

A blue-tinted illustration of a human torso and head in profile, showing the skeletal structure, muscles, and a complex network of nerves. The heart is highlighted in a realistic red and orange color, positioned centrally in the chest area. The background is a solid dark blue.

HUMAN ANATOMY

Eighth Edition

MARTINI
TIMMONS
TALLITSCH

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HUMAN ANATOMY

Eighth Edition

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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

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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.

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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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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.

SPOTLIGHT

Figure 22.1
The Structure of Blood Vessels

Histological Organization of Blood Vessels

The walls of arteries and veins contain three distinct layers: (1) an outer adventitia, (2) a middle media, and (3) an inner intima.

Layers of the Blood Vessel Wall

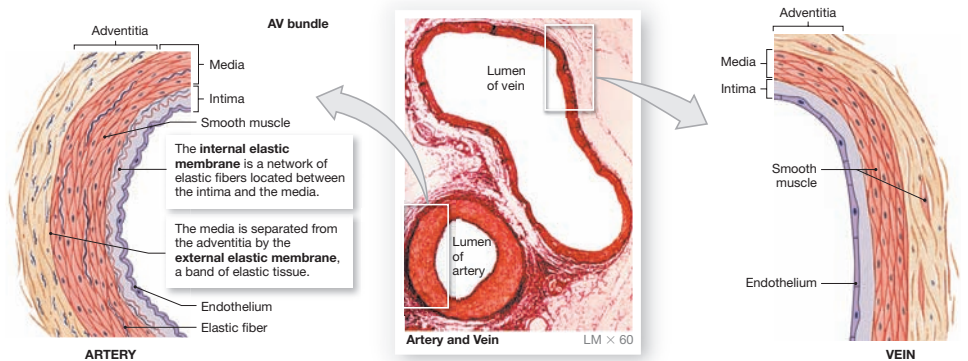
The outer **adventitia** (ad-ven-TISH-a) (*tunica adventitia*) forms a connective tissue sheath around the vessel. This layer is very thick, consisting of collagen fibers with scattered bands of elastic fibers. The connective tissue fibers of the adventitia typically blend into those of adjacent tissues, stabilizing and anchoring the blood vessel.

The **media** (*tunica media*) is the middle layer. It contains layers of circularly arranged smooth muscle. These layers form sheets that are organized and supported by a framework of elastic tissue.

The **intima** (*tunica intima*) is the innermost layer of the blood vessel. This layer includes the endothelial lining of the vessel and an underlying layer of areolar tissue containing variable amounts of elastic fibers and sometimes scattered smooth muscle cells.

Histological Comparison of Arteries and Veins

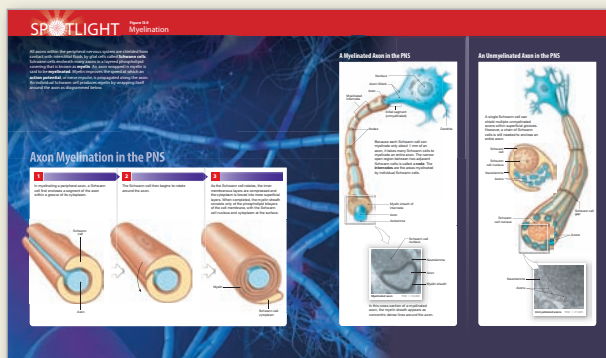
In general, when comparing two adjacent vessels, the walls of arteries are thicker than those of the corresponding veins, and the lumen is relatively smaller. Whereas in arteries the adventitia is usually thinner than the media, in veins the adventitia is typically the thickest layer of the vessel wall. Because the media of an artery contains more smooth muscle and elastic fibers than does that of a vein, when the wall of an artery is no longer stretched by blood pressure it constricts and the endothelium wrinkles as the luminal diameter decreases. As a result, in a cross section the arterial lining has a pleated appearance. In contrast, when venous blood pressure falls, veins simply collapse and in section the lining of a vein is relatively smooth.



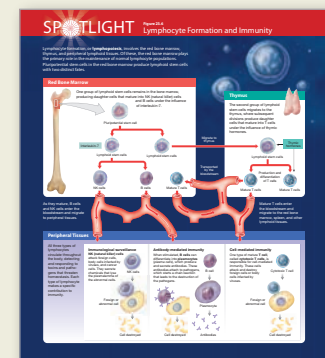
NEW There are 22 Spotlight Figures included in the Eighth Edition.



Mitosis
Chapter 2, page 45



Myelination
Chapter 13, page 352



Lymphocyte Formation and Immunity
Chapter 23, page 618

Structural Differences between Arteries and Veins

VEINS

7 Large Vein

Large veins include the superior and inferior venae cavae (also termed the *great veins*) and their tributaries within the abdominopelvic and thoracic cavities.

Adventitia
Media
Endothelium
Intima

6 Medium-Sized Vein

Medium-sized veins, such as the radial and ulnar veins, range from 2 to 9 mm in internal diameter and correspond in general size to muscular arteries. In these veins the media is thin, and it contains relatively few smooth muscle cells.

Adventitia
Media
Endothelium
Intima

5 Venule

Venules, the smallest veins, collect blood from capillaries. They vary widely in diameter and character, and the small venules are both innumerable and unnamed. The smallest venules resemble expanded capillaries, and venules smaller than 50 μm in total diameter lack a media altogether.

Adventitia
Endothelium

ARTERIES

Elastic Artery 1

The walls of elastic arteries, such as the aorta and brachiocephalic arteries, are not very thick relative to the vessel diameter, but they are extremely resilient. The media of these vessels contains relatively few smooth muscle cells and a high density of elastic fibers.

Internal elastic layer
Endothelium
Media
Adventitia

Muscular Artery 2

A typical muscular artery has a diameter of approximately 4 mm (0.15 in.). Muscular arteries, such as the radial and ulnar arteries, have a thicker media with a greater percentage of smooth muscle cells than elastic arteries.

Adventitia
Media
Endothelium
Intima

Arteriole 3

Arterioles have an average diameter of about 30 μm. They are considerably smaller than muscular arteries, and they are both innumerable and unnamed. Arterioles have a poorly defined adventitia, and the media consists of scattered smooth muscle cells that may not form a complete layer.

Smooth muscle cells
Endothelium
Basal lamina

4 Capillaries

Fenestrated Capillary

Fenestrated capillaries are capillaries that contain "windows," or pores in their walls, due to an incomplete or perforated endothelial lining.

Pores
Endothelial cells
Basal lamina

Continuous Capillary

Continuous capillaries are found in most regions of the body. In these capillaries the endothelium is a complete lining, and the endothelial cells are connected by tight junctions and desmosomes.

Endothelial cells
Basal lamina

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.

SPOTLIGHT MasteringA&P
The Cardiac Cycle

The Conducting System of the Heart

The heart's electrical system is the cardiac conduction system. It consists of specialized cardiac muscle cells that generate and conduct electrical impulses that coordinate the heart's pumping action. The electrical impulses travel through the conduction system in a specific sequence, starting at the sinoatrial node and ending at the ventricles.

Components of the Conducting System

- Sinoatrial node (SA node)
- Atrioventricular node (AV node)
- Atrioventricular bundle (AV bundle)
- Bundle branches
- Purkinje fibers

Measurement of Electrical Impulses through the Conducting System

1. The SA node generates an electrical impulse that spreads across the atria, causing them to contract.

2. The impulse reaches the AV node, where it is delayed for a brief period.

3. The impulse then travels down the AV bundle and into the bundle branches.

4. The impulse reaches the Purkinje fibers, which cause the ventricles to contract.

The Phases of the Cardiac Cycle

The cardiac cycle is the sequence of events that occurs in the heart during each heartbeat. It consists of three main phases: atrial systole, ventricular systole, and diastole.

Cardiac Cycle

1. Atrial Systole: The atria contract, pushing blood into the ventricles.

2. Ventricular Systole: The ventricles contract, pushing blood out to the lungs and the rest of the body.

3. Diastole: The ventricles relax, and blood flows back into them from the atria.

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.

