flexion at atlanto-occipital joints (acting unilaterally)
Rectus capitis lateralis	Base of cranium just lateral to occipital condyle	Transverse process of atlas (C1)		Flexion at atlanto-occipital joints (acting bilaterally)
Anterior scalene	Anterior tubercles of TVP C3–C6	Scalene tubercle of 1st rib	Anterior rami of C3–C8 (cervical and brachial plexus)	Forced inspiration (ribs mobile): elevate superior ribs
Middle scalene	TVP C1–C2	Superior surface of 1st rib; posterior to groove for subclavian artery		Ribs fixed: lateral flexion of cervical spine (acting unilaterally) Flexes neck (acting bilaterally)
	Posterior tubercles of TVP C3–C7			
Posterior scalene	Posterior tubercles of TVP C5–C7	External border of 2nd rib		

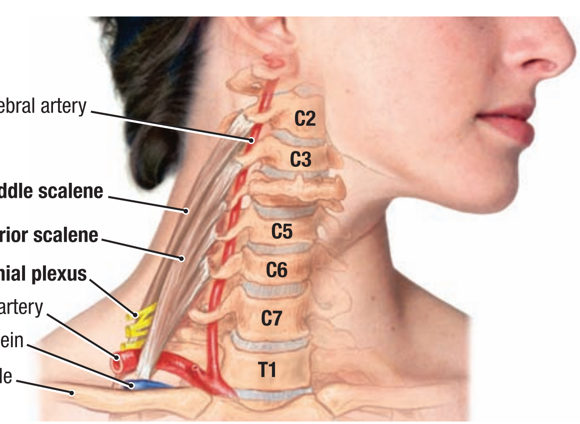
TVP, Transverse process.



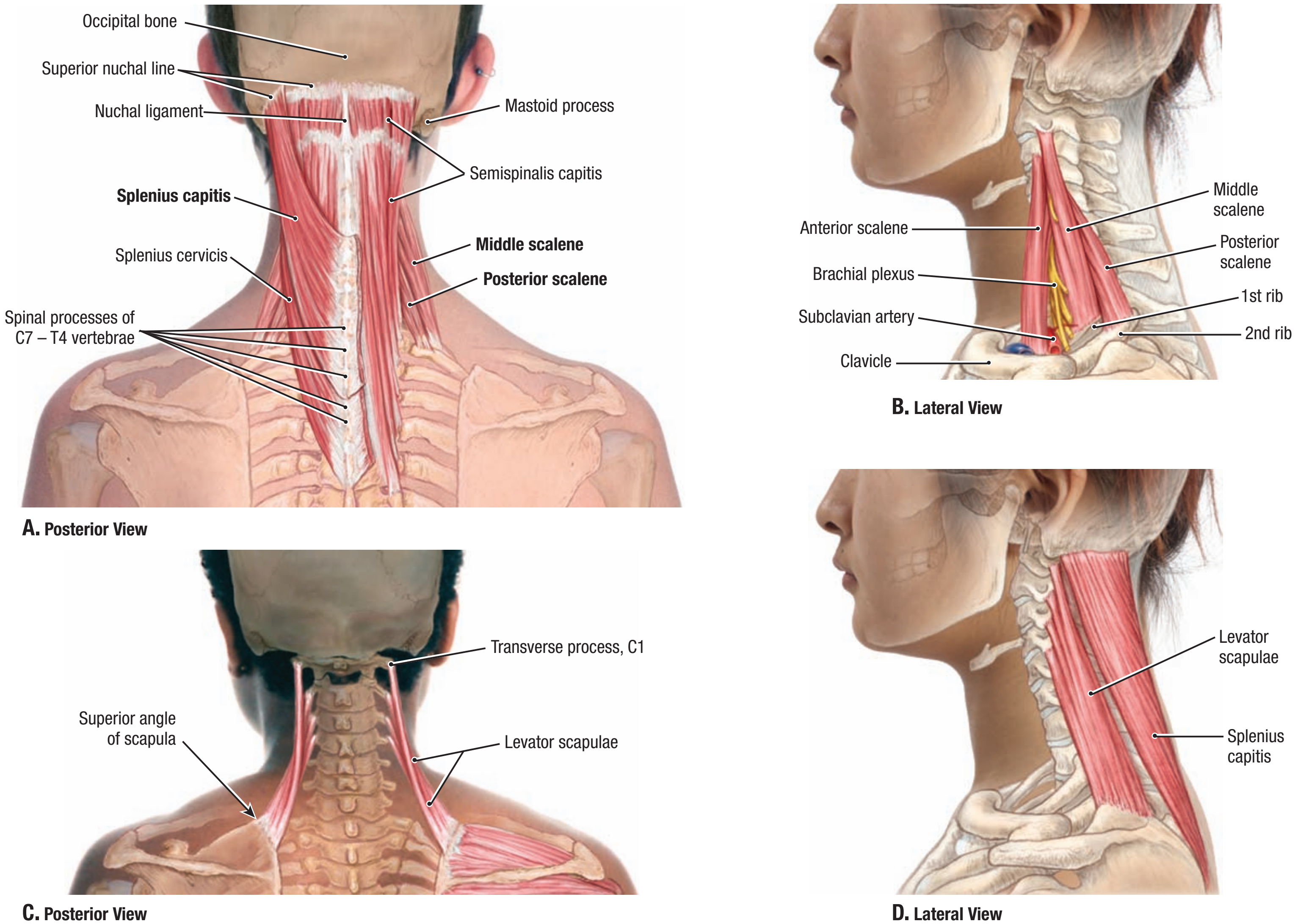
A. **Anterior View**

8.24 BRACHIAL PLEXUS AND SYMPATHETIC TRUNK IN ROOT OF NECK

A. Dissection of right side of specimen. The pleura has been depressed, the vertebral artery retracted medially, and the brachial plexus retracted superiorly to reveal the cervicothoracic (stellate) ganglion (the combined inferior cervical and 1st thoracic ganglia). Anesthetic injected around the cervicothoracic (stellate) ganglion blocks transmission of stimuli through the cervical and superior thoracic ganglia. This **stellate ganglion block** may relieve vascular spasms involving the brain and upper limb. It is also useful when deciding if surgical resection of the ganglion would be beneficial to a person with excess vasoconstriction of the ipsilateral limb. **B.** Relation of brachial plexus and subclavian artery to anterior and middle scalene muscles.



B. **Anterolateral View**



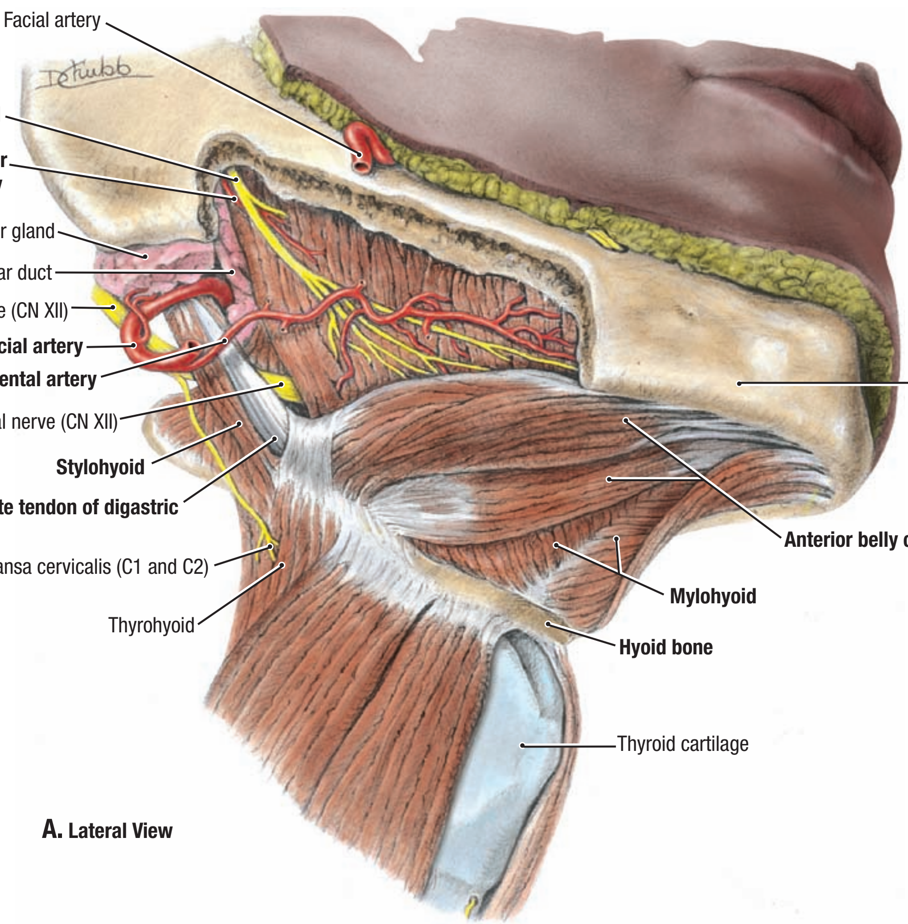
8.25 LATERAL VERTEBRAL MUSCLES

A. Overview. **B.** Scalene muscles. **C.** Levator scapulae. **D.** Levator scapulae and splenius capitis.

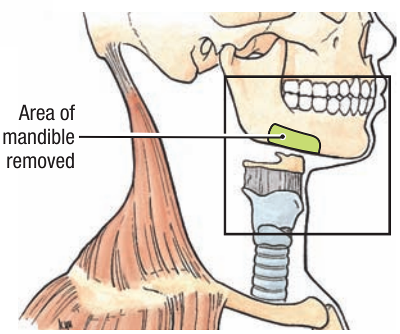
TABLE 8.7 LATERAL VERTEBRAL MUSCLES

Muscle	Superior Attachment	Inferior Attachment	Innervation	Main Action
Splenius capitis	Inferior half of nuchal ligament and spinous processes of C7 and superior 3–4 thoracic vertebrae	Lateral aspect of mastoid process and lateral third of superior nuchal line	Posterior rami of middle cervical spinal nerves	Laterally flexes and rotates head and neck to same side; acting bilaterally, extends head and neck[a]
Levator scapulae	Posterior tubercles of transverse processes of C1–C4 vertebrae	Superior part of medial border of scapula	Dorsal scapular nerve (C5) and cervical spinal nerves C3 and C4	Elevates scapula and tilts glenoid cavity inferiorly by rotating scapula
Middle scalene	See Table 8.6.			
Posterior scalene				

[a]Rotation of head occurs at atlanto-axial joints.



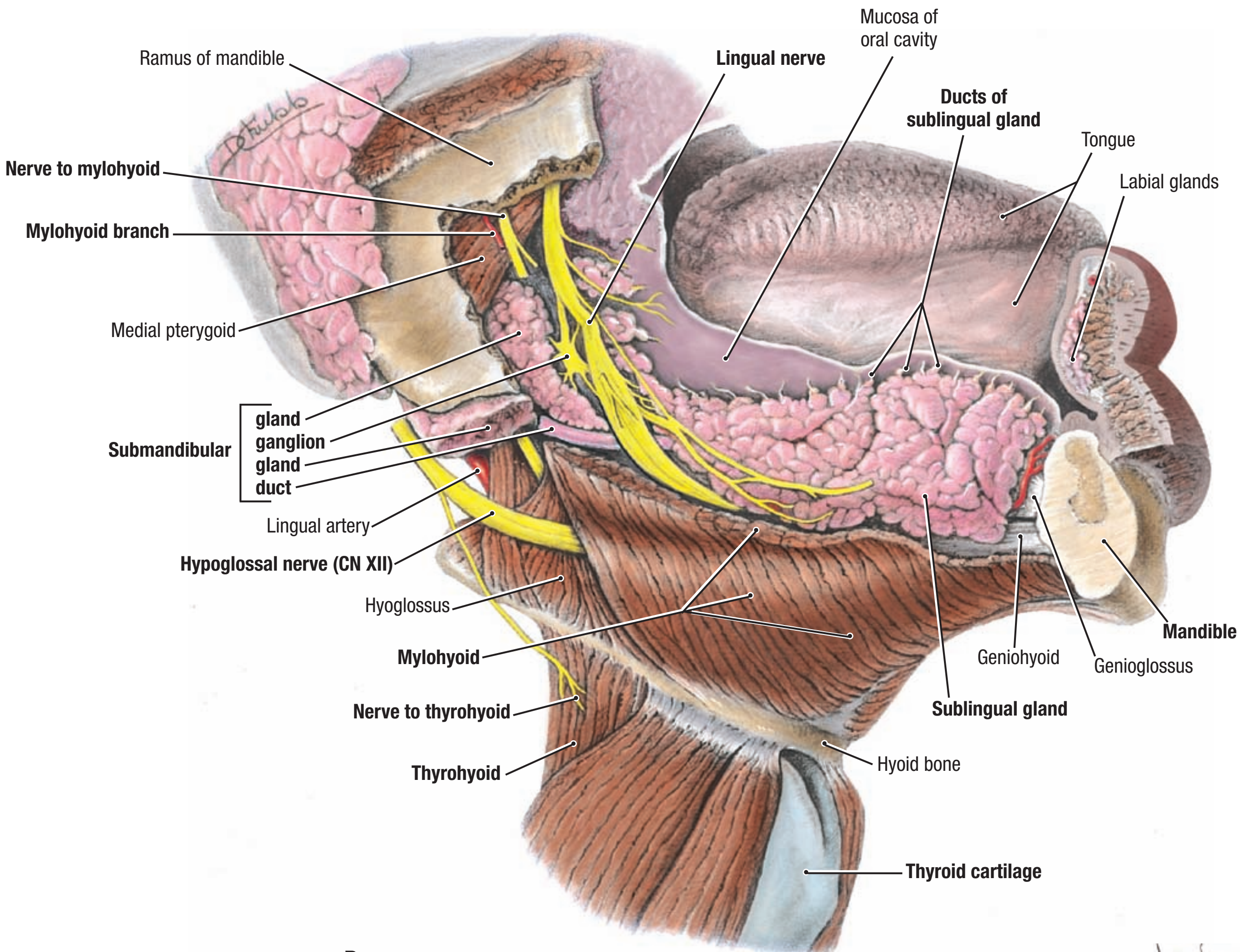
A. Lateral View



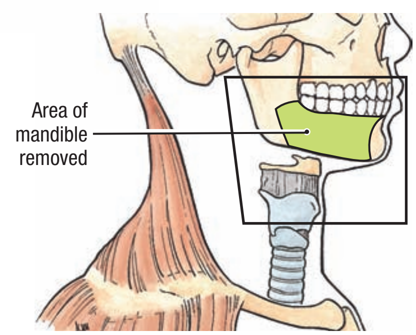
8.26 SERIAL DISSECTION OF SUBMANDIBULAR REGION AND FLOOR OF MOUTH I

Mylohyoid and digastric muscles. **A.** Structures overlying the mandible and a portion of the body of the mandible have been removed.

- The stylohyoid and posterior belly and intermediate tendon of the digastric muscle form the posterior border of the submandibular triangle; the facial artery passes superficial to these muscles.
- The anterior belly of the digastric muscle forms the anterior border of the submandibular triangle. In this specimen, the anterior belly has an additional origin from the hyoid bone; the mylohyoid muscle forms the medial wall of the triangle and has a thick, free posterior border.
- The nerve to mylohyoid, which supplies the mylohyoid muscle and anterior belly of the digastric muscle, is accompanied by the mylohyoid branch of the inferior alveolar artery posteriorly and the submental artery from the facial artery anteriorly.



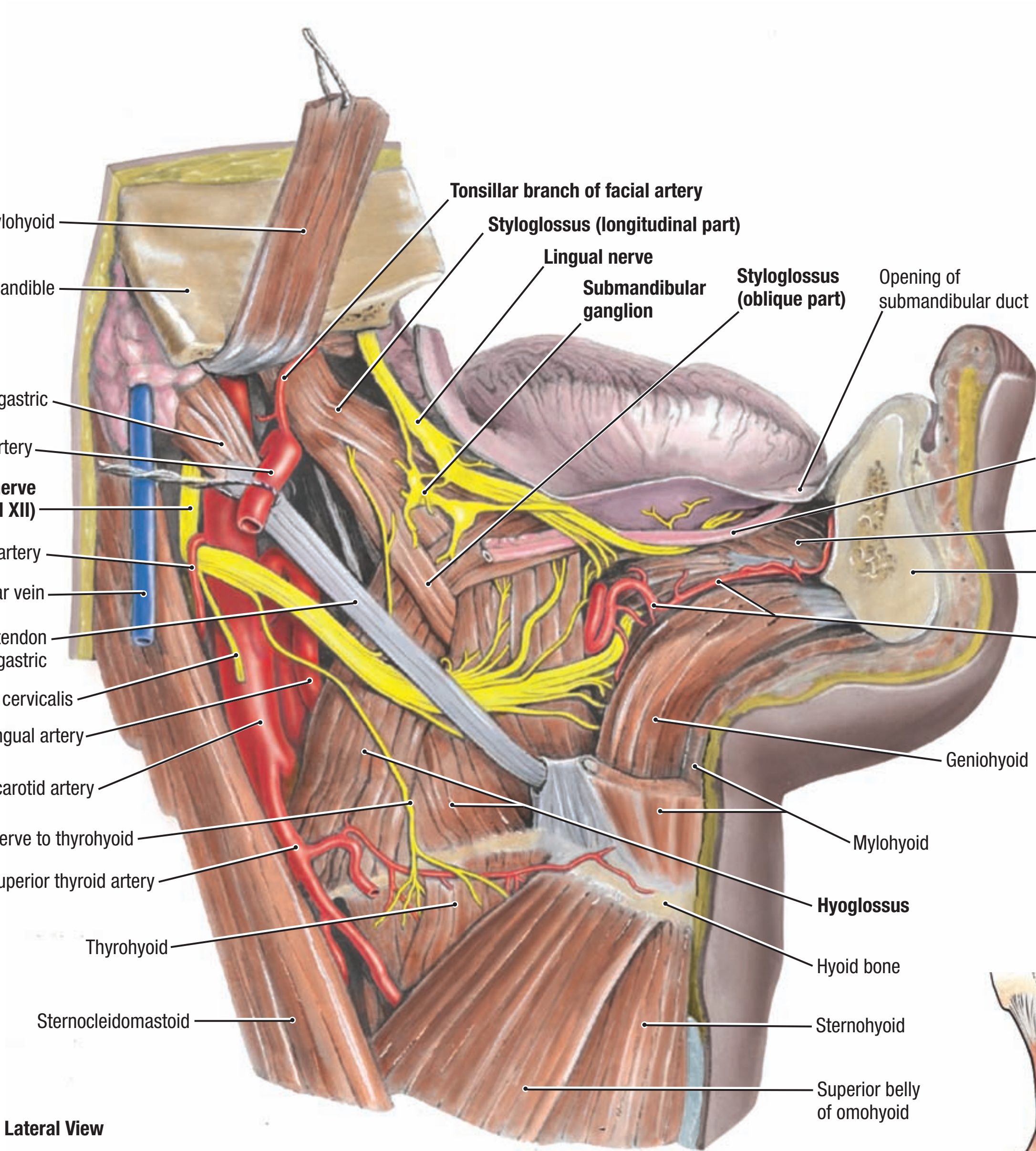
B. Lateral View



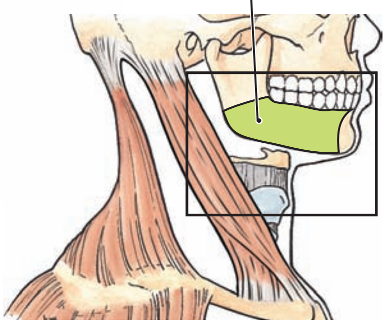
8.26 SERIAL DISSECTION OF SUBMANDIBULAR REGION AND FLOOR OF MOUTH II

B. Sublingual and submandibular glands. The body and adjacent portion of the ramus of the mandible have been removed.

- The sublingual salivary gland lies posterior to the mandible and is in contact with the deep part of the submandibular gland posteriorly.
- Numerous fine ducts pass from the superior border of the sublingual gland to open on the sublingual fold of the overlying mucosa.
- The lingual nerve lies between the sublingual gland and the deep part of the submandibular gland; the submandibular ganglion is suspended from this nerve.
- Spinal nerve C1 fibers, conveyed by the hypoglossal nerve (CN XII), pass to the thyrohyoid muscle before the hypoglossal nerve passes deep to the mylohyoid muscle.



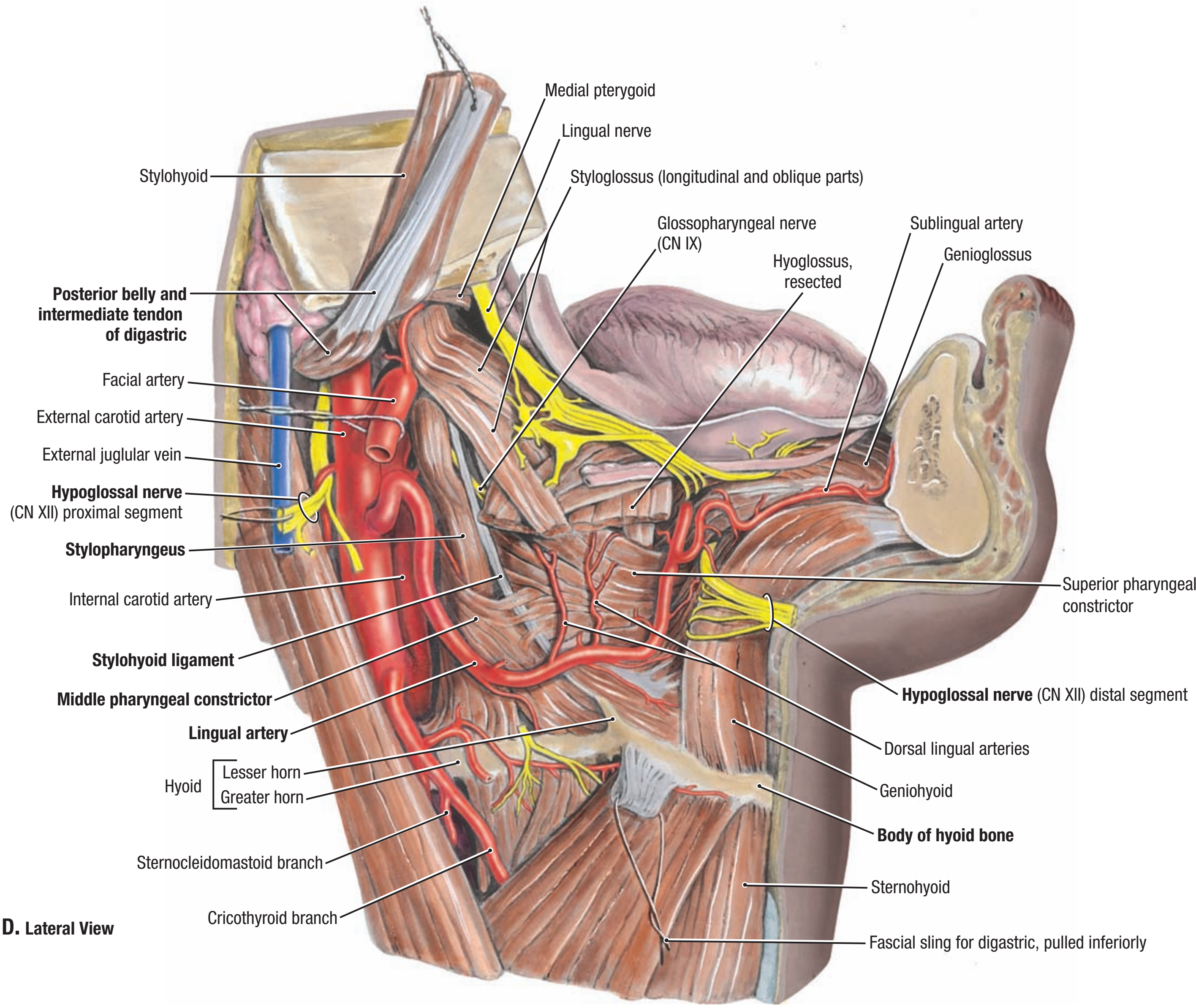
C. Lateral View



8.26 SERIAL DISSECTION OF SUBMANDIBULAR REGION AND FLOOR OF MOUTH III

C. Hyoglossus muscle, lingual (CN V_3) and hypoglossal nerves (CN XII). All of the right half of the mandible, except the superior part of the ramus, has been removed. The stylohyoid muscle is reflected superiorly, and the posterior belly of the digastric muscle is left in situ.

- The hyoglossus muscle ascends from the greater horn and body of the hyoid bone to the side of the tongue.
- The styloglossus muscle is crossed by the tonsillar branch of the facial artery posterosuperiorly, and its oblique part interdigitates with bundles of the hyoglossus muscle inferiorly.
- The hypoglossal nerve (CN XII) supplies all of the muscles of the tongue, both extrinsic and intrinsic, except the palatoglossus (a palatine muscle, innervated by CN X).
- The submandibular duct runs anteriorly in contact with the hyoglossus and genioglossus muscles to its opening on the side of the frenulum of the tongue.
- The lingual nerve is in contact with the mandible posteriorly, looping inferior to the submandibular duct and ending in the tongue. The submandibular ganglion is suspended from the lingual nerve; twigs leave the nerve to supply the mucous membrane.

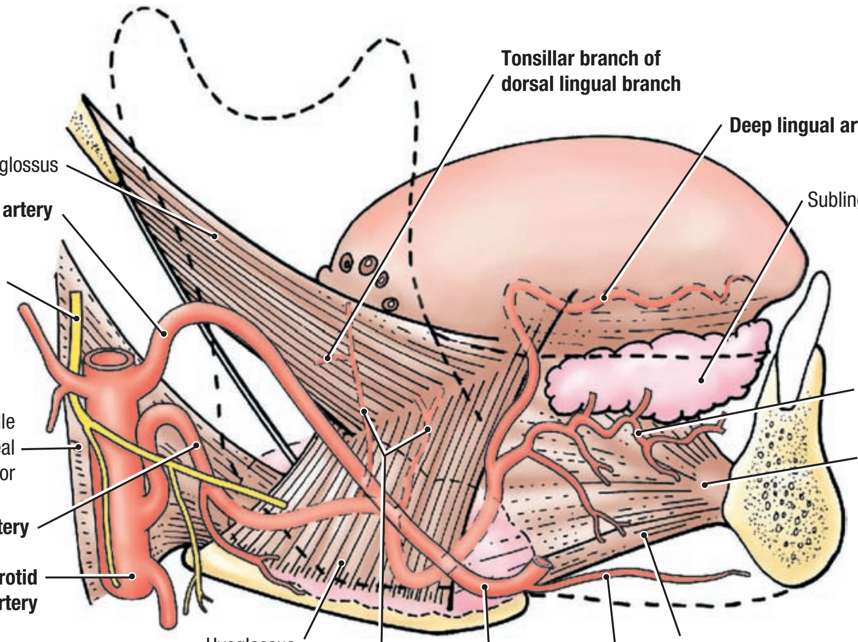


D. Lateral View

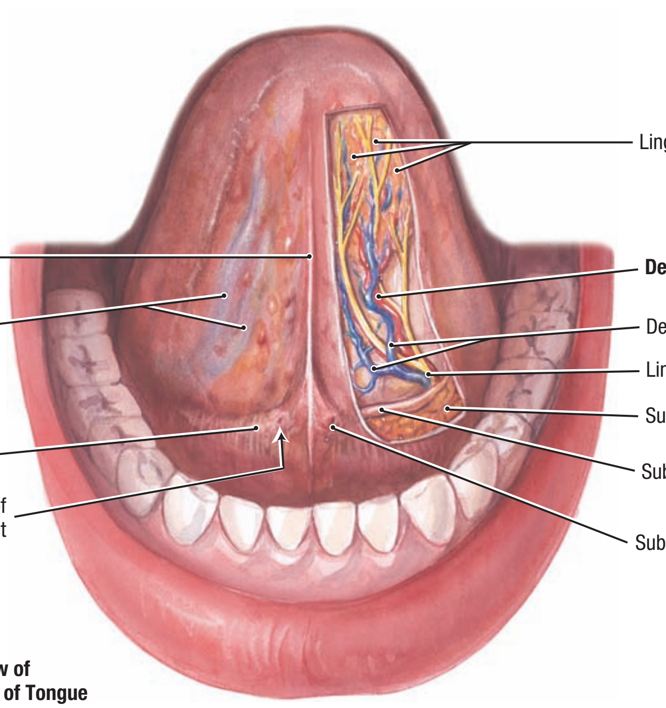
8.26 SERIAL DISSECTION OF SUBMANDIBULAR REGION AND FLOOR OF MOUTH IV

D. Genioglossus and geniohyoid muscles. The stylohyoid, posterior belly and intermediate tendon of the digastric muscle are reflected superiorly, the hypoglossal nerve (CN XII) is divided, and the hyoglossus muscle is mostly removed.

- The lingual artery passes deep to the hyoglossus muscle (resected here), close to the greater horn of the hyoid, and then passes lateral to the middle pharyngeal constrictor muscle, stylohyoid ligament, and genioglossus muscle and turns into the tongue as the deep lingual arteries.



A. Lateral View



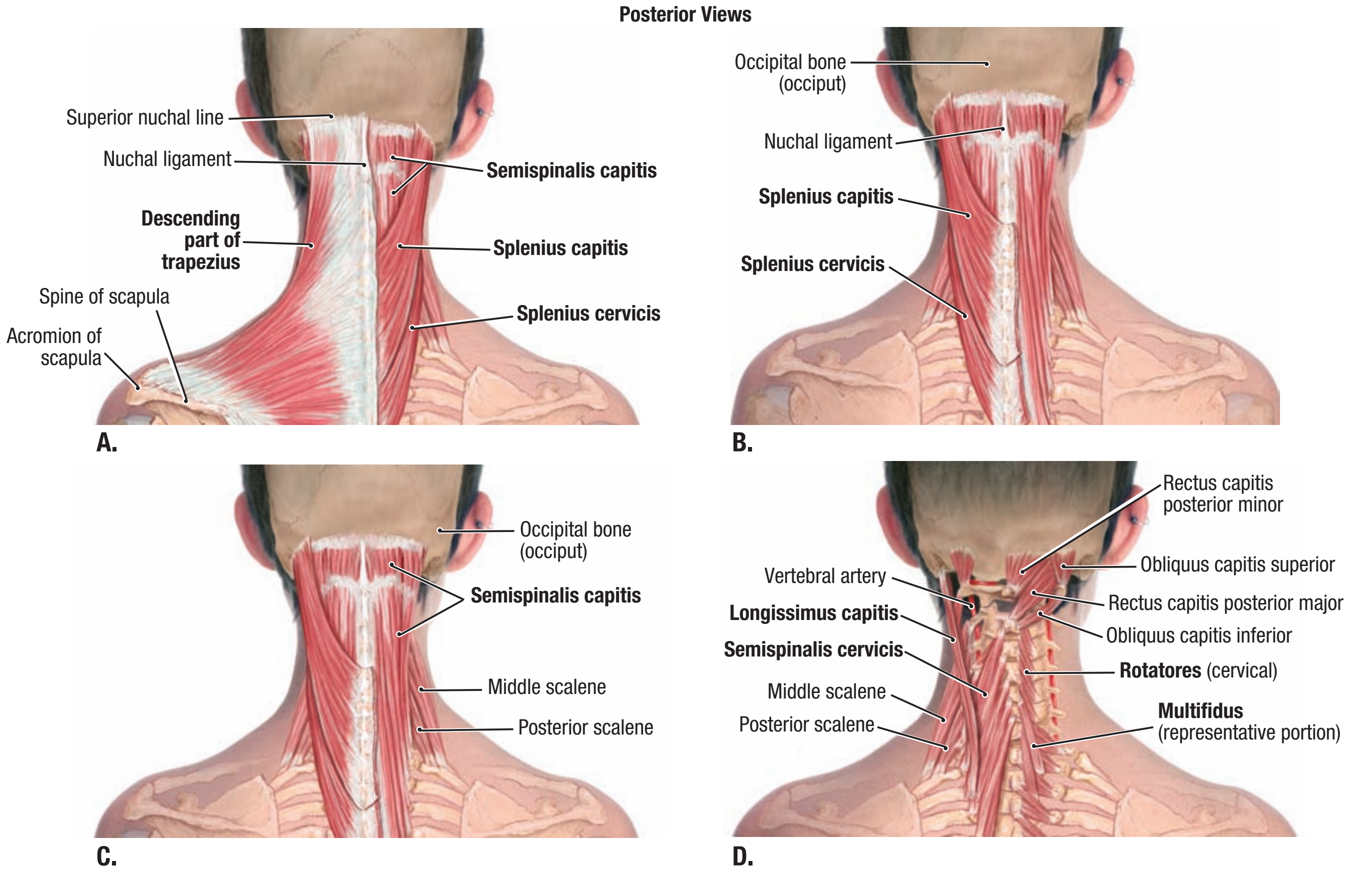
B. Anterior View of Inferior Surface of Tongue

8.27 LINGUAL AND FACIAL ARTERIES IN SUBMANDIBULAR REGION AND FLOOR OF MOUTH

A. Course of the lingual artery. **B.** Inferior surface of the tongue and floor of the mouth.

In **A**: The lingual artery arises from the anterior aspect of the external carotid artery, where it lies on the middle pharyngeal constrictor. Then it arches supero-anteriorly, passes deep to CN XII and disappears deep to the hyoglossus muscle, giving branches to the posterior tongue (dorsal lingual branches). It then turns superiorly at the anterior border of hyoglossus, bifurcating into the deep lingual and sublingual arteries.

In **B**: The inferior (sublingual) surface of the tongue is covered by mucous membrane through which the underlying deep lingual veins can be seen.

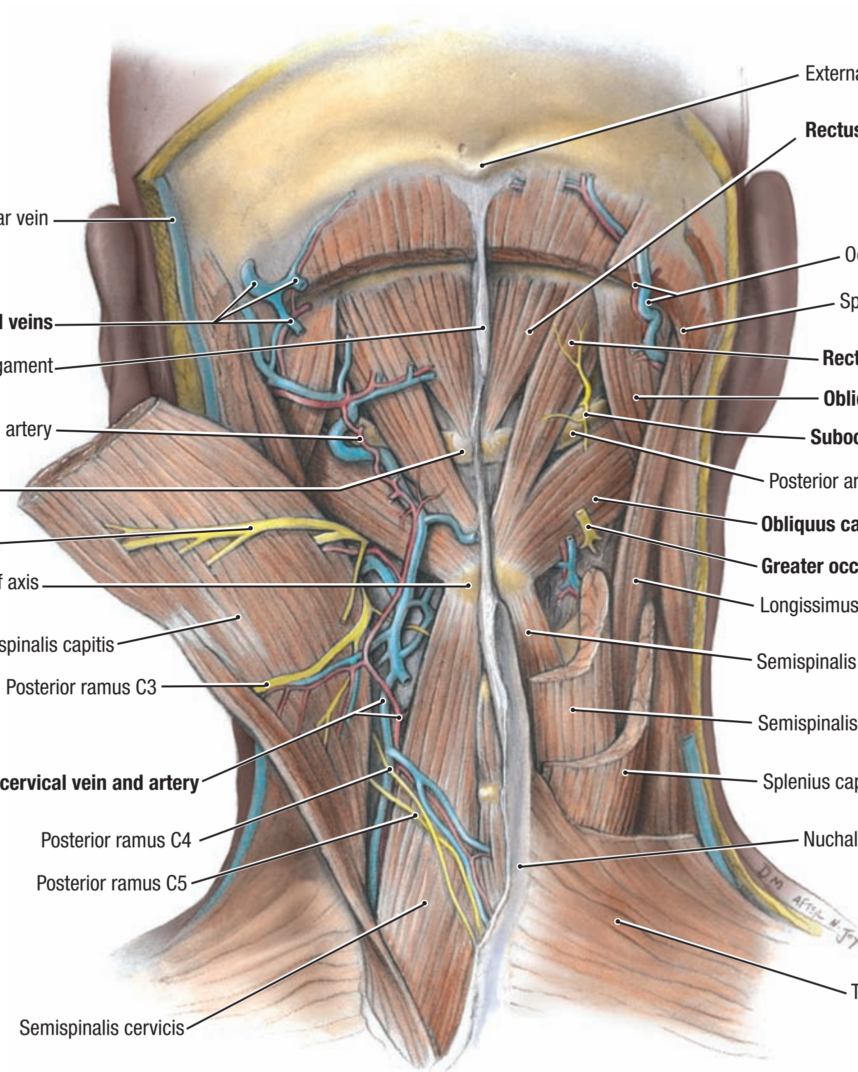


8.28 MUSCLES OF POSTERIOR CERVICAL REGION

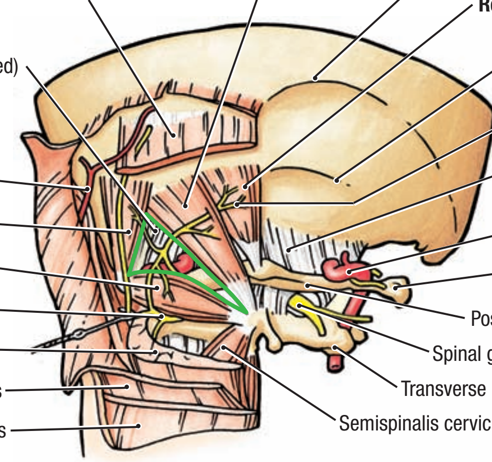
A. Trapezius. **B.** Splenius. **C.** Semispinalis. **D.** Deep muscles.

