SECTION 1

The Nervous System

Which of the following activities do NOT involve your nervous system: eating, playing a musical instrument, reading a book, running, or sleeping?

This is a trick question. All of these activities involve your nervous system. In fact, your nervous system controls almost everything you do.

READING WARM-UP

Objectives

- Describe the relationship between the central nervous system and the peripheral nervous system.
- Compare the somatic nervous system with the autonomic nervous system.
- List one function of each part of the brain.

Terms to Learn

central nervous system
peripheral nervous system
neuron
nerve
brain

READING STRATEGY

Discussion Read this section silently. Write down questions that you have about this section. Discuss your questions in a small group.

Two Systems Within a System

The nervous system acts as the body's central command post. Its 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 (puh RIF uhr uhl) nervous system. The **central nervous system** (CNS) is your brain and spinal cord. The CNS processes and responds to all messages coming from the peripheral nervous system. The **peripheral nervous system** (PNS) is 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.

Reading Check **Explain the difference between the CNS and the PNS.** (*See the Appendix for answers to Reading Checks.*)

central nervous system (CNS) the brain and the spinal cord

peripheral nervous system (PNS) all of the parts of the nervous system except for the brain and the spinal cord

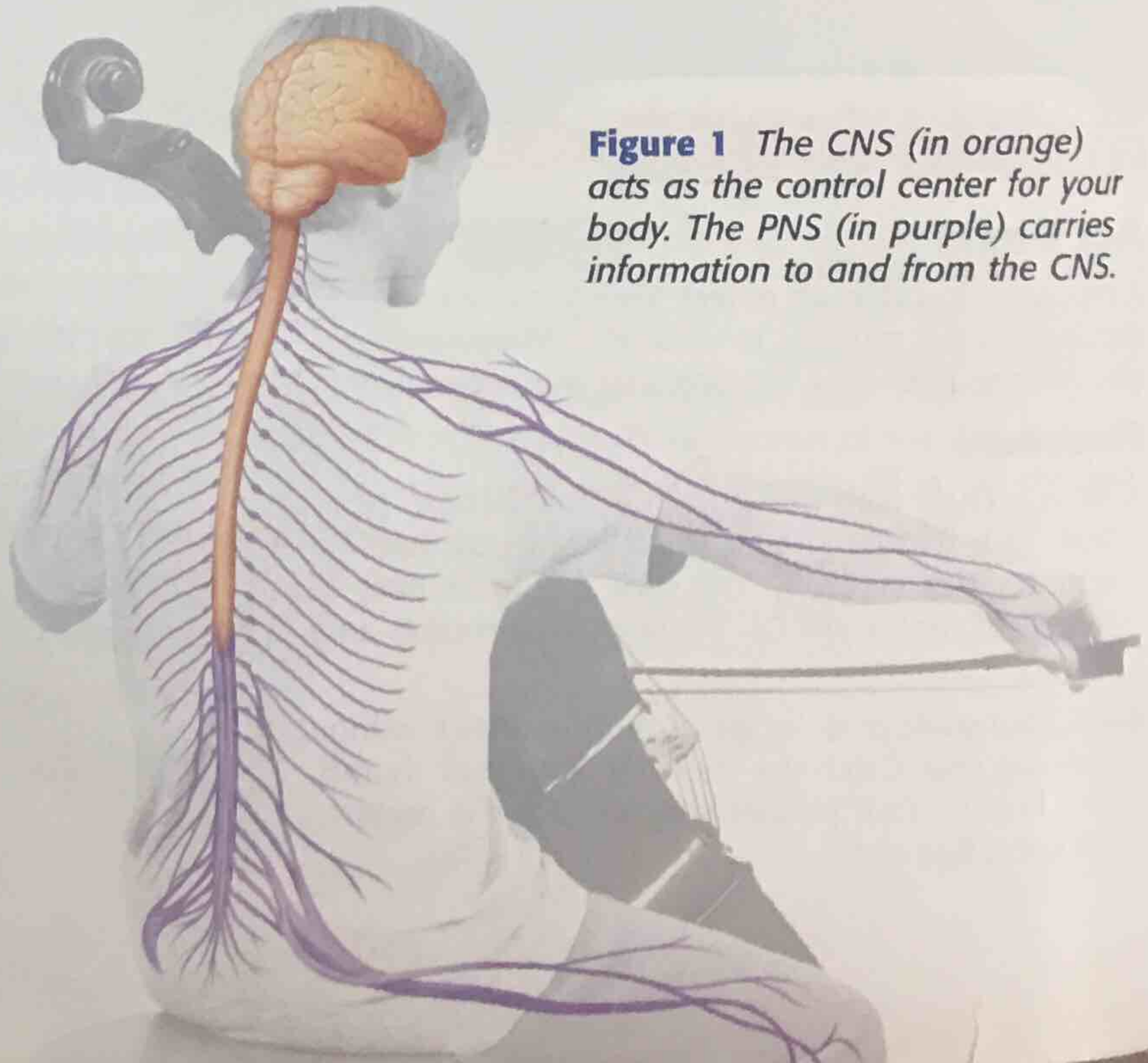


Figure 1 *The CNS (in orange) acts as the control center for your body. The PNS (in purple) carries information to and from the CNS.*

