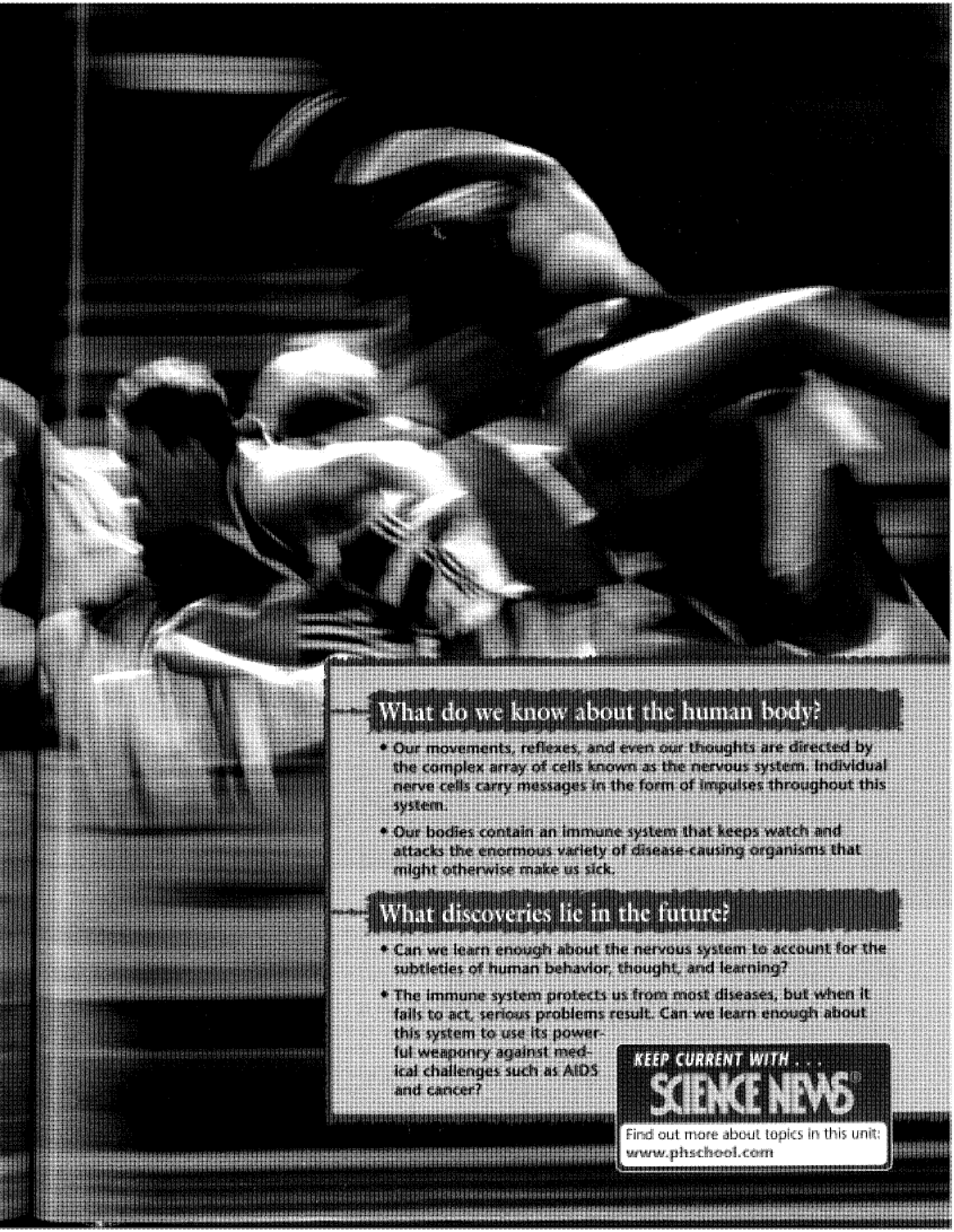
UNIT 10

The Human Body

Chapters

▶ Each body system performs its function and works with other systems to keep the bodies of these hurdlers in perfect working order.



What do we know about the human body?

- Our movements, reflexes, and even our thoughts are directed by the complex array of cells known as the nervous system. Individual nerve cells carry messages in the form of impulses throughout this system.
- Our bodies contain an immune system that keeps watch and attacks the enormous variety of disease-causing organisms that might otherwise make us sick.

What discoveries lie in the future?

- Can we learn enough about the nervous system to account for the subtleties of human behavior, thought, and learning?
- The immune system protects us from most diseases, but when it fails to act, serious problems result. Can we learn enough about this system to use its powerful weaponry against medical challenges such as AIDS and cancer?

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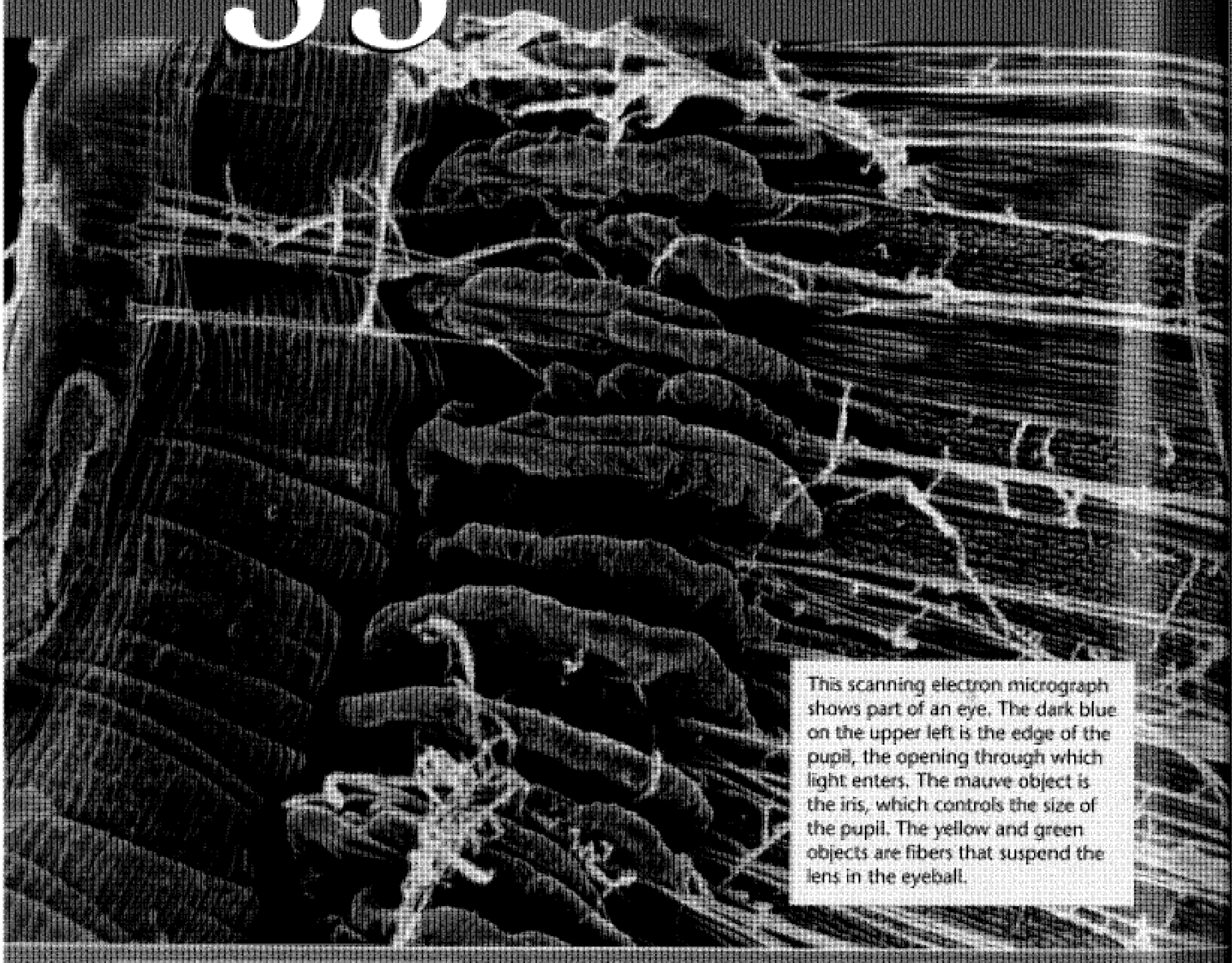
Chapter 35 Nervous System



This scanning electron micrograph shows part of an eye. The dark blue on the upper left is the edge of the pupil, the opening through which light enters. The mauve object is the iris, which controls the size of the pupil. The yellow and green objects are fibers that suspend the lens in the eyeball.

Inquiry Activity

What are the organ systems?

Procedure

1. Draw an outline of the human body on a sheet of paper. Without referring to any illustrations, do your best to locate the following organs on your outline: brain, stomach, kidneys, heart, and lungs. Pay attention to the shapes of the organs and their relative sizes.
2. Make a second drawing using **Figure 35–2** on pages 892 and 893 as a reference. Indicate which organs belong to which organ systems.

Think About It

1. **Predicting** Can an organ belong to more than one organ system? Explain.
2. **Evaluating and Revising** Compare your two drawings. Describe any misconceptions you had about the size, shape, or location of the organs.

35–1 Human Body Systems

Guide for Reading

Key Concepts
- How does the human body maintain homeostasis?

Vocabulary
muscle tissue
epithelial tissue
connective tissue
nervous tissue
feedback inhibition

Reading Strategy: Predicting Before you read, use **Figure 35–2** to predict how many organ systems help to regulate body temperature. As you read, look for evidence to support your prediction.

As the missed shot bounces high in the air, one of the defenders decides to take a chance. She breaks for the other end of the court. Another defender grabs the rebound, glances upcourt, and throws a long, arching pass toward the basket. Wide open, her teammate grabs the pass, dribbles, and leaps into the air, laying the basketball carefully off the backboard and into the unguarded basket. The buzzer goes off, and the game is over.

Organization of the Body

Teamwork is a wonderful thing! Anyone watching the end of this game would be impressed at the way these two players worked together to make the winning play. But the real teamwork on this play involved a much larger number of players—nearly a hundred trillion cells that make up the human body.

Every cell in the human body is both an independent unit and an interdependent part of a larger community—the entire organism. To make a winning basket, a basketball player has to use her eyes to watch the play and her brain to figure out how to score. With the support of her bones, her muscles propel her body up the court. As she sprints for a pass, her lungs absorb oxygen, which her blood carries to her cells. Her brain monitors the sensation of the ball on her fingertips and sends signals that guide her body into the air for the final play.

Levels of Organization How does the body get so many individual cells to work together so beautifully? You can begin to answer this question by studying the organization of the human body. Recall the levels of organization in a multicellular organism—cells, tissues, organs, and organ systems. Tissues are groups of similar cells that perform a single function, such as connecting a muscle to a bone. An organ is a group of tissues that work together to perform a complex function, such as sight. An organ system is a group of organs that perform closely related functions.

The eleven organ systems of the human body work together to maintain homeostasis. The organ systems are shown in **Figure 35–2** on pages 892 and 893.

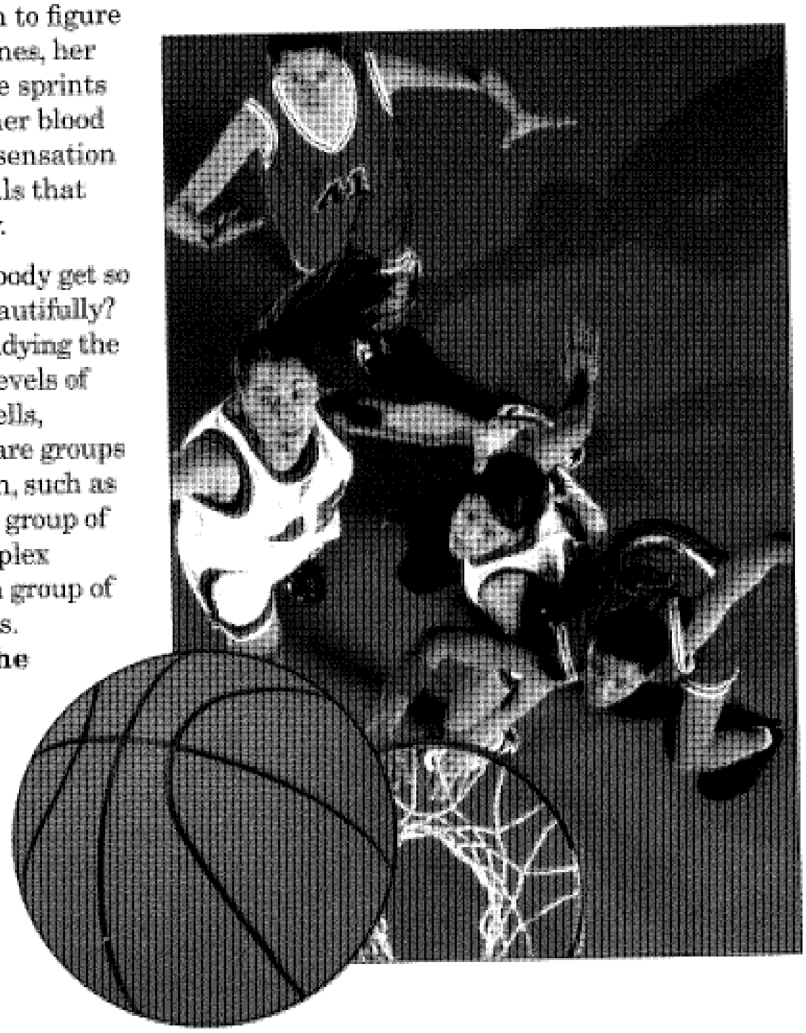
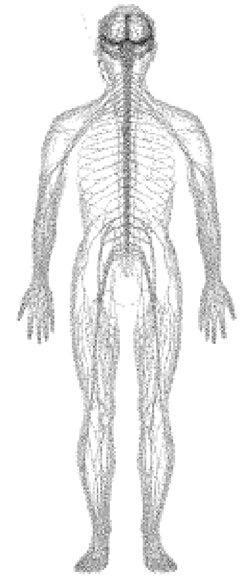


Figure 35–1 Each player on a basketball team has a different role, but together the team works toward a common goal—winning the game.

