

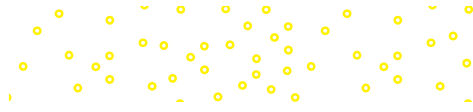
Anatomy & Physiology

An Integrative Approach

**FOURTH
EDITION**

Valerie Dean O'Loughlin
Theresa Stouter Bidle
Michael P. McKinley

**Mc
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ANATOMY & PHYSIOLOGY: AN INTEGRATIVE APPROACH, FOURTH EDITION

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This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 LWI 26 25 24 23 22 21

ISBN 978-1-260-26521-7 (bound edition)
MHID 1-260-26521-8 (bound edition)
ISBN 978-1-264-26541-1 (loose-leaf edition)
MHID 1-264-26541-7 (loose-leaf edition)

Portfolio Manager: *Matthew Garcia*
Product Developer: *Melisa Seegmiller*
Marketing Manager: *Valerie Kramer*
Content Project Managers: *Jessica Portz & Brent dela Cruz*
Buyer: *Sandy Ludovissy*
Designer: *David E. Hash*
Content Licensing Specialist: *Lori Hancock*
Cover Image: *Erin O'Loughlin*
Compositor: *MPS Limited*

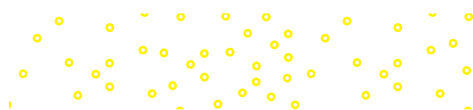
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Library of Congress Cataloging-in-Publication Data

Names: O'Loughlin, Valerie Dean, author. | Bidle, Theresa Stouter, author. | McKinley, Michael P., author.
Title: Anatomy & physiology : an integrative approach / Valerie Dean O'Loughlin, Indiana University, Theresa Stouter Bidle, Hagerstown Community College, Michael P. McKinley, Glendale Community College.
Other titles: Anatomy and physiology
Description: 4e. | New York : McGraw-Hill LLC, [2022] | Includes index.
Identifiers: LCCN 2020008768 (print) | LCCN 2020008769 (ebook) | ISBN 9781260265217 (hardcover) | ISBN 9781264265435 (ebook)
Subjects: LCSH: Human anatomy. | Human physiology.
Classification: LCC QM25 .M32 2022 (print) | LCC QM25 (ebook) | DDC 612--dc23
LC record available at <https://lcn.loc.gov/2020008768>
LC ebook record available at <https://lcn.loc.gov/2020008769>

The Internet addresses listed in the text were accurate at the time of publication. The inclusion of a website does not indicate an endorsement by the authors or McGraw Hill LLC, and McGraw Hill LLC does not guarantee the accuracy of the information presented at these sites.

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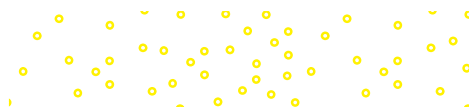


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*Author team: Michael McKinley, Valerie Dean O’Loughlin,
and Theresa Bidle*

Dedications

*To my husband Bob and my daughter Erin:
Thank you for always being there for me.*

—Valerie Dean O’Loughlin

*With love and thanks to my husband Jay
and my daughter Stephanie for the many ways
that they have supported me during this project.*

—Terri Stouter Bidle

*I am indebted to Jan (my wife); Renee, Ryan, and Shaun
(my children); and Connor, Eric, Patrick,
Keighan, Aydan, and Abbygail (my grandchildren).
They are the love of my life and my inspiration always.*

—Michael P. McKinley





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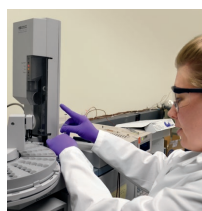
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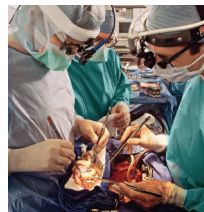
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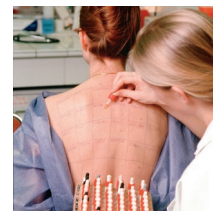
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preface

Human anatomy and physiology is a fascinating subject. However, students can be overwhelmed by the complexity, the interrelatedness of concepts from different chapters, and the massive amount of material in the course. Our goal was to create a textbook to guide students on a clearly written and expertly illustrated beginner's path through the human body.

An Integrative Approach

One of the most daunting challenges that students face in mastering concepts in an anatomy and physiology course is integrating related content from numerous chapters. Understanding a topic like blood pressure, for example, requires knowledge from the chapters on the heart, blood vessels, kidneys, and how these structures are regulated by the nervous and endocrine systems. The usefulness of a human anatomy and physiology text is dependent in part on how successfully it helps students integrate these related concepts. Without this, students are only acquiring what seems like unrelated facts without seeing how they fit into the whole.

To adequately explain such complex concepts to beginning students in our own classrooms, we as teachers present multiple topics over the course of many class periods, all the while balancing these detailed explanations with refreshers of content previously covered and intermittent glimpses of the big picture. Doing so ensures that students learn not only the individual pieces, but also how the pieces ultimately fit together. This book represents our best effort to replicate this teaching process. In fact, it is the effective integration of concepts throughout the text that makes this book truly unique from other undergraduate anatomy and physiology texts.

Our goal of emphasizing the interrelatedness of body systems and the connections between form and function necessitates a well-thought-out pedagogical platform to deliver the content. First and foremost, we have written a very user-friendly text with concise, accurate descriptions that are thorough, but don't overwhelm readers with nonessential details. The text narrative is deeply integrated with corresponding illustrations drawn specifically to match the textual explanations. In addition, we have included a set of "Integrate" features that support our theme and work together to give the student a well-rounded introduction to anatomy and physiology. **Integrate: Concept Overview** figures are one- or two-page visual summaries that aggregate related concepts in a big-picture view. These comprehensive figures link multiple sections of a chapter together in a cohesive snapshot ideal for study and review. **Integrate: Concept Connections** boxes provide glimpses of how concepts at hand will play out in upcoming chapters, and also pull vital information from earlier chapters back into the discussion at crucial points when relevant to a new topic. **Integrate: Clinical View** discussions apply concepts from the surrounding narrative to practical or clinical contexts, providing examples of what can go wrong in the human body to help crystallize understanding of the "norm." **Integrate: Learning Strategy** boxes infuse each chapter with practical study tips to understand and remember information. Learning strategies include mnemonics, analogies, and kinesthetic activities that students can perform to relate the anatomy and physiology to their own bodies.

