

ANATOMY, PHYSIOLOGY, AND PATHOPHYSIOLOGY

for Allied Health



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ANATOMY, PHYSIOLOGY, AND PATHOPHYSIOLOGY FOR ALLIED HEALTH

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ANATOMY, PHYSIOLOGY, AND PATHOPHYSIOLOGY FOR ALLIED HEALTH

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1 2 3 4 5 6 7 8 9 0 QWE/QWE 0 9 8 7

ISBN 978-0-07-337393-5

MHID 0-07-337393-1

Publisher: *Michelle Watnick/David T. Culverwell*

Senior Sponsoring Editor: *Roxan Kinsey*

Developmental Editor: *Connie Kuhl*

Senior Marketing Manager: *Nancy Bradshaw*

Senior Project Manager: *Sheila M. Frank*

Senior Production Supervisor: *Laura Fuller*

Designer: *Laurie B. Janssen*

Cover Designer: *Studio Montage*

Lead Photo Research Coordinator: *Carrie K. Burger*

Photo Research: *Pam Carley*

Supplement Producer: *Mary Jane Lampe*

Compositor: *ICC Macmillan Inc.*

Typeface: *10/12 Slimbach*

Printer: *Quebecor World Eusey, MA*

Photo credits: Front (left to right); ©Norbert Schafer/CORBIS, ©JFPI Studios, Inc./CORBIS, ©Photodisc: Medical Perspectives, ©Ed Bock/CORBIS, ©PhotoDisc: VL59 Medicine Today, ©Jose Luis Pelaez, Inc./CORBIS, Total Care Programming, Inc. Back (left to right); ©Photodisc: Medicine & Health Care, Total Care Programming, Inc., ©Photodisc: VL08 Emergency Room, ©Photodisc: Medical Perspectives Photodisc, ©Photodisc: V18 Health & Medicines, ©Brand X Pictures: Medical Still Life, ©Royalty-Free/CORBIS

Library of Congress Cataloging-in-Publication Data

Booth, Kathryn A., 1957-

Anatomy, physiology, and pathophysiology for allied health / Kathryn A. Booth, Terri D. Wyman. – 1st ed.

p. cm.

Includes index.

ISBN 978-0-07-337393-5 — ISBN 0-07-337393-1

1. Human anatomy—Handbooks, manuals, etc. 2. Human physiology—Handbooks, manuals, etc. 3. Physiology, Pathological—Handbooks, manuals, etc. 4. Allied health personnel—Handbooks, manuals, etc. I. Wyman, Terri D. II. Title.

QM23.2.B66 2008

612—dc22

2006046972

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Preface

Anatomy, Physiology, and Pathophysiology for Allied Health, first edition, is an introductory book to the body systems for medical assisting students. It acquaints students with basic information about all of the body systems. The book speaks directly to the student, with chapter introductions, case studies, and chapter summaries written to engage the student's attention.

When referring to patients in the third person, we have alternated between passages that describe a male patient and passages that describe a female patient. Thus, the patient will be referred to as “he” half the time and as “she” half the time. The same convention is used to refer to the physician. The medical assistant is consistently addressed as “you.”

Patient Education

Throughout the book we provide the medical assistant with the information needed to educate patients so the patients can participate fully in their health care.

There is a particular focus on patient education. It is always desirable for patients to be as knowledgeable as possible about their health. Patients who do not understand what is expected of them may become confused, frightened, angry, and uncooperative; educated patients are better able to understand why compliance is important.

Organization of the Text

Anatomy, Physiology, and Pathophysiology for Allied Health provides the student with information on anatomy, physiology, and pathophysiology, beginning with a chapter on the organization of the body; each chapter that follows addresses a particular body system. These chapters also include information on the most common diseases and disorders of each body system.

Each chapter opens with a page of material that includes the chapter outline and objectives, and a list of key terms. Each chapter begins with an introduction and a case study for students to consider as they read the contents. Color photographs, anatomical and technical illustrations, tables, and text features help educate the student about various aspects of medical assisting. The text features, set off within the text, include the following:

- Case Studies are provided at the beginning of all chapters. They represent situations similar to those that the medical assistant may encounter in daily practice. Students are encouraged to consider the case study as they read each chapter. Case Study Questions in the end-of-chapter review check students' understanding and application of chapter content.
- “Educating the Patient” focuses on ways to instruct patients about caring for themselves outside of the medical office.
- “Pathophysiology” features within the chapters provide a description about the most common diseases and disorders, including information on the causes, signs and symptoms, and treatment options.

Each chapter closes with a summary of the chapter material, focusing on the role of the medical assistant. The summary is followed by an end-of-chapter review that consists of the following elements:

- Case Study Questions
- Discussion Questions
- Critical Thinking Questions
- Application Activities
- Internet Activities

These questions and activities allow students to practice specific skills.

The book also includes a glossary and several appendices for use as reference tools. The glossary lists all the words presented as key terms in each chapter and some other terms that the medical assisting students should know, along with a pronunciation guide and the definition for each term. The appendices include the Medical Assistant Role Delineation Chart, commonly used prefixes and suffixes used in medical terminology, and a comprehensive list of professional organizations and agencies.

Ancillaries

The instructor's manual provides the instructor with materials to help organize lessons and classroom interactions. It includes:

- A complete lesson plan for each chapter, including an introduction to the lesson, teaching strategies, pathophysiology review, alternate teaching strategies, case

studies, chapter close, resources, and an answer key to the student textbook.

The Instructor's CD-ROM (IPC) includes the following:

- EZ Test Questions
- PowerPoint® Presentations
- Image bank of illustrations from the student text
- Anatomy and Physiology Drag and Drop Exercises

Together the student edition and the instructor's manual and resource CD-ROM form a complete teaching and learning package.

There is an Online Learning Center that offers an extensive array of learning and teaching tools, including chapter quizzes with immediate feedback, newsfeeds, links to relevant websites, and many more study resources. Log on at www.mhhe.com/medicalassisting

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CHAPTER 2

The Integumentary System

KEY TERMS

alopecia
apocrine gland
arrector pili
cellulitis
cyanosis
dermatitis
dermis
eccrine gland
eczema
epidermis
follicle
folliculitis
hemoglobin
herpes simplex
herpes zoster
hypodermis
impetigo
keratin
keratinocyte
lumula
melanin
melanocyte
nail bed
psoriasis
rosacea
scabies
sebaceous
sebum
stratum basale
stratum corneum
subcutaneous
warts

CHAPTER OUTLINE

- Functions of the Integumentary System
- Skin Structure
- Skin Color
- Accessory Organs
- Skin Healing

OBJECTIVES

After completing Chapter 2, you will be able to:

- 2.1 List the functions of skin.
- 2.2 Explain the role of skin in regulating body temperature.
- 2.3 Describe the layers of skin and the characteristics of each layer.
- 2.4 Explain the factors that affect skin color.
- 2.5 List the accessory organs of skin and describe their structures and functions.
- 2.6 Describe the appearance, causes, and treatments of various types of skin cancer.
- 2.7 Describe the appearance, causes, and treatment of common skin disorders.
- 2.8 Explain the ABCD rule and its use in evaluating melanoma.
- 2.9 List the different types of burns and describe their appearances and treatments.
- 2.10 Describe the signs, symptoms, causes, and treatments of other skin disorders and diseases.

Introduction

The integumentary system consists of skin and its accessory organs. The accessory organs of skin are hair follicles, nails, and skin glands. Skin is the body's outer covering and its largest organ.

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TABLE 9-1 Common Vitamins and Their Importance in the Body

Vitamin	Function
Vitamin A	Needed for the production of visual receptors, mucus, the normal growth for bones and teeth, and the repair of epithelial tissues
Vitamin B ₁ (thiamine)	Needed for the metabolism of carbohydrates
Vitamin B ₂ (riboflavin)	Needed for carbohydrate and fat metabolism and for the growth of cells
Vitamin B ₆	Needed for the synthesis of protein, antibodies, and nucleic acid
Vitamin B ₁₂ (cyanocobalamin)	Needed for myelin production and the metabolism of carbohydrates and nucleic acids
Biotin	Needed for the metabolism of proteins, fats, and nucleic acids
Folic acid	Needed for the production of amino acids, DNA, and red blood cells
Pantothenic acid	Needed for carbohydrate and fat metabolism
Niacin	Needed for the metabolism of carbohydrates, proteins, fats, and nucleic acids
Vitamin C (ascorbic acid)	Needed for the production of collagen, amino acids, and hormones and for the absorption of iron
Vitamin D	Needed for the absorption of calcium
Vitamin E	Antioxidant that prevents the breakdown of certain tissues
Vitamin K	Needed for blood clotting

make cell membranes and some hormones. People should have the essential fatty acid **linoleic acid** in their diet since the body cannot make it. This fatty acid is found in corn and sunflower oils. People also need a certain amount of fat to absorb fat-soluble vitamins.

Foods rich in protein include meats, eggs, milk, fish, chicken, turkey, nuts, cheese, and beans. Protein requirements vary from individual to individual, but all people must take in proteins that contain certain amino acids (called essential amino acids) because the body cannot make them. Proteins are used by the body for growth and the repair of tissues.

The fat-soluble vitamins are vitamins A, D, E, and K, and the water-soluble vitamins are all the B vitamins and vitamin C. Vitamins have many functions; they are summarized in Table 9-1.

Minerals make up about 4% of total body weight. They are primarily found in bones and teeth. Cells use minerals to make enzymes, cell membranes, and various proteins such as hemoglobin. The most important minerals to the human body are calcium, phosphorus, sulfur, sodium, chlorine, and magnesium. Trace elements are elements needed in very small amounts by the body. They include iron, manganese, copper, iodine, and zinc.

Pathophysiology

Common Diseases and Disorders of the Digestive System

Appendicitis is an inflammation of the appendix. If not treated promptly, it can be life-threatening.

- **Causes.** This disorder is caused by blockage of the appendix with feces or a tumor.

- **Signs and symptoms.** The signs and symptoms include lack of appetite, pain in or around the navel area or in the abdomen, nausea, slight fever, pain in the right leg, and an increased white blood cell count.

continued →

The Digestive System 127

Every chapter opens with a Chapter Outline, Objectives, Key Terms, and an Introduction that prepares students for the learning experience.

Case studies present situations similar to those that a medical assistant may encounter in daily practice.

Introduction

Bones and joints do not themselves produce movement. By alternating between contraction and relaxation, muscles cause bones and supported structures to move. The human body has more than 600 individual muscles. Although each muscle is a distinct structure, muscles act

in groups to perform particular movements. This chapter focuses on the differences among three muscle tissue types, the structure of skeletal muscles, muscle actions, and the names of skeletal muscles.

CASE STUDY

Five days ago, a 40-year-old woman came to the doctor's office where you work as a medical assistant. She complained about pain in her back and right leg. Because this patient had a history of disc damage in her spine, she was sent home with pain medication and an order for bed rest for a 24-hour period. Two days later, she returned to the office with nausea, a severe headache, muscle twitching in her legs and arms, severe back pain, and tightness in her chest. The doctor once more asked the patient to elaborate on her activities the day before she fell ill. He was told that she had sprayed her furniture and carpets with an organophosphate insecticide to get rid of fleas in her house. She had also dipped her cats and dogs with the same insecticide. The doctor explained that organophosphates block acetylcholinesterase and immediately transferred her to the hospital for respiratory therapy and medicine to combat the insecticide poisoning.

As you read this chapter, consider the following questions:

1. What is the function of acetylcholinesterase?
2. Why does this patient exhibit muscle twitching and back pain?
3. What type of respiratory therapy will this patient require?
4. What precautions should a person take when using insecticides that contain organophosphates?
5. Why is it important for patients to give their doctor a complete account of their activities prior to an illness?

Functions of Muscle

Muscle tissue is unique because it has the ability to contract. It is this contraction that allows muscles to perform various functions. In addition to allowing the human body to move, muscles provide stability, the control of body openings and passages, and warming of the body.

Movement

Because skeletal muscles are attached to bones, when they contract, the bones attached to them move. This allows for various body motions, such as walking or waving your hand. Facial muscles are attached to the skin of the face, so when they contract, different facial expressions are produced, such as smiling or frowning. Smooth muscle is found in the walls of various organs, such as the stomach, intestines, and uterus. The contraction of smooth muscle in these organs produces movements of their contents, such as the movement of food material through the intestine. Cardiac muscle in the heart produces the pumping of blood into blood vessels.

Stability

You rarely think about it but muscles are holding your bones tightly together so that your joints remain stable. There are also very small muscles holding your vertebrae together to make your spinal column stable.

Control of Body Openings and Passages

Muscles form valve-like structures called **sphincters** around various body openings and passages. These sphincters control the movement of substances into and out of these passages. For example, a urethral sphincter prevents urination, or it can be relaxed to permit urination.

Heat Production

When muscles contract, heat is released, which helps the body maintain a normal temperature. This is why moving your body can make you warmer if you are cold.

The Muscular System 45

Tables provide students with important information in an easy-to-read format.

Educating the Patient boxes give the medical assistant important information to share with the patients for self care outside the medical office.

Pathophysiology section at the end of each chapter lists common diseases and disorders associated with that body system.

Educating the Patient

Snoring

Snoring occurs when the muscles of the palate, tongue, and throat relax. Airflow then causes these soft tissues to vibrate. These vibrating tissues produce the harsh sounds characteristic of snoring.

Snoring causes daytime sleepiness and is sometimes associated with sleep apnea. In this condition, the relaxed throat tissues cause airways to collapse, which prevent a person from breathing. Snoring affects approximately 50% of men and 25% of women over the age of 40. The common causes of snoring include:

- Enlargement of the tonsils or adenoids
- Being overweight
- Alcohol consumption
- Nasal congestion
- A deviated (crooked) nasal septum

The severity of snoring varies among people. The Mayo Clinic's Sleep Disorders Center uses the following scale to determine the severity of snoring:

- Grade 1: Snoring can be heard from close proximity to the face of the snoring person.
- Grade 2: Snoring can be heard from anywhere in the bedroom.
- Grade 3: Snoring can be heard just outside the bedroom with the door open.
- Grade 4: Snoring can be heard outside the bedroom with the door closed.

You can educate patients about making lifestyle modifications and using aids to help reduce their snoring:

- Lose weight
- Change the sleeping position from the back to the side
- Avoid the use of alcohol and medications that cause sleepiness
- Use nasal strips to widen the nasal passageways
- Use dental devices to keep airways open

In addition, patients may benefit from using a mask attached to a pump that forces air into their passageways while they sleep. If these therapies are not effective, patients may need surgery to trim excess tissues in the throat or laser surgery to remove a portion of the soft palate.

Pathophysiology

Common Diseases and Disorders of the Urinary System

Acute kidney failure is a sudden loss of kidney function.

- **Causes.** There are many causes and risk factors for kidney failure, including burns, dehydration, low blood pressure, hemorrhaging, allergic reactions, obstruction of the renal artery, various poisons, alcohol abuse, trauma to the kidneys and skeletal muscles, blood disorders, blood transfusion reactions, kidney stones, urinary tract infections, enlarged prostate, childhood and immune system disorders, and food poisoning involving the bacterium *E. coli*.
- **Signs and symptoms.** The signs and symptoms include decreased urine production or no urine production, excessive urination, swelling of the arms or legs, bloating, mental confusion, coma, seizures, hand tremors, nosebleeds, easy bruising, pain in the back or abdomen, high blood pressure, abnormal heart or lung sounds, abnormal urinalysis, and an increase in potassium levels.
- **Treatment.** The first treatment measure is modifying the diet to decrease the amount of protein consumed. Controlling fluid intake and potassium levels is also recommended. Antibiotics and dialysis may also be needed.

Chronic kidney failure is a condition in which the kidneys slowly lose their ability to function. Sometimes symptoms do not appear until the kidneys have lost about 90% of their function.

- **Causes.** This disorder results from diabetes, high blood pressure, glomerulonephritis, polycystic kidney disease, kidney stones, obstruction of the ureters, and acute kidney failure.
- **Signs and symptoms.** The list of signs and symptoms is extensive and includes headache, mental confusion, coma, seizures, fatigue, frequent hiccups, itching, easy bruising, abnormal bleeding, anemia, excessive thirst, fluid retention, nausea, high blood pressure, abnormal heart or lung sounds, weight loss, white spots on the skin or increased pigmentation, high potassium levels, an increased or decreased urine output, urinary tract infections, and abnormal urinalysis results.
- **Treatment.** This disorder can be treated with antibiotics; blood transfusions; medications to control anemia; restricting the intake of fluids, electrolytes, and protein; controlling high blood pressure; and dialysis. The most serious cases may require surgery to repair an obstruction of the ureters or a kidney transplant.

Cystitis is a urinary bladder infection. Women are much more likely to develop this disorder than men because of the short length of their urethras. The urethral opening in women is also close to the anal opening, allowing bacteria from this area to be more easily introduced into the urinary tract.

- **Causes.** This infection is caused by different types of bacteria (especially those that are found in the rectum) and the placement of a catheter in the bladder. Good hygiene, urinating frequently, and wiping from front to back (for females) can help to prevent this infection.
- **Signs and symptoms.** Common symptoms include fatigue, chills, fever, painful urination, a frequent need to urinate, cloudy urine, and blood in the urine.
- **Treatment.** This infection is treated with antibiotics.

Glomerulonephritis is an inflammation of the glomeruli of the kidney.

- **Causes.** This disorder is caused by renal diseases, immune disorders, and bacterial infections.
- **Signs and symptoms.** The signs and symptoms are hiccups, drowsiness, coma, seizures, nausea, anemia, high blood pressure, increased skin pigmentation, abnormal heart sounds, abnormal urinalysis results, blood in the urine, and a decreased or increased urine output.
- **Treatment.** Treatment begins with a low-sodium, low-protein diet. Medications to control high blood pressure, corticosteroids to reduce inflammation, and dialysis are other treatment options.

Incontinence is a condition in which a person (other than a child) cannot control urination. This condition can be either temporary or long lasting. Women are more likely to develop incontinence than men are.

- **Causes.** This condition can be caused by various medications, excessive coughing (for example, in smokers), urinary tract infections, nervous system disorders, and bladder cancer. In men, prostate problems can lead to the development of this disorder. The weakness of the urinary sphincters from surgery, trauma, or pregnancy can also cause incontinence. It may be prevented by avoiding urinary bladder irritants such as coffee, cigarettes, diuretics, and various medications.
- **Signs and symptoms.** The primary symptom is the involuntary leakage of urine.
- **Treatment.** Treatment includes various medications, incontinence pads, removal of the prostate, Kegel exercises to increase the control of urinary sphincters, and surgery to repair damaged bladders or urethral sphincters.

continued →

The Urinary System 155

Pathophysiology

Common Diseases and Disorders of the Respiratory System

Asthma is a condition in which the tubes of the bronchial tree become obstructed due to inflammation.

- **Causes.** The causes can include allergens (pollen, pets, dust mites, etc.), cigarette smoke, pollutants, perfumes, cleaning agents, cold temperatures, and exercise (in susceptible individuals).
- **Signs and symptoms.** Symptoms include difficulty breathing, a tight feeling in the chest, wheezing, and coughing.
- **Treatment.** Treatment includes avoiding allergens, using a steroid inhaler to reduce inflammation, using a bronchodilator, and stopping smoking.

Bronchitis is inflammation of the bronchi and often follows a cold. Bronchitis that occurs frequently often indicates more serious conditions such as asthma or emphysema. Smokers are much more likely to develop bronchitis than

are nonsmokers. Repeated episodes of bronchitis increase a person's chance of eventually developing lung cancer.

- **Causes.** This condition can be caused by viruses and gastroesophageal reflux (acids that move from the stomach into the esophagus). Exposure to cigarette smoke, pollutants, and the fumes of household cleaners can also contribute to the development of bronchitis.
- **Signs and symptoms.** The signs and symptoms include chills, fever, coughing up yellow-gray or green mucus, tightness in the chest, wheezing, and difficulty breathing.
- **Treatment.** This condition can be treated with rest, fluids, nonprescription and prescription cough medicines, and the use of a humidifier. Antibiotics are usually prescribed only for smokers. Patients who also have asthma may need to use inhalers. They should also wear masks if they may be exposed to lung irritants.

continued →

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REVIEW

CHAPTER 10

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. Where is the pituitary gland located?
2. What structures are likely to be compressed by a tumor of the pituitary gland?
3. What hormones are normally produced by the pituitary gland?
4. What signs and symptoms would this patient have if she did not take supplemental hormones following the removal of her pituitary gland?

Application Activities

1. Tell which endocrine gland secretes the following hormones:
 - a. Insulin
 - b. ADH
 - c. Testosterone
 - d. Prolactin
 - e. Growth hormone
2. Describe the effects the following hormones produce:
 - a. Oxytocin
 - b. Cortisol
 - c. LH and FSH
 - d. Glucagon
 - e. Estrogen
3. For each of the following diseases, name the hormone that is involved:
 - a. Acromegaly
 - b. Myxedema
 - c. Dwarfism
 - d. Diabetes
 - e. Cushing's disease
4. Define what a stressor is and give an example.

Discussion Questions

1. Explain the difference between an endocrine gland and an exocrine gland.
2. Name the major endocrine organs of the body and give their locations.
3. Explain how the body responds to stress.
4. Explain why the testes and ovaries are described as both endocrine organs and reproductive organs.

Critical Thinking Questions

1. If a patient had his pituitary gland removed, what hormone supplements would he need?
2. What is the danger of a diabetic injecting too much insulin?
3. Why is hyposecretion (insufficient secretion) of thyroid hormone in newborns more serious than hyposecretion in adults?

Internet Activity

Find a Web site that discusses endocrinology. Research the roles of an endocrinologist and how weight management and endocrinology are related.

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Each chapter ends with a review section with case studies, discussion questions, critical thinking questions, application activities, and an Internet activity to reinforce the information that was just learned.

CHAPTER 1

Organization of the Body

CHAPTER OUTLINE

- The Study of the Body
- Organization of the Body
- Body Organs and Systems
- Anatomical Terminology
- Body Cavities and Abdominal Regions
- Chemistry of Life
- Cell Characteristics
- Movement Through Cell Membranes
- Cell Division
- Genetic Techniques
- Heredity
- Major Tissue Types

OBJECTIVES

After completing Chapter 1, you will be able to:

- 1.1 Describe how the body is organized from simple to more complex levels.
- 1.2 List all body organ systems, their general functions, and the major organs contained in each.
- 1.3 Define the anatomical position and explain its importance.
- 1.4 Use anatomical terminology correctly.
- 1.5 Name the body cavities and the organs contained in each.
- 1.6 Explain the abdominal regions.
- 1.7 Explain why a basic understanding of chemistry is important in studying the body.
- 1.8 Describe important molecules and compounds of the human body.
- 1.9 Label the parts of a cell and list their functions.
- 1.10 List and describe the ways substances move across a cell membrane.
- 1.11 Describe the stages of cell division.
- 1.12 Describe the uses of the genetic techniques, DNA fingerprinting, and the polymerase chain reaction.
- 1.13 Explain how mutations occur and what effects they may produce.
- 1.14 Describe the different patterns of inheritance.
- 1.15 Describe the signs and symptoms of various genetic conditions.
- 1.16 Describe the locations and characteristics of the four main tissue types.

KEY TERMS

acids
active transport
allele
anatomical position
anatomy
anterior
atoms
autosome
bases
biochemistry
caudal
cell membrane
cells
chemistry
chromosome
complex inheritance
compound
connective tissue
cranial
cytokinesis
cytoplasm
deep
diaphragm
diffusion
distal
DNA
dorsal
electrolytes
endocrine gland
epithelial tissue
exocrine gland
femoral
filtration
frontal
gene

KEY TERMS (Continued)

homeostasis	meiosis	nucleus	RNA
homologous chromosome	metabolism	organ	sagittal
inferior	midsagittal	organ systems	sex chromosome
inorganic	mitosis	organelle	sex-linked trait
interphase	molecule	organic	superficial
ions	muscle tissue	organism	superior
lateral	mutation	osmosis	tissue
matrix	nervous tissue	physiology	transverse
matter	neuroglial cells	posterior	ventral
medial	neurons	proximal	

Introduction

The human body is complex in its structure and function. This chapter provides an overview of the human body. It introduces you to the way the body is organized from the chemical level all the way up to the organ system level. You

will also learn important terminology used in the clinical setting to describe body positions and parts. This chapter also focuses on how diseases develop at the genetic level.

CASE STUDY

Last week a 12-year-old boy came to the doctor's office complaining of severe abdominal pains and nausea. He was diagnosed with appendicitis, requiring the removal of his appendix. The boy's medical chart indicates that he was diagnosed with *situs inversus*, a condition in which the organs of the thoracic and abdominal cavities are reversed from left to right. He has returned to the office for suture removal and bandage change.

As you read this chapter, consider the following questions:

1. On what side of the body is the appendix normally located?
2. If the medical assistant observes the boy's right lower abdominal quadrant for the bandage, is this correct? Why or why not?
3. Where should the bandage be found?
4. What precautions should this patient take given his diagnosis of *situs inversus*?

The Study of the Body

Anatomy is the scientific term for the study of body structure. For example, in discussing the structure or anatomy of the heart, it may be described as a hollow, cone-shaped organ with an average size of 14 centimeters in length and 9 centimeters in width. It is also very important to know the position of normal body structures and how to describe these positions precisely and correctly. **Physiology** is the term used for the study of function. For example, the physiology of the heart can be described by saying that the heart pumps blood into blood vessels for the transportation of nutrients throughout the body. Anatomy and physiology are commonly studied together because they are always related. For example, the anatomy of the heart (a

hollow, muscular organ) allows it to do its function (pump blood into tubular blood vessels). If the heart was not hollow, it could not allow blood to flow into it. If the heart was not muscular, it could not pump blood.

Knowledge of anatomy and physiology will help you grasp the meaning of diagnostic and procedural codes and can help you understand the clinical procedures you will perform as a medical assistant. It will also make it easier to see how and why certain diseases develop. Disease states develop in the body when homeostasis is not maintained. **Homeostasis** is defined as the maintenance of stable internal conditions. Conditions in the body that must remain stable include body temperature, blood pressure, and the concentration of various chemicals within the blood. Individual cells must also maintain homeostasis.

For example, if chemicals within a cell change the DNA or genetic makeup of the cell, that cell can become cancerous.

Organization of the Body

The structure of the body can be divided into different levels of organization. The chemical level is the simplest level and refers to the billions of atoms and molecules in the body. **Atoms** are the simplest units of all matter, and many are essential to life. **Matter** is anything that takes up space and has weight. The four most common atoms in the human body are carbon, hydrogen, oxygen, and nitrogen. **Molecules** are made up of atoms that bond together. For example, water is formed when two hydrogen atoms bond

to an oxygen atom, which is an example of a small but very important molecule. Proteins and carbohydrates are examples of much larger molecules that consist of hundreds of atoms.

Molecules join together to form **organelles**, which can be thought of as cell parts. Organelles combine to form cells such as leukocytes (white blood cells), erythrocytes (red blood cells), neurons (nerve cells), and adipocytes (fat cells). **Cells** are considered the smallest living units of structure and function in the body. When cells of the same type organize together, they form **tissues**. The four major types of body tissue are epithelia, connective, nervous, and muscle. Two or more tissue types combine to form **organs**, and organs arrange to form **organ systems**. Finally, organ systems combine to form the **organism** called the human body (Figure 1-1).

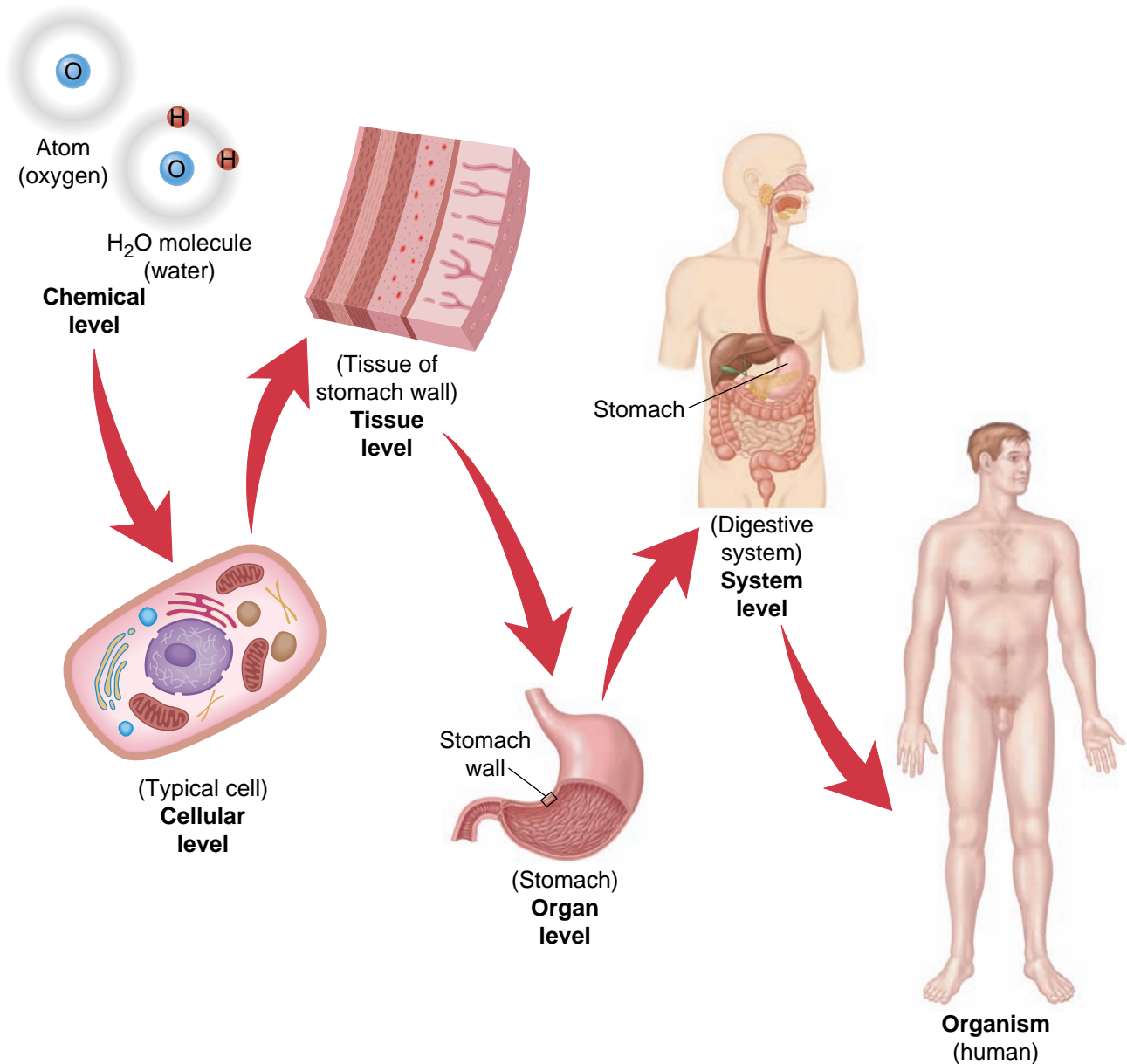
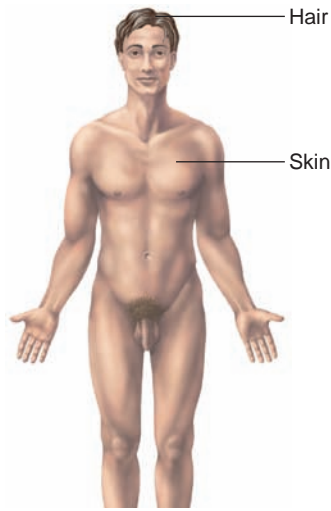


Figure 1-1. The human body is organized in levels, beginning with the chemical level and progressing to the cellular, tissue, organ, system, and organism (whole body) levels.

Body Organs and Systems

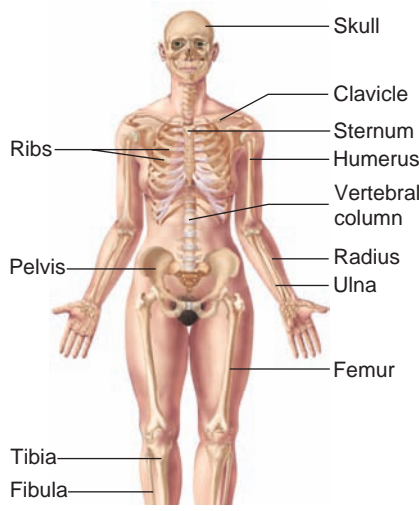
Organs can be defined as structures formed by the organization of two or more different tissue types that work together to carry out specific functions. For example, the heart is composed of a wall of cardiac muscle tissue and connective tissue and is lined with an epithelial tissue. These tissues work together to carry out the function of

the heart, which is to effectively pump blood into blood vessels. Organ systems are formed when organs join together to carry out vital functions. For example, the heart and blood vessels unite to form the cardiovascular system. The organs of the cardiovascular system function to circulate blood throughout the body to ensure that all body cells receive an adequate supply of nutrients. See Figure 1-2 for a summary of the organ systems of the



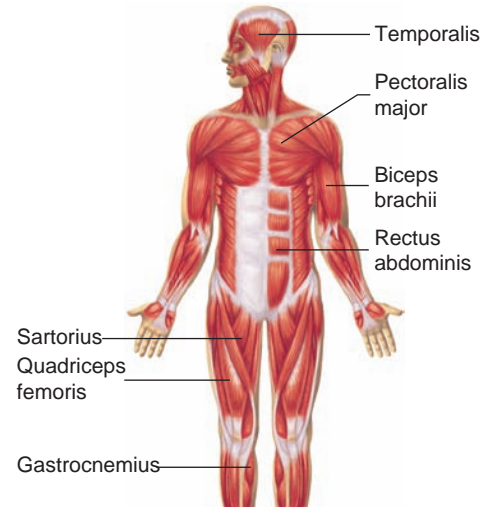
Integumentary System

Provides protection, regulates temperature, prevents water loss, and produces vitamin D precursors. Consists of skin, hair, nails, and sweat glands.



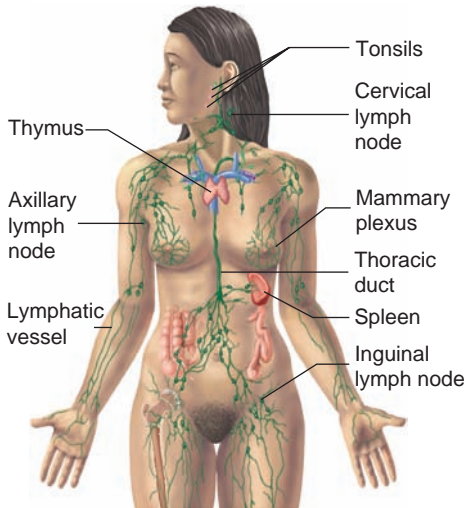
Skeletal System

Provides protection and support, allows body movements, produces blood cells, and stores minerals and fat. Consists of bones, associated cartilages, ligaments, and joints.



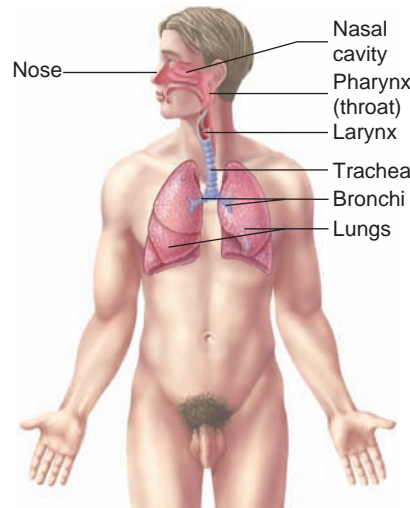
Muscular System

Produces body movements, maintains posture, and produces body heat. Consists of muscles attached to the skeleton by tendons.



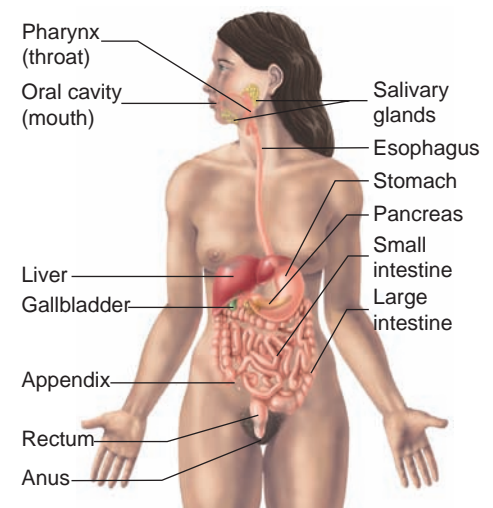
Lymphatic System

Removes foreign substances from the blood and lymph, combats disease, maintains tissue fluid balance, and absorbs fats from the digestive tract. Consists of the lymphatic vessels, lymph nodes, and other lymphatic organs.



Respiratory System

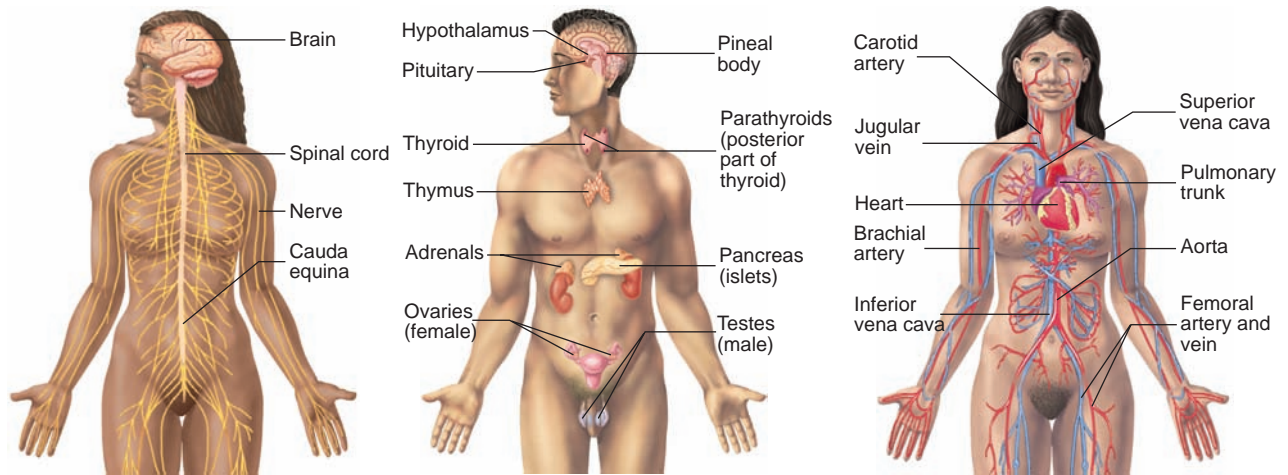
Exchanges oxygen and carbon dioxide between the blood and air and regulates blood pH. Consists of the lungs and respiratory passages.



Digestive System

Performs the mechanical and chemical processes of digestion, absorption of nutrients, and elimination of wastes. Consists of the mouth, esophagus, stomach, intestines, and accessory organs.

Figure 1-2. Organ systems of the body.



Nervous System

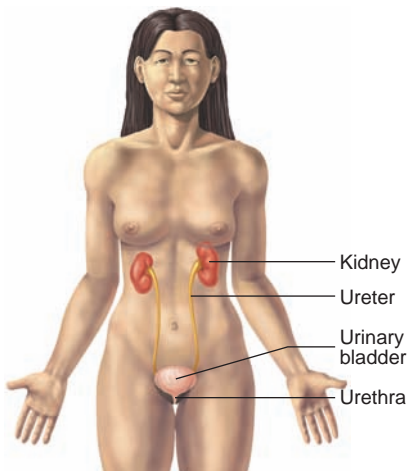
A major regulatory system that detects sensations and controls movements, physiologic processes, and intellectual functions. Consists of the brain, spinal cord, nerves, and sensory receptors.

Endocrine System

A major regulatory system that influences metabolism, growth, reproduction, and many other functions. Consists of glands, such as the pituitary, that secrete hormones.

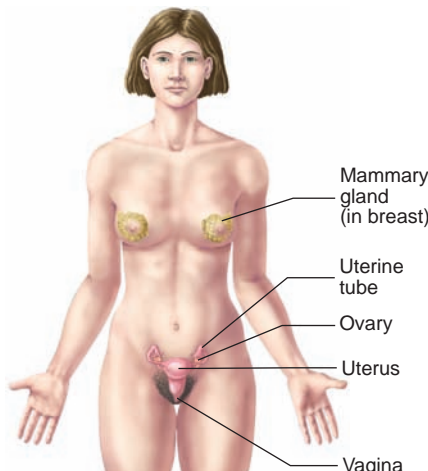
Cardiovascular System

Transports nutrients, waste products, gases, and hormones throughout the body; plays a role in the immune response and the regulation of body temperature. Consists of the heart, blood vessels, and blood.



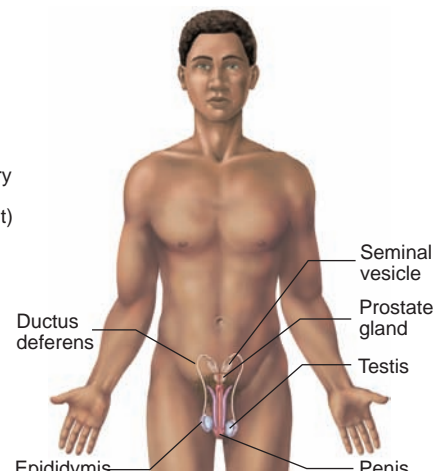
Urinary System

Removes waste products from the blood and regulates blood pH, ion balance, and water balance. Consists of the kidneys, urinary bladder, and ducts that carry urine.



Female Reproductive System

Produces oocytes and is the site of fertilization and fetal development; produces milk for the newborn; produces hormones that influence sexual function and behaviors. Consists of the ovaries, vagina, uterus, mammary glands, and associated structures.



Male Reproductive System

Produces and transfers sperm cells to the female and produces hormones that influence sexual functions and behaviors. Consists of the testes, accessory structures, ducts, and penis.

Figure 1-2. (continued)

body, their general functions, and the organs contained in each.

Anatomical Terminology

Anatomical terms are a group of universal terms used to describe the location of body parts and various body regions. In order to correctly use these terms, it is assumed that the body is in the anatomical position. In the **anatomical position**, a body is standing upright and facing forward with the arms at the sides and the palms of the hands facing forward. Even if patients are lying down, for

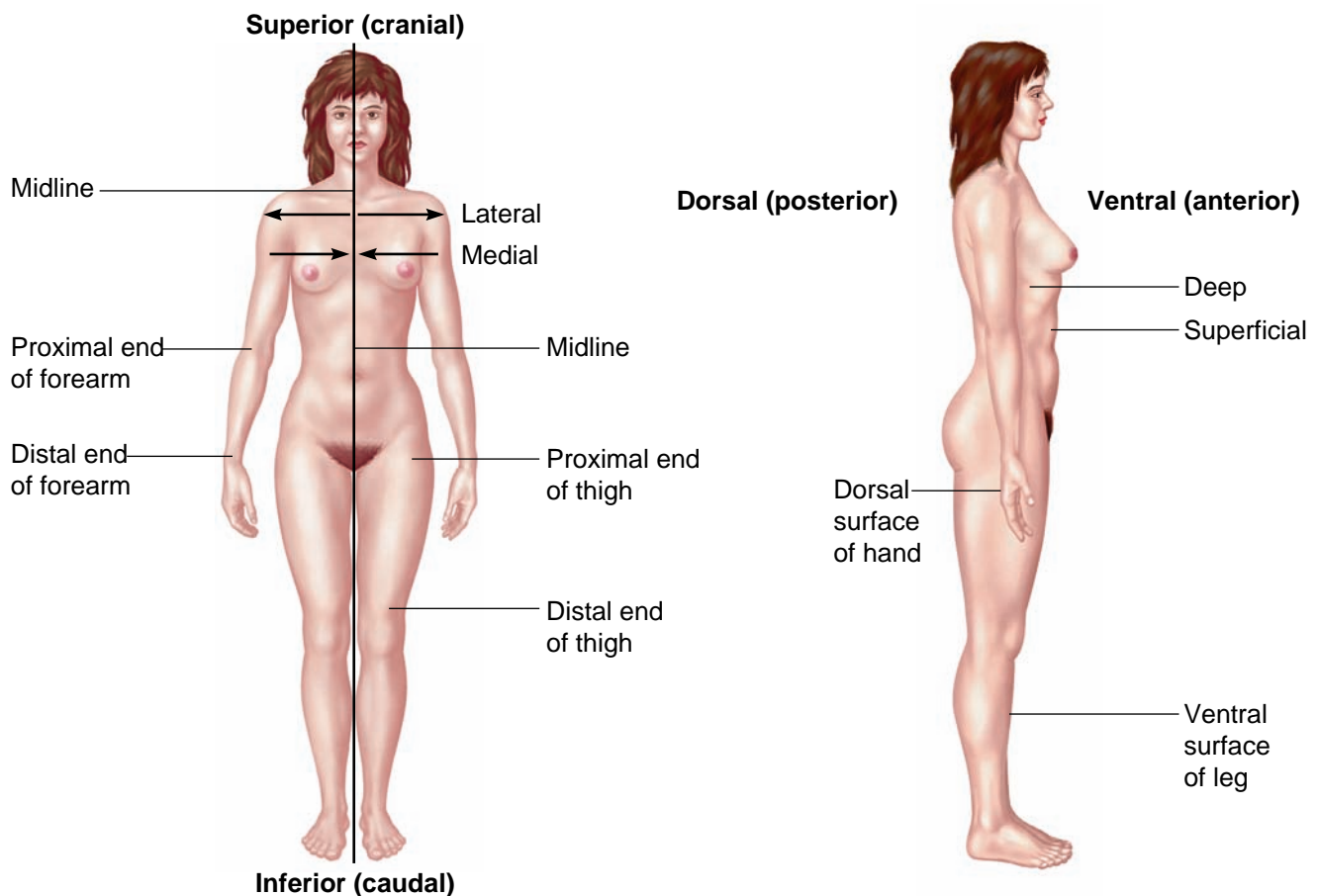
consistency and correct communication when you use anatomical terms, always refer to patients as if they are in the anatomical position.

Directional Anatomical Terms

The directional anatomical terms are **cranial**, **caudal**, **ventral**, **dorsal**, **medial**, **lateral**, **proximal**, **distal**, **superficial**, and **deep**. They are used to identify the position of body structures compared to other body structures. For example, the eyes are medial to the ears but lateral to the nose. See Table 1-1 and Figure 1-3 for an explanation and illustration of these important directional terms.

TABLE 1-1 Directional Anatomical Terms

Term	Definition	Example
Superior (cranial)	Above or close to the head	The thoracic cavity is superior to the abdominal cavity.
Inferior (caudal)	Below or close to the feet	The neck is inferior to the head.
Anterior (ventral)	Toward the front of the body	The nose is anterior to the ears.
Posterior (dorsal)	Toward the back of the body	The brain is posterior to the eyes.
Medial	Close to the midline of the body	The nose is medial to the ear.
Lateral	Farther away from the midline of the body	The ears are lateral to the nose
Proximal	Close to a point of attachment or to the trunk of the body	The knee is proximal to the toes
Distal	Farther away from a point of attachment or from the trunk of the body	The fingers are distal to the elbow
Superficial	Close to the surface of the body	Skin is superficial to muscles.
Deep	More internal	Bones are deep to skin.

**Figure 1-3.** Directional terms provide mapping instructions for locating organs and body parts.

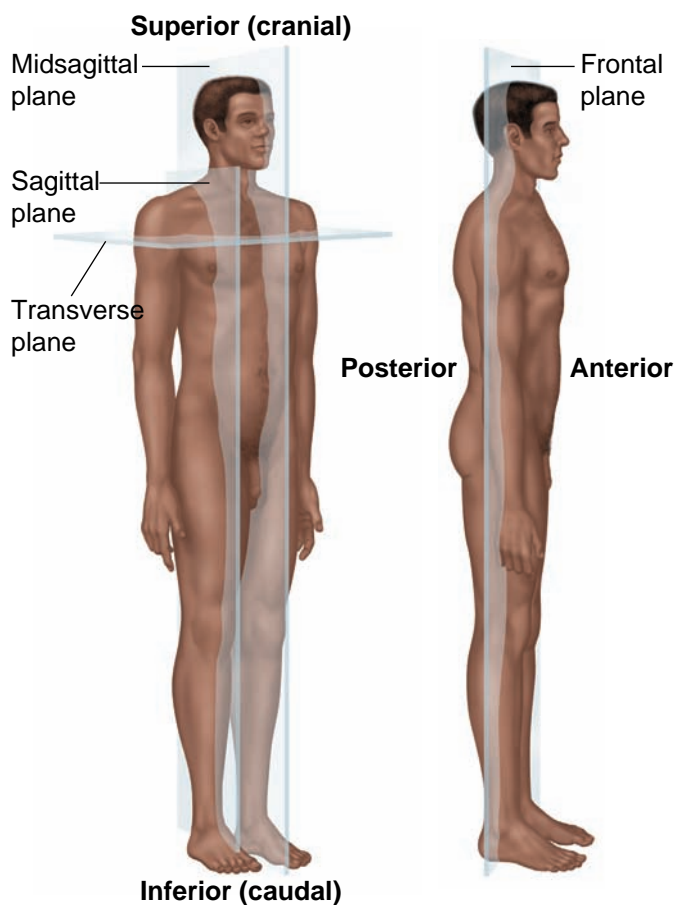


Figure 1-4. Spatial terms are based on imaginary cuts or planes through the body.

Anatomical Terms Used to Describe Body Sections

Sometimes in order to study internal body parts, the body has to be imagined as being divided into sections. It is useful to use the following terms to describe how the body is divided into sections: sagittal, transverse, and frontal (coronal).

A **sagittal** plane divides the body into left and right portions. A **midsagittal** plane runs lengthwise down the midline of the body and divides it into equal left and right halves. A **transverse** plane divides the body into **superior** (upper) and **inferior** (lower) portions. A **frontal**, or coronal, plane divides the body into **anterior** (frontal) and **posterior** (rear) portions. Figure 1-4 illustrates these planes.

Anatomical Terms Used to Describe Body Parts

Many other anatomical terms are used to describe different regions or parts of the body. For example, the term *brachium* refers to the arm and the term **femoral** refers to the thigh. Figure 1-5 illustrates many of the common anatomical terms used to describe body parts.

Body Cavities and Abdominal Regions

The largest body cavities are the dorsal cavity and the ventral cavity. The dorsal cavity is divided into the cranial cavity and the spinal cavity. The cranial cavity houses the brain, and the spinal cavity contains the spinal cord. The ventral cavity is divided into the thoracic cavity and the abdominopelvic cavity. The muscle called the **diaphragm** separates the thoracic and abdominopelvic cavities from each other. The lungs, heart, esophagus, and trachea are contained in the thoracic cavity. The abdominopelvic cavity is divided into a superior abdominal cavity and an inferior pelvic cavity. Most of the organs of digestion are found in the abdominal cavity, and the bladder and internal reproductive organs are located in the pelvic cavity. Figure 1-6 depicts these cavities. The abdominal area is further divided into nine regions or four quadrants, which are illustrated in Figure 1-7.

Chemistry of Life

The lowest level of organization is the chemical level, which includes all the chemical elements that make up matter. Liquids, solids, and gases are all matter. **Chemistry** is the study of what matter is composed of and how matter changes. It is important to have a basic understanding of chemistry when studying anatomy and physiology because body structures and functions result from chemical changes that occur within body cells or fluids.

When two or more atoms are chemically combined, a molecule is formed. Molecules are the basic units of compounds. A **compound** is formed when two or more atoms of more than one element are combined. An example of a molecule is water, which is composed of two hydrogen atoms and one oxygen atom. Water is also an example of a compound because its molecules are made up of atoms of two different elements—hydrogen and oxygen. Water is critical to both chemical and physical processes in human physiology, and it accounts for approximately two-thirds of a person's body weight.

Metabolism is the overall chemical functioning of the body. Metabolism includes all the processes that build small molecules into large ones (anabolism) and break down large molecules into small ones (catabolism).

Electrolytes

When put into water, some substances release **ions**, which are either positively or negatively charged particles; these substances are called **electrolytes**. For example, NaCl (sodium chloride) is an electrolyte. When you put NaCl in water, it releases the sodium ion (Na^+) and the chloride ion (Cl^-). Electrolytes are critical because the movements of ions into and out of body structures regulate or trigger many physiologic states and activities in the body. For

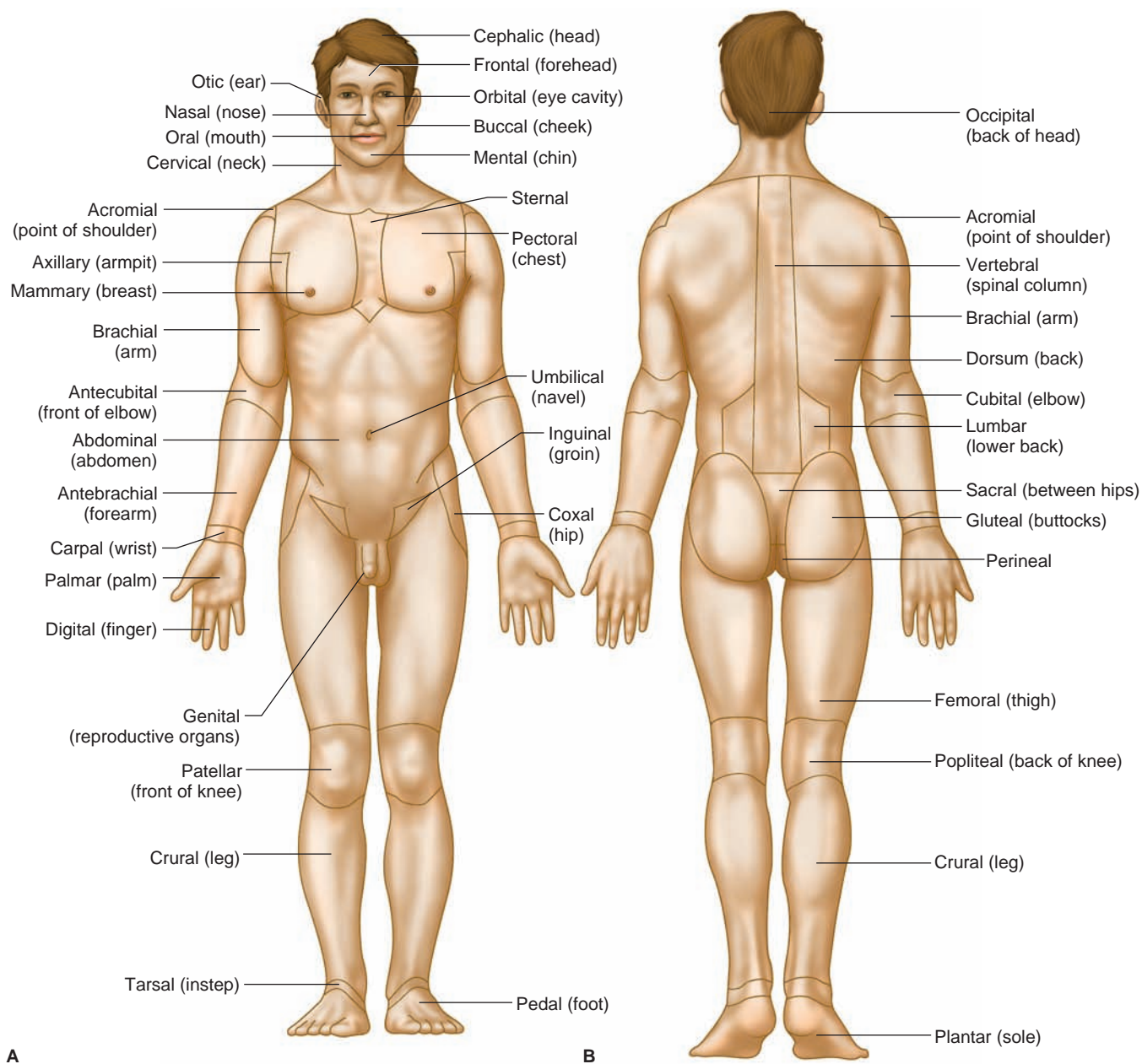


Figure 1-5. Numerous anatomical terms are used to describe regions of the body: (a) anterior view and (b) posterior view.

example, electrolytes are essential to fluid balance, muscle contraction, and nerve impulse conduction.

Acids. Acids are a type of electrolytes. They are defined as electrolytes that release hydrogen ions (H^+) in water. For example, hydrochloric acid (HCl) will release hydrogen ions when you put it in water. Therefore, it is acidic. It is also an electrolyte because it releases ions. Many acids, such as lemon juice and vinegar, have a sour taste.

Bases. Bases are also a type of electrolytes. They release hydroxyl ions (OH^-) in water. Sodium hydroxide (NaOH) is an example of a base because in water, it releases hydroxyl ions. A basic substance may also be referred to as an alkali. Many basic substances are slippery

and bitter to the taste. Detergents are examples of basic substances.

Testing Acids and Bases. In the clinical setting, litmus paper or a pH meter is often used to determine if a substance is acidic or basic. An acidic substance will turn blue litmus paper red, and a basic substance will turn red litmus paper blue. The pH scale runs from 0 to 14. If a solution has a pH of 7, the solution is neutral, which means that it is neither acidic nor basic. If a solution has a pH less than 7, the solution is acidic. If a solution has a pH greater than 7, it is basic, or alkaline. The more acidic a solution is, the higher the concentration of hydrogen ions it contains. The pH values of some common substances are shown in Figure 1-8.

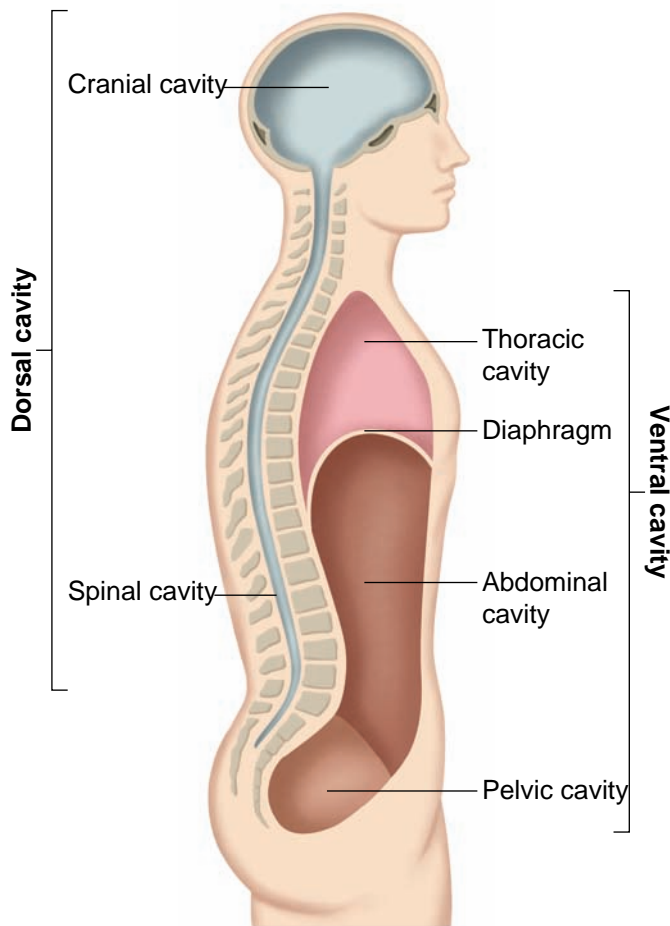


Figure 1-6. The two main body cavities are dorsal and ventral.

Biochemistry

The study of matter and chemical reactions in the body is called **biochemistry**. Matter can be divided into two large categories—organic and inorganic matter. **Organic** matter contains carbon and hydrogen. **Inorganic** matter generally does not contain carbon and hydrogen. Organic molecules tend to be large, whereas inorganic molecules tend to be small. Examples of inorganic substances are water, oxygen, carbon dioxide, and salts such as sodium chloride. Water is the most abundant inorganic compound in the body. The four major classes of organic matter in the body are carbohydrates, lipids, proteins, and nucleic acids.

Carbohydrates. Body cells depend on carbohydrate molecules primarily to make energy. The most common carbohydrate used by body cells is glucose. Glucose can also be stored in the body as a more complex carbohydrate called glycogen. Starches are a type of carbohydrate commonly found in potatoes, pastas, and breads.

Lipids. Three types of lipids found in the body are triglycerides, phospholipids, and steroids. Triglycerides are used to store energy for cells, and phospholipids are primarily used to make cell membranes. Butter and oils are composed of triglycerides, and the body stores these molecules in adipose tissue (fat). Steroids are very large lipid molecules used to make cell membranes and some hormones. Cholesterol is an example of an essential steroid for body cells.

Proteins. Proteins have many functions in the body. Many proteins act as structural materials for the building

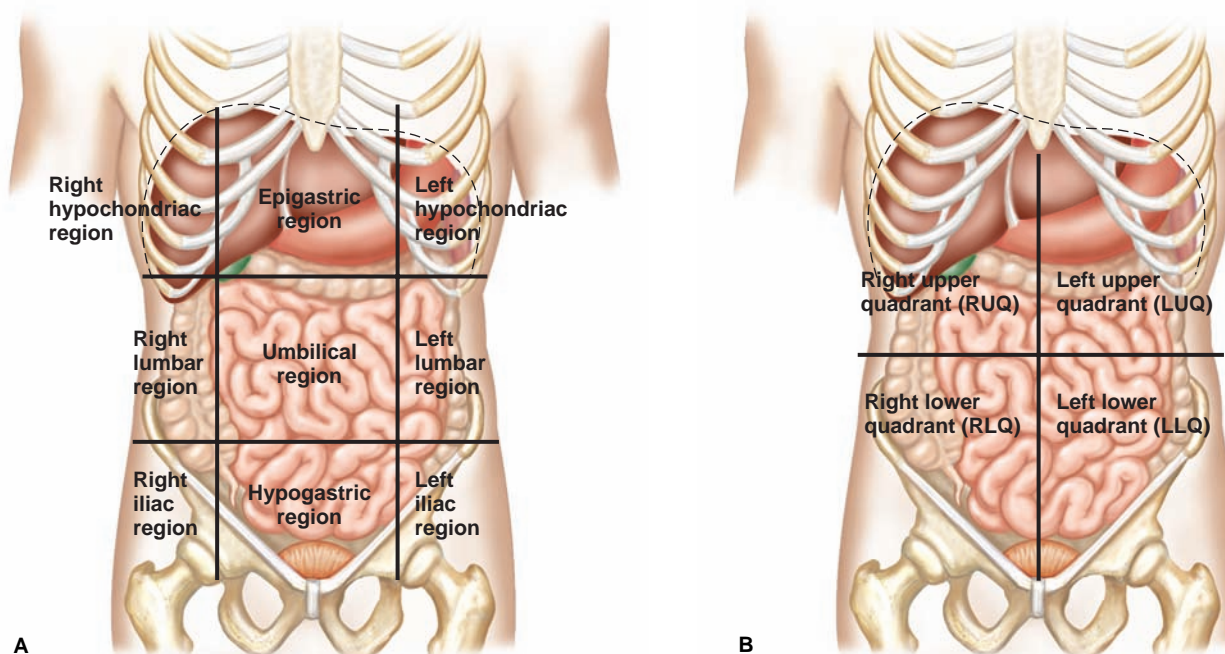


Figure 1-7. (a) The abdominal area divided into nine regions and (b) the abdominal area divided into four quadrants.

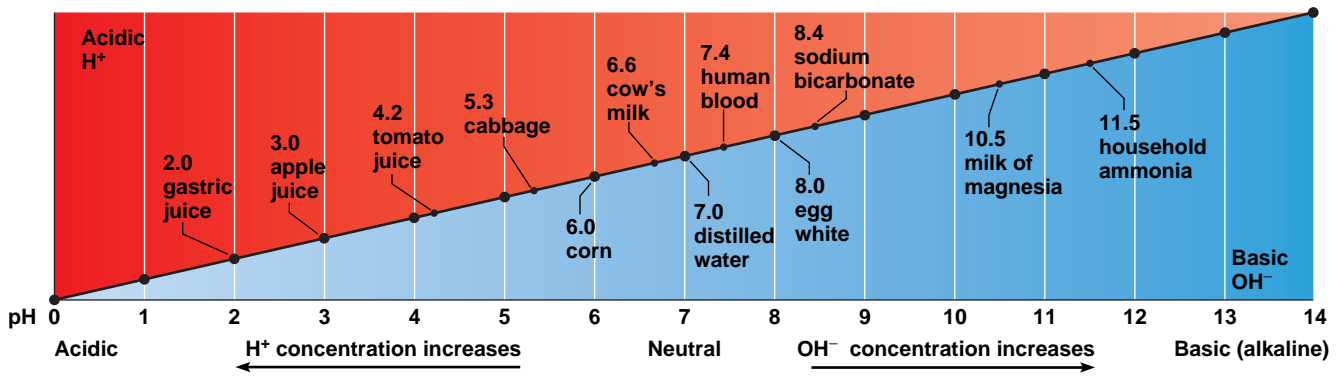


Figure 1-8. pH scale. As the concentration of hydrogen ions (H⁺) increases, a solution becomes more acidic and the pH decreases. As the concentration of hydroxyl ions (OH⁻) increases, a solution becomes more basic and the pH increases.

of solid body parts. Other proteins act as hormones, enzymes, receptors, and antibodies.

Nucleic Acids. DNA (deoxyribonucleic acid) and RNA (ribonucleic acid) are two examples of nucleic acids. DNA contains the genetic information of cells, and RNA is used to make proteins.

Cell Characteristics

Chemicals react to form the complex substances that make up cells, the basic units of life. The human body is composed of millions of cells. There are many kinds of cells, and each type has a specific function. Most cells have three main parts: cell membrane, cytoplasm, and nucleus. Figure 1-9 shows the structure of a composite cell.

Cell Membrane

The **cell membrane** is the outer limit of a cell. It is very thin and is described as being selectively permeable, which means that it allows some substances to pass through it while preventing other substances from passing through. The cell membrane is composed of two layers of phospholipids, different types of proteins, cholesterol, and a few carbohydrates.

Cytoplasm

The **cytoplasm** of a cell can be imagined as the “inside” of the cell. It is mostly made up of water, proteins, ions, and nutrients.

Nucleus

The **nucleus** of a cell is typically round in structure and is placed near the center of a cell. It is enclosed by a nuclear membrane that contains nuclear pores so that larger substances can move into and out of the nucleus. It contains

chromosomes, which are threadlike structures made up of DNA.

Movement Through Cell Membranes

The cell membrane controls what moves into and out of cells. Some substances move across the cell membrane without the use of energy. These movements are called passive mechanisms. Sometimes the cell has to use energy to move a substance across its membrane. In this case, the substances move through active mechanisms.

Diffusion

Diffusion is the movement of a substance from an area of high concentration to an area of low concentration—it can be described as the spreading out of a substance. Substances that easily diffuse across the cell membrane include gases such as oxygen and carbon dioxide.

Osmosis

Osmosis refers to the diffusion or movement of water across a semipermeable membrane, such as a cell membrane. You should remember that water will always try to diffuse or move toward the higher concentration of solutes (solids in solution).

Filtration

In **filtration**, some type of pressure, such as gravity or blood pressure, forces substances across a membrane that acts like a filter. Filtration separates substances in solutions. For example, you could separate sand from water by pouring the sand/water mixture through a filter. In the body, capillaries in the kidneys act as filters to separate components in blood.

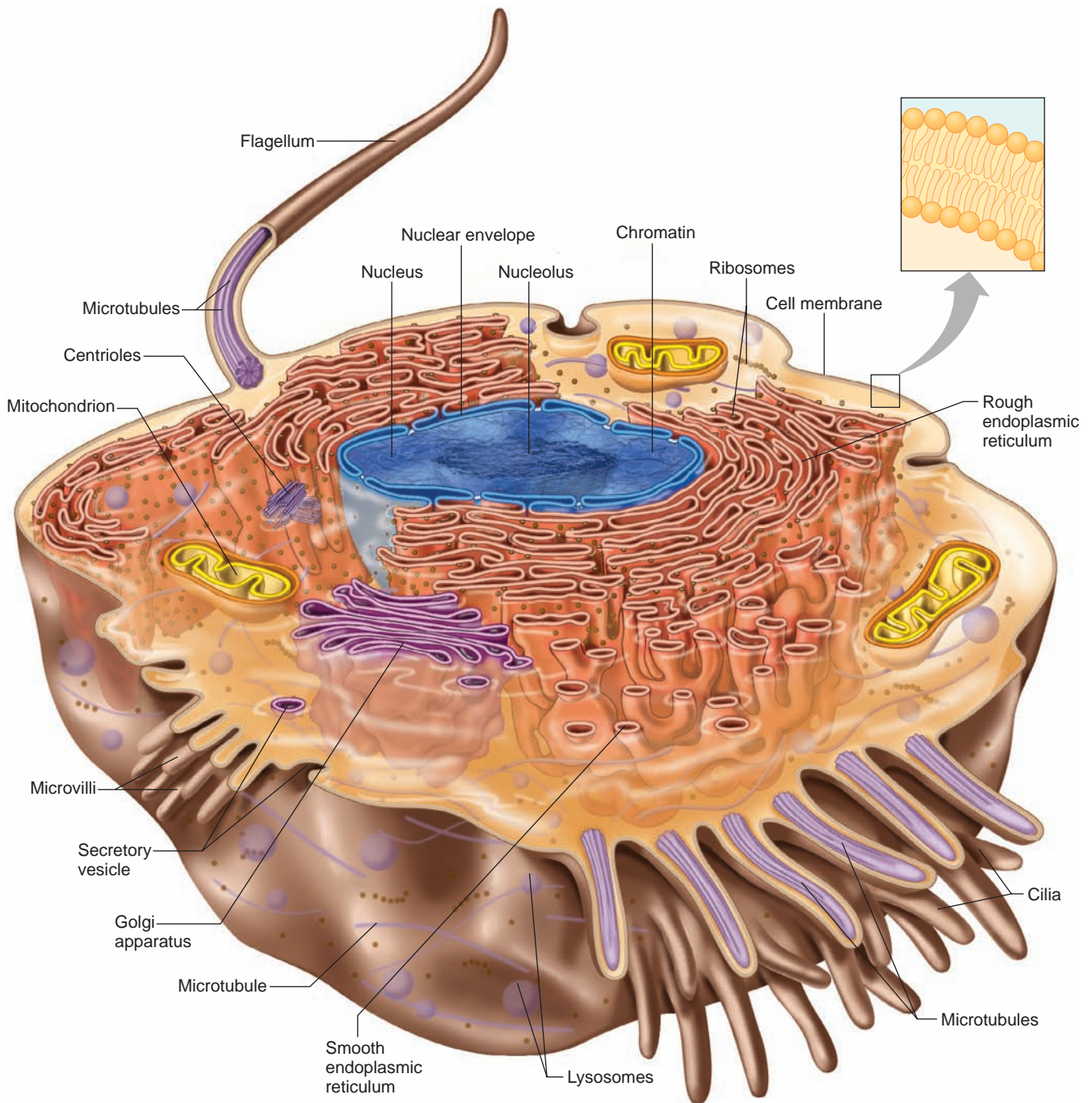


Figure 1-9. Composite cell.

Active Transport

In **active transport**, substances move across the cell membrane with the help of carrier molecules from an area of low concentration to an area of high concentration. In other words, substances are gathered together, which is the opposite of diffusion. Some substances that are moved across the cell membrane through active transport include sugars, amino acids, potassium, calcium, and hydrogen ions.

Cell Division

Cells can become damaged, diseased, or worn out, and replacements must be made. Also, new cells are needed for normal growth. Cells reproduce by cell division, a process that involves splitting the nucleus, through **mitosis** or **meiosis**, and splitting the cytoplasm, called **cytokinesis**.

A cell that carries out its normal daily functions and is not dividing is said to be in **interphase**. For example, if a

liver cell is in interphase, it is making liver enzymes, detoxifying blood, and processing nutrients. During interphase, a cell prepares for cell division by duplicating its DNA and cytoplasmic organelles. For most body cells, each daughter cell will have the exact same copy of DNA and organelles as the original mother cell. Sometimes when the DNA is duplicated, errors called **mutations** occur. These mutations will be passed on to the descendants (daughter cells) of that cell and may or may not affect the cells in harmful ways.

Mitosis

Following interphase, a cell may enter mitosis, a part of cell division in which the nucleus divides. When mitosis is almost complete, cytoplasmic division (cytokinesis) occurs. During this process, the cell membrane constricts to divide the cytoplasm of the cell. The result is that the organelles of the original cell get distributed almost evenly into the two new cells.

During mitosis, the nucleus makes a complete copy of all 23 of its chromosome pairs (46 chromosomes altogether). As the cell divides, each new cell receives a complete set of chromosome pairs. The resulting cells are identical to each other.

Meiosis

Reproductive cell division, or meiosis, takes place only in the reproductive organs when the male and female sex cells are formed. During meiosis, the nucleus copies all 23 chromosome pairs, but two divisions take place. The four cells that are formed each contain only one of each chromosome pair, for a total of 23 chromosomes. This type of cell division must occur so that when the sex cells combine during fertilization, the resulting cell contains the usual number of chromosomes (46).

Genetic Techniques

DNA is the primary component of genes and is found in the nucleus of most cells within the body. A segment of DNA that determines a body trait is called a **gene**. Genetic techniques involve using or manipulating genes.

DNA molecules are made up of a linear sequence of compounds called nucleotides, and each nucleotide contains one of four different nitrogen bases. The chemical structure of every person's DNA is the same. The only difference among people is the order of the nitrogen bases. The unique sequence of the nucleotides determines the characteristics of an individual. One DNA molecule will contain hundreds or thousands of genes. Each gene occupies a particular location on the DNA molecule, making it possible to compare the same gene in a number of different samples. Two widely used genetic techniques in the clinical setting are the polymerase chain reaction and DNA fingerprinting.

Polymerase Chain Reaction

The polymerase chain reaction, PCR, is a quick, easy method for making millions of copies of any fragment of DNA. This technique has been revolutionary in the study of genetics and has very quickly become a necessary tool for improving human health.

Because PCR can produce millions of gene copies from tiny amounts of DNA, even from just one cell, the method is especially useful for detecting disease-causing organisms that are impossible to culture, such as many kinds of bacteria, fungi, and viruses. It can, for example, detect the AIDS virus sooner—during the first few weeks after infection—than other tests. PCR is also more accurate than standard tests. The technique can detect bacterial DNA in children's middle ear fluid, which indicates an infection, even when culture methods fail to detect bacteria. Other diseases diagnosed through PCR include Lyme disease, stomach ulcers, viral meningitis, hepatitis, tuberculosis, and many sexually transmitted diseases, including herpes and chlamydia.

PCR is also leading to new kinds of genetic testing because it can easily distinguish among the tiny variations in DNA that all people possess. This testing can diagnose people who have inherited disorders or who carry mutations that could be passed to their children. PCR is also used in tests that determine who may develop common disorders such as heart disease and various types of cancer. This knowledge helps individuals take steps to prevent those diseases.

DNA Fingerprinting

A DNA “fingerprint” refers to the unique sequences of nucleotides in a person's DNA and is the same for every cell, tissue, and organ of that person. It cannot be altered by any known method. Consequently, DNA fingerprinting is a reliable method for identifying and distinguishing among human beings, such as in a criminal case.

DNA fingerprinting is also used to diagnose genetic disorders; it can be used to detect inherited disorders in unborn babies. These disorders include cystic fibrosis, hemophilia, Huntington's disease, familial Alzheimer's, sickle cell anemia, thalassemia, and many others. Detecting genetic diseases early allows patients and medical staff to prepare for proper treatment. Also, studying the DNA fingerprints of groups of individuals with the same disease allows researchers to identify DNA patterns associated with genetic diseases.

Another important use of DNA fingerprints is to establish paternity for custody and child support issues. The biological father has a DNA fingerprint that is very similar to the DNA fingerprint of his child. If the DNA fingerprints are not similar, the paternity test is negative.

Heredity

Heredity is the transfer of genetic traits from parent to child. When a sperm cell and an egg unite, a cell called a

zygote forms. The zygote has 46 chromosomes, or 23 chromosomal pairs. One half of each pair came from the sperm, and the other half from the egg. Two chromosomes in each pair are called **homologous chromosomes**. The chromosomes of the first 22 pairs are called **autosomes**, and those of the 23rd pair are called **sex chromosomes**. If the sex chromosomes are an X chromosome and a Y chromosome, the child is a male. If the sex chromosomes are both X chromosomes, the child is a female. Although the sex chromosomes determine the gender of the child, they also determine other body traits. However, the autosomes determine most body traits.

Each chromosome possesses many genes. Homologous chromosomes carry the same genes that code for a particular trait, but the genes may be of different forms, which are called **alleles**. Many times only one allele is actually expressed as a trait even if another allele is present. The allele that is always expressed over the other is called a dominant allele. The one that is not expressed is called recessive. The only way a recessive allele can be expressed is if there is no dominant allele present.

Detached earlobes are an example of a trait that is determined by a dominant allele. If a child inherits a dominant allele for this trait from one parent but inherits the recessive allele from the other parent, the child will have

detached earlobes. If the child inherits recessive alleles from both parents, then he will have attached earlobes.

Most traits in the body are determined by multiple alleles. For example, hair color, height, skin tone, eye color, and body build are each determined by many different genes. **Complex inheritance** is the term used to describe inherited traits that are determined by multiple genes. It explains why different children within the same family can each have different characteristics.

Sex-linked traits are carried on the sex chromosomes, X and Y. The Y chromosome is much smaller than the X chromosome and does not carry many genes. Therefore, if the X chromosome carries a recessive allele, it is likely to be expressed because there is usually no corresponding allele on the Y chromosome. For example, red-green color blindness is determined by the presence of a recessive allele that is always found on the X chromosome. This disorder (like most sex-linked disorders) primarily affects males because the corresponding Y chromosome does not have any allele to prevent the expression of the recessive allele.

Genetic influences are known to contribute to many thousands of different health conditions. See the Pathophysiology section for a description of some of the more common genetic disorders.

Pathophysiology

Common Genetic Disorders

Albinism is a condition in which a person is born with little or no pigmentation in the skin, eyes, or hair. Albinism affects all races, and in most cases there is no family history.

- **Causes.** At least six different genes are involved with pigment production. This condition develops when a person inherits one or more faulty genes that do not produce the usual amounts of a pigment.
- **Signs and symptoms.** People with the condition experience visual problems and sun-sensitive skin.
- **Treatment.** Although there is no cure, treatments are available to help the symptoms. Prenatal testing for the condition is available.

Attention deficit hyperactivity disorder (ADHD) is the most common behavioral disorder. It usually begins in childhood.

- **Causes.** Although ADHD is not normally considered a genetic disorder, there is evidence that genetic factors play a role in increasing the susceptibility to this condition. Twin and genetic studies show that several genes are likely to be involved.
- **Signs and symptoms.** People with this disorder have difficulty paying attention without being distracted and

find it difficult to control impulsive physical actions. Children with ADHD have normal intelligence but are more likely to be depressed and anxious as well as to have problems with speech and language. Hyperactivity usually improves when the child reaches puberty.

- **Treatment.** There is no cure for ADHD, but treatments such as the drug Ritalin or behavior modification are available.

Cleft lip and *cleft palate* are gaps or depressions in the upper lip or palate (roof of the mouth). These conditions commonly occur together.

- **Causes.** These conditions develop when separate areas of a developing fetus's face and head do not join together during early fetal development. Although genes may play a role in the development of these conditions, other causes include maternal rubella (German measles) or the use of certain medications during pregnancy.
- **Signs and symptoms.** Cleft lip or palate may lead to problems with feeding, recurrent ear infections, aspiration pneumonia, and speech problems later in life.
- **Treatment.** Surgery is usually very successful in repairing these conditions.

continued —>

Common Genetic Disorders (continued)

Cystic fibrosis is a life-threatening disease that mainly affects the lungs and pancreas. This disease is one of the most common inherited life-threatening disorders among white people in the United States.

- **Causes.** Inheritance is autosomal recessive, so if both parents are carriers, there is a 25% chance that each child born to them will develop cystic fibrosis.
- **Signs and symptoms.** Patients with this disorder have increasing problems with breathing. Thick secretions eventually block passageways in the air, and these secretions may become infected.
- **Treatment.** There is no cure, but treatments are available to help patients live with the complications associated with this disorder. Newborn babies are commonly screened for the disease because the sooner treatment begins, the healthier the child can be. Parents are also commonly screened for the gene to determine the likelihood of having a child with cystic fibrosis.

Down syndrome is a disorder that causes mental retardation and physical abnormalities.

- **Causes.** This disorder occurs when a person has three copies of chromosome 21 instead of two. This condition can be diagnosed through prenatal tests such as amniocentesis. The risk of having a child with Down syndrome increases with the age of the mother.
- **Signs and symptoms.** The signs of Down syndrome include a flat facial profile, protruding tongue, oblique slanting eyes, abundant neck skin, short broad hands, and poor muscle tone. Heart, digestive, hearing, and visual problems are also common in people with this condition. Learning difficulties are common in Down syndrome and can range from moderate to severe.
- **Treatment.** There is no cure, but support programs and the treatment of health problems allow many patients with Down syndrome to live a relatively normal life.

Fragile X syndrome is the most common inherited cause of learning disability. All races and ethnic groups seem to be affected equally by this syndrome.

- **Causes.** In this disorder, one of the genes on the X chromosome is defective and makes the chromosome susceptible to breakage. This sex-linked disorder affects boys more severely than girls. It is estimated that approximately 1 in 300 females are carriers for this disorder.
- **Signs and symptoms.** Mental impairment, learning disabilities, attention deficit disorder, a long face, large ears, and flat feet are some of the signs and symptoms. Fragile X syndrome can be easily diagnosed using prenatal tests such as amniocentesis.
- **Treatment.** There is no cure, but some treatments and support groups are available to patients with this disorder.

Hemophilia is a group of inheritable blood disorders. Each condition may be severe to mild.

- **Causes.** In each type, an essential clotting factor is low or missing. Most types of hemophilia are X-linked recessive disorders; therefore, this disorder primarily affects males. Carriers of the gene can be identified with a blood test, and prenatal tests can diagnose the condition in the fetus.
- **Signs and symptoms.** Symptoms include easy bruising, spontaneous bleeding, and prolonged bleeding. Repeated bleeding in the joints leads to arthritis and permanent joint damage.
- **Treatment.** Treatments include injections of the missing clotting factors.

Klinefelter's syndrome is a chromosomal abnormality that affects males.

- **Causes.** People with this disorder have an extra X chromosome.
- **Signs and symptoms.** Tall stature, pear-shaped fat distribution, small testes, sparse body hair, and infertility are the most common signs and symptoms. Thyroid problems, diabetes, and osteoporosis are also common in patients with this syndrome.
- **Treatment.** There is no cure, but treatments such as testosterone replacement therapy can decrease the risk of osteoporosis and produce more male characteristics.

Muscular dystrophy is a group of genetic disorders that primarily affect the muscular and nervous systems. It most often affects males.

- **Causes.** Most types involve mutations in the genes responsible for producing muscle proteins. Some types of muscular dystrophy are inherited as an X-linked disorder, but some are caused by gene mutations.
- **Signs and symptoms.** In this disorder, muscle cells gradually break down, causing progressive muscle weakness.
- **Treatment.** There is no cure, and few treatments are available to slow down the loss of muscle cells. Prenatal genetic tests are available for some types of muscular dystrophies.

Phenylketonuria (PKU) develops if a person cannot synthesize the enzyme that converts phenylalanine to tyrosine. Phenylalanine is an essential amino acid, but too much of it can be harmful, so the body regularly converts it to tyrosine.

- **Causes.** This condition is inherited as an autosomal recessive disorder.
- **Signs and symptoms.** If phenylalanine builds up in the blood, it can lead to the irreversible damage of organs, including the brain.

continued →

Common Genetic Disorders (continued)

- **Treatment.** Phenylalanine is found in many proteins, so meats and other protein-rich foods must be avoided. The early detection of PKU is important in order to prevent developmental delays. There is no cure for PKU, but special diets allow a person to lead a normal life. Most newborns are tested for PKU, and prenatal diagnosis is also available.

Sickle cell anemia is an inheritable genetic condition in which abnormal hemoglobin is produced in red blood cells. Normal hemoglobin carries most of the oxygen in the blood. Patients with sickle cell anemia produce an abnormal type of hemoglobin that cannot carry oxygen and that also causes red blood cells to become rigid and have a sickle shape. These rigid red blood cells are less able to squeeze through small blood vessels, so these blood vessels become blocked. It primarily affects people of African or Caribbean descent.

- **Causes.** This disease is inherited as an autosomal recessive disorder.
- **Signs and symptoms.** Blood vessels can become blocked in organs such as the liver, kidney, lungs, heart, and spleen and can cause severe pain. The red blood cells also break down easily, which leads to anemia.
- **Treatment.** There is no cure for sickle cell anemia, but treatments have been successful in preventing the complications associated with this disease. This condition can be diagnosed with prenatal tests.

Spina bifida occurs when one or more vertebrae do not form properly, leaving a gap in the spinal column and leading to damage of the spinal cord.

- **Causes.** This condition is thought to be caused by a combination of genetic and environmental factors.
- **Signs and symptoms.** Signs and symptoms will vary greatly, depending on the level of the gap in the spinal column. In the most severe forms, paralysis of many body muscles can result. Hydrocephalus (increased pressure in the fluid of the brain) often accompanies spina bifida, which can lead to brain damage. Prenatal tests can sometimes diagnose the condition. Folic acid supplements are believed to reduce the risk of the development of this disorder.
- **Treatment.** The treatment primarily consists of physical therapy, which helps to keep muscles strong.

Turner's syndrome is a disorder that almost exclusively affects females.

- **Causes.** This disease results when an X chromosome is completely or partially missing.
- **Signs and symptoms.** The signs and symptoms may include web neck, broad chest, widely spaced nipples, low hairline, short stature, and infertility. Prenatal tests can diagnose the condition, but most girls are diagnosed in late childhood when they fail to start menstruating.
- **Treatment.** There is no cure for Turner's syndrome, but treatments with growth hormone replacements can increase the height of the patient.

Major Tissue Types

As you learned earlier in the chapter, tissues are groups of cells that have similar structures and functions. The four major tissue types in the body are **epithelial**, **connective**, **muscle**, and **nervous**.

Epithelial Tissue

When you think of epithelial tissue, you should think of a covering, lining, or gland. Epithelial tissue covers the body and most organs. Epithelial tissue lines tubes of the body such as blood vessels and the esophagus as well as hollow organs of the body such as the stomach and heart. This type of tissue also lines body cavities (such as the thoracic cavity and the abdominopelvic cavity). Glandular tissue is also classified as a type of epithelial tissue.

Glandular epithelium is composed of cells that make and secrete (give off) substances. If a gland secretes its product into a duct, it is called an **exocrine gland**. If a gland secretes its product directly into tissue fluids or blood, it is called an **endocrine gland**. Endocrine glands do not have ducts, so they have to secrete their products into surrounding tissue fluids or blood.

Epithelial tissues are avascular, which means that they lack blood vessels. However, these tissues have a nerve supply and are very mitotic—they divide constantly. In addition, the cells within epithelial tissues are packed together tightly. Epithelial tissues possess many functions, depending on their location in the body. For example, those covering the body provide protection against invading pathogens and toxins. Those that line the digestive tract secrete a variety of enzymes needed for digestion and often possess microvilli, which allow the body to absorb nutrients. Epithelial tissues lining the respiratory tract have cilia and goblet cells. The goblet cells produce mucus that traps small particles that enter the respiratory tract. The cilia constantly push the mucus and trapped particles away from the lungs (Figure 1-10). Epithelial cells within the kidneys act as filters that help to remove waste products from blood.

Connective Tissue

Connective tissues are the most abundant tissues in the body. The cells of connective tissues do not pack together tightly. Instead, a **matrix** separates the cells. Think of the matrix simply as the matter that is between the cells of

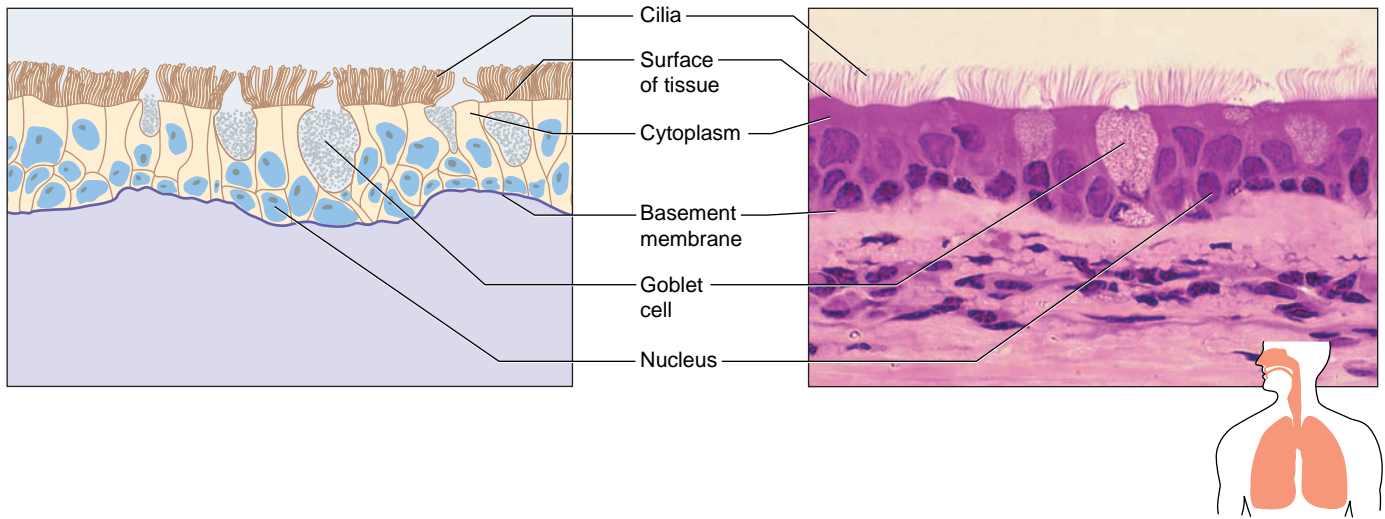


Figure 1-10. Epithelial tissue lining the respiratory tract.

connective tissue. It contains fibers, water, proteins, inorganic salts, and other substances. The components of the matrix vary, depending on the type of connective tissue. Connective tissues generally have a rich blood supply, except for cartilage and some dense connective tissues that contain a very poor blood supply.

There are many different cell types located in connective tissues. The most common cell types are fibroblasts, mast cells, and macrophages. Fibroblasts make fibers, and mast cells secrete substances such as heparin and histamine that promote inflammation during times of tissue damage. Macrophages are cells that destroy unwanted material such as bacteria or toxins.

Blood. This tissue is composed of red blood cells, white blood cells, and plasma. Plasma is the matrix of blood. Unlike other connective tissues, this matrix does not contain

fibers. Blood functions to transport substances throughout the body.

Osseous (Bone) Tissue. The matrix of osseous tissue contains mineral salts that make it a very hard tissue. Contrary to popular belief, bone tissue is metabolically active.

Cartilage. The matrix of cartilage is rigid, although it is not as hard as osseous tissue. Cartilage gives shape to structures such as the ears and nose. It also protects the ends of long bones and forms the discs between the vertebrae of the neck and spine.

Dense Connective Tissue. The matrix of dense connective tissue is packed with tough fibers that make it a soft but very strong tissue. Ligaments, tendons, and joint capsules have large amounts of this tissue type. Ligaments

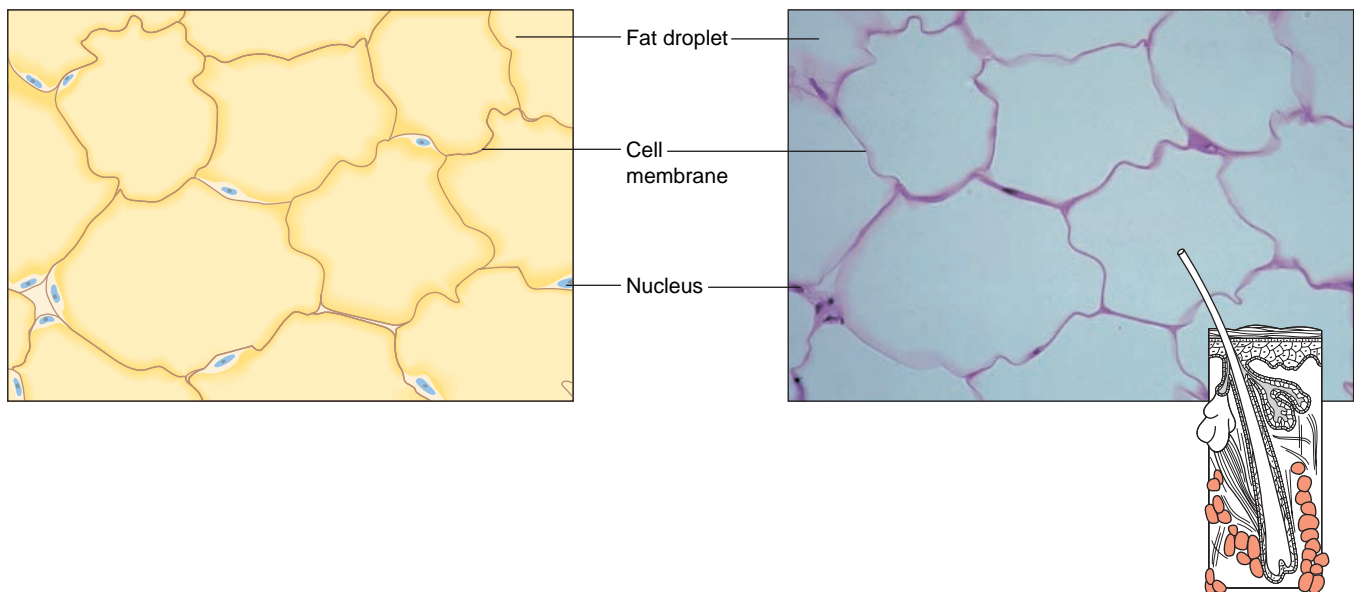


Figure 1-11. Adipose tissue.

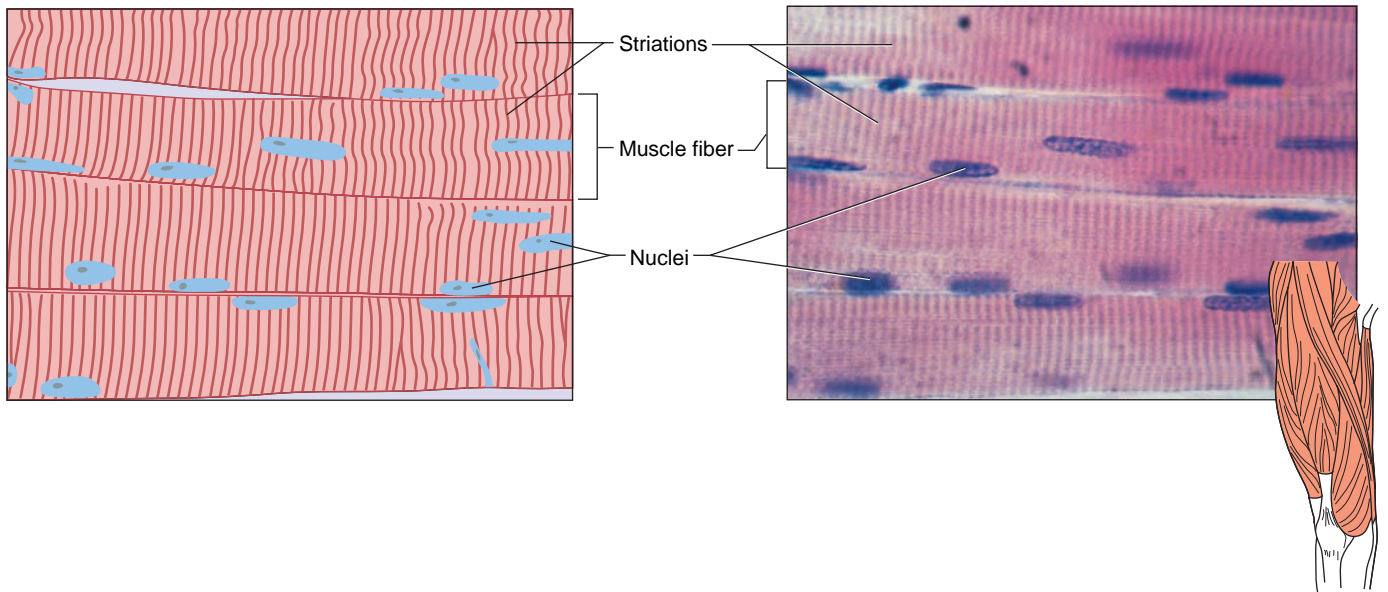


Figure 1-12. Skeletal muscle tissue.

connect bones to bones, tendons connect bones to muscles, and joint capsules surround moveable joints in the body. Dense connective tissues also make up a large part of the dermis of skin. When skin is damaged, this tissue “fills” in the space of damage and forms a scar.

Adipose (Fat) Tissue. Within adipose tissue, unique cells—adipocytes—store fats. The functions of this tissue type include storing energy for cells of the body, cushioning body parts and organs, and insulating the body against excessive heat or cold (Figure 1-11).

Muscle Tissue

Muscle tissue is a specialized type of tissue that shortens and elongates; in other words, it contracts and relaxes. The

three types of muscle tissue are skeletal, smooth, and cardiac. Skeletal muscle tissue, as its name suggests, is attached to the skeleton. This type of muscle tissue is described as voluntary because we can consciously control its movement. For example, we can consciously decide to contract the skeletal muscles attached to our arm bones and make them move. It is also referred to as being striated because the cells of this muscle tissue type have striations or stripes in their cytoplasm (Figure 1-12).

Smooth muscle tissue is located in the walls of hollow organs (except the heart), the walls of blood vessels, and the dermis of skin. It is not voluntary because we cannot consciously control its movement. For example, you do not consciously decide when the smooth muscle of your stomach contracts. This tissue is called smooth because its cells do not possess striations in their cytoplasm.

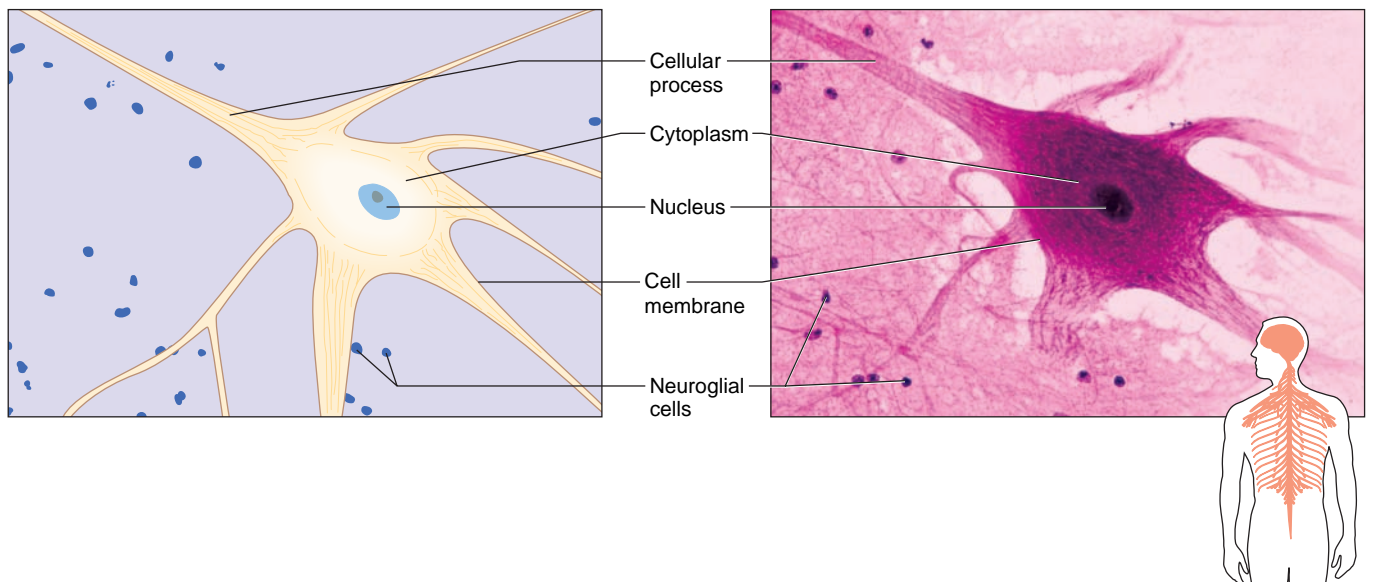


Figure 1-13. Nervous tissue.

Cardiac muscle tissue is located in the wall of the heart. Like skeletal muscle tissue, it is striated and like smooth muscle tissue, it is not under voluntary control.

Nervous Tissue

Nervous tissue is located in the brain, spinal cord, and peripheral nerves. This tissue specializes in sending impulses or electrical messages to the neurons, muscles, and glands in the body. Nervous tissue contains two types of cells: **neurons** and **neuroglial cells**. Neurons are the largest cells and possess characteristic cellular processes. Although neuroglial cells are smaller, they are more abundant and support neurons (Figure 1-13).

Summary

The human body is divided into several levels of organization, from the simplest to the most complex. These levels are chemical, cellular, tissue, organ, organ system, and organism. Anatomy is the study of the structure of the human body. Physiology is the study of its functions. Directional terms are used to describe the location of body parts and regions. These terms always relate to the anatomic position. It is important to understand the basics of the organization of the human body before studying the individual systems.

REVIEW

CHAPTER 1

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. On what side of the body is the appendix normally located?
2. If the medical assistant observes the boy's right lower abdominal quadrant for the bandage, is this correct? Why or why not?
3. Where should the bandage be found?
4. What precautions should this patient take given his diagnosis of *situs inversus*?

Discussion Questions

1. Explain the function of the four types of tissues in one of the body systems.
2. Describe the four abdominal quadrants and the nine abdominal regions. What is the importance of knowing these areas in the clinical setting?
3. What are acids and bases? Describe the pH scale.

Critical Thinking Questions

1. Diseases develop when homeostasis is not maintained. What treatments can bring the following conditions back to normal: high body temperature, dehydration, and high blood pressure?
2. What clinical laboratory tests have you encountered that require a knowledge of chemistry to interpret?
3. Moveable joints like elbows and knees always contain cartilage and dense connective tissues. Why are they so slow to heal once they have been injured?

Application Activities

1. Referring to figures in the chapter, name an organ or part of the body that is located:
 - a. Distal to the elbow
 - b. Proximal to the ankle
 - c. In the thoracic cavity
 - d. In the pelvic cavity
 - e. Medial to the acromial region
2. What organs would you expect to see if you were looking at a transverse plane cut at the level of the umbilicus?

Internet Activity

1. Go to the Web site for the Centers for Disease Control and Prevention (<http://www.cdc.gov>) and answer the following questions:
 - a. What are the Centers for Disease Control and Prevention?
 - b. Click on Health Topics A-Z, and then click on Spina Bifida. How are spina bifida and folic acid related?
 - c. Each year in the United States, about how many infants are born with spina bifida or anencephaly?
 - d. What are the annual medical care and surgical costs for persons with spina bifida in the United States?
2. Find an interactive periodic table of elements, and answer the following questions:
 - a. Carbon, hydrogen, oxygen, and nitrogen are the four most abundant elements of the human body. What are the atomic symbols for each of these elements?
 - b. Who discovered hydrogen?
 - c. What is the origin of the name of oxygen?
 - d. When was nitrogen discovered?
 - e. How many protons does one carbon atom contain?

CHAPTER 2

The Integumentary System

KEY TERMS

alopecia
apocrine
arrector pili
cellulitis
cyanosis
dermatitis
dermis
eccrine
eczema
epidermis
follicle
folliculitis
hemoglobin
herpes simplex
herpes zoster
hypodermis
impetigo
keratin
keratinocyte
lunula
melanin
melanocyte
nail bed
psoriasis
rosacea
scabies
sebaceous
sebum
stratum basale
stratum corneum
subcutaneous
warts

CHAPTER OUTLINE

- Functions of the Integumentary System
- Skin Structure
- Skin Color
- Accessory Organs
- Skin Healing

OBJECTIVES

After completing Chapter 2, you will be able to:

- 2.1 List the functions of skin.
- 2.2 Explain the role of skin in regulating body temperature.
- 2.3 Describe the layers of skin and the characteristics of each layer.
- 2.4 Explain the factors that affect skin color.
- 2.5 List the accessory organs of skin and describe their structures and functions.
- 2.6 Describe the appearance, causes, and treatments of various types of skin cancer.
- 2.7 Describe the appearance, causes, and treatment of common skin disorders.
- 2.8 Explain the ABCD rule and its use in evaluating melanoma.
- 2.9 List the different types of burns and describe their appearances and treatments.
- 2.10 Describe the signs, symptoms, causes, and treatments of other skin disorders and diseases.

Introduction

The integumentary system consists of skin and its accessory organs. The accessory organs of skin are hair follicles, nails, and skin glands. Skin is the body's outer covering and its largest organ.

CASE STUDY

Last New Year's Eve, a 23-year-old man came to the urgent care facility where you work as a medical assistant. He had been in an accident involving fireworks and was diagnosed with second-degree burns to his anterior torso.

As you read this chapter, consider the following questions:

1. Using the rule of nines, estimate the percentage of the patient's body surface that was affected by this burn.
2. What layers of skin has the burn affected?
3. What functions of the skin are lost by this injury?
4. What types of treatments does this burn require?

Functions of the Integumentary System

People are often interested in the appearance of their skin but rarely consider its functions. The integumentary system serves many purposes, including these important functions:

- **Protection.** As long as skin is intact and not inflamed, it provides very good protection against the entry of bacteria and viruses. It also protects underlying structures from ultraviolet radiation and dehydration.
- **Body temperature regulation.** Skin plays a major role in regulating body temperature. When a person is hot, dermal blood vessels dilate, which is why a person's skin becomes pinkish. Because the dermal blood vessels are dilated, more blood than normal passes through the skin. This is beneficial because blood carries a lot of the heat in the body. When the blood gets close to the surface of the body (to skin), the heat can escape. Conversely, if a person is cold, the dermal blood vessels constrict, preventing the heat in blood from escaping.
- **Vitamin D production.** When exposed to sunlight, the skin produces a molecule that is turned into vitamin D. The body needs vitamin D for calcium absorption.
- **Sensation.** The skin is packed with sensory receptors that can detect touch, heat, cold, and pain.
- **Excretion.** Small amounts of waste products are lost through skin when a person perspires.

Skin Structure

The skin is a complex organ consisting of two layers, the **epidermis** and the **dermis**. Skin sits on a third layer called the **hypodermis**, also called the **subcutaneous** layer (Figure 2-1).

Epidermis

The epidermis is the most superficial layer of skin. It is made up of many layers of tightly packed cells. The epidermis can be divided into two layers, the stratum corneum and the stratum basale.

The **stratum corneum** is the most superficial layer of the epidermis. Most of the cells in this layer are dead and very flat. Because they have accumulated keratin, the cells in this layer stick together and form an impermeable layer for skin. Most bacteria, viruses, and water cannot penetrate the stratum corneum.

The **stratum basale** is the deepest layer of the epidermis. The cells in this layer are constantly dividing, and older cells are constantly pushed up toward the stratum corneum.

The most common cell type in the epidermis is the **keratinocyte**. This cell makes and accumulates the protein keratin. **Keratin** is a durable protein that makes the epidermis waterproof and resistant to bacteria and viruses. Another cell type of the epidermis is the **melanocyte**, which makes the pigment **melanin**. Melanin is deposited throughout the layers of the epidermis. This pigment traps ultraviolet (UV) radiation from sunlight and prevents the radiation from harming structures in the underlying layers of the skin.

Dermis

The dermis is the deep layer of skin and is the most complex layer. The dermis contains all the major tissue types, including epithelial tissue, connective tissues, muscle tissue, and nervous tissue. The dermis contains sweat glands, sebaceous (oil) glands, hair follicles, the arrector pili muscles, collagen fibers, elastic fibers, nerve fibers, and many blood vessels. The dermis binds the epidermis to the hypodermis.

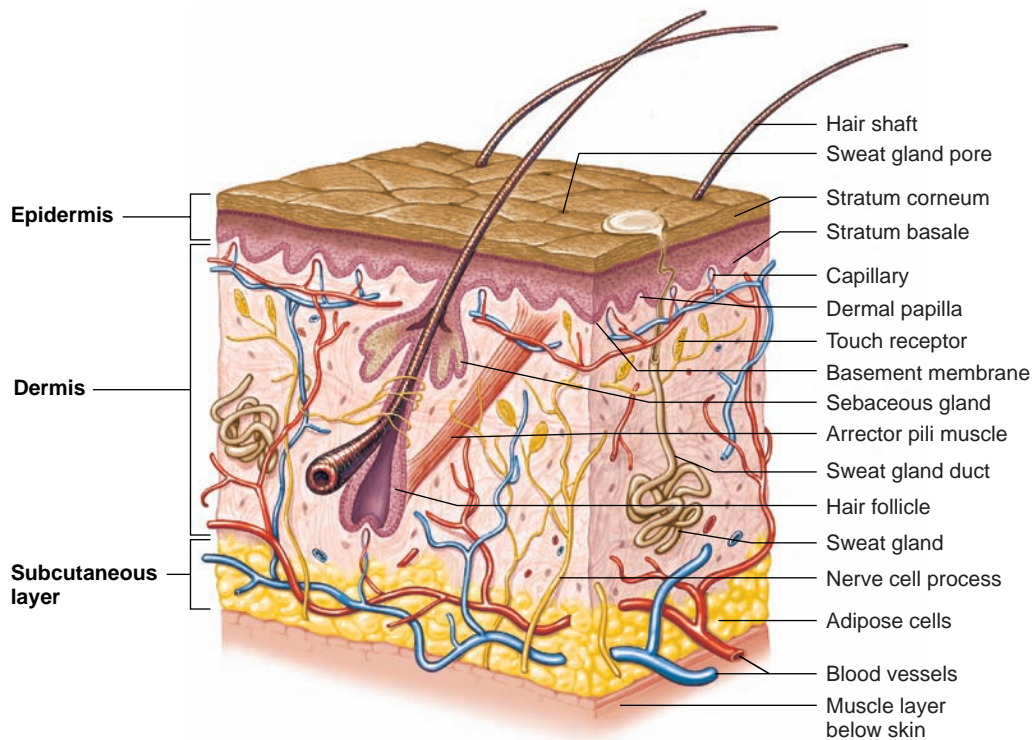


Figure 2-1. Section of skin.

Hypodermis

The subcutaneous layer of skin, the hypodermis, is largely made of adipose tissue. In fact, most adipose tissue in the body is found in your hypodermis. This layer also contains blood vessels and nerves.

Skin Color

Skin color is largely determined by the amount of melanin in the epidermis of skin. Melanin can range in color from yellowish to brownish. The more melanin a person has in

the skin, the darker the skin color. All people have about the same number of melanocytes regardless of skin color. What varies from person to person is how active the melanocytes are in producing melanin. A person with dark skin has very active melanocytes.

Another factor that determines skin color is the amount of oxygenated blood in the dermis of skin. **Hemoglobin** is a pigment in blood that is bright red when it is oxygenated. Hemoglobin that is not oxygenated is a dark red color. A person with a rich supply of oxygenated blood will have skin that is a pinkish hue. When the supply of oxygen in the blood is low, the skin looks rather pale or bluish. A bluish color of skin is called **cyanosis**.

Pathophysiology

Skin Cancer and Common Skin Disorders

Skin is vulnerable to many disorders because it is the most exposed of all body organs.

SKIN CANCER

Skin cancer develops from cells in the epidermis of skin. It is more common in people who have light-colored skin and who have had excessive exposure to sunlight. It can occur anywhere on the body but is most likely to appear

on skin that is readily exposed to sunlight. The two most common types of skin cancer are basal cell carcinoma and squamous cell carcinoma, but the most deadly type is melanoma (Figure 2-2).

Basal cell carcinoma accounts for approximately 90% of all skin cancers in the United States. Fortunately, it progresses slowly and rarely spreads to other body parts. It is derived from cells of the stratum basale of the epidermis.

continued →

Skin Cancer and Common Skin Disorders (continued)



Figure 2-2. Types of skin cancer: (a) squamous cell carcinoma, (b) basal cell carcinoma, and (c) malignant melanoma.

- **Signs and symptoms.** Signs and symptoms include changes on the skin and a new growth or sore on the skin that does not heal. Its appearance may be waxy, smooth, red, pale, flat, or lumpy, and it may or may not bleed.
- **Treatment.** Several forms of treatment are available:
 - Curettage and electrodesiccation. In curettage, a sharp instrument is used to scoop out the cancerous spot. Electrodesiccation uses electrical currents to minimize bleeding as well as to kill any remaining cancer cells.
 - Mohs' surgery. The cancerous spot is shaved off one layer at a time.
 - Cryosurgery. Freezing is used to kill cancer cells.
 - Laser Therapy. A beam of light destroys cancer cells.

Squamous cell carcinoma is much less common than basal cell carcinoma but is more likely to spread to surrounding tissues. It arises from flat cells of the epidermis. The signs and symptoms and the treatments for this type of cancer are the same as for basal cell carcinoma.

Melanoma is much more aggressive than both basal cell and squamous cell carcinomas. Melanoma can occur anywhere on the body but most often appears on the trunk, head, and neck in men and on the arms and legs in women. Melanoma is cancer that arises from melanocytes.

- **Signs and symptoms.** A mole that itches or bleeds is a common symptom. New moles may develop near it. It may change to have any sign of the ABCD rule:
 - Asymmetry. The mole should not become asymmetrical.
 - Border. The border of the mole should not become irregular.
 - Color. The mole should not change color or become a mixture of colors.
 - Diameter. The mole should not grow larger than the diameter of a pencil eraser.

- **Treatment.** The treatment will depend on the staging of this cancer. Available treatments include the following:
 - Surgery to remove the melanoma
 - Lymph node biopsy to determine if the cancer has spread
 - Removal of cancerous lymph nodes
 - Chemotherapy for advanced stages of cancer
 - Radiation therapy for advanced stages of cancer
 - Immunotherapy to boost the patient's immune system
- **Stages of melanoma.** Melanoma has five different stages, which are described from the least to the most serious:
 - Stage 0. Melanoma is found only in the epidermis
 - Stage I. Melanoma has spread to the epidermis and dermis and has a thickness of 1 to 2 millimeters.
 - Stage II. Melanoma has a thickness of 2 to 4 millimeters and may have ulceration.
 - Stage III. Melanoma has spread to one or more nearby lymph nodes.
 - Stage IV. Melanoma has spread to other body organs or other lymph nodes far away from the original melanoma site.

COMMON SKIN AND HAIR DISORDERS

Alopecia is a disorder that specifically targets hair. This disorder results in hair loss.

- **Causes.** Most of the time, alopecia is inherited. Other common causes include hormonal changes, chemotherapy, stress, burns, and fungal infections of the skin.
- **Signs and symptoms.** Alopecia is more commonly called baldness, but it may occur on areas of skin other than the scalp.

continued →

Skin Cancer and Common Skin Disorders (continued)

- **Treatment.** If due to heredity, this disorder is not curable. Hair transplants and some drugs may slow down hair loss. Hair loss caused by other factors is usually temporary.

Cellulitis is an inflammation of connective tissues in skin and primarily occurs on the face and legs.

- **Causes.** This skin disease is caused by staphylococcal and streptococcal bacteria.
- **Signs and symptoms.** Skin appears red and tight and is often painful. The inflammation may trigger a fever.
- **Treatment.** Treatment is with antibiotics.

Dermatitis is a general term defined as inflammation of skin or a rash. It has many causes and is a sign of many types of skin disorders.

Eczema is one type of chronic dermatitis. This condition most commonly occurs in infants but it may also occur in adults.

- **Causes.** Causes of eczema are mostly unknown, but it is thought to be a type of allergy. Environmental irritants, stress, and dry skin can bring about episodes of this disease.
- **Signs and symptoms.** The rashes of eczema are scaly and itchy.
- **Treatment.** Treatments include steroids and other types of anti-inflammatory drugs. Of course, avoiding factors that trigger eczema is also helpful.

