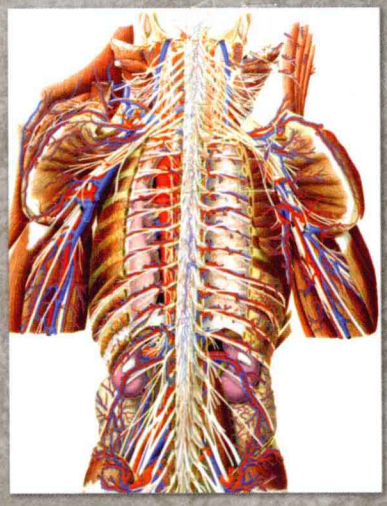
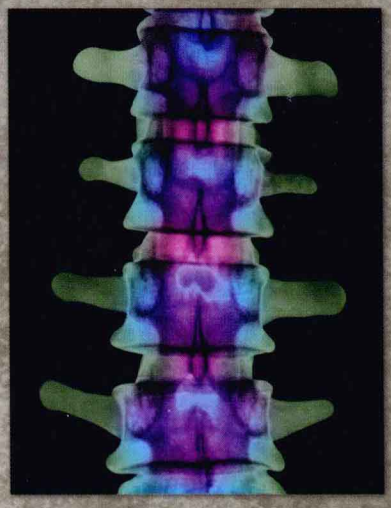
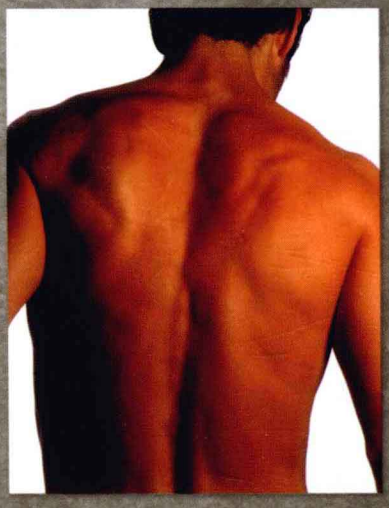
HUMAN ANATOMY







SALADIN

HUMAN ANATOMY

KENNETH S. SALADIN
Georgia College and State University

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HUMAN ANATOMY

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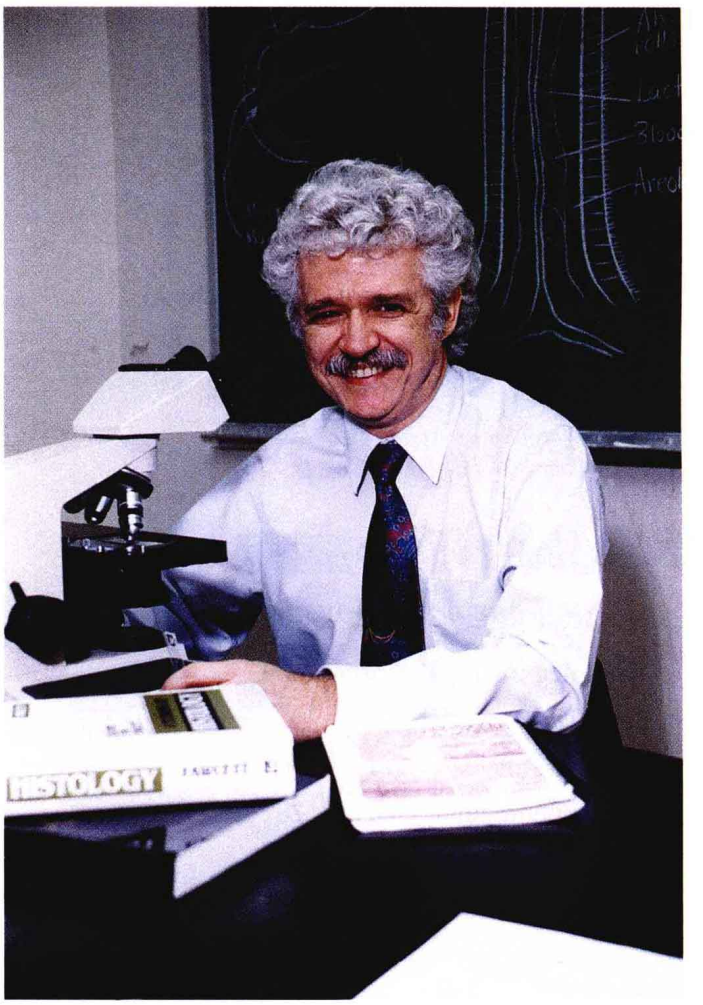
ABOUT THE AUTHOR

KEN SALADIN is Distinguished Professor of Biology at Georgia College and State University in Milledgeville, Georgia. He received his B.S. from Michigan State University in zoology and his Ph.D. from Florida State University in parasitology. He has taught at GC&SU since 1977, where his course assignments have covered a very broad range including majors' and nonmajors' biology, general zoology, biological etymology, comparative animal behavior, sociobiology, parasitology, histology, neuroanatomy, human anatomy and physiology, and varied senior and graduate seminars on topics in evolution and biophilosophy. He also leads an annual Study Abroad class in the Galápagos Islands. Ken has been repeatedly recognized for superior teaching and scholarship, with six Phi Kappa Phi Honor Professor awards, a 1998 Excellence in Research and Publication Award, and selection as Distinguished Professor in 2001. He is an active member of the Human Anatomy and Physiology Society and the Society for Integrative and Comparative Biology. After several years of reviewing textbooks and writing instructor supplements for various publishers, Ken began his first textbook in 1993. His *Anatomy and Physiology: The Unity of Form and Function,* now in its third edition (McGraw-Hill, 2004), rose quickly to become one of the few most widely used books in that market. *Human Anatomy* is his second book. You can write to Ken at ken.saladin@gcsu.edu.



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This book is dedicated to my father

ALBERT SALADIN

who taught me more than either of us realized at the time.

• • • • •

PREFACE

Human Anatomy is designed primarily for a one-semester course, usually taken in the first or second year of college in preparation for admission to programs in nursing, therapy, health education, or pre-professional health programs. This book has evolved through extensive research on the needs and likes of anatomy students and instructors. In developing this first edition we commissioned detailed reviews from scores of instructors and held focus groups in which instructors discussed their course, challenges, text illustration programs, and the general content of anatomy textbooks. We created consultant panels of anatomy instructors to thoroughly analyze the entire book and its art program. These efforts have generated thousands of pages of reviews, all of which I read carefully in developing this book.

AUDIENCE

Human Anatomy is based on an assumption that most users are just beginning or returning to college. At this stage, many are still developing the study habits and skills necessary for success in a health science curriculum. The complexity of human anatomy can be a daunting subject, and I have tried to make it more manageable through a variety of learning aids described in this preface. Also mindful that English is not the primary language of many students who take human anatomy, I have tried to keep the prose free of unnecessary jargon and idioms, and as clear as any writing on this complex subject can be.

I also realize that many human anatomy students have taken no prior college biology or chemistry, since many institutions have no prerequisites for human anatomy. Other students, too, return to college to train for a health career after extended absences to raise families or try other careers. So even if the student has had college biology or chemistry, we cannot assume that he or she remembers it. Some chemistry is needed even for the study of anatomy, but chemistry is introduced infrequently and in relatively simple terminology in this book. All anatomy is based ultimately on cell biology, which is covered in chapter 2. This introduction provides all the background on cytology necessary for understanding the later chapters.

HOW WE MET YOUR NEEDS

Reviewers and focus group members consistently tell us that the most important qualities of an acceptable textbook are accuracy, writing style, and quality of illustrations.

Accuracy

Textbook inaccuracies are an important source of frustration for instructors, students, and writers alike. We have taken several measures to avoid them in this book. The book itself was diligently reviewed by colleagues during its development—in the first and second draft manuscripts and the first and revised page proofs—to ensure that the content is accurate, concise, and clear. Page proofs were double-checked not only by me but also the editor against the manuscript to ensure the correction of any errors introduced during page composition (typesetting).