Chapter Organization

In order to successfully execute an integrative approach, foundational topics must be presented at the point when it matters most for understanding. This provides students with a baseline of knowledge about a given concept before it comes time to apply that information in a more complex situation. Topics are thus subdivided and covered in this sequence:

- **Chapter 2: Atoms, Ions, and Molecules** Most students taking an A&P course have limited or no chemistry background, which requires a textbook to provide a detailed, organized treatment of atomic and molecular structure, bonding, water, and biological macromolecules as a basis to understanding physiological processes.
- **Chapter 3: Energy, Chemical Reactions, and Cellular Respiration** ATP is essential to all life processes. A solid understanding of ATP furthers student comprehension of movement of materials across a membrane, muscle contractions, production of needed replacement molecules and structures in cells, action potentials in nerves, pumping of the heart, and removal of waste materials in the kidneys. This textbook elevates the importance of the key concept of ATP by teaching it early. We then utilize this knowledge in later chapters as needed, expanding on what has already been introduced rather than reteaching it entirely.
- **Chapter 13: Nervous System: Brain and Cranial Nerves and Chapter 14: Nervous System: Spinal Cord and Spinal Nerves** Instead of subdividing the nervous system discussion into separate central nervous system (CNS) and peripheral nervous system (PNS) chapters, nervous system structures are grouped by region. Thus, students can integrate the cranial nerves with their respective nuclei in the brain, and they can integrate the spinal cord regions with the specific spinal nerves that originate from these regions.
- **Chapter 17: Endocrine System** We have organized both the endocrine system chapter and the specific coverage of the many hormones released from endocrine glands to most effectively and efficiently guide students in understanding how this system of control functions in maintaining homeostasis. Within the chapter on the endocrine system, we provide an introduction and general discussion of the endocrine system's central concepts and describe selected representative hormones that maintain body homeostasis. The details of the actions of most other hormones—which require an understanding of specific anatomic structures covered in other chapters—are described in those chapters; for example, sex hormones are discussed in Chapter 28: Reproductive System. Learning the various hormones is facilitated by the inclusion of a "template" figure for each major hormone; each visual template includes the same components (stimulus, receptor, control center, and effectors) organized in a similar layout. In addition, information on each major hormone described in this text can be quickly accessed in the summary tables following chapter 17.

- **Chapter 21: Lymphatic System and Chapter 22: Immune System and the Body's Defense** A single chapter that discusses both the lymphatic system and immune system is overwhelming for most students. Thus, we separated the discussion into two separate chapters. The lymphatic system chapter focuses on the anatomic structures that compose the system, and provides a brief functional overview of each structure. This allows us to provide a thorough discussion and overview of the immune system in a separate chapter, where we frequently reference and integrate material from the earlier chapter.
- **Chapter 29: Development, Pregnancy, and Heredity** Coverage of heredity is included in the chapter on pregnancy and human development as a natural extension of Chapter 28: Reproductive System. This introduction will serve well as a precursor for students who follow their A&P course with a genetics course.

Changes to the Fourth Edition

Real student data points derived from thousands of SmartBook users have guided the revision process for this edition. In addition, this revision has been informed by dozens of chapter reviews by A&P instructors. The following global changes have been implemented throughout all chapters:

- Additional references were added to concepts previously covered, as well as to related material in upcoming sections and chapters, to further connect concepts.
- Art or photos added to many of the Clinical Views throughout the text.
- Terminology has been updated and definitions are added throughout.
- Learning Objectives were updated throughout the text.
- New “What Do You Think?” and “What Did You Learn?” questions were added throughout the text.
- Adjusted wording in text throughout to be more gender inclusive.
- Numbered Learning Strategies.
- Edited chapter questions to include more active learning exercises.

Chapter 1

- New section 1.1a: Anatomy, Physiology, and the Scientific Method
- Revised: figure 1.3, figure 1.7, figure 1.13
- New Clinical View 1.2: The Human Microbiome, which examines the microbiome's effect on health
- New Learning Strategy 1.3 for the serous membranes
- Revised section 1.6b (homeostasis)
- Updated Clinical View 1.5: Medical Imaging, the term *ultrasound* replacing *sonography*, updated information about DSA, reorganized discussion

Chapter 2

- Modified section 2.2a: Ions
- Edited section 2.3b: Covalent Bonds
- Revised section 2.5c: pH, Neutralization, and the Action of Buffers
- Revised: figure 2.2, figure 2.11, figure 2.15, figure 2.17

- Modified table 2.6: Protein Functions, to include six functions with images

Chapter 3

- Revised: figure 3.1, figure 3.2, figure 3.5, figure 3.6, figure 3.7, figure 3.14, figure 3.16, figure 3.18, and figure 3.19

Chapter 4

- Reorganized section 4.1a: How Cells Are Studied
- Updated section 4.3a: Passive Processes: Diffusion
- Edited section 4.3b: Passive Processes: Osmosis
- Added Concept Connection regarding solvent, solutes, and solutions.
- Edited section 4.5: Active Transport including additional content on H⁺ pumps
- Added Concept Connection on concentration gradient in various cell types
- Edited section 4.6d: Membrane Junctions
- New Learning Strategy on functions of the Golgi apparatus
- Edited section 4.8 Function of the Nucleus and Ribosomes
- Revised: figure 4.1, figure 4.5, figure 4.7, figure 4.8, figure 4.13, figure 4.15, figure 4.16, figure 4.19, figure 4.23, figure 4.28, figure 4.32, figure 4.33, figure 4.35, figure 4.39

Chapter 5

- Updated text in table 5.1
- Tables 5.2 through 5.9 reformatted and reorganized to maximize size of art and photomicrographs.
- Revised: figure 5.2, figure 5.10, figure 5.12, figure 5.13
- Modified section 5.1d: Glands
- Section 5.2a: Characteristics of Connective Tissue was simplified and updated
- Updated Clinical View 5.2: What Are You Planning to Do with Your Baby's Umbilical Cord?
- Replaced the term *hemopoieis* with *hematopoiesis* in discussions of bone and blood
- Updated section 5.3 to explicitly state the general functions and characteristics of skeletal muscle tissue
- Updated Clinical View 5.4: Stem Cells to include information about induced pluripotent stem cells
- Section 5.6b: Tissue Modification, updated the discussion of necrosis to include discussion of necrotizing fasciitis

Chapter 6

- Updated section 6.1a: Epidermis to include more detail about the types of melanin and carotene
- Revised: figure 6.5, figure 6.6, figure 6.8
- Revised section 6.1d: Functions of the Integument
- Updated Clinical View 6.3: Nail Disorders to include discussion about nail pitting (and its relationship to psoriasis) and nail clubbing
- Updated Clinical View 6.5: Psoriasis
- Updated section 6.4a: Development of the Integument and Its Derivatives
- Updated section 6.4b: Aging of the Integument to discuss p53 gene mutations
- Updated table 6.2

