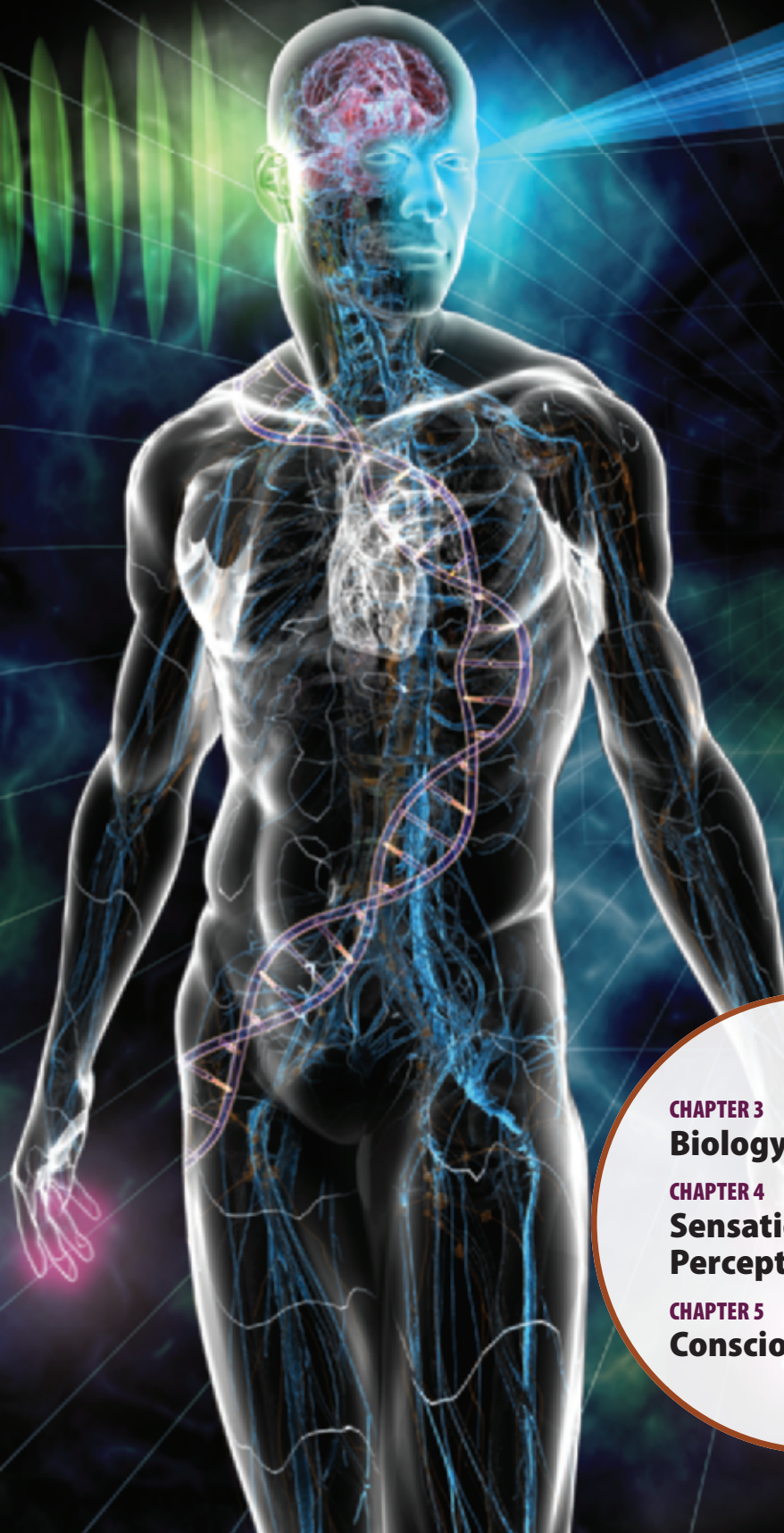


UNIT 2

Body and Mind



CHAPTER 3
Biology and Behavior

CHAPTER 4
Sensation and Perception

CHAPTER 5
Consciousness

CASE STUDY

THE BRAIN OF PHINEAS GAGE

The ability of the brain to withstand accidents is nothing less than remarkable. In some instances, people have not only survived severe injuries to the brain, but they have continued to live fairly normal lives. Sometimes, though, the victims are not quite the same as before the accident. Consider the case of Phineas Gage.

Mr. Gage was a promising railroad worker. His character was outstanding and he was well liked. But all that changed on September 13, 1848. While Gage was tamping down the blasting powder for a dynamite charge with an iron rod, the powder accidentally ignited. The inch-thick metal rod, which weighed more than 13 pounds, shot out of the hole. It rammed through Gage's brain and out the top of his head.

The rod landed many yards away. Gage fell back in a heap, but he was not dead. His coworkers watched in shock as, a few moments later, he stood up and spoke. They drove him by oxcart to a local doctor, John Harlow. As the doctor marveled at the hole through Gage's head, Gage asked the doctor when he could go back to work.

Two months later, the physical effects of Gage's wound had healed. Everyone, including the doctor, was surprised that Phineas Gage had survived the accident. He walked about, spoke normally enough, and was aware of his surroundings. However, Gage had changed. He no longer was a dependable worker. He had also become foul-mouthed and ill-mannered. It was clear that the accident had serious psychological consequences.

Phineas Gage's skull was pierced by an iron rod.



The Granger Collection, New York

Gage died 13 years later during an epileptic seizure. Dr. Harlow persuaded Gage's family to donate his skull to the Warren Medical Museum at Harvard University. Generations of biologists and psychologists have studied the skull and wondered how Gage's changes in personality might have been caused by damage to his brain.

Biologists Hanna and Antonio Damasio explain that the way in which the rod entered the brain spared the areas involved in language and movement. Thus, Gage was able to speak normally and walk about easily. However, the rod had severely damaged an area in the brain related to personality. According to the Damasios, people who suffer damage to the same part of the brain today experience similar changes in personality. These people are often unable to censor their thoughts before speaking. As a result, they blurt out thoughts that they would have kept to themselves before their brains were injured.

Other researchers have found similar changes in patients' personalities after injuries to the same area of the brain. Some patients develop rule-breaking and impulsive behaviors. For example, they may

CHAPTER 3

BIOLOGY AND BEHAVIOR

Watch the Video

Explore topics on human biology and behavior.



begin to interrupt conversations. They are also less likely to make spontaneous facial expressions. The combination of excessive talking and lack of expression can make these individuals seem like entirely different people.

Brain injuries can result from many different types of accidents. During the war in Iraq, roadside bombs seriously injured the brains of thousands of soldiers. These injuries and one man's road to recovery were described by ABC News reporter Bob Woodruff, who suffered a traumatic brain injury in Iraq while covering the fighting. His book *In An Instant* provides details about the struggle to survive and to recover from traumatic brain injury. In this chapter you will learn more about the biology of the brain, its parts, and how it functions.



An American soldier recovers from a traumatic brain injury sustained in Iraq. Doctors removed a large portion of his skull to allow for swelling of his brain.

What do you think?

1. How did Phineas Gage's personality change after his brain injury?
2. What are some other possible circumstances in which individuals experience brain trauma?

Chapter at a Glance

SECTION 1: The Nervous System

- The nervous system functions as a communication system for the body. Messages are transmitted by neurons to axons and dendrites.
- The nervous system is made up of the central nervous system and the peripheral nervous system, which transmits messages between the central nervous system and all parts of the body.

SECTION 2: The Brain: Our Control Center

- The brain is composed of three major sections: the hindbrain, the midbrain, and the forebrain.
- The cerebral cortex is the part of the brain that controls thinking, memory, language, emotions, complex motor functions, perceptions, and much more.

SECTION 3: The Endocrine System

- The endocrine system secretes hormones that stimulate growth and many kinds of reactions, such as activity levels and moods.
- The major endocrine glands include the pituitary, the thyroid, the adrenals, the testes, and the ovaries.

SECTION 4: Heredity: Our Genetic Background

- Heredity plays a key role in the development of individuals' traits. Heredity is transmitted through genes, which are found in chromosomes.
- Kinship studies allow researchers to determine the influence of heredity and environment on individuals.

The Nervous System

Before You Read

Main Idea

The nervous system contains billions of cells called neurons. Neurons communicate with one another through the central and peripheral nervous systems.

Reading Focus

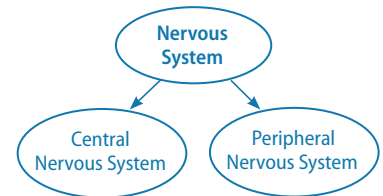
1. What are neurons, and how do they work?
2. How do neurotransmitters work as chemical messengers?
3. What does the central nervous system control?
4. How is the peripheral nervous system structured?

Vocabulary

central nervous system
peripheral nervous system
neurons
cell body
dendrites
axon
myelin
axon terminals
synapse
neurotransmitters
spinal cord
somatic nervous system
autonomic nervous system

TAKING NOTES

Use a graphic organizer like this one to take notes on the nervous system.



FIGHT OR FLIGHT



PSYCHOLOGY CLOSE UP

How do you react to the image at the left? Do you inwardly cringe even though you know it is just a photograph? Humans have physical and psychological reactions to dangerous situations. This response is commonly called the “fight or flight” response, that is, the body is ready to fight or to flee from a threat. When this response is activated, the heart rate increases, more blood flows to major muscle groups, and the body has a burst of energy and strength to help it either fight or run away. Eyesight sharpens and sensory awareness increases. In the case of an attack from this dog, you may assess whether your safety would best be met by running away from the animal or by defending yourself from its vicious jaws. Most reactions occur in an instant, without actual conscious thought.

In the early 1900s, physiologist Walter Cannon first argued that animals likely developed the “fight or flight” response in prehistoric times to avoid falling victim to predators. In our modern lives only rarely do we face a snarling dog, but we do face situations that cause the body to automatically respond to stress. In this section you will read about the system that allows the body to do this—the nervous system. ■

Neurons

The human nervous system is involved in thinking, dreaming, feeling, moving, and much more. It is working when we are active or still, awake or asleep. The nervous system regulates our internal functions. It is also involved in how we react to the external world. Even learning and memory are made possible by the nervous system. When we learn a new behavior or acquire new information, the nervous system registers that experience and changes to accommodate its storage.

The nervous system has two parts: the central nervous system and the peripheral nervous system. The **central nervous system** consists of the brain and the spinal cord. The **peripheral nervous system** is made up of nerve cells that send messages between the central nervous system and other parts of the body. In order to understand how the central and peripheral nervous systems work, we must first understand how nerve cells communicate with one another and how their messages travel through the body.

