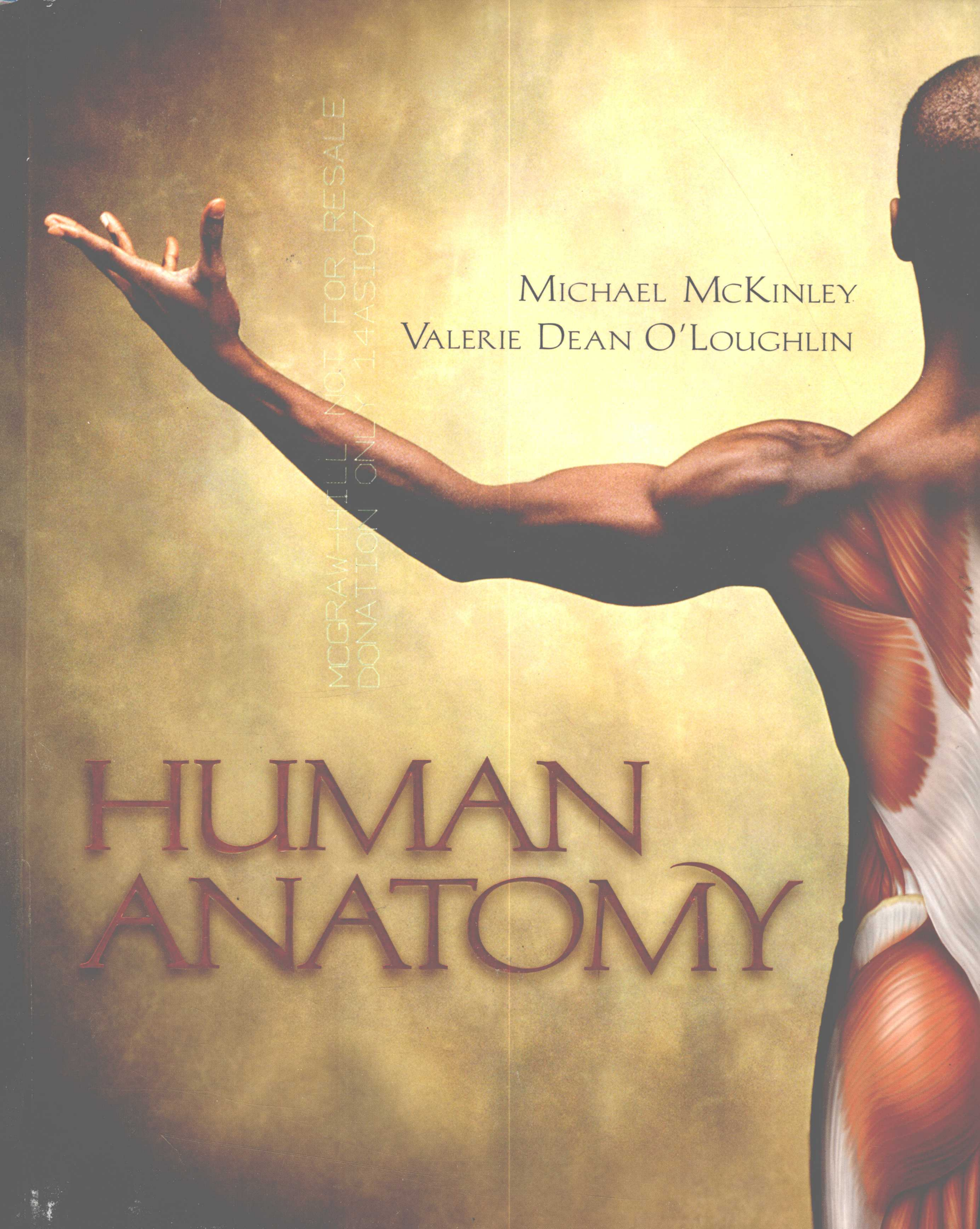

MICHAEL MCKINLEY
VALERIE DEAN O'LOUGHLIN

HUMAN ANATOMY

MICHAEL MCKINLEY
GLENDALE COMMUNITY COLLEGE
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INDIANA UNIVERSITY

HUMAN ANATOMY

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To Jan, Renee, Ryan, and Shaun, and Janet Silver (the McKinley family).

To Bob and Erin (the O'Loughlin family).

And to Kris Queck and Laurel Shelton (our extended book family).

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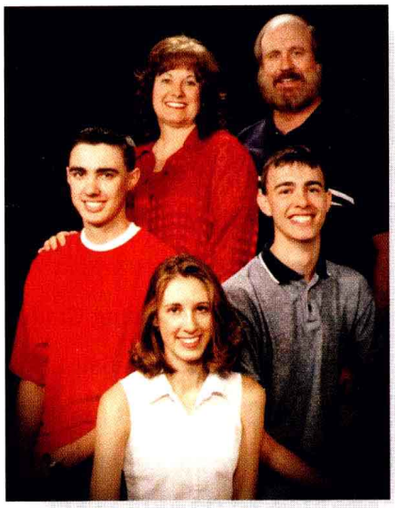
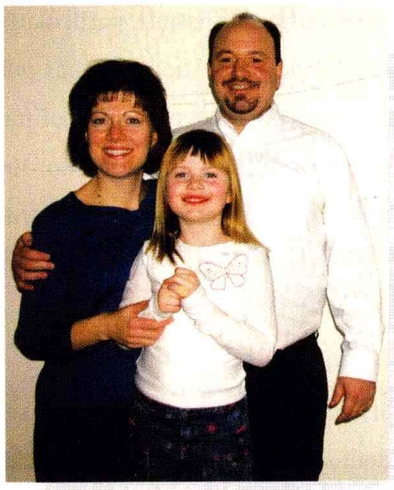


MICHAEL MCKINLEY received his undergraduate degree from the University of California at Berkeley, and both his M.S. and Ph.D. degrees from Arizona State University. In 1978, he accepted a postdoctoral fellowship at the University of California at San Francisco (UCSF) Medical School in the laboratory of Dr. Stanley Prusiner, where he worked for 2 years investigating prions and prion-diseases. In 1980, he became a member of the anatomy faculty at the UCSF Medical School and taught medical students for 10 years while continuing to do research on prions. He was an author or co-author of more than 80 scientific papers during this time. Since 1991, Mike has been a member of the biology faculty at Glendale Community College, where he teaches anatomy and physiology to pre-health-care students. Between 1991 and 2000, in addition to teaching at Glendale Community College, he participated in Alzheimer disease research at Sun Health Research Institute, and taught developmental biology and human genetics classes at Arizona State University, West. Mike is an active member of the Human Anatomy and Physiology Society (HAPS). He resides in Tempe, AZ, with his wife Jan and their youngest son Shaun.



VALERIE DEAN O'LOUGHLIN received her undergraduate degree from the College of William and Mary and her Ph.D. in biological anthropology from Indiana University. Since 1995, she has been a member of the Indiana University School of Medicine faculty, where she teaches human gross anatomy to first-year medical students and basic human anatomy to undergraduates. Her research interests span craniofacial growth and development, osteology, paleopathology, anatomy, educational research, and the scholarship of teaching and learning. Valerie has presented and published articles in all of these fields. In addition, she has prepared numerous Web-based human embryology teaching modules. She has been the recipient of the SBC Fellows and IHETS educational grants as well as several teaching awards, including a Teaching Excellence Recognition Award and a Trustee Teaching Award from Indiana University.

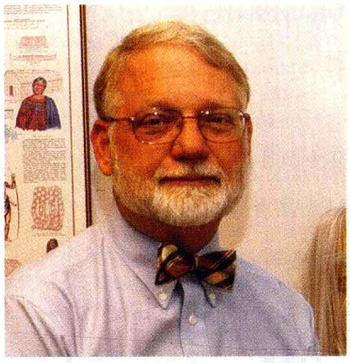
Valerie is an active member of the American Association of Anatomists (AAA), the American Association of Physical Anthropologists (AAPA), and the Human Anatomy and Physiology Society (HAPS). She resides in Bloomington, IN, with her husband Bob and her daughter Erin.

SPECIAL CONTRIBUTORS

CHRISTINE M. ECKEL, cadaver prosectionist and biomedical photographer for this book, received her B.A. and M.A. degrees in integrative biology and human biodynamics from the University of California at Berkeley. She is currently finishing work on a Ph.D. in human anatomy at the University of Utah School of Medicine, where she also teaches gross anatomy and pathology courses for first-year medical students. She has taught undergraduate courses in general biology, human anatomy and human physiology for the past 7 years at Salt Lake Community College.

Christine has received several teaching honors, including an Outstanding Graduate Student Instructor Award from UC Berkeley and a Teaching Excellence Award from Salt Lake Community College; she was also named the Betty Cook Karrh Endowed P.E.O. Scholar for 2004–2005. Christine's animal dissection photographs have appeared in several publications, and she has authored numerous ancillary materials for both human anatomy and human physiology textbooks. She is an active member of the Human Anatomy and Physiology Society (HAPS), the American Association of Anatomists (AAA), and the American Association of Clinical Anatomists (AACA).

DR. MARK BRAUN served as a clinical consultant for the Clinical View boxes in this book. He holds a B.S. in biology from Purdue University (1970), an M.D. from Indiana University School of Medicine (1975), and an M.A. in anthropology from Indiana University (1997). Dr. Braun practiced pathology while on the medical staff of Bloomington Hospital in Bloomington, IN, for 17 years. He began teaching general and systemic pathology at the Indiana University School of Medicine in 1995. His research interests include the study of Native American health issues, particularly the introduction of European infectious diseases into New World populations. He has published articles concerning the diagnosis of human disease, including the identification of fragments of ancient tuberculosis DNA in Native American skeletal remains dating from A.D. 1000.



