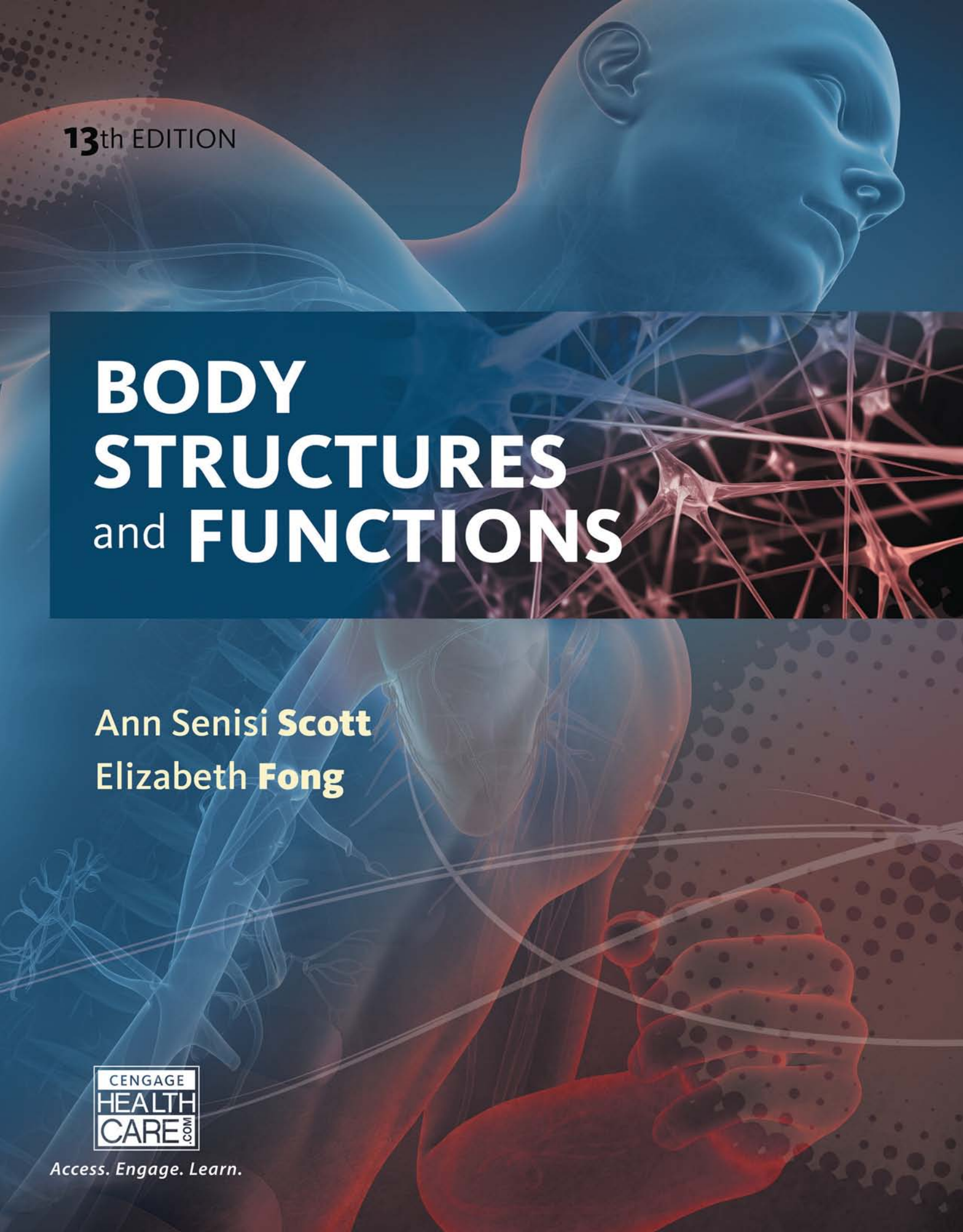
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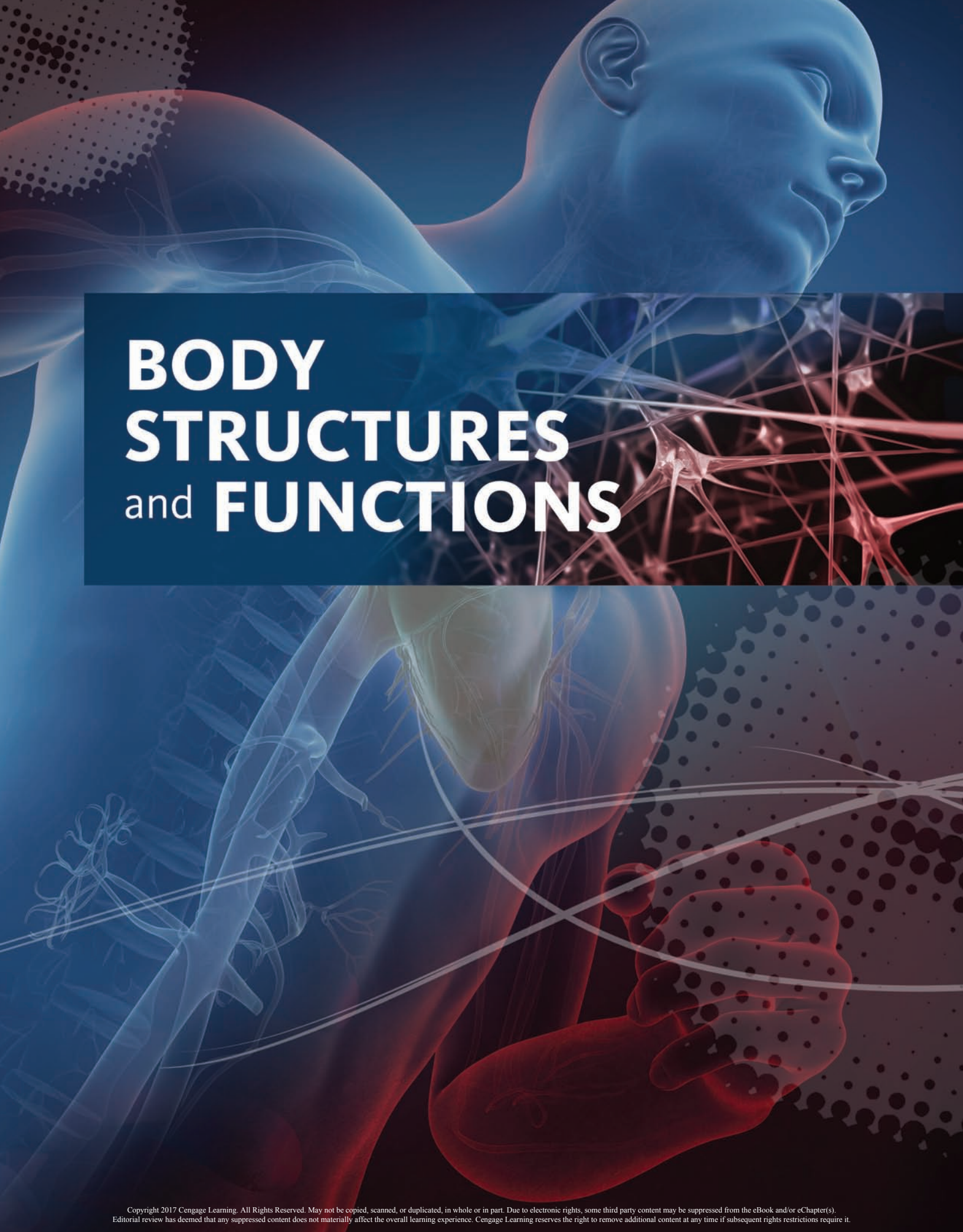

13th EDITION

BODY STRUCTURES and FUNCTIONS

Ann Senisi Scott
Elizabeth Fong

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Body Structures and Functions, 13th Edition

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PREFACE

Introduction

The thirteenth edition of *Body Structures and Functions* has been revised to reflect the many changes that are occurring in today's health science and medical fields. The multiskilled health practitioner (MSHP) of today must know the structure and function of each body system as well as the common diseases. All disease and disorder content is integrated within each chapter as appropriate.

This book and the accompanying teaching materials are designed to facilitate learning. Review the introductory section "How to Study Using *Body Structures and Functions*."

Key Features

Key features retained in the Thirteenth Edition include the following:

- Phonetic pronunciations of key words are included in each chapter.
- The feature **One Body** outlines how each body system interacts with other body systems.
- The feature **Study Tools** directs learners to additional resources to enhance learning and assess mastery of the material.

Phonetic Pronunciations of Key Words

Phonetic pronunciations of key words are included in each chapter in parentheses following the key word. Pronounce the word by saying each syllable, placing more emphasis on the syllable in boldface capital letters. In the following example, the syllable *NAT* would receive more emphasis than the rest of the syllables would: anatomy (ah-**NAT**-oh-mee).

Most key word pronunciations contain only one syllable in boldface; however, some key words contain more than one. When a pronunciation contains more than one syllable in boldface, place *some* emphasis on the syllable in boldface *lowercase* letters and the *most* emphasis on the syllable in boldface *capital* letters. In the following example, the syllable *em* would receive some emphasis and the syllable *OL* would receive the most emphasis: embryology (**em**-bree-**OL**-oh-jee).

Major Changes to the Thirteenth Edition

- Chapter 1: Introduction to the Structural Units—includes new information on positive feedback.
- Chapter 2: Chemistry of Living Things—provides expanded information on water, and new information on dehydration synthesis and hydrolysis.