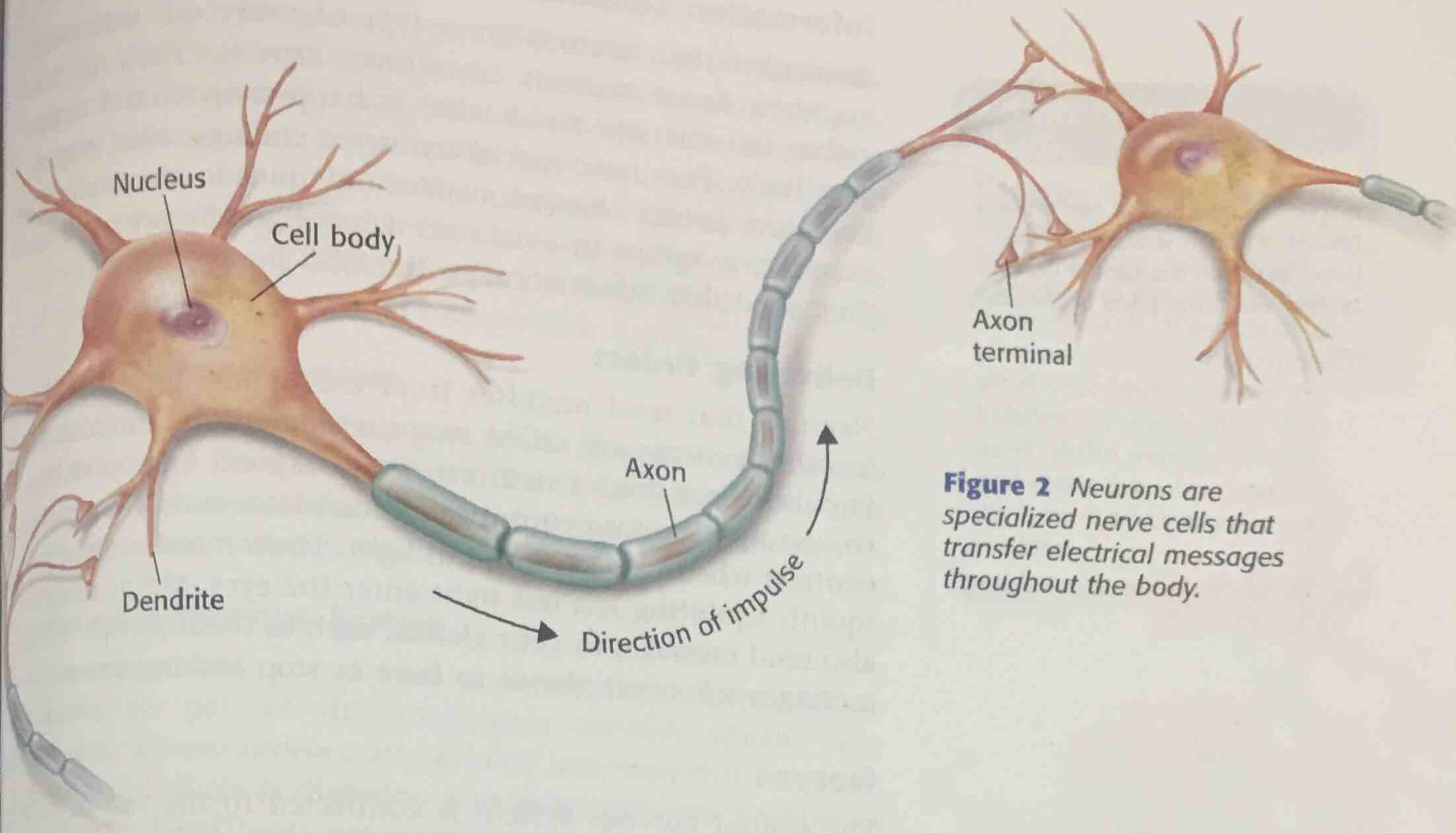


Figure 2 *Neurons are specialized nerve cells that transfer electrical messages throughout the body.*

The Peripheral Nervous System

Messages about your environment travel through the nervous system along neurons. A **neuron** (NOO RAHN) 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 a nerve cell that is specialized to receive and conduct electrical impulses

Neuron Structure

In many ways, a neuron is similar to other cells. A neuron has a large region in its center 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. Neurons receive information from other cells through their 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*.

Reading Check **In your own words, describe a neuron.**

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 would it take an impulse to travel 10 m?

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

Information Collection

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.

Delivering Orders

Neurons that send impulses from the brain and spinal cord to other systems are called *motor neurons*. When muscles get impulses from motor neurons, they 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. Squinting lets less light enter the eyes. Motor neurons also send messages to your glands, such as sweat glands. These messages tell sweat glands to start or stop making 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 everywhere in your body. Most nerves have axons of both sensory neurons and motor neurons. Axons are parts of nerves, but nerves are more than just axons. **Figure 3** shows the structure of a nerve. The axon in this nerve transmits information from the spinal cord to muscle fibers.

