

The Nervous and Endocrine Systems

ESSENTIAL QUESTION

How do the nervous and endocrine systems work?

By the end of this lesson, you should be able to relate the structures of the nervous and endocrine systems to their functions in the human body.



SC.6.L.14.5 Identify and investigate general functions of the major systems of the human body (digestive, respiratory, circulatory, reproductive,

excretory, immune, nervous, and musculoskeletal) and describe ways these systems interact with each other to maintain homeostasis. **HE.6.C.1.5** Explain how body systems are impacted by hereditary factors and infectious agents.



This sky diver can sense his surroundings and feel the rush of excitement with the help of his nervous and endocrine systems.

Lesson Labs

Quick Labs

- Measuring Reaction Time
- Speed of a Reflex
- Negative Feedback

Exploration Lab

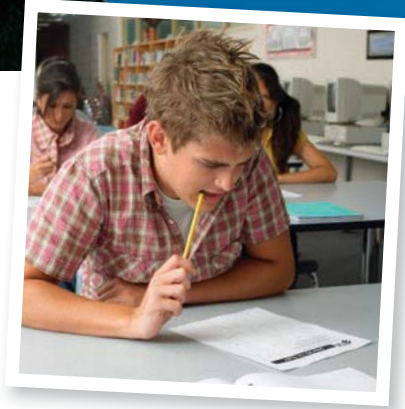
- Mapping Sensory Receptors



Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false.

- | T | F | |
|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | The central nervous system allows us to sense the environment. |
| <input type="checkbox"/> | <input type="checkbox"/> | The endocrine system functions by sending chemical signals. |
| <input type="checkbox"/> | <input type="checkbox"/> | The spinal cord is part of the peripheral nervous system. |
| <input type="checkbox"/> | <input type="checkbox"/> | The endocrine system helps regulate our blood sugar after we eat a meal. |



2 Describe Think about a situation that makes you feel very nervous or anxious. Describe how this makes you feel inside. What do you think is going on in your body?

ACTIVE READING

3 Apply You can often understand the meaning of a word if you use it in a sentence. Use the following definition to write your own sentence that has the word *gland*.

Definition

gland: a group of cells that make special chemicals for the body

gland:

Vocabulary Terms

- nervous system
- brain
- spinal cord
- neuron
- axon
- dendrite
- endocrine system
- hormone
- gland

4 Apply As you learn the definition of each vocabulary term in this lesson, create your own definition or sketch to help you remember the meaning of the term.

Brainiac!

What is the function of the nervous system?

The **nervous system** is made of the structures that control the actions and reactions of the body in response to stimuli from the environment. Your nervous system has two parts: the central nervous system (CNS) and the peripheral (puh•RIFF•uh•rahl) nervous system (PNS).

The CNS Processes Information

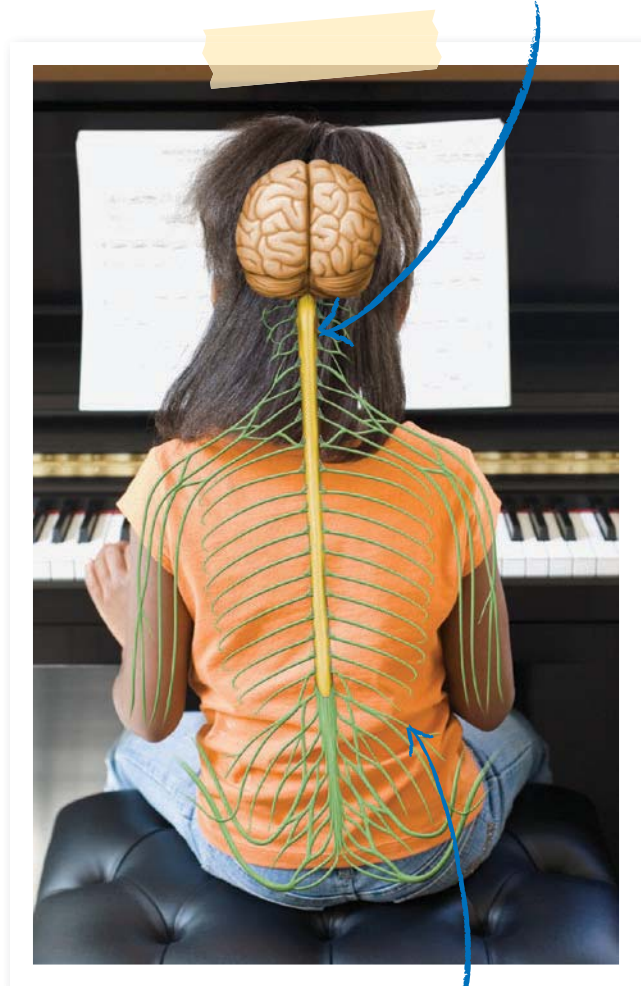
The brain and the spinal cord make up the CNS. The **brain** is the body's central command organ. It constantly receives impulses from all over the body. Your **spinal cord** allows your brain to communicate with the rest of your body. Your nervous system is mostly made up of specialized cells that send and receive electrical signals.