- Chapter 3: Cells—provides guidelines from the National Institutes of Health on stem cell research.
- Chapter 5: Integumentary System—includes new information on moles, and a change in treatment of first-degree burns.
- Chapter 6: Skeletal System—includes new information on stress fractures. Information on microfracture procedure is included in the Medical Highlights feature.
- Chapter 8: Central Nervous System—provides an expanded discussion on glial cells, astrocytes, oligodendrocytes, and Schwann cells, and additional information on Alzheimer's disease.
- Chapter 10: Special Senses—provides additional information on general sensory receptors, and new information on hearing aids in the Medical Highlights feature. A new "Did You Know?" feature regarding eyes has been added.
- Chapter 11: Endocrine System—includes new information on pheochromocytoma and values for fasting blood sugar (FBS) and HbA1C.
- Chapter 14: Circulation and Blood Vessels—provides additional information on factors that influence blood pressure.
- Chapter 15: The Lymphatic and Immune Systems—includes updated schedules for immunizations for children 0 to 18 years old and catch-up immunizations. Information on Guillain-Barré syndrome and preexposure treatment for AIDS has been added.
- Chapter 16: Infection Control and Standard Precautions—provides information on the Ebola virus, whooping cough, and measles in the Medical Highlights feature.
- Chapter 17: Respiratory System—provides information on nitrogen and breathing, and safety precautions to be taken when someone is using oxygen.
- Chapter 18: Digestive System—provides a discussion on nerve cells in the stomach. Information on common symptoms of digestive disorders, including nausea and vomiting, has been added. New material on cleft lip and cleft palate and a new "Did You Know?" feature about butterflies in the stomach have also been added.
- Chapter 19: Nutrition–provides information on antioxidants in Medical Highlights, and new material on trans fat and weight loss surgery.
- Chapter 20: Urinary System—provides new material on overactive bladder.
- Chapter 21: Reproductive System—includes new information on the hormone relaxin, cervical cancer testing, and additional information on menorrhagia. In the Medical Highlights for Treatment for BPH, expanded information on types of treatment is provided.
- Chapter 22: Genetics and Genetically Linked Diseases—provides updated information on cystic fibrosis.

Medical Highlights

- Biotechnology and Nanotechnology (Chapter 1)
- Medical Imaging (Chapter 2)
- Stem Cells (Chapter 3)
- Tissue and Organ Transplant (Chapter 4)
- Hazards of the Sun (Chapter 5)
- RICE Treatment (Chapter 6)
- Surgical Joint Procedures (Chapter 6)
- Massage Therapy and Health (Chapter 7)
- Specialized Brain Cells: Mirror Neurons (Chapter 8)
- Headaches (Chapter 8)
- Parkinson's Disease and Deep Brain Stimulation (Chapter 8)
- Types of Anesthesia (Chapter 9)
- Lasers (Chapter 10)
- Eye Surgery (Chapter 10)
- Hearing Aids (Chapter 10)
- Taste: Umami (Chapter 10)
- Hormone Imbalance: Mental Health (Chapter 11)
- Bone Marrow Transplant (Chapter 12)
- Diagnostic Tests for the Heart (Chapter 13)
- Pacemakers, Defibrillators, and Heart Pumps (Chapter 13)
- Mucosa-Associated Lymphoid Tissue (MALT) (Chapter 15)
- Changes Occurring in Infectious Diseases (Chapter 16)
- Sleep Apnea (Chapter 17)
- Pulmonary Function Tests (Chapter 17)

- Minimally Invasive Surgery: Laparoscopy (Chapter 18)
- Antioxidants (Chapter 19)
- Kidney Stone Removal (Chapter 20)
- Treatment for Benign Prostatic Hypertrophy and Prostate Cancer (Chapter 21)
- Human Papillomavirus Vaccine (Chapter 21)

Career Profiles

- Audiologists (Chapter 10)
- Cardiovascular Technologists and Technicians/EKG Technicians (Chapter 13)
- Certified Patient Care Technician (Chapter 15)
- Chiropractors (Chapter 7)
- Clinical Medical Laboratory Technicians and Clinical Medical Laboratory Technologists (Chapter 12)
- Dental Hygienists, Dental Assistants, and Dental Laboratory Technicians (Chapter 18)
- Dentists (Chapter 18)
- Dietitians and Nutritionists (Chapter 19)
- Doctor of Osteopathic Medicine (Chapter 6)
- Electroneurodiagnostic Technicians/EEG Technicians (Chapter 8)
- Emergency Medical Technicians and Paramedics (Chapter 13)
- Home Health Aides (Chapter 15)
- Licensed Practical Nurses (Chapter 14)
- Massage Therapists (Chapter 7)
- Medical Assistants (Chapter 21)
- Nursing Aides and Psychiatric Aides (Chapter 15)
- Optometrists and Dispensing Opticians (Chapter 10)
- Orthotists and Prosthetists (Chapter 6)
- Physical Therapists and Physical Therapist Assistants (Chapter 6)
- Physicians (Chapter 5)
- Radiologic Technologists (Chapter 2)
- Registered Nurses and Nurse Practitioners (Chapter 14)
- Respiratory Therapists (Chapter 17)
- Sports Medicine/Athletic Training (Chapter 7)

Student Workbook

The student workbook includes activities that focus on applied academics through a variety of practical application exercises, including multiple choice, fill in the blanks, matching, labeling, word puzzles, basic skill problems, application of theory to practice, and a Surf-the-Net feature.

Online Resources

Online resources are available to accompany this new textbook that includes slide presentations in PowerPoint and 3D animations.

How to Access the Online Resources

1. GO TO http://www.CengageBrain.com
2. REGISTER as a new user or LOG IN as an existing user if you already have an account with Cengage Learning or CengageBrain.com

About the Author

Ann Senisi Scott, RN, BS, MA, is the author of the thirteenth edition of *Body Structures and Functions*. Ann was previously the Coordinator of Health Occupations and Practical Nursing at Nassau Tech Board of Cooperative Education Services, Westbury, New York. As the Health Occupations Coordinator, she worked to establish a career ladder program from health care worker to practical nurse. Before becoming the administrator of these programs, she taught practical nursing for more than 12 years.

Acknowledgments

To complete this revision of the textbook, I have had the assistance of many people at Cengage Learning. I want to extend my thanks to all the personnel in the Health Sciences area. To Debra Myette-Flis: You have generated so much encouragement and enthusiasm as you guided me through this revision and other revisions—a very heartfelt thank you. Thanks to the reviewers who highlighted areas that needed additional information and corrections; your comments were invaluable. Thanks to Dr. Bryan Senisi, who assisted with some valuable insight into disease conditions.

Special thanks to Wayne Scott, my personal reviewer and mentor, and to my family cheering

section: Vincent, Margaret, Carolyn, Daniel, Michael, Kenneth, Leslie, Scotty, and their spouses.

To my grandchildren and future students: Have a love for learning because it will bring much knowledge and rewards as you journey through life.

To the health care professionals of tomorrow: Your knowledge will be an asset in the art of caring for the people entrusted to your care.

Reviewers

We are particularly grateful to the reviewers who continue to be a valuable resource in guiding this book as it evolves. Their insights, comments, suggestions, and attention to detail were very important in guiding the development of this textbook.

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We would like to acknowledge and include a special thank you for the keen eye and thoroughness of our technical reviewer:

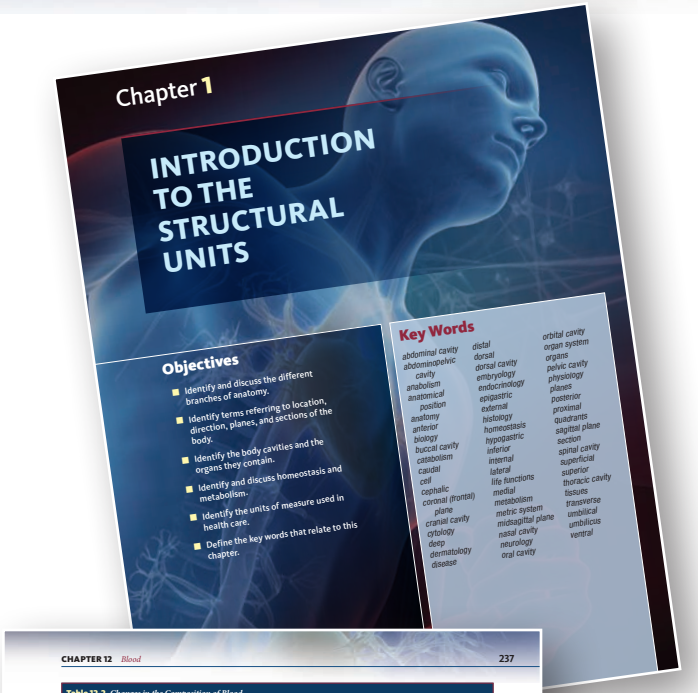
Caryl Tickner
Associate Professor of Biology
President Emeritus Human Anatomy & Physiology Society
Stark State College

How to Study Using BODY STRUCTURES AND FUNCTIONS

Preview the text before attempting to study the material covered in the individual chapters. By reviewing each section of this textbook, you will better understand its organization and purpose. Reading comprehension and long-term memory levels improve dramatically when you take the time to review the text and discover how it can help you learn.

To get the most from this course, take an active role in your learning by integrating your senses to increase your retention. You may want to

- *Visually* highlight important material.
- *Read* critically—turn headings, subheadings, and sentences into questions.
- *Recite* important material aloud to stimulate your auditory memory.
- *Draw* your own illustrations of anatomy or function processes and check them for accuracy.
- *Answer* (in writing or verbally) the review questions at the end of the chapter.


Chapter 1

INTRODUCTION TO THE STRUCTURAL UNITS

Objectives

- Identify and discuss the different branches of anatomy.
- Identify terms referring to location, direction, planes, and sections of the body.
- Identify the body cavities and the organs they contain.
- Identify and discuss homeostasis and metabolism.
- Identify the units of measure used in health care.
- Define the key words that relate to this chapter.

Key Words

abdominal cavity, abdominopelvic cavity, anabolism, anatomical position, anatomy, anterior, biology, buccal cavity, catabolism, caudal, cell, cephalic, coronal (frontal) plane, cranial cavity, cytology, deep, dermatology, disease, distal, dorsal, dorsal cavity, embryology, endocrinology, epigastric, external, histology, homeostasis, hypogastric, inferior, internal, lateral, life functions, medial, metabolism, metric system, midsagittal plane, nasal cavity, neurology, oral cavity, orbital cavity, organ system, organs, pelvic cavity, physiology, planes, posterior, proximal, quadrants, sagittal plane, section, spinal cavity, superficial, superior, thoracic cavity, tissues, transverse, umbilical, umbilicus, ventral

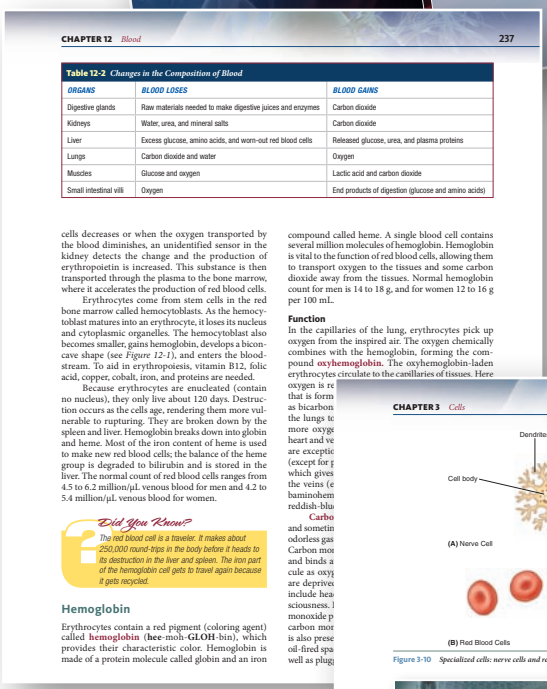

CHAPTER 12 *Blood* 237

Table 12-2 *Changes in the Composition of Blood*

ORGANS	BLOOD LOSES	BLOOD GAINS
Digestive glands	Raw materials needed to make digestive juices and enzymes	Carbon dioxide
Kidneys	Water, urea, and mineral salts	Carbon dioxide
Liver	Excess glucose, amino acids, and worn-out red blood cells	Released glucose, urea, and plasma proteins
Lungs	Carbon dioxide and water	Oxygen
Muscles	Glucose and oxygen	Lactic acid and carbon dioxide
Small intestinal villi	Oxygen	End products of digestion (glucose and amino acids)

cells decreases or when the oxygen transported by the blood diminishes, an unidentified sensor in the kidney detects the change and the production of erythropoietin is increased. This substance is then transported through the plasma to the bone marrow, where it accelerates the production of red blood cells.

