Interactions with the Nervous System

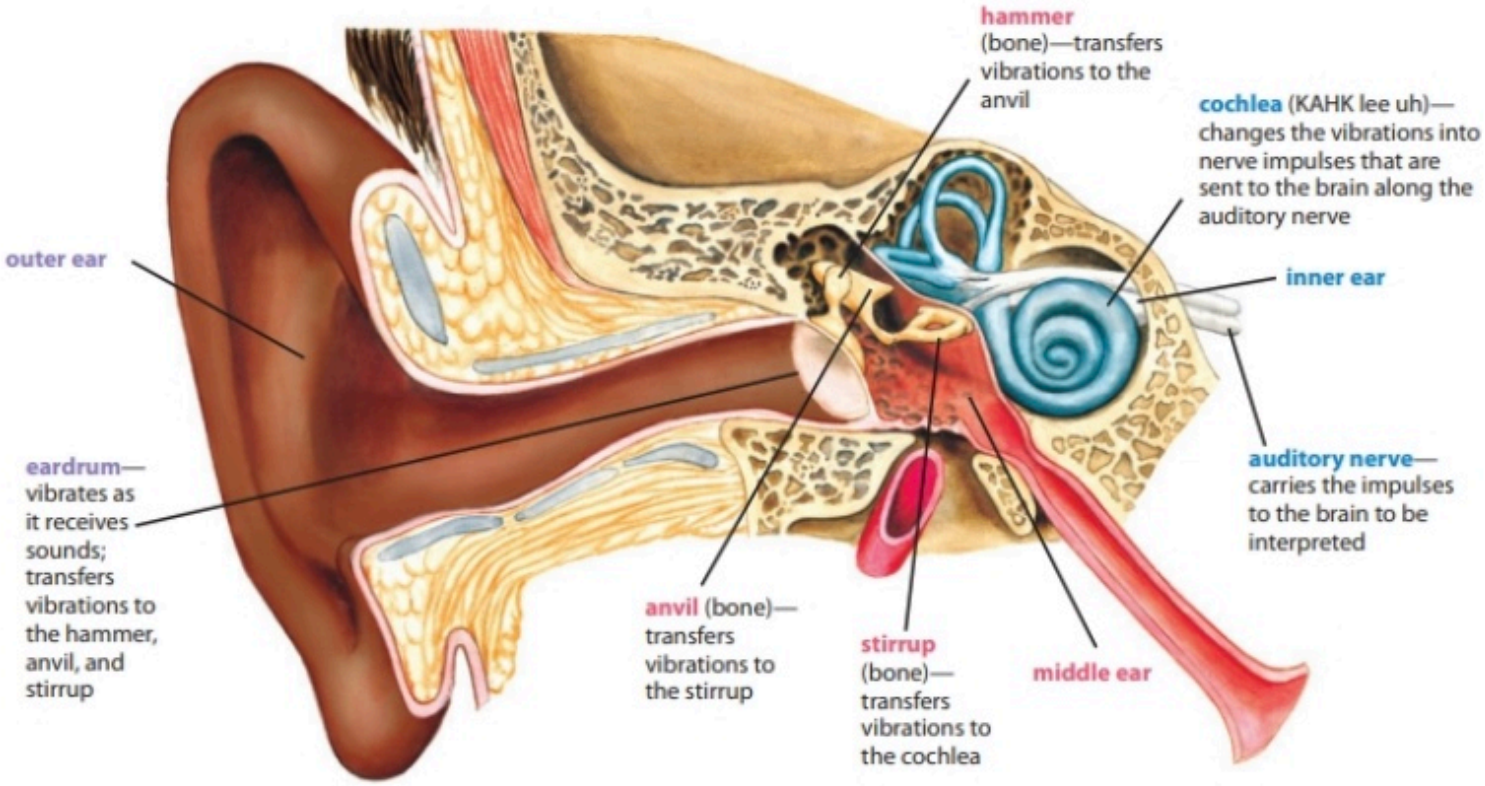
The Five Senses

Our five senses help us to be aware of the world around us. Without these senses we would not be able to understand or appreciate God's creation. But our senses only gather information. The interaction of the senses and the central nervous system allows us to interpret the sensory information, or stimuli, that is gathered. All five senses can function only with the help of the nervous system.

