GLOBAL EDITION

Fundamentals of Anatomy & Physiology

TENTH EDITION

Frederic H. Martini • Judi L. Nath • Edwin F. Bartholomew

ALWAYS LEARNING

PEARSON

Chapters

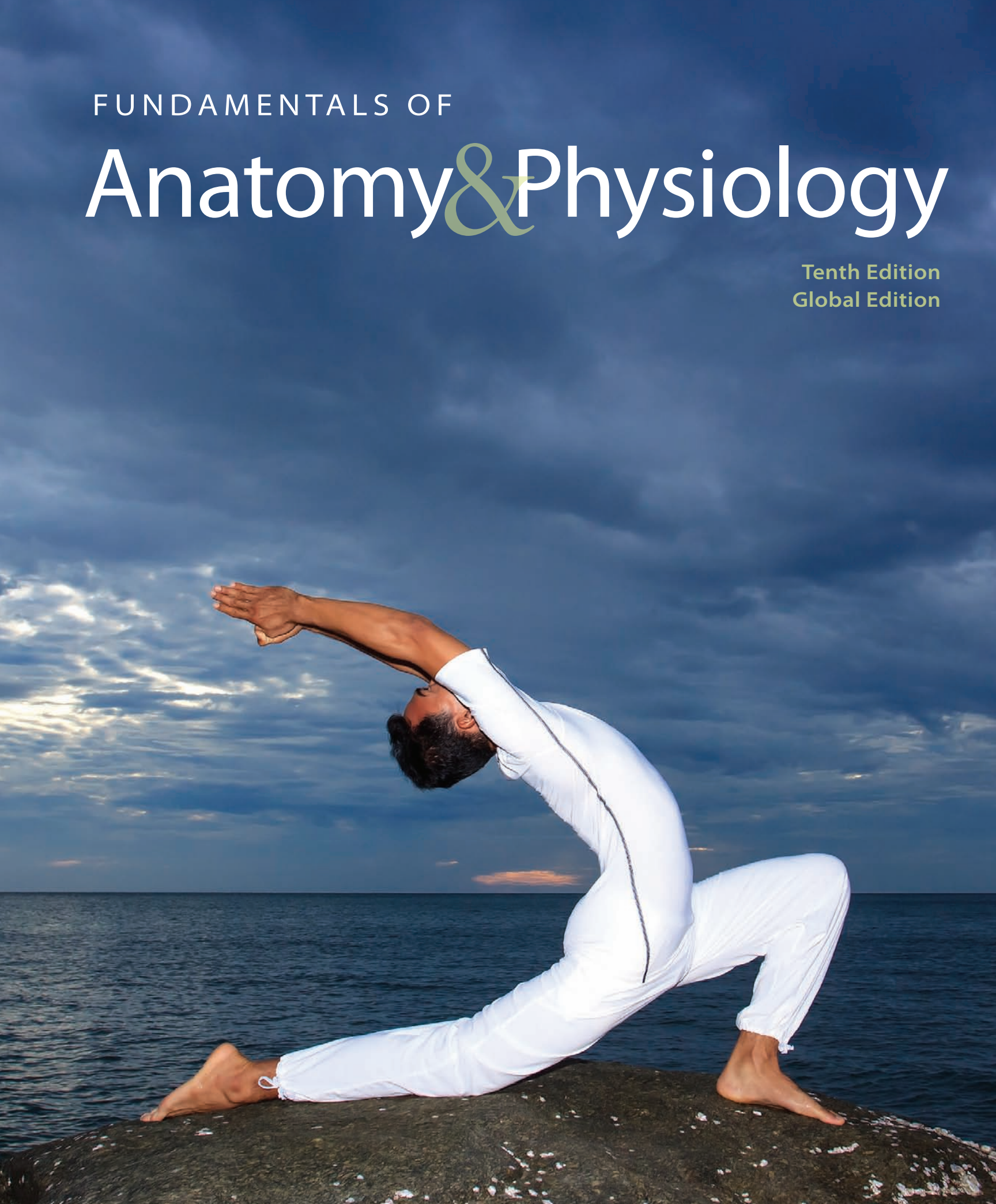
Clinical Cases

Spotlight Figures

FUNDAMENTALS OF

Anatomy & Physiology

Tenth Edition
Global Edition

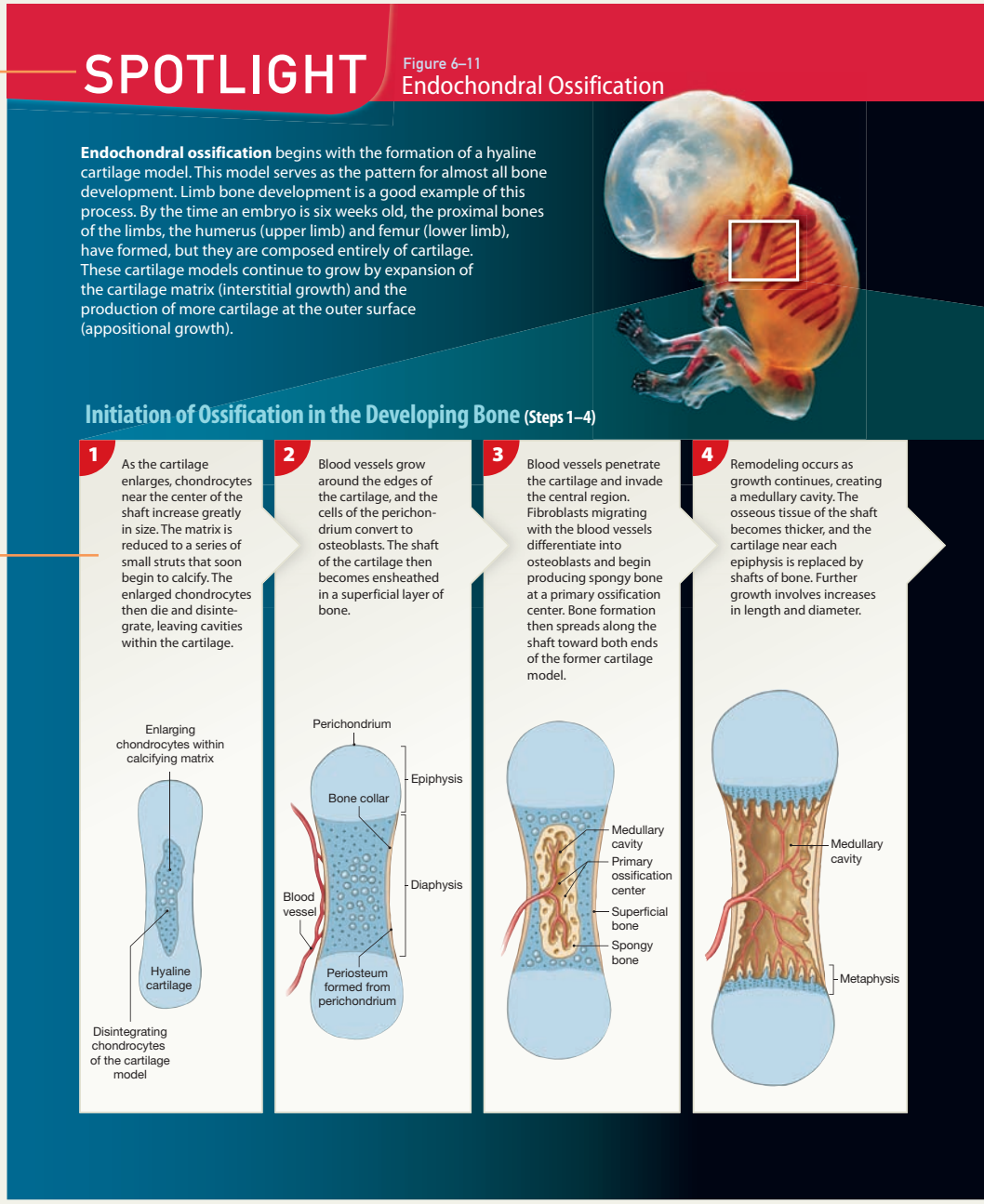


Spotlight Figures

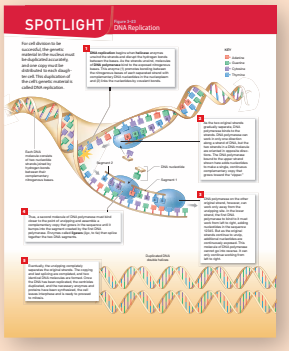
Spotlight Figures

are one- or two-page presentations that integrate text and art to communicate physiological, organizational, or clinical information in a visually effective format.

Clear steps use text and art to guide students through complex processes.

