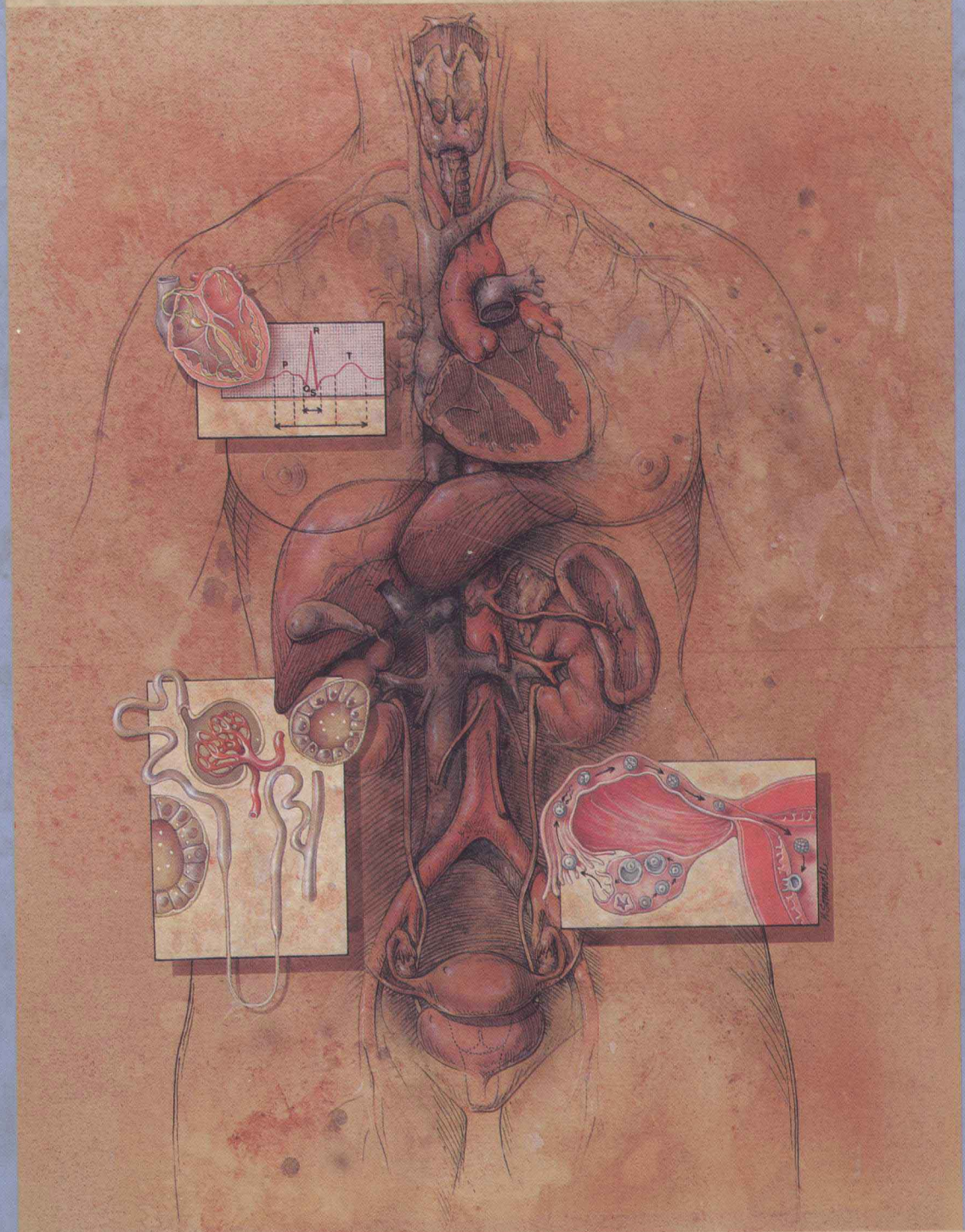


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TORTORA GRABOWSKI

NINTH EDITION



PRINCIPLES OF ANATOMY AND PHYSIOLOGY

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NINTH EDITION

Gerard J. Tortora
Bergen Community College

Sandra Reynolds Grabowski
Purdue University



科技阅览室



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About The Cover

The cover was created by Kevin Somerville, a well-known contemporary medical illustrator who also has contributed many new drawings to the seventh, eighth, and ninth editions. Somerville was inspired by Leonardo DaVinci's so-called Great Lady Anatomy, drawn about 1508. Though DaVinci's drawing was beautiful, we now know that it was anatomically incorrect. By melding an aged appearance with contemporary science, Somerville reminds us of a long, highly valued tradition in medical illustration: the commitment to both beauty and accuracy in the study of human anatomy and physiology.

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To my wife, Melanie, and to my children, Christopher, Anthony, and Andrew, who make it all worthwhile. — G.J.T.

Sandy received her BS in biology and her PhD in neurophysiology from Purdue. She is an active member of the Human Anatomy and Physiology Society (HAPS), served as editor of *HAPS News* from 1990 through 1992, and was elected to serve a 3-year term as President Elect, President, and Past President from 1992 to 1995. In addition, she is a member of the American Association for the Advancement of Science (AAAS), the Association for Women in Science (AWIS), the National Science Teachers Association (NSTA), and the Society for College Science Teachers (SCST).

To my students, who continually inspire improvements in this work by the suggestions they make and the questions they ask. — S.R.G.

PREFACE

The study of human anatomy and physiology is an inquiry into the fascinating complexity of one's body. An anatomy and physiology course is a gateway to a rewarding career in a host of health-related fields, Massotherapy, and athletic training, and it provides a foundation for advanced scientific studies. Remaining true to the heritage of its predecessors, we wrote the ninth edition of *Principles of Anatomy and Physiology* to meet the exacting requirements of introductory anatomy and physiology courses. As educators, we offer this edition fully confident that it will advance the personal and professional aspirations of all its readers.

