DIVERSIFIED HEALTH OCCUPATIONS

Seventh Edition

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CHAPTER 7

Anatomy and Physiology

Chapter Objectives

After completing this chapter, you should be able to:

- Apply the appropriate terminology to major organs and systems of the human body
- Identify the major functions of each body system
- Compare interrelationships of body systems
- Describe basic diseases affecting each of the body systems
- Define, pronounce, and spell all key terms

NOTE: This chapter is meant to serve as a brief introduction to anatomy and physiology. For more detailed information, refer to the references listed in the bibliography at the back of the book.

Observe Standard Precautions 

Instructor's Check—Call Instructor at This Point 

Safety—Proceed with Caution 

OBRA Requirement—Based on Federal Law 

Math Skill 

Legal Responsibility 

Science Skill 

Career Information 

Communications Skill 

Technology 

KEY TERMS

anatomy
cell
cell membrane
centrosome *(sen′-troh-sohm)*
chromatin *(crow′-ma-tin)*
connective tissue
cytoplasm *(sy′-toe-plaz-um)*
dehydration
edema *(eh-dee′-mah)*
endoplasmic reticulum *(en′-doe-plaz-mik re-tik′-you-lum)*
epithelial tissue *(ep′-eh-thiel″-e-al tish′-u)*
genes
genome
Golgi apparatus *(gawl′-jee ap-a-rat′-us)*
lysosomes *(ly′-sah-soms)*
meiosis *(my-o′-sis)*
mitochondria *(my-toe-con′-dree-ah)*
mitosis *(my-toe′-sis)*
muscle tissue
nerve tissue
nucleolus *(new″-klee-oh′-lus)*
nucleus
organ
organelles
pathophysiology
physiology *(fizz-ee-all′-oh-gee)*
pinocytic vesicles
protoplasm *(pro′-toe-plaz-um)*
stem cells
system
tissue
vacuoles

7:1 Basic Structure of the Human Body

Objectives

After completing this section, you should be able to:

- Label a diagram of the main parts of a cell
- Describe the basic function of each part of a cell
- Compare the four main types of tissue by describing the basic function of each type
- Explain the relationships among cells, tissues, organs, and systems
- Define, pronounce, and spell all key terms

7:1 INFORMATION

The human body is often described as an efficient, organized machine. When this machine does not function correctly, disease occurs. Before

RELATED HEALTH CAREERS

NOTE: A basic knowledge of human anatomy and physiology is essential for almost every health care provider. However, some health careers are related to specific body systems. As each body system is discussed, examples of related health careers are listed. The following health career categories require knowledge of the structure and function of the entire human body and will not be listed in specific body system units.

- Athletic Trainer
- Emergency Medical Careers
- Medical Laboratory Careers
- Medical Assistant
- Medical Illustrator
- Nursing Careers
- Pharmacy Careers
- Physician Assistant
- Physician
- Surgical Technologist

understanding the disease processes, however, the health worker must first understand the normal functioning of the body. A basic understanding of anatomy and physiology is therefore necessary. **Anatomy** is the study of the form and structure of an organism. **Physiology** is the study of the processes of living organisms, or why and how they work. **Pathophysiology** is the study of how disease occurs and the responses of living organisms to disease processes.

The basic substance of all life is **protoplasm.** This material makes up all living things. Although protoplasm is composed of ordinary elements such as carbon, oxygen, hydrogen, sulfur, nitrogen, and phosphorus, scientists are unable to combine such elements to create that characteristic called *life.*

CELLS

Protoplasm forms the basic unit of structure and function in all living things: the **cell.** Cells are microscopic structures that carry on all the functions of life. They take in food and oxygen; produce heat and energy; move and adapt to their environment; eliminate wastes; perform special functions; and reproduce to create new, identical cells. The human body contains trillions of cells. These cells vary in shape and size, and perform many different functions.

Most cells have the following basic parts (figure 7-1):

- **Cell membrane:** the outer protective covering of the cell. It is also called the *plasma membrane* or *plasmalemma.* It is semipermeable; that is, it allows certain substances to enter and leave the cell while preventing the passage of other substances.
- **Cytoplasm:** a semifluid inside the cell but outside the nucleus. It contains water (70–90 percent), proteins, lipids (fats), carbohydrates, minerals, and salts. It is the site for all chemical reactions that take place in the cell, such as protein synthesis (formation) and cellular respiration. **Organelles,** or cell structures that help a cell to function, are located in the cytoplasm. The main organelles are the nucleus, mitochondria, ribosomes, lysosomes, centrioles, Golgi apparatus, and endoplasmic reticulum.
- **Nucleus:** a mass in the cytoplasm. It is separated from the cytoplasm by a nuclear membrane that contains pores to allow substances to pass between the nucleus and cytoplasm. It is often called the "brain" of the cell because it controls many cell activities and is important in the process of mitosis or cell division.
- **Nucleolus:** one or more small, round bodies located inside the nucleus, and important in cell reproduction. Ribosomes, made of ribonucleic acid (RNA) and protein, are manufactured in the nucleolus. The ribosomes move from the nucleus to the cytoplasm, where they aid in the synthesis (production) of protein. They can exist freely in the cytoplasm or be attached to the endoplasmic reticulum.
- **Chromatin:** located in the nucleus and made of deoxyribonucleic acid (DNA) and protein. During cell reproduction, the chromatin condenses to form rodlike structures called *chromosomes.* A human cell has 46 chromosomes or 23 pairs. Each chromosome contains between 30,000 to 45,000 **genes,** the structures that carry inherited characteristics. Each gene has a specific and unique sequence of approximately 1,000 base pairs of DNA; the DNA sequence carries the genetic coding that allows for exact duplication of the cell. Because the DNA sequence on genes is unique for each individual, it is sometimes used as an identification tool similar to fingerprints, but much more exact. A **genome** is the total mass of genetic instruction humans inherit from their parents. It consists of strings of DNA nucleotides. Human beings have about three billion nucleotides in their genome. The order of the nucleotides on the DNA sequences provides instructions for the body to build all of its parts, everything from permanent structures such as teeth and brain cells to short-lived substances such as blood and hormones.
- **Centrosome:** located in the cytoplasm and near the nucleus. It contains two centrioles. During mitosis, or cell division, the centrioles separate. Thin cytoplasmic spindle fibers form between the centrioles and attach to the chromosomes. This creates an even division of the chromosomes in the two new cells.
- **Mitochondria:** rod-shaped organelles located throughout the cytoplasm. These are often called the "furnaces" or "powerhouses" of the cell because they break down carbohydrates, proteins, and fats to produce adenosine triphosphate (ATP), the major energy

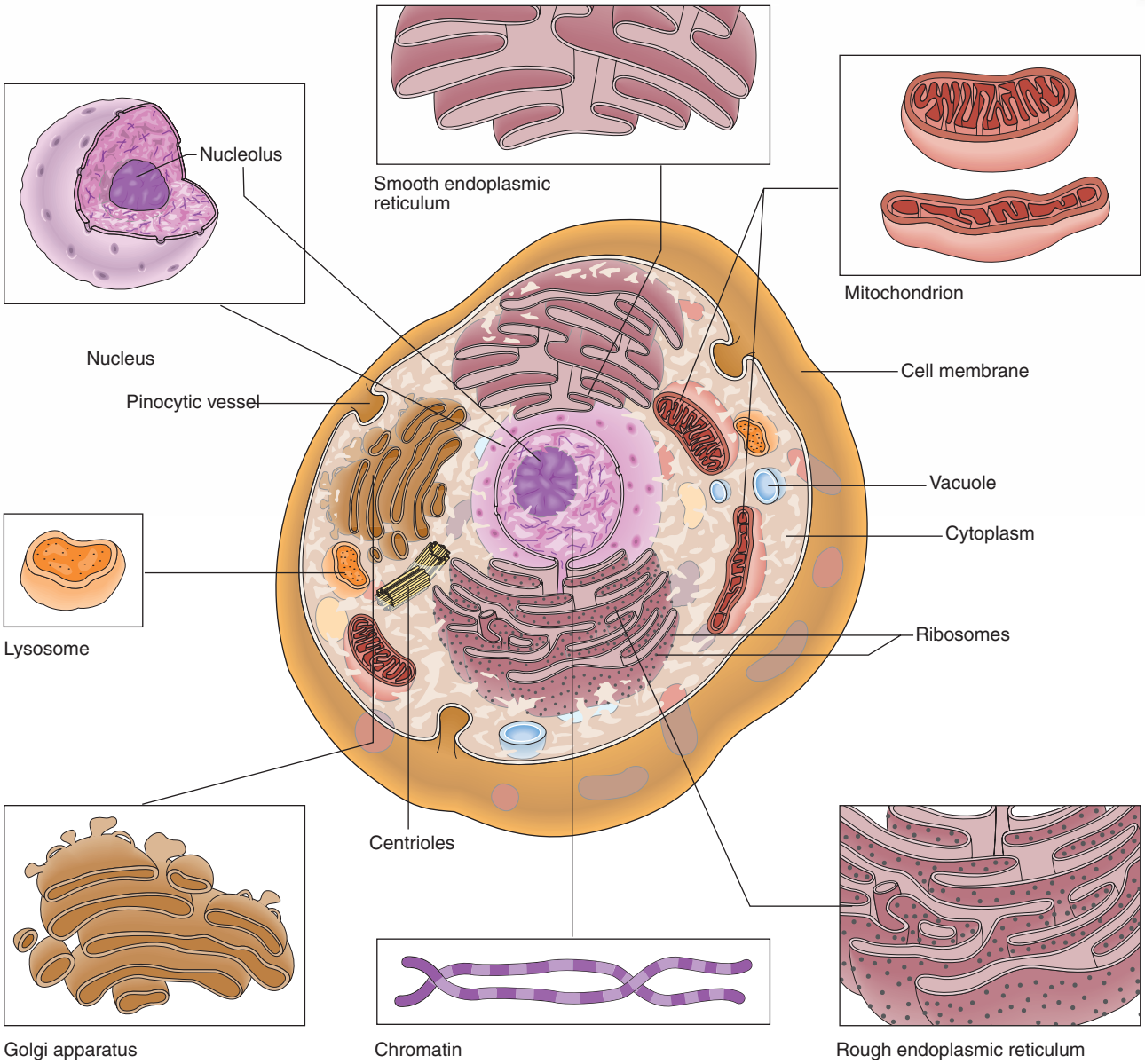


FIGURE 7-1 Basic parts of a cell.

source of the cell. A cell can contain just 1 to more than 1,000 mitochondria, depending on how much energy the cell requires.

- **Golgi apparatus:** a stack of membrane layers located in the cytoplasm. This structure produces, stores, and packages secretions for discharge from the cell. Cells of the salivary, gastric, and pancreatic glands have large numbers of Golgi apparatus.
- **Endoplasmic reticulum:** a fine network of tubular structures located in the cytoplasm. This network allows for the transport of materials into and out of the nucleus, and also aids in the synthesis and storage of proteins. Rough endoplasmic reticulum contains ribosomes, which are the sites for protein synthesis (production). Smooth endoplasmic reticulum does not contain ribosomes and is not present in all cells. It assists with cholesterol synthesis, fat metabolism, and detoxification of drugs.
- **Vacuoles:** pouchlike structures found throughout the cytoplasm that have a vacuolar membrane with the same structure as the cell membrane. They are filled with a watery substance, stored food, or waste products.
- **Lysosomes:** oval or round bodies found throughout the cytoplasm. These structures contain digestive enzymes that digest and

destroy old cells, bacteria, and foreign materials, an important function of the body's immune system. Lysosomes also fuse with stored food vacuoles to convert the food to a form that can be used by the mitochondria to produce ATP (energy).

- **Pinocytic vesicles:** pocketlike folds in the cell membrane. These folds allow large molecules such as proteins and fats to enter the cell. When such molecules are inside the cell, the folds close to form vacuoles or bubbles in the cytoplasm. When the cell needs energy, the vesicles fuse with lysosomes to allow the proteins and fats to be digested and used by the mitochondria to produce ATP (energy).

Cell Reproduction

Most cells reproduce by dividing into two identical cells. This process is called **mitosis,** a form of asexual reproduction (figure 7-2). Skin cells, blood-forming cells, and intestinal tract cells reproduce continuously. Muscle cells only reproduce every few years, but muscle tissue can be enlarged with exercise. Some specialized cells, such as nerve cells in the brain and spinal cord, do not reproduce after birth. If these cells are damaged or destroyed, others are not formed to replace them.

Prior to mitosis, the chromatin material in the nucleus condenses to form chromosomes, and an exact duplicate of each chromosome is made. Each chromosome then consists of two identical strands, called *chromatids,* joined together by a structure called a *centromere.* When mitosis begins, the two centrioles in the centrosome move to opposite ends of the cell. A spindle of threadlike fibers trails from the centrioles. The nuclear membrane disappears, and the pairs of duplicated chromosomes attach to the spindles at the center of the cell. The chromatids then split from their duplicated halves and move to opposite ends of the cell. Each end now has 46 chromosomes, or 23 pairs. The cytoplasm divides, and a new cell membrane forms to create two new identical cells.

Sex cells (gametes) divide by a process known as **meiosis.** This process uses two separate cell divisions to produce four new cells. When female cells (ova) or male cells (spermatozoa or sperm) divide by meiosis, the number of chromosomes is reduced to 23, or one-half the number found in cells created by mitosis. When an ovum and sperm join to create a new life, the zygote, or new

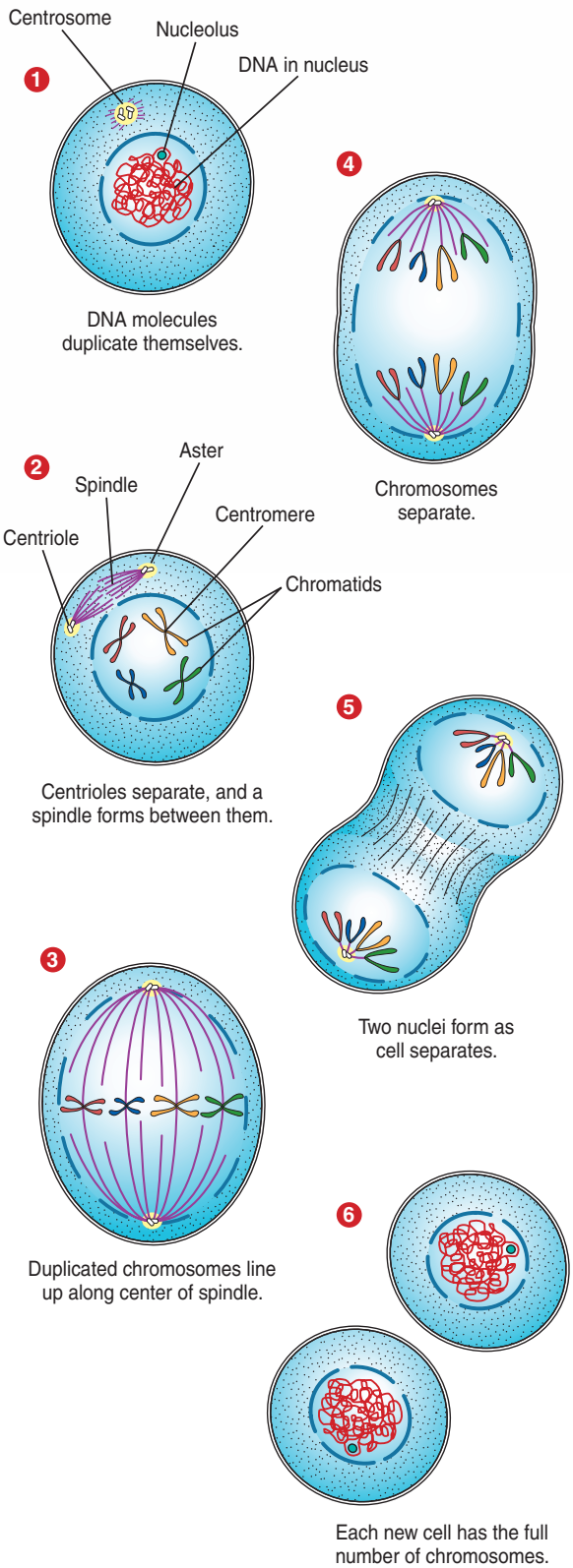


FIGURE 7-2 Mitosis is a form of asexual reproduction where a cell divides into two identical cells.

cell, has 46 chromosomes: 23 from the ovum and 23 from the sperm. Thus, the zygote has 46, or 23 pairs, of chromosomes, the normal number for all body cells except the sex cells.

Immediately after the ovum and sperm join to form a zygote, the zygote begins a period of rapid mitotic division. Within 4–5 days, the zygote is a hollow ball-like mass of cells called a *blastocyst*. Within this blastocyst are embryonic **stem cells.** These stem cells have the ability to transform themselves into any of the body's specialized cells and perform many different functions. A controversial area of research is now concentrated on these stem cells. Scientists are attempting to determine whether stem cells can be transplanted into the body and used to cure diseases such as diabetes mellitus, Parkinson's, heart disease, osteoporosis, arthritis, and spinal cord injuries. The hope is that the stem cells can be programmed to produce new specialized cells that can replace a body's damaged cells and cure a disease. The controversy arises from the fact that a 4–5-day embryo, capable of creating a new life, is used to obtain the cells. Right-to-life advocates are strongly opposed to stem cell research if the cells are obtained from embryos. Another source of stem cells is the blood in the discarded umbilical cord and placenta of a newborn. Currently, parents have the option of preserving this blood for its stem cells. The blood is collected and frozen in liquid nitrogen. If the child later develops a disease for which a stem cell transplant can provide a cure, the cells can be harvested from the blood and used for the transplant. The cost of this procedure limits its use, however. Stem cells also exist in adult tissues, such as bone marrow and the liver. Adult stem cells, however, do not have the ability to evolve into every kind of cell; these stem cells evolve into more cells of their own kind. This controversy will continue as scientists expand stem cell research.

TISSUE

Although most cells contain the same basic parts, cells vary greatly in shape, size, and special function. When cells of the same type join together for a common purpose, they form a **tissue.** Tissues are 60–99 percent water with various dissolved substances. This water is slightly salty in nature and is called *tissue fluid.* If there is an insufficient amount (not enough tissue fluid), a condition called **dehydration** occurs. When there is an excess amount (too much tissue fluid), a condition called **edema,** or swelling of the tissues, occurs.

There are four main groups of tissues: epithelial, connective, nerve, and muscle (figure 7-3).

Epithelial tissue covers the surface of the body and is the main tissue in the skin. It forms the lining of the intestinal, respiratory, circulatory, and urinary tracts, as well as that of other body cavities. Epithelial tissue also forms the body glands, where it specializes to produce specific secretions for the body, such as mucus and digestive juices.

Connective tissue is the supporting fabric of organs and other body parts. There are two main classes of connective tissue: soft and hard. One

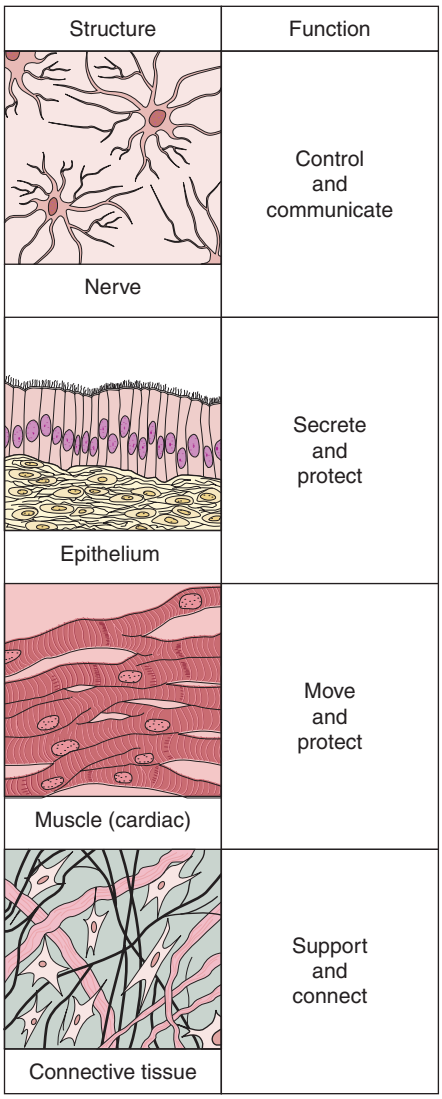


FIGURE 7-3 Four main groups of tissues and their functions.

type of soft connective tissue is adipose, or fatty, tissue, which stores fat as a food reserve or source of energy, insulates the body, fills the area between tissue fibers, and acts as padding. A second type of soft connective tissue is fibrous connective tissue, such as ligaments and tendons, which help hold body structures together. Hard connective tissue includes cartilage and bone. Cartilage is a tough, elastic material that is found between the bones of the spine and at the end of long bones. It acts as a shock absorber and allows for flexibility. It is also found in the nose, ears, and larynx, or "voice box," to provide form or shaping. Bone is similar to cartilage but has calcium salts, nerves, and blood vessels; it is frequently called *osseous tissue*. Bone helps form the rigid structure of the human body. Blood and lymph are classified as liquid connective tissue, or *vascular tissue*. Blood carries nutrients and oxygen to the body cells and carries metabolic waste away from cells. Lymph transports tissue fluid, proteins, fats, and other materials from the tissues to the circulatory system.

Nerve tissue is made up of special cells called *neurons*. It controls and coordinates body activities by transmitting messages throughout the body. The nerves, brain, and spinal cord are composed of nerve tissue.

Muscle tissue produces power and movement by contraction of muscle fibers. There are three main kinds of muscle tissue: skeletal, cardiac,

TABLE 7-1 Systems of the Body

SYSTEM	FUNCTIONS	MAJOR ORGANS/STRUCTURES
Integumentary	Protects body from injury, infection, and dehydration; helps regulate body temperature; eliminates some wastes; produces vitamin D	Skin, sweat and oil glands, nails, and hair
Skeletal	Creates framework of body, protects internal organs, produces blood cells, acts as levers for muscles	Bones and cartilage
Muscular	Produces movement, protects internal organs, produces body heat, maintains posture	Skeletal, smooth, and cardiac muscles
Nervous	Coordinates and controls body activities	Nerves, brain, spinal cord
Special Senses	Allow body to react to environment by providing sight, hearing, taste, smell, and balance	Eye, ear, tongue, nose, general sense receptors
Circulatory	Carries oxygen and nutrients to body cells; carries waste products away from cells; helps produce cells to fight infection	Heart, blood vessels, blood, spleen
Lymphatic	Carries some tissue fluid and wastes to blood, assists with fighting infection	Lymph nodes, lymph vessels, spleen, tonsils, and thymus gland
Respiratory	Breathes in oxygen and eliminates carbon dioxide	Nose, pharynx, larynx, trachea, bronchi, lungs
Digestive	Digests food physically and chemically, transports food, absorbs nutrients, eliminates waste	Mouth, salivary glands, pharynx, esophagus, stomach, intestine, liver, gallbladder, pancreas
Urinary	Filters blood to maintain fluid and electrolyte balance in the body, produces and eliminates urine	Kidneys, ureters, urinary bladder, urethra
Endocrine	Produces and secretes hormones to regulate body processes	Pituitary, thyroid, parathyroid, adrenal, and thymus glands; pancreas, ovaries, testes
Reproductive	Provides for reproduction	Male: testes, epididymis, vas deferens, ejaculatory duct, seminal vesicles, prostate gland, penis, urethra Female: ovaries, fallopian tubes, uterus, vagina, breasts

and visceral (smooth). Skeletal muscle attaches to the bones and provides for movement of the body. Cardiac muscle causes the heart to beat. Visceral muscle is present in the walls of the respiratory, digestive, urinary tract, and blood vessels.

ORGANS AND SYSTEMS

Two or more tissues joined together to perform a specific function are called an **organ.** Examples of organs include the heart, stomach, and lungs.

Organs and other body parts joined together to perform a particular function are called a **system.** The basic systems (discussed in more detail in succeeding sections) are the integumentary, skeletal, muscular, circulatory, lymphatic, nervous, respiratory, digestive, urinary (or excretory), endocrine, and reproductive. Their functions and main organs are shown in table 7-1.

In summary, cells combine to form tissues, tissues combine to form organs, and organs and other body parts combine to form systems. These systems working together help create the miracle called the human body (figure 7-4).

STUDENT: *Go to the workbook and complete the assignment sheet for 7:1, Basic Structure of the Human Body.*

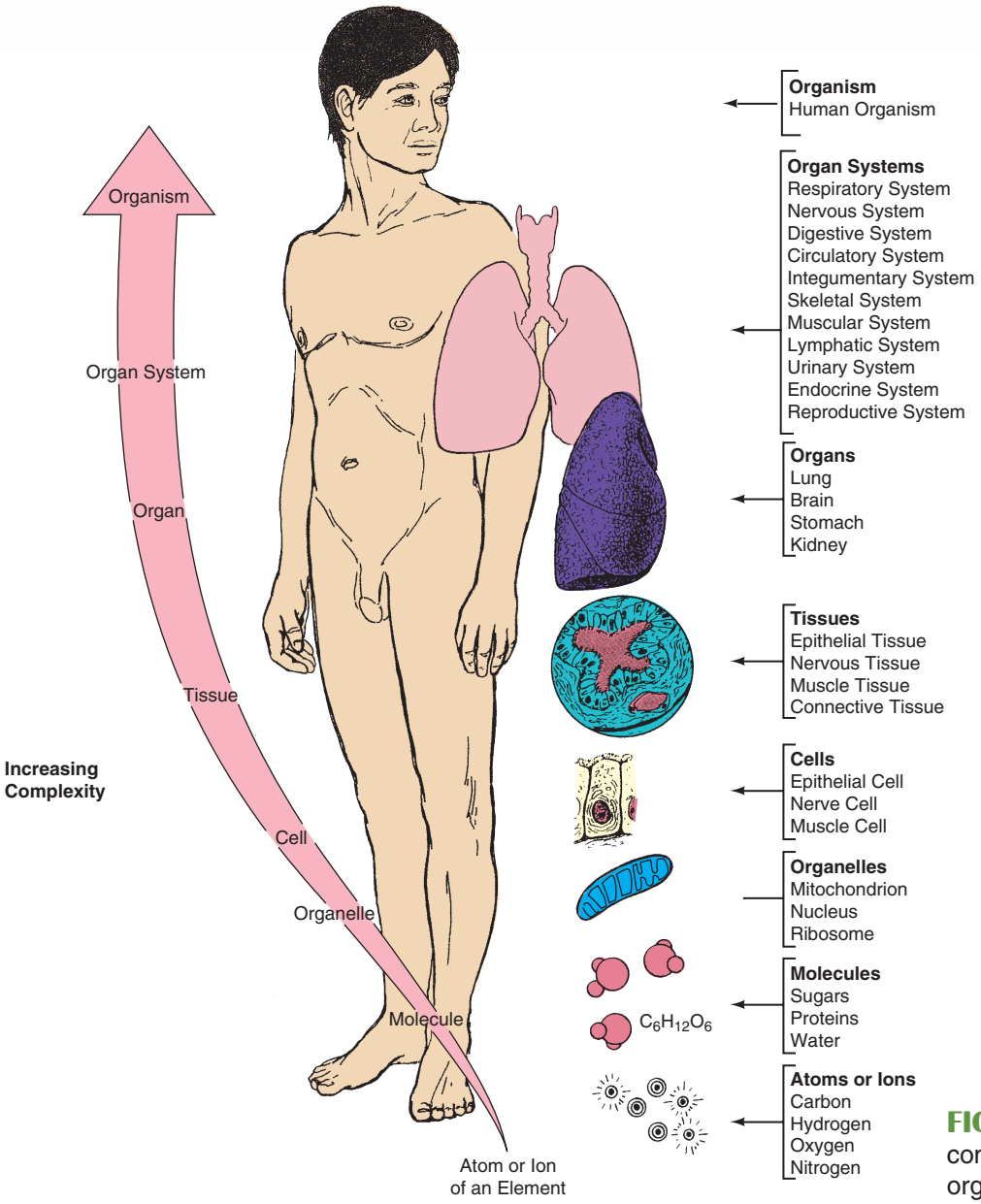


FIGURE 7-4 The levels of complexity in the human organism.

7:2 Body Planes, Directions, and Cavities

Objectives

After completing this section, you should be able to:

- Label the names of the planes and the directional terms related to these planes on a diagram of the three planes of the body
- Label a diagram of the main body cavities
- Identify the main organs located in each body cavity
- Locate the nine abdominal regions
- Define, pronounce, and spell all key terms

KEY TERMS

abdominal cavity
abdominal regions
anterior
body cavities
body planes
buccal cavity
caudal *(kaw'-doll)*
cranial *(kray'-nee-al)*
cranial cavity
distal
dorsal
dorsal cavity
frontal (coronal) plane
inferior
lateral *(lat'-eh-ral)*
medial *(me'-dee-al)*
midsagittal (median) plane *(mid-saj'-ih-tahl)*
nasal cavity
orbital cavity
pelvic cavity
posterior
proximal *(prox'-ih-mahl)*
spinal cavity
superior
thoracic cavity *(tho-rass'-ik)*
transverse plane
ventral
ventral cavity

7:2 INFORMATION

Because terms such as *south* and *east* would be difficult to apply to the human body, other directional terms have been developed. These terms are used to describe the relationship of one part of the body to another part. The terms are used when the body is in anatomic position. This means the body is facing forward, standing erect, and holding the arms at the sides with the palms of the hands facing forward.

BODY PLANES

Body planes are imaginary lines drawn through the body at various parts to separate the body into sections. Directional terms are created by these planes. The three main body planes are the transverse, midsagittal, and frontal (figure 7-5).

The **transverse plane** is a horizontal plane that divides the body into a top half and a bottom half. Body parts above other parts are termed **superior,** and body parts below other parts are termed **inferior.** For instance, the knee is superior to the ankle, but inferior to the hip. Two other directional terms related to this plane include **cranial,** which means body parts located near the head, and **caudal,** which means body parts located near the sacral region of the spinal column (also known as the "tail").

The **midsagittal** or **median plane** divides the body into right and left sides. Body parts close to the midline, or plane, are called **medial,** and body parts away from the midline are called **lateral.**

The **frontal** or **coronal plane** divides the body into a front section and a back section. Body parts in front of the plane, or on the front of the body, are called **ventral** or **anterior.** Body parts on the back of the body are called **dorsal** or **posterior.**

Two other directional terms are **proximal** and **distal.** These are used to describe the loca-

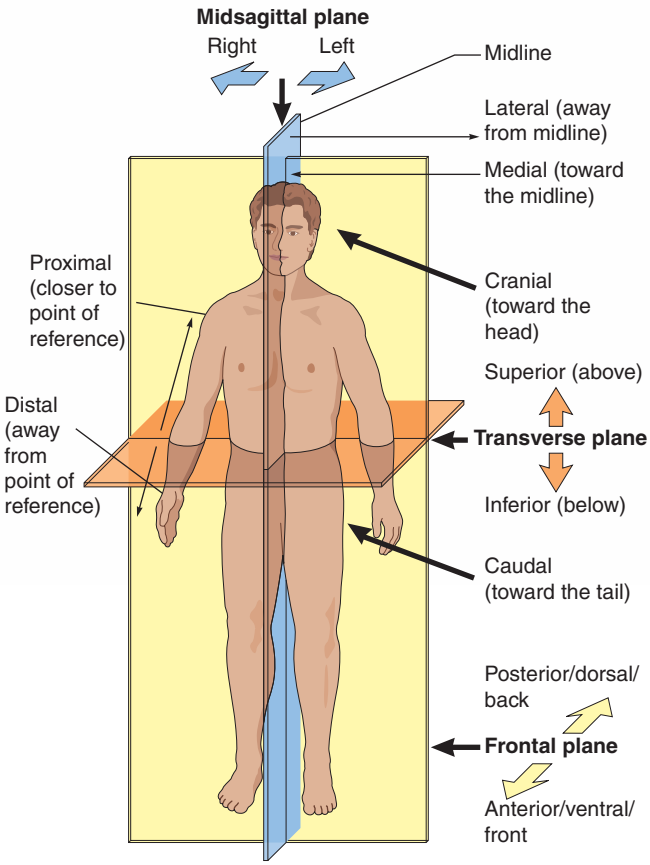


FIGURE 7-5 Body planes and directional terms.

tion of the extremities (arms and legs) in relation to the main trunk of the body, generally called the *point of reference.* Body parts close to the point of reference are called *proximal,* and body parts distant from the point of reference are called *distal*. For example, in describing the relationship of the wrist and elbow to the shoulder (or point of reference), the wrist is distal and the elbow is proximal to the shoulder.

BODY CAVITIES

Body cavities are spaces within the body that contain vital organs. There are two main body cavities: the dorsal, or posterior, cavity and the ventral, or anterior, cavity (figure 7-6).

The **dorsal cavity** is one long, continuous cavity located on the back of the body. It is divided into two sections: the **cranial cavity,** which contains the brain, and the **spinal cavity,** which contains the spinal cord.

The **ventral cavities** are larger than the dorsal cavities. The ventral cavity is separated into two distinct cavities by the dome-shaped muscle called the *diaphragm,* which is important for respiration (breathing). The **thoracic cavity** is located in the chest and contains the esophagus, trachea, bronchi, lungs, heart, and large blood vessels. The **abdominal cavity,** or abdominopelvic cavity, is divided into an upper part and a lower part. The upper abdominal cavity contains the stomach, small intestine, most of the large intestine, appendix, liver, gallbladder, pancreas, and spleen. The lower abdominal cavity, or **pelvic cavity,** contains the urinary bladder, the reproductive organs, and the last part of the large intestine. The kidneys and adrenal glands are technically located outside the abdominal cavity because they are behind the peritoneal membrane (peritoneum) that lines the abdominal cavity. This area is called the *retroperitoneal space*.

Three small cavities are the **orbital cavity** for the eyes, the **nasal cavity** for the nose structures, and the **buccal cavity,** or mouth, for the teeth and tongue.

ABDOMINAL REGIONS

The abdominal cavity is so large that it is divided into regions or sections. One method of division is into quadrants, or four sections. As shown in figure 7-7, this results in a right upper quadrant (RUQ), left upper quadrant (LUQ), right lower quadrant (RLQ), and left lower quadrant (LLQ). A more precise method of division is into nine **abdominal regions** (figure 7-8). The center regions are the epigastric (above the stomach), umbilical (near the umbilicus or belly button), and hypogastric, or pelvic (below the stomach). On either side of the center the regions are the hypochondriac (below the ribs), lumbar (near the large bones of the spinal cord), and iliac, or inguinal (near the groin).

The terms relating to body planes, directions, and cavities are used frequently in the study of human anatomy.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:2, Body Planes, Directions, and Cavities.*

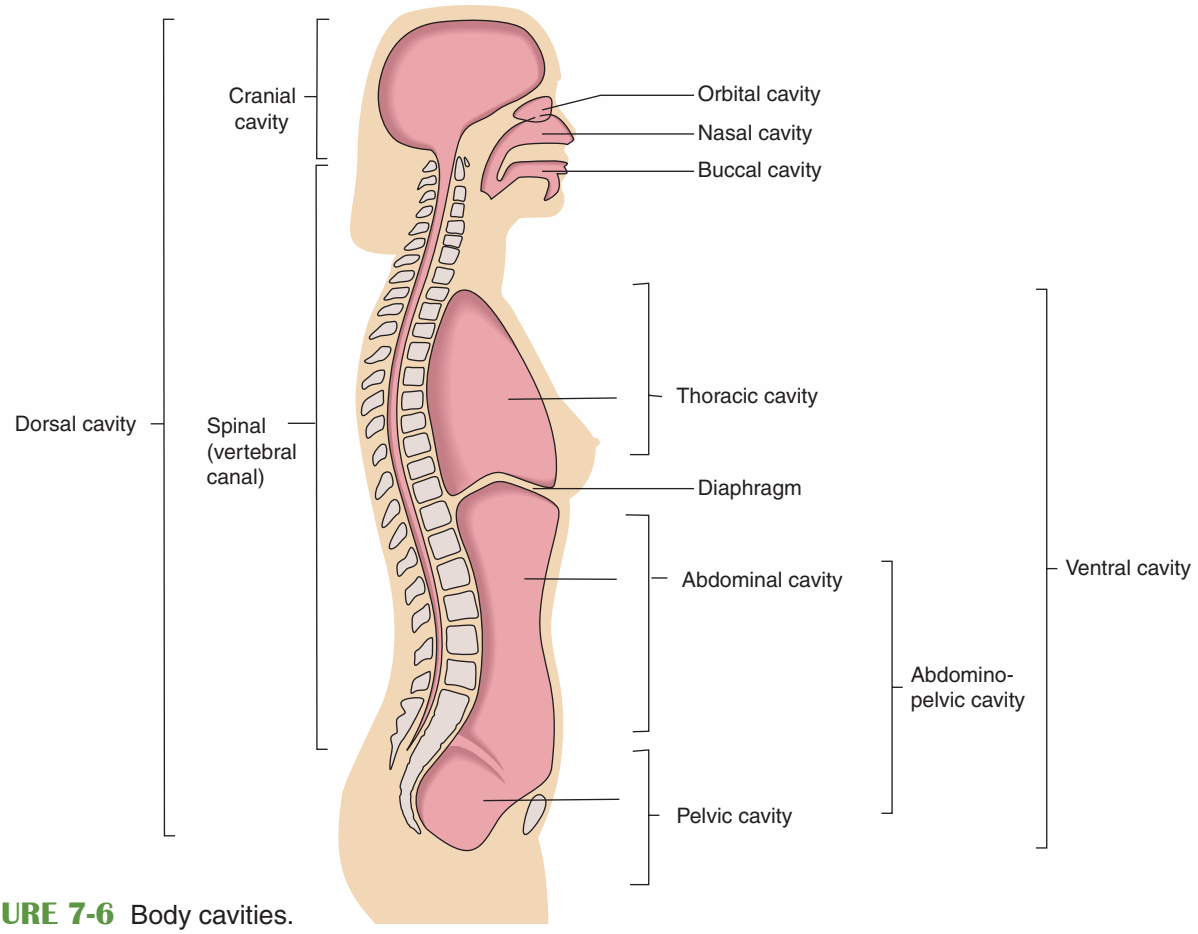


FIGURE 7-6 Body cavities.

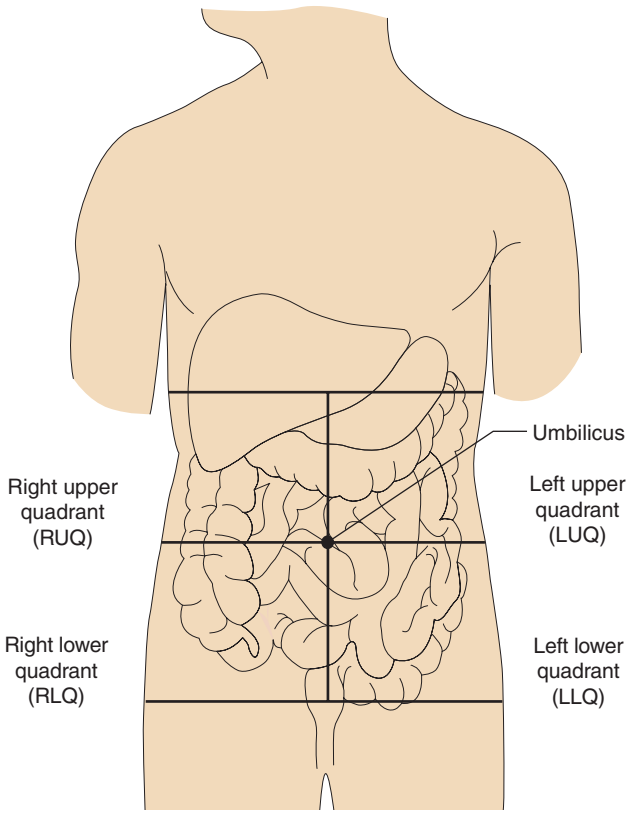


FIGURE 7-7 Abdominal quadrants.

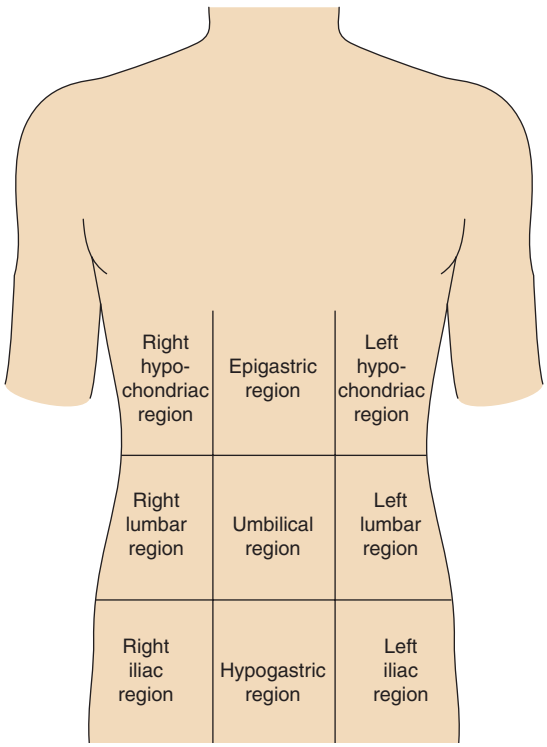


FIGURE 7-8 Nine abdominal regions.

7:3 Integumentary System

Objectives

After completing this section, you should be able to:

- Label a diagram of a cross section of the skin
- Differentiate between the two types of skin glands
- List six functions of the skin
- Provide the correct names for three abnormal colors of the skin and identify the cause of each abnormal color
- Describe at least four skin eruptions
- Describe at least four diseases of the integumentary system
- Define, pronounce, and spell all key terms

KEY TERMS

albino
alopecia
constrict *(kun-strict')*
crusts
cyanosis *(sy'-eh-noh'-sis)*
dermis
dilate *(die'-late)*
epidermis *(eh-pih-der'-mis)*
erythema *(err-ih-thee'-ma)*
integumentary system *(in-teg-u-men'-tah-ree)*
jaundice *(jawn'-diss)*
macules *(mack'-youlz)*
melanin
papules *(pap'-youlz)*
pustules *(pus'-tyoulz)*
sebaceous glands *(seh-bay'-shus)*
subcutaneous fascia (hypodermis) *(sub-q-tay'-nee-us fash'-ee-ah)*
sudoriferous glands *(sue-de-rif'-eh-rus)*
ulcer
vesicles *(ves'-i-kulz)*
wheals

RELATED HEALTH CAREERS

- Allergist
- Dermatologist
- Plastic Surgeon

7:3 INFORMATION

The **integumentary system,** or skin, has been called both a membrane, because it covers the body, and an organ, because it contains several kinds of tissues. Most anatomy courses, however, refer to it as a system because it has organs and other parts that work together to perform a particular function. On an average adult, the skin covers more than 3,000 square inches of surface area and accounts for about 15 percent of total body weight.

Three main layers of tissue make up the skin (figure 7-9):

- **Epidermis:** the outermost layer of skin. This layer is actually made of five smaller layers but no blood vessels or nerve cells. Two main layers are the *stratum corneum,* the outermost layer, and the *stratum germinativum,* the innermost layer. The cells of the stratum corneum are constantly shed and replaced by new cells from the stratum germinativum.
- **Dermis:** also called *corium,* or "true skin." This layer has a framework of elastic connective tissue and contains blood vessels, lymph vessels, nerves, involuntary muscle, sweat and oil glands, and hair follicles. The top of the dermis is covered with papillae, which fit into ridges on the stratum germinativum of the epidermis. These ridges form lines, or striations, on the skin. Because the pattern of ridges is unique to each individual, fingerprints and footprints are often used as methods of identification.