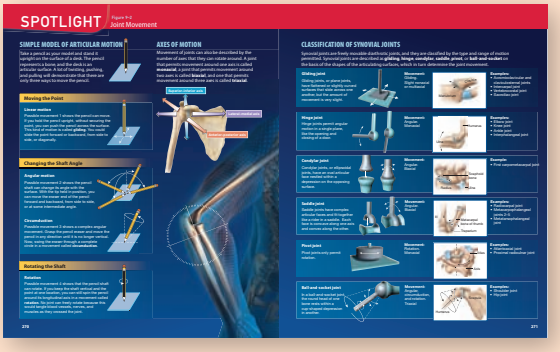


NEW The Tenth Edition has 18 new Spotlight Figures for a total of 50, including at least one in every chapter.



DNA Replication

Chapter 3, page 128



Joint Movement

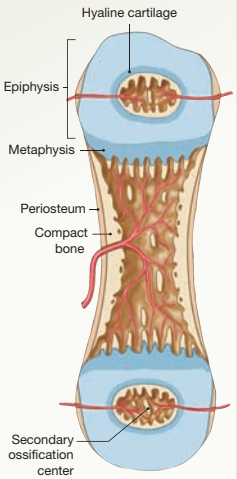
Chapter 9, pages 296-297

Watch the MasteringA&P® > A&P Flix on Endochondral Ossification.

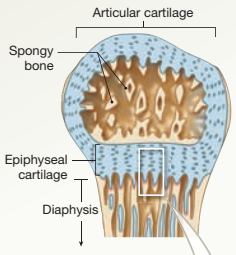
Increasing the Length of a Developing Long Bone (Steps 5–7)

During the initial stages of ossification, osteoblasts move away from the primary ossification center toward the epiphyses. But they do not complete the ossification of the model immediately, because the cartilages of the epiphyses continue to grow. The region where the cartilage is being replaced by bone lies at the metaphysis, the junction between the diaphysis and an epiphysis. On the diaphyseal (shaft) side of the metaphysis, osteoblasts continually invade the cartilage and replace it with bone, while on the epiphyseal side, new cartilage is produced at the same rate. The situation is like a pair of joggers, one in front of the other. As long as they are running at the same speed, they can run for miles without colliding. In this case, the osteoblasts and the epiphysis are both "running away" from the primary ossification center. As a result, the osteoblasts never catch up with the epiphysis, and the bone continues to grow longer and longer.

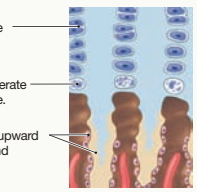
5 Capillaries and osteoblasts migrate into the epiphyses, creating secondary ossification centers.



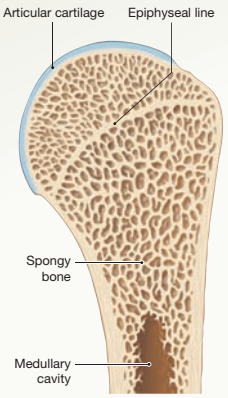
6 The epiphyses eventually become filled with spongy bone. The metaphysis, a relatively narrow cartilaginous region called the **epiphyseal cartilage**, or *epiphyseal plate*, now separates the epiphysis from the diaphysis. On the shaft side of the metaphysis, osteoblasts continuously invade the cartilage and replace it with bone. New cartilage is produced at the same rate on the epiphyseal side.



Within the epiphyseal cartilage, the chondrocytes are organized into zones.



7 At puberty, the rate of epiphyseal cartilage production slows and the rate of osteoblast activity accelerates. As a result, the epiphyseal cartilage gets narrower and narrower, until it ultimately disappears. This event is called **epiphyseal closure**. The former location of the epiphyseal cartilage becomes a distinct **epiphyseal line** that remains after epiphyseal growth has ended.



A thin cap of the original cartilage model remains exposed to the joint cavity as the **articular cartilage**. This cartilage prevents damaging the joint from bone-to-bone contact.

NEW There is one coordinating Spotlight Figure for every A&P Flix available in MasteringA&P.

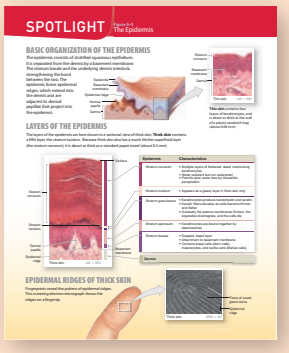
The explanation is built directly into the illustration for efficient and effective learning.

The all-in-one-place presentation means no flipping back and forth between narrative and illustration to get the full story.

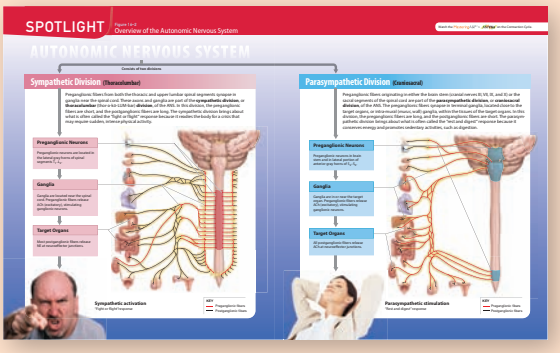
MasteringA&P®

NEW Spotlight Figure Coaching Activities

One Spotlight Figure in each chapter now has an assignable Coaching Activity in MasteringA&P.



The Epidermis
Chapter 5, page 180



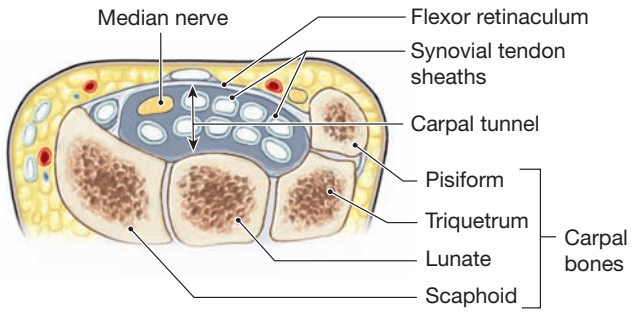
Overview of the Autonomic Nervous System
Chapter 16, pages 560-561

Clinical Content

Clinical Notes appear within every chapter, expand upon topics just discussed, and present diseases and pathologies along with their relationship to normal function.

Clinical Note

Carpal Tunnel Syndrome The carpal bones articulate with one another at joints that permit limited sliding and twisting. Ligaments interconnect the carpal bones and help stabilize the wrist joint. The tendons of muscles that flex the fingers pass across the anterior surface of the wrist. These tendons are sandwiched between the intercarpal ligaments and a broad, superficial transverse ligament called the *flexor retinaculum*. Inflammation of the connective tissues between the flexor retinaculum and the carpal bones can compress the tendons and the adjacent *median nerve*. The result is pain, weakness, and reduced wrist mobility. This condition is called *carpal tunnel syndrome*.



Cross section of right wrist (palm up)

Related Clinical Terms end every chapter with a list of relevant clinical terms and definitions.

Related Clinical Terms

ankylosing spondylitis: A chronic, progressive inflammatory disease of the intervertebral spaces that causes abnormal fusion of the vertebrae.

arthroplasty: The surgical reconstruction or creation of an artificial joint.

arthroscopy: Insertion of a narrow tube containing optical fibers and a tiny camera (arthroscope) directly into the joint for visual examination.

joint mice: Small fibrous, cartilaginous, or bony loose bodies in the synovial cavity of a joint.

Lyme disease: An infectious disease transmitted to humans from the bite of a tick infected with *Borrelia burgdorferi*, causing flu-like symptoms and joint pain.

pannus: Granulation tissue (combination of fibrous connective tissue and capillaries) forming within a synovial membrane, which releases cartilage-destroying enzymes.

Examples of Clinical Notes:

Congenital Talipes Equinovarus

Chapter 8, page 284

Abnormal Bone Development

Chapter 6, page 222

AIDs

Chapter 22, page 845

NEW | Clinical Cases get students motivated for their future careers.
Each chapter opens with a story-based Clinical Case related to the chapter content.

CLINICAL CASE

When Your Heart Is in the Wrong Place

Five-year-old Jackson came home from kindergarten with yet another ear infection. He is a happy child with a great appetite, but he can't seem to stay healthy. His nose is constantly plugged, and he always has a nasty cough. Sometimes he coughs so hard he vomits.

Jackson has been checked for cystic fibrosis, a genetic disease that causes thick, sticky, mucus secretions, to be sure this was not the cause of his earaches and chronic cough. There are no pets or smokers in the home.