CORE VALUES

Over the years, our students have taught us to value simplicity, directness, and the power of clear illustrations. The noteworthy success of previous editions of this book, and its transformation into a standard-bearer in education, is a testament to the fact that many of our colleagues value these qualities too. Chapter after chapter, we built our core teaching values into *Principles of Anatomy and Physiology* by providing:

- clear, compelling, and up-to-date discussions of anatomy and physiology
- expertly executed and generously sized art
- classroom-tested pedagogy
- outstanding student study support.

Although this book offers a host of useful features that will appeal to a variety of learning styles, experience has taught us that features alone will not help students learn unless every discussion is easy to understand. By any measure, we trust that students will find the ninth edition of *Principles of Anatomy and Physiology* to be easier than ever to read.

CORE PRINCIPLES

Human anatomy and physiology is a formidable body of knowledge to present in an introductory course, and master-

ing the subject can require a great deal of memory work on a student's part. We have woven several interrelated strands of information throughout the ninth edition to fulfill the following three aims: helping readers develop a working knowledge of the subject, enabling them to use anatomical and physiological terminology confidently, and highlighting the practical application of anatomical and physiological concepts to students' career choices or in their everyday lives.

Introducing Homeostasis The dynamic physiological constancy known as homeostasis is the cardinal theme in *Principles of Anatomy and Physiology*. We immediately introduce this unifying concept in Chapter 1 and describe how various feedback mechanisms work to maintain physiological processes within the narrow range that is compatible with life. Homeostatic mechanisms are discussed throughout the book, and homeostatic processes are clarified and reinforced through our well-received series of homeostasis feedback illustrations. Moreover, we believe students can better understand normal physiological processes by examining situations in which those processes are undermined by diseases or disorders. The "Disorders: Homeostatic Imbalances" sections at the end of most chapters include concise discussions of major diseases and disorders that illustrate departures from normal homeostasis.

Laying a Foundation of Basic Science From the outset, students need to understand how individual structures relate to the composition of the entire body. For this reason, we introduce anatomical nomenclature such as regional names, directional terms, and the planes and sections that enable students to precisely describe the relationship of one body structure to another. We believe, too, that students learn more readily when they fully appreciate the chemical and cellular basis of anatomy and physiology. Accordingly, we extensively clarified and updated the chemistry and cellular biology coverage in the ninth edition to reflect current thinking on these subjects. Beautiful new three-dimensional illustrations of cellular structures and chemical processes complement this coverage.

Correlating Structure and Function Years of student feedback have convinced us that readers learn anatomy and physiology more readily when they remain mindful of the relationship between structure and function. The challenge, of course, is to correlate structure and function without overwhelming readers with extraneous details about either. As a writing team—an anatomist and a physiologist—our very different specializations offer practical advantages in fine-tuning the balance between anatomy and physiology. Throughout three editions, we have collaborated to clarify and refine discussions of the relationship between structure and function in each chapter.

Building a Professional Vocabulary Students—even the best ones—generally find it difficult at first to read and pronounce anatomical and physiological terms. Moreover, as educators we are sympathetic to the needs of the growing ranks of college students who speak English as a second language. For these reasons, we have striven since the book's inception to ensure that it has a strong and helpful vocabulary component.

ORGANIZATION

The book follows the same unit and topic sequence as its eight earlier editions. It is divided into five principal sections: Unit 1, "Organization of the Human Body," provides an understanding of the structural and functional levels of the body, from molecules to organ systems. Unit 2, "Principles of Support and Movement," analyzes the anatomy and physiology of the skeletal system, articulations, and the muscular system. Unit 3, "Control Systems of the Human Body," emphasizes the importance of neural communication in the immediate maintenance of homeostasis, the role of sensory receptors in providing information about the internal and external environment, and the significance of hormones in maintaining long-term homeostasis. Unit 4, "Maintenance of the Human Body," explains how body systems function to maintain homeostasis on a moment-to-moment basis through the processes of circulation, respiration, digestion, cellular metabolism, urinary functions, and buffer systems. Unit 5, "Continuity," covers the anatomy and physiology of the reproductive systems, development, and the basic concepts of genetics and inheritance.

SPECIAL TOPICS

Developmental Anatomy We often tell our students that they can better appreciate the "logic" of human anatomy by becoming aware of how various structures developed in the first place. As in previous editions, illustrated discussions of developmental anatomy are found near the conclusion of most body system chapters. Placing this coverage at the end of chapters enables students to master the anatomical terminology they need before attempting to learn about embryonic and fetal structures. The fetus icon designates the start of each discussion.

Aging Students need to be reminded from time to time that anatomy and physiology is not static. As the body ages, its structure and related functions subtly change. Moreover, aging is a professionally relevant topic for the majority of this book's readers, who will go on to careers in health-related fields in which the average age of the client population is steadily advancing. For these reasons, many of the body system chapters explore age-related changes in anatomy and physiology at the end of most chapters.

Exercise Physical exercise can produce favorable changes in some anatomical structures and enhance many physiological functions, most notably those associated with the muscular, skeletal and cardiovascular systems. This information is especially relevant to readers embarking on careers in physical education, sports training, and dance. Hence, key chapters include brief discussions of exercise, which are signaled by a distinctive "running shoe" icon.