To produce an accurate and dependable textbook, I consider myself obligated, of course, to continue learning. It is not just an obligation but a pleasure to increase the depth of my own understanding, keep my knowledge updated, and arrive at better and clearer ways of explaining human form and function. As Isaac Asimov once said, "the greatest satisfaction for any conscientious and enthusiastic author comes from what one learns by writing." What stronger motivation than teaching and writing can there be for pursuing a life of perpetual scholarship? What better reward for knowledge can there be than these opportunities to share it?

My approaches to this life of scholarly inquiry and sharing include keeping up with the biological and medical journals that arrive in my mailbox almost daily; keeping my reference library updated with the newest editions of the most highly regarded biomedical text and reference books; enlightening discussions with colleagues on the HAPP-L listserv of the Human Anatomy and Physiology Society; attending annual conferences; and enrolling in continuing education courses in human anatomy and physiology, including courses I have taken during recent summers in neuroanatomy and neurophysiology, musculoskeletal anatomy and kinesiology, and cadaver dissection.

Writing Style

My writing style has also been shaped greatly by more than a decade of feedback from skillful editors and perceptive colleagues and students. The style that has drawn so many gratifying compliments to my previous book has, of course, been employed in this one as well. Students benefit most from a book they enjoy reading; a book that goes beyond presenting information to also telling an interesting story; and a book that steers a middle course between dry formality on one hand and a chatty condescending tone on the other. This has

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been my guiding principle in developing the right voice for my books. It is not the place of any writer to judge how successful he or she has been in achieving such stylistic ideals; that is for the reader to say. But I feel confident in inviting the reader to choose topics that students typically find most difficult, reading the presentation in this book alongside those of other books written for the same audience, and deciding which presentation will best serve his or her classes.

Quality of Illustrations

For the visual appeal and instructional value of this book, I am highly indebted to the professional medical illustrators and graphic artists who rendered the art in such beautiful and captivating style. The art program has benefited greatly from reviewers of my older textbook who, over the course of three editions, gave us valuable direction with respect to the desirable size, color palette and saturation, and amount of labeling appropriate to their esthetic tastes and teaching needs.

What Sets This Book Apart

The following features are designed to serve the student's needs and adapt the book to the abilities of most beginning college students.

Anatomy Atlases

Basic anatomical terminology such as directional terms, body regions, and body cavities, as well as a broad overview of the 11 organ systems, are provided in atlas A following chapter 1. In many other books, this is included in chapter 1, but reviewers and users of my previous book have found it more useful to have these fundamental concepts covered in a module of their own.

Surface anatomy incorporates elements of integumentary, skeletal, and muscular anatomy and is therefore presented through a series of photographs in atlas B, following chapter 12. Photographic cadaver anatomy is presented in atlas A and in many individual chapters. For those especially interested in photographic anatomy of the cadaver, all such photos are listed in the index at "cadaveric anatomy."

"Insight" Sidebars

Each chapter has from two to five special topics set apart as sidebars called Insights, listed by title and page number on the chapter opener page. These are of three types: Clinical Applications, Evolutionary Medicine essays, and Medical History essays. Additional clinical, evolutionary, and historical remarks are interwoven with the main text of each chapter.

Clinical Applications

The Clinical Application insights are by no means meant to make this a clinical textbook. Rather, their importance and purpose is that most students who study from this book will be interested in clinical careers, and clinical insights show how the basic biology of the body is relevant to those interests. The importance of bone collagen, for example, may not be convincingly obvious to all readers, but it becomes more so when reading about osteogenesis imperfecta (brittle bone disease), a tragic result of defective collagen deposition (insight 3.3). Similarly, the warming and humidifying function of the nasal cavity becomes especially apparent when it is bypassed by tracheostomy (insight 23.1). Each organ system chapter also has a section on developmental and clinical perspectives at the end, including a table that briefly describes some of the most common or interesting dysfunctions of that system.

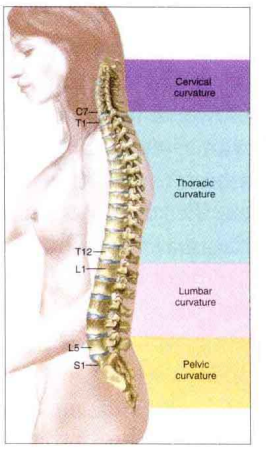


FIGURE 7.19
Curvatures of the Adult Vertebral Column.

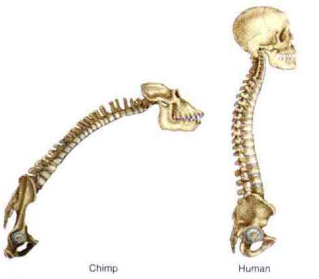
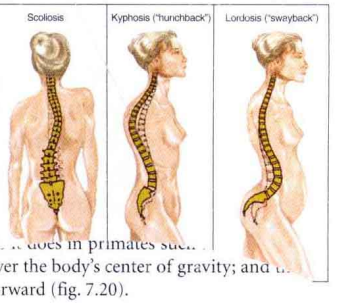


FIGURE 7.20
Comparison of Chimpanzee and Human Vertebral Columns. The S-shaped human vertebral column is an adaptation for bipedal locomotion.



not lean forward as it does in primates such as a chimpanzee; the head is balanced over the body's center of gravity; and the eyes are directed straight forward (fig. 7.20).

INSIGHT 7.3 CLINICAL APPLICATION

ABNORMAL SPINAL CURVATURES

Abnormal spinal curvatures (fig. 7.21) can result from disease, weak... or paralysis of the trunk muscles, poor posture, or congeni... vertebral anatomy. The most common deformity is a ... curvature called *scoliosis*. It occurs most often in ... ticularly among adolescent girls. It sometimes r... tal abnormality in which the body and arch ... fail to develop on one side. If the person's ... plete, scoliosis can be corrected with a ba... An exaggerated thoracic curva... is c... language). It is usually a result of osteoporos... with osteomalacia or spinal tuberculosis and ... heavily in such sports as wrestling and weightlifting. ... curvature is called *lordosis* (swayback). It may have the sa... sis, or it may result from added abdominal weight in pregnancy.

...anced over the body's center of gravity; and t... ...ected straight forward (fig. 7.20).

INSIGHT 7.3 CLINICAL APPLICATION

ABNORMAL SPINAL CURVATURES

...rmal spinal curvatures (fig. 7.21) can result from disease, we... ...f the trunk muscles, poor posture, or congen... ...body, or ...narrow covered

Evolutionary Medicine

No understanding of the human body can be complete without taking its evolutionary history into account; the human body today must be seen as reflecting adaptations to past environments. Since the mid-1990s, an increasing number of books on evolutionary (darwinian) medicine have appeared, along with many articles in medical journals exploring evolutionary interpretations of human structure, function, and disease. This trend shows no signs of abating. And indeed, the 38th edition of *Gray's Anatomy* (1995) is thoroughly evolutionary, with 11 pages of evolution in its first chapter, and pervasive evolutionary interpretations of human anatomy throughout that esteemed tome. Yet no other human anatomy textbook for this introductory undergraduate market has incorporated evolutionary medicine into its perspective. There is little room to

delve very far into this subject, but the importance of evolution to human anatomy is introduced in a section of chapter 1, "The Evolution of Human Structure," and is reinforced by six of the insight essays and by evolutionary comments elsewhere in the main body of text. Insight 4.2, for example, provides an evolutionary interpretation of morning sickness as an adaptation for protecting the embryo from teratogens, and insight 25.2 clarifies the function of the nephron loop through an evolutionary comparison of humans to aquatic and desert mammals.

Medical History

Other books also say little if anything about the history and personalities behind the science of human anatomy. They seem to expect students to accept the information *ex cathedra* without asking, "Who says? How do they know that?" Again, introductory anatomy textbooks allow little room or luxury to discuss history at any great length, but I do provide a brief history of anatomy ("Early Anatomists") in chapter 1, and add historical remarks in Medical History insight essays, such as an insight into the function of the prefrontal cortex from the accident of Phineas Gage (insight 15.2). Historical comments are also found in the general text, such as Hippocrates' interpretation of brain function (chapter 15), Harvey's discoveries in blood circulation (chapter 21), and William Beaumont's experiments in gastric physiology (chapter 24). Such stories add considerable human interest to human anatomy, taking it beyond the realm of merely memorizing the facts.

