To the Student

Welcome to the fascinating study of the human body! Though you and I might never meet in person, I consider you and every other student who uses this textbook to be “my” student. Just as I want to ensure the success of the students in my classroom, I am similarly invested in your success. For this reason, this book was designed with you in mind—every feature, study tool, and media presentation is intended to help you achieve your goals.

This book was written not only for you, but also about you. The great thing about human A&P is that no matter what your goals are, it is relevant to your life. Human A&P is you: it’s also me, your family, your friends, and indeed every human who ever lived or will live. There’s nothing in the study of A&P that is irrelevant or esoteric, because every single detail revolves around you and your life. How many other courses can make that claim?

So dive right in and begin to explore the science of you. I sincerely hope that you enjoy your study of human A&P and find it as fascinating and wondrous as I do.

—Dr. A.
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To the Instructor

Why I Wrote This Book

I get the question, “Why did you write this book?” quite regularly. The short answer to this is that writing and teaching are just in my DNA somewhere. For the long answer, we have to look back in time and start with my 5-year-old self.

When I was in kindergarten, I was placed with another kid, Kyle, into a separate group for reading time because we were the only two kids in the class who could already read. It struck my 5-year-old brain as inconceivable that so many of my classmates couldn’t read. Reading was so easy; anyone could do it! Maybe, I reasoned, they just needed a book to teach them how to read. So I gathered up some construction paper and crayons and got to writing. And thus my first “textbook” was born: The Bird and Mr. Bear.

Fast forward a few years to my medical school education. While in medical school, I co-taught a human physiology course, and during my first class I had one of those “aha” moments: Teaching somehow just “felt right.” I connected with my students, and they connected with me. This feeling only grew over the next two semesters. But still, I was in medical school, and who would be crazy enough to go through the pain of medical school, graduate, and then not ever practice as a physician?

Well, it turns out that I was crazy enough to do just that. I was lucky enough to find a full-time position teaching anatomy and physiology. And while I loved teaching, there were far more challenges than I had anticipated. My students were different from my former classmates. The difference wasn’t in intelligence—my students were smart. But, this new generation of students seemed to be ill prepared for the rigors of a college science course. They lacked study skills, they had little to no background in science, and—alarmingly—they couldn’t read or understand their textbooks. For these reasons, so many bright, motivated students struggled with the course.

As a teacher, this was the last thing I wanted to see. So I did the same thing I did in kindergarten: grabbed some paper and started writing. First came my own lab exercises, which were followed by lecture outlines and notes. As I wrote, I “Americanized” the content (a term coined by a student) with concise prose, simple diagrams, stories/analogies, and active-learning exercises. My students’ responses were enthusiastic; indeed, many asked if they could return their textbooks and just use my notes instead.

A vision for a new textbook began to form in my mind: one for today’s students. It would:

• be written at a level my students could understand and, at the same time, still provide the information they need;
• anticipate where they need help with the science and provide the necessary in-the-moment coaching; and
• reduce cognitive overload and present information—in both text and art—in manageable chunks that are more easily digestible.

Eight years later, in 2014, my vision finally became reality with the publication of Human Anatomy & Physiology. Today I am thrilled with the very positive response to the first edition and am happy to now be able to offer the second edition. We worked very hard to ensure that it is even stronger in motivating and helping students learn. This is what I have wanted since The Bird and Mr. Bear—to help people learn.

Key Features

Many of the key features found in this textbook, the companion workbook, Active-Learning Workbook, and media came directly from my experience teaching and working with a range of students and seeing what helps them learn. These features include the following:

• Module 1.1 How to Succeed in A&P in Chapter 1 introduces students to core study skills, including how to manage time, how to take notes, and how to study for an A&P exam. I also guide students through how to use the textbook, workbook, and online tools.
• Recurring Core Principles icons appear throughout the book and remind students to recall and apply four core principles introduced in Chapter 1: Structure-Function, Feedback Loops, Gradients, and Cell-Cell Communication.
• Over 50 Concept Boosts and Study Boosts coach students on key A&P concepts that are often difficult or complex.

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Preface

Emphasis is placed on explaining challenging topics, often incorporating familiar analogies and simple illustrations, giving students a boost in fully understanding the content.

- **Concept Boost Video Tutors** walk students through select Concept Boost topics that are particularly tough to understand. **Concept Boost Video Tutors include:**
  - Chapter 3: Understanding Water Movement in Osmosis
  - Chapter 10: How Do Positive Ions Create a Negative Resting Membrane Potential?
  - Chapter 16: Understanding the Relationship between Negative Feedback Loops and Thyroid Function
  - Chapter 21: Making Sense of the Oxygen-Hemoglobin Dissociation Curve
  - Chapter 25: How Can Respiratory Changes Compensate for Metabolic Acidosis?

These Video Tutors are assignable in MasteringA&P® and are also available in the Study Area of MasteringA&P.

- **One-concept-at-a-time art** focuses on teaching one concept per figure so that a student can instantly grasp the key idea without being distracted by a sea of details. For key physiology concepts, unique sequence figures unpack information systematically so that each scene contains only the most important information, again making it easier for today’s students to focus on key details.

- **In-text simple illustrations** appear as needed to help students visualize concepts being described.

- **Big Picture figures** visually summarize key physiological processes and anatomy concepts, highlighting only what is most important.

- Mobile-ready **Big Picture Animations** with interactive quizzes bring the Big Picture figures to life and help reinforce students’ understanding of each step in a key process. These animations are assignable in MasteringA&P and are also available in the Study Area of MasteringA&P.