Chapter 7

- In section 7.2, adjusted definition and description of metaphysis, included more information about periosteum and endosteum
- Revised: figure 7.3, figure 7.5, figure 7.9, figure 7.11, figure 7.12
- Revised discussion of epiphyseal plate formation to discuss osteoprogenitor cells and osteoblasts
- Updated and clarified Clinical View 7.4: Achondroplastic Dwarfism
- Replaced the term *hemopoiesis* with *hematopoiesis* in discussions of red bone marrow
- Expanded section 7.5b: Bone Remodeling to include more detail
- Table 7.2 updated
- Updated Clinical View 7.7: Osteoporosis to include information about cancer patients

Chapter 8

- Updated table 8.2, table 8.3, table 8.4, table 8.5, table 8.6
- Revised: figure 8.2, figure 8.3, figure 8.4, figure 8.7, figure 8.8, figure 8.9, figure 8.12a, and figure 8.30
- Reorganized section 8.1b to reflect the order presented in figure 8.2
- Added new Learning Strategy 8.2
- Replaced the phrase *sex differences* with *sexually dimorphic features* in discussions of skull and pelvis in order to use more appropriate and gender-inclusive language
- Revised Clinical View 8.3: Spinal Curve Abnormalities to use the more appropriate terms *hyperkyphosis* and *hyperlordosis*
- Revised Clinical View 8.4: Herniated Discs to include more recent treatments for herniated discs
- New Learning Strategy 8.4
- In section 8.11b: Tibia and Fibula, added information about how the fibula may be used for bone grafts
- Reorganized discussion in Clinical View 8.9: Pathologies of the Foot

Chapter 9

- New Learning Strategy 9.2
- Section 9.4: Synovial Joints reorganized and edited; simplified discussion about synovial fluid, more consistent use of the term *articular capsule*
- Revised: figure 9.6, figure 9.7, figure 9.11, figure 9.15
- Updated table 9.2, table 9.4
- New Learning Strategy 9.3
- Removed discussion of hyperextension, as it is not a normal movement
- New photo for Clinical View 9.4: Shoulder Joint Dislocations, comparing normal and abnormal shoulder joints
- Included discussion about Tommy John surgery in section 9.7c: Elbow Joint
- Updated Clinical View 9.9: Arthritis to include mention of DMARDs (disease-modifying antirheumatic drugs)

Chapter 10

- Revised section 10.2b: Microscopic Anatomy of Skeletal Muscle to align with changes to figure 10.3: Structure and Organization of a Skeletal Muscle Fiber

- In section 10.2c: Innervation of Skeletal Muscle Fibers, reformatted resting conditions of synaptic knobs as bullet list
- Updated section 10.3a: Neuromuscular Junction: Excitation of a Skeletal Muscle Fiber to align steps in the text with sequence in figure 10.10
- Revised section 10.3b: Sarcolemma, T-Tubules, and Sarcoplasmic Reticulum: Excitation-Contraction Coupling to align steps in text with sequence in figure 10.11
- Edited section 10.3c: Sarcomere: Crossbridge Cycling to align steps in text with sequence in figure 10.13
- Updated table 10.1: Structural and Functional Characteristics of Different Types of Skeletal Muscle Fibers
- Updated Clinical View 10.6: Muscle Pain Associated with Exercise
- Revised section 10.7d: Muscle Fatigue
- Revised: figure 10.3, figure 10.5, figure 10.6, figure 10.7, figure 10.8, figure 10.9, figure 10.10, figure 10.11, figure 10.12, figure 10.16, figure 10.22, figure 10.23, and figure 10.28
- New figure for Clinical View 10.3: Muscular Paralysis and Neurotoxins

Chapter 11

- Revised headers and table with more accurate wording, such as “move the arm at the glenohumeral joint”
- Removed the outdated and technically incorrect term *urogenital diaphragm* from text and images
- Edited section 11.8c to clarify brachioradialis compartment classification
- Edited and clarified section 11.9a
- New Clinical View 11.9: Thigh Muscle Injuries
- Added information about variability of fibularis tertius in section 11.9c
- Revised: table 11.12, table 11.14, table 11.15, table 11.16, table 11.21
- Revised: figure 11.1, figure 11.17, figure 11.19, figure 11.22, figure 11.34
- Extensive revisions for COV figure 11.12, COV figure 11.23

Chapter 12

- Revised section 12.1b: Organization of the Nervous System to align with changes to figure 12.1: Organization of the Nervous System
- New Learning Strategy 12.1 comparing nerves to city streets
- Section 12.4: Nervous Tissue: Glial Cells, updated numbers of cells and functions of astrocytes
- Updated Clinical View 12.3: Nervous System Disorders Affecting Myelin
- New figure for Learning Strategy 12.5 on summation
- New Learning Strategy 12.3 on myelination
- Updated section 12.7: Introduction to Neuron Physiology
- Revised section 12.8a: Receptive Segment to align text on generation of an EPSP with figure 12.17: Postsynaptic Potentials in the Receptive Segment: Generation of an EPSP
- Revised section 12.8a: Receptive Segment to align text on generation of an IPSP with figure 12.18: Postsynaptic Potentials in the Receptive Segment: Generation of an IPSP

- Revised section 12.8c: Conductive Segment to align text with figure 12.20: Generation of an Action Potential: Depolarization and Its Propagation
- Revised section 12.8c: Conductive Segment to align text with figure 12.21: Generation of an Action Potential: Repolarization and Its Propagation
- Revised section 12.8d: Transmissive Segment to align steps in text with figure 12.25: Transmissive Segment: Release of Neurotransmitter
- Revised: figure 12.1, figure 12.3, figure 12.5, figure 12.6, figure 12.11, figure 12.13, figure 12.17, figure 12.18, figure 12.19, figure 12.20, figure 12.21, figure 12.22, figure 12.23, figure 12.24, figure 12.25, figure 12.26, and figure 12.28
- New figure 12.13: Electrical Energy in a Battery