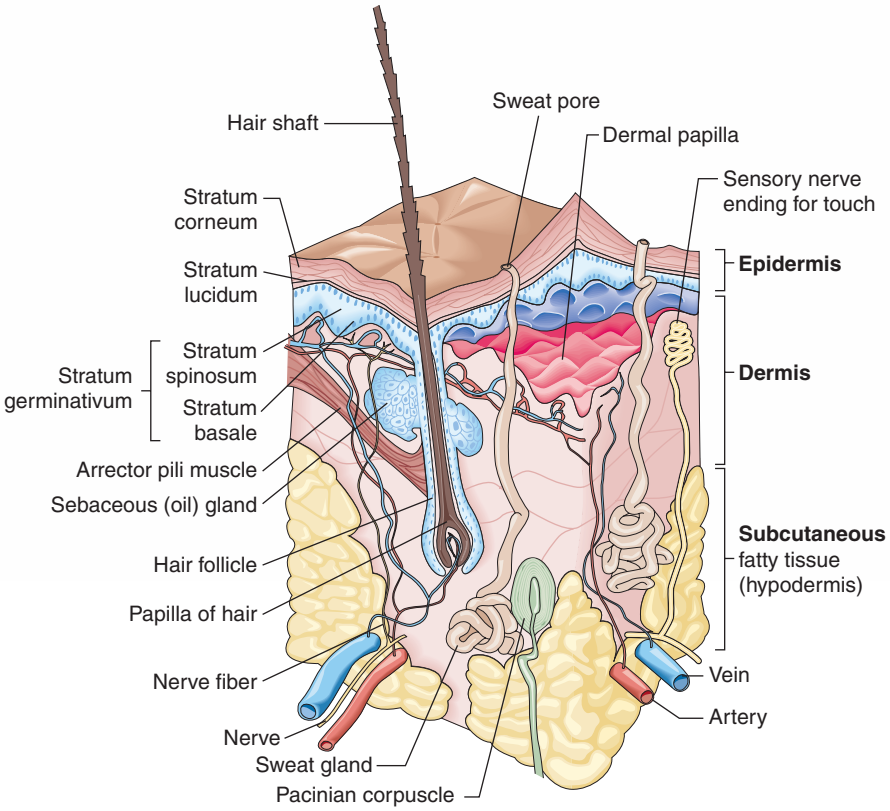


FIGURE 7-9 Cross-section of skin.

- **Subcutaneous fascia** or **hypodermis:** the innermost layer. It is made of elastic and fibrous connective tissue and adipose (fatty) tissue, and connects the skin to underlying muscles.

The integumentary system has two main types of glands: sudoriferous and sebaceous. The **sudoriferous glands** (sweat glands) are coiled tubes that extend through the dermis and open on the surface of the skin at pores. The sweat, or perspiration, eliminated by these glands contains water, salts, and some body wastes. Even though sweat contains body wastes, it is basically odorless. However, when the sweat interacts with bacteria on the skin, body odor occurs. The process of perspiration removes excess water from the body and cools the body as the sweat evaporates into the air. The **sebaceous glands** are oil glands that usually open onto hair follicles. They produce sebum, an oil that keeps the skin and hair from becoming dry and brittle. Because sebum is slightly acidic, it acts as an antibacterial and antifungal secretion to help prevent infections. When an oil gland becomes plugged, the accumulation of dirt and oil results in a blackhead or pimple.

Two other parts of the integumentary system are the hair and nails. Each hair consists of a root (which grows in a hollow tube called a *follicle*) and a hair shaft. Hair helps protect the body and covers all body surfaces except for the palms of the hands and the soles of the foot. Due to genetics, male (and some female) individuals may experience **alopecia** or baldness, a permanent loss of hair on the scalp. Nails protect the fingers and toes from injury. They are made of dead, keratinized epidermal epithelial cells packed closely together to form a thick, dense surface. They are formed in the nail bed. If lost, nails will regrow if the nail bed is not damaged.

FUNCTIONS

The integumentary system performs the following important functions:

- *Protection*: It serves as a barrier to the sun's ultraviolet rays and the invasion of pathogens, or germs. It also holds moisture in and prevents deeper tissues from drying out.
- *Sensory perception*: The nerves in the skin help the body respond to pain, pressure, temperature (heat and cold), and touch sensations (figure 7-10).

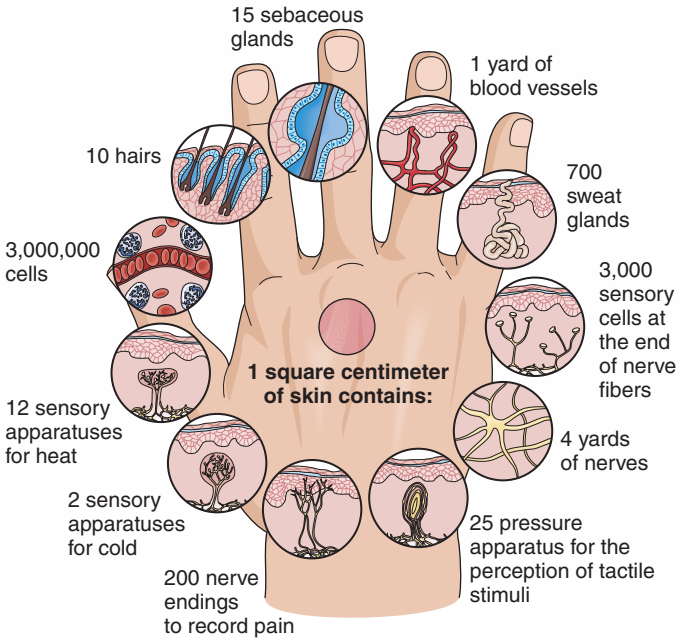


FIGURE 7-10 The nerves in the skin allow the body to respond to many different sensations.

- *Body temperature regulation*: The blood vessels in the skin help the body retain or lose heat. When the blood vessels **dilate** (get larger), excess heat from the blood can escape through the skin. When the blood vessels **constrict** (get smaller), the heat is retained in the body. The sudoriferous glands also help cool the body through evaporation of perspiration.
- *Storage*: The skin has tissues for temporary storage of fat, glucose (sugar), water, vitamins, and salts. Adipose (fatty) tissue in the subcutaneous fascia is a source of energy.
- *Absorption*: Certain substances can be absorbed through the skin, such as medications for motion sickness or heart disease and nicotine patches to help stop smoking. The medications are placed on sticky patches and applied to the skin. This is called a *transdermal medication*.
- *Excretion*: The skin helps the body eliminate salt, a minute amount of waste, and excess water and heat through perspiration.
- *Production*: The skin helps in the production of vitamin D by using ultraviolet rays from the sun to form an initial molecule of vitamin D that matures in the liver.

PIGMENTATION

Basic skin color is inherited and is determined by pigments in the epidermis of the skin. A brownish black pigment, **melanin,** is produced in the epidermis by specialized cells called *melanocytes*. Even though everyone has the same number of melanocytes, genes present in each racial group determine the amount of melanin produced. Melanin can lead to a black, brown, or yellow skin tint, depending on the amount of melanin present and racial origin. Ultraviolet light activates the melanocytes to produce more melanin to protect and to tan the skin. Small concentrated areas of melanin pigment form freckles. Carotene, a yellowish red pigment, also helps determine skin color. A person with an absence of color pigments is an **albino.** An albino's skin has a pinkish tint and the hair is pale yellow or white. The person's eyes also lack pigment and are red and very sensitive to light.

Abnormal colors of the skin can indicate disease. **Erythema** is a reddish color of the skin that can be caused by either burns or a congestion of blood in the vessels. **Jaundice,** a yellow discoloration of the skin, can indicate bile in the blood as a result of liver or gallbladder disease. Jaundice also occurs in conjunction with certain diseases that involve the destruction of red blood cells.

Cyanosis is a bluish discoloration of the skin caused by insufficient oxygen. It can be associated with heart, lung, and circulatory diseases or disorders. Chronic poisoning may cause a gray or brown skin discoloration.

SKIN ERUPTIONS

Skin eruptions can also indicate disease. The most common eruptions include:

- **Macules:** (macular rash) flat spots on the skin, such as freckles
- **Papules:** (papular rash) firm, raised areas such as pimples and the eruptions seen in some stages of chickenpox and syphilis
- **Vesicles:** blisters, or fluid-filled sacs, such as those seen in chickenpox
- **Pustules:** pus-filled sacs such as those seen in acne, or pimples
- **Crusts:** areas of dried pus and blood, commonly called *scabs*
- **Wheals:** itchy, elevated areas with an irregular shape; hives and insect bites are examples
- **Ulcer:** a deep loss of skin surface that may extend into the dermis; may cause periodic bleeding and the formation of scars

DISEASES AND ABNORMAL CONDITIONS

Acne Vulgaris

Acne vulgaris is an inflammation of the sebaceous glands. Although the cause is unknown, acne usually occurs at adolescence. Hormonal changes and increased secretion of sebum are probably underlying causes. Symptoms include papules, pustules, and blackheads. These occur when the hair follicles become blocked with dirt, cosmetics, excess oil, and/or bacteria. Treatment methods include frequent, thorough skin washing; avoidance of creams and heavy makeup; antibiotic or vitamin A ointments; oral antibiotics; and/or ultraviolet light treatments.

Athlete's Foot

Athlete's foot is a contagious fungal infection that usually affects the feet. The skin itches, blisters, and cracks into open sores. Treatment involves applying an antifungal medication and keeping the area clean and dry.

Skin Cancer

Cancer of the skin is the most common type of cancer. There are three main types of skin cancer: basal cell carcinoma, squamous cell carcinoma, and melanoma. *Basal cell carcinoma* is cancer of the basal cells in the epidermis of the skin. It grows slowly and does not usually spread (figure 7-11). The lesions can be pink to yellow-white. They are usually smooth with a depressed center and an elevated, irregular-shaped border.

Squamous cell carcinoma affects the thin cells of the epithelium but can spread quickly to other areas of the body. The lesions start as small, firm, red, flat sores that later scale and crust (figure 7-12). Sores that do not heal are frequently squamous cell carcinomas.

Melanoma develops in the melanocytes of the epidermis and is the most dangerous type of

FIGURE 7-11 Basal cell carcinomas usually grow more slowly. *(Courtesy of Robert A. Silverman, MD, Clinical Associate Professor, Department of Pediatrics, Georgetown University)*

FIGURE 7-12 Squamous cell carcinomas resemble sores that scale and crust. *(Courtesy of Robert A. Silverman, MD, Clinical Associate Professor, Department of Pediatrics, Georgetown University)*

FIGURE 7-13 Melanoma is the most dangerous form of skin cancer. *(Courtesy of Robert A. Silverman, MD, Clinical Associate Professor, Department of Pediatrics, Georgetown University)*

skin cancer (figure 7-13). The lesions can be brown, black, pink, or multicolored. They are usually flat or raised slightly, asymmetric and irregular or notched on the edges.

Frequently, skin cancer develops from a mole or nevus that changes in color, shape, size, or texture. Bleeding or itching of a mole can also indicate cancer. Exposure to the sun, prolonged use of tanning beds, irritating chemicals, or radiation are the usual causes of skin cancer. Treatment involves surgical removal of the cancer, radiation, and/or chemotherapy.

Dermatitis

Dermatitis, an inflammation of the skin, can be caused by any substance that irritates the skin. It is frequently an allergic reaction to detergents, cosmetics, pollen, or certain foods. One example of contact dermatitis is the irritation caused by contact with poison ivy, poison sumac, or poison oak (figure 7-14). Symptoms include dry skin, erythema, itching, edema, macular-papular rashes, and scaling. Treatment is directed at eliminating the cause, especially in the case of allergens. Anti-inflammatory ointments, antihistamines, and/or steroids are also used in treatment.

Eczema

Eczema is a noncontagious, inflammatory skin disorder caused by an allergen or irritant. Diet, cosmetics, soaps, medications, and emotional stress can all cause eczema. Symptoms include dryness, erythema, edema, itching, vesicles,

FIGURE 7-14 A contact dermatitis caused by contact with poison oak. *(Courtesy of Timothy Berger, MD, Clinical Professor, Department of Dermatology, University of California, San Francisco)*

crusts, and scaling. Treatment involves removing the irritant and applying corticosteroids to reduce the inflammatory response.

Impetigo

Impetigo is a highly contagious skin infection usually caused by streptococci or staphylococci organisms. Symptoms include erythema, oozing vesicles, pustules, and the formation of a yellow crust. Lesions should be washed with soap and water and kept dry. Antibiotics, both topical and oral, are also used in treatment.

Psoriasis

Psoriasis is a chronic, noncontagious skin disease with periods of exacerbations (symptoms present) and remission (symptoms decrease or disappear). The cause is unknown, but there may be a hereditary link. Stress, cold weather, sunlight, pregnancy, and endocrine changes tend to cause an exacerbation of the disease. Symptoms include thick, red areas covered with white or silver scales, (figure 7-15). Although there is no cure, treatment methods include coal/tar or cortisone ointments, ultraviolet light, and/or scale removal.

FIGURE 7-15 Psoriasis is characterized by white or silver scales. *(Courtesy of Robert A. Silverman, MD, Pediatric Dermatology, Georgetown University)*

Ringworm

Ringworm (tineas) is a highly contagious fungal infection of the skin or scalp. The characteristic symptom is the formation of a flat or raised circular area with a clear central area surrounded by an itchy, scaly, or crusty outer ring. Antifungal medications, both oral and topical, are used in treatment.

Verrucae

Verrucae, or warts, are caused by a viral infection of the skin. Plantar warts usually occur at pressure points on the sole of the foot. A rough, hard, elevated, rounded surface forms on the skin. Some warts disappear spontaneously, but others must be removed with electricity, liquid nitrogen, acid, chemicals, or laser.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:3, Integumentary System.*

7:4 Skeletal System

Objectives

After completing this section, you should be able to:

- List five functions of bones
- Label the parts of a bone on a diagram of a long bone
- Name the two divisions of the skeletal system and the main groups of bones in each division
- Identify the main bones of the skeleton
- Compare the three classifications of joints by describing the type of motion allowed by each
- Give one example of each joint classification
- Describe at least four diseases of the skeletal system
- Define, pronounce, and spell all key terms

KEY TERMS

appendicular skeleton *(ap-pen-dick'-u-lar)*
axial skeleton
carpals
clavicles *(klav'-ih-kulz)*
cranium
diaphysis *(dy-af'-eh-sis)*
endosteum *(en-dos'-tee-um)*
epiphysis *(ih-pif'-eh-sis)*
femur *(fee'-mur)*
fibula *(fib'-you-la)*
fontanels
foramina *(for-ahm'-e-nah)*
humerus *(hue'-mer-us)*
joints
ligaments
medullary canal *(med'-hue-lair-ee)*
metacarpals *(met-ah-car'-pulz)*
metatarsals *(met-ah-tar'-sulz)*
os coxae *(ahs cock'-see)*
patella *(pa-tell'-ah)*
periosteum *(per-ee-os'-tee-um)*
phalanges *(fa-lan'-jeez)*
radius
red marrow
ribs

(continues)

KEY TERMS (continued)

scapula
sinuses *(sigh'-nuss-ez)*
skeletal system
sternum
sutures
tarsals
tibia
ulna
vertebrae *(vur'-teh-bray)*
yellow marrow

RELATED HEALTH CAREERS

- Athletic Trainer
- Chiropractor
- Orthopedist
- Orthoptist
- Osteopathic Physician
- Physiatrist
- Physical Therapist
- Podiatrist
- Prosthetist
- Radiologic Technologist
- Sports Medicine Physician

7:4 INFORMATION

The **skeletal system** is made of organs called *bones*. An adult human has 206 bones. These bones work as a system to perform the following functions:

- *Framework*: bones form a framework to support the body's muscles, fat, and skin
- *Protection*: bones surround vital organs to protect them (for example the skull, which surrounds the brain, and the ribs, which protect the heart and lungs)
- *Levers*: muscles attach to bones to help provide movement
- *Production of blood cells*: bones help produce red and white blood cells and platelets, a process called *hemopoiesis* or *hematopoiesis*
- *Storage*: bones store most of the calcium supply of the body in addition to phosphorus and fats

Bones vary in shape and size depending on their locations within the body. Bones of the extremities (arms and legs) are called *long bones*. The basic parts of these bones are shown in figure 7-16. The long shaft is called the **diaphysis,** and the two extremities, or ends, are each called an **epiphysis.** The **medullary canal** is a cavity in the diaphysis. It is filled with **yellow marrow,** which is mainly a storage area for fat cells. Yellow marrow also contains cells that form leukocytes, or white blood cells. The **endosteum** is a membrane that lines the medullary canal and keeps the yellow marrow intact. It also produces some bone growth. **Red marrow** is found in certain bones, such as the vertebrae, ribs, sternum, and cranium, and in the proximal ends of the humerus and femur. It produces red blood cells (erythrocytes), platelets (thrombocytes), and some white blood cells (leukocytes). Because bone marrow is important in the manufacture of blood cells and is involved with the body's immune response, the red marrow is used to diagnose blood diseases and is sometimes transplanted in people with defective immune systems. The outside of bone is covered with a tough membrane, called the **periosteum,** which contains blood vessels, lymph vessels, and *osteoblasts,* special cells that form new bone tissue. The periosteum is necessary for bone growth, repair, and nutrition. A thin layer of articular cartilage covers the epiphysis and acts as a shock absorber when two bones meet to form a joint.

The skeletal system is divided into two sections: the axial skeleton and the appendicular skeleton. The **axial skeleton** forms the main trunk of the body and is composed of the skull, spinal column, ribs, and breastbone. The **appendicular skeleton** forms the extremities and is composed of the shoulder girdle, arm bones, pelvic girdle, and leg bones.

The skull is composed of the cranial and facial bones (figure 7-17). The **cranium** is the spherical structure that surrounds and protects the

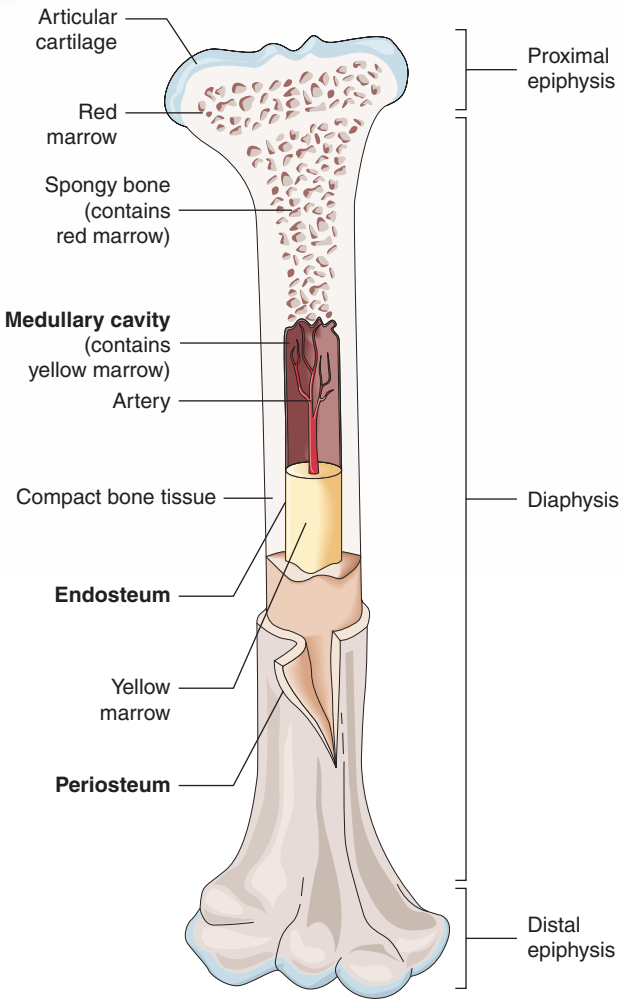


FIGURE 7-16 Anatomic parts of a long bone.

brain. It is made of eight bones: one frontal, two parietal, two temporal, one occipital, one ethmoid, and one sphenoid. At birth, the cranium is not solid bone. Spaces called **fontanels,** or "soft spots," allow for the enlargement of the skull as brain growth occurs. The fontanels are made of membrane and cartilage, and turn into solid bone by approximately 18 months of age. There are 14 facial bones: 1 mandible (lower jaw), 2 maxilla (upper jaw), 2 zygomatic (cheek), 2 lacrimal (inner aspect of eyes), 5 nasal, and 2 palatine (hard palate or roof of the mouth). **Sutures** are areas where the cranial bones have joined together. **Sinuses** are air spaces in the bones of the skull that act as resonating chambers for the voice. They are lined with mucous membranes. **Foramina** are openings in bones that allow nerves and blood vessels to enter or leave the bone.

The spinal column is composed of 26 bones called **vertebrae** (figure 7-18). These bones protect the spinal cord and provide support for the head and trunk. They include 7 cervical (neck), 12 thoracic (chest), 5 lumbar (waist), 1 sacrum (back of pelvic girdle), and 1 coccyx (tailbone). Pads of cartilage tissue, called *intervertebral disks,* separate the vertebrae. The disks act as shock absorbers and permit bending and twisting movements of the vertebral column.

There are 12 pairs of **ribs,** or costae. They attach to the thoracic vertebrae on the dorsal sur-

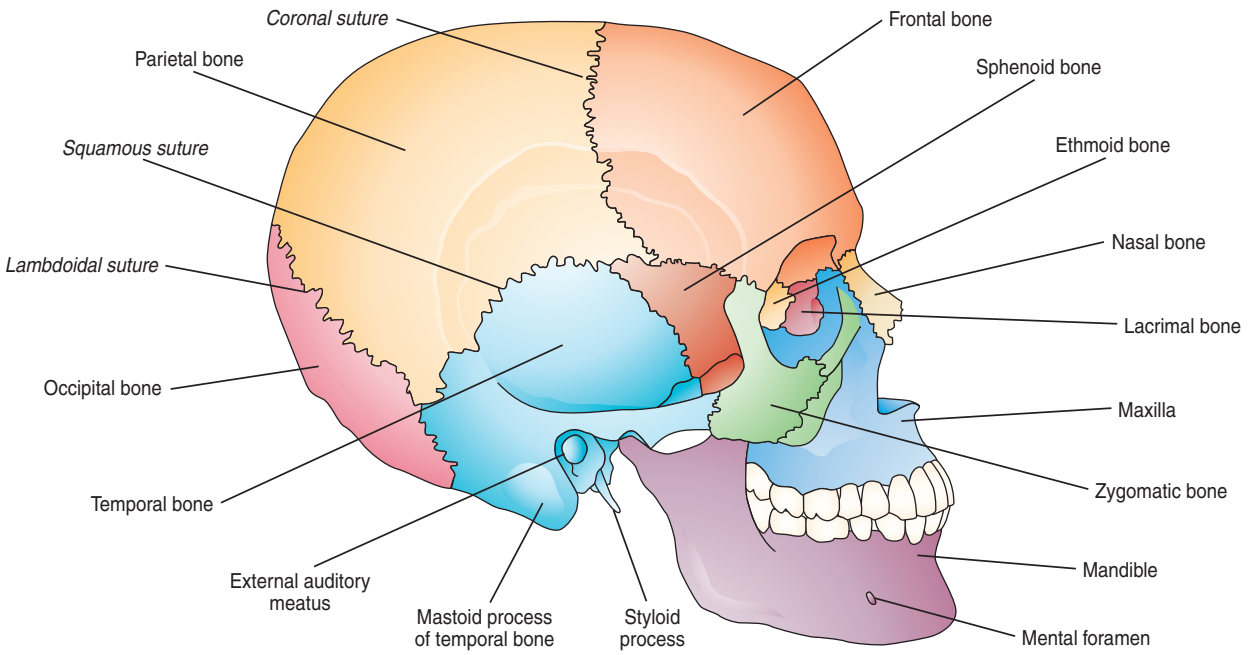


FIGURE 7-17 Bones of the skull.

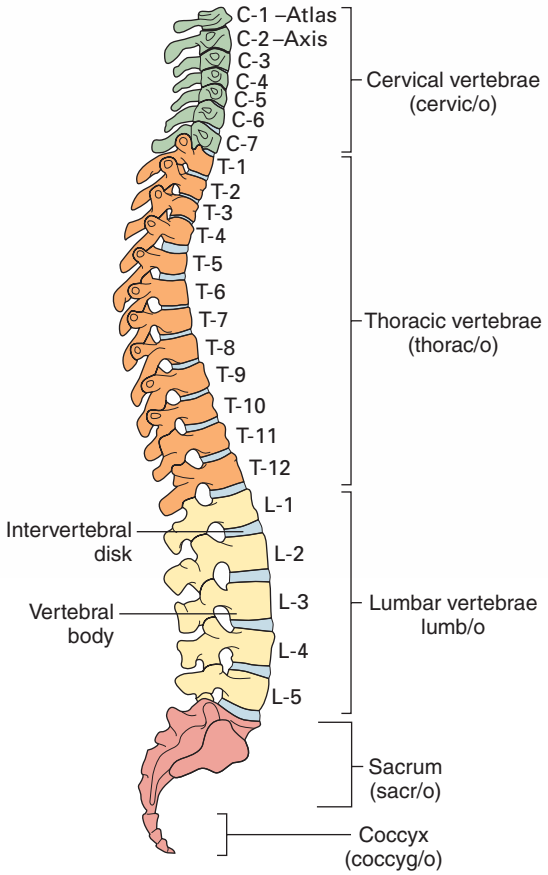


FIGURE 7-18 Lateral view of the vertebral, or spinal, column.

face of the body. The first seven pairs are called *true ribs* because they attach directly to the sternum, or breastbone, on the front of the body. The next five pairs are called *false ribs*. The first three pairs of false ribs attach to the cartilage of the rib above. The last two pairs of false ribs are called *floating ribs* because they have no attachment on the front of the body.

The **sternum,** or breastbone, is the last bone of the axial skeleton. It consists of three parts: the manubrium (upper region), the gladiolus (body), and the xiphoid process (a small piece of cartilage at the bottom). The two collarbones, or clavicles, are attached to the manubrium by ligaments. The ribs are attached to the sternum with costal cartilages to form a "cage" that protects the heart and lungs.

The shoulder, or pectoral, girdle is made of two **clavicles** (collarbones) and two **scapulas** (shoulder bones). The scapulas provide for attachment of the upper arm bones.

Bones of each arm include one **humerus** (upper arm), one **radius** (lower arm on thumb side that rotates around the ulna to allow the hand to turn freely), one **ulna** (larger bone of lower arm with a projection called the *olecranon process* at its upper end, forming the elbow), eight **carpals** (wrist), five **metacarpals** (palm of the hand), and fourteen **phalanges** (three on each finger and two on the thumb).

The pelvic girdle is made of two **os coxae** (coxal, or hip, bones), which join with the sacrum on the dorsal part of the body (figure 7-19). On the ventral part of the body, the os coxae join together at a joint called the *symphysis pubis.* Each os coxae is made of three fused sections: the ilium, the ischium, and the pubis. The pelvic girdle contains two recessed areas, or sockets. These sockets, called *acetabula,* provide for the attachment of the smooth rounded head of the femur (upper leg bone). An opening between the ischium and pubis, called the *obturator foramen,* allows for the passage of nerves and blood vessels to and from the legs.

Each leg consists of one **femur** (thigh), one **patella** (kneecap), one **tibia** (the larger weight-bearing bone of the lower leg commonly called the *shin bone*), one **fibula** (the slender smaller bone of the lower leg that attaches to the proximal end of the tibia), seven **tarsals** (ankle), five **metatarsals** (instep of foot), and fourteen phalanges (two on the great toe and three on each of the other four toes). The heel is formed by the large tarsal bone called the *calcaneous.* The bones of the skeleton are shown in figure 7-20.

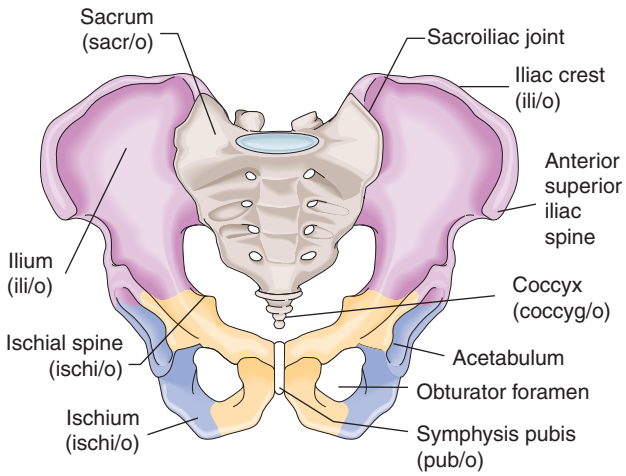


FIGURE 7-19 Anterior view of the pelvic girdle.

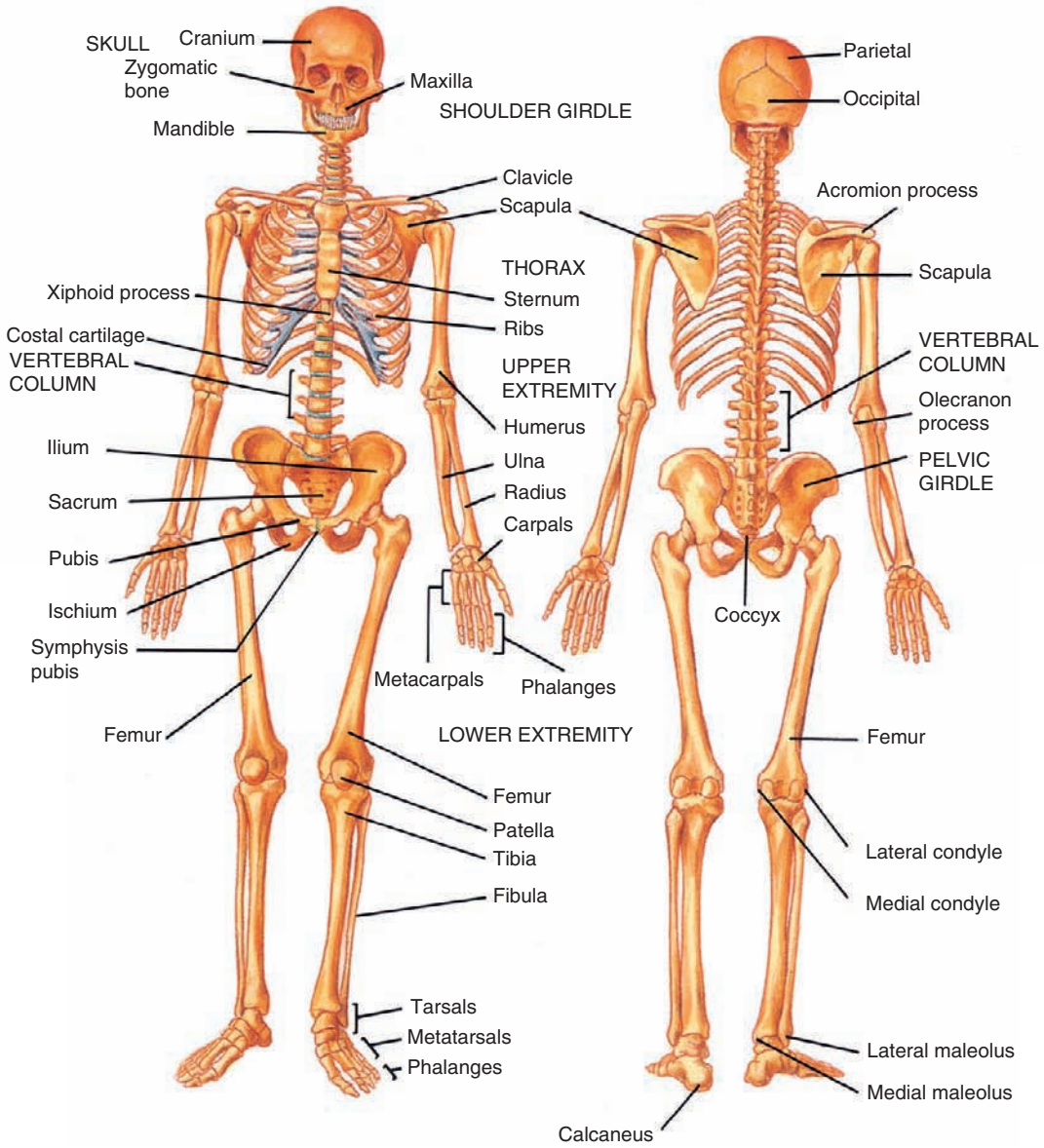


FIGURE 7-20 Bones of the skeleton.

Joints

Joints are areas where two or more bones join together. Connective tissue bands, called **ligaments,** help hold long bones together at joints. There are three main types of joints:

- *Diarthrosis* or *synovial*: freely movable; examples include the ball-and-socket joints of the shoulder and hip, or the hinge joints of the elbow and knee
- *Amphiarthrosis*: slightly movable; examples include the attachment of the ribs to the thoracic vertebrae and the symphysis pubis, or joint between the two pelvic bones
- *Synarthrosis*: immovable; examples are the suture joints of the cranium

DISEASES AND ABNORMAL CONDITIONS

Arthritis

Arthritis is actually a group of diseases involving inflammation of the joints. Two main types are osteoarthritis and rheumatoid arthritis. *Osteoarthritis,* the most common form, is a chronic disease that usually occurs as a result of aging. It

frequently affects the hips and knees. Symptoms include joint pain, stiffness, aching, and limited range of motion. Although there is no cure, rest, applications of heat and cold, aspirin and anti-inflammatory medications, injection of steroids into the joints, and special exercises are used to relieve the symptoms. *Rheumatoid arthritis* is a chronic inflammatory disease that affects the connective tissues and joints. It is three times more common in women than in men, and onset often occurs between the ages of 35 and 45. Progressive attacks can cause scar tissue formation and atrophy of bone and muscle tissue, which result in permanent deformity and immobility (figure 7-21). Early treatment is important to reduce pain and limit damage to joints. Rest, prescribed exercise, anti-inflammatory medications such as aspirin, and careful use of steroids are the main forms of treatment. Surgery, or arthroplasty, to replace damaged joints, such as those in the hips and knees, is sometimes performed when severe joint damage has occurred.

Bursitis

Bursitis is an inflammation of the bursae, which are small, fluid-filled sacs surrounding the joints. It frequently affects the shoulders, elbows, hips, or knees. Symptoms include severe pain, limited movement, and fluid accumulation in the joint. Treatment consists of administering pain medications, injecting steroids and anesthetics into the affected joint, rest, aspirating (withdrawing fluid with a needle) the joint, and physical therapy to preserve joint motion.

FIGURE 7-21 Rheumatoid arthritis can cause permanent deformity and immobility.

Fractures

A fracture is a crack or break in a bone. Types of fractures, shown in figure 7-22, include:

- *Greenstick*: bone is bent and splits, causing a crack or incomplete break; common in children
- *Simple* or *closed*: complete break of the bone with no damage to the skin
- *Compound* or *open*: bone breaks and ruptures through the skin; creates an increased chance of infection
- *Impacted*: broken bone ends jam into each other
- *Comminuted*: bone fragments or splinters into more than two pieces
- *Spiral*: bone twists, resulting in one or more breaks; common in skiing and skating accidents
- *Depressed*: a broken piece of skull bone moves inward; common with severe head injuries
- *Colles*: breaking and dislocation of the distal radius that causes a characteristic bulge at the wrist; caused by falling on an outstretched hand

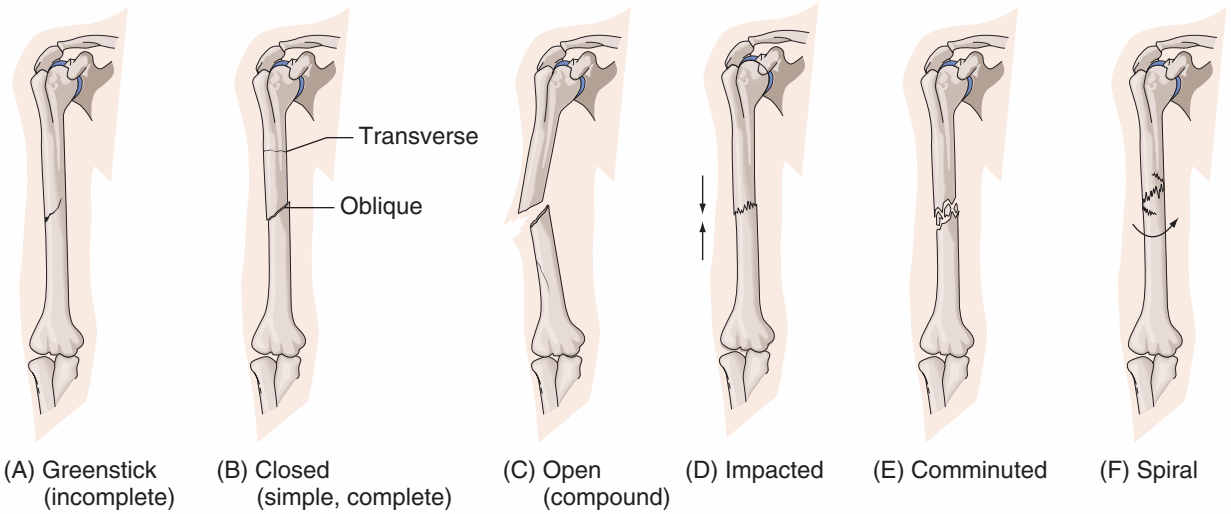
Before a fracture can heal, the bone must be put back into its proper alignment. This process is called *reduction*. *Closed reduction* involves positioning the bone in correct alignment, usually with traction, and applying a cast or splint to maintain the position until the fracture heals. *Open reduction* involves surgical repair of the bone. In some cases, special pins, plates, or other devices are surgically implanted to maintain correct position of the bone.

Dislocation

A dislocation is when a bone is forcibly displaced from a joint. It frequently occurs in shoulders, fingers, knees, and hips. After the dislocation is reduced (the bone is replaced in the joint), the dislocation is immobilized with a splint, a cast, or traction.

Sprain

A sprain is when a twisting action tears the ligaments at a joint. The wrists and ankles are common sites for sprains. Symptoms include pain,



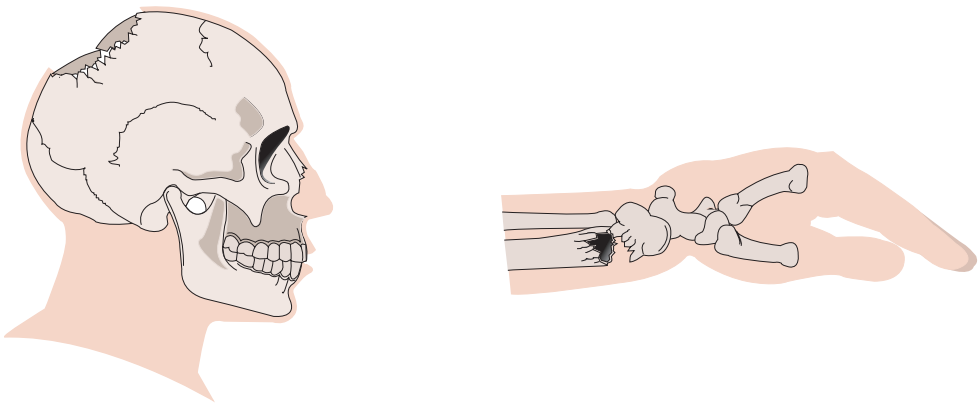


FIGURE 7-22 Types of fractures.

swelling, discoloration, and limited movement. Treatment methods include rest, elevation, immobilization with an elastic bandage or splint, and/or cold applications.

Osteomyelitis

Osteomyelitis is a bone inflammation usually caused by a pathogenic organism. The infectious organisms cause the formation of an abscess within the bone and an accumulation of pus in the medullary canal. Symptoms include pain at the site, swelling, chills, and fever. Antibiotics are used to treat the infection.

Osteoporosis

Osteoporosis, or increased porosity or softening of the bones, is a metabolic disorder caused by a hormone deficiency (especially estrogen in women), prolonged lack of calcium in the diet, and a sedentary lifestyle. The loss of calcium and phosphate from the bones causes the bones to become porous, brittle, and prone to fracture. Bone density tests lead to early detection and preventative treatment for osteoporosis. Treatment methods include increased intake of calcium and vitamin D, medications such as Fosamax and Citracel to increase bone mass, exercise, and/or estrogen replacement.

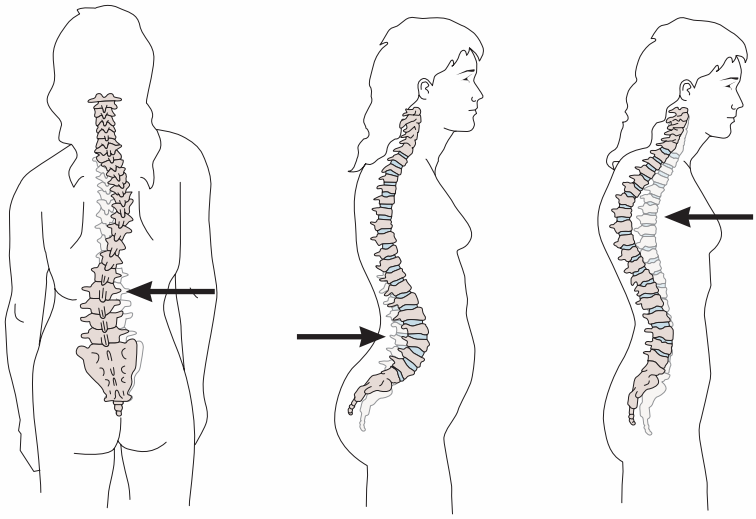


FIGURE 7-23 Abnormal curvatures of the spinal column.

Ruptured Disk

A ruptured disk, also called a *herniated* or *slipped disk*, occurs when an intervertebral disk (pad of cartilage separating the vertebrae) ruptures or protrudes out of place and causes pressure on the spinal nerve. The most common site is at the lumbar–sacral area, but a ruptured disk can occur anywhere on the spinal column. Symptoms include severe pain, muscle spasm, impaired movement, and/or numbness. Pain, anti-inflammatory, and muscle relaxant medications may be used as initial forms of treatment. Other treatments include rest, traction, physical therapy, massage therapy, chiropractic treatment, and/or heat or cold applications. A laminectomy, surgical removal of the protruding disk, may be necessary in severe cases that do not respond to conservative treatment. If pain persists, a spinal fusion may be performed to insert a screw/rod assembly into the spine to permanently immobilize the affected vertebrae.

Spinal Curvatures

Abnormal curvatures of the spinal column include kyphosis, scoliosis, and lordosis (figure 7-23). *Kyphosis*, or "hunchback," is a rounded bowing of the back at the thoracic area. *Scoliosis* is a side-to-side, or lateral, curvature of the spine. *Lordosis*, or "swayback," is an abnormal inward curvature of the lumbar region. Poor posture, congenital (at birth) defects, structural defects of the vertebrae, malnutrition, and degeneration of the vertebrae can all be causes of these defects. Therapeutic exercises, firm mattresses, and/or braces are the main forms of treatment. Severe deformities may require surgical repair.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:4, Skeletal System.*

7:5 Muscular System

Objectives

After completing this section, you should be able to:

- Compare the three main kinds of muscle by describing the action of each
- Differentiate between voluntary muscle and involuntary muscle
- List at least three functions of muscles
- Describe the two main ways muscles attach to bones
- Demonstrate the five major movements performed by muscles
- Describe at least three diseases of the muscular system
- Define, pronounce, and spell all key terms

KEY TERMS

abduction *(ab-duck′-shun)*
adduction *(ad-duck′-shun)*
cardiac muscle
circumduction
contract *(con-trackt′)*
contractibility
contracture *(con-track′-shur)*
elasticity
excitability
extensibility
extension
fascia *(fash′-ee″-ah)*
flexion *(flek′-shun)*
insertion
involuntary
muscle tone
muscular system
origin
rotation
skeletal muscle
tendons
visceral (smooth) muscle
voluntary

RELATED HEALTH CAREERS

- Athletic Trainer
- Chiropractor
- Doctor of Osteopathic Medicine
- Massage Therapist
- Myologist
- Neurologist
- Orthopedist
- Physiatrist
- Physical Therapist
- Podiatrist
- Prosthetist
- Rheumatologist
- Sports Medicine Physician

7:5 INFORMATION

More than 600 muscles make up the system known as the **muscular system.** Muscles are bundles of muscle fibers held together by connective tissue. All muscles have certain properties or characteristics:

- **Excitability:** irritability, the ability to respond to a stimulus such as a nerve impulse
- **Contractibility:** muscle fibers that are stimulated by nerves **contract,** or become short and thick, which causes movement
- **Extensibility:** the ability to be stretched
- **Elasticity:** allows the muscle to return to its original shape after it has contracted or stretched

There are three main kinds of muscle: cardiac, visceral, and skeletal (figure 7-24). **Cardiac muscle** forms the walls of the heart and contracts to circulate blood. **Visceral,** or **smooth, muscle** is found in the internal organs of the body, such as those of the digestive and respiratory systems, and the blood vessels and eyes. Visceral muscle contracts to cause movement in these organs. Cardiac muscle and visceral muscle are **involuntary,** meaning they function without conscious thought or control. **Skeletal muscle** is attached to bones and causes body movement. Skeletal muscle is **voluntary** because a person has control over its action. Because cardiac muscle and visceral muscle are discussed in sections on other systems, the following concentrates on skeletal muscle.