- **HAPS-based Learning Outcomes** begin each module within a chapter. Additionally, the assessments in MasteringA&P are organized by these Learning Outcomes.

- **Pronunciations** use phonetic sounds (instead of traditional symbols) to help students learn correct pronunciations.

- **Flashback** questions encourage students to think about previously learned concepts they will need to apply in order to understand upcoming discussions.

- **Quick Check** questions appear throughout each module to test students’ basic understanding of the material. Answers to Quick Check questions are available in the Study Area of MasteringA&P.

- **Apply What You Learned** questions at the end of each module ask students to think critically and apply what they’ve just learned to a real-world scenario. Answers to Apply What You Learned questions can be found in Appendix A.

- **A&P in the Real World** features highlight clinical conditions and disorders that illustrate and reinforce key A&P concepts discussed in the chapter.

- **Chapter running case studies** with assessments challenge students to apply their knowledge of key A&P concepts to a real-world clinical scenario, while allowing instructors to “flip” the classroom and incorporate critical thinking and/or group activities. These cases are assignable in MasteringA&P. They can also be found in MasteringA&P both in the Instructor Resources and in the Study Area.

- **Active-Learning Workbook** provides students with a kinesthetic learning modality. It includes labeling, drawing, and build-your-own summary-table exercises that students can complete as they read the textbook. This workbook can be packaged as a print supplement with the Amerman textbook at no additional cost. It is also available in MasteringA&P as an editable Word document and as a downloadable PDF in the Instructor Resources and in the Study Area.

**What’s New in the Second Edition**

- **IMPROVED** one-concept-at-a-time art and Big Picture figures: The Amerman art program is already touted for visually unpacking concepts, making it easier for students to focus on the key ideas. The second edition of Amerman builds on this one-concept-at-a-time approach by including over 20 new or revised critical figures that conclude with Big Picture visual summaries (e.g., see newly revised The Big Picture of Chemical Synaptic Transmission, The Big Picture of Pulmonary Ventilation, The Big Picture of Tubular Reabsorption and Secretion).

- **NEW** summary tables help consolidate and summarize key information (e.g., Figure 3.5: Functions of membrane proteins; Figure 10.1: Three types of muscle tissue; Figure 12.9: Structures of the limbic system; Table 20.1: Summary of the First and Second Lines of Defense; Table 21.2: Accessory Muscles of Inspiration and Expiration).

- **EXPANDED** coaching throughout: Building off the very positive feedback to Amerman’s coaching in the first edition, the second edition features several new or revised Concept Boost discussions. The Concept Boosts help demystify foundational principles or concepts that students often find to be stumbling blocks (e.g., new Concept Boosts in Chapter 3: Is Osmosis the Diffusion of Water?; Chapter 10: Connecting the Crossbridge Cycle to the Sliding-Filament Mechanism).

- **EXPANDED animations:** 5 Big Picture Animations (for a total of 10) animate key figures from the Amerman textbook, using the same visuals, terminology, and explanations found in the book. This helps students visualize key processes and reinforces the main ideas behind the process. These animations are assignable as coaching activities in MasteringA&P and are available in the Study Area of MasteringA&P.

  The Big Picture Animations from the first edition included Chapter 3: The Big Picture of Protein Synthesis; Chapter 10: The Big Picture of Skeletal Muscle Contraction; Chapter 11: The Big Picture of Action Potentials and the Big Picture of Chemical Synaptic Transmission; and Chapter 24: The Big Picture of Renal Physiology.
The new Big Picture Animations for the second edition include:

- Chapter 16: The Big Picture of Hormonal Response to Stress
- Chapter 17: The Big Picture of Blood Flow through the Heart
- Chapter 20: The Big Picture of the Immune Response to the Common Cold
- Chapter 21: The Big Picture of Respiration
- Chapter 26: The Big Picture of Hormonal Regulation of the Ovarian and Uterine Cycles

NEW Practice Tests via QR codes at the end of every chapter provide students with quick on-the-go practice on their smartphones, tablets, and computers.

What’s New in MasteringA&P
Please see the front of this book for information on the new media and assignments for the second edition of Amerman with MasteringA&P.

Chapter-by-Chapter Changes in the Second Edition

Chapter 1: Introduction
Module 1.1: How to Succeed in Your Anatomy and Physiology Course
- “Learning styles” was changed to “learning modalities.”

Module 1.3: The Language of Anatomy and Physiology
- New A&P in the Real World box on Medical Errors has been added.
- In Figure 1.7: Regional terms, part a, the length of the bracket for Cephalic term was fixed.

Module 1.4: Organization of the Human Body
- “Dorsal” was changed to “posterior” and “ventral” to “anterior” when discussing body cavities, including in Figure 1.9: The posterior and anterior body cavities.

Module 1.5: Core Principles in Anatomy and Physiology
- Receptors in Figure 1.13: Comparison of how negative feedback mechanisms control room and body temperature, part b, were changed to those in skin.
- An additional paragraph example of positive versus negative feedback processes was added.
- Figure 1.18: Core principles icons, was updated to combine illustrations and icons with definitions and examples of each core principle.

Chapter 2: The Chemistry of Life
Module 2.2: Matter Combined: Mixtures and Chemical Bonds
- In Figure 2.6: Nonpolar versus polar covalent bonds, the number of electrons in the valence shell of the water molecule has been corrected to be eight.
- In the Concept Boost: Determining the Type of Bonds in a Molecule or Compound, three new small illustrations of the possible atomic and molecular combinations have been added.

