

section ● The Nervous System

● Before You Read

Do you remember the last time you touched something very hot by mistake? How did you react?

What You'll Learn

- the basic structure of a neuron
- how an impulse moves across a synapse
- differences between central and peripheral nervous systems
- how drugs affect the body

● Read to Learn

How the Nervous System Works

What happens when you hear a sudden, loud noise? Your heart may begin to race and your hands may shake. Once the surprise passes, your breathing returns to normal and your heartbeat is back to its regular rate. The way you react to a sudden, unexpected sound or event is one example of how your body responds to changes in your environment.

What are stimuli?

Any change that brings about a response is called a stimulus (STIHM yuh lus) (plural, *stimuli*). You respond to thousands of stimuli every day. Noise and light are examples of stimuli from outside your body. Hormones are stimuli from inside your body. Your nervous system helps your body adjust to changing stimuli.

What is homeostasis?

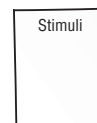
Your body has control systems that handle stimuli. The control systems help keep steady internal conditions. The changing of conditions inside an organism to keep it alive, even though the environment changes, is called homeostasis (hoh mee oh STAY sus). Your nervous system is one of the control systems that your body uses to maintain homeostasis.

Mark the Text

Define Words Skim the section before you read it. Circle any words you do not know. As you read the text, underline the words that help you identify the meaning of the words you circled.

FOLDABLES™

● **Organize** Make a quarter sheet Foldable, as shown below, to organize information about stimuli.

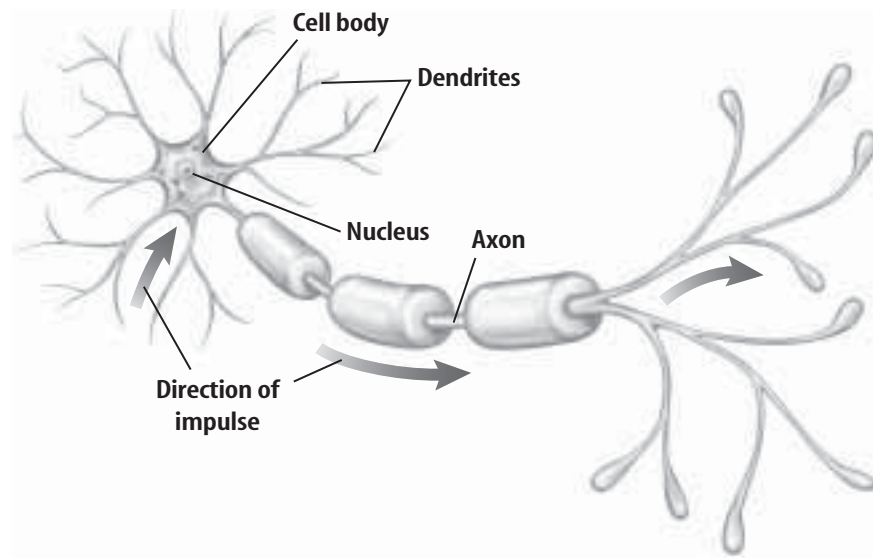


Nerve Cells

The basic units of the nervous system are nerve cells, or **neurons** (NOOR ahnz). The neuron shown in the figure below is made up of a cell body and branches called dendrites and axons. Any message carried by a neuron is called an impulse. **Dendrites** receive impulses from other neurons and send them to the cell body. **Axons** (AK sahns) carry impulses away from the cell body and send them to other neurons. Notice the branching at the end of the axon. This allows impulses to move to many other muscles, neurons, or glands.

Picture This

- 1. Identify** In the figure, two dendrites and one axon are labeled. Add labels to identify two more dendrites and one more axon.

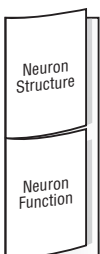


What are the types of nerve cells?

Your body can detect changes in the environment. Sensory receptors detect such things as temperature, sound, pressure, and light. Sensory receptors respond to stimuli by producing electrical impulses that are carried to the brain. Three types of neurons—sensory neurons, motor neurons, and interneurons—carry impulses. Sensory neurons receive information and send impulses to the brain or spinal cord. For example, when you hear a loud noise, sensory receptors in your ears are stimulated. These sensory neurons produce electrical impulses that travel to the brain. In the brain or spinal cord, interneurons send the impulses to motor neurons. The motor neurons move impulses from the brain or spinal cord to muscles or glands throughout your body. In the example of a loud noise, muscles in your arms contract to jerk your arms in response to the noise.