Skeletal muscles perform four important functions:

- Attach to bones to provide voluntary movement
- Produce heat and energy for the body
- Help maintain posture by holding the body erect
- Protect internal organs

Skeletal muscles attach to bones in different ways. Some attach by **tendons,** which are strong, tough, fibrous connective-tissue cords. An example is the gastrocnemius muscle on the calf of the

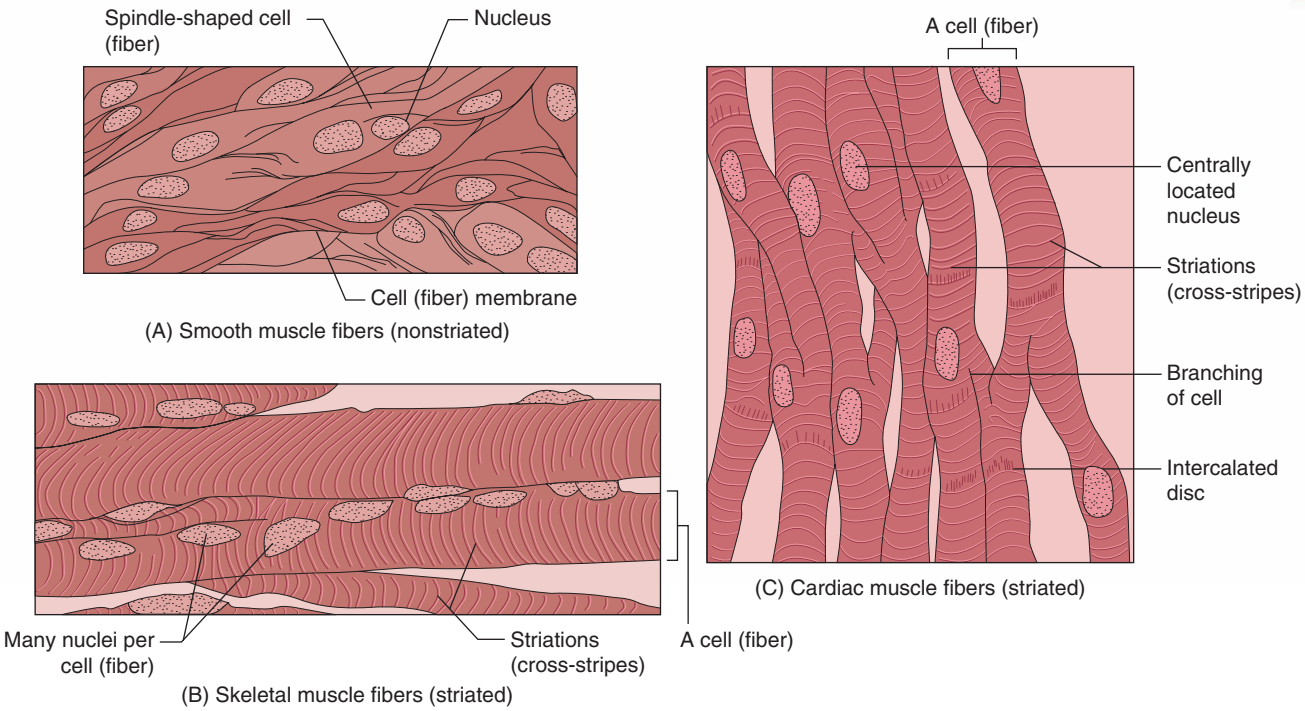


FIGURE 7-24 Three main kinds of muscle.

leg, which attaches to the heelbone by the Achilles tendon. Other muscles attach by **fascia,** a tough, sheetlike membrane that covers and protects the tissue. Examples include the deep muscles of the trunk and back, which are surrounded by the lumbodorsal fascia. When a muscle attaches to a bone, the end that does not move is called the **origin.** The end that moves when the muscle contracts is called the **insertion.** For example, the origin of the shoulder muscle, called the *deltoid,* is by the clavicle and scapula. Its insertion is on the humerus. When the deltoid contracts, the area by the scapula remains stationary, but the area by the humerus moves and abducts the arm away from the body.

A variety of different actions or movements performed by muscles are shown in figure 7-25 and are described as follows:

- **Adduction:** moving a body part toward the midline
- **Abduction:** moving a body part away from the midline
- **Flexion:** decreasing the angle between two bones, or bending a body part
- **Extension:** increasing the angle between two bones, or straightening a body part
- **Rotation:** turning a body part around its own axis; for example, turning the head from side to side
- **Circumduction:** moving in a circle at a joint, or moving one end of a body part in a circle while the other end remains stationary, such as swinging an arm in a circle

The major superficial muscles of the body are shown in figure 7-26; the locations and actions of the major muscles are noted in table 7-2.

Muscles are partially contracted at all times, even when not in use. This state of partial contraction is called **muscle tone** and is sometimes described as a state of readiness to act. Loss of muscle tone can occur in severe illness such as paralysis. When muscles are not used for a long period, they can *atrophy* (shrink in size and lose strength). Lack of use can also result in a **contracture,** a severe tightening of a flexor muscle resulting in bending of a joint. Foot drop is a common contracture, but the fingers, wrists, knees, and other joints can also be affected.

DISEASES AND ABNORMAL CONDITIONS

Fibromyalgia

Fibromyalgia is chronic, widespread pain in specific muscle sites. Other symptoms include muscle stiffness, numbness or tingling in the arms or

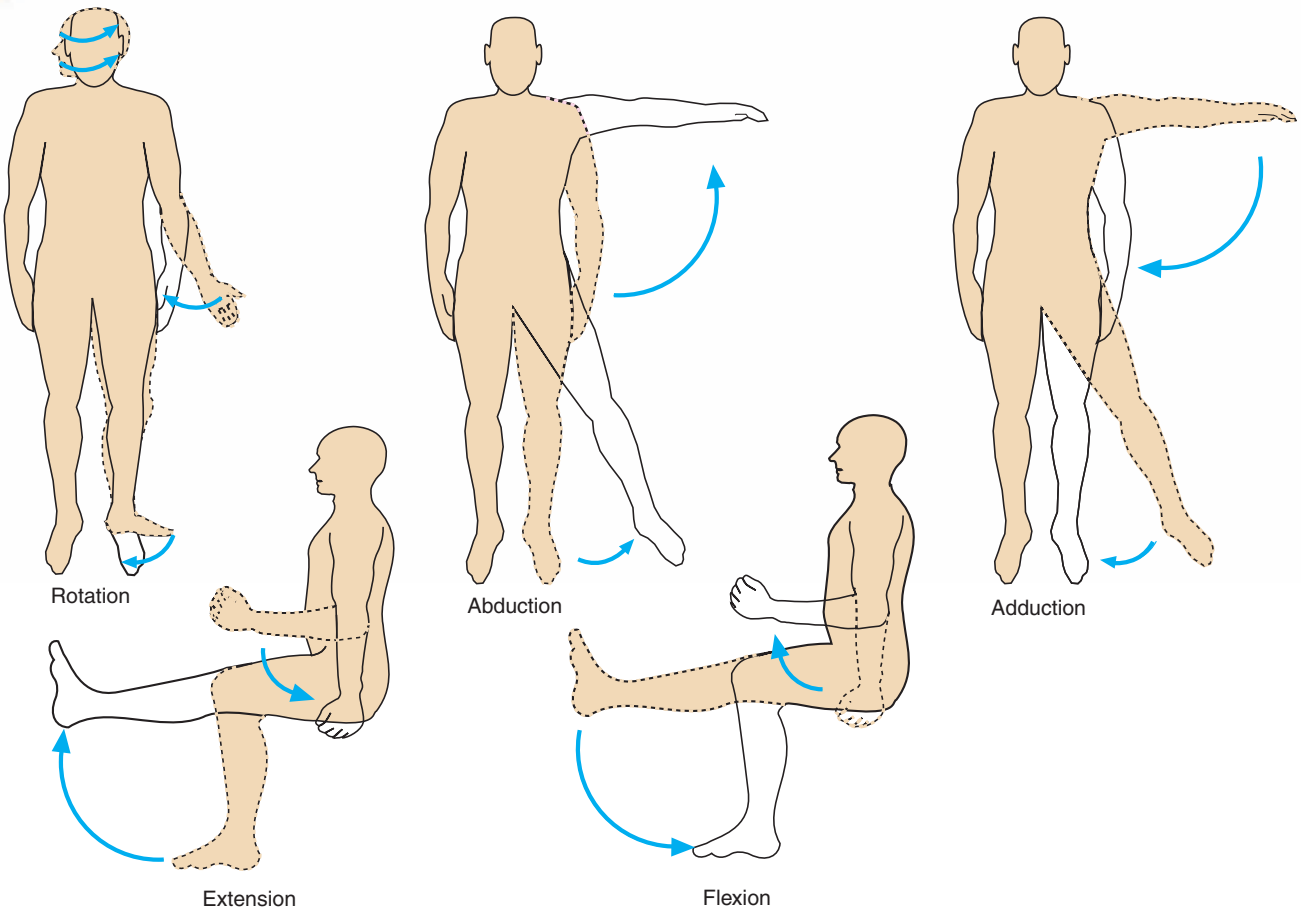


FIGURE 7-25 Types of muscle movement.

TABLE 7-2 Locations and Functions of Major Muscles of the Body

MUSCLE	LOCATION	FUNCTION
Sternocleidomastoid	Side of neck	Turns and flexes head
Trapezius	Upper back and neck	Extends head, moves shoulder
Deltoid	Shoulder	Abducts arm, injection site
Biceps brachii	Upper arm	Flexes lower arm and supinates hand
Triceps brachii	Upper arm	Extends and adducts lower arm
Pectoralis major	Upper chest	Adducts and flexes upper arm
Intercostals	Between ribs	Moves ribs for breathing
Rectus abdominus	Ribs to pubis (pelvis)	Compresses abdomen and flexes vertebral column
Latissimus dorsi	Spine around to chest	Extends and adducts upper arm
Gluteus maximus	Buttocks	Extends and rotates thigh, injection site
Sartorius	Front of thigh	Abducts thigh, flexes leg
Quadriceps femoris	Front of thigh	Extends leg, injection site
Tibialis anterior	Front of lower leg	Flexes and inverts foot
Gastrocnemius	Back of lower leg	Flexes and supinates sole of the foot

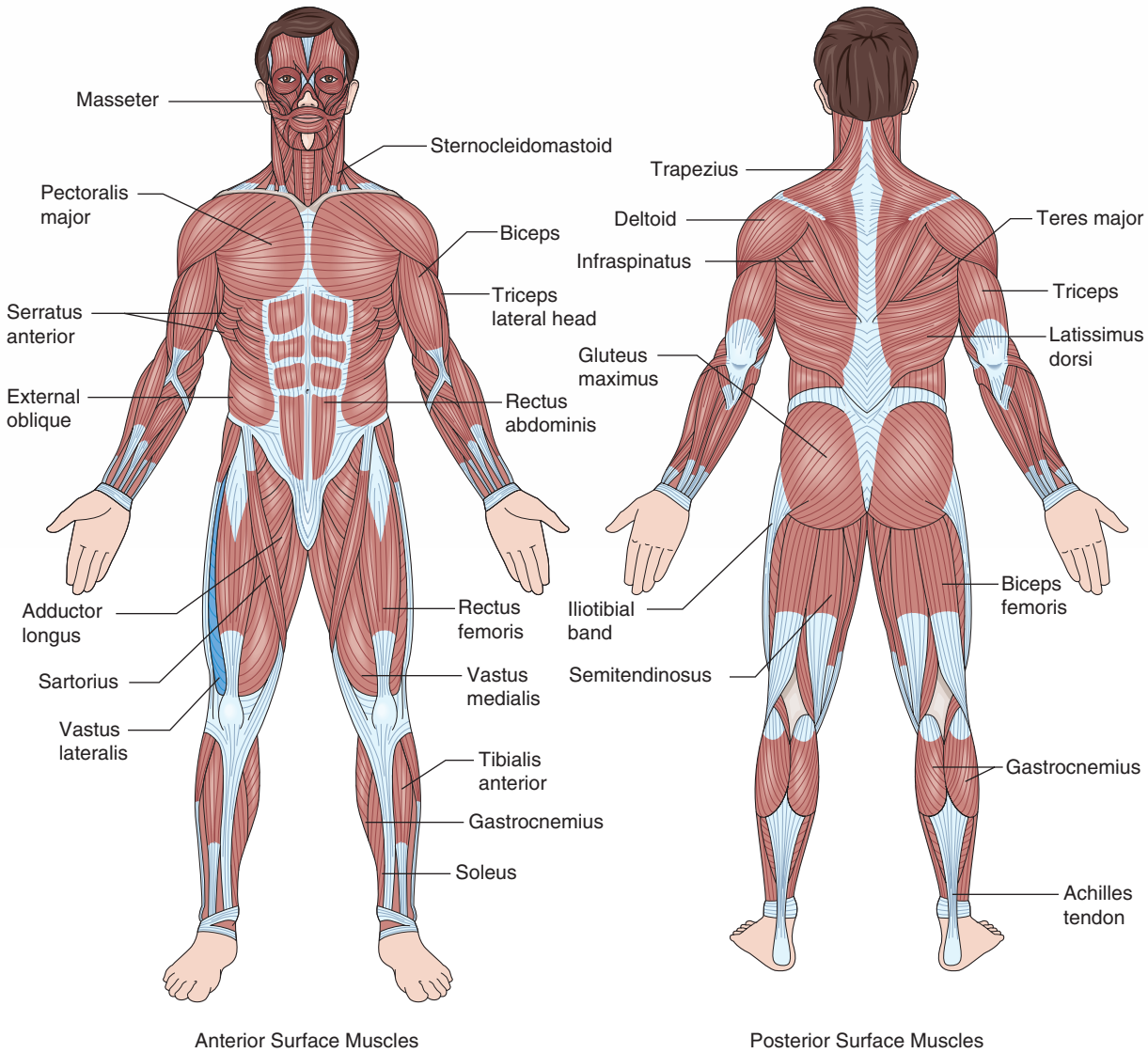


FIGURE 7-26 Main muscles of the body.

legs, fatigue, sleep disturbances, headaches, and depression. The cause is unknown, but stress, weather, and poor physical fitness affect the condition. Treatment is directed toward pain relief and includes physical therapy, massage, exercise, stress reduction, and medication to relax muscles and relieve pain.

Muscular Dystrophy

Muscular dystrophy is actually a group of inherited diseases that lead to chronic, progressive muscle atrophy. Muscular dystrophy usually appears in early childhood; most types result in total disability and early death. The most common type is Duchenne muscular dystrophy, which is caused by a genetic defect. At birth, the infant is healthy. As muscle cells die, the child loses the ability to move. The onset usually occurs between 2 and 5 years of age. By age 9 to 12, the child is confined to a wheelchair. Eventually, the muscle weakness affects the heart and diaphragm, resulting in respiratory and/or cardiac failure that causes death. The life expectancy is usually from the late teens to the early twenties. Although there is no cure, physical therapy is used to slow the progress of the disease.

Myasthenia Gravis

Myasthenia gravis is a chronic condition where nerve impulses are not properly transmitted to the muscles. This leads to progressive muscular weakness and paralysis. If the condition affects the respiratory muscles, it can be fatal. Although the cause is unknown, myasthenia gravis is

thought to be an autoimmune disease, with antibodies attacking the body's own tissues. There is no cure, and treatment is supportive.

Muscle Spasms

Muscle spasms, or cramps, are sudden, painful, involuntary muscle contractions. They usually occur in the legs or feet and may result from overexertion, low electrolyte levels, or poor circulation. Gentle pressure and stretching of the muscle are used to relieve the spasm.

Strain

A strain is an overstretching of or injury to a muscle and/or tendon. Frequent sites include the back, arms, and legs. Prolonged or sudden muscle exertion is usually the cause. Symptoms include myalgia (muscle pain), swelling, and limited movement. Treatment methods include rest, muscle relaxants or pain medications, elevating the extremity, and alternating hot and cold applications.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:5, Muscular System.*

7:6 Nervous System

Objectives

After completing this section, you should be able to:

- Identify the four main parts of a neuron
- Name the two main divisions of the nervous system
- Describe the function of each of the five main parts of the brain
- Explain three functions of the spinal cord
- Name the three meninges
- Describe the circulation and function of cerebrospinal fluid
- Contrast the actions of the sympathetic and parasympathetic nervous systems
- Describe at least five diseases of the nervous system
- Define, pronounce, and spell all key terms

KEY TERMS

autonomic nervous system
brain
central nervous system (CNS)
cerebellum *(seh″-reh-bell′-um)*
cerebrospinal fluid *(seh-ree″-broh-spy′-nal fluid)*
cerebrum *(seh-ree′-brum)*
diencephalon
hypothalamus
medulla oblongata *(meh-due′-la ob-lawn-got′-ah)*
meninges (singular: meninx) *(meh-nin′-jeez)*
midbrain
nerves
nervous system
neuron *(nur′-on)*
parasympathetic *(par″-ah-sim″-pah-thet′-ik)*
peripheral nervous system (PNS) *(peh-rif′-eh-ral)*
pons *(ponz)*
somatic nervous system
spinal cord
sympathetic
thalamus
ventricles

RELATED HEALTH CAREERS

- Acupressurist
- Acupuncturist
- Anesthesiologist
- Chiropractor
- Diagnostic Imager
- Doctor of Osteopathic Medicine
- Electroencephalographic Technologist
- Electroneurodiagnostic Technologist
- Mental Health Technician
- Neurologist
- Neurosurgeon
- Physical Therapist
- Polysomnographic Technologist
- Psychiatrist
- Psychologist

7:6 INFORMATION

The **nervous system** is a complex, highly organized system that coordinates all the activities of the body. This system enables the body to respond and adapt to changes that occur both inside and outside the body.

The basic structural unit of the nervous system is the **neuron,** or nerve cell (figure 7-27). It consists of a cell body containing a nucleus; nerve fibers, called *dendrites* (which carry impulses toward the cell body); and a single nerve fiber, called an *axon* (which carries impulses away from the cell body). Many axons have a lipid (fat) covering called a *myelin sheath,* which increases the rate of impulse transmission and insulates and maintains the axon. The axon of one neuron lies close to the dendrites of many other neurons. The spaces between them are known as *synapses.* Impulses coming from one axon "jump" the synapse to get to the dendrite of another neuron, which will carry the impulse in the right direction. Special chemicals, called *neurotransmitters,* located at the end of each axon, allow the nerve impulses to pass from one neuron to another. In this way, impulses can follow many different routes.

Nerves are a combination of many nerve fibers located outside the brain and spinal cord. *Afferent,* or sensory, nerves carry messages from all parts of the body to the brain and spinal cord. *Efferent,* or motor, nerves carry messages from the brain and spinal cord to the muscles and glands. *Associative,* or *internuncial,* nerves carry both sensory and motor messages.

There are two main divisions to the nervous system: the central nervous system and the peripheral nervous system (figure 7-28). The

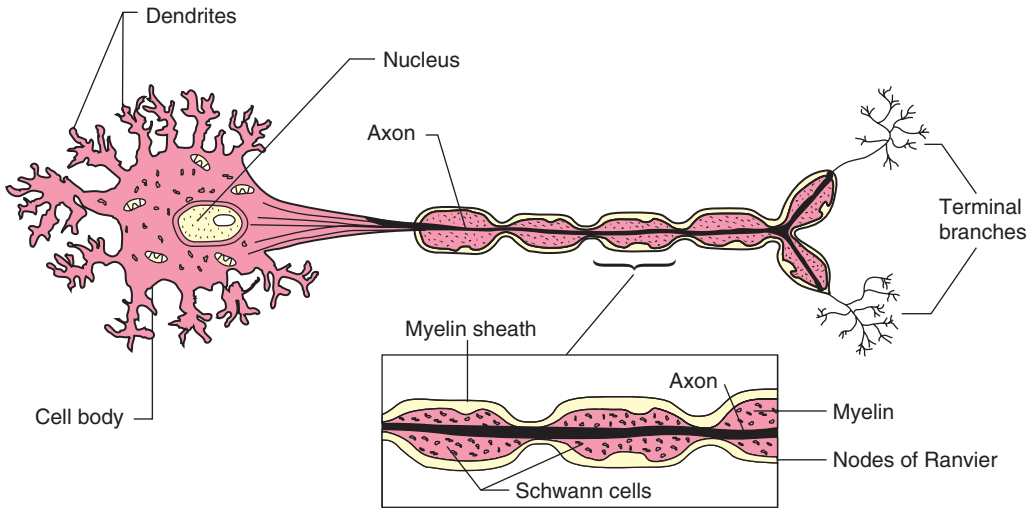


FIGURE 7-27 A neuron, the basic structural unit of the nervous system.

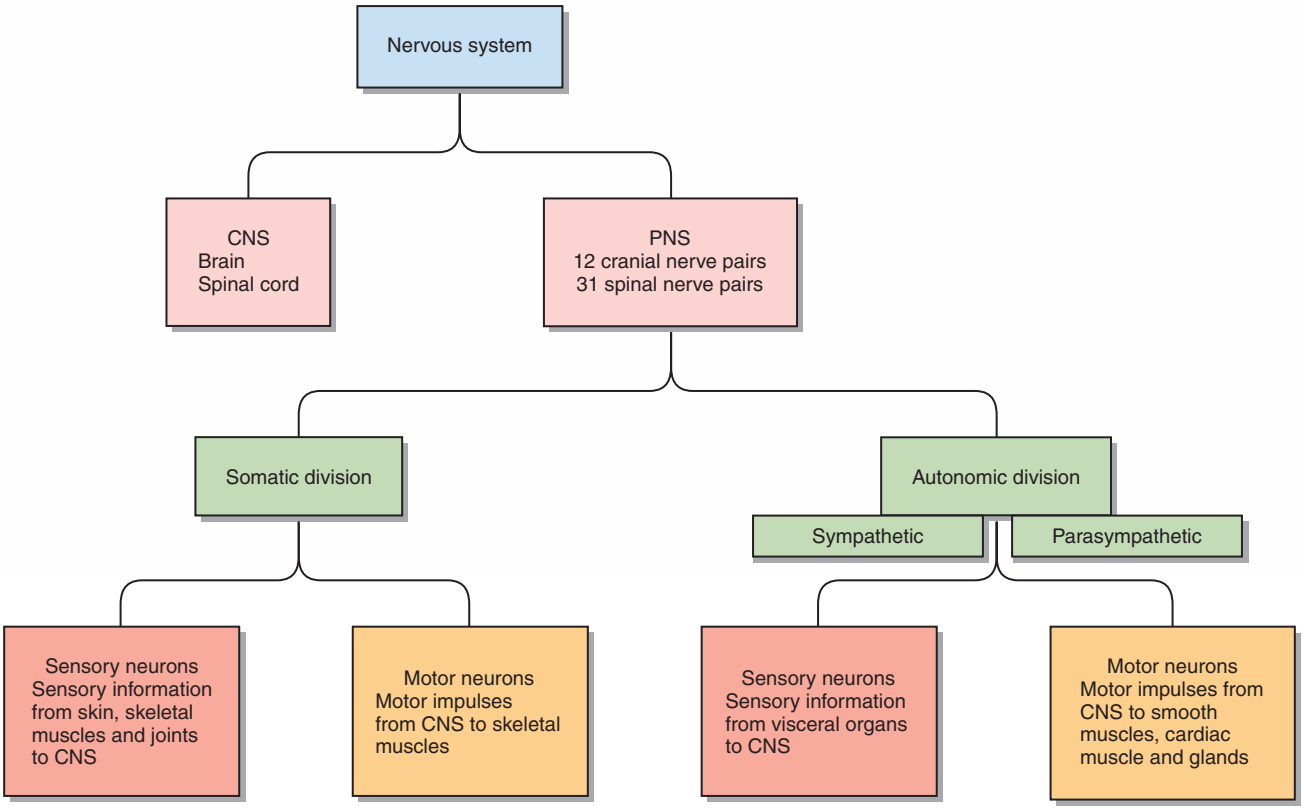


FIGURE 7-28 Divisions of the nervous system.

central nervous system (CNS) consists of the brain and spinal cord. The **peripheral nervous system (PNS)** consists of the nerves and has two divisions: the somatic nervous system and the autonomic nervous system. The **somatic nervous system** carries messages between the CNS and the body. The **autonomic nervous system** contains the sympathetic and parasympathetic nervous systems, which work together to control involuntary body functions.

CENTRAL NERVOUS SYSTEM

The **brain** is a mass of nerve tissue well protected by membranes and the cranium, or skull (figure 7-29). The main sections include:

- **Cerebrum:** the largest and highest section of the brain. The outer part is arranged in folds, called *convolutions,* and separated into lobes. The lobes include the frontal, parietal, temporal, and occipital, named from the skull bones that surround them (figure 7-30). The cerebrum is responsible for reasoning, thought, memory, judgment, speech, sensation, sight, smell, hearing, and voluntary body movement.
- **Cerebellum:** the section below the back of the cerebrum. It is responsible for muscle coordination, balance, posture, and muscle tone.
- **Diencephalon:** the section located between the cerebrum and midbrain. It contains two structures: the thalamus and hypothalamus. The **thalamus** acts as a relay center and directs sensory impulses to the cerebrum. It also allows conscious recognition of pain and temperature. The **hypothalamus** regulates and controls the autonomic nervous system, temperature, appetite, water balance, sleep, and blood vessel constriction and dilation. The hypothalamus is also involved in emotions such as anger, fear, pleasure, pain, and affection.
- **Midbrain:** the section located below the cerebrum at the top of the brainstem. It is responsible for conducting impulses between

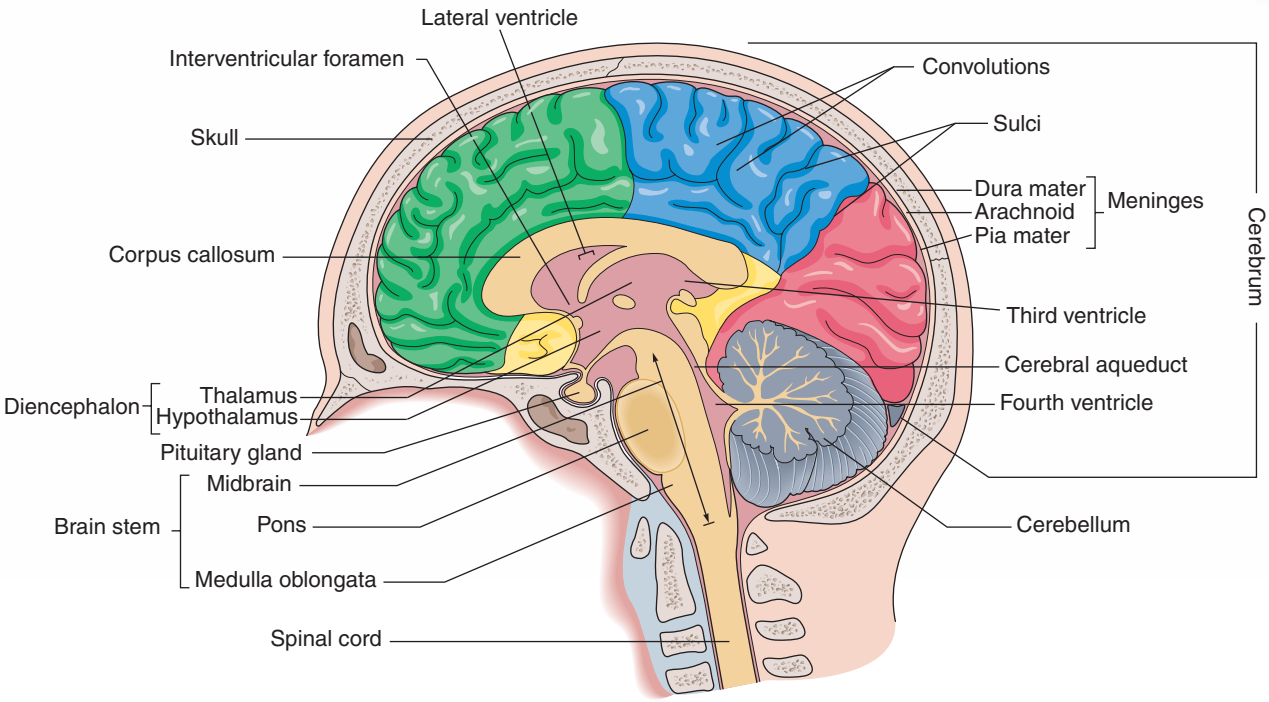


FIGURE 7-29 The brain and spinal cord.

brain parts and for certain eye and auditory reflexes.

- **Pons:** the section located below the midbrain and in the brainstem. It is responsible for conducting messages to other parts of the brain; for certain reflex actions including chewing, tasting, and saliva production; and for assisting with respiration.
- **Medulla oblongata:** the lowest part of the brainstem. It connects with the spinal cord and is responsible for regulating heartbeat, respiration, swallowing, coughing, and blood pressure.

The **spinal cord** continues down from the medulla oblongata and ends at the first or second lumbar vertebrae (figure 7-31). It is surrounded and protected by the vertebrae. The spinal cord is responsible for many reflex actions and for carrying sensory (afferent) messages up to the brain and motor (efferent) messages from the brain to the nerves that go to the muscles and glands.

The **meninges** are three membranes that cover and protect the brain and spinal cord. The *dura mater* is the thick, tough, outer layer. The middle layer is delicate and weblike, and is called the *arachnoid membrane.* It is loosely attached to the other meninges to allow space for fluid to flow between the layers. The innermost layer, the *pia mater,* is closely attached to the brain and spinal cord, and contains blood vessels that nourish the nerve tissue.

The brain has four **ventricles,** hollow spaces that connect with each other and with the space under the arachnoid membrane (the subarachnoid space). The ventricles are filled with a clear, colorless fluid called **cerebrospinal fluid.** This fluid circulates continually between the ventricles and through the subarachnoid space. It serves as a shock absorber to protect the brain and spinal cord. It also carries nutrients to some parts of the brain and spinal cord and helps remove metabolic products and wastes. The fluid is produced in the ventricles of the brain by the special structures called *choroid plexuses.* After circulating, it is absorbed into the blood vessels of the dura mater and returned to the bloodstream through special structures called *arachnoid villi.*

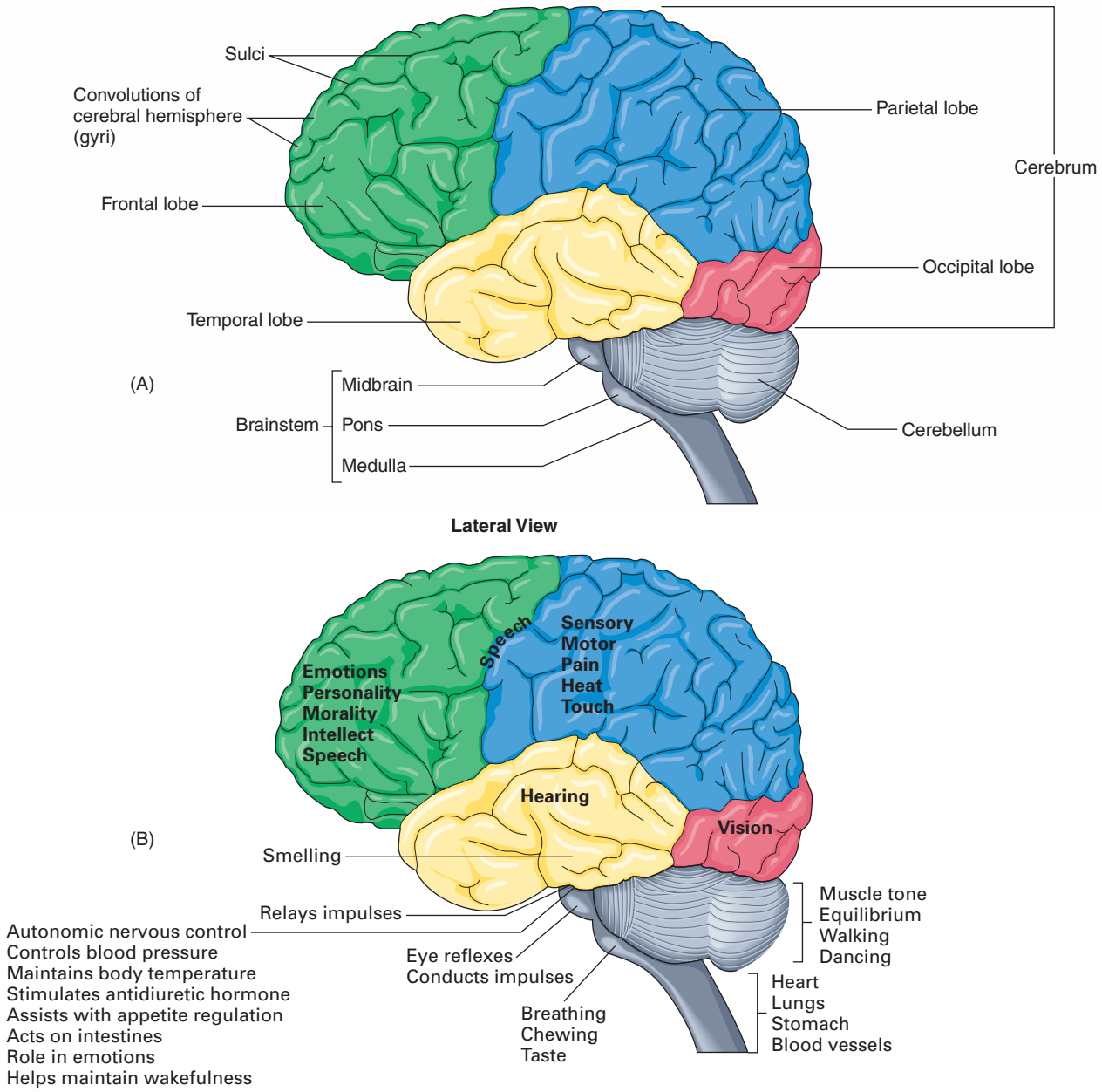


FIGURE 7-30 Each lobe of the brain is responsible for different functions.

PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system consists of the somatic and the autonomic nervous systems.

Somatic Nervous System

The somatic nervous system consists of 12 pairs of cranial nerves and their branches, and 31 pairs of spinal nerves and their branches. Some of the cranial nerves are responsible for special senses such as sight, hearing, taste, and smell. Others receive general sensations such as touch, pressure, pain, and temperature, and send out impulses for involuntary and voluntary muscle control. The spinal nerves carry messages to and from the spinal cord and are mixed nerves, both sensory (afferent) and motor (efferent). There are 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 pair of coccygeal spinal nerves. Each nerve goes

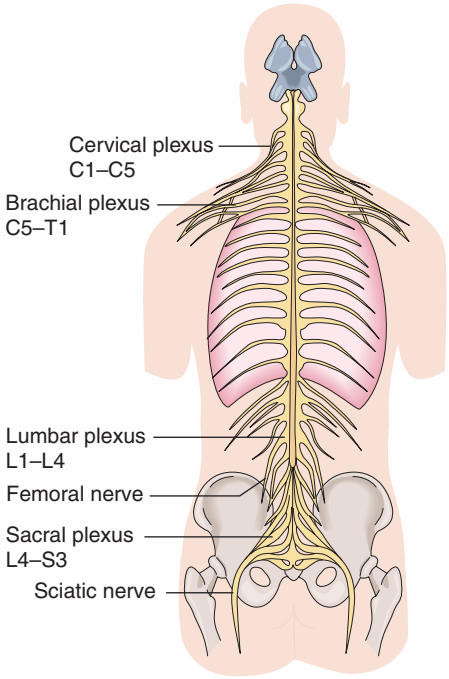


FIGURE 7-31 The spinal cord and nerves.

directly to a particular part of the body or networks with other spinal nerves to form a plexus that supplies sensation to a larger segment of the body.

Autonomic Nervous System

The autonomic nervous system is an important part of the peripheral nervous system. It helps maintain a balance in the involuntary functions of the body and allows the body to react in times of emergency. There are two divisions to the autonomic nervous system: the **sympathetic** and **parasympathetic** nervous systems. These two systems usually work together to maintain a balanced state, or *homeostasis,* in the body and to control involuntary body functions at proper rates. In times of emergency, the sympathetic nervous system prepares the body to act by increasing heart rate, respiration, and blood pressure, and slowing activity in the digestive tract. This is known as the *fight or flight response.* After the emergency, the parasympathetic nervous system counteracts the actions of the sympathetic system by slowing heart rate, decreasing respiration, lowering blood pressure, and increasing activity in the digestive tract.

DISEASES AND ABNORMAL CONDITIONSS

Amyotrophic Lateral Sclerosis

Amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig's disease, is a chronic, degenerative neuromuscular disease. The cause is unknown, but genetic or viral-immune factors are suspected. Nerve cells in the CNS that control voluntary movement degenerate, resulting in a weakening and atrophy (wasting away) of the muscles they control. Initial symptoms include muscle weakness, abnormal reflexes, tripping and falling, impaired hand and arm movement, and difficulty in speaking or swallowing. As the disease progresses, more muscles are affected, resulting in total body paralysis. In the later stages, the patient loses all ability to communicate, breathe, eat, and move. Mental acuity is unaffected, so an active mind is trapped inside a paralyzed body. No treatment exists, but drugs such as Riluzole may slow the progress of the disease. ALS is usually fatal within 4 to 6 years of symptom onset, but some patients with slower rates of progression have survived 10–20 years after the onset of the disease.

Carpal Tunnel Syndrome

Carpal tunnel syndrome is a condition that occurs when the medial nerve and tendons that pass through a canal or "tunnel" on their way from the forearm to the hands and fingers are pinched. Repetitive movement of the wrist causes swelling around this tunnel, which puts pressure on the nerves and tendons. Symptoms include pain, muscle weakness in the hand, and impaired movement. A classic symptom is pain, numbness, and tingling in the thumb, ring finger, and middle finger. Initially, carpal tunnel is treated with anti-inflammatory medications, analgesics for pain, and splinting to immobilize the joint. Severe cases that do not respond to this treatment may require surgery to enlarge the "tunnel" and relieve the pressure on the nerves and tendons.

Cerebral Palsy

Cerebral palsy is a disturbance in voluntary muscle action and is caused by brain damage. Lack of oxygen to the brain, birth injuries, prenatal rubella (German measles), and infections can all cause cerebral palsy. Of the three forms—spastic, athetoid, and atactic—spastic is the most common. Symptoms include exaggerated reflexes, tense muscles, contracture development, seizures, speech impairment, spasms, tremors, and in some cases, mental retardation. Although there is no cure, physical, occupational, and speech therapy are important aspects of treatment. Muscle relaxants, anticonvulsive drugs, casts, braces, and/or orthopedic surgery (for severe contractures) are also used.

Cerebrovascular Accident

A cerebrovascular accident (CVA), also called a *brain attack, stroke,* or *apoplexy,* occurs when the blood flow to the brain is impaired, resulting in a lack of oxygen and a destruction of brain tissue. It can be caused by cerebral hemorrhage resulting from hypertension, an aneurysm, or a weak blood vessel; or by an occlusion, or blockage, caused by atherosclerosis or a thrombus (blood clot). Factors that increase the risk for a CVA include smoking, a high-fat diet, obesity, and a sedentary lifestyle. Symptoms vary depending on the area and amount of brain tissue damaged. Some common symptoms of an acute CVA include loss of consciousness, weakness or paralysis on one side of the body (hemiplegia), dizziness, dysphagia (difficult swallowing), visual disturbances, mental confusion, aphasia (speech and language impairment), and incontinence. When a CVA occurs, immediate care during the first 3 hours can help prevent brain damage. Treatment with thrombolytic or "clot-busting" drugs such as TPA (tissue plasminogen activator) or angioplasty of the cerebral arteries can dissolve a blood clot and restore blood flow to the brain. Computerized tomography (CT) scans (noninvasive computerized X-rays that show cross-sectional views of body tissue) are used to determine the cause of the CVA. Clot-busting drugs cannot be used if the CVA is caused by a hemorrhage. Neuroprotective agents, or drugs that help prevent injury to neurons, are also used initially to prevent permanent brain damage. Additional treatment depends on symptoms and is directed toward helping the person recover from or adapt to the symptoms that are present. Physical, occupational, and speech therapy are the main forms of treatment.

Encephalitis

Encephalitis is an inflammation of the brain and is caused by a virus, bacterium, chemical agent, or as a complication of measles, chicken pox, or mumps. The virus is frequently contracted from a mosquito bite because mosquitos can carry the encephalitis virus. Symptoms vary but may include fever, extreme weakness or lethargy, visual disturbances, headaches, vomiting, stiff neck and back, disorientation, seizures, and coma. Treatment methods are supportive and include antiviral drugs, maintenance of fluid and electrolyte balance, antiseizure medication, and monitoring of respiratory and kidney function.

Epilepsy

Epilepsy, or seizure syndrome, is a brain disorder associated with abnormal electrical impulses in the neurons of the brain. Although causes can include brain injury, birth trauma, tumors, toxins such as lead or carbon monoxide, and infections, many cases of epilepsy are idiopathic (spontaneous, or primary). Absence, or petit mal, seizures are milder and are characterized by a loss of consciousness lasting several seconds. They are common in children and frequently disappear by late adolescence. Generalized tonic-clonic, or grand mal, are the most severe seizures. They are characterized by a loss of consciousness lasting several minutes; convulsions accompanied by violent shaking and thrashing movements; hypersalivation, causing foaming at the mouth; and loss of body functions. Some individuals experience an *aura*, such as a particular smell, ringing in the ears, visual disturbances, or tingling in the fingers and/or toes just before a seizure occurs. Anticonvulsant drugs are effective in controlling epilepsy.

Hydrocephalus

Hydrocephalus is an excessive accumulation of cerebrospinal fluid in the ventricles and, in some cases, the subarachnoid space of the brain. It is usually caused by a congenital (at birth) defect, infection, or tumor that obstructs the flow of cerebrospinal fluid out of the brain. Symptoms

include an abnormally enlarged head, prominent forehead, bulging eyes, irritability, distended scalp veins, and when pressure prevents proper development of the brain, retardation. The condition is treated by the surgical implantation of a shunt (tube) between the ventricles and the veins, heart, or abdominal peritoneal cavity to provide for drainage of the excess fluid.

Meningitis

Meningitis is an inflammation of the meninges of the brain and/or spinal cord and is caused by a bacterium, virus, fungus, or toxin such as lead or arsenic. Symptoms include high fever, headaches, back and neck pain and stiffness, nausea and vomiting, delirium, convulsions, and if untreated, coma and death. Treatment methods include antibiotics, antipyretics (for fever), anticonvulsants, and/or medications for pain and cerebral edema.

Multiple Sclerosis

Multiple sclerosis (MS) is a chronic, progressive, disabling condition resulting from a degeneration of the myelin sheath in the CNS. It usually occurs between the ages of 20 and 40 (figure 7-32). The cause is unknown but genetics or a viral infection of the immune system are suspected. The disease progresses at different rates and has periods of remission. Early symptoms include visual disturbances such as diplopia (double vision), weakness, fatigue, poor coordination, and tingling and numbness. As the disease progresses, tremors, muscle spasticity, paralysis, speech impairment, emotional swings, and incontinence occur. There is no cure. Treatment methods such as physical therapy, muscle relaxants, steroids, and psychological counseling are used to maintain functional ability as long as possible.