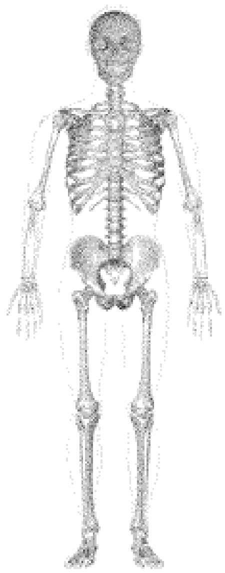
FIGURE 35–2 HUMAN ORGAN SYSTEMS

Each of the eleven organ systems shown here has a different set of functions. **The organ systems work together to maintain a stable internal environment.**

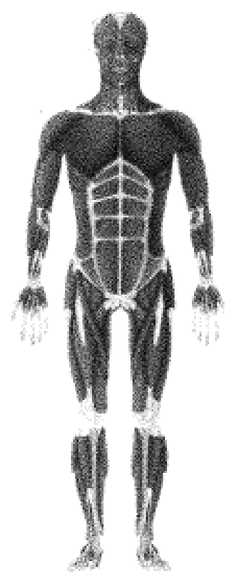


Nervous System
Structures: Brain, spinal cord, peripheral nerves
Function: Coordinates the body's response to changes in its internal and external environments

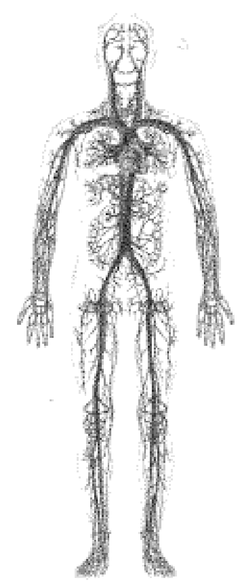
Integumentary System
Structures: Skin, hair, nails, sweat and oil glands
Function: Serves as a barrier against infection and injury; helps to regulate body temperature; provides protection against ultraviolet radiation from the sun



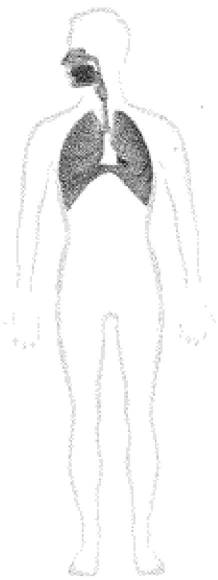
Skeletal System
Structures: Bones, cartilage, ligaments, tendons
Function: Supports the body; protects internal organs; allows movement; stores mineral reserves; provides a site for blood cell formation



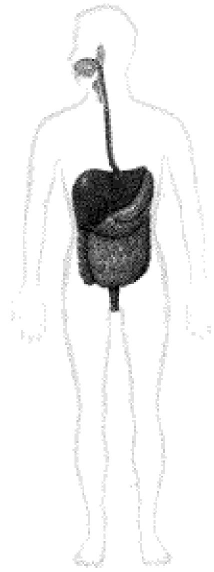
Muscular System
Structures: Skeletal muscle, smooth muscle, cardiac muscle
Function: Works with skeletal system to produce voluntary movement; helps to circulate blood and move food through the digestive system



Circulatory System
Structures: Heart, blood vessels, blood
Function: Brings oxygen, nutrients, and hormones to cells; fights infection; regulates body temperature



Respiratory System
Structures: Nose, pharynx, larynx, trachea, bronchi, bronchioles, lungs
Function: Provides oxygen needed for cellular respiration and removes excess carbon dioxide from the body

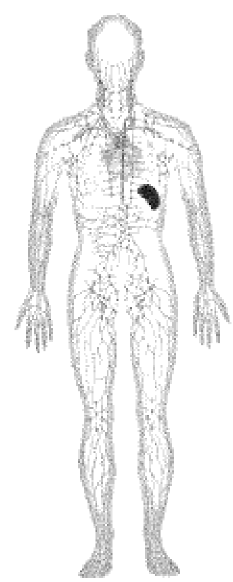


Digestive System
Structures: Mouth, pharynx, esophagus, stomach, small and large intestines
Function: Converts foods into simpler molecules that can be used by the cells of the body; absorbs food

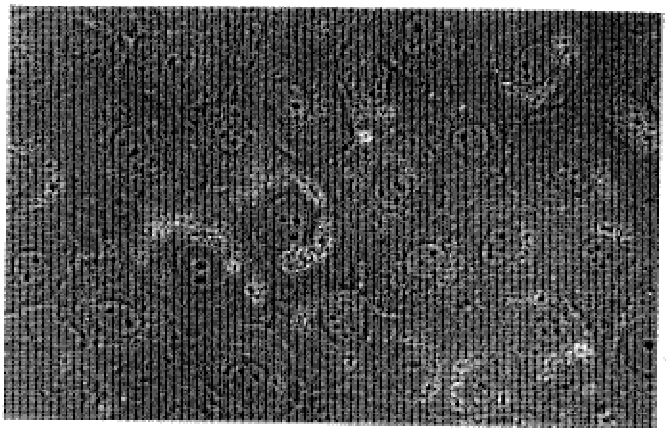
Excretory System
Structures: Skin, lungs, kidneys, ureters, urinary bladder, urethra
Function: Eliminates waste products of metabolism from the body; maintains homeostasis

Endocrine System
Structures: Hypothalamus, pituitary, thyroid, parathyroids, adrenals, pancreas, ovaries (in females), testes (in males)
Function: Controls growth, development, metabolism, and reproduction

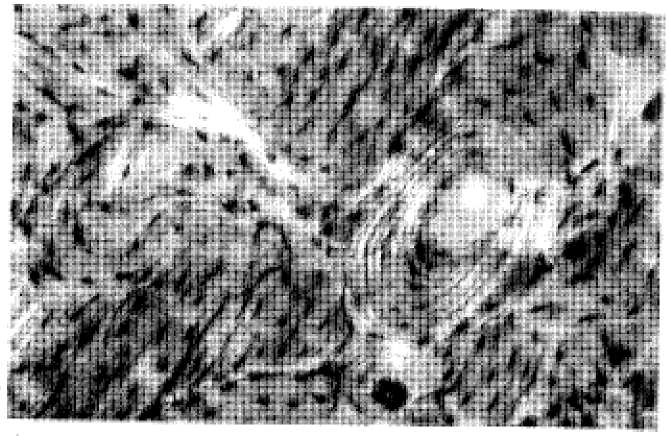
Reproductive System
Structures: Testes, epididymis, vas deferens, urethra, and penis (in males); ovaries, Fallopian tubes, uterus, vagina (in females)
Function: Produces reproductive cells; in females, nurtures and protects developing embryo



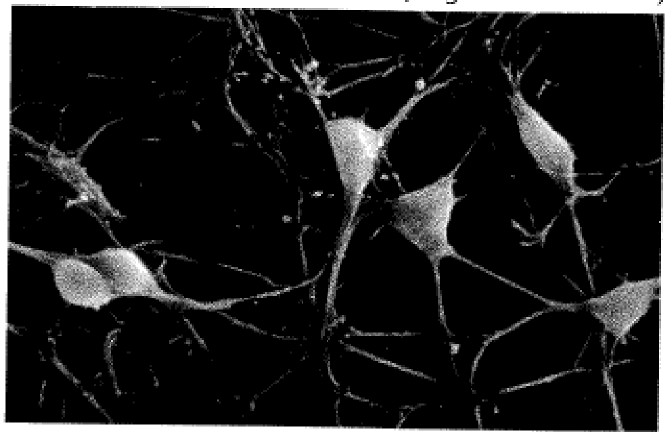
Lymphatic System
Structures: White blood cells, thymus, spleen, lymph nodes, lymph vessels
Function: Helps protect the body from disease; collects fluid lost from blood vessels and returns the fluid to the circulatory system



Epithelial Tissue (magnification: 6000×)



Connective Tissue (magnification: about 50×)



Nervous Tissue (magnification: 1100×)

Muscle Tissue (magnification: 150×)

▲ **Figure 35–3** The four major types of tissues in the human body are epithelial tissue, connective tissue, nervous tissue, and muscle tissue. **Inferring** *What kind of tissue is bone?*

Types of Tissues Different tissue types work together within organs. **Muscle tissue** is the most abundant tissue in most animals. Muscle tissue controls the internal movement of materials such as blood through the circulatory system and food through the digestive system. Muscle tissue also controls the external movements of the entire body or parts of the body, such as your hands when you type on a computer keyboard.

The heart is mainly muscle tissue, but three other types of tissues are needed for the heart to function. The closely packed cells in **epithelial tissue** cover the surface of the body and line internal organs. Epithelial tissue lining the chambers of the heart prevents leakage of blood. Glands are made from epithelial tissue. A gland is a structure that makes and secretes, or releases, a particular product such as saliva, sweat, or milk.

Connective tissue does more than its name implies. It holds organs in place and binds different parts of the body together. The tendons that connect bones to muscles and the ligaments that join bones to bones are examples of connective tissue. This type of tissue also provides support for the body. Connective tissue keeps the walls of the heart flexible, but strong. Some connective tissue pads and insulates the body.

Nervous tissue receives messages from the body's external and internal environments, analyzes the data, and directs the response. Nervous tissue in the heart controls the rate at which the heart beats.

✔CHECKPOINT *What is the role of nervous tissue?*

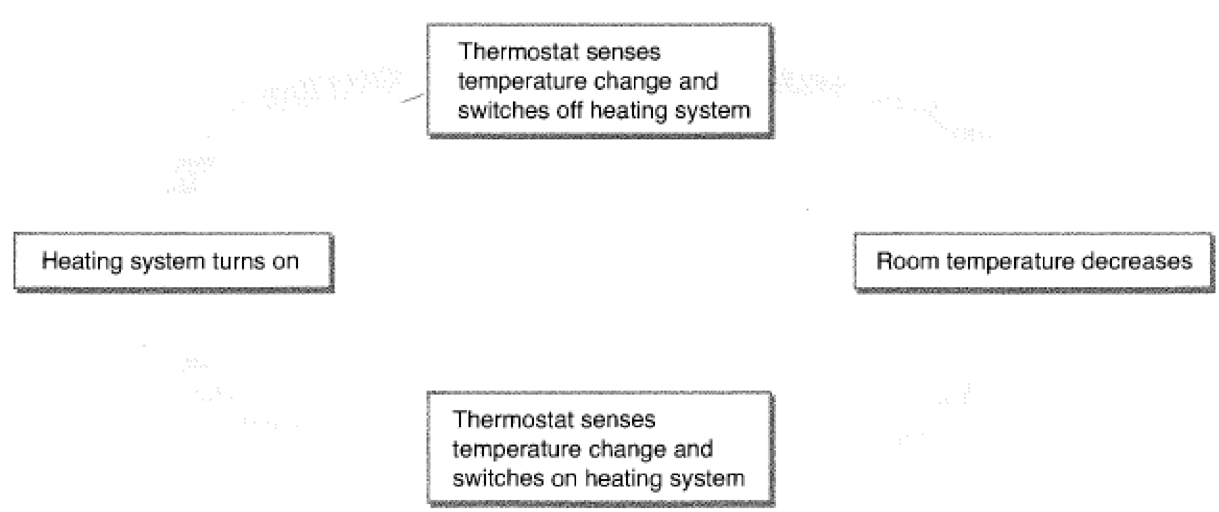
Maintaining Homeostasis

You can get a glimpse of the functions of your organ systems when you breathe deeply after climbing a steep hill or your blood clots to seal a cut. Behind the scenes, your organ systems are working constantly to do something that few people appreciate—maintain a controlled, stable internal environment. Recall from Chapter 1 that this process is called homeostasis. The cells of the body must be kept at a temperature within a certain narrow range, supplied with energy through cellular respiration, bathed in fluid, and cleansed of their waste products. Failure at any of these tasks, even for a few minutes, could lead to permanent injury or death of the entire organism.

A Nonliving Example One way to understand homeostasis is to look at a nonliving system that also keeps environmental conditions within a certain range. The heating system of a house is a perfect example. In most houses, heat is supplied by a furnance that burns oil or natural gas. When the temperature within the house drops below a set point, a sensor in a device called a thermostat switches the furnace on. Heat produced by the furnace warms the house. When the temperature rises above the set point, the thermostat switches the furnace off. Because the furnace runs only when it is needed, the temperature of the house is kept within a narrow range.

A heating system like the one described is said to be controlled by feedback inhibition. **Feedback inhibition** is the process by which the product of a system shuts down the system or limits its operation. **Figure 35–4** summarizes the feedback inhibition process in a home heating system. When the furnace is switched on, it produces a product (heat) that changes the environment of the house (by raising the air temperature). This environmental change then "feeds back" to "inhibit" the operation of the furnace. In other words, heat from the furnace eventually raises the temperature enough to send a feedback signal to switch the furnace off. Systems controlled by feedback inhibition are generally fully automated and very stable. That is why a house with a good heating system is a comfortable place to be, even on the coldest of days.

▼ **Figure 35–4** A home heating system uses feedback inhibition to maintain a stable, comfortable environment within a house. **Predicting** *In which organ system is the thermostat for the human body located?*



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In the Body Could biological systems achieve homeostasis through feedback inhibition? Absolutely. All that is needed is a system that regulates some aspect of the cellular environment and that can respond to feedback from its own activities by switching on or off as needed.

For the body to maintain a stable temperature, there must be a balance between heat production and heat loss. The body regulates temperature by a mechanism that is remarkably similar to that of a household heating system. A part of the brain called the hypothalamus contains nerve cells that monitor both the temperature of the skin at the surface of the body and the temperature of organs in the body's core. The temperature of the core is generally higher than the temperature of the skin.

If the nerve cells sense that the core temperature has dropped much below 37°C, the hypothalamus produces chemicals that signal cells throughout the body to speed up their activities. Heat produced by this increase in cellular activity causes a gradual rise in body temperature, which is detected by nerve cells in the hypothalamus. This feedback inhibits the production of the chemicals that speed up cellular activity and keeps body temperature from rising to a dangerous level.

