Body Structure and Function

CHAPTER 8

OBJECTIVES

- Define the key terms and key abbreviations listed in this chapter
- Identify the basic structures of the cell
- Explain how cells divide
- Describe four types of tissue
- Identify the structures of each body system
- Identify the functions of each body system
- Explain how to promote quality of life

KEY TERMS

artery A blood vessel that carries blood away from the heart

capillary A tiny blood vessel; food, oxygen, and other substances pass from the capillaries to the cells

cell The basic unit of body structure

digestion The process of physically and chemically breaking down food so that it can be absorbed for use by the cells

hemoglobin The substance in red blood cells that carries oxygen and gives blood its color

hormone A chemical substance secreted by the endocrine glands into the bloodstream

immunity Protection against a disease or condition; the person will not get or be affected by the disease

menstruation The process in which the lining of the uterus breaks up and is discharged from the body through the vagina

metabolism The burning of food for heat and energy by the cells

organ Groups of tissues with the same function

peristalsis Involuntary muscle contractions in the digestive system that move food down the esophagus through the alimentary canal

respiration The process of supplying the cells with oxygen and removing carbon dioxide from them

system Organs that work together to perform special functions

tissue A group of cells with similar functions

vein A blood vessel that returns blood back to the heart

KEY ABBREVIATIONS

ACTH Adrenocorticotropic hormone
ADH Antidiuretic hormone
CNS Central nervous system
GH Growth hormone
GI Gastrointestinal
mL Milliliter
RBC Red blood cell
TH Thyroid hormone; thyroxine
TSH Thyroid-stimulating hormone
WBC White blood cell

You help patients and residents meet basic needs. Their bodies do not work at peak levels because of illness, disease, or injury. Your care promotes comfort, healing, and recovery. You need to know the body's normal structure and function. It will help you understand signs, symptoms, and the reasons for care and procedures. You will give safe and more efficient care.

See Chapter 10 for changes in body structure and function that occur with aging.

CELLS, TISSUES, AND ORGANS

The basic unit of body structure is the cell. Cells have the same basic structure. Function, size, and shape may differ. Cells are very small. You need a microscope to see them. Cells need food, water, and oxygen to live and function.

Figure 8-1 shows the cell and its structures. The *cell membrane* is the outer covering. It encloses the cell and helps it hold its shape. The *nucleus* is the control center of the cell. It directs the cell's activities. The nucleus is in the center of the cell. The *cytoplasm* surrounds the nucleus. Cytoplasm contains smaller structures that perform cell functions. *Protoplasm* means "living substance." It refers to all structures, substances, and water within the cell. Protoplasm is a semi-liquid substance much like an egg white.

Chromosomes are thread-like structures in the nucleus. Each cell has 46 chromosomes. Chromosomes contain *genes*. Genes control the traits children inherit from their parents. Height, eye color, and skin color are examples.

The nucleus controls cell reproduction. Cells reproduce by dividing in half. The process of cell division is called *mitosis*. It is needed for tissue growth and repair. During mitosis, the 46 chromosomes arrange themselves in 23 pairs. As the cell divides, the 23 pairs are pulled in half. The two new cells are identical. Each has 46 chromosomes (Fig. 8-2).

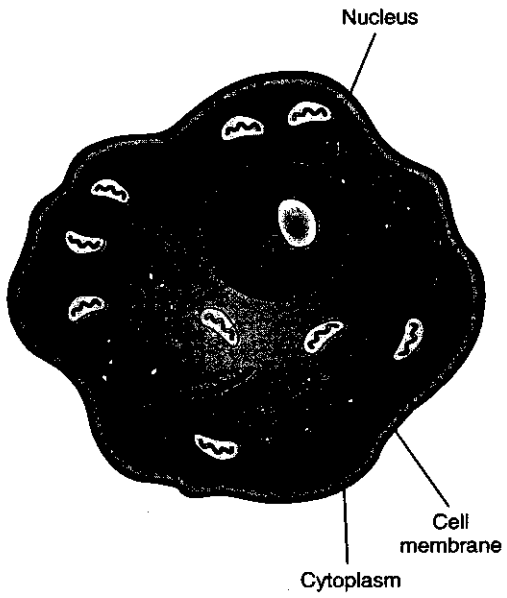

FIGURE 8-1 Parts of a cell.

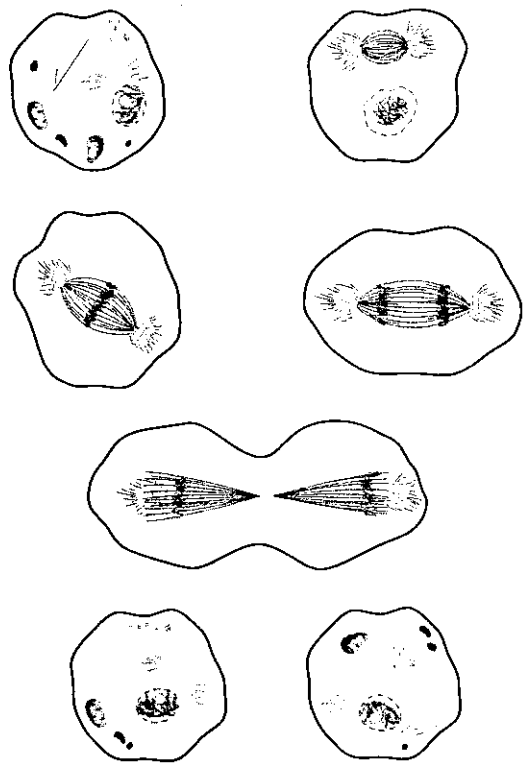

FIGURE 8-2 Cell division.

Cells are the body's building blocks. Groups of cells with similar functions combine to form tissues:

- *Epithelial tissue* covers internal and external body surfaces. Tissue lining the nose, mouth, respiratory tract, stomach, and intestines is epithelial tissue. So are the skin, hair, nails, and glands.
- *Connective tissue* anchors, connects, and supports other tissues. It is in every part of the body. Bones, tendons, ligaments, and cartilage are connective tissue. Blood is a form of connective tissue.
- *Muscle tissue* stretches and contracts to let the body move.
- *Nerve tissue* receives and carries impulses to the brain and back to body parts.

Groups of tissue with the same function form organs. An organ has one or more functions. Examples of organs are the heart, brain, liver, lungs, and kidneys. Systems are formed by organs that work together to perform special functions (Fig. 8-3).

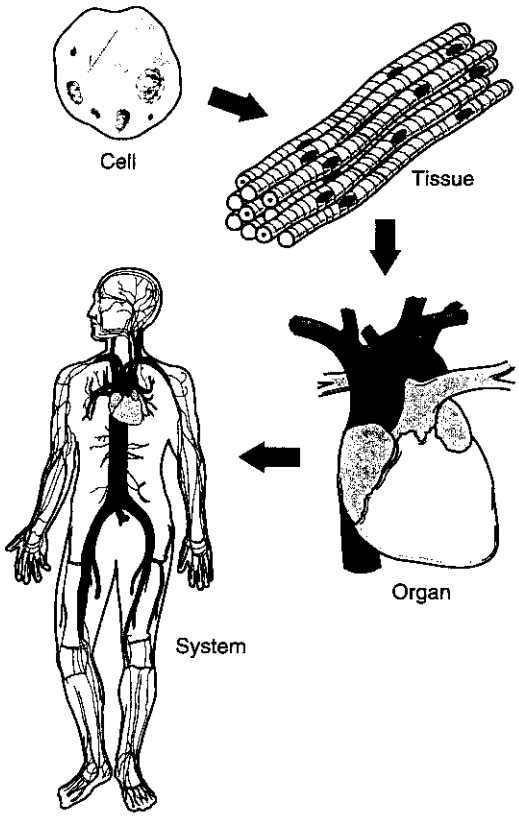

FIGURE 8-3 Organization of the body.

THE INTEGUMENTARY SYSTEM

The *integumentary system*, or *skin*, is the largest system. *Integument* means covering. The skin covers the body. It has epithelial, connective, and nerve tissue. It also has oil glands and sweat glands. There are two skin layers (Fig. 8-4):

- The *epidermis* is the outer layer. It has living cells and dead cells. The dead cells were once deeper in the epidermis. They were pushed upward as the cells divided. Dead cells constantly flake off. They are replaced by living cells. Living cells also die and flake off. Living cells of the epidermis contain *pigment*. Pigment gives skin its color. The epidermis has no blood vessels and few nerve endings.
- The *dermis* is the inner layer. It is made up of connective tissue. Blood vessels, nerves, sweat glands, and oil glands are found in the dermis. So are hair roots.

The epidermis and dermis are supported by *subcutaneous tissue*. The subcutaneous tissue is a thick layer of fat and connective tissue.

Oil glands and *sweat glands*, *hair*, and *nails* are skin appendages:

- Hair—covers the entire body, except the palms of the hands and the soles of the feet. Hair in the nose and ears and around the eyes protects these organs from dust, insects, and other foreign objects.
- Nails—protect the tips of the fingers and toes. Nails help fingers pick up and handle small objects.
- Sweat glands—help the body regulate temperature. Sweat consists of water, salt, and a small amount of wastes. Sweat is secreted through pores in the skin. The body is cooled as sweat evaporates.
- Oil glands—lie near the hair shafts. They secrete an oily substance into the space near the hair shaft. Oil travels to the skin surface. This helps keep the hair and skin soft and shiny.