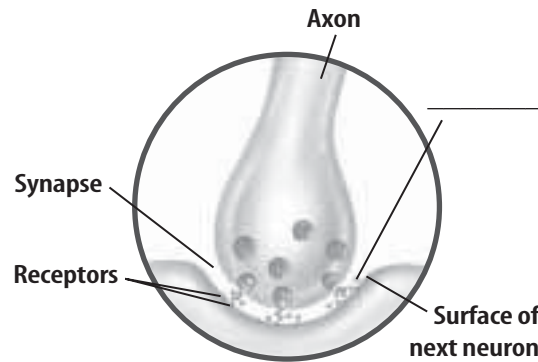
FOLDABLES™

- Describe** Make a two-tab Foldable, as shown below, to list the three types of neurons and their functions.



What is a synapse?

Neurons do not touch each other. Neurons are separated by a small space called a **synapse** (SIH naps), as shown in the figure below. To move from one neuron to another, the impulse must cross the synapse. When an impulse reaches the end of an axon, the axon releases a chemical. The chemical flows across the synapse and stimulates an impulse in the dendrite of the next neuron. Neurons allow impulses to move in only one direction.



Picture This

2. **Draw** an arrow to show the direction that chemicals flow across the synapse.

The Central Nervous System

The **central nervous system** (CNS) is made up of the brain and spinal cord. The **peripheral (puh RIH fuh rul) nervous system** (PNS) is made up of all the nerves that are not part of the CNS. The PNS includes the nerves in the head, called cranial nerves. The PNS also includes the spinal nerves, which come from the spinal cord. The PNS connects the brain and spinal cord to other body parts.

What does the brain do?

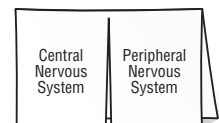
The brain directs all the activities of the body. If someone tickles your feet, your brain directs your reaction. The brain is made up of about 100 billion neurons. That is about ten percent of all the neurons in the human body. The brain is surrounded and protected by a bony skull, three membranes, and a layer of fluid. The brain is divided into three parts: the brain stem, the cerebellum (ser uh BE lum), and the cerebrum (suh REE brum).

What is the role of the cerebrum?

The largest part of the brain is the **cerebrum**. This is where thinking takes place. The cerebrum interprets the meaning of impulses that come from sensory neurons. The cerebrum also stores memory and controls movements. The outer layer of the cerebrum is the cortex. The cortex has many ridges and grooves that increase its surface area. The greater surface area allows more complex thoughts to be processed.



- **Describe** Make a half book Foldable, like the one shown below, to list things that affect the central and peripheral nervous systems.



Reading Check

3. **Explain** What are the three parts of the brain stem?

Think it Over

4. **Explain** What part of the peripheral nervous system controls blood pressure?

What does the cerebellum do?

The cerebellum is the part of the brain that interprets stimuli from the eyes and ears and from muscles and tendons. Tendons are tissues that connect muscles to bones. The information received by the cerebellum helps it coordinate voluntary muscle movements, maintain muscle tone, and maintain balance. For example, the cerebellum coordinates muscle movements to help you balance while riding a bike.

What are the three parts of the brain stem?

The brain stem is at the base of the brain. The brain stem extends down from the cerebrum and connects the brain to the spinal cord. It is made up of the midbrain, the pons, and the medulla (muh DUH luh). The midbrain and pons connect various parts of the brain with each other. The medulla controls involuntary actions such as breathing and heartbeat. The medulla is also involved in actions such as coughing and sneezing. 

Why is the spinal cord important?

Your spinal cord is an extension of the brain stem. The spinal cord is made up of neurons that carry impulses from all parts of the body to the brain and from the brain to all parts of the body.

The Peripheral Nervous System

Your brain and spinal cord are connected to the rest of the body by the peripheral nervous system (PNS). The PNS is made up of cranial nerves and spinal nerves. Spinal nerves contain bundles of sensory and motor neurons. Because most spinal nerves have these two kinds of neurons, a single spinal nerve can have impulses going to and from the brain at the same time.