Dr. Braun has been recognized repeatedly for his teaching abilities, and in 1999 received the prestigious American Medical Association's national award for innovative teaching.

FRANK BAKER compiled all of the pronunciations, word origins, and glossary terms for this book. Recognized by students and colleagues for his commitment to student success and innovative teaching strategies, Frank teaches human anatomy and physiology and college success as a professor of biology in the Life Sciences Department at Golden West College, Huntington Beach, CA. He is committed to empowering and enabling students to achieve their goals, and is known as a teacher who teaches to the whole student. His interest in learning skills and his years of classroom experience are a perfect partnership for his work on this textbook.

A graduate of UCLA, Frank is a member of several professional, community, and charitable organizations. He has authored student workbooks and instructional aids for human anatomy textbooks, and has written and produced instructional video lessons. Frank shares his life with his wife Annie, a lawyer, and their teenage daughter Nathalie, both of whom he acknowledges as the "teachers of life's important lessons to the teacher."

Preface

Human anatomy is a fascinating field that has many layers of complexity. The subject is difficult to teach, and students can often be overwhelmed by its massive amount of material. In many respects, studying anatomy is similar to studying a foreign language because students must understand the vocabulary before they can apply the material. As many instructors know, textbook selection can either help or hinder student understanding. Throughout our teaching careers, we have examined and reviewed many textbooks. Some texts provide relatively accurate terminology and description but are too difficult for the average undergraduate to read. Other texts are easier to read but not as thorough or accurate in their discussions. We felt that a new textbook was in order—one that was accurate and in-depth in its anatomic descriptions and yet easy to understand and full of pedagogical elements to help the student. This is the vision of this first edition of *Human Anatomy.*

Audience

This textbook is designed for a one-semester human anatomy course, typically taken in the second or third year of college, for students in pre-allied health professions, nursing, exercise science, kinesiology, and/or other pre-professional health programs. It assumes the reader has no prior knowledge of biology or chemistry, and so the early chapters serve as a primer for the history of anatomy, biological terminology, and cell biology. This text provides all the background the introductory student needs to learn the basics of human anatomy.

What Makes This Book Special?

Although several human anatomy books are already on the market, a variety of features make this text different from the rest.

Designed and Written "From the Ground Up" as a Human Anatomy Text

Most, if not all, current undergraduate human anatomy textbooks are primarily "cut-down" versions of existing anatomy and physiology textbooks. Our text, *Human Anatomy,* was written exclusively for and with attention to the human anatomy course. Our text is not a "pared down" version of an A&P text; we have designed it from the ground up to satisfy the needs of anatomy students and instructors.

Authors' Experience in Gross Anatomy and Histology

Using our combined experience in teaching undergraduate and graduate anatomy courses, we have worked to create a textbook that combines our extensive knowledge of the material with our understanding of how to best teach human anatomy.

Valerie Dean O'Loughlin has spent the past decade teaching human gross anatomy to medical students and performing cadaver dissections at Indiana University. She has developed an expert eye for both gross human anatomy and the variability typically seen, and drew heavily upon this experience to ensure that both the narrative and the gross anatomy artwork in this book conform to standards typically seen in medical atlases and medical textbooks. Incorporating her experience in teaching undergraduates, Valerie has made sure that the art and text are accurate but presented at a level that will not overwhelm the undergraduate reader.

Michael McKinley has 10 years of experience teaching histology to medical students at the University of California at San Francisco, and also was the director of the Brain Donation Program at the Sun Health Research Institute. More recently, Mike has spent the past 15 years teaching anatomy and physiology, general biology, and genetics to undergraduates at Glendale Community College. Mike carefully focused his eye for detail and accuracy on the text and artwork for the histological and nervous system chapters.

Superior Illustrations and a Quality Art Program

Anatomy is a visual subject, and one of the best ways a student can learn it is by studying beautiful, accurate drawings. We have been dismayed in the past to see texts in which sound anatomic discussions were accompanied by weak or inaccurate illustrations. One of our prime goals in producing this book was that the illustrations be just as accurate as the text. To meet this objective, we worked with an experienced team of certified medical illustrators to produce a collection of anatomic images unsurpassed by other anatomy texts. These images are both beautiful and as accurate as possible. We painstakingly scrutinized each rendering, relying on experience in human gross anatomy, cadaver dissection, histology, and A&P—as well as trusted anatomic bibles such as Gray, Grant, Clemente, Netter, and a host of photographic atlases—to make sure the art matches life. Every illustration also went through an intensive peer review in which dozens of fellow instructors gave us pointed feedback on how to clarify concepts and make the drawings even more accurate—welcome assistance for our sometimes-weary eyes! Finally, we have carefully labeled the illustrations to coincide with coverage in the narrative to ensure that the pictures and words work together to tell a cohesive story. We challenge you to compare the artwork in this text with that in other human anatomy texts, and see which you and your students prefer.

Human Cadaver Photographs to Complement the Illustrations

Sometimes even the most beautiful art cannot prepare us for what anatomic structures look like in a real human being or for the normal variations that occur among individuals. Whenever possible, we have paired illustrations with human cadaver photographs to provide two valuable perspectives of key views: an artist's rendering that utilizes color and texture to make features stand out, and a photograph that demonstrates the appearance of real specimens. Furthermore, we have applied labels to complementary illustrations and photos so that they mirror each other whenever possible to make it easier for students to correlate structures between images. Christine Eckel of Salt Lake Community College tirelessly worked on the dissections and photographs of the cadavers. Her work is beautiful, and many of her dissections are presented in a way that is unparalleled in other texts. We suggest you turn to chapter 11 (Axial Muscles) and examine these photos. You will be impressed—and your students will appreciate their value as they are learning the laboratory material.

Writing Style: Blending Accuracy with Readability

Both authors have distinct writing styles that, when combined in this text, provide the optimum balance between concise anatomic accuracy and user-friendly readability. We felt that a text that was too condensed in its descriptions would be more frustrating than

helpful for students to use. Likewise, if a text is too verbose in its descriptions, students feel they have read many pages that have said little. We have tried to strike a happy medium between these two extremes, so a student will feel that the text is easy to read and understand, while the instructor recognizes that the information is accurate, concise, and expertly written. We have been meticulous in our descriptions and level of accuracy. Through each draft that we wrote and refined, we checked multiple literature sources to ensure that our discussions were accurate and correct to the best of current knowledge. Many gracious human anatomy instructors lent us their eyes as well, as they evaluated our manuscripts and page proofs, providing critical guidance and feedback that kept us on our toes each step of the way.

In addition to making the text readable and accurate, we wanted to make it engaging and effective. To this end, we have incorporated many active learning techniques into the narrative. As we tell our students, you don't lose weight merely by watching an exercise program; you have to *do* the exercises in order to get results. Therefore, throughout our text, we have provided opportunities for the student to be an active learner, not just a passive reader. For example, students are encouraged to palpate structures on their bodies, perform basic experiments to test anatomic principles, and observe certain features on themselves. As the students perform these anatomy "exercises," their understanding will increase.

Themes and Distinctive Topic Approaches

Through our teaching experience, we have developed a few approaches that really seem to help students grasp certain topics or spark their interest. Thus, we have tried to incorporate these successful ideas from our own courses into our book.

Embryology

In many cases, a student can gain a complete understanding of adult anatomy only by first learning about the embryologic events that formed this anatomy. For this reason, we have placed an entire chapter on embryology (chapter 3) early in our text, as opposed to having a development chapter at the end of the book. In addition, "systems embryology" sections in each systems chapter (e.g., integumentary system, digestive system, etc.) provide a brief but thorough overview of the developmental processes for that particular system at a level that will not overwhelm the introductory student.

Forensic Anthropology

Many of our students are fascinated by crime scene shows and love to learn how knowledge of anatomy can play a part in forensic analysis. With a Ph.D. in biological anthropology, Valerie shares this interest, and utilized her experience to craft the forensic applications in the skeletal system chapters. Chapters 6–8 feature discussions on such topics as epiphyseal plate fusion as a reliable indicator of age at death, sex differences in the skull, sex differences in the pelvis, and how morphologic changes in the pubic symphysis of the os coxae can be used to estimate age at death. These forensic applications are a great way to reinforce learning, and students will enjoy the "real-life" applications.

Surface Anatomy

Many of the students who take anatomy will become health-care professionals who use surface anatomy throughout their careers and need to know the importance of these landmarks. To best serve our student audience, we have given surface anatomy the coverage it deserves. Our chapter 13, Surface Anatomy, contains beautiful photographs and clear, concise text as well as numerous Clinical Views that illustrate the importance of the landmarks and how they are used daily in health care. Placing this chapter directly after the musculoskeletal chapters allows students to establish knowledge of the body's underlying framework before trying to understand surface landmarks.

Nervous System

In order to understand the workings of the nervous system, it is best to learn how the brain controls all aspects of the nervous system. Thus, in this text we examine the brain first, followed by a chapter illustrating its similarities, differences, and relationships with the spinal cord.

It seemed appropriate to use central nervous system terminology to describe the brain first, then the spinal cord. Additionally, because the nuclei of the cranial nerves are housed within the brain, we felt it made more sense to present the cranial nerves with the brain.