Developmental Biology

My manuscript reviewers had widely disparate opinions of how much embryology this book should contain. Some said they have no time to teach embryology and wanted none at all, while others regarded chapter 4 (Human Development) to be the most important chapter in the book and wanted much more depth. The modal response was that there should be a moderate amount of embryology on each organ system, but not very much detail. I have aimed at this middle ground.

Chapter 4 presents basic embryology and lays a foundation for understanding the more specialized embryology of individual organ systems. For each organ system, there is a developmental section near the end of the chapter that goes briefly into its further development from the basic primordia described in chapter 4. These sections are not meant to be encyclopedic treatments of human embryology, but broad overviews and key examples. The eye and ear suffice for sense organ embryology, and the pituitary, thyroid, and adrenal glands for the endocrine system, for example. Neither space limitations nor, apparently, the interests of prospective users warrant greater detail or a comprehensive treatment of the development of every organ.

Aging

At the other end of the life span are the degenerative changes of old age. In view of the steadily increasing average age of the North American population, these are becoming increasingly important to health care providers. The effects of aging are presented for each organ system in a section following prenatal development ("The Aging Vascular System," for example).

PEDAGOGY

The following features are designed to serve the student's needs and adapt the book to the abilities of most beginning college students.

Brushing Up

Each chapter opener page (beginning with chapter 2) has a "Brushing Up" box which lists concepts from earlier chapters that the reader should understand before embarking on the new one. It helps to tie the organ systems together and show their relevance to each other. It also serves as an aid in courses that teach the systems in a different order from the one presented here, and for students returning after an absence from college who may need to refresh their memories of some concepts.

Objectives and "Before You Go On" Questions

Each chapter is broken down into typically three to six major sections, framed between a set of learning objectives at the beginning and a set of review questions ("Before You Go On") at the end of each section. Blocking the chapters out in this manner makes it easier for a student to plan a study session around concrete goals with a defined beginning and end. "Before You Go On" is an opportunity to test one's comprehension of the preceding material, or for instructors to test that comprehension, before moving on to a new section.

Vocabulary Aids

Among the greatest hurdles to studying human anatomy are its massive vocabulary and many students' unfamiliarity with biological word roots based heavily in Greek and Latin. Even as a graduate teaching assistant, I developed the habit of breaking words down into familiar roots in my lectures, and I have taught a course on biomedical etymology for many years. I am convinced that students find such terms as *pterygoid* and *extensor carpi radialis brevis* less forbidding, and easier to pronounce, spell, and remember, if they cultivate the habit of looking for familiar roots and affixes.

I have brought my etymological habit to *Human Anatomy.* Chapter 1 has a section, unique among human anatomy textbooks at this level, titled "The Language of Anatomy." It aims to instill the habit of breaking words down into familiar roots, intuiting the meaning of new terms from a familiarity with frequently used roots, and perceiving the relationship between singular and plural forms such as *corpus, corpora.* It explains the historic rationale for a medical language based in Greek and Latin, and the importance of precision and spelling in not confusing similar words such as *malleus* and *malleolus,* or *ileum* and *ilium.*

Following up on this, every chapter has footnotes identifying the roots and origins of new vocabulary terms, and easily understood "pro-NUN-see-AY-shun" guides for terms whose pronunciation is not intuitively obvious. The most frequently used roots, prefixes, and suffixes are listed with their meanings and biomedical examples inside the back cover of the book.

Terminology

The vocabulary in this book follows the *Terminologia Anatomica,* which has been the global standard for anatomical terms since 1998. My adherence to the TA is not absolute, however; I retain some traditional terms where TA would seem more confusing than helpful to the beginning student. Following the recommendations of the *AMA Manual of Style* and *Stedman's Medical Dictionary,* I also minimize the use of eponyms and substitute descriptive names, such as *tactile disc* for *Merkel disc* and *intestinal crypts* for *crypts of Lieberkühn.* I give the traditional eponyms in parentheses when first introducing the term. Some eponyms remain unavoidable (*Golgi complex* and the *Broca area,* for example). Also following the AMA's and Stedman's recommendations, when I do use eponyms, I use nonpossessive forms—thus, *Cushing syndrome* and *Alzheimer disease* rather than *Cushing's syndrome* and *Alzheimer's disease.*

Concept Reviews

Each chapter has a Review of Key Concepts at the end, a concise restatement of the chapter's main points for the purpose of study and review. Key vocabulary terms are italicized to make them stand out in this review activity.

Self-Testing Exercises

There are multiple types of self-testing questions in each chapter. At the end of the chapter are 10 multiple choice and 10 sentence completion questions on simple recall of information (Testing Your Recall); 10 True or False questions that call for more than just identifying (or guessing) which statements are true or false, but also for briefly explaining *why* the false statements are untrue; and 5 essay questions (Testing Your Comprehension) that call for deeper interpretive thought or application of the chapter's information to new clinical scenarios.

Within the body of each chapter there are an average of 17 "Before You Go On" questions and 3 "Think About It" questions. The latter are questions dispersed through the chapter calling for the student to apply what he or she has just read to a new situation, draw comparisons between concepts in different chapters, and so forth.

The questions in each chapter thus draw upon three levels of cognitive skill: (1) simple recall and recognition, as in Testing Your Recall; (2) ability to express concepts in one's own words, as in Before You Go On; and (3) analytical insight, as in Think About It, Testing Your Comprehension, and the explanation task in the True or False questions.

Suggestions Welcome!

Even though this book is now post-partum and dressed in hard covers, it is still very much a work in progress. It has benefited greatly from the many reviewers who provided critiques of the manuscript and art during its development. Undoubtedly it will improve still more as I hear from students and colleagues who use it, and who wish to point out its strong features or make suggestions for improvement. I welcome any user to send feedback to me at the following address, and will be grateful for your contribution to the quality and accuracy of future editions.

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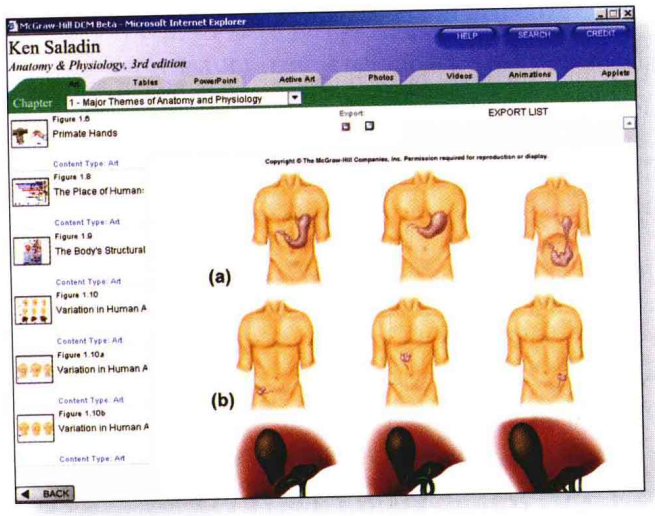
For the Instructor:

DIGITAL CONTENT MANAGER CD-ROM

This multimedia collection of visual resources allows instructors to utilize artwork from the text in multiple formats to create customized classroom presentations, visually based tests and quizzes,



dynamic course website content, or attractive printed support material. The digital assets on this cross-platform CD-ROM include:

Art Library—Full-color digital files of all illustrations in the book, plus the same art saved in unlabeled and gray scale versions, can be readily incorporated into lecture presentations, exams, or custom-made classroom materials. These images are also pre-inserted into blank PowerPoint slides for ease of lecture preparation.

TextEdit Art Library—Every line art piece is placed in a PowerPoint presentation that allows the user to revise and/or move or delete labels as desired for creation of customized presentations and/or for testing purposes.