Folliculitis, which is a disorder specific to hair, is an inflammation of hair follicles.

- **Causes.** This disorder usually results from shaving or excess rubbing of skin areas. It may also be caused by bacteria and fungi.
- **Signs and symptoms.** Follicles become red and itchy and often look like pimples.
- **Treatment.** Treatments include regular cleansing of skin, topical antibiotics, and use of electric razors instead of razor blades.

Herpes simplex types 1 and 2 are the most common types of herpes simplex.

- **Causes.** Herpes simplex types 1 and 2 are both caused by a virus. Herpes simplex type 1 is very contagious and is spread through saliva. Herpes simplex type 2 is sexually transmitted.
- **Signs and symptoms.** Herpes simplex type 1 causes painful sores on the lips, mouth, and face. Herpes simplex type 2 normally causes painful sores on genital areas.
- **Treatment.** There is no cure for herpes simplex, and its skin lesions usually recur throughout life. However, antiviral drugs prevent frequent outbreaks.

Herpes zoster is a disorder commonly known as shingles.

- **Causes.** Herpes zoster is caused by the same virus that causes chickenpox. After a person has chickenpox, the virus becomes inactive but can become active again later in life to cause shingles.
- **Signs and symptoms.** Herpes zoster causes inflammation that affects the nerves on one side of the body and results in very painful skin blisters.
- **Treatment.** Some antiviral medications shorten the duration of the disease, but normally it is treated only with pain medications. Recovery is usually complete, and reoccurrences of the disease are rare. It is uncertain whether the chickenpox vaccine prevents herpes zoster.

Impetigo causes the formation of oozing skin lesions that eventually crust over.

- **Causes.** This disease is caused by staphylococcal and streptococcal bacteria.
- **Signs and symptoms.** The skin develops oozing lesions that eventually crust over.
- **Treatment.** This condition is treated with antibiotics.

Psoriasis is a common skin problem.

- **Causes.** This skin disorder is most likely an inherited autoimmune disorder.
- **Signs and symptoms.** Patients with psoriasis have frequent episodes of itching and redness and have outbreaks of scaly skin lesions. Some people also have joint pain.
- **Treatment.** Mild cases are treated with anti-inflammatory drugs and special ointments. Severe cases require hospitalization.

Rosacea is a skin disorder that commonly appears as facial redness.

- **Causes.** Rosacea's causes are unknown, but it occurs most frequently in fair-skinned people.
- **Signs and symptoms.** Redness and acne-like symptoms on the face are the most common symptoms.
- **Treatment.** Although it is not curable, rosacea is usually managed well with various medications.

Scabies is a very contagious skin condition.

- **Causes.** Scabies is caused by mites that burrow beneath skin. Sometimes the burrows of the mites, which look like red pencil marks, can be seen.
- **Signs and symptoms.** Redness and severe itching are usually the only symptoms of scabies.
- **Treatment.** Most cases are easily treated with prescription medications. Because scabies is contagious, it is wise to treat an entire family if one member is infected.

continued →

Skin Cancer and Common Skin Disorders (continued)

Warts (verrucae) are harmless skin growths that can appear almost anywhere on the body surface but most commonly occur on the hands, feet, and face.

- **Causes.** These growths are caused by a virus.
- **Signs and symptoms.** Warts vary greatly in appearance; they can be smooth, flat, rough, raised, dark, small, or large.

- **Treatment.** Warts are often removed with over-the-counter medications but can also be treated through surgery, lasers, freezing, or burning.

Accessory Organs

The accessory organs of the skin include hair follicles, oil glands, nails, and sweat glands.

Hair Follicles

Hair **follicles** are tube-like depressions in the dermis of skin. Hair follicles are made of epithelial tissue and function to generate hairs (Figure 2-3). Cells called keratinocytes make up most of the hair follicle. As new keratinocytes are produced in the base of the hair follicles, old ones are pushed toward the surface of skin. The old keratinocytes stick together to produce a hair. The portion of the hair embedded in skin is called the root, and the portion of the hair extending from the surface of skin is called the shaft.

Melanocytes are also found in hair follicles. They produce and distribute pigments to create hair color. A person develops gray hair when these melanocytes produce less pigment than normal.

When a hair follicle goes into a resting cycle, the hair falls out. Most of the time, the hair follicle will begin

a growing cycle again and produce a new hair. However, sometimes hair follicles completely die, and baldness (alopecia) develops.

Arrector pili muscles are attached to most hair follicles. When a person is cold or nervous, these muscles pull on hair follicles and cause hairs to stand erect. These muscles also pull on fibers in the dermis of skin, causing goose bumps to form (see Figure 2-1).

Sebaceous Glands

Sebaceous glands are more commonly called oil glands. They produce an oily substance called **sebum**. Sebum is secreted onto hairs to keep them soft and pliable. Sebum eventually is deposited onto skin to keep it soft as well. Sebum also prevents bacteria from growing on skin (see Figures 2-1 and 2-3).

Nails

Nails function to protect the ends of the fingers and toes. The portion of a nail that you can see is the nail body, and the portion embedded in skin is called the nail root. The nail root contains active keratinocytes that constantly divide to produce nail growth. The white half-moon-shaped area at the base of a nail is called a **lunula**. The lunula also contains very active keratinocytes. Beneath each nail is a layer called the **nail bed**. The nail bed holds the nail down to underlying skin and provides nutrients to the nail (Figure 2-4).

Sweat Glands

Most sweat glands are located in the dermis of skin. However, their ducts open onto the epidermis of skin. There are two types of sweat glands—eccrine and apocrine.

Eccrine sweat glands are the most numerous type. They produce a watery type of sweat and are activated primarily by heat. Once sweat is deposited onto skin, it evaporates and carries heat away from the body. Eccrine sweat glands are most concentrated on the forehead, neck, and back.

Apocrine sweat glands produce a thicker type of sweat that contains more proteins than the type of sweat produced by eccrine sweat glands. Apocrine glands are most concentrated in areas of skin with coarse hair, such

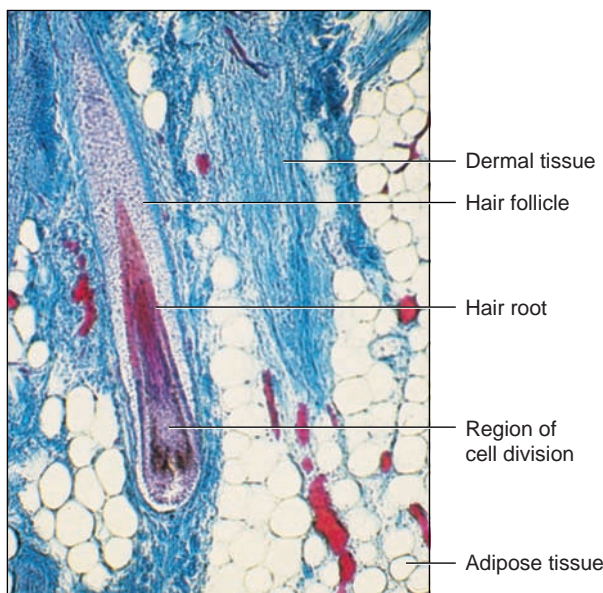


Figure 2-3. Hair follicle.

Educating the Patient

Preventing Acne

Acne is a clinical term used to describe pimples and blackheads. This skin condition occurs when excess oil and dead skin cells clog pores. Bacteria easily accumulate in the clogged pores, which results in pimples or whiteheads. Acne is not the result of poor hygiene or diet. If patients have acne, you can instruct them to follow these steps to help minimize it:

- Use skin-care products that are *noncomedogenic*, meaning that they will not clog pores

- Wash the face twice a day
- Keep hands away from the face
- Remove all makeup daily
- Use makeup or lotion that contains sunscreen
- Wash hair frequently because oils from hair can end up on the face

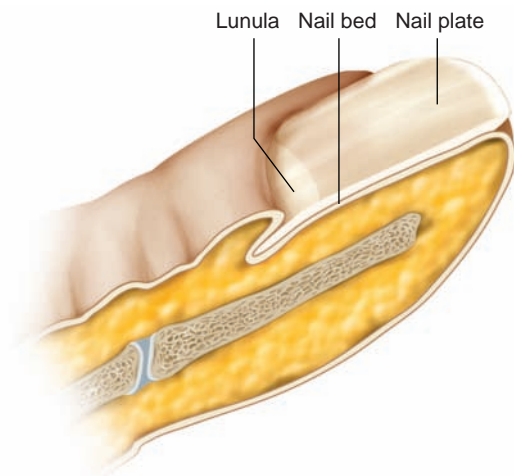


Figure 2-4. Section of a nail.

as the armpit and groin areas. They are primarily activated by nervousness or stress but can also be activated by heat. These are the glands responsible for producing a cold sweat. Bacteria often break down the proteins in the sweat produced by apocrine glands. As the proteins are digested,

the bacteria release a foul-smelling waste product that is responsible for the smell of body odor.

Skin Healing

When skin is injured, it becomes inflamed. An inflamed area looks red because nearby blood vessels dilate. The inflamed area also swells because the dilated blood vessels “leak” and fluids seep into spaces between cells. Inflamed areas are often painful because the excess fluid activates pain receptors. However, inflammation promotes healing because more blood is delivered to the area. The extra blood carries more nutrients needed for skin repair as well as defensive cells to clear up the cause of inflammation.

When structures and blood vessels of the dermis are injured, a blood clot initially forms. The blood clot is eventually replaced by a scab, which is basically clotted blood and other dried tissue fluids. The scab is normally replaced by collagen fibers that act to bind the edges of the wound together. Collagen fibers are whitish and the major component of scars. Sometimes skin scars are replaced with new skin, but if the wound is extensive, a scar will persist. Scars cannot carry out most functions of skin so their formation leads to the loss of certain functions.

Pathophysiology

Burns

The second leading cause of accidental death in the United States, after motor vehicle accidents, is burn injuries. There are more than 200 special burn care centers in the United States. More than 2 million burn injuries are reported each year, and more than 11,000 patients die annually from burn injuries. This year, about 1 million people

will suffer a burn injury that causes a significant or permanent disability.

The extent of the body surface area affected and the severity (degree) of a burn are the most important factors in predicting the risk of death associated with burn injuries. The rule of nines is a quick way to estimate the

continued →

Burns (continued)

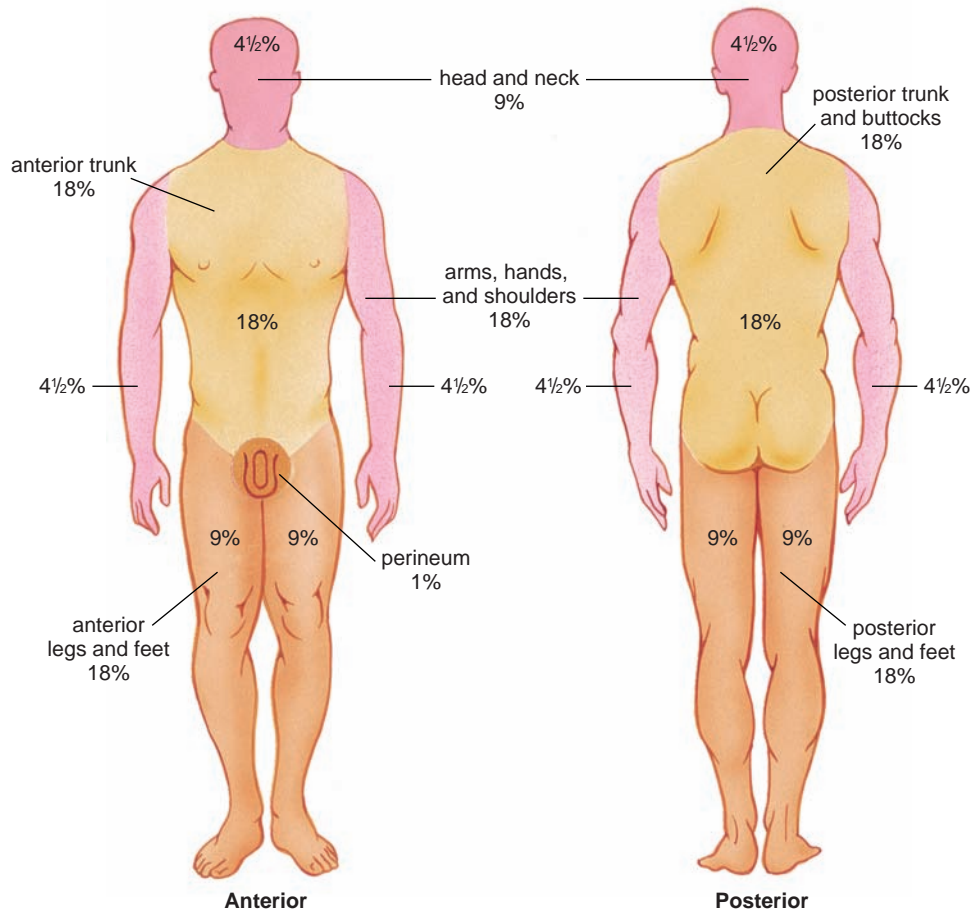


Figure 2-5. Using the rule of nines aids in estimating the extent of burns.

extent of body surface area affected by burns. This method divides the body into 11 areas, each accounting for 9% of the total body surface. The genital area accounts for 1% (Figure 2-5).

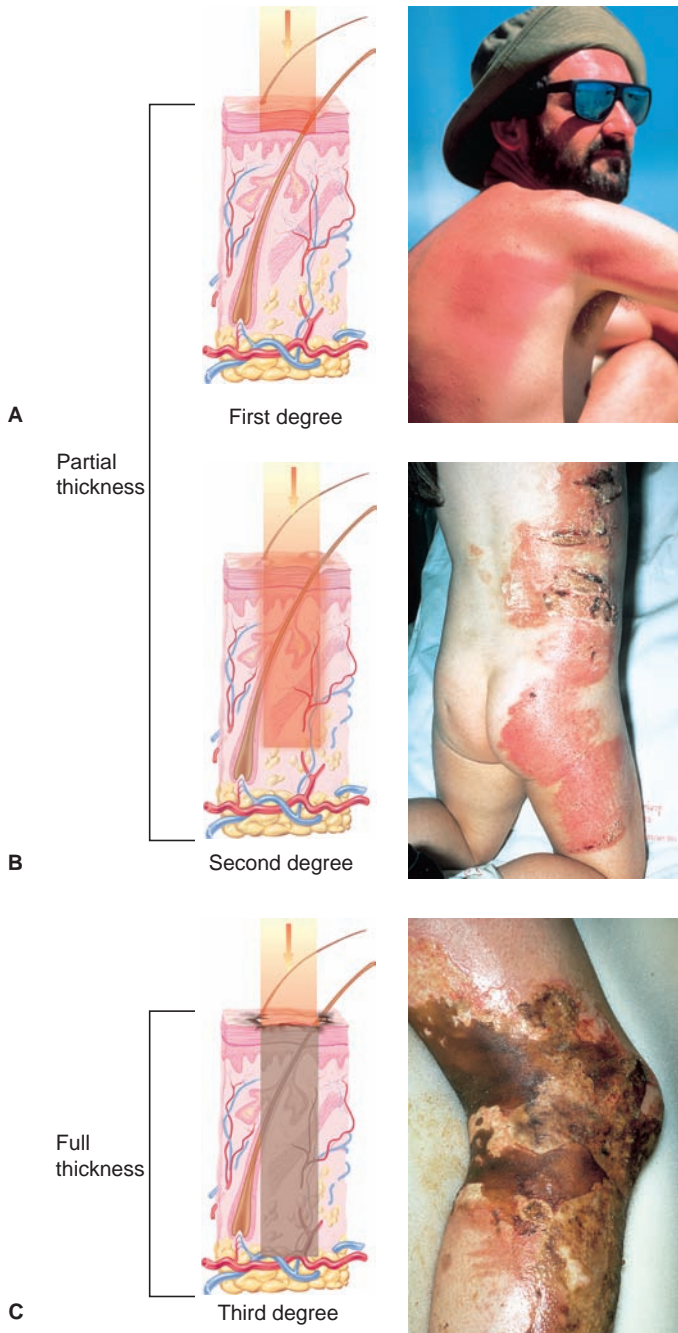
- Rule of nines. The 11 body areas of the rule of nines are identified as follows:
 - Head
 - Right arm
 - Left arm
 - Front of right leg
 - Front of left leg
 - Back of right leg
 - Back of left leg
 - Front of body trunk is two areas
 - Back of body trunk is two areas
- Burn severity. The severity of burns indicates the thickness of the injury (Figure 2-6). The following terms are used to report burn severity:
 - *First-degree*. These burns are also called superficial burns. They involve only the epidermis and are characterized by pain, redness, and swelling. Unless they are extensive, they do not require medical attention and usually heal well.

- *Second-degree*. These burns are also called partial-thickness burns and involve the epidermis and dermis. Pain, redness, swelling, and blisters characterize them. Medical staff should treat any second-degree burn that affects 1% or more of the body surface. A body surface area of 1% is about the size of a person's hand. Shock is likely to develop in second-degree burn injuries that affect 9% or more of the body surface. Second-degree burns can be life-threatening, depending on their extent.
- *Third-degree*. These burns are also called full-thickness burns. They involve all layers of skin and often underlying structures such as muscles and bones. The skin often looks black or charred in these burns. They always require medical attention regardless of the extent. A full-thickness burn of any size should always be medically treated.

- General Guidelines for Treating Burns
 - Anything sticking to the burn should not be removed.
 - Butter, lotions, or ointments should not be applied to the burn. Only ointments prescribed by a doctor or recommended by a pharmacist should be used.

continued →

Burns (continued)



- The burn should be cooled with large amounts of cold water.
- The burn should be covered with a sterile sheet or plastic bag. Burns to the face, however, should not be covered.
- Emergency medical personnel should be contacted for serious burns.
- In burns to the mouth and throat, the airways should be checked to see if there is any swelling. Burns to the head are always more serious than burns to other body parts. They almost always require emergency medical treatment.

Figure 2-6. The degrees of burn severity include (a) first-degree (superficial burns), (b) second-degree (partial-thickness burns), and (c) third-degree (full-thickness burns).

Summary

The integumentary system is the first line of defense for the body. The skin covers the surface of the body, protecting it from invading organisms, chemicals, UV light, and water loss. Hair and nails also serve as protective barriers.

In addition, the skin helps regulate body temperature. This system plays an important role in diagnostic testing, including allergy testing and tuberculosis screening. Understanding this system can help you be more effective in your role as a medical assistant.

REVIEW

CHAPTER 2

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. Using the rule of nines, estimate the percentage of the patient's body surface that was affected by this burn.
2. What layers of skin has the burn affected?
3. What functions of the skin are lost by this injury?
4. What types of treatments does this burn require?

Discussion Questions

1. Describe the factors that determine skin color.
2. Name the two layers of the epidermis and tell how they differ.
3. Name two types of sweat glands. Where is each located, and how do their secretions differ?

Critical Thinking Questions

1. Why do anti-inflammatory drugs reduce pain? Are these drugs likely to prevent healing or promote healing?

2. Which is more serious, a cat born without arrector pili muscles or a human? Why?
3. Albinos lack melanin. What body structures are affected by this? What precautions must an albino take that non-albinos do not have to worry about?

Application Activities

1. Describe the functions of the following cell types of the epidermis:
 - a. Keratinocyte
 - b. Melanocyte
2. Describe the role of skin in the following functions:
 - a. Protection
 - b. Sensation
 - c. Body temperature regulation
 - d. Excretion
 - e. Vitamin D production
3. Describe the following parts of a nail:
 - a. Nail root
 - b. Lunula
 - c. Nail bed
 - d. Nail body

CHAPTER 3

The Skeletal System

KEY TERMS

appendicular
articular cartilage
atlas
axial
axis
bursitis
calcaneus
canaliculi
carpal
carpal tunnel syndrome
clavicle
coccyx
condyle
costal
coxal
diaphysis
ear ossicle
endochondral
endosteum
epiphyseal disk
epiphysis
ethmoid
femur
fibula
fontanel
foramen magnum
gout
humerus
hyoid
ilium
intramembranous
ischium
lacunae
lamella
ligament
mandible
marrow
mastoid process

CHAPTER OUTLINE

- Bone Structure
- Functions of Bones
- Bone Growth
- The Skull
- The Spinal Column
- The Rib Cage
- Bones of the Shoulders, Arms, and Hands
- Bones of the Hips, Legs, and Feet
- Bone Fractures
- Joints

OBJECTIVES

After completing Chapter 3, you will be able to:

- 3.1 Describe the parts of a long bone.
- 3.2 List the substances that make up bone tissue.
- 3.3 List the functions of bones.
- 3.4 Describe how long bones grow.
- 3.5 List the bones of the skull, spinal column, rib cage, shoulders, arms, hands, hips, legs, and feet. Describe the location of each bone.
- 3.6 Define fontanels and explain their importance.
- 3.7 List different types of bone fractures and describe their characteristics.
- 3.8 Explain how fractures heal.
- 3.9 Describe the three major types of joints and give examples of each.
- 3.10 Describe the structure of a synovial joint.
- 3.11 Describe the characteristics, causes, and treatments of various diseases and disorders of the skeleton.

KEY TERMS (Continued)

maxillae	osteosarcoma	scoliosis
medullary cavity	palatine	sella turcica
metacarpal	parietal	sphenoid
metatarsal	patella	sternum
nasal	pectoral girdle	suture
occipital	pelvic girdle	synovial
ossification	periosteum	tarsal
osteoblast	phalanges	temporal
osteoclast	pubis	tibia
osteocyte	radius	ulna
osteon	sacrum	vomer
osteoporosis	scapula	zygomatic

Introduction

Bones provide the body with structure and support. In this chapter you will learn about the bones of the body, their structure, and how the joints of the body work. The skeletal system is composed of 206 bones as well as joints and related connective tissues. The skeleton has two major divisions—the **axial** skeleton and the **appendicular** skeleton. The axial skeleton contains 80 bones. It includes the bones of the skull, vertebral column, and rib cage. It

functions to support the head, neck, and trunk and protects the brain, spinal cord, and the organs in the thorax. The **hyoid** bone, which anchors the tongue, is also included in the axial skeleton. The appendicular skeleton includes the bones of the arms, the legs, the **pectoral girdle** and the **pelvic girdle**. The pectoral girdle attaches the arms to the axial skeleton, and the pelvic girdle attaches the legs to the axial skeleton (Figure 3-1).

CASE STUDY

Yesterday afternoon, an 11-year-old boy came to the orthopedic clinic with a closed fracture at the distal end of his left radius (Colles fracture). His chart also notes that the distal epiphyseal plate was damaged as a result of the break.

As you read this chapter, consider the following questions:

1. Where is the distal end of the left radius?
2. Will this patient need surgery?
3. Have other tissues been damaged besides bone?
4. Why is the damage to the epiphyseal plate of special concern?

Bone Structure

Bones contain various kinds of tissues, including osseous tissue, blood vessels, and nerves. Osseous tissue can appear compact or spongy (Figure 3-2). At the microscopic level, spongy bone has more spaces within it than compact bone does. These spaces are filled with red marrow. Compact bone looks solid; however, the following structures can be observed with a microscope (Figure 3-3):

- **Osteons.** Osteons are elongated cylinders that run up and down the long axis of the bone. Each osteon has a central canal that contains blood vessels and nerves.
- **Bone matrix.** The matrix is the substance between bone cells. Bone cells are called **osteocytes**. The components of the matrix are inorganic salts, collagen fibers, and proteins. The primary salt of the matrix is calcium phosphate. This salt makes the matrix of bone very hard.
- **Lamella.** Lamella are layers of bone surrounding the canals of osteons.
- **Lacunae.** Lacunae are holes in the matrix of bone that hold osteocytes.
- **Canaliculi.** These tiny canals connect lacunae to each other. They allow osteocytes to spread nutrients to each other.

All bones are made up of both compact and spongy bone. They are classified according to their shape:

- **Long bones.** Long bones are located primarily in the arms and legs. Examples include the **femur** (thigh bone) and the **humerus** (upper arm bone). Long bones have the following parts (Figure 3-4):
 - **Diaphysis**—the shaft of a long bone. It is tubular and consists of a thick collar of compact bone that surrounds a central medullary cavity.
 - **Epiphysis**—the expanded end of a long bone. It consists of a thin layer of compact bone surrounding spongy bone. Long bones have an epiphysis at both ends.
 - **Articular cartilage**—the cartilage that covers the epiphyses of long bones. It functions to cushion bones and to absorb stress during bone movements.
 - **Medullary cavity**—a canal that runs through the center of the diaphysis. In adults it contains yellow bone **marrow**, which is mostly fat.
 - **Periosteum**—a membrane that surrounds the diaphysis. It contains bone-forming cells, dense fibrous connective tissue, nerves, and blood vessels.
 - **Endosteum**—a membrane that lines the medullary cavity and the holes of spongy bone. It contains bone-forming cells.

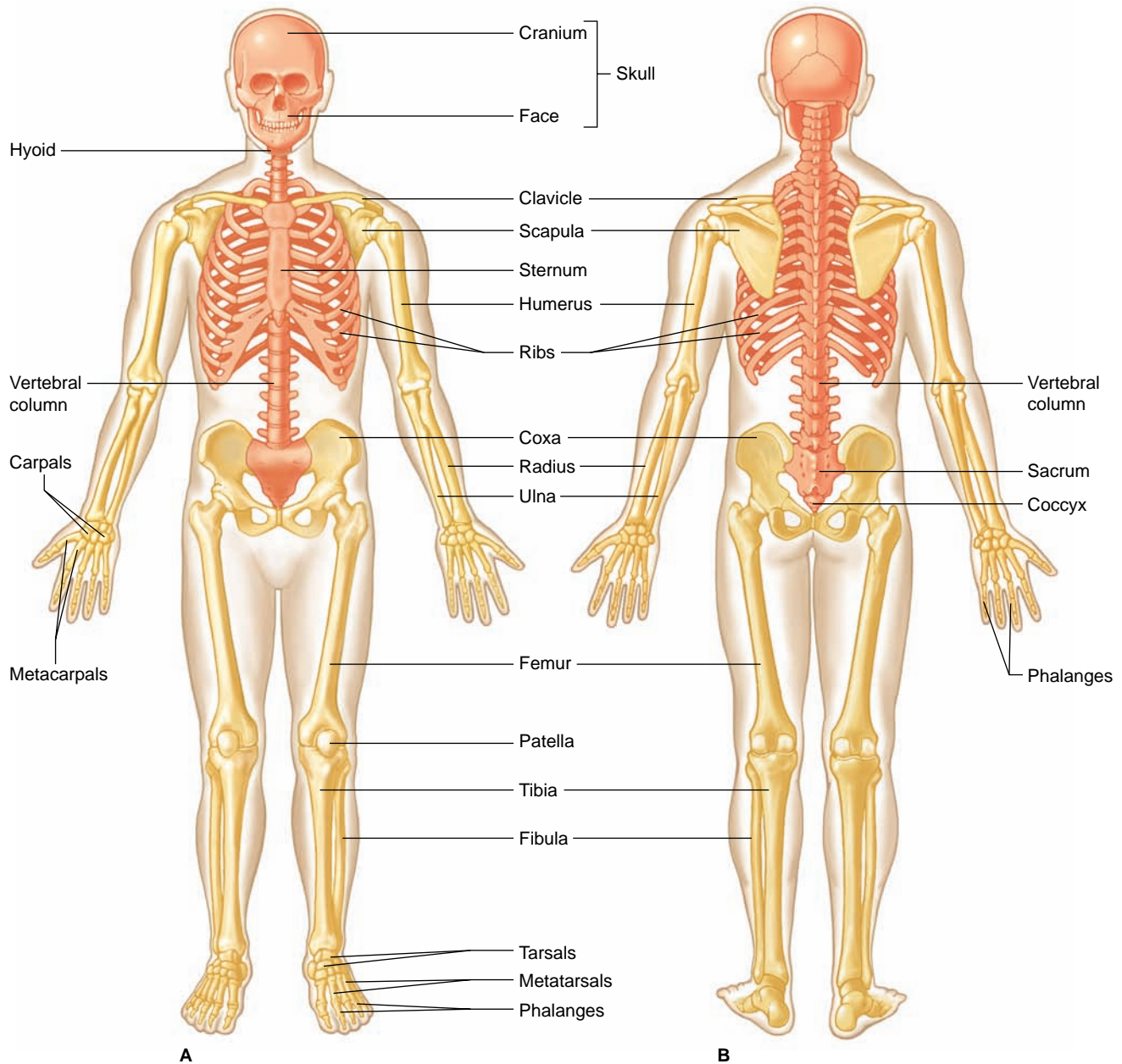


Figure 3-1. Major bones of the skeleton: (a) anterior view and (b) posterior view. The axial skeleton is shown in orange and the appendicular skeleton is shown in yellow.

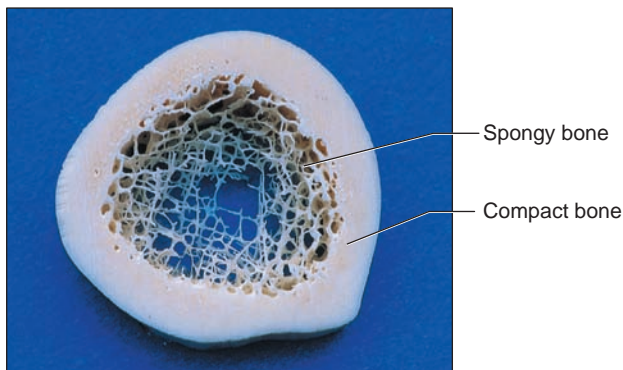


Figure 3-2. Cross section of bone showing compact and spongy bone tissue.

- Short bones. The small bones are located in the wrists and ankles. Examples include the **carpals** (wrist bones) and some of the **tarsals** (ankle bones).
- Flat bones. Flat bones are primarily located in the skull and rib cage. Examples include the ribs and frontal bone.
- Irregular bones. Irregular bones include the vertebrae and the bones of the pelvic girdle.

Functions of Bones

Bones have many functions. They give shape to body parts such as the head, legs, arms, and trunk. Bones also support and protect soft structures in the body. For

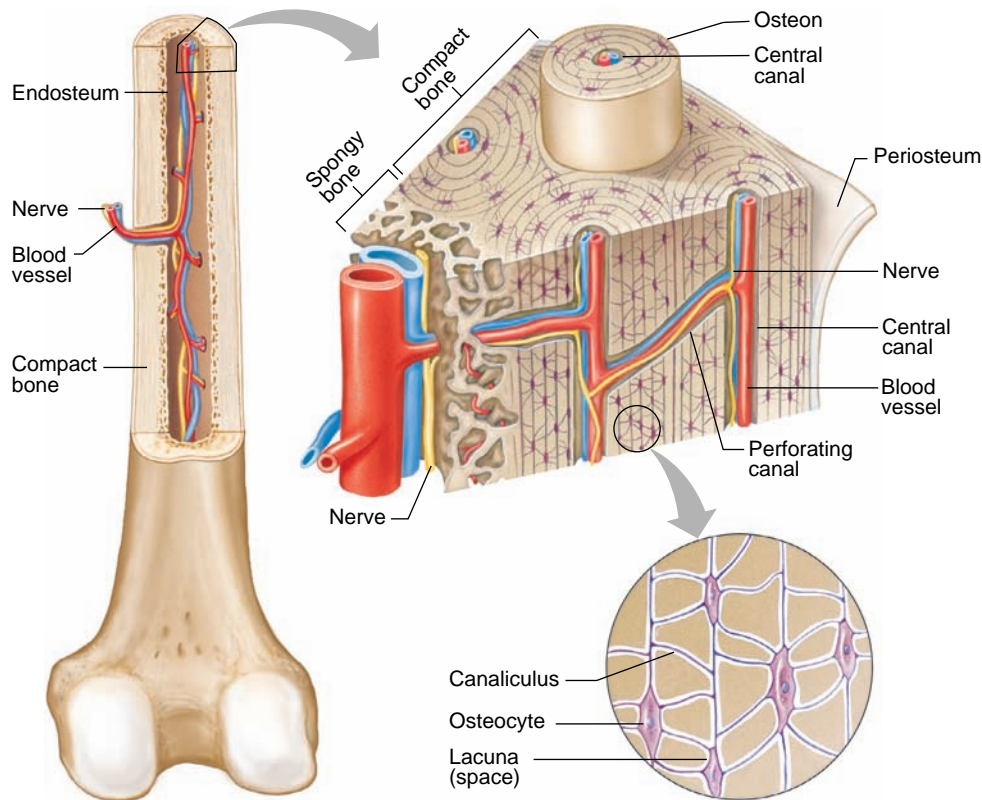


Figure 3-3. Compact bone at the microscopic level.

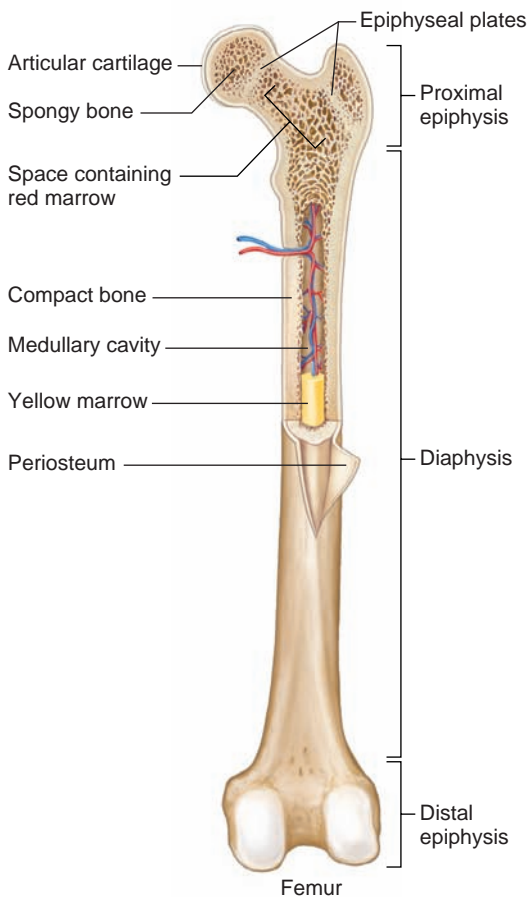


Figure 3-4. Parts of a long bone.

example, the skull protects the brain. Bones also function in body movement because skeletal muscles attach to them.

The red marrow of bone produces new blood cells. Red bone marrow is normally found in spaces of spongy bone. Bones also store calcium for the body. Every cell in the body needs calcium, so the body must have a large supply readily available.

Bone Growth

Bones grow through a process called **ossification**. Two types of ossification are intramembranous and endochondral.

In **intramembranous** ossification, bones begin as tough, fibrous membranes. Eventually, bone-forming cells called **osteoblasts** turn the membrane to bone. Intramembranous bones are found in the skull, except for the lower jawbone.

In **endochondral** ossification, bones start out as cartilage models. Eventually, the osteoblasts form a bone collar around the diaphysis of the cartilage model. Then bone is formed in the diaphysis of the bone. This area is called the primary ossification center. Later, the epiphyses turn to bone (secondary ossification centers), and the medullary cavity and spaces in spongy bone are formed. The cells that form holes in bone are called **osteoclasts**. As long as a bone contains some cartilage between an

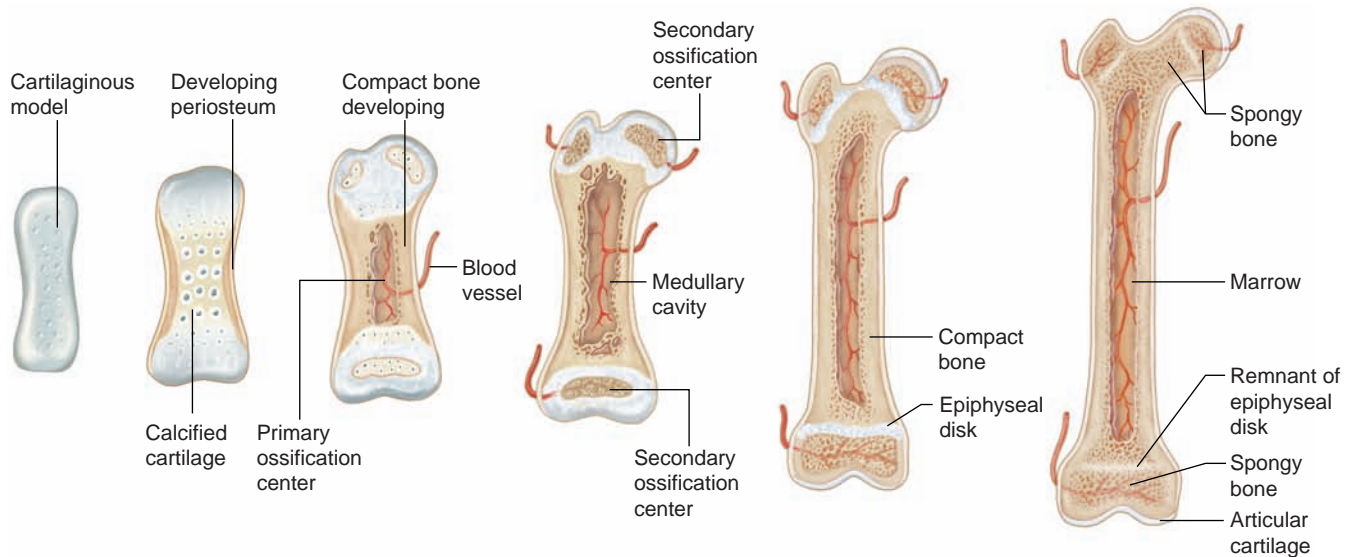


Figure 3-5. Steps in endochondral ossification.

epiphysis and the diaphysis, it can continue to grow in length. This plate of cartilage is called an **epiphyseal disk**. Once the cartilage is gone, bone growth stops. For most people, bone growth stops between the ages of 18 and 25 (Figure 3-5).

Even after bone growth stops, osteoclasts and osteoblasts continually remodel bone tissue. Throughout life, osteoclasts break down bone when the body needs more calcium in the blood, and osteoblasts replace the bone when there is excess calcium in the blood.

Pathophysiology

Common Diseases and Disorders of Bone

Bursitis is inflammation of a bursa, which is a fluid-filled sac that cushions tendons. It occurs most commonly in the elbow, knee, shoulder, and hip.

- **Causes.** Overuse of and trauma to joints are the most common causes of this condition. Bacterial infections can also cause bursitis.
- **Signs and symptoms.** Signs and symptoms include joint pain and swelling as well as tenderness in the structures surrounding the joint.
- **Treatment.** The most common treatments are bed rest, pain medications, steroid injections, aspiration of excess fluid from the bursa, and antibiotics.

Carpal tunnel syndrome occurs when the median nerve in the wrist is excessively compressed. Typists, assembly-line workers, painters, and people who play sports such as racquetball are most likely to develop carpal tunnel syndrome.

- **Causes.** Overuse of the wrist is a common cause of this syndrome.

- **Signs and symptoms.** Weakness and numbness in the hand, and pain in the wrist, hand, or elbow are common symptoms.
- **Treatment.** This condition can be treated with wrist splints, pain medications, and steroid injections and by having the patient change work habits to better position and support the wrists. If these treatments do not improve the patient's condition, surgery to reduce pressure on the nerves may be needed.

Ewing's family of tumors (EFT) is a group of tumors that affect different tissue types. However, the tumors primarily affect bone.

- **Causes.** Causes of EFT are not clear, but it most often affects Caucasians, the long bones of the body, and people between the ages of 10 and 20.
- **Signs and symptoms.** Fever, pain in the tumor location, fractures, and bruises in the tumor location are the primary symptoms.

continued →

Common Diseases and Disorders of Bone (continued)

- **Treatment.** Treatment options include surgery, chemotherapy, radiation therapy, a bone marrow transplant, or a stem cell transplant.

Gout is a type of arthritis that usually occurs more frequently with age.

- **Causes.** Gout is caused by deposits of uric acid crystals in the joints. People with gout cannot break down uric acid properly and remove it from their bloodstream.
- **Signs and symptoms.** Symptoms include sudden or chronic joint pain, joint swelling and stiffness, and fever.
- **Treatment.** The most common treatments are pain medications and changes to the patient's diet. Patients should eliminate from their diet certain foods that cause the formation of uric acid (meats, fish, beer, or wine).

Osteogenesis imperfecta is more commonly called brittle-bone disease. People with this disease have decreased amounts of collagen in their bones, which leads to very fragile bones. There are four types of this disease: type 1 is the most common, and type 2 is the most severe.

- **Causes.** The disorder is hereditary and very often runs in a family.
- **Signs and symptoms.** Signs and symptoms include fractures (all types), blue sclera (type 1), dental problems (types 1 and 4), hearing loss (type 1), a triangular face (type 1), abnormal spinal curves (types 1 and 4), very small stature (types 2 and 3), a small chest (type 2), a barrel-shaped chest (type 3), fractures at birth (type 3), loose joints (types 3 and 4), and small muscles (type 3).
- **Treatment.** Because there are many symptoms of this disease, the list of treatments is extensive and includes the following: fractures, surgery to strengthen bones by inserting metal rods into them, dental procedures, physical therapy, braces to prevent bone deformities, wheelchairs and other supportive aids, medications, and counseling. Other surgeries may be required to treat lung and heart problems that sometimes occur with this disease.

Osteoporosis is a condition in which bones become thinned over time. It is a very common disorder in the United States and affects women more than men and Caucasians more than any other race. This condition occurs when bone is broken down to release calcium into the blood but it is not sufficiently replaced.

- **Causes.** The causes include hormone deficiencies (estrogen in women and testosterone in men), a sedentary lifestyle, a lack of calcium and vitamin D in the diet, bone cancers, corticosteroid excess (usually as a result of endocrine diseases), smoking, excess alcohol consumption, and the use of steroids.

- **Signs and symptoms.** There are usually no symptoms in the early stages of this disease. Patients may later experience fractures (usually in spine, wrists, or hips), back and neck pain, a loss of height over time, and an abnormal curving of the spine.

- **Treatment.** The most common treatments include medications to prevent bone loss and relieve bone pain, estrogen replacement therapy, lifestyle changes to prevent bone loss (including regular exercise and diets or supplements that include calcium, phosphorus, and vitamin D), moderation in use of alcohol, and stopping smoking.

Osteosarcoma is a type of bone cancer that originates from osteoblasts, the cells that make bony tissue. It occurs most often in children, teens, and young adults and more often in males than females. Usually this type of cancer affects bones of the legs.

- **Causes.** The causes of this type of cancer are unclear.
- **Signs and symptoms.** Primary symptoms include pain in affected bones (usually the legs), swelling around affected bones, and an increase in pain with movement of the affected bones.
- **Treatment.** Treatments include surgery, chemotherapy, and radiation therapy. Amputation of the affected limb, followed by a prosthesis fitting, may be needed in some cases.

Paget's disease causes bones to enlarge and become deformed and weak. It usually affects people over the age of 40.

- **Causes.** This disease may be caused by a virus or various hereditary factors.
- **Signs and symptoms.** Bone pain, deformed bones, and fractures are common symptoms. Patients may experience headaches and hearing loss if the disease affects skull bones.
- **Treatment.** Treatments include surgery to remodel bones, hip replacements, medications to prevent bone weakening, and physical therapy.

Scoliosis is an abnormal curvature of the spine.

- **Causes.** This disorder can develop prenatally when vertebrae do not fuse together. It can also result from diseases that cause weakness of the muscles that hold vertebrae together. Other causes of scoliosis are unknown but they may be genetic.
- **Signs and symptoms.** A patient with scoliosis usually has a spine that looks bent to one side, with one shoulder or hip appearing to be higher than the other. Patients often experience back pain.
- **Treatment.** Treatment includes different types of back braces, surgery to correct spinal curves, and physical therapy.



Educating the Patient

Building Better Bones

Bone health is influenced by many factors, including diet, exercise, and a person's overall lifestyle. You can help patients improve or maintain their bone health by teaching them about behaviors that will support bone health.

Bone-Healthy Diet

Good nutrition is essential for proper bone growth during childhood and the teen years. It is equally important in adulthood in order to maintain healthy bones. Bone-building nutrients are found in dairy products, broccoli, kale, spinach, salmon, sardines, egg yolks, whole grains, and fruits—especially bananas and oranges. Calcium and vitamin D are particularly important for healthy bones. Without vitamin D, calcium cannot be absorbed from the digestive tract into the bloodstream. Without calcium, bone tissue will slowly wear away. Supplements can always be taken if a person's diet does not include adequate amounts of calcium and vitamin D.

Bone-Healthy Exercises

Weight-bearing and strength-training exercises are best for bone health. When your muscles contract, they pull on your bones. This tension stimulates

bones to thicken and strengthen. Lifting weights is an effective way to increase the tension on bones. Other activities such as jogging, walking briskly, or playing a sport regularly will also stimulate bones to increase in density.

Bone-Healthy Lifestyle

A person with a bone-healthy lifestyle avoids smoking and alcohol. Smoking rids the body of calcium, which is necessary for bone growth. Alcohol prevents calcium absorption in the digestive tract. People who smoke are almost twice as likely to develop osteoporosis as nonsmokers.

Bone Tests

Bone-density tests and bone scans are currently the most useful tools in determining bone health. Bone-density tests are painless procedures used to determine the density of a person's bones. Because osteoporosis shows no symptoms in early stages, these tests are important to have done when your doctor recommends them. Bone scans help diagnose the causes of bone pain, arthritis, bone infections, and bone cancers. These scans use radioactive dyes that are injected into the patient and that concentrate in bone tissue.

The Skull

Skull bones are divided into two types: cranial and facial bones. Cranial bones form the top, sides, and back of the skull. Facial bones form the face (Figure 3-6). The skull bones of an infant are not completely formed. The “soft spots” felt on an infant's skull are actually **fontanelles**, which are tough membranes that connect the incompletely developed bones.

The major cranial bones are the following:

- The frontal bone forms the anterior portion of the cranium. It is also called the forehead bone.
- **Parietal** bones form most of the top and sides of the skull.
- The **occipital** bone forms the back of the skull. A large hole in the occipital bone is called the **foramen magnum**. It allows the brain to connect to the spinal cord. Two bumps called occipital **condyles** are on either side of the foramen magnum. They sit on top of the first vertebra. When you nod your head, your occipital condyles are rocking back and forth on the first vertebra of the spinal column.
- Two **temporal** bones form the lower sides of the skull. A canal called the external auditory meatus runs

through each temporal bone. This canal is commonly called the ear canal. A large bump called the **mastoid process** is located on each temporal bone just behind each ear. Mastoid processes are where major neck muscles attach to your skull.

- A **sphenoid** bone forms part of the floor of the cranium. It is shaped like a butterfly. In the center of this bone is a deep depression called the **sella turcica**. The pituitary gland sits in this deep depression.
- **Ethmoid** bones are between the sphenoid bone and the nasal bones. They also form part of the floor of the cranium.
- **Ear ossicles** are the smallest bones of the body. They are the malleus, incus, and stapes and are in the middle ear cavities of the temporal bones.

The following are major facial bones:

- The **mandible** is the lower jawbone and is the only moveable bone in the skull. It anchors the lower teeth and forms the chin.
- The **maxillae** form the upper jawbone. They anchor the upper teeth to form the central portion of the facial skeleton.
- The **zygomatic** bones form the prominence of the cheeks.

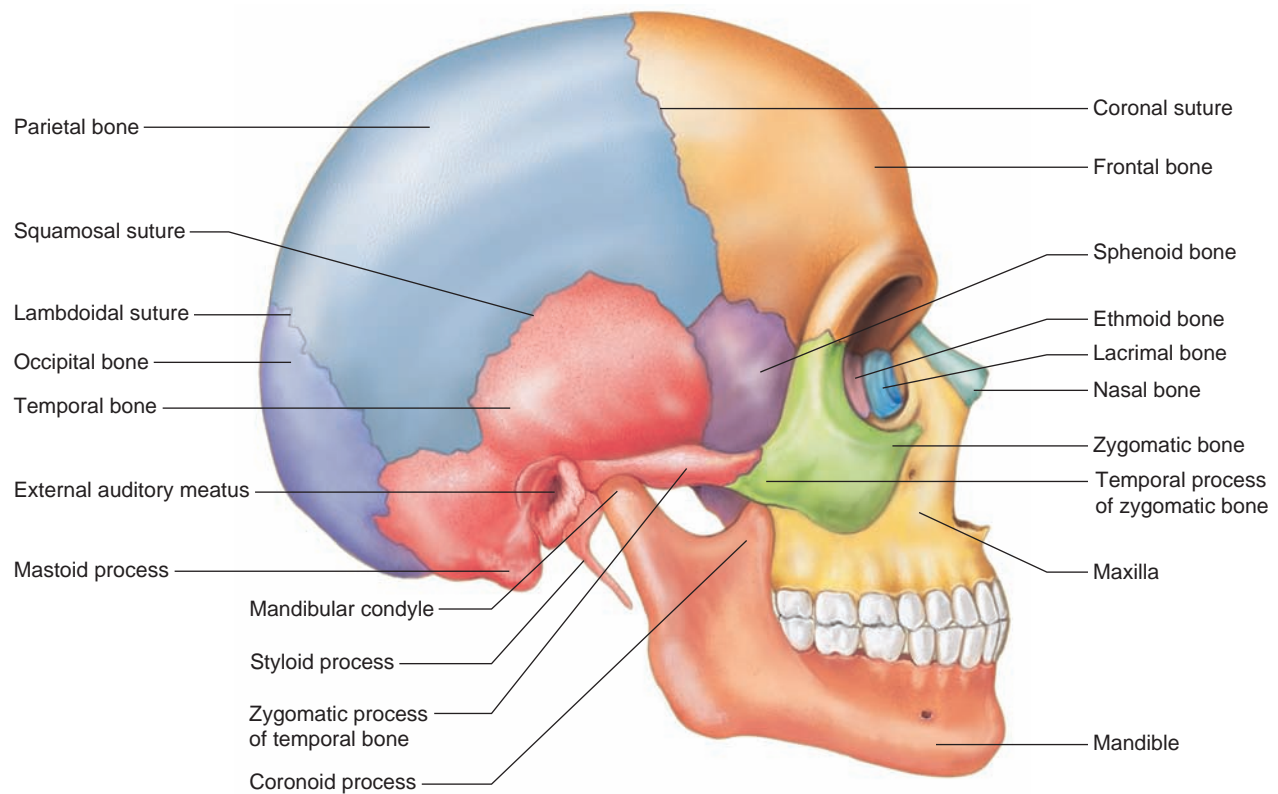


Figure 3-6. Lateral view of the skull.

- Several thin **nasal** bones fuse together to form the bridge of the nose.
- **Palatine** bones form the anterior portion of the palate, which is the roof of the mouth.
- The **vomer** is a thin bone that divides the nasal cavity.

The Spinal Column

The spinal column consists of 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, a sacrum, and a coccyx (Figure 3-7):

- Cervical vertebrae are the smallest and lightest of the vertebrae and are located in the neck region. The first cervical vertebra is called the **atlas** and the second is called the **axis**. When you turn your head from side to side, your atlas is pivoting around your axis.
- Thoracic vertebrae join the 12 pairs of ribs. They have long, sharp, spinous processes that you can feel when you run your finger down someone's spine.
- Lumbar vertebrae have very sturdy structures. They form the small of the back and bear the most weight of all the vertebrae.
- The **sacrum** is a triangular-shaped bone that consists of five fused vertebrae. The **coccyx** is a small, triangular-shaped bone made up of three to five fused vertebrae and is considered unnecessary. It is more commonly called the tailbone.

The Rib Cage

The rib cage is made of 12 pairs of ribs and the **sternum** (Figure 3-8). The sternum forms the front, middle portion of the rib cage. It is often called the breastplate. The sternum joins with the clavicles and most ribs. All 12 pairs of ribs are attached posteriorly to thoracic vertebrae. Most ribs are also attached to structures anteriorly. Based on what ribs attach to anteriorly, they can be classified as follows:

- **True.** The first seven pairs of ribs are true ribs. They attach directly to the sternum through pieces of cartilage called **costal** cartilages.
- **False.** Rib pairs 8, 9 and 10 are called false ribs. They attach to the costal cartilage of rib pair number 7.
- **Floating.** Rib pairs 11 and 12 are called floating ribs because they do not attach anteriorly to any structure.

Bones of the Shoulders, Arms, and Hands

The bones of the shoulders are called pectoral girdles and include **clavicles** and **scapulae**. They function to attach the arm to the trunk of the body. The clavicles are commonly known as the collarbones. They are slender in shape and each joins with the sternum and a scapula. Clavicles are very commonly broken bones in the body.

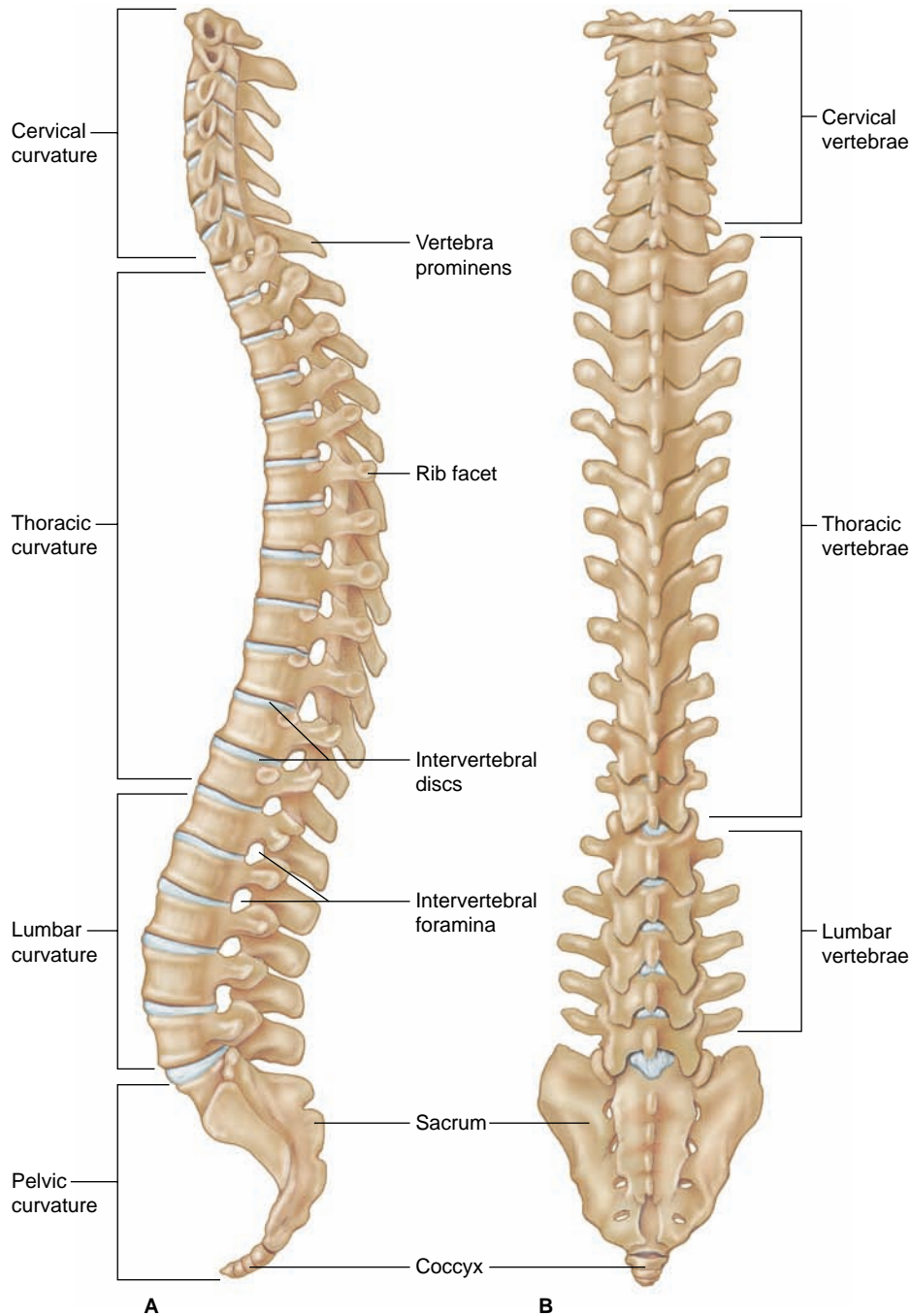


Figure 3-7. Vertebral column: (a) lateral view and (b) posterior view.

Scapulae are thin, triangular-shaped flat bones. They are also called shoulder blades and are located on the dorsal surface of the rib cage. Each scapula joins with the head of a humerus and a clavicle.

The upper limb, or arm, bones include the humerus, radius, and ulna. The humerus is located in the upper part of the arm. It joins with the scapula, the radius, and the ulna. The **radius** is the lateral bone of the forearm. It is on the same side of the arm as your thumb. It joins with the humerus, the ulna, and the wrist bones. The **ulna** is the medial bone of the lower arm. It joins with the humerus to

form the elbow joint. It also joins with the radius and some of the bones of the wrist.

The bones of the hand include carpals, metacarpals, and phalanges. Carpals are wrist bones. Each wrist contains eight marble-sized carpal bones. **Metacarpals** form the palms of the hands. Each hand has five metacarpals. **Phalanges** are the bones of the fingers. There are 14 phalanges in each hand—three for each finger and two per thumb.

Refer to Figure 3-1 for the bones of the shoulders, arms, and hands.

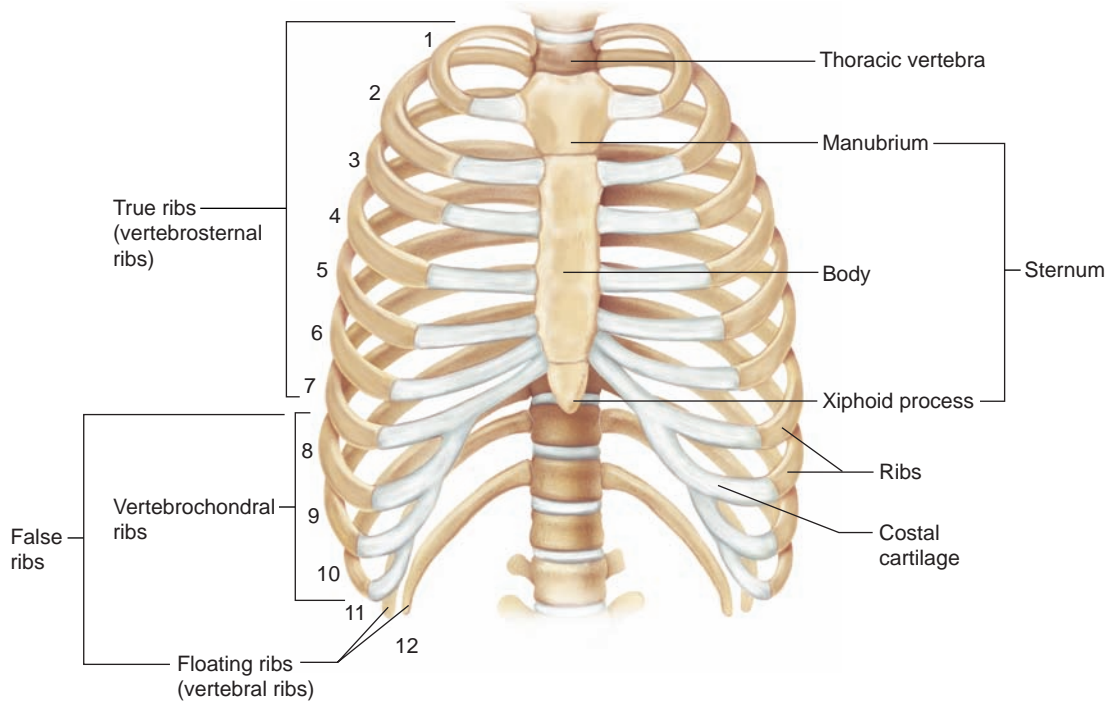


Figure 3-8. Rib cage.

Bones of the Hips, Legs, and Feet

The hipbones are also called **coxal** bones. They attach the leg to the axial skeleton. They also protect pelvic organs. Each coxal bone has three parts: the ilium, the ischium, and the pubis. The **ilium** is the most superior part of a coxal bone. When you put your hands on your hips, you are touch-

ing the ilium. The **ischium** forms the lower part of a coxal bone and the **pubis** forms the front. The **pubis** bones of each coxal bone join together to form the pubic symphysis, which is also referred to as the pelvic girdle (Figure 3-9).

The bones of the lower limb, or leg, include the femur, the patella, the tibia, and the fibula. The femur is the thigh-bone and the largest bone in the body. It joins with the hip-bone, the tibia, and the **patella** (kneecap). The **tibia** is the

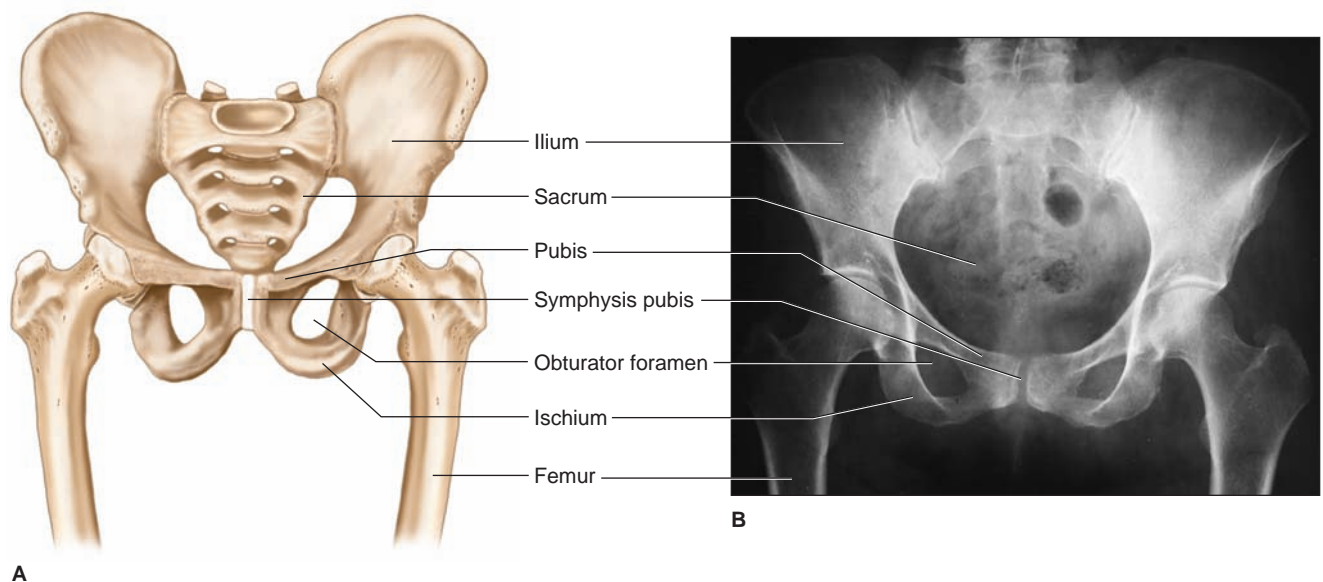


Figure 3-9. (a) Pelvic girdle. (b) Radiograph of the pelvic girdle.

medial bone of the lower leg. It is commonly called the shinbone. It joins with the femur, the fibula, and the anklebones. The **fibula** is the lateral bone of the lower leg. It is much thinner than the tibia. It joins with the anklebones.

The bones of the foot include the tarsals, the metatarsals, and the phalanges. The tarsal bones form the back of the foot. The **calcaneus**, or heel bone, is the largest tarsal bone. There are seven tarsal bones per foot. **Metatarsals** are bones that form the front of the foot. There are five metatarsals per foot. The bones of the toes are called phalanges. Each foot contains 14—two for each big toe and three in all the other toes.

Refer to Figure 3-1 for the bones of the hips, legs, and feet.

Bone Fractures

Bone fractures can be classified in many ways. For example, if a bone breaks because of trauma such as a car accident or sports injury, it is called a stress fracture. If a bone breaks because of some disease process, it is called a pathologic fracture. Table 3-1 defines some other commonly used terms to describe various types of fractures (also see Figure 3-10).

A broken bone may take three months or longer to heal, depending on the type of fracture and the general health of the patient. Fractures must be reduced, or set

back into their normal position. If surgery is required to reduce the fracture, this procedure is called an open reduction. Pins, screws, or plates are often used to hold the bone fragments together. If surgery is not required to set the bones, the procedure is called a closed reduction. Once fractures are reduced, it is important to immobilize the bone with braces or casts while the bone heals.

When a bone breaks, the following steps occur in the body's repair of the bone (Figure 3-11):

1. A hematoma (blood clot) forms around the fracture.
2. Granulation tissue slowly replaces the hematoma. Granulation tissue is a very delicate tissue made up of capillaries and various cells. The cells include macrophages, which help to prevent microbes from invading the broken bone. Other cells include fibroblasts that produce collagen fibers to help hold the bone ends together and osteoblasts that will start to make new bone tissue.
3. A soft callus is formed that replaces the granulation tissue. The soft callus contains cartilage that holds the broken ends of the bones securely together.
4. A hard callus replaces the soft callus. Bone tissue makes up the hard callus, and this is the structure that cements the broken ends back together most securely.
5. The hard callus is remodeled so that it takes on the shape of the original bone.

TABLE 3-1 Types of Fractures

Type	Description
Closed (simple)	Ends of fractured bone do not break through skin
Open (compound)	Ends of fractured bone break through skin
Complete	Bone is completely broken into two or more pieces
Incomplete	Bone is partially broken
Greenstick	Bone is bent on one side and has an incomplete fracture on the opposite side
Hairline	Bone has fine cracks but bone sections remain in place
Comminuted	Bone is broken into three or more pieces
Displaced	Ends of fractured bone move out of the normal position
Nondisplaced	Ends of fractured bone stay in the normal position
Impacted	Piece of broken bone is forced into a space of another bone fragment
Depressed	Fractured bone forms a concavity; mostly seen in skull fractures
Linear	Fracture is parallel to the long axis of the bone
Transverse	Fracture is perpendicular to the long axis of the bone
Oblique	Fracture runs diagonally across the bone
Spiral	Fracture spirals around long axis of bone, usually the result of twisting a bone
Colles	Fracture is at the distal end of the radius and ulna
Potts	Fracture is at the distal end of the tibia or fibula

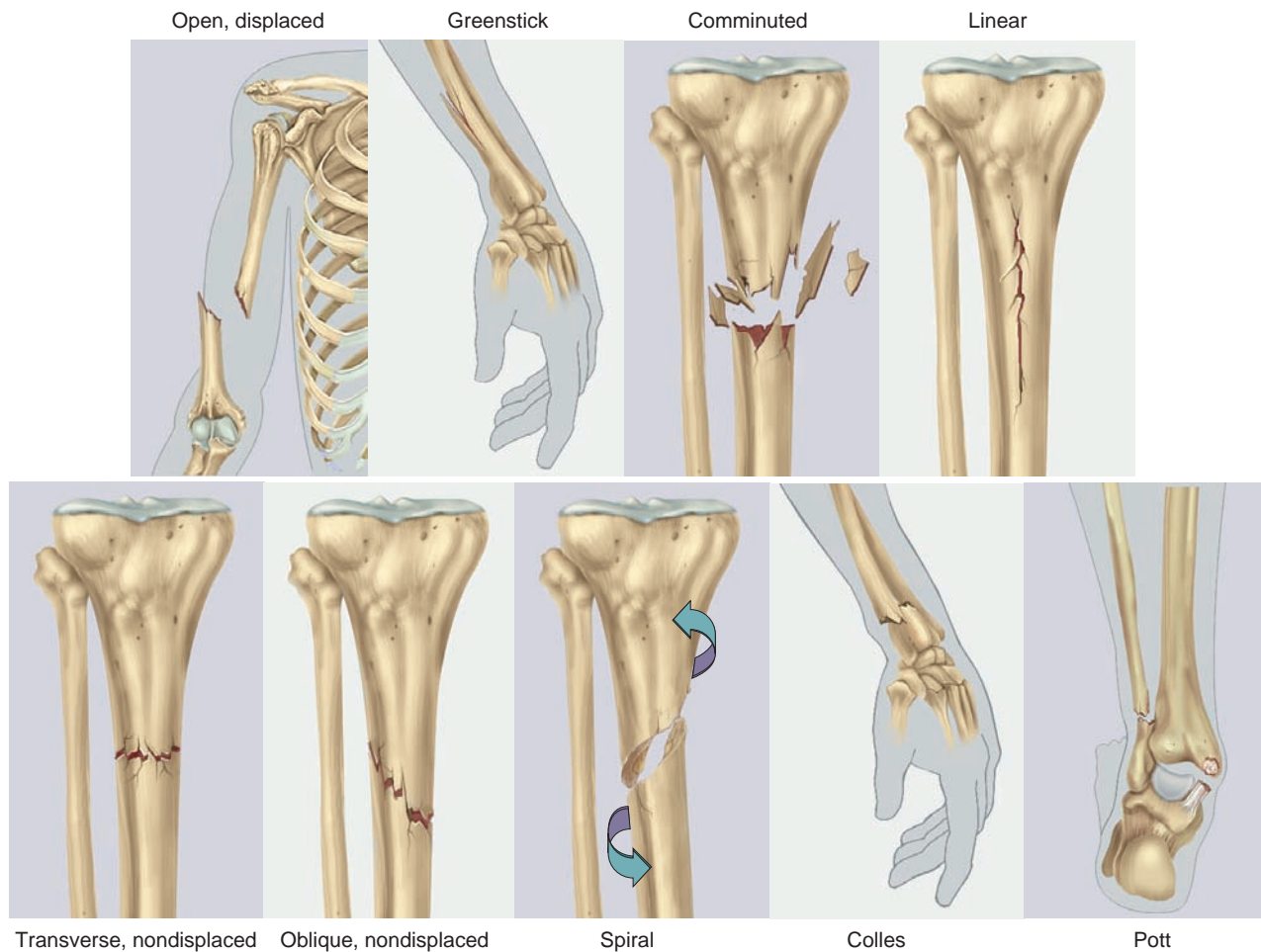


Figure 3-10. Types of bone fractures.

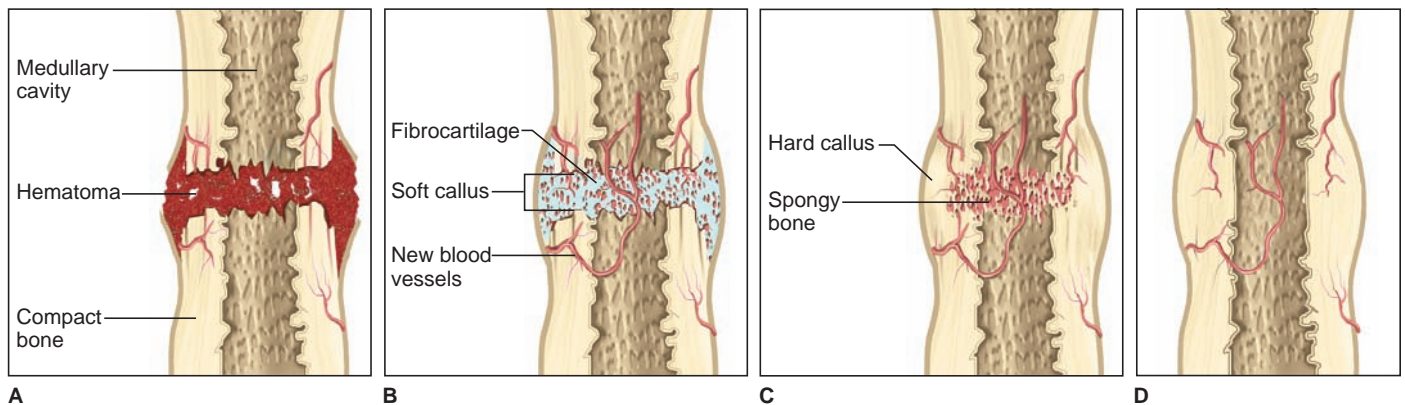


Figure 3-11. The healing of a bone fracture includes (a) hematoma formation, (b) soft callus formation, (c) hard callus formation, and (d) the remodeling of bone.

Joints

Joints are the junctions between bones. Based on their structure, joints can be classified as fibrous, cartilaginous, or synovial.

The bones of fibrous joints are connected together with short fibers. Therefore, the bones of this type of joint do not normally move against each other. Most fibrous joints are found between cranial bones and facial bones. Fibrous joints in the skull are called **sutures**.

Educating the Patient

Falls and Fractures

Falls account for about 50% of all fractures, so it is important to teach patients about preventing falls. Although most fractures are not life-threatening, some are. For example, hip fractures in the elderly can result in complications such as pneumonia. Approximately half of all patients who suffer hip fractures will use some type of walking aid for the rest of their lives.

Persons most at risk for falling are those with the following conditions:

- Muscle weakness
- Difficulty walking
- Poor vision
- Dependence on bifocals
- Hearing loss
- Dependence on medications that cause dizziness or drowsiness
- Alzheimer's disease
- Parkinson's disease

Falls can be prevented through the following steps:

- Awareness. Educate patients to try not to climb or stretch for items that they use regularly. Instead, they should move these items to easy-to-reach places.

- Balance. Patients should stand up gradually, especially from a lying-down position. They should stand for a few seconds before walking. This allows time for blood flow to reach the brain, preventing dizziness.
- Lifestyle. Patients should drink alcohol in moderation in order to prevent falls that result from intoxication. They should also avoid foods high in sugar to prevent dizziness caused by sudden surges of blood sugar. You can also recommend that patients clean up any clutter in their living space so that they are less likely to trip on items.

When a fall can't be prevented, the following steps may be helpful:

- Falling backward, instead of forward or sideways, is less risky.
- Breaking the fall with one's hands is better than not breaking the fall at all. Wrist fractures are painful but are not life-threatening like hip or skull fractures.
- Grabbing onto anything to help break the fall.
- Wearing soft shoes or padded clothing if prone to falls. Hip padding is available from doctors.

The bones of cartilaginous joints are connected together with a disc of cartilage. This type of joint is slightly moveable. The joints between vertebrae are cartilaginous joints.

The bones of **synovial** joints are covered with hyaline cartilage and are held together by a fibrous joint capsule (Figure 3-12). The joint capsule is lined with a synovial membrane. The membrane secretes a slippery fluid called synovial fluid, which allows the bones to move easily against each other. Bones are also held together through tough, cord-like structures called **ligaments**. Synovial joints are freely moveable. Examples of synovial joints are the elbows, knees, shoulders, and knuckles.

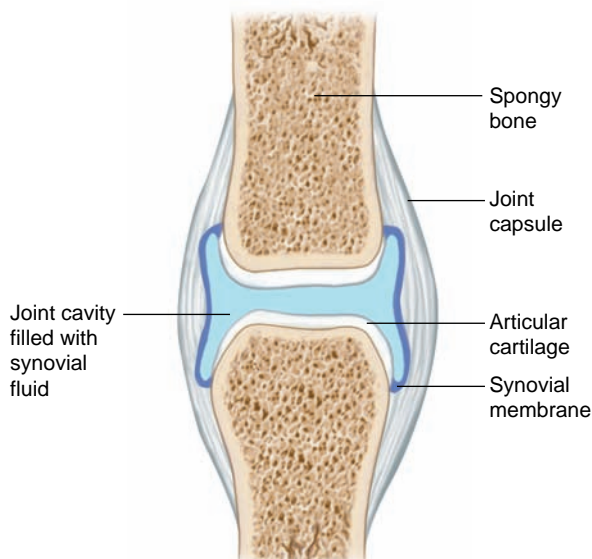


Figure 3-12. Structure of a synovial joint.

Summary

The bones of the skeletal system are divided into two major divisions: the axial and the appendicular skeletons. In addition to bones, the skeletal system consists of cartilage, tendons, and ligaments. The skeletal system provides support for the body, protects internal organs, serves as attachments for muscles to produce movement, stores minerals such as calcium, and produces new blood cells. Bones are used as landmarks for procedures such as injections, electrocardiograms, and x-rays. It is important for medical assistants to have knowledge of this system in order to effectively perform their duties.

REVIEW

CHAPTER 3

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. Where is the distal end of the left radius?
2. Will this patient need surgery?
3. Have other tissues been damaged besides bone?
4. Why is the damage to the epiphyseal plate of special concern?

Discussion Questions

1. List and describe the functions of bone.
2. Describe how joints are classified. Give examples of each classification.
3. What are the bones and functions of the pectoral and pelvic girdles?

Critical Thinking Questions

1. If a 32-year-old woman developed arthritis, what type is she likely to have? Why?
2. If a physician needed a red bone marrow sample from a patient, from where is he likely to get the sample?
3. Tarsal bones are often called anklebones. Why is this term not entirely correct?

Application Activities

1. State whether each of the following is a bone of the axial skeleton or the appendicular skeleton.
 - a. Humerus
 - b. Femur
 - c. Clavicle
 - d. Parietal bone
 - e. Nasal bone
 - f. Ear ossicles

2. Name the bone that forms the following:
 - a. Forehead
 - b. Chin
 - c. Palms of the hands
 - d. Fingers
 - e. Hip
 - f. Cheekbone
3. Name the bone that contains the following:
 - a. External auditory meatus
 - b. Foramen magnum
 - c. Sella turcica
 - d. Mastoid process

Internet Activity

1. Go to the University of Maryland Web site <http://www.umm.edu/bone/> and choose Diagnostic Procedures. Answer the following questions:
 - a. What is the role of MRI in diagnosing bone diseases?
 - b. What are the two types of biopsy used?
 - c. What is bone densitometry and what is it used for?

CHAPTER 4

The Muscular System

KEY TERMS

abduction
acetylcholine
acetylcholinesterase
adduction
aerobic respiration
antagonist
aponeurosis
botulism
circumduction
creatine phosphate
depression
dorsiflexion
elevation
endomysium
epimysium
eversion
extension
fascia
fascicle
fibromyalgia
flexion
hyperextension
insertion
intercalated disc
inversion
Krebs cycle
lactic acid
multiunit smooth muscle
muscle fatigue
muscle fiber
muscular dystrophy
myasthenia gravis
myofibrils
myoglobin

CHAPTER OUTLINE

- Functions of Muscle
- Types of Muscle Tissue
- Production of Energy for Muscle
- Structure of Skeletal Muscles
- Attachments and Actions of Skeletal Muscles
- Major Skeletal Muscles

OBJECTIVES

After completing Chapter 4, you will be able to:

- 4.1 List the functions of muscle.
- 4.2 Explain how muscle tissue generates energy.
- 4.3 List the three types of muscle tissue and describe the locations and characteristics of each.
- 4.4 Describe how smooth muscle produces peristalsis.
- 4.5 Describe the structure of a skeletal muscle.
- 4.6 List and define the various types of body movements produced by skeletal muscles.
- 4.7 Define the terms *origin* and *insertion*.
- 4.8 List the major skeletal muscles of the body and give the action of each.
- 4.9 Describe various disorders and diseases of the muscular system.

KEY TERMS (Continued)

norepinephrine	protraction	striations
origin	retraction	supination
oxygen debt	rhabdomyolysis	synergist
perimysium	rotation	tendon
peristalsis	sarcolemma	tetanus
plantar flexion	sarcoplasm	trichinosis
prime mover	sarcoplasmic reticulum	visceral smooth muscle
pronation	sphincter	

Introduction

Bones and joints do not themselves produce movement. By alternating between contraction and relaxation, muscles cause bones and supported structures to move. The human body has more than 600 individual muscles. Although each muscle is a distinct structure, muscles act

in groups to perform particular movements. This chapter focuses on the differences among three muscle tissue types, the structure of skeletal muscles, muscle actions, and the names of skeletal muscles.

CASE STUDY

Five days ago, a 40-year-old woman came to the doctor's office where you work as a medical assistant. She complained about pain in her back and right leg. Because this patient had a history of disc damage in her spine, she was sent home with pain medication and an order for bed rest for a 24-hour period. Two days later, she returned to the office with nausea, a severe headache, muscle twitching in her legs and arms, severe back pain, and tightness in her chest. The doctor once more asked the patient to elaborate on her activities the day before she fell ill. He was told that she had sprayed her furniture and carpets with an organophosphate insecticide to get rid of fleas in her house. She had also dipped her cats and dogs with the same insecticide. The doctor explained that organophosphates block acetylcholinesterase and immediately transferred her to the hospital for respiratory therapy and medicine to combat the insecticide poisoning.

As you read this chapter, consider the following questions:

1. What is the function of acetylcholinesterase?
2. Why does this patient exhibit muscle twitching and back pain?
3. What type of respiratory therapy will this patient require?
4. What precautions should a person take when using insecticides that contain organophosphates?
5. Why is it important for patients to give their doctor a complete account of their activities prior to an illness?

Functions of Muscle

Muscle tissue is unique because it has the ability to contract. It is this contraction that allows muscles to perform various functions. In addition to allowing the human body to move, muscles provide stability, the control of body openings and passages, and warming of the body.

Movement

Because skeletal muscles are attached to bones, when they contract, the bones attached to them move. This allows for various body motions, such as walking or waving your hand. Facial muscles are attached to the skin of the face, so when they contract, different facial expressions are produced, such as smiling or frowning. Smooth muscle is found in the walls of various organs, such as the stomach, intestines, and uterus. The contraction of smooth muscle in these organs produces movements of their contents, such as the movement of food material through the intestine. Cardiac muscle in the heart produces the pumping of blood into blood vessels.

Stability

You rarely think about it but muscles are holding your bones tightly together so that your joints remain stable. There are also very small muscles holding your vertebrae together to make your spinal column stable.

Control of Body Openings and Passages

Muscles form valve-like structures called **sphincters** around various body openings and passages. These sphincters control the movement of substances into and out of these passages. For example, a urethral sphincter prevents urination, or it can be relaxed to permit urination.

Heat Production

When muscles contract, heat is released, which helps the body maintain a normal temperature. This is why moving your body can make you warmer if you are cold.

Types of Muscle Tissue

There are three types of muscle tissue: skeletal, smooth, and cardiac. Study Table 4-1 to review their locations and features.

Muscle cells are called **muscle fibers** because of their long lengths. The cell membrane of a muscle fiber is called a **sarcolemma**. The cytoplasm of this cell type is called **sarcoplasm**, and the endoplasmic reticulum is called **sarcoplasmic reticulum**. Most of the sarcoplasm is filled with long structures called **myofibrils**. The arrangement of filaments in myofibrils produce the **striations** observed in skeletal and cardiac muscle cells. Muscle fibers are controlled by motor neurons that release neurotransmitters onto the fibers. See Figure 4-1 for an illustration of the structure of a skeletal muscle.

Skeletal Muscle

Skeletal muscle fibers respond only to the neurotransmitter **acetylcholine**. Acetylcholine causes skeletal muscle to contract. Once contraction has occurred, skeletal muscles release an enzyme called **acetylcholinesterase**, which breaks down acetylcholine. This allows the muscle to relax.

Smooth Muscle

There are two types of smooth muscle—multiunit and visceral. **Multiunit smooth muscle** is found in the iris of the eye and the walls of blood vessels. This muscle type contracts in response to neurotransmitters and hormones. **Visceral smooth muscle** contains sheets of muscle cells that closely contact each other. It is found in the walls of hollow organs such as the stomach, intestines, bladder, and uterus. Muscle fibers in visceral smooth muscle respond to neurotransmitters, but they also stimulate each other to contract; therefore, the muscle fibers tend to contract and relax together. This type of muscle produces an action called peristalsis. **Peristalsis** is a rhythmic contraction that pushes substances through tubes of the body.

Two neurotransmitters are involved in smooth muscle contraction—acetylcholine and **norepinephrine**. Depending on the smooth muscle type, these neurotransmitters cause or inhibit contraction.

Cardiac Muscle

Groups of cardiac muscle are connected to each other through **intercalated discs**. These discs allow the fibers in that group to contract and relax together. This design allows the heart to work as a pump. Cardiac muscle is also self-exciting, which means that it does not need nerve stimulation to contract. Nerves only speed up or slow down the contraction of the heart. Like smooth muscle, cardiac muscle responds to two neurotransmitters—acetylcholine and norepinephrine. Acetylcholine slows the heart rate, and norepinephrine speeds it up.

Production of Energy for Muscle

Because a lot of ATP (adenosine triphosphate), which is a type of chemical energy, is needed for sustained or repeated muscle contractions, a muscle cell must have multiple ways to store or make this substance. There are three ways through which muscle cells make this energy:

- 1. Creatine phosphate production.** Creatine phosphate is a protein that stores extra phosphate groups. When ATP is used to produce work, it loses a phosphate and energy. Creatine phosphate can then donate a phosphate group to the resulting molecule to restore its energy potential. This is a very rapid way for muscles to produce energy.
- 2. Aerobic respiration of glucose.** When a cell wants to make a lot of ATP, it turns to its glucose stores. A cell will break down glucose into pyruvic acid. As long as oxygen is available, the pyruvic acid is converted to a substance called acetyl coenzyme A. Acetyl coenzyme A starts a series of reactions called the **Krebs cycle**, which is also known as the citric acid cycle. This cycle

TABLE 4-1 Types of Muscle Tissue

Muscle Group	Major Location	Major Function	Mode of Control	Rate of Contraction	Intercalated Discs
Skeletal Muscle	Attached to bones and skin of the face	Produces body movements and facial expressions	Voluntary	Fast to contract and relax	No
Smooth Muscle	Walls of hollow organs, blood vessels, and iris	Moves contents through organs; vasoconstriction	Involuntary	Slow to contract and relax	No
Cardiac Muscle	Wall of the heart	Pumps blood through heart	Involuntary	Groups of muscle fibers contact as a unit	Yes

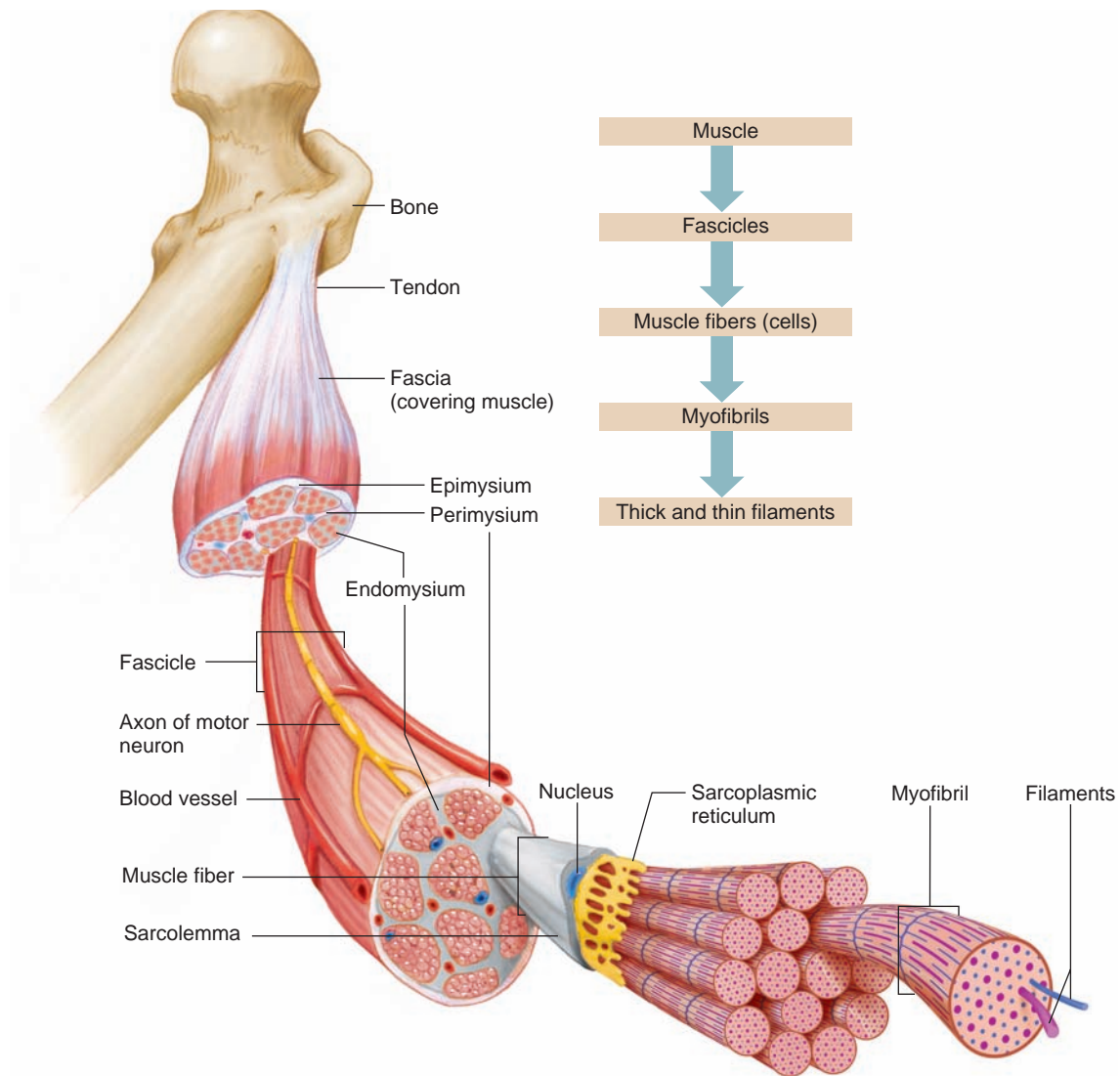


Figure 4-1. Structure of a skeletal muscle.

generates a lot of ATP for the muscle cell. The use of glucose to make ATP is called aerobic respiration because oxygen is required for this production. Because this process requires large amounts of oxygen, muscle cells contain a pigment called **myoglobin**, which stores extra oxygen. This pigment is pinkish in color and is responsible for giving muscles their color.

- Lactic acid** production. When a cell is low on oxygen, it must convert pyruvic acid to lactic acid. This reaction generates a small amount of ATP for the cell, but the lactic acid is a waste product that must be released from the cell.

Oxygen Debt

When skeletal muscles are used strenuously for a minute or two, **oxygen debt** develops. This condition occurs when oxygen supplies in the muscle are low and the aerobic respiration of glucose can no longer be used to produce ATP.

When oxygen is low, muscle fibers must convert pyruvic acid to lactic acid to produce energy. The buildup of lactic acid causes muscle fatigue. Lactic acid is then carried by the bloodstream to the liver where it can be converted back into glucose. However, this process requires energy. The oxygen debt is the amount of oxygen the liver cells need to make enough ATP to convert lactic acid into glucose. This process explains why your body still burns energy even after you are done exercising.

Muscle Fatigue

Muscle fatigue is a condition in which a muscle has lost its ability to contract. It usually develops because of an accumulation of lactic acid. It can occur also if the blood supply to a muscle is interrupted or if a motor neuron loses its ability to release acetylcholine onto muscle fibers. Cramps—which are painful, involuntary contractions of muscles—can accompany muscle fatigue.

Structure of Skeletal Muscles

Skeletal muscles are the major organs that make up the muscular system. A skeletal muscle consists of connective tissues, skeletal muscle tissue, blood vessels, and nerves. When you see marbling in a steak, you are actually viewing connective tissues in the steak. The red portion of the steak is the muscle tissue.

The following connective tissue coverings are associated with skeletal muscles (see Figure 4-1):

- **Fascia.** This structure covers entire skeletal muscles and separates them from each other.

- **Tendon.** This tough, cord-like structure is made of fibrous connective tissue that connects muscles to bones.
- **Aponeurosis.** This tough, sheet-like structure is made of fibrous connective tissue. It typically attaches muscles to other muscles.
- **Epimysium.** This tissue is a thin covering that is just deep to the fascia of a muscle. It surrounds the entire muscle.
- **Perimysium.** This connective tissue divides a muscle into sections called **fascicles**.
- **Endomysium.** This covering of connective tissue surrounds individual muscle cells.

Pathophysiology

Common Diseases and Disorders of the Muscular System

Botulism is usually thought of as a disease that affects the gastrointestinal tract, but it can also affect various muscle groups. This disease most commonly affects infants. Although a person can survive this disease, its effects may be long-lasting.

- **Causes.** This disease is a rare but very serious disorder caused by the bacterium *Clostridium botulinum*, which normally lives in soil and water. If this bacterium gets on food, it can produce a toxin that can lead to a type of food poisoning. The foods most likely to contain *Clostridium botulinum* are canned vegetables, cured pork, raw fish, honey, and corn syrup. A person can also acquire this bacterium through open wounds that are not cleaned properly.
- **Signs and symptoms.** This disease causes many symptoms, including difficulty swallowing, paralysis, weak muscles, nausea and vomiting, abdominal cramps, double vision, difficulty breathing, poor feeding and suckling in infants, the inability to urinate, the absence of reflexes, and constipation. The signs and symptoms usually appear 8 to 40 hours after the toxin is ingested. The diagnosis is usually made by either a blood test to identify the toxin or an analysis of the suspected food.
- **Treatment.** Treatment includes emergency hospitalization, intubation to open airways, mechanical ventilation if respiratory muscles are impaired, intravenous fluids or nasogastric feeding if swallowing is impaired, and the administration of an antitoxin.
- **Prevention tips.** You can instruct patients to prevent botulism by observing the following guidelines:
 - Never give honey or corn syrup to infants
 - Sterilize home-canned foods properly (250°F for 35 minutes)

- Do not use foods from bent or bulging cans
- Never eat foods that smell as if they may have spoiled
- Cook and store foods properly

Fibromyalgia is a fairly common condition that results in chronic pain primarily in joints, muscles, and tendons. It most commonly affects women between the ages of 20 and 50.

- **Causes.** The causes of this disorder are poorly understood. Fibromyalgia may be caused by sleep disturbance, emotional distress, a decreased blood flow to muscles, a virus, or any combination of these factors.
- **Signs and symptoms.** Symptoms include fatigue, tenderness in different areas of the body, sleep disturbances, and chronic facial pain. The diagnosis is usually made by ruling out other possible diseases. It is not normally diagnosed unless a person has muscle and joint pain for at least three months in certain body areas.
- **Treatment.** Treatment is varied and includes antidepressants, anti-inflammatory medications, physical therapy, lifestyle changes to reduce stress, counseling to improve coping skills, reduction or elimination of caffeine to improve sleeping, and diet supplements to improve nutrition.

Muscular dystrophy is a group of inherited disorders characterized by muscle weakness and a loss of muscle tissue. There are at least seven types of muscular dystrophy, and they are distinguished from each other by types of symptoms, the age at which symptoms appeared, and the cause.

- **Causes.** The causes of this disorder are primarily hereditary. Genetic fetal testing is available.

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Common Diseases and Disorders of the Muscular System (continued)

- **Signs and symptoms.** The signs and symptoms vary widely and depend on the type of muscular dystrophy. The symptoms of Duchenne muscular dystrophy progress steadily and are eventually fatal. Other types cause mild symptoms, and patients usually have normal life expectancies. Specific signs and symptoms include muscle weakness in various muscle groups, depending on the type; difficulty walking; drooling; a delayed development of motor skills; frequent falls; mental retardation in some types; a curved spine; the formation of a claw hand or clubfoot; a loss of muscle mass; the accumulation of fat or fibrous connective tissue in muscles; and arrhythmias in some types. The diagnosis is primarily made through a muscle biopsy. Other tests include DNA testing; an EMG (electromyography) test, which tests muscle weakness; or an ECG (electrocardiogram), which tests cardiac function.
- **Treatment.** Treatment includes physical therapy to maintain muscle function, the use of braces and wheelchairs, various medications based on the type, and spinal surgery.

Myasthenia gravis is a condition in which affected persons experience muscle weakness. In this condition, a person produces antibodies that prevent muscles from receiving neurotransmitters from neurons. It most commonly affects young women and older men, especially if they have other autoimmune disorders.

- **Causes.** This disease is usually considered an autoimmune disorder.
- **Signs and symptoms.** The signs and symptoms usually get better with rest and worsen with activity. They include double vision; muscle weakness; difficulty swallowing, talking, chewing, lifting, or walking; fatigue; drooling; and difficulty breathing. The diagnosis may be difficult, but a single-fiber EMG test is often useful. This test measures the response of a muscle fiber to nervous stimulation. Other tests include acetylcholine receptors antibody tests and the Tensilon test. In a positive Tensilon test, muscle activity increases after medication is given that blocks the breakdown of acetylcholine.
- **Treatment.** Treatments include lifestyle changes to avoid excessive stress and heat, the use of an eye patch to treat double vision, medications to improve communication between nerves and muscles, medications to suppress the immune system, plasmapheresis to remove harmful antibodies from blood, and removal of the thymus.

Rhabdomyolysis is a condition in which the kidneys have been damaged and is related to serious muscle injuries.

- **Causes.** Kidneys become damaged because of toxins released from muscle cells. When muscles are damaged, excessive amounts of the pigment myoglobin

are released, which is then broken down into harmful chemicals. Muscles are most often damaged through trauma; excessive use (for example, marathon running); overdoses of cocaine, heroin, and other drugs; alcoholism; and a blockage of the blood supply to the muscles.

- **Signs and symptoms.** Symptoms include dark urine, muscle tenderness, muscle weakness, muscle stiffness, seizures, joint pain, and fatigue. The diagnosis includes urinalysis for the presence of myoglobin, creatine phosphokinase (CPK), and creatinine; blood is also tested for the presence of myoglobin, CPK, or high levels of potassium. CPK is an enzyme released into the blood when muscles are damaged. Creatinine is a protein released by the breakdown of muscle tissue.
- **Treatment.** Treatment includes hydration to rapidly eliminate toxins from the kidneys, diuretics to help flush toxins from the body, medications to flush excess potassium from the body, and therapy for kidney failure.

Tetanus is commonly called lockjaw. This disease has a high mortality rate, especially in infants. Immediate treatment is necessary to prevent death or long-lasting effects. However, this disease is completely preventable through regular vaccinations.

- **Causes.** A toxin produced by the bacterium *Clostridium tetani*, which lives naturally in soil and water, causes this disease. People most commonly acquire this bacterium through open wounds caused by objects contaminated with soil.
- **Signs and symptoms.** Symptoms usually appear between 5 and 10 days after infection. Muscle spasms in the jaw, neck, and facial muscles are usually the first signs. Other signs and symptoms include severe spasms of muscles that spread to other body locations; muscle spasms that may cause bone fractures; breathing difficulties; irritability; fever; profuse sweating; and drooling. The diagnosis is usually based on the type of wound and the characteristic signs and symptoms of the disease. Tetanus antibody tests can also be used in diagnosis, but cultures of the wound site often produce false-negative findings.
- **Treatment.** Administering antitoxin and antibiotics is a key treatment. Others include wound cleaning, muscle relaxants, sedation, and bed rest. The insertion of an endotracheal tube and mechanical ventilation may be needed for patients with severe breathing difficulties.

Trichinosis is an infection caused by parasites (worms).

- **Causes.** This disease is caused by worms that are usually ingested by eating undercooked meat. Once ingested, the worms can leave the digestive tract and infect skeletal muscles, the heart, the lungs, and the brain. This disease is preventable by not eating meat

continued →

Common Diseases and Disorders of the Muscular System (continued)

from wild animals. Proper cooking will also prevent trichinosis. There is no cure for this disease once the worms leave the digestive tract and infect other tissues.

- **Signs and symptoms.** Common symptoms include abdominal pain, diarrhea, muscle pain, fever, and pneumonia. In more serious cases, arrhythmias (irregular heart rhythms), heart failure, and encephalitis (swelling of the brain) can result. The diagnosis is

usually based on the symptoms, a blood test to determine if there is an increase in eosinophils in blood, or by a muscle biopsy that reveals the presence of the worm.

- **Treatment.** Patients with this disease are treated with medications to kill worms in the digestive tract and with anti-inflammatory drugs to reduce muscle pain and swelling.

Attachments and Actions of Skeletal Muscles

The actions of skeletal muscles depend largely on what the skeletal muscles are attached to. Insertions and origins are sites of attachments for skeletal muscles. An **insertion** is an attachment site that moves when a muscle contracts. An **origin** is an attachment site that does not move when a muscle contracts. For example, the biceps brachii (the muscle on the front of the upper arm) attaches to two places on the scapula and to one site on the radius. When the biceps brachii contracts, the radius moves and the arm bends at the elbow. Therefore, the insertion site of the biceps brachii is its attachment site on the radius. The origin of the biceps brachii is where it attaches to the scapula (Figure 4-2).

Most of the time a body movement is produced not just by one muscle but by a group of muscles. However, one muscle is responsible for most of the movement; this muscle is called the **prime mover**. Other muscles help the prime mover by stabilizing joints; these muscles are called **synergists**. An **antagonist** is a muscle that produces a

movement opposite to the prime mover. When the prime mover contracts, the antagonist must relax in order to produce a smooth body movement. For example, when you bend your arm at the elbow, the prime mover is the biceps brachii. The synergist muscles are the brachialis and brachioradialis. The antagonist is the triceps brachii because its action is to extend the arm at the elbow.

The body movements produced by skeletal muscles include the following:

- **Flexion**—bending a body part
- **Extension**—straightening a body part
- **Hyperextension**—extending a body part past the normal anatomical position
- **Dorsiflexion**—pointing the toes up
- **Plantar flexion**—pointing the toes down
- **Abduction**—moving a body part away from its position in the anatomical position
- **Adduction**—moving a body part toward its position in the anatomical position
- **Rotation**—twisting a body part; for example, turning your head from side to side
- **Circumduction**—moving a body part in a circle; for example, moving your arm in a circular motion
- **Pronation**—turning the palm of the hand down
- **Supination**—turning the palm of the hand up
- **Inversion**—turning the sole of the foot medially
- **Eversion**—turning the sole of the foot laterally
- **Retraction**—moving a body part posteriorly
- **Protraction**—moving a body part anteriorly
- **Elevation**—lifting a body part; for example, elevating your shoulders as in a shrugging expression
- **Depression**—lowering a body part; for example, lowering your shoulders

See Figures 4-3, 4-4, and 4-5 for illustrations of these types of movements.

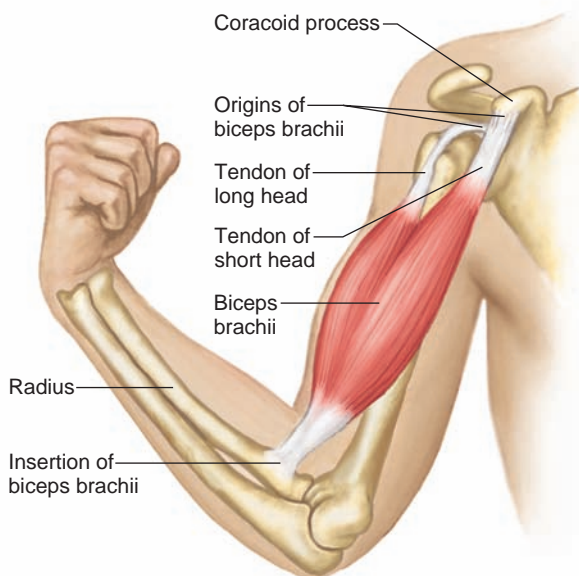


Figure 4-2. Origins and insertion of biceps brachii.

Major Skeletal Muscles

The name of a skeletal muscle often describes it in some way. Usually the name indicates the location, size, action, shape, or number of attachments of the muscle. For

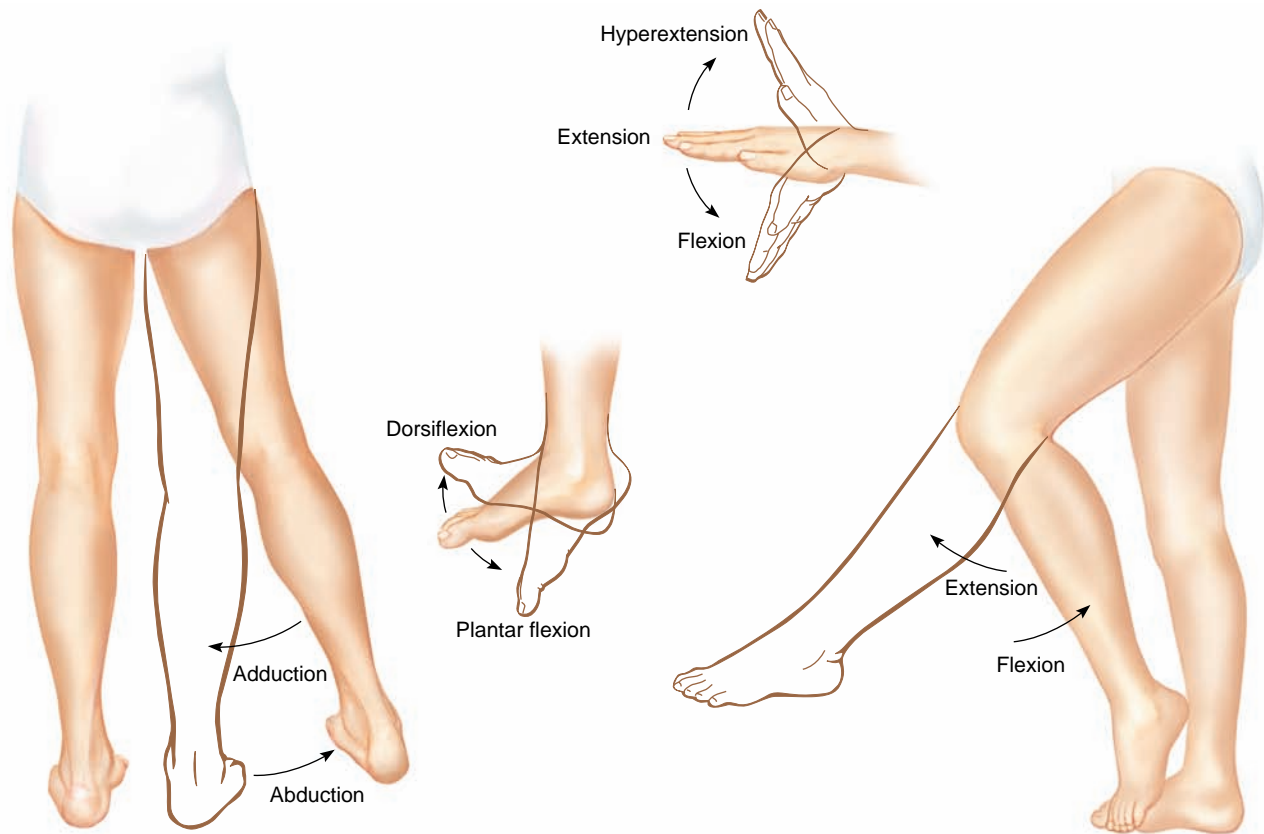


Figure 4-3. Adduction, abduction, dorsiflexion, plantar flexion, hyperextension, extension, and flexion.

example, the pectoralis major is named for its large size (major) and its location (pectoral, or chest, region). The sternocleidomastoid is named for its attachment sites—*sterno* (sternum), *cleido* (clavicle), and *mastoid* (the mastoid process of the temporal bone). As you study muscles, you will find it easier to remember them if you think about what the name describes.

Muscles of the Head

The muscles of the head include those that move the head, provide facial expression, and move the jaw. See Figures 4-6 and 4-7 for illustrations of these various muscles.

Muscles that move the head include the following:

- Sternocleidomastoid. This muscle pulls the head to one side and also pulls the head to the chest.
- Splenius capitis. This muscle rotates the head and allows it to bend to the side.

Muscles of facial expression include the following:

- Frontalis. This muscle raises the eyebrows.
- Orbicularis oris. This muscle allows the lips to pucker.
- Orbicularis oculi. This muscle allows the eyes to close.
- Zygomaticus. This muscle pulls the corners of the mouth up.
- Platysma. This muscle pulls the corners of the mouth down.

The muscles of the jaw allow for mastication (chewing) and include the following:

- Masseter and temporalis. These muscles close the jaw.

Arm Muscles

Muscles that move the arm include muscles of the arm and forearm (see Figures 4-6, 4-7, and 4-8). The muscles of the arm include the following:

- Pectoralis major. This muscle pulls the arm across the chest; it also rotates and adducts the arms.
- Latissimus dorsi. This muscle acts to extend, adduct, and rotate the arm inwardly.
- Deltoid. This muscle acts to abduct and extend the arm at the shoulder.
- Subscapularis. This muscle rotates the arm medially.
- Infraspinatus. This muscle rotates the arm laterally.

Muscles that move the forearm include the following:

- Biceps brachii. This muscle flexes the arm at the elbow and rotates the hand laterally.
- Brachialis. This muscle flexes the arm at the elbow.
- Brachioradialis. This muscle flexes the forearm at the elbow.
- Triceps brachii. This muscle extends the arm at the elbow.

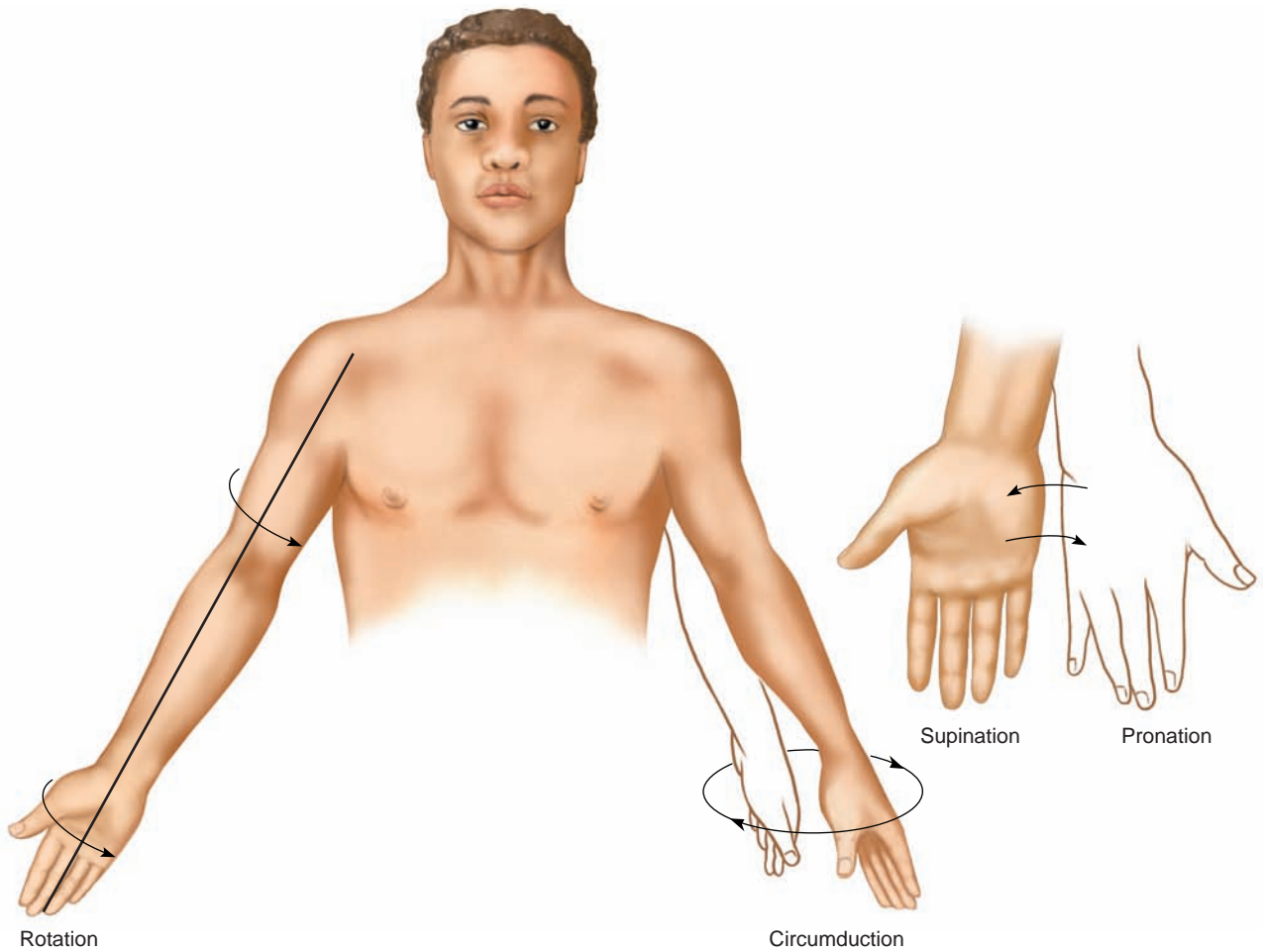


Figure 4-4. Rotation, circumduction, supination, and pronation.

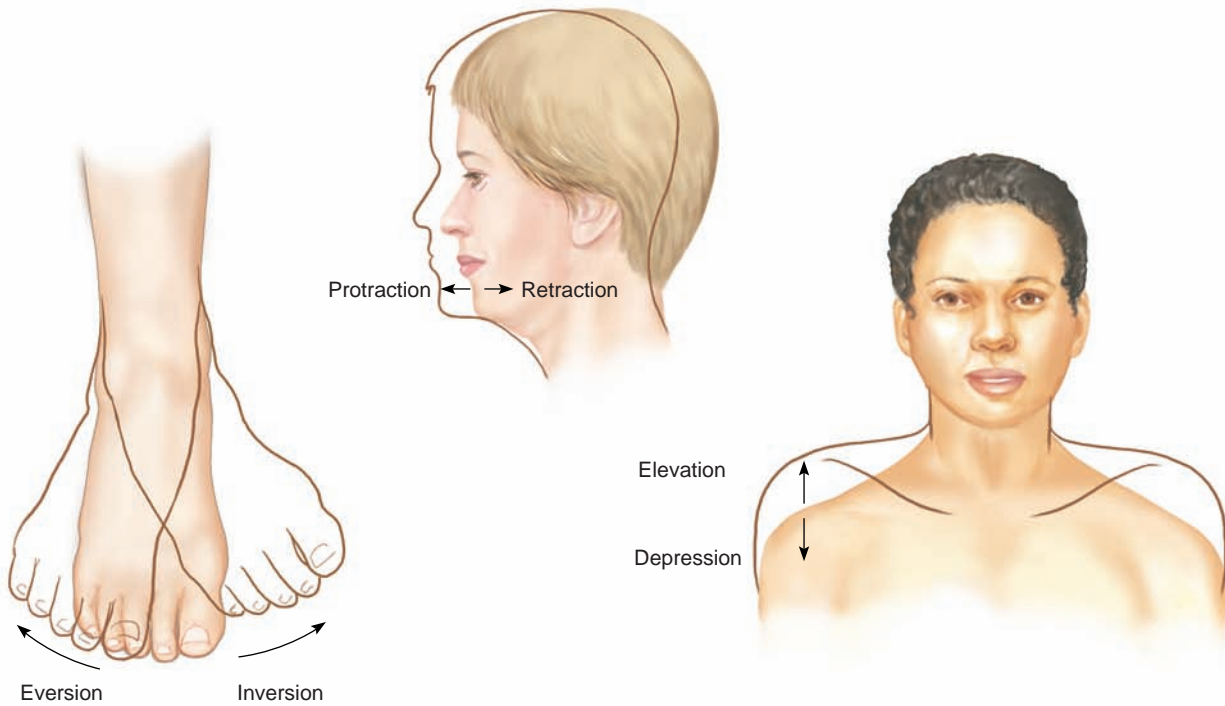


Figure 4-5. Eversion, inversion, protraction, retraction, elevation, and depression.

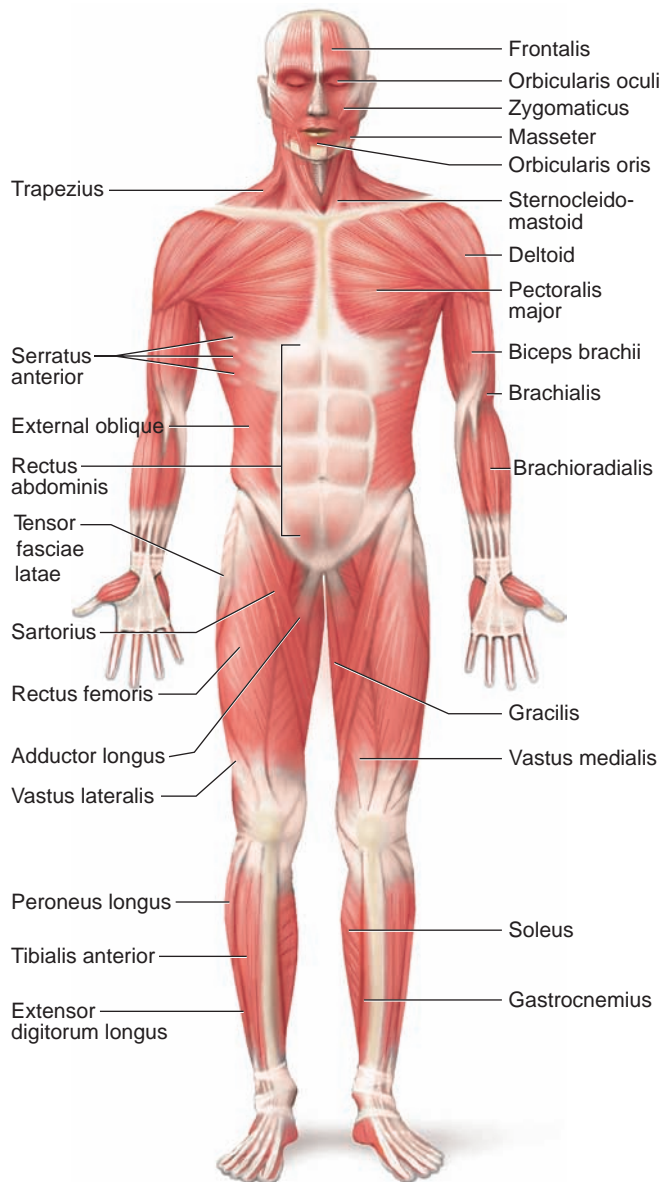


Figure 4-6. Anterior view of superficial skeletal muscles.