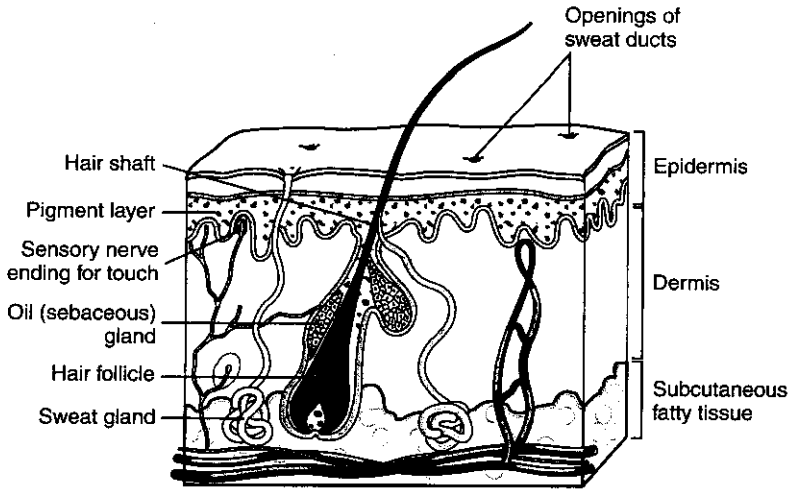

FIGURE 8-4 Layers of the skin.

The skin has many functions:

- It is the body's protective covering.
- It prevents microorganisms and other substances from entering the body.
- It prevents excess amounts of water from leaving the body.
- It protects organs from injury.
- Nerve endings in the skin sense both pleasant and unpleasant stimulation. Nerve endings are over the entire body. They sense cold, pain, touch, and pressure to protect the body from injury.
- It helps regulate body temperature. Blood vessels dilate (widen) when temperature outside the body is high. More blood is brought to the body surface for cooling during evaporation. When blood vessels constrict (narrow), the body retains heat. This is because less blood reaches the skin.

THE MUSCULOSKELETAL SYSTEM

The musculoskeletal system provides the framework for the body. It lets the body move. This system also protects and gives the body shape.

Bones

The human body has 206 *bones* (Fig. 8-5). There are four types of bones:

- *Long bones* bear the body's weight. Leg bones are long bones.
- *Short bones* allow skill and ease in movement. Bones in the wrists, fingers, ankles, and toes are short bones.
- *Flat bones* protect the organs. They include the ribs, skull, pelvic bones, and shoulder blades.
- *Irregular bones* are the vertebrae in the spinal column. They allow various degrees of movement and flexibility.

Bones are hard, rigid structures. They are made up of living cells. They are covered by a membrane called *periosteum.* Periosteum contains blood vessels that supply bone cells with oxygen and food. Inside the hollow centers of the bones is a substance called *bone marrow.* Blood cells are formed in the bone marrow.

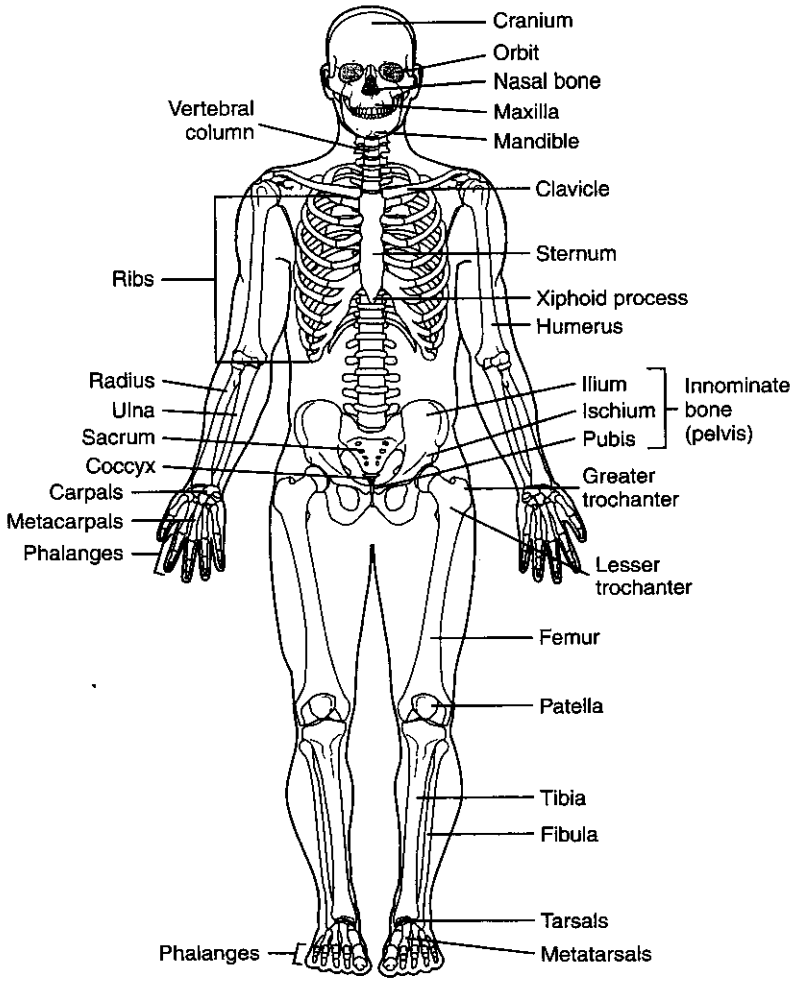

FIGURE 8-5 Bones of the body.

Joints

A *joint* is the point at which two or more bones meet. Joints allow movement (Chapter 26). *Cartilage* is the connective tissue at the end of the long bones. It cushions the joint so that the bone ends do not rub together. The *synovial membrane* lines the joints. It secretes *synovial fluid.* Synovial fluid acts as a lubricant so the joint can move smoothly. Bones are held together at the joint by strong bands of connective tissue called *ligaments.*

There are three major types of joints (Fig. 8-6):

- *Ball-and-socket joint* allows movement in all directions. It is made up of the rounded end of one bone and the hollow end of another bone. The rounded end of one fits into the hollow end of the other. The joints of the hips and shoulders are ball-and-socket joints.
- *Hinge joint* allows movement in one direction. The elbow is a hinge joint.
- *Pivot joint* allows turning from side to side. A pivot joint connects the skull to the spine.

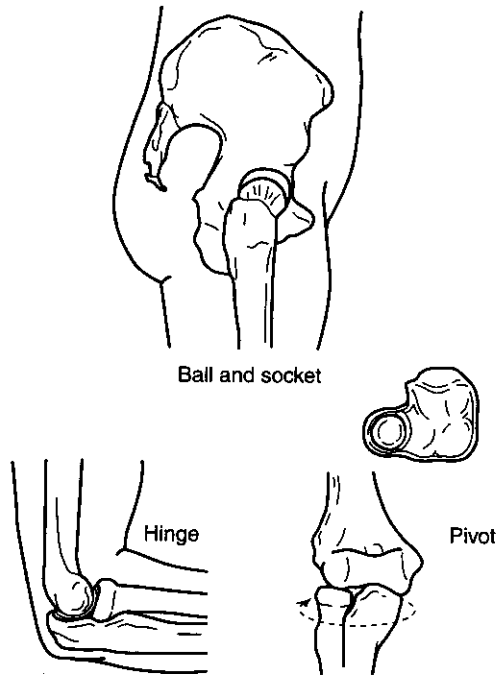

FIGURE 8-6 Types of joints.

Muscles

The human body has more than 500 *muscles* (Figs. 8-7 and 8-8). Some are voluntary. Others are involuntary.

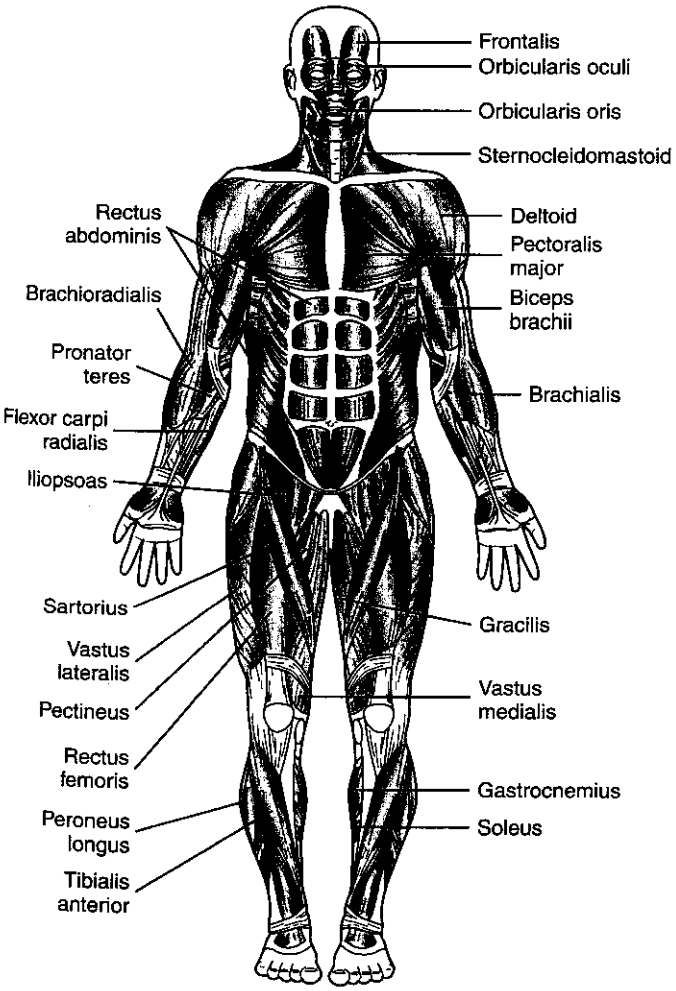

FIGURE 8-7 Anterior view of the muscles of the body.

