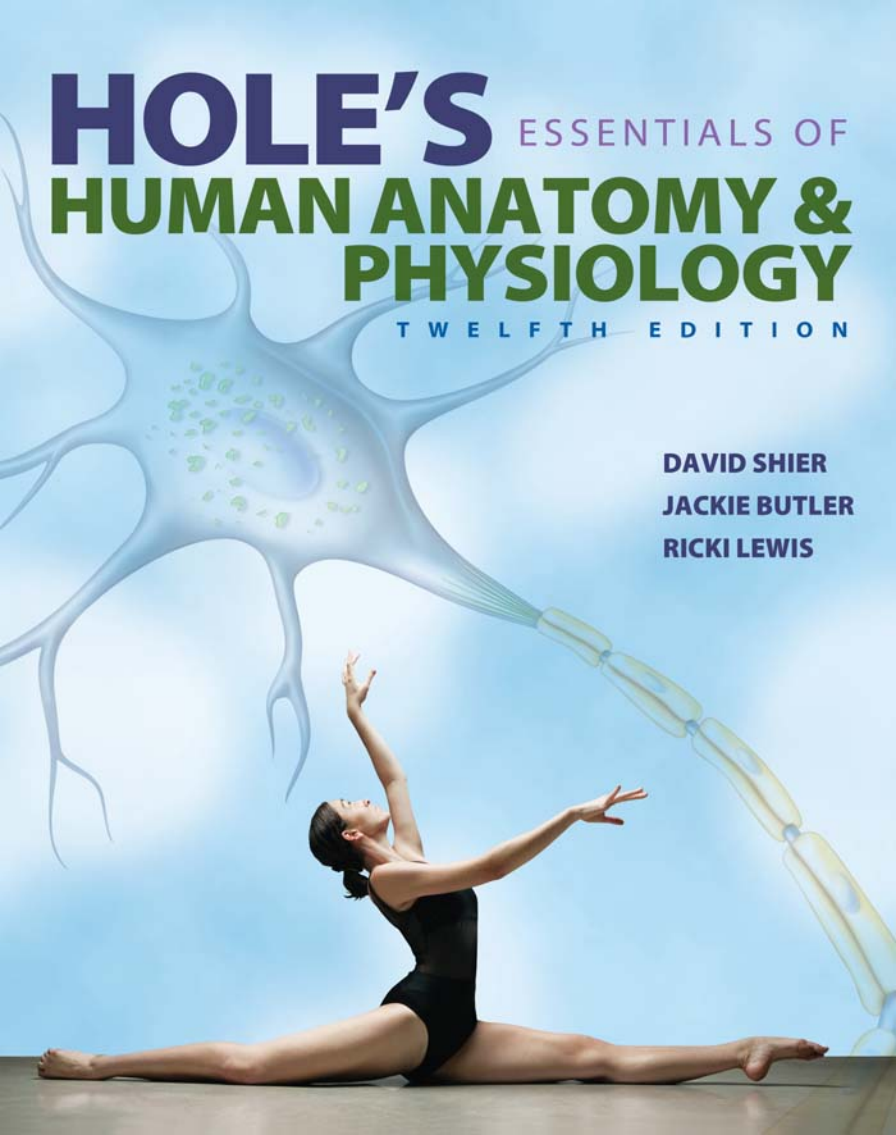
HOLE'S ESSENTIALS OF HUMAN ANATOMY & PHYSIOLOGY

TWELFTH EDITION

DAVID SHIER
JACKIE BUTLER
RICKI LEWIS



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TWELFTH EDITION

DAVID SHIER
WASHTENAW COMMUNITY COLLEGE

JACKIE BUTLER
GRAYSON COLLEGE

RICKI LEWIS
ALBANY MEDICAL COLLEGE

Mc Graw Hill Education

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This book is printed on acid-free paper.

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ISBN 978–0–07—340372–4
MHID 0–07–340372–5

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Typeface: *10.5/12 ITC Garamond STD Light*
Printer: *R. R. Donnelley*

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Library of Congress Cataloging-in-Publication Data

Shier, David.
Hole's essentials of human anatomy & physiology / David Shier, Washtenaw Community College ; Jackie Butler, Grayson College ; Ricki Lewis. – Twelfth edition.
pages cm.
Includes index.
ISBN 978–0–07–340372–4 — ISBN 0–07–340372–5 (hbk. : alk. paper) 1. Human physiology. 2. Human anatomy. I. Butler, Jackie. II. Lewis, Ricki. III. Title. IV. Title: Hole's essentials of human anatomy and physiology.
[DNLM: 1. Anatomy. 2. Physiology.]
QP34.5.S49 2015
612–dc23 2013035627

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BRIEF CONTENTS

ABOUT THE AUTHORS

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*. His interest in physiology and teaching began with a job as a research assistant at Harvard Medical School from 1976-1979. He completed his Ph.D. at the University of Michigan in 1984, and served on the faculty of the Medical College of Ohio from 1985-1989. He began teaching at Washtenaw Community College in 1990. David has recent experience in online course delivery, including recording lectures for so-called "flipped" classrooms. He has also been interested in the relationship between pedagogy and assessment, and the use of tools traditionally associated with assessment (e.g. lab quizzes) as pedagogical tools, often associated with group activities.

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 thirty years at Grayson College, Jackie has taught 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'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 has authored the textbook *Human Genetics: Concepts and Applications* and books about gene therapy, stem cells, and scientific discovery. She is a genetic counselor for a large medical practice, teaches a graduate online course in "Genethics" at Albany Medical College, and writes for Medscape, the Multiple Sclerosis Discovery Forum, and Scientific American. Ricki writes the popular DNA Science blog at Public Library of Science and is a frequent public speaker.

MEET THE AUTHORS
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DIGITAL AUTHORS

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 with her research on the kinematics of locomotion. She currently works as an Assistant Clinical Professor in the Physical Therapy Department of Northeastern University with her main teaching role in Gross Anatomy and Neuroanatomy courses. Students enjoy her clinical teaching style and use of technology. She has received the teaching with technology award three times and in 2009 was awarded the Excellence in Teaching Award. She has been asked to speak about teaching with technology at national conferences and to give workshops on gross anatomy to a variety of professionals. She has also worked as a personal trainer both in local fitness facilities and at clients' homes, a strength and conditioning coach for collegiate athletic teams, an Assistant Groups Exercise Director for Healthworks and Group Exercise, and Fitness Director of three sites for Gold's Gym.

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 full-time at the University of Southern Indiana, Evansville. Her work with McGraw-Hill began several years ago, doing reviews of textbook chapters and lab manuals. More recently, she has been involved in content development for LearnSmart. In her A&P course at USI, she has also used Connect and has enjoyed the challenge of writing some of her own assignments. When the opportunity arose to become more involved in the authoring of digital content for McGraw-Hill, she could not pass it up. Based on her own experience, students are using more and more online resources, and she is pleased to be part of that aspect of A&P education. .

NEW TO THIS EDITION

Global Changes

- Every piece of art updated to make it more vibrant, three-dimensional, and instructional.
- New digital authors created a seamless relationship between textbook and ancillaries/digital products in clever and engaging ways.
- Connect Question Bank has the same new art as the text and many new questions. Each Connect Question Bank chapter also includes an integrated question (a multi-step integration of chapter concepts).
- Career Corners, new to each chapter, introduce students to interesting career options.
- Each chapter ends with a list of online tools that students may use to study and master the concepts presented.

Specific Changes At-a-Glance

Chapter	Topic	Change
1	Scientific method	Chapter 1 introduces and Appendix B expands coverage
1	A&P updates	Rewritten with new examples
1	Body fluid compartments	New figure (1.4)
1	Homeostasis	Figure 1.8 (previously 1.4) simplified
1	Systems	More detailed introduction
1	Positional terms	Figure 1.14 redone with model
1	Body sections	Figure 1.15 sections now match sectional planes
1	Body regions	Use of terms "lateral," "inguinal," and "pubic"
1	Anatomical Plates	Redrawn for accuracy
2	Proteins	Levels of protein structure section rewritten
2	Atomic structure	Figures 2.4, 2.5, 2.7, now show corresponding IUPAC color of the element and number of protons, neutrons, and electrons
2	Polar molecules	Description reworded
2	Protein structure	Figure 2.18 better shows relationships among structural levels of a protein
3	Cell structure	Figure 3.2 added depth and vertical perspective; organelles more realistic
3	Mitochondria	New box on mitochondrial inheritance
3	Cilia	New box on cilia subtypes and related ciliopathies
3	Intracellular membranes	Figures 3.4, 3.5, 3.6, 3.10 have enlargement boxes that show phospholipid bilayers in membrane bounded organelles
3	Ion channels	Figure 3.14 now includes an ion channel
3	Phagocytosis	Figure 3.19 now has five steps
3	Cellular differentiation	Figure 3.23 simplified to better illustrate the roles of stem cells and progenitor cells
4	Metabolic reactions	New text art overview of metabolism
4	Metabolic pathways	New figure 4.8 shows a general metabolic pathway as a cycle, to lead into the specific example of citric acid cycle; reordered text to facilitate understanding
4	DNA structure	Figures 4.11 and 4.12 better depict relationship between bases and sugar-phosphate backbone
4	DNA versus RNA	Table 4.2 replaces figure 4.12 comparing DNA and RNA complementary base pairing
4	Complementary base pairing	Art for base pairs moved into figure 4.13, in context of transcription and translation
4	Transcription and translation	Figure 4.13 now shows translation beginning at the start codon
4	Translation	Figure 4.14 now shows translation beginning at the start codon and depicts correspondence between specific amino acids and specific codons
5	Tissue structure	All figures show more 3D idealized structure alongside a micrograph
5	Thin sections	Figure 5.1 is new and presents examples of how different cut sections would appear on a microscope slide