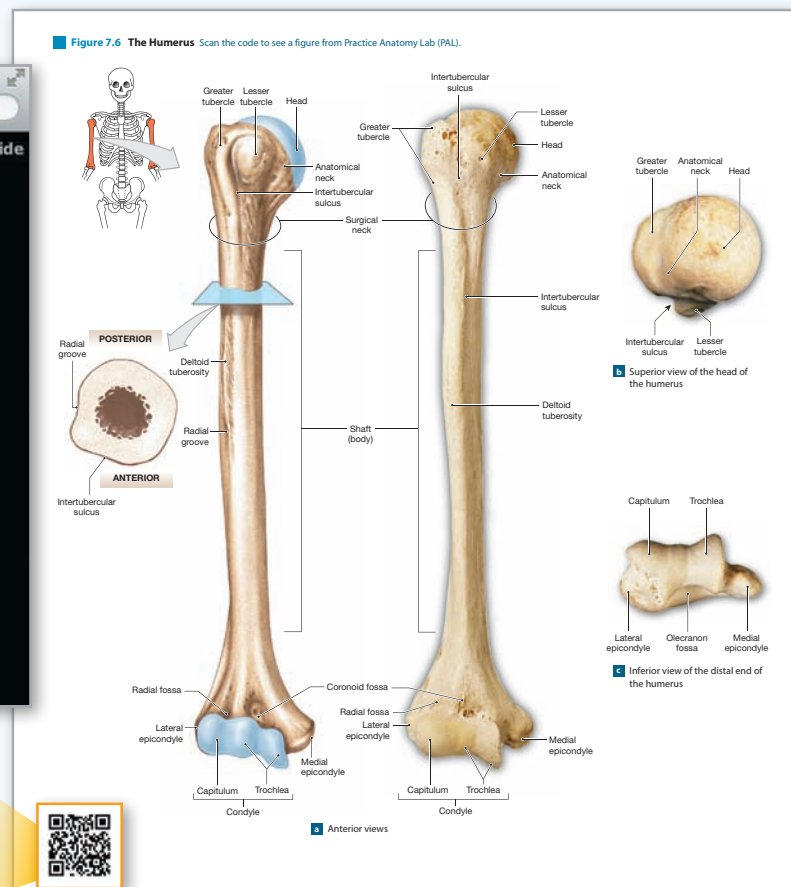
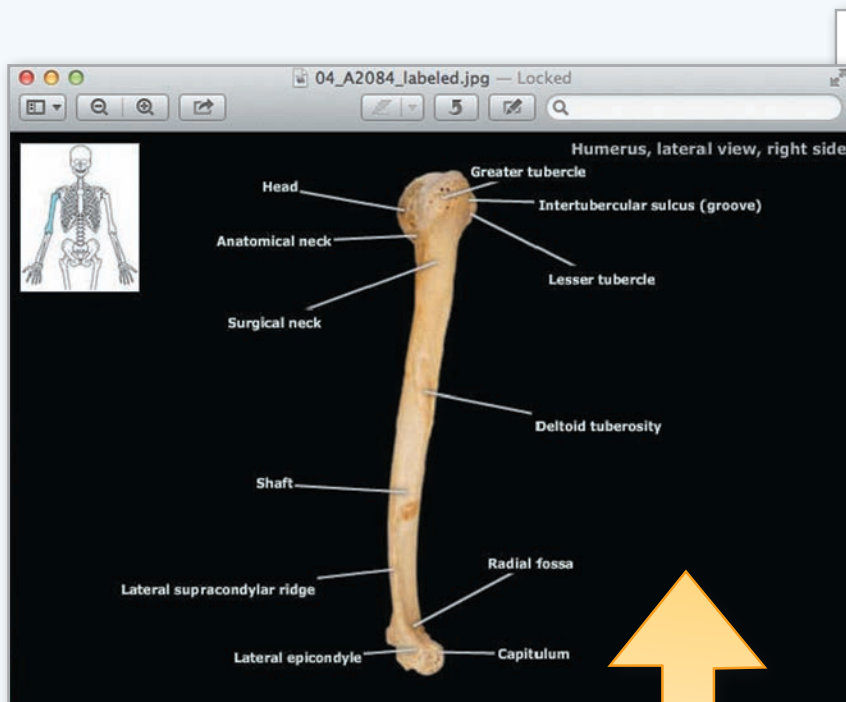
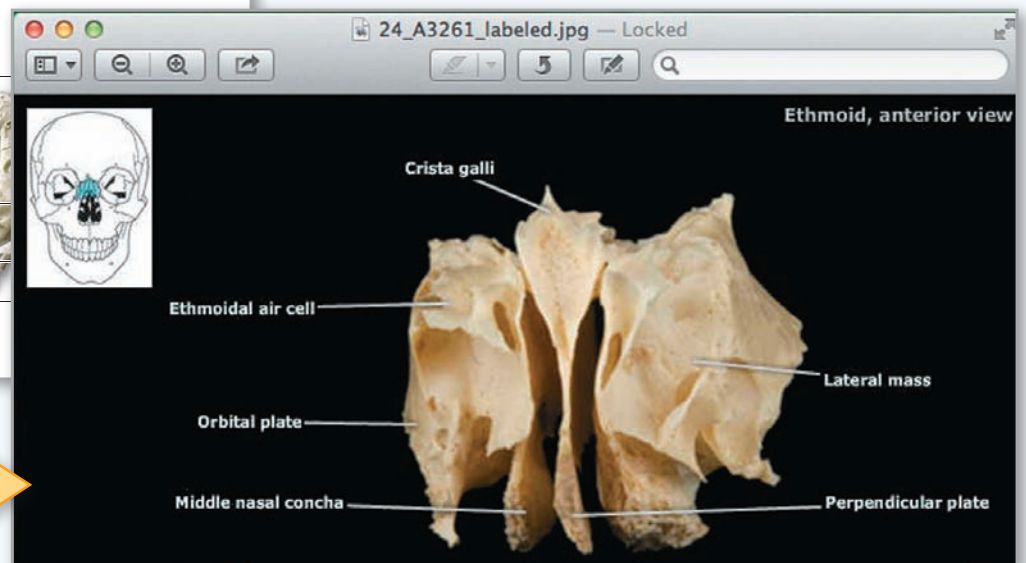
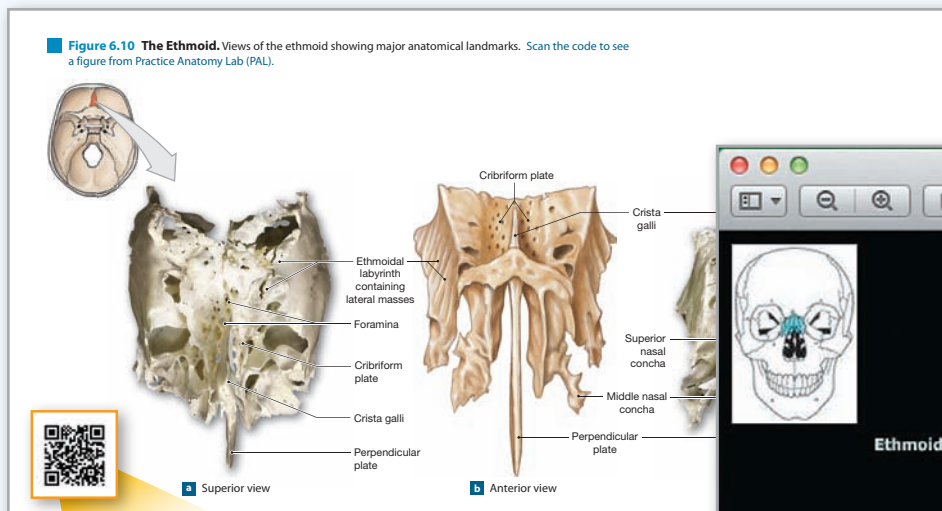
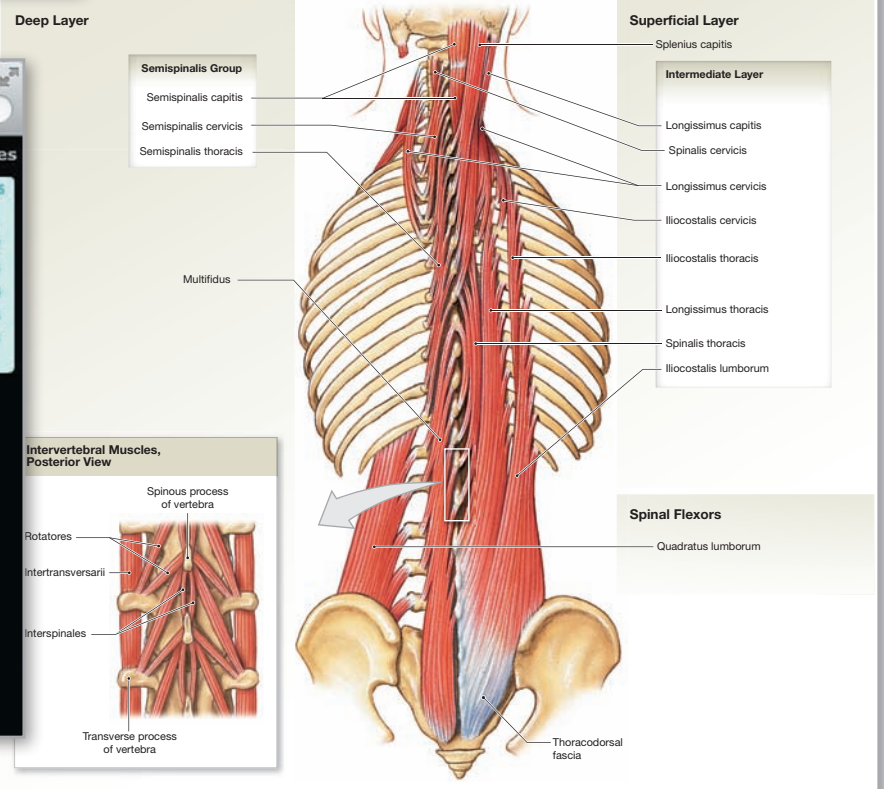
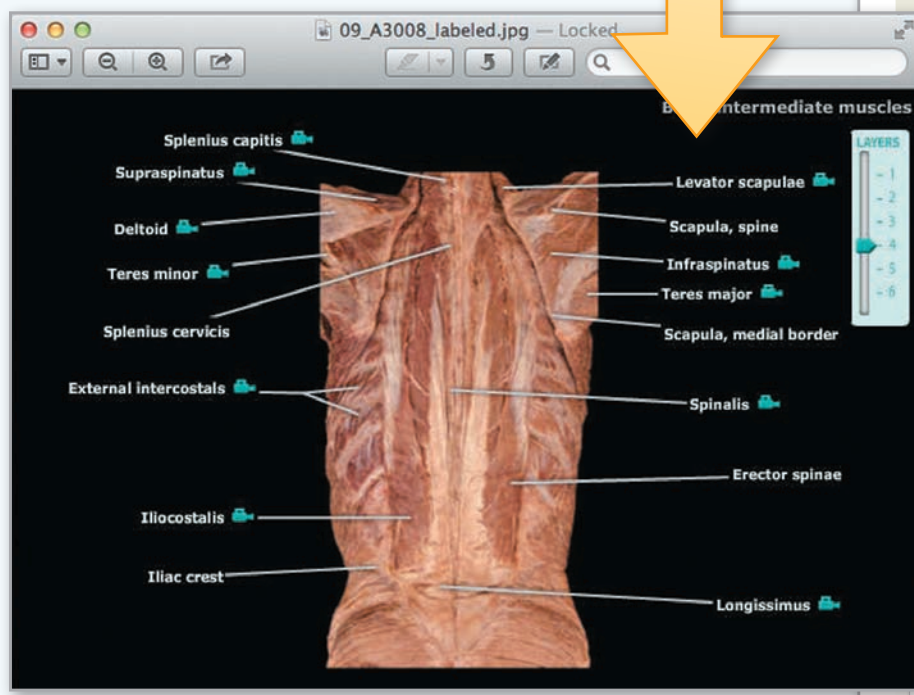


