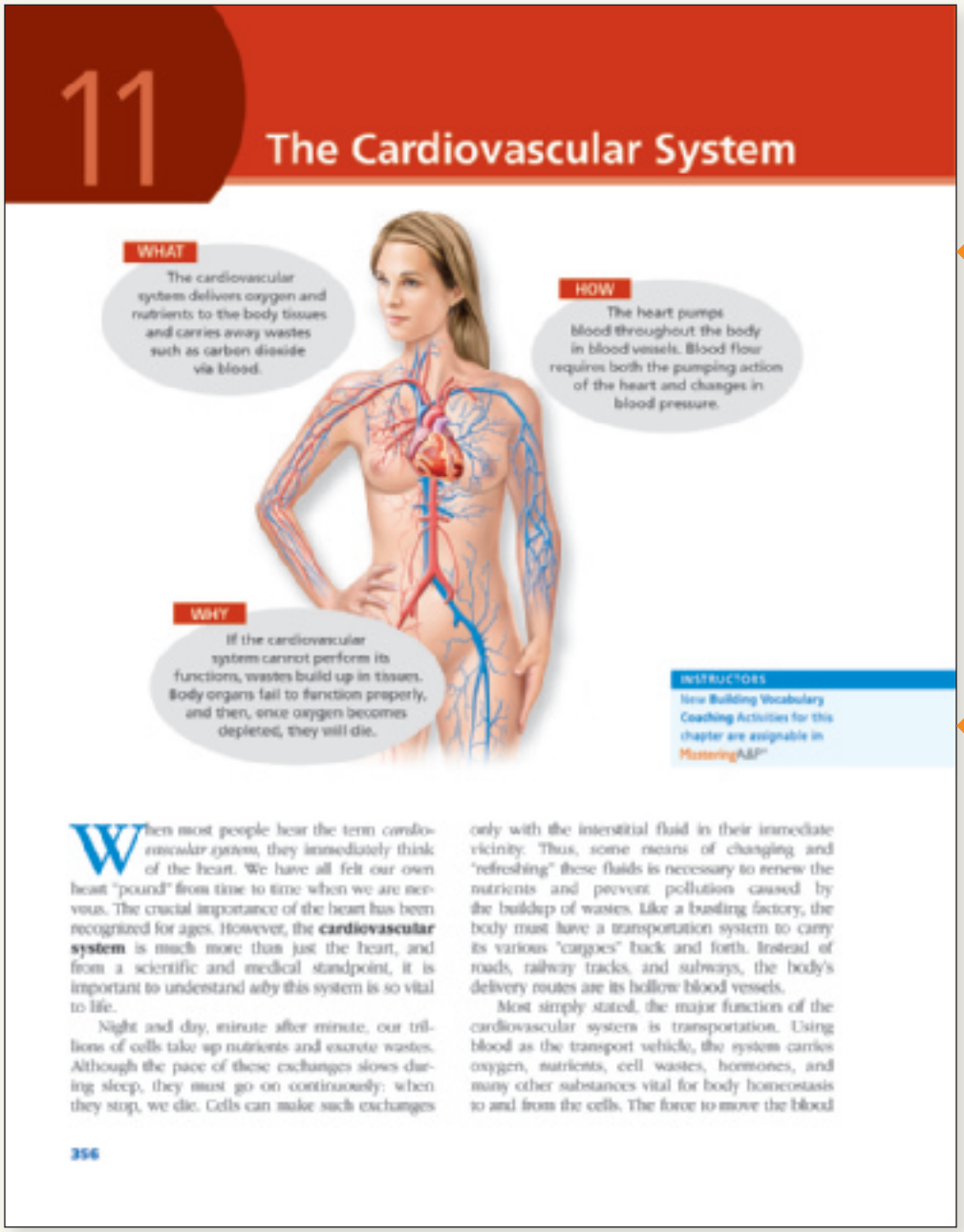
Learn the Essential *What, How & Why* of Human Anatomy & Physiology

With the **Twelfth Edition** of ***Essentials of Human Anatomy & Physiology,*** science educator Suzanne Keller joins bestselling author Elaine Marieb in helping learners focus on the *What, How & Why* of A&P, without getting sidetracked in details.



11 The Cardiovascular System

WHAT
The cardiovascular system delivers oxygen and nutrients to the body tissues and carries away wastes such as carbon dioxide via blood.

HOW
The heart pumps blood throughout the body in blood vessels. Blood flow requires both the pumping action of the heart and changes in blood pressure.

WHY
If the cardiovascular system cannot perform its functions, wastes build up in tissues. Body organs fail to function properly, and then, once oxygen becomes depleted, they will die.

INSTRUCTORS
New Building Vocabulary Coaching Activities for this chapter are assignable in MasteringA&P™

When most people hear the term *cardiovascular system*, they immediately think of the heart. We have all felt our own heart "pound" from time to time when we are nervous. The crucial importance of the heart has been recognized for ages. However, the **cardiovascular system** is much more than just the heart, and from a scientific and medical standpoint, it is important to understand why this system is so vital to life.

Night and day, minute after minute, our trillions of cells take up nutrients and excrete wastes. Although the pace of these exchanges slows during sleep, they must go on continuously: when they stop, we die. Cells can make such exchanges only with the interstitial fluid in their immediate vicinity. Thus, some means of changing and "refreshing" these fluids is necessary to renew the nutrients and prevent pollution caused by the buildup of wastes. Like a bustling factory, the body must have a transportation system to carry its various "cargoes" back and forth. Instead of roads, railway tracks, and subways, the body's delivery routes are its hollow blood vessels.

Most simply stated, the major function of the cardiovascular system is transportation. Using blood as the transport vehicle, the system carries oxygen, nutrients, cell wastes, hormones, and many other substances vital for body homeostasis to and from the cells. The force to move the blood

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NEW! *What, How & Why* chapter previews introduce key examples of anatomy and physiology concepts that will be covered in the chapter. This technique helps learners hone in on ***what*** they are studying, ***how*** it functions, and ***why*** it is important for them to learn.

NEW! Building Vocabulary Coaching Activities in MasteringA&P help students learn the essential language of A&P.

See p. 356.

Focus on Essential A&P Concepts

Throughout every chapter, the text's conversational writing style and straightforward explanations have been strengthened with **familiar analogies** and **abundant mnemonic cues** to help students learn and remember concepts.

