Each day people use their senses—seeing, hearing, tasting, smelling, and touching—to observe God's world. But none of the information gathered by the senses would be of any value without a way to understand it. God designed a complicated network to gather and process, or interpret, information. This network is called the nervous system.

Even the most complex computer network cannot compare to the human nervous system. Just imagine all that is happening in your body while you read this paragraph! Your eyes gather information, and your ears hear sounds. Your hands touch the book. And besides all this, your nervous system keeps your heart beating and your lungs breathing without you even having to think about it. Your skin feels the temperature of the room, and your body stays balanced in your seat, all because of your nervous system. But that is only the beginning of the nervous system's responsibilities.

Many parts of the nervous system work together to allow a person to go white-water rafting.

Structure of the Nervous System

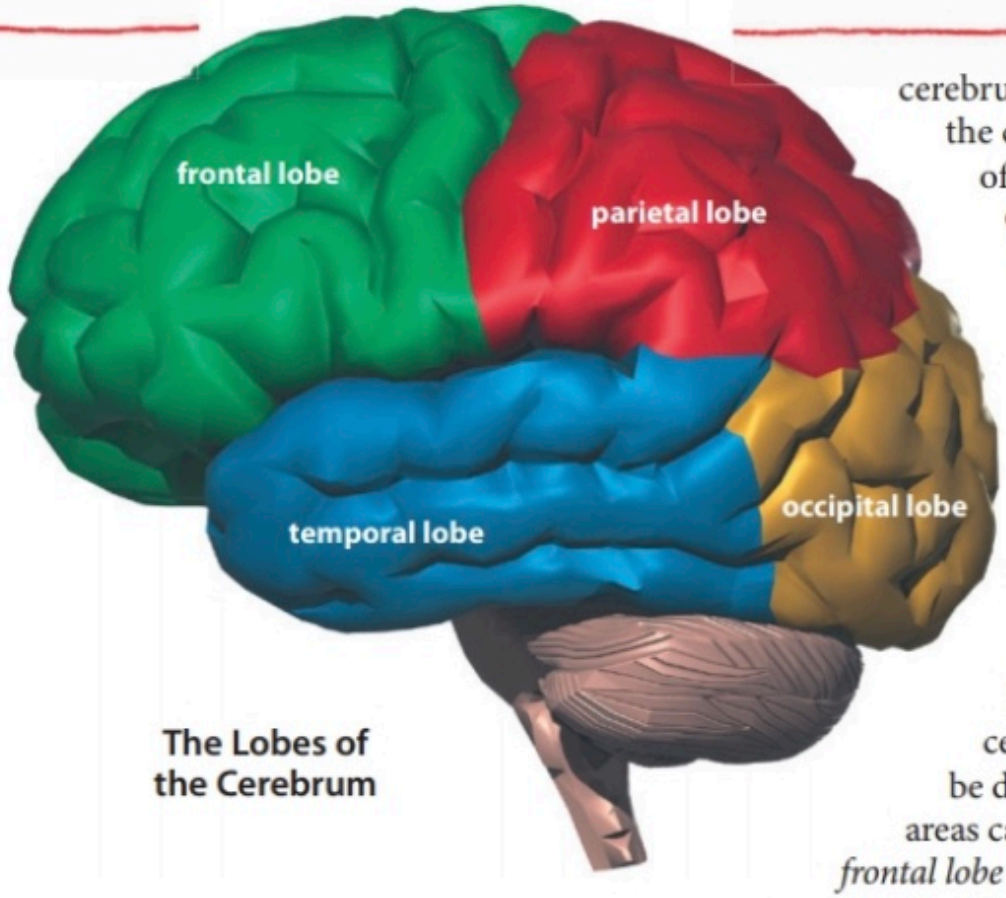
The nervous system is divided into two main parts. The **central nervous system** consists of the brain and the spinal cord. This part of the nervous system makes decisions and controls the body's actions. The **peripheral** (puh RIF ur ul) **nervous system** consists of millions of nerve cells that communicate with the central nervous system about what goes on in and around the body.

The Central Nervous System

Brain

The **brain** acts as the command center for the body. Thousands of pieces of data are transmitted to and from the brain every second. The brain organizes and interprets this information and tells the body how to respond. It not only controls actions and speech but also influences emotions. The brain is protected both by the skull and by *cerebrospinal* (sehr uh broh SPY nul) *fluid*. This fluid acts like a cushion and shock absorber for the brain and the spinal cord.

