

This International Student Edition is for use outside of the U.S.

HOLE'S Essentials of Human Anatomy & Physiology

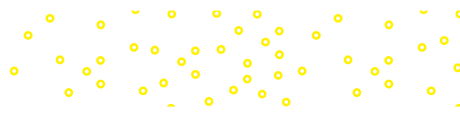
Fifteenth Edition



Mc
Graw
Hill

Charles J. Welsh
Cynthia Prentice-Craver





HOLE'S ESSENTIALS OF HUMAN ANATOMY & PHYSIOLOGY

Fifteenth Edition

Charles J. Welsh

DUQUESNE UNIVERSITY

Cynthia Prentice-Craver

CHEMEKETA COMMUNITY COLLEGE

DIGITAL AUTHORS

Leslie Day

TEXAS A&M
UNIVERSITY

Julie Pilcher

UNIVERSITY OF
SOUTHERN INDIANA

PREVIOUS EDITION AUTHORS

David Shier

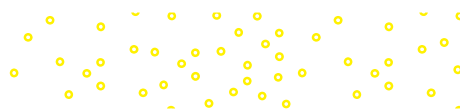
WASHTENAW
COMMUNITY COLLEGE

Jackie Butler

GRAYSON COLLEGE

Ricki Lewis

ALBANY MEDICAL
COLLEGE





HOLE'S ESSENTIALS OF HUMAN ANATOMY & PHYSIOLOGY

Published by McGraw Hill LLC, 1325 Avenue of the Americas, New York, NY 10019. Copyright ©2024 by McGraw Hill LLC. All rights reserved. Printed in the United States of America. No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written consent of McGraw Hill LLC, including, but not limited to, in any network or other electronic storage or transmission, or broadcast for distance learning.

Some ancillaries, including electronic and print components, may not be available to customers outside the United States.

This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 LWI 28 27 26 25 24 23

ISBN 978-1-266-23504-7

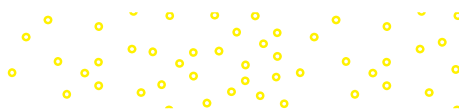
MHID 1-266-23504-3

Cover Image: *Coolakov_com/Shutterstock*

All credits appearing on page are considered to be an extension of the copyright page.

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

mheducation.com/highered





BRIEF CONTENTS

UNIT 1 LEVELS OF ORGANIZATION



1. Introduction to Human Anatomy and Physiology 9
2. Chemical Basis of Life 39
3. Cells 59
4. Cellular Metabolism 85
5. Tissues 103

UNIT 2 SUPPORT AND MOVEMENT



6. Integumentary System 126
7. Skeletal System 144
8. Muscular System 190

UNIT 3 INTEGRATION AND COORDINATION



9. Nervous System 226
10. The Senses 273
11. Endocrine System 303

UNIT 4 TRANSPORT



12. Blood 332
13. Cardiovascular System 356
14. Lymphatic System and Immunity 395

UNIT 5 ABSORPTION AND EXCRETION



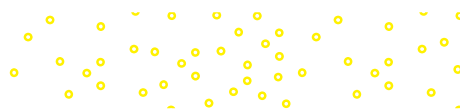
15. Digestive System and Nutrition 420
16. Respiratory System 465
17. Urinary System 491
18. Water, Electrolyte, and Acid-Base Balance 515

UNIT 6 THE HUMAN LIFE CYCLE



19. Reproductive Systems 531
20. Pregnancy, Growth, Development, and Genetics 565

Unit 1: maxuser/Shutterstock; Unit 2: Adam Gault/OJO Images/Getty Images; Unit 3: JoeSAPhotos/Shutterstock; Unit 4: Steve Allen/Getty Images; Unit 5: Janice Haney Carr/CDC; Unit 6: Profs. P.M. Motta & J. Van Blerkom/Science Source





ABOUT THE AUTHORS



Courtesy of Leeanna Smith

CHARLES J. WELSH began his Anatomy & Physiology teaching career upon graduating with a B.S. in Biology from the University of Pittsburgh in 1989. He entered graduate school in 1992 and continued teaching night classes. He accepted his first full-time teaching position at Clarion University of Pennsylvania in 1996. In 1997, he completed his Ph.D. in Comparative Anatomy, Evolutionary Biology, and Ornithology at the University of Pittsburgh. Teaching primarily in nursing and other allied health programs, he now brings his thirty years of classroom experience to the fifteenth edition of *Hole's Essentials of Human Anatomy & Physiology*. At Duquesne University in Pittsburgh, Pennsylvania, he received several teaching awards, as well as the Mentor of the Year Award for training graduate students to teach Anatomy & Physiology. Chuck and his wife, Lori, have three children and three grandchildren. They live in the historic town of Harmony, thirty miles north of Pittsburgh, with their youngest son, where they raise chickens and have a huge garden.



Courtesy of William Craver

CYNTHIA PRENTICE-CRAVER has been teaching human anatomy and physiology for over twenty-eight years at Chemeketa Community College. Cynthia's teaching experience both in grades 6–12 and in college, her passion for curriculum development, and her appetite for learning fuel her desire to write. Her M.S. in Curriculum and Instruction, B.S. in Exercise Science, and extended graduate course-work in biological sciences have been instrumental in achieving effective results in the online and on-campus courses she teaches. Cynthia was a contributing author for the *Martin Laboratory Manual for Human Anatomy & Physiology, Third Edition*, and *Hole's Essentials of Human Anatomy & Physiology, Fourteenth Edition*. She co-authored *Hole's Human Anatomy & Physiology, Sixteenth Edition*, and the *Martin Laboratory Manual for Human Anatomy & Physiology, Fourth and Fifth Editions*, and authored the digital content for these laboratory manuals. Cynthia is a member of the Human Anatomy and Physiology Society (HAPS) and the Textbook & Academic Authors Association (TAA). Her professional experiences include serving as a program chair for eight years, developing curriculum, serving on various committees, and being a reviewer and advisor of textbooks and digital products. Beyond her professional pursuits, Cynthia's passions include reading and listening to books, exercising, gardening, attending concerts, traveling, and spending time with her family and friends.

DIGITAL AUTHORS



Leslie Day

LESLIE DAY earned her B.S. in Exercise Physiology from UMass Lowell, an M.S. in Applied Anatomy & Physiology from Boston University, and a Ph.D. in Biology from Northeastern University. She currently is an Instructional Professor at Texas A&M University with dual appointments in the School of Engineering Medicine and School of Medicine. Her primary focus is teaching Gross Anatomy and Neuroanatomy to dual major medical and engineering students. Leslie has won several university and national awards for her teaching, including the ADInstruments Sam Drogo Technology in the Classroom Award from the Human Anatomy and Physiology Society (HAPS). Her current research focuses on the effectiveness of technology and pedagogical approaches, such as the flipped classroom and self-directed learning, in anatomy and medical education. She brings her love for anatomy and willingness to try new technology in the classroom, both in person and online, to make for a dynamic evidence-based teaching style that is inclusive for all students.



Courtesy of Gary Pilcher

JULIE PILCHER began teaching during her graduate training in Biomedical Sciences at Wright State University, Dayton, Ohio. She found, to her surprise, that working as a teaching assistant held her interest more than her research. Upon completion of her Ph.D. in 1986, she embarked on her teaching career, working for many years as an adjunct in a variety of schools as she raised her four children. In 1998, she began teaching full-time at the University of Southern Indiana, Evansville. Her work with McGraw Hill began with doing reviews of textbook chapters and lab manuals and in content development for LearnSmart. In her A&P course at USI, she used Connect and enjoyed the challenge of writing some of her own assignments. She later accepted the opportunity to be more involved in the authoring of digital content for McGraw Hill, understanding the importance of such content to both the instructors and the students.



DEDICATION

To my wife, Lori, our three children, Leeanna, Timothy, and Brady, and our three grandchildren, Milla, Holden, and Carolina, for the love and joy they bring me.

To Bill Daugherty for over 20 years of friendship, support, and encouragement.

Charles J. Welsh

To my adoring husband, Bill, who makes me smile and laugh every day, and to our children Forrest, Addison, Avery, Austin, and Aiden, who are fine, young gentlemen who brighten my life.

Cynthia Prentice-Craver

To Krystal Faust and Ann Courtney for their unwavering support, patience, and guidance during the preparation of this manuscript.

CJW & CPC

ACKNOWLEDGMENTS

We are honored and privileged to continue our work revising this book, which is based on the efforts and expertise of Chuck Welsh, who directed the revision in the fourteenth edition, and of the previous authors: David Shier, Jackie Butler, Ricki Lewis, and John Hole, the original author of this classic work. A project of this magnitude also requires the recognition of a large, dedicated, and talented team. We would like to thank the editorial team of Matt Garcia, Krystal Faust, Ann Courtney, and Michael Koot for their unwavering support and belief in our ability; marketing team Monica Lewis and Jim Connely; and the production team. A thank-you goes out to copyeditor Wendy Nelson and proofreaders Jennifer Grubba and Mike McGee for helping improve the quality of this product. Most importantly, we thank our spouses for their love, patience, and tremendous support.

REVIEWERS AND CONTRIBUTORS

A special thanks for the valuable contributions of all the professors, and their students, who have provided detailed recommendations for improving chapter content and illustrations, as well as suggestions regarding the development of ancillary resources for this new edition. They have played a vital role in building a solid foundation for *Hole's Essentials of Human Anatomy & Physiology*.