Autonomic Nervous System

The autonomic nervous system is perhaps one of the most challenging topics in human anatomy. Why, then, do so many texts make a difficult topic even *more* difficult by presenting the sympathetic division first? We have seen in our own teaching experience that presenting the parasympathetic division (the relatively "easier" system) first increases the overall understanding of the autonomic nervous system. Thus, in chapter 18 (Autonomic Nervous System), we discuss the parasympathetic division first, and follow up with a discussion of the more complex sympathetic division.

Arteries and Veins

We have been confused as to why other texts discuss all of the arteries in the body first, and then follow with a separate discussion of all of the veins. Presenting this material in such a fragmented fashion does not give students "the big picture." We feel that it makes much more sense to discuss blood flow in its entirety. For this reason, our text discusses arteries and veins in unison by region. For example, we present the veins and arteries of the upper limb together. This approach emphasizes to students that arteries often have corresponding veins and that both are responsible for the blood flow in a general region. We challenge you to compare our chapter 23 (Vessels and Circulation) with chapters from other texts. We predict that you and your students will appreciate our more unified presentation.

Reproductive System Homologues

Embryology has shown us that the female and male reproductive systems, and thus the homologues within those systems, originate from the same basic structures. An emphasis on homologues helps students grasp the similarities and differences between the female and male reproductive systems. Because the female reproductive system is the "basic" embryologic system (meaning that if no male hormonal influences occur in utero, the female pattern remains), we present the female reproductive system first, followed by the male reproductive system.

Accurate Terminology and Pronunciation Aids

The terms used in this text follow the standards set by the FCAT (Federative Committee on Anatomical Terminology) and published in *Terminologia Anatomica (TA)*. This reference is the international standard by which anatomic vocabulary should be based. In a few cases, TA terminology was not used because an alternative term

was less confusing and more understandable for the student. In the case of an ambiguous term, *Stedman's Medical Dictionary* also was consulted. We have eliminated the use of eponyms as primary terms whenever possible. However, eponyms are given in italics so the student and instructor can correlate an eponym with its proper anatomic term.

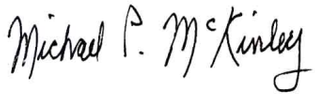
A large contributor to success in the human anatomy course is mastering the terminology. Students cannot properly learn the anatomy if they cannot "talk the talk"—that is, pronounce the words and know what the words mean. Pronunciation guides and word origins are included throughout the book to teach students how to say the terms and give them helpful, memorable hints for decoding meaning. These vocabulary aids were derived from *Stedman's Medical Dictionary.*

Pedagogy

Learning human anatomy is often seen as an endeavor of rote memorization. In *Human Anatomy,* we have employed many pedagogical techniques that aim to take students beyond memorization and engage them in a more thought-provoking discovery of facts that will lead to a well-rounded understanding. Individuals learn in a variety of ways—some learn best by reading text, others by using visuals, and still others by studying information organized in tables. We have been careful to cover concepts using all three of these mediums. These multifaceted concept presentations are then organized within a framework of pedagogical tools that help students build their knowledge base and encourage them to actively apply the information they read. Question sets within each chapter and review activities at the end of each chapter provide a balanced combination of simple retention-based questions and more complex critical-thinking activities. Study Tip! boxes offer practical advice for understanding and remembering the material. Clinical View essays promote a deeper understanding of the material discussed in the text by demonstrating how basic concepts play out in disease processes. All of these pedagogical elements work together, sparking students to practice, remember, apply, and understand. The "Guided Tour" beginning on the next page offers more specifics about the learning features in *Human Anatomy.*

Your Feedback Is Welcome!

We are dedicated to producing the best materials available to help students learn human anatomy and engender a love of this topic. Your suggestions for improving this textbook are always welcome!



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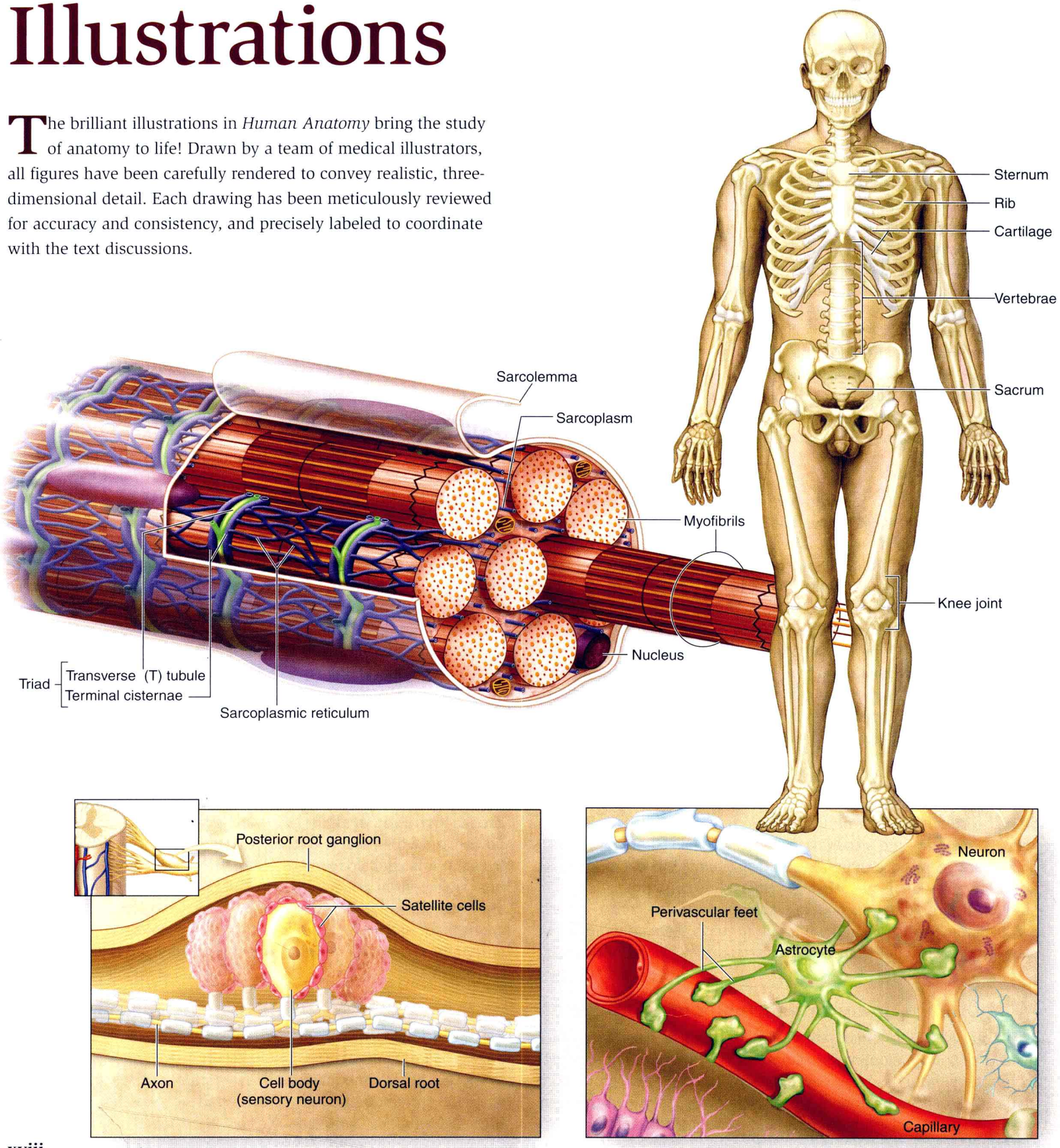
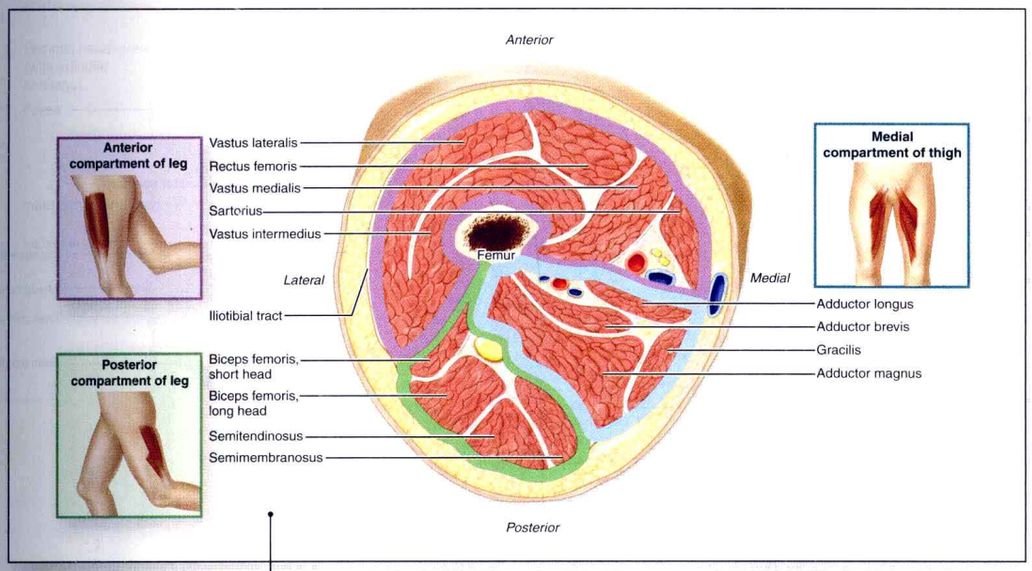
Accurate and Engaging Illustrations

The brilliant illustrations in *Human Anatomy* bring the study of anatomy to life! Drawn by a team of medical illustrators, all figures have been carefully rendered to convey realistic, three-dimensional detail. Each drawing has been meticulously reviewed for accuracy and consistency, and precisely labeled to coordinate with the text discussions.