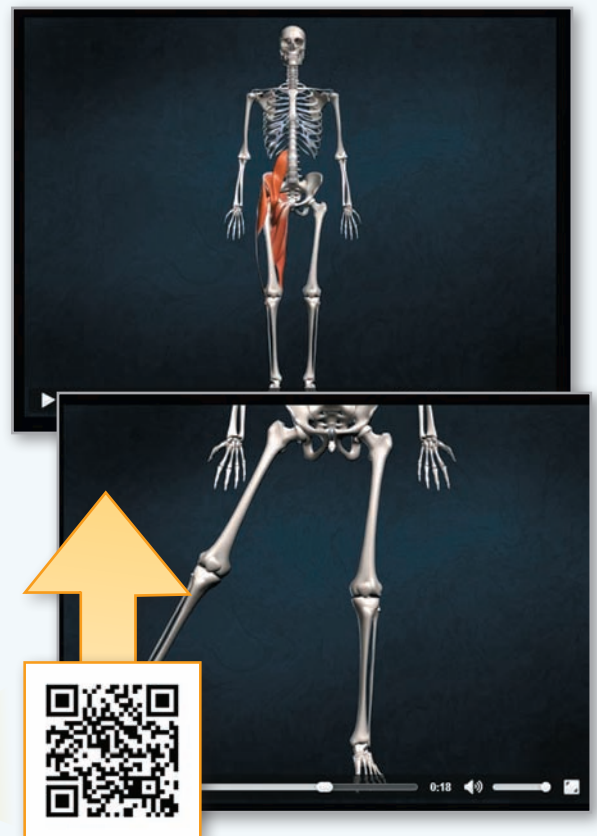


Figure 10.10 Muscles of the Vertebral Column. Collectively, these muscles adjust the position of the vertebral column, head, neck, and ribs. Selected origins and insertions are shown. Scan the code to see a figure from Practice Anatomy Lab (PAL).



Posterior view of superficial (right) and deeper (left) muscles of the vertebral column

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



SPOTLIGHT Figure 11.2 Factors Affecting Appendicular Muscle Function

Scan the codes in this Spotlight to see Mastering A&P™ A&P Flix animations on Group Muscle Actions & Innervation.

The Anatomy of the Shoulder Joint
When an entire muscle or part of a larger muscle contracts, it pulls the insertion in a specific direction. The direction of applied force is called an **action line**. The movement resulting at the associated joint depends on the relationship between the action line and the anatomical structure of the joint that determines its axes of motion. Knowing what movements the anatomy of a particular joint allows will help you understand or predict the actions of a particular muscle at that joint.

Flexion and Extension
Muscles whose action lines cross the anterior aspect of the shoulder joint are flexors of that joint, and muscles whose action lines cross the posterior aspect are extensors.

Medial and Lateral Rotation
Muscles whose action lines cross the superior aspect of the shoulder joint may produce medial rotation as well as flexion, and muscles whose action lines cross the posterior aspect of a joint may produce lateral rotation as well as extension.

Adduction and Abduction
Muscles whose action lines cross the superior aspect of the shoulder joint are adductors of that joint, and muscles whose action lines cross the inferior aspect of the joint are abductors.

Action Lines at the Shoulder Joint
Here is a superficial lateral view showing the action lines of the deltoid, biceps brachii, and triceps brachii muscles. As you have seen, analyzing how those action lines cross the shoulder joint enables one to determine the actions of these muscles on the humerus.

Spurt and Shunt Muscles
Determining the location of the insertion of a muscle relative to the axis of the joint will provide additional details about the functions of the muscle at that joint. The primary action of a muscle whose insertion is close to the joint will be the production of movement at that joint. Such a muscle is termed a **spurt muscle**, and spurt muscles are prime movers. However, a muscle whose insertion is considerably further from the joint will generally help to stabilize that joint in addition to producing motion at that joint. This type of muscle, a **synergist**, is termed a **shunt muscle**.

Action Lines at the Hip Joint
The hip joint, like the shoulder joint, is a multiaxial synovial joint that permits flexion/extension, adduction/abduction, and medial/lateral rotation. Determining the action of a muscle on the hip is identical to the process utilized for the shoulder, in that the action of a muscle on the hip is determined by the structure of the joint and the location of the insertion of the muscle on the femur (not shown) relative to the permitted axes of motion at the joint.