- Supinator. This muscle rotates the forearm laterally (supination).
- Pronator teres. This muscle rotates the forearm medially (pronation).

Muscles of the Wrist, Hand, and Fingers

Muscles that move the wrist, hand, and fingers can be seen in Figures 4-6, 4-7, and 4-8. These muscles include the following:

- Flexor carpi radialis and flexor carpi ulnaris. These muscles flex and abduct the wrist.
- Palmaris longus. This muscle flexes the wrist.
- Flexor digitorum profundus. This muscle flexes the distal joints of the fingers but not the thumb.

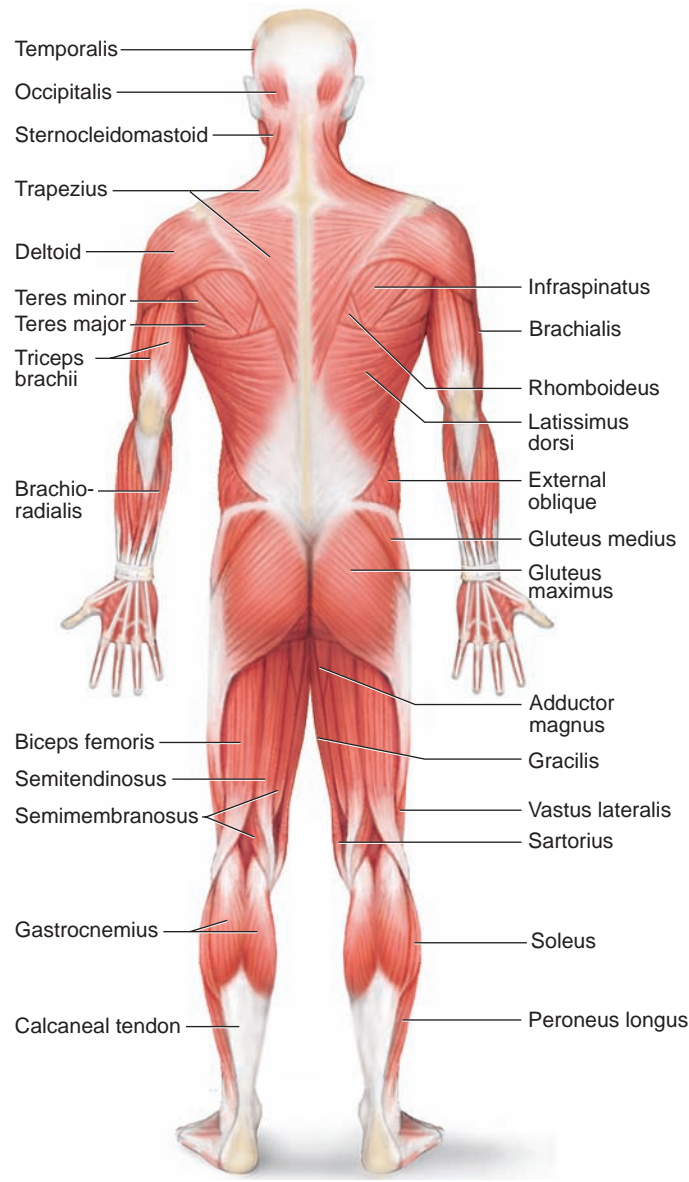


Figure 4-7. Posterior view of superficial skeletal muscles.

- Extensor carpi radialis longus and brevis. These muscles extend the wrist and abduct the hand.
- Extensor carpi ulnaris. This muscle extends the wrist.
- Extensor digitorum. This muscle extends the fingers but not the thumb.

Respiratory Muscles

The muscles of respiration include the following:

- Diaphragm. This muscle separates the thoracic cavity from the abdominal cavity; its contraction causes inspiration.
- External and internal intercostals. The contraction of these muscles expands and lowers the ribs during breathing. See Figure 4-9 for an illustration of the internal intercostal muscle.

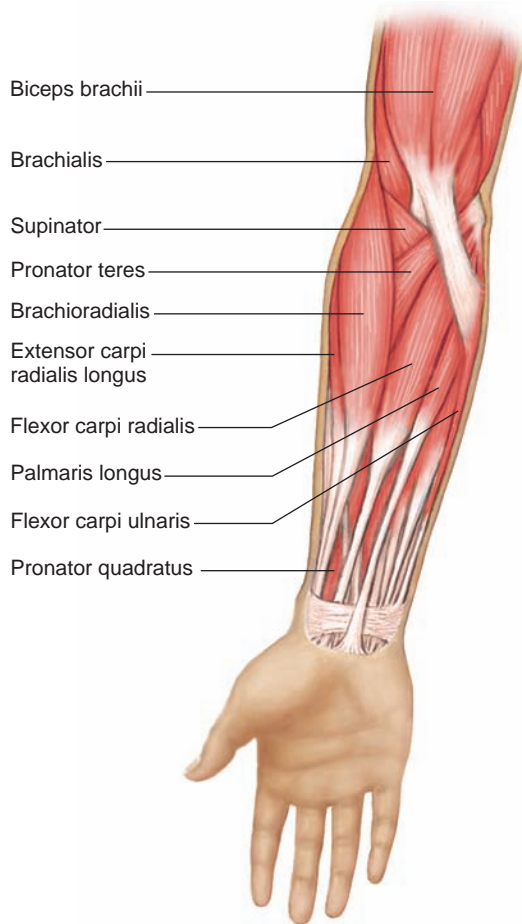


Figure 4-8. Muscles of the anterior forearm.

Abdominal Muscles

The muscles of the abdominal wall include the following:

- External and internal obliques. These muscles compress the abdominal wall.
- Transversus abdominis. This muscle also compresses the abdominal wall.
- Rectus abdominis. This muscle acts to flex the vertebral column and compress the abdominal wall.

See Figures 4-6, 4-7, and 4-9 for illustrations of these muscles.

Muscles of the Pectoral Girdle

The muscles that move the pectoral girdle (shoulder) include these muscles:

- Trapezius. This muscle raises the arms and pulls the shoulders downward.
- Pectoralis minor. This muscle pulls the scapula downward and raises the ribs.

See Figures 4-6, 4-7, and 4-9 for illustrations of these muscles.

Leg Muscles

The leg muscles include muscles of the thigh and lower leg (see Figures 4-6 and 4-7). Muscles that move the thigh include the following:

- Psoas major. This muscle flexes the thigh.
- Iliacus. This muscle also flexes the thigh.
- Gluteus maximus. This muscle extends the thigh.

Educating the Patient

Muscle Strains and Sprains

Muscle strains are injuries that excessively stretch muscles or tendons. Muscle sprains are more serious injuries that result in tears to muscles, tendons, ligaments, or cartilage. You can teach patients to prevent these types of injuries by doing the following:

- Warm up. Warming up muscles for just a few minutes before an intense activity raises muscle temperature. This increase in temperature prevents injuries by making muscle tissue more pliable.
- Stretch. Stretching improves muscle performance and should always be done after the warm-up or after exercising. A person should never stretch further than he can hold for 10 seconds.
- Cool down. Slowing down the exercise before completely stopping prevents dizziness and fainting. If a person suddenly stops exercising, blood can pool in the legs and is prevented from reaching the brain. Cooling down also helps to remove lactic acid from muscles.

If sprains or strains do occur, immediate RICE treatment is recommended:

- R is for rest. Resting minimizes bleeding, further injury, and swelling.
- I is for ice. Ice minimizes swelling and pain. A bag that is filled with crushed ice conforms better to a body part than one filled with ice cubes. A bag full of frozen peas or other small

continued →

Educating the Patient

Muscle Strains and Sprains *(continued)*

vegetables can also be used. The ice should be applied for 10 minutes and then removed for 10 minutes. This should be kept up for about an hour and repeated several times during a 24-hour period. Ice can be applied for a shorter period of time if blood vessels dilate during its application.

- C is for compression, which minimizes swelling. A bandage should be loosely wrapped around

the injured area and the bag of ice. Compression should be applied and removed along with the ice.

- E is for elevation. The injured muscle should be elevated, which minimizes swelling, and elevation should be continued as long as swelling is present.

- Gluteus medius and minimus. These muscles abduct the thighs and rotate them medially.
- Adductor longus and magnus. These muscles adduct the thighs and rotate them laterally.
- Biceps femoris, semitendinosus, and semimembranosus. These three muscles are known as the hamstring group. They act to flex the leg at the knee and extend the leg at the thigh.

- Rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius. These four muscles are known as the quadriceps group; they act to extend the leg at the knee.
- Sartorius. This muscle flexes the leg at the knee and thigh. It also abducts the thigh, rotating the thigh laterally but rotating the lower leg medially; it carries out the act of sitting cross-legged.

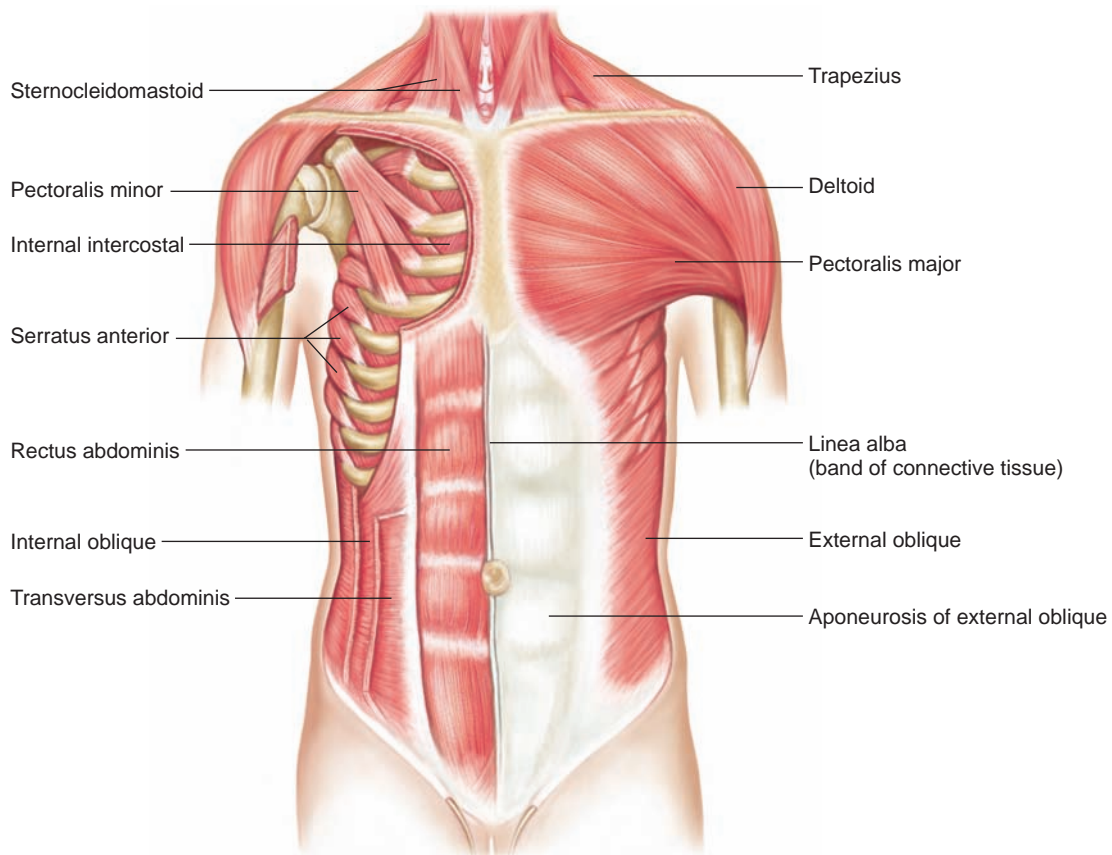


Figure 4-9. Muscles of the anterior chest and abdominal wall.

Muscles of the Ankle, Foot, and Toes

Muscles that move the ankle, foot, and toes include the following:

- Tibialis anterior. This muscle inverts the foot and points the foot up (dorsiflexion).
- Extensor digitorum longus. This muscle extends the toes and points the foot up.
- Gastrocnemius. This muscle flexes the foot and flexes the leg at the knee.
- Soleus. This muscle also flexes the foot.
- Flexor digitorum longus. This muscle flexes the foot and toes.

See Figures 4-6 and 4-7 for illustrations of these muscles.

Summary

Skeletal muscle works in conjunction with the skeletal system to produce movement. This movement is accomplished voluntarily. In addition, skeletal muscles help stabilize joints and are important in heat production. Muscles under involuntary control include smooth and cardiac muscle. Smooth muscles control body openings and passages. Cardiac muscle is responsible for the pumping action of the heart. Medical assistants should understand the muscular system in order to give muscular injections, prepare patients for massage therapy, demonstrate ambulatory techniques, and assist in the care of sprains and strains.

REVIEW

CHAPTER 4

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. What is the function of acetylcholinesterase?
2. Why does this patient exhibit muscle twitching and back pain?
3. What type of respiratory therapy will this patient require?
4. What precautions should a person take when using insecticides that contain organophosphates?
5. Why is it important for patients to give their doctor a complete account of their activities prior to an illness?

Discussion Questions

1. Name the muscles used for facial expression. Tell what facial expression each produces.
2. How are muscles named? Give examples for each method of naming a muscle.
3. What are the functions of muscles?
4. What is oxygen debt, and how does it develop?

Critical Thinking Questions

1. Why is it important to do warm-up activities before participating in sporting events?
2. What steps can be taken to minimize muscle wasting or decline in the legs of patients who are dependent on wheelchairs?
3. How does the application of heat ease the pain associated with muscle soreness?
4. If a workout buddy at the gym told you his muscles were getting bigger because he was growing more muscle cells, would he be correct? What actually makes a muscle larger?

Application Activities

1. Define the following terms related to muscle structure:
 - a. Fascia
 - b. Epimysium
 - c. Fascicle
 - d. Perimysium
 - e. Aponeurosis
 - f. Tendon
2. Describe the following actions:
 - a. Flexion
 - b. Extension
 - c. Pronation
 - d. Supination
 - e. Abduction
 - f. Adduction
 - g. Rotation
 - h. Circumduction
3. Describe the actions of the following muscles:
 - a. Biceps brachii
 - b. Triceps brachii
 - c. Orbicularis oris
 - d. Hamstring group
 - e. Quadriceps group
 - f. Deltoid
 - g. Gastrocnemius
4. Give the locations of each of the following muscle types:
 - a. Cardiac muscle
 - b. Visceral smooth muscle
 - c. Multiunit smooth muscle
 - d. Skeletal muscle

CHAPTER 5

The Nervous System

KEY TERMS

action potential
areflexia
ascending tracts
autonomic
axon
blood-brain barrier
brain stem
cell body
central nervous system (CNS)
cerebellum
cerebrospinal fluid (CSF)
cerebrum
cervical enlargement
convolutions
corpus callosum
cortex
cranial nerves
dendrite
depolarized
descending tracts
diencephalon
dorsal root
effectors
epilepsy
ganglia
gray matter
gyri
hyperreflexia
hyporeflexia
hypothalamus
interneuron
lobe
lumbar enlargement
membrane potential
meninges

CHAPTER OUTLINE

- General Functions of the Nervous System
- Neuron Structure
- Nerve Impulse and Synapse
- Central Nervous System
- Peripheral Nervous System
- Neurologic Testing

OBJECTIVES

After completing Chapter 5, you will be able to:

- 5.1 Explain the difference between the central nervous system and the peripheral nervous system.
- 5.2 Describe the functions of the nervous system.
- 5.3 Describe the structure of a neuron.
- 5.4 Describe the function of a nerve impulse and how a nerve impulse is created.
- 5.5 Describe the structure and function of a synapse.
- 5.6 Describe the function of the blood-brain barrier.
- 5.7 Describe the structure and functions of meninges.
- 5.8 Describe the structure and functions of the spinal cord.
- 5.9 Define reflex and list the parts of a reflex arc.
- 5.10 List the major divisions of the brain and give the general functions of each.
- 5.11 Describe the differences between the somatic nervous system and autonomic nervous system.
- 5.12 Explain the two divisions of the autonomic nervous system.
- 5.13 Explain the functions of the cranial and spinal nerves.
- 5.14 Describe the location and function of cerebrospinal fluid.
- 5.15 Describe various disorders of the nervous system and how they are diagnosed and treated.

KEY TERMS (Continued)

meningitis	plexus	subarachnoid space
motor	polarized	sulci
myelin	reflex	sympathetic
nerve fiber	repolarization	synaptic knob
nerve impulse	Schwann cell	thalamus
neuralgia	sciatica	ventral root
neurotransmitter	seizure	ventricle
parasympathetic	sensory	vesicles
paresthesias	somatic	white matter
peripheral nervous system	spinal nerves	

Introduction

The nervous system is a highly complex system. It controls all other organ systems and is important for maintaining balance within those systems. Disorders of the nervous

system are numerous and often very difficult to diagnose and treat because of the complexity of this system.

CASE STUDY

A 22-year-old woman comes to the family practice office where you work. She complains of tingling sensations in her fingers and toes. She also states that even though she wears thick mittens during cold weather, her fingers and toes turn blue and she experiences a lot of pain. A doctor diagnoses her with Raynaud's disease and tells her that it is an overreaction of the sympathetic nerves in her fingers and toes. She is scheduled for a regional sympathectomy, which will cut the sympathetic fibers to her fingers and toes.

As you read this chapter, consider the following questions:

1. What effect do sympathetic nerves have on blood vessels?
2. Why does Raynaud's disease produce pain and blue coloration in the fingers and toes?
3. How is a sympathectomy going to help this patient's condition?

General Functions of the Nervous System

The nervous system is divided into two major parts—the **central nervous system (CNS)** and the **peripheral nervous system**. The CNS consists of the brain and the spinal cord, and the peripheral nervous system consists of peripheral nerves.

The three functions of the nervous system are to (1) detect and interpret **sensory** information, (2) make decisions about the sensory information that is received, and (3) carry out **motor** functions based on the decisions made.

Sensory receptors at the ends of peripheral nerves pick up information about the body's internal and external environment. For example, when you feel pain, a sensory receptor identifies that information. When you see images, special types of sensory receptors called visual receptors detect those images. All sensory information is picked up in the peripheral nervous system and sent to the CNS for interpretation. When sensory information reaches a part of the brain called the cerebral cortex, a person actually perceives the sensory information.

The decision-making function (also called the integrative function) takes place in the brain or spinal cord. These organs receive sensory information and make decisions regarding the information. For example, if you feel pain your brain might decide you need to move away from the painful stimulus. If you see a red light, your brain might decide you need to stop your car.

Once decisions are made, the nervous system carries out motor functions. A motor function is the stimulation of a muscle (skeletal, smooth, or cardiac) or a gland. For example, if your brain interpreted that you are touching

something hot and decided you should move away from the painful stimulus, the motor function would be stimulation of the skeletal muscles in your arm that allow you to pull your finger away from the painful stimulus. If you see a red light and your brain decided that you need to stop the car, the motor function would be activating the muscles in the leg that allow you to push a brake pedal. Muscles and glands are called **effectors** of the nervous system.

Neuron Structure

Neurons are the functional cells of the nervous system. They transmit electrochemical messages called **nerve impulses** to other neurons and effectors (muscles or glands). An important characteristic about neurons is that they lose their ability to divide. Therefore, when neurons are destroyed by disease, they cannot be replaced. However, the neuroglial cells that surround and support neurons never lose their ability to divide. All neurons have a **cell body** and processes called **nerve fibers** that extend from the cell body (Figure 5-1).

The cell body is the portion of the neuron that contains the nucleus and typical organelles such as rough endoplasmic reticulum, mitochondria, lysosomes, and a Golgi apparatus. It is responsible for generating the large amounts of proteins and energy that the neuron needs to carry out its important functions.

Extending from the cell body are nerve fibers. The two types of nerve fibers are axons and dendrites. A neuron may have one or more dendrites but typically has only one axon. **Dendrites** are usually short and branch profusely near the cell body. Their function is to receive information for the neuron. **Axons** are typically long and branch profusely after they have extended far away from the cell body.

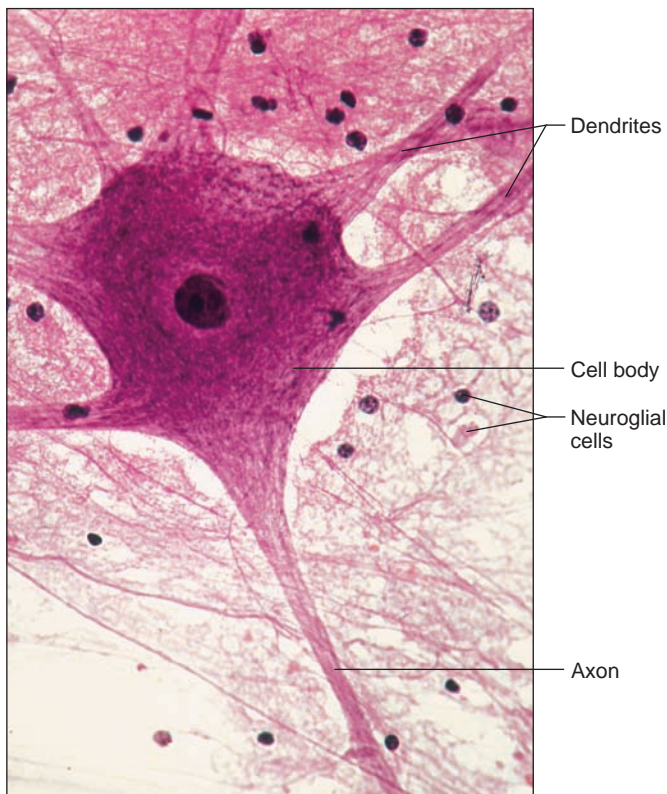


Figure 5-1. A typical neuron surrounded by neuroglial cells.

Their function is to send information (nerve impulses) away from the cell body.

In the peripheral nervous system, neuroglial cells, called **Schwann cells**, wrap themselves around axons; the axons are coated by the cell membranes of the Schwann cells. The cell membranes contain large amounts of **myelin**, which is a fatty substance. Myelin insulates the axons and allows them to send nerve impulses quickly.

Neurons can be classified as sensory neurons, **inter-neurons**, or motor neurons based on their functions. Sensory (afferent) neurons carry sensory information from the periphery to the CNS. These neurons pick up sensory information from their receptors, which are usually at the tips of their dendrites. Interneurons are found only in the CNS, and they function to link neurons together. Interneurons also transmit impulses from one part of the spinal cord or brain to another. They are involved in the decision-making function of the nervous system, and they direct information to motor neurons. Motor (efferent) neurons carry information from the CNS to effectors (muscles or glands) in the peripheral nervous system. They are responsible for stimulating muscles to contract or glands to secrete their products.

Nerve Impulse and Synapse

Neuron cell membranes have a cell **membrane potential**. This means the membrane is polarized. Just like a battery is polar—one end is negative and the other end is

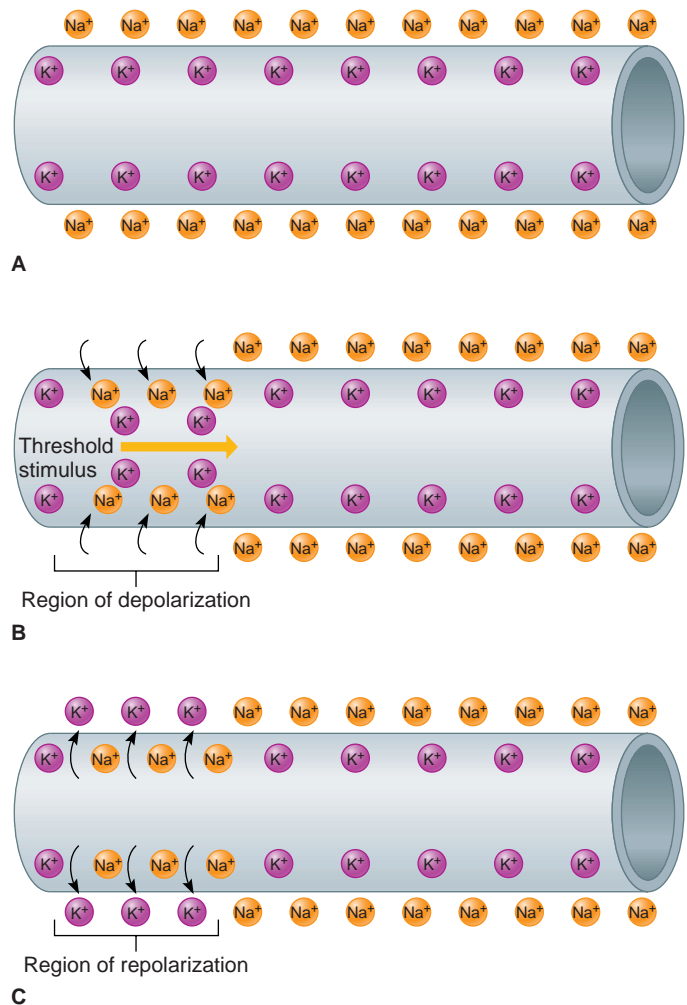


Figure 5-2. Nerve impulse. (a) At rest, or in its polar state, more Na^+ is on the outside of the membrane, which makes the outside positive and the inside negative (less positive). (b) When Na^+ moves into the cell, the membrane depolarizes, meaning that the inside becomes more positive. (c) The membrane repolarizes when K^+ and later Na^+ move to the outside of the cell membrane.

positive—neuron cell membranes are polar because the inside is negatively charged and the outside is positively charged. In most of the cells in the body, the outside of cell membranes is positively charged because more positive ions are on the outside. The inside of cell membranes is negatively charged because more negative ions are on the inside. This membrane potential is very important for the function of neurons (Figure 5-2).

Potassium and sodium ions are both positively charged and play important roles in generating nerve impulses. When a neuron is at rest or without stimulation, the outside of its membrane is positively charged and the inside is negatively charged because the total of sodium and potassium ions is greater outside the membrane. As long as the neuron is at rest, it remains in this **polarized** state.

However, a neuron will respond to stimuli such as heat, pressure, and chemicals by changing the amount of polarization across its membrane. For example, it can respond to

a stimulus by making the outside of its membrane less positive. When this happens, the neuron has **depolarized**. In other words, it has become less polar. To make the outside of the membrane less positive, some of the sodium ions flow to the inside of the cell membrane. If the membrane of an axon becomes depolarized enough, a nerve impulse (**action potential**) is created. A nerve impulse is the flow of electric current along the axon membrane. Eventually, the axon membrane becomes polar again by the return of positively charged ions to the outside of the cell membrane. The return to the original polar (resting) state is called **repolarization**.

An unmyelinated axon does not conduct a nerve impulse as quickly as a myelinated axon does. Also, the speed of the nerve impulse is related to the diameter of the axon. The larger the diameter, the faster the nerve impulse travels to the end of the axon.

When a nerve impulse travels down an axon, the impulse eventually reaches the ends of axon branches, called **synaptic knobs**. These synaptic knobs contact dendrites, cell bodies, and the axons of other neurons. Whatever the synaptic knob is contacting is called a postsynaptic structure. Within synaptic knobs are **vesicles**, or small sacs that contain chemicals called **neurotransmitters**. When the nerve impulse reaches the synaptic knobs, the neurotransmitters are released onto postsynaptic structures (Figure 5-3).

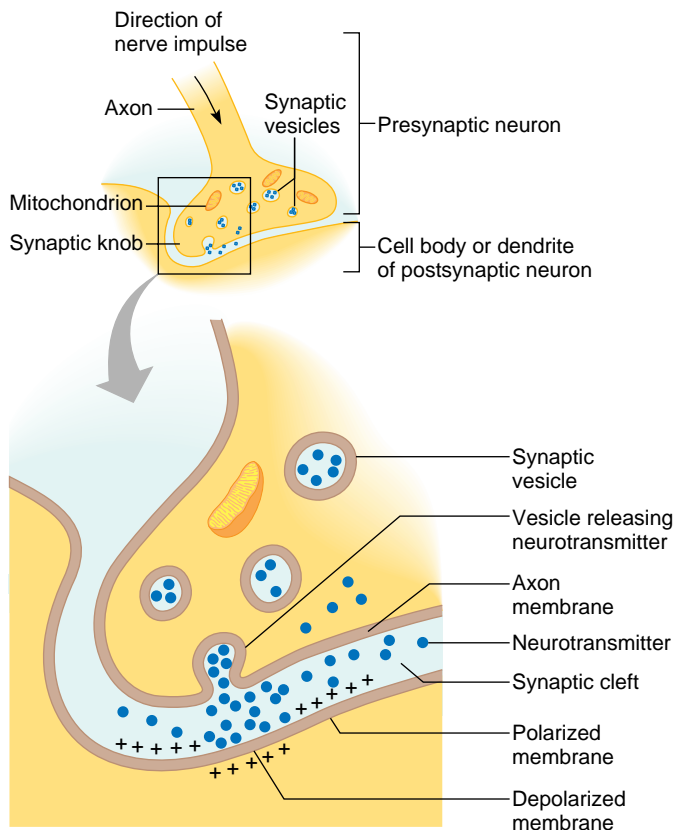


Figure 5-3. Synapse. When a nerve impulse reaches a synaptic knob, it releases a neurotransmitter onto the postsynaptic structure.

There are about 50 different neurotransmitters. Most neurons release only one type of neurotransmitter but some will release more than one type. Neurotransmitters are released through exocytosis. Their functions include causing muscles to contract or relax, causing glands to secrete products, activating neurons to send nerve impulses, or inhibiting neurons from sending nerve impulses.

Central Nervous System

The central nervous system includes the spinal cord and brain (Figure 5-4). The tissues of the CNS are so delicate that a **blood-brain barrier** and layers of membranes protect them. Tight capillaries form the blood-brain barrier. This barrier prevents certain substances from entering the tissues of the CNS. For example, various waste products and drugs do not cross the blood-brain barrier very well. Inflammation, however, can make this barrier more permeable.

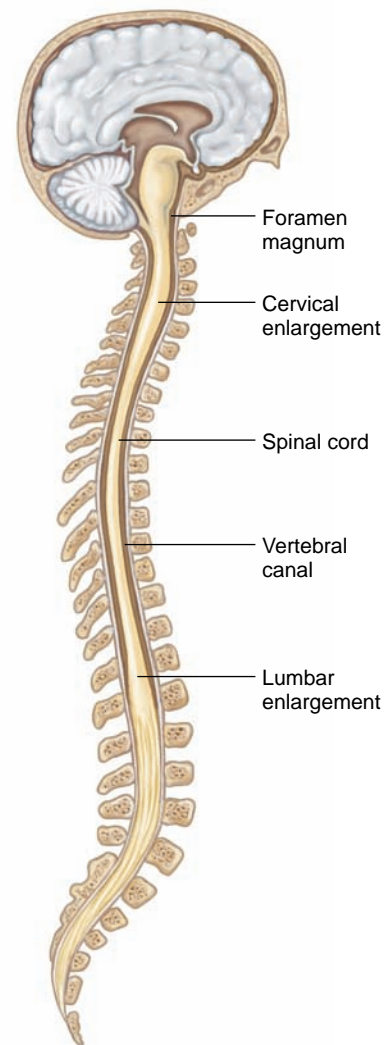


Figure 5-4. The central nervous system (CNS) consists of the brain and spinal cord. The spinal cord ends at the level of second lumbar vertebra.

Meninges are membranes that protect the brain and spinal cord. The three layers of meninges are dura mater, arachnoid mater, and pia mater. Dura mater is the toughest and outermost layer of the meninges. Arachnoid mater is the middle layer and is wispy in appearance (much like a spider's web—hence the name arachnoid, which means spider). Pia mater is the innermost and most delicate layer. It sits directly on top of the brain and spinal cord and holds blood vessels onto the surface of these structures. Between the arachnoid mater and pia mater is an area called the **sub-arachnoid space**. It contains **cerebrospinal fluid (CSF)**, which cushions the CNS.

Spinal Cord

The spinal cord is a slender structure that is continuous with the brain. The spinal cord descends into the vertebral canal and ends around the level of the second lumbar vertebra. The spinal cord is divided into 31 spinal segments: 8 cervical segments, 12 thoracic segments, 5 lumbar segments, 5 sacral segments, and 1 coccygeal segment. The thickening of the spinal cord in the neck region is called the **cervical enlargement** and contains the motor neurons that control the muscles of the arms. Another thickening of the spinal cord occurs in the lumbar region. This thickening is called the **lumbar enlargement** and contains the motor neurons that control the muscles of the legs (Figure 5-4).

Gray and White Matter. When you view a cross section of the spinal cord, you observe two differently colored areas. The inner tissue is termed **gray matter** because its color is darker than the outer tissue, which is termed **white matter**. The gray matter contains neuron cell bodies and their dendrites, whereas the white matter contains myelinated axons. The divisions of the gray matter are called horns, and the divisions of the white matter are called columns (funiculi). The columns contain groups of axons called nerve tracts. A canal runs down the entire length of the spinal cord through the center of the gray matter. This canal is called the central canal and contains CSF (Figure 5-5).

Ascending and Descending Tracts. One function of the spinal cord is to carry sensory information up to the brain. The tracts that carry sensory information up to the brain are called **ascending tracts**. Another function of the spinal cord is to carry motor information down from the brain to muscles and glands. These tracts are called **descending tracts**.

Reflexes. Another important function of the spinal cord is to participate in reflexes. A **reflex** is a predictable, automatic response to stimuli. For example, if you touch something very hot, the predictable response is that you will pull your finger away from the hot surface; this type of reflex is called a withdrawal reflex. The information that flows through a typical reflex moves in the following order: from receptors to sensory neurons to interneurons

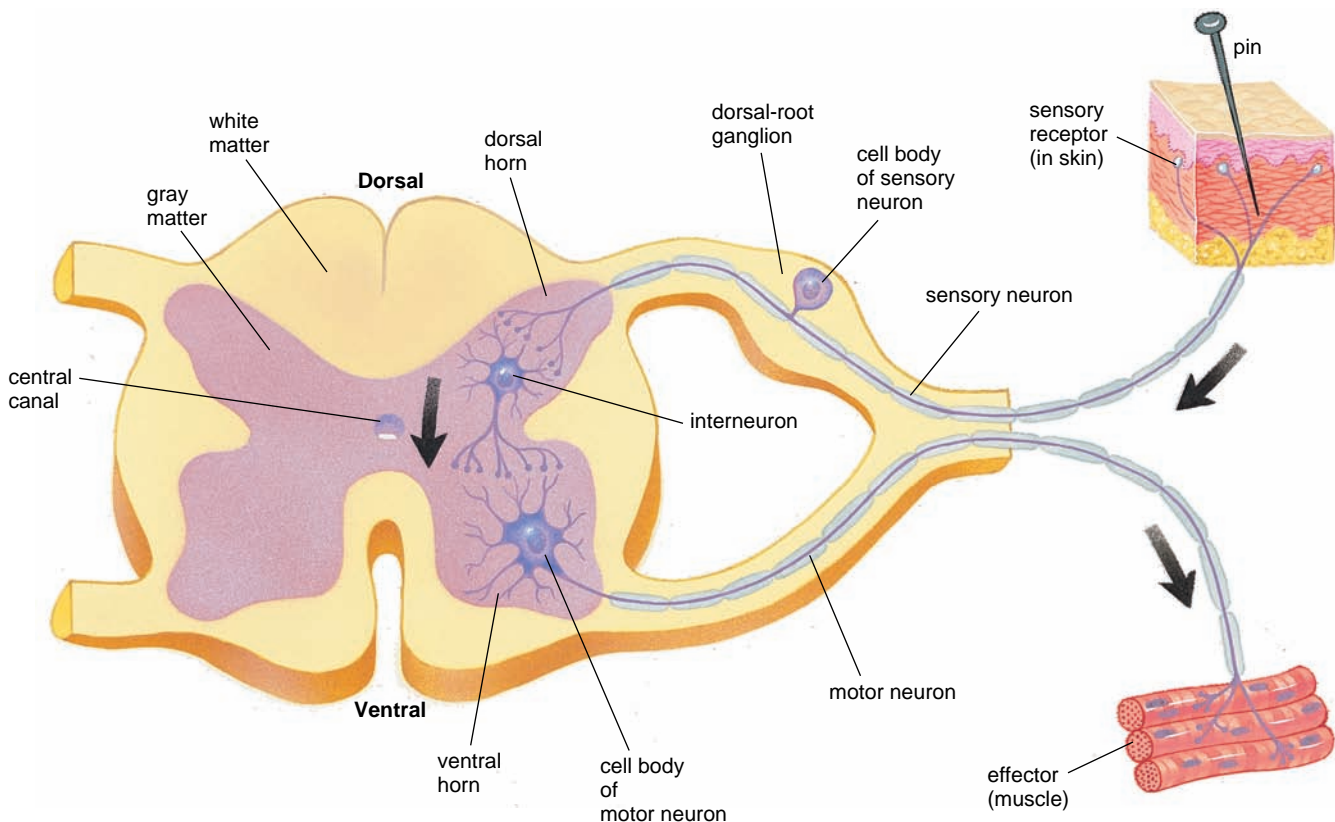


Figure 5-5. This cross section of the spinal cord and a spinal nerve illustrates a reflex arc.

to motor neurons to effectors. In this example of the withdrawal reflex, the receptors are in the skin at the tips of the fingers. These receptors send their information to sensory neurons that relay the information to interneurons in the spinal cord. The interneurons immediately relay the information to motor neurons that activate the muscles (effectors) in the arm. The muscles in the arm coordinate the movement of pulling your finger away from the painful stimulus. A person can consciously inhibit a reflex because the information also goes to the cerebral cortex where a person makes conscious decisions.

Brain

The brain can be divided into four major areas: the cerebrum, the diencephalon, the brainstem, and the cerebellum (Figure 5-6).

Cerebrum. The **cerebrum** is the largest part of the brain. It is divided into two halves called cerebral hemispheres. A thick bundle of nerve fibers called the **corpus callosum** connects the two hemispheres. The grooves on the surface of the cerebrum are called **sulci**. The “bumps” of brain matter between the sulci are called **gyri**, or **convolutions**. A deep groove called the longitudinal fissure runs between the two longitudinal hemispheres.

Lobes. Each cerebral hemisphere is divided into **lobes**—frontal, parietal, temporal, and occipital. The frontal lobes contain motor areas that allow a person to consciously decide to produce a body movement such as walking or tapping a pencil. Somatosensory areas are located in parietal lobes. These areas interpret sensations felt on or within the body. For example, if you feel a light touch on your right hand, the somatosensory area interprets the sensation and

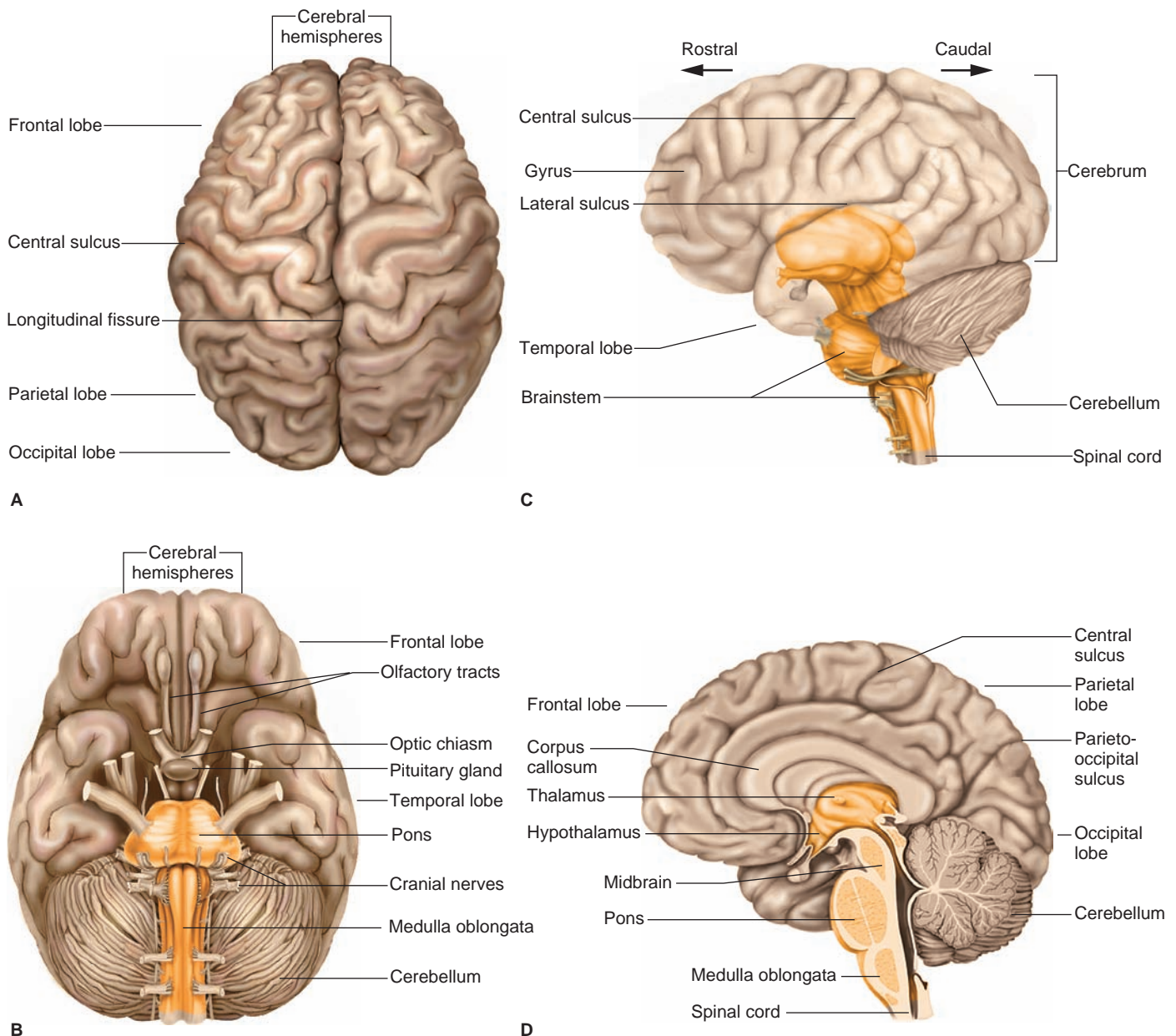


Figure 5-6. Four views of the brain: (a) superior, (b) inferior, (c) left lateral, and (d) sagittal section.

where it is occurring. The temporal lobes contain auditory areas that interpret sounds. Visual areas are located in the occipital lobes, and they interpret what a person sees.

Cortex. The outermost layer of the cerebrum is called the cerebral **cortex**. It is composed of gray matter and therefore contains neuron cell bodies and dendrites. This layer contains nearly 75% of all neurons in the entire nervous system. Beneath the cerebral cortex is white matter. Besides interpreting sensory information and initiating body movements, the cortex also stores memories and creates emotions.

Ventricles. **Ventricles** are interconnected cavities within the brain. They are filled with CSF. Recall that this fluid is also found in the subarachnoid space of the meninges and the central canal of the spinal cord. Therefore, CSF is located within the brain and spinal cord and also around the brain and spinal cord. This fluid protects and cushions the central nervous system.

Diencephalon. The **diencephalon** is located between the cerebral hemispheres and is superior to the brainstem. The diencephalon includes the thalamus and hypothalamus. The **thalamus** serves as a relay station for sensory information that heads to the cerebral cortex for interpretation. If sensory information does not pass through the thalamus before it reaches the cerebral cortex,

it cannot be interpreted correctly. For example, say you are feeling pain in your left forearm. This information goes up the spinal cord and through the thalamus and then to the cerebral cortex for interpretation. If the information did not go through the thalamus, the cerebral cortex may interpret that you are feeling cold instead of pain in your left forearm. The **hypothalamus** maintains balance by regulating many vital activities such as heart rate, blood pressure, and breathing rate.

Brainstem. The **brainstem** is a structure that connects the cerebrum to the spinal cord. The three parts of the brainstem are the midbrain, the pons, and the medulla oblongata. The midbrain lies just beneath the diencephalon. It controls both visual and auditory reflexes. An example of a visual reflex is when you see something in your peripheral vision and you automatically turn your head to view it more clearly.

The pons is a rounded bulge on the underside of the brain stem situated between the midbrain and the medulla oblongata. It contains nerve tracts to connect the cerebrum to the cerebellum. The pons also regulates breathing.

The medulla oblongata is the most inferior portion of the brain stem and is directly connected to the spinal cord. It controls many vital activities such as heart rate, blood pressure, and breathing. It also controls reflexes associated with coughing, sneezing, and vomiting.



Educating the Patient

Preventing Brain and Spinal Cord Injuries

In the United States alone, almost half a million people a year suffer brain and spinal cord injuries. The most common causes of these injuries are motor vehicle accidents, sports and recreational accidents—especially diving—and violence. People at the highest risk for spinal cord injuries are children and teens. However, most brain and spinal cord injuries can be prevented. You can use the following tips to educate patients on preventing these types of injuries.

Prevention Tips

- Know the depth of water into which you are diving. More than 90% of diving injuries occur in 5 feet of water or less.
- Explore diving areas before diving. For example, know where rocks are located before you dive.
- Do not drive or do any recreational activity while intoxicated. Alcohol affects good judgment and control. Alcohol-related traffic crashes are the leading cause of disabling brain and spinal cord injuries.
- Always wear a helmet when riding a bike or motorcycle. Your risk of brain injury is 85% greater during a biking accident if you are not wearing a helmet. Make sure your helmet fits properly.
- Always wear appropriate protective gear while playing any sport.
- Avoid surfing headfirst.
- Always wear your safety belt.
- Make sure children use car seats that are appropriate for their age and weight.
- Be familiar with ways to get help quickly in emergencies.
- Follow traffic rules and signs while walking, biking, or driving.
- Follow safety rules on playgrounds.
- Store firearms and ammunition in separate and locked places.
- Teach children the safety rules to follow if they find a gun.

Cerebellum. The **cerebellum** is inferior to the occipital lobes of the cerebrum and posterior to the pons and medulla oblongata. It coordinates complex skeletal muscle contractions that are needed for body movements. For example, when you walk, many muscles have to contract and relax at appropriate times. Your cerebellum coordinates these activities. The cerebellum also coordinates fine movements such as threading a needle, playing an instrument, and writing.

Peripheral Nervous System

The peripheral nervous system consists of nerves that branch off the CNS. These nerves are called peripheral nerves and are classified in two types—**cranial nerves** and **spinal nerves**.

Cranial Nerves

Cranial nerves are peripheral nerves that originate from the brain. Roman numerals and names designate the twelve different cranial nerves.

- I. *Olfactory nerves* carry smell information to the brain for interpretation.
- II. *Optic nerves* carry visual information to the brain for interpretation.
- III. *Oculomotor nerves* are found within the muscles that move the eyeball, eyelid, and iris.
- IV. *Trochlear nerves* act in the muscles that move the eyeball.
- V. *Trigeminal nerves* carry sensory information from the surface of the eye, the scalp, facial skin, the lining of the gums, and the palate to the brain for interpretation. They also are found within the muscles needed for chewing.
- VI. *Abducens nerves* act in the muscles that move the eyeball.
- VII. *Facial nerves* are found in the muscles of facial expression as well as in the salivary and tear glands. These nerves also carry sensory information from the tongue.
- VIII. *Vestibulocochlear nerves* carry hearing and equilibrium information from the inner ear to the brain for interpretation.
- IX. *Glossopharyngeal nerves* carry sensory information from the throat and tongue to the brain for interpretation. They also act in the muscles of the throat.
- X. *Vagus nerves* carry sensory information from the thoracic and abdominal organs to the brain for interpretation. These nerves are also found within the muscles in the throat, stomach, intestines, and heart.
- XI. *Accessory nerves* are found within the muscles of the throat, neck, back, and voice box.
- XII. *Hypoglossal nerves* are found within the muscles of the tongue.

Spinal Nerves

Spinal nerves are peripheral nerves that originate from the spinal cord (Figure 5-7). There are 31 pairs of spinal nerves: 8 pairs of cervical nerves (numbered C1 through C8), 12 pairs of thoracic nerves (numbered T1 through T12), 5 pairs of lumbar nerves (numbered L1 through L5), 5 pairs of sacral nerves (numbered S1 through S5), and one pair of coccygeal nerves (Co).

Two roots, a ventral root and a dorsal root, form each spinal nerve (see Figure 5-5). The **ventral root** contains axons of motor neurons only, and the dorsal root contains axons of sensory neurons only. The **dorsal root** also contains a dorsal root ganglion, which contains the cell bodies of sensory neurons.

Except in the thoracic region, the main portions of spinal nerves fuse together to form nerve **plexuses**. The major nerve plexuses are the cervical, brachial, and lumbosacral. Nerves coming off the cervical plexus supply the skin and the muscles of the neck. The phrenic nerve also originates from the plexus. This nerve controls the diaphragm, which is a muscle that is needed for breathing.

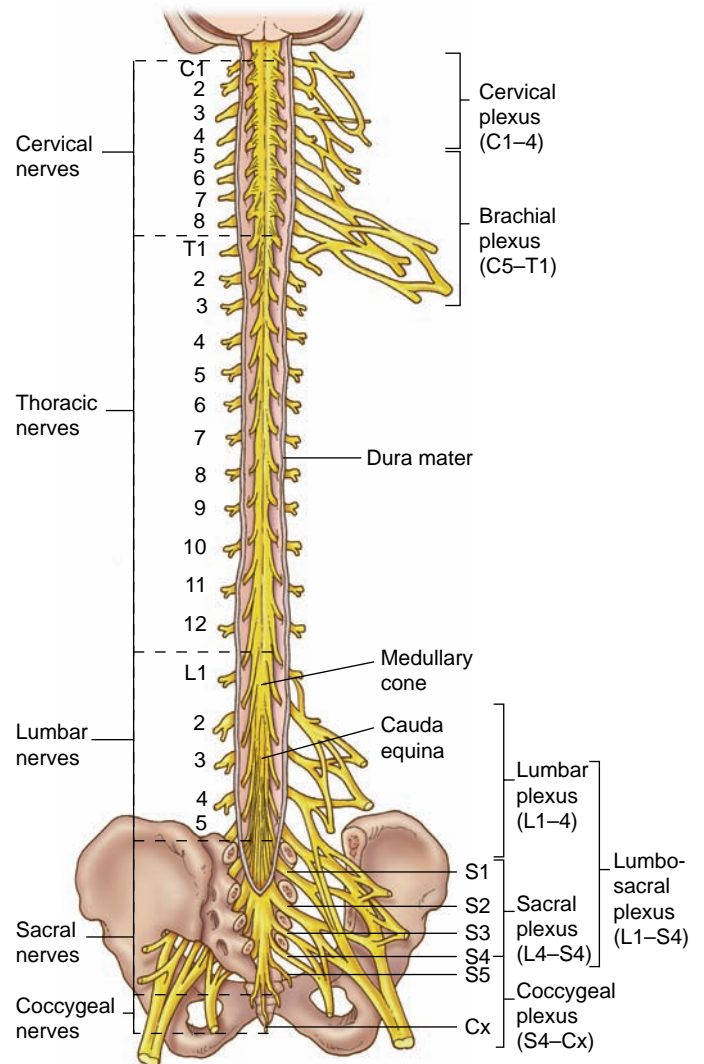


Figure 5-7. Spinal cord, spinal nerves, and plexuses.

The brachial plexus forms nerves that control muscles in the arms. The lumbosacral plexus supplies the lower abdominal wall, external genitalia, buttocks, thighs, legs, and feet. The largest nerve of the body, the sciatic nerve, originates from this plexus. This nerve controls the muscles of the legs.

Somatic and Autonomic Nervous Systems

The peripheral nervous system is divided into a somatic nervous system and an autonomic nervous system. The **somatic** nervous system consists of nerves that connect the CNS to skin and skeletal muscle. The somatic nervous system is often called the “voluntary” nervous system because it controls skeletal muscles, which are under voluntary control. The **autonomic** nervous system consists of nerves that connect the CNS to organs and other structures such as the heart, stomach, intestines, glands, blood vessels, and bladder (among others). The autonomic nervous system controls organs not under voluntary control, so it is often referred to as the “involuntary” nervous system.

In the autonomic nervous system, motor neurons from the brain and spinal cord communicate to other motor neurons that are located in ganglia. **Ganglia** are collections of neuron cell bodies outside the CNS. The motor neurons of ganglia then communicate to various organs and blood vessels.

The two divisions of the autonomic nervous system are the sympathetic and the parasympathetic (Figure 5-8). The **sympathetic** division prepares organs for “fight-or-flight” situations. In other words, it prepares them for stressful or emergency situations. For example, the sympathetic division prepares the heart for a stressful or frightening situation by increasing the heart rate. The **parasympathetic** division prepares the body for resting and digesting. For example, the parasympathetic division prepares the heart for resting by keeping the heart rate relatively low. Notice that sympathetic and parasympathetic actions are antagonistic, meaning that they function in opposite ways. Most of the body’s organs are under parasympathetic control.

Many neurons of the sympathetic division are located in the thoracic and lumbar regions of the spinal cord. For this reason, this division is also called the thoracolumbar division. The sympathetic neurons usually release the neurotransmitter norepinephrine into organs and glands. Norepinephrine increases the heart and breathing rates, slows down the activity of the digestive glands, slows down the muscles of the stomach and the intestines, and dilates the pupils. Sympathetic nerves also control the constriction of blood vessels. When blood vessels constrict, blood pressure increases, which is a needed response during an emergency situation.

Many neurons of the parasympathetic division are located in the brain stem and the sacral regions of the spinal

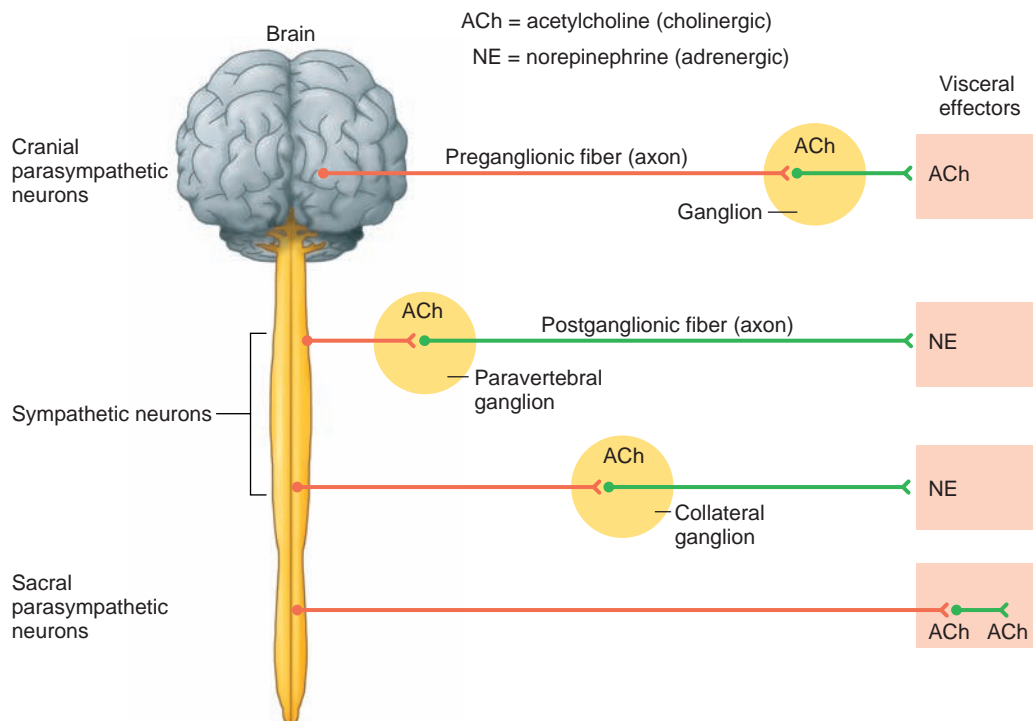


Figure 5-8. Divisions of the autonomic nervous system. Most parasympathetic fibers release acetylcholine onto visceral effectors. Most sympathetic fibers release norepinephrine onto visceral effectors.

cord. For this reason, this division is also referred to as the craniosacral division. All parasympathetic neurons release acetylcholine onto organs and glands. Acetylcholine is a neurotransmitter that slows the heart and breathing rates, constricts the pupils, activates digestive glands, and activates the muscles of the stomach and intestines. Most blood vessels in the body do not receive communication from parasympathetic nerves.

Neurologic Testing

Patients with nervous system disorders may have a wide variety of signs and symptoms, but the most common are headache, muscle weakness, and **paresthesias** (loss of feeling). A typical neurologic examination can determine the following:

- State of consciousness. This state can vary from normal to a state of coma. A patient in a coma cannot respond to stimuli and cannot be awakened. Other terms used to describe states of consciousness include *stupor* (difficulty being awakened), *delirium* (being confused or having hallucinations), *vegetative* (having no cortical function), and *asleep* (can be aroused with normal stimulation).
- Reflex activity. Reflex tests primarily determine the health of the peripheral nervous system.
- Speech patterns. Abnormal speech patterns include a loss of the ability to form words correctly or to form sentences that make sense.
- Motor patterns. Abnormal motor patterns include the loss of balance, abnormal posture, or inappropriate movements of the body. For example, chorea is an exaggerated and sudden jerking of a body part.

Diagnostic Procedures

Common diagnostic procedures to determine neurologic disorders include the following specialized tests:

- Lumbar puncture. Whenever a physician needs to examine CSF, a lumbar puncture is performed. A needle is used to remove CSF from the subarachnoid space usually below the third lumbar vertebra of the spinal column. Analysis of this fluid reveals a great deal about the health of a patient. For example, cancer cells in CSF often indicate a brain or spinal cord tumor. White blood cells in this fluid indicate infections such as meningitis. Red blood cells indicate abnormal bleeding.
- Magnetic resonance imaging (MRI). This procedure allows for the brain and spinal cord to be visualized from many angles. It uses powerful magnets to generate images and is useful at detecting tumors, bleeding, or other abnormalities.
- Positron emission tomography (PET) scan. This procedure uses radioactive chemicals that collect in specific

areas of the brain. These chemicals allow images of those specific areas to be generated. This test is useful in detecting blood flow to areas of the brain, brain tumors, and the diagnosis of such diseases as Parkinson's and Alzheimer's.

- Cerebral angiography. This procedure uses dyes that can be visualized in the blood vessels of the brain. It is useful in detecting aneurysms (abnormally dilated blood vessels).
- Computerized tomography (CT) scan. This very common procedure produces images that provide more information than a standard x-ray. It is useful in detecting tumors and other abnormal structures.
- Electroencephalogram (EEG). This test detects electrical activity in the brain. It is useful in diagnosing various states of consciousness.
- X-ray. This procedure is useful in detecting skull or vertebral fractures.

Cranial Nerve Tests

Disorders of the cranial nerves can be determined using the following tests:

- The olfactory nerves (I) are tested by asking a patient to smell various substances.
- Cranial nerves III, IV, and VI are tested by asking a patient to track the movement of the physician's finger. If a patient cannot move her eyeballs properly, there may be damage to one of these nerves. Recall that these nerves control the muscles that move the eyeballs.
- Cranial nerve V controls the muscles needed for chewing. To assess this nerve, a patient is asked to clench his teeth. The physician then feels the jaw muscles. If they feel limp or weak, this nerve may be damaged.
- If a person can no longer make facial expressions, then cranial nerve VII may be damaged. This nerve controls the muscles needed to make facial expressions.
- If a patient cannot extend his tongue and move it from side to side, cranial nerve XII may be damaged. This nerve controls tongue movement.

Reflex Testing

Testing a patient's reflexes allows a physician to evaluate the components of a reflex as well as the overall health of the individual's nervous system. The absence of a reflex is called **areflexia**. **Hyporeflexia** is a decreased reflex, and **hyperreflexia** is a stronger than normal reflex. The following are common reflex tests:

- Biceps reflex. The absence of this reflex may indicate spinal cord damage in the cervical region.
- Knee reflex. The absence of this reflex may indicate damage to lumbar or femoral nerves.
- Abdominal reflexes. These reflexes are used to evaluate damage to thoracic spinal nerves.

Pathophysiology

Common Diseases and Disorders of the Nervous System

Alzheimer's disease is a progressive, degenerative disease that occurs in the brain.

- **Causes.** Fiber tangles within neurons, degenerating nerve fibers, and a decreased production of neurotransmitters cause the symptoms of this disorder. This disease is associated with advanced age, family history, certain genes, and possibly some environmental factors. Many causes have not yet been determined.
- **Signs and symptoms.** Common symptoms include a loss of memory, confusion, personality changes, language deterioration, impaired judgment, and restlessness.
- **Treatment.** There is no cure, but proper nutrition, physical exercise, social activity, and calm environments help to manage the disease.

Amiotrophic lateral sclerosis (ALS) is a fatal disorder characterized by the degeneration of neurons in the spinal cord and brain.

- **Causes.** Most causes are unknown but they are likely to involve hereditary and environmental factors.
- **Signs and symptoms.** Early symptoms include cramping of hand and feet muscles, persistent tripping and falling, chronic fatigue, and slurred speech. Signs and symptoms that appear in later stages include breathing difficulty and muscle paralysis.
- **Treatment.** There is no cure for this disorder; however, physical, speech, and respiratory therapies help to manage the symptoms. Some medications relieve muscle cramping, and one drug that prolongs the life of ALS patients has been approved by the FDA.

Bell's palsy is a disorder in which facial muscles are very weak or totally paralyzed.

- **Causes.** This condition can result from damage to cranial nerve VII (the facial nerve), but many times the cause is unknown. It is more common in people with diabetes, the flu, or a cold.
- **Signs and symptoms.** The most common signs and symptoms are a loss of feeling in the face, the inability to produce facial expressions, headache, and excessive tearing or drooling.
- **Treatment.** Treatments include the use of eyedrops, anti-inflammatory medications, and pain relievers. Symptoms usually diminish or go away within 5 to 10 days.

Brain tumors and cancers are abnormal growths in the brain. A brain tumor with cancer cells is termed malignant. Malignant tumors that start in any tissue of the brain are called primary brain cancers. Those that start in body

parts and spread to the brain are classified as secondary brain cancers. The most common primary brain tumors are gliomas that arise from neuroglial cells.

- **Causes.** Like most cancers, the causes are gene mutations. Factors associated with gene mutations include exposure to toxins, an impaired immune system, and hereditary factors.
- **Signs and symptoms.** The signs and symptoms depend on size and location of the tumor. Common symptoms include headache, seizures, nausea, weakness in the arms or legs, fatigue, changes in speech patterns, and a loss of memory.
- **Treatment.** Treatment often includes surgery, radiation therapy, chemotherapy, and gene therapy. The success of the treatment depends on the type of tumor, the extent of the diseases, the location of the tumor, the tumor's response to treatment, and the overall health of the patient.

Epilepsy and seizures occur when parts of the brain receive a burst of electrical signals that disrupt normal brain functioning. Seizures may be either partial or generalized. Partial seizures occur on one side of the brain, and generalized seizures occur on both sides. Epilepsy is the condition of having repeated, long-term seizures.

- **Causes.** Causes vary but may include birth trauma, high fevers, alcohol and drug withdrawal, head trauma, infections, brain tumors, and certain medications. Many causes are unknown.
- **Signs and symptoms.** The signs and symptoms may include visual disturbances, nausea, generalized abnormal feelings, a loss of consciousness, and uncontrolled muscle contractions and tremors.
- **Treatment.** The primary treatment is medication to prevent seizures. Surgery is sometimes an option in patients with partial seizures.

Guillain-Barré syndrome is a disorder in which the body's immune system attacks part of the peripheral nervous system. It usually has a sudden and unexpected onset.

- **Causes.** The destruction of myelin by the body's immune system produces the signs and symptoms. Viral infections, immunizations, and pregnancy sometimes trigger the disease.
- **Signs and symptoms.** Symptoms may include weakness or tingling sensations in the legs or arms that can progress to paralysis. Difficulty breathing and an abnormal heart rate are dangerous signs and symptoms. The disease normally runs its course, and with proper medical treatment, it is not fatal.

continued —→

Common Diseases and Disorders of the Nervous System (continued)

- **Treatment.** Various supportive therapies, such as the use of respirators and heart machines, are necessary until the disease subsides. Physical therapy is used to keep muscles strong.

Headaches affect almost everyone at some point in life. They can affect the very young to the very old. A wide variety of factors produce headaches. Most headaches do not require medical attention, but a physician should evaluate repetitive and severe headaches. Headaches commonly include tension headaches, migraines, and cluster headaches.

Tension headaches are classified as either episodic (occurring randomly) or chronic (occurring frequently):

Episodic tension headaches are the most common type of tension headache.

- **Causes.** This type of headache occurs randomly and is often the result of temporary stress or anger.
- **Signs and symptoms.** Symptoms include pain or soreness in the temples and the contraction of head and neck muscles.
- **Treatment.** Most of these headaches can be managed by taking an over-the-counter (OTC) medicine, and relief usually occurs in 1 or 2 hours. A person who takes medication daily or almost daily for headaches, should see a physician.

Chronic tension headaches occur almost every day and persist for weeks or months.

- **Causes.** This type of headache may be the result of stress or fatigue, but it may also be associated with physical problems, psychological issues, or depression.
- **Signs and symptoms.** As with episodic tension headaches, the symptoms include pain or soreness in the temples and the contraction of head and neck muscles.
- **Treatment.** People who suffer from chronic headaches should seek medical treatment.

Migraines are the most severe type of headache. They are responsible for more “sick days” than any other headache type. Almost 30 million people in the United States suffer from migraines.

- **Causes.** Hormones may influence migraines, which may explain why women experience migraines at least three times more often than men do. Migraine headaches are considered vascular headaches because they are associated with the distension of the arteries of the brain.
- **Signs and symptoms.** Migraines often begin as dull pains that develop into throbbing pains accompanied by nausea and a sensitivity to light and noise. There are many types of migraines but the two most common are *migraine with aura* and *migraine without aura*. Some patients have migraines that begin with an

aura. Auras may include the appearance of jagged lines or flashing lights, tunnel vision, hallucinations, or the detection of strange odors. The auras may last up to an hour and usually go away as the headache begins. Most migraine headaches last about 4 hours but some can last up to a week.

- **Treatment.** When treating migraines, a physician will prescribe a drug to relieve the pain but will also try to identify the factors that trigger it. There are many medicines available to treat migraines.

Cluster headaches are so named because the attacks come in groups. They are the most severe type of migraines. More men than women experience these types of headaches.

- **Causes.** Some research indicates that alcohol consumption can bring on attacks of cluster headaches.
- **Signs and symptoms.** Common symptoms include a runny nose, watery eyes, and swelling below the eyes. Cluster headaches normally last about 45 minutes to an hour, although they can last longer. It is common for a patient with this disorder to experience 1 to 4 headaches a day during a cluster time span. Cluster time spans can last weeks or months.
- **Treatment.** Various drugs are available for the treatment of these headaches.

Meningitis is an inflammation of the meninges.

- **Causes.** Causes may include bacterial, viral, and fungal infections. Some types of meningitis can be prevented with vaccines.
- **Signs and symptoms.** Fever, headache, vomiting, stiffness in the neck, sensitivity to light, drowsiness, and joint pain usually accompany this disorder.
- **Treatment.** The treatment varies depending on the type of meningitis. Intravenous antibiotics are used for bacterial meningitis, supportive therapy for viral meningitis, and antifungal drugs for fungal meningitis.

Multiple sclerosis (MS) is a chronic disease of the central nervous system in which myelin is destroyed.

- **Causes.** The causes are mostly unknown, but some known causes are viruses, genetic factors, and immune system abnormalities.
- **Signs and symptoms.** Depending on the type of MS, symptoms can range from mild to severe. In severe cases, a person will lose the ability to walk or speak.
- **Treatment.** There is no cure for MS, but supportive treatments can lessen the symptoms. Some medications are also available to treat symptoms.

Neuralgias are a group of disorders commonly referred to as nerve pain. They most frequently occur in the nerves of the face.

- **Causes.** There are many causes of neuralgia, including trauma, chemical irritation of the nerves, bacterial

continued →

Common Diseases and Disorders of the Nervous System (continued)

infections, and diabetes. Many times the causes are unknown.

- **Signs and symptoms.** Sudden and severe skin pain are the most common symptoms. The pain repeatedly occurs in the same body area. Numbness of skin areas is also common.
- **Treatment.** Many times the disorder goes away by itself, and treatment, other than pain medication, is not needed. Other treatments include injections of anesthetics or surgery to remove the affected nerves.

Parkinson's disease is a motor system disorder. It is slowly progressive and degenerative.

- **Causes.** Most causes are undetermined, although it is known that patients with this disease lack certain chemicals in the brain. Brain tumors, certain drugs, carbon monoxide, or repeated head trauma may produce Parkinson's disease.
- **Signs and symptoms.** The most common signs and symptoms include trembling and stiffness of the arms and legs as well as a lack of coordination and balance.
- **Treatment.** There is no cure, but medications alleviate some symptoms and slow down the progression of this disease. Surgery is useful in some cases of Parkinson's.

Sciatica occurs when the sciatic nerve is damaged.

- **Causes.** The sciatic nerve is commonly damaged by excessive pressure on the nerve from prolonged sitting

or lying down. It is also easily damaged from trauma to the pelvis, buttocks, or thighs.

- **Signs and symptoms.** The most usual symptoms include numbness, pain, or tingling sensations on the back of a leg or foot. Weakness of leg and foot muscles can also develop.
- **Treatment.** This disorder is usually treated with pain medication and steroids. Physical therapy is also needed following trauma to the nerve.

Stroke occurs when brain cells die because of an inadequate blood flow. Stroke is sometimes referred to as a "brain attack."

- **Causes.** Most strokes are caused by the blockage of an artery in the neck or brain. They may also be caused by aneurysms that burst.
- **Signs and symptoms.** Signs and symptoms may include paralysis, speech problems, memory and reasoning deficits, coma, and possibly death. Symptoms will vary depending on the location of the stroke within the brain.
- **Treatment.** Because neurons in the brain cannot be replaced, the effects of a stroke can be permanent. However, physical and speech therapy are often very useful in lessening the effects of a stroke.

Summary

The functions of the nervous system include detecting and interpreting sensory information, making decisions about that information, and responding to and carrying out motor functions based on those decisions. The cells responsible for these functions are neurons.

There are two divisions of the nervous system. The CNS consists of the brain and spinal cord. The peripheral nervous system is made up of cranial nerves and spinal nerves. All organs are under the control of the nervous system. Knowledge of this system is essential when assisting the physician during a neurologic exam.

REVIEW

CHAPTER 5

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. What effect do sympathetic nerves have on blood vessels?
2. Why does Raynaud's disease produce pain and blue coloration in the fingers and toes?
3. How is a sympathectomy going to help this patient's condition?

Discussion Questions

1. Explain the three general functions of the nervous system.
2. Describe the differences between the ascending and descending tracts of the spinal cord.
3. What are the two divisions of the autonomic nervous system? How do these two divisions differ?

Critical Thinking Questions

1. In some diseases, such as multiple sclerosis, myelin is destroyed. What is the function of myelin in the nervous system, and how can the destruction of myelin contribute to the signs and symptoms of multiple sclerosis?
2. What functional losses would you expect to observe in patients with the following brain injuries?
 - a. Stroke in an occipital lobe of the cerebrum
 - b. Damage to a temporal lobe of the cerebrum
 - c. Stroke in the medulla oblongata
 - d. Brain tumor in the primary motor area of the frontal lobe

Application Activities

1. Give the Roman numeral designations and functions of the following cranial nerves:
 - a. Facial nerve
 - b. Hypoglossal nerve
 - c. Trigeminal nerve
 - d. Vagus nerve
 - e. Optic nerve
2. What are the uses of the following diagnostic procedures?
 - a. Lumbar puncture
 - b. MRI
 - c. CT scan
 - d. Cerebral angiography
3. Give the functions of the following neuron types:
 - a. Sensory neurons
 - b. Motor neurons
 - c. Interneurons
4. What parts of a neuron are found in gray matter? In white matter?

Internet Activity

Go to the *MEDLINEplus* Web site at <http://www.nlm.nih.gov/medlineplus/fainting.html>, and answer these questions:

- a. What is the clinical term for fainting?
- b. What are the two major types of fainting?
- c. What tests can be done to determine the causes of fainting?

CHAPTER 6

The Circulatory System

KEY TERMS

agglutination
agranulocyte
albumins
anemia
aneurysm
aortic valve
arrhythmia
atherosclerosis
atria
atrioventricular bundle
atrioventricular node
baroreceptors
basophil
bicuspid valve
bilirubin
biliverdin
capillary
carditis
chordae tendineae
chylomicron
coagulation
coronary sinus
deoxyhemoglobin
diapedesis
diastolic pressure
edema
embolus
endocardium
eosinophil
epicardium
erythroblastosis fetalis
erythrocyte
erythropoietin
fibrinogen
globulins
granulocyte

CHAPTER OUTLINE

- The Heart
- Blood Vessels
- Blood Pressure
- Circulation
- Blood
- The Lymphatic System

OBJECTIVES

After completing Chapter 6, you will be able to:

- 6.1 Describe the structure of the heart and the function of each part.
- 6.2 Trace the flow of blood through the heart.
- 6.3 List the most common heart sounds and what events produce them.
- 6.4 Explain how heart rate is controlled.
- 6.5 List the different types of blood vessels and describe the functions of each.
- 6.6 Define blood pressure and tell how it is controlled.
- 6.7 Trace the flow of blood through the pulmonary and systemic circulation.
- 6.8 List the major arteries and veins of the body and describe their locations.
- 6.9 List and describe the components of blood.
- 6.10 Give the functions of red blood cells, the different types of white blood cells, and platelets.
- 6.11 List the substances normally found in plasma.
- 6.12 Explain how bleeding is controlled.
- 6.13 Explain the differences among blood types A, B, AB, and O.
- 6.14 Explain the difference between Rh-positive blood and Rh-negative blood.
- 6.15 Explain the importance of blood typing and tell which blood types are compatible.
- 6.16 List the organs of the lymphatic system and give their locations and functions.
- 6.17 Define lymph and tell how it is circulated in the body.
- 6.18 Describe signs, symptoms, causes, and treatments of various diseases and disorders of the heart, blood vessels, blood, and the lymphatic system.

KEY TERMS *(Continued)*

hematocrit	lipoprotein	parietal pericardium	systemic circuit
hemocytoblast	lymph	pathogen	systolic pressure
hemostasis	lymphocyte	pericardium	thrombocytes
hepatic portal system	megakaryocytes	platelets	thrombophlebitis
hilum	mitral valve	pulmonary circuit	thrombus
hypertension	monocytes	pulmonary trunk	tricuspid valve
jaundice	murmur	pulmonary valve	varicose veins
leukemia	myocardial infarction	Purkinje fibers	vasoconstriction
leukocyte	myocardium	Rh antigen	vasodilation
leukocytosis	neutrophils	RhoGAM	ventricles
leukopenia	oxyhemoglobin	sinoatrial node	visceral pericardium

Introduction

The circulatory system consists of the heart and blood vessels. It is responsible for sending blood to the lungs to pick up oxygen and to the digestive system to pick up nutrients in order to deliver oxygen and nutrients to all the organ

systems in the body. This system also circulates waste products to certain organ systems so that these wastes can be removed from the blood. This chapter discusses the lymphatic system because it also circulates fluids throughout the body.

CASE STUDY

A 42-year-old man was referred to the cardiologist's office for an evaluation. The patient had recently started an exercise program for weight loss. For the last 3 weeks, following exercise, he had noticed radiating chest pain (angina pectoris) that stopped after rest. This condition had worsened in the last week. The cardiologist ordered a stress echocardiogram (a test that visualizes the heart during increasing stress). The echocardiogram results suggested that the patient had coronary artery disease. The patient was scheduled for a cardiac catheterization the next morning. It was noted in the patient's chart that he smoked two packs of cigarettes per day.

As you read this chapter, consider the following questions:

1. What symptoms suggest that this patient is suffering from coronary artery disease and not some other disorder?
2. Why is it important to test the heart under stress rather than obtaining a resting echocardiogram?
3. What lifestyle changes should this patient make to prevent future heart attacks?
4. Why is a cardiac catheterization needed in addition to the stress echocardiogram?
5. What are the treatment options for this patient?

The Heart

Structures of the Heart

The heart is a cone-shaped organ about the size of a loose fist. It is located within the mediastinum and extends from the level of the second rib to about the level of the sixth rib. Although many people think that the heart is found in the left side of the chest, the heart is located only slightly left of the midline of the body. The heart is bordered

laterally by the lungs, posteriorly by the vertebral column, and anteriorly by the sternum. Inferiorly, the heart rests on the diaphragm.

Cardiac Membranes. A membrane called the **pericardium** covers the heart and the large blood vessels attached to it (Figure 6-1). The pericardium consists of an outer fibrous layer that covers two inner layers. The innermost layer is called the **visceral pericardium**, and it lies directly on top of the heart. The layer on top of the visceral

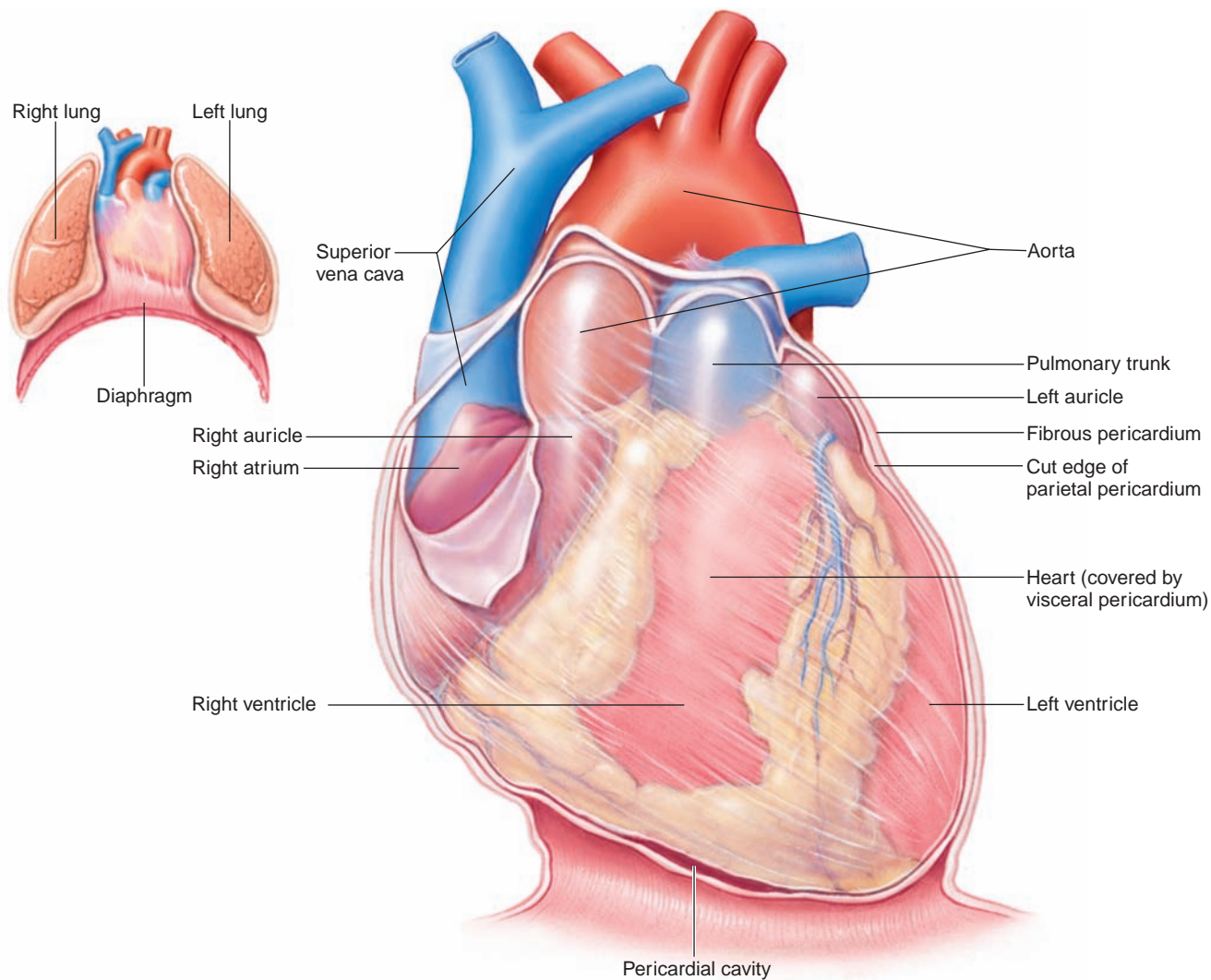


Figure 6-1. Location and membranes of the heart.

pericardium is called the **parietal pericardium**. The fibrous pericardium and the parietal pericardium form the pericardial sac. The space between the parietal pericardium and visceral pericardium is called the pericardial cavity. The pericardial cavity contains a slippery fluid called serous fluid. Serous fluid reduces friction between the membranes when the heart contracts.

The Heart Wall. The wall of the heart (Figure 6-2) is made of the following three layers:

- **Epicardium.** This outermost layer is also known as the visceral pericardium and contains fat, which helps to cushion the heart.
- **Myocardium.** This middle layer is the thickest layer of the wall and is made primarily of cardiac muscle.
- **Endocardium.** This innermost layer is thin and very smooth and stretches as the heart pumps blood. This layer also contains Purkinje fibers (see the section titled Cardiac Conduction System later in this chapter).

Heart Chambers and Valves. The heart contains four hollow chambers, two on the left and two on the right (Figure 6-3). The upper chambers of the heart are called **atria**. They have thin walls and function to receive blood returning to the heart from the lungs and the body. The bottom chambers of the heart are called **ventricles**. They function to pump blood into the arteries. The four valves of the heart keep blood flowing in one direction and include the tricuspid, bicuspid, pulmonary, and aortic valves.

Tricuspid Valve. The **tricuspid valve** has three cusps and is situated between the right atrium and the right ventricle. It prevents blood from flowing back into the right atrium when the right ventricle contracts. This valve is also called the right AV (atrioventricular) valve. The cusps of this valve are anchored by cordlike structures called **chordae tendineae** to bumps of cardiac muscle called **papillary muscles**. These muscles contract when the ventricles contract to close the valve.

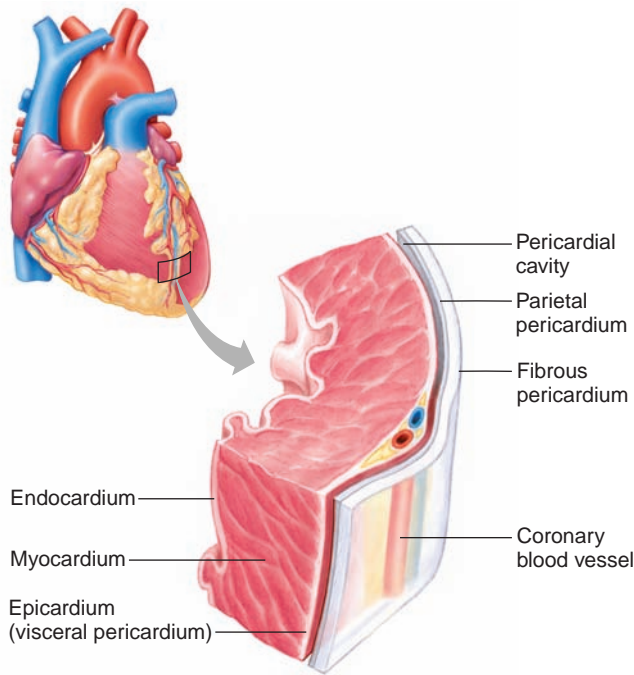


Figure 6-2. Layers of the wall of the heart.

Bicuspid Valve. The **bicuspid valve** has two cusps and is located between the left atrium and the left ventricle. It prevents blood from flowing back into the left atrium when the left ventricle contracts. This valve is known as

the **mitral valve** and the left AV valve. Like the tricuspid valve, the bicuspid valve also has chordae tendineae attached to papillary muscles.

Pulmonary Valve. The **pulmonary valve** is situated between the right ventricle and the pulmonary trunk. It prevents blood from flowing back into the right ventricle. Because its cusps are shaped like a half moon, this valve is called a semilunar valve.

Aortic Valve. The **aortic valve** is situated between the left ventricle and the aorta. It prevents blood from flowing back into the left ventricle and is also known as a semilunar valve.

Blood Flow Through the Heart

Blood that is low in oxygen and rich in carbon dioxide enters the right atrium of the heart through large veins called the inferior and superior vena cavae. From the right atrium, the blood flows over the tricuspid valve into the right ventricle. When the right ventricle contracts, blood is pushed over the pulmonary valve into a larger artery called the **pulmonary trunk**. The pulmonary trunk branches into pulmonary arteries, which carry blood to the lungs. In the lungs, blood picks up oxygen and gets rid of carbon dioxide. Blood rich in oxygen and low in carbon dioxide then returns to the heart through four veins called the pulmonary veins. The pulmonary veins empty the blood into

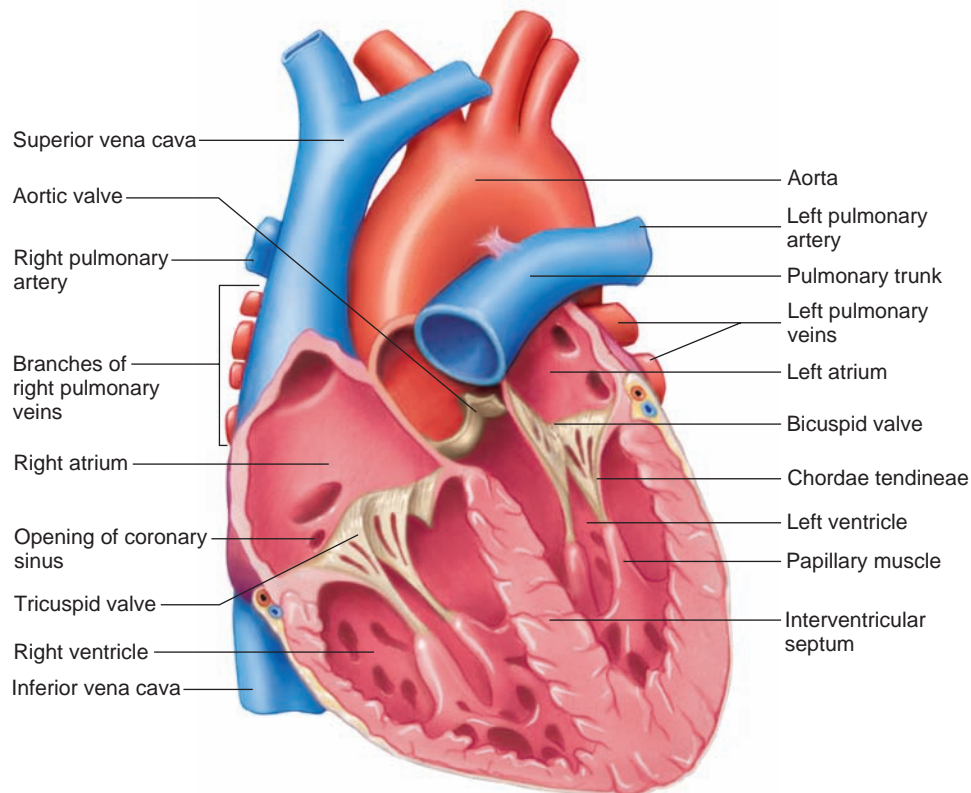


Figure 6-3. Coronal section of the heart.

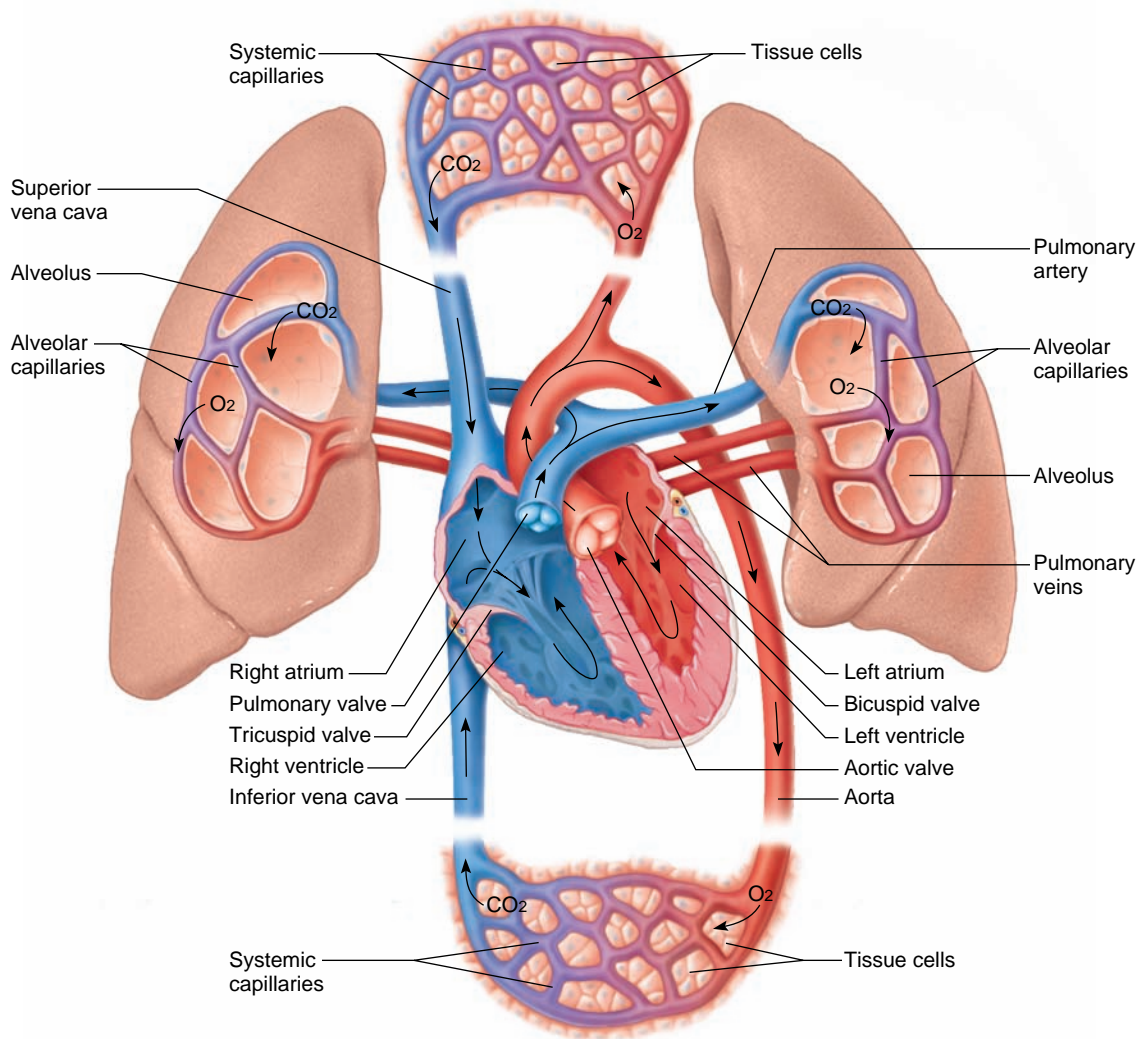


Figure 6-4. Pathway of blood through the heart and lungs and on to other body parts. The right side of the heart delivers blood to the lungs and the left side delivers blood to all other body parts.

the left atrium. From the left atrium, blood flows over the bicuspid valve into the left ventricle. When the left ventricle contracts, blood is pushed over the aortic valve into the aorta. The aorta distributes blood into its branches and throughout the body.

In the body, the blood gives oxygen to cells and picks up carbon dioxide. Veins of the body pick up the oxygen-poor blood and empty it into the vena cavae, and the whole circuit starts all over again. Note that arteries carry blood away from the heart and veins carry blood to the heart (Figure 6-4).

Cardiac Cycle

One heartbeat makes up one cardiac cycle. In one cardiac cycle, the top chambers (atria) of the heart contract and relax together and then the bottom chambers (ventricles) of the heart contract and relax together. When the right atrium contracts, the tricuspid valve opens and blood flows into the right ventricle. Likewise, when the left

atrium contracts, the bicuspid valve opens and blood flows into the left ventricle. When the right ventricle contracts, the tricuspid valve must close, the pulmonary valve opens, and blood is pushed into the pulmonary trunk. When the left ventricle contracts, the bicuspid valve must close, the aortic valve opens, and blood is pushed into the aorta.

The following factors influence the cardiac cycle:

- Exercise. Strenuous exercise increases the heart rate because skeletal muscles need more oxygen.
- Parasympathetic nerves. The parasympathetic nerve to the heart is the vagus nerve, and it generally keeps the heart rate relatively low.
- Sympathetic nerves. The sympathetic nerves increase the heart rate during times of stress.
- Cardiac control center. This center is located in the medulla oblongata. When blood pressure rises, this control center sends impulses to decrease the heart rate. When blood pressure falls, it sends impulses to increase the heart rate.

- Body temperature. An increase in body temperature usually increases the heart rate. This explains the high heart rate when a person runs a fever.
- Potassium ions. Low concentrations of potassium ions in the blood decrease the heart rate, but a high concentration causes an arrhythmia (abnormal heart rate).
- Calcium ions. Low concentrations of calcium ions in the blood depress heart actions, but high concentrations cause heart contractions called titanic contractions, which are longer than normal heart contractions.

Heart Sounds

During one cardiac cycle you can hear two heart sounds. The sounds are called *lubb* and *dupp*. These sounds are generated when valves in the heart snap shut. Lubb is the first heart sound and occurs when the ventricles contract and the tricuspid and bicuspid valves snap shut. Dupp is the second heart sound and occurs when the atria contract and the pulmonary and aortic valves snap shut.

Physicians will listen to heart sounds in order to diagnose certain conditions. For example, if AV valves are damaged, they will not close completely. This allows blood to leak back into atria when the ventricles contract and produces an abnormal heart sound called a **murmur**. Murmurs may indicate serious heart conditions, although many times heart murmurs are harmless.

Cardiac Conduction System

The cardiac conduction system consists of a group of structures that send electrical impulses through the heart. When cardiac muscle receives an electrical impulse, it contracts (Figure 6-5). The components of the cardiac conduction system are as follows:

- **Sinoatrial node (SA node)**. This node is located in the wall of the right atrium and generates an impulse that flows to the atrioventricular node. The SA node is also called the pacemaker of the heart because it generates the heart's rhythmic contractions.
- **Atrioventricular node (AV node)**. This node is located between the atria. After the impulse reaches the

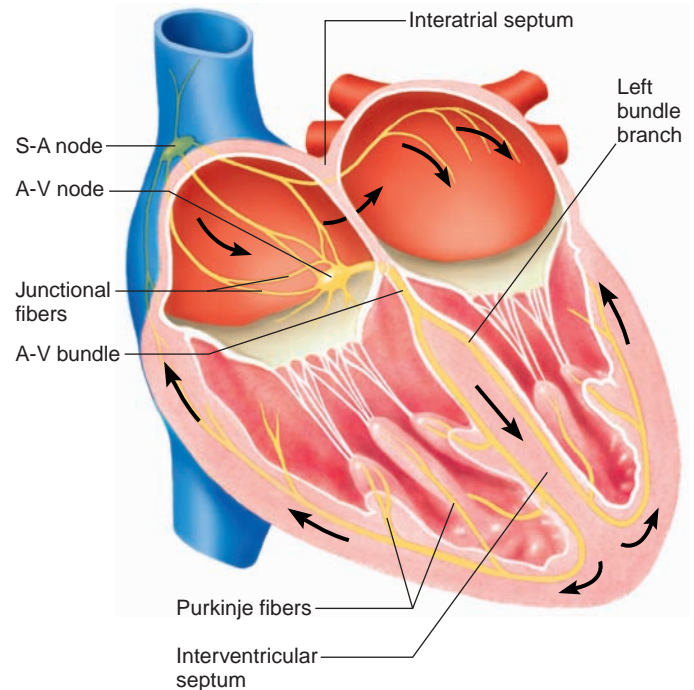
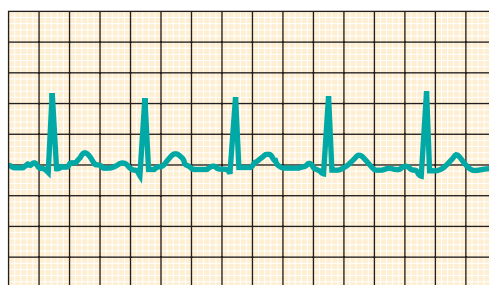


Figure 6-5. Cardiac conduction system.

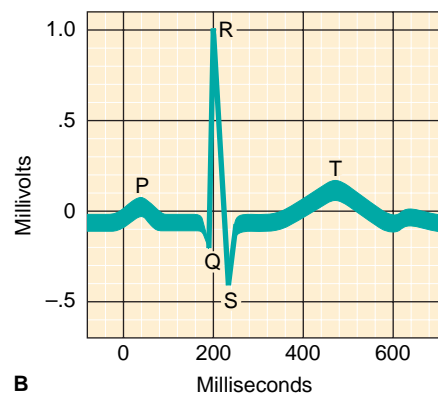
AV node, the atria contract and the impulse is sent to the atrioventricular bundle.

- **Atrioventricular bundle (AV bundle)**. This structure is located between the ventricles and sends an electrical impulse to the Purkinje fibers.
- **Purkinje fibers**. These fibers are located in the lateral walls of the ventricles. After the impulse flows through the Purkinje fibers, the ventricles contract and the SA node will start the flow of a new impulse.

Physicians use a test called an electrocardiogram (ECG or EKG) to tell if the cardiac conduction system is working properly. In a normal ECG, three waves are produced (Figure 6-6). The first wave (P wave) indicates that an electrical impulse was sent through the atria, which causes them to contract. The second wave (the QRS wave) is the largest of the three and indicates that an electrical impulse



A



B

Figure 6-6. Electrocardiogram. (a) A normal ECG and (b) waves of a normal ECG pattern.

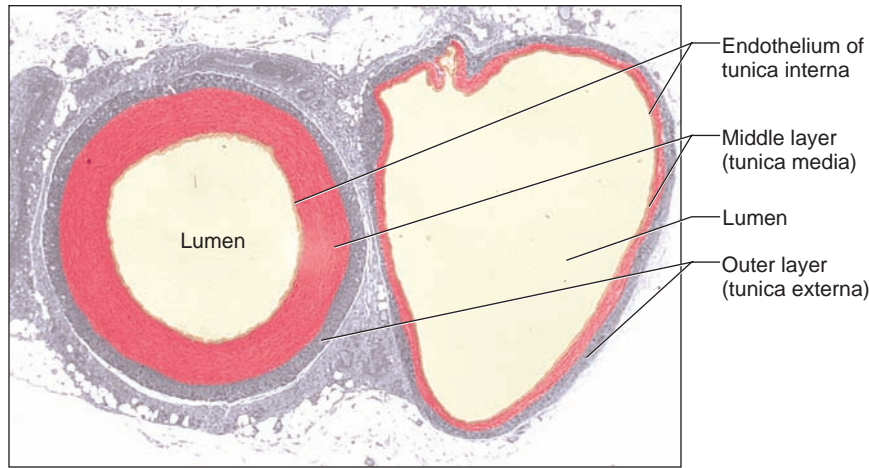


Figure 6-7. Cross sections of an artery (left) and a vein (right).

was sent through the ventricles, which causes them to contract. The third wave (T wave) indicates electrical changes that are occurring in the ventricles as they relax.

Blood Vessels

Blood vessels form a closed pathway that carries blood from the heart to cells and back again. These vessels include arteries, arterioles, veins, venules, and capillaries.

Arteries and Arterioles

Arteries are the strongest of the blood vessels. The muscular layer of arteries contains smooth muscle and is thicker than the muscular layer of other types of blood vessels (Figure 6-7). Arteries carry blood away from the heart and are under high pressure, which is the main reason they need to have thick walls. The muscular wall of an artery can constrict (**vasoconstriction**) to increase blood pressure or it can dilate (**vasodilation**) to decrease blood pressure. Small branches of arteries are called arterioles.

The tissues of the heart receive their blood supply through coronary arteries. Branches of the coronary arteries eventually give rise to very small blood vessels called capillaries. The capillaries of the heart are in the myocardium and allow oxygen to diffuse into the cardiac muscle cells. Blood leaving capillaries in the heart goes into cardiac veins. Cardiac veins eventually deliver the oxygen-poor blood to a large vein called the **coronary sinus**. The coronary sinus empties the blood into the right atrium. A heart attack or myocardial infarction often involves the blocking of one of the coronary arteries.

Veins and Venules

Blood is under no pressure in veins and does not move very easily. Therefore, the movement of blood through veins requires skeletal muscle contractions and valves. When skeletal muscles contract, they squeeze the veins

and blood is pushed through them, much like the way toothpaste is pushed out of a tube. The valves in veins prevent blood from flowing backward (Figure 6-8). **Varicose veins** occur when valves are destroyed and blood pools in veins, causing them to become dilated or expanded.

The sympathetic nervous system also influences the flow of blood through veins. The sympathetic nervous system causes vein walls to constrict, which forces blood through the veins. This only happens if blood pressure gets abnormally low in arteries.

Venules are very small blood vessels that are formed when capillaries merge together (Figure 6-9). Venules merge together to make veins, and veins carry blood toward the heart. The muscular layer in the walls of veins is thinner than the layer found in arteries.

Capillaries

Capillaries are branches of arterioles and are the smallest type of blood vessel. They connect arterioles to venules and have very thin walls that are only about one cell layer

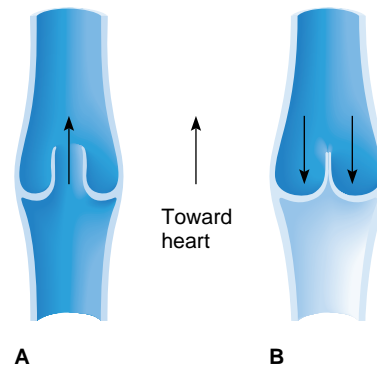


Figure 6-8. Venous valve. (a) Valve opens when blood is flowing toward the heart. (b) Valve closes to prevent blood from flowing away from the heart.

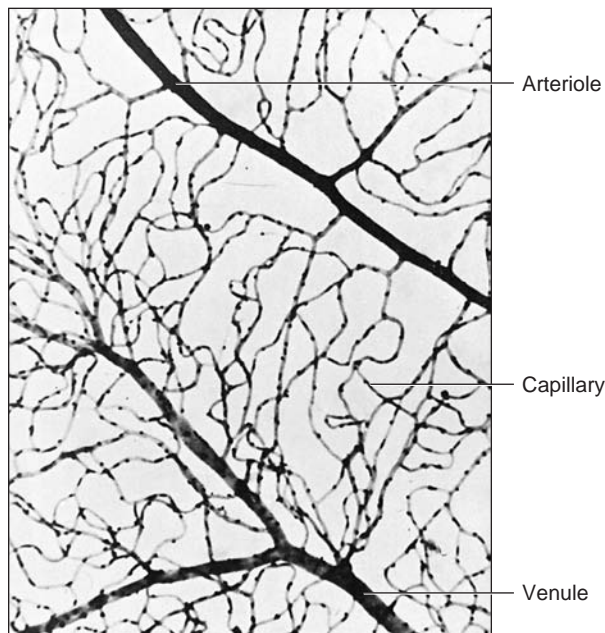


Figure 6-9. Light micrograph of a capillary network.

thick. These thin walls allow substances to pass into and out of capillaries (Figures 6-9 and 6-10). For example, oxygen and nutrients can pass out of a capillary into a body cell, and carbon dioxide and other waste products can pass out of a body cell into a capillary. In fact, capillaries are the only type of blood vessel that allows substances to move into and out of the blood.

Tissues that require a lot of oxygen, such as muscle and nervous tissues, will have a lot of capillaries. Capillary openings have precapillary sphincters that control the amount of blood that flows into them. When the sphincter relaxes, more blood flows into the capillary.

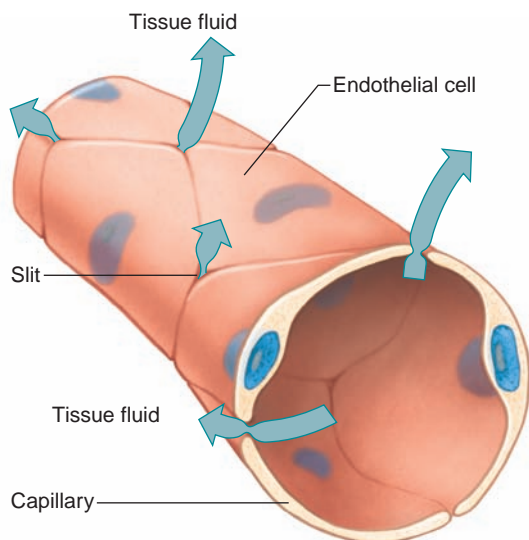


Figure 6-10. Structure of a capillary wall.

The substances that move through the capillary wall (oxygen, carbon dioxide, nutrients, water, and metabolic wastes) do so through diffusion, filtration, and osmosis. When blood first enters a capillary, it has high concentrations of oxygen and nutrients. The body cells surrounding the capillary usually have low concentrations of oxygen and nutrients but high concentrations of carbon dioxide and other waste products. Substances naturally diffuse from an area of high concentration to an area of low concentration. Therefore, oxygen and nutrients diffuse out of the capillary and into body cells. At the same time, carbon dioxide and waste products diffuse out of the body cells and into the capillary.

Because blood is under pressure as it enters the capillary, water is forced through the capillary wall via filtration. This allows water to enter a body cell. By the time blood leaves a capillary, it has a high solid concentration and a low water concentration; water therefore moves back into the capillary through osmosis. Water always moves toward the greater concentration of solids, if possible.

Blood Pressure

Blood pressure is defined as the force that blood exerts on the inner walls of blood vessels. Blood pressure is highest in arteries and lowest in veins. In the clinical setting, blood pressure refers to the pressure in arteries.

Arterial blood pressure rises and falls as the ventricles of the heart contract and relax. When the ventricles contract, blood pressure is greatest in the arteries. This pressure is called the **systolic pressure**. When the ventricles relax, blood pressure in arteries is at its lowest. This pressure is called the **diastolic pressure**. Blood pressure is usually reported as the systolic number over the diastolic number.

You can feel the surge of blood through arteries when you take a pulse. The pulse is created as the artery expands when pressure increases and then subsequently relaxes as blood pressure decreases. Common places to feel a pulse are the carotid and radial arteries.

Many factors affect blood pressure, the most common being cardiac output, blood volume, vasoconstriction, and blood viscosity. Cardiac output is the total amount of blood pumped out of the heart in one minute. As cardiac output increases and decreases, blood pressure increases and decreases. When a person loses a large amount of blood, his blood pressure significantly decreases. If blood pressure falls too low, vasoconstriction, which is the tightening of blood vessel walls, helps to raise blood pressure. In contrast, if blood pressure is too high, vasodilation, which is the widening of blood vessels, decreases the blood pressure. Under certain circumstances, such as dehydration, blood becomes more viscous, or thicker, than normal. This also decreases blood pressure.

Blood pressure is controlled to a large extent by the amount of blood pumped out of the heart. The amount of blood entering the heart should be equal to the amount of

blood pumped out of the heart. The heart has a way to ensure that this happens. When blood enters the left ventricle, the wall of the ventricle is stretched. The more the wall is stretched, the harder it will contract and the more blood it will pump out. This is referred to as *Starling's law of the heart*. If only a small amount of blood enters the left ventricle, it will not be stretched very much and therefore will not contract very forcefully. In this case, not much blood is pumped out of the heart.

Baroreceptors also help regulate blood pressure. Baroreceptors measure blood pressure and are located in the aorta and carotid arteries. If pressure increases in these blood vessels, this information is sent to the cardiac center in the medulla oblongata. The cardiac center then knows to decrease the heart rate, which lowers blood pressure. If pressure gets too low in the aorta, baroreceptors pick up this information and relay it to the cardiac center. The cardiac center then increases the heart rate to raise blood pressure.

Circulation

Pulmonary Circuit

The **pulmonary circuit** is the route that blood takes from the heart to the lungs and back to the heart again. The function of this circuit is to oxygenate blood. It also allows carbon dioxide to leave blood and enter the lungs (see Figure 6-4). The pulmonary circuit can be summarized as follows:

right atrium → right ventricle → pulmonary trunk → pulmonary arteries → lungs → pulmonary veins → heart (left atrium)

Systemic Circuit

The **systemic circuit** is the route blood takes from the heart through the body and back to the heart. The function of this circuit is to deliver oxygen and nutrients to body cells. It also picks up carbon dioxide and waste products from body cells (see Figure 6-4). The systemic circuit can be summarized as follows:

left atrium → left ventricle → aorta → arteries → arterioles → capillaries → venules → veins → vena cavae → heart (right atrium)

Arterial System

Arteries carry blood away from the heart. Most of them carry oxygen-rich blood, although pulmonary arteries carry oxygen-poor blood. Many arteries in the body are also paired, meaning that there is a left and a right artery of the same name. The aorta comes directly off the left ventricle and is the largest artery in the body. It has many branches that supply blood to various parts of the body.

Artery	Anatomic Location or Organ Supplied
Lingual	Tongue
Facial	Face
Occipital	Back of scalp and neck
Maxillary	Teeth, jaw, and eyelids
Ophthalmic	Eye
Axillary	Armpit area
Brachial	Upper arm
Ulnar	Forearm and hand
Radial	Forearm and hand
Intercostals	Rib area
Lumbar	Posterior abdominal wall
External iliac	Anterior abdominal wall
Common iliac	Legs, gluteal area, and pelvic organs
Femoral	Thigh
Popliteal	Posterior knee
Tibial	Lower leg and foot

Other arteries are summarized in Table 6-1. Also see Figure 6-11.

Venous System

Veins are blood vessels that carry blood toward the heart. Most veins in the body carry oxygen-poor blood, but the pulmonary veins are exceptions. Large veins often have the same names as the arteries they run next to. However, there are exceptions to this rule as well. For example, the veins next to carotid arteries are called jugular veins.

Large veins empty blood into vena cavae, which are the largest veins of the body. The superior vena cava generally collects blood from veins above the heart and the inferior vena cava collects blood from veins below the heart. The major veins of the body are summarized in Table 6-2. Also see Figure 6-12.

Veins of digestive organs carry blood from the digestive tract to the liver. The liver then processes nutrients in the blood and returns it to general circulation through hepatic veins. The collection of veins carrying blood to the liver is called the **hepatic portal system**.

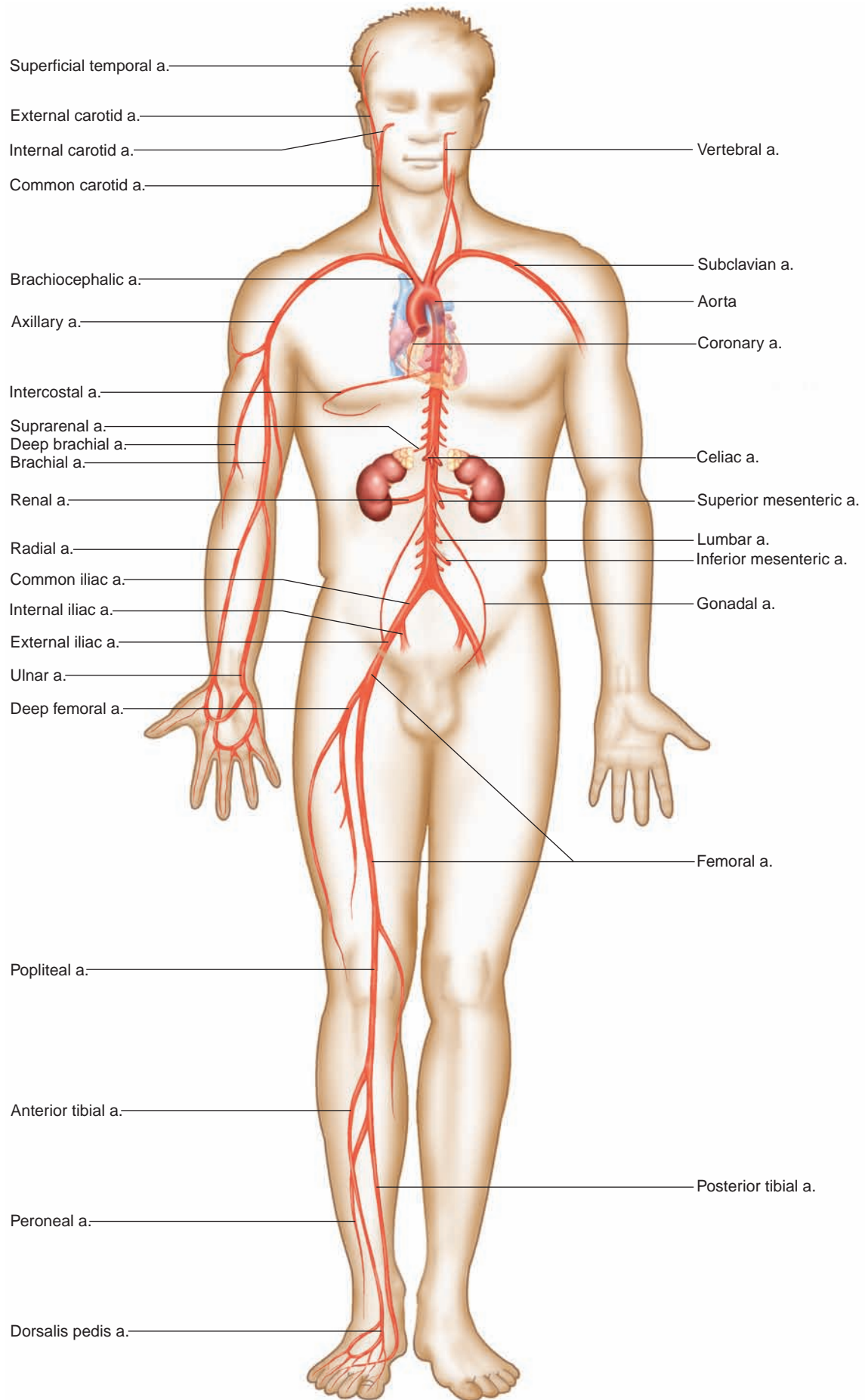


Figure 6-11. Major arteries of the body. (*a.* stands for *artery.*)

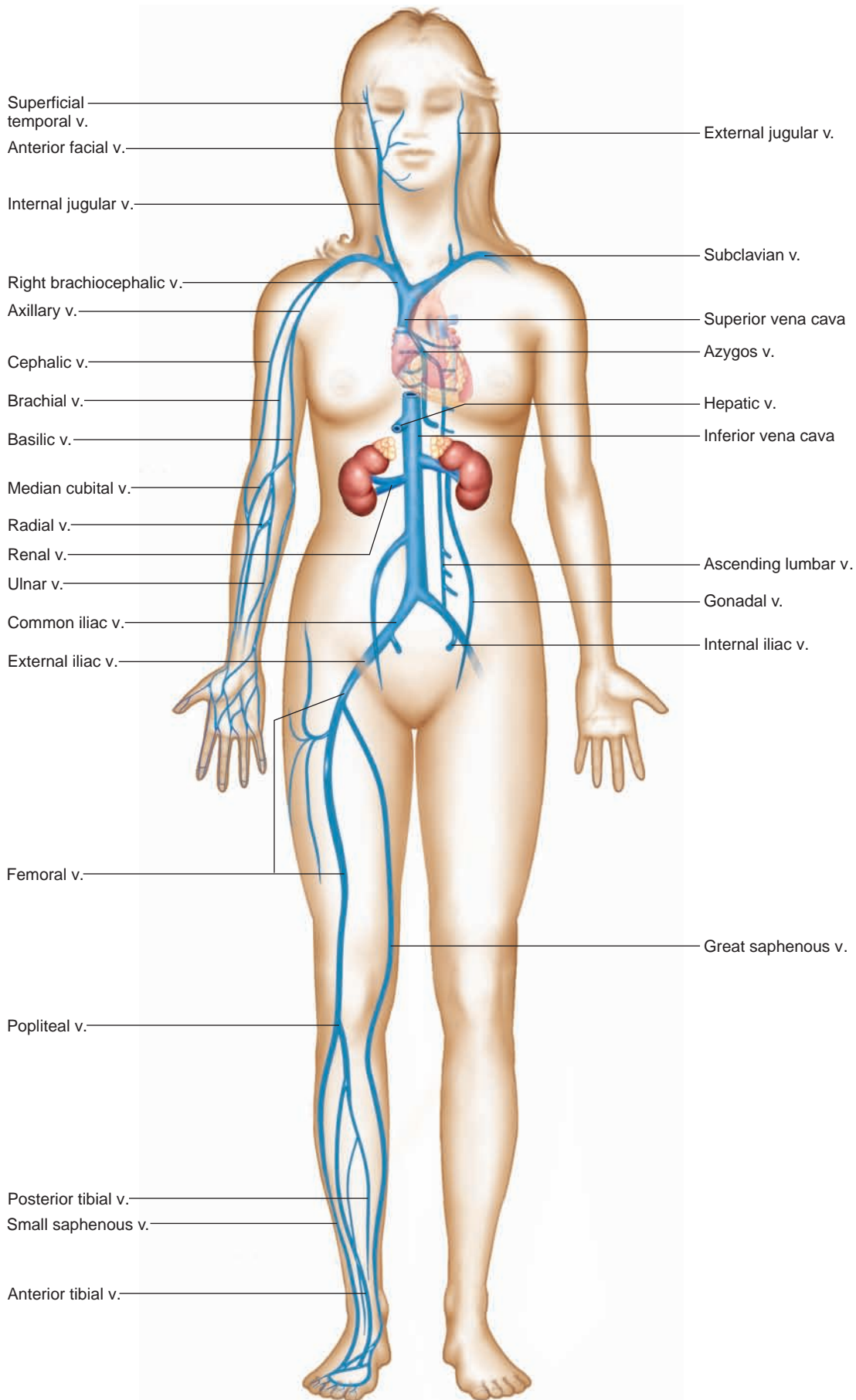


Figure 6-12. Major veins of the body. (*v.* stands for *vein.*)

TABLE 6-2 Major Veins of the Body	
Vein	Anatomic Location or Organ Drained
Jugular	Head and neck
Brachiocephalic	Head and neck
Axillary	Armpit area
Brachial	Upper arm
Ulnar	Lower arm and hand
Radial	Lower arm and hand
Intercostal	Thorax
Azygos	Thorax and abdomen
Gastric—part of the hepatic portal system	Stomach to the liver
Splenic—part of the hepatic portal system	Spleen, pancreas, and stomach to the liver
Mesenteric—part of the hepatic portal system	Intestines to the liver
Hepatic portal—part of the hepatic portal system	Gastric, splenic, and mesenteric veins to the liver
Hepatic	Liver to the inferior vena cava
Iliac	Pelvic organs, legs, and gluteal areas
Femoral	Thighs
Popliteal	Knees
Saphenous	Legs

Blood

Blood is a type of connective tissue that is made up of various parts, including red and white blood cells, cell fragments called platelets, and plasma (the fluid part of the blood). An average-sized adult contains approximately 5 liters of blood. However, blood volume varies from person to person depending on the person's size, the amount of adipose tissue, and the concentrations of certain ions in the blood.