Chapter 13

- Revised section 13.1: Brain Organization and Development
- Revised section 13.2a: Cranial Meninges
- New Learning Strategy 15.2 about remembering the cerebral lobes
- Revised: figure 13.6, figure 13.12, figure 13.13, figure 13.15, figure 13.22b, figure 13.26, and figure 13.32a
- Extensive reorganization and clarification of section 13.3c: Functional Areas of the Cerebrum
- Edited and updated section 13.3f: Cerebral Nuclei
- New Learning Strategy 13.5 about the cerebellar peduncles
- Updated and edited section 13.6: Cerebellum to include information about the nonmotor functions of the cerebellum
- New section 13.6c discussing how the midbrain, cerebellum, cerebral nuclei, and frontal lobes coordinate to control somatic motor movement
- Simplified section 13.7a: Limbic System
- Updated and revised Clinical View 13.12: Pathologic States of Unconsciousness

Chapter 14

- Revised Clinical View 14.1: Lumbar Puncture
- Revised section 14.4b and table 14.1 for posterior funiculus–medial lemniscal pathway
- Updated Clinical View 14.4: Shingles (Herpes Zoster)
- Updated table 14.1, table 14.4, table 14.5, and table 14.6
- Revised section 14.6d: Spinal Reflexes
- Revised: figure 14.3, figure 14.4, figure 14.11, and figure 14.22

Chapter 15

- Extensive reorganization of entire chapter to provide consistent discussion in tables, figures, and text
- Revised figure 15.1, figure 15.2, figure 15.4, figure 15.5, figure 15.6, figure 15.8, figure 15.10, figure 15.11
- Reorganized and updated table 15.1, table 15.3, table 15.5, table 15.6
- New Clinical View 15.2: Drug Binding of Nicotinic and Muscarinic Receptors
- New Clinical View 15.5: Drugs That Affect Pupil Size
- Updated and edited section 15.3a: Cranial Components regarding vagus functions

- New Learning Strategy 15.4 about parasympathetic activities
- Section 15.4b: clarification of adrenal medulla pathway in text and table 15.3
- New section 15.4c: Effector Stimulation by the Sympathetic Division to summarize the physiological changes that occur
- Simplified section 15.5a: Autonomic Plexuses
- Edited section 15.6c: Adrenergic Receptors

Chapter 16

- New introductory text for section 16.2: The General Senses
- New section 16.2b: Proprioceptors with new table
- Updated section 16.2c: Referred Pain for referred pain of the heart
- Edited section 16.3a: Olfaction: The Sense of Smell
- New Learning Strategy 16.2 on similarities of gustation and smell
- Edited section 16.4b: Eye Structure, including aligning text with figure 16.10
- Edited section 16.4c: Physiology of Vision: Refraction and Focusing of Light
- New Learning Strategy 16.3 on functions of rods and cones
- Revised: figure 16.4, figure 16.5, figure 16.10, figure 16.13, figure 16.14, figure 16.17, figure 16.21, figure 16.22, figure 16.25, figure 16.26, figure 16.27, figure 16.29, figure 16.32, figure 16.34, and figure 16.37
- New photo for Clinical View 16.2: Eye Infections
- New table 16.3: Proprioceptors with figures

Chapter 17

- Updated Clinical View 17.2: Hormone Analogs
- Updated section 17.7d: Growth Hormone: Its Regulation and Effects and aligned with steps in figure 17.13: Regulation and Action of Growth Hormone
- Updated section 17.8b: Thyroid Hormone: Its Regulation and Effects and aligned with steps in figure 17.17: Regulation and Action of Thyroid Hormone
- Revised subheadings in section 17.9a: Anatomy of the Adrenal Glands
- Updated section 17.9b: Cortisol: Its Regulation and Effects and aligned with steps in figure 17.19: Regulation and Action of Cortisol Hormone
- Updated Clinical View 17.7: The Stress Response (General Adaptation Syndrome)
- Updated section 17.10b: Pancreatic Hormones and aligned with steps in figure 17.22: Regulation and Action of Insulin and figure 17.23: Regulation and Action of Glucagon
- Revised: figure 17.1, figure 17.6, figure 17.8, figure 17.10, figure 17.11, figure 17.12, figure 17.13, figure 17.14, figure 17.16, figure 17.17, figure 17.19, figure 17.22, and figure 17.23
- New image for Clinical View 17.1: Synthesis of Eicosanoids

Chapter 18

- Throughout chapter, the term *hemopoiesis* replaced by the more appropriate term *hematopoiesis*
- Section 18.3a: Hematopoiesis edited to introduce an alternative model of hematopoiesis, and explain why we still use the classical model

- In section 18.3b: Erythrocytes, removed discussion of rouleau (abnormal accumulation of erythrocytes)
- Updated Clinical View 18.2: Anemia to include information about erythroblastic anemia
- New Learning Strategy 18.2 to remember which blood type may be safely transfused to a recipient
- Edited section 18.3c: Leukocytes
- New Learning Strategy 18.5 about blood clots
- Revised: figure 18.3, figure 18.5, figure 18.7, figure 18.8, and figure 18.10
- New figure 18.9c, a table listing which blood types can donate blood to and receive blood from other blood types
- New figure 18.11a showing electron micrograph of platelets

Chapter 19

- Edited Clinical View 19.1: Congestive Heart Failure
- Edited section 19.1b: Overview of Components to align with changes to figure 19.2: Significant Anatomic Features of the Heart
- New Learning Strategy 19.2 on how to remember heart valve locations
- Content of former figure 19.3 incorporated into COV figure 19.3: Blood Flow Through the Heart and Circulatory Routes
- Edited section 19.2b: The Pericardium
- Updated Clinical View 19.3, including title change from Teenage Athletes and Sudden Cardiac Death to Cardiomegaly and Hypertrophic Cardiomyopathy
- New photo for Clinical View 19.3: Cardiomegaly and Hypertrophic Cardiomyopathy
- Edited Clinical View 19.4: Heart Sounds and Heart Murmurs
- Edited Clinical View 19.5: Coronary Heart Disease, Angina Pectoris, and Myocardial Infarction and new photo
- New photo for Clinical View 19.6: Ectopic Pacemaker
- Former section 19.4: Coronary Vessels: Blood Supply Within the Heart Wall is now section 19.3f
- Former section 19.3f: Microscopic Structure of Cardiac Muscle is now section 19.4
- Organized section 19.4: Microscopic Structure and Metabolism of Cardiac Muscle to include two subheadings, 19.4a: Microscopic Structure of Cardiac Muscle, and 19.4b: Metabolism of Cardiac Muscle
- Added Concept Connection on atrial natriuretic peptide (ANP)
- Edited introduction to section 19.6: Stimulation of the Heart
- Revised section 19.6a: SA Nodal Cells at Rest
- Edited section 19.6b: Electrical Events at the SA Node: Initiation of the Action Potential, with two new subheadings, Autorhythmicity and Pacemaker Potential of SA Nodal Cells, and SA Nodal Cells as the Heart Pacemaker
- Edited section 19.7d: Electrocardiogram (ECG) to align with new figure 19.22: Integration of Heart Activity and an ECG
- Updated section 19.8b: Events of the Cardiac Cycle and aligned with steps in figure 19.23: Phases of the Cardiac Cycle
- New Learning Strategy 19.7 on cardiac cycle, with new image
- Revised: figure 19.2, figure 19.4, figure 19.7, figure 19.9, figure 19.10, figure 19.13, figure 19.14, figure 19.15, figure 19.16, figure 19.18, figure 19.19, figure 19.23, figure 19.24, figure 19.25, figure 19.26, and figure 19.29

