



**Memmler's**

# **Structure and Function of**

# **The Human Body**

**12th Edition**

**Barbara Janson Cohen  
Kerry L. Hull**

## KEY IDEA TABLE

Key Idea	Explanation	Chapter (page)
1 • Structure-Function	The anatomy (structure) of an element determines its physiology (function).	1 (p. 4)
2 • Levels of Organization	All living things are organized from very simple levels (e.g. atoms) to very complex levels (e.g. organisms). Anatomy and physiology can be studied at any of these levels.	1 (p. 4)
3 • Homeostasis and Negative Feedback	Despite changing environmental conditions, critical body functions such as blood pressure and temperature are maintained within tight limits. Negative feedback is a control system based on information returning to a source. It reverses any upward or downward shift in a particular body condition.	1 (p. 5)
4 • Barriers	Barriers help the body maintain distinct environments. For instance, the skin and mucous membranes separate the inside of the body from the external environment, and the cell's plasma membrane separates the intracellular fluid from the extracellular fluid.	1 (p. 7)
5 • Gradients and Resistance	The movement (flow) of a particular substance is promoted by a gradient (a difference in a physical or chemical value between two areas) and opposed by resistance. For instance, resistance can reflect membrane thickness for flow across barriers, and tube width for flow through tubes.	1 (p. 8)
6 • Water	Water is of critical importance in many physiological processes.	2 (p. 27)
7 • Enzymes	Most chemical reactions require the actions of enzymes. The activity of specific enzymes can be increased or decreased in response to changing body conditions.	2 (p. 32)
8 • Energy	Organisms need to generate and use energy. Tracking the flow of energy and matter through systems is a key part of understanding physiology.	2 (p. 34)
9 • Genes Code for Proteins	DNA is the cell's master blueprint, determining the body's structures and functions. Mutations, changes in the DNA sequence of a gene, can change the shape of the resulting protein, or even stop it from being synthesized.	3 (p. 54)
10 • Adaptation	Organisms adapt to the environment; that is, their structure, function, or behavior changes in response to changes in their environment. Adaptation often results from injury, and helps protect against future damage.	5 (p. 86)
11 • Communication	The body uses chemical and electrical signals to convey information. Chemical signals alter the activity of target cells by binding specific receptors.	7 (p. 129)
12 • Causation and Correlation	Two events may be correlated (i.e. frequently occur together) without one event causing the other. Establishing causation involves specifying a sequence of interactions linking the cause to the effect.	9 (p. 191)
13 • Mass Balance	The amount of a substance stored in a system is determined by inputs and outputs.	13 (p. 271)

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**Kerry L. Hull, BSC, PhD**



Philadelphia • Baltimore • New York • London  
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12th Edition

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9 8 7 6 5 4 3 2 1

Printed in China

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**Cataloging-in-Publication Data available on request from the Publisher**

**ISBN: 978-1-9751-3892-9**

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# Preface

*Memmler's Structure and Function of the Human Body* is a textbook for introductory-level allied health and nursing students who need a basic understanding of anatomy and physiology and the interrelationships between structure and function.

Like preceding editions, the 12th edition remains true to Ruth Memmler's original vision. The features and content specifically meet the needs of those who may be starting their health career preparation with little or no science background. This book's primary goals are

- To provide the essential knowledge of human anatomy and physiology at an ideal level of detail and in language that is clear and understandable
- To illustrate the concepts discussed with anatomic art of appropriate detail with accuracy, simplicity, and style that is integrated seamlessly with the narrative
- To incorporate the most recent scientific findings into the fundamental material on which Ruth Memmler's classic text is based
- To include pedagogy designed to enhance interest in and understanding of the concepts presented
- To teach the basic anatomic and medical terminology used in health care settings, preparing students to function efficiently in their chosen health careers
- To present an integrated teaching–learning package that includes all of the elements necessary for a successful learning experience

This revision is the direct result of in-depth market feedback solicited to tell us what instructors and students at this level most need. We listened carefully to the feedback, and the results we obtained are integrated into many features of this book and into the ancillary package accompanying it. The text itself has been revised and updated where needed to improve organization of the material and to reflect current scientific thought.

Because visual learning devices are so important to students, this new edition continues to include “The Body Visible,” a series of illustrations of the major body systems described in the text with labeled transparent overlays. In addition to being a learning and testing tool, these illustrations provide enrichment and are a valuable general reference.

The 12th edition retains its extensive art program with updated versions of figures from previous editions and many new figures. These features appear in a modified design that makes the content more user-friendly and accessible than ever. Our innovative ancillary package on *thePoint* provides students with a wealth of resources, while the comprehensive package of instructor resources provides instructors with maximum flexibility and efficiency. The online Instructor's Manual describes all of the updates in this new edition and presents teaching and learning strategies for traditional classrooms, flipped classrooms, and online



courses.

## ORGANIZATION AND STRUCTURE

Like previous editions, this 12th edition uses a body systems approach to the study of the normal human body. The book is divided into seven units, grouping related information and body systems together as follows:

- Unit I, The Body as a Whole (Chapters 1–5), focuses on the body’s organization; basic chemistry needed to understand body functions; cells and their functions; tissues, glands, and membranes; and the skin.
- Unit II, Movement and Support (Chapters 6 and 7), includes the skeletal and muscular systems.
- Unit III, Coordination and Control (Chapters 8–11), focuses on the nervous system, the sensory system, and the endocrine system.
- Unit IV, Circulation and Body Defense (Chapters 12–15), includes the blood, the heart, blood vessels and circulation, the lymphatic system, and the immune system.
- Unit V, Energy: Supply and Use (Chapters 16–19), includes the respiratory system; the digestive system; metabolism, nutrition, and temperature control; as well as the urinary system and body fluids.
- Unit VI, Perpetuation of Life (Chapters 20 and 21), covers the male and female reproductive systems, as well as development, birth, and heredity.

The main Glossary defines all the chapters’ key terms and many additional terms emphasized in the text. An additional Glossary of Word Parts is a reference tool that not only teaches basic medical and anatomic terminology but also helps students learn to recognize unfamiliar terms. Appendices include a variety of supplementary information that students will find useful as they work with the text, including a photographic Dissection Atlas (Appendix 3) and answers to the Chapter Checkpoint questions, Casepoint questions, and Zooming In illustration questions (Appendix 2) that are found in every chapter.

## PEDAGOGIC FEATURES

Every chapter contains pedagogy that has been designed with the health professions and nursing student in mind.

- **Key Ideas:** The foundational concepts of Anatomy and Physiology are summarized in the Key Idea Table on page i of the textbook. A large numbered key within a chapter indicates where each key idea is introduced, and small numbered keys indicate when a key idea is used to explain a new concept. These key ideas help students organize and deepen their knowledge.
- **Learning Objectives:** Chapter objectives at the start of every chapter help the student organize and prioritize learning.
- **Ancillaries At-A-Glance:** Learning Tools, Learning Resources, and Learning Activities

are highlighted in a one-stop overview of the supplemental materials available for the chapter. These resources are organized for use when the student is preparing to learn, while he or she is learning the material, and when it's time for reviewing the chapter.

- **A & P in Action:** Familiar scenarios transport chapter content into a real-life setting, bringing the information to life for students and showing how the body maintains a state of internal balance.
- **A Look Back:** With the exception of Chapter 1, each chapter starts with a brief review of how its content relates to prior chapters, especially the key ideas.
- **Checkpoint questions:** Brief questions at the end of main sections test and reinforce the student's recall of key information in that section. Answers are in Appendix 2.
- **Casepoint questions:** Critical thinking questions challenge students to apply concepts learned to the A & P in Action case study. Answers are in Appendix 2.
- **Key Points:** Critical information in figure legends spotlights essential aspects of the illustrations.
- **“Zooming In” questions:** Questions in the figure legends test and reinforce student understanding of concepts depicted in the illustration. Answers are in Appendix 2.
- **Phonetic pronunciations:** Easy-to-learn phonetic pronunciations are spelled out in the narrative, appearing in parentheses directly following many terms—no need for students to understand dictionary-style diacritical marks (see the “Guide to Pronunciation”).
- **Special interest boxes:** Each chapter contains special interest boxes focusing on topics that augment chapter content. The book includes four kinds of boxes:
  - **One Step at a Time:** Uses the case study to teach scientific literacy and problem solving skills. Each box outlines a step-by-step approach that students can use to answer end of chapter questions or Study Guide problems.
  - **A Closer Look:** Provides additional in-depth scientific detail on topics in or related to the text.
  - **Clinical Perspectives:** Focuses on diseases and disorders relevant to the chapter, exploring what happens to the body when the normal structure–function relationship breaks down.
  - **Hot Topics:** Focuses on current trends and research, reinforcing the link between anatomy and physiology and related news coverage that students may have seen.
- **New! Concept Mastery Alerts:** Text boxes at specific points in the chapters highlight common student misconceptions to help your understanding of potentially confusing topics, as identified by Lippincott's online adaptive learning platform, powered by PrepU. Data from thousands of actual students using this program in courses across the United States have identified common misconceptions that are clarified in this feature.
- **Figures:** The art program includes full-color anatomic line art, many new or revised, with a level of detail that matches that of the narrative. Photomicrographs, radiographs, and other scans give students a preview of what they might see in real-world healthcare settings. Supplementary figures are available on the companion website on *thePoint*.
- **Tables:** The numerous tables in this edition summarize key concepts and information in an easy-to-review form. Additional summary tables are available on the companion website on *thePoint*.