Continued next page—

NEW TO THIS EDITION

Specific Changes At-a-Glance *—Continued*

Chapter	Topic	Change
5	Connective tissues	Material added regarding blood supply
5	Micrographs	New micrographs for figures 5.2, 5.3, 5.4, 5.11, 5.12, 5.14, 5.19, 5.22, 5.23, 5.24, and 5.25
6	Skin functions	Material added to section on Vitamin D
6	Skin structure	Figure 6.1 adds hair bulge and new micrograph
6	Hair follicles	Material on the hair bulge added to text
6	Fingernails	Figure 6.4 redrawn and a new second view (orientation) added
6	Hair follicle	Figure 6.5 redrawn to include hair bulge, apocrine sweat gland and merocrine sweat gland
6	Sweat glands	Text describes merocrine (eccrine) and apocrine sweat glands
6	Wound healing	Figure 6.8 is new and shows the stages in healing of skin wounds
7	Bone marrow transplants	Rewritten box
7	Bone figures	Figures of the skeleton and of individual bones redrawn throughout
7	Skeletal structures	Table 7.2 "sulcus" added
7	Levers and movement	Figure 7.7 redrawn
7	Skull	Figures 7.10–7.16 have new coloring to clearly identify individual skull bones
7	Cleft palate	Rewritten box
7	Vertebrae	Wording added to section on the atlas
7	Vertebrae	Figures 7.18 and 7.19 redrawn
7	Atlas and axis	Figure 7.19 orientation arrows added
7	Scapula	Figure 7.22 redrawn to better correspond to location icon
7	Skeleton	Figures 7.23, 7.24, 7.25, 7.26, and 7.27, location icons added
7	Male and female skeletons	Table 7.3 rewritten
7	Hip bone	Figure 7.28 redrawn
7	Synovial joint	Figure 7.36 redrawn
7	Synovial joints	Rewritten text on joint capsule
7	Movements	Paragraphs added to clarify movement terms in context of anatomical position. Lateral flexion added
7	Movements	Figure 7.38 lateral flexion added
8	Muscle structure	Figure 8.1 redrawn to better show the relationship among epimysium, perimysium, and endomysium
8	Muscle fiber structure	Figure 8.4 redrawn to better show transverse tubules and to better illustrate relationship between thick and thin filaments
8	Neuromuscular junction	Section reorganized
8	Role of actin and myosin	Myosin heads distinguished from cross-bridges formed with actin
9	Contraction cycle	Figure redrawn to better separate continued contraction from relaxation
8	Mechanism of contraction	Figure redrawn to show pulling from both ends of sarcomere. Enlargement boxes added
8	Creatine phosphate	Figure 8.9 redrawn
8	Oxygen supply	Role of myoglobin rewritten
8	Oxygen debt and muscle fatigue	Formation of lactic acid, fate of lactate, and their roles in muscle fatigue rewritten
8	Motor units	Figure 8.13 redrawn to better isolate motor units
8	Agonists	Description of different muscle roles, such as agonist and antagonist, rewritten. New box on difference between agonist and prime mover
8	Muscle actions	Paragraphs added to clarify movement terms in context of anatomical position; paragraph added on multiple actions of certain muscles
8	Scalene muscles	Figures 8.17 and 8.19 now include scalenes
8	Muscles that move the head	Table 8.6 now includes scalenes and alternate role of muscles that aid in forceful inhalation
8	Muscles that move the arm	Paragraph added to clarify movements of flexion and extension of the shoulder
8	Muscle actions	Anatomical terms from chapter 1 are used throughout
8	Muscle illustrations	Figures redrawn throughout
8	Muscles of the pelvic floor	Text and figure 8.24 now include the central tendon
9	"Nerve impulse" and "Nerve cell"	New box clarifying usage
9	Synapse	New paragraph on the synapse added to introduction

Specific Changes At-a-Glance —*Continued*

Chapter	Topic	Change
9	Action potential, impulse conduction, and synaptic transmission	Rewritten to clearly distinguish among these terms
9	Classification of neurons	Figure 9.7 now more diagrammatic
9	Facilitation	Explanation rewritten
9	Synapses	Figure 9.8 has a new part to show the schematic style of presenting neurons and synapses used throughout the chapter
9	Action potential	Figure 9.13 and the action potential introduction appear earlier in the chapter
9	Threshold	Figure 9.14 now includes a graph illustrating sub-threshold and threshold depolarization
9	Withdrawal reflex	Portions of this section rewritten
9	Brain	New brain figure
9	Brainstem	Figure 9.33 redrawn and locator icons added for anterior and posterior views
9	Cranial nerves	Figure 9.35 now has a (b) part illustrating the relationship of the nasal cavity, the olfactory nerve, and the olfactory bulb
10	Pain	Section now includes a reference to inhibition of pain pathways
10	Olfactory pathways	Limbic system added to discussion
10	Spiral organ	Figure 10.9 has improved drawings of innervation
10	Equilibrium	Figures 10.12 and 10.13 have improved location icons
10	Eye	Figures 10.14 and 10.17 now have location icons
10	Eye	FIgure 10.17 macula lutea added
10	Retina	Figure 10.22 new micrograph
10	Retinal neurons	Figures 10.21, 10.25, and 10.26 present same style for synapses as in chapter 9
11	Target cells	Figure 11.1 redrawn to emphasize that hormones reach all cells, but only target cells respond
11	Pituitary gland	New text on intermediate lobe added to box
11	Pituitary hormones	New discussion of neurons that secrete pituitary hormones
11	Pituitary blood vessels	Redrawn presentation of hypophyseal portal system and associated vessels
11	Adrenal gland	Figure 11.13 redrawn to better show different zones and adrenal medulla
11	Effects of epinephrine and norepinephrine	Table 11.5 rewritten
11	Pancreas	Reworked description of the exocrine pancreas
11	Melatonin	Rewritten box
12	Blood cell counts	New box on variations in counts from different sources
12	Red blood cells	Figure 12.3 now shows cell membrane in section
12	Red blood cell life cycle	Figure 12.6 redrawn and legend brought up into text in numbered steps
12	White blood cell counts	Text and Table 12.1 include new values
12	Blood groups and transfusions	Substantial text rewrite
12	Rh incompatibility	Figure 12.19 redone
13	Overview of circulation	Figure 13.1 is new
13	Blood oxygenation	New terms used are “oxygen-rich” and “oxygen-poor” blood
13	Pericardial membranes	New figure with an enlargement box
13	Heart valves	Figure 13.6 adjusted for better orientation
13	Blood flow through the heart	Figure 13.7 modeled after 13.1 with only certain areas highlighted
13	Coronary vessels	Figure 13.9 redrawn
13	Cardiac cycle	Substantial rewrite
13	Cardiac muscle fibers	Detail added on intercalated discs
13	Electrocardiogram	Substantial rewrite, figure 13.14 has new art
13	Blood pressure	Figure 13.24 shows pulsatile pressure ending at capillaries
13	Arteries	Figures 13.27, 13.28, 13.29, 13.30, and 13.31 were redrawn for accuracy and consistency
13	Veins	Figures 13.32, 13.33, and 13.35 redrawn; figure 13.34, labels added
14	Overview of lymphatic system	Figure 14.1 is new and modeled after 13.1 for consistency
14	Lymphatic structures	Section 14.5, Lymph Nodes, is expanded to include MALT and titled Lymphatic Tissues and Lymphatic Organs

NEW TO THIS EDITION

Specific Changes At-a-Glance —*Continued*

Chapter	Topic	Change
14	Spleen	Figure 14.6 redrawn to better illustrate sinuses and red pulp
14	Lymphocytes and fetal development	Figure 14.13 redrawn to more accurately represent a fetal bone
14	Body defenses	Figure 14.11 is a new summary table
14	T and B cell activation	Figure 14.14 redrawn to include phagolysosome
14	Primary and secondary responses	Figure 14.17 redrawn with peak levels corresponding to text description
14	Allergic reactions	Section rewritten and expanded, and box on anaphylaxis made part of text
15	Mesentery	Figure 15.3 redrawn to better show mesentery
15	Movements through alimentary canal	Figure 15.4 redrawn to better show mucosa
15	Pancreas	Box on pancreatitis rewritten
15	Appendix	Update regarding role in maintaining gut microbiome
15	Duodenum	Figures 15.15 and 15.19 redrawn to show duodenum in its normal position
15	Liver	Figure 15.17 redrawn and combined with a new micrograph that corresponds better to art
15	Mesentery	Figure 15.21 has a new enlargement box detailing mesentery structure
15	Villus	Figure 15.24 redrawn to be consistent with figure 15.3
15	Nutrition	Figure 15.33 now shows ChooseMyPlate.gov
15	Nutrients	Definition of nutrients added
15	Proteins	Wording added regarding protein digestion, absorption, and utilization
15	Vitamins	Table 15.9 has designations B7 and B9 added to vitamin names already listed
16	Organs of the respiratory system	Figure 16.1 and others redrawn, including lung anatomy
16	Pleural membranes	Figures 16.6, 16.7, and 16.11 redrawn, including color-coded representations
16	Inspiration	Scalenes added to text and figure 16.13
16	Expiration	Figure 16.14 now includes elastic recoil of the lungs
16	Respiratory volumes and capacities	Table 16.2 reworded
16	Control of breathing	Figure 16.18 representation of cranial nerves redrawn
16	Diffusion across the respiratory membrane	Added to explanation of how partial pressures and diffusional gradients are related
16	Gas transport	Added a sentence explaining oxygen–binding capacity of hemoglobin
16	Gas transport	Added a paragraph explaining drop on PO_2 due to mixing with bronchial venous blood
16	Gas transport	Figures 16.20, 16.21, 16.22, and 16.23 redrawn with similar presentations
17	Location of the kidneys	Figure 17.1 redrawn, vertebrae labeled as markers
17	Kidney structure	Rewritten section on renal cortex and renal medulla
17	Nephrons	Explanation of functional units
17	Blood Supply of a nephron	Clarification regarding pressure in the peritubular capillaries
17	Structure of a nephron	Figure 17.6 has new part showing functional relationships
17	Overview of urinary system	Figure 17.7 is a new flow chart summarizing the urinary system
17	Filtration pressure and filtration rate	Sections rewritten
17	Urine formation	Figures 17.9, 17.13, 17.14, and 17.15 redrawn in same style to highlight relationships among processes in urine formation
17	Renin-angiotensin system	Figure 17.12 redrawn to better show the primary source of angiotensin converting enzyme
18	Body Fluids	Figure 18.1 redrawn with new schematic presentation
18	Transcellular fluid	Reworded description
18	Fluid movements	Figure 18.3 redrawn and legend elements labeled in figure
18	Balance	Significant rewording
18	Hydrogen ion concentration	Reworded to ensure that changes in pH are reinforced in terms of changes in hydrogen ion concentration
18	Respiratory alkalosis	Figure 18.13 redrawn to parallel related figures
18	Metabolic alkalosis	Figure 18.14 redrawn with new material
19	Semen	Expanded description of seminal fluid and prostate secretions
19	Sperm count	Table 19A values updated
19	Hormonal effects in males	Figure 19.6 relabeled to be consistent with figure 19.13 on hormonal effects in the female

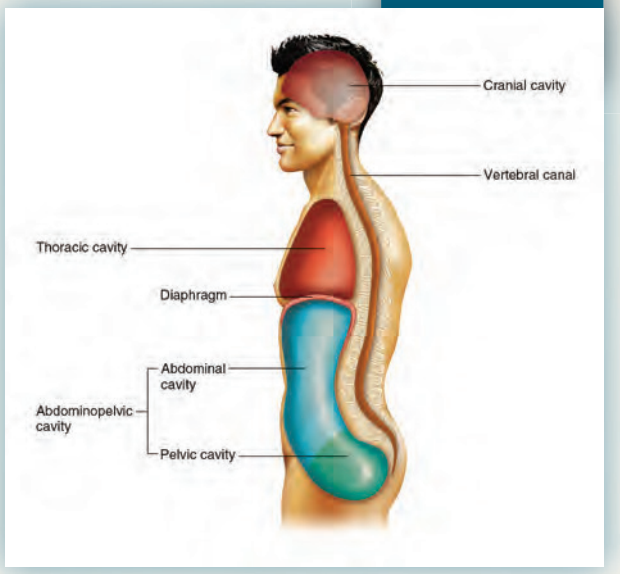
Specific Changes At-a-Glance —*Continued*

Chapter	Topic	Change
19	Female reproductive anatomy	Figure redrawn for accuracy
19	Oogenesis	Text rewritten to describe year-long maturation of a follicle
19	Ovarian cycle	Figure 19.9 redrawn to show stages of oogenesis as a timeline rather than cycle
19	Hormones of the ovarian cycle	Figure 19.14 redrawn to show more accurate hormone levels and only stages of follicle development in ovarian cycle
19	Menopause	Text reordered and rewritten for clarity
19	Contraceptives	Significant rewrite and additions
20	Fertilization	Section 20.2 retitled "Fertilization" and material on pregnancy moved to later section
20	Steps in fertilization	Text rewritten and figure 20.2 redrawn to more accurately show involvement of sperm cell membrane and enzymes
20	Pregnancy	Section 20.3 retitled "Pregnancy and the Prenatal Period" with text material added
20	Cleavage	Figure 20.3 redrawn for accuracy and consistency
20	Embryonic stage	Significantly reworked text with new material
20	Placenta	Figures 20.7, 20.8, 20.9, and 20.10 redrawn for consistency
20	Embryo	Figure 20.11 size expressed in millimeters
20	Prolactin	Material added to text
20	Fetal circulation	Terms "oxygen-poor blood" and "oxygen-rich blood" added to text and art

DYNAMIC NEW ART PROGRAM

Every piece of art has been updated to make it more vibrant, three-dimensional, and instructional. The authors examined every piece of art to ensure it was engaging and accurate. The twelfth edition's art program will help students understand the key concepts of anatomy and physiology.