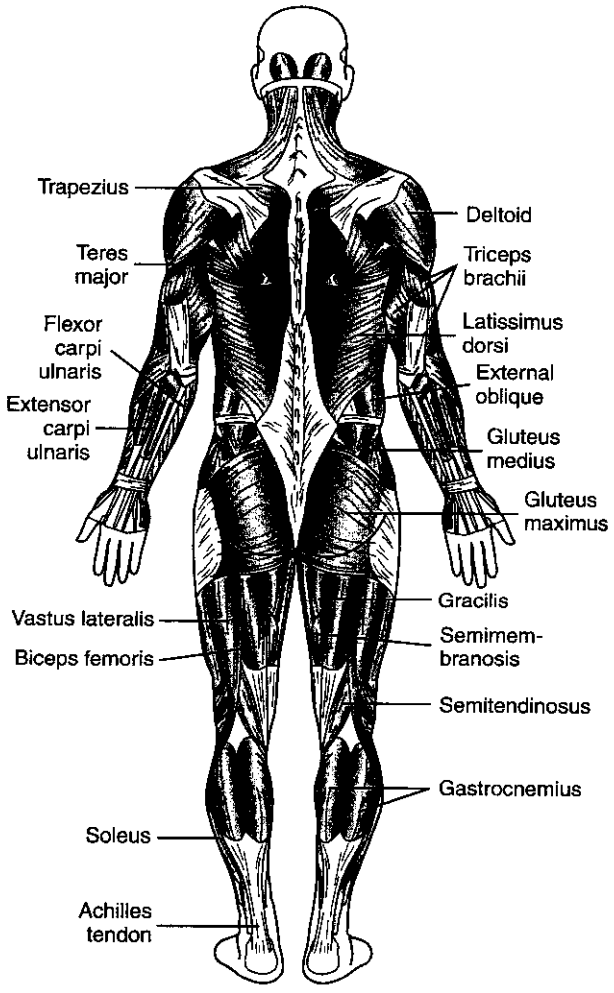

FIGURE 8-8 Posterior view of the muscles of the body.

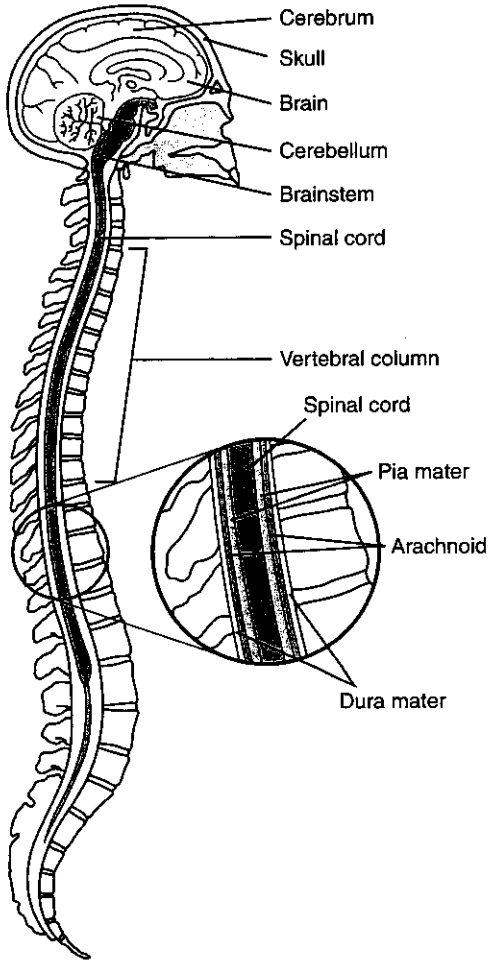

FIGURE 8-9 Central nervous system.

Voluntary muscles can be consciously controlled. Muscles attached to bones *(skeletal muscles)* are voluntary. Arm muscles do not work unless you move your arm; likewise for leg muscles. Skeletal muscles are *striated.* That is, they look striped or streaked.

Involuntary muscles work automatically. You cannot control them. They control the action of the stomach, intestines, blood vessels, and other body organs. Involuntary muscles also are called *smooth muscles.* They look smooth, not streaked or striped.

Cardiac muscle is in the heart. It is an involuntary muscle. However, it appears striated like skeletal muscle.

Muscles have three functions:

- Movement of body parts
- Maintenance of posture
- Production of body heat

Strong, tough connective tissues called *tendons* connect muscles to bones. When muscles contract (shorten), tendons at each end of the muscle cause the bone to move. The body has many tendons. See the Achilles tendon in Figure 8-8. Some muscles constantly contract to maintain the body's posture. When muscles contract, they burn food for energy. Heat is produced. The more muscle activity, the greater the amount of heat produced. Shivering is how the body produces heat when exposed to cold. Shivering is from rapid, general muscle contractions.

THE NERVOUS SYSTEM

The nervous system controls, directs, and coordinates body functions. Its two main divisions are:

- The *central nervous system* (CNS). It consists of the brain and spinal cord (Fig. 8-9).
- The *peripheral nervous system.* It involves the *nerves* throughout the body (Fig. 8-10).

Nerves carry messages or impulses to and from the brain. Nerves connect to the spinal cord. They are easily damaged and take a long time to heal. Some nerve fibers have a protective covering called a *myelin sheath.* The myelin sheath also insulates the nerve fiber. Nerve fibers covered with myelin conduct impulses faster than those fibers without it.

The Central Nervous System

The *brain* and *spinal cord* make up the central nervous system. The brain is covered by the skull. The three main

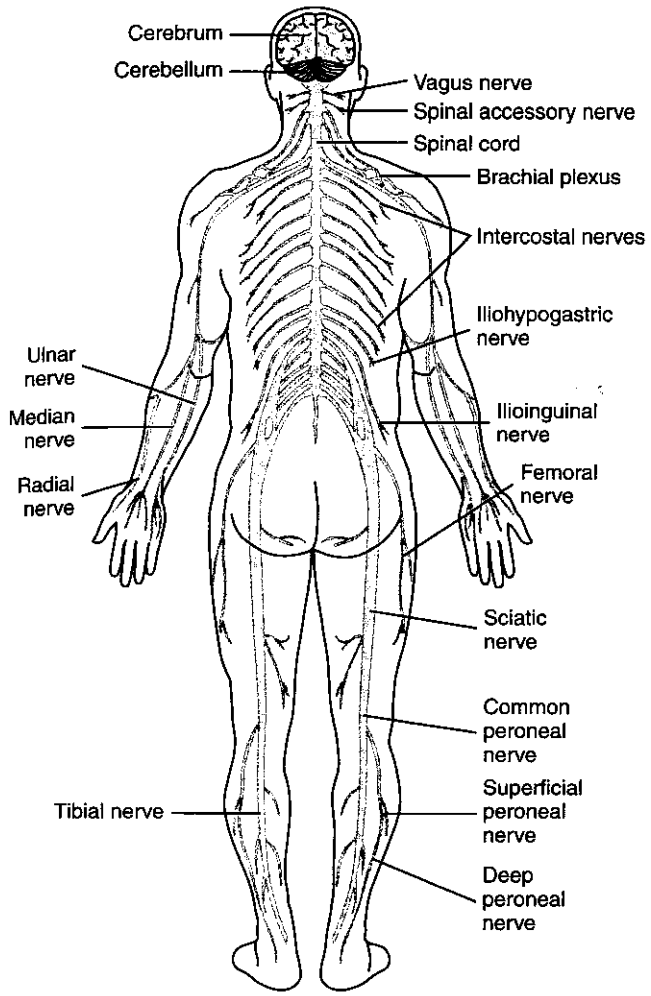

FIGURE 8-10 Peripheral nervous system.

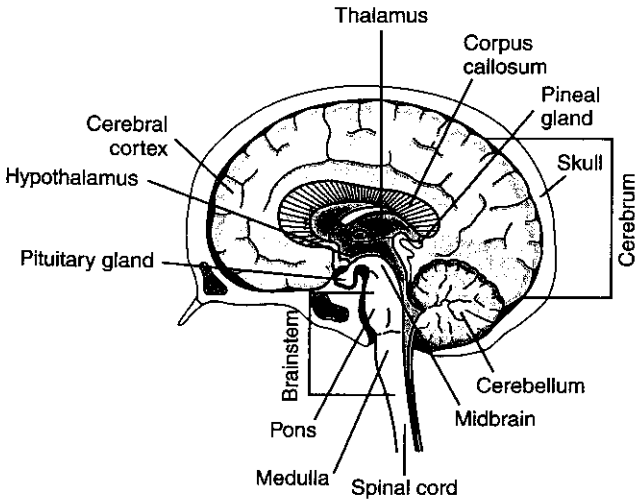

FIGURE 8-11 The brain.

parts of the brain are the *cerebrum*, the *cerebellum*, and the *brainstem* (Fig. 8-11).

The cerebrum is the largest part of the brain. It is the center of thought and intelligence. The cerebrum is divided into two halves called the *right* and *left hemispheres*. The right hemisphere controls movement and activities on the body's left side. The left hemisphere controls the right side.

The outside of the cerebrum is called the *cerebral cortex*. It controls the highest functions of the brain. These include reasoning, memory, consciousness, speech, voluntary muscle movement, vision, hearing, sensation, and other activities.

The cerebellum regulates and coordinates body movements. It controls balance and the smooth movements of voluntary muscles. Injury to the cerebellum results in jerky movements, loss of coordination, and muscle weakness.

The brainstem connects the cerebrum to the spinal cord. The brainstem contains the *midbrain*, *pons*, and *medulla*. The midbrain and pons relay messages between the medulla and the cerebrum. The medulla is below the pons. The medulla controls heart rate, breathing, blood vessel size, swallowing, coughing, and vomiting. The brain connects to the spinal cord at the lower end of the medulla.