Reviewers

Jennifer M. Boalick
Guilford Technical Community College

Peggy Dutcher
Lansing Community College

Linda D. Gaylo
Mercer County Community College

Scott R. Hargraves
Associate Professor, California University of Pennsylvania, Department of Health Science

Milton Muldrow Jr.
Wilmington University

Adila Nathu
Bryant & Stratton College

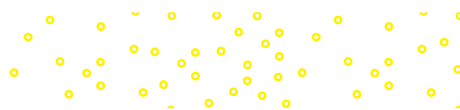
Rebecca Rebhorn
Austin Community College

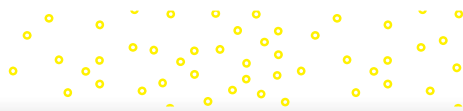
Dee Ann S. Sato
Cypress College

Padmaja Vedartham
Lone Star College Cy-Fair

Jacqueline Waltz
Stanly Community College

Allison Ward-Moore
McLennan Community 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, forearm, and arm), you are using your body to do so. Indeed, some of you may be using your fingers, hand, forearm, and arm to read through the eBook on your computer, tablet, or smartphone. The structure and function of the human body can be complex, and comprehending the material might not always seem easy. But what could be more fascinating than learning about your own body? To assist your learning, the fifteenth edition of *Hole's Essentials of Human Anatomy & Physiology* continues the tradition of presenting material in a conversational, accessible style.

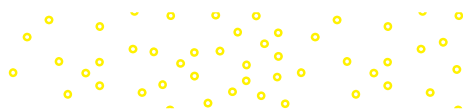
Many of you are on a path toward a career in health care, athletics, science, or education. If you have not yet committed to a particular area of study, be sure to check out the Career Corner in every chapter for ideas and inspiration. They present interesting options for future careers. Balancing family, work, and academics is challenging, but try to look at this course not as a hurdle along your way but as a stepping stone. The book has been written to help you succeed in your coursework and to help prepare you in your journey to a successful and rewarding career.

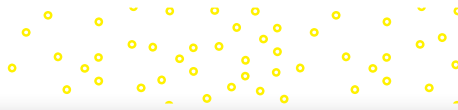
To the Teacher

Written for ease of readability and organized for classroom use, this text serves the student as well as the instructor. This fifteenth edition of *Hole's Essentials of Anatomy & Physiology* continues the Learn, Practice, Assess approach that has substantially contributed to instructional efficiency and student success.

Each main chapter heading opens with Learning Outcomes, contains many opportunities to Practice throughout, and closes with Assessments that are closely tied to the Learning Outcomes. Instructors can assign these, and students can use these features 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 / Foundations for Success beginning on page 1. In addition, thanks to the expertise of our digital authors Leslie Day and Julie Pilcher, the Connect digital platforms continue to enhance the printed content and the Learn, Practice, Assess approach. We are proud to have developed and to offer the latest and most efficient technologies to support teaching and learning.

Chuck Welsh and Cynthia Prentice-Craver





NEW TO THIS EDITION

Global Changes

Art: Revised colors, and placement of colors, to create better contrast to meet accessibility standards.

Clinical Applications: Images added to many of the clinical applications to enhance understanding.

Diversity, Equity, and Inclusion: Revised language to improve inclusivity. Gender-specific pronouns and nouns have been minimized, balanced where some remain, and deleted where they were adding nothing to the meaning of the writing.

Pronunciations: Revised style used in pronunciations.

Specific Chapter Changes

- Chapter 1 Revised discussion of the scientific method.
- Chapter 2 Revised discussion of atomic weight, atomic number, and mass number.
- Chapter 3 Figure 3.3 revised some labels for clarification.
Revised Of Interest on exosomes; added Of Interest on a microtubule-associated protein.
Figures 3.12 and 3.15 added practice figure questions.
Figure 3.16 rearranged (a), (b), and (c).
Figure 3.20 added to show phagolysosome formation and exocytosis.
- Chapter 4 Figure 4.6 added (b); added a practice figure question.
Figure 4.10 added a practice figure question.
Added Of Interest on exons.
- Chapter 5 Revised Figure 5.1 for clarity.
- Chapter 6 Figure 6.3 revised (b).
Clinical Application 6.2 revised to include immunotherapy and gene mutations.
Added Of Interest on antioxidants.
Figure 6.4 updated to show nail matrix.
Figure 6.5 added (c).
Table 6.2 created to show common skin disorders.
Figure 6B added to Clinical Application 6.3.
- Chapter 7 Revised the introduction for clarity.
Revised Figure 7.4 for accuracy.
- Chapter 8 Revised discussion of muscle relationships: prime mover, agonist, synergist, and antagonist.
- Chapter 9 Revised the discussion of the action potential for clarity and accuracy.
Revised Figure 9.9 for clarity and accuracy.
- Chapter 10 Added images to Clinical Applications 10.2, 10.3, and 10.4.
- Chapter 11 Added Of Interest on prostaglandins.
Added images to Clinical Applications 11.1, 11.2, and 11.4.
Figure 11.10 added to compare histology of anterior pituitary and posterior pituitary.
Figure 11.11c added.
Moved hypothyroidism and hyperthyroidism text to a Clinical Application 11.2.
Moved hypoparathyroidism and hyperparathyroidism text to a Clinical Application 11.3.
Figure 11.13 added a practice figure question.
Figure 11.17 revised to include labeling of exocrine cells.
- Chapter 12 Revised heading to Breakdown of Red Blood Cells.
Added image to Clinical Application 12.1.
Table 12.4 changed title of two columns for clarity.
Table 12.5 added of preferred and permissible ABO blood types for transfusions.

continued next page—

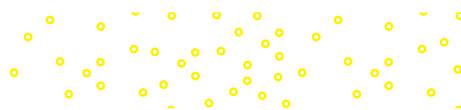




NEW TO THIS EDITION

Specific Chapter Changes—*Continued*

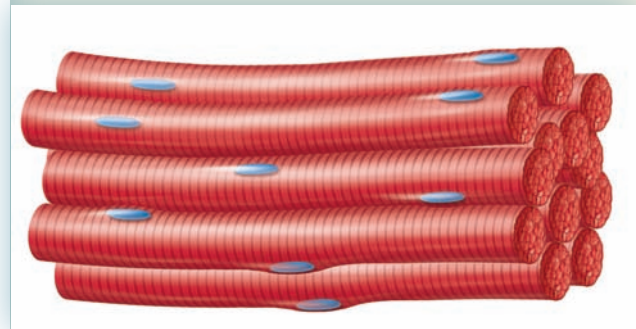
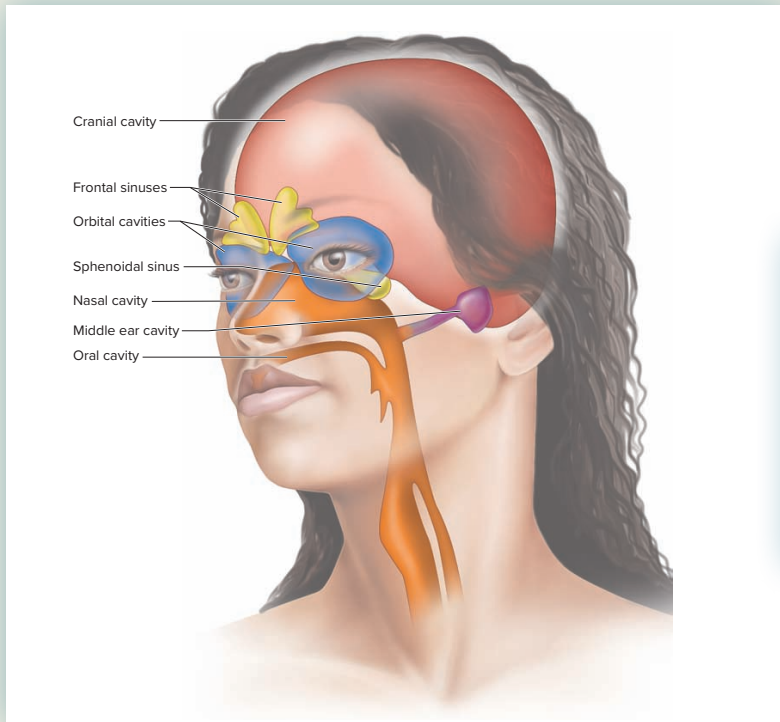
- Chapter 13 Added images to Clinical Applications 13.1 and 13.3.
Figure 13.7 added a practice figure question.
Revised discussions in Clinical Applications 13.1 and 13.4.
- Chapter 14 Figure 14.6 revised for clarification; added a practice figure question.
Added or revised discussion to sections on Lymphatic Capillaries, Lymph Nodes, Body Defenses Against Infection, Chemical Barriers, Practical Classification of Immunity, Hypersensitivity, and Autoimmunity for clarity and relevance.
Added Of Interest on classes of MHC protein molecules and on spike protein of SARS-CoV-2.
Figures 14.14 and 14.15 added practice figure questions.
- Chapter 15 Table 15.1 revised for clarity.
Images added to Clinical Applications 15.1, 15.2, 15.3, 15.4, and 15.6.
Figures 15.10, 15.12, and 15.15 added practice figure questions.
Added or revised discussion to sections on Gastric Secretions and Pancreatic Juice for clarity.
Table 15.2 updated to include chemical messengers.
Added Of Interest on Celiac disease.
- Chapter 16 Added images to Clinical Applications 16.1, 16.2, and 16.4.
- Chapter 17 Figure 17.12 added a practice figure question.
Table 17.1 created from Figure 17.12.
Figure 17.20 added of male urethra and female urethra.
Added Integrative Assessment/Critical Thinking question.
- Chapter 18 Revised Clinical Application 18.1 for clarity and accuracy.
- Chapter 19 Figure 19.8 added of generalized ovary.
Figure 19.11 added of perineum.
Figure 19.12 revised for improved accuracy.
Figure 19.13 added micrograph of developing follicles.
Added or revised discussion on sections on Follicle Maturation, Menopause, and Emergency Contraception for better understanding.
Added Integrative Assessment/Critical Thinking question.
- Chapter 20 Revised the discussion of Down syndrome.



