An artistic anatomical illustration of a human torso, focusing on the rib cage and thoracic cavity. The rib cage is shown in a semi-transparent manner, revealing the lungs and the heart. A dense, dark forest scene with tall, thin trees is superimposed over the internal organs, creating a surreal and symbolic image. The overall color palette is dark, with deep reds, browns, and blacks, giving it a somber and dramatic feel.

Anatomy & Physiology

THE UNITY OF FORM AND FUNCTION

Kenneth S. Saladin

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Kenneth S. Saladin

Georgia College and State University

with

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Clinical Consultant



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ANATOMY & PHYSIOLOGY: THE UNITY OF FORM AND FUNCTION

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Preface to Instructors

A New Approach to the Study of Anatomy and Physiology

It may seem surprising that anyone would launch another textbook of human anatomy and physiology when there are already so many to choose from. I set out to express a unique vision of how to present the subject. During the development of the manuscript, the comments of more than 300 reviewers assured the editorial team and me that we were, indeed, on to something that would be received as a novel and welcome entry into this field. We pulled out all the stops to make this a textbook without equal. I explain here how it differs from others, and in the Preface to Students that follows, I discuss pedagogic features of special relevance to them. I encourage instructors to read that as well, since it deals with issues important to the effective use of the book and with some of the most fundamental differences between this A&P textbook and others.

Intended Audience

I designed *Anatomy and Physiology: The Unity of Form and Function* for a two-semester college course, primarily for students who hope to enter the health professions. I assume little or no prior college chemistry or cell biology. Chapters 2 to 5 are a comprehensive introduction to these subjects. I also assume that many students, like mine, are still forming the study and thinking habits essential for success in the technical disciplines. Thus, the book aims not only to convey information, but also to promote the development of these skills through a consistent framework of pedagogic devices in each chapter. A “Brushing Up” list at the start of each chapter reminds students that each chapter builds on knowledge gained from those before it and gives instructors more flexibility to cover the chapters in a different order than presented.

Novel and Unifying Themes

Certain themes are indispensable to the teaching of A&P and are well represented in these pages. Students are re-

peatedly reminded of the central importance of homeostasis, the complementarity of form and function, and the cellular basis of all anatomy and physiology. Clinical applications and dysfunctions are used generously, not only to lend deeper insight into the normal function of the body, but also to demonstrate why this subject is relevant to the student’s career aspirations.

But in addition to these time-honored themes, the book introduces some that are more unusual in the A&P marketplace of ideas—scientific method, biomedical history, and human evolution. These are among the elements that reviewers found most noteworthy and welcome. They enrich and humanize the subject and promote analytical thinking. The textbook controversies that have raged in American newspapers, school board meetings, and federal courts have made it glaringly apparent how few people understand what science is, how to weigh competing claims of truth, and how to distinguish science from pseudoscience. Many biology textbooks have redressed these misunderstandings by paying increasing attention to scientific thought and method and to the personalities and history of science. Anatomy and physiology textbooks, however, have lagged behind. A&P is a field jam-packed with information. Students and instructors want clinical relevance, and it may be hard to see how there could be room to include any history, biography, or the philosophy of science. But without compromising information on the basic biology of the human body, and without glossing over clinical applications of this information, I have woven these other threads into the story and produced a textbook no longer than others written for the same market niche.

Scientific Method Most A&P textbooks do little more than present facts, creating the impression that science is a massive body of data rather than a method of discovery. If students have no appreciation of how such information was obtained, then they have no particular reason to believe that it’s more trustworthy than any other claims to truth. If any science is vulnerable to boisterous fads and costly frauds, it is surely the health sciences. In this field, we have a special duty to cultivate scientific skepticism and sound judgment. I introduce some basic ideas of scientific method in chapter 1 and reinforce them with asides and thought questions throughout the book.

A Historical and Humanistic Perspective A&P has a colorful, engrossing history. I often make time in my lectures for little stories of biomedical history, and these are among the things students remember most favorably in their course evaluations, spontaneous feedback, and return visits. Thus, I have instilled that approach into this book. Chapter 1 describes the growth of rationalism in medical thought from the ancient Greeks to the dawn of modern science. Later chapters carry on the story with vignettes of the discoverers, their tribulations, and their sacrifices in engrossing, sometimes poignant and tragic stories—for example, Rosalind Franklin's undercelebrated role in the discovery of DNA structure; William Beaumont's studies of gastric function on the reluctant “man with the hole in his stomach”; the bitter feud that followed Crawford Long's discovery of ether anesthesia; and Charles Drew's pioneering work in blood banking before he, himself, bled to death. We can hope that such stories inspire our students to enter their professions with more historical and humane vision and make their reading more satisfying.

Human Evolution The human body can never be fully appreciated without a sense of its evolutionary past. Much of what we know about it has been won through comparative anatomy and physiology—twin sciences grounded in evolutionary theory. Evolution provides a deep and inspiring vision of human form and function, as recognized by several books of “evolutionary (Darwinian) medicine” that appeared in the 1990s for general readers and by a growing number of research and review papers in the medical journals. Yet the recent textbook controversies have left legions of teachers wary of covering this subject, emboldened some to denounce it, and flooded our colleges with students who have never been exposed to the most revolutionary idea and unifying principle in all of biology. This is perhaps the first A&P textbook that gives more than a brief nod to the subject. Chapter 1 introduces the logic of natural selection and a few high points of human evolution. Later chapters reinforce the point with evolutionary insights ranging from muscle anatomy to menopause. I use comparative A&P to explain such features as skeletal adaptations to bipedalism, the four-chambered heart, and the nephron loop—not merely to state that we differ from other animals, but to show *why* our differences are adaptive.

Developmental Biology and Aging Some instructors will want to know how much embryology the book covers. I describe the embryonic development of the bones, central nervous system, pituitary, heart, and reproductive systems, but not of the integumentary, muscular, lymphatic, respiratory, urinary, or digestive systems. Some omissions are necessary in any book, and I had two reasons for these particular ones: a tepid response from re-

viewers on their necessity and my feeling that the space would be better dedicated to the *aging* of the organ systems. Demographers and journalists frequently remind us of the health-care implications of a population that is markedly increasing in age. Our students today will be caring for this aging population tomorrow. In this context, I find it more important that they understand, for example, how the skin ages and how this affects other organ systems than how it develops in the embryo. In addition, the quality of life in old age depends on how we treat our bodies in our youth. Most of our students are at an age when they can best benefit from this foresight. Chapter 29 therefore has a system-by-system overview of age-related changes in the body.

