SECTION 1

The Nervous System

Key Concept Your nervous system is an organ system that gathers, interprets, and responds to sensory information.

What You Will Learn

- The central nervous system processes and responds to all messages coming from the peripheral nervous system.
- The somatic nervous system controls voluntary movements. The autonomic nervous system controls functions that are involuntary.
- The brain is made of many parts that function together as the control center of the nervous system.

Why It Matters

Without a nervous system, you would not be able to sense or respond to your environment.

Vocabulary

- central nervous system
- peripheral nervous system
- neuron
- nerve
- brain

READING STRATEGY

Clarifying Concepts Take turns reading this section out loud with a partner. Stop to discuss ideas that seem confusing.

What is one thing that you have done today that did NOT involve your nervous system? This is a trick question! In fact, your nervous system controls almost everything that you do.

Two Systems Within a System

The nervous system acts as the body's central command post. It has two basic functions. First, it gathers and interprets information. This information comes from inside your body and from the world outside your body. Then, the nervous system responds to that information as needed.

The nervous system has two parts: the central nervous system and the peripheral nervous system. The **central nervous system** (CNS) is the brain and spinal cord. The CNS processes and responds to all messages coming from the peripheral nervous system. The **peripheral nervous system** (PNS) includes all of the parts of the nervous system except for the brain and the spinal cord. The PNS connects all parts of the body to the CNS. The PNS uses specialized structures called *nerves* to carry information between your body and your CNS. **Figure 1** shows the major divisions of the nervous system.

Standards Check **Describe the difference between the function of the CNS and the function of the PNS.** 7.5.a

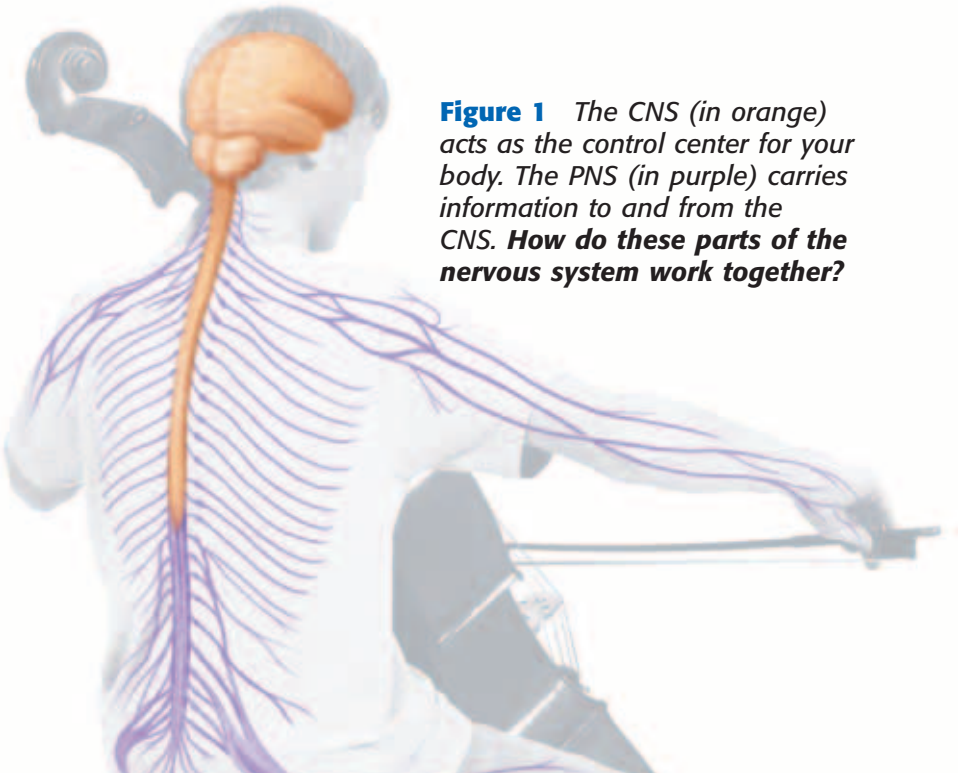


Figure 1 *The CNS (in orange) acts as the control center for your body. The PNS (in purple) carries information to and from the CNS.* ***How do these parts of the nervous system work together?***