IMPROVED COVERAGE

Every chapter in the ninth edition of *Principles of Anatomy and Physiology* incorporates a host of improvements to both the text and the art, many suggested by reviewers, educators, and students. In addition, most chapters offer new Clinical Applications. Complete discussions of the improvements we made to each chapter are available in the *Professor's Resource Manual* to the ninth edition. Here are just some of the more noteworthy changes:

Chapter 3: The Cellular Level of Organization This foundational chapter was updated from front to back to reflect the latest thinking in cell biology. Students will benefit in particular from improved coverage of the plasma membrane and membrane transport mechanisms. Virtually every figure has been redrawn in a new, vibrant, three-dimensional style.

Chapter 4: Tissues The much-imitated tissue tables in this chapter were redesigned to improve student comprehension of histology. Now, every photomicrograph is accompanied by an interpretive illustration. We have added an orientation diagram next to each photomicrograph that indicates a location where a particular tissue type occurs in the body.

Chapter 9: Joints We clarified and strengthened this chapter by reorganizing the coverage according to the structural properties of joints and by offering more comprehensive coverage of movements at synovial joints. Students will benefit from new illustrated Exhibits that focus on the com-

ponents and mechanics of four major joints: shoulder, elbow, hip, and knee. The improved coverage is further accentuated by clear and consistently stylized new range-of-motion photographs.

Chapter 10: Muscle Tissue We reorganized and rewrote this chapter to provide clearer, simpler, and up-to-date explanations of the mechanics and physiology of muscle tissue. New, generously sized, three-dimensional illustrations of muscle tissue and its components complement our enhancements to this chapter's coverage.

Chapter 11: The Muscular System The hallmark muscle Exhibits now feature a narrative tour of each muscle group. Clinical Applications are easier to spot, and a new feature, Relating Muscles to Movements, encourages readers to group related muscles according to their common actions. Innervation information now is provided in the discussion, a change that makes each Exhibit's table simpler and easier to study.

Chapter 16: The Special Senses New three-dimensional drawings of major sensory organs by noted science illustrator Tomo Narashima superbly enhance the content and utility of this chapter. The chapter also offers enhanced coverage of extrinsic eye muscles and refraction abnormalities.

Chapter 21: Blood Vessels In this chapter's Exhibits we provide a more consistent level of detail when discussing the arterial and venous circulation, especially in the limbs. Meticulously revised illustrations more clearly reveal the relevant blood vessel anatomy, and extended flow diagrams visually reinforce learning of relevant anatomy and blood vessel pathways.

HALLMARK FEATURES OF THE NINTH EDITION

The ninth edition of *Principles of Anatomy and Physiology* builds on the legacy of thoughtful and clearly designed features that distinguished its predecessors. Some regular features are totally redesigned for this edition. For example, the tables are easier to read and use and are now labeled as **Tables**. The term "Exhibit" is now reserved for a new, self-contained feature (described next). Some features are completely new. Here are the most noteworthy changes and additions:

More Helpful Exhibits Students of anatomy and physiology need extra help learning the numerous structures that constitute certain body systems—most notably skeletal muscles, articulations, blood vessels, and nerves. As in previous editions, the chapters that present these topics are organized around **Exhibits**, each of which consists of a newly

expanded overview, a tabular summary of the relevant anatomy, and an associated suite of illustrations or photographs. Each Exhibit is prefaced by an Objective and closes with a Review Activity. We trust you will agree that our newly revised Exhibits, along with their spacious new design, make them ideal study vehicles for learning anatomically complex body systems.

Updated Clinical Focus A perennial favorite among students, the numerous **Clinical Applications** in every chapter explore the clinical, professional, or everyday relevance of a particular anatomical structure or its related function. Some applications are new to this edition, and all have been reviewed for accuracy and relevance by a consulting panel of nurses. Each application directly follows the discussion to which it relates. Additionally, the **Homeostatic Imbalances** discussions found at the conclusion of most chapters have been updated and simplified.

New or Revised Study Tools In response to students' and instructors' requests, we've added focused **Student Objectives** to the beginning of major sections of reading throughout each chapter. Complementing this change, new **Review Activities** appear at strategic intervals within chapters to give students the chance to validate their understanding as they read. As always, readers will benefit from the popular end-of-chapter **Study Outline** that is page referenced to the chapter discussions.

New study tools include the end-of-chapter **Self-Quiz Questions** written in a variety of styles that are calculated to appeal to readers' different testing preferences. Another new feature, **Critical Thinking Questions**, asks readers to apply concepts to real-life situations. The style of these questions ought to make students smile on occasion as well as think! Answers to the Self-Quiz and Critical Thinking Questions are located in Appendix D. Finally, the new **Student Companion CD-ROM** located inside the back cover provides a host of new interactive learning activities and testing opportunities.

Study Tools for Mastering Vocabulary Every chapter **highlights key terms in boldface type**. We include **pronunciation guides** when major, or especially hard-to-pronounce, structures and functions are introduced in the discussions, Tables, or Exhibits. **Word roots** citing the Greek or Latin derivations of anatomical terms are offered as an additional aid. As a further service to readers, we provide a list of **Medical Terminology** at the conclusion of most chapters, and a comprehensive **Glossary** at the back of the book. The basic building blocks of medical terminology—**Combining Forms, Word Roots, Prefixes, and Suffixes**—are listed inside the back cover. Finally, the new Student Companion CD-ROM includes an audio pronunciation dictionary.