Components of Blood

The percentage of red blood cells in a sample of blood is referred to as **hematocrit**. A healthy person normally has a hematocrit level of about 45%. Most of the cells are red blood cells, and only about 1% are white blood cells and platelets. The rest of blood (approximately 55%) is plasma (Figure 6-13).

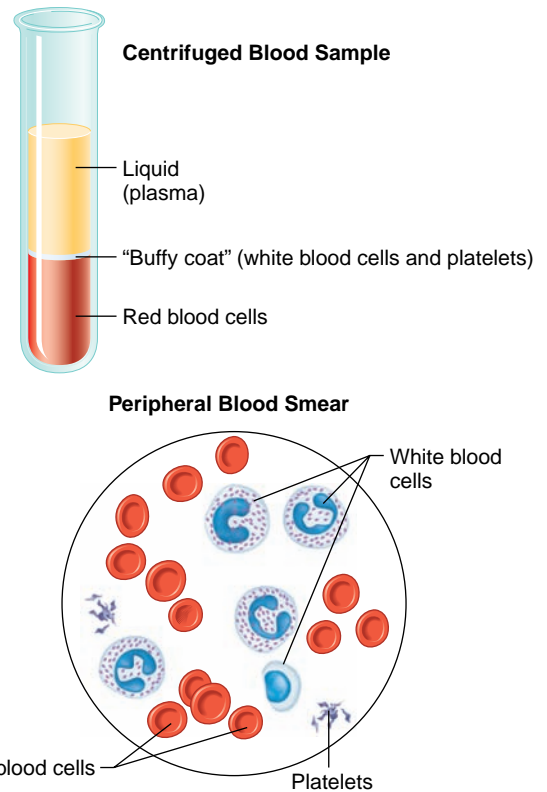


Figure 6-13. Centrifuged blood sample and peripheral blood smear showing blood components.

Red Blood Cells. Red blood cells, called **erythrocytes**, are biconcave-shaped cells that are small enough to pass through capillaries (Figure 6-14). Mature red blood cells do not contain nuclei because they must lose their nuclei in order to make room for a pigment called hemoglobin. Hemoglobin's function is to carry oxygen. Hemoglobin that carries oxygen is called **oxyhemoglobin** and is bright red in color; hemoglobin that does not carry oxygen is called **deoxyhemoglobin** and has a darker red color.

A red blood cell count is the number of red blood cells in one cubic millimeter of blood (a cubic millimeter of blood is roughly 20 drops of blood). This count is normally between 4 million and 6.5 million red blood cells. Because the function of a red blood cell is to transport oxygen throughout the body, a low count reflects a decreased ability to carry oxygen. This condition is known as **anemia**.

When red blood cells age, macrophages in the liver and spleen destroy them. When a red blood cell is destroyed, a pigment called **biliverdin** is released from the cell. The liver usually converts biliverdin into an orange-colored pigment called **bilirubin**. Bilirubin is used to make bile, which is needed for the digestion of fats. However, sometimes bilirubin is not used to make bile; instead, it persists in the bloodstream. This causes a person's skin to appear yellowish, which is a condition known as **jaundice**.

During development, red blood cells are made in the fetal yolk sac, the liver, and the spleen. However, once a baby is born, most red blood cells are produced in red

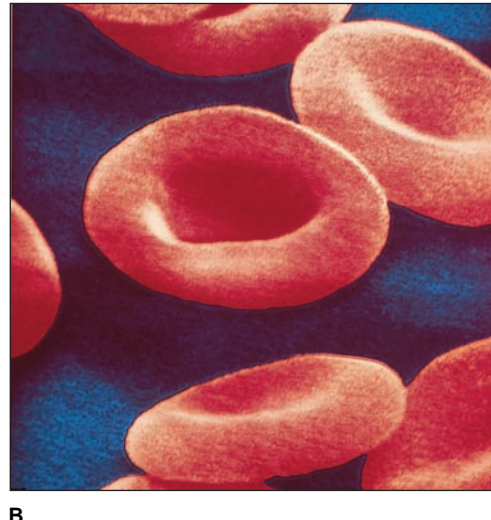
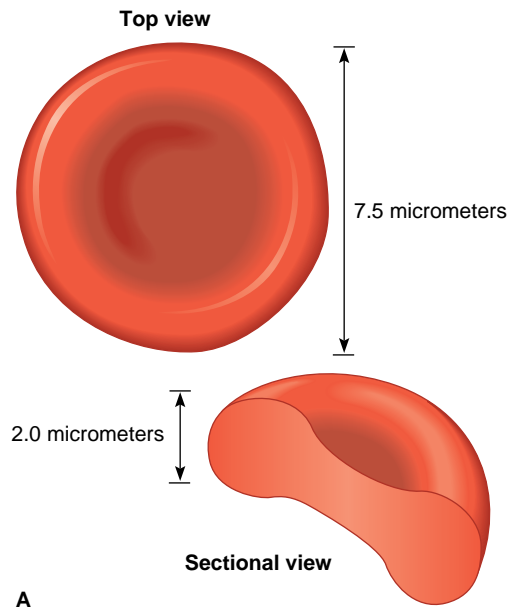


Figure 6-14. Red blood cells. (a) Biconcave shape of red blood cells and (b) scanning electron micrograph of red blood cells.

Educating the Patient

Chest Pain

Chest pain is a common reason people go to the emergency room every year. Although all chest pains should be taken seriously, they do not always indicate life-threatening heart conditions. There are two primary causes of chest pain—cardiac and noncardiac. Use the information in this box to teach patients about the conditions that cause chest pain.

The cardiac causes of chest pain include the following:

- **Heart attack.** Heart attacks are caused by the complete blockage of coronary arteries and are life-threatening conditions. The pain associated with a heart attack feels like pressure or fullness in the chest. Sometimes pain also occurs in the back, neck, face (especially jaw), shoulder, or arms (the left arm more than the right). Other signs and symptoms include shortness of breath, sweating, nausea, and dizziness.
- **Angina.** Angina is caused by a narrowing of coronary arteries and is not immediately life-threatening. The pain of angina is usually described as a tight feeling in the chest and is often brought about by stress or physical activity. This type of chest pain usually goes away after the stress or physical activity stops. A

doctor should monitor patients with angina regularly.

- **Pericarditis.** This condition is characterized by inflammation of the sac surrounding the heart. It usually produces a sharp and localized pain in the chest. It is not immediately life-threatening but should be treated. This condition often produces a fever.
- **Coronary spasms.** In this condition, coronary arteries temporarily spasm and limit blood flow to cardiac muscle tissue. The pain accompanied by coronary spasms is similar to that of angina. It should be treated as soon as possible.

The noncardiac causes of chest pain include the following:

- **Heartburn.** Heartburn occurs when acids from the stomach are pushed into the esophagus. Heartburn pain is described as a burning sensation. This pain usually follows a meal and gets worse if a patient bends forward.
- **Panic attacks.** During times of intense stress or fear, chest pains can occur and are often accompanied by increased heart and breathing rates as well as excessive sweating.

continued →



Educating the Patient

Chest Pain (*continued*)

- **Pleurisy.** This condition occurs when the membranes surrounding the lungs become inflamed. Pleurisy produces a sharp chest pain that usually feels worse when a patient coughs or inhales.
 - **Costochondritis.** This condition occurs when the cartilage attached to ribs becomes inflamed. The chest pain associated with this condition feels much like the pain of a heart attack but generally occurs only when someone pushes on the patient's chest.
 - **Pulmonary embolism.** This condition occurs when a blood clot blocks an artery in the lungs. The pain associated with it is severe, sharp, and increases when a patient inhales deeply or coughs. A pulmonary embolism can also produce shortness of breath, an increased heart rate, and dizziness. This condition is life threatening.
 - **Sore muscles.** Chest pain from sore muscles usually occurs only during body movements such as raising the arms.
 - **Broken ribs.** Fractures of the ribs tend to produce sharp and localized chest pains.
 - **Shingles.** This disease is caused by the chickenpox virus. It appears in adulthood during periods of sickness or stress. Shingles produces blisters on the skin, but a burning type of chest pain can occur days before the blisters appear.
 - **Inflammation of the gallbladder or pancreas.** Pain associated with these conditions usually begins in the abdomen and spreads to the chest.
- Tests used to determine the cause of chest pain include the following:
- **Electrocardiogram (ECG).** This test is useful in determining if a heart attack is occurring or has already occurred.
 - **Stress tests.** Stress tests are ECGs performed while a patient is exercising or has been given drugs to increase her heart rate. Stress tests are useful for determining the health of coronary blood vessels.
 - **Blood tests.** These tests are useful in determining if a heart attack has occurred. When heart tissue is damaged, certain enzymes are found in the blood.
 - **Chest x-ray.** X-rays show the size and shape of the lungs and heart and can therefore indicate any serious conditions.
 - **Nuclear scan.** These scans follow radioactive substances through the blood vessels of the heart and lungs. They can reveal narrow or obstructed arteries.
 - **Electron beam computerized tomography (EBCT).** This procedure is much like a CT scan of the arteries. It is useful for finding narrowed arteries.
 - **Coronary catheterization.** This procedure uses a dye that is followed through coronary arteries. It can also show narrowing of the arteries.
 - **Echocardiogram.** This procedure uses sound waves to visualize the shape of the heart.
 - **Endoscopy.** This procedure involves inserting a tube with a tiny camera down the throat and into the stomach. It helps to diagnose disorders of the stomach or esophagus that might produce chest pains.

bone marrow by cells called **hemocytoblasts**. The average life span of a red blood cell is only about 120 days, so red bone marrow is constantly making new cells. The hormone **erythropoietin** is responsible for regulating the production of red blood cells. This hormone is produced by the kidneys and stimulates the red bone marrow to produce new red blood cells. The kidneys release this hormone when oxygen concentrations in the blood get low.

Vitamin B₁₂ and folic acid are two dietary factors that affect red blood cell production. These vitamins are necessary for DNA synthesis, so any actively dividing tissue such as red bone marrow is affected when DNA cannot be produced.

Iron is also necessary to make hemoglobin. Too few red blood cells or too little hemoglobin can result in anemia.

White Blood Cells. White blood cells, which are called **leukocytes**, are divided into two categories: granulocytes and agranulocytes. **Granulocytes** have granules in their cytoplasm and include neutrophils, eosinophils, and basophils. **Agranulocytes** do not have granules in their cytoplasm and include monocytes and lymphocytes.

Neutrophils account for about 55% of all white blood cells (Figure 6-15). They are important for destroying bacteria, viruses, and toxins in the blood. **Eosinophils** account

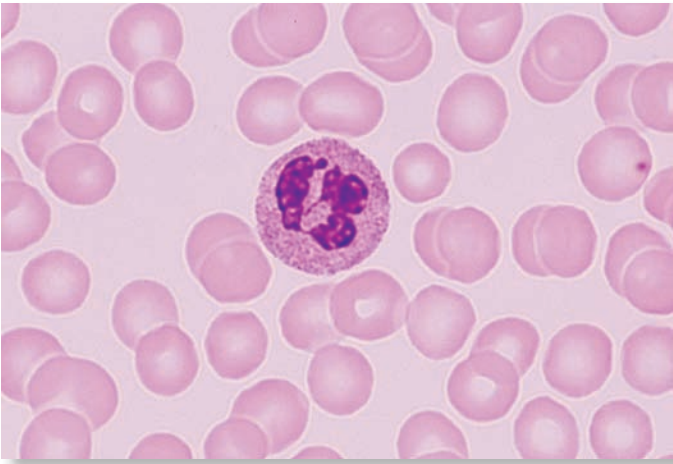


Figure 6-15. Neutrophils have distinct nuclei with many lobes.

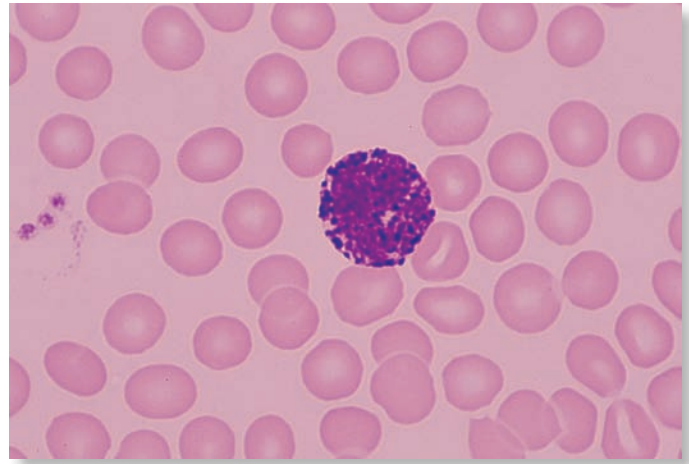


Figure 6-17. Basophils have cytoplasmic granules that stain deep blue.

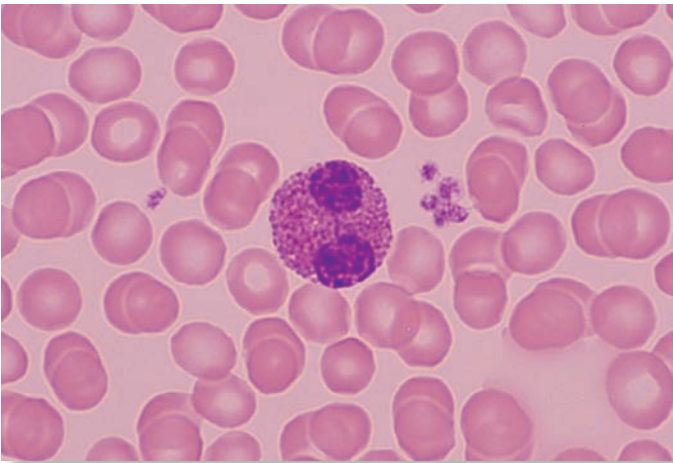


Figure 6-16. Eosinophils have cytoplasmic granules that stain red.

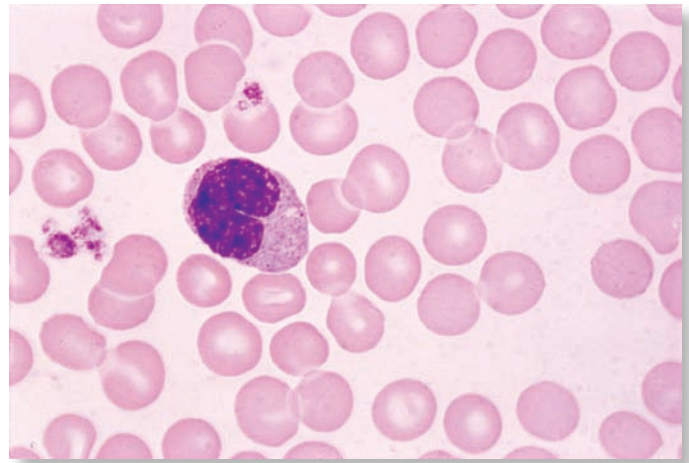


Figure 6-18. Monocytes have large kidney-shaped nuclei. They do not have cytoplasmic granules.

for about 3% of all white blood cells and are effective in getting rid of parasitic infections such as worms (Figure 6-16). Eosinophils also help control inflammation and allergic reactions. **Basophils** account for less than 1% of all white blood cells. They release substances such as histamine and heparin, which promote inflammation (Figure 6-17).

Monocytes account for about 8% of all white blood cells. They are important for destroying bacteria, viruses, and toxins in the blood (Figure 6-18). **Lymphocytes** account for about 33% of all white blood cells and provide immunity for the body (Figure 6-19).

A white blood cell count is the number of white blood cells in 1 cubic millimeter of blood. This count is normally between 5000 and 10,000 cells. A white blood cell count above normal is termed **leukocytosis**. This condition often results from bacterial infections. A white blood cell count below normal is called **leukopenia**, which is caused by some viral infections and various other conditions.

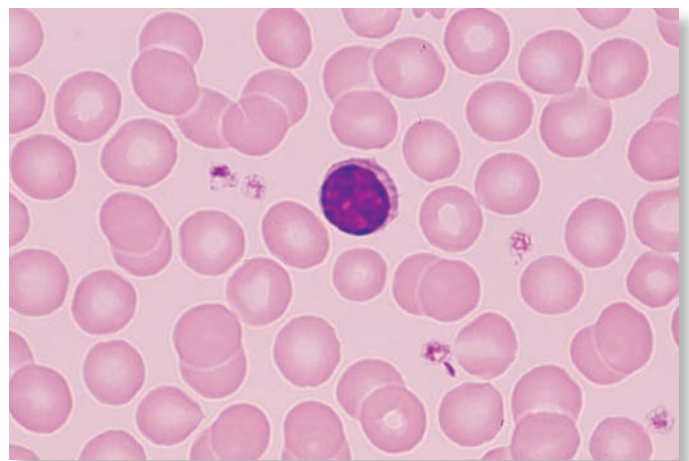


Figure 6-19. Lymphocytes have large round nuclei.

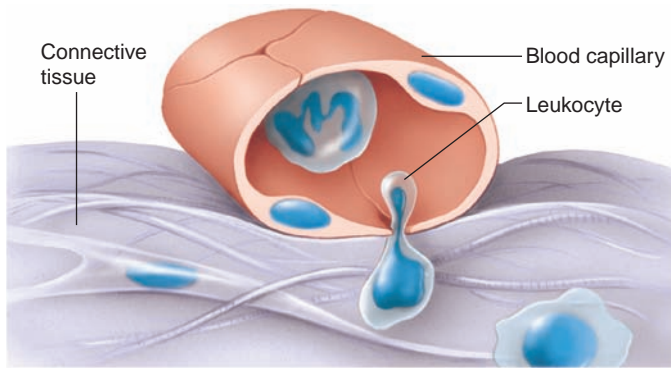


Figure 6-20. Diapedesis of a white blood cell into surrounding tissue.

A differential white blood cell count lists the percentages of the different types of leukocytes in a sample of blood. This is a useful test because the numbers of different white blood cells change in certain diseases. For example, neutrophil numbers increase at the beginning of a bacterial infection but monocyte numbers will not increase until about two weeks after a bacterial infection. Eosinophil numbers increase during worm infections. In AIDS, lymphocyte numbers fall.

Some white blood cells stay in the bloodstream to fight infections while others leave the bloodstream by squeezing through blood vessel walls to reach other tissues. The squeezing of a cell through a blood vessel wall is called **diapedesis** (Figure 6-20).

Blood Platelets. Platelets are fragments of cells that are found in the bloodstream (Figure 6-13). Platelets are also called **thrombocytes** and are important in the clotting of blood. Platelets come from cells called **megakaryocytes** that are in red bone marrow. A normal platelet count is between 130,000 and 360,000 platelets per cubic millimeter of blood.

Blood Plasma. Plasma is the liquid portion of blood. It is mostly water but also contains a mixture of proteins, nutrients, gases, electrolytes, and waste products. The three major types of proteins found in plasma are albumins, globulins, and fibrinogen. **Albumins** are the smallest of the plasma proteins and are important for pulling water into the bloodstream to help maintain blood pressure. **Globulins** transport lipids and some vitamins in plasma. Some globulins become antibodies. **Fibrinogen** is important for blood clotting.

Nutrients in plasma include amino acids, glucose, nucleotides, and lipids that have all been absorbed from the digestive tract. Because lipids are not water soluble and because plasma is mostly water, lipids must combine with molecules called **lipoproteins** to be transported. The different types of lipoproteins are **chylomicrons**, very low-density lipoproteins (VLDL), low-density lipoproteins (LDL), and high-density lipoproteins (HDL).

The gases dissolved in plasma include oxygen, carbon dioxide, and nitrogen. Many electrolytes are dissolved in plasma. They include sodium, potassium, calcium, magnesium, chloride, bicarbonate, phosphate, and sulfate. Molecules that contain nitrogen but are not proteins make up a group called nonprotein nitrogenous substances. They include amino acids, urea, and uric acid. Urea and uric acid are waste products produced by cells.

Bleeding Control

Hemostasis refers to the stoppage of bleeding. This is important when blood vessels are damaged and bleeding begins. Three processes occur in hemostasis: (1) blood vessel spasm, (2) platelet plug formation, and (3) blood coagulation.

When a blood vessel breaks, the smooth muscle at the site of the damage in its wall contracts and causes the blood vessel to spasm. This spasm reduces the amount of blood lost through the vessel. Platelets also begin to stick to the broken area and to each other to form a platelet plug. The platelet plug stops the bleeding temporarily (Figure 6-21).

A blood clot eventually replaces the platelet plug. The formation of a blood clot is called **blood coagulation**. In this process, the plasma protein fibrinogen is converted to fibrin. Once fibrin forms, it sticks to the damaged area of

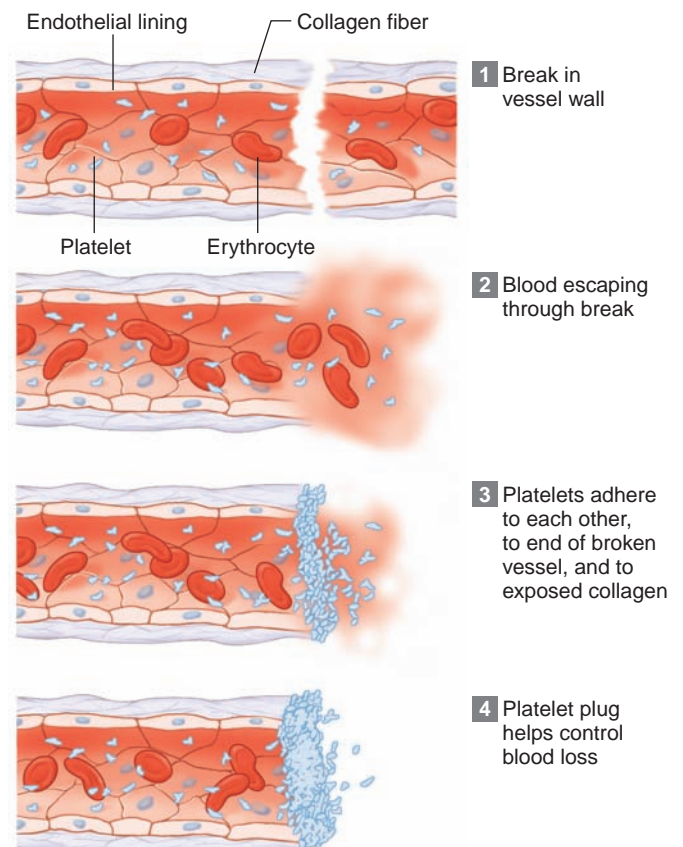


Figure 6-21. Steps in platelet plug formation.

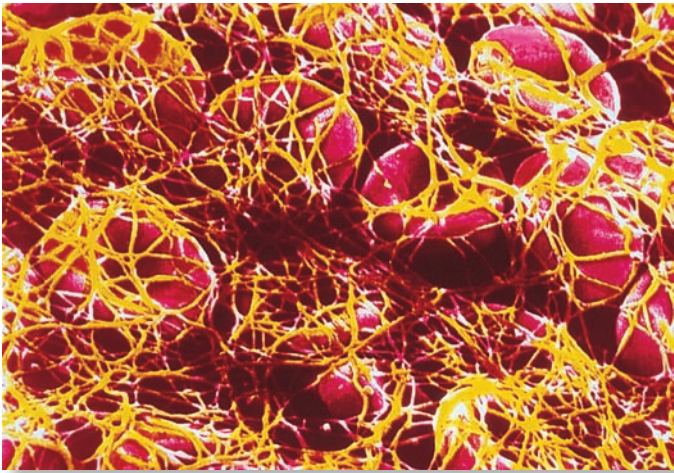


Figure 6-22. Scanning electron micrograph of a blood clot. Yellow fibrin threads are covering red blood cells.

the blood vessel, creating a meshwork that entraps blood cells and platelets. The resulting mass, the blood clot, stops bleeding until the vessel has repaired itself (Figure 6-22).

When a blood vessel is injured, it is normal for a blood clot to form. However, sometimes blood clots form on the side of a blood vessel with no known injury; this abnormal blood clot is called a **thrombus**. The danger of a thrombus is that a portion of it can break off and start moving

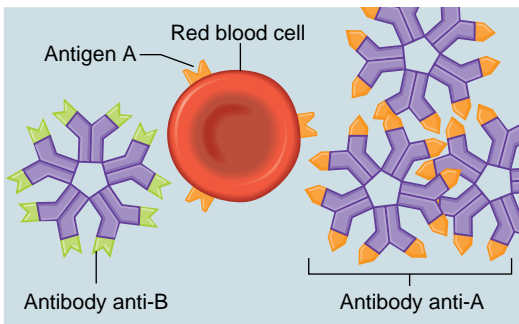
through the bloodstream. The moving portion of the thrombus is called an **embolus**. An embolus is dangerous because it will eventually block a small artery. An embolus that originates in the vein of a leg travels to the right atrium of the heart through the inferior vena cava and is pumped by the right ventricle to the lungs. Here the embolus gets stuck in a small artery and causes pulmonary embolism, a fatal condition if not treated.

Blood Types

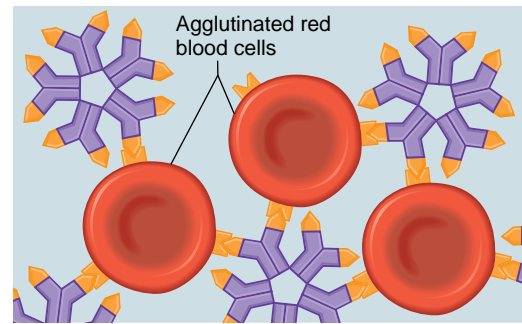
The ABO blood group consists of four different blood types: A, B, AB, and O. They are distinguished from each other in part by their antigens and antibodies.

Agglutination is the clumping of red blood cells following a blood transfusion. This clumping is not desirable because it leads to severe anemia. Agglutination occurs because proteins called *antigens* on the surface of red blood cells bind to antibodies in plasma (Figure 6-23). To prevent agglutination, antigens should not be mixed with antibodies that will bind to them. Fortunately, most antibodies do not bind to antigens on blood cells; only very specific ones bind to them.

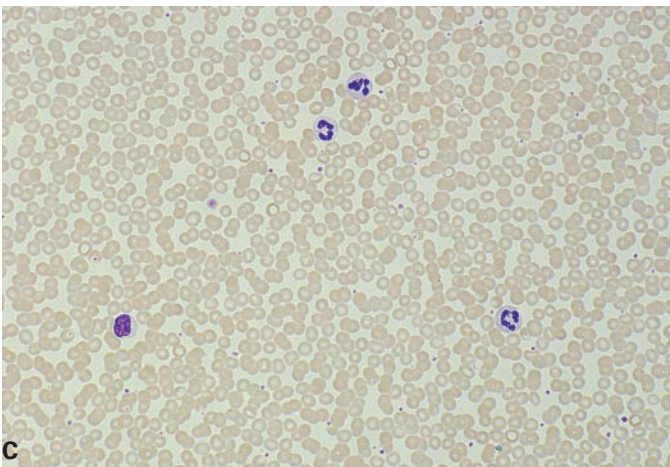
Type A. People with type A blood have antigen A on the surface of their red blood cells. They also have antibody B in their plasma. Antibody B will only bind to antigen B.



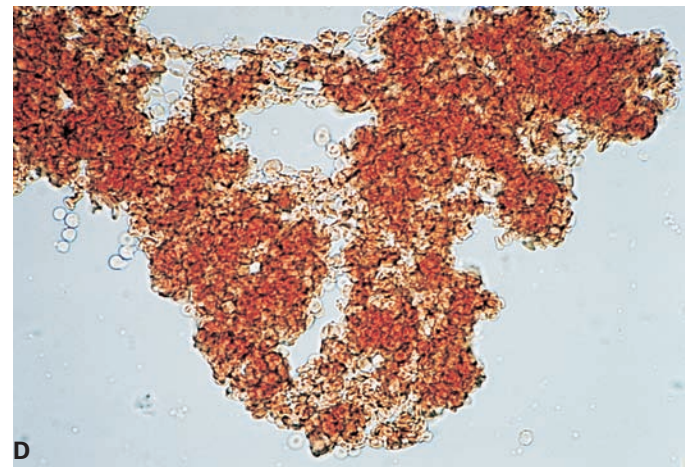
A



B



C



D

Figure 6-23. Agglutination. (a) Red blood cells with antigen A are added to blood that contains antibody anti-A. (b) Antibody anti-A reacts with antigen A, causing the agglutination of blood. (c) Normal blood. (d) Agglutinated blood.

TABLE 6-3 ABO Blood Group

Blood Type	Antigen Present	Antibody Present	Blood That Can Be Received
A	A	B	A and O
B	B	A	B and O
AB	AB	None	A, B, AB, and O
O	None	A and B	O

Type B. People with type B blood have antigen B on the surface of their red blood cells. They also have antibody A in their plasma.

If a person with type A blood is given type B blood, then the antibody B in the recipient's blood will bind with the red blood cells of the donor blood because those cells have antigen B on their surfaces. Therefore, agglutination occurs, and the donated red blood cells are destroyed. This is why a person with type A blood should not be given type B blood (and vice versa).

Type AB. People with type AB blood have both antigen A and antigen B on the surface of their red blood cells. They have neither antibody A nor antibody B in their plasma. People with type AB blood are called universal recipients, because most of them can receive all ABO blood types. They can receive these blood types because they lack antibody A and antibody B in their plasma, so there is no reaction with antigens A and B of the donor blood.

Type O. People with type O blood have neither antigen A nor antigen B on the surface of their red blood cells. However, they do have both antibody A and antibody B in

their plasma. People with type O blood are called universal donors because their blood can be given to most people regardless of recipients' blood type. Type O blood will not agglutinate when given to other people because it does not have the antigens to bind to antibody A or antibody B. Table 6-3 summarizes the ABO blood group. Also see Figure 6-24.

The Rh Factor. The **Rh antigen** is a protein first discovered on red blood cells of the Rhesus monkey, hence the name Rh. People who are Rh-positive have red blood cells that contain the Rh antigen. People who are Rh-negative have red blood cells that do not contain the Rh antigen. If a person who is Rh-negative is given Rh-positive blood, then the Rh-negative person's blood will make antibodies that bind to the Rh antigens. If the Rh-negative person is given Rh-positive blood a second time, the antibodies will bind to the donor cells and agglutination will occur.

Clinically, it is very important for a female to know her Rh type. If an Rh-negative female mates with an Rh-positive male, there is a fifty-fifty chance that her fetus will be Rh-positive. When the blood of a fetus who is Rh-positive mixes with the blood of a mother who is Rh-negative, the

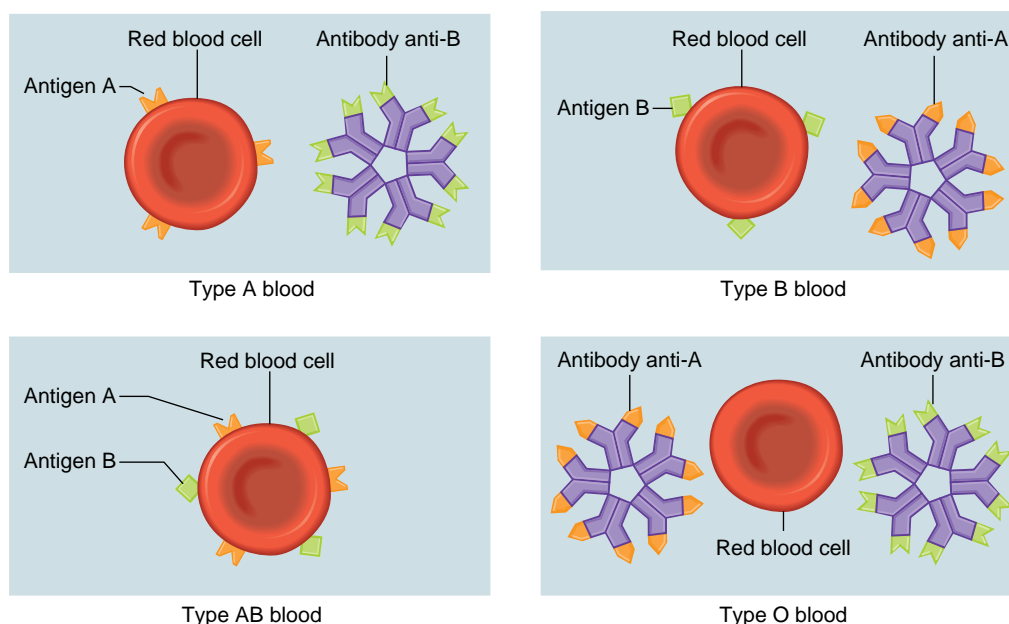


Figure 6-24. A, B, AB, and O blood types.

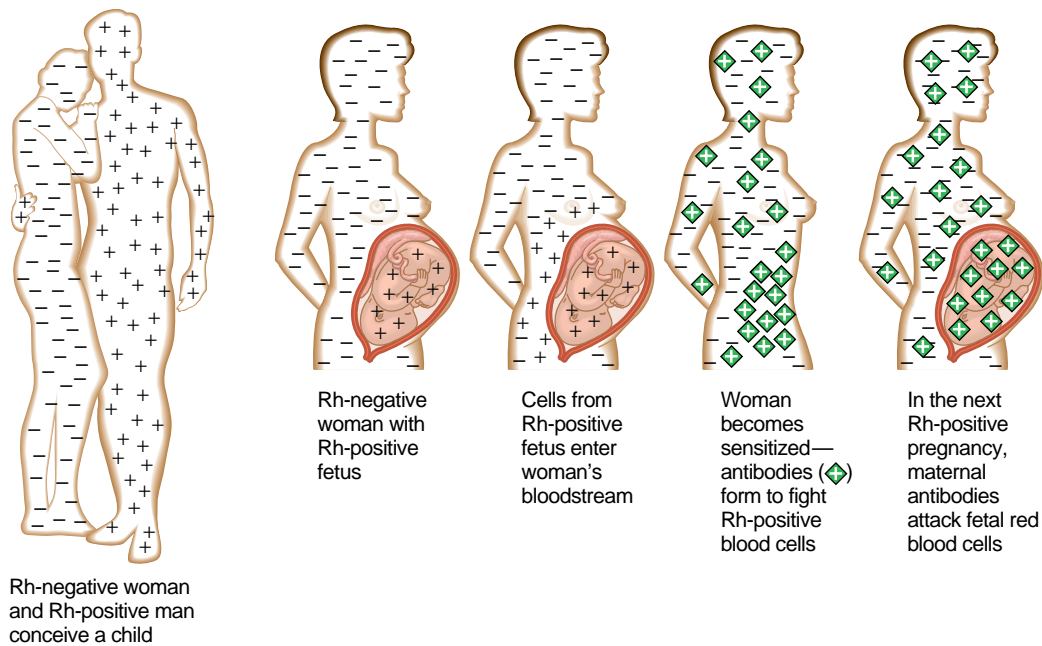


Figure 6-25. Development of antibodies in an Rh-negative woman in relation to the blood of her Rh-positive fetus.

mother develops antibodies against the fetus's red blood cells. The first Rh-positive fetus usually does not suffer from these antibodies because it takes so long for the mother's body to generate them. However, if the mother conceives a second Rh-positive fetus, the fetus's blood will be attacked by the antibodies right away. The second fetus then develops a condition called **erythroblastosis fetalis**, and the baby is born severely anemic (Figure 6-25). Erythroblastosis fetalis is prevented by giving an Rh-negative woman the drug **RhoGAM**. RhoGAM prevents an Rh-negative mother from making antibodies against the Rh antigen.

The Lymphatic System

The lymphatic system is a network of connecting vessels that collects fluids between cells. These lymphatic vessels then return this fluid, called **lymph**, to the bloodstream. The lymphatic system also picks up lipids from the digestive organs and transports them to the bloodstream. Finally, the lymphatic system functions to defend the body against disease-causing agents called **pathogens**. (See Chapter 7 for more information about this function.)

Lymphatic Pathways

Lymphatic pathways start with tiny vessels called lymphatic capillaries. The lymphatic capillaries merge together to make lymphatic vessels. Lymphatic vessels eventually merge together to make lymphatic trunks, and the trunks merge into lymphatic collecting ducts.

Lymphatic capillaries extend into the spaces between cells called interstitial spaces. Lymphatic capillaries have

very permeable, thin walls that are designed to pick up fluids in interstitial spaces. Once fluid enters the lymphatic capillaries, it is called lymph. Lymphatic capillaries deliver lymph to lymphatic vessels, and lymphatic vessels deliver the fluid to lymph nodes. The cells inside lymph nodes can remove pathogens from lymph or start an immune response against the pathogen.

Lymph leaves lymph nodes through efferent lymphatic vessels. Efferent lymphatic vessels eventually deliver lymph to lymphatic trunks, and the trunks deliver the lymph to lymphatic collecting ducts. There are two major lymphatic collecting ducts in the body—the thoracic duct and the right lymphatic duct. Both of these ducts empty lymph into the bloodstream, usually near the right and left subclavian veins in the thoracic cavity. See Figures 6-26, 6-27, and 6-28.

The right lymphatic duct is much smaller than the thoracic duct. The right lymphatic duct collects all the lymph from the right side of the head and neck, the right arm, and the right side of the chest. The thoracic duct collects lymph from the left side of the head and neck, the left arm, the left side of the thorax, the entire abdominopelvic area, and both legs (Figure 6-28).

Tissue Fluid and Lymph

Fluid constantly leaks out of blood capillaries into the spaces between cells. This fluid is high in nutrients, oxygen, and small proteins. Most of this fluid is picked up by body cells. However, some of the fluid persists between cells. This fluid is called tissue fluid and is destined to become lymph.

Once lymph enters lymphatic vessels, it is pushed through the vessels by the squeezing action of neighboring

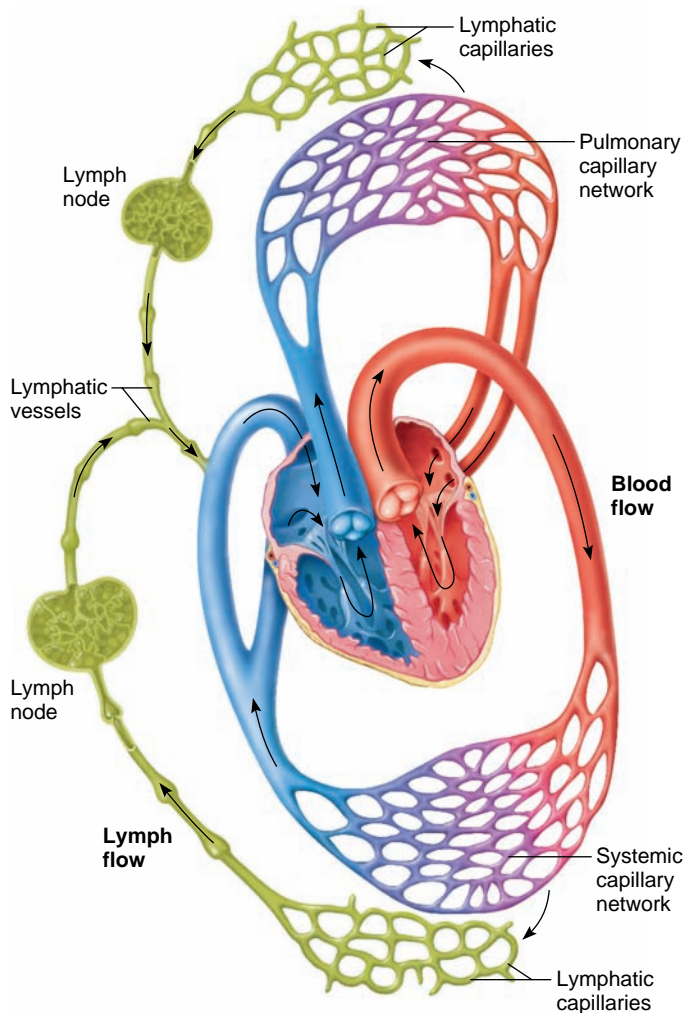


Figure 6-26. Schematic flow of lymph from the lymphatic capillaries to the bloodstream.

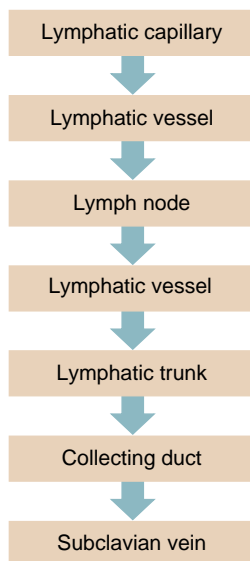


Figure 6-27. Lymphatic pathway.

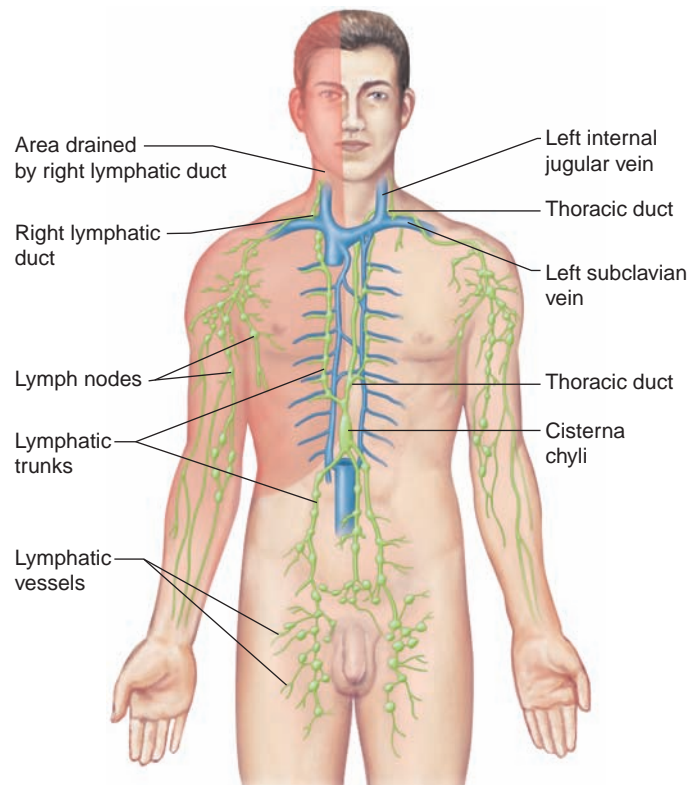


Figure 6-28. Areas drained by the right lymphatic duct (shaded) and thoracic duct (not shaded).

skeletal muscles. Lymphatic vessels contain valves that prevent the backflow of lymph. Breathing movements also squeeze lymphatic vessels and therefore promote lymph movement. If lymph is not pushed through a lymphatic vessel, it will leak back out of the lymphatic capillaries. When this happens, swelling of the surrounding tissue occurs. This condition is called **edema**.

Lymph Nodes

Lymph nodes are very small, glandular structures that usually cannot be felt very easily. They are located along the paths of larger lymphatic vessels and are spread throughout the body, but they do not occur in the nervous system. One side of a lymph node, called the **hilum**, is indented. Nerves and blood vessels enter the node through the hilum.

Some lymphatic vessels carry lymph to a lymph node on the side away from the hilum. These vessels are called afferent lymphatic vessels (afferent, meaning “to”). About four or five afferent vessels are associated with each node. Lymphatic vessels that carry lymph out of a node are called efferent vessels (efferent, meaning “away from”). A lymph node usually has only one or two efferent vessels. Because more lymph enters the node than can exit at one time, lymph tends to pool, or stay, in the node for some period of time.

Two important cell types are found inside the node—macrophages and lymphocytes. Macrophages digest unwanted pathogens in the lymph as it sits in the node, and the lymphocytes start an immune response against the pathogen. Lymph nodes are also responsible for the generation of some lymphocytes. See Figure 6-29.

The Thymus and Spleen

The thymus is a soft, bilobed organ located just above the heart. As a person ages, the thymus shrinks. The thymus carries out the same functions as a lymph node but is also responsible for the production of lymphocytes and the hormone called thymosin. Thymosin stimulates the production of mature lymphocytes.

The spleen is the largest lymphatic organ. It is located in the upper left portion of the abdominal cavity. The spleen is filled with blood, macrophages, and lymphocytes. It filters blood in much the same way that lymph nodes filter lymph. The spleen also removes worn-out red blood cells from the bloodstream.

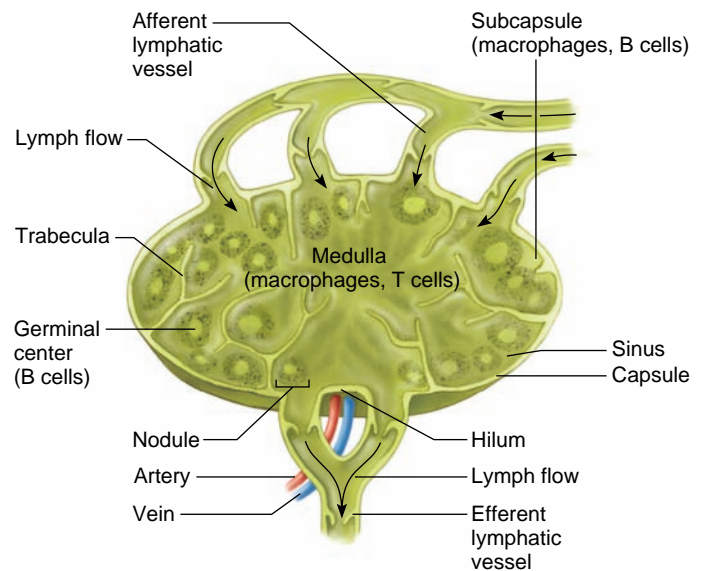


Figure 6-29. Section of a lymph node.

Pathophysiology

Common Diseases and Disorders of the Circulatory System

Anemia is a condition in which a person does not have enough red blood cells or hemoglobin in the blood to carry an adequate amount of oxygen to the body's cells. It is the most common blood disorder in the United States and can be a sign of a more serious disorder. It generally affects more women than men.

- **Causes.** The causes of this condition are many and include the following:
 - Iron deficiency. Iron deficiency is the most common cause of anemia. Iron is needed to make hemoglobin, which is the pigment that carries most oxygen in the blood. Pregnant women and women with heavy menstrual cycles are most susceptible to this type of anemia.
 - Chronic blood loss. Slow blood loss can occur in conditions such as ulcers, colon polyps, or colon cancer.
 - Vitamin deficiency. Vitamin B₁₂ and folic acid are needed to make enough red blood cells.
 - Inability to absorb vitamin B₁₂. This condition is called *pernicious anemia*. Some intestinal disorders prevent the absorption of vitamin B₁₂.
 - Side effect of medication. Some oral contraceptives, seizure medications, and drugs used to treat cancer can cause anemia.
 - Chronic illness. Chronic diseases such as AIDS, cancer, rheumatoid arthritis, leukemia, and kidney failure can cause anemia.
 - Bone marrow disorder. When the bone marrow fails to produce enough blood cells, aplastic anemia

results. This is a life-threatening type of anemia. Toxins, chemotherapy, and radiation therapy can destroy bone marrow.

- Destruction of red blood cells. Some blood diseases, such as sickle cell disease, cause red blood cells to be destroyed faster than they can be made.

Anemia can be prevented through a healthy diet high in iron, vitamin B₁₂, and folic acid.

- **Signs and symptoms.** Signs and symptoms include tiredness, weakness, pale skin, rapid heartbeat, numb or cold hands and feet, dizziness, headache, and jaundice.
- **Treatment.** Injections of vitamin B₁₂ may be necessary. Treatment often begins with addressing the underlying causes, such as an ulcer or colon polyps. Other treatment options include administering various medications, discontinuing the use of medications that can cause anemia, and blood transfusions if defective bone marrow is the cause.

An **aneurysm** is defined as a ballooning of an artery wall that results when the wall of the blood vessel becomes weak. The most common locations of aneurysms are the aorta and arteries in the brain, legs, intestines, and spleen. An aortic aneurysm is a bulge in the wall of the aorta. Most aortic aneurysms occur in the abdominal aorta but some occur in the thoracic aorta. Most aortic aneurysms do not rupture; however, when they do, serious life-threatening emergencies result.

continued →

Common Diseases and Disorders of the Circulatory System (continued)

- **Causes.** Most causes are unknown. One identified risk to developing an aneurysm is **atherosclerosis**, which is a hardening of the arteries usually associated with a diet high in cholesterol. Smoking and obesity also increase the risk of atherosclerosis. Congenital conditions may cause an aneurysm—some individuals are born with weak aortic walls. A traumatic injury to the chest may also be a risk factor. The risk of developing an aneurysm can be reduced by not smoking, by losing excess weight, and by having a diet low in cholesterol. Periodic screening is an option for patients with a family history of aortic aneurysms.
- **Signs and symptoms.** There are usually no signs and symptoms of an aneurysm, although hypertension can be a sign. When symptoms do exist, a pulsation in the abdomen and back pain are the most commonly seen. A sudden pain in the abdomen or back, dizziness, a fast pulse, or a loss of consciousness are signs that an aneurysm has burst.
- **Treatment.** The primary treatment is surgery to repair the aneurysm.

Arrhythmias are abnormal heart rhythms in which the heart beats too quickly (tachycardia) or too slowly (bradycardia). The most common type of heart arrhythmia is atrial fibrillation, which is a sporadic and quick beating of the atria. The most serious type of heart arrhythmia is ventricular fibrillation, which produces ineffective contractions of the ventricles. Most sudden cardiac deaths are caused by ventricular fibrillation.

- **Causes.** These abnormal rhythms usually result when electrical impulses of the cardiac conduction system do not flow correctly through the heart. The list of risk factors and causes is long and includes electrical shock, certain drugs (for example, over-the-counter cough medicines that contain pseudoephedrine), herbal supplements containing ephedra, high blood pressure, a previous heart attack, decreased blood flow to the heart, coronary artery disease, heart valve disorders, weakening of the heart muscle (cardiomyopathy), some genetic diseases such as Wolff-Parkinson-White syndrome, thyroid problems, diabetes, sleep apnea, electrolyte imbalances (including potassium, sodium, and calcium), excess alcohol consumption, smoking, caffeine consumption, and drugs such as amphetamines or cocaine.
- **Signs and symptoms.** Symptoms include shortness of breath, dizziness or fainting, an uncharacteristically rapid or slow heart rate, a fluttering feeling in the chest, and chest pain.
- **Treatment.** The first management of arrhythmias should be to treat the underlying cause. Other treatment options include the following:
 - Pacemakers.
 - Various medications.

- Cardiopulmonary resuscitation if there is no evidence of blood flow.
- Vagal maneuvers to slow the heart rate. These include holding the breath, straining (bearing down as when a person is having a bowel movement), or putting one's face in cold water.
- Electrical shock to reset heart rhythms.
- Radiofrequency catheter ablation, a procedure that destroys a small amount of heart tissue in order to change the flow of the electrical current through the heart.
- Implantation of an ICD (implantable cardioverter defibrillator), a device that regulates heart rhythms.
- Maze procedure, which is an operation to form scars in the atria. These scars correct the electrical flow through the heart.
- Surgery to correct heart defects such as narrow coronary arteries.

Carditis is an inflammation of the heart. It is more specifically referred to as *endocarditis*, *myocarditis*, or *pericarditis*, depending on the layer of the heart that is affected.

Endocarditis is an inflammation of the lining of the heart, including the heart valves.

- **Causes.** Bacterial infections are the most common cause of endocarditis. Patients are more susceptible to this condition if they have abnormal heart valves.
- **Signs and symptoms.** Common signs and symptoms include weakness, fever, excessive sweating, general body aches, difficulty breathing, and blood in the urine.
- **Treatment.** The treatment for this condition is intravenous antibiotics followed by oral antibiotics for up to 6 weeks.

Myocarditis is an inflammation of the muscular layer of the heart. It is relatively uncommon but very serious because it leads to weakening of the heart wall.

- **Causes.** The most common cause of myocarditis is a viral infection, but it may also be caused by exposure to certain chemicals, allergens, and bacteria.
- **Signs and symptoms.** Signs and symptoms include fever as well as chest pains that feel like a heart attack. Difficulty breathing, decreased urine output, fatigue, and fainting may also accompany myocarditis.
- **Treatment.** Treatment normally includes steroids to reduce inflammation, bed rest, and a low-salt diet.

Pericarditis is inflammation of the pericardium, which is a group of membranes that surround the heart.

- **Causes.** This condition is most commonly caused by complications of viral or bacterial infections. However, heart attacks and chest injuries can also lead to pericarditis.
- **Signs and symptoms.** Symptoms include sharp, stabbing chest pains, especially during deep breaths.

continued →

Common Diseases and Disorders of the Circulatory System *(continued)*

Fever, fatigue, and difficulty breathing while lying down are also common symptoms.

- **Treatment.** The treatment usually includes painkillers. Diuretics are used to remove excess fluids around the heart. If pericarditis is caused by bacteria, antibiotics are used. In chronic cases, surgery may be required to remove part of the membranes surrounding the heart.

Congestive heart failure is a slowly developing condition in which the heart weakens over time. Eventually, the heart is no longer able to pump enough blood to meet the body's needs.

- **Causes.** There are many risk factors for this condition, including smoking, being overweight, a diet high in cholesterol, a lack of exercise, atherosclerosis, a heart attack, high blood pressure, a damaged heart valve, excessive alcohol consumption, and diabetes. Congenital heart defects, present at birth, and drugs that weaken the heart (especially cocaine, heroin, and some cancer drugs) may also contribute to the development of this disorder. This condition may be prevented by controlling high blood pressure and high cholesterol, not smoking, having a healthy diet, engaging in regular exercise, and treating any existing atherosclerosis or diabetes.
- **Signs and symptoms.** Signs and symptoms include shortness of breath, constant wheezing, prominent veins in the neck, swelling in the legs or feet, swelling of the abdomen, fluid retention, nausea, dizziness, and an irregular or rapid heartbeat.
- **Treatment.** Common treatment options include medications to slow a rapid heartbeat, diuretics to decrease fluid accumulation in the lungs, and medications to reduce blood pressure. In more serious cases, surgery to repair defective heart valves or other heart defects, a heart transplant, or the implantation of a cardiac pacemaker may be needed.

Coronary artery disease is also known as atherosclerosis. It affects more Americans than any other type of heart disease. Males and African Americans are more likely to develop coronary artery disease than are women or Caucasians.

- **Causes.** This condition is characterized by the narrowing of coronary arteries. Usually the narrowing is produced by the buildup of fat, cholesterol, and calcium in the arteries. The risk factors for developing this condition include high levels of LDL cholesterol in the blood, a diet high in fat and cholesterol, smoking, high blood pressure, obesity, a lack of exercise, and diabetes. As with congestive heart failure, this condition may be prevented by controlling high blood pressure and high cholesterol, not smoking, having a healthy diet, engaging in regular exercise, and treating any existing diabetes.

- **Signs and Symptoms.** There are often no signs or symptoms until a heart attack occurs. The most common symptoms include angina (a type of chest pain caused by a decreased flow of blood to the heart), shortness of breath, tightness in the chest, fatigue, and swelling in the legs or feet.

- **Treatment.** Treatment includes aspirin therapy and medications to slow a rapid heartbeat. Surgery to repair or widen narrowed coronary arteries may be needed in more serious cases.

Hypertension, commonly known as high blood pressure, is defined as a consistent resting blood pressure measured at 140/90 mm Hg or higher. This condition increases a person's risk of heart attack, stroke, heart failure, and kidney failure. African Americans are twice as likely to have high blood pressure as Caucasians are.

- **Causes.** Many of the causes are unknown. Known causes and risk factors include narrowing of the arteries, various medications such as oral contraceptives and cold medicines, kidney disease, endocrine disorders, pregnancy, drug use (especially cocaine and amphetamines), sleep apnea, obesity, smoking, a high-sodium diet, excessive alcohol consumption, stress, and diabetes.
- **Signs and symptoms.** There are usually no symptoms to hypertension. When symptoms do present, they include excessive sweating, muscle cramps, fatigue, frequent urination, and an irregular heart rate.
- **Treatment.** The first management of hypertension should be to treat the underlying causes. Other common treatments include a diet low in sodium and cholesterol, regular exercise, various medications to slow the heart rate and dilate blood vessels, diuretics to reduce blood volume, and lifestyle changes such as managing stress and stopping smoking.

Leukemia is a condition in which the bone marrow produces a large number of white blood cells that are not normal. These abnormal cells prevent normal white blood cells from carrying out their defensive functions. This disorder is sometimes referred to as cancer of the white blood cells. There are several different kinds of leukemia.

- **Causes.** Causes include mutations (changes) in white blood cells, chemotherapy for the treatment of other cancers, genetic factors (for example, the inheritance of abnormal genes), and exposure to agents that cause changes in the white blood cells.
- **Signs and symptoms.** The signs and symptoms are many and include fatigue, difficulty breathing during physical activity, an enlarged liver or spleen, swollen lymph nodes, abnormal bruising, cuts that heal slowly, frequent infections, nosebleeds, bleeding gums, chronic fever, unexplained weight loss, and excessive sweating.

continued →

Common Diseases and Disorders of the Circulatory System (continued)

- **Treatment.** Treatment options include chemotherapy, bone marrow transplant, medications to strengthen the immune system, a stem cell transplant, radiation therapy, and antibodies to destroy mutated white blood cells.

Murmurs are simply defined as abnormal heart sounds. Normally, heart sounds are clear and strong, as valves close completely, and smooth, as blood flows over the lining of the heart with no resistance. Not all murmurs indicate a heart disorder. Murmurs are graded from 1 to 6, 1 being barely audible (and the least serious).

- **Causes.** Not all the causes of heart murmurs are known. In children, the failure of the foramen ovale or ductus arteriosus to close completely after birth can cause murmurs. Other causes include stress and defective heart valves that cannot close completely.
- **Signs and symptoms.** The signs and symptoms vary considerably depending on the cause and severity of the heart murmur. Severe symptoms include weakness, pale skin, edema (fluid retention), and other common signs associated with heart failure.
- **Treatment.** Many times, no treatment is required. Surgery to correct valve defects or other heart defects may be needed in more serious cases.

A **myocardial infarction**, which is the term used for a heart attack, is characterized by damage to cardiac muscle due to a lack of blood supply. Heart attacks are often fatal or can leave permanent damage because cardiac muscle does not grow back once it is lost.

- **Causes.** The causes and contributing factors include blockage of the coronary artery due to atherosclerosis or a blood clot, or drugs such as cocaine that cause coronary arteries to spasm. Preventing a heart attack includes treating or reducing the risk of atherosclerosis. This condition may be further prevented by controlling high blood pressure and high cholesterol, not smoking, having a healthy diet, and engaging in regular exercise.
- **Signs and symptoms.** Common symptoms include recurring chest pain; a squeezing pain in the chest; pain in the shoulder, arm, back, teeth, or jaw; chronic pain in the upper abdomen; shortness of breath; sweating; dizziness or fainting; and nausea or vomiting.
- **Treatment.** The first treatment, if possible, is chewing an aspirin at the onset of the heart attack. In an unconscious patient, CPR (cardiopulmonary resuscitation) should be administered. Other treatment options include the use of a defibrillator (if available), thrombolytic drugs to destroy the blood clots that block a coronary artery, medications to thin the blood and slow the heart rate, and surgery to replace or repair blocked coronary arteries.

Sickle cell anemia is a condition in which abnormal hemoglobin causes red blood cells to change to a sickle

(crescent) shape. These sickle-shaped red blood cells get stuck in capillaries. Sickle cell anemia affects about 1 in every 500 African Americans and 1 in every 1400 Hispanics born in the United States.

- **Causes.** The primary cause is hereditary. A person with this disease must inherit a sickle cell gene from both parents. If only one sickle cell gene is inherited, the person is said to have sickle cell trait and may have mild symptoms of the disease. This condition may be prevented through genetic screening.
- **Signs and symptoms.** The signs and symptoms are many and include anemia, periodic episodes of pain called *crises*, chest pain, numbness in the hands or legs, fainting, fatigue, swollen hands and feet, jaundice, frequent infections, sores on the skin, delayed growth, stroke, seizures, and breathing difficulties. Retina damage, which causes visual problems, and spleen, liver, or kidney damage may also be seen.
- **Treatment.** Treatment includes antibiotics to treat infections, blood transfusions, pain medications, bone marrow transplants, supplemental oxygen, and medications to promote the development of normal hemoglobin.

Thrombophlebitis is a condition in which a blood clot and inflammation develop in a vein. It most commonly occurs in the veins of the legs. The danger of this disorder is that the blood clot may break loose. Once it reaches the heart, it is pumped to the lungs and is likely to block a blood vessel, causing a pulmonary embolism (an obstruction in the lungs). If the blood clot reaches the aorta and is pumped into arterial circulation, it can block either a coronary artery, causing a heart attack, or an artery in the brain, causing a stroke.

- **Causes.** The causes and risk factors include prolonged inactivity, oral contraceptives, hormone replacement therapy for estrogen, certain types of cancer, paralysis in the arms or legs, the presence of a catheter in a vein, a family history of this condition, varicose veins, and trauma to veins.
- **Signs and symptoms.** The most common symptoms are tenderness and pain in the affected area, redness, swelling, and fever.
- **Treatment.** This disorder is most often treated by the application of heat to the affected area, elevation of the legs, anti-inflammatory drugs, blood-thinning medications, the wearing of support stockings, and the removal of varicose veins. Surgery to remove the clot may be needed in some cases.

Varicose veins are dilated veins that are usually seen in the legs. They affect women more often than men.

- **Causes.** Varicose veins may be caused by prolonged sitting or standing, damage to valves in the veins, a loss of elasticity in the veins, obesity, pregnancy, oral

continued →

Common Diseases and Disorders of the Circulatory System *(continued)*

contraceptives, or hormone replacement therapy. Varicose veins may be prevented through exercise and elevation of the legs.

- **Signs and symptoms.** Signs and symptoms include discomfort in the legs, discolorations around the ankles, clusters of veins, and enlarged, dark veins that are seen through skin.
- **Treatment.** The treatment of varicose veins includes the following:
 - Sclerotherapy, which is a procedure that prevents blood from flowing through varicose veins.

- Laser surgery to prevent blood from flowing through affected veins.
- Vein stripping, which involves removing affected veins.
- Insertion of a catheter in the affected veins in order to destroy them.
- Endoscopic vein surgery to close off affected veins.

Summary

The circulatory system acts as the transport system for the body. It brings oxygen to tissues and carries carbon dioxide away. Nutrients are picked up from the digestive system and delivered throughout the body, while waste products are carried away so that certain organs may remove them. The circulatory system consists of the heart and blood vessels and includes arteries, veins, and capillaries.

Blood is the transport medium that is pumped throughout the body. It is a liquid tissue that consists of plasma and formed elements (red blood cells, white blood cells, and platelets). It is important for the medical assistant to have an understanding of this system in order to effectively perform electrocardiograms, phlebotomy, and blood tests.

REVIEW

CHAPTER 6

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. What symptoms suggest that this patient is suffering from coronary artery disease and not some other disorder?
2. Why is it important to test the heart under stress rather than obtaining a resting echocardiogram?
3. What lifestyle changes should this patient make to prevent future heart attacks?
4. Why is a cardiac catheterization needed in addition to the stress echocardiogram?
5. What are the treatment options for this patient?

Discussion Questions

1. Trace the flow of blood from the right atrium and back.
2. List the components of plasma and give the importance of each.
3. Define hemostasis and describe the three events involved in this process.

Critical Thinking Questions

1. Why is it important for a woman to know her Rh blood type either before she gets pregnant or early into her pregnancy?
2. If an embolism begins in a saphenous vein, where is it most likely to block a blood vessel?
3. What is the difference between a white blood cell count and a differential white blood cell count? If monocyte numbers came back high on a differential count, what would be the significance?

Application Activities

1. For each blood type, give the antigen present on the red blood cells and the antibody present in plasma:
 - a. Type A
 - b. Type B
 - c. Type AB
 - d. Type O
2. Give the area of the body supplied by each of the following arteries:
 - a. Brachial
 - b. Femoral
 - c. Renal
 - d. Coronary
 - e. Iliac
 - f. Carotid
3. Give the area of the body drained by each of the following veins:
 - a. Jugular
 - b. Gastric
 - c. Popliteal
 - d. Mesenteric
4. Tell how the following affect systemic blood pressure:
 - a. An increase in stroke volume
 - b. A decrease in peripheral resistance
 - c. A decrease in blood volume
 - d. Vasoconstriction of systemic arteries

Internet Activity

Go to the Web site <http://www.americanheart.org/>, the American Heart Association, and choose Health Tools on the left menu bar. Then click Risk Assessment. Fill in the form to determine your risk of developing a heart disorder.

CHAPTER 7

The Immune System

KEY TERMS

acquired
immunodeficiency
syndrome (AIDS)
allergens
anaphylaxis
antibody
antigen
antihistamines
biopsy
carcinogen
complement
cytokines
epinephrine
haptens
human immunodeficiency
virus (HIV)
humors
immunoglobulins
infection
inflammation
interferon
lupus erythematosus
lymphedema
lysozyme
macrophage
major histocompatibility
complex (MHC)
malignant
natural killer (NK) cells
phagocytosis

CHAPTER OUTLINE

- Defenses Against Disease
- Antibodies
- Immune Responses and Acquired Immunities
- Major Immune System Disorders

OBJECTIVES

After completing Chapter 7, you will be able to:

- 7.1 Define the terms *infection*, *pathogen*, and *antigen*.
- 7.2 List and describe the nonspecific body defense mechanisms.
- 7.3 Explain the signs and causes of inflammation.
- 7.4 Explain what is meant by specific body defenses.
- 7.5 Define B cells and T cells and describe their locations and functions.
- 7.6 Explain the importance of MHC proteins.
- 7.7 List the different types of T cells and describe their functions.
- 7.8 List the different types of antibodies and tell how they differ.
- 7.9 Explain how antibodies fight infection.
- 7.10 Define complement proteins and give their function.
- 7.11 Explain the difference between the primary immune response and secondary immune response.
- 7.12 Describe the function of a vaccine.
- 7.13 Explain the four different types of acquired immunities.
- 7.14 Describe how allergies develop.
- 7.15 Explain how the AIDS virus affects the immune system.
- 7.16 Identify the ways a person acquires the AIDS virus.
- 7.17 Define the terms *cancer* and *carcinogen*.
- 7.18 Explain how cancers are classified.
- 7.19 Describe how cancers are diagnosed and treated.
- 7.20 Describe the signs and symptoms of other common immune disorders.

Introduction

The immune system is responsible for protecting the body against bacteria, viruses, fungi, toxins, parasites, and cancer. It works with the organs of the lymphatic system to clear the body of these disease-causing agents.

CASE STUDY

A few days ago a 17-year-old female came to the doctor's office convinced that she had AIDS. She had been running a slight fever for the past week, had been very tired, had tender lymph nodes in her neck, and had been losing weight without dieting. Her chart indicated that she had never been sexually active, had never used intravenous drugs, and had never received a blood transfusion.

As you read this chapter, consider the following questions:

1. Why is the 17-year-old female not likely to have AIDS?
2. What test can be done to assure the patient that she does not have AIDS?
3. What other diseases can cause the signs and symptoms of AIDS?
4. Based on her symptoms, what disease—beside AIDS—is this patient least likely to have?

Defenses Against Disease

An **infection** is the presence of a pathogen in or on the body. A **pathogen** is a disease-causing agent such as a bacterium, virus, toxin, fungus, or protozoan. The body has mechanisms to protect itself against pathogens in general; these mechanisms are called nonspecific defenses. The body also has mechanisms to protect itself against very specific pathogens; these mechanisms are called immunities and are considered specific defenses.

Nonspecific Defenses

The nonspecific mechanisms that protect bodies against pathogens include species resistance, mechanical and chemical barriers, and **phagocytosis**. Fever and **inflammation** are also effective in protecting the body from invading organisms.

Species Resistance. Species resistance simply means that a species typically gets only diseases that are unique to that species. For example, humans do not get diseases that affect plants. Humans also do not get most diseases that affect animals.

Mechanical Barriers. The covering of the body (skin) and the linings of the tubes of the body (mucous membranes) provide mechanical barriers against pathogens. Intact skin is impermeable to most pathogens. Intact mucous membranes, although generally impermeable, do permit the entry of a few pathogens.

Chemical Barriers. Chemicals and enzymes in body fluids provide chemical barriers that destroy pathogens. For example, acids in the stomach destroy pathogens that are swallowed. **Lysozymes** in tears destroy pathogens on the surface of the eye. Salt in sweat also kills bacteria, and **interferon** in blood blocks viruses from infecting cells.

Phagocytosis. Neutrophils and monocytes are the most active phagocytes in blood. They can also leave the

bloodstream to attack pathogens in other tissues. When a monocyte leaves the bloodstream, it becomes a macrophage, which is simply a larger phagocytic cell.

Fever. An elevated body temperature is a fever. Fever causes the liver and spleen to take iron out of the bloodstream. Many pathogens need iron to survive in a body, so when their iron sources are gone, they die. Fever also activates phagocytic cells in the body to attack pathogens.

Inflammation. When an area of the body becomes injured or infected with a pathogen, inflammation can result. In inflammation, blood vessels in the injured area dilate and become leaky. Because blood vessels dilate, more blood enters the area, bringing phagocytic white blood cells to the area to attack the pathogen. The blood also brings proteins to replace injured tissues and clotting factors to stop any bleeding. The clotting factors also “wall off” the area so that pathogens cannot spread. Because blood vessels become leaky, more fluid accumulates in the injured area, which leads to edema. The excess fluid often irritates pain receptors. The four cardinal signs of inflammation are redness, heat, swelling, and pain.

Specific Defenses

Specific defenses are called immunities. They protect the body against very specific pathogens. For example, a person who has chickenpox develops a specific defense that prevents that person from getting chickenpox again. However, this specific defense does not protect the person from any other disease.

Antigens are very simply defined as foreign substances in the body. Pathogens have many antigens on their surfaces. The immune system is programmed to recognize antigens in the body. Foreign substances in the body too small to start an immune response by themselves are called **haptens**. Many times, haptens join to proteins in the blood where they are then able to trigger an immune response. Penicillin is an example of a hapten.

Antibodies and **complements** are the major proteins involved in specific defenses. **Lymphocytes** and **macrophages** are the major white blood cells involved in specific defenses.

B Cells and T Cells. Two major types of lymphocytes are B cells and T cells. Although both B cells and T cells circulate in the blood, most of the lymphocytes in blood are T cells. B cells and T cells are also found in lymph nodes, the spleen, the thymus, the lining of digestive organs, and bone marrow.

Both T cells and B cells recognize antigens in the body; however, they respond to antigens in different ways. T cells bind to antigens on cells and attack them directly. This type of response is called a cell-mediated response. T cells also respond to antigens by secreting different types of chemicals called **cytokines**. Cytokines increase T cell produc-

tion, increase B cell production, directly kill cells that have antigens, and stimulate red bone marrow to produce more white blood cells.

B cells do not attack antigens directly. B cells respond to antigens by becoming plasma cells. The plasma cells then make antibodies against the specific antigen. The antibodies end up attaching to antigens in the **humors** (fluids) of the body; this response is called a humoral response.

B cells become activated when a specific antigen binds to receptors on their surfaces. Each group of B cells only recognizes one type of antigen. Once activated, B cells divide to make plasma cells and memory B cells. Plasma cells make antibodies. Antibodies go out into the fluids of the body and bind to the antigens that activated the B cells. Memory B cells trigger a stronger immune response the next time the person is exposed to the same antigen (Figures 7-1 and 7-2).

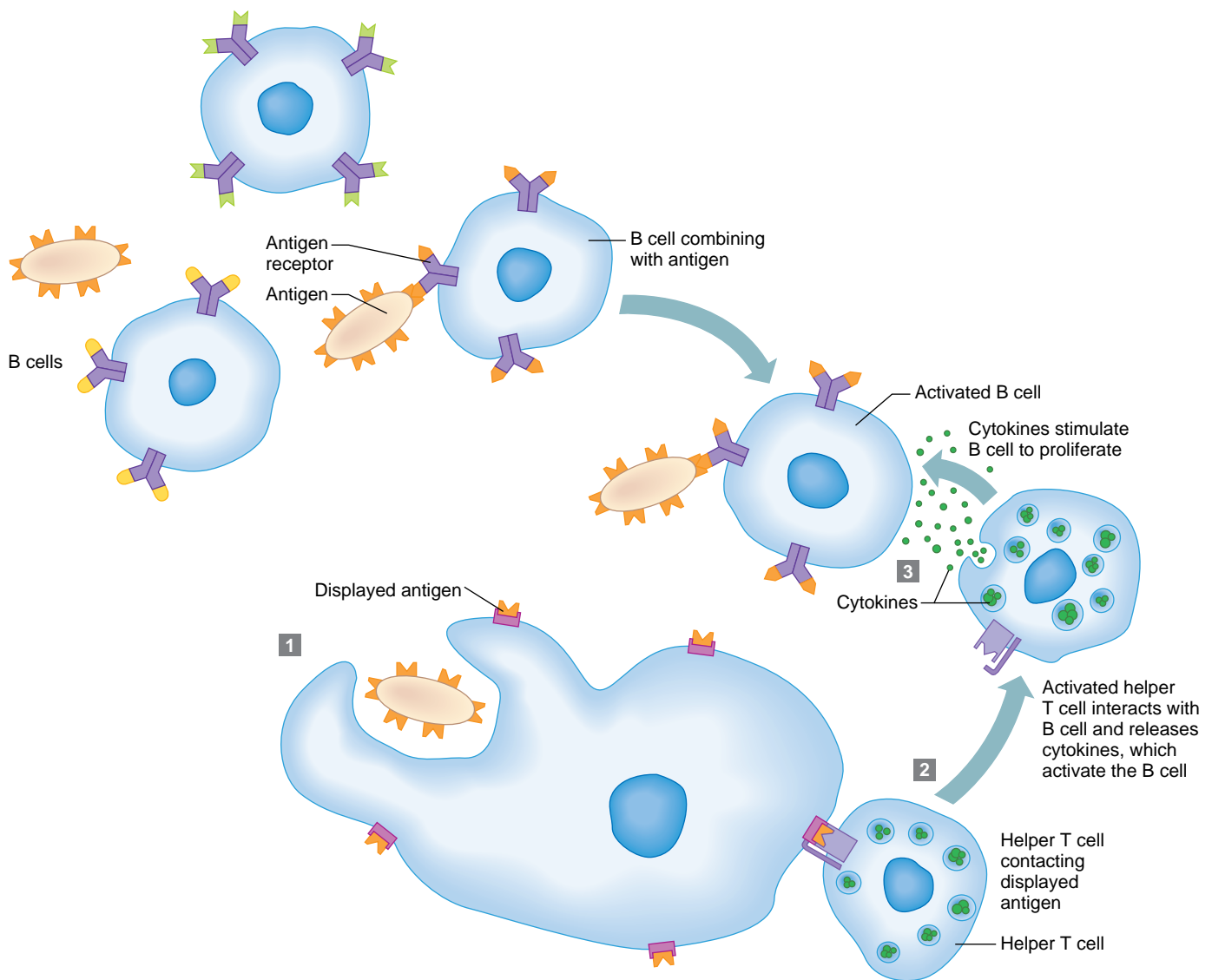


Figure 7-1. T cell and B cell activation. (1) A macrophage displays an antigen on its cell membrane. (2) A helper T cell binds to the antigen on the macrophage and becomes activated. (3) An activated helper T cell releases cytokines to help an activated B cell proliferate. Notice that the B cell must also bind to an antigen to become activated.

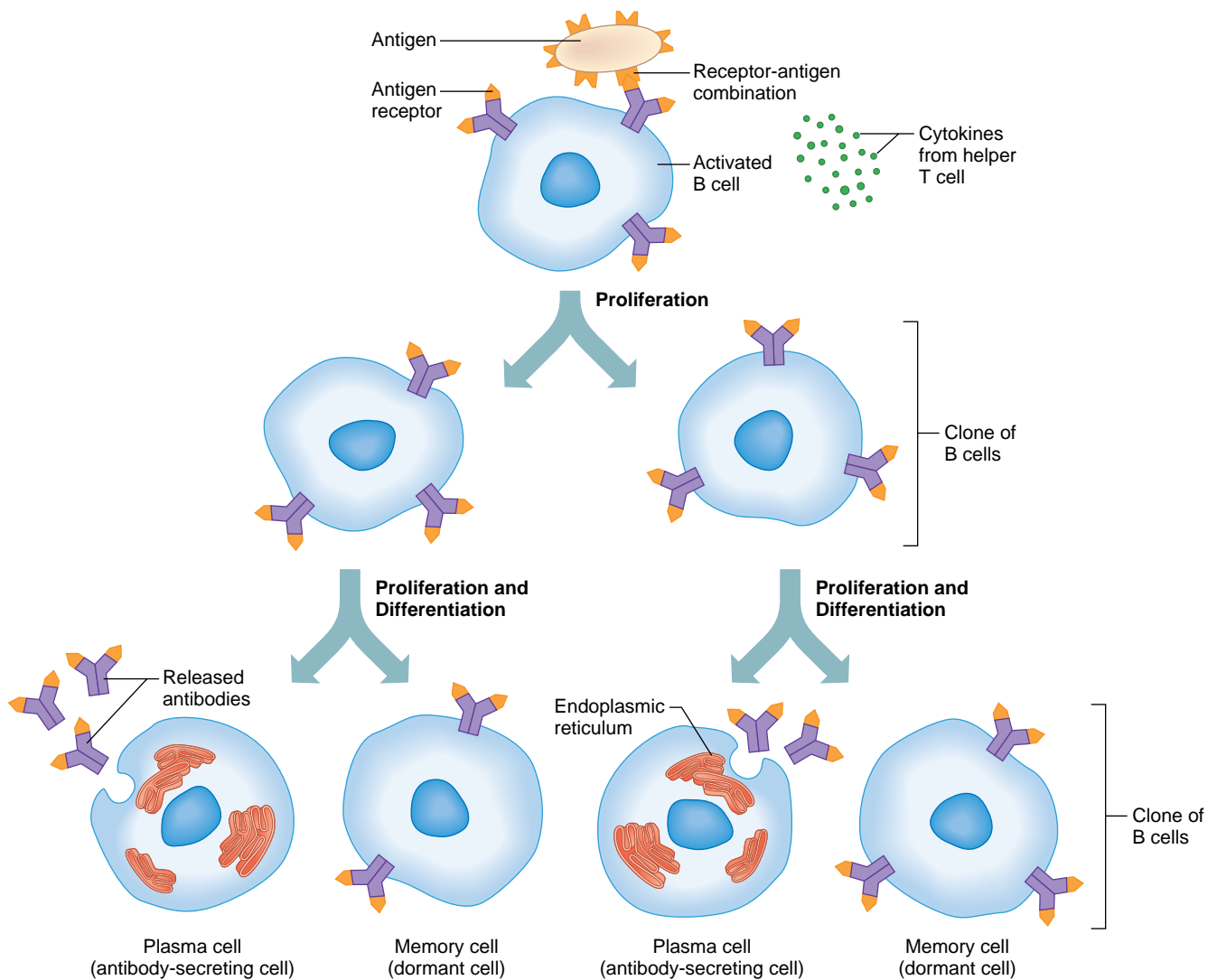


Figure 7-2. An activated B cell multiplies to become memory cells and plasma cells. Plasma cells secrete antibodies.

Before a T cell can respond to an antigen, it must be activated. T cell activation begins when a macrophage ingests and digests a pathogen that has antigens on it. The macrophage then takes some of the antigens from the pathogen and puts them on its cell membrane next to a large protein complex called a **major histocompatibility complex (MHC)**. A T cell that has a receptor for the antigen recognizes and binds to the antigen and the MHC on the surface of the macrophage. The T cell is now activated and begins to divide to form other types of T cells and T memory cells. It is important to note that T cells cannot be activated without macrophages and MHC proteins.

Some activated T cells form cytotoxic T cells. This type of T cell is important in protecting the body against viruses and cancer cells. Other activated T cells become helper T cells, which carry out many important roles in immunity. Helper T cells increase antibody formation, memory cell

formation, B cell formation, and phagocytosis. Some activated T cells become memory T cells. The memory cells “remember” the pathogen that activated the original T cell. When a person is later exposed to the same pathogen, memory cells trigger an immune response that is more effective than the first immune response. The production of memory cells prevents a person from suffering from the same disease twice.

Natural Killer (NK) Cells. Natural killer (NK) cells are another type of lymphocyte. They primarily target cancer cells but also protect the body against many types of pathogens. Like cytotoxic T cells, NK cells kill harmful cells on contact. They secrete chemicals that produce holes in the membranes of harmful cells, which cause the cells to burst. Unlike B cells and T cells, NK cells do not have to recognize a specific antigen to start destroying pathogens.

Antibodies

Antibodies are also called **immunoglobulins**. The following is a list of different types of immunoglobulins (Ig):

- IgG. This antibody primarily recognizes bacteria, viruses, and toxins. It can also activate complements, which are proteins in serum that attack pathogens.
- IgA. This antibody is found in secretions of the body such as breast milk, sweat, tears, saliva, and mucus. It prevents pathogens from entering the body.
- IgM. This antibody is very large and primarily binds to antigens on food, bacteria, or incompatible blood cells. It also activates complements.
- IgE. This antibody is found wherever IgA is located. It is involved in triggering allergic reactions.

When antibodies bind to antigens, they take one of the following actions:

- They allow phagocytes to recognize and destroy antigens.
- They make antigens clump together, causing them to be destroyed by macrophages. This is how incompatible blood cells are destroyed.
- They cover the toxic portions of antigens to make them harmless.
- They activate complements. Complements are proteins in serum that attack pathogens by forming holes in them. Complement proteins also attract macrophages to pathogens and can stimulate inflammation.

Immune Responses and Acquired Immunities

A primary immune response occurs the first time a person is exposed to an antigen. This response is slow and takes several weeks to occur. In this response, memory cells are made. A secondary immune response occurs the next time a person is exposed to the same antigen. This response is very quick and usually prevents a person from developing a disease from the antigen. Memory cells carry out the secondary immune response.

A person is born with very few immunities but normally develops them as long as the person's immune system is healthy. The four types of immunities a person can acquire are: (1) naturally acquired active immunity, (2) artificially acquired active immunity, (3) naturally acquired passive immunity, and (4) artificially acquired passive immunity.

Naturally Acquired Active Immunity

A person develops this immunity by being naturally exposed to an antigen and subsequently making antibodies and memory cells against the antigen. Having an infectious disease caused by pathogens leads to the development of this type of immunity. This immunity is usually long lasting.

Artificially Acquired Active Immunity

A person develops this immunity by being injected with a pathogen and then subsequently making antibodies and memory cells against the pathogen. Immunizations or vaccines cause this type of immunity. This type is usually long lasting.

Naturally Acquired Passive Immunity

A person is given this immunity through his mother. When a mother breast-feeds, she passes antibodies to her baby through breast milk. A mother also passes antibodies to her baby across the placenta. This type of immunity is short lived.

Artificially Acquired Passive Immunity

A person is given this immunity when she is injected with antibodies. If a snake bites a person, a physician will inject the patient with antibodies (antivenom) to neutralize the venom. This type of immunity is short lived.

Major Immune System Disorders

A number of diseases and disorders can challenge the immune system. Among them, HIV infection, AIDS, cancer, and allergies are the most significant.

Human Immunodeficiency Virus

Human immunodeficiency virus (HIV) is a viral infection that seriously damages an individual's immunity, primarily by destroying lymphocytes. It causes **acquired immunodeficiency syndrome (AIDS)** and can leave the immune system weak and susceptible to other diseases.

Routes of Transmission. HIV can be located in many body fluids including saliva, tears, blood, semen, vaginal secretions, and breast milk. The most common routes of transmission are through sexual contact, through blood, or from mother to child during pregnancy or breast-feeding. Less common routes of transmission are through accidental needlesticks, artificial insemination, and organ transplants. HIV is not transmitted through casual contact such as holding hands, hugging, and touching objects previously touched by HIV-infected persons. Statistically, persons most likely to get HIV infection are homosexual men, bisexual men, intravenous drug users who share needles, and infants born to HIV-infected mothers.

HIV Testing. A person can have an HIV infection for years before developing any symptoms of this disease. Fortunately, a few tests are available to determine if a person

has been infected with HIV. The most sensitive test—but one that is very costly—is polymerase chain reaction (PCR). This test can determine the number of HIV particles in a sample of blood, even if the number is less than 25 viral particles per cubic centimeter of plasma. For this reason, this test is useful for the early diagnosis of HIV infection.

Acquired Immunodeficiency Syndrome

AIDS is the development of severe signs and symptoms caused by HIV. In the United States, AIDS is the fifth leading cause of death in individuals between the ages of 25 and 44. This disease severely suppresses a person's immune system so that what would be minor infections in healthy individuals end up being fatal in patients with AIDS.

AIDS Testing. The most commonly used test to determine the presence of the AIDS virus is called ELISA. This test is considerably less expensive than PCR but is also less reliable. ELISA cannot detect early HIV infections. For this reason, it is preferable to test a high-risk patient three times with ELISA or alternate tests to ensure an accurate diagnosis.

Counts of CD4 cells are used to diagnose the stage of HIV infection. Once CD4 counts fall below 200, a person is diagnosed with AIDS. CD4 cells are types of T cells and are important for the functions of other components of the immune system.

Signs and Symptoms. The signs and symptoms of people who have developed AIDS include low T cell counts, fever, profuse sweating, weakness, weight loss, swollen glands, frequent infections, and some rare types of cancers. Common infections include ulcers of the mouth, skin, or genitals caused by herpes viruses; tuberculosis; yeast infections within the mouth, esophagus, or vagina; pneumonia; meningitis; and encephalitis. Cytomegalovirus (CMV), which is a type of infection caused by the herpes virus, can infect the eyes and other organs. A cancer that commonly appears in AIDS patients is Kaposi's sarcoma. It forms lesions on the skin—usually on the hands and feet first.

Treatment. There is no cure for AIDS, but in the United States, treatments are available that significantly delay the progression of the disease for many patients. Treatments include the use of various antiviral drugs, but many of these drugs have serious side effects. Antibiotics are also used to treat infections.

Cancer

Cancer is defined as the uncontrolled growth of abnormal cells. Healthy cells normally know when to stop reproducing, but cancer cells have lost this ability. Cancer cells often form growths called **malignant** tumors, which are often fatal. In many cases, these cancerous cells or tumors

damage normal cells of tissues and organs, which cause organ systems to fail.

At least 200 different types of cancers are known. In the United States, the three most common cancer types in men are prostate, lung, and colon cancer. The three most common types in women are breast, lung, and colon cancer. Lung cancer is the leading killer of all types of cancer for all people.

Causes. The causes of cancer are mostly unknown but certain risk factors have been identified. These factors include a suppressed immune system, radiation, tobacco, and some viruses. Many other factors are suspected. One of the best ways to prevent cancer is to not smoke and to avoid other known risk factors. A factor that is known to cause the formation of cancer is called a **carcinogen**.

Diagnosis. Most cancers are diagnosed with a **biopsy**, which is a removal of tissues for examination. CT scans are also used to help diagnose most cancer types. Other diagnostic tests include blood counts, an analysis of blood chemistry, and x-rays.

Signs and Symptoms. The symptoms of different types of cancer vary but the following are usually observed in most types: fever, chills, unintended weight loss, fatigue, and a general sense of not feeling well.

Treatment. The treatment of cancer differs depending on the type and stage of cancer. The stage of cancer refers to how large a tumor is and how far cancer cells have spread throughout the body. Table 7-1 provides a summary of cancer staging.

If tumors are localized and have not spread, the cancer can often be successfully treated by surgically removing the tumor. Other treatment options are chemotherapy and radiation therapy. Even if a cancer cannot be cured, its progression can sometimes be slowed, allowing patients to live additional years.

Allergies

An allergic reaction is an immune response to a substance, such as pollen, that is not normally harmful to the body. An allergy can also be an excessive immune response. Substances that trigger allergic responses are called **allergens**.

Allergic reactions involve IgE antibodies and mast cells. When IgE antibodies bind to allergens, they cause mast cells to release histamine and heparin. These chemicals trigger allergic reactions. A patient receiving allergy shots is being injected with tiny amounts of the allergen. This causes the body to produce IgG antibodies that will prevent IgE antibodies from binding to the allergen. IgG antibodies do not trigger immune responses because they do not activate mast cells.

Most allergies do not cause life-threatening conditions, but some do. One life-threatening condition that can result is **anaphylaxis**. In this condition, blood vessels dilate so quickly that blood pressure drops too quickly for organs to adjust.

TABLE 7-1 Cancer Staging

Stage	Description
Stage 0	Very early cancer. Cancer cells are localized in a few cell layers.
Stage I	Cancer cells have spread to deeper cell layers, or some may have spread to surrounding tissues.
Stage II	Cancer cells have spread to surrounding tissues but are considered contained in the primary cancer site.
Stage III	Cancer cells have spread beyond the primary cancer site to nearby areas.
Stage IV	Cancer cells have spread to other organs of the body.
Recurrent	Cancer cells have reappeared after treatment.

Signs and Symptoms. The signs and symptoms of allergies vary depending on what part of the body is exposed to allergens. Allergens that are inhaled often cause a runny nose, sneezing, coughing, or wheezing. An allergen that is ingested causes nausea, diarrhea, or vomiting. Allergens that are contacted by skin cause rashes. Allergens in the blood, such as penicillin for people who are allergic to it, are often the most life threatening because they can affect many organ systems.

Treatment. Many allergies are effectively treated with over-the-counter medications called **antihistamines**. Prescription-strength antihistamines are also available. Various types of nasal sprays and decongestants can also reduce the symptoms of allergies. When a person experiences anaphylaxis, an injection of **epinephrine** is usually an effective treatment. Epinephrine causes vasoconstriction, which increases blood pressure.

Pathophysiology

Common Diseases and Disorders of the Immune System

Chronic fatigue syndrome is a condition in which a person feels severe tiredness that cannot be relieved by rest and is not related to other illness.

- **Causes.** The causes are primarily unknown, although the herpes virus is suspected as a possible cause. This condition may also be caused by an autoimmune response against the nervous system.
- **Signs and symptoms.** The most common symptom is severe fatigue. Other signs and symptoms include mild fever, sore throat, tender lymph nodes in the neck or armpit, general body aches, joint pain, sleep disturbances, and depression.
- **Treatment.** Treatment includes antiviral drugs, medications to treat depression, and pain medications.

Lupus erythematosus, commonly referred to as lupus, is an autoimmune disorder that affects few or many organ systems of the body. In this condition, people produce antibodies that target their own cells and tissues. Lupus affects women more often than men.

- **Causes.** This disorder may be caused by some drugs or by bacterial infections.

- **Signs and symptoms.** The list of signs and symptoms is extensive and includes all of the following:
 - Fatigue
 - General body aches
 - Fever
 - Weight loss
 - Hair loss
 - Arthritis
 - Numbness of the fingers and toes
 - “Butterfly” rash on the face
 - Sensitivity to sunlight
 - Vision problems
 - Nausea
 - Nosebleeds
 - Headaches
 - Mental disorders
 - Seizures
 - Abnormal blood clots
 - Chest pains
 - Inflammation of heart tissues
 - Anemia
 - Shortness of breath

continued →

Common Diseases and Disorders of the Immune System (continued)

- Fluid accumulation around the lungs
- Renal failure
- Blood in the urine
- **Treatment.** Treatment options include anti-inflammatory medications as well as protective clothing and creams to prevent damage from sunlight. Dialysis, medications to suppress the immune system, and kidney transplants may be necessary for more serious cases.

Lymphedema is the blockage of lymphatic vessels. These vessels typically drain excess fluids from various areas of the body.

- **Causes.** This condition may be caused by parasitic infections, trauma to the vessels, tumors, radiation therapy, cellulitis (a skin infection), and surgeries in which lymph tissues have been removed.
- **Signs and symptoms.** Common symptoms are swelling that lasts longer than a few days or increases over time.
- **Treatment.** Treatment options include compression stockings for swelling in the legs or arms, elevation of the affected limb, or surgery to remove abnormal lymphatic tissue.

Rheumatoid arthritis is an autoimmune disorder in which a person's immune system attacks the joints of the body. Women are more likely to be affected than men.

- **Causes.** This disorder may be caused by some bacterial infections. In addition, it can be caused by immune cells that attack the structures associated with joints.
- **Signs and symptoms.** There are a number of signs and symptoms associated with this disorder. They include fatigue, joint pain and swelling (especially in the hands and feet), body aches, cartilage and bone destruction, anemia, nodules that appear under the skin, lung tissue scarring, shortness of breath, and stomach and skin ulcers. Patients may also present with inflammation of blood vessels, heart muscle, and the eyes.
- **Treatment.** This disorder may be treated with physical therapy, pain medications, and anti-inflammatory medicines. More serious treatments include medications to suppress the immune system, the removal of antibodies from the blood through a process called apheresis, surgery to remove inflamed joint membranes, and knee and hip replacement surgeries.

Summary

The body's major line of defense is the immune system. It protects the body against infection, toxins, and cancer. These defenses can be either nonspecific or specific. Lymphocytes are the major types of cells in the immune system and are classified as either B cells or T cells.

When the body is first exposed to an antigen, a primary immune response occurs. This response is less specific and

slower than a secondary immune response, which occurs the next time the body is exposed to the same antigen. An intact immune system is important because the body is attacked by numerous invaders every day. In order to effectively perform aseptic technique and infection control, the medical assistant must have a working knowledge of the immune system.

REVIEW

CHAPTER 7

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. Why is the 17-year-old female not likely to have AIDS?
2. What test can be done to assure the patient that she does not have AIDS?
3. What other diseases can cause the signs and symptoms of AIDS?
4. Based on her symptoms, what disease—beside AIDS—is this patient least likely to have?

Discussion Questions

1. List four types of antibodies and give their locations and functions.
2. What are nonspecific body defenses? Give examples.
3. How do secondary immune responses occur?
4. Discuss how B cells and T cells are activated.

Critical Thinking Questions

1. Why are passively acquired immunities temporary and short lasting compared to actively acquired immunities?
2. How does AIDS destroy the immune system?
3. How do vaccines produce favorable effects?

Application Activities

1. Give an example of each of the following nonspecific defense mechanisms:
 - a. Mechanical barrier
 - b. Chemical barrier
 - c. Phagocytic cell
2. Describe what produces the following signs of inflammation:
 - a. Redness
 - b. Swelling
 - c. Heat
 - d. Pain
3. Give the functions of each of the following defensive proteins or cells:
 - a. Complement proteins
 - b. Macrophages
 - c. Helper T cells
 - d. Memory cells
 - e. Plasma cells
4. What are disease-causing agents in the body called?

Internet Activity

Find a Web site that provides information on lymphedema. Research the types of patients who are most likely to develop this disorder. How can these people prevent the development of this condition?

CHAPTER 8

The Respiratory System

CHAPTER OUTLINE

- Organs of the Respiratory System
- The Mechanisms of Breathing
- Respiratory Volumes
- The Transport of Oxygen and Carbon Dioxide in the Blood

OBJECTIVES

After completing Chapter 8, you will be able to:

- 8.1 Explain the functions of the respiratory system.
- 8.2 Explain the difference between internal respiration and external respiration.
- 8.3 Describe how the larynx produces voice sounds.
- 8.4 List the structures contained within the lungs.
- 8.5 Describe the coverings of the lungs and chest cavity.
- 8.6 Describe the events that lead to the inspiration and expiration of air.
- 8.7 Explain how the brain controls breathing and how normal breathing patterns can be disrupted.
- 8.8 List and explain various respiratory volumes and tell how they are used to diagnose respiratory problems.
- 8.9 Describe how oxygen is transported from the lungs to body cells.
- 8.10 Describe how carbon dioxide is transported from body cells to the lungs.
- 8.11 Describe the signs, symptoms, causes, and treatments of various respiratory disorders and diseases.

Introduction

The respiratory system functions to move air in and out of the lungs. This process is called ventilation, or breathing. This system also functions to deliver oxygen (O_2) via the bloodstream. It also removes a waste product—carbon dioxide (CO_2)—from the blood. This exchange of oxygen and carbon dioxide is called external respiration.

KEY TERMS

alveoli
bicarbonate ions
bronchi
bronchial tree
bronchioles
chronic obstructive pulmonary disease (COPD)
cricoid cartilage
epiglottic cartilage
epiglottis
expiration
glottis
hyperventilation
inspiration
larynx
nasal conchae
nasal septum
paranasal sinuses
pharynx
pleura
pleuritis
pneumothorax
respiratory volume
sinusitis
thyroid cartilage
trachea
ventilation

CASE STUDY

A 5-year-old boy is brought to the pediatrician's office. He has been coughing at night for the past week. Today he presents with shortness of breath, tightness in his chest, and wheezing. The doctor recognizes the child's symptoms as those of asthma and orders a bronchodilator—a drug that relaxes the muscles around the airway—to be delivered using a nebulizer. He also refers the child for allergy testing.

As you read this chapter, consider the following questions:

1. Why is the patient wheezing?
2. Is asthma a life-threatening condition?
3. What is the advantage of using a nebulizer to deliver the bronchodilator?
4. Why did the doctor refer the patient for allergy testing?

Organs of the Respiratory System

The organs of the respiratory system are the nose, pharynx, larynx, trachea, bronchial tree (including the bronchi and bronchioles), and the lungs (Figure 8-1). The nose is made of bones and cartilage and the skin covering them. The openings of the nose are called nostrils. The hairs of the nostrils prevent large particles from entering the nose through air.

The Nasal Cavity and Paranasal Sinuses

The nasal cavity is simply the hollow space behind the nose. The nasal cavity is divided into a left and right portion by the **nasal septum**. There are structures called **nasal conchae** that extend from the lateral walls of the nasal cavity. Most of the nasal cavity is lined with a mucous membrane that acts to warm and moisten air as it passes through the nasal cavity.

The nasal cavity is also lined with cells that possess cilia. As mucus traps dust and other particles in the nasal cavity, the cilia push the mucus toward the throat where it is swallowed. The enzymes of the stomach then destroy the particles in the dust.

The **paranasal sinuses** are air-filled spaces within the skull bones that open into the nasal cavity. The paranasal sinuses reduce the weight of the skull and also give your voice a certain tone. When your paranasal sinuses are “stopped up,” the tone of your voice changes. The bones of the skull that contain the sinuses include the frontal, sphenoid, ethmoid, and maxillae bones.

The Pharynx

The **pharynx** is an organ of the respiratory system as well as the digestive system. During inspiration, air flows from

the nasal or oral cavity into the pharynx. From the pharynx, air flows into the larynx.

The Larynx and Vocal Cords

The **larynx** is more commonly called the voice box. It sits superior to and is continuous with the trachea. It functions to move air into and out of the trachea and to produce the sounds of a person's voice. The larynx is mostly made of cartilage and muscle tissue. There are three cartilages in the larynx (Figure 8-2). The largest cartilage is called the **thyroid cartilage**, and it forms the anterior wall of the larynx. During the puberty of a male, testosterone causes the thyroid cartilage to enlarge to produce the “Adam's apple.” A smaller cartilage called the **epiglottic cartilage** forms the framework of the epiglottis. The **epiglottis** is the flap-like structure that closes off the larynx during swallowing. The third cartilage of the larynx is called the **cricoid cartilage**. It forms most of the posterior wall of the larynx and a small part of the anterior wall.

The vocal cords stretch between the thyroid cartilage and the cricoid cartilage. The opening between the vocal cords is called the **glottis** (see Figure 8-2, part C). The upper vocal cords are referred to as false vocal cords because they do not produce sound. The lower vocal cords are called true vocal cords because muscles stretch and relax them to produce different types of sounds. If the true vocal cords are stretched, the voice becomes higher in pitch. When the true vocal cords are relaxed, the voice becomes lower in pitch. Men have thicker vocal cords, which is why their voices are deeper than female voices.

The Trachea, Bronchi, and Bronchioles

The **trachea** is more commonly referred to as the *windpipe*. It is a tubular organ made of rings of cartilage and smooth muscle. It extends from the larynx to the bronchi. The trachea is lined with cells that possess cilia that constantly

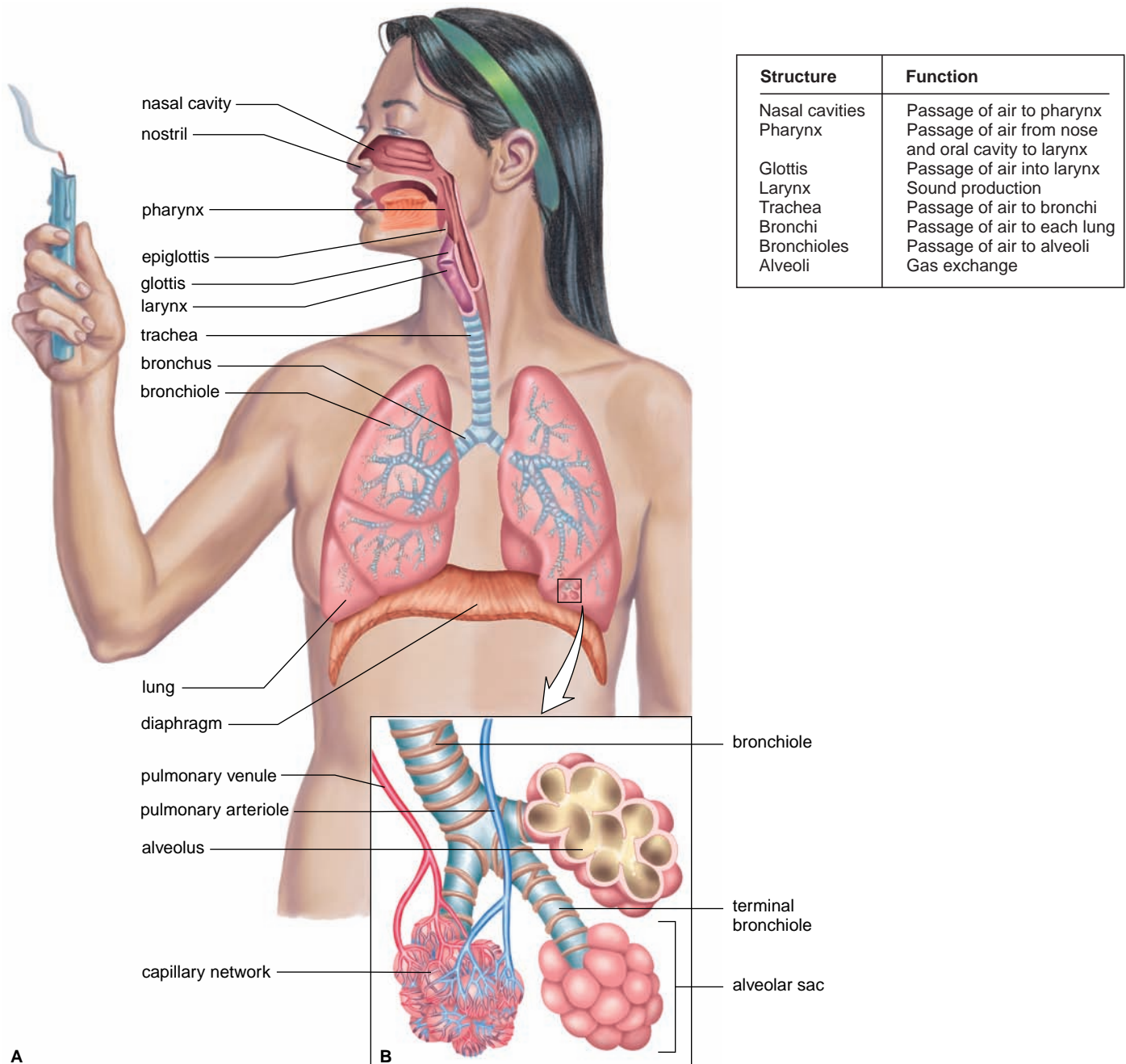


Figure 8-1. (a) Organs of the respiratory system and (b) the flow of air through respiratory organs.

move mucus up to the throat where it is swallowed. Mucus traps bacteria, viruses, and any other harmful substances a person inhales—as in the process that occurs in the nasal cavity. The digestive juices of the stomach then destroy the harmful substances. Smoking destroys cilia so the only way a smoker can get mucus out of his trachea is to cough. Smokers often feel the urgency to cough more frequently than nonsmokers.

The distal end of the trachea branches and starts a series of tubes called the **bronchial tree**. The first branches off the trachea are called primary, or main stem, **bronchi**. The branches of the primary bronchi are called secondary bronchi. The secondary bronchi branch into tertiary

bronchi. Tertiary bronchi branch into **bronchioles**. At the ends of the bronchioles are air sacs called alveoli.

Alveoli are very thin sacs made of simple squamous epithelial cells and are surrounded by capillaries. They are considered the “working tissue” of the lung because in the alveoli is where gaseous exchanges take place. Many physicians refer to the alveoli as the *pulmonary parenchyma* (parenchymal means “working tissue” of any organ or organ system). Blood in the capillaries releases carbon dioxide into the alveoli, and air in the alveoli releases oxygen into the blood of the capillaries. This is the process by which oxygen moves into the blood and carbon dioxide is removed.

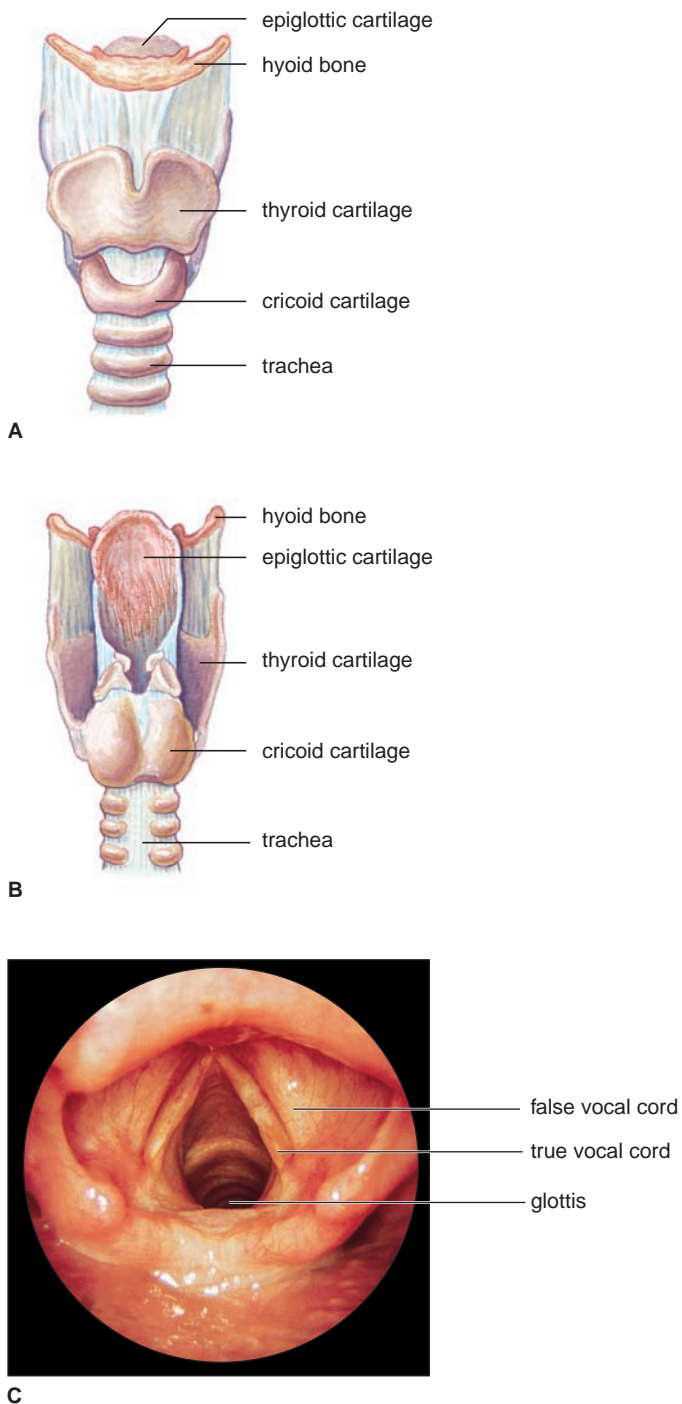


Figure 8-2. (a) Anterior view of larynx. (b) Posterior view of larynx. (c) Photograph of the vocal cords and glottis.

The Lungs

The lungs are cone-shaped organs that contain connective tissue, the bronchial tree, nerves, lymphatic vessels, and many blood vessels. The right lung is larger than the left; the right lung is divided into three lobes and the left into two. The membranes that surround the lungs are called

pleura. Pleura produce a slippery fluid called serous fluid that helps the lungs slide easily along the thoracic wall during breathing.

The Mechanisms of Breathing

Breathing, or pulmonary **ventilation**, consists of two events—**inspiration** and **expiration**. During inspiration, or inhalation, oxygen-rich air eventually flows into the alveoli of the lungs. Air flows into the airways during inspiration because the thoracic cavity enlarges. When the thoracic cavity enlarges, pressure decreases in the cavity. The atmospheric pressure outside the body is greater than the pressure inside the cavity, and air passively flows from an area of high pressure to an area of low pressure. The events that enlarge the thoracic cavity and therefore lead to inspiration are as follows (Figure 8-3):

- The diaphragm contracts. When the diaphragm contracts, it becomes flat, which increases the amount of space in the thoracic cavity.
- The intercostal muscles raise the ribs; this further enlarges the thoracic cavity.

During expiration, or exhalation, air rich with carbon dioxide flows out of the airways. Air flows out because the thoracic cavity becomes smaller, which increases the pressure inside the cavity. When the pressure inside the cavity becomes greater than the atmospheric pressure, air flows out. The events that lead to expiration are as follows (Figure 8-3):

- The diaphragm relaxes. When the diaphragm relaxes, it domes up into the thoracic cavity, which decreases the space in the cavity.
- The intercostal muscles lower the ribs; this further decreases the size of the thoracic cavity.

Breathing is controlled by the respiratory center, which is a group of neurons in the pons and medulla oblongata. The medulla oblongata controls both the rhythm and the depth of breathing. The pons controls the rate of breathing.

Other factors that affect breathing are the carbon dioxide levels in the blood and the pH of the blood. When carbon dioxide levels rise in the blood, the rate and depth of breathing increase. The rate and depth of breathing also increase when the blood pH drops. Fear and pain also increase the breathing rate. Breathing rapidly and deeply is called **hyperventilation**. Hyperventilation decreases the amount of carbon dioxide in the blood.

The inflation reflex also helps to regulate the depth of breathing. Stretch receptors in pleural membranes are activated when the lungs are stretched past a certain point. This triggers the depth of breathing to decrease to prevent overinflation of the lungs.

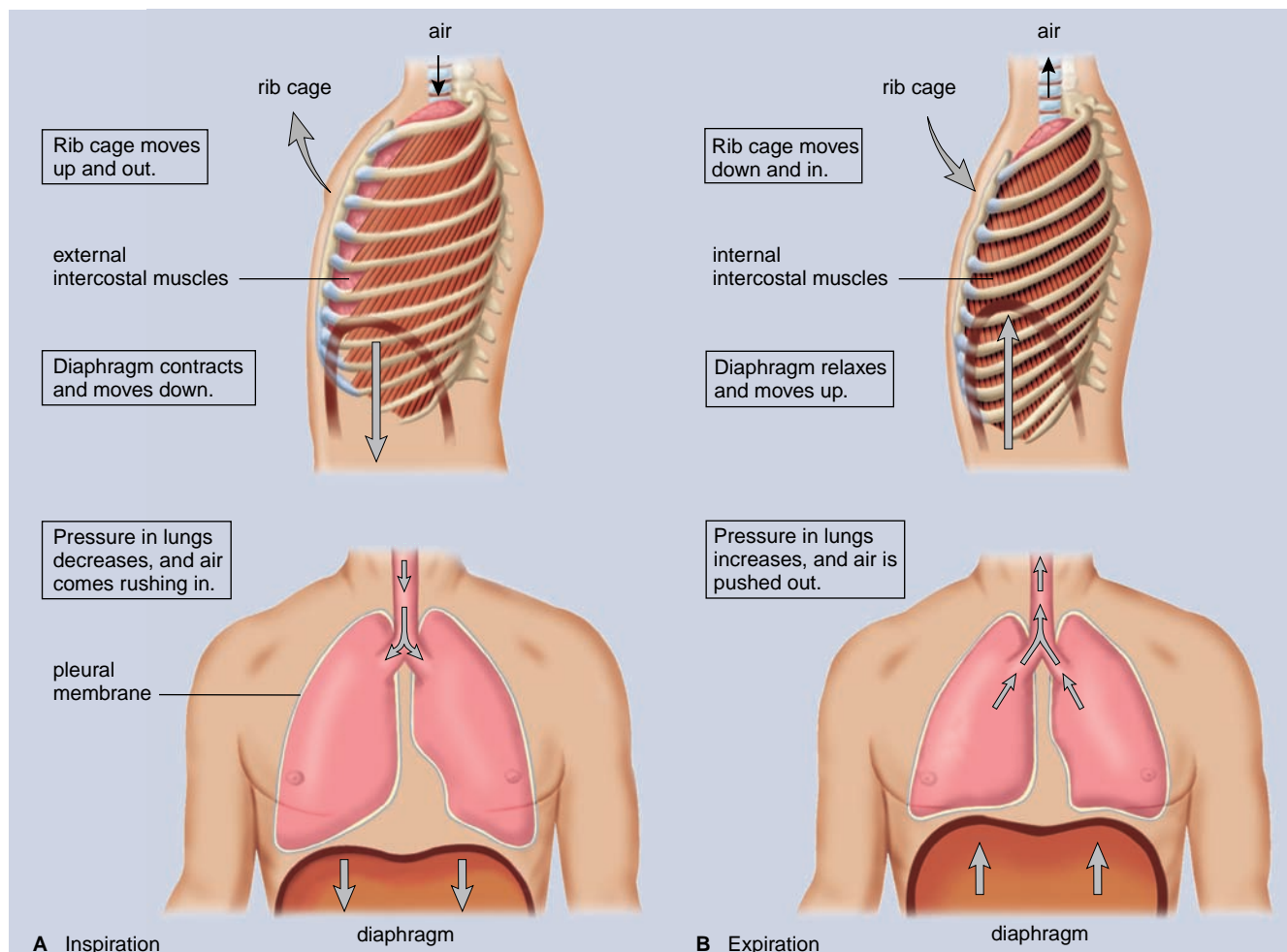


Figure 8-3. (a) Events of inspiration and (b) events of expiration.