Reading Check **What is a nerve?**

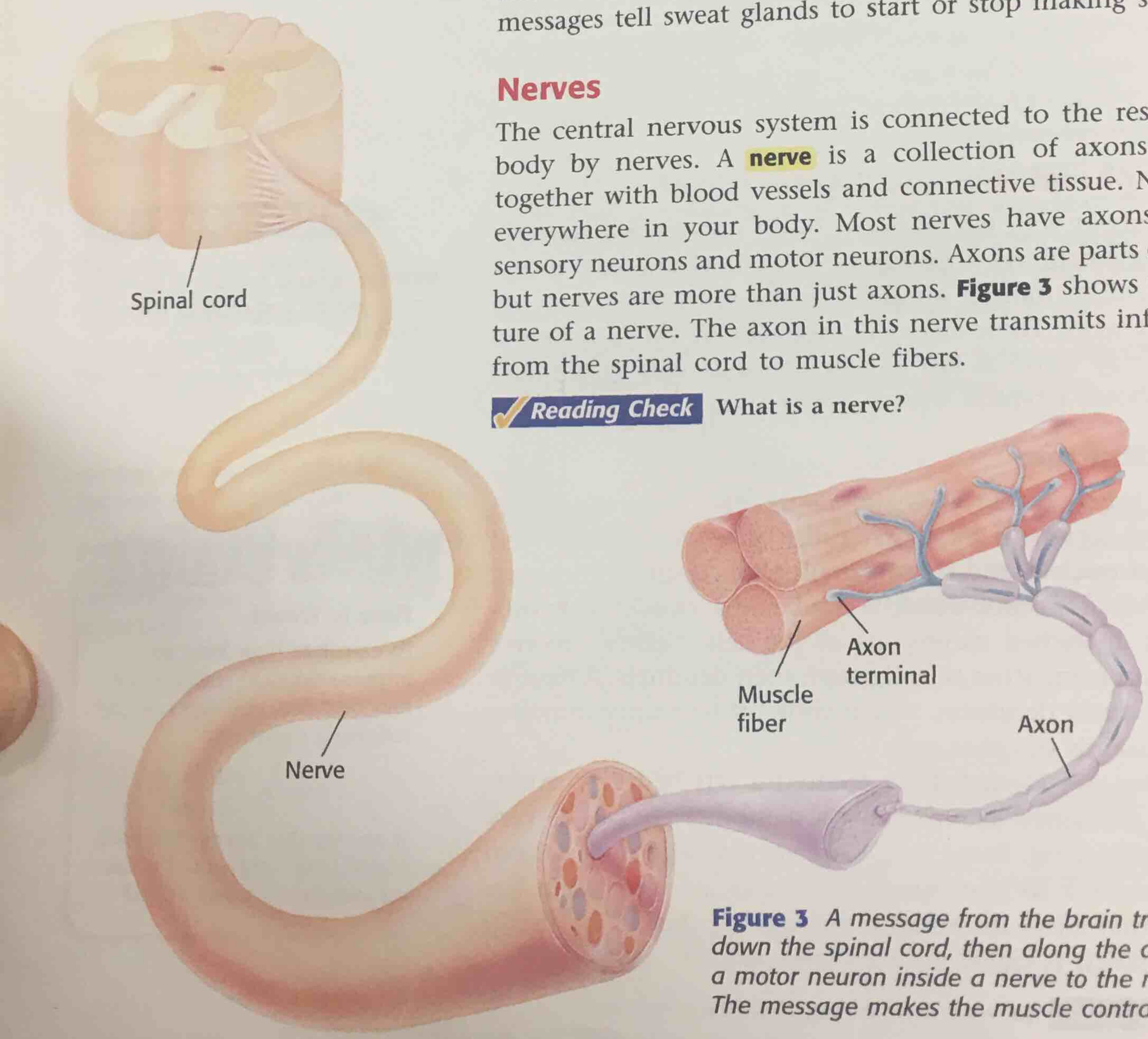


Figure 3 *A message from the brain travels down the spinal cord, then along the axon of a motor neuron inside a nerve to the muscle. The message makes the muscle contract.*

Somatic and Autonomic Nervous Systems

Remember, the PNS connects your CNS to the rest of your body. And the PNS has two main parts—the sensory part (sensory neurons) and the motor part (motor neurons). You know that sensory nerves collect information from your senses and send that information to the CNS. You also know that motor nerves carry out the CNS's responses to that sensory information. To carry those responses, the motor part of the PNS has two kinds of nerves: somatic nerves and autonomic nerves.

Somatic Nervous System

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

Autonomic Nervous System

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

The main job of the autonomic nervous system is to keep all 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 division* and the *parasympathetic division*. These two divisions work together to keep your internal environment stable. This is called *homeostasis*. Some of these functions are shown in **Table 1.**

Reading Check **Describe three functions of the PNS.**

CONNECTION TO Chemistry

Keeping Your Balance The autonomic nervous system has two parts—the sympathetic division and the parasympathetic division. These parts of your nervous system help keep all of your body systems in balance. Research these two parts of the nervous system, and make a poster showing how they keep your body healthy.

ACTIVITY

Table 1 Effects of the Autonomic Nervous System on the Body

Organ	Effect of sympathetic division	Effect of parasympathetic division
Eyes	pupils dilate (grow larger; makes it easier to see objects)	pupils constrict (vision normal)
Heart	heart rate increases (increases blood flow)	heart rate slows (blood flow slows)
Lungs	bronchioles dilate (grow larger; increases oxygen in blood)	bronchioles constrict
Blood vessels	blood vessels dilate (increases blood flow except to digestion)	little or no effect
Intestines	digestion slows (reduces blood flow to stomach and intestines)	digestion returns to normal

The Central Nervous System

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

The Control Center

brain the mass of nerve tissue 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 called *involuntary*. For example, you couldn't 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.