Each of us has more than 100 billion neurons, most of which are found in the brain. **Neurons** are nerve cells that run through our entire bodies and communicate with each other. Neurons send and receive messages from other parts of the body, such as muscles

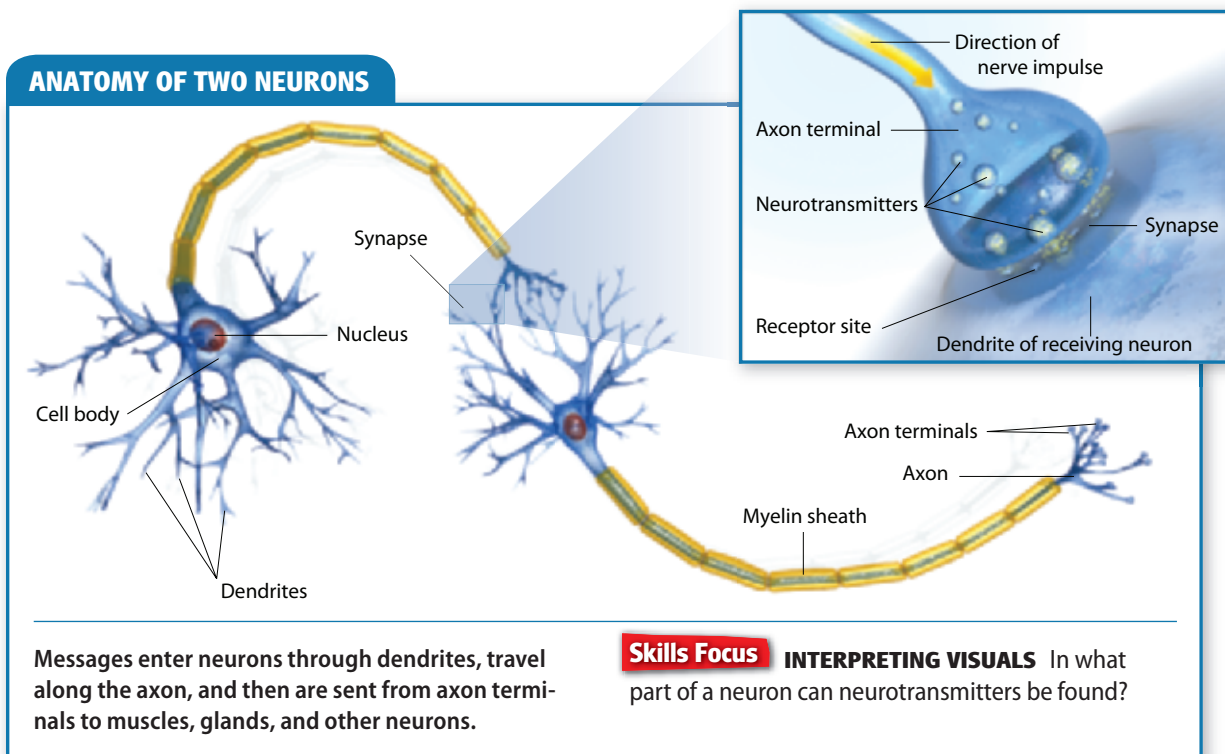
and glands. These messages relate to events: the sensation of a pinprick, the first steps of a child, the writing of a poem, the memory of a past event.

Recent research has shown that the brain has the ability to reorganize itself by altering the connections between neurons to make up for injury or disease, or to adjust to changes in the environment. This phenomenon is known as neuroplasticity. These changes can occur in response to new experiences at different times throughout an individual's life.

Components of a Neuron Neurons are somewhat like trees in structure. Parts of neurons resemble branches, trunk, and roots. And, as in forests, many nerve cells lie alongside one another like a thicket of trees. Unlike trees, however, neurons can also lie end to end. Some neurons' "roots" are intertwined with the "branches" of neurons that lie below.

Every neuron consists of three basic components: a cell body, dendrites, and an axon. The **cell body** produces energy that fuels the neuron's activity. Branching out from the cell body are thin fibers called **dendrites** that receive information from other neurons and pass the message through the cell body. While a dendrite carries information to the cell body, an **axon** transmits messages away from it.

WEBQUEST
Complete a Webquest at thinkcentral.com on brain plasticity.



A neuron has many dendrites but usually only one axon. Axons vary greatly in length. Some are just a tiny fraction of an inch, while others stretch to several feet. Some neurons in your legs are several feet long.

Many axons are covered with **myelin**, a white fatty substance that insulates and protects the axon. This myelin sheath, or casing, also helps to speed up the transmission of the messages sent by neurons. At the end of the axon, smaller fibers branch out. These fibers are called **axon terminals**.

The Communication Process Messages are sent from the axon terminals of one neuron to the dendrites of other neurons. In order for a message to be sent from one neuron to another neuron, it must cross the **synapse**. The synapse is a junction between the axon terminals of one neuron and the dendrites of another. Messages travel in only one direction. Thus, messages enter the dendrites and travel through the cell body and axon to the axon terminals. From there, they cross synapses to the dendrites of other neurons.

The information that is sent depends on the location of the neuron in the body and the event that produced the message. Sensory neurons are nerve cells that carry information received by the senses to the central nervous system. Motor neurons, on the other hand, are nerve cells that carry information from the central nervous system to the muscles and the glands and influence their functioning. Suppose you stub your big toe. Sensory

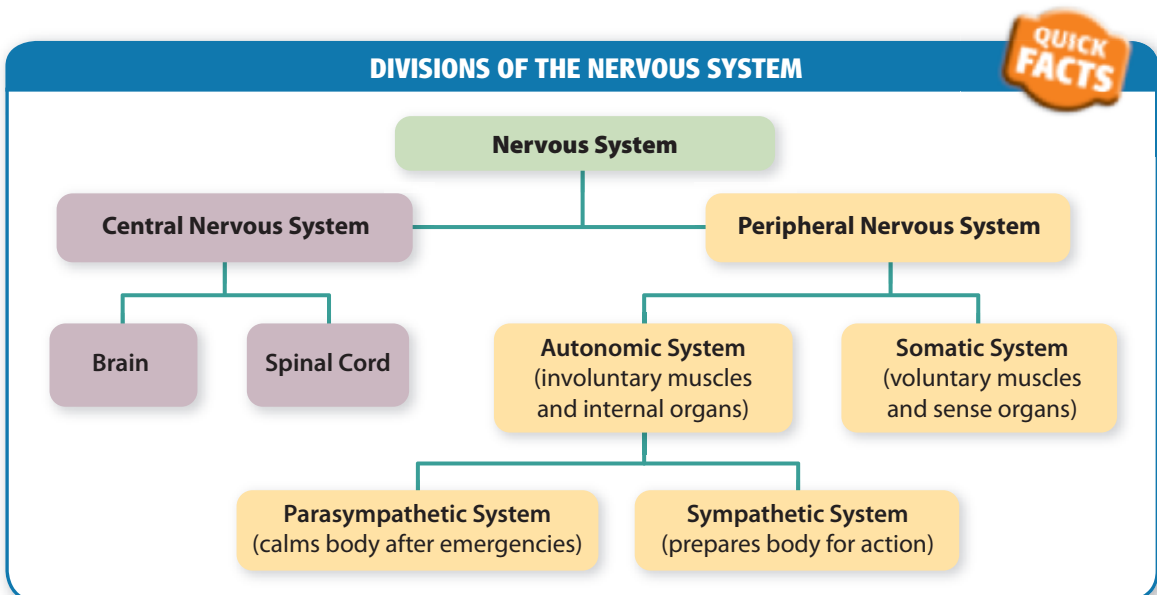
neurons take the message to the brain. Motor neurons take messages back to your foot so that you pull it up. These messages can move at speeds exceeding 200 miles per hour.

Occasionally, something happens to disrupt the message-sending process. A hard blow to the head from a car accident or a sports mishap, for example, can cause a concussion—an injury in which the soft tissue of the brain hits against the skull. This concussion may cause memory loss. Sometimes, the person is affected for only a few seconds. Other times, the person may experience effects for a much longer time. For example, a football player suffers a concussion during a game. He remembers being at the game, but he cannot remember what happened during the game. He may never be able to recall the event again. Research shows that memory is in large part a biological process.

Reading Check Identify Supporting Details How does each of the main parts of a neuron function?

Neurotransmitters: The Body's Chemical Messengers

Neurons send messages across synapses through the release of **neurotransmitters**. Neurotransmitters are chemicals that are stored in sacs in the axon terminals. A neuron fires, or sends a message, by releasing neurotransmitters—much like a spray bottle releasing droplets of water. Each message is converted into an electrical impulse that trav-



els the length of the neuron. The message is then transmitted to the next neuron by other neurotransmitters, and the process continues until the message arrives at its destination. This whole process takes only a fraction of a second, and neurons can fire hundreds of times every second.

Neurotransmitters are involved in everything people do. Whenever you wave a hand, yawn, or think about a friend, neurotransmitters are involved. Some diseases and psychological disorders may also be caused by the presence of too many or too few of various neurotransmitters.

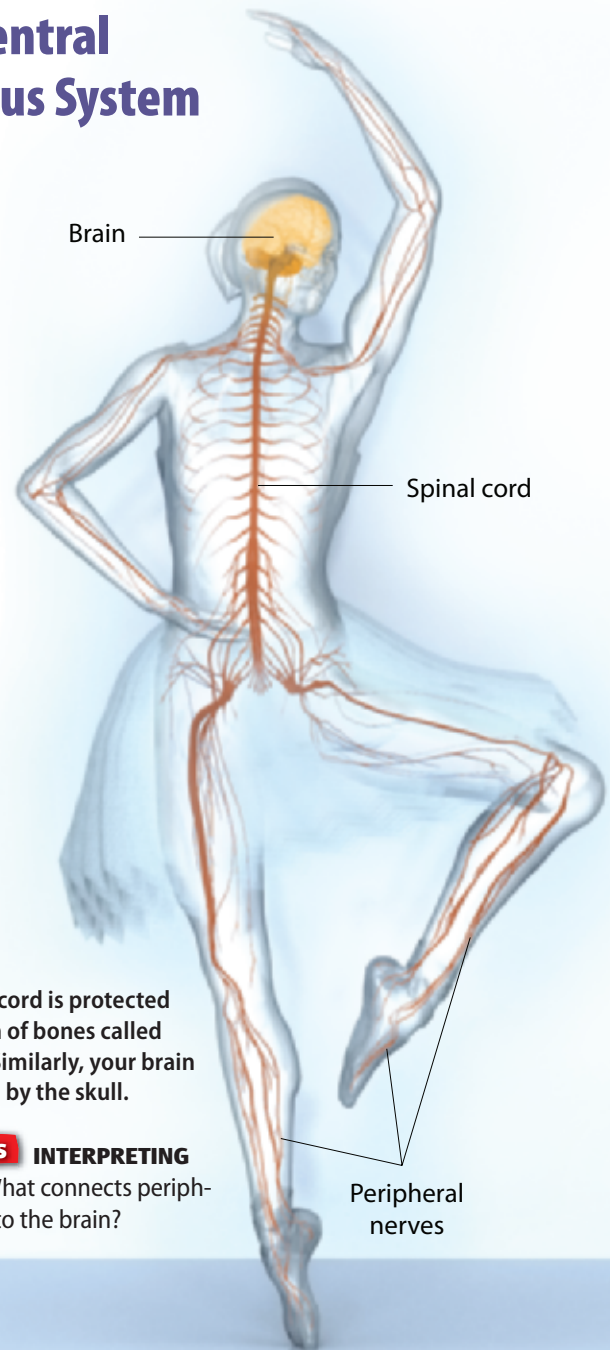
There are several types of neurotransmitters. Each has its own structure and fits into a receptor site on the next neuron, similar to how a key fits into a lock. Researchers have identified dozens of neurotransmitters and their functions. For example, acetylcholine is involved in the control of muscles. It is used by the motor neurons of the spinal cord and stimulates skeletal muscles. Acetylcholine is also involved in learning and memory. When the amount of acetylcholine decreases, the formation of memories is impaired. Scientists believe that too little acetylcholine may be associated with Alzheimer's disease.

Another neurotransmitter, dopamine, is involved primarily in motor behavior. A deficiency in dopamine levels plays a role in Parkinson's disease, which is characterized by trembling hands, problems with balance, and uncoordinated, rigid movements. On the other hand, an excess of dopamine may contribute to the brain disorder schizophrenia. Other neurotransmitters include noradrenaline, which is primarily involved in preparing the body for action, and serotonin, which is involved in emotional arousal and sleep. Too little of both may be a factor in depression.

Although we are often unaware of the processes in our bodies, we can be sure that our bodies are hard at work whether we are running or sitting still. At any given moment, millions of neurons are shooting neurotransmitters across synapses and sending complicated messages to various parts of the body. These messages are carried via the spinal cord and the peripheral nervous system.

Reading Check Find the Main Idea How do neurotransmitters function?

The Central Nervous System



Your spinal cord is protected by a column of bones called vertebrae. Similarly, your brain is protected by the skull.

Skills Focus INTERPRETING VISUALS What connects peripheral nerves to the brain?

Peripheral nerves

The Central Nervous System

The illustration above shows the central nervous system, which consists of the neurons of the spinal cord and the brain. The **spinal cord** is a column of nerves about as thick as a thumb that extends from the brain down the back. It is protected by the bones of the spine and transmits messages between the brain and the muscles and glands in the body.