Abduction and Adduction
Deltoid
Teres minor
Teres major
Subscapularis
Triceps brachii

Flexion and Extension
Posterior portion of deltoid
Clavicular head of biceps brachii
Tendons of biceps brachii

Medial and Lateral Rotation
Lateral rotation
Superior rotation
Teres minor
Subscapularis

Action Lines at the Shoulder Joint
Acromion
Clavicle
Entire deltoid: abduction at the shoulder
Scapular deltoid: extension and lateral rotation
Clavicular deltoid: flexion and medial rotation
Trapezius: extension and abduction
Trapezius: flexion
Humerus


Spurt and Shunt Muscles
Flexors
Biceps brachii: movement and torque (spurt muscle)
Brachioradialis: stability and movement (shunt muscle)
Extensors
Triceps brachii: movement and torque (spurt muscle)

Action Lines at the Hip Joint
Gluteal Group
Flexion, abduction, and medial rotation
Extension and abduction
Extension
Gluteus medius
Gluteus minimus
Tensor fasciae latae
Gluteus maximus
Anterior
Posterior
Adductor Group
Adductor longus
Adductor magnus
Adduction
Lateral Rotator Group
Hamstring group: extension and lateral rotation
Adductor magnus
Adductor longus
Medial rotation
Hamstring group: extension and lateral rotation
Action lines of the adductor group

Item Type: Coaching Activities | Difficulty: 1 | Time: 3m | Learning Outcomes | Contact the Publisher | Manage this Item: Standard View

Temporomandibular Joint Video Questions

Watch the animation, then answer the questions below



Part A
Identify the region of the mandible that forms part of the temporomandibular joint.

- Mandibular fossa
- Mandibular condyle
- Coronoid process
- Mandibular notch

Part B
Identify the region of the temporal bone that articulates with the mandible.

- Styloid process
- Mandibular notch
- Mandibular condyle
- Mandibular fossa

Part C
Identify the best description of the mandibular fossa.

- A shallow depression
- A projection
- A slight elevation
- An opening

Navigation: Previous Item | Item 10 of 17 | Next Item

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

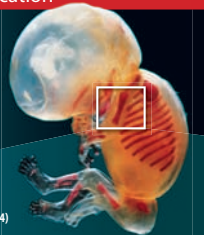
can be assigned to help students prepare for their lab practical quizzes and tests.



NEW Spotlight Figure Coaching Activities bring interactivity to the Spotlight Figures from the book by asking students to manipulate the visuals.

SPOTLIGHT
Figure 5.7
Endochondral Ossification
119

Endochondral ossification begins with the formation of a hyaline cartilage model. The bones of the limbs form in this way. By the time an embryo is six weeks old, the proximal bones of the limbs, the humerus (upper limb) and femur (lower limb), have formed, but they are composed entirely of cartilage. These cartilage models continue to grow by expansion of the cartilage matrix (**interstitial growth**) and by the production of more cartilage at the outer surface (**appositional growth**).



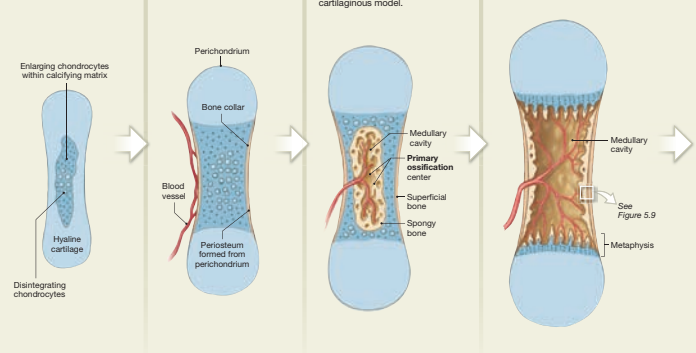
Initiation of Ossification in the Developing Bone (Steps 1–4)

1 As the cartilage enlarges, chondrocytes near the center of the shaft increase greatly in size, and the surrounding matrix begins to calcify. Deprived of nutrients, these chondrocytes die and disintegrate, leaving cavities within the cartilage.

2 Blood vessels grow around the edges of the cartilage, and the cells of the perichondrium begin differentiating into osteoblasts. The perichondrium has now been converted into a periosteum, and the inner **osteogenic** (os-TE-jen-ik) layer soon produces a bone collar, a thin layer of compact bone around the shaft of the cartilage.

3 While these changes are under way, the blood supply to the periosteum increases, and capillaries and osteoblasts migrate into the heart of the cartilage, invading the spaces left by the disintegrating chondrocytes. The calcified cartilaginous matrix then breaks down, and osteoblasts replace it with spongy bone. Bone development proceeds from this **primary ossification center** in the shaft, toward both ends of the cartilaginous model.

4 While the diameter is small, the entire shaft is filled with spongy bone, but as it enlarges, osteoblasts erode the central portion and create a medullary cavity. The bone of the shaft becomes thicker, and the cartilage of the metaphysis is invaded by osteoblasts that produce columns of bone. Further growth involves two distinct processes: an increase in length and an enlargement in diameter (Figure 5.9).



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

During the initial stages of osteogenesis, osteoblasts move away from the primary ossification center toward the epiphyses. But they do not manage to complete the ossification of the model immediately, because the cartilages of the epiphyses continue to grow. The situation is like a pair of joggers, one in front of the other. As long as they are running at the same speed, they can run for miles without colliding. In this case, the osteoblasts and the epiphyses are both "running away" from the primary ossification center. As a result, the osteoblasts never catch up with the epiphysis, although the skeletal element continues to grow longer and longer.

5 Capillaries and osteoblasts then migrate into the centers of the epiphyses, creating **secondary ossification centers**. The time of appearance of secondary ossification

6 The epiphyses eventually become filled with spongy bone. The epiphysis and diaphysis are now separated by a narrow **epiphyseal cartilage**, or **epiphyseal plate**, within the metaphysis. Osteoblasts invade the shaft

7 At maturity, the rate of epiphyseal cartilage enlargement slows and the rate of osteoblast activity accelerates. As a result, the epiphyseal cartilage gets narrower and

Spotlight Figure 5-7: Endochondral Ossification

Item Type: Coaching Activities | Difficulty: -- | Time: -- | Learning Outcomes

Sort the stages of endochondral ossification.

Part A

Place the appropriate description over each stage of endochondral ossification.

Fibroblasts begin producing spongy bone

Creation of secondary ossification centers

Remodeling occurs


Blood vessels grow around edges

Epiphysis is replaced by shafts of bone


Calcified matrix deteriorates

Chondrocytes enlarge


Stage 1




Stage 2



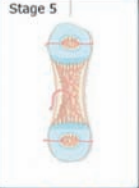
Stage 3



Stage 4



Stage 5



[reset](#) [help](#)

[Submit](#) [My Answers](#) [Give Up](#)

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[®] 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.



PAL 3.0 [Home](#) > [Human Cadaver: Nervous System](#) > [Central Nervous System](#) [Animations](#) [Index](#) [Help](#)

Self Review **Quiz** **Lab Practical**

Tap image to view structure name.

Tap structure or label to hear a pronunciation.

Pinch or zoom to magnify the image.

Touch with two fingers and drag to move the image.

Double-tap structure or label to see animation.

Drag slider to see different layers.

8 of 44 **LABELS ON** **SHOW GALLERY**

Ventricular system, left side


Bone and Dissection Videos

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

Item Type: Coaching Activities | Difficulty: 1 | Time: 3m | Learning Outcomes | Contact the Publisher | Manage this Item: Standard View

Dissection Video Activity: Sheep Brain (1 of 7)

Watch the animation, then answer the questions below.



one on the right and one on the left.

00:29 01:55

Part A
Which of the following ventricles is found under the corpus callosum?

- Fourth ventricle
- Lateral ventricles
- Third ventricle
- Fornix

Submit Hints My Answers Give Up Review Part

Part B
Which passageway connects the third and fourth ventricles?

- Septum pellucidum
- Central canal
- Cerebral aqueduct
- Interventricular foramen

Submit Hints My Answers Give Up Review Part

Part C
Identify the passageway found in the spinal cord that is continuous with the ventricles.