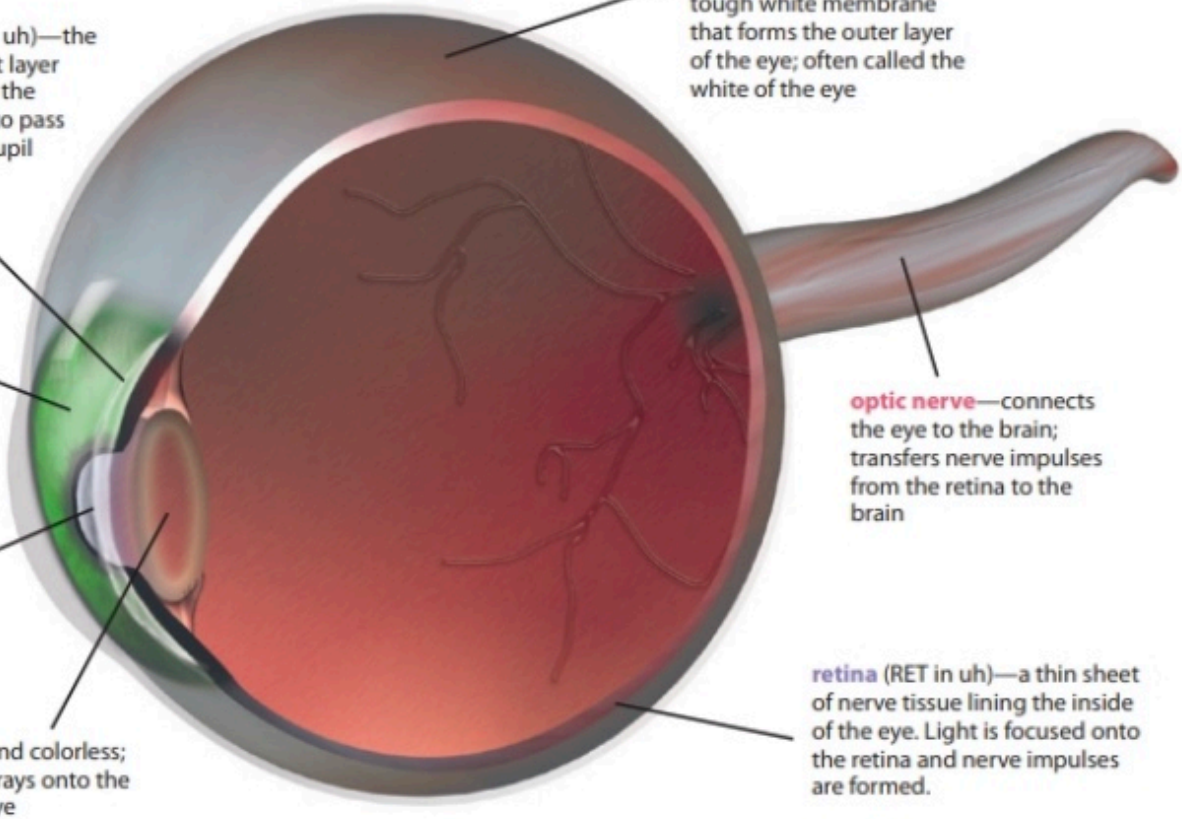
Hearing

Sound waves, caused by vibrations, are funneled into the ear canal by the outer ear. The vibrations continue to move through the middle ear and inner ear, where the cochlea changes them into nerve impulses. Finally, the impulses reach the brain, which interprets them to let you know what sounds you are hearing. Without your brain to interpret the sounds, your ear would still receive sound waves, but the vibrations of your ear would have no meaning to you.

The Ear



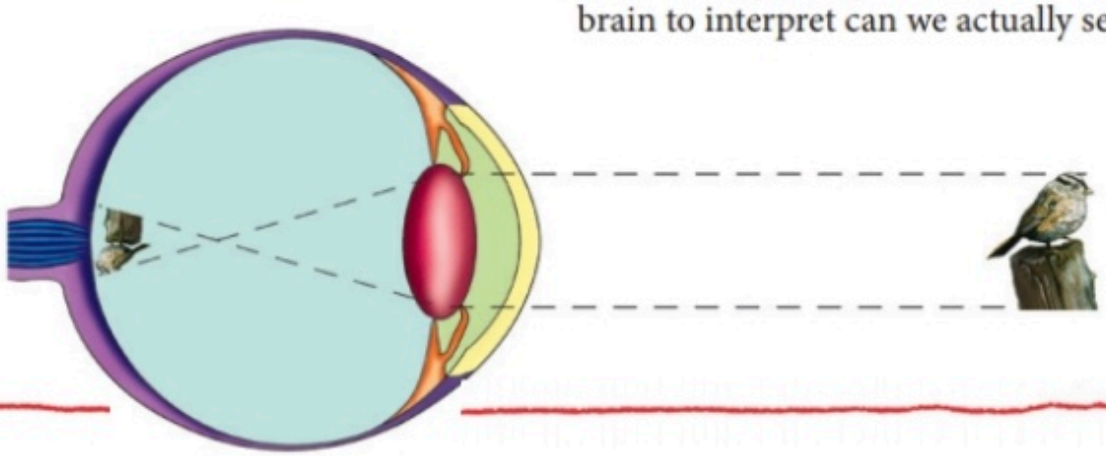
The Eye



Sight

Without light you would not be able to see anything. When light bounces off objects, the parts of the eye work together to allow the brain to see an image. However, images received by the brain are upside down. The brain flips the images over and recognizes what you are seeing.

We speak of the eye as seeing. But the eye only provides the means for the brain to receive sensory information. Only as the sensory receptor neurons in the retina collect information and send it along the optic nerve for the brain to interpret can we actually see.



