Name ______________________ Date ____________ Class ____________

TAKS OBJECTIVE

2 ORGANIZATION OF LIVING SYSTEMS

Interrelationships of Living Systems

ORGAN SYSTEMS

Your body is an amazing machine, and like all matter in the universe, it is made of atoms. These atoms form the many different kinds of molecules that make up the cells in your body—more than 100 trillion of them. Your body has more than 100 kinds of cells, and each kind has a specialized function. For example, your red blood cells carry oxygen throughout the body, and your nerve cells transmit nerve impulses. Regardless of its function, each cell in your body depends on other cells to live.

Groups of cells, called **tissue**, work together in your body to perform a particular function. Your body has four basic kinds of tissues.

- **Epithelial tissue** lines most of the body surfaces. It protects other tissues from dehydration and physical damage. Epithelial cells typically are flat and have little cytoplasm. Most epithelial tissue forms layers that are only a few cells thick. Epithelial cells are being damaged constantly, so these cells are continuously replaced.
- **Nervous tissue** consists of nerve cells and their supporting cells. These cells carry information throughout your body.
- **Connective tissue** supports, protects, and insulates the body. Various types of connective tissue can be found as fat, cartilage, bone, tendons, and blood.
- **Muscle tissue** contracts to enable body structures to move.

Within the body, two or more types of tissue work together as **organs** to perform certain functions. Your heart, stomach, and lungs are examples of organs. Each organ belongs to at least one **organ system**, which is a group of organs that work together to carry out major activities or processes, such as digestion and respiration. You will learn about each system in the pages that follow.

Name ______________________ Date ____________ Class ____________

INTEGUMENTARY SYSTEM

Did you ever think of your skin as an organ? Well, it is! In fact, it's the largest organ in your body. Your skin looks flat and smooth, but if you looked at it under a microscope, you'd see that it is made of different kinds of tissues. Many specialized structures make up the skin, which along with the hair and nails, makes up the **integumentary system**.

The skin has many functions—it protects the body from injury, provides defense against pathogens, helps regulate body temperature, and prevents the body from drying out. Find each part of the skin in Figure 7-1 as you read about it below.

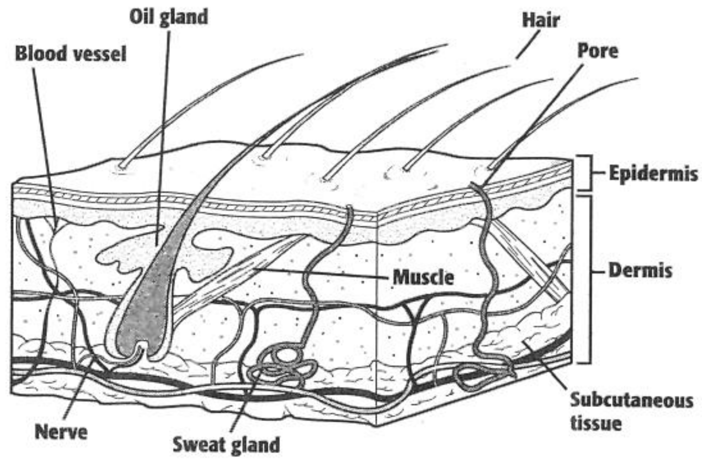


Figure 7-1

When you look at skin under a microscope, you see a thin layer of flattened dead cells that form part of the outermost layer, the **epidermis**. These cells contain **keratin**, a protein that makes skin tough and waterproof.

Each day you lose millions of dead epidermal cells. As the cells of the epidermis are damaged, they are replaced continuously by new cells produced in the inner layer of the epidermis. The cells of the inner layer produce new cells rapidly, and as the new cells form, they push older cells toward the surface of the skin. As new skin cells move upward, they flatten and their organelles disintegrate. They begin to produce large amounts of keratin.

The inner layer of the epidermis also contains cells that produce the pigment **melanin**. The color of melanin ranges from yellow to reddish brown to black, and it helps determine skin color.

The **dermis** is made of only living cells—nerve cells, blood vessels, specialized skin cells, and hair follicles. Goosebumps are caused by tiny muscles in the dermis that are attached to hair follicles. When you get cold, these muscles contract and pull the hair shafts upright, helping to insulate the body.

The network of blood vessels in the dermis provides nutrients to skin cells and regulates body temperature. **Sweat glands** in the dermis produce sweat, which helps remove excess body heat as it evaporates. Sebaceous oil glands secrete **sebum**, an oil that helps keep the skin flexible and waterproof.

Below the dermis is **subcutaneous tissue**, composed mostly of fat. This layer acts as a shock absorber, provides insulation, stores energy, and anchors the skin to the organs below.

Name ______________________ Date ______________ Class ____________

SKELETAL SYSTEM

If you counted all the bones in the skeleton in Figure 7-2, you'd find that there are 206 of them. Bones provide protection for internal organs and work with muscles to enable movement. You can see the names of some of the larger bones in the picture.

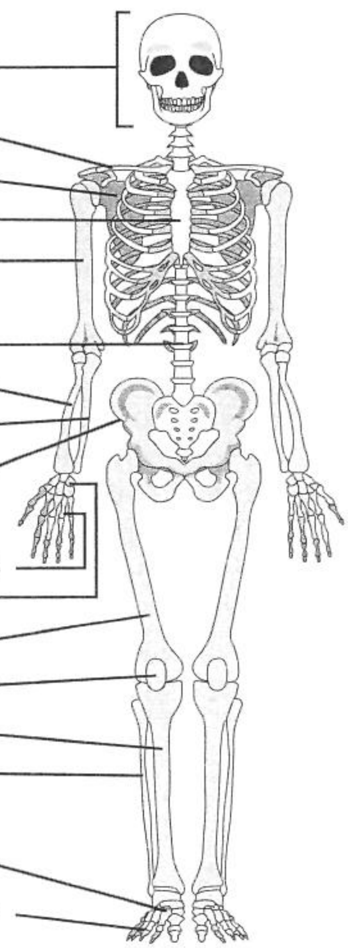


Figure 7-2

Structure of bones

Although your bones look like they are made of rock, they actually contain living cells. The hard outer covering of bones, **compact bone**, is a dense connective tissue. Minerals such as calcium help make this layer hard. You can see in Figure 7-3 that bone cells release minerals in circles called mineral rings. The rings form a series of tubes called **Haversian canals**. Notice that blood vessels are found inside these canals. The blood vessels bring nutrients and oxygen to the bone cells and carry away wastes.

The inner layer of bone, **spongy bone**, is a loosely structured network of connective tissue with many cavities. Some cavities are filled with **bone marrow**, a soft tissue that begins the production of all blood cells and platelets. One type of bone marrow, yellow bone marrow, contains fat, which stores energy. Spongy bone is found in the ends of long bones and in the middle part of short, flat bones. A tough exterior membrane, the **periosteum**, covers the bone, and it contains many blood vessels that supply nutrients to the bone.

Metatarsals

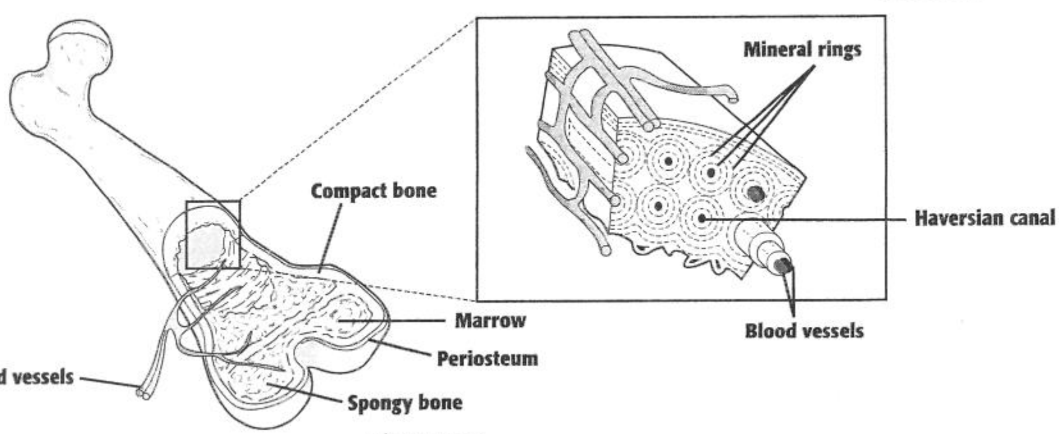


Figure 7-3

Name ______________________ Date ______________ Class ______________

Joints

Imagine that all the bones in your body were connected together in a way that didn't allow you to move. How would you perform most of your daily activities? Although bones are hard, they are connected in a way that allows your body to move.

The place where two bones meet is called a **joint**. Various joints are shown in Figure 7-4. A strong, flexible connective tissue called **cartilage** cushions the ends of bones where they meet and enables them to move smoothly. Bands of connective tissue called **ligaments** hold bones together. Ligaments also keep your bones from moving too far in one direction. The direction in which bones can move is determined by the structure of the joint.

- **Ball-and-socket joints** allow the widest range of movement: backward, forward, sideways, and in a circle. Your shoulder and hip have this type of joint.
- **Pivot joints** allow a rotation movement. When you turn your head, you are using a pivot joint.
- **Hinge joints** allow bending and straightening. Bend your finger and you are using a hinge joint.
- **Gliding joints**, like those found in your wrists and ankles, allow a sliding motion.
- The **saddle joint** at the base of your thumb allows the thumb to rotate, bend, and straighten.