Active Art Library—Active Art consists of art files that have been converted to a format that allows the artwork to be edited inside of PowerPoint. Each piece can be broken down to its core elements, grouped or ungrouped, and edited to create customized illustrations.

Animations Library—Full-color presentations involving key figures in the book have been brought to life via animation. These animations offer total flexibility for instructors and were designed to be used in lecture. Instructors can pause, rewind, fast forward, and turn audio off and on to create dynamic lecture presentations.

Photo Library—Like the Art Library, digital files of all photographs from the book are available.

Table Library—Every table that appears in the book is provided in electronic form.

PowerPoint Lecture Outlines—Based on the information in the Instructor's Manual described below, it is possible to create ready-made presentations that combine art and lecture notes for each of the 26 chapters of the book. Written by Roger Gilchrist, University of Alabama-Birmingham, these lectures can be used as they are, or can be customized to reflect your preferred lecture topics and sequences.

INSTRUCTOR'S TESTING AND RESOURCE CD-ROM

The cross-platform CD-ROM contains the Instructor's Manual and Test Item File, written by Robin McFarland, Cabrillo College, are both available in Word and PDF formats. The manual follows the order of sections and subsections in the textbook and summarizes the main points in the text, figures, and tables. The Instructor's Manual also includes links to relevant websites, the answers to the problem sets at the end of each chapter, and a Test Bank of additional questions that can be used for homework assignments and/or the preparation of exams. These additional questions are found in a computerized test bank utilizing Brownstone Diploma testing software to quickly create customized exams. This user-friendly program allows instructors to search questions by topic, format, or difficulty level; edit existing questions or add new ones; and scramble questions and answer keys for multiple versions of the same test.

LABORATORY MANUAL

The *Human Anatomy Laboratory Manual* by Eric Wise, Santa Barbara City College, is expressly written to coincide with the chapters of *Human Anatomy.* This lab manual uses the same four-color art program as this book. It is accompanied by a separate Instructor's Manual, which contains solutions and keys for grading laboratory reports.

TRANSPARENCIES

A set of 600 transparency overheads includes nearly every piece of line art in the text. The images are printed with better visibility and contrast than ever before, and labels are large and bold for clear projection.

CLINICAL APPLICATIONS MANUAL

This manual written by Michael Hendrix, Southwest Missouri State University, expands on *Human Anatomy*'s clinical themes and introduces new clinical topics and case studies to develop the student's ability to apply his or her knowledge to realistic situations.

eINSTRUCTION

This Classroom Performance System (CPS) brings interactivity into the classroom/lecture hall. It is a wireless response system that gives the instructor and students immediate feedback from the entire class. The wireless response pads are essentially remotes that are easy to use and engage students. CPS allows you to motivate student preparation, interactivity and active learning so you can receive immediate feedback and know what students understand.

COURSE DELIVERY SYSTEMS

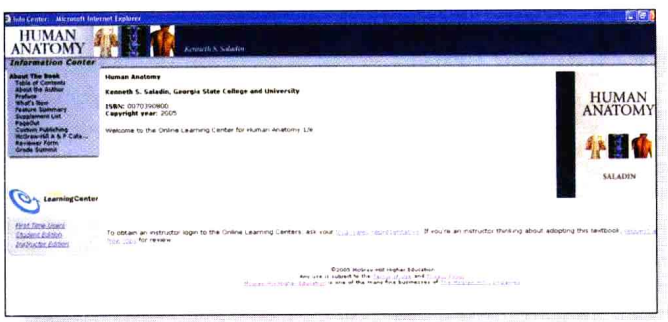
With help from our partners, WebCT, Blackboard, TopClass, eCollege and other course management systems, instructors can take comple

control over their course content. These course cartridges also provide online testing and powerful student tracking features. The Saladin Online Learning Center is available within all of these platforms.

For the Student:

ONLINE LEARNING CENTER (OLC)

The website offers an extensive array of learning and teaching tools. The site includes quizzes for each chapter, links to websites, clinical applications, interactive activities, art labeling exercises, and study outlines. Instructor resources at this site include lecture outlines and teaching tips.



SALADIN INTERACTIVE CD-ROM

Set up in easy to use tabular format, this dual-platform CD-ROM is a fully interactive learning tool. The CD is organized chapter-by-chapter and provides a link directly to the text's Online Learning Center. Standard features include chapter-based quizzes, animations of complex processes, and PowerPoints of all the images found in the textbook. Saladin Interactive CD-ROM offers an indispensable resource for enhancing topics covered within the text.

INTERACTIVE CLINICAL RESOURCE CD-ROM

The Interactive Clinical Resource CD-ROM offers 150 3-D animations and 3-D models of human disease and disorders. It also contains 13 sections of clinical content (and nearly every body system) including Urinary, Skeletal, Reproductive, Nervous, Muscular, Immune, Digestive, Circulatory, and Endocrine.

VIRTUAL ANATOMY DISSECTION REVIEW CD-ROM

This multimedia program created by John Waters of Pennsylvania State University, and Melissa Janssen and Donna White of Collin County Community College, contains vivid, high-quality, labeled cat dissection photographs. The program helps students easily identify and compare the corresponding structures and functions between the cat and the human body.

STUDENT STUDY ART NOTEBOOK

This visual guide contains every illustration from the text to make it easier for students to learn anatomy. This collection of images provides a comprehensive resource for studying anatomical structures and a convenient place to write notes during lecture or lab.

Acknowledgments

As every textbook author knows, a book on this scale is never his or hers alone, but the product of many people's hard work and support. I am very indebted to Vice President and Editor-in-Chief Michael Lange and Publisher Marty Lange for their unfailing encouragement and material support; Sponsoring Editor Michelle Watnick and Marketing Manager Jim Connely for their infectious enthusiasm and promotion of the book; my editor Kristine Tibbetts, Director of Development, who has worked with me from year one of my textbook writing endeavors and spared no effort to make this book of highest quality; Mary E. Powers, Senior Project Manager, for keeping all parts of this project meshed like fine clockwork; Designer K. Wayne Harms for the esthetic appearance of the book; Photo Coordinator John Leland and Photo Researcher Mary Reeg for locating the great number of photographs between these covers; Copyeditor Cathy Conroy, for a sharp eye that spared me from innumerable embarrassments; Jack Haley and his team of medical illustrators and graphic artists at Imagineering STA Media Services in Toronto; and photographer Tim Vacula and illustrator Linda Chandler, who worked with me at Milledgeville on illustrative concepts for the book. And as always, I owe a thousand thanks to Colin Wheatley for talking me into textbook writing in the first place.

For factual accuracy and effective presentation, I also greatly appreciate the reviewers listed on the following pages, who provided a great deal of very helpful and detailed corrections, feedback, and encouragement during the writing process.

To my family—Diane, Emory, and Nicole—I thank you once again for your forbearance with the obsessions of an author and for helping me dispose of the royalties in ways that have been fun and enlightening.

Reviewers

No words could adequately convey my indebtedness and gratitude to the anatomy instructors and experts who have reviewed this book, and who have provided such a wealth of scientific information, corrections, suggestions for effective presentation, and encouragement. For making the book beautiful, I am indebted to the team described earlier. For making it *right*, I am thankful to the colleagues listed on the following pages.