FIGURE 7-32 Multiple sclerosis usually occurs between the ages of 20 and 40.

Neuralgia

Neuralgia is nerve pain. It is caused by inflammation, pressure, toxins, and other disease. Treatment is directed toward eliminating the cause of the pain.

Paralysis

Paralysis usually results from a brain or spinal cord injury that destroys neurons and results in a loss of function and sensation below the level of injury. *Hemiplegia* is paralysis on one side of the body and is caused by a tumor, injury, or CVA. *Paraplegia* is paralysis in the lower extremities or lower part of the body and is caused by a spinal cord injury. *Quadriplegia* is paralysis of the arms, legs, and body below the spinal cord injury. Currently, no cure exists, although much research is being directed toward repairing spinal cord damage. Treatment methods are supportive and include physical and occupational therapy.

Parkinson's Disease

Parkinson's disease is a chronic, progressive condition involving degeneration of brain cells, usually in persons over 50 years of age. Symptoms include tremors, stiffness, muscular rigidity, a forward leaning position, a shuffling gait, difficulty in stopping while walking, loss of facial expression, drooling, mood swings and frequent depression, and behavioral changes. Although no cure exists, a drug called levodopa is used to relieve the symptoms. In some cases, surgery can be performed to destroy selectively a small area of the brain and control involuntary movements. Physical therapy is also used to limit muscular rigidity.

Shingles

Shingles, or herpes zoster, is an acute inflammation of nerve cells and is caused by the herpes virus, which also causes chicken pox. It charac-

teristically occurs in the thoracic area on one side of the body and follows the path of the affected nerves (figure 7-33). Fluid-filled vesicles appear on the skin, accompanied by severe pain, redness, itching, fever, and abnormal skin sensations. Treatment is directed toward relieving pain and itching until the inflammation subsides, usually in 1–4 weeks.

FIGURE 7-33 The vesicles of shingles follow the path of the affected nerves.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:6, Nervous System.*

7:7 Special Senses

Objectives

After completing this section, you should be able to:

- Identify five special senses
- Label the major parts on a diagram of the eye
- Trace the pathway of light rays as they pass through the eye
- Label the major parts on a diagram of the ear
- Trace the pathway of sound waves as they pass through the ear
- Explain how the ear helps maintain balance and equilibrium
- State the locations of the four main taste receptors
- List at least four general senses located throughout the body
- Describe at least six diseases of the eye and ear
- Define, pronounce, and spell all key terms

KEY TERMS

aqueous humor *(a′-kwee″-us hue-more)*
auditory canal
auricle *(or′-eh-kul″)*
choroid coat *(koh′-royd)*
cochlea *(co′-klee-ah)*
conjunctiva *(kon-junk″-tye′-vah)*
cornea
eustachian tube *(you-stay′-she-en)*
iris
lacrimal glands *(lack′-rih″-mal)*
lens
organ of Corti
ossicles *(os′-ick-uls)*
pinna *(pin′-nah)*
pupil
refracts
retina *(ret′-in-ah)*
sclera *(sklee′-rah)*
semicircular canals
tympanic membrane *(tim-pan′-ik)*
vestibule *(ves′-tih-bewl)*
vitreous humor *(vit′-ree-us hue′-more)*

RELATED HEALTH CAREERS

- Allergist
- Audiologist
- Eye, Ear, Nose, and Throat Specialist
- Ophthalmic Assistant
- Ophthalmic Laboratory Technician
- Ophthalmic Medical Technologist
- Ophthalmic Technician
- Ophthalmologist
- Optician
- Optometrist
- Otolaryngologist
- Otologist

7:7 INFORMATION

Special senses allow the human body to react to the environment by providing for sight, hearing, taste, smell, and balance maintenance. These senses are possible because the body has structures that receive sensations, nerves that carry sensory messages to the brain, and a brain that interprets and responds to sensory messages.

THE EYE

The eye is the organ that controls the special sense of sight. It receives light rays and transmits impulses from the rays to the optic nerve, which carries the impulses to the brain, where they are interpreted as vision, or sight.

The eye (figure 7-34A) is well protected. It is partially enclosed in a bony socket of the skull. Eyelids and eyelashes help keep out dirt and pathogens. **Lacrimal glands** in the eye produce tears, which constantly moisten and cleanse the eye. The tears flow across the eye and drain through the nasolacrimal duct into the nasal cavity. A mucous membrane, called the **conjunctiva,** lines the eyelids and covers the front of the eye to provide additional protection and lubrication.

There are three main layers to the eye (figure 7-34B). The outermost layer is the tough connective tissue called the **sclera.** It is frequently referred to as the "white" of the eye. The sclera maintains the shape of the eye. Extrinsic muscles, responsible for moving the eye within the socket, are attached to the outside of the sclera. The **cor-**

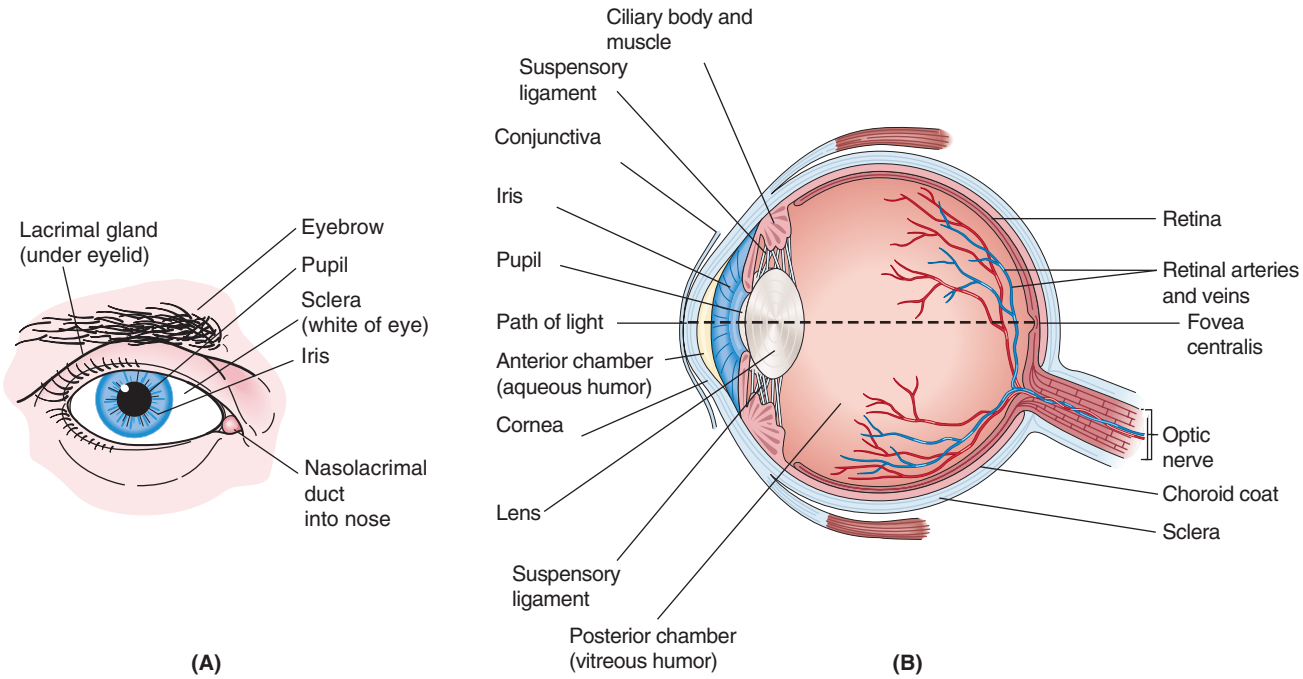


FIGURE 7-34 (A) External view of the eye; (B) structures of the eye.

nea is a circular, transparent part of the front of the sclera. It allows light rays to enter the eye. The middle layer of the eye, the **choroid coat,** is interlaced with many blood vessels that nourish the eyes. The innermost layer of the eye is the **retina.** It is made of many layers of nerve cells, which transmit the light impulses to the optic nerve. Two such special cells are *cones* and *rods.* Cones are sensitive to color and are used mainly for vision when it is light. Most of the cones are located in a depression located on the back surface of the retina called the *fovea centralis*; this is the area of sharpest vision. Rods are used for vision when it is dark or dim.

The **iris** is the colored portion of the eye. It is located behind the cornea on the front of the choroid coat. The opening in the center of the iris is called the **pupil.** The iris contains two muscles, which control the size of the pupil and regulate the amount of light entering the eye.

Other special structures are also located in the eye. The **lens** is a circular structure located behind the pupil and suspended in position by ligaments. It **refracts** (bends) light rays so the rays focus on the retina. The **aqueous humor** is a clear, watery fluid that fills the space between the cornea and iris. It helps maintain the forward curvature of the eyeball and refracts light rays. The **vitreous humor** is the jellylike substance that fills the area behind the lens. It helps maintain the shape of the eyeball and also refracts light rays. A series of muscles located in the eye provide for eye movement.

When light rays enter the eye, they pass through a series of parts that refract the rays so that the rays focus on the retina. These parts are the cornea, the aqueous humor, the pupil, the lens, and the vitreous humor. In the retina, the light rays (image) are picked up by the rods and cones, changed into nerve impulses, and transmitted by the optic nerve to the occipital lobe of the cerebrum, where sight is interpreted. If the rays are not refracted correctly by the various parts, vision can be distorted or blurred (figure 7-35).

Diseases and Abnormal Conditions

Amblyopia

Amblyopia, or lazy eye, commonly occurs in early childhood. It results in poor vision in one eye and is caused by the dominance of the other eye. Treatment methods include covering the good eye to stimulate development of the "lazy" eye, exercises to strengthen the weak eye, corrective lenses, and/or surgery. If the condition is not treated before 8 to 9 years of age, blindness of the affected eye may occur.

Astigmatism

Astigmatism is an abnormal shape or curvature of the cornea that causes blurred vision. Light rays focus on multiple areas of the retina (figure 7-35). Corrective lenses (glasses or contact lenses) correct the condition.

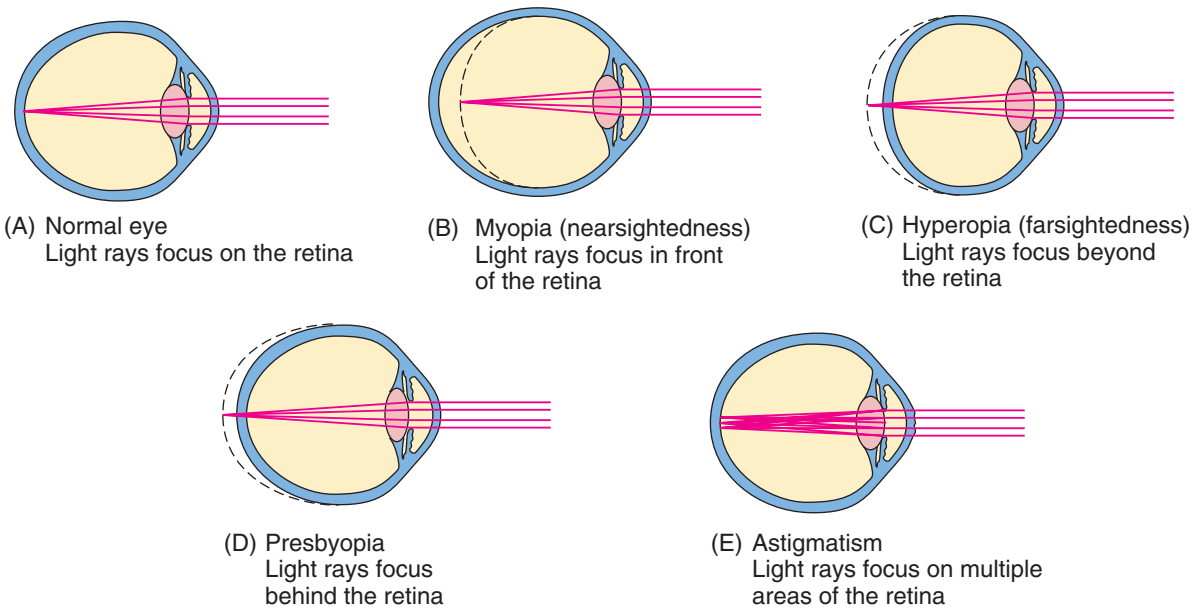


FIGURE 7-35 Improper refraction of light rays causes impaired vision.

Cataract
A cataract occurs when the normally clear lens becomes cloudy or opaque (figure 7-36). This occurs gradually, usually as a result of aging, but may be the result of trauma. Symptoms include blurred vision, halos around lights, gradual vision loss, and in later stages, a milky white pupil. Sight is restored by the surgical removal of the lens. An implanted intraocular lens or prescription glasses or contact lenses correct the vision and compensate for the removed lens.

Conjunctivitis
Conjunctivitis, or pink eye, is a contagious inflammation of the conjunctiva and is usually caused by a bacterium or virus. Symptoms include redness, swelling, pain, and, at times, pus formation in the eye. Antibiotics, frequently in the form of an eye ointment, are used to treat conjunctivitis.

Glaucoma
Glaucoma is a condition of increased intraocular (within the eye) pressure caused by an excess amount of aqueous humor. It is common after age 40 and is a leading cause of blindness. A tonometer (instrument that measures intraocular pressure) is usually used during regular eye examinations to check for this condition. Symptoms include loss of peripheral (side) vision, halos around lights, limited night vision, and mild aching. Glaucoma is usually controlled with medications that decrease the amount of fluid produced or improve the drainage. In some cases, surgery is performed to create an opening for the flow of the aqueous humor.

Hyperopia
Hyperopia is farsightedness. It occurs when the light rays are not refracted sharply enough and the image focuses behind the retina (figure 7-35). Vision is corrected by the use of convex lenses.

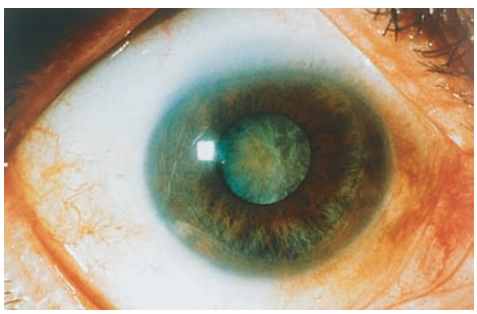


FIGURE 7-36 A cataract occurs when the lens of the eye becomes cloudy or opaque. *(Courtesy of National Eye Institute, NEH)*

Macular Degeneration
Macular degeneration, a major cause of vision loss and blindness, is a disease of the macula, the central and most sensitive section of the retina. It is an age-related disorder caused by damage to the blood vessels that nourish the retina. The most common type is dry macular degeneration that occurs as fatty deposits decrease the blood supply to the retina, resulting in a gradual thinning of the retina. It progresses slowly and results in blurred distorted vision with an absence of central vision. Peripheral (side) vision is usually not affected. No treatment currently exists, but optical aids such as special lighting or magnifiers may improve vision slightly. Wet macular degeneration is caused by an abnormal growth of blood vessels that leak blood and fluids that damage the retina. Laser treatment to coagulate or seal the leaking blood vessels can preserve sight. New research directed toward creation of an artificial retina or bionic eye may allow individuals with this disease to regain the ability to see light and large objects in the future.

Myopia
Myopia is nearsightedness. It occurs when the light rays are refracted too sharply and the image focuses in front of the retina (figure 7-35). Vision is corrected by the use of concave lenses. A newer method of treatment is a surgical procedure called *radial keratotomy* (RK). Small incisions are made in the cornea to flatten it so it can refract light rays correctly. In some cases, a laser is used to flatten the cornea without cutting. RK can correct myopia and eliminate the need for corrective lenses.

Presbyopia
Presbyopia is farsightedness caused by a loss of lens elasticity. Light rays focus behind the retina (figure 7-35). It results from the normal aging process and is treated by the use of corrective lenses or "reading" glasses.

Strabismus
Strabismus is a disorder in which the eyes do not move or focus together. The eyes may move inward (cross-eyed) or outward, or up or down. It is caused by muscle weakness in one or both eyes. Treatment methods include eye exercises, covering the good eye, corrective lenses, and/or surgery on the muscles that move the eye.

THE EAR

The ear is the organ that controls the special senses of hearing and balance. It transmits impulses from sound waves to the auditory nerve (vestibulocochlear), which carries the impulses to the brain for interpretation as hearing. The ear is divided into three main sections: the outer ear, the middle ear, and the inner ear (figure 7-37).

The outer ear contains the visible part of the ear, called the **pinna,** or **auricle.** The pinna is elastic cartilage covered by skin. It leads to a canal, or tube, called the *external auditory meatus,* or **auditory canal.** Special glands in this canal produce *cerumen,* a wax that protects the ear. Sound waves travel through the auditory canal until they reach the eardrum, or **tympanic membrane.** The tympanic membrane separates the outer ear from the middle ear. It vibrates when sound waves hit it and transmits the sound waves to the middle ear.

The middle ear is a small space, or cavity, in the temporal bone. It contains three small bones **(ossicles):** the malleus, the incus, and the stapes. The bones are connected and transmit sound waves from the tympanic membrane to the inner ear. The middle ear is connected to the pharynx, or throat, by a tube called the **eustachian tube.** This tube allows air to enter the middle ear and helps equalize air pressure on both sides of the tympanic membrane.

The inner ear is the most complex portion of the ear. It is separated from the middle ear by a membrane called the *oval window.* The first section is the **vestibule,** which acts as the entrance to the two other parts of the inner ear. The **cochlea,** shaped like a snail's shell, contains delicate, hairlike cells, which compose the **organ of Corti,** a receptor of sound waves. The organ of Corti transmits the impulses from sound waves to the auditory nerve. This nerve carries the impulses to the temporal lobe of the cerebrum, where they are interpreted as hearing. **Semicircular canals** are also located in the inner ear. These canals contain a liquid and delicate, hairlike cells that bend when the liquid moves with head and body movements. Impulses sent from the semicircular canals to the cerebellum of the brain help to maintain our sense of balance and equilibrium.

Diseases and Abnormal Conditions

Hearing Loss

Hearing loss is classified as either conductive or sensory. Conductive hearing loss or deafness occurs when sound waves are not conducted to the inner ear. Possible causes include a wax (cerumen) plug, a foreign body obstruction, otosclerosis, an infection, or a ruptured tympanic

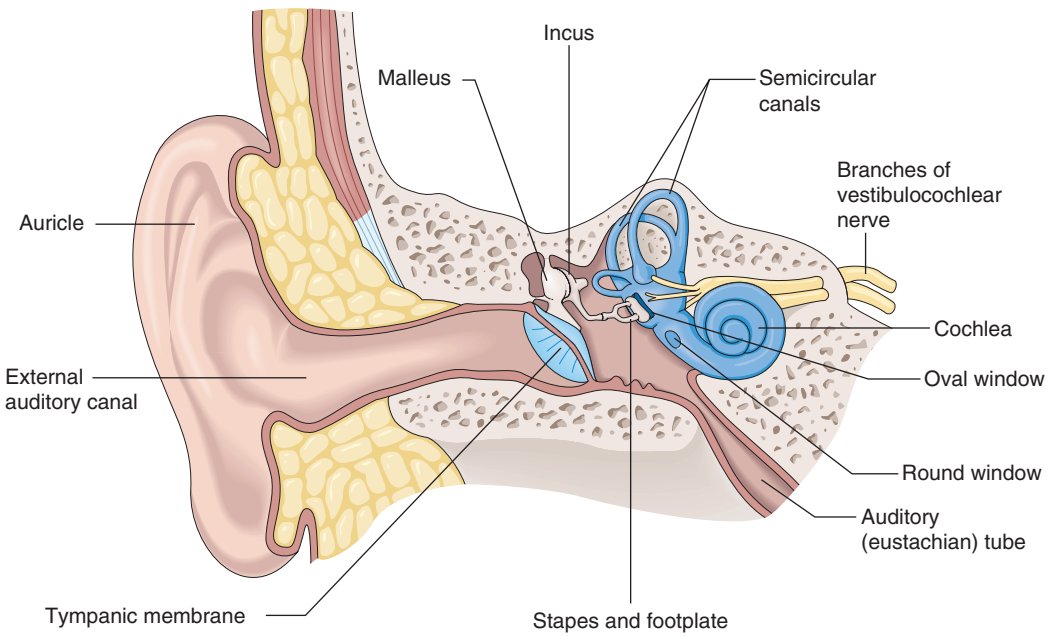


FIGURE 7-37 Structures of the ear.

membrane. Treatment is directed toward eliminating the cause. Surgery and the use of hearing aids are common forms of treatment. Sensory hearing loss or deafness occurs when there is damage to the inner ear or auditory nerve. This type of hearing loss usually cannot be corrected, but cochlear implants can improve severe hearing loss.

Ménière's Disease
Ménière's disease results from a collection of fluid in the labyrinth of the inner ear and a degeneration of the hair cells in the cochlea and vestibule. Symptoms include severe vertigo (dizziness), tinnitus (ringing in the ears), nausea and vomiting, loss of balance, and a tendency to fall. Forms of treatment include drugs to reduce the fluid, draining the fluid, and antihistamines. In severe, chronic cases, surgery to destroy the cochlea may be performed; however, this causes permanent deafness.

Otitis Externa
Otitis externa is an inflammation of the external auditory canal. It is caused by a pathogenic organism such as a bacterium or virus. Swimmer's ear is one form. It is caused by swimming in contaminated water. Inserting bobby pins, fingernails, or cotton swabs into the ear can also cause this condition. Treatment methods include antibiotics; warm, moist compresses; and/or pain medications.

Otitis Media
Otitis media is an inflammation or infection of the middle ear that is caused by a bacterium or virus. It frequently follows a sore throat because organisms from the throat can enter the middle ear through the eustachian tube. Infants and young children are very susceptible to otitis media because the eustachian tube is angled differently than in adults. Secretions from the nose and throat accumulate in the middle ear, resulting in an inflammatory response that causes the eustachian tube to swell shut. Symptoms include severe pain, fever, vertigo (dizziness), nausea and vomiting, and fluid buildup in the middle ear. Treatment usually consists of administering antibiotics and pain medications. At times, a *myringotomy* (incision of the tympanic membrane) is performed, and tubes are inserted to relieve pressure and allow fluid to drain.

Otosclerosis
Otosclerosis occurs when the stapes becomes immobile, causing conductive hearing loss. Symptoms include gradual hearing loss, tinnitus, and at times, vertigo. Surgical removal of the stapes and insertion of an artificial stapes corrects the condition.

THE TONGUE AND SENSE OF TASTE

The tongue is a mass of muscle tissue with projections called *papillae* (figure 7-38). The papillae contain taste buds that are stimulated by the flavors of foods moistened by saliva. There are four main tastes: sweet tastes and salty tastes at the tip of the tongue; sour tastes at the sides of the tongue; and bitter tastes at the back of the tongue. Taste is influenced by the sense of smell.

THE NOSE AND SENSE OF SMELL

The nose is the organ of smell (figure 7-39). The sense of smell is made possible by olfactory receptors, which are located in the upper part of the nasal cavity. Impulses from these receptors are carried to the brain by the olfactory nerve. The human nose can detect more than 6,000 different smells. The sense of smell is more sensitive than taste, but is closely related to the sense of taste. This is clearly illustrated by the fact that food does not taste as good when you have a head cold and your sense of smell is impaired.

THE SKIN AND GENERAL SENSES

General sense receptors for pressure, heat, cold, touch, and pain are located throughout the body in the skin and connective tissue. Each receptor perceives only one type of sense. For example, the skin contains special receptors for heat and different receptors for cold. Messages from these receptors allow the human body to respond to its environment and help it react to conditions that can cause injury.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:7, Special Senses.*

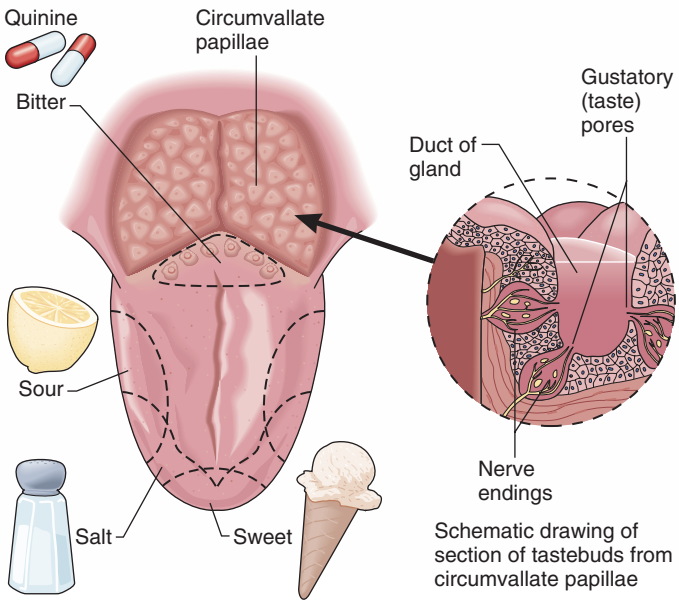


FIGURE 7-38 Locations of taste buds.

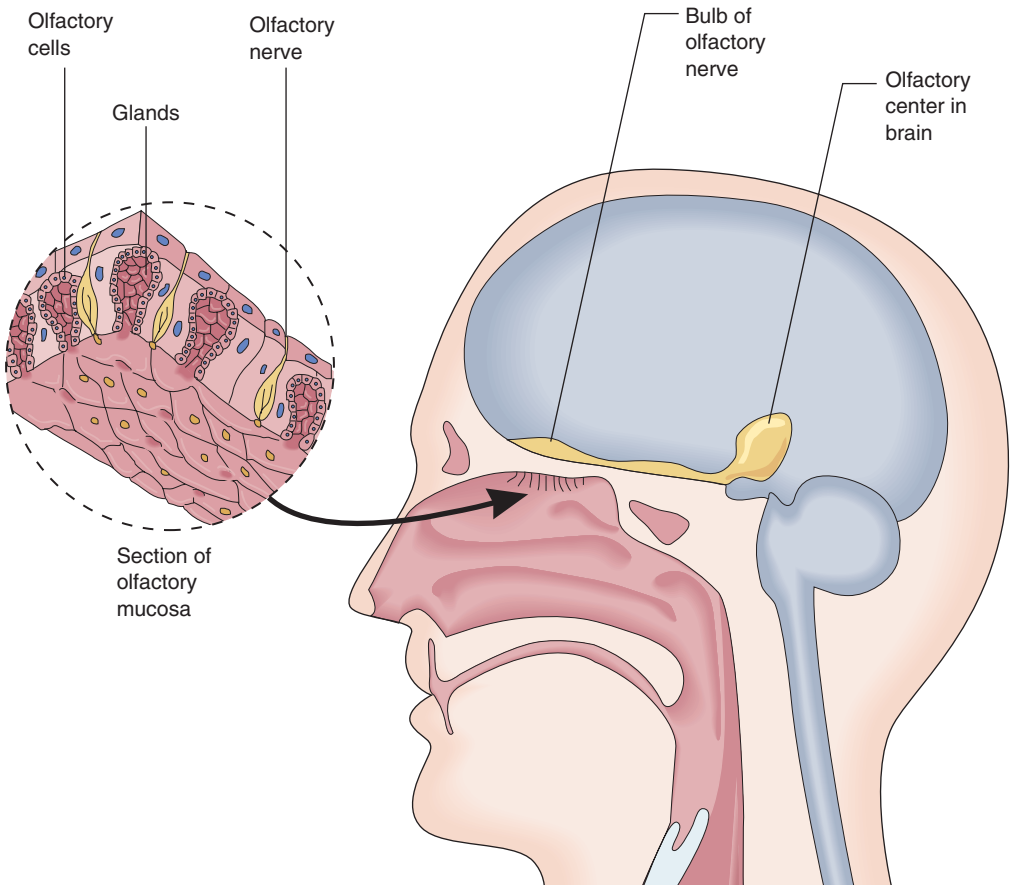


FIGURE 7-39 The sense of smell.

7:8 Circulatory System

Objectives

After completing this section, you should be able to:

- Label the layers, chambers, valves, and major blood vessels on a diagram of the heart
- Differentiate between systole and diastole by explaining what happens in the heart during each phase
- List the three major types of blood vessels and the action of each type
- Compare the three main types of blood cells by describing the function of each
- Describe at least five diseases of the circulatory system
- Define, pronounce, and spell all key terms

KEY TERMS

aortic valve *(ay-or′-tick)*
arrhythmias
arteries
blood
capillaries *(cap′-ih-lair-eez)*
circulatory system
diastole *(dy-az′-tah-lee″)*
endocardium *(en-doe-car′-dee-um)*
erythrocytes *(eh-rith′-row-sitez)*
hemoglobin *(hee′-mow-glow″-bin)*
left atrium *(ay′-tree-um)*
left ventricle *(ven′ tri″-kul)*
leukocytes *(lew′-coh-sitez″)*
mitral valve *(my′-tral)*
myocardium
pericardium
plasma *(plaz′-ma)*
pulmonary valve
right atrium
right ventricle
septum
systole *(sis′-tah-lee″)*
thrombocytes *(throm′-bow-sitez)*
tricuspid valve
veins

RELATED HEALTH CAREERS

- Cardiac Surgeon
- Cardiologist
- Cardiovascular Technologist
- Echocardiographer
- Electrocardiographic Technician
- Hematologist
- Internist
- Medical Laboratory Technologist/Technician
- Perfusionist
- Phlebotomist
- Radiology Technologist
- Thoracic Surgeon

7:8 INFORMATION

The **circulatory system,** also known as the cardiovascular system, is often referred to as the "transportation" system of the body. It consists of the heart, blood vessels, and blood. It transports oxygen and nutrients to the body cells, and carbon dioxide and metabolic materials away from the body cells.

THE HEART

The heart is a muscular, hollow organ often called the "pump" of the body (figure 7-40). Even though

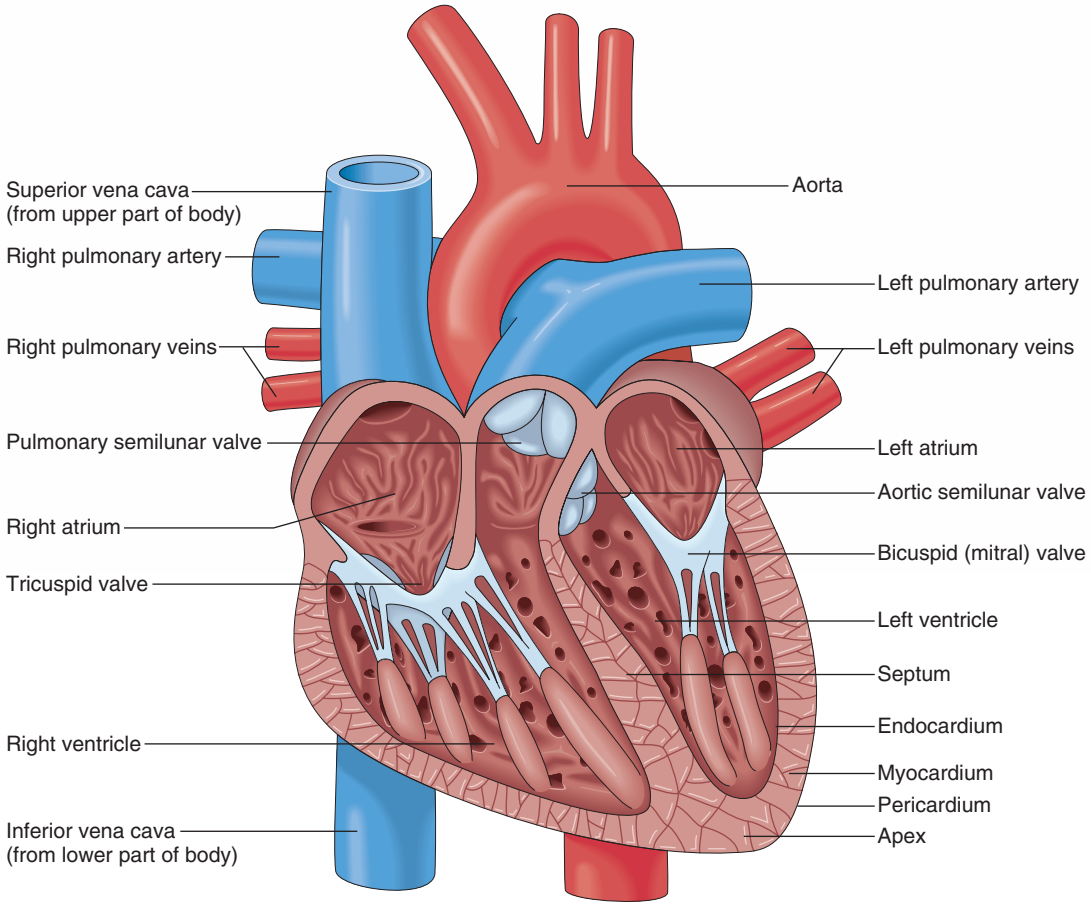


FIGURE 7-40 Basic structure of the heart.

it weighs less than one pound and is approximately the size of a closed fist, it contracts about 100,000 times each day to pump the equivalent of 2,000 gallons of blood through the body. The heart is located in the mediastinal cavity, between the lungs, behind the sternum, and above the diaphragm. Three layers of tissue form the heart. The **endocardium** is a smooth layer of cells that lines the inside of the heart and is continuous with the inside of blood vessels. It allows for the smooth flow of blood. The thickest layer is the **myocardium,** the muscular middle layer. The **pericardium** is a double-layered membrane, or sac, that covers the outside of the heart. A lubricating fluid, pericardial fluid, fills the space between the two layers to prevent friction and damage to the membranes as the heart beats or contracts.

The **septum** is a muscular wall that separates the heart into a right side and a left side. It prevents blood from moving between the right and left sides of the heart. The upper part of the septum is called the *interatrial septum,* and the lower part is called the *interventricular septum.*

The heart is divided into four parts, or chambers. The two upper chambers are called *atria,* and the two lower chambers are called *ventricles.* The **right atrium** receives blood as it returns from the body cells. The **right ventricle** receives blood from the right atrium and pumps the blood into the pulmonary artery, which carries the blood to the lungs for oxygen. The **left atrium** receives oxygenated blood from the lungs. The **left ventricle** receives blood from the left atrium and pumps the blood into the aorta for transport to the body cells.

One-way valves in the chambers of the heart keep the blood flowing in the right direction. The **tricuspid valve** is located between the right atrium and the right ventricle. It closes when the right ventricle contracts, allowing blood to flow to the lungs and preventing blood from flowing back into the right atrium. The **pulmonary valve** is located between the right ventricle and the pul-

monary artery, a blood vessel that carries blood to the lungs. It closes when the right ventricle has finished contracting, preventing blood from flowing back into the right ventricle. The **mitral valve** is located between the left atrium and left ventricle. It closes when the left ventricle is contracting, allowing blood to flow into the aorta (for transport to the body) and preventing blood from flowing back into the left atrium. The **aortic valve** is located between the left ventricle and the aorta, the largest artery in the body. It closes when the left ventricle is finished contracting, allowing blood to flow into the aorta and preventing blood from flowing back into the left ventricle.

Cardiac (Heartbeat) Cycle

Although they are separated by the septum, the right and left sides of the heart work together in a cyclic manner. The cycle consists of a brief period of rest, called **diastole,** followed by a period of ventricular contraction, called **systole** (figure 7-41). At the start of the cycle, the atria contract and push blood into the ventricles. The atria then relax, and blood returning from the body enters the right atrium, while blood returning from the lungs enters the left atrium. As the atria are filling, systole begins, and the ventricles contract. The right ventricle pushes blood into the pulmonary artery, sending the blood to the lungs for oxygen. The left ventricle pushes blood into the aorta, sending the blood to all other parts of the body. The blood in the right side of the heart is low in oxygen and high in carbon dioxide. When this blood arrives in the lungs, the carbon dioxide is released into the lungs, and oxygen is taken into the blood. This oxygenated blood is then carried to the left side of the heart by the pulmonary veins. This blood in the left side of the heart, high in oxygen and low in carbon dioxide, is ready for transport to the body cells.

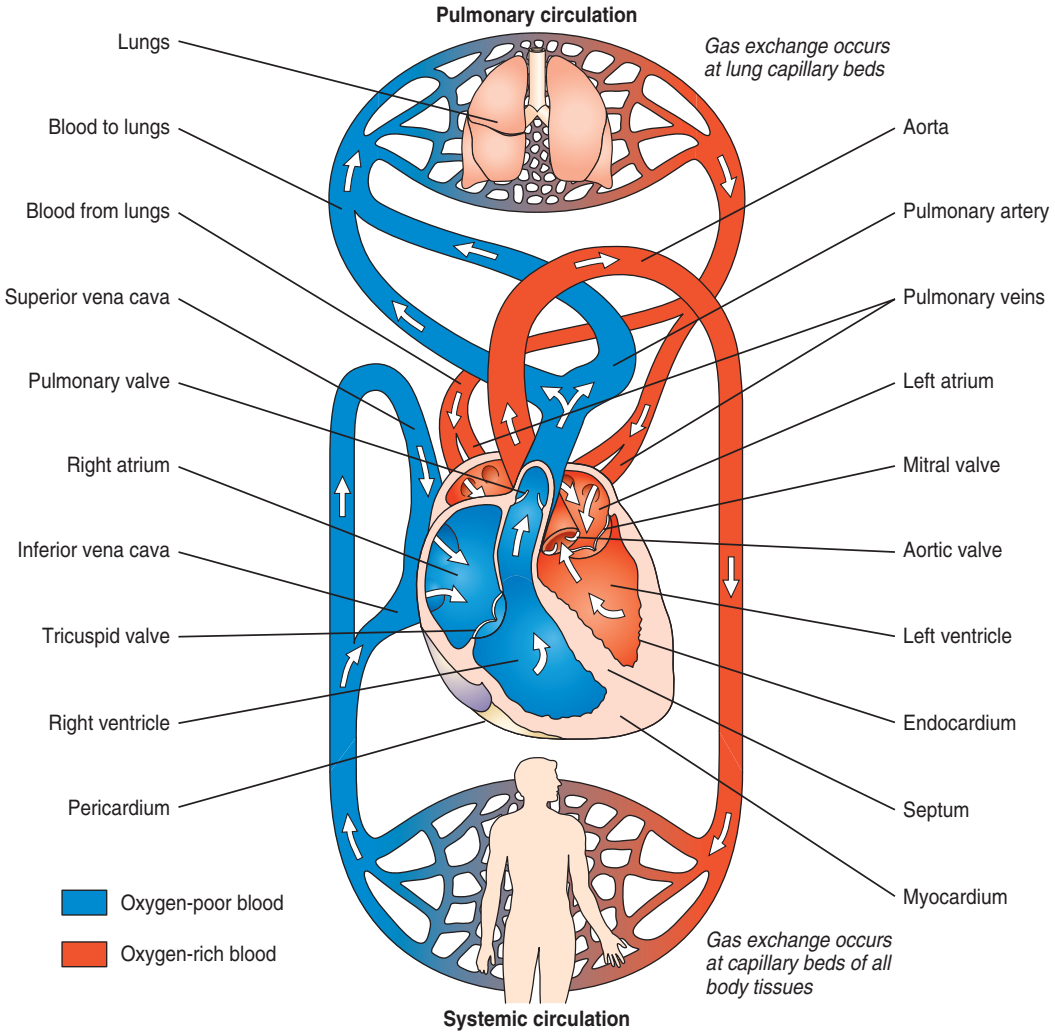


FIGURE 7-41 The pattern of circulation in the cardiovascular system.

Conductive Pathway

Electrical impulses originating in the heart cause the cyclic contraction of the muscles (figure 7-42). A group of nerve cells located in the right atrium and called the *sinoatrial (SA) node,* or the "pacemaker," sends out an electrical impulse that spreads out over the muscles in the atria. The atrial muscles then contract and push blood into the ventricles. After the electrical impulse passes through the atria, it reaches the *atrioventricular (AV) node,* a group of nerve cells located between the atria and ventricles. The AV node sends the electrical impulse through the *bundle of His,* nerve fibers in the septum. The bundle of His divides into a *right bundle branch* and a *left bundle branch,* which carry the impulse down through the ventricles. The bundle branches further subdivide into the *Purkinje fibers,* a network of nerve fibers throughout the ventricles. In this way, the electrical impulse reaches all the muscle tissue in the ventricles, and the ventricles contract. This electrical conduction pattern occurs approximately every 0.8 seconds. The movement of the electrical impulse can be recorded on an electrocardiogram (ECG) and used to detect abnormal activity or disease.

If something interferes with the normal electrical conduction pattern of the heart, arrhythmias occur. **Arrhythmias** are abnormal heart rhythms and can be mild to life-threatening. For example, an early contraction of the atria, or premature atrial contraction (PAC), can occur in anyone and usually goes unnoticed. Ventricle fibrillation, in which the ventricles contract at random without coordination, decreases or eliminates blood output and causes death if not treated. Cardiac monitors and electrocardiograms are used to diagnose arrhythmias. Treatment depends on the type and severity of the arrhythmia. Life-threatening fibrillations are treated with a *defibrillator,* a device that shocks the heart with an electrical current to stop the uncoordinated contraction and allow the SA node to regain control.

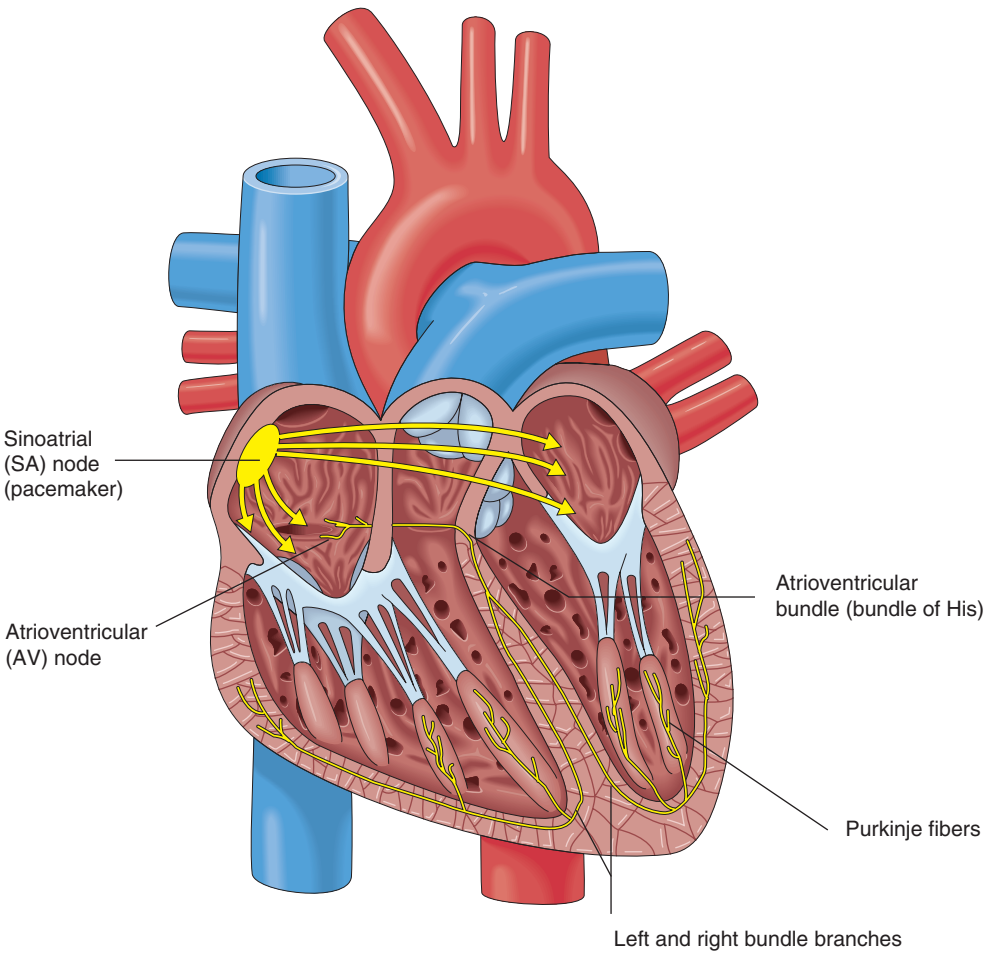


FIGURE 7-42 Electrical conduction pathways in the heart.