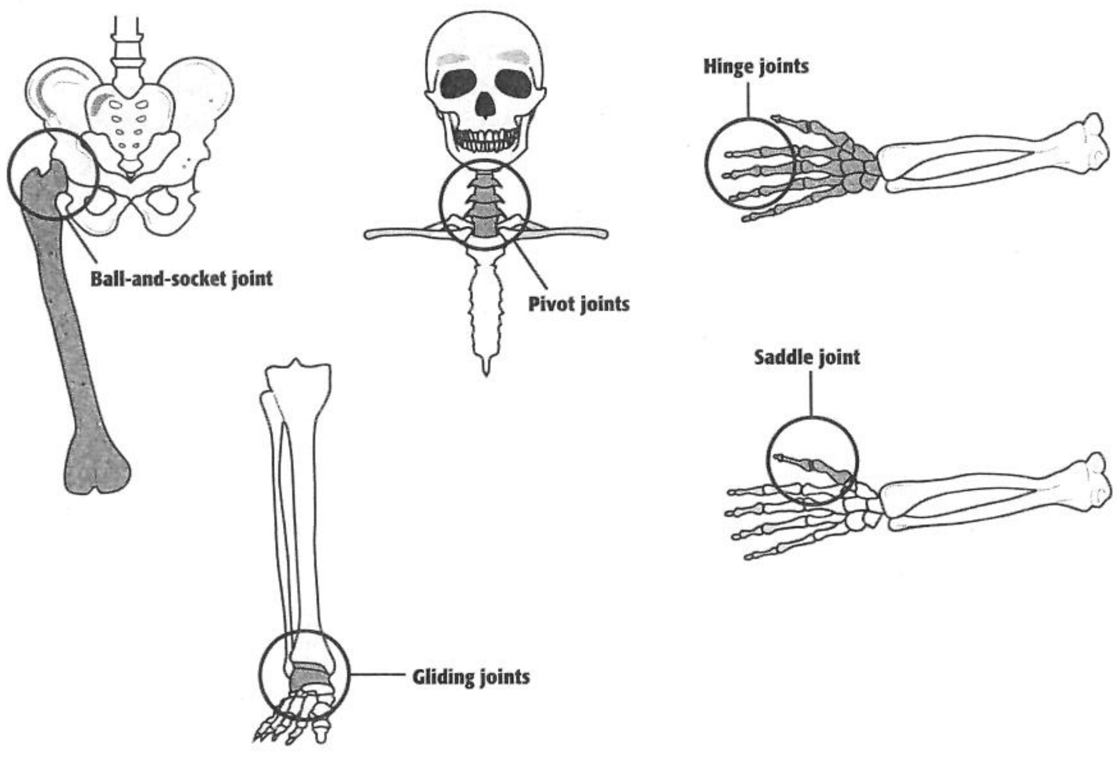


Figure 7-4

MUSCULAR SYSTEM

Although your bones are put together in a way that allows them to move, no movement would be possible without your muscles. Your body has more than 600 muscles. These muscles can be grouped into three main types: smooth, cardiac, and skeletal.

Smooth muscle is called involuntary muscle because usually you can't control it. Smooth muscle controls the diameter of your blood vessels and the size of the pupils in your eyes. Smooth muscle also lines the walls of organs, such as those of the digestive system, where it moves food along the organs.

Cardiac muscle is found only in the heart, where its rhythmic contractions control the pumping action of the heart. Unlike other types of muscle that receive nerve impulses from the nervous system to regulate their movement, cardiac muscle cells generate their own electrical signals that cause them to contract.

Skeletal muscles are attached to bones. They sometimes are called voluntary muscles because you can control their actions. You use your skeletal muscles when you throw a ball, walk down the street, or lift a cup to drink. Most skeletal muscles are attached to bones by strips of dense connective tissue called **tendons**.

Bones move when muscles shorten, or contract, in response to a signal from the nervous system. Your muscle cells are bundled together and covered by connective tissue, which holds the cells together and makes them elastic. When a muscle receives a nerve impulse to contract, protein filaments in the muscle slide past each other at the same time. This action shortens the muscle. After contracting, a muscle relaxes and returns to its original length until the next signal arrives.

When a muscle moves a bone, two bones are involved. One end of the muscle is attached to a bone that remains stationary when the muscle contracts. The other end of the muscle is attached to the bone that moves during muscle contraction.

Muscles are attached to bones in opposing pairs. One muscle in a pair pulls a bone in one direction; the other muscle pulls in the opposite direction. In your arms and legs, each opposing pair of muscles includes a **flexor** muscle, which causes a joint to bend, and an **extensor** muscle, which causes the joint to straighten.

Name ________________________ Date ____________ Class ____________

CIRCULATORY SYSTEM

You probably know that the muscles in your legs need energy in order to move. You might also know that the energy comes from the food you eat. But how does the energy in the food get to your leg? It's simple—after food is digested, your circulatory system carries it to all parts of your body, including your legs.

The circulatory system is like a network of highways throughout your body. It connects all the organs in your body through a system of blood vessels that transport blood, which carries many substances the body needs. The heart is the pump that propels the blood throughout the blood vessels.

In addition to transporting materials throughout your body, the circulatory system distributes heat to help your body maintain a constant temperature. When the temperature outside your body is warm, blood vessels in the skin relax to let more heat move from inside your body to the surface, where it can be released into the air. When the air surrounding your body is cold, blood vessels in your skin constrict to keep heat deep within the body.

Blood vessels

The network of blood vessels that make up your circulatory system consists of arteries, capillaries, and veins, as shown in Figure 7-5. **Arteries** are blood vessels that carry blood away from the heart. Blood enters the arteries with force each time the heart beats. The elastic walls of the arteries allow them to expand, much the way a balloon expands when you blow air into it.

Blood passes from the arteries into **capillaries**, tiny vessels that allow the exchange of materials between the blood and other parts of the body. Gases, nutrients, hormones, and other substances are transferred from blood to body cells. Wastes are transferred from cells to capillaries. Every cell in your body is close to a capillary.

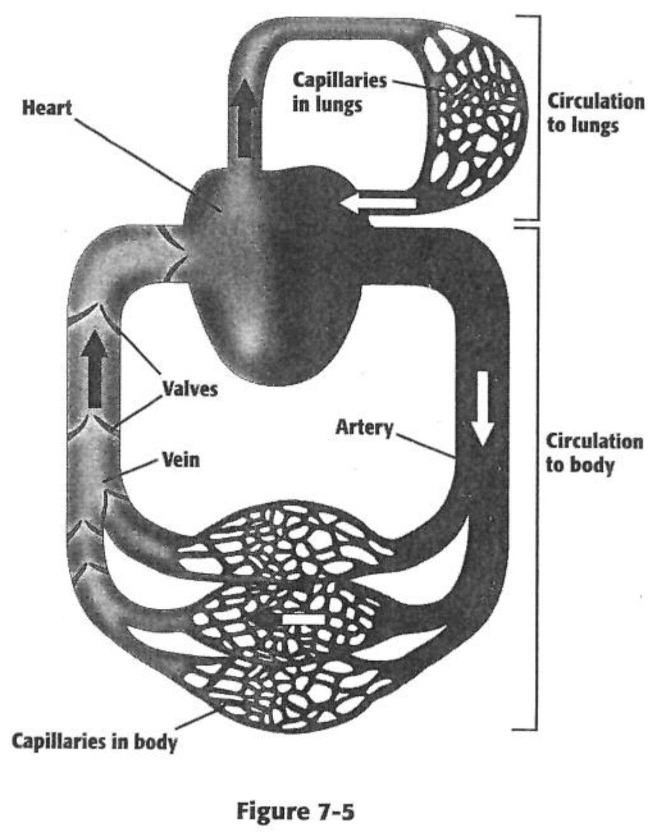


Figure 7-5

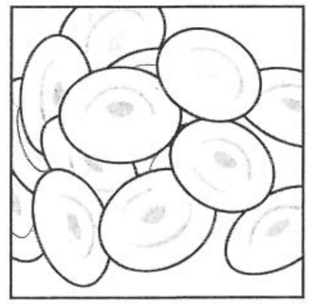
Once blood has passed through capillaries, it must return to your heart by your **veins**. Veins are larger in diameter than arteries, and their walls are not as elastic. Most veins have one-way valves that keep blood from flowing backward.

Name ______________________________ Date ____________ Class ____________

Blood

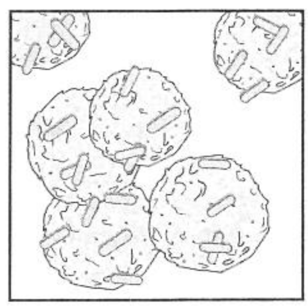
The human body contains 4 to 6 L of blood. The blood you see when you cut your finger is made of water, dissolved substances, and cells. About 60 percent of the total volume of blood is **plasma**, a straw-colored liquid. Most of the plasma—about 90 percent—is water that acts as a solvent to dissolve other materials called solutes, including wastes, salts, glucose, food molecules, vitamins, hormones, and proteins.