Because this cough has gone on so long, Jackson is now getting a chest x-ray. The radiology technologist asked if she could take another film and carefully checked to be sure she had the "right" marker on Jackson's right side.

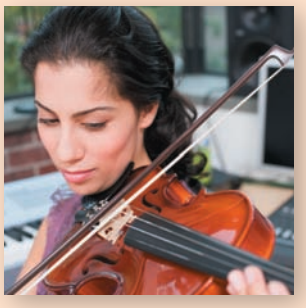
"Now that's funny," the tech said. "It looks like this x-ray is backward, but I know I took it correctly. Jackson's heart must be on the wrong side." **Could Jackson's heart really be on the wrong side? To find out, turn to the Clinical Case Wrap-Up on p. 112.**

| Each chapter ends with a Clinical Case Wrap-Up that incorporates the deeper content knowledge students will have gained from the chapter.

Examples of Clinical Cases:

A Case of Child Abuse?
Chapter 6, page 205

A Chance to See
Chapter 17, page 590



A Real Eye Opener
Chapter 10, page 316

MasteringA&P®

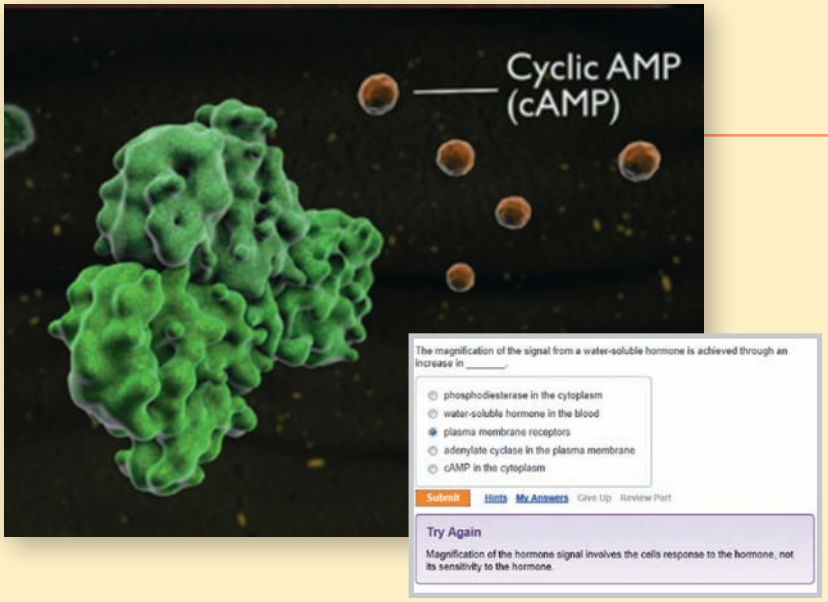
NEW Book-specific Clinical Case Activities

Every Clinical Case has a related assignable Activity in MasteringA&P.

MasteringA&P® Assignable Content

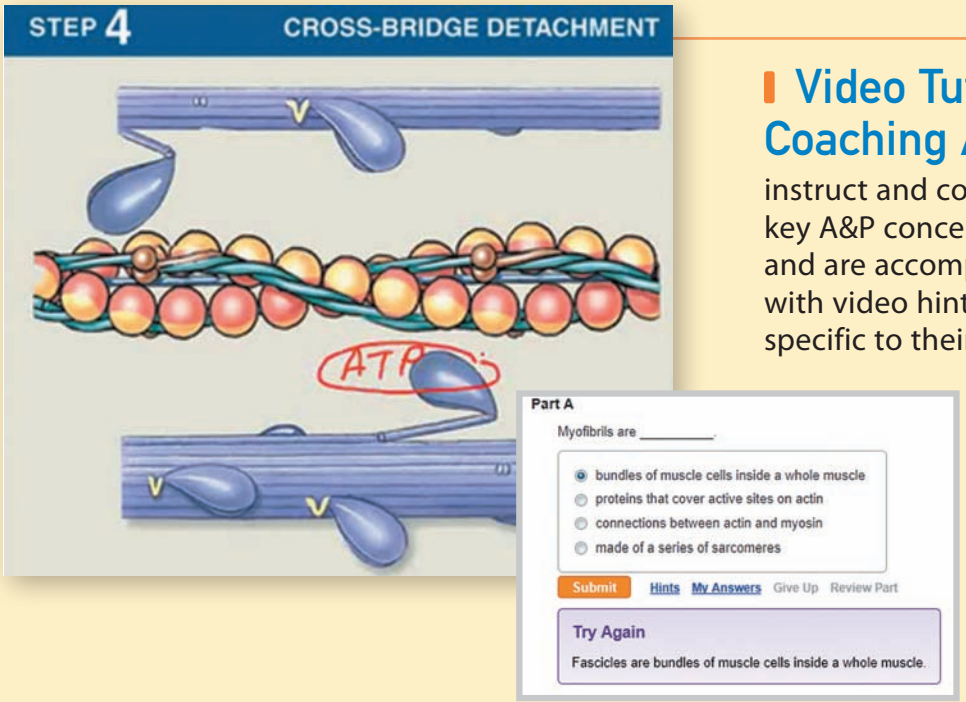
NEW | Interactive and Adaptive Capabilities

- **Adaptive Follow-Up Assignments** allow instructors to easily assign personalized content for each individual student based on strengths and weaknesses identified by his or her performance on MasteringA&P parent assignments.
- **Dynamic Study Modules** help students acquire, retain, and recall information faster and more efficiently than ever before. The flashcard-style modules are available as a self-study tool or can be assigned by the instructor. They can be easily accessed with smartphones.
- **Learning Catalytics** is a "bring your own device" (laptop, smartphone, or tablet) student engagement, assessment, and classroom intelligence system. With Learning Catalytics, instructors can assess students in real time using open-ended tasks to probe student understanding.



NEW | A&P Flix™ Coaching Activities

bring interactivity to these popular 3D movie-quality animations by asking students to manipulate the visuals.

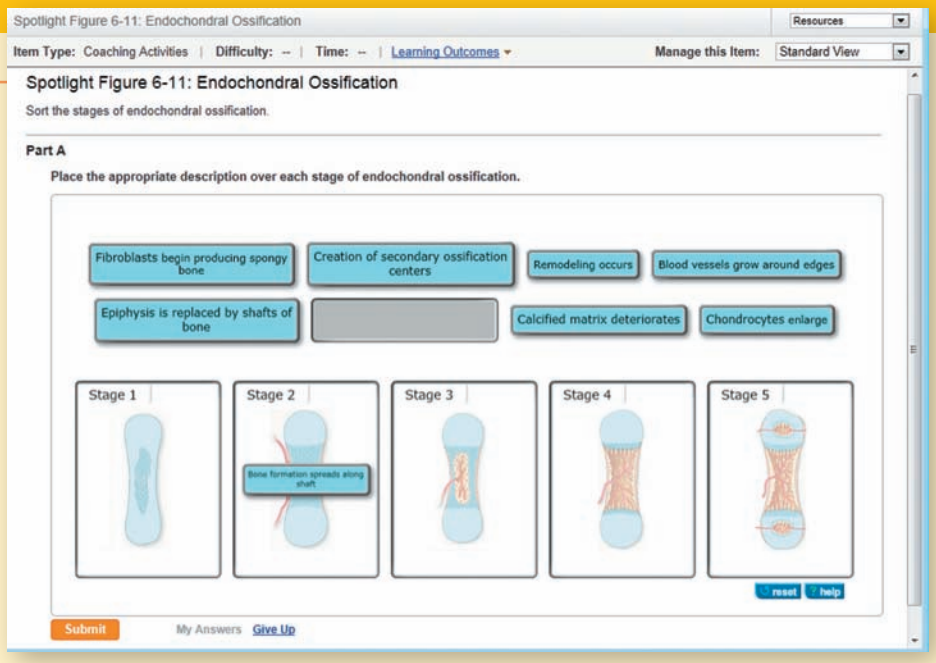


| Video Tutor Coaching Activities

instruct and coach students on key A&P concepts from the book and are accompanied by questions with video hints and feedback specific to their misconceptions.