UPDATED!
Exceptionally clear photos and illustrations, including dozens of new and improved figures, present concepts and processes at the right level of detail. Many figures from the text are assignable as Art-Labeling Activities in MasteringA&P.

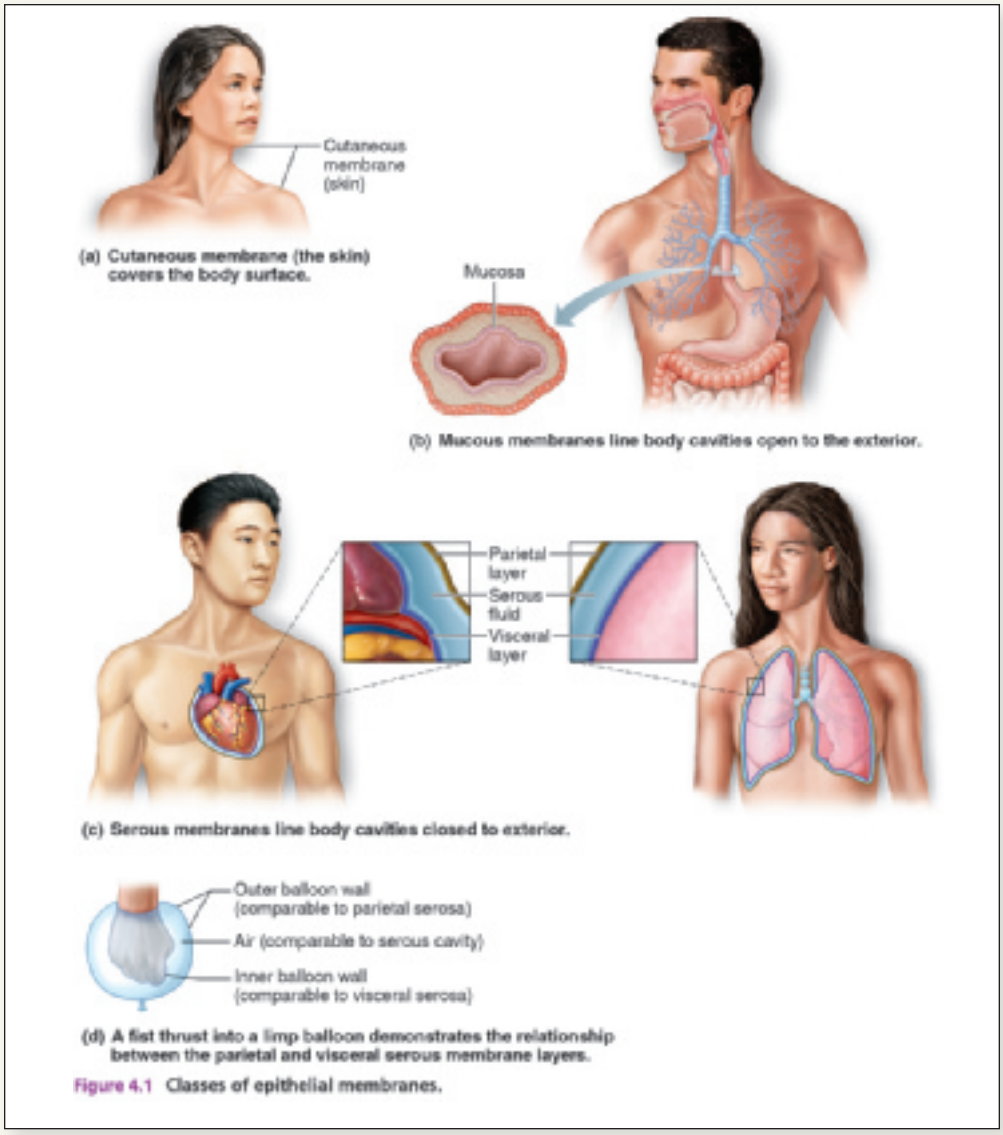


Figure 4.1 Classes of epithelial membranes.

See p. 111.

Unique Concept Links reinforce previously-learned concepts and help students make connections across body systems while learning new material.

CONCEPTLINK

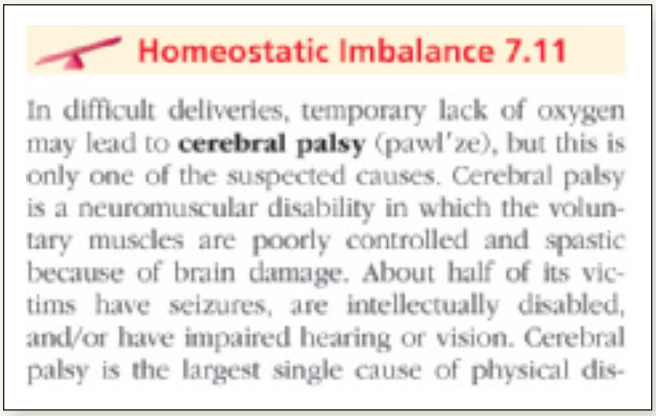
The terms for the connective tissue coverings of a nerve should seem familiar: We discussed similar structures in the muscle chapter (Figure 6.1, p. 183). Names of muscle structures include the root word *mys*, whereas the root word *neuro* tells you that the structure relates to a nerve. For example, the endomysium covers one individual muscle fiber, whereas the endoneurium covers one individual neuron fiber. ←

See p. 256.

Explore Essential Careers and Clinical Examples

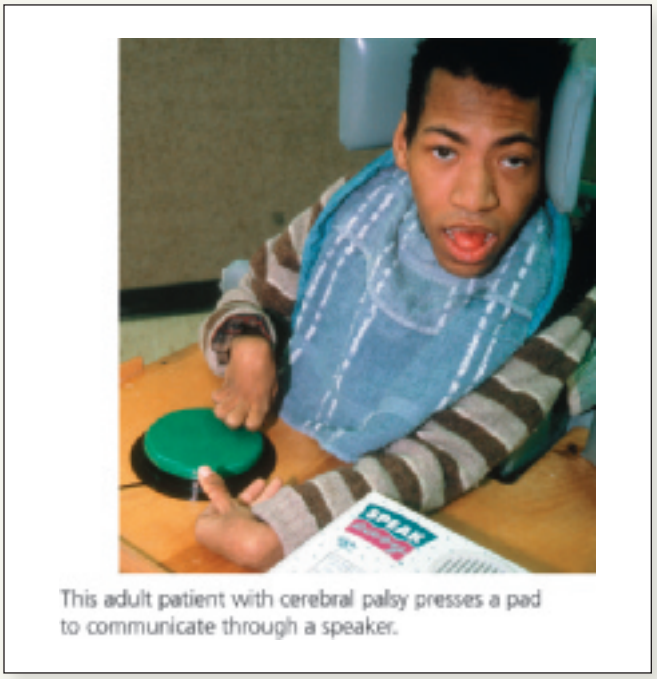
To inspire and inform students who are preparing for future healthcare careers, **up-to-date clinical applications** are integrated in context with discussions about the human body.