The cells that make up your blood include red blood cells, white blood cells, and platelets. The most numerous cells in your blood are **red blood cells** (Figure 7-6), also called erythrocytes. The main function of these cells is to carry oxygen. Red blood cells get their color from **hemoglobin**, an iron-containing protein that picks up oxygen in the lungs and transports it to the tissues of the body. Red blood cells are produced from specialized stem cells in bone marrow. The disc-shaped red blood cell does not have a nucleus.



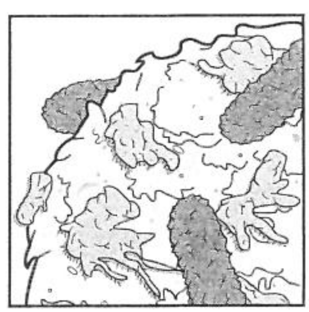
Red blood cells
Figure 7-6

The primary function of **white blood cells** or leukocytes, is to defend the body against disease (Figure 7-7). These cells are larger than red blood cells, and each contains a nucleus. But there are far fewer white blood cells than red blood cells—about 1 or 2 for every 1,000 red blood cells. Like red blood cells, white blood cells are produced in bone marrow. There are many different kinds of white blood cells, and each has a different function. For example, some engulf disease-causing agents called **pathogens**, killing them. Some kill pathogens by producing toxic chemicals. Others release chemical signals that alert other body cells to attack invading cells.



White blood cells
Figure 7-7

When you cut your finger, the wound may bleed for a short time, but eventually the bleeding stops. This ability of blood to clot is made possible by the third type of blood cell, **platelets** (Figure 7-8). Platelets form when certain large cells in bone marrow regularly pinch off bits of their cytoplasm. When your body has a wound, blood vessels break. When platelets come into contact with a broken vessel, their surfaces become sticky and the platelets clump together to seal the hole.



Platelets
Figure 7-8

Heart

Clench your fist and observe its size. Your heart is about that size. This relatively small organ is something like a bag of muscle, pumping blood to all parts of your body. Notice in Figure 7-9 that the heart has a wall that divides it into a right and a left portion. At the top of each portion is a chamber, or **atrium**, that receives blood into the heart. Below the two top chambers (the right and left atria) are the two bottom chambers, called **ventricles**. These thick-walled parts of the heart pump blood away from the heart.

You might think that blood travels in a single loop from your heart to the body and back. But to provide oxygen to all your body cells, blood flows through two separate circulatory loops. Follow the path of blood as you read about each loop.

The right side of the heart pumps oxygen-poor blood to the lungs, where carbon dioxide waste is released and oxygen is picked up. The oxygenated blood is then returned to the left side of the heart. This pathway is known as the **pulmonary circulation loop**.

The left side of the heart drives the **systemic circulation loop**. This part of the heart pumps oxygen-rich blood to tissues of the body. Oxygen-poor blood then returns to the right side of the heart, where it again enters the pulmonary circulation loop.

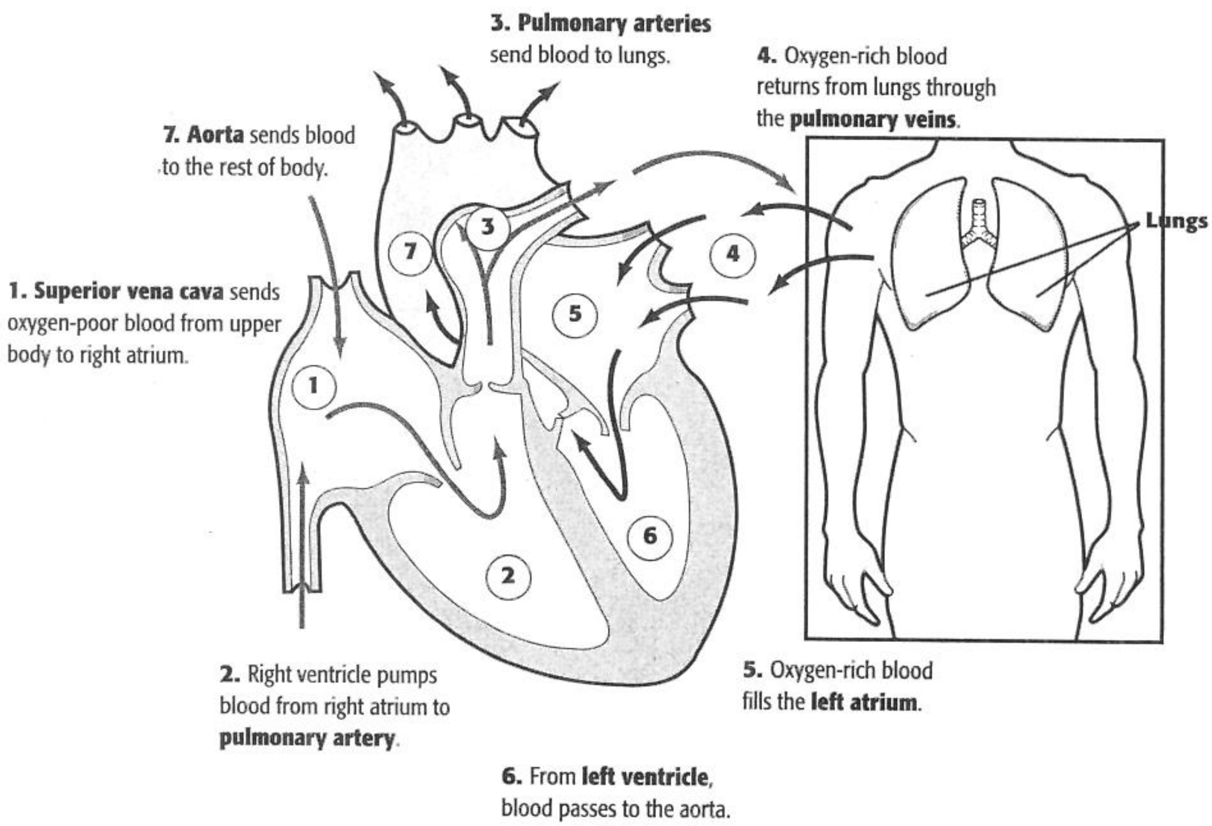


Figure 7-9

Name ______________________ Date ______________ Class ______________

RESPIRATORY SYSTEM

As blood travels in your capillaries throughout your body, it provides oxygen to the body's cells for use in cellular respiration. The oxygen in the blood must be replenished constantly. Also, during cellular respiration, carbon dioxide is produced as a waste, and it must be carried away by the blood for removal from the body. Your blood carries the oxygen and carbon dioxide between your body cells and your **lungs**, the organ where the blood picks up oxygen and releases carbon dioxide.

Breathing is the process by which your body moves air into and out of the lungs. Your lungs don't have muscle tissue to pull air in or push it out, so what causes this movement? The **diaphragm**, a powerful muscle in the bottom of the rib cage, helps move the air in and out. To draw air into the lungs, the rib muscles contract, drawing the rib cage up and out, and the diaphragm contracts, moving downward. The result is that the volume of the chest cavity increases. The air pressure within the cavity becomes lower than the pressure outside the body, and air is drawn into the lungs. When you breathe out, the reverse process takes place. Muscles in the rib cage and diaphragm relax, decreasing the volume of the chest cavity. Air pressure increases and air is forced from the lungs.

Use figure 7-10 to follow the path that the air takes as it moves in and out of your body. When you breathe, air enters your body through the nose or mouth. Hairs in the nose filter out dust and other particles from the air. The nose also moistens and warms the air. The nose and mouth join at the back of the throat to form the **pharynx**, which carries the warm, moistened air to the **trachea**. This long, narrow tube is also called the windpipe. The **larynx**, or voice box, is located at the upper end of the trachea. Sounds are produced when air is forced past the vocal cords that stretch across the larynx.

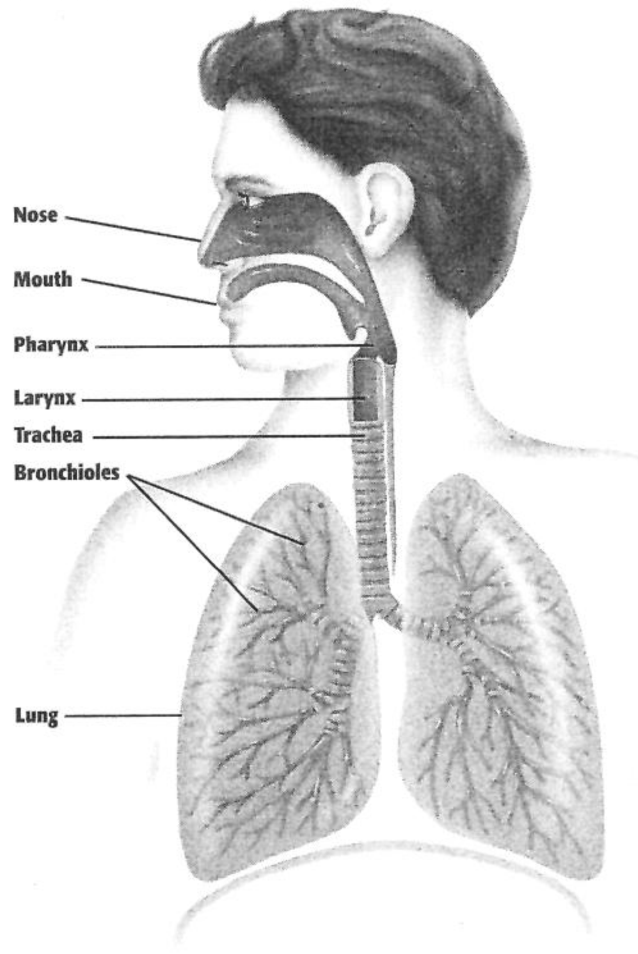


Figure 7-10

RESPIRATORY SYSTEM, CONTINUED

The trachea divides into two smaller tubes, the **bronchi**, which lead to the lungs. In the lungs the bronchi divide into smaller and smaller tubes called **bronchioles**. The smallest bronchioles end in clusters of air sacs called **alveoli**. There are about 150 million alveoli in your body. Their clustered structure increases the surface area of the lungs so that the important function of the respiratory system—gas exchange—can take place faster. Notice in Figure 7-11 that many capillaries surround the alveoli. Oxygen in the air diffuses from alveoli into the blood, and carbon dioxide waste diffuses in the opposite direction—from the blood into the alveoli.