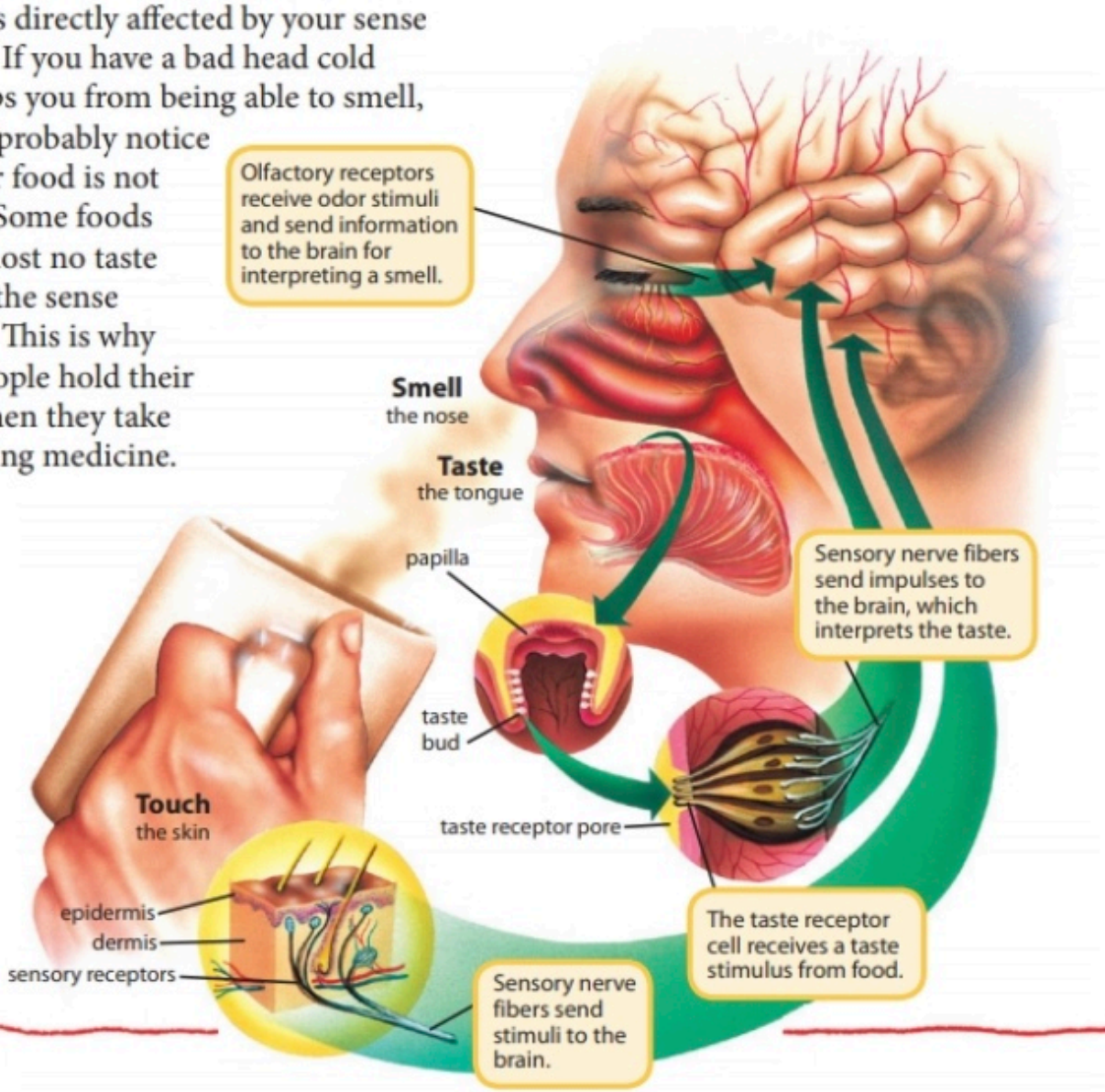
Taste

Taste buds help us recognize different tastes and flavors. If you look inside your mouth, you will see lots of tiny bumps, called papillae (puh PILL ee) all over your tongue. Those bumps are not taste buds. The taste buds are located inside the bumps. Some bumps contain only a few taste buds, but others have more than one hundred taste buds.

Inside the taste buds are sensory receptors. The receptors receive the taste and send it along to the brain to be interpreted. The brain then decides what the taste is. However, your sense of taste is directly affected by your sense of smell. If you have a bad head cold that keeps you from being able to smell, you will probably notice that your food is not as tasty. Some foods have almost no taste without the sense of smell. This is why some people hold their noses when they take bad-tasting medicine.

Smell

The air contains many different odor particles. As you breathe in, air enters into the nasal cavity. Inside the nasal cavity, the odor particles first pass through a thick layer of mucus. Then they float up to the top of the nasal cavity. *Olfactory* (ohl FAK tuh ree) *receptor cells* detect the particles and send impulses to the olfactory nerve. The olfactory nerve sends the impulses to the brain. The brain interprets the message and identifies the smell.



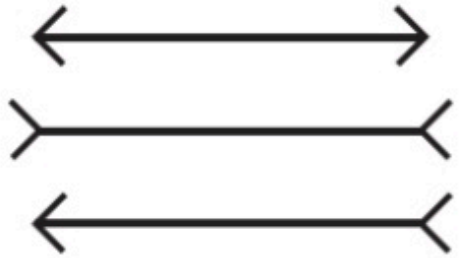
Touch

You use your sense of touch to feel things. Each of the other four senses is located in just one certain place. But the sense of touch is located all over your body. The outer skin, or *epidermis* (ep ih DUR mis), however, is not responsible for your sense of touch. There are no nerve receptors in the epidermis.