UPDATED! Homeostatic Imbalance discussions are clinical examples that revisit the text's unique theme by describing how the loss of homeostasis leads to pathology or disease. Related assessment questions are assignable in MasteringA&P, along with Clinical Case Study coaching activities.



Homeostatic Imbalance 7.11

In difficult deliveries, temporary lack of oxygen may lead to **cerebral palsy** (pawl'ze), but this is only one of the suspected causes. Cerebral palsy is a neuromuscular disability in which the voluntary muscles are poorly controlled and spastic because of brain damage. About half of its victims have seizures, are intellectually disabled, and/or have impaired hearing or vision. Cerebral palsy is the largest single cause of physical dis-



This adult patient with cerebral palsy presses a pad to communicate through a speaker.

See p. 269.

Focus on Careers essays feature conversations with working professionals and explain the relevance of anatomy and physiology course topics across a wide range of allied health careers. Featured careers include:

- Ch. 2 Pharmacy Technician
- Ch. 4 Medical Transcriptionist
- Ch. 5 Radiologic Technologist
- Ch. 8 Physical Therapy Assistant
- Ch. 10 Phlebotomy Technician
- Ch. 15 Licensed Practical Nurse

Students can visit the **MasteringA&P Study Area** for more information about career options that are relevant to studying anatomy and physiology.

FOCUS ON CAREERS

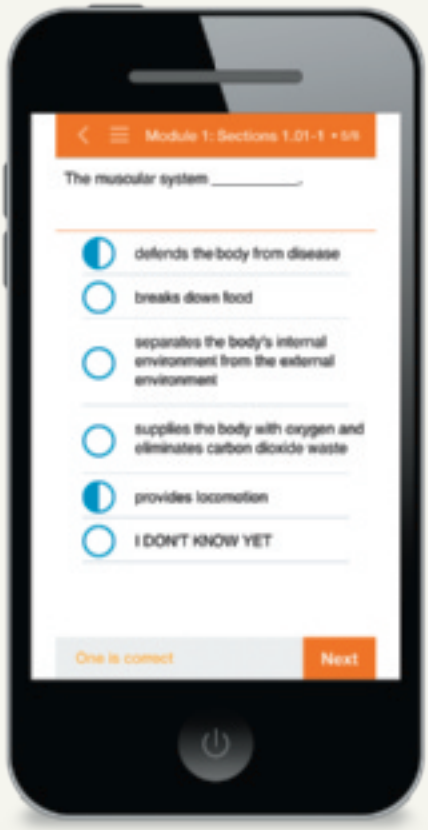
Pharmacy Technician

Pharmacy technicians must have a good grasp of anatomy and physiology to understand each drug's chemical properties.

See p. 56.

Continuous Learning Before, During, and After Class

MasteringA&P improves results by engaging students before, during, and after class.



Before Class

Dynamic Study Modules enable students to study more effectively on their own. With the Dynamic Study Modules mobile app, students can quickly access and learn the concepts they need to be more successful on quizzes and exams. **NEW!** Instructors can now select which questions to assign to students within each module.

Instructors can further encourage students to prepare for class by assigning **NEW! Building Vocabulary activities,** reading questions, art labeling activities, and more.

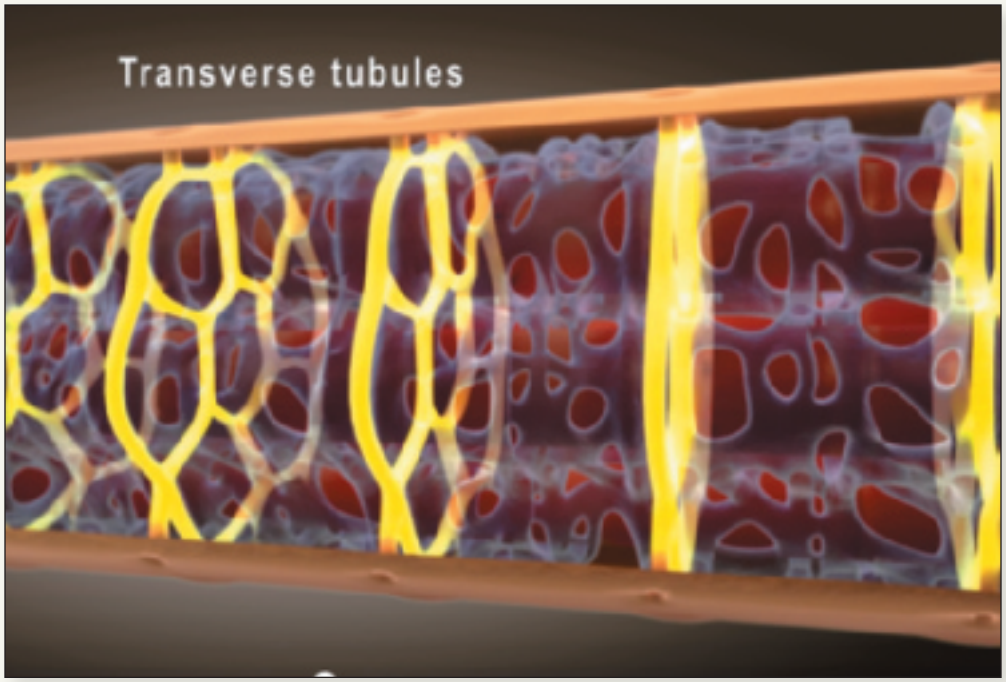
with MasteringA&P

During Class

NEW! Learning Catalytics is a "bring your own device" (laptop, smartphone, or tablet) engagement, assessment, and classroom intelligence system. Students use their device to respond to open-ended questions and then discuss answers in groups based on their responses. Visit learningcatalytics.com to learn more.

After Class

A wide variety of interactive coaching activities can be assigned to students as homework, including Art-Labeling Activities, Interactive Physiology 2.0 tutorials, Clinical Case Studies, and activities featuring **A&P Flix** 3-D movie-quality animations of key physiological processes.