Module 2.3: Chemical Reactions
- The text discussing Figure 2.10: Enzyme-substrate interaction, has been updated to cover each step of the process.

Module 2.4: Inorganic Compounds: Water, Acids, Bases, and Salts
- In Figure 2.11: The behavior of hydrophilic and hydrophobic molecules in water, the illustrations have been updated with larger blow-ups that show hydration spheres and label partial charges.

Module 2.5: Organic Compounds: Carbohydrates, Lipids, Proteins, and Nucleotides
- In Figure 2.23: Levels of protein structure, the primary structure (part a) has been redone to show the atomic components of the amino acid molecules, and the secondary structures (part b) have been reworked to show the atoms of the alpha helix and beta-pleated sheet structures. In addition, in part d, the quaternary structures, one chain in each structure now shows the underlying tertiary structure.
- Under ATP, a bit of additional explanation of how ATP is used as energy storage for cellular processes was added.
- In Figure 2.26: Structure of the nucleic acids DNA and RNA, the top adenine in part a has been changed to the correct purple color.

Chapter 3: The Cell
Module 3.2: Structure of the Plasma Membrane
- Figure 3.5: Functions of membrane proteins, has been made into an illustrated table.

Module 3.3: Transport across the Plasma Membrane
- The section on Osmosis has been updated to prevent the oversimplification that this process is the diffusion of water, with the addition of the concept of osmotic pressure. In addition, Figure 3.8: Passive transport: osmosis, has been reworked to clarify the concentrations of solute in all compartments. Also, the Concept Boost has been replaced with a new one—called Is Osmosis the Diffusion of Water? Taking a Closer Look—that includes a new illustration.

Module 3.4: Cytoplasmic Organelles
- In Figure 3.15: The cell and its organelles, labels have been added for additional structures such as those in the nucleus.

Chapter 4: Histology
Module 4.1: Introduction to Tissues
- The first edition (1e) A&P in the Real World box on Diseases of Collagen and Elastic Fibers has been refocused in second edition (2e) on Marfan Syndrome.

Module 4.2: Epithelial Tissues
- In Figure 4.5: Structure of simple epithelia, orientation diagrams have been added to each part showing where in the body the examples were taken from.
- In Figure 4.10: Multicellular exocrine glands, the structures of the compound acinar and compound tubuloacinar glands have been updated and clarified.
- There is now a mention of apocrine secretion under Glandular Epithelia.
Module 4.7 Membranes
- In Figure 4.24: True membranes, in part b on synovial membranes, the orientation diagram has been enlarged and clarified.

Chapter 5: The Integumentary System

Module 5.1: Overview of the Integumentary System
- Figure 5.1: Basic anatomy of the skin, has been enhanced to clarify the structures shown. This enhanced art has been used as orientation diagrams throughout the chapter as appropriate.
- In Figure 5.2: Homeostatic regulation of the body temperature by the integumentary system, part a illustrating the response to rising body temperature has been clarified by showing a brain as the site of thermoreceptors.

Module 5.5: Accessory Structures of the Integument: Hair, Nails, and Glands
- In Figure 5.9: Hair structure, part b has been redone to clarify the structure of the hair bulb.
- In Figure 5.11: Sweat glands and sebaceous glands, a new part has been added showing an illustration of an apocrine sweat gland.

Chapter 6: Bones and Bone Tissue

Module 6.2: Microscopic Structure of Bone Tissue
- In Figure 6.7: Functions of osteoblasts and osteocytes, step 3 has been reworked to show that the “arms” of the osteocytes contact each other through the canaliculi.

Module 6.3: Bone Formation: Ossification
- Figure 6.11: The process of intramembranous ossification, has been reimagined to make the structures more realistic and clearer using a horizontal layout. The steps in the figure and text have been updated to clarify the description as well.
- Figure 6.12: The process of endochondral ossification, has been enhanced to clarify the structures in the process and to make it match the visual presentation in Figure 6.11.

Module 6.4: Bone Growth in Length and Width
- Figure 6.14: Growth at the epiphyseal plate, has been reimagined to show the process more clearly.

Chapter 7: The Skeletal System

Module 7.2: The Skull
- In Figure 7.3: Cavities of the skull, and 1e Figure 7.4: Cranial vault and base, have been switched in order to cover all of the cranial cavity before discussing other cavities.
- In Table 7.2: Bones of the skull, view identification labels have been added to all illustrations to keep students oriented.
- In Figure 7.7: Posterior, superior, and inferior views of the skull, in part c the position and extent of the vomer have been clarified.
- In Figure 7.9: Internal view of the skull, the labels have been repositioned to clarify relationships between the bones and their components.

Chapter 8: Articulations

Module 8.1: Overview of Joints
- The first module has been broadened to include an overview of joint function (moved from the 1e chapter introduction) and joint classification.

Module 8.2: Fibrous and Cartilaginous Joints
- The information on fibrous and cartilaginous joints has now been combined into the second module.
- In Figure 8.2: The two types of cartilaginous joints, the epiphyseal plate in part a has been redone to look more realistic.

Module 8.6: Types of Synovial Joints
- In A&P in the Real World, Knee Injuries and the Unhappy Triad, the text and illustration have been reworked to discuss and show the tear in the lateral meniscus.
- Figure 8.15: Anatomical structure of the shoulder joint, has been reimagined. It now has a new part a showing an anterior view of the articular capsule, and a new part c showing a frontal section.