- **Color figure and table callouts:** Figure and table numbers appear in color in the narrative, helping students quickly find their place after stopping to look at an illustration or table.
- **A & P in Action Revisited:** Traces the outcome of the medical story that opens each chapter and shows how the cases relate to material in the chapter and to others in the book.
- **Word Anatomy:** This chart defines and illustrates the various word parts that appear in terms within the chapter. The prefixes, roots, and suffixes presented are grouped according to chapter headings so that students can find the relevant text. This learning tool helps students build vocabulary and promotes understanding even of unfamiliar terms based on a knowledge of common word parts.
- **Chapter Overview:** A graphic outline at the end of each chapter provides a concise overview of chapter content, aiding in study and test preparation.
- **Key Terms:** Selected boldface terms throughout the text are listed at each chapter’s end and defined in the book’s glossary.
- **Questions for Study and Review:** Study questions are organized hierarchically into three levels. (Note that answers appear in the student resources on *thePoint*.) This section includes questions that direct students to “The Body Visible” and the various appendices to promote use of these resources. Question levels include the following:
  - **Building Understanding:** Includes fill-in-the-blank, matching, and multiple choice questions that test factual recall
  - **Understanding Concepts:** Includes short-answer questions (define, describe, compare/contrast) that test and reinforce understanding of concepts
  - **Conceptual Thinking:** Includes short-essay questions that promote critical thinking skills. Included are thought questions related to the Disease in Context case stories.

## FOR STUDENTS

Look for callouts throughout the chapters for pertinent supplementary material on the companion website on *thePoint*.

This companion website also includes resources that helps students learn faster, remember more, and achieve success. Students may choose from a wealth of materials including a pre-quiz; animations; various types of online learning activities; an audio glossary; and other supplemental materials, such as health professions career information, additional charts and images, and study and test-taking tips. Answers to the chapter Questions for Study and Review are also included.

See the inside front cover of this text for the passcode you will need to gain access to the companion website, and see pages xv–xvii for details about the website and a complete listing of student resources.

## INSTRUCTOR ANCILLARY PACKAGE

All instructor resources are available to approved adopting instructors and can be accessed online at <http://thepoint.lww.com/MemmlerSFHB12e>.

- Instructor’s Manual materials available for each chapter summarize the changes in the new edition, and provide background information and activities relevant to each learning objective.
- Brownstone Test Generator allows you to create customized exams from a bank of questions.
- PowerPoint Presentations use visuals to emphasize the key concepts of each chapter.
- Image Bank includes labels-on and labels-off options.
- Supplemental Image Bank with additional images can be used to enhance class presentations.
- Lesson Plans are organized around the learning objectives and include lecture notes, in-class activities, and assignments, including student activities from the student companion website.
- Answers to “Questions for Study and Review” provide responses to the quiz material found at the end of each chapter in the textbook.
- Strategies for Effective Teaching provide sound, tried-and-true advice for successful instruction in traditional, flipped, and online learning environments.
- WebCT/Blackboard/Angel Cartridge allows easy integration of the ancillary materials into learning management systems.

Instructors also have access to all student ancillary assets, via *thePoint* website.

## **GUIDE TO PRONUNCIATION**

The stressed syllable in each word is shown with capital letters. The vowel pronunciations are as follows:

Any vowel that appears alone or at the end of a syllable is given a long sound, as follows:

- a as in say
- e as in be
- i as in nice
- o as in go
- u as in true

A vowel followed by a consonant and the letter e (as in rate) also is given a long pronunciation. For example, re-PETE for repeat.

Any vowel followed by a consonant receives a short pronunciation, as follows:

- a as in absent
- e as in end

i as in bin

o as in not

u as in up

The letter *h* may be added to a syllable to make vowel pronunciation short, as in *vanilla* (vah-NIL-ah).

## **SUMMARY**

The 12th edition of *Memmler's Structure and Function of the Human Body* builds on the successes of the previous 11 editions by offering clear, concise narrative into which accurate, aesthetically pleasing anatomic art has been woven. We have made every effort to respond thoughtfully and thoroughly to reviewers' and instructors' comments, offering the ideal level of detail for students preparing for careers in the health professions and nursing and the pedagogic features that best support them. With the online resources, we have provided students with an integrated system for succeeding in the course. We hope you will agree that the 12th edition of *Memmler's* suits your educational needs.

# User's Guide

For today's health careers, a thorough understanding of human anatomy and physiology is more important than ever. *Memmler's Structure and Function of the Human Body*, 12th edition, not only provides the conceptual knowledge you'll need but also teaches you how to apply it. This User's Guide introduces you to the features and tools that will help you succeed as you work through the materials.

Your journey begins with your textbook, *Memmler's Structure and function of the Human Body*. Newly updated and fully illustrated, this easy-to-use textbook is filled with resources and activities to help you succeed.

**A & P in Action** provides an interesting case story that uses a familiar, real-life scenario to illustrate key concepts in anatomy and physiology. Later in the chapter, the case story is revisited in more detail—improving your understanding and helping you remember the information.



## A & P in Action

### Mike's Case: Emergency Care and Possible System Failure

"Location—Belle Grove Road. Single MVA. Male. Early 20s. Fire and police on scene," crack-

led the radio. "Medic 12. Respond channel 2."

"Medic 12 responding. En route to Belle Grove Road," Ed radioed back, while his partner, Samantha, flipped the switch for the lights and siren and hit the accelerator. When they arrived at the scene, police officers were directing traffic, and a fire crew was at work on the vehicle. Samantha parked the ambulance just as the crew breached the door of the crumpled minivan. Samantha and Ed grabbed their trauma bags and approached the wreck.

Ed bent down toward the injured man. "I hear your name is Mike. Mine is Ed. I'm a paramedic. My partner and I are going to take a quick look at you and then get you out of here." Samantha and Ed carefully immobilized Mike's cervical spine and with the help of the fire crew, transferred him to a stretcher. They immediately checked his blood pressure, pulse rate, and blood oxygen content. Samantha placed an oxygen mask over Mike's nose and mouth and watched to verify that he continued to breathe regularly.

After asking Mike if he was alone at the time of the crash, Samantha inspected the vehicle. "Looks like the impact sent him up and over the steering wheel. Guessing from the cracked windshield, he may have a head injury.

The steering column is bent, so I wouldn't rule out thoracic or abdominal injuries either."

Ed agreed. "He's got forehead lacerations, and he's disoriented. Chest seems fine, but his abdominal cavity could be a problem. There is significant bruising across the left lower quadrant and periumbilical regions—probably from the steering wheel. When I palpated his left upper quadrant, it caused him considerable pain." Mike's blood pressure was very low, and his heart rate was very high—both signs of a cardiovascular emergency.

Ed then began a quick physical examination, first checking Mike's pupillary responses for any signs of intracranial pressure and then continuing inferiorly. Ed shared his findings with Samantha. "He's hypotensive and tachycardic. With the pain he reported earlier, signs are pointing to intra-abdominal hemorrhage. We've got to get him to the trauma center right now."

Ed and Samantha depend on their understanding of anatomy and physiology to help their patients and communicate with their partners. Ed suspects that Mike is bleeding internally and that his heart is working hard to compensate for the decrease in blood pressure. As we will see later, Mike's state of internal balance, known as homeostasis, must be restored, or his body systems will fail.

As you study this chapter, CasePoints will give you opportunities to apply your learning to this case.

Visit [thePoint](#) to access the following resources. For guidance in using these resources most effectively, see pp. xv–xvii.



#### Preparing to Learn

- Tips for Effective Studying
- Pre-Quiz



#### While You Are Learning

- Web Figure: Abdominal Regions
- Web Figure: Abdominal Quadrants
- Web Chart: Body Systems
- Web Chart: Directional Terms
- Web Chart: The Metric System
- Web Chart: Abdominal Quadrants
- Animation: Structure-Function
- Animation: Levels of Organization
- Animation: Homeostasis and Negative Feedback
- Animation: Barriers and Gradients
- Chapter Notes Outline
- Audio Pronunciation Glossary



#### When You Are Reviewing

- Answers to Questions for Study and Review
- Health Professions: Health Information Technician
- Interactive Learning Activities

**Ancillaries At-A-Glance** highlights the Learning Resources and Learning Activities available for the chapter.

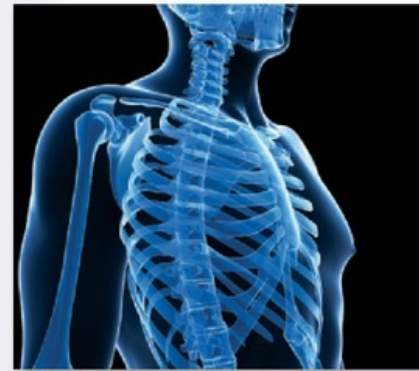


# The Skeletal System: Bones and Joints

## Learning Objectives

After careful study of this chapter, you should be able to:

- 1 List the functions of bones. *p. 100*
- 2 Describe the structure of a long bone. *p. 100*
- 3 Name the three different types of cells in bone, and describe the functions of each. *p. 100*
- 4 Differentiate between compact bone and spongy bone with respect to structure and location. *p. 101*
- 5 Explain how a long bone grows. *p. 103*
- 6 Name and describe nine markings found on bones. *p. 104*
- 7 Name, locate, and describe the bones in the axial skeleton. *p. 105*
- 8 Describe the normal curves of the spine, and explain their purpose. *p. 110*
- 9 Name, locate, and describe the bones in the appendicular skeleton. *p. 111*
- 10 Describe three categories of joints based on degree of movement, and give examples of each. *p. 117*
- 11 Name six types of synovial joints, and demonstrate the movements that occur at each. *p. 119*
- 12 Describe how the skeletal system changes with age. *p. 120*
- 13 Using the case study, discuss how fractures heal. *pp. 99, 121*
- 14 Show how word parts are used to build words related to the skeleton (see Word Anatomy at the end of the chapter). *p. 123*



**Learning Objectives** help you identify learning goals and familiarize yourself with the materials covered in the chapter. These objectives are referenced to page numbers in the text.



