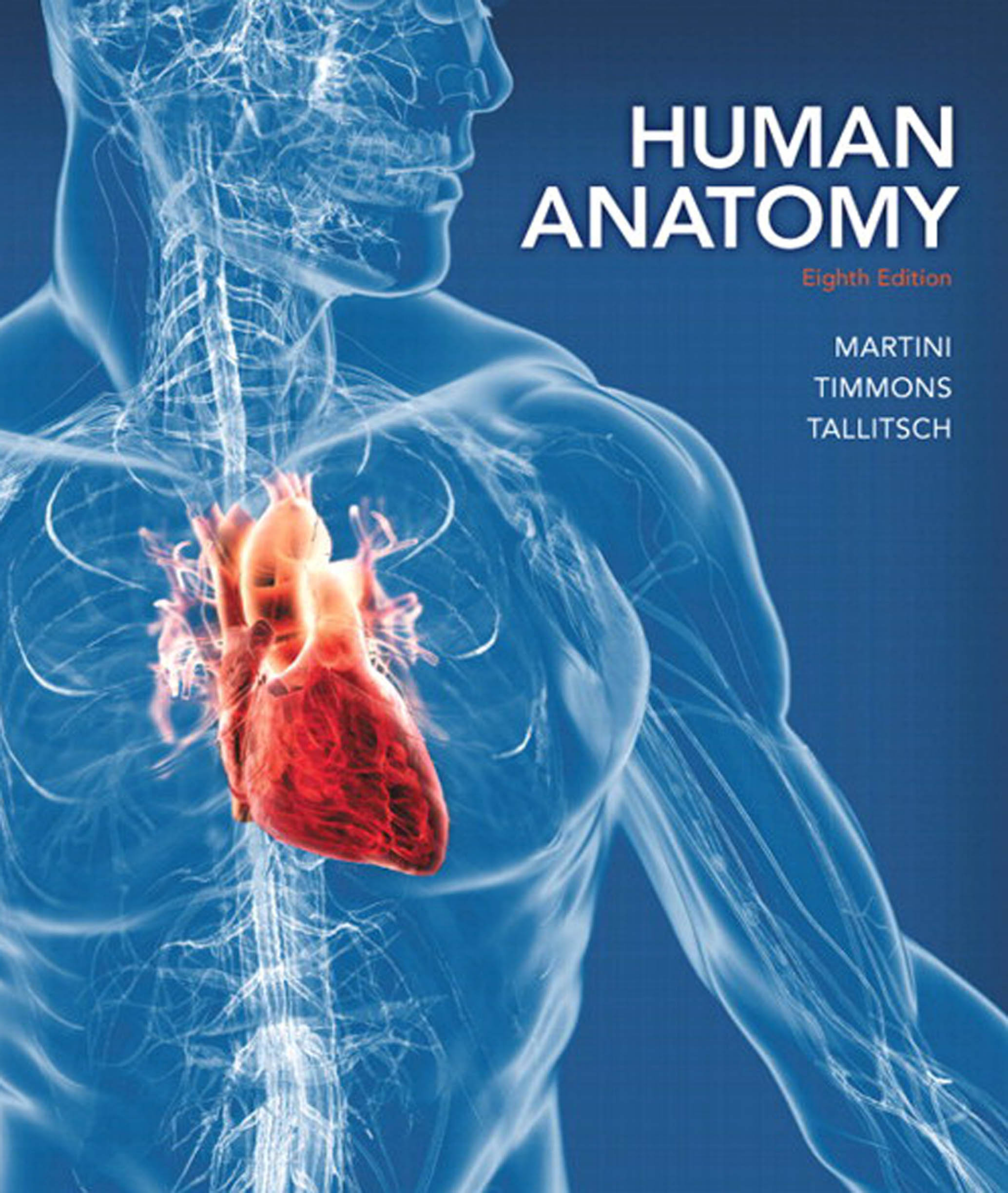
HUMAN ANATOMY

Eighth Edition

MARTINI
TIMMONS
TALLITSCH



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SPOTLIGHT FIGURES

HUMAN ANATOMY

Eighth Edition

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Claire E. Ober, R.N.
Illustrator

Kathleen Welch, M.D.
Clinical Consultant

Ralph T. Hutchings
Biomedical Photographer

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Library of Congress Cataloging-in-Publication Data
Martini, Frederic.
Human anatomy / Frederic H. Martini, Ph.D., University of Hawaii at Manoa, Michael J. Timmons, M.S., Moraine Valley Community College, Robert B. Tallitsch, Ph.D., Augustana College; with William C. Ober, M.D., art coordinator and illustrator, Claire E. Ober, R.N., illustrator, Kathleen Welch, M.D.; clinical consultant, Ralph T. Hutchings, biomedical photographer.—Eighth edition.
pages cm.
ISBN-13: 978-0-321-88332-2
ISBN-10: 0-321-88332-2
1. Human anatomy. 2. Human anatomy—Atlases.
I. Timmons, Michael J. II. Tallitsch, Robert B. III. Title.
QM23.2.M356 2015
611—dc23 2013036907

1 2 3 4 5 6 7 8 9 10—DOW— 17 16 15 14 13

PEARSON

ISBN 10: 0-321-88332-2 (Student edition)
ISBN 13: 978-0-321-88332-2 (Student edition)
ISBN 10: 0-321-90913-5 (Exam copy)
ISBN 13: 978-0-321-90913-8 (Exam copy)

Text and Illustration Team

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Author

Dr. Martini received his Ph.D. from Cornell University in comparative and functional anatomy for work on the pathophysiology of stress. In addition to professional publications that include journal articles and contributed chapters, technical reports, and magazine articles, he is the lead author of ten undergraduate texts on anatomy and physiology or anatomy. Dr. Martini is currently affiliated with the University of Hawaii at Manoa and has a long-standing bond with the Shoals Marine Laboratory, a joint venture between Cornell University and the University of New Hampshire. He has been active in the Human Anatomy and Physiology Society (HAPS) for 20 years and was a member of the committee that established the course curriculum guidelines for A&P. He is now a President Emeritus of HAPS after serving as President-Elect, President, and Past-President over 2005–2007. Dr. Martini is also a member of the American Physiological Society, the American Association of Anatomists, the Society for Integrative and Comparative Biology, the Australia/New Zealand Association of Clinical Anatomists, the Hawaii Academy of Science, the American Association for the Advancement of Science, and the International Society of Vertebrate Morphologists.

Michael J. Timmons
Author

Michael J. Timmons received his degrees from Loyola University, Chicago. For more than three decades he has taught anatomy to nursing, EMT, and pre-professional students at Moraine Valley Community College. He was honored with the Professor of the Year Award by MVCC and the Excellence Award from the National Institute for Staff and Organizational Development for his outstanding contributions to teaching, leadership, and student learning. He is the recipient of the Excellence in Teaching Award by the Illinois Community College Board of Trustees. Professor Timmons, a member of the American Association of Anatomists, has authored several anatomy and physiology lab manuals and dissection guides. His areas of interest include biomedical photography, crafting illustration programs, and developing instructional technology learning systems. He chaired the Midwest Regional Human Anatomy and Physiology Conference and is also a national and regional presenter at the League for Innovation Conferences on Information Technology for Colleges and Universities and at Human Anatomy and Physiology Society meetings.

Robert B. Tallitsch
Author

Dr. Tallitsch received his Ph.D. in physiology with an anatomy minor from the University of Wisconsin–Madison at the ripe old age of 24. Dr. Tallitsch has been on the biology faculty at Augustana College (Illinois) since 1975. His teaching responsibilities include Human Anatomy, Neuroanatomy, Histology, and Cadaver Dissection. He is also a member of the Asian Studies faculty at Augustana College, teaching a course in Traditional Chinese Medicine. Dr. Tallitsch has been designated numerous times as one of the "unofficial teachers of the year" by the graduating seniors at Augustana. Dr. Tallitsch is a member of the American Physiological Society (APS); American Association of Anatomists, where he serves as a Career Development Mentor; American Association of Clinical Anatomists, where he is a member of the Educational Affairs Committee; and the Human Anatomy and Physiology Society. In addition to his teaching responsibilities at Augustana College, Dr. Tallitsch has served as a visiting faculty member at the Beijing University of Chinese Medicine and Pharmacology (Beijing, PRC), the Foreign Languages Faculty at Central China Normal University (Wuhan, PRC), and in the Biology Department at Central China Normal University (Wuhan, PRC).

William C. Ober
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 22 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
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
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 of England 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.

Preface

In this eighth edition of *Human Anatomy*, we have made a highly visual book even more visual in an effort to support student understanding of the intricacies of the human body. The new visuals are especially apparent in the new Spotlight Figures. Student learning is further supported by new highly visual and interactive activities in MasteringA&P®, the online homework, tutorial, and assessment system.

New to the Eighth Edition

To build on the strengths of previous editions while meeting the needs of today's students, the author team and the publisher conducted student focus groups and gathered input from numerous instructors who teach the human anatomy course. The changes presented below reflect advancements resulting from the invaluable input of students and instructors.

- **NEW Spotlight Figures** are one- and two-page presentations that seamlessly integrate text and visuals to guide students through complex topics. With the explanations built directly into the illustrations, students can find everything they need to understand a topic in one place—with no page flipping. Students study the Spotlight Figures in the book, and then instructors can assign them in MasteringA&P. The 22 new Spotlight Figures are listed on the inside front cover of this book.
- **NEW QR Codes** in the chapters on the skeletal and muscular systems let students use their smartphones to link directly from figures in the book to figures in the Practice Anatomy Lab™ (PAL™) virtual anatomy program, giving students additional views to help them learn bones (Chapters 6 and 7) and muscles (Chapters 10 and 11).
- **NEW Learning Outcomes** on each chapter-opening page indicate to students what they should be able to do after studying the chapter. These Learning Outcomes are coordinated by number to the main chapter headings, creating a predictable one-to-one correspondence and allowing students to check their understanding by both Learning Outcomes and chapter topics. The Learning Outcomes correlate with the **Concept Check questions** that close out each main section and ask students to pause and check their understanding before moving to the next section. (The answers are at the back of the book.) Additionally, the assessments in MasteringA&P are organized by these Learning Outcomes, allowing instructors to assign homework, assess understanding, and demonstrate teaching results by Learning Outcomes.
- **NEW Visual Study Outlines** at the end of each chapter have memory-triggering visuals to help students remember chapter content.
- **NEW MasteringA&P activities** include the following:
  - **NEW Spotlight Figure Coaching Activities** are highly visual, assignable activities designed to bring interactivity to the one- and two-page Spotlight Figure presentations in the book. Multi-part activities include the ranking and sorting types that ask students to manipulate the visuals.
  - **NEW Dynamic Study Modules** help students acquire, retain, and recall information faster and more effectively than before. The modules are available as a self-study tool or can be assigned by the instructor. They can be easily accessed with smartphones.
  - **NEW Bone Videos (29 total) and Dissection Videos (16 total) Coaching Activities** with hints and specific wrong answer feedback help students preview or review for lab exercises involving bone and dissection identification.

Chapter-by-Chapter Revisions

Specific chapter-by-chapter revisions include:

1 Foundations: An Introduction to Anatomy

- Eight new or significantly revised illustrations were added.
- Presentation of the material throughout the chapter was revised to better facilitate student learning and comprehension.

2 Foundations: The Cell

- Three new Spotlight Figures were added.
- The Hot Topics feature was updated with new research information.
- Ten new or significantly revised illustrations were added.
- The presentation of material throughout the chapter was revised to better facilitate student learning and comprehension.

3 Foundations: Tissues and Early Embryology

- One new Spotlight Figure was added.
- The Hot Topics feature was updated with new research information.
- Ten new or significantly revised illustrations were added.
- Changes were made in terminology according to the *Terminologia Anatomica (TA)* and *Terminologia Histologica (TH)*.
- The presentation order of some material was rearranged in order to facilitate student learning.
- New material was added to update the chapter according to current histological research.

4 The Integumentary System

- Eight new or significantly revised illustrations were added.
- The Hot Topics feature was updated with new research information.
- Changes were made in terminology according to the *TA* and *TH*.
- Existing chapter material was revised for easier comprehension and to better facilitate student learning.

5 The Skeletal System: Osseous Tissue and Skeletal Structure

- Two new Spotlight Figures were added.
- The Hot Topics feature was updated with new research information.
- Four new or significantly revised illustrations were added.
- New material was added to the discussion of bone remodeling and repair, and the existing material was revised for easier reading and comprehension.
- New material was added to the discussion of the cells of bone to match current histological terminology and research.

6 The Skeletal System: Axial Division

- Three new or significantly revised illustrations were added.
- Seventeen QR codes linking to related Practice Anatomy Lab (PAL) human cadaver images were added to figures throughout the chapter.
- Chapter material was revised for easier comprehension and to better facilitate student learning.

7 The Skeletal System: Appendicular Division

- Five illustrations are either new or have been significantly revised.
- Eight QR codes linking to related Practice Anatomy Lab (PAL) human cadaver images were added to figures throughout the chapter.
- New material was added, and existing material has been clarified to better facilitate student learning.

8 The Skeletal System: Articulations

- One new Spotlight Figure was added.
- Three illustrations are either new or have been significantly revised.
- New material was added and existing material clarified for better student comprehension.

9 The Muscular System: Skeletal Muscle Tissue and Muscle Organization

- Two new Spotlight Figures were added.
- Eleven illustrations are either new or have been significantly revised.
- Material within the chapter was revised to better facilitate student comprehension and learning.

10 The Muscular System: Axial Musculature

- Eleven illustrations are either new or have been significantly revised.
- Four QR codes linking to related Practice Anatomy Lab (PAL) human cadaver images were added to figures throughout the chapter.
- The Hot Topics feature was updated with new research information.
- The presentation of all the material within this chapter was revised and reorganized to better facilitate student comprehension and learning.

11 The Muscular System: Appendicular Musculature

- One new Spotlight Figure was added.
- Eighteen QR codes linking to related Practice Anatomy Lab (PAL) human cadaver images were added to figures throughout the chapter.
- Three QR codes linking to related A&P Flix animations were added to the Spotlight Figure 11.2.
- Twenty-six illustrations are either new or have been significantly revised.
- The presentation of all the material within this chapter was revised and reorganized to better facilitate student comprehension and learning.

12 Surface Anatomy and Cross-Sectional Anatomy

- Four illustrations are either new or have been significantly revised.
- Clinically relevant material was added to the Surface Anatomy illustrations throughout the chapter.

13 The Nervous System: Neural Tissue

- One new Spotlight Figure was added.
- The Hot Topics feature was updated with new research information.
- Nine illustrations are either new or have been significantly revised.
- The sections entitled "Neuroglia of the CNS" and "Synaptic Communication" were updated in order to match current research findings in the field.

14 The Nervous System: The Spinal Cord and Spinal Nerves

- Two new Spotlight Figures were added.
- Nine illustrations are either new or have been significantly revised.
- The discussion of the sectional anatomy of the spinal cord was expanded, with particular emphasis on the revision of the section on "Organization of the Gray Matter."
- The section on "Spinal Nerves" has been rewritten in order to facilitate student learning and comprehension.

15 The Nervous System: Sensory and Motor Tracts of the Spinal Cord

- One new Spotlight Figure was added.
- The Hot Topics feature was updated with new research information.
- Five illustrations are either new or have been significantly revised.
- All sections of this chapter were revised, either partially or totally, to better facilitate student comprehension.
- At the request of reviewers, a section dealing with Higher-Order Functions has been added to the chapter.

16 The Nervous System: The Brain and Cranial Nerves

- Eleven illustrations are either new or have been significantly revised.
- The Hot Topics feature was updated with new research information.

17 The Nervous System: Autonomic Nervous System

- One new Spotlight Figure was added.
- Eight illustrations are either new or have been significantly revised.
- All sections of this chapter were revised, either partially or totally, to better facilitate student comprehension.

18 The Nervous System: General and Special Senses

- Fifteen illustrations are either new or have been significantly revised.
- The Hot Topics feature was updated with new research information.
- All sections of this chapter were revised, either partially or totally, to better facilitate student comprehension.