- New figure 19.22: Integration of Heart Activity and an ECG
- New figure 19.27: The Frank-Starling Law

Chapter 20

- Edited Clinical View 20.1: Atherosclerosis
- Modified section 20.6b: Hormonal Regulation of Blood Pressure
- Edited section 20.8b: Characteristics of the Pulmonary Circulation
- Edited section 20.10a: Head and Neck, the subsection “Venous Drainage”
- Section 20.10c: Thoracic Organs and Spinal Cord, new title and new content on blood flow to spinal cord
- New Learning Strategy 20.5 for location of cephalic and basilic veins
- New Learning Strategy 20.6 on relationship of great saphenous vein and great toe
- Revised figure 20.4, figure 20.10, figure 20.14, and figure 20.29

Chapter 21

- Updated terminology, replacing the term *lymphatic* with *lymphoid* throughout the chapter
- Edited section 21.4c: Lymphoid Nodules and MALT
- Revised: figure 21.1, figure 21.6, figure 21.8, and figure 21.9
- New image for Concept Connection on lacteals

Chapter 22

- Throughout the chapter, replaced the term *lymphatic* with *lymphoid*
- Throughout chapter, replaced term *humoral immunity* with *antibody-mediated immunity*
- Throughout the chapter, replaced the term *innate immune system* with *innate immunity*, and replaced the term *adaptive immune system* with either *adaptive immunity* or *adaptive immune response*
- Updated chapter introduction
- Edited table 22.2: Major Categories of Cytokines
- Edited section 22.2c: Comparison of Innate Immunity and Adaptive Immunity
- Changed title of section 22.3a to First Line of Defense: Preventing Entry
- Added new section 22.3b: Second Line of Defense: Nonspecific Internal Defenses
- Modified section 22.3c: Nonspecific Internal Defenses: Cells
- Updated section 22.3d: Nonspecific Internal Defenses: Antimicrobial Proteins, including aligning steps in text with figure 22.4: Effects of Interferon Against a Virus
- Modified section 22.3e: Nonspecific Internal Defenses: Inflammation to have steps that align with figure 22.6
- Edited table 22.3: First Line of Defense: Preventing Entry of Pathogens
- Updated Clinical View 22.2: Applying Ice for Acute Inflammation
- Edited section 22.3f: Nonspecific Internal Defenses: Fever
- Updated Clinical View 22.3: Chronic Inflammation

- Changed title for Clinical View 22.4 to General Causes of Autoimmune Disorders
- Edited Section 22.4a: Antigens
- Edited section 22.4c: Antigen-Presenting Cells and MHC Molecules
- Updated Learning Strategy 22.5 for MHC interaction with T-lymphocytes
- Edited introduction to section 22.5: Formation and Selection of T-Lymphocytes in Primary Lymphoid Structures
- Edited section 22.5b: Selection and Differentiation of T-Lymphocytes
- Edited introduction to section 22.6: Activation and Clonal Selection of Lymphocytes
- Modified section 22.6a: Activation of T-Lymphocytes
- Modified introduction to section 22.7: Effector Response at Infection Site
- Integrated content in section 22.7a: Effector Response of T-lymphocytes with discussion of NK cells
- Clinical View 22.7: added content on herd immunity and changed title to Vaccinations and Herd Immunity
- Updated figures in table 22.1: Major Categories of Infectious Agents
- Revised: figure 22.1, figure 22.2, figure 22.4, figure 22.5, figure 22.6, figure 22.7, figure 22.8, figure 22.10, figure 22.11, figure 22.12, figure 22.13, figure 22.14, figure 22.15, figure 22.16, figure 22.18, and figure 22.20

Chapter 23

- Throughout the chapter replaced the term *alveolar gas exchange* with *pulmonary gas exchange*
- Throughout the chapter replaced the term *systemic gas exchange* with *tissue gas exchange*
- Moved section 23.3a: Larynx to become section 23.2d, so that larynx is discussed with upper respiratory tract
- Moved Clinical View on Cystic Fibrosis to section 23.1
- Clinical View 23.5: added content and changed title to Tracheotomy and Cricothyrotomy
- Deleted table 23.1: Structures of the Lower Respiratory Tract
- Edited Clinical View 23.8: Pneumonia
- Edited section 23.3c: Respiratory Zone: Respiratory Bronchioles, Alveolar Ducts, and Alveoli
- Edited section 23.3d: Respiratory Membrane
- Edited section 23.4a: Gross Anatomy of the Lung
- Combined Clinical View on Lung Cancer with Clinical View 23.9 on Smoking and changed title to Smoking and Lung Cancer
- Edited introduction to section 23.5: Respiration: Pulmonary Ventilation
- Integrated former table 23.2: Respiration Processes into figure 23.18: Overview of Respiration
- Added Learning Strategy 23.2 on pulmonary ventilation
- Edited section 23.5b: Mechanics of Breathing, including integration with updated figure 23.21: Pressure Gradients and the Respiratory System and integration of steps in text to align with updated figure 23.22: Volume and Pressure Changes Associated with the Mechanics of Quiet Breathing