ENHANCEMENTS TO THE ILLUSTRATION PROGRAM

Teaching human anatomy and physiology is both a visual and a descriptive enterprise. Countless students have now benefited from the detailed and generously proportioned bone and muscle art that characterizes our book. Continuing in this tradition, you will find exciting new three-dimensional illustrations gracing the pages of Chapter 3, The Cellular Level of Organization, and Chapter 16, The Special Senses. Beyond this, over twenty-five percent of the art is new to this edition, and nearly every figure has been revised or improved in some way. Here are some of the new, as well as the tried-and-true, features of our illustration program:

New Histology-Based Art As part of our plan of continuous improvement, many of the anatomical illustrations based on histological preparations have been replaced in this edition. See, for example, the beautifully rendered illustration of the layers of the gastrointestinal tract on page 820 or the new illustration of the interior of the eye on page 519.

Revised Feedback Loop Illustrations As in editions past, this popular series of illustrations (see page 8) captures and clarifies the body's dynamic counterbalancing act in maintaining homeostasis. We subtly revised the feedback loops in the ninth edition to visually accentuate the roles that receptors, control centers, and effectors play in modifying a controlled physiological condition.

Helpful Orientation Diagrams Students sometimes need help figuring out the plane of view of anatomy illustrations—descriptions alone do not always suffice. Every major anatomy illustration is accompanied by an orientation diagram that depicts and explains the perspective of the view represented in the figure.

Key Concept Statements This art-related feature summarizes an idea that is discussed in the text and demonstrated in a figure. Each Key Concept Statement is positioned adjacent to its figure and is denoted by a distinctive “key” icon.

Revised Figure Questions This highly applauded feature asks readers to synthesize verbal and visual information, think critically, or draw conclusions about what they see in a figure. Each Figure Question appears adjacent to its illustration and is highlighted in this edition by the distinctive “Q” icon. Answers are located at the back of each chapter.

Functions Banners This feature succinctly lists the functions of an anatomical structure or body system depicted within a figure (see page 915). This juxtaposition of text and

art further reinforces the connection between structure and function.

Cadaver Photos As before, we provide an assortment of large, clear cadaver photos at strategic points in many chapters. What is more, many anatomy illustrations are keyed to the large cadaver photos available in *A Photographic Atlas of the Human Body*, by Gerard J. Tortora. This new atlas is available through John Wiley & Sons, Inc.

COMPLETE TEACHING AND LEARNING PACKAGE

Continuing the tradition of providing a complete teaching and learning package, the ninth edition of *Principles of Human Anatomy and Physiology* is available with a host of carefully planned supplementary materials that will help you and your students to attain the maximal benefit from our textbook. Complete descriptions of the supplements in the following list can be found on the inside front cover. Please contact your Wiley sales representative for additional information about any of these resources.

For Instructors:

- **Professor's Resource Manual** by Jerri K. Lindsey (0-471-37466-0)
- **Electronic Lecture Guide** (0-471-37460-1)
- **Printed Test Bank** by Pamela Langley (0-471-37469-5)
- **Microtest Computerized Test Bank** (Mac: 0-471-37464-4; Win: 0-471-37465-2)
- **Instructor's Presentation CD-ROM** (0-471-37459-8)
- **Full-color Overhead Transparencies** (0-471-37463-6)

For Students:

- **Student Companion CD-ROM**—free, at back of book
- **Learning Guide** by Kathleen Schmidt Prezbindowski (0-471-37467-9)
- **Illustrated Notebook** (0-471-37468-7)
- **Tortora/Grabowski Web Site** at <http://www.wiley.com/college/tortora>
- **Photographic Atlas of the Human Body** by Gerard Tortora (0-471-37487-3)
- **A Brief Atlas of the Human Skeleton**—accompanies the text

Like each of our students, this book has a life of its own. The structure, content, and production values of *Principles of Anatomy and Physiology* are shaped as much by its relationship with educators and readers as by the vision that gave birth to the book nine editions ago. Today you, our readers, are the “heart” of this book. We invite you to continue the

tradition of sending in your suggestions to us so that we can include them in the tenth edition.

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ACKNOWLEDGMENTS

For the ninth edition of *Principles of Anatomy and Physiology*, we have enjoyed the opportunity of collaborating with a group of dedicated and talented professionals. Accordingly, we would like to recognize and thank the members of our book team.

First, thanks go out to two contributors whose efforts enrich this edition. The challenging new end-of-chapter Self-Quiz Questions were written by Jerri K. Lindsey. Joan Barber contributed the new Critical Thinking Questions. We trust that readers will appreciate Joan's spirited and gently humorous approach to encouraging critical thinking. We greatly appreciate the work of Martha DePecol Sanner, Thomas Lancraft, Temma al-Mukhtar, Izak Paul, and James White in the development of the new Student Companion CD-ROM which enhances the integrated learning package of this text. We are grateful that Pamela Langely continues to lend her expert skills in developing test questions to our team. The value of her work cannot be underestimated. And a special thank you to Kathleen Prezbindowski, author of the Learning Guide, who has worked with us for many editions. The high quality of her work ensures student success.

The assistance from the editorial and production staff has been equally valuable. Kay Ueno, Senior Project Editor, worked very closely with us to guide the project to completion. Her directed comments, editorial wisdom, and continuous support and encouragement have been very much appreciated. Mark Wales, Senior Developmental Editor, guided our efforts to maintain a focus on pedagogy that directs and reinforces student learning. His insights, careful attention to detail, and years of experience have helped maintain the level of excellence of our textbook. Nicki Richesin, Editorial Assistant, facilitated the flow of manuscript and communications

between us and other team members, which proved very useful to the timely completion of this book.

Wendy Earl, Managing Editor of Wendy Earl Productions, assumed the responsibility for producing *Principles of Anatomy and Physiology*. Her experience and professionalism are her trademarks and have meant so much to the book. Sharon Montooth, Production Editor, expertly coordinated the evolution of manuscript and galleys and then pages with efficiency and accuracy.