Have you ever been so cold that you began to shiver? If your body temperature drops well below its normal range, the hypothalamus releases chemicals that signal muscles just below the surface of the skin to contract involuntarily—to "shiver." These muscle contractions release heat, which helps the body temperature to rise back toward the normal range.

If body temperature rises too far above 37°C, the hypothalamus slows down cellular activities, minimizing the production of heat. This is one of the main reasons you may feel tired and sluggish on a hot day. The body also responds to high temperatures by producing sweat, which helps to cool the body surface by evaporation. Because heat from the body's core is carried by the blood to the skin, evaporation at the body surface also helps to lower the temperature of the core. When this temperature returns to its set point, the body stops producing sweat.

Word Origins

Thermometer comes from the Greek words *therme,* meaning "heat," and *metron,* meaning "measure." So, thermometer means an instrument used to measure heat. **If *hypo-* is Greek for "under," what does *hypothermia* mean?**

35–1 Section Assessment

1. **Key Concept** Explain the role the nervous system plays in maintaining homeostasis.
2. What are the four types of tissue?
3. Which organ systems help to maintain body temperature?
4. Explain why the hypothalamus can be compared to a thermostat.
5. **Critical Thinking Classifying** Would you classify blood as a cell, a tissue, or an organ? Explain your answer.

iTEXT Assessment Use iText to review the important concepts in Section 35–1.

ALTERNATIVE ASSESSMENT

Making a Venn Diagram Draw a Venn diagram to link the four basic levels of organization in the human body. Provide at least three examples for each level included in your diagram.

35–2 The Nervous System

Play any team sport—basketball, softball, soccer—and you will discover that communication is one of the keys to success. Coaches call plays, players signal to one another, and the very best teams communicate in a way that enables them to play as a single unit. Communication can make the difference between winning and losing.

The same is true for living organisms. Nearly all multicellular organisms have communication systems. Specialized cells carry messages from one cell to another so that communication among all body parts is smooth and efficient. In humans, these cells are in the nervous system. **The nervous system controls and coordinates functions throughout the body and responds to internal and external stimuli.**

Neurons

The messages carried by the nervous system are electrical signals called impulses. The cells that transmit these impulses are called **neurons.** Neurons can be classified into three types according to the direction in which an impulse travels. Sensory neurons carry impulses from the sense organs to the spinal cord and brain. Motor neurons carry impulses from the brain and the spinal cord to muscles and glands. Interneurons connect sensory and motor neurons and carry impulses between them.

Although neurons come in all shapes and sizes, they have certain features in common. **Figure 35–5** shows a typical neuron. The largest part of a typical neuron is the **cell body.** The cell body contains the nucleus and much of the cytoplasm. Most of the metabolic activity of the cell takes place in the cell body.

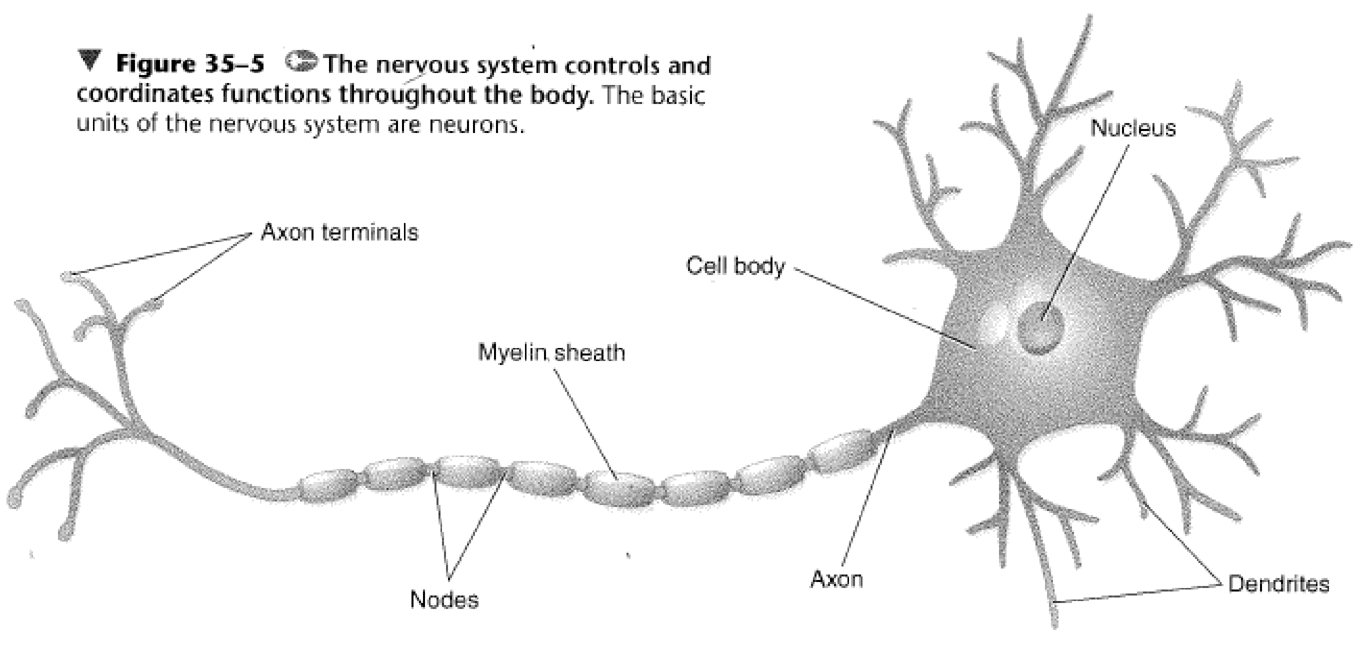
Guide for Reading

Key Concepts
- What is the function of the nervous system?
- How is a nerve impulse transmitted?

Vocabulary
neuron • cell body
dendrite • axon
myelin sheath
resting potential
action potential
threshold • synapse
neurotransmitter

Reading Strategy: Summarizing As you read, find the key ideas for each paragraph. Write down a few key words from each main idea. Then, use the key words in your summary.

▼ **Figure 35–5 The nervous system controls and coordinates functions throughout the body.** The basic units of the nervous system are neurons.



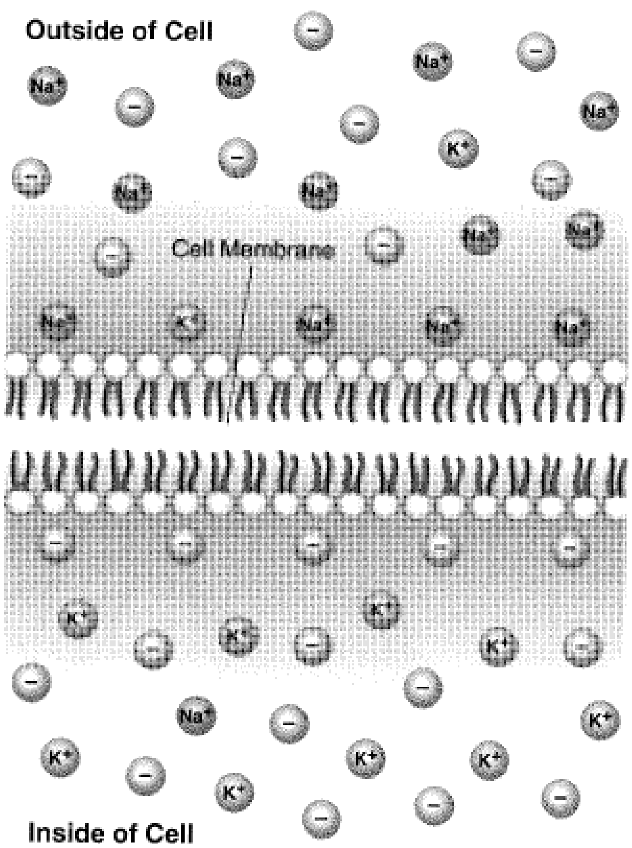
Spreading out from the cell body are short, branched extensions called **dendrites.** Dendrites carry impulses from the environment or from other neurons toward the cell body. The long fiber that carries impulses away from the cell body is called the **axon.** The axon ends in a series of small swellings called axon terminals, located some distance from the cell body. Neurons may have dozens of dendrites but usually have only one axon. In most animals, axons and dendrites are clustered into bundles of fibers called nerves. Some nerves contain only a few neurons, but many others have hundreds or even thousands of neurons.

In some neurons, the axon is surrounded by an insulating membrane known as the **myelin sheath** (MY-uh-lin). The myelin sheath that surrounds a single long axon leaves many gaps, called nodes, where the axon membrane is exposed. As an impulse moves along the axon, it jumps from one node to the next, which increases the speed at which the impulse can travel.

The Nerve Impulse

The production of a nerve impulse can be compared to the flow of electricity through a wire. The transmission of electricity depends on the movement of negatively charged electrons. The production of a nerve impulse depends on the movement of positively charged ions across a cell membrane.

▼ **Figure 35–6** At rest, the inside of the neuron's membrane has a negative charge. **Predicting** *Is the distribution of positive ions shown the result of diffusion or of active transport?*



Resting Potential The distribution of sodium ions (Na^+) and potassium ions (K^+) inside and outside a neuron is shown in **Figure 35–6.** There are more potassium ions (K^+) in the cytoplasm than in the fluid outside the cell and more sodium ions in the fluid outside the cell than in the cytoplasm. Because both potassium and sodium ions can diffuse across the cell membrane, the unequal distribution of these ions must be maintained by active transport. Proteins in the cell membrane pump sodium ions out of the neuron and potassium ions into the neuron.

Potassium and sodium ions continue to diffuse across the membrane, but potassium ions diffuse out of the cell more easily than sodium ions diffuse in. As a result, a negative charge builds up on the inside of the membrane and a positive charge builds up on the outside of the membrane. This difference in electrical charge across the cell membrane of a resting neuron is its **resting potential.** A neuron has a resting potential of about –70 millivolts (mV). Thus, the magnitude of the voltage across a tiny neuron's membrane is roughly one twentieth the voltage of a flashlight battery (1.5 volts).

CHECKPOINT *What is resting potential?*

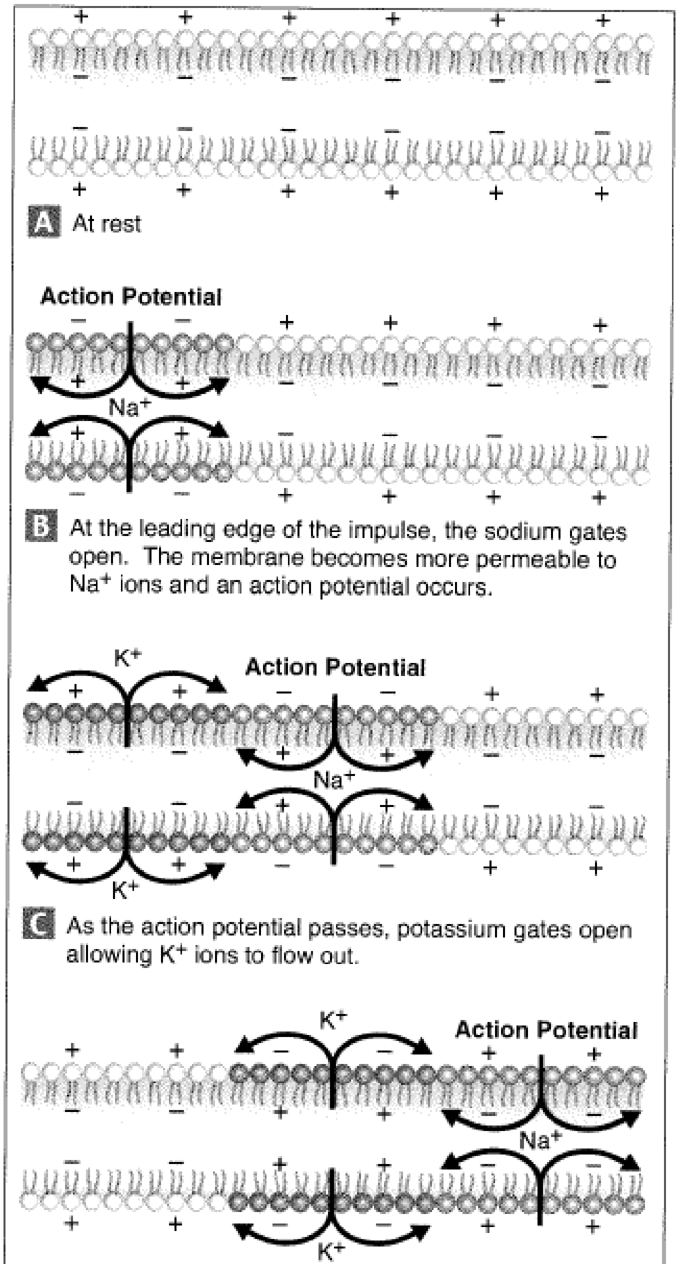
The Moving Impulse A nerve impulse is similar to the ripple caused when a rock is dropped into a pond. The ripple is caused by the up-and-down movement of water. The impulse is caused by the movement of ions across the cell membrane. **A nerve impulse begins when a neuron is stimulated by another neuron or by its environment.** The impulse travels along the axon, away from the cell body and toward the axon terminals. **Figure 35–7** summarizes the transmission of a nerve impulse along an axon.

The cell membrane of a neuron contains thousands of protein channels that allow ions to pass through when the gates to these channels are open. Generally, the gates are closed. At the leading edge of an impulse, however, the sodium gates open, allowing sodium ions to flow into the cell. This flow of positive ions causes a temporary change in the charges on the cell membrane. The inside of the membrane gains a positive charge and the outside gains a negative charge. This reversal of charges is called an **action potential.** A neuron has an action potential of about +30 mV. As the impulse passes, the potassium gates open, allowing positively charged potassium ions to flow out of the cell. The resting potential of the membrane is re-established. The membrane is once again negatively charged on the inside and positively charged on the outside.

A nerve impulse is self-propagating. That is, an impulse at any point on the membrane causes an impulse at the next point along the membrane. You can compare the flow of an impulse to the fall of a row of dominoes. As each domino falls, it causes its neighbor to fall.