You might expect something as hard working as your brain to be quite large. Actually, the brain weighs only about 1.4 kg (3 lb)! It is shaped



The Lobes of the Cerebrum

like a large, wrinkly walnut. The brain has three distinct parts: the cerebrum (SEHR uh brum), the cerebellum (sehr uh BELL um), and the brain stem. Each part has different functions, but all three parts work together to allow you to live and interact with your environment.

The largest part of the brain is the **cerebrum**, which means "brain." The cerebrum takes up most of the space inside the skull. It can be divided into two halves, the left hemisphere and the right hemisphere. The left hemisphere controls the right side of the body, and the right hemisphere controls the left side of the body. These two halves of the cerebrum are connected in the center by a bundle of nerve fibers. Certain abilities and talents seem to be controlled by one side or the other, but in many cases of severe brain injury to one side, the other is able to take over.

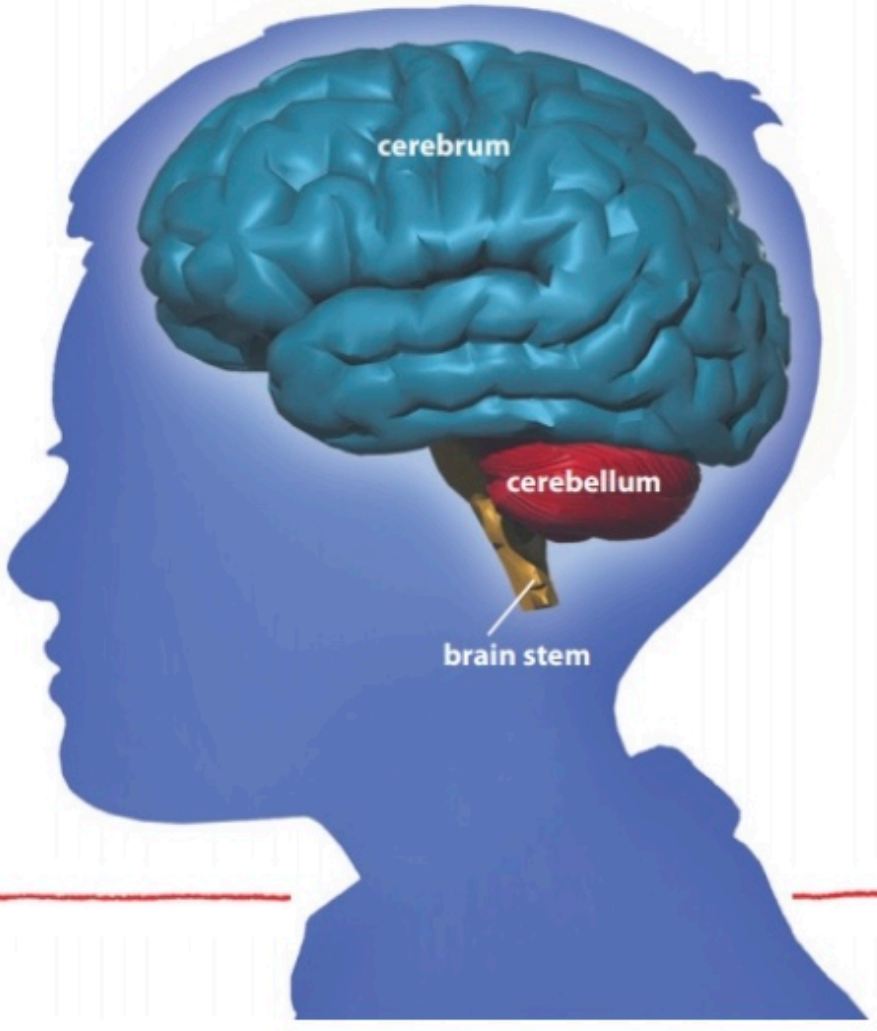
Each hemisphere of the cerebrum can also be divided into distinct areas called **lobes**. The *frontal lobe* controls conscious movement and makes a person alert to what is going on around him. It is the center of reasoning and decision making and also influences personality. The *parietal* (puh RY uh tul) *lobe* interprets pain, touch, and temperature, as well as some tastes and pressure on the skin. Another part, the *temporal* (TEM pur ul) *lobe*, deals with hearing, speech, and memory. This lobe helps classify sounds as speech, music, or noise. The *occipital* (ahk SIP uh tul) *lobe* stores information about what a person sees. This lobe receives messages from the eyes and interprets those messages. God designed each part of the cerebrum to help people understand and appreciate the world that He created.