At times it is necessary to use external or internal artificial pacemakers to regulate the heart's rhythm, (figure 7-43). The *pacemaker* is a small, battery-powered device with electrodes. The electrodes are threaded through a vein and positioned in the right atrium and in the apex of the right ventricle. The pacemaker monitors the heart's activity and delivers an electrical impulse through the electrodes to stimulate contraction. Fixed pacemakers deliver electrical impulses at a predetermined rate. Demand pacemakers, the most common type, deliver electrical impulses only when the heart's own conduction system is not responding correctly. Even though modern pacemakers are protected from electromagnetic forces, such as microwave ovens, most manufacturers still recommend that people with pacemakers avoid close contact with digital cellular telephones. For example, the cellular telephone should not be stored in a shirt pocket close to the pacemaker.

BLOOD VESSELS

When the blood leaves the heart, it is carried throughout the body in blood vessels. The heart and blood vessels form a closed system for the flow of blood. There are three main types of blood vessels: arteries, capillaries, and veins.

Arteries (figure 7-44) carry blood away from the heart. The aorta is the largest artery in the body; it receives the blood from the left ventricle of the heart. The aorta branches into all of the other arteries that supply blood to the body. The first branch of the aorta is the coronary artery, which divides into a right and left coronary artery to carry blood to the myocardium of the heart.

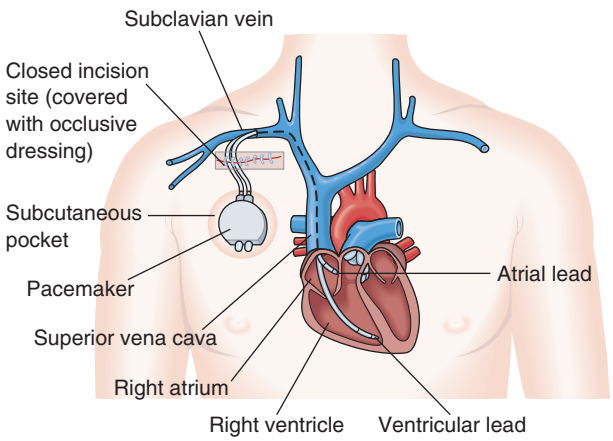


FIGURE 7-43 Artificial pacemakers can help regulate the heart's rhythm.

Additional branches of the aorta carry blood to the head, neck, arms, chest, back, abdomen, and legs. The smallest branches of arteries are called *arterioles*. They join with capillaries. Arteries are more muscular and elastic than are the other blood vessels because they receive the blood as it is pumped from the heart.

Capillaries connect arterioles with *venules,* the smallest veins. Capillaries are located in close proximity to almost every cell in the body. They have thin walls that contain only one layer of cells. These thin walls allow oxygen and nutrients to pass through to the cells and allow carbon dioxide and metabolic products from the cells to enter the capillaries.

Veins (figure 7-45) are blood vessels that carry blood back to the heart. *Venules,* the smallest branches of veins, connect with the capillaries. The venules join together and, becoming larger, form veins. The veins continue to join together until they form the two largest veins: the superior vena cava and the inferior vena cava. The superior vena cava brings the blood from the upper part of the body, and the inferior vena cava brings the blood from the lower part of the body. Both vena cavae drain into the right atrium of the heart. Veins are thinner and have less muscle tissue than do arteries. Most veins contain valves, which keep the blood from flowing in a backward direction (figure 7-46).

BLOOD COMPOSITION

The **blood** that flows through the circulatory system is often called a *tissue* because it contains many kinds of cells. There are approximately 4–6 quarts of blood in the average adult. This blood circulates continuously throughout the body. It transports oxygen from the lungs to the body cells, carbon dioxide from the body cells to the lungs, nutrients from the digestive tract to the body cells, metabolic and waste products from the body cells to the organs of excretion, heat produced by various body parts, and hormones produced by endocrine glands to the body organs.

Plasma

Blood is made of the fluid called *plasma* and formed or solid elements called *blood cells* (figure 7-47). **Plasma** is approximately 90 percent water,

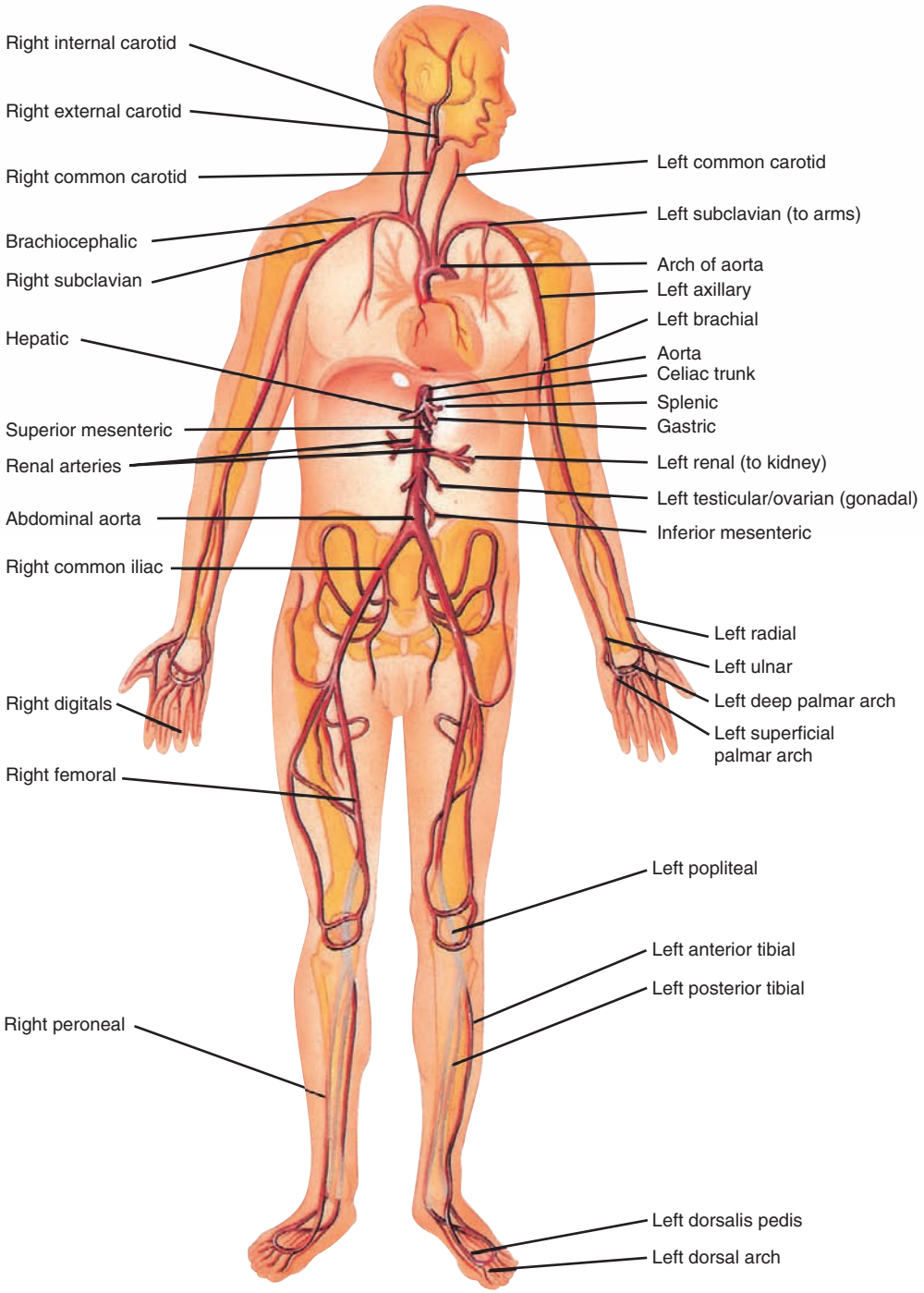


FIGURE 7-44 Major arteries of the body.

with many dissolved, or suspended, substances. Among these substances are blood proteins such as fibrinogen and prothrombin (both necessary for clotting); nutrients such as vitamins, carbohydrates, and proteins; mineral salts or electrolytes such as potassium, calcium, and sodium; gases such as carbon dioxide and oxygen; metabolic and waste products; hormones; and enzymes.

Blood Cells

There are three main kinds of blood cells: erythrocytes, leukocytes, and thrombocytes.

The **erythrocytes,** or red blood cells, are produced in the red bone marrow at a rate of about one million per minute. They live approximately 120 days before being broken down by the

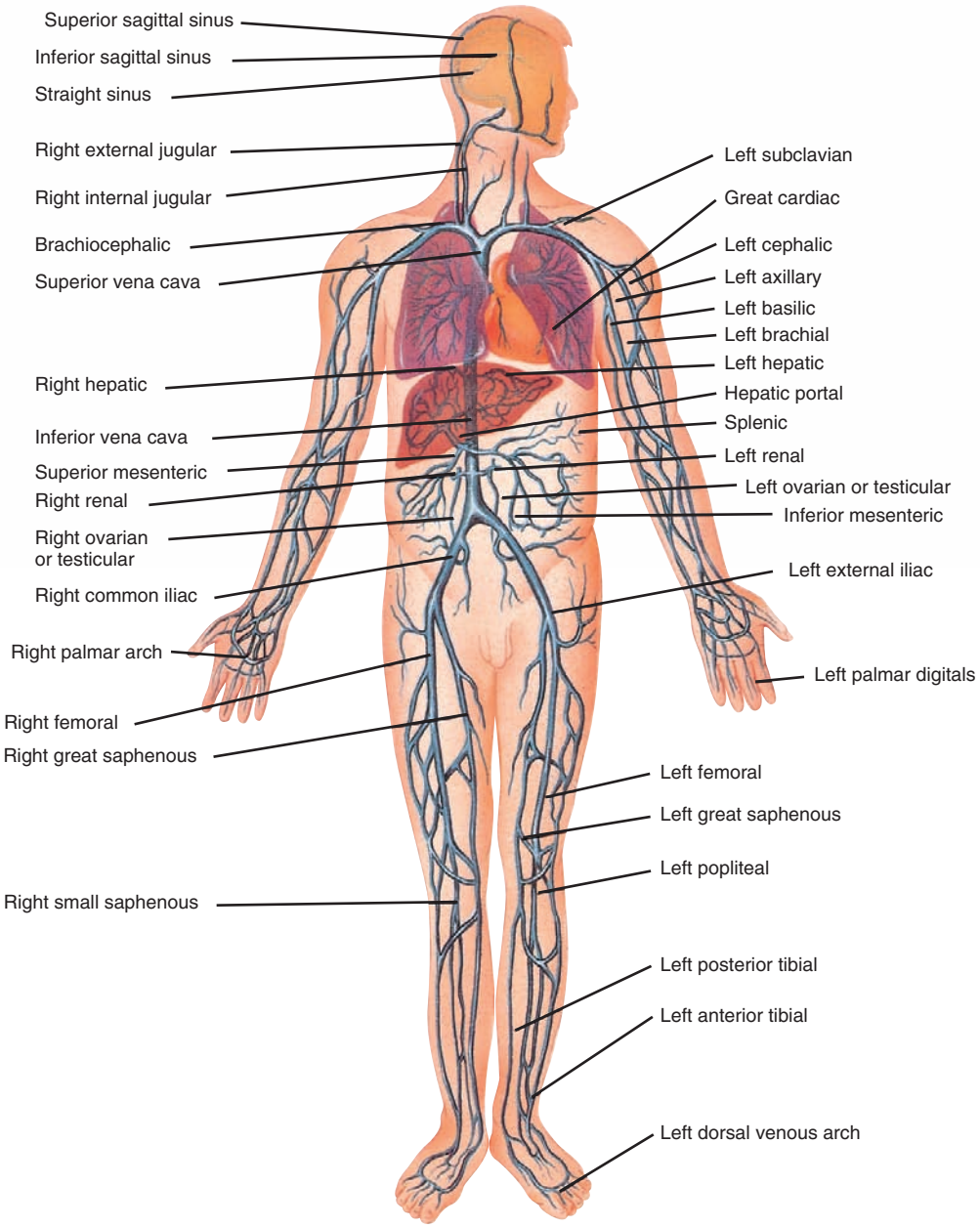


FIGURE 7-45 Major veins of the body.

liver and spleen. There are 4.5–5.5 million erythrocytes per cubic millimeter (approximately one drop) of blood, or approximately 25 trillion in the body. The mature form circulating in the blood lacks a nucleus and is shaped like a disk with a thinner central area. The erythrocytes contain **hemoglobin,** a complex protein composed of the protein molecule called *globin* and the iron compound called *heme*. Hemoglobin carries both oxygen and carbon dioxide. When carrying oxygen, hemoglobin gives blood its characteristic red color. When blood contains a lot of oxygen, it is bright red; when blood contains less oxygen and more carbon dioxide, it is a much darker red with a bluish cast.

Leukocytes, or white blood cells, are not as numerous as are erythrocytes. They are formed in the bone marrow and lymph tissue and usually live about 3–9 days. A normal count is 5,000–9,000 leukocytes per cubic millimeter of blood. Leukocytes can pass through capillary walls and enter body tissue. Their main function is to fight infection. Some do this by engulfing, ingesting, and destroying pathogens, or germs, by a process

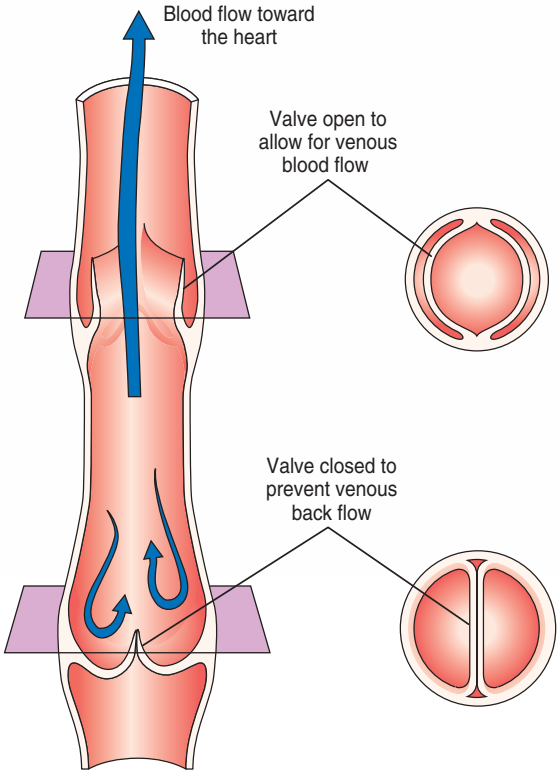


FIGURE 7-46 Most veins contain valves to prevent the backflow of blood.

called *phagocytosis*. The five types of leukocytes and their functions include:

- *Neutrophils*: phagocytize bacteria by secreting an enzyme called *lysozyme*
- *Eosinophils*: remove toxins and defend the body from allergic reactions by producing antihistamines
- *Basophils*: participate in the body's inflammatory response; produce histamine, a vasodilator, and heparin, an anticoagulant
- *Monocytes*: phagocytize bacteria and foreign materials
- *Lymphocytes*: provide immunity for the body by developing antibodies; protect against the formation of cancer cells

Thrombocytes, also called *platelets,* are usually described as fragments or pieces of cells because they lack nuclei and vary in shape and size. They are formed in the bone marrow and live for about 5–9 days. A normal thrombocyte count is 250,000–400,000 per cubic millimeter of blood. Thrombocytes are important for the clotting process, which stops bleeding. When a blood

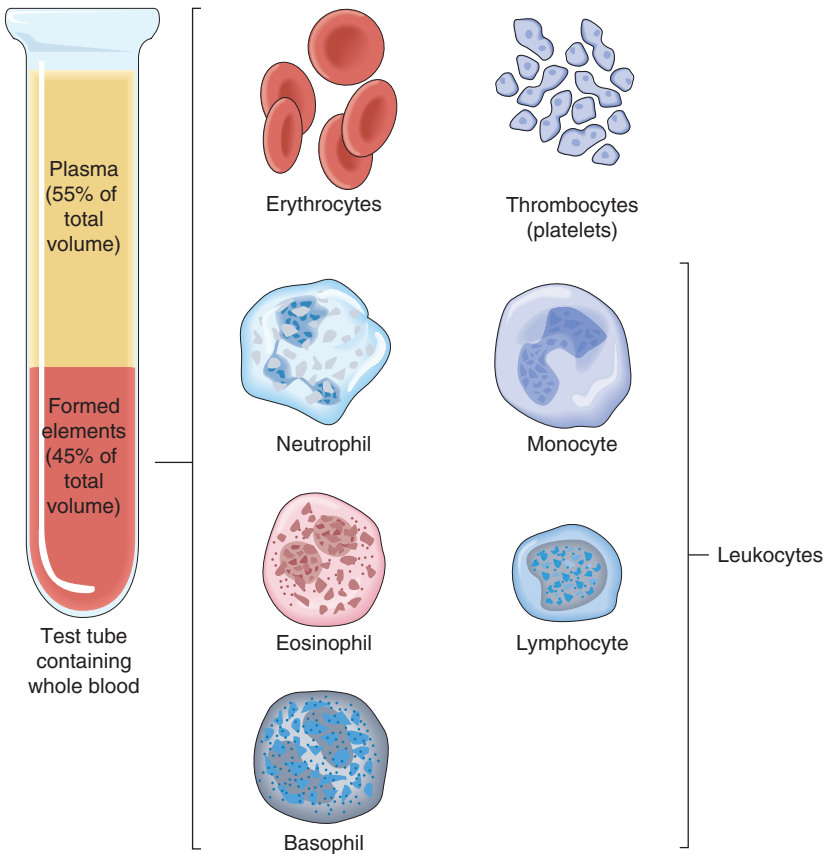


FIGURE 7-47 The major components of blood.

vessel is cut, the thrombocytes collect at the site to form a sticky plug. They secrete a chemical, serotonin, which causes the blood vessel to spasm and narrow, decreasing the flow of blood. At the same time, the thrombocytes release an enzyme, thromboplastin, which acts with calcium and other substances in the plasma to form thrombin. Thrombin acts on the blood protein fibrinogen to form fibrin, a gel-like net of fine fibers that traps erythrocytes, platelets, and plasma to form a clot. This is an effective method for controlling bleeding in smaller blood vessels. If a large blood vessel is cut, the rapid flow of blood can interfere with the formation of fibrin. In these instances, a doctor may have to insert sutures (stitches) to close the opening and control the bleeding.

DISEASES AND ABNORMAL CONDITIONS

Anemia

Anemia is an inadequate number of red blood cells, hemoglobin, or both. Symptoms include pallor (paleness), fatigue, dyspnea (difficult breathing), and rapid heart rate. Hemorrhage can cause rapid blood loss, resulting in acute-blood-loss anemia. Blood transfusions are used to correct this form of anemia. *Iron deficiency anemia* results when there is an inadequate amount of iron to form hemoglobin in erythrocytes. Iron supplements and increased iron intake in the diet from green leafy vegetables and other foods can correct this condition. *Aplastic anemia* is a result of injury to or destruction of the bone marrow, leading to poor or no formation of red blood cells. Common causes include chemotherapy, radiation, toxic chemicals, and viruses. Treatment includes eliminating the cause, blood transfusions, and in severe cases, a bone marrow transplant. Unless the damage can be reversed, it is frequently fatal. *Pernicious anemia* results in the formation of erythrocytes that are abnormally large in size, but inadequate in number. The cause is a lack of intrinsic factor (a substance normally present in the stomach), which results in inadequate absorption of vitamin B_{12}. Vitamin B_{12} and folic acid are required for the development of mature erythrocytes. Administering vitamin B_{12} injections can control and correct this condition. *Sickle cell anemia* is a chronic, inherited anemia. It results in the production of abnormal, crescent-shaped erythrocytes that carry less oxygen, break easily, and block blood vessels (figure 7-48). Sickle cell anemia occurs almost exclusively among African Americans. Treatment methods include transfusions of packed cells and supportive therapy during crisis. Research directed toward bone marrow transplants, stem cell transplants from placental blood, and gene cell therapy may offer a cure for sickle cell anemia in the near future. Genetic counseling can lead to prevention of the disease if carriers make informed decisions not to have children.

Aneurysm

An aneurysm is a ballooning out of, or saclike formation on, an artery wall. Disease, congenital defects, and injuries leading to weakened arterial wall structure can cause this defect. Although some aneurysms cause pain and pressure, others generate no symptoms. Common sites are the cerebral, aortal, and abdominal arteries. If an aneurysm ruptures, hemorrhage, which can cause death, occurs. Treatment usually involves surgically removing the damaged area of blood vessel and replacing it with a plastic graft or another blood vessel.

Arteriosclerosis

Arteriosclerosis is a hardening or thickening of the arterial walls, resulting in a loss of elasticity and contractility. It commonly occurs as a result of aging. Arteriosclerosis causes high blood pressure, or hypertension, and can lead to an aneurysm or cerebral hemorrhage. The main focus of treatment is lowering blood pressure through the use of diet, medications, or both.

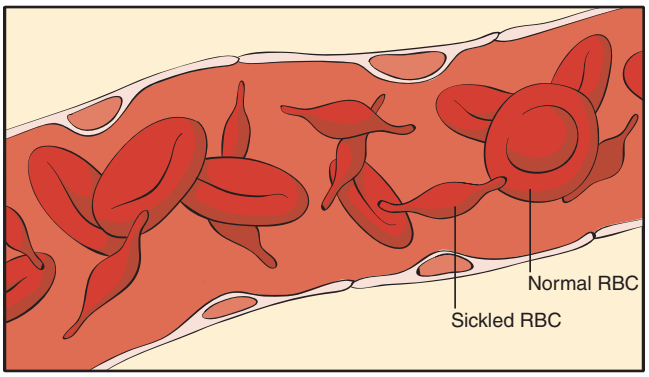


FIGURE 7-48 Sickle cell anemia is characterized by abnormal, crescent-shaped erythrocytes.

Atherosclerosis

Atherosclerosis occurs when fatty plaques (frequently cholesterol) are deposited on the walls of the arteries. This narrows the arterial opening, which reduces or eliminates blood flow. If plaques break loose, they can circulate through the bloodstream as *emboli*. A low-cholesterol diet, medications to lower cholesterol blood levels, abstaining from smoking, reduction of stress, and exercise are used to prevent atherosclerosis. Angioplasty (figure 7-49) may be used to remove or compress the deposits, or to insert a stent to allow blood flow. Bypass surgery is used when the arteries are completely blocked.

Congestive Heart Failure

Congestive heart failure (CHF) is a condition that occurs when the heart muscles do not beat adequately to supply the blood needs of the body. It may involve either the right side or the left side of the heart. Symptoms include edema (swelling); dypsnea; pallor or cyanosis; distention of the neck veins; a weak, rapid pulse; and a cough accompanied by pink, frothy sputum. Cardiotonic drugs (to slow and strengthen the heartbeat), diuretics (to remove retained body fluids), elastic support hose, oxygen therapy, bedrest, and/or a low-sodium diet are used as treatment methods.

Embolus

An embolus is a foreign substance circulating in the bloodstream. It can be air, a blood clot, bacterial clumps, a fat globule, or other similar substances. When an embolus enters an artery or capillary too small for passage, blockage of the blood vessel occurs.

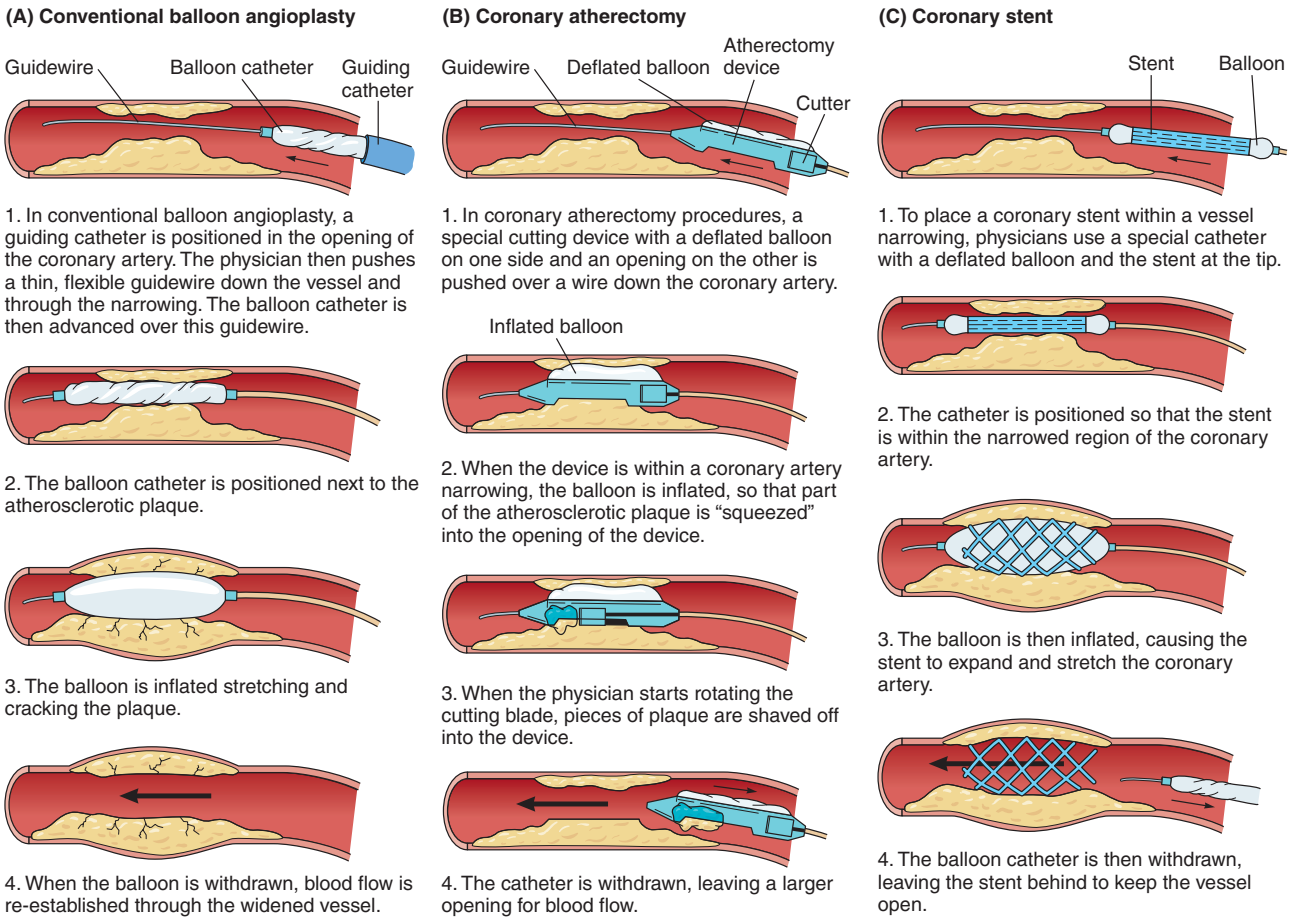


FIGURE 7-49 Ways to open clogged arteries: (A) balloon angioplasty, (B) coronary atherectomy, and (C) coronary stent.

Hemophilia

Hemophilia is an inherited disease that occurs almost exclusively in male individuals but can be carried by female individuals. Because of the lack of a plasma protein required for the clotting process, the blood is unable to clot. A minor cut can lead to prolonged bleeding, and a minor bump can cause internal bleeding. Treatment involves transfusing whole blood, or plasma, and administering the missing protein factor.

Hypertension

Hypertension is high blood pressure. A systolic pressure above 140 and a diastolic pressure above 90 millimeters of mercury (mmHg) is usually regarded as hypertension. Risk factors that increase the incidence of hypertension include family history, race (higher in African Americans), obesity, stress, smoking, aging (higher in postmenopausal women), and a diet high in saturated fat. Although there is no cure, hypertension can usually be controlled with antihypertensive drugs, diuretics (to remove retained body fluids), limited stress, avoidance of tobacco, and/or a low-sodium or low-fat diet. If hypertension is not treated, it can cause permanent damage to the heart, blood vessels, and kidneys.

Leukemia

Leukemia is a malignant disease of the bone marrow or lymph tissue. It results in a high number of immature white blood cells. There are different types of leukemia, some acute and some chronic. Symptoms include fever, pallor, swelling of lymphoid tissues, fatigue, anemia, bleeding gums, excessive bruising, and joint pain. Treatment methods vary with the type of leukemia but can include chemotherapy, radiation, and/or bone marrow transplant.

Myocardial Infarction

A myocardial infarction, or heart attack, occurs when a blockage in the coronary arteries cuts off the supply of blood to the heart. The affected heart tissue dies and is known as an *infarct.* Death can occur immediately. Symptoms include severe crushing pain (angina pectoris) that radiates to the arm, neck, and jaw; pressure in the chest; perspiration and cold, clammy skin; dypsnea; and a change in blood pressure. If the heart stops, cardiopulmonary resuscitation should be started immediately. Immediate treatment with a thrombolytic or "clot-busting" drug such as streptokinase or TPA, tissue plasminogen activator, may open the blood vessel and restore blood flow to the heart. However, the clot-busting drug must be used within the first several hours, and its use is prohibited if bleeding is present. Additional treatment methods include complete bed rest, pain medications, vasodilators, cardiotonic drugs (to slow and strengthen the heartbeat), oxygen therapy, anticoagulants (to prevent additional clots), and control of arrhythmias (abnormal heart rhythms). Long-term care includes control of blood pressure, a diet low in cholesterol and saturated fat, avoidance of tobacco and stress, regular exercise, and weight control.

Phlebitis

Phlebitis is an inflammation of a vein, frequently in the leg. If a thrombus, or clot, forms, the condition is termed *thrombophlebitis.* Symptoms include pain, edema, redness, and discoloration at the site. Treatment methods include anticoagulants; pain medication; elevation of the affected area; antiembolism or support hose; and if necessary, surgery to remove the clot.

Varicose Veins

Varicose veins are dilated, swollen veins that have lost elasticity and cause stasis, or decreased blood flow. They frequently occur in the legs and result from pregnancy, prolonged sitting or standing, and hereditary factors. Treatment methods include exercise, antiembolism or support hose, and avoidance of prolonged sitting or standing and tight-fitting or restrictive clothing. In severe cases, surgery can be performed to remove the vein.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:8, Circulatory System.*

7:9 Lymphatic System

Objectives

After completing this section, you should be able to:

- Explain the function of lymphatic vessels
- List at least two functions of lymph nodes
- Identify the two lymphatic ducts and the areas of the body that each drains
- List at least three functions of the spleen
- Describe the function of the thymus
- Describe at least three diseases of the lymphatic system
- Define, pronounce, and spell all key terms

KEY TERMS

cisterna chyli *(sis-tern′-uh-kye′-lee)*
lacteals
lymph *(limf′)*
lymph nodes
lymphatic capillaries *(lim-fat′-ik)*
lymphatic system
lymphatic vessels
right lymphatic duct
spleen
thoracic duct *(tho-rass′-ik)*
thymus
tonsils

RELATED HEALTH CAREERS

- Immunologist
- Internist

7:9 INFORMATION

The **lymphatic system** consists of lymph, lymph vessels, lymph nodes, and lymphatic tissue. This system works in conjunction with the circulatory system to remove wastes and excess fluids from the tissues (figure 7-50).

Lymph is a thin, watery fluid composed of *intercellular,* or *interstitial,* fluid, which forms when plasma diffuses into tissue spaces. It is composed of water, digested nutrients, salts, hormones, oxygen, carbon dioxide, lymphocytes, and metabolic wastes such as urea. When this fluid enters the lymphatic system, it is known as lymph.

Lymphatic vessels are located throughout the body in almost all of the tissues that have blood vessels. Small, open-ended lymph vessels act like drainpipes and are called **lymphatic capillaries.** The lymphatic capillaries pick up lymph at tissues throughout the body. The capillaries then join together to form larger lymphatic vessels, which pass through the lymph nodes. Contractions of skeletal muscles against the lymph vessels cause the lymph to flow through the vessels. Lymphatic vessels also have valves that keep the lymph flowing in only one direction. In the area of the small intestine, specialized lymphatic capillaries, called **lacteals,** pick up digested fats or lipids. When lymph is mixed with the lipids it is called *chyle.* The lacteals transport the chyle to the bloodstream through the thoracic duct.

Lymph nodes, popularly called "glands," are located all over the body, usually in groups or clusters. They are small, round, or oval masses ranging in size from that of a pinhead to that of an almond. Lymph vessels bring lymph to the nodes. The nodes filter the lymph and remove impurities such as carbon, cancer cells, pathogens (disease-producing organisms), and dead blood cells. In addition, the lymphatic tissue in the nodes produces lymphocytes (a type of leukocyte, or white blood cell) and antibodies (substances used to combat infection). The purified lymph, with lymphocytes and antibodies added, leaves the lymph node by a single lymphatic vessel.

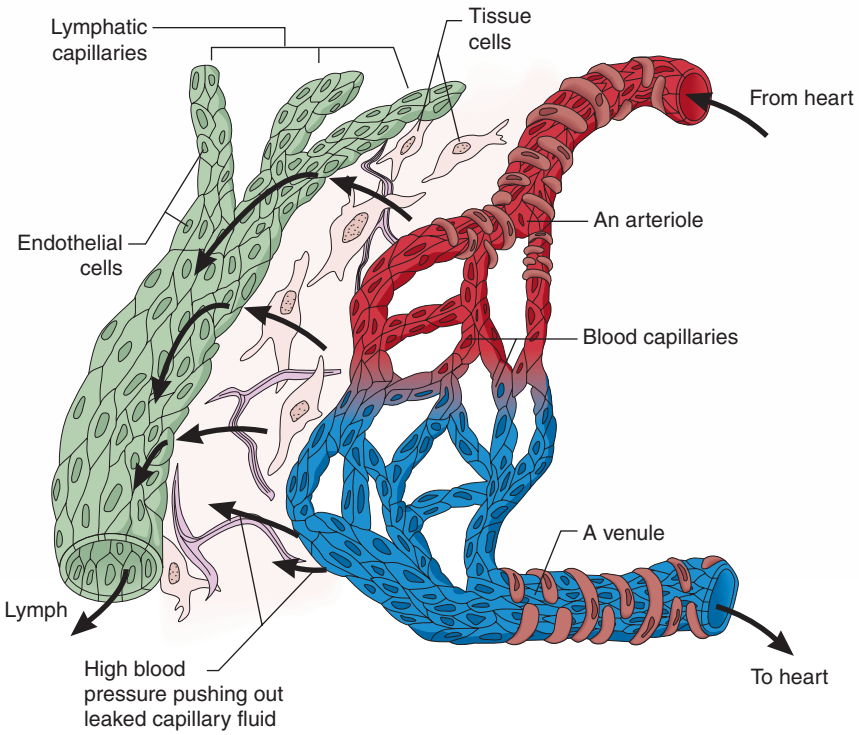


FIGURE 7-50 The lymphatic system works with the circulatory system to remove metabolic waste and excess fluid from the tissues.

As lymphatic vessels leave the lymph nodes, they continue to join together to form larger lymph vessels (figure 7-51). Eventually, these vessels drain into one of two lymphatic ducts: the right lymphatic duct or the thoracic duct. The **right lymphatic duct** is the short tube that receives all of the purified lymph from the right side of the head and neck, the right chest, and the right arm. It empties into the right subclavian vein, returning the purified lymph to the blood. The **thoracic duct,** a much larger tube, drains the lymph from the rest of the body. It empties into the left subclavian vein. At the start of the thoracic duct, an enlarged pouchlike structure called the **cisterna chyli** serves as a storage area for purified lymph before this lymph returns to the bloodstream. The cisterna chyli also receives chyle from the intestinal lacteals.

In addition to being found in the lymph nodes, lymphatic tissue is located throughout the body. The tonsils, spleen, and thymus are examples of lymphatic tissue.

The **tonsils** are masses of lymphatic tissue that filter interstitial fluid. There are three pairs of tonsils:

- *Palatine tonsils*: located on each side of the soft palate

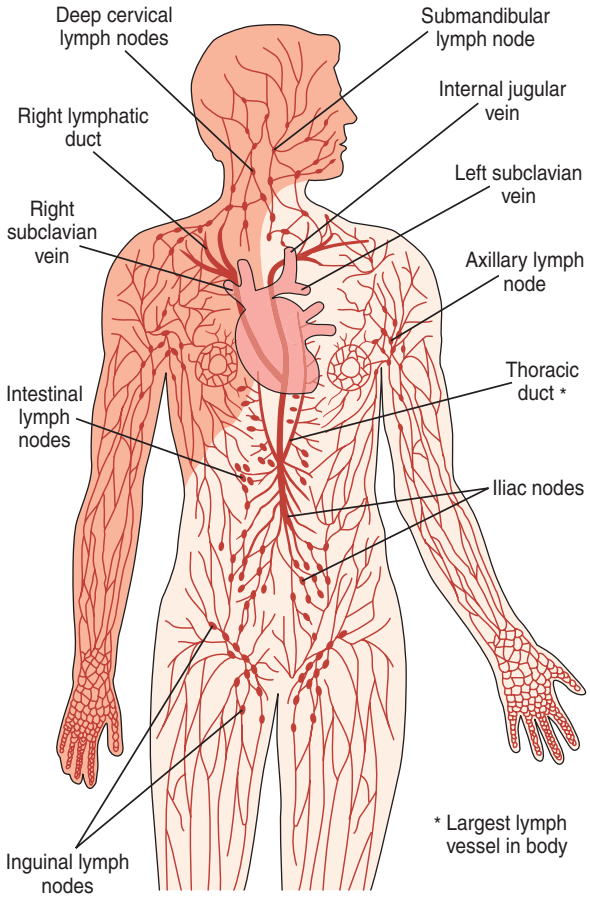


FIGURE 7-51 Main components of the lymphatic system.

- *Pharyngeal tonsils*: (also called *adenoids*) located in the nasopharynx (the upper part of the throat)
- *Lingual tonsils*: located on the back of the tongue

The **spleen** is an organ located beneath the left side of the diaphragm and in back of the upper part of the stomach. It produces leukocytes and antibodies, destroys old erythrocytes (red blood cells), stores erythrocytes to release into the bloodstream if excessive bleeding occurs, destroys thrombocytes (platelets), and filters metabolites and wastes from body tissues.

The **thymus** is a mass of lymph tissue located in the center of the upper chest. It atrophies (wastes away) after puberty and is replaced by fat and connective tissue. During early life, it produces antibodies and manufactures lymphocytes to fight infection. Its function is taken over by the lymph nodes.

DISEASES AND ABNORMAL CONDITIONS

Adenitis

Adenitis is an inflammation or infection of the lymph nodes. It occurs when large quantities of harmful substances, such as pathogens or cancer cells, enter the lymph nodes and infect the tissue. Symptoms include fever and swollen, painful nodes. If the infection is not treated, an abscess may form in the node. Usually treatment methods are antibiotics and warm, moist compresses. If an abscess forms, it is sometimes necessary to incise and drain the node.

Hodgkin's Disease

Hodgkin's disease is a chronic, malignant disease of the lymph nodes. It is the most common form of lymphoma (tumor of lymph tissue). Symptoms include painless swelling of the lymph nodes, fever, night sweats, weight loss, fatigue, and pruritus (itching). Chemotherapy and radiation are usually effective forms of treatment.

Lymphangitis

Lymphangitis is an inflammation of lymphatic vessels, usually resulting from an infection in an extremity. Symptoms include a characteristic red streak extending up an arm or leg from the source of infection, fever, chills, and tenderness or pain. Treatment methods include antibiotics, rest, elevation of the affected part, and/or warm, moist compresses.

Splenomegaly

Splenomegaly is an enlargement of the spleen. It can result from an abnormal accumulation of red blood cells, mononucleosis, and cirrhosis of the liver. The main symptoms are swelling and abdominal pain. An increased destruction of blood cells can lead to anemia (low red blood cell count), leukopenia (low white blood cell count), and thrombocytopenia (low thrombocyte count). If the spleen ruptures, intraperitoneal hemorrhage and shock can lead to death. In severe cases, where the underlying cause cannot be treated, a splenectomy (surgical removal of the spleen) is performed.

Tonsillitis

Tonsillitis is an inflammation or infection of the tonsils. It usually involves the pharyngeal (adenoid) and palatine tonsils. Symptoms include throat pain, dysphagia (difficulty swallowing), fever, white or yellow spots of exudate on the tonsils, and swollen lymph nodes near the mandible. Antibiotics, warm throat irrigations, rest, and analgesics for pain are the main forms of treatment. Chronic, frequent infections or hypertrophy (enlargement) that causes obstruction are indications for a tonsillectomy, or surgical removal of the tonsils.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:9, Lymphatic System.*

7:10 Respiratory System

Objectives

After completing this section, you should be able to:

- Label a diagram of the respiratory system
- List five functions of the nasal cavity
- Identify the three sections of the pharynx
- Explain how the larynx helps create sound and speech
- Describe the function of the epiglottis
- Compare the processes of inspiration and expiration, including the muscle action that occurs during each process
- Differentiate between external and internal respiration
- Describe at least five diseases of the respiratory system
- Define, pronounce, and spell all key terms

KEY TERMS

alveoli *(ahl-vee′-oh″-lie)*
bronchi *(bron′-kie)*
bronchioles *(bron′-key″-ohlz)*
cellular respiration
cilia *(sil′-lee-ah)*
epiglottis *(ep-ih-glot′-tiss)*
expiration
external respiration
inspiration
internal respiration
larynx *(lar′-inks)*
lungs
nasal cavities
nasal septum
nose
pharynx *(far′-inks)*
pleura
respiration
respiratory system *(res′-peh-reh-tor′-ee)*
sinuses
trachea *(tray′-key″-ah)*
ventilation

RELATED HEALTH CAREERS

- Internist
- Otolaryngologist
- Perfusionist
- Pulmonologist
- Respiratory Therapist
- Respiratory Therapy Technician
- Thoracic Surgeon

7:10 INFORMATION

The **respiratory system** consists of the lungs and air passages. This system is responsible for taking in oxygen, a gas needed by all body cells, and removing carbon dioxide, a gas that is a metabolic waste product produced by the cells when the cells convert food into energy. Because the body has only a 4–6-minute supply of oxygen, the respiratory system must work continuously to prevent death.

The parts of the respiratory system are the nose, pharynx, larynx, trachea, bronchi, alveoli, and lungs (figure 7-52).