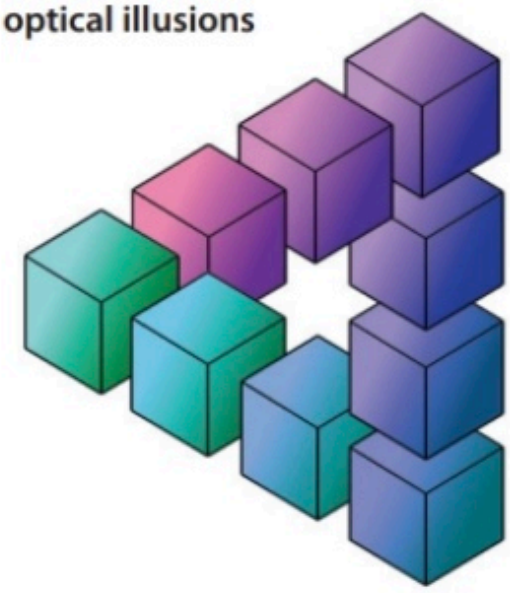
Your sense of touch originates in the *dermis*, or inner layer of skin. The dermis is filled with tiny sensory receptors. Some of these receptors detect movement and pressure. Others recognize temperature changes or detect pain. These sensory receptors send messages to the brain about what you touch. The brain processes the information and sends messages back, letting you know how things feel.

You might have noticed the pressure of your shoes on your feet when you first put them on. In just a short while, though, you do not even feel your shoes on your feet. When your brain constantly receives the same pressure signals from your skin, it becomes used to the pressure. God designed your senses to adapt to the environment around you to keep from being overloaded with stimuli. Have you ever noticed a certain odor, such as air freshener, when you entered a room? After you have been in the room for several minutes the odor is not as noticeable.

Your body has many different types of receptors that send specific messages to the brain. These receptors allow the brain and senses to work together, keeping us aware of the world around us. However, we cannot completely trust our senses. Sometimes the information we gather is inaccurate. For example, optical illusions can confuse our sight perception. Only one source of information—God's Word—is completely accurate and trustworthy.



optical illusions



QUICK CHECK

1. Which nerves are associated with sight and hearing?
2. Which other sense is closely associated with your sense of taste?
3. How is your sense of touch different from your other senses?

Touch Tester

Process Skills
- Predicting
- Measuring
- Inferring
- Recording data

The nerve endings in the skin contain neurons that send messages to the brain about the things we touch. God made some areas of our bodies more sensitive than other areas by giving them more neurons. In this activity you will test and compare the sensitivity of different places on your body.

Problem

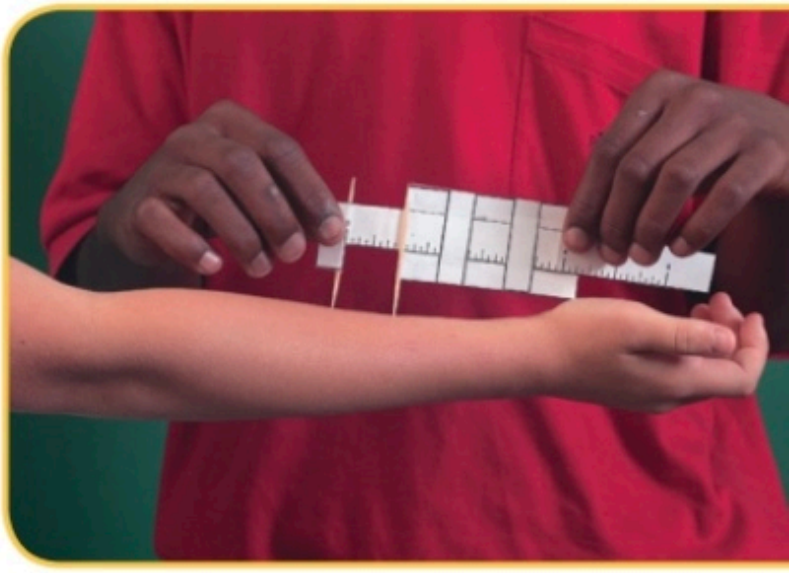
Which place on your body—the arm, finger, palm, or neck—is most sensitive to touch?

Procedures

Note: This activity uses English rather than metric measurements.

Materials
Touch Tester
scissors
2 toothpicks
tape
blindfold (optional)
Activity Manual

1. Assemble the Touch Tester that your teacher gives you.
2. Predict the sensitivity of the areas of your body listed in your Activity Manual. Number from 1–4, with 1 being the place on your body you think will be the most sensitive.
3. With your eyes closed or blindfolded, have your partner begin testing the areas of your body listed.
4. To use the Touch Tester, begin with both toothpicks together at the 0 mark. Gently press the toothpicks on the skin. Determine the number of toothpicks that are felt. If only one toothpick is felt, slide the toothpick to the next mark and test the skin again. Continue sliding the toothpick and retesting until both toothpicks are felt.
5. Record the distance between the toothpicks.