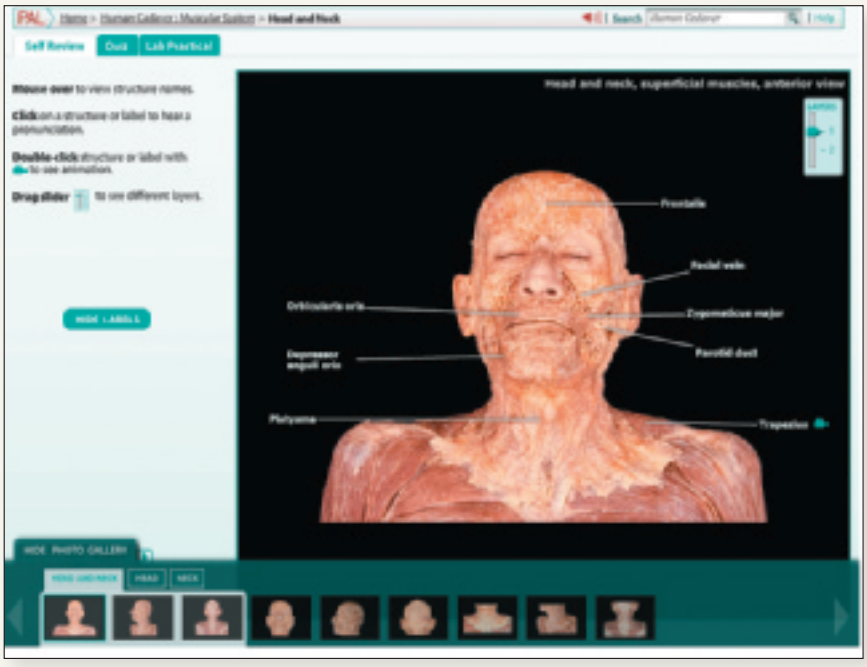
A&P concepts come to life with MasteringA&P

Media references in the text direct learners to digital resources in the MasteringA&P Study Area, including practice tests and quizzes, flashcards, a complete glossary, and more.

NEW! Interactive Physiology 2.0

NEW! Interactive Physiology 2.0 helps students advance beyond memorization to a genuine understanding of complex physiological processes. Fun, interactive tutorials, games, and quizzes give students additional explanations to help them grasp difficult concepts. IP 2.0 features brand-new graphics, quicker navigation, and more robust interactivity.

Practice Anatomy Lab (PAL™ 3.0) is a virtual anatomy study and practice tool that gives students 24/7 access to the most widely used lab specimens, including the human cadaver, anatomical models, histology, cat, and fetal pig. PAL 3.0 is easy to use and includes built-in audio pronunciations, rotatable bones, and simulated fill-in-the-blank lab practical exams.



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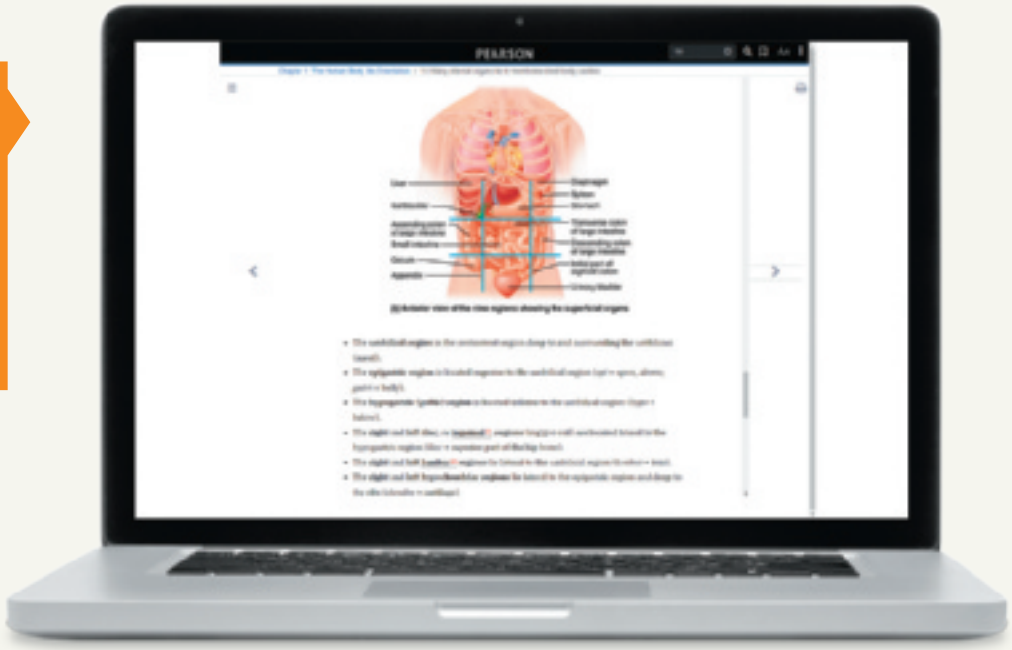
NEW! The **Twelfth Edition** is available in Pearson's fully-accessible eText 2.0 platform.*

NEW! The eText 2.0 mobile app offers offline access and can be downloaded for most iOS and Android phones and tablets from the iTunes or Google Play stores.

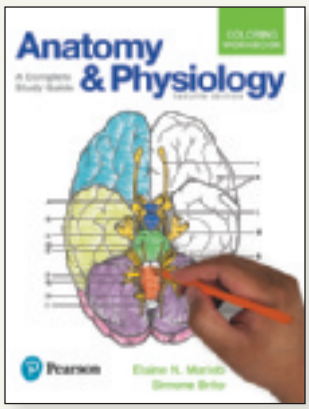
Powerful interactive and customization functions include instructor and student note-taking, highlighting, bookmarking, search, and links to glossary terms.



*The eText 2.0 edition will be live for Fall 2017 classes.

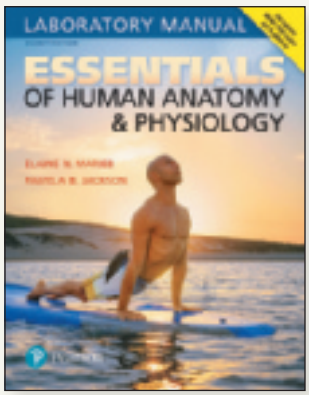
Additional Support for Students and Instructors

FOR THE STUDENT



NEW! *Anatomy & Physiology Coloring Workbook* Twelfth Edition by Elaine N. Marieb and Simone Brito

The perfect companion to ***Essentials of Human Anatomy & Physiology,*** this engaging interactive workbook helps students get the most out of their study time. The ***Twelfth Edition*** includes **NEW!** crossword puzzles for every chapter, along with coloring activities, self-assessments, "At the Clinic" questions, and unique "Incredible Journey" visualization exercises that guide learners into memorable explorations of anatomical structures and physiological functions. Available for purchase.



