

GLOBAL  
EDITION



# Essentials of Anatomy & Physiology

SEVENTH EDITION

Martini • Bartholomew

ALWAYS LEARNING

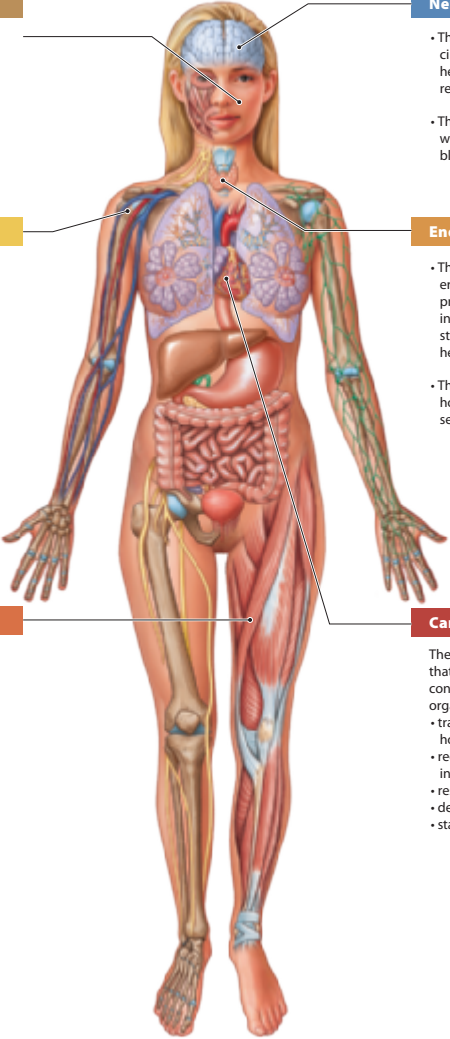
PEARSON

# Students Synthesize Information

At the end of each body system, a capstone Build Your Knowledge System Integrator helps students understand how body systems work together. Build Your Knowledge Concept Map Coaching Activities are assignable in **MasteringA&P®**

### Build Your Knowledge

How the **CARDIOVASCULAR SYSTEM** integrates with the other body systems presented so far



**Integumentary System**

- The Integumentary System has mast cells that trigger localized changes in blood flow and capillary permeability
- The cardiovascular system delivers immune system cells to injury sites; clotting response seals breaks in skin surface; carries away toxins from sites of infection; provides heat

**Skeletal System**

- The Skeletal System provides calcium needed for normal cardiac muscle contraction; protects blood cells developing in red bone marrow
- The cardiovascular system transports calcium and phosphate for bone deposition; delivers EPO to red bone marrow, parathyroid hormone and calcitonin to osteoblasts and osteoclasts

**Muscular System**

- The Muscular System assists venous circulation through skeletal muscle contractions; protects superficial blood vessels, especially in neck and limbs
- The cardiovascular system delivers oxygen and nutrients, removes carbon dioxide, lactic acid, and heat during skeletal muscle activity

**Nervous System**

- The Nervous System controls patterns of circulation in peripheral tissues; modifies heart rate and regulates blood pressure; releases antidiuretic hormone (ADH)
- The cardiovascular system has capillaries whose endothelial cells maintain the blood-brain barrier; help generate CSF

**Endocrine System**

- The Endocrine System produces erythropoietin (EPO), which regulates production of RBCs; several hormones increase blood pressure; epinephrine stimulates cardiac muscle, increasing heart rate and force of contraction
- The cardiovascular system distributes hormones throughout the body; the heart secretes atrial natriuretic peptide (ANP)

**Cardiovascular System**

The cardiovascular system has blood vessels that provide extensive anatomical connections between it and all the other organ systems. It:

- transports dissolved gases, nutrients, hormones, and metabolic wastes
- regulates pH and ion composition of interstitial fluid
- restricts fluid losses at injury sites
- defends against toxins and pathogens
- stabilizes body temperature

# MORE! SPOTLIGHT FIGURES Teach

**Spotlight Figures** provide highly visual one- and two-page presentations of tough topics in the book. Brief text and related figures and photos communicate information in a visually effective and student-friendly format.

In the Seventh Edition, there is now at least one Spotlight Figure in every chapter along with a correlating new Coaching Activity in **MasteringA&P**®

## Spotlight

Figure 20-5

### EXTRAEMBRYONIC MEMBRANES AND PLACENTA FORMATION

The germ layers introduced in Figure 20-4 also form four **extraembryonic membranes**: (1) The **yolk sac** (endoderm and mesoderm), (2) the **amnion** (ectoderm and mesoderm), (3) the **allantois** (endoderm and mesoderm), and (4) the **chorion** (mesoderm and trophoblast). These membranes support embryonic and fetal development, but few traces of their existence remain in adults.

#### Yolk sac

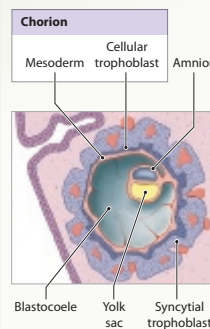
The yolk sac begins as a layer of cells spreads out around the outer edges of the blastocoele to form a complete pouch. It is the primary nutrient source for early embryonic development, and becomes an important site for blood cell formation.

#### Amnion

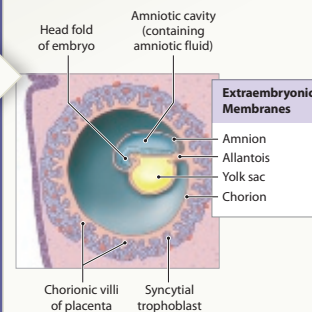
Ectodermal cells spread over the inner surface of the amniotic cavity, soon followed by mesodermal cells. Amniotic fluid is produced, which cushions the developing embryo.



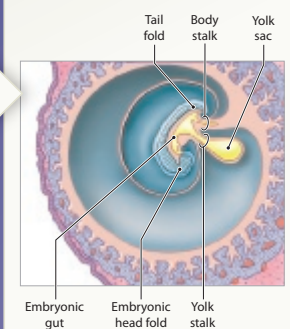
**1 Week 2**  
Migration of mesoderm around the inner surface of the cellular trophoblast forms the chorion. Mesodermal migration around the outside of the amniotic cavity, between the ectodermal cells and the trophoblast, forms the amnion. Mesodermal migration around the endodermal pouch creates the yolk sac.



**2 Week 3**  
The embryonic disc bulges into the amniotic cavity at the head fold. The allantois, an endodermal extension surrounded by mesoderm, extends toward the trophoblast.



**3 Week 4**  
The embryo now has a head fold and a tail fold. Constriction of the connections between the embryo and the surrounding trophoblast narrows the yolk stalk and body stalk.



## NEW SPOTLIGHT FIGURES IN THE SEVENTH EDITION

**Figure 1-1:** Levels of Organization

**Figure 4-16:** Inflammation and Regeneration

**Figure 5-2:** The Epidermis

**Figure 6-7:** Types of Fractures and Steps in Repair

**Figure 8-9:** Propagation of an Action Potential

**Figure 12-5:** The Heart: Internal Anatomy and Blood Flow

**Figure 13-13:** Major Vessels of the System Circuit

**Figure 14-4:** Origin and Distribution of Lymphocytes

**Figure 15-10:** Pulmonary Ventilation

**Figure 15-16:** The Control of Respiration

# Tough Topics

## Allantois

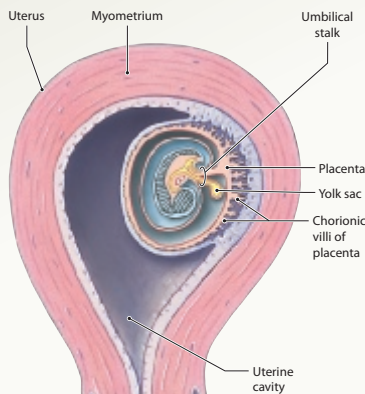
The allantois begins as an outpocket of the endoderm near the base of the yolk sac. The free endodermal tip then grows toward the wall of the blastocyst, surrounded by a mass of mesodermal cells. The base of the allantois eventually gives rise to the urinary bladder.

## Chorion

The mesoderm associated with the allantois spreads around the entire blastocyst, separating the cellular trophoblast from the blastocoel. The appearance of blood vessels in the chorion is the first step in the creation of a functional placenta. By the third week of development, the mesoderm extends along the core of each trophoblastic villus, forming chorionic villi in contact with maternal tissues and blood vessels. These villi continue to enlarge and branch forming the placenta, the exchange platform between mother and fetus for nutrients, oxygen, and wastes.

## 4 Week 5

The developing embryo and extraembryonic membranes bulge into the uterine cavity. The trophoblast pushing out into the uterine cavity remains covered by endometrium but no longer participates in nutrient absorption and embryo support. The embryo moves away from the placenta, and the body stalk and yolk stalk fuse to form an umbilical stalk.



## 5 Week 10

The amnion has expanded greatly, filling the uterine cavity. The fetus is connected to the placenta by an elongated umbilical cord that contains a portion of the allantois, blood vessels, and the remnants of the yolk stalk.

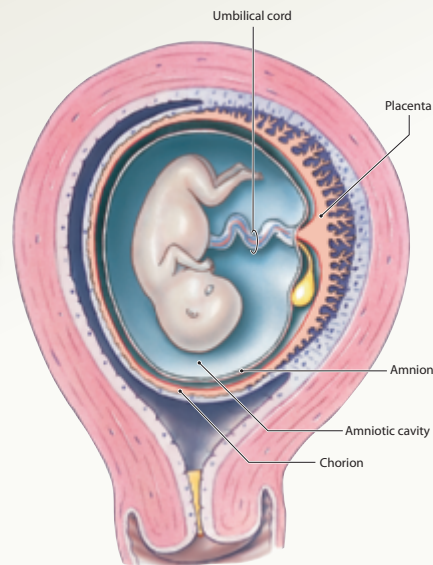


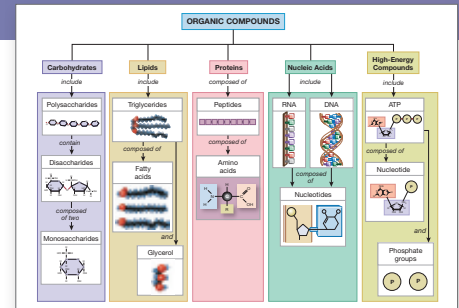
Figure 16-9: Regulation of Gastric Activity

Figure 16-18: Chemical Events in Digestion

Figure 17-5: Electron Transport System and ATP Formation

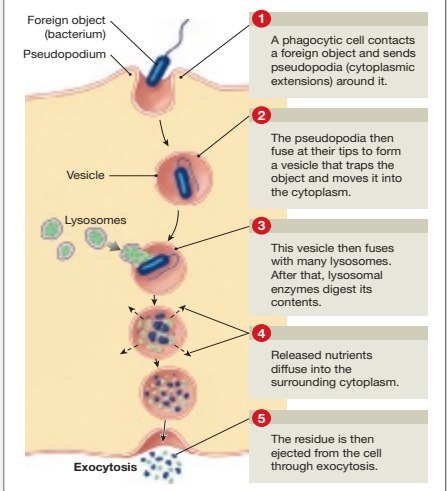
Figure 20-5: Extraembryonic Membranes and Placenta Formation

## MORE! Text/Art Integration



An Overview of the Structures of Organic Compounds in the Body, p. 77

Figure 3-11 Phagocytosis.