Your brain depends on your spinal cord to carry messages to specific muscles. The messages tell the muscles exactly how to move. The brain sends an impulse down the spinal cord. The impulse is directed to the neurons that connect with the muscles. When the receptors are stimulated by the impulse, the muscles move.

The spinal cord is also involved in spinal reflexes. A spinal reflex is your body's automatic response to a trigger without input from the brain. This involuntary reflex occurs when nerve impulses are received from the body's sense organs. These impulses pass immediately into the spinal cord, which sends a message out. Although input from the brain is not required, a message will be sent to the brain telling it what has happened.

ACADEMIC VOCABULARY

peripheral
relating to the outer edge of the body

Quick Lab

Reaction Time

Do distractions overload the nervous system and change reaction time? In this lab you will work with a partner to measure reaction time, or how long it takes to prepare for and complete an action.

PROCEDURE

- 1 Sitting across the table from your partner, hold the top of a ruler between your thumb and forefinger at about eye level.
- 2 Have your partner place the thumb and forefinger of his or her dominant hand about an inch away from each side of the bottom of the ruler. Count 10 seconds, then release the ruler. Your partner should catch it, and hold it in place. Record the level of the ruler above the table in inches. Repeat three times.
- 3 Repeat the experiment, but this time attempt to distract your partner by having another student make loud noises and sudden gestures. Record the level in inches. Repeat three times.

ANALYSIS

1. Average the distance from the table for the first three catches. Did the distance increase or decrease with each catch?
2. Compare the average with the last three catches. Did the distractions change the distance?
3. Which conditions produced the fastest reaction times? What do you think accounts for the difference?

Quick Lab **THINK** central thinkcentral.com

For example, if a person touches a hot stove, a message goes immediately from his or her hand to the spinal cord. A message to remove the hand is then sent back to motor neurons in the hand. The removal of the hand is a spinal reflex. The person may also register pain in his or her brain, but the pain is not what causes the reflex. In fact, pain might not even occur until after the person removes his or her hand.

Many of our simple actions are reflexive. They are the way the body protects itself from harm. Have you ever wondered why you blink when you get a speck of dust in your eye? Or why some people sneeze when they sniff pepper? These are reflexive actions designed to protect your eyes or prevent irritants from entering your lungs. Physicians sometimes test people's reflexes to make sure their nervous systems are functioning properly. When a doctor taps just below your knee cap to make your leg move, the purpose is to check the knee-jerk reflex, that is, to check that neurons are responding the way they are supposed to. The tap stimulates sensory neurons in the tendon of the thigh muscle. A message then gets sent to the spinal cord that the tendon has been stretched. In reaction, the thigh muscle contracts, causing the leg to straighten from the knee with a sudden kick.

Reading Check Summarize What are the functions of the central nervous system?

The Peripheral Nervous System

The peripheral nervous system lies outside the central nervous system and is responsible for transmitting messages between the central nervous system and all other parts of the body. The two main divisions of the peripheral nervous system are the somatic nervous system and the autonomic nervous system.

The Somatic Nervous System The **somatic nervous system** transmits sensory messages to the central nervous system. Its function is to carry messages from the voluntary muscles and sense organs. Activated by touch, pain, changes in temperature, and changes in body position, the somatic nervous system enables us to experience the sensations of heat and cold and to feel pain and pressure. For example, we can feel the softness of a cat's fur,

warmth if the cat is sitting on our lap, and pain if the cat scratches us. The somatic system also alerts us that parts of the body have moved or changed position. It sends messages to the muscles and the glands and helps us maintain posture and balance.

The Autonomic Nervous System The word *autonomic* means “occurring involuntarily,” or automatically. The human **autonomic nervous system** regulates the body’s vital functions, such as heartbeat, breathing, digestion, and blood pressure. We generally do not have to think about these activities—they occur automatically and are essential for keeping us alive. Involuntary muscles and internal organs are governed by this system.

The autonomic nervous system has two divisions: the sympathetic and the parasympathetic nervous systems. Psychologists are interested in the autonomic nervous system because of the role it plays in feeling emotions. The responses of the autonomic nervous system are particularly important when a person experiences something stressful in his or her environment.

The sympathetic system is activated when a person is going into action, perhaps because of some stressful event. It prepares the body either to confront the situation or to run away. This is the “fight or flight” response.

When a person suddenly comes face to face with a snake, for example, the sympathetic nervous system is called into action. Should he or she stay or run away? The sympathetic nervous system prepares the body for this decision by suppressing digestion, increasing the heart and respiration rates, and elevating the blood pressure. In other words, the body is preparing the muscles most needed to respond to an emergency situation and strenuous activity. Do you ever feel queasy when you are in a stressful situation—such as when you are about to take a big test? This is because your sympathetic nervous system has kicked into action and has suppressed your digestive processes.

In contrast to the sympathetic system, the parasympathetic nervous system is sometimes called the “rest and digest” response. The parasympathetic system restores the body’s reserves of energy after intense activity. Heart rate and blood pressure normalize,

breathing slows, and digestion returns to normal. The actions of both systems take place automatically. You do not have to consciously think about your body’s responses. Imagine how difficult your life would be without the responses of the autonomic nervous system. You would have to make a decision about every action your body takes, even in dangerous situations.

If you are having trouble remembering which system is which, keep in mind that “sympathetic” and “stress” both start with the letter *s*, while “parasympathetic” and “peace” both begin with the letter *p*. The sympathetic nervous system reacts to stress; the parasympathetic nervous system restores peace to your body’s systems.

Reading Check Identify Supporting Details What are the systems that make up the peripheral nervous system?

Online Quiz



thinkcentral.com

SECTION 1 Assessment

Reviewing Main Ideas and Vocabulary

- 1. Identify** What are the main divisions of the nervous system?
- 2. Contrast** How do the functions of the autonomic nervous system differ from the functions of the somatic nervous system?
- 3. Describe** What is the role of the sympathetic nervous system in the “fight or flight” response?

Thinking Critically

- 4. Explain** How do messages travel from one neuron to another?
- 5. Elaborate** In what way do the parasympathetic and sympathetic nervous systems work together?
- 6. Compare** Using your notes and a graphic organizer like the one below, compare the functions of each major part of the nervous system discussed in this section.

System	Function

FOCUS ON WRITING

- 7. Descriptive** Recall a time in your life when you experienced a stressful situation such as a job or scholarship interview or even a bad dream. Write a paragraph describing how you felt nervous and relate those feelings to the action of the sympathetic nervous system.

The Brain: Our Control Center

Before You Read

Main Idea

The human brain has many parts that work together to coordinate body movement, create thought and emotions, and shape behaviors.

Reading Focus

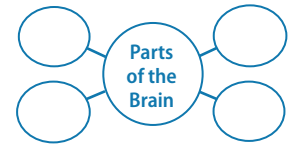
1. What were some of the early beliefs about the brain?
2. What are the parts of the brain, and how do they function?
3. How is the cerebral cortex divided?
4. Which methods do scientists use to study the brain?

Vocabulary

medulla
pons
cerebellum
reticular activating system
thalamus
hypothalamus
limbic system
cerebrum
cerebral cortex
corpus callosum
association areas

TAKING NOTES

Use a graphic organizer like this one to take notes on the parts of the brain.



RIGHT BRAIN, WRONG FACE

PSYCHOLOGY CLOSE UP

What if you could only see the right side of your face? Neurologist Oliver Sacks tells the story of Mrs. S, one of his most curious cases. Mrs. S had suffered a massive stroke that damaged the right side of her brain—the side of the brain that controls a person’s ability to see things that are on one’s left. As a result, *left* did not exist for Mrs. S. For example, when she ate, Mrs. S could only see the food on the right side of her plate. To complete a meal, Mrs. S would rotate her chair to the right, keeping her eyes turned right until she could see the rest of her dinner. When she looked at herself

in a mirror, she only saw the right half of her face. Visitors were often surprised when they met Mrs. S and she wore make-up only on the right side of her face.

Mrs. S suffered from hemi-inattention, a rare condition that makes it impossible to understand information processed by the right half of the brain. When doctors devised a way for Mrs. S to see her “missing half,” she became extremely distressed. What she saw and how she experienced her body no longer matched her self-image. The way the left and right sides of the brain function separately and together controls our view of ourselves and of the world. ■

Early Beliefs About the Brain

Every person is unique in part because of the capacities for learning and thought made possible by the human brain. But we have gained our knowledge of the brain only recently. In ancient times, people did not attribute human psychological processes such as thinking to the working of the brain. They thought that what was inside a person's body was not very different from what was inside an animal's body. Therefore, they reasoned, the abilities that make people different from animals—such as creativity and imagination—could not be explained in biological terms. Instead, people widely believed that the body was inhabited by souls or demons.

The ancient Egyptians believed that a little person dwelled within the skull and regulated behavior. Greek philosopher Aristotle thought that the soul resided in the heart. The English language still reflects the belief in the heart as the seat of will, thought, hunger, and joy. We use expressions such as “deep in one's heart,” “to know something by heart,” and “to have a change of heart.”

Today, however, we recognize that the mind, or consciousness, dwells within the brain. We now have greater understanding of the brain and the links between biological processes and psychological phenomena.

Reading Check **Sequence** How have ideas about the human brain changed over time?

Parts of the Brain

The human brain is composed of many parts that work together to organize our movements, create our thoughts, form our emotions, and produce our behaviors. Scientists have identified the localized functions of different parts of the brain.

The brain is divided into three sections: the hindbrain, the midbrain, and the forebrain. The hindbrain is the lower portion of the brain and is involved in many vital functions such as heart rate, respiration, and balance. It is called the hindbrain because it is at the back of the brain as it rests in the skull. The midbrain includes areas that are involved in vision and hearing. The forebrain, the front area of the brain, is involved in complex functions such as thought and emotion.

The Hindbrain The medulla, the pons, and the cerebellum are important structures of the hindbrain. The **medulla** is involved in vital functions such as heart rate, blood pressure, and breathing. The **pons** is located in front of the medulla and is involved in regulating body movement, attention, sleep, and alertness.

Cerebellum is the Latin word for “little brain.” The **cerebellum** looks like the larger part of the brain (the cerebrum), under which it rests, but it is much smaller. It is involved in balance and coordination. A person whose cerebellum is injured may have trouble with coordination. The person may walk unsteadily and even occasionally fall down.

The Midbrain The midbrain is located between the hindbrain and the forebrain. Areas within the midbrain are involved in vision and hearing. Eye movement, for example, is controlled by an area in the midbrain. In addition, the midbrain contains part of the **reticular activating system**. The **reticular** activating system begins in the hindbrain and rises through the midbrain into the lower part of the forebrain. This system is important for attention, sleep, and arousal. Stimulation of the reticular activating system makes us alert. It affects arousal by increasing heart rate and blood pressure, and it increases brain activity. Some drugs, such as alcohol, reduce the activity of the reticular activating system, thus affecting alertness and reaction time.

Sudden, loud noises stimulate the reticular activating system and can awaken a sleeping person. However, the reticular activating system can screen out some noises. A person who lives in the city may not be awakened by the sounds of traffic roaring by. This same person may, however, awaken to sounds that are more out of the ordinary, such as a bird singing, even if these sounds are fairly soft.

The Forebrain Four key areas of the forebrain are the thalamus, the hypothalamus, the limbic system, and the cerebrum. Certain parts of the forebrain are very well developed in human beings. The forebrain is the part of the brain that makes it possible for humans to engage in complex thinking processes.