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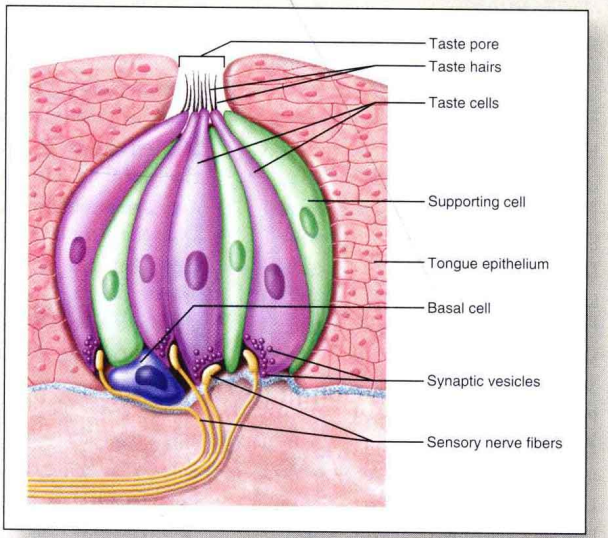
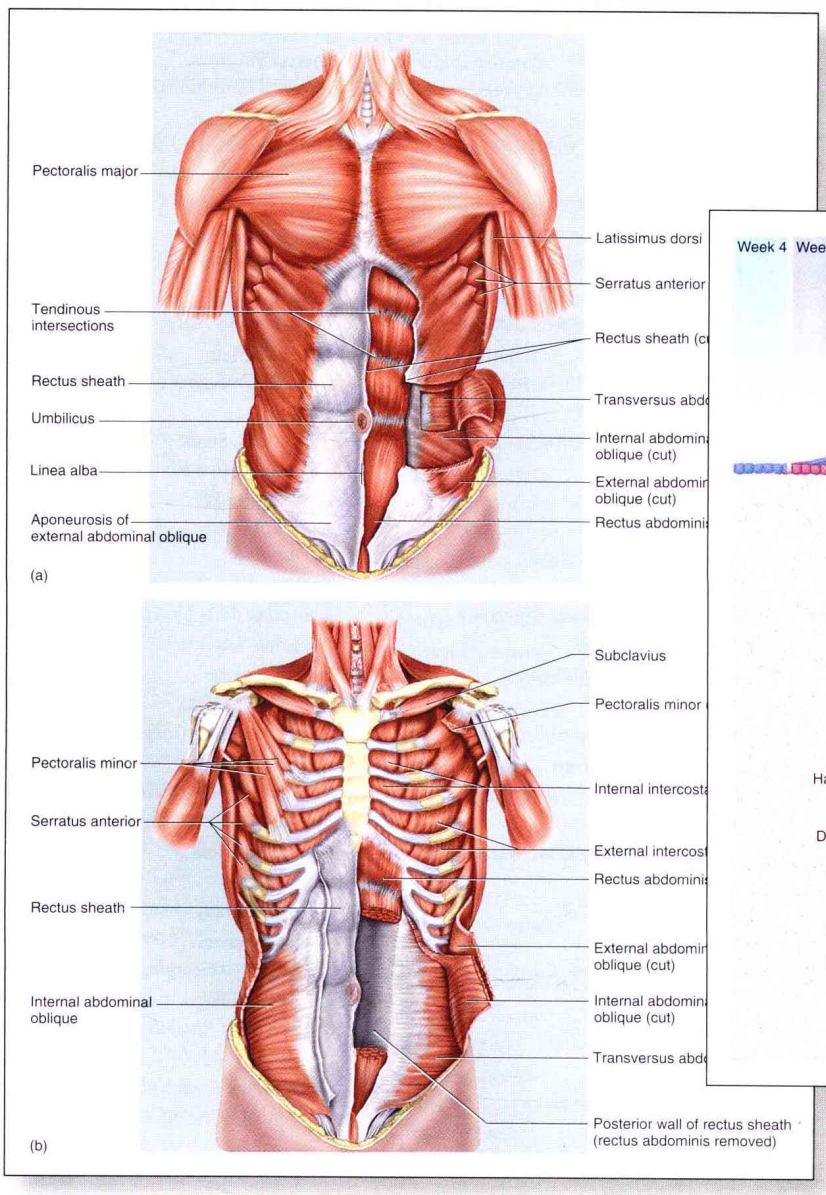
Vivid and Captivating Illustrations Contribute to Learning

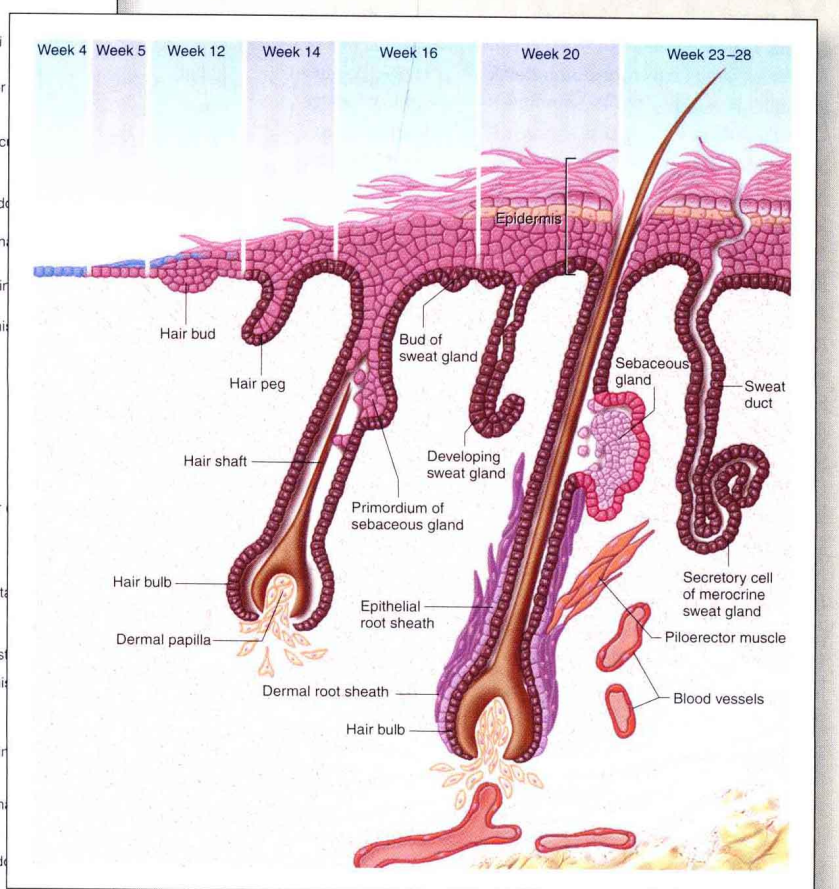
Saladin's *Human Anatomy* brings key concepts to life with its unique style of biomedical illustration. The digitally rendered images have a vivid three-dimensional look that will not only stimulate your students' interest and enthusiasm, but also give them the clearest possible understanding of important concepts.