This page intentionally left blank

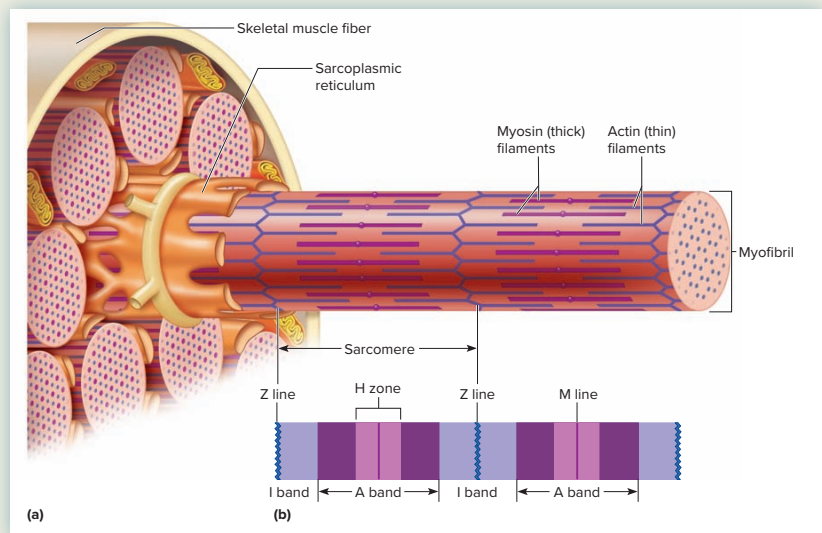
DYNAMIC ART PROGRAM

Art is vibrant, three-dimensional, and instructional. The authors examined every piece to ensure it was engaging and accurate. The fifteenth edition's art program will help students understand the key concepts of anatomy and physiology.

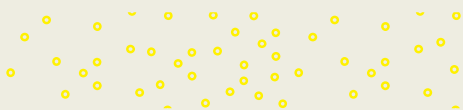


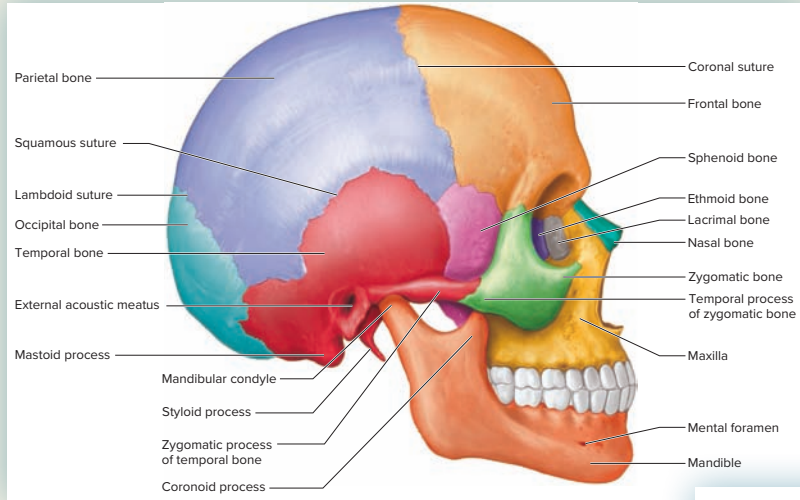
Line art for micrographs is three-dimensional to help students visualize more than just the flat microscopic sample.

Realistic, three-dimensional figures provide depth and orientation.

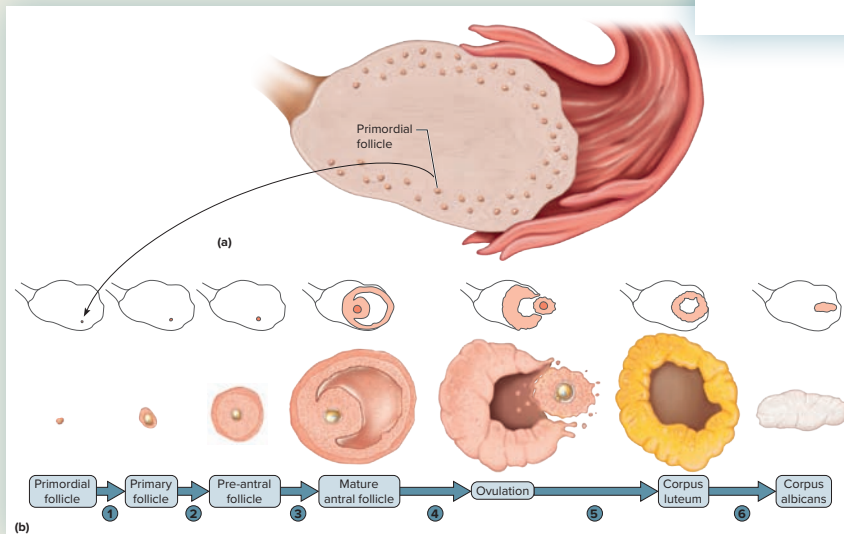
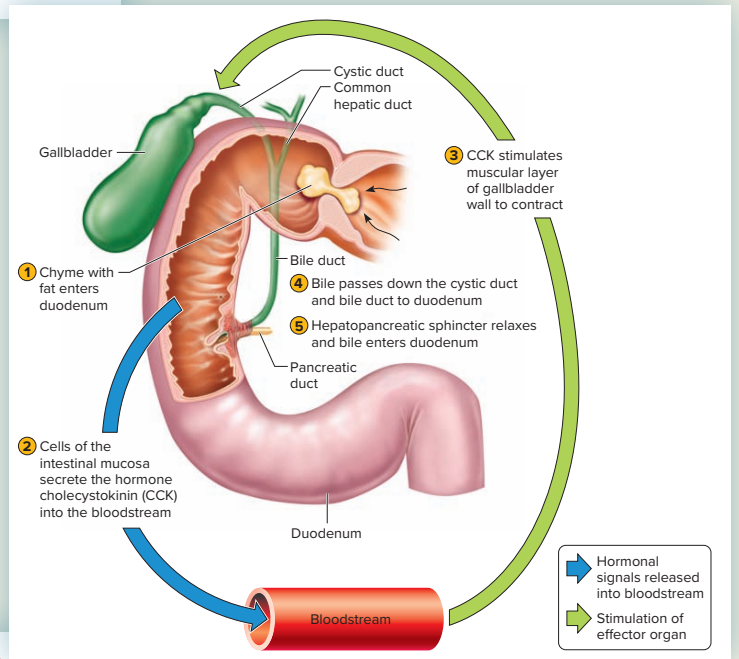


A transverse section shows the interior structures of a skeletal muscle fiber and reveals detail of the myofibrils, thick and thin filaments.



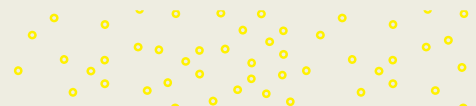


Colors readily distinguish bones of the skull.



The explanation of this feedback loop is part of the figure, not lost in the legend.

Locator icons help portray the process more accurately.



Learn, Practice, Assess!

Learn

Learning Outcomes follow the appropriate heading within the chapter. They are closely linked to Chapter Assessments and Integrative Assessments/Critical Thinking questions found at the end of each chapter.

Learning tools to help you succeed . . .

Check out the Chapter Preview, *Foundations for Success*, on page 1. The Chapter Preview was specifically designed to help you **LEARN** how to study. It provides helpful study tips.

8.2 | Structure of a Skeletal Muscle

LEARN

1. Identify the structures that make up a skeletal muscle.
2. Identify the major parts of a skeletal muscle fiber, and the function of each.
3. Discuss nervous stimulation of a skeletal muscle.



6 UNIT 2 SUPPORT AND MOVEMENT
Integumentary System

Administering a tattoo. Jeffrey Cook/Getty Images/Getty Images

Tattoos. With their dramatic rise in popularity and being more socially acceptable than ever, you might even have one yourself. If not, you probably can't walk very far on campus without seeing tattoos on other students, and maybe even on some faculty. Often referred to as body art, the canvas for these illustrations is your skin.

The outer layer of the skin, the epidermis, is what we usually see. But the ink used for tattooing resides in the deeper layer called the dermis. Initially, the ink is injected into the region between the epidermis and dermis. The damaged epidermis is shed. Trapped by white blood cells as part of an immune response, the pigments remain in the upper part of the dermis. This becomes the long-term image, or art, that is visible. The fading of a tattoo over time is the result of the pigments migrating into deeper layers of the dermis.

Tools for tattooing recovered from some archeological sites are as old as 12,000 years. This long history of tattoos reveals ancient knowledge of anatomy and the healing arts. Otzi the iceman was found preserved in 1991 in the Italian Alps. He lived about 5,300 years ago and possesses the oldest surviving tattoos. 61 in all. It is thought that most of his tattoos had medical relevance, where either the tattoos themselves served as treatment, or they indicated areas of focus for medical interventions.

Contemporary tattoos are usually decorative, and most often are a form of self-expression. They exhibit a wide range of images in various categories. Animals such as tigers, lions, and family pets are popular standards. Hearts, roses, and skulls also seem to be quite numerous. Equally prevalent is fantasy art including dragons and the grim reaper, as well as Bible verses and important personal dates. Others are known as "functional tattoos." For example, people with Alzheimer disease may get them to recall important information such as their name and home address.

Tattoos have also been used to mark inmates and prisoners of war. The most notorious was the tattooing of people imprisoned in Nazi concentration camps during the Second World War.

The American Academy of Dermatology warns against tattoos due to the possibility of infection, scarring, and the desire to have a tattoo removed later in one's life. To minimize potential danger, it recommends employing only certified and licensed tattoo artists.

Anatomy & Physiology REVEALED® 8.0
Module 4 Integumentary System

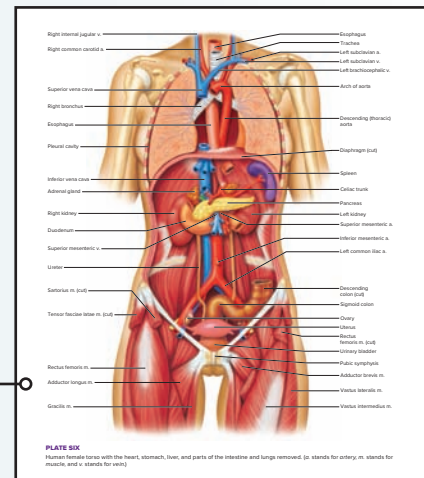
126

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

Anatomy & Physiology REVEALED® (APR) icon at the beginning of each chapter tells you which system in APR applies to this chapter.