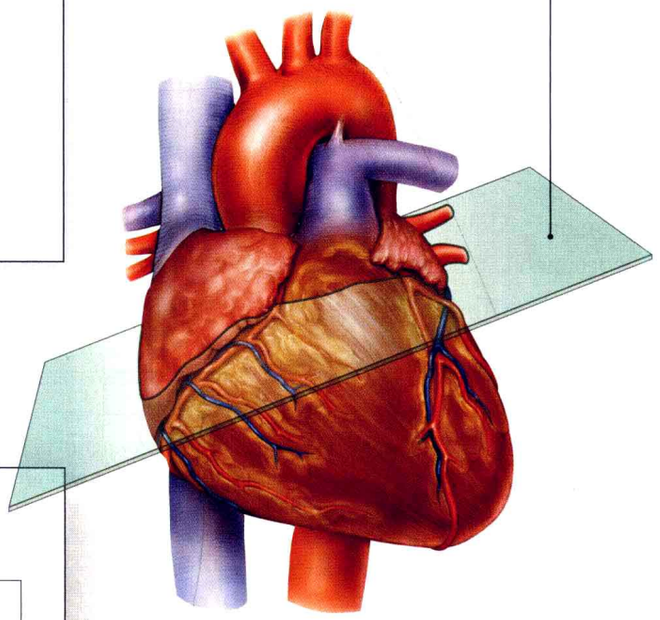


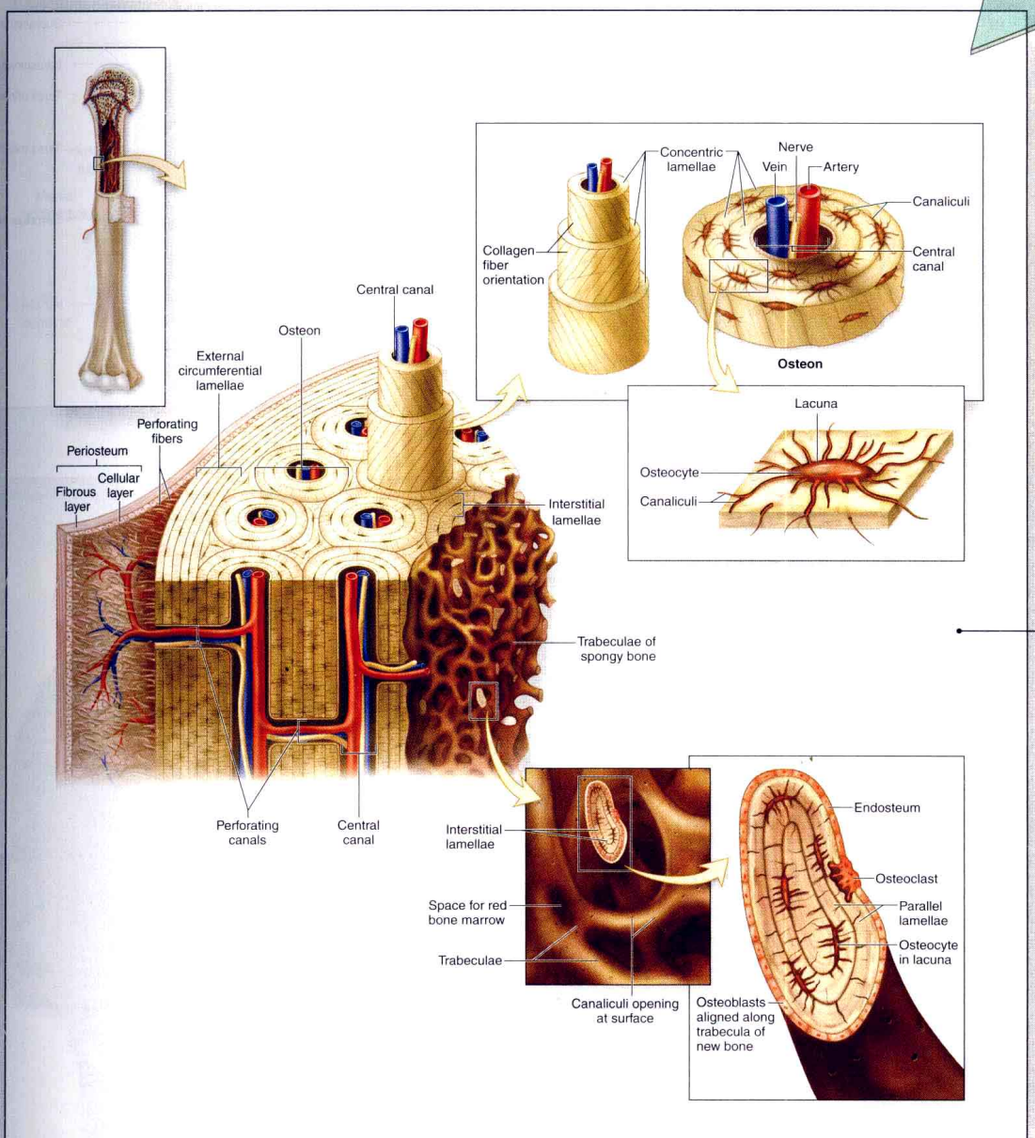
Color-Coding

Many illustrations use color-coding to organize information and clarify concepts for visual learners.

View Orientation

Reference diagrams clarify the view or plane an illustration represents.



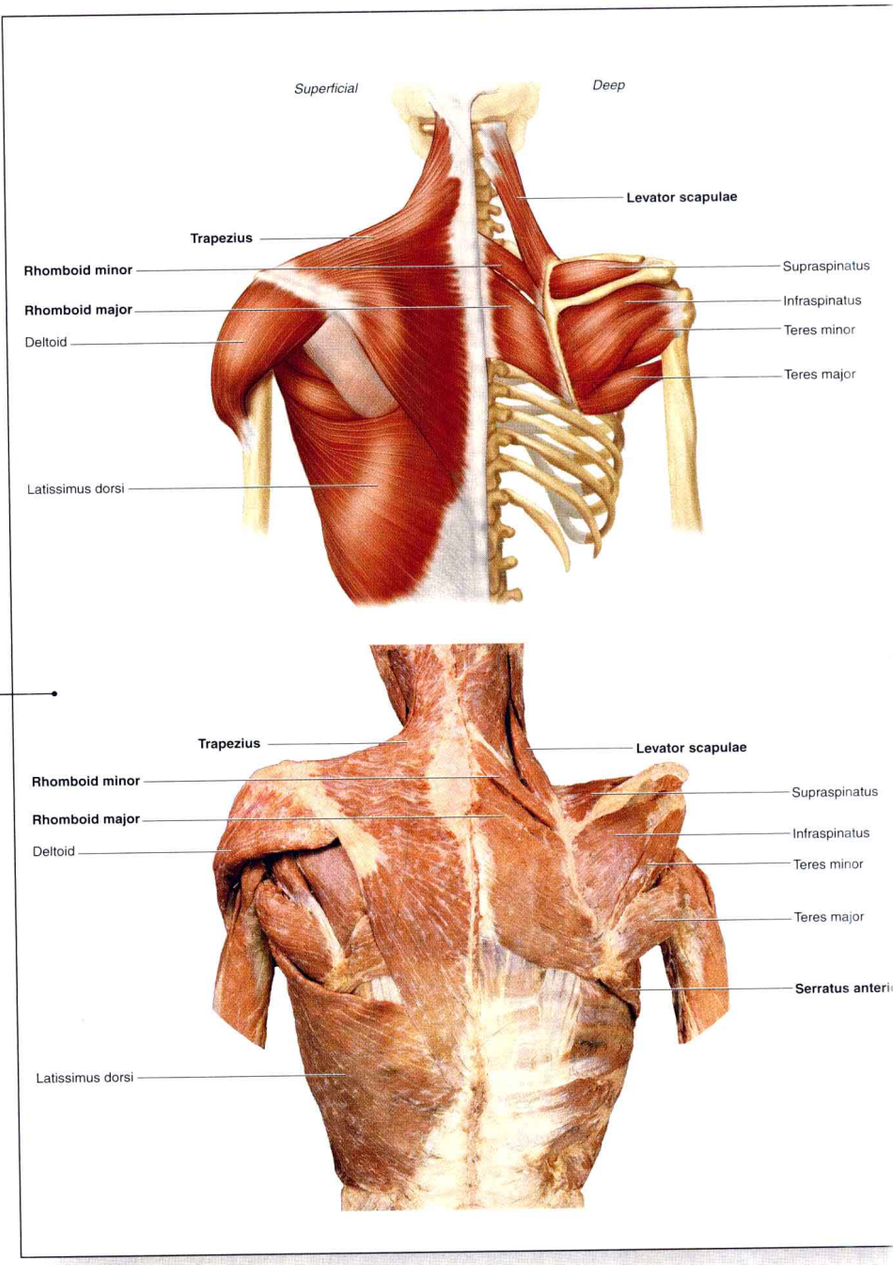


Multi-Level Perspective

Illustrations depicting complex structures connect macroscopic and microscopic views to show the relationships between increasingly detailed drawings.