Claudia Durrell, Art Coordinator, has worked with us for many years, and her attention to design and knowledge of our art preferences have made our job so much easier and have enhanced the graphic elements of this book in ways we could never imagine. Mira Schachne, another long-time associate, was the Photo Coordinator. If the photo exists, Mira will find it—or pose for it herself! Her tenacity and sense of humor have been her signature for all the years we have known her.

Alan Titche, Copyeditor, helped in many ways to make the manuscript consistent in presentation and style and helped us to polish our transitions. Martha Ghent, Proofreader, alerted us to any needed corrections prior to publication. Katherine Pitcoff, our Indexer, assembled the comprehensive new index that will ably serve the needs of students and instructors alike.

The illustrations and photographs have always been a signature feature of *Principles of Anatomy and Physiology*. Respected scientific and medical illustrators Tomo Narashima, Steve Oh, and Wendy Hiller Gee join our team of outstanding artists: Leonard Dank, Sharon Ellis, Jean Jackson, Lauren Keswick, Lynn O'Kelley, Hilda Muinos, Nadine Sokol, Kevin Somerville, and Beth Willert. Mark Nielsen of the University of Utah provided many of the cadaver photos that appear in this edition. Jared Schneidman Design and Imagineering deserve special thanks for their computer graphics finesse.

We are particularly pleased by the challenging new interactive *Student Companion CD-ROM*. Lauren Fogel, Media Producer, and the talented design team at Red Hill Studios have created a CD-ROM that is outstanding in pedagogic sophistication and visual appeal.

We are extremely grateful to our colleagues who reviewed the manuscript and offered insightful suggestions for improvement. In addition, we were privileged to have the advice of various consultants on anatomy, art, pathophysiology, and vocabulary issues. The contributions of all these people, who generously provided their time and expertise to help us maintain the book's accuracy and clarity, are acknowledged in the list that follows.

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TO THE STUDENT

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1

ANTICIPATE

A preview reading of the **Study Outline** at the end of the chapter will help you recognize the important concepts you are about to explore. Use this balanced synopsis to acquaint yourself with the topics of the chapter.

STUDY OUTLINE

PECTORAL (SHOULDER) GIRDLE (p. 218)

1. Each pectoral (shoulder) girdle consists of a clavicle and scapula.
2. Each pectoral girdle attaches an upper limb to the axial skeleton.

UPPER LIMB (p. 221)

1. There are 60 bones in the two upper limbs.
2. The bones of each upper limb include the humerus, the ulna, the radius, the carpals, the metacarpals, and the phalanges.

PELVIC (HIP) GIRDLE (p. 224)

1. The pelvic (hip) girdle consists of two hip bones.

2. The female pelvis is adapted for pregnancy and childbirth. Gender-related differences in pelvic structure are listed and illustrated in Table 8.1.

COMPARISON OF PECTORAL AND PELVIC GIRDLES (p. 231)

1. The pectoral girdle does not directly articulate with the vertebral column; the pelvic girdle does.
2. The glenoid fossae of the scapulae are shallow and maximize movement; the acetabula of the hip bones are deep and allow less movement.

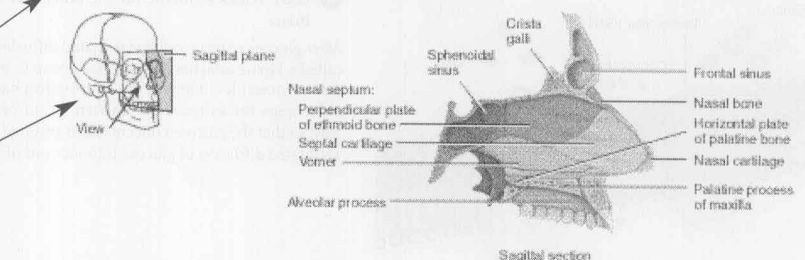
2

SCAN

Examine the figures before reading a chapter. Study *all* the parts of a figure and read the labels carefully to familiarize yourself with the anatomical or physiological concepts it portrays. Start by reading the **legend**, which explains what the figure is about. Next, study the **key concept statement**, which reveals a basic idea portrayed in the figure. The **orientation diagram** located alongside some anatomy figures shows you the viewing angle of the featured image or where the structure is found in the body. Finally, consider the **figure question**, which asks you to draw conclusions about the figure. (Answers are at the end of the chapter.)

Figure 7.14 Nasal septum. (See Tortora, *A Photographic Atlas of the Human Body*, Figure 3.4.)

The structures that form the nasal septum are the perpendicular plate of the ethmoid bone, the vomer, and septal cartilage.



Q What is the function of the nasal septum?

3

READ

Start reading the chapter. Notice the following aids that are built in to help you learn:

ANATOMY AND PHYSIOLOGY DEFINED

OBJECTIVE

- Define anatomy and physiology, and name several sub-disciplines of these sciences.

Two branches of science—anatomy and physiology—provide the foundation for understanding the body's parts and functions. **Anatomy** (a-NAT-ō-mē; *ana-* = up; *-tomy* = process of cutting) is the science of body structures and the relationships among structures. Anatomy was first studied by **dissection** (dis-SEK-shun; *dis-* = apart; *-section* = act of cutting), the careful cutting apart of body structures to study their relationships. Nowadays, many imaging techniques also contribute to the advancement of anatomical knowledge. We will compare some common imaging techniques

Student objectives reveal what you should learn from each major section.