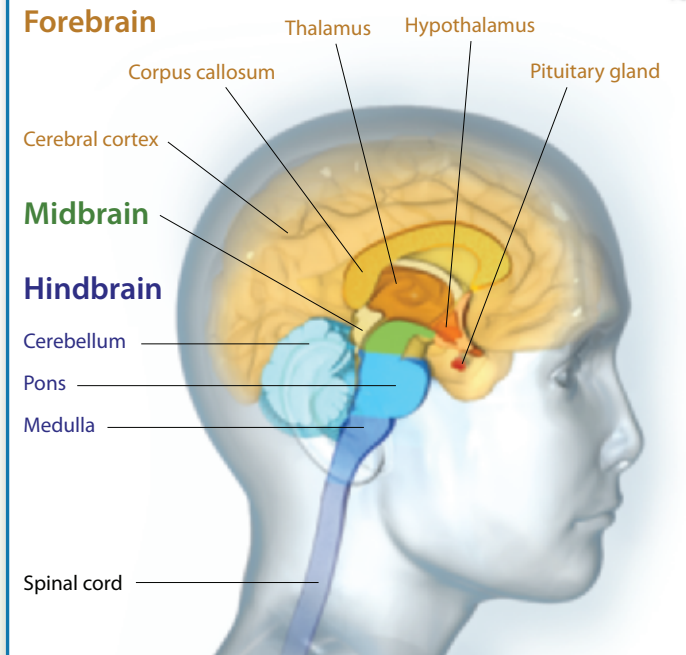
Thalamus is a Latin word meaning “inner chamber.” The **thalamus** is a critical structure of the brain because it serves as a relay station for sensory stimulation.

ACADEMIC VOCABULARY

reticular resembling a net in appearance or form

PARTS OF THE HUMAN BRAIN

INTERACTIVE



Most of the messages coming from the sense organs go through the thalamus on the way to the higher levels of the brain (those areas responsible for mental processes such as thinking and reasoning). The thalamus transmits sensory information to the areas of the brain that interpret and respond to the information. The thalamus also relays sensory input from the eyes and the ears to the appropriate parts of the brain for interpretation of the input.

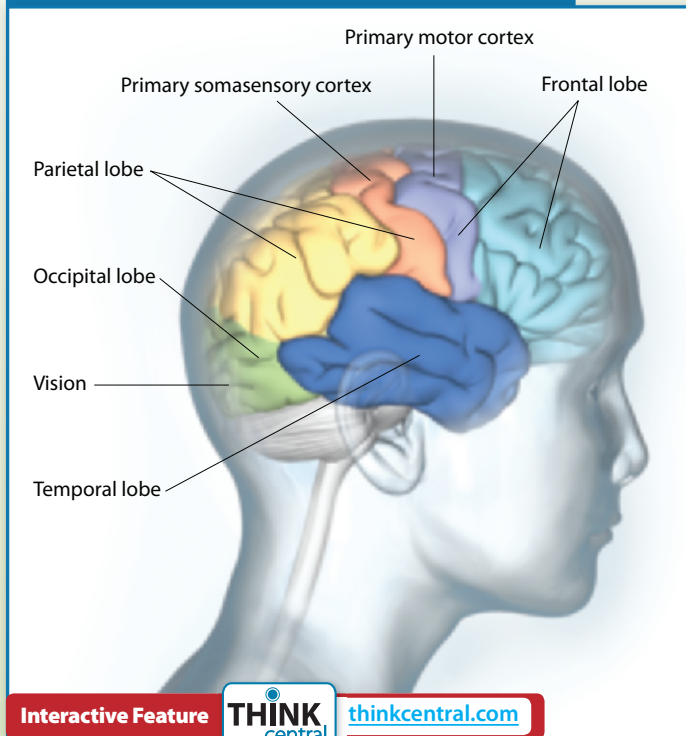
Hypo- is a Greek prefix meaning “under.” Thus, the **hypothalamus** lies below the thalamus. The hypothalamus is tiny, but it is extremely important because it is involved in many aspects of behavior and physiological functions. It is vital to the regulation of body temperature, the storage of nutrients, and various aspects of motivation and emotion. It is also involved in hunger, thirst, sexual behavior, caring for offspring, and aggression. Disturbances within the hypothalamus can lead to unusual drinking and eating behaviors.

Among animals, stimulation of parts of the hypothalamus triggers behaviors such as fighting, mating, and even nest building. Although the hypothalamus is also important to humans, our behavior is less mechanical than other animals and tends to be influenced by cognitive functions such as thought, choice, and value systems.

The **limbic system** forms a fringe along the inner edge of the cerebrum. It gets its name from the Latin word *limbus*, which implies the idea of a circle or ring. The limbic system forms a kind of border around the brain stem. It is involved in learning and memory, emotion, hunger, sex, and aggression. A branch of psychology called evolutionary psychology has studied this area extensively. Evolutionary psychologists believe that the limbic system controls behaviors that are necessary for the survival of humans and other mammals. For example, it allows a person to distinguish between agreeable and disagreeable situations. The brain forms emotional memories of situations that help the person respond and adapt to the situation. Psychologists believe these areas are very specialized and only activate when triggered.

If a particular part of the limbic system is damaged, people can recall old memories but do not create new memories. For example, a man with damage to that area may have vivid

SENSORY AND MOTOR AREAS OF THE BRAIN



The average human adult brain has more than 10 billion cells. Although the brain makes up about 2 to 3 percent of a person’s body weight, it requires about 20 percent of the blood’s oxygen supply.

Skills Focus **INTERPRETING VISUALS** What parts of the brain make up the forebrain?

childhood memories of playing with his sister but may not remember that the same sister visited earlier that day. Researchers have also found that destruction of another specific area of the limbic system can lead animals to show passive behavior. Destruction of still another area of the limbic system causes some animals to behave aggressively, even when there seems no reason to do so.

The **cerebrum** (Latin for “brain”) is the crowning glory of the brain. Only in human beings does the cerebrum make up such a large part of the brain. It accounts for about 70 percent of the brain’s total weight. The cerebrum is the site of most conscious and intellectual activities. The surface of the cerebrum is wrinkled with ridges and valleys. This surface is the cerebral cortex. The **cerebral cortex** is the outer layer of the brain, just as bark is the outer layer of a tree. (*Cortex* is the Latin word for “bark.”)

The cerebral cortex is the part of the brain that we tend to think of when we talk about the brain. It is the part that makes us uniquely human—the part that thinks. In addition to thinking, the cerebral cortex also deals with memory, language, emotions, complex motor functions, perception, and much more.

Reading Check Contrast How do the functions of the midbrain and the forebrain differ?

The Cerebral Cortex

The cerebral cortex is composed of two sides—a left side and a right side. Each side is called a hemisphere. (The Greek *hemi-* means “half.” Thus, each half of the brain is half a sphere, just as each half of Earth is a hemisphere.) To visualize the cerebral cortex, think of a walnut. The shell of the walnut is like the skull. Just as the walnut has two sides that are connected, so does the brain. In the brain, the structure that connects the two hemispheres is called the **corpus callosum**.

Information received by one side of the body is transmitted to the *opposite* hemisphere of the brain. For example, if you touch something with your left hand, that information is sent to the right side of your brain. And if you touch something with your right hand, the left hemisphere of your brain receives the information. The corpus callosum aids in getting information from one side of the brain to the other.

Each hemisphere of the cerebral cortex is divided into four parts called lobes. The frontal lobe lies behind the forehead, and the parietal lobe lies to the top and rear of the head. The temporal lobe lies to the side, just below the ears. The occipital lobe is located at the back of the head.

Some sensations, such as visual sensations, are received primarily in one lobe. However, each lobe does not necessarily act independently from the others. Some functions require the interplay of several lobes. The involvement of the cerebral cortex in the senses and motor behavior is a good illustration of this interaction.

Senses and Motor Behavior The occipital lobe is the primary visual area of the cerebral cortex. When light strikes the eyes, neurons in the occipital lobe fire, enabling us to see. We also “see” flashes of light if neurons in the occipital lobe are stimulated by electrodes.

Damage to different parts of the occipital lobe can create unusual conditions. People with damage to one area may be able to recognize an object, but they may be unable to differentiate it from another object that is similar. For example, if shown a key, they may know that they see a key, but they may not be able to tell it apart from another key.

Brain Facts

- Neurons create and send more messages than all the phones in the entire world. Combined, the neurons create enough electricity to power a 10-watt light bulb.
- Sensory neurons send information to the brain at a speed of more than 150 miles per hour.
- Motor neurons relay information at a speed of more than 200 miles per hour.
- The adult human brain weighs about 3 pounds—about the same as this textbook—and it contains about 100 billion neurons.
- If the cerebral cortex was unfolded, it would cover a typical classroom desk. The surface area of the cerebral cortex is large enough to hold more than 10 billion neurons.
- The average human brain is about 75 percent water.
- During the first month of life, the number of synapses in an infant’s brain increases from 50 trillion to 1 quadrillion.

People with damage to another area may be able to report that they see a face, but they may not be able to identify exactly whose face it is that they see.

The hearing, or auditory, area of the cortex lies in the temporal lobe. Sounds are relayed from the ears to the thalamus to the auditory area. When this occurs, we hear sounds. If a specific area of the temporal cortex is damaged, a person may not be able to recognize very common sounds.

Messages received from the skin's sensory receptors are projected to the sensory cortex in the parietal lobe. These sensations include warmth, cold, touch, and pain. Different neurons fire depending on whether you have scratched your nose, touched the burner of a hot stove, or been stung by a bee.

Association Areas Much of the cerebral cortex is composed of areas that involve sensory and motor functions. Other areas, called **association areas**, shape information into something meaningful. For example, certain neurons in the visual area of the occipital lobe fire when we see vertical lines. Others fire in response to horizontal lines. Association areas put it all together. As a result, we see a box or an automobile or a road map instead of a confusing display of verticals and horizontals.

The association areas in the frontal lobes, near the forehead, could be called the brain's executive center. It appears to be where we solve problems and make plans and decisions.

Executive functions also require memory, like the memory in your computer. Association areas also provide the core of your working memory. They are connected with sensory areas in the brain and can tap whatever sensory information is needed or desired. The frontal region of the brain thus retrieves visual, auditory, and other kinds of memories and manipulates them—similar to the way in which a computer retrieves information from files in storage and manipulates it in working memory. Other association areas make possible the psychological functions of language.

Language Abilities Although the left and the right hemispheres of the brain have many of the same functions, they differ in several ways. For example, for nearly all right-handed

people, language functions are based in the left hemisphere. Language functions are also based in the left hemisphere of about two out of three left-handed people.

Within the hemisphere containing the language functions, two key language areas are Broca's area and Wernicke's area. Damage to either area is likely to cause an aphasia, a difficulty with specific aspects of understanding or producing language.

Wernicke's area, which is located in the temporal lobe, pieces together sounds and sights. People with damage to this area may find it difficult to understand speech, and their speech often is meaningless. For example, when asked to describe a picture of two boys stealing cookies behind a woman's back, one person responded: "Mother is away her working her work to get her better, but when she's looking the two boys looking the other part. She's working another time."

Broca's area is located in the frontal lobe near the section of the motor cortex that controls the areas of the face used for speaking. When Broca's area is damaged, people speak slowly and laboriously, using simple sentences.

Left and Right Hemispheres The same hemisphere that contains most language functions is usually more involved in logic, problem solving, and mathematical computation than is the other hemisphere. The right hemisphere is relatively more concerned with the imagination, art, feelings, and spatial relations. People often speak of certain abilities as belonging to the right brain or to the left brain. Thus, people who are very logical are said to be "left-brained," while people who are creative are called "right-brained." This idea, however, has become exaggerated. Although some differences do exist, the hemispheres do not act independently of each other.

Much of what psychologists have learned about left- and right-hemisphere functioning comes from people who have had split-brain operations. In a split-brain operation, the corpus callosum, which connects the two hemispheres, is cut. This rarely performed procedure is sometimes used to help people with serious neural disorders such as severe epilepsy. People with epilepsy experience seizures, which are bursts of abnormal neuron firings that generally occur in one hemisphere

and then spread to the other. Cutting the corpus callosum can reduce the severity and frequency of the seizures by preventing them from spreading. After the surgery, patients usually function quite effectively despite their hemispheres' inability to communicate with each other.

Still, the surgery does have effects on other brain functions. For example, someone who has undergone the procedure may be able to describe verbally an object she holds in her right hand but not one she holds in her left hand. This is because if an object is held in the right hand, the information is sent to the left hemisphere, which (in most people) contains language abilities. However, if the same object

is held in the left hand, this information is sent to the right hemisphere, which has little language ability. Remember that in a brain with an intact corpus callosum, the hemispheres usually work together. Thus, most people can describe objects held in either hand.

