# How the Nervous System Works

**Lab zone Standards Warm-Up**

### How May Systems Work Together?

1. Trace the outline of a penny in twelve different places on a piece of paper.
2. Number the circles 1 through 12. Write the numbers randomly, in no particular order.
3. Now, pick up the penny again. Put it in each circle, one after another, in numerical order, starting at 1 and ending at 12.

**Think It Over**

**Inferring** Make a list of all the sense organs, muscle movements, and thought processes used in this activity. Compare your list with your classmates' lists. Which organ systems were working together? What organ system coordinated all the different processes involved in this task?

The ball whizzes toward the soccer goalie. She lunges for the ball, and in one swift movement blocks it from entering the net. To tend goal, soccer players need excellent coordination and keen vision. In addition, they must remember what they have learned from years of practice.

Whether or not you play soccer, you too need coordination, memory, and the ability to learn. Your nervous system carries out all these functions. The nervous system includes the brain, spinal cord, and nerves that run throughout the body. It also includes sense organs, such as the eyes and ears.

## Functions of the Nervous System

The Internet lets people gather information from anywhere in the world with the click of a button. Like the Internet, your nervous system is a communications network. But it is much more efficient than the Internet.

**The nervous system receives information about what is happening both inside and outside your body. It also directs the way in which your body responds to this information. In addition, your nervous system helps maintain homeostasis.** Without your nervous system, you could not move, think, feel pain, or taste a spicy taco.

**Receiving Information** Because of your nervous system, you are aware of what is happening in the environment around you. For example, you know that a fly is buzzing around your head, that the wind is blowing, or that a friend is telling a funny joke. Your nervous system also checks conditions inside your body, such as the level of your blood pressure.

**Responding to Information** Any change or signal in the environment that can make an organism react is called a **stimulus** (STIM yoo lus) (plural: *stimuli*). A buzzing fly is a stimulus. After your nervous system analyzes the stimulus, it causes a response. A **response** is what your body does in reaction to a stimulus—you swat at the fly.

Some nervous system responses, such as swatting a fly, are voluntary, or under your control. However, many processes necessary for life, such as the beating of your heart, are controlled by involuntary actions of the nervous system.

**Maintaining Homeostasis** The nervous system helps maintain homeostasis by directing the body to respond appropriately to the information it receives. For example, when you need energy, your nervous system prompts you to feel hungry and then eat. This action maintains homeostasis by supplying your body with the nutrients and energy it needs.