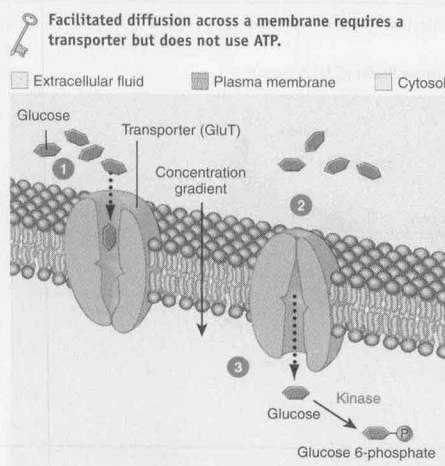
A term in **boldface** is your signal that a word and the ideas associated with it are important to learn.

Pronunciation guides appear after the most important or hard-to-pronounce terms.

Some terms are followed by **word roots**, which can help you remember a term by telling you about its original meaning or how it is put together.

If you are unsure about the meaning of anatomy and physiology terms, check the **glossary** at the back of the book.

Figure 3.10 Facilitated diffusion of glucose across a plasma membrane. The transporter (GluT) binds to glucose in the extracellular fluid and releases it into the cytosol.



In some places, you will find **keyed narratives** that correlate the steps of a complex process described in the reading with an illustration of that same process.



What factors determine the rate of facilitated diffusion?

You will encounter brief **clinical applications**. They will acquaint you with the clinical, professional, or personal significance of the preceding discussion.



CLINICAL APPLICATION *Sprain and Strain*

A **sprain** is the forcible wrenching or twisting of a joint that stretches or tears its ligaments but does not dislocate the bones. It occurs when the ligaments are stressed beyond their normal capacity. Sprains also may damage surrounding blood vessels, muscles, tendons, or nerves. Severe sprains may be so painful that the joint cannot be moved. There is considerable swelling, which results from hemorrhage of ruptured blood vessels. The ankle joint is most often sprained; the lower back is another frequent location for

Concluding most chapters, you will find **Homeostatic Imbalances**, which are discussions of diseases and disorders and how these disrupt normal homeostatic processes, and **Medical Terminology**, a listing of related terms that supplements terms defined in the chapter.

DISORDERS: HOMEOSTATIC IMBALANCES

RHEUMATISM AND ARTHRITIS

Rheumatism (ROO-ma-tizm) is any of a variety of painful disorders of the supporting structures of the body—bones, ligaments, tendons, or muscles. **Arthritis** is a form of rheumatism in which the joints have become inflamed. Inflammation, pain, and stiffness may also involve adjacent muscles. Arthritis afflicts about 40 million people in the United States.

Three important classes of arthritis are (1) diffuse connective tissue diseases, such as rheumatoid arthritis, (2) degenerative joint disease, such as osteoarthritis, and (3) metabolic and endocrine diseases with associated arthritis, such as gouty arthritis.

Rheumatoid Arthritis

Rheumatoid arthritis (RA) is an autoimmune disease

irritation of the joints, and wear and abrasion. It is commonly known as "wear-and-tear" arthritis and is the leading cause of disability in older individuals.

Osteoarthritis is a progressive disorder of synovial joints, particularly weight-bearing joints. It is characterized by the deterioration of articular cartilage and by the formation of new bone in the subchondral areas and at the margins of the joint. The cartilage

MEDICAL TERMINOLOGY

Osteoarthritis (os'-tē-ō-ar-THRĭ-tis; *arthr* = joint) The degeneration of articular cartilage such that the bony ends touch; the resulting friction of bone against bone worsens the condition. Usually associated with the elderly.

Osteogenic sarcoma (os'-tē-ō-JEN-ik sar-KŌ-ma; *sarcoma* = connective tissue tumor) Bone cancer that primarily affects

4

MASTER THE EXHIBITS

Some body systems contain scores of structures, to be memorized, which makes the study of anatomy and physiology particularly challenging. To help, chapters that present complex anatomy have special **Exhibits**. Each Exhibit is a self-contained learning exercise that consists of a narrative tour, a Table summarizing the structures to learn, and a group of illustrations. Spend as much time as you need mastering one Exhibit before moving to the next.

Exhibit 11.4 Muscles that Move the Tongue—Extrinsic Muscles (Figure 11.7)

OBJECTIVE

Describe the origin, insertion, action, and innervation of the extrinsic muscles of the tongue.

The tongue is a highly mobile structure that is vital to digestive functions such as mastication, perception of taste, and deglutition (swallowing). It is also important in speech. The tongue's mobility is greatly aided by its suspension from the mandible, styloid process of the temporal bone, and hyoid bone.

The tongue is divided into lateral halves by a median fibrous septum. The septum extends throughout the length of the tongue and is attached inferiorly to the hyoid bone. Muscles of the tongue are of two principal types: extrinsic and intrinsic. **Extrinsic muscles** originate outside the tongue and insert into it. They move the entire tongue in various directions, such as anteriorly, posteriorly, and laterally. **Intrinsic muscles** originate and insert within the tongue. These muscles alter the shape of the tongue rather than moving the entire tongue. The extrinsic and intrinsic muscles of the tongue insert into both lateral halves of the tongue.

When you study the extrinsic muscles of the tongue, you will notice that all of the names end in *glossus*, meaning tongue. You will also notice that the actions of the muscles are obvious, considering the positions of the mandible, styloid process, hyoid bone, and soft palate, which serve as origins for these muscles. For example, the **genioglossus** (originates on the mandible) pulls the tongue downward and forward; the **styloglossus** (originates on the styloid process) pulls the tongue upward and backward; the **hyoglossus** (originates on the hyoid bone) pulls the tongue downward and flattens it; and the **palatoglossus** (originates on the soft palate) raises the back portion of the tongue.