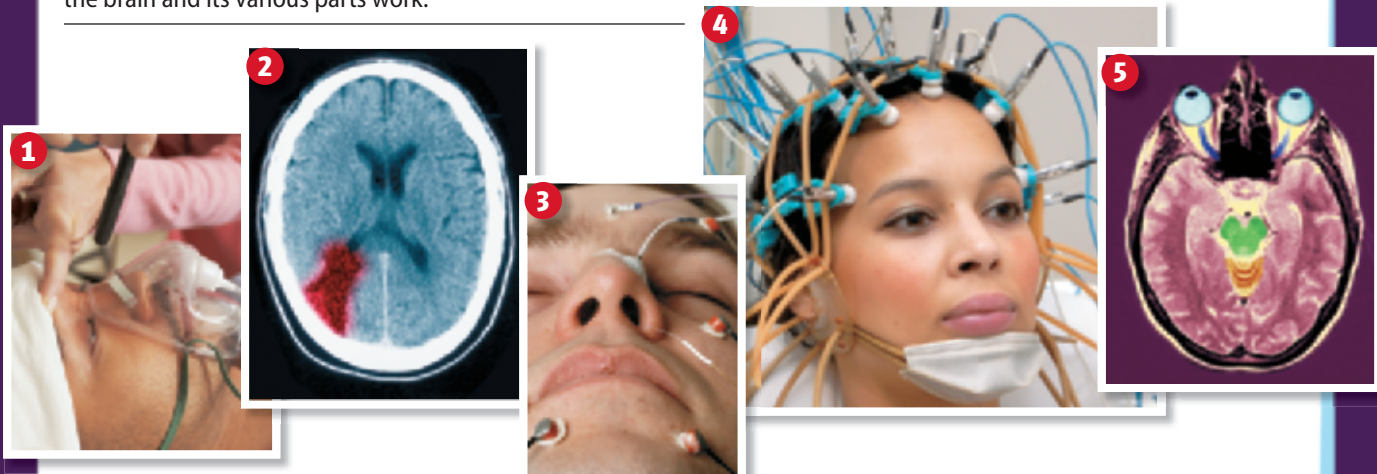
Reading Check Summarize What are the main functions of each part of the cerebral cortex?

Methods of Studying the Brain

Much of our earlier understanding of the brain came from studies of people with head injuries. Today, researchers increase their knowledge of the brain and its functions by using a variety of techniques to study damaged and intact brains.

Studying the Human Brain

Researchers rely on a number of different methods for studying how the brain and its various parts work.



1 Accidents Accidents that cause brain injuries provide researchers with opportunities for learning about how different parts of the brain function.

2 Lesions By creating a lesion, or deliberately destroying a part of an animal's brain, researchers can track how the damage affects certain behaviors.

3 Electrical Stimulation By electrically stimulating the brain, researchers have been able to determine which areas of the brain respond to visual, auditory, or sensory sensations.

4 Electroencephalogram Electrical brain wave activity is transmitted by electrodes and enables researchers to diagnose certain disorders.

5 Brain Imaging Scans such as MRI, CAT, PET, and fMRI allow researchers to create images of the brain and record certain brain functions, such as the ability to see a photograph.

Skills Focus INTERPRETING CHARTS What can scientists learn from accidents?

Accidents One way that researchers are able to see how the brain is related to psychological functions is through the study of brain damage due to accidents.

Brain damage from head injuries can result in confusion, loss of vision or hearing, and loss of memory. In some cases, the loss of large portions of the brain may result in relatively little loss of function. Yet the loss of vital smaller parts can result in language problems or memory loss. In other words, the location of the damage may have a greater effect than the amount of the damage.

CASE STUDY

CONNECTION

Accidental Injuries

Information gathered from accidents involving the brain can help researchers learn more about how the brain functions.

The case of Phineas Gage is an example of how brain injuries can lead to a new understanding about the functions of the brain. Neurologist Antonio Damasio cites Gage's story as the historical beginning of the biological study of the brain.

Lesions Scientists can also study a brain by cutting, removing, or destroying parts of it. By observing an animal's behavior after a part has been removed, scientists can determine what types of behavior that area of the brain controls. For example, removal of a part of the brain may cause an animal to become more aggressive or more passive. Obviously, ethical considerations prevent this type of research on humans, but research can take place on laboratory animals. In addition, new imaging

techniques, such as scans, allow researchers to observe changes in the behavior or bodily functions of humans with brain lesions.

Electrical Stimulation Electrical stimulation of the brain has shown that specific areas are associated with specific types of sensations (such as seeing light or feeling a tap on the arm) or motor activities (such as walking). In a classic experiment, physiologist José Delgado showed how electrical stimulation of the brain could make an animal change its behavioral patterns. The researcher implanted an electrode into a bull's brain. When the brain was stimulated, the bull dramatically stopped charging and circled to the right. In humans, electrical stimulation has been used to relieve pain and to control violent behavior.

In another study, James Olds and Peter Milner implanted electrodes in rats' brains to learn about the functions of the hypothalamus. When the rats pressed a lever, the electrodes stimulated a portion of the hypothalamus. As it turned out, the rats found this stimulation pleasurable—so pleasurable that the rats would press the lever up to 100 times a minute just to receive the stimulation. In some cases, hungry rats chose electrical stimulation over food. The part of the hypothalamus where the electrodes were implanted became known as a “pleasure center.”

Electrical stimulation of the brain is not always reliable as a research tool. Stimulation in the same place can produce different effects at different times. On one occasion, a rat may eat when a portion of the brain is stimulated, but on another occasion it may drink. The areas that produce pleasant and unpleasant sensations in people may also vary from person to person and from day to day.

The Electroencephalograph The electroencephalograph (EEG) is a device that records the electrical activity of the brain. Electrodes attached to the scalp detect small amounts of electrical activity called brain waves. Researchers have learned that the brain has overall activity that rises and falls in predictable patterns. Some brain wave patterns are associated with wakefulness, relaxation, or sleep. Others show active thinking or certain bodily functions. EEG readings are used to help diagnose some kinds of psychological disorders and to help locate tumors.

Experimenting with the Brain

Researchers can trigger rats to eat more or less by electrically stimulating different parts of a rat's brain.



Brain Imaging Images of the brain can provide information about brain damage and other abnormalities. Imaging techniques are also used for early diagnoses of cancers and other problems. Surgeons use imaging to aid them during difficult and intricate surgeries.

In computerized axial tomography (CAT) scans, a moving ring passes X-ray beams around and through the head. The density of the brain tissue determines how much radiation is absorbed. Computers measure the amounts of radiation and piece together a three-dimensional view of the brain that can be displayed on a video monitor.

Similar to CAT scans, magnetic resonance imaging (MRI) is a noninvasive medical procedure. During an MRI, a person lies in a very powerful magnetic field. Radio waves then cause parts of the brain to give off extra energy. This energy is measured from multiple angles. A computer translates the information into a visual image of the brain's anatomy. It can also be used to produce detailed images of other organs, soft tissues, bones, and virtually all other internal body structures. An MRI is more powerful than a CAT scan and can show details more clearly. An MRI is more effective at revealing small injuries and abnormalities in hard-to-see areas.

While CAT scans and MRIs show snapshots of the brain, other new technologies allow researchers to see the brain at work. Top among these technologies are the positron emission

tomography (PET) scan and a fast kind of MRI called the functional MRI (fMRI). In a PET scan, a person is injected with radioactive sugar. As the sugar reaches the brain, more of it is used in the locations where brain activity is greater. A computer uses the sugar levels to create an image showing the amount of activity in different areas of the brain.

The fMRI can show which parts of the brain are active when we perform different activities, such as listening to music or working on a math problem. If you raise your hand, the fMRI image will show activity in the part of the brain associated with that movement. If you start to sing a song, other parts of the brain will light up. Research with PET scans and fMRIs support the view that much of our problem solving takes place in the frontal lobes of the brain.

Using these methods, scientists have learned that the mind is a product of the brain. Today the scientific community agrees that for every mental event there are accompanying, underlying biological events. Imaging techniques have allowed us to explore more deeply how the nervous system, particularly the brain, functions while we are thinking, feeling, and moving. Moreover, the study of brain abnormalities has revealed that when parts of the brain undergo damage, other areas of the brain can sometimes take over the functions of the damaged areas.

Reading Check Compare How does the information researchers gain from accidents compare to brain imaging techniques?

SECTION 2 Assessment

Online Quiz



thinkcentral.com

Reviewing Main Ideas and Vocabulary

- Contrast** How did ancient Egyptian and Greek ideas about the human capacity for thought differ?
- Recall** Why do scientists say that the cerebral cortex is the part of the brain that makes us unique as humans?
- Infer** Which methods of studying the brain are best for seeing brain function as it happens?

Thinking Critically

- Compare and Contrast** How are left-brained and right-brained people thought to be different?
- Predict** What might happen to a person's capacity for language if his or her cerebral cortex was damaged?

- Summarize** Using your notes and a graphic organizer like the one below, summarize the parts of the brain and the functions each performs.

Hindbrain	Midbrain	Forebrain

FOCUS ON WRITING

- Descriptive** Imagine that you are explaining the parts of the brain to a student in elementary school. Write a descriptive paragraph that would help the student understand the parts of the brain and the functions they fulfill.

The Endocrine System

Before You Read

Main Idea

The endocrine system produces hormones that affect growth, development, and some behaviors.

Reading Focus

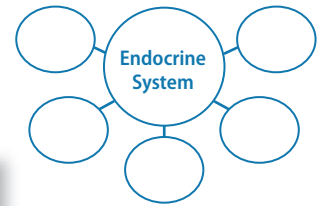
1. What are three major glands of the endocrine system, and how do they affect the body?
2. What are the testes and ovaries, and what are their functions?

Vocabulary

endocrine system
hormones

TAKING NOTES

Use a graphic organizer like this one to take notes on the endocrine system and its functions.



STEROID ABUSE AND TRAGEDY

PSYCHOLOGY CLOSE UP

Could tinkering with the body's endocrine system cause a violent rampage?

The memorial in this photograph is for professional wrestler Chris Benoit and his family, all of whom died in a double murder-suicide in 2007. Benoit had a prescription for anabolic steroids, synthetic hormones that build muscle and strength. Police speculated that Benoit killed his family as a result of steroid abuse. Steroids can have devastating side effects: irritability and uncontrolled anger, depression, and suicidal thoughts.

Violence wasn't typical of Benoit's nature, so the wrestler's father agreed to have his son's brain analyzed. The results showed that Benoit's brain was similar to that of an 85-year-old Alzheimer's patient. Although repeated concussions from his wrestling bouts probably caused the damage, the steroids could have contributed to an agitated mental state and horrible acts of violence. Most hormones, however, are essential and beneficial. In this section, you will learn about the endocrine system, the body's system for manufacturing and regulating these powerful chemicals. ■

Three Endocrine Glands

The **endocrine system** consists of glands that secrete substances, called **hormones**, into the bloodstream. The word *hormone* is derived from the Greek *horman*, meaning “to stimulate” or “to excite.” Hormones stimulate growth and many kinds of reactions, such as changes in activity levels and physical moods. Because hormones affect behavior and emotional reactions, psychologists who study the biology of behavior are also interested in the endocrine system.

Hormones travel in the bloodstream throughout the body. Like neurotransmitters, hormones have specific receptor sites. The various hormones circulate throughout the body and act only on hormone receptors on the body part that they influence. Hormones are produced by several different glands. Three important glands in the endocrine system are the pituitary gland, the thyroid gland, and the adrenal glands.

The Pituitary Gland The pituitary gland lies just below the hypothalamus in the middle of the brain. It is about the size of a pea, but it is so important that it has been referred to as “the master gland.” The pituitary gland, which is stimulated by the hypothalamus, is responsible for the secretion of many different hormones that affect various aspects of behavior. Some pituitary hormones stimulate other endocrine glands such as the adrenals, thyroid, and ovaries or testes.