Chapter 9: The Muscular System

Module 9.1: Overview of Skeletal Muscles
- Under Structure of Skeletal Muscles, the subheading Gross Anatomy of a Skeletal Muscle has been added to point out this coverage.
- Figure 9.2: Fascicle pattern and muscle shape, has been rearranged to clarify the relationship between the muscles and the different shapes.
- Under Lever Systems and in Figure 9.5: Lever systems, the text and illustrations have been updated to use some new analogies.
- The 1e Concept Boost on Understanding Lever Systems and Mechanical Advantage has been replaced by a Study Boost on How to Tell the Three Types of Levers Apart that uses simplified illustrations of these concepts.

Module 9.2: Muscles of the Head, Neck, and Vertebral Column
- Figure 9.10: Muscles of chewing, part b, has been replaced with a lateral view showing the pterygoid muscles.
- The Concept Boost on Demystifying Muscle Actions now includes an illustrated example using the muscles of the jaw, so the Boost has been moved up to follow the Muscles of Mastication subsection.
- In Figure 9.13: Muscles of the vertebral column, parts a and b have been combined into a single part, which shows the erector spinae group on the left side of the torso and the transversospinalis group on the right side. Part b is now the cadaver photo.
- The 1e Study Boost: Sorting Out the Erector Spinae has been deleted.

Module 9.4: Muscles of the Pectoral Girdle and Upper Limb
- In Figure 9.18: Muscles that move the scapula, the label Rotator cuff has been added.

Module 9.5: Muscles of the Hip and Lower Limb
- In Figure 9.21: Anterior and medial muscles that move the thigh and leg, parts b and c have been switched.
Chapter 10: Muscle Tissue and Physiology

Module 10.1: Overview of Muscle Tissue
- Figure 10.1: Three types of muscle tissue, has been made into an illustrated table with additional information on the location, structure, and function of each tissue type.

Module 10.2: Structure and Function of Skeletal Muscle Fibers
- The text section called Myofilament Arrangement and the Sarcomere (with 1e Figure 10.7: Structure and bands of the sarcomere, now 2e Figure 10.6) has been moved before Putting It All Together: The Big Picture of Skeletal Muscle Structure. In addition, the sarcomere has now been labeled in 1e Figure 10.6: The Big Picture of Levels of Organization within a Skeletal Muscle (2e Figure 10.8).
- Figure 10.9: The sliding-filament mechanism, has been reworked to show one relaxed sarcomere above one contracted, with all bands indicated in both.

Module 10.3: Skeletal Muscle Fibers as Electrically Excitable Cells
- Several subsections from 1e Chapter 11 (Nervous Tissue) have been moved here in order to present a more complete explanation of action potentials. These subsections, which include Ion Channels and Gradients, Generation of the Resting Membrane Potential, and The Electrochemical Gradient (with the included figures), replace the 1e section called The Na⁺/K⁺ ATPase Pump and the Sodium and Potassium Ion Concentration Gradients. The Concept Boost on How Do Positive Ions Create a Negative Resting Membrane Potential has also been moved here.
- Several ion channels have been added to the depictions of the axon terminal structure and function in 2e Figures 10.14 and 10.15 (1e Figures 10.12 and 10.13).

Module 10.4: The Process of Skeletal Muscle Contraction and Relaxation
- A new Concept Boost on Connecting the Crossbridge Cycle to the Sliding-Filament Mechanism has been added.

Module 10.6: Muscle Tension at the Fiber Level
- The 1e Concept Boost on Understanding How Events at the Myofilaments Produce Tension of a Whole Muscle has been deleted.

Chapter 11: Introduction to the Nervous System and Nervous Tissue

Module 11.1: Overview of the Nervous System
- In Figure 11.3: Summary of the structural and functional divisions of the nervous system, the presentation of the information has been reworked, and illustrations of example organs for the divisions have been added.

Module 11.3: Electrophysiology of Neurons
- A reminder section on Generation of the Resting Membrane Potential has been added, to take into account the sections on this subject that have been moved to Chapter 10.
- 1e Figure 11.11: Measurement of voltage across a plasma membrane, has been added as an orientation diagram to 1e Figure 11.14: Ion movements leading to changes in the membrane potential, forming 2e Figure 11.11 on ion movements.
- The Big Picture of Action Potentials, 1e Figure 11.20, now 2e Figure 11.17, has been enlarged and updated so the depictions of structures are clearer and more 3D.

Module 11.4: Neuronal Synapses
- The section now called Summation of Postsynaptic Potentials and Neural Integration has been moved before the section on Termination of Synaptic Transmission to reflect the chronological order of these processes.
- What was 1e Figure 11.22: The structures of electrical and chemical synapses, now 2e Figure 11.19, has been reworked to focus more on the blow-ups showing the channels and receptors.
- The 1e Concept Boost called How Summation Connects Local Potentials and Action Potentials has been deleted and the information incorporated into the Big Picture of Chemical Synaptic Transmission, 1e Figure 11.26, now 2e Figure 11.25, to illustrate the entire process in one place.
- A new illustrated Concept Boost has been added on Sorting Out the Different Types of Channels and Pumps in the Membrane of a Neuron.
- 1e Figure 11.25: Methods of termination of synaptic transmission, now 2e Figure 11.23, has been reworked to add a blow-up showing events at the synaptic cleft more clearly.