Respiratory Volumes

During different intensities of breathing, different volumes of air move in and out of the lungs. These volumes are called **respiratory volumes** and can be measured to assess the healthiness of the respiratory system. Respiratory capacities can be calculated by adding certain respiratory volumes together. The following are the different types of volumes and capacities:

- Tidal volume: the amount of air that moves in or out of the lungs during a normal breath.
- Inspiratory reserve volume: the amount of air that can be forcefully inhaled following a normal inhalation.
- Expiratory reserve volume: the amount of air that can be forcefully exhaled following a normal exhalation.
- Residual volume: the volume of air that always remains in the lungs, even after a forceful expiration.
- Vital capacity: the total amount of air that can be forcefully exhaled after the deepest inhalation possible.
- Total lung capacity: the total amount of air the lungs can hold.

The Transport of Oxygen and Carbon Dioxide in the Blood

Once oxygen gets into the bloodstream, about 97% of it binds to **hemoglobin** in red blood cells. Hemoglobin bound to oxygen is called **oxyhemoglobin** and is bright red in color. Some oxygen stays dissolved in plasma and does not bind to hemoglobin.

Carbon dioxide in the bloodstream reacts with water to form **bicarbonate ions**; most carbon dioxide is actually carried in the blood as bicarbonate ions. When bicarbonate ions reach the respiratory membranes of the lungs, an enzyme changes them back into carbon dioxide and water. Then the carbon dioxide diffuses out of the blood and into the air of the lungs so it can be exhaled. Some carbon dioxide binds to hemoglobin or dissolves in plasma to be transported to the lungs.

Not to be confused with carbon dioxide, carbon monoxide is an odorless, clear gas that is poisonous to humans. Carbon monoxide binds to the hemoglobin at the same site that oxygen binds to it. Thus, when someone is exposed to carbon monoxide, it attaches to hemoglobin instead of oxygen causing the person to suffocate.



Educating the Patient

Snoring

Snoring occurs when the muscles of the palate, tongue, and throat relax. Airflow then causes these soft tissues to vibrate. These vibrating tissues produce the harsh sounds characteristic of snoring.

Snoring causes daytime sleepiness and is sometimes associated with sleep apnea. In this condition, the relaxed throat tissues cause airways to collapse, which prevent a person from breathing. Snoring affects approximately 50% of men and 25% of women over the age of 40. The common causes of snoring include:

- Enlargement of the tonsils or adenoids
- Being overweight
- Alcohol consumption
- Nasal congestion
- A deviated (crooked) nasal septum

The severity of snoring varies among people. The Mayo Clinic's Sleep Disorders Center uses the following scale to determine the severity of snoring:

- **Grade 1:** Snoring can be heard from close proximity to the face of the snoring person.

- **Grade 2:** Snoring can be heard from anywhere in the bedroom.
- **Grade 3:** Snoring can be heard just outside the bedroom with the door open.
- **Grade 4:** Snoring can be heard outside the bedroom with the door closed.

You can educate patients about making lifestyle modifications and using aids to help reduce their snoring:

- Lose weight
- Change the sleeping position from the back to the side
- Avoid the use of alcohol and medications that cause sleepiness
- Use nasal strips to widen the nasal passageways
- Use dental devices to keep airways open

In addition, patients may benefit from using a mask attached to a pump that forces air into their passageways while they sleep. If these therapies are not effective, patients may need surgery to trim excess tissues in the throat or laser surgery to remove a portion of the soft palate.

Pathophysiology

Common Diseases and Disorders of the Respiratory System

Asthma is a condition in which the tubes of the bronchial tree become obstructed due to inflammation.

- **Causes.** The causes can include allergens (pollen, pets, dust mites, etc.), cigarette smoke, pollutants, perfumes, cleaning agents, cold temperatures, and exercise (in susceptible individuals).
- **Signs and symptoms.** Symptoms include difficulty breathing, a tight feeling in the chest, wheezing, and coughing.
- **Treatment.** Treatment includes avoiding allergens, using a steroid inhaler to reduce inflammation, using a bronchodilator, and stopping smoking.

Bronchitis is inflammation of the bronchi and often follows a cold. Bronchitis that occurs frequently often indicates more serious conditions such as asthma or emphysema. Smokers are much more likely to develop bronchitis than

are nonsmokers. Repeated episodes of bronchitis increase a person's chance of eventually developing lung cancer.

- **Causes.** This condition can be caused by viruses and gastroesophageal reflux (acids that move from the stomach into the esophagus). Exposure to cigarette smoke, pollutants, and the fumes of household cleaners can also contribute to the development of bronchitis.
- **Signs and symptoms.** The signs and symptoms include chills, fever, coughing up yellow-gray or green mucus, tightness in the chest, wheezing, and difficulty breathing.
- **Treatment.** This condition can be treated with rest, fluids, nonprescription and prescription cough medicines, and the use of a humidifier. Antibiotics are usually prescribed only for smokers. Patients who also have asthma may need to use inhalers. They should also wear masks if they may be exposed to lung irritants.

continued →

Common Diseases and Disorders of the Respiratory System (continued)

Chronic obstructive pulmonary disease (COPD) is a group of lung disorders that limit airflow to lungs and usually cause enlargement of the air sacs in lungs. Emphysema and chronic bronchitis are the most common types of COPD.

- **Causes.** The primary causes are smoking and air pollution.
- **Signs and symptoms.** Common signs and symptoms include difficulty breathing, fatigue, and frequent coughing.
- **Treatment.** Treatment should first be focused on lifestyle changes, especially stopping smoking. Other treatment options include respiratory therapy and the use of inhalers. In more serious cases, a lung transplant may be necessary.

Emphysema is a chronic condition that damages the alveoli of the lungs. It is heavily associated with smoking.

- **Causes.** The most common causes are exposure to cigarette smoke, pollutants, and the dust from grains, cotton, wood, or coal.
- **Signs and symptoms.** Symptoms include shortness of breath that progresses over time, chronic cough, unintended weight loss, and fatigue.
- **Treatment.** Stopping smoking and preventing exposure to cold environments and pollutants should be the first treatment measures. Vaccinations to prevent the flu and pneumonia as well as antibiotics to control the respiratory infections associated with emphysema may also be administered. In addition, patients can be treated with bronchodilators, supplemental oxygen, inhaled steroids, and respiratory therapy. The most serious cases may require either surgery to remove damaged lung tissue or a lung transplant.

Influenza is more commonly called the flu. Babies, the elderly, and people with suppressed immune systems are at the highest risk of developing influenza. The flu normally lasts between 5 and 10 days.

- **Causes.** This disease is caused by a number of different viruses that attack the respiratory system. It can be prevented through a flu vaccination.
- **Signs and symptoms.** Common symptoms include a runny nose, sore throat, sneezing, fever or chills, a dry cough, muscle pain, fatigue, loss of appetite, and diarrhea.
- **Treatment.** Over-the-counter pain medications can alleviate the aches and pains associated with the flu. Other treatment options include bed rest, fluids, and antiviral medications.

Laryngitis is an inflammation of the larynx. Chronic laryngitis is associated with lung cancer.

- **Causes.** The causes of this condition are varied and include the following: viruses; bacteria; polyp formation in the larynx; excessive talking, shouting, or singing;

allergies; smoking; frequent heartburn; the frequent use of alcohol; damage to nerves that supply the larynx; and a stroke that paralyzes vocal cord muscles.

- **Signs and symptoms.** Signs and symptoms include a hoarse voice, sore throat, a dry cough and throat, and tickling sensations in the throat.
- **Treatment.** The most common treatment options are antibiotics, the management of heartburn, and the avoidance of cigarettes and alcohol. The treatment of more serious cases includes removing polyps in the larynx and surgery to tighten the vocal cords.

Legionnaire's disease is a type of pneumonia.

- **Causes.** This disease is caused by bacteria that usually grow in air conditioning systems.
- **Signs and symptoms.** The symptoms include fever, fatigue, difficulty breathing, frequent coughing, chest pain, muscle aches, and headache.
- **Treatment.** Antibiotics, respiratory therapy, and supportive therapy such as IV fluids are the primary treatment options.

Lung cancer is closely associated with smoking and kills more people in the United States than any other type of cancer. Smoking accounts for approximately 85% of all lung cancer cases.

- **Causes.** The primary causes are smoking and exposure to radon, asbestos, and industrial carcinogens.
- **Signs and symptoms.** The respiratory symptoms include a cough that worsens over time, coughing up blood, difficult breathing, wheezing, and recurring bronchitis. Other symptoms are chest pain, chronic hoarseness, unintended weight loss, and bone pain if the cancer spreads.
- **Classification.** Lung cancer is classified by the following types:
 - *Small cell lung cancer.* This type occurs almost exclusively in smokers. It is the most aggressive type and spreads readily to other organs. Small cell lung cancer that spreads to other organs is termed *extensive*.
 - *Squamous cell lung cancer.* This type of lung cancer arises from the epithelial cells that line the tubes of the lungs. It occurs most commonly in men.
 - *Adenocarcinoma.* This type arises from the mucous-producing cells of the lungs. It develops most commonly in women and nonsmokers.
 - *Large cell carcinoma.* This type of lung cancer arises from the peripheral parts of the lungs.
- **Stages.** Squamous cell lung cancer, adenocarcinoma, and large cell carcinoma are staged as follows:
 - Stage 0: Cancer is found only in the lining of the tubes of the lungs.
 - Stage 1: Cancer has spread from the lining of the tubes to lung tissues.

continued →

Common Diseases and Disorders of the Respiratory System (continued)

- Stage 2: Cancer has spread to the lymph nodes or the chest wall.
- Stage 3: Cancer has spread to the lymph nodes and to other organs within the chest.
- Stage 4: Cancer has spread to organs outside the chest.
- **Treatment.** Treatment will vary depending on the type of cancer and the stage. Stopping smoking should be the first treatment consideration. Common treatment options include chemotherapy and radiation therapy. More serious cases may require the surgical removal of tumors (if they are confined), a lobectomy (the removal of a lung lobe or lobes), or a pneumonectomy (the removal of an entire lung).

Pleuritis is a condition in which the membranes that cover the lungs, known as pleura, become inflamed. This often causes the membranes to stick together or can cause an excess amount of fluid to form between the membranes.

- **Causes.** Causes include viruses, pneumonia, autoimmune diseases such as lupus or rheumatoid arthritis, tuberculosis, a pulmonary embolism, inflammation of the pancreas, and trauma to the chest.
- **Signs and symptoms.** Symptoms include fever or chills, a dry cough, shortness of breath, and chest pain during inhalation or exhalation.
- **Treatment.** Pain medications may be prescribed to relieve chest pain. Anti-inflammatory drugs, antibiotics, and the removal of fluid around the lungs are the primary treatment options.

Pneumonia is characterized by an inflammation of the lungs that is most often caused by a bacterial or viral infection of the lungs. There are at least 50 different types of pneumonia, and they range from mild to very serious. Double pneumonia refers to inflammation of both lungs.

- **Causes.** Pneumonia can be caused by bacteria, viruses, fungi, and parasites. It can also be caused by foreign matter that enters the lungs (for example, stomach contents that enter the lungs after vomiting). This disorder may be prevented by not smoking and, for some types of pneumonia, by vaccinations.
- **Signs and symptoms.** Common signs and symptoms include fever or chills, headache, chest or muscle pain, fatigue, difficulty breathing, and coughing up rust-colored, green, or yellowish mucus.
- **Treatment.** Rest, fluids, over-the-counter pain medications, and antibiotics are the most common treatments.

Pneumothorax is a collection of air in the chest around the lungs.

- **Causes.** Some causes of this disorder are unknown. Various respiratory diseases and trauma to the chest,

such as a stabbing wound, can also contribute to the development of pneumothorax.

- **Signs and symptoms.** The primary symptoms include tightness in the chest or a sharp chest pain, shortness of breath, and a rapid heart rate.
- **Treatment.** The insertion of a chest tube to remove air from the chest and surgery to repair chest wounds are the primary treatments.

Pulmonary edema is a condition in which fluids fill spaces within the lungs. This disorder makes it very difficult for the lungs to oxygenate the blood. It most commonly occurs when the heart cannot pump all the blood it receives from the lungs. Blood then backs up in the lungs, causing fluids to seep into lung spaces.

- **Causes.** The causes of this condition are many and include the following: congestive heart failure, heart attack, cardiomyopathy, heart valve disorders, lung infections, allergic reactions, smoke inhalation, drowning, various drugs such as narcotics and heroin, chest injuries, and high altitudes. This disorder may be prevented by avoiding high altitudes and smoking. Preventing heart disease may also reduce the chance of developing this disorder.
- **Signs and symptoms.** The symptoms of pulmonary edema are shortness of breath, difficulty breathing (especially when lying down), a feeling of suffocating, wheezing, a cough that produces pink mucus, rapid weight gain, pale skin, and profuse sweating.
- **Treatment.** Treatment includes oxygen therapy, diuretics to eliminate excess fluids, and morphine to reduce anxiety and shortness of breath.

Pulmonary embolism is a blocked artery in the lungs. Usually the artery is blocked by a blood clot that has traveled from a vein in the legs. If an artery in the lungs is completely blocked, death can occur quickly.

- **Causes.** People at the highest risk of developing this condition are those who have had previous heart attacks, cancer, a fractured hip, or chronic lung diseases. Women who use birth control pills and individuals who have a pacemaker may be at risk for developing a pulmonary embolism. In addition, long periods of inactivity, increased levels of clotting factors in the blood (usually caused by certain cancers), injury to veins, and a stroke that causes paralysis of the arms or legs may also cause this condition. A sedentary lifestyle as well as auto or airplane travel—or any activity that requires prolonged sitting or standing—are also major risk factors for developing a pulmonary embolism. A baby aspirin taken daily, as well as plenty of fluids and frequent movement of the arms and legs, may help prevent the development of a pulmonary embolism.

continued →

Common Diseases and Disorders of the Respiratory System (continued)

- **Signs and symptoms.** Symptoms include fainting, a sudden shortness of breath, coughing up blood, wheezing, a rapid heartbeat, profuse sweating, and chest pain that may spread to a shoulder, arm, or the face.
- **Treatment.** Support stockings can be used to promote circulation. The patient should rest until the blood clot has dissolved and may be prescribed clot-dissolving medications. Anticoagulants may be used to prevent new blood clots from forming in the deep veins of the body. Finally, surgery may be used to place a filter in the vena cava to prevent blood clots from reaching the lungs.

Severe acute respiratory syndrome (SARS) is a relatively new respiratory disease that is sometimes fatal and contagious.

- **Causes.** SARS is caused by viruses associated with the common cold as well as by unknown viruses. It can be prevented by thoroughly washing the hands, wearing a mask, and avoiding exposure to individuals with this disease.
- **Signs and symptoms.** Signs and symptoms include fever or chills, headache, a dry cough, and muscle aches.
- **Treatment.** Rest and antiviral drugs are the primary treatments.

Sinusitis is an inflammation of the membranes lining the sinuses of the skull.

- **Causes.** Bacteria, excess mucus production in the sinuses, the blockage of sinus openings, and the destruction of cilia that move mucus out of sinuses can cause this disorder.
- **Signs and symptoms.** Fever, cough, headache, a sore throat, facial pain, and nasal congestion are the common signs and symptoms.
- **Treatment.** Treatment options include the use of nasal decongestants, nasal steroid sprays, a humidifier, and antibiotics. Surgery to clear the sinuses or unblock sinus openings may be required.

Sudden infant death syndrome (SIDS) claims the life of more than 7000 babies a year in the United States. There are no characteristic signs or symptoms. Usually a baby with this disorder simply goes to sleep and never wakes up. The causes of SIDS are unknown but certain risk factors have been identified.

- Babies who are male are more likely to die of SIDS.
- Babies are most susceptible between the ages of 2 weeks and 6 months.
- Premature or low birth weight babies are more likely to have SIDS.
- A baby with a sibling who died of SIDS is more likely to also die of this disorder.
- Babies who are African American or Native American are more likely to die of SIDS.
- Babies who were prenatally exposed to alcohol, cocaine, heroine, or nicotine are at a higher risk of developing SIDS.
- Babies who sleep on their stomachs are approximately three times more likely to die of SIDS.

Tuberculosis (TB) is a disease that kills more than 2 million people worldwide each year. Although it primarily affects the lungs, it can spread to other parts of the body.

- **Causes.** This disease is caused by various strains of the bacterium *Mycobacterium tuberculosis*. Widespread tuberculosis may be complicated by the following factors:
 - HIV infection. HIV infection makes a person more vulnerable to TB.
 - Crowded living conditions. This factor allows TB to spread easily; this disease, therefore, is found in some prisons and homeless shelters.
 - Poverty. Poverty prevents some patients with TB from seeking or completing therapy.
 - Drug-resistant bacterium. Drug-resistant strains of the bacterium that causes TB have increased.
 - Long-term therapy. Current treatments require antibiotic therapy for many months, which some patients with TB do not complete.
- **Signs and symptoms.** The symptoms include a cough that lasts more than 3 weeks, unintended weight loss, fever or chills, fatigue, night sweats, pain when breathing or difficulty breathing, and pain in other affected areas.
- **Treatment.** The first step should be TB testing to detect carriers of this disease, who should then be treated. Drug-resistant cases of TB may require years of drug therapy to treat; this therapy normally lasts 6 months to a year.

Summary

The major function of the respiratory system is the exchange of oxygen and carbon dioxide between the blood and the atmosphere. In addition to this gas exchange, the respiratory system also regulates blood pH.

The organs of this system include the nose, pharynx, larynx, trachea, bronchial tree, and the lungs. Each of these

structures has a role in ventilation (bringing air in and out of the body) and external respiration (the gas exchange of oxygen and carbon dioxide). Understanding this system is important in assisting with patients and instructing them in the use of an inhaler.

REVIEW

CHAPTER 8

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. Why is the patient wheezing?
2. Is asthma a life-threatening condition?
3. What is the advantage of using a nebulizer to deliver the bronchodilator?
4. Why did the doctor refer the patient for allergy testing?

Discussion Questions

1. Describe the actions of the diaphragm and the rib cage during inspiration and expiration.
2. List the various respiratory volumes that are commonly measured in the clinical setting. What does each volume represent?
3. Describe how the larynx varies the loudness and pitch of the voice. Besides producing sound, what is another function of the larynx?

Critical Thinking Questions

1. Smoking destroys cilia in the respiratory tract. Describe how smoking damages the lungs.
2. What effect would breathing in a paper bag have on oxygen concentrations in the blood? Would this be helpful for a person who is hyperventilating? Why or why not?

Application Activities

1. Describe the locations and functions of the following structures:
 - a. pharynx
 - b. larynx
 - c. primary bronchi
 - d. alveoli
 - e. epiglottis
2. What carries most oxygen in the blood?
3. How many lobes does the left lung have? The right lung?

CHAPTER 9

The Digestive System

CHAPTER OUTLINE

- Characteristics of the Alimentary Canal
- The Mouth
- The Pharynx
- The Esophagus
- The Stomach
- The Small Intestine
- The Liver
- The Gallbladder
- The Pancreas
- The Large Intestine
- The Rectum and Anal Canal
- The Absorption of Nutrients

OBJECTIVES

After completing Chapter 9, you will be able to:

- 9.1 List the functions of the digestive system.
- 9.2 Trace the pathway of food through the alimentary canal.
- 9.3 Describe the structure and functions of the mouth, teeth, tongue, and salivary glands.
- 9.4 Describe the structure and function of the pharynx.
- 9.5 Describe the swallowing process.
- 9.6 Describe the structure of the esophagus and tell how it propels food into the stomach.
- 9.7 Describe the structure and functions of the stomach.
- 9.8 List the substances secreted by the stomach and give their functions.
- 9.9 Describe the structure and functions of the small intestine.
- 9.10 List the substances secreted by the small intestine and describe the importance of each.
- 9.11 Explain the structures and functions of the liver, gallbladder, and pancreas.
- 9.12 List the substances released by the liver, gallbladder, and pancreas into the small intestine and give the function of each secretion.
- 9.13 Describe the structure and functions of the large intestine.
- 9.14 Tell what types of nutrients are absorbed by the digestive system and where they are absorbed.
- 9.15 Describe the signs, symptoms, causes, and treatments of various disorders and diseases of the digestive system.

KEY TERMS

acinar cells
adenoids
alimentary canal
anal canal
appendicitis
ascending colon
bicuspid
bile
carboxypeptidase
cecum
cellulose
chief cells
chyme
chymotrypsin
cirrhosis
colitis
common bile duct
cuspid
cystic duct
defecation reflex
descending colon
disaccharide
diverticulitis
duodenum
esophageal hiatus
feces
gastric juice
gastritis
gastroesophageal reflux disease (GERD)
glycogen
hemorrhoid
hepatic duct
hepatic lobule
hepatic portal vein

KEY TERMS (Continued)

hepatitis	lingual tonsil	palatine tonsils	serous cells
hepatocytes	linoleic acid	pancreatic amylase	sigmoid colon
hernia	maltase	pancreatic lipase	sublingual gland
ileocecal sphincter	microvilli	parietal cells	submandibular gland
ileum	molars	parotid glands	submucosa
incisors	monosaccharide	pepsin	sucrase
intestinal lipase	mucosa	pepsinogen	transverse colon
intrinsic factor	mucous cells	peptidases	triglyceride
jejunum	nasopharynx	pharyngeal tonsils	trypsin
lactase	nucleases	polysaccharide	uvula
laryngopharynx	oropharynx	rectum	vermiform appendix
lingual frenulum	palate	serosa	

Introduction

Digestion is the mechanical and chemical breakdown of foods into forms that your body cells can absorb. The organs of the digestive system carry out digestion and can be divided into two categories—those of the alimentary canal and accessory organs. Organs of the alimentary canal

extend from the mouth to the anus. They are the mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anal canal. The accessory organs include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas (Figure 9-1).

CASE STUDY

Yesterday afternoon, a 55-year-old female came to the gastroenterologist's office complaining of severe pain in her upper right abdomen. She was nauseated and stated that for several months—and especially following meals—she had been having periodic abdominal pain. After several tests, she was diagnosed as having gallstones and was scheduled for the surgical removal of her gallbladder.

As you read this chapter, consider the following questions:

1. What is the function of the gallbladder?
2. How does the gallbladder empty bile into the small intestine?
3. What conditions can result if gallstones are not removed?
4. Will this patient need to change her diet once her gallbladder is removed?

Characteristics of the Alimentary Canal

The wall of the **alimentary canal** consists of four layers:

1. **Mucosa.** The **mucosa** is the innermost layer of the wall and is mostly made of epithelial tissue that secretes enzymes and mucus into the lumen, or passageway, of the canal. This layer also is very active in absorbing nutrients.
2. **Submucosa.** The **submucosa** is the layer just deep to the mucosa. It contains loose connective tissue, blood

vessels, glands, and nerves. The blood vessels in this layer carry away absorbed nutrients.

3. **Muscular layer.** This layer is just outside the submucosa. It is made of layers of smooth muscle tissue and contracts to move materials through the canal.
4. **Serosa.** The **serosa** is the outermost layer of canal and is also known as the visceral peritoneum. It secretes serous fluid to keep the outside of the canal moist and to prevent it from sticking to other organs.

Smooth muscle in the wall of the canal can contract to produce two basic types of movements—churning and

ACCESSORY ORGANS

Salivary glands

Secrete saliva, which contains enzymes that initiate breakdown of carbohydrates

Liver

Produces bile, which emulsifies fat

Gallbladder

Stores bile and introduces it into small intestine

Pancreas

Produces and secretes pancreatic juice, containing digestive enzymes and bicarbonate ions, into small intestine

ALIMENTARY CANAL

Mouth

Mechanical breakdown of food; begins chemical digestion of carbohydrates

Pharynx

Connects mouth with esophagus

Esophagus

Peristalsis pushes food to stomach

Stomach

Secretes acid and enzymes. Mixes food with secretions to begin enzymatic digestion of proteins

Small intestine

Mixes food with bile and pancreatic juice. Final enzymatic breakdown of food molecules; main site of nutrient absorption

Large intestine

Absorbs water and electrolytes to form feces

Rectum

Regulates elimination of feces

Anus

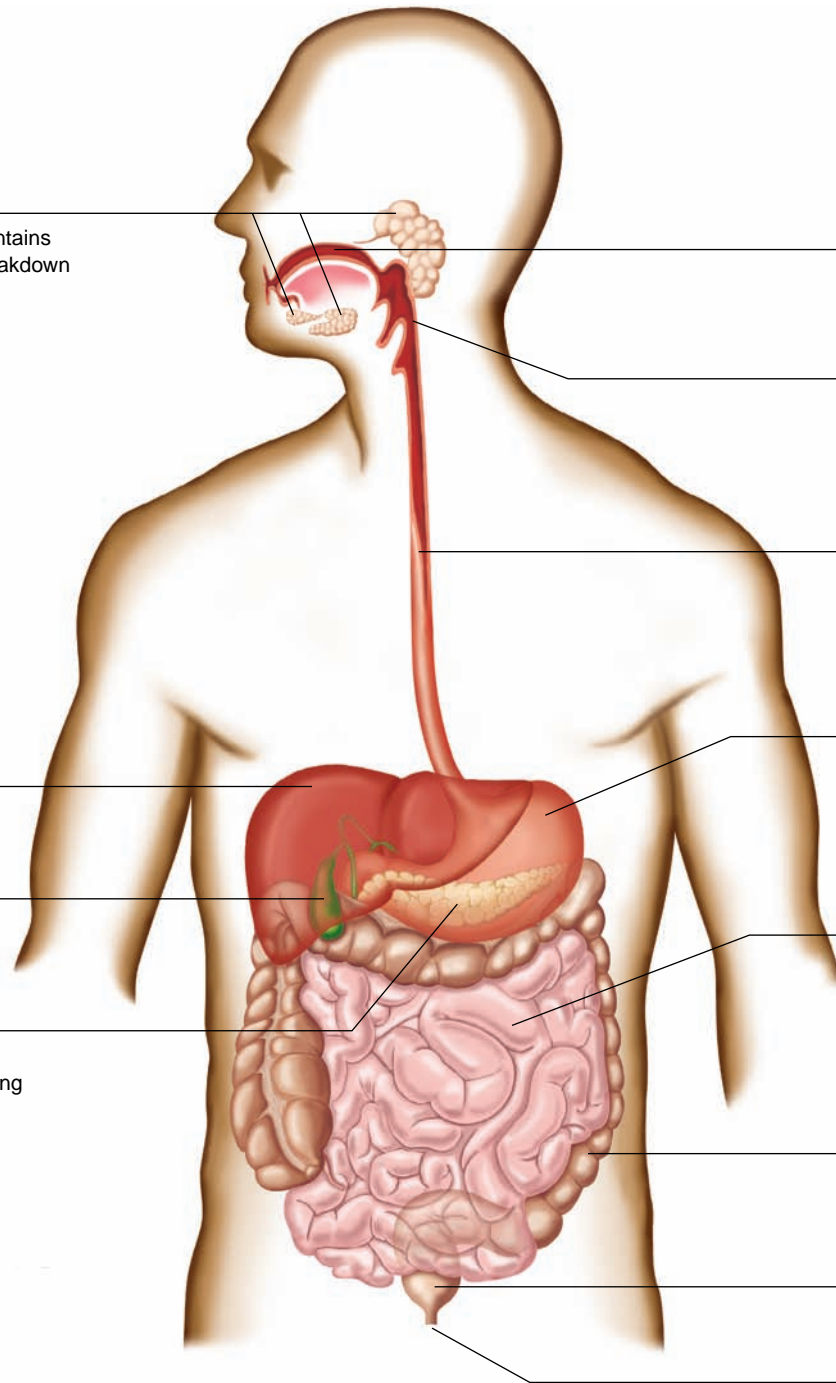


Figure 9-1. Major organs of the digestive system.

peristalsis. Churning mixes substances in the canal. Peristalsis propels substances through the tract (Figure 9-2).

The Mouth

The mouth takes in food and reduces its size through chewing. The mouth also starts to chemically digest food because saliva (spit) contains an enzyme that breaks down carbohydrates.

The cheeks consist of skin, adipose tissue, skeletal muscles, and an inner lining of moist stratified squamous epithelium. The cheeks act to hold food in the mouth. The lips contain a lot of sensory nerve fibers that can judge the temperature of food before it enters the mouth.

The tongue is mostly made of skeletal muscles and is covered by a mucous membrane. The body of the tongue is held to the floor of the oral cavity by a flap of mucous membrane called the **lingual frenulum**. The tongue acts to mix food in the mouth and to hold the food between

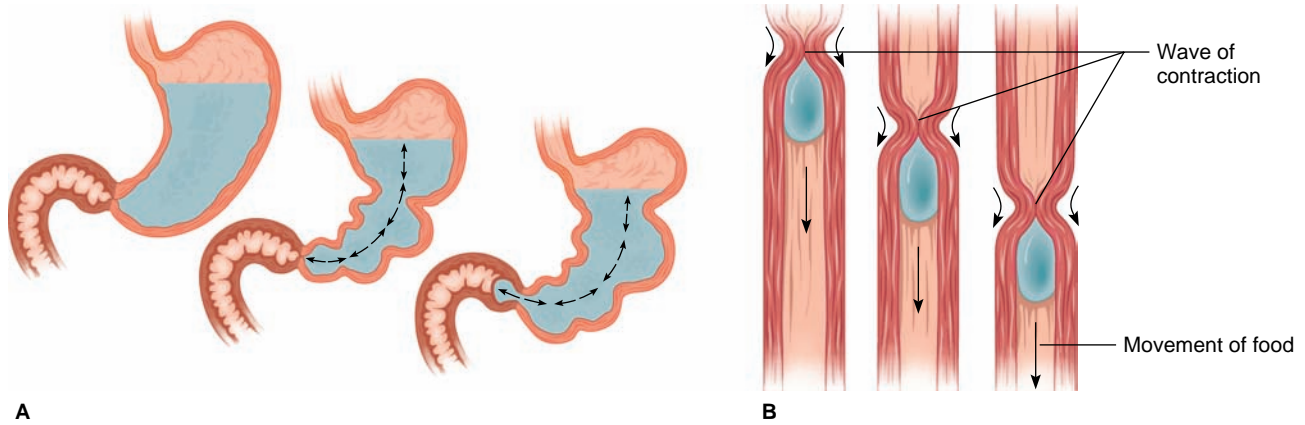


Figure 9-2. Movements through the alimentary canal. (a) Churning movements move substances back and forth to mix them. (b) Peristalsis moves contents along the canal.

teeth. It also contains taste buds. The back of the tongue contains two lumps of lymphatic tissue called **lingual tonsils**. Lingual tonsils act to destroy bacteria and viruses on the back of the tongue.

The **palate** is the roof of the mouth. It functions to separate the oral cavity from the nasal cavity. The front of the palate, the hard palate, is rigid because it has bony plates in it. The back of the palate, soft palate, lacks bony material and therefore is not rigid. The back of the

soft palate hangs down into the throat, and this portion of the soft palate is called the **uvula**. The uvula acts to prevent food and liquids from entering the nose during swallowing.

At the back of the mouth are two masses of lymphatic tissue called **palatine tonsils**. Just above the palatine tonsils are two more masses of lymphatic tissue called the **pharyngeal tonsils (adenoids)**. These masses of lymphatic tissue act to protect the area from bacteria and viruses (Figure 9-3).

Teeth act to decrease the size of food particles, and different types of teeth are adapted to handle food in different ways. The most medial teeth, called **incisors**, act as chisels to bite off food pieces. Teeth called **cuspids** are the sharpest teeth and they act to tear tough food (Figure 9-4). The back teeth, called **bicuspids** and **molars**, are flat. They are designed to grind food (Figure 9-5).

Salivary glands secrete saliva, which is a mixture of water, enzymes, and mucus. Salivary glands are made of two types of cells—**serous cells** and **mucous cells**. Serous cells secrete a fluid made mostly of water but the fluid also contains an enzyme called amylase that digests carbohydrates. Mucous cells secrete mucus.

All major salivary glands are paired (Figure 9-6):

- **Parotid glands:** the largest of the salivary glands, located beneath the skin just in front of the ears
- **Submandibular glands:** located in the floor of the mouth just inside the surface of the mandibles (jaws)
- **Sublingual glands:** the smallest of the salivary glands, located in the floor of the mouth beneath the tongue

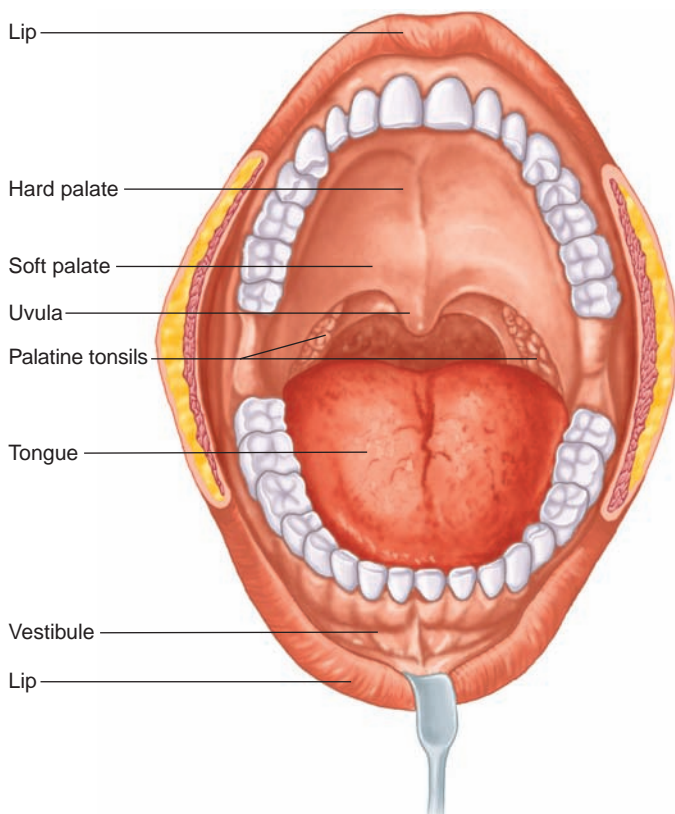


Figure 9-3. Structures of the mouth.

The Pharynx

The **pharynx** is more commonly called the throat. It is a long, muscular structure that extends from the area behind the nose to the esophagus. It acts to connect the nasal cavity with the oral cavity for breathing through the nose. It

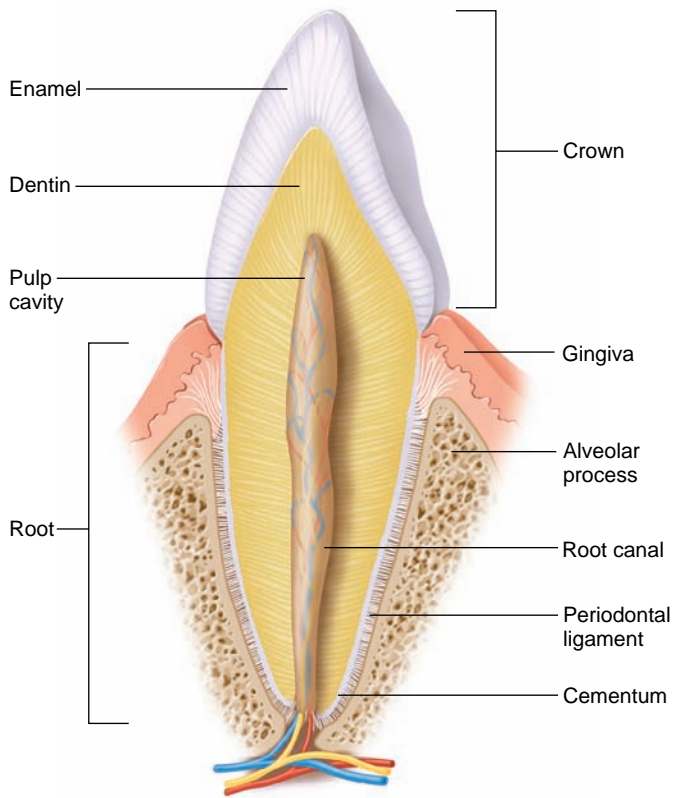


Figure 9-4. Structure of a cuspid tooth.

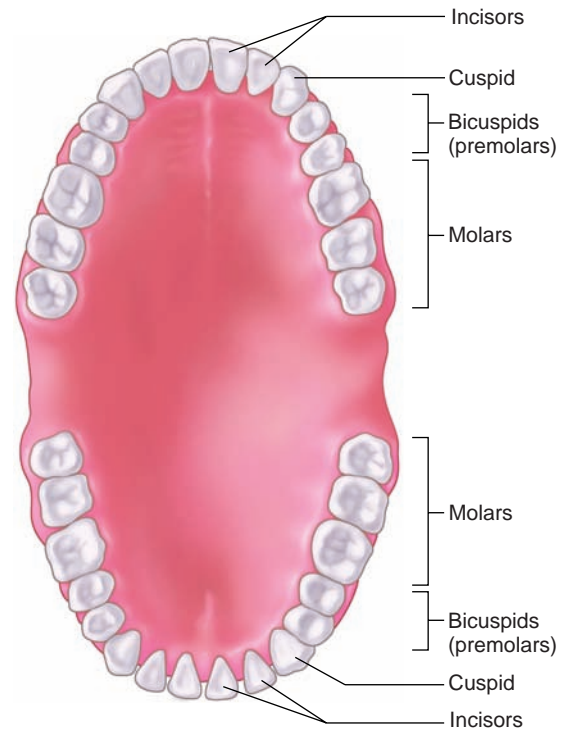


Figure 9-5. Types of teeth.

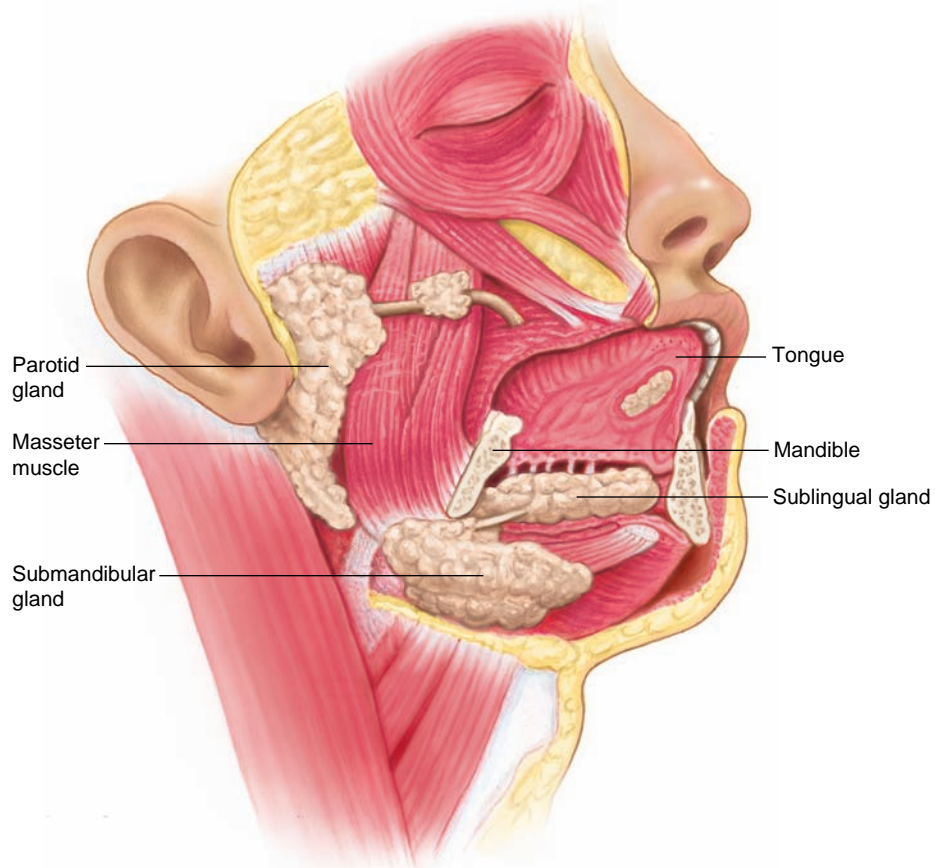


Figure 9-6. Major salivary glands.

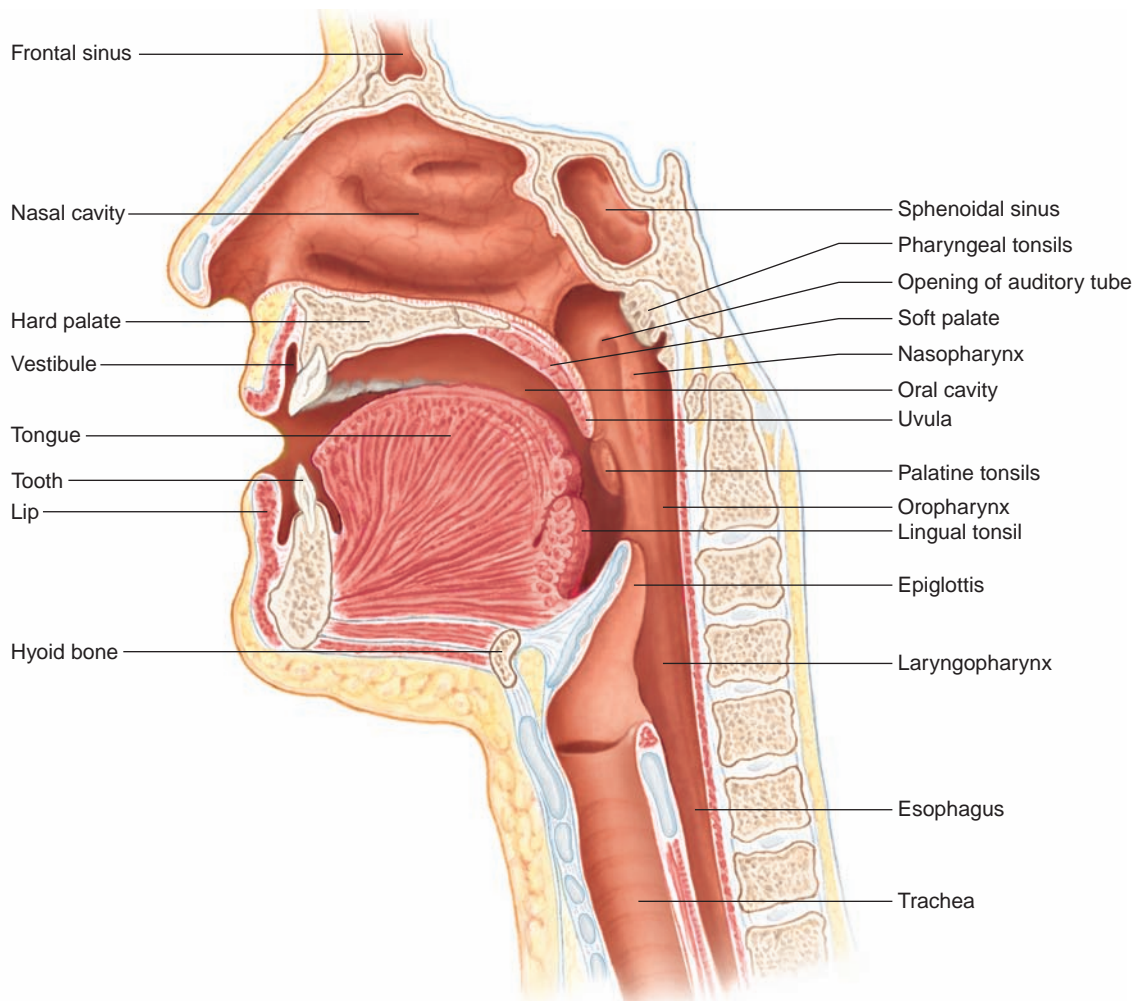


Figure 9-7. Sagittal section of the mouth, nasal cavity, and pharynx.

also acts to push food into the esophagus (Figure 9-7). The divisions of the pharynx are:

- **Nasopharynx:** the portion behind the nasal cavity.
- **Oropharynx:** the portion behind the oral cavity.
- **Laryngopharynx:** the portion behind the larynx. The laryngopharynx continues as the esophagus.

Swallowing is largely a reflex. In other words, it is an automatic response that does not require much thought. The following events occur during swallowing:

1. The soft palate rises, causing the uvula to cover the opening between the nasal cavity and the oral cavity.
2. The **epiglottis** covers the opening of the larynx so that food does not enter it (see Figure 9-7).
3. The tongue presses against the roof of the mouth, forcing food into the oropharynx.
4. The muscles in the pharynx contract, forcing food toward the esophagus.
5. The esophagus opens.
6. Food is pushed into the esophagus by the muscles of the pharynx.

The Esophagus

The esophagus is a muscular tube that connects the pharynx to the stomach (Figures 9-7 and 9-8). It descends through the thoracic cavity, through the diaphragm, and into the abdominal cavity where it joins the stomach. The hole in the diaphragm that the esophagus goes through is called the **esophageal hiatus**. This hiatus is a common place for hernias to occur. A **hernia** develops when the stomach gets pushed up into the thoracic cavity through the esophageal hiatus. The esophageal sphincter, also known as the cardiac sphincter, controls the movement of food into the stomach. **Sphincters** are circular bands of muscle located at the openings of many tubes in the body. They open and close to allow or prevent the movement of substances out of a tube.

The Stomach

The stomach lies below the diaphragm in the upper left region of the abdominal cavity. It functions to receive food from the esophagus, mix food with **gastric juice** (secretions

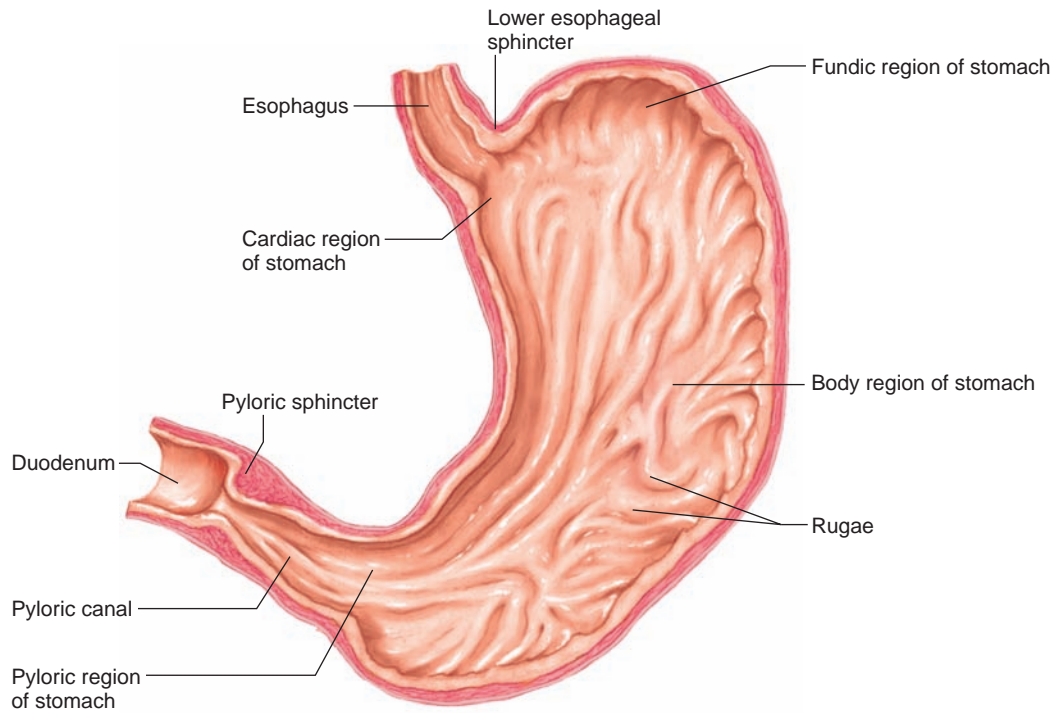


Figure 9-8. Regions of the stomach.

of the stomach lining), start protein digestion, and move food into the small intestine.

The beginning portion of the stomach that is attached to the esophagus is called the cardiac region. The portion of the stomach that balloons over the cardiac portion is called the fundic region, or fundus. The main part of the stomach is called the body, and the narrow portion that is connected to the small intestine is called the pyloric region or pylorus. A sphincter called the pyloric sphincter controls the movement of substances from the pyloric region of the stomach into the small intestine (Figure 9-8).

The lining of the stomach contains gastric glands. These glands are made of the following cell types:

- **Mucous cells.** These cells secrete mucus to protect the lining of the stomach.
- **Chief cells.** These cells secrete **pepsinogen**, which becomes **pepsin** in the presence of acid. Pepsin digests proteins.
- **Parietal cells.** These cells secrete hydrochloric acid, which is necessary to convert pepsinogen to pepsin. They also secrete **intrinsic factor**, which is necessary for vitamin B₁₂ absorption.

When a person smells, tastes, or sees appetizing food, the parasympathetic nervous system stimulates the gastric glands to secrete their products. A hormone called gastrin, made by the stomach, also stimulates the gastric glands to become active. A hormone called cholecystokinin (CCK) made by the small intestine inhibits gastric glands. The stomach does not absorb many substances but it can absorb alcohol, water, and some fat-soluble drugs. The mixture of food and gastric juice is called **chyme**. Once chyme

is well mixed, stomach contractions push it into the small intestine a little at a time. It takes 4 to 8 hours for the stomach to empty following a meal.

The Small Intestine

The small intestine is a tubular organ that extends from the stomach to the large intestine. It fills most of the abdominal cavity and is coiled. The small intestine carries out most of the digestion in the body and is responsible for absorbing most of the nutrients into the bloodstream.

The beginning of the small intestine is called the **duodenum**. It is C-shaped and relatively short. The middle portion of the small intestine is called the **jejunum**. It is coiled and forms the majority of the small intestine. The last portion of the small intestine is called the **ileum**, and it is directly attached to the large intestine (Figure 9-9).

The lining of the small intestine contains cells that have **microvilli**. Microvilli greatly increase the surface area of the small intestine so that it can absorb many nutrients. The lining of the small intestine also contains intestinal glands that secrete various substances. The secretions of the small intestine include mucus and water. Water aids in digestion but some toxins cause the secretion of too much water, and this leads to diarrhea—which in turn aids the body in eliminating the toxins. Mucus protects the lining of the small intestine. The following are the major enzymes secreted by the small intestine:

- **Peptidases.** These enzymes digest proteins.
- **Sucrase, maltase, and lactase.** These enzymes digest sugars. A person who cannot produce lactase will not be

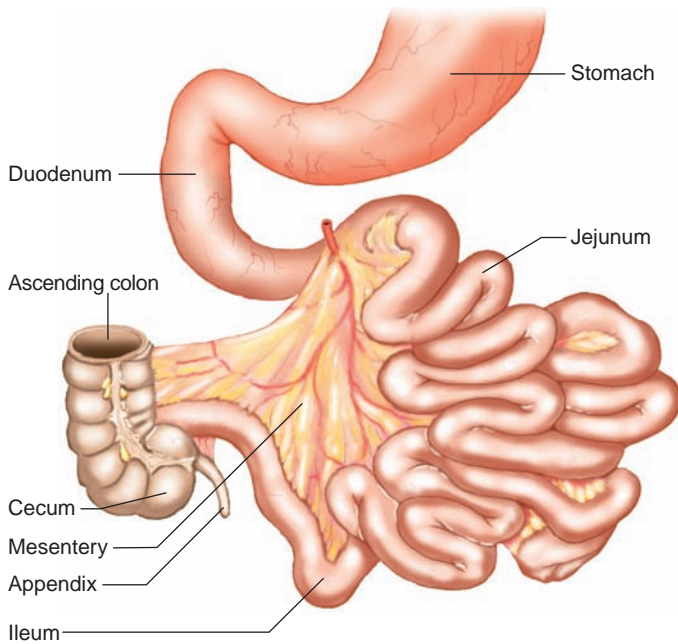


Figure 9-9. Parts of the small intestine.

able to digest lactose, which is the sugar in dairy products. This causes a condition called lactose intolerance.

- **Intestinal lipase.** This enzyme digests fats.

The parasympathetic nervous system and the stretching of the small intestine wall are the primary factors that trigger the small intestine to secrete its products. Almost all nutrients (water, glucose, amino acids, fatty acids, glycerol, and electrolytes) are absorbed by the small intestine. The wall of the small intestine contracts to mix chyme and to propel it toward the large intestine. If chyme moves too quickly through the small intestine, nutrients are not absorbed and diarrhea results. The **ileocecal sphincter** controls the movement of chyme from the ileum to the **cecum**, which is the beginning of the large intestine.

The Liver

The liver is quite large and fills most of the upper right abdominal quadrant. Part of its function is to store vitamins and iron. It is reddish-brown in color and is enclosed by a tough capsule. This capsule divides the liver into a large right lobe and a small left lobe (Figure 9-10). Each lobe is separated into smaller divisions called **hepatic lobules**. Branches of the **hepatic portal vein** carry blood from the digestive organs to the hepatic lobules. The hepatic lobules contain macrophages that destroy bacteria and viruses in the blood. Each lobule contains many cells called **hepatocytes**. Hepatocytes process the nutrients in blood and make **bile**, which is used in the digestion of fats. Bile leaves the liver through the **hepatic duct**. The hepatic duct merges with the **cystic duct** (the duct from the gallbladder) to form the **common bile duct**. This duct delivers bile to the duodenum.

The Gallbladder

The gallbladder is a small, sac-like structure located beneath the liver (Figure 9-10). Its only function is to store bile. Bile leaves the gallbladder through the cystic duct. The hormone cholecystokinin causes the gallbladder to release bile. The salts in bile break large fat globules into smaller ones so that they can be more quickly digested by the digestive enzymes. Bile salts also increase the absorption of fatty acids, cholesterol, and fat-soluble vitamins into the bloodstream.

The Pancreas

The pancreas is located behind the stomach. Pancreatic **acinar cells** produce pancreatic juice, which ultimately flows through the pancreatic duct to the duodenum (Figure 9-11). Pancreatic juice contains the following enzymes:

- **Pancreatic amylase.** This enzyme digests carbohydrates.

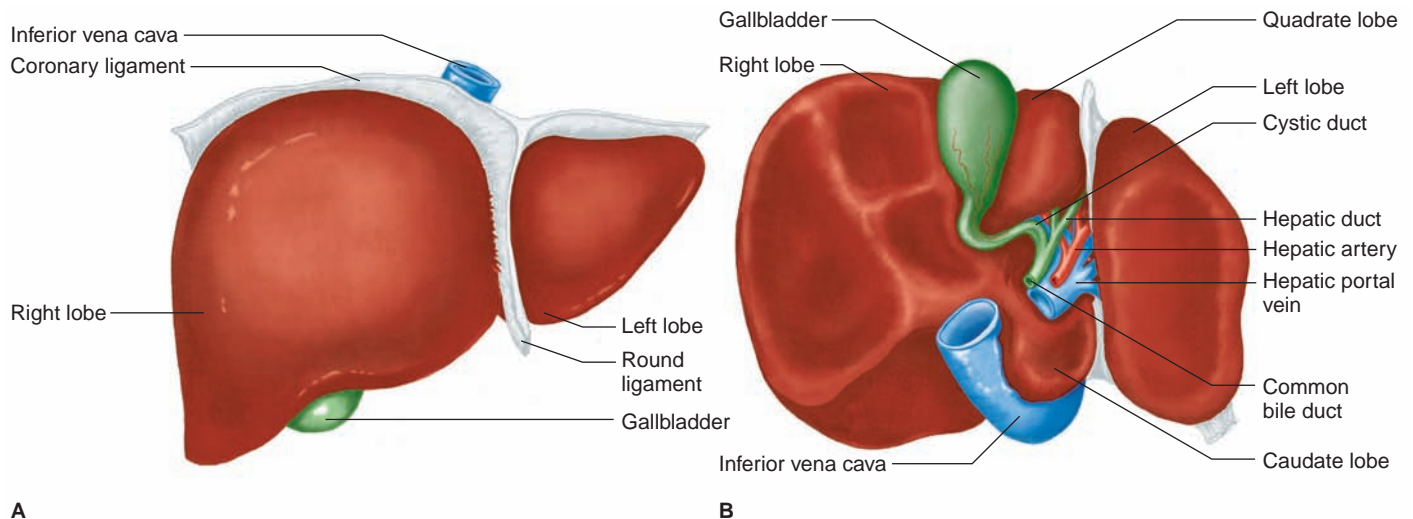


Figure 9-10. Liver and gallbladder: (a) anterior view and (b) inferior view.

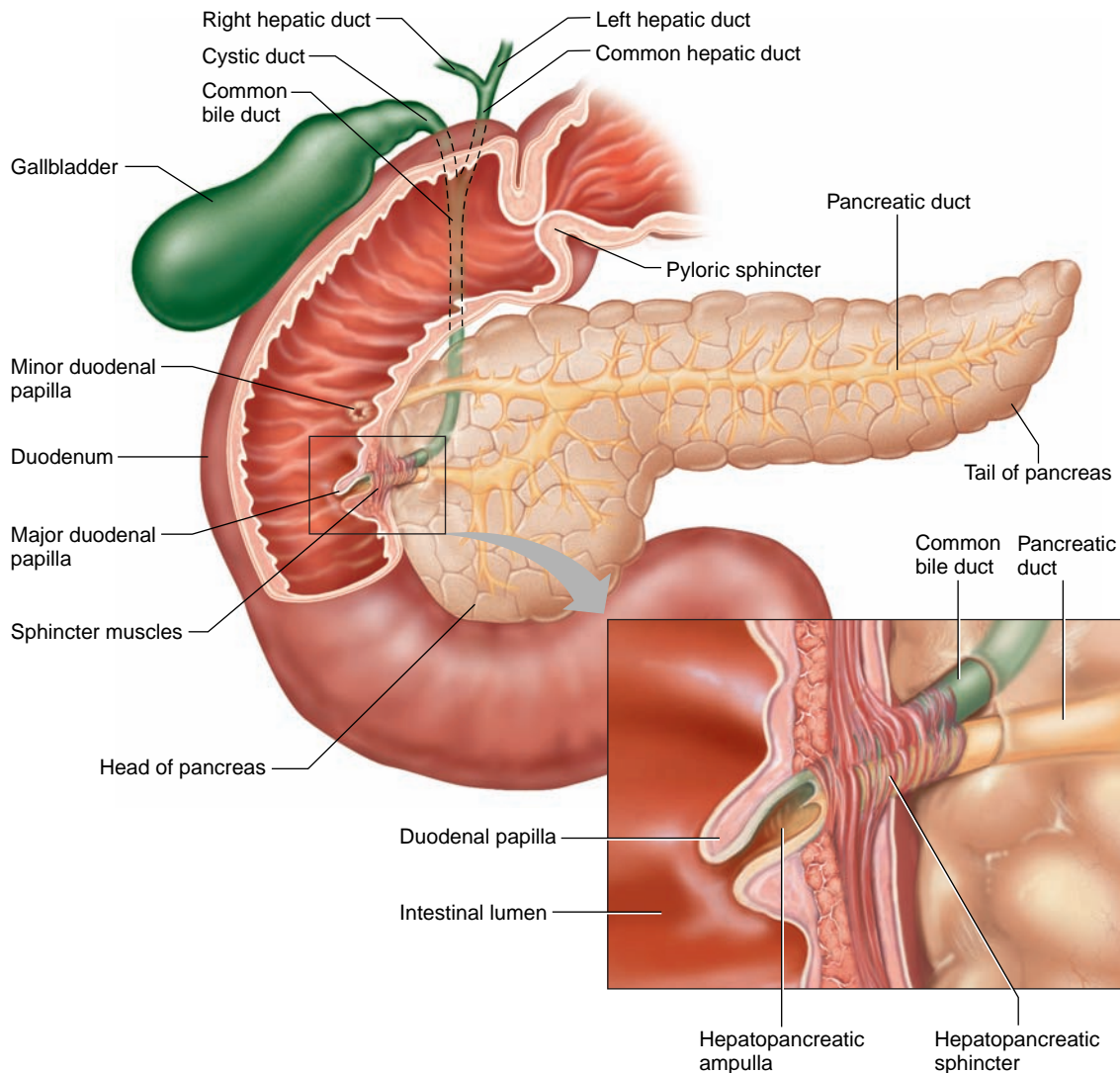


Figure 9-11. Pancreas and its connections to the gallbladder and duodenum.

- **Pancreatic lipase.** This enzyme digests lipids.
- **Nucleases.** These enzymes digest nucleic acids.
- **Trypsin, chymotrypsin, and carboxypeptidase.** These enzymes digest proteins.

The pancreas also secretes bicarbonate ions into the duodenum. These ions neutralize the acidic chyme arriving from the stomach. The parasympathetic nervous system stimulates the pancreas to release its enzymes. The hormones secretin and cholecystokinin also stimulate the pancreas to release digestive enzymes. Secretin and cholecystokinin come from the small intestine.

The Large Intestine

The large intestine extends from the ileum of the small intestine to where it opens to the outside world as the anus. The beginning of the large intestine is the cecum. Projecting off the cecum is the **vermiform appendix**. The appendix is mostly made of lymphoid tissue and has no significant

function in humans. The cecum eventually gives rise to the **ascending colon**, which is the portion of the large intestine that runs up the right side of the abdominal cavity. The ascending colon becomes the **transverse colon** as it crosses the abdominal cavity; from there it becomes the **descending colon** as it descends the left side of the abdominal cavity. In the pelvic cavity, the descending colon then forms an S-shaped tube called the **sigmoid colon**.

The Rectum and Anal Canal

Eventually the sigmoid colon straightens out to become the **rectum**. The last few centimeters of the rectum is called the **anal canal**, and the opening of the anal canal to the outside world is called the anus (Figure 9-12).

The lining of the large intestine only secretes mucus to aid in the movement of substances. As chyme leaves the small intestine and enters the large intestine, the proximal portion of the large intestine absorbs water and a few electrolytes from it. The leftover chyme is then called **feces**.

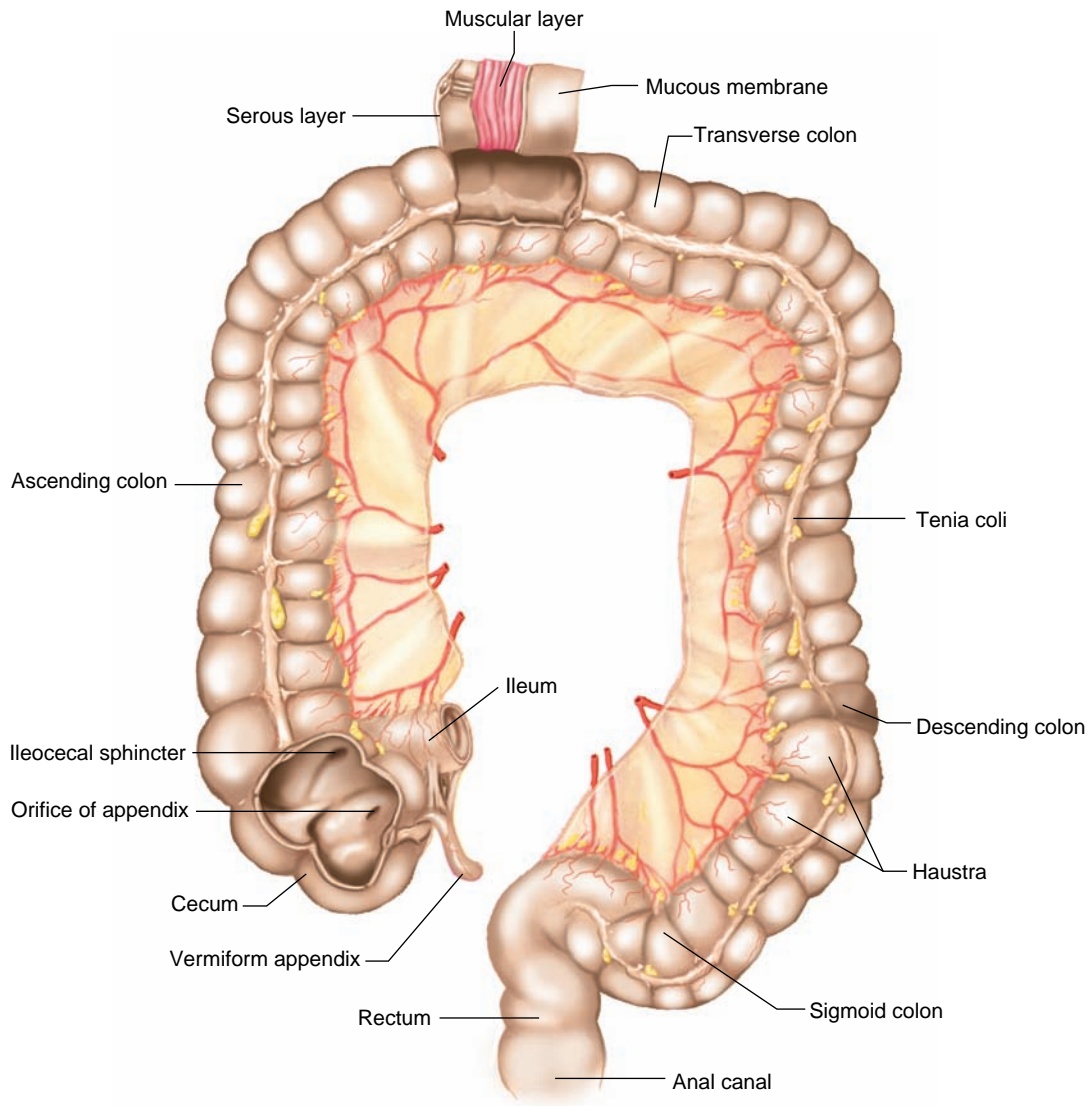


Figure 9-12. Parts of the large intestine.

Feces are made of undigested solid materials, a little water, ions, mucus, cells of the intestinal lining, and bacteria.

The contractions of the large intestine propel feces forward but these contractions normally occur periodically and as mass movements. Mass movements trigger the **defecation reflex**, which allows anal sphincters to relax and feces to move through the anus in the process of elimination. The squeezing actions of the abdominal wall muscles also aid in the emptying of the large intestine.

The Absorption of Nutrients

Nutrients are defined as necessary food substances. They include carbohydrates, proteins, lipids, vitamins, minerals, and water.

Three types of carbohydrates that humans ingest are starches (**polysaccharides**), simple sugars (**monosaccharides** and **disaccharides**), and **cellulose**. Starches come

from foods such as pasta, potatoes, rice, and breads. Monosaccharides and disaccharides are obtained from sweet foods and fruits. Cellulose is a type of carbohydrate found in many vegetables that cannot be digested by humans. Therefore, cellulose provides fiber or bulk for the large intestine. This fiber helps the large intestine empty more regularly.

Most body cells use the monosaccharide glucose to make ATP. When a person has an excess of glucose, it can be stored in the liver and skeletal muscle cells as **glycogen**.

Lipids (fats) are obtained through various foods. The most abundant dietary lipids are **triglycerides**. They are found in meats, eggs, milk, and butter. Cholesterol is another common dietary lipid and is found in eggs, whole milk, butter, and cheeses. Lipids are used by the body primarily to make energy when glucose levels are low. Excess triglycerides are stored in adipose tissue. Cholesterol is essential to cell growth and function; cells use it to

TABLE 9-1 Common Vitamins and Their Importance in the Body

Vitamin	Function
Vitamin A	Needed for the production of visual receptors, mucus, the normal growth for bones and teeth, and the repair of epithelial tissues
Vitamin B ₁ (thiamine)	Needed for the metabolism of carbohydrates
Vitamin B ₂ (riboflavin)	Needed for carbohydrate and fat metabolism and for the growth of cells
Vitamin B ₆	Needed for the synthesis of protein, antibodies, and nucleic acid
Vitamin B ₁₂ (cyanocobalamin)	Needed for myelin production and the metabolism of carbohydrates and nucleic acids
Biotin	Needed for the metabolism of proteins, fats, and nucleic acids
Folic acid	Needed for the production of amino acids, DNA, and red blood cells
Pantothenic acid	Needed for carbohydrate and fat metabolism
Niacin	Needed for the metabolism of carbohydrates, proteins, fats, and nucleic acids
Vitamin C (ascorbic acid)	Needed for the production of collagen, amino acids, and hormones and for the absorption of iron
Vitamin D	Needed for the absorption of calcium
Vitamin E	Antioxidant that prevents the breakdown of certain tissues
Vitamin K	Needed for blood clotting

make cell membranes and some hormones. People should have the essential fatty acid **linoleic acid** in their diet since the body cannot make it. This fatty acid is found in corn and sunflower oils. People also need a certain amount of fat to absorb fat-soluble vitamins.

Foods rich in protein include meats, eggs, milk, fish, chicken, turkey, nuts, cheese, and beans. Protein requirements vary from individual to individual, but all people must take in proteins that contain certain amino acids (called essential amino acids) because the body cannot make them. Proteins are used by the body for growth and the repair of tissues.

The fat-soluble vitamins are vitamins A, D, E, and K, and the water-soluble vitamins are all the B vitamins and vitamin C. Vitamins have many functions; they are summarized in Table 9-1.

Minerals make up about 4% of total body weight. They are primarily found in bones and teeth. Cells use minerals to make enzymes, cell membranes, and various proteins such as hemoglobin. The most important minerals to the human body are calcium, phosphorus, sulfur, sodium, chlorine, and magnesium. Trace elements are elements needed in very small amounts by the body. They include iron, manganese, copper, iodine, and zinc.

Pathophysiology

Common Diseases and Disorders of the Digestive System

Appendicitis is an inflammation of the appendix. If not treated promptly, it can be life-threatening.

- **Causes.** This disorder is caused by blockage of the appendix with feces or a tumor.

- **Signs and symptoms.** The signs and symptoms include lack of appetite, pain in or around the navel area or in the abdomen, nausea, slight fever, pain in the right leg, and an increased white blood cell count.

continued →

Common Diseases and Disorders of the Digestive System (continued)

- **Treatment.** The primary treatments are antibiotics to prevent infection or surgery to remove the appendix.

Cirrhosis is a long-lasting liver disease in which normal liver tissue is replaced with nonfunctional scar tissue.

- **Causes.** This disease is often an autoimmune disease. It may be caused by some medications and alcohol consumption. Hepatitis B and C infections can also contribute to the development of cirrhosis.
- **Signs and symptoms.** There are many symptoms to this disease. They include anemia, fatigue, mental confusion, fever, vomiting, blood in the vomit, an enlarged liver, jaundice, unintended weight loss, swelling of the legs or abdomen, abdominal pain, a decreased urine output, and pale feces.
- **Treatment.** Alcohol consumption should be discontinued. A patient with cirrhosis may be given various medications, including antibiotics and diuretics. A liver transplant may be needed for the most seriously ill patients.

Colitis is defined as inflammation of the large intestine. This condition can be chronic or short-lived, depending on the cause.

- **Causes.** Colitis can be caused by a viral or bacterial infection or the use of antibiotics. Ulcers in the large intestine, Crohn's disease, various other diseases, and stress may also contribute to the development of this disorder.
- **Signs and symptoms.** The primary symptoms are abdominal pain, bloating, and diarrhea.
- **Treatment.** The first goal of therapy is to treat the underlying causes. Changing antibiotics, treating existing ulcers, and drinking plenty of fluids are other treatment options.

Colorectal cancer usually comes from the lining of the rectum or colon. This type of cancer is curable if treated early.

- **Causes.** The causes are mostly unknown. Polyps in the colon or rectum can become cancerous, leading to this disease. Colorectal cancer may be prevented through regular screenings for polyps.
- **Signs and symptoms.** Anemia, unintended weight loss, abdominal pain, blood in the feces, narrow feces, or changes in bowel movement are all common symptoms.
- **Treatment.** Chemotherapy is the first line of treatment. Surgery to remove a cancerous tumor or the affected portions of colon or rectum may be needed in more serious cases.

Constipation is the condition of difficult defecation, which is the elimination of feces.

- **Causes.** The primary causes are a lack of physical activity, a lack of fiber in the diet, the use of certain medications, and thyroid and colon disorders.

- **Signs and symptoms.** Common signs and symptoms include infrequent bowel movements (for example, no bowel movement for 3 days), bloating, abdominal pain and pain during bowel movements, hard feces, and blood on the surface of feces.

- **Treatment.** Treatment includes an increase in fiber intake, regular exercise, and the use of stool softeners, laxatives, and enemas.

Crohn's disease is a common type of disorder called inflammatory bowel disease. It typically affects the end of the small intestine.

- **Causes.** This disease is an autoimmune disorder.
- **Signs and symptoms.** The signs and symptoms of Crohn's disease include fever, tender gums, joint pain, ulcers, abdominal pain and gas, constipation or diarrhea, abnormal abdominal sounds, weight loss, intestinal bleeding, and blood in the feces.
- **Treatment.** The first treatment is to change the patient's diet. Other treatments include medications to reduce inflammation and antibiotics. For the most serious cases, surgery to remove the affected part of the intestine may be needed.

Diarrhea is the condition of watery and frequent feces. Many cases of diarrhea do not require treatment because they usually stop within a day or two.

- **Causes.** The causes of diarrhea include bacterial, viral, or parasitic infections of the digestive system. It may also be caused by the ingestion of toxins; food allergies, including lactose intolerance; ulcers; Crohn's disease; laxatives; antibiotics; chemotherapy; and radiation therapy. Diarrhea may be prevented by thoroughly washing hands and cooking food properly.
- **Signs and symptoms.** The symptoms include abdominal cramps, watery feces, and the frequent passage of feces.
- **Treatment.** Patients should drink fluids to prevent dehydration. The underlying causes should be treated. Medications and dietary changes are the primary treatment options.

Diverticulitis is inflammation of diverticuli in the intestine. Diverticuli are abnormal dilations in the intestinal wall.

- **Causes.** The causes are mostly unknown. Lack of fiber in the diet and a bacterial infection of the diverticuli can cause this disorder.
- **Signs and symptoms.** Signs and symptoms include fever, nausea, abdominal pain, constipation or diarrhea, blood in the feces, and a high white blood cell count.
- **Treatment.** Treatments include a diet high in fiber, antibiotics, and surgery to remove the affected portion of the intestine.

continued →

Common Diseases and Disorders of the Digestive System (continued)

Gastritis is an inflammation of the stomach lining. It is often referred to as an “upset stomach.”

- **Causes.** Gastritis can be caused by bacteria or viruses, some medications, the use of alcohol, spicy foods, excessive eating, poisons, and stress. Cooking food properly to kill harmful bacteria and viruses can help to prevent this condition.
- **Signs and symptoms.** Symptoms include nausea, lack of appetite, heartburn, vomiting, and abdominal cramps.
- **Treatment.** Lifestyle changes should be implemented to avoid foods or medications that irritate the stomach lining. Treatment with various medications to reduce the production of stomach acids can provide relief from the symptoms of this disorder.

Heartburn is also called **gastroesophageal reflux disease (GERD)**. It occurs when stomach acids are pushed into the esophagus.

- **Causes.** Alcohol, some foods, a defective esophageal sphincter, pregnancy, obesity, a hiatal hernia, and repeated vomiting can contribute to the development of this disease.
- **Signs and symptoms.** Common symptoms include frequent burping, difficulty swallowing, a sore throat, a burning sensation in the chest following meals, nausea, and blood in the vomit.
- **Treatment.** Treatment includes losing weight, making dietary changes, reducing the consumption of alcohol, taking medications, and not lying down after meals.

Hemorrhoids are varicose veins of the rectum or anus.

- **Causes.** Hemorrhoids are caused by constipation, excessive straining during bowel movements, liver disease, pregnancy, and obesity.
- **Signs and symptoms.** Signs and symptoms include itching in the anal area, painful bowel movements, bright red blood on feces, and veins that protrude from the anus.
- **Treatment.** Constipation can be avoided or improved by eating a high-fiber diet. Other treatments include stool softeners, medications to reduce the inflammation of hemorrhoids, and the surgical removal of hemorrhoids.

Hepatitis is defined as inflammation of the liver. There are many different types of hepatitis.

- **Causes.** Causes include bacteria, viruses, parasites, immune disorders, the use of alcohol and drugs, and an overdose of acetaminophen. Preventive measures include getting vaccinations, practicing safe sex, avoiding undercooked food (especially seafood), and using prescription or over-the-counter drugs at their recommended dosages.

- **Signs and symptoms.** Symptoms include mild fever, bloating, lack of appetite, nausea, vomiting, abdominal pain, weakness, jaundice, the itching of various body parts, an enlarged liver, dark urine, and breast development in males.
- **Treatment.** Patients should avoid using alcohol and drugs. Various medications may be prescribed.

A **hiatal hernia** occurs when a portion of the stomach protrudes into the chest through an opening in the diaphragm.

- **Causes.** The causes are mostly unknown, although obesity and smoking are considered risk factors. Eating small meals can be an effective preventive measure.
- **Signs and symptoms.** Signs and symptoms include excessive burping, difficulty swallowing, chest pain, and heartburn.
- **Treatment.** Treatments are weight reduction, medications to reduce the production of stomach acid, and surgical repair of the hernia.

Inguinal hernias occur when a portion of the large intestine protrudes into the inguinal canal, which is located where the thigh and the body trunk meet. In males, the hernia can also protrude into the scrotum.

- **Causes.** The causes are mostly unknown, although these hernias may be caused by weak muscles in the abdominal walls.
- **Signs and symptoms.** A lump in the groin or scrotum, or pain in the groin area that gets worse when bending or straining are the common symptoms.
- **Treatment.** Pain medications may be prescribed. Surgery to repair the hernia is needed when the large intestine is pushed back into the abdominal cavity.

Oral cancer usually involves the lips or tongue but can occur anywhere in the mouth. This type of cancer tends to spread rapidly to other organs.

- **Causes.** The causes are mostly unknown, although the use of tobacco products and alcohol are known risk factors. Poor oral hygiene and ulcers in the mouth can also cause oral cancer.
- **Signs and symptoms.** Signs and symptoms include difficulty tasting, problems swallowing, and ulcers on the tongue, lip, or other mouth structures.
- **Treatment.** Radiation therapy, chemotherapy, and surgical removal of the tumor are the treatment options.

Pancreatic cancer is the fourth leading cause of cancer death in the United States.

- **Causes.** Causes are mostly unknown, although smoking is considered a risk factor.
- **Signs and symptoms.** Common signs and symptoms include depression, fatigue, lack of appetite, nausea or

continued —>

Common Diseases and Disorders of the Digestive System *(continued)*

vomiting, abdominal pain, constipation or diarrhea, jaundice, and unintended weight loss.

- **Treatment.** Treatment includes radiation therapy, chemotherapy, and surgical removal of the tumor.

Stomach cancer most commonly occurs in the uppermost portion of the stomach, which is called the cardiac portion. It occurs much more frequently in Japan, Chile, and Iceland than in the United States.

- **Causes.** The causes are mostly unknown, although stomach ulcers may contribute to the development of stomach cancer.
- **Signs and symptoms.** Signs and symptoms include frequent bloating, lack of appetite, feeling full after eating small amounts, nausea, vomiting (with or without blood), abdominal cramps, excessive gas, and blood in the feces.

- **Treatment.** Treatment includes radiation therapy, chemotherapy, and surgical removal of the tumor.

Stomach ulcers occur when the lining of the stomach breaks down.

- **Causes.** Stomach ulcers can be caused by bacteria, smoking, alcohol, aspirin, and excess acid secretions in the stomach. They may be prevented by stopping smoking and avoiding aspirin, certain foods, and alcohol.
- **Signs and symptoms.** Symptoms include nausea, abdominal pain, vomiting (with or without blood), and weight loss.
- **Treatment.** Treatment options include antibiotics, medications to reduce stomach acid production, surgery to remove the affected portion of the stomach, and a vagotomy (cutting the vagus nerve) in order to reduce the production of stomach acid.

Summary

The purpose of the digestive system is to provide nutrients to the body. This is accomplished by taking in food, breaking it down, and absorbing the digested molecules. The organs responsible for this process are the mouth, teeth, salivary glands, pharynx, esophagus, stomach, small in-

testine, pancreas, liver, gallbladder, and large intestine. An additional function of this system is to eliminate the waste products of digestion. A healthy digestive system is important for the health of all other body systems. Understanding this system is essential when assisting with procedures such as endoscopic exams and when teaching a patient about diet and nutrition.

REVIEW

CHAPTER 9

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. What is the function of the gallbladder?
2. How does the gallbladder empty bile into the small intestine?
3. What conditions can result if gallstones are not removed?
4. Will this patient need to change her diet once her gallbladder is removed?

Discussion Questions

1. Describe the location of the liver. What is the digestive function of the liver?
2. What substances are normally digested in the small intestine? What substances are normally absorbed through the wall of the small intestine?
3. Discuss the functions of the mouth.
4. Describe the location of the appendix and its function. Why can a person live without an appendix?

Critical Thinking Questions

1. Describe how the digestive system processes a piece of pepperoni pizza so the body can use it.
2. What complications might a person encounter after the removal of his gallbladder?

3. How does a person mechanically digest food? Why is mechanical digestion important for proper chemical digestion?

Application Activities

1. Give the locations of each of the following digestive organs:
 - a. Salivary glands
 - b. Gallbladder
 - c. Pharynx
 - d. Esophagus
 - e. Small intestine
 - f. Large intestine
 - g. Pancreas
2. Give the functions of the following enzymes or chemicals:
 - a. Amylase
 - b. Lipase
 - c. Lactase
 - d. Pepsin
 - e. Hydrochloric acid
3. Minerals make up about what percentage of total body weight? Where are minerals primarily found?

Internet Activity

Find a Web site that provides information about the health risks associated with smoking. List the effects that smoking has on the digestive system.

CHAPTER 10

The Endocrine System

KEY TERMS

acromegaly
adrenocorticotropic hormone (ACTH)
aldosterone
antidiuretic hormone (ADH)
atrial natriuretic peptide
calcitonin
cortisol
Cushing's disease
diabetes mellitus
dwarfism
estrogen
follicle-stimulating hormone (FSH)
gigantism
glucagon
gonads
G-protein
Graves' disease
growth hormone (GH)
hormone
insulin
islets of Langerhans
luteinizing hormone (LH)
melatonin
myxedema
nonsteroid hormone
optic chiasm
oxytocin (OT)
pineal body
progesterone
prolactin (PRL)
prostaglandin
steroid hormone
stressor
testosterone
thymosin
thymus gland
thyroid hormone
thyroid-stimulating hormone (TSH)

CHAPTER OUTLINE

- Hormones
- The Pituitary Gland
- The Thyroid Gland and Parathyroid Glands
- The Adrenal Glands
- The Pancreas
- Other Hormone-Producing Organs
- The Stress Response

OBJECTIVES

After completing Chapter 10, you will be able to:

- 10.1** Describe the general functions of the endocrine system.
- 10.2** Compare the endocrine and exocrine glands.
- 10.3** Define the term *hormone*.
- 10.4** Describe the locations of the pituitary gland, thyroid gland, parathyroid glands, adrenal glands, pancreas, thymus, and gonads.
- 10.5** List the hormones released by the pituitary gland and give the functions of each.
- 10.6** List the hormones released by the thyroid gland and parathyroid glands and give the functions of each.
- 10.7** List the hormones released by the adrenal glands and give the functions of each.
- 10.8** List the hormones released by the pancreas and give the functions of each.
- 10.9** List the hormones released by the thymus and gonads and give the function of each.
- 10.10** Describe the signs, symptoms, causes, and treatments of various endocrine disorders.

Introduction

The endocrine system includes the organs of the body that secrete hormones directly into body fluids such as blood. Hormones help to regulate the chemical reactions within cells. They therefore control the functions of the organs, tissues, and other cells that comprise these cells. In this chapter you will learn about the processes and organs of the endocrine system. See Figure 10-1 for an illustration of the major organs.

CASE STUDY

Six months ago, a 32-year-old female patient was diagnosed with a nonfunctioning tumor of her pituitary gland. This is a noncancerous tumor that does not produce any hormones. However, if it continues to grow, it can compress the pituitary gland and surrounding structures. Unfortunately, this patient's tumor has grown and now must be surgically removed.

As you read this chapter, consider the following questions:

1. Where is the pituitary gland located?
2. What structures are likely to be compressed by a tumor of the pituitary gland?
3. What hormones are normally produced by the pituitary gland?
4. What signs and symptoms would this patient have if she did not take supplemental hormones following the removal of her pituitary gland?

Hormones

Hormones can be defined as chemicals secreted by a cell that affect the functions of other cells. Once released, most hormones enter the bloodstream where they are carried to their target cells. The target cells of a hormone are the cells that contain the receptors for the hormone. A hormone cannot affect a cell unless the cell has receptors for it.

Many hormones in the body are derived from steroids. Steroids are soluble in lipids and can therefore cross cell membranes very easily. Once a **steroid hormone** is inside a cell, it binds to its receptor, which is commonly in the nucleus of the cell. The hormone-receptor complex turns a gene on or off. When new genes are turned on or off, the cell begins to carry out new functions, and this is ultimately how steroid hormones affect their target cells. Examples of steroid hormones are **estrogen**, **progesterone**, **testosterone**, and **cortisol**.

Nonsteroid hormones are those that are made of amino acids or proteins. Proteins cannot cross the cell membrane easily. Therefore, these hormones bind to receptors on the surface of the cell. The hormone-receptor complex in the membrane usually activates a **G-protein**. The G-protein causes enzymes inside the cell to be turned on. Different chemical reactions then begin inside the cell. The cell now takes on new functions.

Prostaglandins are local hormones. They are derived from lipid molecules and typically do not travel in the bloodstream to find their target cells. Instead, their target cells are located close by. They have the same effects as other hormones and are produced by many body organs, including the kidneys, stomach, uterus, heart, and brain.

The Pituitary Gland

The pituitary gland is located at the base of the brain and is controlled by the hypothalamus. This gland is well protected by a bony structure called the **sella turcica**. Just superior to the gland is the **optic chiasm**, which carries visual information to the brain for interpretation. The

pituitary is divided into two lobes—the anterior and the posterior (Figures 10-1 and 10-2).

The Anterior Lobe of the Pituitary Gland

The anterior lobe of the pituitary gland secretes the following hormones:

- **Growth hormone (GH)**. As its name suggests, this hormone stimulates an increase in the size of the muscles

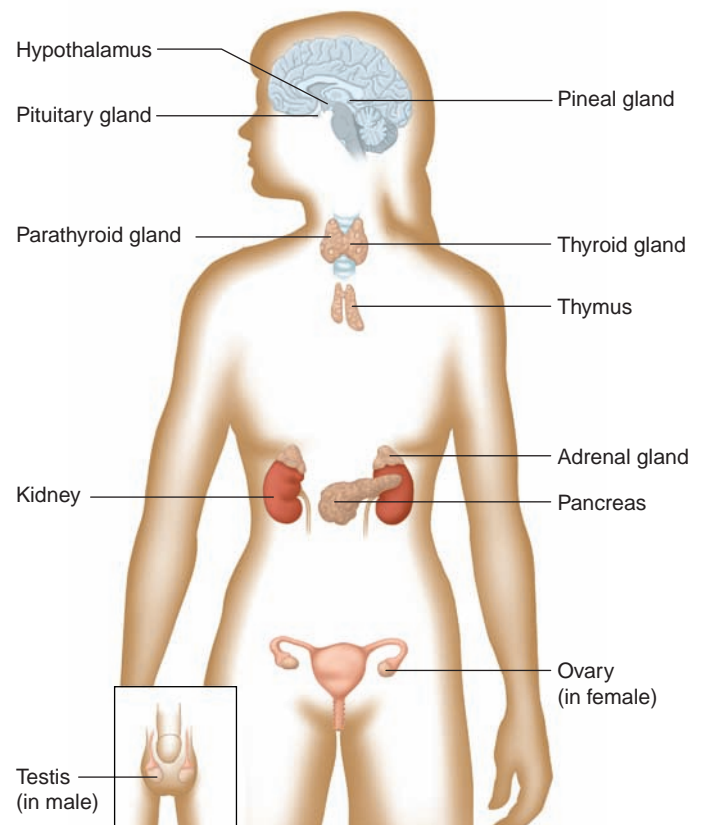


Figure 10-1. Major organs of the endocrine system.

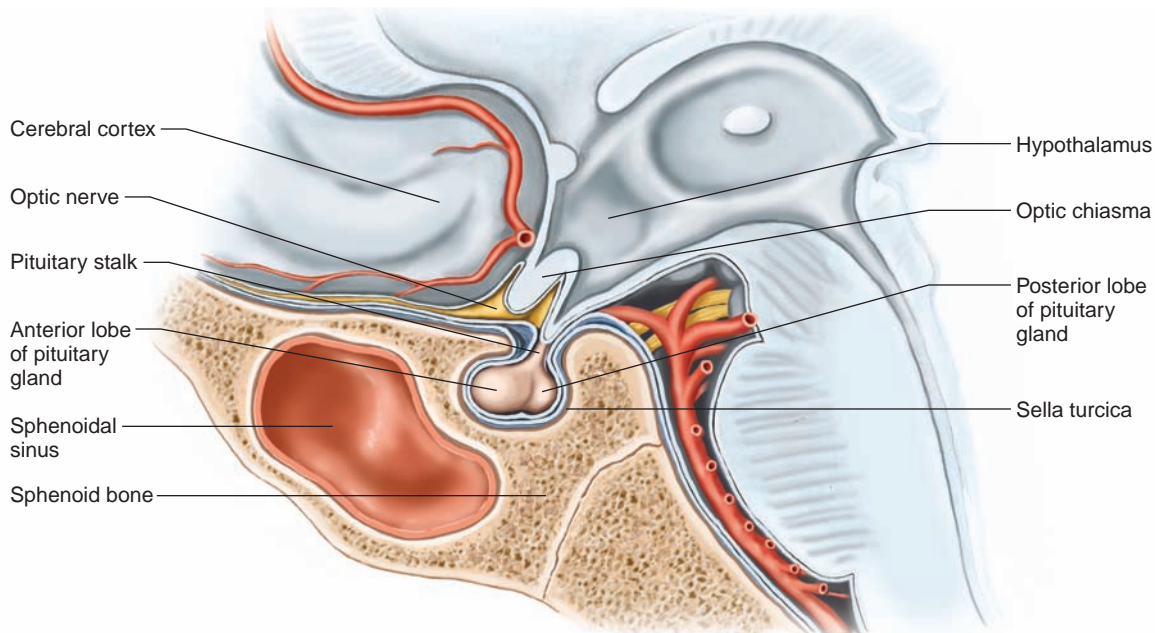


Figure 10-2. Location of the pituitary gland.

and bones in the body. It is very important in childhood for growth. It also stimulates the repair of tissues.

- **Prolactin (PRL).** This hormone stimulates milk production by mammary glands. Its function in males is not clear.
- **Adrenocorticotropic hormone (ACTH).** This hormone stimulates the adrenal cortex to release its hormones.
- **Thyroid-stimulating hormone (TSH).** This hormone stimulates the thyroid gland to release its hormones.
- **Follicle-stimulating hormone (FSH).** In females, this hormone stimulates the production of estrogen by the ovaries. More significantly, FSH stimulates maturation of the ova (eggs) before ovulation. In males, it stimulates sperm production.
- **Luteinizing hormone (LH).** In females, this hormone stimulates ovulation (the release of an egg from the ovaries) and the production of estrogen. In males, it stimulates the production of testosterone.

The Posterior Lobe of the Pituitary Gland

The posterior lobe of the pituitary gland secretes the following hormones:

- **Antidiuretic hormone (ADH).** This hormone stimulates the kidneys to conserve water. It therefore decreases urine output and helps to maintain blood pressure.
- **Oxytocin (OT).** In females, this hormone causes contractions of the uterus during childbirth. It also causes the ejection of milk from mammary glands during breast-feeding. Its function in males is not clear.

The Thyroid Gland and Parathyroid Glands

The thyroid gland consists of two lobes and sits below the larynx (voice box). It is covered by a capsule and is divided into follicles. The follicles store some of the hormones produced by the thyroid gland. Two major hormones produced by the thyroid gland are **thyroid hormones** and **calcitonin**. There are two main types of thyroid hormones—triiodothyronine (T_3) and thyroxine (T_4). The *T* stands for thyroid, and the numeral refers to the number of iodine atoms that are needed for each of these hormones to work properly.

Thyroid hormones increase energy production by cells, stimulate protein synthesis, and speed up the repair of damaged tissues. In children, they are important for normal growth and the development of the nervous system. Calcitonin lowers blood calcium levels by activating osteoblasts. Osteoblasts use excess blood calcium to build new bone tissue.

Most people have four parathyroid glands. They are small glands that are embedded into the posterior surface of the thyroid gland. The only hormone secreted by the parathyroid glands is called parathyroid hormone (PTH). This hormone acts to raise blood calcium levels by activating osteoclasts. Osteoclasts are bone-dissolving cells. When they dissolve bone, calcium is released into the bloodstream.

The Adrenal Glands

An adrenal gland sits on top of each kidney. It is divided into two portions—the adrenal medulla and the adrenal cortex. The adrenal medulla is the central portion of the

gland and secretes **epinephrine** and **norepinephrine**. These hormones produce the same effects that the sympathetic nervous system produces. They increase heart rate, breathing rate, blood pressure, and all the other actions that prepare the body for stressful situations.

The adrenal cortex is the outermost portion of the adrenal gland. It secretes many hormones but the two major ones are aldosterone and cortisol. **Aldosterone** stimulates the body to retain sodium, which helps it to retain water. It is important for maintaining blood pressure. Cortisol is released when a person is stressed. It decreases protein synthesis, so it slows down the repair of tissues. Its advantage is that it also decreases inflammation, which decreases pain.

The Pancreas

The pancreas is located behind the stomach. It is an endocrine gland as well as an exocrine gland. It is considered an exocrine gland because it secretes digestive enzymes into a duct that leads to the small intestine. It is considered an endocrine gland because it contains structures known as **islets of Langerhans** that secrete hormones into the bloodstream. The islets of Langerhans secrete two hormones—**insulin** and **glucagon**.

Insulin promotes the uptake of glucose by cells. It therefore reduces glucose concentrations in the bloodstream. It also promotes the transport of amino acids into cells and increases protein synthesis. Glucagon increases glucose concentrations in the bloodstream and slows down protein synthesis.

Other Hormone-Producing Organs

The **pineal body** is a small gland located between the cerebral hemispheres. It secretes a hormone called **melatonin**. Melatonin helps to regulate your circadian rhythms, which

is your biological clock. Your biological clock helps you decide when you should be awake or asleep. Melatonin is also thought to play a role in the onset of puberty.

The **thymus gland** lies between the lungs. It secretes a hormone called **thymosin**. Thymosin promotes the production of certain lymphocytes.

Sometimes referred to as the **gonads**, the ovaries and testes are reproductive organs that secrete hormones. The ovaries release estrogen and progesterone, and the testes produce testosterone. The functions of these hormones are provided in Chapter 13.

The stomach and small intestines also secrete hormones. The stomach produces gastrin, and the small intestine releases secretin and cholecystokinin. These hormones are discussed in Chapter 9.

The heart secretes a hormone called **atrial natriuretic peptide**, which regulates blood pressure. The kidneys secrete a hormone called **erythropoietin**, which stimulates blood cell production.

The Stress Response

Any stimulus that produces stress is termed a **stressor**. Stressors include physical factors such as extreme heat or cold, infections, injuries, heavy exercise, and loud sounds. Stressors can also include psychological factors such as personal loss, grief, anxiety, depression, and guilt. Even positive stimuli such as sexual arousal, joy, and happiness can be stressors.

The body's physiologic response to stress consists of a group of reactions called the general stress syndrome, which is primarily caused by the release of hormones. This syndrome results in an increase in the heart rate, breathing rate, and blood pressure. Glucose and fatty acid concentrations also increase in the blood, which leads to weight loss. Prolonged stress causes the release of cortisol. Cortisol slows down body repair because it prevents protein synthesis and inhibits immune responses, which is why a person under stress becomes more susceptible to being sick.

Pathophysiology

Common Diseases and Disorders of the Endocrine System

Acromegaly is a disorder in which too much growth hormone is produced in adults.

- **Causes.** This disorder is caused by an increased production of growth hormone or by a tumor of the pituitary gland.
- **Signs and symptoms.** The primary signs and symptoms include enlargement of the bones in the entire skull as well as in the hands and feet, and thickening of the skin.

Other symptoms include headache, fatigue, profuse sweating, pain (especially in the arms and legs), gaps between the teeth, weight gain, excessive hair production, cardiovascular diseases, arthritis, and vision problems.

- **Treatment.** Treatment includes medications to lower the production of growth hormone, radiation therapy to reduce the size of a pituitary tumor, or surgery to remove a pituitary tumor.

continued —→

Common Diseases and Disorders of the Endocrine System (continued)

Addison's disease is a condition in which the adrenal glands fail to produce enough corticosteroids. It affects about 1 in every 25,000 people.

- **Causes.** The cause of this disease is most often unknown. It may be caused by an autoimmune dysfunction. It can be caused by cancer and other serious diseases that damage the adrenal glands.
- **Signs and symptoms.** The signs and symptoms may begin long before a diagnosis is made. They include weakness, fatigue, and dizziness after rising from a sitting or reclining position. Other symptoms include weight loss, muscle pain, lack of appetite, nausea, vomiting, diarrhea, and dehydration.
- **Treatment.** Because this disease can be life threatening, the first treatment is to administer corticosteroids. Medications or other hormones may be prescribed to help balance the levels of sodium and potassium.

Cushing's disease is also known as hypercortisolism. In this condition, a person produces too much cortisol.

- **Causes.** This disease is caused by an excessive production of ACTH (a hormone that increases the production of cortisol), a tumor of the adrenal gland (the source of cortisol), a tumor of the pituitary gland (the source of ACTH), or the long-term use of steroid hormones.
- **Signs and symptoms.** Common symptoms include a round or full face, a hump of fat between the shoulders, thin arms and legs with a large abdomen, fatigue, thin skin, acne, frequent thirst, frequent urination, mental disabilities, a loss of menstrual cycle in females, high blood pressure, high glucose blood levels, and body aches in the muscles, back, or head.
- **Treatment.** The first treatment is lifestyle changes, especially stopping the use of steroid hormones. Radiation therapy or surgery may be needed to treat any tumors.

Diabetes mellitus is a chronic disease that is characterized by high glucose levels in the blood. There are at least three different types of diabetes mellitus. Type 1 is referred to as early-onset diabetes and usually develops during childhood. Type 2 is the most common type and is often called late-onset diabetes because it is primarily diagnosed in adults. Gestational diabetes occurs only in pregnant women and is usually temporary. African Americans, Hispanics, and Native Americans are more likely to develop diabetes than any other ethnic groups.

- **Causes.** This disease is caused by the production of too little or no insulin by the pancreas. Other causes include body cells having too few insulin receptors, obesity, high blood pressure, pregnancy, and high cholesterol levels in the blood.
- **Signs and symptoms.** There are many signs and symptoms of this disease. They include high levels of

glucose in the blood, excessive thirst, frequent urination, fatigue, increased appetite, unexplained weight loss, blurry vision, impotence in men, nausea, skin wounds that heal slowly, high ketone levels in the urine, and foot problems (due to poor circulation).

- **Treatment.** Treatment includes daily injections of insulin, oral medications to increase insulin production, oral medications to increase the body's sensitivity to insulin, frequent monitoring of glucose levels in the blood, and frequent monitoring of ketone levels in the urine. Lifestyle changes are important and should include reducing weight (especially if obese), changing eating habits, and getting regular exercise. Lifestyle changes to prevent injury to legs or feet may also be needed.
- **Complications.** Left untreated, diabetes can result in long-term and life-threatening complications. Blood vessels become thickened, which can damage vital organs including the kidneys, eyes, heart, and brain. Long-term damage can result in kidney disease, blindness, and atherosclerosis (the buildup of fatty deposits in blood vessels). Circulation worsens, which not only affects organs but may result in slower overall healing and ulcers that develop in the feet. Because of the body's decreased ability to heal, these ulcers may require the amputation of the affected foot and possibly part of the leg.

Dwarfism is a condition in which too little growth hormone is produced.

- **Causes.** This condition can be caused by an underproduction of the growth hormone during childhood, trauma to the pituitary gland, or a pituitary tumor.
- **Signs and symptoms.** Symptoms include short height, abnormal facial features, cleft lip or palate, delayed puberty, headaches, frequent urination, and excessive thirst.
- **Treatment.** Treatment is the administration of supplemental growth hormone.

Gigantism is a condition in which too much growth hormone is produced during childhood.

- **Causes.** This condition is caused by overproduction of the growth hormone during childhood. It can also be caused by a tumor in the pituitary gland.
- **Signs and symptoms.** Very tall height, delayed sexual maturity, thick facial bones, thick skin, weakness, and vision problems are common symptoms.
- **Treatment.** Treatment includes medications to reduce growth hormone levels, radiation therapy, and surgery to remove the tumor.

Graves' disease is a disorder in which a person develops antibodies that attack the thyroid gland. This attack causes the thyroid to produce too many thyroid hormones.

continued →

Common Diseases and Disorders of the Endocrine System *(continued)*

Graves' disease is the most common type of hyperthyroidism in the United States.

- **Causes.** This disease is caused by an overproduction of thyroid hormones. It is also considered an autoimmune disorder.
- **Signs and symptoms.** The most common signs and symptoms include protrusion of the eyes (exophthalmos) and thyroid enlargement (goiter). Other symptoms include insomnia, unexplained weight loss, anxiety, muscle weakness, increased appetite, excessive sweating, vision problems, thyroid enlargement, and an increased heart rate.
- **Treatment.** Treatment includes medications to reduce heart rate, sweating, and nervousness; radiation to destroy the thyroid gland; surgery to remove the thyroid gland; and supplemental thyroid hormones if the gland is destroyed or removed.

Myxedema is a disorder in which the thyroid gland does not produce adequate amounts of thyroid hormone. It is a

severe type of hypothyroidism that is most common in females over age 50.

- **Causes.** Causes include the removal of the thyroid, radiation treatments to the neck area, and obesity. This disorder may be congenital.
- **Signs and symptoms.** Signs and symptoms include weakness, fatigue, weight gain, depression, general body aches, dry skin and hair, hair loss, puffy hands or feet, a decreased ability to taste food, abnormal menstrual periods, pale or yellow skin, a slow heart rate, low blood pressure, anemia, an enlarged heart, high cholesterol levels, or coma.
- **Treatment.** Treatment consists of giving supplemental thyroid hormones intravenously or orally and closely monitoring the levels of thyroid hormones.

Summary

The endocrine system regulates all chemical reactions in cells. The substances responsible for this regulation are known as hormones. Hormones are produced by endocrine glands. The major endocrine glands are the pitu-

itary, thyroid, parathyroid, adrenal, and pancreas. Once a hormone is released into the bloodstream, it travels to its target tissue and produces a response. An awareness of this system can help medical assistants be more effective when teaching a patient about the advantages and disadvantages of hormone replacement therapy.

REVIEW

CHAPTER 10

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. Where is the pituitary gland located?
2. What structures are likely to be compressed by a tumor of the pituitary gland?
3. What hormones are normally produced by the pituitary gland?
4. What signs and symptoms would this patient have if she did not take supplemental hormones following the removal of her pituitary gland?

Discussion Questions

1. Explain the difference between an endocrine gland and an exocrine gland.
2. Name the major endocrine organs of the body and give their locations.
3. Explain how the body responds to stress.
4. Explain why the testes and ovaries are described as both endocrine organs and reproductive organs.

Critical Thinking Questions

1. If a patient had his pituitary gland removed, what hormone supplements would he need?
2. What is the danger of a diabetic injecting too much insulin?
3. Why is hyposecretion (insufficient secretion) of thyroid hormone in newborns more serious than hyposecretion in adults?

Application Activities

1. Tell which endocrine gland secretes the following hormones:
 - a. Insulin
 - b. ADH
 - c. Testosterone
 - d. Prolactin
 - e. Growth hormone
2. Describe the effects the following hormones produce:
 - a. Oxytocin
 - b. Cortisol
 - c. LH and FSH
 - d. Glucagon
 - e. Estrogen
3. For each of the following diseases, name the hormone that is involved:
 - a. Acromegaly
 - b. Myxedema
 - c. Dwarfism
 - d. Diabetes
 - e. Cushing's disease
4. Define what a stressor is and give an example.

Internet Activity

Find a Web site that discusses endocrinology. Research the roles of an endocrinologist and how weight management and endocrinology are related.

CHAPTER 11

Special Senses

CHAPTER OUTLINE

- The Nose and the Sense of Smell
- The Tongue and the Sense of Taste
- The Eye and the Sense of Sight
- The Ear and the Senses of Hearing and Equilibrium

OBJECTIVES

After completing Chapter 11, you will be able to:

- 11.1 Describe the anatomy of the nose and the function of each part.
- 11.2 Describe how smell sensations are created and interpreted.
- 11.3 Describe the anatomy of the tongue and the function of each part.
- 11.4 Describe how taste sensations are created and interpreted.
- 11.5 Name the four primary taste sensations.
- 11.6 Describe the anatomy of the eye and the function of each part.
- 11.7 Describe various disorders of the eye.
- 11.8 Trace the path of a visual image through the eye and to the brain for interpretation.
- 11.9 Describe the anatomy of the ear and the function of each part.
- 11.10 Describe various disorders of the ear.
- 11.11 Explain how sounds travel through the ear and are interpreted in the brain.
- 11.12 Explain the role of the ear in maintaining equilibrium.

KEY TERMS *(Continued)*

retina	sensorineural hearing loss	tinnitus
rods	sensory adaptation	tympanic membrane
sclera	strabismus	vestibule
semicircular canals	taste bud	vitreous humor

Introduction

The special senses are smell, taste, vision, hearing, and equilibrium. They are called special senses because their sensory receptors are located within relatively large sensory organs in the head—the nose, tongue, eyes, and ears. This chapter introduces the structure and function of these sense organs and focuses on common diseases of the eyes and ears.

KEY TERMS

amblyopia
aqueous humor
astigmatism
auditory tube
auricle
cataracts
chemoreceptor
choroid
ciliary body
cochlea
conductive hearing loss
cones
conjunctiva
conjunctivitis
cornea
endolymph
external auditory canal
extrinsic eye muscles
glaucoma
gustatory receptors
hyperopia
iris
lacrimal apparatus
lacrimal gland
macular degeneration
myopia
nasolacrimal duct
olfactory
orbicularis oculi
oval window
papillae
perilymph
presbyopia
pupil

CASE STUDY

A 42-year-old man comes to the doctor's office complaining of dizziness, nausea, and a loud ringing in his left ear. He is diagnosed with Meniere's disease. The doctor explains to him that this disorder is caused by the buildup of fluid in the inner ear.

As you read this chapter, consider the following questions:

1. Why is the patient experiencing dizziness and difficulty hearing?
2. What is the clinical term for ringing in the ear?
3. What precautions should this patient take because of his dizziness?
4. A diuretic is a drug that decreases fluids in the body. Why might the doctor prescribe a diuretic?

The Nose and the Sense of Smell

Smell receptors are also called **olfactory** receptors and are **chemoreceptors**. This means that they respond to changes in chemical concentrations. Chemicals that activate smell receptors must be dissolved in the mucus of the nose. Therefore, a person who has a "dry nose" has trouble smelling.

Smell receptors are located in the olfactory organ, which is in the upper part of the nasal cavity. Humans have a relatively poor sense of smell compared to animals because chemicals must diffuse all the way up the nasal cavity in order to activate smell receptors.

Once smell receptors are activated, they send their information to the olfactory nerves. The olfactory nerves send the information along olfactory bulbs and tracts to different areas of the cerebrum. The cerebrum interprets the information as a particular type of smell (Figure 11-1).

An interesting fact about smell is that it undergoes **sensory adaptation**, which means that the same chemical can stimulate smell receptors for only a limited amount of time. Eventually, the smell receptors no longer respond to the chemical, and it can no longer be smelled. Sensory adaptation explains why you smell perfume when you first encounter it, but after a few minutes you cannot smell it or may be less aware of it.

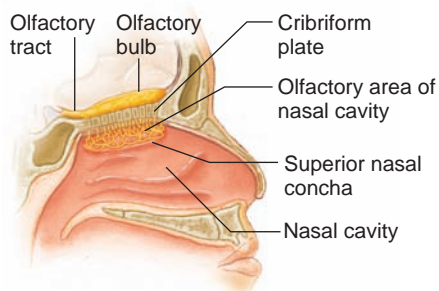


Figure 11-1. The olfactory area (organ) is located in the superior part of the nasal cavity.

The Tongue and the Sense of Taste

Taste, or **gustatory**, **receptors** are located on taste buds. **Taste buds** are found on the "bumps" of the tongue. These bumps are called **papillae**, which many people incorrectly think are the actual taste buds. Taste buds are microscopic and cannot be seen with the naked eye. Some taste buds are also scattered on the roof of the mouth and in the walls of the throat.

Each taste bud is made of taste cells and supporting cells. The taste cells function as taste receptors, and the supporting cells simply fill in the spaces between the taste cells. Taste cells are types of chemoreceptors because they are activated by chemicals that must be dissolved in saliva (Figure 11-2).

There are four types of taste cells, and each type is activated by a particular group of chemicals. Therefore, the following four primary taste sensations are produced:

1. Sweet. Taste cells that respond to "sweet" chemicals are concentrated at the tip of the tongue.
2. Sour. Taste cells that respond to "sour" chemicals are concentrated on the sides of the tongue.
3. Salty. Taste cells that respond to "salty" chemicals are concentrated on the tip and sides of the tongue.
4. Bitter. Taste cells that respond to "bitter" chemicals are concentrated at the back of the tongue.

Eating spicy foods activates pain receptors on the tongue. Once taste cells are activated, they send their information to several cranial nerves. The information eventually reaches the gustatory cortex in the parietal lobe of the cerebrum. The gustatory cortex interprets the information as a particular taste.

The Eye and the Sense of Sight

The sense of sight comes from the eyes and is also supported by visual accessory organs.

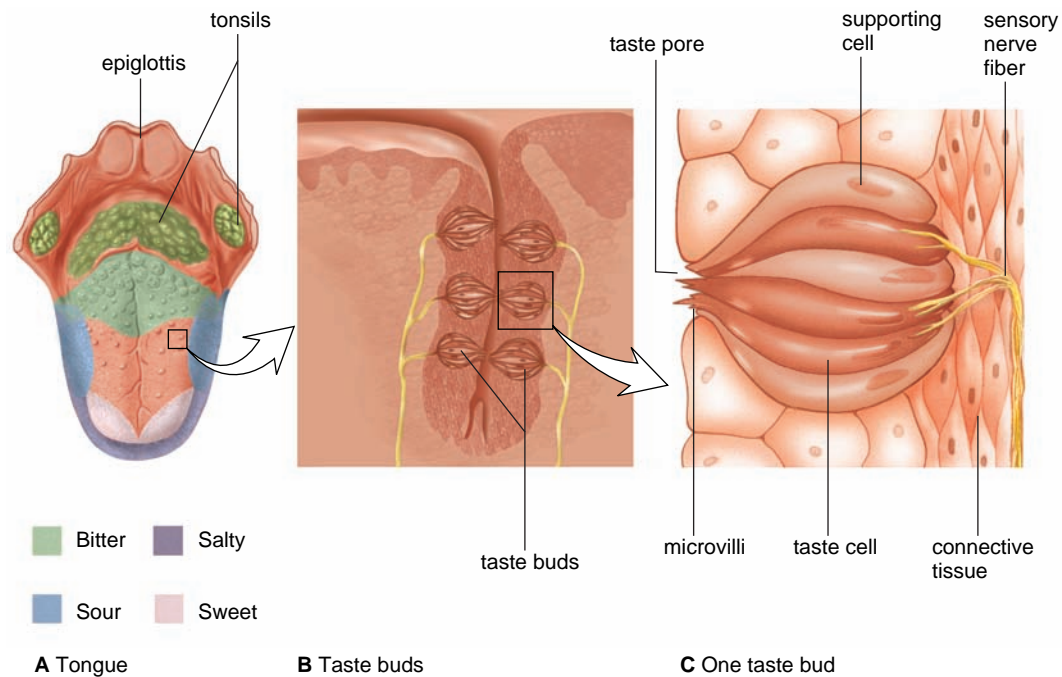


Figure 11-2. Tongue and taste buds. (a) Areas of the tongue are sensitive to different tastes, as indicated. (b) Taste buds are on and in papillae. (c) Taste buds are composed of taste cells and supporting cells.

Structure of the Eye

The eye is hollow and spherical shaped. It consists of cavities, wall layers, and other structures.

The Cavities of the Eye. Each eyeball is divided into two cavities—the anterior and the posterior.

The Anterior Cavity. The anterior cavity is in front of the lens and is filled with a watery fluid called **aqueous humor**. Aqueous humor provides nutrients to structures in the anterior cavity of the eyeball. When too much aqueous humor is produced, a person develops **glaucoma**.

The Posterior Cavity. The posterior cavity of the eyeball is behind the lens and is filled with a very thick fluid called **vitreous humor**. Vitreous humor keeps the retina flat and helps to maintain the shape of the eye.

The Wall of the Eye. In addition to the cavities of the eye, the eye is composed of a wall that has three layers: the outer, middle, and inner (Figure 11-3).

Outer Layer. The outer layer is also called the fibrous layer because it is composed of tough, dense connective tissue. The two divisions of the outer layer are the sclera and cornea. The **sclera** is the “white of the eye” and does not allow light to enter the eye. The **cornea** is anterior to the sclera and allows light to enter the eye. It is often called the “window of the eye.” The entire outer layer contains no blood vessels but is supplied with many sensory receptors that can detect even the smallest of particles on the surface of the eyeball.

Middle Layer. The middle layer is also called the vascular and pigmented layer because it is richly supplied with blood vessels and pigments. The middle layer consists of the **choroid**, **ciliary body**, and **iris**. The choroid lines the sclera and functions to absorb extra light that has entered the eye. The ciliary body functions to hold and move the lens. The lens is moved back and forth to allow the eye to focus on images. The lens is usually transparent but “cloudy” areas called **cataracts** can form, which prevent light from reaching visual receptors. The iris, which is the most anterior structure of this layer, controls the amount of light that enters the eye. The iris also contains the color of a person’s eyes. The hole in the iris is called the **pupil**.

Inner Layer. The inner layer is also called the **retina**. This layer contains visual receptors called **rods** and **cones**. Rods allow a person to see images in dim light as well as the general outlines of structures. Rods also detect black, white, and gray shades. A person who suffers from night blindness has defective rods. Cones allow a person to see images in bright light and to see details of structures. Cones also detect colors other than white, black, and gray. A person who has red-green color blindness lacks the cones needed to see reds and greens.