Aids to Understanding Words examines root words, stems, prefixes, suffixes, and pronunciations to help you build a solid anatomy and physiology vocabulary.

Reference Plates offer vibrant detail of body structures.



Practice

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 knowledge . . .

Figure Questions allow an additional assessment. They are found on key figures throughout the chapter.

PRACTICE 1.6

1. Which organ occupies the cranial cavity? The vertebral canal?
2. What does *viscera* mean?
3. Name the cavities of the head.
4. Describe the membranes associated with the thoracic and abdominopelvic cavities.

Figure 15.10 Locations of the major salivary glands. Secretions enter ducts that lead to the mouth. **APR**

PRACTICE FIGURE 15.10
Where does the digestion of carbohydrates begin?
Answer can be found in Appendix E.

“Of Interest” boxes provide interesting bits of anatomy and physiology information, adding a touch of wonder to chapter topics.



OF INTEREST Contraction of the human heart can create enough pressure to squirt blood almost 10 feet into the air.



Clinical Application sections present disorders, physiological responses to environmental factors, and other topics of general interest and applies them to clinical situations.



CLINICAL APPLICATION 16.2
Cystic Fibrosis

Many young children with this disease who cannot pronounce its name call it “65 roses.” Cystic fibrosis (CF) is an inherited defect in ion channels that control chloride movement out of cells in certain organs. In the lungs, thick, sticky mucus accumulates and creates an environment hospitable to certain bacteria that are not common in healthy lungs. A mucus-clogged pancreas prevents digestive secretions from reaching the intestines, impairing nutrient digestion and absorption. A child with CF has trouble breathing and maintaining weight (Fig. 16B).

CF is inherited from two carrier parents, and affects about 30,000 people in the United States and about 70,000 worldwide. Many others may have milder cases, with recurrent respiratory infections. More than 2,000 mutations have been recognized in the cystic fibrosis transmembrane regulator (*CFTR*) gene, which encodes the chloride channel protein. Today, fetuses and newborns with CF are diagnosed using genetic tests, but years ago the first signs were typically “failure to thrive,” salty sweat, and foul-smelling stools.

When CF was recognized in 1938, life expectancy was only five years, but today median survival is about age fifty, with many patients living longer, thanks to drug treatments. Inhaled antibiotics control the respiratory infections, and daily “bronchial drainage” exercises shake stifling mucus from the lungs. A vibrating vest worn for half-hour periods two to four times a day also loosens mucus. Digestive enzymes mixed into soft foods enhance nutrient absorption, although some patients require feeding tubes.

Discovery of the most common *CFTR* mutation in 1989 enabled development of more-targeted



Figure 16B Young girl with cystic fibrosis receiving a breathing treatment. Dalibor Despotovic/Shutterstock

treatments. Drugs are now in development. The new drugs work in various ways: correcting misfolded *CFTR* protein, restoring liquid on airway surfaces, breaking up mucus, improving nutrition, and fighting inflammation and infection.

Children with severe CF are susceptible to more significant illnesses and symptoms. In summertime, a child must avoid water from hoses, which harbor lung-loving *Pseudomonas* bacteria. Cookouts spew lung-irritating particulates. Too much chlorine in pools irritates lungs, whereas too little invites bacterial infection. New infections arise, too. In the past few years, multidrug-resistant *Mycobacterium abscessus*, related to the pathogen that causes tuberculosis, has affected as many as 10% of CF patients in the United States and Europe.

Assess

Tools to help you make the connection and master Anatomy and Physiology!

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.

ASSESS

CHAPTER ASSESSMENTS

8.1 Introduction

1. The three types of muscle tissue are _____ and _____.

8.2 Structure of a Skeletal Muscle

- Describe the difference between a tendon and an aponeurosis.
- Describe how connective tissue associates with skeletal muscle.
- List the major parts of a skeletal muscle fiber, and describe the function of each part.
- Describe a neuromuscular junction.
- A neurotransmitter _____
- binds actin filaments, causing them to slide

14. Explain the causes of skeletal muscle hypertrophy and atrophy.

8.4 Muscular Responses

- Define *threshold stimulus*.
- Sketch a myogram of a single muscular twitch, and identify the latent period, period of contraction, and period of relaxation.
- Define *motor unit*.
- Which of the following describes the addition of muscle fibers to take part in a contraction?
 - summation
 - recruitment
 - tetany
 - twitch
- Explain how skeletal muscle stimulation produces a

ASSESS

INTEGRATIVE ASSESSMENTS/CRITICAL THINKING

Outcomes 4.4, 8.3

1. As lactate and other substances accumulate in an active muscle, they stimulate pain receptors and the muscle may feel sore. How might the application of heat or substances that dilate blood vessels relieve such soreness?

Outcomes 5.3, 8.2

2. Discuss how connective tissue is part of the muscular system.

Outcomes 5.5, 8.2

3. What purpose is served by skeletal muscle cells being multinucleated?

Outcomes 8.3, 8.4

5. A woman takes her daughter to a sports medicine specialist and asks the specialist to determine the percentage of fast- and slow-twitch fibers in the child’s leg muscles. The parent wants to know if her daughter, who is in good health, should try out for soccer or cross-country running. Do you think this is a valid reason to test muscle tissue? Why or why not?

6. Following an injury to a nerve, the muscle it innervates may become paralyzed. How would you explain to a patient the importance of moving the disabled muscles passively or contracting them using electrical stimulation?

Outcomes 8.3, 8.6

7. Make an argument as to why cardiac muscle is suitable for the wall of the heart, while skeletal muscle is not.



Chapter Summary

10.1 Introduction

Sensory receptors sense changes in their surroundings.

10.2 Receptors, Sensations, and Perception

- Types of receptors
 - Each type of receptor is most sensitive to a distinct type of stimulus.
 - The major types of receptors are **chemoreceptors, pain receptors, thermoreceptors, mechanoreceptors, and photoreceptors**.
- Sensations
 - A **sensation** is the awareness of sensory stimulation.
 - A particular part of the cerebral cortex interprets every impulse reaching it in a specific way.
 - The cerebral cortex projects a sensation back to the region of stimulation.
- Sensory adaptation** may involve receptors becoming unresponsive or inhibition along the CNS pathways leading to the sensory regions of the cerebral cortex.

10.4 Special Senses

Special senses have receptors within large, complex sensory organs of the head.

10.5 Sense of Smell

- Olfactory receptors
 - Olfactory receptors are chemoreceptors that are stimulated by chemicals dissolved in liquid.
 - Olfactory receptors function with taste receptors and aid in food selection.
- Olfactory organs
 - Olfactory organs** consist of receptors and supporting cells in the nasal cavity.
 - Olfactory receptor cells** are bipolar neurons with cilia.
- Olfactory pathways

Impulses travel from the olfactory receptor cells through the olfactory nerves, **olfactory bulbs**, and **olfactory tracts** to interpreting centers in the temporal and frontal lobes of the cerebrum.
- Olfactory stimulation
 - Olfactory impulses may result when odorant



McGraw Hill Connect® empowers students to learn and succeed in the Anatomy and Physiology course with user-friendly digital solutions.

Anatomy & Physiology Revealed (APR)

is an interactive cadaver dissection tool to enhance lecture and lab. Featuring real cadaver photography, animations, interactive 3D models, histology, imaging and more. Now assignable in Connect! **The result? Students are prepared for lab, engaged in the material, and utilize critical thinking.**



Virtual Labs helps connect the dots between lab and lecture, boosts student confidence and knowledge, and improves student success rates. Interactive animations and simulations also encourage students to explore key physiological processes and difficult concepts. **The result? Students are engaged, prepared, and utilize critical thinking skills.**



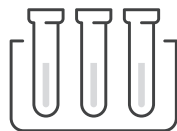
Practice ATLAS

Practice Atlas for A&P is integrated into APR, pairing images of common anatomical models with stunning cadaver photography, which allows students to practice naming structures on both models and human bodies. **The result? Students are better prepared, engaged, and move beyond basic memorization.**



A&P Prep

A&P Prep helps students thrive in college-level A&P by helping solidify knowledge in the key areas of cell biology, chemistry, study skills, and math. **The result? Students are better prepared for the A&P course.**



PhILS

PhILS (Physiology Interactive Lab Simulations) is the perfect way to reinforce key physiology concepts with powerful lab experiments. **The result? Students gain critical thinking skills and are better prepared for lab.**



SmartBook®

SmartBook 2.0 provides personalized learning to individual student needs, continually adapting to pinpoint knowledge gaps and focus learning on concepts requiring additional study. **The result? Students are highly engaged in the content and better prepared for lecture.**


DIGITAL & LAB EXPERIENCE

In this edition of *Hole's Essentials of Human Anatomy & Physiology*, the digital author team, Leslie Day and Julie Pilcher, worked hand-in-hand with the print author team to deliver a seamless experience for instructors and students.

The digital authors make sure there is a variety of questions with different Bloom's Taxonomy levels. In this edition, we have increased the number of questions that are higher-level Bloom's to about 30 percent.

Place the following muscles in order based on the proximity of their insertions to the axial skeleton. Begin with the most proximal insertion (on the coracoid process).

Pronator teres	1.
Pectoralis minor	2.
Brachialis	3.
Pectoralis major	4.
Biceps brachii	5.
Supraspinatus	6.
Flexor digitorum profundus	7.
Flexor carpi ulnaris	8.
Brachioradialis	9.
Deltoid	10.