7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
7.5.b Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

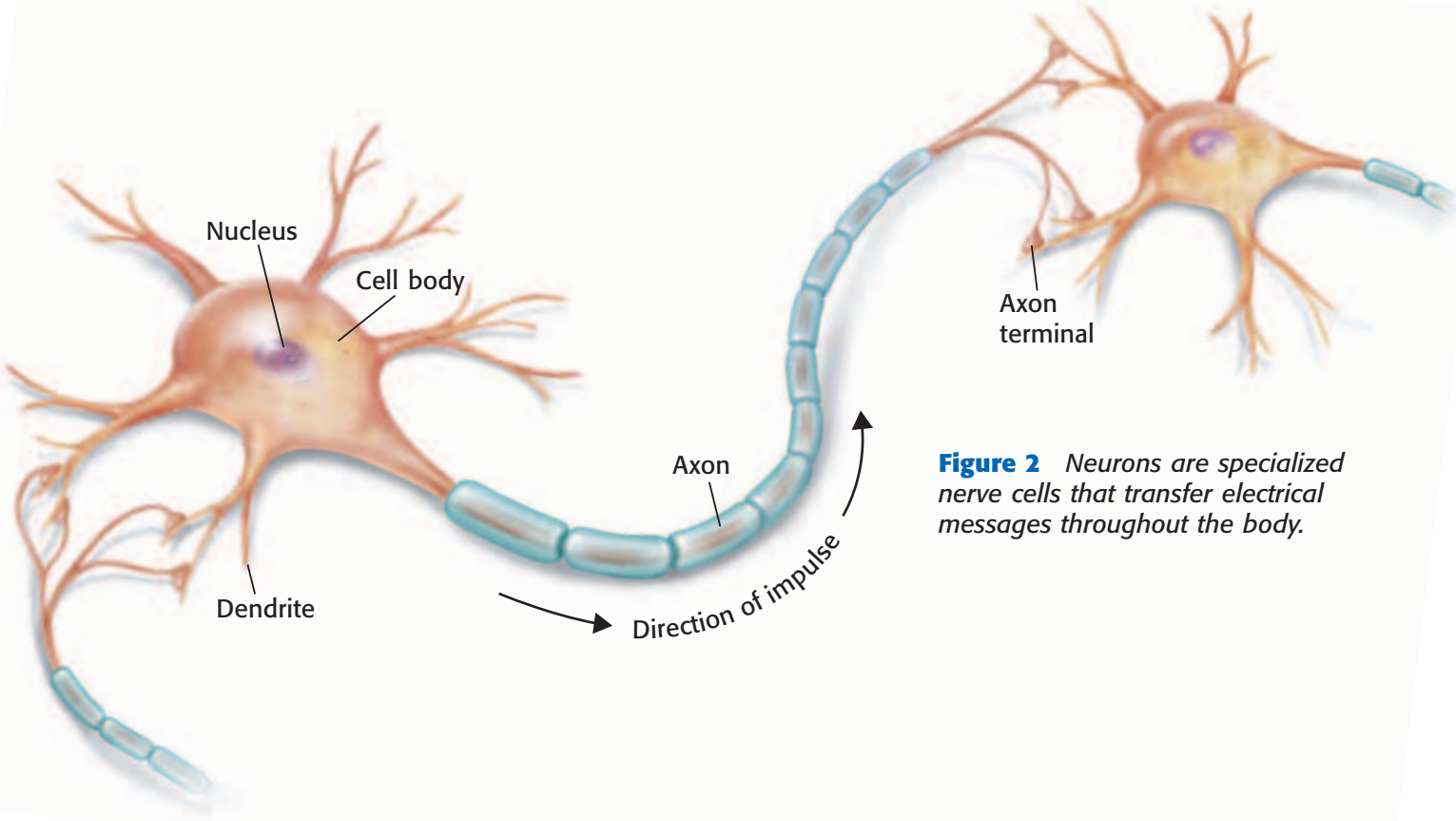


Figure 2 *Neurons are specialized nerve cells that transfer electrical messages throughout the body.*