19 The Endocrine System

- One new Spotlight Figure has been added.
- The Hot Topics feature was updated with new research information.
- Five illustrations are either new or have been significantly revised.
- All sections of this chapter were revised, either partially or totally, to better facilitate student comprehension.

20 The Cardiovascular System: Blood

- Three illustrations are either new or have been significantly revised.
- All sections of this chapter were updated in order to match current research findings in the field.

21 The Cardiovascular System: The Heart

- One new Spotlight Figure was added.
- The Hot Topics feature was updated with new research information.
- Four illustrations are either new or have been significantly revised.
- New material dealing with the histology of cardiac muscle has been rewritten in order to reflect new research findings.
- The section discussing the anatomy of the mediastinum and pericardial sac was revised in order to better facilitate student comprehension.

22 The Cardiovascular System: Vessels and Circulation

- One new Spotlight Figure was added.
- A new Clinical Note on Repair of an Aortic Aneurysm was added.
- Seven illustrations are either new or have been significantly revised.
- All sections of this chapter were revised, either partially or totally, in order to better facilitate student comprehension.

23 The Lymphatic System

- One new Spotlight Figure was added.
- The Hot Topics feature was updated with new research information.
- Three illustrations are either new or have been significantly revised.
- All sections of this chapter were revised, either partially or totally, in order to better facilitate student comprehension.

24 The Respiratory System

- One new Spotlight Figure was added.
- The Hot Topics feature was updated with new research information.
- Six illustrations are either new or have been significantly revised.
- Revisions were made to reflect the current histological information on the respiratory system.
- All sections of this chapter were revised, either partially or totally, in order to better facilitate student comprehension.

25 The Digestive System

- One new Spotlight Figure was added.
- The Hot Topics feature was updated with new research information.
- Thirteen illustrations are either new or have been significantly revised.
- Revisions were made to reflect the current histological information on the various organs of the digestive system.

26 The Urinary System

- One new Spotlight Figure was added.
- The Hot Topics feature was updated with new research information.
- Three illustrations are either new or have been significantly revised.
- Revisions were made to reflect the current histological information on the various organs of the urinary system.
- All sections of this chapter were revised, either partially or totally, in order to better facilitate student comprehension.

27 The Reproductive System

- Twelve illustrations are either new or have been significantly revised.
- The Hot Topics feature was updated with new research information.
- Revisions were made to reflect the current histological information on the various organs of the male and female reproductive systems.
- All sections of this chapter were revised, either partially or totally, in order to better facilitate student comprehension.

28 The Reproductive System: Embryology and Human Development

- All of the Embryology Summaries have been revised.

Acknowledgments

The creative talents and patience brought to this project by our artist team, William Ober, M.D., Claire E. Ober, R.N., and Anita Impagliazzo, M.F.A., are inspiring and valuable beyond expression. Bill, Claire, and Anita worked intimately and tirelessly with us, imparting a unity of vision to the book while making each illustration clear and beautiful. Their superb art program is greatly enhanced by the incomparable bone and cadaver photographs of Ralph T. Hutchings, formerly of The Royal College of Surgeons of England. In addition, Dr. Pietro Motta, Professor of Anatomy, University of Roma, La Sapienza, provided several superb SEM images for use in the text. We also gratefully acknowledge Shay Kilby, Ken Fineman, and Steve Sandy of Fovia, Inc., and Donna Wefers and Cormac Donovan of TeraRecon, Inc., for creating and providing the 3-D spiral scans that appear in this edition. We are deeply indebted to Jim Gibson of Gibson Design Associates for his wonderful work on the spectacular design of the Eighth Edition of *Human Anatomy*.

We would like to acknowledge the many users and reviewers whose advice, comments, and collective wisdom helped shape this text into its final form. Their passion for the subject, their concern for accuracy and method of presentation, and their experience with students of widely varying abilities and backgrounds have made the revision process interesting and educating.

Reviewers

Pamela Byrd-Williams, *Los Angeles Valley College*
David L. Chambers, *Clarion University*
Lu Anne Clark, *Lansing Community College*
Brian Cross, *Tulsa Community College*
John Duncan, *Pacific Union College*
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Scott Zimmerman, *Missouri State University*

We are also indebted to the Pearson staff, whose efforts were vital to the creation of this edition. A special note of thanks and appreciation goes to the editorial staff at Pearson, especially Leslie Berriman, Executive Editor, for her dedication to the success of this project. Thanks to Nicole George-O'Brien, Project Editor, for her management of the text and its supplements. Thanks also to Barbara Yien, Director of Development, and Cady Owens, Assistant Editor. We express thanks to Aimee Pavy and Julia Akpan for their work on the media programs that support *Human Anatomy,* especially MasteringA&P and Practice Anatomy Lab™ (PAL™). Thanks also to Caroline Ayres, Project Manager, for her steady hand managing this complex text, and Mike Early, Norine Strang, Maureen Spuhler, Donna Kalal, and Stacey Weinberger for their roles in the production of the text.

We are very grateful to Paul Corey, President, and Frank Ruggirello, Editorial Director, for their continued enthusiasm and support of this project. We appreciate the contributions of Derek Perrigo, Senior Anatomy & Physiology Specialist, and Allison Rona, Senior Marketing Manager, who keep their fingers on the pulse of the market and help us meet the needs of our customers, and the remarkable and tireless Pearson Science sales reps.

We are also grateful that the contributions of all the aforementioned people have led to this text receiving the following awards: The Association of Medical Illustrators Award, The Text and Academic Authors Award, the New York International Book Fair Award, the 35th Annual Bookbuilders West Award, and the 2010 Text and Academic Authors Association "Texty" Textbook Excellence Award.

Finally, we would like to thank our families for their love, patience, and support during the revision process. We could not have accomplished this without the help of our wives—Kitty, Judy, and Mary—and the patience of our children—P.K., Molly, Kelly, Patrick, Katie, Ryan, Molly, and Steven.

No three people could expect to produce a flawless textbook of this scope and complexity. Any errors or oversights are strictly our own rather than those of the reviewers, artists, or editors. In an effort to improve future editions, we ask that readers with pertinent information, suggestions, or comments concerning the organization or content of this textbook send their remarks to Robert Tallitsch directly, by the e-mail address below, or care of Publisher, Applied Sciences, Pearson Benjamin Cummings, 1301 Sansome Street, San Francisco, CA 94111.

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Michael J. Timmons, Orland Park, IL
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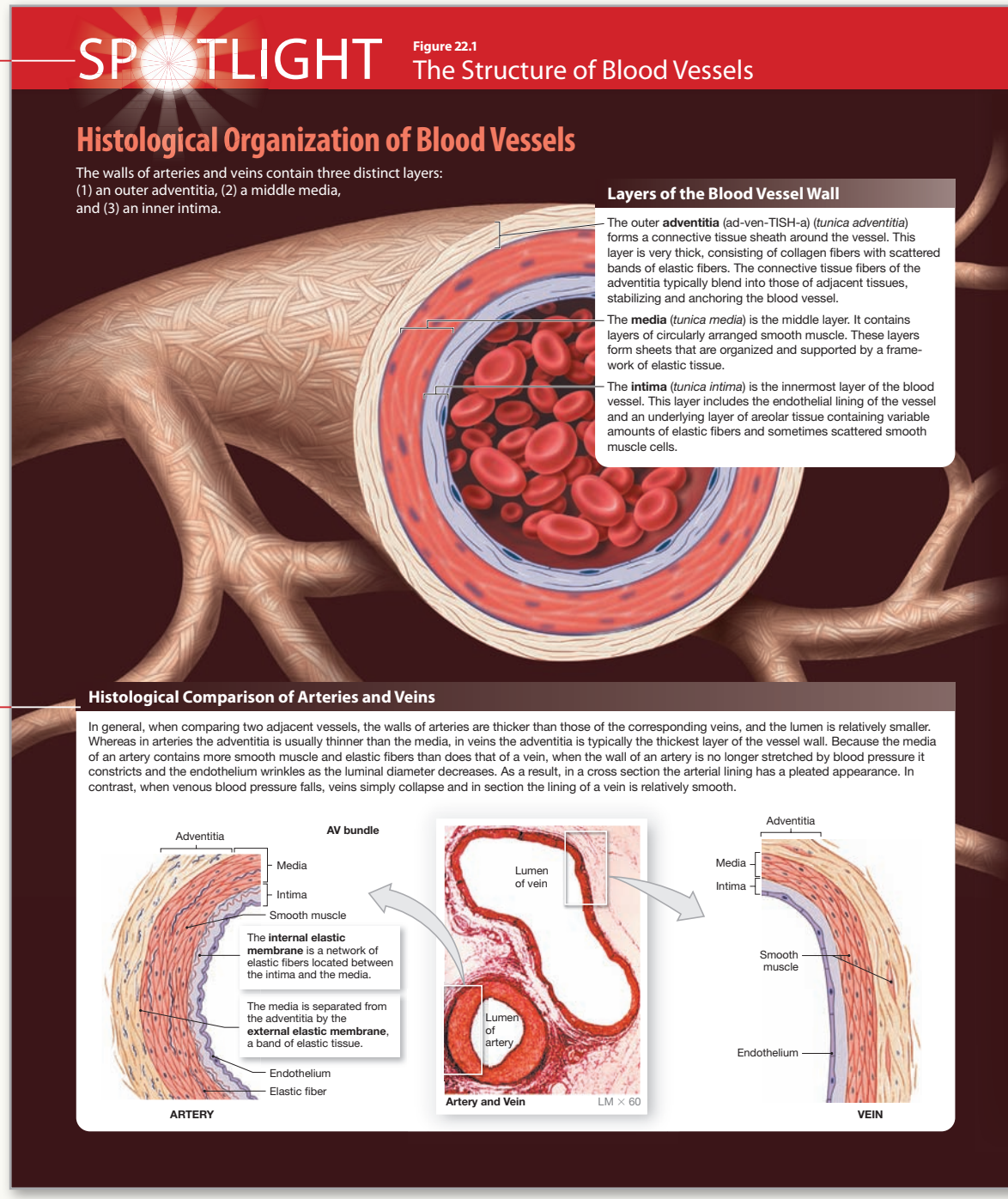
SPOTLIGHT FIGURES

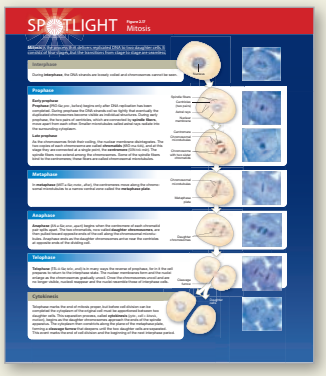
NEW Spotlight Figures

are one- or two-page presentations that integrate text and art to communicate complex topics in a visually effective format.

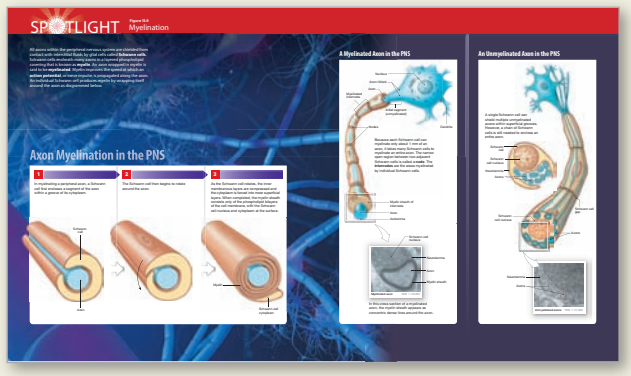
The explanation is built directly into the illustration for efficient and effective learning.



NEW There are 22 Spotlight Figures included in the Eighth Edition.



Mitosis
Chapter 2, page 45



Myelination
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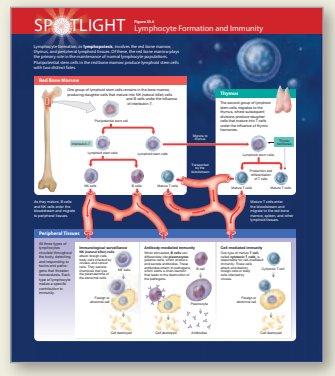
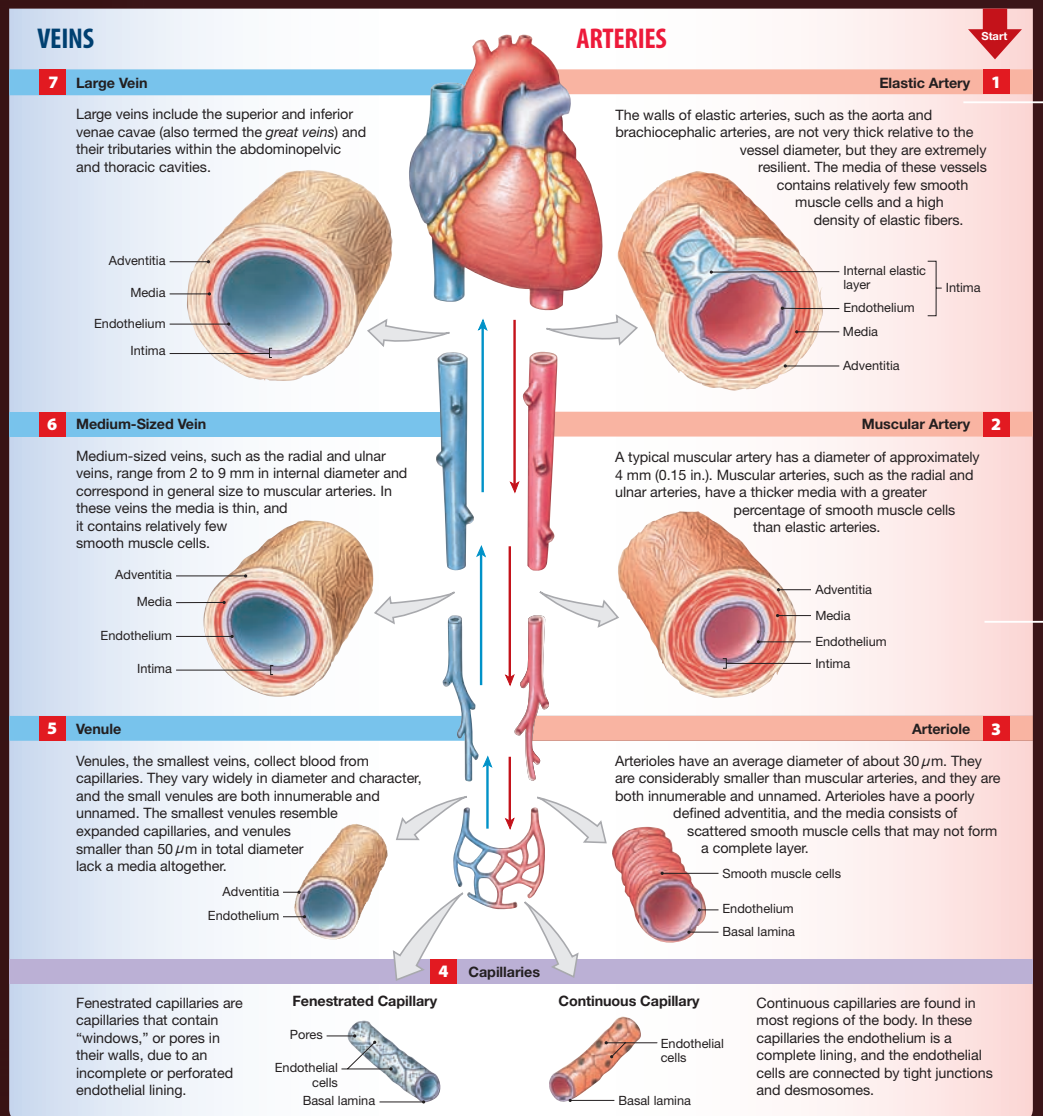


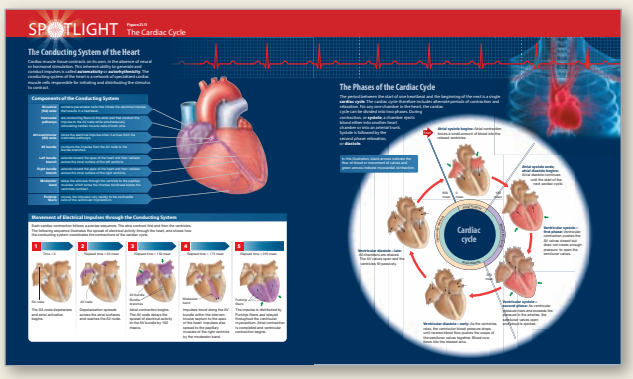
Lymphocyte Formation and Immunity
Chapter 23, page 618

Structural Differences between Arteries and Veins



Clear steps use text and art to guide students through the topic.