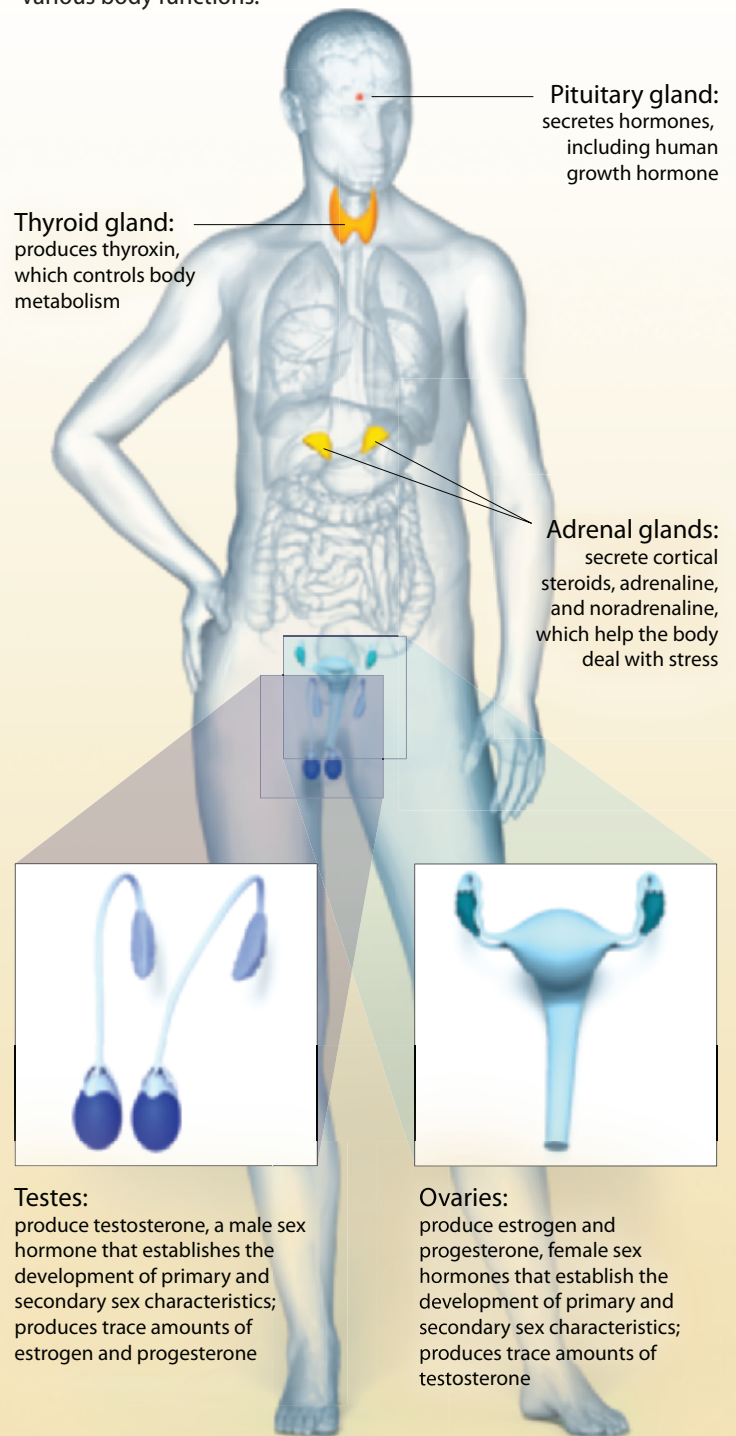
Human growth hormone, for example, regulates the growth of muscles, bones, and glands. Children whose growth patterns seem abnormally slow often catch up to others the same age when doctors give them human growth hormone.

Some hormones affect females in relation to pregnancy and mothering. Prolactin stimulates production of milk in nursing women. Oxytocin is responsible for stimulating labor in pregnant women. Sometimes when a pregnant woman is overdue, an obstetrician causes labor to begin by injecting the woman with oxytocin hormone.

Oxytocin and prolactin have been shown in some lower mammals to be connected to maternal behaviors, such as caring for young. The role of these hormones in human maternal behaviors, however, remains unclear.

The Endocrine System

The glands of the endocrine system secrete hormones that stimulate various body functions.



Skills Focus INTERPRETING VISUALS

Why are psychologists interested in how the endocrine system functions?

The Thyroid Gland The thyroid gland produces the hormone thyroxin. Thyroxin affects the body's metabolism—its rate of converting food to energy. The production of too little thyroxin can lead to a condition called hypothyroidism. People with hypothyroidism are likely to be sluggish and often overweight. For children, too little thyroxin can cause a condition called cretinism, which is characterized by stunted growth and mental retardation.

People who produce too much thyroxin may develop hyperthyroidism. Hyperthyroidism is characterized by excitability, inability to sleep, and weight loss.

The Adrenal Glands The adrenal glands are located above the kidneys. The Latin prefix *ad-* means “toward” or “at,” and *renal* derives from the Latin *renes*, meaning “kidneys.”

The outer layer, or cortex, of the adrenal glands secretes cortical steroids. Cortical steroids increase resistance to stress and promote muscle development. They also cause the liver to release stored sugar, making energy available for emergencies.

The adrenal glands also produce adrenaline and noradrenaline. When a person faces a stressful situation, the sympathetic nervous system causes the adrenal glands to release a mixture of adrenaline and noradrenaline. These hormones help arouse the body, enabling the person to cope with the stressful situation.

Adrenaline also plays a role in the emotions people experience. It can intensify emotions such as fear and anxiety. Another function of noradrenaline is to raise blood pressure. In the nervous system, it also acts as a neurotransmitter.

Reading Check Summarize What body processes do the pituitary, thyroid, and adrenal glands influence?

Ovaries and Testes

Other glands are the ovaries (in females) and the testes (in males). These glands produce the hormones that influence sexual development and functions. Both glands produce the same hormones—estrogen, progesterone, and testosterone. The difference lies in the amounts of each hormone that are produced in females and males.

Estrogen and Progesterone Estrogen and progesterone are female sex hormones, although low levels are found in males. The ovaries in females produce these hormones. Estrogen is also produced in smaller amounts by the testes in males.

Estrogen is actually a group of chemically similar hormones. In humans and other animals, estrogen hormones foster the growth and development of female sexual characteristics, such as breast enlargement and rounded hips. Progesterone has multiple functions. It stimulates growth of the female reproductive organs and helps prepare the body for pregnancy.

Together, estrogen and progesterone regulate the menstrual cycle, and their levels vary greatly during that cycle. Changes in levels of estrogen have been linked to premenstrual syndrome (PMS) in some women. PMS is a collection of symptoms (such as irritability, depression, and fatigue) that some women experience before menstruating. At the same time, monthly increases in progesterone may cause other symptoms associated with PMS, such as a rise in body temperature.

As women grow older, their ovaries secrete smaller and smaller amounts of estrogen. In time, estrogen levels in the blood become so low that they no longer trigger the menstrual cycle. At this point a woman is said to have entered menopause, and she is no longer fertile. During menopause, many women may receive medical treatment with estrogens to relieve hot flashes and other menopausal symptoms.

Estrogen has psychological effects as well as biological effects. Higher levels of estrogen seem to be connected with optimal cognitive functioning and feelings of well-being among women. Women are also more interested in sexual activity when their estrogen levels are high—particularly during ovulation, when they are fertile.

Testosterone Testosterone is the primary male sex hormone, although females have small amounts of this hormone as well. Testosterone is produced by the testes in males. Small amounts of it are also secreted by the ovaries in females. Testosterone plays an important role in development.

In the prenatal period, testosterone influences development of the sex organs in the fetus. About eight weeks after fertilization, if testos-



TEENS AND ANABOLIC STEROID USE

Use of anabolic steroids among teenagers has decreased over the last 10 years. However, teens who continue to use steroids do not always know what can happen as a result. Here are some effects of the use of anabolic steroids on the bodies of teenagers.

Sex of User	Effect
Male	<ul style="list-style-type: none"> • May have breast development • Risk of hair loss and male-pattern baldness
Female	<ul style="list-style-type: none"> • Risk male-type facial and body hair growth, and male-pattern baldness • May experience a deepening of the voice
Both Sexes	<ul style="list-style-type: none"> • May have stunted growth, or worsening acne • May develop liver tumors or abnormalities that affect the heart • May exhibit violent or aggressive behavior or mood swings

Skills Focus INTERPRETING CHARTS What are the effects of steroid use on both male and female users?

terone is secreted by the fetus, it stimulates development of male sex organs. If testosterone is not secreted, female sex organs develop.

In adolescence, testosterone aids the growth of muscle and bone as well as the development of primary and secondary sex characteristics. Primary sex characteristics are directly involved in reproduction. Secondary sex characteristics, such as beard growth, distinguish males and females but are not directly involved in reproduction.

Testosterone is a kind of steroid. Steroids affect muscle mass, heighten resistance to stress, and increase the body's energy supply. Steroids also stimulate the sex drive and can raise self-esteem.

Recently, the production of synthetic human growth hormones and steroids known as anabolic steroids has gained the attention of behavioral psychologists. Because our society is highly competitive, some people are tempted to use steroids to enhance their performance or body appearance. Such use, however, has serious medical and ethical implications. These substances can produce changes not only in physical aspects of the body, but also in behaviors, moods, anger levels, aggressive behavior, and depression. Researchers have also reported links between steroid use and sleep disturbances, liver damage, heart disease, and other medical problems. Because some athletes use steroids to enhance their

athletic ability, steroids also cause ethical problems. They give athletes who use them an unfair advantage over those who do not.

Reading Check Identify Supporting Details

What hormones are produced by the ovaries and the testes?

ACADEMIC VOCABULARY

anabolic a phase of metabolism in which substances are synthesized into living tissue

SECTION 3 Assessment

Online Quiz



thinkcentral.com

Reviewing Main Ideas and Vocabulary

- 1. Recall** What are the functions of hormones?
- 2. Explain** Why is the pituitary gland often called "the master gland"?
- 3. Draw Conclusions** How are the adrenal glands and the sympathetic nervous system related?

Thinking Critically

- 4. Compare** In what way are neurotransmitters and hormones similar?
- 5. Explain** How does the endocrine system affect sexual development?

- 6. Elaborate** What are some possible ways the endocrine system might affect behavior?
- 7. Categorize** Using your notes and a graphic organizer like the one below, list the endocrine glands and their function.

Pituitary	Thyroid	Adrenal	Ovaries	Testes

FOCUS ON WRITING



- 8. Persuasive** Write a paragraph explaining why the use of anabolic steroids to enhance sports performance is a bad idea for athletes.

Heredity: Our Genetic Background

Before You Read

Main Idea

Heredity is the transmission of characteristics from parents to offspring. Both heredity and environment shape an individual's personal traits.

Reading Focus

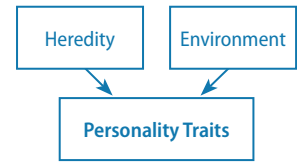
1. What are the roles of genes and chromosomes in heredity?
2. What are the main points of the nature-nurture issue?
3. What are kinship studies?

Vocabulary

heredity
genes
chromosomes

TAKING NOTES

Use a graphic organizer like this one to understand the role of heredity and environment in shaping personality.



Identical Strangers



PSYCHOLOGY CLOSE UP

Why were identical twins separated at birth? Imagine getting a phone call in which the caller says, “Hi, I just found out you are my twin.” Such a call took place between Paula Bernstein and Elyse Schein after 35 years of being separated. As they got to know each other, the twins learned they had much in common. For example, both were interested in film: one sister was a filmmaker and the other wrote about films. Both had even suffered from depression in college.

Bernstein and Schein were separated shortly after birth and sent to different adoptive families. They were part of a secret study that focused on the effects of nature versus nurture—or heredity versus environment—on twins. Even the adoptive parents were unaware of the study's purpose. (Today, separation of siblings for adoption is illegal in most states.) Although it cannot be verified, many people think the study was designed to explore the inheritability of mental illness. The girls' mother had schizophrenia. The study was stopped in 1980 and the results sealed until 2066, so the twins may never know the exact nature or results of the study.