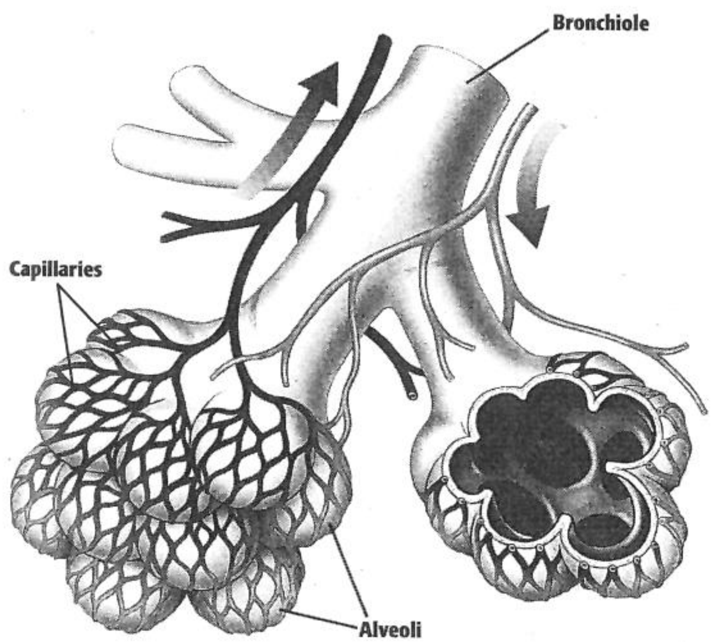


Figure 7-11

Name ________________ Date ________ Class ________

DIGESTIVE SYSTEM

The food you eat contains nutrients—carbohydrates, proteins, fats, vitamins, and minerals. These nutrients provide your body cells with energy and building materials, but the molecules that make up most nutrients are too large to pass through the cell membrane. So before your body can use most nutrients, it must break them down into molecules the body can use. The process in which this happens is **digestion**.

As shown in Figure 7-12, your digestive system begins in the mouth and winds about 8 m (26 ft) through the body to the rectum. Digestion begins with mechanical digestion—biting, tearing, and grinding the food you eat. Your teeth have different shapes, and each type has a specific purpose. The front teeth, your incisors, cut food. The cuspids, or canines, shred food. Your molars crush and grind food.

As your teeth cut and grind food, three pairs of **salivary glands** in the mouth secrete **saliva**, which moistens and lubricates the food so that you can swallow it more easily. Saliva contains **amylases**, enzymes that begin the breakdown of carbohydrates.

When you swallow, food moves from the mouth through the esophagus. No digestion takes place in the esophagus. Wavelike contractions of the smooth muscles surrounding the esophagus push food through the esophagus. These contractions, called **peristalsis**, move food down the length of the esophagus in about 5 to 10 seconds. If you imagine putting a marble in a flexible tube and squeezing the tube to move the marble through it, you'd have some idea of how peristalsis works. But instead of a single "wave" moving the marble, a series of waves would run the length of the tube.

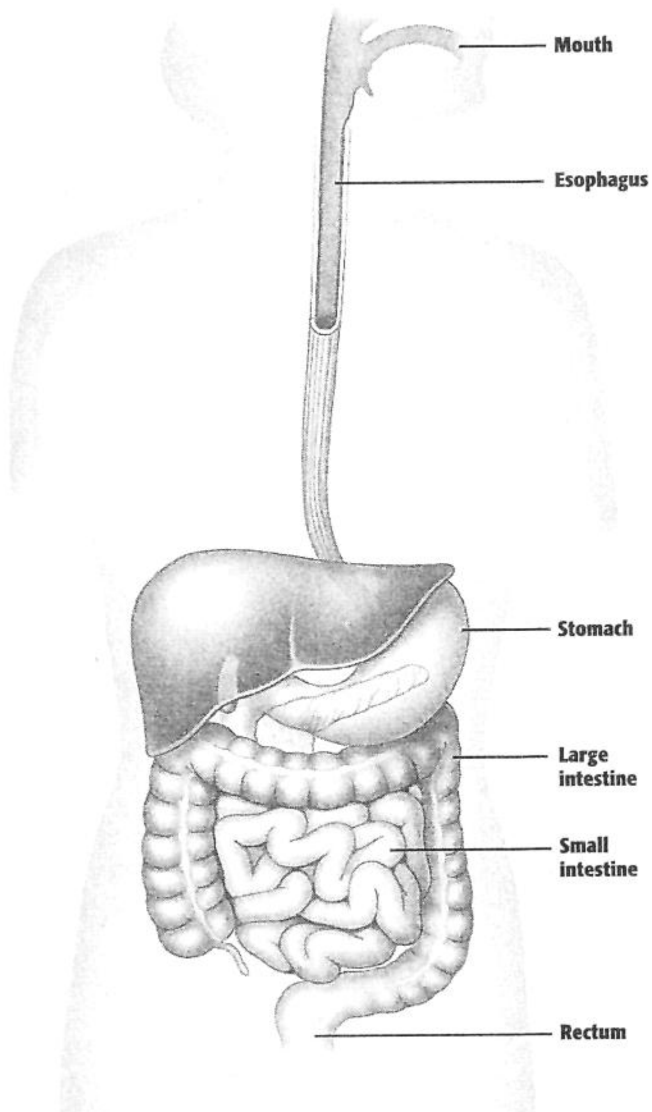


Figure 7-12

DIGESTIVE SYSTEM, CONTINUED

At the lower end of the esophagus, a circular muscular valve called a sphincter closes after food passes through to the stomach. The sphincter prevents the acidic contents of the stomach from moving back into the esophagus. (If you've ever experienced "heartburn," you've felt the result of stomach acid acting on your esophagus.)

The stomach is a saclike organ that stores food. The muscular contractions of the stomach churn food and mix it with substances that are produced by the stomach. The lining of your stomach contains millions of gastric glands that secrete gastric juice. The hydrochloric acid and pepsin in gastric juice break down large protein molecules. Cells in the stomach wall also produce mucus, which lubricates and protects the stomach from the acids it produces.

Most chemical digestion occurs in the small intestine. Secretions from the pancreas, liver, and gall bladder enter the first part of the small intestine, the duodenum. These enzymes complete the digestion of carbohydrates, proteins, and fats. Most of these digested nutrients are absorbed into the bloodstream from the small intestine. The remaining parts of the small intestine—the jejunum and the ileum—are especially adapted to absorb nutrients. The lining of these parts of the small intestine is covered with fingerlike projections called **villi**. The villi are covered with even smaller projections called microvilli. The villi and microvilli greatly increase the surface area of the intestines so nutrients can be absorbed faster.

As food leaves the small intestine, most of the nutrients have been removed. Only water and other indigestible substances remain as the material moves into the large intestine, or **colon**. No digestion takes place in the large intestine, but water and mineral ions are absorbed there. The colon also is home to a colony of bacteria that produce compounds such as vitamins K and B, which you cannot easily get from the food you eat. The bacteria also help to compact the waste materials into the final waste product, **feces**. The solid feces move from the colon into the rectum, and then pass out of the body through the **anus** some 12 to 24 hours after the food was first eaten.

EXCRETORY SYSTEM

Your body is an efficient machine, but even an efficient machine produces wastes. In some machines, the waste might be heat or light. In the human body, the wastes are in the form of feces, carbon dioxide, ammonia, and other substances. Your body must get rid of these wastes to maintain good health. The process by which wastes other than feces are eliminated from the body is **excretion**. Excretion is one of the many processes that enable your body to maintain homeostasis.

Three organs in your body are specialized for excretion: lungs, skin, and kidneys. You have already learned how the lungs get rid of carbon dioxide gas when you exhale. The skin gets rid of excess water, salts, and other wastes in the form of sweat when you perspire. How do kidneys remove body wastes?

The two bean-shaped, reddish brown **kidneys** remove water-soluble wastes that result from the chemical changes in cells. One of these wastes is ammonia, a substance produced during the metabolism of proteins and nucleic acids. Ammonia is converted to **urea**, a less toxic substance, in the liver before being sent to the kidneys.