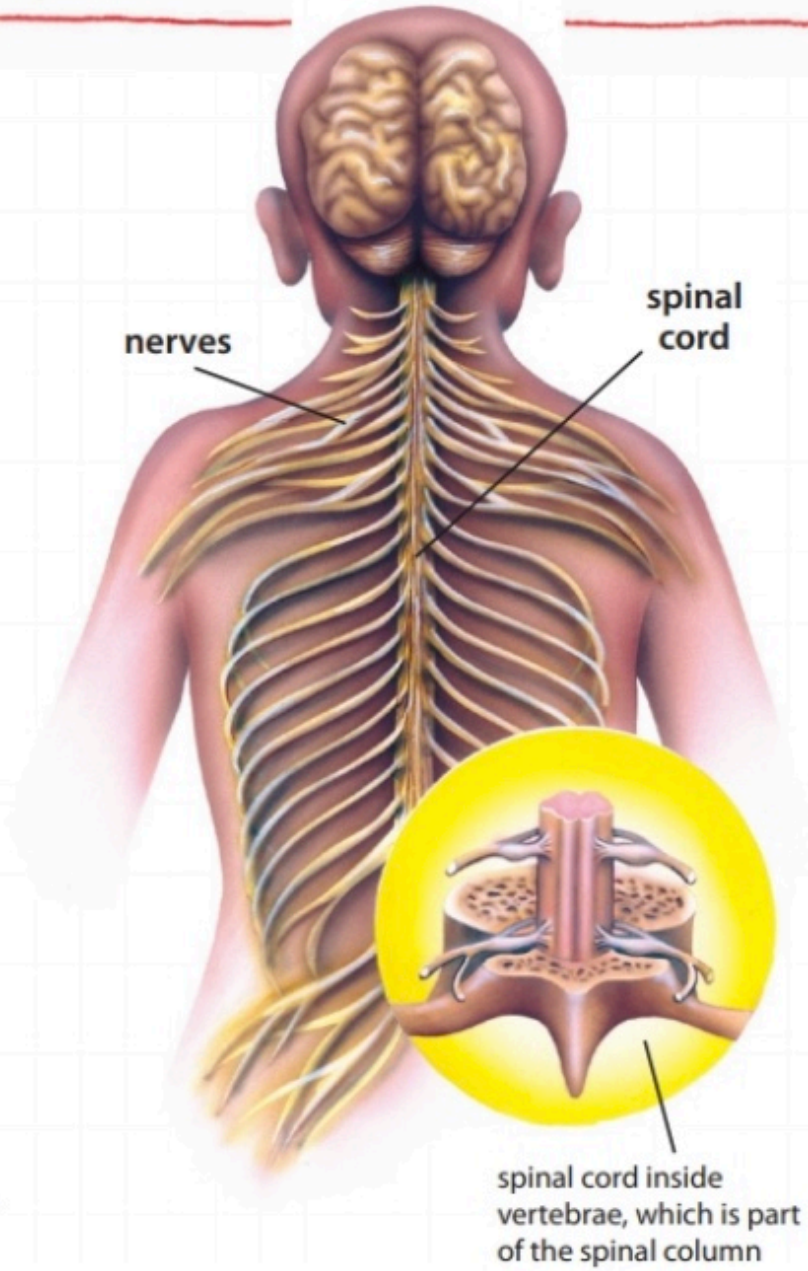
The next part of the brain is the **cerebellum**, which means "little brain." The cerebellum is located underneath the cerebrum and is much smaller. It receives orders from the frontal lobes and sends messages to muscles throughout the body in order to accomplish tasks. The cerebellum does not decide when or where a person should move, but it does control the speed and force with which he moves.

Whenever you learn a new activity, such as bike riding, the cerebrum directs your muscles. Once the activity has been learned, the cerebellum takes over. It remembers how to do that task. The cerebellum also helps to control balance and muscle coordination. If this part of the brain is damaged, a person may have difficulty with motor skills such as eating, talking, or walking.