Stepwise illustration of Phagocytosis, p. 96

### CLINICAL NOTE DIABETES MELLITUS

Untreated diabetes mellitus disrupts metabolic activities throughout the body. Clinical problems arise because the tissues involved are experiencing an energy crisis—in essence, most of the tissues are responding as they would during chronic starvation, breaking down lipids and even proteins because they are unable to absorb glucose from their surroundings. Problems involving abnormal changes in blood vessel structure are particularly dangerous. An estimated 28.8 million people in the United States have some form of diabetes.

**Retinal Damage**  
The proliferation of capillaries and hemorrhaging at the retina may cause partial or complete blindness. This condition is called **diabetic retinopathy**.

**Early Heart Attacks**  
Deposits of lipids in the cardiac circulation can lead to early heart attacks. For some age groups, heart attacks are three to five times more likely in people with diabetes than in nondiabetic people.

**Peripheral Nerve Problems**  
Abnormal blood flow to neural tissues is probably responsible for a variety of neural problems with peripheral nerves, including abnormal autonomic function. These disorders are collectively termed **diabetic neuropathies**.

**Peripheral Tissue Damage**  
Blood flow to the distal portions of the limbs is reduced, and peripheral tissues may suffer an avascular foot, equine, or hand. For example, a person's toes may fall as the feet can lead to tissue death, ulcers, infections, and loss of toes or a major portion of one or both feet.

**Diabetes Mellitus**  
Diabetes mellitus (med fac, mellifera, honey), is characterized by glucose concentrations that are high enough to overwhelm the reabsorptive capabilities of the kidneys. (The presence of abnormally high glucose levels in the blood is termed **hyperglycemia**.) In people 65 years of age or older, glucose appears in the urine **glycosuria** (glukoh-SYU-ree-ah), and urine volume generally becomes excessive **polyuria**.

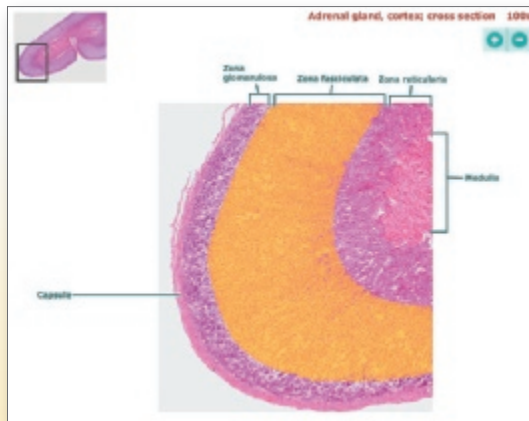
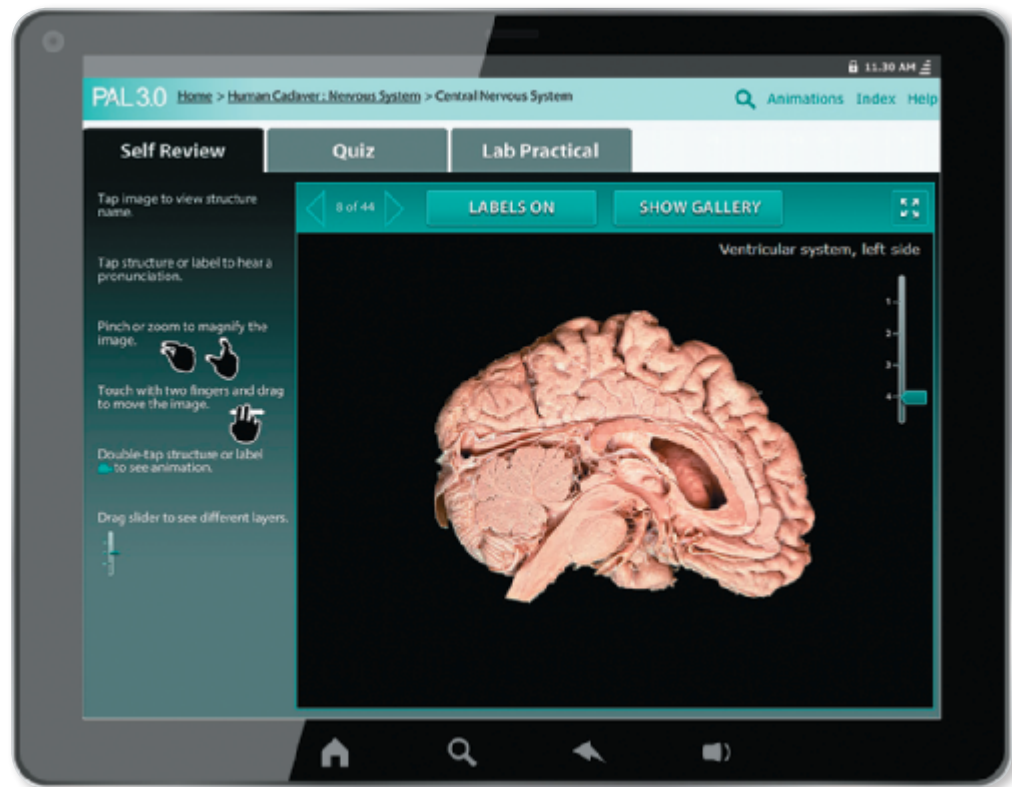
**Type 1 Diabetes**  
Type 1 is characterized by inadequate insulin production by the pancreatic beta cells. Persons with Type 1 diabetes require insulin to live and usually require multiple injections daily or continuous infusion through an insulin pump or other device. This form of diabetes accounts for approximately 10% of cases. It usually develops in children and young adults.

**Type 2 Diabetes**  
Type 2 is the most common form of diabetes mellitus. Most people with Type 2 diabetes produce normal amounts of insulin, at least initially, but their tissues do not respond properly, a condition known as insulin resistance. Type 2 diabetes is associated with obesity. Weight loss through diet and exercise can be an effective treatment, especially when coupled with oral medications.

Full-page Clinical Note on Diabetes Mellitus, p. 394

# MasteringA&P<sup>®</sup> Provides Tools for

**Practice Anatomy Lab<sup>™</sup> (PAL<sup>™</sup>) 3.0** is an indispensable virtual anatomy study and practice tool that gives students 24/7 access to the most widely used lab specimens, including human cadaver, anatomical models, histology, cat, and fetal pig. PAL 3.0 also includes multiple-choice quizzes and practice fill-in-the-blank lab practicals.



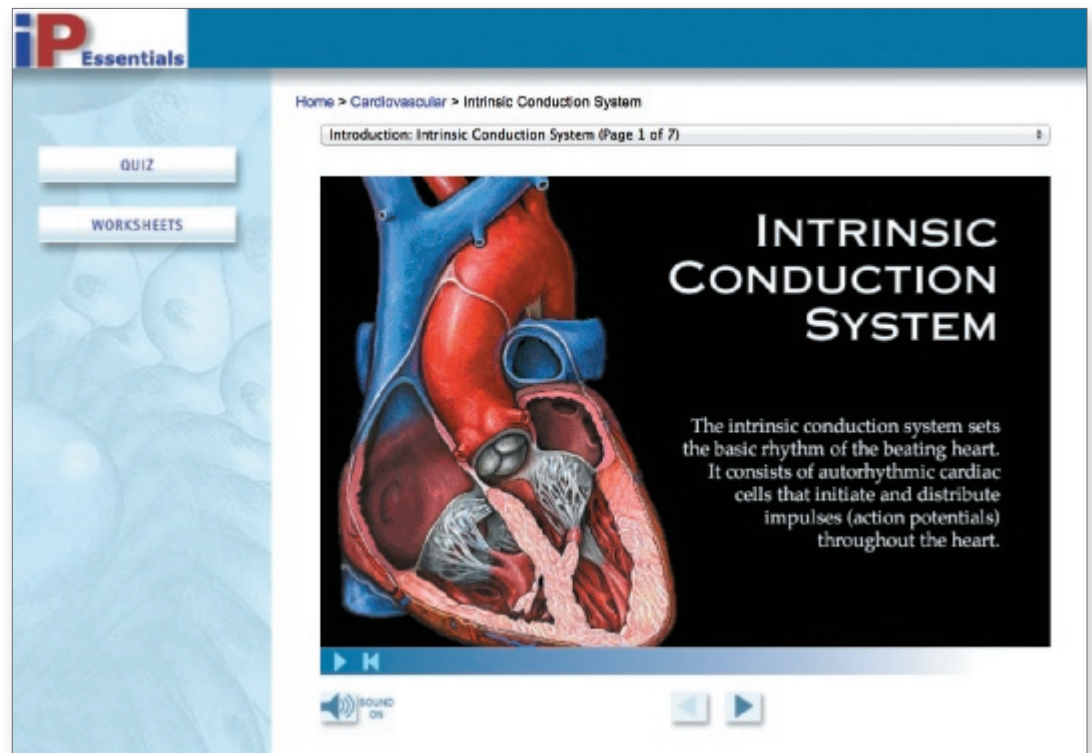
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3-D Anatomy Animations

# Study, Review, and Practice

**Essentials of Interactive Physiology®** tutorials help students advance beyond memorization to a genuine understanding of complex physiological processes. Full-color animations and videos demonstrate difficult concepts to reinforce the material.



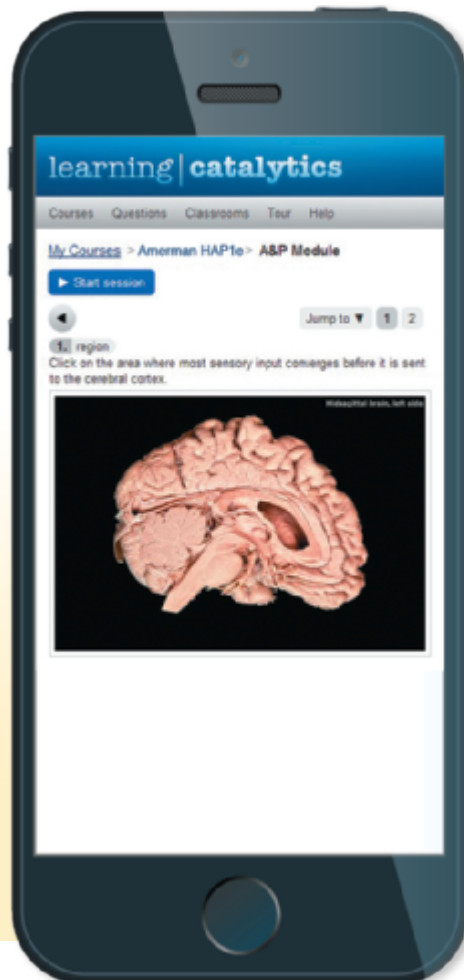
**Fun, interactive tutorials, games, and quizzes provide additional explanations to help students grasp difficult concepts.**

## **MODULES:**

- Muscular System
- Nervous System
- Cardiovascular System
- Respiratory System
- Urinary System
- Fluids & Electrolytes
- Endocrine System
- Digestive System
- Immune System

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**Dynamic Study Modules** help students study effectively on their own by continuously assessing their activity and performance in real time. These mobile-friendly questions adapt to a student's performance and include art and explanations from the text-book to cement the student's understanding. Modules can also be assigned in **MasteringA&P**®



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## Instructor's Resource Center

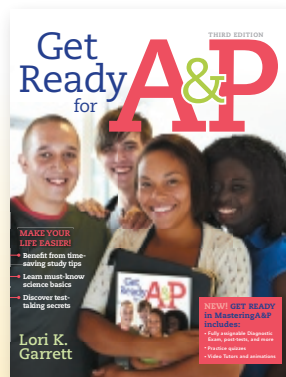
The Instructor Resource Center organizes all instructor media resources by chapter into one convenient and easy-to-use package.