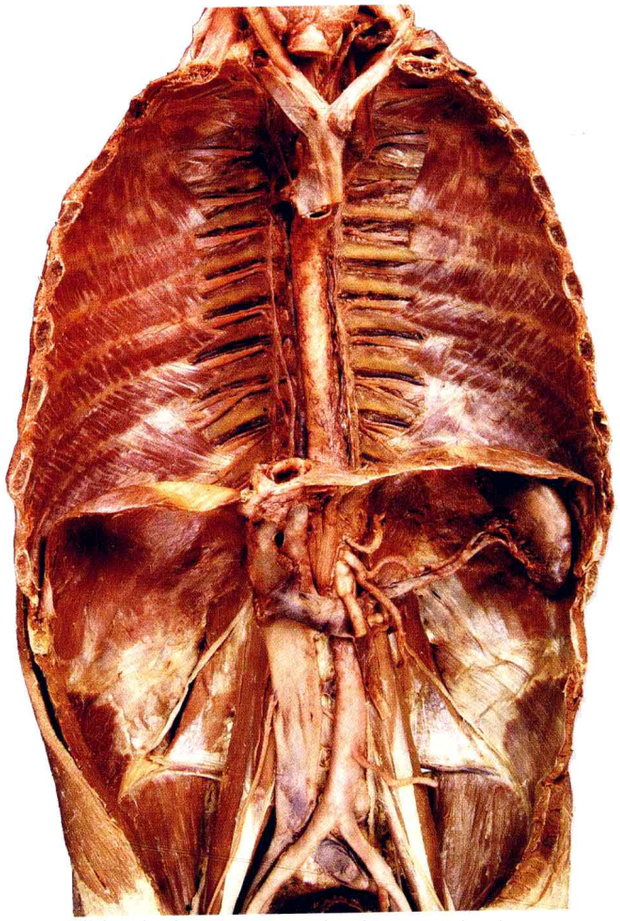
Atlas-Quality Photographs

Human Anatomy features a beautiful collection of cadaver dissection images, bone photographs, surface anatomy shots, and histology micrographs. These detailed images capture the intangible characteristics of human anatomy that can only be conveyed in human specimens, and help familiarize students with the appearance of structures they will encounter in lab.



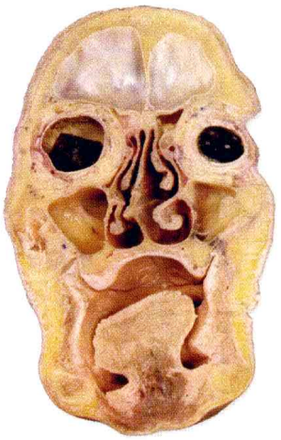
Complementary Views

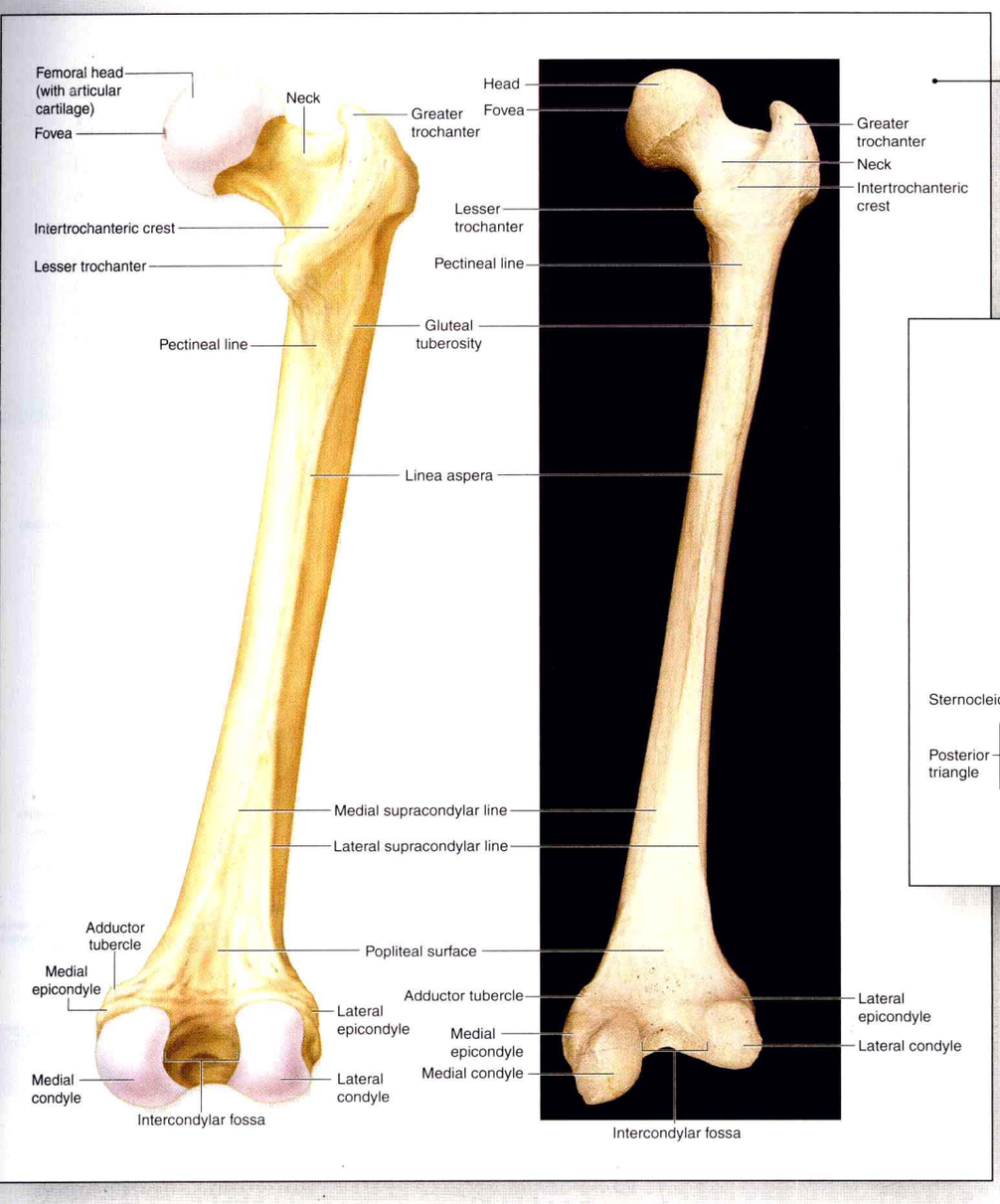
Drawings are often paired with photographs to enhance visualization of structures. Labels on art and photos mirror each other whenever possible, making it easy to correlate structures between views.



Cadaver Dissections

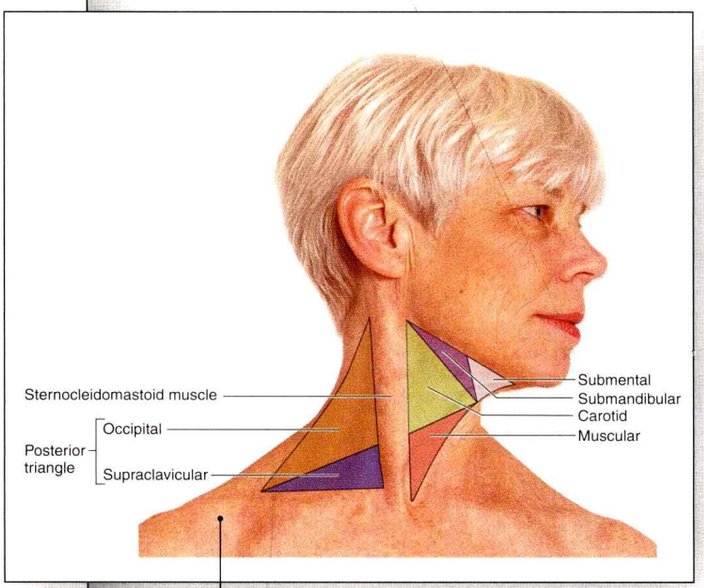
Expertly dissected specimens are preserved in richly colored photos that reveal incredible detail. Many unique views show relationships between anatomic structures from a new perspective.





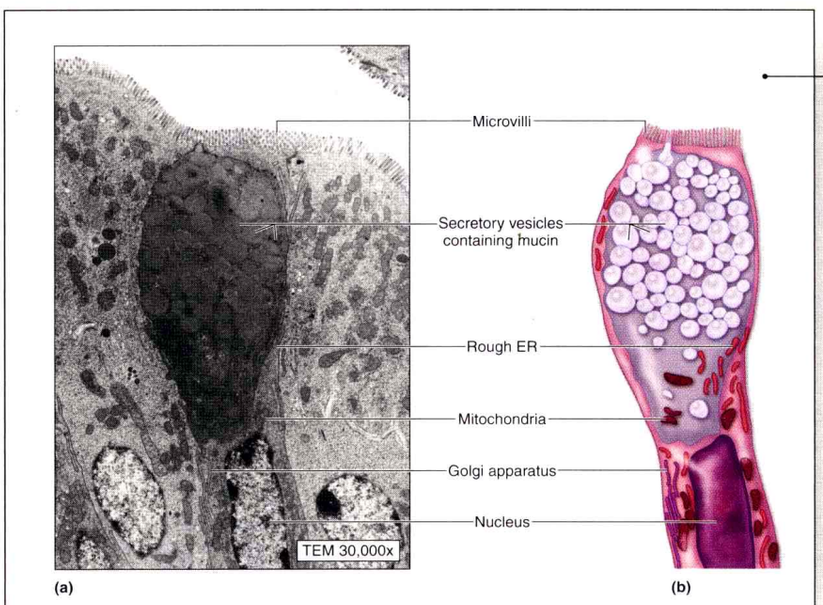
Bones

Crisp, clear bone photographs paired with detailed drawings offer dual perspectives—artist's rendition and actual specimen.