12th Edition



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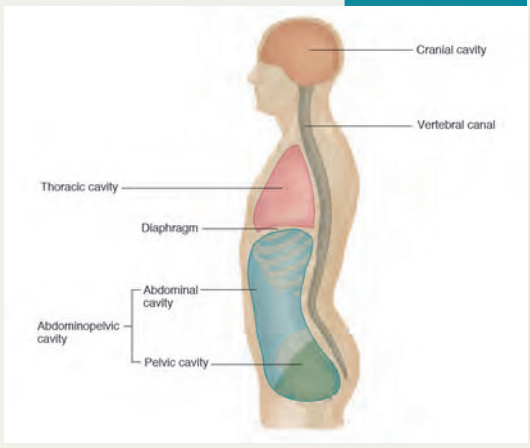

Realistic, three-dimensional figures provide depth and orientation.

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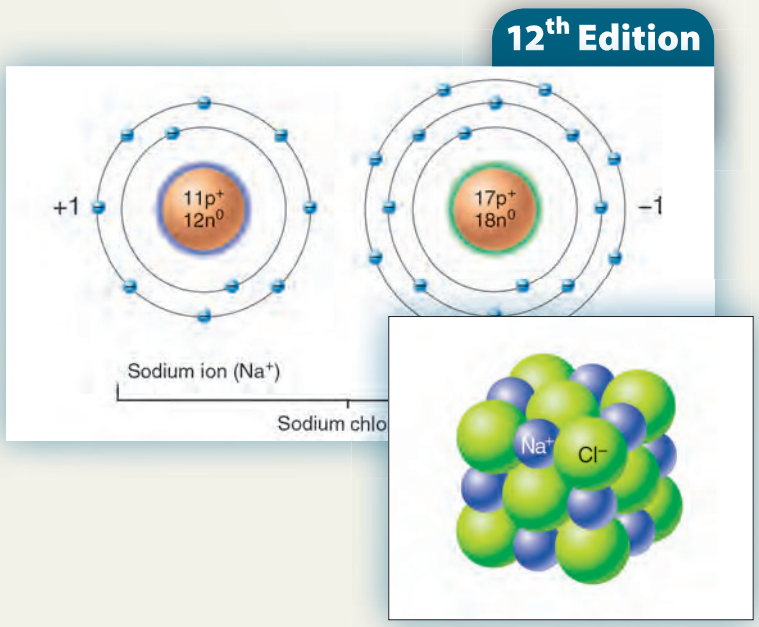

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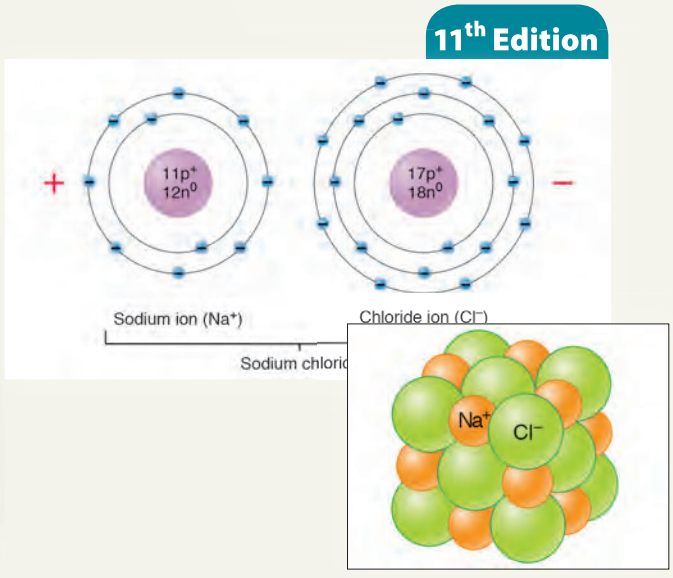

Colors highlighting atomic nuclei complement the atom colors in molecular models.

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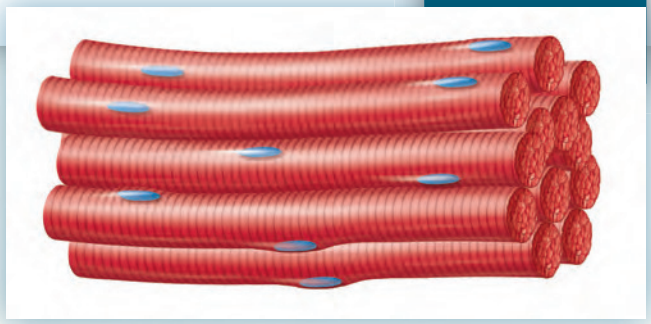

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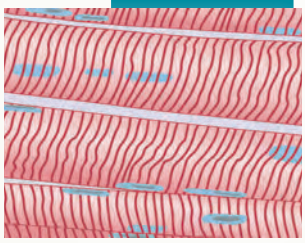

Line art for micrographs is three-dimensional to help students visualize more than just the flat microscopic sample.

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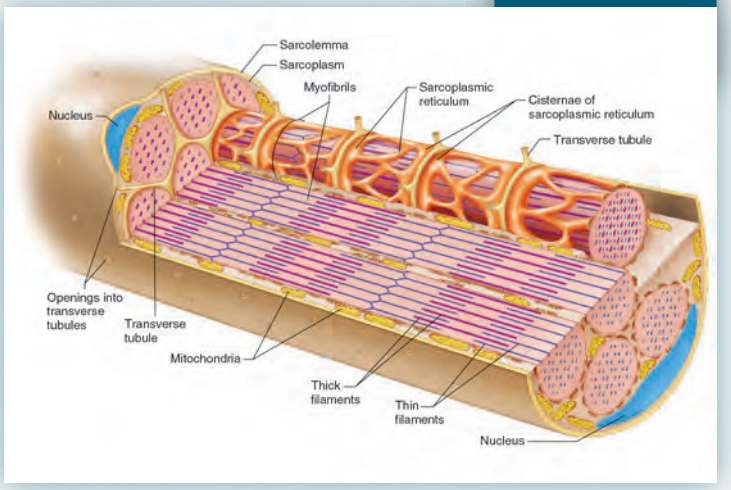

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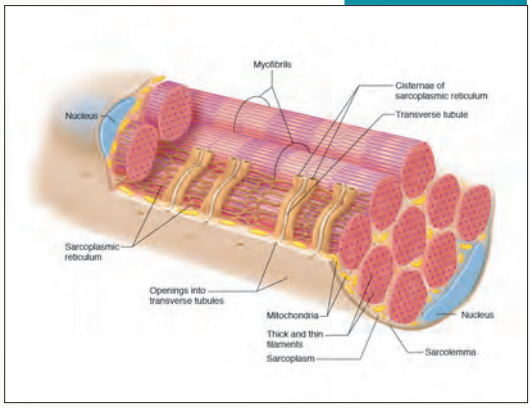

This longitudinal section shows the interior structures of a muscle fiber revealing more detail of the myofibrils, and thick and thin filaments.

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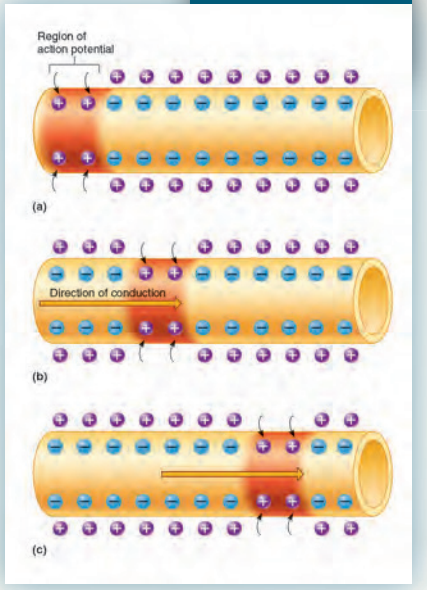

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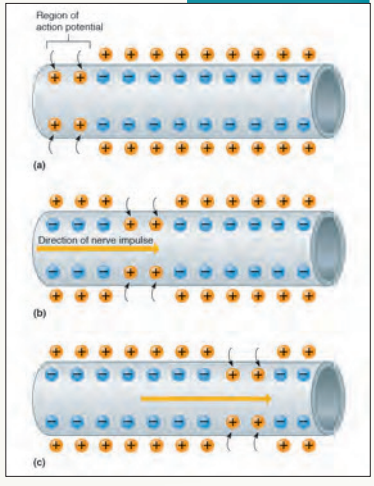

Color follows the movement of the action potential.

DYNAMIC NEW ART PROGRAM

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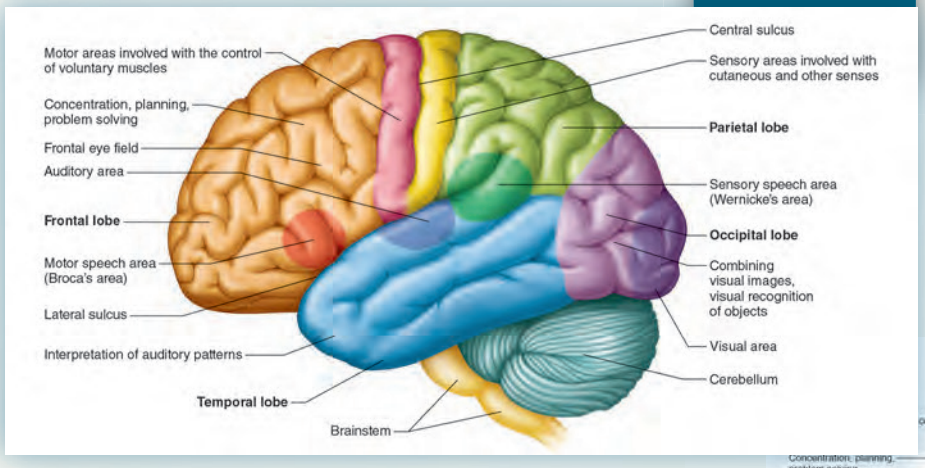

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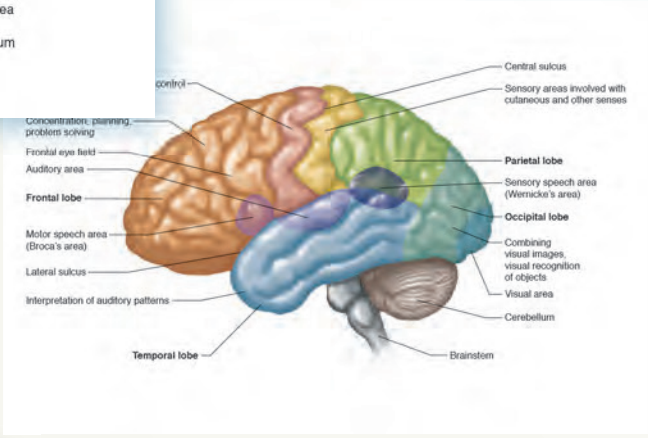

Colors distinguish functional areas more readily and figures are more accurately drawn.

