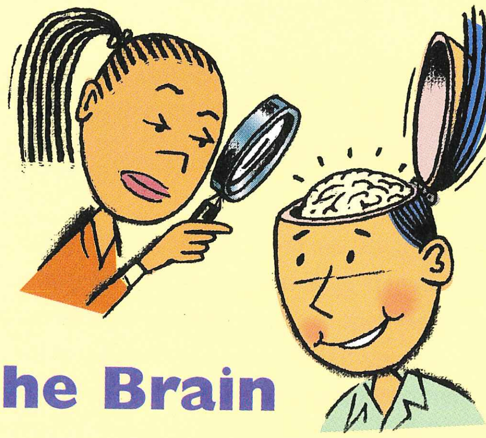
CHAPTER 3



Psychology and the Brain

In this chapter, you will learn about:

- the nervous and endocrine systems
- brain cells and how they communicate
- structures and functions of the brain

Picture yourself at a rock concert. The music is loud, and you're surrounded by thousands of other teenagers. You are moving to the beat, applauding or screaming when your favorite songs are played. Your brain is masterminding your every move and processing everything you see and hear, your memory of the songs, and your appreciation of them.

The brain is the command center of the body: planning, coordinating, and guiding actions to avoid trouble and ensure survival. It is the seat of what is uniquely human: language, creativity, logic, and thought.

Through the past decades, researchers have deciphered many of its secrets, but the brain is still considered one of the last frontiers of the human body. To understand why we behave as we do, we must first understand what is going on inside the brain.

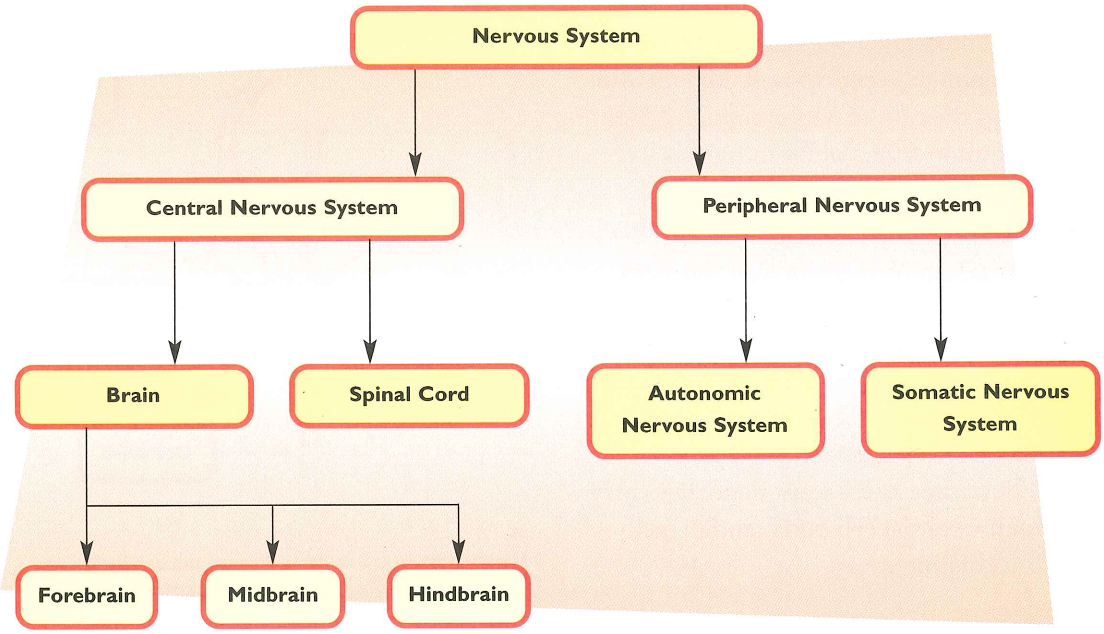
Overview of the Nervous System

The brain is the most important part of the nervous system, which—along with the endocrine system—coordinates and controls all actions of the body. The **nervous system** processes thousands of bits of information from the body's other organs and the outside environment. The nervous system makes sense of them and determines the response the body will make. The **endocrine system**, which we will discuss later in this chapter, houses the production factories for hormones, which control growth, sexual development, and other processes that keep us alive.

We can begin to get a sense of the elaborate information exchange that goes on in our bodies day and night by dividing the nervous system by its functions.

The nervous system is a massive information highway from the brain down the spinal cord and through a network of nerves that branch throughout the body. The prick of a pin is information. The degree your arm bends to hold this book is information. The facts you read, the intensity of light around you, anything that has to do with your body or its immediate vicinity is information. The primary function of the brain is to send information from one point to another in the nervous system so it can be used.