## A LOOK BACK

*The skin is introduced in Chapter 4 as one of the epithelial membranes, the cutaneous (ku-TA-ne-us) membrane, overlying a connective tissue membrane, the superficial fascia. In this chapter, we describe the skin in much greater detail as it forms the major portion of the integumentary system. **1** As with all body systems, studying the structure of skin helps us understand its function. The key idea of barriers **4** is particularly relevant to this chapter, because the skin provides the major barrier between the external and internal environments.*

**A Look Back** relates each chapter's content to concepts in the preceding chapters.

## CHECKPOINTS



- 5-1** What is the name of the system that comprises the skin and all its associated structures?
- 5-2** Moving from the superficial to the deeper layer, what are the names of the two layers of the skin?
- 5-3** What is the composition of the subcutaneous layer?

**Chapter Checkpoints** pose brief questions at the end of main sections that test and reinforce student recall.

## CASEPOINTS

- 5-1** Name the skin layers involved in Hazel's burns in the opening case study.
- 5-2** Which skin layer will produce new cells to replace Hazel's damaged epidermis?

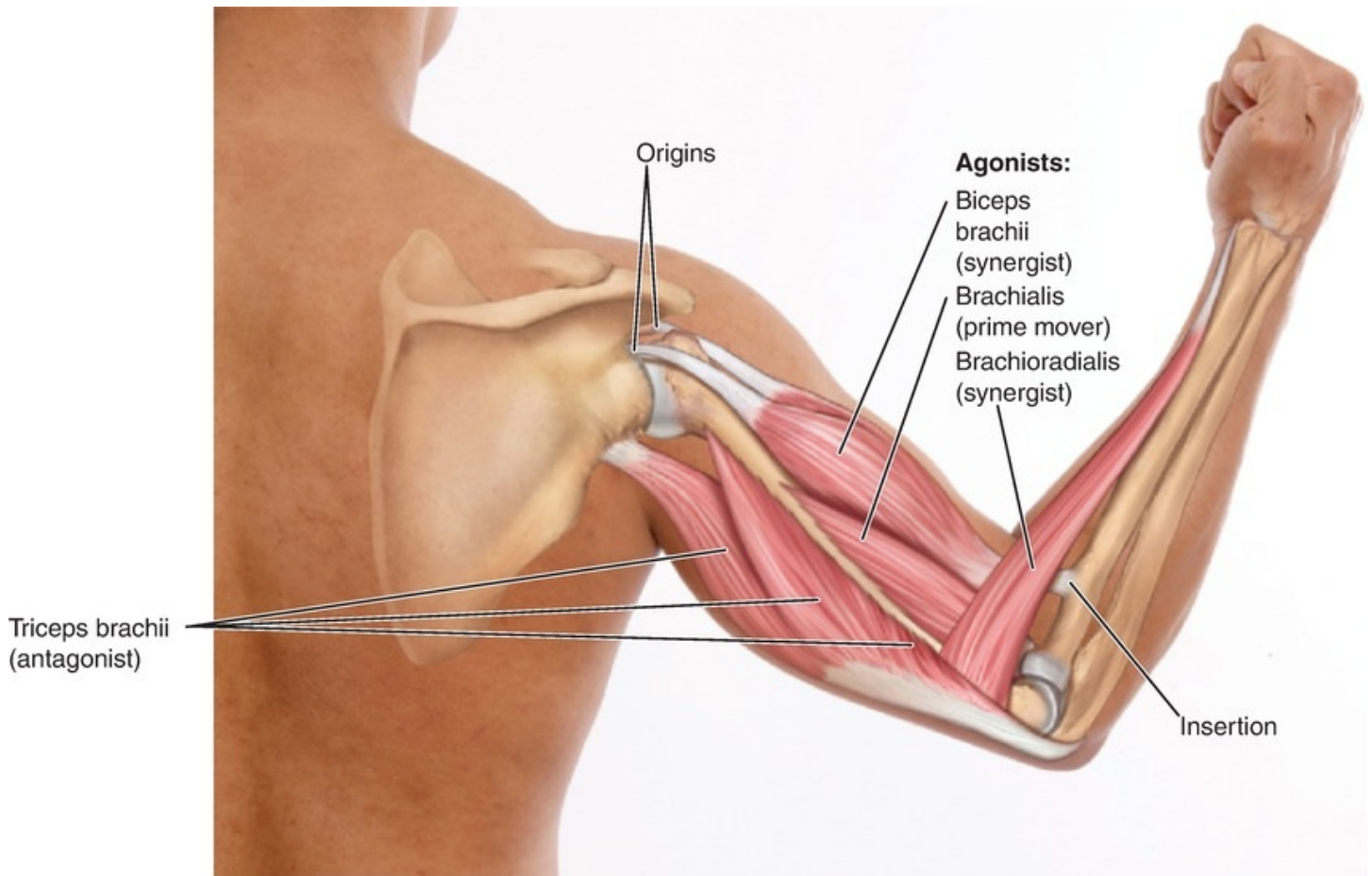
**Case Points** Critical thinking questions challenge students to apply concepts learned to the Disease in Context case study. Answers are in Appendix 2.



### *Concept Mastery Alert*

**Hair loss involves only the shaft and the root (the small bulblike portion of the hair). The hair follicle is firmly anchored within the skin, ready to make a new hair.**

**Concept Mastery Alerts** highlight common student misconceptions to help understanding of potentially confusing topics, as identified by Lippincott's online adaptive learning platform, powered by PrepU. Data from thousands of actual students using this program in courses across the United States have identified common misconceptions that are clarified in this feature.



**FIGURE 7-6 Muscle attachments to bones.** 🔑 **KEY POINT** Tendons attach muscles to bones. The stable point is the origin; the movable point is the insertion. In this diagram, three attachments are shown—two origins and one insertion. 🔍 **ZOOMING IN** Does contraction of the brachialis produce flexion or extension at the elbow?

**New Key Ideas:** The foundational concepts of Anatomy and Physiology are summarized in the Key Idea Table on page i of the textbook. A large numbered key within a chapter indicates where each key idea is introduced, and small numbered keys indicate when a key idea is used to explain a new concept. These key ideas help students organize and deepen their knowledge.

## 12 • COMMUNICATION

The negative feedback key idea **3** introduced the concept of signals conveying information between the different components of the feedback loop. However, signals also function outside such loops. **Communication**—the transmission of signals between cells or even within a single cell—is critical to all aspects of body function, ranging from muscle contraction to the development of an entire individual from a single cell. Defects in communication are responsible for many diseases.

Chapter 1 discussed the two types of signals: electri-

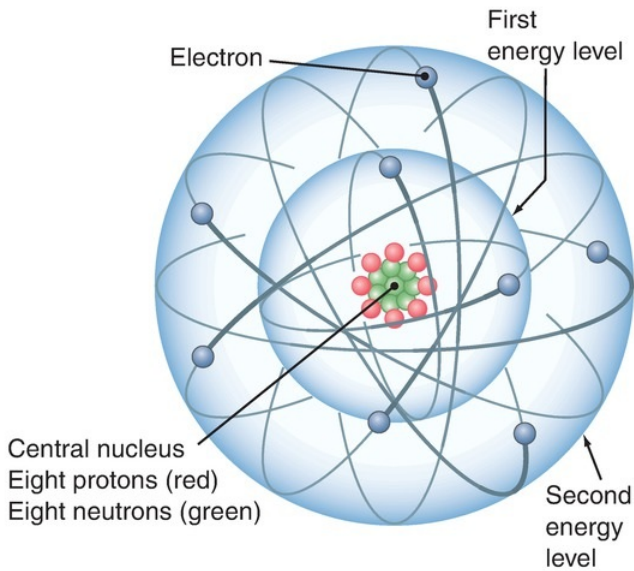
**Key Points** in the figure captions spotlight essential aspects of the illustrations.

**“Zooming In”** questions in the figure captions test and reinforce student understanding of concepts depicted in the illustration.

Two other types of lipids are important in the body. **Phospholipids** (fos-fo-LIP-ids) are complex lipids containing the element phosphorus. Among other functions, phospholipids make up a major part of the membrane around living cells. **Steroids** are lipids that contain rings of carbon atoms. The most important sterol is **cholesterol** (ko-LES-ter-ol), another component of cellular membranes (**see FIG. 2-9B**). Cholesterol is also used to make steroid hormones, including cortisol, testosterone, and estrogen.

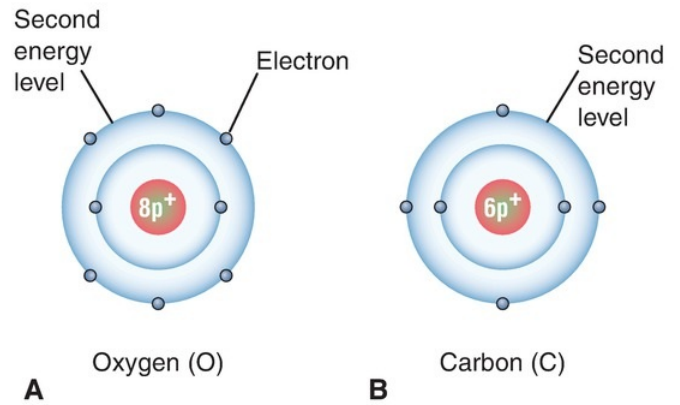
**Phonetic pronunciations** spelled out in the narrative directly following many terms make learning pronunciation easy—no need to understand dictionary-style diacritical marks.

number at the bottom of each box. It takes about 1,850 electrons to equal the weight of a single neutron or proton, so electrons are not counted in the determination of atomic weight.