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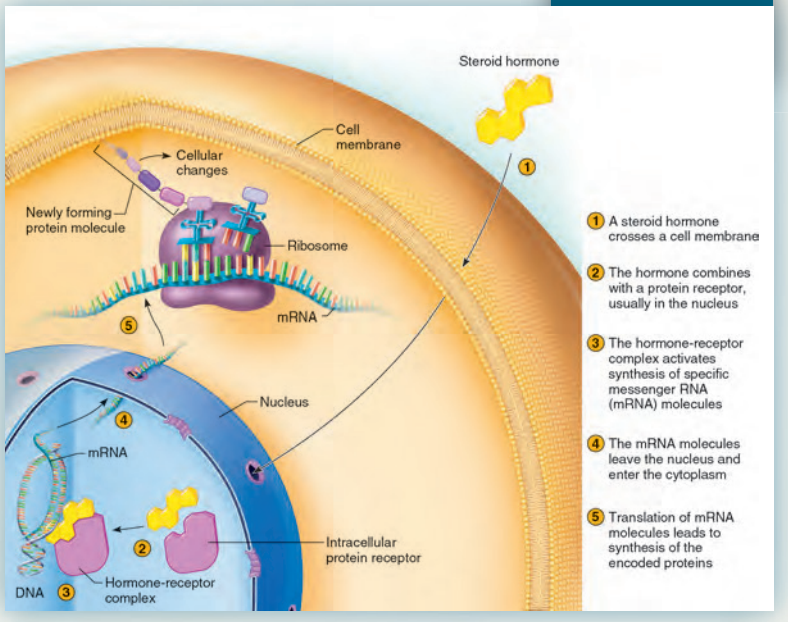

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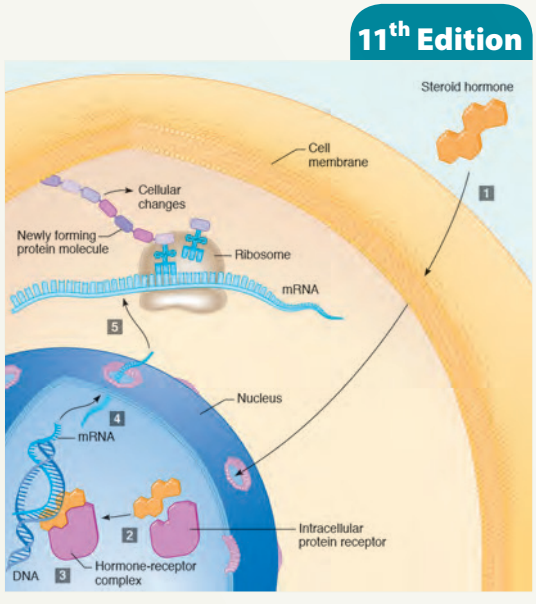

The explanation has been moved out of the legend to become part of the figure.

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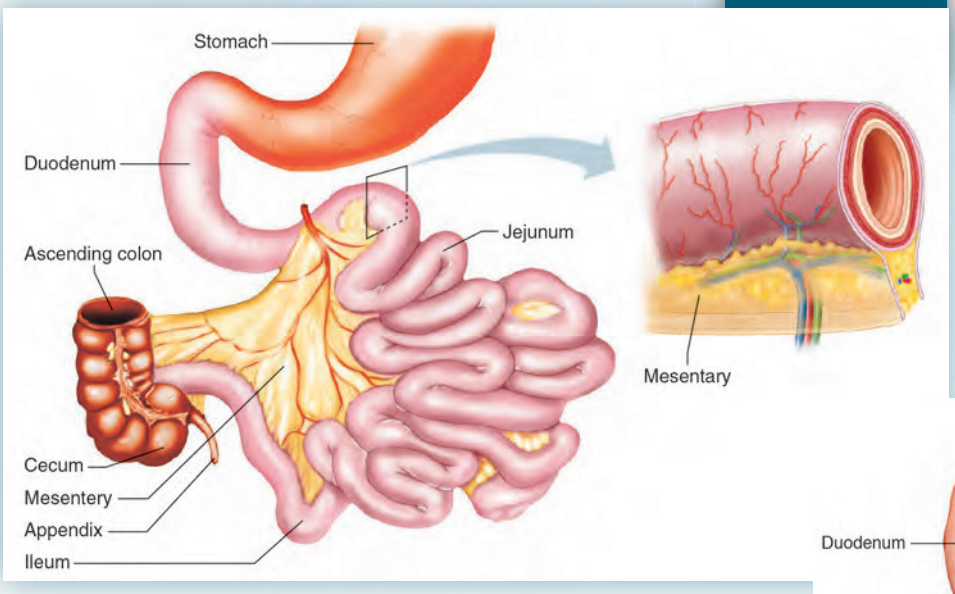
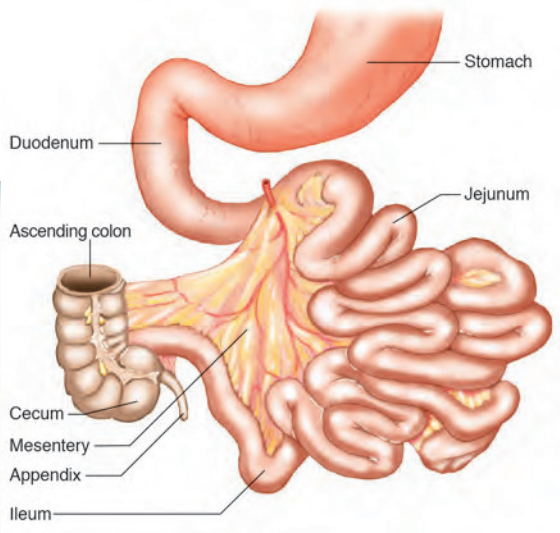


New enlargement shows the detail in the structure of the mesentery.

11th Edition



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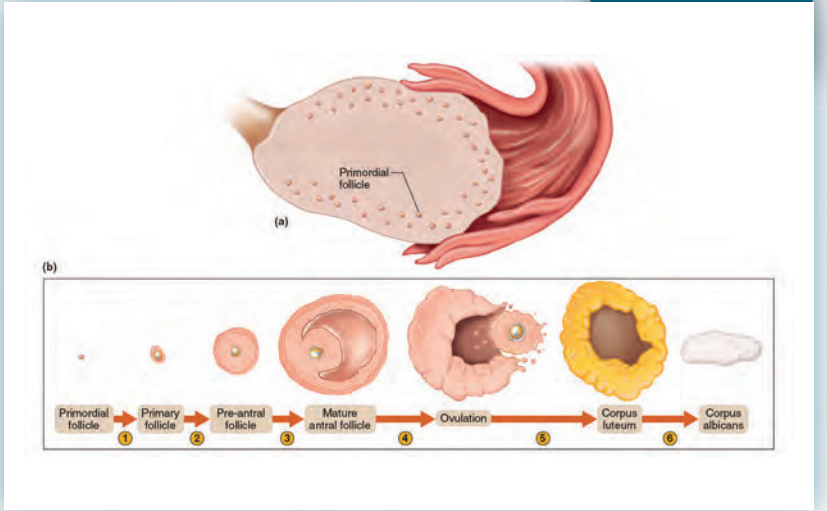

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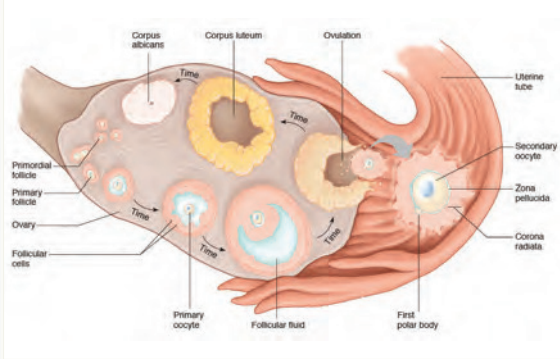
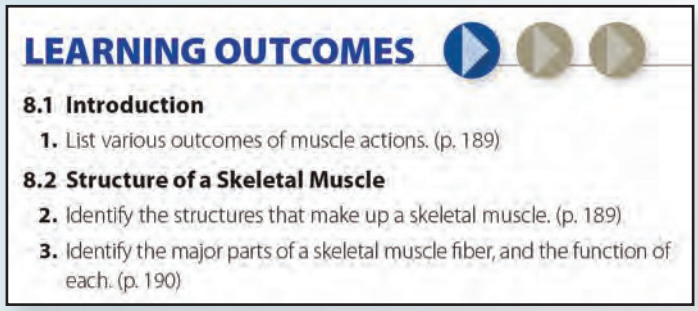


Process portrayed more accurately.

Learn, Practice, Assess!

Learn

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



LEARNING OUTCOMES

8.1 Introduction

1. List various outcomes of muscle actions. (p. 189)

8.2 Structure of a Skeletal Muscle

2. Identify the structures that make up a skeletal muscle. (p. 189)
3. Identify the major parts of a skeletal muscle fiber, and the function of each. (p. 190)

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

Muscular System

Double the muscle. The newborn had an astonishing appearance—his prominent arm and thigh muscles looked as if he'd been weightlifting in the womb. When the child reached five years of age, his muscles were twice normal size, and he could lift weights heavier than many adults could lift. He also had half the normal amount of body fat.

The boy's muscle cells cannot produce a protein called myostatin, which normally stops stem cells from developing into muscle cells. In this boy a mutation turned off this genetic brake, and as a result his muscles bulge, their cells both larger and more numerous than those in the muscles of an unaffected child. The boy is healthy so far, but because myostatin is also normally made in cardiac muscle, he may develop heart problems.

Other species with myostatin mutations are well known. Naturally "double-muscled" cattle and sheep are valued for their high weights early in life. Chicken breeders lower myostatin production to yield meatier birds, and "mighty mice" with silenced myostatin genes are used in basic research to study muscle overgrowth. In clinical applications, researchers are investigating ways to block myostatin activity to stimulate muscle growth to reverse muscle-wasting from AIDS, cancer, and muscular dystrophy. Myostatin could also be abused to enhance athletic performance.

Regular resistance training (weight training) can strengthen muscles.

Apart from double-muscle mutations, resistance (weight) training can increase the ratio of muscle to fat in our bodies, which offers several benefits. Because muscle cells burn calories at three times the rate of fat cells, a lean body is more energetically efficient. Weight training increases muscle strength and bone density; lowers blood pressure; decreases the risks of developing arthritis, osteoporosis, and diabetes mellitus; and is even associated with improved self-esteem and fewer sick days.

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

8.1 Introduction
1. List various outcomes of muscle actions. (p. 189)

8.2 Structure of a Skeletal Muscle
2. Identify the structures that make up a skeletal muscle. (p. 189)
3. Identify the major parts of a skeletal muscle fiber, and the function of each. (p. 190)
4. Discuss nervous stimulation of a skeletal muscle. (p. 192)

8.3 Skeletal Muscle Contraction
5. Identify the major events of skeletal muscle fiber contraction. (pp. 193–195)
6. List the energy sources for muscle fiber contraction. (p. 195)
7. Describe how oxygen debt develops. (p. 196)
8. Describe how a muscle may become fatigued. (p. 197)

8.4 Muscular Responses
9. Distinguish among a twitch, recruitment, and a sustained contraction. (pp. 198–200)
10. Explain how muscular contractions move body parts and help maintain posture. (pp. 198–200)

8.5 Smooth Muscle
11. Distinguish between the structures and functions of multiunit smooth muscle and visceral smooth muscle. (p. 201)
12. Compare the contraction mechanisms of skeletal and smooth muscle fibers. (p. 201)

188 LEARN PRACTICE ASSESS

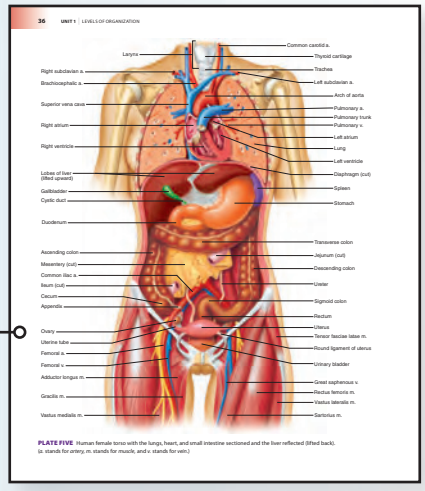
Module 6: Muscular System

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

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 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.