**Reading Checkpoint** **What is a stimulus?**

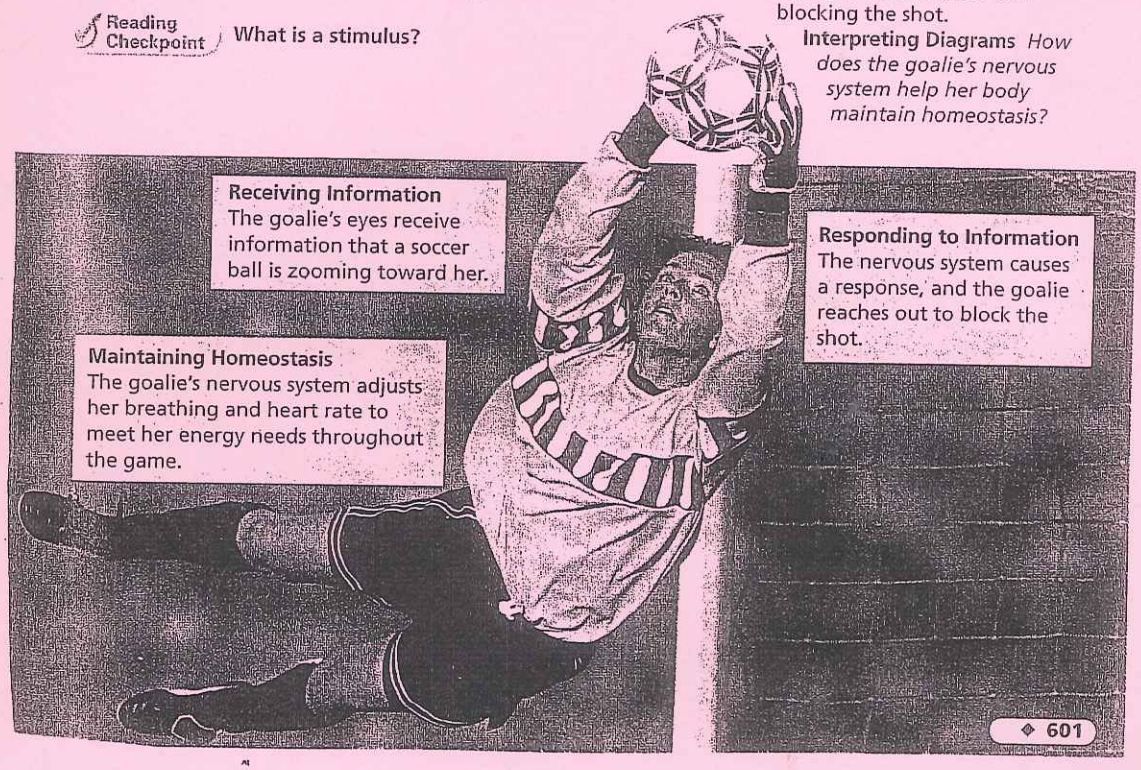
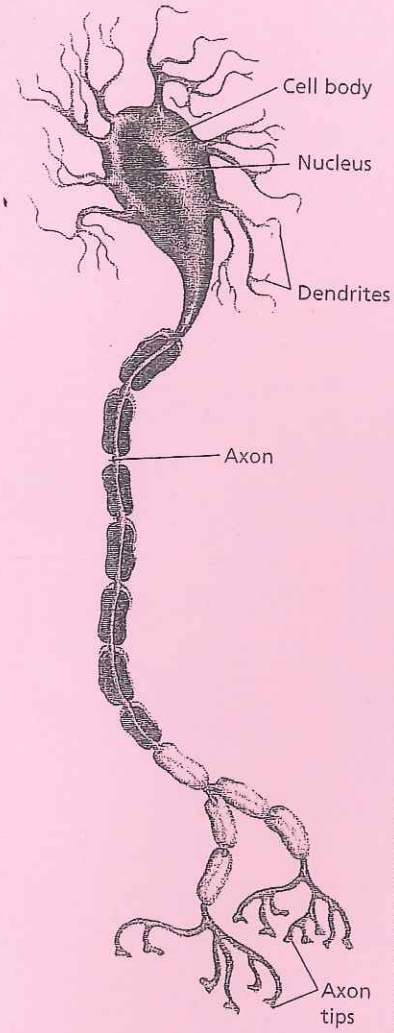



**FIGURE 1**
**The Nervous System at Work**
The zooming soccer ball is a stimulus. The goalie responds by lunging toward the ball and blocking the shot.
**Interpreting Diagrams** *How does the goalie's nervous system help her body maintain homeostasis?*

FIGURE 2
**Structure of a Neuron**
A neuron has one axon and many dendrites that extend from the cell body.




## The Neuron

Your nervous system includes various organs, tissues, and cells. For example, your brain is an organ, and the nerves running throughout your body are tissues. The cells that carry information through your nervous system are called **neurons** (NOO rahnz), or nerve cells. The message that a neuron carries is called a **nerve impulse.**

**The Structure of a Neuron** The structure of a neuron enables it to carry nerve impulses. **A neuron has a large cell body that contains the nucleus, threadlike extensions called dendrites, and an axon.** The **dendrites** carry impulses toward the neuron's cell body. The **axon** carries impulses away from the cell body. Find the dendrites and axon in Figure 2. Nerve impulses begin in a dendrite, next move toward the cell body, and then move down the axon. A neuron can have many dendrites, but it has only one axon. An axon, however, can have more than one tip, so the impulse can go to more than one other cell.