Visual Accessory Organs

Visual accessory organs assist and protect the eyeball. They include eyelids, conjunctivas, the lacrimal apparatus, and extrinsic eye muscles.

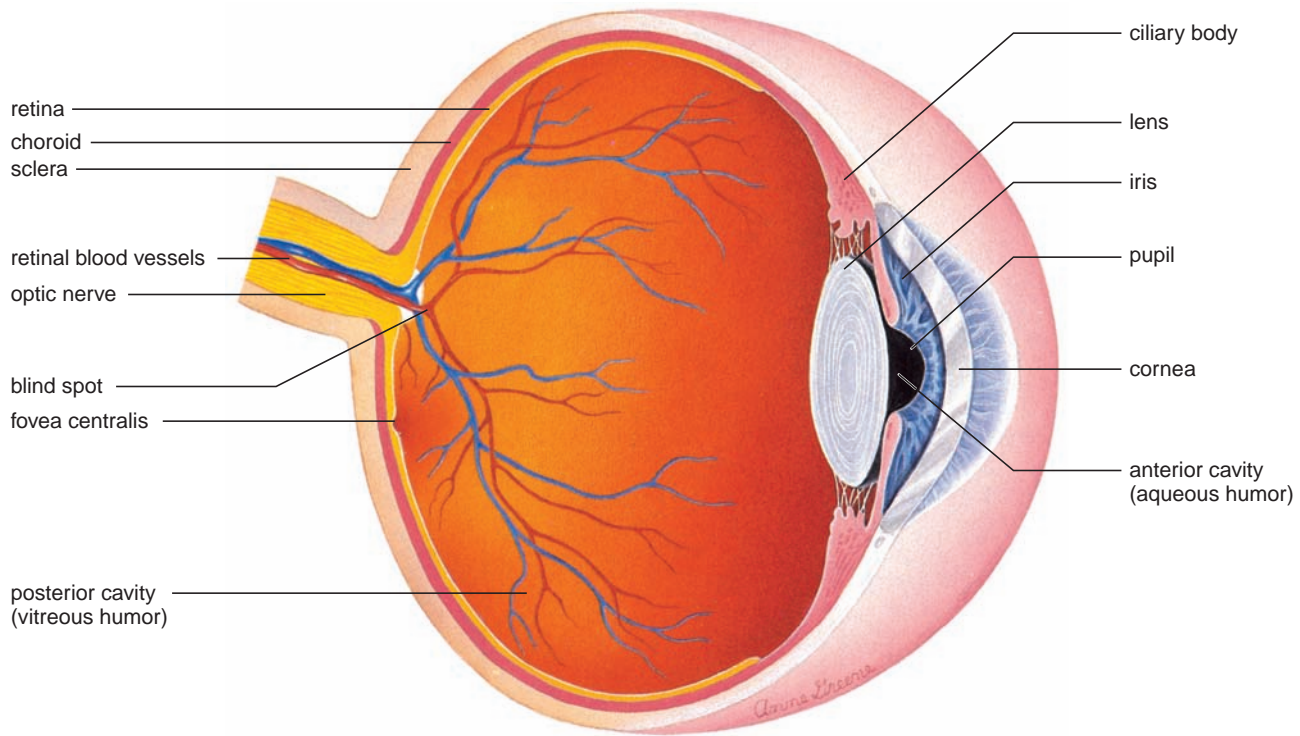


Figure 11-3. Sectioned eyeball.

Eyelids. Each eyelid is composed of skin, muscle, and dense connective tissue. The muscle in the eyelid is called the **orbicularis oculi** and is responsible for blinking. Blinking the eyelids prevents the eyeball surface from drying and also protects the eyes. A moist eyeball surface is much less likely to grow bacteria than a dry one is.

Conjunctivas. **Conjunctivas** are mucous membranes that line the inner surfaces of the eyelids; they fold back onto the anterior surface of each eyeball. They are called

mucous membranes because they produce mucus that keeps the surface of the eyeballs moist.

The Lacrimal Apparatus. The **lacrimal apparatus** consists of lacrimal glands and nasolacrimal ducts. **Lacrimal glands** are located on the lateral edge of each eyeball and produce tears. Tears are mostly water, but they also contain enzymes that can destroy bacteria and viruses. Tears also have an outer oily layer that prevents them from evaporating. **Nasolacrimal ducts** are located on the medial aspect of each eyeball. They drain tears into the nose. When a person cries, the abundance of tears entering the nose produces the “runny nose” associated with crying (Figure 11-4).

Extrinsic Eye Muscles. **Extrinsic eye muscles** are skeletal muscles that move the eyeball. Each eyeball has six extrinsic eye muscles attached to it that move the eyeball superiorly, inferiorly, laterally, or medially.

Visual Pathways

When visual receptors are activated, they send their information to optic nerves. Parts of the optic nerves cross at a structure called the **optic chiasm**, which is located at the base of the brain. The visual area in the occipital lobes of the cerebrum is responsible for interpreting vision. Because visual information crosses in the optic chiasm, about half of the visual information detected in each eye is interpreted on the opposite side of the brain. Therefore, half of what a person sees in the right eye is interpreted in the left side of the brain. See Table 11-1 for a summary of the parts of the eye and their functions.

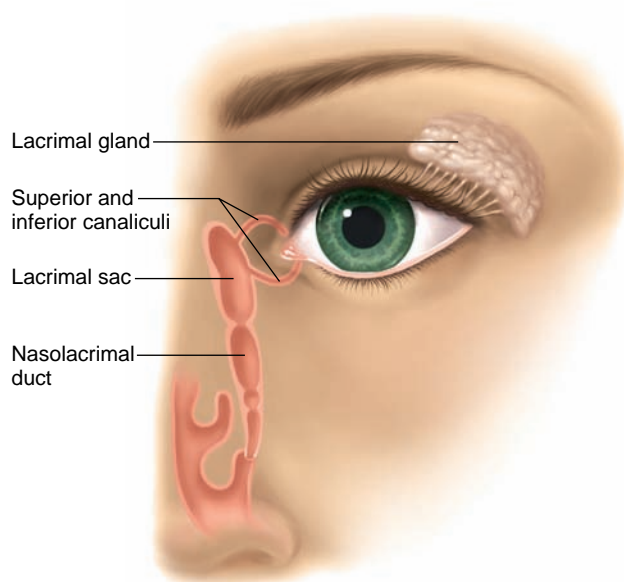



Figure 11-4. Lacrimal apparatus.

TABLE 11-1 The Functions of the Parts of the Eye

Structure	Function
Aqueous humor	Nourishes structures in anterior eye cavity
Vitreous humor	Holds retina in place; maintains shape of eyeball
Sclera	Protects eye
Cornea	Allows light to enter eye; bends light as it enters eye
Choroid	Absorbs extra light in eye
Ciliary body	Holds lens; moves lens for focusing
Iris	Controls amount of light entering eye
Lens	Focuses light onto retina
Retina	Contains visual receptors
Rods	Allow vision in dim light; detect black-and-white images; detect broad outlines of images
Cones	Allow vision in bright light; detect colors; detect details
Optic nerve	Carries visual information from rods and cones toward the brain



Educating the Patient

Eye Safety and Protection

Almost 90% of all eye injuries can be prevented by eye safety practices or proper protective eyewear. You can educate patients about preventing eye injuries in the home, at work, and during recreational activities.

Eye Safety in the Home

Patients should follow these suggestions to protect their eyes in the home:

- Pad or cushion the sharp corners and edges of furniture and home fixtures.
- Make sure adequate lighting and handrails are available on stairs.
- Keep personal use items (for example, cosmetics and toiletries), kitchen utensils, and desk supplies out of the reach of children.
- Keep toys with sharp edges out of the reach of children. Also, make sure toys intended for older children are kept away from younger children.
- Before mowing the lawn, remove dangerous debris.
- Wear safety goggles when operating any type of power equipment.
- Keep dangerous solvents, paints, cleaners, fertilizers, and other chemicals out of the reach of children.
- Never mix cleaning agents.

Eye Safety at Work

Approximately 15% of eye injuries in the workplace lead to temporary or permanent vision loss. Eye injuries at work can be diminished if patients take the following precautions:

- Safety eyewear should be chosen according to the type of work being performed and the type of eye protection that is needed.
- Safety eyewear should be worn whenever there is a chance of flying objects from machines.
- Safety eyewear should be worn whenever there is possible exposure to harmful chemicals or radiation.

Eye Safety During Sports and Recreational Activities

Common eye injuries that occur while playing a sport include scratched corneas, inflamed irises and retinas, bleeding in the anterior chamber of the eye, traumatic cataracts, and fractures of the eye socket. Wearing sports eye guards can prevent most sports eye injuries. These guards are recommended for baseball, basketball, soccer, football, rugby, and hockey.

Pathophysiology

Common Diseases and Disorders of the Eyes

Amblyopia is more commonly called lazy eye and occurs when a child does not use one eye regularly. A child with this disorder does not have normal depth perception and often has eyes that turn in or out.

- **Causes.** Amblyopia can be caused by any disorder of the eyes that affects normal eye development and use, including farsightedness, nearsightedness, cataracts, and astigmatism.
- **Signs and symptoms.** The most common symptoms are blurred vision and an eye that appears to turn inward.
- **Treatment.** Treating the underlying conditions and placing a patch over the normal eye are the primary treatment options.

Astigmatism means that the cornea has an abnormal shape, which causes blurred images during near or distant vision.

- **Causes.** A person with this condition is normally born with it.
- **Signs and symptoms.** There are no symptoms with this condition. However, it can be diagnosed during an ophthalmic (eye) exam.
- **Treatment.** Treatment includes corrective lenses or surgery to reshape the cornea.

Cataracts are structures in the lens that prevent light from going through the lens. Over time, images begin to look fuzzy.

- **Causes.** Aging is the most significant risk factor associated with this disorder. Cataracts can be caused by eye injuries, some medications, and certain diseases.
- **Signs and symptoms.** The primary symptom is poor or impaired vision.
- **Treatment.** Treatment includes the use of eyeglasses, medications to dilate the pupils, or surgery to remove the cataracts.

Conjunctivitis is commonly called pink eye and is highly contagious.

- **Causes.** This disease is caused by bacteria, viruses, or allergies.
- **Signs and symptoms.** The signs and symptoms are red eyes, itchy eyes, swollen eyelids, a watery discharge (in the types caused by viruses and allergies), and a stringy discharge (in the type caused by bacteria). The allergic type usually affects both eyes, whereas viral and bacterial conjunctivitis begins in one eye and then spreads to the other.
- **Treatment.** Cool compresses and anti-inflammatory drugs are used to treat conjunctivitis caused by viruses

and allergies. Antihistamines are used for the type caused by allergies. The bacterial type is best treated with antibiotics.

Dry eye syndrome is one of the most common eye problems treated by physicians. This syndrome results from a decreased production of the oil within tears, which normally occurs with age.

- **Causes.** Dry eye can be caused by cigarette smoke; air conditioning; long hours at a computer; some medications; contact lenses; hormonal changes associated with menopause; and hot, dry, or windy climates.
- **Signs and symptoms.** The common eye symptoms include burning, irritation, redness, itching, and excessive tearing.
- **Treatment.** Artificial tears can provide relief to many patients. People with this condition should drink 8 to 10 glasses of water a day and make a conscious effort to blink more frequently and avoid rubbing their eyes. In addition, punctal plugs can be inserted to trap tears on the eyes, which prevents the tears from entering the nasolacrimal duct.

Glaucoma is a condition in which too much pressure is created in the eye by excessive aqueous humor. If untreated, this excess pressure can lead to permanent damage of the optic nerves, resulting in blindness.

- **Causes.** *Open-angle glaucoma* progresses relatively slowly; it can be caused by the slow drainage of aqueous humor from the anterior segment of the eye, which is the space between the cornea and the iris. *Acute-angle closure glaucoma* is a more serious type of glaucoma; it results when the space between the iris and the cornea is more narrow than normal. Certain medications, trauma, and tumors may all cause secondary glaucoma.
- **Signs and symptoms.** There are usually no symptoms of open-angle glaucoma. Common symptoms of acute-angle closure glaucoma include nausea, vomiting, extreme eye pain, headache, and a sudden loss of vision.
- **Treatment.** Treatments include medications to control pressure in the anterior segment of the eye, and surgery.

Hyperopia is commonly called farsightedness. It occurs when light entering the eye is focused behind the retina. Common causes include flat corneas or short eyes. Treatments include corrective lenses or surgery to alter the shape of the cornea.

Macular degeneration is a progressive disease that usually affects people over the age of 50. It occurs when the

continued →

Common Diseases and Disorders of the Eyes *(continued)*

retina no longer receives an adequate blood supply. It is the most common cause of vision loss in the United States.

- **Causes.** Genetics, age, smoking, and exposure to ultraviolet radiation (from sunlight) are known risk factors. Nutrition plays an important role in preventing this disease—diets high in fruits and vegetables are associated with the prevention of macular degeneration.
- **Signs and symptoms.** Common symptoms include loss of central vision (may be gradual or sudden), distortions in vision (straight lines begin to look wavy, for example), and difficulty seeing details.
- **Treatment.** In most cases, there are no treatments. Laser treatments may repair the damaged blood vessels of the retina.

Myopia is commonly called nearsightedness. It occurs when light entering the eye is focused in front of the retina. Treatments include corrective lenses or surgery to alter the shape of the cornea.

Presbyopia is a common eye disorder that results in the loss of lens elasticity. It develops with age and causes a person to have difficulty seeing objects close up. Treatments include contact lenses, eyeglasses, and eye surgeries.

Retinal detachment occurs when the layers of the retina separate. It is considered a medical emergency and, if not treated right away, leads to permanent vision loss.

- **Causes.** This disorder is sometimes caused by fluids that seep between layers of the retina; this occurs most

commonly in nearsighted people. In diabetics, vitreous body or scar tissue pulls the retina loose. Other causes include eye trauma that causes fluid to collect underneath the layers of the retina.

- **Signs and symptoms.** Signs and symptoms include light flashes, wavy vision, a sudden loss of vision, and a larger amount of floaters.
- **Treatment.** The treatment measures include the following:
 - Pneumatic retinopexy, which involves injecting a gas bubble into the posterior segment of the eye. The pressure flattens the retina, and the retina is later fixed in place with a laser.
 - Scleral buckle, which involves using a silicone band to hold the retina in place.
 - Replacing the vitreous body with silicone oil to reattach the retina.

Strabismus is more commonly referred to as crossed eyes. In this condition, the eyes do not focus on the same image.

- **Causes.** The causes are mostly unknown, although some known causes include eye and brain injuries, cerebral palsy, and various disorders of the retina.
- **Signs and symptoms.** Blurred vision and depth perception are the most common symptoms.
- **Treatment.** Treatment includes eyeglasses, eye exercises, a patch over the stronger eye, and surgery to realign the eyes.

The Ear and the Senses of Hearing and Equilibrium

The organ of hearing is the ear. In addition to providing the sense of hearing, the ear aids the body in maintaining balance, or equilibrium.

Structure of the Ear

The ear is divided into three parts—external ear, middle ear, and inner ear (Figure 11-5).

External Ear. The external ear is composed of the **auricle** and the **external auditory canal**. The auricle is the flap of skin and cartilage that hangs off the side of the head. It is also called the pinna and functions to collect sound waves. The external auditory canal is more commonly called the ear canal. When you stick your finger in your ear, you are sticking it in your external auditory canal. This canal carries sound waves to the **tympanic membrane** (eardrum).

Middle Ear. The middle ear begins with the tympanic membrane. This membrane is relatively thin and vibrates

when sound waves hit it. On the other side of the tympanic membrane are three tiny bones called **ear ossicles**—the malleus, incus, and stapes. When the tympanic membrane vibrates, it causes the ossicles to vibrate and hit a membrane called the oval window. The **oval window** is the beginning of the inner ear.

The middle ear is connected to the throat by a tube called the **auditory tube**, which is also known as the Eustachian tube. This tube helps maintain equal pressure on both sides of the eardrum, which is important for normal hearing. Because the middle ear is connected to the throat by this tube, any throat infection can easily spread to the ear.

Inner Ear. The inner ear is a very complex system of communicating chambers and tubes. It is divided into three portions—**semicircular canals**, a **vestibule**, and a **cochlea**. There are three semicircular canals per ear, and they function to detect the balance of the body. The cochlea is shaped like a snail's shell and contains hearing receptors. The vestibule is the area between the semicircular canals and the cochlea. Like the semicircular canals, it also functions in equilibrium. When the head moves, fluids in the semicircular canals and vestibule move, which

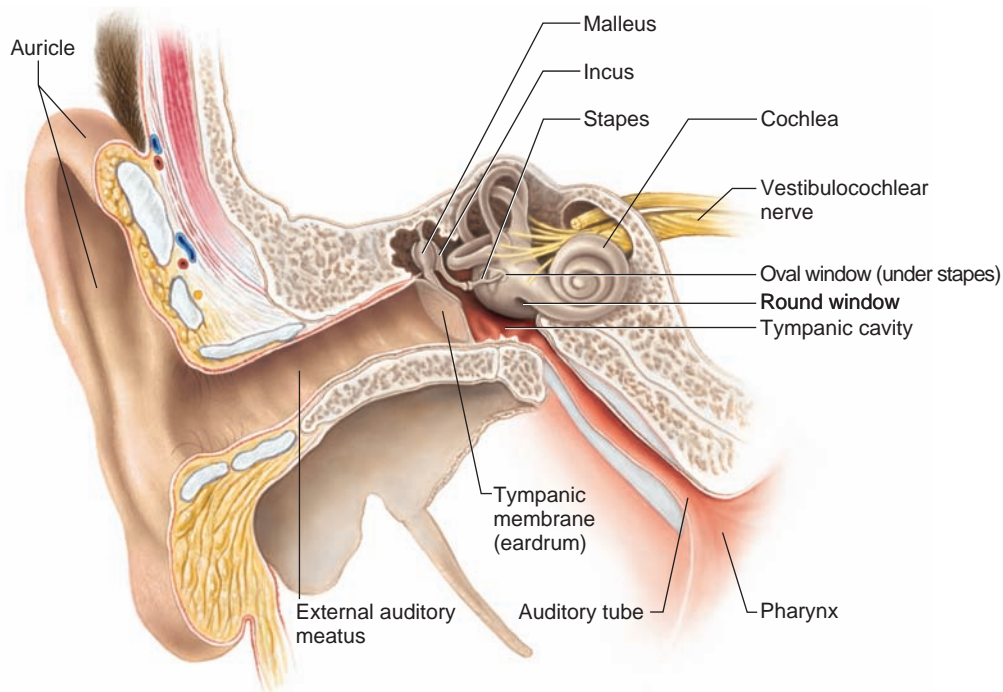


Figure 11-5. Major parts of the ear.

activates equilibrium receptors. The receptors send the information along vestibular nerves to the cerebrum for interpretation. The cerebrum can then advise the body if it needs to make any adjustments to prevent a fall.

There are two types of fluid in the inner ear—**perilymph** and **endolymph**. When these fluids move, they activate hearing and equilibrium receptors.

When sound waves reach the inner ear, fluids move and activate the hearing receptors in the cochlea. Sounds of different volumes and frequencies activate various types of hearing receptors. Once hearing receptors are activated, they send their information to auditory nerves. Auditory nerves (vestibulocochlear nerves) eventually deliver the information to the auditory cortex in the temporal lobe of

Educating the Patient

How to Recognize Hearing Problems in Infants

Hearing problems in infants are not easy to recognize. The following general guidelines can be used to teach parents how to identify normal hearing in infants. Any deviations from these guidelines may indicate a hearing loss.

- Infants up to 4 months old:
 - They should be startled by loud noises (barking dog, hand clap, etc.).
 - When sleeping in a quiet room, they should wake up at the sound of voices.
 - Around the fourth month of age, they should turn their head or move their eyes to follow a sound.
 - They should recognize the mother's or primary caregiver's voice better than other voices.
- Infants 4 to 8 months of age:
 - They should regularly turn their heads or move their eyes to follow sounds.
 - Their facial expressions should change at the sound of familiar voices or loud noises.
 - They should begin to enjoy certain sounds such as rattles or ringing bells.
 - They should begin to babble at people who talk to them.
- Babies 8 to 12 months of age:
 - They should turn quickly to the sound of their name.
 - They should begin to vary the pitch of the sounds they produce in their babbling.
 - They should begin to respond to music.
 - They should respond to the instruction "no."

the cerebrum. The auditory cortex interprets the information as sounds.

Hearing Loss

The two most common types of hearing loss are **conductive** and **sensorineural**.

Conductive Hearing Loss. Conductive hearing loss develops when sound waves cannot be conducted through the ear. For example, inserting an earplug can temporarily cause conductive hearing loss. The causes of conductive hearing loss include a buildup of earwax and damage to the tympanic membrane. Most types of conductive hearing loss are temporary.

Sensorineural Hearing Loss. Sensorineural hearing loss develops when neural structures associated with the ear are damaged. Neural structures include hearing receptors and the auditory nerve. **Tinnitus**, which is an

abnormal ringing in the ear, suggests damage to the auditory nerve. Most types of sensorineural hearing loss are permanent.

Summary

The ability to detect changes in the environment is critical to survival. The human body has various organs for this purpose. The nose senses odors in the environment, the tongue senses tastes, and the eyes are important for visual sense. The ears serve two functions—hearing and equilibrium.

Each of these special senses works in concert with the nervous system to assist the body in coping with environmental changes experienced throughout the day. A medical assistant should understand the special senses in order to test distance and near visual acuity, color vision, and hearing. Knowledge of the anatomy of the eye and ear is essential when performing irrigation or instillation of these structures.

REVIEW

CHAPTER 11

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. Why is the patient experiencing dizziness and difficulty hearing?
2. What is the clinical term for ringing in the ear?
3. What precautions should this patient take because of his dizziness?
4. A diuretic is a drug that decreases fluids in the body. Why might the doctor prescribe a diuretic?

Discussion Questions

1. Describe how sound waves travel through the ear from the auricle to hearing receptors. Where is sound interpreted?
2. Describe the structures that light must pass through in order to reach the retina. Where is vision interpreted?
3. Identify the four primary taste sensations and tell what part of the tongue is associated with each.
4. Describe how smell receptors are activated.

Critical Thinking Questions

1. Why does a sewage treatment plant have a strong, offensive odor to visitors of the plant but not to regular workers at the plant?

2. How are the signs and symptoms of cataracts, glaucoma, and macular degeneration different?
3. Sudden loud sounds can damage the eardrums. What type of hearing loss will these sounds produce? Chronic loud sounds damage hearing receptors. What type of hearing loss do these sounds produce?

Application Activities

1. Give the functions of the following:
 - a. Iris
 - b. Cornea
 - c. Lens
 - d. Retina
 - e. Ciliary body
2. State if the following structures are part of the outer, middle, or inner ear. Also give the function of each.
 - a. Vestibule
 - b. Cochlea
 - c. External auditory canal
 - d. Ear ossicles
 - e. Tympanic membrane
3. What are the two kinds of cells in taste buds?
4. Where is the olfactory organ located?

Internet Activity

Find a Web site that provides information on hearing and balance. Research ways to prevent ear damage that could cause problems with balance.

CHAPTER 12

The Urinary System

CHAPTER OUTLINE

- The Kidneys
- Urine Formation
- The Ureters, Urinary Bladder, and Urethra

OBJECTIVES

After completing Chapter 12, you will be able to:

- 12.1 Describe the structure, location, and functions of the kidney.
- 12.2 Define the term *nephron* and describe its structure.
- 12.3 Explain how nephrons filter blood and form urine.
- 12.4 List substances normally found in urine.
- 12.5 Describe the locations, structures, and functions of the ureters, bladder, and urethra.
- 12.6 Explain how urination is controlled.
- 12.7 Describe the signs, symptoms, causes, and treatments of various diseases and disorders of the urinary system.

KEY TERMS *(Continued)*

renin	tubular reabsorption	ureters
retroperitoneal	tubular secretion	urethra
trigone	urea	uric acid

KEY TERMS

afferent arterioles
angiotensin II
calyces
cystitis
detrusor muscle
distal convoluted tubule
efferent arterioles
glomerular capsule
glomerular filtrate
glomerular filtration
glomerulonephritis
glomerulus
incontinence
juxtaglomerular apparatus
juxtaglomerular cells
loop of Henle
macula densa
micturition
nephrons
proximal convoluted tubule
pyelonephritis
renal calculi
renal column
renal corpuscle
renal cortex
renal medulla
renal pelvis
renal pyramids
renal sinus
renal tubule

Introduction

The organs of the urinary system are the kidneys, ureters, urinary bladder, and urethra (Figure 12-1). This system functions to remove waste products from the bloodstream. These waste products are excreted from the body in the form of urine. Nephrons are microscopic structures in the kidneys that filter blood and form urine.

CASE STUDY

Last week at his yearly physical, a 53-year-old male patient was diagnosed with high blood pressure. After many tests, the patient was diagnosed as having atherosclerosis of the left renal artery. All routine lab test results were normal, and the patient did not have any endocrine organ disorders.

As you read this chapter, consider the following questions:

1. How does atherosclerosis affect blood flow?
2. How does atherosclerosis of a renal artery produce high blood pressure?
3. What lifestyle changes should this patient make?
4. What can happen to the patient's kidney if his atherosclerosis is not treated?

The Kidneys

The kidneys are responsible for removing metabolic waste products from the blood. These metabolic wastes are combined with water and ions to form urine, which is excreted from the body. The kidneys also secrete the hormone erythropoietin, which helps to regulate red blood cell production, and the hormone **renin**, which helps to regulate blood pressure.

The kidneys are bean-shaped organs that are reddish brown in color. Tough, fibrous capsules cover them. The kidneys are **retroperitoneal** in position, which means that they lie behind the peritoneal cavity. They lie on either side of the vertebral column at about the level of the lumbar vertebrae.

The medial depression of a kidney is called a **renal sinus**. The entrance of the sinus is called the hilum and contains the renal artery, renal vein, and ureter. The **ureter** is a tube that carries urine out of a kidney to the urinary bladder. Inside the kidney, the ureter expands as the **renal pelvis**. The renal pelvis divides into small tubes inside the kidney called **calyces**.

The outermost layer of the kidney is called the **renal cortex**, and the middle portion is called the **renal medulla**. The renal medulla is divided into triangular-shaped areas called **renal pyramids**. The renal cortex covers the pyramids and also dips down between the pyramids. The portion of the cortex between pyramids is called a **renal column** (Figure 12-2.)

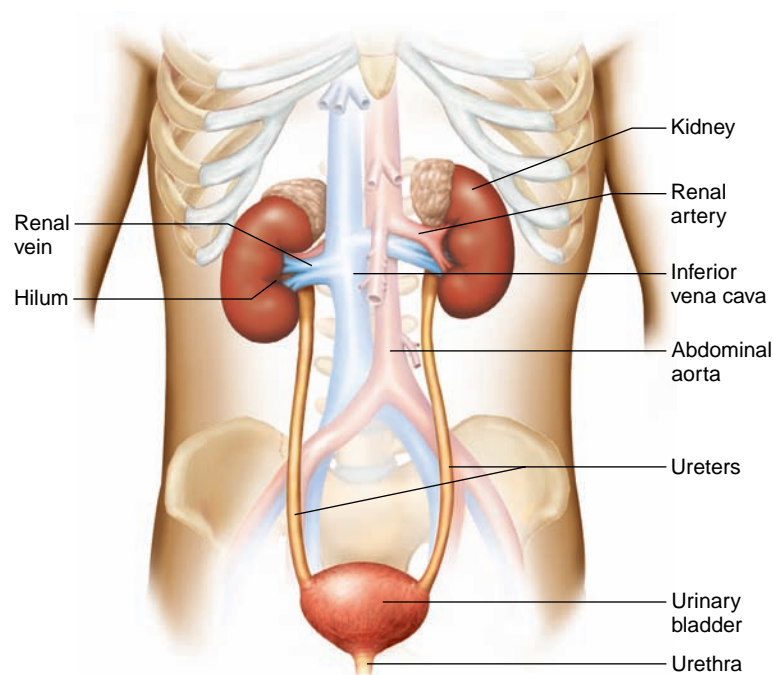


Figure 12-1. Organs of the urinary system.

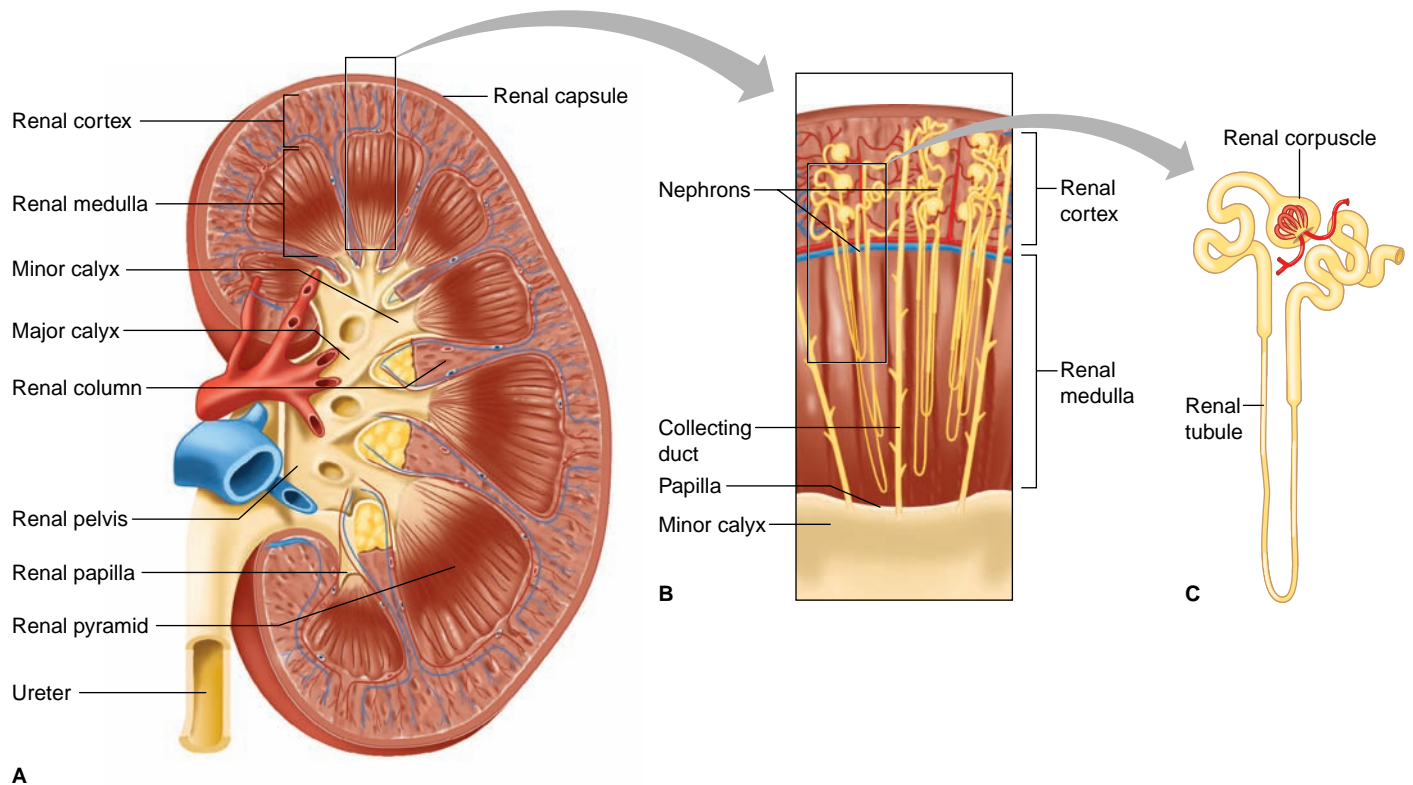


Figure 12-2. (a) Longitudinal section of a kidney, (b) the location of nephrons, and (c) a single nephron.

Blood flows through a kidney by the following pathway:

renal artery → interlobar arteries → arcuate arteries → interlobular arteries → afferent arterioles → nephrons

Blood eventually leaves the kidney through a renal vein.

Nephrons

Waste products are removed from the blood through **nephrons**. Each kidney contains about one million nephrons. Nephrons are made of a **renal corpuscle** and a **renal tubule** (Figure 12-2). A renal corpuscle is composed of a group of capillaries called a **glomerulus**, and the capsule that surrounds the glomerulus is called a **glomerular capsule**. The renal corpuscle is where blood filtration occurs.

Renal tubules extend from the glomerular capsule of a nephron. The three parts of a renal tubule are the **proximal convoluted tubule**, the **loop of Henle**, and the **distal convoluted tubule**. The proximal convoluted tubule is directly attached to the glomerular capsule and eventually straightens out to become the loop of Henle. The loop of Henle curves back toward the renal corpuscle and starts to twist again, becoming the distal convoluted tubule. Distal convoluted tubules from several nephrons merge together to form collecting ducts. These ducts collect urine and deliver it to the renal pelvis, which in turn empties urine into the ureters (Figures 12-2 and 12-3).

Afferent arterioles deliver blood to the glomeruli, and **efferent arterioles** carry blood away from them. Efferent arterioles deliver blood to peritubular capillaries, which are wrapped around the renal tubules of the nephron. Blood leaves the peritubular capillaries through the veins of the kidneys. By the time the blood leaves the peritubular capillaries, it has been cleansed of waste products. Blood flows through a nephron in the following pathway:

afferent arteriole → glomerulus → efferent arteriole → peritubular capillaries → the veins of the kidney

Juxtaglomerular Apparatus. Most nephrons contain a **juxtaglomerular apparatus**, which is made up of two structures—the **macula densa** and **juxtaglomerular cells**. The macula densa is an area of the distal convoluted tubule that touches afferent and efferent arterioles. Juxtaglomerular cells are simply enlarged smooth muscle cells in the walls of either the afferent or efferent arteriole. The juxtaglomerular apparatus secretes the hormone renin, which regulates blood pressure.

Urine Formation

The three processes of urine formation are **glomerular filtration**, **tubular reabsorption**, and **tubular secretion**.

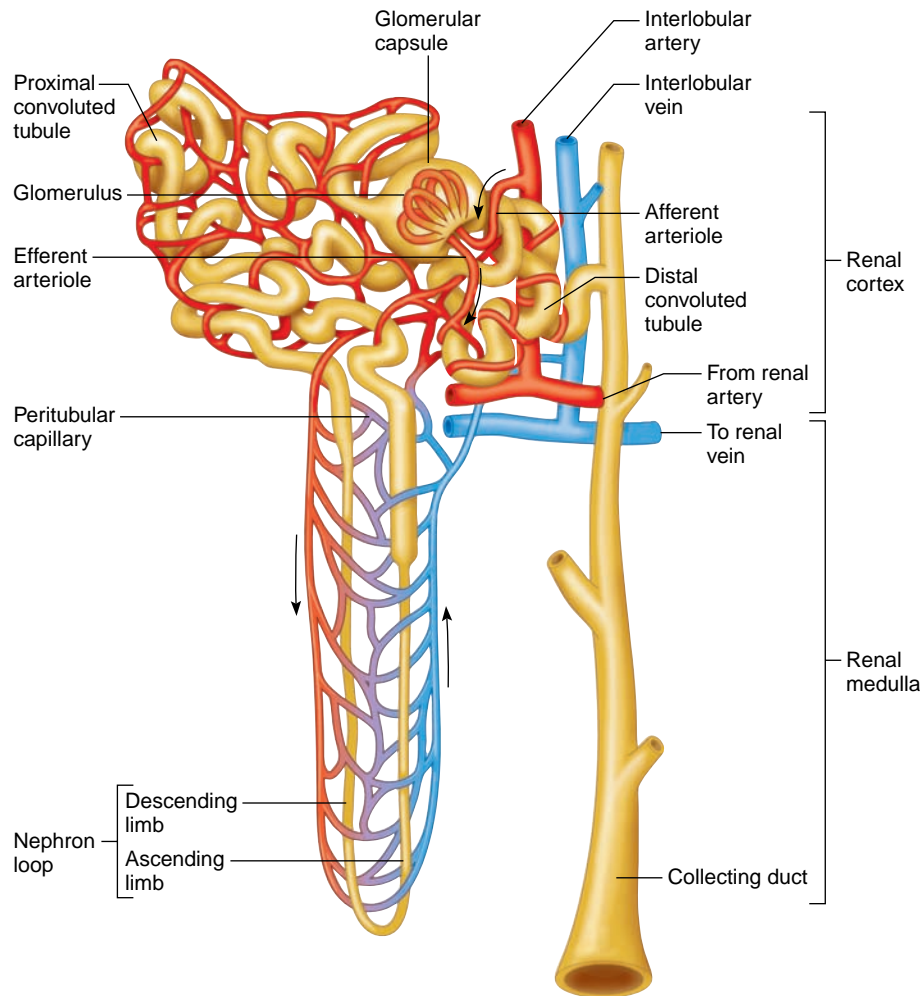


Figure 12-3. Structure of a nephron and its associated blood vessels.

Glomerular Filtration

Glomerular filtration takes place in the renal corpuscles of nephrons. In this process, the fluid part of blood is forced from the glomerulus (the capillaries) into the glomerular capsule (Figure 12-4). The fluid in the glomerular capsule is called the **glomerular filtrate**.

Glomerular filtration depends on filtration pressure, which is the amount of pressure that forces substances out of the glomerulus into the glomerular capsule. It is largely determined by blood pressure. If a person's blood pressure is too low, glomerular filtrate will not form. If filtration pressure increases, the rate of filtration and the amount of glomerular filtrate also increase.

The sympathetic nervous system largely controls the rate of filtration. If blood pressure or blood volume drops, the sympathetic nervous system causes the afferent arterioles in the kidneys to constrict. When afferent arterioles constrict, glomerular filtration pressure decreases and less glomerular filtrate is formed. When less glomerular filtrate is formed, less urine is ultimately formed. This allows the

body to retain fluids that are needed to raise blood pressure and blood volume.

The juxtaglomerular apparatus also helps to regulate the filtration rate. When blood pressure drops, juxtaglomerular cells secrete renin. Renin causes the formation of **angiotensin II**, which raises blood pressure and causes the secretion of a hormone called aldosterone. Aldosterone causes the body to retain the fluids needed to maintain blood volume and pressure.

Tubular Reabsorption

Tubular reabsorption is the second process in urine formation. In this process, the glomerular filtrate flows into the proximal convoluted tubule (Figure 12-5a). The body needs to keep many of the substances (nutrients, water, and ions) that are found in glomerular filtrate. In tubular reabsorption, all the necessary substances in the glomerular filtrate pass through the wall of the renal tubule into the blood of the peritubular capillaries.

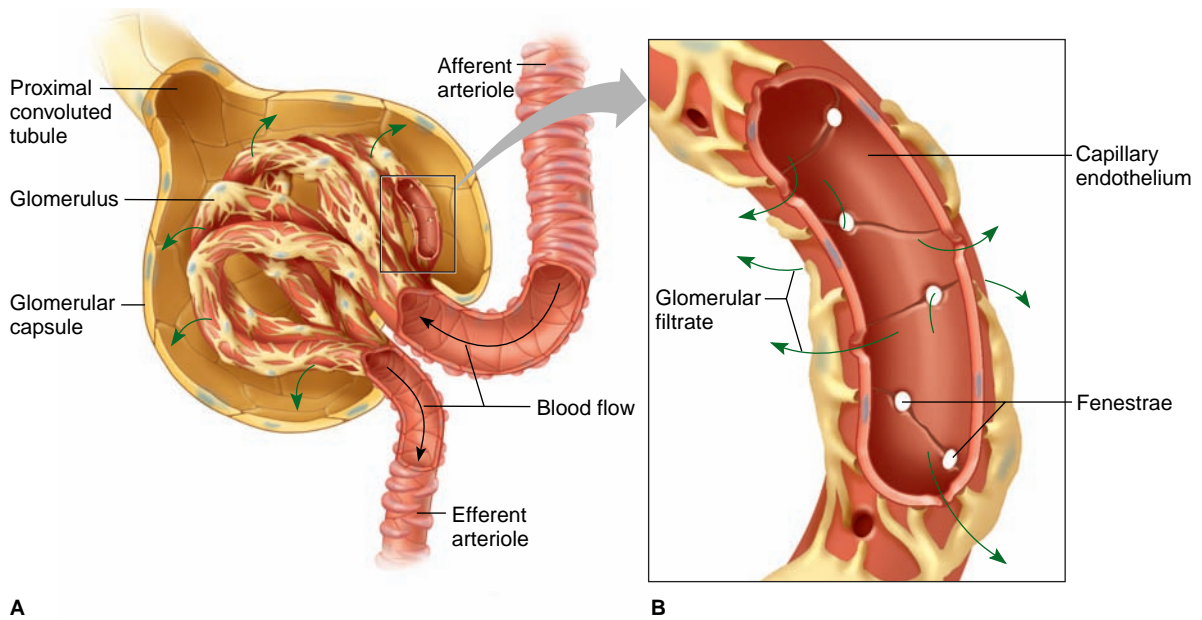


Figure 12-4. Glomerular filtration. (a) Substances move out of glomerular capillaries and into the glomerular capsule. (b) Glomerular capillaries have large holes called fenestrae that allow substances to move out of them and into a glomerular capsule.

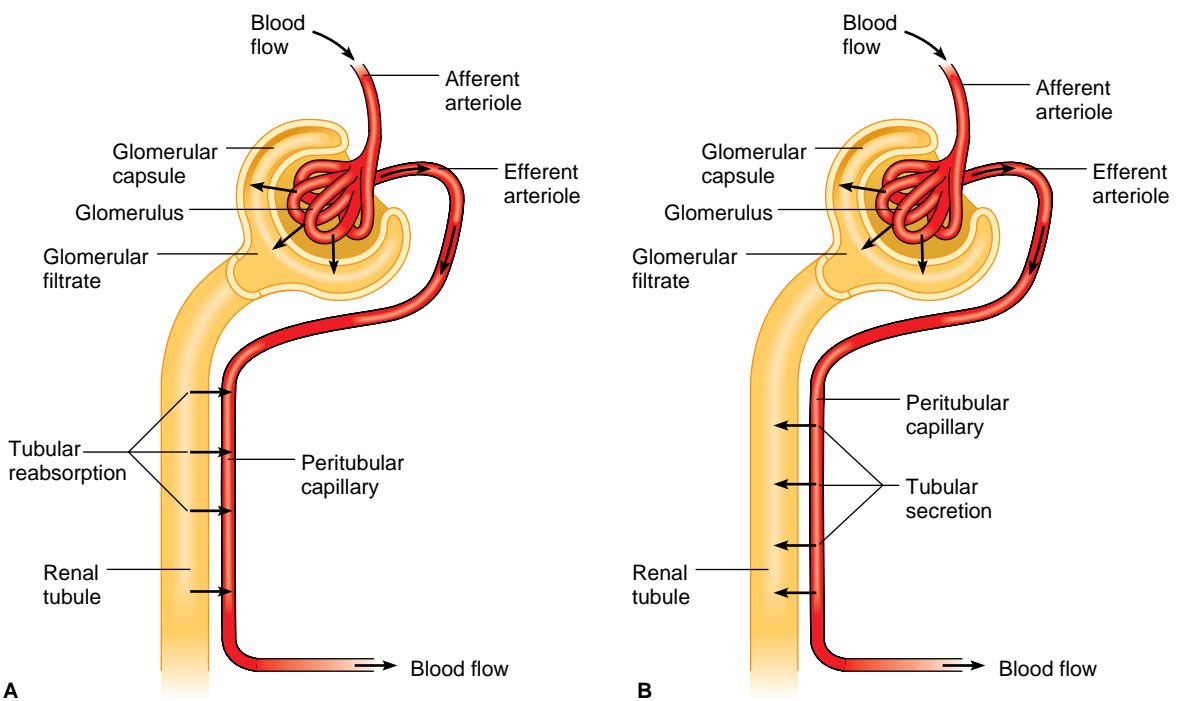


Figure 12-5. (a) Tubular reabsorption. Substances move from the glomerular filtrate into the blood of peritubular capillaries. (b) Tubular secretion. Substances move out of the blood of the peritubular capillaries into the renal tubule.

Water reabsorption varies depending on the presence of two hormones—antidiuretic hormone and aldosterone. Both of these hormones increase water reabsorption, which decreases urine production.

Tubular Secretion

Tubular secretion is the third process of urine formation. In tubular secretion, substances move out of the blood in the peritubular capillaries and into the renal tubules (Figure 12-5b). Substances that are secreted include drugs, hydrogen ions, and waste products. All of these secreted substances will be excreted in the urine.

Urine Composition

The final solution that reaches the collecting ducts of the kidneys is urine. Urine is mostly made of water but also normally contains **urea**, **uric acid**, trace amounts of amino acids, and various ions. Urea and uric acid are waste products formed by the breakdown of proteins and nucleic acids.

The Ureters, Urinary Bladder, and Urethra

The Ureters

Ureters are long, muscular tubes that carry urine from the kidneys to the urinary bladder. They propel urine toward the bladder through peristalsis.

Urinary Bladder

The urinary bladder is a distensible (expandable) organ that is located in the pelvic cavity. Its function is to store urine until it is eliminated from the body. The internal floor of the bladder contains three openings—one for the urethra and two for the ureters. These three openings form a triangle called the **trigone** of the bladder. The wall of the bladder contains smooth muscle, called the **detrusor muscle**. This muscle contracts to push urine from the bladder into the urethra (Figure 12-6).

The process of urination is called **micturition**. The stretching of the bladder triggers this process. The major events of micturition are the following:

1. The detrusor muscle contracts.
2. The internal urethral sphincter opens. This sphincter is located just above the opening of the urethra. When this sphincter opens, a person feels the urgency to urinate.
3. The external urethral sphincter opens. This sphincter is located below the internal urethral sphincter. A person can voluntarily keep this sphincter closed.
4. When the external urethral sphincter opens, urine flows out of the bladder through the urethra.

The Urethra

The **urethra** is a tube that moves urine from the bladder to the outside world. In females, the urethra is much shorter than in males. For this reason, females are much more susceptible to urinary tract infections.

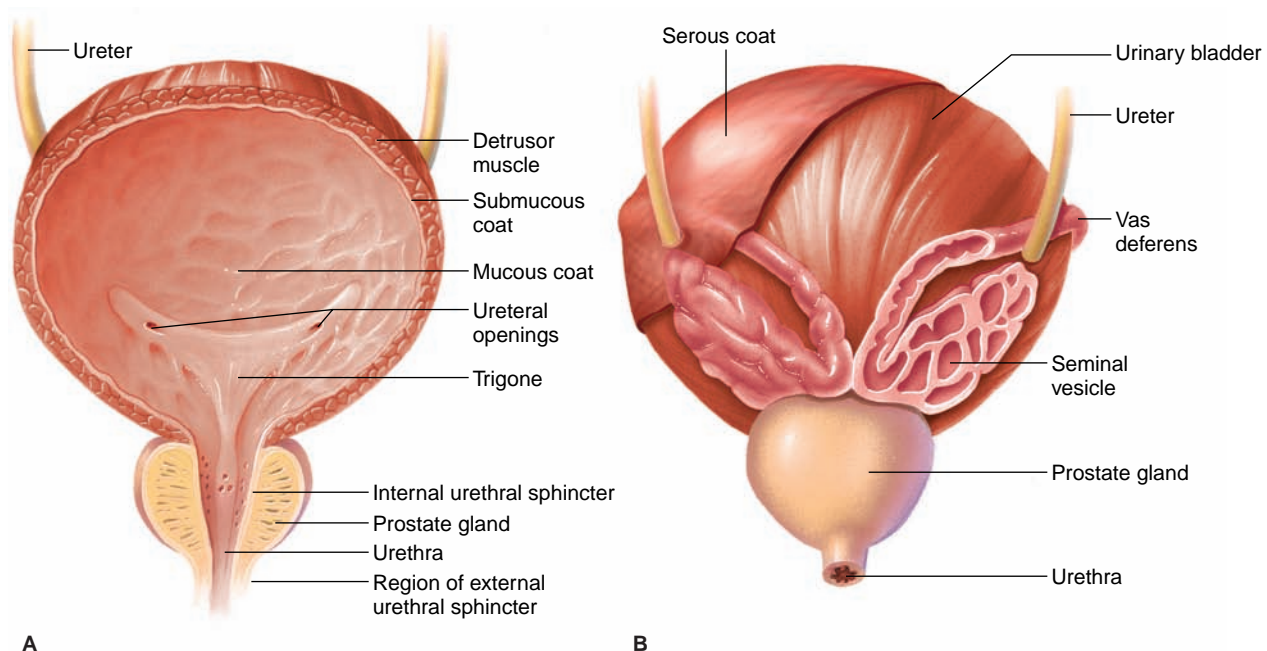


Figure 12-6. Male urinary bladder: (a) anterior view and (b) posterior view.

Pathophysiology

Common Diseases and Disorders of the Urinary System

Acute kidney failure is a sudden loss of kidney function.

- **Causes.** There are many causes and risk factors for kidney failure, including burns, dehydration, low blood pressure, hemorrhaging, allergic reactions, obstruction of the renal artery, various poisons, alcohol abuse, trauma to the kidneys and skeletal muscles, blood disorders, blood transfusion reactions, kidney stones, urinary tract infections, enlarged prostate, childbirth and immune system disorders, and food poisoning involving the bacterium *E. coli*.
- **Signs and symptoms.** The signs and symptoms include decreased urine production or no urine production, excessive urination, swelling of the arms or legs, bloating, mental confusion, coma, seizures, hand tremors, nosebleeds, easy bruising, pain in the back or abdomen, high blood pressure, abnormal heart or lung sounds, abnormal urinalysis, and an increase in potassium levels.
- **Treatment.** The first treatment measure is modifying the diet to decrease the amount of protein consumed. Controlling fluid intake and potassium levels is also recommended. Antibiotics and dialysis may also be needed.

Chronic kidney failure is a condition in which the kidneys slowly lose their ability to function. Sometimes symptoms do not appear until the kidneys have lost about 90% of their function.

- **Causes.** This disorder results from diabetes, high blood pressure, glomerulonephritis, polycystic kidney disease, kidney stones, obstruction of the ureters, and acute kidney failure.
- **Signs and symptoms.** The list of signs and symptoms is extensive and includes headache, mental confusion, coma, seizures, fatigue, frequent hiccups, itching, easy bruising, abnormal bleeding, anemia, excessive thirst, fluid retention, nausea, high blood pressure, abnormal heart or lung sounds, weight loss, white spots on the skin or increased pigmentation, high potassium levels, an increased or decreased urine output, urinary tract infections, and abnormal urinalysis results.
- **Treatment.** This disorder can be treated with antibiotics; blood transfusions; medications to control anemia; restricting the intake of fluids, electrolytes, and protein; controlling high blood pressure; and dialysis. The most serious cases may require surgery to repair an obstruction of the ureters or a kidney transplant.

Cystitis is a urinary bladder infection. Women are much more likely to develop this disorder than men because of

the short length of their urethras. The urethral opening in women is also close to the anal opening, allowing bacteria from this area to be more easily introduced into the urinary tract.

- **Causes.** This infection is caused by different types of bacteria (especially those that are found in the rectum) and the placement of a catheter in the bladder. Good hygiene, urinating frequently, and wiping from front to back (for females) can help to prevent this infection.
- **Signs and symptoms.** Common symptoms include fatigue, chills, fever, painful urination, a frequent need to urinate, cloudy urine, and blood in the urine.
- **Treatment.** This infection is treated with antibiotics.

Glomerulonephritis is an inflammation of the glomeruli of the kidney.

- **Causes.** This disorder is caused by renal diseases, immune disorders, and bacterial infections.
- **Signs and symptoms.** The signs and symptoms are hiccups, drowsiness, coma, seizures, nausea, anemia, high blood pressure, increased skin pigmentation, abnormal heart sounds, abnormal urinalysis results, blood in the urine, and a decreased or increased urine output.
- **Treatment.** Treatment begins with a low-sodium, low-protein diet. Medications to control high blood pressure, corticosteroids to reduce inflammation, and dialysis are other treatment options.

Incontinence is a condition in which a person (other than a child) cannot control urination. This condition can be either temporary or long lasting. Women are more likely to develop incontinence than men are.

- **Causes.** This condition can be caused by various medications, excessive coughing (for example, in smokers), urinary tract infections, nervous system disorders, and bladder cancer. In men, prostate problems can lead to the development of this disorder. The weakness of the urinary sphincters from surgery, trauma, or pregnancy can also cause incontinence. It may be prevented by avoiding urinary bladder irritants such as coffee, cigarettes, diuretics, and various medications.
- **Signs and symptoms.** The primary symptom is the involuntary leakage of urine.
- **Treatment.** Treatment includes various medications, incontinence pads, removal of the prostate, Kegel exercises to increase the control of urinary sphincters, and surgery to repair damaged bladders or urethral sphincters.

continued →

Common Diseases and Disorders of the Urinary System (continued)

Polycystic kidney disease is a disorder in which the kidneys enlarge because of the presence of many cysts within them. The disease develops relatively slowly, with symptoms worsening over time.

- **Causes.** The causes are hereditary (via an inherited dominant gene from a parent).
- **Signs and symptoms.** Fatigue, high blood pressure, anemia, pain in the back or abdomen, joint pain, heart murmurs, the formation of kidney stones, kidney failure, blood in the urine, and liver disease are the symptoms of this disorder.
- **Treatment.** Treatment includes medications to control anemia and high blood pressure, blood transfusions, draining of the cysts, dialysis, and surgery to remove one or both kidneys.

Pyelonephritis is a type of complicated urinary tract infection. It begins as a bladder infection and spreads to one or both kidneys. This condition can develop suddenly, or it may be long lasting.

- **Causes.** This disorder is caused by bacteria, a bladder infection, kidney stones, or an obstruction of the urinary system ducts.

- **Signs and symptoms.** Signs and symptoms include fatigue, mental confusion, fever, nausea, pain in the back or abdomen, enlarged kidneys, painful urination, and cloudy or bloody urine.

- **Treatment.** Treatment includes intravenous fluids, pain medication, and antibiotics.

Renal calculi are more commonly called kidney stones. These stones can become lodged in the ducts within the kidneys or ureters.

- **Causes.** This condition is caused by gouty arthritis, defects of the ureters, overly concentrated urine, and urinary tract infections.
- **Signs and symptoms.** The signs and symptoms include fever, nausea, severe back or abdominal pain, a frequent urge to urinate, blood in the urine, and abnormal urinalysis results.
- **Treatment.** Treatment includes pain medication, intravenous fluids, medications to decrease stone formation, surgery to remove kidney stones, and lithotripsy (a procedure that uses shock waves to break up stones).

Summary

The kidneys, ureters, bladder, and urethra work together to remove waste products from the blood. The nephrons of the kidneys are involved in urine formation. The ureters, bladder, and urethra are responsible for eliminating urine

from the body. The kidneys also play an important role in regulating blood cell production and blood pressure. Knowledge of the anatomy and physiology of the urinary system is important when collecting urine specimens, performing urinary testing, and assisting with cystoscopy.

REVIEW

CHAPTER 12

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. How does atherosclerosis affect blood flow?
2. How does atherosclerosis of a renal artery produce high blood pressure?
3. What lifestyle changes should this patient make?
4. What can happen to the patient's kidney if his atherosclerosis is not treated?

Discussion Questions

1. Describe the three steps in the formation of urine.
2. Describe the composition of normal urine.
3. What are the differences between a renal corpuscle and a renal tubule?
4. Explain the functions of the kidneys.

Critical Thinking Questions

1. Why are females more likely than males to develop urinary tract infections?
2. What is the significance of proteins in urine?

3. The position of the kidneys is retroperitoneal. What would be the easiest way for a surgeon to reach a kidney?
4. What effect would vascular shock have on urine production?

Application Activities

1. Define the following parts of a kidney:
 - a. Renal pyramid
 - b. Renal cortex
 - c. Renal medulla
 - d. Renal pelvis
2. Name the three openings of the urinary bladder.
3. What is the name of the tubes that carry urine from the kidneys to the bladder?
4. What is the name of the tube that carries urine from the bladder to the outside world?

CHAPTER 13

The Reproductive System

KEY TERMS

acrosome
alveolar glands
amnion
areola
blastocyst
bulbourethral glands
cervical orifice
cervicitis
cervix
cleavage
clitoris
corpus luteum
ductus arteriosus
ductus venosus
dysmenorrhea
ectoderm
embryonic period
endoderm
endometriosis
endometrium
epididymis
epididymitis
erectile tissue
fallopian tubes
fertilization
fetal period
fibroid
fimbriae
follicular cells
foramen ovale
glans penis
gonadotropin-releasing hormone (GnRH)
human chorionic gonadotropin (HCG)

CHAPTER OUTLINE

- The Male Reproductive System
- The Female Reproductive System
- Sexually Transmitted Diseases
- Pregnancy
- The Birth Process
- Contraception
- Infertility

OBJECTIVES

After completing Chapter 13, you will be able to:

- 13.1** List the organs of the male reproductive system and give the locations, structures, and functions of each.
- 13.2** Describe how sperm cells are formed.
- 13.3** List the actions of testosterone.
- 13.4** Describe the substances found in semen.
- 13.5** Describe the processes of erection and ejaculation.
- 13.6** Describe the causes, signs and symptoms, and treatment of various disorders of the male reproductive system.
- 13.7** List the organs of the female reproductive system and give the locations, structures, and functions of each.
- 13.8** Explain how eggs develop.
- 13.9** List the actions of estrogen and progesterone.
- 13.10** Explain how and when ovulation occurs.
- 13.11** Describe what happens to an egg after ovulation occurs.
- 13.12** List the purpose and events of the menstrual cycle.
- 13.13** Define menopause and explain what causes it.
- 13.14** List the most common sexually transmitted diseases and give the signs, symptoms, causes, and treatments of each.
- 13.15** Explain how and where fertilization occurs.
- 13.16** Describe the process of implantation.
- 13.17** Explain the difference between an embryo and a fetus.
- 13.18** Describe the changes that occur in a woman during pregnancy.
- 13.19** List several birth control methods and explain why they are effective.
- 13.20** List the causes and treatment of infertility.
- 13.21** Describe the causes, signs and symptoms, and treatment of various disorders of the female reproductive system.

KEY TERMS *(Continued)*

hysterectomy	morula	prenatal period	spermatogenic cells
impotence	myometrium	prepuce	spermatogonia
infundibulum	neonatal period	primary germ layer	testes
inner cell mass	neonate	primordial follicle	umbilical cord
interstitial cell	oocyte	prostate gland	uterus
labia majora	oogenesis	prostatitis	vagina
labia minora	ovulation	relaxin	vaginitis
lactogen	parathyroid hormone	scrotum	vas deferens
mammary glands	perimetrium	semen	vasectomy
menopause	placenta	seminal vesicles	vestibular glands
menses	polar body	seminiferous tubules	yolk sac
menstrual cycle	postnatal period	spermatids	zona pellucida
mesoderm	premenstrual syndrome (PMS)	spermatocytes	zygote
mons pubis		spermatogenesis	

Introduction

The male and female reproductive systems function together to produce offspring. The female reproductive system nurtures a developing offspring. If a female breast-feeds, her

reproductive system is also used to nurture a newborn baby. The male and female reproductive systems also produce a number of important hormones.

CASE STUDY

Last week, a 27-year-old female came to the doctor's office complaining of abnormal vaginal discharge, pain during urination, and pain in her abdominopelvic area. Her symptoms have been occurring for a couple of weeks but have recently started to get worse. She says that her sexual partner also has abnormal discharge coming from his penis but is not experiencing any pain. The doctor diagnoses her with a urinary tract infection and a sexually transmitted disease caused by bacteria. The doctor also tells the patient that she has peritonitis, which is inflammation in the abdominopelvic cavity. The patient is treated with antibiotics and pain medication. The doctor tells her that her sexual partner must also be treated with antibiotics.

As you read this chapter, consider the following questions:

1. What sexually transmitted diseases are caused by bacteria?
2. How did the infection spread to the patient's abdominopelvic cavity?
3. Why is her sexual partner not experiencing pain in his abdominopelvic cavity?
4. Why is it important for her sexual partner to be treated with antibiotics?
5. Why is it common for women with sexually transmitted diseases to also have urinary tract infections?

The Male Reproductive System

Testes

Testes are the primary organs of the male reproductive system because they produce the sex cells (sperm) of the male (Figure 13-1). They also make the male hormone **testosterone**. Most males have two testes that are held just below

the pelvic cavity in the **scrotum**. A fibrous capsule encloses each testis and invades the testis to divide it into lobules. Each lobule is filled with **seminiferous tubules**, which are filled with **spermatogenic cells**. These cells give rise to sperm cells. Between the seminiferous tubules are cells called **interstitial cells** that make testosterone.

Sperm Cell Formation. Spermatogenic cells of the seminiferous tubules begin the process of making sperm

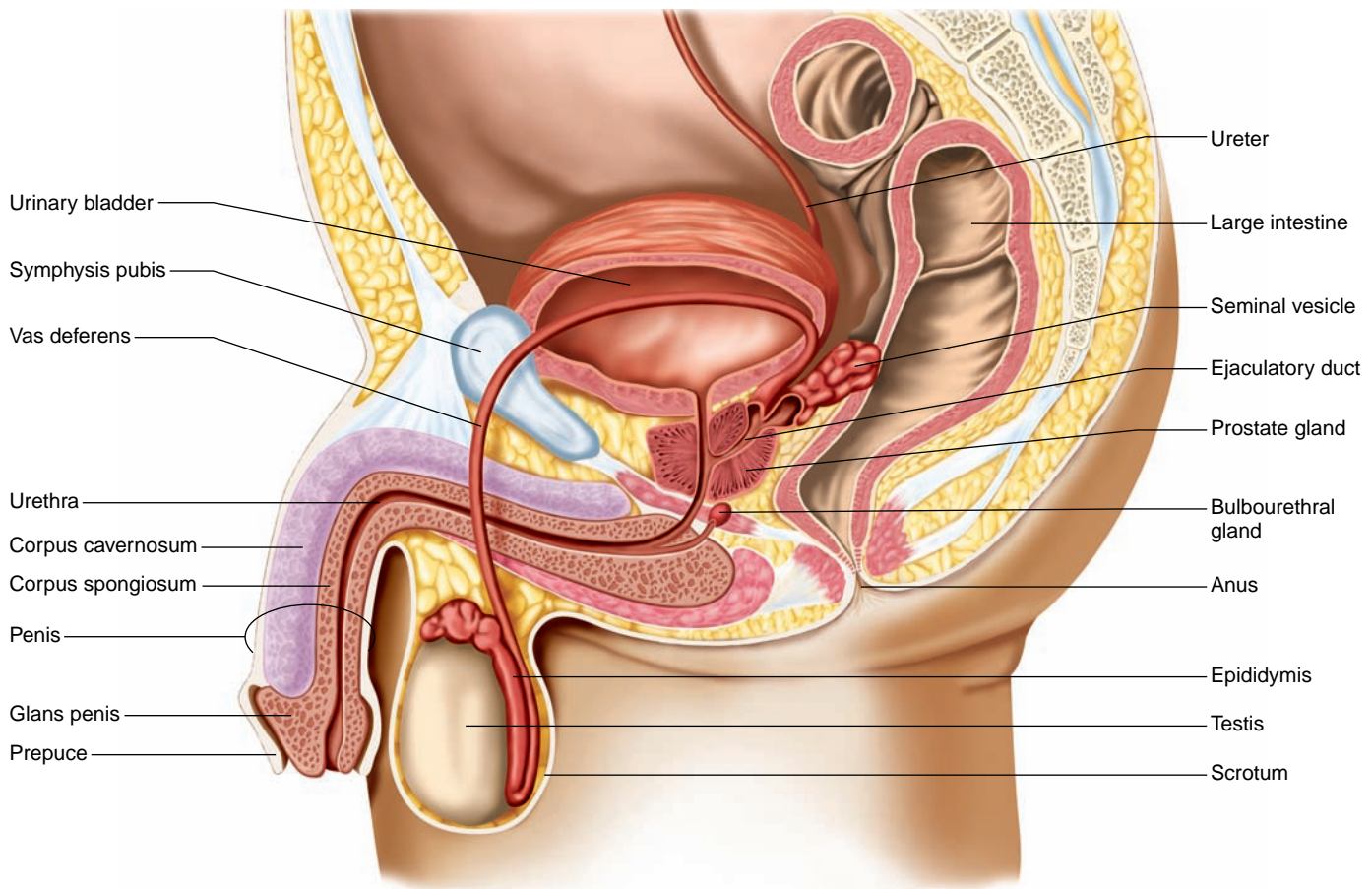


Figure 13-1. Sagittal view of male reproductive organs. The male reproductive system produces sperm and delivers them in a form that keeps them viable long enough to fertilize an egg.

cells, but the sperm cells do not mature until they go to the **epididymis**. **Spermatogenesis** is the process of sperm cell formation. At the beginning of spermatogenesis, spermatogenic cells are called **spermatogonia**. Spermatogonia contain 46 chromosomes. These cells undergo mitosis, and the resulting cells are called primary **spermatocytes**. Primary spermatocytes also contain 46 chromosomes, which is the normal number of chromosomes. At about the time of puberty, primary spermatocytes undergo a process called **meiosis**. In meiosis, each primary spermatocyte divides to make two secondary spermatocytes. Each secondary spermatocyte divides to make two **spermatids**. Therefore, from one primary spermatocyte, four spermatids are formed. Spermatids develop flagella to become mature sperm cells. They contain only 23 chromosomes (Figure 13-2).

Structure of Sperm Cells. A mature sperm (Figure 13-3) has following three parts: the head, the midpiece, and the tail.

The Head. The head is oval in structure and holds a nucleus with 23 chromosomes. The head is covered with an enzyme-filled sac called an **acrosome**, which helps the sperm penetrate an egg at the time of fertilization.

The Midpiece. This portion of the sperm is between the head and tail. It is filled with mitochondria that generate the energy needed by the cell to move.

The Tail. The tail is a flagellum that moves in such a way as to propel the sperm forward in the female reproductive tract.

Internal Accessory Organs of the Male Reproductive System

The internal accessory organs of the male reproductive system are the epididymis, **vas deferens**, **seminal vesicles**, **prostate gland**, and **bulbourethral glands**.

Epididymis. An epididymis sits on top of each testis. It is a highly coiled tube that receives spermatids from seminiferous tubules as these cells are formed. Inside the epididymis, spermatids mature to become sperm cells.

Vas Deferens. A tube called a vas deferens is connected to each epididymis. These tubes carry sperm cells from an epididymis to the urethra in the pelvic cavity of the male. When a male has a **vasectomy**, this is the tube that is cut and tied.

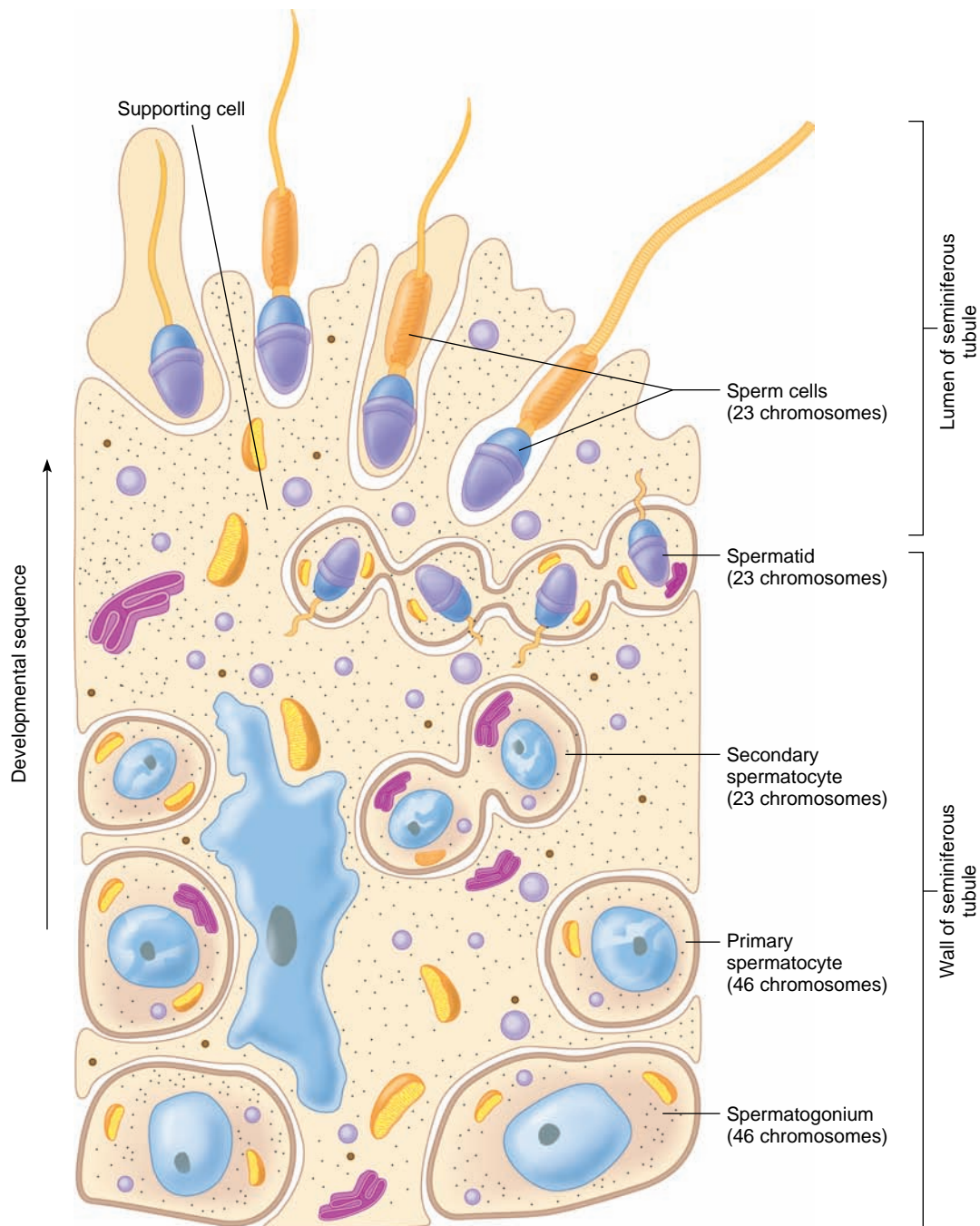


Figure 13-2. The process of spermatogenesis.

Seminal Vesicle. Seminal vesicles are sac-like organs that secrete an alkaline fluid rich in sugars and **prostaglandins**. The sugars are used by sperm cells to make energy, and the prostaglandins stimulate muscular contractions in the female reproductive system. These muscular contractions help to propel sperm forward in the female reproductive tract. Seminal vesicles release their product into the vas deferens just before ejaculation.

Prostate Gland. The prostate gland surrounds the proximal portion of the urethra. It makes a milky, alkaline fluid and secretes this fluid into the urethra just before

ejaculation. This fluid helps to protect the sperm when they enter the female reproductive system.

Bulbourethral Glands. Bulbourethral glands are inferior to the prostate gland. They make a mucus-like fluid that is secreted before ejaculation into the urethra. This fluid lubricates the end of the penis in preparation for sexual intercourse.

Semen. **Semen** is a mixture of sperm cells and fluids from the seminal vesicles, prostate gland, and bulbourethral glands. This mixture is alkaline and contains

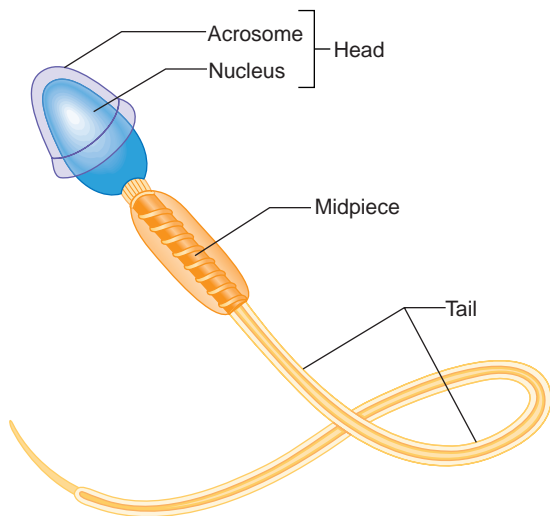


Figure 13-3. Parts of a mature sperm cell.

nutrients and prostaglandins. One milliliter of semen usually contains about 120 million sperm cells.

External Organs of the Male Reproductive System

The two male external reproductive organs are the scrotum and the penis (Figure 13-1).

Scrotum. The scrotum is a pouch of skin that holds the testes. It is lined with a serous membrane that secretes serous fluid to ensure that the testes move freely within it.

Penis. The penis is a cylindrical organ that moves urine and semen to the outside world. The body, or shaft, of the penis contains specialized tissue called **erectile tissue**. The urethra runs the length of the penis. The end of the penis is enlarged into a cone-shaped structure called the **glans penis**. If a male has not been circumcised, a piece of skin, called the **prepuce**, covers the glans penis. The function of the penis is to deliver sperm to the female reproductive tract. The penis also functions in urination because it contains the urethra.

Erection, Orgasm, and Ejaculation

During sexual arousal, the parasympathetic nervous system causes erectile tissue of the penis to become engorged with blood, which produces erection of the penis. During orgasm, sperm cells are propelled out of the testes toward the urethra. The secretions of the prostate, seminal vesicles, and bulbourethral glands are also released into the urethra. The movement of the sperm and secretions into the urethra is called emission. The process of ejaculation occurs when semen is forced out of the urethra. After ejaculation, sympathetic nerve fibers cause the erectile tissue to release blood, and the penis gradually returns to a non-erect state.

Male Reproductive Hormones

The hypothalamus, anterior pituitary gland, and the testes secrete hormones that regulate male reproductive functions. At the onset of puberty, the hypothalamus releases a hormone called **gonadotropin-releasing hormone (GnRH)**. GnRH stimulates the anterior pituitary gland to release **follicle-stimulating hormone (FSH)** and **luteinizing hormone (LH)**. FSH causes spermatogenesis to begin, and LH stimulates interstitial cells to produce testosterone.

Testosterone stimulates the development of male secondary sex characteristics, which are defined as characteristics that are typically unique to males. Examples of these characteristics are chest hair, thick facial hair, enlarged muscles, enlarged bones, and thickening of vocal cords that produces a deep voice. Testosterone also stimulates the maturation of male reproductive organs.

Testosterone levels in the male are regulated by a negative feedback mechanism. When testosterone levels in the blood increase above normal, the hypothalamus no longer releases GnRH. Therefore, the anterior pituitary gland no longer secretes LH and FSH, which causes testosterone levels to fall. When testosterone levels fall below normal, the hypothalamus begins to secrete GnRH again, which causes the anterior pituitary gland to release LH and FSH again. Testosterone levels begin to rise again, and the cycle repeats itself.

Pathophysiology

Common Diseases and Disorders of the Male Reproductive System

Epididymitis is inflammation of an epididymis. Most cases start out as an infection of the urinary tract that spreads to an epididymis.

- **Causes.** The causes include the use of certain medications, placement of a catheter in the urethra, and bacteria—especially those that cause gonorrhea and chlamydia.

- **Signs and symptoms.** Signs and symptoms include fever, pain in the testes, a lump in the testes, swelling of the scrotum, painful ejaculation, blood in the semen, pain during urination, discharge from the urethra, and enlarged lymph nodes in the pelvic area.
- **Treatment.** Treatment includes pain medication, antibiotics for both the patient and his sexual partner,

continued →

Common Diseases and Disorders of the Male Reproductive System (continued)

elevation of the scrotum, and ice packs applied to the scrotum.

Erectile dysfunction is more commonly called **impotence**. It is a disorder in which a male cannot maintain an erect penis to complete sexual intercourse. It is estimated that half of all men between the ages of 40 and 70 have some degree of impotence. Most causes are physical and not psychological.

- **Causes.** Anxiety and depression can cause erectile dysfunction. Common causes include diabetes, high blood pressure, anemia, coronary artery disease, peripheral vascular problems, low testosterone production, various medications, smoking, excessive alcohol consumption, and drugs such as cocaine, marijuana, and heroin.
- **Signs and symptoms.** Signs and symptoms are an inability to achieve an erection and an inability to maintain an erection long enough to complete sexual intercourse.
- **Treatment.** The first treatment step should be lifestyle changes to quit smoking and stop using alcohol or drugs. Counseling to reduce anxiety and depression may also be helpful. Other treatment options include various medications, penile implants, and penile injections of medications if oral medications do not work.

Prostate cancer is the third most common cause of cancer death in men of all ages, although it most frequently occurs in men over the age of 40. In the United States, most cases of prostate cancer are diagnosed before they cause signs or symptoms because most men over age 40 are screened regularly.

- **Causes.** The causes are mostly unknown, although decreased testosterone production may contribute to the development of this disease.
- **Signs and symptoms.** Common symptoms include anemia, weight loss, incontinence, difficult urination, painful urination, pain in the lower back or abdomen, pain during bowel movements, high levels of PSA (a specific type of antigen) in the blood, blood in the urine, and bone pain in advanced cases.
- **Treatment.** Treatments are hormone therapy, chemotherapy, radiation therapy to destroy the tumor, and surgery to remove the prostate.

Prostatitis is an inflammation of the prostate gland. If it develops suddenly, it is called *acute prostatitis*. The slow development of this condition is termed *chronic prostatitis*.

- **Causes.** This condition can be caused by excessive alcohol consumption, a bacterial infection, a catheter in the urethra, trauma to the urethra or urinary bladder, and scarring of the urethra or prostate due to frequent infections. Urinating frequently can help to prevent infection.
- **Signs and symptoms.** Signs and symptoms include fever; pain in the scrotum, pelvic area, or abdomen; difficult urination; frequent urination; painful urination; blood in the urine; painful ejaculation; blood in the semen; discharge from the urethra; a low sperm count; and white blood cells in urine or semen.
- **Treatment.** This condition is treated with antibiotics and may also be treated with surgery to repair damage to the urethra.

The Female Reproductive System

Ovaries and Egg Cell Formation

The ovaries are the primary sex organs of the female because they produce the sex cells (eggs) of the female (Figures 13-4 and 13-5). They also produce **estrogen** and **progesterone**. Most females have two ovaries. They are oval in shape and are located in the pelvic cavity. Each ovary is divided into an inner area called the medulla and an outer area called the cortex. The medulla contains nerves, lymphatic vessels, and many blood vessels. The cortex contains small masses of cells called ovarian follicles. Epithelial tissue and dense connective tissue cover each ovary.

Before a female child is born, **primordial follicles** develop in her ovarian cortex. Each primordial follicle contains a large cell called a primary **oocyte** (immature egg) and smaller cells called **follicular cells**. Unlike males, who make sperm cells throughout their entire life, a female is

born with the maximum number of primary oocytes she will ever produce.

Oogenesis is the process of egg cell formation. At the onset of puberty, some primary oocytes are stimulated to continue meiosis. When a primary oocyte divides, it becomes one **polar body** (a nonfunctional cell) and a secondary oocyte. It is the secondary oocyte that is released from an ovary each month during a process called **ovulation**. When the secondary oocyte is fertilized, it divides to form a mature, fertilized egg cell. Therefore, the process of meiosis begins before a female is born and is completed only if a secondary oocyte is fertilized. The mature egg cell contains 23 chromosomes; when it combines with a sperm cell, the resulting cell contains 46 chromosomes.

Internal Accessory Organs of the Female Reproductive System

The female reproductive internal accessory organs are the **fallopian tubes**, **uterus**, and **vagina**.

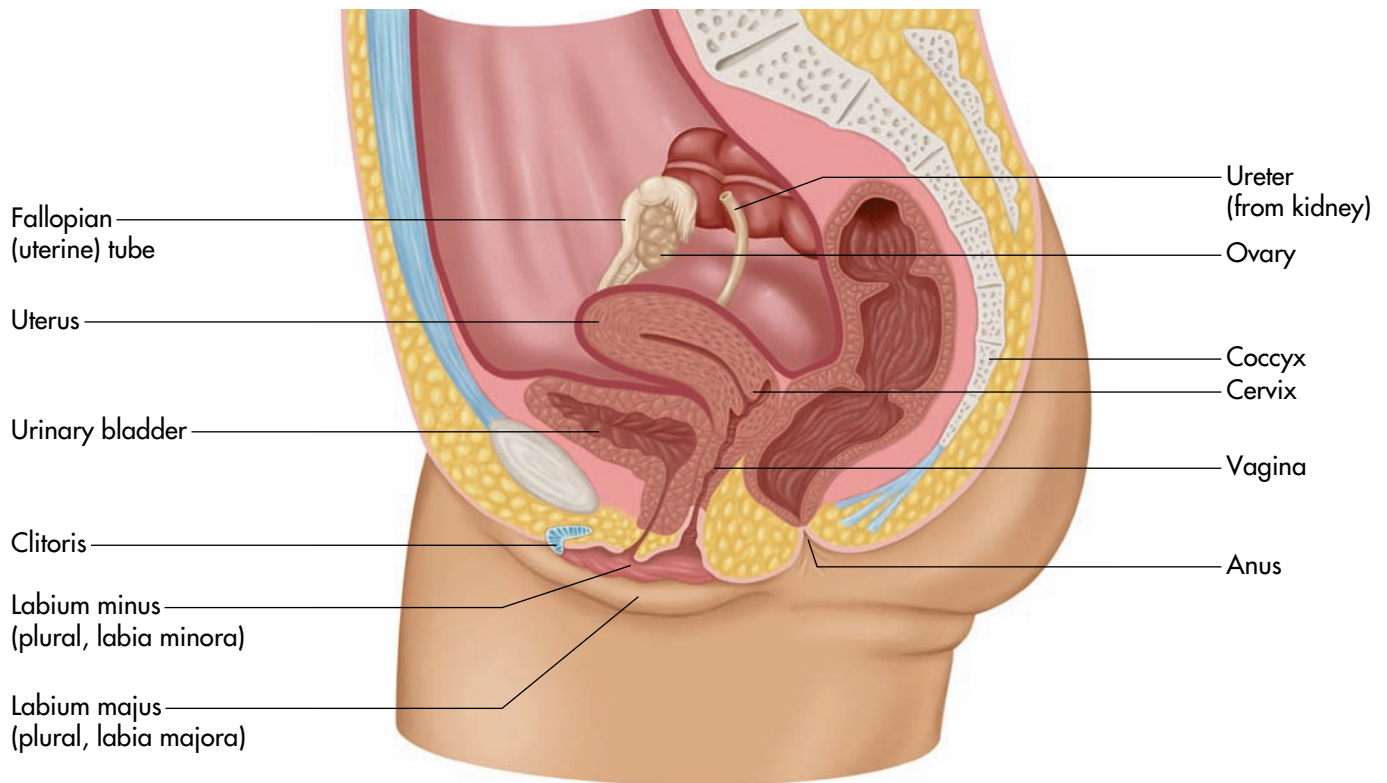


Figure 13-4. Sagittal view of female reproductive organs. The female reproductive system produces eggs for fertilization and provides the place and means for a fertilized egg to develop.

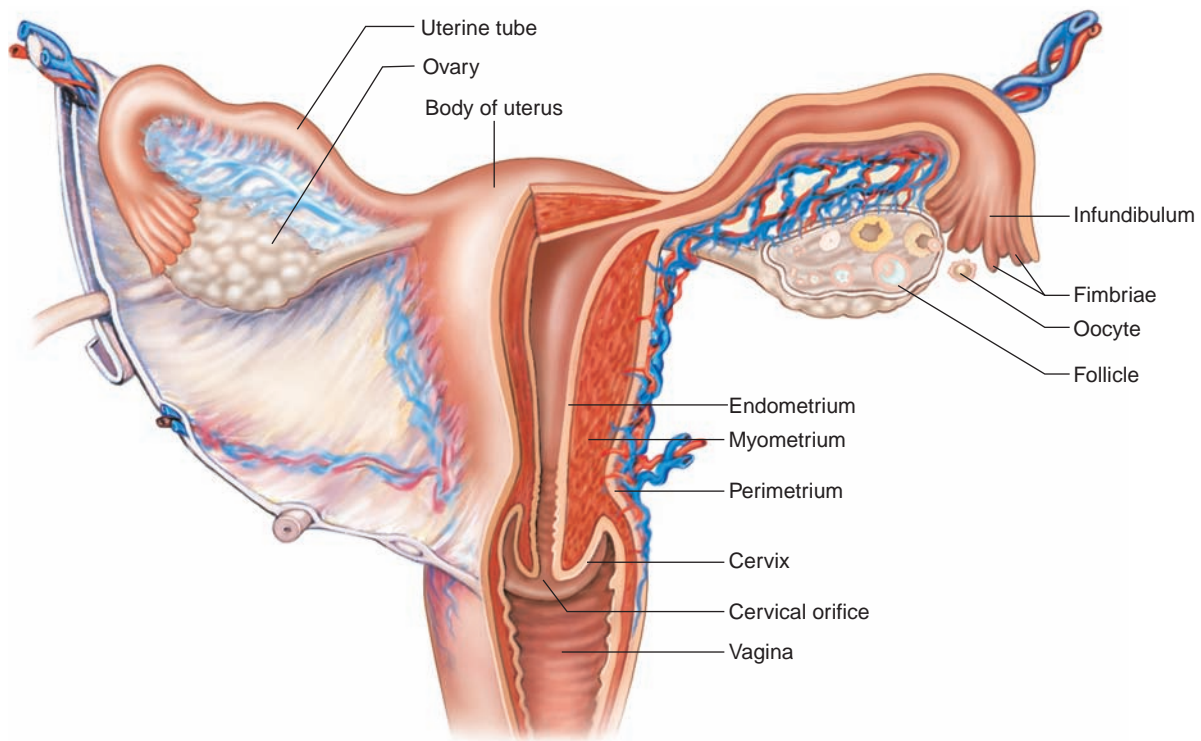


Figure 13-5. Anterior view of internal female reproductive organs. Ovulation of an oocyte is also demonstrated.

Fallopian Tubes. A fallopian tube opens near each ovary and into the uterus. The end of a fallopian tube near an ovary is expanded and is called an **infundibulum** and **fimbriae**. The infundibulum and its fimbriae function to “catch” a secondary oocyte as it leaves an ovary. Fallopian tubes are lined with ciliated cells that sweep the oocyte toward the uterus.

Uterus. The uterus is a hollow, muscular organ that functions to receive an embryo and sustain its development. The upper two-thirds of the uterus is called the body of the uterus, and the narrow, lower portion of the uterus that extends into the vagina is called the **cervix**. The opening of the cervix is called the **cervical orifice**.

The wall of the uterus has three layers—the **endometrium**, **myometrium**, and **perimetrium**. The endometrium is the innermost lining of the uterus and contains numerous tubular glands that secrete mucus. The myometrium is the middle, thick, muscular layer. The perimetrium is a thin layer that covers the myometrium. It secretes serous fluid that coats the uterus.

Vagina. The vagina is a tubular organ that extends from the uterus to the outside of the body. It functions to receive an erect penis during sexual intercourse, and it provides an open passageway for uterine secretions and offspring. The opening of the vagina is posterior to the urinary opening and anterior to the anal opening. The wall of the vagina has three layers—an innermost mucosal layer that secretes mucus, a middle muscular layer, and an outermost fibrous layer.

External Accessory Organs of the Female Reproductive System

Mammary glands are the accessory organs of the female reproductive system (Figure 13-6). They secrete milk after pregnancy.

Mammary glands are located beneath the skin in the breast area. A nipple is located near the center of each breast. The pigmented area that surrounds the nipple is called the **areola**. Each gland is made of 15 to 20 lobes and contains **alveolar glands** that make milk under the influence of the hormone prolactin. The hormone oxytocin induces alveolar ducts to deliver milk through openings in the nipples. Therefore, if a woman wants to breast-feed, she must produce adequate amounts of prolactin and oxytocin.

External Organs of the Female Reproductive System

The female external reproductive organs are the **labia majora**, **labia minora**, and **clitoris**.

Labia Majora. The labia majora are rounded folds of adipose tissue and skin that serve to protect the other external female reproductive organs. At their anterior ends, the labia majora form the **mons pubis**, which is a fatty area that overlies the pubic bones. The labia majora and mons pubis are typically covered in pubic hair in postpubescent females.

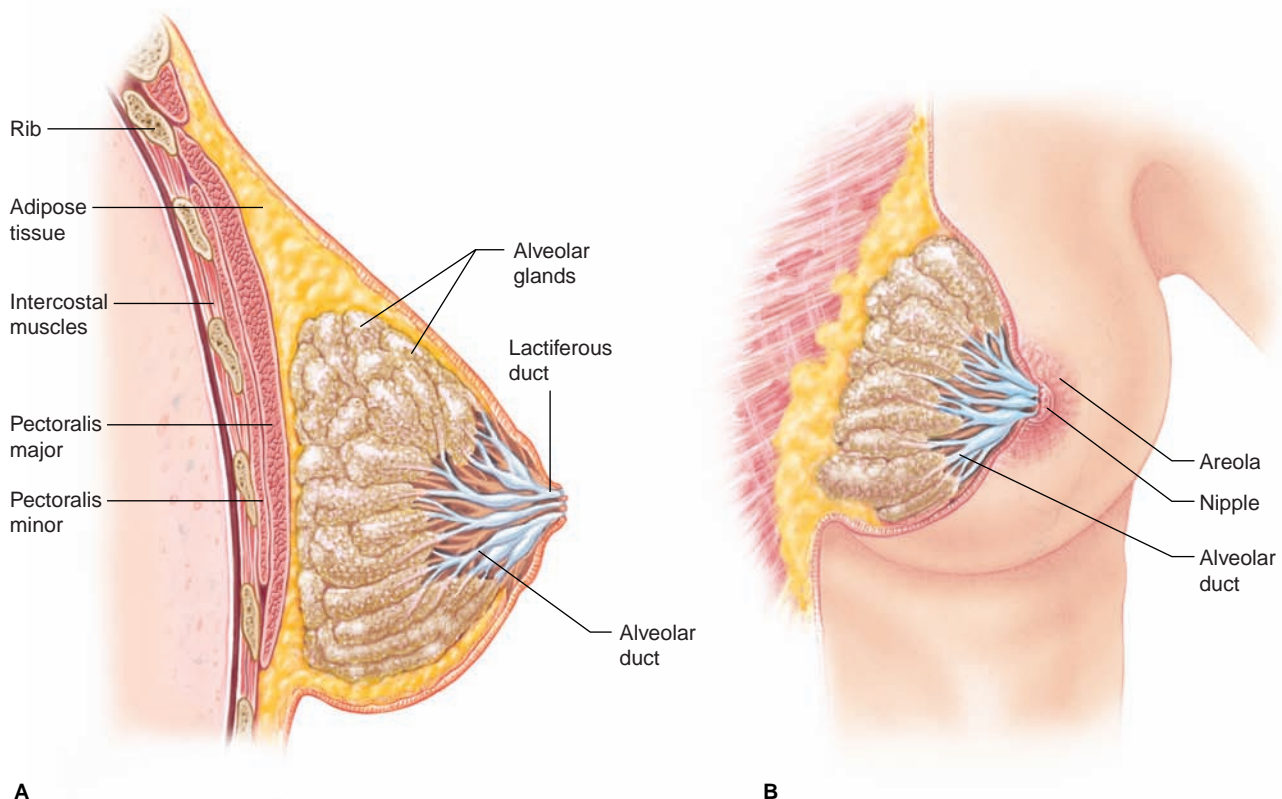


Figure 13-6. Mammary glands: (a) sagittal view and (b) anterior view.

Labia Minora. The labia minora are folds of skin between the labia majora. They are pinkish in color because of their high degree of vascularity. They merge together anteriorly to form a hood over the clitoris.

The space enclosed by the labia minora is called the vestibule. **Vestibular glands** secrete mucus into this area during sexual arousal. This mucus facilitates insertion of the penis into the vagina.

Clitoris. The clitoris is anterior to the urethral opening. It contains erectile tissue and is rich in sensory nerves.

Erection, Lubrication, and Orgasm

During sexual arousal, nervous stimulation causes the clitoris to become erect and the vestibular glands to become active. At the same time, the vagina elongates. If the clitoris is sufficiently stimulated, an orgasm occurs. During orgasm, the walls of the uterus and fallopian tubes contract to help propel sperm toward the upper ends of the fallopian tubes.

Female Reproductive Hormones

At the onset of puberty, the hypothalamus secretes increasing amounts of GnRH. GnRH causes the anterior pituitary gland to release FSH and LH. FSH and LH then stimulate the ovary to produce estrogen, progesterone, and mature follicles. Estrogen and progesterone also stimulate enlargement of the reproductive organs and the production of female secondary sex characteristics, which are characteristics that are typically unique to females. They include

breast development, increased vascularization of the skin, and increased fat deposits in the breasts, thighs, and hips.

Female Reproductive Cycle

The female reproductive cycle is also called the **menstrual cycle**. It consists of regular changes in the uterine lining that leads to a monthly “period,” or bleeding. **Menopause** is the termination of the menstrual cycle because of normal aging of the ovaries. The following steps are the major hormonal changes that occur during one reproductive cycle:

1. The anterior pituitary gland releases FSH. FSH stimulates an ovarian follicle to mature.
2. The maturing follicle secretes estrogen. Estrogen causes the uterine lining to thicken.
3. The anterior pituitary gland releases a sudden surge of LH. The LH surge triggers ovulation.
4. Following ovulation, follicular cells of the follicle become a **corpus luteum**.
5. The corpus luteum secretes progesterone, which causes the uterine lining to become more vascular and glandular.
6. If the released oocyte is not fertilized, the corpus luteum degenerates.
7. The degenerating corpus luteum causes estrogen and progesterone levels to fall. The decline in estrogen and progesterone levels causes the uterine lining to break down, and bleeding (**menses**) starts.
8. When the anterior pituitary releases FSH, the reproductive cycle begins again.

Pathophysiology

Common Diseases and Disorders of the Female Reproductive System

Breast cancer affects approximately one in eight women. Depending on tumor size and how far cancer cells have spread, breast cancer is classified in stages from 0 to 4, with stage 4 cancer being the most serious. Early diagnosis through regular mammograms and self-breast examinations greatly increases the success of treatment.

- **Causes.** The causes are largely unknown, although breast cancer may be related to hormonal changes or the presence of certain genes.
- **Signs and symptoms.** Signs and symptoms include a lump in the breast that is usually painless and firm, a lump in the armpit, discharge from the nipples, dimpled skin on the breast or nipple, and breast pain. Swelling of the arm and bone pain may be present in advanced cases.
- **Treatment.** Nonsurgical treatment methods include hormone therapy, radiation therapy, and chemotherapy.

Surgical options include surgery to remove affected lymph nodes, lumpectomy (surgery to remove a lump), and mastectomy (surgery to remove a breast).

Cervical cancer develops slowly and most of the time is treatable without removing the uterus. Early screening for cervical cancer is successful with a yearly Pap smear, which is a test that looks for abnormal cells in the cervix.

- **Causes.** A weak immune system may be a factor in the development of this cancer. It can also be caused by sexual intercourse early in life, multiple sexual partners, and infection with the human papilloma virus.
- **Signs and symptoms.** Primary symptoms include frequent vaginal discharge, sporadic vaginal bleeding, vaginal bleeding after sexual intercourse, and abnormal cells in the cervix. Patients who are in later stages of this disease may experience pain in the pelvic area or legs, or bone fractures.

continued →

Common Diseases and Disorders of the Female Reproductive System *(continued)*

- **Treatment.** Radiation therapy, chemotherapy, the removal of diseased tissue, and the removal of the uterus (**hysterectomy**) are the treatments for this disease.

Cervicitis is defined as an inflammation of the cervix, which is usually caused by an infection.

- **Causes.** Causes include bacterial or viral infections and allergic reactions to spermicidal creams and latex condoms.
- **Signs and symptoms.** Frequent vaginal discharge, pain during intercourse, and vaginal bleeding after intercourse are common signs and symptoms.
- **Treatment.** This condition is treated with antibiotics and by changing the method of contraception.

Dysmenorrhea is the condition of experiencing severe menstrual cramps that limit normal daily activities. It is a common cause of lost time from work for women.

- **Causes.** Causes include anxiety, endometriosis, pelvic inflammatory disease, fibroid tumors in the uterus, ovarian cysts, abnormally high levels of prostaglandins, and multiple sexual partners.
- **Signs and symptoms.** Common symptoms are abdominal pains, including sharp or dull pain in the pelvic area.
- **Treatment.** Nonsurgical treatments include pain medication, anti-inflammatory drugs, medications that inhibit prostaglandin formation, oral contraceptives, and antibiotics in the case of pelvic inflammatory disease. Surgical treatments include hysterectomy and surgery to remove cysts or fibroids.

Endometriosis is a condition in which tissues that make up the lining of the uterus grow outside the uterus.

- **Causes.** The cause of this disorder is unknown; it may be inherited.
- **Signs and symptoms.** Signs and symptoms include infertility, heavy bleeding from the uterus, pain in the abdomen or pelvis, painful periods, spotting between periods, and pain during sexual intercourse.
- **Treatment.** Oral contraceptives, pain medications, and various hormone therapies may be prescribed. Surgical treatments include laser surgery to remove endometrial tissue outside the uterus, and hysterectomy.

Fibrocystic breast disease is the presence of abnormal tissue in the breasts. It is a common disorder and occurs in more than 60% of women in the United States between the ages of 30 and 50. It is rare in women who have gone through menopause.

- **Causes.** This disorder is caused by hormonal changes associated with the menstrual cycle and various dietary substances (for example, caffeine).

- **Signs and symptoms.** Common symptoms include breasts that feel “bumpy,” breast tenderness or pain, itchy nipples, and dense tissues as seen in a mammogram.
- **Treatment.** Treatments are changing one’s diet, taking oral contraceptives, and preventing pain by wearing support bras.

Fibroids are benign (noncancerous) tumors that grow in the uterine wall. They are most common in African American women.

- **Causes.** The causes are mostly unknown, although it has been found that tumors enlarge as estrogen levels increase.
- **Signs and symptoms.** The signs and symptoms are pressure in the abdomen, severe menstrual cramps, abdominal gas, heavy menstrual bleeding, and an enlarged uterus.
- **Treatment.** Treatment includes pain medications, hormone treatments to shrink tumors, surgery to remove tumors, hysterectomy, and surgery to decrease the blood supply to the uterus.

Ovarian cancer is more deadly than other types of cancer because its signs and symptoms are usually mild until the disease has spread to other organs. It is the fifth leading cause of cancer death in women.

- **Causes.** The causes are unknown, although the presence of certain genes has been indicated as a risk factor. Some oral contraceptives may lower the risk of developing this disease.
- **Signs and symptoms.** Abdominal and pelvic discomfort, unusual menstrual cycles, indigestion, bloating, nausea, and excessive hair growth are signs and symptoms.
- **Treatment.** Treatments are radiation therapy, chemotherapy, and surgery to remove the ovaries.

Premenstrual syndrome (PMS) is a collection of symptoms that occur just before a menstrual period.

- **Causes.** The causes are mostly unknown.
- **Signs and symptoms.** The signs and symptoms include anxiety, depression, irritability, acne, fatigue, food cravings, bloating, aches in the head or back, abdominal pain, breast tenderness, muscle spasms, diarrhea, weight gain, and loss of sex drive.
- **Treatment.** MS is commonly treated with pain medications, diuretics, medications to treat depression or anxiety, and oral contraceptives.

Vaginitis is the condition of having abnormal vaginal discharge. Some vaginal discharge is normal for all women,

continued →

Common Diseases and Disorders of the Female Reproductive System (continued)

and it varies throughout the menstrual cycle. Normal vaginal discharge is clear, whitish, or yellowish in color.

- **Causes.** This condition can be caused by yeast infections, tampon use, poor hygiene, bacteria, antibiotics, and sexually transmitted diseases. Vaginitis may be prevented through good hygiene.
- **Signs and symptoms.** Common symptoms include fever, vaginal itching, abnormal increases in the amount of vaginal discharge, decreases in the amount of vaginal discharge, an abnormal color of vaginal discharge (brown or pinkish), and vaginal discharge that has an abnormal odor.
- **Treatment.** The patient may be given medications for fungal or bacterial infections, or the patient and her

sexual partner may be treated for sexually transmitted diseases.

Uterine cancer is most common in women between the ages of 60 and 70. In the United States, it occurs in about 1% of women.

- **Causes.** The causes are mostly unknown, although it may be related to increased levels of estrogen.
- **Signs and symptoms.** Signs and symptoms include abdominal pain, abnormal bleeding from the uterus, pelvic pain, and a thin, white vaginal discharge in postmenopausal women.
- **Treatment.** Treatment includes radiation therapy, chemotherapy, and surgery to remove the uterus, fallopian tubes, and ovaries.

Sexually Transmitted Diseases

Sexually transmitted diseases (STDs) can be caused by bacteria, viruses, or parasites.

Bacterial Causes of STDs

STDs caused by bacteria are chlamydia, syphilis, and gonorrhea. The symptoms of STDs caused by bacterial infections are often absent or too mild to be noticed in both men and women. These symptoms include:

- Discharge from the vagina or penis
- Burning sensations during urination
- Pelvic pain
- Pain in the testes

STDs caused by bacteria are easily and effectively treated with antibiotics. However, both partners must take antibiotics to prevent reinfection. These STDs can lead to complications if left untreated. The most common complication of an untreated bacterial STD is *pelvic inflammatory disease (PID)*. PID is a leading cause of infertility in women because it leads to scarring of the fallopian tubes.

Viral Causes of STDs

STDs caused by viruses are herpes and AIDS. *Herpes simplex 1* usually infects the mouth and causes fever blisters, or cold sores. *Herpes simplex 2* affects the genital area. This virus usually causes only genital ulcers, but it can also infect the eyes, lungs, skin, brain, and a developing fetus. There is no cure for any type of herpes but medication is available to prevent outbreaks. *AIDS* is discussed in Chapter 7.

Parasitic Causes of STDs

Parasites can cause STDs. *Crabs* is an STD caused by bloodsucking insects called lice. Lice that invade hair in the genital region are called pubic lice. They typically attach to pubic hair to lay their eggs. They produce severe itching and can be seen with a magnifying glass and sometimes with the naked eye. They are usually treated with insecticides. It is also important to wash all clothing and linens during treatment.

Trichomonas is caused by a parasitic protozoan. It most often does not produce noticeable symptoms in males. In females, it usually produces a large amount of foul-smelling vaginal discharge. This disease also causes itching and swollen labia. It is easily treated with specific antibiotics.

Pregnancy

Fertilization

Pregnancy is defined as the condition of having a developing offspring in the uterus. Pregnancy results when a sperm cell unites with an egg in a process called **fertilization** (Figure 13-7).

Prior to fertilization, an egg is released from an ovary, and it travels through a fallopian tube. During sexual intercourse, the male deposits semen into the vagina. Sperm cells must travel up through the uterus to the fallopian tubes to fertilize the egg.

Prostaglandins in semen stimulate the flagella of sperm cells to undulate, causing the swimming action of sperm. Prostaglandins also stimulate muscles in the uterus and fallopian tubes to contract. These contractions help the sperm reach the egg. Normally about 10 to 14 days after ovulation, high estrogen levels stimulate the uterus and

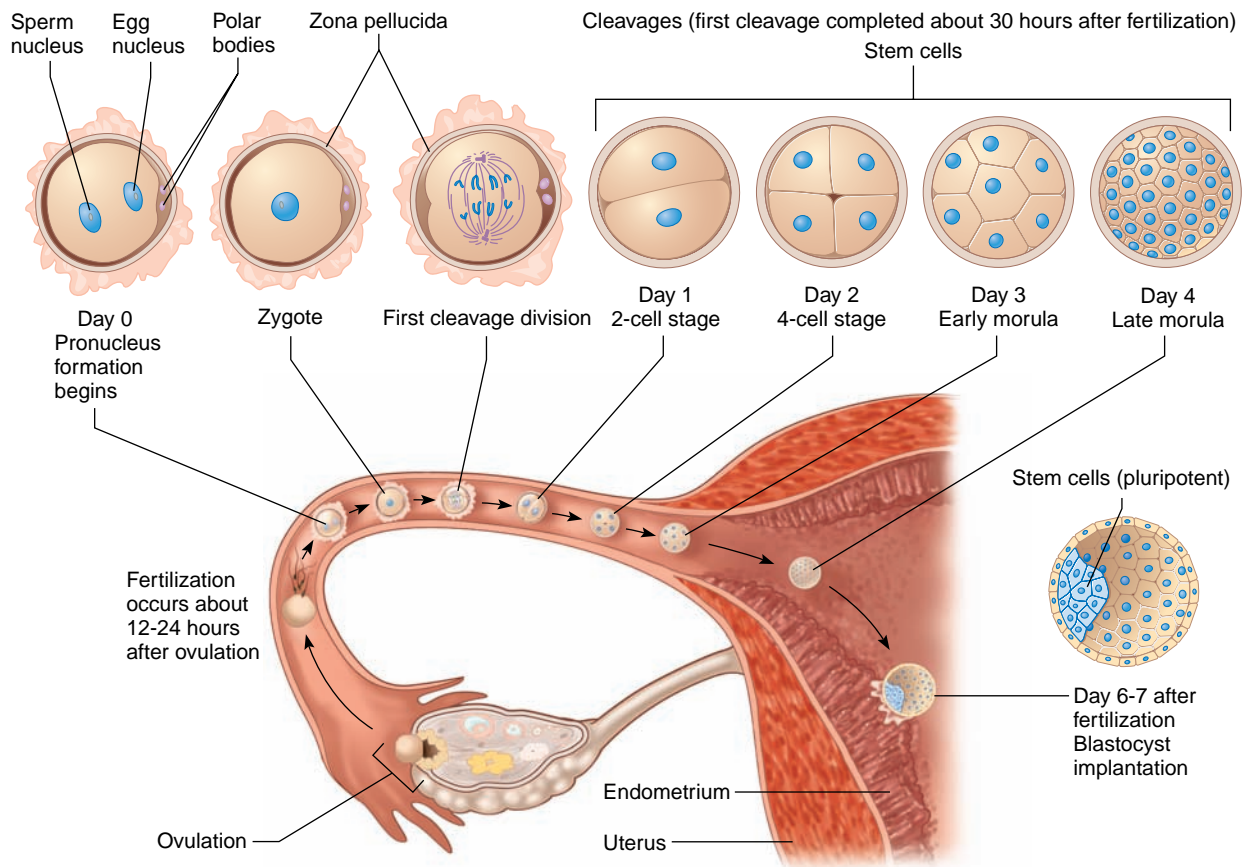


Figure 13-7. Stages of early embryo development.

cervix to secrete a thin, watery fluid that also promotes the movement of sperm toward the egg.

Although many sperm cells normally reach an egg, only one unites with the egg to fertilize it. The sperm cell that unites with the egg penetrates the follicular cells and a layer called the **zona pellucida**, which surround the cell membrane of the egg. The acrosome of the sperm releases enzymes to help the sperm penetrate the membrane of the egg. Once a sperm unites with an egg, the egg releases enzymes that prevent other sperm from invading it. The enzymes cause the zona pellucida to become hard and therefore impenetrable to other sperm.

The nucleus of the egg (with 23 chromosomes) and the nucleus of the sperm (with 23 chromosomes) eventually fuse together to make one nucleus that contains 46 chromosomes. The cell that is formed by this union is called a **zygote**.

The Prenatal Period

The **prenatal period** is the time before the offspring is born. The prenatal period is divided into an **embryonic period** (weeks 2 through 8 of pregnancy) and a **fetal period** (week 9 to the delivery of the offspring).

About one day after the zygote forms, it begins to undergo mitosis at a relatively rapid rate. This rapid cell division is called **cleavage**. The resulting ball of cells is called

a **morula**. The morula travels down the fallopian tube to the uterus. Fluid then invades the morula, and this organism is called a **blastocyst**. The blastocyst implants in the wall of the uterus. The process of moving from zygote formation to implantation of the blastocyst takes about one week. Once the blastocyst implants, a group of cells in the blastocyst, called the **inner cell mass**, gives rise to an embryo. Other cells in the blastocyst, along with cells of the uterus, eventually form the **placenta**.

The Embryonic Period. The embryonic period extends from the second week of pregnancy to the end of the eighth week of development. During this stage, the placenta, **amnion**, **umbilical cord**, and **yolk sac** form along with most of the internal organs and external structures of the embryo (Figure 13-8). The cells of the inner cell mass organize into layers called **primary germ layers**. All organs are formed from the primary germ layers, which include the ectoderm, mesoderm, and endoderm.

- The **ectoderm** gives rise to nervous tissue and some epithelial tissue.
- The **mesoderm**, the middle layer, gives rise to connective tissues and some epithelial tissue.
- The **endoderm** gives rise to epithelial tissues only.

The placenta allows nutrients and oxygen from maternal blood to pass to embryonic blood. It also allows waste

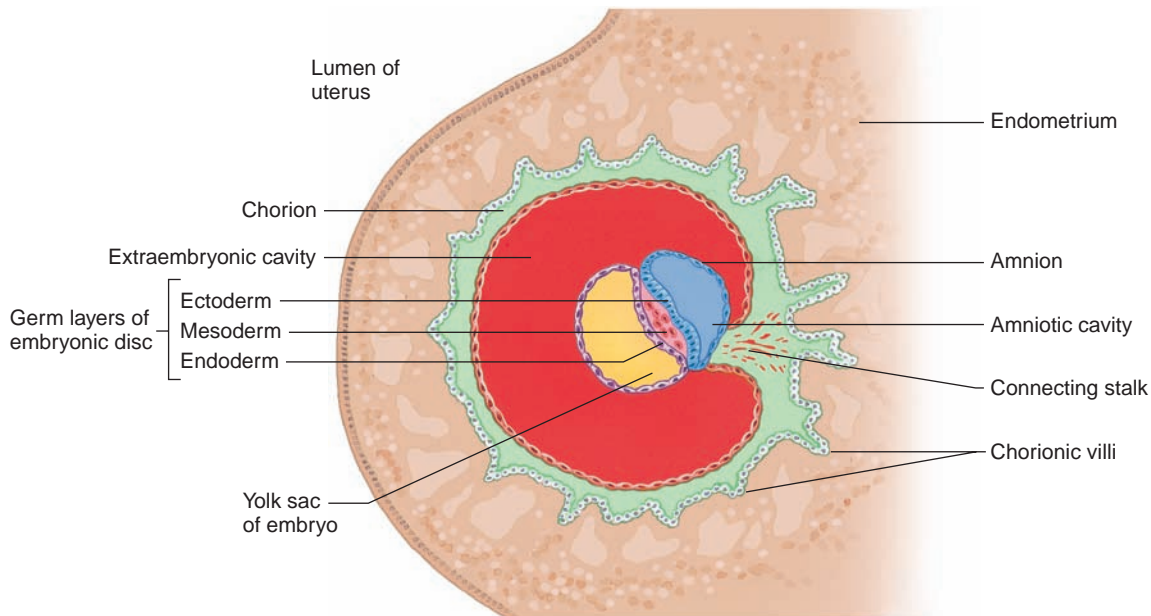


Figure 13-8. Primary germ layers and membranes associated with an embryo.

products from the fetal blood to pass into maternal blood. The amnion is a protective, fluid-filled sac that surrounds the embryo. The umbilical cord contains three blood vessels—one umbilical vein and two umbilical arteries. These blood vessels transport blood between the fetus and the placenta.

The yolk sac makes new blood cells for the fetus as well as cells that eventually become sex cells of the baby. By the end of the embryonic stage, the baby closely resembles a human because all external structures (arms, hands, legs, feet, etc.) have formed.

The Fetal Period. The fetal period begins at the end of the eighth week of development and ends at birth. During this period, the growth of the offspring, which is now called a fetus, is rapid. By the twelfth week bones have begun to harden and the external reproductive organs can be distinguishable as male or female.

The growth rate of the fetus slows down in the fifth month but skeletal muscles become active. In the sixth month, the fetus starts to gain substantial weight. In the seventh month, the eyelids open. In the last three months of pregnancy, fetal brain cells divide rapidly and organs continue to grow. The testes of the male descend into the scrotum. The last organ systems to completely develop are the digestive and respiratory systems. By the end of the ninth month, the fetus is usually positioned upside down in the uterus.

Fetal Circulation

Throughout prenatal development, the placenta and umbilical blood vessels carry out the exchange of nutrients, oxygen, and waste products between maternal and fetal blood. Therefore, the fetus does not need to send blood to

the lungs to pick up oxygen nor does it need to send blood to the liver to process nutrients.

Fetal circulation has some important differences from normal circulation, which are illustrated in Figure 13-9. In the fetal heart, a hole called the **foramen ovale** is located between the right atrium and the left atrium. Therefore, in the fetal heart, most blood flows from the right atrium into the left atrium. In the adult heart, blood flows from the right atrium into the right ventricle so it can be pumped to the lungs. However, some fetal blood does flow from the right atrium into the right ventricle, and the right ventricle then delivers the blood to the pulmonary trunk.

In the fetus, there is a connection between the pulmonary trunk and the aorta called the **ductus arteriosus**. This connection allows blood to flow from the pulmonary trunk into the aorta. In the adult, this connection does not exist and blood flows from the pulmonary trunk to the lungs.

The fetus also contains a blood vessel that allows most of the blood to bypass the liver. This vessel is called the **ductus venosus**. After a baby is born, the foramen ovale, ductus arteriosus, and ductus venosus close.

Hemoglobin within the fetus has a much higher affinity for oxygen than does the normal hemoglobin that is found after birth and growth. Therefore, the fetus's blood is adapted to carry more oxygen.

Hormonal Changes During Pregnancy

Many hormonal changes take place when a woman is pregnant. Following implantation of the embryo, the cells of the embryo begin to secrete **human chorionic gonadotropin (HCG)**. HCG maintains the corpus luteum in the ovary so it will continue to secrete estrogen and progesterone. The

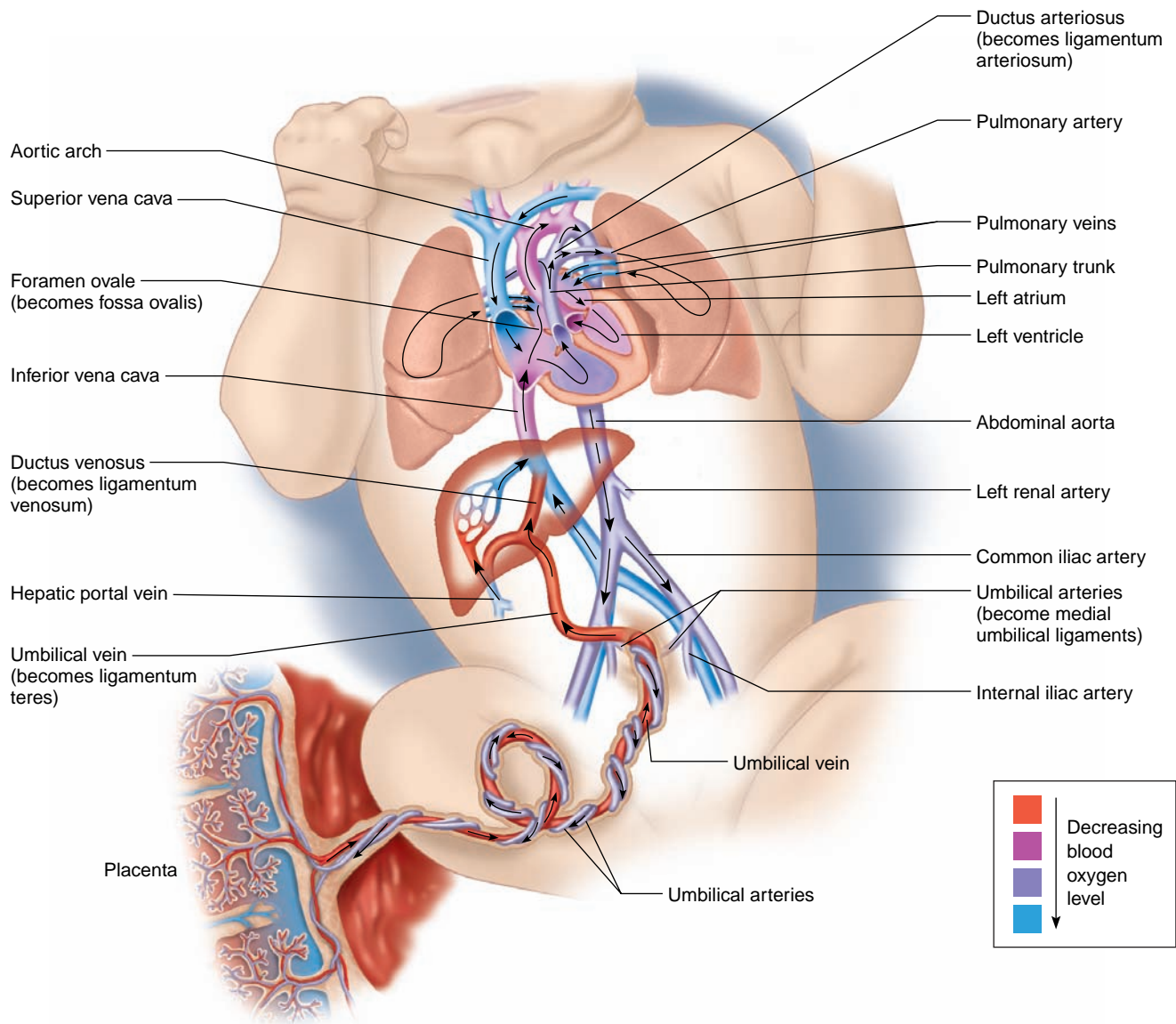


Figure 13-9. Fetal circulation.

placenta also secretes large amounts of progesterone and estrogen.