What is the difference between the somatic and autonomic systems?

The peripheral nervous system has two major parts, the autonomic system and the somatic system. The somatic system controls voluntary actions, such as raising your hand. It is made up of cranial and spinal nerves that go from your central nervous system to your skeletal muscles. The autonomic system controls involuntary actions. These are actions that you do without making a choice, such as digestion and the beating of your heart.

Safety and the Nervous System

The central and peripheral nervous systems are involved with every mental process and physical action of your body. Therefore, an injury to the brain or the spinal cord can be serious. For example, the back of the brain controls vision. A blow to the back of the head could result in a loss of vision.

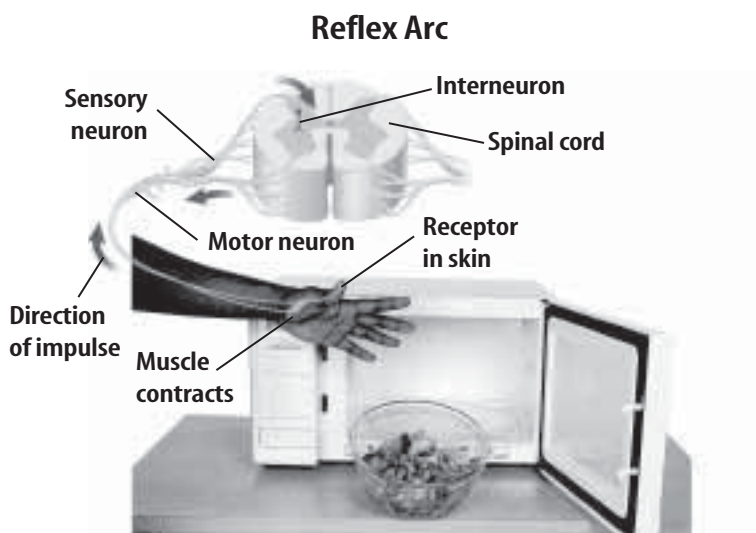
The spinal cord is surrounded by the bones of the spine, which protect the spinal cord. However, injuries to the spinal cord do occur. A spinal cord injury can damage nerve pathways and lead to paralysis (puh RA luh suhs). Paralysis is the loss of muscle movement.

Types of paralysis Damage to one side of the brain can cause the opposite side of the body to be paralyzed. If the spinal cord is damaged in the neck area, the body can be paralyzed from the neck down. Damage to the middle or lower part of the spinal cord can paralyze the legs and the lower part of the body.

Automobile, motorcycle, and bicycle accidents, and sports injuries, are the major causes of head and spinal injuries. You can help protect yourself from serious injury. Wear your seat belt while riding in a car and wear the safety gear for a sport or when riding a bicycle or motorized vehicle.

How do reflexes work?

When you accidentally touch something that is very hot, you experience a reflex. A **reflex** is an involuntary, automatic response to a stimulus. You cannot control a reflex because it occurs before you know what has happened. A reflex involves a simple nerve pathway called a reflex arc.



Think it Over

- 5. Determine** What safety equipment is used to protect the head or spinal cord?

Picture This

- 6. Interpret Scientific Illustrations** Trace the pathway of the reflex arc.

What is an example of a reflex?

A reflex allows the body to respond without having to think about what action to take. If you step on a sharp object, you experience a shooting pain. Sensory receptors in your foot respond to this sharp object, and an impulse is sent to the spinal cord. The impulse then passes to an interneuron in the spinal cord that immediately sends the impulse to motor neurons. Motor neurons send the impulse to muscles in the leg. Instantly, without thinking, you lift your leg away from the sharp object. This is a withdrawal reflex.

Reflex responses are controlled in your spinal cord, not in your brain. Your brain acts after the reflex to help figure out what to do to make the pain stop. Reflexes also happen if you touch something very cold or when you cough or vomit. 

Reading Check

- 7. Identify** What part of the nervous system controls reflexes?

Reading Check

- 8. Distinguish** What effect do depressants and stimulants have on the central nervous system?