- Interventricular foramina
- Central canal
- Cerebral aqueduct
- Choroid plexus

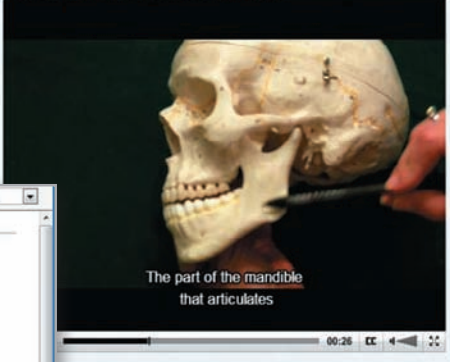
Submit Hints My Answers Give Up Review Part

Previous Item Item 16 of 178 Next Item

Item Type: Coaching Activities | Difficulty: 1 | Time: 3m | Learning Outcomes | Contact the Publisher | Manage this Item: Standard View

Temporomandibular Joint Video Questions

Watch the animation, then answer the questions below.



The part of the mandible that articulates

00:26

Part A
Identify the region of the mandible that forms part of the temporomandibular joint.

- Mandibular fossa
- Mandibular condyle
- Coronoid process
- Mandibular notch

Submit Hints My Answers Give Up Review Part

Part B
Identify the region of the temporal bone that articulates with the mandible.

- Styloid process
- Mandibular notch
- Mandibular condyle
- Mandibular fossa

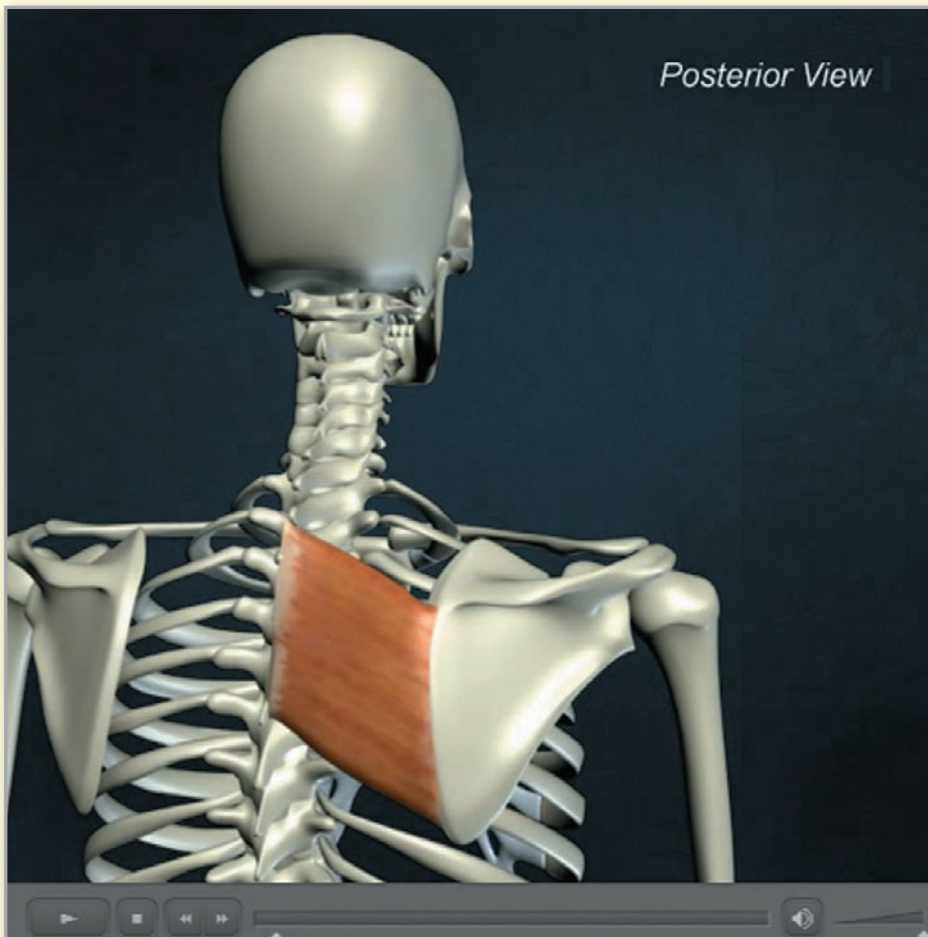
Submit Hints My Answers Give Up Review Part

Part C
Identify the best description of the mandibular fossa.

- A shallow depression
- A projection
- A slight elevation
- An opening

Submit Hints My Answers Give Up Review Part

Previous Item Item 10 of 17 Next Item



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™

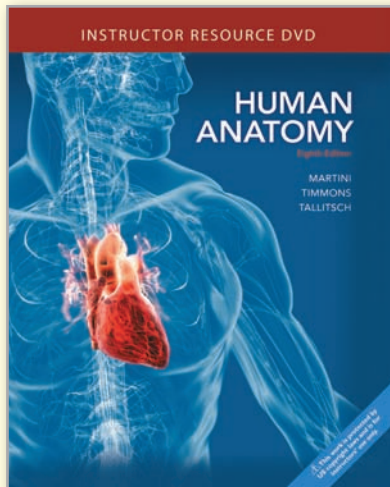
MyReadinessTest for A&P is a powerful online system that gets students prepared before their course starts. It assesses students' proficiency in study skills and foundational science and math concepts and provides coaching in core areas where students need additional practice and review.

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:

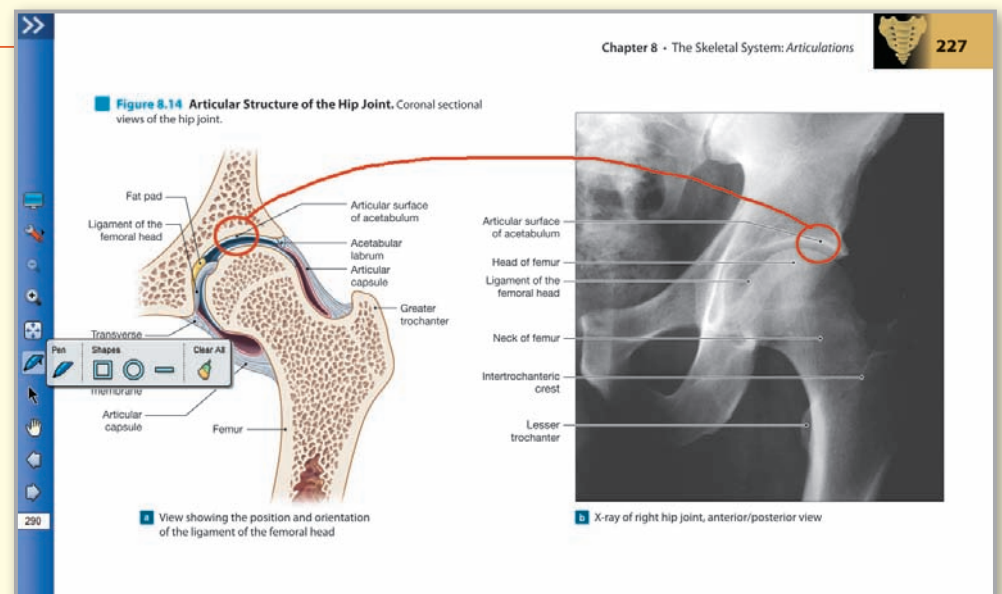
- Customizable PowerPoint Lecture Presentations that combine lecture notes, figures, tables, and links to animations
- All figures from the book in JPEG format and PowerPoint slides (with editable labels and without) plus figures from *Martini's Atlas of the Human Body* and *A&P Applications Manual*
- 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.

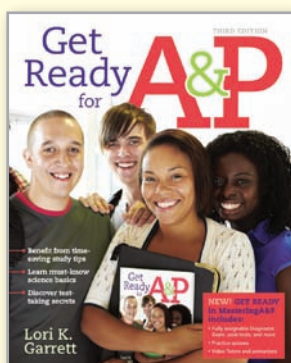
Instructors can also add notes to guide students, upload documents, and share their custom-enhanced eText with the whole class.

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



SUPPORT FOR STUDENTS

Every item can be packaged with the main student text.