**FIGURE 2-2 Representation of the oxygen atom.** **KEY POINT** Eight protons and eight neutrons are tightly bound in the central nucleus. The eight electrons are in orbit around the nucleus,

tances from the nucleus in regions called energy levels (see **FIG. 2-2**). The first energy level, the one closest to the nucleus, can hold only two electrons. The second energy level, the next in distance away from the nucleus, can hold up to eight electrons. **FIGURE 2-3A** shows the oxygen atom with only the protons in the nucleus and the electrons in fixed positions in their energy levels. It has two electrons in its first energy level and six electrons in its second, outermost, level. The carbon atom, with an atomic number of 6, has four electrons in its outermost energy level (see **FIG. 2-3B**). More



**FIGURE 2-3 Examples of atoms.** **KEY POINT** The first energy

**Color figure and table callouts** help students quickly find their place after stopping to look at an illustration or table.

Blood cell antigens vary among individuals and become important when blood components are donated from one individual to another in a process called a **transfusion**. Antibodies that recognize red cell antigens are known as *agglutinins*, because they cause red cells to undergo **agglutination** (ah-glu-tih-NA-shun) (clumping). The cells then rupture and release their hemoglobin by a process called **hemolysis** (he-MOL-ih-sis). The resulting condition is dangerous to a patient who has received incompatible blood. There are many types of RBC antigens, but only two groups are particularly likely to cause a transfusion reaction: the so-called A and B antigens and the Rh factor.

## THE ABO BLOOD TYPE SYSTEM

There are four blood types involving the A and B antigens: A, B, AB, and O (TABLE 12-3). These letters indicate the type of antigen present on the red cells. If only the A antigen is present, the person has type A blood; if only the B antigen

a person's blood type. The percentage of people with each of the different blood types varies in different populations. For example, about 45% of the white population of the United States have type O blood, 40% have A, 11% have B, and only 4% have AB. The percentages vary within other population groups.

In an emergency, type O blood can be given to any ABO type because the cells lack both A and B antigens and will not react with either A or B antibodies (see TABLE 12-3). People with type O blood are called *universal donors*. Conversely, type AB blood contains no antibodies to agglutinate red cells, and people with this blood type can therefore receive blood from any ABO type donor. Those with AB blood are described as *universal recipients*. Whenever possible, it is safest to give the same blood type as the recipient's blood.

## THE RH FACTOR

More than 85% of the US population has another red cell antigen group called the **Rh factor**, named for *Rhesus*

Table 12-3 The ABO Blood TYPE System

Blood Type	Red Blood Cell Antigen	Reacts with Antiserum	Plasma Antibodies	Can Take From	Can Donate To
A	A	Anti-A	Anti-B	A, O	A, AB
B	B	Anti-B	Anti-A	B, O	B, AB
AB	A, B	Anti-A, Anti-B	None	AB, A, B, O	AB
O	None	None	Anti-A, Anti-B	O	O, A, B, AB



## A CLOSER LOOK

### Hydrogen Bonds: Strength in Numbers

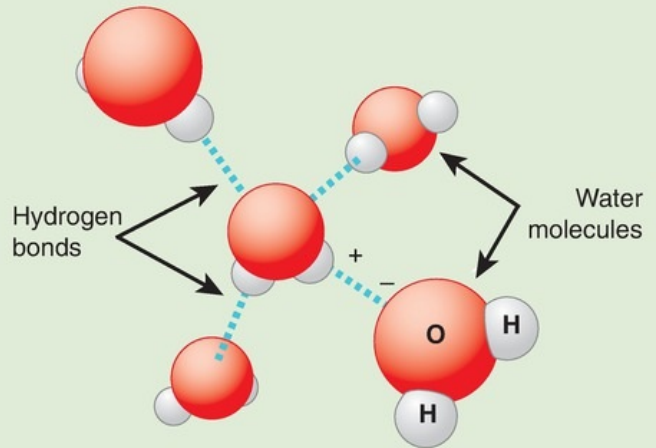
BOX 2-1

In contrast to ionic and covalent bonds, which hold atoms together, hydrogen bonds hold molecules together. Hydrogen bonds are much weaker than ionic or covalent bonds—in fact, they are more like “attractions” between molecules. While ionic and covalent bonds rely on electron transfer or sharing, hydrogen bonds form bridges between two molecules. A hydrogen bond forms when a slightly positive hydrogen atom in one molecule is attracted to a slightly negative atom in another molecule. Even though a single hydrogen bond is weak, many hydrogen bonds between two molecules can be strong.

Hydrogen bonds hold water molecules together, with the slightly positive hydrogen atom in one molecule attracted to a slightly negative oxygen atom in another. Many of water’s unique properties come from its ability to form hydrogen bonds. For example, hydrogen bonds keep water liquid over a wide range of temperatures, which provides a constant environment for body cells.

Hydrogen bonds form not only between molecules but also within large molecules. Hydrogen bonds between regions of the same molecule cause it to fold and coil into a specific shape, as in the process that creates the precise three-

dimensional structure of proteins. Because a protein’s structure determines its function in the body, hydrogen bonds are essential to protein activity.



**Hydrogen bonds.** The bonds shown here are holding water molecules together.

**Special interest boxes** focus on topics that augment chapter content.

**A Closer Look** boxes give in-depth scientific detail on topics in or related to the text.



## CLINICAL PERSPECTIVES

### Anabolic Steroids: Winning at All Costs?

BOX 7-2

Anabolic steroids mimic the effects of the male sex hormone testosterone by promoting metabolism and stimulating growth. These drugs are legally prescribed to promote muscle regeneration and prevent atrophy from disuse after surgery. However, some athletes also purchase them illegally, using them to increase muscle size and strength and improve endurance.

When steroids are used illegally to enhance athletic performance, the doses needed are large enough to cause serious side effects. They increase blood cholesterol levels, which may lead to atherosclerosis, heart disease, kidney failure, and

stroke. They damage the liver, making it more susceptible to cancer and other diseases, and suppress the immune system, increasing the risk of infection and cancer. In men, steroids cause impotence, testicular atrophy, low sperm count, infertility, and the development of female sex characteristics, such as breasts (gynecomastia). In women, steroids disrupt ovulation and menstruation and produce male sex characteristics, such as breast atrophy, enlargement of the clitoris, increased body hair, and deepening of the voice. In both sexes, steroids increase the risk for baldness and, especially in men, cause mood swings, depression, and violence.

**Clinical Perspectives** boxes focus on diseases and disorders relevant to the chapter, exploring what happens to the body when the normal structure–function relationship breaks down.





## HOT TOPICS

BOX 2-3

### Radioactive Tracers: Medicine Goes Nuclear

Like radiography, computed tomography (CT), and magnetic resonance imaging, **nuclear medicine imaging (NMI)** offers a noninvasive way to look inside the body. An excellent diagnostic tool, NMI not only shows structural details but also provides information about body function. NMI can help diagnose cancer, stroke, and heart disease earlier than can techniques that provide only structural information.

NMI uses **radiotracers**, radioactive substances that specific organs absorb. For example, radioactive iodine is used to image the thyroid gland, which absorbs more iodine than does any other organ. After a patient ingests, inhales, or is injected with a radiotracer, a device called a gamma camera detects the radiotracer in the organ under study and produces a picture, which is used in making a diagnosis. Radiotracers are broken down and eliminated through urine or feces, so they leave the body quickly. A patient's exposure

to radiation in NMI is usually considerably lower than with x-ray or CT scan.

Three NMI techniques are positron emission tomography (PET), **bone scanning**, and the **myocardial perfusion imaging (MPI)** stress test. PET is often used to evaluate brain activity by measuring the brain's use of radioactive glucose. PET scans can reveal brain tumors because tumor cells are often more metabolically active than are normal cells and thus absorb more radiotracer. Bone scanning detects radiation from a radiotracer absorbed by bone tissue with an abnormally high metabolic rate, such as a bone tumor. The MPI test is used to diagnose heart disease. A nuclear medicine technologist injects the patient with a radionuclide (e.g., thallium, technetium), and a gamma camera images the heart during exercise and later rest. When compared, the two sets of images help evaluate blood flow to the working, or "stressed," heart.

Hot Topics boxes examine current trends and research.



## ONE STEP AT A TIME

BOX 7-3

### Muscles and Their Movements

Learning the locations of different muscles is the first step to knowing which muscles accomplish which movements. You can use this knowledge for many purposes, from predicting the impact of muscle disorders to optimizing muscle training regimes. This box shows you how to predict muscle actions based on muscle locations and attachments.

#### Question

Shane has particular weakness in his rectus femoris muscle. Predict which movements will be impacted.

#### Answer

**Step 1.** Locate the muscle on your body. The rectus femoris is located on the anterior thigh.

**Step 2.** Identify the bones where the muscle attaches. You can use a skeleton with labeled muscle origins and insertions, the text, later **FIGURE 7-15**, or later **TABLE 7-5**. The rectus femoris attaches to the ilium at one end and the tibia on the other end.

**Step 3.** Use your knowledge of skeletal anatomy to identify any joints that the muscle crosses. Based on the arrangement of bones identified in step 2, the rectus femoris must cross both the hip joint and the knee joint.