As shown in Figure 7-13, the kidneys are located on either side of your spine near the lower back. A tube called the **ureter** carries wastes from each kidney to the urinary bladder. The **urinary bladder** is a saclike organ that stores liquid wastes until they are released from the body. Urine leaves the bladder and exits the body through the **urethra**. A healthy adult eliminates 1.5 to 2.3 L (1.6 to 2.4 qt) of urine each day. Let's take a closer look at how the kidneys remove wastes from the body.

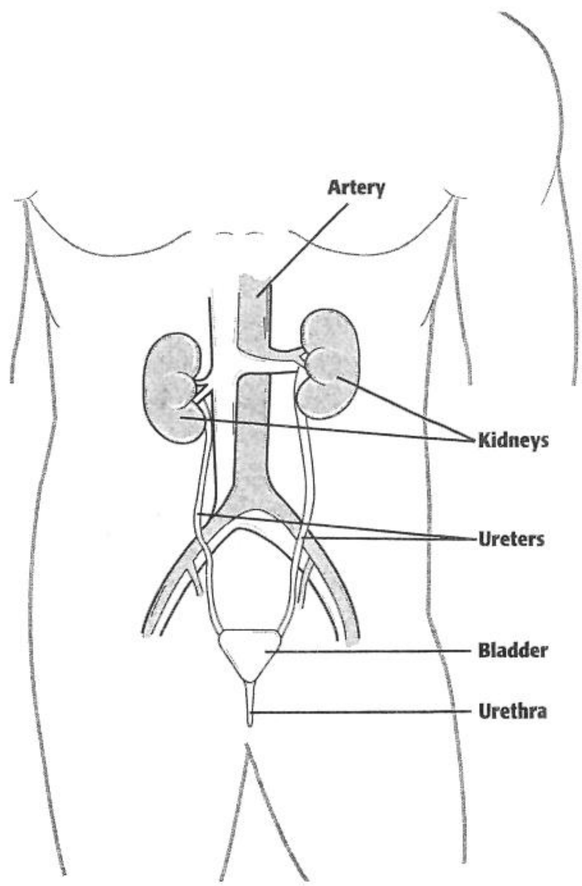


Figure 7-13

Name ______________________________ Date ______________ Class ______________

Blood purification

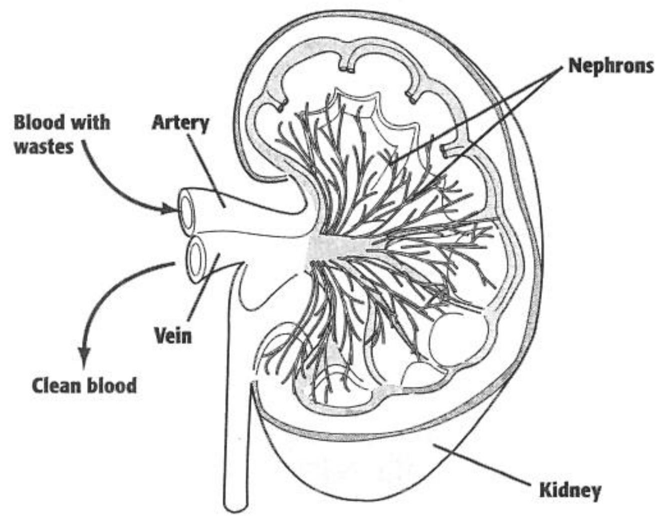


Figure 7-14

Look at the diagram of the kidney in Figure 7-14. Each kidney is made of about 1 million microscopic **nephrons.** Each nephron is an independent filtering and processing unit. Purified blood leaves the nephron through a vein attached to the glomerulus.

The actual process of blood purification in the kidneys is a complicated process that can be summarized in two steps:

- **Filtration.** Filtration begins when fluid from the blood filters through the permeable capillary walls into a cup-shaped collecting capsule. The materials to be filtered, called the **filtrate**, include water, salts, glucose, amino acids, and urea. Because blood cells, plasma proteins, and certain other molecules are too large to pass through the permeable membrane, they remain in the blood.
- **Reabsorption.** The kidneys filter more than four times the total volume of body water every day. Not all of that water is excreted. Most of the material removed from the blood during filtration is returned to the blood through the process of reabsorption. Materials such as glucose, amino acids, and sugars are returned to the blood through active transport. Water follows these materials through the process of osmosis and about 99 percent of it returns to the blood. The water, urea, and various salts that are left after reabsorption make up **urine**.

These processes happen in each of the millions of nephrons in each kidney. The urine from all nephrons empties into the ureters and is eventually removed from the body.

NERVOUS SYSTEM

Have you ever played a group sport such as basketball or soccer? If so, you probably know that one key to winning is communication among team members. No one player can function alone. Team members signal each other in ways that make the team function as one. The same is true for your body. It too has a system of signals that lets one part of the body know what is going on in other parts. The system that controls and coordinates functions throughout the body is the nervous system. It uses chemical and electrical signals to send messages rapidly to all parts of your body.

Neurons

The nervous system contains a complex network of nerve cells, called **neurons**. Neurons vary in appearance, but you can see a typical neuron in Figure 7-15.

The largest part of the neuron is the cell body. It contains the nucleus and much of the cytoplasm of the cell. Spreading out from the cell body are the **dendrites**, the "antennae" of the neuron. These structures receive information from other neurons or from the environment and carry it to the cell body. The long fiber that carries information, in the form of an electrical impulse, away from the neuron is the **axon**. Neurons may have dozens of dendrites but usually only one axon. A nerve impulse begins in the part of the axon closest to the cell body. The impulse moves away from the cell body, down the length of the axon to its end. A bundle of the axons of a few or many neurons is called a nerve.

Many neurons have a fatty outer layer called a **myelin sheath**, which insulates the axon. Myelin is produced by cells that surround the axon. The presence of the myelin sheath enables nerve impulses to travel faster along the axon. The myelin sheath has gaps, called nodes, where the axon is exposed. As an impulse moves along the axon, it jumps from node to node, greatly increasing the speed of the impulse.

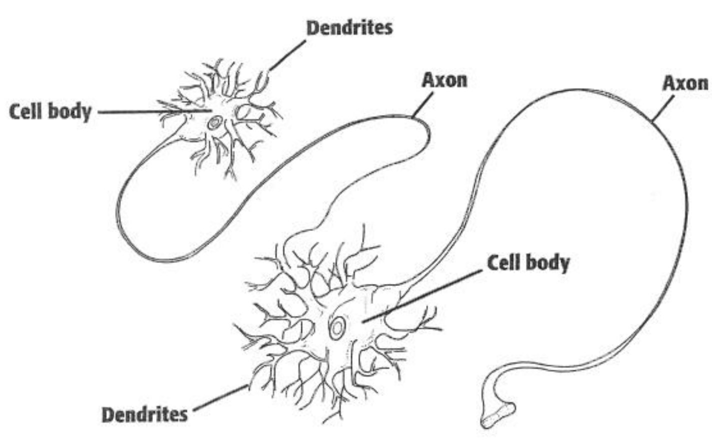


Figure 7-15

Nerve impulses

Nerve impulses travel fast—about 400 km (250 mi) per hour! But what makes the nerve impulse move? A neuron is able to transmit an impulse because its cell membrane contains gated channels that can open or close. Some channels allow only sodium ions to pass through, others only potassium ions. Information passes along a neuron as electrical current that is produced by ions moving in and out across the cell membrane through the gated channels. Some channels open or close in response to changes in electrical voltage. Others respond to chemicals.

As a nerve impulse travels the length of the neuron's axon, it eventually reaches the end of the axon. Axons usually are positioned near the dendrites of other neurons. As a nerve impulse travels from one neuron to another, it must cross the **synapse**, a small gap between the axon of one neuron and the cell body or dendrite of another neuron. Messages don't jump across the synapse. Instead they are carried by messengers called **neurotransmitters**, chemicals packaged in tiny sacs at the end of the axon.

When a nerve impulse reaches the end of an axon, it causes the neuron to release the neurotransmitter into the synapse. The neurotransmitter molecules diffuse across the synapse and bind to receptors in the cell membrane of the adjacent cell, causing electrical changes. Neurotransmitter molecules are quickly removed from the synapse so that additional messages can cross it. Depending on the type, neurotransmitters may be absorbed into the first neuron, or enzymes may break them down.

Structures of the nervous system

The nervous system is divided into two parts—the **central nervous system** (CNS) and the **peripheral nervous system** (PNS). The brain and spinal cord, which make up the central nervous system, are the control center of the body. The CNS interprets and responds to information received from the environment and from within the body. The PNS contains two types of nerve cells. **Sensory neurons** send information from sense organs to the spinal cord and brain. **Motor neurons** send commands from the brain and spinal cord to muscles and other organs.

Name ______________________ Date ____________ Class ____________

IMMUNE SYSTEM

Microscopic organisms surround you. They are everywhere—in the air, on your food, even all over your body. Most of these organisms are harmless; some are even helpful. Other microscopic organisms, called **pathogens**, can harm the body by causing diseases. Your body uses several defense mechanisms to prevent infection and to detect and destroy pathogens.