- Textbook images in JPEG format
- Customizable textbook images embedded in PowerPoint® slides
- Customizable PowerPoint lecture slides
- A&P Flix™ 3-D movie-quality animations on tough topics
- Essentials of Interactive Physiology® Exercise Sheets and Answer Key
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- Instructor Manual in Microsoft Word and PDF formats
- Bone and dissection videos embedded in PowerPoint lecture presentations
- And More!

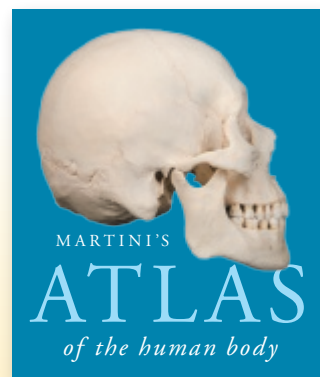
## Also Available:

- Instructor's Manual by Patty Bostwick-Taylor
- Test Bank for Essentials of Anatomy & Physiology—Printed and TestGen

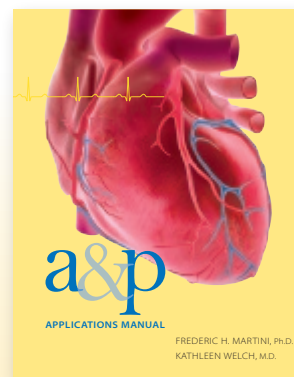
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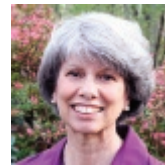
**EDWIN F. BARTHOLOMEW, M.S.** (author) received his undergraduate degree from Bowling Green State University in Ohio and his M.S. from the University of Hawaii. His interests range widely, from human anatomy and physiology to the marine environment, “backyard” aquaculture, and art. Mr. Bartholomew has taught human anatomy and physiology at both the secondary and undergraduate levels. In addition, he has taught a range of other science courses (from botany to zoology) at Maui Community College (now the University of Hawaii Maui College). For many years, he taught at historic Lahainaluna High School, the oldest high school west of the Rockies, where he assisted in establishing an LHS Health Occupations Students of America (HOSA) chapter. He has written journal articles, a weekly newspaper column, and many magazine articles. Working with Dr. Martini, he coauthored *Structure & Function of the Human Body* and *The Human Body in Health and Disease* (Pearson). Along with Dr. Martini and Dr. Judi Nath, he coauthored *Fundamentals of Anatomy & Physiology, 10th edition*. He also coauthored *Visual Anatomy & Physiology, 2nd edition*, with Dr. Martini, Dr. William Ober, Dr. Judi Nath, and Dr. Kevin Petti. Mr. Bartholomew is a member of the Human Anatomy and Physiology Society, National Science Teacher’s Association, and the American Association for the Advancement of Science.

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**WILLIAM C. OBER, M.D.** (art coordinator and illustrator) received his undergraduate degree from Washington and Lee University and his M.D. from the University of Virginia. While in medical school, he also studied in the Department of Art as Applied to Medicine at Johns Hopkins

University. After graduation, Dr. Ober completed a residency in Family Practice and later was on the faculty at the University of Virginia in the Department of Family Medicine. He was Chief of Medicine at Martha Jefferson Hospital and was an Instructor in the Division of Sports Medicine at UVA. He also was part of the Core Faculty at Shoals Marine Laboratory for 22 years, where he taught Biological Illustration every summer. He is currently a visiting professor of Biology at Washington and Lee University. The textbooks illustrated by his company Medical & Scientific Illustration have won numerous design and illustration awards.



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**KATHLEEN WELCH, M.D.** (clinical consultant) received her M.D. from the University of Washington in Seattle and did her residency at the University of North Carolina in Chapel Hill. For two years, she served as Director of Maternal and Child Health at the LBJ Tropical Medical Center in American Samoa and subsequently was a member of the Department of Family Practice at the Kaiser Permanente Clinic in Lahaina, Hawaii. She was in private practice from 1987 until her retirement in 2012. Dr. Welch has been the Clinical Consultant for nine textbooks and the coauthor of one textbook and several clinical supplements. Dr. Welch is a Fellow of the American Academy of Family Practice and a member of the Hawaii Medical Association, the Maui County Medical Association, and the Human Anatomy and Physiology Society.



**RALPH T. HUTCHINGS** (biomedical photographer) was associated with the Royal College of Surgeons for 20 years. An engineer by training, he has focused for years on photographing the structure of the human body. The result has been a series of color atlases, including the *Color Atlas of Human Anatomy*, the *Color Atlas of Surface Anatomy*, and *The Human Skeleton* (all published by Mosby-Yearbook Publishing). For his anatomical portrayal of the human body, the International Photographers Association chose Mr. Hutchings as the best photographer of humans in the twentieth century. He lives in North London, where he tries to balance the demands of his photographic assignments with his hobbies of early motorcars and airplanes.

## DEDICATION

*To Kitty, P.K., Ivy, and Kate:*

*We couldn't have done this without you.*

*Thank you for your encouragement, patience,  
and understanding.*

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# Preface

Welcome to the Seventh Edition of *Essentials of Anatomy & Physiology*! This textbook introduces the essential concepts needed for an understanding of the human body and helps students place information in a meaningful context, develop their problem-solving skills, and prepare for a career in a medical or allied health field. In this edition, we continue to build on this text's hallmark quality: a clear, effective visual and narrative presentation of anatomy and physiology. During the revision process, the author and illustrator team drew upon their combined content knowledge, research skills, artistic talents, and 50-plus years of classroom experience to make this the best edition yet.

The broad changes to this edition are presented in the **New to the Seventh Edition** section below. Also below are the sections **Learning Outcomes** and **Chapter-by-Chapter Changes in the Seventh Edition**.

## New to the Seventh Edition

In addition to the technical changes in this edition, such as updated statistics and anatomy and physiology descriptions, we have simplified the presentations to make the narrative easier to read. We have also focused on improving the integration of illustrations with the narrative. These are the key changes in this new edition:

- **Improved readability** uses simpler, shorter, more active sentences to make reading and studying easier for students. In all chapters, the Flesch/Kincaid reading levels have been decreased.
- **New Build Your Knowledge** feature within the narrative is an immediate reminder of earlier-presented material that will increase comprehension and integration of new information.
- **New Spotlight figures** have been added so that at least one is included in each chapter. Spotlight figures combine text and art to communicate key topics in visually effective single-page or two-page presentations.
- **New Design of Homeostasis figures** replace former 6th edition figures in various chapters.
- **Improved text-art integration** throughout the illustration program enhances the readability of figures. Tabular information is now integrated into the figures so that the relevant text is located immediately next to each part of a figure. Increased color saturation was also applied to the art throughout the text.

- **More Clinical Notes** contain visuals to draw students' attention to clinical information and scenarios they might encounter in their future careers.
- **New Build Your Knowledge Body System figures** for each body system chapter present representative portions of each body system. These figures continue to “build-a-body” as each new system is presented. System integration is again reinforced by the gradual increase in complexity.
- **Terminology** has been revised in selected cases to match the most common usage in medical specialties. We used *Terminologia Anatomica* and *Terminologia Histologica* as our reference for anatomical and tissue terms. We continue to use possessive forms of diseases when the proposed alternative has not been widely accepted, e.g., Parkinson disease is now Parkinson's disease.
- **MasteringA&P**<sup>®</sup>, Pearson's online learning and assessment system, contains new assignable activities tied to features in the book. Many Spotlight figures have Coaching Activities in Mastering. Build Your Knowledge sections are tied to multipart Mastering activities, and the Body System figures correspond to Concept Map Coaching Activities that will bring home the concept of body system integration. Instructors can assign homework from proven media programs such as Practice Anatomy Lab<sup>™</sup> (PAL<sup>™</sup>) 3.0 and Essentials of Interactive Physiology<sup>®</sup>—all organized by chapter—and have assignments automatically graded. New Dynamic Study Module questions use mobile-ready technology to help students retain information efficiently. In the MasteringA&P<sup>®</sup> Study Area, students can access a full suite of self-study tools, including Bone and Dissection videos and A&P Flix.

## Learning Outcomes

The chapters of the Seventh Edition are organized around specific Learning Outcomes that indicate what students should be able to do after studying the chapter.

- **Learning Outcomes** appear in chapter-opening numbered lists, as well as directly below each relevant chapter section heading.
- **Full-sentence chapter headings** do more than introduce new topics; they state the core fact or concept that will be presented in the section. There is a one-to-one

correspondence between the Learning Outcomes and the full-sentence section headings in every chapter.

- **Checkpoints** are located at the close of each section and ask students to pause and check their understanding of facts and concepts. The Checkpoints reinforce the Learning Outcomes presented on the chapter-opening page and below chapter section headings, resulting in a systematic integration of the Learning Outcomes over the course of the chapter. Answers are located in the blue Answers tab at the back of the book. All the Checkpoints have been reviewed, and questions were added or revised to reflect our improved readability.

All assessments in MasteringA&P are organized by the Learning Outcomes, making it easy for instructors to organize their courses and demonstrate results against goals for student achievement.

## Chapter-by-Chapter Changes in the Seventh Edition

This annotated Table of Contents provides select examples of revision highlights in each chapter of the Seventh Edition.

### Chapter 1 An Introduction to Anatomy and Physiology

- New Spotlight Figure 1-1 Levels of Organization
- Figure 1-2 The Organ Systems of the Human Body revised
- New Figure 1-3 The Control of Room Temperature
- New Figure 1-4 Negative Feedback in Thermoregulation
- New Figure 1-8 Directional References (incorporates former Table 1-1 Directional Terms)
- New Figure 1-9 Sectional Planes (incorporates former Table 1-2 Terms That Indicate Sectional Planes)
- Figure 1-10 Relationships among the Subdivisions of the Body Cavities of the Trunk revised
- New Clinical Note: Imaging Techniques (added PET scan of the brain; replaces Spotlight Figure 1-9 Imaging Techniques)

### Chapter 2 The Chemical Level of Organization

- Figure 2-4 Ionic Bonding revised (new part c)
- Spotlight Figure 2-7 Chemical Notation revised (“reactants” and “product” labels added)
- Figure 2-11 The Structures of Glucose revised (new part c replaced former part c)
- Figure 2-17 Amino Acids and the Formation of Peptide Bonds revised
- New Figure 2-18 Protein Structure
- Figure 2-20 The Structure of Nucleic Acids revised

### Chapter 3 Cell Structure and Function

- Figure 3-1 The Diversity of Cells in the Human Body revised
- Spotlight Figure 3-2 Anatomy of a Model Cell revised (distinguishes primary and motile cilia)
- Figure 3-4 Diffusion revised (Step art [1–4] added)
- New Figure 3-7 Osmotic Flow across a Plasma Membrane
- New Figure 3-11 Phagocytosis
- Figure 3-13 The Endoplasmic Reticulum revised
- New Figure 3-14 The Golgi Apparatus
- Spotlight Figure 3-15 Protein Synthesis, Processing, and Packaging revised
- Figure 3-16 Mitochondria revised (added ribosome label)
- New Figure 3-20 Translation
- Figure 3-23 Interphase, Mitosis, and Cytokinesis revised

### Chapter 4 The Tissue Level of Organization

- New Figure 4-1 An Orientation to the Tissues of the Body
- Figure 4-2 Cell Junctions revised
- Figure 4-4 Simple Epithelia revised
- Figure 4-5 Stratified Epithelia revised
- Figure 4-6 Modes of Glandular Secretion revised
- New Figure 4-7 Major Types of Connective Tissue
- Figure 4-8 Cells and Fibers of Connective Tissue Proper revised (added Fibrocyte)
- Figure 4-9 Loose Connective Tissues revised
- Figure 4-10 Dense Connective Tissues revised
- Figure 4-11 Types of Cartilage revised
- Figure 4-13 Tissue Membranes revised (text in part b)
- Figure 4-14 Muscle Tissue revised
- Figure 4-15 Neural Tissue revised