Nervous System Diagram



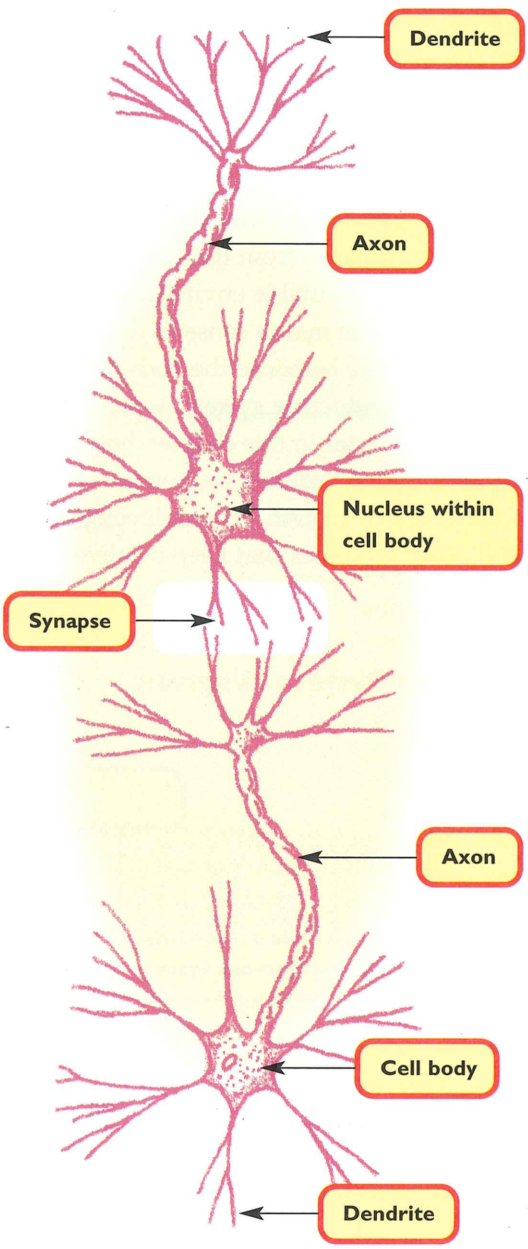
Nerve Cells

The brain is probably the most complex structure known in the universe. It is a mass of tissue composed of about 100 billion nerve cells, more than the number of stars in the Milky Way. These cells, the powerhouse of the whole nervous system, are particularly concentrated in the brain. Because of them, the computing power of your brain is far greater than the most sophisticated computer in existence.

The nervous system is composed of two types of cells, glia and neurons, many of which are smaller than the period at the end of this sentence. There are 10 to 50 times more glial cells than neurons in the brain, but they play more of a supporting role. They participate in the movement of nerve impulses and in the neurons' response to injury. Glia produce myelin, a protective coating along the nerve cells. Just like the coating of a wire, the myelin prevents "crosstalk," such as might happen if telephone wires get crossed. Myelin also speeds up the rate of nerve impulses. The most common forms of brain tumors affect the glia.

Neurons have a *nucleus*, or center, that contains genes, as other cells of the body do, but neurons are vastly different from other cells. There are dozens of different classes of neurons, and each has a particular function (such as motion or senses). Neurons have specialized projections called dendrites and axons: dendrites carry information to the cell body, and axons take information away.

The Neuron



Information enters neurons through the dendrites. The cell body decides to pass along the information, and the axon transmits the message to the nerve endings.

How Nerve Cells Communicate

When your teacher writes a question on the blackboard and turns to you for the answer, your nervous system swings into action. Information from your eyes, ears, and other senses is relayed simultaneously through the nervous system's extremely complicated networks of neurons to the brain. There the information is integrated. That's where you hope some memory of the correct response is stored! Through an equally complicated process, that response is conveyed back and spoken.

Although much is yet to be learned about this seemingly miraculous process, we do know how neurons communicate with one another at a very basic level. A neuron sends a message by first firing electrical impulses (at speeds up to 200 miles per hour) down the axon. When the impulse reaches the synapse, the contact point between two neurons, it triggers the release of chemicals from the vesicles, "storage tanks" at the end of the axons. These chemicals, called **neurotransmitters**, carry information to the next neuron in line, instructing it either to fire another electrical signal, called an action potential, or to remain silent.

Neurons communicate with each other in a complex network of connections: each neuron may make 1,000 to 10,000 synapses on its target neuron. The timing and rhythm of the electrical impulses are important ways that neurons determine which are the important messages. Neurons that have the same rhythm at the same time connect with each other more easily, like two people who dance well together.

The Importance of Neurotransmitters

Most major psychiatric disorders (schizophrenia, major depression, manic-depression) are now believed to result, in large part, from some form of abnormal chemical transmission in the brain. Scientists in the past several decades have learned an enormous amount about mental illnesses and their possible treatment by focusing on neurotransmitters and their receptors, the sites where they are received by the next neuron.