MUSCLE	ORIGIN	INSERTION	ACTION
Genioglossus (jĕ-'mē-ō-GLOS-us; <i>genĭo</i> = chin; <i>glossus</i> = tongue)	Mandible.	Undersurface of tongue and hyoid bone.	Depresses tongue and thrusts it anteriorly (protraction).
Styloglossus (stī-'ō-GLOS-us; <i>stylō</i> = stake or pole; <i>glossus</i> = process of temporal bone)	Styloid process of temporal bone.	Side and undersurface of tongue.	Elevates tongue and draws it posteriorly (retraction).
Palatoglossus (pal-'a-tō-GLOS-us; <i>palatō</i> = palate)	Anterior surface of soft palate.	Side of tongue.	Elevates posterior portion of tongue and draws soft palate down on tongue.
Hyoglossus (hī-'ō-GLOS-us)	Greater horn and body of hyoid bone.	Side of tongue.	Depresses tongue and draws down its sides.

INNERVATION

All muscles are innervated by the hypoglossal (XII) cranial nerve, except the palatoglossus, which is innervated by the pharyngeal plexus, which contains axons from both the vagus (X) and the accessory (XI) cranial nerves.

CLINICAL APPLICATION *Intubation During Anesthesia*

When general anesthesia is administered during surgery, a total relaxation of the genioglossus muscle results. This causes the tongue to fall posteriorly, which may obstruct the airway to the lungs. To avoid this, the mandible is either manually thrust forward and held in place, or a tube is inserted from the lips through the laryngopharynx (inferior portion of the throat) into the trachea (endotracheal intubation).

RELATING MUSCLES TO MOVEMENTS

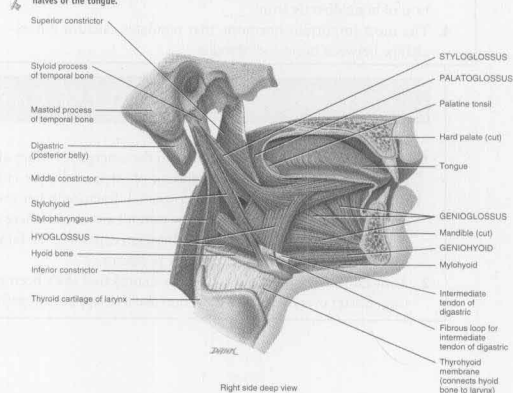
Arrange the muscles in this exhibit according to the following actions on the tongue: (1) depression, (2) elevation, (3) protraction, and (4) retraction. The same muscle may be mentioned more than once.

When your physician says, "Open your mouth, stick out your tongue, and say ah," so the can examine the inside of your mouth for possible signs of infection, which muscles do you contract?

Exhibit 11.4 Muscles that Move the Tongue—Extrinsic Muscles (continued)

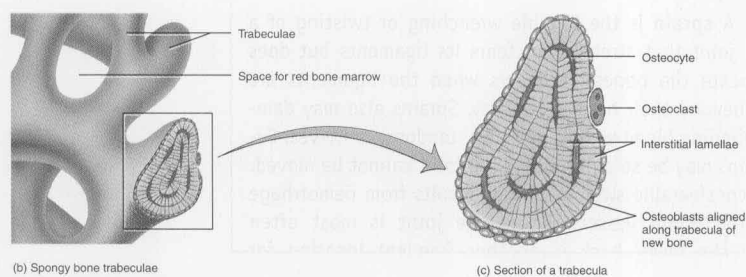
Figure 11.7 Muscles that move the tongue.

The extrinsic and intrinsic muscles of the tongue are arranged in both lateral halves of the tongue.



What are the functions of the tongue?

Figure 6.3 (continued)



(b) Spongy bone trabeculae

(c) Section of a trabecula

Q As people age, some central (Haversian) canals may become blocked. What effect would this have on the osteocytes?

well organized. However, the trabeculae in spongy bone tissue are precisely oriented along lines of stress, a characteristic that helps bones resist stresses and transfer force without breaking. Spongy bone tissue tends to be located where bones are not heavily stressed or where stresses are applied from many directions.

Spongy bone tissue is different from compact bone tissue in two respects. First, spongy bone tissue is light, which reduces the overall weight of a bone so that it moves more readily when pulled by a skeletal muscle. Second, the trabeculae of spongy bone tissue support and protect the red bone marrow. The spongy bone tissue in the hip bones, ribs, breastbone, backbones, and the ends of long bones is the only site of red bone marrow and, thus, of hemopoiesis in adults.

growth. Lighter areas are called "cold spots," areas of decreased metabolism that absorb less of the radioactive tracer. Cold spots may indicate problems such as degenerative bone disease, decalcified bone, fractures, bone infections, Paget's disease, and rheumatoid arthritis. A bone scan not only detects abnormalities 3–6 months sooner than standard x-ray procedures, it exposes the patient to less radiation. ■

1. Why is bone considered a connective tissue?
2. Describe the four types of cells in bone tissue.
3. What is the composition of the matrix of bone tissue?
4. Distinguish between spongy and compact bone tissue in terms of its microscopic appearance, location, and function.

5

VALIDATE

As you read, answer the numbered **review activities**, which validate your understanding of the student objectives.

When you are finished, take the **self-quizz**, which poses questions in a variety of testing styles. (Answers are in Appendix D.)

SELF-QUIZ QUESTIONS**Complete the following:**

1. Whereas the ____ of bone depends on the crystallized mineral salts, the collagen fibers and other organic molecules provide bone with ____.
2. Compact bone tissue is composed of ____; spongy bone tissue is composed of ____.
3. Endochondral ossification refers to the formation of bone within ____; intramembranous ossification refers to the formation of bone directly from ____.
4. The most important hormone that regulates calcium ion exchange between bone and blood is ____.