### Chapter 5 The Integumentary System

- New Terminology: added keratinocytes
- Figure 5-1 The General Structure of the Integumentary System revised (now includes papillary plexus)
- New Spotlight Figure 5-2 The Epidermis
- Figure 5-5 Hair Follicles and Hairs revised
- Figure 5-8 The Structure of a Nail revised (added cross-sectional view)
- New Figure 5-10 A Keloid
- New Clinical Note: Dermatitis
- Clinical Note: Hair Loss revised (new discussion of hair loss due to chemotherapy and radiation)
- New Clinical Note: Burns
- New Build Your Knowledge: How the INTEGUMENTARY SYSTEM integrates with the other body systems presented so far

## Chapter 6 The Skeletal System

- Figure 6-2 The Structure of a Long Bone revised (added periosteum art)
- Figure 6-3 The Microscopic Structure of a Typical Bone revised (added Types of Bone Cells art)
- Figure 6-6 Appositional Bone Growth revised
- New Figure 6-7 An Introduction to Bone Markings
- Figure 6-10 The Adult Skull, Part I revised (added color-coded labels)
- Figure 6-11 The Adult Skull, Part II revised
- Figure 6-12 Sectional Anatomy of the Skull revised
- Figure 6-15 The Skull of an Infant revised
- Figure 6-16 The Vertebral Column revised (added text to labels)
- Figure 6-19 The Sacrum and Coccyx revised (added a lateral view)
- Figure 6-20 The Thoracic Cage revised
- Figure 6-25 The Bones of the Wrist and Hand revised
- Figure 6-26 The Hip Bones and the Pelvis revised (added a lateral view)
- Figure 6-30 The Bones of the Ankle and Foot revised (added arches and a lateral view)
- Figure 6-31 The Structure of a Synovial Joint revised
- Spotlight Figure 6-35 Synovial Joints revised (added descriptions of types of synovial joints)
- Figure 6-40 The Knee Joint revised (boxed ligament labels)
- New Clinical Note: Types of Fractures and Steps in Repair
- New Clinical Note: Osteoporosis
- New Build Your Knowledge: How the SKELETAL SYSTEM integrates with the other body systems presented so far

## Chapter 7 The Muscular System

- Figure 7-2 The Organization of a Skeletal Muscle Fiber revised (added titin label)
- Spotlight Figure 7-4 Events at the Neuromuscular Junction revised
- New Figure 7-6 Steps Involved in Skeletal Muscle Contraction and Relaxation
- Figure 7-10 Muscle Metabolism revised
- New Figure 7-12 An Overview of the Major Skeletal Muscles
- Figure 7-14 Muscles of the Anterior Neck revised (added omohyoid muscle and boxed labels)
- Table 7-3 Muscles of the Head and Neck revised
- Figure 7-15 Muscles of the Spine revised
- Figure 7-16 Oblique and Rectus Muscles and the Diaphragm revised (parts b and c captions)
- Figure 7-19 Muscles That Move the Arm revised (added identification of rotator cuff muscles)

- New Figure 7-20 Muscles That Move the Forearm and Wrist
- Figure 7-22 Muscles That Move the Leg revised (added identification of hamstring muscles)
- Figure 7-23 Muscles That Move the Foot and Toes revised (added new anterior view and fibularis tertius muscle)
- Table 7-12 Muscles That Move the Foot and Toes revised (added fibularis tertius, brevis, and longus muscles)
- Clinical Note: Interference at the NMJ and Muscular Paralysis revised
- Clinical Note: Rigor Mortis revised
- Clinical Note: Tetanus revised
- Clinical Note: Intramuscular Injections revised
- New Build Your Knowledge: How the MUSCULAR SYSTEM integrates with the other body systems presented so far

## Chapter 8 The Nervous System

- Figure 8-1 A Functional Overview of the Nervous System revised (new art is added and definitions are added for the CNS, PNS, Receptors, and Effectors)
- Figure 8-2 The Anatomy of a Representative Neuron revised (new three-dimensional neuron art)
- Figure 8-4 Neuroglia in the CNS revised (added descriptions of neuroglia to correlate the art with text)
- New Figure 8-7 The Resting Membrane Potential
- Spotlight Figure 8-8 The Generation of an Action Potential revised
- New Spotlight Figure 8-9 Propagation of an Action Potential
- Figure 8-11 The Events at a Cholinergic Synapse revised
- Figure 8-13 The Meninges of the Brain and Spinal Cord revised (art moved for label sharing and correlation between similar structures)
- New Figure 8-14 Gross Anatomy of the Spinal Cord
- Figure 8-16 The Brain revised (labels boxed to better correlate art and text)
- Figure 8-18 The Formation and Circulation of Cerebrospinal Fluid revised (added new art for part a and steps to improve correlation between art and text)
- Figure 8-19 Motor and Sensory Regions of the Cerebral Hemispheres revised (labels boxed to better correlate art and text)
- Figure 8-22 The Basal Nuclei revised (labels boxed to better correlate art and text)
- Figure 8-24 The Diencephalon and Brain Stem revised (labels boxed to better correlate art and text)
- Figure 8-25 The Cranial Nerves revised (incorporated table of cranial nerves to better correlate art and text)
- New Figure 8-26 Peripheral Nerves and Nerve Plexuses
- Figure 8-27 Dermatomes revised (added color-coded art and key to better correlate art and text)

- Figure 8-30 The Flexor Reflex, a Type of Withdrawal Reflex revised (step art added to better correlate art and text)
- Figure 8-31 The Posterior Column Pathway revised (step art added to better correlate art and text)
- Figure 8-32 The Corticospinal Pathway revised (step art added to better correlate art and text)
- Figure 8-34 The Sympathetic Division revised (shading added to spinal cord to better correlate art and text)
- Figure 8-35 The Parasympathetic Division revised (shading added to brain stem and spinal cord to better correlate art and text)
- Clinical Note: Epidural and Subdural Hemorrhages revised (added photograph)
- Clinical Note: Aphasia and Dyslexia revised
- Clinical Note: Alzheimer's Disease revised
- New Build Your Knowledge: How the NERVOUS SYSTEM integrates with the other body systems presented so far

### Chapter 9 The General and Special Senses

- Figure 9-1 Receptors and Receptive Fields revised
- Figure 9-2 Referred Pain revised
- Figure 9-3 Tactile Receptors in the Skin revised (boxed text added to better correlate art and text)
- Figure 9-4 Baroreceptors and the Regulation of Autonomic Functions revised
- Figure 9-5 Locations and Functions of Chemoreceptors revised
- Figure 9-6 The Olfactory Organs revised (changed olfactory cilia label to olfactory dendrites)
- Figure 9-7 Gustatory Receptors revised (changed supporting cell label to transitional cell)
- Figure 9-10 The Sectional Anatomy of the Eye revised
- Figure 9-13 The Circulation of Aqueous Humor revised (enhanced color of arrow showing circulation route)
- Figure 9-14 Focal Point, Focal Distance, and Visual Accommodation revised
- Spotlight Figure 9-16 Refractive Problems revised (title corrected from Accommodation Problems)
- Figure 9-19 Bleaching and Regeneration of Visual Pigments revised (added step art and text to improve topic comprehension)
- Figure 9-22 The Middle Ear revised
- New Figure 9-23 The Internal Ear
- New Figure 9-24 The Semicircular Ducts
- New Figure 9-25 The Utricle and Sacculae
- Figure 9-27 Sound and Hearing revised (added diagram to better correlate step art and text)
- Clinical Note: Cataracts revised (added photograph)

### Chapter 10 The Endocrine System

- Figure 10-1 Organs and Tissues of the Endocrine System revised (new art)
- Figure 10-2 The Role of Target Cell Receptors in Hormone Action revised (added step art and text)
- Figure 10-3 Processes of Hormone Action revised (added step art and text to improve topic comprehension)
- Figure 10-5 The Location and Anatomy of the Pituitary Gland revised (new photomicrograph)
- Figure 10-6 The Hypophyseal Portal System and the Blood Supply to the Pituitary Gland revised (added boxed text to improve topic comprehension)
- Figure 10-9 The Thyroid Gland revised (added new diagram to clarify histological details in photomicrograph)
- New Figure 10-10 The Homeostatic Regulation of Calcium Ion Concentrations
- New Figure 10-12 The Adrenal Gland and Adrenal Hormones (added new photomicrograph and incorporated former Table 10-3 The Adrenal Hormones)
- New Figure 10-14 The Regulation of Blood Glucose Concentrations
- New Clinical Note: Diabetes Mellitus
- New Clinical Note: Endocrine Disorders
- New Build Your Knowledge: How the ENDOCRINE SYSTEM integrates with the other body systems presented so far

### Chapter 11 The Cardiovascular System: Blood

- Spotlight Figure 11-1 The Composition of Whole Blood revised
- Figure 11-4 The Origins and Differentiation of RBCs, Platelets, and WBCs revised (replaced specific names of developing WBCs with "Developmental stages")
- New Figure 11-5 The Role of EPO in the Stimulation of Erythropoiesis
- Figure 11-7 Blood Type Testing revised (part of text, no longer within a Clinical Note)
- New Figure 11-9 The Vascular, Platelet, and Coagulation Phases of Hemostasis
- New Figure 11-10 The Structure of a Blood Clot
- Clinical Note: Hemolytic Disease of the Newborn revised (added new art)
- Clinical Note: Abnormal Hemostasis revised (added new thrombus art)

### Chapter 12 The Cardiovascular System: The Heart

- New Figure 12-1 An Overview of the Cardiovascular System
- Figure 12-3 The Position and Surface Anatomy of the Heart revised (added new part b of cadaver dissection)

- Figure 12-4 The Heart Wall and Cardiac Muscle Tissue revised (improved correlation between parts a and c)
- New Spotlight Figure 12-5 The Heart: Internal Anatomy and Blood Flow
- Figure 12-8 Action Potentials and Muscle Cell Contraction in Skeletal and Cardiac Muscle revised
- Figure 12-9 The Conducting System of the Heart revised (new three-dimensional art in part b)
- Figure 12-10 An Electrocardiogram revised (new three-dimensional art in part b)
- Figure 12-11 The Cardiac Cycle revised (art enlarged)
- New Figure 12-12 Heart Sounds
- Figure 12-13 Autonomic Innervation of the Heart revised
- Clinical Note: Heart Valve Disorders revised (added photograph of bioprosthetic valve)

### Chapter 13 The Cardiovascular System: Blood Vessels and Circulation

- Figure 13-1 A Comparison of a Typical Artery and a Typical Vein revised (clarified thickness of artery wall)
- New Figure 13-2 The Structure of the Various Types of Blood Vessels
- Figure 13-5 Pressures within the Systemic Circuit revised (clarified pulse pressure within the diagram)
- Figure 13-6 Forces Acting across Capillary Walls revised (added tissue cells to highlight capillary surroundings)
- New Figure 13-7 Short-Term and Long-Term Cardiovascular Responses
- New Figure 13-8 The Baroreceptor Reflexes of the Carotid and Aortic Sinuses
- New Figure 13-9 The Chemoreceptor Reflexes
- New Figure 13-10 The Hormonal Regulation of Blood Pressure and Blood Volume
- New Spotlight Figure 13-13 Major Vessels of the Systemic Circuit
- New Figure 13-14 Arteries of the Chest and Upper Limb (incorporates former art and flowchart)
- Figure 13-16 Major Arteries of the Trunk revised (added boxed labels to better correlate art and text)
- Figure 13-19 A Flowchart of the Tributaries of the Superior and Inferior Venae Cavae revised
- Figure 13-20 The Hepatic Portal System revised (added boxed labels to better correlate art and text)
- Clinical Note: Arteriosclerosis revised (added photomicrograph of a normal coronary artery for comparison)
- New Build Your Knowledge: How the CARDIOVASCULAR SYSTEM integrates with the other body systems presented so far