Clinical Concepts and Consultants

The best understanding of human form and function often comes from an appreciation of what happens when things go wrong. It could be rather dull for a student to study ion pumps, for example, just because scientists have decreed that they are important. But if the student can empathize with a child with cystic fibrosis, then understand how the symptoms of CF result from a defect in chloride pumps, cell membranes and ion pumps take on striking relevance to a future nurse or respiratory therapist. Thus, I have repeatedly used clinical examples and thought questions to lead the student to deeper insights into normal human form and function.

In developing these applications, I was aided not only by my local colleagues and the instructors who reviewed the manuscript, but also by Dr. Carol Mattson Porth, author of a leading textbook, *Pathophysiology: Concepts of Altered Health States* (J. B. Lippincott Company), who served as clinical consultant to this project. I was also significantly aided in this by my in-house clinical consultant, a registered nurse to whom I have been married for 18 years and who played an active role in the development of this book. I am grateful to both for their valuable input.

Chapter Content and Order

The order and content of the chapters is clear enough from the Table of Contents, but let me call your attention to a few places where these differ from other A&P textbooks.

Major Themes of A&P Chapter 1, Major Themes of Anatomy and Physiology, has two purposes: to set a historical and philosophical stage for the study of A&P and to identify five major themes that run through the rest of the book—the unity of form and function, the hierarchy of human structure, cell theory, evolution, and homeostasis. This chapter addresses the meaning of human

life through two questions: What is life? and What is a human? It places humans in taxonomic context and describes the characteristics that define our species. It introduces the logic of Darwinian thought and describes how the habitats of our ancestors shaped several aspects of human form and function we now take for granted. The section on scientific method discusses inductive and hypothetico-deductive reasoning, experimental design, and peer review, and clarifies the widely misunderstood concepts of fact, law, and theory in science. This is followed by a short history of medical thought, extending roughly from Hippocrates to Harvey, with emphasis on people who challenged and overthrew entrenched superstitions and dogmas. Some reviewers felt that this section ended prematurely and wished it had continued into the twentieth century, but those stories are told in the sidebars and vignettes of later chapters. The twentieth-century ideas of homeostasis and feedback, however, have such central importance that they are presented in chapter 1.

We have grown accustomed to finding directional terminology, body planes, membranes, cavities, and so forth treated in chapter 1 of most A&P textbooks. I found it more effective, however, to consolidate this information in a 15-page atlas following that chapter. The beautiful illustrations subsequently prepared for the atlas further enhance its value as a stand-alone reference. Since the terminology introduced here is fundamental to the rest of the book, I conclude the atlas with a set of self-testing questions similar to those in the chapters, and I include it in the test items in the *Instructor's Manual* and *Student Study Guide*.

Chemistry Well-prepared students can probably skip chapter 2, Matter and Energy, and focus on chapter 3, The Molecules of Life. Chapter 2 deals with general and inorganic chemistry and elementary principles of thermodynamics. Chapter 3 is concerned with biochemistry, including enzymology but not the nucleic acids (see chapter 5). It gives a clear but concise introduction to the synthesis and uses of ATP, sufficient for understanding such later topics as muscle physiology but without going prematurely into such details as glycolysis and the citric acid cycle. Those are treated in chapter 26.

Cytology and Histology Chapter 4 focuses on cell structure and membrane transport processes, while chapter 5 deals with the nucleic acids, protein synthesis and secretion, mitosis and the cell cycle, and fundamentals of heredity. Most textbooks bury heredity in the last chapter, which I feel is a mistake. It would be difficult to explain blood types, sickle-cell anemia, or color blindness, for example, if a student had no concept of dominant and recessive alleles, codominance, sex linkage, and pleiotropy. I reserve anomalies such as nondis-

junction and trisomy to the final chapter, but I feel it is important to introduce the basic ideas of normal heredity early. Chapter 6, Histology, concludes part 1. The student is then prepared to embark on a study of the organ systems.

Systems of Support and Movement The next six chapters and atlas B concern the integumentary, skeletal, and muscular systems. Beginning in chapter 7, each organ system has a feature we call Connective Issues—a chart that shows how that system affects others and is affected by them. The order of the muscular system chapters is opposite that found in most books. I treat gross anatomy of the muscular system (chapter 11) before its physiology (chapter 12). There are two reasons for this: (1) It provides a continuous story line from the morphology of the bones, through the joints and their actions, to the muscles and tendons that produce those actions and whose origins and insertions are explained with reference to bone morphology. (2) It links muscle as an excitable tissue to the ensuing chapter on neurons. Resting membrane potentials, action potentials, and synaptic function are introduced for the first time in the muscle physiology chapter (12) and segue into the more detailed investigation of these processes in the neuron chapter (13). Atlas B, Surface Anatomy, is a set of photographs of living subjects showing muscular and skeletal anatomy. It ends with a photographic quiz that can engage your students in relating surface structure to the skeletomuscular anatomy described in chapters 9 to 11.

Systems of Integration and Control The next five chapters deal with the nervous and endocrine systems. Today's major two-semester textbooks have at least five chapters on the nervous system, and some have six or seven. Most of us are struggling to finish the first semester at this point, and many instructors and students are finding this much material on the nervous system unmanageable at term's end—all the more so for students because this is one of the hardest systems for them to understand. Among instructors, there seem to be increasing calls for a more concise treatment of the nervous system. I have therefore limited it to four chapters: chapter 13, Nervous Tissue; chapter 14, The Central Nervous System; chapter 15, The Peripheral Nervous System and Reflexes; and chapter 16, Sense Organs. Under reflexes in chapter 15, I include both somatic reflexes and visceral autonomic reflexes. Under sense organs in chapter 16, I include not only the special senses but also the general (somesthetic) senses, which some authors treat in separate chapters.

In the endocrine system (chapter 17), I depart from convention by treating the glands and their hormones before the cellular and molecular mechanisms of hormone synthesis, transport, and action. This enables students to start with the perspective they usually find

easiest to grasp and then move on to the finer cellular and molecular details, which tend to give them more trouble. It also provides a “cast of characters”—an inventory of glands and hormones—that we can call upon to explain how hormones work. This has worked better in my teaching than the molecules-to-organs approach, which discourages some chemophobic students from hope of understanding the subject. This chapter also covers topics a little beyond the scope of the endocrine system—the eicosanoids and stress.