36 UNIT 1 LEVELS OF ORGANIZATION

PLATE FIVE Human female torso with the lungs, heart, and small intestine sectioned and the liver reflected (lifted back). (a. stands for artery, m. stands for muscle, and v. stands for vein.)

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. Found on key figures throughout the chapter.

PRACTICE

14. What are the functions of anabolism? Of catabolism?
15. What is the product of anabolism of monosaccharides? Of glycerol and fatty acids? Of amino acids?
16. Distinguish between dehydration synthesis and hydrolysis.

FIGURE 8.5 APR A neuromuscular junction includes the end of a motor neuron and the motor end plate of a muscle fiber.

Q *How does neurotransmitter released into the synaptic cleft reach the muscle fiber membrane?*

Answer can be found in Appendix F on page 582.

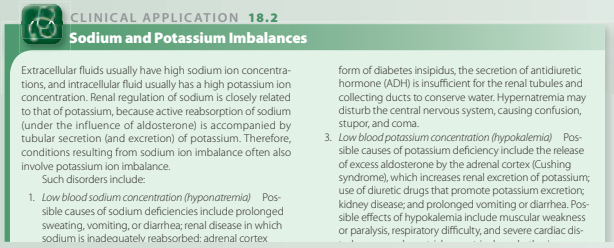
Boxed information expands on the concepts discussed in the text.

> Several hours after death, skeletal muscles partially contract and become rigid, fixing the joints in place. This condition, *rigor mortis,* may continue for 72 hours or more. It results from an increase in membrane permeability to calcium ions and a decrease in ATP in muscle fibers, which prevents relaxation. The actin and myosin filaments of the muscle fibers remain linked until the muscles begin to decompose.

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

FACTS OF LIFE The human body has more than 600 distinct skeletal muscles. The face alone includes 60 muscles, more than 40 of which are used to frown, and 20 to smile. Thinner than a thread and barely visible, the stapedius in the middle ear is the body's smallest muscle. In contrast is the gluteus maximus, the largest muscle, located in the buttock. The sartorius, which pulls on the leg just below the knee, is the longest muscle in the body.

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



CLINICAL APPLICATION 18.2

Sodium and Potassium Imbalances

Extracellular fluids usually have high sodium ion concentrations, and intracellular fluid usually has a high potassium ion concentration. Renal regulation of sodium is closely related to that of potassium, because active reabsorption of sodium (under the influence of aldosterone) is accompanied by tubular secretion (and excretion) of potassium. Therefore, conditions resulting from sodium ion imbalance often also involve potassium ion imbalance.

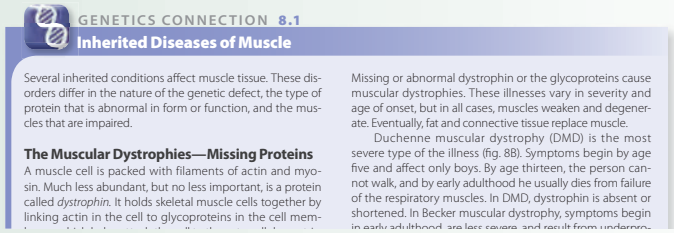
Such disorders include:

1. *Low blood sodium concentration (hyponatremia)* Possible causes of sodium deficiencies include prolonged sweating, vomiting, or diarrhea; renal disease in which sodium is inadequately reabsorbed; adrenal cortex

form of diabetes insipidus, the secretion of antidiuretic hormone (ADH) is insufficient for the renal tubules and collecting ducts to conserve water. Hypernatremia may disturb the central nervous system, causing confusion, stupor, and coma.

3. *Low blood potassium concentration (hypokalemia)* Possible causes of potassium deficiency include the release of excess aldosterone by the adrenal cortex (Cushing syndrome), which increases renal excretion of potassium; use of diuretic drugs that promote potassium excretion; kidney disease; and prolonged vomiting or diarrhea. Possible effects of hypokalemia include muscular weakness or paralysis, respiratory difficulty, and severe cardiac dis-

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.



GENETICS CONNECTION 8.1

Inherited Diseases of Muscle

Several inherited conditions 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 muscles that are impaired.

The Muscular Dystrophies—Missing Proteins

A muscle cell is packed with filaments of actin and myosin. Much less abundant, but no less important, is a protein called *dystrophin.* It holds skeletal muscle cells together by linking actin in the cell to glycoproteins in the cell mem-

Missing or abnormal dystrophin or the glycoproteins cause muscular dystrophies. These illnesses vary in severity and age of onset, but in all cases, muscles weaken and degenerate. Eventually, fat and connective tissue replace muscle.

Duchenne muscular dystrophy (DMD) is the most severe type of the illness (fig. 8B). Symptoms begin by age five and affect only boys. By age thirteen, the person cannot walk, and by early adulthood he usually dies from failure of the respiratory muscles. In DMD, dystrophin is absent or shortened. In Becker muscular dystrophy, symptoms begin

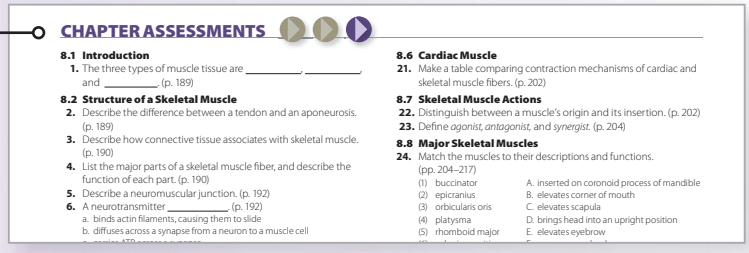
Assess

Tools to help you make the connection and master anatomy & 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.



CHAPTER ASSESSMENTS

8.1 Introduction

1. The three types of muscle tissue are _____, _____, and _____. (p. 189)

8.2 Structure of a Skeletal Muscle

2. Describe the difference between a tendon and an aponeurosis. (p. 189)

3. Describe how connective tissue associates with skeletal muscle. (p. 190)

4. List the major parts of a skeletal muscle fiber, and describe the function of each part. (p. 190)

5. Describe a neuromuscular junction. (p. 192)

6. A neurotransmitter _____. (p. 192)

a. binds actin filaments, causing them to slide

b. diffuses across a synapse from a neuron to a muscle cell

8.6 Cardiac Muscle

21. Make a table comparing contraction mechanisms of cardiac and skeletal muscle fibers. (p. 202)

8.7 Skeletal Muscle Actions

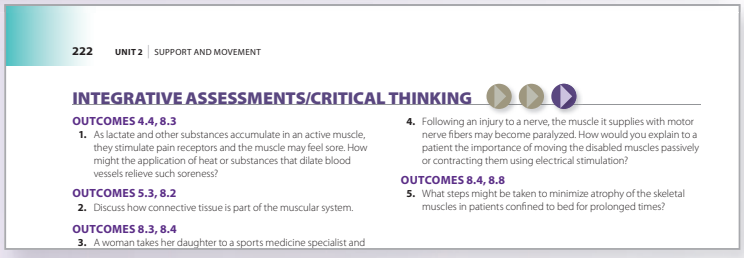
22. Distinguish between a muscle's origin and its insertion. (p. 202)

23. Define *agonist, antagonist,* and *synergist.* (p. 204)

8.8 Major Skeletal Muscles

24. Match the muscles to their descriptions and functions. (pp. 204–217)

(1) buccinator	A. inserted on coronoid process of mandible
(2) epicranius	B. elevates corner of mouth
(3) orbicularis oris	C. elevates scapula
(4) platysma	D. brings head into an upright position
(5) rhomboid major	E. elevates eyebrow



222 UNIT 2 | SUPPORT AND MOVEMENT

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.

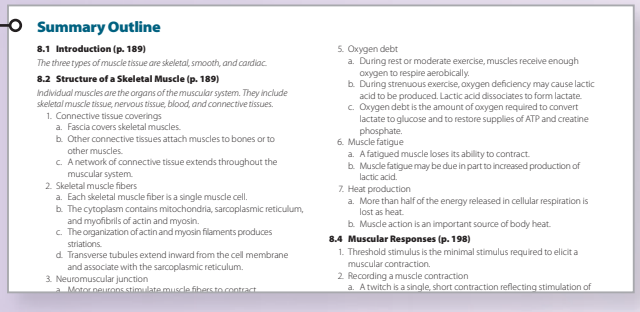
OUTCOMES 8.3, 8.4

3. A woman takes her daughter to a sports medicine specialist and

4. Following an injury to a nerve, the muscle it supplies with motor nerve fibers 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 8.4, 8.8

5. What steps might be taken to minimize atrophy of the skeletal muscles in patients confined to bed for prolonged times?



Summary Outline

8.1 Introduction (p. 189)

The three types of muscle tissue are skeletal, smooth, and cardiac.

8.2 Structure of a Skeletal Muscle (p. 189)

Individual muscles are the organs of the muscular system. They include skeletal muscle tissue, nervous tissue, blood, and connective tissues.

1. Connective tissue coverings
   a. Fascia covers skeletal muscles.
   b. Other connective tissues attach muscles to bones or to other muscles.
   c. A network of connective tissue extends throughout the muscular system.
2. Skeletal muscle fibers
   a. Each skeletal muscle fiber is a single muscle cell.
   b. The cytoplasm contains mitochondria, sarcoplasmic reticulum, and myofibrils of actin and myosin.
   c. The organization of actin and myosin filaments produces striations.
   d. Transverse tubules extend inward from the cell membrane and associate with the sarcoplasmic reticulum.
3. Neuromuscular junction
   a. Motor neurons stimulate muscle fibers to contract.

5. Oxygen debt
   a. During rest or moderate exercise, muscles receive enough oxygen to respire aerobically.
   b. During strenuous exercise, oxygen deficiency may cause lactic acid to be produced. Lactic acid dissociates to form lactate.
   c. Oxygen debt is the amount of oxygen required to convert lactate to glucose and to restore supplies of ATP and creatine phosphate.
6. Muscle fatigue
   a. A fatigued muscle loses its ability to contract.
   b. Muscle fatigue may be due in part to increased production of lactic acid.
7. Heat production
   a. More than half of the energy released in cellular respiration is lost as heat.
   b. Muscle action is an important source of body heat.