The Peripheral Nervous System

Messages about your environment travel through the nervous system along neurons. A **neuron** is a nerve cell that is specialized to transfer messages in the form of fast-moving electrical energy. These electrical messages are called *impulses*. Impulses may travel as fast as 150 m/s or as slow as 0.2 m/s. **Figure 2** shows a typical neuron transferring an impulse.

Neuron Structure

In many ways, a neuron is similar to other cells. A neuron has a large region called the *cell body*. The cell body has a nucleus and cell organelles. But neurons also have special structures called *dendrites* and *axons*. Dendrites are usually short, branched extensions of the cell. A neuron receives information from other cells through its dendrites. A neuron may have many dendrites, which allows it to receive impulses from thousands of other cells.

Impulses are carried away from the cell body by axons. Axons are elongated extensions of a neuron. They can be very short or quite long. Some long axons extend almost 1 m from your lower back to your toes. The end of an axon often has branches that allow information to pass to other cells. The tip of each branch is called an *axon terminal*.

Standards Check **In your own words, describe the structure of a neuron.** 7.5.a

central nervous system (SEN trahl NUHR vuhs SIS tuhm) the brain and the spinal cord

peripheral nervous system (puh RIF uhr uhl NUHR vuhs SIS tuhm) all of the parts of the nervous system except for the brain and the spinal cord

Wordwise The root *peri-* means "around" or "near." The root *pher-* means "to bear" or "to go."

neuron (NOO RAHN) a nerve cell that is specialized to receive and conduct electrical impulses

Sensory Neurons: Collecting Information

Remember that neurons are a type of nerve cell that carries impulses. Some neurons are *sensory neurons*. These neurons gather information about what is happening in and around your body. They have specialized nerve endings called *receptors*. Receptors detect changes inside and outside the body. For example, receptors in your eyes detect light. Sensory neurons then send this information to the CNS for processing.

Motor Neurons: Delivering Orders

nerve (NUHRV) a collection of nerve fibers through which impulses travel between the central nervous system and other parts of the body

Neurons that send impulses from the brain and spinal cord to other systems are called *motor neurons*. When muscles get impulses from motor neurons, the muscles respond by contracting. For example, motor neurons cause muscles around your eyes to contract when you are in bright light. These muscles make you squint so that less light enters your eyes. Motor neurons also send messages to glands, such as sweat glands. These messages tell sweat glands when to make sweat.

Nerves

The central nervous system is connected to the rest of your body by nerves. A **nerve** is a collection of axons bundled together with blood vessels and connective tissue. Nerves are found everywhere in your PNS. Most nerves have axons of both sensory neurons and motor neurons. Axons are parts of nerves, but nerves are more than simply axons. **Figure 3** shows the structure of a nerve. The axon in this nerve transmits information from the spinal cord to muscle fibers.