Axons and dendrites are sometimes called nerve fibers. Nerve fibers are often arranged in parallel bundles covered with connective tissue, something like a package of uncooked spaghetti wrapped in cellophane. A bundle of nerve fibers is called a **nerve.**

**Kinds of Neurons** **Three kinds of neurons are found in the body—sensory neurons, interneurons, and motor neurons.** Figure 3 shows how these three kinds of neurons work together.

A **sensory neuron** picks up stimuli from the internal or external environment and converts each stimulus into a nerve impulse. The impulse travels along the sensory neuron until it reaches an interneuron, usually in the brain or spinal cord. An **interneuron** is a neuron that carries nerve impulses from one neuron to another. Some interneurons pass impulses from sensory neurons to motor neurons. A **motor neuron** sends an impulse to a muscle or gland, and the muscle or gland reacts in response.

Reading Checkpoint What is the function of an axon?

## How a Nerve Impulse Travels

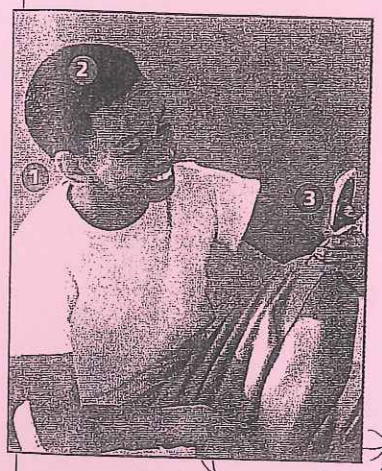
Every day of your life, billions of nerve impulses travel through your nervous system. Each of those nerve impulses begins in the dendrites of a neuron. The impulse moves rapidly toward the neuron's cell body and then down the axon until it reaches the axon tip. A nerve impulse travels along the neuron in the form of electrical and chemical signals. Nerve impulses can travel as fast as 120 meters per second!

FIGURE 3

## The Path of a Nerve Impulse

When you hear your phone ring, you pick it up to answer it. Many sensory neurons, interneurons, and motor neurons are involved in this action.

**Interpreting Diagrams** *To where does the impulse pass from the sensory neurons?*







**1 Sensory Neuron**
Nerve impulses begin when receptors pick up stimuli from the environment. Receptors in the ear pick up the sound of the phone ringing. The receptors trigger nerve impulses in sensory neurons.

**2 Interneuron**
From the sensory neurons, the nerve impulse passes to interneurons in the brain. Your brain interprets the impulses from many interneurons and makes you realize that the phone is ringing. Your brain also decides that you should answer the phone.

**3 Motor Neuron**
Impulses then travel along thousands of motor neurons. The motor neurons send the impulses to muscles. The muscles carry out the response, and you reach for the phone.

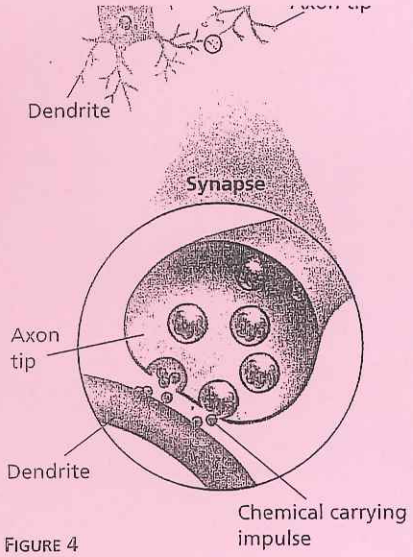



FIGURE 4
**The Synapse**
When a nerve impulse reaches the tip of an axon, chemicals are released into the gap at the synapse. The chemicals carry the nerve impulse across the gap.

reaches the axon tip at the end of a neuron? At that point, the impulse can pass to the next structure. Sometimes the structure is the dendrite of another neuron. Other times, the structure is a muscle or a cell in another organ, such as a sweat gland. The junction where one neuron can transfer an impulse to another structure is called a **synapse** (SIN aps).

