Hole’s
ESSENTIALS OF
HUMAN
ANATOMY &
PHYSIOLOGY

eleventh edition

Reinforced Binding

What does it mean?

Since high schools frequently adopt textbooks for several years, durability is important. To ensure that this textbook can withstand the wear and tear of usage by multiple students, McGraw-Hill has elected to manufacture this textbook in compliance with the “Manufacturing Standards and Specifications for Textbook Administrators” (MSST) published by the National Association of State Textbook Administrators (NASTA). The MSST manufacturing guidelines provide minimum standards for the binding, paper type, and other physical characteristics of a text with the goal of making it more durable.
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About the Authors

David Shier

David Shier has more than thirty years of experience teaching anatomy and physiology, primarily to premedical, nursing, dental, and allied health students. He has effectively incorporated his extensive teaching experience into another student-friendly revision of Hole’s Essentials of Human Anatomy and Physiology and Hole’s Human Anatomy and Physiology. David has published in the areas of renal and cardiovascular physiology, the endocrinology of fluid and electrolyte balance, and hypertension. A faculty member in the Life Science Department at Washtenaw Community College, he is actively involved in a number of projects dealing with assessment, articulation, and the incorporation of technology into instructional design. David holds a Ph.D. in physiology from the University of Michigan.

Jackie Butler

Jackie Butler’s professional background includes work at the University of Texas Health Science Center conducting research about the genetics of bilateral retinoblastoma. She later worked at Houston’s M. D. Anderson Hospital investigating remission in leukemia patients. A popular educator for more than twenty-five years at Grayson County College, Jackie teaches microbiology and human anatomy and physiology for health science majors. Her experience and work with students of various educational backgrounds have contributed significantly to another revision of Hole’s Essentials of Human Anatomy and Physiology and Hole’s Human Anatomy and Physiology. Jackie Butler received her B.S. and M.S. degrees from Texas A&M University, focusing on microbiology, including courses in immunology and epidemiology.

Ricki Lewis

Ricki Lewis’s career communicating science began with earning a Ph.D. in genetics from Indiana University in 1980. It quickly blossomed into writing for newspapers and magazines, and writing the introductory textbook Life. Since then she has taught a variety of life science courses and published the textbook Human Genetics: Concepts and Applications, an essay collection, and a novel about stem cells. Since 1984 Ricki has been a genetic counselor for a large ob/gyn practice. She is active with the American Society of Human Genetics, and teaches an online course in “Genethics” at Albany Medical College.

A Note from the Authors

To the Student

Welcome! As you read this (with your eyes) and understand it (with your brain), perhaps turning to the next page (with muscle actions of your fingers, hand, foreararm, and arm), you are using the human body to do so. In this eleventh edition of Hole’s Essentials of Human Anatomy and Physiology, our goal is to provide you with an interesting and readable introduction to how all of this works! It is not simple, and there are times when it may not seem easy, but it is always fascinating, and understanding how your body works can be fun!

Many of you are on a path toward a career in health care, athletics, science, or education. We understand that many of you face the challenges of balancing family, work, and academics. Always remember that your course is not so much a hurdle along your way as it is a stepping stone. We have written this book to help you succeed in your coursework and to help prepare you to make that journey.

To the Teacher

We are authors, but first and foremost we are teachers, active in the classroom. What we and our reviewers do in class is reflected in this new edition. Students have always come first in our approach to teaching and textbook authoring, but we now feel more excited than ever about the student-oriented, teacher-friendly quality of this text.

Along with updated versions of the extra resources that students and teachers alike have found so helpful over the years (Anatomy and Physiology Revealed®, text websites, and so on), we are especially pleased to present the new Learn, Practice, Assess approach. Each chapter opens with Learning Outcomes, contains many opportunities to Practice throughout, and closes with Assessments that are closely tied to the learning outcomes. Students can use this new feature not only to focus their study efforts, but also to take an active role in monitoring their own progress toward mastering the material. All of these resources are described in more detail in the Chapter Preview beginning on page xviii.

David Shier, Jackie Butler, Ricki Lewis
New to this Edition

Global Changes

- End-of-chapter Integrative Assessments/Critical Thinking questions include reference to previous chapters.
- Practice Questions are added to the legends of selected figures.
- Clinical Terms are on the book website.
- Complex figures include the legend content in the artwork, paralleling the text.
- Many new vignettes and small boxes.
- All boxed material updated, with a more clinical focus.