Threshold The strength of an impulse is always the same—either there is an impulse in response to a stimulus or there is not. In other words, a stimulus must be of adequate strength to cause a neuron to transmit an impulse. The minimum level of a stimulus that is required to activate a neuron is called the **threshold.** Any stimulus that is stronger than the threshold will produce an impulse. Any stimulus that is weaker than the threshold will produce no impulse. Thus, a nerve impulse follows the all-or-none principle: either the stimulus will produce an impulse, or it won't produce an impulse.

The all-or-none principle can be illustrated by using a row of dominoes. If you were to gently press the first domino in a row, it might not move at all. A slightly harder push might make the domino teeter back and forth but not fall. A slightly stronger push would cause the first domino to fall into the second. You have reached the threshold at which the row of dominoes would fall.



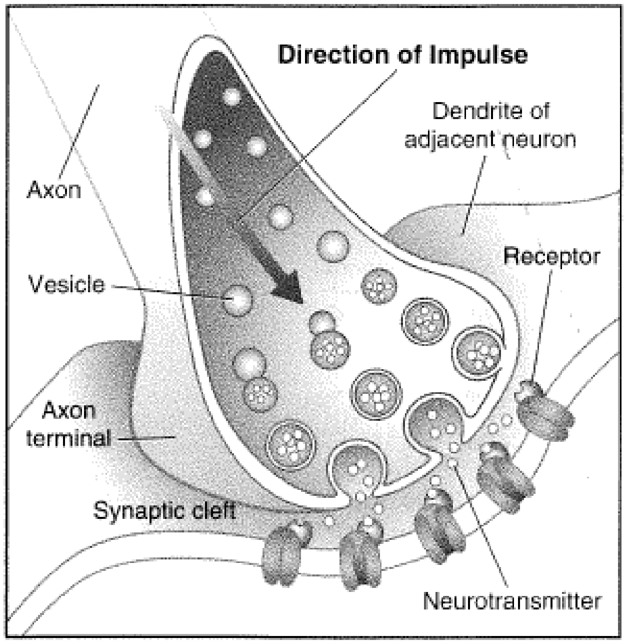
A At rest

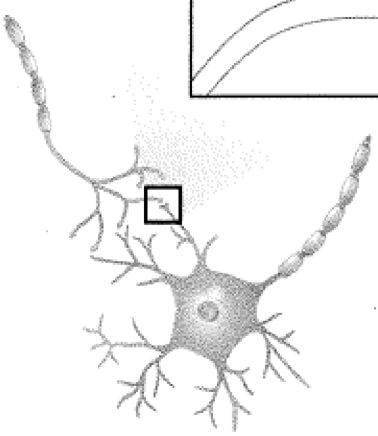
B At the leading edge of the impulse, the sodium gates open. The membrane becomes more permeable to Na^+ ions and an action potential occurs.

C As the action potential passes, potassium gates open allowing K^+ ions to flow out.

D The action potential continues to move along the axon in the direction of the nerve impulse.

▲ **Figure 35–7** **A nerve impulse is self-propagating.** Sodium ions flowing into the neuron reverse the charges on the membrane. As the impulse passes, potassium ions flow out of the neuron and the resting potential is restored.





▲ **Figure 35–8** When an impulse reaches the end of the axon of one neuron, neurotransmitters are released into the synaptic cleft. The neurotransmitters bind to receptors on the membrane of an adjacent neuron. **Predicting** *Is the adjacent cell always another neuron?*

The Synapse

At the end of the neuron, the impulse reaches an axon terminal. Usually the neuron makes contact with another cell at this location. The neuron may pass the impulse along to the second cell. Motor neurons, for example, pass their impulses to muscle cells.

The location at which a neuron can transfer an impulse to another cell is called a **synapse** (SIN-aps). As shown in **Figure 35–8,** a small cleft, or gap, separates the axon terminal from the dendrites of the adjacent cell, in this case a neuron. The terminals contain tiny sacs, or vesicles, filled with neurotransmitters (noo-roh-TRANZ-mit-urs). **Neurotransmitters** are chemicals used by a neuron to transmit an impulse across a synapse to another cell.

When an action potential arrives at an axon terminal, the sacs release the neurotransmitters into the small gap between the two cells. The neurotransmitter molecules diffuse across the gap and attach themselves to receptors on the membrane of the neighboring cell. This stimulus causes positive sodium ions to rush across the cell membrane, stimulating the second cell. If the stimulation exceeds the cell's threshold, a new impulse begins.

Only a fraction of a second after binding to their receptors, the neurotransmitter molecules are released from the cell surface. They may then be broken down by enzymes, or taken up and recycled by the axon terminal.

35–2 Section Assessment

1. **Key Concept** Describe the functions of the nervous system.
2. **Key Concept** What happens when a neuron is stimulated by another neuron?
3. What are the three types of neurons?
4. Describe the role of the myelin sheath.
5. **Critical Thinking Applying Concepts** How can the level of pain you feel vary if a stimulus causes an all-or-none response?

iTEXT Assessment Use iText to review the important concepts in Section 35–2.

ALTERNATIVE ASSESSMENT

Creating a Flowchart
Create a flowchart to show the events that occur as a nerve impulse travels from one neuron to the next. Include as much detail as you can. Use your flowchart to explain the process to a classmate.

35–3 Divisions of the Nervous System

Neurons do not act alone. Instead, they are joined together to form a complex network—the nervous system. The human nervous system is separated into two major divisions: the central nervous system and the peripheral nervous system.

The central nervous system is the control center of the body. The functions of the central nervous system are similar to those of the central processing unit of a computer. **The central nervous system relays messages, processes information, and analyzes information.** The peripheral nervous system receives information from the environment and relays commands from the central nervous system to organs and glands.

The Central Nervous System

The **central nervous system** consists of the brain, shown in **Figure 35–9,** and the spinal cord. The skull and vertebrae in the spinal column protect the brain and spinal cord. Both the brain and spinal cord are wrapped in three layers of connective tissue known as **meninges** (muh-NIN-jeez). Between two of these layers is a space filled with cerebrospinal fluid. **Cerebrospinal fluid** (sehr-uh-broh-SPY-nul) bathes the brain and spinal cord and acts as a shock absorber that protects the central nervous system. The fluid also allows for the exchange of nutrients and waste products between blood and nervous tissue.

Guide for Reading

Key Concepts

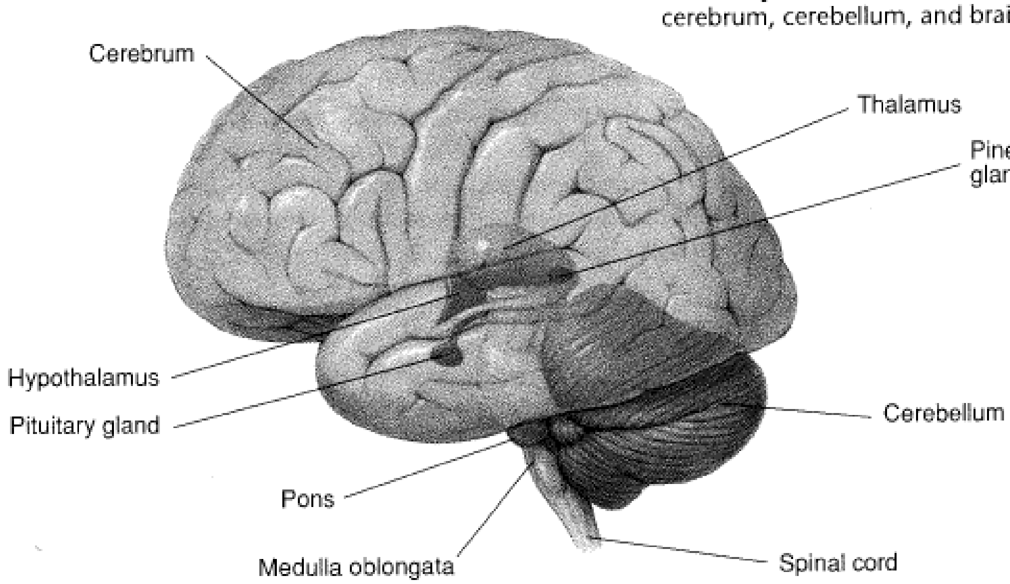
- What are the functions of the central nervous system?
- What are the two divisions of the peripheral nervous system?

Vocabulary

central nervous system
meninges • cerebrospinal fluid
cerebrum • cerebellum
brain stem • thalamus
hypothalamus • reflex

Reading Strategy: Asking Questions Before you read, rewrite the headings in the section as *how, why,* or *what* questions about the nervous system. As you read, write down the answers to your questions.

▼ **Figure 35–9 The brain—the main switching area of the central nervous system—helps to relay messages, process information, and analyze information.** The brain consists of the cerebrum, cerebellum, and brain stem.

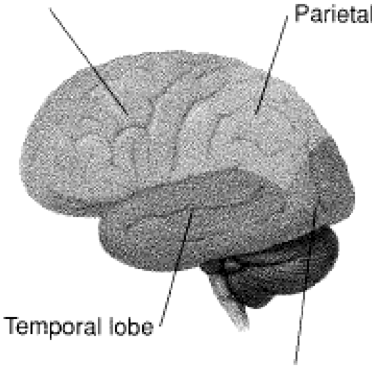


The Brain

The brain contains approximately 100 billion neurons. The neurons in the brain are mainly interneurons. The brain has a mass of about 1.4 kilograms. It is the main switching unit of the central nervous system.

The Cerebrum The largest and most prominent region of the human brain is the **cerebrum.** The cerebrum is responsible for the voluntary, or conscious, activities of the body. It is the site of intelligence, learning, and judgment. A deep groove divides the cerebrum into right and left hemispheres. The hemispheres are connected by a band of tissue called the corpus callosum.

Folds and grooves on the surface of each hemisphere greatly increase the surface area of the cerebrum. Each hemisphere of the cerebrum is divided into regions called lobes. The lobes are named for the skull bones that cover them. The locations of four lobes of the brain are shown in **Figure 35–10.**



▲ **Figure 35–10** Each hemisphere of the cerebrum is divided into four lobes. Different functions of the body are controlled by different lobes of the brain. **Drawing Conclusions** ***The frontal lobe controls voluntary muscle movements. What might happen if this part of the brain became injured?***

Remarkably, each half of the cerebrum deals mainly with the opposite side of the body. Sensations from the left side of the body go to the right hemisphere of the cerebrum, and those from the right side of the body go to the left hemisphere. Commands to move muscles are generated in the same way. The left hemisphere controls the body's right side and the right hemisphere controls the body's left side.

There is more than a simple left-right division of labor between the hemispheres. For example, some studies have suggested that the right hemisphere may be associated with creativity and artistic ability, whereas the left hemisphere may be associated with analytical and mathematical ability.

The cerebrum consists of two surfaces. The outer surface of the cerebrum is called the cerebral cortex and consists of gray matter. Gray matter consists mainly of densely packed nerve cell bodies. The cerebral cortex processes information from the sense organs and controls body movements. The inner surface of the cerebrum consists of white matter, which is made up of bundles of axons with myelin sheaths. The myelin sheaths give the white matter its characteristic color.

The Cerebellum The second largest region of the brain is the **cerebellum.** The cerebellum is located at the back of the skull. Although the commands to move muscles come from the cerebral cortex, the cerebellum coordinates and balances the actions of the muscles so that the body can move gracefully and efficiently.

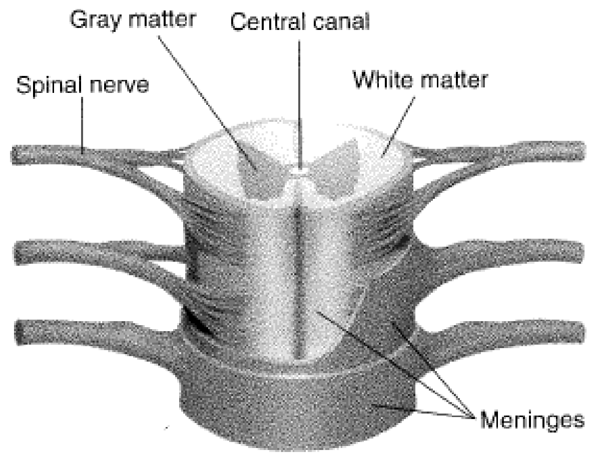
The Brain Stem The **brain stem** connects the brain and spinal cord. Located just below the cerebellum, the brain stem includes two regions known as the pons and the medulla oblongata (ahb-lahn-GAHT-uh). Each of these regions acts as a neural "switchboard," regulating the flow of information between the brain and the rest of the body. Some of the body's most important functions—including blood pressure, heart rate, breathing, and swallowing—are controlled in the brain stem.

The Thalamus and Hypothalamus The thalamus and hypothalamus are found between the brain stem and the cerebrum. The **thalamus** receives messages from the sense organs. It relays the information to the proper region of the cerebrum for further processing. The hypothalamus is just below the thalamus. The **hypothalamus** is the control center for recognition and analysis of hunger, thirst, fatigue, anger, and body temperature.

The Spinal Cord

Like a major telephone line that carries thousands of calls at once, the spinal cord is the main communications link between the brain and the rest of the body. Thirty-one pairs of spinal nerves branch out from the spinal cord, connecting the brain to the body. **Figure 35–11** shows a cross section of the spinal cord.

Certain kinds of information, such as reflexes, are processed directly in the spinal cord. A **reflex** is a quick, automatic response to a stimulus. Sneezing and blinking are two examples of reflexes. A reflex allows your body to respond to danger immediately, without spending time thinking about a response. Animals rely heavily on reflex behaviors for survival.