Chapter 12: The Central Nervous System

Module 12.1: Overview of the Central Nervous System
- A new A&P in the Real World box on The Myth of Brain Differences between the Sexes has been added. This box has the new subtitle Pseudoscience Exposed. This subtitle has been added to appropriate A&P boxes throughout the text.

Module 12.2: The Brain
- The section on The Limbic System has been moved after the sections on Basal Nuclei and White Matter.
- A table of information has been added to Figure 12.9: Structure of the Limbic System, to make the information more accessible.

2e Module 12.3: Homeostasis Part I: Role of the Brain in Maintenance of Homeostasis
2e Module 12.4: Higher Mental Functions
- The modules on Homeostasis Part I: Role of the Brain in Maintenance of Homeostasis and Higher Mental Functions have been moved up in the chapter to follow Module 12.2: The Brain, in order to have the discussion of brain functions follow that of brain structures directly.

Chapter 13: The Peripheral Nervous System

Module 13.3 Spinal Nerves
- In Figure 13.4: Structure and function of roots, spinal nerves, and rami, the depiction of the rami communicantes has been reworked to clarify them.
- Under Brachial Plexus, there is a new Concept Boost called Sorting Out the Brachial Plexus, with a new schematic illustration.
- In Figure 13.9: The sacral plexus, text was rearranged to clarify the relationships.
Chapter 16: The Endocrine System

Module 16.1: Overview of the Endocrine System
- A new Figure 16.1 called Overview of Hormone Function has been added.
- The 1e section Types of Chemical Signals is now called Paracrine and Autocrine Signals to reflect the clarified text.
- The second half of the module under the heading Hormones has been reorganized. We now introduce Classes of Hormones first, then a new subsection on Hormone Transport through the Blood. Then we get to Target Cells and Receptors, followed by Mechanisms of Hormone Action. This is followed up with Effects of Hormone Actions, then Hormone Interactions, and a new subsection gathering information on Hormone Half-Life and Elimination. Regulation of Hormone Secretion is its own section following Hormones.
- 1e Figure 16.3 on mechanisms of hormone action has been split into two figures. The first, 2e Figure 16.4, now presents a G-protein second-messenger system; it is titled Mechanism of action of hydrophilic hormones via an adenylate cyclase–cAMP second-messenger system. The second, 2e Figure 16.5, is titled Mechanism of action of hydrophobic hormones via an intracellular receptor mechanism.

Module 16.2: The Hypothalamus and the Pituitary Gland
- All figures in the chapter that depict the anterior and posterior pituitary glands, particularly 2e Figures 16.8 and 16.9 (1e Figures 16.6 and 16.7), now show clarified anatomy of the infundibulum.

Module 16.3: The Thyroid and Parathyroid Glands
- MIT and DIT have been added to the discussion of thyroid hormone synthesis and its depiction in 2e Figure 16.15 (1e Figure 16.13).

Chapter 17: The Cardiovascular System I: The Heart

Module 17.1: Overview of the Heart
- A new part has been added to Figure 17.1: Location and basic anatomy of the heart in the thoracic cavity, showing the mediastinum in a transverse section. What was part c of this figure, on the heart chambers, has now been split off into a separate figure, 2e Figure 17.2.

Module 17.2: Heart Anatomy and Blood Flow Pathway
- In what was 1e Figure 17.3, now 2e Figure 17.4, on the pericardium and layers of the heart wall, a new blow-up has been added to part b showing the heart wall layers in more detail.
- A cadaver photo has been added to 2e Figure 17.6: The internal anatomy of the heart (1e Figure 17.5).
- The Big Picture of Blood Flow through the Heart, 2e Figure 17.8, has been reworked to be shown as a cycle.
- The section on Coronary Circulation has been moved after the sections on heart internal anatomy and blood flow.
- A new A&P in the Real World box on Thoracotomy was added.

Module 17.3: Cardiac Muscle Tissue Anatomy and Electrophysiology
● A new blow-up and a light micrograph have been added to 1e Figure 17.9, now 2e Figure 17.10: Cardiac muscle cells.
● The section on Electrophysiology of Cardiac Muscle Tissue: Pacemaker Cells has been moved before the section on Electrophysiology of Cardiac Muscle Tissue: Contractile Cells.

Chapter 18: The Cardiovascular System II: The Blood Vessels

Module 18.2: Physiology of Blood Flow
● Figure 18.4: Factors that determine blood pressure, has been changed to show vessel radius (rather than diameter) to match the text discussion.
● A new Concept Boost called Taking a Closer Look at Systemic Arterial Pressure.

Module 18.3: Maintenance of Blood Pressure
● The text under Nervous System Maintenance of Blood Pressure—and Figure 18.7: Effects of the autonomic nervous system on blood pressure, Figure 18.8: Maintaining homeostasis, and Figure 18.9: Blood pressure maintenance—have all been updated to emphasize that it is not parasympathetic neurons that cause vasodilation, but the autonomic centers in the brainstem inhibiting sympathetic neurons.
● The 1e A&P in the Real World box on Carotid Sinus Massage has been replaced by one on Vasovagal Syncope. A brief discussion of carotid sinus massage has been moved into the text.

Module 18.5: Capillary Pressures and Water Movement
● The discussion of osmotic pressure has been updated to match the current explanation of osmosis in 2e Chapter 3.

For the same reason, the 1e Concept Boost on Understanding the Pulling Force of Osmotic Pressure has been replaced. In its place there is a Study Boost called Another Way to Think about Hydrostatic and Osmotic Pressure.