The spinal cord lies within the spinal column. The cord is 17 to 18 inches long. It contains pathways that conduct messages to and from the brain.

The brain and spinal cord are covered and protected by three layers of connective tissue called meninges:

- The outer layer lies next to the skull. It is a tough covering called the *dura mater*.
- The middle layer is the *arachnoid*.
- The inner layer is the *pia mater*.

The space between the middle layer (arachnoid) and inner layer (pia mater) is the *arachnoid space*. The space is filled with *cerebrospinal fluid*. It circulates around the brain and spinal cord. Cerebrospinal fluid protects the central nervous system. It cushions shocks that could easily injure brain and spinal cord structures.

The Peripheral Nervous System

The peripheral nervous system has 12 pairs of *cranial nerves* and 31 pairs of *spinal nerves*. Cranial nerves conduct impulses between the brain and the head, neck, chest, and abdomen. They conduct impulses for smell, vision, hearing, pain, touch, temperature, and pressure. They also conduct impulses for voluntary and involuntary muscles. Spinal nerves carry impulses from the skin, extremities, and the internal structures not supplied by cranial nerves.

Some peripheral nerves form the *autonomic nervous system*. This system controls involuntary muscles and certain body functions. The functions include the heartbeat, blood pressure, intestinal contractions, and glandular secretions. These functions occur automatically.

The autonomic nervous system is divided into the *sympathetic nervous system* and the *parasympathetic nervous system*. They balance each other. The sympathetic nervous system speeds up functions. The parasympathetic nervous

system slows functions. When you are angry, scared, excited, or exercising, the sympathetic nervous system is stimulated. The parasympathetic system is activated when you relax or when the sympathetic system is stimulated for too long.

The Sense Organs

The five senses are *sight*, *hearing*, *taste*, *smell*, and *touch*. Receptors for taste are in the tongue. They are called *taste buds*. Receptors for smell are in the nose. Touch receptors are in the dermis, especially in the toes and fingertips.

The Eye

Receptors for vision are in the *eyes* (Fig. 8-12). The eye is easily injured. Bones of the skull, eyelids and eyelashes, and tears protect the eyes from injury. The eye has three layers:

- The *sclera*, the white of the eye, is the outer layer. It is made of tough connective tissue.
- The *choroid* is the second layer. Blood vessels, the *ciliary muscle*, and the *iris* make up the choroid. The iris gives the eye its color. The opening in the middle of the iris is the *pupil*. Pupil size varies with the amount of light entering the eye. The pupil constricts (narrows) in bright light. It dilates (widens) in dim or dark places.
- The *retina* is the inner layer. It has receptors for vision and the nerve fibers of the *optic nerve*.

Light enters the eye through the *cornea*. It is the transparent part of the outer layer that lies over the eye. Light rays pass to the *lens*, which lies behind the pupil. The light is then reflected to the retina. Light is carried to the brain by the optic nerve.

The *aqueous chamber* separates the cornea from the lens. The chamber is filled with a fluid called *aqueous humor*. The fluid helps the cornea keep its shape and position. The *vitreous humor* is behind the lens. It is a gelatin-like substance that supports the retina and maintains the eye's shape.

The Ear

The *ear* is a sense organ (Fig. 8-13). It functions in hearing and balance. It has three parts: the *external ear*, *middle ear*, and *inner ear*.

The external ear (outer part) is called the *pinna* or *auricle*. Sound waves are guided through the external ear into the *auditory canal*. Glands in the auditory canal secrete a waxy substance called *cerumen*. The auditory canal extends about 1 inch to the *eardrum*. The eardrum *(tympanic membrane)* separates the external and middle ear.

The middle ear is a small space. It contains the *eustachian tube* and three small bones called *ossicles*. The eustachian tube connects the middle ear and the throat. Air enters the eustachian tube so that there is equal pressure on both sides of the eardrum. The ossicles amplify sound received from the eardrum and transmit the sound to the inner ear. The three ossicles are:

- The *malleus*. It looks like a hammer.
- The *incus*. It looks like an anvil.
- The *stapes*. It is shaped like a stirrup.

The inner ear consists of *semicircular canals* and the *cochlea*. The cochlea looks like a snail shell. It contains fluid. The fluid carries sound waves from the middle ear to the *auditory nerve*. The auditory nerve then carries the message to the brain.

The three semicircular canals are involved with balance. They sense the head's position and changes in position. They send messages to the brain.

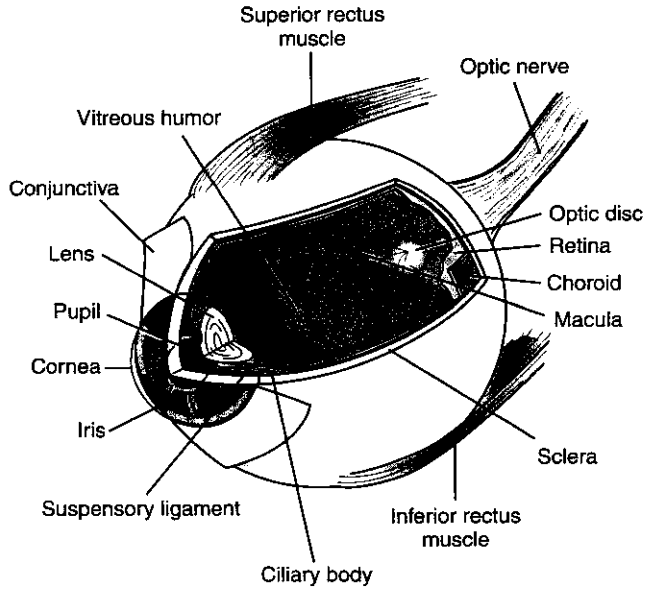

FIGURE 8-12 The eye.

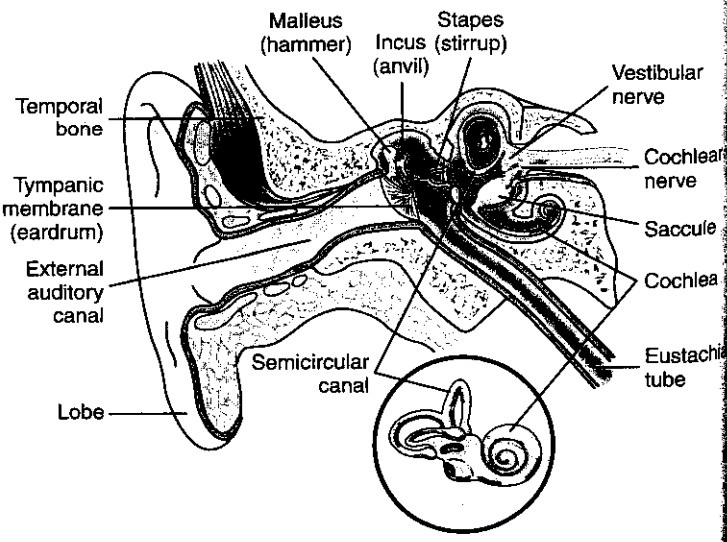

FIGURE 8-13 The ear.

THE CIRCULATORY SYSTEM

The circulatory system is made up of the *blood*, *heart*, and *blood vessels*. The heart pumps blood through the blood vessels. The circulatory system has many functions:

- Blood carries food, oxygen, and other substances to the cells.
- Blood removes waste products from cells.
- Blood and blood vessels help regulate body temperature. The blood carries heat from muscle activity to other body parts. Blood vessels in the skin dilate to cool the body. They constrict to retain heat.
- The system produces and carries cells that defend the body from microbes that cause disease.

The Blood

The blood consists of blood cells and *plasma*. Plasma is mostly water. It carries blood cells to other body cells. Plasma also carries substances that cells need to function. This includes food (proteins, fats, and carbohydrates), hormones (p. 110), and chemicals.

Red blood cells (RBCs) are called *erythrocytes*. They give blood its red color because of a substance in the cell called hemoglobin. As RBCs circulate through the lungs, hemoglobin picks up oxygen. Hemoglobin carries oxygen to the cells. When blood is bright red, hemoglobin in the RBCs is saturated (filled) with oxygen. As blood circulates through the body, oxygen is given to the cells. Cells release carbon dioxide (a waste product). It is picked up by the hemoglobin. RBCs saturated with carbon dioxide make the blood look dark red.

The body has about 25 trillion (25,000,000,000,000) RBCs. About 4½ to 5 million cells are in a cubic millimeter of blood (the size of a tiny drop). RBCs live for 3 or 4 months. They are destroyed by the liver and spleen as they wear out. New RBCs are formed in the bone marrow. About 1 million RBCs are produced every second.

White blood cells (WBCs) are called *leukocytes*. They have no color. They protect the body against infection. There are about 5,000 to 10,000 WBCs in a cubic millimeter of blood. At the first sign of infection, WBCs rush to the infection site. There they multiply rapidly. The number of WBCs increases when there is an infection. WBCs are formed by the bone marrow. They live about 9 days.

Platelets (thrombocytes) are needed for blood clotting. They are formed by the bone marrow. There are about 200,000 to 400,000 platelets in a cubic millimeter of blood. A platelet lives about 4 days.

The Heart

The heart is a muscle. It pumps blood through the blood vessels to the tissues and cells. The heart lies in the middle to lower part of the chest cavity toward the left side (Fig. 8-14). The heart is hollow and has three layers (Fig. 8-15):

- The *pericardium* is the outer layer. It is a thin sac covering the heart.