Erythrocytes come from stem cells in the red bone marrow called hemocytoblasts. As the hemocytoblast matures into an erythrocyte, it loses its nucleus and cytoplasmic organelles. The hemocytoblast also becomes smaller, gains hemoglobin, develops a biconcave shape (see *Figure 12-1*), and enters the bloodstream. To aid in erythropoiesis, vitamin B12, folic acid, copper, cobalt, iron, and proteins are needed.

Because erythrocytes are enucleated (contain no nucleus), they only live about 120 days. Destruction occurs as the cells age, rendering them more vulnerable to rupturing. They are broken down by the spleen and liver. Hemoglobin breaks down into globin and heme. Most of the iron content of heme is used to make new red blood cells; the balance of the heme group is degraded to bilirubin and is stored in the liver. The normal count of red blood cells ranges from 4.5 to 6.2 million/μL venous blood for men and 4.2 to 5.4 million/μL venous blood for women.

Did You Know?

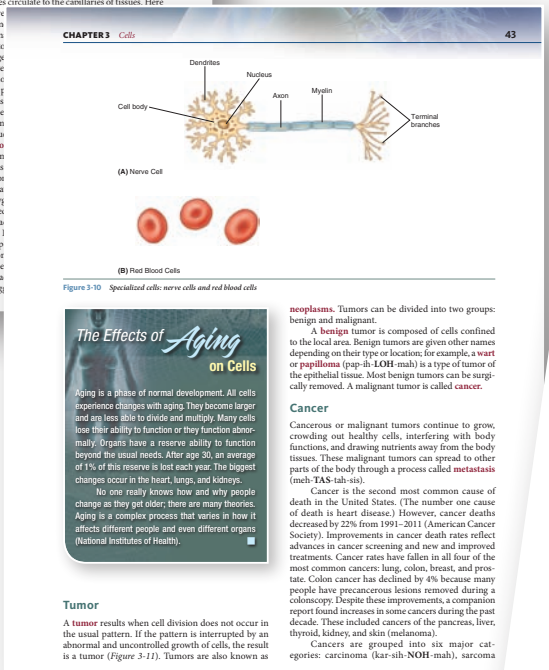
The red blood cell is a traveler. It makes about 250,000 round-trips in the body before it heads to its destruction in the liver and spleen. The iron part of the hemoglobin cell gets to travel again because it gets recycled.

Hemoglobin

Erythrocytes contain a red pigment (coloring agent) called **hemoglobin** (**hee**-moh-**GLOH**-bin), which provides their characteristic color. Hemoglobin is made of a protein molecule called globin and an iron compound called heme. A single blood cell contains several million molecules of hemoglobin. Hemoglobin is vital to the function of red blood cells, allowing them to transport oxygen to the tissues and some carbon dioxide away from the tissues. Normal hemoglobin count for men is 14 to 18 g, and for women 12 to 16 g per 100 mL.

Function

In the capillaries of the lung, erythrocytes pick up oxygen from the inspired air. The oxygen chemically combines with the hemoglobin, forming the compound **oxyhemoglobin.** The oxyhemoglobin-laden erythrocytes circulate to the capillaries of tissues. Here


CHAPTER 3 *Cells* 43

(A) Nerve Cell

(B) Red Blood Cells

Figure 3-10 *Specialized cells: nerve cells and red blood cells*

The Effects of Aging on Cells

Aging is a phase of normal development. All cells experience changes with aging. They become larger and are less able to divide and multiply. Many cells lose their ability to function or they function abnormally. Organs have a reserve ability to function beyond the usual needs. After age 30, an average of 1% of this reserve is lost each year. The biggest changes occur in the heart, lungs, and kidneys.

No one really knows how and why people change as they get older; there are many theories. Aging is a complex process that varies in how it affects different people and even different organs (National Institutes of Health). ■

Tumor

A **tumor** results when cell division does not occur in the usual pattern. If the pattern is interrupted by an abnormal and uncontrolled growth of cells, the result is a tumor (*Figure 3-11*). Tumors are also known as **neoplasms.** Tumors can be divided into two groups: benign and malignant.

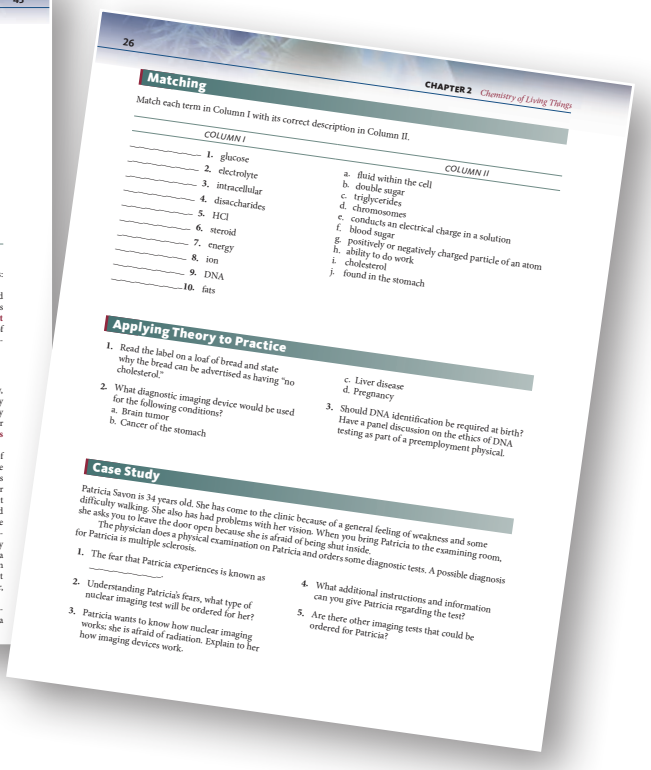
A **benign** tumor is composed of cells confined to the local area. Benign tumors are given other names depending on their type or location; for example, a **wart** or **papilloma** (pap-ih-**LOH**-mah) is a type of tumor of the epithelial tissue. Most benign tumors can be surgically removed. A malignant tumor is called **cancer.**

Cancer

Cancerous or malignant tumors continue to grow, crowding out healthy cells, interfering with body functions, and drawing nutrients away from the body tissues. These malignant tumors can spread to other parts of the body through a process called **metastasis** (meh-**TAS**-tah-sis).

Cancer is the second most common cause of death in the United States. (The number one cause of death is heart disease.) However, cancer deaths decreased by 22% from 1991–2011 (American Cancer Society). Improvements in cancer death rates reflect advances in cancer screening and new and improved treatments. Cancer rates have fallen in all four of the most common cancers: lung, colon, breast, and prostate. Colon cancer has declined by 4% because many people have precancerous lesions removed during a colonoscopy. Despite these improvements, a companion report found increases in some cancers during the past decade. These included cancers of the pancreas, liver, thyroid, kidney, and skin (melanoma).

Cancers are grouped into six major categories: carcinoma (kar-sih-**NOH**-mah), sarcoma


26 CHAPTER 2 *Chemistry of Living Things*

Matching

Match each term in Column I with its correct description in Column II.

COLUMN I	COLUMN II
1. glucose	a. fluid within the cell
2. electrolyte	b. double sugar
3. intracellular	c. triglycerides
4. disaccharides	d. chromosomes
5. HCl	e. conducts an electrical charge in a solution
6. steroid	f. blood sugar
7. energy	g. positively or negatively charged particle of an atom
8. ion	h. ability to do work
9. DNA	i. cholesterol
10. fats	j. found in the stomach

Applying Theory to Practice

1. Read the label on a loaf of bread and state why the bread can be advertised as having "no cholesterol."
2. What diagnostic imaging device would be used for the following conditions?
   a. Brain tumor
   b. Cancer of the stomach
   c. Liver disease
   d. Pregnancy
3. Should DNA identification be required at birth? Have a panel discussion on the ethics of DNA testing as part of a preemployment physical.

Case Study

Patricia Savon is 34 years old. She has come to the clinic because of a general feeling of weakness and some difficulty walking. She also has had problems with her vision. When you bring Patricia to the examining room, she asks you to leave the door open because she is afraid of being shut inside.

The physician does a physical examination on Patricia and orders some diagnostic tests. A possible diagnosis for Patricia is multiple sclerosis.

1. The fear that Patricia experiences is known as _____.
2. Understanding Patricia's fears, what type of nuclear imaging test will be ordered for her?
3. Patricia wants to know how nuclear imaging works; she is afraid of radiation. Explain to her how imaging devices work.
4. What additional instructions and information can you give Patricia regarding the test?
5. Are there other imaging tests that could be ordered for Patricia?