▲ **Figure 35–11** The spinal cord—the major nerve pathway to and from the brain—is protected by the vertebral column and meninges. **Comparing and Contrasting** *What is the difference between the white and gray matter?*

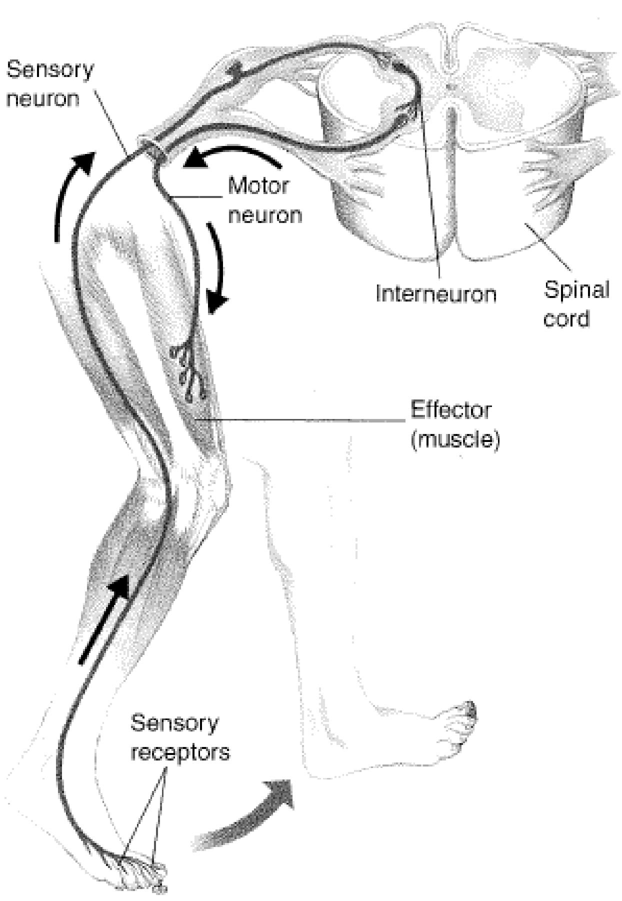
CHECKPOINT *What is a reflex?*

The Peripheral Nervous System

The peripheral nervous system lies outside of the central nervous system. It consists of all of the nerves and associated cells that are not part of the brain and the spinal cord. Included here are cranial nerves that pass through holes in the skull and stimulate regions of the head and neck, spinal nerves, and ganglia. Ganglia are collections of nerve cell bodies.

The peripheral nervous system can be divided into the sensory division and the motor division. **The sensory division of the peripheral nervous system transmits impulses from sense organs to the central nervous system. The motor division transmits impulses from the central nervous system to the muscles or glands.** The motor division is further divided into the somatic nervous system and the autonomic nervous system.

The Somatic Nervous System The somatic nervous system regulates activities that are under conscious control, such as the movement of the skeletal muscles. Every time you lift your finger or wiggle your toes, you are using the motor neurons of the somatic nervous system. Some somatic nerves are also involved with reflexes and can act with or without conscious control.



▲ **Figure 35–12 The peripheral nervous system transmits impulses from sense organs to the central nervous system and back to muscles or glands.** When you step on a tack, sensory receptors stimulate a sensory neuron, which relays the signal to an interneuron within the spinal cord. The signal is then sent to a motor neuron, which in turn stimulates a muscle in your leg to lift your leg.

If you accidentally step on a tack with your bare foot, your leg may recoil before you are aware of the pain. This rapid response is possible because receptors in your skin stimulate sensory neurons, which carry the impulse to your spinal cord. Even before the information is relayed to your brain, a group of neurons in your spinal cord automatically activates the appropriate motor neurons. These motor neurons cause the muscles in your leg to contract, pulling your foot away from the tack.

The pathway that an impulse travels from your foot back to your leg is known as a reflex arc. As shown in **Figure 35–12**, a reflex arc includes a sensory receptor (in this case, a receptor in your toe), sensory neuron, motor neuron, and effector (leg muscle). Some reflex arcs include interneurons. In other reflex arcs, a sensory neuron communicates directly with a motor neuron.

CHECKPOINT *What is a reflex arc?*

The Autonomic Nervous System The autonomic nervous system regulates activities that are automatic, or involuntary. The nerves of the autonomic nervous system control functions of the body that are not under conscious control. For example, the autonomic nervous system regulates the heartbeat and controls the contraction of smooth muscles in the digestive system and in blood vessels.

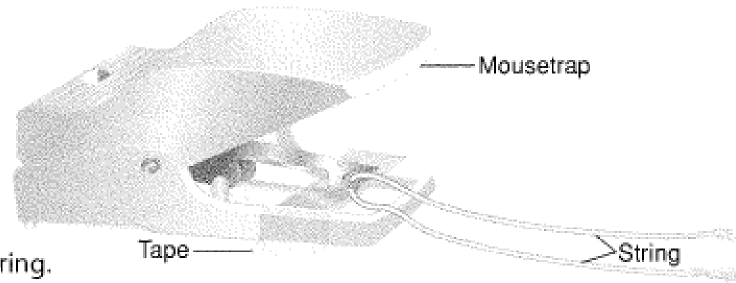
The autonomic nervous system is further subdivided into two parts that have opposite effects on the organs they control. The two parts are known as the sympathetic nervous system and the parasympathetic nervous system. Most organs controlled by the autonomic nervous system are under the control of both sympathetic and parasympathetic neurons.

Why is it important to have two systems that control the same organs? The sympathetic and parasympathetic nervous systems have opposite effects on the same organ system. For example, heart rate is increased by the sympathetic nervous system, but decreased by the parasympathetic nervous system. The process can be compared to the process of controlling the speed of a car. One system is like the gas pedal and the other is like the brake. Because there are two different sets of neurons, the autonomic nervous system can quickly speed up the activities of major organs in response to a stimulus, or slam on the brakes if necessary.

Quick Lab

How do reflexes occur?

Materials string, scissors, 3 plastic mousetraps, packing tape, 30-cm ruler



Procedure

1. To model a synapse, cut a 30-cm piece of string. **CAUTION:** *Handle scissors carefully.*
2. Hold a mousetrap open. Pull the string through the bait platform as shown. **CAUTION:** *Do not let the mousetrap snap on your fingers.* Slide a piece of tape under the bait platform and tape the trap to the table as shown. Label the trap "sensory neuron."
3. Hold one end of the string in each hand. Gently pull one end without setting off the trap. Now gradually pull harder.
4. To model a reflex arc, cut two more 30-cm pieces of string. Tie one end of each piece of string to the bait platform of a separate trap.
5. Tape the 2 new traps to the table, 20 cm from the first trap. Label one new trap "motor neuron," and the other "brain."
6. Reset the first trap, then set the new ones. Tape both ends of the strings attached to the new traps to the top of the first trap. Leave these strings slightly slack.
7. Pull the strings attached to the bait platform of the "sensory neuron."

Analyze and Conclude

1. **Drawing Conclusions** What was required for the trap to close in step 3? How does this behavior compare to the transmission of a nerve impulse?
2. **Applying Concepts** Does a stronger stimulus produce a stronger nerve impulse? Explain your answer.
3. **Using Analogies** Use your observations from step 7 to explain how your hand withdraws from a hot stove before you feel pain.

35–3 Section Assessment

1. **Key Concept** Discuss the overall function of the central nervous system.
2. **Key Concept** What are the functions of the two divisions of the peripheral nervous system?
3. Compare the central nervous system to the central processing unit of a computer.
4. Is a reflex part of the central nervous system, the peripheral nervous system, or both? Explain your answer.
5. **Critical Thinking Inferring** Why do you think the cerebrum is larger and more developed in humans than it is in other vertebrates?

iTEXT Assessment Use iText to review the important concepts in Section 35–3.

MAKING CONNECTIONS

Animal Behavior
Using Section 34–1, decide which parts of the nervous system are most likely to be involved with innate behaviors. Which parts are likely to be involved with learned behaviors? Explain your reasoning.

35–4 The Senses

Guide for Reading

Key Concept
- What are the five types of sensory receptors?

Vocabulary
sensory receptor
pupil
lens
retina
rod
cone
cochlea
semicircular canal
taste bud

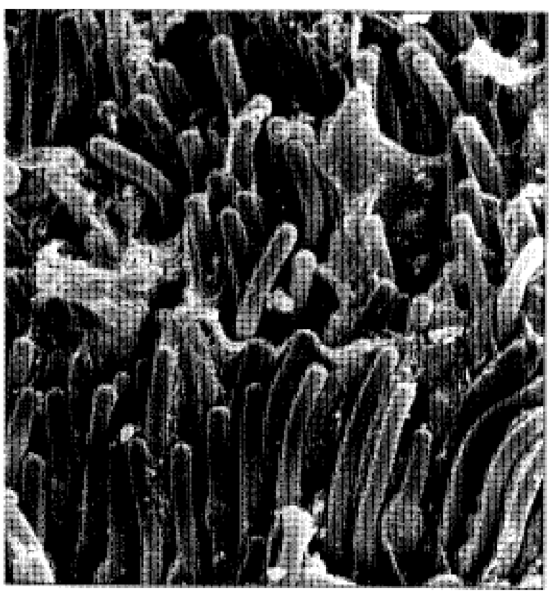
Reading Strategy: Outlining Before you read, use the headings of the section to make an outline about the five senses. As you read, fill in the subtopics and smaller topics. Then, add phrases or a sentence after each to provide key information.

The body contains millions of neurons that react directly to stimuli from the environment, including light, sound, motion, chemicals, pressure, or changes in temperature. These neurons, known as **sensory receptors,** react to light, sound, or other specific stimuli by sending impulses to other neurons, and eventually to the central nervous system. Sensory receptors are located throughout the body but are concentrated in the sense organs. These sense organs include the eyes, the inner ears, the nose, the mouth, and the skin. Sensory receptors within each organ enable it to respond to a particular stimulus.

There are five general categories of sensory receptors: pain receptors, thermoreceptors, mechanoreceptors, chemoreceptors, and photoreceptors. Pain receptors are located throughout the body except in the brain. Pain receptors respond to chemicals released by damaged cells. Pain is important to recognize because it usually indicates danger, injury, or disease. Thermoreceptors are located in the skin, body core, and hypothalamus. Thermoreceptors detect variations in temperature. Mechanoreceptors are found in the skin, skeletal muscles, and inner ears. They are sensitive to touch, pressure, stretching of muscles, sound, and motion. Chemoreceptors, located in the nose and taste buds, are sensitive to chemicals in the external environment. Photoreceptors, found in the eyes, are sensitive to light. **Figure 35–13** shows the type of photoreceptor that distinguishes the color of objects.

Vision

The world around us is bathed in light. The sense organs that we use to sense light are the eyes. The structures of the eye are shown in **Figure 35–14.** Light enters the eye through the cornea, a tough transparent layer of cells. The cornea helps to focus the light, which then passes through a small chamber called the anterior chamber. This chamber is filled with a fluid called aqueous (AY-kwee-uhs) humor. At the back of the chamber is a disklike structure called the iris. The iris is the colored part of the eye. In the middle of the iris is a small opening called the **pupil.** Tiny muscles in the iris adjust the size of the pupil to regulate the amount of light that enters the eye. In dim light, the pupil becomes larger so that more light can enter the eye. In bright light, the pupil becomes smaller so that less light enters the eye.



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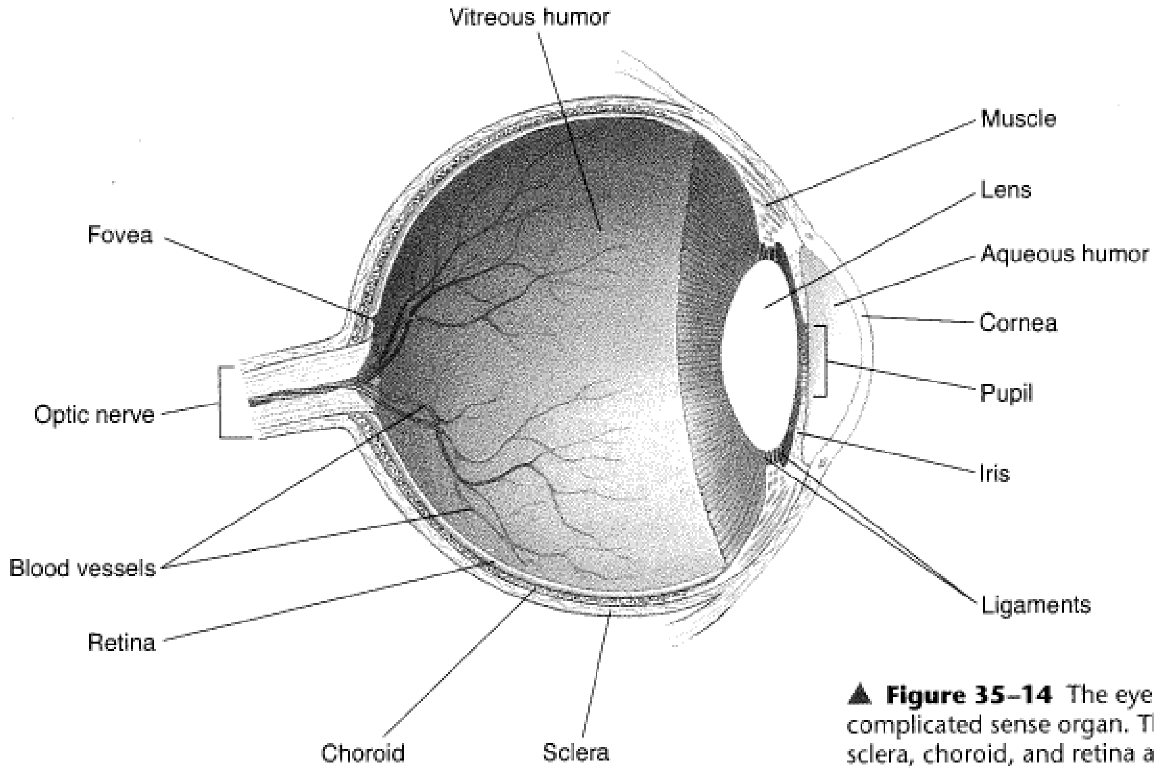
◀ **Figure 35–13** **There are two types of light-sensitive photoreceptor cells in the retina—rods and cones.** This color-enhanced scanning electron micrograph shows the rod cells of an eye.