Reading Check **What is the difference between a voluntary action and an involuntary action?**

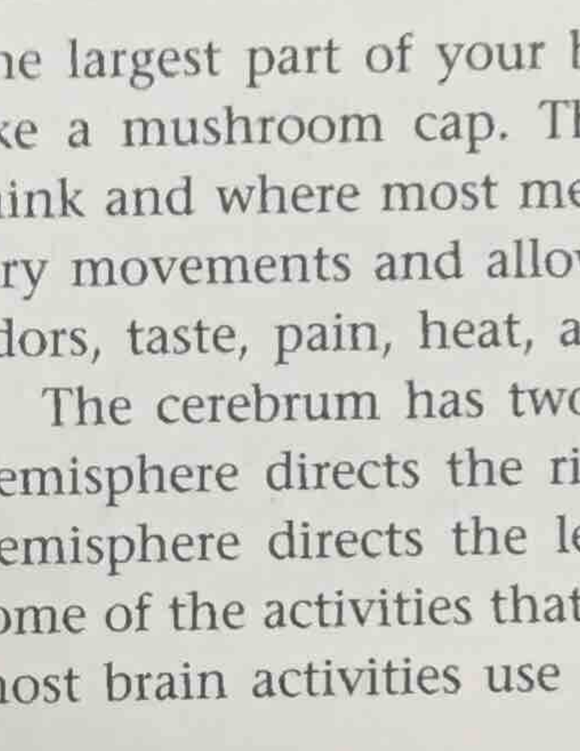
The Cerebrum

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. It controls voluntary movements and allows you to sense touch, light, sound, odors, taste, pain, heat, and cold.

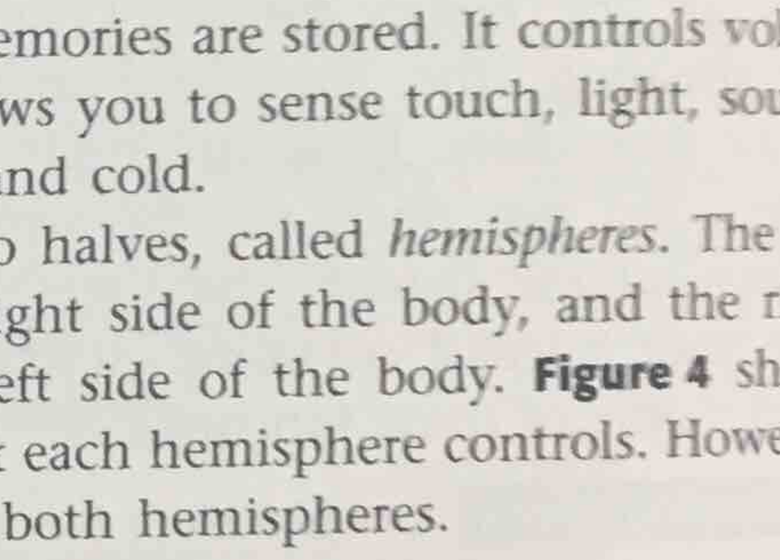
The cerebrum has two halves, called *hemispheres*. The left hemisphere directs the right side of the body, and the right hemisphere directs the left side of the body. **Figure 4** shows some of the activities that each hemisphere controls. However, most brain activities use both hemispheres.

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 spatial thinking, 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 allows the brain to keep track of your body's position. If you begin to lose your balance, the cerebellum sends impulses telling different skeletal muscles to contract. Those muscles shift a person's weight and keep a person, such as the girl in **Figure 5,** from losing her balance.