The PNS Connects the CNS to Muscles and Organs

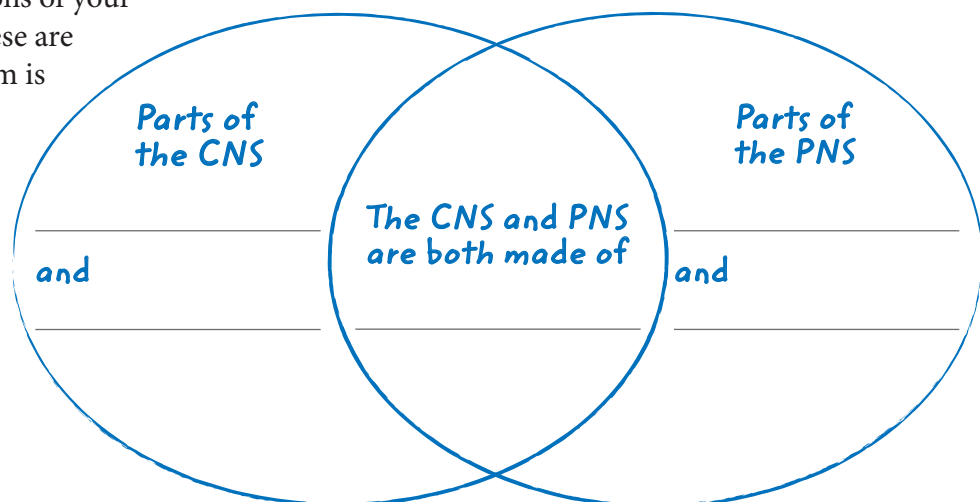
Your PNS connects your CNS to the rest of your body. The PNS has two main parts—the sensory part and the motor part. Many processes that the brain controls happen automatically—you have no control over them. These processes are called *involuntary*. For example, you could not stop your heart from beating even if you tried. However, some of the actions of your brain you can control—these are *voluntary*. Moving your arm is a voluntary action.

5 Compare Fill in the Venn diagram to compare and contrast the structure of the CNS and the PNS.

The CNS is shown in yellow.



The PNS is shown in green.



©Picturener/Getty Images

© Houghton Mifflin Harcourt Publishing Company

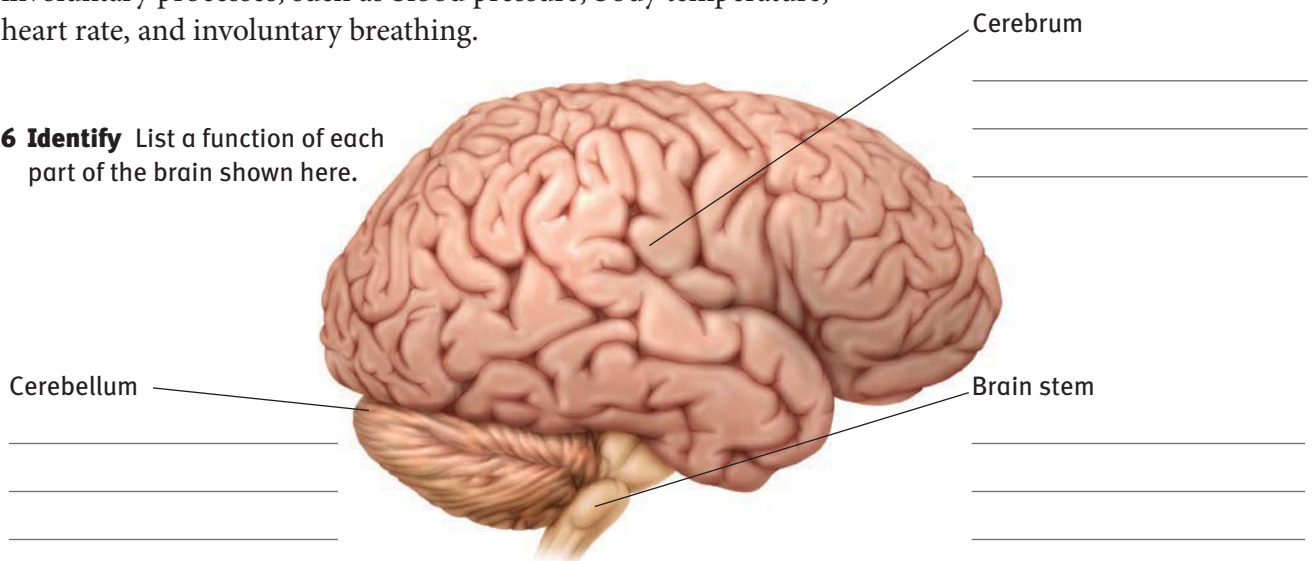
What are the parts of the CNS?

The CNS is made up of the brain and the spinal cord.

The Brain

The three main areas of the brain are the cerebrum, the cerebellum, and the brain stem. The largest part of the brain is the cerebrum. The cerebrum is where you think and problem-solve, and where most of your memories are stored. It controls voluntary movements and allows you to sense touch, light, sound, odors, taste, pain, heat, and cold. The second largest part of your brain is the cerebellum. It processes information from your body. This allows the brain to keep track of your body's position and coordinate movements. The brain stem connects your brain to your spinal cord. The medulla is part of the brain stem. It controls involuntary processes, such as blood pressure, body temperature, heart rate, and involuntary breathing.