Nonspecific defenses

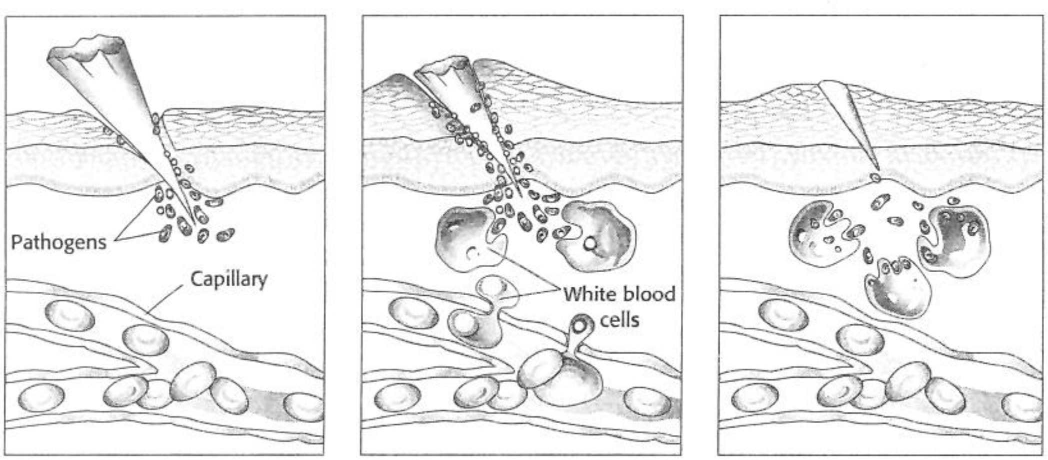
Your body's first line of defense against pathogens is nonspecific—that is, your body doesn't target particular pathogens. One nonspecific defense is your skin. Oil and sweat make the skin acidic, a condition that inhibits the growth of many pathogens. Sweat also contains an enzyme that digests bacterial cell walls.

Another nonspecific defense against pathogens is the body's mucous membranes, which line the digestive system, nasal passages, respiratory passages, lungs, and vagina. Mucus traps many pathogens and prevents them from entering parts of the body where they can multiply.

Sometimes pathogens manage to break through the first line of defense—most often entering the body at an opening like the mouth or at the site of a wound. When you get a splinter, the area of your finger where the splinter entered may swell and get hot. That's the body's **inflammatory response**—a series of events that suppresses infection and speeds recovery.

You can see in Figure 7-16 that when a splinter punctures your finger, pathogens enter the body. The infected or injured cells of your finger release chemicals, called **histamines**, which cause local blood vessels to dilate. Blood flow to the area increases, and white blood cells arrive to attack pathogens.

At the same time, body temperature increases. Most pathogens grow only in a particular temperature range that is close to the normal temperature of the body—98.6°F (37°C). The increased temperature kills many pathogens.



When the skin is punctured, pathogens enter the body.

Blood flow to the area increases and the area swells and becomes red.

White blood cells arrive to attack and destroy the pathogens.

Figure 7-16

Name ______________________ Date ______________ Class ______________

White blood cells

Pathogens carry surface markers called **antigens**, which are different from the surface markers of your body cells. Three kinds of white blood cells attack invaders:

- **Neutrophils** are white blood cells that engulf and destroy pathogens. When neutrophils engulf bacteria, they release chemicals that kill the bacteria. The chemicals also kill the neutrophil itself.
- **Macrophages** are white blood cells that ingest and kill pathogens. They also remove dead cells and other debris from the body.
- **Killer T cells** are large white blood cells that attack cells infected with pathogens. They destroy the infected cell by puncturing its cell membrane, causing water to rush into the cell. The cell bursts.

The immune response

Most of the time, your body's nonspecific defenses kill invading pathogens before they cause serious damage to the body. But occasionally pathogens survive these defenses. That's when the immune response kicks in. Figure 7-17 summarizes the **immune response** that activates when flu viruses attack your body.

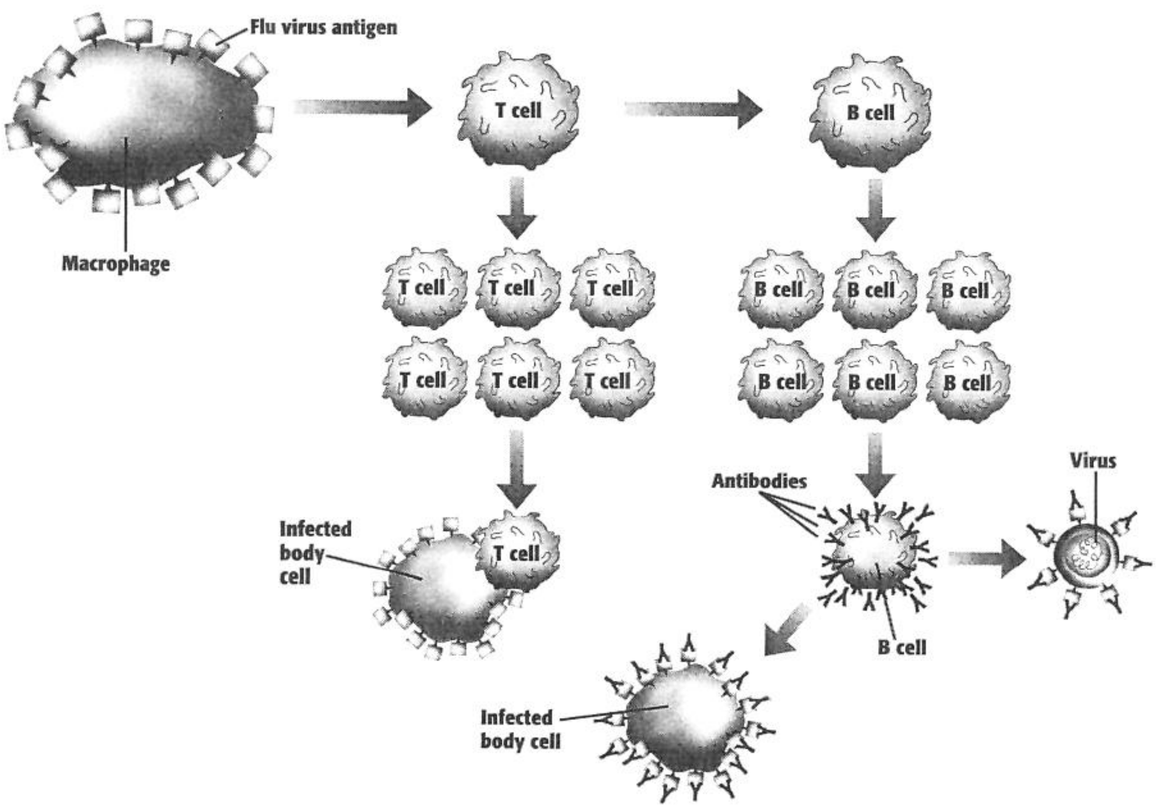


Figure 7-17

Name ______________________ Date __________ Class __________

ENDOCRINE SYSTEM

If you were taking a hike and suddenly came upon a dangerous snake, your first impulse might be to run. Or you might freeze on the spot and begin to sweat. Some of these actions—running, for example—are under the control of your nervous system, which uses nerve impulses to send messages. But other reactions aren't controlled by your nerve impulses. The sweating you might experience is under the control of your endocrine system, which uses chemical messengers called hormones.

Endocrine glands

Hormones are substances secreted by cells to regulate the activity of other body cells. Some hormones carry instructions to the cells of the heart to increase the rate at which it beats. Some help maintain the right amount of nutrients in the blood. Hormones are produced in **endocrine glands**, which secrete hormones directly into either the blood or the fluid around cells.

Your endocrine glands are scattered throughout the body. Each acts independently, but they also interact to help the body maintain homeostasis. Table 7-1 summarizes information about each endocrine gland.

Glands	Hormone	Function
Adrenal glands (adrenal cortex)	aldosterone cortisol	maintains salt-and-water balance regulates carbohydrate and protein metabolism
Adrenal glands (adrenal medulla)	epinephrine norepinephrine	initiates body's response to stress and the "fight or flight" response to danger
Ovaries	estrogen progesterone	regulates female secondary sex characteristics maintains growth of uterine lining
Pancreas (islets of Langerhans)	glucagon insulin	stimulates release of glucose stimulates absorption of glucose
Parathyroid glands	parathyroid hormone	increases blood calcium concentration
Pineal gland	melatonin	regulates sleep patterns
Testes	androgens (testerone)	regulates male secondary sex characteristics
Thymus gland	thymosin	stimulates T-cell formation
Thyroid gland	thyroxine, triliodothyronine	increase cellular metabolic rates

Table 7-1

Name ______________________________ Date ______________ Class ______________

REPRODUCTIVE SYSTEM

A new baby is born! Family and friends rush to visit and see this new addition to the family. The comments are familiar: Look at those eyes. Wow, what a lot of hair! She looks like her mother. She looks like her father.

Sexual reproduction involves the formation of a zygote from two sex cells, or gametes—a **sperm**, the male gamete, and an **egg**, the female gamete. Each human cell contains 46 chromosomes, except the gametes, which contain half that number—23.

Male reproductive system

The male reproductive system produces millions of sperm each day in the **testes**. The testes are located in the **scrotum**, an external skin sac. Each testis contains hundreds of highly coiled tubes, called **seminiferous tubules**, where sperm is produced by meiosis. Three hormones work together to stimulate sperm production: luteinizing hormone (LH), follicle stimulating hormone (FSH), and testosterone. Testosterone is the principal male sex hormone that regulates the development of male characteristics. Use Figure 7-18 to follow the path of a sperm cell as it travels from the testes and is released from the body.