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



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Chapter 21, page 566

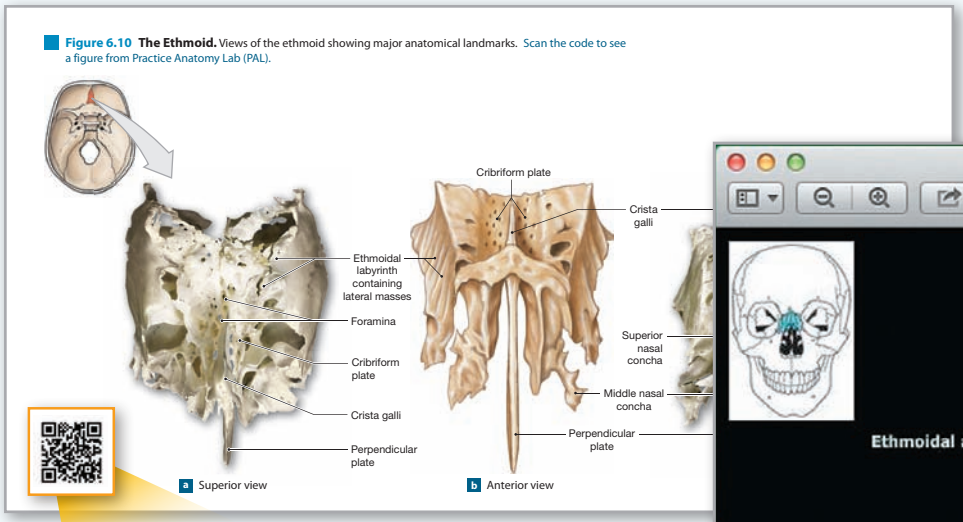
MasteringA&P®

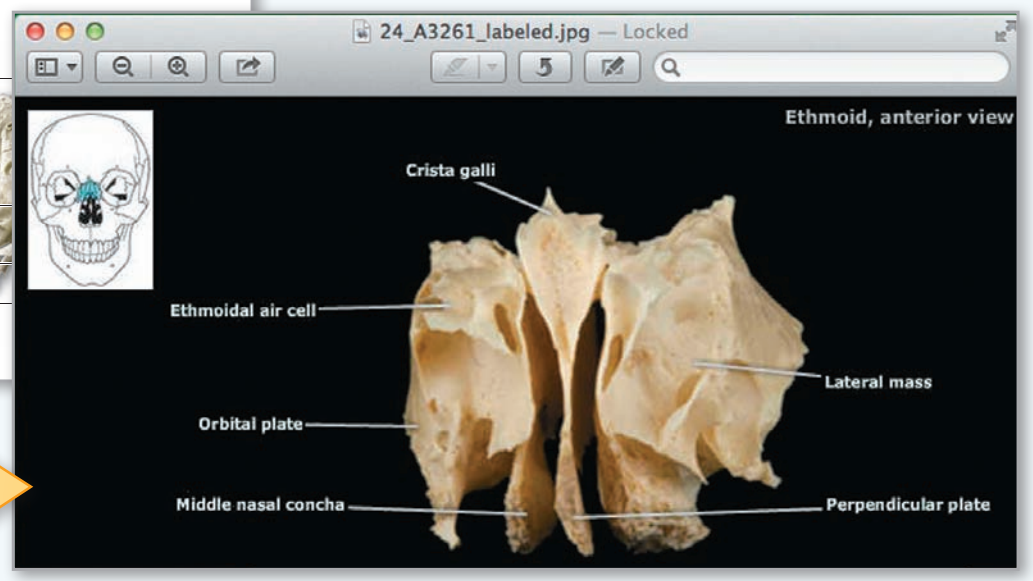
NEW Spotlight Figure Coaching Activities

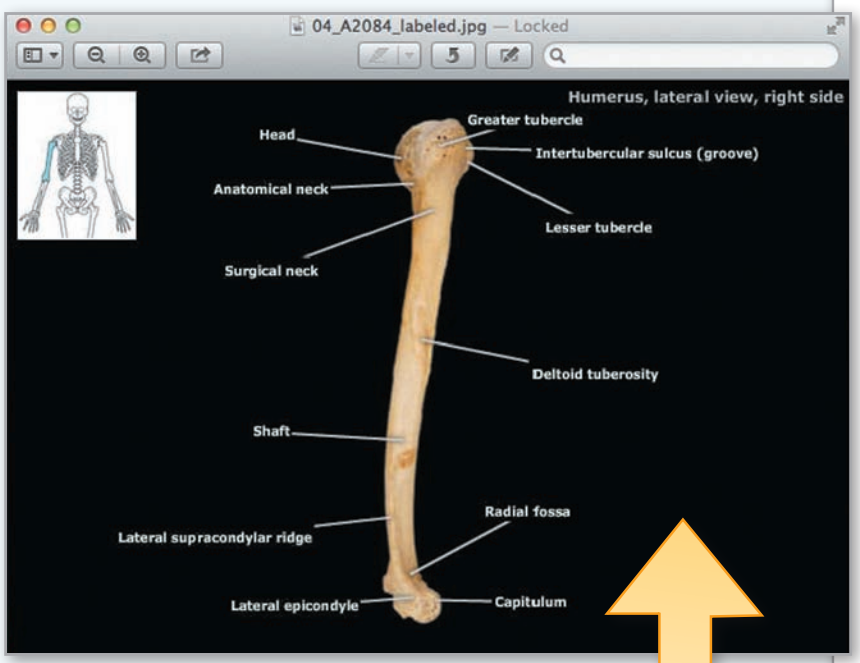
Every Spotlight Figure has an assignable Coaching Activity in MasteringA&P.

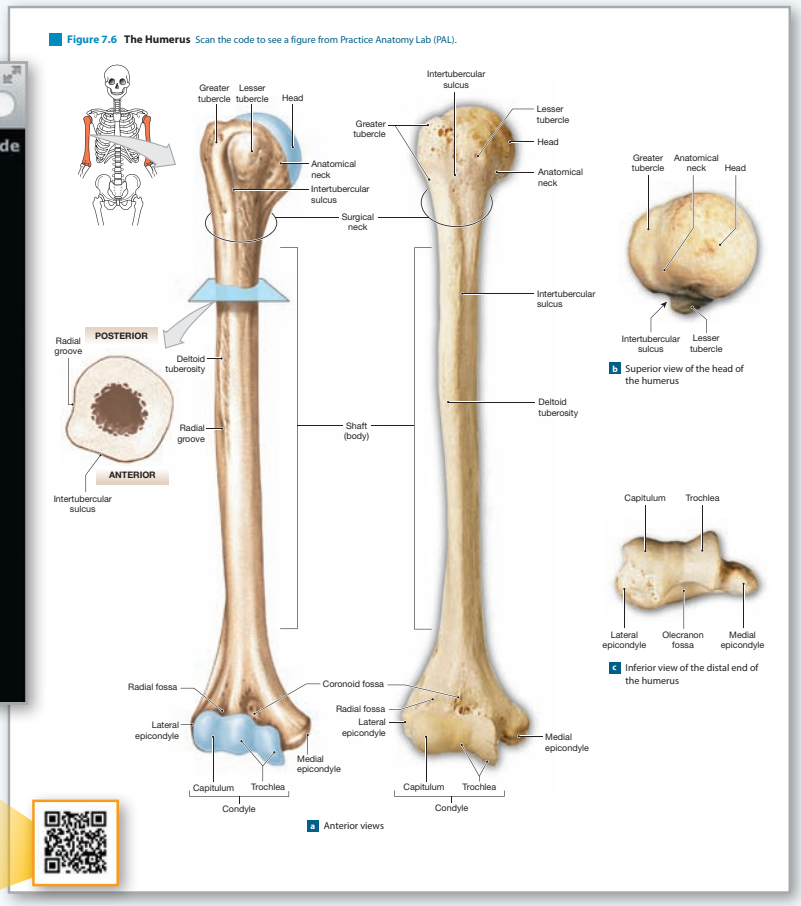
TEXT-MEDIA INTEGRATION

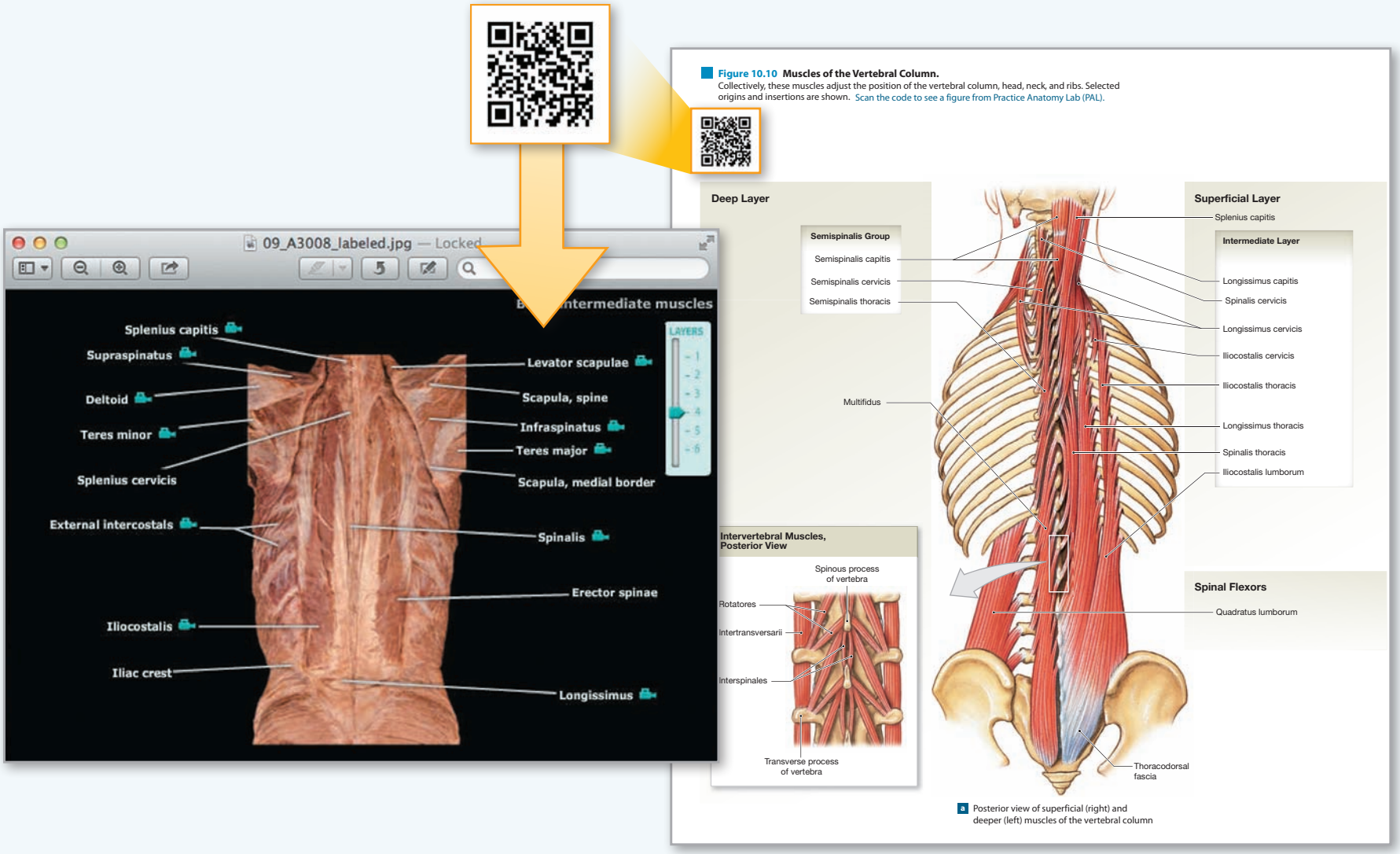
QR Codes let students link directly from figures in the book to figures in the Practice Anatomy Lab™ (PAL™) virtual anatomy program, giving them additional views to help them learn bones (Chapters 6 and 7) and muscles (Chapters 10 and 11). After students have downloaded a QR code reader app to their smartphones, they can use that app to scan the codes in the book and see the associated images on their smartphones.