6 Identify List a function of each part of the brain shown here.

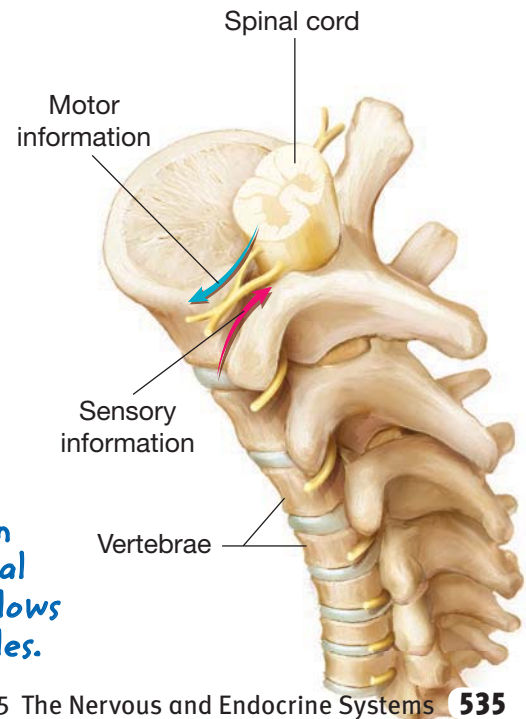


The Spinal Cord

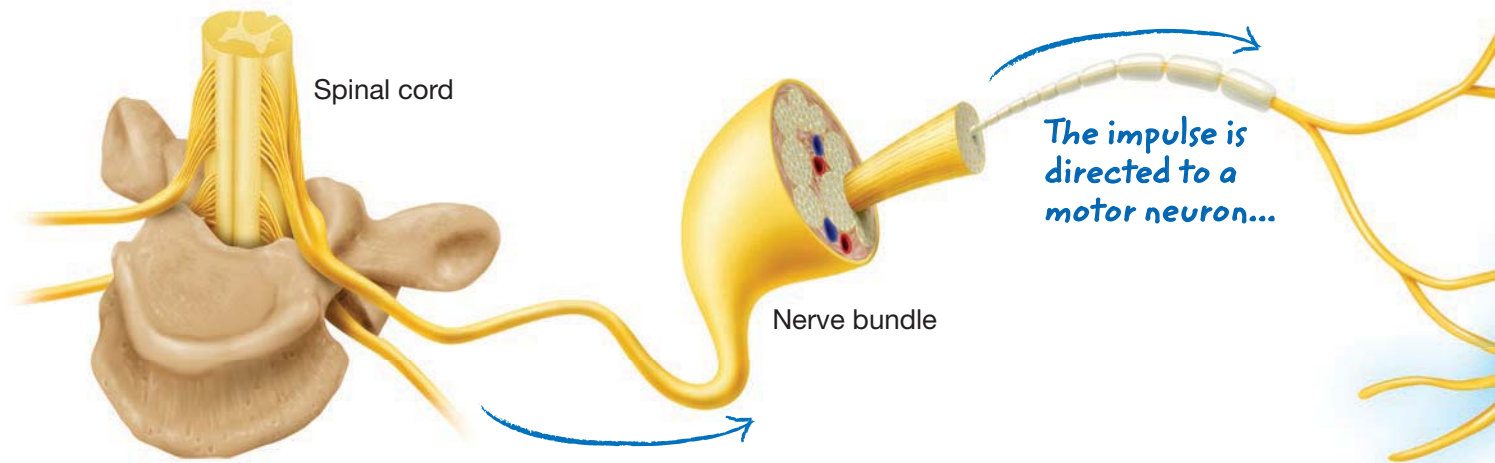
The spinal cord is made of bundles of nerves. A *nerve* is a collection of nerve cell extensions bundled together with blood vessels and connective tissue. Nerves are everywhere in your body. The spinal cord is surrounded by protective bones called *vertebrae*.

Special cells in your skin and muscles carry sensory information to the spinal cord. The spinal cord carries these impulses to the brain. The brain interprets these impulses as warmth, pain, or other sensations and sends information back to the spinal cord. Different cells in the spinal cord then send impulses to the rest of the body to create a response.

Sensory information (red) flows in from the environment to the spinal cord. Motor information (blue) flows out from the spinal cord to muscles.



You've Got Nerves!



If you notice that your shoe is untied, your brain interprets this information and sends an impulse down the spinal cord.

How do signals move through the nervous system?

Your nervous system works by receiving information from the environment and translating that information into electrical signals. Those electrical signals are sent from the brain to the rest of the body by special cells called *neurons*. A **neuron** is a cell that moves messages in the form of fast-moving electrical energy. These electrical messages are called *impulses*.

Signals move through the central and peripheral nervous systems with the help of glial (GLEE•uhl) cells. Glial cells do not transmit nerve impulses, but they protect and support neurons. Without glial cells, neurons would not work properly. Your brain has about 100 billion neurons, but there are about 10 to 50 times more glial cells in your brain.