After sperm are produced in the seminiferous tubules, they enter a long coiled tube called the **epididymis**. There the sperm mature and become capable of moving. The epididymis is also a storage place for sperm. From the epididymis, sperm move through the **vas deferens** and into the **urethra**. There they mix with fluids from three glands—the seminal vesicles, the prostate, and the bulbourethral glands. The secretions from these glands nourish the sperm and aid their passage through the female reproductive system. The mixture of these secretions with sperm is called **semen**. Sperm leave the body by passing through the urethra, the same duct that urine uses to leave the body. The urethra passes through the **penis**, the male organ that deposits sperm in the female reproductive system during sexual intercourse.

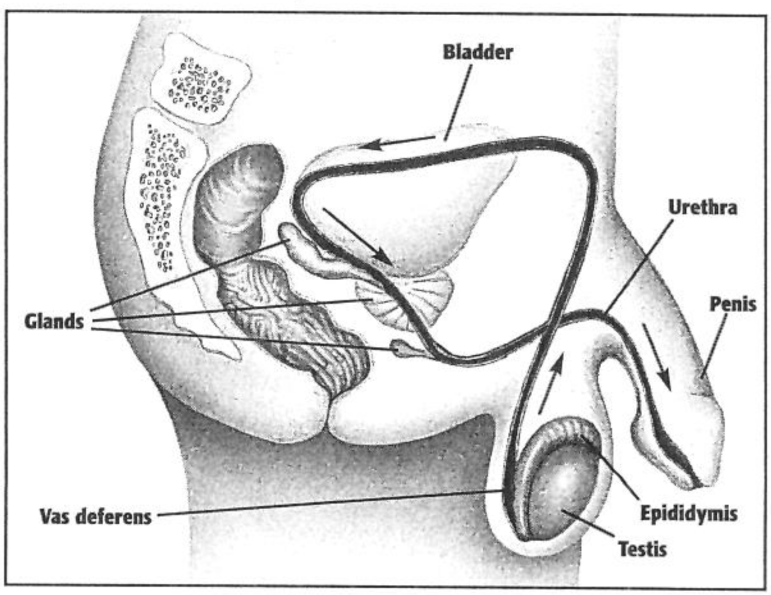


Figure 7-18

Name ______________________________ Date ______________ Class ____________

Male reproductive system, continued

As you can see in Figure 7-19, a mature sperm cell consists of a head with very little cytoplasm, a midpiece, and a long tail. Study the diagram to find out what the function of each part is.

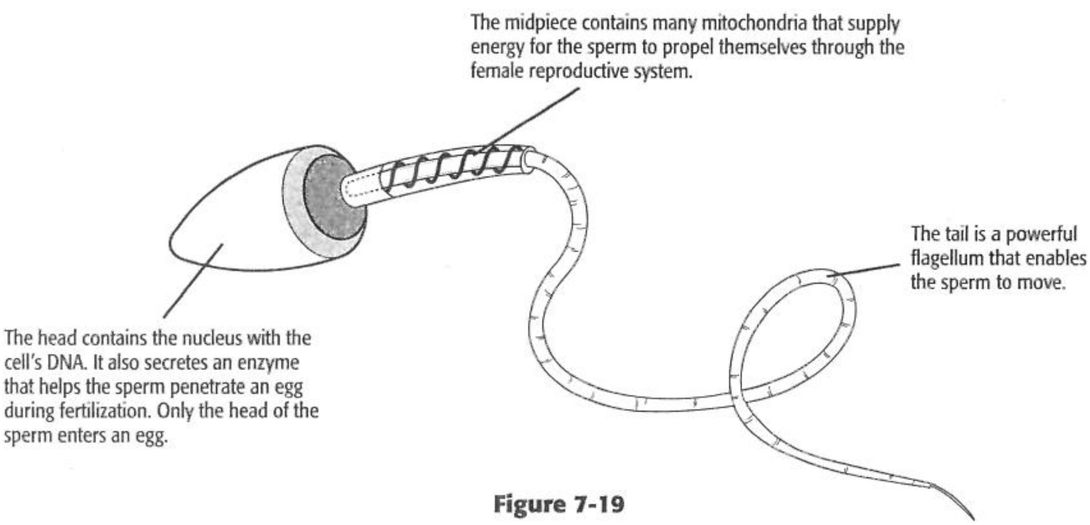


Figure 7-19

Name ______________________ Date ____________ Class ____________

Female reproductive system

While the male produces millions of sperm daily, the female reproductive system usually produces only one gamete, an egg, each month. In the lifetime of a female, only about 400 eggs will mature. A mature egg is called an **ovum**. It is much larger than a sperm cell.

Follow the path of the ovum in Figure 7-20 through the female reproductive system. Eggs are produced by meiosis in two egg-shaped **ovaries**. In addition to producing eggs, the ovaries produce sex hormones, such as estrogen and progesterone, which regulate the release of eggs and direct the development of female characteristics.

About every 28 days, an ovum is released from the ovary. This process is called **ovulation**. The ovum enters into one of two **fallopian tubes**. Smooth muscles lining the fallopian tube contract to move the ovum toward the **uterus**, a hollow muscular organ. The trip to the uterus takes about 3 to 4 days. If the ovum is not fertilized within the first day or two, it dies. If the ovum is fertilized, it will develop in the uterus.

Every month, starting at puberty, the lining of the uterus thickens in preparation for pregnancy. If fertilization occurs, the fertilized egg embeds itself in the lining of the uterus. When a baby is born, the baby passes through the **vagina**, the same passageway where sperm are deposited during sexual intercourse.

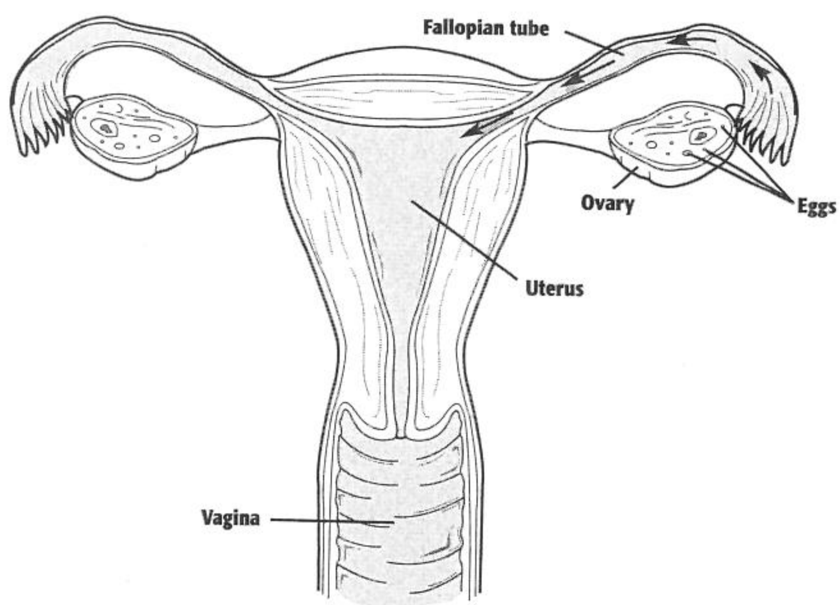


Figure 7-20

Name ______________________ Date ____________ Class ____________

Female reproductive system, continued

To prepare for pregnancy, the female reproductive system goes through a series of changes called the **menstrual cycle**. Figure 7-21 shows how the lining of the uterus changes each month during the menstrual cycle in preparation for receiving a fertilized egg. Notice that the lining starts to thicken before the release of an egg. The changes are caused by hormones and result from increased blood flow to the area. If an egg is not fertilized, the lining of the uterus breaks down and passes out of the body through the vagina during **menstruation**.

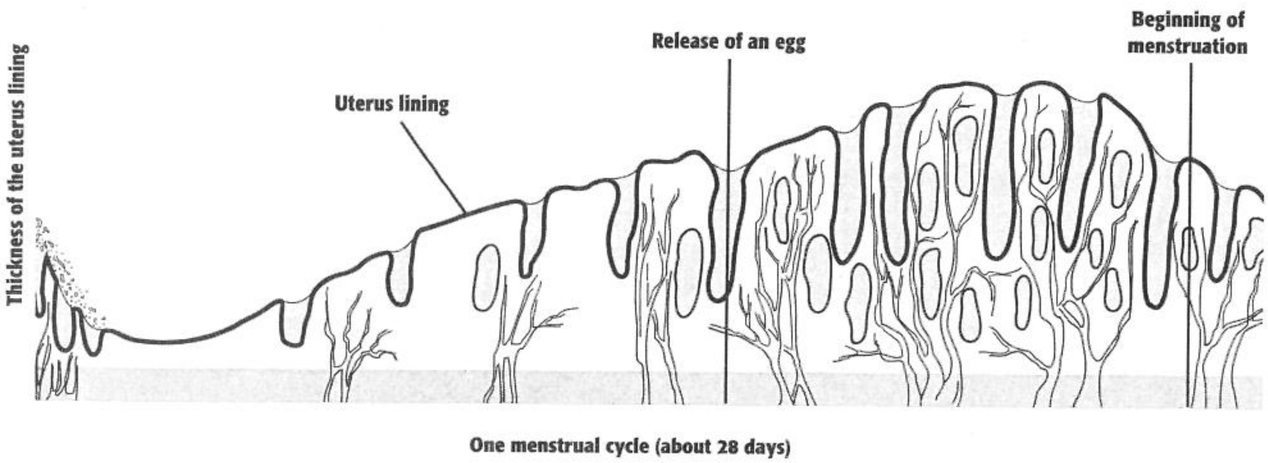


Figure 7-21

INTERRELATIONSHIPS OF BODY SYSTEMS

Although we usually look at individual systems when studying the human body , no system is independent of others. All your body systems must work together to carry on life processes and keep your body healthy. For example, your body makes more than 40 hormones. The body must regulate the release of these hormones. But how? The nervous system can control the secretion of some hormones. This is the case when a baby nurses on a mother's breast. The stimulation of the baby's mouth on the mother's breast causes the release of the hormone oxytocin, which in turn stimulates the release of milk.