Drugs and the Nervous System

Many drugs, such as alcohol and caffeine, directly affect the nervous system. When alcohol is swallowed, it passes directly through the walls of the stomach and small intestine into the blood stream. Once in the circulatory system, alcohol can travel throughout the body. When the alcohol reaches neurons, it moves in through their cell membranes and upsets their normal cell functions. Since alcohol slows the activities of the central nervous system, it is called a depressant. Activities such as muscle control, judgment, and memory are reduced, or impaired. Heavy alcohol use destroys brain and liver cells.

A stimulant is a drug that speeds up the activity of the central nervous system. Caffeine is a stimulant found in coffee, tea, and many soft drinks. Too much caffeine can increase heart rate. It can cause increased restlessness in some people and make it difficult to sleep. Caffeine can also stimulate the kidneys to make more urine. 

The nervous system controls responses that help keep homeostasis within the body. Drugs make it more difficult for the body to maintain homeostasis.

● After You Read

Mini Glossary

axon (AK sahn): the branch of a neuron that carries impulses away from the body of the nerve cell

brain stem: connects the brain to the spinal cord; made up of the midbrain, the pons, and the medulla

central nervous system: the part of the nervous system made up of the brain and spinal cord

cerebellum (ser uh BE lum): the part of the brain that interprets stimuli from the eyes and ears and from muscles

cerebrum (suh REE brum): the largest part of the brain, in which thinking takes place

dendrite: the branch of a neuron that receives impulses from other neurons and sends them to the body of the nerve cell

homeostasis (hoh mee oh STAY sus): the regulation of conditions inside an organism to maintain life, even when the outside environment changes

neuron (NOOR ahn): the basic unit of the nervous system—nerve cell

peripheral (puh RIH fuh rul) nervous system: the part of the nervous system made up of all the nerves outside the central nervous system

reflex: an involuntary, automatic response to a stimulus

synapse (SIH naps): small space between neurons through which an impulse crosses

1. Review the terms and their definitions in the Mini Glossary. Choose one of the parts of the brain and write a sentence that describes the part and explains its function.

2. Complete the chart below to identify the parts of the central nervous system (CNS) and the peripheral nervous system (PNS) and to explain what each part does.

	Kind of Nervous System (CNS or PNS)	What It Does
Brain		
Spinal cord		
Somatic system		
Autonomic system		

Control and Coordination

section ● The Senses

What You'll Learn

- the sensory receptors in each sense organ
- the type of stimulus each sense organ responds to and how
- why the body needs healthy senses

● Before You Read

On the lines below, list which one of your senses you consider the most important. Explain why you think it is the most important.

Study Coach

Create a Quiz As you study the information in this section, create questions about the information you read. After you read, use the questions as a quiz.

● Read to Learn

The Body's Alert System

Your sense organs are your body's alert system. They sense stimuli, such as light rays, sound waves, and heat. Your sense organs convert these stimuli into nerve impulses.

Vision

The eye is the sense organ for vision. Your eyes have adaptations that make it possible for you to see objects, shadows, and colors.

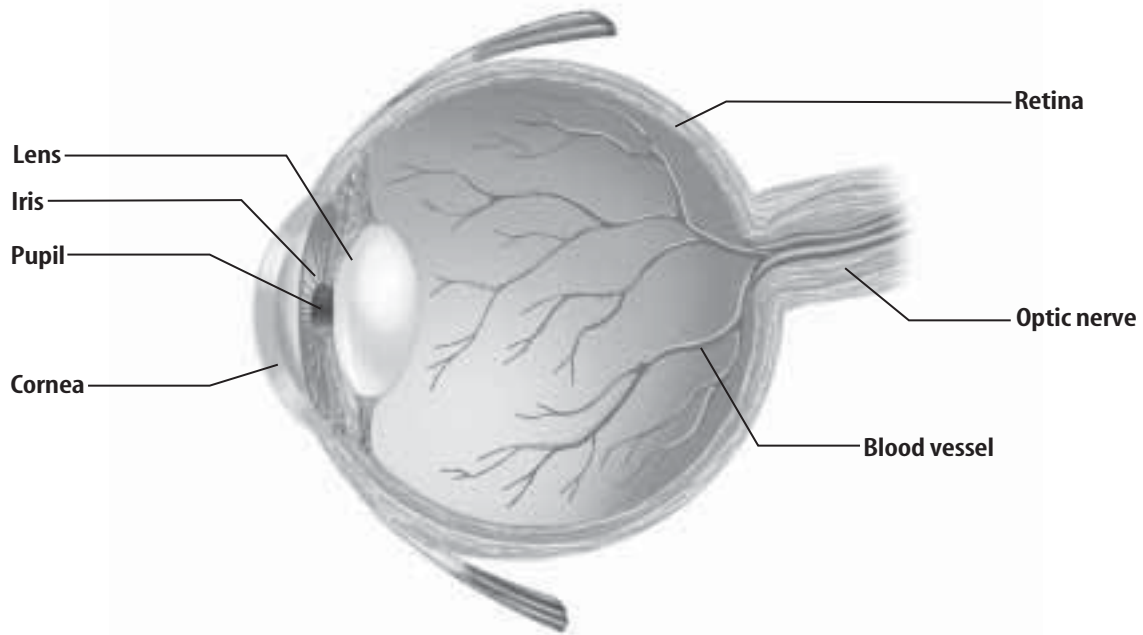
How do you see?