Systems of Regulation and Maintenance The next nine chapters concern the circulatory, immune, respiratory, urinary, and digestive systems. Chapter 18, on the blood, introduces antigens and antibodies in the context of blood typing, transfusions, and Rh compatibility, but the details of immunology and leukocyte functions are treated in chapter 21. Chapters 19 and 20 discuss the heart and the blood vessels and circulation, respectively. Chapter 21 embraces the lymphatic system, non-specific resistance, and specific immunity.

Except for the detour into immunology, we return quickly to systems that regulate the blood composition, pH, and blood pressure, namely the respiratory and urinary systems. Most textbooks treat the urinary system in association with the reproductive system. If this were only an anatomy book, I would do so too, since they have several points of embryological and anatomical relationship. But from a physiological standpoint, the urinary system has a much closer working relationship with the circulatory and respiratory systems. The kidneys regulate the hematocrit, they have more influence on blood pressure than any other organ, they collaborate with the respiratory system in controlling the acid-base balance of the blood, and they regulate the concentrations of other blood solutes. In turn, the kidneys are regulated by hormones that are secreted in response to blood pressure variations, and the capillary fluid exchange mechanisms studied in chapter 20 are needed for students to understand glomerular filtration and tubular reabsorption. In light of this intimate, bidirectional relationship between the organ systems, it seems a mistake to separate the circulatory and urinary systems any more than necessary. Chapter 24, Water, Electrolyte, and Acid-Base Balance, ties together many of the concepts from the preceding circulatory, respiratory, and urinary chapters.

This section of the book ends with chapters 25 and 26 on digestion, nutrition, and metabolism. Chapter 26 also covers the issues of body heat and thermoregulation. In chapter 26, I kept the tables of nutrient requirements and functions relatively concise. Some books go on for page after page listing nutrient functions that require a knowledge of enzymes and metabolic pathways beyond the scope of an introduc-

tory textbook. Health science students who need that knowledge usually receive it in a later nutrition course. In discussing intermediary metabolism, I have again tried to convey the clearest possible “big picture” unlabored by the structural formulae of metabolic intermediates. This chapter discusses mechanisms of appetite and satiety more than most textbooks do, and covers blood lipoproteins in a way that reviewers found especially clear and original.

Reproduction and Development Chapter 27 covers not only the male reproductive system but also some general issues of reproductive biology: What is sex? What defines male and female? What prenatal factors govern sexual differentiation? Meiosis is also introduced here. Chapter 28 runs the normal gamut of female reproductive biology through prenatal differentiation, puberty and adolescence, adult reproductive cycles, pregnancy, and lactation. Chapter 29 covers prenatal development, neonatal adaptations, and congenital anomalies, then jumps to the other end of the life span and discusses the senescence of each organ system in some depth. The last topic can serve as an excellent capstone to a two-semester course, not only sensitizing students to some issues of gerontology, but also refreshing their memory of concepts treated in earlier chapters. It integrates the organ systems by showing how each is affected by senescence of the others, thus reinforcing the concept of system interactions conveyed through the Connective Issues pages. Chapter 29 concludes with molecular to evolutionary theories of senescence; issues of longevity and death; and in the final chapter essay, new beginnings through reproductive technology.

End Matter

At the back of the book are a periodic table of the elements, color-coded with reference to human physiology and with a short discussion of the history and logic of the table; answers to the objective chapter review questions; a brief discussion, Understanding Biomedical Vocabulary, which gives insight into understanding word derivations; and a 1,000-word glossary. A well-crafted glossary is an important working tool for the student, and I did not want this to be a last-minute rush job done as the book was being readied for press. I began early to gather terms from the manuscript that I felt the student would refer back to most often and to write clear, complete, unambiguous definitions.

Answers to the more analytical Testing Your Comprehension questions at the end of each chapter exceeded our space limits for this book, but are printed in the *Student Study Guide* and *Instructor's Manual*. Answers to the Think About It questions dispersed through each chapter are also in the *Instructor's Manual* but not

in the *Study Guide*. You can make these available to your students or withhold them and assign those questions to your class. Answers are not provided for the Key Point Review questions that come at intervals through each chapter, mostly for lack of space but also because these usually are simple recall questions that can be answered from the material within the preceding five or six pages.

Inside the back cover are 400 of the word roots and affixes most often footnoted throughout the text, and inside the front cover are reference tables of symbols, weights, measures, and biomedical abbreviations.

Key Features

Art Program

Today's A&P students are the heirs to a rich tradition of medical illustration extending from the historic art of Vesalius through *Gray's Anatomy* and its twentieth-century successors. That tradition just got richer, as the medical illustrators of The Observatory Group, Inc. (OGI) of Cincinnati, Ohio, combined their anatomical training and state-of-the-art technology to produce the illustrations in this textbook and its ancillaries. Many of these began as my own black-ink and colored-pencil drawings of new concepts that I felt would be helpful or necessary. But it was the artists of OGI who brought these concepts to life with a wonderful palette, translucency, and three-dimensionality that exceeded my expectations.

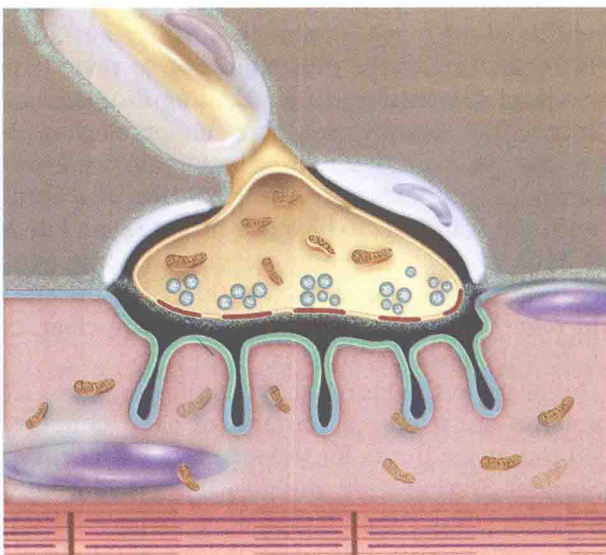
Whatever success I may enjoy with this writing endeavor, I will owe a great deal to accredited medical illustrators Lisa Petkun-Klancher, Quade Paul, and

Emiko Koike; graphic illustrators Jenny Robinson, Troy Hitch, and Susan Young; and contributing medical illustrators Stephanie Orr and David Baker. We worked together very closely to ensure the best combination of scientific accuracy and artistic skill. When you look at such figures as the neuromuscular junction shown on this page, the muscle spindle on page 526, or the middle ear on page 565 and compare them to the same subjects illustrated in other textbooks, perhaps you will agree that these illustrators have created an entirely new echelon of artistic quality in A&P textbooks. These figures are available to adopters in formats that can be integrated into your lectures, ranging from color transparencies to a CD-ROM for Powerpoint presentations (see Supplemental Materials).