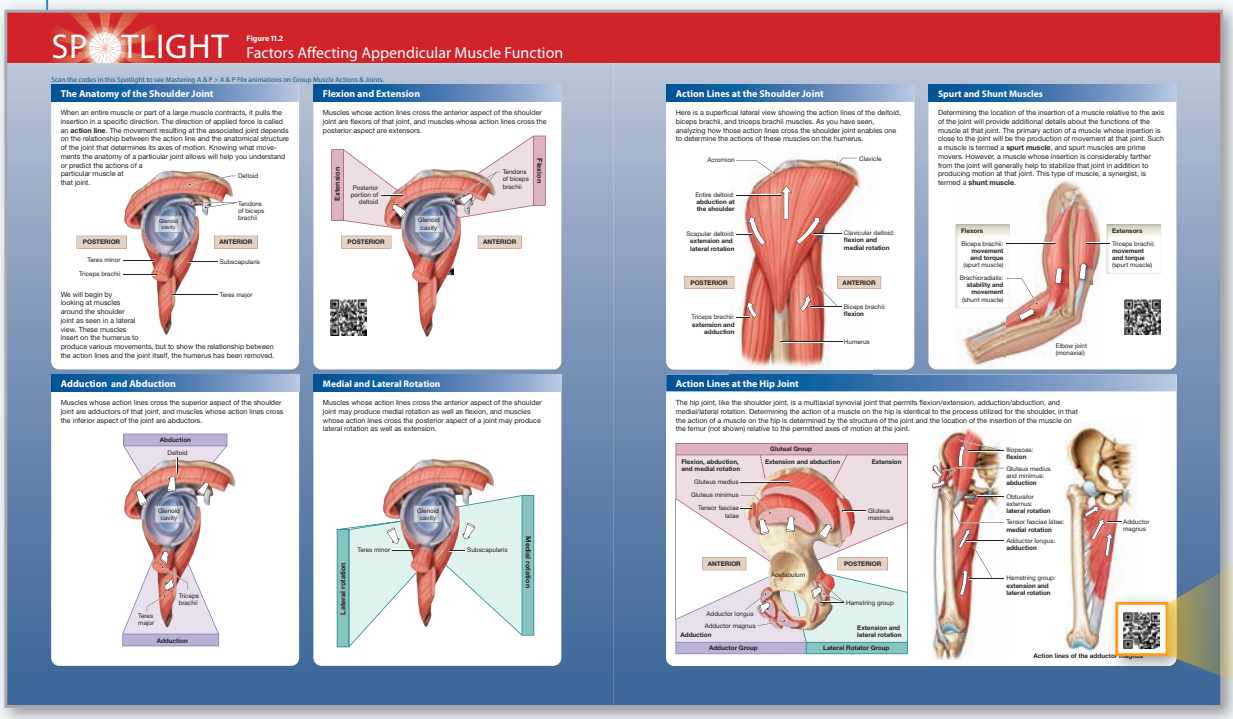


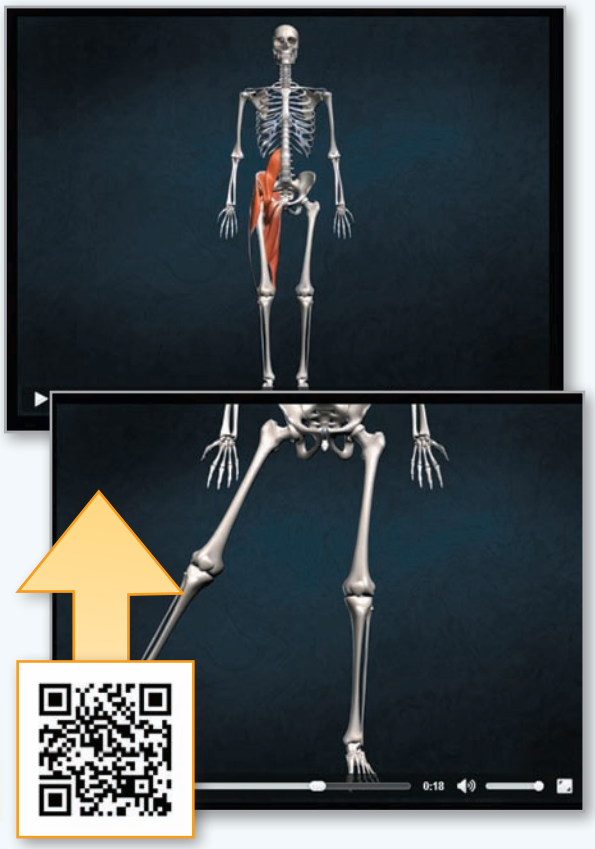




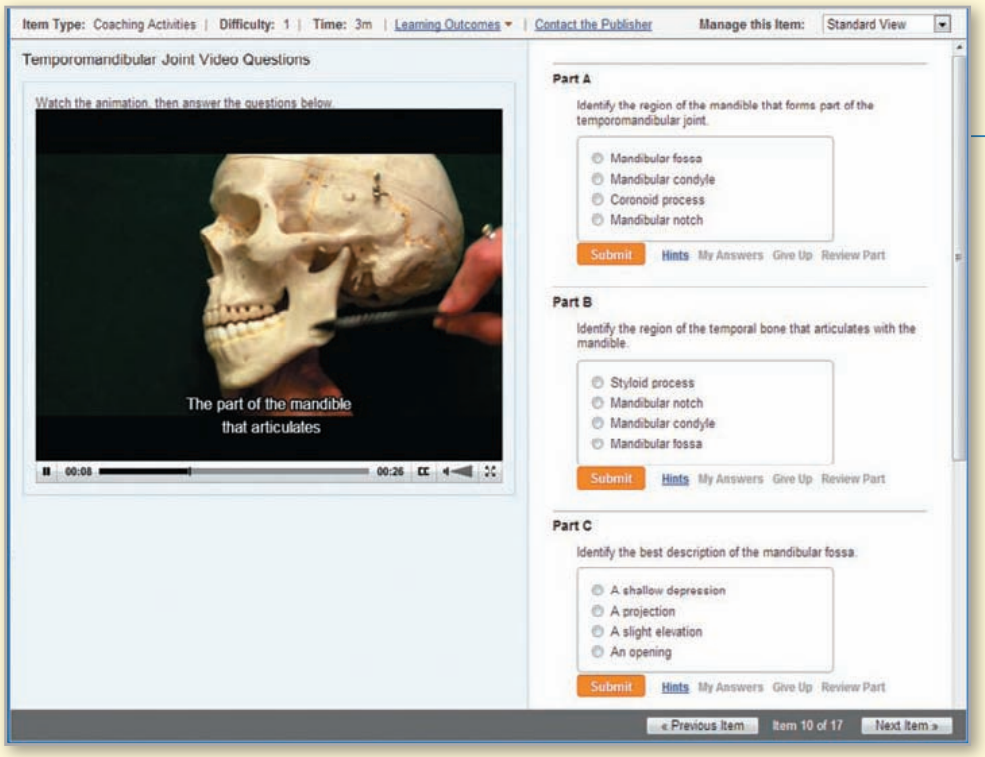


Select QR Codes in Chapter 11 link to A&P Flix animations on muscle movement.





MasteringA&P® ASSIGNABLE CONTENT

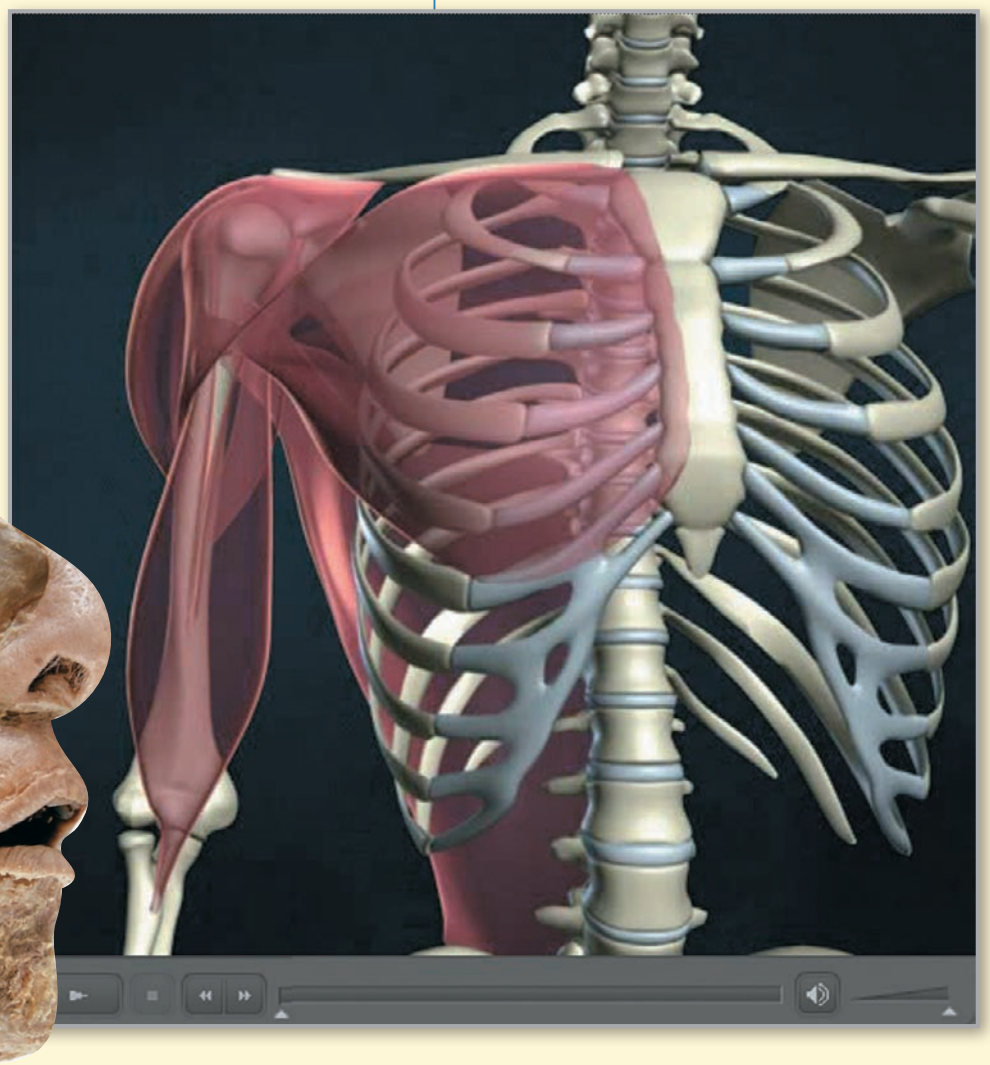


NEW Bone and Dissection Video Coaching Activities

with wrong-answer feedback and hints help students learn bone identification and organ dissection.

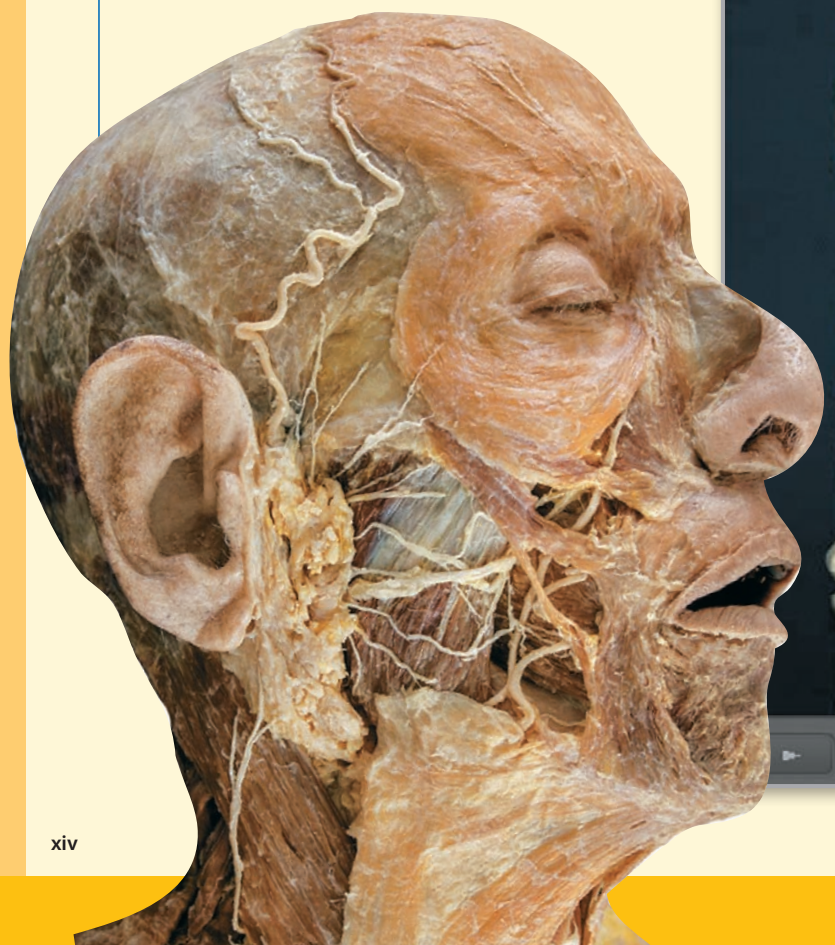
A&P Flix™ Activities for Anatomy Topics

allow instructors to assign animations on difficult anatomy topics.



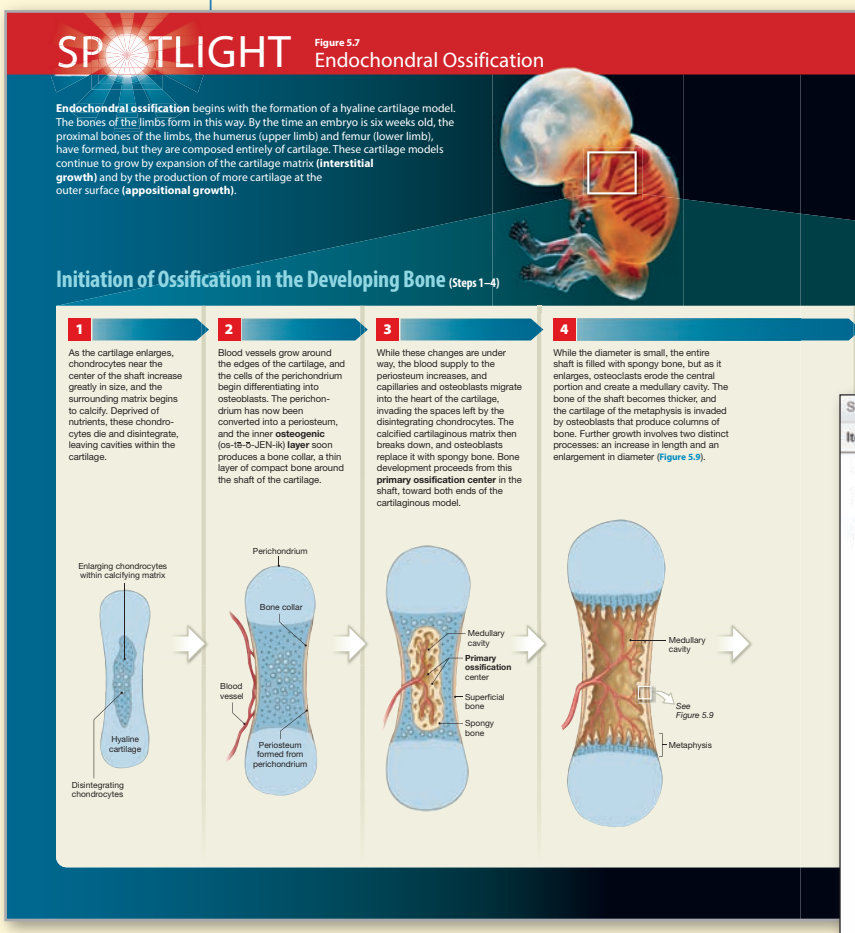
Practice Anatomy Lab™ (PAL™) 3.0 Assessments

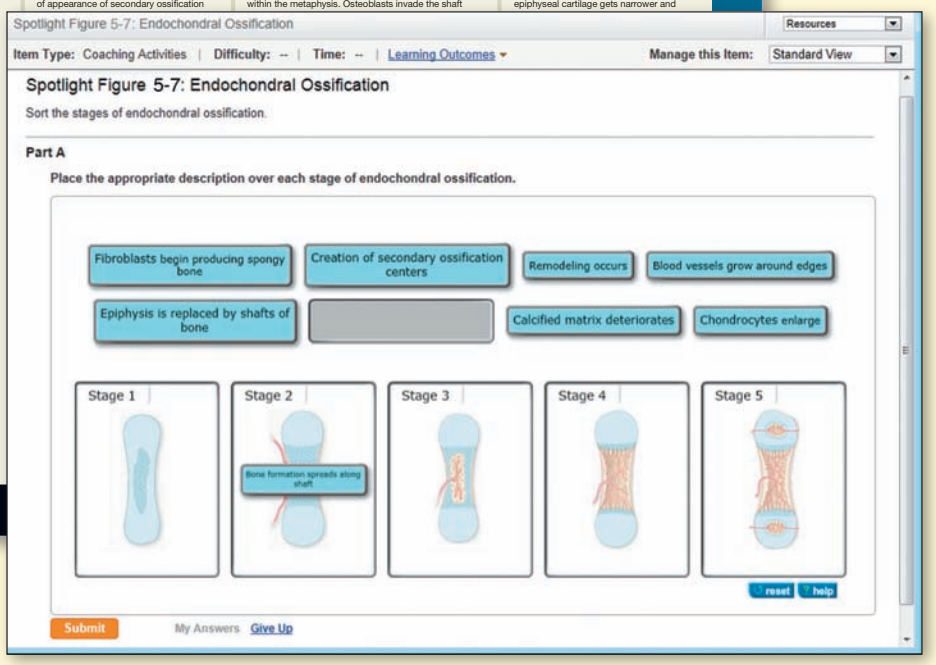
can be assigned to help students prepare for their lab practical quizzes and tests.



NEW Spotlight Figure Coaching Activities bring interactivity

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





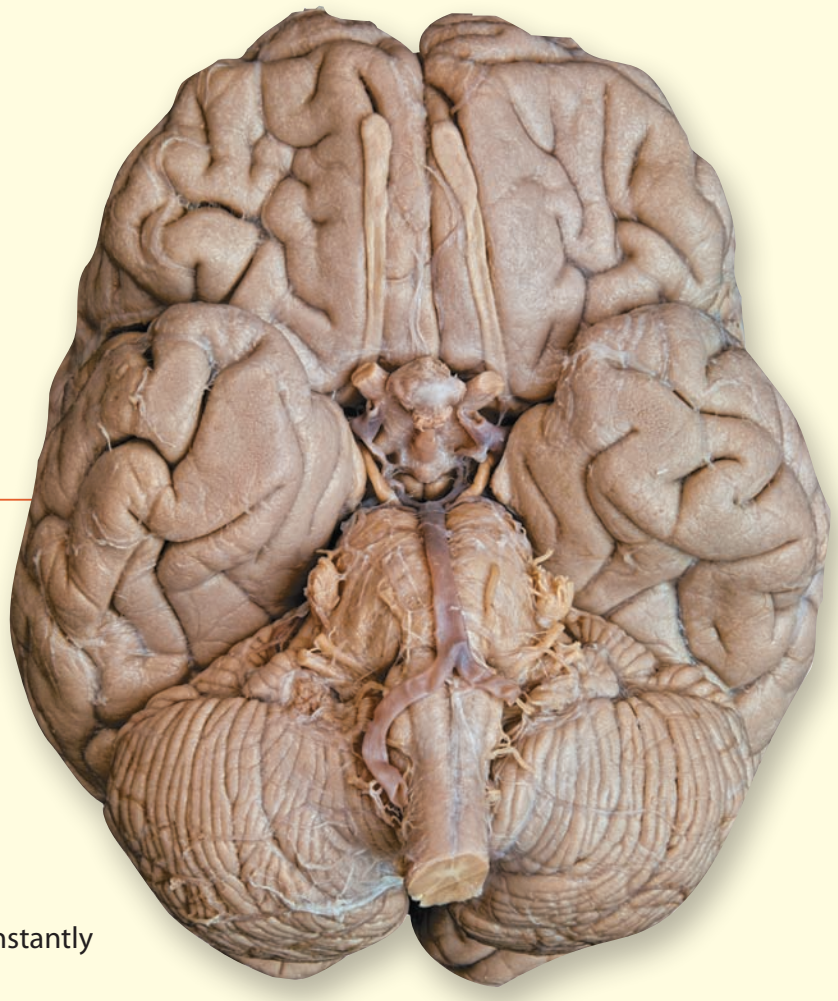
NEW Interactive and Adaptive Capabilities

- **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.