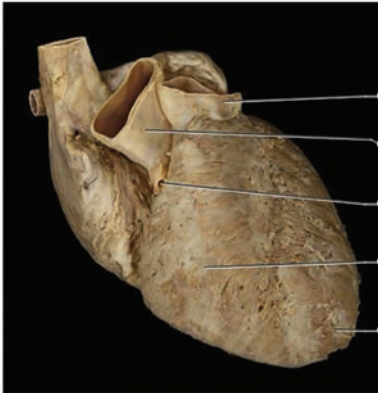


Reset

McGraw Hill

Label the external features of the heart on a cadaveric heart.

Right ventricle	
Pulmonary trunk	
Left ventricle	
Aorta	
Right coronary a.	
Left coronary a.	
Superior vena cava	




©McGraw-Hill Education

McGraw Hill

McGraw Hill Connect® gives the instructor access to additional course-wide material for A&P. Instructors can access questions for Anatomy & Physiology REVEALED®, a variety of animations, diagnostic exam for LearnSmart Prep®, concept application questions, and supplemental laboratory questions.

Place each description of the plasma membrane extensions to the correct group (cilia or flagella). Labels can be used more than once.

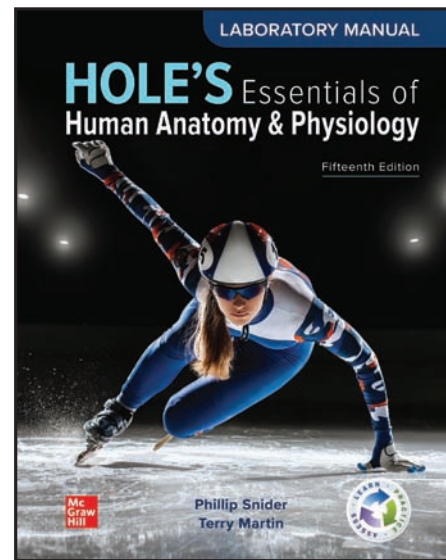
Propels fluids across the cell surface.	Found on sperm cells.
Motile extension.	Small hairlike extensions.
Moves the cell through the environment.	Found on cells of the respiratory tract.
Word means "cellular eyelashes".	Usually only one on a cell.



Reset Zoom

Oliver Meckes/Science Source; Colin Anderson /Brand X Pictures/Getty Images

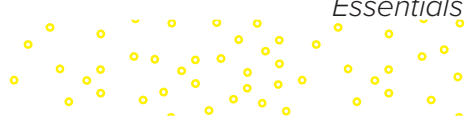
Leslie and Julie ensure that there is an appropriate number of questions for each learning outcome in the chapter. They tagged questions to textbook learning outcomes and to the Human Anatomy & Physiology Society (HAPS) learning outcomes. This makes it easy for instructors to find questions to assign in their course.



McGraw Hill

Laboratory Manual

Laboratory Manual for Hole's Essentials of Human Anatomy & Physiology, Fifteenth Edition, by Phillip Snider, Gadsden State Community College, and Terry R. Martin, Kishwaukee College, is designed to accompany the fifteenth edition of *Hole's Essentials of Human Anatomy & Physiology*.



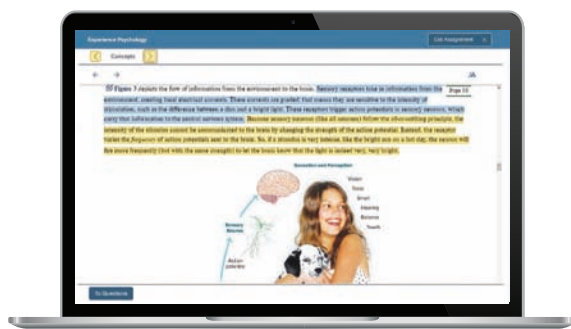
Instructors

Student Success Starts with You

Tools to enhance your unique voice

Want to build your own course? No problem. Prefer to use an OLC-aligned, prebuilt course? Easy. Want to make changes throughout the semester? Sure. And you'll save time with Connect's auto-grading, too.

65%
Less Time
Grading



Laptop: Getty Images; Woman/dog: George Doyle/Getty Images

A unique path for each student

In Connect, instructors can assign an adaptive reading experience with SmartBook® 2.0. Rooted in advanced learning science principles, SmartBook 2.0 delivers each student a personalized experience, focusing students on their learning gaps, ensuring that the time they spend studying is time well-spent.

mheducation.com/highered/connect/smartbook

Affordable solutions, added value

Make technology work for you with LMS integration for single sign-on access, mobile access to the digital textbook, and reports to quickly show you how each of your students is doing. And with our Inclusive Access program, you can provide all these tools at the lowest available market price to your students. Ask your McGraw Hill representative for more information.

Solutions for your challenges

A product isn't a solution. Real solutions are affordable, reliable, and come with training and ongoing support when you need it and how you want it. Visit supportateverystep.com for videos and resources both you and your students can use throughout the term.

SUPPORT AT
every step

Students

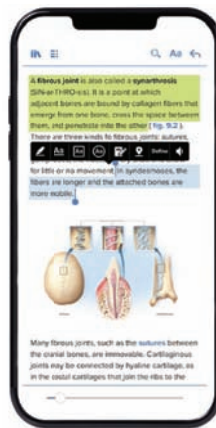
Get Learning that Fits You

Effective tools for efficient studying

Connect is designed to help you be more productive with simple, flexible, intuitive tools that maximize your study time and meet your individual learning needs. Get learning that works for you with Connect.

Study anytime, anywhere

Download the free ReadAnywhere® app and access your online eBook, SmartBook® 2.0, or Adaptive Learning Assignments when it's convenient, even if you're offline. And since the app automatically syncs with your Connect account, all of your work is available every time you open it. Find out more at mheducation.com/readanywhere



“I really liked this app—it made it easy to study when you don't have your textbook in front of you.”

- Jordan Cunningham,
Eastern Washington University

iPhone: Getty Images



Everything you need in one place

Your Connect course has everything you need—whether reading your digital eBook or completing assignments for class, Connect makes it easy to get your work done.

Learning for everyone

McGraw Hill works directly with Accessibility Services Departments and faculty to meet the learning needs of all students. Please contact your Accessibility Services Office and ask them to email accessibility@mheducation.com, or visit mheducation.com/about/accessibility for more information.





CONTENTS

CHAPTER PREVIEW Foundations for Success 1

- P.1 Introduction 2
- P.2 Strategies for Your Success 3



Comstock Images/Stockbyte/Getty Images

UNIT 1 LEVELS OF ORGANIZATION

1 Introduction to Human Anatomy and Physiology 9

- 1.1 Introduction 10
- 1.2 Anatomy and Physiology 11
- 1.3 Levels of Organization 12
- 1.4 Characteristics of Life 13
- 1.5 Maintenance of Life 13
- 1.6 Organization of the Human Body 16
- 1.7 Anatomical Terminology 22

REFERENCE PLATES
THE HUMAN ORGANISM 31

2 Chemical Basis of Life 39

- 2.1 Introduction 40
- 2.2 Fundamentals of Chemistry 40
- 2.3 Bonding of Atoms 42
- 2.4 Molecules, Compounds, and Chemical Reactions 45
- 2.5 Acids and Bases 47
- 2.6 Chemical Constituents of Cells 48

3 Cells 59

- 3.1 Introduction 60
- 3.2 Composite Cell 61
- 3.3 Movements Into and Out of the Cell 70
- 3.4 The Cell Cycle 76

4 Cellular Metabolism 85

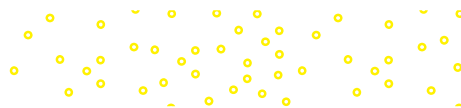
- 4.1 Introduction 86
- 4.2 Metabolic Reactions 86
- 4.3 Control of Metabolic Reactions 88
- 4.4 Energy for Metabolic Reactions 90
- 4.5 DNA (Deoxyribonucleic Acid) 93
- 4.6 Protein Synthesis 96



maxuser/Shutterstock

5 Tissues 103

- 5.1 Introduction 104
- 5.2 Epithelial Tissues 105
- 5.3 Connective Tissues 112
- 5.4 Types of Membranes 120
- 5.5 Muscle Tissues 120
- 5.6 Nervous Tissue 122



UNIT 2

SUPPORT AND MOVEMENT

6 Integumentary System 126

- 6.1 Introduction 127
- 6.2 Layers of the Skin 128
- 6.3 Accessory Structures of the Skin: Epidermal Derivatives 132
- 6.4 Skin Functions 135

7 Skeletal System 144

- 7.1 Introduction 145
- 7.2 Bone Structure 145
- 7.3 Bone Function 148

- 7.4 Bone Development, Growth, and Repair 149
- 7.5 Skeletal Organization 151
- 7.6 Skull 155
- 7.7 Vertebral Column 162
- 7.8 Thoracic Cage 165
- 7.9 Pectoral Girdle 166
- 7.10 Upper Limb 168
- 7.11 Pelvic Girdle 169
- 7.12 Lower Limb 172
- 7.13 Joints 174

REFERENCE PLATES

HUMAN SKULL 187



Adam Gault/OJO Images/Getty Images

8 Muscular System 190

- 8.1 Introduction 191
- 8.2 Structure of a Skeletal Muscle 191
- 8.3 Skeletal Muscle Contraction 195
- 8.4 Muscular Responses 201
- 8.5 Smooth Muscle 203
- 8.6 Cardiac Muscle 203
- 8.7 Skeletal Muscle Actions 204
- 8.8 Major Skeletal Muscles 207

UNIT 3

INTEGRATION AND COORDINATION

9 Nervous System 226

- 9.1 Introduction 227
- 9.2 Nervous System Organization 228
- 9.3 Neurons 229
- 9.4 Neuroglia 231
- 9.5 Charges Inside a Cell 233
- 9.6 Impulse Conduction 235
- 9.7 The Synapse 237
- 9.8 Synaptic Transmission 238
- 9.9 Impulse Processing 240
- 9.10 Types of Nerves 241
- 9.11 Neural Pathways 241
- 9.12 Meninges 243
- 9.13 Spinal Cord 245
- 9.14 Brain 247
- 9.15 Peripheral Nervous System 257
- 9.16 Autonomic Nervous System 262