Supplemental Materials

In addition to this book itself, the production team has commissioned and assembled a rich package of supplemental materials, some of them obtainable by students, and others provided to qualified instructors who adopt the book.

1. *Anatomy and Physiology Laboratory Manual* by Eric Wise (0-697-20554-1) is a new manual written to support this textbook, but is suitable for independent use. This manual uses the same four-color art program as this book and follows the same order of presentation. Dissection exercises are based on the cat but are not indispensable to the manual. It is accompanied by a separate *Instructor's Manual* (0-697-20555-X), which contains solutions and keys for grading laboratory reports.
2. *Instructor's Manual and Test Item File* by David Evans (0-697-23097-X) includes suggested lecture outlines, chapter overviews, key concepts, discussion topics, transparency list, suggested readings, learning strategies, lists of related media and suppliers, answers to textbook questions, 75 new test questions for each chapter, and a visual testbank of black-and-white transparency masters.
3. *Student Study Guide* by Kenneth S. Saladin (0-697-23096-1) discusses study habits, time management, and A&P "survival tips"; for each chapter, a set of vocabulary-building and content-testing exercises and a practice exam; and for each of the five main sections of the book, a comprehensive practice exam calling for more integration and comparison of information from related chapters. Answer keys are provided for all practice exams and for the Testing Your Comprehension questions in the textbook.
4. *MicroTest III* (Windows 0-697-23091-0, Macintosh 0-697-23092-9) is a computerized test generator,



- available free to qualified adopters, which enables instructors to generate tests from questions in the Instructor's Manual.
5. *Transparencies* (0-697-23095-3) include 500 color illustrations and photographs from this book reprinted as overhead lecture transparencies, packaged in a 3-ring binder.
 6. *QuickStudy* by Kenneth S. Saladin (IBM 0-697-29787-X, Macintosh 0-697-29788-8) is a computerized study guide for the student with a wide selection of questions for each chapter in true/false, multiple choice, and short answer formats.
 7. *The Dynamic Human Powerpoint Presentation and Visual Resource Library* (0-697-39933-8) is a CD-ROM with all of the color art in this textbook and related animations from *The Dynamic Human*; allows for easy incorporation of all the textbook art into computer-assisted lecture presentations.
 8. *The Dynamic Human CD-ROM*, Version 2.0 (Windows 0-697-38935-9; Macintosh 0-697-38936-7) consists of three-dimensional and other visualizations of relationships between human structure and function. A *Dynamic Human* icon () appears in relevant figure legends in this book. A list of these correlations by Jeffrey and Karianne Prince is on page xxvi.
 9. *The Dynamic Human Videodisc* (0-697-38937-5) contains all of the CD-ROM animations, with a barcode directory.
 10. *Explorations in Human Biology CD-ROM* by George Johnson (Windows, 0-697-37906-X, and Macintosh 0-697-37907-8) consists of 16 interactive animations on human biology.
 11. *Explorations in Cell Biology, Metabolism, and Genetics CD-ROM* by George Johnson (Windows and Macintosh 0-697-29214-2) provides 17 colorful animations that afford an engrossing way for students to delve into these often-challenging topics.
 12. *Life Sciences Living Lexicon CD-ROM* by William Marchuk (0-697-29266-5) provides interactive vocabulary-building exercises closely related to appendix C, "Understanding Biomedical Vocabulary." It includes the meanings of word roots, prefixes, and suffixes, with illustrations and audio pronunciations.
 13. *Virtual Physiology Lab* (0-697-37994-9) has 10 simulations of animal-based experiments common in the physiology component of a laboratory course; allows students to repeat experiments for improved mastery.
 14. *WCB Anatomy and Physiology Videodisc* (0-697-27716-X) has more than 30 physiological animations, line art, and photomicrographs, with a barcode directory.
 15. *WCB's Life Science Animations* (LSA) contains 53 animations on five VHS videocassettes: Chemistry, the Cell, and Energetics (0-697-25068-7); Cell Division, Heredity, Genetics, Reproduction, and Development (0-697-25069-5); Animal Biology No. 1 (0-697-25070-9); Animal Biology No. 2 (0-697-25071-7); and Plant Biology, Evolution, and Ecology (0-697-26600-1). A videocassette icon () appears in figure legends in this book to alert the reader to related animations. A list of these correlations by Jeffrey and Karianne Prince is on page xxix. Another available videotape is *Physiological Concepts of Life Science* (0-697-21512-1).
 16. *WCB Anatomy and Physiology Videotape Series* consists of four videotapes, free to qualified adopters, including Blood Cell Counting, Identification, and Grouping (0-697-11629-8); Introduction to the Human Cadaver and Prosection (0-697-11177-6); Introduction to Cat Dissection: Cat Musculature (0-697-11630-1); and Internal Organs and Circulatory System of the Cat (0-697-13922-0).
 17. *Human Anatomy and Physiology Study Cards* by Kent Van De Graaff, Ward Rhees, and Christopher Creek (0-697-26447-5) is a boxed set of 300 illustrated cards (3 × 5 in), each of which concisely summarizes a concept of structure or function, defines a term, and provides a concise table of related information.
 18. *Coloring Guide to Anatomy and Physiology* by Robert and Judith Stone (0-697-17109-4) consists of outline drawings and text that emphasize learning through color association. Students retain information through a meditative exercise in color-coding structures and correlated labels. This can be an especially effective aid for students who remember visual concepts more easily than verbal ones.
 19. *Atlas of the Skeletal Muscles* by Robert and Judith Stone (0-697-13790-2) illustrates each skeletal muscle in a diagram that the student can color, and provides a concise table of the origin, insertion, action, and innervation of each muscle.
 20. *Laboratory Atlas of Anatomy and Physiology*, 2/e, by Douglas Eder et al. (0-697-39480-8) is a full-color atlas including histology, skeletal and muscular anatomy, dissections, and reference tables.
 21. *Case Histories in Human Physiology*, 2/e, by Donna Van Wynsberghe and Gregory Cooley (0-697-13791-0) stimulates analytical thinking through case studies and problem solving; includes an instructor's answer key.
 22. *Survey of Infectious and Parasitic Diseases* by Kent Van De Graaff (0-697-27535-3) is a booklet of essential information on 100 of the most significant infectious diseases.