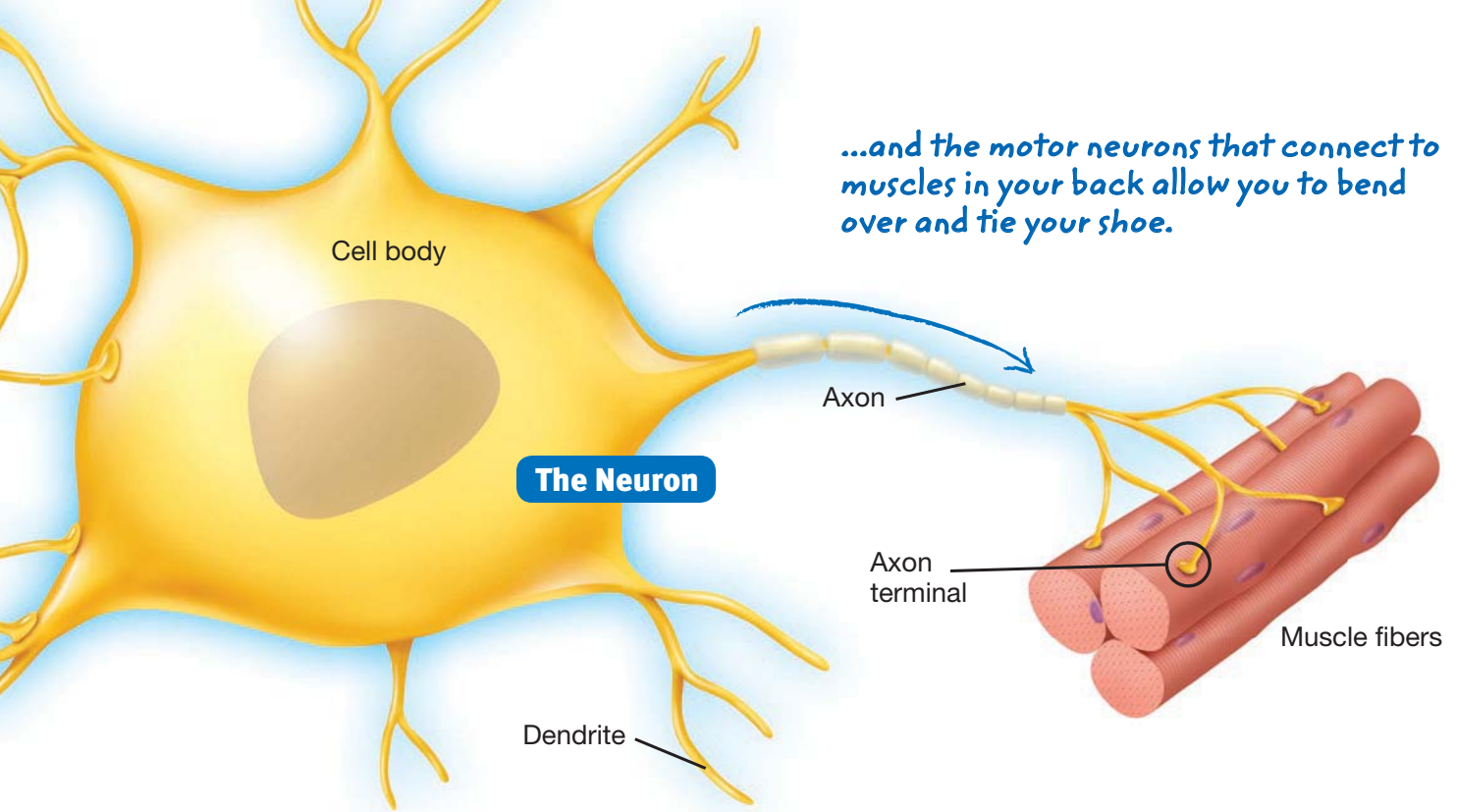
Through Sensory and Motor Neurons

Neurons carry information from the body to the brain, and carry instructions from the brain back to the rest of the body. The two groups of neurons are sensory neurons and motor neurons.

Sensory neurons gather information from in and around your body. They then move this information to the brain. Motor neurons move impulses from the brain and spinal cord to other parts of the body. For example, when you are hot, motor neurons move messages from your brain to your sweat glands to tell the sweat glands to make sweat. Sweating cools your body.

ACTIVE READING

7 Identify As you read, underline the special types of neurons that receive and send messages.



What are the parts of a neuron?

A neuron is made up of a large region called the *cell body*, a long extension called the *axon*, and short branches called *dendrites*. At the end of the axon is the *axon terminal*.

Like other cells, a neuron's cell body has a nucleus and organelles. But neurons have other structures that allow them to communicate with other cells. A **dendrite** (DEHN•dryt) is a usually short, branched extension of the cell body. A neuron may have one, two, or many dendrites. Neurons with many dendrites can receive impulses from thousands of cells at a time. The cell body gathers information from the dendrites and creates an impulse.

Impulses are carried away from the cell body by extensions of the neuron, called an **axon**. A neuron has only one axon, and they can be very short or quite long. Some long axons extend almost 1 m from your lower back to your toes! Impulses move in one direction along the axon.

At the end of an axon is the axon terminal, where a signal is changed from an electrical signal to a chemical signal. This chemical signal, called a *neurotransmitter*, is released into the gap between the neuron and other cells.

Visualize It!

8 Apply In the boxes below, fill in the appropriate neuron parts, structures, or functions.

NEURON PART	STRUCTURE	FUNCTION
Cell body	region containing nucleus and organelles	
	branches of the cell body	gathers information from other cells
Axon		sends impulse away from cell body
	end of an axon	changes electrical signal to chemical signal

That Makes Sense!

What are the main senses?

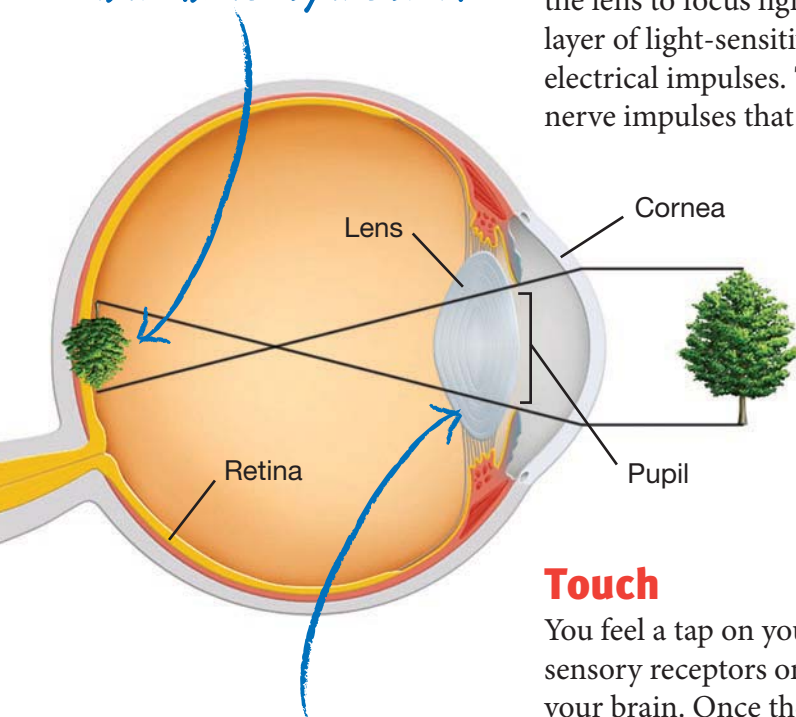
The body senses the environment with specialized structures called *sensory organs*. These structures include the eyes, the skin, the ears, the mouth, and the nose.