Surface Anatomy

Carefully posed and photographed, these images clearly demonstrate surface landmarks.



Histology Micrographs

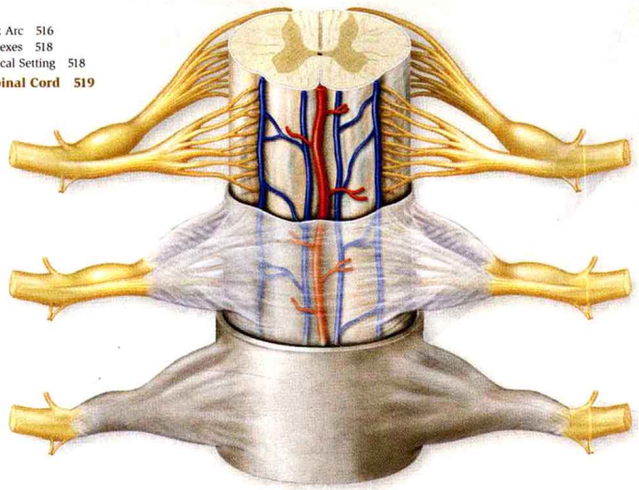
Light micrographs, as well as scanning and transmission electron micrographs, are used in conjunction with illustrations to present a true picture of microscopic anatomy. Magnifications provide a reference point for the sizes of structures shown in the micrographs.

Sound Pedagogical Aids

Human Anatomy is built around a pedagogical framework designed to foster retention of facts and encourage the application of knowledge that leads to understanding. The learning aids in this book help organize studying, reinforce learning, and promote critical-thinking skills.

OUTLINE

16



Spinal Cord and Spinal Nerves

Chapter Outline

Each chapter begins with a page-referenced outline that provides a quick snapshot of the chapter contents and organization.

Key Topics

A brief list at the beginning of each section introduces the major concepts students should understand after completing the section. Reviewing these objectives before reading helps focus attention on critical information.

Epidermal Derivatives

Key topics in this section:

Structure of nails
Components of a hair and a hair follicle
Growth, distribution, and replacement of hairs
How hair changes throughout life
The different types of glands in the skin

Nails, hair, and sweat and sebaceous glands are derived from epidermis and are considered accessory organs, or appendages, of the integument. These structures originate from the invagination of the epidermis during embryological development; they are located in the dermis and may project through the epidermis to the surface. Both hair and nails are composed primarily of dead, keratinized cells.

Nails

Nails are scalelike modifications of the epidermis that form on the dorsal surfaces of the tips of the fingers and toes. They protect the exposed distal tips and prevent damage or distortion during jumping, kicking, catching, or grasping. Nails are hard derivatives formed from the stratum corneum layer of the epidermis. The cells that form the nails are densely packed together and filled with parallel fibers of hard keratin.

Each nail has a distal **free edge,** the whitish layer of the nail; a **nail body,** the pinkish part of the nail; and a **nail root,** the proximal part embedded in the skin (**figure 5.8**). Together, these parts compose the **nail plate.** The nail rests on a layer of epidermis called the **nail bed,** which contains only the deeper, living cell layers of the epidermis. The body of the nail covers the nail bed.

Most of the nail body appears pink because of the blood in the underlying capillaries. At the root and the proximal end of the nail body, the bed thickens to form the **nail matrix,** which is the actively growing part of the nail. The matrix is usually so thick that the pink shades of the dermis are not visible. The free edge of the nail appears white because there are no underlying capillaries. The **lunula** (loo'noo-lă; *luna* = moon) is the whitish, semilunar area of the proximal end of the nail body. It has a whitish appearance because a thickened underlying stratum basale obscures the underlying blood vessels.

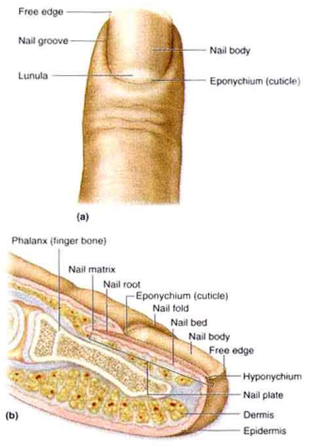


Figure 5.8
Structure of a Fingernail. Nails, the hard derivative of the stratum corneum, protect sensitive fingertips. *(a)* Surface view of a fingernail. *(b)* Sagittal section showing the internal details of a fingernail.

WHAT DID YOU LEARN?

14. Describe the difference between soft keratin (in hair) and hard keratin (in hair).
15. Why does the lunula of the nail have a whitish appearance?
16. Compare the hair matrix and the medulla.
17. What stimulates the arrector pili muscle to contract?

What Did You Learn?

Review questions at the end of each section prompt students to test their comprehension of key concepts. These mini self-tests help students determine whether they have a sufficient grasp of the information before moving on to the next section in the chapter. Answers to the What Did You Learn? questions are provided at the Online Learning Center (www.mhhe.com/mckinley) and also on the Instructor's Testing and Resource CD.

Vocabulary Aids

Learning anatomy is, in many ways, like learning a new language. Human Anatomy *stresses the use of proper anatomic terms, and includes vocabulary aids that help students master the terminology.*

Key terms are set in boldface where they are defined in the chapter, and many terms are included in the glossary at the end of the book. Pronunciation guides are included for difficult words.

Support and Protection of the Brain

Key topics in this section:

- Characteristics of the cranial meninges and the cranial dural septa
- Origin, function, and pattern of cerebrospinal fluid circulation
- Structure of the blood-brain barrier and how it protects the brain

The brain is protected and isolated by multiple structures. The bony cranium provides rigid support, while protective connective tissue membranes called meninges surround and partition portions of the brain. Cerebrospinal fluid (CSF) acts as a cushioning fluid. Finally, the brain has a blood-brain barrier to prevent entry of harmful materials from the bloodstream.

Cranial Meninges

The **cranial meninges** (mĕ-nin'jes, mĕ'nin-jēz; sing., *meninx,* men'ingks, mĕ'ninks; membrane) are three connective tissue layers that separate the soft tissue of the brain from the bones of the cranium, enclose and protect blood vessels that supply the brain, and contain and circulate cerebrospinal fluid. In addition, some parts of the cranial meninges form some of the veins that drain blood from the brain. From superficial (farthest away from the brain) to deep (closest to the brain), the cranial meninges are the dura mater, the arachnoid, and the pia mater (**figure 15.4**).

Dura Mater

The **dura mater** (doo'ră mă'ter; *dura* = tough; *mater* = mother) is an external tough, dense irregular connective tissue layer composed of two fibrous layers. As its Latin name indicates, it is the strongest of the meninges. Within the cranium, the dura mater is composed of two layers. The **periosteal** (per-ē-os'tē-ăl) **layer,** the more superficial layer, forms the periosteum of the cranial bones. The **meningeal** (mĕ-nin'jē-ăl, men'in-jē'ăl) **layer** lies deep to the periosteal layer.

The meningeal layer is usually fused to the periosteal layer, except in specific areas where the two layers separate to form large, blood-filled spaces called **dural venous sinuses.** Dural venous sinuses are typically triangular in cross section, and unlike most other veins, they do not have valves to regulate venous blood flow. The dural venous sinuses are, in essence, large veins that drain blood from the brain and transport this blood to the internal jugular veins.

The dura mater and the bones of the skull may be separated by the potential **epidural** (ep-i-doo'răl) **space,** which contains the arteries and veins that nourish the meninges and bones of the cranium.

Arachnoid

The **arachnoid** (ă-rak'noyd), also called the *arachnoid mater* or the *arachnoid membrane,* lies immediately internal to the dura mater (see figure 15.4). The term *arachnoid* means "resembling a spider web," and this meninx is so named because it is partially composed of a delicate web of collagen and elastic fibers, termed the arachnoid trabeculae. Between the arachnoid and the overlying dura mater is a potential space, the **subdural space.** Immediately deep to the arachnoid is the **subarachnoid space.** The arachnoid trabeculae extend through this space from the arachnoid to the underlying pia mater.

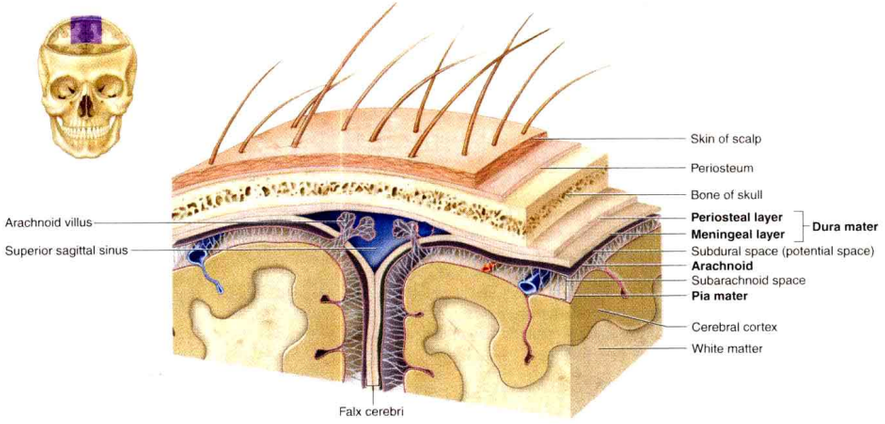


Figure 15.4

Cranial Meninges. A coronal section of the head depicts the organization of the three meningeal layers: the dura mater, the arachnoid, and the pia mater. In the midline, folds of the inner meningeal layer of the dura mater form the falx cerebri, which partitions the two cerebral hemispheres. The inner meningeal layer and the outer periosteal layer sometimes separate to form the dural venous sinuses, such as the superior sagittal sinus, which drain blood away from the brain.