**How an Impulse Is Transferred** Figure 4 shows a synapse between the axon tip of one neuron and the dendrite of another neuron. Notice that a small gap separates these two structures. **For a nerve impulse to be carried along at a synapse, it must cross the gap between the axon and the next structure. The axon tips release chemicals that carry the impulse across the gap.**

You can think of the gap at a synapse as a river, and an axon as a road that leads up to the riverbank. The nerve impulse is like a car traveling on the road. To get to the other side, the car has to cross the river. The car gets on a ferry boat, which carries it across the river. The chemicals that the axon tips release are like the ferry, carrying the nerve impulse across the gap.

## Section 1 Assessment

S 7.5.b, E-LA: Reading: 7.2.0

**Target Reading Skill** **Identify Main Ideas** Reread the text following the heading Functions of the Nervous System (pages 600–601). Note that the Key Concept is the main idea. List three details that support this main idea.

**Reviewing Key Concepts**

1. a. **Listing** What are three functions of the nervous system?
   b. **Describing** Give an example of a stimulus and describe how the nervous system produces a response.
   c. **Predicting** Your heart rate is controlled by involuntary actions of the nervous system. What would life be like if your heartbeat were under voluntary control?
2. a. **Identifying** Identify the three kinds of neurons that are found in the nervous system.
   b. **Explaining** How do the three kinds of neurons interact to carry nerve impulses?
   c. **Comparing and Contrasting** How do sensory neurons and motor neurons differ?
3. a. **Reviewing** What is a synapse?
   b. **Sequencing** Outline the steps by which a nerve impulse reaches and then crosses the gap at a synapse.

**Lab zone At-Home Activity**

**Pass the Salt, Please** During dinner, ask a family member to pass the salt to you. Observe what your family member then does. Explain that the words you spoke were a stimulus and that the family member's reaction was a response. Describe which structures of the nervous system detect stimuli and enable a response.

### How Does Your Knee React?

1. Sit on a table or counter so that your legs dangle freely. Make sure that your partner is not directly in front of your legs.
2. Have your partner use the side of his or her hand to tap one of your knees gently just below the kneecap. Observe what happens to your leg. Note whether you have any control over your reaction.
3. Change places with your partner. Repeat Steps 1 and 2.

**Think It Over**
**Inferring** When might it be an advantage for your body to react very quickly and without your conscious control?

You are standing at a busy street corner, waiting to cross the street. A traffic cop blows his whistle and waves his arms energetically. For the heavy traffic to move smoothly, there needs to be a traffic cop and responsive drivers. The traffic cop coordinates the movements of the drivers, and they steer the cars safely through the intersection.

Similarly, your nervous system has two divisions that work together. The **central nervous system** consists of the brain and spinal cord. The **peripheral nervous system** (puh RIF uh rul) includes all the nerves located outside of the central nervous system. The central nervous system is like a traffic cop. The peripheral nervous system is like the drivers and pedestrians.

## Central Nervous System

You can see the central and peripheral nervous systems in Figure 5. **The central nervous system is the control center of the body. It includes the brain and spinal cord.** All information about what is happening in the world inside or outside your body is brought to the central nervous system. The **brain,** located in the skull, is the part of the central nervous system that controls most functions in the body. The **spinal cord** is the thick column of nervous tissue that links the brain to most of the nerves in the peripheral nervous system.

Most impulses from the peripheral nervous system travel through the spinal cord to get to the brain. Your brain then directs a response. The response usually travels from the brain, through the spinal cord, and then to the peripheral nervous system.