Progesterone and estrogen stimulate the uterine lining to thicken. They also inhibit the anterior pituitary gland from secreting FSH and LH to prevent ovulation during pregnancy. Estrogen and progesterone also stimulate the development of the mammary glands, inhibit uterine contractions, and stimulate the enlargement of female reproductive organs.

Another hormone called **relaxin**, which comes from the corpus luteum, inhibits uterine contractions and relaxes the ligaments of the pelvis in preparation for childbirth. The placenta also secretes **lactogen**, a hormone that stimulates the enlargement of mammary glands. **Aldosterone**, which is secreted from the adrenal gland, increases sodium and water retention. The secretion of **parathyroid hormone** (PTH) increases, helping to maintain high calcium levels in the blood.

The Birth Process

The birth process ends pregnancy. This process begins when progesterone levels fall. When progesterone levels fall, uterine contractions are no longer inhibited and the uterus secretes prostaglandins. Prostaglandins stimulate uterine contractions, which cause the posterior pituitary gland to release **oxytocin**. Oxytocin stimulates strong uterine contractions until the birth process ends. Following the birth of a baby, the placenta is expelled from the uterus (Figure 13-10).

The Postnatal Period

The **postnatal period** is the period following birth. The first four weeks of the postnatal period is called the **neonatal period** and the offspring is called a **neonate**. The neonatal period is marked by adjustment to life outside the uterus. The lungs of the neonate must expand, which

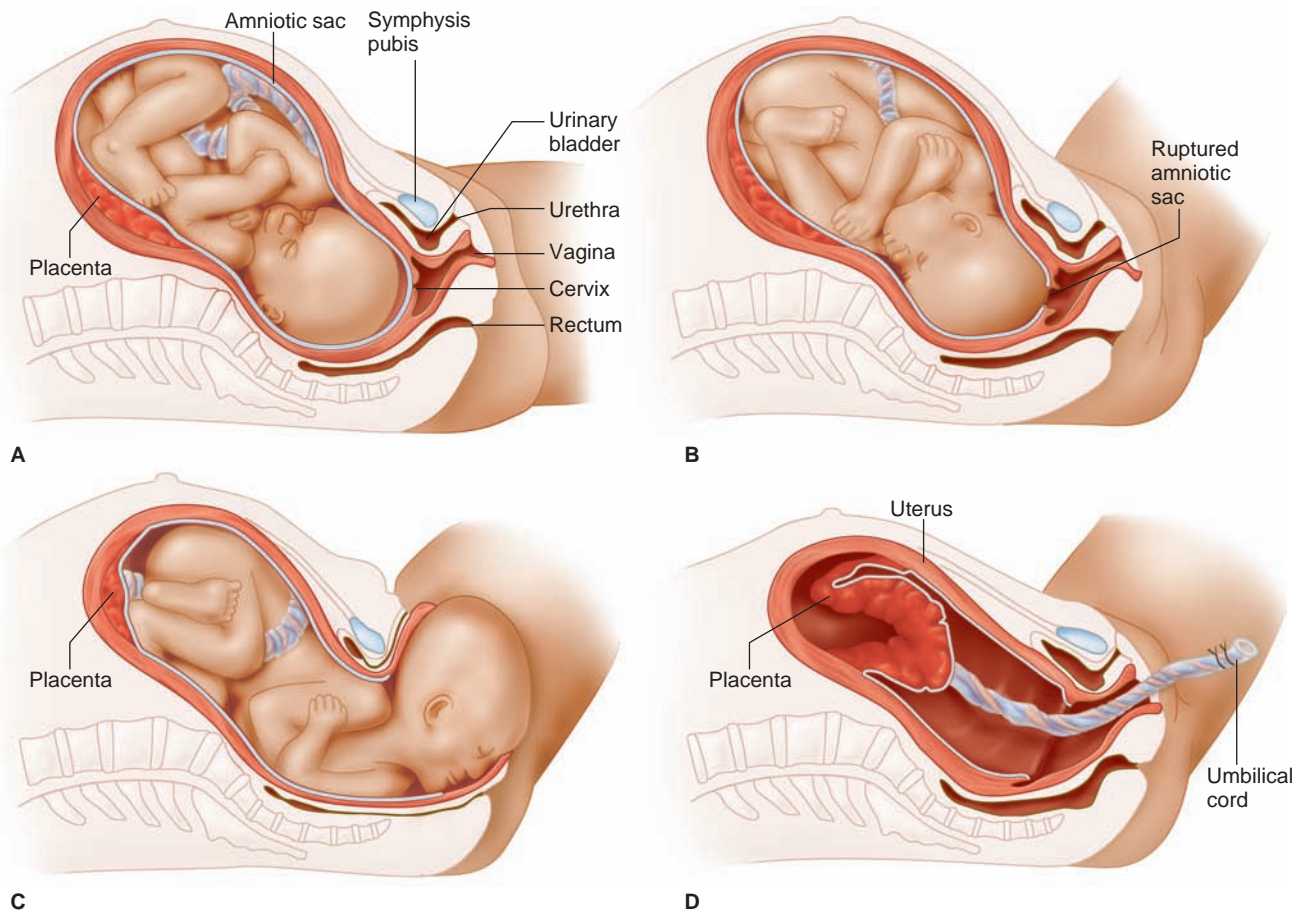


Figure 13-10. Stages of the birth process: (a) the fetal position before birth; (b) dilatation of the cervix; (c) delivery of the fetus; and (d) delivery of the placenta.

is why the first breath of a baby is forceful. The liver of the newborn is immature, so the baby must obtain most of its glucose from fat stores in the skin. The newborn urinates a lot because the kidneys are too immature to concentrate urine well. In addition, body temperature tends to be unstable. The umbilical vessels of the newborn must constrict, and the foramen ovale, ductus arteriosus, and ductus venosus must close.

Milk Production and Secretion

During pregnancy, hormones stimulate the breasts to enlarge. After childbirth, prolactin causes the mammary glands to produce milk. The hormone oxytocin stimulates the ejection of milk from mammary gland ducts. As long as milk is removed from the mammary glands, milk production will continue. Once a female stops breast-feeding, the hypothalamus will inhibit the release of prolactin and oxytocin so that milk production will stop.

Contraception

Birth control methods, also referred to as contraception, reduce the risk that pregnancy will occur. Although many methods of birth control are available, some are more

reliable than others. The following are the most commonly used birth control methods:

- **Coitus interruptus.** The penis is withdrawn from the vagina before ejaculation. This method is not very reliable because small amounts of semen may enter the vagina before ejaculation.
- **Rhythm method.** The rhythm method requires abstinence from sexual intercourse at about the time a female is ovulating. However, predicting ovulation can be difficult; therefore, this type of contraception can be unreliable.
- **Mechanical barriers.** Mechanical barriers prevent sperm from entering the female reproductive tract. They include condoms, diaphragms, and cervical caps.
- **Chemical barriers.** Chemical barriers destroy sperm in the female reproductive tract. They primarily include spermicides.
- **Oral contraceptives.** Birth control pills are oral contraceptives. These pills normally include low doses of estrogen or progesterone that prevent the LH surge necessary for ovulation. These pills therefore prevent ovulation.
- **Injectable contraceptives.** Depo-Provera is one brand of injectable contraceptive. It prevents ovulation and

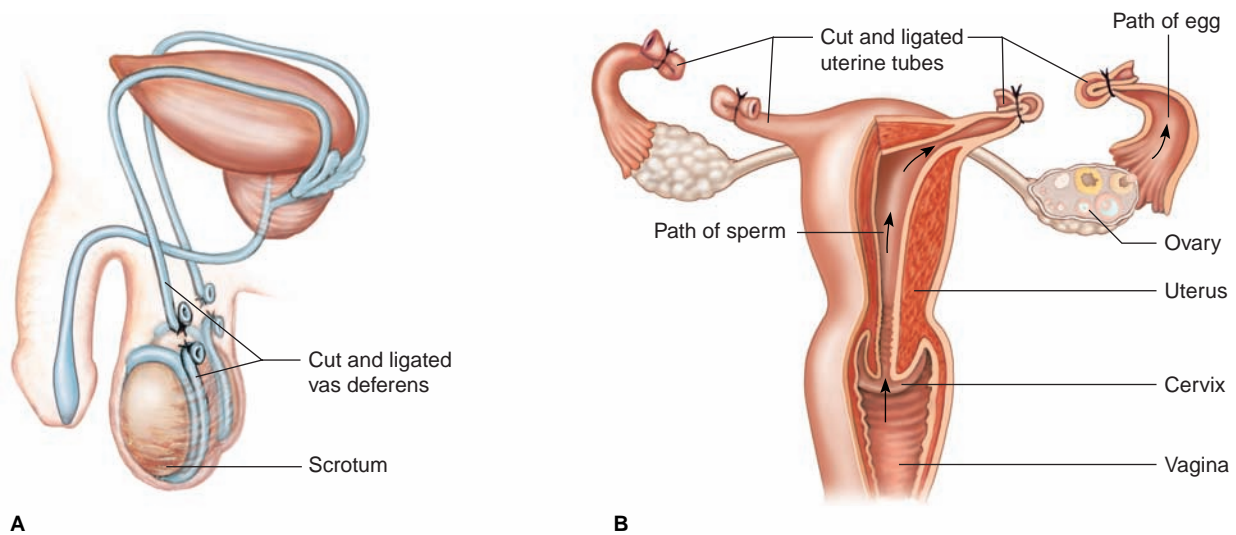


Figure 13-11. (a) Vasectomy involves cutting and ligating the vas deferens. (b) Tubal ligation involves cutting and ligating each fallopian tube.

alters the lining of the uterus so that implantation of a blastocyst is not likely.

- Contraceptive implants. Contraceptive implants are small rods of progesterone that are implanted beneath the skin. They also prevent ovulation.
- Intrauterine devices. An intrauterine device (IUD) is a small, solid device that a physician places in the uterus. It prevents the implantation of a blastocyst.
- Surgical methods. *Tubal ligation* is a surgical method used in females to prevent pregnancy. In this process, each fallopian tube is cut and tied to prevent sperm from reaching the oocyte. *Vasectomy* is a surgical method used in males to prevent pregnancy. In this process, each vas deferens is cut and tied to prevent sperm from being ejaculated. Figure 13-11 illustrates these methods.

Infertility

Infertility is the inability to conceive a child. If a couple has never been pregnant and has tried for 12 months to achieve pregnancy, they are said to have primary infertility. If a couple has had at least one pregnancy but has not been able to get pregnant after one year, they are said to have secondary infertility.

In the United States, about 15% of infertility causes are unknown, about 35% are due to problems in the male, and about 50% are due to problems in the female. Common causes of infertility due to male factors include the following:

- Impotence
- Retrograde ejaculation
- Low or absent sperm count
- Use of various medications or drugs
- Decreased testosterone production

- Scarring of the male reproductive tract from sexually transmitted diseases
- Mumps that infect the testes
- Inflammation of the epididymis or testes

Infertility due to female factors includes these common causes:

- Scarring of fallopian tubes from sexually transmitted diseases
- Pelvic inflammatory disease
- Inadequate diet
- Lack of ovulation
- Lack of menstrual cycles
- Endometriosis
- Abnormal shape of the uterus or cervix
- Hormone imbalances
- Cysts in ovaries
- Being over the age of 40

Women are most likely to get pregnant in their early 20s. By the time a woman reaches the age of 40, her chance of conceiving a child is less than 10% each month. In general, infertility in men is not age related.

Infertility Tests

A number of tests are used to diagnose infertility. They include the following:

- Semen analysis. This test determines the thickness of semen and how many normal sperm cells are in a sample.
- Monitoring of morning body temperature. If a woman's body temperature does not rise slightly once a month, which is best determined by taking her temperature first thing in the morning, a woman may not be ovulating.

- Blood hormone measurements. In females, various hormone levels can be monitored to predict ovulation and the general health of ovaries. In males, testosterone levels are primarily measured.
- Endometrial biopsy. This test determines the health of the uterine lining.
- Urinary analysis for luteinizing hormone. The absence of this hormone in urine may indicate a lack of ovulation.
- Hysterosalpingogram. This type of x-ray uses dye to visualize the shape of the uterus and the fallopian tubes. If a woman has excess scar tissue in her fallopian tubes, the dye cannot run through them.
- Laparoscopy. Laparoscopy is a procedure that is used to visualize pelvic organs.

Treatment of Infertility

Many treatments are available for infertility, but often there is no cure for this condition. Common treatments

include surgery to repair abnormal fallopian tubes, fertility drugs to increase ovulation, and hormone therapies. In cases where infertility cannot be cured, procedures such as artificial insemination or in vitro fertilization may help a couple to conceive.

Summary

The ability to reproduce is one of the basic characteristics of life. The male and female reproductive systems work together to produce offspring. The male produces sperm and delivers them to the female. The female produces ova and once fertilization occurs, she nurtures the fetus until birth. The medical assistant must understand the anatomy and physiology of the reproductive systems in order to assist with exams and procedures such as colposcopy and vasectomy. Knowledge of the system is also important when teaching patients about breast and testicular self-examination and sexually transmitted diseases.

REVIEW

CHAPTER 13

CASE STUDY QUESTIONS

Now that you have completed this chapter, review the case study at the beginning of the chapter and answer the following questions:

1. What sexually transmitted diseases are caused by bacteria?
2. How did the infection spread to the patient's abdominopelvic cavity?
3. Why is her sexual partner not experiencing pain in his abdominopelvic cavity?
4. Why is it important for her sexual partner to be treated with antibiotics?
5. Why is it common for women with sexually transmitted diseases to also have urinary tract infections?

Discussion Questions

1. Describe the components of semen. What is the function of each component?
2. What are male and female secondary sex characteristics? Give examples of each.
3. Explain the difference between the embryonic period and the fetal period.

Critical Thinking Questions

1. Why is coitus interruptus not a reliable birth control method?

2. Why do condoms prevent the spread of sexually transmitted diseases while most other methods of birth control do not?
3. What changes occur as a result of a tubal ligation?

Application Activities

1. Describe the functions of the following parts of a sperm:
 - a. Head
 - b. Midpiece
 - c. Tail
2. List the primary sex organs of the male. List the primary sex organs of the female.
3. List the structures that are derived from the following embryonic germ layers:
 - a. Endoderm
 - b. Mesoderm
 - c. Ectoderm

Internet Activity

Find a Web site that discusses AIDS, and answer the following questions:

- a. How can AIDS be prevented?
- b. What are the current treatments for AIDS?
- c. Is an AIDS vaccine currently available?

APPENDIX I

Medical Assistant Role Delineation Chart

Administrative

Administrative Procedures

- Perform basic administrative medical assisting functions
- Schedule, coordinate, and monitor appointments
- Schedule inpatient/outpatient admissions and procedures
- Understand and apply third-party guidelines
- Obtain reimbursement through accurate claims submission
- Monitor third-party reimbursement
- Understand and adhere to managed care policies and procedures
- * *Negotiate managed care contracts*

Practice Finances

- Perform procedural and diagnostic coding
- Apply bookkeeping principles
- Manage accounts receivable
- * *Manage accounts payable*
- * *Process payroll*
- * *Document and maintain accounting and banking records*
- * *Develop and maintain fee schedules*
- * *Manage renewals of business and professional insurance policies*
- * *Manage personnel benefits and maintain records*
- * *Perform marketing, financial, and strategic planning*

Clinical

Fundamental Principles

- Apply principles of aseptic technique and infection control
- Comply with quality assurance practices
- Screen and follow up patient test results

Diagnostic Orders

- Collect and process specimens
- Perform diagnostic tests

Patient Care

- Adhere to established patient screening procedures
- Obtain patient history and vital signs
- Prepare and maintain examination and treatment areas
- Prepare patient for examinations, procedures, and treatments
- Assist with examinations, procedures, and treatments
- Prepare and administer medications and immunizations
- Maintain medication and immunization records
- Recognize and respond to emergencies
- Coordinate patient care information with other health-care providers
- Initiate IV and administer IV medications with appropriate training and as permitted by state law

General

Professionalism

- Display a professional manner and image
- Demonstrate initiative and responsibility
- Work as a member of the health-care team
- Prioritize and perform multiple tasks
- Adapt to change
- Promote the CMA credential
- Enhance skills through continuing education
- Treat all patients with compassion and empathy
- Promote the practice through positive public relations

Communication Skills

- Recognize and respect cultural diversity
- Adapt communications to individual's ability to understand
- Use professional telephone technique
- Recognize and respond effectively to verbal, nonverbal, and written communications
- Use medical terminology appropriately
- Utilize electronic technology to receive, organize, prioritize, and transmit information
- Serve as liaison

Legal Concepts

- Perform within legal and ethical boundaries
- Prepare and maintain medical records
- Document accurately

- Follow employer's established policies dealing with the health-care contract
- Implement and maintain federal and state health-care legislation and regulations
- Comply with established risk management and safety procedures
- Recognize professional credentialing criteria
- * *Develop and maintain personnel, policy, and procedure manuals*

Instruction

- Instruct individuals according to their needs
- Explain office policies and procedures
- Teach methods of health promotion and disease prevention
- Locate community resources and disseminate information
- * *Develop educational materials*
- * *Conduct continuing education activities*

Operational Functions

- Perform inventory of supplies and equipment
- Perform routine maintenance of administrative and clinical equipment
- Apply computer techniques to support office operations
- * *Perform personnel management functions*
- * *Negotiate leases and prices for equipment and supply contracts*

* Denotes advanced skills.

Source: This chart is part of the "AAMA Role Delineation Study: Occupational Analysis of the Medical Assisting Profession," released by the American Association of Medical Assistants in June 2003.

APPENDIX II

Prefixes and Suffixes Commonly Used in Medical Terms

a-, an- without, not	dacry-, dacryo- tears, lacrimal apparatus	herni- rupture
ab- from, away	dactyl-, dactylo- finger, toe	hetero- other, unlike
ad-, -ad to, toward	de- down, from	histo- tissue
adeno- gland, glandular	deca- ten	homeo, homo- same, like
aero- air	deci- tenth	hydra-, hydro- water
-aesthesia sensation	demi- half	hyper- above, over, increased, excessive
-al characterized by	dent-, denti-, dento- teeth	hypo- below, under, decreased
-algia pain	derma-, dermat-, dermat-, -derm skin	hyster-, hystero- uterus
ambi-, amph-, amphi- both, on both sides, around	dextro- to the right	-ia condition
andr-, andro- man, male	di- double, twice	-iasis condition of
angio- blood vessel	dia- through, apart, between	-ic, -ical pertaining to
ano- anus	dipla-, diplo- double, twin	ictero- jaundice
ante- before	dis- apart, away from	idio- personal, self-produced
antero- in front of	dorsi-, dorso- back	ileo- ileum
anti- against, opposing	dynia- pain	im-, in-, ir- not
arterio- artery	dys- difficult, painful, bad, abnormal	in- in, into
arthro- joint	e-, ec-, ecto- away, from, without, outside	infra- beneath
-ase enzyme	-ectomy cutting out, surgical removal	inter- between, among
-asthenia weakness	em-, en- in, into, inside	intra-, intro- into, within, during
auto- self	-emesis vomiting	-ism condition, process, theory
bi- twice, double	-emia blood	-itis inflammation of
bili- bile	encephalo- brain	-ium membrane
bio- life	endo- within, inside	-ize to cause to be, to become, to treat by special method
blasto-, -blast developing stage, bud	entero- intestine	juxta- near, nearby
brachy- short	ento- within, inner	karyo- nucleus, nut
brady- slow	epi- on, above	kata-, kath- down, lower, under
broncho- bronchial (windpipe)	erythro- red	kera-, kerato- horn, hardness, cornea
cardio- heart	esthesio-, -esthesia sensation	kineto-, -kinesis, -kinetic motion
cata- down, lower, under	eu- good, true, normal	lact- milk
-cele swelling, tumor	ex-, exo- outside of, beyond, without	laparo- abdomen
-centesis puncture, tapping	extra- outside of, beyond, in addition	latero- side
centi- hundred	fibro- connective tissue	-lepsis, -lepsy seizure, convulsion
cephal-, cephalo- head	fore- before, in front of	leuco-, leuko- white
cerebr-, cerebro- brain	-form shape	levo- to the left
chol-, chole-, cholo- gall	-fuge driving away	lipo- fat
chondro- cartilage	galact-, galacto- milk	lith-, -lith stone
chromo- color	gastr-, gastro- stomach	-logy science of, study of
-cidal killing	-gene, -genic, -genetic, -genous arising from, origin, formation	-lysis setting free, disintegration, decomposition
-cide causing death	glosso- tongue	macro- large, long
circum- around	gluco-, glyco- sugar, sweet	mal- bad
-cise cut	-gram recorded information	-malacia abnormal softening
co-, com-, con- together, with	-graph instrument for recording	-mania insanity, abnormal desire
-coele cavity	-graphy the process of recording	mast-, masto- breast
colo- colon	-gravida pregnant female	med-, medi- middle
colp-, colpo- vagina	gyn-, gyno-, gyne-, gynec- woman, female	mega-, megalo- large, great
contra- against	haemo-, hemato-, hem-, hemo- blood	meio- contraction
cost-, costo- rib	hemi- half	melan-, melano- black
crani-, cranio- skull	hepa-, hepar-, hepato- liver	meno- month
cryo- cold		mes-, meso- middle
cysto-, -cyst bladder, bag		meta- beyond
-cyte, cyto- cell, cellular		

-meter measure
metro-, metra- uterus
-metry process of measuring
micro- small
mio- smaller, less
mono- single, one
multi- many
my-, myo- muscle
myel-, myelo- marrow
narco- sleep
nas-, naso- nose
necro- dead
neo- new
nephr-, nephro- kidney
neu-, neuro- nerve
niter-, nitro- nitrogen
non-, not- no
nucleo- nucleus
-nuli none
ob- against
oculo- eye
odont- tooth
-odynia pain
-oid resembling
-ole small, little
olig-, oligo- few, less than normal
-oma tumor
onco- tumor
oo- ovum, egg
oophor- ovary
ophthalmo- eye
-opia vision
-opsy to view
orchid- testicle
ortho- straight
os- mouth, bone
-osis disease, condition of
oste-, osteo- bone
-ostomy to make a mouth, opening
oto- ear
-otomy incision, surgical cutting
-ous having
oxy- sharp, acid
pachy- thick
paedo, pedo- child

pan- all, every
par; para- alongside of, with; woman who has given birth
path-, patho-, -pathy disease, suffering
ped-, pedi-, pedo- foot
-penia too few, lack, decreased
per- through, excessive
peri- around
pes- foot
-pexy surgical fixation
phag-, phagia, phago-, -phage eating, consuming, swallowing
pharyng- throat, pharynx
phlebo- vein
-phobia fear, abnormal fear
-phylaxis protection
-plasia formation or development
-plastic molded
-plasty operation to reconstruct, surgical repair
-plegia paralysis
pleuro- side, rib
pluri- more, several
pneo-, -pnea breathing
pneumo- air, lungs
-pod foot
poly- many, much
post- after, behind
pre-, pro- before, in front of
presby-, presbyo- old age
primi- first
procto- rectum
proto- first
pseudo- false
psych- the mind
pulmon-, pulmono- lung
pyelo- pelvis (renal)
pyo- pus
pyro- fever, heat
quadri- four
re- back, again
reni-, reno- kidney
retro- backward, behind
rhino- nose
-rrhage, -rrhagia abnormal or excessive discharge, hemorrhage, flow

-rrhaphy suture of
-rrhea flow, discharge
sacchar- sugar
sacro- sacrum
salpingo- tube, fallopian tube
sarco- flesh
sclero- hard, sclera
-sclerosis hardening
-scopy examining
semi- half
septi-, septic-, septic- poison, infection
-spasm cramp or twitching
-stasis stoppage
steno- contracted, narrow
stereo- firm, solid, three-dimensional
stomato- mouth
-stomy opening
sub- under
super-, supra- above, upon, excess
sym-, syn- with, together
tachy- fast
tele- distant, far
teno-, tenoto- tendon
tetra- four
-therapy treatment
thermo-, -thermy heat
thio- sulfur
thoraco- chest
thrombo- blood clot
thyro- thyroid gland
-tome cutting instrument
tomo-, -tomy incision, section
trans- across
tri- three
-tripsy surgical crushing
tropho-, -trophy nutrition, growth
-tropy turning, tendency
ultra- beyond, excess
uni- one
-uria urine
urino-, uro- urine, urinary organs
utero- uterus, uterine
vaso- vessel
ventri-, ventro- abdomen
xanth- yellow

APPENDIX III

Latin and Greek Equivalents Commonly Used in Medical Terms

abdomen	venter	hand	manus; cheir (Gr)	poison	venenum
adhesion	adhaesio	harelip	labrum fissum; cheiloschisis (Gr)	powder	pulvis
and	et	head	caput; kephale (Gr)	pregnant	praegnans, gravida
arm	brachium; brachion (Gr*)	health	sanitas	pubic bone	os pubis
artery	arteria	hear	audire	pupil	pupilla
back	dorsum	heart	cor; kardia (Gr)	rash	exanthema (Gr)
backbone	spina	heat	calor; therme (Gr)	recover	convalescere
backward	retro; opistho (Gr)	heel	calx, talus	redness	rubor
bend	flexus	hysterics	hysteria	rib	costa
bile	bilis; chole (Gr)	infant	infans	ringing	tinnitus
bladder	vesica, cystus	infectious	contagiosus	scaly	squamosus
blister	vesicula	injection	injectio	sciatica	sciaticus; ischiadikos (Gr)
blood	sanguis; haima (Gr)	intellect	intellectus	seed	semen
body	corpus; soma (Gr)	internal	internus	senile	senilis
bone	os, ossis; osteon (Gr)	intestine	intestinum; enteron (Gr)	sheath	vagina; theke (Gr)
brain	encephalon	itching	pruritis	short	brevis; brachys (Gr)
break	ruptura	jawbone	maxilla	shoulder	omos (Gr)
breast	mamma; mastos (Gr)	joint	vertebra; arthron (Gr)	shoulder blade	scapula
buttock	gloutos (Gr)	kidney	ren, renis; nephros (Gr)	side	latus
cartilage	cartilago; chondros (Gr)	knee	genu	skin	cutis; derma (Gr)
cavity	cavum	kneecap	patella	skull	cranium; kranion (Gr)
chest	pectoris, pectus; thorax (Gr)	lacerate	lacerare	sleep	somnus
child	puer, puerilis	larynx	guttur	solution	solutio
choke	strangulo	lateral	lateralis	spinal	spinalis
corn	clavus	limb	membrum	stomach	stomachus; gaster (Gr)
cornea	kerat (Gr)	lip	labium, labrum; cheilos (Gr)	stone	calculus
cough	tussis	listen	auscultare	sugar	saccharum
deadly	lethalis	liver	jecur; hepar (Gr)	swallow	glutio
death	mors	loin	lapara	tail	cauda
dental	dentalis	looseness	laxativus	taste	gustatio
digestive	pepticos	lung	pulmo; pneumon (Gr)	tear	lacrima
disease	morbus	male	masculinus	testicle	testis; orchis (Gr)
dislocation	luxatio	malignant	malignons	thigh	femur
doctor	medicus	milk	lac	throat	fauces; pharynx (Gr)
dose	dosis (Gr)	moisture	humiditas	tongue	lingua; glossa (Gr)
ear	auris; ous (Gr)	month	mensis	tooth	dens; odontos (Gr)
egg	ovum	monthly	menstruus	touch	tactus
erotic	erotikos (Gr)	mouth	oris, os; stoma, stomato (Gr)	tremor	tremere
exhalation	exhalatio, expiro	nail	unguis; onyx (Gr)	twin	gemellus
external	externus	navel	umbilicus; omphalos (Gr)	ulcer	ulcus
extract	extractum	neck	cervix; trachelos (Gr)	urine	urina; ouran (Gr)
eye	oculus; ophthalmos (Gr)	nerve	nervus; neuron (Gr)	uterus	hystera (Gr)
eyelid	palpebra	nipple	papilla; thele (Gr)	vagina	vagina; kolpos (Gr)
face	facies	no, none	nullus	vein	vena; phlebos, phleps (Gr)
fat	adeps; lipos (Gr)	nose	nasus; rhis (Gr)	vertebra	spondylos (Gr)
female	femella	nostril	naris	vessel	vas
fever	febris	nourishment	alimentum	wash	diluere
finger (or toe)	digitus	ointment	unguentum	water	aqua
flesh	carnis, caro	pain	dolor; algia	wax	cera
foot	pes	patient	patiens	weak	debilis
forehead	frons	pectoral	pectoralis	windpipe	arteria aspera
gum	gingiva	pimple	pustula	wrist	carpus; karpos (Gr)
hair	capillus, pilus; thrix (Gr)				

* Parenthetical "Gr" means the preceding term is Greek. Other terms in the column are Latin.

APPENDIX IV

Abbreviations Commonly Used in Medical Notations

a before	Dr. doctor	NED no evidence of disease
a.c. before meals	DTs delirium tremens	no. number
AD right ear	D/W dextrose in water	noc, noct night
ADD attention deficit disorder	Dx, dx diagnosis	npo, NPO nothing by mouth
ADL activities of daily living	ECG, EKG electrocardiogram	NPT new patient
ad lib as desired	ED emergency department	NS normal saline
ADT admission, discharge, transfer	EEG electroencephalogram	NSAID nonsteroidal anti-inflammatory drug
AIDS acquired immunodeficiency syndrome	EENT eyes, ears, nose, and throat	NTP normal temperature and pressure
a.m.a. against medical advice	EP established patient	N & V nausea and vomiting
AMA American Medical Association	ER emergency room	NYD not yet diagnosed
amp. ampule	ESR erythrocyte sedimentation rate	OB obstetrics
amt amount	FBS fasting blood sugar	OC oral contraceptive
aq., AQ water; aqueous	FDA Food and Drug Administration	o.d. once a day
AS left ear	FH family history	OD overdose
ausc. auscultation	Fl, fl, fld fluid	O.D., OD right eye
AU both ears	F/u follow-up	oint ointment
ax axis	Fx fracture	OOB out of bed
Bib, bib drink	GBS gallbladder series	OPD outpatient department
b.i.d., bid, BID twice a day	GI gastrointestinal	OPS outpatient services
BM bowel movement	Gm gram	OR operating room
BP, B/P blood pressure	gr grain	O.S., OS left eye
BPC blood pressure check	gt, gtt drops	OTC over-the-counter
BPH benign prostatic hypertrophy	GTT glucose tolerance test	O.U., OU both eyes
BSA body surface area	GU genitourinary	P & P Pap smear (Papanicolaou smear) and pelvic examination
c., c̄ with	GYN gynecology	PA posteroanterior
Ca calcium; cancer	HB, Hgb hemoglobin	Pap Pap smear
cap, caps capsules	HEENT head, ears, eyes, nose, throat	Path pathology
CBC complete blood (cell) count	HIV human immunodeficiency virus	p.c., pc after meals
cc cubic centimeter	HO history of	PE physical examination
C.C., CC chief complaint	h.s., hs, HS hour of sleep/at bedtime	per by, with
CDC Centers for Disease Control and Prevention	Hx history	PH past history
CHF congestive heart failure	ICU intensive care unit	PID pelvic inflammatory disease
chr chronic	I & D incision and drainage	p/o postoperative
CNS central nervous system	I & O intake and output	POMR problem-oriented medical record
Comp, comp compound	IM intramuscular	PMFSH past medical, family, social history
COPD chronic obstructive pulmonary disease	inf. infusion; inferior	PMS premenstrual syndrome
CP chest pain	inj injection	p.r.n., prn, PRN whenever necessary
CPE complete physical examination	IT inhalation therapy	Pt patient
CPR cardiopulmonary resuscitation	IUD intrauterine device	PT physical therapy
CSF cerebrospinal fluid	IV intravenous	PTA prior to admission
CT computed tomography	KUB kidneys, ureters, bladder	PVC premature ventricular contraction
CV cardiovascular	L1, L2, etc. lumbar vertebrae	pulv powder
d day	lab laboratory	q. every
d/c, D/C discontinue, discharge	liq liquid	q2, q2h every 2 hours
D & C dilation and curettage	LLL left lower lobe	q.a.m., qam every morning
DEA Drug Enforcement Administration	LLQ left lower quadrant	q.d., qd every day
Dil, dil dilute	LMP last menstrual period	q.h., qh every hour
DM diabetes mellitus	LUQ left upper quadrant	qhs every night, at bedtime
DOB date of birth	MI myocardial infarction	q.i.d., QID four times a day
DTP diphtheria-tetanus-pertussis vaccine	MM mucous membrane	
	MRI magnetic resonance imaging	
	MS multiple sclerosis	
	NB newborn	

qns, QNS quantity not sufficient
qod every other day
qs, QS quantity sufficient
RA rheumatoid arthritis; right atrium
RBC red blood cells; red blood (cell) count
RDA recommended dietary allowance, recommended daily allowance
REM rapid eye movement
RF rheumatoid factor
RLL right lower lobe
RLQ right lower quadrant
R/O rule out
ROM range of motion
ROS/SR review of systems/systems review
RUQ right upper quadrant
RV right ventricle
Rx prescription, take
SAD seasonal affective disorder
s.c., SC, SQ, subq, SubQ subcutaneously
SIDS sudden infant death syndrome
Sig directions

sig sigmoidoscopy
SOAP subjective, objective, assessment, plan
SOB shortness of breath
sol solution
S/R suture removal
ss, \overline{ss} one-half
Staph staphylococcus
stat, STAT immediately
STD sexually transmitted disease
Strep streptococcus
subling, SL sublingual
surg surgery
S/W saline in water
SX symptoms
T1, T2, etc. thoracic vertebrae
T & A tonsillectomy and adenoidectomy
tab tablet
TB tuberculosis
TBS, tbs. tablespoon
TIA transient ischemic attack
t.i.d., tid, TID three times a day
tinc, tinct, tr tincture

TMJ temporomandibular joint
top topically
TPR temperature, pulse, and respiration
tsp teaspoon
TSH thyroid stimulating hormone
Tx treatment
U unit
UA urinalysis
UCHD usual childhood diseases
UGI upper gastrointestinal
ung, ungt ointment
URI upper respiratory infection
US ultrasound
UTI urinary tract infection
VA visual acuity
VD venereal disease
Vf visual field
VS vital signs
WBC white blood cells; white blood (cell) count
WNL within normal limits
wt weight
y/o year old

APPENDIX V

Symbols Commonly Used in Medical Notations

Apothecaries' Weights and Measures

℥	minim
℥	scruple
ʒ	dram
℥	fluidram
℥	ounce
℥	fluidounce
℥	pint
℥	pound

Other Weights and Measures

#	pounds
°	degrees
'	foot; minute
"	inch; second
μm	micrometer
μ	micron (former term for micrometer)
mμ	millimicron; nanometer
μg	microgram
mEq	milliequivalent
mL	milliliter
dL	deciliter
mg%	milligrams percent; milligrams per 100 mL

Abbreviations

\overline{aa} , \overline{AA}	of each
\overline{c}	with

M	mix (Latin <i>misce</i>)
<i>m-</i>	meta-
<i>o-</i>	ortho-
<i>p-</i>	para-
\overline{p}	after
\overline{s}	without
ss, \overline{ss}	one-half (Latin <i>semis</i>)

Mathematical Functions and Terms

#	number
+	plus; positive; acid reaction
-	minus; negative; alkaline reaction
±	plus or minus; either positive or negative; indefinite
×	multiply; magnification; crossed with, hybrid
÷, /	divided by
=	equal to
≈	approximately equal to
>	greater than; from which is derived
<	less than; derived from
⩾	not less than
⩽	not greater than
≤	equal to or less than
≥	equal to or greater than
≠	not equal to
√	square root
$\sqrt[3]{}$	cube root
∞	infinity

:	ratio; "is to"
∴	therefore
%	percent
π	pi (3.14159)—the ratio of circumference of a circle to its diameter

Chemical Notations

Δ	change; heat
⇌	reversible reaction
↑	increase
↓	decrease

Warnings

Ⓒ	Schedule I controlled substance
Ⓓ	Schedule II controlled substance
Ⓔ	Schedule III controlled substance
Ⓕ	Schedule IV controlled substance
Ⓖ	Schedule V controlled substance
☠	poison
☢	radiation
☣	biohazard

Others

Rx	prescription; take
□, ♂	male
○, ♀	female
ī	one
īī	two
īīī	three

APPENDIX VI

Professional Organizations and Agencies

American Academy of Dental Practice Administrators

1063 Whippoorwill Lane
Palatine, IL 60067
(312) 934-4404

American Academy of Medical Administrators

30555 Southfield Road, Suite 150
Southfield, MI 48076
(313) 540-4310

American Academy of Ophthalmology

655 Beach Street
San Francisco, CA 94109
(415) 561-8500

American Academy of Pediatrics

PO Box 927
Elk Grove, IL 60009-0927
(708) 228-5005

American Association for Medical Transcription

PO Box 576187
Modesto, CA 95355
(209) 527-9620

American Association for Respiratory Care

11030 Ables Lane
Dallas, TX 75229
(214) 243-2272

American Association of Medical Assistants

20 N. Wacker Drive, Suite 1575
Chicago, IL 60606
(312) 899-1500

American Cancer Society

777 Third Avenue
New York, NY 10017
(212) 586-8700

American College of Cardiology

9111 Old Georgetown Road
Bethesda, MD 20814
(301) 897-5400

American College of Physicians

2011 Pennsylvania Avenue, NW
Washington, DC 20006
(202) 261-4500

American Diabetes Association

Two Park Avenue
New York, NY 10016
(212) 683-7444

American Dietetic Association

216 West Jackson Boulevard, Suite 800
Chicago, IL 60606-6995
(800) 366-1655

American Health Information Management Association

(formerly the American Medical Record Association)
233 N. Michigan Avenue, Suite 2150
Chicago, IL 60601-5800
(312) 233-1100

American Heart Association

National Center
7272 Greenville Avenue
Dallas, TX 75231-4596
(800) 242-8721, or call your local center

American Hospital Association

One North Franklin, Suite 2706
Chicago, IL 60606
(312) 422-3000

American Lung Association

1740 Broadway
New York, NY 10019
(212) 315-8700

American Medical Association

Division of Allied Health Education and Accreditation
515 North State Street
Chicago, IL 60610
(312) 464-5000

American Medical Technologists

710 Higgins Road
Park Ridge, IL 60068
(847) 823-5169

American Occupational Therapy Association

4720 Montgomery Lane
PO Box 31220
Bethesda, MD 20824-1220
(301) 948-9626

American Pharmacists Association

2215 Constitution Avenue, NW
Washington, DC 20037-2985
(202) 628-4410

American Physical Therapy Association

1111 North Fairfax Street
Alexandria, VA 22314
(703) 684-2782

American Red Cross

17th and D Streets, NW
Washington, DC 20006
(202) 728-6400, or call your local chapter

American Red Cross

HIV/AIDS Education, Health and Safety Services
8111 Gatehouse Road, 6th Floor
Falls Church, VA 22042
(703) 206-7180

American Society for Cardiovascular Professionals

120 Falcon Drive, Unit 3
Fredericksburg, VA 22408
(540) 891-0079

American Society for Clinical Laboratory Science

7910 Woodmont Avenue, Suite 1301
Bethesda, MD 20814
(301) 657-2768

American Society of Clinical Pathologists

2100 West Harrison Street
Chicago, IL 60612
(312) 738-1336

American Society of Hand Therapists

401 North Michigan Avenue
Chicago, IL 60611
(312) 321-6866

American Society of Phlebotomy Technicians

PO Box 1831
Hickory, NC 28603
(704) 322-1334

American Society of Radiologic Technologists

15000 Central Avenue SE
Albuquerque, NM 87123
(505) 298-4500

The Arthritis Foundation

1314 Spring Street, NW
Atlanta, GA 30309
(404) 872-7100

Association of Surgical Technologists

7108-C South Alton Way
Englewood, CO 80112
(303) 694-9130

**Association of Technical Personnel
in Ophthalmology**

50 Lee Road
Chestnut Hill, MA 02167
(617) 232-4433

**Asthma and Allergy Foundation
of America**

1717 Massachusetts Avenue, Suite 305
Washington, DC 20036
(202) 265-0265

**International Society for Clinical
Laboratory Technology**

818 Olive Street, Suite 918
St. Louis, MO 63101
(314) 241-1445

**Joint Commission on Allied Health
Personnel in Ophthalmology**

2025 Woodlane Drive
St. Paul, MN 55125-2995
(800) 284-3937

**Medical Group Management
Association**

104 Inverness Terrace East
Englewood Cliffs, CA 80112
(313) 799-1111

**National Accrediting Agency for
Clinical Laboratory Services**

8410 West Bryn Mawr Avenue, Suite 670
Chicago, IL 60631
(312) 714-8880

National AIDS Hotline

215 Park Avenue South, Suite 714
New York, NY 10003
(800) 342-AIDS
(800) 344-SIDA (Spanish)

**National Association of Medical
Staff Services**

PO Box 23590
Knoxville, TN 37933-1590
(615) 531-3571

National Cancer Institute

9000 Rockville Pike
Building 31, Room 10A18
Bethesda, MD 20205
(800) 4-CANCER

**National Clearinghouse for Alcohol
and Drug Information**

PO Box 2345
Rockville, MD 20852
(301) 468-2600

National Health Council

1730 Street NW, Suite 500
Washington, DC 20036
(202) 785-3910

National Health Information Center

PO Box 1133
Washington, DC 20013-1133
(800) 336-4797

National Institute of Mental Health

Office of Communications
6001 Executive Boulevard, Room 8184,
MSC 9663
Bethesda, MD 20892-9663
(301) 443-4513

National Institute on Aging

Building 31, Room 5C27
31 Center Drive, MSC 2292
Bethesda, MD 20892
(301) 496-1752

National Kidney Foundation

30 East 33rd Street
New York, NY 10016
(212) 889-2210

**National Mental Health
Association**

2001 N. Beauregard Street, 12th Floor
Alexandria, VA 22311
(703) 684-7722

**National Organization for Rare
Disorders**

100 Route 37, PO Box 8923
New Fairfield, CT 06812
(800) 999-NORD

National Phlebotomy Association

5615 Landover Road
Hyattsville, MD 20784
(301) 386-4200

National Rehabilitation Association

633 South Washington Street
Alexandria, VA 22314
(703) 836-0850

National Society for Histotechnology

4201 Northview Drive, Suite 502
Bowie, MD 20716-1073
(301) 262-6221

**President's Council on Physical Fitness
and Sports**

Department of Health and Human
Services
Washington, DC 20001
(202) 272-3421

**Society of Diagnostic Medical
Sonographers**

12770 Coit Road, Suite 508
Dallas, TX 75251
(214) 239-7367

Glossary

Note: (†) Pronunciation from Stedman's Medical Dictionary 26th edition, all others from American Heritage 4th edition, in case you need to consult.

- 10× lens (tén)** A magnifying lens in the ocular of a microscope that magnifies an image ten times.
- 24-hour urine specimen (twéntē fôr our yôor'ín spē'sə-mən)** A urine specimen collected over a 24-hour period and used to complete a quantitative and qualitative analysis of one or more substances, such as sodium, chloride, and calcium.
- abandonment (ə-bān'dən-mənt)** A situation in which a health-care professional stops caring for a patient without arranging for care by an equally qualified substitute.
- ABA number (nūm'bər)** A fraction appearing in the upper right corner of all printed checks that identifies the geographic area and specific bank on which the check is drawn.
- abduction (ab-dūk'shūn) (†)** Movement away from the body.
- abscess (əb'sēs')** A collection of pus (white blood cells, bacteria, and dead skin cells) that forms as a result of infection.
- absorption (əb-sôrp'shən)** The process by which one substance is absorbed, or taken in and incorporated, into another, as when the body converts food or drugs into a form it can use.
- access (ək'sēs)** The way patients enter and exit a medical office.
- accessibility (ək-sēs'ə-bīl'ī-tē)** The ease with which people can move into and out of a space.
- accounts payable (ə-kəunt's pā-ā-bəl)** Money owed by a business; the practice's expenses.
- accounts receivable (ə-kəunt's rī-sē'və-bəl)** Income or money owed to a business.
- accreditation (ə-krəd'ī-tā'shən)** The documentation of official authorization or approval of a program.
- acetylcholine (as-e-tīl-kō'lēn) (†)** A neurotransmitter released by the parasympathetic nerves onto organs and glands for resting and digesting.
- acetylcholinesterase (asē-tīl-kō-līn-estē-ās)** An enzyme within the nervous system that hydrolyzes acetylcholine to acetate and choline.
- acid-fast stain (ās'īd fāst stān)** A staining procedure for identifying bacteria that have a waxy cell wall.
- acids (ās'īds)** Electrolytes that release hydrogen ions in water.
- acinar cells (asī-nar sēlz) (†)** Cells in the pancreas that produce pancreatic juice.
- acquired immunodeficiency syndrome (AIDS) (ə-kwīrd im'yū-nō-dē-fish'ēnsē sīn'drōm') (†)** The most advanced stage of HIV infection; it severely weakens the body's immune system.
- acromegaly (ak-rō-meg'ā-lē) (†)** A disorder in which too much growth hormone is produced in adults.
- acrosome (ak'rō-sōm) (†)** An enzyme-filled sac covering the head of a sperm that aids in the penetration of the egg during fertilization.
- action potential (āk'shən pə-tēn'shəl)** The flow of electrical current along the axon membrane.
- active file (āk'tīv fīl)** A file used on a consistent basis.
- active listening (āk'tīv līs'ənīŋ)** Part of two-way communication, such as offering feedback or asking questions; contrast with **passive listening**.
- active transport (ak'tiv trans-pōrt)** The movement of a substance across a cell membrane from an area of low concentration to an area of high concentration.
- acupuncturist (āk'yōō-pūngk'chər-īst)** A practitioner of acupuncture. The acupuncturist uses hollow needles inserted into the patient's skin to treat pain, discomfort, or systemic imbalances.
- acute (ə-kyōōt')** Having a rapid onset and progress, as acute appendicitis.
- addiction (ā-dīk'shun) (†)** A physical or psychological dependence on a substance, usually involving a pattern of behavior that includes obsessive or compulsive preoccupation with the substance and the security of its supply, as well as a high rate of relapse after withdrawal.
- add-on code (ād'on' kōd)** A code indicating procedures that are usually carried out in addition to another procedure. Add-on codes are used together with the primary code.
- adduction (ā-dūk'shūn) (†)** Movement toward the body.
- adenoids (ād'n-oidz')** See **pharyngeal tonsils**.
- administer (ād-mīn'ī-stər)** To give a drug directly by injection, by mouth, or by any other route that introduces the drug into the body.
- adrenocorticotrophic hormone (ā-drē'nō-kōr'ti-kō-trōpik hōr'mōn)** Hormone that stimulates the adrenal cortex to release its hormones.
- advance scheduling (ād-vāns skěj'ool-īng)** Booking an appointment several weeks or even months in advance.
- aerobes (ār'ōbs')** Bacteria that grow best in the presence of oxygen.
- aerobic respiration (ār-rō'bik rēs'pə-rā'shən)** A process that requires large amounts of oxygen and uses glucose to make ATP.
- afebrile (ā-feb'rīl) (†)** Having a body temperature within one's normal range.
- afferent arterioles (āf'ər-ənt ar-tēr'ē-ōlz) (†)** Structures that deliver blood to the glomeruli of the kidneys.
- affiliation agreement (ə-fīl'ē-ā'shən ə-grē'mənt)** An agreement that externship participants must sign that states the expectations of the facility and the expectations of the student.
- agar (ā'gār')** A gelatinlike substance derived from seaweed that gives a culture medium its semisolid consistency.
- age analysis (āj ə-nāl'ī-sīs)** The process of clarifying and reviewing past due accounts by age from the first date of billing.
- agenda (ə-jēn'də)** The list of topics discussed or presented at a meeting, in order of presentation.
- agent (ā-jənt)** (legal) A person who acts on a physician's behalf while performing professional tasks; (clinical) an active principle or entity that produces a certain effect, for example, an infectious agent.
- agglutination (ā-glū-ti-nā'shūn) (†)** The clumping of red blood cells following a blood transfusion.
- aggressive (ə-grēs'īv)** Imposing one's position on others or trying to manipulate them.
- agranular leukocyte (ā-gran'yulər lū'kō-sīt) (†)** A type of leukocyte

(white blood cell) with a solid nucleus and clear cytoplasm; includes lymphocytes and monocytes.

agranulocyte (ă-gran'yū-lō-sīt) (†) See **agranular leukocyte**.

albumins (āl-byōō mīns) The smallest of the plasma proteins. Albumins are important for pulling water into the bloodstream to help maintain blood pressure.

aldosterone (al-dos'ter-ōn) (†) A hormone produced in the adrenal glands that acts on the kidney. It causes the body to retain sodium and excrete potassium. Its role is to maintain blood volume and pressure.

alimentary canal (āl'ə-mēn'tə-rē kə-nāl') The organs of the digestive system that extend from the mouth to the anus.

allele (ə-lēl') Any one of a pair or series of **genes** that occupy a specific position on a specific **chromosome**.

allergen (āl'ər-jən) An antigen that induces an allergic reaction.

allergist (āl'ər-jīst) A specialist who diagnoses and treats physical reactions to substances including mold, dust, fur, pollen, foods, drugs, and chemicals.

allowed charge (ə-loud' chārj) The amount that is the most the payer will pay any provider for each procedure or service.

alopecia (āl'ə-pē'shə) The clinical term for baldness.

alphabetic filing system (āl'fə-bēt'īkəl fī'ling sis'təm) A filing system in which the files are arranged in alphabetic order, with the patient's last name first, followed by the first name and middle initial.

Alphabetic Index (āl'fə-bēt'īk ĩn'dēks') One of two ways diagnoses are listed in the ICD-9-CM. They appear in alphabetic order with their corresponding diagnosis codes.

alveolar glands (al-vē'ō-lār glāndz) (†) Glands that make milk under the influence of the hormone **prolactin**.

alveoli (āl-vē'ə-lī') Clusters of air sacs in which the exchange of gases between air and blood takes place; located in the lungs.

American Association of Medical Assistants (AAMA) (ə-mēr'īkən ə-sō'sē-ā'shən mēd'ī-kəl ə-sīs'tants) The professional organization that certifies medical assistants and works to maintain professional standards in the medical assisting profession.

Americans With Disabilities Act (ADA) (ə-mēr'ī-kəns dīs'ə-bīl'ī-tēs ākt) A U.S. civil rights act forbidding discrimination against people because of a physical or mental handicap.

amblyopia (am-blē'ō-pē-ā) (†) Poor vision in one eye without a detectable cause.

amino acids (ə-mēnō ā'sīds) Natural organic compounds found in plant and animal foods and used by the body to create protein.

amnion (ām'nē-ən) The innermost membrane enveloping the embryo and containing amniotic fluid.

anabolism (ə-nāb'ə-līz'əm) The stage of metabolism in which substances such as nutrients are changed into more complex substances and used to build body tissues.

anaerobe (ān'ə-rōb') A bacterium that grows best in the absence of oxygen.

anal canal (ā'nəl kə-nāl') The last few centimeters of the rectum.

anaphylaxis (an'ā-fī-lāk'sis) A severe allergic reaction with symptoms that include respiratory distress, difficulty in swallowing, pallor, and a drastic drop in blood pressure that can lead to circulatory collapse.

anatomical position (ān'ə-tōm'ī-kəl pə-zīsh'ən) When the body is standing upright and facing forward with the arms at the side and the palms of the hands facing forward.

anatomy (ə-nāt'ə-mē) The scientific term for the study of body structure.

anemia (ə-nēmē-ə) A condition characterized by low red blood cell count. This condition decreases the ability to transport oxygen throughout the body.

anergic reaction (an-er'jik rē-āk'shən) A lack of response to skin testing that indicates the body's inability to mount a normal response to invasion by a pathogen.

anesthesia (ān'īs-thē'zhə) A loss of sensation, particularly the feeling of pain.

anesthetic (ān'īs-thē'tīk) A medication that causes anesthesia.

anesthetist (ā-nes'thē-tist) (†) A specialist who uses medications to cause patients to lose sensation or feeling during surgery.

aneurysm (ān'yə-rīz'əm) A serious and potentially life-threatening bulge in the wall of a blood vessel.

angiography (an-jē-og'rā-fē) (†) An x-ray examination of a blood vessel, performed after the injection of a contrast medium, that evaluates the function and structure of one or more arteries or veins.

angiotensin II (an-jē'ō-ten'sin tōō) (†) A hormone that raises blood pressure and causes the secretion of another hormone called **aldosterone**.

annotate (ān'ō-tāt') To underline or highlight key points of a document or to write reminders, make comments, and suggest actions in the margins.

anorexia nervosa (ān'ə-rēk'sē-ə nūr-vō'sə) An eating disorder in which people starve themselves because they fear that if they lose control of eating they will become grossly overweight.

antagonist (ān-tāg'ə-nīst) A muscle that produces the opposite movement of the **prime mover**.

antecubital space (an-te-kyū'bi-tāl spās) The inner side or bend of the elbow; the site at which the brachial artery is felt or heard when a pulse or blood pressure is taken.

anterior (ān-tīr'ē-ər) Anatomical term meaning toward the front of the body; also called ventral.

antibodies (ān'tī-bod'ēs) Highly specific proteins that attach themselves to foreign substances in an initial step in destroying such substances, as part of the body's defenses.

antidiuretic hormone (an'tē-dī-yū-ret'īk hōr'mōn') (†) A hormone that increases water reabsorption, which decreases urine production and helps to maintain blood pressure.

antigen (an'tī-jən) A foreign substance that stimulates white blood cells to create antibodies when it enters the body.

antihistamines (ān'tē-hīs'tə-mēnz) Medications used to treat allergies.

antimicrobial (an'tē-mī-krō'bē-āl) (†) An agent that kills microorganisms or suppresses their growth.

antioxidants (ān'tē-ōk'sī-dənt) Chemical agents that fight cell-destroying chemical substances called free radicals.

antiseptic (ān'tī-sēp'tīk) A cleaning product used on human tissue as an anti-infection agent.

anuria (an-yū-rē-ā) (†) The absence of urine production.

aortic valve (ā-ōr'tīk vālv) Heart valve that is a semilunar valve and that is

- situated between the left ventricle and the aorta.
- apex (á'pěks)** The left lower corner of the heart, where the strongest heart sounds can be heard.
- apical (ap'i-kál)(†)** Located at the apex of the heart.
- apocrine gland (ap'ō-krin glánd)(†)** A type of sweat gland. It produces a thicker type of sweat than other sweat glands and contains more proteins.
- aponeurosis (ap'ō-nū-rō'sis)(†)** A tough, sheet-like structure that is made of fibrous connective tissue. It typically attaches muscles to other muscles.
- appendicitis (ə-pěn'dī-sī'tis)** Inflammation of the appendix.
- appendicular (ap'en-dik'yū-lār)** The division of the skeletal system that consists of the bones of the arms, legs, pectoral girdle, and pelvic girdle.
- approximation (ə-prōk'sə-má'shən)**
The process of bringing the edges of a wound together, so the tissue surfaces are close, to protect the area from further contamination and to minimize scar and scab formation.
- aqueous humor (á'kwē-əs hyōō'mər)**
A liquid produced by the eye's ciliary body that fills the space between the cornea and the lens.
- arbitration (ár'bī-trā'shən)** A process in which opposing sides choose a person or persons outside the court system, often someone with special knowledge in the field, to hear and decide a dispute.
- areflexia (ā-rē-flek'sē-ā)(†)** The absence of reflexes.
- areola (ā-rē-ō-lā)(†)** The pigmented area that surrounds the nipple.
- arrector pili (ā-rek'tōr pī'li)(†)**
Muscles attached to most hair follicles and found in the dermis.
- arrhythmia (ə-rith'mē-ə)** Irregularity in heart rhythm.
- arterial blood gases (ár-tīr'ē-əl blūd gās'ses)** A test that measures the amount of gases, such as oxygen and carbon dioxide, dissolved in arterial blood.
- arthrography (ar-throg'rā-fē)(†)** A radiologic procedure performed by a radiologist, who uses a contrast medium and fluoroscopy to help diagnose abnormalities or injuries in the cartilage, tendons, or ligaments of the joints—usually the knee or shoulder.
- arthroscopy (ār-thōs'kə-pē)** A procedure in which an orthopedist examines a joint, usually the knee or shoulder, with a tubular instrument called an arthroscope; also used to guide surgical procedures.
- articular cartilage (ar-tik'yū-lār kār'tl-ij)(†)** The cartilage that covers the epiphysis of long bones.
- artifact (ár'tə-fákt')** Any irrelevant object or mark observed when examining specimens or graphic records that is not related to the object being examined; for example, a foreign object visible through a microscope or an erroneous mark on an ECG strip.
- ascending colon (ə-sénd'ing kō'lən)**
The segment of the large intestine that runs up the right side of the abdominal cavity.
- ascending tracts (ə-sénd'ing trákt's)**
The tracts of the spinal cord that carry sensory information to the brain.
- asepsis (ā-sep'sis)(†)** The condition in which pathogens are absent or controlled.
- assault (ə-sólt')** The open threat of bodily harm to another.
- assertive (ə-súr'tív)** Being firm and standing up for oneself while showing respect for others.
- asset (ás'ět')** An item owned by the practice that has a dollar value, such as the medical practice building, office equipment, or accounts receivable.
- assignment of benefits (ə-sin'mənt bēn'ə-fīts)** An authorization for an insurance carrier to pay a physician or practice directly.
- astigmatism (ə-stig'mə-tíz'əm)** A condition in which the cornea has an abnormal shape, which causes blurred images during near or distant vision.
- atherosclerosis (áth'ə-rō-sklə-rō'sis)**
The accumulation of fatty deposits along the inner walls of arteries.
- atlas (át'ləs)** The first cervical vertebra.
- atoms (át'əmz)** The simplest units of all matter.
- atria (á'trē-ā)(†) [Singular: atrium]**
Chambers of the heart that receive blood from the veins and circulate it to the ventricles.
- atrial natriuretic peptide (á'trē-əl ná'trē-yū-ret'ik pep'tid)(†)** A hormone secreted by the heart that regulates blood pressure.
- atrioventricular bundle (á'trē-ō-ventrik'yū-lar bŭn'dl)(†)** A structure that is located between the ventricles of the heart and that sends the electrical impulse to the Purkinje fibers.
- atrioventricular node (á'trē-ō-ventrik'yū-lar nōd)** A node that is located between the atria of the heart. After the electrical impulse reaches the atrioventricular node, the atria contract and the impulse is sent to the ventricles.
- audiologist (aw-dē-ol'ōjist)(†)** A health-care specialist who focuses on evaluating and correcting hearing problems.
- audiometer (aw-dē-om'ē-ter)** An electronic device that measures hearing acuity by producing sounds in specific frequencies and intensities.
- auditory tube (ó'dī-tōr'ē tōōb)** A structure that connects the middle ear to the throat. Also called the **eustachian tube**.
- auricle (ōr'i-kəl)** The outside part of the ear, made of cartilage and covered with skin.
- auscultated blood pressure (ó'skəl-tāt-əd blūd prěsh'ər)** Blood pressure as measured by listening with a stethoscope.
- auscultation (ó'skəl-t ā'shən)** The process of listening to body sounds.
- authorization (ó'thər-ī-zā'shən)** A form that explains in detail the standards for the use and disclosure of patient information for purposes other than treatment, payment, or health-care operations.
- autoclave (aw'tō-klāv)(†)** A device that uses pressurized steam to sterilize instruments and equipment.
- automated external defibrillator (AED) (ó'tə-má'tid ik-stúr'nəl dē-fib'ri-lā-ter)**
A computerized defibrillator programmed to recognize lethal heart rhythms and deliver an electrical shock to restore a normal rhythm.
- autonomic (ó'tə-nóm'ik)** A division of the peripheral nervous system that connects the central nervous system to viscera such as the heart, stomach, intestines, glands, blood vessels, and bladder.
- autosome (ó'tə-sóm')** A chromosome that is not a sex chromosome.
- axial (áksē-əl)** The division of the skeletal system that consists of the skull, vertebral column, and rib cage.
- axilla (áks-sil'ə)** Armpit; one of the four locations for temperature readings.
- axis (áks-səs)** The second vertebra of the neck on which the head turns.
- axon (áks'són')** A type of nerve fiber that is typically long and branches far from the cell body. Its function is to send information away from the cell body.
- bacillus (ba-sil'ŭs)(†)** A rod-shaped bacterium.
- bacterial spore (bákt-tír'ēəl spōr)** A primitive, thick-walled reproductive

- body capable of developing into a new individual; resistant to killing through disinfection.
- balance billing (bāl'əns bīl'ɪŋ)** Billing a patient for the difference between a higher usual fee and a lower allowed charge.
- barium enema (bār'ē-əm ɛn'ə-mə)** A radiologic procedure performed by a radiologist who administers barium sulfate through the anus, into the rectum, and then into the colon to help diagnose and evaluate obstructions, ulcers, polyps, diverticulosis, tumors, or motility problems of the colon or rectum; also called a lower GI (gastrointestinal) series.
- barium swallow (bār'ē-əm swōl'ə)** A radiologic procedure that involves oral administration of a barium sulfate drink to help diagnose and evaluate obstructions, ulcers, polyps, diverticulosis, tumors, or motility problems of the esophagus, stomach, duodenum, and small intestine; also called an upper GI (gastrointestinal) series.
- baroreceptors (bar'ō-rē-sep'ters) (†)** Structures, located in the aorta and carotid arteries, that help regulate blood pressure.
- bases (bā'sēz')** Electrolytes that release hydroxyl ions in water.
- basophil (bā-sō-fil) (†)** A type of granular leukocyte that produces the chemical histamine, which aids the body in controlling allergic reactions and other exaggerated immunologic responses.
- battery (bāt'ə-rē)** An action that causes bodily harm to another.
- behavior modification (bī-hāv'yər mōd'ə-fī-kā-shən)** The altering of personal habits to promote a healthier lifestyle.
- benefits (bɛn'ə-fits)** Payments for medical services.
- bicarbonate ions (bī-kar'bon-āt'ionz)** Elements formed when carbon dioxide gets into the bloodstream and reacts with water. In the alimentary canal, these ions neutralize acidic chyme arriving from the stomach.
- bicuspid (bī-kūs'pids)** Teeth with two cusps. There are two in front of each set of molars.
- bicuspid valve (bī-kūs'pid vālv)** Heart valve that has two cusps and that is located between the left atrium and the left ventricle. Also known as the mitral valve.
- bile (bil)** A substance created in the liver and stored in the gallbladder.
- Bile is a bitter yellow-green fluid that is used in the digestion of fats.
- bilirubin (bīl-i-rū'bin) (†)** A bile pigment formed by the breakdown of hemoglobin in the liver.
- bilirubinuria (bil'i-rū-bi-nū'rē-ā) (†)** The presence of bilirubin in the urine; one of the first signs of liver disease or conditions that involve the liver.
- birthday rule (būrth'dā'rōol)** A rule that states that the insurance policy of a policyholder whose birthday comes first in the year is the primary payer for all dependents.
- biliverdin (bil-i-ver'din) (†)** A pigment released when a red blood cell is destroyed.
- biochemistry (bī'ō-kēm'ī-strē)** The study of matter and chemical reactions in the body.
- bioethics (bī'ō-ēth'iks)** Principles of right and wrong in issues that arise from medical advances.
- biohazard symbol (bī'ō-hāz'ərd sīm'bəl)** A symbol that must appear on all containers used to store waste products, blood, blood products, or other specimens that may be infectious.
- biohazardous materials (bī'ō-hāz'ərd-əs mē-tīr'ə-əls)** Biological agents that can spread disease to living things.
- biohazardous waste container (bī'ō-hāz'ərd-əs wāst kən-tā'nər)** A leakproof, puncture-resistant container, color-coded red or labeled with a special biohazard symbol, that is used to store and dispose of contaminated supplies and equipment.
- biopsy (bī'ōps'ē)** The process of removing and examining tissues and cells from the body.
- biopsy specimen (bī'ōps'ē spēs'ə-mən)** A small amount of tissue removed from the body for examination under a microscope to diagnose an illness.
- bioterrorism (bī'ō-tēr'ə-rīz'əm)** The intentional release of a biologic agent with the intent to harm individuals.
- blastocyst (blas'tō-sist)** A morula that travels down the uterine tube to the uterus and is invaded with fluid. It then implants into the wall of the uterus.
- blood-borne pathogen (blūd-bōrn pāth'ə-jən)** A disease-causing microorganism carried in a host's blood and transmitted through contact with infected blood, tissue, or body fluids.
- blood-brain barrier (blūd brān bār'ē-ər)** A structure that is formed from tight capillaries to protect the tissues of the central nervous system from certain substances.
- B lymphocyte (bē līm'fə-sīt')** A type of nongranular leukocyte that produces antibodies to combat specific pathogens.
- body language (bōd'ē lāŋg'wɪj)** Non-verbal communication, including facial expressions, eye contact, posture, touch, and attention to personal space.
- bookkeeping (bōok'kē'pɪŋ)** The systematic recording of business transactions.
- bone conduction (bōnkən-dūk'shən)** The process by which sound waves pass through the bones of the skull directly to the inner ear, bypassing the outer and middle ears.
- botulism (bōch'ə-līz'əm)** A life-threatening type of food poisoning that results from eating improperly canned or preserved foods that have been contaminated with the bacterium *Clostridium botulinum*.
- brachial artery (brāk'ē-əl ār'tə-rē)** An artery that provides a palpable pulse and audible vascular sounds in the antecubital space (the bend of the elbow).
- brachytherapy (brak-ē-thār'ā-pe') (†)** A radiation therapy technique in which a radiologist places temporary radioactive implants close to or directly into cancerous tissue; used for treating localized cancers.
- brain stem (brān stēm)** A structure that connects the cerebrum to the spinal cord.
- breach of contract (brēch kōn'trākt')** The violation of or failure to live up to a contract's terms.
- bronchi (brōn-ki)** The two branches of the trachea that enter the lungs.
- bronchial tree (brōŋg'kē-əl trē)** A series of tubes that begins where the distal end of the trachea branches.
- bronchioles (brōŋg'kē-ōlz)** A part of the respiratory tract that branches from the tertiary bronchi.
- buccal (būk'āl) (†)** Between the cheek and gum.
- bulbourethral glands (būl'bō-yū-rē'thrāl glāndz) (†)** Glands that lie beneath the prostate and empty their fluid into the urethra. Their fluid aids in sperm movement.
- buffy coat (buf'ē kōt)** The layer between the packed red blood cells and plasma in a centrifuged blood sample; this layer contains the white blood cells and platelets.

- bulimia** (būō-lē'mē-ə) An eating disorder in which people eat a large quantity of food in a short period of time (bingeing) and then attempt to counter the effects of bingeing by self-induced vomiting, use of laxatives or diuretics, and/or excessive exercise.
- burnout** ('bər-naūt) The end result of prolonged periods of stress without relief. Burnout is an energy-depleting condition that can affect one's health and career. It can be common for those who work in health care.
- bursitis** (bər-sī'tis) Inflammation of a bursa.
- calcaneus** (kal-kā-nē-ūs)(†) The largest tarsal bone; also called the heel bone.
- calcitonin** (kal-si-tō'nin) A hormone produced by the thyroid gland that lowers blood calcium levels by activating osteoblasts.
- calibrate** (kāl'ə-brāt) to determine the caliber of.
- calibration syringe** (kāl'ə-brā'shən sə-rinj) A standardized measuring instrument used to check and adjust the volume indicator on a spirometer.
- calorie** (kāl'ə-rē) A unit used to measure the amount of energy food produces; the amount of energy needed to raise the temperature of 1 kg of water by 1°C.
- calyces** (kāl'i-sēz') Small cavities of the renal pelvis of the kidney.
- canaliculi** (kan-ā-lik'yū-lī) Tiny canals that connect lacunae to each other.
- capillary** (kăp'ə-lēr'ē) Branches of arterioles and the smallest type of blood vessel.
- capillary puncture** (kăp'ə-lēr'ē pŭngk'chər) A blood-drawing technique that requires a superficial puncture of the skin with a sharp point.
- capitation** (kăp'ī-tā'shən) A payment structure in which a health maintenance organization prepays an annual set fee per patient to a physician.
- carboxypeptidase** (kar-bok-sē-pep'ti-dās)(†) A pancreatic enzyme that digests proteins.
- carcinogen** (kăr-sin'ə-jən) A factor that is known to cause the formation of cancer.
- cardiac catheterization** (kăr'dē-āk' kath'ē-ter-ī-zā'shun)(†) A diagnostic method in which a catheter is inserted into a vein or artery in the arm or leg and passed through blood vessels into the heart.
- cardiac cycle** (kăr'dē-āk' sī'kəl) The sequence of contraction and relaxation that makes up a complete heartbeat.
- cardiologist** (kăr'dē-ōl'ə-jist) A specialist who diagnoses and treats diseases of the heart and blood vessels (cardiovascular diseases).
- carditis** (kar-dī'tis)(†) Inflammation of the heart.
- carpal** (kăr'pəl) Bones of the wrist.
- carpal tunnel syndrome** (kăr'pəl tŭn'əl sīn'drōm') A painful disorder caused by compression of the median nerve in the carpal tunnel of the wrist.
- carrier** (kăr'ē-ər) A reservoir host who is unaware of the presence of a pathogen and so spreads the disease while exhibiting no symptoms of infection.
- cast** (kăst) A rigid, external dressing, usually made of plaster or fiberglass, that is molded to the contours of the body part to which it is applied; used to immobilize a fractured or dislocated bone. Cylinder-shaped elements with flat or rounded ends, differing in composition and size, that form when protein from the breakdown of cells accumulates and precipitates in the kidney tubules and is washed into the urine.
- catabolism** (kə-tăb'ə-liz'əm) The stage of metabolism in which complex substances, including nutrients and body tissues, are broken down into simpler substances and converted into energy.
- cataracts** (kăt'ə-răkts') Cloudy areas that form in the lens of the eye that prevent light from reaching visual receptors.
- cash flow statement** (kăsh flō stāmənt) A statement that shows the cash on hand at the beginning of a period, the income and disbursements made during the period, and the new amount of cash on hand at the end of the period.
- cashier's check** (kă-shīrz' chē'k) A bank check issued by a bank on bank paper and signed by a bank representative; usually purchased by individuals who do not have checking accounts.
- catheterization** (kath'ē-ter-ī-zā'shun)(†) The procedure during which a catheter is inserted into a vessel, an organ, or a body cavity.
- caudal** (kōd'l) See **inferior**.
- CD-ROM** (sē'dē'rōm') A compact disc that contains software programs; an abbreviation for "compact disc—read-only memory."
- cecum** (sē'kəm) The first section of the large intestine.
- cell body** (sēl bōd'ē) The portion of the neuron that contains the nucleus and organelles.
- cell membrane** (sēl mēm'brān') The outer limit of a cell that is thin and selectively permeable. It controls the movement of substances into and out of the cell.
- cells** (sēlz) The smallest living units of structure and function.
- cellulitis** (sel-yū-lī'tis) Inflammation of cellular or connective tissue.
- cellulose** (sēl'yə-lōs') A type of carbohydrate that is found in vegetables and cannot be digested by humans; commonly called fiber.
- Celsius** (centigrade) (sēl'sē-əs) One of two common scales for measuring temperature; measured in degrees Celsius, or °C.
- Centers for Medicare and Medicaid Services (CMS)** (sēn'tərs mēd'ī-kār' mēd'ī-kād' sŭr'vīs-əz) A congressional agency designed to handle Medicare and Medicaid insurance claims. It was formerly known as the Health Care Financing Administration.
- central nervous system (CNS)** (sēn'trəl nŭr'vəs sīs'təm) A system that consists of the brain and the spinal cord.
- central processing unit (CPU)** (sēn'trəl prōs'es'ing yōō'nīt) A microprocessor, the primary computer chip responsible for interpreting and executing programs.
- centrifuge** (sēn'trə-fyōōj) A device used to spin a specimen at high speed until it separates into its component parts.
- cerebellum** (sēr'ə-bēl'əm) An area of the brain inferior to the cerebrum that coordinates complex skeletal muscle coordination.
- cerebrospinal fluid (CSF)** (ser'ē-brō-spī-nāl flōō'id) The fluid in the subarachnoid space of the meninges and the central canal of the spinal cord.
- cerebrum** (sēr'ə-brəm) The largest part of the brain; it mainly includes the cerebral hemispheres.
- Certificate of Waiver tests** (sər-tif'ī-kīt wā'vər tēsts) Laboratory tests that pose an insignificant risk to the patient if they are performed or interpreted incorrectly, are simple and

accurate to such a degree that the risk of obtaining incorrect results is minimal, and have been approved by the Food and Drug Administration for use by patients at home; laboratories performing only Certificate of Waiver tests must meet less stringent standards than laboratories that perform tests in other categories.

certified check (sūr'tə-fīd' chĕk) A payer's check written and signed by the payer, which is stamped "certified" by the bank. The bank has already drawn money from the payer's account to guarantee that the check will be paid.

Certified Medical Assistant (CMA) (sūr'tə-fīd' mĕd'ī-kəl ə-sīs'tənt) A medical assistant whose knowledge about the skills of medical assistants, as summarized by the 2003 AAMA Role Delineation Study areas of competence, has been certified by the Certifying Board of the American Association of Medical Assistants (AAMA).

cerumen (sə-rŭŏ'mən) A waxlike substance produced by glands in the ear canal; also called earwax.

cervical enlargement (sūr'vī-kəl in-lār'j-mənt) The thickening of the spinal cord in the neck region.

cervical orifice (sūr'vī-kəl ôr'ə-fis) The opening of the uterus through the cervix into the vagina.

cervicitis (ser-vi-sī'tis) Inflammation of the cervix.

cervix (sūr'vīks) The lowest portion of the uterus that extends into the vagina.

chain of custody (chān kŭs'tə-dĕ) A procedure for ensuring that a specimen is obtained from a specified individual, is correctly identified, is under the uninterrupted control of authorized personnel, and has not been altered or replaced.

CHAMPVA (Civilian Health and Medical Program of the Veterans Administration) (sī-vīl'yən hĕlth mĕd'ī-kəl prŏ'grām vĕt'ər-enz əd-mīn'ī-strā'shən) A type of health insurance that covers the expenses of families (dependent spouses and children) of veterans with total, permanent, and service-connected disabilities. It also covers the surviving families of veterans who die in the line of duty or as a result of service-connected disabilities.

chancre (shang'ker)(†) A painless ulcer that may appear on the tongue, the lips, the genitalia, the rectum, or elsewhere.

charge slip (chārj slīp) The original record of services performed for a patient and the charges for those services.

check (chĕk) A bank draft or order written by a payer that directs the bank to pay a sum of money on demand to the payee.

chemistry (kĕm'ī-strĕ) The study of the composition of matter and how matter changes.

chemoreceptor (kĕmŏ-rī-sĕp'tŏr) Any cell that is activated by a change in chemical concentration and results in a nerve impulse. The olfactory or smell receptors in the nose are an example of a chemoreceptor.

chief cells (chĕf sĕlz) Cells in the lining of the stomach that secrete pepsinogen.

chief complaint (chĕf kəm-plān't) The patient's main issue of pain or ailment.

chiropractor (kī'rə-prāk'tŏr) A physician who uses a system of therapy, including manipulation of the spine, to treat illness or pain. This treatment is done without drugs or surgery.

cholangiography (kŏ-lan-jĕ-ŏg'rā-fĕ)(†) A test that evaluates the function of the bile ducts by injection of a contrast medium directly into the common bile duct (during gallbladder surgery) or through a T-tube (after gallbladder surgery or during radiologic testing) and taking an x-ray.

cholecystography (kŏ-lĕ-sis-tŏg'rā-fĕ)(†) A gallbladder function test performed by x-ray after the patient ingests an oral contrast agent; used to detect gallstones and bile duct obstruction.

cholesterol (kŏ-lĕs'tə-rŏl) A fat-related substance that the body produces in the liver and obtains from dietary sources; needed in small amounts to carry out several vital functions. High levels of cholesterol in the blood increase the risk of heart and artery disease.

chordae tendineae (kŏr'dĕ ten-dīn'ā)(†) Cord-like structures that attach the cusps of the heart valves to the papillary muscles in the ventricles.

choroid (kŏr'oid') The middle layer of the eye, which contains the iris, the ciliary body, and most of the eye's blood vessels.

chromosome (krŏ'mə-sŏm') Thread-like structures comprised of DNA.

chronic (krŏn'īk) Lasting a long time or recurring frequently, as in chronic osteoarthritis.

chronic obstructive pulmonary disease (COPD) (krŏn'īk ŏb-strŭk'tīv pŭŏl'mə-nĕr'ĕ dī-zĕz') A disease characterized by the presence of airflow obstruction due to chronic bronchitis or emphysema. It is typically progressive. Cigarette smoking is the leading cause.

chronological résumé (krŏn'ə-lŏj'ī-kəl rĕzŏŏ-mā') The type of résumé used by individuals who have job experience. Jobs are listed according to date, with the most recent being listed first.

chylomicron (kī-lŏ-mī'kron) The least dense of the lipoproteins; it functions in lipid transportation.

chyme (kīm)(†) The mixture of food and gastric juice.

chymotrypsin (kī-mŏ-trīp'sin)(†) A pancreatic enzyme that digests proteins.

ciliary body (sīl'ĕ-ĕr'ĕ bŏd'ĕ) A wedge-shaped thickening in the middle layer of the eyeball that contains the muscles that control the shape of the lens.

circumduction (ser-kŭm-dŭk'shŭn) Moving a body part in a circle; for example, tracing a circle with your arm.

cirrhosis (sī-rŏ'sis) A long-lasting liver disease in which normal liver tissue is replaced with nonfunctioning scar tissue.

civil law (sīv'əl lô) Involves crimes against persons. A person can sue another person, business, or the government. Judgments often require a payment of money.

clarity (klār'ī-tĕ) Clearness in writing or stating a message.

class action lawsuit (klās-āk'shən lŏ'sŏŏt') A lawsuit in which one or more people sue a company or other legal entity that allegedly wronged all of them in the same way.

clavicle (klāv'ī-kəl) A slender, curved long bone that connects the sternum and the scapula; also called the collar bone.

clean-catch midstream urine specimen (klĕn-käch mīd'strĕm yŏŕ'īn spĕs'əmən) A type of urine specimen that requires special cleansing of the external genitalia to avoid contamination by organisms residing near the external opening of the urethra and is used to identify the number and types of pathogens present in urine; sometimes referred to as midvoid.

clearinghouse (klīr'īng-hŏus') A group that takes nonstandard medical billing

software formats and translates them into the standard EDI formats.

cleavage (klé'vij) The rapid rate of mitosis of a zygote immediately following fertilization.

clinical coordinator (klín'í-kəl kō-ór'dn-á'tor) The person associated with the medical assisting school that procures externship sites and qualifies them to ensure that they provide a thorough educational experience.

clinical diagnosis (klín'í-kəl dí-əg-nō'sis) A diagnosis based on the signs and symptoms of a disease or condition.

clinical drug trial (klín'í-kəl drŭg trī'əl) An internationally recognized research protocol designed to evaluate the efficacy or safety of drugs and to produce scientifically valid results.

Clinical Laboratory Improvement Amendments (CLIA '88) (klé'ə) A law enacted by Congress in 1988 that placed all laboratory facilities that conduct tests for diagnosing, preventing, or treating human disease or for assessing human health under federal regulations administered by the Health Care Financing Administration (HCFA) and the Centers for Disease Control and Prevention (CDC).

clitoris (klīt'ər-īs) Located anterior to the urethral opening in females. It contains erectile tissue and is rich in sensory nerves.

closed file (klōzd fil) A file for a patient who has died, moved away, or for some other reason no longer consults the office for medical expertise.

closed posture (klōzd pōs'chər) A position that conveys the feeling of not being totally receptive to what is being said; arms are often rigid or folded across the chest.

cluster scheduling (klŭs'tər skěj'ool-íng) The scheduling of similar appointments together at a certain time of the day or week.

coagulation (kō-əg'yə-lá'shən) The process by which a clot forms in blood.

coccus (kōk'əs) A spherical, round, or ovoid bacterium.

coccyx (kōk'síks) A small, triangular-shaped bone consisting of three to five fused vertebrae.

cochlea (kōk'lē-ə) A spiral-shaped canal in the inner ear that contains the hearing receptors.

code linkage (kōd líng'kij) Analysis of the connection between diagnostic

and procedural information in order to evaluate the medical necessity of the reported charges. This analysis is performed by insurance company representatives.

coinsurance (kō-ín-shōór'əns) A fixed percentage of covered charges paid by the insured person after a deductible has been met.

colitis (kə-lí'tis) Inflammation of the colon.

colonoscopy (kō-lon-os' kō-pē)(†) A procedure used to determine the cause of diarrhea, constipation, bleeding, or lower abdominal pain by inserting a scope through the anus to provide direct visualization of the large intestine.

colony (kōl'ə-nē) A distinct group of microorganisms, visible with the naked eye, on the surface of a culture medium.

color family (kŭl'ər fām'ə-lē) A group of colors that share certain characteristics, such as warmth or coolness, allowing them to blend well together.

colposcopy (kol-pōs'kō-pē)(†) The examination of the vagina and cervix with an instrument called a colposcope to identify abnormal tissue, such as cancerous or precancerous cells.

common bile duct (kōm'ən bīl dŭkt) Duct that carries bile to the duodenum. It is formed from the merger of the cystic and hepatic ducts.

compactible file (kəm-pákt'əbəl fil) Files kept on rolling shelves that slide along permanent tracks in the floor and are stored close together or stacked when not in use.

complement (kōm'plə-mənt) A protein present in serum that is involved in specific defenses.

complete proteins (kəm-plét' prō'ten') Proteins that contain all nine essential amino acids.

complex carbohydrates (kəm-pléks' kār'bō-hí'drāt's) Long chains of sugar units; also known as polysaccharides.

complex inheritance (kəm-pléks' ín-hēr'í-təns) The inheritance of traits determined by multiple genes.

compliance plan (kəm-plí'əns plān) A process for finding, correcting, and preventing illegal medical office practices.

compound (kōm'pound') A substance that is formed when two or more atoms of more than one element are chemically combined.

compound microscope (kōm'pound' mī'krə-skōp') A microscope that uses two lenses to magnify the image created by condensed light focused through the object being examined.

computed tomography (kəm-pyōōt'éd tō-mogra-fē)(†) A radiographic examination that produces a three-dimensional, cross-sectional view of an area of the body; may be performed with or without a contrast medium.

conciseness (kən-sís'nəs) Brevity; the use of no unnecessary words.

concussion (kən-kŭsh'ən) A jarring injury to the brain; the most common type of head injury.

conductive hearing loss (kon-dŭk-tiv'hēr'íng lōs)(†) A type of hearing loss that occurs when sound waves cannot be conducted through the ear. Most types are temporary.

condyle (kon'dil)(†) Rounded articular surface on a bone.

cones (kōnz) Light-sensing nerve cells in the eye, at the posterior of the retina, that are sensitive to color, provide sharp images, and function only in bright light.

conflict (kōn'flíkt') An opposition of opinions or ideas.

conjunctiva (kōn'jŭngk-tí'və) The protective membrane that lines the eyelid and covers the anterior of the sclera, or the white of the eye.

conjunctivitis (kən-jŭngk'tə-vít'is) A contagious infection of the conjunctiva caused by bacteria, viruses, and allergies. The symptoms may include discharge, red eyes, itching, and swollen eyelids; also commonly called pinkeye.

connective (kə-něk'tív) A tissue type that is the framework of the body.

consumable (kən-sōō'mə-bəl) Able to be emptied or used up, as with supplies.

consumer education (kən-sōō'mər ěj'ə-ka'shən) The process by which the average person learns to make informed decisions about goods and services, including health care.

constructive criticism (kən-stre'k-tiv kr'í-tə-si-zəm) A type of critique that is aimed at giving an individual feedback about his or her performance in order to improve that performance.

contagious (kən-tá'jəs) Having a disease that can easily be transmitted to others.

contaminated (kən-tám'ə-nát'éd) Soiled or stained, particularly

- through contact with potentially infectious substances; no longer clean or sterile.
- contract (kŏn'trăkt')** A voluntary agreement between two parties in which specific promises are made.
- contraindication (kŏn'trə-in'dī-kă-shən)** A symptom that renders use of a remedy or procedure inadvisable, usually because of risk.
- contrast medium (kŏn'trast' mĕ'dĕ-əm)** A substance that makes internal organs denser and blocks the passage of x-rays to photographic film. Introducing a contrast medium into certain structures or areas of the body can provide a clear image of organs and tissues and highlight indications of how well they are functioning.
- controlled substance (kən-trŏld' sŭb'stəns)** A drug or drug product that is categorized as potentially dangerous and addictive and is strictly regulated by federal laws.
- control sample (kən-trŏl' sām'pəl)** A specimen that has a known value; used as a comparison for test results on a patient sample.
- contusion (kŏn-tŭ'shŭn)(†)** A closed wound, or bruise.
- conventions (kən-vĕn'shənz)** A list of abbreviations, punctuation, symbols, typefaces, and instructional notes appearing in the beginning of the ICD-9. The items provide guidelines for using the code set.
- convolutions (kŏn'və-lŏv'shənz)** The ridges of brain matter between the sulci; also called **gyri**.
- coordination of benefits (kŏ-ŏr'dn-ă-shən bĕn'ə-fits)** A legal principle that limits payment by insurance companies to 100% of the cost of covered expenses.
- co-payment (kŏ-pă'mənt)** A small fee paid by the insured at the time of a medical service rather than by the insurance company.
- cornea (kŏr'nĕ-ə)** A transparent area on the front of the outer layer of the eye that acts as a window to let light into the eye.
- coronary sinus (kŏr'ə-nĕr'ĕ sĭ'nəs)** The large vein that receives oxygen-poor blood from the cardiac veins and empties it into the right atrium of the heart.
- corpus callosum (kŏr'pəs ka-l'ŏ-səm)** A thick bundle of nerve fibers that connects the cerebral hemispheres.
- corpus luteum (kŏr'pŭs lŭ-tĕ'ŭm)(†)** A ruptured follicle cell in the ovary following ovulation.
- cortex (kŏr'təks')** The outermost layer of the cerebrum.
- cortisol (kŏr'ti-sŏl)(†)** A steroid hormone that is released when a person is stressed. It decreases protein synthesis.
- costal (kŏs'təl)(†)** Cartilage that attaches true ribs to the sternum.
- counter check (koun'tər chĕk)** A special bank check that allows a depositor to draw funds from his own account only, as when he has forgotten his checkbook.
- courtesy title (kŭr'ti-sĕ tŭt'l)** A title used before a person's name, such as Dr., Mr., or Ms.
- cover sheet (kŭr'ər shĕt)** A form sent with a fax that provides details about the transmission.
- coxal (kŏks-əl)(†)** Pertaining to the bones of the pelvic girdle. The coxa is composed of the ilium, ischium, and pubis.
- CPT** See *Current Procedural Terminology*.
- cranial (kră-nĕ-ăl)(†)** See **superior**.
- cranial nerves (kră-nĕ-ăl nŭrvs)(†)** Peripheral nerves that originate from the brain.
- crash cart (krăsh kărt)** A rolling cart of emergency supplies and equipment.
- creatine phosphate (krĕ-ă-tĕn fos'fāt)(†)** A protein that stores extra phosphate groups.
- credit (krĕd'it)** An extension of time to pay for services, which are provided on trust.
- credit bureau (krĕ-dit byŭr'ŏ)** A company that provides information about the credit worthiness of a person seeking credit.
- cricoid cartilage (kri'koyd kăr'tl-ij)(†)** A cartilage of the larynx that forms most of the posterior wall and a small part of the anterior wall.
- crime (krĭm)** An offense against the state committed or omitted in violation of public law.
- criminal law (krĭm'ə-nəl lô)** Involves crimes against the state. When a state or federal law is violated, the government brings criminal charges against the alleged offender.
- cross-reference (krŏs'rĕf'ər-əns)** The notation within the ICD-9 of the word *see* after a main term in the index. The *see* reference means that the main term first checked is not correct. Another category must then be used.
- cross-referenced (krŏs'rĕf'ər-ənsd)** Filed in two or more places, with each place noted in each file; the exact contents of the file may be duplicated, or a cross-reference form can be created, listing all the places to find the file.
- cross-training (krŏs-trĕ-ă-ning)** The acquisition of training in a variety of tasks and skills.
- cryotherapy (kri'ŏ-thĕr'ə-pĕ)** The application of cold to a patient's body for therapeutic reasons.
- cryosurgery (kri'ŏ-sŭr'jə-rĕ)** The use of extreme cold to destroy unwanted tissue, such as skin lesions.
- crystals (kris'təls)** Naturally produced solids of definite form; commonly seen in urine specimens, especially those permitted to cool.
- culture (kŭl'chər)** In the sociological sense, a pattern of assumptions, beliefs, and practices that shape the way people think and act. To place a sample of a specimen in or on a substance that allows microorganisms to grow in order to identify the microorganisms present.
- culture and sensitivity (C and S) (kŭl'chər sĕnsĭ-tĭv'ə-tĕ)** A procedure that involves culturing a specimen and then testing the isolated bacteria's susceptibility (sensitivity) to certain antibiotics to determine which antibiotics would be most effective in treating an infection.
- culture medium (kŭl'chər mĕ'dĕ-əm)** A substance containing all the nutrients a particular type of microorganism needs to grow.
- Current Procedural Terminology (CPT) (kŭr'ənt prĕ-sĕ'jər-əl tŭr'mə-nŏl'ə-jĕ)** A book with the most commonly used system of procedure codes. It is the HIPAA-required code set for physicians' procedures.
- cursor (kŭr'sər)** A blinking line or cube on a computer screen that shows where the next character that is keyed will appear.
- Cushing's disease (kush'ingz dĭ-zĕz')** A condition in which a person produces too much **cortisol** or has used too many steroid hormones. Some of the signs and symptoms include buffalo hump obesity, a moon face, and abdominal stretch marks; also called hypercortisolism.
- cuspid (kŭs'pidz)** The sharpest teeth; they act to tear food.
- cyanosis (sĭ'ə-nŏ'sĭs)** A bluish color of skin that results when the supply of oxygen is low in the blood.
- cycle billing (sĭ'kəl bĭl'ing)** A system that sends invoices to groups of patients every few days, spreading the

- work of billing all patients over the month while billing each patient only once.
- cystic duct** (sīs'tīk dūkt) The duct from the gallbladder that merges with the hepatic duct to form the common bile duct.
- cystitis** (sis-tī'tis) (†) Inflammation of the urinary bladder caused by infection.
- cytokines** (sī'tō-kīnz) A chemical secreted by T lymphocytes in response to an antigen. Cytokines increase T and B cell production, kill cells that have antigens, and stimulate red bone marrow to produce more white blood cells.
- cytokinesis** (sī'tō-ki-né'sis) (†) Splitting of the cytoplasm during cell division.
- cytoplasm** (sī'tə-plāz'əm) The watery intracellular substance that consists mostly of water, proteins, ions, and nutrients.
- damages** (dām'ijz) Money paid as compensation for violating legal rights.
- database** (dā'tə-bās) A collection of records created and stored on a computer.
- dateline** (dāt'lin') The line at the top of a letter that contains the month, day, and year.
- debridement** (dā-brēd-mont') (†) The removal of debris or dead tissue from a wound to expose healthy tissue.
- decibel** (dēs'ə-bəl) A unit for measuring the relative intensity of sounds on a scale from 0 to 130.
- deductible** (dī-dūk'tə-bəl) A fixed dollar amount that must be paid by the insured before additional expenses are covered by an insurer.
- deep** (dēp) Anatomical term meaning closer to the inside of the body.
- defamation** (dēf'ə-mā'shən) Damaging a person's reputation by making public statements that are both false and malicious.
- defecation reflex** (def-ě-kā'shūn rē'flēks') The relaxation of the anal sphincters so that feces can move through the anus in the process of elimination.
- deflection** (dī-flēk'shən) A peak or valley on an electrocardiogram.
- dehydration** (dē-hī'drā'shən) The condition that results from a lack of adequate water in the body.
- dementia** (dī-mēn'shə) The deterioration of mental faculties from organic disease of the brain.
- dendrite** (dēn'drīt') A type of nerve fiber that is short and branches near the cell body. Its function is to receive information from the neuron.
- deoxyhemoglobin** (dē-oks-ē-hē-mō-glō'bin) (†) A type of hemoglobin that is not carrying oxygen. It is darker red in color than hemoglobin.
- dependent** (dī-pēn'dənt) A person who depends on another person for financial support.
- depolarization** (dē-pō'lār-i-za-shūn) (†) The loss of polarity, or opposite charges inside and outside; the electrical impulse that initiates a chain reaction resulting in contraction.
- depolarized** (dē-pō'lār-īzd) (†) A state in which sodium ions flow to the inside of the cell membrane, making the outside less positive. Depolarization occurs when a neuron responds to stimuli such as heat, pressure, or chemicals.
- depression** (dī'pre-shan) The lowering of a body part.
- dermatitis** (dūr'mə-tī'tis) Inflammation of the skin.
- dermatologist** (der-mā-to'lō-jist) (†) A specialist who diagnoses and treats diseases of the skin, hair, and nails.
- dermis** (dūr'mis) The middle layer of the skin, which contains connective tissue, nerve endings, hair follicles, sweat glands, and oil glands.
- descending colon** (dī-sēnd'ing kō'lən) The segment of the large intestine after the transverse colon that descends the left side of the abdominal cavity.
- descending tracts** (dī-sēnd'ing trākts) Tracts of the spinal cord that carry motor information from the brain to muscles and glands.
- detrusor muscle** (dē-trūs'or mūs'əl) A smooth muscle that contracts to push urine from the bladder into the urethra.
- diabetes mellitus** (dī'ə-bē'tis mə-lī'təs) Any of several related endocrine disorders characterized by an elevated level of glucose in the blood, caused by a deficiency of insulin or insulin resistance at the cellular level.
- diagnosis** (Dx) (dī'æg-nō'sis) The primary condition for which a patient is receiving care.
- diagnosis code** (dī'æg-nō'sis kōd) The way a diagnosis is communicated to the third-party payer on the health-care claim.
- diagnostic radiology** (dī'æg-no'stik rā'dē-ōl'ə-jē) The use of x-ray technology to determine the cause of a patient's symptoms.
- diapedesis** (dī'ā-pē-dē'sis) (†) The squeezing of a cell through a blood vessel wall.
- diaphragm** (dī'ə-frām') A muscle that separates the thoracic and abdominopelvic cavities.
- diaphysis** (dī'af'i-sis) The shaft of a long bone.
- diastolic pressure** (dī'ə-stōl'ik prēsh'ər) The blood pressure measured when the heart relaxes.
- diathermy** (dī'ə-thūr'mē) A type of heat therapy in which a machine produces high-frequency waves that achieve deep heat penetration in muscle tissue.
- diencephalon** (dī-en-sef'ā-lon) (†) A structure that includes the thalamus and the hypothalamus. It is located between the cerebral hemispheres and is superior to the brain stem.
- differential diagnosis** (dīf'ə-rēn'shəl dī'æg-nō'sis) The process of determining the correct diagnosis when two or more diagnoses are possible.
- differently abled** (dīf'ər-ənt-lē ā'bəld) Having a condition that limits or changes a person's abilities and may require special accommodations.
- diffusion** (dī-fyū'zhūn) (†) The movement of a substance from an area of high concentration to an area of low concentration.
- digital examination** (dij'i-tl ig-zam'ə-nā'shən) Part of a physical examination in which the physician inserts one or two fingers of one hand into the opening of a body canal such as the vagina or the rectum; used to palpate canal and related structures.
- diluent** (dīlyōō-ənt) A liquid used to dissolve and dilute another substance, such as a drug.
- disaccharide** (dī-sak'ā-rīd) (†) A type of carbohydrate that is a simple sugar.
- disability insurance** (dīs'ə-bilī-tē in-shōōr'əns) Insurance that provides a monthly, prearranged payment to an individual who cannot work as the result of an injury or disability.
- disbursement** (dīs-būrs'mənt) Any payment of funds made by the physician's office for goods and services.
- disclaimer** (dīs-klāmər) A statement of denial of legal liability.
- disclosure** (dī-sklō'zhər) The release of, the transfer of, the provision of access to, or the divulgence in any manner of patient information.

- disclosure statement (dī-skłō'zhər stāt'mənt)** A written description of agreed terms of payment; also called a federal Truth in Lending statement.
- disinfectant (dīs'in-fēk'tānt)** A cleaning product applied to instruments and equipment to reduce or eliminate infectious organisms; not used on human tissue.
- disinfection (dīs'in-fēk'shən)** The destruction of infectious agents on an object or surface by direct application of chemical or physical means.
- dislocation (dīs'lō-kā'shən)** The displacement of a bone end from a joint.
- dispense (dī-spēns')** To distribute a drug, in a properly labeled container, to a patient who is to use it.
- distal (dīs'təl)** Anatomical term meaning farther away from a point of attachment or farther away from the trunk of the body.
- distal convoluted tubule (dīs'təl kon'vō-lū-ted tū'byūl)** The last twisted section of the renal tubule; it is located after the loop of Henle. Several of these tubules merge together to form collecting ducts.
- distribution (dīs'tri-byōō'shən)** The biochemical process of transporting a drug from its administration site in the body to its site of action.
- diverticulitis (dī'ver-tik-yū-lī'tis) (†)** Inflammation of the diverticuli, which are abnormal dilations in the intestine.
- DNA (dē'ēn-ā')** A nucleic acid that contains the genetic information of cells.
- doctor of osteopathy (dok'tər ōs'tē-ōp'ə-thē)** A doctor who focuses special attention on the musculoskeletal system and uses hands and eyes to identify and adjust structural problems, supporting the body's natural tendency toward health and self-healing.
- documentation (dōk'yə-mən-tā'shən)** The recording of information in a patient's medical record; includes detailed notes about each contact with the patient and about the treatment plan, patient progress, and treatment outcomes.
- dorsal (dōrsəl)** See **posterior**.
- dorsal root (dōrsəl rōōt)** A portion of a spinal nerve that contains axons of sensory neurons only.
- dorsiflexion (dōr-si-flek'shūn) (†)** Pointing the toes upward.
- dosage (dōs'āj)** The size, frequency, and number of doses.
- dose (dōs)** The amount of a drug given or taken at one time.
- dot matrix printer (dōt mā'triks prīn'tər)** An impact printer that creates characters by placing a series of tiny dots next to one another.
- double-booking system (dūb'əl bōōk'ing sistəm)** A system of scheduling in which two or more patients are booked for the same appointment slot, with the assumption that both patients will be seen by the doctor within the scheduled period.
- douche (dōōsh)** Vaginal irrigation, which can be used to administer vaginal medication in liquid form.
- drainage catheter (drā'nij kāth'i-tər)** A type of catheter used to withdraw fluids.
- dressings (drēs'ings)** Sterile materials used to cover a surgical or other wound.
- ductus arteriosus (dūktūs ar-tēr'ē-ō'sus) (†)** The connection in the fetus between the pulmonary trunk and the aorta.
- ductus venosus (duk'tūs ven-ō'sus) (†)** A blood vessel that allows most of the blood to bypass the liver in the fetus.
- duodenum (dōō'ə-dē'nəm)** The first section of the small intestine.
- durable item (dōōr'ə-bəl ĩ'təm)** A piece of equipment that is used repeatedly, such as a telephone, computer, or examination table; contrast with **expendable item**.
- durable power of attorney (dōōr'ə-bəl pōūr ə-tūr'nē) (†)** A document naming the person who will make decisions regarding medical care on behalf of another person if that person becomes unable to do so.
- dwarfism (dwōrf'izm)** A condition in which too little growth hormone is produced, resulting in an abnormally small stature.
- dysmenorrhea (dis-men-ōr-ē'ā) (†)** Severe menstrual cramps that limit daily activity.
- dyspnea (disp-nē'ā) (†)** Difficult or painful breathing.
- ear ossicles (ĭr ōs'i-kl) (†)** Three tiny bones called the malleus, the incus, and the stapes located in the middle ear cavity. They are the smallest bones of the body.
- eccrine gland (ek'rin glānd) (†)** The most numerous type of sweat gland. Eccrine sweat glands produce a watery type of sweat and are activated primarily by heat.
- echocardiography (ek'ō-kar-dē-ōgrā-fē) (†)** A procedure that tests the structure and function of the heart through the use of reflected sound waves, or echoes.
- E code (ē kōd)** A type of code in the ICD-9. E-codes identify the external causes of injuries and poisoning.
- ectoderm (ek'tō-derm) (†)** The primary germ layer that gives rise to nervous tissue and some epithelial tissue.
- eczema (ēk'sə-mə)** Inflammatory condition of the skin.
- edema (ī-dē'mə)** An excessive buildup of fluid in body tissue.
- editing (ēd'it-ing)** The process of ensuring that a document is accurate, clear, and complete; free of grammatical errors; organized logically; and written in the appropriate style.
- effectors (ī-fēk'tərs)** Muscles and glands that are stimulated by motor neurons in the peripheral nervous system.
- efferent arterioles (ēf'ər-ənt ar-tēr'ē-ōlz) (†)** Structures that deliver blood to peritubular capillaries that are wrapped around the renal tubules of the nephron in the kidneys.
- efficacy (ēf'ī-kə-sē)** The therapeutic value of a procedure or therapy, such as a drug.
- efficiency (ī-fīsh'an-sē)** The ability to produce a desired result with the least effort, expense, and waste.
- electrocardiogram (ECG or EKG) (ī-lēk'trō-kār'dē-ə-grām')** The tracing made by an **electrocardiograph**.
- electrocardiograph (ī-lēk'trō-kār'dē-ə-grāf')** An instrument that measures and displays the waves of electrical impulses responsible for the cardiac cycle.
- electrocardiography (ī-lēk'trō-kār'dē-ōgrā-fē)** The process by which a graphic pattern is created to reflect the electrical impulses generated by the heart as it pumps.
- electrocauterization (ī-lēk'trō-kōtər-ī-zā'shən)** The use of a needle, probe, or loop heated by electric current to remove growths such as warts, to stop bleeding, and to control nosebleeds that either will not subside or continually recur.
- electrodes (ī-lēk'trōds')** Sensors that detect electrical activity.
- electroencephalography (ī-lēk'trō-ēn-sēf'ə-lōgrā-fē)** A procedure that records the electrical activity of the brain as a tracing called an electroencephalogram, or EEG, on a strip of graph paper.

- electrolytes** (i-lĕk'trā-līts) Substances that carry electrical current through the movement of ions.
- electromyography** (i-lĕk'trō-mī-og'rā-fē) A procedure in which needle electrodes are inserted into some of the skeletal muscles and a monitor records the nerve impulses and measures conduction time; used to detect neuromuscular disorders or nerve damage.
- electron microscope** (i-lĕk'trōn mī'krā-skōp) A microscope that uses a beam of electrons instead of a beam of light; can magnify an image several million times.
- electronic data interchange (EDI)** (i-lĕk'trōn'ik dātā in'tar-chānj) Transmitting electronic medical insurance claims from providers to payers using the necessary information systems.
- electronic mail** (i-lĕk'trōn'iks) A method of sending and receiving messages through a computer network; commonly known as e-mail.
- electronic transaction record** (i-lĕk'trōn'ik trān-sāk'shən rī-kōrd) The standardized codes and formats used for the exchange of medical data.
- elevation** (e-lā-vā-shən) The raising of a body part.
- embolism** (ĕm'bā-līz'əm) An obstruction in a blood vessel.
- embolus** (ĕm'bā-lās) A portion of a thrombus that breaks off and moves through the bloodstream.
- embryonic period** (em-brē-on'ik pīr'ē-əd) (†) The second through eighth weeks of pregnancy.
- E/M code** (ĕ/ĕm kōd) Evaluation and management codes that are often considered the most important of all CPT codes. The E/M section guidelines explain how to code different levels of services.
- empathy** (ĕm'pā-thē) Identification with or sensitivity to another person's feelings and problems.
- employment contract** (ĕm-ploī'mənt kōn'trākt) A written agreement of employment terms between employer and employee that describes the employee's duties and the considerations (money, benefits, and so on) to be given by the employer in exchange.
- enclosure** (ĕn-klē'zhərz) Materials that are included in the same envelope as the primary letter.
- endocardium** (en-dō-kar'dē-ŭm) (†) The innermost layer of the heart.
- enchondral** (en-dō-kon'drāl) (†) A type of ossification in which bones start out as cartilage models.
- endocrine gland** (ĕn'dā-kra-n glānd) A gland that secretes its products directly into tissue, fluid, or blood.
- endocrinologist** (ĕn'dā-kra-nōl'ə-jīst) A specialist who diagnoses and treats disorders of the endocrine system, which regulates many body functions by circulating hormones that are secreted by glands throughout the body.
- endoderm** (ĕn'dō-derm) (†) The primary germ layer that gives rise to epithelial tissues only.
- endogenous infection** (ĕn-dōj'ə-nəs in-fĕk'shən) An infection in which an abnormality or malfunction in routine body processes causes normally beneficial or harmless microorganisms to become pathogenic.
- endolymph** (ĕn'dō-limf) (†) A fluid in the inner ear. When this fluid moves, it activates hearing and equilibrium receptors.
- endometriosis** (en'dō-mē-trē-ō'sis) (†) A condition in which tissues that make up the lining of the uterus grow outside the uterus.
- endometrium** (en'dō-mē-trē-ŭm) (†) The innermost layer of the uterus. It undergoes significant changes during the menstrual cycle.
- endomysium** (en'dō-miz'ē-ŭm) (†) A connective tissue covering that surrounds individual muscle cells.
- endorse** (ĕn-dōrs') To sign or stamp the back of a check with the proper identification of the person or organization to whom the check is made out, to prevent the check from being cashed if it is stolen or lost.
- endoscopy** (ĕn-dōs'kə-pē) Any procedure in which a scope is used to visually inspect a canal or cavity within the body.
- endosteum** (en-dōs'tē-ŭm) (†) A membrane that lines the medullary cavity and the holes of spongy bone.
- enunciation** (i-nūn'sē-ā'shən) Clear and distinct speaking.
- enzyme immunoassay (EIA)** (ĕnzīm im'yū-nō-as'ā) (†) The detection of substances by immunological methods. This method involves an antigen, an antibody specific for the antigen, and a second antibody conjugated to an enzyme.
- enzyme-linked immunosorbent assay (ELISA) test** (ĕnzīm-līngkt im'yū-nō-sōr-bent ā'sā tĕst) (†) A blood test that confirms the presence of antibodies developed by the body's immune system in response to an initial HIV infection.
- eosinophil** (ē-ō-sin'ō-fil) (†) A type of granular leukocyte that captures invading bacteria and antigen-antibody complexes through phagocytosis.
- epicardium** (ep-i-kar'dē-ŭm) (†) The outermost layer of the wall of the heart. Also known as the **visceral pericardium**.
- epidermis** (ĕp'i-dūr'mīs) The most superficial layer of the skin.
- epididymis** (ep-i-did'i-mis) (†) An elongated structure attached to the back of the testes and in which sperm cells mature.
- epididymitis** (ep-i-did-i-mī'tis) (†) Inflammation of an **epididymis**. Most cases result from infection.
- epiglottic cartilage** (ep-i-glot'ik kār'tl-ij) (†) A cartilage of the larynx that forms the framework of the epiglottis.
- epiglottis** (ep-i-glot'ī'tis) (†) The flap-like structure that closes off the larynx during swallowing.
- epilepsy** (ĕp'ə-lĕp'sē) A condition that occurs when parts of the brain receive a burst of electrical signals that disrupt normal brain function; also called **seizures**.
- epimysium** (ep-i-mis'ē-ŭm) (†) A thin covering that is just deep to the fascia of a muscle. It surrounds the entire muscle.
- epinephrine** (ĕp'ə-nĕf'rīn) An injectable medication used to treat anaphylaxis by causing vasoconstriction to increase blood pressure. A hormone secreted from the adrenal glands. It increases heart rate, breathing rate, and blood pressure.
- epiphyseal disk** (ep-i-fiz'ē-āl dīsk) (†) A plate of cartilage between the **epiphysis** and the **diaphysis**.
- epiphysis** (e-pīf'i-sis) (†) The expanded end of a long bone.
- epistaxis** (ĕp'i-stak'sis) Nosebleed.
- epithelial tissue** (ep-i-thē'lē-ēl tīsh'ō) (†) A tissue type that lines the tubes, hollow organs, and cavities of the body.
- erectile tissue** (i-rĕk'təl tīsh'ō) A highly specialized tissue located in the shaft of the penis. It fills with blood to achieve an erection.
- erythema** (er-i-thē'mā) Redness of the skin.
- erythroblastosis fetalis** (ĕ-rith'rō-blastō'sis fé'tāl-is) (†) A serious anemia that develops in a fetus with Rh-positive blood as a result of antibodies in an Rh-negative mother's body.

- erythrocytes** (i-rīth' rə-sīt' s) Red blood cells.
- erythrocyte sedimentation rate (ESR)** (i-rīth' rə-sīt' sēd' ə-mən-tā'shən rāt) The rate at which red blood cells, the heaviest blood component, settle to the bottom of a blood sample.
- erythropoietin** (ē-rīth-rō-poy' ē-tin) (†) A hormone secreted by the kidney that is responsible for regulating the production of red blood cells.
- esophageal hiatus** (i-sōf' ə-jē' əl) Hole in the diaphragm through which the esophagus passes.
- established patient** (i-stāb' lish' pā'shənt) A patient who has seen the physician within the past three years. This determination is important when using E/M codes.
- estrogen** (ēs' trə-jən) A female sex hormone; when produced during ovulation, estrogen causes a buildup of the lining of the uterus (womb) to prepare it for a possible pregnancy.
- ethics** (ēth' iks) General principles of right and wrong, as opposed to requirements of law.
- ethmoid** (ēth' moyd) (†) Bones located between the sphenoid and nasal bone that form part of the floor of the cranium.
- etiologic agent** (ē'tē-ə-lōj' ik ə-jənt) A living microorganism or its toxin that may cause human disease.
- etiquette** (ēf' i-kef') Good manners.
- eustachian tube** (yōō-stā'shən tōōb) An opening in the middle ear, leading to the back of the throat, that helps equalize air pressure on both sides of the eardrum.
- eversion** (ē-ver' zhūn) (†) Turning the sole of the foot laterally.
- exclusion** (ik-sklōōzh' ən) An expense that is not covered by a particular insurance policy, such as an eye examination or dental care.
- excretion** (ik-skrē'shən) The elimination of waste by a discharge; in drug metabolism, the manner in which a drug is eliminated from the body.
- exocrine gland** (ēk'sə-krīn glānd) A gland that secretes its product into a duct.
- exogenous infection** (ēk-sōj' ə-nəs' in-fēk' shən) An infection that is caused by the introduction of a pathogen from outside the body.
- expendable item** (ik-spən' dəbəl i' təm) An item that is used and must then be restocked; also known collectively as supplies. Contrast with **durable item**.
- expiration** (ēk'spə-rā'shən) The process of breathing out; also called exhalation.
- expressed contract** (ik-sprēst' kōn'trākt) A contract clearly stated in written or spoken words.
- extension** (ik-stēn'shən) An unbending or straightening movement of the two elements of a jointed body part.
- external auditory canal** (ik-stūr' nəl' ōdī-tōr' ē kə-nāl') Canal that carries sound waves to the tympanic membrane; commonly called the ear canal.
- externship** (ik-stūr'nshīp) A period of practical work experience performed by a medical assisting student in a physician's office, hospital, or other health-care facility.
- extrinsic eye muscles** (ik-strīn' sīk i' mūs' əlz) The skeletal muscles that move the eyeball.
- facsimile machine** (fāk-sīm' ə-lē' mə-shēn') A piece of office equipment used to send a facsimile, or fax, over telephone lines from one modem to another; more commonly called a fax machine.
- facultative** (fak' ūl-tā'tiv) (†) Able to adapt to different conditions; in microbiology, able to grow in environments either with or without oxygen.
- Fahrenheit** (fār' ən-hīt) One of two common scales used for measuring temperature; measured in degrees Fahrenheit, or °F.
- fallopian tubes** (fə-l' ō-pē-ən tūbz) Tubes that extend from the uterus on each side and that open near an ovary.
- family practitioner** (fām' ə-lē' prāk-tīsh' ə-nər) (†) A physician who does not specialize in a branch of medicine but treats all types and ages of patients; also called a general practitioner.
- fascia** (fash' ē-ə) (†) A structure that covers entire skeletal muscles and separates them from each other.
- fascicle** (fās' i-kəl) Sections of a muscle divided by connective tissue called perimysium.
- febrile** (fēb' rəl) Having a body temperature above one's normal range.
- feces** (fē'sēz) Material found in the large intestine and made from leftover chyme. Feces are eventually eliminated through the anus.
- feedback** (fēd' bāk') Verbal and nonverbal evidence that a message was received and understood.
- fee-for-service** (fē fōr sūr' vīs) A major type of health plan. It repays policyholders for the costs of health care that are due to illness and accidents.
- fee schedule** (fē skēj' ōōl) A list of the costs of common services and procedures performed by a physician.
- felony** (fēl' ə-nē) A serious crime, such as murder or rape, that is punishable by imprisonment. In certain crimes, a felony is punishable by death.
- femoral** (femō-rāl) (†) Relating to the femur or thigh.
- femur** (fē' mər) The bone in the upper leg; commonly called the thigh bone.
- fenestrated drape** (fēn' i-strāt' ēd drāp) A drape that has a round or slitlike opening that provides access to the surgical site.
- fertilization** (fer'til-i-zā'shūn) The process in which an egg unites with a sperm.
- fetal period** (fēt' l pīr' ē-əd) A period that begins at week nine of pregnancy and continues through delivery of the offspring.
- fiber** (fī' bər) The tough, stringy part of vegetables and grains, which is not absorbed by the body but aids in a variety of bodily functions.
- fibrinogen** (fī-brinō-jen) (†) A protein found in plasma that is important for blood clotting.
- fibroid** (fī' broid') A benign tumor in the uterus composed of fibrous tissue.
- fibromyalgia** (fī-brō-mī-əl' jē-ə) (†) A condition that exhibits chronic pain primarily in joints, muscles, and tendons.
- fibula** (fīb' yə-lə) The lateral bone of the lower leg.
- file guide** (filgīd) A heavy cardboard or plastic insert used to identify a group of file folders in a file drawer.
- filtration** (fil-trā'shən) A process that separates substances into solutions by forcing them across a membrane.
- fimbriae** (fīm-brē-ə) Fringe-like structures that border the entrances of the **fallopian tubes**.
- first morning urine specimen** (fūr'st mōr' ning yōōr' in spēs' ə-mən) A urine specimen that is collected after a night's sleep; contains greater concentrations of substances that collect over time than specimens taken during the day.
- fixative** (fīk'sə-tiv) A solution sprayed on a slide immediately after the specimen is applied. It is used to preserve and hold the cells in place until a microscopic examination is performed.
- flexion** (flek'shūn) (†) A bending movement of the two elements of a jointed body part.

floater (flō'tər) A nonsterile assistant who is free to move about the room during surgery and attend to unsterile needs.

fluidotherapy (flōō'id-ōthēr'ə-pē) A technique for stimulating healing, particularly in the hands and feet, by placing the affected body part in a container of glass beads that are heated and agitated with hot air.

follicle (fōl'ī-kəl) An accessory organ of the skin that is found in the dermis and the sites at which hairs emerge.

follicle-stimulating hormone (FSH) (fōl'ī-kəl stim'yū-lā-ting hōr'mōn') A hormone that in females stimulates the production of estrogen by the ovaries; in males, it stimulates sperm production.

follicular cells (fə-lī'kyə-lər selz) Small cells contained in the primordial follicle along with a large cell called a primary **oocyte**.

folliculitis (fō-lik-yū-lī'tis) (†) Inflammation of the hair follicle.

fomite (fō'mīt) (†) An inanimate object, such as clothing, body fluids, water, or food, that may be contaminated with infectious organisms and thus serve to transmit disease.

fontanel (fān-tə-n'el) The soft spot in an infant's skull that consists of tough membranes that connect to incompletely developed bone.

food exchange (fōōd īks-chānj') A unit of food in a particular food category that provides the same amounts of protein, fat, and carbohydrates as all other units of food in that category.

foramen magnum (fə-rā-mən mag-nəm) The large hole in the occipital bone that allows the brain to connect to the spinal cord.

foramen ovale (fō-rā-men ō-vā'lē) (†) A hole in the fetal heart between the right atrium and the left atrium.

forced vital capacity (FVC) (fōrst vīt'l kə-pās'ī-tē) The greatest volume of air that a person is able to expel when performing rapid, forced expiration.

formalin (fōr-mā-lin) (†) A dilute solution of formaldehyde used to preserve biological specimens.

formed elements (fōrmd ēl'ə-mənts) Red blood cells, white blood cells, and platelets; comprise 45% of blood volume.

formulary (fōr'myū-lā-rē) (†) An insurance plan's list of approved prescription medications.

fraud (frōd) An act of deception that is used to take advantage of another person or entity.

fracture (frāk'chər) Any break in a bone.

frequency (fré'kwən-sē) The number of complete fluctuations of energy per second in the form of waves.

frontal (frūn'tl) Anatomical term that refers to the plane that divides the body into anterior and posterior portions. Also called coronal.

full-block letter style (fōōl blōk lēt'ər stīl) A letter format in which all lines begin flush left; also called block style.

functional résumé (fūngk'shə-nəl rēz'ōō-mā') A résumé that highlights specialty areas of a person's accomplishments and strengths.

fungus (fūng'gəs) A eukaryotic organism that has a rigid cell wall at some stage in the life cycle.

gait (gāt) The way a person walks, consisting of two phases: stance and swing.

ganglia (gāng'glē-ə) Collections of neuron cell bodies outside the central nervous system.

gastric juice (gās'trīk jüs) Secretions from the stomach lining that begin the process of digesting protein.

gastritis (gā-strī'tis) Inflammation of the stomach lining.

gastroenterologist (gās'trō-ēn-ter-ol'ō-jīst) (†) A specialist who diagnoses and treats disorders of the entire gastrointestinal tract, including the stomach, intestines, and associated digestive organs.

gastroesophageal reflux disease (GERD) (gās'trō-ē-sof'ā-jē'āl'rē'flēks dī-zēz') A condition that occurs when stomach acids are pushed into the esophagus and cause heartburn.

gene (jēn) A segment of DNA that determines a body trait.

general physical examination (jēn'ər-əl fīz'ī-kəl īg-zām'ə-nā'shən) An examination performed by a physician to confirm a patient's health or to diagnose a medical problem.

generic name (jə-nēr'īk nām) A drug's official name.

gerontologist (jēr'ən-tōl'ə-jīst) A specialist who studies the aging process.

gigantism (jī'an-tizm) (†) A condition in which too much growth hormone is produced in childhood, resulting in an abnormally increased stature.

glans penis (glanz pē'nīs) A cone-shaped structure at the end of the penis.

glaucoma (glou-kō'mə) A condition in which too much pressure is created in

the eye by excessive aqueous humor. This excess pressure can lead to permanent damage of the optic nerves, resulting in blindness.

global period (glō'bəl pīr'ē-əd) The period of time that is covered for follow-up care of a procedure or surgical service.

globulins (glōb'yū-lin) (†) Plasma proteins that transport lipids and some vitamins.

glomerular capsule (glō-mār'yū-lār kāp'səl) (†) A capsule that surrounds the **glomerulus** of the kidney.

glomerular filtrate (glō-mār'yū-lār fīl'trāt') (†) The fluid remaining in the **glomerular capsule** after **glomerular filtration**.

glomerular filtration (glō-mār'yū-lār fīl-trā'shən) (†) The process by which urine forms in the kidneys as blood moves through a tight ball of capillaries called the glomerulus.

glomerulonephritis (glō-mār'yū-lō-nef-rī'tis) (†) An inflammation of the glomeruli of the kidney.

glomerulus (glō-mār'yū-lūs) (†) A group of capillaries in the renal corpuscle.

glottis (glō'tis) (†) The opening between the vocal cords.

glucagon (glōō'kə-gōn') A hormone that increases glucose concentrations in the bloodstream and slows down protein synthesis.

glycogen (glī'kə-jən) An excess of glucose that is stored in the liver and in skeletal muscle.

glycosuria (glī-kō-sū-rē-ā) (†) The presence of significant levels of glucose in the urine.

gonads (gō'nādz) The reproductive organs; namely, in women, the ovaries, and in men, the testes.

gonadotropin-releasing hormone (GnRH) (gō'nad-ō-trō-pinrī-lēs'ing hōr'mōn') Hormone that stimulates the anterior pituitary gland to release **follicle-stimulating hormone (FSH)**.

goniometer (gō-nē-ā'-me-tər) A protractor device that measures range of motion.

gout (gowt) (†) A medical condition characterized by an elevated uric acid level and recurrent acute arthritis.