RESPIRATORY ORGANS AND STRUCTURES

The **nose** has two openings, called *nostrils* or *nares,* through which air enters. A wall of cartilage, called the **nasal septum,** divides the nose into two hollow spaces, called **nasal cavities.** The nasal cavities are lined with a mucous membrane and have a rich blood supply. As air enters the cavities, it is warmed, filtered, and moistened. Mucus, produced by the mucous membranes, moistens the air and helps trap pathogens and dirt. Tiny, hairlike structures, called **cilia,** filter

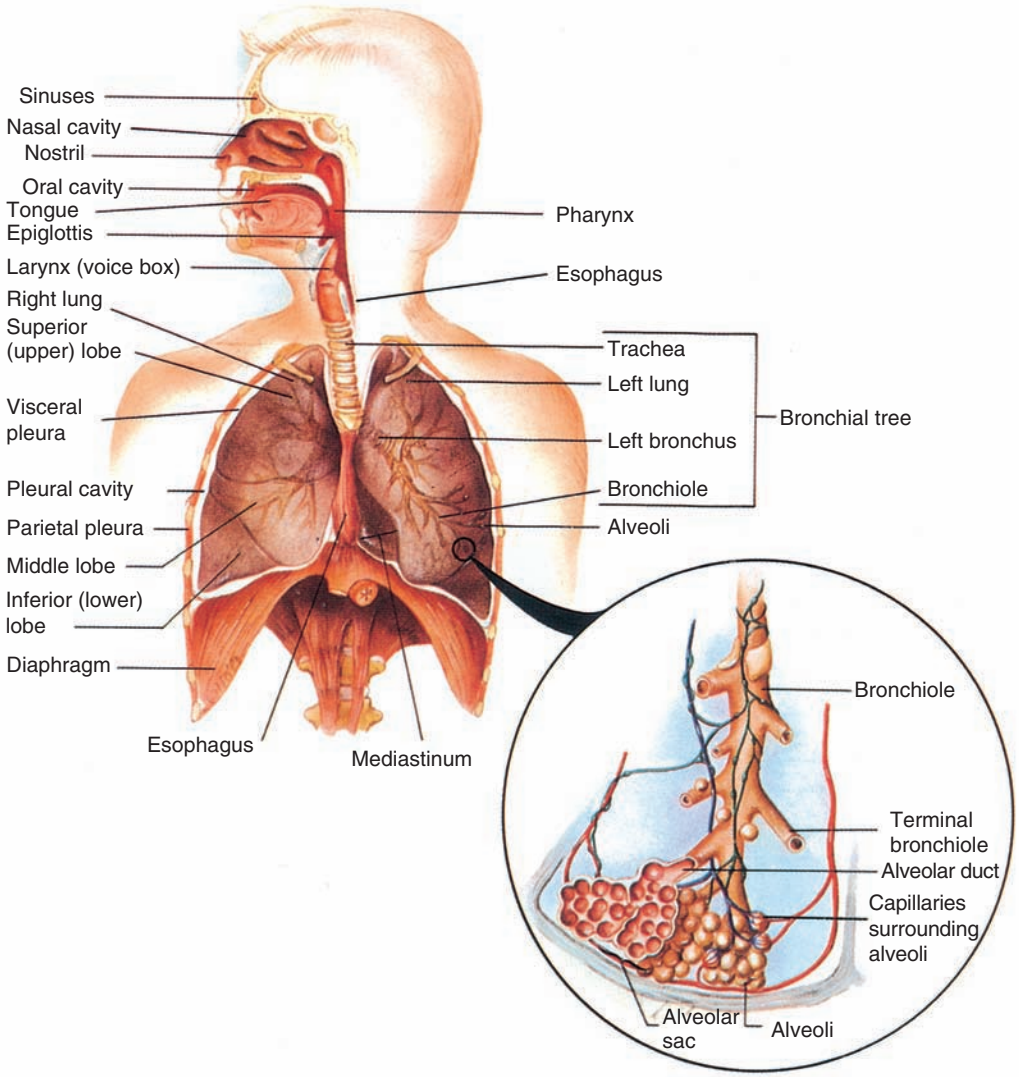


FIGURE 7-52 The respiratory system.

inhaled air to trap dust and other particles. The cilia then help move the mucous layer that lines the airways to push trapped particles toward the esophagus, where they can be swallowed. The *olfactory receptors* for the sense of smell are also located in the nose. The *nasolacrimal ducts* drain tears from the eye into the nose to provide additional moisture for the air.

Sinuses are cavities in the skull that surround the nasal area. They are connected to the nasal cavity by short ducts. The sinuses are lined with a mucous membrane that warms and moistens air. The sinuses also provide resonance for the voice.

The **pharynx,** or throat, lies directly behind the nasal cavities. As air leaves the nose, it enters the pharynx. The pharynx is divided into three sections. The *nasopharynx* is the upper portion, located behind the nasal cavities. The pharyngeal tonsils, or adenoids (lymphatic tissue), and the eustachian tube (tube to middle ear) openings are located in this section. The *oropharynx* is the middle section, located behind the oral cavity (mouth). This section receives both air from the nasopharynx and food and air from the mouth. The *laryngopharynx* is the bottom section of the pharynx. The esophagus, which carries food to the stomach, and the trachea, which carries air to and from the lungs, branch off the laryngopharynx.

The **larynx,** or voice box, lies between the pharynx and trachea. It has nine layers of cartilage. The largest, the thyroid cartilage, is commonly called the *Adam's apple.* The larynx

contains two folds, called *vocal cords*. The opening between the vocal cords is called the *glottis*. As air leaves the lungs, the vocal cords vibrate and produce sound. The tongue and lips act on the sound to produce speech. The **epiglottis,** a special leaflike piece of cartilage, closes the opening into the larynx during swallowing. This prevents food and liquids from entering the respiratory tract.

The **trachea** (windpipe) is a tube extending from the larynx to the center of the chest. It carries air between the pharynx and the bronchi. A series of C-shaped cartilages (which are open on the dorsal, or back, surfaces) help keep the trachea open.

The trachea divides into two **bronchi** near the center of the chest, a right bronchus and a left bronchus. The right bronchus is shorter, wider, and extends more vertically than the left bronchus. Each bronchus enters a lung and carries air from the trachea to the lung. In the lungs, the bronchi continue to divide into smaller and smaller bronchi until, finally, they divide into the smallest branches, called **bronchioles.** The smallest bronchioles, called *terminal bronchioles,* end in air sacs, called *alveoli.*

The **alveoli** resemble a bunch of grapes. An adult lung contains approximately 500 million alveoli. They are made of one layer of squamous epithelial tissue and contain a rich network of blood capillaries. The capillaries allow oxygen and carbon dioxide to be exchanged between the blood and the lungs. The inner surfaces of the alveoli are covered with a lipid (fatty) substance, called *surfactant,* to help prevent them from collapsing.

The divisions of the bronchi and the alveoli are found in organs called **lungs.** The right lung has three sections, or lobes: the superior, the middle, and the inferior. The left lung has only two lobes: the superior and the inferior. The left lung is smaller because the heart is located toward the left side of the chest. Each lung is enclosed in a membrane, or sac, called the **pleura.** The pleura consists of two layers of serous membrane: a visceral pleura attached to the surface of the lung, and a parietal pleura attached to the chest wall. A pleural space, located between the two layers, is filled with a thin layer of pleural fluid that lubricates the membranes and prevents friction as the lungs expand during breathing. Both of the lungs, along with the heart and major blood vessels, are located in the thoracic cavity.

PROCESS OF BREATHING

Ventilation is the process of breathing. It involves two phases: inspiration and expiration. **Inspiration** (inhalation) is the process of breathing in air. The diaphragm (dome-shaped muscle between the thoracic and abdominal cavities) and the intercostal muscles (between the ribs) contract and enlarge the thoracic cavity to create a vacuum. Air rushes in through the airways to the alveoli, where the exchange of gases takes place. When the diaphragm and intercostal muscles relax, the process of **expiration** (exhalation) occurs. Air is forced out of the lungs and air passages. This process of inspiration and expiration is known as **respiration.** The process of respiration is controlled by the respiratory center in the medulla oblongata of the brain. An increased amount of carbon dioxide in the blood, or a decreased amount of oxygen as seen in certain diseases (asthma, congestive heart failure, or emphysema), causes the center to increase the rate of respiration. Although this process is usually involuntary, a person can control the rate of breathing by breathing faster or slower.

STAGES OF RESPIRATION

There are two main stages of respiration: external respiration and internal respiration (figure 7-53). **External respiration** is the exchange of oxygen and carbon dioxide between the lungs and bloodstream. Oxygen, breathed in through the respiratory system, enters the alveoli. Because the oxygen concentration in the alveoli is higher than the oxygen concentration in the blood capillaries, oxygen leaves the alveoli and enters the capillaries and the bloodstream. Carbon dioxide, a metabolic waste product, is carried in the bloodstream. Because the carbon dioxide concentration in the capillaries is higher than the carbon dioxide concentration in the alveoli, carbon dioxide leaves the capillaries and enters the alveoli, where it is expelled from the body during exhalation. **Internal respiration** is the exchange of carbon dioxide and oxygen between the tissue cells and the bloodstream. Oxygen is carried to the tissue cells by the blood. Because the oxygen

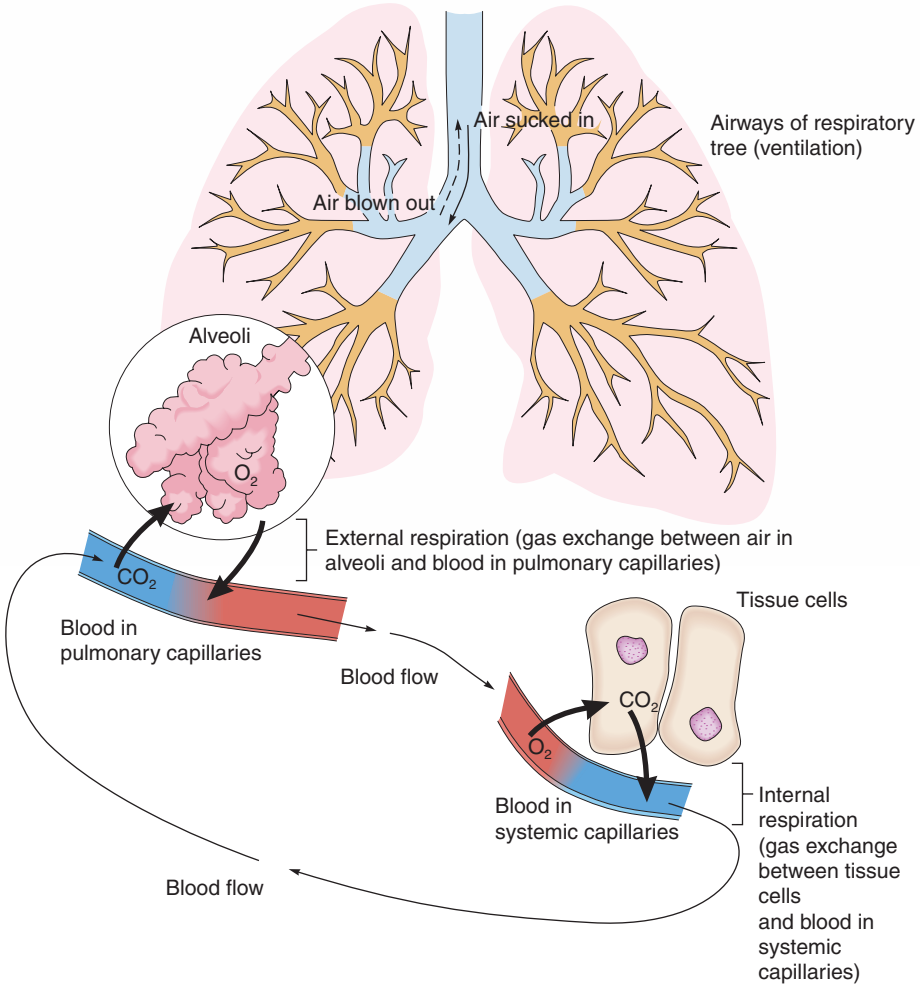


FIGURE 7-53 External and internal respiration.

concentration is higher in the blood than in the tissue cells, oxygen leaves the blood capillaries and enters the tissue cells. The cells then use the oxygen and nutrients to produce energy, water, and carbon dioxide. This process is called **cellular respiration.** Because the carbon dioxide concentration is higher in tissue cells than in the bloodstream, carbon dioxide leaves the cells and enters the bloodstream to be transported back to the lungs, where external respiration takes place.

DISEASES AND ABNORMAL CONDITIONS

Asthma

Asthma is a respiratory disorder usually caused by a sensitivity to an allergen such as dust, pollen, an animal, medications, or a food. Stress, overexertion, and infection can also cause an asthma attack, during which bronchospasms narrow the openings of the bronchioles, mucus production increases, and edema develops in the mucosal lining. Symptoms of an asthma attack include dyspnea (difficult breathing), wheezing, coughing accompanied by expectoration of sputum, and tightness in the chest. Treatment methods include bronchodilators (to enlarge the bronchioles), anti-inflammatory medications, epinephrine, and oxygen therapy. Identification and elimination of or disensitization to allergens are important in preventing asthma attacks.

Bronchitis

Bronchitis is an inflammation of the bronchi and bronchial tubes. *Acute bronchitis* is usually caused by infection and is characterized by a productive cough, dyspnea, rales (bubbly or noisy breath

sounds), chest pain, and fever. It is treated with antibiotics, expectorants (to remove excessive mucus), rest, and drinking large amounts of water. *Chronic bronchitis* results from frequent attacks of acute bronchitis and long-term exposure to pollutants or smoking. It is characterized by chronic inflammation, damaged cilia, and enlarged mucous glands. Symptoms include excessive mucus resulting in a productive cough, wheezing, dyspnea, chest pain, and prolonged air expiration. Although there is no cure, antibiotics, bronchodilators, and/or respiratory therapy are used in treatment.

Chronic Obstructive Pulmonary Disease

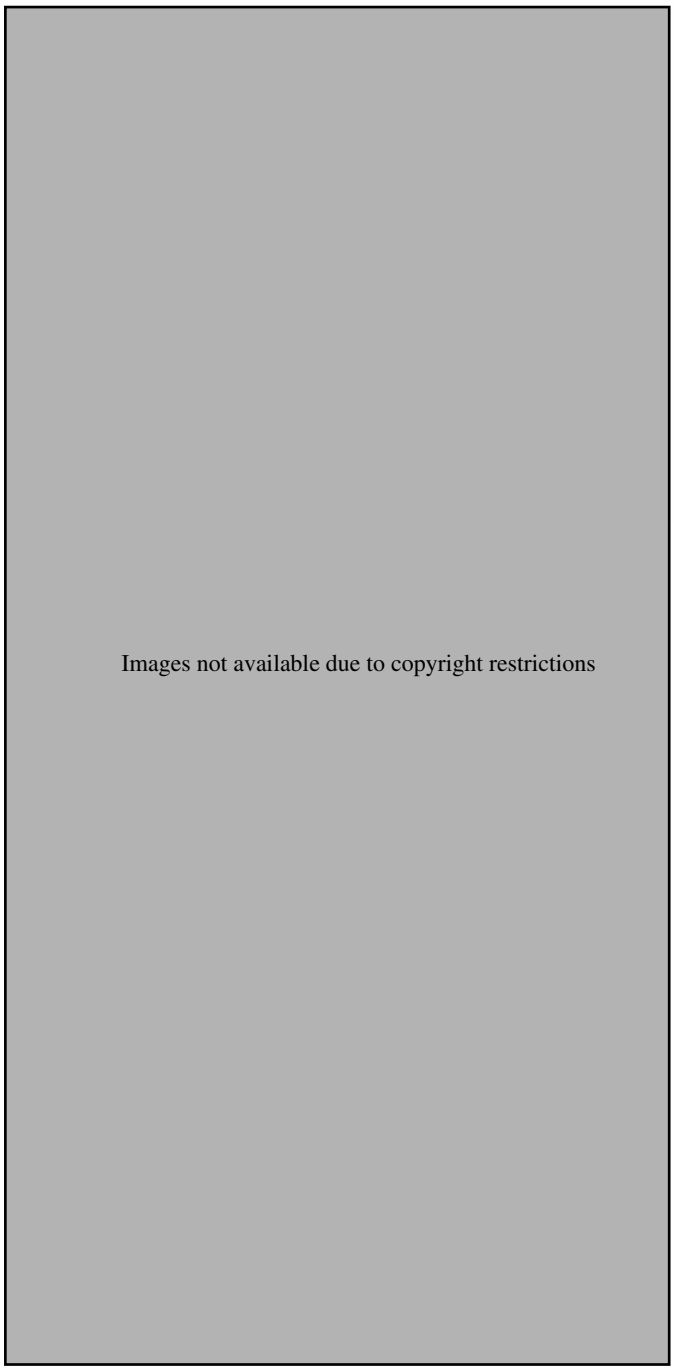
Chronic obstructive pulmonary disease (COPD) is a term used to describe any chronic lung disease that results in obstruction of the airways. Disorders such as chronic asthma, chronic bronchitis, emphysema, and tuberculosis lead to COPD. Smoking is the primary cause, but allergies and chronic respiratory infections are also factors. Treatment methods include bronchodilators, mucolytics (loosen mucus secretions), and cough medications. The prognosis is poor because damage to the lungs causes a deterioration of pulmonary function, leading to respiratory failure and death.

Emphysema

Emphysema is a noninfectious, chronic respiratory condition that occurs when the walls of the alveoli deteriorate and lose their elasticity (figure 7-54). Carbon dioxide remains trapped in the alveoli, and there is poor exchange of gases. The most common causes are heavy smoking and prolonged exposure to air pollutants. Symptoms include dyspnea, a feeling of suffocation, pain, barrel chest, chronic cough, cyanosis, rapid respirations accompanied by prolonged expirations, and eventual respiratory failure and death. Although there is no cure, treatment methods include bronchodilators, breathing exercises, prompt treatment of respiratory infections, oxygen therapy, respiratory therapy, and avoidance of smoking.

Epistaxis

Epistaxis, or a nosebleed, occurs when capillaries in the nose become congested and bleed. It can be caused by an injury or blow to the nose, hypertension, chronic infection, anticoagulant drugs, and blood diseases such as hemophilia and leukemia. Compressing the nostrils toward the septum; elevating the head and tilting it slightly forward; and applying cold compresses will usually control epistaxis, although it is sometimes necessary to insert nasal packs or cauterize (burn



and destroy) the bleeding vessels. Treatment of any underlying cause, such as hypertension, is important in preventing epistaxis.

Influenza

Influenza, or flu, is a highly contagious viral infection of the upper respiratory system. Onset is sudden, and symptoms include chills, fever, a cough, sore throat, runny nose, muscle pain, and fatigue. Treatment methods include bed rest, fluids, analgesics (for pain), and antipyretics (for fever). Antibiotics are not effective against the viruses that cause influenza, but they are sometimes given to prevent secondary infections such as pneumonia. Immunization with a flu vaccine is recommended for the elderly, individuals with chronic diseases, pregnant women, and health care workers. Because many different viruses cause influenza, vaccines are developed each year to immunize against the most common viruses identified.

Laryngitis

Laryngitis is an inflammation of the larynx and vocal cords. It frequently occurs in conjunction with other respiratory infections. Symptoms include hoarseness or loss of voice, sore throat, and dysphagia (difficult swallowing). Treatment methods include rest, limited voice use, fluids, and medication, if an infection is present.

Lung Cancer

Lung cancer is the leading cause of cancer death in both men and women (figure 7-54). It is a preventable disease because the main cause is exposure to carcinogens in tobacco, either through smoking or through exposure to "second-hand" smoke. Three common types of lung cancer include small cell, squamous cell, and adenocarcinoma. In the early stages, there are no symptoms. In later stages, symptoms include a chronic cough, hemoptysis (coughing up blood-tinged sputum), dyspnea, fatigue, weight loss, and chest pain. The prognosis (outcome) for lung cancer patients is poor because the disease is usually advanced before it is diagnosed. Treatment includes surgical removal of the cancerous sections of the lung, radiation, and/or chemotherapy.

Pleurisy

Pleurisy is an inflammation of the pleura, or membranes, of the lungs. It usually occurs in conjunction with pneumonia or other lung infections. Symptoms include sharp, stabbing pain while breathing; crepitation (grating sounds in the lungs); dyspnea; and fever. Treatment methods include rest and medications to relieve pain and inflammation. If fluid collects in the pleural space, a *thoracentesis* (withdrawal of fluid through a needle) is performed to remove the fluid and prevent compression of the lungs.

Pneumonia

Pneumonia is an inflammation or infection of the lungs characterized by exudate (a buildup of fluid) in the alveoli. It is usually caused by bacteria, viruses, protozoa, or chemicals. Symptoms include chills, fever, chest pain, productive cough, dyspnea, and fatigue. Treatment methods include bed rest, oxygen therapy, fluids, antibiotics (if indicated), respiratory therapy, and/or pain medication.

Rhinitis

Rhinitis is an inflammation of the nasal mucous membrane, resulting in a runny nose, watery eyes, sneezing, soreness, and congestion. Common causes are infections and allergens. Treatment consists of administering fluids and medications to relieve congestion. Rhinitis is usually self-limiting.

Sinusitis

Sinusitis is an inflammation of the mucous membrane lining the sinuses. One or more sinuses may be affected. Sinusitis is usually caused by a bacterium or virus. Symptoms include headache or pressure, dizziness, thick nasal discharge, congestion, and loss of voice resonance. Treatment methods include analgesics (for pain), antibiotics (if indicated), decongestants (medications to loosen secretions), and moist inhalations. Surgery is used in cases of chronic sinusitis to open the cavities and encourage drainage.

Sleep Apnea

Sleep apnea is a condition in which an individual stops breathing while asleep, causing a measurable decrease in blood oxygen levels. There

are two main kinds of sleep apnea: obstructive and central. *Obstructive sleep apnea* is caused by a blockage in the air passage that occurs when the muscles that keep the airway open relax and allow the tongue and palate to block the airway. *Central sleep apnea* is caused by a disorder in the respiratory control center of the brain. The condition is more common in men. Factors such as obesity, hypertension, smoking, alcohol ingestion, and/or the use of sedatives may increase the severity. Sleep apnea is diagnosed when more than 5 periods of apnea lasting at least 10 seconds each occur during 1 hour of sleep. The periods of apnea reduce the blood oxygen level. This causes the brain to awaken the individual, who then gasps for air and snores loudly. This interruption of the sleep cycle leads to excessive tiredness and drowsiness during the day. Treatment involves losing weight, abstaining from smoking and the use of alcohol or sedatives, and sleeping on the side or stomach. In more severe cases of obstructive sleep apnea, a continuous positive airway pressure, or CPAP (pronounced see-pap), is used to deliver pressure to the airway to keep the airway open while the individual sleeps (figure 7-55). The CPAP consists of a mask that is fit securely against the face. Tubing connects the mask with a blower device that can be adjusted to deliver air at different levels of pressure. Treatment of central sleep apnea usually involves the use of medications to stimulate breathing.

Tuberculosis

Tuberculosis (TB) is an infectious lung disease caused by the bacterium *Mycobacterium tuberculosis.* At times, white blood cells surround the invading TB organisms and wall them off, creating nodules, called *tubercles,* in the lungs. The TB organisms remain dormant in the tubercles but can cause an active case of TB later, if body resistance is lowered. Symptoms of an active case of TB include fatigue, fever, night sweats, weight loss, hemoptysis (coughing up blood-tinged sputum), and chest pain. Treatment includes administering drugs for one or more years to destroy the bacteria. Good nutrition and rest are also important. In recent years, a new strain of the TB bacteria resistant to drug therapy has created concern that TB will become a widespread infectious disease.

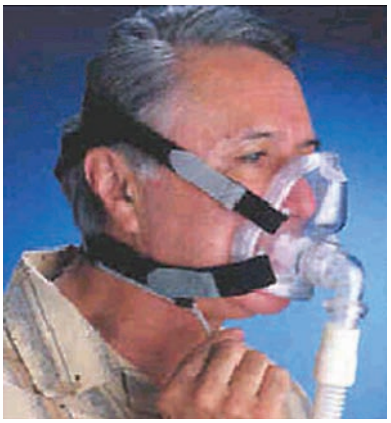


FIGURE 7-55 The continuous positive airway pressure (CPAP) mask attaches to a blower device that uses air pressure to keep the airway open and prevent sleep apnea.

Upper Respiratory Infection

An upper respiratory infection (URI), or common cold, is an inflammation of the mucous membrane lining the upper respiratory tract. Caused by viruses, URIs are highly contagious. Symptoms include fever, runny nose, watery eyes, congestion, sore throat, and hacking cough. There is no cure, and symptoms usually last approximately one week. Analgesics (for pain), antipyretics (for fever), rest, increased fluid intake, and antihistamines (to relieve congestion) are used to treat the symptoms.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:10, Respiratory System.*

7:11 Digestive System

Objectives

After completing this section, you should be able to:

- Label the major organs on a diagram of the digestive system
- Identify at least three organs that are located in the mouth and aid in the initial breakdown of food
- Cite two functions of the salivary glands
- Describe how the gastric juices act on food in the stomach
- Explain how food is absorbed into the body by the villi in the small intestine

- List at least three functions of the large intestine
- List at least four functions of the liver
- Explain how the pancreas helps digest foods
- Describe at least five diseases of the digestive system
- Define, pronounce, and spell all key terms

KEY TERMS

alimentary canal *(ahl-ih-men′-tar″-ee)*
anus
colon *(coh′-lun)*
digestive system
duodenum *(dew-oh-deh′-num)*
esophagus *(ee″-sof′-eh-gus)*
gallbladder
hard palate
ileum *(ill′-ee″-um)*
jejunum *(jeh-jew′-num)*
large intestine
liver
mouth
pancreas *(pan′-cree″-as)*
peristalsis *(pair″-ih-stall″-sis)*
pharynx *(far′-inks)*
rectum
salivary glands
small intestine
soft palate
stomach
teeth
tongue
vermiform appendix
villi *(vil′-lie)*

RELATED HEALTH CAREERS

- Dental Assistant
- Dental Hygienist
- Dentist
- Dietetic Assistant
- Dietitian
- Enterostomal RN or Technician
- Gastroenterologist
- Hepatologist
- Internist
- Proctologist

7:11 INFORMATION

The **digestive system,** also known as the *gastrointestinal system,* is responsible for the physical and chemical breakdown of food so that it can be taken into the bloodstream and used by body cells and tissues. The system consists of the alimentary canal and accessory organs (figure 7-56). The **alimentary canal** is a long, muscular tube that begins at the mouth and includes the mouth (oral cavity), pharynx, esophagus, stomach, small intestine, large intestine, and anus. The accessory organs are the salivary glands, tongue, teeth, liver, gallbladder, and pancreas.

PARTS OF THE ALIMENTARY CANAL

The **mouth,** also called the *buccal cavity* (figure 7-57) receives food as it enters the body. While food is in the mouth, it is tasted, broken down physically by the teeth, lubricated and partially digested by saliva, and swallowed. The **teeth** are special structures in the mouth that physically break down food by chewing and grinding. This process is called *mastication.* The **tongue** is a muscular organ that contains special receptors called *taste buds.* The taste buds allow a person to taste sweet, salty, sour, and bitter sensations. The

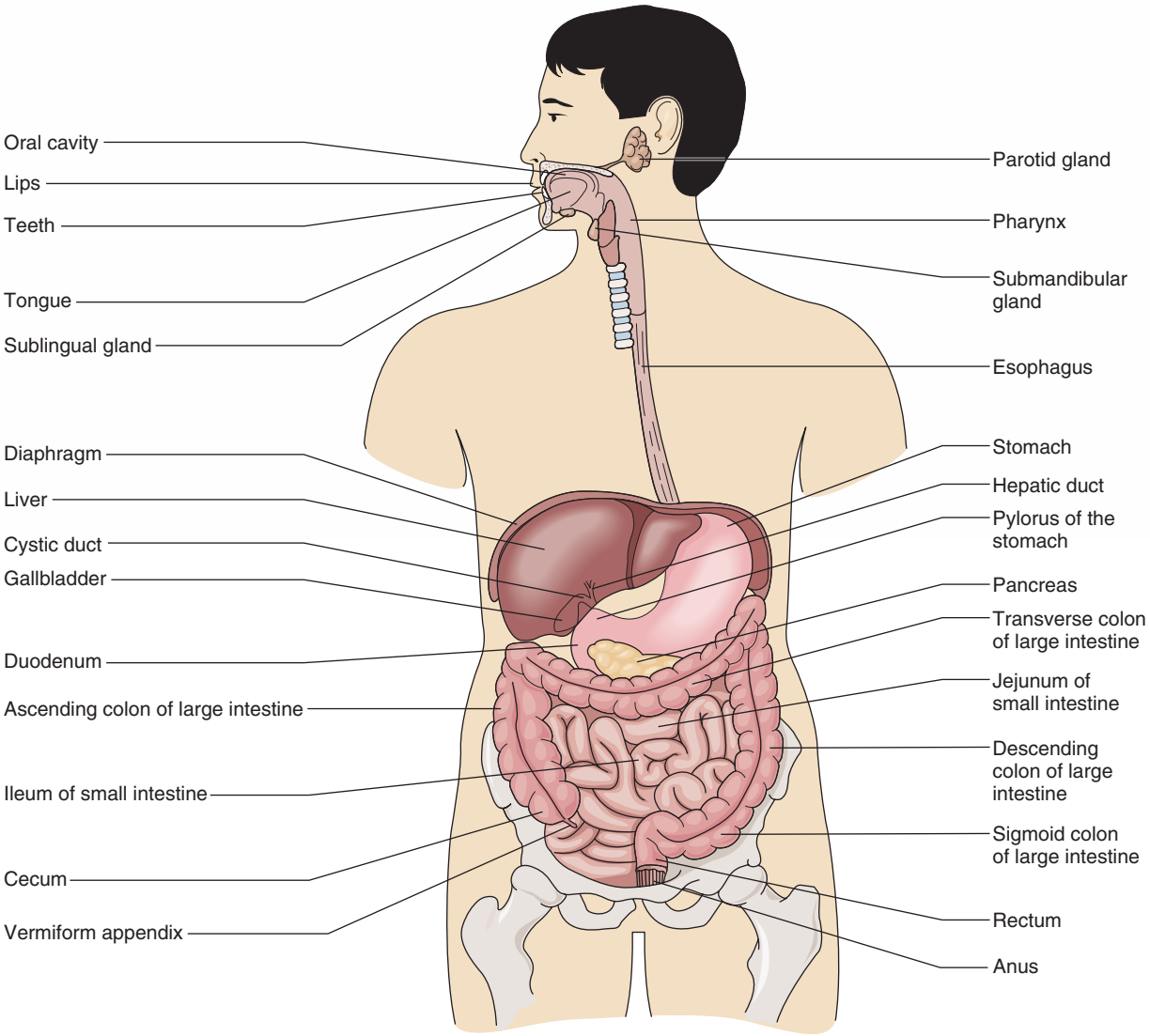


FIGURE 7-56 The digestive system.

tongue also aids in chewing and swallowing food. The **hard palate** is the bony structure that forms the roof of the mouth and separates the mouth from the nasal cavities. Behind the hard palate is the **soft palate,** which separates the mouth from the nasopharynx. The *uvula,* a cone-shaped muscular structure, hangs from the middle of the soft palate. It prevents food from entering the nasopharynx during swallowing. Three pairs of **salivary glands,** the parotid, sublingual, and submandibular, produce a liquid called *saliva.* Saliva lubricates the mouth during speech and chewing and moistens food so that it can be swallowed easily. Saliva also contains an enzyme (a substance that speeds up a chemical reaction) called *salivary amylase,* formerly known as *ptyalin.* Salivary amylase begins the chemical breakdown of carbohydrates, or starches, into sugars that can be taken into the body.

After the food is chewed and mixed with saliva, it is called a *bolus.* When the bolus is swallowed, it enters the **pharynx** (throat). The pharynx is a tube that carries both air and food. It carries the air to the trachea, or windpipe, and food to the esophagus. When a bolus is being swallowed, muscle action causes the epiglottis to close over the larynx, preventing the bolus from entering the respiratory tract and causing it to enter the esophagus.

The **esophagus** is the muscular tube dorsal to (behind) the trachea. This tube receives the bolus from the pharynx and carries the bolus to the stomach. The esophagus, like the remaining part of the alimentary canal, relies on a rhythmic,

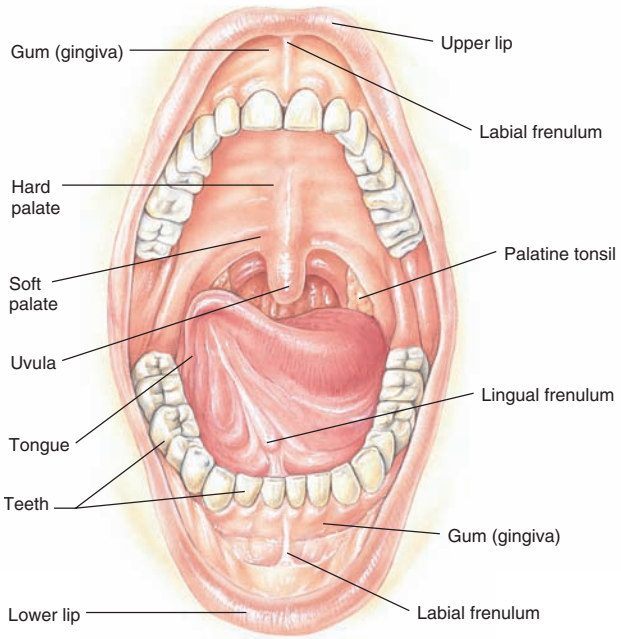


FIGURE 7-57 Parts of the oral cavity, or mouth.

wavelike, involuntary movement of its muscles called **peristalsis** to move the food in a forward direction.

The **stomach** is an enlarged part of the alimentary canal. It receives the food from the esophagus. The mucous membrane lining of the stomach contains folds, called *rugae.* These disappear as the stomach fills with food and expands. The cardiac sphincter, a circular muscle between the esophagus and stomach, closes after food enters the stomach and prevents food from going back up into the esophagus. The pyloric sphincter, a circular muscle between the stomach and small intestine, keeps food in the stomach until the food is ready to enter the small intestine. Food usually remains in the stomach for approximately 2–4 hours. During this time, food is converted into a semifluid material, called *chyme,* by gastric juices produced by glands in the stomach. The gastric juices contain hydrochloric acid and enzymes. Hydrochloric acid kills bacteria, facilitates iron absorption, and activates the enzyme pepsin. The enzymes in gastric juices include lipase, which starts the chemical breakdown of fats, and pepsin, which starts protein digestion. In infants, the enzyme rennin is also secreted to aid in the digestion of milk. Rennin is not present in adults.

When the food, in the form of chyme, leaves the stomach, it enters the small intestine. The **small intestine** is a coiled section of the alimentary canal. It is approximately 20 feet in length and 1 inch in diameter, and is divided into three sections: the duodenum, the jejunum, and the ileum. The **duodenum** is the first 9–10 inches of the small intestine. Bile (from the gallbladder and liver) and pancreatic juice (from the pancreas) enter this section through ducts, or tubes. The **jejunum** is approximately 8 feet in length and forms the middle section of the small intestine. The **ileum** is the final 12 feet of the small intestine, and it connects with the large intestine at the cecum. The circular muscle called the *ileocecal valve* separates the ileum and cecum and prevents food from returning to the ileum. While food is in the small intestine, the process of digestion is completed, and the products of digestion are absorbed into the bloodstream for use by the body cells. Intestinal juices, produced by the small intestine, contain the enzymes maltase, sucrase, and lactase, which break down sugars into simpler forms. The intestinal juices also contain enzymes known as *peptidases,* which complete the digestion of proteins, and *steapsin (lipase),* which aids in the digestion of fat. Bile from the liver and gallbladder emulsifies (physically breaks down) fats. Enzymes from the pancreatic juice complete the process of digestion. These enzymes include pancreatic *amylase* or *amylopsin* (which acts on sugars), *trypsin* and *chymotrypsin* (which act on proteins), and *lipase* or *steapsin* (which acts on fats). After food has been digested, it is absorbed into the bloodstream. The walls of the small intestine are lined with fingerlike projections called **villi** (figure 7-58). The villi contain blood capillaries and lacteals. The blood capillaries absorb the digested nutrients and carry them to the liver, where they are either stored or released into general circulation for use by the body cells. The lacteals absorb most of the digested fats and carry them to the thoracic duct in the lymphatic system, which releases them into the circulatory system. When food has completed its passage through the small intestine, only wastes, indigestible materials, and excess water remain.

The **large intestine** is the final section of the alimentary canal. It is approximately 5 feet in length and 2 inches in diameter. Functions include absorption of water and any remaining nutrients; storage of indigestible materials before they are eliminated from the body; synthesis (formation) and absorption of some B-complex vitamins and vitamin K by bacteria present in the

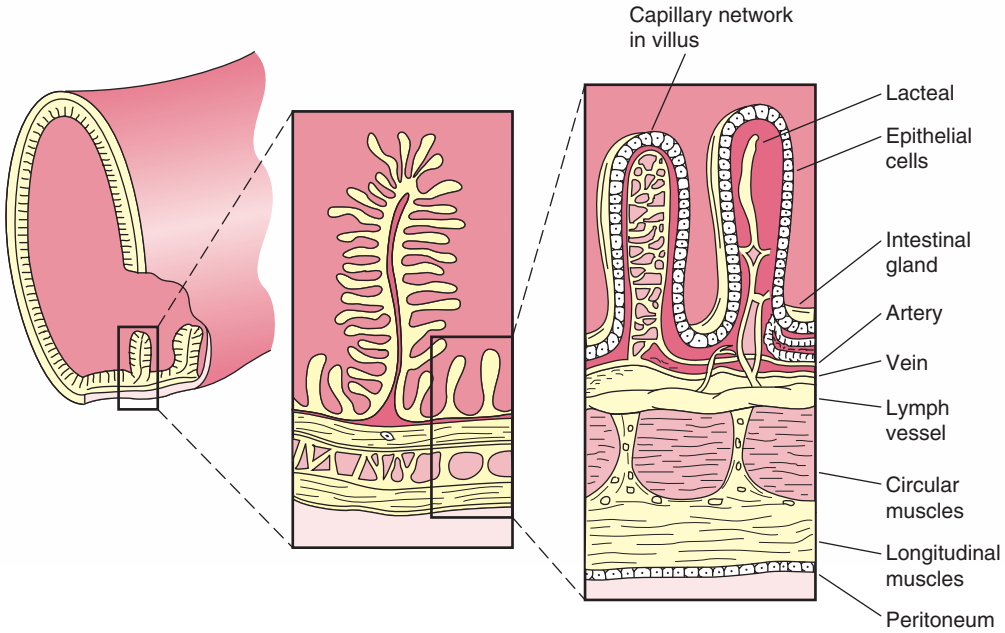


FIGURE 7-58 Lymphatic and blood capillaries in the villi of the small intestine provide for the absorption of the products of digestion.

intestine; and transportation of waste products out of the alimentary canal. The large intestine is divided into a series of connected sections. The *cecum* is the first section and is connected to the ileum of the small intestine. It contains a small projection, called the **vermiform appendix.** The next section, the **colon,** has several divisions. The *ascending colon* continues up on the right side of the body from the cecum to the lower part of the liver. The *transverse colon* extends across the abdomen, below the liver and stomach and above the small intestine. The *descending colon* extends down the left side of the body. It connects with the *sigmoid colon,* an S-shaped section that joins with the rectum. The **rectum** is the final 6–8 inches of the large intestine and is a storage area for indigestibles and wastes. It has a narrow canal, called the *anal canal,* which opens at a hole, called the **anus.** Fecal material, or stool, the final waste product of the digestive process, is expelled through this opening.

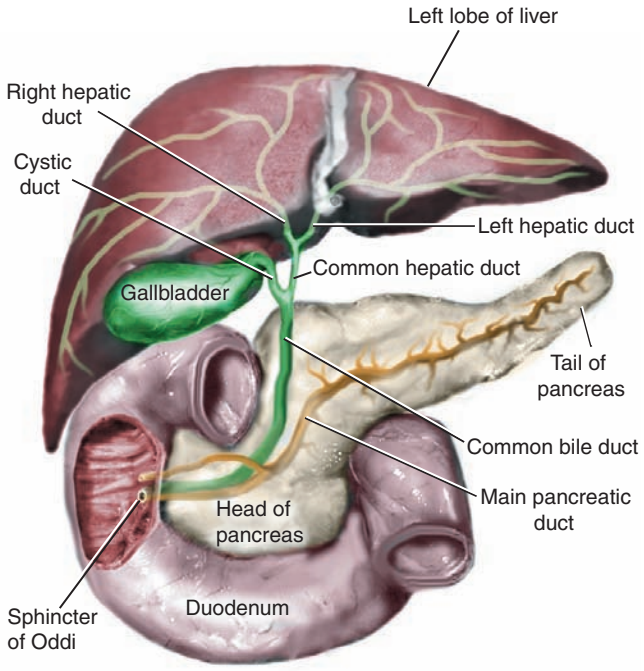


FIGURE 7-59 The liver, gallbladder, and pancreas.

ACCESSORY ORGANS

The **liver** (figure 7-59), is the largest gland in the body and is an accessory organ to the digestive system. It is located under the diaphragm and in the upper right quadrant of the abdomen. The liver secretes bile, which is used to emulsify fats in the digestive tract. Bile also makes fats water soluble, which is necessary for absorption. The liver stores sugar in the form of glycogen. The glycogen is converted to glucose and released into the bloodstream when additional blood sugar is needed. The liver also stores iron and certain vitamins. It produces heparin, which prevents clotting of the blood; blood proteins such as fibrinogen and prothrombin, which aid in clot-

ting of the blood; and cholesterol. Finally, the liver detoxifies (renders less harmful) substances such as alcohol and pesticides, and destroys bacteria that have been taken into the blood from the intestine.

The **gallbladder** is a small, muscular sac located under the liver and attached to it by connective tissue. It stores and concentrates bile, which it receives from the liver. When the bile is needed to emulsify fats in the digestive tract, the gallbladder contracts and pushes the bile through the cystic duct into the common bile duct, which drains into the duodenum.

The **pancreas** is a glandular organ located behind the stomach. It produces pancreatic juices, which contain enzymes to digest food. These juices enter the duodenum through the pancreatic duct. The enzymes in the juices include pancreatic amylase or amylopsin (to break down sugars), trypsin and chymotrypsin (to break down proteins), and lipase or steapsin (to act on fats). The pancreas also produces insulin, which is secreted into the bloodstream. Insulin regulates the metabolism, or burning, of carbohydrates to convert glucose (blood sugar) to energy.

DISEASES AND ABNORMAL CONDITIONS

Appendicitis

Appendicitis is an acute inflammation of the appendix, usually resulting from an obstruction and infection. Symptoms include generalized abdominal pain that later localizes at the lower right quadrant, nausea and vomiting, mild fever, and elevated white blood cell count. If the appendix ruptures, the infectious material will spill into the peritoneal cavity and cause peritonitis, a serious condition. Appendicitis is treated by an appendectomy (surgical removal of the appendix).

Cholecystitis

Cholecystitis is an inflammation of the gallbladder. When gallstones form from crystallized cholesterol, bile salts, and bile pigments, the condition is known as *cholelithiasis*. Symptoms frequently occur after eating fatty foods and include indigestion, nausea and vomiting, and pain that starts under the rib cage and radiates to the right shoulder. If a gallstone blocks the bile ducts, the gallbladder can rupture and cause peritonitis. Treatment methods include a low-fat diet, lithotripsy (shock waves that are used to shatter the gallstones), and/or a cholecystectomy (surgical removal of the gallbladder).

Cirrhosis

Cirrhosis is a chronic destruction of liver cells accompanied by the formation of fibrous connective and scar tissue. Causes include hepatitis, bile duct disease, chemical toxins, and malnutrition associated with alcoholism. Symptoms vary and become more severe as the disease progresses. Some common symptoms are liver enlargement, anemia, indigestion, nausea, edema in the legs and feet, hematemesis (vomiting blood), nosebleeds, jaundice (yellow discoloration), and ascites (an accumulation of fluid in the abdominal peritoneal cavity). When the liver fails, disorientation, hallucinations, hepatic coma, and death occur. Treatment is directed toward preventing further damage to the liver. Alcohol avoidance, proper nutrition, vitamin supplements, diuretics (to reduce ascites and edema), rest, infection prevention, and appropriate exercise are encouraged. A liver transplant may be performed if too much of the liver is destroyed.

Constipation

Constipation is when fecal material remains in the colon too long, causing excessive reabsorption of water. The feces or stool becomes hard, dry, and difficult to eliminate. Causes include poor bowel habits, chronic laxative use leading to a "lazy" bowel, a diet low in fiber, and certain digestive diseases. The condition is usually corrected by a high-fiber diet, adequate fluids, and exercise. Although laxatives are sometimes used to stimulate defecation, frequent laxative use may be habit forming and lead to chronic constipation.

Diarrhea

Diarrhea is a condition characterized by frequent watery stools. Causes include infection, stress, diet, an irritated colon, and toxic substances. Diarrhea can be extremely dangerous in infants and small children because of the excessive fluid

loss. Treatment is directed toward eliminating the cause, providing adequate fluid intake, and modifying the diet.

Diverticulitis

Diverticulitis is an inflammation of the diverticula, pouches (or sacs) that form in the intestine as the mucosal lining pushes through the surrounding muscle. When fecal material and bacteria become trapped in the diverticula, inflammation occurs. This can result in an abscess or rupture, leading to peritonitis. Symptoms vary depending on the amount of inflammation but may include abdominal pain, irregular bowel movements, flatus (gas), constipation or diarrhea, abdominal distention (swelling), low-grade fever, and nausea and vomiting. Treatment methods include antibiotics, stool-softening medications, pain medications, high-fiber diet, and in severe cases, surgery to remove the affected section of colon.