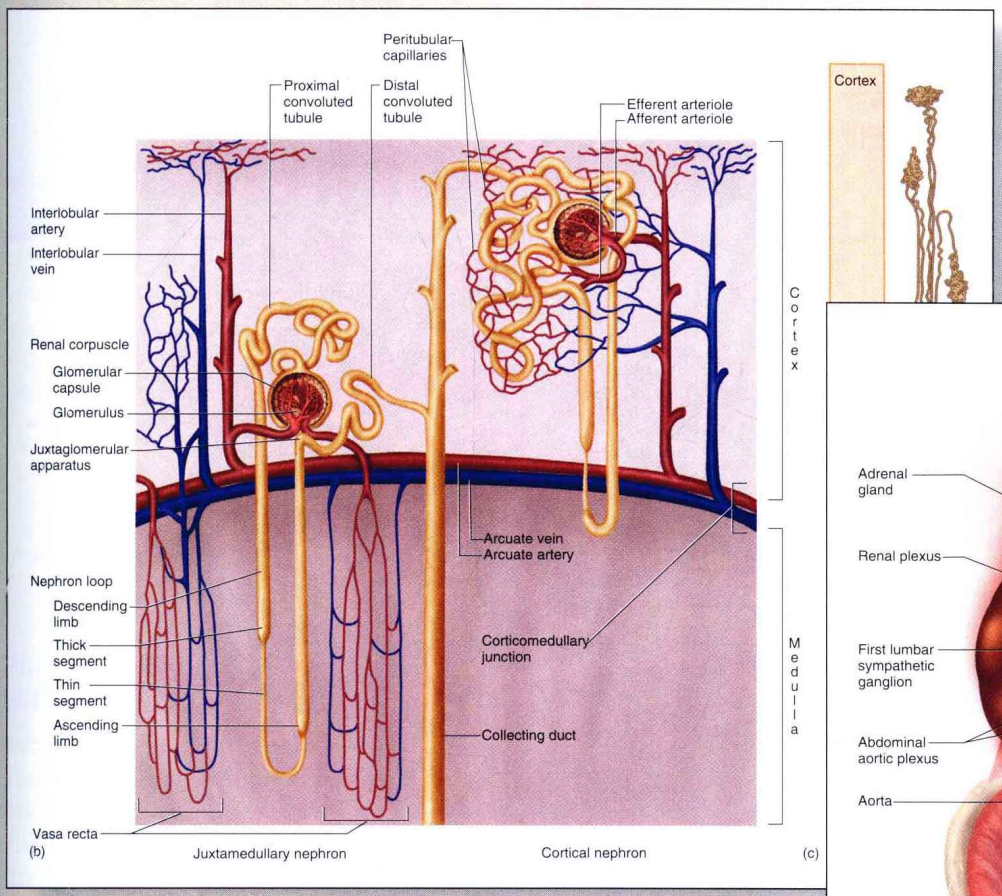
Unparalleled Art Program

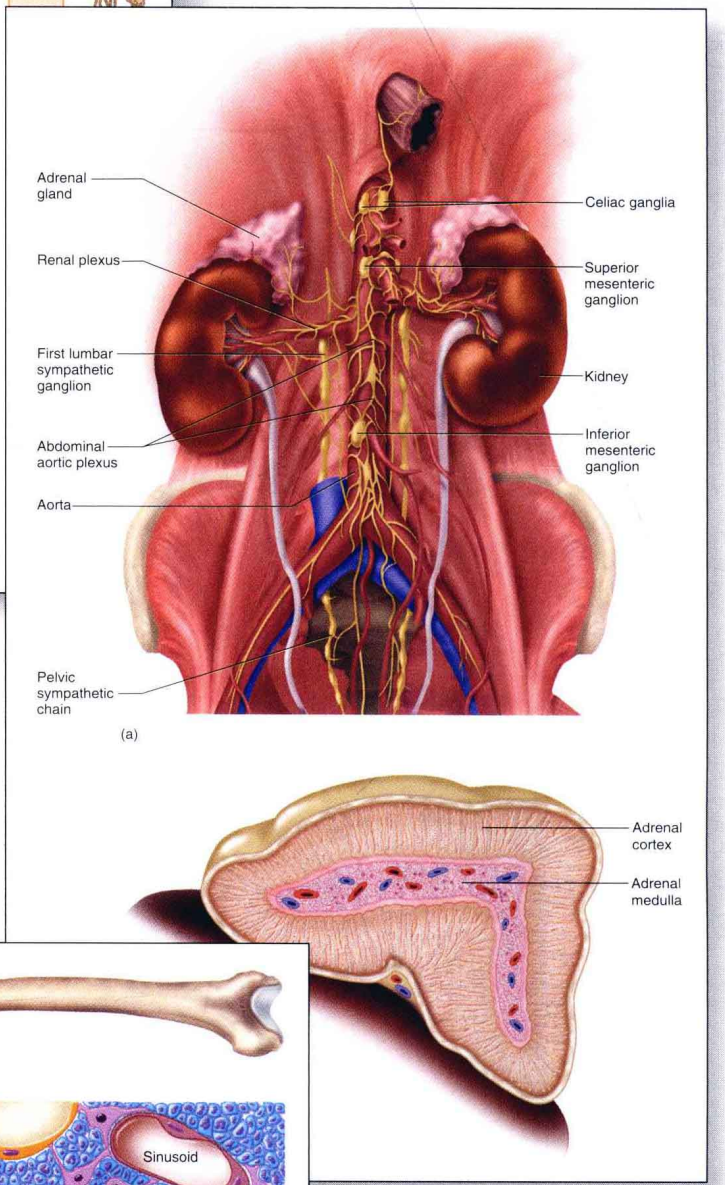
Saladin's illustration program includes digital line art, numerous cadaver photographs, and light, TEM, and SEM photomicrographs. Larger images and brighter colors in the third edition will help draw your students into the subject.

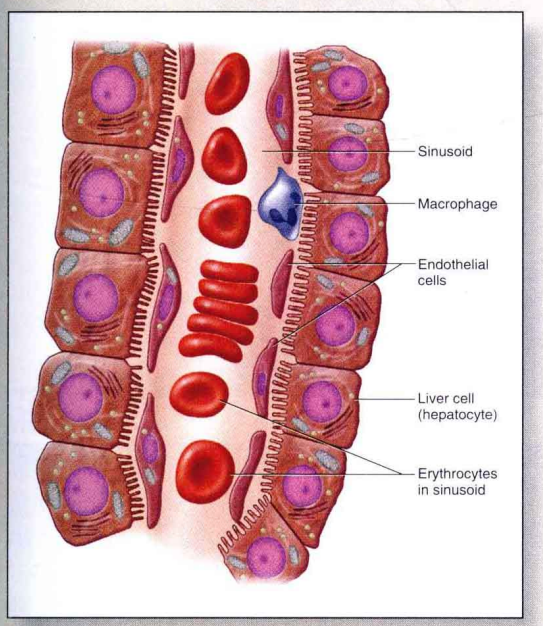


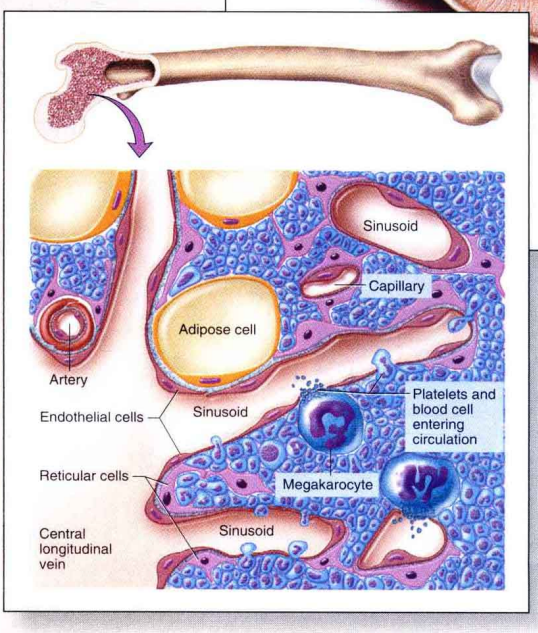





Peritubular capillaries
Proximal convoluted tubule
Distal convoluted tubule
Efferent arteriole
Afferent arteriole
Cortex
Interlobular artery
Interlobular vein
Renal corpuscle
Glomerular capsule
Glomerulus
Juxtaglomerular apparatus
Nephron loop
Descending limb
Thick segment
Thin segment
Ascending limb
Vasa recta
Arcuate vein
Arcuate artery
Corticomedullary junction
Collecting duct
Cortex
Medulla
(b)
Juxtamedullary nephron
Cortical nephron
(c)

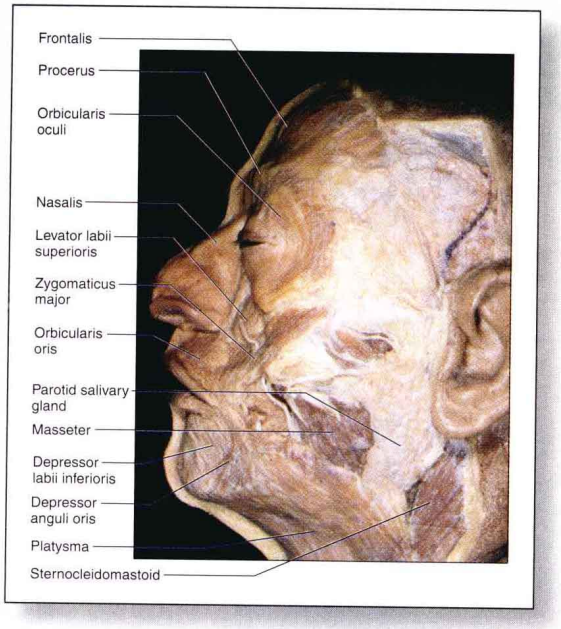

Adrenal gland
Renal plexus
First lumbar sympathetic ganglion
Abdominal aortic plexus
Aorta
Pelvic sympathetic chain
Celiac ganglia
Superior mesenteric ganglion
Kidney
Inferior mesenteric ganglion
(a)
Adrenal cortex
Adrenal medulla