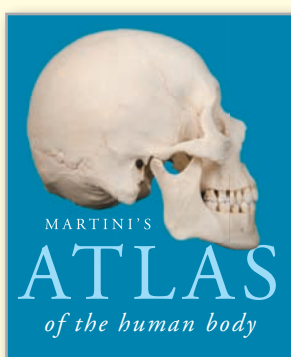


Get Ready for A&P

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.

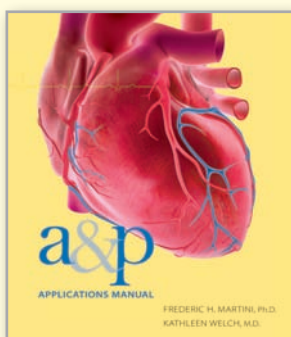


Martini's Atlas of the Human Body

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.

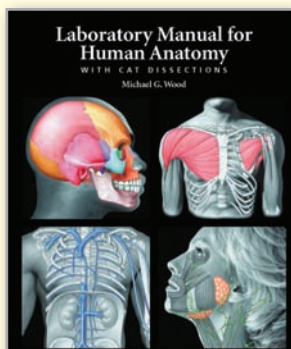


A&P Applications Manual

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.

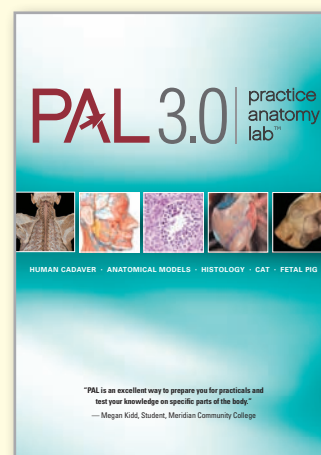


Laboratory Manual for Human Anatomy with Cat Dissections

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.

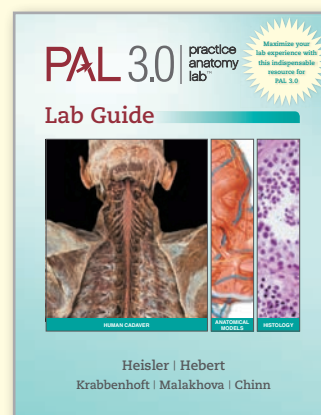


Practice Anatomy Lab™ (PAL™) 3.0 DVD

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.

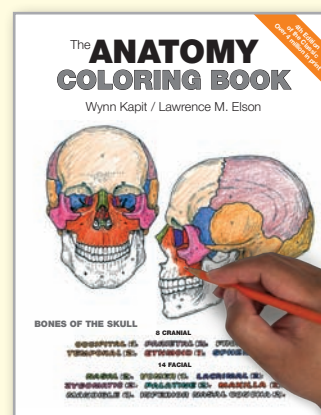


Practice Anatomy Lab (PAL) 3.0 Lab Guide

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

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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.

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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

- 4** Disease, Pathology, and Diagnosis
- 7** The Diagnosis of Disease
- 19** The Visible Human Project
- 22** Clinical Anatomy and Technology



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

- Histologists study what structures?
- 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

- How does the work of a gross anatomist differ from that of a histologist?
- What is an organ system, and how does it apply to systemic anatomy?

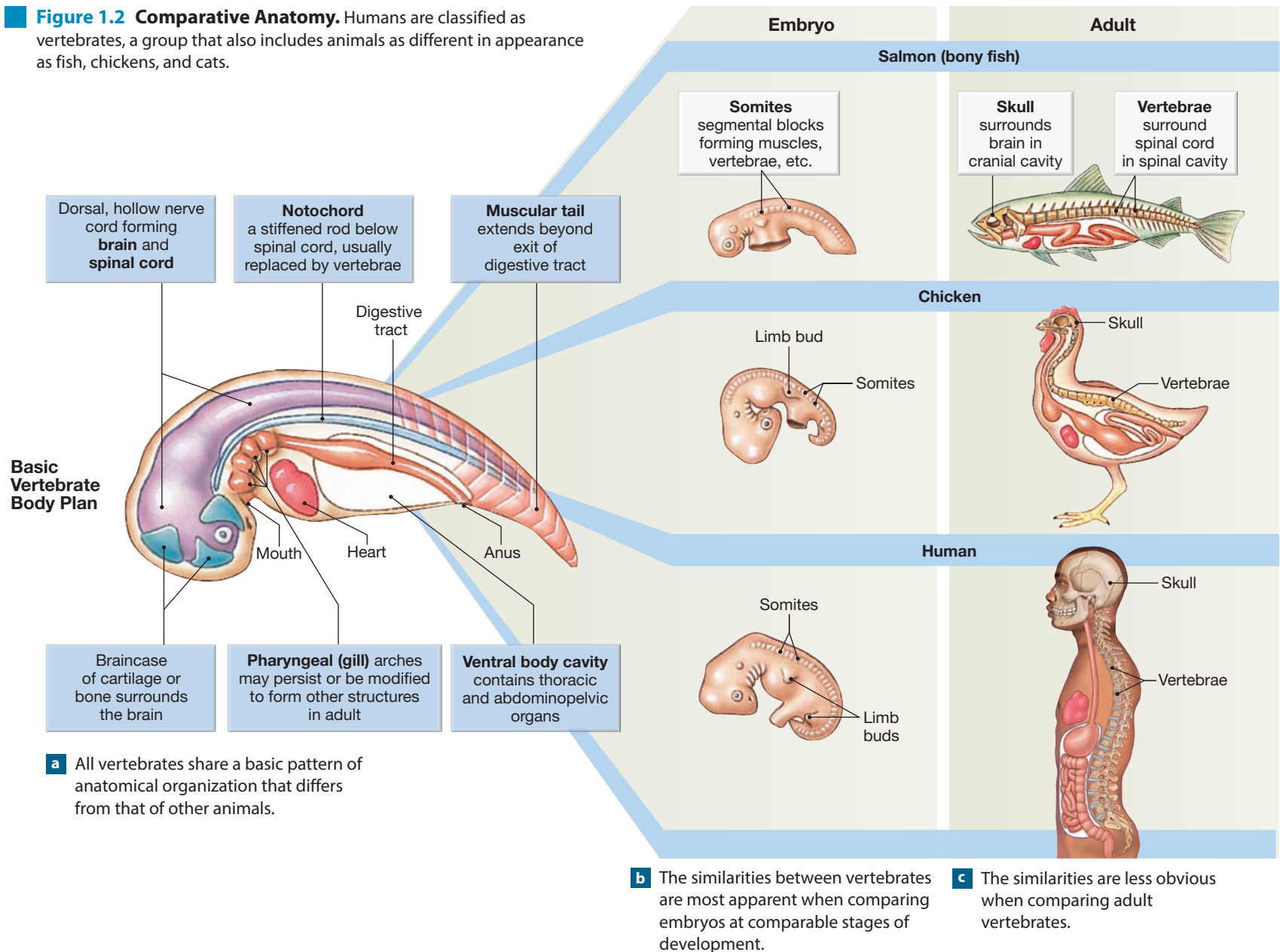
See the blue Answers tab at the back of the book.

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



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.

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**.