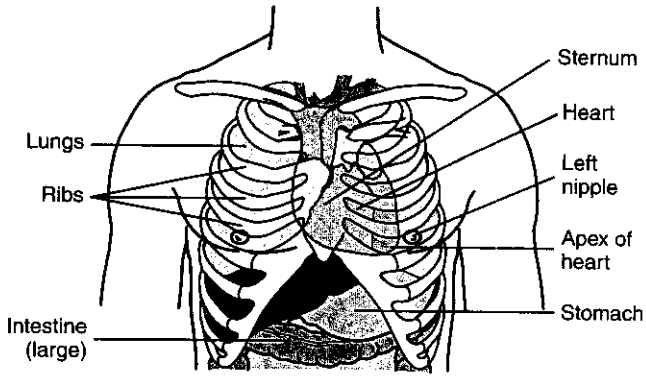

FIGURE 8-14 Location of the heart in the chest cavity.

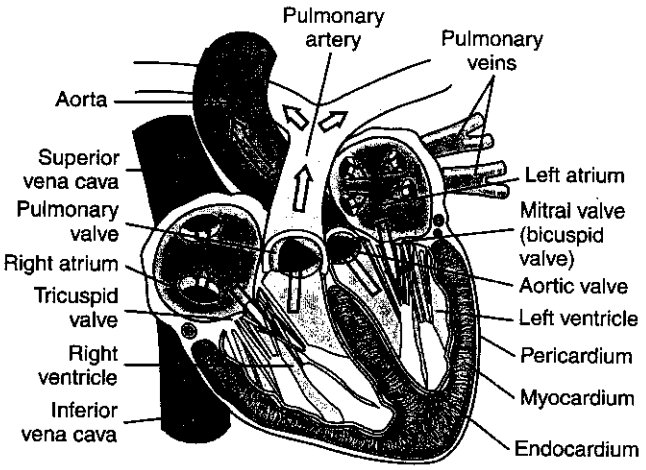

FIGURE 8-15 Structures of the heart.

- The *myocardium* is the second layer. It is the thick, muscular part of the heart.
- The *endocardium* is the inner layer. A membrane, it lines the inner surface of the heart.

The heart has four chambers (see Fig. 8-15). Upper chambers receive blood and are called *atria*. The *right atrium* receives blood from body tissues. The *left atrium* receives blood from the lungs. Lower chambers are called *ventricles*. Ventricles pump blood. The *right ventricle* pumps blood to the lungs for oxygen. The *left ventricle* pumps blood to all parts of the body.

Valves are between the atria and ventricles. The valves allow blood flow in one direction. They prevent blood from flowing back into the atria from the ventricles. The *tricuspid valve* is between the right atrium and the right ventricle. The *mitral valve (bicuspid valve)* is between the left atrium and left ventricle.

Heart action has two phases:

- *Diastole*. It is the resting phase. Heart chambers fill with blood.
- *Systole*. It is the working phase. The heart contracts. Blood is pumped through the blood vessels when the heart contracts.

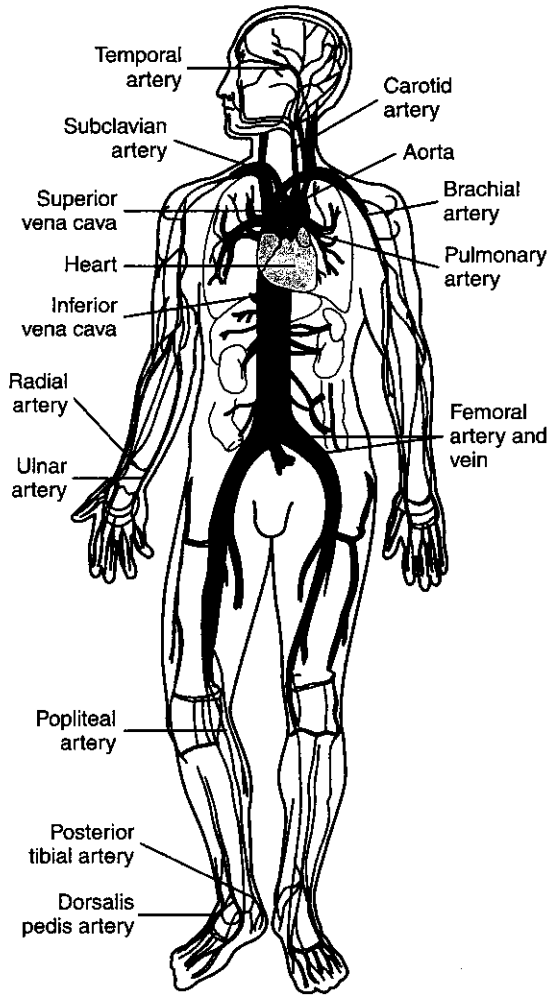

FIGURE 8-16 Arterial and venous systems. Arterial system is red. Venous system is blue.

The Blood Vessels

Blood flows to body tissues and cells through the blood vessels. There are three groups of blood vessels: arteries, capillaries, and veins.

Arteries carry blood away from the heart. Arterial blood is rich in oxygen. The *aorta* is the largest artery. It receives blood directly from the left ventricle. The aorta branches into other arteries that carry blood to all parts of the body (Fig. 8-16). These arteries branch into smaller parts within the tissues. The smallest branch of an artery is an *arteriole*.

Arterioles connect to capillaries. Capillaries are very tiny blood vessels. Food, oxygen, and other substances pass from capillaries into the cells. The capillaries pick up waste products (including carbon dioxide) from the cells. Veins carry waste products back to the heart.

Veins return blood to the heart. They connect to the capillaries by *venules*. Venules are small veins. Venules branch together to form veins. The many veins also branch together as they near the heart to form two main veins (see Fig. 8-16). The two main veins are the *inferior vena cava* and the *superior vena cava*. Both empty into the right atrium. The inferior vena cava carries blood from the legs and trunk. The superior vena cava carries blood from the head and arms. Venous blood is dark red. It has little oxygen and a lot of carbon dioxide.

Blood flow through the circulatory system is shown in Fig. 8-15. The path of blood flow is as follows:

- Venous blood, poor in oxygen, empties into the right atrium.
- Blood flows through the tricuspid valve into the right ventricle.
- The right ventricle pumps blood into the lungs to pick up oxygen.
- Oxygen-rich blood from the lungs enters the left atrium.
- Blood from the left atrium passes through the mitral valve into the left ventricle.
- The left ventricle pumps the blood to the aorta. It branches off to form other arteries.
- Arterial blood is carried to the tissues by arterioles and to the cells by capillaries.
- Cells and capillaries exchange oxygen and nutrients for carbon dioxide and waste products.
- Capillaries connect with venules.
- Venules carry blood that has carbon dioxide and waste products.
- Venules form veins.
- Veins return blood to the heart.

THE RESPIRATORY SYSTEM

Oxygen is needed to live. Every cell needs oxygen. Air contains about 21% oxygen. This meets the body's needs under normal conditions. The respiratory system (Fig. 8-17) brings oxygen into the lungs and removes carbon dioxide. Respiration is the process of supplying the cells with oxygen and removing carbon dioxide from them. Respiration involves *inhalation* (breathing in) and *exhalation* (breathing out). The terms *inspiration* (breathing in) and *expiration* (breathing out) also are used.

Air enters the body through the *nose*. The air then passes into the *pharynx* (throat). It is a tube-shaped passageway for air and food. Air passes from the pharynx into the *larynx* (voice box). A piece of cartilage, the *epiglottis*, acts like a lid over the larynx. The epiglottis prevents food from entering the airway during swallowing. During inhalation the epiglottis lifts up to let air pass over the larynx. Air passes from the larynx into the *trachea* (windpipe).

The trachea divides at its lower end into the *right bronchus* and the *left bronchus*. Each bronchus enters a lung. Upon entering the lungs, the bronchi divide many times into smaller branches. The smaller branches are called *bronchioles*. Eventually the bronchioles subdivide. They end up in tiny, one-celled air sacs called *alveoli*.

Alveoli look like small clusters of grapes. They are supplied by capillaries. Oxygen and carbon dioxide are exchanged between the alveoli and capillaries. Blood in the capillaries picks up oxygen from the alveoli. Then the blood is returned to the left side of the heart and pumped

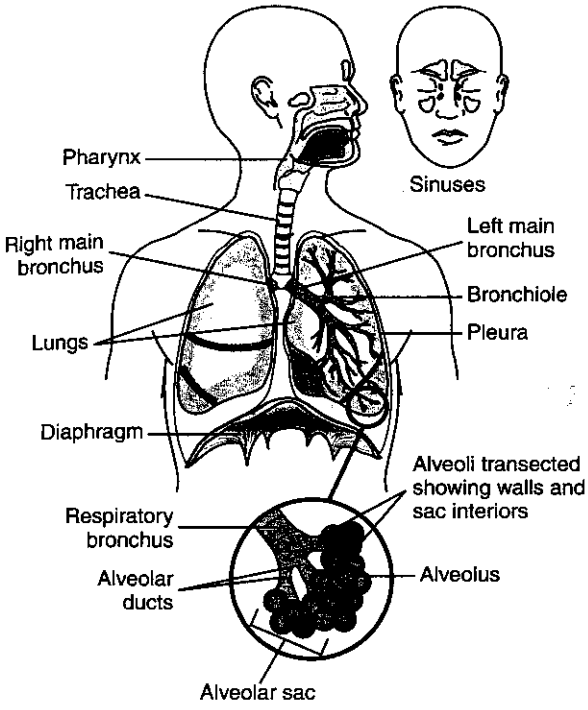

FIGURE 8-17 Respiratory system.