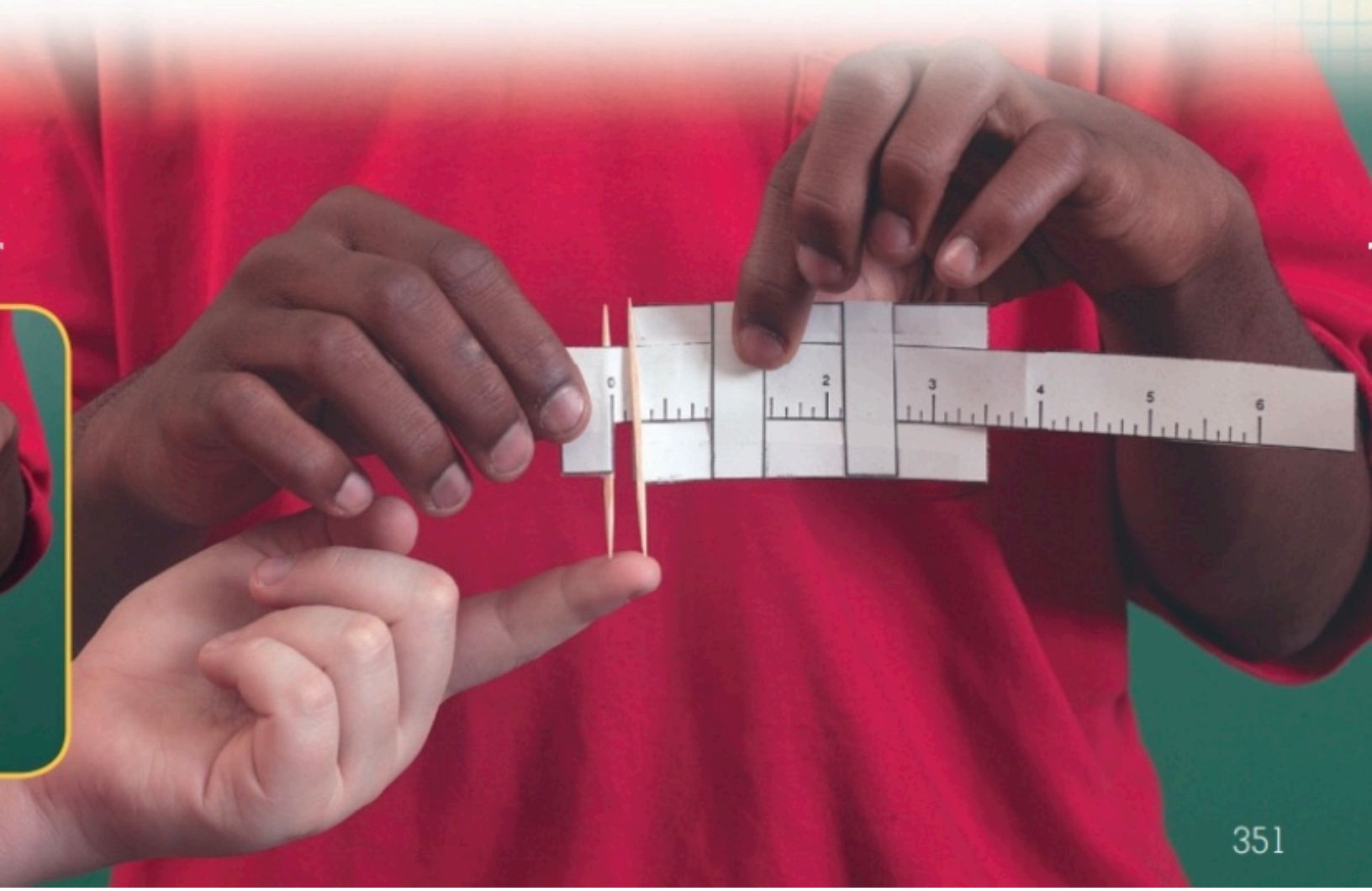
6. Repeat steps 3–5 to test the sensitivity of each place on your body.
7. Number the places again based on your measurements. Write 1 next to the place with the smallest measurement.

Conclusions

- Were your predictions correct?
- Think how you use each part of the body that you tested. Why do you think God made some places on your body more sensitive than other places?

Follow-up

- Research to find how the distance between the toothpicks compares with the number of neurons in each area of skin.
- Test other areas of your body, such as your face, ear, the top of your foot, and the bottom of your foot.



Memory

Memory plays a very important role in our daily lives. Suppose you woke up one morning and could not remember your name, how to tie your shoes, or where you put your homework assignment. You would have a difficult time functioning that day. But God has given your brain the ability to store and retrieve information. In fact, God tells us to remember. For example, in Deuteronomy 8:2, God told the Israelites to remember how He brought them out of Egypt and protected them during their forty years of wandering. The ability to remember is called **memory**.

What kinds of things do you remember? You remember sounds, smells, things that you saw, and hopefully, things that you have studied. The entire brain is involved in making and keeping memories. Scientists think that memories are formed by neurons communicating with each other. They identify a memory as a specific pathway from neuron to neuron. The brain continually makes new connections between neurons as you learn and process new information.

Some memories are kept longer than other memories. **Short-term memory** stores information only temporarily. This information might be a phone number, a grocery list, or the number of points scored in a basketball game. Usually when you look up a phone number, your short-term memory remembers the number only for a little while. The more often you see or hear something, though, the longer you will remember it. We need to be careful about what kinds of information we take in through our senses. Things that we see or hear can stay in our memory for a long time.

Long-term memory can store information for months, years, or even for a lifetime. These memories can be a mixture of sensory information as well as facts and experiences. Some scientists think that emotions play a part in transferring information to long-term memory. If something you experienced was unpleasant, you want to remember to avoid it. On the other hand, if the experience was comforting or pleasurable, you usually want to repeat it.