i **9 Imagine** If you were at this amusement park, what do you think you would see, hear, smell, taste, and feel?



An amusement park is full of sensory information! How do we sense it all?

Rays form an upside-down image on the retina at the back of the eye. This image is translated by the brain.



Light enters the eye through the lens. Light rays are bent by the cornea.

Sight

Your eye allows you to see the size, shape, motion, and color of objects around you. The front of the eye is covered by a clear membrane called the *cornea*. Light from an object passes through an opening called the *pupil*. Light hits the eye's lens, an oval-shaped piece of clear, curved material. Eye muscles change the shape of the lens to focus light onto the retina. The *retina* (RET•nuh) is a layer of light-sensitive photoreceptor cells that change light into electrical impulses. These cells, called *rods* and *cones*, generate nerve impulses that are sent to the brain.

Visualize It!

10 Identify What part of the eye focuses light on to the retina?

Touch

You feel a tap on your shoulder. The tap produces impulses in sensory receptors on your shoulder. These impulses travel to your brain. Once the impulses reach your brain, they create an awareness called a *sensation*. In this case, the sensation is that of your shoulder being touched. The skin has different kinds of receptors that detect pressure, temperature, pain, and vibration.

Hearing

Ears pick up sound wave vibrations. These sound waves push air particles, creating a wave of sound energy. The sensory cells of your ears turn sound waves into electrical impulses. These electrical impulses then travel to your brain. Each ear has an outer, a middle, and an inner portion. Sound waves reaching the outer ear are funneled toward the middle ear. There, the waves make the eardrum vibrate. The *eardrum* is a thin membrane separating the outer ear from the middle ear. The vibrating eardrum makes three tiny bones in the middle ear vibrate. The last of these bones vibrates against the *cochlea* (KOH•klee•uh), a fluid-filled organ of the inner ear. Inside the cochlea, the vibrations make waves in the fluid. Sensory receptors called *hair cells* move about in the fluid. Movement of the hair cells causes neurons in the cochlea to send electrical impulses. These impulses travel to the brain via the auditory nerve and are interpreted as sound.

The ears also help you maintain balance. Special fluid-filled canals in the inner ear are filled with hair cells that respond to changes in head orientation. These hair cells then send signals to the brain about the position of the head with respect to gravity.

Taste

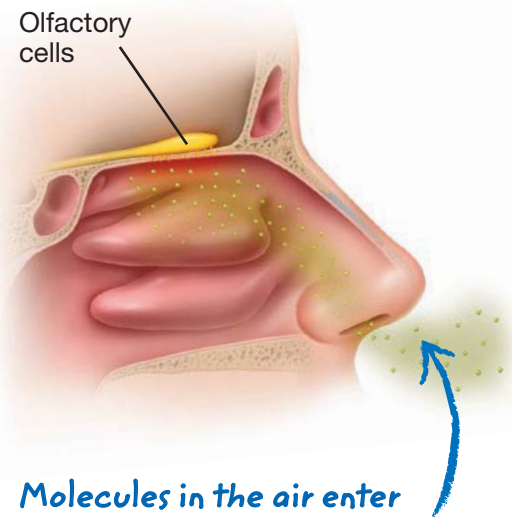
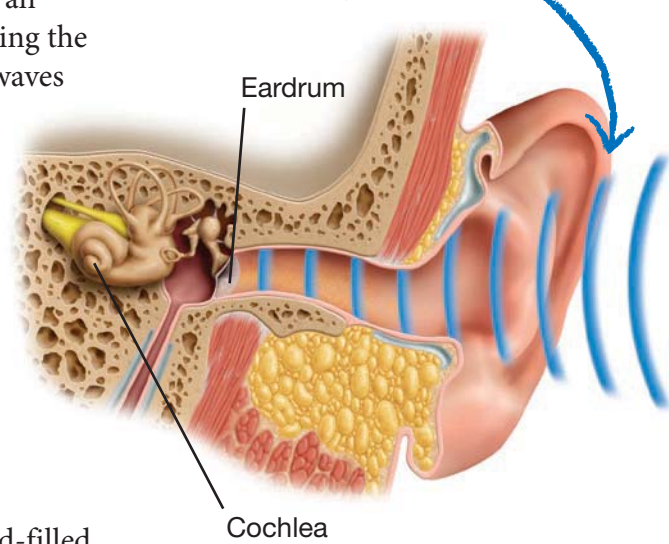
Your tongue is covered with taste buds. These taste buds contain clusters of *taste cells* that respond to signals in dissolved molecules in food. Taste cells react to five basic tastes: sweet, sour, salty, bitter, and savory. Your sense of taste can protect you from eating something that could be harmful.