NEW! IN FULL COLOR! *Essentials of Human Anatomy & Physiology Laboratory Manual Seventh Edition* by Elaine N. Marieb and Pamela B. Jackson

This popular lab manual provides 27 exercises for a wide range of hands-on laboratory experiences, designed especially for a short A&P Lab course. This edition, which includes a Histology Atlas with 55 photomicrographs, features **NEW!** full-color illustrations, photos, and page design that help students navigate and learn the material faster and easier than ever before. Each concise lab exercise includes a Pre-Lab Quiz, brief background information, integrated learning objectives, student-friendly review sheets, and more. Available for purchase.

FOR THE INSTRUCTOR

The Instructor Resources Area in MasteringA&P includes the following downloadable tools:

- All of the figures, photos, and tables from the text in JPEG and PowerPoint® formats, in labelled and unlabeled versions, and with customizable labels and leader lines
- Step-edit Powerpoint slides that present multi-step process figures step-by-step
- Clicker Questions and Quiz Show Game questions that encourage class interaction
- A&PFlix™ animations bring human anatomy and physiology concepts to life
- Customizable PowerPoint® lecture outlines save valuable class prep time
- A comprehensive Instructor's Guide includes lecture outlines, classroom activities, and teaching demonstrations for each chapter.
- Test Bank provides a wide variety of customizable questions across Bloom's taxonomy levels. Includes art labeling questions, and available in Microsoft® Word and TestGen® formats.

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MasteringA&P® is the most effective and widely used online homework, tutorial, and assessment system for the sciences. It delivers self-paced tutorials that focus on your course objectives, provides individualized coaching, and responds to each student's progress. The Mastering system helps teachers maximize class time with easy-to assign, customizable, and automatically graded assessments that motivate students to learn.

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Brief Contents

TWELFTH EDITION

ESSENTIALS OF HUMAN ANATOMY & PHYSIOLOGY

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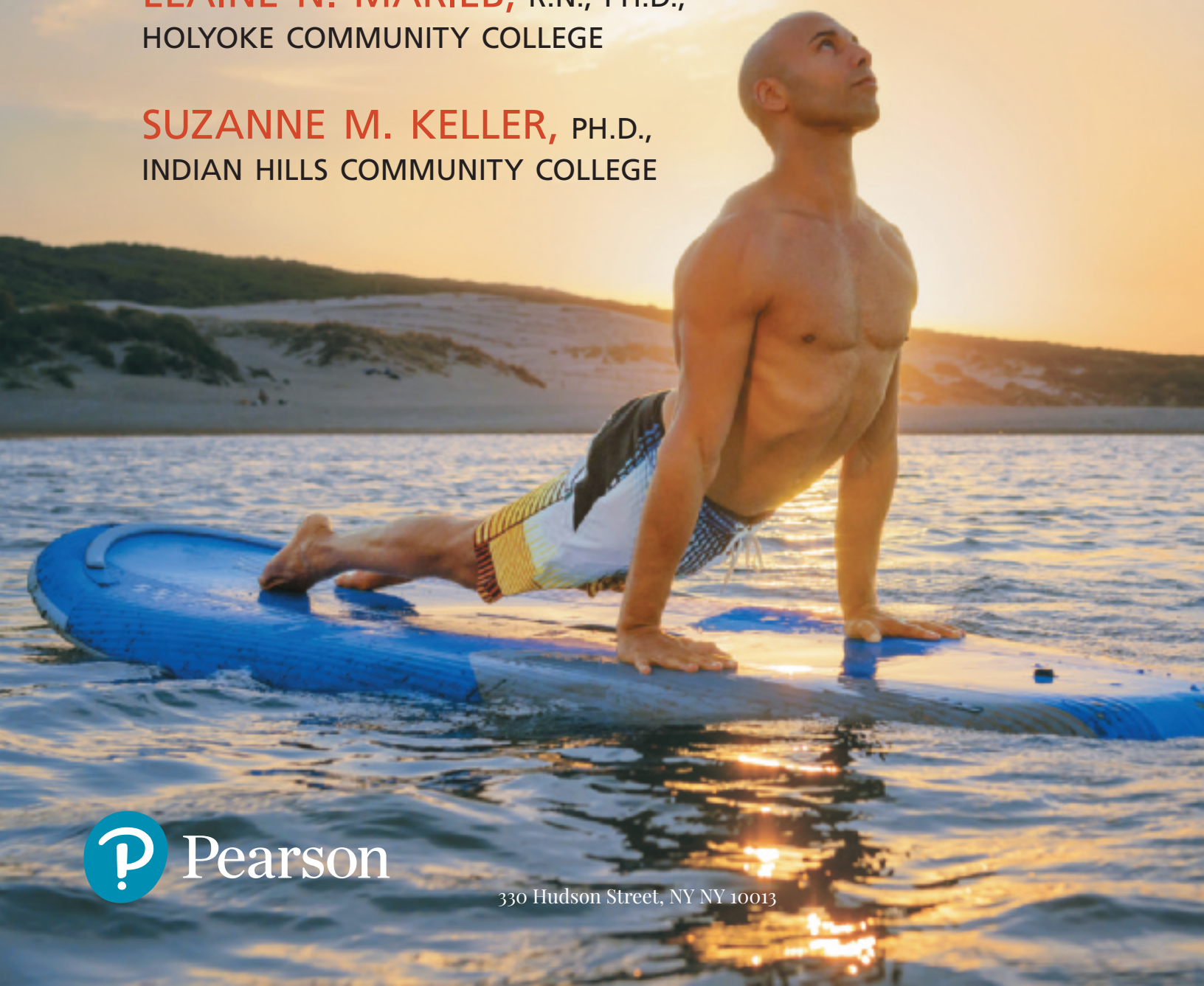

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About the Authors

Elaine Marieb After receiving her Ph.D. in zoology from the University of Massachusetts at Amherst, Elaine N. Marieb joined the faculty of the Biological Science Division of Holyoke Community College. While teaching at Holyoke Community College, where many of her students were pursuing nursing degrees, she developed a desire to better understand the relationship between the scientific study of the human body and the clinical aspects of the nursing practice. To that end, while continuing to teach full time, Dr. Marieb pursued her nursing education, which culminated in a Master of Science degree with a clinical specialization in gerontology from the University of Massachusetts. It is this experience that has informed the development of the unique perspective and accessibility for which her publications are known.