**Step 4.** Use your body or a model skeleton to shorten the distance between the origin at the hip and insertion on

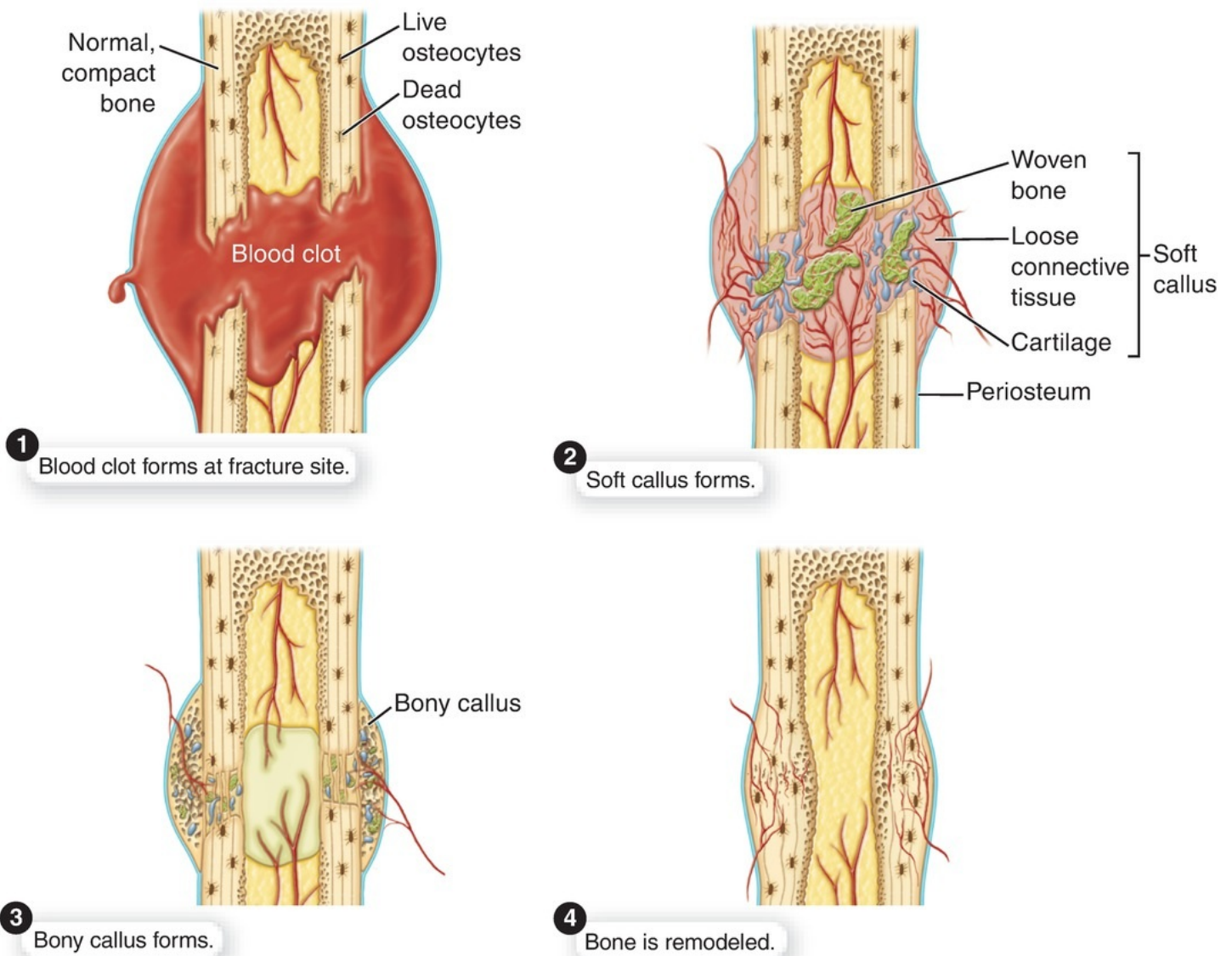
the tibia over the knee. What happens? The rectus femoris most commonly straightens the leg at the knee joint (extension). There might be other possibilities, depending on which bone moves and which bone remains stationary. For instance, this muscle can also act at the hip joint to flex the thigh.

**Step 5.** If you identified more than one possible outcome in step 4, use your body to figure out when the different movements occur. For the rectus femoris, stabilizing the trunk enables this muscle to flex the thigh and extend the leg. Stabilizing both the trunk and the thigh enables the muscle to extend the leg without flexing the thigh.

**Step 6.** Which muscles must relax to permit the movement? Remember that antagonist muscles must relax to enable a given movement. Antagonistic muscles in the limbs are usually found on the opposite side of the limb. So, the antagonist of the rectus femoris is the hamstring muscle group. Relaxing the hamstring as much as possible can optimize the function of the rectus femoris.

You can use a similar procedure to answer Question 26 at the end of this chapter, which asks you to design training regimes to strengthen a patient's shoulder and thigh muscles.

**One Step at a Time** boxes expand on basic science concepts introduced in the case studies by walking students step-by-step through higher level critical thinking activities, such as developing scientific literacy and problem-solving skills.

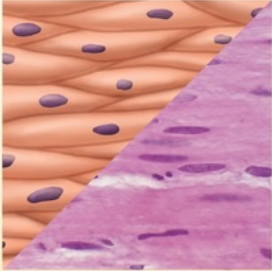
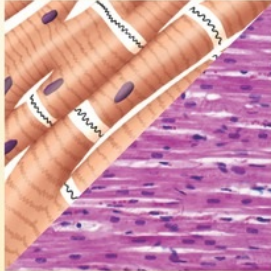
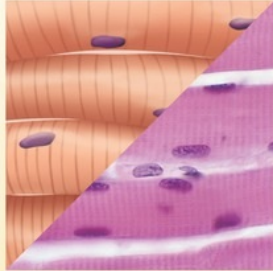


**FIGURE 6-4 Fracture repair.** When bone is fractured, stem cells in the periosteum direct the formation of new bone tissue to repair the injury. **ZOOMING IN** Which forms first—the soft callus or the bony callus?

**Figures:** The art program includes full-color anatomic line art, many new or revised, with a level of detail that matches that of the narrative. Photomicrographs, radiographs, and other scans give students a preview of what they might see in real-world health care settings. Supplementary figures are available on the companion website on .

Table 7-1

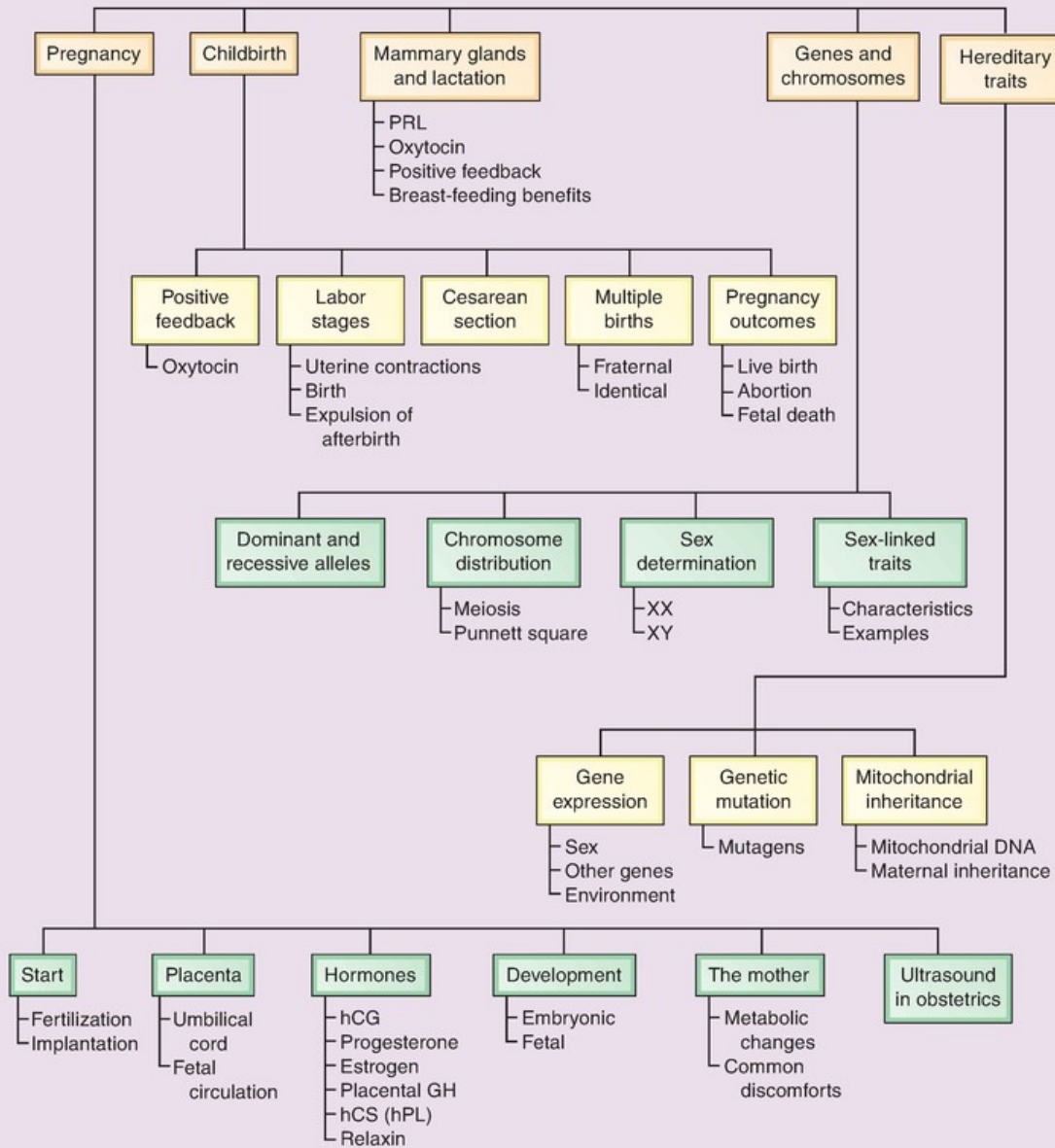
## Comparison of the Different Types of the Muscle

	Smooth	Cardiac	Skeletal
Location	Wall of hollow organs, vessels, respiratory, passageways	Wall of the heart	Attached to bones
Cell characteristics	Tapered at each end, branching networks, nonstriated	Branching networks; special membranes (intercalated disks) between cells; single nucleus; lightly striated	Long and cylindrical; multinucleated; heavily striated
			
Control	Involuntary	Involuntary	Voluntary
Action	Produces peristalsis; contracts and relaxes slowly; may sustain contraction	Pumps blood out of the heart; self-excitatory but influenced by nervous system and hormones	Produces movement at joints; stimulated by nervous system; contracts and relaxes rapidly

**Tables:** The numerous tables in this edition summarize key concepts and information in an easy-to-review form. Additional summary tables are available on the companion website on .