10 The Senses 273

- 10.1 Introduction 274
- 10.2 Receptors, Sensations, and Perception 274
- 10.3 General Senses 275
- 10.4 Special Senses 279
- 10.5 Sense of Smell 279
- 10.6 Sense of Taste 281
- 10.7 Sense of Hearing 282
- 10.8 Sense of Equilibrium 287
- 10.9 Sense of Sight 289

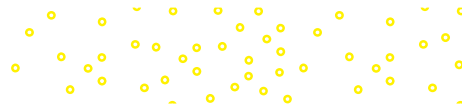
11 Endocrine System 303

- 11.1 Introduction 304
- 11.2 Hormone Action 306
- 11.3 Control of Hormonal Secretions 308
- 11.4 Pituitary Gland 309



JoeSAPhotos/Shutterstock

- 11.5 Thyroid Gland 314
- 11.6 Parathyroid Glands 316
- 11.7 Adrenal Glands 317
- 11.8 Pancreas 321
- 11.9 Pineal, Thymus, and Other Endocrine Tissues and Organs 324
- 11.10 Stress and Health 324



UNIT 4 TRANSPORT

12 | Blood 332

- 12.1 Introduction 333
- 12.2 Formed Elements 335
- 12.3 Plasma 344
- 12.4 Hemostasis 345
- 12.5 Blood Groups and Transfusions 348

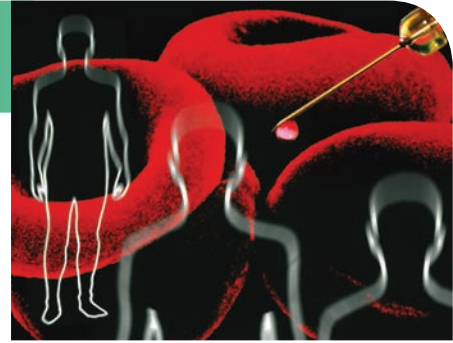
13 | Cardiovascular System 356

- 13.1 Introduction 357
- 13.2 Structure of the Heart 358

- 13.3 Heart Actions 365
- 13.4 Blood Vessels 372
- 13.5 Blood Pressure 377
- 13.6 Arterial System 382
- 13.7 Venous System 387

14 | Lymphatic System and Immunity 395

- 14.1 Introduction 396
- 14.2 Lymphatic Pathways 397
- 14.3 Tissue Fluid and Lymph 399



Steve Allen/Getty Images

- 14.4 Lymphatic Tissues and Organs 400
- 14.5 Body Defenses Against Infection 403
- 14.6 Innate (Nonspecific) Defenses 403
- 14.7 Immunity: Adaptive (Specific) Defenses 404

UNIT 5 ABSORPTION AND EXCRETION

15 | Digestive System and Nutrition 420

- 15.1 Introduction 421
- 15.2 General Characteristics of the Alimentary Canal 423
- 15.3 Mouth 424
- 15.4 Salivary Glands 428
- 15.5 Pharynx and Esophagus 429
- 15.6 Stomach 431
- 15.7 Pancreas 434
- 15.8 Liver and Gallbladder 435
- 15.9 Small Intestine 441
- 15.10 Large Intestine 445
- 15.11 Nutrition and Nutrients 448

16 | Respiratory System 465

- 16.1 Introduction 466
- 16.2 Organs and Structures of the Respiratory System 467
- 16.3 Mechanics of Breathing 474
- 16.4 Control of Breathing 480
- 16.5 Alveolar Gas Exchanges 482
- 16.6 Gas Transport 484

17 | Urinary System 491

- 17.1 Introduction 492
- 17.2 Kidneys 492
- 17.3 Urine Formation 498
- 17.4 Urine Elimination 507



Janice Haney Carr/CDC

18 | Water, Electrolyte, and Acid-Base Balance 515

- 18.1 Introduction 516
- 18.2 Distribution of Body Fluids 516
- 18.3 Water Balance 518
- 18.4 Electrolyte Balance 519
- 18.5 Acid-Base Balance 522
- 18.6 Acid-Base Imbalances 526



UNIT 6

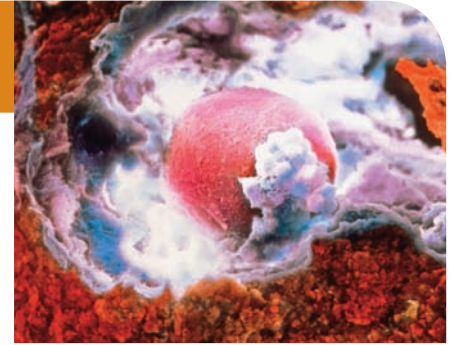
THE HUMAN LIFE CYCLE

19 Reproductive Systems 531

- 19.1 Introduction 532
- 19.2 Organs of the Male Reproductive System 532
- 19.3 Spermatogenesis 538
- 19.4 Hormonal Control of Male Reproductive Functions 539
- 19.5 Organs of the Female Reproductive System 542
- 19.6 Oogenesis and the Ovarian Cycle 546
- 19.7 Mammary Glands 552
- 19.8 Birth Control 553
- 19.9 Sexually Transmitted Infections 558

20 Pregnancy, Growth, Development, and Genetics 565

- 20.1 Introduction 566
- 20.2 Fertilization 566
- 20.3 Pregnancy and the Prenatal Period 568
- 20.4 Aging: The Human Life Span 581
- 20.5 Genetics 585



Prof. P.M. Motta & J. Van Blerkom/Science Source

APPENDIX A Aids to Understanding Words 594

APPENDIX B Scientific Method 595

APPENDIX C Metric Measurement System and Conversions 596

APPENDIX D Periodic Table of the Elements 597

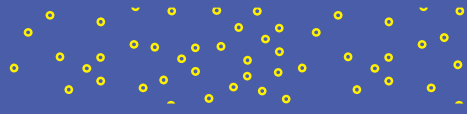
APPENDIX E Figure Question Answers 598

Glossary 600

Application Index 620

Subject Index 622

This page intentionally left blank



PREVIEW

Foundations for Success



A photo on the opening page for each chapter generates interest.
Comstock/Stockbyte/Getty Images

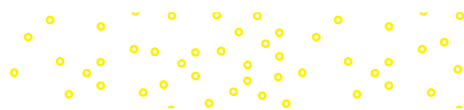
AN OPENING VIGNETTE discusses current events or research news relating to the subject matter in the chapter. These vignettes apply the concepts learned in the study of anatomy and physiology.

Pay attention. It is a beautiful day. You can't help but stare wistfully out the window, the scent of spring blooms and the 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—a classmate has dropped a human anatomy and physiology textbook on the floor. You jump. Your heart hammers 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 class. In this course, you will learn all about the events you have just experienced, including your response to the sudden stimulation. This is a good reason to stay focused.

This chapter Preview not only provides great study tips to offer a foundation for success, but it also offers tips on how to utilize this particular text. Those tips will be found in boxes just like this.

The digital tool, as indicated below and with APR icons within the chapters, allows you to explore the human body in depth through simulated dissection of cadavers, histology preparations, and 3D and anatomical model images. It also offers animations on chapter concepts.





LEARNING OUTLINE

After studying this chapter, you should be able to complete the “Learning Outcomes” that follow the major headings throughout the chapter.

P.1 Introduction

P.2 Strategies for Your Success

Each chapter has a learning outline introducing what will be discussed in the chapter.

The section Aids to Understanding Words introduces building blocks of words that your instructor may assign. Learning them is a good investment of your time, because they can be used over and over and apply to many of the terms you will use in your career. Appendix A has a comprehensive list of these prefixes, suffixes, and root words.

AIDS TO UNDERSTANDING WORDS

ana- [up] *anatomy*: the study of breaking up the body into its parts.

multi- [many] *multitasking*: performing several tasks simultaneously.

physio- [relationship to nature] *physiology*: the study of how body parts function.

(Appendix A has a complete list of Aids to Understanding Words.)

Major divisions within a chapter are called “A-heads.” They are numbered sequentially and set in very large, blue type to designate major content areas.

P.1 | Introduction

After each A-head is a list of learning outcomes indicating the knowledge you should gain as you work through the section. (Note the blue learn arrow preceding the “LEARN” heading.) These outcomes are intended to help you master the similar outcomes set by your instructor. The outcomes are tied directly to assessments of knowledge gained.



LEARN

1. Explain the importance of an individualized approach to learning.

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 different 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 although 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 with and use more effectively one or two, often referred to as 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 accommodates the range of learning styles. Read-write learners will appreciate the lists, definitions (glossary), and tables. Visual learners will discover many diagrams, flow charts, and figures, all with consistent and purposeful use of color. For example, a particular bone is always the same color in figures where bones are color-coded. Auditory learners will find pronunciations for new scientific terms to help sound them out, and kinesthetic learners can relate real-life examples and applications 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 new information. (Note the green practice arrow preceding the “PRACTICE” heading.) If you cannot answer the question(s), you should reread that section, being on the lookout for the answer(s).



PRACTICE P.1

1. List some difficulties a student may experience when studying the human body.
2. Describe the ways people learn.

P.2 | Strategies for Your Success



LEARN

1. Summarize what you should do before attending class.
2. Identify student activities that enhance classroom experience.
3. List and describe several study techniques that can facilitate learning new material.

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

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

Before Class

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 strategy introduces the topics of the next class discussion, as well as new terms. Some students team a vocabulary list with each chapter’s notes. Take the notes from the reading to class and expand them. At a minimum, the student should at least skim the text, reading the A-heads and B-heads and the summary outline to become acquainted with the topics and vocabulary before class.

Of Interest provides bits of anatomy and physiology information that add wonder and awe to some of the chapter concepts.



OF INTEREST The skeleton of an average 160-pound person contributes about 29 pounds total body weight.

Many students who use this book and take various other courses in the health sciences are preparing for careers in health care. Some students may be undecided as to a specific area or specialty. The Career Corner feature presents a description of a particular career choice with each chapter. If it doesn’t describe a career that you seek, perhaps it will give you a better sense of what some of your coworkers and colleagues do!