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Any project of this magnitude involves an enormous team effort, and I am gratefully indebted to the people who made it happen. Thank you, first of all, to Colin Wheatley for sensing that this book was in me waiting to come out, and for securing the opportunity to produce it. Thanks to Michael Lange for making me feel so much at home with WCB/McGraw-Hill and for sparing no effort to put the company's confidence and resources into making this book second to none. The team of Kris Noel Tibbetts, Kelly Drapeau, Sue Dillon, Carrie Burger, John Leland, Kathleen Timp, and Darlene Schueller were wonderful in their ability to make all the trains run on time and keep me reasonably sane and optimistic, even through the periods of daunting details and relentless deadlines. Copyeditors Ann Mirels and Laura Beaudoin provided many helpful content and style suggestions and contributed greatly to the congenial spirit of this collaborative effort.

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<http://www.mhhe.com/sciencemath/biology/saladin/>

My students were a special source of encouragement as they watched this project develop from raw manuscript

to page proofs with keen interest. Many of them read portions of the manuscript and compared it to other books in this field. Sherylyn Bond and Jane Talisman were especially enthusiastic and thorough; their input is reflected at several places in the textbook and study guide.

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Reviewers

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- William M. Chamberlain
Indiana State University
- Carol Fordham Clarke
The Nightingale Institute, King's College
- Conrad A. Claytor
Community Hospital/College of Health Sciences
- John Patrick Click
Indiana University Southeast
- William Cliff
Niagara University
- Craig W. Clifford
Northeastern State University
- Joe Coelho
Western Illinois University
- D. Colborn
East London and the City Health Authority
- B. Theodore Cole
University of South Carolina
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Midlands Technical College
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Central Arizona College
- Desmond Cornes
Glasgow College of Nursing and Midwifery
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University of Technology, Sydney Kuring-gai Campus
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Muhlenberg College
- Clementine A. de Angelis
Tarrant County Junior College
- Harold F. Delisle
Moorpark College
- Brent G. DeMars
Lakeland Community College
- Fiona Ann Dick
Forth Valley College
- Elissa N. Ditto
Red Rocks Community College
- Michele Don
Griffith University
- Maureen S. Donaldson
Bishop State Community College
- Gerald R. Dotson
Front Range Community College
- Douglas Duff
Indiana University-South Bend
- William E. Dunscombe
Union County College
- John Dziak
Community College of Allegheny County-Allegheny Campus
- Phillip Eichman
University of Rio Grande
- Victor P. Eroschenko
University of Idaho
- David L. Evans
Pennsylvania College of Technology/Penn State University
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Penn State University
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Community College of Aurora
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Nunez Community College
- Kathleen Flickinger
Iowa State University
- Margaret D. Folsom
Methodist College
- Pamela B. Fouché
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Preface to Students

As you embark on your study of human A&P, I count you among my wider sphere of students and consider it my job not only to present you with information you will need in your career, but also to make it enjoyable and provide you with aids to understanding it. Your success may depend partly on how effectively you use these features, so I would like to familiarize you with them.

Chapter Outline Before you begin a chapter, it is important to have a broad overview of what it covers. This is provided by an outline on the first page of each chapter, page-referenced to facilitate your later review and study.

Brushing Up Knowledge doesn't come in little compartments that you can forget as soon as an exam is over. In the health professions, you must have a comprehensive understanding of the entire body, and as you begin each new book chapter, you will need to remember concepts covered in earlier ones. Chapters 3 to 29 have a "Brushing Up" box that lists major concepts, with page references, that you should understand before continuing. If your memory is rusty, review those pages before you start the new material. "Brushing Up" will also help in the event that your instructor covers the chapters in a different order than the book does and you haven't yet studied information that is prerequisite to understanding the new chapter.

Objectives and Key Point Review There's no escaping the fact that human A&P encompasses a lot of information, but you don't have to swallow it all in one bite. I divide each chapter into short, digestible sections averaging five to six pages each. Each section begins with a short list of objectives and ends with a few self-testing questions titled "Key Point Review." This makes it easier for you to break down the subject matter, plan your goals for a study session, and test your progress at frequent intervals. Use the Key Point Review as a test of your memory and ability to explain an idea, not your ability to look it up. To get the most out of them, answer the questions in writing and without looking back at the text. It's doubtful that your instructor will allow you to look up answers during an exam, so you don't cheat yourself by doing so on practice questions. I regret that there isn't enough space to print the answers to these, but most of them are based on simple recall and you can check your answers by reading back just a

few pages and discussing the questions with your study partners. They don't cover every important concept in a section. Getting them right doesn't guarantee that you're completely prepared for your instructor's exam, but getting several of them wrong does indicate that you need to study a section more carefully.

Think About It Success in the health professions requires far more than memorization. More important is your insight and ability to *apply* what you remember to new cases and problems. Scattered throughout each chapter are four or five "Think About It" questions identified by a brain icon. Pause for a moment at these points, reflect on what you have just read, and see how well you can apply that knowledge to these questions. Ideally, you'll find yourself figuring out more about the body than I directly tell you, and the most exciting kind of knowledge is that which you discover for yourself. These questions may lead to new insights into the relationship between concepts presented in different chapters—for example, how an egg's way of blocking excess sperm resembles the way a nerve cell releases its chemical signals. The answers to these questions are in the *Instructor's Manual*. Your instructor might provide them for you, or might prefer that you think them through for yourself before he or she discloses the answer.

Special Topics and Chapter Essays Each chapter has three to five Special Topics intended as diversionary reading for enjoyment, not as part of the core information essential to a chapter. Most of these fall into three categories: the clinical relevance of a concept; historical sketches of the personalities and events behind the facts of A&P; and evolutionary insights into the body's structure and function. The essay at the end of each chapter has a similar purpose but allows a topic to be explored in a little more depth. They range from technical subjects such as medical imaging and genetic engineering to engrossing historical accounts of how a frontier military doctor studied digestion in a man with a shotgun wound, and how ether went from being a party drug to a surgical anesthetic.