8.4 Muscular Responses (p. 198)

1. Threshold stimulus is the minimal stimulus required to elicit a muscular contraction.
2. Recording a muscle contraction
   a. A twitch is a single, short contraction reflecting stimulation of

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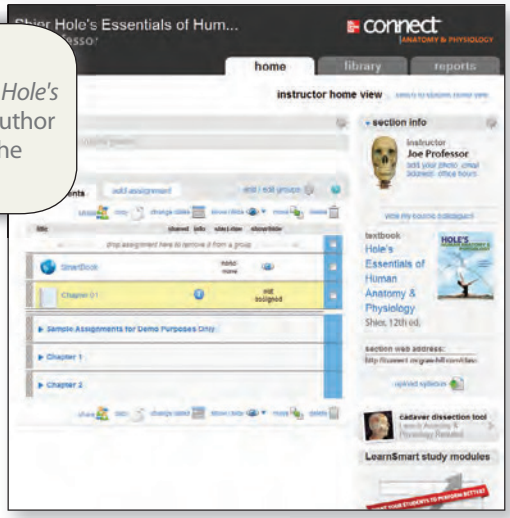
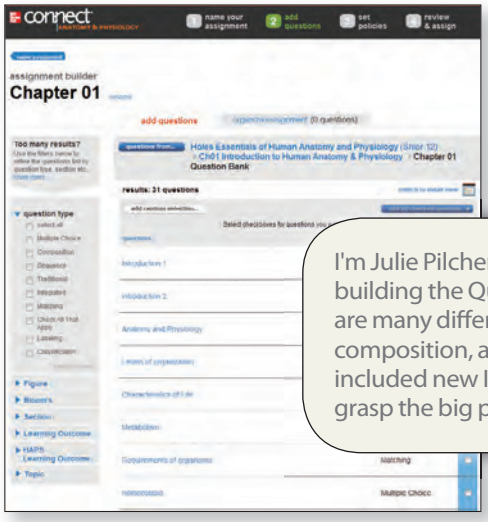
ANATOMY & PHYSIOLOGY

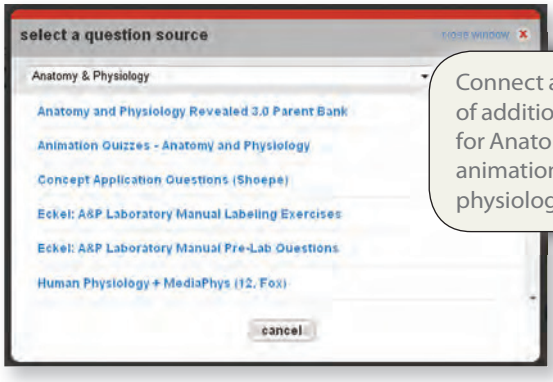
Hi! I'm Leslie Day. We know that it's frustrating when your online homework questions contradict your textbook. In this edition of *Hole's Essentials of Human Anatomy & Physiology*, Julie and I joined the author team to ensure that our online resources correlate directly with the information and learning tools you will find in the textbook.





I'm Julie Pilcher. You can call us the Digital Authors! We work on building the Question Bank in Connect. We make sure that there are many different question types, like labeling, multiple choice, composition, and sequencing. For the twelfth edition we have included new Integrated questions. These questions help the student grasp the big picture by connecting concepts throughout the course.

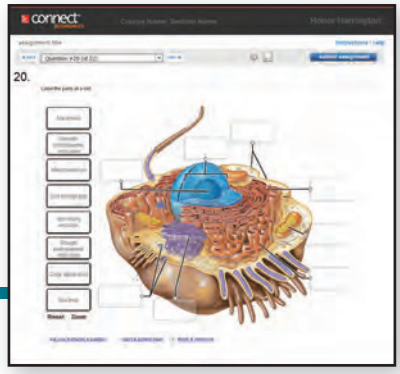
We also ensure that there is an appropriate number of questions for each learning outcome in the chapter. We tagged the questions not only to learning outcomes in the text but also to the Human Anatomy & Physiology Society (HAPS) Learning Outcomes. This makes it easy for the instructor to find just the question they want. We also make sure that there is a variety of questions with different Bloom's Taxonomy levels!



Connect also gives the instructor access to a lot of additional material. They can access questions for Anatomy & Physiology Revealed, a variety of animations, and also every other anatomy and physiology title from McGraw-Hill Education.

Here are some of the question types we have created for the twelfth edition!

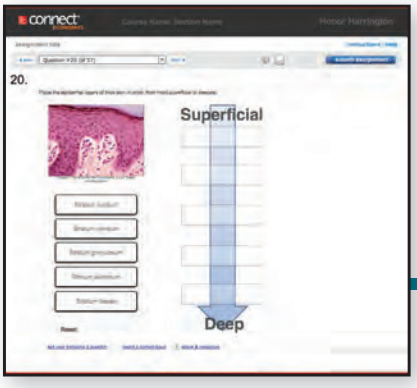
Integrated activities use a series of interactive questions to allow students to apply their new knowledge and/or see how different processes are related. Some integrated questions also include animations to help the visual learner.



Labeling activities allow students to identify structures using figures from the text. Also available are questions in which functions or descriptions are used as drag-and-drop labels.

Classification questions ask students to place terms into appropriate categories, to recognize the differences and similarities in structures.

Composition questions allow for completion of a series of sentences describing structures, processes, or functions. Some composition questions then require arranging the completed sentences in a logical order.



Sequence questions have been designed around ordering physiological processes or some anatomical topics, such as listing structures' locations from proximal to distal.

TEACHING AND LEARNING SUPPLEMENTS

Text Website – www.mhhe.com/shieress12

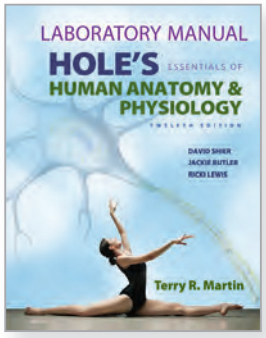
Ancillary Correlation Guide—instructors will find this guide invaluable. McGraw-Hill offers a variety of ancillary products to accompany our texts. The authors have gone through the ancillaries and correlated them to the specific Learning Outcomes found at the beginning of each chapter! The ancillaries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

- Ph.I.L.S. 4.0
- 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.

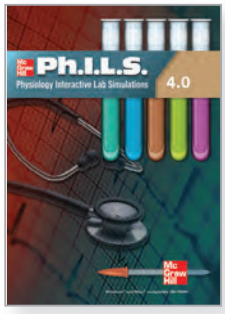
McGraw-Hill's Presentation Tools

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

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



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



NEW! Ph.I.L.S. 4.0 has been updated! Users have requested and we are providing five new exercises (Respiratory Quotient, Weight & Contraction, Insulin and Glucose Tolerance, Blood Typing, and Anti-Diuretic Hormone). Ph.I.L.S. 4.0 is the perfect way to reinforce key physiology concepts with powerful lab experiments. Created by Dr. Phil Stephens at Villanova University, this program offers 42 laboratory simulations that may be used to supplement or substitute for wet labs. All 42 labs are self-contained experiments—no lengthy instruction manual required. Users can adjust variables, view outcomes, make predictions, draw conclusions, and print lab reports. This easy-to-use software offers the flexibility to change the parameters of the lab experiment. There is no limit!

Chapter	FlexArt PPTs (Fully editable images from the text, optimized for presentation. All art, tables and photos included.)	*Lecture PPTs (Lecture outlines ready for you to use with art and animations in place where appropriate. Also available without animations embedded.)	APR Enhanced PPT	Animations (Animation files that can be easily downloaded and played without PowerPoint.)	*Animation PowerPoints (Animations placed into PowerPoint for easy presentation and custom slide shows.)	Labeled Images (Illustration files as they appear in the text.)	Base Art Images (Illustration files without labels and leader lines.)	A&P Game Show
All Chapters	shilie_flexart_ppts.zip (583,286 KB)	shilie_lecture_ppts.zip (380,755 KB)	shilie_apr_lecture_ppts.zip (1,197,352 KB)	All Animations (81,047 KB)	all animation PowerPoint (276,893 KB)	shilie_labeled.zip (622,858 KB)	shilie_baseart.zip (406,433 KB)	All AP Game Shows (1618.0K)
Ch01	Ch01 FlexArt PPT (12,730 KB)	Ch01 Lecture PPT (5,124 KB)	Ch01 APR Enhanced Lecture PPT (17,001 KB)	Ch01 Animations (396 KB)	Ch01 Animation PowerPoint (1,588 KB)	Ch01 Labeled Images (32,998 KB)	Ch01 Base Art Images (24,473 KB)	Ch01 AP Game Show (61.0K)
Ch02	Ch02 FlexArt PPT (8,436 KB)	Ch02 Lecture PPT (3,756 KB)	Ch02 APR Enhanced Lecture PPT (4,921 KB)	Ch02 Animations (4,563 KB)	Ch02 Animation PowerPoint (17,140 KB)	Ch02 Labeled Images (17,715 KB)	Ch02 Base Art Images (4,552 KB)	Ch02 AP Game Show (58.0K)
Ch03	Ch03 FlexArt PPT (19,008 KB)	Ch03 Lecture PPT (14,702 KB)	Ch03 APR Enhanced Lecture PPT (37,221 KB)	Ch03 Animations (10,787 KB)	Ch03 Animation PowerPoint (37,058 KB)	Ch03 Labeled Images (29,894 KB)	Ch03 Base Art Images (22,044 KB)	Ch03 AP Game Show (61.0K)
Ch04	Ch04 FlexArt PPT (3,637 KB)	Ch04 Lecture PPT (1,933 KB)	Ch04 APR Enhanced Lecture PPT (6,492 KB)	Ch04 Animations (10,787 KB)	Ch04 Animation PowerPoint (5,818 KB)	Ch04 Labeled Images (11,737 KB)	Ch04 Base Art Images (4,227 KB)	Not available for this chapter
Ch05	Ch05 FlexArt PPT (14,383 KB)	Ch05 Lecture PPT (11,961 KB)	Ch05 APR Enhanced Lecture PPT (72,492 KB)	Not available for this chapter.	Not available for this chapter.	Ch05 Labeled Images (22,985 KB)	Ch05 Base Art Images (16,620 KB)	Ch05 AP Game Show (53.0K)
Ch06	Ch06 FlexArt PPT (9,917 KB)	Ch06 Lecture PPT (5,929 KB)	Ch0e APR Enhanced Lecture PPT (46,371 KB)	Not available for this chapter.	Not available for this chapter.	Ch06 Labeled Images (15,368 KB)	Ch06 Base Art Images (13,084 KB)	Ch06 AP Game Show (52.0K)

ACKNOWLEDGMENTS

Reviewers

We would like to acknowledge the valuable contributions of the reviewers for the twelfth edition who read either portions or all of the text, and who provided detailed criticisms and ideas for improving the narrative and the illustrations. They include the following:

Christina C. Alevras, *Saint Joseph College*

Michelle Baragona, *Northeast Mississippi Community College*

Chuck Benton, *Madison College*

Mark Danley, *Central New Mexico Community College*

Camille DiScala, *Chandler-Gilbert Community College—Pecos Campus*

Amy Fenech Sandy, *Columbus Technical College*

Paul Fierimonte, *University of Massachusetts—Lowell*

Eric Geiman, *Sinclair Community College*

Dawn Hilliard, *Northeast Mississippi Community College*

Karen Huffman-Kelly, *Erie Community College*

Thomas "Doc" Johnson, *Tidewater Community College—Chesapeake Campus*

Stephanie S. Kidd, *Sinclair Community College*

Beverly P. Kirk, *Northeast Mississippi Community College*

Christi A.Laurent, *Gwinnett Technical College*

Katharine B. Lormand, *Colorado Community College, Online*

Sheri L. Martin, *Central Georgia Technical College*

Cathleen Murphy, *SBI Campus/Nassau Community College*

Susan Rohde, *Triton College*

Bobby Tefft, *Columbus Technical College*

Liz Torrano, *American River College*

Padmaja Vedartham, *Lone Star College Cy-Fair*

Leesa Whicker, *Central Piedmont Community College*

A special thanks also to the following individuals who assisted with ancillary development:

Janet Brodsky, *Ivy Tech Community College*; Debbie McCool, *Penn State University*; Monica R. McLemore PhD, MPH, RN, *University of California, San Francisco*; Patrice Parsons, *Grayson College*; and Ximara Peckham, *Xipec Consulting*.