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.
- **Clinical Case Activities** prepare students for future careers in allied health fields.
- **Clinical Note Questions**
- **Reading Quiz Questions**
- **Chapter Test Questions**
- **Test Bank Questions**

MasteringA&P® STUDY AREA



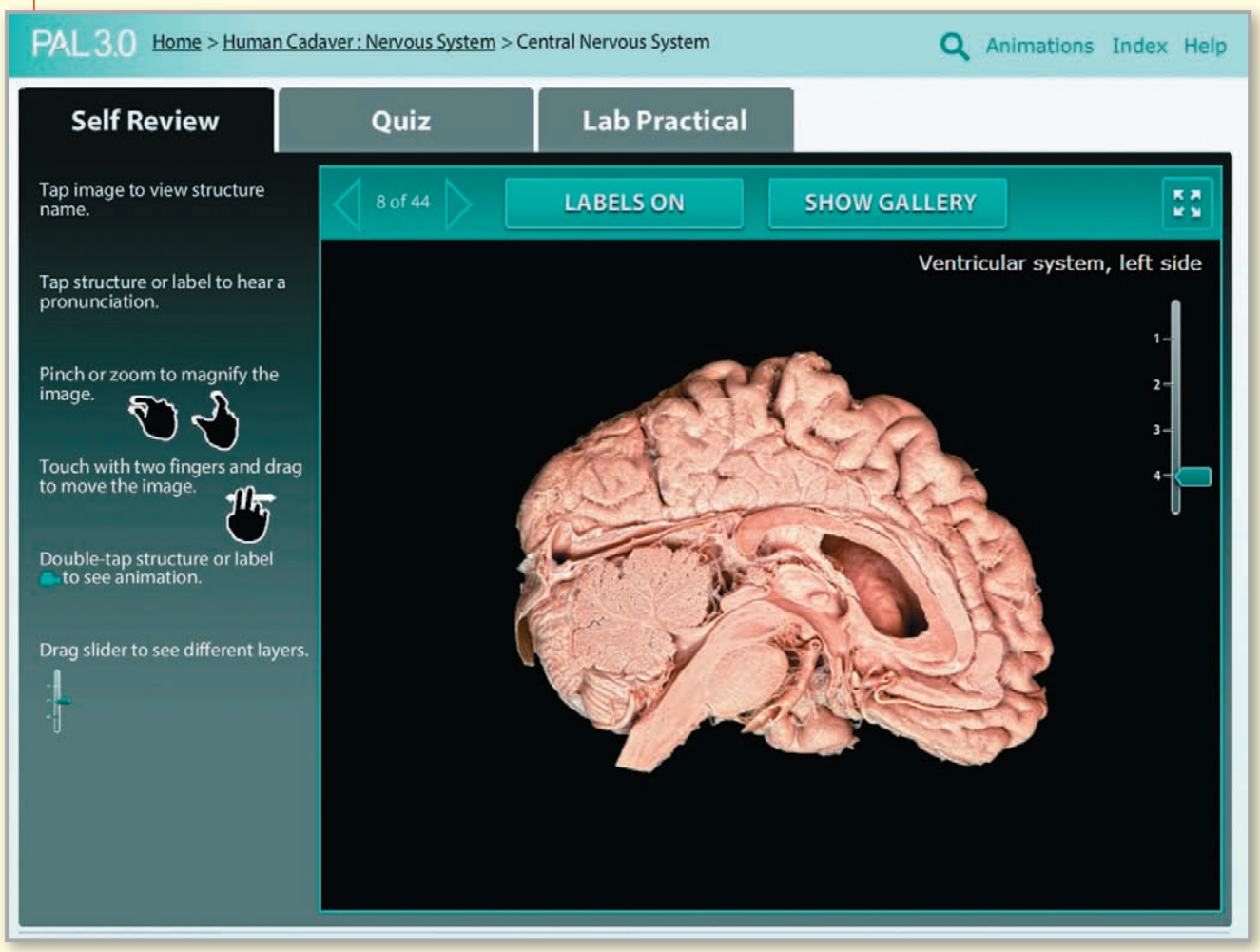
MasteringA&P® includes a **Study Area** that will help students get ready for tests with its simple three-step approach. Students can:

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

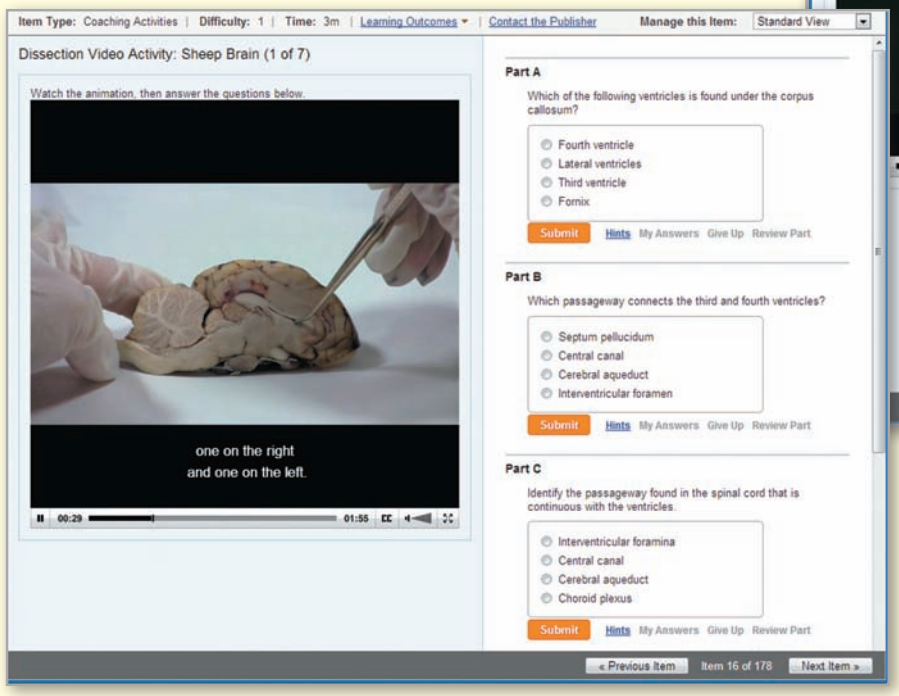
is a virtual anatomy study and practice tool that gives students 24/7 access to the most widely used lab specimens, including the human cadaver, anatomical models, histology, cat, and fetal pig. PAL 3.0 is easy to use and includes built-in audio pronunciations, rotatable bones, and simulated fill-in-the-blank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

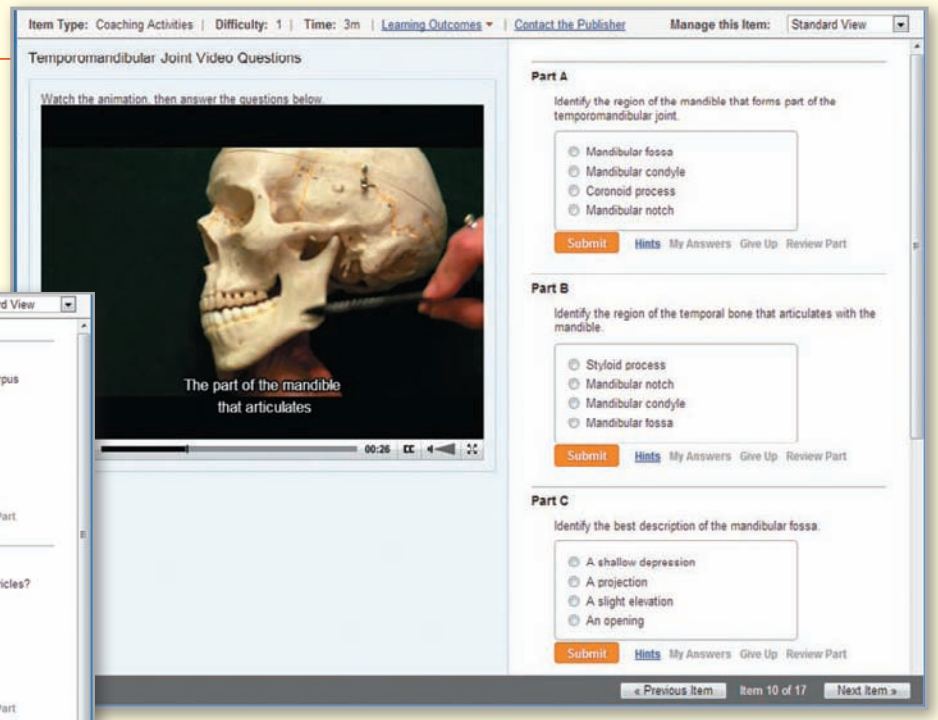
NEW The PAL 3.0 App lets you access PAL 3.0 on **your iPad or Android tablet**. With the pinch-to-zoom feature, images can instantly be enlarged in Self Review, Quiz, and Lab Practical activities.

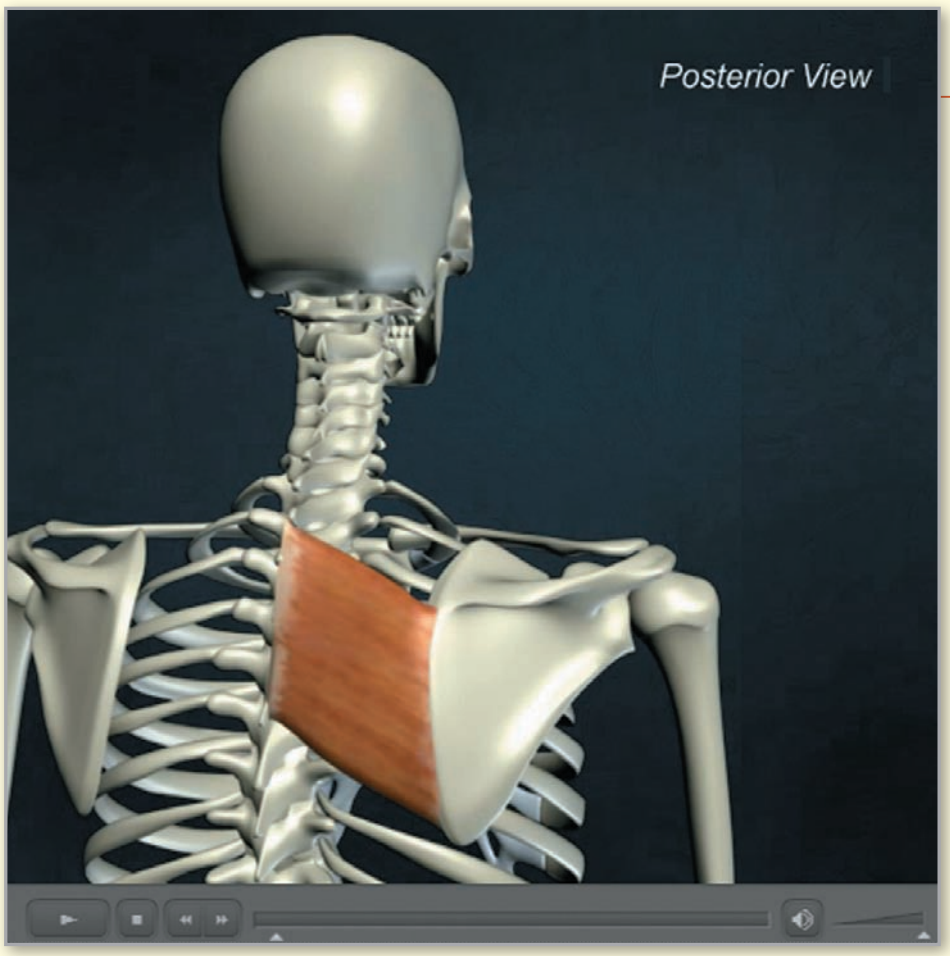


Bone and Dissection Videos

cover major bones and organ dissections to help students prepare for lecture and lab.







A&P Flix™ for Anatomy Topics

are 3D movie-quality animations on two sets of human anatomy topics:

- Origins, Insertions, Actions, and Innervations
  Over 60 animations on this topic
- Group Muscle Actions and Joints
  Over 50 animations on this topic

Also Available: eText

Students can access their textbook online and use additional functionality to create notes, highlight text, create bookmarks, zoom, click words to view definitions, link directly to animations, and search for specific content.

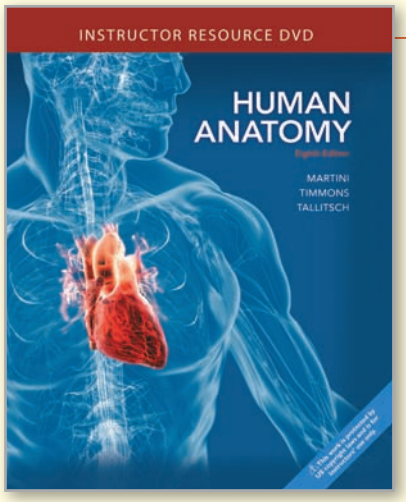
SUPPORT FOR INSTRUCTORS

MyReadinessTest™

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.

Printed Test Bank
by Michael Yard, Agnes Yard, and Jason LaPres
978-0-321-90570-3 / 0-321-90570-9

Instructor's Manual
978-0-321-90871-1 / 0-321-90871-6



Instructor Resource DVD (IRDVD)

with Lecture Outlines and Clicker Questions by Steven Bassett
978-0-321-90571-0 / 0-321-90571-7

The IRDVD organizes all instructor media resources by chapter into one convenient and easy-to-use package. Highlights include:

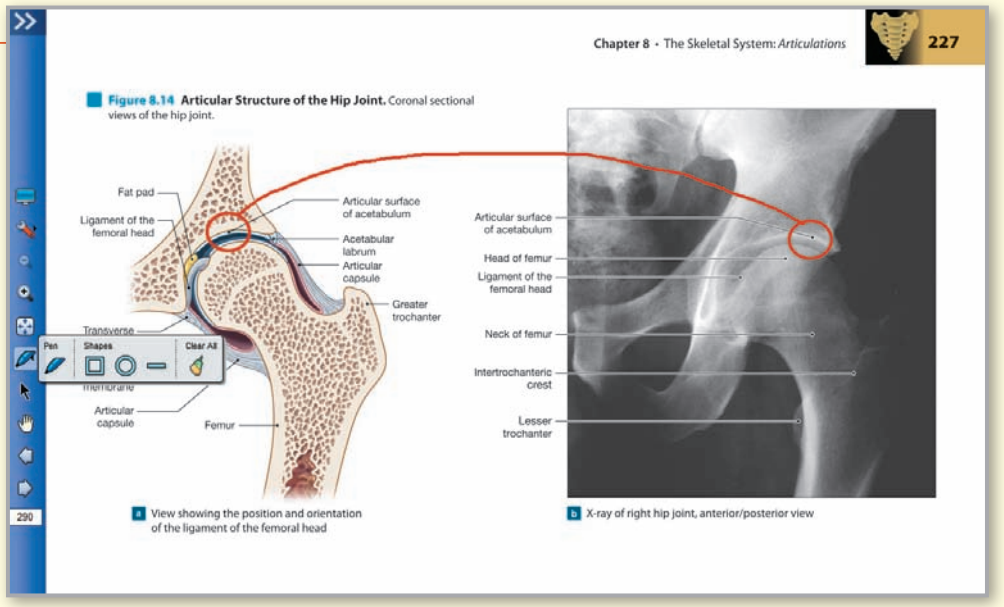
- Customizable PowerPoint Lecture Presentations that combine lecture notes, figures, tables, and links to animations
- All figures from the book in JPEG format and PowerPoint slides (with editable labels and without) plus figures from *Martini's Atlas of the Human Body* and *A&P Applications Manual*
- Another set of JPEGs from the book featuring unlabeled figures *with leader lines* for quick and easy quizzing
- A&P Flix for Anatomy Topics
- Clicker Questions in PowerPoint that check comprehension
- Quiz Show Questions in PowerPoint that engage students
- Bone and Dissection Videos
- Test Bank in TestGen and Microsoft Word formats
- Instructor's Manual in Microsoft Word format
- Transparency Acetate masters for all figures and tables
- The IRDVD for Practice Anatomy Lab (PAL) 3.0

eText with Whiteboard Mode

The *Human Anatomy* 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.