The final part of the brain is the **brain stem**. The brain stem is located below the cerebrum and in front of the cerebellum. It connects the brain to the spinal cord. Part of the brain stem also controls the functions necessary for life, such as breathing, heartbeat, blood pressure, swallowing, and digestion. These are involuntary activities. You do not have to think about them to make them happen. God has designed our brains to operate some functions automatically. Think of how hard it would be if you had to remember to breathe, make your heart beat, and digest your food all at the same time.

Parts of the Brain





Spinal cord

Can you feel the bumpy bone that goes down the center of your back? That backbone, your *spinal column*, protects your spinal cord. The spinal cord is inside the tunnel made by the *vertebrae*, or bones, in your spinal column. It is surrounded by cerebrospinal fluid and covered by three membranes. These membranes act like filters, protecting the spinal cord from any harmful substances that may be in the blood stream.

God created the **spinal cord** to be the main pathway of information connecting the brain to the rest of the body. The spinal cord is a column of nerve fibers about as thick as one of your fingers. It will be about 43–45 cm (17–18 in.) long when you are an adult. Usually the spinal cord ends at a person's waist.

The spinal cord is divided into thirty-one sections. Each section has pairs of nerves that branch out from between the vertebrae in the spinal column. These nerves continue to branch out and reach all parts of the body. Nerves connect with every spot of skin as well as with each organ and muscle.

The central nervous system is a very important part of the body. Injuries to the brain or spinal column can result in problems such as blindness, paralysis, and loss of speech or movement. Sometimes an injury to the central nervous system can be fatal. That is one reason why it is important to wear the proper protective equipment for sports and other athletic activities.

QUICK CHECK

1. What functions does the central nervous system have?
2. What are the two main parts of the central nervous system?
3. What are the three parts of the brain?