Specific Changes At-a-Glance

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<td>Head cavities (fig. 1.9)</td>
<td>Improved depth</td>
<td>Accuracy</td>
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<td>1</td>
<td>Directional terms (fig. 1.13)</td>
<td>Rewritten</td>
<td>Clarity</td>
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<tr>
<td>1</td>
<td>Anatomical terms (fig. 1.14)</td>
<td>Rewritten</td>
<td>Clarity, consistency</td>
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<tr>
<td>1</td>
<td>Anatomical terms</td>
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<td>Clarity, consistency</td>
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<td>2</td>
<td>Matter and mass</td>
<td>Rewritten</td>
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<td>2</td>
<td>Ionically-bonded substances</td>
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<td>3</td>
<td>Reprogrammed cells</td>
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<td>3</td>
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<td>Fate of pyruvic acid</td>
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<td>Catabolism of macronutrients (fig. 4.9)</td>
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<td>DNA replication (fig 4.11)</td>
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<td>Accuracy, detail</td>
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<td>5</td>
<td>Tissues (figs. 5.1c, d; 5.2; 5.3; 5.4; 5.5; 5.6; 5.7; 5.13; 5.14; 5.15; 5.16; 5.17; 5.18; 5.19; 5.20; 5.21; 5.22; 5.23; 5.24)</td>
<td>Many new micrographs and corresponding line art</td>
<td>Clarity, an attempt to more closely resemble the microscope slides the students will be observing in lab</td>
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<tr>
<td>5</td>
<td>Extracellular matrix Clinical Application</td>
<td>Rewritten, new figure</td>
<td>Update, more clinical approach</td>
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<td>Itching</td>
<td>New vignette</td>
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<td>Skin (figs. 6.1; 6.2; 6.5; 6.7)</td>
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<td>6</td>
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<td>Burns</td>
<td>Rule of nines added to Clinical Application</td>
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<td>Skeletal system (figs. 7.1; 7.9; 7.38; 7.39; 7.40)</td>
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<td>Nerve impulse, nerve tract, axons, fibers, nerve fibers</td>
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<td>Factor V Leiden replaces ITP, which is not genetic; also includes coagulation disorders</td>
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<td>12</td>
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<td>Fig. 13.11 redrawn</td>
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<td>Varicose veins</td>
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<td>Figs. 13.33 and 13.35 redone</td>
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<td>14</td>
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<td>Thymus and spleen</td>
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<td>14</td>
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<td>Fig. 14.13 redone and corresponding text rewritten</td>
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<td>Agglutination and neutralization added</td>
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<td>14</td>
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<td>Graphs in fig. 14.16 separated</td>
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<td>Gut microbiome</td>
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<td>Movements in alimentary canal (fig. 15.4), mouth (fig. 15.6), skull (fig. 15.7), salivary glands (fig. 15.10) and stomach (fig. 15.11)</td>
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<td>16</td>
<td>Mechanics of inspiration</td>
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<td>Spirometry</td>
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<td>16</td>
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<td>17</td>
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<td>Location, new fig. 17.7</td>
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<td>17</td>
<td>Afferent and efferent arterioles</td>
<td>Anatomical differences moved to part on glomerular filtration</td>
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<td>Consistency</td>
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<td>Water intoxication</td>
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<td>Spermatogonia and sperm</td>
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<td>Prostate cancer</td>
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<td>Uterus</td>
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<td>Breast cancer</td>
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<td>Contraceptives</td>
<td>Fig. 19.15 redone</td>
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<td>Sexually transmitted diseases</td>
<td>Changed to sexually transmitted infections</td>
<td>Update, accuracy</td>
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<td>Postmortem sperm retrieval</td>
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<td>Added to discussion, new orange box</td>
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<td>Clinical Application 20.2 rewritten</td>
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<td>New</td>
<td>Students need help making conversations to/from metric measurements.</td>
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<td>Figure Questions Answers</td>
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<td>Provides answers to the new figure questions</td>
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Assessments and Integrative Assessments/Critical Thinking questions found at the end of each chapter.

Learning Outcomes open chapters, and are closely linked to Chapter Assessments and Integrative Assessments/Critical Thinking questions found at the end of each chapter.

Check out the Chapter Preview, Foundations for Success, on page xviii. The Chapter Preview was specifically designed to help you LEARN how to study. It provides helpful study tips.