- Incorporated the content of former table 23.3: Changes Associated with Quiet Breathing into section 23.5b: Mechanics of Breathing
- Edited section 23.5c: Nervous Control of Breathing
- Added new Learning Strategy 23.3 on respiratory center
- Updated Clinical View 23.12: Apnea including new photo
- Edited heading for section 23.5d to read Pressure Gradients, Resistance, and Airflow
- Edited section 23.5d: Pressure Gradients, Resistance, and Airflow to integrate content with concepts on pressure gradients, resistance, and blood flow
- Added image to Concept Connection on blood pressure gradients, resistance, and blood flow
- Added Learning Strategy 23.5 on compliance
- Changed heading for section 23.5e from Pulmonary and Alveolar Ventilation to Minute Volume and Alveolar Ventilation and edited content
- Changed heading for section 23.5f from Volume and Capacity to Measuring Respiratory Function and edited content
- Edited section 23.6a: Chemical Principles of Gas Exchange
- Edited section 23.6b: Pulmonary Gas Exchange to align with new figure 23.28
- New introduction for section 23.6c: Tissue Gas Exchange
- Edited Clinical View 23.15: Emphysema
- Edited section 23.7c: Hemoglobin as a Transport Molecule
- Revised: figure 23.1, figure 23.2, figure 23.3, figure 23.5, figure 23.6, figure 23.12, figure 23.17, figure 23.18, figure 23.19, figure 23.21, figure 23.22, figure 23.23, figure 23.25, figure 23.27, figure 23.28, figure 23.29, figure 23.30, figure 23.32, figure 23.33, figure 23.34, and figure 23.35
- New figure 23.24: Factors That Influence Airflow
- New Figure 23.26: Partial Pressure
- New photo for Clinical View 23.14: Decompression Sickness and Hyperbaric Oxygen Chambers
- New photo for Clinical View 23.17: Measuring Blood Oxygen Levels with a Pulse Oximeter
- New table 23.1: Gas Laws Associated with Respiration, with images

Chapter 24

- Edited Clinical View 24.2: Renal Ptosis and Hydronephrosis and updated figure
- New photo in Clinical View 24.2: Kidney Variations and Anomalies
- Added image for Learning Strategy 24.3 for filtration membrane as a sieve
- Edited section 24.5e: Regulation of Glomerular Filtration Rate
- Added image to Learning Strategy 24.4 on tubular fluid
- Edited section 24.6b: Transport Maximum and Renal Threshold
- New figure 24.18: Reclaiming Filtered Protein
- Edited section 24.6d: Substances with Regulated Reabsorption
- Edited section 24.6f: Establishing the Concentration Gradient
- New Learning Strategy 24.6 on transitional epithelium
- New image for Clinical View 24.7: Renal Calculi

- Updated section 24.8b: Urinary Tract (Ureters, Urinary Bladder, Urethra)
- Added image to Clinical View 24.8: Urinary Tract Infections
- Revised: figure 24.13, figure 24.15, figure 24.17, figure 24.19, figure 24.20, figure 24.21, figure 24.23, figure 24.25, figure 24.27, and figure 24.28

Chapter 25

- New photo for Clinical View 25.1: Intravenous (IV) Solution
- Edited section 25.2c: Regulation of Fluid Balance
- New Clinical View 25.4: Cerebral Edema
- Edited section 25.4a: Angiotensin II including aligning steps with figure 25.8 Renin-Angiotensin System
- Edited section 25.4b: Antidiuretic Hormone including aligning steps with figure 25.9: Actions and Effects of Antidiuretic Hormone
- Edited Section 25.4c: Aldosterone including aligning steps with figure 25.10: Actions and Effects of Aldosterone
- Edited section 25.4d: Atrial Natriuretic Peptide including aligning steps with figure 25.11: Actions and Effects of Atrial Natriuretic Peptide
- Edited section 25.5a: Categories of Acid
- Edited section 25.5b: The Kidneys and Regulation of Fixed Acids
- Added image to Learning Strategy 25.4 on chemical buffers
- Changed title of section 25.6a to Overview of Acid-Base Disturbances and edited content
- Edited section 25.6b: Respiratory-Induced Acid-Base Disturbances
- Edited section 25.6c: Metabolic-Induced Acid-Base Disturbances
- Changed title of section 25.6d to Compensation for Acid-Base Disturbances and edited content
- Edited Clinical View 25.9: Arterial Blood Gas (ABG) and Diagnosing Different Types of Acid-Base Disturbances
- Revised: figure 25.2, figure 25.3, figure 25.5, figure 25.8, figure 25.9, figure 25.10, figure 25.11, figure 25.12, and figure 25.14

Chapter 26

- Changed title of section 26.2 to Upper Gastrointestinal Tract and Associated Accessory Digestive Structures
- Changed title of section 26.2a to Overview
- Changed title of section 26.3 to Lower Gastrointestinal Tract and Associated Accessory Digestive Organs
- Changed title of section 26.3a to Overview
- Added image for Learning Strategy 26.1 for structures that are retroperitoneal
- Edited section 26.1: Introduction to the Digestive System (Introductory paragraph)
- Edited section 26.1d: Overview of the Regulation of the Digestive System, including adding content on receptors
- Added image to Concept Connection on cranial nerves involved in regulating digestive activities
- Edited section 26.1e: Serous Membranes of the Abdominal Cavity

- Edited section 26.2c: Pharynx and Esophagus
- Added image to Clinical View 26.4: Gastric Bypass
- Updated Clinical View 26.9: Gallstones
- Edited Clinical View 26.10: Pancreatic Cancer
- Revised section 26.3d: Large Intestine to include content on microbiota
- Added image to Clinical View 26.16: Celiac Disease (Gluten-Sensitive Enteropathy)
- Edited section 26.4a Carbohydrate Digestion including aligning steps with figure 26.26: Carbohydrate Digestion in the Small Intestine
- Edited section 26.4b: Protein Digestion including aligning steps with figure 26.27: Protein Digestion in the Small Intestine
- Edited section 26.4c: Lipid Digestion including aligning steps with figure 26.28: Lipid Digestion and Absorption in the Small Intestine
- Revised: figure 26.2, figure 26.6, figure 26.7, figure 26.10, figure 26.11, figure 26.12, figure 26.14, figure 26.16, figure 26.20, figure 26.24, figure 26.25, and figure 26.29
- Updated table 26.1: Primary Hormones That Control Digestion

Chapter 27

- Added content to the introduction regarding the Mediterranean diet
- Throughout chapter, replaced the term *absorptive state* with *fed (absorptive) state*, and replaced the term *post-absorptive state* with *fasting (postabsorptive) state*
- Edited section 27.2a: Carbohydrates
- Edited section 27.2c: Proteins
- Edited section 27.3a: Vitamins
- Updated Clinical View 27.2: Iron Deficiency
- Updated Clinical View 27.3: Obesity
- Revised figure 27.2, figure 27.4, and figure 27.5

Chapter 28

- In Section 28.1, added a paragraph explaining how gender identity and genetic sex might not align and that we will try to use gender-inclusive terms throughout this chapter
- In section 28.2, description of meiosis was clarified
- Simplified discussion of the ligaments in section 28.3a: Ovaries
- Section 28.3b: Oogenesis and the Ovarian Cycle extensively revised to better describe the length of the ovarian cycle, as well as the preantral and antral stages of folliculogenesis
- Section 28.3e: External Genitalia edited to include information about shape and structure of the hymen
- In section 28.3g: Female Sexual Response, added hypotheses about the biologic purpose of the female orgasm
- Updated Clinical View 28.5: Cervical Cancer to include information about high-risk HPV and treatment procedures
- Updated Clinical View 28.7: Contraception Methods
- New Learning Strategy 28.4 about spermatogenesis
- Updated section 28.5: Development and Aging of Female and Male Reproductive Systems

- Revised: figure 28.2, figure 28.5, figure 28.6, figure 28.7, figure 28.8, figure 28.11, and figure 28.14
- Updated Clinical View 28.11: Circumcision, to discuss female genital mutilation and how it should not be equated with male circumcision.