Because knowing the derivation of a term can enhance understanding and retention, word origins are given when relevant. Furthermore, a handy list of prefixes, suffixes, and combining forms is printed on the inside back cover as a quick reference for commonly used word roots.

WHAT DO YOU THINK?

2. Try this experiment to determine the value of serous fluid: First, rub the palms of your hands quickly against one another. The sound you hear and the heat you feel are consequences of the friction being produced. Now put lotion (our version of serous fluid) on the palms of your hand and repeat the experiment. Do you still hear the noise and feel heat from your hands? What do you think would happen to your body organs if there were no serous fluid?

What Do You Think?

These critical-thinking questions actively engage students in application or analysis of the chapter material and encourage students to think more globally about the content. Answers to What Do You Think? questions are given at the end of each chapter, allowing students to evaluate the logic used to solve the problem.

Study Tip!

Developing a code or phrase called a **mnemonic** (nē-mon'ik) may help you remember the cranial nerves. Mnemonics you prepare yourself will be the most relevant to you, but here is a sample mnemonic for the cranial nerves:

Oh	(olfactory)
once	(optic)
one	(oculomotor)
takes	(trochlear)
the	(trigeminal)
anatomy	(abducens)
final	(facial)
very	(vestibulocochlear)
good	(glossopharyngeal)
vacations	(vagus)
are	(accessory)
heavenly!	(hypoglossal)

Study Tips

Many anatomy instructors provide students with everyday analogies, mnemonics, and other useful tips to help them understand and remember the information. Study Tip! boxes throughout each chapter offer tried-and-tested practical learning strategies that students can apply as they read. These tips are not just useful—they can also be fun!

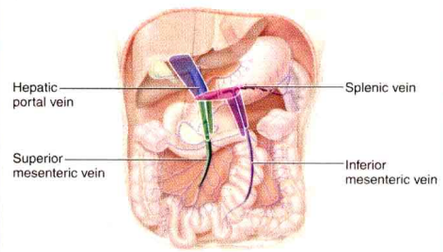
se the GI tract absorbs
bsorbed and processed
agents that have been
he most efficient route
ents and any absorbed
ains the GI tract direct-
aterials throughout the
l system also receives
pleen, so that the liver
can "recycle" some of these components.

The **hepatic portal vein** is the large vein that receives oxygen-poor but nutrient-rich blood from the gastrointestinal organs. Three main venous branches merge to form this vein: (1) The **inferior mesenteric vein,** a vertically positioned vein draining the distal part of the large intestine, receives blood from the *superior rectal vein, sigmoid veins,* and *left colic vein.* The inferior mesenteric vein typically (but not always) drains into the splenic vein. (2) The **splenic vein,** a horizontally positioned vein draining the spleen, receives blood from *pancreatic veins, short gastric veins,* and the *right gastroepiploic vein.* (3) The **superior mesenteric vein,** another vertically positioned vein on the right side of the body, drains the small intestine and part of the large intestine. It receives blood from the *intestinal veins, pancreaticoduodenal veins, ileocolic vein,* and *right* and *middle colic veins.* Some small veins, such as the *left* and *right gastric veins,* drain directly into the hepatic portal vein.

Figure 23.17 is a cadaver photo showing the arteries and veins of the posterior abdominal wall region. Note in this example that the inferior mesenteric vein drains into the superior mesenteric vein, not the splenic vein. This figure illustrates that the hepatic portal system can show great variation in some individuals.

Study Tip!

Although the pattern of the veins of the hepatic portal system can vary, together they typically resemble the side view of a chair. The front leg of the "chair" represents the inferior mesenteric vein, while the back leg represents the superior mesenteric vein. The seat of the chair is the splenic vein, while the back represents the hepatic portal vein.



The configuration of the veins of the hepatic portal system resembles the side view of a chair.

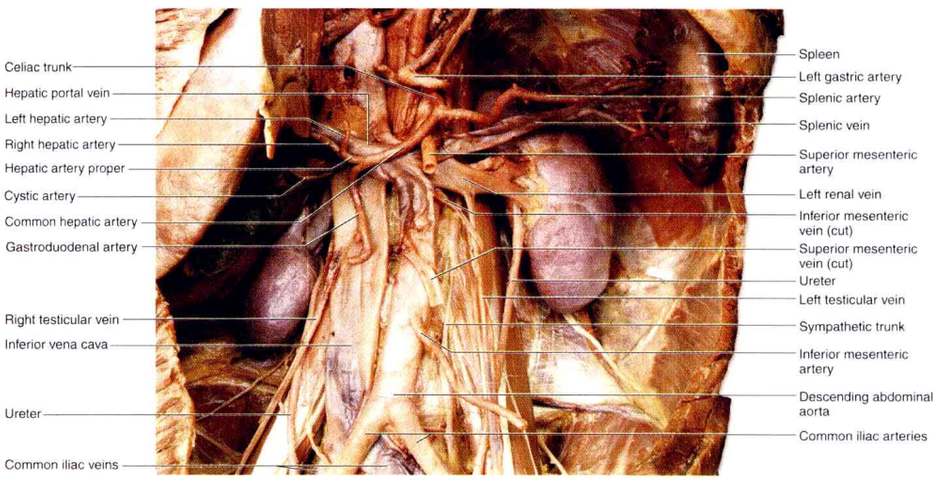


Figure 23.17

Major Vessels of the Posterior Abdominal Wall. In this cadaver photo, note that the inferior mesenteric vein varies from the "average" hepatic portal system pattern by draining into the superior mesenteric vein.

Clinical Coverage

Sometimes, an example of what can go wrong in the body helps crystallize understanding of the "norm." Clinical Views interspersed throughout each chapter provide insights into health or disease processes. Carefully checked by a clinician for accuracy with respect to patient care and the most recent treatments available, these clinical boxes expand upon topics covered in the text and provide relevant background information for students pursuing health-related careers.

Clinical View

Interesting clinical sidebars reinforce or expand upon the facts and concepts discussed within the narrative.

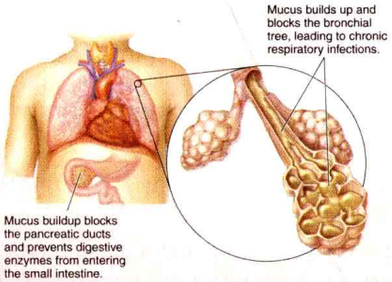
CLINICAL VIEW

Cystic Fibrosis

Cystic fibrosis (sis'tik fi-brō'sis) is the most common serious genetic disease in Caucasians, occurring with a frequency of 1 in 3200 births. The condition is inherited as an autosomal recessive trait, and is rare among people of Asian and African descent. Cystic fibrosis affects the organs that secrete mucin, tears, sweat, digestive juices, and saliva. A defective gene produces an abnormal plasma membrane protein involved in chloride ion transport, so individuals with cystic fibrosis cannot secrete chloride. This lack of chloride secretion causes sodium and water to move from the mucus back into the secretory cell itself, thus dehydrating the mucus covering the epithelial surface. The mucus becomes thick and sticky, obstructing the airways of the lungs and the ducts of the pancreas and salivary glands. In the lungs, the mucus becomes so thick it results in airway obstruction. Pulmonary infections, secondary to airway obstruction, are common and can be life-threatening. In the case of the pancreas, the obstructed ducts lead to a backup of digestive enzymes that eventually destroy the pancreas itself.

Interestingly, the normal chloride transport protein works in the opposite direction in the sweat glands of the skin. Chloride and sodium are not reabsorbed from the sweat, and so they become concentrated on the skin in individuals with cystic fibrosis. Mothers of babies with cystic fibrosis often find that the baby tastes "salty" when kissed. Thus, clinically elevated chloride levels in sweat are one method of diagnosing the disease.

The primary treatment of cystic fibrosis involves agents that break up the thick mucus in the lungs. In addition, antibiotics for pulmonary infections are required chronically, because prevention and early treatment of infection are vital to reducing long-term complications. Absorption problems caused by pancreatic damage are treated with orally administered digestive enzymes, vitamins, and caloric supplements. Since the gene responsible for cystic fibrosis has been identified, scientists have been investigating ways to insert copies of the healthy gene into the epithelial cells of the respiratory tracts of cystic fibrosis patients. In the most promising method found thus far, the healthy gene is transmitted via a modified adenovirus.



Cystic fibrosis results in thickened mucus that obstructs both the respiratory passageways and the pancreatic ducts.

CLINICAL VIEW: In Depth

Knee Ligament Injuries

Although the knee is capable of bearing much weight and has numerous strong supporting ligaments, it is highly vulnerable to injury, especially among atheletes. The knee is susceptible to both horizontal and rotational stress, most commonly when struck either from the lateral or posterior aspect while slightly flexed. Because the knee is reinforced by tendons and ligaments only, ligamentous injuries to the knee are very common.

The medial (tibial) collateral ligament is frequently injured when the leg is forcibly abducted at the knee. For example, if a person's knee is hit on the lateral side, the leg is hyperabducted, and the medial collateral ligament is strained and frequently torn. Because the medial collateral ligament is attached to the medial meniscus, the medial meniscus may be injured as well.