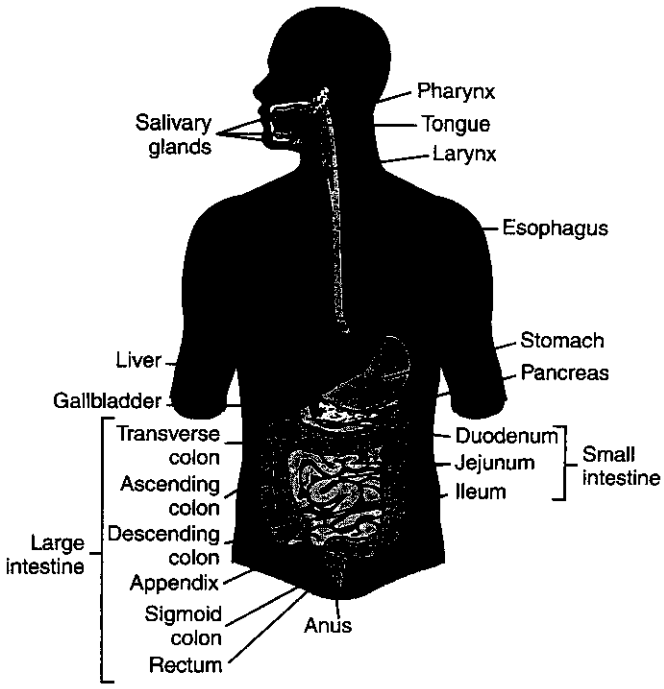

FIGURE 8-18 Digestive system.

to the rest of the body. Alveoli pick up carbon dioxide from the capillaries for exhalation.

The lungs are spongy tissues. They are filled with alveoli, blood vessels, and nerves. Each lung is divided into lobes. The right lung has three lobes; the left lung has two. The lungs are separated from the abdominal cavity by a muscle called the *diaphragm.*

Each lung is covered by a two-layered sac called the *pleura.* One layer is attached to the lung and the other to the chest wall. The pleura secretes a very thin fluid that fills the space between the layers. The fluid prevents the layers from rubbing together during inhalation and exhalation. A bony framework made up of the ribs, sternum, and vertebrae protects the lungs.

THE DIGESTIVE SYSTEM

The digestive system breaks down food physically and chemically so it can be absorbed for use by the cells. This process is called digestion. The digestive system is also called the *gastrointestinal (GI) system.* The system also removes solid wastes from the body.

The digestive system involves the *alimentary canal (GI tract)* and the accessory organs of digestion (Fig. 8-18). The alimentary canal is a long tube. It extends from the mouth to the anus. Its major parts are the mouth, pharynx, esophagus, stomach, small intestine, and large intestine. Accessory organs are the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.

Digestion begins in the *mouth.* The mouth also is called the *oral cavity.* It receives food and prepares it for digestion. Using chewing motions, the *teeth* cut, chop, and grind food into small particles for digestion and swallowing. The *tongue* aids in chewing and swallowing. Taste buds on the tongue's surface contain nerve endings. Taste buds allow sweet, sour, bitter, and salty tastes to be sensed. *Salivary glands* in the mouth secrete *saliva.* Saliva moistens food particles to ease swallowing and begin digestion. During swallowing, the tongue pushes food into the *pharynx.*

The pharynx (throat) is a muscular tube. Swallowing continues as the pharynx contracts. Contraction of the pharynx pushes food into the *esophagus.* The esophagus is a muscular tube about 10 inches long. It extends from the pharynx to the *stomach.* Involuntary muscle contractions called peristalsis move food down the esophagus through the alimentary canal.

The stomach is a muscular, pouch-like sac. It is in the upper left part of the abdominal cavity. Strong stomach muscles stir and churn food to break it up into even smaller particles. A mucous membrane lines the stomach. It contains glands that secrete *gastric juices.* Food is mixed and churned with the gastric juices to form a semi-liquid substance called *chyme.* Through peristalsis, the chyme is pushed from the stomach into the small intestine.

The *small intestine* is about 20 feet long. It has three parts. The first part is the *duodenum.* There more digestive juices are added to the chyme. One is called *bile.* Bile is a greenish liquid made in the *liver.* Bile is stored in the *gallbladder.* Juices from the *pancreas* and small intestine are added to the chyme. Digestive juices chemically break down food so it can be absorbed.

Peristalsis moves the chyme through the two other

parts of the small intestine: the *jejunum* and the *ileum*. Tiny projections called *villi* line the small intestine. Villi absorb the digested food into the capillaries. Most food absorption takes place in the jejunum and the ileum.

Some chyme is not digested. Undigested chyme passes from the small intestine into the *large intestine (large bowel* or *colon)*. The colon absorbs most of the water from the chyme. The remaining semi-solid material is called *feces*. Feces contain a small amount of water, solid wastes, and some mucus and germs. These are the waste products of digestion. Feces pass through the colon into the *rectum* by peristalsis. Feces pass out of the body through the *anus*.

THE URINARY SYSTEM

The digestive system rids the body of solid wastes. The lungs rid the body of carbon dioxide. Water and other substances are in sweat. There are other waste products in the blood from cells burning food for energy. The urinary system (Fig. 8-19):

- Removes waste products from the blood
- Maintains water balance within the body

The *kidneys* are two bean-shaped organs in the upper abdomen. They lie against the back muscles on each side of the spine. They are protected by the lower edge of the rib cage.

Each kidney has over a million tiny *nephrons* (Fig. 8-20). Each nephron is the basic working unit of the kidney. Each nephron has a *convoluted tubule*, which is a tiny coiled tubule. Each convoluted tubule has a *Bowman's capsule* at one end. The capsule partly surrounds a cluster

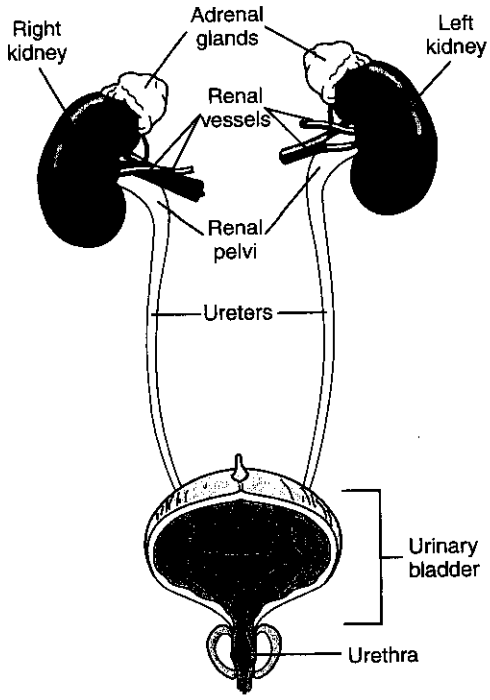

FIGURE 8-19 Urinary system.

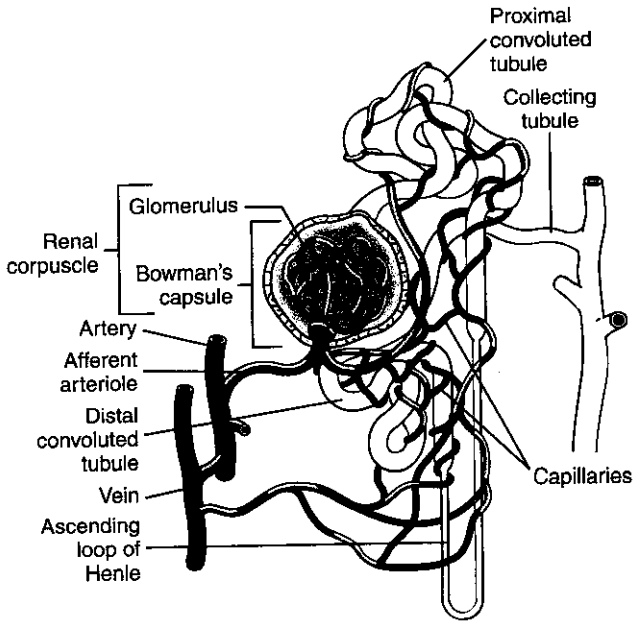

FIGURE 8-20 A nephron.

of capillaries called a *glomerulus*. Blood passes through the glomerulus and is filtered by the capillaries. The fluid part of the blood is squeezed into the Bowman's capsule. The fluid then passes into the tubule. Most of the water and other needed substances are reabsorbed by the blood. The rest of the fluid and the waste products form *urine* in the tubule. Urine flows through the tubule to a *collecting tubule*. All collecting tubules drain into the *renal pelvis* in the kidney.

A tube, called the *ureter*, is attached to the renal pelvis of the kidney. Each ureter is about 10 to 12 inches long. The ureters carry urine from the kidneys to the *bladder*. The bladder is a hollow, muscular sac. It lies toward the front in the lower part of the abdominal cavity.

Urine is stored in the bladder until the need to urinate is felt. This usually occurs when there is about a half pint (250 mL) of urine in the bladder. Urine passes from the bladder through the *urethra*. The opening at the end of the urethra is the *meatus*. Urine passes from the body through the meatus. Urine is a clear, yellowish fluid.

THE REPRODUCTIVE SYSTEM

Human reproduction results from the union of a male sex cell and a female sex cell. The male and female reproductive systems are different. This allows for the process of reproduction.

The Male Reproductive System

The male reproductive system is shown in Figure 8-21. The *testes (testicles)* are the male sex glands. Sex glands also are called *gonads*. The two testes are oval or almond-shaped glands. Male sex cells are produced in the testes. Male sex cells are called *sperm* cells.