Standards Check **What would happen if your nerves stopped working?** 7.5.b

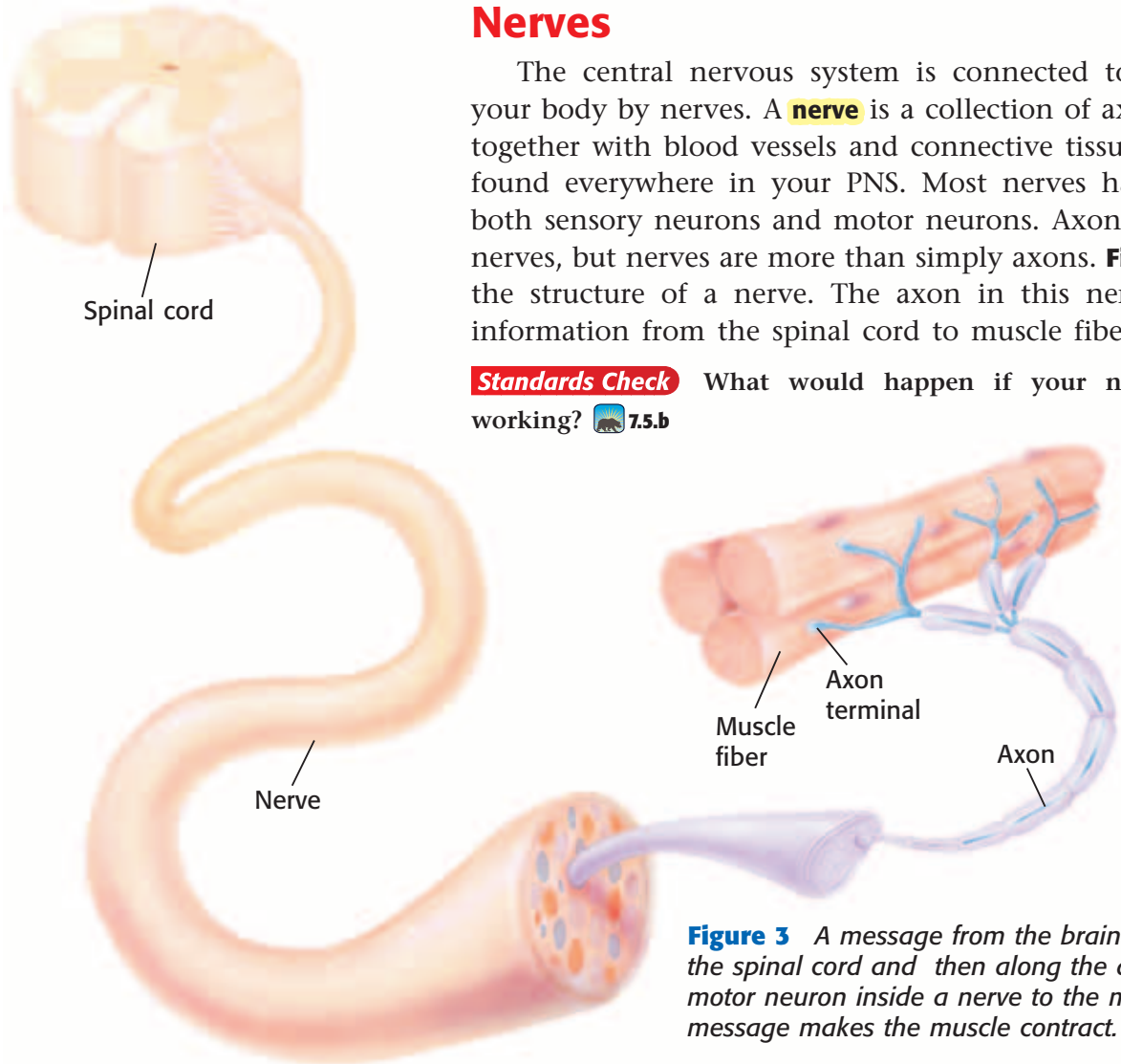


Figure 3 *A message from the brain travels down the spinal cord and then along the axon of a motor neuron inside a nerve to the muscle. The message makes the muscle contract.*

Somatic and Autonomic Nervous Systems

Remember, the peripheral nervous system (PNS) connects the central nervous system (CNS) to the rest of the body. And the PNS includes two main kinds of neurons: sensory neurons and motor neurons. You know that sensory neurons collect information from your senses and send that information to the CNS. You also know that motor neurons carry out the CNS's responses to that sensory information. The PNS has two types of motor neurons to carry out these responses: somatic neurons and autonomic neurons.