NEW! for this edition is a section on learning styles!

- **Vignettes** lead into chapter content. They connect you to many areas of health care including technology, physiology, medical conditions, historical perspectives, and careers.

NEW! **Anatomy and Physiology Revealed (APR)** icon at the beginning of each chapter tells you which system in APR applies to this chapter.

**Aids to Understanding Words** help you remember scientific word meanings. Examine root words, stems, prefixes, suffixes, pronunciations, and build a solid anatomy and physiology vocabulary.

**Reference Plates** offer vibrant detail of body structures.

Learning tools to help you succeed...
Practice

with a question or series of questions after major sections. They will test your understanding of the material.

Interesting applications help you practice and apply their knowledge…

Boxed information applies ideas and facts in the narrative to clinical situations.

NEW! Clinical Applications present disorders, physiological responses to environmental factors, and other topics of general interest.

Genetics Connections explore the molecular underpinnings of familiar as well as not so familiar illnesses. Read about such topics as ion channel disorders, muscular dystrophy, and cystic fibrosis.

Facts of Life provides interesting bits of anatomy and physiology information, adding a touch of wonder to chapter topics.

Clinical Application 10.1
Synesthesia: Connected Senses

A series of inherited disorders affect muscle tissue. These disorders differ in the nature of the genetic defect, the type of protein that is abnormal in form or function, and the particular muscles in the body that are impaired.

The Muscular Dystrophies—Missing Proteins

A muscle cell is packed with filaments of actin and myosin that interact to create tension in the cell. If the genetic defect affects either actin or myosin, the cell membrane is disrupted and the cell dies. Duchenne muscular dystrophy (DMD), in the most severe type of the disease (fig. 10.10), affects only boys. In other forms of muscular dystrophy, the muscle fibers weaken and degenerate, eventually failing and causing tissue replacement.

Cardiomyopathy—A Tiny Glitch

Charcot-Marie-Tooth disease (CMT) is a hereditary disease that causes a slowly progressive weakness or atrophy of the muscles of the hands and feet and a decrease in tendon reflexes. In CMT, as some nerve axons degenerate, muscle fibers no longer receive nerve impulses, and the affected muscle begins to waste away. Duchenne muscular dystrophy (DMD), however, is often mistaken for muscular dystrophy (MD) because the types of symptoms begin at early childhood, are less severe, and result from an underproduction of proteins. Duchenne muscular dystrophy (DMD), in the most severe type of the disease (fig. 10.10), affects only boys. CMT is also possible to see for the gene mutation that causes a muscle weakness called Charcot-Marie-Tooth disease (CMT). Duchenne muscular dystrophy (DMD) is also possible to see for the gene mutation that causes a muscle weakness called Charcot-Marie-Tooth disease (CMT). However, the difference is that in DMD, the muscle fibers are more severely affected, and in CMT, the muscles are affected primarily in the legs.
**Chapter Assessments** check your understanding of the chapter’s learning outcomes.

**Integrative Assessments/Critical Thinking questions** allow you to connect and apply information from previous chapters as well as information within the current chapter.

**Chapter Summary Outlines** help you review the chapter’s main ideas.
**Book Website – www.glencoe.com/shier11**

NEW! for the eleventh edition is the Ancillary Correlation Guide—teachers will find this guide invaluable. McGraw-Hill offers a variety of ancillary products to accompany our texts. The authors have gone through the ancillaries and correlated them to the specific Learning Outcome found at the beginning of each chapter! Here are the ancillaries that are correlated to the specific Learning Outcomes for *Hole’s Essentials of Human Anatomy & Physiology*, Eleventh Edition:

- Textbook
- Website—www.glencoe.com/shier11
- EZ Test Online
- Ph.I.L.S. 3.0
- MediaPhys 3.0
- Anatomy & Physiology Revealed
- Virtual Anatomy Dissection Review
- Student Study Guide—offers chapter overviews, chapter outcomes, focus questions, mastery tests, study activities, and mastery test answers.
- ExamView® CD-ROM

**McGraw-Hill’s Presentation Tools**

Presentation Materials for Lecture and Lab—incorporate customized lectures, visually enhanced test and quizzes, compelling course websites, or attractive printed support materials.