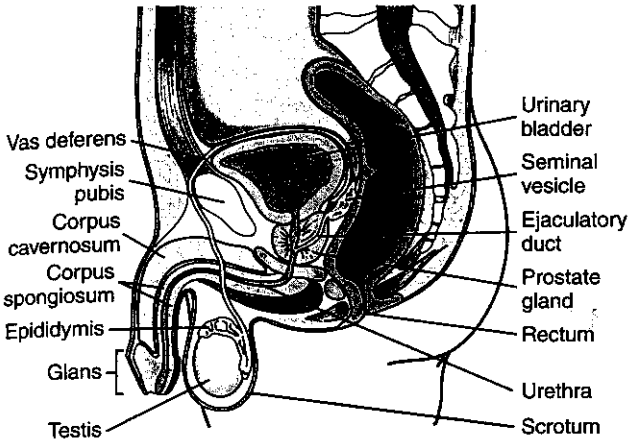

FIGURE 8-21 Male reproductive system.

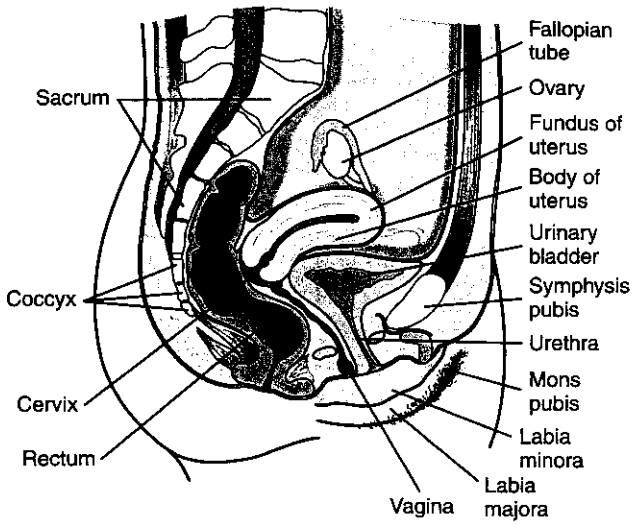

FIGURE 8-22 Female reproductive system.

Testosterone, the male hormone, is produced in the testes. This hormone is needed for reproductive organ function. It also is needed for the development of the male secondary sex characteristics. There is facial hair; pubic and axillary (underarm) hair; and hair on the arms, chest, and legs. Neck and shoulder sizes increase.

The testes are suspended between the thighs in a sac called the *scrotum*. The scrotum is made of skin and muscle.

Sperm travel from the testis to the *epididymis*. The epididymis is a coiled tube on top and to the side of the testis. From the epididymis, sperm travel through a tube called the *vas deferens*. Each vas deferens joins a seminal vesicle. The two seminal vesicles store sperm and produce *semen*. Semen is a fluid that carries sperm from the male reproductive tract. The ducts of the seminal vesicles unite to form the *ejaculatory duct*. It passes through the *prostate gland*.

The prostate gland lies just below the bladder. It is shaped like a donut. The gland secretes fluid into the semen. As the ejaculatory ducts leave the prostate, they join the *urethra*. The urethra runs through the prostate gland. The urethra is the outlet for urine and semen. The urethra is contained within the *penis*.

The penis is outside of the body and has *erectile* tissue. When a man is sexually excited, blood fills the erectile tissue. The penis enlarges and becomes hard and erect. The erect penis can enter a female's vagina. The semen, which contains sperm, is released into the vagina.

The Female Reproductive System

Figure 8-22 shows the female reproductive system. The female gonads are two almond-shaped glands called *ovaries*. An ovary is on each side of the uterus in the abdominal cavity.

The ovaries contain *ova* or eggs. Ova are the female sex cells. One ovum (egg) is released monthly during the woman's reproductive years. Release of an ovum is called *ovulation*.

The ovaries secrete the female hormones *estrogen* and *progesterone*. These hormones are needed for reproductive system function. They also are needed for the development of secondary sex characteristics in the female. These include increased breast size, pubic and axillary (underarm) hair, slight deepening of the voice, and widening and rounding of the hips.

When an ovum is released from an ovary, it travels through a *fallopian tube*. There are two fallopian tubes, one on each side. The tubes are attached at one end to the uterus. The ovum travels through the fallopian tube to the *uterus*.

The *uterus* is a hollow, muscular organ shaped like a pear. It is in the center of the pelvic cavity behind the bladder and in front of the rectum. The main part of the uterus is the *fundus*. The neck or narrow section of the uterus is the *cervix*. Tissue lining the uterus is called the *endometrium*. The endometrium has many blood vessels. If sex cells from the male and female unite into one cell, that cell implants into the endometrium. There the cell grows into a baby. The uterus serves as a place for the *fetus* (unborn baby) to grow and receive nourishment.

The cervix of the uterus projects into a muscular canal called the *vagina*. The vagina opens to the outside of the body. It is just behind the urethra. The vagina receives the penis during intercourse. It also is part of the birth canal. Glands in the vaginal wall keep it moistened with secretions. In young girls, the external vaginal opening is partially closed by a membrane called the *hymen*. The hymen ruptures when the female has intercourse for the first time.

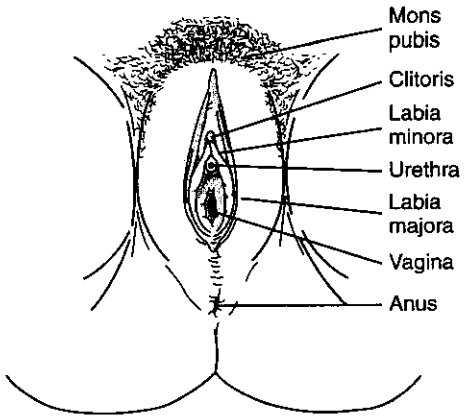

FIGURE 8-23 External female genitalia.

The external female genitalia are called the *vulva* (Fig. 8-23):

- The *mons pubis* is a rounded, fatty pad over a bone called the *symphysis pubis.* The mons pubis is covered with hair in the adult female.
- The *labia majora* and *labia minora* are two folds of tissue on each side of the vaginal opening.
- The *clitoris* is a small organ composed of erectile tissue. It becomes hard when sexually stimulated.

The *mammary glands (breasts)* secrete milk after childbirth. The glands are on the outside of the chest. They are made up of glandular tissue and fat (Fig. 8-24). The milk drains into ducts that open onto the *nipple.*

Menstruation

The endometrium is rich in blood to nourish the cell that grows into a fetus. If pregnancy does not occur, the endometrium breaks up. It is discharged from the body through the vagina. This process is called menstruation. Menstruation occurs about every 28 days. Therefore it is called the *menstrual cycle.*

The first day of the menstrual cycle begins with menstruation. Blood flows from the uterus through the vaginal opening. Menstrual flow usually lasts 3 to 7 days. Ovulation occurs during the next phase. An ovum matures in an ovary and is released. Ovulation usually occurs on or about day 14 of the cycle.

Meanwhile, estrogen and progesterone (the female hormones) are secreted by the ovaries. These hormones cause the endometrium to thicken for pregnancy. If pregnancy does not occur, the hormones decrease in amount. This causes the blood supply to the endometrium to decrease. The endometrium breaks up. It is discharged through the vagina. Another menstrual cycle begins.

Fertilization

To reproduce, a male sex cell (sperm) must unite with a female sex cell (ovum). The uniting of the sperm and ovum into one cell is called *fertilization.* A sperm has 23 chromosomes. An ovum has 23 chromosomes. When the two cells unite, the fertilized cell has 46 chromosomes.

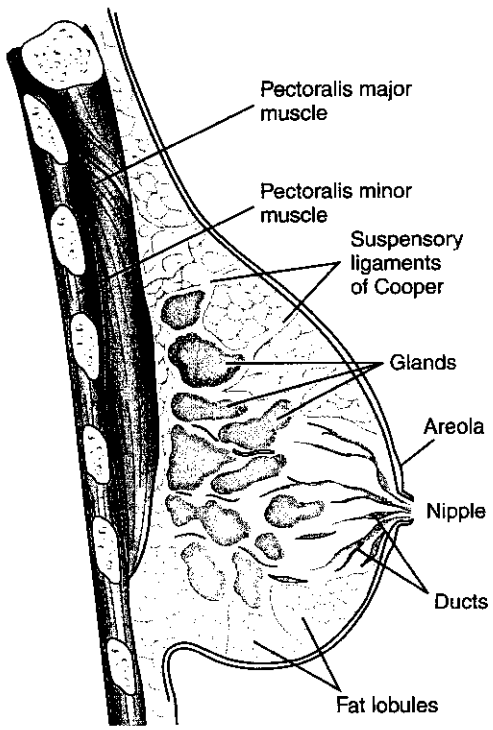

FIGURE 8-24 The female breast.

During intercourse, millions of sperm are deposited into the vagina. Sperm travel up the cervix, through the uterus, and into the fallopian tubes. If a sperm and an ovum unite in a fallopian tube, fertilization results. Pregnancy occurs. The fertilized cell travels down the fallopian tube to the uterus. After a short time, the fertilized cell implants in the thick endometrium and grows during pregnancy.

THE ENDOCRINE SYSTEM

The endocrine system is made up of glands called the *endocrine glands* (Fig. 8-25). The endocrine glands secrete chemical substances called hormones into the bloodstream. Hormones regulate the activities of other organs and glands in the body.