Light travels in a straight line unless something causes it to change direction. Your eyes have structures that refract, or bend, light. Two of these structures are the cornea (KOR nee uh) and the lens. The cornea is the transparent part at the front of the eye. As light passes through the cornea, it is refracted. The lens directs the light onto the retina (RET nuh). The **retina** is a tissue at the back of the eye that is sensitive to light energy. Cells called cones and rods are found in the retina. Cones respond to bright light and color. Rods respond to dim light. Rods help you distinguish shapes and movement. 

Reading Check

1. **Determine** Which structure of the eye is sensitive to light energy?

Structures of the Eye



How do your eyes sense distance?

The light energy that reaches the retina stimulates the rods and cones to produce impulses. The impulses pass to the optic nerve, which is shown in the figure above. This nerve carries the impulses to the vision part of the cortex, located in your brain's cerebrum. The image that is passed from the retina to the brain is upside down and reversed. The brain interprets the image correctly, and you see what you are looking at. The brain also interprets the images it receives from both eyes. It blends them into one image that gives you a sense of distance. This helps you to tell how close or how far away something is.

Lenses

Light is refracted when it passes through a lens. The way light refracts depends on the kind of lens it passes through. A lens that is thicker in the middle and thinner on the edges is called a convex lens. The lens in your eye is a convex lens. It bends light so that it passes through a point, called a focal point. Convex lenses can be used to make objects appear larger. The light passes through a convex lens and enters the eye in a way that causes your brain to interpret the image as enlarged. ✓

A lens that is thicker at its edges than in its middle is called a concave lens. A concave lens causes the light to spread out.

Picture This

- 2. Identify** Circle the name of the structure where rods and cones are found.

✓ Reading Check

- 3. Describe** What type of lens is in your eye?
-

✓ Reading Check

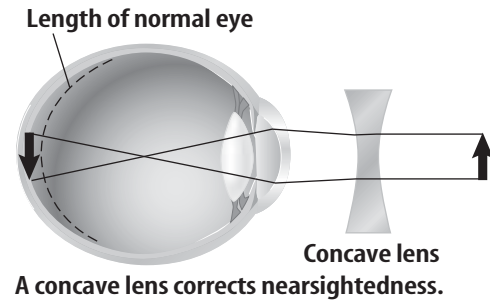
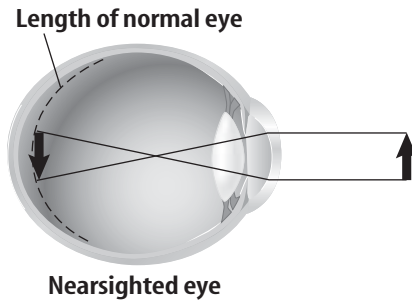
4. **Identify** What type of lens corrects nearsightedness?

How can vision problems be corrected?