G-protein (jē-prō'tēn) (†) A substance that causes enzymes in the cell to activate following the activation of the hormone-receptor complex in the cell membrane.

gram-negative (grām'nēg'ə-tīv) Referring to bacteria that lose their purple

- color when a decolorizer has been added during a Gram's stain.
- gram-positive** (grām'pōz'ī-tīv) Referring to bacteria that retain their purple color after a decolorizer has been added during a Gram's stain.
- Gram's stain** (grāmz stān) A method of staining that differentiates bacteria according to the chemical composition of their cell walls.
- granular leukocyte** (grăn'yə-lər lōō'kə-sīt') A type of leukocyte (white blood cell) with a segmented nucleus and granulated cytoplasm; also known as a polymorphonuclear leukocyte.
- granulocyte** (gran'yū-lō-sīt) (†) See **granular leukocyte**.
- Graves' disease** (grāvz dī-zēz') A disorder in which a person develops antibodies that attack the thyroid gland.
- gray matter** (grā māt'ər) The inner tissue of the brain and the spinal cord that is darker in color than **white matter**. It contains all the bodies and dendrites of nerve cells.
- gross earnings** (grōs ūr'nīngz) The total amount an employee earns before deductions.
- growth hormone** (GH) (grōth hōr'mōn') A hormone that stimulates an increase in the size of the muscles and bones of the body.
- gustatory receptors** (gās-tə-tōr-ē ri-sé'p-tər) Taste receptors that are found on taste buds.
- gynecologist** (gī nī-kōl'ə-jīst) A specialist who performs routine physical care and examinations of the female reproductive system.
- gyri** (jī'ri) (†) The ridges of brain matter between the sulci; also called **convolutions**.
- hapten** (hap'tēn) (†) Foreign substances in the body too small to start an immune response by themselves.
- HCPCS Level II codes** (āch sē pē se ēs lēv'əl tōō kōdz) Codes that cover many supplies such as sterile trays, drugs, and durable medical equipment; also referred to as national codes. They also cover services and procedures not included in the CPT.
- hairy leukoplakia** (hār'ē lū-kō-plā'kē-ā) (†) A white lesion on the tongue associated with AIDS.
- hard copy** (hārd kōp'ē) A readable paper copy or printout of information.
- hardware** (hārd'wār') The physical components of a computer system, including the monitor, keyboard, and printer.
- hazard label** (hāz'ərd lā'bəl) A shortened version of the Material Safety Data Sheet; permanently affixed to a hazardous substance container.
- Health Care Common Procedure Coding System (HCPCS)** (hēlth kār kōm'ən prə-sé'jər kōd'īng sīs'təm) A coding system developed by the Centers for Medicare and Medicaid Services that is used in coding services for Medicare patients.
- health maintenance organization (HMO)** (hēlth māntə-nəns ōr'gə-nī-zā'shən) A health-care organization that provides specific services to individuals and their dependents who are enrolled in the plan. Doctors who enroll in an HMO agree to provide certain services in exchange for a prepaid fee.
- helper T-cells** (hēl'pər té'sēlz) White blood cells that are a key component of the body's immune system and that work in coordination with other white blood cells to combat infection.
- hematemesis** (hē'mā-tem'ē-sis) The vomiting of blood.
- hematocrit** (hē'mā-tō-krit) (†) The percentage of the volume of a sample made up of red blood cells after the sample has been spun in a centrifuge.
- hematology** (hēmə-tōl'ə-jē) The study of blood.
- hematoma** (hē'mə-tō'mə) A swelling caused by blood under the skin.
- hematuria** (hē-mā-tu'rē-ā) (†) The presence of blood in the urine.
- hemocytoblast** (hē'mā-tō-sī'tō-blāst) (†) Cells of the red bone marrow that produce most red blood cells.
- hemoglobin** (hē'mə-glō'bīn) A protein that contains iron and bonds with and carries oxygen to cells; the main component of erythrocytes.
- hemoglobinuria** (hē'mō-glō-bi-nū'rē-ā) (†) The presence of free **hemoglobin** in the urine; a rare condition caused by transfusion reactions, malaria, drug reactions, snake bites, or severe burns.
- hemolysis** (hē-mōl'ī-sis) (†) The rupturing of red blood cells, which releases hemoglobin.
- hemorrhoids** (hēm'ə-roidz) Varicose veins of the rectum or anus.
- hemostasis** (hē'mō-stā-sis) (†) The stoppage of bleeding.
- hepatic duct** (hī-pāt'ik dūkt) A duct that leaves the liver carrying bile and merges with the cystic duct to form the common bile duct.
- hepatic lobule** (he-pāt'ik lob'yūl) (†) Smaller divisions within the lobes of the liver.
- hepatic portal system** (he-pāt'ik pōr'tl sīs'təm) (†) The collection of veins carrying blood to the liver.
- hepatic portal vein** (hī-pāt'ik pōr'tl vān) A blood vessel that carries blood from the other digestive organs to the **hepatic lobules**.
- hepatitis** (hēp'ə-tī'tiss) Inflammation of the liver usually caused by viruses or toxins.
- hepatocytes** (hep'ā-tō-sītz) (†) The cells within the lobules of the liver. Hepatocytes process nutrients in the blood and make bile.
- hernia** (hūr'nē-ə) The protrusion of an organ through the wall that usually contains it, such as a hiatal or inguinal hernia.
- herpes simplex** (her'pēz sīm'plēks) (†) A medical condition characterized by an eruption of one or more groups of vesicles on the lips or genitalia.
- herpes zoster** (her'pēz zōs'ter) (†) A medical condition characterized by an eruption of a group of vesicles on one side of the body following a nerve root.
- hierarchy** (hī'ə-rār'kē) A term that pertains to Abraham Maslow's hierarchy of needs. This hierarchy states that human beings are motivated by unsatisfied needs and that certain lower needs must be satisfied before higher needs can be met.
- hilum** (hī'lūm) (†) The indented side of a lymph node. The entrance of the renal sinus that contains the renal artery, renal vein, and ureter.
- HIPAA (Health Insurance Portability and Accountability Act)** (hīp'ə) A set of regulations whose goals include the following: improving the portability and continuity of health-care coverage in group and individual markets; combating waste, fraud, and abuse in health-care insurance and health-care delivery; promoting the use of a medical savings account; improving access to long-term care services and coverage; and simplifying the administration of health insurance.
- Holter monitor** (hol'tər mōn'ī-tər) An electrocardiography device that includes a small portable cassette recorder worn around a patient's waist or on a shoulder strap to record the heart's electrical activity.
- homeostasis** (hō'mē-ō-stā'sis) A balanced, stable state within the body.
- homologous chromosome** (hō-mōlō-gūs krō'mā-sōm') (†) Members in each pair of chromosomes.

- hormone (hōr'mōn)** A chemical secreted by a cell that affects the functions of other cells.
- hospice (hōs'pīs)** Volunteers who work with terminally ill patients and their families.
- human chorionic gonadotropin (HCG) (hyōō'mən kō-rē-on'ik gō'nad-ō-trō'pin)** A hormone secreted by cells of the embryo after implantation. It maintains the corpus luteum in the ovary so it will continue to secrete estrogen and progesterone.
- human immunodeficiency virus (HIV) (hyōō'mən im'yū-nō-dē-fish'en-sē vī'rās)** A retrovirus that gradually destroys the body's immune system and causes AIDS.
- humerus (hyū-mə-rəs)** The bone of the upper arm.
- humors (hyōō'mərz)** Fluids of the body.
- hydrotherapy (hī'drə-thēr'ə-pē)** The therapeutic use of water to treat physical problems.
- hyoid (hī-oid)** The bone that anchors the tongue.
- hyperextension (hī'per-eks-ten'shūn) (†)** Extension of a body part past the normal anatomical position.
- hyperglycemia (hī'pər-glī-sē'mē-ə)** High blood sugar.
- hyperopia (hī'per-ō'pē-ə)** A condition that occurs when light entering the eye is focused behind the retina; commonly called farsightedness.
- hyperpnea (hī'per-nē-ə) (†)** Abnormally deep, rapid breathing.
- hyperreflexia (hī'per-rē-flek'sē-ə)** Reflexes that are stronger than normal reflexes.
- hypertension (hī'pər-tēn'shən)** High blood pressure.
- hyperventilation (hī'pər-vēn'tl-ā'shən)** The condition of breathing rapidly and deeply. Hyperventilating decreases the amount of carbon dioxide in the blood.
- hypodermis (hī'pə-dūr'mīs)** The subcutaneous layer of the skin that is largely made of adipose tissue.
- hypoglycemia (hī'pō-glī-sē'mē-ə)** Low blood sugar.
- hyporeflexia (hī'pō-rē-flek'sē-ə) (†)** A condition of decreased reflexes.
- hypotension (hī'pō-tēn'shən)** Low blood pressure.
- hypothalamus (hī'pō-thāl'ə-məs)** A region of the **diencephalon**. It maintains homeostasis by regulating many vital activities such as heart rate, blood pressure, and breathing rate.
- hypovolemic shock (hī'per-vō-lē'mē-ə shōk) (†)** A state of shock resulting from insufficient blood volume in the circulatory system.
- hysterectomy (hīs'tə-rēk'tə-mē)** Surgical removal of the uterus.
- ICD-9** See *International Classification of Diseases, Ninth Revision, Clinical Modification*.
- icon (ī'kōn)** A pictorial image; on a computer screen, a graphic symbol that identifies a menu choice.
- identification line (ī-dēn'tə-fī-kā'shən līn)** A line at the bottom of a letter containing the letter writer's initials and the typist's initials.
- ileocecal sphincter** A structure that controls the movement of **chyme** from the **ileum** to the **cecum**.
- ileum (īl'ē-əm)** The last portion of the small intestine. It is directly attached to the large intestine.
- ilium (ī'lē-əm)** The most superior part of the hip bone. It is broad and flaring.
- immunity (ī-myōōn'ī-tē)** The condition of being resistant or not susceptible to pathogens and the diseases they cause.
- immunization (im'yū-nī-zā-shən)** The administration of a vaccine or toxoid to protect susceptible individuals from communicable diseases.
- immunocompromised (im'yū-nō-kom'pro-mīzd) (†)** Having an impaired or weakened immune system.
- immunofluorescent antibody (IFA) test (im'yū-nō-flūr-esēnt āntī-bōd-ē tēst) (†)** A blood test used to confirm enzyme-linked immunosorbent assay (ELISA) test results for HIV infection.
- immunoglobulins (im'yū-nō-glob'yū-līnz) (†)** A class of structurally related proteins that include IgG, IgA, IgM, and IgE; also called **antibodies**.
- impetigo (im'pī-tī-gō)** A contagious skin infection usually caused by germs commonly called staph and strep.
- implied contract (īm-plīd kōn'trākt')** A contract that is created by the acceptance or conduct of the parties rather than the written word.
- impotence (īmpō-tens) (†)** A disorder in which a male cannot maintain an erect penis to complete sexual intercourse; also called erectile dysfunction.
- inactive file (īn-āk'tīv fil)** A file used infrequently.
- incision (īn-sīzh'ən)** A surgical wound made by cutting into body tissue.
- incisors (īn-sī-zərz)** The most medial teeth. They act as chisels to bite off food.
- incomplete proteins (īn'kəm-plēt'prō'tēnz')** Proteins that lack one or more of the essential amino acids.
- incontinence (īn-kōn'ti-nens) (†)** The involuntary leakage of urine.
- incus (īng'kəs)** A small bone in the middle ear, located between the malleus and the stapes; also called the anvil.
- indication (īndī-kā'shən)** The purpose or reason for using a drug, as approved by the FDA.
- induration** The process of hardening or of becoming hard.
- infection (īn-fēk'shən)** The presence of a pathogen in or on the body.
- infectious waste (īn-fēk'shəs wāst)** Waste that can be dangerous to those who handle it or to the environment; includes human waste, human tissue, and body fluids as well as potentially hazardous waste, such as used needles, scalpels, and dressings, and cultures of human cells.
- inferior (īn-fīr'ē-ər)** Anatomical term meaning below or closer to the feet; also called caudal.
- inflammation (īn-flā-mā'shən)** The body's reaction when tissue becomes injured or infected. The four cardinal signs are redness, heat, pain, and swelling.
- informed consent form (īn-fōrmd' kən-sēnt fōrm)** A form that verifies that a patient understands the offered treatment and its possible outcomes or side effects.
- infundibulum (īn-fūn-dīb'yū-lūm) (†)** The funnel-like end of the uterine tube near an ovary. It catches the secondary oocyte as it leaves the ovary.
- infusion (īn-fyū'zhūn) (†)** A slow drip, as of an intravenous solution into a vein.
- ink-jet printer (īngkjēt' prīn'tər)** A nonimpact printer that forms characters by using a series of dots created by tiny drops of ink.
- inner cell mass (īn'ər sēl mās)** A group of cells in a blastocyte that gives rise to an embryo.
- inorganic (īn'ōr-gān'īk)** Matter that generally does not contain carbon and hydrogen.
- insertion (īn-sūr'shən)** An attachment site of a skeletal muscle that moves when a muscle contracts.
- inspection (īn-spēk'shən)** The visual examination of the patient's entire body and overall appearance.
- inspiration (īn-spə-rā'shən) (†)** The act of breathing in; also called inhalation.

- insulin (ín-sə-lín)** A hormone that regulates the amount of sugar in the blood by facilitating its entry into the cells.
- interactive pager (ín-tər-āk-tív pāj'ər)**
A pager designed for two-way communication. The pager screen displays a printed message and allows the physician to respond by way of a mini keyboard.
- intercalated disc (in-ter'kă-lă-ted disk)(†)** A disc that connects groups of cardiac muscles. This disc allows the fibers in that group to contract and relax together.
- interferon (in-ter-fēr'on)(†)** A protein that blocks viruses from infecting cells.
- interim room (ín-tər-ím rōóm)** A room off the patient reception area and away from the examination rooms for occasions when patients require privacy.
- International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9) (ín-tər-năsh'ə-nəl klăs'ə-fī-kă'shən dī-zēz'əz nínth rī-víz'h'ən klín'ī-kəl mōd'ə-fī-kă'shən)** Code set that is based on a system maintained by the World Health Organization of the United Nations. The use of the ICD-9 codes in the health-care industry is mandated by HIPAA for reporting patients' diseases, conditions, and signs and symptoms.
- Internet (ín-tər-nēt')** A global network of computers.
- interneuron (ín-ter-nū'ron)(†)** A structure found only in the central nervous system that functions to link sensory and motor neurons together.
- internist (in-túr'níst)** A doctor who specializes in diagnosing and treating problems related to the internal organs.
- interpersonal skills (ín-tər-púr'sə-nəl skílz)** Attitudes, qualities, and abilities that influence the level of success and satisfaction achieved in interacting with other people.
- interphase (ín-ter-fāz)(†)** The state of a cell carrying out its normal daily functions and not dividing.
- interstitial cell (in-ter-stish'əl sěl)** A cell located between the seminiferous tubules that is responsible for making testosterone.
- intestinal lipase (in-tēs'ti-n lipās)** An enzyme that digests fat.
- intra dermal (ID) (ín-tră-der'măl)**
Within the upper layers of the skin.
- intra dermal test (ín-tră-der'măl tēst)**
An allergy test in which dilute solutions of allergens are introduced into the skin of the inner forearm or upper back with a fine-gauge needle.
- intramembranous (in-trə-mém-brə-nəs)** A type of ossification in which bones begin as tough fibrous membranes.
- intramuscular (IM) (ín-tră-mūs'kyū-lăr)**
Within muscle; an IM injection allows administration of a larger amount of a drug than a subcutaneous injection allows.
- intraoperative (ín-tră-ōp'ər-ə-tív)** Taking place during surgery.
- intravenous IV (ín-tră-vē'nəs)** Injected directly into a vein.
- intravenous pyelography (IVP) (ín-tră-vē'nəs pī'ē-log'ră-fē)(†)** A radiologic procedure in which the doctor injects a contrast medium into a vein and takes a series of x-rays of the kidneys, ureters, and bladder to evaluate urinary system abnormalities or trauma to the urinary system; also known as excretory urography.
- intrinsic factor (in-trín'zík făk'tər)** A substance secreted by **parietal cells** in the lining of the stomach. It is necessary for vitamin B₁₂ absorption.
- invasive (in-vă'sív)** Referring to a procedure in which a catheter, wire, or other foreign object is introduced into a blood vessel or organ through the skin or a body orifice. Surgical asepsis is required during all invasive tests.
- inventory (ín-vən-tōrē)** A list of supplies used regularly and the quantities in stock.
- inversion (in-vúr'zhən)** Turning the sole of the foot medially.
- invoice (ín'vois')** A bill for materials or services received by or services performed by the practice.
- ions (í'onz)** Positively or negatively charged particles.
- iris (í'ris)** The colored part of the eye, made of muscular tissue that contracts and relaxes, altering the size of the pupil.
- ischium (is'kē-əm)** A structure that forms the lower part of the hip bone.
- islets of Langerhans (í'lít lan'ger-hans)** Structures in the pancreas that secrete insulin and glucagon into the bloodstream.
- itinerary (ī-tín'ə-rēr'ē)** A detailed travel plan listing dates and times for specific transportation arrangements and events, the location of meetings and lodgings, and phone numbers.
- jaundice (jôn'dīs)** A condition characterized by yellowness of the skin, eyes, mucous membranes, and excretions; occurs during the second stage of hepatitis infection.
- jejunum (jə-jōō'nəm)** The mid-portion and the majority of the small intestine.
- journalizing (júr'nə-líz'ing)** The process of logging charges and receipts in a chronological list each day; used in the single-entry system of bookkeeping.
- juxtaglomerular apparatus (jüks'tă-glō-mer'yū-lăr əp'ə-răt'əs)(†)** A structure contained in the nephron and made up of the macula densa and **juxtaglomerular cells**.
- juxtaglomerular cells (jüks'tă-glō-mer'yū-lăr sēlz)** Enlarged smooth muscle cells in the walls of either the afferent or efferent arterioles.
- Kaposi's sarcoma (kap'ō-sēz sar-kō'mă)** Abnormal tissue occurring in the skin, and sometimes in the lymph nodes and organs, manifested by reddish-purple to dark blue patches or spots on the skin.
- keratin (kér'ə-tín)** A tough, hard protein contained in skin, hair, and nails.
- keratinocyte (kē-rat'ī-nō-sīt)(†)** The most common cell type in the epidermis of the skin.
- key (kē)** The act of inputting or entering information into a computer.
- KOH mount (kă'ō-ăch mount)** A type of mount used when a physician suspects a patient has a fungal infection of the skin, nails, or hair and to which potassium hydroxide is added to dissolve the keratin in cell walls.
- Krebs cycle (krēbz sī'kəl)** Also called the citric acid cycle. This cycle generates ATP for muscle cells.
- KUB radiography (kă'yōō-bē ră'dē-og'ră-fē)(†)** The process of x-raying the abdomen to help assess the size, shape, and position of the urinary organs; evaluate urinary system diseases or disorders; or determine the presence of kidney stones. It can also be helpful in determining the position of an intrauterine device (IUD) or in locating foreign bodies in the digestive tract; also called a flat plate of the abdomen.
- kyphosis (kī-fō'sis)** A deformity of the spine characterized by a bent-over position; more commonly called humpback.
- labeling (lă'bəl-ing)** Information provided with a drug, including FDA-approved indications and the form of the drug.
- labia majora (lă'bē-ă mă'jōr-ă)** The rounded folds of adipose tissue and

- skin that serve to protect the other female reproductive organs.
- labia minora (lā'bē-ā mī'nōr-ā)** The folds of skin between the labia majora.
- labyrinth (lāb'ə-rīnth')** The inner ear.
- laceration (lās'ə-rā'shən)** A jagged, open wound in the skin that can extend down into the underlying tissue.
- lacrimal apparatus (lāk'rə-məl āp'ə-rāt'əs)** A structure that consists of the lacrimal glands and nasolacrimal ducts.
- lacrimal gland (lāk'rə-məl glānd)** A gland in the eye that produces tears.
- lactase (lāk'tās)(†)** An enzyme that digests sugars.
- lactic acid (lāk'tik ās'id)** A waste product that must be released from the cell. It is produced when a cell is low on oxygen and converts pyruvic acid.
- lactogen (lak'tō-jen)** Substance secreted by the placenta that stimulates the enlargement of the mammary glands.
- lacunae (lə-kū-na)** Holes in the matrix of bone that hold osteocytes.
- lag phase (lāg fāz)** The initial phase of wound healing, in which bleeding is reduced as blood vessels in the affected area constrict.
- lamella (lə-mē'-lə)** Layers of bone surrounding the canals of osteons.
- lancet (lān'sīt)** A small, disposable instrument with a sharp point used to puncture the skin and make a shallow incision; used for capillary puncture.
- laryngopharynx (lā-ring'gō-far-ingks)(†)** The portion of the pharynx behind the **larynx**.
- larynx (lār'ingks)** The part of the respiratory tract between the pharynx and the trachea that is responsible for voice production; also called the voice box.
- laser printer (lā'zər prīn'tər)** A high-resolution printer that uses a technology similar to that of a photocopier. It is the fastest type of computer printer and produces the highest-quality output.
- lateral (lāt'ər-əl)** A directional term that means farther away from the midline of the body.
- lateral file (lāt'ər-əl fīl)** A horizontal filing cabinet that features doors that flip up and a pull-out drawer, where files are arranged with sides facing out.
- law (lō)** A rule of conduct established and enforced by an authority or governing body, such as the federal government.
- law of agency (lō ā'jən-sē)** A law stating that an employee is considered to be acting on the physician's behalf while performing professional duties.
- lead (lēd)** A view of a specific area of the heart on an electrocardiogram.
- lease (lēs)** To rent an item or piece of equipment.
- legal custody (lēgəl kūs'tə-dē)** The court-decreed right to have control over a child's upbringing and to take responsibility for the child's care, including health care.
- lens (lēnz)** A clear, circular disc located in the eye, just posterior to the iris, that can change shape to help the eye focus images of objects that are near or far away.
- letterhead (lēt'ər-hēd')** Formal business stationery, with the doctor's (or office's) name and address printed at the top, used for correspondence with patients, colleagues, and vendors.
- leukemia (lōō-kē'mē-ə)** A medical condition in which bone marrow produces a large number of white blood cells that are not normal.
- leukocytes (lōō-kə-sīt's)** White blood cells.
- leukocytosis (lū'kō-sī-tō'sis)(†)** A white blood cell count that is above normal.
- leukopenia (lū'kō-pē'nē-ā)(†)** A white blood cell count that is below normal.
- liable (lī-ə-bəl)** Legally responsible.
- liability insurance (lī-ə-bīl'ī-tē ĩn-shōōr'əns)** A type of insurance that covers injuries caused by the insured or injuries that occurred on the insured's property.
- lifetime maximum benefit (līf'tīm māk'sə-məm bēn'ə-fit)** The total sum that a health plan will pay out over the patient's life.
- ligament (līg'ə-mənt)** A tough, fibrous band of tissue that connects bone to bone.
- ligature (līg'ə-chōōr')** Suture material.
- limited check (līm'ī-tīd chēk)** A check that is void after a certain time limit; commonly used for payroll.
- lingual frenulum (līng'gwāl fren'yū-lūm)(†)** A flap of mucosa that holds the body of the tongue to the floor of the oral cavity.
- lingual tonsils (līng'gwāl ton'silz)(†)** Two lumps of lymphatic tissue on the back of the tongue that act to destroy bacteria and viruses.
- linoleic acid (līn-ō-lē'ik ās'id)(†)** An essential fatty acid found in corn and sunflower oils.
- lipoproteins (lip-ō-prō'tēnz)** Large molecules that are fat-soluble on the inside and water-soluble on the outside and carry lipids such as cholesterol and triglycerides through the bloodstream.
- living will (līv'ing wīl)** A legal document addressed to a patient's family and health-care providers stating what type of treatment the patient wishes or does not wish to receive if he becomes terminally ill, unconscious, or permanently comatose; sometimes called an advance directive.
- lobe (lōb)** The frontal, parietal, temporal, or occipital regions of the cerebral hemisphere.
- locum tenens (lō'kum tēn'ens)(†)** A substitute physician hired to see patients while the regular physician is away from the office.
- loop of Henle (lōōp hen'lē)** The portion of the renal tubule that curves back toward the renal corpuscle and twists again to become the distal convoluted tubule.
- lumbar enlargement (lūm'bər ěn-lār'j mənt)** The thickening of the spinal cord in the low back region.
- lunula (lū'nū-lā)** The white half-moon-shaped area at the base of a nail.
- lupus erythematosus (lōō'pəs er-ə-thē-tō'səs)** An autoimmune disorder in which a person produces antibodies that target the person's own cells and tissues.
- luteinizing hormone (LH) (lū'tē-in-iz-ing hōr'mōn')(†)** Hormone that in females stimulates ovulation and the production of estrogen; in males, it stimulates the production of testosterone.
- lymph (līm'f)** A pale fluid found between cells that is collected by the lymphatic system and returned to the bloodstream.
- lymphedema (līm'f-e-dē'mā)** The blockage of lymphatic vessels that results in the swelling of tissue from the accumulation of lymphatic fluid.
- lymphocyte (līm'fō-sīt)(†)** An agranular leukocyte formed in lymphatic tissue. Lymphocytes are generally small. See **T lymphocyte** and **B lymphocyte**.
- lysozyme (lī'sō-zīm)(†)** An enzyme in tears that destroys pathogens on the surface of the eye.
- macrophage (māk'rə-fāj')** A type of phagocytic cell found in the liver, spleen, lungs, bone marrow, and connective tissue. Macrophages play several roles in humoral and

cell-mediated immunity, including presenting the antigens to the lymphocytes involved in these defenses; also known as monocytes while in the bloodstream.

macula densa (mak'yū-lā den'sa) (†)

An area of the distal convoluted tubule that touches afferent and efferent arterioles.

macular degeneration (mak'yū-lār dē-jen-er-ā'shūn) (†) A progressive disease that usually affects people over the age of 50. It occurs when the retina no longer receives an adequate blood supply.

magnetic resonance imaging (māg-nēt'ik rēz'ə-nəns ĩ-māj'ing) A viewing technique that uses a powerful magnetic field to produce an image of internal body structures.

maintenance contract (mān'tə-nəns kōn'trākt') A contract that specifies when a piece of equipment will be cleaned, checked for worn parts, and repaired.

major histocompatibility complex (MHC) (mā'jər his'tō-kom-pat-ibil'i-tē kəm-plēks) A large protein complex that plays a role in T cell activation.

malignant (mə-līg'nənt) A type of tumor or neoplasm that is invasive and destructive and that tends to metastasize; it is commonly known as cancerous.

malleus (māl'ē-əs) A small bone in the middle ear that is attached to the eardrum; also called the hammer.

malpractice claim (māl-prāk'tis klām) A lawsuit brought by a patient against a physician for errors in diagnosis or treatment.

maltase (mawl-tās) An enzyme that digests sugars.

mammary glands (mam'ā-rē glāndz) Accessory organs of the female reproductive system that secrete milk after pregnancy.

mammography (mā-mōg'rā-fē) X-ray examination of the breasts.

managed care organization (MCO) (mān'ijd kār ōr'gə-nī-zā'shən) A health-care business that, through mergers and buyouts, can deliver health care more cost-effectively.

mandible (man'-də-bəl) A bone that forms the lower portion of the jaw.

manipulation (mə-nīp'yə-lā'shən) The systematic movement of a patient's body parts.

marrow (mer'-ō) A substance that is contained in the medullary cavity. In adults, it consists primarily of fat.

massage therapist (mə-sāzh'thēr'ə-pīst)

An individual who is trained to use pressure, kneading, and stroking to promote muscle and full-body relaxation.

mastoid process (mas'-tō'id pr'ā-sēs)

A large bump on each temporal bone just behind each ear. It resembles a nipple, hence the name mastoid.

Material Safety Data Sheet (MSDS) (mə-tīr'ē-əl sāf'tē dā'tə shēt) A form that is required for all hazardous chemicals or other substances used in the laboratory and that contains information about the product's name, ingredients, chemical characteristics, physical and health hazards, guidelines for safe handling, and procedures to be followed in the event of exposure.

matrix (mā'trīks) The basic format of an appointment book, established by blocking off times on the schedule during which the doctor is able to see patients. The material between the cells of connective tissue.

matter (māt'er) Anything that takes up space and has weight. Liquids, solids, and gases are matter.

maturation phase (māch'ə-rā'shən fāz) The third phase of wound healing, in which scar tissue forms.

maxillae (mak-sī-lə) A bone that forms the upper portion of the jaw.

Mayo stand (mā'ō stānd) A movable stainless steel instrument tray on a stand.

medial (mē'dē-əl) A directional term that describes areas closer to the midline of the body.

Medicaid (mēd'ī-kād') A federally funded health cost assistance program for low-income, blind, and disabled patients; families receiving aid to dependent children; foster children; and children with birth defects.

medical asepsis (mēd'ī-kəl ə-sēp'sīs) Measures taken to reduce the number of microorganisms, such as hand washing and wearing examination gloves, that do not necessarily eliminate microorganisms; also called clean technique.

medical practice act (mēd'ī-kəl prāk'tis ākt) A law that defines the exact duties that physicians and other health-care personnel may perform.

Medicare (mēd'ī-kār') A national health insurance program for Americans aged 65 and older.

Medicare + Choice Plan (mēd'ī-kār' chois plān) Medicare benefit in which beneficiaries can choose to

enroll in one of three major types of plans instead of the **Original Medicare Plan**.

Medigap (mēd'ī-gāp') Private insurance that Medicare recipients can purchase to reduce the gap in coverage—the amount they would have to pay from their own pockets after receiving Medicare benefits.

medullary cavity (mē'-de-ler-ē ká'-və-tē) The canal that runs through the center of the **diaphysis**.

megakaryocytes (meg-ā-kar'ē-ō-sīts) (†) Cells within red blood marrow that give rise to platelets.

meiosis (mī-ō'sis) (†) A type of cell division in which each new cell contains only one member of each chromosome pair.

melanin (mēl'ə-nīn) A pigment that is deposited throughout the layers of the epidermis.

melanocyte (mēl'ə-nō-sīt) (†) A cell type within the epidermis that makes the pigment **melanin**.

melatonin (mēl'ə-tō'nīn) A hormone that helps to regulate circadian rhythms.

membrane potential (mēm'brān' pə-tēn'shəl) The potential inside a cell relative to the fluid outside the cell.

meninges (mē-nīn'jēz) (†) Membranes that protect the brain and spinal cord.

meningitis (mēn'in-jī'tis) An inflammation of the **meninges**.

meniscus (mə-nīs'kəs) The curve in the air-to-liquid surface of a liquid specimen in a container.

menopause (mēn'ə-pōz') The termination of the menstrual cycle due to the normal aging of the ovaries.

menses (mēn'sēz) The clinical term for menstrual flow.

menstrual cycle (mēn'strō-əl sī'kəl) The female reproductive cycle. It consists of regular changes in the uterine lining that lead to monthly bleeding.

mensuration (mēn'sə-rā'shən) The process of measuring.

mesoderm (mez'ō-derm) (†) The primary germ layer that gives rise to connective tissue and some epithelial tissue.

metabolism (mī-tāb'ə-līz'əm) The overall chemical functioning of the body, including all body processes that build small molecules into large ones (anabolism) and break down large molecules into small ones (catabolism).

metacarpals (me-tə-kār-pəl) The bones that form the palms of the hand.

metastasis (mə-tās'tə-sis) The transfer of abnormal cells to body sites far removed from the original tumor.

metatarsals (mēt'ə-tār'salz) The bones that form the front of the foot.

microbiology (mī'krō-bī-ōl'ə-jē) The study of microorganisms.

microfiche (mī'krō-fēsh') Microfilm in rectangular sheets.

microfilm (mī'krō-film') A roll of film stored on a reel and imprinted with information on a reduced scale to minimize storage space requirements.

microorganism (mī'krō-ōr'gə-nīz'əm) A simple form of life, commonly made up of a single cell and so small that it can be seen only with a microscope.

micropipette (mī'krō-pī-pet') A small pipette that holds a small, precise volume of fluid; used to collect capillary blood.

microvilli (mī'krō-vil'i-ī)(†) Structures found in the lining of the small intestine. They greatly increase the surface area of the small intestine so it can absorb many nutrients.

micturition (mik-chū-rish'ūn)(†) The process of urination.

midsagittal (mid'saj'i-tāl)(†) Anatomical term that refers to the plane that runs lengthwise down the midline of the body, dividing it into equal left and right halves.

minerals (mīn'ər-əlz) Natural, inorganic substances the body needs to help build and maintain body tissues and carry on life functions.

minutes (mī-nōōtz') A report of what happened and what was discussed and decided at a meeting.

mirroring (mīr'ər-īng) Restating in your own words what a person is saying.

misdemeanor (mīs'dī-mē'nər) A less serious crime such as theft under a certain dollar amount or disturbing the peace. A misdemeanor is punishable by fines or imprisonment.

mitosis (mī-tō'sis) A type of cell division that produces ordinary body, or somatic, cells; each new cell receives a complete set of paired chromosomes.

mitral valve (mī'trāl vālv)(†) See bicuspid valve.

mobility aids (mō'bəl-ə-tē ādz) Devices that improve one's ability to move from one place to another; also called mobility assistive devices.

modeling (mōd'l-īng) The process of teaching the patient a new skill by having the patient observe and imitate it.

modem (mō'dəm) A device used to transfer information from one computer to another through telephone lines.

modified-block letter style (mōd'ə-fīd blōk lēt'ər stīl) A letter format similar to full-block style, except that the dateline, complimentary closing, signature block, and notations are aligned and begin at the center of the page or slightly to the right of center.

modified-wave schedule (mōd'ə-fīd wāv skēj'ōōl) A scheduling system similar to the wave system, with patients arriving at planned intervals during the hour, allowing time to catch up before the next hour begins.

modifier (mōd'ə-fī'ər) One or more two-digit codes assigned to the five-digit main code to show that some special circumstance applied to the service or procedure that the physician performed.

molars (mō'lərz) Back teeth that are flat and are designed to grind food.

mold (mōld) Fungi that grow into large, fuzzy, multicelled organisms that produce spores.

molecule (mōl'ī-kyōōl') The smallest unit into which an element can be divided and still retain its properties; it is formed when atoms bond together.

money order (mūn'ē ōr'dər) A certificate of guaranteed payment, which may be purchased from a bank, a post office, or some convenience stores.

monocytes (mōn'ō-sīts)(†) A large white blood cell with an oval or horseshoe-shaped nucleus that defends the body by phagocytosis; develops into a macrophage when it moves from blood into other tissues.

monosaccharide (mon-ō-sak'ā-rīd)(†) A type of carbohydrate that is a simple sugar.

mons pubis (m'ānz py'ū-bəs) A fatty area that overlies the pubic bone.

moral values (mōr'əl vāl'yōōz) Values or types of behavior that serve as a basis for ethical conduct and are formed through the influence of the family, culture, or society.

mordant (mōr'dnt) A substance, such as iodine, that can intensify or deepen

the response a specimen has to a stain.

morphology (mōr-fōl'ə-jē) The study of the shape or form of objects.

morula (mōr'ū-lā)(†) A zygote that has undergone cleavage and results in a ball of cells.

motherboard (mūth'ər-bōrd') The main circuit board of a computer that controls the other components in the system.

motor (mō'tər) Efferent neurons that carry information from the central nervous system to the effectors.

mucocutaneous exposure (myū-kō-kyū'tā-nē-əs ik-spō'-zhər) Exposure to a pathogen through mucous membranes.

mucosa (myōō-kō'sə) The innermost layer of the wall of the alimentary canal.

mucous cells (myōō'kəs sēlz) Cells that are found in the salivary glands and the lining of the stomach and that secrete mucous.

MUGA scan (mūg'ə skān) A radiologic procedure that evaluates the condition of the heart's myocardium; it involves injection of radioisotopes that concentrate in the myocardium, followed by the use of a gamma camera to measure ventricular contractions to evaluate the patient's heart wall.

multimedia (mūl'tē-mē'dē-ə) More than one medium, such as in graphics, sound, and text used to convey information.

multitasking (mūl'tē-tās'kīng) Running two or more computer software programs simultaneously.

multiunit smooth muscle (mūl'tə-yōō'nīt smōōth mūs'əl) A type of smooth muscle that is found in the iris of the eye and in the walls of blood vessels.

murmur (mūr'mər) An abnormal heart sound heard when the ventricles contract and blood leaks back into the atria.

muscle tissue (mūs'əl tīsh'ōō) A tissue type that is specialized to shorten and elongate.

muscle fatigue (mūs'əl fa-tēg') A condition caused by a buildup of lactic acid.

muscle fiber (mūs'əl fī'bər) Muscle cells that are called fibers because of their long lengths.

muscular dystrophy (mūs'kyə-lər dīs'trō-fē)(†) A group of inherited disorders characterized by a loss of muscle tissue and by muscle weakness.

- mutation (myōō-tá'shən)** An error that sometimes occurs when DNA is duplicated. When it occurs, it is passed to descendent cells and may or may not affect them in harmful ways.
- myasthenia gravis (mī-as-thē-nē-ā grav'is)** An autoimmune disorder that is characterized by muscle weakness.
- myelin (mī'ē-līn)** A fatty substance that insulates the axon and allows it to send nerve impulses quickly.
- myelography (mī'ē-log'rā-fē)** An x-ray visualization of the spinal cord after the injection of a radioactive contrast medium or air into the spinal subarachnoid space (between the second and innermost of three membranes that cover the spinal cord). This test can reveal tumors, cysts, spinal stenosis, or herniated disks.
- myocardial infarction (mī'ō-kār'dē-āl ĩn-fark'shən)** A heart attack that occurs when the blood flow to the heart is reduced as a result of blockage in the coronary arteries or their branches.
- myocardium (mī'ō-kār'dē-əm)** The middle and thickest layer of the heart. It is made primarily of cardiac muscle.
- myofibrils (mī'ō-fī'brils)(†)** Long structures that fill the sarcoplasm of a muscle fiber.
- myoglobin (mī'ō-glō'bīn)(†)** A pigment contained in muscle cells that stores extra oxygen.
- myoglobinuria (mī'ō-glō-bi-nūrē-ā)** The presence of myoglobin in the urine; can be caused by injured or damaged muscle tissue.
- myometrium (mī'ō-mē'trē-ūm)(†)** The middle, thick muscular layer of the uterus.
- myopia (mī'ō-pē-ə)** A condition that occurs when light entering the eye is focused in front of the retina; commonly called nearsightedness.
- myxedema (mik-se-dē-mā)(†)** A severe type of hypothyroidism that is most common in women over the age of 50.
- nail bed (nāl bēd)** The layer beneath each nail.
- narcotic (nār-kōt'ik)** A popular term for an opioid and term of choice in government agencies; see **opioid**.
- nasal (nā'zəl)** Relating to the nose. The nasal bones fuse to form the bridge of the nose.
- nasal conchae (nā'zəl kon'kē)(†)** Structures that extend from the lateral walls of the nasal cavity.
- nasal mucosa (nā'zəl myōō-kō'sə)** The lining of the nose.
- nasal septum (nā'zəl sēp'təm)** A structure that divides the nasal cavity into a left and right portion.
- nasolacrimal duct (nā-zō-lāk'rə-məl dūkt)** A structure located on the medial aspect of each eyeball. These ducts drain tears into the nose.
- nasopharynx (nā-zō-far'ingks)(†)** The portion of the pharynx behind the nasal cavity.
- natural killer (NK) cells (nāch'ər-el kīl'ər selz)** Non-B and non-T lymphocytes. NK cells kill cancer cells and virus-infected cells without previous exposure to the antigen.
- needle biopsy (nēd'l bī'ōp'sē)** A procedure in which a needle and syringe are used to aspirate (withdraw by suction) fluid or tissue cells.
- negligence (nēg'li-jəns)** A medical professional's failure to perform an essential action or performance of an improper action that directly results in the harm of a patient.
- negotiable (nī-gō'shē-ə-bəl)** Legally transferable from one person to another.
- neonatal period (nē-ō-nā'tāl pīr'ē-əd)(†)** The first four weeks of the postnatal period of an offspring.
- neonate (nē'ə-nāt')** An infant during the first four weeks of life.
- nephrologist (ne-frol'ō-jīst)(†)** A specialist who studies, diagnoses, and manages diseases of the kidney.
- nephrons (nef'ronz)(†)** Microscopic structures in the kidneys that filter blood and form urine.
- nerve fiber (nūrv fī'bər)** A structure that extends from the cell body. It consists of two types: axons and dendrites.
- nerve impulse (nūrv ĩm'pūls')** Electrochemical messages transmitted from neurons to other neurons and effectors.
- nervous tissue (nūrv'vəs tīsh'ōō)** A tissue type located in the brain, spinal cord, and peripheral nerves.
- net earnings (nēt ũr'nīngz)** Take-home pay, calculated by subtracting total deductions from gross earnings.
- network (nēt'wūrk')** A system that links several computers together.
- networking (nēt'wūrk'ing)** Making contacts with relatives, friends, and acquaintances that may have information about how to find a job in your field.
- neuralgia (nōō-rāl'jə)** A medical condition characterized by severe pain along the distribution of a nerve.
- neuroglial cell (nū-roglē-āl sēl)(†)** Non-neuronal type of nervous tissue that is smaller and more abundant than neurons. Neuroglial cells support neurons.
- neurologist (nōō-rəl'ə-jē)** A specialist who diagnoses and treats disorders and diseases of the nervous system, including the brain, spinal cord, and nerves.
- neuron (nōōr'ōn')** A nerve cell; it carries nerve impulses between the brain or spinal cord and other parts of the body.
- neurotransmitter (nōōr'ō-trāns'mīt-ər)** A chemical within the vesicles of the synaptic knob that is released into the postsynaptic structures when a nerve impulse reaches the synaptic knob.
- neutrophil (nū'trō-fīl)(†)** A type of granular leukocyte that aids in phagocytosis by attacking bacterial invaders; also responsible for the release of pyrogens.
- new patient (nōō pā'shənt)** Patient that, for CPT reporting purposes, has not received professional services from the physician within the past three years.
- nocturia (nok-tū'rē-ā)(†)** Excessive nighttime urination.
- noncompliant (nōn'kəm-plī'ent)** The term used to describe a patient who does not follow the medical advice given.
- noninvasive (non-ĩn-vā'siv)(†)** Referring to procedures that do not require inserting devices, breaking the skin, or monitoring to the degree needed with invasive procedures.
- nonsteroid hormone (non-stēr'oyd hōr'mōn')(†)** A type of hormone made of amino acids and proteins.
- norepinephrine (nōr'ep-i-nef'rīn)(†)** A neurotransmitter released by sympathetic neurons onto organs and glands for fight-or-flight (stressful) situations.
- normal flora (nōr'məl flō'rā)** Beneficial bacteria found in the body that create a barrier against pathogens by producing substances that may harm invaders and using up the resources pathogens need to live.
- no-show (nō shō)** A patient who does not call to cancel and does not come to an appointment.
- nosocomial infection (nos-ō-kō'mē-āl ĩn-fēk-shən)** An infection contracted in a hospital.
- Notice of Privacy Practices (NPP) (nō'tīs prī'vā-sē prāk'tīs-əs)** A document that informs patients

of their rights as outlined under **HIPAA**.

nuclear medicine (nōō'klē-ər mēd'ī-sīn) The use of radionuclides, or radioisotopes (radioactive elements or their compounds), to evaluate the bone, brain, lungs, kidneys, liver, pancreas, thyroid, and spleen; also known as radionuclide imaging.

nucleases (nū'klē-ās-ēz) Pancreatic enzymes that digest nucleic acids.

nucleus (nōō'klē-əs)(+) The control center of a cell; contains the chromosomes that direct cellular processes.

numeric filing system (nōō-mēr'ik fīl'ing sīs'təm) A filing system that organizes files by numbers instead of names. Each patient is assigned a number in the order in which she joins the practice.

O and P specimen (ō and pē spē'sə-mən) An ova and parasites specimen, or a stool sample, that is examined for the presence of certain forms of protozoans or parasites, including their eggs (ova).

objective (əb-jēk'tiv) Pertaining to data that is readily apparent and measurable, such as vital signs, test results, or physical examination findings.

objectives (əb-jēk'tivs) The set of magnifying lenses contained in the nosepiece of a compound microscope.

occipital (ōk-sip'ī-tl) Relating to the back of the head. The occipital bone forms the back of the skull.

occult blood (ə-kūlt blūd) Blood contained in some other substance, not visible to the naked eye.

ocular (ōk'yə-lər) An eyepiece of a microscope.

oil-immersion objective (oilī-mūr'zhən əb-jēk'tiv) A microscope objective that is designed to be lowered into a drop of immersion oil placed directly above the prepared specimen under examination, eliminating the air space between the microscope slide and the objective and producing a much sharper, brighter image.

ointment (oint'mənt) A form of topical drug; also known as a salve.

Older Americans Act of 1965 (ōl'dər ə-mēr'ī-kəns ākt) A U.S. law that guarantees certain benefits to elderly citizens, including health care, retirement income, and protection against abuse.

olfactory (ōl-fāk'tə-rē) Relating to the sense of smell.

oliguria Insufficient production (or volume) of urine.

oncologist (ōn-kōl'ə-jist) A specialist who identifies tumors and treats patients who have cancer.

onychectomy (ōn-i-kek'tō-mē) The removal of a fingernail or toenail.

oocyte (ōō-sīt)(+) The immature egg.

oogenesis (ō-ō-jen'ē-sis)(+) The process of egg cell formation.

open-book account (ō'pən bōōk ə-kount') An account that is open to charges made occasionally as needed.

open hours scheduling (ō'pən ourz skēj'ōōl-īng) A system of scheduling in which patients arrive at the doctor's office at their convenience and are seen on a first-come, first-served basis.

open posture (ōpən pōs'chər) A position that conveys a feeling of receptiveness and friendliness; facing another person with arms comfortably at the sides or in the lap.

ophthalmologist (ōf-thəl-mōl'ə-jist) A medical doctor who is an eye specialist.

ophthalmoscope (of-thal'mōskōp)(+) A hand-held instrument with a light; used to view inner eye structures.

opiod (ō'-pē-ōid) A natural or synthetic drug that produces opium-like effects.

optic chiasm (ōp'tik kī'azm)(+) A structure located at the base of the brain where parts of the optic nerves cross. It carries visual information to the brain.

optical microscope (ōp'ti-kāl mī'krə-skōp') A microscope that uses light, concentrated through a condenser and focused through the object being examined, to project an image.

opportunistic infection (ōp'ər-tōōnīs'tik īn-fēk-shən) Infection by microorganisms that can cause disease only when a host's resistance is low.

optometrist (ōp-tōm'ī-trīst) A trained and licensed vision specialist who is not a physician.

orbicularis oculi (ōr-bīk'yū-lā'ris ōk'yū-lī) The muscle in the eyelid responsible for blinking.

orbit (ōr'bit) The eye socket, which forms a protective shell around the eye.

organ (ōr'gan) Structure formed by the organization of two or more different tissue types that carries out specific functions.

organelle (ōr'gə-nəl') A structure within a cell that performs a specific function.

organic (ōr-gān'ik) Pertaining to matter that contains carbon and hydrogen.

organism (ōr'gə-nīz'əm) A whole living being that is formed from organ systems.

organ system (ōr'gən sīs'təm) A system that consists of organs that join together to carry out vital functions.

origin (ōr'ə-jīn) An attachment site of a skeletal muscle that does not move when a muscle contracts.

Original Medicare Plan (ə-rīj'ə-nəl mēd'ī-kār'plān) The Medicare fee-for-service plan that allows the beneficiary to choose any licensed physician certified by Medicare.

oropharynx (ōr'ō-far'ingks)(+) The portion of the pharynx behind the oral cavity.

orthopedist (ōr'thə-pēdist) A specialist who diagnoses and treats diseases and disorders of the muscles and bones.

OSHA (Occupational Safety and Health Act) (ō'shə) A set of regulations designed to save lives, prevent injuries, and protect the health of workers in the United States.

osmosis (ōz-mō'sīs) The diffusion of water across a semipermeable membrane such as a cell membrane.

ossification (ā-sə-fē-kā'shən) The process of bone growth.

osteoblast (ōs'tē-ō-bləst)(+) Bone-forming cells that turn membrane into bone. They use excess blood calcium to build new bone.

osteoclast (ōs'tē-ō-kləst)(+) Bone-dissolving cells. When bone is dissolved, calcium is released into the bloodstream.

osteocyte (ās'tē-ə-sīt) A cell of osseous tissue; also called a bone cell.

osteon (ās'tē-ən) Elongated cylinders that run up and down the long axis of bone.

osteopathic manipulative medicine (OMM) (ōs'tē-ō-pāth'ik mən'ip'ū-lā'tiv mēd'ī-sīn) A system of hands-on techniques that help relieve pain, restore motion, support the body's natural functions, and influence the body's structure. Osteopathic physicians study OMM in addition to medical courses.

osteoporosis (ōs'tē-ō-pə-rō'sīs) An endocrine and metabolic disorder of the musculoskeletal system, more common in women than in men, characterized by hunched-over posture.

- osteosarcoma (os'tē-ō-sar-kō'mā)** A type of bone cancer that originates from osteoblasts, the cells that make bony tissue.
- otologist (ō-tol'ō-jist) (†)** A medical doctor who specializes in the health of the ear.
- otorhinolaryngologist (ō-tō-rī-nō-lar-ing-gol'ō-jist)** A specialist who diagnoses and treats diseases of the ear, nose, and throat.
- out guide (out gīd)** A marker made of stiff material and used as a placeholder when a file is taken out of a filing system.
- oval window (ō'vəl win'dō)** The beginning of the inner ear.
- overbooking (ō'vər-bōōk'ing)** Scheduling appointments for more patients than can reasonably be seen in the time allowed.
- ovulation (ō'vyā-lā'shən)** The process by which the ovaries release one ovum (egg) approximately every 28 days.
- oxygen debt (ōk'sī-jən)** A condition that develops when skeletal muscles are used strenuously for a minute or two.
- oxyhemoglobin (oks-ē-hē-mō-glō'bīn) (†)** Hemoglobin that is bound to oxygen. It is bright red in color.
- oxytocin OT (ok-sē-tō'sin) (†)** A hormone that causes contraction of the uterus during childbirth and the ejection of milk from mammary glands during breast-feeding.
- packed red blood cells (pākt rēd blud sēlz)** Red blood cells that collect at the bottom of a centrifuged blood sample.
- palate (pal'āt) (†)** The roof of the mouth.
- palatine (pa'-lā-tīn)** Bones that form the anterior portion of the roof of the mouth and the **palate**.
- palatine tonsils (pal'ā-tīn tōn'sils) (†)** Two masses of lymphatic tissue located at the back of the throat.
- palpation (pāl-pā'shən)** A type of touch used by health-care providers to determine characteristics such as texture, temperature, shape, and the presence of movement.
- palpatory method (pal-pā'tōr-ē mēth'əd)** Systolic blood pressure measured by using the sense of touch. This measurement provides a necessary preliminary approximation of the systolic blood pressure to ensure an adequate level of inflation when the actual auscultatory measurement is made.
- palpitations (pāl'pī-tā'shənz)** Unusually rapid, strong, or irregular pulsations of the heart.
- pancreatic amylase (pan-krē-at'ik am'il-ās) (†)** An enzyme that digests carbohydrates.
- pancreatic lipase (pan-krē-at'ik lipās) (†)** An enzyme that digests lipids.
- panel (pān'əl)** Tests frequently ordered together that are organ or disease oriented.
- papillae (pā-pīl'ē)** The “bumps” of the tongue in which the taste buds are found.
- paranasal sinuses (par-ā-nā'zəl sī'nūs-ēz)** Air-filled spaces within skull bones that open into the nasal cavity.
- parasite (pār'ə-sīt')** An organism that lives on or in another organism and relies on it for nourishment or some other advantage to the detriment of the host organism.
- parasympathetic (pār'ə-sīm'pə-thēt'ik) (†)** A division of the autonomic nervous system that prepares the body for rest and digestion.
- parathyroid hormone (par-ā-thī'royd hōr'mōn') (†)** A hormone that helps regulate calcium levels in the bloodstream.
- parenteral nutrition (pā-ren'ter-āl nōō-trīsh'ən)** Nutrition obtained when specially prepared nutrients are injected directly into patients' veins rather than taken by mouth.
- paresthesias (par-es-thē-zē-ās) (†)** Abnormal sensations ranging from burning to tingling.
- parietal (pā-rī-ē-tāl)** Bones that form most of the top and sides of the skull.
- parietal cells (pā-rī-ē-tāl sēlz)** Stomach cells that secrete hydrochloric acid, which is necessary to convert **pepsinogen** to **pepsin**. Parietal cells also secrete **intrinsic factor**, which is necessary for vitamin B₁₂ absorption.
- parietal pericardium (pā-rī-ē-tāl per-i-kar'dē-ūm) (†)** The layer on top of the visceral pericardium.
- parotid glands (pā-rof'id glāndz) (†)** The largest of the salivary glands. The parotid glands are located beneath the skin just in front of the ears.
- participating physicians (pār-tis'ə-pāt'ing fī-zīsh'ənz)** Physicians who enroll in managed care plans. They have contracts with MCOs that stipulate their fees.
- passive listening (pās'iv līs'ən-īng)** Hearing what a person has to say without responding in any way; contrast with **active listening**.
- patch test (pāch tēst)** An allergy test in which a gauze patch soaked with a suspected allergen is taped onto the skin with nonallergenic tape; used to discover the cause of contact dermatitis.
- patella (pə-té-lə)** The bone commonly referred to as the kneecap.
- pathogen (pāth'ə-jən)** A microorganism capable of causing disease.
- pathologist (pā-thōf'ə-jist)** A medical doctor who studies the changes a disease produces in the cells, fluids, and processes of the entire body.
- patient compliance (pā'shənt kəm-plī'əns)** Obedience in terms of following a physician's orders.
- patient ledger card (pā'shənt lēj'ər kārd)** A card containing information needed for insurance purposes, including the patient's name, address, telephone number, Social Security number, insurance information, employer's name, and any special billing instructions. It also includes the name of the person who is responsible for charges if this is anyone other than the patient.
- patient record/chart (pā'shənt rēk'ərd/chārt)** A compilation of important information about a patient's medical history and present condition.
- payee (pā-ē')** A person who receives a payment.
- payer (pā'ər)** A person who pays a bill or writes a check.
- pay schedule (pā skēj'ōōl)** A list showing how often an employee is paid, such as weekly, biweekly, or monthly.
- pectoral girdle** The structure that attaches the arms to the axial skeleton.
- pediatrician (pē'dē-ə-trīsh'ən)** A specialist who diagnoses and treats childhood diseases and teaches parents skills for keeping their children healthy.
- pegboard system (pēg'bōrd sīs'təm)** A bookkeeping system that uses a lightweight board with pegs on which forms can be stacked, allowing each transaction to be entered and recorded on four different bookkeeping forms at once; also called the one-write system.
- pelvic girdle** The structure that attaches the legs to the axial skeleton.
- pepsin (pēp'sin) (†)** An enzyme that allows the body to digest proteins.
- pepsinogen (pēp-sin'ō-jen) (†)** Substance that is secreted by the chief cells in the lining of the stomach and becomes **pepsin** in the presence of acid.
- peptidases (pēp'ti-dās-ēz) (†)** Enzymes that digest proteins.

- percussion** (pər-kūsh'ən) Tapping or striking the body to hear sounds or feel vibration.
- percutaneous exposure** (per-kyū-tā-nē-ūs ik-spō'zhər)(†) Exposure to a pathogen through a puncture wound or needlestick.
- pericardium** (per-i-kar'dē-ūm)(†) A membrane that covers the heart and large blood vessels attached to it.
- perilymph** (per'i-limf)(†) A fluid in the inner ear. When this fluid moves, it activates hearing and equilibrium receptors.
- perimetrium** The thin layer that covers the myometrium of the uterus.
- perimysium** (per-i-mis'ē-ūm)(†) The connective tissue that divides a muscle into sections called fascicles.
- periosteum** (pēr'ē.ostē.əm)(†) The membrane that surrounds the diaphysis of a bone.
- peripheral nervous system** (pə-rīf'ər-əl nūr'vəs sīs'təm) A system that consists of nerves that branch off the central nervous system.
- peristalsis** (pēr'ī-stōl'sīs) The rhythmic muscular contractions that move food through the digestive tract.
- personal space** (pūr'sə-nəl spās) A certain area that surrounds an individual and within which another person's physical presence is felt as an intrusion.
- petty cash fund** (pētē kash fūnd) Cash kept on hand in the office for small purchases.
- phagocyte** (fāg'ə-sīf') A specialized white blood cell that engulfs and digests pathogens.
- phagocytosis** (fag'ō-sī-tō'sis)(†) The process by which white blood cells defend the body against infection by engulfing invading pathogens.
- phalanges** (fə-lān'jēz)(†) The bones of the fingers.
- pharmaceutical** (fār'mə-sōō'ti-kəl) Pertaining to medicinal drugs.
- pharmacodynamics** (fār'mā-kō-dī-nam'iks)(†) The study of what drugs do to the body: the mechanism of action, or how they work to produce a therapeutic effect.
- pharmacognosy** (fār'mā-kog'nō-sē)(†) The study of characteristics of natural drugs and their sources.
- pharmacokinetics** (fār'mā-kō-kinet'iks)(†) The study of what the body does to drugs: how the body absorbs, metabolizes, distributes, and excretes the drugs.
- pharmacology** (fār'ma-kōl'ə-jē)(†) The study of drugs.
- pharmacotherapeutics** (fār'mā-kō-thēr'ə-pyōō'tiks) The study of how drugs are used to treat disease; also called clinical **pharmacology**.
- pharyngeal tonsils** (fā-rin'jē-āl tōn'səls)(†) Two masses of lymphatic tissue located above the palatine tonsils; also called adenoids.
- pharynx** (fār'ingks) Structure below the mouth and nasal cavities that is an organ of the respiratory system as well as the digestive system.
- phenylketonuria (PKU)** (fen'il-kē'tō-nūr'ē-ā)(†) A genetically inherited disorder in which the body cannot properly metabolize the nutrient phenylalanine, resulting in the buildup of phenylketones in the blood and their presence in the urine. The accumulation of phenylketones results in mental retardation.
- philosophy** (fī-lōs'ə-fē) The system of values and principles an office has adopted in its everyday practice.
- phlebotomy** (flī-bōt'ə-mē) The insertion of a needle or cannula (small tube) into a vein for the purpose of withdrawing blood.
- photometer** (fō-tōm'ī-trē) An instrument that measures light intensity.
- physiatrist** (fiz-ī'ā-trist)(†) A physical medicine specialist, who diagnoses and treats diseases and disorders with physical therapy.
- physical therapy** (fiz'ī-kəl thēr'ə-pē) A medical specialty that uses cold, heat, water, exercise, massage, traction, and other physical means to treat musculoskeletal, nervous, and cardiopulmonary disorders.
- physician assistant (PA)** (fī-zish'ən ə-sis'tənt) A health-care provider who practices medicine under the supervision of a physician.
- physician's office laboratory (POL)** (fī-zish'ənz ɔ'fīs lāb'rə-tōr'ē) A laboratory contained in a physician's office; processing tests in the POL produces quick turnaround and eliminates the need for patients to travel to other test locations.
- physiology** (fiz'ē-ōl'ə-jē) The science of the study of the body's functions.
- pineal body** (pin'ē-āl bōd'ē) A small gland located between the cerebral hemispheres that secretes melatonin.
- pitch** (pich) The high or low quality in the sound of a person's speaking voice.
- placenta** (plə-sēn'tə) An organ located between the mother and the fetus. It permits the absorption of nutrients and oxygen. In some cases, harmful substances such as viruses are absorbed through the placenta.
- plantar flexion** (plan'tār flek'shūn)(†) Pointing the toes downward.
- plasma** (plāz'mə) The fluid component of blood, in which formed elements are suspended; makes up 55% of blood volume.
- plastic surgeon** (plās'tik sūr'jən) A specialist who reconstructs, corrects, or improves body structures.
- platelets** (plāt'līts) Fragments of cytoplasm in the blood that are crucial to clot formation; also called thrombocytes.
- pleura** (plūr'ā)(†) The membranes that surround the lungs.
- pleuritis** A condition in which the **pleura** become inflamed, which causes them to stick together. It can also cause an excess amount of fluid to form between the membranes.
- plexus** (plēk'səs) A structure that is formed when spinal nerves fuse together. It includes the cervical, brachial, and lumbosacral nerves.
- pneumothorax** (nū-mō-thōr'aks)(†) The presence of air or gas in the pleural cavity. The lung typically collapses with pneumothorax.
- polar body** (pō'lār bōd'ē) A nonfunctional cell that is one of two small cells formed during the division of an oocyte.
- polarity** (pō-lār'ī-tē) The condition of having two separate poles, one of which is positive and the other, negative.
- polarized** (pō'lə-rīzd') The state in which the outside of a cell membrane is positively charged and the inside is negatively charged. Polarization occurs when a neuron is at rest.
- polysaccharide** (pol-ē-sak'ā-rīd)(†) A type of carbohydrate that is a starch.
- POMR** (pēō-ēm-ār) The problem-oriented medical record system for keeping patients' charts. Information in a POMR includes the database of information about the patient and the patient's condition, the problem list, the diagnostic and treatment plan, and progress notes.
- portfolio** (pōrt-fō'lē-ō) A collection of an applicant's résumé, reference letters, and other documents of interest to a potential employer.
- positron emission tomography** A radiologic procedure that entails injecting isotopes combined with other substances involved in metabolic activity, such as glucose. These special isotopes emit positrons, which a computer processes and displays on a screen.

- posterior (pō-stīrē-ar)** Anatomical term meaning toward the back of the body. Also called dorsal.
- postnatal period (pōst-nā'tāl pīr'ē-əd) (†)** The period following childbirth.
- postoperative (pōst-ōp'ər-ə-tīv)** Taking place after a surgical procedure.
- posture (pōs'chər)** Body position and alignment.
- power of attorney (pou'ər ə-túr'nē)** The legal right to act as the attorney or agent of another person, including handling that person's financial matters.
- practitioner (prāk-tīsh'ə-nər)** One who practices a profession.
- preferred provider organization (PPO) (prī-fúrd' prə-vīd'ər or 'gə-nī-zā'shən)** A managed care plan that establishes a network of providers to perform services for plan members.
- premenstrual syndrome (PMS) (prē-me'n(†)-strə-wal sin'-drōm)** A syndrome that is a collection of symptoms that occur just before the menstrual period.
- premium (prémē-əm)** The basic annual cost of health-care insurance.
- prenatal period (prē-nā'tāl pīr'ē-əd) (†)** The period that includes the embryonic and fetal periods until the delivery of the offspring.
- preoperative (prē-ōp'ər-ə-tīv)** Taking place prior to surgery.
- prepuce (prépūs) (†)** A piece of skin in the uncircumcized male that covers the glans penis.
- presbyopia (prez-bē-ōpē-ă)** A common eye disorder that results in the loss of lens elasticity. Presbyopia develops with age and causes a person to have difficulty seeing objects close up.
- prescribe (prī-skrīb')** To give a patient a prescription to be filled by a pharmacy.
- prescription (prī-skrīp'shən)** A physician's written order for medication.
- prescription drug (prī-skrīp'shən drūg)** A drug that can be legally used only by order of a physician and must be administered or dispensed by a licensed health-care professional.
- primary care physician (prīm'ēr'ē kār fī-zīsh'ən)** A physician who provides routine medical care and referrals to specialists.
- primary germ layer (prīm'ēr'ē jūrm lā'ər)** An inner cell mass that organizes into layers: the ectoderm, mesoderm, and endoderm.
- prime mover (prīm mōō'vər)** The muscle responsible for most of the movement when a body movement is produced by a group of muscles.
- primordial follicle (prī-mōr'dēl-əl fōl'ī-kəl) (†)** A structure that develops in the ovarian cortex of a female infant before she is born.
- Privacy Rule (prī'və-sē rōōl)** Common name for the HIPAA Standard for Privacy of Individually Identifiable Health Information, which provides the first comprehensive federal protection for the privacy of health information. The Privacy Rule creates national standards to protect individuals' medical records and other personal health information.
- procedure code (prə-sēj'ər kōd)** Codes that represent medical procedures, such as surgery and diagnostic tests, and medical services, such as an examination to evaluate a patient's condition.
- proctoscopy (prok-toś'kō-pē)** An examination of the lower rectum and anal canal with a 3-inch instrument called a proctoscope to detect hemorrhoids, polyps, fissures, fistulas, and abscesses.
- proficiency testing program (prə-fīsh'ən-sē tēst'ing prō'grām')** A required set of tests for clinical laboratories; the tests measure the accuracy of the laboratory's test results and adherence to standard operating procedures.
- progesterone (prō-jēs'tə-rōn')** A female steroid hormone primarily produced by the ovary.
- prognosis (prōg-nō'sīs)** A prediction of the probable course of a disease in an individual and the chances of recovery.
- prolactin (PRL) (prō-lak'tin) (†)** A hormone that stimulates milk production in the mammary glands.
- proliferation phase (prə-līf'ər-ā'shən fāz)** The second phase of wound healing, in which new tissue forms, closing off the wound.
- pronation (prō-nā'shūn) (†)** Turning the palms of the hand downward.
- pronunciation (prə-nun'sē-ā'shən)** The sounding out of words.
- proofreading (prōōf'rēd'ing)** Checking a document for formatting, data, and mechanical errors.
- prostaglandin (pros-tā-glan'din) (†)** A local hormone derived from lipid molecules. Prostaglandins typically do not travel in the bloodstream to find their target cells because their targets are close by. This hormone has numerous effects, including uterine stimulation during childbirth.
- prostate gland (prōs'tāt' glānd)** A chestnut-shaped gland that surrounds the beginning of the urethra in the male.
- prostatitis (pros-tā-tī'tis)** Inflammation of the prostate gland, which can be acute or chronic.
- protected health information (PHI) (prə-tēkt-əd hēlth inf'ər-mā'shən)** Individually identifiable health information that is transmitted or maintained by electronic or other media, such as computer storage devices. The core of the HIPAA Privacy Rule is the protection, use, and disclosure of protected health information.
- proteinuria (prō-tē-nū-rē-ă)** An excess of protein in the urine.
- protozoan (prō'tə-zō'ən)** A single-celled eukaryotic organism much larger than a bacterium; some protozoans can cause disease in humans.
- protraction (prō-trāk'shən)** Moving a body part anteriorly.
- proximal (prok'si-māl) (†)** Anatomical term meaning closer to a point of attachment or closer to the trunk of the body.
- proximal convoluted tubule (prok'si-māl kon'vō-lū-ted tū'byūl) (†)** The portion of the renal tubule that is directly attached to the glomerular capsule and becomes the loop of Henle.
- psoriasis (sə-rī'ā-sīs)** A common skin condition characterized by reddish-silver scaly lesions most often found on the elbows, knees, scalp, and trunk.
- puberty (pyōō'bər-tē)** The period of adolescence when a person begins to develop secondary sexual traits and reproductive functions.
- pulmonary circuit (pōōl'mə-nēr'ē sūr'kīt)** The route that blood takes from the heart to the lungs and back to the heart again.
- pulmonary trunk (pōōl'mə-nēr'ē trūngk)** A large artery that branches into the pulmonary arteries and carries blood to the lungs.
- pulmonary valve (pōōl'mə-nēr'ē vālv)** A heart valve that is a semilunar valve. It is situated between the right ventricle and the pulmonary trunk.
- pubis (pyū-bəs)** The area that forms the front of a hip bone.
- pulmonary function test (pōōl'mə-nēr'ē fūngk'shən tēst)** A test that evaluates a patient's lung volume and capacity; used to detect and diagnose pulmonary problems or to monitor certain respiratory disorders and

- evaluate the effectiveness of treatment.
- puncture wound (pŭngkchær wound)** A deep wound caused by a sharp, pointed object.
- punitive damages (pyōō'ni-tiv dāmijz)** Money paid as punishment for intentionally breaking the law.
- pupil (pyōōpəl)** The opening at the center of the iris, which grows smaller or larger as the iris contracts or relaxes, respectively; it regulates the amount of light that enters the eye.
- purchase order (pŭrchis órðær)** A form that authorizes a purchase for the practice.
- purchasing groups (pŭrchis-ing grōops)** Groups of medical offices associated with a nearby hospital that order supplies through the hospital to obtain a quantity discount.
- Purkinje fibers (per'kin-jē fi'bærz)** Cardiac fibers that are located in the lateral walls of the ventricles.
- pyelonephritis (pi'ē-lō-ne-frī-tis) (†)** A urinary tract infection that involves one or both of the kidneys.
- pyrogens (piō-jenz) (†)** Fever-producing substances released by neutrophils.
- quadrants (kwōd'ræntz)** Four equal sections, such as those into which the abdomen is figuratively divided during an examination.
- qualitative analysis (kwōl'i-tā'tiv ə-nāl'ī-sis)** In microbiology, identification of bacteria present in a specimen by the appearance of colonies grown on a culture plate.
- qualitative test response (kwōl'i-tā'tiv tēst ri-spōns')** A test result that indicates the substance tested for is either present or absent.
- quality assurance program (kwōl'i-tē ə-shōōr'æns prō'grām')** A required program for clinical laboratories designed to monitor the quality of patient care, including quality control, instrument and equipment maintenance, proficiency testing, training and continuing education, and standard operating procedures documentation.
- quality control (QC) (kwōl'i-tē kæn-trōl')** An ongoing system, required in every physician's office, to evaluate the quality of medical care provided.
- quality control program (kwōl'i-tē kæn-trōl' prō'grām')** A component of a quality assurance program that focuses on ensuring accuracy in laboratory test results through careful monitoring of test procedures.
- quantitative analysis (kwōnti-tā'tiv ə-nāl'ī-sis)** In microbiology, a determination of the number of bacteria present in a specimen by direct count of colonies grown on a culture plate.
- quantitative test results (kwōnti-tā'tiv tēst ri-zŭltz')** The concentration of a test substance in a specimen.
- quarterly return (kwōr'tar-lē ri-tŭrn')** The Employer's Quarterly Federal Tax Return, a form submitted to the IRS every 3 months that summarizes the federal income and employment taxes withheld from employees' paychecks.
- radial artery (rādē-əl ār'tā-rē)** An artery located in the groove on the thumb side of the inner wrist, where the pulse is taken on adults.
- radiation therapy (rādē-ā'shən thēr'ə-pē)** The use of x-rays and radioactive substances to treat cancer.
- radiologist (rādē-ōl' ə-jist)** A physician who specializes in taking and reading x-rays.
- radius (rā-dā-əs)** The lateral bone of the forearm.
- random access memory (RAM) (rāndəm āksēs mēmə-rē)** The temporary, or programmable, memory in a computer.
- random urine specimen (rāndəm yōōr' in spēs ə-mən)** A single urine specimen taken at any time of the day; the most common type of sample collected.
- range of motion (ROM) (rānj mō'shən)** The degree to which a joint is able to move.
- rapport (rā-pōr')** A harmonious, positive relationship.
- read only memory (ROM) (rēd ōn'lē mēmə-rē)** A computer's permanent memory, which can be read by the computer but not changed. It provides the computer with the basic operating instructions it needs to function.
- reagent (rē-ājənt)** A chemical or chemically treated substance used in test procedures and formulated to react in specific ways when exposed under specific conditions.
- reconciliation (rēkən-sil'ē-ā'shən)** A comparison of the office's financial records with bank records to ensure that they are consistent and accurate; usually done when the monthly checking account statement is received from the bank.
- records management system (ri-kōrdz mānj-mənt sis'təm)** How patient records are created, filed, and maintained.
- recovery position (ri-kŭv'ær-ē pə-zishən)** The position a person is placed in after receiving first aid for choking or cardiopulmonary resuscitation.
- rectum (rēktəm)** The last section of the sigmoid colon that straightens out and becomes the anal canal.
- reference (rēfær-əns)** A recommendation for employment from a facility or a preceptor.
- reference laboratory (rēfær-əns lābrə-tōrē)** A laboratory owned and operated by an organization outside the physician's practice.
- referral (ri-fŭrəl)** An authorization from a medical practice for a patient to have specialized services performed by another practice; often required for insurance purposes.
- reflex (rēflēks')** A predictable automatic response to stimuli.
- refraction examination (ri-frāk'shən ig-zāmə-nā'shən)** An eye examination in which the patient looks through a succession of different lenses to find out which ones create the clearest image.
- refractometer (rē-frac-tom'ē-ter) (†)** An optical instrument that measures the refraction, or bending, of light as it passes through a liquid.
- Registered Medical Assistant (RMA) (rēj'ī-stərd mēd'ī-kəl ə-sis'tənt)** A medical assistant who has met the educational requirements and taken and passed the certification examination for medical assisting given by the American Medical Technologists (AMT).
- relaxin (rē-lak'sin) (†)** A hormone that comes from the corpus luteum. It inhibits uterine contractions and relaxes the ligaments of the pelvis in preparation for childbirth.
- remittance advice (RA) (ri-mit'ns ād-vīz')** A form that the patient and the practice receive for each encounter that outlines the amount billed by the practice, the amount allowed, the amount of subscriber liability, the amount paid, and notations of any service not covered, including an explanation of why that service is not covered; also called an explanation of benefits.
- renal calculi (rēnəl kāl'kyə-lī')** Kidney stones.
- renal column (rēnəl kōl'əm)** The portion of the renal cortex between the renal pyramids.
- renal corpuscle (rēnəl kōr'pə-səl)** Corpuscle that is composed of the glomerulus and the glomerular

- capsule. The filtration of blood occurs here.
- renal cortex (rĕnəl kōr'tĕks')** The outermost layer of the kidney.
- renal medulla (rĕnəl mī-dŭl'ə)** The middle portion of the kidney.
- renal pelvis (rĕnəl pĕl'vīs)** The internal structure of the kidney. Urine flows from the renal pelvis down the ureter.
- renal pyramids (rĕnəl pīr'ə-mīdz)** Triangular-shaped areas in the medulla of the kidney.
- renal sinus (rĕnəl sīnəs)** The medial depression of a kidney.
- renal tubule (rĕnəl tŭ'byŭl)** Structure that extends from the glomerular capsule of a nephron and is comprised of the proximal convoluted tubule, the loop of Henle, and the distal convoluted tubule.
- renin (rĕn'in)(†)** A hormone secreted by the kidney that helps to regulate blood pressure.
- repolarization (rĕpō-lār-i-zā'shŭn)(†)** The process of returning to the original polar (resting) state.
- reputable (rĕpyə-tə-bəl)** Having a good reputation.
- requisition (rĕkwi-zīshən)** A formal request from a staff member or doctor for the purchase of equipment or supplies.
- reservoir host (rĕzər-vwār hōst)** An animal, insect, or human whose body is susceptible to growth of a pathogen.
- respiratory volume (rĕspər-ə-tōrĕ vōl'yōōm)** The different volumes of air that move into and out of the lungs during different intensities of breathing. These volumes can be measured to assess the healthiness of the respiratory system.
- resource-based relative value scale (RBRVS) (rĕsōrs' bāst rĕl'ə-tīv vāl'yōō skāl)** The payment system used by Medicare. It establishes the relative value units for services, replacing the providers' consensus on usual fees.
- résumé (rĕzōō-mā')** A typewritten document summarizing one's employment and educational history.
- retention schedule (rĕ-tĕn'shən skĕj'ōōl)** A schedule that details how long to keep different types of patient records in the office after they have become inactive or closed and how long the records should be stored.
- retina (rĕt'n-ə)** The inner layer of the eye; contains light-sensing nerve cells.
- retraction (rĕ-trāk'shən)** Moving a body part posteriorly.
- retrograde pyelography (rĕtrə-grād' pī'ĕ-logrā-fĕ)(†)** A radiologic procedure in which the doctor injects a contrast medium through a urethral catheter and takes a series of x-rays to evaluate function of the ureters, bladder, and urethra.
- retroperitoneal (rĕ-trō-per-ə-tə-nĕ-əl)** An anatomical term that means behind the peritoneal cavity. It is where the kidneys lie.
- return demonstration (rĕ-tŭrn' dĕm'ən-strāshən)** Participatory teaching method in which the technique is first described to the patient and then demonstrated to the patient; the patient is then asked to repeat the demonstration.
- rhabdomyolysis (rab'dō-mī-ol'i-sis)(†)** A condition in which the kidneys have been damaged due to toxins released from muscle cells.
- Rh antigen (ār'āch ant'i-jən)** A protein first discovered on the red blood cells of rhesus monkeys, hence the name Rh.
- RhoGAM (rōgām)** A medication that prevents an Rh-negative mother from making antibodies against the Rh antigen.
- RNA (ār'ĕn-ā')** A nucleic acid used to make protein.
- rods (rōdz)** Light-sensing nerve cells in the eye, at the posterior of the retina, that function in dim light but do not provide sharp images or detect color.
- rosacea (rō-zāshĕ-ā)(†)** A condition characterized by chronic redness and acne over the nose and cheeks.
- rotation (rō-tā'shən)** Twisting a body part.
- route (rōōt)** The way a drug is introduced into the body.
- sacrum (sā-krām)** A triangular-shaped bone that consists of five fused vertebrae.
- sagittal (saj'i-tāl)(†)** An anatomical term that refers to the plane that divides the body into left and right portions.
- salutation (sāl'yə-tā'shən)** A written greeting, such as "Dear," used at the beginning of a letter.
- sanitization (săn'ī-tī-zā'shən)(†)** A reduction of the number of microorganisms on an object or a surface to a fairly safe level.
- sarcolemma (sar'kō-lem'ā)** The cell membrane of a muscle fiber.
- sarcoplasm** The cytoplasm of a muscle fiber.
- sarcoplasmic reticulum (sar-kō-plaz'mik rĕ-tik'yū-lŭm)** The endoplasmic reticulum of a muscle fiber.
- SARS (severe acute respiratory syndrome) (sārzs)** A severe and acute respiratory illness characterized by fever and a nonproductive cough that progresses to the point at which insufficient oxygen is present in the blood.
- saturated fat (sāch'ə-rā'tīd fāt)** Fats, derived primarily from animal sources, that are usually solid at room temperature and that tend to raise blood cholesterol levels.
- scabies (skā'bĕz)** Skin lesions that are very itchy and caused by a burrowing mite. Scabies is most commonly found between the fingers and on the genitalia.
- scanner (skā'nər)** An optical device that converts printed matter into a format that can be read by the computer and inputs the converted information.
- scapula (sk'a-py-ə-lə)** Thin, triangular-shaped, flat bones located on the dorsal surface of the rib cage; also called shoulder blades.
- Schwann cell (shwahn sĕl)(†)** A neuroglial cell whose cell membrane coats the axons.
- sciatica (sī-āt'i-kə)** Pain in the low back and hip radiating down the back of the leg along the sciatic nerve.
- sclera (sklīr'ə)** The tough, outermost layer, or "white," of the eye, through which light cannot pass; covers all except the front of the eye.
- scoliosis (skō'lĕ-ō'sīs)** A lateral curvature of the spine, which is normally straight when viewed from behind.
- scratch test (skrāch tĕst)** An allergy test in which extracts of suspected allergens are applied to the patient's skin and the skin is then scratched to allow the extracts to penetrate.
- screening (skrĕn'ing)** Performing a diagnostic test on a person who is typically free of symptoms.
- screen saver (skrĕn sāvər)** A program that automatically changes the monitor display at short intervals or constantly shows moving images to prevent burn-in of images on the computer screen.
- scrotum (skrōtəm)** In a male, the sac of skin below the pelvic cavity that contains the testes.
- sebaceous (sī-bāshəs)** A type of oil gland found in the dermis.
- sebum (sĕ'bŭm)(†)** An oily substance produced by sebaceous glands.
- Security Rule (sī-kyōōr'i-tĕ rōōl)** The technical safeguards that protect the

- confidentiality, integrity, and availability of health information covered by **HIPAA**. The Security Rule specifies how patient information is protected on computer networks, the Internet, disks, and other storage media.
- seizure (sēzhər)** A series of violent and involuntary contractions of the muscles; also called a convulsion.
- sella turcica (selā tūrṣē-kā) (†)** A deep depression in the sphenoid bone where the pituitary gland sits.
- semen (sēmən)** Sperm and the various substances that nourish and transport them.
- semicircular canals (sēmē-sūrkyə-lər kə-nälz) (†)** Structures in the inner ear that help a person maintain balance; each of the three canals is positioned at right angles to the other two.
- seminal vesicles (sem-näl ves-i-klz) (†)** A pair of convoluted tubes that lie behind the bladder. These tubes secrete a fluid that provides nutrition for the sperm.
- seminiferous tubules (semí-nifer-üs tū-byülz) (†)** These tubes contain spermatogenic cells and are located in the lobules of the testes.
- sensorineural hearing loss (senśör-i-nüräl hīr'ing lōs)** This type of hearing loss occurs when neural structures associated with the ear are damaged. Neural structures include hearing receptors and the auditory nerve.
- sensory (senśə-rē)** Afferent neurons that carry sensory information from the periphery to the central nervous system.
- sensory adaptation (senśə-rē äd'äp-tāshən)** A process in which the same chemical can stimulate receptors only for a limited amount of time until the receptors eventually no longer respond to the chemical.
- septic shock (sēptik shök)** A state of shock resulting from massive, widespread infection that affects the blood vessels' ability to circulate blood.
- sequential order (sī'kwēnshəl ör'dər)** One after another in a predictable pattern or sequence.
- serosa (se-rōsā) (†)** The outermost layer of the alimentary canal; also known as the visceral peritoneum.
- serous cells (sērūs sēlz) (†)** One of two types of cells that make up the salivary glands. These cells secrete a watery fluid that contains amylase.
- serum (sērüm) (†)** The clear, yellow liquid that remains after a blood clot forms; it is separated from the clotted elements by centrifugation.
- service contract (sūr'vīs kōn'trākt')** A contract that covers services for equipment that are not included in a standard maintenance contract.
- sex chromosome (sēks krōmā-sōm')** Chromosome of the 23rd pair.
- sex-linked trait (sēks līngk trāt)** Traits that are carried on the sex chromosomes, or X and Y chromosomes.
- sigmoid colon (sig-moid ko-lən)** An S-shaped tube that lies between the **descending colon** and the **rectum**.
- sigmoidoscopy (sig'moy-dōskō-pē)** A procedure in which the interior of the sigmoid area of the large intestine, between the descending colon and the rectum, is examined with a sigmoidoscope, a lighted instrument with a magnifying lens.
- sign (sīn)** An objective or external factor, such as blood pressure, rash, or swelling, that can be seen or felt by the physician or measured by an instrument.
- simplified letter style (sīm'plē-fīd' lētər stīl)** A modification of the full-block style in which the salutation and complimentary closing are omitted and a subject line typed in all capital letters is placed between the address and the body of the letter.
- single-entry account (sīng'gəl-ēn'trē ə-kōunt')** An account that has only one charge, usually for a small amount, for a patient who does not come in regularly.
- sinoatrial node (sīnō-ā'trē-äl nōd) (†)** A small bundle of heart muscle tissue in the superior wall of the right atrium that sets the rhythm (or pattern) of the heart's contractions; also called sinus node or pacemaker.
- sinusitis (sīnə-sīt'is)** Inflammation of the lining of a sinus.
- skinfold test (skīn' tēst)** A method of measuring fat as a percentage of body weight by measuring the thickness of a fold of skin with a caliper.
- slit lamp (slīt lāmp)** An instrument composed of a magnifying lens combined with a light source; used to provide a minute examination of the eye's anatomy.
- smear (smīr)** A specimen spread thinly and unevenly across a slide.
- SOAP (sōp)** An approach to medical records documentation that documents information in the following order: S (**subjective** data), O (**objective** data), A (**assessment**), P (**plan of action**).
- software (sōft'wār')** A program, or set of instructions, that tells a computer what to do.
- solution (sə-lōōshən)** A homogeneous mixture of a solid, liquid, or gaseous substance in a liquid, such as a dissolved drug in liquid form.
- somatic (sō-māt'ik)** A division of the peripheral nervous system that connects the central nervous system to skin and skeletal muscle.
- SPECT (spēkt)** Single photon emission computed tomography; a radiologic procedure in which a gamma camera detects signals induced by gamma radiation and a computer converts these signals into two- or three-dimensional images that are displayed on a screen.
- speculum (spēkyə-ləm)** An instrument that expands the vaginal opening to permit viewing of the vagina and cervix.
- spermatids (sper'mā-tīdz) (†)** Immature sperm before they develop their flagella (tails).
- spermatocytes (sper'mā-tō-sīts) (†)** The cells that result when **spermatogonia** undergo mitosis.
- spermatogenesis (sper'mā-tō-jeñē-sis) (†)** The process of sperm cell formation.
- spermatogenic cells (sper'mā-tō-jeñik sēlz) (†)** The cells that give rise to sperm cells.
- spermatogonia (sper'mā-tō-gōnē-ä) (†)** The earliest cell in the process of **spermatogenesis**.
- sphenoid (sfē'noid') (†)** A bone that forms part of the floor of the cranium.
- sphincter (sfīngktər)** A valve-like structure formed from circular bands of muscle. Sphincters are located around various body openings and passages.
- sphygmomanometer (sfīgmō-mānomē-ter) (†)** An instrument for measuring blood pressure; consists of an inflatable cuff, a pressure bulb used to inflate the cuff, and a device to read the pressure.
- spinal nerves (spī'nāl nūrvs) (†)** Peripheral nerves that originate from the spinal cord.
- spirillum (spī-ril'üm) (†)** A spiral-shaped bacterium.
- spirometer (spī-romē-ter) (†)** An instrument that measures the air taken in and expelled from the lungs.
- spirometry (spī-romē-trē) (†)** A test used to measure breathing capacity.
- splint** A device used to immobilize and protect a body part.

splinting catheter (splīnt'ing káth'ī-tər)

A type of catheter inserted after plastic repair of the ureter; it must remain in place for at least a week after surgery.

sprain (sprān) An injury characterized by partial tearing of a ligament that supports a joint, such as the ankle. A sprain may also involve injuries to tendons, muscles, and local blood vessels and contusions of the surrounding soft tissue.

stain (stān) In microbiology, a solution of a dye or group of dyes that impart a color to microorganisms.

standard (stāndərd) A specimen for which test values are already known; used to calibrate test equipment.

Standard Precautions (stāndərd prī-kóshənz) A combination of Universal Precautions and Body Substance Isolation guidelines; used in hospitals for the care of all patients.

stapes (stāpēz) A small bone in the middle ear that is attached to the inner ear; also called the stirrup.

statement (stāt'mənt) A form similar to an invoice; contains a courteous reminder to the patient that payment is due.

statute of limitations (stāch'ōōt

līm'ī-tā'shənz)

A state law that sets a time limit on when a collection suit on a past-due account can legally be filed.

stereoscopy (ster-ē-ōskō-pē)(†) An x-ray procedure that uses a specially designed microscope (stereoscopic, or Greenough, microscope) with double eyepieces and objectives to take films at different angles and produce three-dimensional images; used primarily to study the skull.

sterile field (stēr'əl fēld) An area free of microorganisms used as a work area during a surgical procedure.

sterile scrub assistant (stēr'əl skrub ə-sīstənt) An assistant who handles sterile equipment during a surgical procedure.

sterilization (stēr'ə-lī-zāshən) The destruction of all microorganisms, including bacterial spores, by specific means.

sterilization indicator (stēr'ə-lī-zāshən īndī-kāshən) A tag, insert, tape, tube, or strip that confirms that the items in an autoclave have been exposed to the correct volume of steam at the correct temperature for the correct amount of time.

steroid hormone (stīr'ōid hōr'mōn') A hormone derived from steroids that

are soluble in lipids and can cross cell membranes very easily.

sternum (st'ər-nəm) A bone that forms the front and middle portion of the rib cage; also called the breastbone or breast plate.

stethoscope (stēthə-skōp') An instrument that amplifies body sounds.

strabismus (strə-bīz'məs) A condition that results in a lack of parallel visual axes of the eyes; commonly called crossed eyes.

strain (strān) A muscle injury that results from overexertion or overstretching.

stratum basale (strat'ūm bā-sā'le)(†) The deepest layer of the epidermis of the skin.

stratum corneum (strat'ūm kōrnē-ūm)(†) The most superficial layer of the epidermis of the skin.

stressor (stres'ōr)(†) Any stimulus that produces stress.

stress test (strēs tēst) A procedure that involves recording an electrocardiogram while the patient is exercising on a stationary bicycle, treadmill, or stair-stepping ergometer, which measures work performed.

striations (strī-āsh'ūns)(†) Bands produced from the arrangement of filaments in myofibrils in skeletal and cardiac muscle cells.

stroke (strōk) A condition that occurs when the blood supply to the brain is impaired. It may cause temporary or permanent damage.

stylus (stī'ləs) A penlike instrument that records electrical impulses on ECG paper.

subarachnoid space (süb-ā-rak'noyd spās)(†) An area between the arachnoid mater and the pia mater.

subclinical case (süb-klin'ī-kāl kās)(†) An infection in which the host experiences only some of the symptoms of the infection or milder symptoms than in a full case.

subcutaneous (SC) (süb'kyōō-tānē-əs) Under the skin.

subjective (səb-jēkt'iv) Pertaining to data that is obtained from conversation with a person or patient.

sublingual (süb-linggwāl)(†) Under the tongue.

sublingual gland (süb-linggwāl glānd)(†) The smallest of the salivary glands.

submandibular gland (süb-man-dib'yū-lār glānd)(†) The gland that is located in the floor of the mouth.

submucosa (süb-mū-kōsā)(†) The layer of the alimentary canal located

between the mucosa and the muscular layer.

subpoena (sə-pēnə) A written court order that is addressed to a specific person and requires that person's presence in court on a specific date at a specific time.

substance abuse (süb'stəns ə-byōōz') The use of a substance in a way that is not medically approved, such as using diet pills to stay awake or consuming large quantities of cough syrup that contains codeine. Substance abusers are not necessarily addicts.

sucrase (sū'krās)(†) An enzyme that digests sugars.

sulci (sū'lsi)(†) The grooves on the surface of the cerebrum.

superbill (sōōpər-bīl') A form that combines the charges for services rendered, an invoice for payment or insurance co-payment, and all the information for submitting an insurance claim.

superficial (sōōpər-fish'əl) Anatomical term meaning closer to the surface of the body.

superior (sōō-pīr-ē-ər) Anatomical term meaning above or closer to the head; also called cranial.

supernatant (sū-per-nā'tānt)(†) The liquid portion of a substance from which solids have settled to the bottom, as with a urine specimen after centrifugation.

supination (sū'pī-nā'shūn)(†) Turning the palm of the hand upward.

surgeon (sūr'jən) A physician who uses hands and medical instruments to diagnose and correct deformities and treat external and internal injuries or disease.

surgical asepsis (sūr'jə-kəl ə-sep'sis)(†) The elimination of all microorganisms from objects or working areas; also called sterile technique.

susceptible host (sə-sēp'təbal hōst) An individual who has little or no immunity to infection by a particular organism.

suture (sōōchər) Fibrous joints in the skull.

symmetry (sīm'ī-trē) The degree to which one side of the body is the same as the other.

sympathetic (sīm'pə-thē'tik) A division of the autonomic nervous system that prepares organs for fight-or-flight (stressful) situations.

symptom (sīm'təm) A subjective, or internal, condition felt by a patient, such as pain, headache, or nausea, or another indication that generally

- cannot be seen or felt by the doctor or measured by instruments.
- synaptic knob (si-nap'tik nōb) (†)** The end of the axon branch.
- synergist (sīn'ər-jist')** Muscles that help the **prime mover** by stabilizing joints.
- synovial (sin-ō-vā-əl)** A type of joint, such as the elbow or knee, that is freely moveable.
- systemic circuit (sī-stēm'ik sūr'kit)**
The route that blood takes from the heart through the body and back to the heart.
- systolic pressure (sī-stōl'ik prēsh'ər)**
The blood pressure measured when the left ventricle of the heart contracts.
- tab (tāb)** A tapered rectangular or rounded extension at the top of a file folder.
- Tabular List (tāb'yə-lər list)** One of two ways that diagnoses are listed in the **ICD-9**. In the Tabular List, the diagnosis codes are listed in numerical order with additional instructions.
- tachycardia (tak'i-kar'dē-ă) (†)** Rapid heart rate, generally in excess of 100 beats per minute.
- tachypnea** Abnormally rapid breathing.
- targeted résumé (tār'gīt-əd rēz'ōō-mā')**
A résumé that is focused on a specific job target.
- tarsals (tār'-səlz)** Bones of the ankle.
- taste bud (tāst būd)** A structure that is made of taste cells (a type of chemoreceptor) and supporting cells.
- tax liability (tāk lī-ă-bil'ī-tē)** Money withheld from employees' paychecks and held in a separate account that must be used to pay taxes to appropriate government agencies.
- telephone triage (tēl'ə-fōn trē-ăzh')** A process of determining the level of urgency of each incoming telephone call and how it should be handled.
- teletherapy (tel-ē-thār'ăpē) (†)** A radiation therapy technique that allows deeper penetration than brachytherapy; used primarily for deep tumors.
- teletype (TTY) device (tēl'ə-tip)** A specially designed telephone that looks very much like a laptop computer with a cradle for the receiver of a traditional telephone. It is used by the hearing impaired to type communications onto a keyboard.
- template (tēm'plīt)** A guide that ensures consistency and accuracy.
- temporal (tem'p(a)-rəl)** Bones that form the lower sides of the skull.
- tendon (tēndən)** A cordlike fibrous tissue that connects muscle to bone.
- terminal (tūr'mə-nəl)** Fatal.
- testes (tēs'tēz)** The primary organs of the male reproductive system. Testes produce the hormone **testosterone**.
- testosterone (tēs-tōst'ə-rōn')** A hormone produced by the testes that maintains the male reproductive structures and male characteristics such as deep voice, body hair, and muscle mass.
- tetanus (tē'n-əs)** A disease caused by *clostridium tetani* living in the soil and water; more commonly called lockjaw.
- thalamus (thāl'ə-məs)** Structure that acts as a relay station for sensory information heading to the cerebral cortex for interpretation; a subdivision of the **diencephalon**.
- therapeutic team (thēr'ə-pyōō'tik tēm)**
A group of physicians, nurses, medical assistants, and other specialists who work with patients dealing with chronic illness or recovery from major injuries.
- thermography (ther-mog'ră-fē) (†)** A radiologic procedure in which an infrared camera is used to take photographs that record variations in skin temperature as dark (cool areas), light (warm areas), or shades of gray (areas with temperatures between cool and warm); used to diagnose breast tumors, breast abscesses, and fibrocystic breast disease.
- thermotherapy (ther'mō-thār'ă-pē) (†)**
The application of heat to the body to treat a disorder or injury.
- third-party check (thūrd pār'tē chēk)**
A check made out to one recipient and given in payment to another, as with one made out to a patient rather than the medical practice.
- third-party payer (thūrd pār'tē pā'ər)**
A health plan that agrees to carry the risk of paying for patient services.
- thrombocytes (throm'bō-sīts)** See **platelets**.
- thrombophlebitis (thrōm'bō-flē-bī'tis) (†)**
A medical condition that most commonly occurs in leg veins when a blood clot and inflammation develop.
- thrombus (thrōm'bəs)** A blood clot that forms on the inside of an injured blood vessel wall.
- thymosin (thīmō-sin) (†)** A hormone that promotes the production of certain lymphocytes.
- thymus gland (thīm'əs glānd)** A gland that lies between the lungs. It secretes a hormone called **thymosin**.
- thyroid cartilage (thīroid' kār'tl-ij)**
The largest cartilage in the larynx. It forms the anterior wall of the larynx.
- thyroid hormone (thīroid' hōr'mōn)**
A hormone produced by the thyroid gland that increases energy production, stimulates protein synthesis, and speeds up the repair of damaged tissue.
- thyroid-stimulating hormone (thīroid' stim'yū-lā-ting hōr'mōn')** A hormone that stimulates the thyroid gland to release its hormone.
- tibia (ti-bē-ə)** The medial bone of the lower leg; commonly called the shin bone.
- tickler file (tik'lər fīl)** A reminder file for keeping track of time-sensitive obligations.
- timed urine specimen (tīmd yōōr'īn spē's ə-mən)** A specimen of a patient's urine collected over a specific time period.
- time-specified scheduling (tīm spē'sə-fīd skēj'ōōl-īng)** A system of scheduling where patients arrive at regular, specified intervals, assuring the practice a steady stream of patients throughout the day.
- tinnitus (ti-nī'tus) (†)** An abnormal ringing in the ear.
- tissue (tīshōō)** A structure that is formed when cells of the same type organize together.
- T lymphocyte (tē lim'fə-sīt)** A type of nongranular leukocyte that regulates immunologic response; includes helper T cells and suppressor T cells.
- topical (tōp'ī-kəl)** Applied to the skin.
- tort (tōrt)** In civil law, a breach of some obligation that causes harm or injury to someone.
- tower case (tou'ər kās)** A vertical housing for the system unit of a personal computer.
- toxicology (tōk'si-kōl'ə-jē)** The study of poisons or poisonous effects of drugs.
- trachea (trāk'ē-ə)** The part of the respiratory tract between the larynx and the bronchial tree that is tubular and made of rings of cartilage and smooth muscle; also called the windpipe.
- tracking (trāk'īng)** (financial) Watching for changes in spending so as to help control expenses.
- traction (trāk'shən)** The pulling or stretching of the musculoskeletal system to treat dislocated joints, joints afflicted by arthritis or other diseases, and fractured bones.
- trade name (trād nām)** A drug's brand or proprietary name.
- transcription (trān-skrīp'shən)** The transforming of spoken notes into accurate written form.

- transcutaneous absorption (trans-kyū-tānē-ūs əb-sorpshən) (†)** Entry (as of a pathogen) through a cut or crack in the skin.
- transdermal (trans-derməl)** A type of topical drug administration that slowly and evenly releases a systemic drug through the skin directly into the bloodstream; a transdermal unit is also called a patch.
- transfer (trāns-fūr)** To give something, such as information, to another party outside the doctor's office.
- transverse (trāns-vūrs)** Anatomical term that refers to the plane that divides the body into superior and inferior portions.
- transverse colon (trāns-vūrs kōlən)** The segment of the large intestine that crosses the upper abdominal cavity between the ascending and descending colon.
- traveler's check (trāv'əlz chĕk)** A check purchased and signed at a bank and later signed over to a payee.
- treatment, payments and operations (TPO) (trētmənt pāmənts ōpə-rāshəns)** The portion of HIPAA that allows the provider to use and share patient health-care information for treatment, payment, and operations (such as quality improvement).
- triage (trē-āzh)** To assess the urgency and types of conditions patients present as well as their immediate medical needs.
- TRICARE (trī'kār)** A program that provides health-care benefits for families of military personnel and military retirees.
- trichinosis (trik-i-nōsis) (†)** A disease caused by a worm that is usually ingested from undercooked meat.
- tricuspid valve (trī-kūspid vālv) (†)** A heart valve that has three cusps and is situated between the right atrium and the right ventricle.
- triglycerides (trī-glīsə-rīd'z)** Simple lipids consisting of glycerol (an alcohol) and three fatty acids.
- trigone (trīgōn) (†)** The triangle formed by the openings of the two ureters and the urethra in the internal floor of the bladder.
- troubleshooting (trūb'əl-shōōtīng)** Trying to determine and correct a problem without having to call a service supplier.
- trypsin (trīpsin) (†)** A pancreatic enzyme that digests proteins.
- tubular reabsorption (tūbyū-lār) (†)** The second process of urine formation in which the glomerular filtrate flows into the proximal convoluted tubule.
- tubular secretion (tūbyū-lār sī-krēshən) (†)** The third process of urine formation in which substances move out of the blood in the peritubular capillaries into renal tubules.
- tutorial (tōō-tōr'ē-əl)** A small program included in a software package designed to give users an overall picture of the product and its functions.
- tympanic membrane (tīm-pān'ik mēmbrān)** A fibrous partition located at the inner end of the ear canal and separating the outer ear from the middle ear; also called the eardrum.
- tympanic thermometer (tīm-pān'ik ther-mom'ē-ter)** A type of electronic thermometer that measures infrared energy emitted from the tympanic membrane.
- ulna (əl'-nə)** The medial bone of the lower arm.
- ultrasonic cleaning (ūltrə-sōn'ik klēn'īng)** A method of sanitization that involves placing instruments in a cleaning solution in a special receptacle that generates sound waves through the cleaning solution, loosening contaminants. Ultrasonic cleaning is safe for even very fragile instruments.
- ultrasound (ūltrə-sound') (†)** The noninvasive therapeutic or diagnostic use of ultrasound for examination of internal body structures.
- umbilical cord (ūm-bīl'ī-kəl kōrd)** The rope-like connection between the fetus and the placenta. It contains the umbilical blood vessels.
- underbooking (ūndər-bōōk'īng)** Leaving large, unused gaps in the doctor's schedule; this approach does not make the best use of the doctor's time.
- uniform donor card (yōō'nə-fōrm' dōnər kārd)** A legal document that states a person's wish to make a gift upon death of one or more organs for medical research, organ transplants, or placement in a tissue bank.
- unit price (yōō'nīt prīs)** The total price of a package divided by the number of items that comprise the package.
- Universal Precautions (yōō'nə-vur'səl prī-kōshənz)** Specific precautions required by the Department of Health and Human Services' Centers for Disease Control and Prevention (CDC) to prevent health-care workers from exposing themselves and others to infection by blood-borne pathogens.
- unsaturated fats (ūn-sāch'ə-rātid fāts)** Fats, including most vegetable oils, that are usually liquid at room temperature and tend to lower blood cholesterol.
- urea (yōō-rē'ə)** Waste product formed by the breakdown of proteins and nucleic acids.
- ureters (yōō-rē'tərz)** Long, slender, muscular tubes that carry urine from the kidneys to the urinary bladder.
- urethra (yōō-rē'thrə)** The tube that conveys urine from the bladder during urination.
- uric acid (yōōr'ik əsīd)** Waste product formed by the breakdown of proteins and nucleic acids.
- urinalysis (yōōr'ə-nāl'ī-sīs)** The physical, chemical, and microscopic evaluation of urine to obtain information about body health and disease.
- urinary catheter (yōōr'ə-nēr'ē kāth'ī-tər)** A sterile plastic tube inserted to provide urinary drainage.
- urinary pH (yōōr'ə-nēr'ē pĕ'āch)** A measure of the degree of acidity or alkalinity of urine.
- urine specific gravity (yōōr'īn spī-sīf'ik grāv'ī-tē)** A measure of the concentration or amount (total weight) of substances dissolved in urine.
- urobilinogen (yūr-ō-bī-lin'ō-jen) (†)** A colorless compound formed by the breakdown of hemoglobin in the intestines. Elevated levels in urine may indicate increased red blood cell destruction or liver disease, whereas lack of urobilinogen in the urine may suggest total bile duct obstruction.
- urologist (yōō-rōl'ə-jīst)** A specialist who diagnoses and treats diseases of the kidney, bladder, and urinary system.
- use (yōōz)** The sharing, employing, applying, utilizing, examining, or analyzing of individually identifiable health information by employees or other members of an organization's workforce.
- uterus (yōō'tər-əs)** A hollow, muscular organ that functions to receive an embryo and sustain its development; also called the womb.
- uvula (yōō'vya-lə)** The part of the soft palate that hangs down in the back of the throat.
- vaccine (vāk-sēn')** A special preparation made from microorganisms and administered to a person to produce reduced sensitivity to, or increased immunity to, an infectious disease.

- vagina** (və-jī-nə) A tubular organ that extends from the uterus to the labia.
- vaginitis** (vaj-i-nī-tis) (†) Inflammation of the vagina characterized by an abnormal vaginal discharge.
- varicose veins** (vār-i-kōs vānz) (†) Distended veins that result when vein valves are destroyed and blood pools in the veins, causing these veins to dilate.
- vas deferens** (vās-děf-ər-ənz) A tube that connects the epididymis with the urethra and that carries sperm.
- vasectomy** (və-sěk-tə-mē) A male sterilization procedure in which a section of each vas deferens is removed.
- vasoconstriction** (vā-sō-kon-strik-shŭn) (†) The constriction of the muscular wall of an artery to increase blood pressure.
- vasodilation** (vā-sō-dī-lā-shŭn) (†) The widening of the muscular wall of an artery to decrease blood pressure.
- V code** (vē kōd) A code used to identify encounters for reasons other than illness or injury, such as annual checkups, immunizations, and normal childbirth.
- vector** (vēk-tər) A living organism, such as an insect, that carries microorganisms from an infected person to another person.
- venipuncture** (ven-i-pŭnk-chŭr) (†) The puncture of a vein, usually with a needle, for the purpose of drawing blood.
- ventilation** (vēn-tə-lā-shən) Moving air into and out of the lungs; also called breathing.
- ventral** (vēn-trəl) See **anterior**.
- ventral root** (vēn-trəl rōōt) A portion of the spinal nerve that contains axons of motor neurons only.
- ventricle** (vēn-trī-kəl) Interconnected cavities in the brain filled with cerebrospinal fluid.
- ventricular fibrillation** (ven-trīk-yŭ-lār fī-bri-lā-shŭn) An abnormal heart rhythm that is the most common cause of cardiac arrest.
- verbalizing** (vŭr-bə-līz-īng) Stating what you believe the patient is suggesting or implying.
- vermiform appendix** (uer-mi-fōrm ə-pĕn-dīks) (†) A structure made mostly of lymphoid tissue and projecting off the cecum. It is commonly referred to as simply the appendix.
- vertical file** (vŭr-tī-kəl fil) A filing cabinet featuring pull-out drawers that usually contain a metal frame or bar equipped to handle letter- or legal-sized documents in hanging file folders.
- vesicles** (vēs-ĭ-kəlz) Small sacs within the synaptic knobs that contain chemicals called neurotransmitters.
- vestibular glands** (ves-tīb-yŭ-lār glāndz) (†) Glands that secrete mucus into the vestibule of the female during sexual excitement.
- vestibule** (vēs-tə-byōōl) The area in the inner ear between the semicircular canals and the cochlea.
- vial** (vī-əl) A small glass bottle with a self-sealing rubber stopper.
- vibrio** (†) (vīb-rē-ō) A comma-shaped bacterium.
- virulence** (vīr-yə-ləns) A microorganism's disease-producing power.
- virus** (vī-rəs) One of the smallest known infectious agents, consisting only of nucleic acid surrounded by a protein coat; can live and grow only within the living cells of other organisms.
- visceral pericardium** (vis-er-əl per-i-kar-dē-ŭm) (†) The innermost layer of the pericardium that lies directly on top of the heart; also known as the **epicardium**.
- visceral smooth muscle** (vis-er-əl smōōth mŭs-əl) A type of smooth muscle containing sheets of muscle that closely contact each other. It is found in the walls of hollow organs such as the stomach, intestines, bladder, and uterus.
- vitamins** (vī-tə-mīnz) Organic substances that are essential for normal body growth and maintenance and resistance to infection.
- vitreous humor** (vī-rē-əs hyōō-mər) A jellylike substance that fills the part of the eye behind the lens and helps the eye keep its shape.
- voice mail** (vois māl) An advanced form of answering machine that allows a caller to leave a message when the phone line is busy.
- void** (void) (legal) A term used to describe something that is not legally enforceable.
- volume** (vōl-yōōm) The amount of space an object, such as a drug, occupies.
- vomer** (vō-mər) A thin bone that divides the nasal cavity.
- voucher check** (vou-čər chĕk) A business check with an attached stub, which is kept as a receipt.
- walk-in** (wōk-ĭn) A patient who arrives without an appointment.
- warranty** (wōk-ən-tē) A contract that specifies free service and replacement of parts for a piece of equipment during a certain period, usually a year.
- warts** (wōrts) Flesh-colored skin lesions with distinct round borders that are raised and often have small fingerlike projections; also called verruca.
- wave scheduling** (wāv skěj-ōōl-īng) A system of scheduling in which the number of patients seen each hour is determined by dividing the hour by the length of the average visit and then giving that number of patients appointments with the doctor at the beginning of each hour.
- Western blot test** (wēs-tərn blōt tĕst) A blood test used to confirm enzyme-linked immunosorbent assay (ELISA) test results for HIV infection.
- wet mount** (wĕt mōunt) A preparation of a specimen in a liquid that allows the organisms to remain alive and mobile while they are being identified.
- white matter** (hwīt māt-ər) The outer tissue of the spinal cord that is lighter in color than **gray matter**. It contains myelinated axons.
- whole blood** (hōl blŭd) The total volume of plasma and formed elements, or blood in which the elements have not been separated by coagulation or centrifugation.
- whole-body skin examination** (hōl bōd-ē skīn ĭg-zām-ə-nā-shən) An examination of the visible top layer of the entire surface of the skin, including the scalp, genital area, and areas between the toes, to look for lesions, especially suspicious moles or precancerous growths.
- Wood's light examination** (wōodz lit ĭg-zām-ə-nā-shən) A type of dermatologic examination in which a physician inspects the patient's skin under an ultraviolet lamp in a darkened room.
- written-contract account** (rīt'n kōn-trākt ə-kōunt) An agreement between the physician and patient stating that the patient will pay a bill in more than four installments.
- X12 837 Health Care Claim** (hĕlth kār klām) An electronic claim transaction that is the **HIPAA** Health Care Claim or Equivalent Encounter Information ("HIPAA claim").
- xeroradiography** (zĕrō-rā-dĕ-ōg-rā-fĕ) (†) A radiologic procedure in which x-rays are developed with a powder toner, similar to the toner in

photocopiers, and the x-ray image is processed on specially treated xerographic paper; used to diagnose breast cancer, abscesses, lesions, or calcifications.

xiphoid process (zifoyd prös'ēs) (†)
The lower extension of the breastbone.

yeast (yēst) A fungus that grows mainly as a single-celled organism and reproduces by budding.

yolk sac (yōk sāk) The sac that holds the materials for the nutrition of the embryo.

zona pellucida (zōnā pe-lū'sid-ā) (†) A layer that surrounds the cell membrane of an egg.

zygomatic (zī-gə-m'a-tik) The bones that form the prominence of the cheeks.

zygote (zī'gō) The cell that is formed from the union of the egg and sperm.

Z-track method (zē'trāk mēth'əd) A technique used when injecting an intramuscular (IM) drug that can irritate subcutaneous tissue; involves pulling the skin and subcutaneous tissue to the side before inserting the needle at the site, creating a zigzag path in the tissue layers that prevents the drug from leaking into the subcutaneous tissue and causing irritation.

Credits

Photo

CHAPTER 1

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Text

CHAPTER 8

Context (pg 112) Scale to determine the severity of snoring adapted from The Mayo Clinic's Sleep Disorders Center.

CHAPTER 3

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CHAPTER 5

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CHAPTER 6

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CHAPTER 8

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