The *pituitary gland* is called the *master gland.* About the size of a cherry, it is at the base of the brain behind the eyes. The pituitary gland is divided into the *anterior pituitary lobe* and the *posterior pituitary lobe.* The anterior pituitary lobe secretes:

- *Growth hormone (GH)*—needed for growth of muscles, bones, and other organs. It is needed throughout life to maintain normal-size bones and muscles. Growth is stunted if a baby is born with deficient amounts of growth hormone. Too much of the hormone causes excessive growth.
- *Thyroid-stimulating hormone (TSH)*—needed for thyroid gland function.
- *Adrenocorticotropic hormone (ACTH)*—stimulates the adrenal gland.

The anterior lobe also secretes hormones that regulate growth, development, and function of the male and female reproductive systems.

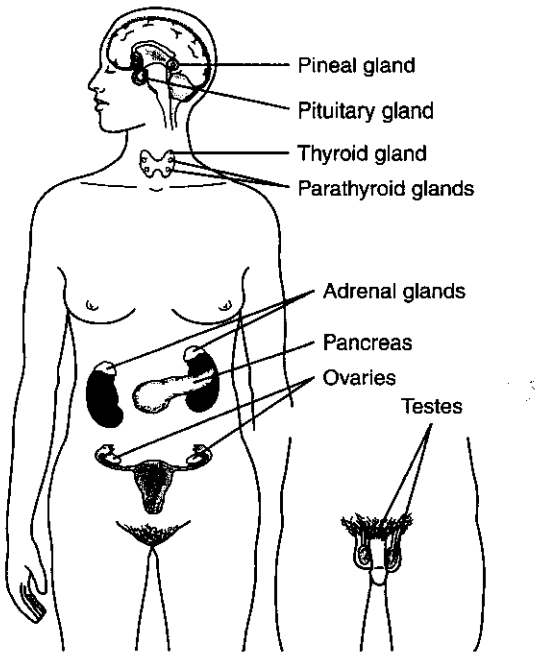

FIGURE 8-25 Endocrine system.

The posterior pituitary lobe secretes *antidiuretic hormone (ADH)* and *oxytocin.* ADH prevents the kidneys from excreting excessive amounts of water. Oxytocin causes uterine muscles to contract during childbirth.

The *thyroid gland,* shaped like a butterfly, is in the neck in front of the larynx. *Thyroid hormone (TH, thyroxine)* is secreted by the thyroid gland. It regulates metabolism. Metabolism is the burning of food for heat and energy by the cells. Too little TH results in slowed body processes, slowed movements, and weight gain. Too much TH causes increased metabolism, excess energy, and weight loss. Some babies are born with deficient amounts of TH. Their physical growth and mental growth are stunted.

The four *parathyroid glands* secrete *parathormone.* Two lie on each side of the thyroid gland. Parathormone regulates calcium use. Calcium is needed for nerve and muscle function. Insufficient amounts of calcium cause *tetany.* Tetany is a state of severe muscle contraction and spasm. If untreated, tetany can cause death.

There are two *adrenal glands.* An adrenal gland is on the top of each kidney. The adrenal gland has two parts: the *adrenal medulla* and the *adrenal cortex.* The adrenal medulla secretes *epinephrine* and *norepinephrine.* These hormones stimulate the body to quickly produce energy during emergencies. Heart rate, blood pressure, muscle power, and energy all increase.

The adrenal cortex secretes three groups of hormones needed for life:

- *Glucocorticoids*—regulate the metabolism of carbohydrates. They also control the body's response to stress and inflammation.
- *Mineralocorticoids*—regulate the amount of salt and water that is absorbed and lost by the kidneys.
- Small amounts of male and female sex hormones—p. 108.

The *pancreas* secretes *insulin.* Insulin regulates the amount of sugar in the blood available for use by the cells. Insulin is needed for sugar to enter the cells. If there is too little insulin, sugar cannot enter the cells. If sugar cannot enter the cells, excess amounts of sugar build up in the blood. This condition is called *diabetes.*

The *gonads* are the glands of human reproduction. Male sex glands (testes) secrete *testosterone.* Female sex glands (ovaries) secrete *estrogen* and *progesterone.*

THE IMMUNE SYSTEM

The immune system protects the body from disease and infection. Abnormal body cells can grow into tumors. Sometimes the body produces substances that cause the body to attack itself. Microorganisms (bacteria, viruses, and other germs) can cause an infection. The immune system defends against threats inside and outside the body.

The immune system gives the body immunity. Immunity means that a person has protection against a disease or condition. The person will not get or be affected by the disease:

- *Specific immunity* is the body's reaction to a certain threat.
- *Nonspecific immunity* is the body's reaction to anything it does not recognize as a normal body substance.

Special cells and substances function to produce immunity:

- *Antibodies*—normal body substances that recognize abnormal or unwanted substances. They attack and destroy such substances.
- *Antigens*—abnormal or unwanted substances. An antigen causes the body to produce antibodies. The antibodies attack and destroy the antigens.
- *Phagocytes*—white blood cells that digest and destroy microorganisms and other unwanted substances (Fig. 8-26, p. 112).
- *Lymphocytes*—white blood cells that produce antibodies. Lymphocyte production increases as the body responds to an infection.
- *B lymphocytes (B cells)*—cause the production of antibodies that circulate in the plasma. The antibodies react to specific antigens.
- *T lymphocytes (T cells)*—cells that destroy invading cells. *Killer T cells* produce poisons near the invading cells. Some T cells attract other cells. The other cells destroy the invaders.

When the body senses an antigen (an unwanted substance), the immune system acts. Phagocyte and lymphocyte production increases. Phagocytes destroy the invaders through digestion. The lymphocytes produce antibodies that attack and destroy the unwanted substances.

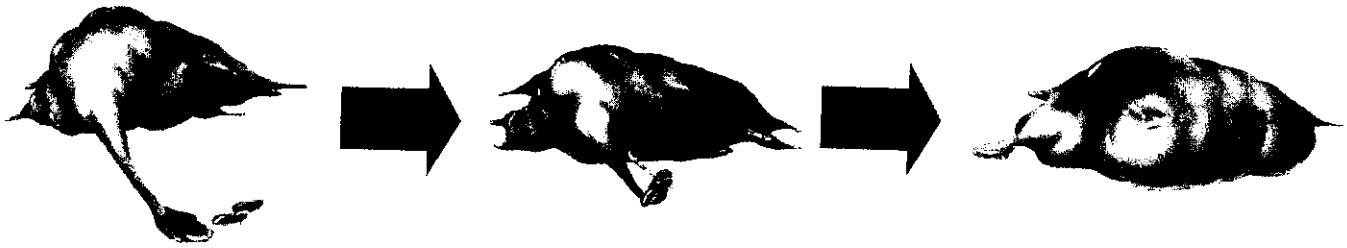

FIGURE 8-26 A phagocyte digests and destroys a microorganism. (From Thibodeau GA, Patton KT: *Structure and function of the body,* ed 11, St Louis, 2000, Mosby.)

REVIEW QUESTIONS

Circle the BEST answer.

1 The basic unit of body structure is the
- **a** Cell
- **b** Neuron
- **c** Nephron
- **d** Ovum

2 The outer layer of the skin is called the
- **a** Dermis
- **b** Epidermis
- **c** Integument
- **d** Myelin

3 Which is *not* a function of the skin?
- **a** Provides the protective covering for the body
- **b** Regulates body temperature
- **c** Senses cold, pain, touch, and pressure
- **d** Provides the shape and framework for the body

4 Which allows movement?
- **a** Bone marrow
- **b** Synovial membrane
- **c** Joints
- **d** Ligaments

5 Skeletal muscles
- **a** Are under involuntary control
- **b** Appear smooth
- **c** Are under voluntary control
- **d** Appear striped and smooth

6 The highest functions in the brain take place in the
- **a** Cerebral cortex
- **b** Medulla
- **c** Brainstem
- **d** Spinal nerves

7 The ear is involved with
- **a** Regulating body movements
- **b** Balance
- **c** Smoothness of body movements
- **d** Controlling involuntary muscles

8 The liquid part of the blood is the
- **a** Hemoglobin
- **b** Red blood cell
- **c** Plasma
- **d** White blood cell

9 Which part of the heart pumps blood to the body?
- **a** Right atrium
- **b** Left atrium
- **c** Right ventricle
- **d** Left ventricle

10 Which carry blood away from the heart?
- **a** Capillaries
- **b** Veins
- **c** Venules
- **d** Arteries

11 Oxygen and carbon dioxide are exchanged
- **a** In the bronchi
- **b** Between the alveoli and capillaries
- **c** Between the lungs and pleura
- **d** In the trachea

12 Digestion begins in the
- **a** Mouth
- **b** Stomach
- **c** Small intestine
- **d** Colon

13 Most food absorption takes place in the
- **a** Stomach
- **b** Small intestine
- **c** Colon
- **d** Large intestine

14 Urine is formed by the
- **a** Jejunum
- **b** Kidneys
- **c** Bladder
- **d** Liver

15 Urine passes from the body through the
- **a** Ureters
- **b** Urethra
- **c** Anus
- **d** Nephrons

16 The male sex gland is called the
- **a** Penis
- **b** Semen
- **c** Testis
- **d** Scrotum

17 The male sex cell is the
- **a** Semen
- **b** Ovum
- **c** Gonad
- **d** Sperm

18 The female sex gland is the
- **a** Ovary
- **b** Cervix
- **c** Uterus
- **d** Vagina

19 The discharge of the lining of the uterus is called
- **a** The endometrium
- **b** Ovulation
- **c** Fertilization
- **d** Menstruation

20 The endocrine glands secrete
- **a** Hormones
- **b** Mucus
- **c** Semen
- **d** Insulin

21 The immune system protects the body from
- **a** Low blood sugar
- **b** Disease and infection
- **c** Loss of fluid
- **d** Stunted growth

Answers for these questions are on p. 779.