Dr. Marieb has given generously to provide opportunities for students to further their education. She funds the E. N. Marieb Science Research Awards at Mount Holyoke College, which promotes research by undergraduate science majors, and has underwritten renovation of the biology labs in Clapp Laboratory at that college. Dr. Marieb also contributes to the University of Massachusetts at Amherst, where she generously provided funding for reconstruction and instrumentation of a cutting-edge cytology research laboratory. Recognizing the severe national shortage of nursing faculty, she underwrites the Nursing Scholars of the Future Grant Program at the university. In January 2012, Florida Gulf Coast University named a new health professions facility in her honor. The Dr. Elaine Nicpon Marieb Hall houses several specialized laboratories for the School of Nursing, made possible by Dr. Marieb's generous support.

Suzanne Keller Suzanne M. Keller began her teaching career while she was still in graduate school at the University of Texas Health Science Center in San Antonio, Texas. Inspired by her lifelong passion for learning, Dr. Keller quickly adopted a teaching style focused on translating challenging concepts into easily understood parts using analogies and stories from her own experiences. An Iowa native, Dr. Keller uses her expertise to teach microbiology and anatomy and physiology at Indian Hills Community College, where most of her students are studying nursing or other health science programs.

Dr. Keller values education as a way for students to express their values through the careers they pursue. She supports those endeavors both in and out of the classroom by participating in her local Lions Club, by donating money to the Indian Hills Foundation to fund scholarships, and by financially supporting service-learning trips for students. Dr. Keller also enjoys sponsoring children in need with gifts for the holidays.

Dr. Keller is a member of the Human Anatomy and Physiology Society (HAPS) and the Iowa Academy of Science. Additionally, while engaged as an author, Dr. Keller has served on multiple advisory boards for various projects at Pearson and has authored assignments for the MasteringA&P online program. When not teaching or writing, Dr. Keller enjoys reading, traveling, family gatherings, and relaxing at home under the watchful eyes of her two canine children.

New to the Twelfth Edition

This edition has been thoroughly updated. New "What, How, Why" art opens each chapter, highlighting key concepts relating to the chapter topic. Other specific chapter-by-chapter changes include the following:

Chapter 1: The Human Body: An Orientation

- Updated description of the integumentary system to include vitamin D production in the presence of sunlight.
- Updated definition of the term *crural* to specify the anterior leg, or shin.
- New "Critical Thinking and Clinical Application" question on blood clotting and feedback regulation.
- New "Critical Thinking and Clinical Application" question on using anatomical language to describe the location of a spinal injury and identifying the best medical imaging technique to diagnose a spinal problem.
- Updated "A Closer Look: Medical Imaging" with new discussion and images of mammogram and bone densitometry.
- New "Did You Get It?" questions throughout the chapter.

Chapter 2: Basic Chemistry

- New example of atomic symbol and Latin derivative for potassium.
- Revised discussion of hydrogen bonds to clarify that electrons are not involved in this type of bond as they are in covalent and ionic bonds.
- New example of importance of hydrogen bond in holding DNA strands together.
- All references to *hydroxyl ion* have been corrected to *hydroxide ion*.
- New sports analogies for acids and bases: putting electrons "in the game," to represent free protons versus taking electrons "out of the game," to represent binding a proton so it cannot contribute to a shift in pH.
- New "Did You Get It?" question part on the difference in pH between solutions at pH 11 and pH 5.
- Introduced concepts of *hydrophilic* and *hydrophobic* in discussion of phospholipids to help explain the functions of the polar head and fatty acid tails in cell membranes.
- Updated "Did You Get It?" question on lipids to include both phospholipids and cholesterol as cell membrane components.
- New analogy comparing the alpha (α)-helix to a metal spring.
- New analogy comparing a beta (β)-sheet to a pleated skirt, or paper folded into a fan.
- New analogy comparing enzymes and substrates to scissors and paper, respectively.
- New description of RNA function as DNA's "molecular assistant."
- New shorthand symbols for messenger (mRNA), transfer (tRNA) and ribosomal (rRNA) added.
- New analogy comparing glucose and ATP to crude oil and gasoline; energy must be in the proper form before it can be used by cells.
- New explanation of why the terminal phosphate bonds in ATP are high energy.
- New "Critical Thinking and Clinical Application" question on sickle cell anemia.

Chapter 3: Cells and Tissues

- New description of the principle of complementarity.
- New information about how mitochondria divide.
- New "cargo" in the form of a membrane-bound receptor protein added to pathway 2 of Figure 3.6.
- New analogy for lysosomes as "cellular stomachs."
- New art of plasma membrane and new detail of mitochondrial function including aerobic respiration in Table 3.1.
- New analogy of dust "crowd surfing" on the mucus that cilia carry from the lungs.
- New description of neuron function includes production of neurotransmitters.
- New colors used in Figure 3.14 DNA images to help students track new and old strands of DNA.
- New description of each chromosome being composed of two sister chromatids.
- New explanation of protein synthesis includes the role of the large ribosomal subunit in peptide bond formation.
- New Figure 3.18 descriptions of nuclei lining up in simple columnar and not lining up in pseudostratified epithelia.
- New description of cell shapes in different layers of stratified epithelia as "squished" and variable.
- New analogy for mucus produced by goblet cells as a "sticky trap" for dust and debris.
- New Figure 3.19 labels for osteocytes, the elastic and collagen fibers in areolar connective tissue, and the fluid matrix of blood; new art for dense fibrous connective tissue.
- New analogy for reticular tissue as "cellular bleachers" where other cells rest to monitor the body.
- Updated Figure 3.21 to include the term *neuroglia* to describe supporting cells.
- New information added to Figure 3.22: cartilage added to the connective tissue list and two major hallmarks of each of the four tissue types.
- New example of atrophy: when a broken leg is in a cast, lack of use causes muscles to atrophy during healing.
- Revised "A Closer Look: Cancer—An Intimate Enemy" and updated art.
- New "Short Answer Essay" questions on the components of the plasma membrane and their functions and on contrasting cytokinesis, interphase, and mitosis.
- New "Critical Thinking and Clinical Application" question on IV fluids and tonicity.
- New "Did You Get It?" questions throughout the chapter.