### Chapter 14 The Lymphatic System and Immunity

- Figure 14-1 The Components of the Lymphatic System revised (added art depicting lymph and lymphocyte and red bone marrow)
- New Spotlight Figure 14-4 Origin and Distribution of Lymphocytes
- Figure 14-5 The Tonsils revised (added photomicrograph of pharyngeal tonsil)
- Figure 14-9 The Body's Innate Defenses revised
- Figure 14-11 Forms of Immunity revised
- Figure 14-13 Antigen Recognition and Activation of Cytotoxic T Cells revised (added costimulation to step 2 to correlate with text description)
- Figure 14-14 The B Cell Response to Antigen Exposure revised (added costimulation to step 2 art)
- Table 14-2 Cells That Participate in Tissue Defenses revised
- Figure 14-17 A Summary of the Immune Response and Its Relationship to Innate (Nonspecific) Defenses revised
- Clinical Note: "Swollen Glands" revised (added photograph)
- New Build Your Knowledge: How the LYMPHATIC SYSTEM integrates with the other body systems presented so far

### Chapter 15 The Respiratory System

- New Figure 15-1 The Structures of the Respiratory System
- Figure 15-2 The Respiratory Mucosa revised (mucous gland added to part a to better correlate art and text)
- Figure 15-4 The Anatomy of the Larynx and Vocal Cords revised (corrected shared labeling between art in part d and photograph in part e)
- Figure 15-6 The Bronchi and Lobules of the Lung revised (improved clarity of pulmonary lobule anatomy in part b)
- Figure 15-7 Alveolar Organization revised (replaced part a art and part b SEM of lung tissue with photomicrograph)
- New Figure 15-8 The Gross Anatomy of the Lungs
- New Spotlight Figure 15-10 Pulmonary Ventilation
- Figure 15-12 An Overview of Respiratory Processes and Partial Pressures in Respiration revised
- Figure 15-14 A Summary of Gas Transport and Exchange revised (added partial pressures of oxygen and carbon dioxide to improve interpretation of the diagram)
- New Spotlight Figure 15-16 The Control of Respiration
- Clinical Note: Tracheal Blockage revised (added photograph of Heimlich maneuver)
- Clinical Note: Emphysema and Lung Cancer revised (added photographs of healthy lung and smoker's lung)
- New Build Your Knowledge: How the RESPIRATORY SYSTEM integrates with the other body systems presented so far



**Chapter 16 The Digestive System**

- Figure 16-1 The Components of the Digestive System revised (Teeth and Tongue moved to Accessory Organs of the Digestive System box)
- Figure 16-5 The Salivary Glands revised
- Figure 16-7 The Swallowing Process revised
- New Spotlight Figure 16-9 Regulation of Gastric Activity
- Figure 16-10 The Segments of the Small Intestine revised (new gross anatomy of the jejunum photograph)
- New Figure 16-12 The Activities of Major Digestive Tract Hormones
- Figure 16-13 The Pancreas revised (added a new part b diagram to improve interpretation of part c photomicrograph)
- Figure 16-15 Liver Histology revised
- Figure 16-17 The Large Intestine revised (added new part b cadaver photo of cecum and appendix)
- Clinical Note: Liver Disease revised (added cirrhosis of the liver art)
- New Build Your Knowledge: How the DIGESTIVE SYSTEM integrates with the other body systems presented so far

**Chapter 17 Metabolism and Energetics**

- Figure 17-3 Glycolysis revised (clarified text in Step 5)
- New Spotlight Figure 17-5 The Electron Transport System and ATP Formation
- Figure 17-6 A Summary of the Energy Yield of Aerobic Metabolism revised (clarified ATP gain per glucose molecule based on recently accepted lower conversion ratios of ATP per NADH and FADH<sub>2</sub>)
- Figure 17-9 Lipoproteins and Lipid Transport revised
- Figure 17-10 A Summary of Catabolic and Anabolic Pathways for Lipids, Carbohydrates, and Proteins revised

**Chapter 18 The Urinary System**

- Figure 18-3 The Structure of the Kidney revised (changed renal lobe to kidney lobe in part a, added papillary duct label to part c)
- Figure 18-5 A Representative Nephron and the Collecting System revised (added boxed text into the art)
- Figure 18-6 The Renal Corpuscle revised (boxed labels added to better correlate art and text)
- Figure 18-8 The Effects of ADH on the DCT and Collecting Duct revised (added compulsory water reabsorption and variable water reabsorption)
- Spotlight Figure 18-9 A Summary of Kidney Function revised (added art showing urea transporter)
- New Figure 18-10 The Renin-Angiotensin-Aldosterone System and Regulation of GFR

- Figure 18-11 Organs for the Conduction and Storage of Urine revised (clarified center of trigone in part c)
- Table 18-4 Water Balance revised (added percentages)
- New Build Your Knowledge: How the URINARY SYSTEM integrates with the other body systems presented so far

**Chapter 19 The Reproductive System**

- Figure 19-1 The Male Reproductive System revised (boxed labels added to better correlate art and text)
- Figure 19-2 The Scrotum, Testes, and Seminiferous Tubules revised (boxed label added to better correlate art and text)
- Figure 19-5 The Ductus Deferens revised (added ampulla of ductus deferens label)
- Figure 19-6 The Penis revised (new terminology: changed glans to glans penis)
- Figure 19-8 The Female Reproductive System revised (boxed labels added to better correlate art and text)
- Figure 19-9 Oogenesis revised
- Figure 19-10 Follicle Development and the Ovarian Cycle revised (added new photomicrograph of secondary follicle and corrected image magnifications)
- Figure 19-11 The Uterus revised
- Figure 19-12 The Female External Genitalia revised (caption now clarifies that left labium minus has been removed to show erectile tissue)
- Spotlight Figure 19-14 Regulation of Female Reproduction revised (clarifies that tertiary follicles are involved in step 2 Follicular Phase of the Ovarian Cycle)
- Table 19-1 Hormones of the Reproductive System revised (new terminology: changed progestins to progesterone.)
- Clinical Note: Birth Control Strategies revised (new photograph of contraceptive devices)
- New Build Your Knowledge: How the REPRODUCTIVE SYSTEM integrates with the other body systems presented so far

**Chapter 20 Development and Inheritance**

- Figure 20-1 Fertilization revised (step 5 title)
- New Spotlight Figure 20-5 Extraembryonic Membranes and Placenta Formation
- Figure 20-7 Development during the First Trimester revised
- Figure 20-8 The Second and Third Trimesters revised (added new ultrasound photograph in part b)
- Table 20-2 An Overview of Prenatal and Early Postnatal Development revised (includes revised sizes and weights at different gestational ages)

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# Contents



## 1 An Introduction to Anatomy and Physiology 29

### An Introduction to Studying the Human Body 30

- 1-1** All living things display responsiveness, growth, reproduction, movement, and metabolism 30
- 1-2** Anatomy is structure, and physiology is function 31  
Anatomy • Physiology
- 1-3** Levels of organization progress from atoms and molecules to a complete organism 32
- 1-4** The human body consists of 11 organ systems 34
- 1-5** Homeostasis is the state of internal balance 34
- 1-6** Negative feedback opposes variations from normal, whereas positive feedback exaggerates them 38  
Negative Feedback • Positive Feedback
- 1-7** Anatomical terms describe body regions, anatomical positions and directions, and body sections 41  
Surface Anatomy • Sectional Anatomy
- 1-8** Body cavities of the trunk protect internal organs and allow them to change shape 43  
The Thoracic Cavity • The Abdominopelvic Cavity

#### SPOTLIGHT

Levels of Organization 33

#### CLINICAL NOTE

Homeostasis and Disease 34

Imaging Techniques 48

**Chapter Review 50**



## 2 The Chemical Level of Organization 53

### An Introduction to the Chemical Level of Organization 54

- 2-1** Atoms are the basic particles of matter 54  
Atomic Structure • Isotopes • Atomic Weight • Electron Shells
- 2-2** Chemical bonds are forces formed by interactions among atoms 56  
Ionic Bonds • Covalent Bonds • Hydrogen Bonds
- 2-3** Decomposition, synthesis, and exchange reactions are important chemical reactions in physiology 59  
Basic Energy Concepts • Types of Reactions • Reversible Reactions

- 2-4** Enzymes catalyze specific biochemical reactions by lowering a reaction's activation energy 62
- 2-5** Inorganic compounds usually lack carbon, and organic compounds always contain carbon 62
- 2-6** Physiological systems depend on water 63
- 2-7** Body fluid pH is vital for homeostasis 64
- 2-8** Acids, bases, and salts have important physiological roles 65  
Salts • Buffers and pH
- 2-9** Carbohydrates contain carbon, hydrogen, and oxygen in a 1:2:1 ratio 66  
Monosaccharides • Disaccharides and Polysaccharides
- 2-10** Lipids contain a carbon-to-hydrogen ratio of 1:2 68  
Fatty Acids • Fats • Steroids • Phospholipids
- 2-11** Proteins contain carbon, hydrogen, oxygen, and nitrogen and are formed from amino acids 71  
Protein Function • Protein Structure • Enzyme Function
- 2-12** DNA and RNA are nucleic acids 74  
Structure of Nucleic Acids
- 2-13** ATP is a high-energy compound used by cells 76
- 2-14** Chemicals form functional units called cells 78

#### SPOTLIGHT

Chemical Notation 60

#### CLINICAL NOTE

Fatty Acids and Health 69

**Chapter Review 79**



## 3 Cell Structure and Function 83

### An Introduction to Cell Structure and Function 84

- 3-1** The study of cells provides the foundation for understanding human physiology 84  
The Study of Cells • An Overview of Cell Anatomy
- 3-2** The plasma membrane separates the cell from its surrounding environment and performs various functions 85  
Membrane Lipids • Membrane Proteins • Membrane Carbohydrates
- 3-3** Diffusion is a passive transport process that assists membrane passage 89  
Diffusion

- 3-4 Carrier-mediated and vesicular transport processes assist membrane passage** 93  
Carrier-Mediated Transport • Vesicular Transport
- 3-5 Organelles within the cytoplasm perform specific functions** 97  
The Cytosol • The Organelles
- 3-6 The nucleus contains DNA and enzymes essential for controlling cellular activities** 104  
Nuclear Structure and Contents • Information Storage in the Nucleus
- 3-7 DNA controls protein synthesis, cell structure, and cell function** 106  
Transcription • Translation
- 3-8 Stages of a cell's life cycle include interphase, mitosis, and cytokinesis** 109  
Interphase • Mitosis • Cytokinesis
- 3-9 Tumors and cancers are characterized by abnormal cell growth and division** 112
- 3-10 Differentiation is cellular specialization as a result of gene activation or repression** 113

**SPOTLIGHTS**

- Anatomy of a Model Cell 86
- Protein Synthesis, Processing, and Packaging 102

**CLINICAL NOTE**

- Inheritable Mitochondrial Disorders 101
- DNA Fingerprinting 106
- Mutations and Mosaicism 110