TABLE 8.8 MUSCLES OF POSTERIOR CERVICAL REGION

Muscle	Superior Attachment	Inferior Attachment	Innervation	Main Action
Extrinsic muscle of back (superior axioappendicular muscle)				
Descending part of trapezius	Medial third of superior nuchal line; external occipital protuberance; nuchal ligament	Lateral third of clavicle and lateral aspect of acromion of scapula	Spinal accessory nerve (CN XI)	Elevates scapulae and works with other parts of muscle to retract scapulae; with shoulder fixed, contributes to extension of head, side bending (lateral flexion) of neck
Intrinsic muscles of back—superficial layer				
Splenius	Nuchal ligament and spinous processes of C7 toT3–T4 vertebrae	*Splenius capitis:* fibers run superolaterally to mastoid process of temporal bone and lateral third of superior nuchal line of occipital bone *Splenius cervicis:* Tubercles of transverse processes of C1–C4 vertebrae	Posterior rami of spinal nerves	*Acting unilaterally:* laterally flex and rotate head to side of active muscle *Acting bilaterally:* extend head and neck
Intrinsic muscles of back—intermediate layer				
Longissimus	Transverse processes of T1–T5 vertebrae	*Longissimus capitis:* posterior mastoid process *Longissimus cervicis:* transverse processes of C2–C6	Posterior rami of spinal nerves	Extends vertebral column; longissimus capitis turns face ipsilaterally
Intrinsic muscles of back—deep layer				
Semispinalis	Transverse processes of C4–T5 vertebrae	*Semispinalis capitis:* Superior nuchal line of occipital bone *Semispinalis cervicis:* Spinous processes of cervical vertebrae		*Acting unilaterally:* contribute to contralateral rotation; *Acting bilaterally:* extend head and neck
Multifidus of cervical region	Transverse processes of T1–T3 Articular processes of C4–C7 vertebrae	Spinous processes 2–4 segments inferior to attachment	Posterior rami of spinal nerves	Stabilizes vertebrae during local movements of vertebral column
Rotatores	Transverse processes	Junction of lamina and transverse process, or spinous process of vertebra immediately (brevis) or two segments (longus) superior to origin		Stabilize, assist with local extension and rotatory movements; may function as proprioceptive organs



A. **Posterior View**

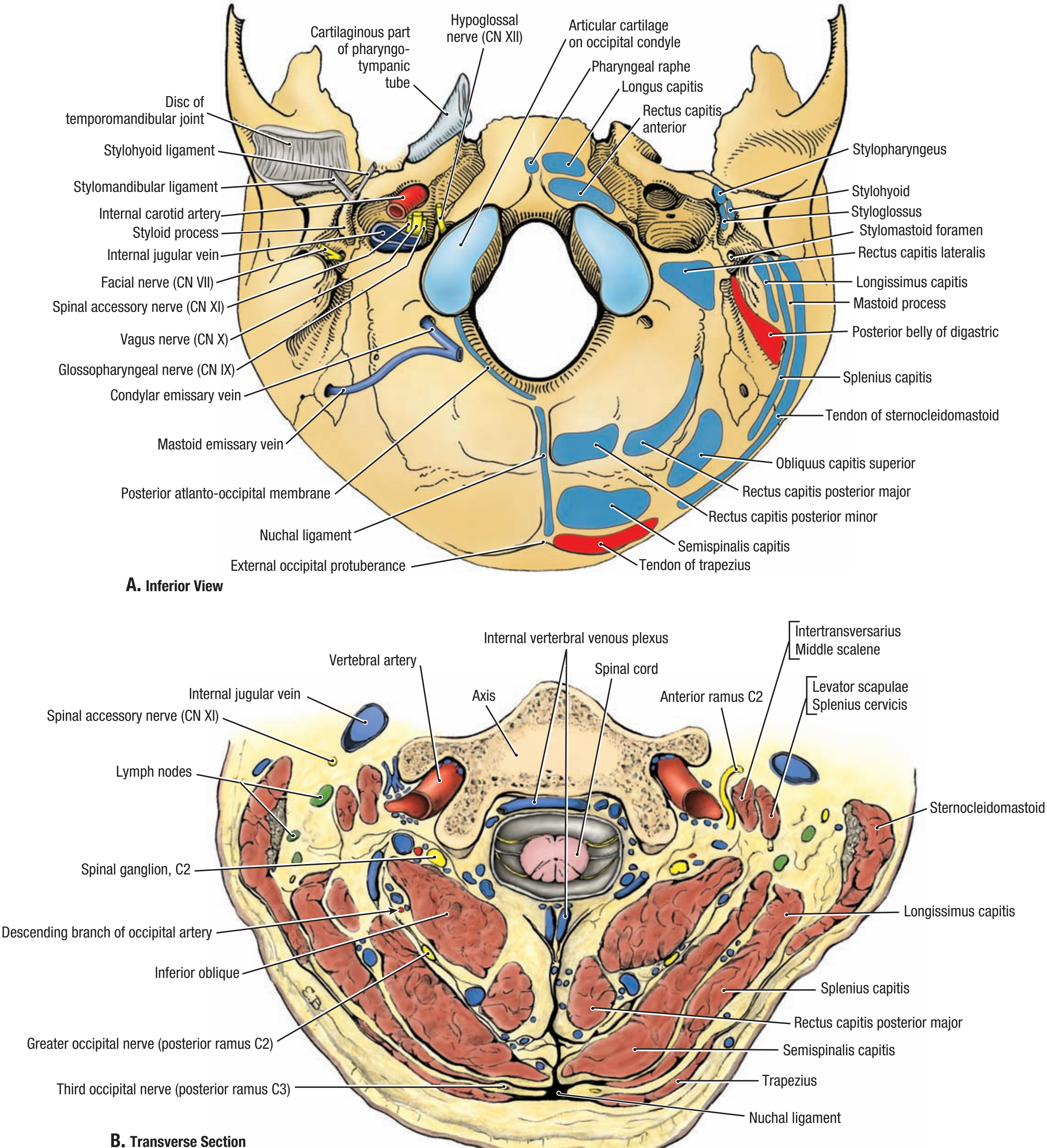


B. **Posterior View**

8.29 SUBOCCIPITAL REGION

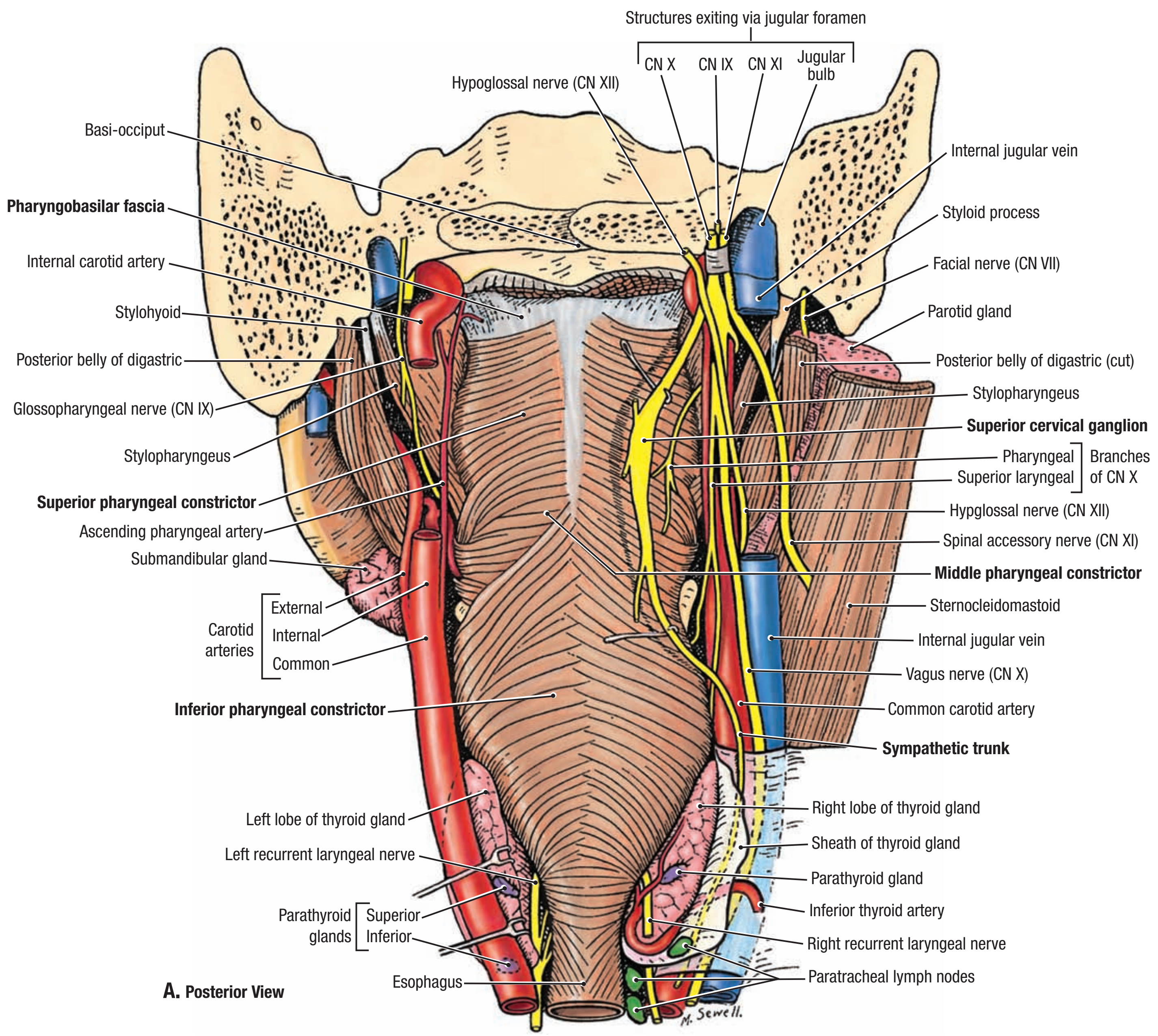
A. Dissection. **B.** Schematic illustration.

- The suboccipital triangle is bounded by three muscles: obliquus capitis inferior and superior, and rectus capitis posterior major.
- The suboccipital nerve (posterior ramus of C1 spinal nerve) emerges through the suboccipital triangle to innervate the muscles forming the triangle.



8.30 POSTERIOR CERVICAL REGION—BASE OF SKULL AND TRANSVERSE SECTION

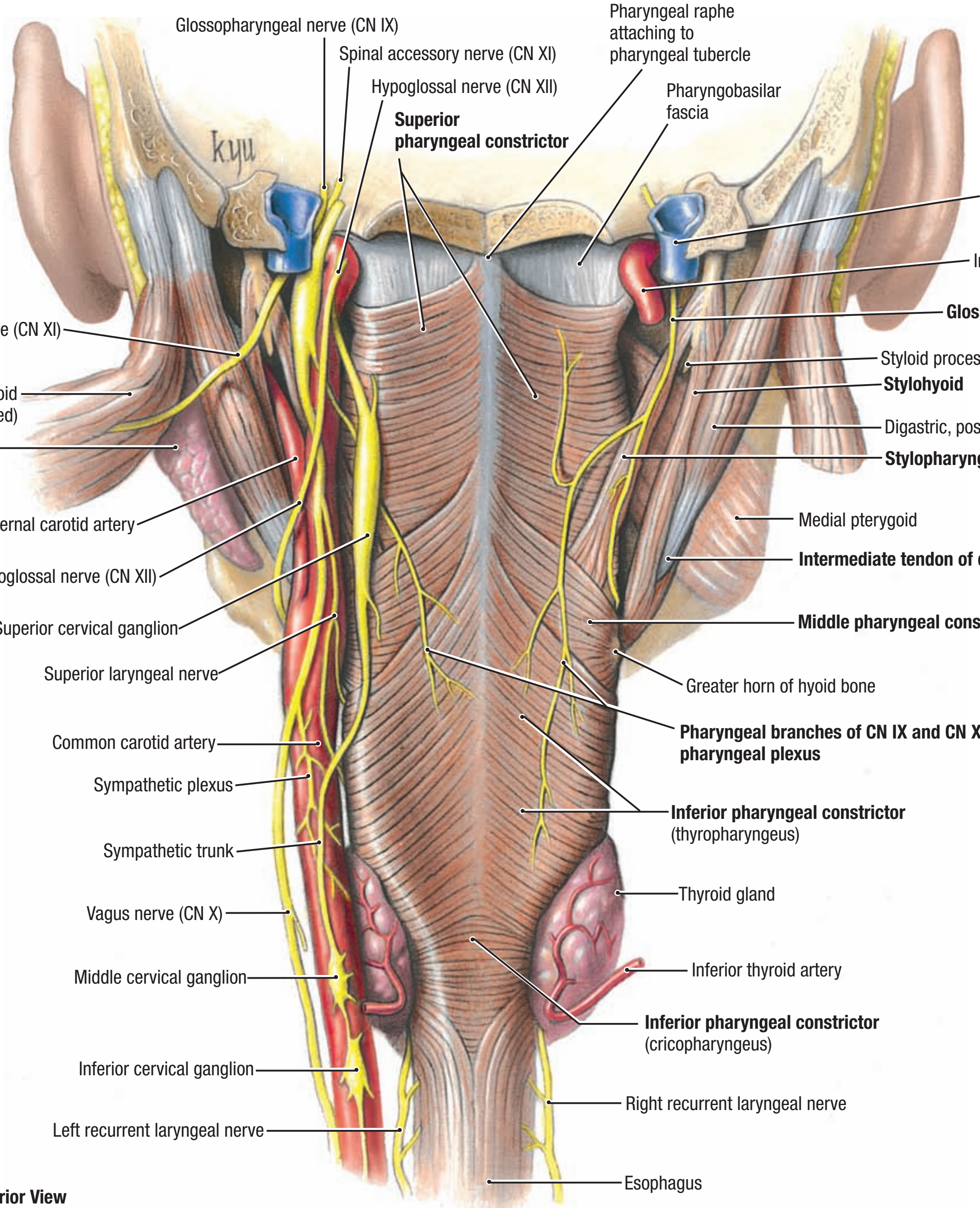
A. Muscular attachments to and neurovascular relationships at the base of the skull. **B.** Transverse section through the axis (C2 vertebra).



8.31 EXTERNAL PHARYNX—POSTERIOR VIEWS

A. Illustration of a dissection similar to **B.** The sympathetic trunk (including the superior cervical ganglion), which normally lies posterior to the internal carotid artery, has been retracted medially.

- The pharyngobasilar fascia, between the superior pharyngeal constrictor muscle and the base of the skull, attaches the pharynx to the occipital bone and forms the wall of the noncollapsible pharyngeal recesses.
- As they exit the jugular foramen, CN IX lies anterior to CN X, and CN XI; CN XII, exiting the hypoglossal canal, lies medially.

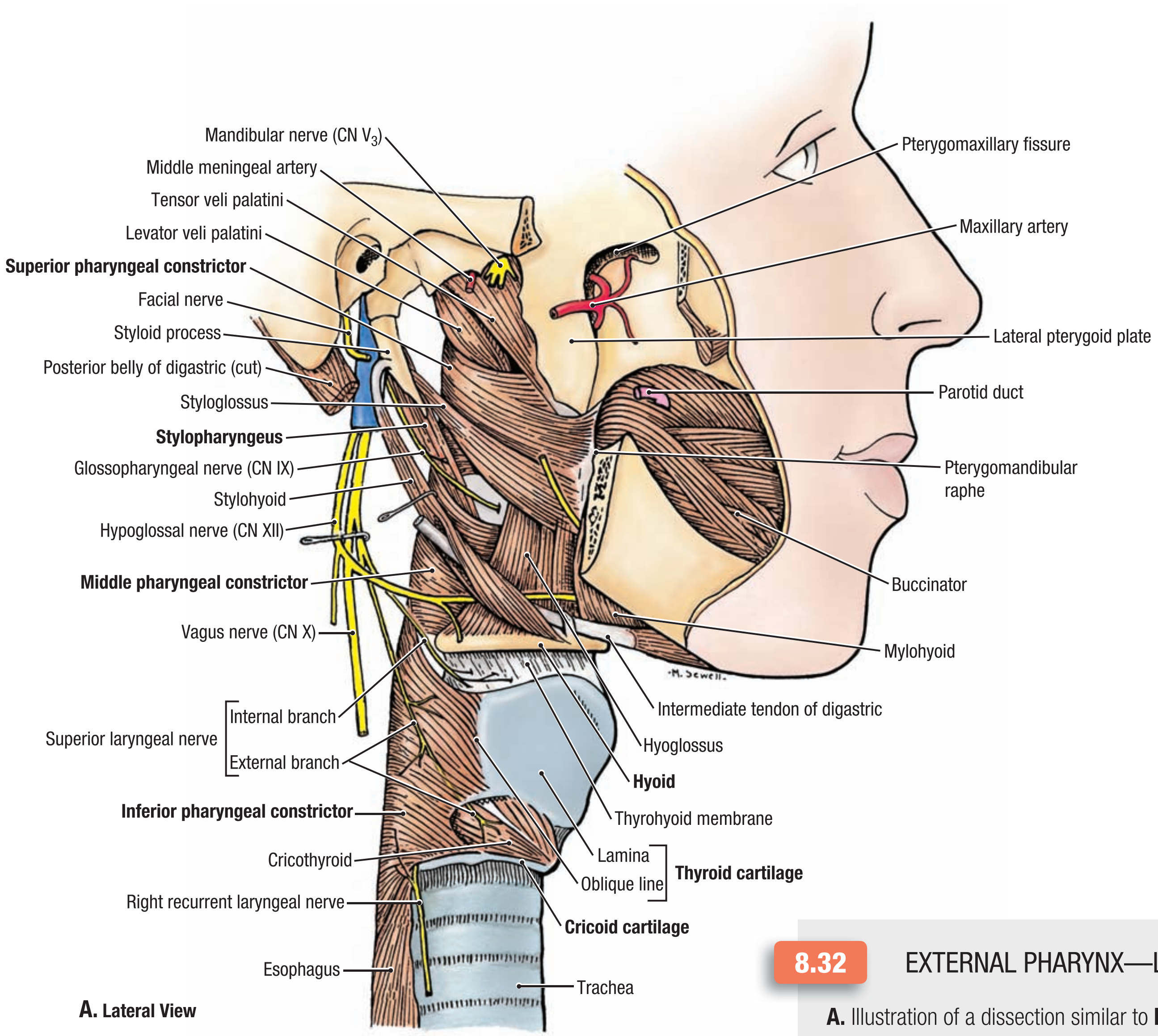


B. **Posterior View**

8.31 EXTERNAL PHARYNX—POSTERIOR VIEWS *(CONTINUED)*

B. Dissection. A large wedge of occipital bone (including the foramen magnum) and the articulated cervical vertebrae have been separated from the remainder (anterior portion) of the head and cervical viscera at the retropharyngeal space and removed.

- The pharynx is a unique portion of the alimentary tract, having a circular layer of muscle externally and a longitudinal layer internally.
- The circular layer of the pharynx consists of the three pharyngeal constrictor muscles (superior, middle, and inferior), which overlap one another.
- On the right side of the specimen, the stylopharyngeus muscle and glossopharyngeal nerve (IX) pass from the medial side of the styloid process anteromedially through the interval between the superior and middle pharyngeal constrictor muscles to become part of the internal longitudinal layer. The stylohyoid muscle passes from the lateral side of the styloid process anterolaterally and splits on its way to the hyoid bone to accommodate passage of the intermediate tendon of the digastric.
- Pharyngeal branches of the glossopharyngeal nerve (CN IX) and the vagus nerve (CN X) form the pharyngeal plexus, which provides most of the pharyngeal innervation. The glossopharyngeal nerve supplies the sensory component, while the vagus supplies motor innervation.



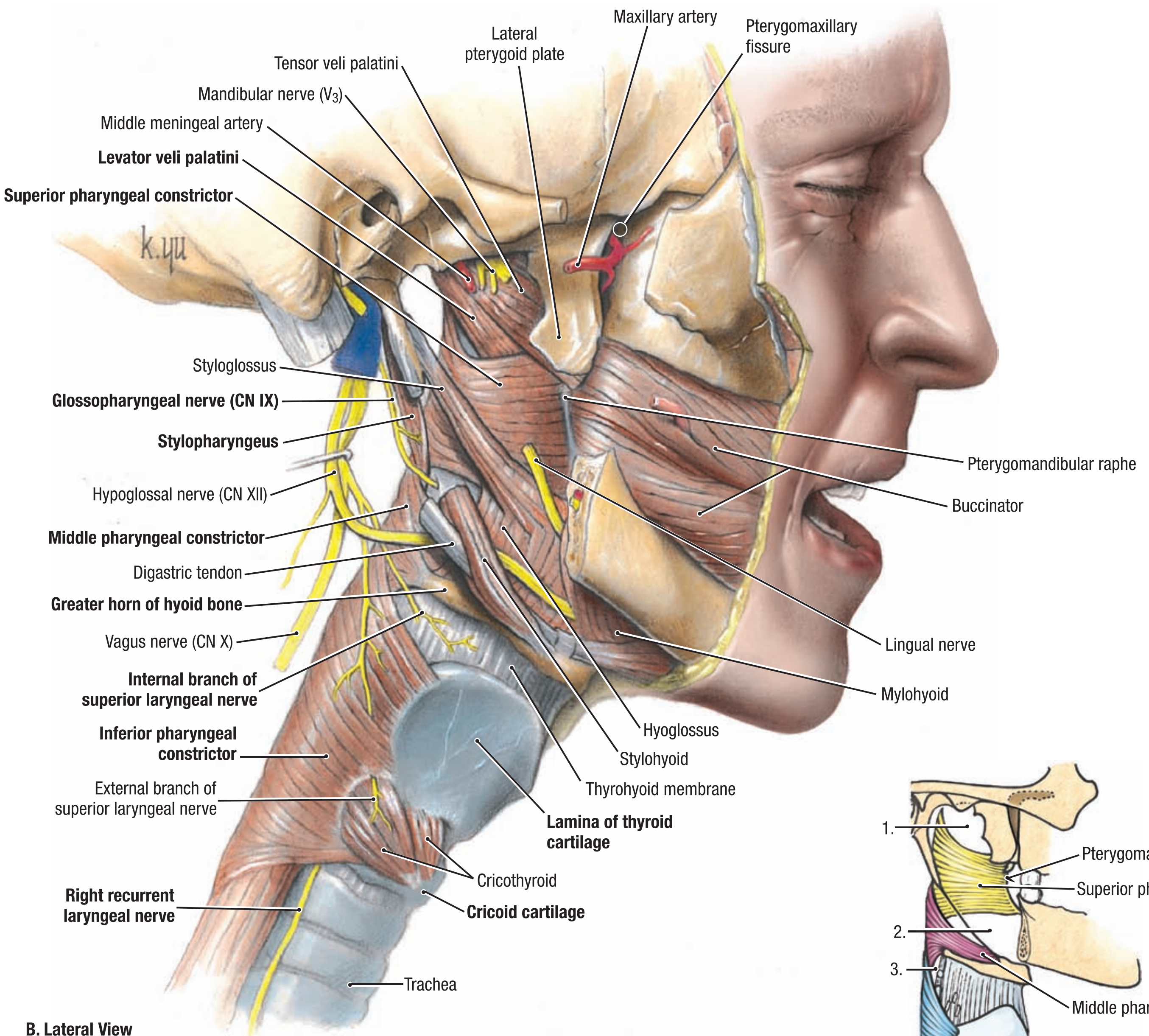
A. **Lateral View**

8.32 EXTERNAL PHARYNX—LATERAL VIEWS

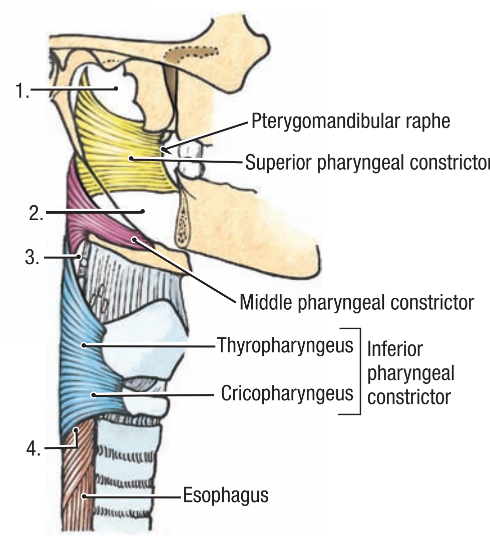
A. Illustration of a dissection similar to **B.**

TABLE 8.9 MUSCLES OF PHARYNX

Muscle	Origin	Insertion	Innervation	Main Action(s)
Superior pharyngeal constrictor	Pterygoid hamulus, pterygo-mandibular raphe, posterior end of mylohyoid line of mandible, and side of tongue	Pharyngeal raphe	Pharyngeal and superior laryngeal branches of vagus (CN X) through pharyngeal plexus	Constrict wall of pharynx during swallowing
Middle pharyngeal constrictor	Stylohyoid ligament and superior (greater) and inferior (lesser) horns of hyoid bone			
Inferior pharyngeal constrictor	Oblique line of thyroid cartilage			
Thyropharyngeus				
Cricopharyngeus (see Fig. 8.20B)	Side of cricoid cartilage	Contralateral side of cricoid cartilage	Pharyngeal and superior laryngeal branches of vagus (CN X) through pharyngeal plexus + external laryngeal plexus	Serves as superior esophageal sphincter
Palatopharyngeus (see Fig. 8.31B)	Hard palate and palatine aponeurosis	Posterior border of lamina of thyroid cartilage and side of pharynx and esophagus	Pharyngeal and superior laryngeal branches of vagus (CN X) through pharyngeal plexus	Elevate pharynx and larynx during swallowing and speaking
Salpingopharyngeus (see Fig. 8.33B)	Cartilaginous part of pharyngotympanic tube	Blends with palatopharyngeus		
Stylopharyngeus	Styloid process of temporal bone	Posterior and superior borders of thyroid cartilage with palatopharyngeus	Glossopharyngeal nerve (CN IX)	



B. Lateral View

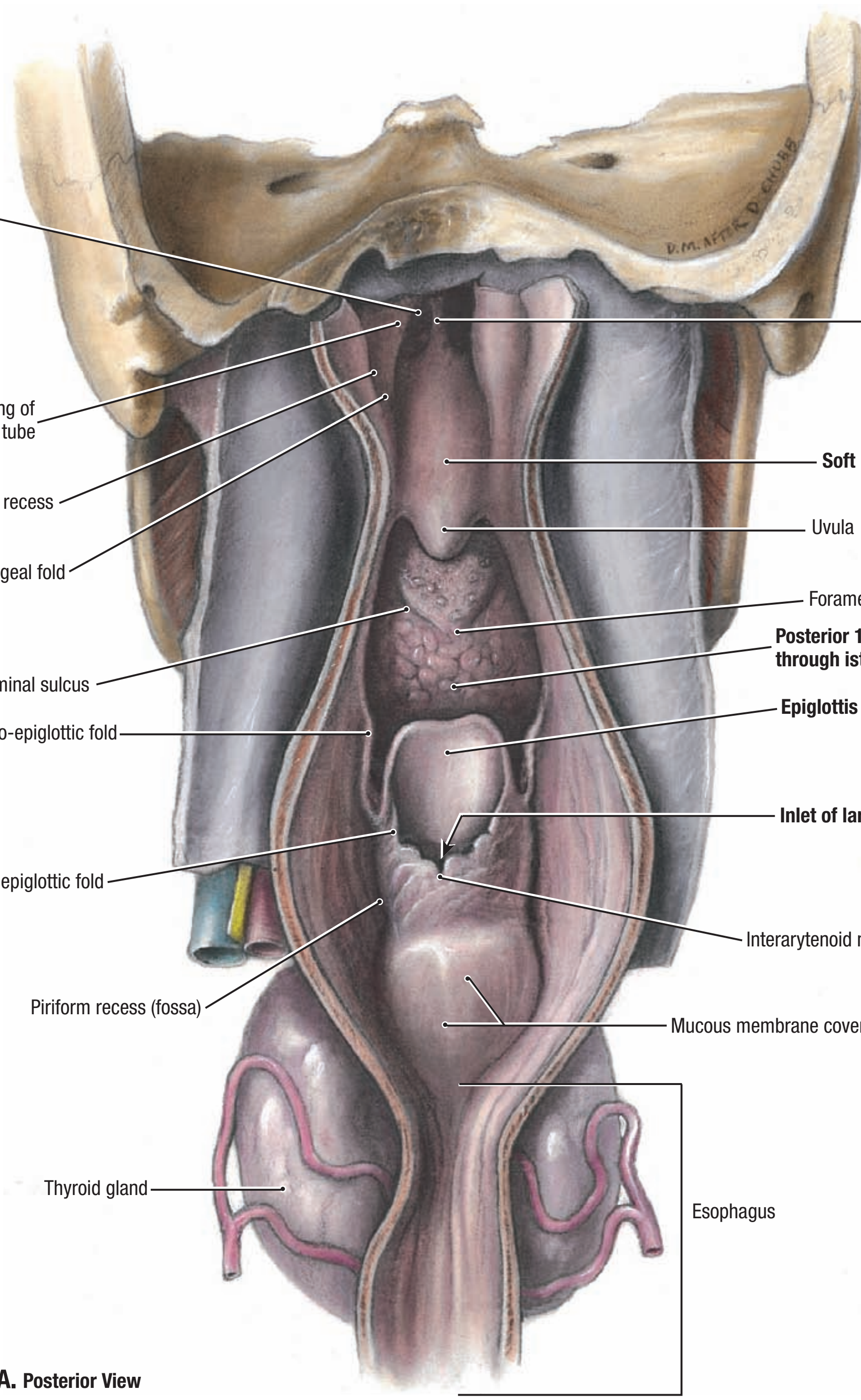


C. Lateral View

8.32 EXTERNAL PHARYNX—LATERAL VIEWS *(CONTINUED)*

B. Dissection. **C. and D.** Observe that there are gaps in the pharyngeal musculature (1-4 in **D**) allowing the entry of structures:

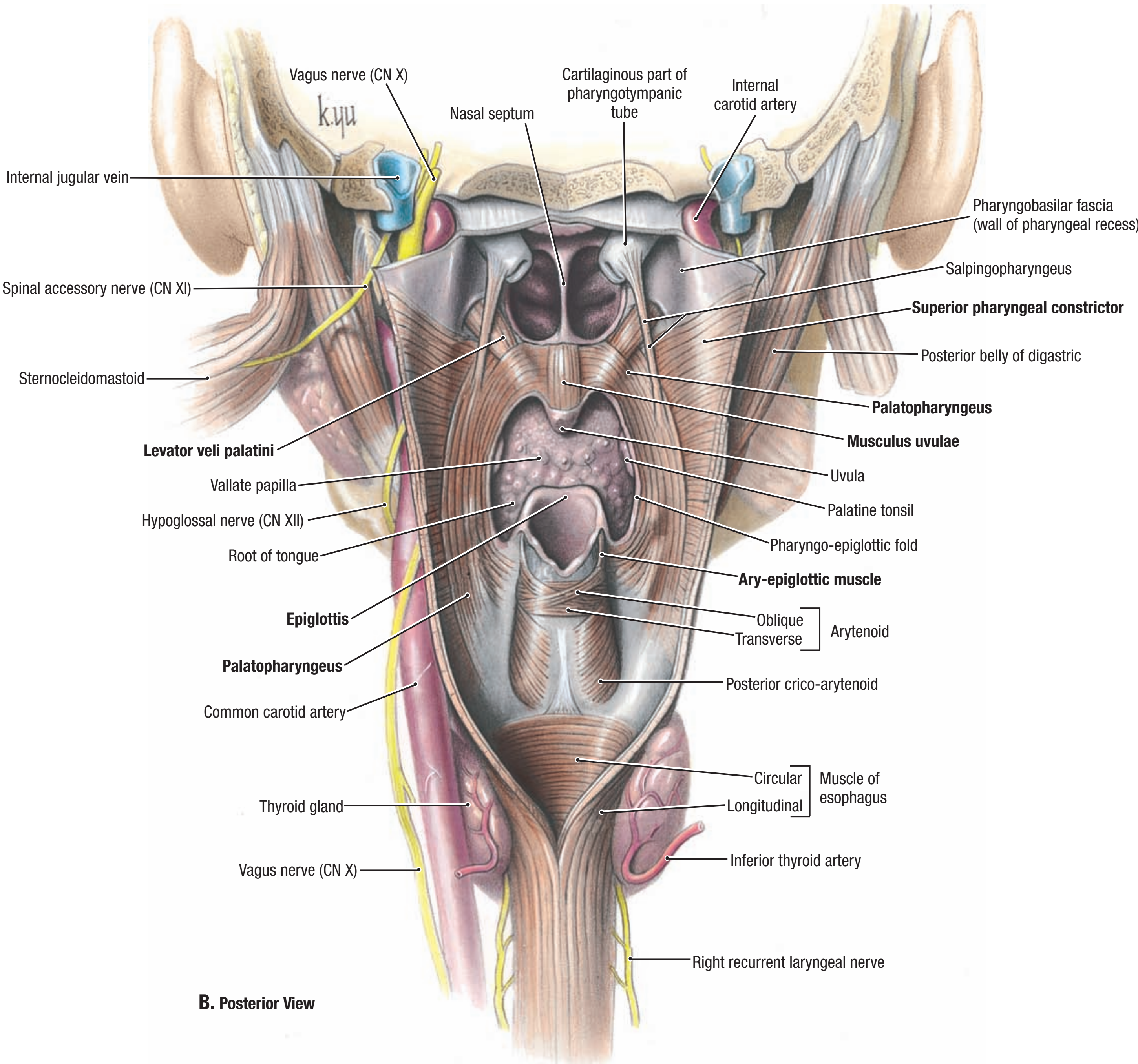
1. Superior to the superior constrictor muscle: levator veli palatini muscle and pharyngotympanic (auditory) tube (see Fig. 8.33B)
2. Between the superior and middle constrictors: stylopharyngeus muscle, CN IX, and stylohyoid ligament
3. Between the middle and inferior constrictors: internal branch of superior laryngeal nerve and superior laryngeal artery and nerve (not shown)
4. Inferior to the inferior constrictor muscle: recurrent laryngeal nerve



A. Posterior View

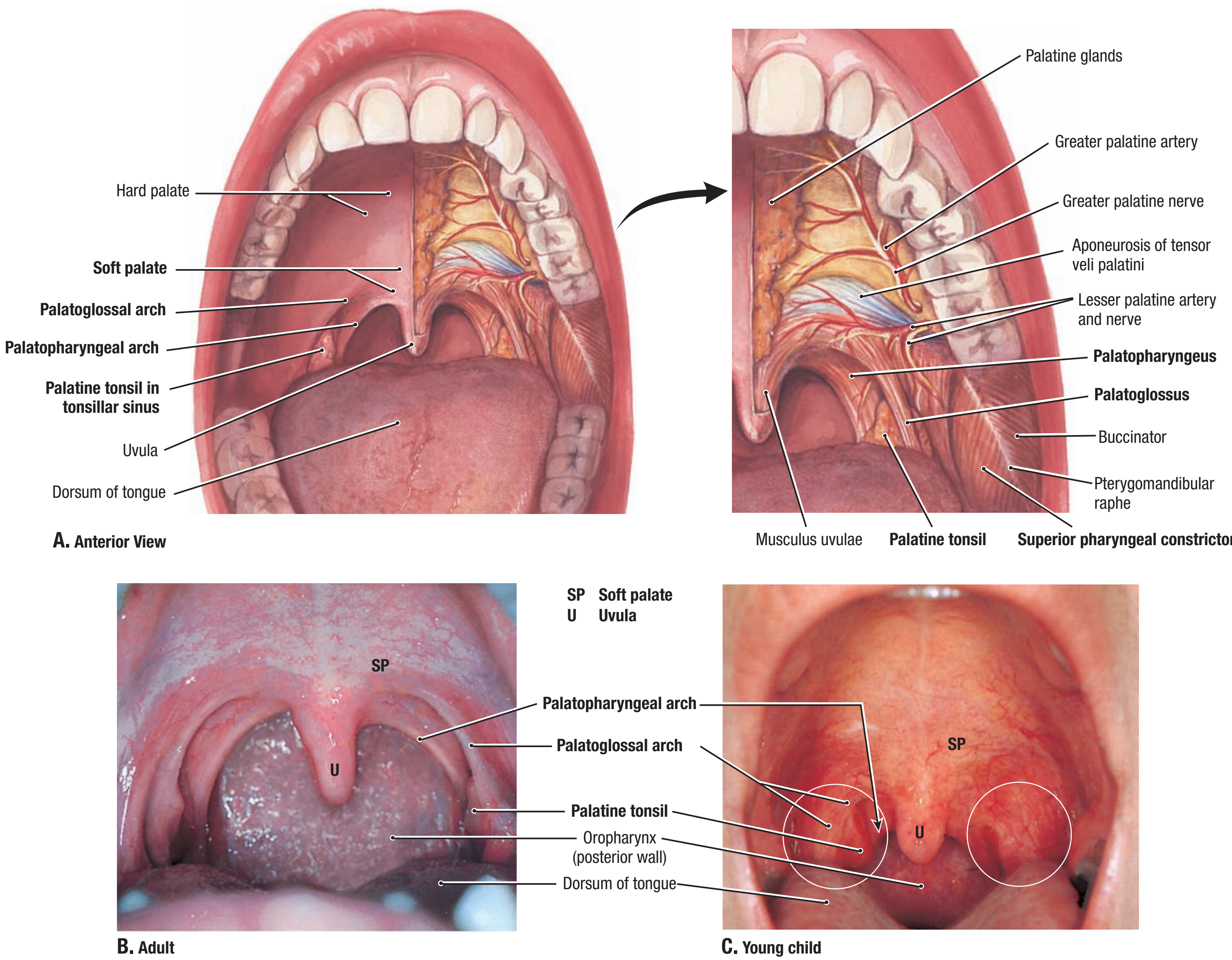
8.33 INTERNAL PHARYNX I

A. Dissection. The posterior wall of the pharynx has been split in the midline and the halves retracted laterally to reveal the internal aspect of the anterior wall of the pharynx, occupied by communications that define three parts of the pharynx: (1) the nasal part (nasopharynx), superior to the level of the soft palate, communicates anteriorly through the choanae with the nasal cavities; (2) the oral part (oropharynx), between the soft palate and the epiglottis, communicates anteriorly through the isthmus of the fauces with the oral cavity; and (3) the laryngeal part (laryngopharynx), posterior to the larynx, communicates with the vestibule of the larynx through the inlet of (aditus to) the larynx. The pharynx extends from the cranial base to the inferior border of the cricoid cartilage. Inferiorly, it is narrowed by the encircling cricopharyngeus.



8.33 INTERNAL PHARYNX II

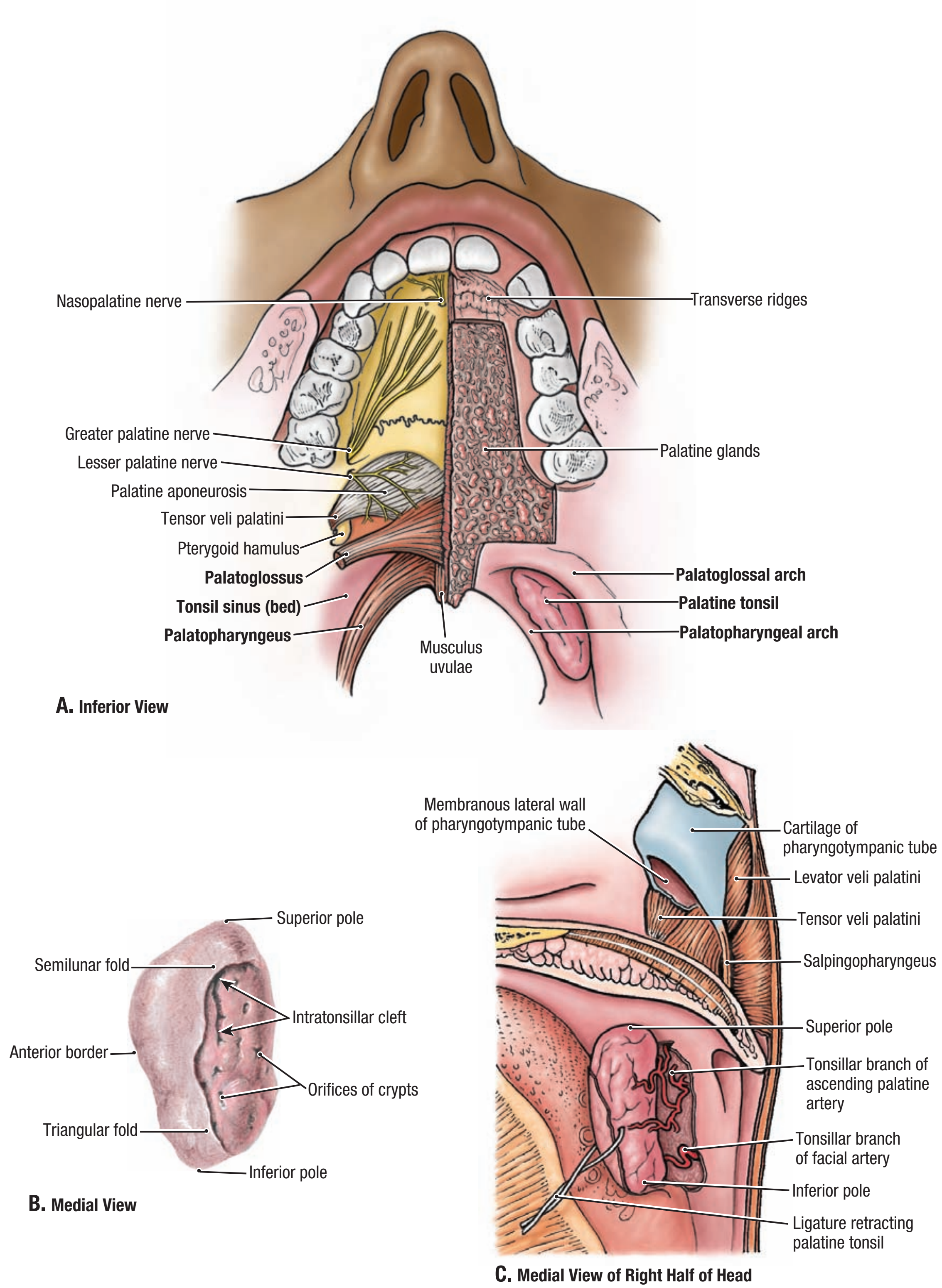
B. Illustration. The posterior wall of the pharynx has been split in the midline and reflected laterally as in **A;** then, the mucous membrane was removed to expose the underlying musculature. The muscles of the soft palate, pharynx, and larynx work together during swallowing, elevating the soft palate, narrowing the pharyngeal isthmus (passageway between the nasal and oral parts of the pharynx) and laryngeal inlet, retracting the epiglottis, and closing the glottis, to keep food and drink out of the nasopharynx and larynx as they pass from oral cavity to esophagus. At other times, as when blowing one's nose, the palatopharyngeus muscles, partially encircling the opening to the oral cavity, constrict this opening and depress the soft palate, working with placement and expansion of the posterior tongue to direct expired air through the nasal cavity.



8.34 SURFACE ANATOMY OF ISTHMUS OF THE FAUCES (OROPHARYNGEAL ISTHMUS)

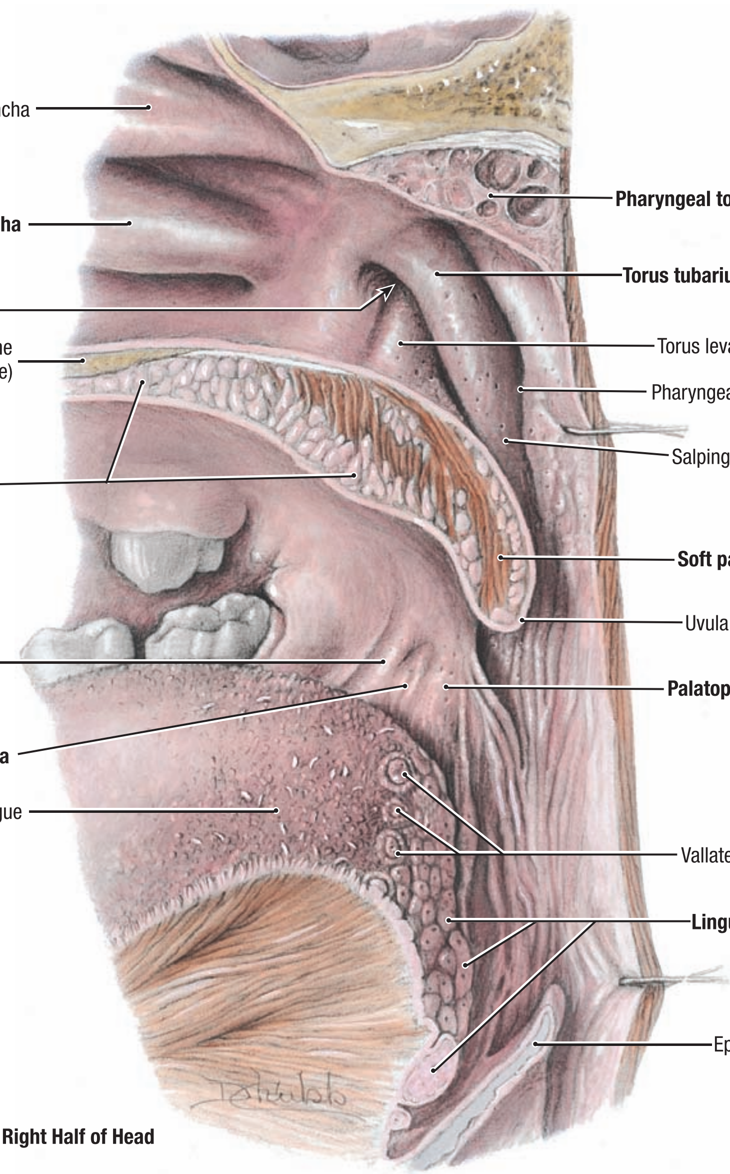
A. Oral cavity and isthmus demonstrating the sinus (bed) of the tonsils. **B. and C.** Tonsillar sinuses with palatine tonsils in situ, and oropharynx in adult **(B)** and young child (**C**).

- The fauces (throat), the passage from the mouth to the pharynx, is bounded superiorly by the soft palate, inferiorly by the root (base) of the tongue, and laterally by the palatoglossal and palatopharyngeal arches.
- The palatine tonsils are located between the palatoglossal and palatopharyngeal arches, formed by mucosa overlying the similarly named muscles; the arches form the boundaries, and the superior pharyngeal constrictor the floor, of the tonsillar sinuses.
- **Normal palatine tonsils.** In the adult the palatine tonsils are normally involuted, with little glandular tissue in the tonsillar sinuses (B). In contrast in young children the palatine tonsils are large relative to the adult, since most of the development of the lymphoid system occurs prior to puberty. Despite their large size, as long as the tonsils are not inflamed and not interfering with swallowing/breathing they are considered normal.