Chapter 4: Skin and Body Membranes

- New Figure 4.1 on epithelial membranes.
- New description of sensory receptors as part of nervous system including a list of the stimuli detected.
- New text updates on Figure 4.4 on epidermal structure; included a new figure question on stratum lucidum.
- New analogy for epidermal dendritic cells as "sentries" guarding the skin.
- New photo of stage 2 decubitus ulcer added to Homeostatic Imbalance 4.2.
- New layout for Figure 4.7 combining scanning electron micrograph of hair shaft with existing art of the hair root and follicle.
- New discussion of fourth-degree burns.
- New criteria for determining whether a burn is critical, including circumferential burns, burns of the airway, and burns to the genital area.
- New images of basal cell and squamous cell carcinoma in Figure 4.11.
- New component added to ABCDE rule: now includes "Evolution," changes in a skin lesion over time.
- New "Short Answer Essay" questions on the risks of full-thickness burns, contrasting eccrine and apocrine sweat glands, and the relative severity of different skin infections.
- New "Critical Thinking and Clinical Application" question on burns.
- New "Did You Get It?" questions throughout the chapter.

Chapter 5: The Skeletal System

- Updated description of long bones.
- New analogy comparing lubrication over articular cartilage at joints to a slick marble floor.

- Updated descriptions of red and yellow bone marrow.
- Updated descriptions of sagittal and coronal sutures.
- Updated description of the capitulum of the humerus.
- New analogy comparing the trochlea meeting the trochlear notch to a curved "tongue-in-groove" joint.
- Updated description of buttock injections to include the consequences of hitting a nerve.
- Updated description of a synovial membrane to include areolar connective tissue.
- Updated description of cartilaginous joints.
- New description of saddle joints including a reference to opposable thumbs.
- Updated list of triggers for rheumatoid arthritis.
- Discussion of the fetal skull and fontanels moved to the Developmental Aspects section.
- New analogy likening skulls of small children to "bobble heads."
- Updated review question on bones that articulate with the sphenoid to reflect only bones shown in the figures of Chapter 5.
- Updated "Short Answer Essay" question on synovial joints to include osteoarthritis.
- New "Short Answer Essay" question contrasting the foramen magnum and obturator foramen.
- New "Critical Thinking and Clinical Application" question on gouty arthritis.
- New statistics, information, and images added to "A Closer Look: Joint Ventures."
- Updated description of comminuted fractures on Table 5.2.
- Updated Figure 5.6 to include osteoblasts and osteoclasts in the descriptions of bone addition and resorption, respectively.
- Updated Systems In Sync with respect to the descriptions of relationships of cardiovascular and muscular systems to the skeletal system.

Chapter 6: The Muscular System

- Updated descriptions of tendons and aponeuroses.
- New analogy about running to explain the difference between the contraction of skeletal muscle (fast) versus smooth muscle (slow).
- Updated description of a sarcomere to include its role as the structural and functional unit of muscle.
- Added discussion of titin to the description of a sarcomere as the elastic filament that attaches myosin to the Z disc.
- New Homeostatic Imbalance on ALS (amyotropic lateral sclerosis, or Lou Gehrig's disease).
- New "Did You Get It?" question on the roles of calcium in muscle contraction.
- Updated descriptions of cross-bridge formation and the sliding filament theory, including the role of ATP.
- New link to IP Essentials for the sliding filament theory.
- New description of flaccid versus spastic paralysis.
- New mnemonic device for *adduction*: "add" back to the body by moving toward the trunk (midline).
- New descriptions of dorsiflexion and plantar flexion with respect to the head: toes point toward the head or away, respectively.
- New girdle analogy for abdominal wall muscles "holding guts in."
- New description of the consequences of an injection being too close to, or hitting, the sciatic nerve.
- New description of tailor's muscle sitting position.
- New description of myasthenia gravis as an autoimmune disease.
- New "Short Answer Essay" question about the relationship between wrist flexors and extensors, including their locations.
- New figure question for Figure 6.20 on the origin(s) and insertion(s) of the rectus femoris depending on the action being performed.
- Updated explanation of steps in Figure 6.5.

Chapter 7: The Nervous System

- Updated Figure 7.13 to use *superior* and *inferior* instead of *cephalad* and *caudal*.
- Updated Figure 7.24 to clarify why there are eight cervical nerves but only seven cervical vertebrae.
- New Learning Outcome on the structures and functions of neurons and neuroglia.
- Updated description of Nissl body function.
- New description clarifying the difference between a synapse and synaptic cleft.
- New analogy for a myelin sheath as the wrapping on an electrical cord.
- New explanation clarifying the differences between myelin sheaths in the CNS and PNS.
- New explanation clarifying the "short circuit" event in multiple sclerosis means that the signal may stop or "jump" to an unmyelinated neuron.
- New analogy for the structure of a unipolar cell body as a "cul-de-sac" off the "main road" that is the axon.
- Replaced references to the term *basal ganglia* with the more accurate term *basal nuclei*.
- Replaced the term *arachnoid villi* with *arachnoid granulations*.
- New statistics on stroke as the fifth leading cause of death in the United States (formerly identified as the third leading cause).
- New statistics regarding the rate of survival after a stroke.
- Replaced the phrase "mentally retarded" in the discussion of cerebral palsy with "intellectually disabled."
- New information included in "A Closer Look: The 'Terrible Three'" reflecting the role of calcium in apoptosis, two new drugs for treatment of Parkinson's disease, and the variation in dopamine levels in patients with Huntington's disease.
- New information incorporated in "A Closer Look: Tracking Down CNS Problems" to include a new dopamine imaging technique called DaTscan.

Chapter 8: Special Senses

- New description of lacrimal caruncle.
- New description of optic disc and the resulting blind spot.
- New analogy comparing the ability to see intermediate colors (between the red, green, and blue cones) to mixing paint.
- Updated the description of cataracts.
- New example of motion detected by dynamic equilibrium: a spinning carnival ride.
- New analogy for bending of the cupula as divers' fins in water.
- New description of foliate papillae on the side of the tongue, another location for taste buds.
- New art showing the retina in Figure 8.5.
- New Figure 8.6 showing the graph of rods and cones, and which wavelengths of light are detected by each.
- Updated Figure 8.12b on maculae.
- New "Did You Get It?" questions throughout the chapter.