Smell

The nose is your sense organ for smell. Receptors for smell are located in the upper part of your nasal cavity. Sensory receptors called *olfactory cells* react to chemicals in the air. These molecules dissolve in the moist lining of the nasal cavity and trigger an impulse in the receptors. The nerve impulses are sent to the brain, where they are interpreted as an odor. Your senses of taste and smell work together to allow you to taste a variety of food flavors. Both senses detect chemical cues in the environment.

11 Claim • Evidence • Reasoning Make a claim about how a cold that causes congestion in your sinuses might affect your sense of smell. Support your claim with evidence and explain your reasoning.

Sound waves enter the ear and cause the eardrum to vibrate. The vibrations are translated by receptors.



Molecules in the air enter your nose. There, they bind to receptors in the top of your nasal cavity.

Keep Your Cool!

What is the function of the endocrine system?

Your **endocrine system** controls body functions and helps maintain homeostasis by using hormones. A **hormone** is a chemical messenger made in one cell or tissue that causes a change in another cell or tissue in a different part of the body. Hormones are produced by endocrine glands or tissues. A **gland** is a group of cells that make special chemicals for your body. Unlike direct signals of the nervous system, the signals sent by the endocrine system are indirect because they cycle through the whole body.

How do hormones work?

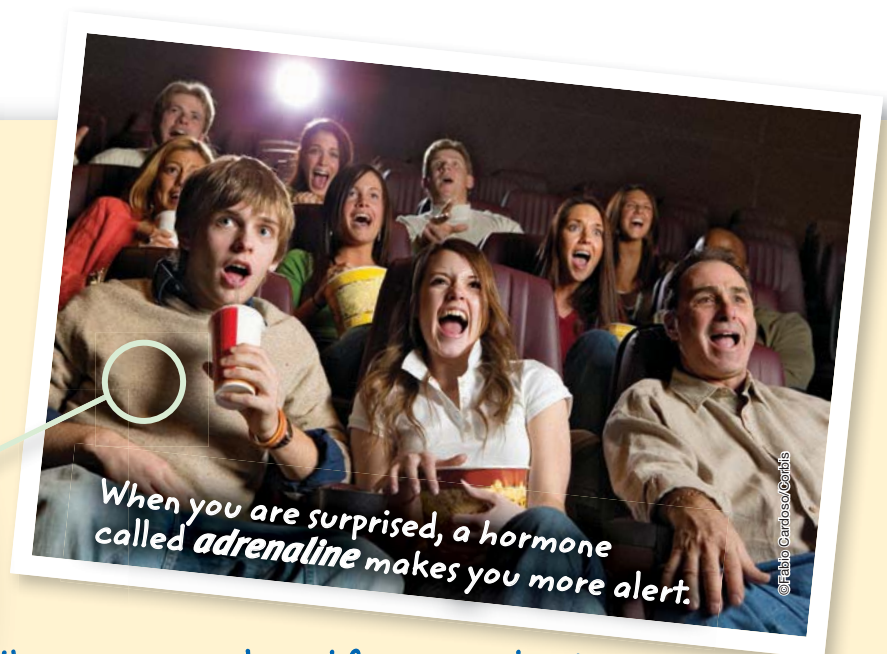
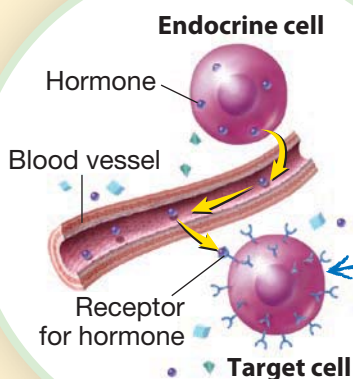
Hormones travel through the bloodstream. They travel from the endocrine gland where they are made and can reach every cell in the body. However, hormones affect only the cells that have specific *receptors*. Each hormone has its own receptor and affects only cells that have that receptor. These cells are called *target cells*. Many cells throughout the body have the same receptors, so hormones are able to perform many functions at the same time in different cells.

ACTIVE READING

12 Identify As you read, underline the structure which allows hormones to affect only certain cells.

Visualize It!

13 Apply Explain the difference between an endocrine cell and a target cell.



When you are surprised, a hormone called **adrenaline** makes you more alert.