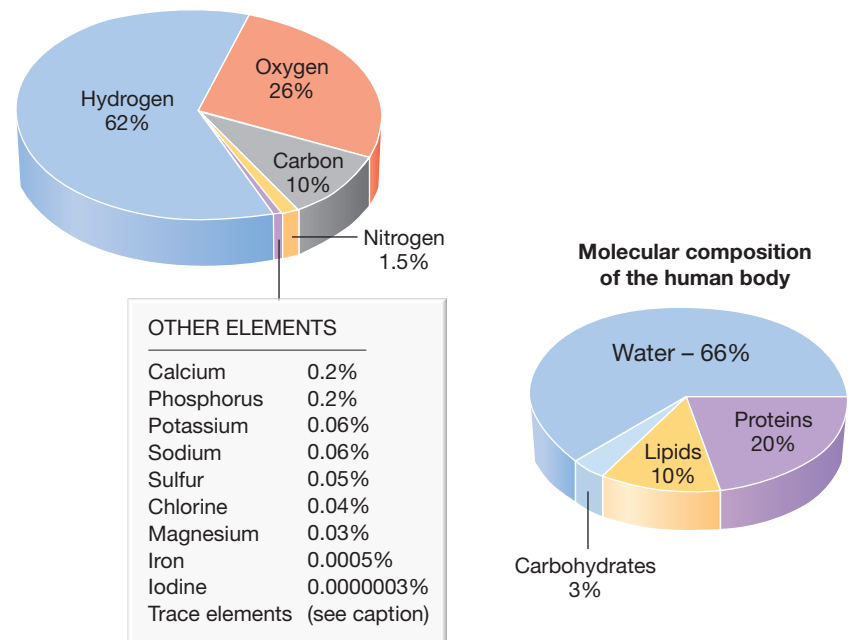
Figure 1.4 presents an example of the relationships between the chemical level and higher levels of organization. The cellular level of organization includes cells, the smallest living units in the body. Cells contain internal structures called organelles. Cells and their organelles are made up of complex 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.

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



a Elemental composition of the body.

Trace elements include silicon, fluorine, copper, manganese, zinc, selenium, cobalt, molybdenum, cadmium, chromium, tin, aluminum, and boron.

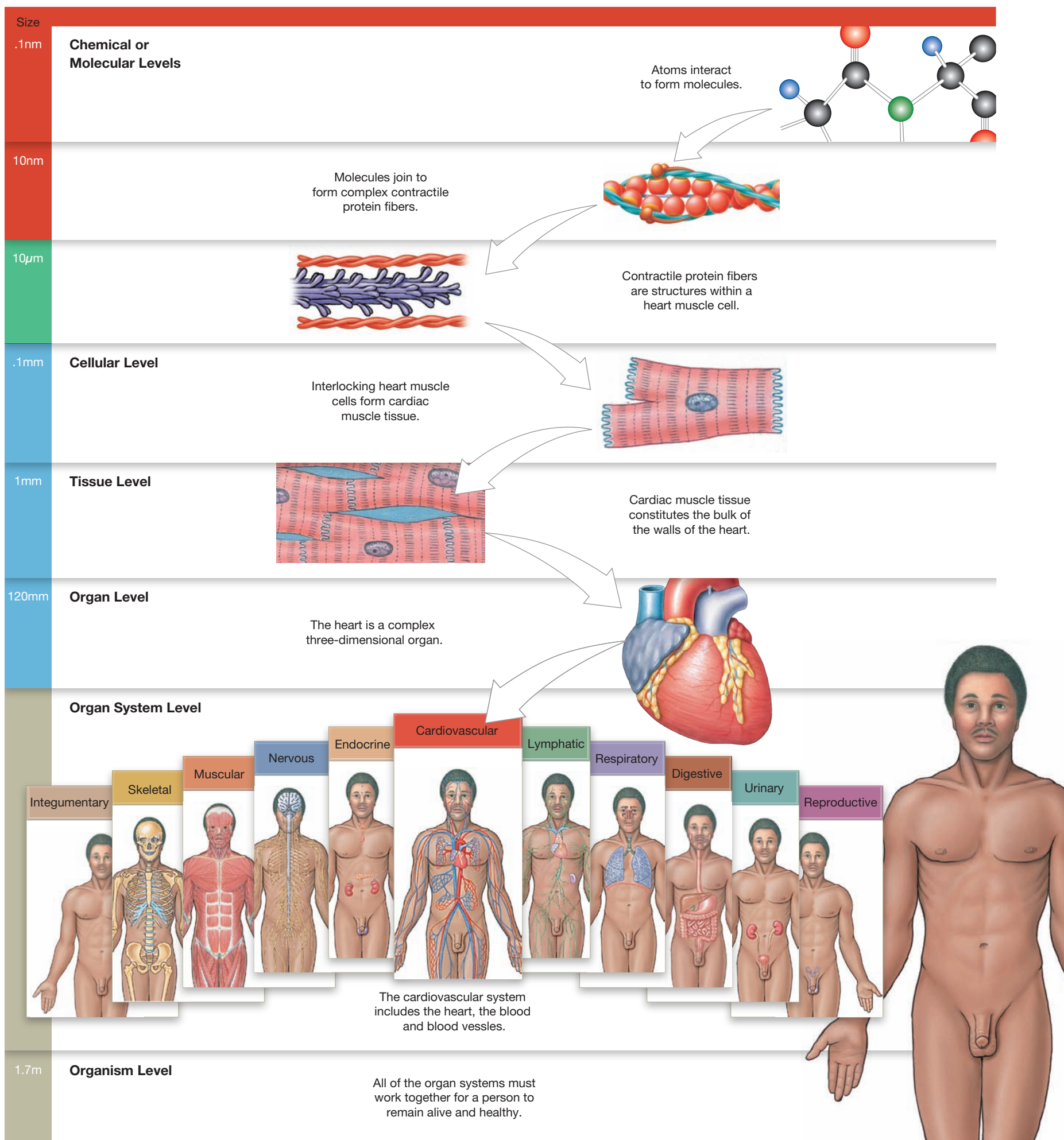
b Molecular composition of the body.

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



✓ 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).
- **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 1.5 An Introduction to Organ Systems. An overview of the 11 organ systems and their major functions.












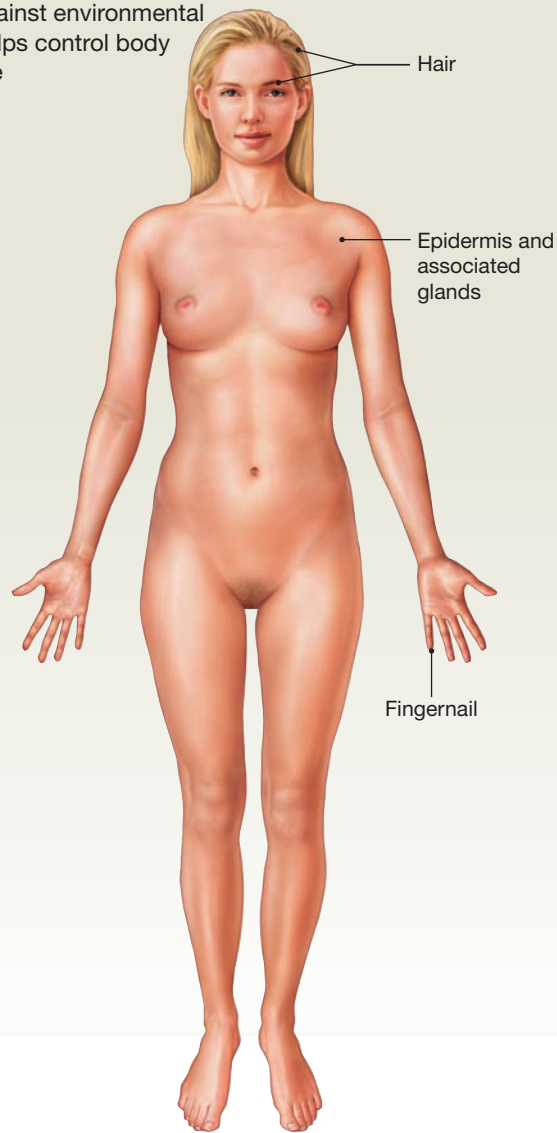
| ORGAN SYSTEM | | MAJOR FUNCTIONS |
|---|------------------------------|---|
|  | Integumentary system | Protection from environmental hazards; temperature control |
|  | Skeletal system | Support, protection of soft tissues; mineral storage; blood formation |
|  | Muscular system | Locomotion, support, 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 |