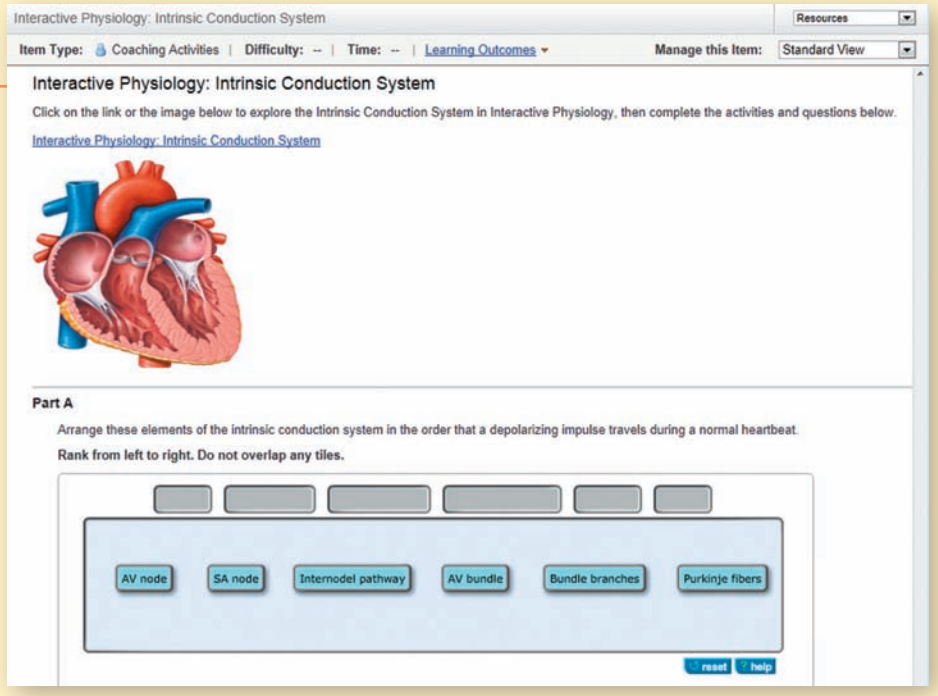
NEW | Spotlight Figure Coaching Activities

bring interactivity to the Spotlight Figures from the book by asking students to manipulate the visuals.



| Interactive Physiology® Coaching Activities

help students dive deeper into complex physiological processes using the Interactive Physiology tutorial program.



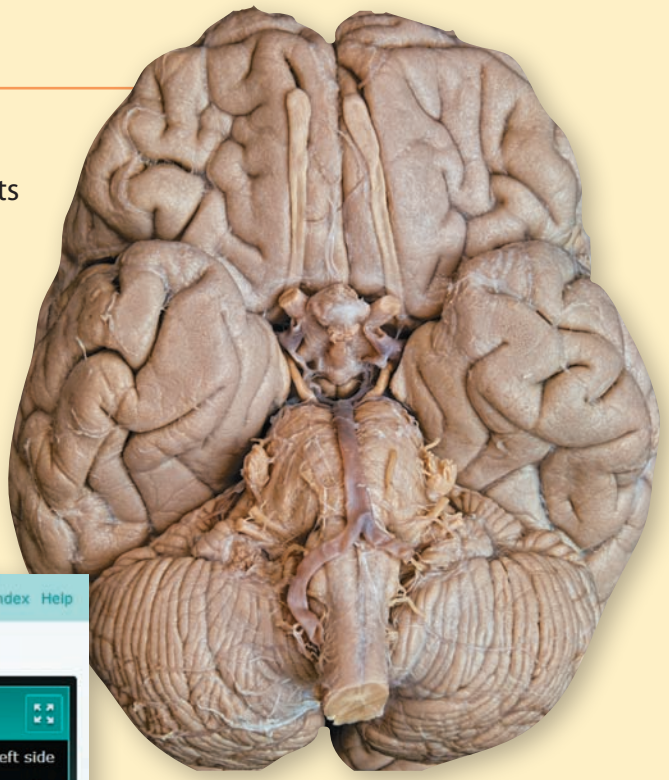
| Also Assignable in MasteringA&P®:

- **Art-labeling Activities** are drag and drop activities that allow students to assess their knowledge of terms and structures.
- **Art-based Questions** are conceptual questions related to art and instruct students with wrong-answer feedback.
- NEW **Book-specific Clinical Case Activities** stem from the story-based Clinical Cases in the book.
- NEW **Clinical Note Activities** prepare students for future careers in allied health fields.
- **Chemistry Review Activities** reinforce chemistry concepts necessary for an understanding of A&P.
- **PAL 3.0** and assessments
- **PhysioEx™ 9.1** and assessments
- **Reading Quiz Questions**
- **Chapter Test Questions**
- **Test Bank Questions**

MasteringA&P® Study Area

MasteringA&P® includes a Study Area that will help students get ready for tests with its simple three-step approach. Students can:

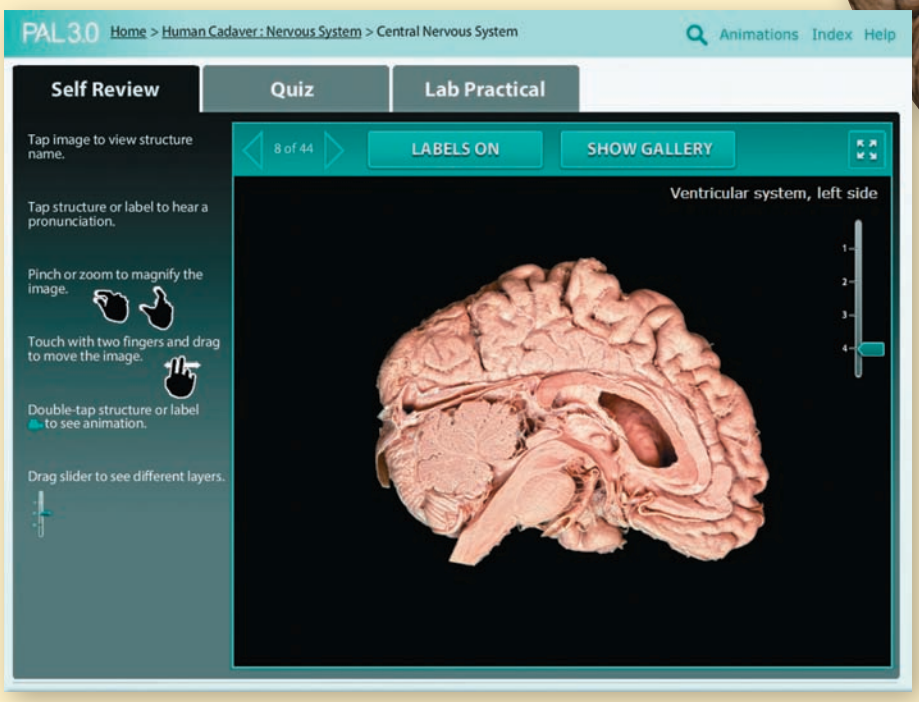
1. Take a pre-test and obtain a personalized study plan.
2. Learn and practice with animations, labeling activities, and interactive tutorials.
3. Self-test with quizzes and a chapter practice test.



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.

NEW The PAL 3.0 App lets you access PAL 3.0 on **your iPad or Android tablet**. With the pinch-to-zoom feature, images can be instantly enlarged.



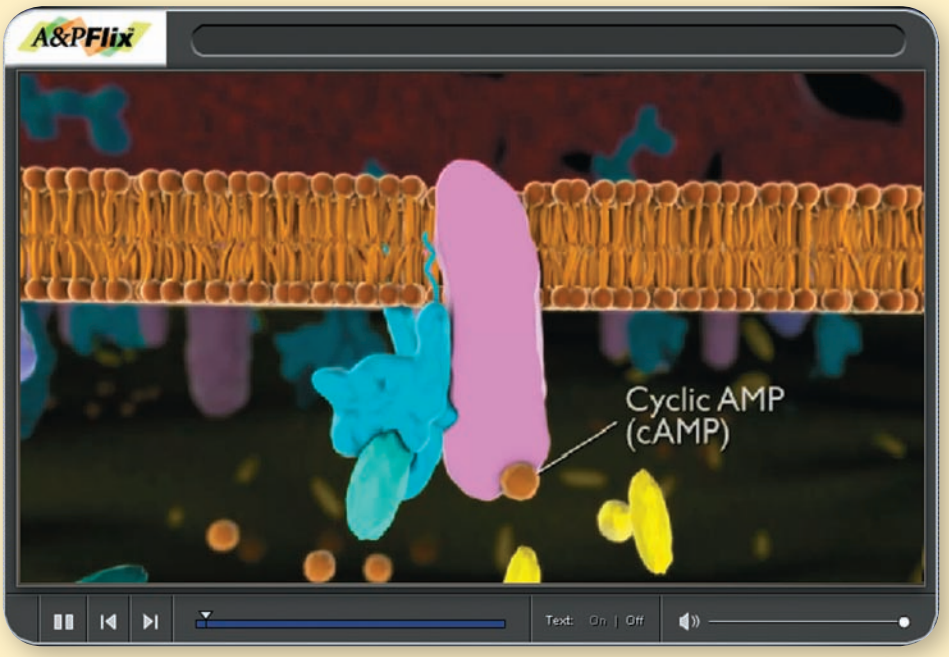
Also Available in the Study Area:

- eText
- PhysioEx™ 9.1
- Video Tutors

A&P Flix™

are 3-D movie-quality animations with self-paced tutorials and gradable quizzes that help students master the toughest topics in A&P:

- **NEW** Protein Synthesis
- Membrane Transport
- DNA Replication
- Mitosis
- **NEW** Endochondral Ossification
- Events at the Neuromuscular Junction
- The Cross Bridge Cycle
- Excitation-Contraction Coupling
- Resting Membrane Potential
- Generation of an Action Potential
- Propagation of an Action Potential
- **NEW** The Stretch Reflex
- **NEW** The Mechanism of Hormone Action: Second Messenger cAMP
- Origins, Insertions, Actions, and Innervations
  Over Over 60 animations on this topic
- Group Muscle Actions and Joints
  Over 50 animations on this topic

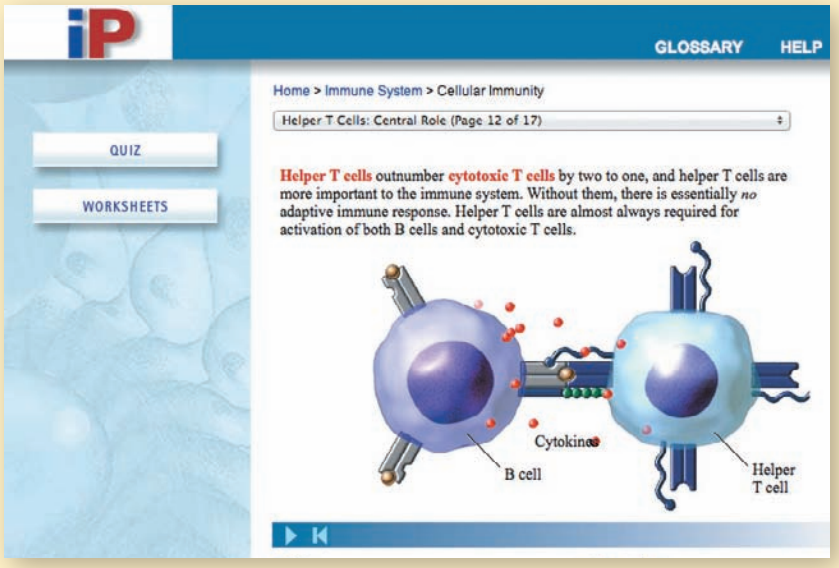


Interactive Physiology® (IP)

helps students understand the hardest part of A&P: physiology. Fun, interactive tutorials, games, and quizzes give students additional explanations to help them grasp difficult concepts.

Modules:

- Muscular System
- Nervous System I
- Nervous System II
- Cardiovascular System
- Respiratory System
- Urinary System
- Fluids & Electrolytes
- Endocrine System
- Digestive System
- Immune System



Support for Instructors

Instructor's Manual

by Jeff Schinske
and Mary L. Puglia

MyReadinessTest™

NEW | MyReadinessTest

by Lori K. Garrett

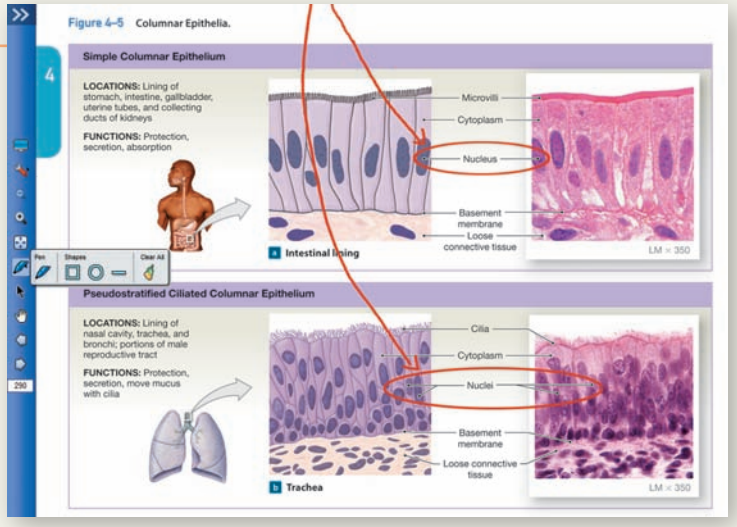
MyReadinessTest for A&P is a powerful online system that gets students prepared before their course starts. It assesses students' proficiency in study skills and foundational science and math concepts and provides coaching in core areas where students need additional practice and review.

eText with Whiteboard Mode

The *Fundamentals of Anatomy & Physiology* eText comes with Whiteboard Mode, allowing instructors to use the eText for dynamic classroom presentations. Instructors can show one-page or two-page views from the book, zoom in or out to focus on select topics, and use the Whiteboard Mode to point to structures, circle parts of a process, trace pathways, and customize their presentations.

Instructors can also add notes to guide students, upload documents, and share their custom-enhanced eText with the whole class.

Instructors can find the eText with Whiteboard Mode on MasteringA&P.



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Edwin F. Bartholomew received his undergraduate degree from Bowling Green State University in Ohio and his M.S. from the University of Hawaii. Mr. Bartholomew has taught human anatomy and physiology at both the secondary and undergraduate levels and a wide variety of other science courses (from botany to zoology) at Maui Community College and at historic Lahainaluna High School, the oldest high school west of the Rockies. He is a coauthor of *Visual Anatomy & Physiology, Essentials of Anatomy & Physiology, Visual Essentials of Anatomy & Physiology, Structure and Function of the Human Body,* and *The Human Body in Health and Disease* (all published by Pearson). Mr. Bartholomew is a member of the Human Anatomy and Physiology Society (HAPS), the National Association of Biology Teachers, the National Science Teachers Association, the Hawaii Science Teachers Association, and the American Association for the Advancement of Science.

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Dr. Judi Nath is a biology professor at Lourdes University, where she teaches anatomy and physiology, pathophysiology, and medical terminology. She received her Bachelor's and Master's degrees from Bowling Green State University and her Ph.D. from the University of Toledo. Dr. Nath is devoted to her students and strives to convey the intricacies of science in captivating ways that are meaningful, interactive, and exciting. She has won the Faculty Excellence Award—an accolade recognizing effective teaching, scholarship, and community service—multiple times. She is active in many professional organizations, notably the Human Anatomy and Physiology Society (HAPS), where she has served several terms on the board of directors. Dr. Nath is a coauthor of *Visual Anatomy & Physiology, Visual Essentials of Anatomy & Physiology,* and *Anatomy & Physiology* (all published by Pearson), and she is the sole author of *Using Medical Terminology*. Her favorite charities are those that have significantly affected her life, including the local Humane Society, the Cystic Fibrosis Foundation, and the ALS Association. On a personal note, Dr. Nath enjoys family life with her husband and their dogs.

William C. Ober, M.D.

Art Coordinator and Illustrator

Dr. Ober received his undergraduate degree from Washington and Lee University and his M.D. from the University of Virginia. He also studied in the Department of Art as Applied to Medicine at Johns Hopkins University. After graduation, Dr. Ober completed a residency in Family Practice and later was on the faculty at the University of Virginia in the Department of Family Medicine and in the Department of Sports Medicine. He also served as Chief of Medicine of Martha Jefferson Hospital in Charlottesville, VA. He is currently a Visiting Professor of Biology at Washington and Lee University, where he has taught several courses and led student trips to the Galapagos Islands. He was on the Core Faculty at Shoals Marine Laboratory for 24 years, where he taught Biological Illustration every summer. Dr. Ober has collaborated with Dr. Martini on all of his textbooks in every edition.

Claire E. Ober, R.N.

Illustrator

Claire E. Ober, R.N., B.A., practiced family, pediatric, and obstetric nursing before turning to medical illustration as a full-time career. She returned to school at Mary Baldwin College, where she received her degree with distinction in studio art. Following a five-year apprenticeship, she has worked as Dr. Ober's partner in Medical & Scientific Illustration since 1986. She was on the Core Faculty at Shoals Marine Laboratory and co-taught the Biological Illustration course with Dr. Ober for 24 years. The textbooks illustrated by Medical & Scientific Illustration have won numerous design and illustration awards.

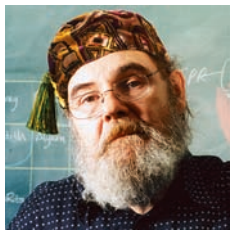
Kathleen Welch, M.D.