## OVERVIEW

A detailed chapter outline with space for note taking is on [thePoint](#). The figure below illustrates the main topics covered in this chapter.



## KEY TERMS

The terms listed below are emphasized in this chapter. Knowing them will help you organize and prioritize your learning. These and other boldface terms are defined in the Glossary with phonetic pronunciations.

abortion	embryo	homozygous	parturition
allele	familial	human chorionic	phenotype
amniotic sac	fertilization	gonadotropin (hCG)	placenta
autosome	fetus	implantation	progeny
carrier	gene	lactation	recessive
chorion	genetic	meiosis	relaxin
chromosome	genotype	mutagen	sex-linked
colostrum	gestation	mutation	trait
decidua	heredity	obstetrics	umbilical cord
dominant	heterozygous	oxytocin	zygote

## WORD ANATOMY

Medical terms are built from standardized word parts (prefixes, roots, and suffixes). Learning the meanings of these parts can help you remember words and interpret unfamiliar terms.

WORD PART	MEANING	EXAMPLE
<b>PREGNANCY</b>		
chori/o	membrane, chorion	Human <i>chorionic</i> gonadotropin is produced by the chorion (outermost cells) of the embryo.
zyg/o	joined	An ovum and spermatozoon join to form a <i>zygote</i> .
<b>CHILDBIRTH</b>		
ox/y	sharp, acute	<i>Oxytocin</i> is the hormone that stimulates labor.
roc/o	labor	See preceding example.
<b>THE MAMMARY GLANDS AND LACTATION</b>		
lact/o	milk	The <i>lactiferous</i> ducts carry milk from the mammary glands.
mamm/o	breast, mammary gland	A <i>mammogram</i> is radiographic study of the breast.
<b>GENES AND CHROMOSOMES</b>		
aut/o-	self	<i>Autosomes</i> are all the chromosomes aside from the two that determine sex.
chrom/o	color	<i>Chromosomes</i> color darkly with stains.
heter/o	other, different	<i>Heterozygous</i> paired genes (alleles) are different from each other.
homo-	same	<i>Homozygous</i> paired genes (alleles) are the same.
phen/o	to show	Traits that can be observed or tested for making up a person's <i>phenotype</i> .
<b>HEREDITARY TRAITS</b>		
multi-	many	<i>Multifactorial</i> traits are determined by multiple pairs of genes.

## QUESTIONS FOR STUDY AND REVIEW

### BUILDING UNDERSTANDING

#### Fill in the Blanks

- Following ovulation, the mature follicle becomes the \_\_\_\_\_.
- The first mammary gland secretion is called \_\_\_\_\_.
- The basic unit of heredity is a(n) \_\_\_\_\_.
- Chromosomes not involved in sex determination are known as \_\_\_\_\_.
- The number of chromosomes in each human body cell is \_\_\_\_\_.

**Key Terms** sections provide a concise list of selected boldface terms used in the chapter and defined in the book's glossary.

**Word Anatomy** tables define and illustrate the various word parts that constitute the chapter's specialized terminology, helping to build vocabulary and promote understanding of unfamiliar terms.

**Questions for Study and Review** sections organize study questions hierarchically into three levels.

**Building Understanding:** Includes fill-in-the-blank, matching, and multiple choice questions that test factual recall.

**Understanding Concepts:** Includes short-answer questions (define, describe, compare/contrast) that test and reinforce understanding of ideas. This section now includes questions pertaining to “The Body Visible” and the diverse information in the appendices.

**Conceptual Thinking:** Includes short-essay questions that promote critical thinking skills. This section includes thought questions related to the A & P in Action case stories.

#### UNDERSTANDING CONCEPTS

17. What do you study in anatomy? In physiology? Would it be wise to study one without the other?
18. List in sequence the levels of organization in the body from simplest to most complex. Give an example for each level.
19. Compare and contrast the anatomy and physiology of the nervous system with that of the endocrine system.
20. In order of action, name the components of a negative feedback loop.
21. Use The Body Visible overlays at the beginning of this book to name the lateral bone of the lower leg. Name the proximal bone of the arm.
22. Referring to the Dissection Atlas in Appendix 3:
  - a. list the figure(s) in which an organ is cut into left and right parts.
  - b. list the figure(s) in which an organ is cut into anterior and posterior parts.

#### CONCEPTUAL THINKING

23. The human body is organized from very simple levels to more complex levels. With this in mind, describe why a disease at the chemical level can have an effect on organ system function.
24. Use a car operating under cruise control as an example of a negative feedback loop, identifying the set point and the components of the system.
25. In Mike's case, the paramedics discovered bruising of the skin over Mike's left lumbar region and umbilical region. Mike also reported considerable pain in his upper left quadrant. Locate these regions on your own body. Why is it important for health professionals to use medical terminology when describing the human body?
26. If a child swallows a marble, does the marble actually get inside his body? Explain.
27. In Mike's case, blood is flowing out of the blood vessels in his abdomen into his abdominal cavity.
  - A. What sort of gradient is driving the flow?
  - B. What do you think changed in Mike's case that enabled this flow to occur: the gradient or the resistance?

For more questions, see the Learning Activities on **thePoint**.

24. Referring to the “Dissection Atlas” **FIGURE A3-1**, name the:
- feature that separates the frontal from the parietal lobe
  - feature that separates the frontal from the temporal lobe
  - raised surface area anterior to the central sulcus
25. Referring to the “Dissection Atlas” **FIGURE A3-2**, name:
- area(s) where cerebrospinal fluid is made
  - the area superior to the corpus callosum

**Dissection Atlas Questions** ask students to respond by examining actual anatomic dissection photographs.



## Getting Started with the Student Resources

Your journey begins with your textbook, *Memmler’s Structure and Function of the Human Body*, 12th edition. The textbook has callouts that guide you to resources and activities to enhance your learning experience.

Look for these callouts throughout the book for pertinent supplementary material on the companion website.

Here’s how to begin:

- Scratch off the personal access code inside the front cover of your textbook.
- Log on to <http://thepoint.lww.com/MemmlerSFHB12e>, the companion website for *Memmler’s Structure and Function of the Human Body*, 12th edition, on .
- Click on “Student Resources” and explore the wide variety of learning activities.

**RESOURCES AND ACTIVITIES AVAILABLE TO**

# INSTRUCTORS INCLUDE THE FOLLOWING:

Instructor's Manual

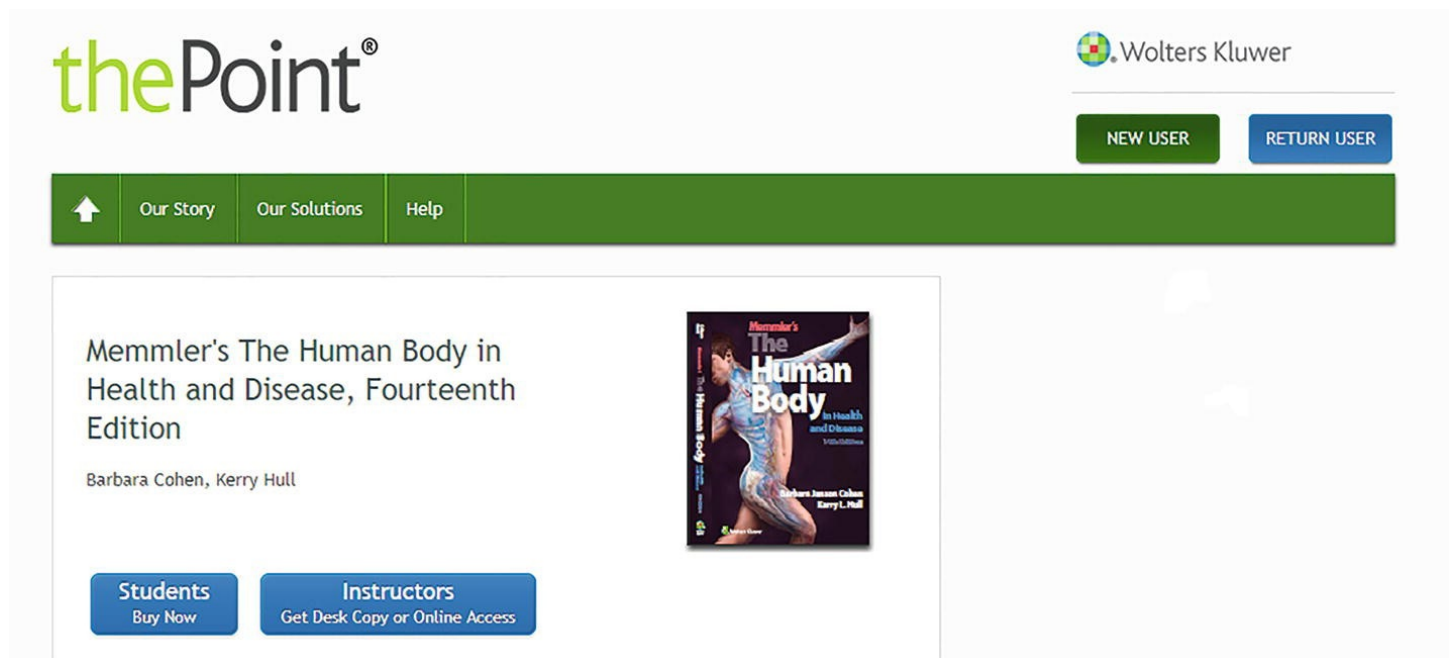
PowerPoints

Image Bank

Answer Key

Customizable Test Generator

WebCT, Angel, and Blackboard-Ready Cartridges



The screenshot shows the website for Memmler's *The Human Body in Health and Disease, Fourteenth Edition*. The page features the 'thePoint' logo in green and black, and the Wolters Kluwer logo in the top right corner. Below the logos are two buttons: 'NEW USER' (green) and 'RETURN USER' (blue). A green navigation bar contains a home icon and links for 'Our Story', 'Our Solutions', and 'Help'. The main content area displays the book title, authors (Barbara Cohen, Kerry Hull), and a book cover image. At the bottom, there are two blue buttons: 'Students Buy Now' and 'Instructors Get Desk Copy or Online Access'.