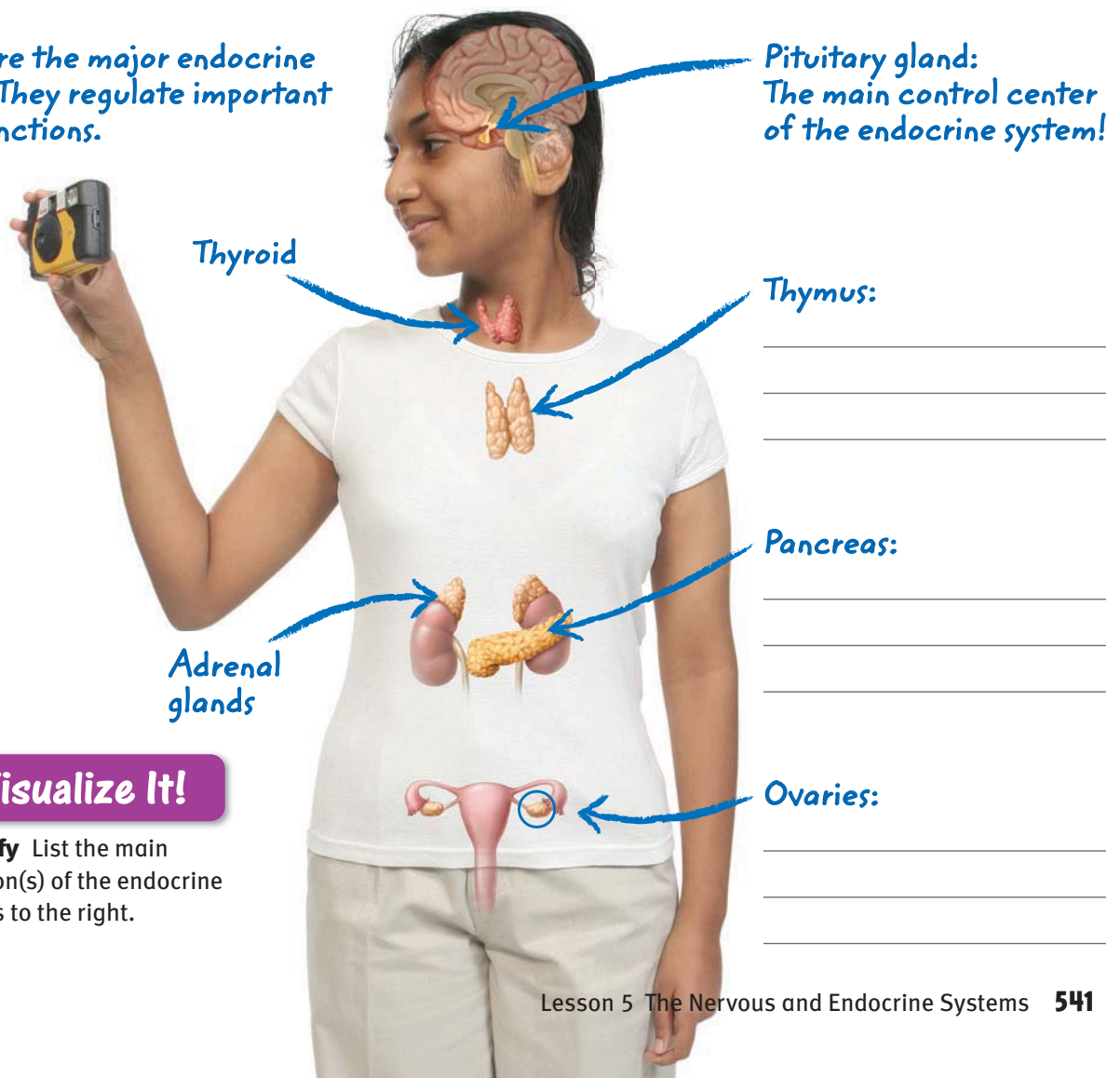
Hormones are released from an endocrine cell and travel through the bloodstream to bind to a receptor on a target cell. Sometimes a target cell is very far away!

What glands make up the endocrine system?

Your body has several endocrine glands or tissues that make up the endocrine system.

- Your pituitary gland is very important because it secretes hormones that affect other glands. It also stimulates growth and sexual development.
- The hypothalamus is a gland in the brain that controls the release of hormones from the pituitary gland.
- The pineal gland, also in the brain, produces hormones essential in the control of sleep, aging, reproduction, and body temperature.
- Hormones from the thyroid control your metabolism.
- The parathyroid gland controls calcium levels in the blood.
- Hormones made in the reproductive organs (ovaries or testes) control reproduction.
- Other endocrine glands include the pancreas and adrenal glands. The pancreas regulates blood sugar levels and the adrenal glands control the body's fight or flight response in dangerous situations.

These are the major endocrine glands. They regulate important body functions.



Visualize It!

14 Identify List the main function(s) of the endocrine glands to the right.

Feed←Back

How are hormone levels controlled?

The endocrine system keeps the body's internal environment in homeostasis. It does this by increasing or decreasing the amount of hormones in the bloodstream, some of which may have opposite effects on body cells. Such a process is called a feedback mechanism. A *feedback mechanism* is a cycle of events in which information from one step controls or affects a previous step.

By Feedback Mechanisms

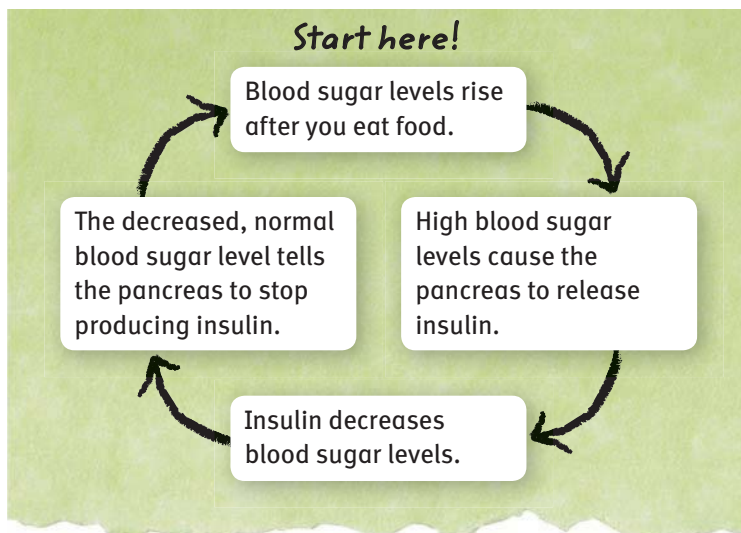
There are two types of feedback, positive and negative. In negative feedback, the effects of a hormone in the body cause the release of that hormone to be turned down. For example, when you eat food, your blood sugar levels go up. Insulin is released and blood sugar levels are lowered. Once this happens, the lower blood sugar levels tell the pancreas to stop releasing insulin. In other words, when the proper level of blood sugar is reached, the insulin-releasing cells are turned off.