For example, here is what happens when you reach under the sofa to find a lost quarter. Your fingers move over the floor, searching for the quarter. When your fingers finally touch the quarter, the stimulus of the touch triggers nerve impulses in sensory neurons in your fingers. These impulses travel through nerves of the peripheral nervous system to your spinal cord. Then the impulses race up to your brain. Your brain interprets the impulses, telling you that you've found the quarter. Your brain starts nerve impulses that move down the spinal cord. From the spinal cord, the impulses travel through motor neurons in your arm and hand. The impulses in the motor neurons cause your fingers to grasp the quarter.

**Reading Checkpoint** What are the parts of the central nervous system?

Go Online
active art

For: Nervous System activity
Visit: PHSchool.com
Web Code: cep-4062

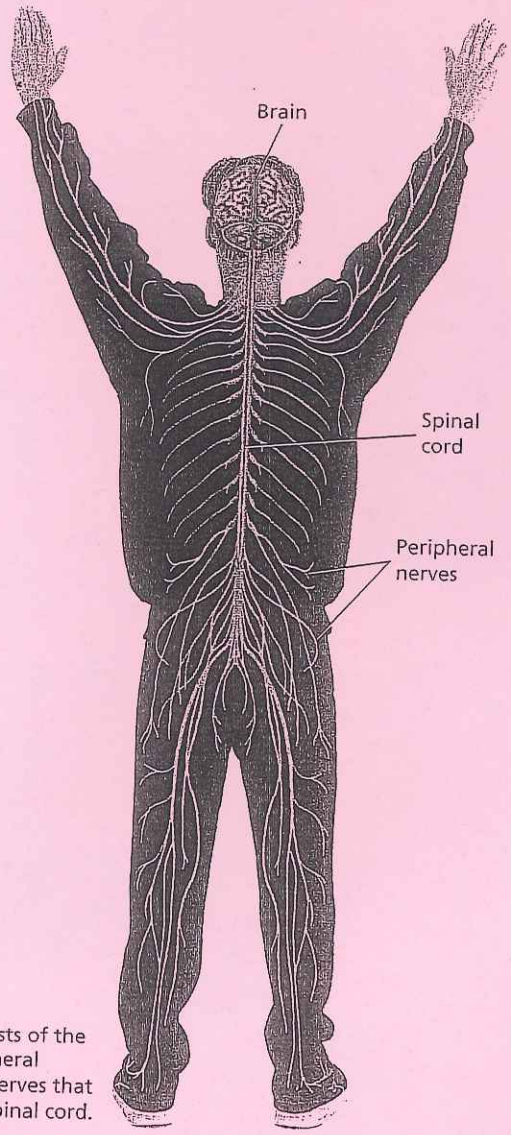



FIGURE 5
**The Nervous System**
The central nervous system consists of the brain and spinal cord. The peripheral nervous system includes all the nerves that branch out from the brain and spinal cord.

## The Brain and Spinal Cord

Your brain contains about 100 billion neurons, all of which are interneurons. Each of those neurons may receive messages from up to 10,000 other neurons and may send messages to about 1,000 more! Three layers of connective tissue cover the brain. The space between the middle layer and innermost layer is filled with a watery fluid. The skull, the layers of connective tissue, and the fluid all help protect the brain from injury.

**There are three main regions of the brain that receive and process information. These are the cerebrum, the cerebellum, and the brain stem.** Find each in Figure 6.

**Cerebrum** The largest part of the brain is called the cerebrum. The **cerebrum** (suh REE brum) interprets input from the senses, controls movement, and carries out complex mental processes such as learning and remembering. Because of your cerebrum, you can locate your favorite comic strip in the newspaper, read it, and laugh at its funny characters.

The cerebrum is divided into a right and a left half. The right half sends impulses to skeletal muscles on the left side of the body. In contrast, the left half controls the right side of the body. When you reach with your right hand for a pencil, the messages that tell you to do so come from the left half of the cerebrum. In addition, each half of the cerebrum controls slightly different kinds of mental activity. The right half is usually associated with creativity and artistic ability. The left half is usually associated with mathematical skills, language, and logical thinking.