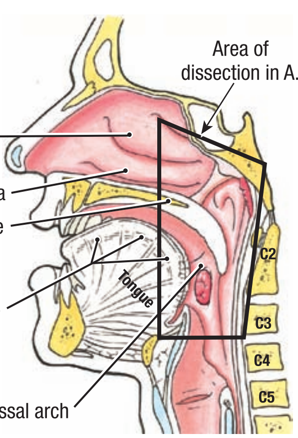


8.35 PALATINE TONSIL

A. Left side: Palatine tonsil in situ and glands of palatine mucosa. Right side: Palatine mucosa and tonsils removed demonstrating palatine nerves and muscles. **B.** Isolated palatine tonsil. **C. Tonsillectomy.** The procedure involves removal of the tonsil and the fascial sheet covering the tonsillar sinus. Because of the rich blood supply of the tonsil, bleeding commonly arises from the large external palatine vein or less commonly from the tonsillar artery or other arterial twigs. The glossopharyngeal nerve accompanies the tonsillar artery on the lateral wall of the pharynx and is vulnerable to injury because this wall is thin. The internal carotid artery is especially vulnerable when it is tortuous, as it lies directly lateral to the tonsil.

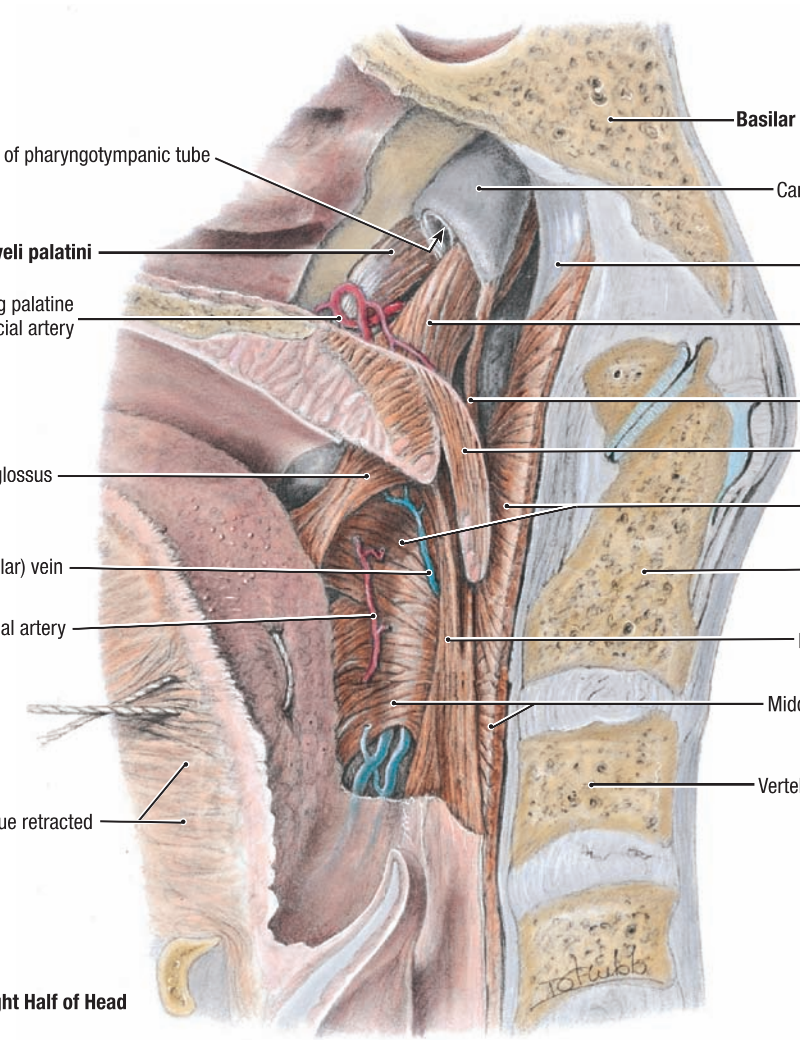


A. Medial View of Right Half of Head

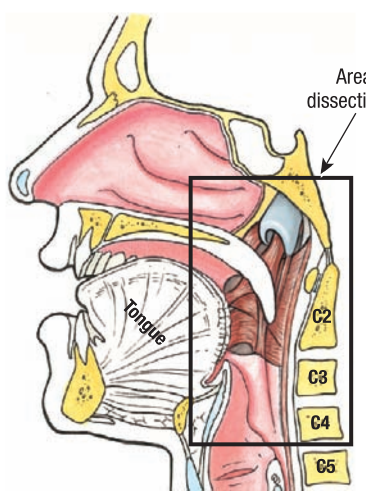


8.36 SERIAL DISSECTION OF ISTHMUS OF FAUCES AND LATERAL WALL OF NASOPHARYNX I

- The pharyngeal opening of the pharyngotympanic tube is located approximately 1 cm posterior to the inferior concha.
- The numerous pinpoint orifices of the ducts of the mucous glands can be seen in the mucosa of the torus.
- The pharyngeal tonsil lies in the mucous membrane of the roof and posterior wall of the nasopharynx.
- The palatine glands lie in the soft palate.
- The palatine tonsil lies in the tonsillar sinus between the palatoglossal and palatopharyngeal arches.
- Each lingual follicle has the duct of a mucous gland opening onto its surface; collectively, the follicles are known as the lingual tonsil.

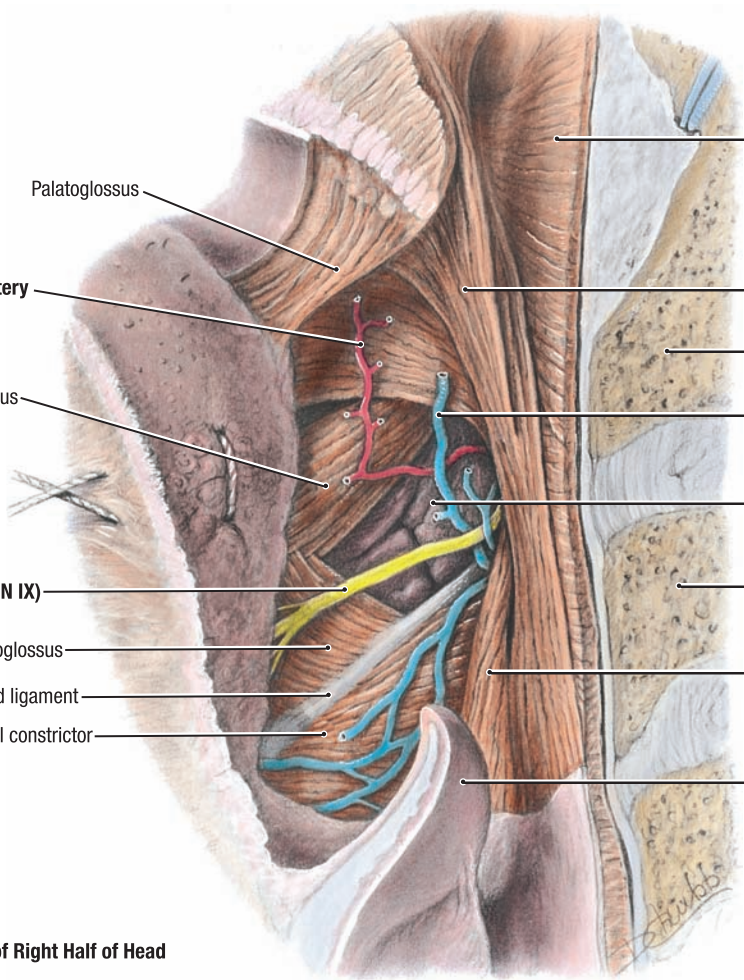


B. Medial View of Right Half of Head

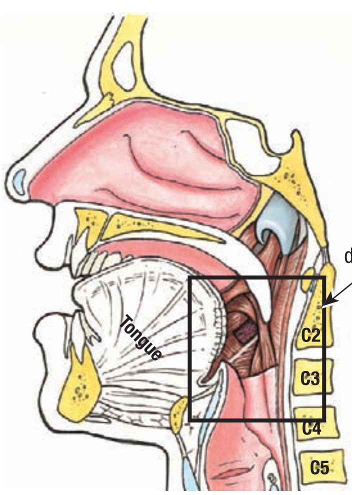


8.36 SERIAL DISSECTION OF ISTHMUS OF FAUCES AND LATERAL WALL OF NASOPHARYNX II

Muscles underlying tonsillar sinus and wall of nasopharynx. The palatine and pharyngeal tonsils and mucous membrane have been removed. The pharyngobasilar fascia, which attaches the pharynx to the basilar part of the occipital bone was also removed, except at the superior, arched border of the superior pharyngeal constrictor.



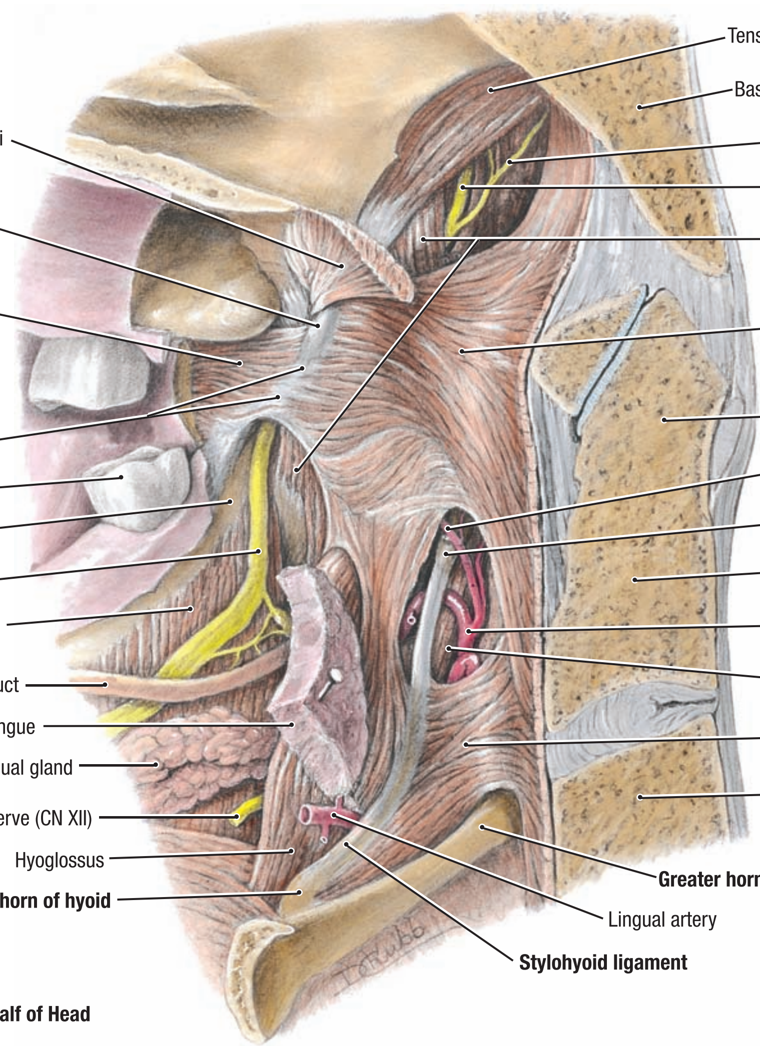
C. Medial View of Right Half of Head



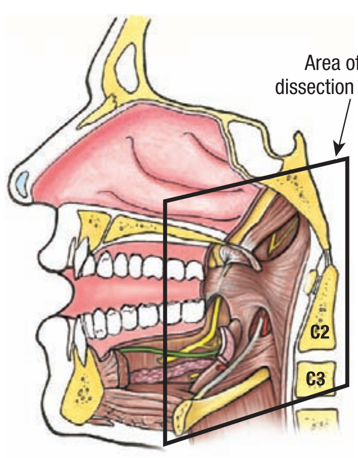
8.36 SERIAL DISSECTION OF ISTHMUS OF FAUCES AND LATERAL WALL OF NASOPHARYNX III

Neurovascular structures of tonsillar sinus and longitudinal muscles of the pharynx.

- In this deeper dissection, the tongue was pulled anteriorly, and the inferior part of the origin of the superior pharyngeal constrictor muscle was cut away.
- The glossopharyngeal nerve passes to the posterior one third of the tongue and lies anterior to the stylopharyngeus muscle.
- The tonsillar branch of the facial artery sends a branch (cut short here) to accompany the glosso-pharyngeal nerve to the tongue; the submandibular gland is seen lateral to the artery and external palatine (paratonsillar) vein.

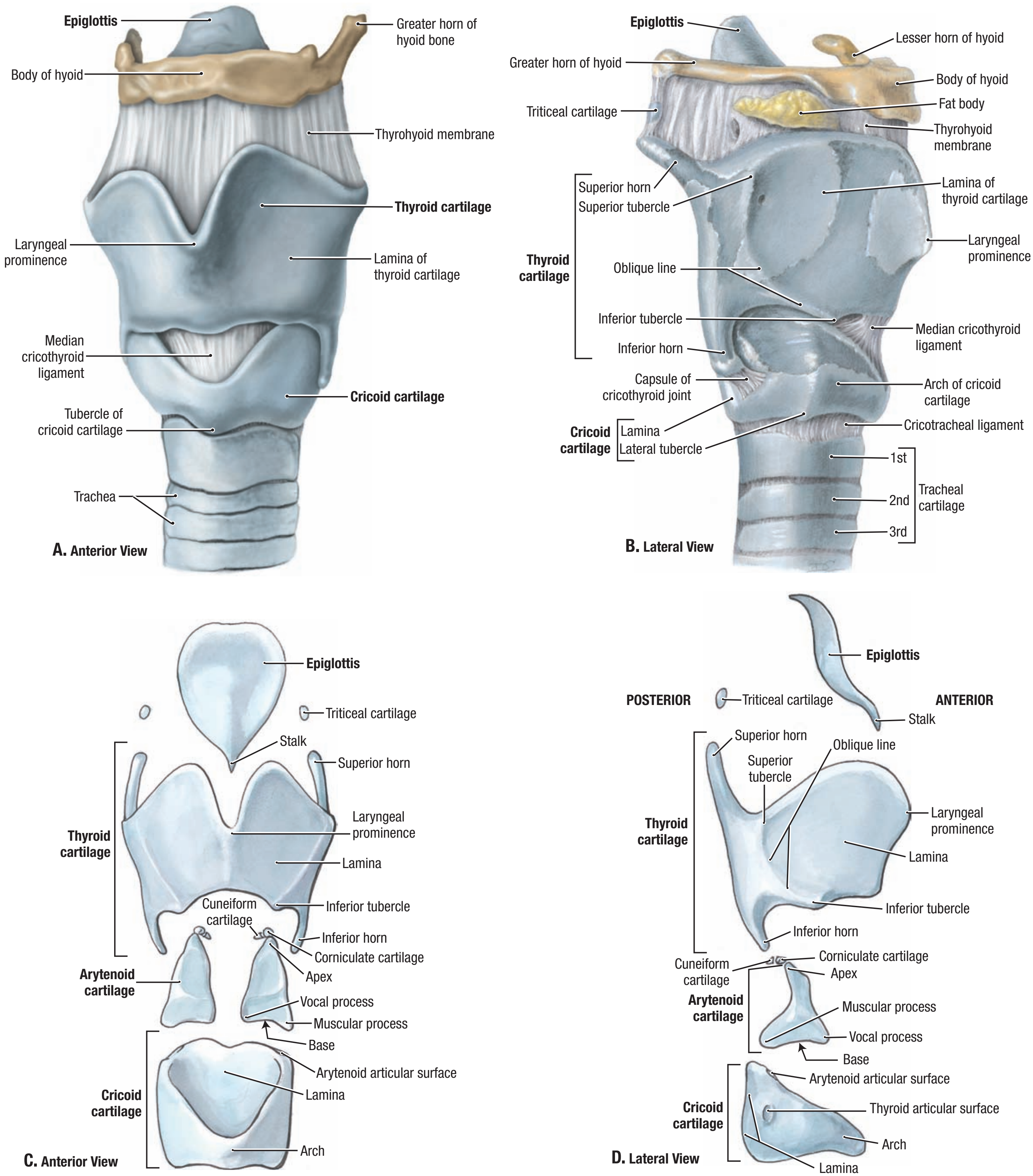


D. Medial View of Right Half of Head

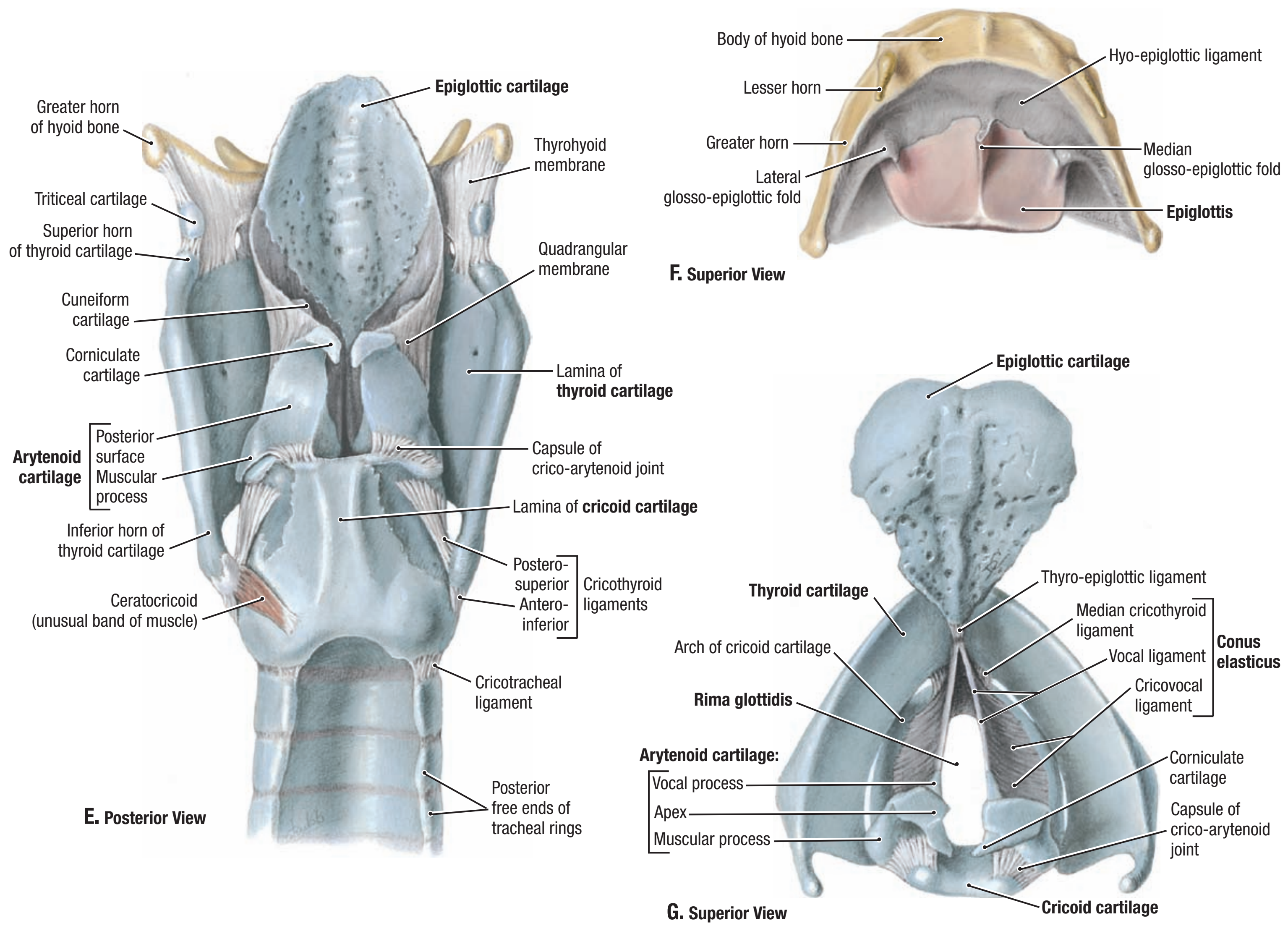


8.36 SERIAL DISSECTION OF ISTHMUS OF FAUCES AND LATERAL WALL OF NASOPHARYNX IV

- The superior pharyngeal constrictor muscle arises from (1) the pterygomandibular raphe, which unites it to the buccinator muscle; (2) the bones at each end of the raphe, the hamulus of the medial pterygoid plate superiorly and the mandible inferiorly; and (3) the root (posterior part) of the tongue.
- The middle pharyngeal constrictor muscle arises from the angle formed by the greater and lesser horns of the hyoid bone and from the stylohyoid ligament; in this specimen, the styloid process is long and, therefore, a lateral relation of the tonsil.
- The lingual nerve is joined by the chorda tympani, disappears at the posterior border of the medial pterygoid muscle, and reappears at the anterior border to follow the mandible.



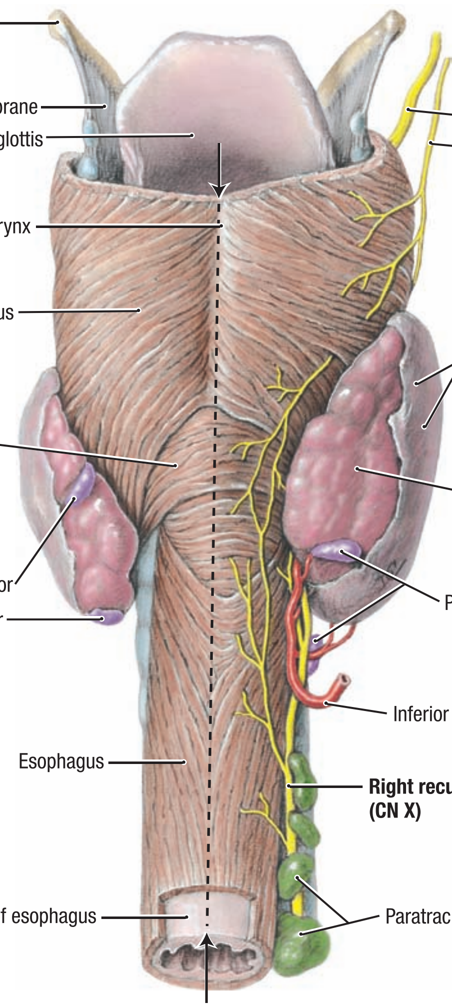
8.37 CARTILAGES OF LARYNGEAL SKELETON



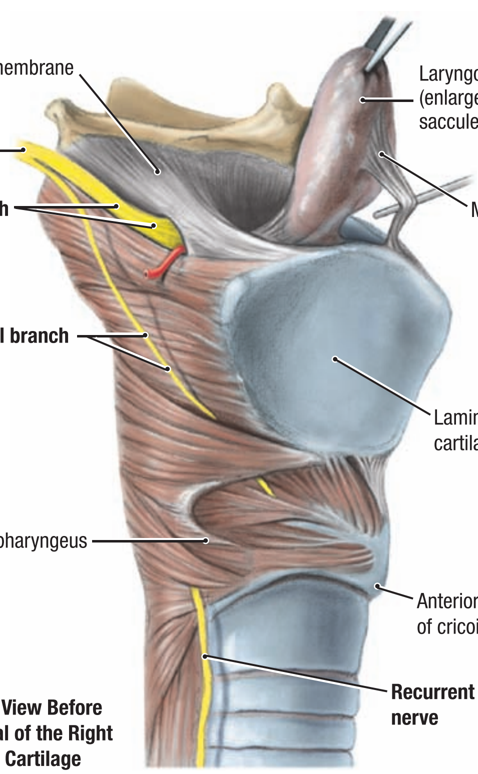
8.37 CARTILAGES OF THE LARYNGEAL SKELETON *(CONTINUED)*

A., B. and E. Articulated laryngeal skeleton. **C. and D.** Cartilages disarticulated and separated. **F.** Epiglottis and hyo-epiglottic ligament. **G.** Conus elasticus and rima glottidis.

- The larynx extends vertically from the tip of the epiglottis to the inferior border of the cricoid cartilage. The hyoid bone is generally not regarded as part of the larynx.
- The cricoid cartilage is the only cartilage that totally encircles the airway.
- The rima glottidis is the aperture between the vocal folds. During normal respiration, it is narrow and wedge shaped; during forced respiration, it is wide. Variations in the tension and length of the vocal folds, in the width of the rima glottidis, and in the intensity of the expiratory effort produce changes in the pitch of the voice.
- **Laryngeal fractures** may result from blows received in sports such as kickboxing and hockey or from compression by a shoulder strap during an automobile accident. Laryngeal fractures produce submucous hemorrhage and edema, respiratory obstruction, hoarseness, and sometimes a temporary inability to speak. The thyroid, cricoid, and most of the arytenoid cartilages often ossify as age advances, commencing at approximately 25 years of age in the thyroid cartilage.



A. **Posterior View**



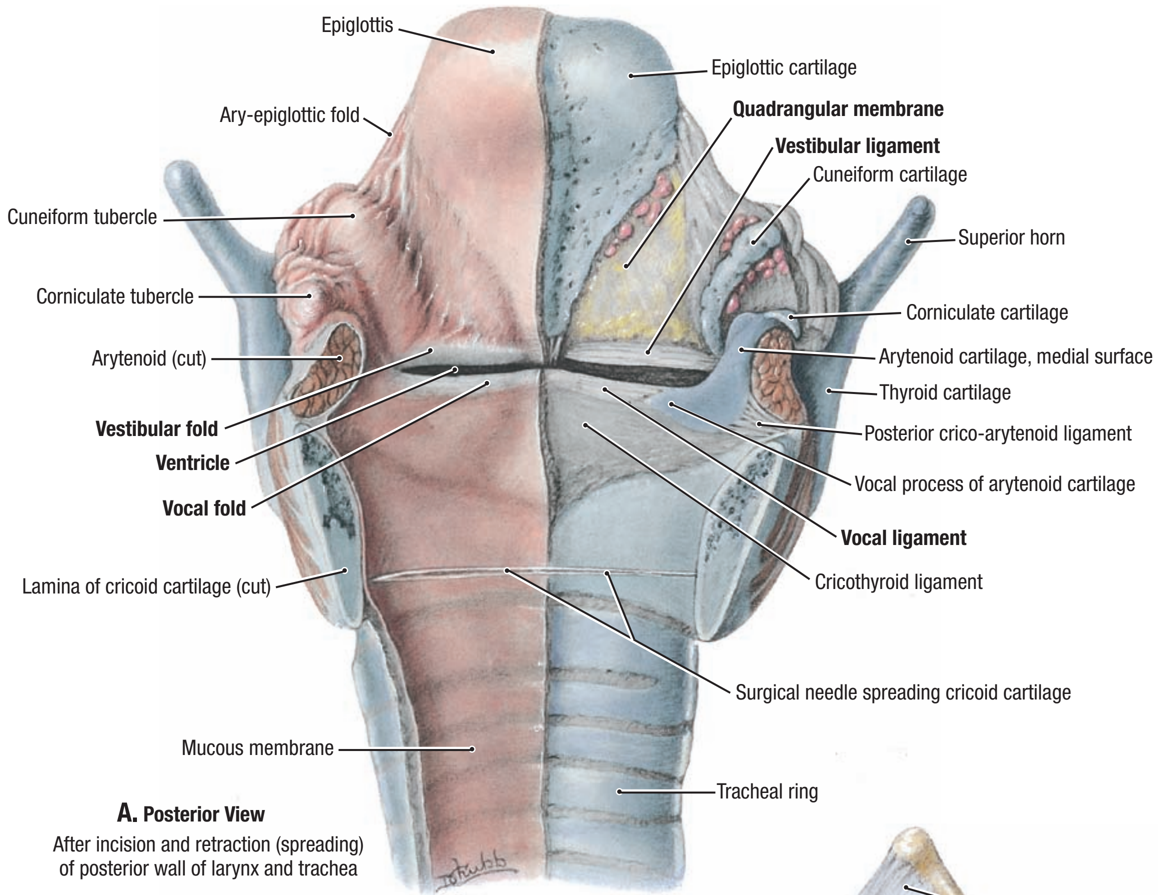
B. **Lateral View Before Removal of the Right Thyroid Cartilage**

8.38 EXTERNAL LARYNX AND LARYNGEAL NERVES

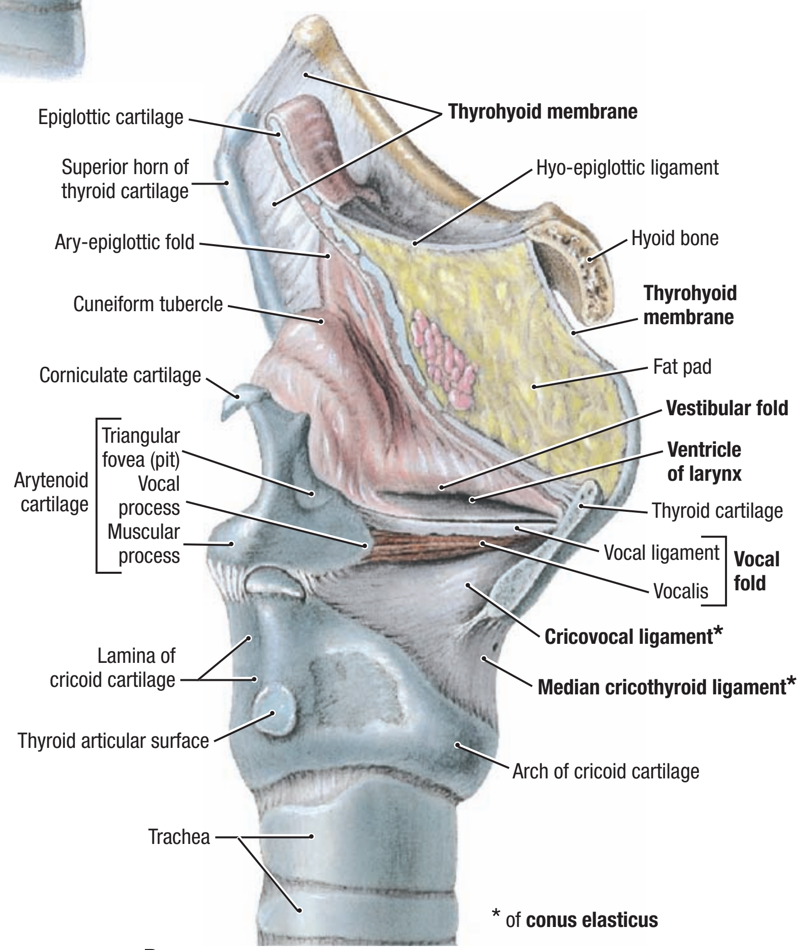
A. Posterior aspect.

- The internal branch of the superior laryngeal nerve innervates the mucous membrane superior to the vocal folds, and the external laryngeal branch supplies the inferior pharyngeal constrictor and cricothyroid muscles.
- The recurrent laryngeal nerve supplies the esophagus, trachea, and inferior pharyngeal constrictor muscle. It supplies sensory innervation inferior to the vocal folds and motor innervation to the intrinsic muscles of the larynx, except the cricothyroid.

B. Laryngocele. A laryngocele (enlarged laryngeal saccule) projects through the thyrohyoid membrane and communicates with the larynx through the ventricle. This air sac can form a bulge in the neck, especially on coughing. The inferior laryngeal nerves are vulnerable to injury during operations in the anterior triangles of the neck. **Injury of the inferior laryngeal nerve** results in paralysis of the vocal fold. The voice is initially poor because the paralyzed fold cannot adduct to meet the normal vocal fold. In a bilateral paralysis, the voice is almost absent. **Injury to the external branch of the superior laryngeal nerve** results in a voice that is monotonous in character because the cricothyroid muscle is unable to vary the tension of the vocal fold. Hoarseness is the most common symptom of serious disorders of the larynx.



A. Posterior View
After incision and retraction (spreading) of posterior wall of larynx and trachea

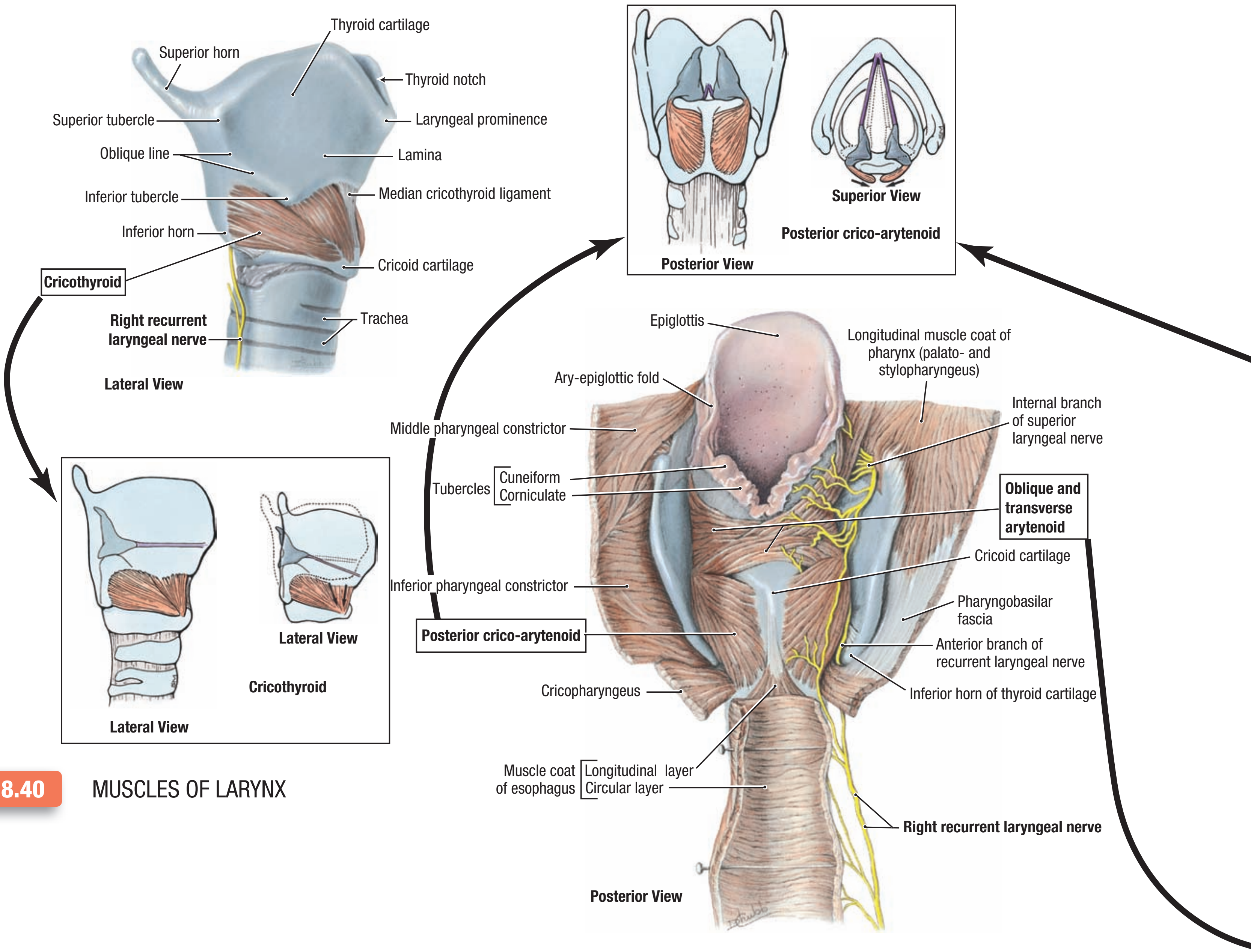


B. Lateral View After Removal of the Right Thyroid Cartilage

8.39 INTERNAL LARYNX

A. The posterior wall of the larynx is split in the median plane (see Fig. 8.29A), and the two sides held apart. On the left side of the specimen, the mucous membrane, which is the innermost coat of the larynx, is intact; on the right side of the specimen, the mucous and submucous coats are peeled off, and the next coat, consisting of cartilages, ligaments, and fibro-elastic membrane, is uncovered. **B.** Interior of the larynx superior to the vocal folds. The larynx is sectioned near the median plane to reveal the interior of its left side. Inferior to this level, the right side of the intact larynx is dissected.

- The three compartments of the larynx are (1) the superior compartment of the vestibule, superior to the level of the vestibular folds (false cords); (2) the middle, between the levels of the vestibular and vocal folds; and (3) the inferior, or infraglottic, cavity, inferior to the level of the vocal folds.
- The quadrangular membrane underlies the ary-epiglottic fold superiorly and is thickened inferiorly to form the vestibular ligament. The cricothyroid ligament (conus elasticus) begins inferiorly as the strong median cricothyroid ligament and is thickened superiorly as the vocal ligament. The lateral recess between the vocal and vestibular ligaments, lined with mucous membrane, is the ventricle.

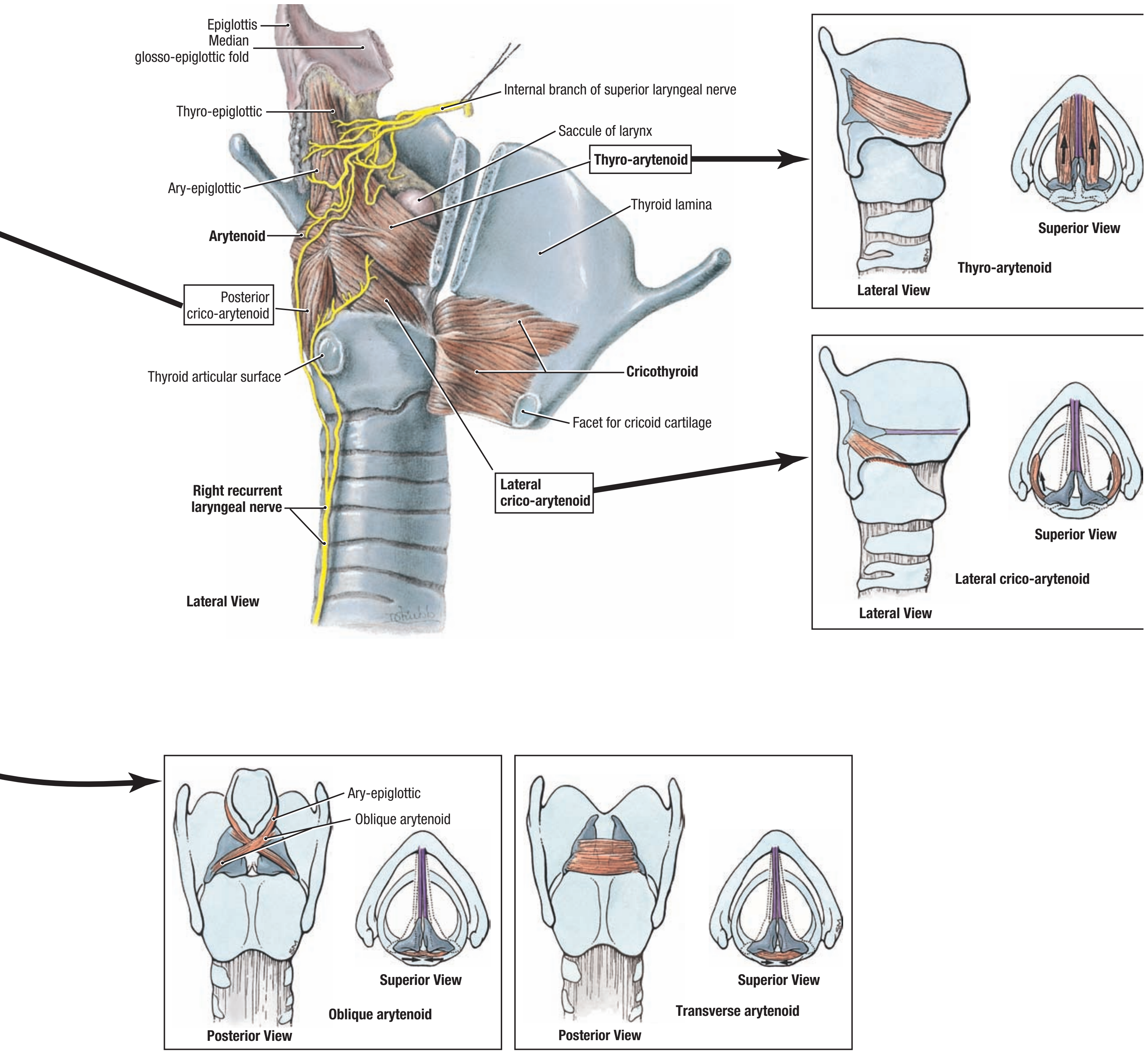


8.40 MUSCLES OF LARYNX

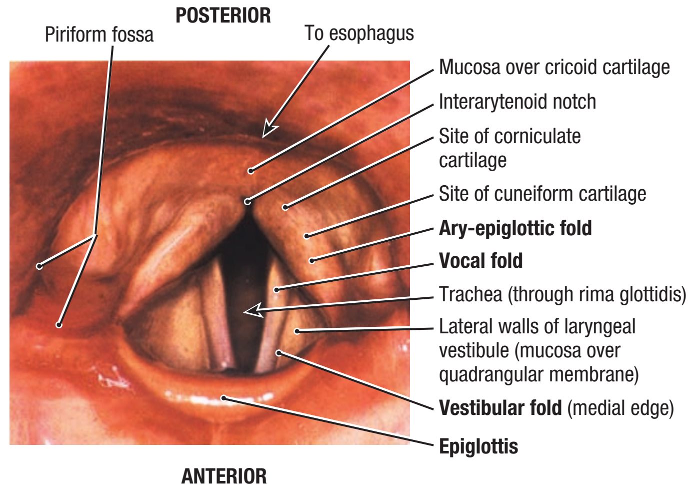
TABLE 8.10 MUSCLES OF LARYNX

Muscle	Origin	Insertion	Innervation	Main Action(s)
Cricothyroid	Anterolateral part of cricoid cartilage	Inferior margin and inferior horn of thyroid cartilage	External branch of superior laryngeal nerve (CN X)	Tenses vocal fold
Posterior cricoarytenoid	Posterior surface of laminae of cricoid cartilage	Muscular process of arytenoid cartilage	Recurrent laryngeal nerve (CN X)	Abducts vocal fold
Lateral cricoarytenoid	Arch of cricoid cartilage			Adducts vocal fold
Thyroarytenoid[a]	Posterior surface of thyroid cartilage			Relaxes vocal fold
Transverse and oblique arytenoids[b]	One arytenoid cartilage	Opposite arytenoid cartilage		Close inlet of larynx by approximating arytenoid cartilages
Vocalis[c]	Angle between laminae of thyroid cartilage	Vocal ligament, between origin and vocal process of arytenoid cartilage		Alters vocal fold during phonation

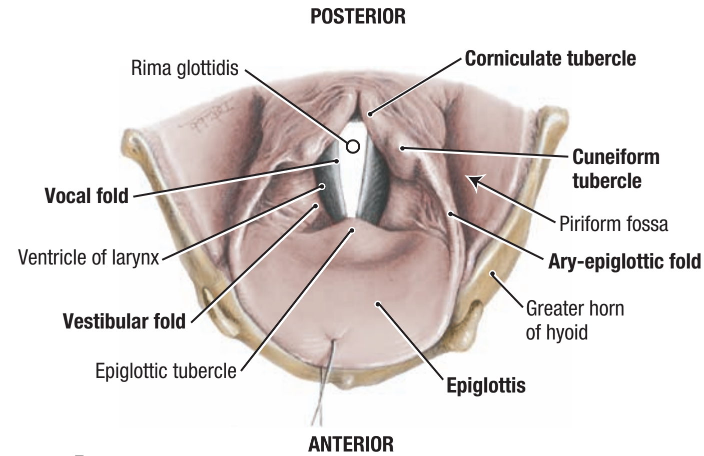
[a]Superior fibers of the thyroarytenoid muscle pass into the aryepiglottic fold, and some of them reach the epiglottic cartilage. These fibers constitute the thyroepiglottic muscle, which widens the inlet of the larynx.
[b]Some fibers of the oblique arytenoid muscle continue as the aryepiglottic muscle.
[c]This slender muscular slip is derived from inferior deeper fibers of the thyroarytenoid muscle.