Chapter 29

- In section 29.1, added a footnote to clarify variation in the length of a pregnancy
- Reorganized section 29.2: Pre-Embryonic Period
- Updated Clinical View 29.1: Infertility and Infertility Treatments to clarify that not all *in vitro* fertilization techniques involve injecting a sperm into an oocyte
- New Clinical View 29.3: Amniocentesis and Chorionic Villus Sampling
- Updated section 29.3c: Organogenesis to include explicit definition of *peak development period*
- In section 29.5b: Hormonal Changes, removed discussion about human chorionic thyrotropin, as research has shown that it is hCG that performs the thyrotropic effects
- Former Clinical View 29.4: Hyperemesis Gravidarum was deleted and pertinent information incorporated directly into the text
- New Clinical View 29.9: Vaginal Bacteria and the Infant Microbiome
- New Clinical View 29.10: Preterm (Premature) Birth
- Footnote added to section 29.9: Heredity, stating this discussion was intentionally left brief, but more detailed genetic information may be found online

- Revised table 29.1, table 29.2, and table 29.3
- Revised: figure 29.2

We Welcome Your Input!

We hope you enjoy reading this textbook, and that it becomes central to mastering the concepts in your anatomy and physiology course. This text is a product that represents over 90 years of combined teaching experience in anatomy and physiology. We are active classroom instructors, and are well aware of the challenges that current students face in mastering these subjects. We have taken what we have learned in the classroom and have created a textbook truly written for students.

Please let us know what you think about this text. We welcome your thoughts and suggestions for improvement, and look forward to your feedback!

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ACKNOWLEDGMENTS

Many people have worked with us over the last several years to produce this text. We would like to thank the many individuals at McGraw-Hill who worked with us to create this textbook. We are especially grateful to Donna Nemmers and Melisa Seegmiller, our Product Developers, Matthew Garcia, our Portfolio Manager, and Jessica Portz, our Content Project Manager, for expertly guiding the project through its production phases; David Hash, Designer, for his beautiful interior and cover designs; and Valerie Kramer, Marketing Manager, for her marketing expertise. We would also like to thank our copyeditor, Wendy Nelson, and our proofreaders, David Heath and Lauren Timmer. We are very grateful for the enthusiasm and expertise of Dr. Justin York, digital author and collaborator on mul-

iple portions of the supporting online assessment and instructor tools that accompany this textbook. Justin’s eye for detail also helped us improve the accuracy of several sections of the text.

Finally, we could not have performed this effort were it not for the love and support of our families: Bob and Erin O’Loughlin; and Jay and Stephanie Bidle—thank you and we love you! We are blessed to have you all.

Many instructors and students across the country have positively affected this text through their careful reviews of manuscript drafts, art proofs, and page proofs, as well as through class tests and through their attendance at focus groups and symposia. We gratefully acknowledge their contributions to this text.

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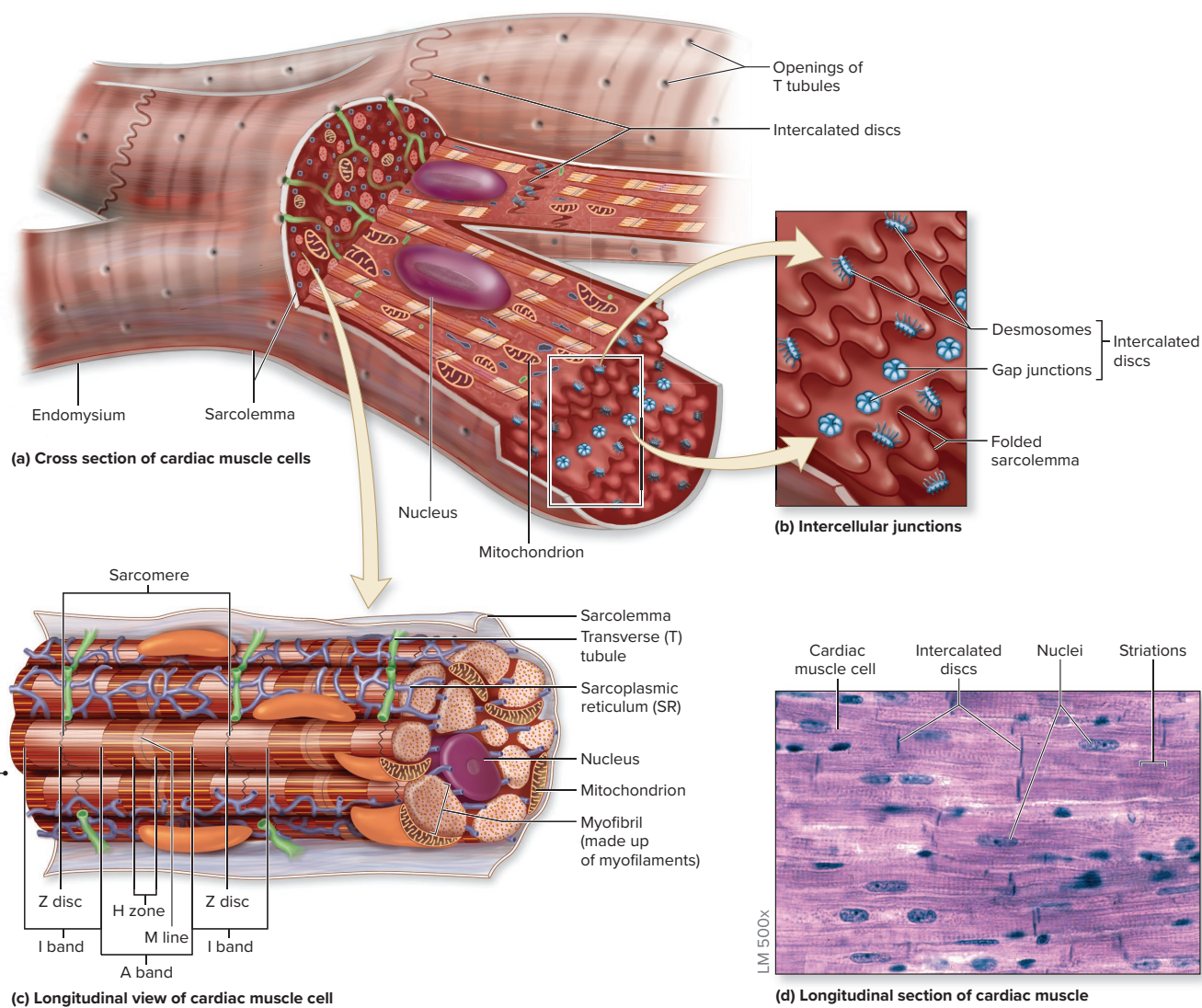
guided tour