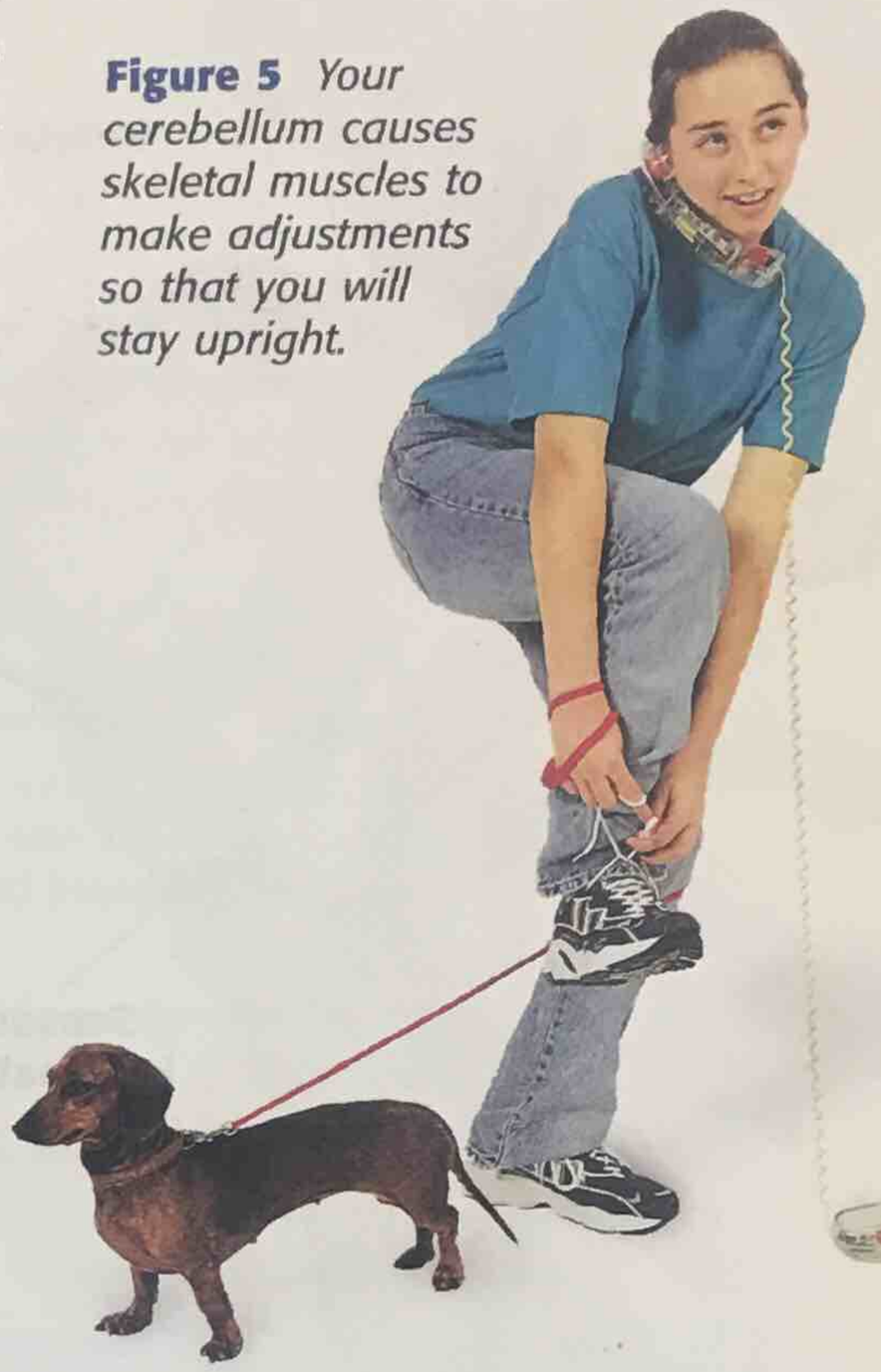


Figure 5 *Your cerebellum causes skeletal muscles to make adjustments so that you will stay upright.*