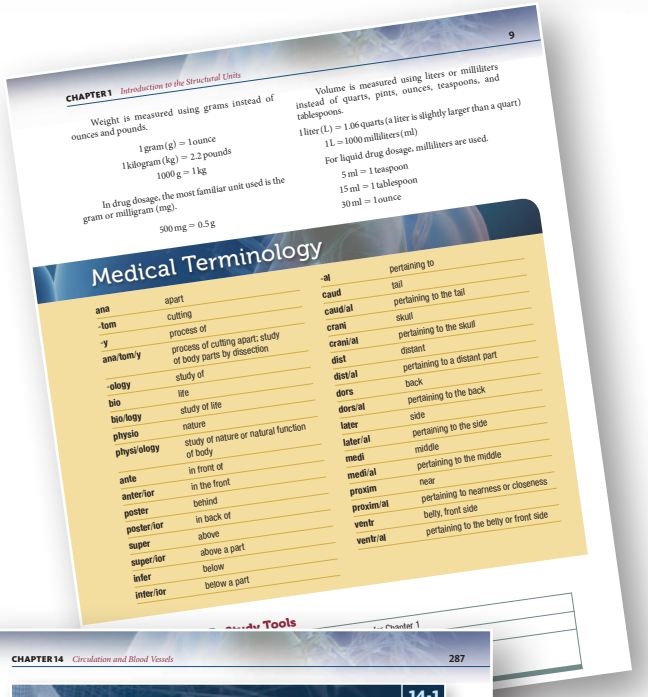
Each time you encounter a new chapter, preview it first to understand its overall structure. Review the **Objectives** presented at the beginning of each chapter to easily identify the key facts *before* you read the chapter. These objectives are also useful to review *after* you have completed a chapter. After reading a chapter, test yourself to see whether you can answer each objective. If you cannot, you will know exactly which areas to study again. The **Key Words** are listed at the beginning of each chapter, are highlighted in ***red*** within the chapter, and are also defined in the glossary.

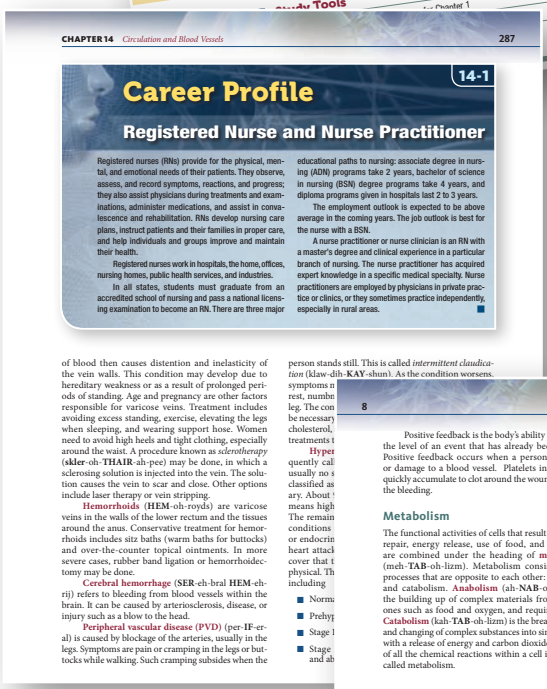
Read the **main headings, subheadings,** and first sentence of each paragraph—these elements serve as the outline for the whole chapter. Be careful not to overlook the **illustrations, photographs,** and **tables,** which can help you comprehend difficult material.

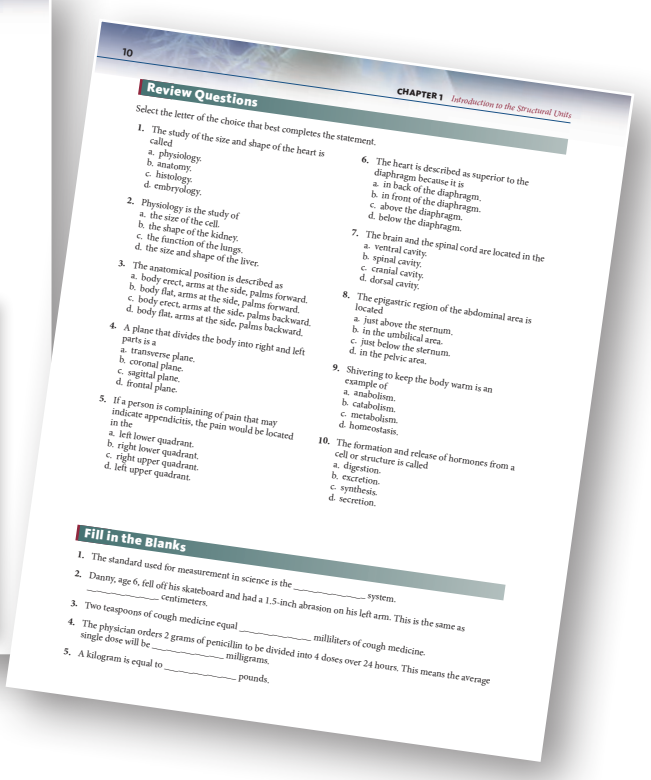
Did You Know? boxes feature fun, interesting, trivialike facts to engage the learner.

Effects of Aging boxes are integrated within the chapters to highlight the changes that are associated with the body systems as we age.

Case Studies promote a real-world view of medical careers and encourage critical thinking.





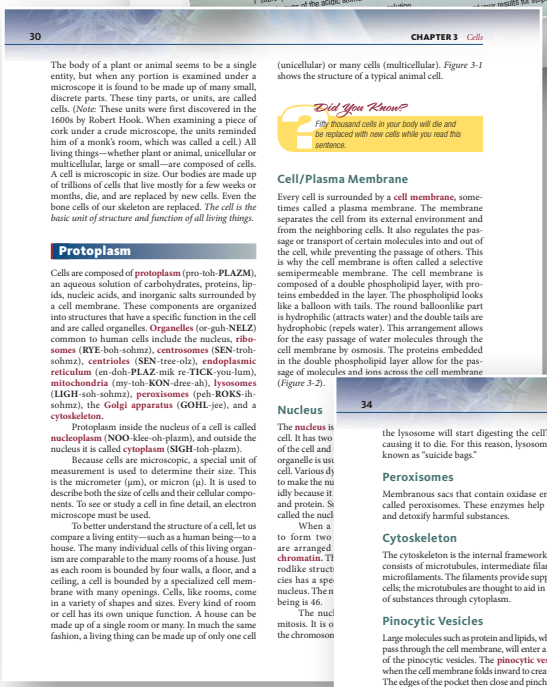


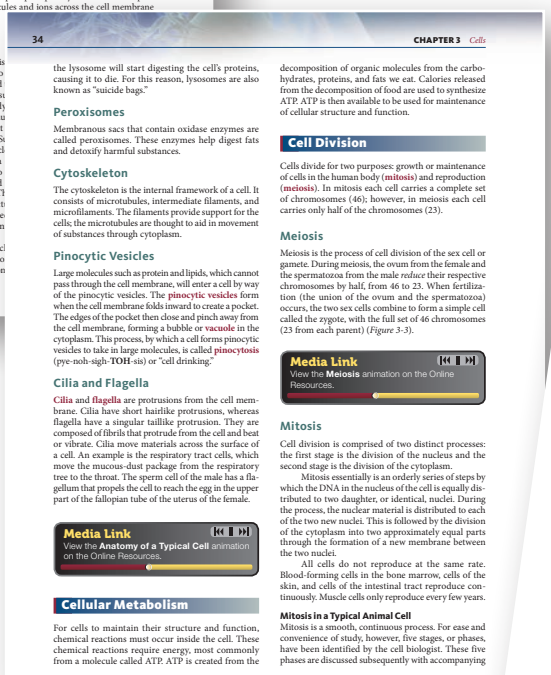
Medical Terminology boxes introduce you to common medical prefixes and suffixes and how they work to form medical terms.

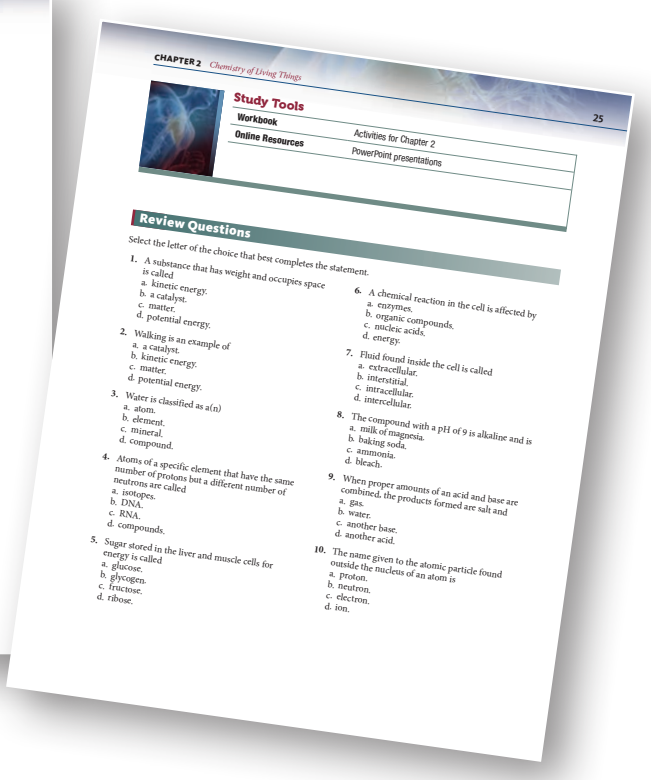
Career Profiles provide descriptions of many health professions in today's dynamic health and medical environment. These profiles describe the role of each professional, and may even provide you with insight into possible future career paths.

Medical Highlights provide information on technology, innovations, discoveries, and bioethical issues in research and medicine. These topics are based on current information obtained from research on various medical websites.

Review Questions will help you measure whether you have mastered the material you have covered. Questions in a variety of formats are presented to reinforce important information within each chapter. Also integrated here and in the workbook are applied academic activities for math, spelling, communication, and legal-ethical issues.





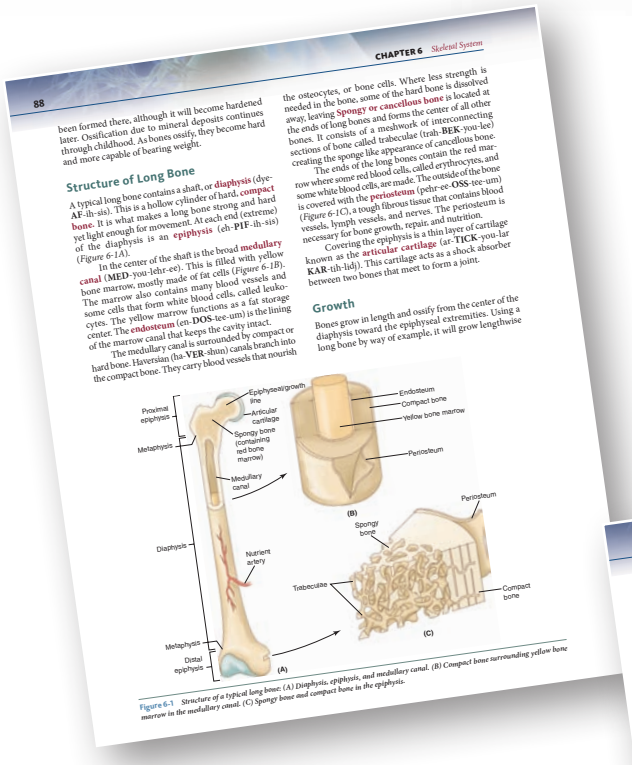


Lab Activities incorporate an element of interactivity to the content, further enhancing comprehension.