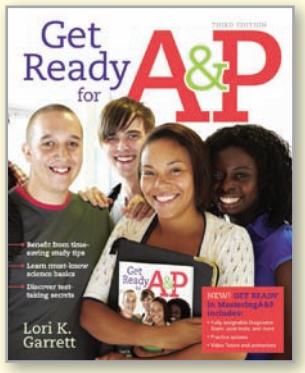
Instructors can also add notes to guide students, upload documents, and share their custom-enhanced eText with the whole class.

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



SUPPORT FOR STUDENTS

Every item can be packaged with the main student text.

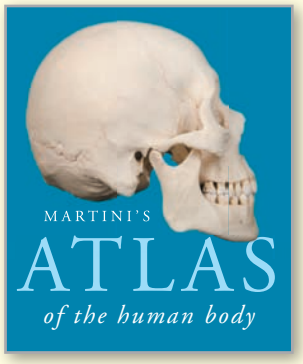


Get Ready for A&P

by Lori K. Garrett

978-0-321-81336-7 / 0-321-81336-7

This book and online component were created to help students be better prepared for their course. Features include pre-tests, guided explanations followed by interactive quizzes and exercises, and end-of-chapter cumulative tests. Also available in the Study Area of MasteringA&P.

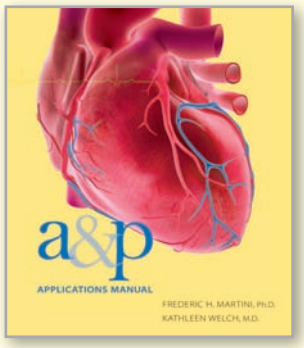


Martini's Atlas of the Human Body

by Frederic H. Martini

978-0-321-94072-8 / 0-321-94072-5

The Atlas offers an abundant collection of anatomy photographs, radiology scans, and embryology summaries, helping students visualize structures.

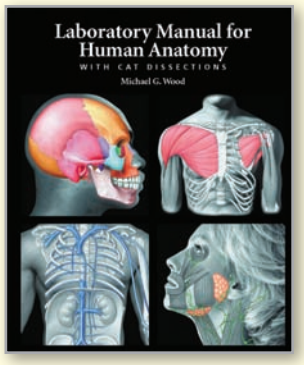


A&P Applications Manual

by Frederic H. Martini and Kathleen Welch

978-0-321-94973-8 / 0-321-94973-0

This manual contains extensive discussions on clinical topics and disorders to help students apply the concepts of anatomy and physiology to daily life and their future health professions.

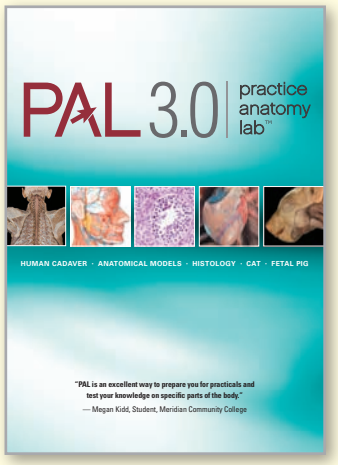


Laboratory Manual for Human Anatomy with Cat Dissections

by Michael G. Wood

978-0-805-37375-2 / 0-805-37375-6

This full-color laboratory manual combines illustrations (modified as needed) and photos from *Human Anatomy* with Michael G. Wood's easy-to-follow writing style and student focused features, making it the most learner-centered Human Anatomy laboratory manual available.

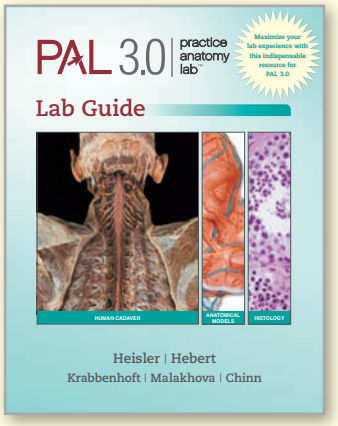


Practice Anatomy Lab™ (PAL™) 3.0 DVD

by Ruth Heisler, Nora Hebert, Jett Chinn, Karen Krabbenhoft, and Olga Malakhova

978-0-321-68211-6 / 0-321-68211-4

PAL 3.0 is an indispensable 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.

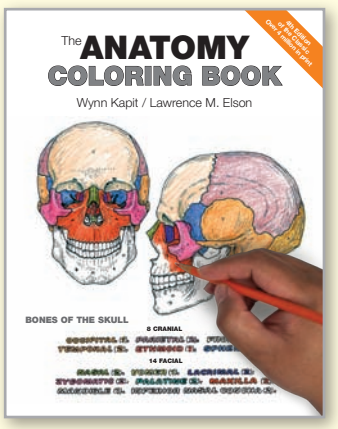


Practice Anatomy Lab (PAL) 3.0 Lab Guide

by Ruth Heisler, Nora Hebert, Jett Chinn, Karen Krabbenhoft, and Olga Malakhova

978-0-321-84025-7 / 0-321-84025-9

The PAL 3.0 Lab Guide enhances students' virtual anatomy lab experience by helping them explore anatomical structures through a series of labeling activities and quizzes using the images from PAL.



The Anatomy Coloring Book

by Wynn Kapit and Lawrence M. Elson

978-0-321-83201-6 / 0-321-83201-9

This text features precise hand-drawn figures for easy coloring and interactive study. Organized according to body systems, each spread includes a color-key system where anatomical terms are linked to detailed illustrations. Students make visual associations with key terminology, and assimilate information while engaging in kinesthetic learning. The Fourth Edition features enlarged art, clearer, text descriptions, and new boldface headings.

CONTENTS

1 Foundations

An Introduction to Anatomy

Learning Outcomes

These Learning Outcomes correspond by number to this chapter's sections and indicate what you should be able to do after completing the chapter.

1.1 Define the limits of microscopic anatomy and compare and contrast cytology and histology.

1.2 Compare and contrast the various ways to approach gross anatomy.

1.3 Define the various subspecialties of anatomy.

1.4 Explain the major levels of organization in a living organism.

1.5 Identify the various organ systems of the human body and compare and contrast their functions.

1.6 Understand and correctly apply descriptive anatomical and directional terminology.

Clinical Notes

WE ARE ALL anatomists in our daily lives, if not in the classroom. For example, we rely on our memories of specific anatomical features to identify our friends and family, and we watch for subtle changes in body movement or position that give clues to what others are thinking or feeling. To be precise, anatomy is the study of external and internal structures and the physical relationships between body parts. But in practical terms, anatomy is the careful observation of the human body. Anatomical information provides clues about probable functions. Physiology is the study of function, and physiological mechanisms can be explained only in terms of the underlying anatomy. *All specific physiological functions are performed by specific anatomical structures*. For instance, filtering, warming, and humidifying inspired air are functions of the nasal cavity. The shapes of the bones projecting into the nasal cavity cause turbulence in the inhaled air, making it swirl against the moist lining. This contact warms and humidifies the air, and any suspended particles stick to the moist surfaces. In this way, the air is conditioned and filtered before it reaches the lungs.

The link between structure and function is always present, but not always understood. For example, the superficial anatomy of the heart was clearly described in the 15th century, but almost 200 years passed before the pumping action of the heart was demonstrated. On the other hand, many important cell functions were recognized decades before the electron microscope revealed the anatomical basis for those functions.

This text will discuss the anatomical structures and functions that make human life possible. The goals are to help you develop a three-dimensional understanding of anatomical relationships as well as prepare you for more advanced courses in anatomy, physiology, and related subjects, and to help you make informed decisions about your personal health.

1.1 Microscopic Anatomy

Microscopic anatomy considers structures that cannot be seen without magnification. The boundaries of microscopic anatomy, or *fine anatomy*, are established by the limits of the equipment used (**Figure 1.1**). A simple hand lens shows details that barely escape the naked eye, while an electron microscope demonstrates structural details that are less than one-millionth as large. As we proceed through the text, we will be considering details at all levels, from macroscopic to microscopic.

Microscopic anatomy can be subdivided into specialties that consider features within a characteristic range of sizes. **Cytology** (sī-TOL-ō-jē) analyzes the internal structure of **cells**, the smallest units of life. Living cells are composed of complex chemicals in various combinations, and our lives depend on the chemical processes occurring in the trillions of cells that form our body.

Histology (his-TOL-ō-jē) takes a broader perspective and examines **tissues**, groups of specialized cells and cell products that work together to perform specific functions. The cells in the human body can be assigned to four basic tissue types: epithelial, connective, muscle, and neural (which will be described in Chapter 3).

Tissues in combination form **organs** such as the heart, kidney, liver, and brain. Organs are anatomical units that have multiple functions. Many tissues and most organs are examined easily without a microscope, and at this point we cross the boundary from microscopic anatomy into gross anatomy.

✓ 1.1 Concept Check

1 ☐ Histologists study what structures?

2 ☐ Define the concept of an organ.

See the blue Answers tab at the back of the book.

1.2 Gross Anatomy

The examination of relatively large structures and features visible to the unaided eye is termed **gross anatomy**, or *macroscopic anatomy*. There are many ways to approach gross anatomy:

- **Surface anatomy** refers to the study of general form, or **morphology**, and superficial anatomical markings.
- **Regional anatomy** considers all the superficial and internal features in a specific area of the body, such as the head, neck, or trunk. Advanced courses in anatomy often stress a regional approach because it emphasizes the spatial relationships among structures.
- **Systemic anatomy** considers the structure of major organ systems, such as the skeletal or muscular systems. **Organ systems** are groups of organs that function together to produce coordinated effects. For example, the heart, blood, and blood vessels form the cardiovascular system, which distributes oxygen and nutrients throughout the body. There are 11 organ systems in the human body, and they will be introduced later in the chapter. Introductory texts in anatomy, including this one, use a systemic approach because it provides a framework for organizing information about important structural and functional patterns.

✓ 1.2 Concept Check

1 ☐ How does the work of a gross anatomist differ from that of a histologist?

2 ☐ What is an organ system, and how does it apply to systemic anatomy?

See the blue Answers tab at the back of the book.

1.3 Other Perspectives on Anatomy

Other anatomical specialties will be encountered in this text.

- **Developmental anatomy** examines the changes in form that occur during the period between conception and physical maturity. Because it considers anatomical structures over such a broad range of sizes (from a single cell to an adult human), developmental anatomy involves the study of both microscopic and gross anatomy. Developmental anatomy is important in medicine because many structural abnormalities can result from errors that occur during development. The most extensive structural changes occur during the first two months of development. **Embryology** (em-brē-OL-ō-jē) is the study of these early developmental processes.
- **Comparative anatomy** considers the anatomical organization of different types of animals. Observed similarities may reflect evolutionary relationships. Humans, lizards, and sharks are all called vertebrates because they share a combination of anatomical features that is not found in any other group of animals. All vertebrates have a spinal column composed of individual elements called vertebrae (**Figure 1.2a**). Comparative anatomy uses techniques of gross, microscopic, and developmental anatomy. Information on developmental anatomy has demonstrated that related animals typically go through very similar developmental stages (**Figure 1.2b,c**).

  Several other gross anatomical specialties are important in medical diagnosis.
- **Clinical anatomy** focuses on anatomical features that may undergo recognizable pathological changes during illness.

Figure 1.1 The Study of Anatomy at Different Scales. The amount of detail recognized depends on the method of study and the degree of magnification.