Vocabulary Aids: Word Origins and Pronunciation Guides At first, the field of A&P seems to present a bewildering array of new terms that many find difficult to spell, pronounce, and remember. This is a field with a large, rich vocabulary that can be either a friend or foe to

your progress. I find that my students use terms with more confidence and accuracy if they recognize the roots that compose them. I've taught a course on this since 1983, and many of my students have reported back from schools of medicine, nursing, and physical therapy to say how much it helped them in their professional coursework.

Therefore, when I introduce a new term, I frequently include a footnote that gives you the derivation of the word. A list of the 400 most common word derivations is included inside the back cover, and appendix C, Understanding Biomedical Vocabulary, gives you some pointers on how to become more comfortable with new terms. You will soon recognize that such elements as *hypo-*, *natri-*, *-cyte*, and *-itis* occur over and over in the book. As their meanings become familiar, you will approach pronunciation, spelling, and comprehension with more confidence and proficiency.

Pronunciation is a difficult issue for many students; it's hard to remember words that we can't pronounce in the first place. You will find pronunciation guides in parentheses following new terms. I worked with many of my students to develop a style for these, like *pro-NUN-see-AY-shun*, that they found simple and easy to understand. I encourage you to sound out words as you read and review. Good pronunciation will greatly improve your memory and understanding and will create a more professional impression on your future instructors, supervisors, and peers.

Study Outline Each chapter ends with a chapter review. Part of this is a Study Outline that can be used as a basis for organizing your work. It organizes the key points you should know about and gives page references so that you can easily check your knowledge, organize your facts, and review the relevant pages.

Vocabulary Checklist The boldfaced terms in a chapter are listed in a page-referenced vocabulary checklist at the end of each chapter. These terms are listed in the order presented in the chapter, which has two advantages over an alphabetical list: (1) it enables you to review the terms one section at a time and to correlate the vocabulary list with the study outline that precedes it, and (2) it keeps related terms together, which makes it easier to remember their meanings. To save space, I do not repeat terms that are listed and defined in tables within the body of the chapter, but I include a note that advises you which tables to study. Terms in the Special Topics and Chapter Essays are not listed. Add these to your list if your instructor tests on that material.

Testing Your Recall Each chapter has 10 multiple choice and 10 short answer questions you can use to check your knowledge. Answer the questions without looking up the answers, then check your answers in appendix B and restudy any concepts you missed.

Connective Issues The human organ systems do not, of course, exist in isolation from each other. Diseases of the circulatory system can lead to failure of the urinary system and aging of the skin can lead to weakening of the skeleton, for example. For each organ system, I include a page called "Connective Issues" to show how it affects other systems of the body and is affected by them. These beautifully illustrated pages will help you get the big picture and appreciate the body as an integrated whole.

Connective Issues

Interactions Between the NERVOUS SYSTEM and Other Organ Systems

Integumentary System

- Provides sensations of heat, cold, pressure, pain, and vibration; protects peripheral nerves
- Nervous system regulates piloerection and sweating; controls cutaneous blood flow to regulate heat loss

Skeletal System

- Serves as reservoir of Ca^{2+} needed for neural function; protects CNS and some peripheral nerves
- Nervous stimulation generates muscle tension essential for bone development and remodeling

Muscular System

- Gives expression to thoughts, emotions, and motor commands that arise in the CNS
- Somatic nervous system activates skeletal muscles and maintains muscle tone

Endocrine System

- Many hormones affect neuronal growth and metabolism; hormones control electrolyte balance essential for neural function
- Hypothalamus controls pituitary gland; sympathetic nervous system stimulates adrenal medulla

Circulatory System

- Delivers O_2 and carries away wastes; transports hormones to and from CNS; CSF produced from and returned to blood
- Nervous system regulates heartbeat, blood vessel diameters, blood pressure, and routing of blood; influences blood clotting

Lymphatic/Immune Systems

- Immune cells provide protection and promote tissue repair
- Nerves innervate lymphoid organs and influence development and activity of immune cells; nervous system plays a role in regulating immune response; emotional states influence susceptibility to infection

Respiratory System

- Provides O_2 , removes CO_2 , and helps to maintain proper pH for neural function
- Nervous system regulates rate and depth of respiration

Urinary System

- Disposes of wastes and maintains electrolyte and pH balance
- Nervous system regulates renal blood flow, thus affecting rate of urine formation; controls emptying of bladder



Digestive System

- Provides nutrients; liver provides stable level of blood glucose for neural function during periods of fasting
- Nervous system regulates appetite, feeding behavior, digestive secretion and motility, and defecation

Reproductive System

- Sex hormones influence CNS development and sexual behavior; hormones of the menstrual cycle stimulate or inhibit hypothalamus
- Nervous system regulates sex drive, arousal, and orgasm; secretes or stimulates pituitary release of many hormones involved in menstrual cycle, sperm production, pregnancy, and lactation

chapter 15 The Peripheral Nervous System and Reflexes 547

Testing Your Comprehension Each chapter has five discussion questions that go beyond memorization to require a deeper level of analysis. These questions, like the Think About It items, call for you to apply your knowledge to a new situation or to think through some implications of what you have learned. There was no space to print the answers to these in the textbook, but they are in the *Study Guide*, which you can obtain separately.

In summary, you can see that each chapter has an abundance of opportunities to evaluate your knowledge of the subject. Each has a total of 50 to 55 questions within the book itself, another 150 or more in the *Student Study Guide*, and still more on the *QuickStudy* computerized study guide (see Preface to Instructors). You can use the Objectives, Study Outlines, and Selected Vocabulary lists to design additional review and testing drills or questions of your own (vocabulary

flashcards, for example). Following are some additional aids that go beyond the scope of individual chapters.

Inside Covers Take a moment to look inside the front and back covers of the book. I've placed features here to provide you with convenient reference to the symbols, weights, measures, abbreviations, and word origins most commonly used in the book.

Glossary The glossary was carefully planned to provide concise but comprehensive definitions of the 1,000 terms I thought you would most likely need to look up. Many glossary entries include pronunciation guides and cite illustrations that help to clarify the concept.

Supplemental Materials A variety of materials can be purchased separately to supplement this book, including flashcards, coloring atlases, self-testing computer software, and a *Student Study Guide*. Please see the Preface to Instructors for a list and description of these items. To order, call the WCB/McGraw-Hill Customer Service Department at 1-800-338-3987.