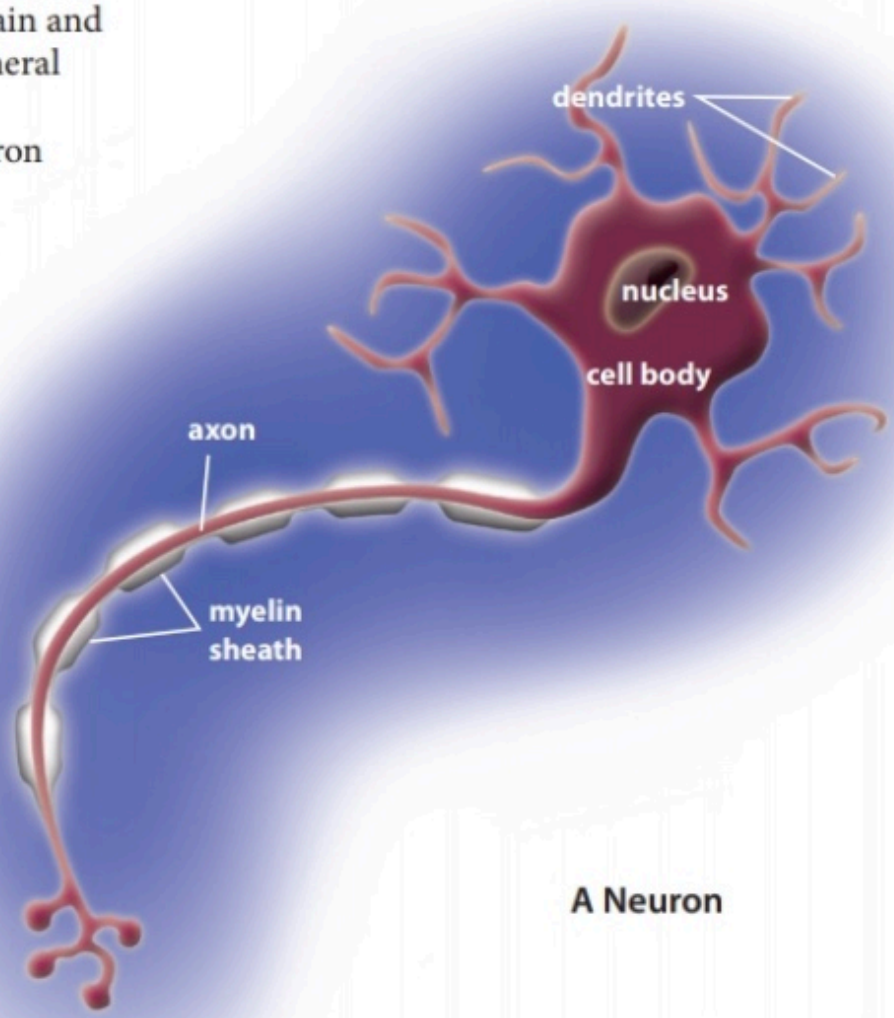
The Peripheral Nervous System

Neurons

When you stub your toe, how do you know that it hurts? Thousands of tiny nerve cells send a message up to your brain. The brain interprets the incoming message as pain, and you become aware that your toe is hurting. The nerve cells are called **neurons** (NUR AHNZ). In some ways neurons are similar to the other cells in your body. Each has a cell body with a nucleus, chromosomes, and DNA. But neurons also have the unique ability to communicate with each other. The neurons located outside the brain and spinal cord make up the peripheral nervous system.

The shape and size of a neuron depend on its function and location in the body. Some neurons are **sensory neurons**. They carry messages to the brain. Others are **motor neurons**, sending messages from the brain and spinal cord to the muscles. Neurons can live for a long time, longer than most cells. However, most neurons that die are not replaced.

The **dendrite** (DEN dryt) receives the electrical **impulse**, or message, from another neuron. The dendrite passes that message to the cell body. The cell body passes the message to the **axon** (AK sahn), which sends the impulse on to the next neuron. Although a neuron usually has only one axon, it can have many dendrites. Some nerve cells have as many as 10,000 dendrites! The nerve fibers in your body are actually bundles of axons and dendrites from many neurons. Your body has over ten billion long and microscopically thin nerve cells. Some of the longest neurons have axons more than a meter long.



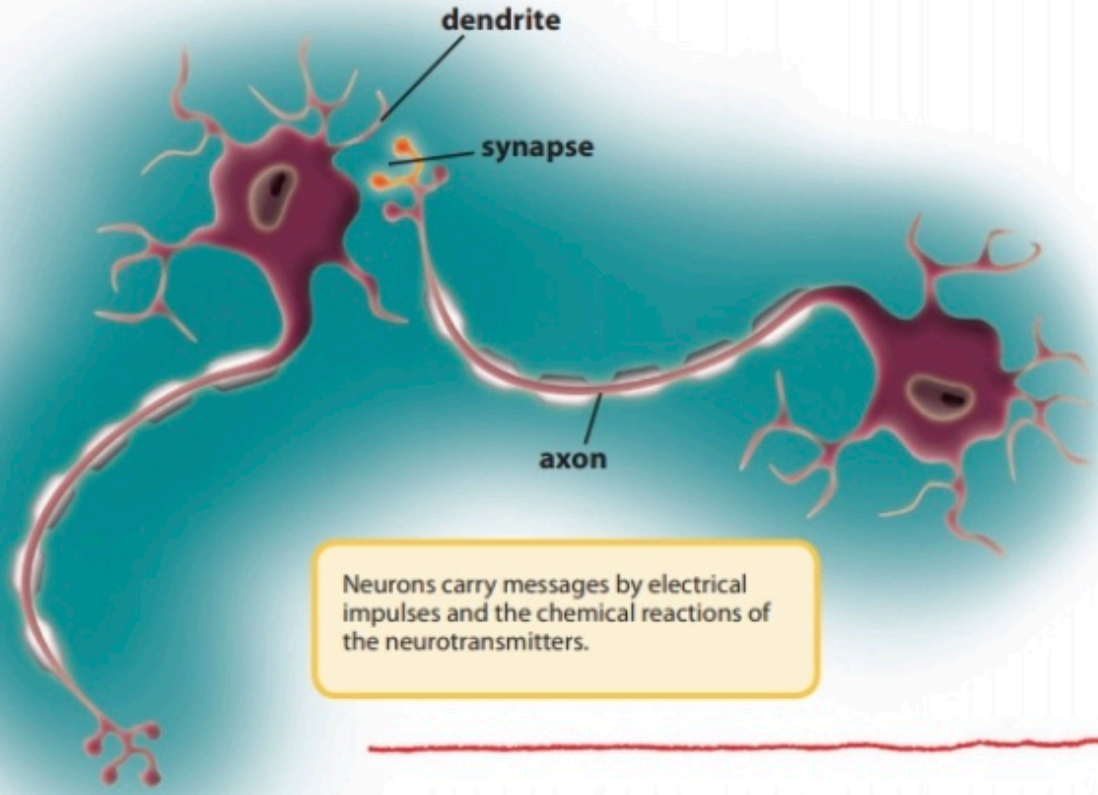
A Neuron

Even though your body contains billions of neurons, the neurons do not touch each other in order to send messages to and from the brain. If you touch a paper clip to your finger, the paper clip presses against the dendrites in your skin. The pressure you feel travels as an electrical impulse through the dendrites, to the cell bodies, and then to the axons.