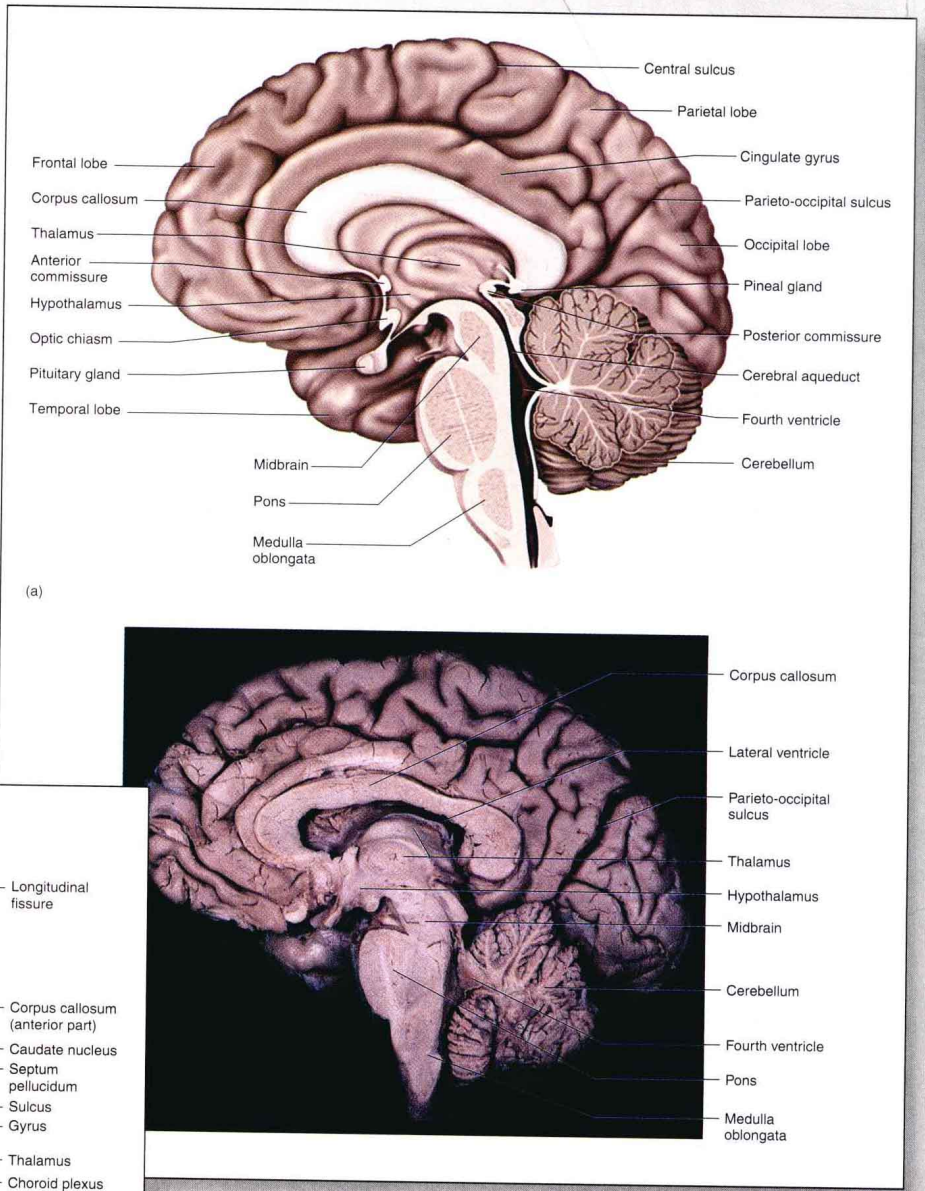

Sinusoid
Macrophage
Endothelial cells
Liver cell (hepatocyte)
Erythrocytes in sinusoid

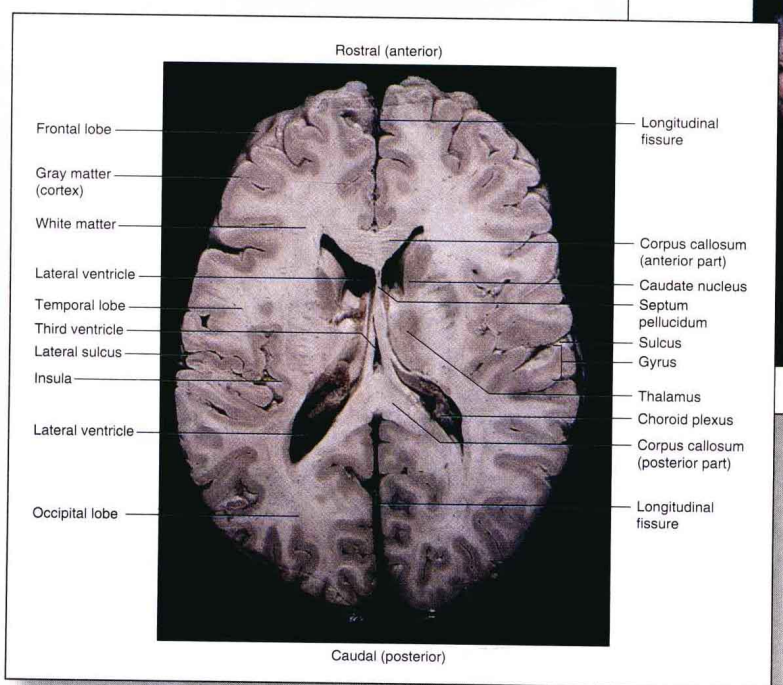

Sinusoid
Capillary
Adipose cell
Artery
Endothelial cells
Sinusoid
Platelets and blood cell entering circulation
Reticular cells
Megakarocyte
Central longitudinal vein
Sinusoid

Atlas Quality Cadaver Images

Color photographs of cadavers dissected specifically for this book allow students to see the real texture of organs and their relationships to each other. This anatomical realism combines with the simplified clarity of line art to give your students a holistic view of bodily structure.

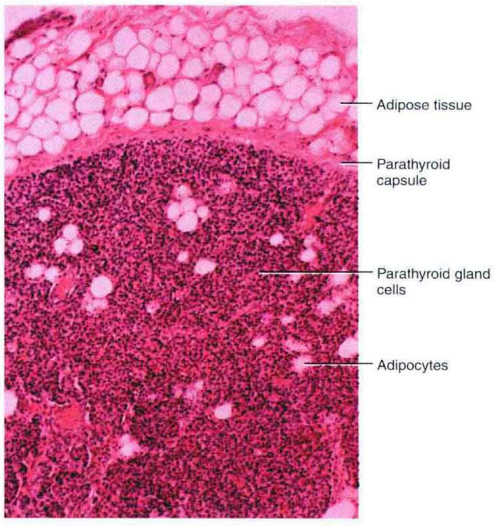






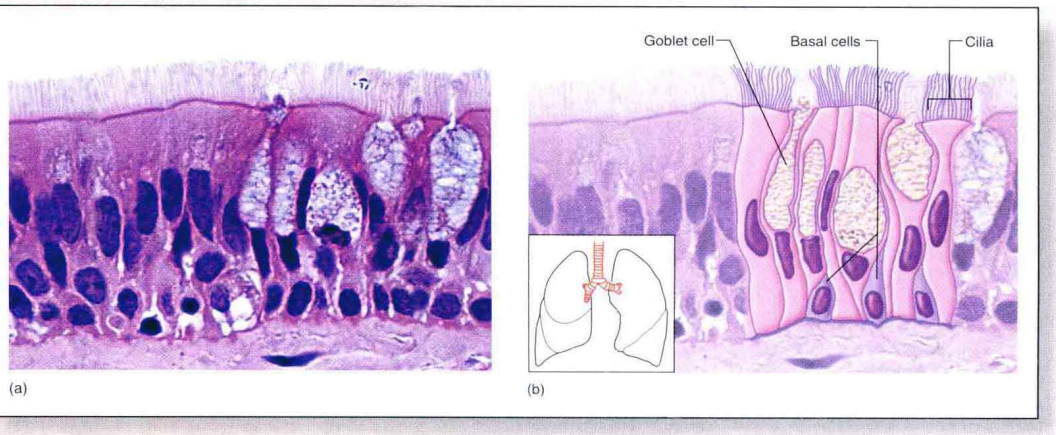
Micrographs

All life processes are ultimately cellular processes. Saladin drives this point home with a variety of histological micrographs in LM, SEM, and TEM formats, including many colorized electron micrographs.