CAREER CORNER

Massage Therapist

The woman feels something give way in her left knee as she lands from a jump in her dance class. She limps away between her classmates, in great pain. At home, she uses “RICE”—rest, ice, compression, elevation—then has a friend take her to an urgent care clinic, where a physician diagnoses patellar tendinitis, or “jumper’s knee.” Frequent jumping followed by lateral movements caused the injury.

Three days later, at her weekly appointment with a massage therapist for stress relief, the patient mentions the injury. Over the next few weeks, the massage therapist applies light pressure to the injured area to stimulate circulation, and applies friction in a transverse pattern to break up scar tissue and relax the muscles. She also massages the muscles to improve flexibility.

A massage therapist manipulates soft tissues, using combinations of stroking, kneading, compressing, and vibrating, to relieve pain and reduce stress. Training includes 300 to 1,000 hours of class time, hands-on practice, and continuing education. Specialties include pediatrics, sports medicine, and even animal massage.

As you read, you may feel the need for a “study break” or to “chill out.” At other times, you may just need to shift gears. Try the following: Look for the Clinical Application boxes throughout the book that present sidelights to the main focus of the text. Some of these may cover topics that your instructor chooses to highlight. Read them! They are interesting, informative, and a change of pace.



CLINICAL APPLICATION P.1

Factors Affecting Synaptic Transmission

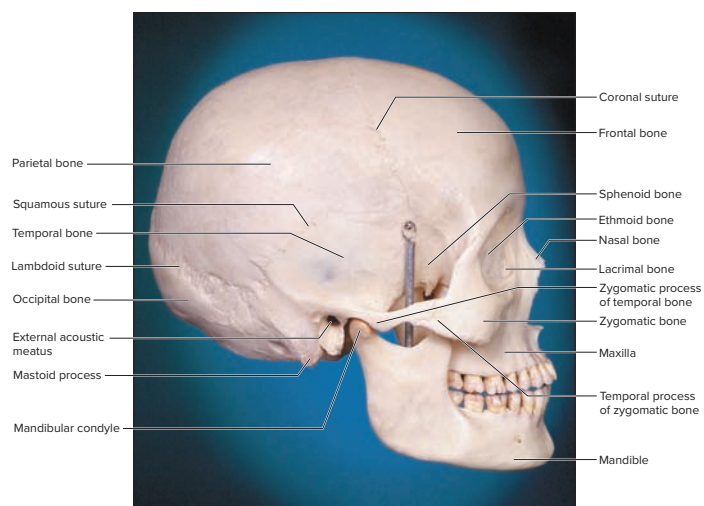
Many chemicals affect synaptic transmission. A drug called Dilantin (diphenylhydantoin) treats seizure disorders by blocking gated sodium channels, thereby limiting the frequency of action potentials reaching the axon terminal. Caffeine in coffee, tea, cola, and energy drinks stimulates nervous system activity by lowering

the thresholds at synapses. As a result, postsynaptic neurons are more easily excited. Antidepressants called “selective serotonin reuptake inhibitors” keep the neurotransmitter serotonin in synapses longer, compensating for a still little-understood decreased serotonin release that presumably causes depression.

Remember when you were very young and were presented with a substantial book for the first time? You were likely intimidated by its length but were reassured that it contained “a lot of pictures.” This book has many “pictures” (figures) too, all designed to help you master the material. Some of the figure legends are followed by a question pertaining to that figure, intended to reinforce a concept or usage of terminology.

Photographs and Line Art

Photographs provide a realistic view of anatomy.



©J & J Photography

Line art can present different positions, layers, or perspectives.

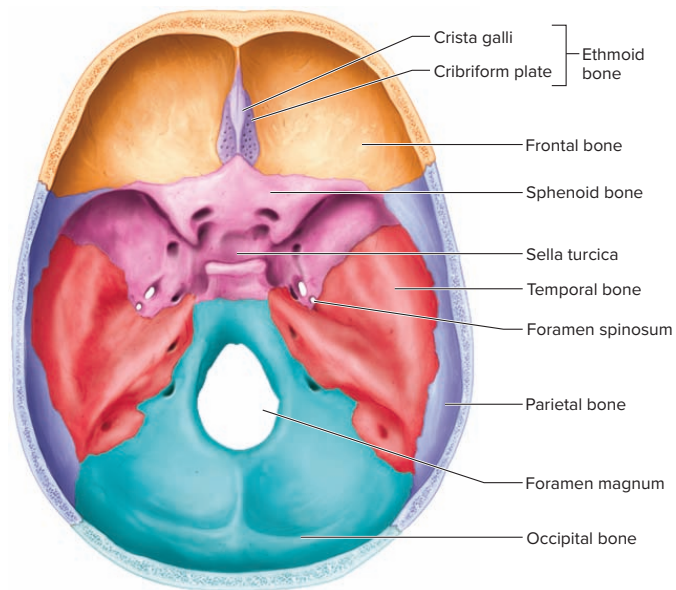


Figure questions encourage you to think about what you are seeing and “PRACTICE” making connections between the visual representation and the words in the text.



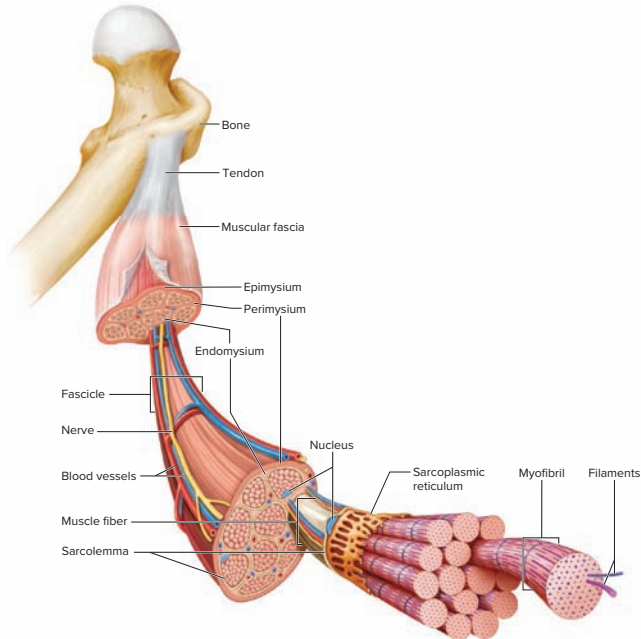
PRACTICE FIGURE P.2

What is the most posterior bone on the skull?

Answer can be found in Appendix E.

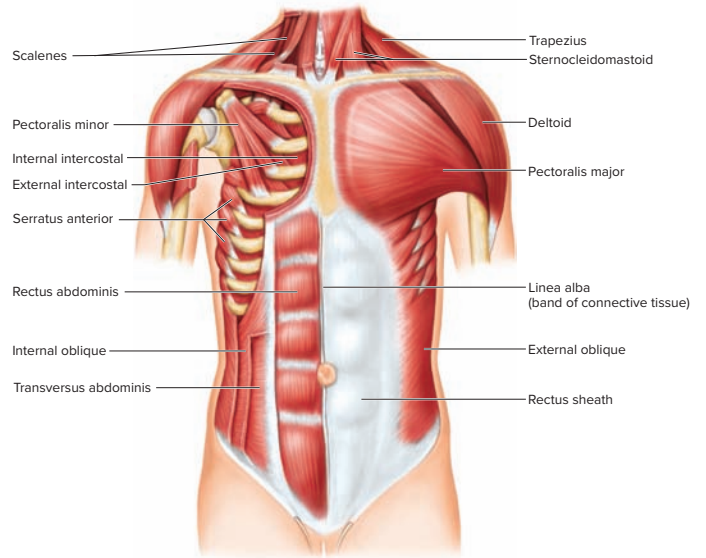
Macroscopic to Microscopic

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



Anatomical Structures

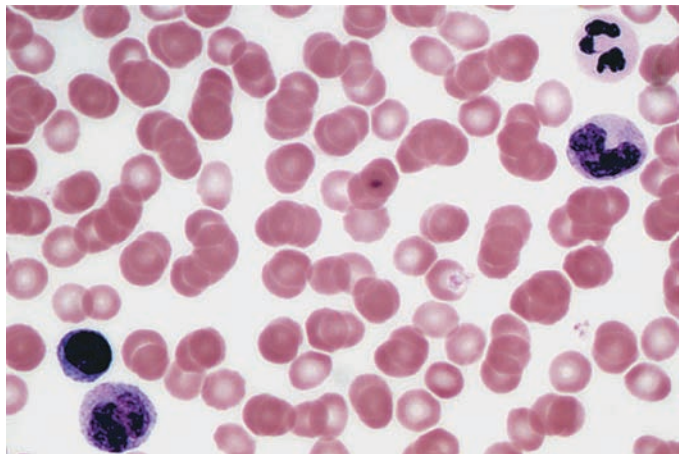
Some figures illustrate the locations of anatomical structures.