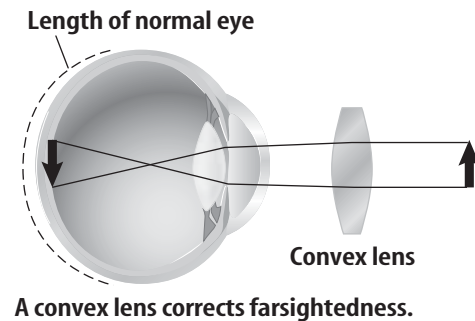
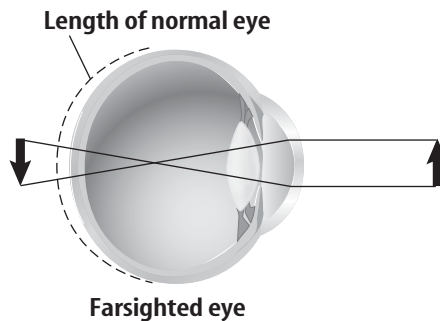
In an eye that has normal vision, the cornea, lens, and muscles work together. These three parts focus the light rays onto the retina. But if the eyeball is too long from front to back, the light from objects is focused in front of the retina. This happens because the shape of the eyeball and lens cannot be changed enough by the eye muscles to focus a sharp image on the retina. The image that reaches the retina is blurred. This condition is called nearsightedness, because objects that are near are seen more clearly than objects at a distance. Concave lenses are used to correct nearsightedness by focusing images sharply on the retina as shown in the figure below. ✓

If the eyeball is too short from front to back, then light from objects is focused behind the retina. This condition is called farsightedness, because distant objects are clearer than near objects. Convex lenses are used to correct farsightedness as shown in the figure below.

A nearsighted person cannot see distant objects because the image is focused in front of the retina.



A farsighted person cannot see close objects because the image is focused behind the retina.



Picture This

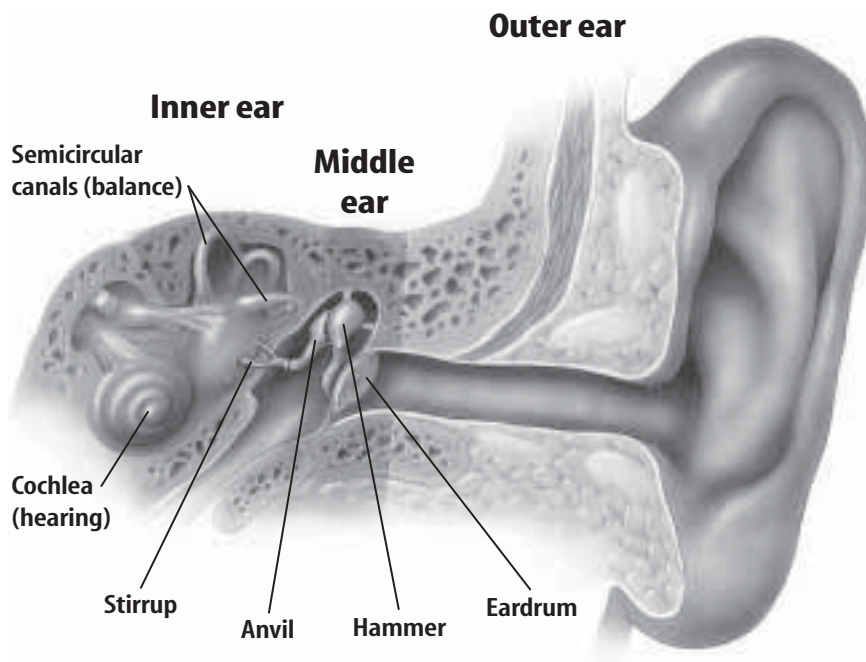
5. **Label** the retina and lens in each eye.

Hearing

You hear a sound when sound waves reach your ears. Sound waves are made when an object vibrates. Sound waves can travel through liquids, solids, and gases. When sound waves reach the ear, they stimulate nerve cells within the ear. Impulses are sent to the hearing area of your brain's cortex. The cortex responds and you hear a sound.

How do the outer ear and middle ear work?

The figure below shows the three sections of the ear: the outer ear, the middle ear, and the inner ear. The outer ear intercepts sound waves and funnels them down the ear canal to the middle ear. The sound waves make the eardrum vibrate much like the membrane on a musical drum vibrates when you tap on it. The vibrations then move through three tiny bones called the hammer, anvil, and stirrup. The stirrup bone rests against a membrane on an opening to the inner ear.



How does the inner ear work?