**Chapter Review** 114

## 4 The Tissue Level of Organization 118

### An Introduction to the Tissue Level of Organization 119

- 4-1 The four tissue types are epithelial, connective, muscle, and neural** 119
- 4-2 Epithelial tissue covers body surfaces, lines cavities and tubular structures, and serves essential functions** 119  
Functions of Epithelia • Intercellular Connections • The Epithelial Surface • The Basement Membrane • Epithelial Renewal and Repair
- 4-3 Cell shape and number of layers determine the classification of epithelia** 123  
Cell Layers • Cell Shapes • Classification of Epithelia • Glandular Epithelia
- 4-4 Connective tissue provides a protective structural framework for other tissue types** 129

Connective Tissue Proper • Types of Connective Tissue Proper • Fluid Connective Tissues • Supporting Connective Tissues

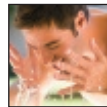
- 4-5 Tissue membranes are physical barriers of four types: mucous, serous, cutaneous, and synovial** 138  
Mucous Membranes • Serous Membranes • The Cutaneous Membrane • Synovial Membranes
- 4-6 The three types of muscle tissue are skeletal, cardiac, and smooth** 139  
Skeletal Muscle Tissue • Cardiac Muscle Tissue • Smooth Muscle Tissue
- 4-7 Neural tissue responds to stimuli and propagates electrical impulses throughout the body** 141
- 4-8 The response to tissue injury involves inflammation and regeneration** 142
- 4-9 With advancing age, tissue repair declines and cancer rates increase** 143  
Aging and Tissue Structure • Aging and Cancer Rates

**SPOTLIGHT**

Inflammation and Regeneration 144

**CLINICAL NOTE**

- Exfoliative Cytology 129
- Marfan's Syndrome 132
- Adipose Tissue and Weight Control 134
- Cartilages and Joint Injuries 135

**Chapter Review** 145

## 5 The Integumentary System 149

### An Introduction to the Integumentary System 150

- 5-1 The epidermis is composed of strata (layers) with various functions** 151  
Stratum Basale • Intermediate Strata • Stratum Corneum
- 5-2 Factors influencing skin color are epidermal pigmentation and dermal circulation** 154  
The Role of Pigmentation • The Role of Dermal Circulation
- 5-3 Sunlight has beneficial and detrimental effects on the skin** 155  
The Epidermis and Vitamin D<sub>3</sub> • Skin Cancers
- 5-4 The dermis is the tissue layer that supports the epidermis** 156
- 5-5 The hypodermis connects the dermis to underlying tissues** 157
- 5-6 Hair is composed of dead, keratinized cells that have been pushed to the skin surface** 157

The Structure of Hair and Hair Follicles • Functions of Hair • Hair Color

- 5-7** Sebaceous glands and sweat glands are exocrine glands found in the skin 160  
Sebacous (Oil) Glands • Sweat Glands
- 5-8** Nails are keratinized epidermal cells that protect the tips of fingers and toes 161
- 5-9** Several steps are involved in repairing the integument following an injury 162  
Repair of Skin Injuries • Effects of Burns
- 5-10** Effects of aging include dermal thinning, wrinkling, and reduced melanocyte activity 165

### SPOTLIGHT

The Epidermis 152

### CLINICAL NOTE

Drug Administration through the Skin 153  
Disorders of Keratin Production 154  
Dermatitis 156  
Hair Loss 159  
Burns 164

**Chapter Review 167**



## 6 The Skeletal System 170

An Introduction to the Skeletal System 171

- 6-1** The skeletal system has five primary functions 171
- 6-2** Bones are classified according to shape and structure 171  
Macroscopic Features of Bone • Microscopic Features of Bone
- 6-3** Ossification and appositional growth are processes of bone formation and enlargement 174  
Intramembranous Ossification • Endochondral Ossification • Bone Growth and Body Proportions • Requirements for Normal Bone Growth
- 6-4** Bone growth and development depend on a balance between bone formation and resorption, and on calcium availability 177  
The Role of Remodeling in Support • The Skeleton as a Calcium Reserve • Repair of Fractures
- 6-5** Osteopenia has a widespread effect on aging skeletal tissue 180
- 6-6** The bones of the skeleton are distinguished by bone markings and grouped into two skeletal divisions 180  
Bone Markings (Surface Features) • Skeletal Divisions
- 6-7** The bones of the skull, vertebral column, and thoracic cage make up the axial skeleton 184  
The Skull • The Vertebral Column and Thoracic Cage

- 6-8** The pectoral girdles and upper limb bones, and the pelvic girdle and lower limb bones, make up the appendicular skeleton 194  
The Pectoral Girdles • The Upper Limb • The Pelvic Girdle • The Lower Limb

- 6-9** Joints are categorized according to their range of motion or anatomical organization 202  
Immovable Joints (Synarthroses) • Slightly Movable Joints (Amphiarthroses) • Freely Movable Joints (Diarthroses)

- 6-10** The structure and functions of synovial joints enable various skeletal movements 204  
Types of Movements at Synovial Joints • Types of Synovial Joints

- 6-11** Intervertebral articulations and appendicular articulations demonstrate functional differences in support and mobility 207  
Intervertebral Articulations • Articulations of the Upper Limb • Articulations of the Lower Limb

- 6-12** The skeletal system supports and stores energy and minerals for other body systems 212

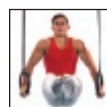
### SPOTLIGHT

Synovial Joints 208

### CLINICAL NOTE

Types of Fractures and Steps in Repair 178  
Osteoporosis 180  
Rheumatism and Arthritis 204  
Hip Fractures 212

**Chapter Review 214**



## 7 The Muscular System 219

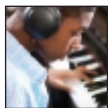
An Introduction to Muscle Tissue 220

- 7-1** Skeletal muscle performs five primary functions 220
- 7-2** A skeletal muscle contains muscle tissue, connective tissues, blood vessels, and nerves 220  
Connective Tissue Organization • Blood Vessels and Nerves
- 7-3** Skeletal muscle fibers have distinctive features 222  
The Sarcolemma and Transverse Tubules • Myofibrils • The Sarcoplasmic Reticulum • Sarcomeres
- 7-4** The nervous system and skeletal muscles communicate at neuromuscular junctions 225  
The Neuromuscular Junction • The Contraction Cycle
- 7-5** Sarcomere shortening and muscle fiber stimulation produce tension 228  
Frequency of Muscle Fiber Stimulation • Number of Muscle Fibers Activated • Isotonic and Isometric Contractions • Muscle Elongation Following Contraction

- 7-6 ATP is the energy source for muscle contraction** 235  
ATP and CP Reserves • ATP Generation • Energy Use and the Level of Muscle Activity • Muscle Fatigue • The Recovery Period
- 7-7 Muscle performance depends on muscle fiber type and physical conditioning** 238  
Types of Skeletal Muscle Fibers • Physical Conditioning
- 7-8 Cardiac and smooth muscle tissues differ in structure and function from skeletal muscle tissue** 239  
Cardiac Muscle Tissue • Smooth Muscle Tissue
- 7-9 Descriptive terms are used to name skeletal muscles** 241  
Origins, Insertions, and Actions • Names of Skeletal Muscles
- 7-10 Axial muscles are muscles of the head and neck, vertebral column, trunk, and pelvic floor** 245  
Muscles of the Head and Neck • Muscles of the Spine • The Axial Muscles of the Trunk • Muscles of the Pelvic Floor
- 7-11 Appendicular muscles are muscles of the shoulders, upper limbs, pelvic girdle, and lower limbs** 253  
Muscles of the Shoulders and Upper Limbs • Muscles of the Pelvis and Lower Limbs
- 7-12 The size and power of muscle tissue decrease with advancing age** 264
- 7-13 Exercise produces responses in multiple body systems** 265
- SPOTLIGHTS**  
Events at the Neuromuscular Junction 226  
The Contraction Cycle 230
- CLINICAL NOTE**  
Interference at the NMJ and Muscular Paralysis 228  
Rigor Mortis 228  
Tetanus 229  
Hernias 248  
Intramuscular Injections 251
- Chapter Review** 267
-  **8 The Nervous System** 271
- An Introduction to the Nervous System 272
- 8-1 The nervous system has anatomical and functional divisions** 272
- 8-2 Neurons are specialized for intercellular communication and are supported by cells called neuroglia** 273  
Neurons • Neuroglia • Organization of Neurons in the Nervous System
- 8-3 In neurons, a change in the plasma membrane's electrical potential may result in an action potential (nerve impulse)** 279  
The Membrane Potential • Propagation of an Action Potential
- 8-4 At synapses, communication takes place among neurons or between neurons and other cells** 286  
Structure of a Synapse • Synaptic Function and Neurotransmitters • Neuronal Pools
- 8-5 The brain and spinal cord are surrounded by three layers of membranes called the meninges** 289  
The Dura Mater • The Arachnoid • The Pia Mater
- 8-6 The spinal cord contains gray matter surrounded by white matter and connects to 31 pairs of spinal nerves** 290  
Gross Anatomy • Sectional Anatomy
- 8-7 The brain has several principal structures, each with specific functions** 294  
The Major Regions of the Brain • The Ventricles of the Brain • The Cerebrum • The Diencephalon • The Midbrain • The Pons • The Cerebellum • The Medulla Oblongata
- 8-8 The PNS connects the CNS with the body's external and internal environments** 306  
The Cranial Nerves • The Spinal Nerves • Nerve Plexuses
- 8-9 Reflexes are rapid, automatic responses to stimuli** 311  
Simple Reflexes • Complex Reflexes • Integration and Control of Spinal Reflexes
- 8-10 Separate pathways carry sensory information and motor commands** 314  
Sensory Pathways • Motor Pathways
- 8-11 The autonomic nervous system, composed of the sympathetic and parasympathetic divisions, is involved in the unconscious regulation of body functions** 317  
The Sympathetic Division • The Parasympathetic Division • Relationships between the Sympathetic and Parasympathetic Divisions
- 8-12 Aging produces various structural and functional changes in the nervous system** 322
- 8-13 The nervous system is closely integrated with other body systems** 324
- SPOTLIGHTS**  
The Generation of an Action Potential 282  
Propagation of an Action Potential 284
- CLINICAL NOTE**  
Demyelination Disorders 279  
Epidural and Subdural Hemorrhages 290

Spinal Cord Injuries 292  
 Aphasia and Dyslexia 302  
 Seizures 303  
 Cerebral Palsy 317  
 Alzheimer's Disease 324

**Chapter Review 326**



## 9 The General and Special Senses 333

### An Introduction to General and Special Senses 334

- 9-1** Sensory receptors connect our internal and external environments with the nervous system 334
- 9-2** General sensory receptors are classified by the type of stimulus that excites them 335  
 Pain • Temperature • Touch, Pressure, and Position • Chemical Detection
- 9-3** Olfaction, the sense of smell, involves olfactory receptors responding to chemical stimuli 339  
 The Olfactory Pathways
- 9-4** Gustation, the sense of taste, involves taste receptors responding to chemical stimuli 341  
 The Taste Pathways
- 9-5** Internal eye structures contribute to vision, while accessory eye structures provide protection 342  
 The Accessory Structures of the Eye • The Eye
- 9-6** Photoreceptors respond to light and change it into electrical signals essential to visual physiology 351  
 Rods and Cones • Photoreceptor Structure • Photoreception • The Visual Pathways
- 9-7** Equilibrium sensations originate within the internal ear, while hearing involves the detection and interpretation of sound waves 356  
 Anatomy of the Ear • Equilibrium • Hearing
- 9-8** Aging is accompanied by a noticeable decline in the special senses 366  
 Smell and Aging • Taste and Aging • Vision and Aging • Equilibrium and Aging • Hearing and Aging

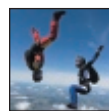
#### SPOTLIGHT

Refractive Problems 352

#### CLINICAL NOTE

Cataracts 349  
 Visual Acuity 354  
 Night Blindness 355  
 Hearing Deficits 364