Somatic Nervous System

Most of the neurons that are part of the *somatic nervous system* are under your conscious control. These neurons stimulate skeletal muscles. So, the neurons control voluntary movements, such as writing, talking, smiling, or jumping.

Autonomic Nervous System

Autonomic neurons do not need your conscious control. These neurons are part of the autonomic nervous system. The *autonomic nervous system* controls body functions that you do not think about, such as digestion and heart rate (the number of times that your heart beats per minute).

The main job of the autonomic nervous system is to keep all of the body's functions in balance. Depending on the situation, the autonomic nervous system can speed up or slow down these functions. The autonomic nervous system has two divisions: the *sympathetic nervous system* and the *parasympathetic nervous system*. These two divisions work together to maintain a stable internal state, called *homeostasis*. **Table 1** shows some effects of these divisions.

MATH PRACTICE

Time to Travel

To calculate how long an impulse takes to travel a certain distance, you can use the following equation:

$$time = \frac{distance}{speed}$$

If an impulse travels 100 m/s, about how long will it take the impulse to travel 10 m? Record your work in your **Science Journal.**

Table 1 **Effects of the Autonomic Nervous System on the Body**

Organ	Effect of sympathetic division	Effect of parasympathetic division
Eyes	dilates (enlarges) pupils; making seeing objects easier	constricts pupils; makes vision normal
Heart	increases heart rate; increases blood flow	slows heart rate; slows blood flow
Lungs	dilates (enlarges) bronchioles; increases oxygen in blood	constricts bronchioles
Blood vessels	constricts blood vessels; increases blood pressure	has little or no effect
Intestines	slows digestion; reduces blood flow to stomach and intestines	returns digestion to normal

The Central Nervous System

The central nervous system receives information from the sensory neurons. Then, the CNS responds by sending messages to the body through motor neurons in the PNS.

The Brain

brain (BRAYN) the organ that is the main control center of the nervous system

The largest organ in the nervous system is the brain. The **brain** is the main control center of the nervous system. Many processes that the brain controls happen automatically. These processes are *involuntary*. For example, you could not stop digesting food even if you tried. On the other hand, some actions controlled by your brain are *voluntary*. When you want to move your arm, your brain sends signals along motor neurons to muscles in your arm. Then, the muscles contract, and your arm moves. The brain has three main parts: the cerebrum (suh REE bruhm), the cerebellum (SER uh BEL uhm), and the medulla (mi DUHL uh). Each part has its own job.

Standards Check **What is the brain's function in the nervous system? Describe what the brain controls.** 7.5.a

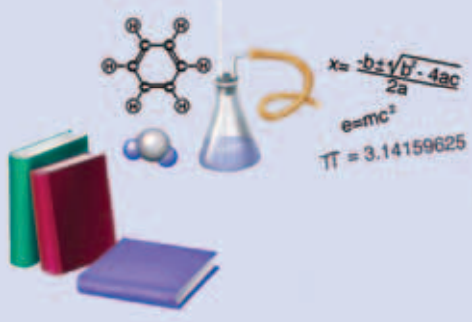
The Cerebrum

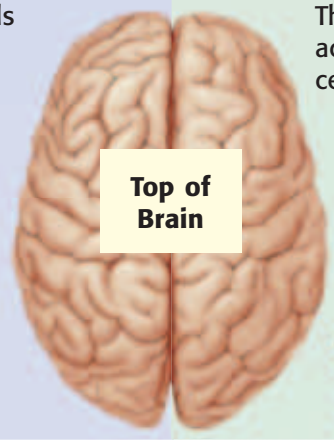
The largest part of your brain is called the *cerebrum*. It looks like a mushroom cap. This dome-shaped area is where you think and where most memories are stored. The cerebrum controls voluntary movements. It also allows you to sense touch, light, sound, odors, taste, pain, heat, and cold.