Scientists do not know exactly how some information in short-term memory transfers into long-term memory. An area inside the temporal lobe, called the *hippocampus* (hip uh KAM pus), seems to be necessary for making new long-term memories. Scientists and doctors have found that if damage occurs to this area of the brain, people can still remember old long-term memories but cannot store any new long-term memories. Their memories of current events or new people and places are held only in short-term memory.

Long-term memories can also be described as *declarative* or *procedural*. Declarative memories involve any knowledge that requires you to recall specific facts. These facts include your friend's birthday, vocabulary words, and definitions. Procedural memories include remembering how to ride a bike, play a violin, and paint a picture.

Scientists are not exactly sure how we learn. But scientists do know that different people learn in different ways and that the ability to learn changes as people grow older. Though some things are easier to learn as children, other information requires more maturity to understand. We know that God never intends for us to stop learning. We should say with David in Psalm 143:10, "Teach me to do thy will; for thou art my God: thy spirit is good; lead me into the land of uprightness."

Sleep and the Nervous System

When you sleep your body rests, but your nervous system remains very active. Not only does the nervous system maintain the autonomic functions such as your breathing and heartbeat, it appears to do some sensory housekeeping as well.

Scientists have identified several different stages of sleep. Although the brain remains active throughout all the stages of sleep, its level of activity changes. When you first fall asleep, your autonomic nervous system slows down your heart rate and breathing. Your body prepares to rest, and you enter the first stages of light sleep. Later, in deep sleep, your body becomes very relaxed. Waking up out of deep sleep can be quite difficult.

People go back and forth between periods of light sleep and deep sleep throughout the night. Scientists have found that there is also another stage of sleep where the brain is very active. The eyes move back and forth quickly, even though the eyelids are closed. Often a person's muscles begin to twitch, and the brain seems to be as active as if the person were awake. This stage of sleep is called rapid eye movement, or *REM* sleep. REM sleep occurs only after the body has gone through periods of light and deep sleep.

REM sleep is very important to our bodies. Some scientists think that this stage of sleep helps our brains to develop. Infants usually spend about 50 percent of their sleep in REM sleep. Scientists also think that REM sleep may be one of the ways that our brains

sort through and organize all of the information received throughout the day. Most dreams occur during REM sleep. A person who can remember details about a dream probably woke up during REM sleep.

Scientists use a machine called an *electroencephalograph* (ih lek troh en SEF uh luh GRAF), or EEG, to study how the brain works while people sleep. The EEG measures the electrical impulses produced by the neurons in the brain. By studying sleep patterns, scientists have noticed that both the quality and the quantity of sleep are important for a person's health. Failing to get adequate rest can affect every area of a person's life. Most scientists also believe that getting a good night's sleep improves a person's memory.

Children usually need about nine to ten hours of sleep each night. Adults require a little less—about seven to eight hours each night. While we are sleeping, our bodies rest and can work on other functions, such as repairing cuts and bruises. Sleep also gives children's bodies time to grow.

Our brains filter sounds while we sleep so that familiar noises do not bother us. The brain can also allow the body to rest while it stays alert to certain noises. Just ask any mother how long it takes for her to awake to her child's cry at night. The brain's multiple abilities show evidence of its wonderful Creator.