Phonetic pronunciations of key words in each chapter are in parentheses following the key word. Pronounce the word by saying each syllable, placing more emphasis on the syllable in boldface capital LETTERS.

Media Links direct you to Online Resources that include PowerPoint presentations and 3D animations.

Study Tools alert you to additional resources to help you understand the material.


88 CHAPTER 6 Skeletal System

been formed there, although it will become hardened later. Ossification due to mineral deposits continues through childhood. As bones ossify, they become hard and more capable of bearing weight.

Structure of Long Bone

A typical long bone contains a shaft, or **diaphysis** (dye-AF-ih-sis). This is a hollow cylinder of hard, **compact bone**. It is what makes a long bone strong and hard yet light enough for movement. At each end (extreme) of the diaphysis is an **epiphysis** (eh-PIF-ih-sis) (*Figure 6-1A*).

In the center of the shaft is the broad **medullary canal** (MED-you-lehr-ee). This is filled with yellow bone marrow, mostly made of fat cells (*Figure 6-1B*). The marrow also contains many blood vessels and some cells that form white blood cells, called leukocytes. The yellow marrow functions as a fat storage center. The **endosteum** (en-DOS-tee-um) is the lining of the marrow canal that keeps the cavity intact.

The medullary canal is surrounded by compact or hard bone. Haversian (ha-VER-shun) canals branch into the compact bone. They carry blood vessels that nourish the osteocytes, or bone cells. Where less strength is needed in the bone, some of the hard bone is dissolved away, leaving **Spongy or cancellous bone** is located at the ends of long bones and forms the center of all other bones. It consists of a meshwork of interconnecting sections of bone called trabeculae (trah-BEK-you-lee) creating the sponge like appearance of cancellous bone.

The ends of the long bones contain the red marrow where some red blood cells, called erythrocytes, and some white blood cells, are made. The outside of the bone is covered with the **periosteum** (pehr-ee-OSS-tee-um) (*Figure 6-1C*), a tough fibrous tissue that contains blood vessels, lymph vessels, and nerves. The periosteum is necessary for bone growth, repair, and nutrition.

Covering the epiphysis is a thin layer of cartilage known as the **articular cartilage** (ar-TICK-you-lar KAR-tih-lidj). This cartilage acts as a shock absorber between two bones that meet to form a joint.

Growth

Bones grow in length and ossify from the center of the diaphysis toward the epiphyseal extremities. Using a long bone by way of example, it will grow lengthwise

Figure 6-1 *Structure of a typical long bone: (A) Diaphysis, epiphysis, and medullary canal. (B) Compact bone surrounding yellow bone marrow in the medullary canal. (C) Spongy bone and compact bone in the epiphysis.*

The **Glossary of Terms** provides you with a concise definition for all the *key words* in the textbook. The **Index** serves as an alphabetical listing of topics, terms, concepts, and important names for easy reference. Note that figure page numbers are listed in **boldface** in the index.


482 GLOSSARY

anemia blood disorder characterized by reduction in red blood cells or hemoglobin
aneurysm a widening, or sac, formed by dilation of a blood vessel
angina pectoris severe chest pain caused by lack of blood supply to heart
angioplasty balloon surgery to open blocked blood vessels
anorexia nervosa an illness in which a person refuses to eat
anoxia a lack of oxygen to cellular structures
antagonist a muscle whose action opposes the action of another muscle
anterior front or ventral
anterior chamber space between cornea and iris
anterior nares external portion of the nostrils
anterior pituitary lobe area of the pituitary gland that is responsible for the secretion of growth hormones
anthrax a disease-causing organism that has three forms: cutaneous, intestinal, and inhalation, the last of which is the most deadly form
antibody substance produced by the body that inactivates a specific foreign substance that has entered the body; formed as a reaction to an antigen
anticoagulant chemical substance that prevents or slows blood clotting (e.g., heparin)
anticonvulsant therapeutic agent that stops or prevents convulsions
antidiuretic hormone (ADH) hormone secreted by the posterior pituitary gland that prevents or suppresses urine excretion
antigen substance stimulating formation of antibodies against itself
antiprothrombin chemical substance, such as heparin, that directly or indirectly reduces or retards the action of prothrombin
antithromboplastin chemical substance that inhibits the clot-accelerating effect of thromboplastins
anuria absence of urine
anus outlet from rectum
anvil (incus) middle ear bone, or ossicle. In a chain of three ossicles of the middle ear
aorta largest artery in body, rising from the left ventricle of the heart
aortic semilunar valve made up of three half-moon shaped cups, located between the junction of the aorta and the left ventricle of the heart
aphasia loss of ability to speak; may be accompanied by loss of verbal comprehension
aplastic anemia anemia caused by a suppression of the bone marrow
apnea temporary stoppage of breathing movements
aponeurosis flattened sheet of white, fibrous connective tissue; holds one muscle to another or to the periosteum
apoptosis an orderly process by which cells intentionally die. The term is used interchangeably with the term *programmed cell death (PCD)*
appendicitis inflammation of the appendix; see vermiform appendix
appendicular skeleton part of skeleton consisting of pectoral and pelvic girdles, and limbs
aqueous humor watery fluid found in anterior chamber of the eye
arachnoid mater weblike middle membrane of meninges
areola pigmented ring around nipple; any small space in tissue
areolar tissue a type of connective tissue that surrounds various organs and supports both nerve and blood vessels
arrector pili muscle a smooth muscle on the side of each hair follicle; when cold, it stimulates the skin to pucker around the hair
arrhythmia absence of a normal heartbeat rhythm
arterioles small branches of an artery
arteriosclerosis hardening of arteries, resulting in thickening of walls and loss of elasticity
artery blood vessel that carries blood away from the heart
arthritis inflammation of a joint
articular cartilage thin layer of cartilage over the ends of long bones
artificial acquired immunity type of immunity acquired as a result of an injection of vaccine, antigen, or toxoid
artificial insemination procedure in which semen is placed in vagina by means of cannula or syringe
artificial pacemaker is a surgically implanted device that sends electrical impulses to regulate the rhythm of the heart.
asbestosis a respiratory disease caused by inhaling asbestos fibers
ascending colon portion of the colon that travels up the right side of the abdominal cavity
ascites accumulation of fluid in the peritoneal cavity
aseptic being free of living pathogenic microorganisms
associative neuron carries messages from sensory neuron to motor neuron; also called *interneuron*
asthma condition in which the airways are obstructed as a result of an inflammatory reaction to a stimulus
astigmatism irregular curvature of cornea or lens
atherosclerosis hardening of arteries due to deposits of fatlike material in the lining of the arteries
athlete's foot fungal infection of the foot
atlas first cervical vertebra; articulates with the axis and occipital skull bone
atom smallest piece of an element
atrial fibrillation occurs when abnormal impulses from the atria bombard the AV node. This action causes the ventricles to beat faster and a person can experience tachycardia
atrioventricular bundle conducting fibers in the septum; also known as the bundle of His
atrioventricular (AV) node small mass of interwoven conducting tissue located between the atria and ventricles
atrium upper chamber of the heart
atrophy wasting away of tissue
auricle (1) pinna, or ear flap, of external ear; (2) atrium of the heart
autoimmune disorder a condition that causes destruction of the body's own tissues
autoimmunity action of antibodies against one's own body
autonomic nervous system collection of nerves, ganglia, and plexuses through which visceral organs, heart, blood vessels, glands, and smooth (involuntary) muscles receive stimulation
avascular without blood vessels
axial skeleton skeleton of head and trunk
axilla armpit
axillary nodes lymph nodes found under the arms and near the breast
axis second cervical vertebra
axon nerve cell structure that carries impulses away from cell bodies to dendrites

B

B lymphocytes white blood cells synthesized in the bone marrow; help form antibodies
bacteria agents capable of causing disease or infection
bactericidal causing the death of bacteria
ball-and-socket joint diarthrosis joint that allows the greatest freedom of movement

PROLOGUE

The History of Anatomical Science and Scientists

Much of the early study of gross anatomy and physiology comes from Aristotle, a Greek philosopher. Aristotle believed that every organ has a specific function and that function is based on the organ's structure. Most of Aristotle's ideas were based on the dissection of plants and animals. He never dissected a human body.

In the third century BC, Herophilus founded the first school of anatomy and encouraged the dissection of the human body. He is credited with demonstrating that the brain is the center of the nervous system. It was a Greek physician, Galen, however, who is credited with the creation of the first standard medical text expanding on Aristotle's ideas. Galen was the first to discover many muscles and the first to find the value in monitoring an individual's pulse. Galen never performed human dissections and many of his theories were later proven wrong.

The first medical schools were founded in the Middle Ages; however, instructors at this time were hesitant to question the theories and beliefs founded by the early Greeks such as Aristotle and Galen. As a result, very few ideas or discoveries were made in the medical field in the Middle Ages.

During the Renaissance, however, interest in anatomy was renewed due in part to the work of artist Leonardo da Vinci, who studied the form and function of the human body. It was during this period in history that the first systematic study of the structure of the human body was made. Many of these early scientists were hindered in their pursuit of knowledge of the human body because it was believed by many that human dissections were immoral and illegal. For example, Andreas Vesalius, a founder of modern anatomy, was sentenced to death because of his anatomical dissections of humans.

In the seventeenth century, the invention of the microscope aided in new anatomical discoveries and research. Scientists could now see structures that were invisible to the naked eye. Robert Hooke's investigation of cork under the microscope was the foundation of the theory that the cell is the basic unit of life. This theory was later proved and expanded on by other scientists in the eighteenth century as technological advances continued to improve.

Advances in technology have continued into today and new anatomical and physiological discoveries are still being made. With the mapping of the human genome, completed in 2003, the complete genetic code has been documented. It is hoped that this knowledge will enable discoveries into disease processes and the development of cures for many of the diseases that continue to plague our society.

The use of new types of medical imaging, such as computerized scanning and digitalized photography, has helped researchers make new discoveries about the body.