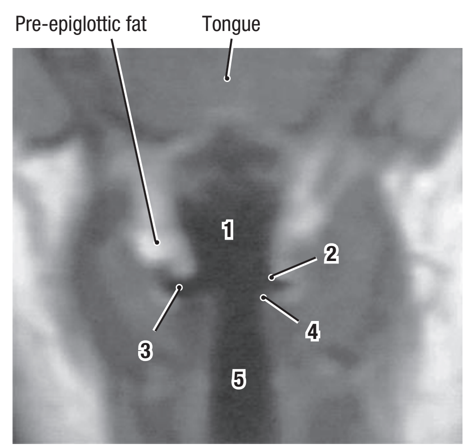
8.40 MUSCLES OF LARYNX *(CONTINUED)*



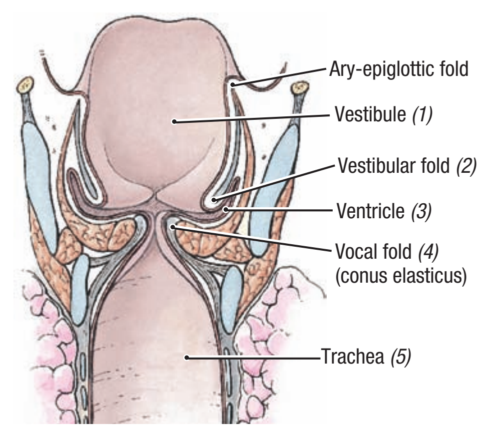
A. **Laryngoscopic Examination**



B. **Superior View**



C. **Coronal MRI**

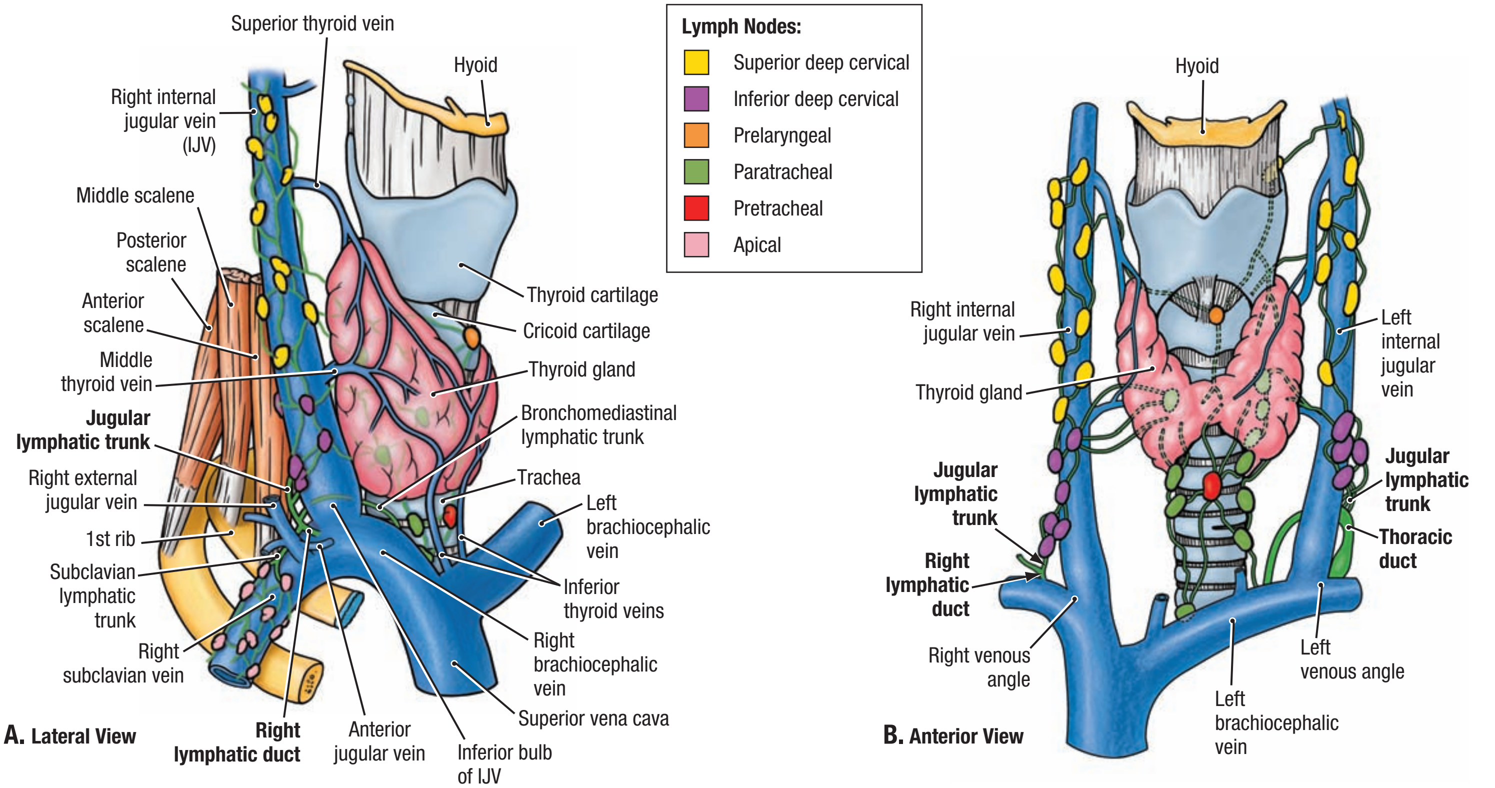


D. **Posterior View**

8.41 LARYNGOSCOPIC EXAMINATION AND MRI IMAGING OF LARYNX

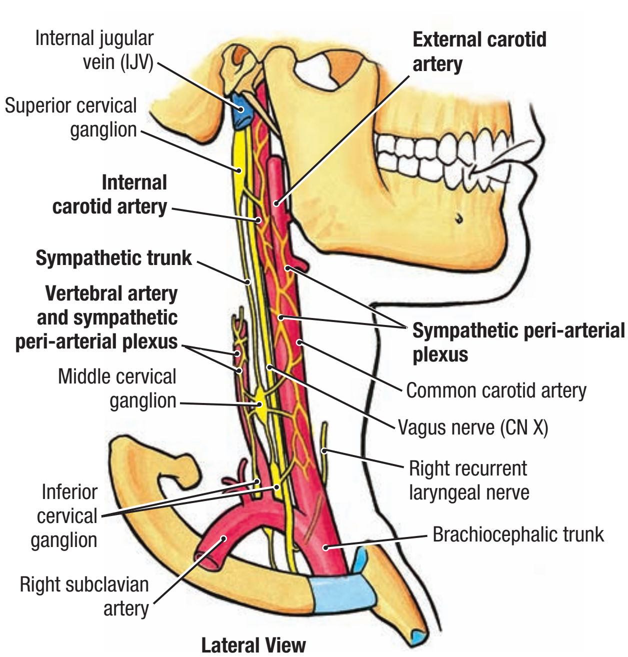
A. Laryngoscopic examination. Laryngoscopy is the procedure used to examine the interior of the larynx. The larynx may be examined visually by indirect laryngoscopy using a laryngeal mirror or it may be viewed by direct laryngoscopy using a tubular and endoscopic instrument, a laryngoscope. The vestibular and vocal folds can be observed. **B.** Vocal folds and rima glottidis. The inlet, or aditus, to the larynx is bounded anteriorly by the epiglottis; posteriorly by the arytenoid cartilages, the corniculate cartilages that cap them, and the interarytenoid fold that unites them; and on each side by the ary-epiglottic fold, which contains the superior end of the cuneiform cartilage. The vocal apparatus of the larynx, the glottis, includes the vocal folds, vocal processes of the arytenoid cartilages and the rima glottidis, the aperture between the vocal folds. **C.** Coronal MRI. **D.** Coronal section. Numbers in parentheses on diagram refer to numbered structures on MRI.

A foreign object, such as a piece of steak, may accidentally aspirate through the laryngeal inlet into the vestibule of the larynx, where it becomes trapped superior to the vestibular folds. When a foreign object enters the vestibule, the laryngeal muscles go into spasm, tensing the vocal folds. The rima glottidis closes and no air enters the trachea. **Asphyxiation** occurs, and the person will die in approximately 5 minutes from lack of oxygen if the obstruction is not removed. Emergency therapy must be given to open the airway. The procedure used depends on the condition of the patient, the facilities available, and the experience of the person giving first aid. Because the lungs still contain air, sudden compression of the abdomen **(Heimlich maneuver)** causes the diaphragm to elevate and compress the lungs, expelling air from the trachea into the larynx. This maneuver may dislodge the food or other material from the larynx.



8.42 LYMPHATIC DRAINAGE OF THYROID GLAND, LARYNX, AND TRACHEA

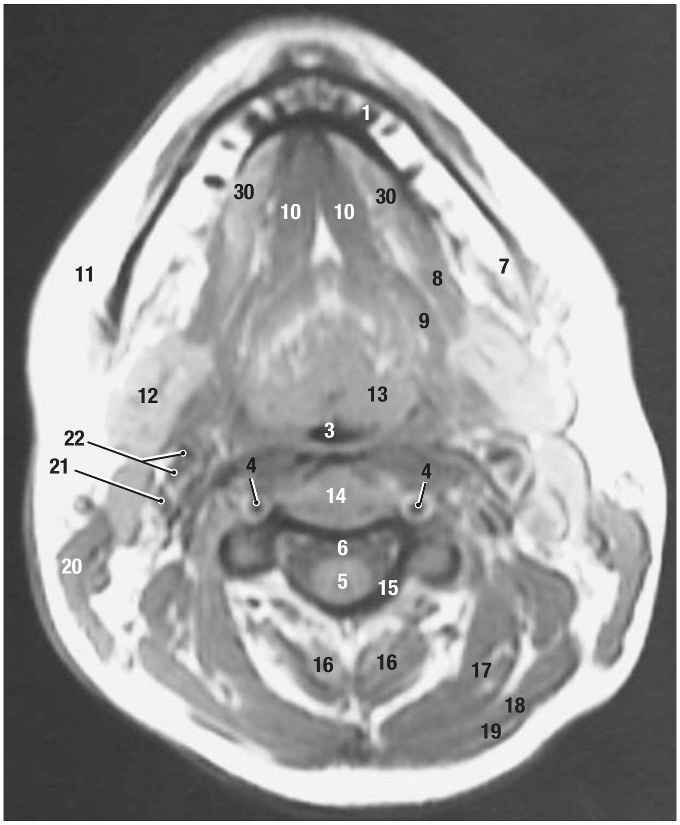
Radical neck dissections are performed when cancer invades the lymphatics. During the procedure, the deep cervical lymph nodes and the tissues around them are removed as completely as possible. Although major arteries, the brachial plexus, CN X, and the phrenic nerve are preserved, most cutaneous branches of the cervical plexus are removed. The aim of the dissection is to remove all tissue that contains lymph nodes in one piece.



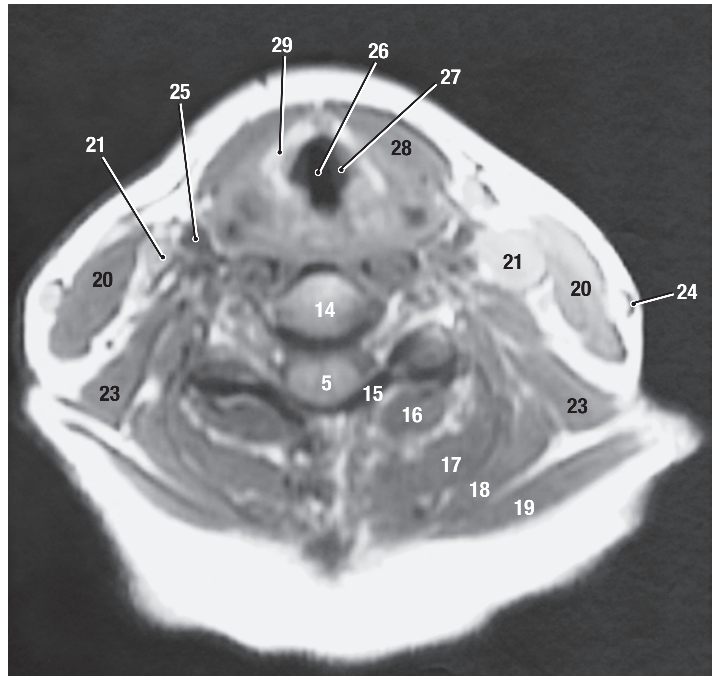
8.43 SYMPATHETIC TRUNK AND SYMPATHETIC PERIARTERIAL PLEXUS

A **lesion of a sympathetic trunk** in the neck results in a sympathetic disturbance called **Horner syndrome,** which is characterized by the following:

- Pupillary constriction resulting from paralysis of the dilator pupillae muscle.
- Ptosis (drooping of the superior eyelid), resulting from paralysis of the smooth (tarsal) muscle intermingled with striated muscle of the levator palpebrae superioris.
- Sinking in of the eyeball (enophthalmos), possibly caused by paralysis of smooth (orbitalis) muscle in the floor of the orbit.
- Vasodilation and absence of sweating on the face and neck (anhydrosis), caused by a lack of sympathetic (vasoconstrictive) nerve supply to the blood vessels and sweat glands.



A



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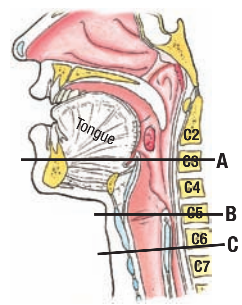
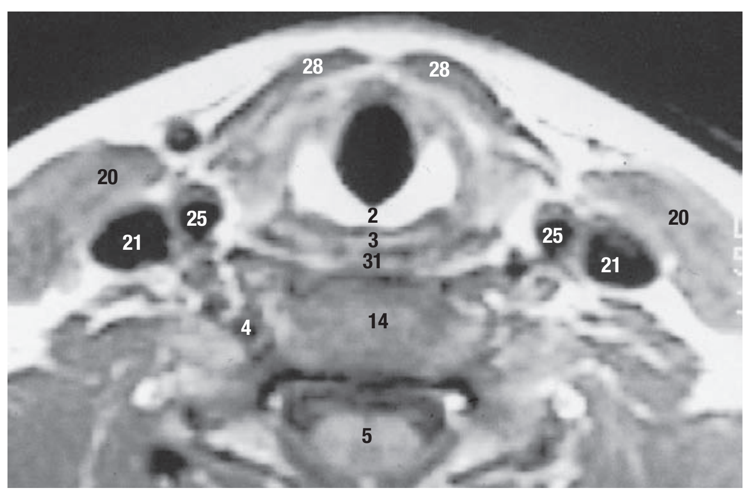


Inferior Views

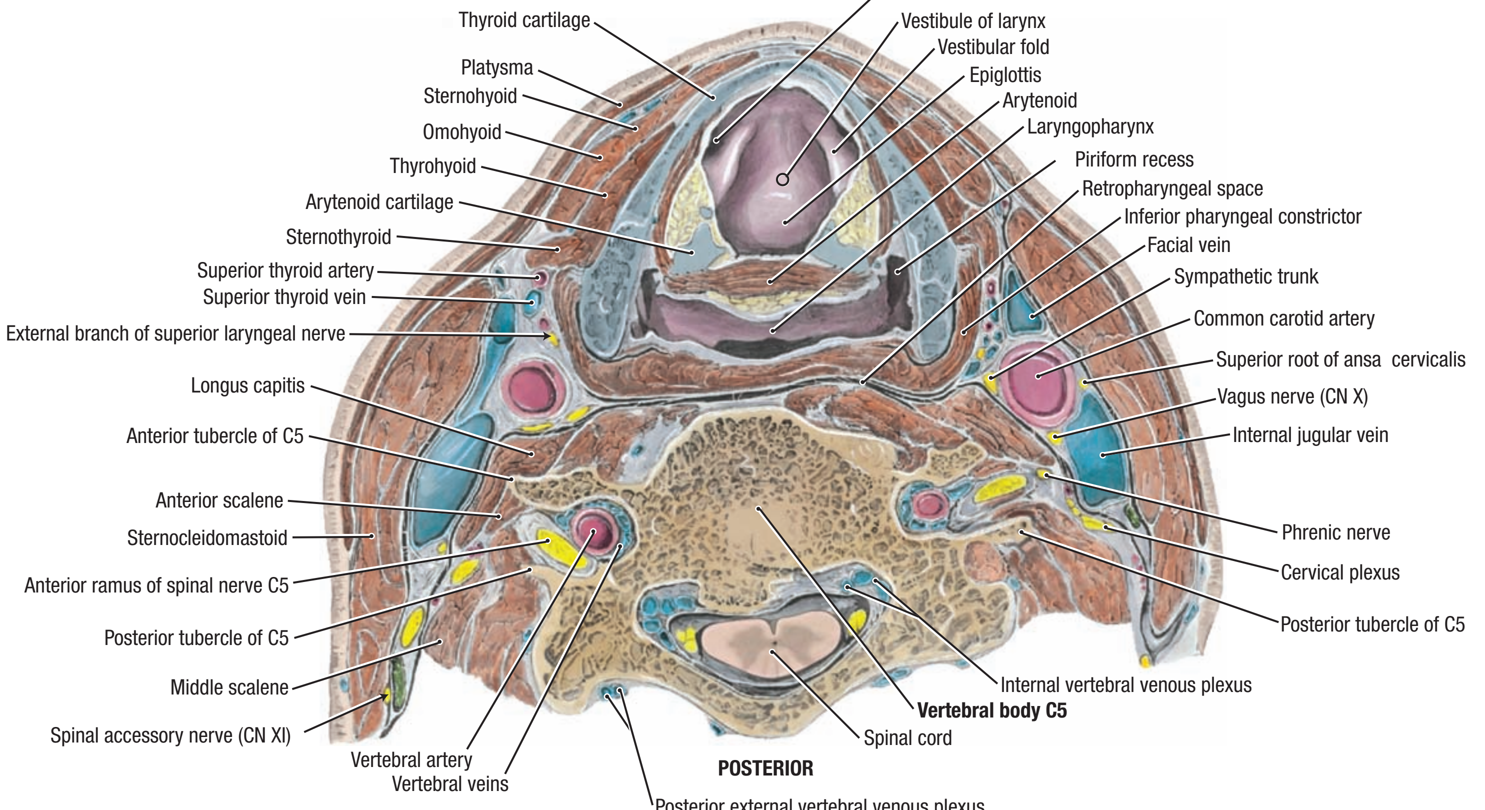


C

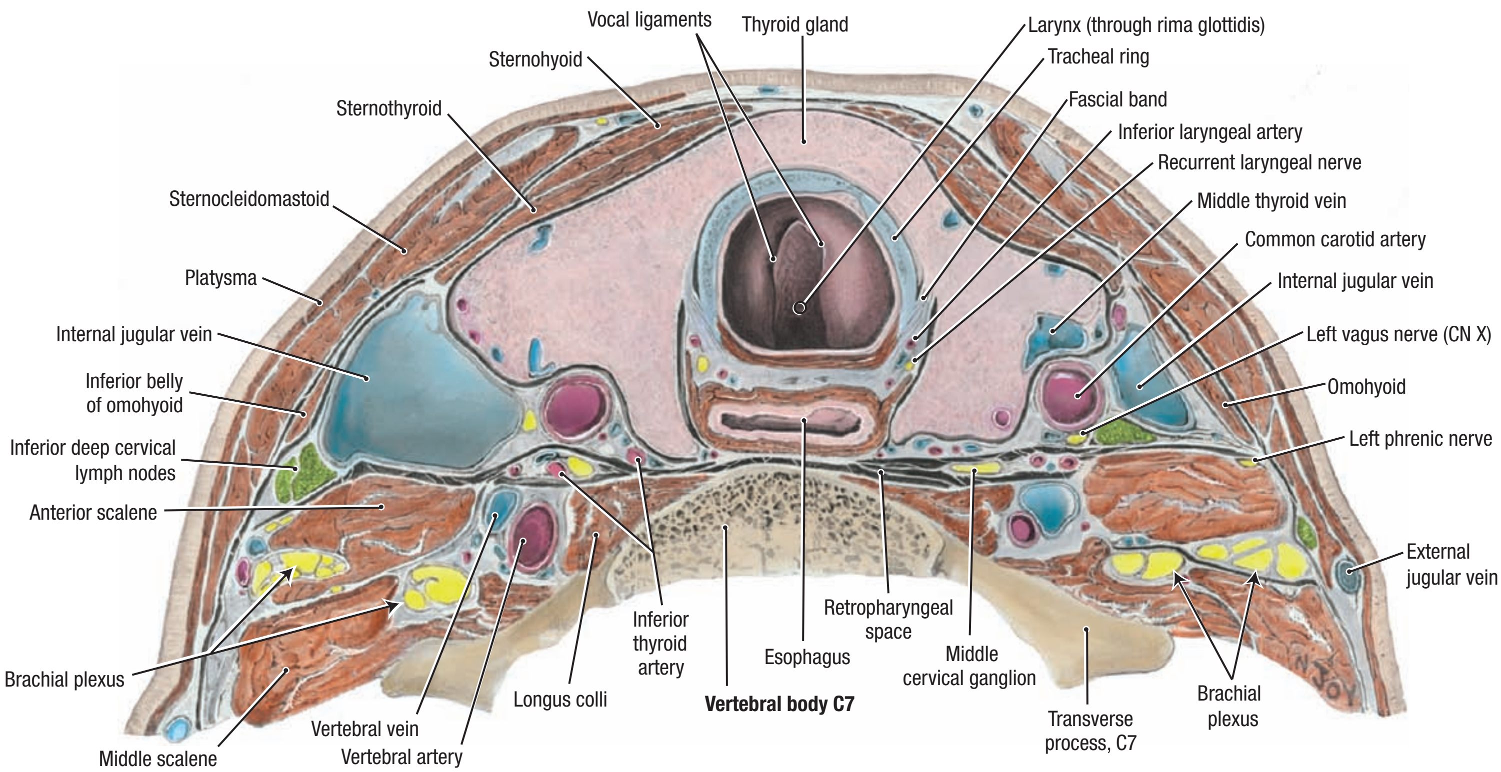
1	Tooth	16	Semispinalis cervicis
2	Cricoid cartilage	17	Semispinalis capitis
3	Pharynx	18	Splenius capitis
4	Vertebral artery	19	Trapezius
5	Spinal cord	20	Sternocleidomastoid
6	Cerebrospinal fluid in subarachnoid space	21	Internal jugular vein
		22	Bifurcation of common carotid artery
7	Body of mandible	23	Levator scapulae
8	Mylohyoid	24	External jugular vein
9	Hyoglossus	25	Common carotid artery
10	Genioglossus	26	Rima glottidis
11	Buccal fat pad	27	Vocal fold
12	Submandibular gland	28	Strap muscles
13	Intrinsic muscles of tongue	29	Thyroid cartilage
14	Vertebral body	30	Sublingual gland
15	Lamina of vertebra	31	Inferior pharyngeal constrictor

8.44 TRANSVERSE MRIs OF NECK

The orientation figure indicates the vertebral level of the MRI sections.

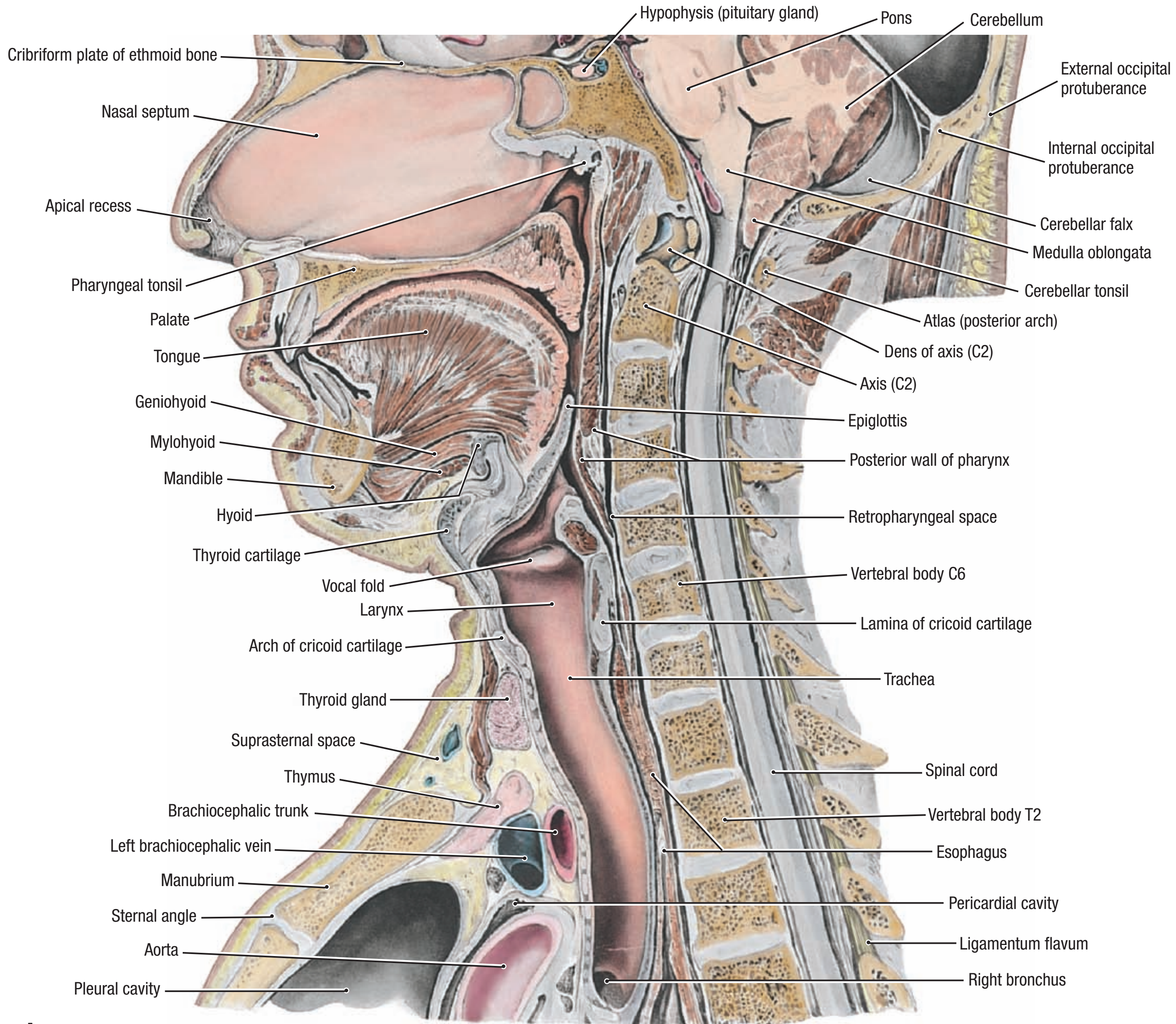


A. Inferior View, at Level of C5 Vertebra

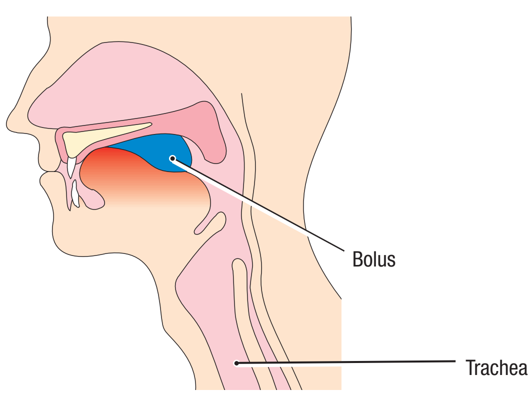


B. Inferior View, at Level of C7 Vertebra

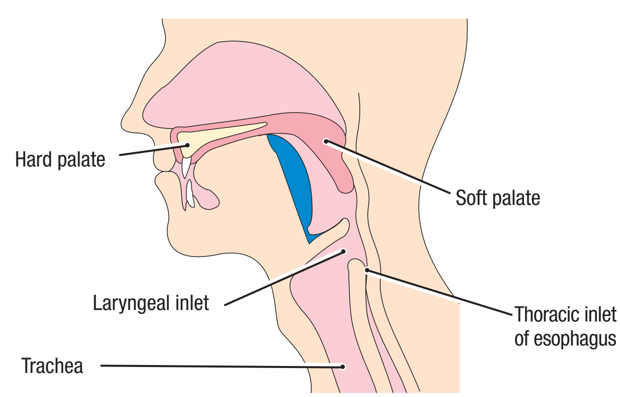
8.45 TRANSVERSE ANATOMICAL SECTIONS OF NECK



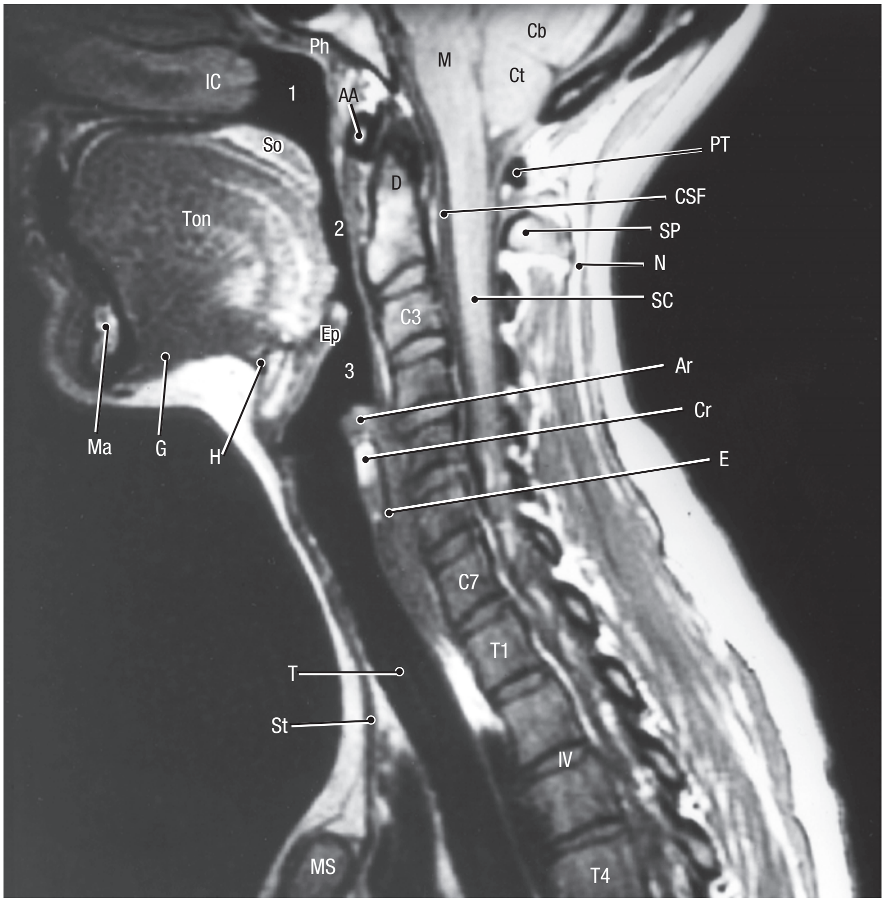
A. Median Section



(1) The bolus of food is squeezed to the back of the mouth by pushing the tongue against the palate.

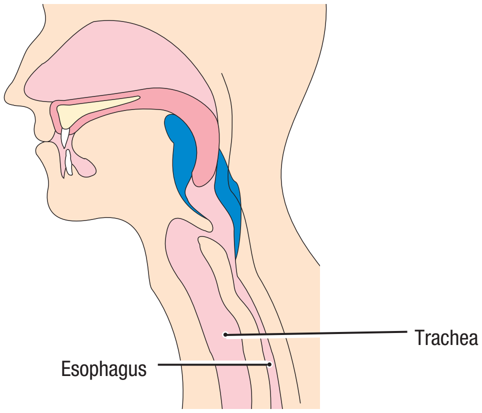


(2) The nasopharynx is sealed off, and the larynx is elevated, enlarging the pharynx to receive food.

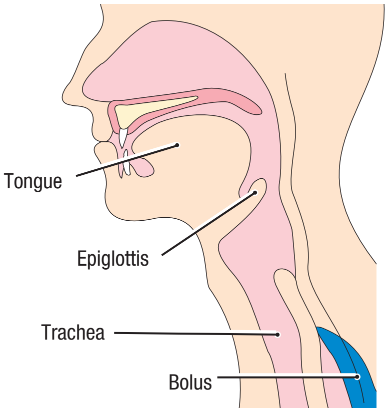


B. **Median MRI Scan**

AA	Anterior arch of C1
Ar	Arytenoid cartilage
C3-T4	Vertebral bodies
Cb	Cerebellum
Cr	Cricoid cartilage
CSF	Cerebrospinal fluid in subarachnoid space
Ct	Tonsil of cerebellum
D	Dens
E	Esophagus
Ep	Epiglottis
G	Genioglossus
H	Hyoid
IC	Inferior concha
IV	Intervertebral disc
M	Medulla oblongata
Ma	Mandible
MS	Manubrium of sternum
N	Nuchal ligament
Ph	Pharyngeal tonsil (adenoid)
PT	Posterior tubercle of C1
SC	Spinal cord
So	Soft palate
SP	Spinous process
St	Strap muscles
T	Trachea
Ton	Tongue
1	Nasopharynx
2	Oropharynx
3	Laryngopharynx



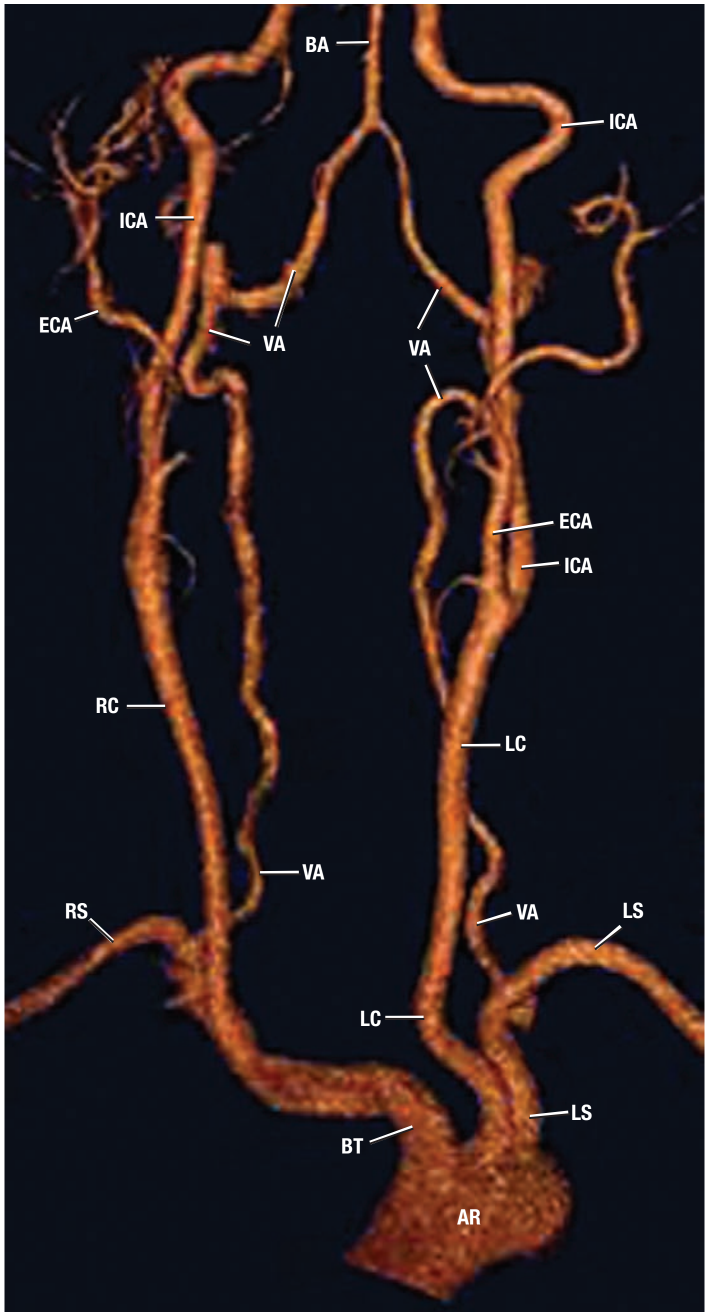
(3) The pharyngeal sphincters contract sequentially, squeezing food into the esophagus. The epiglottis deflects the bolus from but does not close the inlet to the larynx and trachia.



(4) The bolus of food moves down the esophagus by peristaltic contractions.