8. Match the following:

- | | |
|---|-------------------------|
| ____ (a) small spaces between lamellae that contain osteocytes | (1) lacunae |
| ____ (b) perforating canals that penetrate compact bone; carry blood vessels, lymphatic vessels, and nerves from the periosteum | (2) Volkmann's canals |
| ____ (c) areas between osteons | (3) Haversian canals |
| ____ (d) microscopic unit of compact bone tissue | (4) concentric lamellae |
| | (5) epiphyseal plate |
| | (6) trabeculae |
| | (7) interstitial |

CRITICAL THINKING QUESTIONS

1. A father brings his young daughter to the emergency room after she fell off her bicycle. The attending physician tells the father that his daughter has suffered a greenstick fracture in her lower arm. The father is confused—there weren't any sticks where she fell in the street. What should the physician explain to the father? (HINT: *Only children suffer this type of fracture.*)
2. Aunt Edith is 95 years old today. She claims that she's been getting shorter every year, and that soon she'll disappear altogether.

What's happening to Aunt Edith? Think about her bone.

3. Astronauts in space experience problems staying in space. Why does space that you have to work in?

Answer at least one of the **critical thinking** questions, which ask you to apply anatomical and physiological concepts to real-life situations. (Answers are in Appendix D.)

6

GET INTERACTIVE!

CD-ROM

Use the **Student Companion CD-ROM** located inside the back cover. This engaging study tool offers a range of interactive activities and assessment tools that you can access to add to your knowledge or validate your understanding of the reading. Here's what you'll find:

Activities

Intriguing **feedback loop exercises** let you explore how the homeostasis of body systems is maintained under normal conditions, and how it is disrupted by diseases or disorders. Twelve **art exercises** allow you to investigate complex anatomical structures or to trace complex physiological processes step by step. In addition, **anatomy drag-and-drop exercises** in every chapter will sharpen your understanding of anatomical structures.

Testing

Validate your understanding by taking the 30-question **multiple choice quiz** available for each chapter. Each quiz scores automatically and provides you with immediate

feedback about your answers. You can simulate a mid-term or final exam, too, by using the **test feature**. Select the specific chapters you want to be tested on and the number of questions you want.

Special Feature

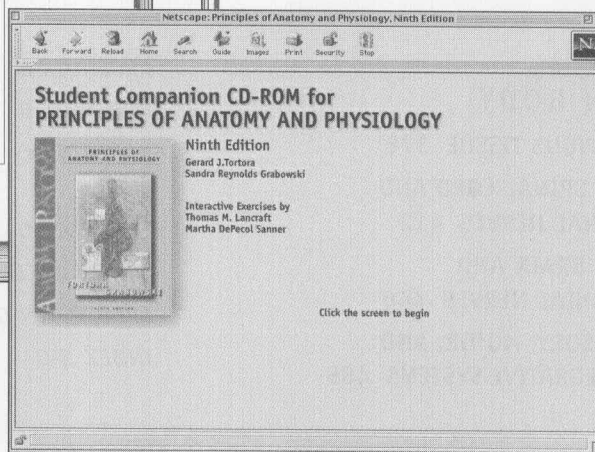
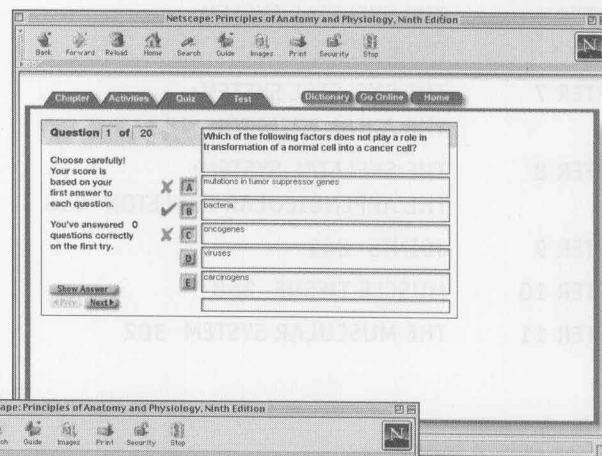
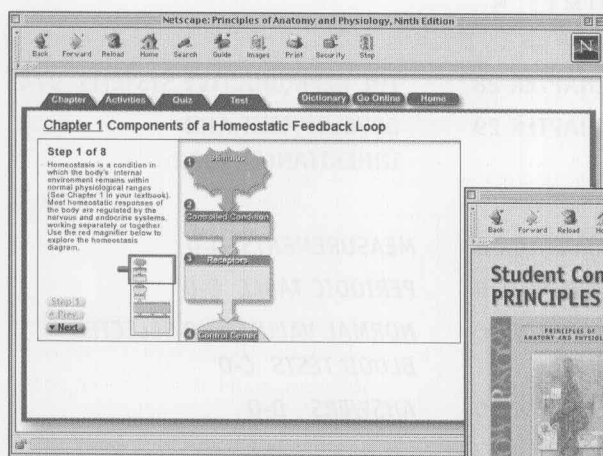
Use the **pronunciation glossary** to review definitions and to hear the actual pronunciation of terms.

Learning Guide

This helpful study companion has chapter summaries, topic outlines and objectives, terminology exercises, and study questions cross-referenced to the book. Each chapter includes an extra Self-Quiz. Ask for the *Learning Guide to Principles of Anatomy and Physiology* (ISBN: 0-471-37467-9) at your college bookstore!

Web Site

For additional study help or to explore topics in more depth, please visit our web site at <http://www.wiley.com/college/bio/tortora>



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