Clinical Consultant

Dr. Welch received her B.A. from the University of Wisconsin–Madison, her M.D. from the University of Washington in Seattle, and did her residency in Family Practice at the University of North Carolina in Chapel Hill. Participating in the Seattle WWAMI rural medical education program, she studied in Fairbanks, Anchorage, and Juneau, Alaska, with time in Boise, Idaho, and Anacortes, Washington, as well. For two years, she served as Director of Maternal and Child Health at the LBJ Tropical Medical Center in American Samoa and subsequently was a member of the Department of Family Practice at the Kaiser Permanente Clinic in Lahaina, Hawaii, and on the staff at Maui Memorial Hospital. She has been in private practice since 1987 and is licensed to practice in Hawaii and Washington State. Dr. Welch is a Fellow of the American Academy of Family Practice and a member of the Maui County Medical Society and the Human Anatomy and Physiology Society (HAPS). With Dr. Martini, she has coauthored both a textbook on anatomy and physiology and the *A&P Applications Manual*. She and Dr. Martini were married in 1979, and they have one son.

Ralph T. Hutchings

Biomedical Photographer



Mr. Hutchings was associated with the Royal College of Surgeons for 20 years. An engineer by training, he has focused for years on photographing the structure of the human body. The result has been a series of color atlases, including the *Color Atlas of Human Anatomy,* the *Color Atlas of Surface Anatomy,* and *The Human Skeleton* (all published by Mosby-Yearbook Publishing). For his anatomical portrayal of the human body, the International Photographers Association has chosen Mr. Hutchings as the best photographer of humans in the twentieth century. He lives in North London, where he tries to balance the demands of his photographic assignments with his hobbies of early motor cars and airplanes.

Ruth Anne O'Keefe, M.D.

Clinical Contributor

Dr. O'Keefe did her undergraduate studies at Marquette University, attended graduate school at the University of Wisconsin, and received her M.D. from George Washington University. She was the first woman to study orthopedics at The Ohio State University during her residency. She did fellowship training in trauma surgery at Loma Linda University in California. In addition to her private orthopedic practice, she has done orthopedic surgery around the world, taking her own surgical teams to places such as the Dominican Republic, Honduras, Peru, New Zealand, and Burkina Faso. She serves on the board of Global Health Partnerships, a group that partners with a clinic serving 35,000 people in remote Kenya. Dr. O'Keefe has always enjoyed teaching and now supervises medical students from the University of New Mexico doing ongoing research in Kenya. She lives in Albuquerque with her Sweet Ed. She is mother of four, grandmother of nine, and foster mother to many.

Preface

The Tenth Edition of *Fundamentals of Anatomy & Physiology* is a comprehensive textbook that fulfills the needs of today's students while addressing the concerns of their professors. We focused our attention on the question "How can we make this information meaningful, manageable, and comprehensible?" During the revision process, we drew upon our content knowledge, research skills, artistic talents, and years of classroom experience to make this edition the best yet.

The broad changes to this edition are presented in the **New to the Tenth Edition** section below, and the specific changes are presented in the **Chapter-by-Chapter Changes in the Tenth Edition** section that follows.

New to the Tenth Edition

In addition to the many technical changes in this edition, such as updated statistics and anatomy and physiology descriptions, we have made the following key changes:

- **NEW 50 Spotlight Figures** provide highly visual one- and two-page presentations of tough topics in the book, with a particular focus on physiology. In the Tenth Edition, 18 new Spotlight Figures have been added for a total of 50 across the chapters. There is now at least one Spotlight Figure in every chapter, as well as one Spotlight Figure corresponding to every A&P Flix.
- **NEW 29 Clinical Cases** get students motivated for their future careers. Each chapter opens with a story-based Clinical Case related to the chapter content and ends with a Clinical Case Wrap-Up that incorporates the deeper content knowledge students will have gained from the chapter.
- **NEW The repetition of the chapter-opening Learning Outcomes below the coordinated section headings within the chapters** underscores the connection between the HAPS-based Learning Outcomes and the associated teaching points. Author Judi Nath sat on the Human Anatomy and Physiology Society (HAPS) committee that developed the HAPS Learning Outcomes, recommended to A&P instructors, and the Learning Outcomes in this book are based on them. Additionally, the assessments in MasteringA&P are organized by these Learning Outcomes. As in the previous edition, full-sentence section headings, correlated with the Learning Outcomes, state a core fact or concept to help students readily see and learn the chapter content; and Checkpoints, located at the close of each section, ask students to pause and check their understanding of facts and concepts. If students cannot answer these questions within a matter of minutes, then they should reread the section before moving on. The Checkpoints reinforce the Learning Outcomes, resulting in a systematic integration of the Learning Outcomes over the course of the chapter. Answers to the Checkpoints are located in the blue Answers tab at the back of the book.
- **Easier narrative** uses simpler, shorter, more active sentences and a reading level that makes reading and studying easier for students.
- **Improved text-art integration** throughout the illustration program enhances the readability of figures. Several tables have been integrated directly into figures to help students make direct connections between tables and art.
- **Eponyms** are now included within the narrative, along with the anatomical terms used in *Terminologia Anatomica*.
- **NEW Assignable MasteringA&P activities** include the following:
  - **NEW Spotlight Figure Coaching Activities** are highly visual, assignable activities designed to bring interactivity to the Spotlight Figures in the book. Multi-part activities include the ranking and sorting types that ask students to manipulate the visuals.
  - **NEW Book-specific Clinical Case Activities** stem from the story-based Clinical Cases that appear at the beginning and end of each chapter in the book.
  - **NEW Adaptive Follow-up Assignments** allow instructors to easily assign personalized content for each individual student based on strengths and weaknesses identified by his or her performance on MasteringA&P parent assignments.
  - **NEW Dynamic Study Modules** help students acquire, retain, and recall information quickly and efficiently. The modules are available as a self-study tool or can be assigned by the instructor. They can be easily accessed with smartphones.

Chapter-by-Chapter Changes in the Tenth Edition

This annotated Table of Contents provides select examples of revision highlights in each chapter of the Tenth Edition. For a more complete list of changes, please contact the publisher.

Chapter 1: An Introduction to Anatomy and Physiology

- **New Clinical Case: Using A&P to Save a Life**
- **New Spotlight Figure 1–10 Diagnostic Imaging Techniques**
- New Clinical Note: Autopsies and Cadaver Dissection
- New Clinical Note: Auscultation
- Figure 1–7 Directional References revised
- Figure 1–8 Sectional Planes revised
- Figure 1–9 Relationships among the Subdivisions of the Body Cavities of the Trunk revised

Chapter 2: The Chemical Level of Organization

- **New Clinical Case: What Is Wrong with My Baby?**
- New Clinical Note: Radiation Sickness
- Clinical Note: Fatty Acids and Health revised
- Section 2-2 includes revised Molecular weight discussion
- Figure 2–4 The Formation of Ionic Bonds revised
- Figure 2–5 Covalent Bonds in Five Common Molecules revised
- Table 2–3 Important Functional Groups of Organic Compounds revised (to clarify structural group and R group)
- Protein Structure subsection includes new discussion of amino acids as zwitterions
- Figure 2–21 Protein Structure revised

Chapter 3: The Cellular Level of Organization

- **New Clinical Case: When Your Heart Is in the Wrong Place**
- New information added about cholesterol and other lipids
- New overview added about roles of microtubules
- Figure 3–5 The Endoplasmic Reticulum revised
- Clinical Note on DNA Fingerprinting revised
- Figure 3–13 The Process of Translation revised
- Figure 3–14 Diffusion revised
- Figure 3–17 Osmotic Flow across a Plasma Membrane revised
- **New Spotlight Figure 3–22 Overview of Membrane Transport incorporates old Figures 3–18, 3–19, and 3–21 and old Table 3–2**
- **New Spotlight Figure 3–23 DNA Replication incorporates old Figure 3–23**
- **Spotlight Figure 3–24 Stages in a Cell's Life Cycle revised**

Chapter 4: The Tissue Level of Organization

- **New Clinical Case: The Rubber Girl**
- Intercellular Connections subsection updated
- Figure 4–2 Cell Junctions revised
- Figure 4–8 The Cells and Fibers of Connective Tissue Proper revised
- Adipose Tissue subsection includes updated discussion of brown fat
- Figure 4–10 Loose Connective Tissues revised
- **Spotlight Figure 4–20 Inflammation and Regeneration revised**