Use key words to search the Internet for new discoveries related to a particular body system and the scientists who made those discoveries.

Chapter 1

INTRODUCTION TO THE STRUCTURAL UNITS

Objectives

- Identify and discuss the different branches of anatomy.
- Identify terms referring to location, direction, planes, and sections of the body.
- Identify the body cavities and the organs they contain.
- Identify and discuss homeostasis and metabolism.
- Identify the units of measure used in health care.
- Define the key words that relate to this chapter.

Key Words

abdominal cavity
abdominopelvic cavity
anabolism
anatomical position
anatomy
anterior
biology
buccal cavity
catabolism
caudal
cell
cephalic
coronal (frontal) plane
cranial cavity
cytology
deep
dermatology
disease
distal
dorsal
dorsal cavity
embryology
endocrinology
epigastric
external
histology
homeostasis
hypogastric
inferior
internal
lateral
life functions
medial
metabolism
metric system
midsagittal plane
nasal cavity
neurology
oral cavity
orbital cavity
organ system
organs
pelvic cavity
physiology
planes
posterior
proximal
quadrants
sagittal plane
section
spinal cavity
superficial
superior
thoracic cavity
tissues
transverse
umbilical
umbilicus
ventral

Anatomy and Physiology

Anatomy and physiology are branches of a much larger science called **biology** (bye-**OL**-oh-jee). Biology is the study of all forms of life. Biology studies microscopic one-celled organisms, multicelled organisms, plants, animals, and humans.

Anatomy (ah-**NAT**-oh-mee) studies the shape and structure of an organism's body and the relationship of one body part to another. The word *anatomy* comes from the Greek *ana*, meaning "apart," and *temuein*, "to cut"; thus, the acquisition of knowledge on human anatomy comes basically from dissection. However, one cannot fully appreciate and understand anatomy without the study of its sister science, **physiology** (fiz-ee-**OL**-oh-jee). Physiology studies the function of each body part and how the functions of the various body parts coordinate to form a complete living organism. Any abnormal change in a structure or function that produces symptoms is considered a **disease** (diz-**EASE**).

Branches of Anatomy

Anatomy is subdivided into many branches based on the investigative techniques used, the type of knowledge desired, or the parts of the body under study.

1. **Gross anatomy.** Gross anatomy is the study of large and easily observable structures on an organism. This is done through dissection and visible inspection with the naked eye. In gross anatomy, the different body parts and regions are studied with regard to their general shape, external features, and main divisions.
2. **Microscopic anatomy.** Microscopic anatomy refers to the use of microscopes to enable one to see the minute details of organ parts. Ultrawave and electron microscopes provide greater magnification and resolution than optical microscopes do. Microscopic anatomy is subdivided into two branches. One branch is **cytology** (sigh-**TOL**-oh-jee), which is the study of the structure, function, and development of cells that comprise the different body parts. The other subdivision is **histology** (hiss-**TOL**-oh-jee), which studies the tissues and organs that make up the entire body of an organism.
3. **Developmental anatomy.** Developmental anatomy studies the growth and development of an organism during its lifetime. More specifically, **embryology** (**em**-bree-**OL**-oh-jee) studies the formation of an organism from fertilized egg to birth.
4. **Comparative anatomy.** Humans are some of the many animals found in the animal kingdom. The different body parts and organs of humans can be studied with regard to similarities with and differences from others in the animal kingdom.
5. **Systematic anatomy.** Systematic anatomy is the study of the structure of various organs or parts that comprise a particular organ system. Depending on the particular organ system under study, a specific term is applied; for example
   a. **Dermatology** (der-mah-**TOL**-oh-jee)—study of the integumentary system (skin, hair, and nails)
   b. **Endocrinology** (**en**-doh-krin-**OL**-oh-jee)—study of the endocrine or hormonal system
   c. **Neurology** (**new**-**ROL**-oh-jee)—study of the nervous system

Anatomical Terminology

In the study of anatomy and physiology, special words are used to describe the specific location of a structure or organ, or the relative position or direction of one body part to another. The initial reference point used is the anatomical position. In the **anatomical position,** a human being is standing erect, with face forward, arms at the side, and palms forward (*Figure 1-1*).

Terms Referring to Location or Position and Direction

See *Figure 1-1* and *Figure 1-2*.

- **Anterior** or **ventral** means "front" or "in front of." For example, the knees are located on the anterior surface of the human body. A ventral hernia may protrude from the front or belly of the abdomen.
- **Posterior** or **dorsal** means "back" or "in back of." For example, human shoulder blades are found on the posterior surface of the body.
- **Cephalic** (seh-**FAL**-ick) and **caudal** (**KAWD**-al) refer to direction: Cephalic means "skull" or "head end" of the body; caudal means "tail end." For example, a blow to the skull may increase cranial pressure and cause headaches. Caudal anesthesia is injected in the lower spine.
- **Superior** means "upper" or "above another" and **inferior** refers to "lower" or "below another." For

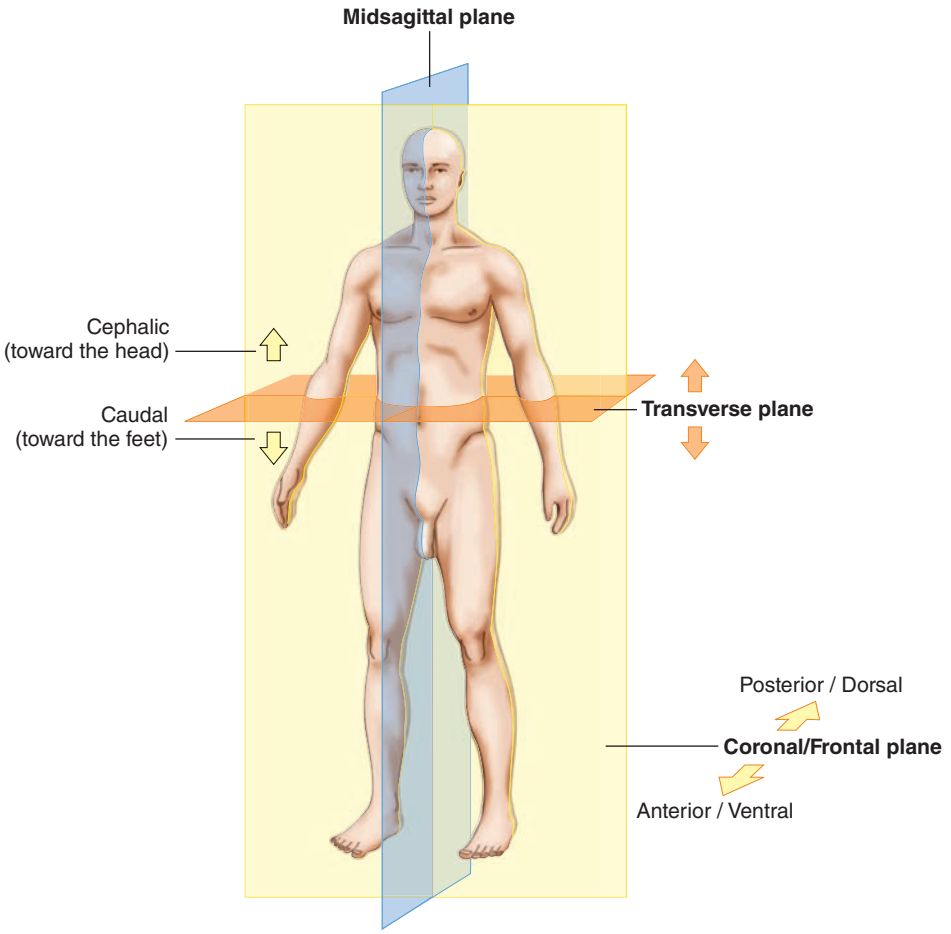


Figure 1-1 *Body directions: Cephalic refers to the skull or head end of the body, and caudal refers to the tail end. Anterior (or ventral) means "front" or "in front of." Posterior (or dorsal) means "back" or "in back of."*

example, the heart and lungs are situated superior to the diaphragm, while the intestines are inferior to the diaphragm.

- **Medial** signifies "toward the midline or median plane of the body," while **lateral** means "away" or "toward the side of the body." For example, the nose is medial to the eyes and the ears are lateral to the nose.
- **Proximal** means "toward the point of attachment to the body" or "toward the trunk of the body"; **distal** means "away from the point of attachment or origin" or "farthest from the trunk." For example, the wrist is proximal to the hand; the elbow is distal to the shoulder. *Note:* these two words are used primarily to describe the appendages or extremities.
- **Superficial** or **external** and **deep** or **internal**—superficial implies "on or near the surface of the body." For example, a superficial wound involves an injury to the outer skin. A deep injury involves damage to an internal organ such as the stomach. The terms *external* and *internal* are specifically used to refer to body cavities and hollow organs.

Terms Referring to Body Planes and Sections

Planes are imaginary anatomical dividing lines that are useful in separating body structures (*Figure 1-3*). A **section** is a cut made through the body in the direction of a certain plane.

The **sagittal plane** (**SAJ**-ih-tal) divides the body into right and left parts. If the plane started in the middle of the skull and proceeded down, bisecting the sternum and the vertebral column, the body would be divided equally into right and left halves. This would be known as the **midsagittal plane.**

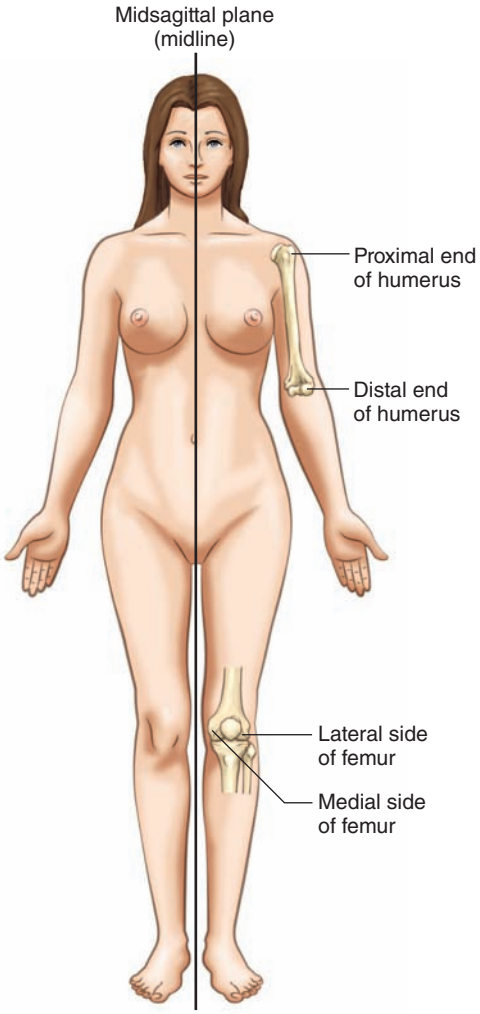


Figure 1-2 *Body directions: Proximal means "toward the point of attachment to the body" or "toward the trunk of the body." Distal means "away from the point of attachment or origin" or "farthest from the trunk." Medial means "toward the midline or median plane of the body," and lateral means "away or toward the side of the body."*

A **coronal (frontal) plane** is a vertical cut at right angles to the sagittal plane, dividing the body into anterior and posterior portions. The term *coronal* comes from the coronal suture, which runs perpendicular (at a right angle) to the sagittal suture. A **transverse** or cross section is a horizontal cut that divides the body into upper and lower portions.