Chapter 19: Blood

Module 19.2: Erythrocytes and Oxygen Transport
● The dimensions of a red blood cell have been added both to the text under Erythrocyte Structure and to Figure 19.2: Erythrocyte structure.
● In Figure 19.3: Hemoglobin structure, an orientation diagram of the depiction of hemoglobin from Figure 19.2 has been added, and the heme in oxyhemoglobin has been deleted.

Module 19.4: Platelets
● A new Putting It All Together: The Big Picture of Formed Elements section has been added to the end of this module, with a new two-page Big Picture figure, 2e Figure 19.11, of the same name.

Module 19.5: Hemostasis
● Under Hemostasis Part 3: Coagulation, the newer term contact activation pathway has been added as an alternate for intrinsic pathway, as well as tissue factor pathway as an alternate for extrinsic pathway. These terms have also been added to 2e Figure 19.14: Hemostasis Part 3: Coagulation cascade.

Chapter 20: The Lymphatic System and Immunity

Module 20.1: Structure and Function of the Lymphatic System
● In Figure 20.7: Location and structure of lymph nodes, the lymph node section in part c has been redrawn for clarity and to make it more 3D. In addition, a bit more explanation of these structures has been added to the text under Lymph Nodes.

Module 20.3: Innate Immunity: Internal Defenses
● Under Phagocytes, additional information about dendritic cells has been added.
● Under Complement, the lectin pathway has been added to both the text and to Figure 20.10: Pathways for activation of the complement system.

Module 20.4: Adaptive Immunity: Cell-Mediated Immunity
● The new Antigens subsection at the beginning of the module emphasizes coverage of this subject.
● In the Concept Boost called Why Do We Need Both Class I and Class II MHC Molecules?, the CD4 molecule has been added to the illustration of the TH cell, and the CD8 molecule to the illustration of the TC cell.
● Figure 20.15: T cell activation, clonal selection, and differentiation, has been updated to show a dendritic cell displaying antigenic fragments to TH and TC cells. The clones produced by both of these types of cells are now shown to differentiate into both memory and effector cells. Explanation of the role of dendritic cells in this process has been added to the text section called T Cell Activation, Clonal Selection, and Differentiation.
● In Figure 20.16: Effects of TH cells, a macrophage is now shown presenting an antigen fragment to and activating the TH cell.

Module 20.5: Adaptive Immunity: Antibody-Mediated Immunity
● Figure 20.19: B cell activation, clonal selection, and differentiation, has been updated with the addition of CD4 molecule to the TH cell.

Module 20.6: Putting It All Together: The Big Picture of the Immune Response
● Figures 20.24, 20.25, and 20.26 are the Big Picture figures of the immune response to the common cold, a bacterial infection, and cancer cells, respectively. All of them have been updated to show the role of the dendritic cell. In addition, CD4 and CD8 molecules have been added as appropriate. The text for each of these has been updated to match these changes.
Chapter 21: The Respiratory System

Module 21.1: Overview of the Respiratory System
- In 1e Figure 21.2, The conducting and respiratory zones of the respiratory system, has been deleted, as these concepts are shown in Figure 21.1.

Module 21.2: Anatomy of the Respiratory System
- The illustration of 1e Figure 21.5, Anatomy of the pharynx, (now 2e Figure 21.4) has been extended, using the 1e figure as an orientation diagram to a new larger illustration showing the pharynx with the tonsils and larynx for context.
- In 1e Figure 21.8 (now 2e Figure 21.7), Anatomy of the trachea, a new blow-up of the carina has been added.

Module 21.3: Pulmonary Ventilation
- Under The Process of Pulmonary Ventilation, there are new subsections called Pressure Gradients of Ventilation, which introduces atmospheric, intrapulmonary, and intrapleural pressures, and Mechanics of Inspiration and Expiration, which replaces Volume Changes during Ventilation.
- In the text on Mechanics of Inspiration and Expiration, more discussion of the accessory muscles has been added. In addition, there is a new Table 21.2 on accessory muscles of inspiration and expiration.
- In Figures 21.14–21.16 (now 2e Figures 21.13–21.15), on pressure and volume changes in pulmonary ventilation as well as the Big Picture figure, are now presented as cycles, with the addition of step 5 Between inspiration and expiration. What was 1e Figure 21.15 has been moved up to become 2e Figure 21.13, to match the text changes, with the other figures renumbered accordingly. 2e Figure 21.15, The Big Picture of Pulmonary Ventilation, has been extended to a full page, with the addition of the pressures involved.

Module 21.5: Gas Transport through the Blood
- In 1e Figure 21.25 (2e Figure 21.24), Transport of carbon dioxide, the illustrations have been enlarged to make the information more accessible.
- A new Concept Boost called How Does a Buffer Work? has been added.
- The 1e Concept Boost on Relating Ventilation and Blood pH is now a Study Boost.

Module 21.7: Neural Control of Ventilation
- In 1e Figure 21.28, now 2e Figure 21.27: Neural control of the basic pattern of ventilation, the information has been updated to include the respiratory pattern generator (RPG), and to show the nuclei for the glossopharyngeal and vague nerves in the brainstem and those nerves innervating the lung and heart.
- The RPG is now also shown in 1e Figure 21.29, now 2e Figure 21.28: Role of the central chemoreceptors in regulation of blood pH via regulation of blood pH via the rate of ventilation.
- In 1e Figure 21.30: Role of the peripheral chemoreceptors has been deleted. Note that the text section on this is still included, however.
- Under Control of the Rate and Depth of Ventilation, a new subsection called Voluntary Control has been added.