**Chapter Review 367**



## 10 The Endocrine System 372

### An Introduction to the Endocrine System 373

- 10-1** Homeostasis is preserved through intercellular communication 373
- 10-2** The endocrine system regulates physiological processes through the binding of hormones to receptors 374  
 The Structure of Hormones • Hormone Action • The Secretion and Distribution of Hormones • The Control of Endocrine Activity
- 10-3** The bilobed pituitary gland is an endocrine organ that releases nine peptide hormones 379  
 The Anterior Lobe of the Pituitary Gland • The Posterior Lobe of the Pituitary Gland
- 10-4** The thyroid gland lies inferior to the larynx and requires iodine for hormone synthesis 384  
 Thyroid Follicles and Thyroid Hormones • The C Cells of the Thyroid Gland and Calcitonin
- 10-5** The four parathyroid glands, embedded in the posterior surfaces of the thyroid gland, secrete parathyroid hormone to elevate blood calcium levels 388
- 10-6** The adrenal glands, consisting of a cortex and a medulla, cap each kidney and secrete several hormones 388  
 The Adrenal Cortex • The Adrenal Medulla
- 10-7** The pineal gland, attached to the third ventricle, secretes melatonin 391
- 10-8** The endocrine pancreas produces insulin and glucagon, hormones that regulate blood glucose levels 391  
 Diabetes Mellitus
- 10-9** Many organs have secondary endocrine functions 393  
 The Intestines • The Kidneys • The Heart • The Thymus • The Gonads • Adipose Tissue
- 10-10** Hormones interact to produce coordinated physiological responses 396  
 Hormones and Growth • Hormones and Stress • Hormones and Behavior • Hormones and Aging
- 10-11** Extensive integration occurs between the endocrine system and other body systems 401

#### SPOTLIGHT

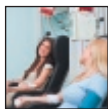
The General Adaptation Syndrome 399

#### CLINICAL NOTE

Diabetes Insipidus 383  
 Diabetes Mellitus 394  
 Hormones and Athletic Performance 397  
 Endocrine Disorders 400

**Chapter Review 403**





## 11 The Cardiovascular System: Blood 407

### An Introduction to the Cardiovascular System 408

- 11-1** Blood has several important functions and unique physical characteristics 408  
Composition of Blood • Blood Collection and Analysis
- 11-2** Plasma, the fluid portion of blood, contains significant quantities of plasma proteins 409  
Plasma Proteins
- 11-3** Red blood cells, formed by erythropoiesis, contain hemoglobin that can be recycled 412  
Abundance of Red Blood Cells • Structure of RBCs • Hemoglobin Structure and Function • RBC Life Span and Circulation • RBC Formation
- 11-4** The ABO blood types and Rh system are based on antigen–antibody responses 418  
Cross-Reactions in Transfusions • Testing for Blood Compatibility
- 11-5** The various types of white blood cells contribute to the body’s defenses 421  
WBC Circulation and Movement • Types of WBCs • The Differential Count and Changes in WBC Abundance • WBC Formation
- 11-6** Platelets, disc-shaped structures formed from megakaryocytes, function in the clotting process 425
- 11-7** Hemostasis involves vascular spasm, platelet plug formation, and blood coagulation 425  
Phases of Hemostasis • The Clotting Process • Clot Retraction and Removal

#### SPOTLIGHT

The Composition of Whole Blood 410

#### CLINICAL NOTE

Abnormal Hemoglobin 414  
Hemolytic Disease of the Newborn 420  
Abnormal Hemostasis 427

#### Chapter Review 429



## 12 The Cardiovascular System: The Heart 432

### The Heart’s Role in the Cardiovascular System 433

- 12-1** The heart is a four-chambered organ, supplied by coronary circulation, that pumps oxygen-poor blood to the lungs and oxygen-rich blood to the rest of the body 433  
The Surface Anatomy of the Heart • The Heart Wall • Internal Anatomy and Organization

- 12-2** Contractile cells and the conducting system produce each heartbeat, and an electrocardiogram records the associated electrical events 443  
Contractile Cells • The Conducting System • The Electrocardiogram

- 12-3** Events during a complete heartbeat make up a cardiac cycle 448  
Phases of the Cardiac Cycle • Heart Sounds

- 12-4** Heart dynamics examines the factors that affect cardiac output 450  
Blood Volume Reflexes • Autonomic Innervation • Hormones

#### SPOTLIGHT

The Heart: Internal Anatomy and Blood Flow 439

#### CLINICAL NOTE

Heart Valve Disorders 440  
Abnormal Conditions Affecting Cardiac Output 451

#### Chapter Review 453



## 13 The Cardiovascular System: Blood Vessels and Circulation 457

### An Introduction to Blood Vessels and Circulation 458

- 13-1** Arteries, arterioles, capillaries, venules, and veins differ in size, structure, and function 458  
The Structure of Vessel Walls • Arteries • Capillaries • Veins
- 13-2** Pressure and resistance determine blood flow and affect rates of capillary exchange 463  
Factors Affecting Blood Flow • Cardiovascular Pressures within the Systemic Circuit
- 13-3** Cardiovascular regulation involves autoregulation, neural processes, and endocrine responses 469  
Autoregulation of Blood Flow within Tissues • Neural Control of Blood Pressure and Blood Flow • Hormones and Cardiovascular Regulation
- 13-4** The cardiovascular system adapts to physiological stress 475  
Exercise and the Cardiovascular System • The Cardiovascular Response to Hemorrhage
- 13-5** The pulmonary and systemic circuits of the cardiovascular system exhibit three general functional patterns 477
- 13-6** In the pulmonary circuit, deoxygenated blood enters the lungs in arteries, and oxygenated blood leaves the lungs in veins 478
- 13-7** The systemic circuit carries oxygenated blood from the left ventricle to tissues other than the lungs’

exchange surfaces, and returns deoxygenated blood to the right atrium 479

Systemic Arteries • Systemic Veins

**13-8** Modifications of fetal and maternal cardiovascular systems promote the exchange of materials until birth 490

Placental Blood Supply • Fetal Circulation in the Heart and Great Vessels • Circulatory Changes at Birth

**13-9** Aging affects the blood, heart, and blood vessels 491

**13-10** The cardiovascular system is both structurally and functionally linked to all other systems 492

**SPOTLIGHT**

Major Vessels of the Systemic Circuit 480

**CLINICAL NOTE**

Arteriosclerosis 461

Capillary Dynamics and Blood Volume and Pressure 467

Checking the Pulse and Blood Pressure 468

Exercise, Cardiovascular Fitness, and Health 475

Shock 476

**Chapter Review 494**



# 14 The Lymphatic System and Immunity 499

An Introduction to the Lymphatic System and Immunity 500

**14-1** Anatomical barriers and defense processes make up nonspecific defense, and lymphocytes provide specific defense 500

**14-2** Lymphatic vessels, lymphocytes, lymphoid tissues, and lymphoid organs function in body defenses 501

Functions of the Lymphatic System • Lymphatic Vessels • Lymphocytes • Lymphoid Tissues • Lymphoid Organs

**14-3** Innate (nonspecific) defenses respond in a characteristic way regardless of the potential threat 509

Physical Barriers • Phagocytes • Immune Surveillance • Interferons • The Complement System • Inflammation • Fever

**14-4** Adaptive (specific) defenses respond to specific threats and are either cell mediated or antibody mediated 513

Forms of Immunity • An Overview of the Immune Response

**14-5** T cells play a role in starting and controlling the immune response 515

Antigen Presentation • T Cell Activation

**14-6** B cells respond to antigens by producing specific antibodies 517

B Cell Sensitization and Activation • Antibody Structure • Antibody Function • Primary and Secondary Responses to Antigen Exposure • Summary of the Immune Response • Hormones of the Immune System

**14-7** Abnormal immune responses result in immune disorders 524

Autoimmune Disorders • Immunodeficiency Diseases • Allergies

**14-8** The immune response diminishes as we age 525

**14-9** For all body systems, the lymphatic system provides defenses against infection and returns tissue fluid to the circulation 526

**SPOTLIGHT**

Origin and Distribution of Lymphocytes 505

**CLINICAL NOTE**

“Swollen Glands” 507

Injury to the Spleen 509

AIDS 521

Stress and the Immune Response 525

Manipulating the Immune Response 526

**Chapter Review 528**



# 15 The Respiratory System 533

An Introduction to the Respiratory System 534

**15-1** The respiratory system, composed of air-conducting and respiratory portions, has several basic functions 534

Functions of the Respiratory System • Structures of the Respiratory System

**15-2** The nose, pharynx, larynx, trachea, bronchi, and larger bronchioles conduct air into the lungs 536

The Nose • The Pharynx • The Larynx • The Trachea • The Bronchi

**15-3** The smallest bronchioles and the alveoli within the lungs make up the respiratory portion of the respiratory tract 542

The Bronchioles • The Respiratory Membrane • The Lungs • The Pleural Cavities

**15-4** External respiration and internal respiration allow gas exchange within the body 546

**15-5** Pulmonary ventilation—the exchange of air between the atmosphere and the lungs—involves pressure changes and muscle movement 547

Pressure and Airflow to the Lungs • Compliance • Modes of Breathing • Lung Volumes and Capacities

- 15-6 Gas exchange depends on the partial pressures of gases and the diffusion of molecules** 550  
Mixed Gases and Partial Pressures • Alveolar Air versus Atmospheric Air • Partial Pressures in the Pulmonary and Systemic Circuits
- 15-7 Most O<sub>2</sub> is transported bound to hemoglobin (Hb), and CO<sub>2</sub> is dissolved in plasma, bound to Hb, or transported as bicarbonate ion** 552  
Oxygen Transport • Carbon Dioxide Transport
- 15-8 Neurons in the medulla oblongata and pons, along with respiratory reflexes, control respiration** 555  
The Local Control of Respiration • Control by the Respiratory Centers of the Brain • The Reflex Control of Respiration • Control by Higher Centers • Respiratory Changes at Birth
- 15-9 Respiratory performance declines with age** 560
- 15-10 The respiratory system provides oxygen to, and removes carbon dioxide from, other organ systems** 560

**SPOTLIGHTS**

- Pulmonary Ventilation 548  
The Control of Respiration 558

**CLINICAL NOTE**

- Cystic Fibrosis 537  
Tracheal Blockage 540  
Pneumonia 544  
Tuberculosis 545  
Decompression Sickness 551  
Carbon Monoxide Poisoning 553  
Emphysema and Lung Cancer 559

**Chapter Review** 562

# 16 The Digestive System

## 566

**An Introduction to the Digestive System** 567

- 16-1 The digestive system—the digestive tract and accessory organs—performs various food-processing functions** 567  
Functions of the Digestive System • Histological Organization of the Digestive Tract • The Movement of Digestive Materials
- 16-2 The oral cavity contains the tongue, salivary glands, and teeth, each with specific functions** 571  
The Tongue • Salivary Glands • Teeth
- 16-3 The pharynx is a passageway between the oral cavity and the esophagus** 574  
The Pharynx • The Esophagus • Swallowing
- 16-4 The J-shaped stomach receives food from the esophagus and aids in chemical and mechanical digestion** 575