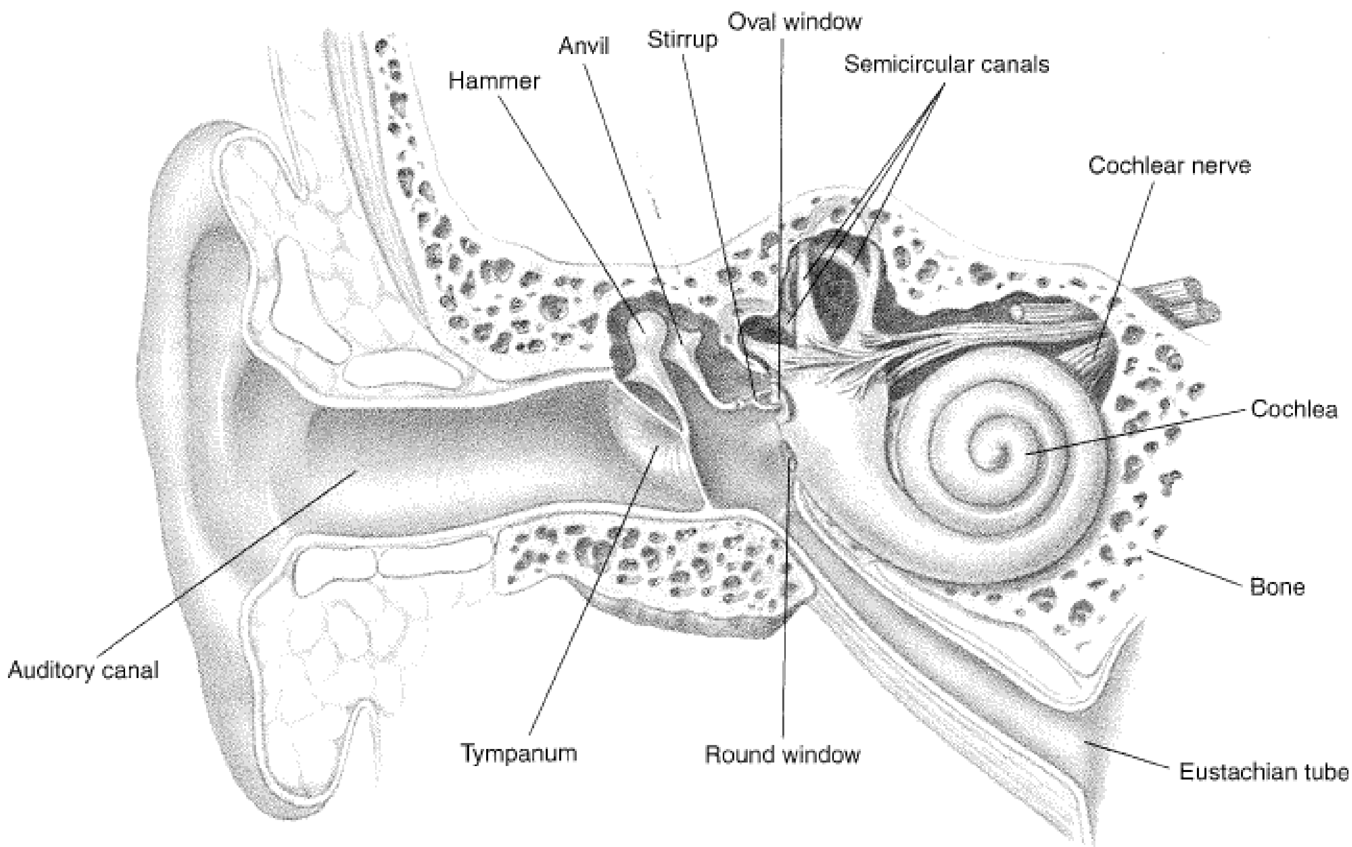
▲ **Figure 35–14** The eye is a complicated sense organ. The sclera, choroid, and retina are three layers of tissue that form the inner wall of the eyeball. **Inferring** ***Why do you think the area in the retina that contains no rods or cones is called the blind spot?***

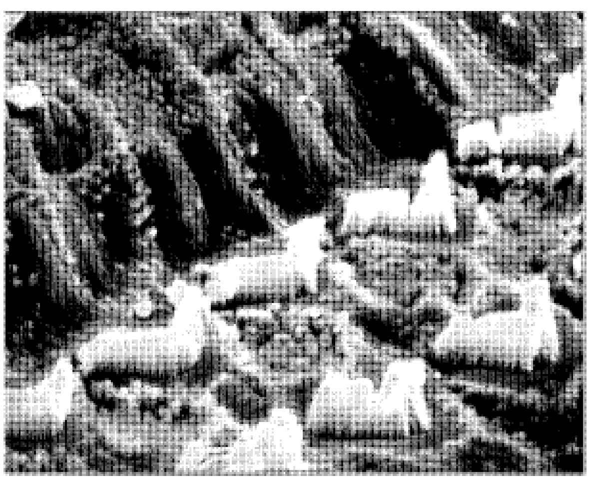
Just behind the iris is the **lens.** Small muscles attached to the lens change its shape to help you adjust your eyes' focus to see near or distant objects. Behind the lens is a large chamber filled with a transparent, jellylike fluid called vitreous (VIH-tree-uhs) humor.

The lens focuses light onto the **retina.** Photoreceptors are arranged in a layer in the retina. The photoreceptors convert light into nerve impulses that are carried to the central nervous system. There are two types of photoreceptors: rods and cones. **Rods** are extremely sensitive to light, but they do not distinguish different colors. **Cones** are less sensitive than rods, but they do respond to light of different colors, producing color vision. Cones are concentrated in the fovea. The fovea is the site of sharpest vision.

The impulses assembled by this complicated layer of interconnected cells leave each eye by way of an optic nerve. The optic nerves then carry the impulses to the appropriate regions of the brain. The brain interprets them as visual images and provides information about the external world.

✓CHECKPOINT *Where are the photoreceptors located in the eye?*





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▲ **Figure 35–15** The diagram shows structures in the ear that transmit sounds. The scanning electron micrograph shows hair cells (yellow) in the inner ear. The motion of these hairs produces a nerve impulse that travels to the brain through the cochlear nerve. **Predicting** ***How would frequent exposure to loud noise affect a person's threshold for detecting sound?***

Hearing and Balance

The human ear has two sensory functions. One of these functions is hearing. The other function is maintaining balance.

Hearing Sound is nothing more than vibrations in the air around us. The ears are the sensory organs that can distinguish both the pitch and loudness of those vibrations. The structure of the ear is shown in **Figure 35–15.**

Vibrations enter the ear through the auditory canal. The vibrations cause the tympanum (TIM-puh-num), or eardrum, to vibrate. These vibrations are picked up by three tiny bones, commonly called the hammer, anvil, and stirrup. The last of these bones, the stirrup, transmits the vibrations to the oval window. Vibrations of the oval window create pressure waves in the fluid-filled **cochlea** (KAHK-lee-uh) of the inner ear.

The cochlea is lined with tiny hair cells that are pushed back and forth by these pressure waves. In response to these movements, the hair cells produce nerve impulses that are sent to the brain through the cochlear nerve.

Balance Your ears contain structures that help your central nervous system maintain your balance, or equilibrium. Within the inner ear just above the cochlea are three tiny canals at right angles to each other. They are called **semicircular canals** because each forms a half circle. The semicircular canals and the two tiny sacs located behind them monitor the position of your body, especially your head, in relation to gravity.

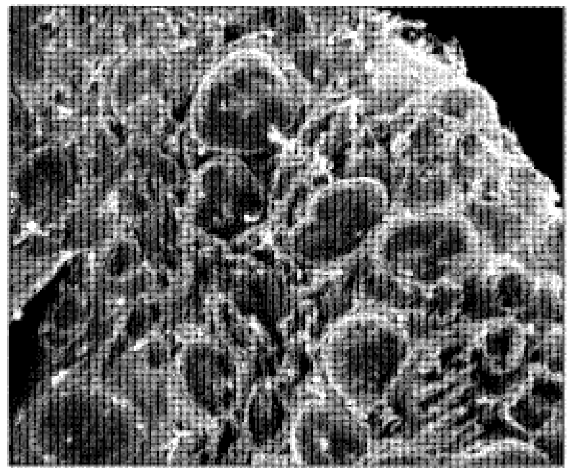
The semicircular canals and the sacs are filled with fluid and lined with hair cells. As the head changes position, the fluid in the canals also changes position. This causes the hair on the hair cells to bend. This action, in turn, sends impulses to the brain that enable it to determine body motion and position.

Smell and Taste

You may never have thought of it this way, but your sense of smell is actually an ability to detect chemicals. Chemoreceptors in the lining of the nasal passageway respond to specific chemicals and send impulses to the brain through sensory nerves.

Your sense of smell is capable of producing thousands of different sensations. In fact, much of what we commonly call the "taste" of food and drink is actually smell. To prove this to yourself, eat a few bites of food while holding your nose. You'll discover that much of the taste of food disappears until you open your nose and breathe freely.

Like the sense of smell, the sense of taste is a chemical sense. The sense organs that detect taste are the **taste buds.** Most of the taste buds are on the tongue, but a few are found at other locations in the mouth. The surface of the tongue is shown in **Figure 35–16.** The tastes detected by the taste buds are classified as salty, bitter, sweet, and sour. Sensitivity to these different categories varies on different parts of the tongue.



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▲ **Figure 35–16** This color-enhanced scanning electron microgram shows the surface of the tongue. The large pink objects are the taste buds. **Chemoreceptors found in the taste buds are sensitive to chemicals in food.**

Touch and Related Senses

The sense of touch, unlike the other senses you have just read about, is not found in one particular place. All of the regions of the skin are sensitive to touch. In this respect, your largest sense organ is your skin. Skin contains sensory receptors that respond to temperature, touch, and pain. Not all parts of the body are equally sensitive to touch, because not all parts have the same number of receptors. The greatest density of touch receptors is found on your fingers, toes, and face.

35–4 Section Assessment

1. **Key Concept** Name the five types of sensory receptors and list where they are found in the body.
2. Identify the parts of the eye and the function of each part.
3. What parts of the ear are responsible for hearing? For balance?
4. Explain why you can't "taste" food when you have a bad cold.
5. **Critical Thinking Applying Concepts** Why do you feel dizzy after spinning around? How can a dancer or ice skater do lengthy spins?

iTEXT Assessment Use iText to review the important concepts in Section 35–4.

ALTERNATIVE ASSESSMENT

Creative Writing
Imagine that you have to do without one of your sense organs for one day. Which one would you choose to give up? In your journal describe how the absence of this sense organ would affect your life.

35–5 Drugs and the Nervous System

Guide for Reading

Key Concepts

- What are the different classes of drugs that directly affect the central nervous system?
- What is the effect of alcohol on the body?

Vocabulary

drug
stimulant
depressant
addiction
fetal alcohol syndrome
drug abuse

Reading Strategy: Using Graphic Organizers

As you read, create a table that lists each of the drugs in this section and the effects that each drug has on the body.

By definition, a **drug** is any substance, other than food, that changes the structure or function of the body. Some drugs, such as cocaine and heroin, are so powerful and dangerous that their possession is illegal. Other drugs, including penicillin and codeine, are prescription drugs and can be used only under the supervision of a doctor. Still other drugs, including cough and cold medicines, are sold over the counter. All drugs, both legal and illegal, have the potential to do harm if they are used improperly or abused.

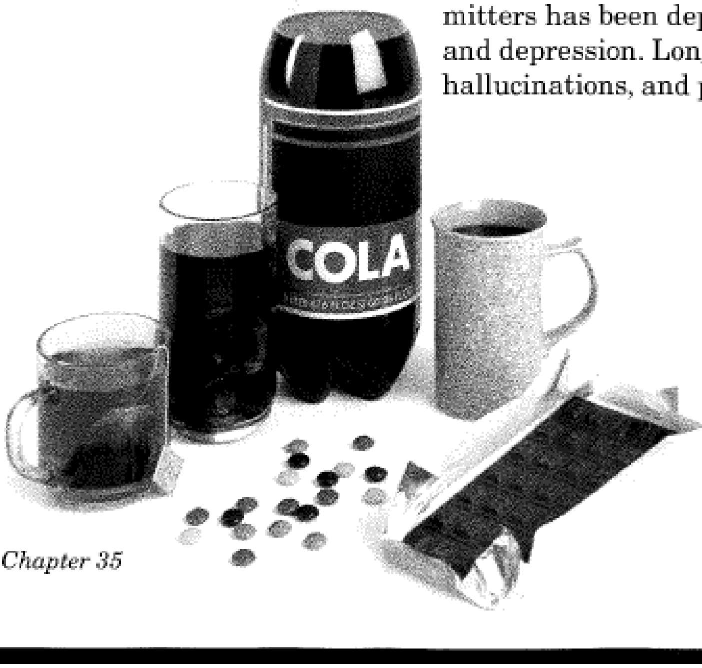
Drugs differ in the ways in which they affect the body. Some drugs kill bacteria and are useful in treating disease. Other drugs affect a particular system of the body, such as the digestive or circulatory systems. Among the most powerful drugs, however, are the ones that cause changes in the nervous system, especially to the brain and the synapses between neurons.

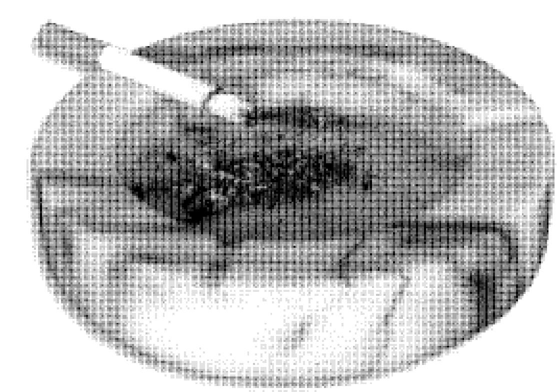
Drugs That Affect the Synapse

The nervous system performs its regulatory functions through the transmission of information along pathways from one part of the body to another. Synapses are key relay stations along the way. The nervous system depends on neurotransmitters to bridge the gap between neurons or between a neuron and an effector. A drug that interferes with the action of neurotransmitters can disrupt the functioning of the nervous system.

Stimulants A number of drugs, called **stimulants,** increase the actions regulated by the nervous system. **Stimulants increase heart rate, blood pressure, and breathing rate. In addition, stimulants increase the release of neurotransmitters at some synapses in the brain.** This release leads to a feeling of energy and well-being. When the effects of stimulants wear off, however, the brain's supply of neurotransmitters has been depleted. The user quickly falls into fatigue and depression. Long-term use can cause circulatory problems, hallucinations, and psychological depression.