The cerebrum is made up of two halves, called *hemispheres*. The left hemisphere directs the right side of the body, and the right hemisphere directs the left side of the body. **Figure 4** shows some of the activities that each hemisphere controls. However, most brain activities use both hemispheres.

Figure 4 **The Cerebral Hemispheres**

The **left hemisphere** primarily controls activities such as speaking, reading, writing, and solving problems.





The **right hemisphere** primarily controls activities such as thinking spatially, processing music, and interpreting emotions.

The Cerebellum

The second-largest part of your brain is the *cerebellum*. It lies beneath the back of the cerebrum. The cerebellum processes sensory information from your body, such as from skeletal muscles and joints. This information allows the brain to keep track of the body's position. Look at the girl in **Figure 5.** If she begins to lose her balance, her cerebellum sends impulses telling skeletal muscles to contract. Those muscles shift her weight and keep her from losing her balance.

Figure 5 *Your cerebellum causes skeletal muscles to make adjustments so that you will stay upright.*

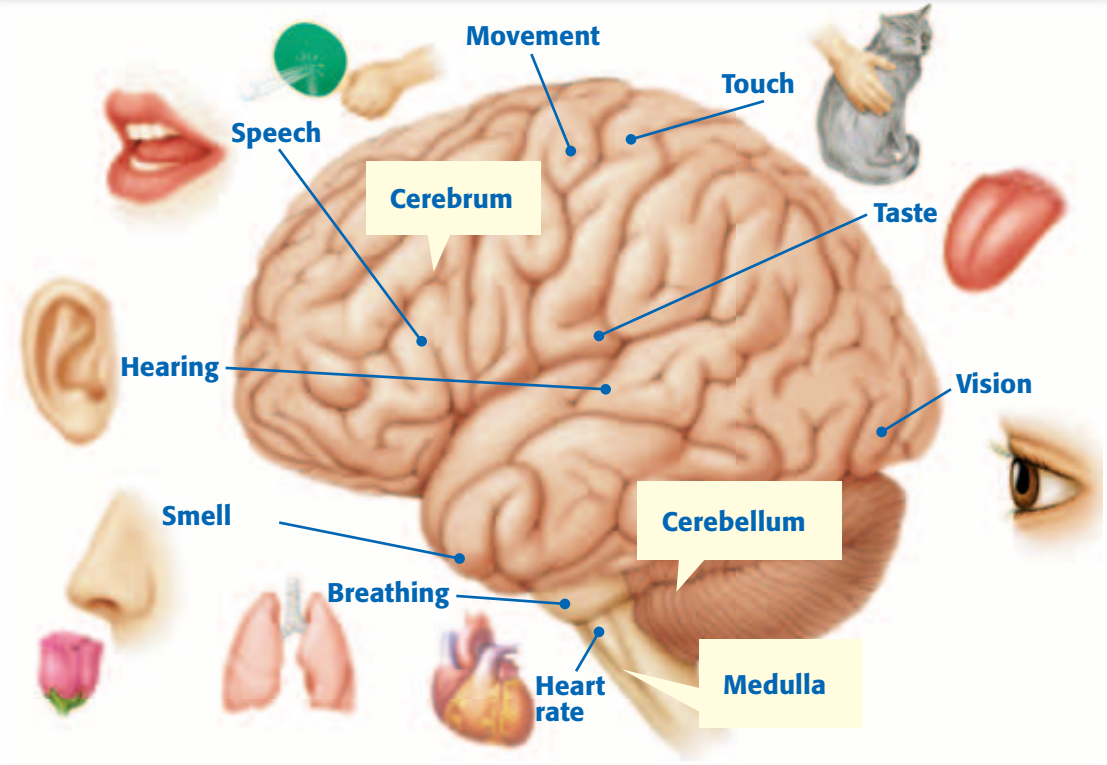
The Medulla

The *medulla* is the part of your brain that connects to your spinal cord. The medulla is about 3 cm long, and you can not live without it. The medulla controls involuntary processes, such as involuntary breathing and the regulation of blood pressure and heart rate.