- NEW! A complete set of pre-made PowerPoints® linking Anatomy & Physiology Revealed to text material are now available for your use!
- NEW! A complete set of animation embedded PowerPoint slides are now available.
- NEW! Along with our online digital library containing photos, artwork, and animations, we now also offer FlexArt. FlexArt allows the teacher to customize artwork.
- Computerized test bank edited by the Author Team is powered by McGraw-Hill’s flexible electronic testing program EZ Test Online. These questions are also available in the ExamView® CD-ROM format.

**Laboratory Manual for Hole’s Essentials of Human Anatomy & Physiology, Eleventh Edition**, by Terry R. Martin, Kishwaukee College, is designed to accompany the eleventh edition of *Hole’s Essentials of Human Anatomy & Physiology*.

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Do More
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After studying this chapter, you should be able to do the following:

1. Explain the importance of an individualized approach to learning.
2. Summarize what you should do before attending class.
3. Identify student activities that enhance classroom experience.
4. List and describe several study techniques that can facilitate learning new material.

**OPENING VIGNETTE**

Beginning each chapter is a vignette that discusses current events or research news relating to the subject matter in the chapter. These vignettes demonstrate applications of the concepts learned in the study of anatomy and physiology.

**It is a beautiful day.** You can’t help but stare wistfully out the window, the scent of spring blooms and sound of birds making it impossible to concentrate on what the instructor is saying. Gradually, the lecture fades as you become aware of your own breathing, the beating of your heart, and the sweat that breaks out on your forehead in response to the radiant heat from the glorious day. Suddenly your reverie is cut short—the instructor has dropped a human anatomy and physiology textbook on your desk. You jump. Your hearthammers and a flash of fear grips your chest—but you soon realize what has happened and recover.

The message is clear: pay attention. So you do, tuning out the great outdoors and focusing on the lecture. In this course, you will learn all about the events that you have just experienced, including your response to the sudden stimulation of the instructor’s wake-up call. This is a good reason to learn about how to stay focused in the course.

**Learning Outcomes**

After studying this chapter, you should be able to do the following:

Each chapter begins with a list of outcomes indicating the knowledge you should gain as you work through the chapter. (Note the blue learn arrow.) These outcomes are intended to help you master the similar outcomes set by your instructor. The outcomes will be tied directly to assessments of knowledge gained.
Studying the human body can be overwhelming at times. The new terminology, used to describe body parts and how they work, can make it seem as if you are studying a foreign language. Learning all the parts of the body, along with the composition of each part, and how each part fits with the other parts to make the whole requires memorization. Understanding the way each body part works individually, as well as body parts working together, requires a higher level of knowledge, comprehension, and application. Identifying underlying structural similarities, from the macroscopic to the microscopic levels of body organization, taps more subtle critical thinking skills. This chapter will catalyze success in this active process of learning. (Remember that while the skills and tips discussed in this chapter relate to learning anatomy and physiology, they can be applied to other subjects.)

Learning occurs in different ways or modes. Most students use several modes (multimodal), but are more comfortable and use more effectively one or two learning styles. Some students prefer to read the written word to remember it and the concept it describes or to actually write the words; others learn best by looking at visual representations, such as photographs and drawings. Still others learn most effectively by hearing the information or explaining it to someone else. For some learners, true understanding remains elusive until a principle is revealed in a laboratory or clinical setting that provides a memorable context and engages all of the senses.

This text is balanced among the learning styles; read-write learners will appreciate the lists, definitions (glossary), and tables; visual learners will discover in the pages of text many diagrams, flow charts, and figures, all with consistent and purposeful use of color (in figures where bones are color-coded, for example, a particular bone is always the same color); auditory learners will find pronunciations whenever new scientific terms are introduced, so that they may “sound out” the new vocabulary; and kinesthetic learners will appreciate real-life examples and applications to relate to their own activities.

After each major section, a question or series of questions tests your understanding of the material and enables you to practice using the information. (Note the green practice arrow.) If you cannot answer the question(s), you should reread that section, being particularly on the lookout for the answer(s).

Check Your Recall
1. List some difficulties a student may experience when studying the human body.
2. List the ways that people learn.

Many strategies for academic success are common sense, but it might help to review them. You may encounter new and helpful methods of learning.

Before Class
The major divisions are subdivided into “B-heads,” which are identified by large, black type. These will help you organize the concepts upon which the major divisions are built.