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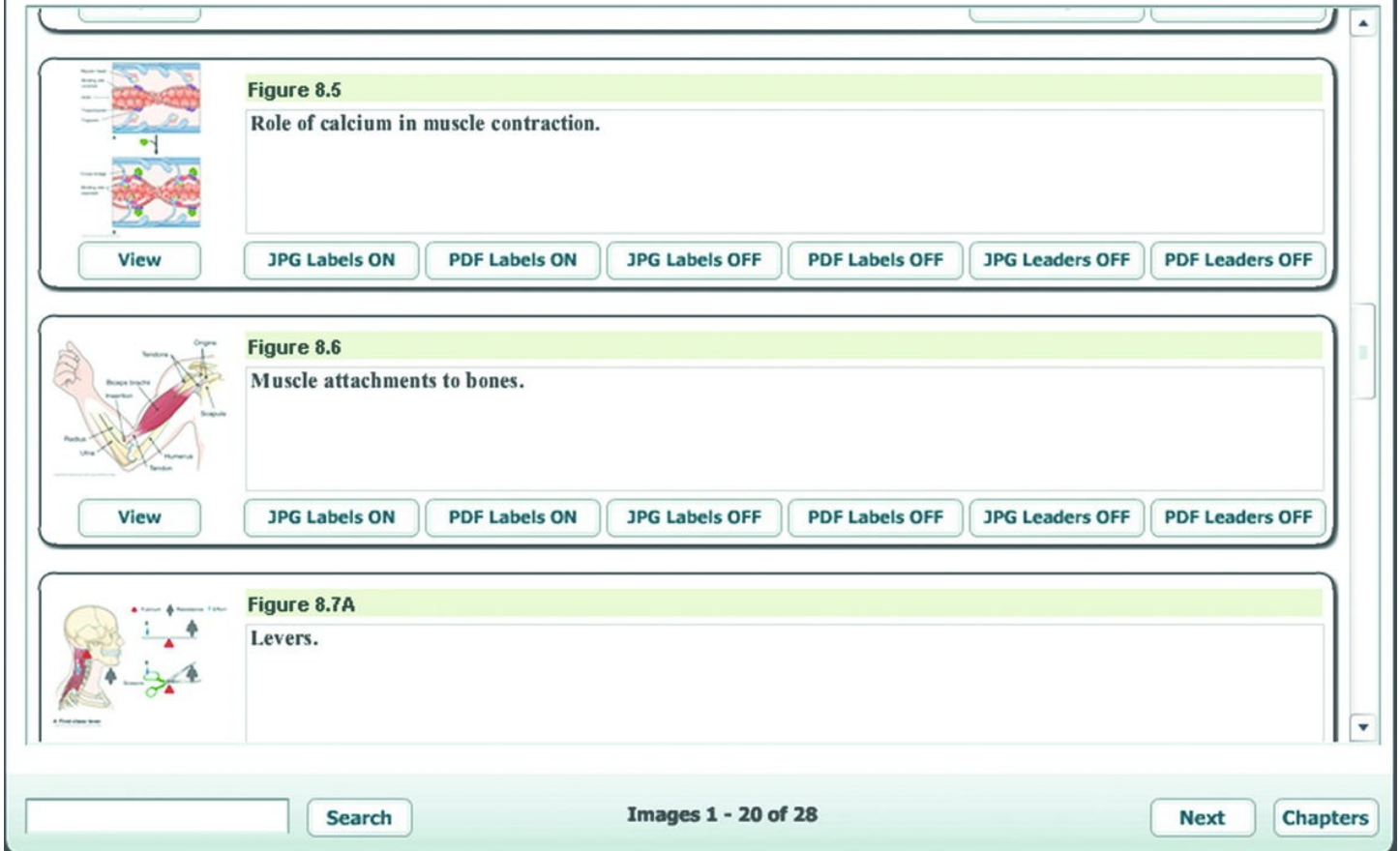
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# Memmler's The Human Body in Health and Disease, Thirteenth Edition



**Figure 8.5**  
Role of calcium in muscle contraction.

**Figure 8.6**  
Muscle attachments to bones.

**Figure 8.7A**  
Levers.

Search Images 1 - 20 of 28 Next Chapters

## RESOURCES AND ACTIVITIES AVAILABLE TO STUDENTS INCLUDE THE FOLLOWING:

Pre-Quiz

True or False?

Key Terms Categories

Fill-in-the-Blank

Crossword Puzzle

Audio Flash Cards

Word Anatomy

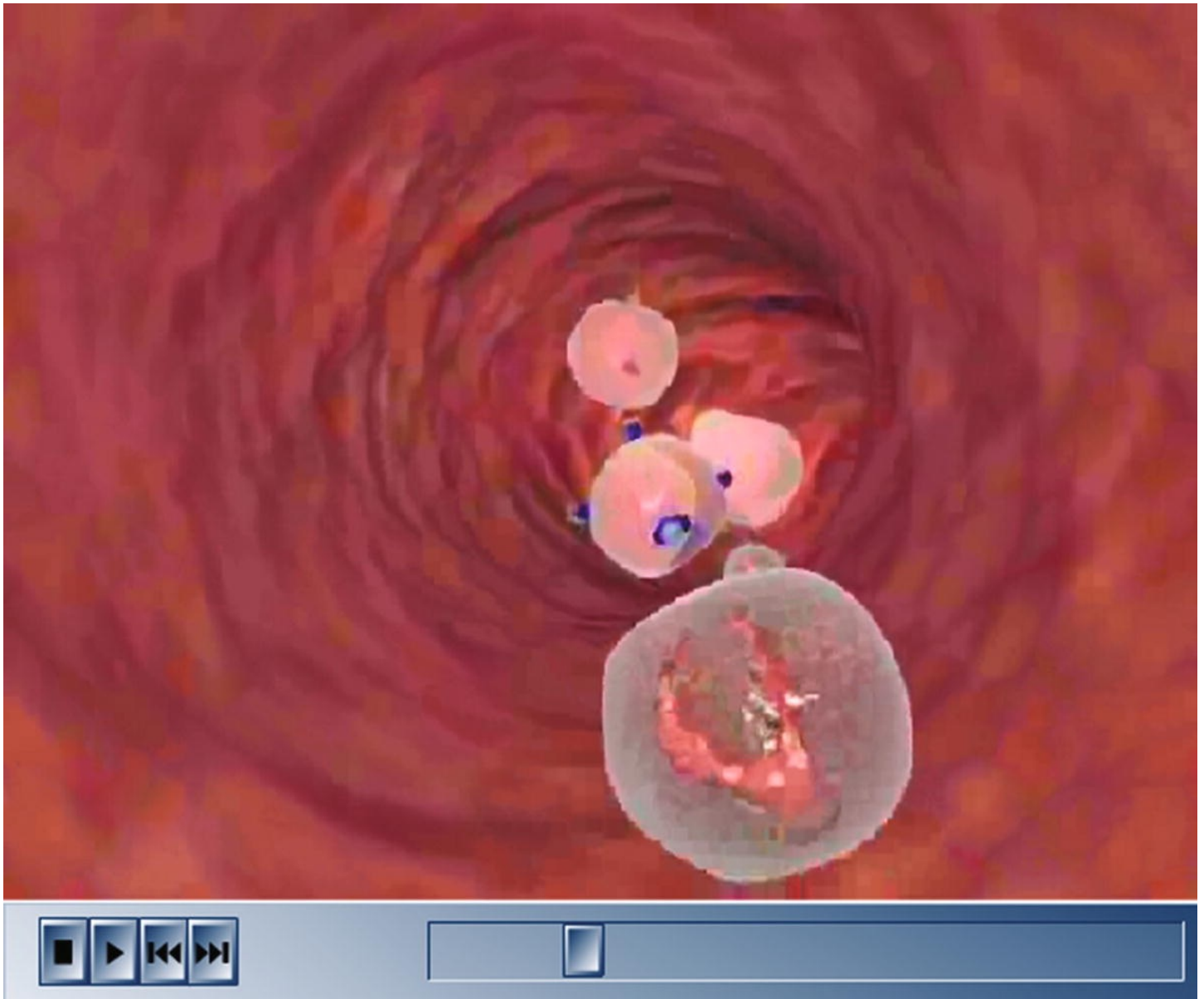
Supplemental Images

Audio Pronunciation Glossary

Health Professions Career Information

# PrepU: An Integrated Adaptive Learning Solution

**PrepU**, Lippincott's adaptive learning system, is an integral component of *Memmler's Structure and Function of the Human Body*.



PrepU uses repetitive and adaptive quizzing to build mastery of A & P concepts, helping students to learn more while giving instructors the data they need to monitor each student's progress, strengths, and weaknesses. The hundreds of questions in PrepU offer students the

chance to drill themselves on A & P and support their review and retention of the information they have learned. Each question provides not only an explanation for the correct answer but also references of the text page for the student to review the source material. PrepU for *Memmler's Structure and Function of the Human Body* challenges students with questions and activities that coincide with the materials they have learned in the text and gives students a proven tool to learn A & P more effectively. For instructors, PrepU provides tools to identify areas and topics of student misconception; instructors can use this rich course data to assess students' learning and better target their in-class activities and discussions, while collecting data that are useful for accreditation.

# PrepU

**A learning experience individualized to each student.** Being an adaptive learning engine, PrepU offers questions customized for each student's level of understanding, challenging students at an appropriate pace and difficulty level, while dispelling common misconceptions. As students review and master PrepU's questions, the system automatically increases the difficulty of questions, effectively driving student understanding of A & P to a mastery level. PrepU not only helps students to improve their knowledge but also helps foster their test-taking confidence.