As you can see in Figure 6, certain areas of the cerebrum are associated with smell, touch, taste, hearing, and vision. Other areas control movement, speech, written language, and abstract thought. Different tissues in the cerebrum carry out different functions.

**Cerebellum and Brain Stem** The second largest part of your brain is the cerebellum. The **cerebellum** (sehr uh BEL um) coordinates muscle action and balance. When you walk, the impulses that move your feet start in your cerebrum. However, your cerebellum gives you the muscular coordination and sense of balance that keep you from falling down.

The **brain stem,** which lies beneath the cerebrum and cerebellum, controls your body's involuntary actions—those that occur automatically. For example, neurons in the brain stem regulate your breathing and help control your heartbeat.

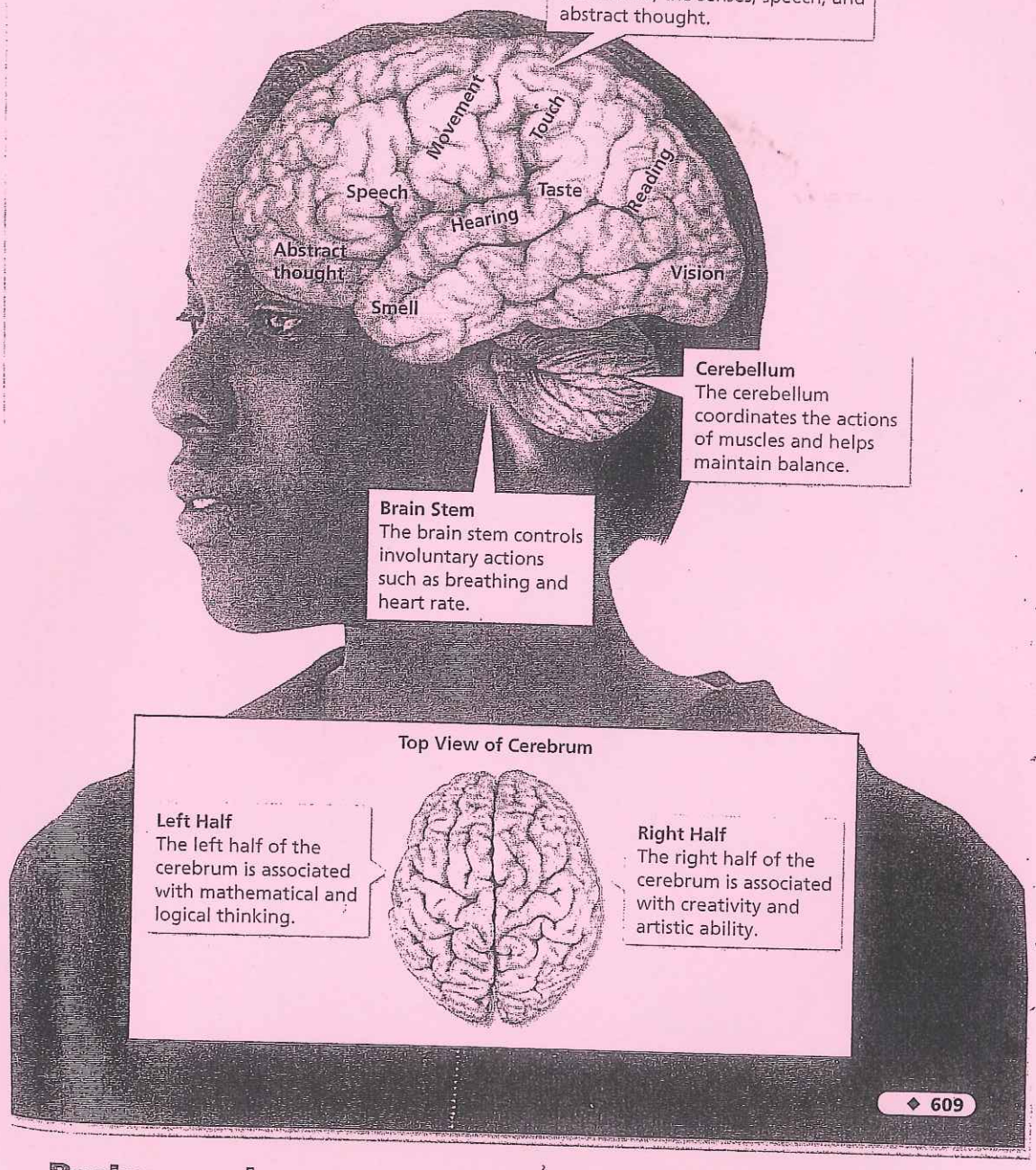
**Reading Checkpoint** What actions does the brain stem control?