Any textbook is the result of hard work by a large team. Although we directed the revision, many "behind-the-scenes" people at McGraw-Hill were indispensable to the project. We would like to thank our editorial team of Jim Connely, Marija Magner, and Fran Simon; Rosie Ellis, marketing manager; our production team, which included Jayne Klein, Sandy Ludovissy, Tara McDermott, John Leland, and Laura Bies. We would also like to thank copyeditor Wendy Nelson, freelance photo researcher Toni Michaels , and Imagineering project manager Alicia Elliott; and most of all, John Hole, for giving us the opportunity and freedom to continue his classic work. We also thank our wonderfully patient families for their support.

David Shier
Jackie Butler
Ricki Lewis

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 the human 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. Whether you use traditional or new technology, the twelfth edition of *Hole's Essentials of Human Anatomy & Physiology* offers an interesting and readable introduction to how the human body accomplishes these tasks. The functioning of the body is not simple, and at times understanding may not seem easy, but learning how the body works is always fascinating and can be both useful and fun!

Many of you are on a path toward a career in health care, athletics, science, or education. Be sure to check out the new Career Corners in every chapter. 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. We have written this book to help you succeed in your coursework and to help prepare you to make that journey to a successful and rewarding career.

To the Teacher

With this edition of *Hole's Essentials of Human Anatomy & Physiology*, we welcome two new authors. Leslie Day and Julie Pilcher are further developing LearnSmart and Connect and fully integrating them with the traditional elements of Hole's. We are extremely excited that Hole's is keeping pace with the ever-changing array of technologies available to support teaching and learning.

The Learn, Practice, Assess approach continues with this twelfth edition. 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 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/Foundations for Success beginning on page 1.

David Shier, Jackie Butler, Ricki Lewis, Leslie Day, and Julie Pilcher

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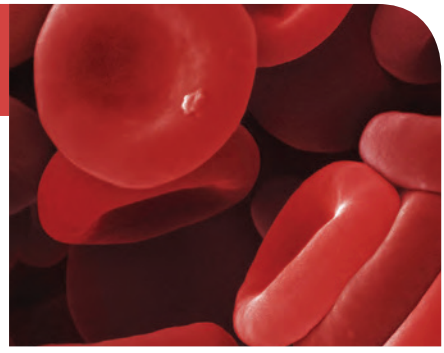
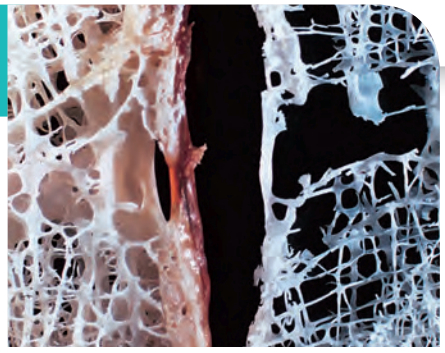


UNIT 2
SUPPORT AND MOVEMENT



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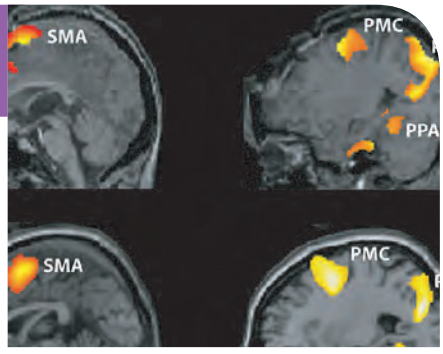

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UNIT 6
THE HUMAN LIFE CYCLE

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CHAPTER PREVIEW

Foundations for Success

The 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.

A photo on the opening page for each chapter generates interest.

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 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 that you have just experienced, including your response to the sudden stimulation. This is a good reason to stay focused.

LEARNING OUTCOMES

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

P.1 Introduction

1. Explain the importance of an individualized approach to learning. (p. 2)

P.2 Strategies for Your Success

2. Summarize what you should do before attending class. (pp. 2–3)
3. Identify student activities that enhance classroom experience. (p. 6)
4. List and describe several study techniques that can facilitate learning new material. (p. 7)

Each chapter has a list of learning outcomes indicating the knowledge you should gain as you work through the chapter. (Note the blue learn arrow following the title of this section.) 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.

This digital tool, as indicated here and with the APR icons within the chapters, allows you to explore the human body in depth through cadaver dissection and histology preparations. It also offers animations on chapter concepts.

This section 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 (p. 577) has a comprehensive list of these prefixes, suffixes, and root words.

AIDS TO UNDERSTANDING WORDS

(Appendix A on page 577 has a complete list of Aids to Understanding Words.)

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

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

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

P.1 | Introduction

The first section of each chapter is an overview that tells you what to expect and why the subject matter is important.

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 higher levels 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, 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 the 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 information. (Note the green practice arrow preceding the questions below.) If you cannot answer the question(s), you should reread that section, being on the lookout for the answer(s)

PRACTICE

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

P.2 | Strategies for Your Success

Major divisions within a chapter are called "A-heads." They are numbered sequentially and entitled with very large, blue type to designate major content areas.

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, black 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 lecture 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.

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 shaded boxes 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.

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

CLINICAL APPLICATION 9.1

Factors Affecting Synaptic Transmission

Impulses reaching synaptic knobs too rapidly can exhaust neurotransmitter supplies, and impulse conduction ceases until more neurotransmitters are synthesized. This happens during an epileptic seizure. Abnormal and too rapid impulses originate from certain brain cells and reach skeletal muscle fibers, stimulating violent contractions. In time, the synaptic knobs run out of neurotransmitters and the seizure subsides.

A drug called Dilantin (diphenylhydantoin) treats seizure disorders by blocking gated sodium channels, thereby limiting the frequency at which action potentials can occur. Many other drugs affect synaptic transmission. For example, caffeine in coffee, tea, and cola drinks stimulates nervous system activity by lowering the thresholds at synapses so that neurons are more easily excited. Antidepressants called "selective serotonin reuptake inhibitors" (SSRIs) keep the neurotransmitter serotonin in synapses longer, compensating for a still little-understood deficit that presumably causes depression.

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 person 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 metabolic activity in the brain.

Students using this book and taking various courses are often preparing for careers in health care. In some cases students may be undecided as to a specific area or specialty. The Career Corner 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 middle-aged woman feels something give way in her left knee as she lands from a jump in her dance class. She limps away between her much younger 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 woman 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 pressing, 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 injuries, and even applying massage techniques to racehorses.

GENETICS CONNECTION 16.1
Cystic Fibrosis

Young children who cannot pronounce the name of their disease 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.

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 1600 mutations have been recognized in the cystic fibrosis transmembrane receptor (*CFTR*) gene, which encodes the chloride channel protein. Today newborns with CF are diagnosed using a genetic test shortly after birth, 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 forty, 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.

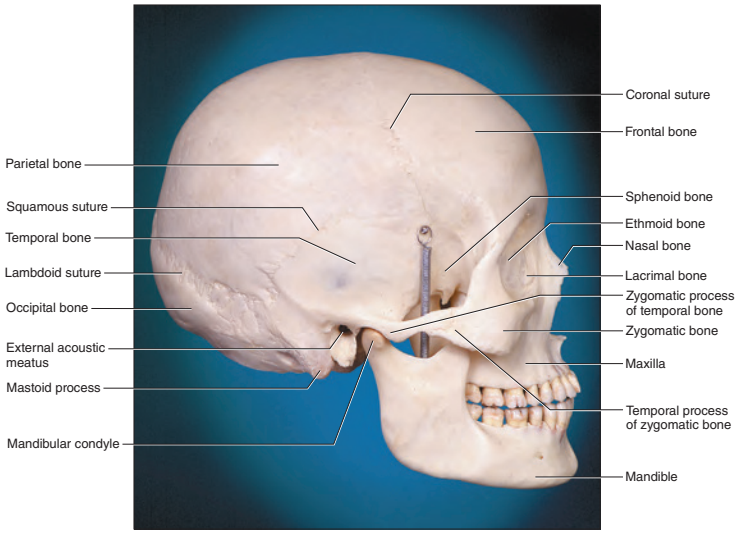
Discovery of the most common *CFTR* mutation in 1989 enabled development of more-targeted treatments. Thirty drugs are now in development. The new drugs work in various ways: correcting misfolded *CFTR* protein, restoring liquid on airway surfaces, breaking up mucus, improving nutrition, and fighting inflammation and infection.

Life with severe CF is challenging. 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 3% to 10% of CF patients in the United States and Europe.

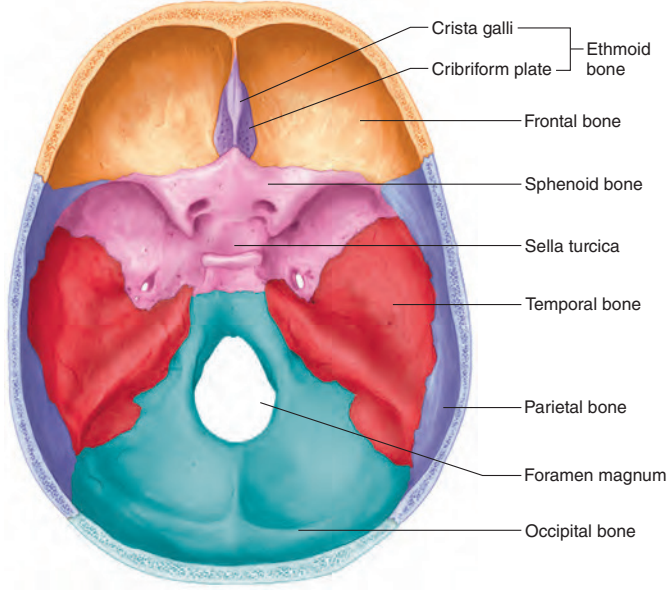
Remember when you were very young and presented with a substantial book for the first time? You were likely intimidated by its length, but were reassured that there were "a lot of pictures." This book has many "pictures" (figures) too, all designed to help you master the material. Some of the figure 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.

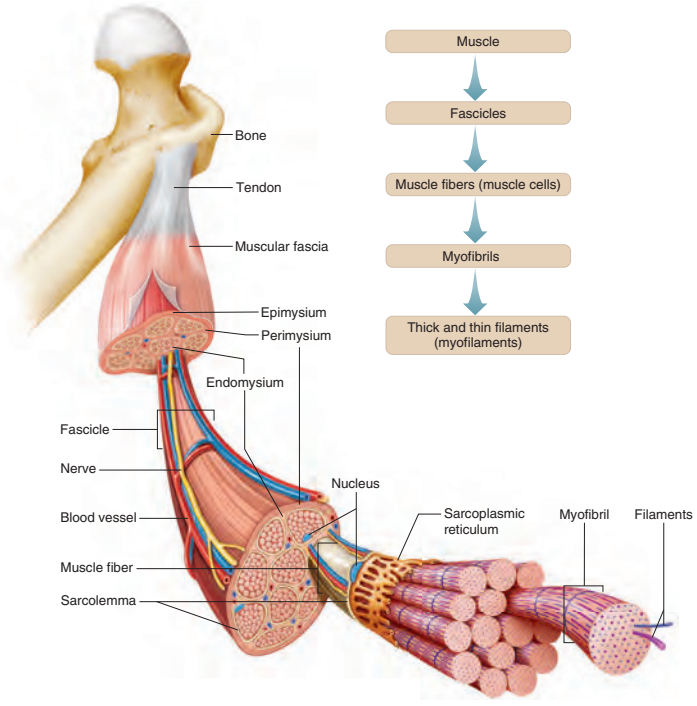


Line art can present different positions, layers, or perspectives.