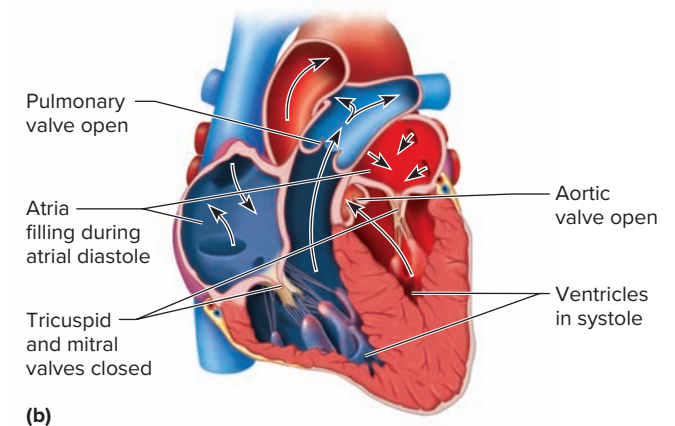
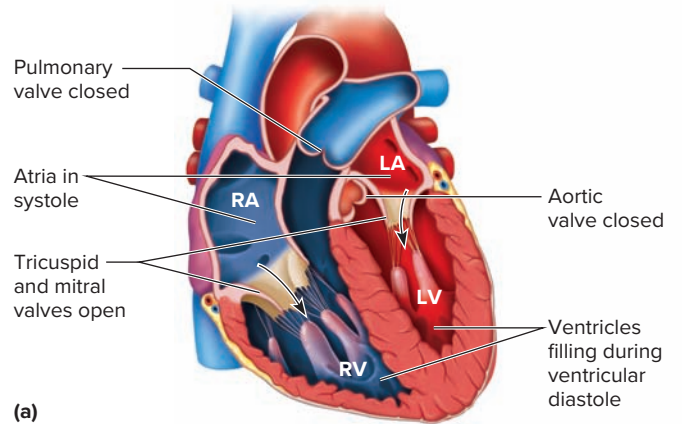
Other figures illustrate the functional relationships of anatomical structures.

Micrographs

Some figures are microscope images of a histological preparation.

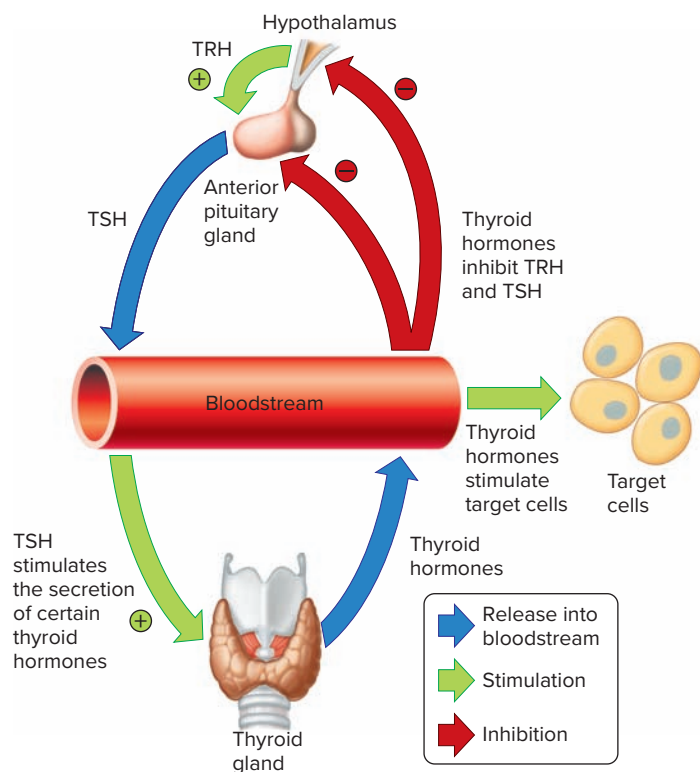


Al Telser/McGraw Hill



Flow Charts

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



Organizational Tables

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

Type	Function	Location
Skeletal muscle tissue (striated)	Voluntary movements of skeletal parts	Muscles usually attached to bones
Smooth muscle tissue (lacks striations)	Involuntary movements of internal organs	Walls of hollow internal organs
Cardiac muscle tissue (striated)	Heart movements	Heart muscle

It is critical that you attend class regularly, and be on time—even if the instructor’s notes are posted online 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 your outline or the notes you took while reading. Auditory learners benefit from recording the lectures and listening to them while doing chores that do not require their cognitive attention, with mental focus being on the lecture content.

Participate in class discussions, asking questions of the instructor and answering questions posed. 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 class, for 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 you. Highlighting or underlining (in color, for visual learners) the key terms, lists, important points, and major topics make them stand out, which is helpful for 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 you study the muscles of the thigh, you will find it easier to learn the insertion, origin, action, and nerve supply of the four muscles making up the quadriceps femoris if you study them as a group, because they all have the same insertion, action at the knee, and nerve supply—they differ only in their origins. Concept mapping is a study strategy that may also be useful to visually identify relationships among concepts, to organize and categorize information into chunks, and to make meaningful connections.

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 parades often test soldiers’ endurance* stands for the skull bones **f**rontal, **p**arietal, **o**ccipital, **t**emporal, **s**phenoid, and **e**thmoid. 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: **i**nterphase, **p**rophase, **m**etaphase, **a**naphase, and **t**elophase. Be inventive! Develop mnemonic devices that you find helpful!

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, then 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 the name of 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, multi-task. When you are waiting for a ride or sitting in a doctor's waiting room, use your time by reviewing notes or reading the text.

Daily repetition is helpful, so you should schedule several short study periods each day instead of an end-of-semester crunch to cram for an exam. This does not take

the place of time spent to prepare for the next class. If you follow these suggestions for learning now, you can maximize your study time throughout the semester and will give yourself your best prospects for academic success. A working knowledge of the structure and function of the human body provides the foundation for all careers in the health sciences.



PRACTICE P.2

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



ASSESS

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.2 Strategies for Your Success

2. Methods to prepare for class include _____.
 - a. reading the chapter
 - b. outlining the chapter
 - c. making a vocabulary list
 - d. all of the above
3. Describe how you can participate in class discussions.



ASSESS

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. Critical thinking is all about linking previous concepts with current concepts under novel circumstances, in new ways. Toward this end, we have included in the Integrative Assessments/Critical Thinking exercises referencing sections from earlier chapters. Making connections is what it is all about!

Outcomes P.1, P.2

1. Which study methods are most successful for you?

Outcome P.2

2. Design a personalized study schedule.



Chapter Summary

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

P.1 Introduction

Try a variety of methods to study the human body.

P.2 Strategies for Your Success

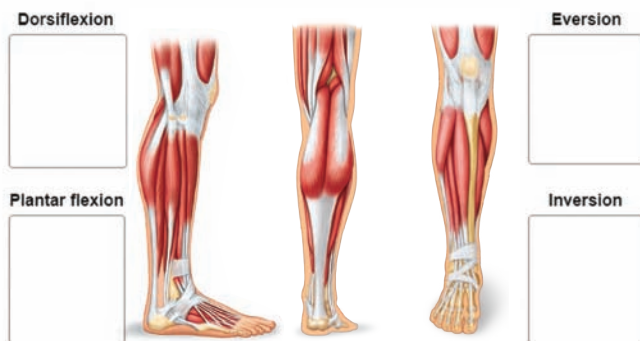
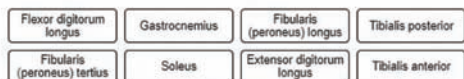
Although strategies for academic success seem to be common sense, you might benefit from reminders of study methods.

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

Check out McGraw Hill online resources that can help you practice and assess your learning.

Digital Connect Resources Reinforce your knowledge and practice your understanding.

Classify each muscle that moves the foot based on its major (primary) action.



- b. Figures depicting macroscopic to microscopic show an increase in detail.
- c. Flow charts depict sequences and steps.
- d. Figures of anatomical structures show locations.
- e. Organizational charts/tables summarize text.
2. During class
 - Take notes and participate in class discussions.
3. After class
 - a. Organize, edit, and review class notes.
 - b. Creating lists, categorizing, and concept mapping are effective study strategies.
 - c. Mnemonic devices aid learning.
 - (1) The first letters of the words you want to remember begin words of an easily recalled phrase.
 - (2) The first letters of the items to be remembered form a word.
 - d. Small study groups reviewing and vocalizing material can divide and conquer the learning task.
 - e. Making flash cards helps the tactile learner.
 - f. Time management skills encourage scheduled studying, including daily repetition instead of cramming for exams.

SmartBook continually adapts to the individual learner's needs, creating a more productive learning experience.

The screenshot shows the SmartBook interface for a lesson on '5.5 | Muscle Tissues'. The interface includes a progress bar, a multiple-choice question, and a confidence level indicator. The question asks: 'What does the most word "tall" mean?' with options: a) give, b) cartage, c) bone, d) cell. The confidence level is set to 'High'.

Anatomy & Physiology Revealed Go more in depth using virtual dissection of a cadaver, histological preparations, 3D and anatomical model images, and animations.



Introduction to Human Anatomy and Physiology

1



Similarities of a robotic hand and human hand. maxuser/Shutterstock



Noticing the metal peeking from her uncle's pant leg, the inquisitive child's eyes widened in awe. She didn't hesitate with her questions, asking "Why do you have it?" and "How does it work?" as he took off the prosthetic limb to show her and explain.

The design of a prosthetic is intended to replace the anatomical structure and function of the original body part. Artificial toes composed of wood and leather were the earliest prosthetics, and have been discovered in Egypt as part of the mummified remains of an ancient Egyptian noblewoman. The artificial toes allowed for the distribution of body weight and forward propulsion, and looked anatomically similar to real toes. Enormous casualties in World War I resulted in a demand for artificial limbs for veterans, so they could return to work after the war. Over the years, prosthetic limbs have evolved from the more rudimentary prosthetics to those that can be controlled by using the mind.

Materials used in the modern-day construction of prosthetic body parts include strong and lightweight materials such as

carbon fiber. Harnessing these new materials and the use of 3D printing has improved function and aesthetics. Cutting-edge technology, called targeted muscle reinnervation, which surgically reassigns nerves that once controlled the arm or hand, has recently been developed by engineers at the Applied Physics Laboratory at Johns Hopkins University. Imagine the excitement of receiving a robotic arm that allows individual and simultaneous finger control, two degrees of movement at the wrist, and multiple grips, enabling a person to control the prosthetic device by just thinking of the action. To avoid the need for a harness that can be uncomfortable, modern devices use osseointegration, a surgical procedure that fixes a titanium implant into the marrow space of bone, and which eventually becomes part of the bone. A few weeks after surgery, a titanium extension is brought out through the skin so the prosthetic can be attached. These technologies can improve the lives of people who were born without their limbs, or who have lost them due to infection, cancer, trauma, or combat.