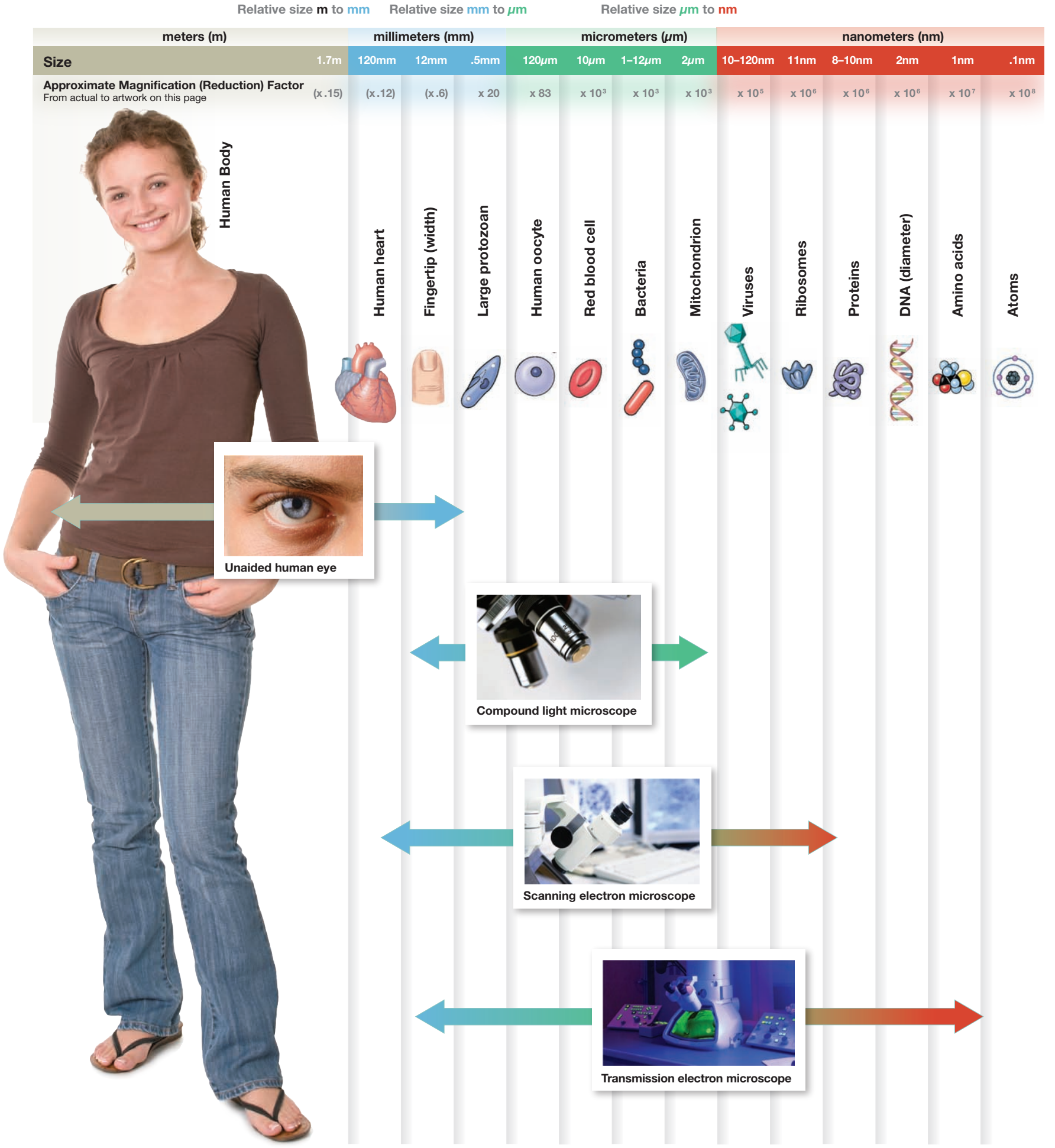
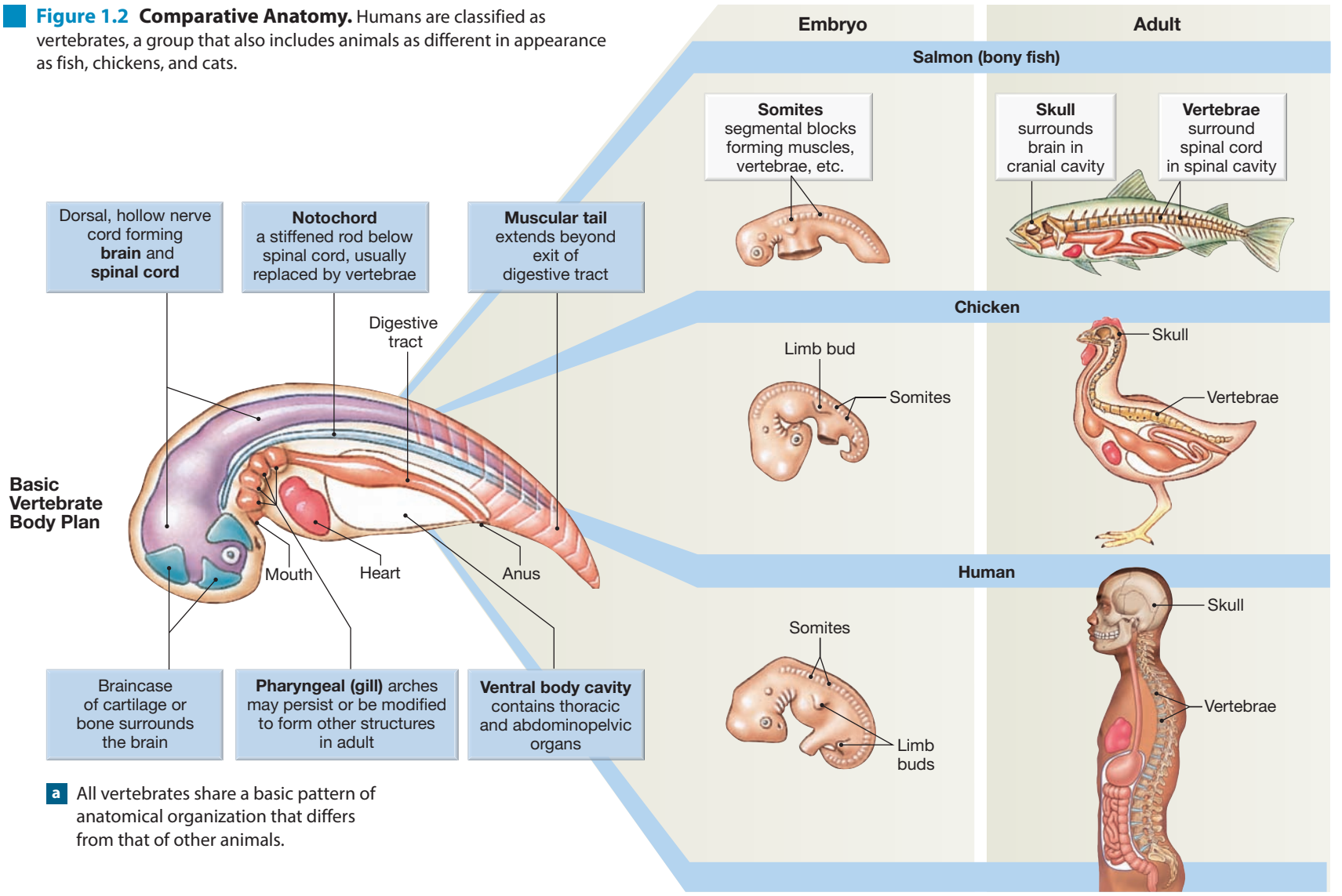


Figure 1.2 Comparative Anatomy. Humans are classified as vertebrates, a group that also includes animals as different in appearance as fish, chickens, and cats.



a All vertebrates share a basic pattern of anatomical organization that differs from that of other animals.

b The similarities between vertebrates are most apparent when comparing embryos at comparable stages of development.

c The similarities are less obvious when comparing adult vertebrates.

Clinical Note

Disease, Pathology, and Diagnosis

THE FORMAL NAME FOR THE STUDY OF DISEASE is **pathology**. Different diseases typically produce similar signs, the physical manifestation of a disease, and symptoms, the patient's perception of a change in normal body function. For example, a person whose lips are paler than normal and who complains of a lack of energy and breathlessness might have (1) respiratory problems that prevent normal oxygen transfer to the blood (as in emphysema); (2) cardiovascular problems that interfere with normal blood circulation to all parts of the body (heart failure); or (3) an inability to transport adequate amounts of oxygen in the blood, due to blood loss or problems with blood formation. In such cases, doctors must ask questions and collect information to determine the source of the problem. The patient's history and physical exam may be enough for a diagnosis in many cases, but laboratory testing and imaging studies such as x-rays are often needed.

A **diagnosis** is a decision about the nature of an illness. The diagnostic procedure is often a process of elimination, in which several potential causes are evaluated and the most likely one is selected. This brings us to a key concept: *All diagnostic procedures presuppose an understanding of the normal structure and function of the human body.*

- **Surgical anatomy** studies anatomical landmarks important for surgical procedures.
- **Radiographic anatomy** involves the study of anatomical structures as they are visualized by x-rays, ultrasound scans, or other specialized procedures performed on an intact body.
- **Cross-sectional anatomy** has emerged as a new subspecialty of gross anatomy as new advances in radiographic anatomy, such as CT (computerized tomography) and spiral scans, have emerged.

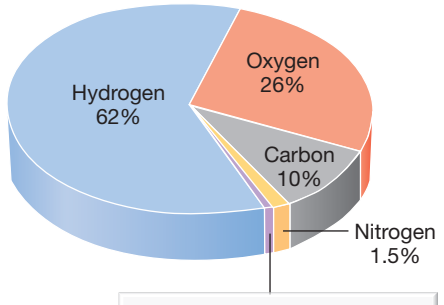
✓ 1.3 Concept Check

1 How does the study of surgical anatomy differ from the study of clinical anatomy?

2 Cross-sectional anatomy is a subspecialty of what other anatomical specialty?

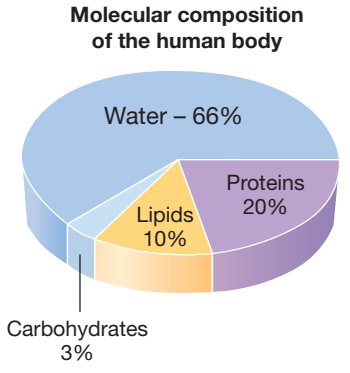
See the blue Answers tab at the back of the book.

Figure 1.3 Composition of the Body at the Chemical Level of Organization. The percent composition of elements and major molecules.



OTHER ELEMENTS	
Calcium	0.2%
Phosphorus	0.2%
Potassium	0.06%
Sodium	0.06%
Sulfur	0.05%
Chlorine	0.04%
Magnesium	0.03%
Iron	0.0005%
Iodine	0.0000003%
Trace elements	(see caption)

a Elemental composition of the body. Trace elements include silicon, fluorine, copper, manganese, zinc, selenium, cobalt, molybdenum, cadmium, chromium, tin, aluminum, and boron.



b Molecular composition of the body.

1.4 Levels of Organization

Our study of the human body will begin with an overview of cellular anatomy and then proceed to the anatomy, both gross and microscopic, of each organ system. When considering events from the microscopic to macroscopic scales, we are examining several interdependent levels of organization.

We begin at the chemical or molecular level of organization. The human body consists of more than a dozen different elements, but four of them (hydrogen, oxygen, carbon, and nitrogen) account for more than 99 percent of the total number of atoms (**Figure 1.3a**). At the chemical level, atoms interact to form three-dimensional compounds with distinctive properties. The major classes of compounds in the human body are indicated in **Figure 1.3b**.

Figure 1.4 presents an example of the relationships between the chemical level and higher levels of organization. The cellular level of organization includes cells, the smallest living units in the body. Cells contain internal structures called organelles. Cells and their organelles are made up of complex chemicals. (Cell structure and the function of the major organelles found within cells will be presented in Chapter 2.) In **Figure 1.4**, chemical interactions produce complex proteins within a muscle cell in the heart. Muscle cells are unusual because they can contract powerfully, shortening along their longitudinal axis.

Heart muscle cells are connected to form a distinctive muscle tissue, an example of the tissue level of organization. Layers of muscle tissue form the bulk of the wall of the heart, a hollow, three-dimensional organ. We are now at the organ level of organization.

Normal functioning of the heart depends on interrelated events at the chemical, cellular, tissue, and organ levels of organization. Coordinated contractions in the adjacent muscle cells of cardiac muscle tissue produce a heartbeat. When that beat occurs, the internal anatomy of the organ enables it to function as a pump. Each time it contracts, the heart pushes blood into the circulatory system, a network of blood vessels. Together the heart, blood, and circulatory system form an organ system, the cardiovascular system (CVS).

Each level of organization is totally dependent on the others. For example, damage at the cellular, tissue, or organ level may affect the entire system. Thus, a chemical change in heart muscle cells may cause abnormal contractions or even stop the heartbeat. Physical damage to the muscle tissue, as in a chest wound, can make the heart ineffective even when most of the heart muscle cells are intact and uninjured. An inherited abnormality in heart structure can make it an ineffective pump, although the muscle cells and muscle tissue are perfectly normal.

Finally, it should be noted that something that affects the system will ultimately affect all its components. For example, the heart may not be able to pump blood effectively after a massive blood loss due to damage of a major blood vessel somewhere in the body. If the heart cannot pump and blood cannot flow, oxygen and nutrients cannot be distributed. In a very short time, the tissue begins to break down as heart muscle cells die from oxygen and nutrient starvation.

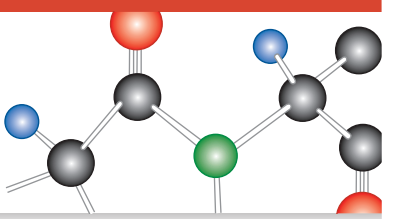
Of course, the changes that occur when the heart is not pumping effectively will not be restricted to the cardiovascular system; all the cells, tissues, and organs in the body will be damaged. This observation brings us to another, higher level of organization, that of the organism, or in this case, a human being. This level reflects the interactions among organ systems. All are vital; every system must be working properly and in harmony with every other system, or survival will be impossible. When those systems are functioning normally, the characteristics of the internal environment will be relatively stable at all levels. This vital state of affairs is called **homeostasis** (hō-mē-ō-STĀ-sis; *homeo*, unchanging + *stasis*, standing).

Figure 1.4 Levels of Organization

Size

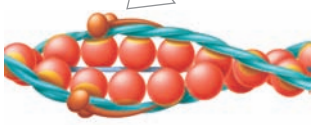
.1nm **Chemical or Molecular Levels**

Atoms interact to form molecules.

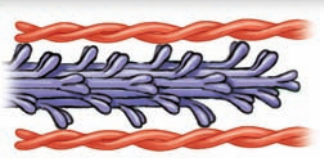


10nm

Molecules join to form complex contractile protein fibers.



10μm



Contractile protein fibers are structures within a heart muscle cell.

.1mm **Cellular Level**

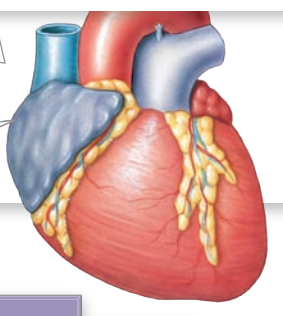
Interlocking heart muscle cells form cardiac muscle tissue.

1mm **Tissue Level**

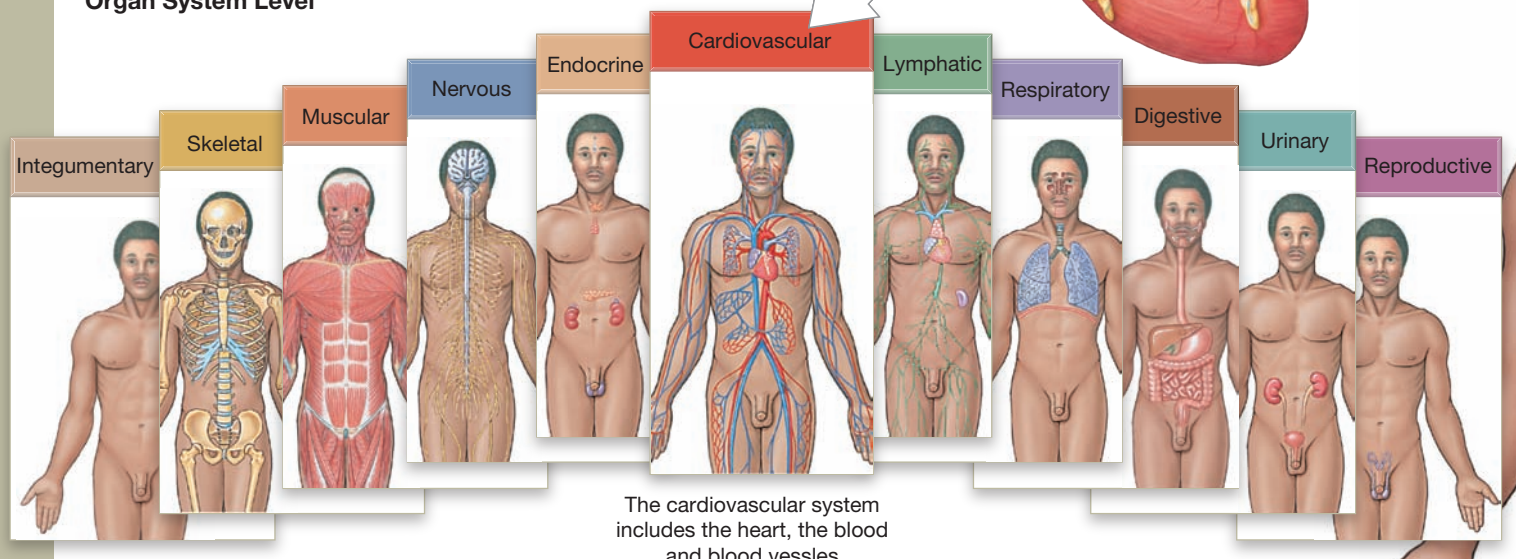
Cardiac muscle tissue constitutes the bulk of the walls of the heart.

120mm **Organ Level**

The heart is a complex three-dimensional organ.



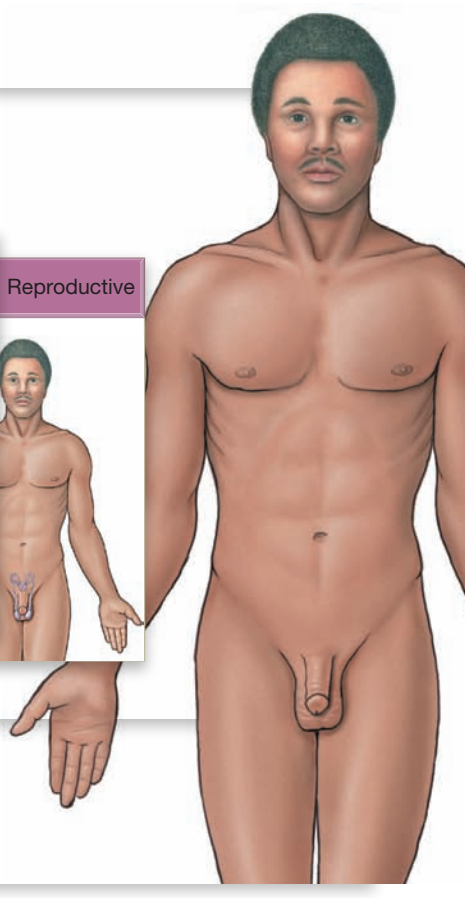
Organ System Level



The cardiovascular system includes the heart, the blood and blood vessles.

1.7m **Organism Level**

All of the organ systems must work together for a person to remain alive and healthy.