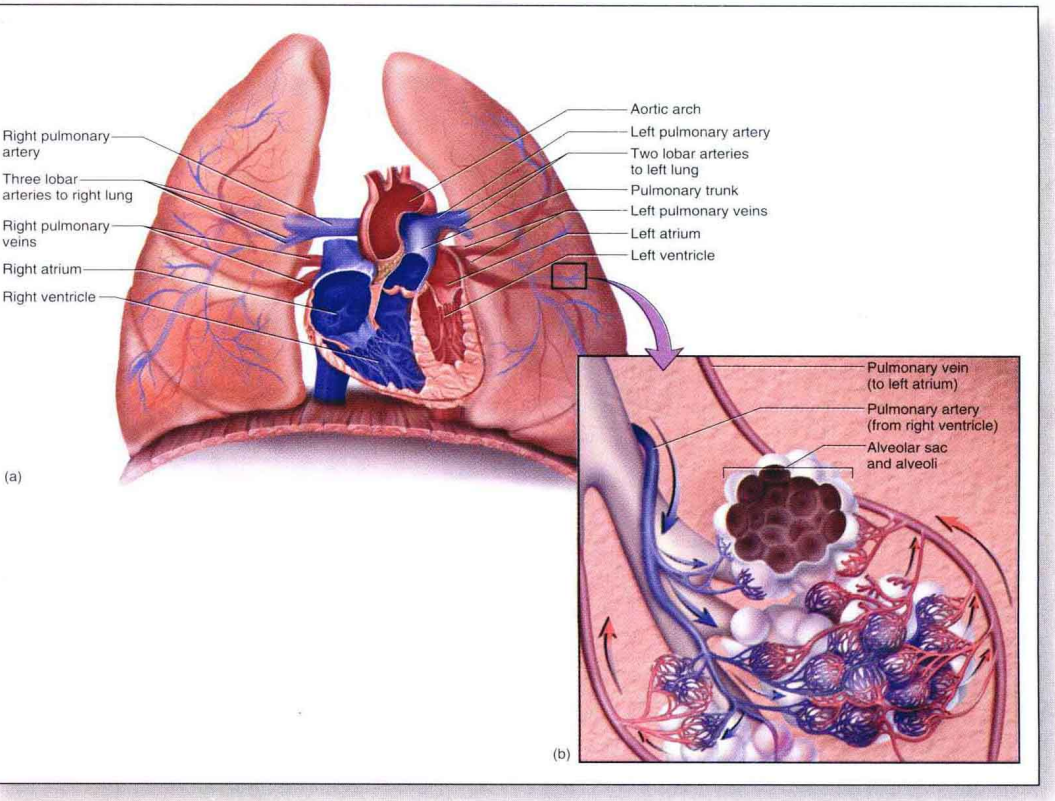
Photomicrographs Correlated with Line Art

Saladin juxtaposes histological photomicrographs with line art. Much like the combination of cadaver gross photographs and line art, this gives students the best of both perspectives: the realism of photos and the explanatory clarity of line drawings.



From Macroscopic to Microscopic

Saladin's line art guides students from the intuitive level of gross anatomy to the functional foundations revealed by microscopic anatomy.



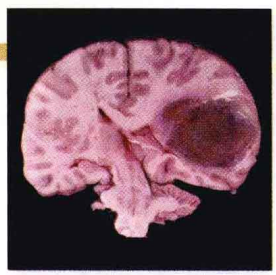
Pedagogical Aids Promote Systematic Learning

Saladin structures each chapter around a consistent and unique framework of pedagogic devices. No matter what the subject matter of a chapter, this enables students to develop a consistent learning strategy, making *Human Anatomy* a superior learning tool.

15

CHAPTER FIFTEEN

The Brain and Cranial Nerves



Frontal section of a brain with a large tumor (glioblastoma) in the left cerebral hemisphere

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- Major Landmarks 414
- Gray and White Matter 414
- Meninges 414
- Ventricles and Cerebrospinal Fluid 417
- Blood Supply and the Brain Barrier System 418

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15.3 Clinical Application: Some Cranial Nerve Disorders 449

BRUSHING UP

To understand this chapter, you may find it helpful to review the following concepts:
- Anatomy of the cranium (pp. 175–183)
- Glial cells and their functions (p. 371)
- Embryonic development of the central nervous system (pp. 378–379)
- Meninges (p. 386)
- Gray and white matter (pp. 338–389)
- Tracts of the spinal cord (pp. 389–392)
- Structure of nerves and ganglia (pp. 393–395)

Brushing Up

A Brushing Up list at the beginning of the chapter ties chapters together and reminds students that all organ systems are conceptually related to each other. They discourage the habit of forgetting about a chapter after the exam is over. Brushing Up lists are also useful to instructors who present the subject in a different order from the textbook.

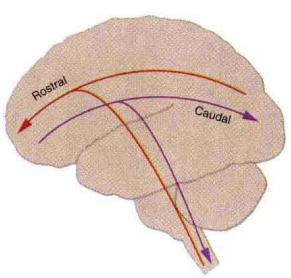

FIGURE 15.3
Directional Terms in CNS Anatomy. The *rostral* direction is from the rear of the head or from lower points in the brainstem or spinal cord toward the forehead. The *caudal* direction is from the forehead toward the rear of the head or toward lower points in the brainstem or spinal cord.

INSIGHT 15.1 CLINICAL APPLICATION

MENINGITIS

Meningitis—inflammation of the meninges—is one of the most serious diseases of infancy and childhood. It occurs especially between 3 months and 2 years of age. Meningitis is caused by a variety of bacteria and viruses that invade the CNS by way of the nose and throat, often following respiratory, throat, or ear infections. The pia mater and arachnoid are most often affected, and from here the infection can spread to the adjacent nervous tissue. In bacterial meningitis, the brain swells, the ventricles enlarge, and the brainstem may exhibit hemorrhages. Signs include a high fever, stiff neck, drowsiness, and intense headache and may progress to vomiting, loss of sensory and motor functions, and coma. Death can occur within hours of the onset. Infants and toddlers with a high fever should therefore receive immediate medical attention.

Meningitis is diagnosed partly by examining the cerebrospinal fluid (CSF) for bacteria and white blood cells. The CSF is obtained by making a *lumbar puncture (spinal tap)* between two lumbar vertebrae and drawing fluid from the subarachnoid space (see insight 14.1).

around the spinal cord. It is attached to the cranial bone only in limited places—around the foramen magnum, the sella turcica, the crista galli, and the sutural lines of the skull.

In some places, the two layers of dura are separated by **dural sinuses,** spaces that collect blood that has circulated through the brain. Two major dural sinuses are the **superior sagittal sinus,** found just under the cranium along the midsagit-

Ventricles and Cerebrospinal Fluid

The brain has four internal chambers called **ventricles.** The largest are the two **lateral ventricles,** which form an arc in each cerebral hemisphere (fig. 15.5). Through a pore called the **interventricular foramen,** each lateral ventricle is connected to the **third ventricle,** a narrow medial space inferior to the corpus callosum. From here, a canal called the **cerebral aqueduct** passes down the core of the

Insights

Each chapter has from two to five special topic Insight essays on the history behind the science, the evolution behind human form and function, and especially the clinical implications of the basic science. Insight sidebars lend the subject deeper meaning, intriguing perspectives, and career relevance to the student.

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