World Wide Web Links For your research needs and personal interest, we have created the Saladin Home Page on the World Wide Web. Point your web browser to

<http://www.mhhe.com/sciencemath/biology/saladin/>

For each chapter of the book, you will find links that take you to an international variety of web sites com-

plied by Dr. David Evans of the Pennsylvania College of Technology. These provide a wealth of supplemental information and images as diverse as updates on AIDS or osteoporosis, medical art and history, histology and cadaver photographs, MRI images, and supplemental readings and research references.

E-mail the Author

Do you ever wish you could ask the author of your textbook a question the way you can ask your own instructor? Now you can. Electronic mail has made long-distance communication so quick and easy that I can extend this opportunity to you. You're invited to write to me at the e-mail address below. There are certain things I *can't* do by e-mail: I am a biologist, not a medical doctor, and I can't give medical advice. I can't answer your homework questions, research your term paper for you, or tutor by e-mail. But I would like to clarify anything in the book you find difficult to understand, and I am interested in knowing what you think of the book—how it could be better, features that should *not* be dropped or changed, and so forth. Many of my past students had a hand in shaping this edition, and you're invited to have a hand in shaping those to come.

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Dynamic Human Correlation Guide

Chapter 1

- E1.1a Skeletal System/Anatomy/3D Viewer: Cranial Anatomy
E1.3, E1.4 Anatomical Orientation/Visible Human/Head

Atlas A

- A.3, A.4, A.6 Anatomical Orientation/Directional Terminology
A.7 Anatomical Orientation/Directional Terminology
Anatomical Orientation/Visible Human/Head
A.14 Anatomical Orientation/Visible Human/Abdomen
A.17 Skeletal System/Anatomy/Gross Anatomy
A.20 Endocrine System/Anatomy/Gross Anatomy
A.22, A.23 Immune and Lymphatic System/Anatomy/Gross Anatomy
A.24 Respiratory System/Anatomy/Gross Anatomy
A.25 Urinary System/Anatomy/Gross Anatomy
A.26 Digestive System/Anatomy/Gross Anatomy
A.27 Reproductive System/Anatomy/Male Reproductive Anatomy
Reproductive System/Anatomy/Female Reproductive Anatomy
A.33 Nervous System/Anatomy/Gross Anatomy of the Brain
A.34 Cardiovascular System/Anatomy/Gross Anatomy
A.35 Anatomical Orientation/Visible Human/Thorax
A.36 Digestive System/Anatomy/Gross Anatomy
A.37 Anatomical Orientation/Visible Human/Abdomen
A.38 Reproductive System/Anatomy/Male Reproductive System
A.39 Reproductive System/Anatomy/Female Reproductive System

Chapter 2

- E2.3 Endocrine System/Anatomy/Gross Anatomy/Thyroid

Chapter 4

- 4.8 Digestive System/Histology/Duodenal Villi

Chapter 6

- 6.3 Muscular System/Histology/Cardiac Muscle
Muscular System/Histology/Smooth Muscle
Muscular System/Histology/Skeletal Muscle (cross section)
Muscular System/Histology/Skeletal Muscle (longitudinal)
6.4 Nervous System/Histology/Spinal Neurons
6.11 Skeletal System/Histology/Elastic Cartilage
Skeletal System/Histology/Fibrocartilage
Skeletal System/Histology/Hyaline Cartilage
6.12 Skeletal System/Histology/Compact Bone
6.15 Digestive System/Histology/Duodenal Villi
Respiratory System/Histology/Alveoli
6.17 Digestive System/Histology/Esoophagus
Urinary System/Histology/Bladder
6.19 Cardiovascular System/Histology/Cardiac Muscle
6.20 Digestive System/Histology/Submandibular Gland
6.23 Respiratory System/Histology/Nasal Cavity

Chapter 8

- 8.1 Skeletal System/Anatomy/Gross Anatomy
8.2, 8.3 Skeletal System/Exploration/Cross Section of a
Long Bone
8.7 Skeletal System/Histology/Compact Bone
8.18, 8.20 Skeletal System/Clinical Concepts/Fractured Femur

Chapter 9

- 9.1–9.4 Skeletal System/Anatomy/3D Viewer: Cranial Anatomy
9.17, 9.26 Skeletal System/Anatomy/3D Viewer: Thoracic Anatomy
9.27–9.35, 9.37–9.39 Skeletal System/Anatomy/Gross Anatomy

Chapter 10

- 10.3, 10.4 Skeletal System/Explorations/Types of Joints/
Fibrous Joint
10.5 Skeletal System/Explorations/Types of Joints/
Cartilagenous Joint
10.6 Skeletal System/Explorations/Types of Joints/
Synovial Joint
10.7 Skeletal System/Explorations/Types of Joints/
Synovial Joint/Generic Synovial Joint
10.8 Skeletal System/Explorations/Types of Joints/
Synovial Joint/Types of Synovial Joints
10.21–10.23 Skeletal System/Explorations/Types of Joints/
Synovial Joint/Synovial Joint Motion
10.25 Skeletal System/Explorations/Types of Joints/
Synovial Joint/Synovial Joint Motion
Skeletal System/Explorations/Types of Joints/
Synovial Joint/Generic Synovial Joint
Skeletal System/Clinical Concepts/MRI of Knee
ST 10.4 Skeletal System/Clinical Concepts/Arthroscopy
(figure 1)

Chapter 11

- 11.2 Muscular System/Anatomy/Skeletal Muscle
11.3 Muscular System/Explorations/Muscle Actions Around
Joints

Chapter 12

- 12.1–12.3 Muscular System/Anatomy/Skeletal Muscle
12.4 Muscular System/Histology/Skeletal Muscle (longitudinal)
12.5 Muscular System/Histology/Skeletal Muscle (longitudinal)
Muscular System/Anatomy/Skeletal Muscle
12.6–12.8, Muscular System/Explorations/Neuromuscular
12.11, 12.12 Junction
12.13 Muscular System/Explorations/Sliding Filament Theory
12.19 Muscular System/Clinical Concepts/Isometric vs.
Isotonic Contraction
12.21 Muscular System/Anatomy/Smooth Muscle
Muscular System/Histology/Smooth Muscle

Chapter 13

- 13.2 Nervous System/Explorations/Motor and Sensory
Pathways
13.4 Nervous System/Histology/Spinal Neurons