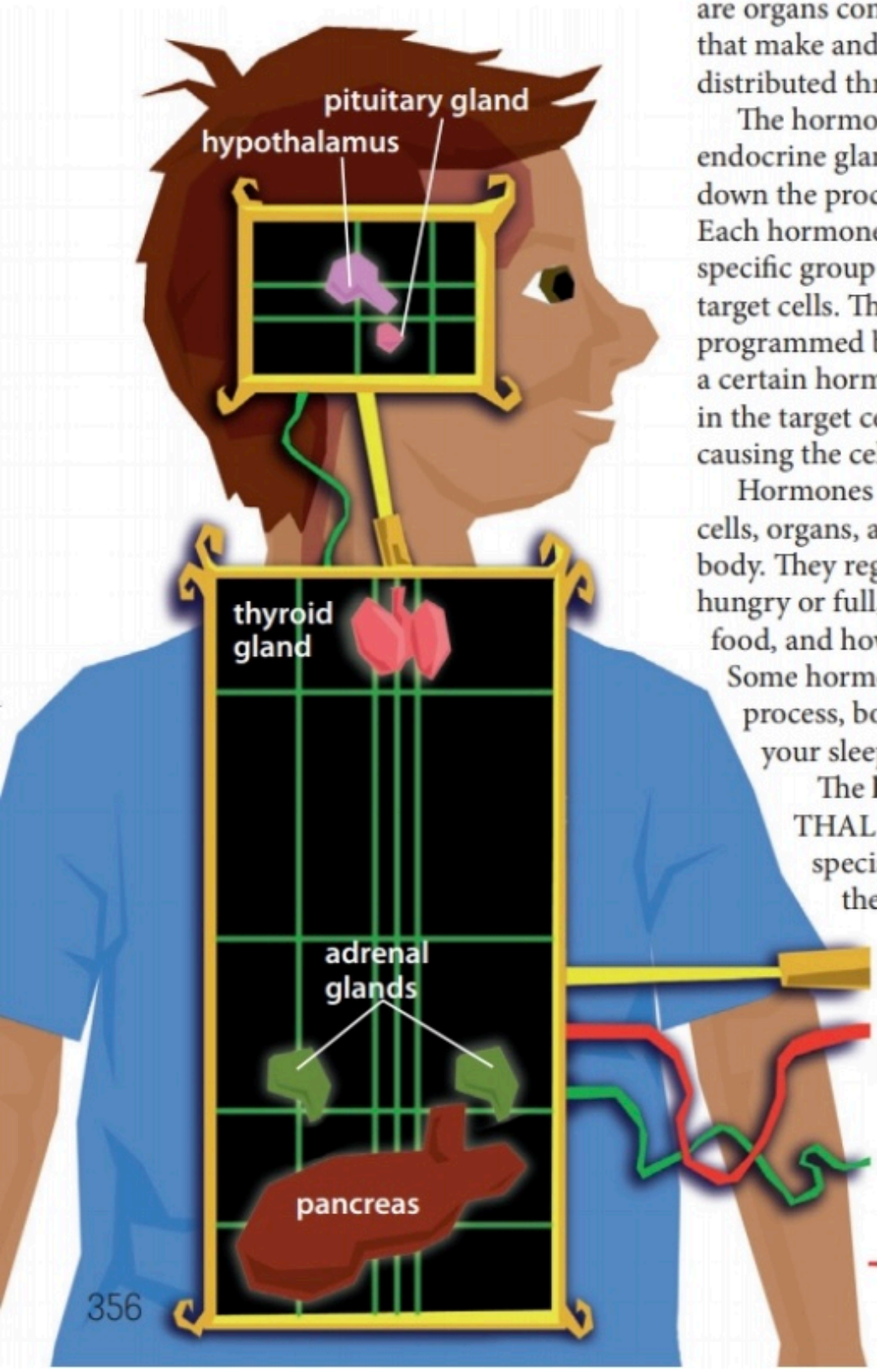
QUICK CHECK

1. Give an example of a short-term memory.
2. How is declarative memory different from procedural memory? How are the two similar?
3. Why do scientists think that REM sleep is important for the body?

a child connected to an EEG

The Endocrine System

The nervous system is directly connected to another system of the body, the endocrine (EN duh krin) system. Together these systems control all the functions of the human body.



The endocrine system works more slowly than the nervous system. Instead of electrical impulses, the endocrine system uses chemical messengers called **hormones**. Most of the body's hormones are produced in the **endocrine glands**. These glands are organs containing special cells that make and release hormones to be distributed throughout the body.

The hormones released by the endocrine glands speed up or slow down the processes of certain cells. Each hormone can affect only a specific group of cells, known as its target cells. These target cells are programmed by genes to receive only a certain hormone. Special receptors in the target cell bind to the hormone, causing the cell to function differently.

Hormones influence almost all the cells, organs, and functions of your body. They regulate whether you feel hungry or full, how your body uses food, and how you handle stress. Some hormones control your growth process, body temperature, and even your sleep.

The **hypothalamus** (hy poh THAL uh mus) is a group of special cells near the base of the brain. Neurons in the hypothalamus help regulate the pituitary (pih TOO ih tehr ee) gland, which is located just underneath it. Even though it is only

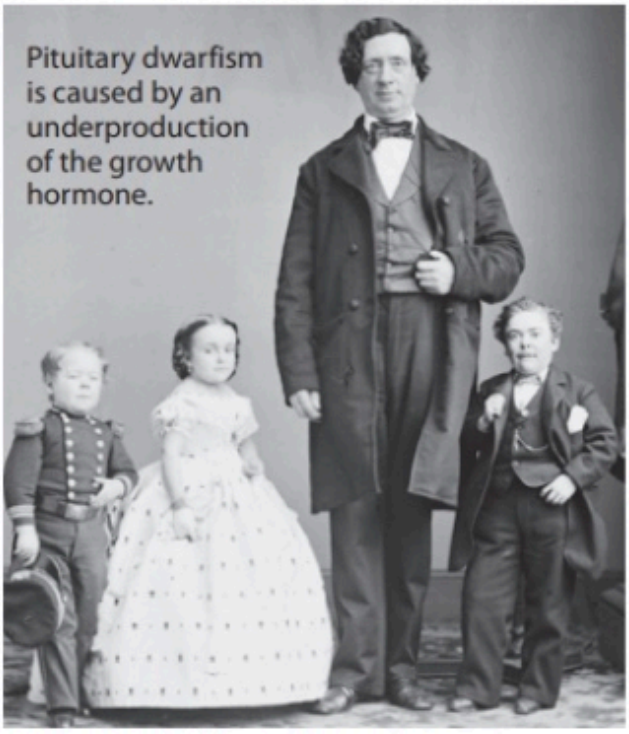
about the size of a pea, the **pituitary gland** is very important for your body. Sometimes called the master gland, the pituitary gland produces hormones that control other glands in the endocrine system. This gland also produces a growth hormone that helps bones grow and develop.

Many times the amount of hormones released also depends on the circumstances in a person's life. Your body has two *adrenal* (uh DREE nul) *glands* located on top of your kidneys. These glands help your body respond to stressful or dangerous situations. They release a substance called adrenaline (uh DREN uh lin), which increases your blood pressure and heart rate during stress. You may have heard of someone who showed great strength and endurance in a dangerous situation. This strength was possible because of the hormones released by the adrenal glands. These hormones also increase a person's heart rate and cause a person to tremble when he is nervous or scared.

The *pancreas* is located near the stomach, and it releases the hormone insulin. Insulin helps control the amount of sugar in the bloodstream. If a person's pancreas does not make enough insulin, a disease called diabetes could develop.