The **cochlea** (KOH klee uh) is a fluid-filled structure shaped like a snail's shell. When the stirrup vibrates, fluids in the cochlea begin to vibrate. The vibrations bend hair cells in the cochlea. When a hair cell bends, it sends electrical impulses to the brain. Depending on how the nerves are stimulated, you hear different types of sound. ✓

How does the inner ear control balance?

Some parts of the inner ear also control your balance. These parts are called the cristae ampullaris (KRIHS tee • am pyew LEER ihs) and the maculae (MA kyah lee). These parts sense different types of body movement.

Picture This

- 6. Interpret Scientific Illustrations** Use a pencil or pen to trace the path of sound waves from outside the ear to the cochlea.

✓ Reading Check

- 7. Explain** What sends the electrical impulses to the brain?

Think it Over

8. **Summarize** What are two functions of the ear?

Reading Check

9. **Explain** What cells in the nasal passage help you smell food?

Picture This

10. **Circle** the name of the structure where the taste buds are found.

The Muscles Respond to the Inner Ear Both the cristae ampullaris and the maculae have tiny hair cells. As the body moves, the fluid surrounding the hair cells moves. This motion stimulates the nerve cells to send nerve impulses to the brain. The brain interprets the body movements and sends impulses to the skeletal muscles. The impulses cause your muscles to move in a way that helps you keep your balance.

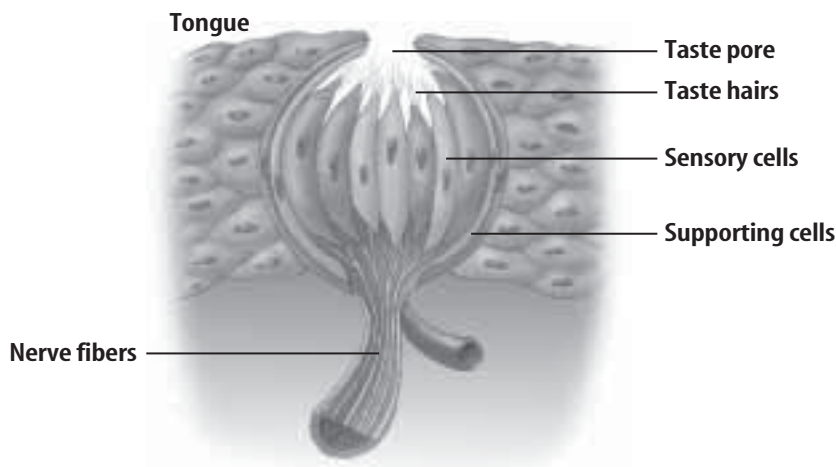
Smell

The sense of smell influences what you eat because you are attracted to some food odors and not others. Some odors can bring to mind strong memories and feelings you may have had the last time you smelled the same odor.

You can smell food because it gives off molecules into the air. The molecules stimulate the **olfactory** (ohl FAK tree) **cells** in your nasal passages. The cells are kept moist by mucus. When molecules in the air dissolve in this moisture, the cells become stimulated and produce impulses. Impulses that start in these cells travel to the brain. The brain interprets the stimulus. If you have smelled the odor before, your brain will recognize it and you can identify the odor. If your brain does not recognize the stimulus, it is remembered and may be identified the next time you smell it. 

Taste

The major sensory receptors for taste are the **taste buds** on your tongue. The tongue has about 10,000 taste buds all over it. The taste buds help you to tell one taste from another. The figure below shows the parts of a taste bud.



How are you able to taste food?

Most taste buds respond to several kinds of tastes. However, certain areas of the tongue respond more to one taste than another. The five tastes are sweet, salty, sour, bitter, and the taste of MSG (monosodium glutamate). Before you can taste something, it has to be dissolved in water. Saliva begins this process. The saliva and food wash over the taste buds. Taste buds are made up of a group of sensory cells with tiny taste hairs projecting from them.

When food is taken into the mouth, it is dissolved in saliva. This mixture stimulates taste buds to send impulses to the brain. The brain interprets the impulses, and you identify the tastes. 

How do smell and taste work together?

Smell and taste are related. You need the sense of smell to identify some foods such as chocolate. When saliva in the mouth mixes with the chocolate, odors travel up the nasal passage in the back of the throat. The olfactory cells are stimulated, and you taste and smell the chocolate.