In positive feedback, the effects of a hormone stimulate the release of more of that hormone. For example, the hormone oxytocin stimulates contractions of the uterus. When a fetus matures in the uterus, both it and the mother produce oxytocin. The oxytocin stimulates contractions, and these contractions stimulate more oxytocin to be released. The contractions expel a baby from the mother's uterus at birth.

ACTIVE READING

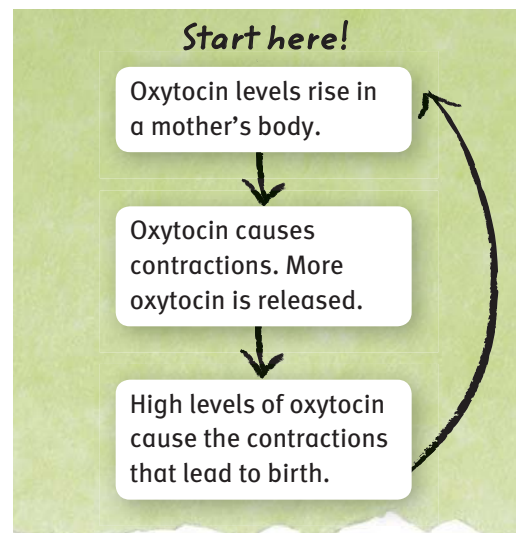
15 Support Your Claim Make a claim about the differences between positive and negative feedback. Support your claim.

Negative Feedback



In negative feedback, hormone levels are kept from rising too high.

Positive Feedback



In positive feedback, the level of hormones continues to rise.

What are disorders of the endocrine and nervous systems?

The endocrine system and nervous system are both responsible for sending messages around our bodies. If a problem developed with one or more of these systems, other systems of the body would need to adjust to compensate for this loss.

Hormone Imbalances

Disorders of the endocrine system occur when an endocrine gland makes too much or not enough of a hormone. For example, a person whose pancreas does not make enough insulin has a condition called type 1 diabetes. This condition causes an imbalance of the blood sugar. A person who has diabetes may need daily injections of insulin to keep blood sugar levels within safe limits. Some patients receive their insulin automatically from a small pump worn next to the body. New technology allows people with type 1 diabetes to intake insulin using an inhaler.

Think Outside the Book

16 Compare Many systems you use every day send messages, such as e-mail, a thermostat, and TV remote controls. Research how one of these systems sends and receives messages. Make a chart to compare this system to the endocrine system.

17 Claim • Evidence • Reasoning

Make a claim about how an insulin pump helps a person with type 1 diabetes maintain homeostasis. Support your claim with evidence and explain your reasoning.



Nerve Damage

Disorders of the nervous system include Parkinson's disease, multiple sclerosis, and spinal cord injury. In Parkinson's disease, the cells that control movement are damaged. Multiple sclerosis affects the brain's ability to send signals to the rest of the body.

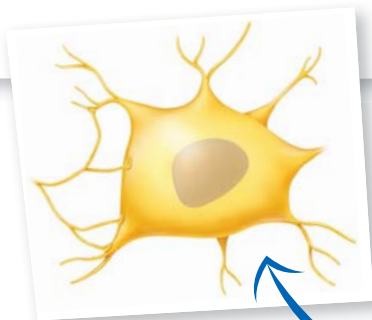
A spinal cord injury may block information to and from the brain. For example, impulses coming from the feet and legs may be blocked. People with such an injury cannot sense pain in their legs. The person would also not be able to move his or her legs, because impulses from the brain could not get past the injury site.

Visual Summary

To complete this summary, fill in the blank to answer the question. You can use this page to review the main concepts of the lesson.

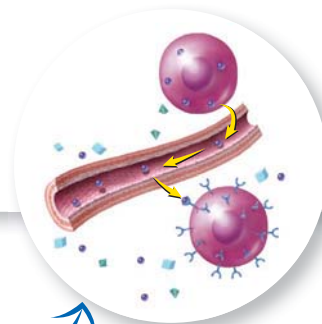
The nervous system gathers information and responds by sending electrical signals.

18 Nerve cells called _____ carry electrical messages called _____



The endocrine system controls conditions in your body by sending chemical messages.

19 Hormones have specific actions by attaching to _____ on target cells.



Sending Signals

Hormones are controlled by feedback mechanisms.

20 _____ feedback is when higher levels of a hormone turn off the production of that hormone.

Negative Feedback Start here!

Blood sugar levels rise after you eat food.

The decreased, normal blood sugar level tells the pancreas to stop producing insulin.

High blood sugar cause the pancreas to release insulin.

Insulin decreases blood sugar levels.

21 **Claim • Evidence • Reasoning** Make a claim about how both your nervous and endocrine systems would be involved if you walked into a surprise party and were surprised. Provide evidence to support your claim and explain your reasoning.

Vocabulary

Use a term from the section to complete each sentence below.

1 The _____ is made up of the brain and spinal cord.

2 Glands in the _____ send messages to target cells.

3 Use *gland* and *hormone* in the same sentence.

4 Use *hormone* and *feedback mechanism* in the same sentence.

Key Concepts

5 **Identify** Describe the function of the PNS and the CNS.

6 **Apply** What are the parts of a neuron?

7 **Identify** How are the messages of the endocrine system moved around the body?

8 **Identify** What is the main sense organ for each of the five senses?

Critical Thinking

The images below show how an eye responds to different light levels. Use the image to answer the following question.



9 **Interpret** The pupil opens and closes automatically in response to light. What part of your nervous system controls this response?