Media Link
View the **Body Planes** animation on the Online Resources.

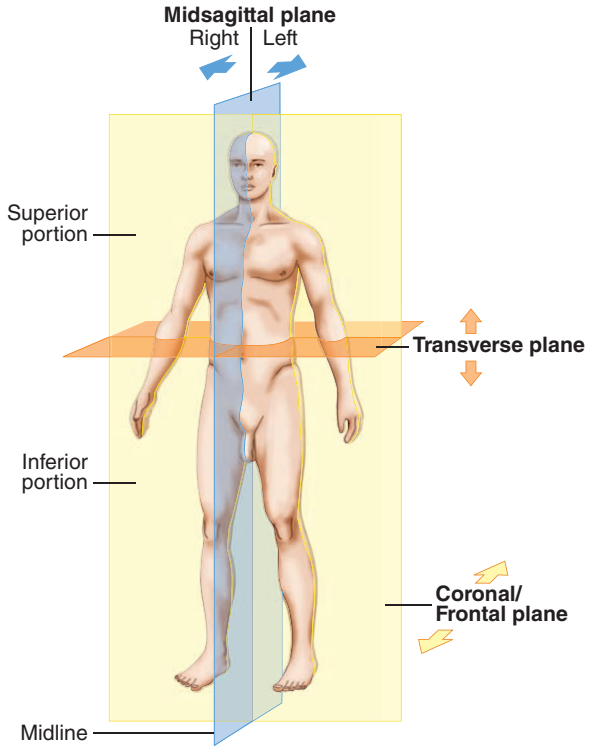


Figure 1-3 *Body planes: The midsagittal plane divides the body equally into right and left halves. The transverse plane divides the body into upper and lower portions. The coronal (or frontal) plane divides the body into anterior and posterior portions.*

Terms Referring to Cavities of the Body

The organs that comprise most of the body systems are located in four major cavities: cranial, spinal, thoracic, and abdominopelvic (*Figure 1-4*). The cranial and spinal cavities are within a larger region known as the posterior (dorsal) cavity. The thoracic and abdominopelvic cavities are found in the anterior (ventral) cavity.

The **dorsal cavity** contains the brain and spinal cord: the brain is in the **cranial cavity** and the spinal cord is in the **spinal cavity** (*Figure 1-4*). The diaphragm divides the ventral cavity into two parts: the upper thoracic and lower abdominopelvic cavities.

The central area of the **thoracic cavity** (tho-**RASS**-ik) is called the mediastinum. It lies between the lungs and extends from the sternum (breastbone) to the vertebrae of the back. The esophagus, bronchi, lungs, trachea, thymus gland, and heart are located in the thoracic cavity. The heart itself is contained within a smaller cavity called the pericardial cavity.

The thoracic cavity is further subdivided into two pleural cavities. The left lung is in the left cavity; the right lung is in the right cavity. Each lung is covered with a thin membrane called the pleura.

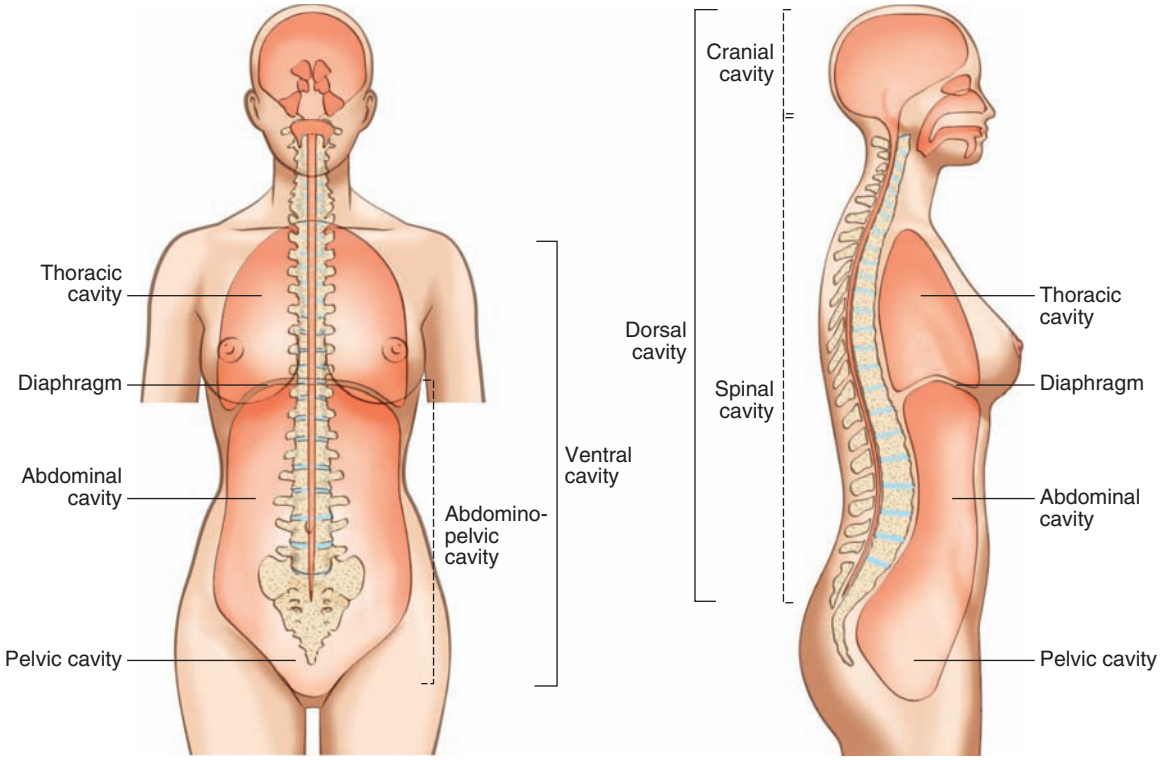


Figure 1-4 *The major body cavities*

The **abdominopelvic cavity** (ab-**dom**-ih-noh-**PEL**-vick) is actually one large cavity with no separation between the abdomen and pelvis. To avoid confusion, this cavity is usually referred to separately as the abdominal cavity and the pelvic cavity. The **abdominal cavity** contains the stomach, liver, gallbladder, pancreas, spleen, small intestine, appendix, and part of the large intestine. The kidneys are close to but behind the abdominal cavity. The urinary bladder, reproductive organs, rectum, and remainder of the large intestine are in the **pelvic cavity.**

Terms Referring to Regions in the Abdominopelvic Cavity

To locate the abdominal and pelvic organs more easily, the abdominopelvic cavity is divided into nine regions (*Figure 1-5*).

The nine regions are located in the upper, middle, and lower parts of the abdomen:

- The upper or **epigastric** (ep-ih-**GAS**-trick) region is located just below the sternum (breastbone). The right and left **hypochondriac** (**high**-poh-**KON**-dree-ack) regions are located below the ribs.
- The middle or **umbilical** area is located around the navel or **umbilicus** (um-**BILL**-ih-kus), and the right and left lumbar regions extend from anterior to posterior. (A person will complain of back pain or lumbar pain.)
- The lower or **hypogastric** (**high**-poh-**GAS**-trick) region may also be referred to as the pubic area; the left and right iliac may also be called the left and right inguinal areas.

Smaller Cavities

In addition to the cranial cavity, the skull contains several smaller cavities. The eyes, eyeball muscles, optic nerves, and lacrimal (tear) ducts are within the **orbital cavity.** The **nasal cavity** contains the parts that form the nose. The **oral cavity** or **buccal cavity** (**BUCK**-ull) encloses the teeth and tongue.

Terms Referring to Quadrants in the Abdominal Area

Another method for referencing the abdominal area is to divide the area into **quadrants.** This method uses one median sagittal plane and one transverse plane that passes through the umbilicus at right angles. The four

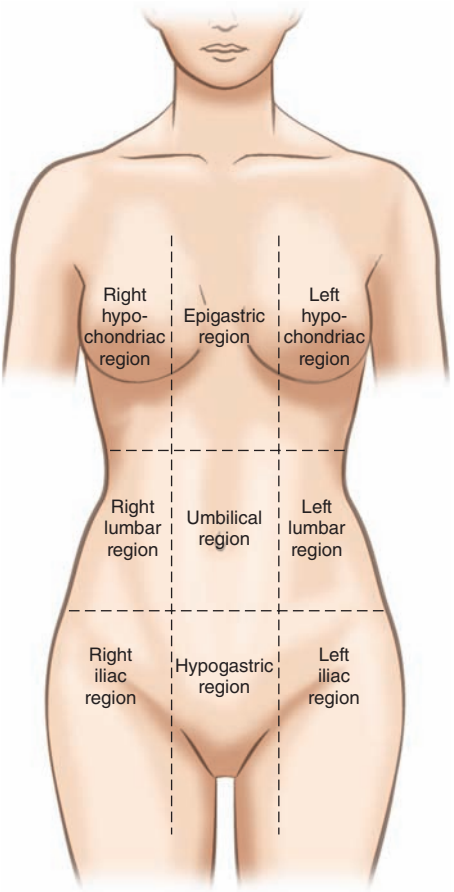


Figure 1-5 *Regions of the thorax and abdomen*

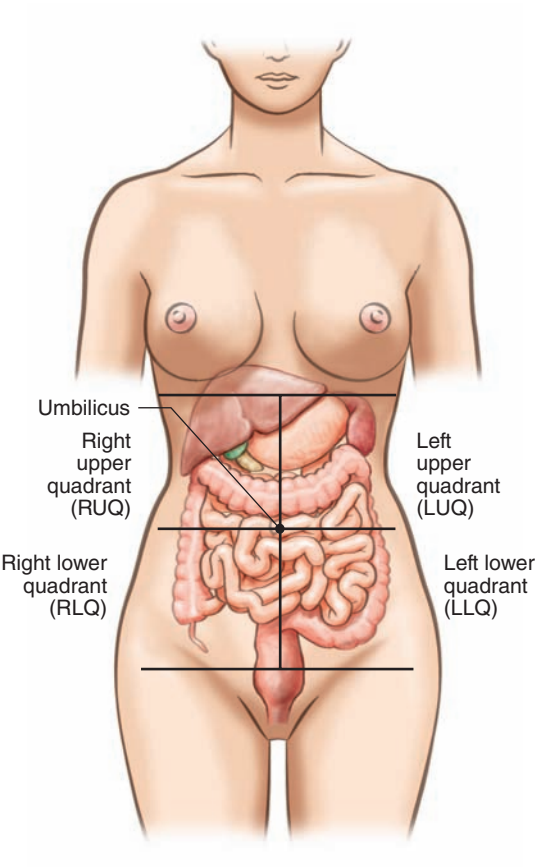


Figure 1-6 *Division of the abdomen into quadrants*

resulting quadrants are named according to their positions: right upper quadrant (RUQ), left upper quadrant (LUQ), right lower quadrant (RLQ), and left lower quadrant (LLQ) (*Figure 1-6*).