8.46 MEDIAN SECTION AND MRI SCAN OF HEAD AND NECK

A. Median anatomical section. **B.** Median MRI scan. **C.** Swallowing.

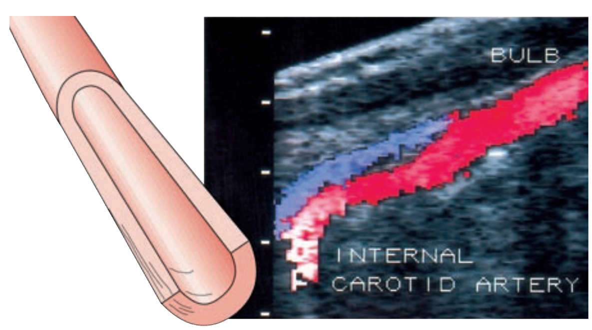


Anterior View

Key	
AR	Arch of aorta
BA	Basilar artery
BT	Brachiocephalic trunk
ECA	External carotid artery
ICA	Internal carotid artery
LC	Left common carotid artery
LS	Left subclavian artery
RC	Right common carotid artery
RS	Right subclavian artery
VA	Vertebral artery

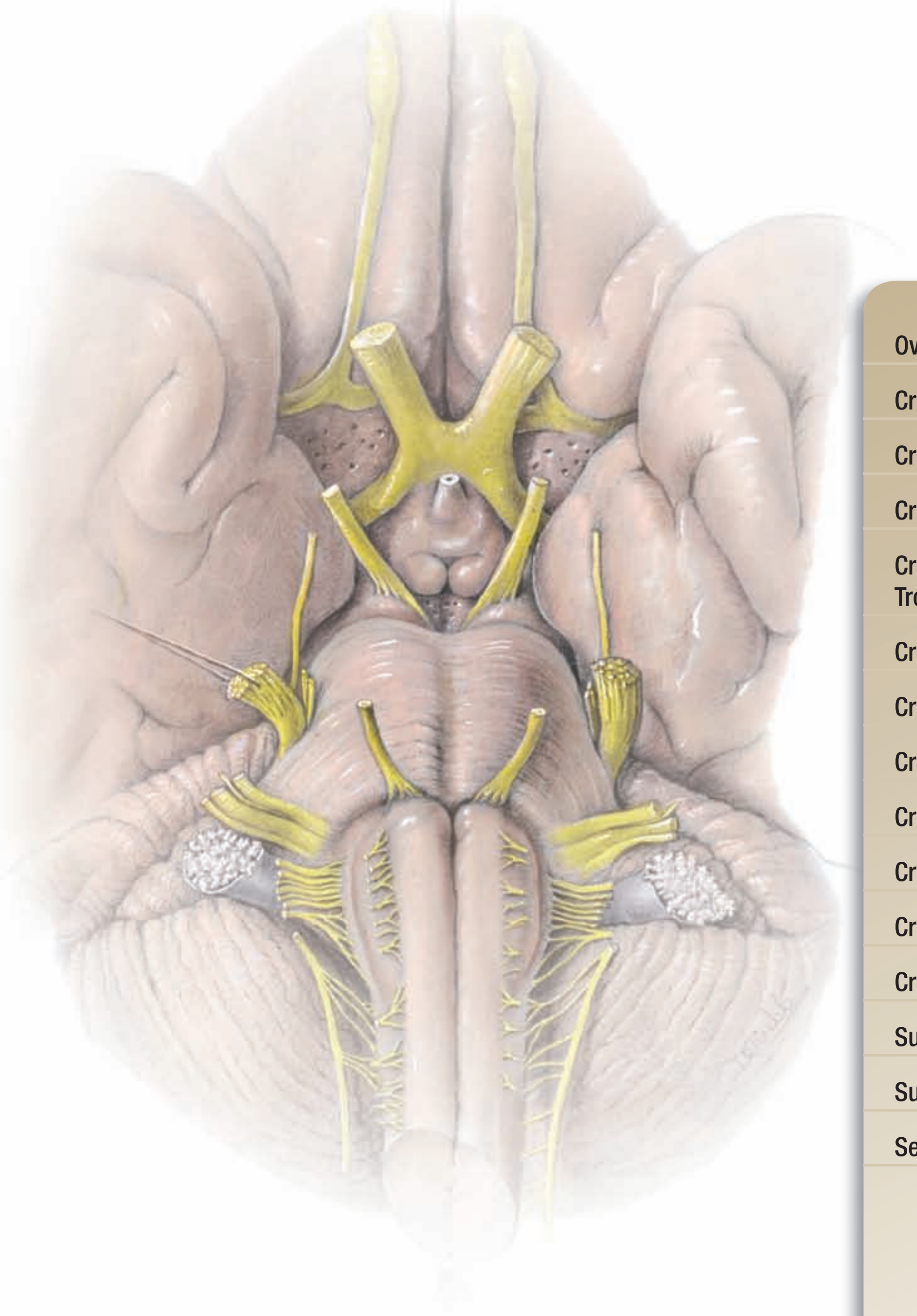
8.47 DOPPLER US COLOR FLOW STUDY OF CAROTID ARTERY

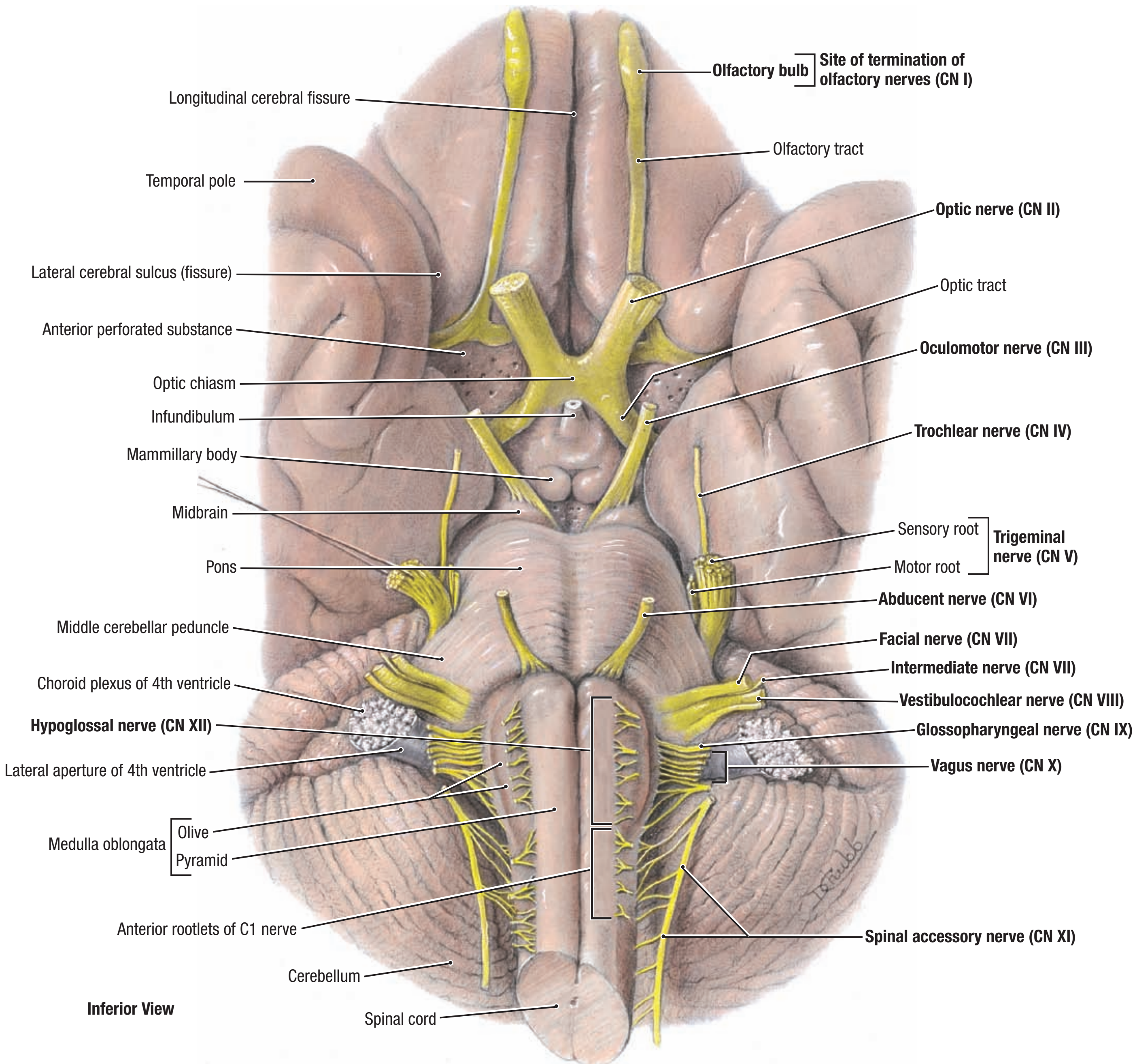
Ultrasonography is a useful diagnostic imaging technique for studying soft tissues of the neck. Ultrasound provides images of many abnormal conditions noninvasively, at relatively low cost, and with minimal discomfort. Ultrasound is useful for distinguishing solid from cystic masses, for example, which may be difficult to determine during physical examination. Vascular imaging of arteries and veins of the neck is possible using intravascular ultrasonography. The images are produced by placing the transducer over the blood vessel. Doppler ultrasound techniques help evaluate blood flow through a vessel (e.g., for detecting stenosis [narrowing] of a carotid artery).



CHAPTER 9

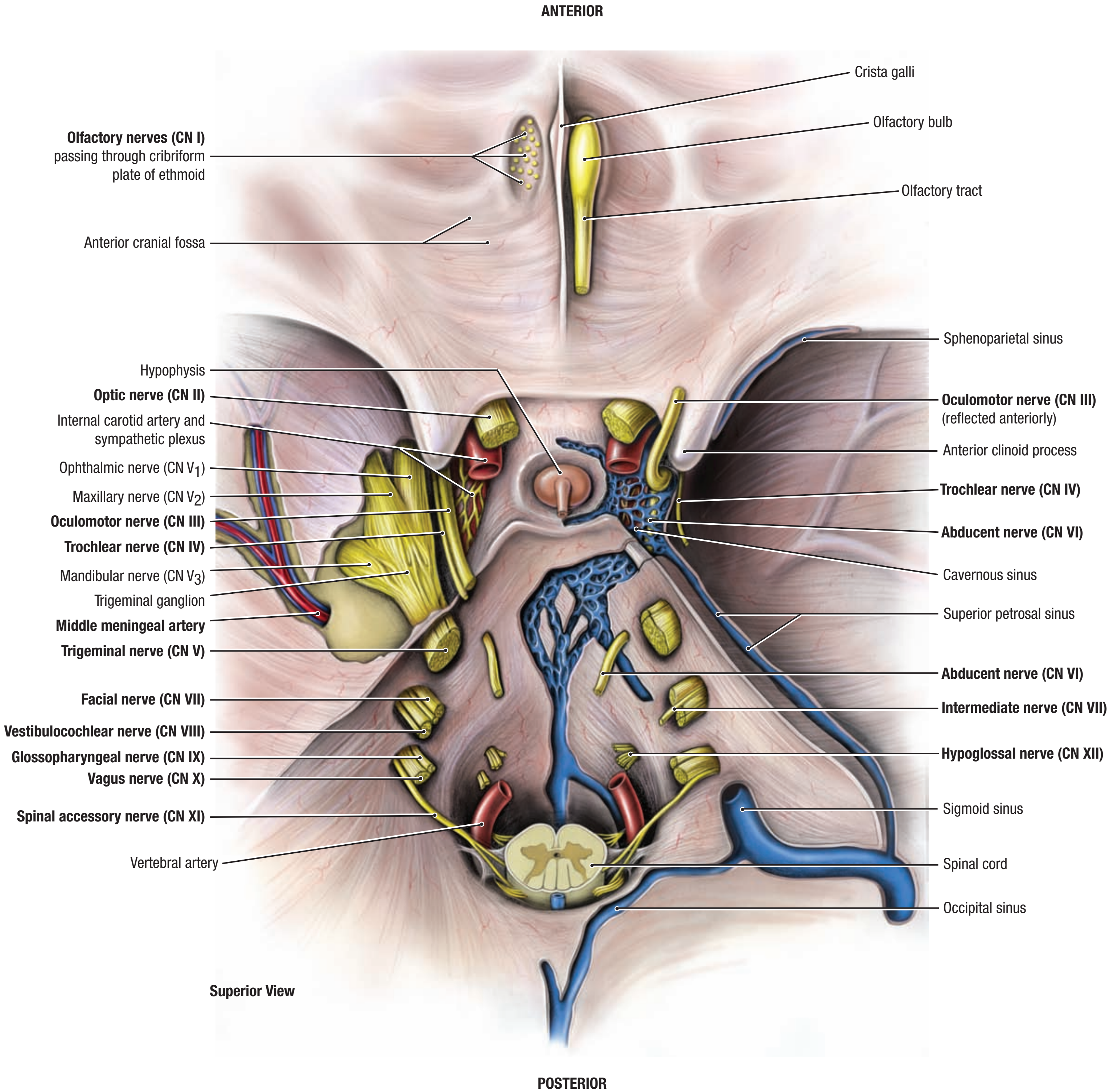
Cranial Nerves





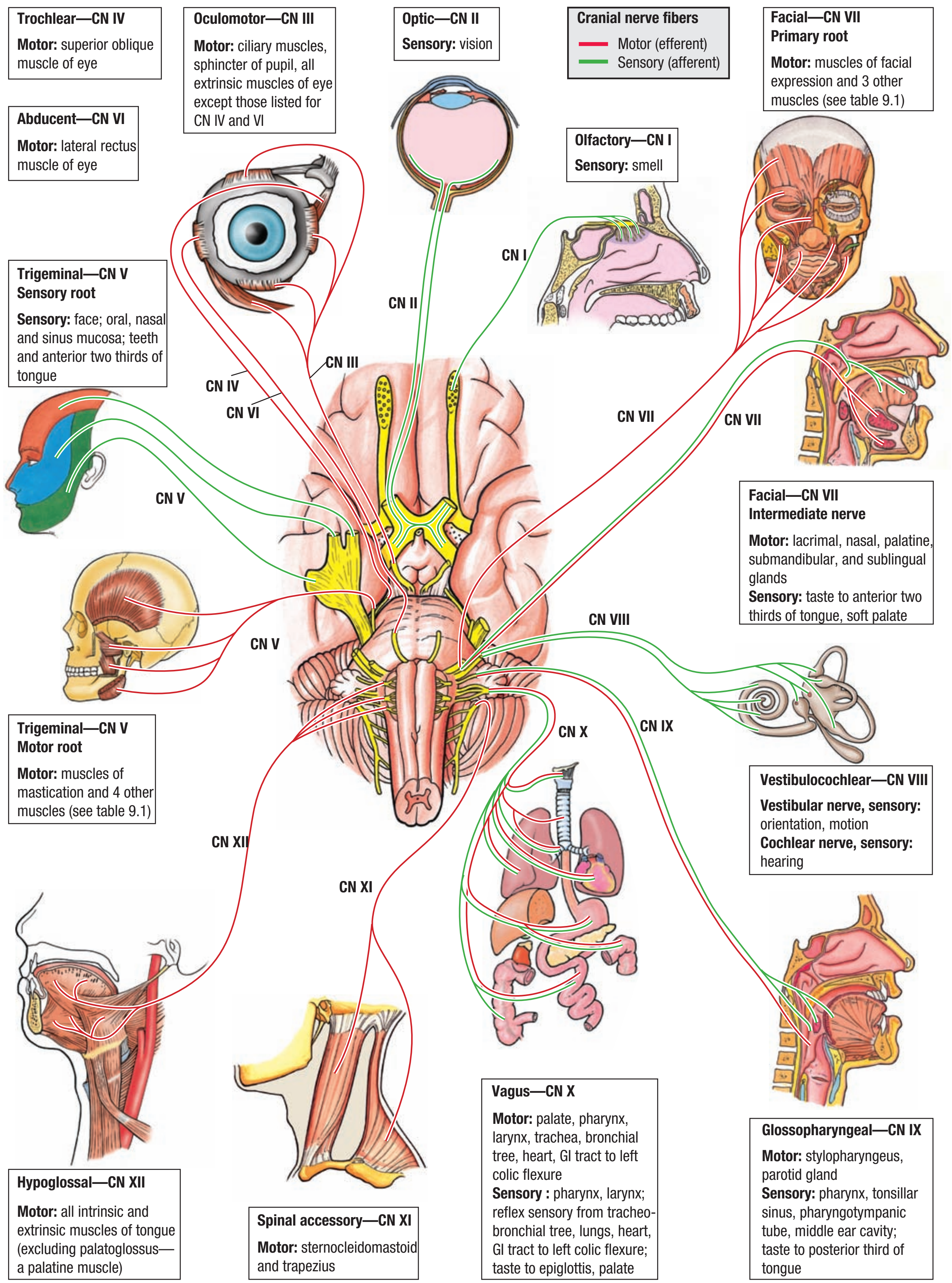
9.1 CRANIAL NERVES IN RELATION TO THE BASE OF THE BRAIN

Cranial nerves are nerves that exit from the cranial cavity through openings in the cranium. There are 12 pairs of cranial nerves that are named and numbered in rostrocaudal sequence of their superficial origins from the brain, brainstem, and superior spinal cord. The olfactory nerves (CN I, not shown) end in the olfactory bulb. The entire origin of the spinal accessory nerve (CN XI) from the spinal cord is not included here; it extends inferiorly as far as the C6 spinal cord segment.



9.2 CRANIAL NERVES IN RELATION TO THE INTERNAL ASPECT OF THE CRANIAL BASE

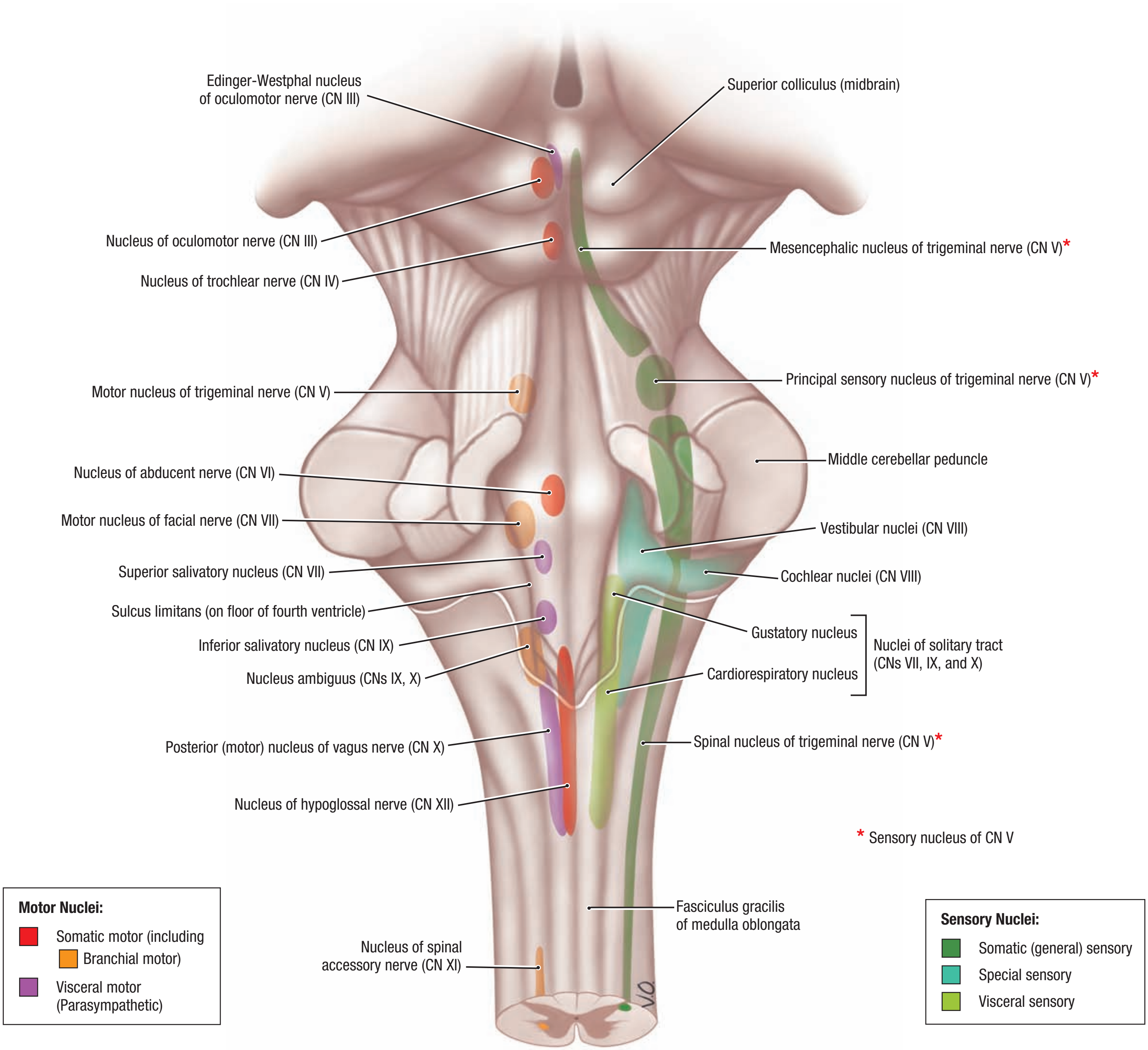
The venous sinuses have been opened on the right side. The ophthalmic division of the trigeminal nerve (CN V_1) and the trochlear (CN IV) and oculomotor (CN III) nerves have been dissected from the lateral wall of the cavernous sinus. Although there are no sympathetic fibers in cranial nerves as they leave the brain, postsynaptic sympathetic nerve fibers “hitch-hike” onto branches of cranial nerves having traveled to the region via major blood vessels.



9.3 SUMMARY OF CRANIAL NERVES

TABLE 9.1 SUMMARY OF CRANIAL NERVES

Nerve	Components	Location of Nerve Cell Bodies	Cranial Exit	Function
Olfactory (CN I)	Special sensory	Olfactory epithelium (olfactory cells)	Foramina in cribriform plate of ethmoid bone	Smell from nasal mucosa of roof of each nasal cavity, superior sides of nasal septum and superior concha
Optic (CN II)	Special sensory	Retina (ganglion cells)	Optic canal	Vision from retina
Oculomotor (CN III)	Somatic motor	Midbrain (nucleus of CN III)	Superior orbital fissure	Motor to superior, inferior, and medial rectus, inferior oblique, and levator palpebrae superioris that raise upper eyelid and direct gaze superiorly, inferiorly, and medially
	Visceral motor	Presynaptic: midbrain (Edinger-Westphal nucleus); Postsynaptic: ciliary ganglion		Parasympathetic innervation to sphincter pupillae and ciliary muscles that constrict pupil and accommodate lens of eye
Trochlear (CN IV)	Somatic motor	Midbrain (nucleus of CN IV)		Motor to superior oblique that assists in directing gaze inferolaterally
Trigeminal (CN V) Ophthalmic division (CN V^1)	Somatic (general) sensory	Trigeminal ganglion Synapse: sensory nucleus of CN V		Sensation from cornea, skin of forehead, scalp, eyelids, nose, and mucosa of nasal cavity and paranasal sinuses
Maxillary division (CN V^2)			Foramen rotundum	Sensation from skin of face over maxilla including upper lip, maxillary teeth, mucosa of nose, maxillary sinuses, and palate
Mandibular division (CN V^3)	Somatic (branchial) motor	Pons (motor nucleus of CN V)	Foramen ovale	Sensation from the skin over mandible, including lower lip and side of head, mandibular teeth, temporomandibular joint, and mucosa of mouth and anterior two thirds of tongue
				Motor to muscles of mastication, mylohyoid, anterior belly of digastric, tensor veli palatini, and tensor tympani
Abducent (CN VI)	Somatic motor	Pons (nucleus of CN VI)	Superior orbital fissure	Motor to lateral rectus to direct gaze laterally
Facial (CN VII)	Somatic (branchial) motor	Pons (motor nucleus of CN VII)	Internal acoustic meatus, facial canal, and stylomastoid foramen	Motor to muscles of facial expression and scalp; also supplies stapedius of middle ear, stylohyoid, and posterior belly of digastric
	Special sensory	Geniculate ganglion Synapse: nuclei of solitary tract		Taste from anterior two thirds of tongue, and palate
	General sensory	Geniculate ganglion Synapse: sensory nucleus of CN V		Sensation from skin of external acoustic meatus
	Visceral motor	Presynaptic: pons (superior salivatory nucleus); Postsynaptic: pterygopalatine ganglion and submandibular ganglion		Parasympathetic innervation to submandibular and sublingual salivary glands, lacrimal gland, and glands of nose and palate
Vestibulocochlear (CN VIII) Vestibular	Special sensory	Vestibular ganglion Synapse: vestibular nuclei	Internal acoustic meatus	Vestibular sensation from semicircular ducts, utricle, and saccule related to position and movement of head
Cochlear	Special sensory	Spiral ganglion Synapse: cochlear nuclei		Hearing from spiral organ
Glossopharyngeal (CN IX)	Somatic (branchial) motor	Medulla (nucleus ambiguus)	Jugular foramen	Motor to stylopharyngeus that assists with swallowing
	Visceral motor	Presynaptic: medulla (inferior salivatory nucleus); Postsynaptic: otic ganglion		Parasympathetic innervation to parotid gland
	Visceral sensory	Inferior ganglion		Visceral sensation from parotid gland, carotid body and sinus, pharynx, and middle ear
	Special sensory	Inferior ganglion Synapse: nuclei of solitary tract		Taste from posterior third of tongue
	General sensory	Superior ganglion Synapse: sensory nucleus of CN V		Cutaneous sensation from external ear
Vagus (CN X)	Somatic (branchial) motor	Medulla (nucleus ambiguus)		Motor to constrictor muscles of pharynx, intrinsic muscles of larynx, muscles of palate (except tensor veli palatini), and striated muscle in superior two thirds of esophagus
	Visceral motor	Presynaptic: medulla; Postsynaptic: neurons in, on, or near viscera		Smooth muscle of trachea, bronchi, and digestive tract, cardiac muscle
	Visceral sensory	Inferior ganglion Synapse: nuclei of solitary tract		Visceral sensation from base of tongue, pharynx, larynx, trachea, bronchi, heart, esophagus, stomach, and intestine
	Special sensory	Inferior ganglion Synapse: nuclei of solitary tract		Taste from epiglottis and palate
	Somatic (general) sensory	Superior ganglion Synapse: sensory nucleus of trigeminal nerve		Sensation from auricle, external acoustic meatus, and dura mater of posterior cranial fossa
Spinal accessory nerve (CN XI)	Somatic motor	Cervical spinal cord		Motor to sternocleidomastoid and trapezius
Hypoglossal (CN XII)	Somatic motor	Medulla (Nucleus of CN XII)	Hypoglossal canal	Motor to muscles of tongue (except palatoglossus)

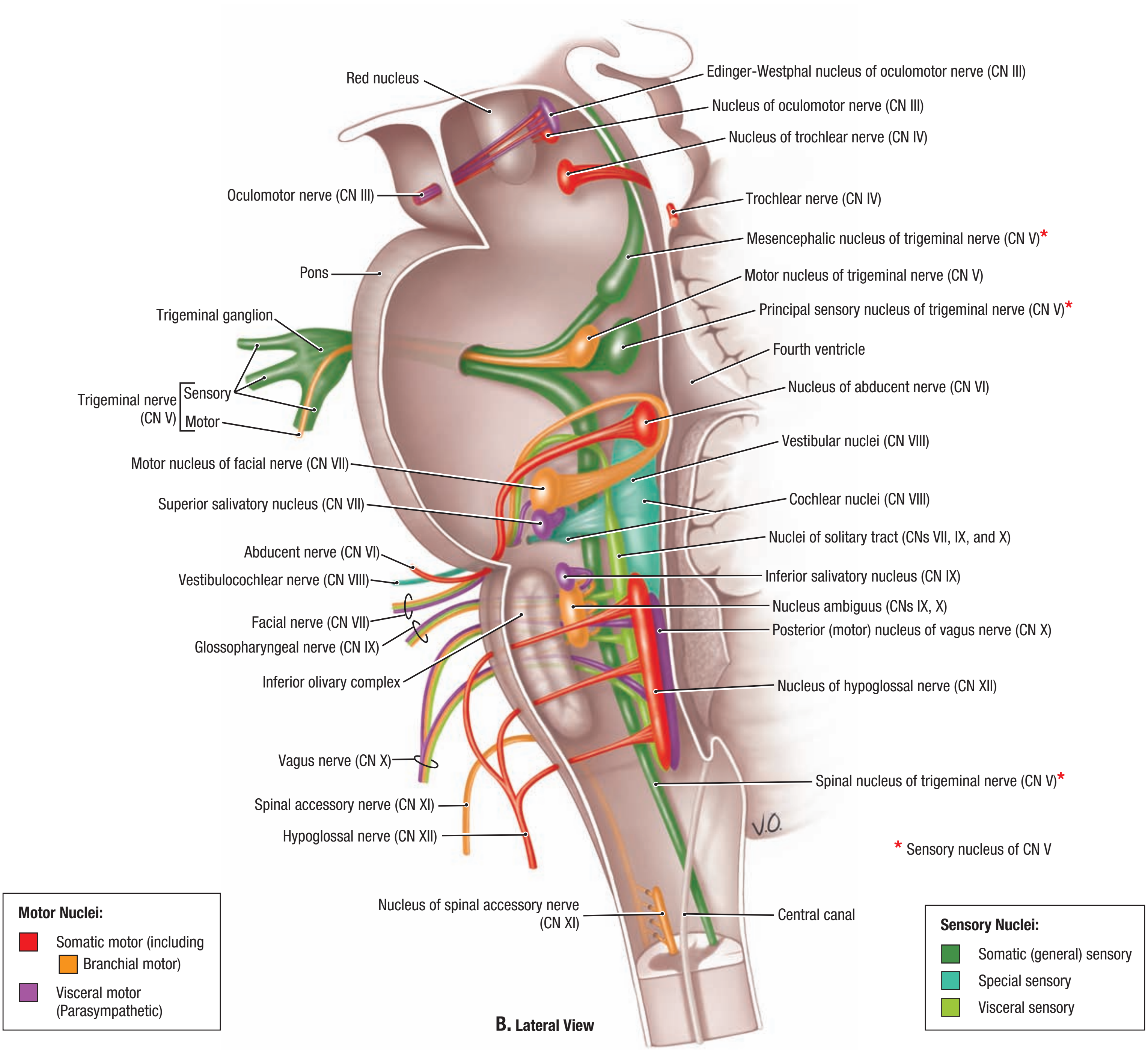


A. Posterior (Dorsal) View

9.4 CRANIAL NERVE NUCLEI

The fibers of the cranial nerves are connected to nuclei (groups of nerve cell bodies in the central nervous system), in which afferent (sensory) fibers terminate and from which efferent (motor) fibers originate. Nuclei of common functional types (motor, sensory, parasympathetic, and special sensory nuclei) have a generally columnar placement within the brainstem, with the sulcus limitans demarcating motor and sensory columns.

Somatic motor: motor fibers innervating voluntary (striated muscle). For the muscles derived from the embryonic pharyngeal arches, their somatic motor innervation can be referred to as *branchial motor.*



B. **Lateral View**

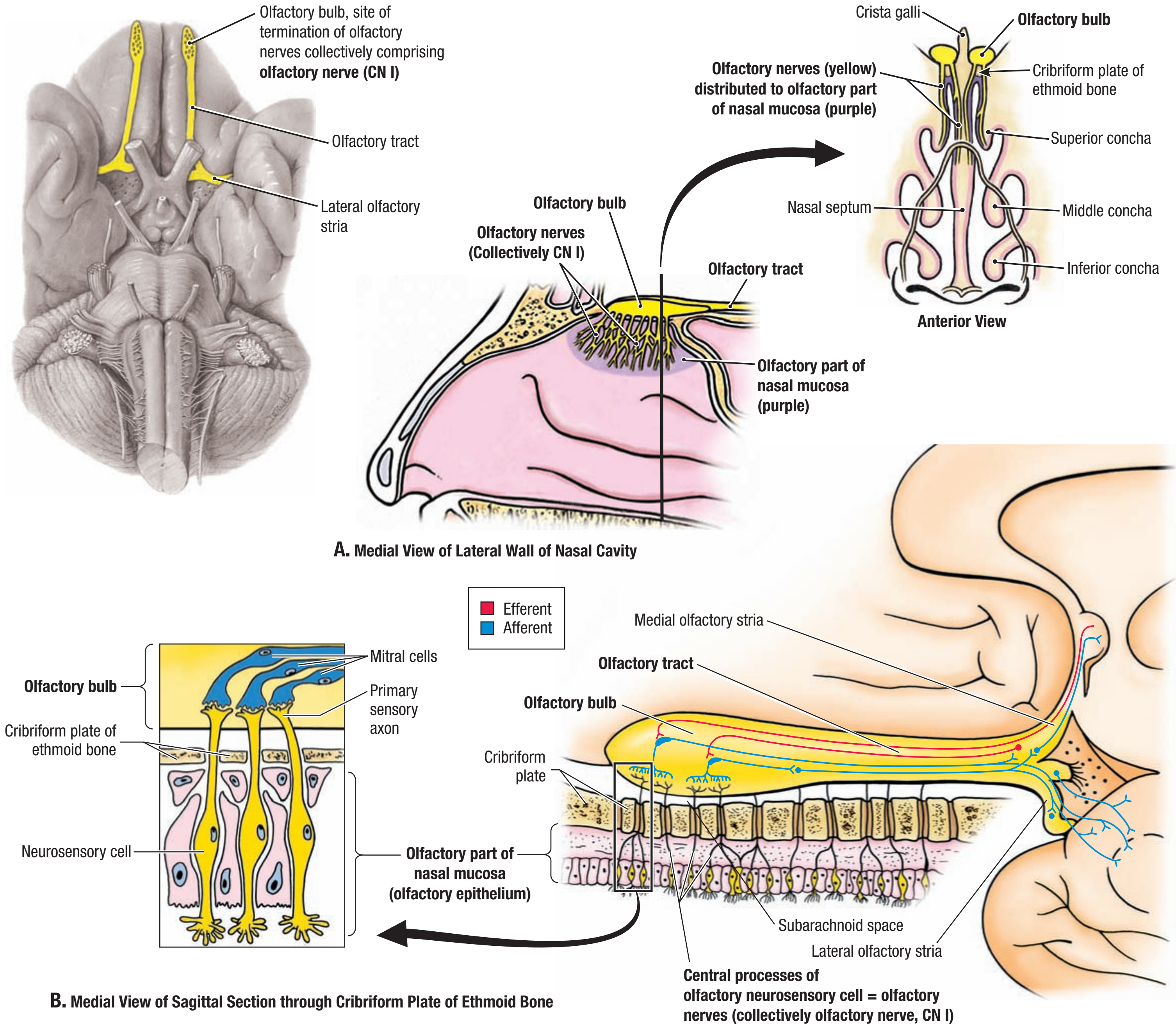
9.4 CRANIAL NERVE NUCLEI *(CONTINUED)*

Visceral motor: Parasympathetic innervation to glands and involuntary (smooth) muscle.

Somatic (general) sensory: Fibers transmitting general sensation from skin and membranes (e.g., touch, pressure, heat, cold).

Visceral sensory: Fibers conveying sensation from viscera (organs) and mucous membranes.

Special sensory: Taste, smell, vision, hearing, and balance.

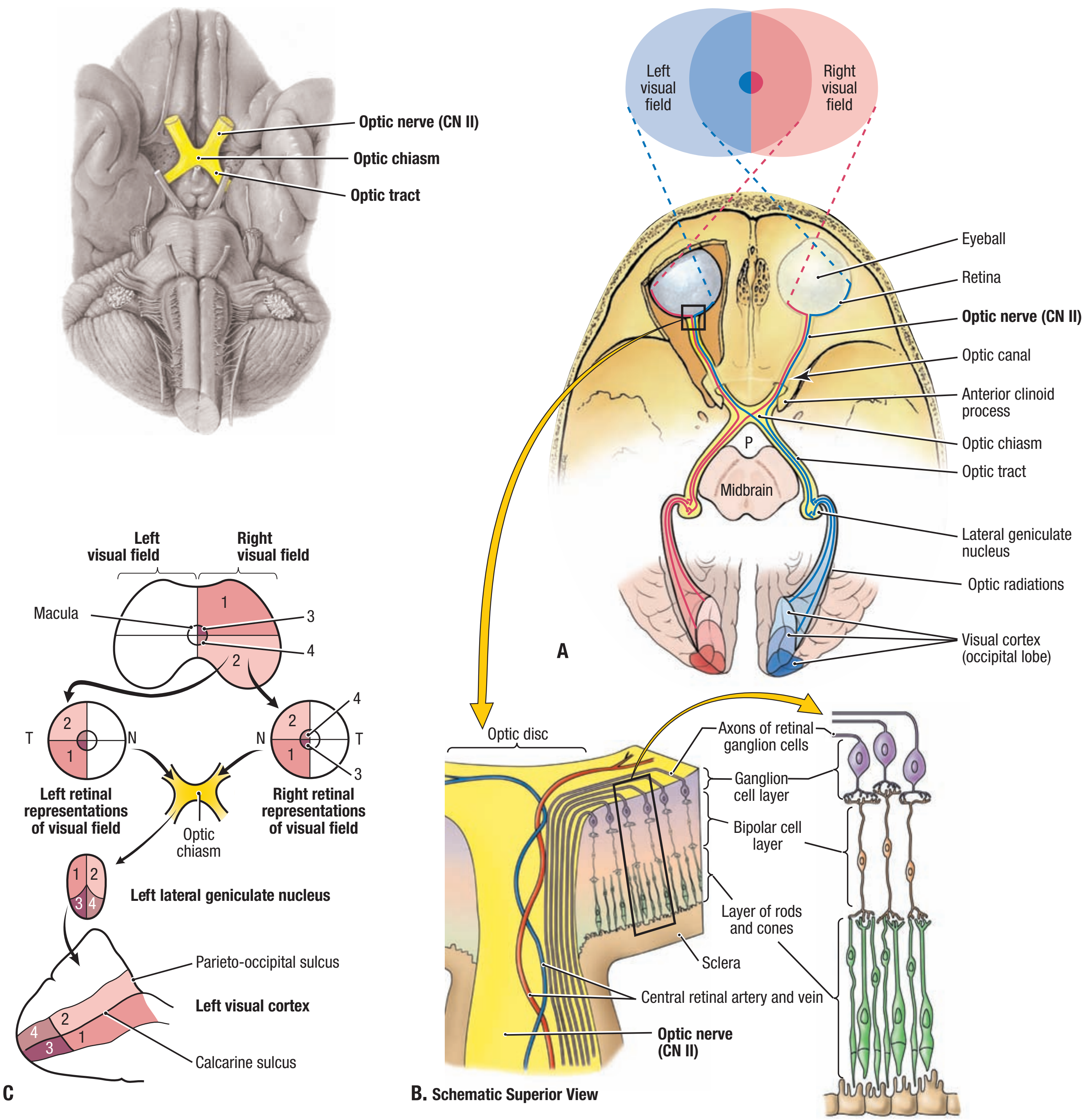


9.5 OLFACTORY NERVE (CN I)

A. Relationship of olfactory mucosa to olfactory bulb. **B.** Olfactory epithelium.

TABLE 9.2 OLFACTORY NERVE (CN I)

Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Olfactory	Special sensory	Olfactory epithelium (olfactory cells/olfactory bulb)	Foramina in cribriform plate of ethmoid bone	Smell from nasal mucosa of roof and superior sides of nasal septum and superior concha of each nasal cavity

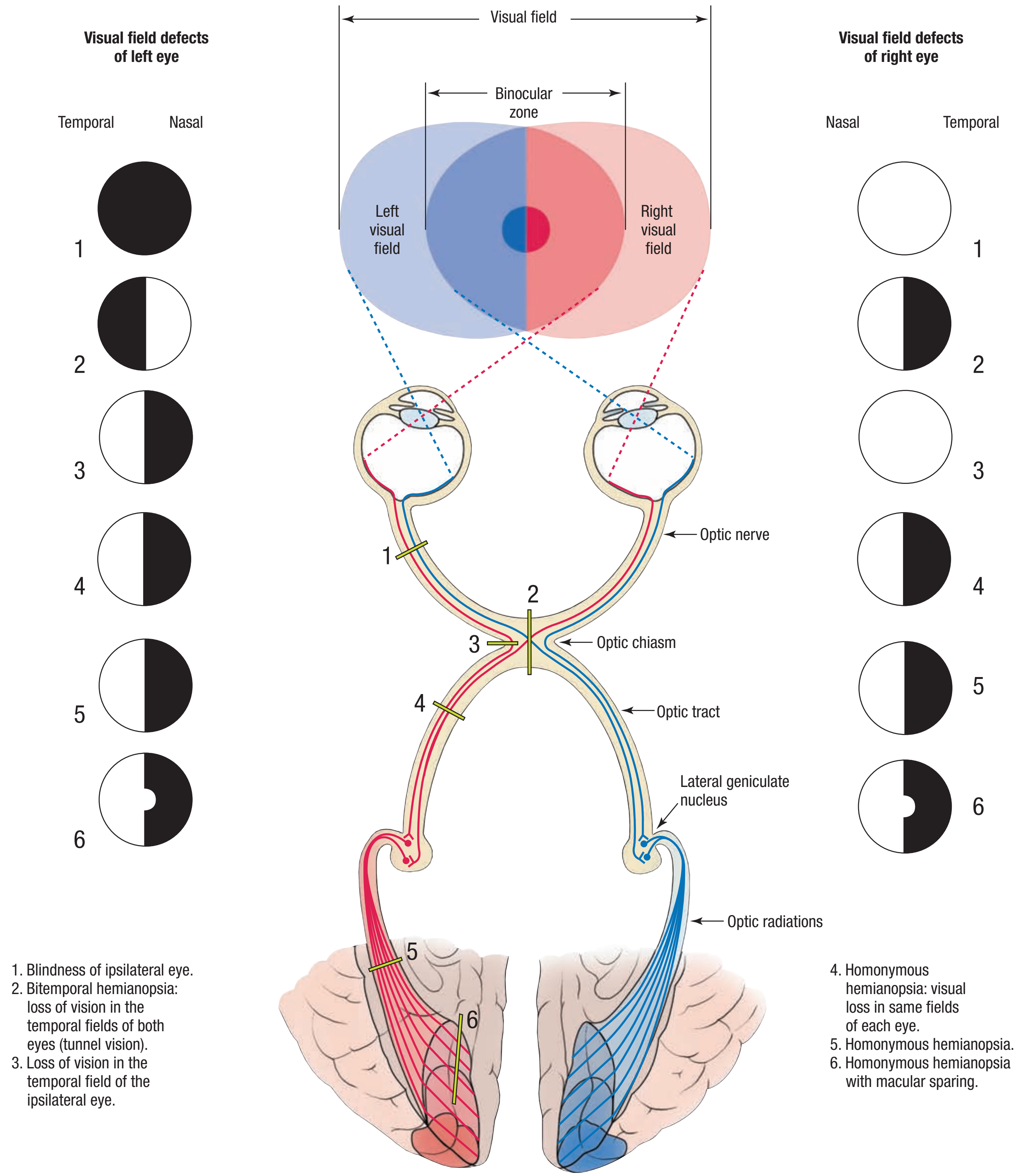


9.6 OPTIC NERVE (CN II)

A. Origin and course of visual pathway. **B.** Rods and cones in retina. **C.** Right visual field representation on retinae, left lateral geniculate nucleus, and left visual cortex.