Gastroenteritis

Gastroenteritis is an inflammation of the mucous membrane that lines the stomach and intestinal tract. Causes include food poisoning, infection, and toxins. Symptoms include abdominal cramping, nausea, vomiting, fever, and diarrhea. Usual treatment methods are rest and increased fluid intake. In severe cases, antibiotics, intravenous fluids, and medications to slow peristalsis may be used.

Hemorrhoids

Hemorrhoids are painful dilated or varicose veins of the rectum and/or anus. They may be caused by straining to defecate, constipation, pressure during pregnancy, insufficient fluid intake, laxative abuse, and prolonged sitting or standing. Symptoms include pain, itching, and bleeding. Treatment methods include a high-fiber diet; increased fluid intake; stool softeners; sitz baths or warm, moist compresses; and in some cases, a hemorrhoidectomy (surgical removal of the hemorrhoids).

Hepatitis

Hepatitis is a viral inflammation of the liver. *Type A, HAV* or infectious hepatitis, is highly contagious and is transmitted in food or water contaminated by the feces of an infected person. It is the most benign form of hepatitis and is usually self-limiting. A vaccine is available to prevent hepatitis A. *Type B, HBV,* or serum hepatitis, is transmitted by body fluids including blood, serum, saliva, urine, semen, vaginal secretions, and breast milk. It is more serious than type A and can lead to chronic hepatitis or to cirrhosis of the liver. A vaccine developed to prevent hepatitis B is recommended for all health care workers. *Type C,* or *HCV,* is also spread through contact with blood or body fluids. The main methods of transmission include sharing needles while injecting drugs, getting stuck with a contaminated needle or sharps while on the job, or passing the virus from an infected mother to the infant during birth. Hepatitis C is much more likely to progress to chronic hepatitis, cirrhosis, or both. There is no vaccine for type C. Other strains of the hepatitis virus that have been identified include types D and E. Symptoms include fever, anorexia (lack of appetite), nausea, vomiting, fatigue, dark-colored urine, clay-colored stool, myalgia (muscle pain), enlarged liver, and jaundice. Treatment methods include rest and a diet high in protein and calories and low in fat. A liver transplant may be necessary if the liver is severely damaged.

Hernia

A hernia, or rupture, occurs when an internal organ pushes through a weakened area or natural opening in a body wall. A hiatal hernia is when the stomach protrudes through the diaphragm and into the chest cavity through the opening for the esophagus (figure 7-60). Symptoms include heartburn, stomach distention, chest pain, and difficult swallowing. Treatment methods include a bland diet, small frequent meals, staying upright after eating, and surgical repair. An inguinal hernia is when a section of the small intestine protrudes through the inguinal rings of the lower abdominal wall. If the hernia cannot be reduced (pushed back in place), a herniorrhaphy (surgical repair) is performed.

Pancreatitis

Pancreatitis is an inflammation of the pancreas. The pancreatic enzymes begin to digest the pancreas itself, and the pancreas becomes necrotic, inflamed, and edematous. If the damage extends

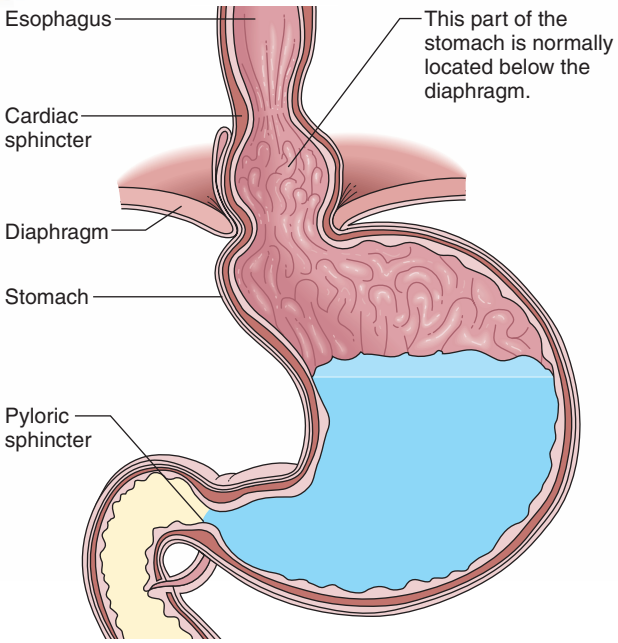


FIGURE 7-60 A hiatal hernia occurs when the stomach protrudes through the diaphragm.

to blood vessels in the pancreas, hemorrhage and shock occur. Pancreatitis may be caused by excessive alcohol consumption or blockage of pancreatic ducts by gallstones. Many cases are *idiopathic*, or of unknown cause. Symptoms include severe abdominal pain that radiates to the back, nausea, vomiting, diaphoresis (excessive perspiration), and jaundice if swelling blocks the common bile duct. Treatment depends on the cause. A cholecystectomy, removal of the gall bladder, is performed if gallstones are the cause. Analgesics for pain and nutritional support are used if the cause of pancreatitis is alcoholism or idiopathic. This type of pancreatitis has a poor prognosis and often results in death.

Peritonitis

Peritonitis, an inflammation of the abdominal peritoneal cavity, usually occurs when a rupture in the intestine allows the intestine contents to enter the peritoneal cavity. A ruptured appendix or gallbladder can cause this condition. Symptoms include abdominal pain and distention, fever, nausea, and vomiting. Treatment methods include antibiotics and, if necessary, surgical repair of the damaged intestine.

Ulcer

An ulcer is an open sore on the lining of the digestive tract. Peptic ulcers include gastric (stomach) ulcers and duodenal ulcers. The major cause is a bacterium, *Helicobacter pylori (H. pylori),* that burrows into the stomach membranes, allowing stomach acids and digestive juices to create an ulcer. Symptoms include burning pain, indigestion, hematemesis (bloody vomitus), and melena (dark, tarry stool). Usual treatment methods are antacids, a bland diet, decreased stress, and avoidance of irritants such as alcohol, fried foods, tobacco, and caffeine. If the *H. pylori* bacteria are present, treatment with antibiotics and a bismuth preparation, such as Pepto-Bismol, usually cures the condition. In severe cases, surgery is performed to remove the affected area.

Ulcerative Colitis

Ulcerative colitis is a severe inflammation of the colon accompanied by the formation of ulcers and abscesses. It is thought to be caused by stress, food allergy, or an autoimmune reaction. The main symptom is diarrhea containing blood, pus, and mucus. Other symptoms include weight loss, weakness, abdominal pain, anemia, and anorexia. Periods of remission and exacerbation are common. Treatment is directed toward controlling inflammation, reducing stress with mild sedation, maintaining proper nutrition, and avoiding substances that aggravate the condition. In some cases, surgical removal of the affected colon and creation of a colostomy (an artificial opening in the colon that allows fecal material to be excreted through the abdominal wall) is necessary.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:11, Digestive System.*

7:12 Urinary System

Objectives

After completing this section, you should be able to:

- Label a diagram of the urinary system
- Explain the action of the following parts of a nephron: glomerulus, Bowman's capsule, convoluted tubule, and collecting tubule

- State the functions of the ureter, bladder, and urethra
- Explain why the urethra is different in male and female individuals
- Interpret at least five terms used to describe conditions that affect urination
- Describe at least three diseases of the urinary system
- Define, pronounce, and spell all key terms

KEY TERMS

bladder
Bowman's capsule
cortex *(core'-tex)*
excretory system *(ex'-kreh-tor"-ee)*
glomerulus *(glow"-mare'-you-luss)*
hilum
homeostasis
kidneys
medulla *(meh-due'-la)*
nephrons *(nef'-ronz)*
renal pelvis
ureters *(you'-reh"-turz)*
urethra *(you"-wreath'-rah)*
urinary meatus *(you'-rih-nah-ree" me-ate'-as)*
urinary system
urine
void

RELATED HEALTH CAREERS

- Dialysis Technician
- Medical Laboratory Technologist/Technician
- Nephrologist
- Urologist

7:12 INFORMATION

The **urinary system,** also known as the **excretory system,** is responsible for removing certain wastes and excess water from the body and for maintaining the body's acid–base balance. It is one of the major body systems that maintains **homeostasis,** a state of equilibrium or constant state of natural balance in the internal environment of the body. The parts of the urinary system are two kidneys, two ureters, one bladder, and one urethra (figure 7-61).

The **kidneys** (figure 7-62) are two bean-shaped organs located on either side of the vertebral column, behind the upper part of the abdominal cavity, and separated from this cavity by the peritoneum. Their location is often described as retroperitoneal. The kidneys are protected by the ribs and a heavy cushion of fat. Connective tissue helps hold the kidneys in position. Each kidney is enclosed in a mass of fatty tissue, called an *adipose capsule,* and covered externally by a tough, fibrous tissue, called the *renal fascia,* or *fibrous capsule.*

Each kidney is divided into two main sections: the cortex and the medulla. The **cortex** is the outer section of the kidney. It contains most of the nephrons, which aid in the production of urine. The **medulla** is the inner section of the kidney. It contains most of the collecting tubules, which carry the urine from the nephrons through the kidney. Each kidney has a **hilum,** a notched or indented area through which the ureter, nerves, blood vessels, and lymph vessels enter and leave the kidney.

Nephrons (figure 7-63) are microscopic filtering units located in the kidneys. There are more than one million nephrons per kidney. Each

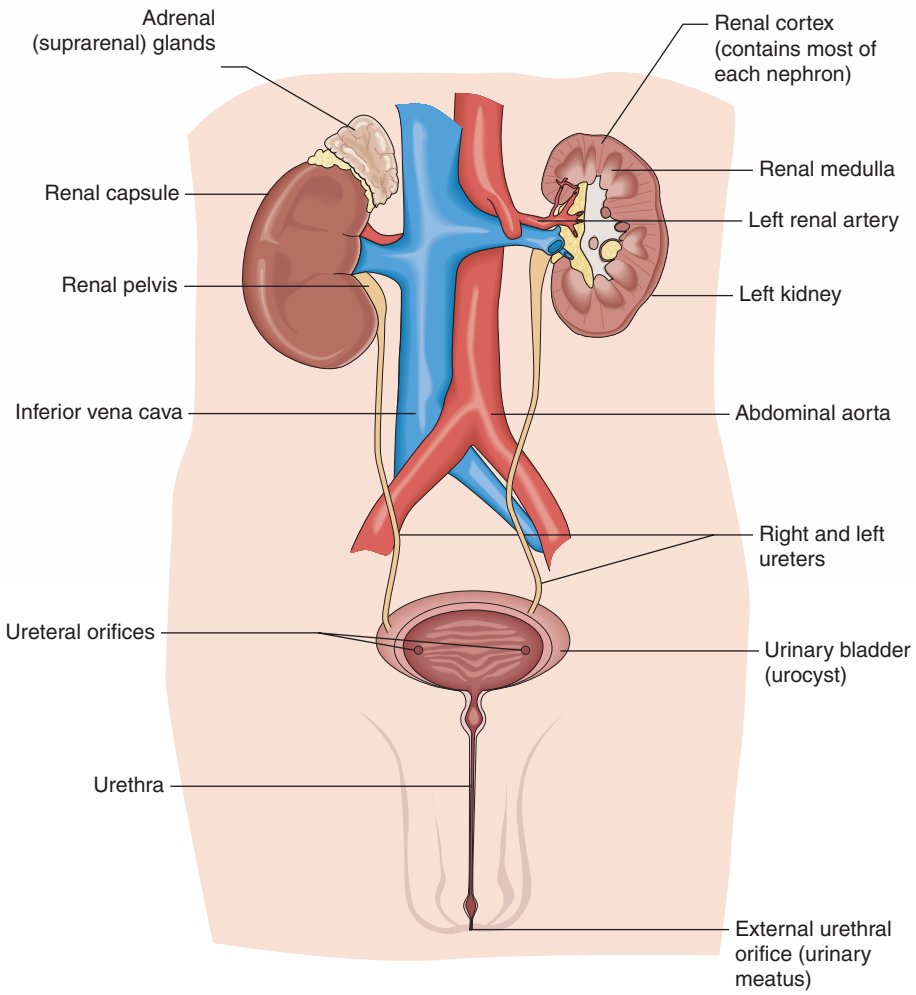


FIGURE 7-61 The urinary system.

nephron consists of a glomerulus, a Bowman's capsule, a proximal convoluted tubule, a distal convoluted tubule, and a collecting duct (tubule). The renal artery carries blood to the kidney. Branches of the renal artery pass through the medulla to the cortex, where the blood enters the first part of the nephron, the **glomerulus,** which is a cluster of capillaries. As blood passes through the glomerulus, water, mineral salts, glucose (sugar), metabolic products, and other substances are filtered out of the blood. Red blood cells and proteins are not filtered out. The filtered blood leaves the glomerulus and eventually makes its way to the renal vein, which carries it away from the kidney. The substances filtered out in the glomerulus enter the next section of the nephron, the **Bowman's capsule.** The Bowman's capsule is a C-shaped structure that surrounds the glomerulus and is the start of the convoluted tubule. It picks up the materials filtered from the blood in the glomerulus and passes them into the convoluted tubule. As these materials pass through the various sections of the tubule, substances needed by the body are reabsorbed and returned to the blood capillaries. By the time the filtered materials pass through the tubule, most of the water, glucose, vitamins, and mineral salts have been reabsorbed. Excess glucose and mineral salts, some water, and wastes (including urea, uric acid, and creatinine) remain in the tubule and become known as the concentrated liquid called *urine*. The urine then enters collecting ducts, or tubules, located in the medulla. These collecting ducts empty into the **renal pelvis** (renal basin), a funnel-shaped structure that is the first section of the ureter.

The **ureters** are two muscular tubes approximately 10–12 inches in length. One extends from the renal pelvis of each kidney to the bladder. Peristalsis (a rhythmic, wavelike motion of muscle) moves the urine through the ureter from the kidney to the bladder.

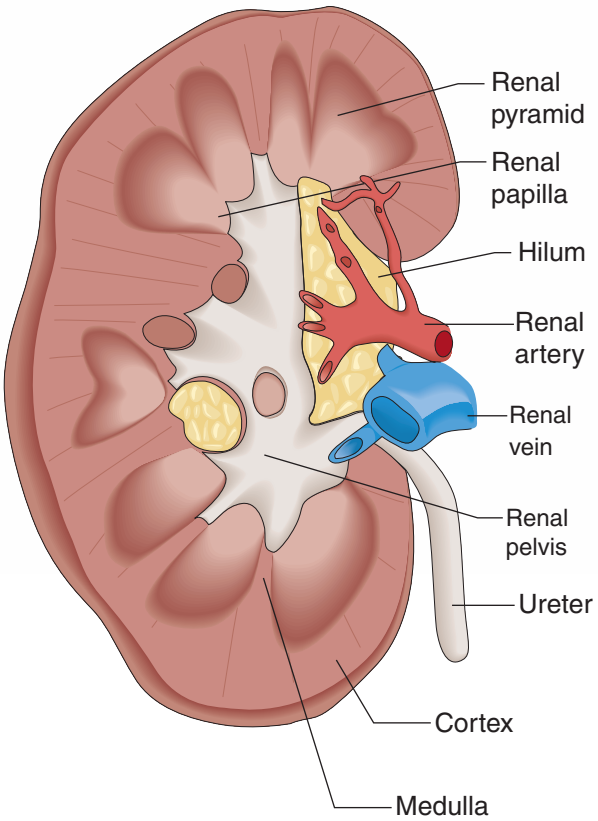


FIGURE 7-62 A cross section of the kidney.

The **bladder** is a hollow, muscular sac that lies behind the symphysis pubis and at the midline of the pelvic cavity. It has a mucous membrane lining arranged in a series of folds, called *rugae*. The rugae disappear as the bladder expands to fill with urine. Three layers of visceral (smooth) muscle form the walls of the bladder, which receives the urine from the ureters and stores the urine until it is eliminated from the body. Although the urge to **void** (urinate, or micturate) occurs when the bladder contains approximately 250 milliliters (mL) (1 cup) of urine, the bladder can hold much more. A circular sphincter muscle controls the opening to the bladder to prevent emptying. When the bladder is full, receptors in the bladder wall send out a reflex action, which opens the muscle. Infants cannot control this reflex action. As children age, however, they learn to control the reflex.

The **urethra** is the tube that carries the urine from the bladder to the outside. The external opening is called the **urinary meatus.** The urethra is different in female individuals and male individual. In females, it is a tube approximately 3.75 cm (1.5 inches) in length that opens in front of the vagina and carries only urine to the outside. In males, the urethra is approximately 20 cm (8 inches) in length and passes through the prostate gland and out through the penis. It carries both urine (from the urinary system) and semen (from the reproductive system), although not at the same time.

Urine is the liquid waste product produced by the urinary system. It is approximately 95 percent water. Waste products dissolved in this liquid are urea, uric acid, creatinine, mineral salts, and various pigments. Excess useful products, such as sugar, can also be found in the urine, but their presence usually indicates disease. Approximately 1,500–2,000 milliliters (mL) (1.5–2 quarts) of urine are produced daily from the approximately 150 quarts of liquid that is filtered through the kidneys.

Terms used to describe conditions that affect urination include:

- *Polyuria*: excessive urination
- *Oliguria*: below normal amounts of urination
- *Anuria*: absence of urination
- *Hematuria*: blood in the urine
- *Pyuria*: pus in the urine
- *Nocturia*: urination at night
- *Dysuria*: painful urination
- *Retention*: inability to empty the bladder
- *Incontinence*: involuntary urination
- *Proteinuria*: protein in the urine
- *Albuminuria*: albumin (a blood protein) in the urine

DISEASES AND ABNORMAL CONDITIONS

Cystitis

Cystitis is an inflammation of the bladder, usually caused by pathogens entering the urinary meatus. It is more common in female individuals because of the shortness of the urethra. Symptoms include frequent urination, dysuria, a burning sensation during urination, hematuria, lower back pain, bladder spasm, and fever. Treatment methods are antibiotics and increased fluid intake.

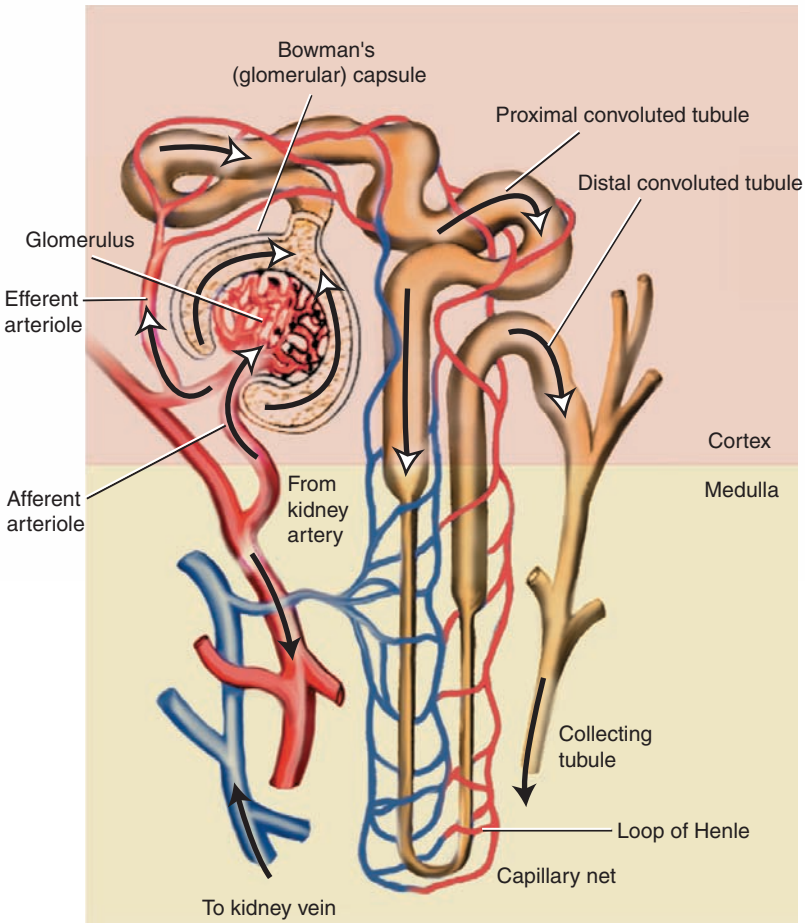


FIGURE 7-63 A nephron unit.

Glomerulonephritis

Glomerulonephritis, or nephritis, is an inflammation of the glomerulus of the kidney. *Acute glomerulonephritis* usually follows a streptococcal infection such as strep throat, scarlet fever, or rheumatic fever. Symptoms include chills, fever, fatigue, edema, oliguria, hematuria, and albuminuria (protein in the urine). Treatment methods include rest, restriction of salt, maintenance of fluid and electrolyte balance, antipyretics (for fever), diuretics (for edema), and at times, antibiotics. With treatment, kidney function is usually restored, and the prognosis is good. Repeated attacks can cause a chronic condition. *Chronic glomerulonephritis* is a progressive disease that causes scarring and sclerosing of the glomeruli. Early symptoms include hematuria, albuminuria, and hypertension. As the disease progresses and additional glomeruli are destroyed, edema, fatigue, anemia, hypertension, anorexia (loss of appetite), weight loss, congestive heart failure, pyuria, and finally, renal failure and death occur. Treatment is directed at treating the symptoms, and treatment methods include a low-sodium diet, antihypertensive drugs, maintenance of fluids and electrolytes, and hemodialysis (removal of the waste products from the blood by a hemodialysis machine) (figure 7-64). When both kidneys are severely damaged, a kidney transplant can be performed.

Pyelonephritis

Pyelonephritis is an inflammation of the kidney tissue and renal pelvis (upper end of the ureter), usually caused by pyogenic (pus-forming) bacteria. Symptoms include chills, fever, back pain, fatigue, dysuria, hematuria, and pyuria (pus in the urine). Treatment methods are antibiotics and increased fluid intake.

FIGURE 7-64 A hemodialysis machine helps remove waste products from the blood when the kidneys are not functioning correctly.

Renal Calculus

A renal calculus, or urinary calculus, is a kidney stone. A calculus is formed when salts in the urine precipitate (settle out of solution). Some small calculi may be eliminated in the urine, but larger stones often become lodged in the renal pelvis or ureter. Symptoms include sudden, intense pain (renal colic); hematuria; nausea and vomiting; a frequent urge to void; and in some cases, urinary retention. Initial treatment consists of increasing fluids, providing pain medication, and straining all urine through gauze or filter paper to determine whether stones are being eliminated. Extracorporeal shock-wave lithotripsy is a procedure where high-energy pressure waves are used to crush the stones so that they can be eliminated through the urine. In some cases, surgery is required to remove the calculi.

Renal Failure

Renal failure is when the kidneys stop functioning. *Acute renal failure (ARF)* can be caused by hemorrhage, shock, injury, poisoning, nephritis, or dehydration. Symptoms include oliguria or anuria, headache, an ammonia odor to the breath, edema, cardiac arrhythmia, and uremia. Prompt treatment involving dialysis, restricted fluid intake, and correction of the condition causing renal failure results in a good prognosis. *Chronic renal failure (CRF)* results from the progressive loss of kidney function. It can be caused by chronic glomerulonephritis, hypertension, toxins, and endocrine disease such as diabetes mellitus. Long-term substance abuse and alcoholism can also lead to renal failure. Waste products accumulate in the blood and affect many body systems. Symptoms include nausea, vomiting, diarrhea, weight loss, decreased mental ability, convulsions, muscle irritability, an ammonia odor to the breath, uremic frost (deposits of white crystals on the skin), and in later stages, coma prior to death. Treatment methods are dialysis, diet modifications and restrictions, careful skin and mouth care, and control of fluid intake. A kidney transplant is the only cure.

Uremia

Uremia, also called *azotemia,* is a toxic condition that occurs when the kidneys fail and urinary waste products are present in the bloodstream. It can result from any condition that affects the proper functioning of the kidneys, such as renal failure, chronic glomerulonephritis, and hypotension. Symptoms include headache, dizziness, nausea, vomiting, an ammonia odor to the breath, oliguria or anuria, mental confusion, convulsions, coma, and eventually, death. Treatment consists of a restricted diet, cardiac medications to increase blood pressure and cardiac output, and dialysis until a kidney transplant can be performed.

Urethritis

Urethritis is an inflammation of the urethra, usually caused by bacteria (such as gonococcus), viruses, or chemicals (such as bubble bath solutions). It is more common in male than female individuals. Symptoms include frequent and

painful urination, redness and itching at the urinary meatus, and a purulent (pus) discharge. Treatment methods include sitz baths or warm, moist compresses; antibiotics; and/or increased fluid intake.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:12, Urinary System.*

7:13 Endocrine System

Objectives

After completing this section, you should be able to:

- Label a diagram of the main endocrine glands
- Describe how hormones influence various body functions
- Describe at least five diseases of the endocrine glands
- Define, pronounce, and spell all key terms

KEY TERMS

adrenal glands *(ah″-dree′-nal)*
endocrine system *(en′-doh″-krin)*
hormones
ovaries
pancreas *(pan-kree-as)*
parathyroid glands
pineal body *(pin′-knee″-ahl)*
pituitary gland *(pih″-too′-ih-tar-ee)*
placenta
testes *(tess′-tees)*
thymus
thyroid gland

RELATED HEALTH CAREERS

- Endocrinologist
- Nuclear Medicine Technologist

7:13 INFORMATION

The **endocrine system** consists of a group of ductless (without tubes) glands that secrete substances directly into the bloodstream. These substances are called *hormones*. The endocrine system consists of the pituitary gland, thyroid gland, parathyroid gland, adrenal glands, pancreas, ovaries, testes, thymus, pineal body, and placenta (figure 7-65).

Hormones, chemical substances produced and secreted by the endocrine glands, are frequently called "chemical messengers." They are transported throughout the body by the bloodstream and perform many functions including:

- Stimulate exocrine glands (glands with ducts, or tubes) to produce secretions
- Stimulate other endocrine glands
- Regulate growth and development
- Regulate metabolism
- Maintain fluid and chemical balance
- Control various sex processes

Table 7-3 lists the main hormones produced by each endocrine gland and the actions they perform.

PITUITARY GLAND

The **pituitary gland** is often called the "master gland" of the body because it produces many hormones that affect other glands. It is located at

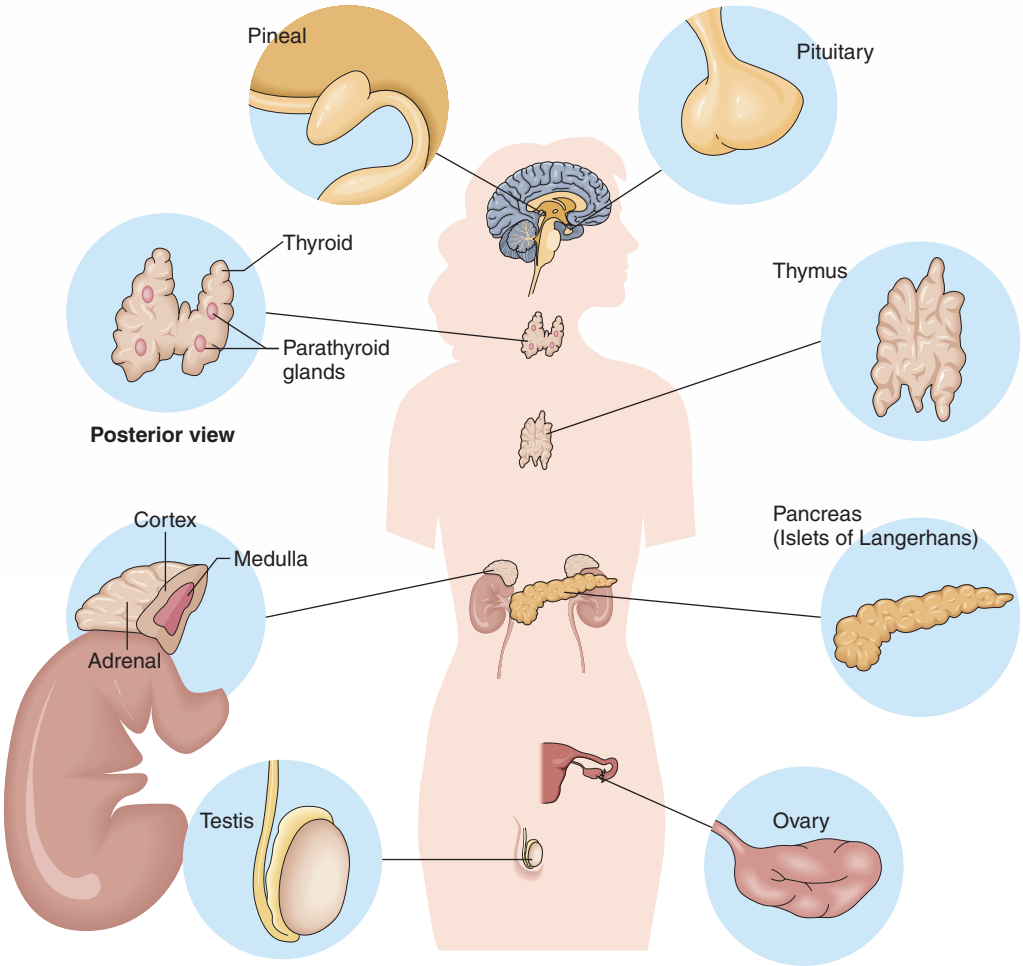


FIGURE 7-65 The endocrine system.

TABLE 7-3 Hormones Produced by the Endocrine Glands and Their Actions

GLAND	HORMONE	ACTION
Pituitary		
Anterior lobe	ACTH—adrenocorticotropic	Stimulates growth and secretion of the cortex of the adrenal gland
	TSH—thyrotropin	Stimulates growth and secretion of the thyroid gland
	GH—somatotropin	Growth hormone, stimulates normal body growth
	FSH—follicle stimulating	Stimulates growth and hormone production in the ovarian follicles of female individuals, production of sperm in male individuals
	LH—luteinizing (female) *or* ICSH—interstitial cell stimulating (male)	Causes ovulation and secretion of progesterone in female individuals / Stimulates testes to secrete testosterone
	LTH—lactogenic or prolactin	Stimulates secretion of milk from mammary glands after delivery of an infant
	MSH—melanocyte stimulating	Stimulates production and dispersion of melanin pigment in the skin

(continues)

TABLE 7-3 Hormones Produced by the Endocrine Glands and Their Actions *(Continued)*

GLAND	HORMONE	ACTION
Posterior lobe	ADH—vasopressin	Antidiuretic hormone, promotes reabsorption of water in kidneys, constricts blood vessels
	Oxytocin (pitocin)	Causes contraction of uterus during childbirth, stimulates milk flow from the breasts
Thyroid		
	Thyroxine and tri-iodothyronine	Increase metabolic rate; stimulate physical and mental growth; regulate metabolism of carbohydrates, fats, and proteins
	Thyrocalcitonin (calcitonin)	Accelerates absorption of calcium by the bones and lowers blood calcium level
Parathyroid		
	Parathormone (PTH)	Regulates amount of calcium and phosphate in the blood, increases reabsorption of calcium and phosphates from bones, stimulates kidneys to conserve blood calcium, stimulates absorption of calcium in the intestine
Adrenal		
Cortex	Mineralocorticoids	Regulate the reabsorption of sodium in the kidney and the elimination of potassium, increase the reabsorption of water by the kidneys
	Aldosterone	
	Glucocorticoids	Aid in metabolism of proteins, fats, and carbohydrates; increase amount of glucose in blood; provide resistance to stress; and depress immune responses (anti-inflammatory)
	Cortisol-hydrocortisone	
	Cortisone	
	Gonadocorticoids	Act as sex hormones
	Estrogens	Stimulate female sexual characteristics
	Androgens	Stimulate male sexual characteristics
Medulla	Epinephrine (adrenaline)	Activates sympathetic nervous system, acts in times of stress to increase cardiac output and increase blood pressure
	Norepinephrine	Activates body in stress situations
Pancreas		
	Insulin	Used in metabolism of glucose (sugar) by promoting entry of glucose into cells to decrease blood glucose levels, promotes transport of fatty acids and amino acids (proteins) into the cells
	Glucagon	Maintains blood level of glucose by stimulating the liver to release stored glycogen in the form of glucose
Ovaries		
	Estrogen	Promotes growth and development of sex organs in female individuals
	Progesterone	Maintains lining of uterus
Testes		
	Testosterone	Stimulates growth and development of sex organs in male individuals, stimulates maturation of sperm
Thymus		
	Thymosin (thymopoietin)	Stimulates production of lymphocytes and antibodies in early life

(continues)

TABLE 7-3 Hormones Produced by the Endocrine Glands and Their Actions *(Continued)*

GLAND	HORMONE	ACTION
Pineal		
	Melatonin	May delay puberty by inhibiting gonadotropic (sex) hormones, may regulate sleep/wake cycles
	Adrenoglomerulotropin	May stimulate adrenal cortex to secrete aldosterone
	Serotonin	May prevent vasoconstriction of blood vessels in the brain, inhibits gastric secretions
Placenta		
	Estrogen	Stimulates growth of reproductive organs
	Chorionic gonadotropin	Causes corpus luteum of ovary to continue secretions
	Progesterone	Maintains lining of uterus to provide fetal nutrition

the base of the brain in the sella turcica, a small, bony depression of the sphenoid bone. It is divided into two sections, or lobes: the anterior lobe and the posterior lobe. Each lobe secretes certain hormones, as shown in table 7-3.

Diseases and Abnormal Conditions

Acromegaly

Acromegaly results from an oversecretion of somatotropin (growth hormone) in an adult and is usually caused by a benign (noncancerous) tumor of the pituitary called an *adenoma*. Bones of the hands, feet, and face enlarge and create a grotesque appearance. The skin and tongue thicken, and slurred speech develops. Surgical removal and/or radiation of the tumor is the usual treatment, but the tumor frequently recurs. Acromegaly eventually causes cardiovascular and respiratory diseases that shorten life expectancy.

Giantism

Giantism results from an oversecretion of somatotropin before puberty (figure 7-66). It causes excessive growth of long bones, extreme tallness, decreased sexual development, and at times, retarded mental development. If a tumor of the pituitary is the cause, surgical removal or radiation is the treatment.

Diabetes Insipidus

Diabetes insipidus is caused by decreased secretion of vasopressin, or antidiuretic hormone (ADH). A low level of ADH prevents water from being reabsorbed in the kidneys. Symptoms include polyuria (excessive urination), polydipsia (excessive thirst), dehydration, weakness, constipation, and dry skin. The condition is corrected by administering ADH.

FIGURE 7-66 Giantism results when the pituitary gland secretes excessive amounts of somatotropin (growth hormone) before puberty.

Dwarfism

Dwarfism results from an undersecretion of somatotropin and can be caused by a tumor, infection, genetic factors, or injury (figure 7-67). It is characterized by small body size, short extremities, and lack of sexual development. Mental development is usually normal. If the condition is diagnosed early, it can be treated with injections of somatotropic hormone for 5 or more years until long bone growth is complete.

FIGURE 7-67 Dwarfism results from an undersecretion of somatotropin (growth hormone).

THYROID GLAND

The **thyroid gland** synthesizes hormones that regulate the body's metabolism and control the level of calcium in the blood. It is located in front of the upper part of the trachea (windpipe) in the neck. It has two lobes, one on either side of the larynx (voice box), connected by the isthmus, a small piece of tissue. To produce its hormones, the thyroid gland requires iodine, which is obtained from certain foods and iodized salt. The hormones secreted by the thyroid gland are shown in table 7-3.

Diseases and Abnormal Conditions

Goiter

A goiter is an enlargement of the thyroid gland. Causes can include a hyperactive thyroid, an iodine deficiency, an oversecretion of thyroid-stimulating hormone on the part of the pituitary gland, or a tumor. Symptoms include thyroid enlargement, dysphagia (difficult swallowing), a cough, and a choking sensation. Treatment is directed toward eliminating the cause. For example, iodine is given if a deficiency exists. Surgery may be performed to remove very large goiters.

Hyperthyroidism

Hyperthyroidism is an overactivity of the thyroid gland, which causes increased production of thyroid hormones and increased basal metabolic rate (BMR). Symptoms include extreme nervousness, tremors, irritability, rapid pulse, diarrhea, diaphoresis (excessive perspiration), heat intolerance, polydipsia (excessive thirst), goiter formation, and hypertension. An excessive appetite with extreme weight loss is a classic symptom. Treatment consists of either radiation to destroy part of the thyroid or a thyroidectomy (surgical removal of the thyroid). If the thyroid is removed, thyroid hormones are given for the lifetime of the individual.

Graves' Disease

Graves' disease is a severe form of hyperthyroidism more common in women than men. Symptoms include a strained and tense facial expression, exophthalmia (protruding eyeballs), goiter, nervous irritability, emotional instability, tachycardia, a tremendous appetite accompanied by weight loss, and diarrhea. Treatment methods include medication to inhibit the synthesis of thyroxine, radioactive iodine to destroy thyroid tissue, and/or a thyroidectomy.

Hypothyroidism

Hypothyroidism is an underactivity of the thyroid gland and a deficiency of thyroid hormones. Two main forms exist: *cretinism* and *myxedema.* Cretinism develops in infancy or early childhood and results in a lack of mental and physical growth, leading to mental retardation and an abnormal, dwarfed stature. If diagnosed early, oral thyroid hormone can be given to minimize mental and physical damage. Myxedema occurs in later childhood or adulthood. Symptoms include coarse, dry skin; slow mental function; fatigue; weakness; intolerance of cold; weight gain; edema; puffy eyes; and a slow pulse. Treatment consists of administering oral thyroid hormone to restore normal metabolism. In some countries where iodized salt is not available, myxedema may be caused by an iodine deficiency. Adding iodine to the diet corrects this type of myxedema.

PARATHYROID GLANDS

The **parathyroid glands** are four small glands located behind and attached to the thyroid gland. Their hormone, parathormone, regulates the amount of calcium in the blood (see table 7-3). It stimulates bone cells to break down bone tissue and release calcium and phosphates into the blood, causes the kidneys to conserve and reabsorb calcium, and activates intestinal cells to absorb calcium from digested foods. Although most of the body's calcium is in the bones, the

calcium circulating in the blood is important for blood clotting, the tone of heart muscle, and muscle contraction. Because there is a constant exchange of calcium and phosphate between the bones and blood, the parathyroid hormone plays an important function in maintaining the proper level of circulating calcium.

Diseases and Abnormal Conditions

Hyperparathyroidism

Hyperparathyroidism is an overactivity of the parathyroid gland resulting in an overproduction of parathormone. This results in hypercalcemia (increased calcium in the blood), which leads to renal calculi (kidney stones) formation, lethargy, gastrointestinal disturbances, and calcium deposits on the walls of blood vessels and organs. Because the calcium is drawn from the bones, they become weak, deformed, and likely to fracture. This condition is often caused by an adenoma (glandular tumor), and removal of the tumor usually results in normal parathyroid function. Other treatments include surgical removal of the parathyroids followed by administration of parathormone, diuretics to increase the excretion of water and calcium, and a low-calcium diet.

Hypoparathyroidism

Hypoparathyroidism is an underactivity of the parathyroid gland, which causes a low level of calcium in the blood. Causes include the surgical removal of or injury to the parathyroid and/or thyroid glands. Symptoms include tetany (a sustained muscular contraction), hyperirritability of the nervous system, and convulsive twitching. Death can occur if the larynx and respiratory muscles are involved. The condition is easily treated with calcium, vitamin D (which increases the absorption of calcium from the digestive tract), and parathormone.

ADRENAL GLANDS

The **adrenal glands** are frequently called the *suprarenal* glands because one is located above each kidney. Each gland has two parts: the outer portion, or cortex, and the inner portion, or medulla. The adrenal cortex secretes many steroid hormones, which are classified into three groups: mineralocorticoids, glucocorticoids, and gonadocorticoids. The groups and the main hormones in each group are listed in table 7-3. The adrenal medulla secretes two main hormones: epinephrine and norepinephrine. These hormones are sympathomimetic; that is, they mimic the sympathetic nervous system and cause the fight or flight response.

Diseases and Abnormal Conditions

Addison's Disease

Addison's disease is caused by decreased secretion of aldosterone on the part of the adrenal cortex. This interferes with the reabsorption of sodium and water and causes an increased level of potassium in the blood. Symptoms include dehydration, diarrhea, fatigue, hypotension (low blood pressure), mental lethargy, weight loss, muscle weakness, excessive pigmentation leading to a "bronzing" (yellow-brown color) of the skin, hypoglycemia (low blood sugar), and edema. Treatment methods include administering corticosteroid hormones, controlled intake of sodium, and fluid regulation to combat dehydration.

Cushing's Syndrome

Cushing's syndrome results from an oversecretion of glucocorticoids on the part of the adrenal cortex. It can be caused by either a tumor of the adrenal cortex or excess production of ACTH on the part of the pituitary gland. Symptoms include hyperglycemia (high blood sugar), hypertension, muscle weakness, fatigue, hirsutism (excessive growth and/or an abnormal distribution of hair), poor wound healing, a tendency to bruise easily, a "moon" face, and obesity (figure 7-68). If a tumor is causing the disease, treatment is removal of the tumor. If the glands are removed, hormonal therapy is required to replace the missing hormones. Cushing's syndrome can also occur in patients receiving long-term steroid therapy such as prednisone. These patients must be monitored closely, and steroid therapy must be reduced gradually if symptoms of Cushing's syndrome develop.

PANCREAS

The **pancreas** is a fish-shaped organ located behind the stomach. It is both an exocrine gland and an endocrine gland. As an exocrine gland, it

FIGURE 7-68 Cushing's syndrome. (A) The classic "moon face" of Cushing's syndrome. (B) The same individual after treatment. *(Courtesy of Ruth Jones)*

secretes pancreatic juices, which are carried to the small intestine by the pancreatic duct to aid in the digestion of food. Special B, or beta, cells located throughout the pancreas in patches of tissue called *islets of Langerhans* produce the hormone insulin, which is needed for the cells to absorb sugar from the blood. Insulin also promotes the transport of fatty acids and amino acids (proteins) into the cells. Alpha, or A, cells produce the hormone glucagon, which increases the glucose level in blood (see table 7-3).

Disease

Diabetes Mellitus

Diabetes mellitus is a chronic disease caused by decreased secretion of insulin. The metabolism of carbohydrates, proteins, and fats is affected. There are two main types of diabetes mellitus, named according to the age of onset and need for insulin. Insulin-dependent diabetes mellitus (IDDM), or Type 1, usually occurs early in life, is more severe, and requires insulin. Noninsulin-dependent diabetes mellitus (NIDDM), or Type 2, is the mature-onset form of diabetes mellitus. It frequently occurs in obese adults and is usually controlled with diet and/or oral hypoglycemic (lower-blood-sugar) medications. The main symptoms include hyperglycemia (high blood sugar), polyuria (excessive urination), polydipsia (excessive thirst), polyphagia (excessive hunger), glycosuria (sugar in the urine), weight loss, fatigue, slow healing of skin infections, and vision changes. If the condition is not treated, diabetic coma and death may occur. Treatment methods are a carefully regulated diet to control the blood sugar level, regulated exercise, and oral hypoglycemic drugs or insulin injections. Newer medications that increase insulin production, increase the sensitivity to insulin, or slow the absorption of glucose into cells are also available. External and implantable insulin pumps that monitor blood glucose levels and deliver the required amount of insulin can be used to replace insulin injections. A new form of therapy is an inhaled form of insulin. However, this is expensive and has not been approved for use in children.

Estimates indicate that more than 16 million Americans have diabetes, and as many as 40–50 percent might not know they have the disease. Researchers have proved that weight control (avoiding obesity) and moderate exercise can

reduce the risk for development of diabetes by as much as 55–70 percent. Preventing diabetes is important because diabetes can cause atherosclerosis, myocardial infarctions (heart attacks), cerebrovascular accidents (strokes), peripheral vascular disease leading to poor wound healing and gangrene in the legs and feet, diabetic retinopathy causing blindness, and kidney disease or failure.