Between each neuron is a little gap called a **synapse** (SIN aps). As the electrical impulse arrives at the synapse, the electricity causes chemicals called *neurotransmitters* (NUR oh TRANZ mit urz) to be released. These chemicals cross the synapse and carry the message on to the next sensory neuron. The impulse continues from neuron to neuron, sometimes as fast as 120 m (400 ft) per second. This impulse could travel the length of a football field in less than one second.

When the sensation reaches your brain, the brain interprets it and lets your finger know that it is experiencing pressure. By the time you feel the pressure of the paper clip, the message has already traveled to the brain, been interpreted, and traveled back through the motor neurons to tell your finger to move. The amount of electricity involved in sending the nerve message to the brain is about one-tenth of a volt.

God gave some axons a protective covering called a *myelin* (MYE uh lin) *sheath*. This extra insulation helps the neuron send messages faster. Because myelin sheaths are white, areas of the nervous system with myelin sheaths are called white matter. Areas of the central nervous system where the neurons do not have myelin sheaths are sometimes called gray matter.



Neurons carry messages by electrical impulses and the chemical reactions of the neurotransmitters.

Somatic nervous system

The peripheral nervous system can be separated into two parts. One part, the *somatic* (soh MAT ik) *nervous system*, controls your skeletal muscle movements. The somatic nervous system helps your body adjust to its external environment. The sensory neurons gather information about things in your environment and send that information to your central nervous system. The central nervous system then sends messages to your muscles, making them contract and relax as you move.

Autonomic nervous system

The peripheral nervous system also helps to regulate your internal environment. This part of the peripheral nervous system is sometimes called the *autonomic nervous system* because it controls involuntary activities. Usually you do not have conscious control over these activities.

For example, the autonomic nervous system controls your heart rate. Stress or fear can cause your heart to beat faster. But when you are resting or digesting food, the autonomic nervous system slows your heartbeat. The autonomic nervous system also helps your body maintain a constant temperature. When you are cold, your body starts to shiver. If you get too warm, your body releases perspiration through its pores. All of these reactions happen automatically.

The autonomic nervous system also regulates your blood pressure, breathing, digestion, and many other bodily functions. If you had to think about each one of these activities in order for it to occur, you would probably not be able to do anything else! The autonomic nervous system uses motor neurons to keep your body running smoothly. It works continuously, even when you are sleeping.

Reflexes

Sometimes your body responds to a situation before your brain makes a conscious decision. For example, if you touch a hot stove accidentally, the electrical impulse immediately begins to travel from neuron to neuron until it reaches the spinal cord. Before the impulse passes on to the brain, an automatic message is sent back to your hand, telling your muscles to move your fingers away from the hot stove.

While this is happening, the impulse continues to the brain. Your brain interprets the message, and you realize that you are touching something hot and should move your hand. Since the whole process happens so quickly, you do not notice the time difference. From the time you touch the stove until you move your hand and your brain registers what has happened, less than one-thousandth of a second has passed.

Even though this seems to happen all at once, you actually pull your hand back before your brain tells you that there is pain. This is called a reflex. A **reflex** is an action that happens before the brain has time to think about the action. A reflex is hard—sometimes impossible—to control.

FANTASTIC FACTS

What triggers you to sneeze? This reflex usually happens whenever the lining of the nose becomes irritated by foreign particles, such as dust or pollen. Scientists have found that a person can sneeze about as fast as a baseball pitcher can pitch a fastball. Some sneezes have been as fast as 150 km/h (about 100 mi/h). Sneezes can be quite powerful because they involve not only the nose but also muscles in the chest, abdomen, face, throat, and eyelids. Sneeze droplets can travel as far as 1.5 m (5 ft) before they settle.

QUICK CHECK

1. What is the difference between sensory and motor neurons?
2. What is the purpose of the autonomic nervous system?
3. How are reflexes different from other muscle movements?