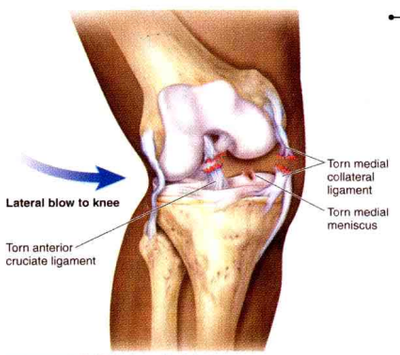
Injury to the lateral (fibular) collateral ligament can occur if the medial side of the knee is struck, resulting in hyperadduction of the leg at the knee. This type of injury is fairly rare, in part because the lateral collateral ligament is very strong and also because medial blows to the knee are not common.

The anterior cruciate ligament (ACL) can be injured when the leg is hyperextended—for example, if a runner's foot hits a hole. Because the ACL is rather weak compared to the other knee ligaments, it is especially prone to injury. ACL injury often occurs in association with another ligament injury. To test for ACL injury, a physician gently tugs anteriorly on the tibia. In this so-called "anterior drawer test," too much forward movement indicates an ACL tear.

Posterior cruciate ligament (PCL) injury may occur if the leg is hyperflexed or if the tibia is driven posteriorly on the femur. PCL injury occurs rarely, because this ligament is rather strong. To test for PCL injury, a physician gently pushes on the tibia. In this "posterior drawer test," too much posterior movement indicates a PCL tear.

The **unhappy triad** of injuries refers to a triple ligamentous injury of the medial collateral ligament, medial meniscus, and anterior cruciate ligament. This is the most common type of football injury. It occurs when a player is illegally "clipped" by a lateral blow to the knee, and the leg is forcibly abducted and laterally rotated. If the blow is severe enough, the medial collateral ligament tears, followed by tearing of the medial meniscus, since these two structures are connected. The force that tears the medial collateral ligament and the medial meniscus is thus transferred to the ACL. Since the ACL is relatively weak, it tears as well.

The treatment of ligamentous knee injuries depends upon the severity and type of injury. Conservative treatment involves immobilizing the knee for a period of time to rest the joint. Surgical treatment can include repairing the torn ligaments or replacing the ligaments with a graft from another tendon or ligament (such as the quadriceps tendon).



"Unhappy triad" of injuries to the right knee.

Clinical View: In Depth

These boxed essays explore topics of clinical interest in detail. Subjects covered include pathologies, current research, treatments, forensics, and pharmacology.

Clinical Terms

Selected clinical terms are defined at the end of each chapter.

CLINICAL TERMS

ankylosis (ang'ki-lō-sis)—stiffening of a joint due to the union of fibers or bones across the joint as the result of a disease.
arthralgia (ar-thral'jē-ă)—joint-associated pain that is not usually inflammatory.
arthroplasty (ar'thrō-plas-tē)—construction of an artificial joint to provide relief from or to correct advanced degenerative arthritis.
arthrosis—condition pertaining to an articulation; a noninflammatory disease of a joint.
bursitis—inflammation of a bursa.
chondromalacia (kon'drō-mă-lā'shē-ă) **patellae**—softening of the articular cartilage of the patella; sometimes considered a subtype of patellofemoral syndrome.
rheumatism (roo'mă-tizm)—any one of various conditions exhibiting joint pain or other symptoms of articular origin; often associated with muscular or skeletal system problems.
synovitis (sin-ō-vī'tis)—inflammation of the synovial membrane of a joint.
tenosynovitis (ten'ō-sin-ō-vī'tis)—inflammation of a tendon or its sheath.

End-of-Chapter Tools

A carefully devised set of learning aids at the end of each chapter helps students review the chapter content, evaluate their grasp of key concepts, and utilize what they have learned. Reading the chapter summary and completing the Challenge Yourself exercises is a great way to assess learning.

Chapter Summary Tables

Chapter summaries are presented in a concise, bulleted table format that provides a basic overview of each chapter. Page references make it easy to look up topics for review.

CHAPTER SUMMARY

The appendicular skeleton includes the bony supports (girdles) that attach the upper and lower limbs to the axial skeleton, as well as the bones of those limbs.

Pectoral Girdle 222

The pectoral girdle is composed of the clavicle and scapula.

Clavicle 222

The clavicle forms the collarbone.

Scapula 222

The scapula forms the "shoulder blade."

The scapula has two processes: the coracoid process and the acromion. The acromion is continuous with the scapular spine.

Upper Limb 225

Each upper limb contains a humerus, radius, ulna, 8 carpals, 5 metacarpals, and 14 phalanges.

Humerus 226

The head of the humerus articulates with the glenoid cavity of the scapula.

The greater tubercle and lesser tubercle are important sites for muscle attachment. The trochlea and capitulum articulate with the radius and ulna at the elbow.

Radius and Ulna 228

The radius and ulna are the bones of the forearm.

Carpals, Metacarpals, and Phalanges 230

Challenge Yourself

This battery of matching, multiple choice, short answer, and critical-thinking questions is designed to test students on all levels of learning, from basic comprehension to synthesis of concepts. Answers to the Matching, Multiple Choice, and Developing Critical Reasoning questions are provided in the appendix. Answers to the Content Review questions are found on the Online Learning Center at www.mhhe.com/mckinley.

CHALLENGE YOURSELF

Matching

Match each numbered item with the most closely related lettered item.

_____ 1. cranial	a. study of tissues
_____ 2. cytology	b. toward the tail
_____ 3. responsiveness	c. contains brain
_____ 4. inguinal region	d. structural change in the body
_____ 5. caudal	e. study of organs of one system
_____ 6. development	f. thoracic cavity
_____ 7. cranial cavity	g. detect and react to stimuli
_____ 8. histology	h. groin
_____ 9. mediastinum	i. toward the head
_____ 10. systemic anatomy	j. study of cells

Multiple Choice

Select the best answer from the four choices provided.

_____ 1. Cutting a midsagittal section through the body separates the
a. anterior and posterior portions of the body.
b. superior and inferior portions of the body.
c. dorsal and ventral portions of the body.

_____ 6. Which body cavity is located inferior to the diaphragm and superior to a horizontal line drawn between the superior edges of the hip bones?
a. abdominal cavity
b. thoracic cavity
c. pleural cavity
d. pelvic cavity

_____ 7. The term used when referring to a structure in the body that is below, or at a lower level than, another structure of interest is
a. ventral.
b. medial.
c. inferior.
d. distal.

_____ 8. Which medical imaging technique uses modified x-rays to prepare three-dimensional cross-sectional "slices" of the body?
a. radiography
b. sonography
c. PET (positron electron tomography) scan
d. computed tomography (CT)

_____ 9. The _____ region is the "front" of the knee.
a. patellar
b. popliteal
c. pedal
d. inguinal

_____ 10. The epineurium is
a. a thick, dense irregular connective tissue layer enclosing the nerve.
b. a group of axons.
c. a delicate layer of areolar connective tissue.
d. a cellular and dense connective tissue layer.

Content Review

1. What are the three structural types of neurons? How do they compare to the three functional types of neurons?
2. What is the function of sensory neurons?
3. Identify the principal types of glial cells, and briefly discuss the function of each type.
4. How does the myelin sheath differ between the CNS and the PNS?
5. Describe the procedure by which a PNS axon may repair itself.
6. Describe the arrangement and structure of the three coverings that surround PNS axons.
7. Clearly distinguish among the following: a neuron, an axon, and a nerve.
8. What are the differences between electrical and chemical synapses? Which is the more common type of synapse in humans?
9. Discuss the similarities and differences between converging and parallel-after-discharge circuits.
10. What are the basic developmental events that occur in neurulation?

Developing Critical Reasoning

1. Over a period of 6 to 9 months, Marianne began to experience vision problems as well as weakness and loss of fine control of the skeletal muscles in her leg. Blood tests revealed the presence of antibodies (immune system proteins) that attack myelin. Beyond the presence of the antibodies, what was the cause of Marianne's vision and muscular difficulties?
2. Surgeons were able to reattach an amputated limb, sewing both the nerves and the blood vessels back together. After the surgery, which proceeded very well, the limb regained its blood supply almost immediately, but the limb remained motionless and the patient had no feeling in it for several months. Why did it take longer to reestablish innervation than circulation?

Answers to What Do You Think?

The What Do You Think? questions are answered at the end of each chapter.

ANSWERS TO "WHAT DO YOU THINK?"

1. The term *viscera* refers to organs, especially thoracic and abdominal organs such as the heart, lungs, and gastrointestinal tract. The visceral sensory and visceral motor (autonomic) nervous systems innervate these viscera.
2. Tumors occur due to uncontrolled mitotic growth of cells. Since glial cells are mitotic and neurons typically are nonmitotic, a "brain tumor" almost always develops from glial cells.
3. Microglia will replicate in response to inflammation and infection from meningitis.
4. A myelinated axon takes up more space than an unmyelinated axon. There simply isn't enough space in the body to hold myelin sheaths for every axon. Thus, the body conserves this space by myelinating only the axons that must transmit nerve impulses very rapidly.
5. Regeneration of axons is less likely to succeed in the CNS for a number of reasons. First, an injury to the CNS axons may have injured cell bodies as well, and an axon can be repaired only if the cell body is intact. Second, axons in the CNS are not stimulated to regrow by the formation of a regeneration tube and the secretion of growth factors to stimulate this growth (as PNS axons are). Third, there may be crowding and scarring in the area that blocks re-growth.