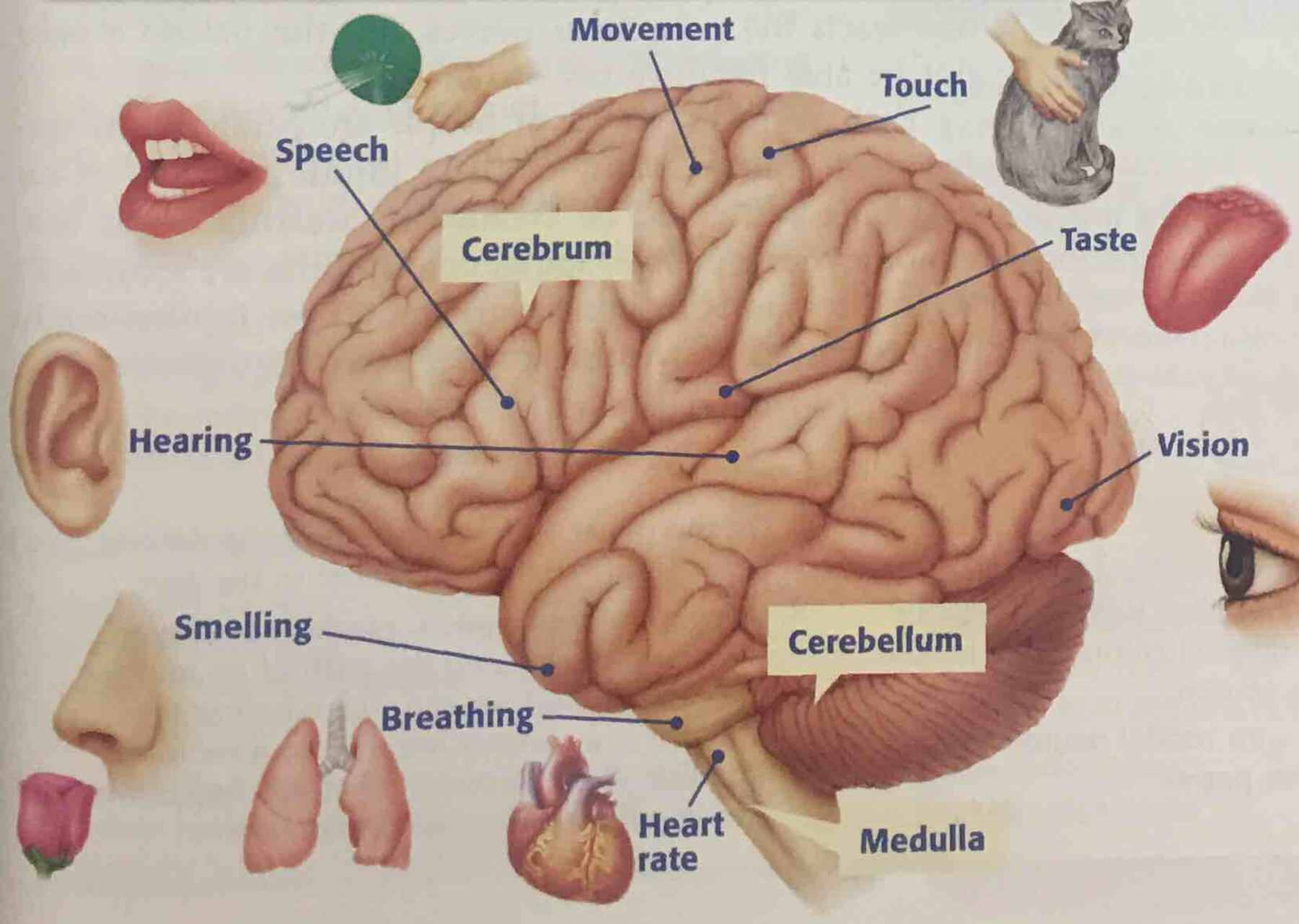
The Medulla

The *medulla* is the part of the brain that connects to your spinal cord. The medulla is about 3 cm long, and you can't live without it. It controls involuntary processes in other body systems, such as the circulatory system (blood pressure and heart rate) and the respiratory system (involuntary breathing).

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 location of the parts of the brain and some of the functions of each part.