Your medulla constantly receives sensory impulses from receptors in your blood vessels. It uses this information to regulate your blood pressure. If your blood pressure gets too low, the medulla sends out impulses that tell blood vessels to tighten up. As a result, blood pressure rises. The medulla also sends impulses to the heart to make the heart beat faster or slower. **Figure 6** shows the locations of the three main parts of the brain and some of the functions of each part.

Standards Check **Explain why the medulla is important.** 7.5.b

Figure 6 **Areas of the Brain at Work**



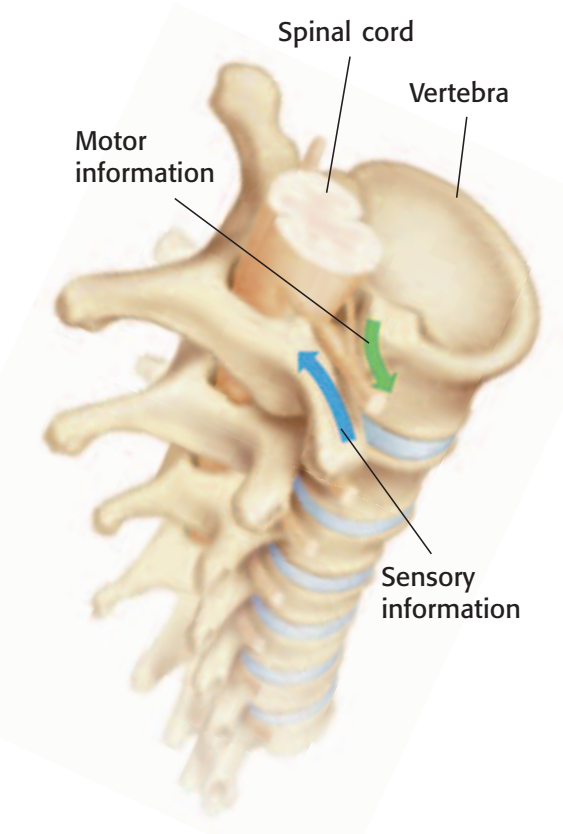


Figure 7 *The spinal cord carries information to and from the brain. Vertebrae protect the spinal cord.*

The Spinal Cord

Your spinal cord, which is part of your central nervous system, is about as big around as your thumb. The spinal cord is made of neurons and bundles of axons that pass impulses to and from the brain. As shown in **Figure 7,** the spinal cord is surrounded by protective bones called *vertebrae* (VUHR tuh BRAY).

The axons in your spinal cord allow your brain to communicate with your PNS. The axons of sensory neurons in your skin and muscles carry impulses to your spinal cord. The spinal cord relays these impulses to your brain. The brain interprets these impulses as pain, temperature, or other sensations. Then, the brain responds to the situation. Impulses moving from the brain down the spinal cord are relayed to motor neurons. The axons of motor neurons carry the impulses to muscles and glands all over your body.

Standards Check **Describe the path of an impulse from the skin to the brain and the path of the response.** 7.5.a

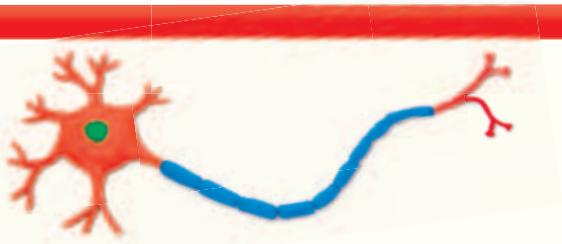
Spinal Cord Injury

A spinal cord injury may block all information to and from the brain. Sensory information coming from below the injury may not get to the brain. For example, a spinal cord injury may block all sensory impulses from the feet and legs. People who have such an injury can not sense pain, touch, or temperature with their feet. And motor commands from the brain to the injured area may not reach the peripheral nerves. So, the person may not be able to move his or her legs.