1.4 Concept Check

1 Cyanosis is a medical condition in which the lips and fingertips of an individual turn blue due to lack of adequate delivery of oxygen to tissues. If a patient is exhibiting cyanosis, why might the physician examine the patient's heart *in addition to* the patient's lungs?

See the blue Answers tab at the back of the book.

Clinical Note

The Diagnosis of Disease

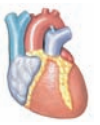
HOMEOSTASIS is the maintenance of a relatively constant internal environment suitable for the survival of body cells and tissues. A failure to maintain homeostatic conditions constitutes **disease**. The disease process may initially affect a specific tissue, an organ, or an organ system, but it will ultimately lead to changes in the function or structure of cells throughout the body. Some diseases can be overcome by the body's defenses. Others require intervention and assistance. For example, when trauma has occurred and there is severe bleeding or damage to internal organs, surgical intervention may be necessary to restore homeostasis and prevent fatal complications.

1.5 An Introduction to Organ Systems

Figure 1.5 provides an overview of the 11 organ systems in the human body, and **Figure 1.6** introduces the major organs in each system. All living organisms share vital properties and processes:

- **Responsiveness:** The ability of an organism to respond to changes in its immediate environment is termed **responsiveness**; this property is also called *irritability*. You move your hand away from a hot stove; your dog barks at approaching strangers; fish are scared by loud noises; and amoebas glide toward potential prey. Organisms also make longer-lasting changes as they adjust to their environments. For example, as winter approaches, an animal may grow a heavier coat or migrate to a warmer climate. The capacity to make such adjustments is termed adaptability.
- **Growth and Differentiation:** Over a lifetime, organisms grow larger, increasing in size through an increase in the size or number of their cells. In multicellular organisms, the individual cells become specialized to perform particular functions. This specialization is called **differentiation**. Growth and differentiation in cells and organisms often produce changes in form and function. For example, the anatomical proportions and physiological capabilities of an adult human are quite different from those of an infant.
- **Reproduction:** Organisms reproduce, creating subsequent generations of their own kind, whether unicellular or multicellular.
- **Movement:** Organisms are capable of producing movement, which may be internal (transporting food, blood, or other materials inside the body) or external (moving through the environment).

Figure 1.5 An Introduction to Organ Systems. An overview of the 11 organ systems and their major functions.

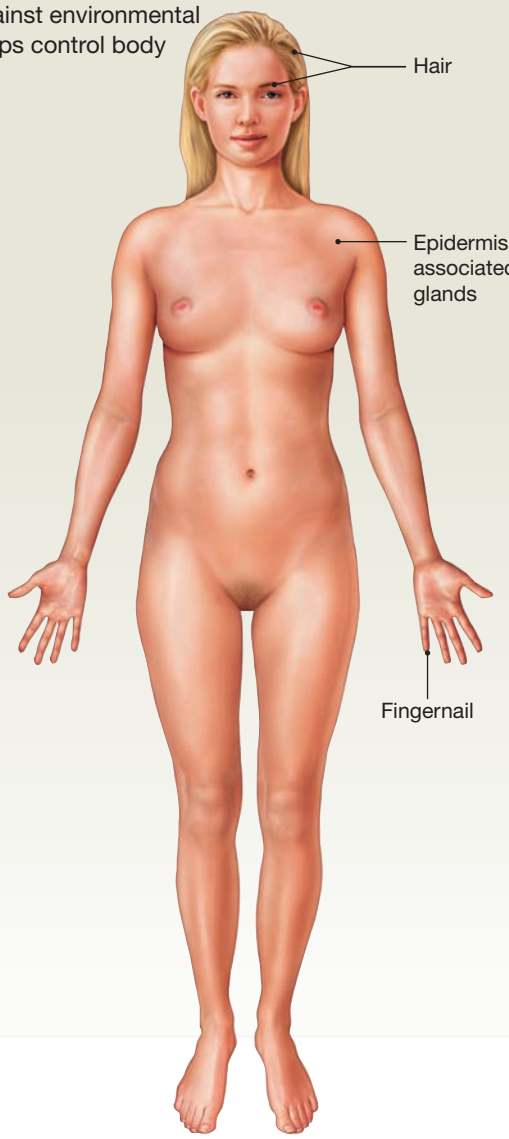
ORGAN SYSTEM		MAJOR FUNCTIONS
	**Integumentary system**	Protection from environmental hazards; temperature control
	**Skeletal system**	Support, protection of soft tissues; mineral storage; blood formation
	**Muscular system**	Locomotion, support, heat production
	**Nervous system**	Directing immediate responses to stimuli, usually by coordinating the activities of other organ systems
	**Endocrine system**	Directing long-term changes in the activities of other organ systems
	**Cardiovascular system**	Internal transport of cells and dissolved materials, including nutrients, wastes, and gases
	**Lymphatic system**	Defense against infection and disease
	**Respiratory system**	Delivery of air to sites where gas exchange can occur between the air and circulating blood
	**Digestive system**	Processing of food and absorption of organic nutrients, minerals, vitamins, and water
	**Urinary system**	Elimination of excess water, salts, and waste products; control of pH
	**Reproductive system**	Production of sex cells and hormones

- **Metabolism and Excretion**: Organisms rely on complex chemical reactions to provide energy for responsiveness, growth, reproduction, and movement. They must also synthesize complex chemicals, such as proteins. The term **metabolism** refers to all the chemical operations under way in the body: **Catabolism** is the breakdown of complex molecules into simple ones, and **anabolism** is the synthesis of complex molecules from simple ones. Normal metabolic operations require the **absorption** of materials from the environment. To generate energy efficiently, most cells require various nutrients, as well as oxygen, an atmospheric gas. The term **respiration** refers to the absorption, transport, and use of oxygen by cells. Metabolic operations often generate unneeded or potentially harmful waste products that must be removed through the process of **excretion**.

Figure 1.6 The Organ Systems of the Body

The Integumentary System

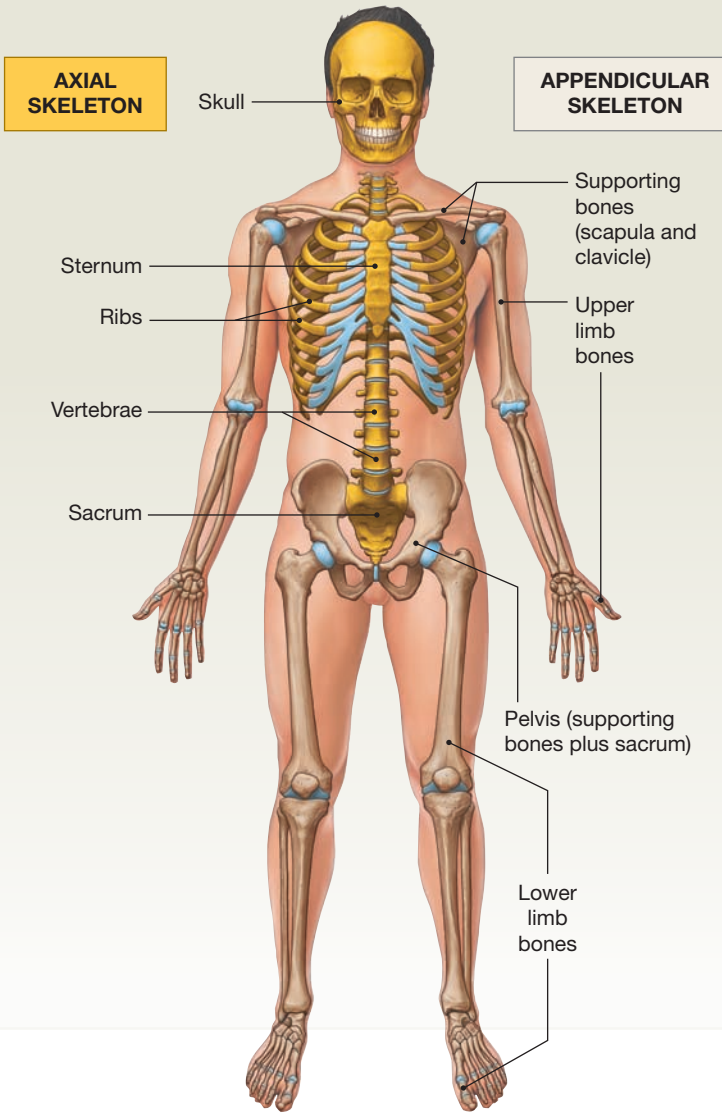
Protects against environmental hazards; helps control body temperature



Organ/Component	Primary Functions
Skin	
Epidermis	Covers surface; protects deeper tissues
Dermis	Nourishes epidermis; provides strength; contains glands
Hair Follicles	Produce hair; innervation provides sensation
Hairs	Provide protection for head
Sebaceous glands	Secrete lipid coating that lubricates hair shaft and epidermis
Sweat Glands	Produce perspiration for evaporative cooling
Nails	Protect and stiffen distal tips of digits
Sensory Receptors	Provide sensations of touch, pressure, temperature, pain
Subcutaneous Layer	Stores lipids; attaches skin to deeper structures and insulates against heat loss

The Skeletal System

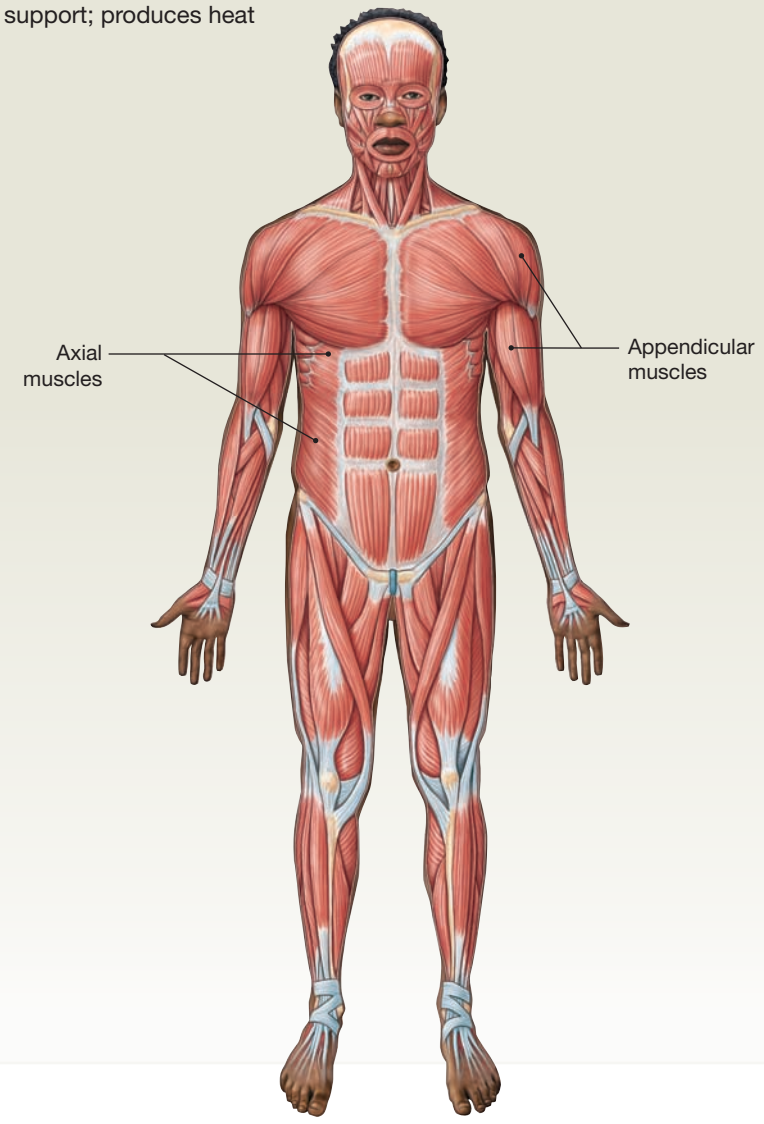
Provides support; protects tissues; stores minerals; forms blood cells



Organ/Component	Primary Functions
Bones, Cartilages, and Joints	Support; protect soft tissues; bones store minerals
Axial skeleton (skull, vertebrae, sacrum, coccyx, sternum, ribs, supporting cartilages and ligaments)	Protects brain, spinal cord, sense organs, and soft tissues of thoracic cavity; supports the body weight over lower limbs
Appendicular skeleton (limbs and supporting bones and ligaments)	Provides internal support and positioning of the limbs; supports and moves axial skeleton
Bone Marrow	Primary site of blood cell production (red marrow); storage of energy reserves in fat cells (yellow marrow)

The Muscular System

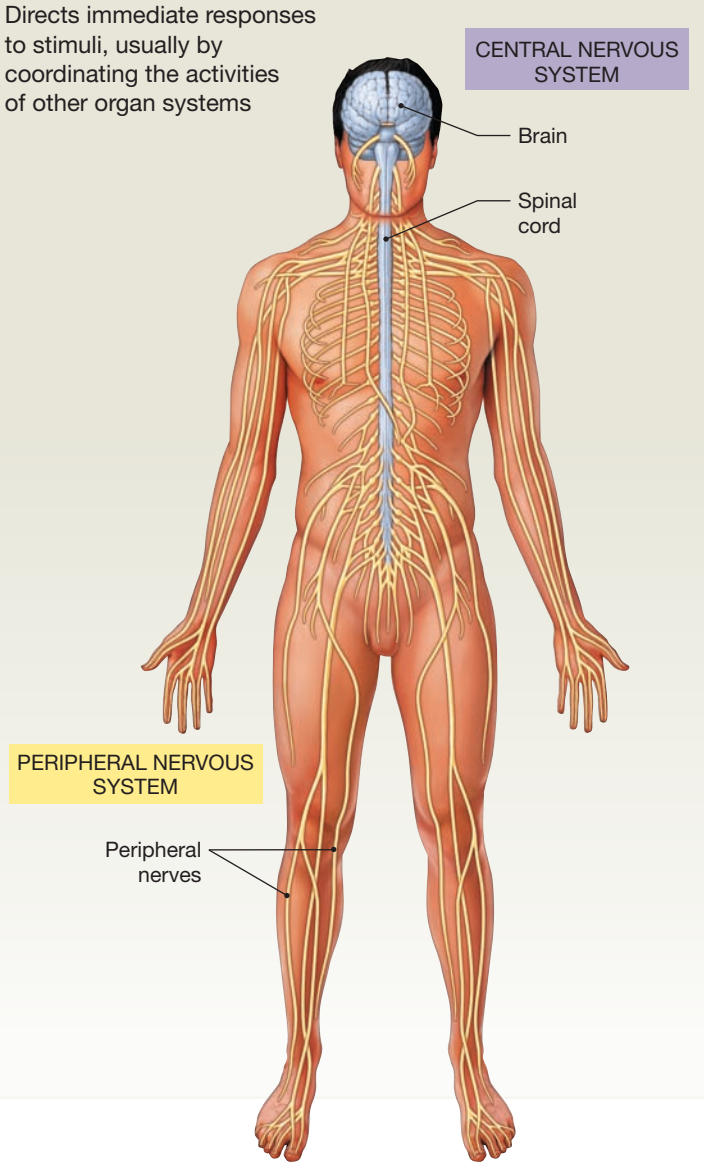
Allows for locomotion; provides support; produces heat



Organ/Component	Primary Functions
Skeletal Muscles	Provide skeletal movement; control entrances to digestive and respiratory tracts and exits to digestive and urinary tracts; produce heat; support skeleton; protect soft tissues
Axial muscles	Support and position axial skeleton
Appendicular muscles	Support, move, and brace limbs
Tendons, Aponeuroses	Harness forces of contraction to perform specific tasks

The Nervous System

Directs immediate responses to stimuli, usually by coordinating the activities of other organ systems



Organ/Component	Primary Functions
Central Nervous System (CNS)	Acts as control center for nervous system; processes information; provides short-term control over activities of other systems
Brain	Performs complex integrative functions; controls both voluntary and autonomic activities
Spinal cord	Relays information to and from brain; performs less-complex integrative activities
Special senses	Provide sensory input to the brain relating to sight, hearing, smell, taste, and equilibrium
Peripheral Nervous System (PNS)	Links CNS with other systems and with sense organs