***PrepU works!*** PrepU works, and not just because we say so. PrepU efficacy is *backed by data*:

1. In an introductory nursing course at Central Carolina Technical College, student course outcomes were positively associated with PrepU usage. The students who answered the most PrepU questions in the class also had the best overall course grades.
2. In a randomized, controlled study at UCLA, students using PrepU (for biology) achieved 62% higher learning gains than those who did not.

To see a video explanation of PrepU, go to [http://download.lww.com/wolterskluwer\\_vitalstream\\_com/mktg/prepuvid/prepupromo01.htm](http://download.lww.com/wolterskluwer_vitalstream_com/mktg/prepuvid/prepupromo01.htm)

# STUDY GUIDE FOR MEMMLER'S STRUCTURE AND FUNCTION OF THE HUMAN BODY, 12TH EDITION

Kerry L. Hull, BSc, PhD

Along with the companion website on *thePoint*, this *Study Guide* is the ideal companion to the 12th edition of *Memmler's Structure and Function of the Human Body*. Following the text's organization chapter by chapter, the *Study Guide* provides a full range of self-study aids that actively engage students in learning and enable them to assess and build their knowledge as they advance through the text. Most importantly, the *Study Guide* allows students to get the most out of their study time, with a variety of exercises that meet the needs of all types of learners.

○

Class Performance

Assignment Results

Student Usage

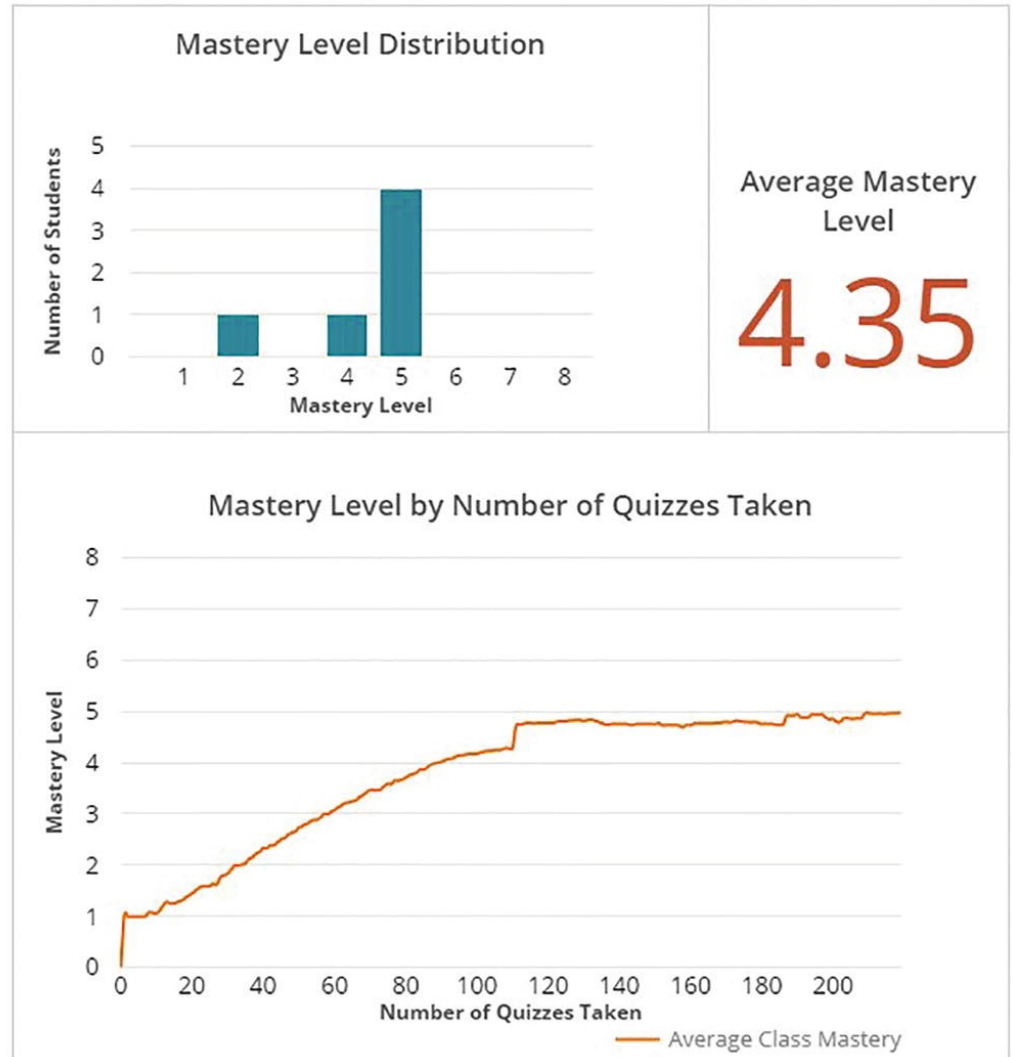
Strengths & Weaknesses

Overall Usage

Specific Misconceptions

○

## Class Performance



INSIDE THE STUDY GUIDE YOU'LL FIND THE

## **FOLLOWING:**

- Chapter Overview summarizes the chapter's critical concepts.
- Addressing the Learning Objectives includes labeling, coloring, matching, and short-answer questions, all designed to foster active learning.
- Making the Connections integrates information from each chapter's learning objectives into concept mapping exercises.
- Testing Your Knowledge provides multiple choice, true/false, completion, short-answer, and essay questions to identify areas requiring further study. Practical Applications questions use clinical situations to test your understanding of a subject.
- Expanding Your Horizons helps students learn from the world around them and highlights emerging issues and discoveries in the health professions.

Visit [www.lww.com](http://www.lww.com), and reference

ISBN 978-1-9751-3894-3 to order your copy of this important resource.

# Acknowledgments

It has been a continuing pleasure to work with Kerry Hull for this 12th edition of *Memmler's Structure and Function of the Human Body*. With her extensive scientific knowledge, familiarity with current pedagogic theory, and teaching experience, Kerry has added immeasurably to this text. She has also coauthored the Study Guide and prepared the Instructor's Manual. I could not have a better coworker or someone more trusted to carry on the traditions of this fine text.

The skilled staff at Wolters Kluwer, as always, has been instrumental in the development of these texts. Consistently striving for improvements and high quality, they have helped achieve the great success of these books over their long history. Thanks to the reviewers, listed separately, who made valuable comments on the text. Their suggestions and insights formed the basis for this revision.

As always, thanks to my husband, Matthew, an instructor in anatomy and physiology, who not only gives consistent support but also contributes advice and suggestions for the text.

**—Barbara Janson Cohen**

My greatest thanks go to Barbara Cohen. I have enormous respect for her writing skills, deep knowledge base, flexible outlook, and tireless attention to detail. It has been a pleasure and an honor to work with Barbara for the past 15 years, and I hope that our collaboration can continue for many more.

I echo Barbara in her thanks to Marthe Adler, Jay Campbell, Jonathan Joyce, John Larkin, Jennifer Clements, and Staci Wolfson, whose creativity and flexibility enabled us to produce the best book and learning package possible. My thanks also go out to the reviewers for their expertise and careful proofreading.

And, finally, my heartfelt thanks to my husband, Norman, and to my children, Evan and Lauren, for their constant encouragement and support.

**—Kerry L. Hull**

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# The Body Visible

*The Body Visible* is a unique study tool designed to enhance your learning of the body's systems in this course and in your future work.

*The Body Visible* illustrates the systems discussed in the text in the same sequence in which they appear in the text. Each full-color detailed illustration also contains numbers and lines for identifying the structures in the illustration. A transparent overlay with labels for all of the numbered structures in the art accompanies each image.

With the labels in place, *The Body Visible* allows you to study each illustration and helps you learn the body's structures. When you view each system without the overlay in place, *The Body Visible* becomes a self-testing resource. As you test your knowledge and identify each numbered part, you can easily check your answers with the overlay.

Many of the images in *The Body Visible* have somewhat more detail than is covered in the text. We encourage you to keep *The Body Visible* available as a general reference and as a useful study tool as you progress to more advanced levels in your chosen healthcare career.

*The Body Visible*\* begins on the next page.

\*The images in *The Body Visible* are adapted with permission from Anatomical Chart Company, *Rapid Review: A Guide for Self-Testing and Memorization*, 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2010.

# UNIT I

## **The Body as a Whole**

- 1 Organization of the Human Body
- 2 Chemistry, Matter, and Life
- 3 Cells and Their Functions
- 4 Tissues, Glands, and Membranes
- 5 The Integumentary System

# CHAPTER 1

## Organization of the Human Body

### Learning Objectives

After careful study of this chapter, you should be able to:

1. Define the terms *anatomy* and *physiology*. p. 4
2. Describe the organization of the body from chemicals to the whole organism. p. 4
3. List 11 body systems, and give the general function of each. p. 4
4. Define and give examples of homeostasis. p. 5
5. Using examples, discuss the components of a negative feedback loop. p. 6
6. Explain the importance of barriers in the body, and give several examples of barriers. p. 7
7. Define a gradient, and explain the effect of resistance on flow down a gradient. p. 8
8. List and define the main directional terms for the body. p. 9
9. List and define the three planes of division of the body. p. 10
10. Name the subdivisions of the dorsal and ventral cavities. p. 12
11. Name and locate the subdivisions of the abdomen. p. 13
12. Cite some anterior and posterior body regions along with their common names. p. 14
13. Find examples of anatomic and physiologic terms in the case study. pp. 3, 15
14. Show how word parts are used to build words related to the body's organization (see Word Anatomy at the end of the chapter). p. 17

### A & P in Action

### Mike's Case: Emergency Care and Possible System Failure