Each year, thousands of people are paralyzed by spinal cord injuries. Among young people, spinal cord injuries are sometimes related to sports or other activities. These injuries may be prevented by wearing proper safety equipment.

Quick Lab

Building a Neuron



7.5.a
7.7.d

1. Your teacher will provide **at least four colors of modeling clay.** Build a model of a neuron by using various colors of clay for the various parts of the neuron.
2. Use **tape** to attach your model to a **piece of plain white paper.**
3. On the paper, label each part of the neuron. Draw an arrow from the label to the part.
4. Use a **colored pencil, marker,** or **crayon** to draw arrows showing the path of an impulse traveling in your neuron. Tell whether the impulse is a sensory impulse or a motor impulse. Then, describe what will happen when the impulse reaches its destination.

20 min

SECTION Review

7.5.a, 7.5.b

Summary

- The central nervous system (CNS) is the brain and the spinal cord.
- The peripheral nervous system (PNS) is all of the parts of the nervous system except for the brain and spinal cord.
- Nerves in the peripheral nervous system are bundles of axons, blood vessels, and connective tissue.
- Sensory neurons have receptors that detect information about the body and its environment. Motor neurons carry messages from the brain and spinal cord to other parts of the body.
- The PNS has two types of motor neurons: somatic neurons and autonomic neurons.
- The cerebrum is the largest part of the brain and controls thinking, sensing, and voluntary movement.
- The cerebellum is the part of the brain that keeps track of the body's position and that helps maintain balance.
- The medulla controls involuntary processes, such as breathing and the regulation of heart rate, blood pressure, and body temperature.

Using Vocabulary

1. Write an original definition for *neuron* and *nerve.*
2. Use *brain* and *peripheral nervous system* in the same sentence.

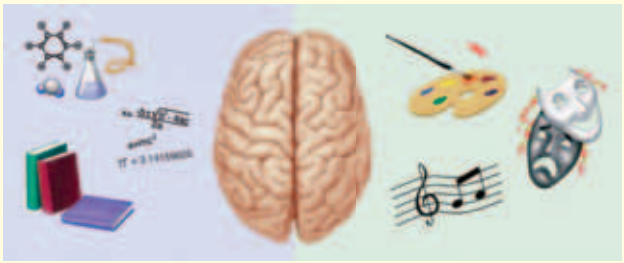
Understanding Concepts

3. **Describing** What is one function of each of the three main parts of the brain?
4. **Comparing** How are the somatic nervous system and the autonomic nervous system related?
5. **Analyzing** What is the relationship between the peripheral nervous system and the central nervous system?
6. **Evaluating** Explain how a severe injury to the spinal cord can affect other parts of the body.

Critical Thinking

7. **Applying Concepts** Some medications slow a person's nervous system. These drugs are often labeled "May cause drowsiness." Explain why a person needs to know about this side effect.
8. **Predicting Consequences** Explain how your life would change if your autonomic nervous system suddenly stopped working.
9. **Making Inferences** Briefly explain why the nervous system is made up of many smaller parts that have specialized functions.

INTERPRETING GRAPHICS Use the figure below to answer the next two questions.



10. **Identifying Relationships** Which hemisphere of the brain recognizes and processes words, numbers, and letters? faces, places, and objects?
11. **Analyzing Processes** For a person whose left hemisphere is primarily in control, would it be easier to learn to play a new computer game by reading the rules and following instructions or by watching a friend play and imitating his actions?

Challenge

12. **Analyzing Relationships** The nervous system is one of eleven systems of the human body. Describe how the other body systems depend on the nervous system to function. How does the nervous system depend on the other body systems?

Internet Resources

For a variety of links related to this chapter, go to www.scilinks.org

Topic: Nervous System

SciLinks code: HY71023