Your *thyroid gland* is located in your neck, just below your voice box. This gland is shaped like a butterfly. It controls how your body uses food to make energy. It also influences your body's growth and development. If the thyroid releases too many hormones, a person may become nervous or hyperactive or may lose too much weight. When the gland does not release enough hormones, the person often gains weight and feels tired all the time. The pituitary gland and the hypothalamus control these glands and many others.

Gigantism is caused by an overproduction of the growth hormone.


Pituitary dwarfism is caused by an underproduction of the growth hormone.

Disorders and Drugs

Both the nervous system and the endocrine system are extremely important to our bodies' health. God designed our bodies in a wonderful and marvelous way. The Bible says that we are "fearfully and wonderfully made" (Ps. 139:14). However, since the Fall when sin entered the world, people's bodies do not always work in the ways God designed them to function.

Sometimes disorders are called diseases. But you cannot catch these diseases. These disorders occur when the body fails to function as it should. Sometimes doctors can treat the symptoms of a disorder. But often they do not know the causes or the cures for the disorders.

Epilepsy (EP uh lep see), often called seizure disorder, occurs when the neurons in the brain send their electrical impulses too quickly and at an irregular rate. Other conditions besides epilepsy can cause seizures. But a person with epilepsy has repeated seizures, usually of a similar pattern. Doctors can prescribe medicine that helps to control the seizures, but they have not discovered a cure.

A disease called **multiple sclerosis** (skluh RO sis) destroys the myelin coating that covers the axon in some neurons. This causes the neurons to "short-circuit" so that the impulses cannot keep moving along. The symptoms that a person with this disease has depend on the location of the damaged nerves. People with multiple sclerosis may experience muscle weakness, paralysis, or loss of vision.

Parkinson's disease and Alzheimer's disease are two diseases of the nervous system that occur mainly in elderly people. **Parkinson's disease** causes damage to certain brain cells that control movement. This disease can cause a person's head, arms, and hands to tremble. A person who has Parkinson's disease may have trouble keeping his balance and doing simple tasks such as eating.

Alzheimer's (AHLTS hy murz) **disease** also destroys brain cells, but in a different way. This disease affects thinking processes. At first, a person with Alzheimer's disease usually has trouble with short-term memories. Later, the person may lose the ability to learn new information or to reason. A person with this disease may not be able to recognize family members and friends. Many people with this disease also suffer from depression and anxiety.

Scientists and doctors are searching for cures for these and other nervous system diseases. Some nervous system problems may be inherited or may happen because of head or back injuries. For some people, the nervous system does not develop properly before birth. Sometimes drug abuse or unhealthful habits cause or intensify nervous system disorders.

When you think of drug abuse, you probably think first of illegal drugs. Drugs such as cocaine and marijuana are harmful to the body. These types of drugs change the way that neurons in the brain send and receive information. Drugs affect the nervous system in many different ways, and some drugs can be addictive. By altering how the neurons work, some drugs make a person's body want to have more of the drug. The person then continues taking the drug even though it actually harms him and could be fatal.

But not all drug abuse happens with drugs such as cocaine, marijuana, or heroin. Some athletes take additional hormones called steroids to make themselves stronger or more muscular. But the improved performance may come with dangerous side effects, such as seizures and heart attacks. Even legal drugs such as cold and fever medicines can be abused. Any time a person uses a medicine in excess or in a way that it is not meant to be used, he could be creating problems for his body. These problems may show up immediately or may not appear for several years. Christians need to remember that their bodies are temples of God and do not belong to them (1 Cor. 6:19). Everything that a Christian does should be to the honor and glory of God (1 Cor. 10:31).

QUICK CHECK

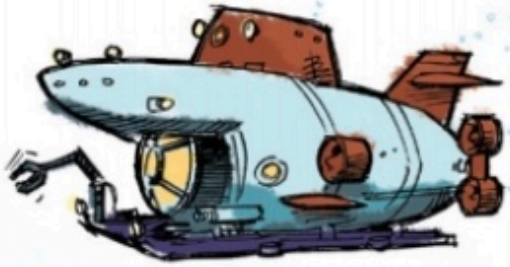
1. Why are the hypothalamus and pituitary gland important to the interaction of the nervous and endocrine systems?
2. What is a disorder?
3. How can legal drugs sometimes be abused?

Words to Know

brain
lobes
spinal cord
neurons
dendrite
impulse
axon
synapse
reflex
memory
hormones
endocrine glands
hypothalamus
pituitary gland
epilepsy
multiple sclerosis
Parkinson's disease
Alzheimer's disease

Key Ideas

Parts of the brain
Relationship between parts of the nervous system
How impulses are transmitted
Differences between sensory neurons and motor neurons
Functions of the somatic nervous system and autonomic nervous system
How the senses interact with the nervous system
Differences between short-term and long-term memory
Importance of sleep
How the endocrine system works
Dangers of drug abuse



Solve the Problem

Yesterday Sara found out that her eighteen-year-old cousin is taking steroids to improve her softball playing. Her cousin says that she needs to take this drug in order to build up her endurance as a softball pitcher. She insists that it is not a dangerous drug like cocaine and that she will not use the drug after softball season. What are some reasons her cousin should not take this drug? What should Sara say? Are there some Bible verses she could share with her cousin?