Chapter 22: The Digestive System

Module 22.1: Overview of the Digestive System
- After the section Basic Digestive Functions and Processes, this module has been reorganized. Next there is a new section called Organization of the Digestive System, with subsections on Peritoneal Membranes, Blood and Nerve Supply, and Histology of the Alimentary Canal. Following this is the moved section Regulation of Motility by the Nervous and Endocrine Systems. In the process of this reorganization, Figure 22.2 is now The abdominopelvic cavity, whereas Figure 22.3 is The basic tissue organization of most of the alimentary canal.

Module 22.3: The Stomach
- Under Stomach Mucosa: Gastric Glands, the term enteroendocrine cells has been replaced with diffuse neuroendocrine system (DNES) cells.

Module 22.6: The Pancreas, Liver, and Gallbladder
- In Figure 22.22: Gross anatomy of the liver, the orientation diagram for part b has been replaced with a posteroinferior view.
- The A&P box called Do We Really Need to “Detox”? has been given the new subtitle Pseudoscience Exposed.
- In Figure 22.26: Secretion of bile, the structures shown in the figure have been rearranged for clarity in understanding the process.

Module 22.7: Nutrient Digestion and Absorption
- Under Lipid Digestion, a new Study Boost called An Analogy to Understanding Emulsification has been added.

Chapter 23: Metabolism and Nutrition

Module 23.2: Glucose Catabolism and ATP Synthesis
- The Concept Boost called Why Do We Breathe? has been reworked to separate the discussion into two questions: Why do we inhale oxygen, and why do we exhale the carbon dioxide we produce?
- The Concept Boost now called ATP Yield from Oxidative Catabolism has been reworked to clarify the text and make it more relatable to students.

Module 23.4: Anabolic Pathways
- In Figure 23.14: The Big Picture of Nutrient Anabolism, organ and cell illustrations have been added to appropriate steps to clarify where these processes are occurring.

Module 23.6: The Metabolic Rate and Thermoregulation
- The subtitle Pseudoscience Exposed has been added to the A&P in the Real World box called “Rev” Your Metabolism.
- In Figure 23.18: Maintaining homeostasis: regulation of core body temperature by negative feedback loops, part b, in response to falling body temperature, the fact that the receptors are primarily in the skin rather than the hypothalamus has been clarified.
Module 23.7: Nutrition and Body Mass
- The subtitle Pseudoscience Exposed has been added to the A&P in the Real World box called Vitamin and Mineral Megadoses.

Chapter 24: The Urinary System
Module 24.4: Renal Physiology I: Glomerular Filtration
- In Figure 24.12, Filtration and the filtration membrane, a new blow-up part a has been added that shows a glomerular capillary and podocyte, leading to the existing illustration of a section through the filtration membrane, now part b.
- In Figure 24.13: Net filtration pressure in the glomerular capillaries, a blow-up illustrated table has been added, showing whether the pressures favor or oppose filtration.

Module 24.5: Renal Physiology II: Tubular Reabsorption and Secretion
- Figure 24.19, The Big Picture of Tubular Reabsorption and Secretion, has been reimagined to move the substances being reabsorbed and secreted closer to where these processes are occurring. Blow-up boxes with illustrations of substance movement along the tubules are now shown.

Module 24.6: Renal Physiology III: Regulation of Urine Concentration and Volume
- Part b of Figure 24.21: The countercurrent multiplier in the nephron loop, has moved into the text as part of the Concept Boost on Demystifying the Countercurrent Multiplier.
- Figure 24.22 has been reworked to focus more on the medullary osmotic gradient. It has been retitled Maintenance of the medullary osmotic gradient by the vasa recta and the countercurrent exchanger.

Module 24.10: The Big Picture of Urine Formation, Storage, and Excretion
- There is a new Module 24.10: The Big Picture of Urine Formation, Storage, and Elimination with a new Big Picture figure, Figure 24.28, of the same name.

Chapter 25: Fluid, Electrolyte, and Acid-Base Homeostasis
Module 25.2: Fluid Homeostasis
- Under Movement of Water between Compartments, three new subsections have been added to update the discussion to match the new explanation of osmosis in Chapter 3: The Cell. These subsections are called Hydrostatic Pressure, Osmotic Pressure and Tonicity, and How Hydrostatic Pressure and Osmotic Pressure Influence Water Movement.
- Figure 25.4: Fluid movement between compartments has been updated to go with the new text discussion.

Module 25.4 Acid-Base Homeostasis
- A new A&P in the Real World box called Pseudoscience Exposed: Alkaline Diets was added.

Chapter 26: The Reproductive System
- All figures that show the pituitary glands have been updated in this chapter to match the clarified illustration used in 2e Chapter 16.

Module 26.1: Overview of the Reproductive System and Meiosis
- The 1e Concept Boost called Comparing Mitosis and Meiosis has been made into a regular text section, in order to incorporate Figure 26.2: Comparing meiosis and mitosis, into the discussion.

Module 26.3: Physiology of the Male Reproductive System
- Figure 26.7: Spermatogenesis in the seminiferous tubules, has been changed to clarify the process.