Before attending class, prepare by reading and outlining or taking notes on the assigned pages of the text. If outlining, leave adequate space between entries to allow room for note-taking during lectures. Or, fold each page of notes taken before class in half so that class notes can be written on the blank side of the paper across from
the reading notes on the same topic. This introduces the topics of the next class lecture, as well as new terms. Some students team a vocabulary list with each chapter’s notes. The outline or notes from the reading can be taken to class and expanded during the lecture. At a minimum, the student should at least skim through the text, reading A-heads, B-heads, and the summary outline to become acquainted with the topics and vocabulary in advance of class attendance.

Health-care workers repeatedly monitor patients’ vital signs—observable body functions that reflect essential metabolic activities. Vital signs indicate that a person is alive. Assessment of vital signs includes measuring body temperature and blood pressure and monitoring rates and types of pulse and breathing movements. Absence of vital signs signifies death. A person who has died displays no spontaneous muscular movements, including those of the breathing muscles and beating heart. A dead body does not respond to stimuli and has no reflexes, such as the knee-jerk reflex and the pupillary reflexes of the eye. Brain waves cease with death, as demonstrated by a flat electroencephalogram (EEG), which signifies a lack of electrical activity in the brain.

As you read, you may feel the need for a “study break” or to “chill out.” Other times, you may just need to shift gears. Try the following. Throughout the book are shaded boxes that present sidelights to the main text. Indeed, some of these may cover topics that your instructor chooses to highlight. Read them! They are interesting, informative, and a change of pace.

The skeleton of an average 160-pound body weighs about 29 pounds.

Genetics Connection 16.1: Cystic Fibrosis

“Woe to that child which when kissed on the forehead tastes salty. He is bewitched and soon must die.” So went a seventeenth-century British saying about a child with cystic fibrosis (CF). Until recently, salty skin, foul stools, and poor weight gain (“failure to thrive”) were typically the first symptoms of CF. Today most new cases are detected before birth, using genetic tests. The disease, inherited from two carrier parents, affects about 30,000 people in the United States and 70,000 worldwide. It isn’t known how many people have mild forms of the disease, merely with symptoms of frequent respiratory infection. More than 1,000 mutations can cause CF; so severity varies widely.

In 1938, physicians first described CF as a defect in channels leading from certain glands. This causes formation of extremely thick, sticky mucus, which encourages infections by microorganisms not otherwise common in the lungs. A clogged pancreas prevents digestive juices from reaching the intestines and thus impairs absorption of nutrients.

In the 1930s, life expectancy for a child with CF was five years, but by 1960 it became possible to treat the symptoms. Antibiotics control the respiratory infections, and daily “bronchial drainage” exercises shake the stifling mucus free from the lungs of infants. Older children and adults wear a vibrating vest for half-hour stretches two to four times a day to shake the mucus free. Some people multitask, taking daily antibiotics in a nebulizer as they wear the vest. Digestive enzymes mixed into soft foods enhance nutrient absorption.

The gene that is mutant in CF normally encodes a protein called the “cystic fibrosis transmembrane regulator,” or CFTR for short. It is an ion channel that controls chloride transport out of cells. In severe CF, the chloride channel is missing one crucial amino acid, and is so deformed that it fails to function. The abnormal handling of chloride ions thickens the mucus. Organs become clogged.

Discovery of the most common CFTR mutation in 1989 enabled development of more targeted treatments. Some drugs allow more chloride to leave the cells lining the lungs. Two new drugs, still experimental, are small molecules that escort abnormal CFTR protein to the cell surface, where it apparently functions. The drugs act as “correctors,” saving the errant CFTR proteins from being dismantled before they can reach the cell surface.

Life with severe CF is difficult. One little girl did not mind the twice-daily vibrating vest, or even the feeding tube she needed at night to pack in nutrients. But she hated the measures to avoid respiratory infections, especially in summertime. She had to stay away from hoses, which harbor lung-loving Pseudomonas bacteria. Bonfires or cookouts could expose her to lung-clogging particulates in the air. She couldn’t even go into a pool—too little chlorine would invite bacterial infections, and too much would irritate her lungs. But unlike children of a generation ago, her disease is controlled enough that she will likely live well into adulthood.
Clinical Application 15.1

Dental Caries

Sticky foods, such as caramel, lodge between the teeth and in the crevices of molars, feeding bacteria such as Actinomyces, Streptococcus mutans, and Lactobacillus. These microorganisms metabolize carbohydrates in the food, producing acid by-products that destroy tooth enamel and dentin. The bacteria also produce sticky substances that hold them in place.