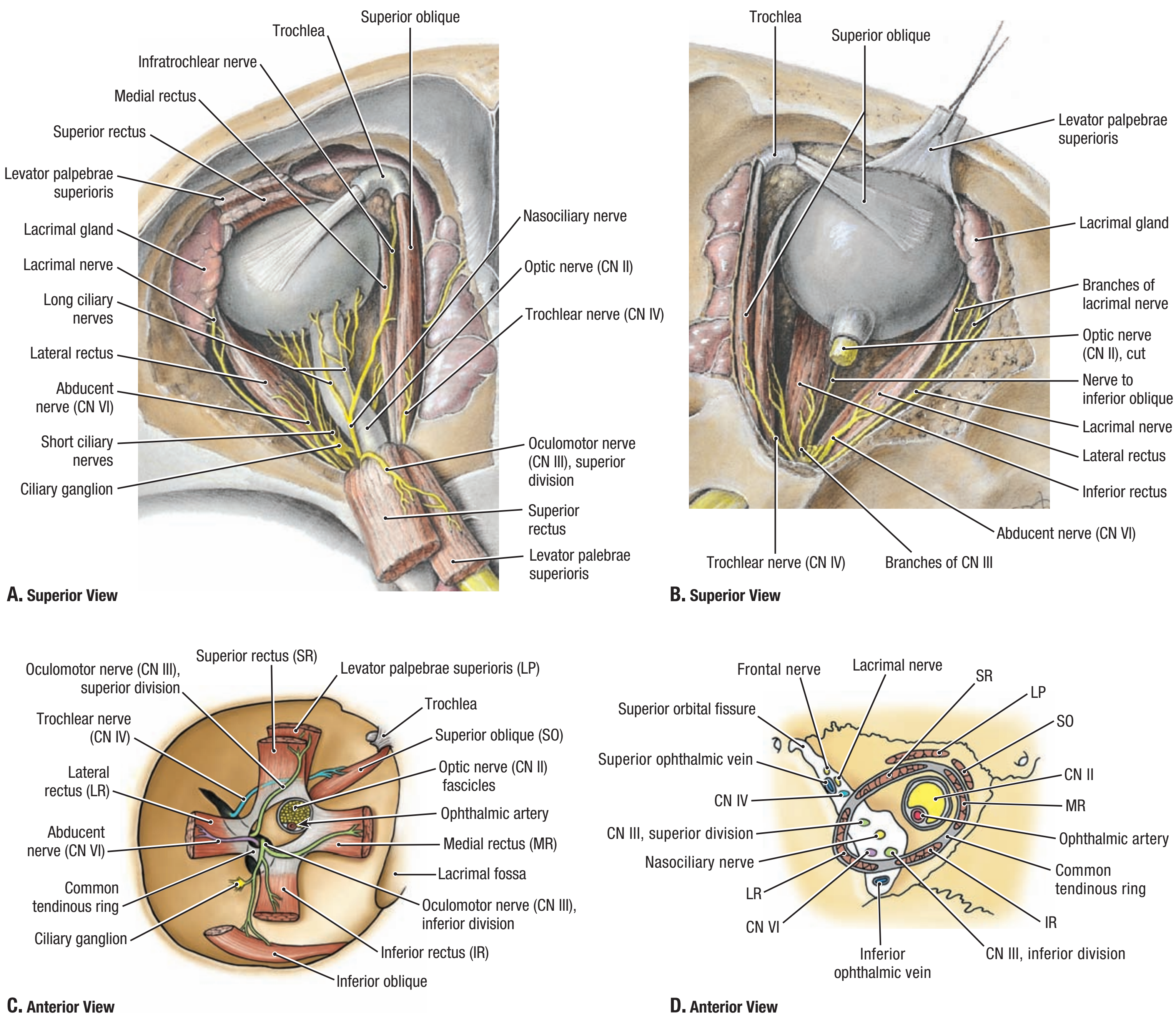
TABLE 9.3 OPTIC NERVE (CN II)

Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Optic	Special sensory	Retina (ganglion cells)/lateral geniculate body (nucleus)	Optic canal	Vision from retina



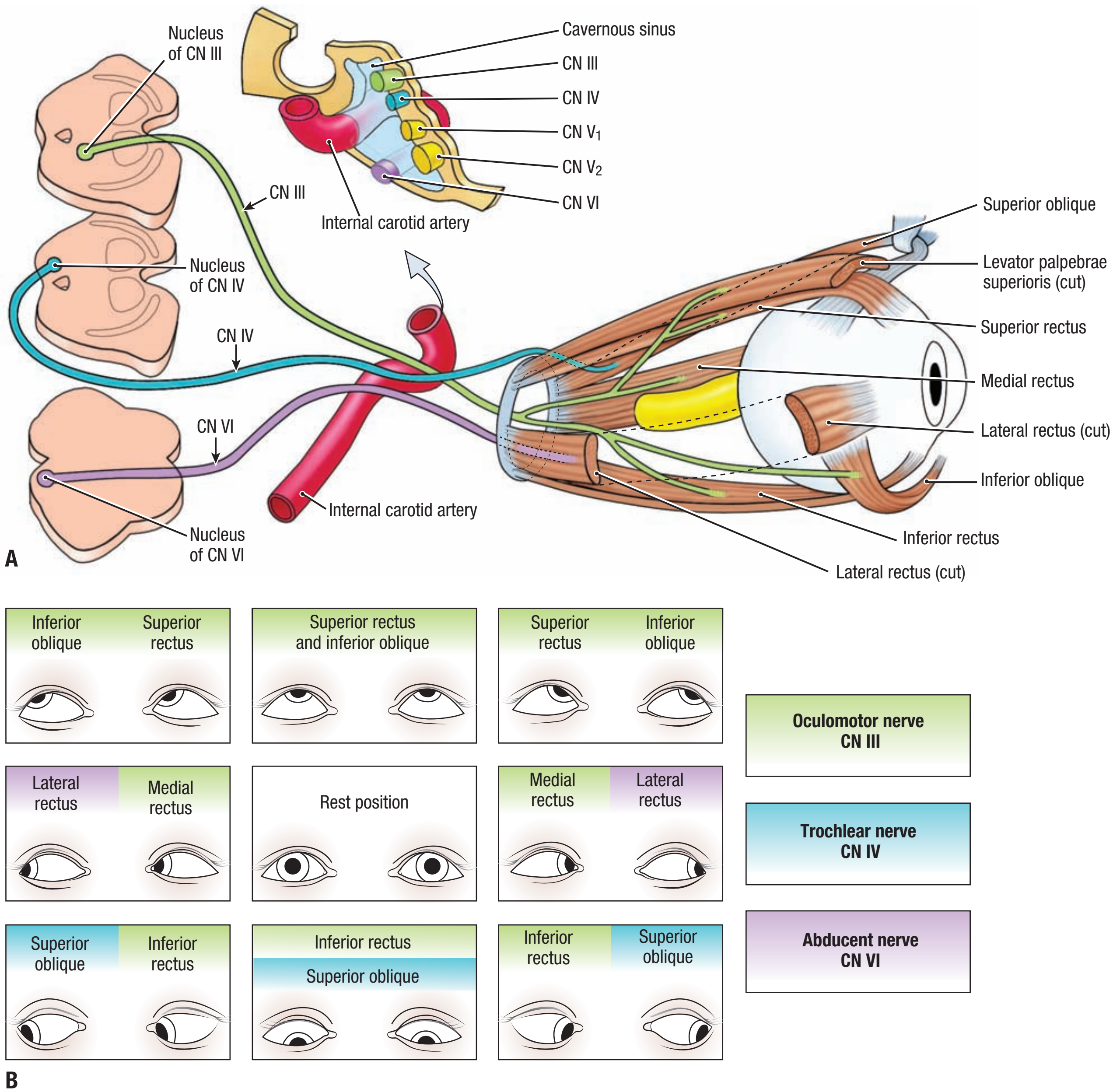
9.7 VISUAL FIELD DEFECTS (CN II)

Visual field defects may result from a large number of neurologic diseases. It is clinically important to be able to link the defects to a likely location of the lesion.



9.8 OVERVIEW OF MUSCLES AND NERVES OF ORBIT

A. and B. Orbital cavities, dissected from a superior approach. The optic nerve is intact in **A** and cut away in **B.**, **C. and D.** Relationship of muscle attachments and nerves at apex of orbit.

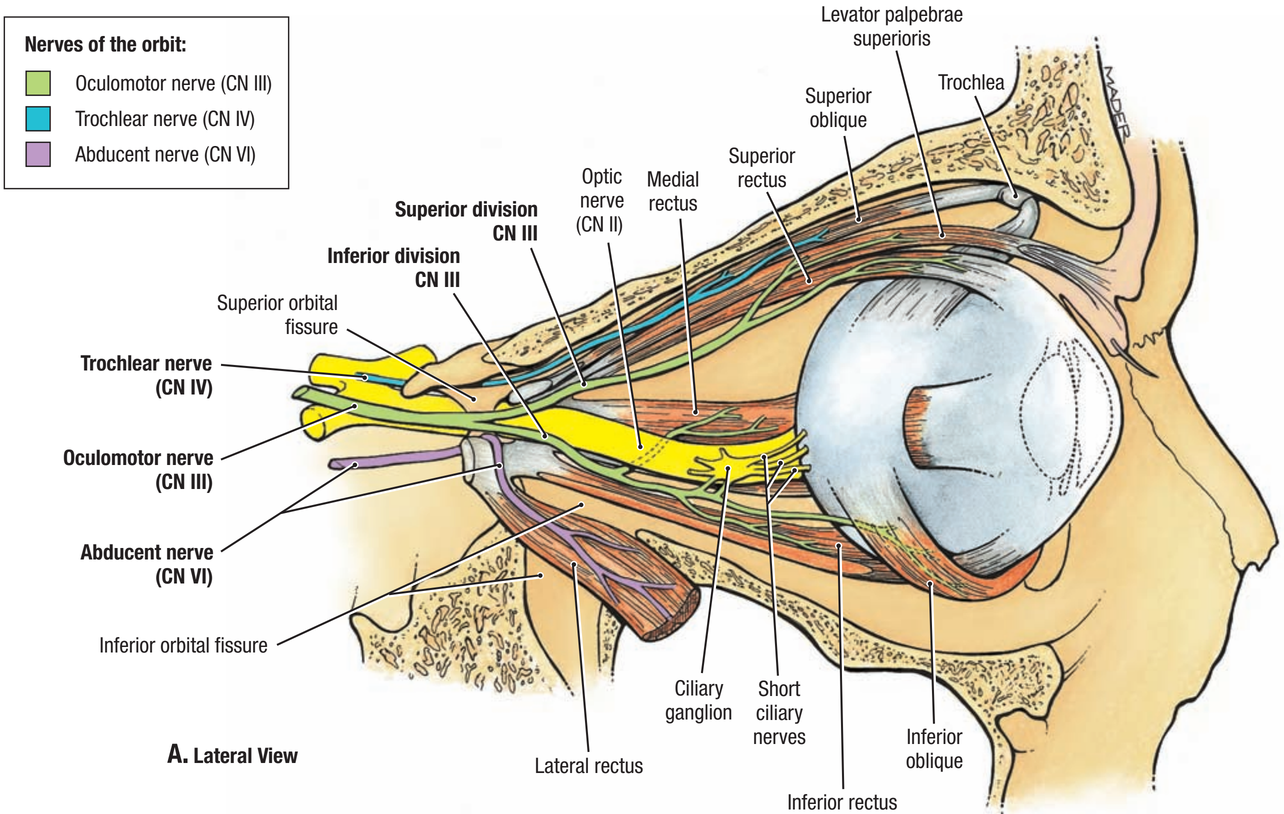


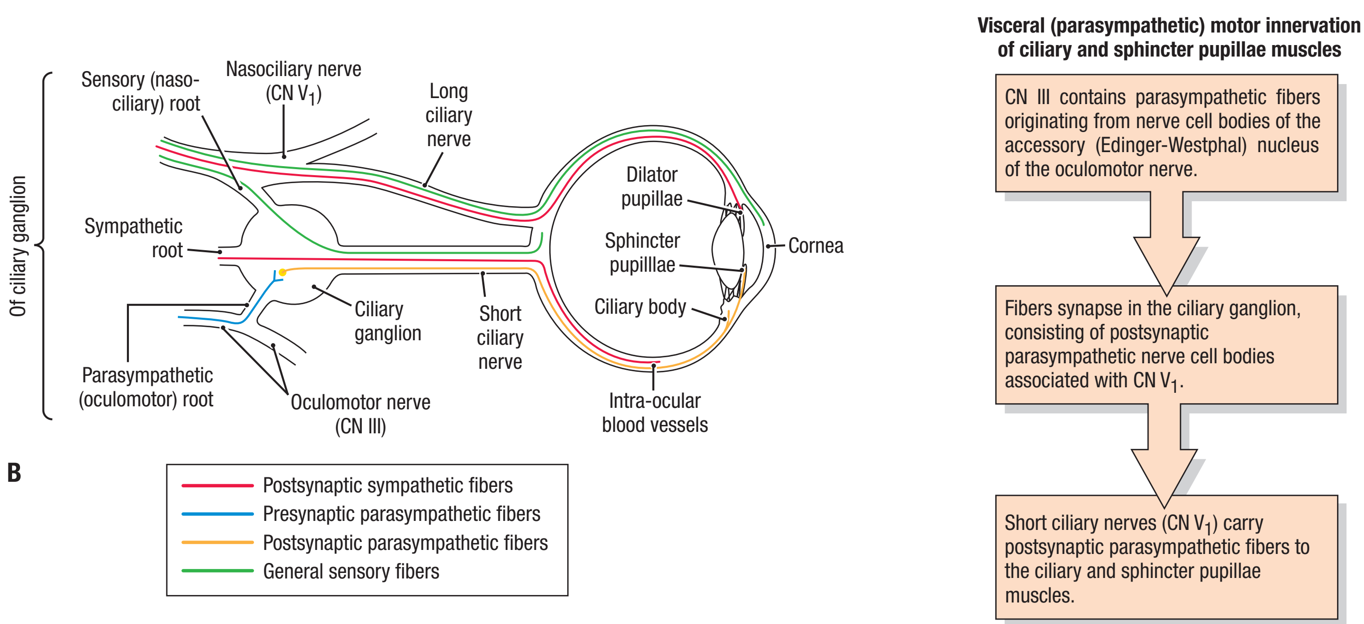
9.9 OCULOMOTOR (CN III), TROCHLEAR (CN IV), AND ABDUCENT (CN VI) NERVES

A. Schematic overview. **B.** Binocular movements and muscles producing them. All movements start from the rest (primary) position.

TABLE 9.4 OCULOMOTOR (CN III), TROCHLEAR (CN IV), AND ABDUCENT (CN VI) NERVES[a]

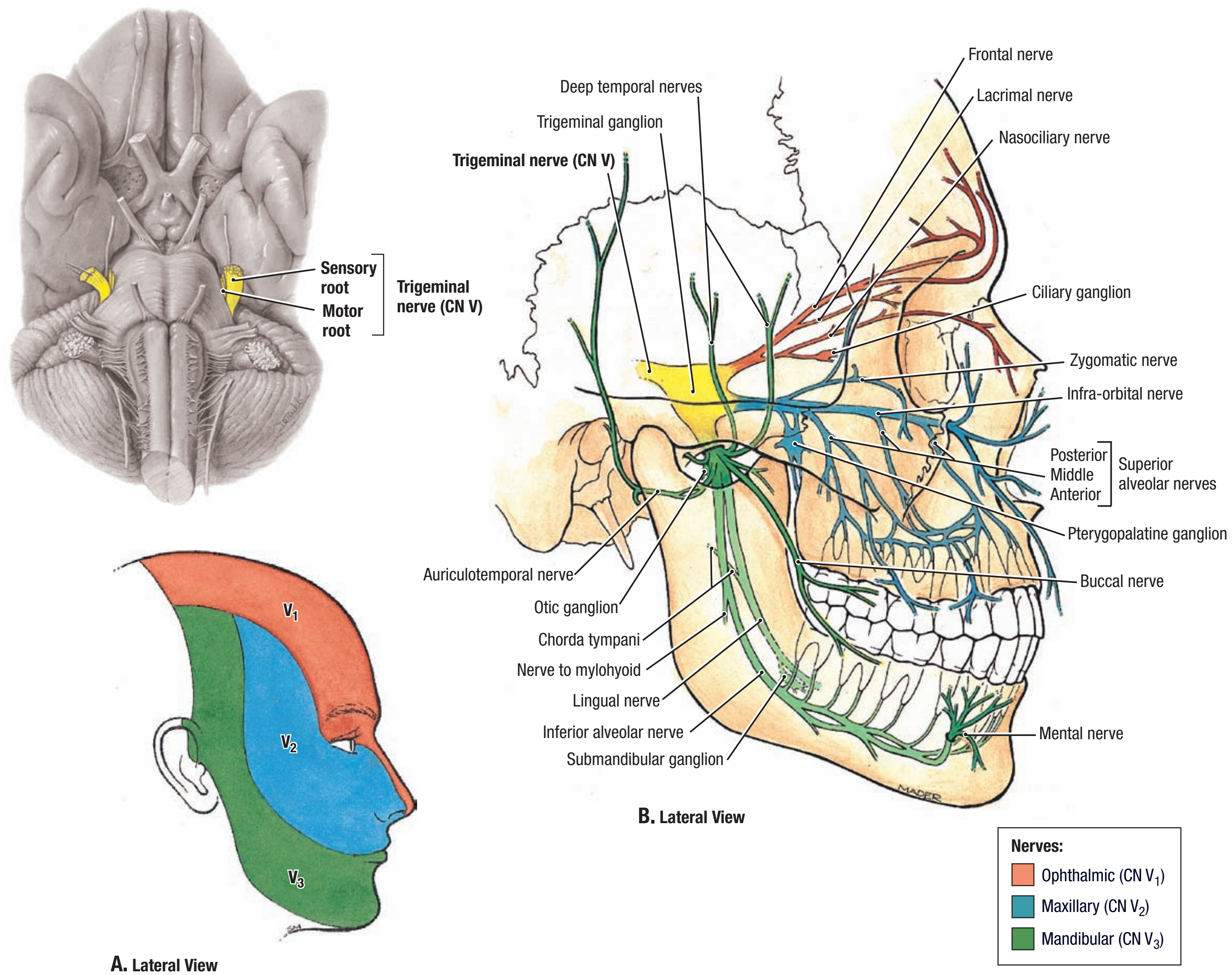
Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Oculomotor	Somatic motor	Nucleus of CN III	Superior orbital fissure	Motor to superior, inferior, and medial recti, inferior oblique, and levator palpebrae superioris muscles; raises upper eyelid, directing gaze superiorly, inferiorly, and medially
	Visceral motor (parasympathetic)	Presynaptic: midbrain (Edinger-Westphal nucleus); Postsynaptic: ciliary ganglion		Motor to sphincter pupillae and ciliary muscle that constrict pupil and accommodate lens of eyeball
Trochlear	Somatic motor	Nucleus of CN IV		Motor to superior oblique that assists in directing gaze inferolaterally
Abducent	Somatic motor	Nucleus of CN VI		Motor to lateral rectus that directs gaze laterally





9.10 INNERVATION OF EYEBALL

A. Nerves of orbit. **B.** Somatic and autonomic innervation of eyeball.

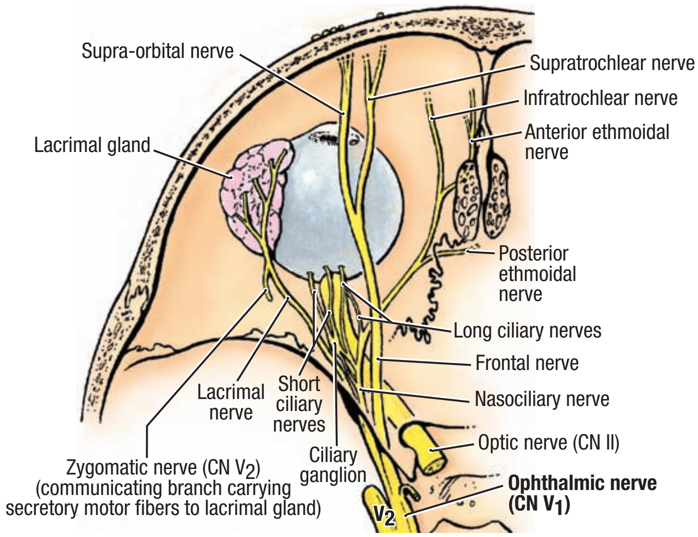


9.11 TRIGEMINAL NERVE (CN V)

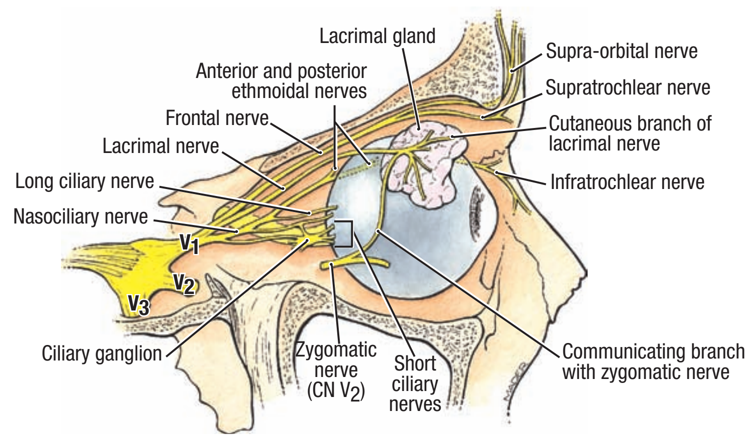
A. Cutaneous (somatic sensory) distribution. **B.** Branches of ophthalmic (CN V_1), maxillary (CN V_2), and mandibular (CN V_3) divisions.

TABLE 9.5 TRIGEMINAL NERVE (CN V)

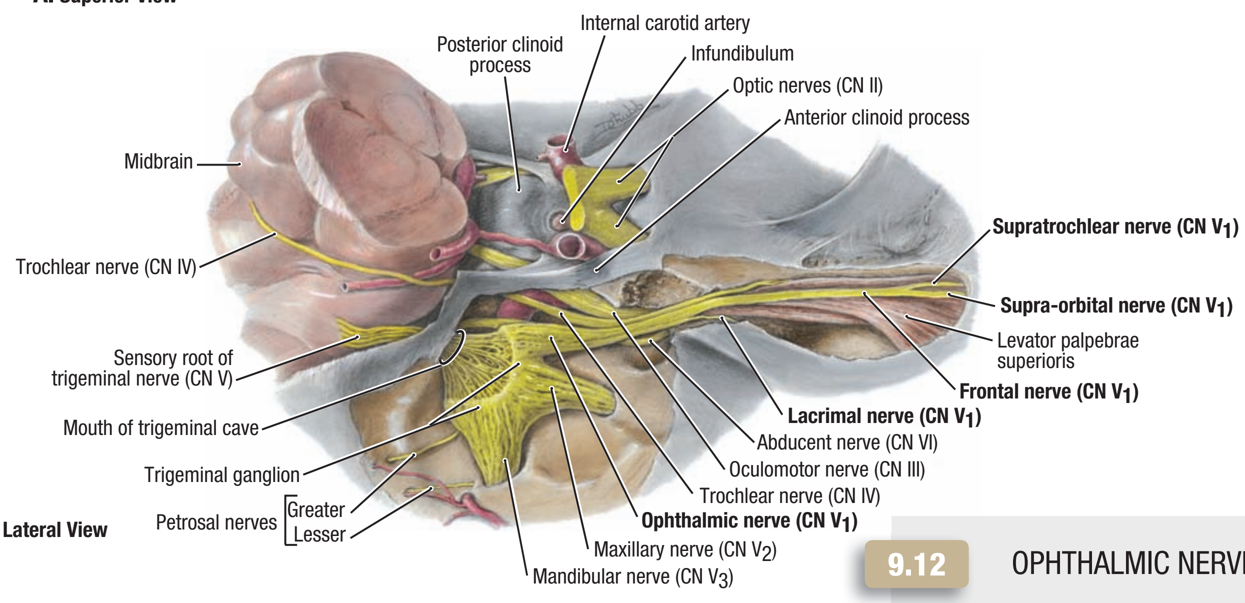
Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Ophthalmic division (CN V_1)	Somatic (general sensory)	Trigeminal ganglion/spinal, principal and mesencephalic nucleus of CN V	Superior orbital fissure	Sensation from cornea, skin of forehead, scalp, eyelids, nose, and mucosa of nasal cavity and paranasal sinuses
Maxillary division (CN V_2)			Foramen rotundum	Sensation from skin of face over maxilla including upper lip, maxillary teeth, mucosa of nose, maxillary sinuses, and palate
Mandibular division (CN V_3)			Foramen ovale	Sensation from the skin over mandible, including lower lip and side of head, mandibular teeth, temporomandibular joint, and mucosa of mouth and anterior two thirds of tongue
	Somatic (branchial) motor	Motor nucleus of CN V		Motor to muscles of mastication, mylohyoid, anterior belly of digastric, tensor veli palatini, and tensor tympani



A. **Superior View**



B. **Lateral View**

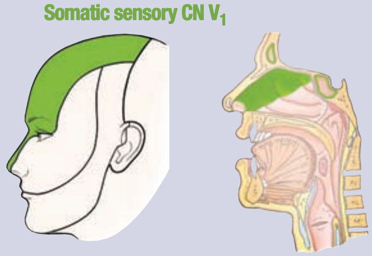


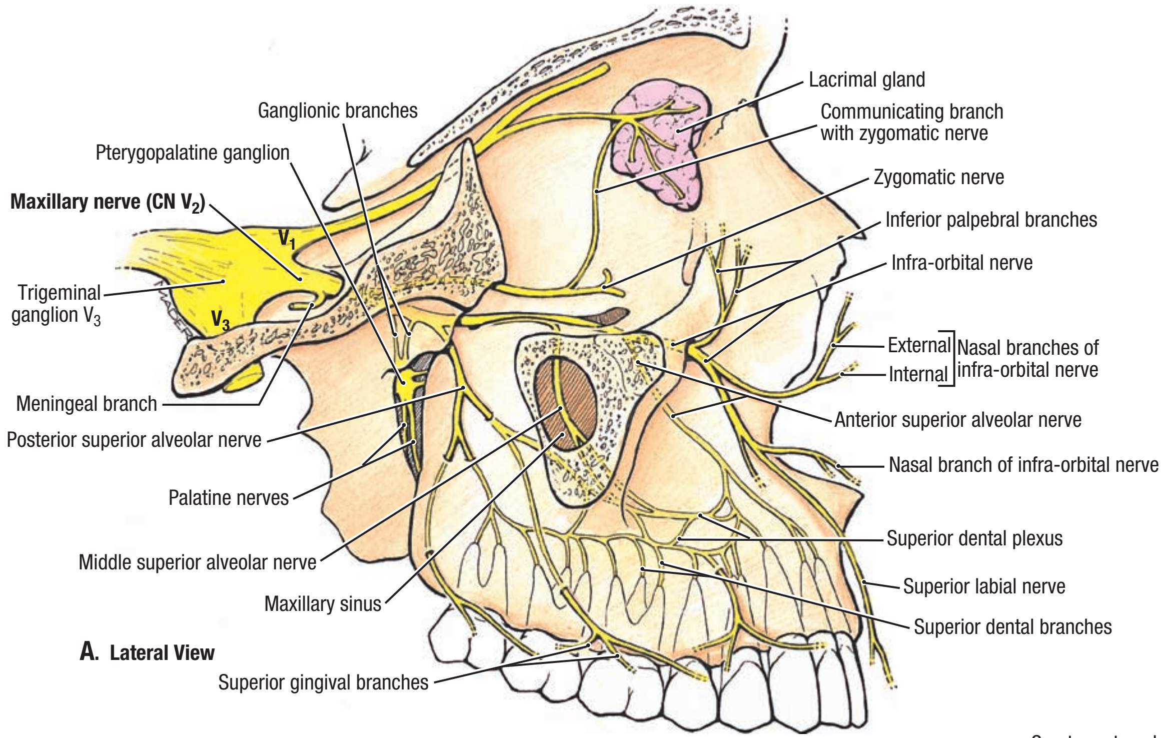
C. **Lateral View**

9.12 OPHTHALMIC NERVE (CN V_1)

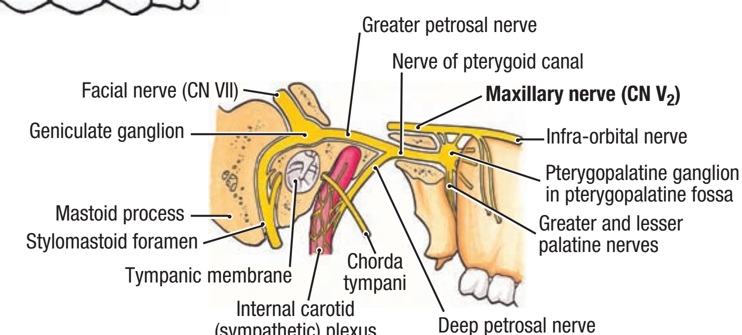
A. and B. Overview. **C.** Course through cavernous sinus.

TABLE 9.6 ***BRANCHES OF OPHTHALMIC NERVE (CN V_1)***

Function	Branches
Ophthalmic nerve (CN V_1) Somatic sensory only at origin from trigeminal ganglion Visceral motor: extracranially, conveys (1) postsynaptic parasympathetic fibers from ciliary ganglion to ciliary body and sphincter of pupillae; (2) postsynaptic parasympathetic fibers from communicating branch of zygomatic nerve (CN V_2) to lacrimal gland; and (3) postsynaptic sympathetic fibers from internal carotid plexus to dilator pupillae and intra-ocular blood vessels. Passes through superior orbital fissure to enter orbit Supplies general sensory innervation to cornea, superior bulbar and palpebral conjunctiva, mucosa of anterosuperior nasal cavity, frontal, ethmoidal, and sphenoidal sinuses, anterior and supratentorial dura mater, skin of dorsum of external nose, superior eyelid, forehead and anterior scalp. **Somatic sensory CN V_1** 	*Somatic sensory branches:* Tentorial nerve (an intracranial meningeal branch) Lacrimal nerve [terminal portion also receives postsynaptic parasympathetic fibers from zygomatic nerve (CN V_2) and conveys them to lacrimal gland] Frontal nerve Supra-orbital nerve Supratrochlear nerve Nasociliary nerve Sensory root of ciliary ganglion Long and short ciliary nerves [also convey postsynaptic sympathetic fibers (from internal carotid plexus to eyeball additionally, short ciliary nerves convey postsynaptic parasympathetic fibers from ciliary ganglion to eyeball] Anterior and posterior ethmoidal nerves Anterior meningeal nerves Internal and external nasal branches Infratrochlear nerve



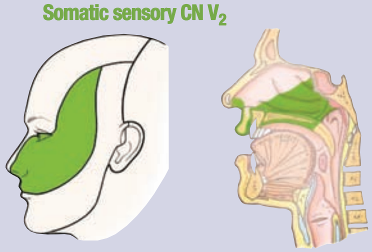
A. Lateral View

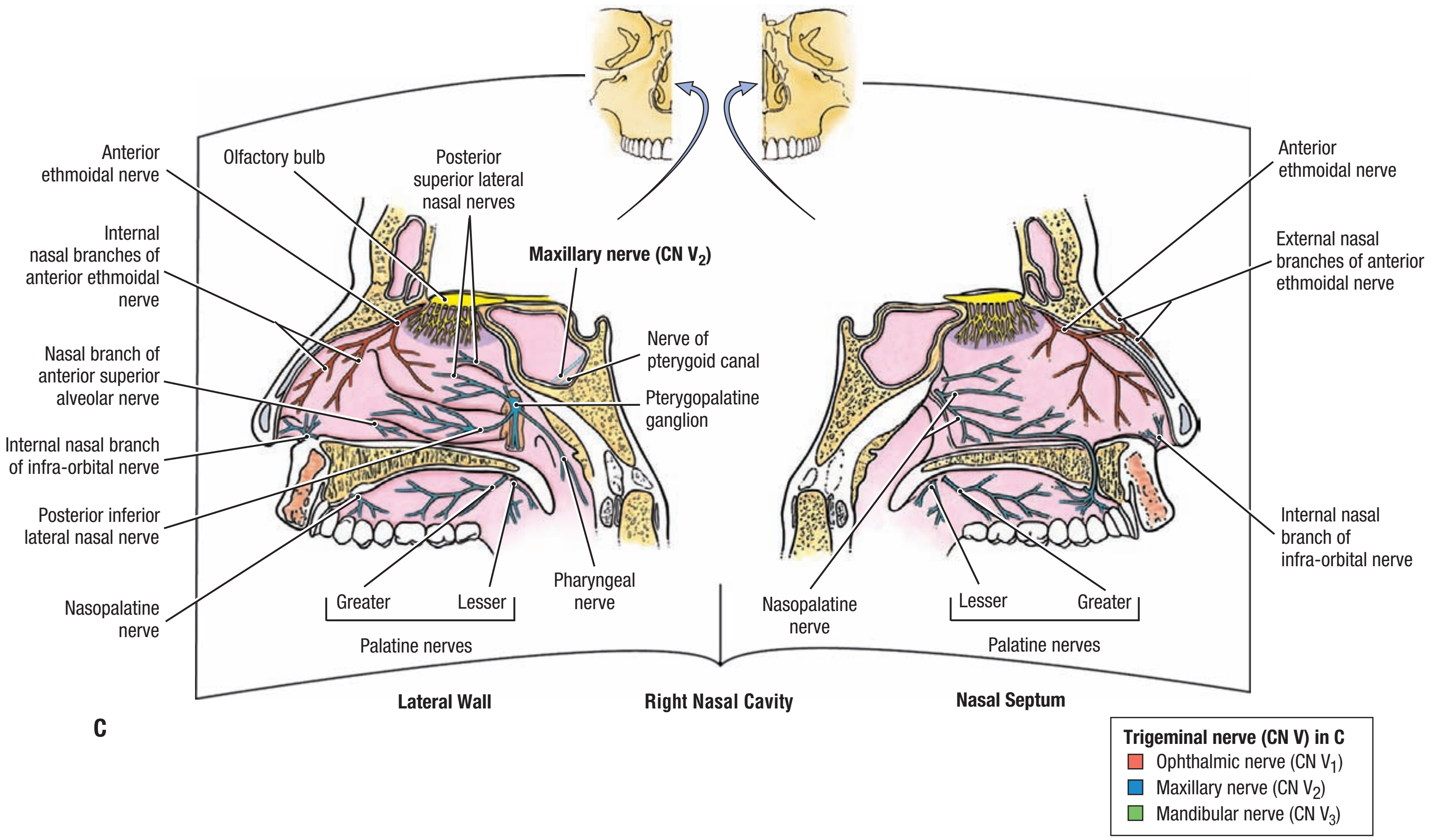


B. Lateral View

9.13 MAXILLARY NERVE (CN V_2)

TABLE 9.7 BRANCHES OF MAXILLARY NERVE (CN V_2)

Function	Branches
Maxillary nerve (CN V_2) Somatic sensory only (proximally, at origin from trigeminal ganglion) Visceral motor: distally, conveys (1) postsynaptic parasympathetic fibers from pterygopalatine ganglion (presynaptic fibers are from CN VII via greater petrosal nerve and nerve of pterygoid canal); and (2) postsynaptic sympathetic fibers from superior cervical ganglion via internal carotid plexus (presynaptic fibers are from intermediolateral column of gray matter, spinal cord segments T1–T3). Passes through foramen rotundum to enter pterygopalatine fossa Supplies dura mater of anterior aspect of lateral part of middle cranial fossa; conjunctiva of inferior eyelid; mucosa of postero-inferior nasal cavity, maxillary sinus, palate, and anterior part of superior oral vestibule; maxillary teeth; and skin of lateral external nose, inferior eyelid, anterior cheek, and upper lip. 	Meningeal branch Zygomatic branch Zygomaticofacial branch Zygomaticotemporal branch Communicating branch to lacrimal nerve Ganglionic branches to (sensory root of) pterygopalatine ganglion Infra-orbital nerve Posterior, middle, and anterior superior alveolar branches Superior dental plexus and branches Superior gingival branches Inferior palpebral branches External and internal nasal branches Superior labial branches Greater palatine nerve Posterior inferior lateral nasal nerves Lesser palatine nerves Posterior superior lateral and medial nasal branches Nasopalatine nerve Pharyngeal nerve



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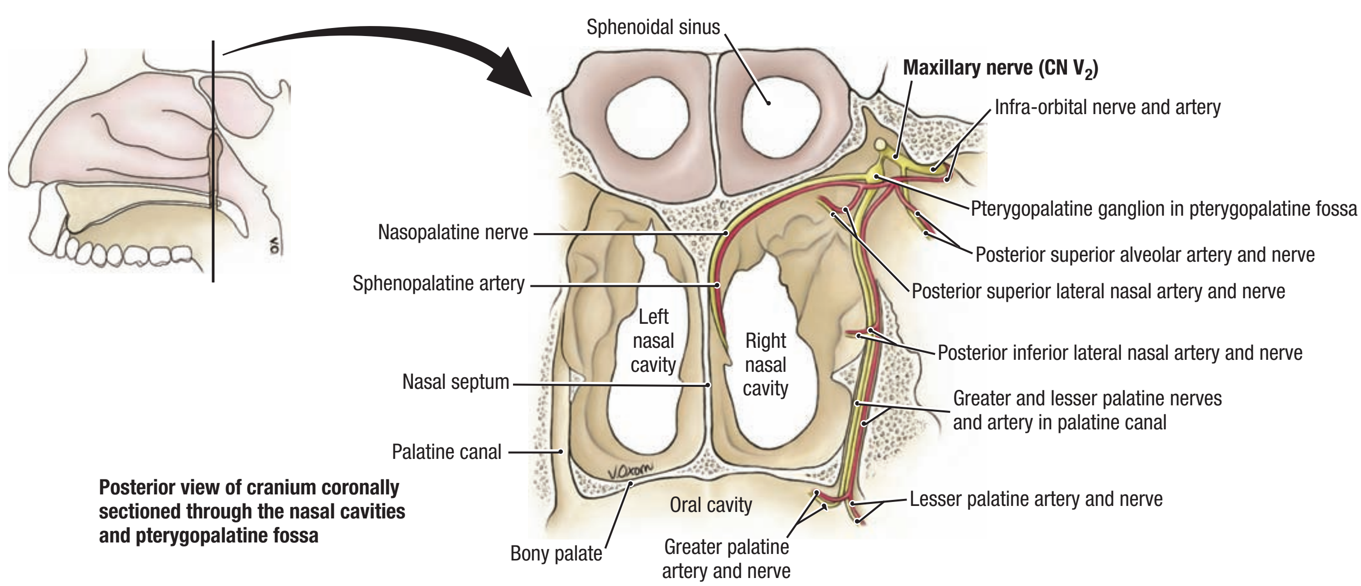
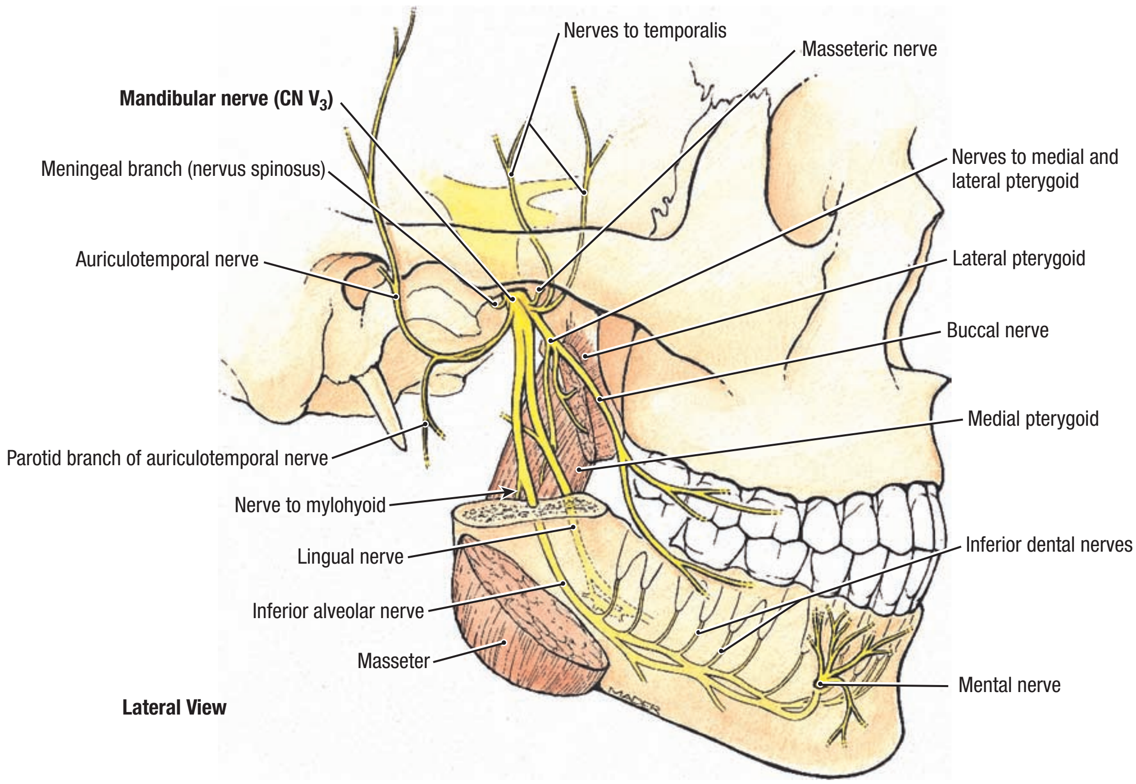


D

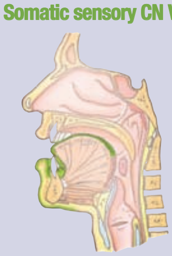
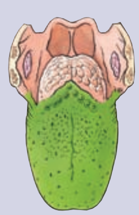
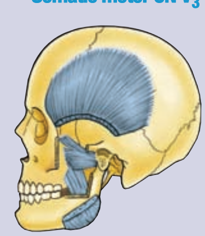
9.13 MAXILLARY NERVE (CN V_2) *(CONTINUED)*

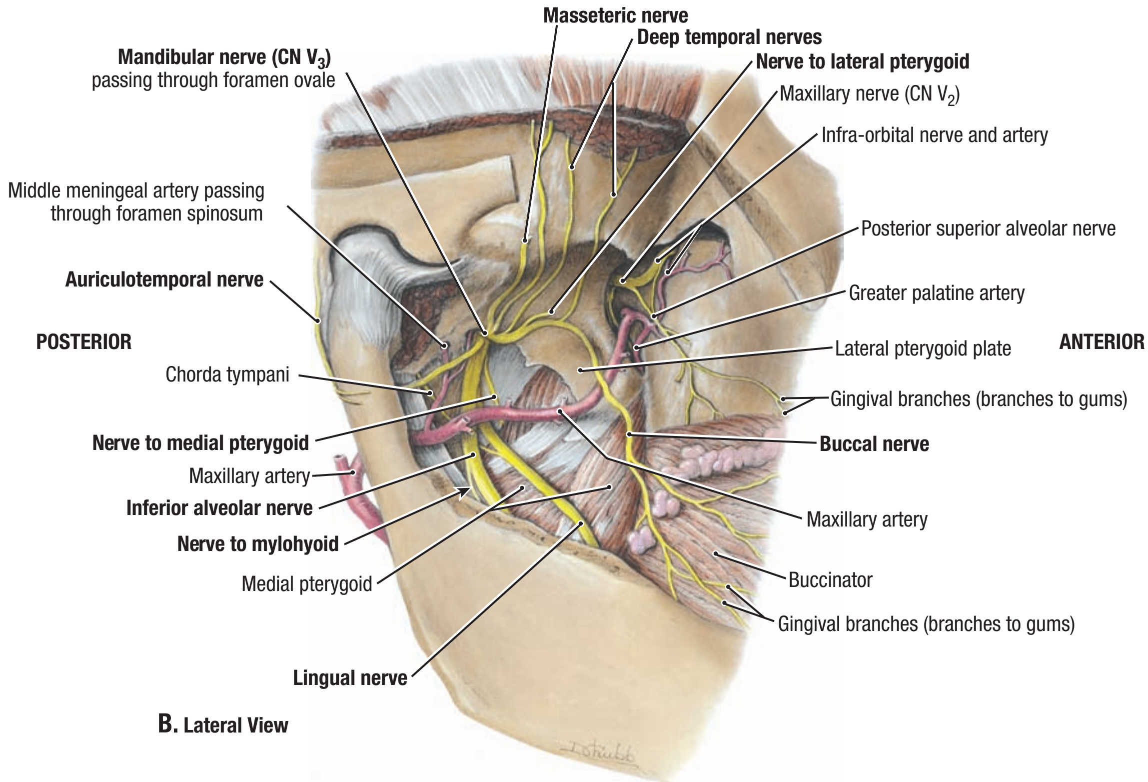
A. Overview. **B.** Nerves of pterygopalatine fossa. **C. and D.** Innervation of lateral wall and septum of nasal cavity and palate.