The Gastric Wall • The Regulation of Gastric Activity • Digestion in the Stomach

- 16-5 The small intestine digests and absorbs nutrients** 580  
The Intestinal Wall • Intestinal Movements • Intestinal Secretions • Intestinal Hormones • Digestion in the Small Intestine
- 16-6 The pancreas, liver, and gallbladder are accessory organs that assist with the digestive process in the small intestine** 584  
The Pancreas • The Liver • The Gallbladder
- 16-7 The large intestine is divided into three parts with regional specialization** 590  
The Cecum • The Colon • The Rectum • The Functions of the Large Intestine
- 16-8 Digestion is the chemical alteration of food that allows the absorption and use of nutrients** 594  
The Processing and Absorption of Nutrients • Water and Electrolyte Absorption • Absorption of Vitamins
- 16-9 Many age-related changes affect digestion and absorption** 597
- 16-10 The digestive system is extensively integrated with other body systems** 598

**SPOTLIGHTS**

- Regulation of Gastric Activity 578  
Chemical Events in Digestion 595

**CLINICAL NOTE**

- Gastritis and Peptic Ulcers 579  
Stomach Cancer 579  
Vomiting 583  
Pancreatitis 586  
Liver Disease 589  
Colorectal Cancer 592  
Diverticulosis 593  
Diarrhea and Constipation 593  
Lactose Intolerance 596

**Chapter Review** 600

# 17 Metabolism and Energetics

## 605

**An Introduction to Nutrition and Metabolism** 606

- 17-1 Metabolism refers to all the chemical reactions in the body, and energetics refers to the flow and transformation of energy** 606
- 17-2 Carbohydrate metabolism involves glycolysis, ATP production, and gluconeogenesis** 608  
Glycolysis • Energy Production Within Mitochondria • Energy Yield of Glycolysis and Cellular Respiration • Gluconeogenesis (Glucose Synthesis) • Alternate Catabolic Pathways

- 17-3** Lipid metabolism involves lipolysis, beta-oxidation, and the transport and distribution of lipids as lipoproteins and free fatty acids 615  
Lipid Catabolism • Lipids and Energy Production • Lipid Synthesis • Lipid Transport and Distribution
- 17-4** Protein catabolism involves transamination and deamination, and protein synthesis involves amination and transamination 617  
Amino Acid Catabolism • Amino Acids and Protein Synthesis
- 17-5** Nucleic acid catabolism involves RNA, but not DNA 619  
RNA Catabolism • Nucleic Acid Synthesis
- 17-6** Adequate nutrition is necessary to prevent deficiency disorders and maintain homeostasis 620  
Food Groups and a Balanced Diet • Minerals, Vitamins, and Water • Diet and Disease
- 17-7** Metabolic rate is the average caloric expenditure, and thermoregulation involves balancing heat-producing and heat-losing processes 624  
The Energy Content of Food • Energy Expenditure: Metabolic Rate • Thermoregulation
- 17-8** Caloric needs decline with advancing age 627

**SPOTLIGHT**

Electron Transport System and ATP Formation 611

**CLINICAL NOTE**Carbohydrate Loading 613  
Dietary Fats and Cholesterol 615  
Ketoacidosis 618**Chapter Review 628**

## 18 The Urinary System 632

An Introduction to the Urinary System 633

- 18-1** The urinary system—made up of the kidneys, ureters, urinary bladder, and urethra—has three major functions 633
- 18-2** The kidneys are highly vascular organs containing functional units called nephrons, which perform filtration, reabsorption, and secretion 634  
Superficial and Sectional Anatomy of the Kidneys • The Blood Supply to the Kidneys • The Nephron
- 18-3** Different portions of the nephron form urine by filtration, reabsorption, and secretion 641  
Nephron Processes • Filtration at the Glomerulus • Reabsorption and Secretion along the Renal Tubule • Normal Urine
- 18-4** Normal kidney function depends on a stable GFR 648  
The Local Regulation of Kidney Function • The Hormonal Control of Kidney Function

- 18-5** Urine is transported by the ureters, stored in the bladder, and eliminated through the urethra, aided by the micturition reflex 651  
The Ureters • The Urinary Bladder • The Urethra • The Micturition Reflex and Urination
- 18-6** Fluid balance, electrolyte balance, and acid-base balance are interrelated and essential to homeostasis 654  
The ECF and the ICF
- 18-7** Blood pressure and osmosis are involved in maintaining fluid and electrolyte balance 656  
Fluid Balance • Electrolyte Balance
- 18-8** In acid-base balance, regulation of hydrogen ions in body fluids involves buffer systems and compensation by respiratory and renal processes 658  
Acids in the Body • Buffers and Buffer Systems • Maintaining Acid-Base Balance • Acid-Base Disorders
- 18-9** Age-related changes affect kidney function and the micturition reflex 662
- 18-10** The urinary system is one of several body systems involved in waste excretion 663

**SPOTLIGHT**

A Summary of Kidney Function 646

**CLINICAL NOTE**Kidney Failure 650  
Urinary Tract Infections 652  
Incontinence 653  
Disturbances of Acid-Base Balance 661**Chapter Review 665**

## 19 The Reproductive System 670

An Introduction to the Reproductive System 671

- 19-1** Basic reproductive system structures are gonads, ducts, accessory glands and organs, and external genitalia 671
- 19-2** Sperm formation (spermatogenesis) occurs in the testes, and hormones from the hypothalamus, pituitary gland, and testes control male reproductive functions 672  
The Testes • The Male Reproductive Tract • The Accessory Glands • The External Genitalia • Hormones and Male Reproductive Function
- 19-3** Ovum production (oogenesis) occurs in the ovaries, and hormones from the pituitary gland and ovaries control female reproductive functions 681  
The Ovaries • The Uterine Tubes • The Uterus • The Vagina • The External Genitalia • The Mammary Glands • Hormones and the Female Reproductive Cycle

**19-4 The autonomic nervous system influences male and female sexual function 693**

Male Sexual Function • Female Sexual Function

**19-5 With age, decreasing levels of reproductive hormones cause functional changes 694**

Menopause • The Male Climacteric

**19-6 The reproductive system secretes hormones affecting growth and metabolism of all body systems 695****SPOTLIGHTS**

Regulation of Male Reproduction 680

Regulation of Female Reproduction 690

**CLINICAL NOTE**

Cryptorchidism 674

Prostatitis 678

Pelvic Inflammatory Disease (PID) 686

Amenorrhea 687

Breast Cancer 689

Infertility 692

Sexually Transmitted Diseases 693

Birth Control Strategies 696

**Chapter Review 699****20 Development and Inheritance 703**

An Introduction to Development and Inheritance 704

**20-1 Development is a continuous process that occurs from fertilization to maturity 704****20-2 Fertilization—the fusion of a secondary oocyte and a spermatozoon—forms a zygote 705**

An Overview of Fertilization • Ovulation and Oocyte Activation

**20-3 Gestation consists of three stages of prenatal development: the first, second, and third trimesters 707****20-4 Critical events of the first trimester are cleavage, implantation, placentation, and embryogenesis 707**

Cleavage and Blastocyst Formation • Implantation • Placentation • Embryogenesis

**20-5 During the second and third trimesters, maternal organ systems support the developing fetus, and the uterus undergoes structural and functional changes 715**

The Effects of Pregnancy on Maternal Systems • Structural and Functional Changes in the Uterus

**20-6 Labor consists of the dilation, expulsion, and placental stages 722**

The Stages of Labor • Premature Labor • Multiple Births

**20-7 Postnatal stages are the neonatal period, infancy, childhood, adolescence, and maturity, followed by senescence 724**

The Neonatal Period, Infancy, and Childhood • Adolescence and Maturity

**20-8 Genes and chromosomes determine patterns of inheritance 726**

Patterns of Inheritance • The Human Genome Project and Beyond

**SPOTLIGHT**

Extraembryonic Membranes and Placenta Formation 712

**CLINICAL NOTE**

Abortion 726

Chromosomal Abnormalities and Genetic Analysis 732

**Chapter Review 733**

Answers Answers to Checkpoint and Chapter Review Questions 737

Appendix Normal Physiological Values 766

Glossary/Index 769

Photo and Illustration Credits 805

# An Introduction to Anatomy and Physiology

## Learning Outcomes

These Learning Outcomes tell you what you should be able to do after completing the chapter. They correspond by number to this chapter's sections.

- 1-1** Describe the basic functions of living organisms.
- 1-2** Explain the relationship between anatomy and physiology, and describe various specialties of each discipline.
- 1-3** Identify the major levels of organization in organisms, from the simplest to the most complex.
- 1-4** Identify the 11 organ systems of the human body and contrast their major functions.
- 1-5** Explain the concept of homeostasis.
- 1-6** Describe how negative feedback and positive feedback are involved in homeostatic regulation.
- 1-7** Use anatomical terms to describe body regions, body sections, and relative positions.
- 1-8** Identify the major body cavities of the trunk and the subdivisions of each.



## Clinical Notes

Homeostasis and Disease, p. 34  
Imaging Techniques, pp. 48–49

## Spotlight

Levels of Organization, p. 33

## An Introduction to Studying the Human Body

In this textbook we will introduce you to the essential, inner workings of your body—giving information about its structure (anatomy) and function (physiology). As a human, you are most likely very curious, and few subjects arouse so much curiosity as our own bodies. You will discover how

your body works under normal and abnormal conditions and how it maintains an internal state of balance. As we proceed, you will see how your body deals with injury, disease, or anything that threatens that crucial balance in a changing environment.



### Build Your Knowledge

Throughout each chapter, you will find Build Your Knowledge boxes that will coach you through anatomy and physiology concepts. This feature will help you connect new material with what you already know. At the end of each chapter that closes a body system, you will see a “capstone”

Build Your Knowledge page that will illustrate the integration of the body system with the other body systems presented up to that point in the book. Be sure to read every Build Your Knowledge box or page so that you can build your knowledge—and confidence!

## 1-1 All living things display responsiveness, growth, reproduction, movement, and metabolism

**Learning Outcome** Describe the basic functions of living organisms.

We live in a world containing an amazing diversity of living organisms that vary widely in appearance and lifestyle. One aim of **biology**—the study of life—is to discover the common patterns that underlie this diversity. Such discoveries show that all living things share these common functions:

- **Responsiveness.** Organisms respond to changes in their immediate environment. This property is also called *irritability*. You move your hand away from a hot stove, your dog barks at approaching strangers, fish are alarmed by loud noises, and tiny amoebas glide toward potential prey. Organisms also make longer-term changes as they adjust to their environments. For example, an animal may grow a heavier coat of fur as winter approaches, or it may migrate to a warmer climate. The capacity to make such adjustments is termed *adaptability*.
- **Growth.** Organisms increase in size through the growth or addition of **cells**, the simplest units of life. Single-celled creatures grow by getting larger. More complex organisms grow primarily by increasing the number of cells. Familiar organisms, such as dogs, cats, and humans, are made up of trillions of cells. As such multicellular

organisms develop, individual cells become specialized to perform particular functions. This specialization is called *differentiation*.

- **Reproduction.** Organisms reproduce, creating new generations of similar, but not identical, organisms.
- **Movement.** Organisms can move. Their movement may be internal (transporting food, blood, or other materials within the body) or external (moving through the environment).
- **Metabolism.** Organisms rely on complex chemical reactions to provide the energy required for responsiveness, growth, reproduction, and movement. They also build complex chemicals, such as proteins. *Metabolism* refers to all the chemical operations in the body.

For normal metabolic operations, organisms must absorb materials from the environment. To generate energy efficiently, most cells require various nutrients they obtain in food, as well as oxygen, a gas. *Respiration* refers to the absorption, transport, and use of oxygen by cells. Metabolic operations often generate unneeded or potentially harmful waste products that must be eliminated through the process of *excretion*.

For very small organisms, absorption, respiration, and excretion involve the movement of materials across exposed surfaces. But creatures larger than a few millimeters across seldom absorb nutrients directly from their environment. For example, humans cannot absorb steaks, apples, or ice cream without processing them first. That processing, called