If a person eats a candy bar but does not brush the teeth soon afterward, the acid-forming bacteria may decay tooth enamel, creating a condition called dental caries. Unless a dentist cleans and fills the resulting cavity that forms where enamel is destroyed, the damage will spread to the underlying dentin.

Dental caries can be prevented in several ways:
1. Brush and floss teeth regularly.
2. Have regular dental exams and cleanings.
3. Talk with your dentist about receiving a fluoride treatment. Fluoride is added to the water supply in many communities. Fluoride is incorporated into the enamel’s chemical structure, strengthening it.
4. The dentist may apply a sealant to children’s and adolescents’ teeth where crevices might hold onto decay-causing bacteria. The sealant is a coating that keeps acids from eating away at tooth enamel.

Photographs and Line Art

The heading above this box is a “C-head.” Sometimes subdivisions have so many parts that the book goes to this third level of organization. This heading is presented in a slightly smaller, italicized font.

Photographs provide a realistic view of anatomy.
Macroscopic to Microscopic

Many figures show anatomical structures in a manner that is macroscopic to microscopic (or vice versa).

Flow Charts

Flow charts depict sequences of related events, steps of pathways, and complex concepts, easing comprehension. Other figures may show physiological processes.

Anatomical Structures

Some figures illustrate the locations of anatomical structures.

Other figures illustrate the functional relationships of anatomical structures.
**Organizational Tables**

Organizational tables can help “put it all together,” but are not a substitute for reading the text or having good lecture notes.

<table>
<thead>
<tr>
<th>Table 5.6</th>
<th>Muscle and Nervous Tissues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>Function</strong></td>
</tr>
<tr>
<td>Skeletal muscle tissue (striated)</td>
<td>Voluntary movements of skeletal parts</td>
</tr>
<tr>
<td>Smooth muscle tissue (lacks striations)</td>
<td>Involuntary movements of internal organs</td>
</tr>
<tr>
<td>Cardiac muscle tissue (striated)</td>
<td>Heart movements</td>
</tr>
<tr>
<td>Nervous tissue</td>
<td>Sensory reception and conduction of electrical impulses</td>
</tr>
</tbody>
</table>

It is critical that you attend class regularly, and be on time—even if the instructor’s notes are posted on the Web, and the information is in the textbook. For many learners, hearing and writing new information is a better way to retain facts than just scanning notes on a computer screen. Attending lectures and discussion sections also provides more detailed and applied analysis of the subject matter, as well as a chance to ask questions.

**During Class**

Be alert and attentive in class. Take notes by adding to either the outline or notes taken while reading. Auditory learners benefit from recording the lectures and listening to them while driving or doing chores. This is called **multitasking**—doing more than one activity at a time.

Participate in class discussions, asking questions of the instructor and answering questions he or she poses. All of the students are in the class to learn, and many will be glad someone asked a question others would not be comfortable asking. Such student response can alert the instructor to topics that are misunderstood or not understood at all. However, respect class policy. Due to time constraints and class size, asking questions may be more appropriate after a large lecture class or during tutorial (small group) sessions.

**After Class**

In learning complex material, expediency is critical. Organize, edit, and review notes as soon after class as possible, fleshing out sections where the lecturer got ahead of the listener. Highlighting or underlining (in color, for visual learners) the key terms, lists, important points and major topics make them stand out, which eases both daily reviews and studying for exams.

**Lists**

Organizing information into lists or categories can minimize information overload, breaking it into manageable chunks. For example, when studying the muscles of the thigh it is easier to learn the insertion, origin, action, and nerve supply of the four muscles making up the quadriceps femoris as a group, because they all have the same insertion, action, and nerve supply . . . they differ only in their origins.

**Mnemonic Devices**

Another method for remembering information is the **mnemonic device**. One type of mnemonic device is a list of words, forming a phrase, in which the first letter of each word corresponds to the first letter of each word that must be remembered. For example, **Frequent parade often tests soldiers’ endurance** stands for the skull bones **frontal**, **parietal**, **occipital**, **temporal**, **sphenoid**, and **ethmoid**. Another type of mnemonic device is a word formed by the first letters of the items to be remembered. For example, **ipmat** represents the stages in the cell cycle: **interphase**, **prophase**, **metaphase**, **anaphase**, and **telophase**.