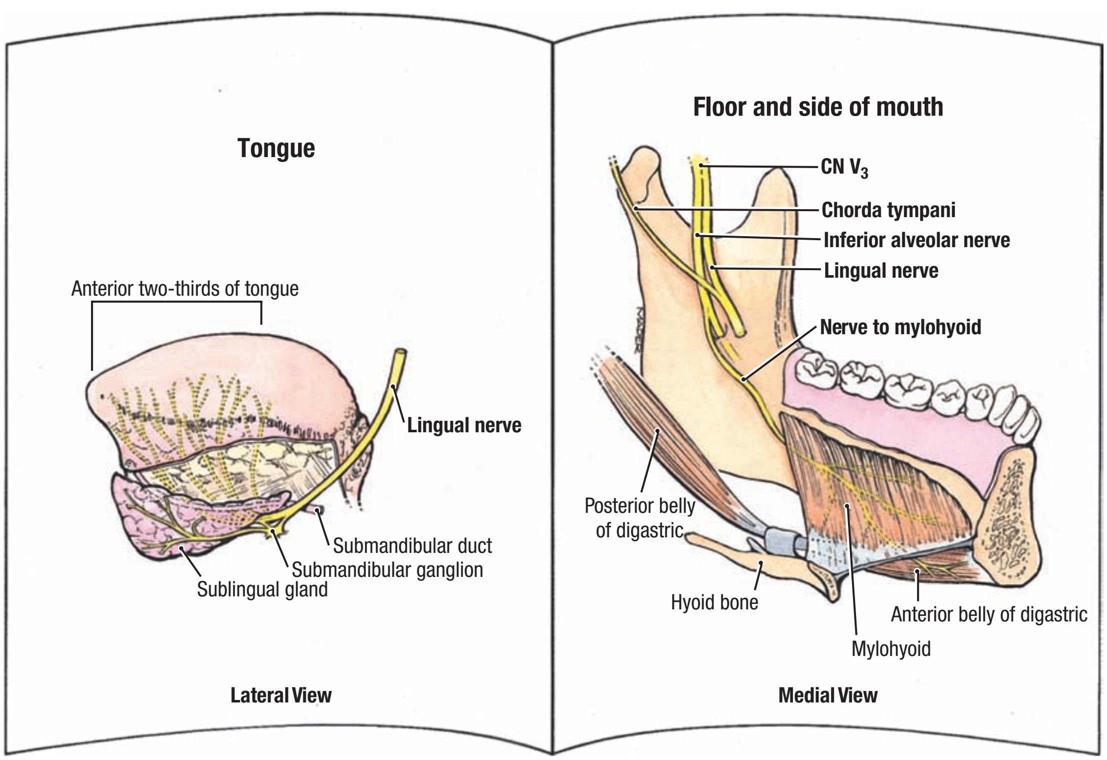
9.14 MANDIBULAR NERVE (CN V_3)

TABLE 9.8 BRANCHES OF MANDIBULAR NERVE (CN V_3)

Function	Branches
Maxillary nerve (CN V_3) Somatic sensory and somatic (branchial) motor Special sensory: extracranially, conveys taste fibers (from CN VII via chorda tympani nerve) to anterior 2/3 of tongue Visceral motor: extracranially, conveys (1) presynaptic parasympathetic fibers to submandibular ganglion (presynaptic fibers are from CN VII via chorda tympani nerve); (2) postsynaptic parasympathetic fibers from submandibular ganglion to submandibular and sublingual glands; and (3) postsynaptic parasympathetic fibers from otic ganglion to parotid gland. Passes through foramen ovale to enter infratemporal fossa Supplies general sensory innervation to mucosa of anterior 2/3 of tongue, floor of mouth, and posterior and anterior inferior oral vestibule; mandibular teeth; and skin of lower lip, buccal and temporal regions of face, and external ear (anterior superior auricle, upper external auditory meatus, and tympanic membrane). Supplies motor innervation to all 4 muscles of mastication, mylohyoid, anterior belly of digastric, tensor tympani and tensor veli palatin Somatic sensory CN V_3    Somatic motor CN V_3 	*Somatic sensory branches:* Meningeal branch (nervus spinosum) Buccal nerve Auriculotemporal nerve (also conveys *visceral motor fibers*) Superficial temporal branches Parotid branches Lingual nerve (also conveys *visceral motor* and *special sensory fibers*) Inferior alveolar nerve Nerve to mylohyoid Inferior dental plexus Inferior dental branches Inferior gingival branches Mental nerve *Somatic (branchial) motor branches:* Masseteric nerve Medial and lateral pterygoid branches Deep temporal nerves Nerve to mylohyoid Nerve to tensor tympani Nerve to tensor veli palatini



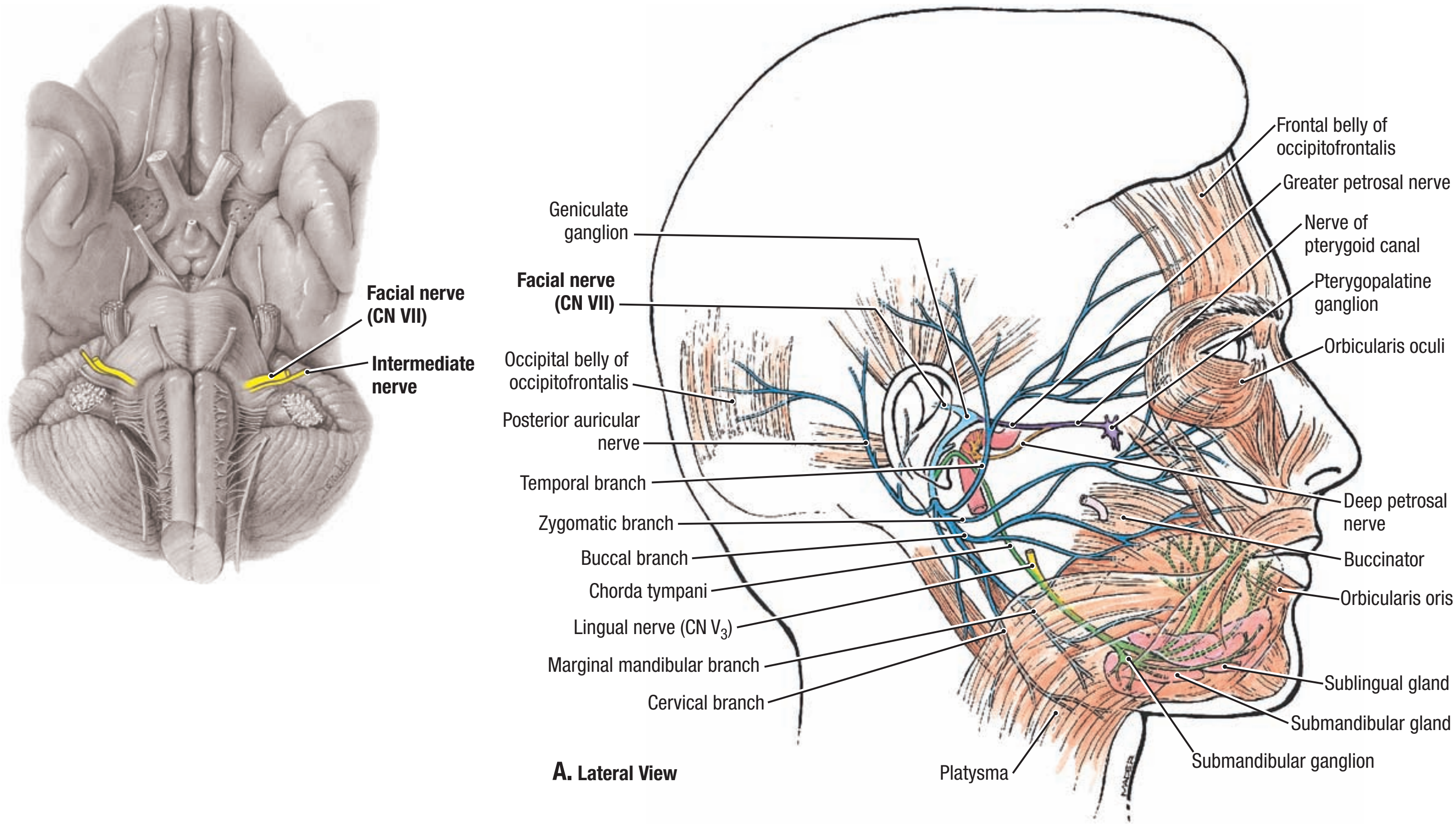
B. Lateral View



C

9.14 MANDIBULAR NERVE (CN V_3) *(CONTINUED)*

A. Overview. **B.** Deep dissection of CN V_3 and branches at foramen ovale. **C.** Lateral aspect of tongue and medial aspect of mandible displayed as pages in an open book that is, the tongue has been reflected from the mandible.



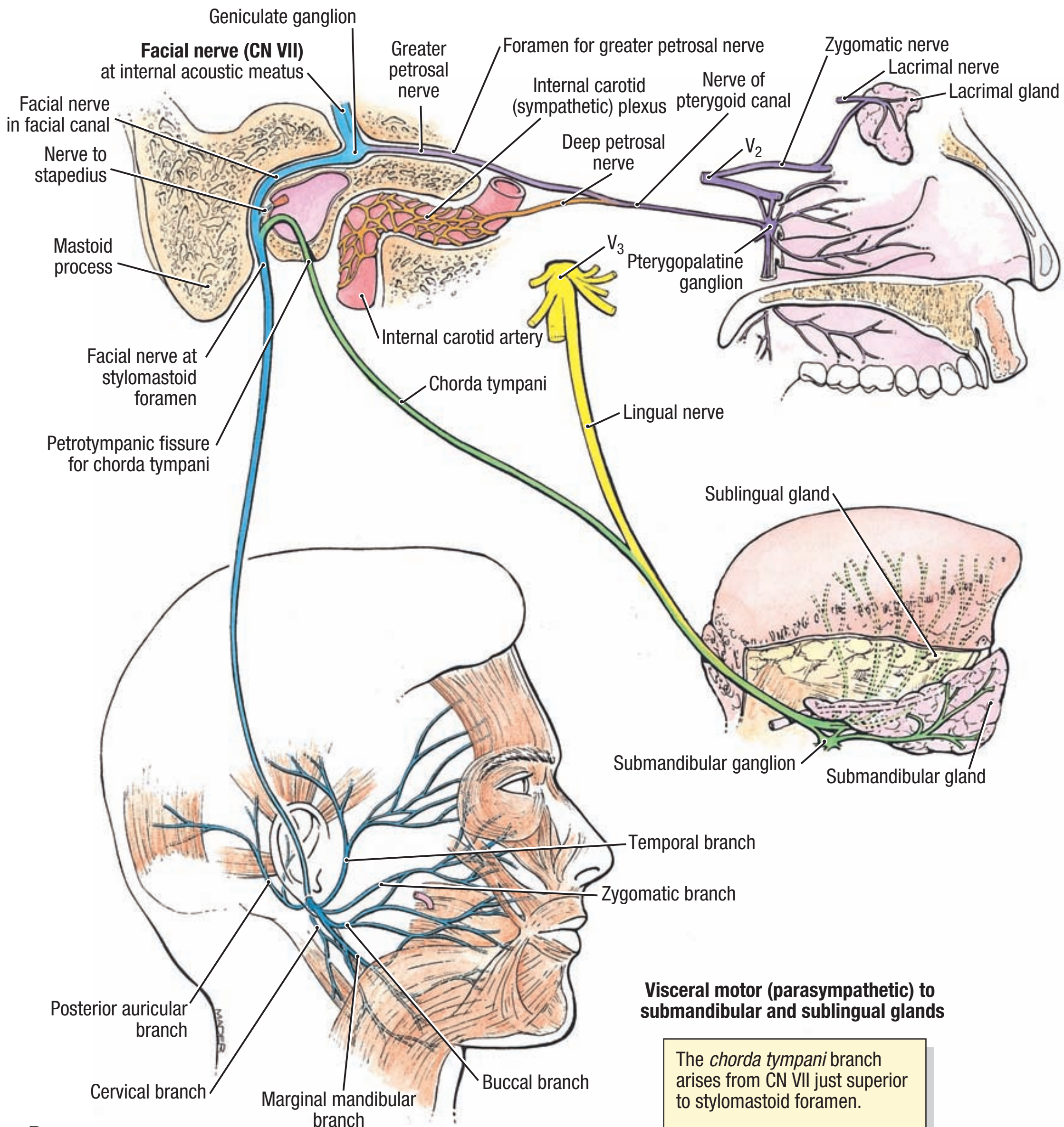
9.15 FACIAL NERVE (CN VII)

A. Overview. **B.** Parasympathetic motor innervation of lacrimal, submandibular, and sublingual glands. **C.** Nerve of pterygoid canal.

TABLE 9.9 FACIAL NERVE (CN VII), INCLUDING MOTOR ROOT AND INTERMEDIATE NERVE[a]

Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Temporal, zygomatic, buccal, mandibular, cervical, and posterior auricular nerves, nerve to posterior belly of digastric, nerve to stylohyoid, nerve to stapedius	Somatic (branchial) motor	Motor nucleus of CN VII	Stylomastoid foramen	Motor to muscles of facial expression and scalp;, also supplies stapedius of middle ear, stylohyoid, and posterior belly of digastric
Intermediate nerve through chorda tympani	Special sensory	Geniculate ganglion/solitary nucleus	Internal acoustic meatus/facial canal/ petrotympanic fissure	Taste from anterior two thirds of tongue, through chorda tympani floor of mouth, and palate
Intermediate nerve	Somatic (general) sensory	Geniculate ganglion/spinal trigeminal nucleus	Internal acoustic meatus	Sensation from skin of external acoustic meatus
Intermediate nerve through greater petrosal nerve	Visceral sensory	Nuclei of solitary tract	Internal acoustic meatus/facial canal/ foramen for greater petrosal nerve	Visceral sensation from mucous membranes of nasopharynx and palate
Greater petrosal nerve Chorda tympani	Visceral motor	Presynaptic: superior salivatory nucleus; Postsynaptic: pterygopalatine ganglion (greater petrosal nerve) and submandibular ganglion (chorda tympani)	Internal acoustic meatus/facial canal/ foramen for greater petrosal nerve, (greater petrosal nerve) petrotympanic fissure (chorda tympani)	Parasympathetic innervation to lacrimal gland and glands of the nose and palate (greater petrosal nerve); submandibular and sublingual salivary glands (chorda tympani)

[a]See also Table 9.15.



B

Visceral motor (parasympathetic) to lacrimal gland

Greater petrosal nerve arises from CN VII at the geniculate ganglion and emerges from the superior surface of the petrous part of the temporal bone to enter the middle cranial fossa.

↓

Greater petrosal nerve joins the *deep petrosal nerve* (sympathetic) at the foramen lacerum to form the nerve of the pterygoid canal.

↓

Nerve of the pterygoid canal travels through the pterygoid canal and enters the pterygopalatine fossa.

↓

Parasympathetic fibers from the nerve of pterygoid canal in pterygopalatine fossa synapse in the *pterygopalatine ganglion.*

↓

Postsynaptic parasympathetic fibers from this ganglion innervate the *lacrimal gland* via the zygomatic branch of CN V_2 and the lacrimal nerve CN V_1.

Visceral motor (parasympathetic) to submandibular and sublingual glands

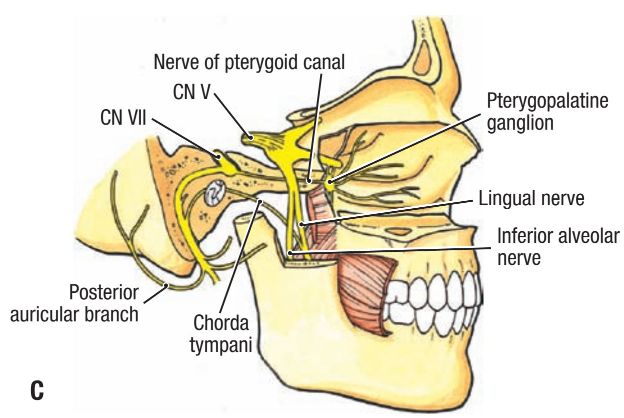
The *chorda tympani* branch arises from CN VII just superior to stylomastoid foramen.

↓

The chorda tympani crosses tympanic cavity medial to handle of malleus.

↓

The chorda tympani passes through the petrotympanic fissure between the tympanic and petrous parts of the temporal bone to join the lingual nerve (CN V_3) in infratemporal fossa; parasympathetic fibers of the chorda tympani synapse in the submandibular ganglion; postsynaptic fibers follow arteries to glands.



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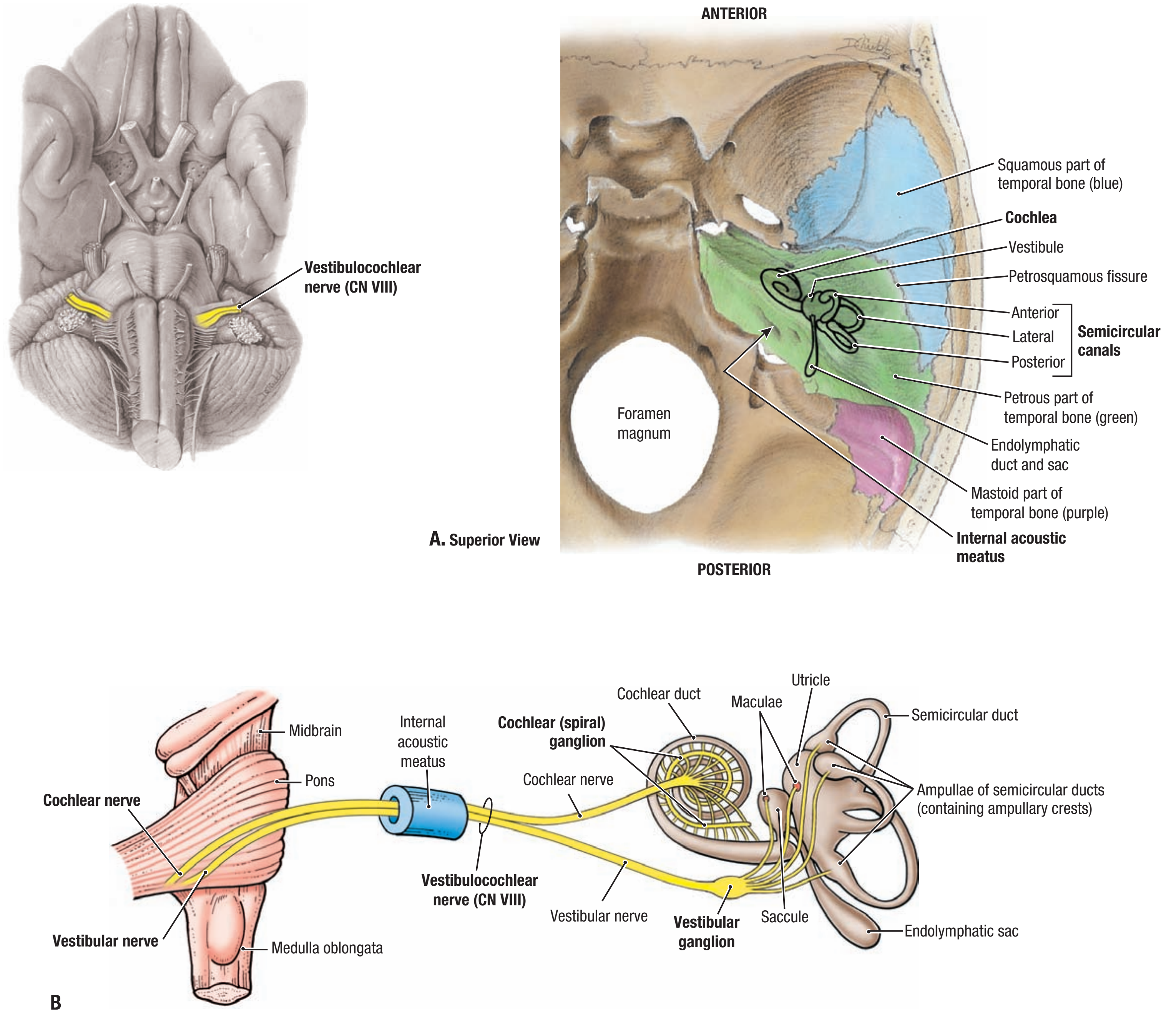
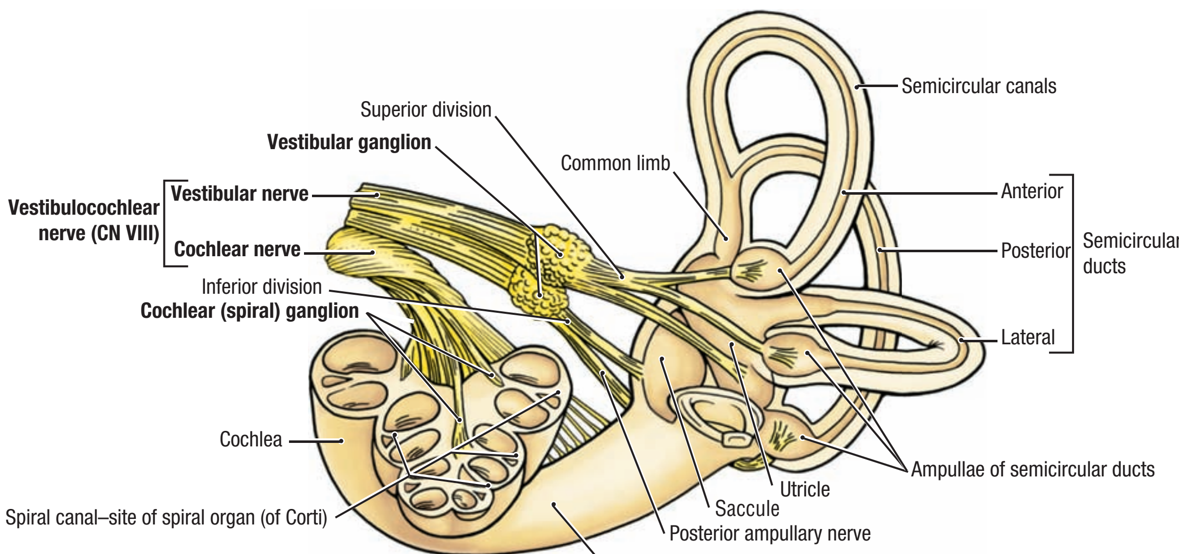


9.16 VESTIBULOCOCHLEAR NERVE (CN VIII)

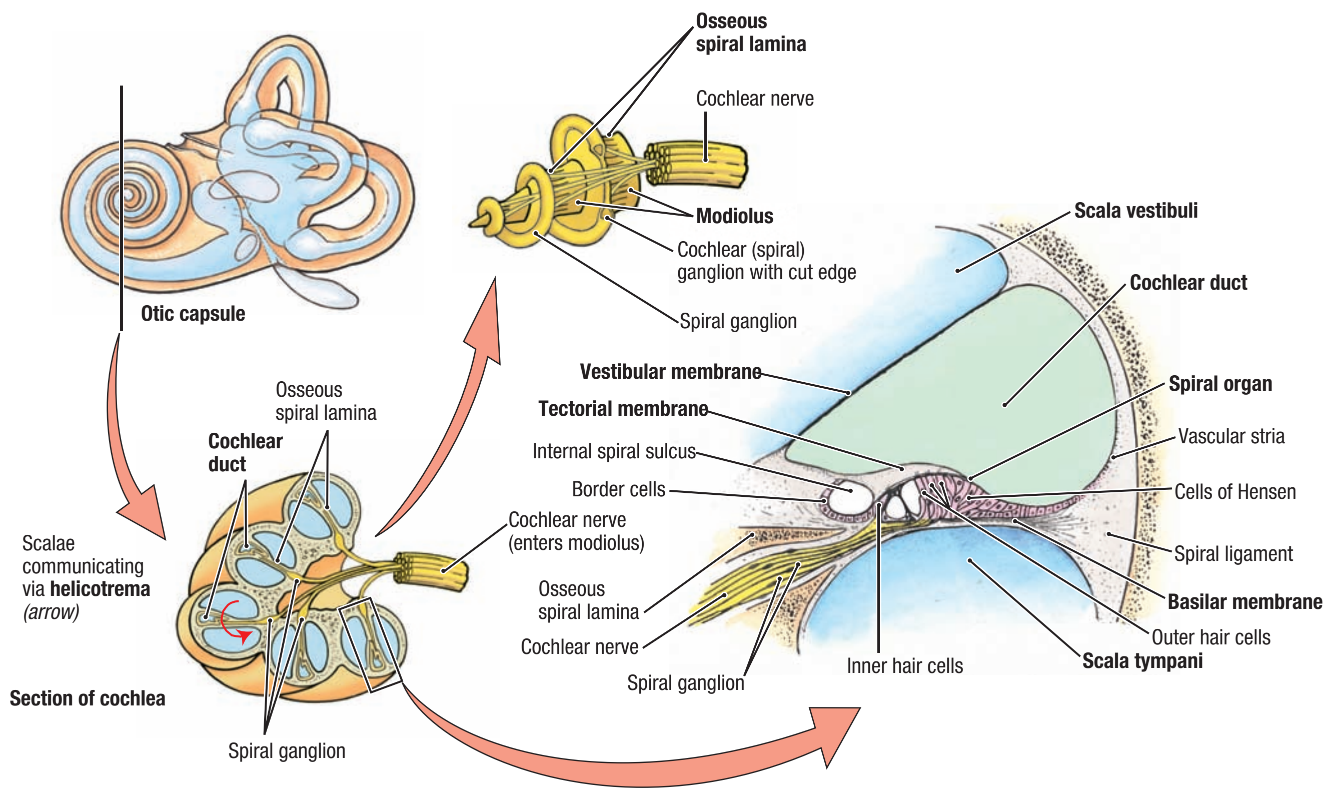
A. Cochlea and semicircular canals in situ in the cranium. **B.** Schematic overview of distribution.

TABLE 9.10 VESTIBULOCOCHLEAR NERVE (CN VIII)

Part of Vestibulocochlear Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Vestibular nerve	Special sensory	Vestibular ganglion/vestibular nuclei	Internal acoustic meatus	Vestibular sensation from semicircular ducts, utricle, and saccule related to position and movement of head
Cochlear nerve		Spiral ganglion/cochlear nuclei		Hearing from spiral organ



C. Lateral View

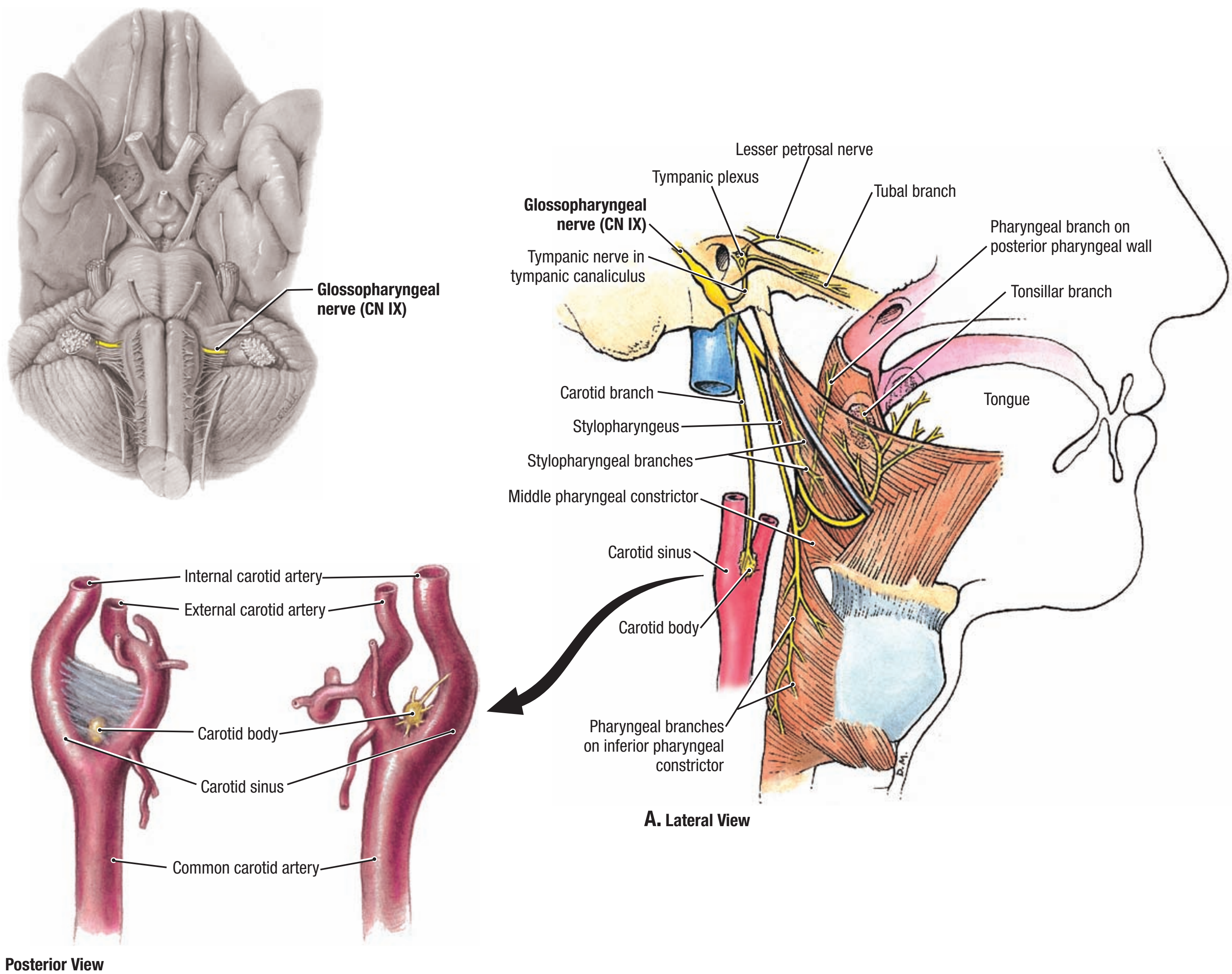


D

9.16 VESTIBULOCOCHLEAR NERVE (CN VIII) *(CONTINUED)*

C. Labyrinthine and cochlear apparatus, nerves and ganglia. **D.** Structure of cochlea. Observe in **D:**

- The cochlear duct is a spiral tube fixed to the internal and external walls of the cochlear canal by the spiral ligament.
- The triangular cochlear duct lies between the osseous spiral lamina and the external wall of the cochlear canal.
- The roof of the cochlear duct is formed by the vestibular membrane and the floor by the basilar membrane and osseous spiral lamina.
- The receptor of auditory stimuli is the spiral organ (of Corti), situated on the basilar membrane; it is overlaid by the gelatinous tectorial membrane.
- The spiral organ contains hair cells that respond to vibrations induced in the endolymph by sound waves.
- The fibers of the cochlear nerve are axons of neurons in the spiral ganglion; the peripheral processes enter the spiral organ (of Corti).



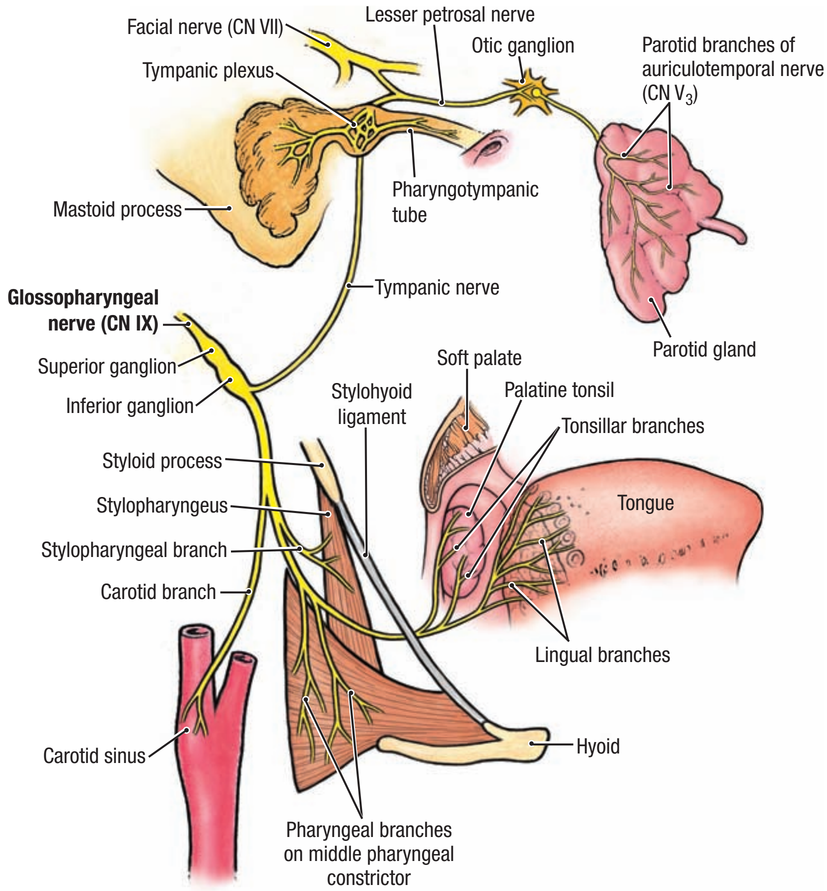
9.17 GLOSSOPHARYNGEAL NERVE (CN IX)

A. Overview of distribution. **B. and C.** Parasympathetic innervation.

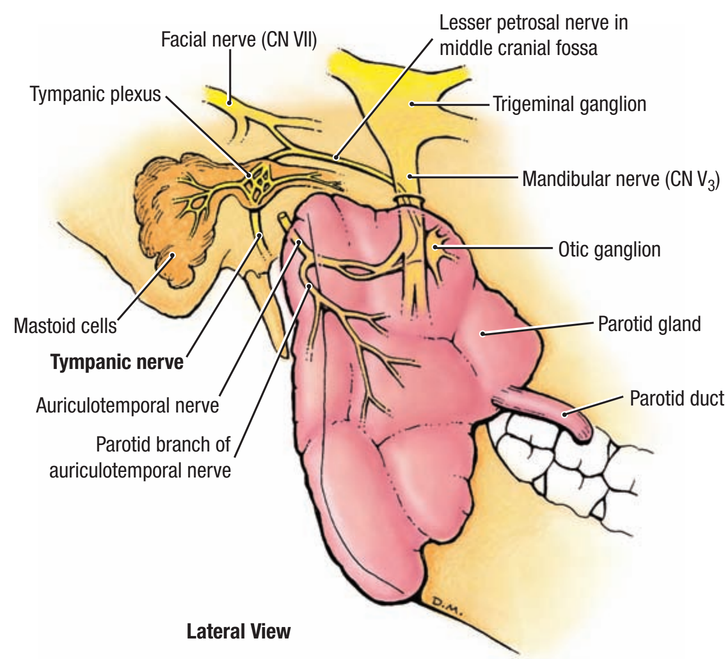
TABLE 9.11 GLOSSOPHARYNGEAL NERVE (CN IX)[a]

Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Glossopharyngeal	Somatic (branchial) motor	Nucleus ambiguus		Motor to stylopharyngeus that assists with swallowing
	Visceral motor	Presynaptic: inferior salivatory nucleus; postsynaptic: otic ganglion		Parasympathetic innervation to parotid gland
	Visceral sensory	Nuclei of solitary tract, spinal trigeminal nucleus/ inferior ganglion	Jugular foramen	Visceral sensation from parotid gland, carotid body, carotid sinus, pharynx, and middle ear
	Special sensory	Nuclei of solitary tract /inferior ganglion		Taste from posterior third of tongue
	General sensory	Spinal trigeminal nucleus/superior ganglion		Cutaneous sensation from external ear

[a]See also Table 9.15.



B



C

Lateral View

Visceral motor (parasympathetic) innervation of parotid gland

Tympanic nerve arises from CN IX and emerges with it from jugular foramen.

↓

Tympanic nerve enters the middle ear via the tympanic canaliculus in petrous part of the temporal bone.

↓

Tympanic nerve forms the tympanic plexus on the promontory of middle ear.

↓

The lesser petrosal nerve arises as a branch of the tympanic plexus.

↓

Lesser petrosal nerve penetrates roof of tympanic cavity (tegmen tympani) to enter middle cranial fossa.

↓

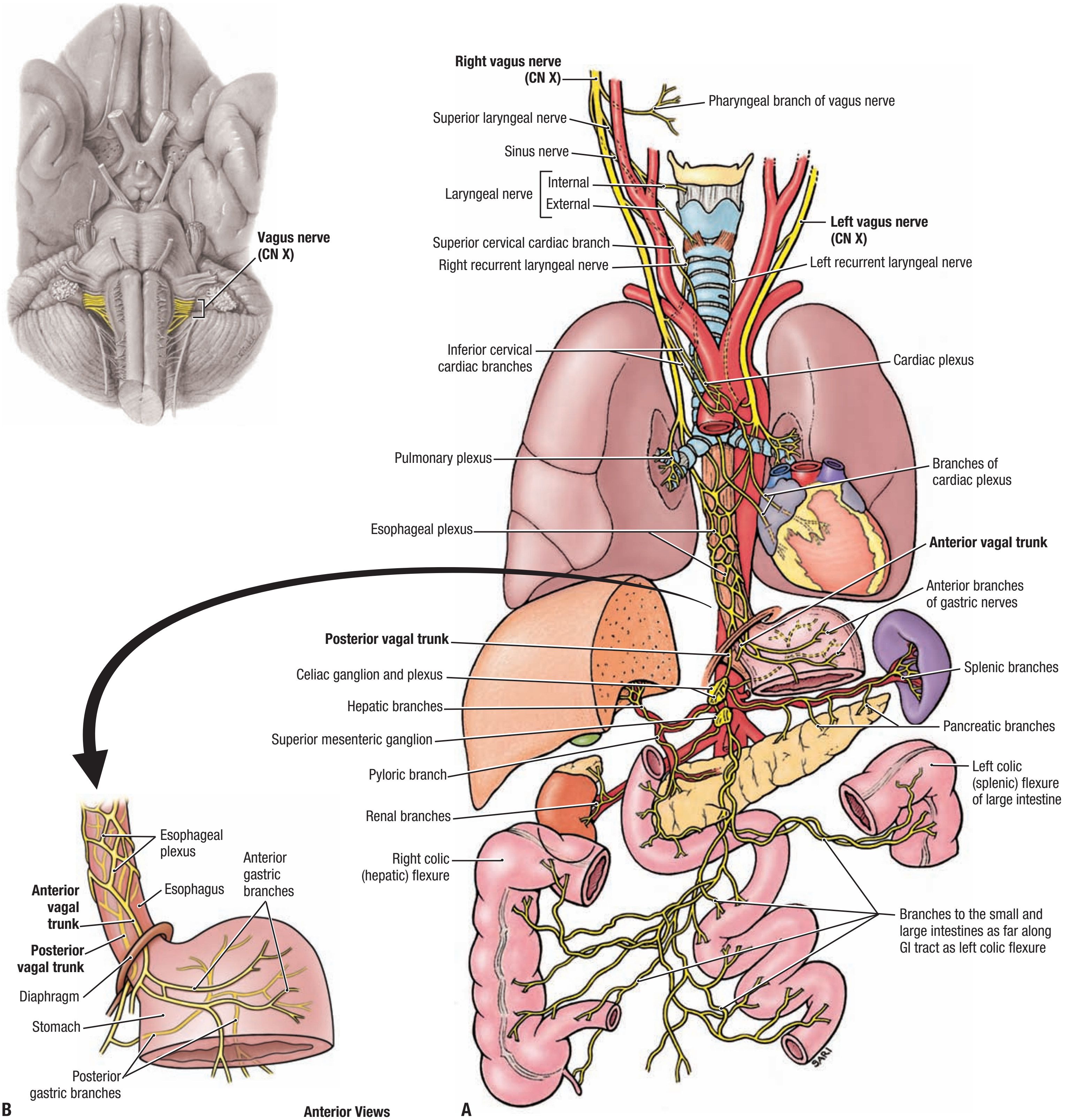
Lesser petrosal nerve leaves the cranium through the foramen ovale.

↓

Parasympathetic fibers synapse in the otic ganglion.