Module 26.5: Physiology of the Female Reproductive System
- In Figure 26.14, the right half of the figure that showed the development of a follicle has been deleted, as this information is shown in Figure 26.15. 2e Figure 26.14 has been retitled The stages of oogenesis.
- The 1e section Hormonal Control of Female Reproduction has been retitled Ovarian Follicles and the Ovarian Cycle to better represent the section’s content. The 1e subheading Comparison of Oogenesis and Follicle Development has been deleted, as it was superseded by the new heading; the content of this subsection is still in the text.
- In Figure 26.15: The ovarian cycle, labels for the three phases of the cycle have been added.
- The Uterine Cycle has now been made an overall heading; this section includes the new subheading Phases of the Uterine Cycle as well as the 1e subheading Hormonal Control of the Uterine Cycle. The content of the section is very similar to that in 1e.
- In Figure 26.19: The Big Picture of Hormonal Regulation of the Ovarian and Uterine Cycles, new illustrations of all parts of the ovarian cycle have been added, as well as new explanatory text and labels.

Chapter 27: Development and Heredity
Module 27.2: Pre-embryonic Period: Fertilization through Implantation
- Under Development of Extraembryonic Membranes, explanatory text has been added under the subheading Allantois.

Module 27.4: Fetal Period: Week 9 until Birth
- In Figure 27.10: Development during the fetal period, the part descriptions under the photos have been corrected to identify the conceptus as a fetus.
- In Figure 27.11: Comparison of fetal and newborn cardiovascular systems, the oxygenation of the blood in various parts of the systems has been clarified using the representative colors.

Appendix
NEW Appendix on the Scientific Method
Believe it or not, this book you are now holding has been about 12 years in the making—over 9 years for the first edition and nearly 3 for the second edition. When I first started writing it, my daughter wasn’t even 2 years old; now she is an eighth grader. But I was certainly not alone on this journey, as a huge number of people were involved in bringing this book to life. Saying a simple “thank you” in the acknowledgments seems so insufficient given the quality and quantity of their contributions, but these thanks are genuine and heartfelt.

I will start with my family because they have gone on this journey with me through both editions. Were it not for the help and understanding of my husband Chris Amerman, my daughter Elise, my mother Cathy Young, and my dear friend David Ferguson, this book would have never been completed. They served as a source of unwavering support, encouragement, and ideas. Elise is also very patient with how much I have to work, and I am so thankful for that. I realize that it isn’t easy having a mom who works 7 days a week, 12 hours per day, always chasing another deadline, so thank you for your understanding. I should also thank my dogs for dropping toys in the middle of my laptop, and my cats for never failing to do precisely the least helpful thing possible.

A special thank you must be extended to the brilliant Lourdes Norman-McKay, who has been such an amazing friend and source of support. Chris, Elise, and I have been so fortunate to get to know her and her family. I can’t wait to read her textbook, and, hey, I won’t just read the ending of the book—I’ll definitely start at the beginning and read it all the way through!

Next is the core team of the book, whom I’ve come to think of as parts of the brain, each performing absolutely vital functions that maintained homeostasis of the whole book. First is Serina Beauparlant, who, as editor-in-chief, is our brainstem. She has tirelessly performed all of those critical behind-the-scenes functions, ranging from wrangling budgets and securing administrative support to running focus groups and analyzing reviewer feedback. It has been Serina’s driving force that kept the book alive over these long years. Simply put, without her, there would be no book.

Our team’s cerebral hemispheres are our two brilliant developmental editors, Suzanne Olivier and Laura Southworth. As our text development editor, Suzanne is the left cerebral hemisphere. Her ability to logically and patiently approach a chapter from a “big picture” perspective ensures our chapters maintain a consistent narrative flow. It’s impossible to overstate her role—not only does Suzanne always manage to find a chapter’s sticking points, but she also always proposes solutions to these problems that make the chapter better. The readability, logical flow, and text-art coordination of this book are largely due to Suzanne’s efforts.

Laura Southworth, as our art development editor, is the right cerebral hemisphere. Laura not only is a very talented artist but also has an incredible ability to analyze a figure and work magic to make it teach better. This is in part due to her amazing skill for visual-spatial layout (a skill I absolutely lack), which is arguably the most important part of a figure. No matter what we gave her or how rough our ideas or sketches, Laura turned it into gold. This is why “Let’s ask Laura” is our mantra when Suzanne and I are working on a chapter. Any time we are perplexed by a figure, Laura unfailingly finds a solution.

The role of team thalamus was played by content producer Jessica Picone, who is new to the team for the second edition. This is a high compliment, as without a functional thalamus, absolutely nothing can get done! Jessica has been a wonderful addition to the team, and I feel very fortunate to be working with her. Like the thalamus, Jessica skillfully manages to monitor, process, and sort absolutely all material for the chapters and supplements for this project. Basically, everything goes through Jessica, and without her ability to juggle it all, we would be lost.

Rounding out the team is Barbara Yien, our cerebellum. Barbara has been involved with this project from the very start, first as a project editor and now as Courseware Director, Content Development. Her even-keeled approach has helped trouble-shoot scheduling, budgeting, and our marketing efforts. Whenever we come to a sticking point, we look to Barbara, who always manages to find a way to correct the “motor error” and keep everything balanced and on track.

(Now that I’ve written this, I’m wondering exactly what part of the brain I represent on the team. The basal nuclei? Maybe the hypothalamus? Hopefully not the pineal gland, as I don’t want to make my students sleepy . . .)

Every member of this core “brain” team deserves the highest praise for their skills, dedication, and willingness to persistently climb the mountain that was this book. I am beyond grateful to them for this, and I am also deeply thankful for their friendship. I’d also like to recognize our new editor Jennifer McGill Walker, with whom I can’t wait to start working—the third edition is just around the corner!

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