Chapter 5: The Integumentary System

- **New Clinical Case: Skin Cells in Overdrive**
- Figure 5–1 The Components of the Integumentary System revised
- New Figure 5–2 The Cutaneous Membrane and Accessory Structures
- **New Spotlight Figure 5–3 The Epidermis incorporates old Figures 5–2 and 5–3**
- New Figure 5–5 Vitiligo
- New Figure 5–6 Sources of Vitamin D_3
- Clinical Note: Decubitus Ulcers revised with new photo
- New Figure 5–8 Reticular Layer of Dermis
- Figure 5–10 Dermal Circulation revised
- Figure 5–12 Hair Follicles and Hairs revised
- New Figure 5–11 Hypodermis

Chapter 6: Osseous Tissue and Bone Structure

- **New Clinical Case: A Case of Child Abuse?**
- Figure 6–1 A Classification of Bones by Shape revised
- New Figure 6–2 An Introduction to Bone Markings incorporates old Table 6–1
- **New Spotlight Figure 6–11 Endochondral Ossification incorporates old Figure 6–10**
- New Figure 6–12 Intramembranous Ossification
- **Spotlight Figure 6–16 Types of Fractures and Steps in Repair revised**
- Clinical Note: Abnormal Bone Development revised

Chapter 7: The Axial Skeleton

- **New Clinical Case: Knocked Out**
- New Clinical Note: Sinusitis
- Figure 7–2 Cranial and Facial Subdivisions of the Skull revised
- Figure 7–3 The Adult Skull revised to incorporate old Table 7–1
- **New Spotlight Figure 7–4 Sectional Anatomy of the Skull incorporates old Figure 7–4 and parts of old Table 7–1**
- Figure 7–6 The Frontal Bone revised
- Figure 7–14 The Nasal Complex revised
- Figure 7–22 The Thoracic Cage revised

Chapter 8: The Appendicular Skeleton

- **New Clinical Case: The Orthopedic Surgeon's Nightmare**
- New Clinical Note: Hip Fracture
- New Clinical Note: Runner's Knee
- New Clinical Note: Stress Fractures
- Carpal Bones subsection now lists the 8 carpal bones in two groups of 4 (proximal and distal carpal bones)
- Figure 8–6 Bones of the Right Wrist and Hand revised
- **New Spotlight Figure 8–10 Sex Differences in the Human Skeleton incorporates old Figure 8–10, old Table 8–1, and old bulleted list in text**
- Clinical Note: Carpal Tunnel Syndrome includes new illustration
- Figure 8–14 Bones of the Ankle and Foot revised
- Clinical Note: Congenital Talipes Equinovarus includes new photo

Chapter 9: Joints

- Chapter title changed from Articulations to Joints
- **New Clinical Case: What's Ailing the Birthday Girl?**
- New Clinical Note: Dislocation and Subluxation
- New Clinical Note: Damage to Intervertebral Discs
- Table 9–1 Functional and Structural Classifications of Articulations redesigned
- **Spotlight Figure 9–2 Joint Movement incorporates old Figures 9–2 and 9–6 and subsection on Types of Synovial Joints**
- Revised discussion of synovial fluid function in shock absorption
- Figure 9–6 Intervertebral Articulations expanded
- Figure 9–7 The Shoulder Joint revised
- Figure 9–10 The Right Knee Joint rearranged and revised
- Clinical Note: Knee Injuries revised

Chapter 10: Muscle Tissue

- **New Clinical Case: A Real Eye Opener**
- New subsection Electrical Impulses and Excitable Membranes added in Section 10-4
- **New Spotlight Figure 10–10 Excitation–Contraction Coupling incorporates old Figures 10–9 and 10–10**
- New Figure 10–13 Steps Involved in Skeletal Muscle Contraction and Relaxation incorporates old Table 10–1
- Treppe subsection includes new discussion of treppe in cardiac muscle
- Motor Units and Tension Production subsection includes new discussion of fasciculation
- Figure 10–20 Muscle Metabolism revised
- Table 10–2 Properties of Skeletal Muscle Fiber Types revised to make column sequences better parallel text discussion

Chapter 11: The Muscular System

- **New Clinical Case: The Weekend Warrior**
- Figure 11–1 Muscle Types Based on Pattern of Fascicle Organization revised
- Figure 11–2 The Three Classes of Levers revised
- **New Spotlight Figure 11–3 Muscle Action**
- Figure 11–14 An Overview of the Appendicular Muscles of the Trunk revised
- Figure 11–18 Muscles That Move the Hand and Fingers revised
- Figure 11–22 Extrinsic Muscles That Move the Foot and Toes revised

Chapter 12: Neural Tissue

- **New Clinical Case: Did President Franklin D. Roosevelt Really Have Polio?**
- New Figure 12–1 A Functional Overview of the Nervous System
- Figure 12–7 Schwann Cells, Peripheral Axons, and Formation of the Myelin Sheath revised and new part c step art added
- **New Spotlight Figure 12–9 Resting Membrane Potential incorporates old Figure 12–9**
- Figure 12–10 Electrochemical Gradients for Potassium and Sodium Ions revised
- Added ligand-gated channels as an alternative term for chemically gated channels
- **New Spotlight Figure 12–15 Propagation of an Action Potential incorporates old Figures 12–6 and 12–15**
- New Figure 12–16 Events in the Functioning of a Cholinergic Synapse incorporates old Figure 12–17 and old Table 12–4

Chapter 13: The Spinal Cord, Spinal Nerves, and Spinal Reflexes

- **New Clinical Case: Prom Night**
- New "Tips & Tricks" added to Cervical Plexus subsection
- Figure 13–7 Dermatomes revised
- New information on the Jendrassik maneuver added to Section 13-8
- New Figure 13–10 The Cervical Plexus incorporates old Table 13–1 and old Figure 13–11
- New Figure 13–11 The Brachial Plexus incorporates old Table 13–2 and old Figure 13–12
- New in-art Clinical Note: Sensory Innervation in the Hand added to Figure 13–11
- New Figure 13–12 The Lumbar and Sacral Plexuses incorporates old Table 13–3 and old Figure 13–13
- New in-art Clinical Note: Sensory Innervation in the Ankle and Foot added to Figure 13–12
- **New Spotlight Figure 13–14 Spinal Reflexes incorporates old Figures 13–15, 13–17, 13–19, and 13–20**

Chapter 14: The Brain and Cranial Nerves

- **New Clinical Case: The Neuroanatomist's Stroke**
- **New Spotlight Figure 14–4 Formation and Circulation of Cerebrospinal Fluid incorporates old Figure 14–4**
- Figure 14–5 The Diencephalon and Brain Stem revised
- New Figures 14–6 The Medulla Oblongata and 14–7 The Pons incorporate old Figure 14–6 and old Table 14–2
- New Figure 14–8 The Cerebellum incorporates old Figure 14–7 and old Table 14–3
- New Figure 14–9 The Midbrain incorporates old Figure 14–8, old Table 14–4, and a new cadaver photograph
- New Figure 14–11 The Hypothalamus in Sagittal Section incorporates old Figure 14–10 and old Table 14–6
- New Figure 14–12 The Limbic System incorporates old Figure 14–11 and old Table 14–7
- Figure 14–14 Fibers of the White Matter of the Cerebrum revised
- Figure 14–15 The Basal Nuclei revised
- Figure 14–16 Motor and Sensory Regions of the Cerebral Cortex revised
- New information on circumventricular organs added to Section 14-2

Chapter 15: Sensory Pathways and the Somatic Nervous System

- **New Clinical Case: Living with Cerebral Palsy**
- New Figure 15–1 An Overview of Events Occurring along the Sensory and Motor Pathways
- New Figure 15–3 Tonic and Phasic Sensory Receptors
- **Spotlight Figure 15–6 Somatic Sensory Pathways revised**
- Figure 15–8 Descending (Motor) Tracts in the Spinal Cord reorganized

Chapter 16: The Autonomic Nervous System and Higher-Order Functions

- **New Clinical Case: The First Day in Anatomy Lab**
- **New Spotlight Figure 16–2 Overview of the Autonomic Nervous System incorporates old Figures 16–3 and 16–7**
- Figure 16–3 Sites of Ganglia in Sympathetic Pathways revised
- Figure 16–4 The Distribution of Sympathetic Innervation revised

Chapter 17: The Special Senses

- **New Clinical Case: A Chance to See**
- Figure 17–1 The Olfactory Organs revised
- **Spotlight Figure 17–2 Olfaction and Gustation revised**
- Figure 17–3 Gustatory Receptors revised
- Figure 17–22 The Middle Ear revised
- Figures 17–23, 17–24, and 17–25 revised to indicate different orientations of maculae in the utricle and saccule
- Figure 17–32 Pathways for Auditory Sensations revised