Figure 1.6 The Organ Systems of the Body

The Integumentary System

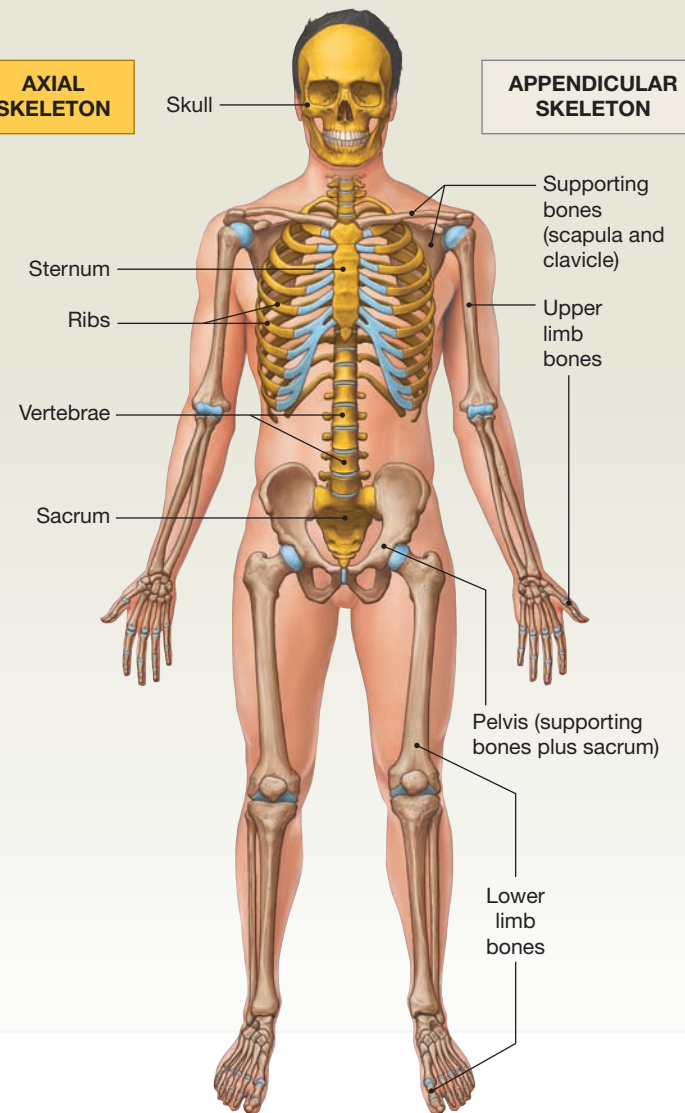
Protects against environmental hazards; helps control body temperature



| Organ/Component | Primary Functions |
|--|---|
| Skin Epidermis Dermis | Covers surface; protects deeper tissues Nourishes epidermis; provides strength; contains glands |
| Hair Follicles Hairs Sebaceous glands | Produce hair; innervation provides sensation Provide protection for head 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

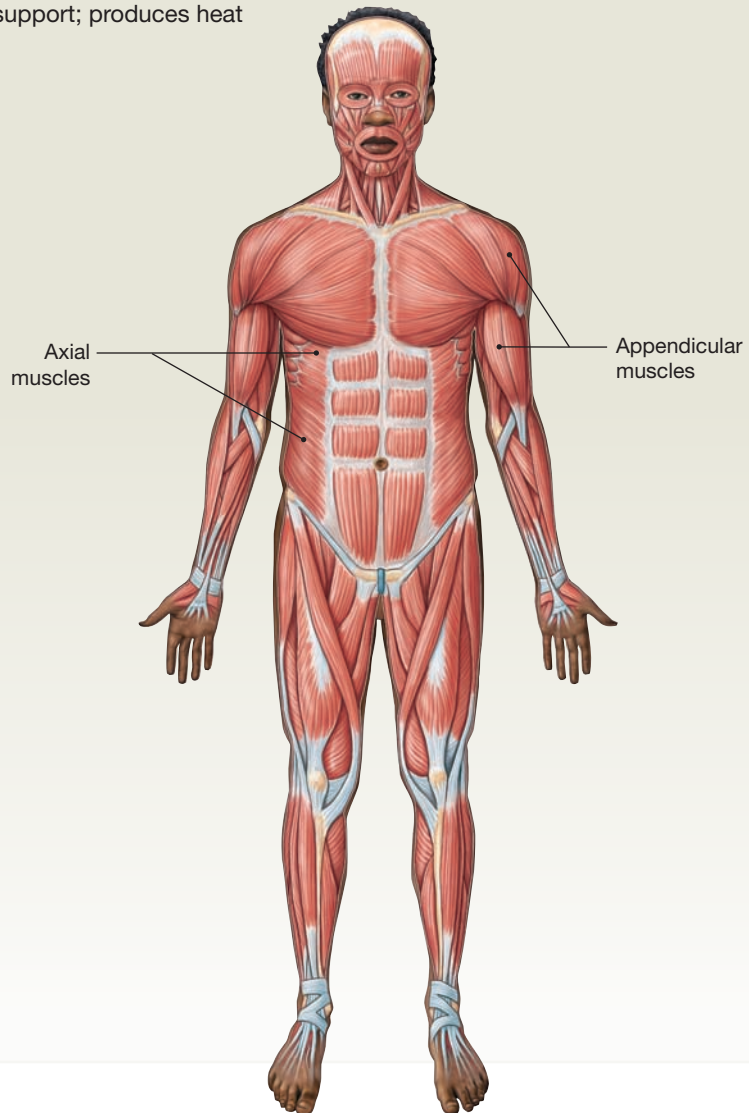
Provides support; protects tissues; stores minerals; forms blood cells



| Organ/Component | Primary Functions |
|---|---|
| Bones, Cartilages, and Joints Axial skeleton (skull, vertebrae, sacrum, coccyx, sternum, ribs, supporting cartilages and ligaments) Appendicular skeleton (limbs and supporting bones and ligaments) | Support; protect soft tissues; bones store minerals Protects brain, spinal cord, sense organs, and soft tissues of thoracic cavity; supports the body weight over lower limbs 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) |

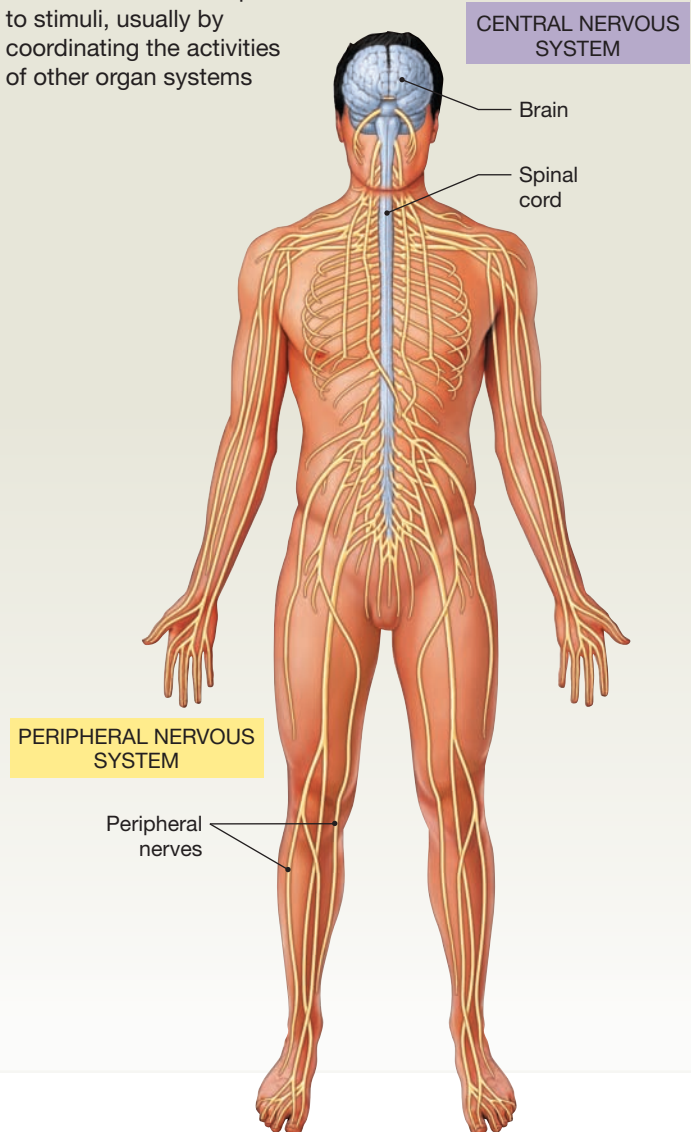
The Muscular System

Allows for locomotion; provides support; produces heat



The Nervous System

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



| 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 |

| 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 |