**Study Groups**

Forming small study groups helps some students. Together the students review course material and compare notes. Working as a team and alternating leaders allows students to verbalize the information. Individual students can study and master one part of the assigned material, and then explain it to the others in the group, which incorporates the information into the memory of the speaker. Hearing the material spoken aloud also helps the auditory learner. Be sure to use anatomical and physiological terms, in explanations and everyday conversation, until they become part of your working vocabulary, rather than intimidating jargon. Most important of all—the group must stay on task, and not become a vehicle for social interaction. Your instructor may have suggestions or guidelines for setting up study groups.

**Flash Cards**

Flash cards may seem archaic in this computer age, but they are still a great way to organize and master complex and abundant information. The act of writing or drawing on a note card helps the tactile learner. Master a few new cards each day, and review cards from previous days, and use them all again at the end of the semester to prepare for the comprehensive final exam. They may even come in handy later, such as in studying for exams for admission to medical school or graduate school. Divide your deck in half and flip half of...
the cards so that the answer rather than the question is showing. Mix and shuffle them. Get used to identifying a structure or process from a description as well as giving a description when provided with a process or structure. This is more like what will be expected of you in the real world of the health-care professional.

**Manage Your Time**

For each hour in the classroom, most students will spend at least three hours outside of class studying. Many of you have important obligations outside of class, such as jobs and family responsibilities. As important as these are, you still need to master this material on your path to becoming a health-care professional. Good time management skills are therefore essential in your study of human anatomy and physiology. In addition to class, lab, and study time, multitask. Spend time waiting for a ride, in a doctor’s office, or online reviewing notes or reading the text.

Daily repetition is helpful, so scheduling several short study periods each day can replace an end-of-semester crunch to cram for an exam. This does not take the place of time to prepare for the next class. Thinking about these suggestions for learning now can maximize study time throughout the semester, and, hopefully, lead to academic success. A working knowledge of the structure and function of the human body provides the foundation for all careers in the health sciences.

**Summary Outline**

A summary of the chapter provides an outline to review major ideas and is a tool for organizing thoughts.

**P.1 Introduction (page xix)**

Try a variety of methods to study the human body.

**P.2 Strategies for Your Success (page xix)**

While strategies for academic success seem to be common sense, you might benefit from reminders of study methods.

1. Before class
   - Read the assigned text material prior to the corresponding class meeting.
   - Photographs give a realistic view and line art shows different perspectives.

2. During class
   - Take notes and participate in class discussions.

3. After class
   - Organize, edit, and review class notes.
   - Mnemonic devices aid learning.
     - (1) The first letters of the words to remember begin words of an easily recalled phrase.
     - (2) The first letters of the items to be remembered form a word.
   - Small study groups reviewing and vocalizing material can divide and conquer the learning task.
   - Making flash cards helps the tactile learner.
   - Time management skills encourage scheduled studying, including daily repetition instead of cramming for exams.

**Check Your Recall**

3. Why is it important to prepare before attending class?
4. Name two ways to participate in class discussions.
5. List several aids for remembering information.

**Chapter Assessments**

Chapter assessments that are tied directly to the learning outcomes allow you to assess your mastery of the material. (Note the purple assess arrow.)

**P.1 Introduction**

1. Explain why the study of the human body can be overwhelming. (p. xix)

**P.2 Strategies for Success**

2. Methods to prepare for class include: (p. xix)
   - reading the chapter.
   - outlining the chapter.
Integrative Assessments/Critical Thinking

A textbook is inherently linear. This text begins with Chapter 1 and ends with Chapter 20. Understanding physiology and the significance of anatomy, however, requires you to be able to recall previous concepts. Toward this end, we have included in the Integrative Assessments/Critical Thinking section references to sections from earlier chapters. Making connections is what it is all about!

OUTCOME P.1
1. Which study methods are most successful for you?

OUTCOMES P.1, P.2
2. Design a personalized study schedule.

Check out the text website at www.mhhe.com/shieress11 for additional study tools. There is also information about the applicable Anatomy & Physiology Revealed® CD-ROM.

WEB CONNECTIONS
Visit the text website at www.mhhe.com/shieress11 for additional quizzes, interactive learning exercises, and more.

APR
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