Chapter 18: The Endocrine System

- **New Clinical Case: Stones, Bones, and Groans**
- **New Spotlight Figure 18–3 G Proteins and Second Messengers incorporates old Figure 18–3**
- Figure 18–7 The Hypophyseal Portal System and the Blood Supply to the Pituitary Gland revised
- Figure 18–11 The Thyroid Follicles revised
- New Figure 18–14 The Adrenal Gland incorporates old Figure 18–14 and old Table 18–5

Chapter 19: Blood
- New Clinical Case: A Mysterious Blood Disorder
- Figure 19–3 The Structure of Hemoglobin revised
- Table 19–4 includes revised names for Factors IX and XI and source of Factor X

Chapter 20: The Heart
- New Clinical Case: A Needle to the Chest
- Figure 20–3 The Superficial Anatomy of the Heart revised
- Figure 20–6 The Sectional Anatomy of the Heart revised
- Figure 20–12 Impulse Conduction through the Heart revised
- Figure 20–16 Phases of the Cardiac Cycle revised
- Figure 20–21 Autonomic Innervation of the Heart revised
- Figure 20–24 A Summary of the Factors Affecting Cardiac Output revised

Chapter 21: Blood Vessels and Circulation
- New Clinical Case: Did Ancient Mummies Have Atherosclerosis?
- Figure 21–2 Histological Structures of Blood Vessels revised
- Figure 21–8 Relationships among Vessel Diameter, Cross-Sectional Area, Blood Pressure, and Blood Velocity within the Systemic Circuit revised
- Figure 21–9 Pressures within the Systemic Circuit revised
- Figure 21–11 Forces Acting across Capillary Walls revised
- Figure 21–20 Arteries of the Chest and Upper Limb revised
- Figure 21–25 Arteries of the Lower Limb revised
- Figure 21–29 Flowcharts of Circulation to the Superior and Inferior Venae Cavae revised
- Figure 21–30 Venous Drainage from the Lower Limb revised

Chapter 22: The Lymphatic System and Immunity
- New Clinical Case: Isn't There a Vaccine for That?
- Figure 22–6 The Origin and Distribution of Lymphocytes revised
- Figure 22–11 Innate Defenses revised
- Complement System subsection – includes revised number of complement proteins in plasma (from 11 to more than 30)
- Figure 22–18 Antigens and MHC Proteins revised

Chapter 23: The Respiratory System
- New Clinical Case: How Long Should a Cough Last?
- Figure 23–1 The Structure of the Respiratory System reorganized
- Figure 23–3 The Structures of the Upper Respiratory System revised
- Figure 23–5 The Glottis and Surrounding Structures revised
- Figure 23–7 The Gross Anatomy of the Lungs revised
- Figure 23–9 The Bronchi, Lobules, and Alveoli of the Lung revised
- Figure 23–10 Alveolar Organization revised
- Figure 23–13 Mechanisms of Pulmonary Ventilation revised
- New Spotlight Figure 23–15 Respiratory Muscles and Pulmonary Ventilation incorporates old Figure 23–16
- Figure 23–16 Pulmonary Volumes and Capacities revised
- Spotlight Figure 23–25 Control of Respiration revised

Chapter 24: The Digestive System
- New Clinical Case: An Unusual Transplant
- Figure 24–10 The Esophagus revised
- Figure 24–12 The Stomach revised
- Figure 24–16 Segments of the Intestine revised
- Figure 24–21 The Anatomy and Physiology of the Gallbladder and Bile Ducts revised

Chapter 25: Metabolism and Energetics
- New Clinical Case: The Miracle Supplement
- Figure 25–9 Lipid Transport and Utilization revised
- Figure 25–12 MyPlate Plan revised
- Figure 25–14 Mechanisms of Heat Transfer revised

Chapter 26: The Urinary System
- New Clinical Case: A Case of "Hidden" Bleeding
- Revised all relevant figure labels by replacing "Renal lobe" with "Kidney lobe"
- Figure 26–6 The Functional Anatomy of a Representative Nephron and the Collecting System revised
- Spotlight Figure 26–16 Summary of Renal Function revised

Chapter 27: Fluid, Electrolyte, and Acid–Base Balance
- New Clinical Case: When Treatment Makes You Worse
- Figure 27–2 Cations and Anions in Body Fluids revised
- Figure 27–3 Fluid Gains and Losses revised
- Figure 27–11 The Role of Amino Acids in Protein Buffer Systems revised (to emphasize amino acids as zwitterions)
- Figure 27–13 Kidney Tubules and pH Regulation revised
- New Spotlight Figure 27–18 The Diagnosis of Acid–Base Disorders incorporates old Figure 27–18

Chapter 28: The Reproductive System
- New Clinical Case: A Post-Game Mystery
- Figure 28–1 The Male Reproductive System revised
- Figure 28–3 The Male Reproductive System in Anterior View revised and reorganized
- Figure 28–4 The Structure of the Testes revised
- Figure 28–7 Spermatogenesis revised
- Figure 28–13 The Female Reproductive System revised
- Figure 28–15 Oogenesis revised
- Figure 28–18 The Uterus revised

Chapter 29: Development and Inheritance
- New Clinical Case: The Twins That Looked Nothing Alike
- Revised all relevant chapter text by replacing "embryological" with "embryonic" for simplification
- New Spotlight Figure 29–5 Extraembryonic Membranes and Placenta Formation incorporates old Figure 29–5
- Table 29–2 An Overview of Prenatal Development includes revised sizes and weights at different gestational ages
- Figure 29–8 The Second and Third Trimesters revised
- Figure 29–9 Growth of the Uterus and Fetus revised
- Figure 29–13 Growth and Changes in Body Form and Proportion revised

Appendix
- New periodic table
- New codon chart

Acknowledgments

This textbook represents a group effort, and we would like to acknowledge the people who worked together with us to create this Tenth Edition.

Foremost on our thank-you list are the instructors who offered invaluable suggestions throughout the revision process. We thank them for their participation and list their names and affiliations below.

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The accuracy and currency of the clinical material in this edition and in the *A&P Applications Manual* in large part reflect the work of Kathleen Welch, M.D. Her professionalism and concern for practicality and common sense make the clinical information especially relevant for today's students. Additionally, our content expert on the Clinical Cases, Ruth Anne O'Keefe, M.D., provided constant, useful feedback on each chapter.

Virtually without exception, reviewers stressed the importance of accurate, integrated, and visually attractive illustrations in helping readers understand essential material. The revision of the art program was directed by Bill Ober, M.D. and Claire E. Ober, R.N. Their suggestions about presentation sequence, topics of clinical importance, and revisions to the proposed art were of incalculable value to us and to the project. The illustration program for this edition was further enhanced by the efforts of several other talented individuals. Jim Gibson designed most of the new Spotlight Figures in the art program and consulted on the design and layout of the individual figures. His talents have helped produce an illustration program that is dynamic, cohesive, and easy to understand. Anita Impagliazzo helped create the new photo/art combinations that have resulted in clearer presentations and a greater sense of realism in important anatomical figures. We are also grateful to the talented team at Imagineering (imagineeringart.com) for their dedicated and detailed illustrative work on key figures for this edition. The new color micrographs in this edition were provided by Dr. Robert Tallitsch, and his assistance is much appreciated. Many of the striking anatomy photos in the text and in *Martini's Atlas of the Human Body* are the work of biomedical photographer Ralph Hutchings; his images played a key role in the illustration program.

We also express our appreciation to the editors and support staff at Pearson Science.

We owe special thanks to Executive Editor, Leslie Berriman, for her creativity and dedication. Her vision helped shape this book in countless ways. Leslie's enthusiasm for publishing the highest quality material spills over onto the author/illustrator team. She is our biggest advocate and is always willing to champion our cause—despite the challenges of working with authors. We are appreciative of all her efforts on our behalf.

Assistant Editor, Cady Owens, and Associate Project Editor, Lisa Damerel, are unquestionably the very finest at what they do. While it is expected that editors pay attention to details and keep projects moving forward, Cady and Lisa are true professionals and extremely skilled at not only preparing our material for publication, but making sure it is the best it could possibly be. This past year could not have happened without them.

Annie Reid, our Development Editor, played a vital role in revising the Tenth Edition. Her unfailing attention to readability, consistency, and quality was invaluable to the authors in meeting our goal of delivering complex A&P content in a more student-friendly way.

We are grateful to Mike Rossa for his careful attention to detail and consistency in his copyedit of the text and art.

This book would not exist without the extraordinary dedication of the Production team, including Caroline Ayres, who solved many problems under pressure with unfailing good cheer. Norine Strang skillfully led her excellent team at S4Carlisle to move the book smoothly through composition.