When you have a stuffy nose, some foods seem tasteless. It may be because the food's molecules are blocked from contacting the olfactory cells in your nasal passage.

Other Sensory Receptors in the Body

Your internal organs have several kinds of sensory receptors. These receptors pick up changes in touch, pressure, pain, and temperature and send impulses to the brain or spinal cord. Your body then responds to the new information.

You also have sensory receptors throughout your skin. Your fingertips have many different types of receptors for touch. These receptors help you tell if an object is rough or smooth, hard or soft, hot or cold. Your lips are very sensitive to heat. They keep you from drinking something so hot that it would burn you.

All of the body's senses work together to maintain homeostasis. Your senses help you enjoy or avoid things around you. You react to your environment because of information that you receive through your senses.

Reading Check

11. **Identify** the five tastes your brain can detect.



Think it Over

12. **Apply** Name two things your senses help you avoid.

● After You Read

Mini Glossary

cochlea (KOH klee uh): fluid-filled structure shaped like a snail's shell; located in the inner ear

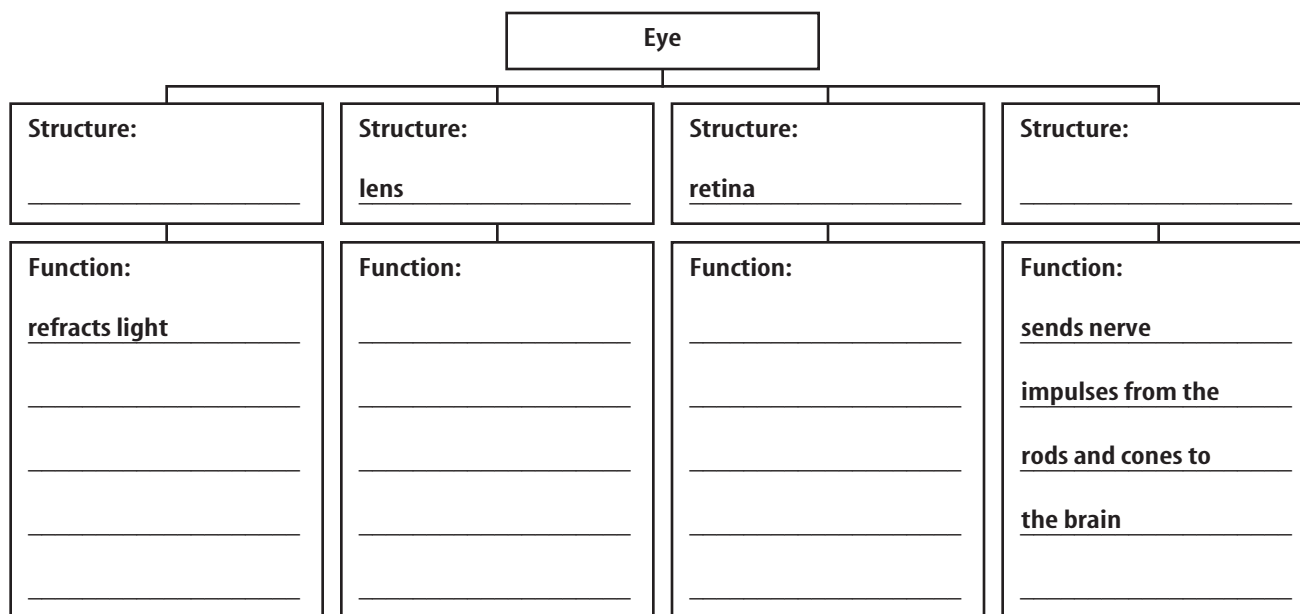
olfactory (ohl FAK tree) cells: nerve cells in the nasal passages

retina (RET nuh): the tissue at the back of the eye that is sensitive to light energy

taste bud: major sensory receptor for taste

1. Review the terms and their definitions in the Mini Glossary. Using one of the terms, write a sentence explaining how it helps you react to your environment.

2. Complete the diagram below to identify the structures of the eye and to name a function of each structure.



3. How can you use the quiz you created for this section to help you study for a test?



Visit life.msscience.com to access your textbook, interactive games, and projects to help you learn more about the senses.