Studies of twins, especially of identical twins, enable researchers to investigate the influence of heredity and environment on individuals. As you will see, genetic makeup has a huge influence on the way each individual develops. ■

Heredity, Genes, and Chromosomes

Heredity is the transmission of characteristics from parents to offspring. Psychologists study heredity, along with the brain and the endocrine system, as a means of understanding why people behave as they do. Heredity plays a key role in the development of traits both in people and in animals. The traits we inherit help shape our behavior.

Heredity is key in the transmission of physical traits such as height, hair texture, and eye color. Heredity is also related, to some extent, to some psychological traits. Researchers have found that some psychological traits, such as shyness, leadership ability, aggressiveness, and even an interest in art, are influenced by heredity, although environmental factors also play an important role. Still, heredity has been shown to be one factor involved in many psychological disorders, including anxiety and depression, schizophrenia, bipolar disorder, and alcoholism.

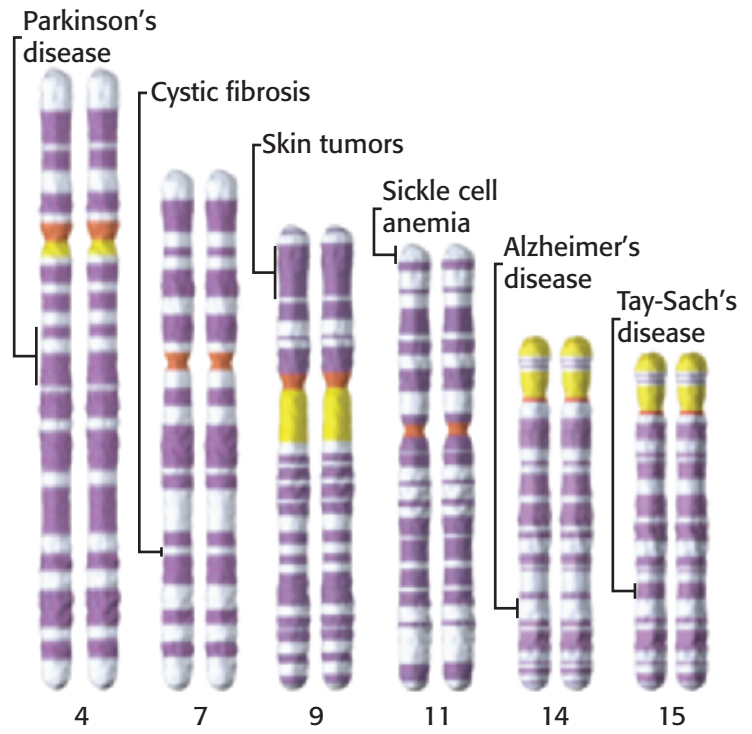
Genes are the basic building blocks of heredity. Traits are determined by pairs of genes, with one gene in each pair inherited from each parent. Some traits, such as blood type, are controlled by a single pair of genes. Complex psychological traits, such as intelligence, involve combinations of genes as well as environmental factors.

Genes are found in threadlike structures called **chromosomes**, which are composed of deoxyribonucleic acid (DNA). DNA is in the form of a double helix. Most normal human cells contain 46 chromosomes that are organized into 23 pairs. In each of the 23 pairs, one chromosome comes from the father and the other comes from the mother. Each chromosome contains instructions for the development of particular traits in the individual.

Genetic disorders can be caused by a mutation of a gene, or a disorder may be inherited. A mutated gene may be passed on from parent to child for many generations. For example, hemophilia, a blood disorder, was passed to members of several royal European families for many generations. Sickle-cell anemia is a genetic mutation that is commonly found among African Americans.

Of the 23 pairs of chromosomes, 22 are similar in males and females. The twenty-third pair, the sex chromosomes, determines

MAPPING GENETIC DISORDERS ON CHROMOSOMES



This computer illustration shows how scientists have been able to locate genetic disorders on numbered pairs of chromosomes.

whether we are female or male. In males, the twenty-third pair consists of an X chromosome (so called because of its X shape) and a Y chromosome (because of its Y shape). Females have two X chromosomes, so they always pass an X chromosome on to their offspring. The chromosome that comes from the father, therefore, determines the sex of the offspring. If the father contributes an X chromosome, then the offspring is female. If the father contributes a Y chromosome, however, then the offspring is male.

When a child is born without all 46 chromosomes in each cell, physical and behavioral disorders may result. One of the most common disabilities of this type occurs when there is an extra, or third, chromosome on the twenty-first pair. When this happens, a baby will be born with Down syndrome. People with Down syndrome usually have some level of mental disability and may also have heart and respiratory problems.

Reading Check Contrast How are genes different from chromosomes?

ACADEMIC VOCABULARY

mutation a sudden and random change in the genetic material of a cell

Nature and Nurture

Throughout history, philosophers and scientists have debated the role of biology in determining who we are as people. This discussion is often called the “nature-nurture” issue. *Nature* refers to what people inherit—the biological groundwork that prepares a person to develop in certain ways. Nature can include such things as physical appearance, intelligence, and abilities in certain areas like math or the arts or language. *Nurture* refers to environmental factors—what a person is exposed to in life. Nurture includes a variety

of factors such as family, education, culture, living conditions, everyday individual experiences, and other factors that make up one’s environment.

People who support the “nature” side of the issue argue that people’s traits and personality are primarily determined by their biological makeup. The argument is that our inherited characteristics determine the kind of people we are. Supporters of the “nurture” side argue that the environment we live in and our everyday experiences—not our biological inheritance—determine how we behave and think.

Parenting—Nature or Nurture?

The discussion among researchers and psychologists about nature versus nurture has always been a spirited one. Although few are completely on one side or the other, researchers have a tendency to favor one view over

the other. The three experts here present their thoughts on the influence of nature and nurture with regard to parenting. *Which of the opinions come closest to your point of view? Explain.*



“Many parenting studies measure a correlation between parenting practices and children’s outcomes and conclude that parenting made the difference . . . [However] It poses a question, how do we explain this very large component of personality that’s not genetic but that just surely doesn’t come from growing up in a particular home?”

—Steven Pinker, Harvard professor and author of *The Blank Slate: The Modern Denial of Human Nature*

“It’s the assumption that what makes children turn out the way they do, aside from their genes, the environmental part of child development, is the experiences they have with their parents. It’s really in the second half of the twentieth century that this idea of parental importance has become so popular and, in my view exaggerated.”

—Judith Harris, author of *The Nurture Assumption*



“Nature/nurture work more as a dance . . . like Fred Astaire and Ginger Rogers. Once the dance starts it’s how they interact together. . . . The potential is only defined by the gene interaction with the environment, and it may be that the environment sets the constraints just as . . . much as the genes do.”

—Stanley Greenspan, M. D., child psychiatrist

Both of these views are extreme. Today most psychologists agree that the influences of both nature and nurture determine our psychological traits. Biology influences us to act in certain ways, but our environment—along with personal factors such as values and decision making—can modify these plans. It is the interaction of heredity and environment that determines who we are. A person who has the genetic potential to write a brilliant novel will never write that novel if he or she never learns to read or write. Likewise, an athlete who has the genetic potential to win a gold medal in figure skating will never win an Olympic medal if he or she has never been to a skating rink.

Although most psychologists agree that genes and the environment interact, the extent of the role that heredity plays is still a controversial topic. Some psychologists believe that many of our traits, including intelligence, are determined largely by genetics. Others have criticized this view and are concerned about its implications. The heredity view can be interpreted to suggest that we cannot control our destiny because it is determined by our biology. Taken to the extreme, the heredity view might suggest, for example, that we should not try to change something about ourselves with which we are not satisfied.

Most psychologists are careful to note that heredity is not destiny. They emphasize that the environment does play a role in determining how a person develops. A new factor has recently been introduced into the debate over nature-versus-nurture—the influence of parenting. Some psychologists suggest that peers and genes are more important in the development of a child than are parents. These psychologists believe that children are strongly influenced by the environment outside the home as well as inside it.

Reading Check Analyze Why do psychologists agree that "heredity is not destiny"?

Kinship Studies

The most common scientific way to sort out the roles that heredity and environment play in determining a trait is to conduct kinship studies. Kinship refers to the degree to which people are related—the more closely related, the more genes they will have in common.

Identical twins share 100 percent of their genes. A parent and child share 50 percent of their genes, as do full brothers and sisters, on average. Aunts and uncles related by blood share an average of 25 percent of their genes with nieces and nephews, and first cousins share an average of 12.5 percent.

Psychologists use this information to determine how much a trait is influenced by genetics and how much by environment. They study certain traits or behavioral patterns in individuals and then compare them to those of relatives. If genes are involved in a certain trait, then people who are more closely related, and who share more genes, should be more likely to exhibit the trait than do people who have less overlap in genes or who are not related. Two common types of kinship studies are twin studies and adoptee studies.

Twin Studies The study of identical and fraternal twins is a useful way to learn about the relative influences of nature and nurture. Because identical twins share the same genetic makeup, differences between identical twins would seem to be the result of the environment. For example, if one identical twin loves jazz, but the other twin prefers rock, that difference would appear to be due to the twins' different experiences in the environment—not their heredity.

In contrast, fraternal twins, like other brothers and sisters of the same parents, share an average of 50 percent of their genes. Thus, differences between fraternal twins might stem from either heredity or the environment. The premise behind twin studies is that if identical twins are more similar on a certain trait than are fraternal twins, then that trait is more influenced by genetics.

Researchers have found that in addition to physically resembling each other, identical twins resemble one another more strongly than fraternal twins in certain other traits, including shyness and activity levels, irritability, sociability, and happiness. Thus, these traits appear to be influenced by heredity.

Identical twins are also more likely than fraternal twins to share physical and psychological disorders, such as autism, substance dependence, and schizophrenia. Autism is a disorder characterized by limited social and communication abilities.

In a study on autism, both twins were likely to be autistic in 96 percent of the identical twin pairs. In contrast, both twins were likely to be autistic in only 24 percent of the fraternal twin pairs. This evidence strongly suggests a role for heredity in autism.

Adoptee Studies One problem with twin studies is that identical twins tend to be treated similarly and are exposed to similar environments. Because they share the same environment and heredity, it is sometimes difficult to determine whether their similarities are due more to nature or nurture.

One way to try to eliminate the effects of common backgrounds is to study children who have been adopted. Children who have been separated from their parents at an early age and then raised elsewhere provide special opportunities for sorting out the effects of nature and nurture. Psychologists look for the relative similarities between children and their adoptive and biological families. If the children act more like their biological families—with whom they share genes—than their adoptive families—with whom they share the environment—then their behavior may be largely influenced by heredity.

Twins Reared Apart One of the most useful types of kinship studies examines twins who have been reared apart. Twins reared apart are less likely than twins reared together to share common experiences. Thus, similarities are more attributable to genetic factors.

In a major study that began in 1979, Thomas Bouchard and his colleagues examined twins who were reared apart. They found that many psychological and personality traits—including intelligence, traditionalism (following rules), risk avoidance, aggression, and leadership—are influenced by heredity. In one study, Bouchard found a pair of identical twins who had been raised separately. Both had police training and had married women named Linda, and both chewed their fingernails.

Twins reared apart even share many of the same mannerisms, such as how they sit or stand. In one study, one pair of twins each wore seven rings, two bracelets on one wrist, and a bracelet and watch on the other wrist. Most researchers, however, acknowledge that the environment also has an important effect on the development of traits and mannerisms.

The results of twin studies were expected to yield important information. However, most of the studies were suspended for ethical reasons. For example, in the study that split Paula Bernstein and Elyse Schein, adoptive families were not notified that the children were a part of a scientific study. People also questioned the deliberate separation of children from siblings and the failure to inform the children or adoptive families of other siblings. Today, many states insist that siblings being adopted go to the same family.

Reading Check Find the Main Idea Why are studies of twins useful to psychologists?

Online Quiz



thinkcentral.com

SECTION 4 Assessment

Reviewing Main Ideas and Vocabulary

- 1. Recall** What is heredity?
- 2. Identify** What factors are included in the idea of nurture?
- 3. Summarize** What can psychologists learn from conducting kinship studies?