OTHER ENDOCRINE GLANDS

The **ovaries** are the gonads, or sex glands, of the female. They are located in the pelvic cavity, one on each side of the uterus. They secrete hormones that regulate menstruation and secondary sexual characteristics (see table 7-3).

The **testes** are the gonads of the male. They are located in the scrotal sac and are suspended outside the body. They produce hormones that regulate sexual characteristics of the male (see table 7-3).

The **thymus** is a mass of tissue located in the upper part of the chest and under the sternum. It contains lymphoid tissue. The thymus is active in early life, activating cells in the immune system, but atrophies (wastes away) during puberty, when it becomes a small mass of connective tissue and fat. It produces one hormone, thymosin (see table 7-3).

The **pineal body** is a small structure attached to the roof of the third ventricle in the brain. Knowledge regarding the physiology of this gland is limited. Three main hormones secreted by this gland are listed in table 7-3.

The **placenta** is a temporary endocrine gland produced during pregnancy. It acts as a link between the mother and infant, provides nutrition for the developing infant, and promotes lactation (the production of milk in the breasts). It is expelled after the birth of the child (when it is called *afterbirth*). Three hormones secreted by this gland are listed in table 7-3.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:13, Endocrine System.*

7:14 Reproductive System

Objectives

After completing this section, you should be able to:

- Label a diagram of the male reproductive system
- Trace the pathway of sperm from where they are produced to where they are expelled from the body
- Identify at least three organs of the male reproductive system that secrete fluids added to semen
- Label a diagram of the female reproductive system
- Describe how an ovum is released from an ovary
- Explain the action of the endometrium
- Describe at least six diseases of the reproductive systems
- Define, pronounce, and spell all key terms

KEY TERMS

Bartholin's glands *(Bar'-tha-lens)*
breasts
Cowper's (bulbourethral) glands *(Cow'-purrs)*
ejaculatory ducts *(ee-jack'-you-lah-tore"-ee)*
endometrium *(en"-doe-me'-tree-um)*
epididymis *(eh"-pih-did'-ih-muss)*
fallopian tubes *(fah-low'-pea"-an)*
fertilization *(fur"-til-ih-zay'-shun)*
labia majora *(lay'-bee"-ah mah"-jore'-ah)*
labia minora *(lay'-bee"-ah ma-nore'-ah)*
ovaries
penis
perineum *(pear"-ih-knee'-um)*
prostate gland
reproductive system
scrotum *(skrow'-tum)*

KEY TERMS

seminal vesicles *(sem′-ih-null ves′-ik-ullz)*
testes *(tes′-tees)*
urethra
uterus
vagina *(vah-jie′-nah)*
vas (ductus) deferens *(vass deaf′-eh-rens)*
vestibule
vulva *(vull′-vah)*

RELATED HEALTH CAREERS

- Embryologist
- Genetic Counselor
- Geneticist
- Gynecologist
- Midwife
- Obstetrician
- Ultrasound Technologist (Sonographer)

7:14 INFORMATION

The function of the **reproductive system** is to produce new life. Although the anatomic parts differ in male and female individuals, the reproductive systems of both have the same types of organs: gonads (sex glands); ducts (tubes) to carry the sex cells and secretions; and accessory organs.

MALE REPRODUCTIVE SYSTEM

The male reproductive system consists of the testes, epididymis, vas deferens, seminal vesicles, ejaculatory ducts, urethra, prostate gland, Cowper's glands, and penis (figure 7-69).

The male gonads are the **testes.** The two testes are located in the **scrotum,** a sac suspended between the thighs. The testes produce the male sex cells called *sperm,* or *spermatozoa*, in seminiferous tubules located within each testis. Because the scrotum is located outside the body, the temperature in the scrotum is lower than that inside the body. This lower temperature is essential for the production of sperm. The testes also produce male hormones. The main hormone is testosterone, which aids in the maturation of the sperm and also is responsible for the secondary male sex characteristics such as body hair, facial hair, large muscles, and a deep voice.

After the sperm develop in the seminiferous tubules in the testes, they enter the **epididymis.** The epididymis is a tightly coiled tube approximately 20 feet in length and located in the scrotum and above the testes. It stores the sperm while they mature and become motile (able to move by themselves). It also produces a fluid that becomes part of the semen (fluid released during ejaculation). The epididymis connects with the next tube, the vas deferens.

The **vas (ductus) deferens** receives the sperm and fluid from the epididymis. On each side, a vas deferens joins with the epididymis and extends up into the abdominal cavity, where it curves behind the urinary bladder and joins with a seminal vesicle. Each vas deferens acts as both a passageway and a temporary storage area for sperm. The vas deferens are also the tubes that are cut during a *vasectomy* (procedure to produce sterility in the male).

The **seminal vesicles** are two small pouch-like tubes located behind the bladder and near the junction of the vas deferens and the ejaculatory ducts. They contain a glandular lining. This lining produces a thick, yellow fluid that is rich in sugar and other substances and provides nourishment for the sperm. This fluid composes a large part of the semen.

The **ejaculatory ducts** are two short tubes formed by the union of the vas deferens and the seminal vesicles. They carry the sperm and fluids known collectively as *semen* through the prostate gland and into the urethra.

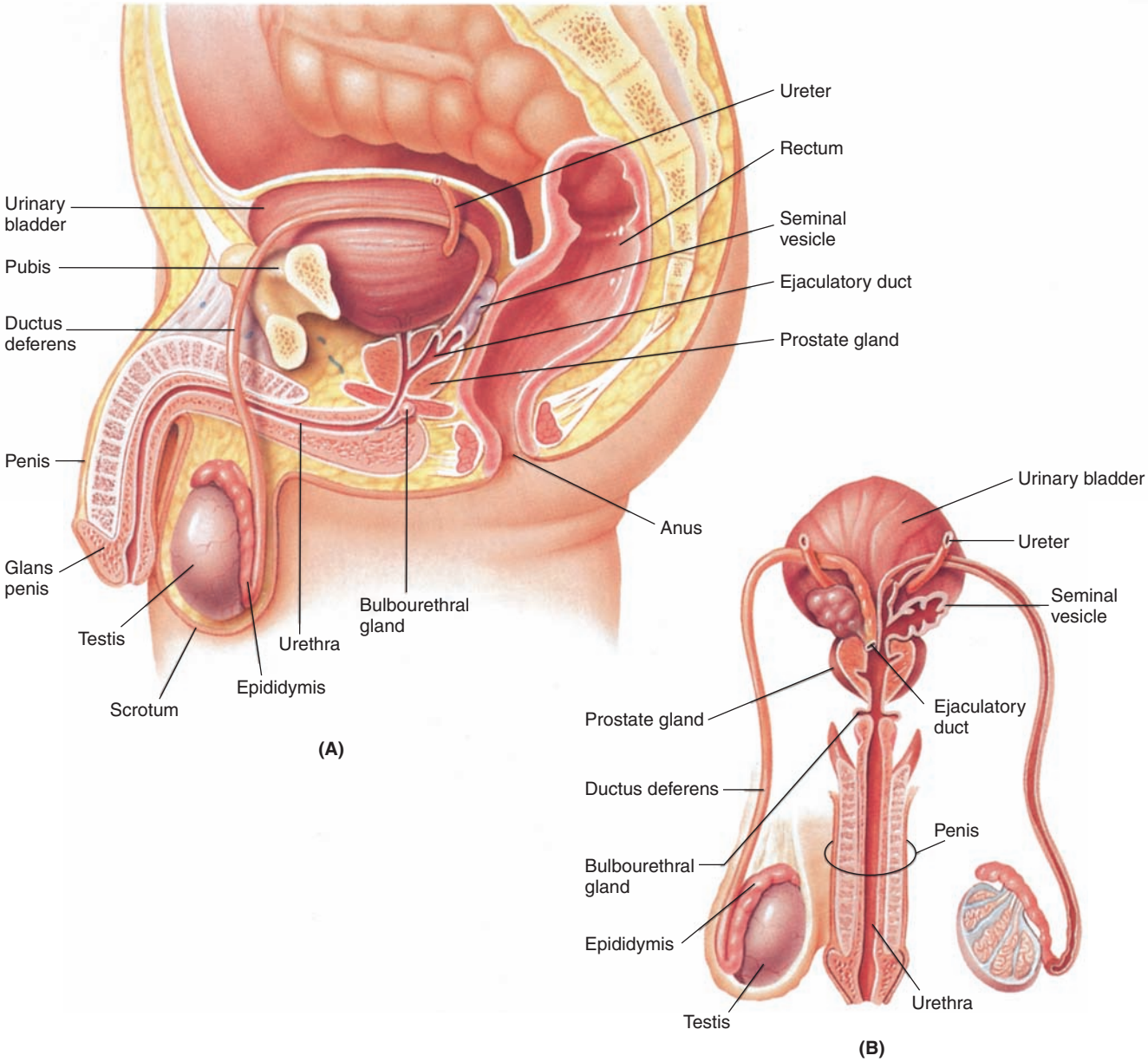


FIGURE 7-69 The male reproductive system. (A) Lateral view. (B) Anterior view.

The **prostate gland** is a doughnut-shaped gland located below the urinary bladder and on either side of the urethra. It produces an alkaline secretion that both increases sperm motility and neutralizes the acidity in the vagina, providing a more favorable environment for the sperm. The muscular tissue in the prostate contracts during ejaculation (expulsion of the semen from the body) to aid in the expulsion of the semen into the urethra. When the prostate contracts, it also closes off the urethra, preventing urine passage through the urethra.

Cowper's (bulbourethral) glands are two small glands located below the prostate and connected by small tubes to the urethra. They secrete mucus, which serves as a lubricant for intercourse, and an alkaline fluid, which decreases the acidity of the urine residue in the urethra, providing a more favorable environment for the sperm.

The **urethra** is the tube that extends from the urinary bladder, through the penis, and to the outside of the body. It carries urine from the urinary bladder and semen from the reproductive tubes.

The **penis** is the external male reproductive organ and is located in front of the scrotum. At the distal end is an enlarged structure, called the *glans penis*. The glans penis is covered with a pre-

puce (foreskin), which is sometimes removed surgically in a procedure called *circumcision*. The penis is made of spongy, erectile tissue. During sexual arousal, the spaces in this tissue fill with blood, causing the penis to become erect. The penis functions as the male organ of copulation, or intercourse; deposits the semen in the vagina; and provides for the elimination of urine from the bladder through the urethra.

Diseases and Abnormal Conditions

Epididymitis

Epididymitis is an inflammation of the epididymis, usually caused by a pathogenic organism such as gonococcus, streptococcus, or staphylococcus. It frequently occurs with a urinary tract or prostate infection, mumps, or sexually transmitted diseases (STDs). If epididymitis is not treated promptly, it can cause scarring and sterility. Symptoms include intense pain in the testes, swelling, and fever. Treatment methods include antibiotics, cold applications, scrotal support, and pain medication.

Orchitis

Orchitis is an inflammation of the testes, usually caused by mumps, pathogens, or injury. It can lead to atrophy of the testes and cause sterility. Symptoms include swelling of the scrotum, pain, and fever. Treatment methods include antibiotics (if indicated), antipyretics (for fever), scrotal support, and pain medication. Prevention methods include mumps vaccinations and observing measures to prevent sexually transmitted diseases (STDs).

Prostatic Hypertrophy and Cancer

Prostatic hypertrophy, or hyperplasia, is an enlargement of the prostate gland. Common in men over age 50, prostatic hypertrophy can be a benign condition, caused by inflammation, a tumor, or a change in hormonal activity, or a malignant (cancerous) condition. Symptoms of prostatic hypertrophy include difficulty in starting to urinate, frequent urination, nocturia (voiding at night), dribbling, urinary infections, and when the urethra is blocked, urinary retention. Initial treatment methods include fluid restriction, antibiotics (for infections), and prostatic massage. When hypertrophy causes urinary retention, a prostatectomy (surgical removal of all or part of the prostate) is necessary. A transurethral resection (TUR), or removal of part of the prostate, is performed by inserting a scope into the urethra and resecting, or removing, the enlarged area. A prostatectomy can also be done by a perineal, or suprapubic (above the pubis bone), incision. Prostatic carcinoma (cancer) can have the same symptoms as prostatic hypertrophy or it may not have any symptoms. A screening blood test, called a *prostatic-specific antigen (PSA) test,* can detect a substance released by cancer cells and aid in an early diagnosis. A digital rectal examination may show a hard, abnormal mass in the prostate gland. A tissue biopsy of the prostate is usually performed to diagnose cancer.

If the condition is malignant, prostatectomy, radiation, and estrogen therapy (to decrease the effects of testosterone) are the main treatments. In some cases, an orchiectomy, surgical removal of the testes, is performed to stop the production of testosterone. Radioactive seeds can also be implanted in the prostate to destroy the cancerous cells without affecting the organs and tissue surrounding the prostate. If prostate cancer is detected early, the prognosis (expected outcome) is good. All men older than 50 years are encouraged to have annual prostate examinations.

Testicular Cancer

Testicular cancer, or cancer of the testes, occurs most frequently in men from ages 20 to 35. It is a highly malignant form of cancer and can metastasize, or spread, rapidly. Symptoms include a painless swelling of the testes, a heavy feeling, and an accumulation of fluid. Treatment includes an *orchiectomy,* or surgical removal of the testis, chemotherapy, and/or radiation. It has been recommended that male individuals begin monthly testicular self-examinations at the age of 15. To perform the examination, the male individuals should examine the testicles after a warm shower when scrotal skin is relaxed. Each testicle should be examined separately with both hands by placing the index and middle fingers under the testicle and the thumbs on top. The testicle should be rolled gently between the fingers to feel for lumps, nodules, or extreme tenderness. In addition, the male should examine the testes for any signs of swelling or changes in appearance. If any abnormalities are noted, the male should be examined by a physician as soon as possible.

FEMALE REPRODUCTIVE SYSTEM

The female reproductive system consists of the ovaries, fallopian tubes, uterus, vagina, Bartholin's glands, vulva, and breasts (figure 7-70).

The **ovaries** are the female gonads (figure 7-71). They are small, almond-shaped glands located in the pelvic cavity and attached to the uterus by ligaments. The ovaries contain thousands of small sacs called *follicles.* Each follicle contains an immature ovum, or female sex cell. When an ovum matures, the follicle enlarges and then ruptures to release the mature ovum. This process, called *ovulation,* usually occurs once every 28 days. The ovaries also produce hormones that aid in the development of the reproductive organs and produce secondary sexual characteristics.

The **fallopian tubes** are two tubes, each approximately 5 inches in length and attached to the upper part of the uterus. The lateral ends of these tubes are located above the ovaries but are not directly connected to the ovaries. These ends have fingerlike projections, called *fimbriae.* The fimbriae help move the ovum, which is released by the ovary, into the fallopian tube. Each fallopian tube serves as a passageway for the ovum as the ovum moves from the ovary to the uterus. The muscle layers of the tube move the ovum by peristalsis. Cilia, hairlike structures on the lining of the tubes, also keep the ovum moving toward the uterus. **Fertilization,** the union of the ovum and a sperm to create a new life, usually takes place in the fallopian tubes.

The **uterus** is a hollow, muscular, pear-shaped organ located behind the urinary bladder and in front of the rectum. It is divided into three parts: the *fundus* (the top section, where the fallopian tubes attach); the body, or *corpus* (the middle section); and the *cervix* (the narrow, bottom section, which attaches to the vagina). The uterus is the organ of menstruation, allows for the development and growth of the fetus, and contracts to aid in expulsion of the fetus during birth. The uterus has three layers. The inner layer is called the **endometrium.** This layer of specialized epithelium provides for implantation of a fertilized ovum and aids in the development of

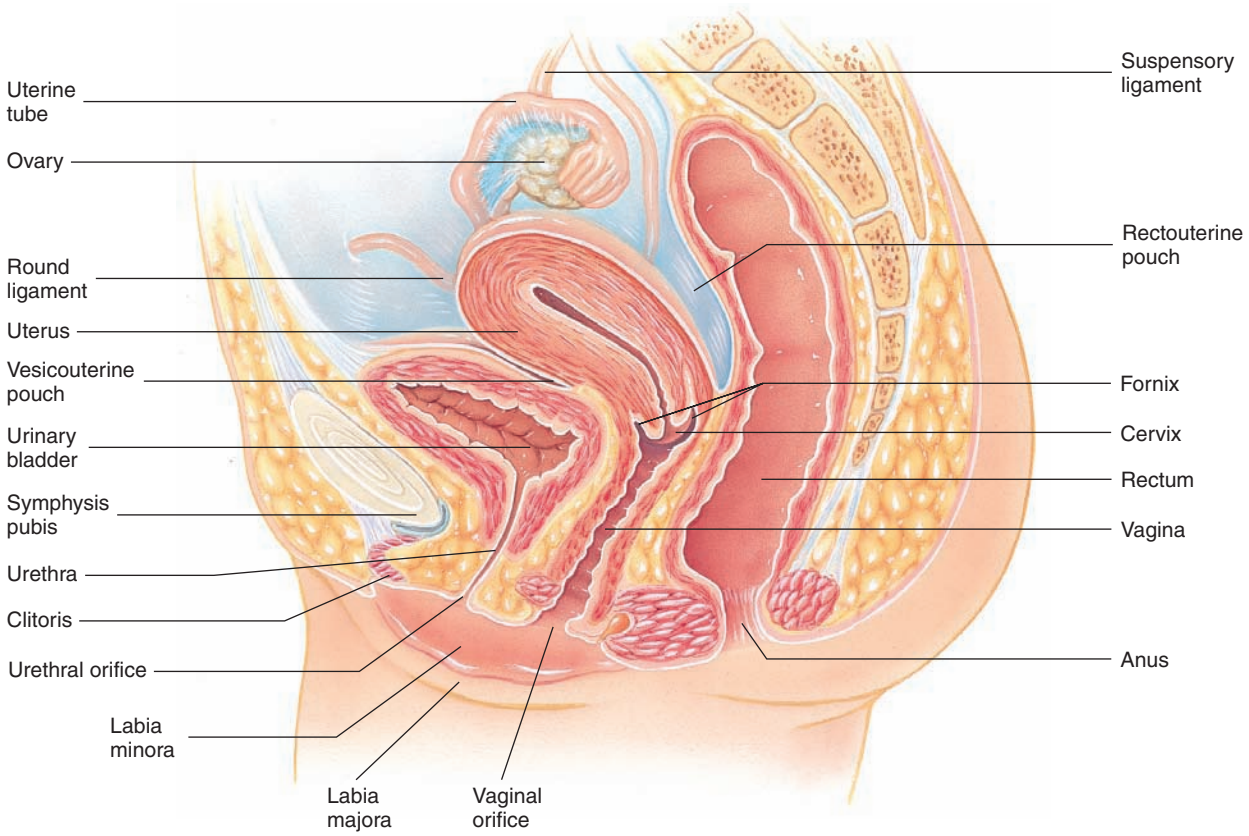


FIGURE 7-70 The female reproductive system.

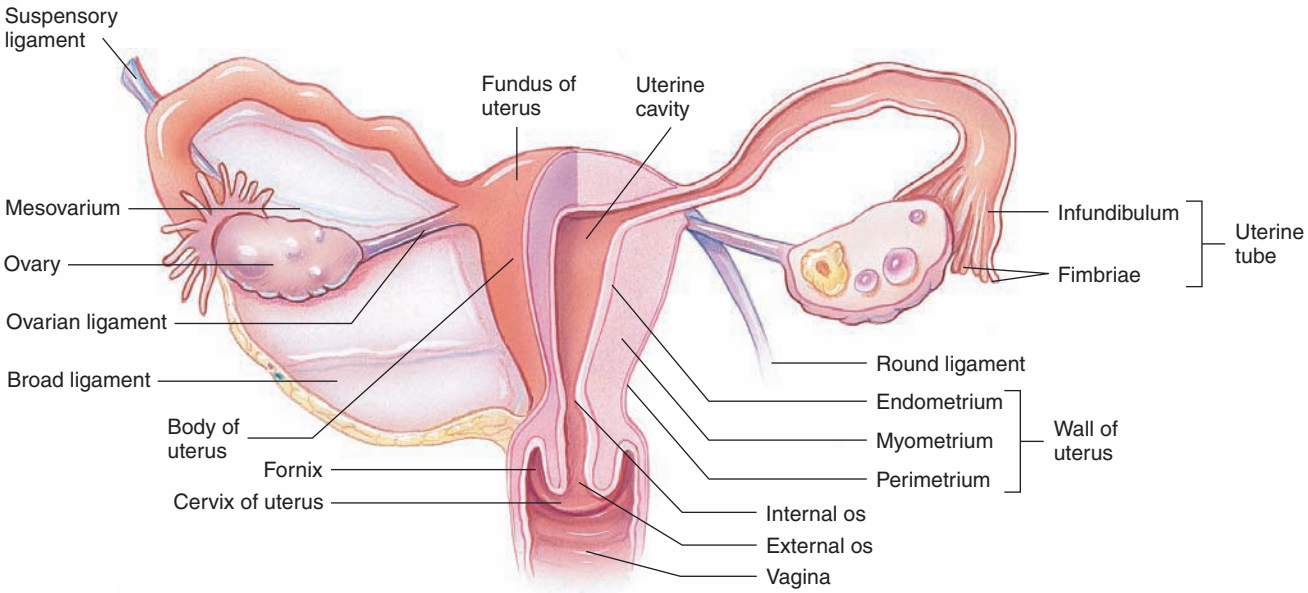


FIGURE 7-71 Anterior view of the female reproductive system.

the fetus. If fertilization does not occur, the endometrium deteriorates and causes the bleeding known as *menstruation.* The middle layer of the uterus, the *myometrium,* is a muscle layer. It allows for the expansion of the uterus during pregnancy and contracts to expel the fetus during birth. The outer layer, the *perimetrium,* is a serous membrane.

The **vagina** is a muscular tube that connects the cervix of the uterus to the outside of the body. It serves as a passageway for the menstrual flow, receives the sperm and semen from the male, is the female organ of copulation, and acts as the birth canal during delivery of the infant. The vagina is lined with a mucous membrane arranged in folds called *rugae.* The rugae allow the vagina to enlarge during childbirth and intercourse.

Bartholin's glands, also called *vestibular glands,* are two small glands located one on each side of the vaginal opening. They secrete mucus for lubrication during intercourse.

The **vulva** is the collective name for the structures that form the external female genital area (figure 7-72). The *mons veneris,* or mons pubis, is the triangular pad of fat that is covered with hair and lies over the pubic area. The **labia majora** are the two large folds of fatty tissue that are covered with hair on their outer surfaces; they enclose and protect the vagina. The **labia minora** are the two smaller hairless folds of tissue that are located within the labia majora. The area of the vulva located inside the labia minora is called the **vestibule.** It contains the openings to the urethra and the vagina. An area of erectile tissue, called the *clitoris,* is located at the junction of the labia minora. It produces sexual arousal when stimulated directly or indirectly during intercourse. The **perineum** is defined as the area between the vagina and anus in the female body, although it can be used to describe the entire pelvic floor in both the male and female individual.

The **breasts,** or mammary glands, contain lobes separated into sections by connective and fatty tissue. Milk ducts located in the tissue exit on the surface at the nipples. The main function of the glands is to secrete milk (lactate) after childbirth.

Diseases and Abnormal Conditions

Breast Tumors

Breast tumors can be benign or malignant. Symptoms include a lump or mass in the breast tissue, a change in breast size or shape (flattening or bulging of tissue), and a discharge from the nipple. Breast self-examination (BSE) can often detect tumors early (figure 7-73). The American Cancer Society recommends that an adult woman should do a BSE every month at the end of menstruation, or on a scheduled day of the month after menopause. The breasts should be examined in front of a mirror to observe for changes in appearance, in a warm shower after soaping the

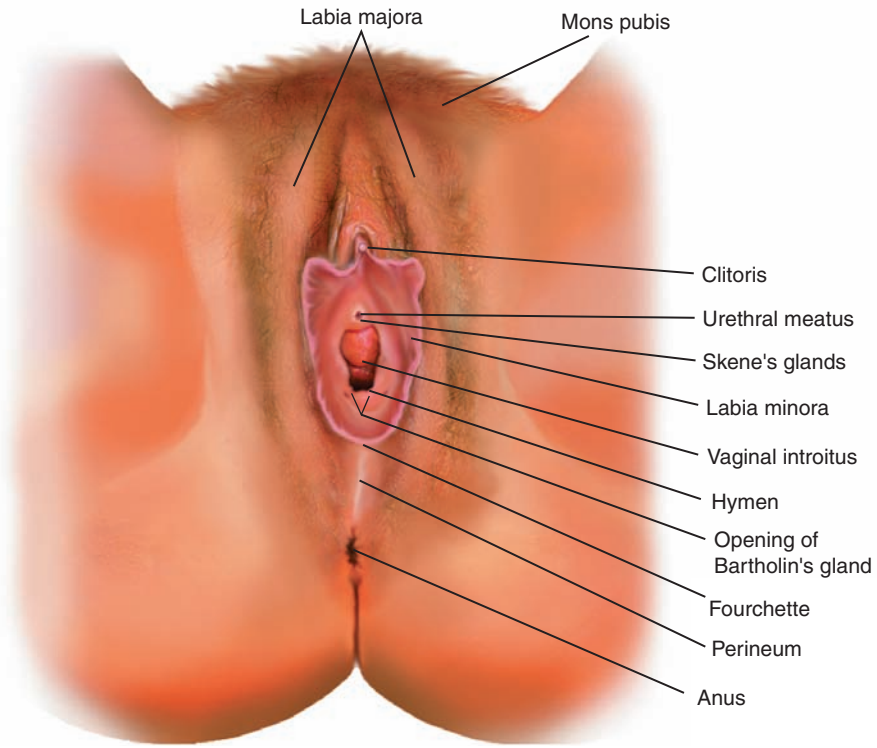


FIGURE 7-72 The external female genital area.

breasts, and while lying flat in a supine position. A physician should be contacted immediately if any abnormalities are found. In addition, the American Cancer Society recommends that women between the ages of 35 and 40 years should have a baseline mammogram. Between ages 40 and 49, women should have a mammogram every 1–2 years, and after age 50, women should have a mammogram every year. Mammograms and ultrasonography can often detect tumors or masses up to 2 years before the tumor or mass could be felt. Treatment methods for breast tumors include a lumpectomy (removal of the tumor), a simple mastectomy (surgical removal of the breast), or a radical mastectomy (surgical removal of the tissue, underlying muscles, and axillary lymph nodes). If the tumor is malignant, chemotherapy and/or radiation are usually used in addition to surgery.

Cervical or Uterine Cancer

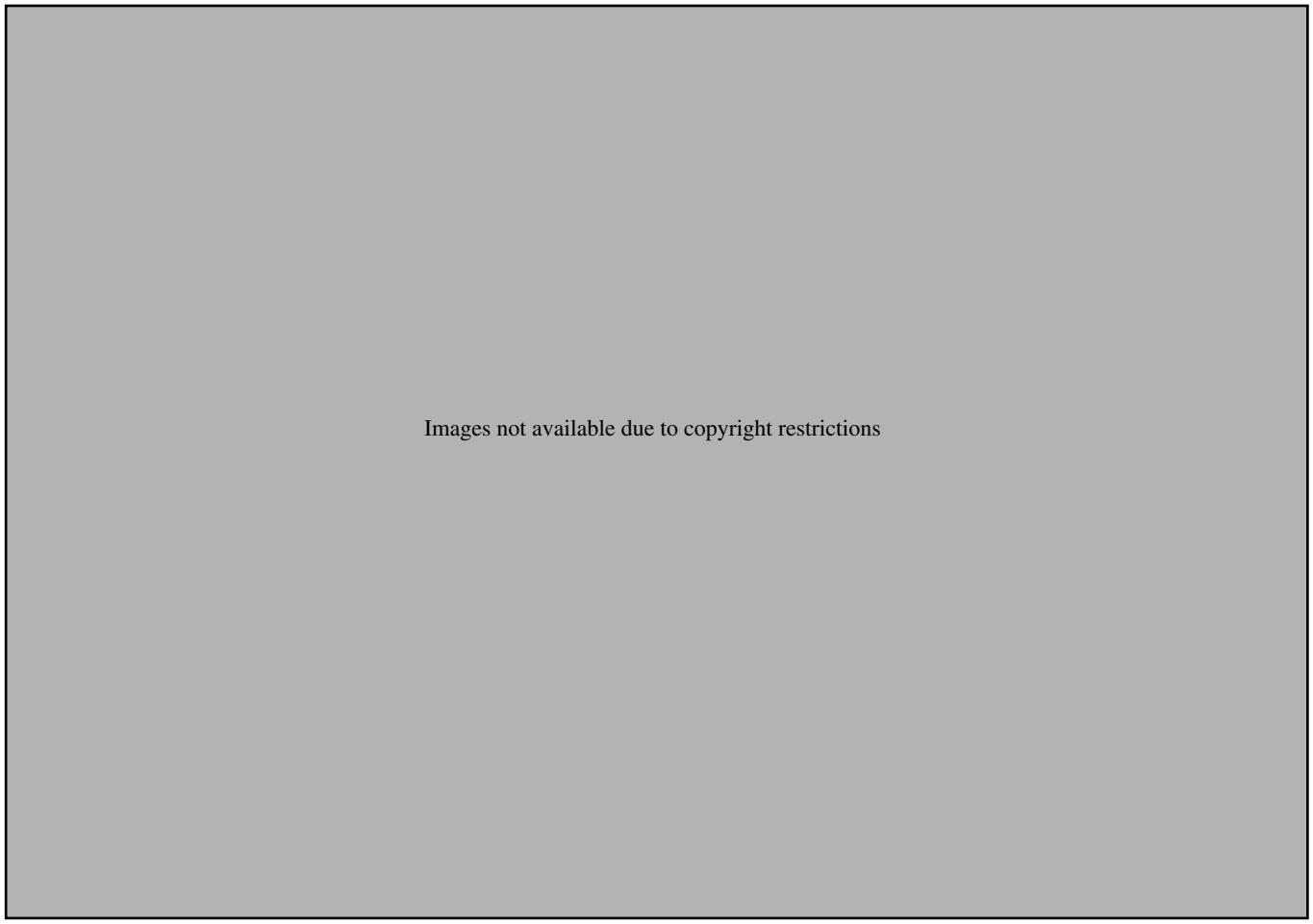
Cancer of the cervix and/or uterus is common in women. Cervical cancer can be detected early by a Pap smear. Symptoms of cervical cancer include abnormal vaginal discharge and bleeding. Symptoms of uterine cancer include an enlarged uterus, a watery discharge, and abnormal bleeding. Treatment methods include a hysterectomy (surgical removal of the uterus and cervix) or panhysterectomy (surgical removal of the uterus, ovaries, and fallopian tubes); chemotherapy; and/or radiation.

Endometriosis

Endometriosis is the abnormal growth of endometrial tissue outside the uterus. The tissue can be transferred from the uterus by the fallopian tubes, blood, or lymph, or during surgery. It usually becomes embedded in a structure in the pelvic area, such as the ovaries or the peritoneal tissues, and constantly grows and sheds. Endometriosis can cause sterility if the fallopian tubes become blocked with scar tissue. Symptoms include pelvic pain, abnormal bleeding, and dysmenorrhea (painful menstruation). Treatment methods vary with the age of the patient and the degree of abnormal growth but can include hormonal therapy, pain medications, and/or surgical removal of affected organs.

Ovarian Cancer

Ovarian cancer is one of the most common causes of cancer deaths in women. It frequently occurs between ages 40 and 65. Initial symptoms are vague and include abdominal discomfort and mild gastrointestinal disturbances such as constipation and/or diarrhea. As the disease progresses, pain, abdominal distention, and urinary



frequency occur. Treatment includes surgical removal of all of the reproductive organs and affected lymph nodes, chemotherapy, and radiation in some cases.

Pelvic Inflammatory Disease

Pelvic inflammatory disease (PID) is an inflammation of the cervix (cervicitis) the endometrium of the uterus (endometritis), fallopian tubes (salpingitis), and at times, the ovaries (oophoritis). It is usually caused by pathogenic organisms such as bacteria, viruses, and fungi. Symptoms include pain in the lower abdomen, fever, and a purulent (pus) vaginal discharge. Treatment methods include antibiotics, increased fluid intake, rest, and/or pain medication.

Premenstrual Syndrome

Premenstrual syndrome (PMS) is actually a group of symptoms that appear 3–14 days before menstruation. A large percentage of women experience some degree of PMS. The cause is unknown but may be related to a hormonal or biochemical imbalance, poor nutrition, or stress. Symptoms vary and may include nervousness, irritability, depression, headache, edema, backache, constipation, abdominal bloating, temporary weight gain, and breast tenderness and enlargement. Treatment is geared mainly toward relieving symptoms, and methods include diet modification, exercise, stress reduction, diuretics to remove excess fluids, analgesics for pain, and/or medications to relieve the emotional symptoms.

SEXUALLY TRANSMITTED DISEASES

Sexually transmitted diseases (STDs), or *sexually transmitted infections (STIs)*, affect both men and women. The incidence of these diseases has increased greatly in recent years, especially

among young people. If not treated, STDs can cause serious chronic conditions and, in some cases, sterility or death.

Acquired Immune Deficiency Syndrome

Acquired immune deficiency syndrome (AIDS) is caused by a virus called the *human immunodeficiency virus (HIV)*. This virus attacks the body's immune system, rendering the immune system unable to fight off certain infections and diseases, and eventually causing death. The virus is spread through sexual secretions or blood, and from an infected mother to her infant during pregnancy or childbirth.

The HIV virus does not live long outside the body and is not transmitted by casual, nonsexual contact. Individuals infected with HIV can remain free of any symptoms for years after infection. During this asymptomatic period, infected individuals can transmit the virus to any other individual with whom they exchange sexual secretions, blood, or blood products. After this initial asymptomatic period, many individuals develop HIV symptomatic infection, formerly called AIDS-related complex (ARC). Symptoms include a positive blood test for antibodies to the HIV virus, lack of infection resistance, appetite loss, weight loss, recurrent fever, night sweats, skin rashes, diarrhea, fatigue, and swollen lymph nodes. When the HIV virus causes a critical low level (below 200 cells per cubic millimeter of blood) of special leukocytes (white blood cells) called CD4 or T cells, and/or opportunistic diseases appear, AIDS is diagnosed. Three of the most common opportunistic diseases include the rare type of pneumonia called *Pneumocystis carinii,* a yeast infection called *Candidiasis,* and the slow-growing cancer called *Kaposi's sarcoma* (figure 7-74).

Currently, there is no cure for AIDS, although much research is being directed toward developing a vaccine to prevent and drugs to cure AIDS. Treatment with a combination of drugs, commonly called a *drug cocktail,* is used to slow the progression of the disease. These drugs, however, do not cure the disease. Although several experimental drugs are currently being tested, many patients cannot tolerate the side effects and bone marrow toxicity of these drugs. Prevention is the best method in dealing with AIDS. Standard precautions should be followed while handling blood, body secretions, and sexual secretions. High-risk sexual activities, such as having multiple partners, should be avoided. A condom and an effective spermicide should be used to form a protective barrier during intercourse. The use of drugs and sharing of intravenous (IV) needles should be avoided. Females infected with HIV should avoid pregnancy. *Everyone* must concern themselves with eliminating the transmission of AIDS.

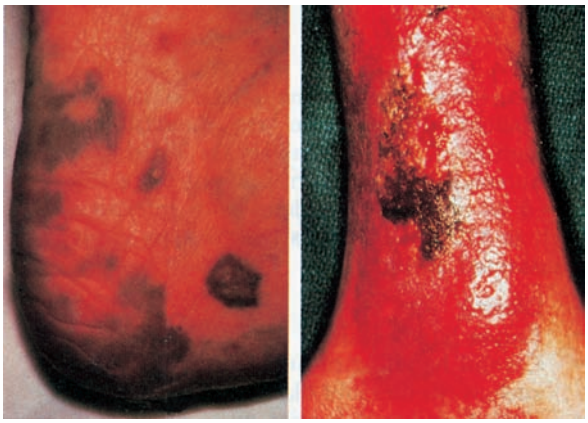


FIGURE 7-74 A common opportunistic disease that occurs in AIDS patients is Kaposi's sarcoma. *(Courtesy of the Centers for Disease Control and Prevention, Atlanta, GA)*

Chlamydia

Chlamydia (klah-mid-e-ah) is one of the most frequently occurring STDs and is caused by several strains of the chlamydia organism, a specialized bacterium that lives as an intracellular parasite. Symptoms are similar to those of gonorrhea. Male individuals experience burning when urinating and a mucoid discharge. Female individuals are frequently asymptomatic, although some may have a vaginal discharge. The disease frequently causes pelvic inflammatory disease and sterility in women, if not treated. Chlamydia can be treated with tetracycline or erythromycin antibiotics.

Gonorrhea

Gonorrhea (gon-oh-re-ah) is caused by the gonococcus bacterium *neisseria gonorrhoeae.* Symptoms in male individuals include a greenish-yellow discharge, burning when urinating, sore throat, and swollen glands. Female individuals are frequently asymptomatic but may experience

TODAY'S RESEARCH: TOMORROW'S HEALTH CARE

Body organs that are grown in the laboratory?

Organ transplants have become a common type of surgery. Hearts, lungs, livers, kidneys, and many other organs are transplanted daily to save lives. The big problem is the major shortage of organs to transplant. Today, almost 100,000 Americans are on the national waiting list for an organ. Statistics show that almost 20 percent, or 1 in every 5 patients, will die before they can receive an organ.

Researchers are trying to grow human organs by using a patient's own cells. Already, researchers in Boston have created a urinary bladder that functions in dogs. They molded a biodegradable material (substance that will dissolve inside the body) in the shape of a bladder. They then coated the outside of the structure with layers of muscle cells and the inside with layers of urothelial cells obtained from a dog's bladder. After the cells grew and multiplied, the dog's own bladder was removed, and the new artificial organ was transplanted. Within a month, the organ performed like a normal urinary bladder, storing urine until it was expelled to the outside. The chance of the dog rejecting the new organ was also slim because the cells that produced it were the dog's own cells.

Israeli scientists are using stem cells to grow human kidneys. Stem cells are obtained from a developing fetus. These cells are capable of transforming themselves into any of the body's specialized cells. The scientists transplanted the stem cells into mice and grew human kidneys in the mice. The kidneys filtered the blood and produced urine. Scientists hope that the chance of rejection is decreased because the stem cells are immature and less likely to carry characteristics of a specific individual. Many more trials are needed before these laboratory produced "organs" will be used in humans. However, the future for individuals needing transplants will be much better when scientists can "grow" the organs the individuals need.

dysuria, pain in the lower abdomen, and greenish-yellow vaginal discharge. An infected woman can transmit the gonococcus organism to her infant's eyes during childbirth, causing blindness. To prevent this, a drop of silver nitrate or antibiotic is routinely placed in the eyes of newborn babies. Gonorrhea is treated with large doses of antibiotics.

Herpes

Herpes is a viral disease caused by the herpes simplex virus type II. Symptoms include a burning sensation, fluid-filled vesicles (blister-like sores) that rupture and form painful ulcers, and painful urination. After the sores heal, the virus becomes dormant. Many people have repeated attacks, but the attacks are milder. There is no cure, and treatment is directed toward promoting healing and easing discomfort. Antiviral medications are used to decrease the number and severity of recurrences.

Pubic Lice

Pubic lice are parasites that are usually transmitted sexually, although they can be spread by contact with clothing, bed linen, or other items containing the lice. Symptoms include an intense itching and redness of the perineal area. Medications that kill the lice are used as treatment. To prevent a recurrence, it is essential to wash all clothing and bed linen to destroy any lice or nits (eggs).

Syphilis

Syphilis is caused by a spirochete bacterium. The symptoms occur in stages. During the primary stage, a painless chancre (shang-ker), or sore, appears, usually on the penis of the male and in the vulva or on the cervix of the female. This chancre heals within several weeks. During the second stage, which occurs if the chancre is not treated, the organism enters the bloodstream and causes a rash that does not itch, a sore throat, a

fever, and swollen glands. These symptoms also disappear within several weeks. The third stage occurs years later after the spirochete has damaged vital organs. Damage to the heart and blood vessels causes cardiovascular disease; damage to the spinal cord causes a characteristic gait and paralysis; and brain damage causes mental disorders, deafness, and blindness. At this stage, damage is irreversible, and death occurs. Early diagnosis and treatment with antibiotics can cure syphilis during the first two stages.

Trichomoniasis

Trichomoniasis is caused by a parasitic protozoan, *Trichomonas vaginalis*. The main symptom is a large amount of a frothy, yellow-green, foul-smelling discharge. Men are frequently asymptomatic but may experience urethral itching. The antiparasitic oral medication Flagyl is used to treat this disease. Both sexual partners must be treated to prevent reinfection.

STUDENT: *Go to the workbook and complete the assignment sheet for 7:14, Reproductive System.*

CHAPTER 7 SUMMARY

A health care worker must understand normal functioning of the human body to understand disease processes. A study of anatomy, the form and structure of an organism, and physiology, the processes of living organisms, adds to this understanding.

The basic structural unit of the human body is the cell. Cells join together to form tissues. Tissues join together to form organs, which work together to form body systems.

Systems work together to provide for proper functioning of the human body. The integumentary system, or skin, provides a protective covering for the body. The skeletal and muscular systems provide structure and movement. The circulatory system transports oxygen and nutrients to all body cells and carries carbon dioxide and metabolic materials away from the cells. The lymphatic system assists the circulatory system in removing wastes and excess fluid from the cells and tissues. The nervous system coordinates the many activities that occur in the body and allows the body to respond and adapt to changes. Special senses provided by organs such as the eyes and ears also allow the body to react to the environment. The respiratory system takes in oxygen for use by the body and eliminates carbon dioxide, a waste product produced by body cells. The digestive system is responsible for the physical and chemical breakdown of food so it can be used by body cells. The urinary system removes certain wastes and excess water from the body. The endocrine system, composed of a group of glands, controls many body functions. The reproductive system allows the human body to create new life.

All of the systems are interrelated, working as a unit to maintain a constant balance (homeostasis) within the human body. When disease occurs, this balance frequently is disturbed. Some of the major diseases and disorders of each system were also discussed in this chapter.

INTERNET SEARCHES

Use the suggested search engines in Chapter 12-4 of this textbook to search the Internet for additional information on the following topics:

1. *Anatomy and physiology*: search the name of a body system, organ, and/or tissue to obtain additional information on the structure and function of the system, organ, or tissue
2. *Pathophysiology*: search the name of specific diseases discussed in each subunit to obtain additional information on occurrence, prognosis, signs and symptoms, and current methods of treatment
3. *American Cancer Society*: search this information base to obtain information on cancer in various parts of the body, breast self-examination, testicular self-examination, and statistics on cancer
4. *Tutorials*: search publishers, software providers, and bookstore sites to find a variety of materials that can be used to learn the anatomy and physiology of the human body

REVIEW QUESTIONS

1. Differentiate between anatomy, physiology, and pathophysiology.

2. Name the four (4) main groups of tissues. By each tissue, list three (3) body systems that contain the tissue.
3. List at least ten (10) body systems and state the main function(s) of each system.
4. Identify the main bones or groups of bones in both the axial and the appendicular skeleton.
5. Describe the five (5) main actions or movements of muscles and provide a specific example for each type of movement.
6. Create a diagram showing the divisions of the nervous system and list the main parts in each division of the system.
7. List four (4) special senses and the organ that is required for each of the senses.
8. Trace a drop of blood as it enters the heart, goes through pulmonary circulation, returns to the heart, and goes to body cells. Name each chamber and valve in the heart, each blood vessel or type of vessel, and any organs blood passes through. Make sure all parts are in correct order.
9. Name all parts of the alimentary canal in correct order. Begin at the mouth and end at the anus.
10. Differentiate between endocrine and exocrine glands. Give five (5) examples of each type of gland and list the main function for each gland.
11. Evaulate three (3) sexually transmitted diseases (STDs) and describe how symptoms are the same or different in male versus female individuals.
12. Body systems are interrelated and work together to perform specific functions. For example, the circulatory and respiratory systems perform a joint function of obtaining oxygen for the body and eliminating carbon dioxide. Describe five (5) other examples of interrelationships between body systems.