Fully Integrated Content and Pedagogy

Anatomy and Physiology: An Integrative Approach is structured around a tightly integrated learning system that combines illustrations and photos with textual descriptions; focused discussions with big-picture summaries; previously learned material with new content; factual explanations with practical and clinical examples; and bite-sized topical sections with multitiered assessment.

Unparalleled Art Program

In a visually oriented subject like A&P, quality illustrations are crucial to understanding and retention. The brilliant illustrations in *Anatomy and Physiology: An Integrative Approach* have been carefully rendered to convey realistic, three-dimensional detail while incorporating pedagogical conventions that help deliver a clear message. Each figure has been meticulously reviewed for accuracy and consistency, and precisely labeled to coordinate with the text discussions.



Rich Detail

Vibrant colors and three-dimensional shading make it easy to envision body structures and processes.

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Photographs

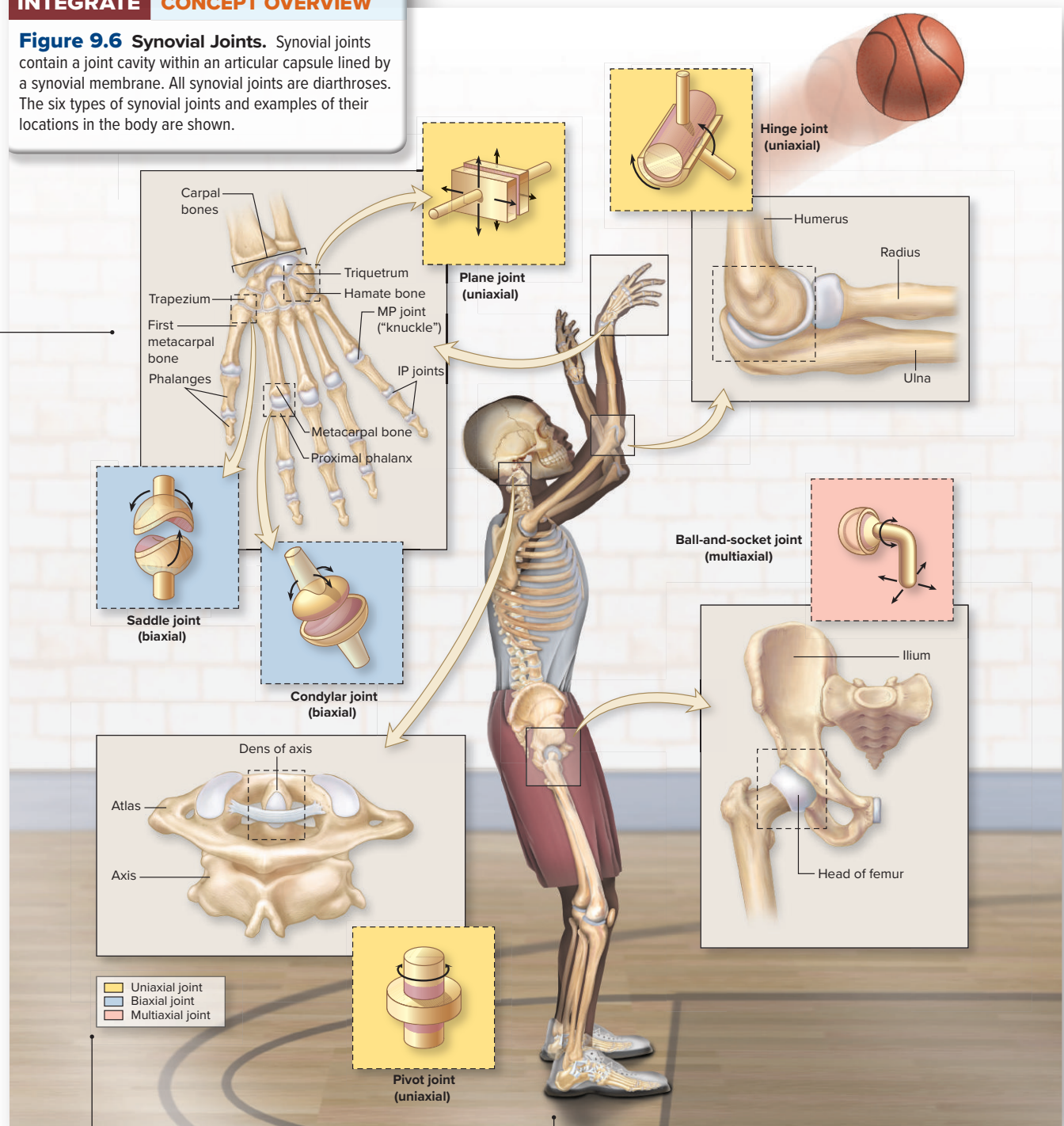
Atlas-quality micrographs and cadaver images are frequently paired with illustrations to expose students to the appearance of real anatomic structures.

INTEGRATE CONCEPT OVERVIEW

Figure 9.6 Synovial Joints. Synovial joints contain a joint cavity within an articular capsule lined by a synovial membrane. All synovial joints are diarthroses. The six types of synovial joints and examples of their locations in the body are shown.

Multilevel Perspective

Microscopic structures are connected to macroscopic views to show changes in perspective between increasingly detailed drawings.



Color Coding

Many figures use color coding to organize information and clarify concepts for visual learners.

Real-Life Context

Illustrations include depictions of realistic people and situations to make figures more relevant and memorable.