Thinking Critically

- 4. Draw Conclusions** Why are psychologists interested in the nature-nurture issue?
- 5. Explain** How do psychologists view the role of environment in determining individual traits?
- 6. Rank** What do you think are the most compelling reasons for and against conducting studies of twins?
- 7. Compare and Contrast** Using your notes and a graphic organizer like the one below, discuss the influence of nature and nurture on an individual.
- 8. Persuasive** Re-read the quotes on the influence of parenting on children in the feature titled “Parenting—Nature or Nurture?” Write a paragraph supporting or refuting the ideas of one of the people quoted.



FOCUS ON WRITING



The Genographic Project

Have you wondered where your ancestors came from? Some families can trace their history back several centuries. But where were your ancestors 1,000 or 10,000 years ago? A remarkable program called the Genographic Project aims to map the migratory history of all humankind. What can it tell us about what we have inherited from our ancestors?

The Genographic Project is an attempt to study patterns and evidence from our past. The project conducts sophisticated analyses of DNA voluntarily contributed by hundreds of thousands of people from around the world, including samples from indigenous and traditional populations on six continents. Ten regional scientific teams collect and analyze data from their region.

Scientists believe that all human beings trace back to Africa, but what is not clearly known is how we migrated and populated the world. Another question is this: If we

all share a common ancestor, why do we look so different from each other? Other questions arise about the impact of culture on our genetic background. For example, what influence did conquerors such as the Mongols or the Romans have on local populations?

An early finding from the study has shed light on the question about conquerors and invaders. Researchers studied men in Lebanon, a country in a region that has been invaded or ruled by several different cultures. The DNA of 926 men from Christian, Muslim, and Druze communities was



The Genographic Project relies on DNA samples voluntarily contributed by hundreds of thousands of people.

analyzed. A genetic marker commonly found in European populations was found in Lebanese Christian men. This was probably the result of European Christian Crusaders, who began invading the region, once called the Levant, in the 1100s.

Among Lebanese Muslim men, a marker appeared that is typical of the populations of the Arabian Peninsula. Most likely these markers were a result of Muslim expansion in the 600s and 700s. Other markers revealed that Lebanese populations are closely related, suggesting that, before the arrival of Arabs and Europeans, the population was more homogenous (Zalloua et al., 2008).

The genetic markers linking Lebanese men to European and Arab ancestry tell one of many human migration stories. The ultimate goal of the Genographic Project is to uncover a web of migration stories that will explain how humans populated the world and show how closely the human family is related.

Thinking Critically

- Infer** Why would the results of this study be of interest to psychologists?
- Discuss** How do you think you would react if you found out that your ancestors came from a place much different from where you originally believed?



Building the Human Brain



Reading and
Activity Workbook

Use the workbook to
complete this lab.

What are the major parts of the brain, and how do they work?

1. Introduction

The purpose of this lab is to help you understand one of the greatest mysteries that has ever existed: the human brain. You will work with a partner to build a three-dimensional mobile of the human brain. Building the human brain will help you identify the brain's major parts and learn the function of each part.

At the end of this lab, your knowledge of the brain will be put to the test. You will be faced with a series of fill-in-the-blank statements, each concerning a damaged region of the brain. Your challenge will be to correctly identify which region of the brain has been damaged. To complete this lab, follow the steps below.

- Following your teacher's instructions, organize the class into groups of two students.
- Read all of the steps of the lab. Then work with your partner to review the chapter material on the brain. Write down a few main points about each part of the brain.
- Conduct additional library or Internet research on the parts of the human brain and their functions, if your teacher instructs you to do so.
- Gather the materials you will need to complete your lab: coat hanger, string, magazines, Internet access, colored pencils, markers, glue, and scissors. You and your partner are now ready to create your model.

2. Diagramming the Brain

Working with your partner, create two diagrams of the brain. One diagram should outline the major lobes of the brain and the other diagram should clearly label the middle and lower brain structures. Be sure to identify all of the items listed below in your maps. When you finish, attach each diagram to one side of the coat hanger.

Diagram 1

frontal lobe
parietal lobe
occipital lobe
temporal lobe
sensory cortex
motor cortex
Broca's area
Wernicke's area

Diagram 2

pons
medulla
reticular formation
cerebellum
thalamus
hypothalamus

3. Crafting Your Mobile

Create an illustration or select an image or an object to represent the function of each part of the brain. Then attach your image or object to the mobile by tying it with string to the bottom of the hanger. Attach a label to each item so that you remember why you and your partner selected that item. For example, you might select a picture of an eye ball and label it "occipital lobes" to represent the occipital lobes, whose primary function is visual interpretation. When you have completed this task, you and your partner should have 14 items, drawings, or objects hanging from your mobile.

4. The Final Challenge: Mind over Matter

Using the knowledge gained from creating your mobile along with information from the chapter, work with your partner to answer the following questions. Write your answers on a single sheet of paper that you can turn in to your teacher along with your mobile.

1. Tom has been in a coma since his car accident last month. The area responsible for waking him is known as the _____.
2. Antonio suffered a head injury playing baseball and is no longer able to produce words and sentences that make sense to others. This is most likely a result of damage to the _____.
3. After suffering a stroke, Jessica is read the following statement: A lion killed the tiger. When asked which animal died, Jessica is unable to answer even though she can read the sentence out loud. Damage has most likely occurred to the _____.
4. Maria has been diagnosed with a brain tumor that makes her prone to fits of aggressive outbursts. The tumor is most likely located on her _____.
5. After suffering from a brain injury, David can no longer make decisions for himself and finds it very difficult to make plans for his future. This is most likely due to damage in the _____.
6. Sarah has recently been diagnosed with the early stages of Alzheimer's disease. She is suffering memory loss due to damage in her _____.
7. Due to complications from diabetes, Trevor has recently had his leg amputated. He now suffers from phantom limb sensations, feeling as if he must move his foot to make himself more comfortable. This is a result of messages still being received in the part of the brain called the _____.
8. Britney was admitted to the hospital for spinal meningitis. If her brain continues to swell, it will cut off her breathing center, otherwise known as the _____.
9. Having fallen off of a ladder and hit the back of his head, Marcus is no longer able to distinguish faces of loved ones from faces of strangers. He has most likely damaged the region of his brain called the _____.
10. Due to a problem during neurosurgery, Allison has suffered some dramatic side effects. Once a slim 120 pounds, she now eats continuously and weighs over 300 pounds. Doctors have concluded they may have damaged the region of her brain known as the _____.

5. Discussion

What did you learn from this lab? Your teacher will call the class together to hold a discussion that focuses on the questions below. Be prepared to use your mobile to help explain your answers to the class.

- Overall, how successful were you and your partner at mapping the different parts of the brain?
- Did attaching images and objects to your mobile help you better remember the functions of different parts of the brain? If so, what part of your brain do you think is responsible for this?
- Were some parts of the brain particularly difficult to illustrate? If so, which ones, and why do you think they were hard to illustrate?
- Were some parts of the brain particularly easy to illustrate? If so, which ones, and why do you think they were easy?
- In your opinion, which part and function of the brain do you think is most important to human survival? Explain.
- Is there any part of the brain that you think you could live without? Describe how your life might change if your brain lost the function of that part.

CHAPTER 3 Review

Comprehension and Critical Thinking

SECTION 1 (pp. 66–71)

1. **a. Identify Main Ideas** Why is the nervous system referred to as a communication system?
- b. Explain** How are messages transmitted from one neuron to another?
- c. Elaborate** How do the sympathetic and parasympathetic systems respond to stress?

SECTION 2 (pp. 72–79)

2. **a. Recall** List the three parts of the brain and one function of each.
- b. Explain** In what ways does the reticular activating system function?
- c. Predict** How might damage to the occipital lobe affect an individual?

SECTION 3 (pp. 80–83)

3. **a. Identify Main Ideas** Why are psychologists who study the biology of behavior interested in the endocrine system?
- b. Sequence** How do the adrenal glands and the nervous system respond when an individual faces a stressful situation?
- c. Evaluate** What are the effects of the endocrine system on human development?

SECTION 4 (pp. 84–88)

4. **a. Describe** What role does heredity play in human behavior?
- b. Contrast** How are twin studies different from adoptee studies?
- c. Elaborate** What are some of the possible consequences of abnormalities in chromosomes?

Reviewing Vocabulary

Match the terms below with their correct definitions.

- | | |
|------------------------------|----------------------|
| 5. peripheral nervous system | 9. cerebrum |
| 6 neurotransmitter | 10. cerebral cortex |
| 7. synapse | 11. reticular |
| 8. autonomic nervous system | 12. endocrine system |
| | 13. genes |
| | 14. PET |

- A. system that regulates the body's vital functions
- B. the outer layer of the brain
- C. basic building blocks of heredity
- D. chemicals that transmit messages in the nervous systems
- E. system that transmits messages between the central nervous system and all other parts of the body
- F. system of glands that secrete hormones into the bloodstream
- G. the junction between an axon terminal and a dendrite
- H. a scan that observes the brain at work
- I. resembling an intricate or complex net
- J. the forebrain with two hemispheres

INTERNET ACTIVITY

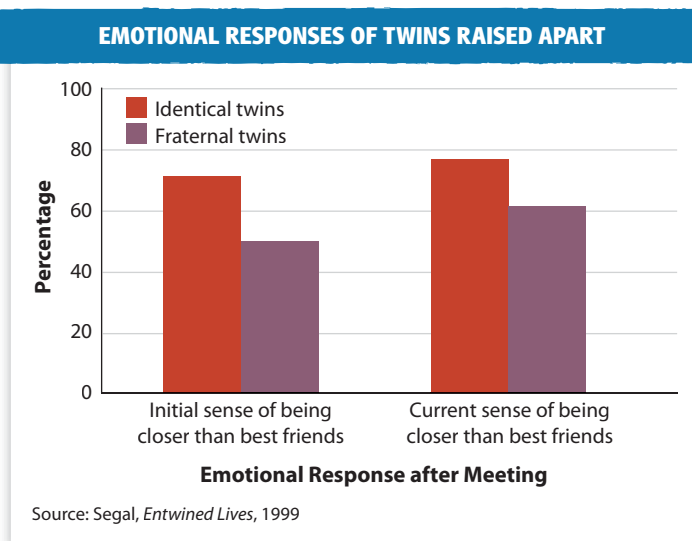
15. How are traumatic brain injuries treated today? With the increased use of improvised explosive devices (IEDs) in war zones, there has been a major increase in traumatic brain injuries in the military. Use the Internet to research the effect of blast waves on the brain and the treatments being used to treat the injuries. Write a report describing the injuries and methods being used to treat them.

Psychology in Your Life

16. Imagine you have stubbed your toe. Think about the function of the nervous system in your body's responses. Write a paragraph describing what happens as your nervous system responds to this minor injury. With your paragraph, include a diagram showing the activity and systems involved in the response.

SKILLS ACTIVITY: INTERPRETING GRAPHS

Study the bar graph below. Then use the information to help you answer the questions that follow.



- 17. Contrast** How are the responses of identical and fraternal twins different?
- 18. Infer** What additional information would make this graph more useful?
- 19. Evaluate** What might this data suggest about the role of heredity or environment in the responses of separated twins?

WRITING FOR AP PSYCHOLOGY

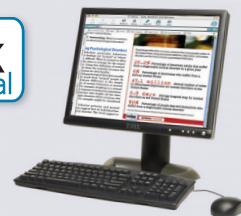


Use your knowledge of methods for studying the brain to answer the question below. Do not simply list facts. Present a clear argument based on your critical analysis of the question, using appropriate psychological terminology

- 20.** Make a judgment about the value of the basic methods of studying the brain. Identify which methods are more likely to provide researchers with information that will benefit brain research.
 - Five methods of research
 - One area in which each method is most valuable in providing information
 - Create a list of criteria for ranking the methods and a ranking order based on the criteria

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QUICK LAB

Reinforce a key concept with a short lab activity.

APPLYING WHAT YOU'VE LEARNED

Review and apply your knowledge by completing a project-based assessment.

Activities

eACTIVITIES

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KEEP IT CURRENT

Link to current news and research in psychology.

Online Textbook



Learn more about key topics in this chapter.