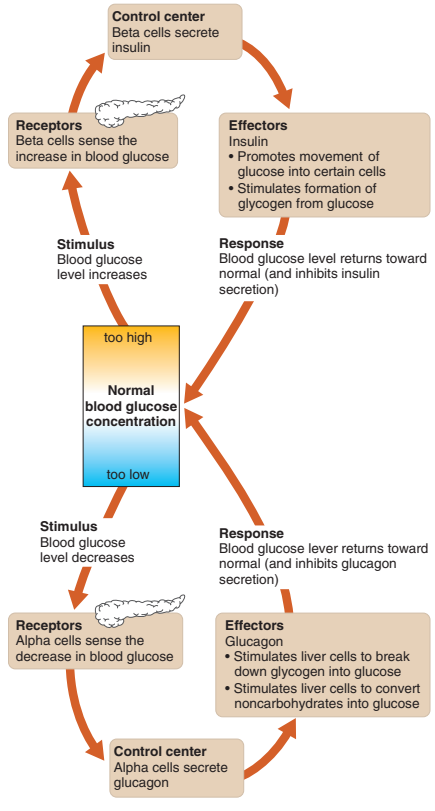
Macroscopic to Microscopic

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



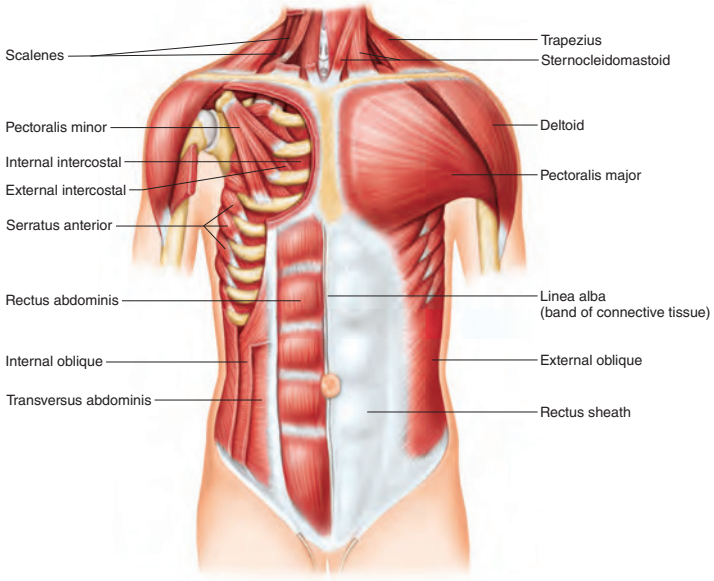
Flow Charts

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

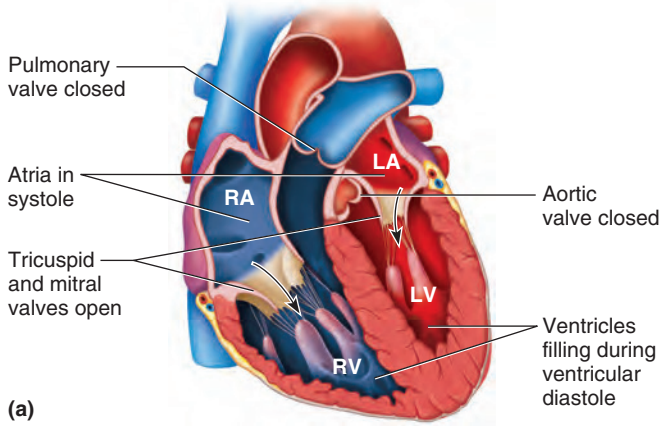


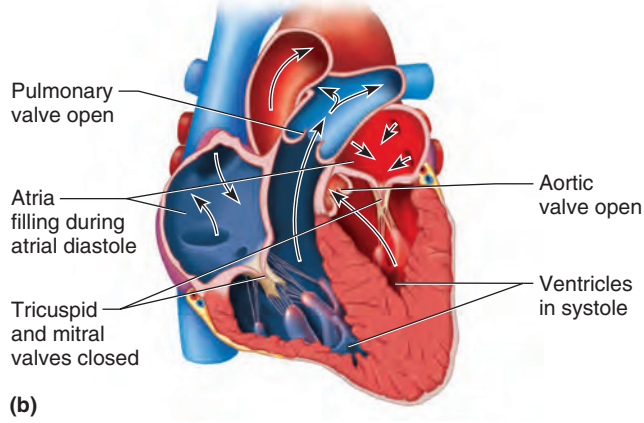
Anatomical Structures

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 notes.

TABLE 5.6 Muscle and Nervous Tissues

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
Nervous tissue	Sensory reception and conduction of electrical impulses	Brain, spinal cord, and peripheral nerves

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 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 identify-

ing 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 or waiting in a doctor's office online reviewing notes or reading the text.

Daily repetition is helpful, so scheduling several short study periods each day should replace 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. 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.

PRACTICE

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.

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 2)

Try a variety of methods to study the human body.

P.2 Strategies for Your Success (page 2)

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.
   a. Photographs give a realistic view and line art shows different perspectives.
   b. Figures depicting macroscopic to microscopic show 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. 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.
   c. Small study groups reviewing and vocalizing material can divide and conquer the learning task.
   d. Making flash cards helps the tactile learner.
   e. Time management skills encourage scheduled studying, including daily repetition instead of cramming for exams.

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)

P.2 Strategies for Your Success

2. Methods to prepare for class include _____ . (pp. 2–3)
   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. (p. 6)
4. Forming the phrase "I passed my anatomy test" to remember the cell cycle (interphase, prophase, metaphase, anaphase, telophase) is a _____ device. (p. 6)
5. Name a benefit and a drawback of small study groups. (p. 6)
6. Give an example of effective time management used in preparation for success in the classroom. (p. 7)

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 section references to sections from earlier chapters. Making connections is what it is all about!

OUTCOME P.1, P.2

1. Which study methods are most successful for you?

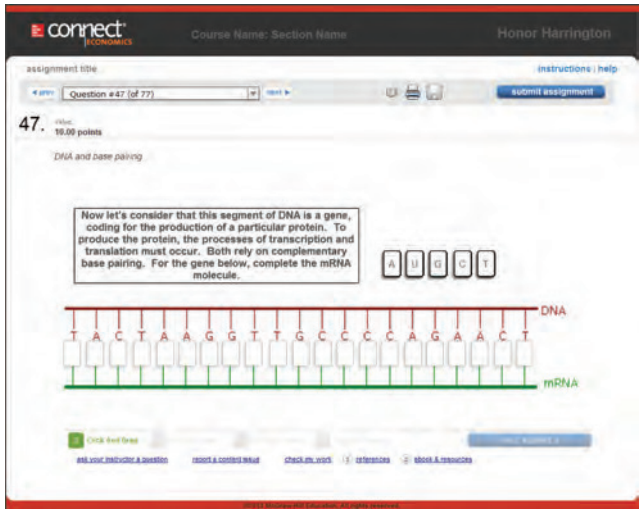
OUTCOMES P.2

2. Design a personalized study schedule.

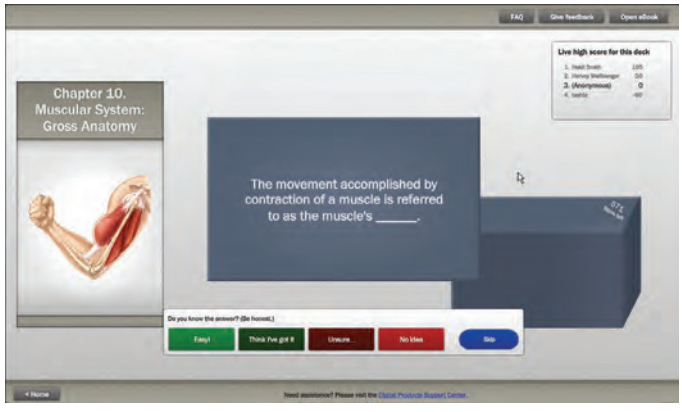
Check out McGraw-Hill online resources that can help you practice and assess your learning.

Connect Interactive Questions Reinforce your knowledge using assigned interactive questions.

Connect Integrated Activity Practice your understanding.



Learn Smart Discover which concepts you have mastered and which require more attention with this personalized, adaptive learning tool.



Anatomy & Physiology Revealed
Go more in depth.

1

Introduction to Human Anatomy and Physiology

A wooden toe on an ancient Egyptian mummy reveals sophisticated knowledge of human anatomy and physiology from long ago.

The mummy's toe. She lived between 1069 and 664 B.C. in Thebes, a city in ancient Egypt. Only pieces of her skeleton remain, held in place with plaster, glue, and linen. Yet, the telltale bones reveal a little of what her life was like.

The shape of the pelvic bones indicates that the person was female. She was 50 to 60 years old when she died, according to the way the bony plates of her skull fit together and the lines of mineral deposition in a well-preserved tooth. Among the preserved bones from the skull, pelvis, upper limbs, and right lower limb, the right big toe stands out, for it ends in a prosthesis, a manufactured replacement for a skeletal part. Was it purely cosmetic, or did it work?

The mummy's toe tip is wooden and painted a dark brown, perhaps to blend in with her skin color. A long part and two smaller parts anchor the structure to the stump. Seven leather strings once attached it to the foot, and it even bears a fake nail. Connective tissue and skin grew over the prosthesis, revealing that her body had accepted the replacement part, and the shape of the prosthesis was remarkably like that of a real toe. Signs of wear indicate that it was indeed used. Modern-day scientists made replicas of the toe and volunteers who were missing the same toe tried them out, demonstrating that the mummy's toe must have been crucial for balance and locomotion.

The replacement toe is evidence of sophisticated medical technology. Modern-day medical sleuths obtained computerized tomography (CT) scans of the remnants of the mummy. They detected poor mineral content in the toe, plus calcium deposits in the largest blood vessel, the aorta, suggesting impaired circulation to the feet. Perhaps the mummy in life suffered from diabetes mellitus, which can impede circulation to the toes. If gangrene had set in, healers might have amputated the affected portion of the toe, replacing it with a very reasonable facsimile.

The ancient Egyptians made other replacement parts, including ears, noses, feet, and lower limbs. Today prosthetic toes are made of silicones, which are plastic-like materials. People use them who have lost digits to injury, cancer, or, perhaps like the ancient Egyptian woman, diabetes.

LEARNING OUTCOMES

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

1.1 Introduction

1. Identify some of the early discoveries that led to our understanding of the body. (p. 10)

1.2 Anatomy and Physiology

2. Explain how anatomy and physiology are related. (p. 11)

1.3 Levels of Organization

3. List the levels of organization in the human body and the characteristics of each. (p.12)

1.4 Characteristics of Life

4. List and describe the major characteristics of life. (p. 13)
5. Give examples of metabolism. (p. 13)

1.5 Maintenance of Life

6. List and describe the major requirements of organisms. (pp. 13–14)
7. Explain the importance of homeostasis to survival. (p. 14)
8. Describe the parts of a homeostatic mechanism and explain how they function together. (pp. 14–15)