Reading Check **Explain why the medulla is important.**

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



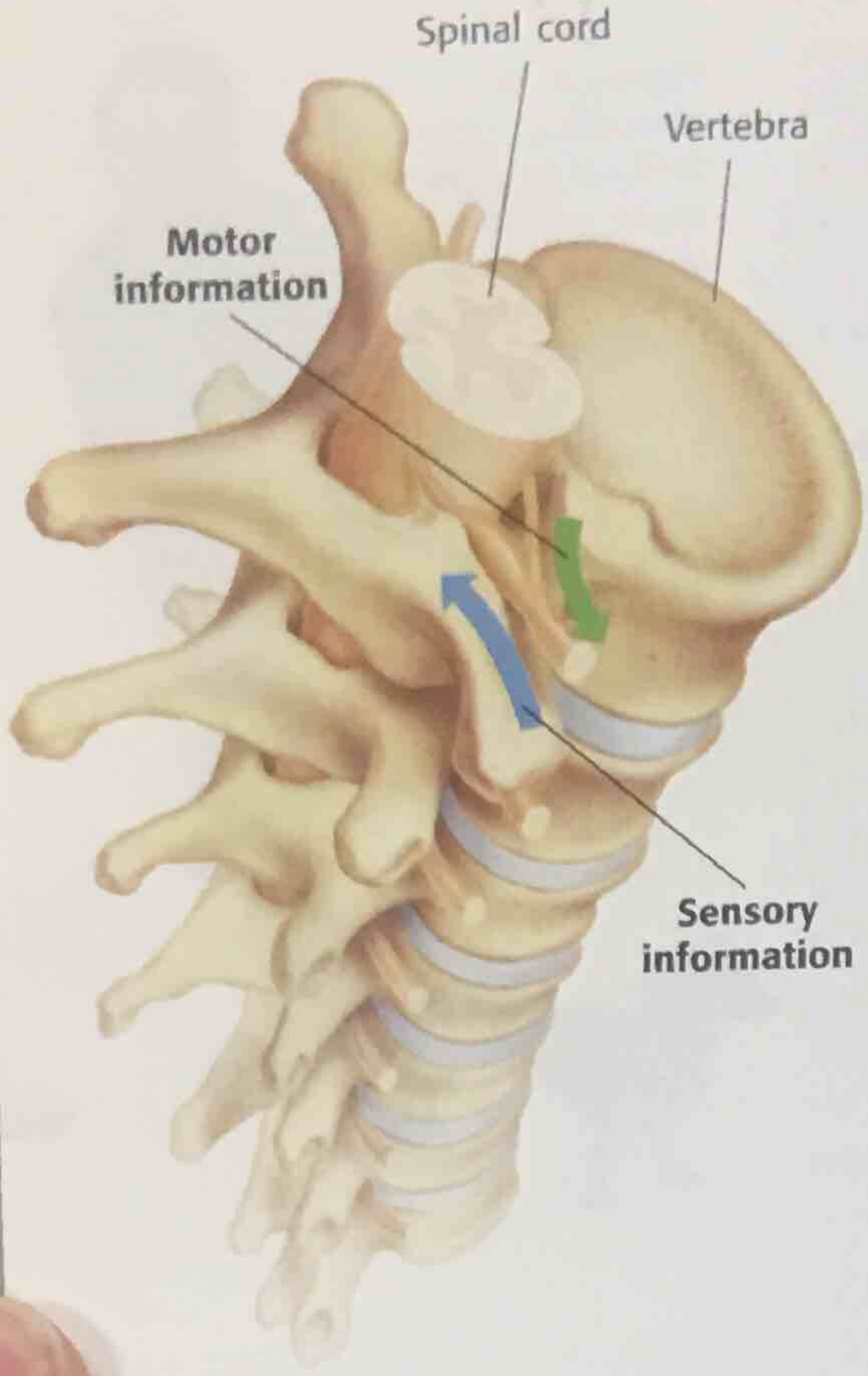


Figure 7 *The spinal cord carries information to and from the brain. Vertebrae protect the spinal cord.*

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 nerve fibers in your spinal cord allow your brain to communicate with your peripheral nervous system. Sensory neurons in your skin and muscles send impulses along their axons to your spinal cord. The spinal cord carries impulses to your brain. The brain interprets these impulses as pain, temperature, or other sensations. The brain then responds to the situation. Impulses moving from the brain down the spinal cord are relayed to motor neurons. Motor neurons carry the impulses along their axons to muscles and glands all over your body.

Reading Check **Describe the path of an impulse from the skin to the brain and the path of the response.**

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 with such an injury would not be able to 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 would not be able to move his or her legs.

Each year, thousands of people are paralyzed by spinal cord injuries. Many of these injuries happen in car accidents and could be avoided by wearing a seat belt. Among young people, spinal cord injuries are sometimes related to sports or other activities. These injuries might be prevented by wearing proper safety equipment.

QUICK LAB

Building a Neuron

1. Your teacher will provide at least four different colors of **modeling clay.** Build a model of a neuron by using different-colored clay for the various parts of the neuron.
2. Use **tape** to attach your model neuron 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. Using a **colored pencil, marker,** or **crayon,** 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.