Other times, the level of a hormone in the blood turns production of the hormone off and on through feedback mechanisms. Feedback mechanisms detect the amount of hormones in circulation or the amount of other chemicals produced because of hormone action. The endocrine system then adjusts the amount of hormones released.

At times, many systems are involved in maintaining homeostasis. Think about what happens in your body when you are very active. When you run, for example, your muscles need more oxygen than when you are resting, and your muscles produce more carbon dioxide. Your circulatory and respiratory systems must provide the needed oxygen and must remove the additional carbon dioxide. You breathe faster. Your heart pumps faster too.

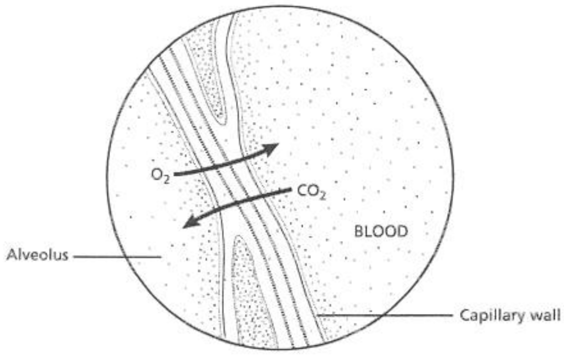
A circular message pathway called a **feedback** loop controls changes in your organs when you are active. The carbon dioxide produced by your muscles is picked up by the blood. The brain sends a message to the muscles of the ribs and diaphragm to increase the rate at which you breathe. The heart gets a message to pump faster. As a result of these actions, extra oxygen enters the blood and is carried to muscle cells. The extra carbon dioxide is removed through the lungs.

Eventually you stop running. You may continue to breathe quickly, and your heart may continue to beat rapidly for a short while. When the levels of carbon dioxide in the blood return to normal, the brain sends a message that slows down your breathing and heart rate. You breathe more slowly, and your heart slows down. The process continues to repeat itself as needed to control the amount of oxygen and carbon dioxide in your blood. Feedback loops help maintain homeostasis by constantly sending information back and forth from one part of your body to another.

Name ______________________ Date ____________ Class ____________

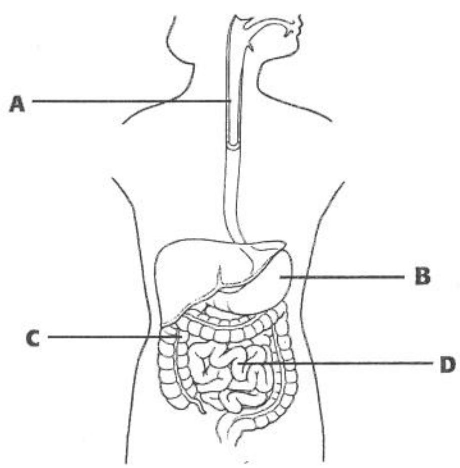
TAKS OBJECTIVE

2 TAKS PRACTICE QUESTIONS



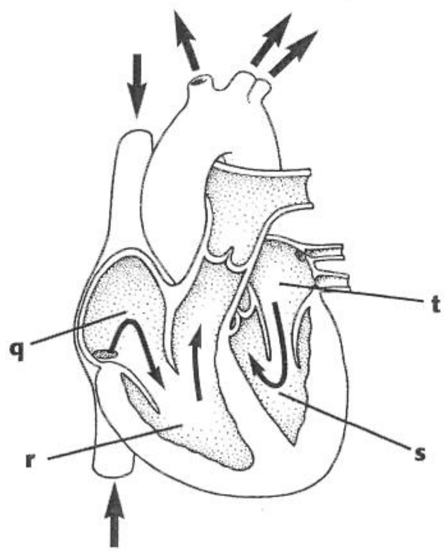
1 The picture shows the exchange of gases between which two body systems?

- **A** Circulatory and digestive
- **B** Respiratory and endocrine
- **C** Circulatory and respiratory
- **D** Endocrine and digestive



2 Which letter in the diagram points to the organ of the digestive system where most nutrients are absorbed?

- **F** Letter A
- **G** Letter B
- **H** Letter C
- **J** Letter D



3 Which statement is true of blood in the chamber labeled q?

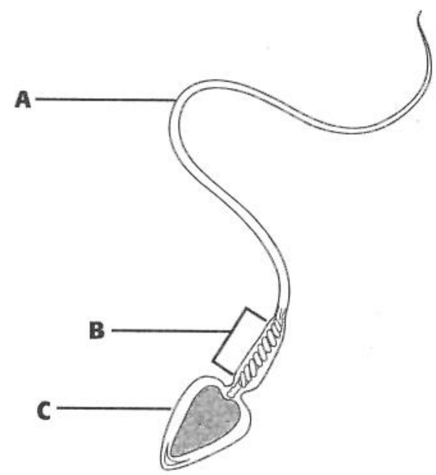
- **A** It is full of oxygen.
- **B** It is returning from the lungs.
- **C** It is oxygen poor.
- **D** It has no red blood cells.

4 Which statement describes the interaction between two different body systems?

- **F** Muscles move when a nerve impulse is received from motor nerves.
- **G** Cells produced in the inner layer of the epidermis move upward toward the outer layer of the skin.
- **H** Air is filtered and warmed in the nose.
- **J** Macrophages attack and kill invading pathogens.

GO ON

TAKS Practice Questions, continued



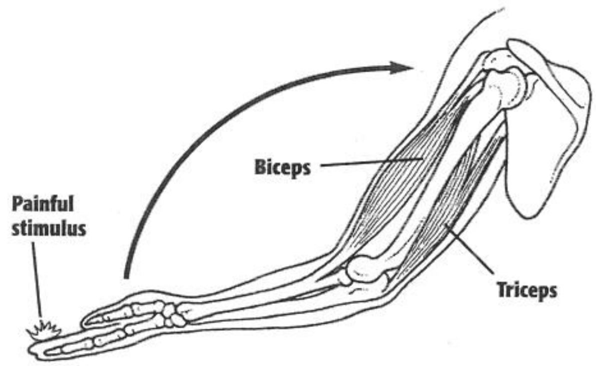
5 Which part of the sperm cell contains the cell's nucleus?

A Part A

B Part B

C Part C

D A sperm cell has no nucleus.



6 The figure shows an arm that is reacting to a painful stimulus, such as a pinprick. Where are the sensory neurons that initiate the reflex response?

F In the biceps

G In the triceps

H In the spinal cord

J In the finger

Question 9

As an athlete is running a 5-kilometer race, her cells need more oxygen. Which change will help her body meet the increased demand for oxygen?

A Her heart beating more quickly

B Her pancreas releasing more insulin

C Her breathing becoming more shallow

D Her sweat glands becoming more active

Question 12

A person drives a car up to a railroad crossing and stops. The driver is startled by the sound of a train blowing its whistle. The driver's heart rate immediately increases, and the driver is more alert. Which body systems are most involved in causing the driver's heart rate and alertness to increase as a result of sudden fright?

A Skeletal and muscular

B Nervous and endocrine

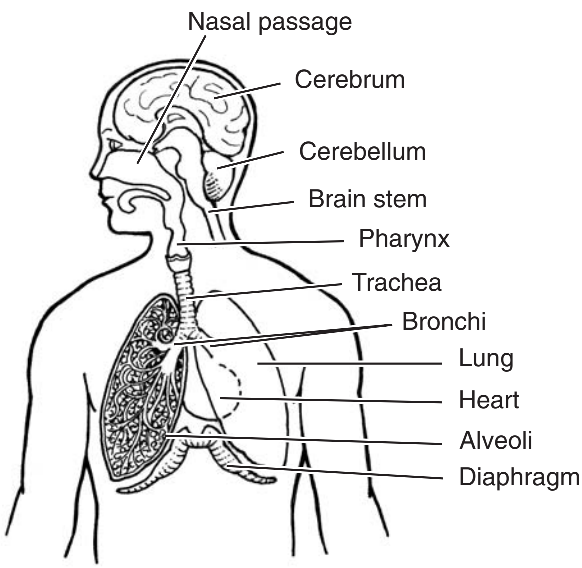
C Circulatory and excretory

D Respiratory and integumentary

Answer Key: page 113

Question 13

An increase in the amount of carbon dioxide in the blood stimulates the respiratory center in the brain. As a result, a message is sent from the brain to the —



A bronchi, causing them to narrow in diameter

B diaphragm, causing an increase in the breathing rate

C alveoli, causing them to actively transport oxygen

D lungs, causing a decrease in the breathing rate

Answer Key: page 113