Chapter 14

- 14.1, 14.2 Nervous System/Anatomy/Gross Anatomy of Brain
14.5, 14.9 Nervous System/Anatomy/Spinal Cord Anatomy
Nervous System/Histology/Spinal Cord
14.10–14.12 Nervous System/Explorations/Motor and Sensory
Pathways
14.20 Nervous System/Anatomy/Gross Anatomy of Brain
14.26, 14.27 Nervous System/Explorations/Motor and Sensory
Pathways

Chapter 15

- 15.3 Nervous System/Histology/Dorsal Root Ganglion
- 15.6, 15.8, 15.12 Nervous System/Anatomy/Gross Anatomy of Brain
- TA15.5, TA15.7, TA15.9 Nervous System/Explorations/Innervation of the Tongue

Chapter 16

- 16.4 Nervous System/Histology/Vallate Papilla
- 16.5 Nervous System/Explorations/Taste
Nervous System/Explorations/Zones of Taste
- 16.6, 16.7 Nervous System/Explorations/Olfaction
- 16.8 Nervous System/Explorations/Hearing
- 16.11–16.13 Nervous System/Explorations/Hearing
- 16.14 Nervous System/Explorations/Hearing
Nervous System/Histology/Organ of Corti
- 16.18 Nervous System/Explorations/Hearing
- 16.20 Nervous System/Explorations/Static Equilibrium
- 16.21 Nervous System/Explorations/Dynamic Equilibrium
- 16.27 Nervous System/Explorations/Vision
Nervous System/Histology/Eye
- 16.29 Nervous System/Histology/Retina
- 16.33 Nervous System/Explorations/Vision

Chapter 17

- 17.1 Endocrine/Explorations/Endocrine Function
- 17.2 Endocrine/Anatomy/Gross Anatomy
- 17.4, 17.5 Endocrine/Anatomy/Gross Anatomy/Hypothalamus and Pituitary Gland
- 17.6 Endocrine/Explorations/Hypothalamo-Pituitary-Thyroid Axis
- 17.9 Endocrine/Anatomy/Gross Anatomy/Thyroid
- 17.10 Endocrine/Anatomy/Gross Anatomy/Thyroid
Endocrine/Histology/Thyroid
- 17.12 Endocrine/Anatomy/Gross
Anatomy/Thyroid/Parathyroid
- 17.13 Endocrine/Anatomy/Gross Anatomy/Adrenal Gland
Endocrine/Histology/Adrenal Gland
- 17.16 Endocrine/Anatomy/Gross Anatomy/Pancreas
- 17.17 Endocrine/Anatomy/Gross Anatomy/Gonads/Ovary
- 17.22–17.24 Endocrine/Explorations/Endocrine Function

Chapter 18

- 18.13, 18.14 Lymphatic and Immune System/Clinical Concepts/
Blood Types

Chapter 19

- 19.1 Cardiovascular System/Explorations/Heart Dynamics/
Blood Flow
- 19.2 Cardiovascular System/Anatomy/3D Viewer: Thoracic
Anatomy
- 19.4 Cardiovascular System/Anatomy/Gross Anatomy
Cardiovascular System/Histology/Cardiac Muscle
Cardiovascular System/Histology/Purkinje Fiber
- 19.5–19.7 Cardiovascular System/Anatomy/Gross Anatomy
- 19.8 Cardiovascular System/Anatomy/Gross Anatomy
Cardiovascular System/Explorations/Heart Dynamics/
Blood Flow

- 19.9 Cardiovascular System/Anatomy/Gross Anatomy
- 19.11 Cardiovascular System/Histology/Cardiac Muscle
- 19.12 Cardiovascular System/Explorations/Heart
Dynamics/Conduction System
- 19.15, 19.16 Cardiovascular System/Explorations/Heart Dynamics/ECG
- 19.19 Cardiovascular System/Explorations/Heart Dynamics/Cardiac
Cycle

Chapter 20

- 20.2 Cardiovascular System/Explorations/Generic Vasculature
Cardiovascular System/Histology/Vasculature
- 20.6 Cardiovascular System/Explorations/Generic
Vasculature/Fenestrated Capillary
- TA20.14 Cardiovascular System/Explorations/Generic Portal System

Chapter 21

- 21.1 Lymphatic and Immune System/Anatomy/Gross Anatomy
- 21.3 Lymphatic and Immune System/Anatomy/Gross Anatomy
Lymphatic and Immune System/Explorations/Lymph
Formation and Movement
- 21.5 Lymphatic and Immune System/Explorations/Lymph
Formation and Movement
- 21.7 Lymphatic and Immune System/Anatomy/Gross Anatomy
- 21.8 Lymphatic and Immune System/Anatomy/Gross Anatomy
Lymphatic and Immune System/Histology/Lymph Node
- 21.10 Lymphatic and Immune System/Anatomy/Gross Anatomy
- 21.11 Lymphatic and Immune System/Histology/Thymus
- 21.12 Lymphatic and Immune System/Anatomy/Gross Anatomy
Lymphatic and Immune System/Histology/Spleen
- 21.13 Lymphatic and Immune System/Explorations/
Nonspecific Immunity/Inflammation
- 21.16 Lymphatic and Immune System/Explorations/
Nonspecific Immunity/Fever
- 21.17, 21.18 Lymphatic and Immune System/Anatomy/Microscopic
Components Lymphatic and Immune System/
Explorations/Specific Immunity/Antibody Mediated Immunity
- 21.19–21.21 Lymphatic and Immune System/Explorations/
Nonspecific Immunity/Phagocytosis Lymphatic and Immune
System/Explorations/Specific Immunity/
Antibody Mediated Immunity
- 21.26 Lymphatic and Immune System/Explorations/Specific
Immunity/T Helper Cell
- 21.27, 21.28 Lymphatic and Immune System/Explorations/Specific
Immunity/Cytotoxic T Cell
- Figure E-1 Lymphatic and Immune System/Clinical Concepts/HIV and AIDS

Chapter 22

- 22.1, 22.3 Respiratory System/Anatomy/Gross Anatomy
- 22.5, 22.6 Respiratory System/Clinical Concepts/Bronchoscopy 1
Respiratory System/Clinical Concepts/Bronchoscopy 2
- 22.7 Respiratory System/Histology/Trachea
- 22.9 Respiratory System/Anatomy/Gross Anatomy
Anatomical Orientation/Visible Human/Thorax
- 22.11 Respiratory System/Histology/Lung
Respiratory System/Histology/Bronchiole
- 22.12 Respiratory System/Histology/Alveoli
- 22.13 Respiratory System/Explorations/Mechanics of Breathing

continued next page