Figure 35–17 Common stimulant drugs include amphetamines, cocaine, nicotine (found in cigarettes), and caffeine (found in coffee, tea, chocolate, and cola products). **Stimulants increase heart rate, blood pressure, and breathing rate.**





Depressants Some drugs, called **depressants,** decrease the rate of functions regulated by the brain. **Depressants slow down heart rate and breathing rate, lower blood pressure, relax muscles, and relieve tension.** Some depressants enhance the effects of neurotransmitters that prevent some nerve cells from starting action potentials. This calms parts of the brain that sense fear and relaxes the individual. As a result, the user comes to depend on the drug to relieve the anxieties of everyday life, which may seem unbearable without the drug. When depressants are used in combination with alcohol, the results are often fatal because the central nervous system can become so depressed that breathing stops.

CHECKPOINT *What is the general function of a depressant?*

Cocaine Even stronger effects are produced by drugs that act on neurons in what are known as the pleasure centers of the brain. The effects of cocaine and opiate drugs are so strong that they produce **addiction**—an uncontrollable craving for more of the drug. Cocaine is obtained from the leaves of coca plants like the one shown in **Figure 35–18. Cocaine causes the sudden release in the brain of a neurotransmitter called dopamine.** Normally, this compound is released when a basic need, such as hunger or thirst, is fulfilled. By fooling the brain into releasing dopamine, cocaine produces intense feelings of pleasure and satisfaction. So much dopamine is released when the drug is used that the supply of dopamine is depleted when the drug wears off. Users quickly discover that they feel sad and depressed without the drug. The psychological dependence that cocaine produces is difficult to break.

Cocaine also acts as a powerful stimulant, increasing heart rate and blood pressure. The stimulation can be so powerful that the heart is damaged. Sometimes, even a first-time user may experience a heart attack after using cocaine.

Crack is a particularly potent and dangerous form of cocaine. Crack becomes addictive after only a few doses. The intense "high" produced by crack wears off quickly and leaves the brain with too little dopamine. As a result, the user suddenly feels sad and depressed, and quickly seeks another dose of the drug. In time, the urge to seek this drug can be so strong that it leads users to commit serious crimes and to abandon their families and children.

Opiates The opium poppy produces a powerful class of pain-killing drugs called opiates. **Opiates mimic natural chemicals in the brain known as endorphins, which normally help to overcome sensations of pain.** The first doses of these drugs produce strong feelings of pleasure and security, but the body quickly adjusts to the higher levels of endorphins. Once this happens, the body cannot do without the drug. A user who tries to stop taking these drugs will suffer from uncontrollable pain and sickness because the body cannot produce enough of the natural endorphins.

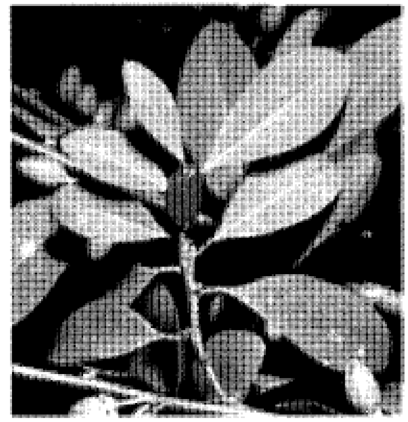


Figure 35–18 Many illegal drugs are found in nature. Cocaine comes from the South American *Erythroxylum coca* plant (top). The centers of opium poppies (below) contain pods from which opiate drugs are derived. **Opiates mimic endorphins, which help overcome pain.** For this reason, opiates are often used medically as painkillers.

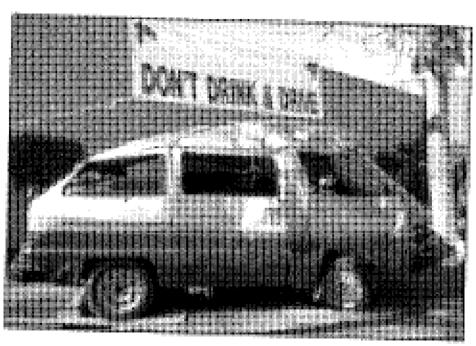
Commonly Abused Drugs			
Drug Type	**Medical Use**	**Examples**	**Effects on the Body**
Stimulants	Used to increase alertness, relieve fatigue	Amphetamines	Increases heart and respiratory rates, elevates blood pressure, dilates pupils, and decreases appetite
Depressants	Used to relieve anxiety, irritability, tension	Barbiturates Tranquilizers	Slows down the actions of the central nervous system; small amounts cause calmness and relaxation; larger amounts cause slurred speech and impaired judgment
Opiates	Used to relieve pain	Morphine Codeine	Acts as a depressant; causes drowsiness, restlessness, nausea

▲ **Figure 35–19** Many abused drugs are legal and used for medical purposes. **Applying Concepts** ***Do you think a person can become addicted to a legal drug?***

Because many users inject drugs for maximum effect, there is another important consequence of drug use—the increased transmission of the HIV virus that causes AIDS. The virus can be spread rapidly from person to person when drug users share contaminated needles. Many of the new AIDS cases reported in the United States can be traced back to the use of injected drugs.

Marijuana Statistically, the most widely abused illegal drug is marijuana. Marijuana comes from *Cannabis sativa,* a species of hemp plant. Marijuana is commonly called grass or pot. Hashish, or hash, is a potent form of marijuana made from the flowering parts of the plant. The active ingredient in all forms of marijuana is tetrahydrocannabinol (THC). Smoking or ingesting THC can produce a temporary feeling of euphoria and disorientation. Smoking marijuana is bad for the lungs. In fact, smoking marijuana is even more destructive to the lungs than smoking tobacco. Long-term use of marijuana can also result in loss of memory, inability to concentrate, and reduced levels of the hormone testosterone in males.

CHECKPOINT *What are the long-term effects of marijuana use?*



▲ **Figure 35–20** **Alcohol is a depressant that slows down the rate at which the nervous system functions.** It slows down reflexes, disrupts coordination, and impairs judgment. For this reason, you should never get into a car with a driver who has been drinking.

Alcohol One of the most dangerous and abused depressant drugs is alcohol. The most immediate effects of alcohol are on the central nervous system. **Alcohol is a depressant, and even small amounts of alcohol slow down the rate at which the central nervous system functions.** Alcohol slows down reflexes, disrupts coordination, and impairs judgment. Heavy drinking fills the blood with so much alcohol that the central nervous system cannot function properly. People who have two or three drinks in the span of an hour may feel relaxed and confident, but their blood contains as much as 0.10 percent alcohol, making them legally drunk in most states. They usually cannot walk or talk properly, and they are certainly not able to safely control an automobile, as shown in **Figure 35–20.**

Alcohol is the drug most commonly abused by teenagers. The abuse of alcohol has a frightening social price. About 40 percent of the 50,000 people who die on American highways in a typical year are victims of accidents in which at least one driver had been drinking. One third of all homicides can be attributed to the effects of alcohol. When health care, property damage, and lost productivity are considered, alcohol abuse costs the U.S. economy at least $150 billion per year.

But the toll of alcohol abuse does not stop there! Women who are pregnant and drink on a regular basis run the risk of having a child with fetal alcohol syndrome. **Fetal alcohol syndrome** (FAS) is a group of birth defects caused by the effects of alcohol on the fetus. Babies born with FAS can suffer from heart defects, malformed faces, delayed growth, and poor motor development. More than 50,000 babies are born in this country every year with alcohol-related birth defects, many of which are irreversible.

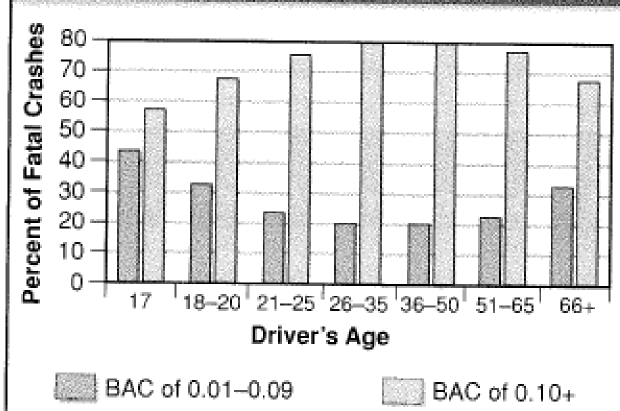
Alcohol and Disease People who have become addicted to alcohol suffer from a disease called alcoholism. Some alcoholics feel the need to have a drink before work or school—every day! They may drink so heavily that they black out and cannot remember what they have done while drinking. Some alcoholics, however, do not drink to the point where it is obvious that they have an alcohol-abuse problem. If a person cannot function properly without satisfying the need or craving for alcohol, that person is considered to have an alcohol-abuse problem.

Analyzing Data

Blood Alcohol Concentration

Blood alcohol concentration (BAC) is a measure of the amount of alcohol in the bloodstream per 100 mL of blood. A BAC of 0.1 percent means that one tenth of 1.0 percent of the fluid in the blood is alcohol. In some states, if a driver has a BAC of 0.08 percent, he or she is considered legally drunk. In other states, drivers with a BAC of 0.10 percent are considered drunk. The graph shows the relative risk of being involved in a fatal accident as a result of the blood alcohol concentration of the driver.

BAC for Drivers Involved in Fatal Crashes, by Age, 1992–1995



1. **Interpreting Data** What trends do you see in the number of fatal crashes from age 17 to age 66+ based on the two ranges of BAC?
2. **Interpreting Data** How does the consumption of alcohol affect driving risk for the average driver?
3. **Drawing Conclusions** Is the effect of alcohol consumption on driving independent of the age of the driver? Are young drivers more affected by alcohol or less affected by it than older drivers?
4. **Making Judgments** All levels of alcohol consumption affect driving skills, although the effect increases dramatically as more drinks are consumed. To minimize accidents and fatalities due to drunk driving, what should be the legal limit of blood alcohol for drivers?

Long-term alcohol use also destroys cells in the liver, where alcohol is broken down. As liver cells die, the liver becomes less able to handle large amounts of alcohol. The formation of scar tissue, known as cirrhosis of the liver, occurs next. The scar tissue blocks the flow of blood through the liver and interferes with its other important functions. Eventually, a heavy drinker may die from liver failure.

As with other drugs, dealing with alcohol abuse is not simply a matter of willpower. Alcoholics often need special help and support to quit their drinking habit. Organizations such as Alcoholics Anonymous are available in most communities to help individuals and families deal with the problems created by alcohol abuse.

Drug Abuse

Each of the drugs discussed so far presents a danger to users. The misuse of either a legal or an illegal drug is a serious problem in modern society. **Drug abuse** can be defined as using any drug in a way that most doctors could not approve. With some drugs, such as cocaine, drug abuse causes serious physical damage to the body. With other drugs, such as marijuana, drug abuse produces psychological dependence that can be strong enough to disrupt family life and schoolwork.

An uncontrollable dependence on a drug is known as a drug addiction. Some drugs cause a strong psychological dependence. People who are psychologically dependent on a drug have a mental craving, or need, for the drug. Other drugs cause a strong physical dependence. Physical dependence occurs when the body cannot function without a constant supply of the drug.

The best way to avoid the effects of drugs is to avoid drugs. The decision not to use drugs can be difficult when you are faced with pressure to take them. By deciding not to take drugs, you are acting to take control of your life.

35–5 Section Assessment

1. **Key Concept** Describe the effects of stimulants, cocaine, depressants, and opiates on the central nervous system.
2. **Key Concept** Explain the effects of alcohol on the body.
3. What is a drug?
4. Based on alcohol's effects on the central nervous system, why is drinking and driving an extremely dangerous behavior?
5. **Critical Thinking Inferring** Which do you think is a more difficult addiction to break: one in which a person is physically dependent on a drug, or one in which a person is psychologically dependent on a drug? Explain your answer.

iTEXT Assessment Use iText to review the important concepts in Section 35–5.

Take It to the NET

Read about the effects of different drugs. Then, create a chart listing five different drugs and their short-term and long-term effects on the body. Use the links provided in the Biology area at the Prentice Hall Web site for help in completing this activity: **www.phschool.com**

Correcting Vision With Lenses

The lenses of your eyes focus light on the retina. The lenses of people who are nearsighted focus images in front of the retina, making distant objects appear blurry. The lenses of people who are farsighted focus behind the retina, making nearby objects difficult to see. To see more clearly, these people wear glasses or contact lenses. The shapes of these artificial lenses depend on the type of correction needed.

Problem **What types of corrective lenses are needed by nearsighted individuals and by farsighted individuals?**

Materials

- tape
- 2 cardboard photo easels
- black construction paper
- unruled white index card
- 6-V light bulb and socket
- 6-V battery and wires with alligator clips
- 2 convex lenses
- modeling clay
- meter stick
- concave lens

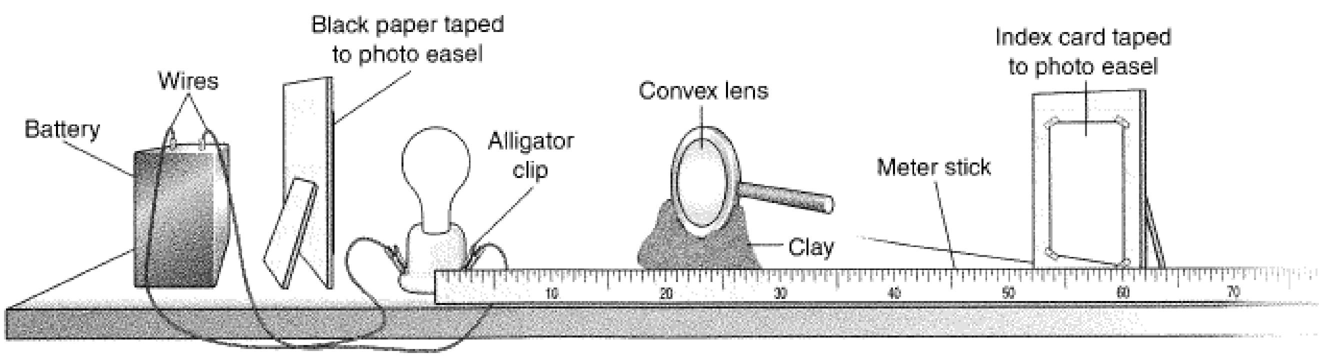
Skills Analyzing Data, Using Models

Procedure

1. Set up your equipment as shown. Place the white index card about 50 to 60 cm in front of the bulb.
2. Place a convex lens in front of the bulb and move the lens until an image of the bulb focuses clearly on the index card. Secure the lens in this position with modeling clay or tape. The distance between the fixed lens and the index card is the focal length of the lens.
3. Move the index card about 5 to 8 cm away from the fixed lens to simulate the formation of an image in front of the retina. Observe the image and record your observations.
4. Hold the concave lens between the light bulb and the fixed lens. Try to focus the image by moving the concave lens between the light bulb and the fixed lens.
5. Repeat step 4, but this time use the second convex lens. Record your observations.
6. Move the index card about 10 to 16 cm closer to the fixed lens to simulate image formation behind the retina. Record your observations.
7. Repeat steps 4 and 5.