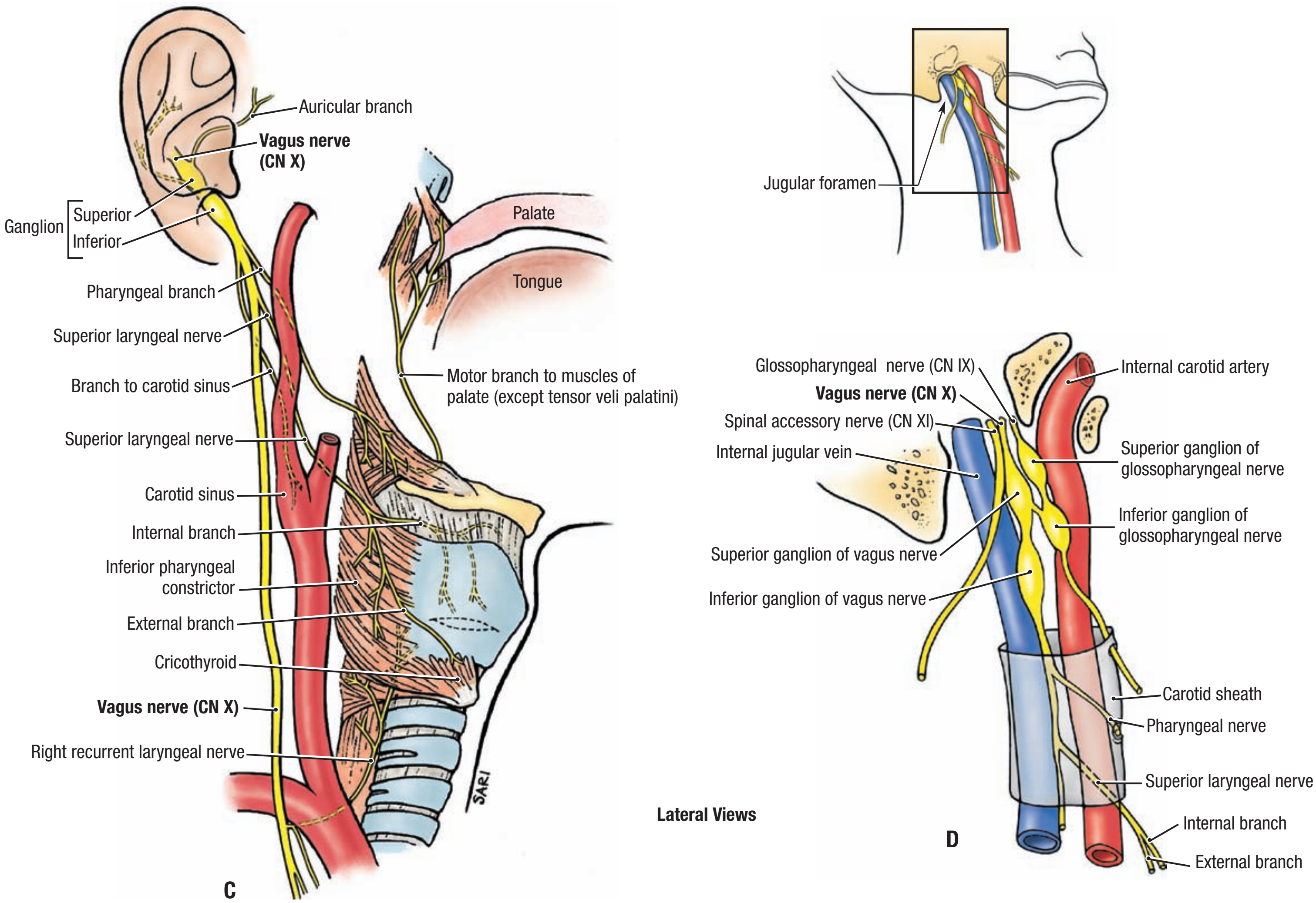
↓

Postsynaptic fibers pass to parotid gland via branches of auriculotemporal nerve (CN V_3).



9.18 VAGUS NERVE (CN X)

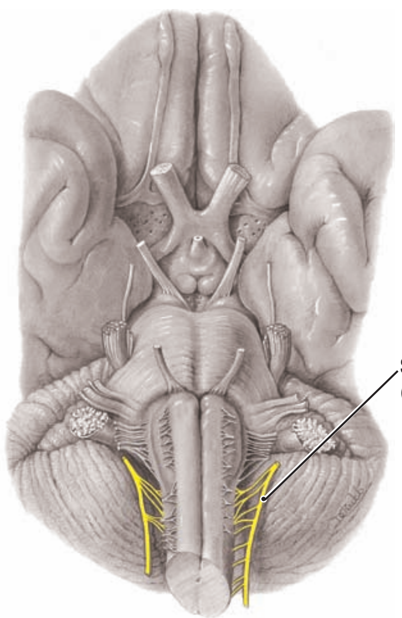
A. Course in neck, thorax and abdomen. **B.** Anterior and posterior vagal trunks. **C.** Branches in neck. **D.** Superior and inferior ganglia of vagus nerve.

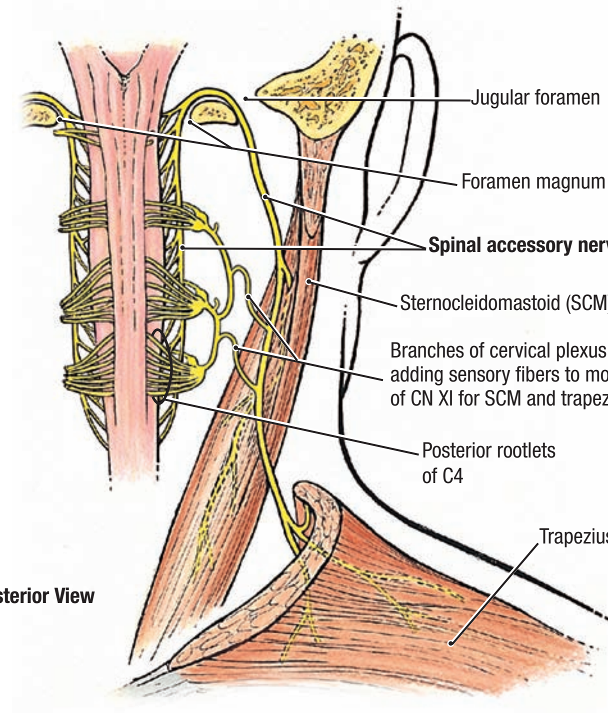


9.18 VAGUS NERVE (CN X) *(CONTINUED)*

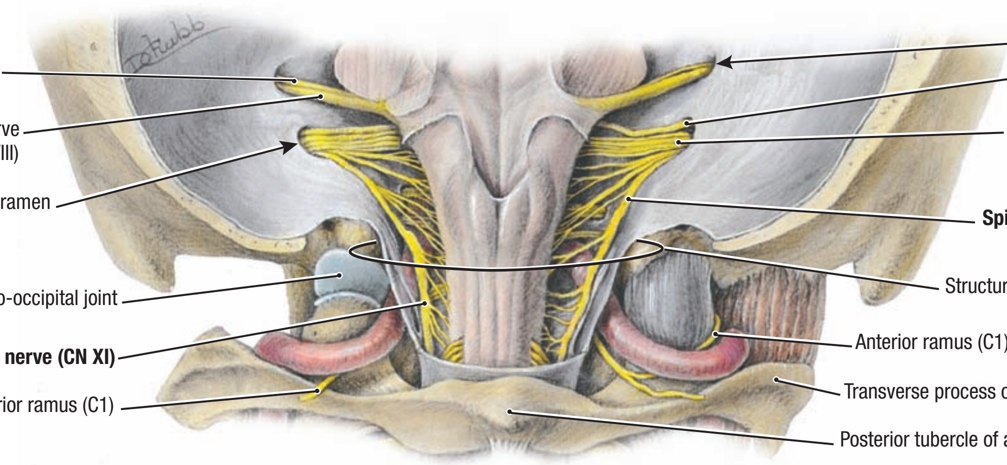
TABLE 9.12 VAGUS NERVE (CN X)

Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Vagus	Branchial motor	Nucleus ambiguus	Jugular foramen	Motor to constrictor muscles of pharynx, intrinsic muscles of larynx, muscles of palate (except tensor veli palatini), and striated muscle in superior two thirds of esophagus
	Visceral motor	Presynaptic: posterior (dorsal) nucleus of CN X; Postsynaptic: neurons in, on, or near viscera		Parasympathetic innervation to smooth muscle of trachea, bronchi, and digestive tract, cardiac muscle
	Visceral sensory	Nuclei of solitary tract, spinal trigeminal nucleus/ inferior ganglion		Visceral sensation from base of tongue, pharynx, larynx, trachea, bronchi, heart, esophagus, stomach, and intestine
	Special sensory	Nuclei of solitary tract/inferior ganglion		Taste from epiglottis and palate
	General sensory	Spinal trigeminal nucleus/superior ganglion		Sensation from auricle, external acoustic meatus, and dura mater of posterior cranial fossa





A. Posterior View



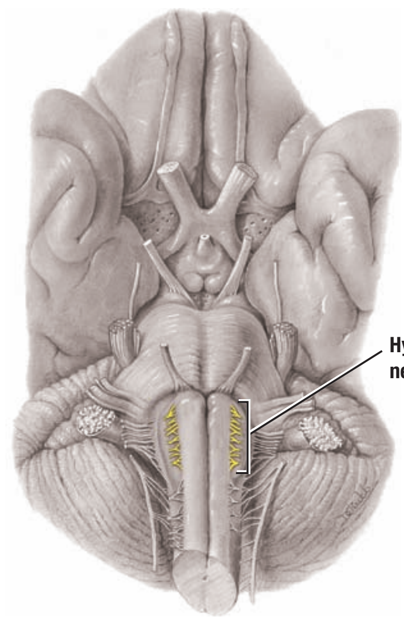
B. Posterior View

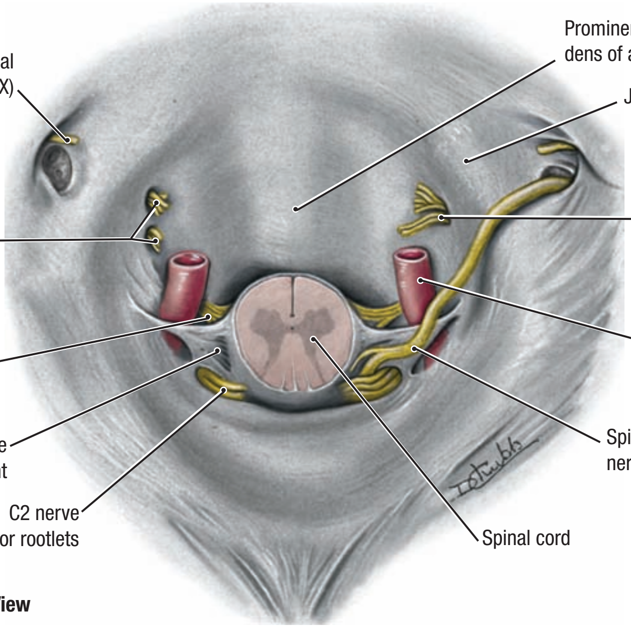
9.19 SPINAL ACCESSORY NERVE (CN XI)

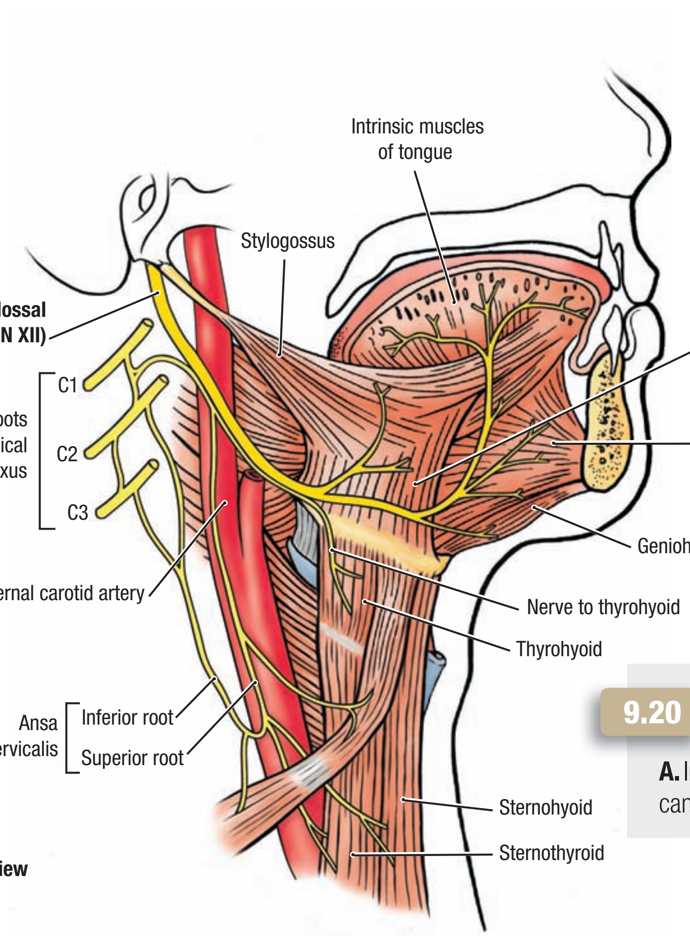
A. Schematic illustration of distribution. **B.** Intracranial course.

TABLE 9.13 SPINAL ACCESSORY NERVE (CN XI)

Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Spinal accessory	Somatic motor	Accessory nucleus of spinal cord	Jugular foramen	Motor to sternocleidomastoid and trapezius





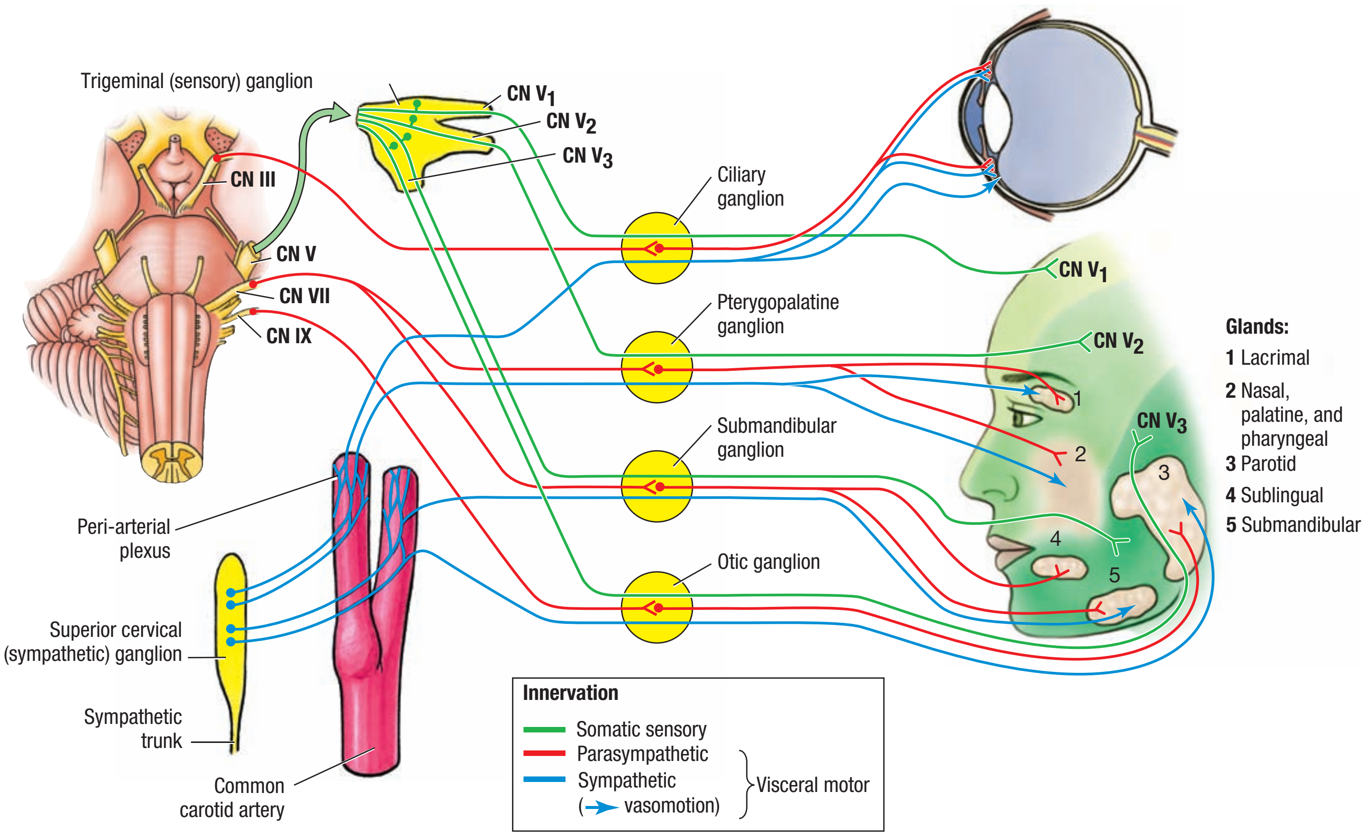


9.20 HYPOGLOSSAL NERVE (CN XII)

A. Intracranial exit from cranium into hypoglossal canal. **B.** Schematic illustration of distribution.

TABLE 9.14 HYPOGLOSSAL NERVE (CN XII)

Nerve	Functional Components	Cells of Origin/Termination	Cranial Exit	Distribution and Functions
Hypoglossal	Somatic motor	Nucleus of CN XII	Hypoglossal canal	Motor to muscles of tongue (except palatoglossus)

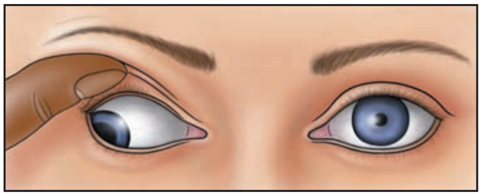


9.21 SUMMARY OF AUTONOMIC INNERVATION OF HEAD

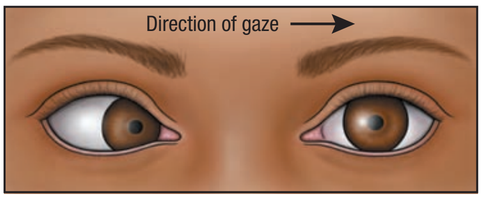
TABLE 9.15 AUTONOMIC GANGLIA OF HEAD

Ganglion	Location	Parasympathetic Root (Nucleus of Origin)[a]	Sympathetic Root	Main Distribution
Ciliary	Between optic nerve and lateral rectus, close to apex of orbit	Inferior branch of oculomotor nerve (CN III) (Edinger-Westphal nucleus)	Branch from internal carotid plexus in cavernous sinus	Parasympathetic postsynaptic fibers from ciliary ganglion pass to ciliary muscle and sphincter, pupillae of iris; sympathetic postsynaptic fibers from superior cervical ganglion pass to dilator pupillae and blood vessels of eye
Pterygopalatine	In pterygopalatine fossa, where it is attached by pterygopalatine branches of maxillary nerve; located just anterior to opening of pterygoid canal and inferior to CN V_2	Greater petrosal nerve from facial nerve (CN VII) (superior salivatory nucleus)	Deep petrosal nerve, a branch of internal carotid plexus that is continuation of postsynaptic fibers of cervical sympathetic trunk; fibers from superior cervical ganglion pass through pterygopalatine ganglion and enter branches of CN V_2	Parasympathetic postsynaptic fibers from pterygopalatine ganglion innervate lacrimal gland through zygomatic branch of CN V_2; sympathetic postsynaptic fibers from superior cervical ganglion accompany branches of pterygopalatine nerve that are distributed to the nasal cavity, palate, and superior parts of the pharynx
Otic	Between tensor veli palatini and mandibular nerve; lies inferior to foramen ovale	Tympanic nerve from glossopharyngeal nerve (CN IX); tympanic nerve continues from tympanic plexus as lesser petrosal nerve (inferior salivatory nucleus)	Fibers from superior cervical ganglion travel via plexus on middle meningeal artery	Parasympathetic postsynaptic fibers from otic ganglion are distributed to parotid gland through auriculotemporal nerve (branch of CN V_3); sympathetic postsynaptic fibers from superior cervical ganglion pass to parotid gland and supply its blood vessels
Submandibular	Suspended from lingual nerve by two short roots; lies on surface of hyoglossus muscle inferior to submandibular duct	Parasympathetic fibers join facial nerve (CN VII) and leave it in its chorda tympani branch, which unites with lingual nerve (superior salivatory nucleus)	Sympathetic fibers from superior cervical ganglion travel via the plexus on facial artery	Postsynaptic parasympathetic fibers from submandibular ganglion are distributed to the sublingual and submandibular glands; sympathetic fibers supply sublingual and submandibular glands and appear to be secretomotor

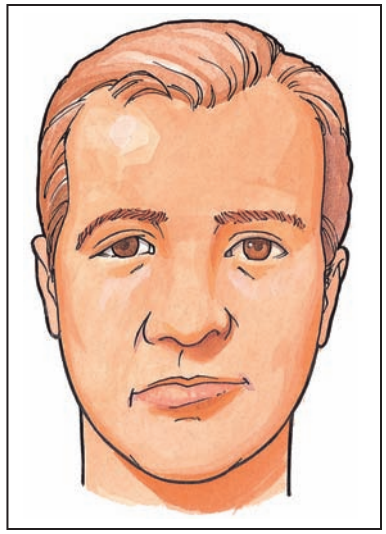
[a]For location of nuclei, see Figure 9.3.



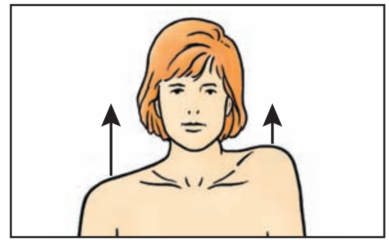
A. Right oculomotor (CN III) nerve palsy



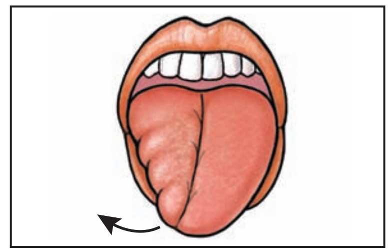
B. Left abducent (CN VI) nerve palsy



C. Right facial (CN VII) palsy (Bell palsy)



D. Right CN XI lesion



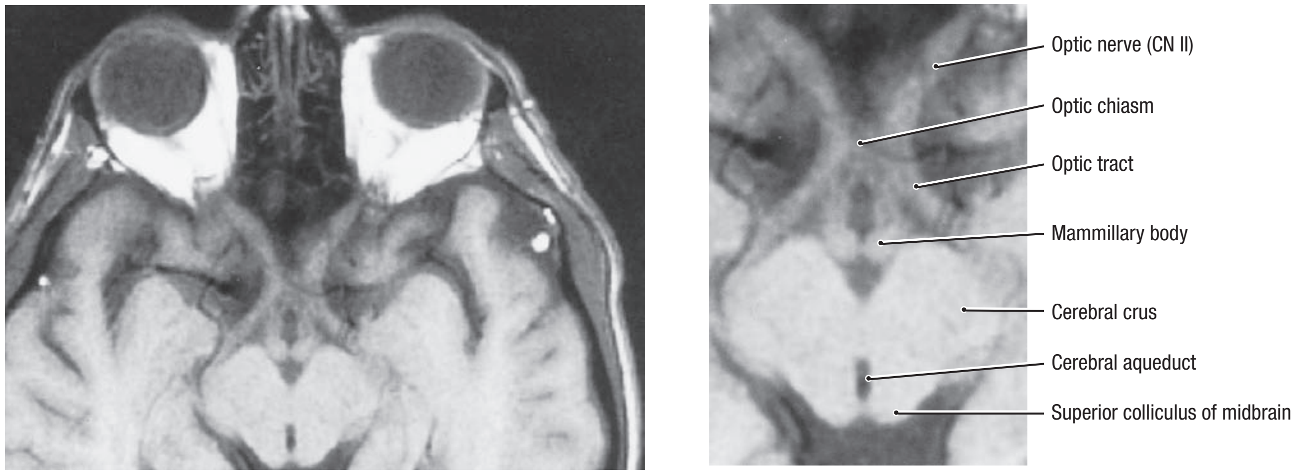
E. Right CN XII lesion

9.22 CRANIAL NERVE LESIONS

TABLE 9.16 SUMMARY OF CRANIAL NERVE LESIONS

Nerve	Lesion Type and/or Site	Abnormal Findings
CN I	Fracture of cribriform plate	Anosmia (loss of smell); cerebrospinal fluid (CSF) rhinorrhea (leakage of CSF through nose)
CN II	Direct trauma to orbit or eyeball; fracture involving optic canal	Loss of pupillary constriction
	Pressure on optic pathway; laceration or intracerebral clot in temporal, parietal, or occipital lobes of brain	Visual field defects
	Increased CSF pressure	Swelling of optic disc (papilledema)
CN III	Pressure from herniating uncus on nerve; fracture involving cavernous sinus; aneurysms	Dilated pupil, ptosis, eye rotates inferiorly and laterally (down and out), pupillary reflex on the side of the lesion will be lost (**A**)
CN IV	Stretching of nerve during its course around brainstem; fracture of orbit	Inability to rotate adducted eye inferiorly
CN V	Injury to terminal branches (particularly CN V_2) in roof of maxillary sinus; pathologic processes (tumors, aneurysms, infections) affecting trigeminal nerve	Loss of pain and touch sensations/paresthesia on face; loss of corneal reflex (blinking when cornea touched); paralysis of muscles of mastication; deviation of mandible to side of lesion when mouth is opened
CN VI	Base of brain or fracture involving cavernous sinus or orbit	Inability to rotate eye laterally; diplopia on lateral gaze (**B**)
CN VII	Laceration or contusion in parotid region	Paralysis of facial muscles; eye remains open; angle of mouth droops; forehead does not wrinkle (**C**)
	Fracture of temporal bone	As above, plus associated involvement of cochlear nerve and chorda tympani; dry cornea and loss of taste on anterior two thirds of tongue
	Intracranial hematoma ("stroke")	Weakness (paralysis) of lower facial muscles contralateral to the lesion, upper facial muscles are not affected because they are bilaterally innervated
CN VIII	Tumor of nerve	Progressive unilateral hearing loss; tinnitus (noises in ear); vertigo (loss of balance)
CN IX[a]	Brainstem lesion or deep laceration of neck	Loss of taste on posterior third of tongue; loss of sensation on affected side of soft palate; loss of gag reflex on affected side
CN X	Brainstem lesion or deep laceration of neck	Sagging of soft palate; deviation of uvula to unaffected side; hoarseness owing to paralysis of vocal fold; difficulty in swallowing and speaking
CN XI	Laceration of neck	Paralysis of sternocleidomastoid and superior fibers of trapezius; drooping of shoulder (**D**)
CN XII	Neck laceration; basal skull fractures	Protruded tongue deviates toward affected side; moderate dysarthria, disturbance of articulation **(E)**

[a]Isolated lesions of CN IX are uncommon; usually, CN IX, X, and XI are involved together as they pass through the jugular foramen.



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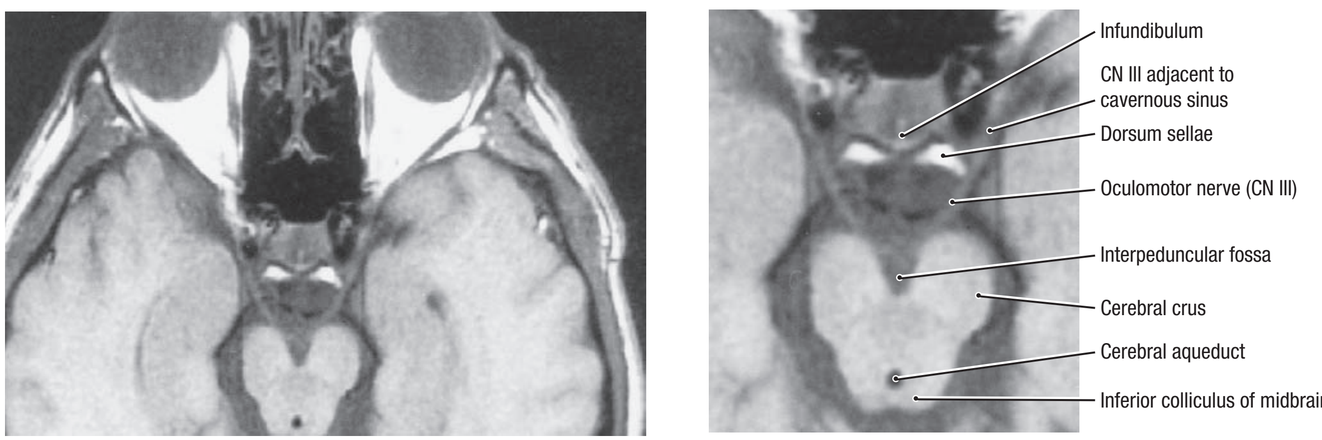
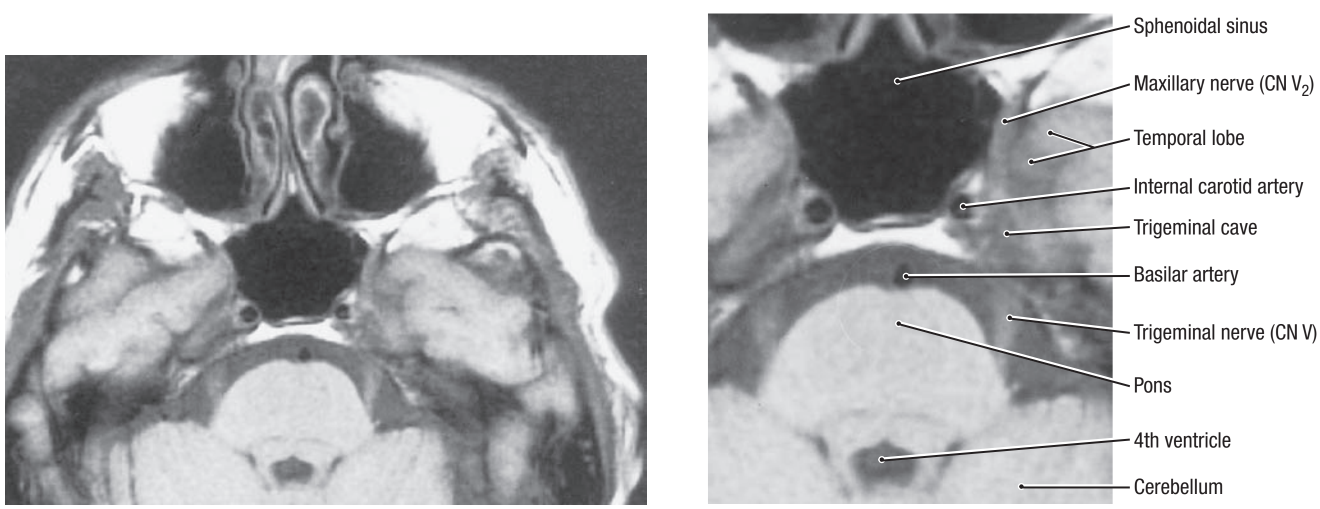


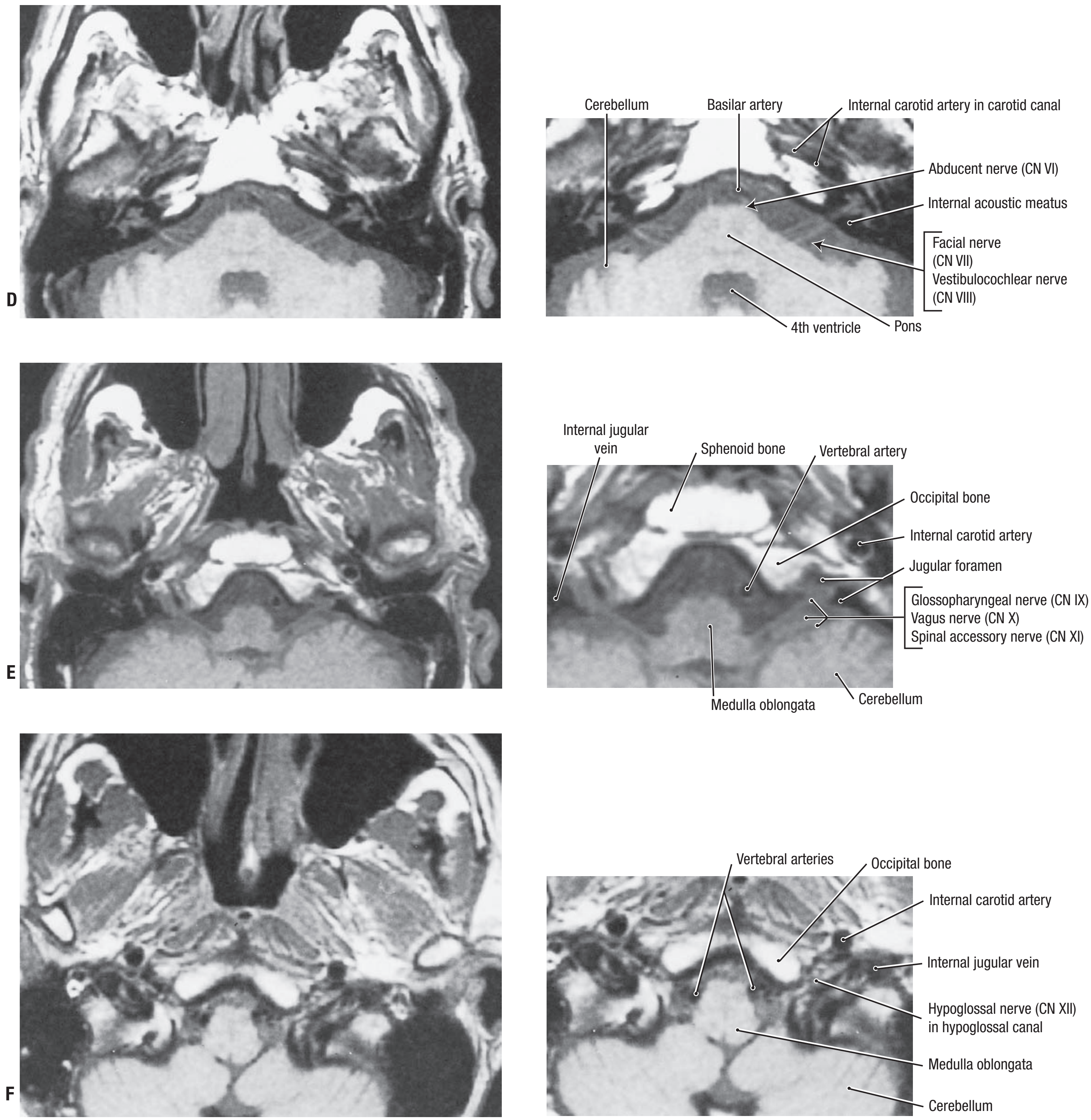
B



C

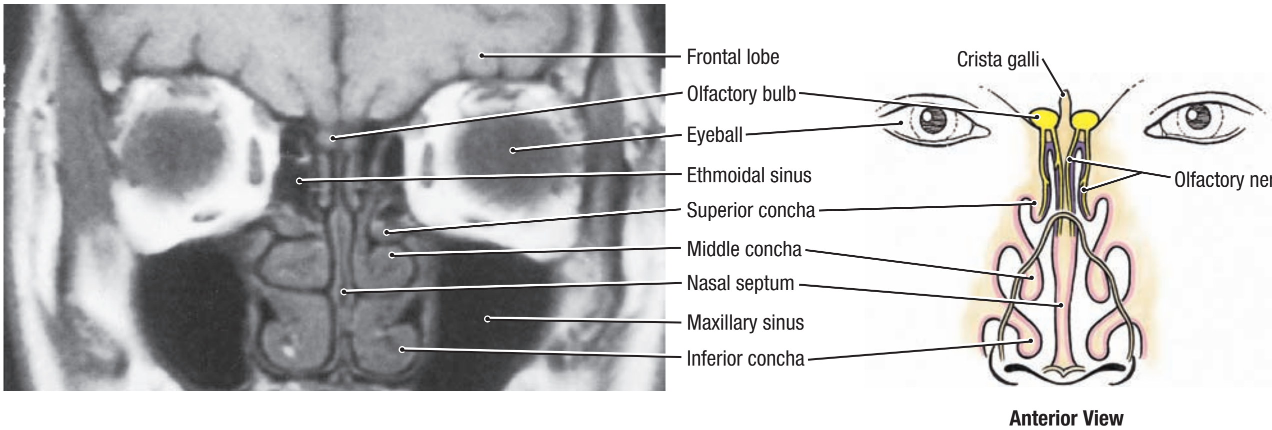
9.23 TRANSVERSE MRIs THROUGH HEAD, SHOWING CRANIAL NERVES

A. Optic nerve (CN II). **B.** Oculomotor nerve (CN III). **C.** Trigeminal nerve (CN V).



9.23 TRANSVERSE MRIs THROUGH HEAD, SHOWING CRANIAL NERVES *(CONTINUED)*

D. Abducent (CN VI), facial (CN VII), and vestibulocochlear (CN VIII) nerves. **E.** Glossopharyngeal (CN IX), vagus (CN X), and spinal accessory (CN XI) nerves. **F.** Hypoglossal nerve (CN XII).



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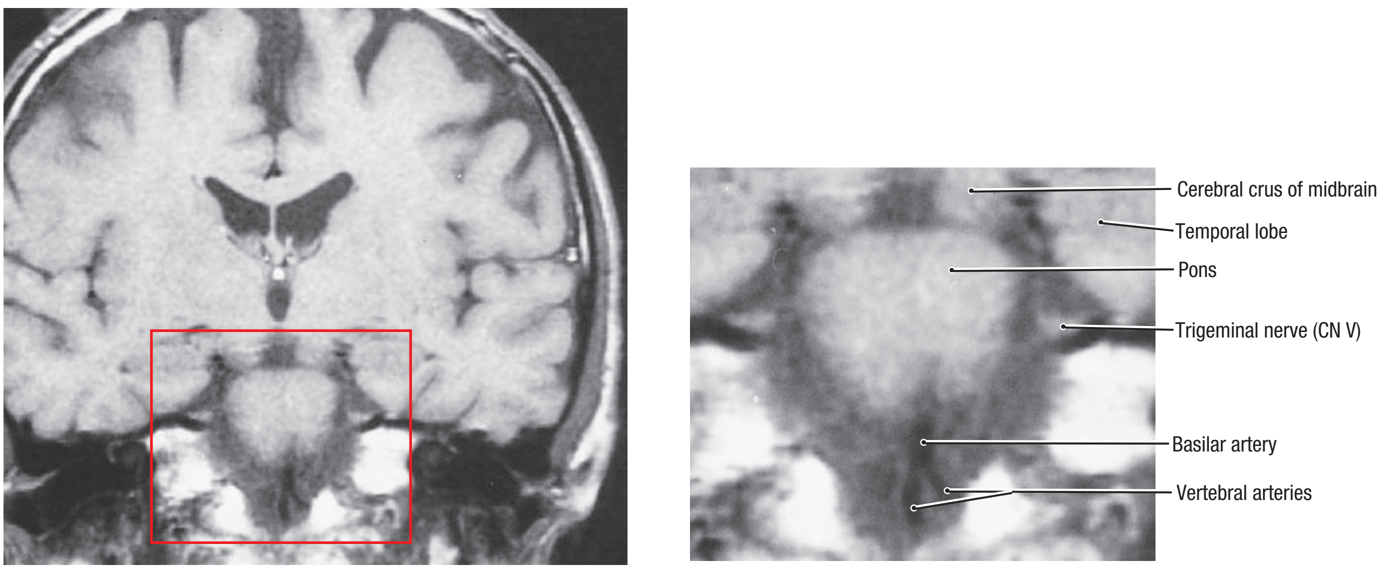

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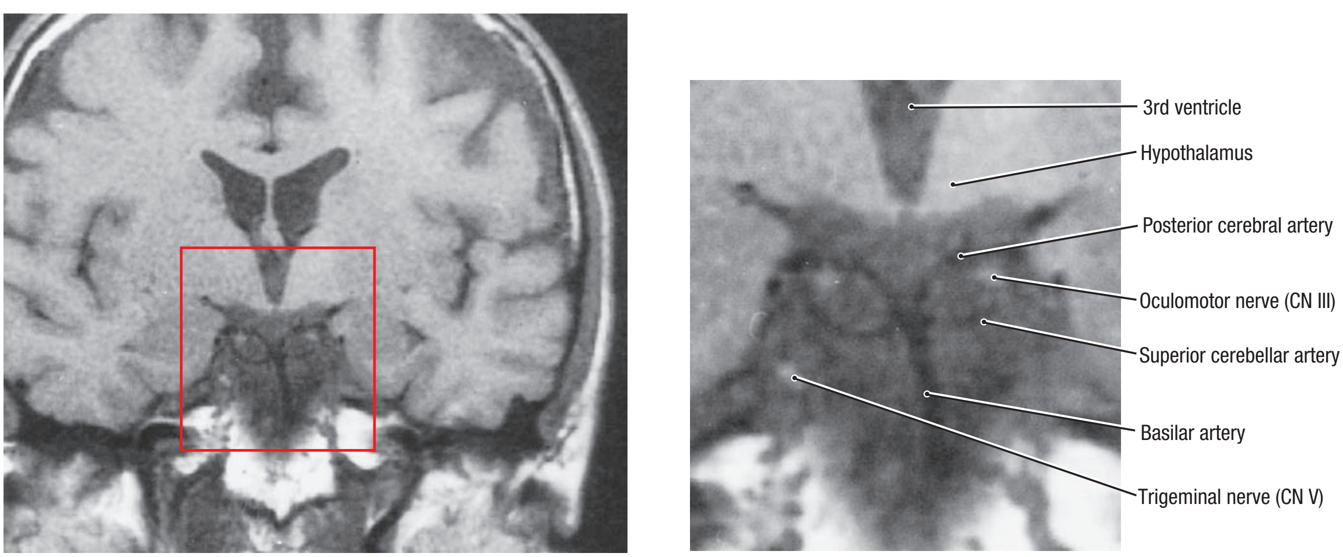

C

9.24 CORONAL MRIs THROUGH HEAD, SHOWING CRANIAL NERVES

A. Olfactory bulb. **B.** Trigeminal (CN V) nerve. **C.** Oculomotor (CN III) and trigeminal (CN V) nerves.

Tribute to Dr. Grant

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Chapter 1

Fig. 1.51: Anson BH. The aortic arch and its branches. *Cardiology*. Vol. 1. New York, NY: McGraw-Hill, 1963.

Chapter 2

Fig. 2.49: Couinaud C. Lobes et segments hepatiques: Note sur l'architecture anatomique et chirurgicale du foie. *Presse Med* 1954;62:709.

Fig. 2.49: Healy JE, Schroy PC. Anatomy of the biliary ducts within the human liver: analysis of the prevailing pattern of branchings and the major variations of the biliary ducts. *Arch Surg* 1953;66:599.

Fig. 2.89B: Campbell M. Ureteral reduplication (double ureter). *Urology*. Vol. 1. Philadelphia, PA: WB Saunders, 1954:309.

Chapter 3

Fig. 3.43A: Oelrich TM. The urethral sphincter muscle in the male. *Am J Anat* 1980;158:229.

Fig. 3.43B: Oelrich TM. The striated urogenital sphincter muscle in the female. *Anat Rec* 1983;205:223.

Chapter 4

Fig. 4.48A: Jit I, Charnakia VM. The vertebral level of the termination of the spinal cord. *J Anat Soc India* 1959;8:93.

Note: Page numbers followed by t denote tables.

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