Chapter 9: The Endocrine System

- Updated discussion of the mechanism of hormone action, including Figure 9.1 and its caption, to reflect that steroid hormones can act via either second messenger or direct gene activation.
- Updated explanation of how hormones alter cell activity.
- New analogy comparing second-messenger systems to delivering a letter.
- Revised coverage of endocrine glands to reflect their location in body from superior to inferior; Table 9.1 has also been revised to reflect the new order.
- Updated description explaining why a goiter forms in the absence of iodine.
- Updated description of body proportions in cretinism.
- New "Did You Get It?" question on adrenal cortex hormones.

Chapter 10: Blood

- Updated explanation of why the normal temperature of blood is a bit higher than body temperature.
- Added definitions for the suffixes *-cytosis* and *-penia*.
- Updated the analogy comparing the shape of the eosinophil nucleus to earmuffs.
- Updated the role of monocytes to include activation of lymphocytes.
- Updated the list of locations where red marrow is found in adults.
- Updated the major anticoagulants to include warfarin.
- New description of petechiae includes comparison to a skin rash.

- Added a learning tool about blood type reminding readers that a person does not make antibodies against their own blood type antigen(s).
- Updated discussion of lack of vitamin B12 as the cause of pernicious anemia and how this relates to intrinsic factor.

Chapter 11: The Cardiovascular System

- Updated description of pericardium.
- Revised discussion of the function of the atria to clarify that they assist with ventricular filling.
- Arteries and veins are now introduced in terms of the direction of blood flow with respect to the heart.
- New analogy comparing valve cusps filling with blood to a parachute filling with air.
- New analogy comparing the intrinsic conduction system setting heart rhythm to a drummer setting the beat for a rock band playing a song.
- New discussion of AEDs (automatic external defibrillators) included in the discussion of fibrillation.
- Reorganized section on the cardiac cycle to include five stages.
- New "Did You Get It?" question about isovolumetric contraction.
- Updated description of the effect of congestive heart failure on stroke volume.
- Updated description of pulmonary congestion.
- Updated description of pulmonary embolism.
- Discussion of fetal circulation moved to the Developmental Aspects section.
- Updated description of the blood pressure gradient to include a pressure of zero in the right atrium.
- New layout of Figure 11.8 reflecting five stages of the cardiac cycle.
- Updated Figure 11.9 description to clarify that any change in heart rate or stroke volume will also cause a change in cardiac output.
- Updated description of Figures 11.13 and 11.14 to include a statement that all vessels are bilateral unless otherwise stated in the text.
- Updated "A Closer Look" box on atherosclerosis.

Chapter 12: The Lymphatic System and Body Defenses

- Updated Figure 12.10 on lysis by complement to reflect water flowing into the cell to cause lysis.
- Added the role of B cells in antigen presentation to Figure 12.19.
- New information added regarding discovery of lymphatics in the central nervous system.
- Updated the description of adaptive defenses as defenses that fight antigens that get past the innate defenses.
- New description of how natural killer cells kill: via *perforin* and *granzymes*.
- Updated the description of positive chemotaxis to include movement toward the stimulus.
- Revised description of interferon to clarify that interferon fights only viral pathogens, not bacteria or fungi.
- New antibody function has been listed: opsonization.
- New description of Graves' disease explaining that excess production of thyroxine is in response to antibodies that mimic TSH (thyroid-stimulating hormone).
- New descriptions of two additional types of hypersensitivities: reactions resulting in cell lysis and those forming antigen-antibody complexes.
- New example of when epinephrine is used during acute hypersensitivity: EpiPen® injection.
- New Short Answer Essay question provided on mechanisms of killing used by the immune system, including lysozyme, perforin, and granzymes, and membrane attack complex (MAC).
- Updated "A Closer Look" box on AIDS, including new title.
- Updated Table 12.1 regarding the role of nasal hairs to include filtration of airborne particles.
- Updated Table 12.3 entry for "Cytokines: Perforin and granzymes" to include natural killer (NK) cells.
- New "Did You Get It?" questions throughout the chapter.

Chapter 13: The Respiratory System

- New information explaining neural regulation of breathing with respect to the dorsal and ventral respiratory groups of the medulla.
- New Short Answer Essay question contrasting hyperventilation and hyperpnea.
- Updated "A Closer Look" on cleanliness and asthma.
- New "Did You Get It?" questions throughout the chapter.

Chapter 14: The Digestive System

- New illustration outlining the parietal and visceral layers of the peritoneum (Figure 14.5).
- New illustrations showing both deciduous and permanent teeth in greater detail (Figure 14.9).
- Updated description of circular folds to provide students with a visual image of a corkscrew that slows progression of food and increases surface area at the same time.
- Added detail that rennin in infants is the same enzyme used to curdle milk in cheesemaking.
- Added narcotic pain medications to the list of causes of constipation, with stool softeners as a method of treatment.
- New "Did You Get It?" question on the four types of teeth and their functions.
- Added brief discussion of nucleic acid digestion, including the source of the enzymes and the reminder that nucleotides are the building blocks.
- Revised "A Closer Look" box on obesity to update references, statistics, and methods used to determine body composition, such as DEXA, the Bod Pod, and underwater weighing.

Chapter 15: The Urinary System

- Updated descriptions of the arterioles that connect to the glomerulus.
- Included a new learning tool describing the *in*ternal urethral sphincter as *in*voluntary.
- New "Short Answer Essay" question contrasting the homeostatic imbalances oliguria, anuria, polyuria, and nocturia.
- New "Critical Thinking and Clinical Application" question about the relationship between hypertension and impaired kidney function, and tests that are used for determining impaired kidney function.
- New information included in "A Closer Look: Renal Failure and the Artificial Kidney" about a blood test to determine the creatinine level in order to estimate the rate of glomerular filtration.
- Did You Get It?

Chapter 16: The Reproductive System

- New explanation of the purpose of polar bodies: to reduce the chromosome number during oogenesis.
- Update of suggested age range for women to begin having regular mammograms: between 45 and 54.
- New Concept Link on chemotaxis.
- New photomicrograph showing sperm swarming an oocyte in Figure 16.16.
- New explanation of how an egg blocks additional sperm from entering; the surface sperm receptors on an oocyte are shed after the first sperm enters the cell.
- New clarification with updated definitions of *miscarriage* and *abortion*.

Contents

Chapter 9, continued

Appendixes