Analyze and Conclude

1. **Drawing Conclusions** Does the lens in your eye focus an image right side up or upside down on your retina? Why does an image appear right side up when you look at objects?
2. **Drawing Conclusions** Which lens sharpened the image that formed in front of the retina? Behind the retina?
3. **Using Models** Which condition—long-focal length or short-focal length—do you think models the problem of nearsightedness? Which condition models farsightedness? Explain your answers.



Chapter 35 Study Guide

35–1 Human Body Systems

Key Concepts

- The eleven organ systems of the human body work together to maintain homeostasis.

Vocabulary

muscle tissue, p. 894
epithelial tissue, p. 894
connective tissue, p. 894
nervous tissue, p. 894
feedback inhibition, p. 895

35–2 The Nervous System

Key Concepts

- The nervous system controls and coordinates functions throughout the body and responds to internal and external stimuli.
- A nerve impulse begins when a neuron is stimulated by another neuron or by its environment.

Vocabulary

neuron, p. 897 • cell body, p. 897
dendrite, p. 898 • axon, p. 898
myelin sheath, p. 898 • resting potential, p. 898
action potential, p. 899 • threshold, p. 899
synapse, p. 900 • neurotransmitter, p. 900

35–3 Divisions of the Nervous System

Key Concepts

- The central nervous system relays messages, processes information, and analyzes information.
- The sensory division of the peripheral nervous system transmits impulses from sense organs to the central nervous system. The motor division transmits impulses from the central nervous system to the muscles or glands.

Vocabulary

central nervous system, p. 901
meninges, p. 901 • cerebrospinal fluid, p. 901
cerebrum, p. 902 • cerebellum, p. 902
brain stem, p. 902 • thalamus, p. 903
hypothalamus, p. 903 • reflex, p. 903

35–4 The Senses

Key Concept

- There are five general categories of sensory receptors: pain receptors, thermoreceptors, mechanoreceptors, chemoreceptors, and photoreceptors.

Vocabulary

sensory receptor, p. 906 • pupil, p. 906
lens, p. 907 • retina, p. 907 • rod, p. 907
cone, p. 907 • cochlea, p. 908
semicircular canal, p. 908 • taste bud, p. 909

35–5 Drugs and the Nervous System

Key Concepts

- Stimulants increase heart rate, blood pressure, and breathing rate. In addition, stimulants increase the release of neurotransmitters at some synapses in the brain.
- Depressants slow down heart rate and breathing rate, lower blood pressure, relax muscles, and relieve tension.
- Cocaine causes the sudden release of a neurotransmitter in the brain called dopamine.
- Opiates mimic natural chemicals in the brain known as endorphins, which normally help to overcome sensations of pain.
- Alcohol is a depressant, and even small amounts of alcohol slow down the rate at which the nervous system functions.

Vocabulary

drug, p. 910 • stimulant, p. 910
depressant, p. 911 • addiction, p. 911
fetal alcohol syndrome, p. 913
drug abuse, p. 914

Thinking Visually

Develop a graphic organizer to show the relationship between the different divisions of the nervous system.

Preparing for the Living Environment Exam

Chapter 35

Part A

Multiple Choice

For each statement or question, select the number of the word or expression that, of those given, best completes the statement or answers the question.

1 The type of tissue that covers the body, lines internal surfaces, and forms glands is
(1) muscle tissue
(2) connective tissue
(3) epithelial tissue
(4) nervous tissue

2 The process of maintaining a relatively constant internal environment despite changes in the external environment is called
(1) regulation (3) homeostasis
(2) synapse (4) stimulation

3 The basic units of structure and function of the nervous system are
(1) neurons
(2) axons
(3) neurotransmitters
(4) dendrites

4 The place where a nerve cell transfers an impulse to another cell is the
(1) synapse (3) axon
(2) sheath (4) receptor

5 Two organs are considered to be part of the same body system if the organs
(1) are located next to each other
(2) work independently of each other
(3) work together to carry out a life function
(4) are made up of cells with organelles

6 A hawk sees a field mouse and then captures it for food. In this activity, the eyes of the hawk function as
(1) dendrites
(2) receptors
(3) stimuli
(4) neurotransmitters

7 Which term is correctly paired with examples of that term?
(1) receptors: leg muscles and testes
(2) stimuli: temperature and light
(3) impulses: skin and eyes
(4) depressants: neurotransmitters and hormones

8 The central nervous system consists of
(1) sense organs
(2) reflexes
(3) brain and spinal cord
(4) sensory and motor neurons

9 Which division of the nervous system controls voluntary activities, such as walking the dog or singing a song?
(1) somatic (3) autonomic
(2) central (4) reflex

10 Which part of the brain controls conscious thought?
(1) medulla oblongata
(2) cerebellum
(3) cerebrum
(4) brain stem

11 The sympathetic nervous system and the parasympathetic nervous system are divisions of the
(1) peripheral nervous system
(2) central nervous system
(3) somatic nervous system
(4) autonomic nervous system

12 The semicircular canals and the two tiny sacs located behind them help the body to maintain
(1) vision
(2) respiratory rate
(3) equilibrium
(4) body temperature

13 The division of the nervous system that controls cardiac muscle is the
(1) autonomic
(2) somatic
(3) cerebellum
(4) hypothalamus

14 Drugs that increase heart rate, blood pressure, and breathing rate are called
(1) stimulants (3) depressants
(2) opiates (4) barbiturates

Test-Taking Tip Questions that begin with a list of lettered choices (A–E) followed by numbered statements are essentially multiple-choice questions. To solve these questions, use the same process that you use to solve standard multiple-choice questions.

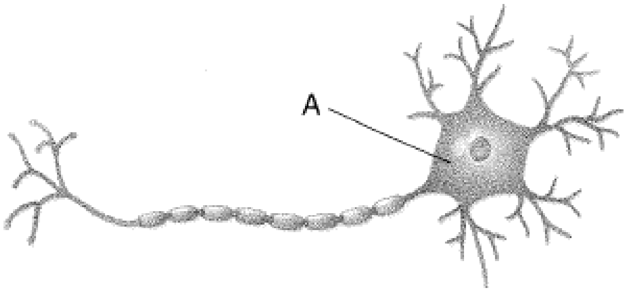
Preparing for the Living Environment Exam

Parts B and C

Multiple Choice and Extended Response

For those questions that ask you to select a response, choose the one that best completes the statement or answers the question. For all others follow the directions given.

Base your answers to questions 15 and 16 on the diagram below and on your knowledge of biology.

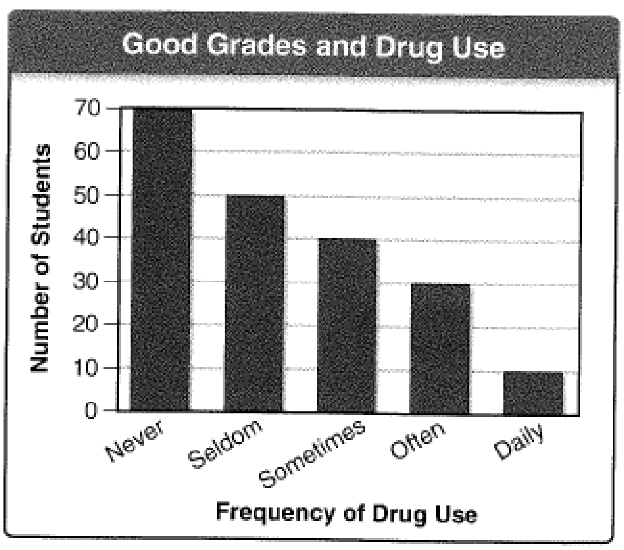


15 Letter A is pointing to the
(1) myelin sheath (3) axon
(2) dendrite (4) cell body

16 Copy the diagram on a sheet of paper. Then, circle the part of the cell that secretes a neurotransmitter.

Base your answers to questions 17 through 19 on the information and graph below and on your knowledge of biology.

A student surveyed 200 students who each had an overall grade point average of A or B. The results of the survey are summarized in the graph.



17 What is the manipulated (independent) variable in the study?
(1) good grades
(2) student age
(3) popularity at school
(4) frequency of drug use

18 What percentage of students with good grades say they never use drugs?
(1) 10% (3) 50%
(2) 30% (4) 70%

19 The student conducting the survey concluded that students with good grades use drugs less frequently than students with poor grades. Why might this conclusion not be valid?
(1) There are no data on students with poor grades.
(2) Students with good grades use drugs 70 percent of the time.
(3) The researcher did not survey enough students.
(4) Only students in one school were surveyed.

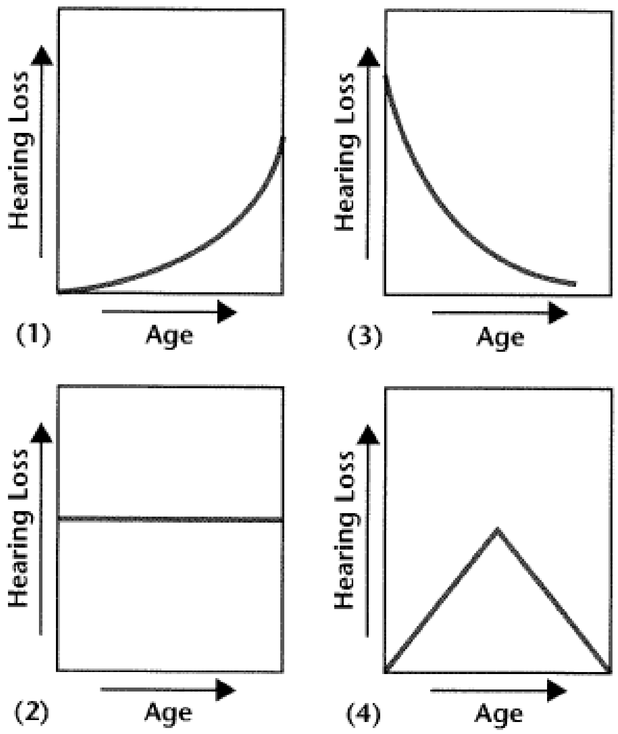
Base your answers to questions 20 through 23 on the reading passage below and on your knowledge of biology.

What Did You Say?

There are three types of hearing loss: conductive, sensorineural, and mixed. In conductive hearing loss, problems in the outer or middle ear block the transmission of vibrations to the inner ear. Conductive hearing loss can result from ear infections, excessive earwax, fluid in the middle ear, or a perforated eardrum. Sensorineural hearing loss, or "nerve deafness," is most often due to changes with aging or to long-term exposure to loud noises. For example, over a 6-year period a rock band player developed a 40 percent hearing loss because he did not use ear protection during performances. The use of personal listening devices, such as headphones, can also cause sensorineural hearing loss, as can high fevers, birth defects, and certain drugs. Mixed hearing loss is a combination of both other types.

Tests to determine the cause and extent of hearing loss include: tympanometry, which examines the middle ear, eardrum, and possible blockage of the ear canal; pure-tone and speech reception testing, which determines the lowest level at which tones and speech can be heard; and word discrimination testing, which measures the ability to distinguish words at a comfortable volume.

20 Which of the graphs below best represents a common relationship between age and nerve deafness?



21 A prolonged body temperature of 105°F (40.4°C) may result in
(1) an inner ear infection
(2) conductive hearing loss
(3) sensorineural hearing loss
(4) a perforated eardrum

22 Which test is used to determine the presence of excessive wax in the ear canal?
(1) sensorineural assessment
(2) word discrimination testing
(3) pure-tone and speech reception testing
(4) tympanometry

23 Explain how a personal listening device can be controlled to decrease the risk of hearing damage.

24 Arrange the following terms in order from simplest to most complex: organ system, tissue, organ, organism, cell.

25 Explain why depressant drugs and alcohol are a life-threatening combination.

26 Explain why it is important for an organism to be able to maintain homeostasis.

27 Describe the changes that occur in a neuron as it carries out its normal functions. In your answer be sure to
- explain the changes that occur during action potential
- explain the changes that occur during resting potential
- discuss the ions involved
- discuss the role of the cell membrane

28 Explain how the all-or-none principle relates to the transmission of a nerve impulse.

29 Describe how the central nervous system is protected from injury.

30 Describe the advantage of a reflex response in the survival of an organism.

31 Describe the functions of rods and cones in the human eye.

32 Explain why a pregnant woman should avoid drinking alcohol.

33 A routine examination by a doctor usually includes a knee-jerk test. What might the absence of a response to this test indicate?

34 Multiple sclerosis (MS) is a disease characterized by the patchy destruction of myelin. Based on your knowledge of neuron structure and the function of various cell parts, predict the symptoms this destruction of myelin might produce.

Take It to the NET

You can visit the Prentice Hall Web site at **www.phschool.com** to explore the many facts and figures about the human nervous system. Then, answer the following questions:
- How many synapses does a typical neuron have?
- What is the average weight of the human brain? Which species have average brain weights greater than the average weight of the human brain?
- How many taste buds does a typical human have? How many of these are on the tongue?
- Compare the number of olfactory (smell) receptors in a human with the number found in a dog.