Did You Know?

McBurney's point is not at the top of a mountain but midway between the umbilicus and the iliac crest (the prominent area on the hip bone) and the right lower quadrant or right inguinal area. This area is painful when a person has appendicitis.

Life Functions

When we examine humans, plants, one-celled organisms, or multicelled organisms, we recognize that all of them have one thing in common: they are alive.

All living organisms are capable of carrying on life functions. **Life functions** are a series of highly organized and related activities that allow living organisms to live, grow, and maintain themselves.

These vital life functions include movement, ingestion, digestion, transport, respiration, synthesis, assimilation, growth, secretion, excretion, regulation (sensitivity), and reproduction (*Table 1-1*).

Human Development

During our lifetime, the body carries on numerous functions that keep us alive and active. Living depends on the constant release of energy in every cell of the body. Powered by the energy released from food, cells are able to maintain their own living condition and, thus, the life of a human being.

A complex life-form like a human being consists of more than 50 trillion cells. The **cell** is the basic unit of structure and function of all living things. Early in human development, certain groups of cells become highly specialized for specific functions, such as movement or growth.

Table 1-1 *Review of the Life Functions and Body Systems*

LIFE FUNCTIONS/ BODY SYSTEMS	DEFINITION
Movement / Muscle System	The ability of the whole organism—or a part of it—to move
Ingestion	The process by which an organism takes in food
Assimilation	The breakdown of complex food molecules into simpler food molecules
Digestion / Digestive System	The transformation of digested food molecules into living tissue for growth and self-repair
Transport / Circulatory System	The movement of necessary substances to, into, and around cells, and of cellular products and wastes out of and away from cells
Respiration / Respiratory System	The burning or oxidation of food molecules in a cell to release energy, water, and carbon dioxide
Immunity / Lymphatic System	The filtering out of harmful bacteria and production of white blood cells (lymphocytes)
Protection / Integumentary System	The waterproof covering of the body
Growth / Skeletal System	The enlargement of an organism due to synthesis and assimilation, resulting in an increase in the number and size of its cells
Secretion / Endocrine System	The formation and release of hormones from a cell or structure
Excretion / Urinary System	The removal of metabolic waste products from an organism
Regulation (Sensitivity) / Nervous System	The ability of an organism to respond to its environment so as to maintain a balanced state (homeostasis)
Reproduction / Reproductive System	The ability of an organism to produce offspring with similar characteristics (This is *essential* for species survival as opposed to individual survival.)

Special cells—grouped according to function, shape, size, and structure—are called **tissues.** Tissues, in turn, form larger functional and structural units known as **organs.** For example, human skin is an organ of epithelial, connective, muscular, and nervous tissue. In much the same way, kidneys consist of highly specialized connective and epithelial tissue.

The organs of the human body do not operate independently; they function interdependently with one another to form a live, functioning organism. Some organs are grouped together because more than one is needed to perform a function. Such a grouping is called an **organ system.** One example is the digestive system, composed of the teeth, esophagus, stomach, small intestine, and large intestine. In this textbook you will study the various body systems and the organs that comprise them.

Homeostasis

Homeostasis (**hoe**-mee-oh-**STAY**-sis) is the ability of the body to regulate its internal environment within narrow limits through negative and positive feedback. Maintaining homeostasis is essential to survival; imbalance results in disease. All organ systems contribute to homeostasis. Examples of homeostasis controls are blood sugar levels, body temperature, heart rate, and the fluid environment of cells. Aging cells no longer respond as quickly, which makes it harder to maintain homeostasis.

Most of homeostasis control works on a **negative feedback loop.** Feedback responses reverse disturbances to our body's condition. An example of how a negative feedback loop operates is seen in maintaining our body temperature. Our normal body temperature is 37°C (98.6°F). Outside, on a hot summer day, our body temperature rises. The hypothalamus in the brain detects this and sends signals to various organs, and we start to sweat (sweating is a cooling process). As water is excreted by the sweat glands on the skin, it evaporates (evaporation is a cooling mechanism). In addition, our blood vessels dilate to bring blood near the skin's surface to dissipate body heat. If we go outside on a cold day and our body temperature falls below 37°C (98.6°F), the hypothalamus of the brain detects this and sends signals to the muscles, causing us to shiver, which raises the body temperature (increased muscle activity produces heat). In addition, the hypothalamus sends signals to the blood vessels, causing them to constrict, which reduces blood flow near the surface, conserving body heat.

Positive feedback is the body's ability to increase the level of an event that has already been started. Positive feedback occurs when a person has a cut or damage to a blood vessel. Platelets in the blood quickly accumulate to clot around the wound and stop the bleeding.

Metabolism

The functional activities of cells that result in growth, repair, energy release, use of food, and secretions are combined under the heading of **metabolism** (meh-**TAB**-oh-lizm). Metabolism consists of two processes that are opposite to each other: anabolism and catabolism. **Anabolism** (ah-**NAB**-oh-lizm) is the building up of complex materials from simpler ones such as food and oxygen, and requires energy. **Catabolism** (kah-**TAB**-oh-lizm) is the breaking down and changing of complex substances into simpler ones, with a release of energy and carbon dioxide. The sum of all the chemical reactions within a cell is therefore called metabolism.

Metric System

To understand the language used in *Body Structures and Functions*, you must be familiar with the metric system. The medical community measures length, weight, and volume using this system. The **metric system** is a decimal system based on the power of 10. Just as there are 100 cents in a dollar, there are 100 centimeters in a meter (see Appendix A).

Some of the prefixes used in the metric system are

centi = 1/100 (one/one-hundredth)
milli = 1/1000 (one/one-thousandth)
micro = 1/1,000,000 (one/one-millionth)

Length is measured using meters instead of inches and feet.

1 centimeter (cm) = 0.4 inch
2.5 cm = 1 inch

1-1

Medical Highlights

BIOTECHNOLOGY AND NANOTECHNOLOGY

In the future we will see advances in the treatment and diagnosis of disease using techniques such as *biotechnology* and *nanotechnology*.

Biotechnology refers to any technological application that uses biological systems, living organisms, or derivatives thereof to make or modify products or processes for specific uses. One field of biotechnology, genetic engineering, has introduced techniques such as gene therapy, recombinant DNA technology, and the polymerase chain reaction. These techniques make use of genes and DNA molecules to diagnose disease and insert new and healthy genes into the body to replace damaged cells. Scientists are trying to develop biopharmaceutical drugs to treat diseases such as hepatitis, cancer, and heart disease.

Nanotechnology is a science that manipulates atoms and molecules to form new materials. Nanotechnology deals with materials a billion times smaller than a soccer ball. We cannot even visualize such minute dimensions. At this size, matter exhibits unusual properties that can be engineered to perform tasks not otherwise possible.

At present the signs of disease first appear at a cellular level. To date, instruments used within medicine have only been able to detect abnormalities at the macro level. Being able to diagnose and treat disease at the molecular level will enable physicians to reach the root origins of disease and assist—or even replace—the healing process.

The long-term goals of the National Institutes of Health (NIH) are to be able to use nanoparticles to seek out cancer cells before tumors grow and to remove and/or replace "broken" parts of cells or cell mechanisms with miniature, molecular-sized biological "machines" and use these "machines" as pumps or robots to deliver medicines when and where needed in the body. Pharmaceutical products are reformulated with nano-sized particles to improve their absorption. ■

Weight is measured using grams instead of ounces and pounds.

1 gram (g) = 1 ounce
1 kilogram (kg) = 2.2 pounds
1000 g = 1 kg

In drug dosage, the most familiar unit used is the gram or milligram (mg).

500 mg = 0.5 g

Volume is measured using liters or milliliters instead of quarts, pints, ounces, teaspoons, and tablespoons.

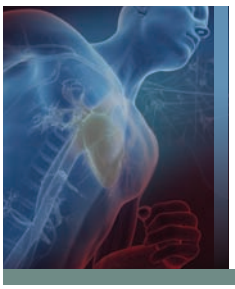
1 liter (L) = 1.06 quarts (a liter is slightly larger than a quart)
1 L = 1000 milliliters (ml)

For liquid drug dosage, milliliters are used.

5 ml = 1 teaspoon
15 ml = 1 tablespoon
30 ml = 1 ounce

Medical Terminology

ana	apart
-tom	cutting
-y	process of
ana/tom/y	process of cutting apart; study of body parts by dissection
-ology	study of
bio	life
bio/logy	study of life
physio	nature
physi/ology	study of nature or natural function of body
ante	in front of
anter/ior	in the front
poster	behind
poster/ior	in back of
super	above
super/ior	above a part
infer	below
infer/ior	below a part
-al	pertaining to
caud	tail
caud/al	pertaining to the tail
crani	skull
crani/al	pertaining to the skull
dist	distant
dist/al	pertaining to a distant part
dors	back
dors/al	pertaining to the back
later	side
later/al	pertaining to the side
medi	middle
medi/al	pertaining to the middle
proxim	near
proxim/al	pertaining to nearness or closeness
ventr	belly, front side
ventr/al	pertaining to the belly or front side



Study Tools

Workbook	Activities for Chapter 1
Online Resources	PowerPoint presentations