FIGURE 6

## The Brain

Each of the three main parts of the brain—the cerebrum, cerebellum, and brain stem—carries out more than one specific function.

**Interpreting Diagrams** *What are three functions of the cerebrum?*






## Background

In the central nervous system, the gray matter is composed of the neurons' cell bodies and dendrites. It is where processing takes place. The gray matter includes the outer layer of the cerebrum, known as the cortex. The axons are covered with a protective sheathing. Because this sheathing is white, axons are called white matter. The function of the white matter is to communicate between gray matter areas and the rest of the body.

**The Spinal Cord** **The spinal cord is the link between your brain and the peripheral nervous system.** Run your fingers down the center of your back to feel the bones of the vertebral column. The vertebral column surrounds and protects the spinal cord. The layers of connective tissue that surround and protect the brain also cover the spinal cord. Like the brain, the spinal cord is further protected by a watery fluid.

## Peripheral Nervous System

The second division of the nervous system is the peripheral nervous system. **The peripheral nervous system consists of a network of nerves that branch out from the central nervous system and connect it to the rest of the body. The peripheral nervous system is involved in both involuntary and voluntary actions.**

A total of 43 pairs of nerves make up the peripheral nervous system. Twelve pairs originate in the brain. The other 31 pairs—the spinal nerves—begin in the spinal cord. One nerve in each pair goes to the left side of the body, and the other goes to the right. As you can see in Figure 7, spinal nerves leave the spinal cord through spaces between the vertebrae.

**How Spinal Nerves Function** A spinal nerve is like a two-lane highway. Impulses travel on a spinal nerve in two directions—both to and from the central nervous system. Each spinal nerve contains axons of both sensory and motor neurons. The sensory neurons carry impulses from the body to the central nervous system. The motor neurons carry impulses in the opposite direction—from the central nervous system to the body.

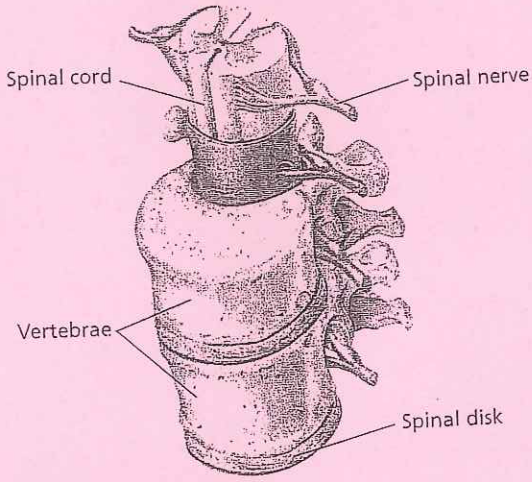



FIGURE 7
**The Spinal Nerves**
The spinal nerves, which connect to the spinal cord, emerge from spaces between the vertebrae. Each spinal nerve consists of both sensory and motor neurons.