There are now more than 50 known neurotransmitters. Each plays some role in most behaviors, but in many cases scientists have associated a behavior particular to one neurotransmitter (see chart on the next page). Certain neurotransmitters, like glutamate, serve an excitatory function, causing the firing of nerve impulses; others, like GABA, are inhibitory, stopping an action. Signs of diseases can occur when there is too much or too little of one or more of these neurotransmitters.

The large variety of neurotransmitter receptors increases considerably the different kinds of information that can be sent to the receiving neuron. Hundreds of neurotransmitter receptor genes have been discovered, which combine in various ways to produce receptors.

Major Neurotransmitters		
Neurotransmitter	**Function**	**Associated Disorder**
acetylcholine	transmits between nerves and muscle: involuntary body movement; memory	Alzheimer's disease
norephinephrine	sleep; blood pressure; mood	depression
serotonin	mood; appetite; aggression	depression; migraines
dopamine	involuntary body movement	Parkinson's disease; possibly schizophrenia and addictions
GABA (gamma-aminobutyric acid)	major inhibitory transmitter in the brain; keeps seizures from happening	Huntington's disease; epilepsy; schizophrenia
glutamate	major excitatory transmitter in the brain (probably present in all the nervous system)	neuron loss after stroke; seizures
endorphin	modulates sensory system, including relief of pain and feeling of well being; pain relief	addictions

The Peripheral Nervous System

The peripheral nervous system carries information between the organs of the body and the central nervous system. The peripheral nervous system is divided even further into the **autonomic nervous system** and the **somatic nervous system.**

Autonomic Nervous System

The autonomic nervous system controls the muscles of the stomach, intestines, and bodily functions including:

* Breathing.
* Heart rate.
* Tears and saliva.
* Urination and defecation.
* The levels of oxygen and carbon dioxide in the bloodstream.
* The "fight or flight" response, which in emergencies diverts blood from our stomach to our muscles, increasing heart and breathing rates, and dilating (opening wide) our pupils.

Somatic Nervous System

The somatic nervous system is generally associated with all of the body's movements. Its nerve network includes:

* All the sensory neurons, which bring information about the environment to the brain to be sorted and processed.
* All the motor neurons, which lead back from the brain to the muscles, telling them what to do.
* Reflexes, such as immediately pulling your hand away from a hot pan, or reactions that don't wait for the brain to dictate action.

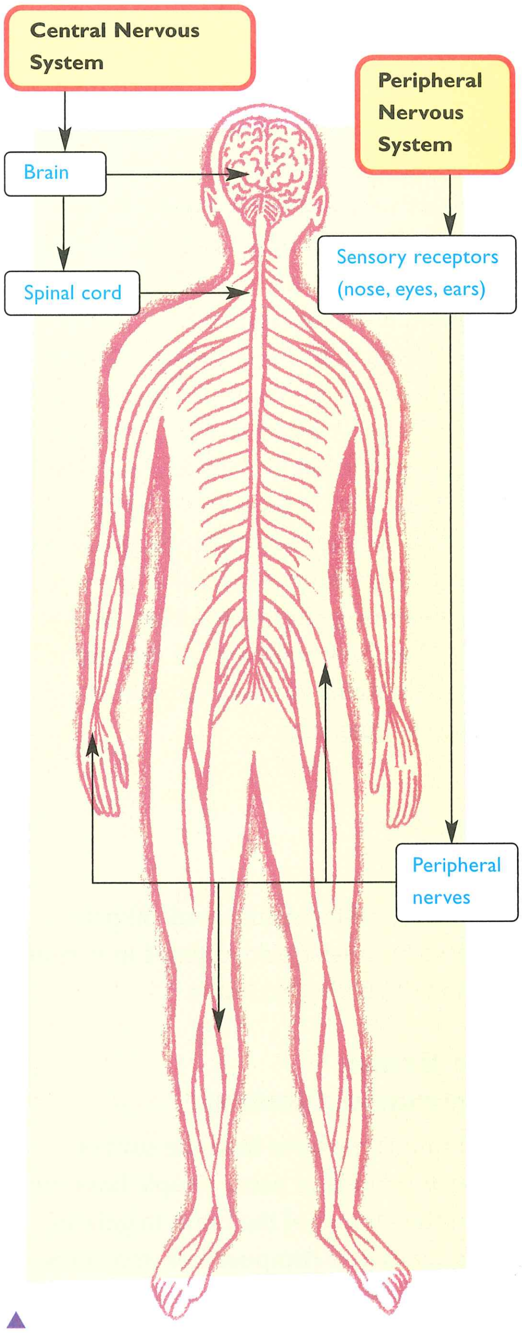
The Central Nervous System

The **central nervous system** consists of the spinal cord and the brain. Information from the peripheral nervous system is conveyed here, where it is coordinated, processed, and relayed back through the peripheral nervous system with a response. In the example of the teacher asking you a question, a response might be a spoken answer. If your brain is not quickly finding an answer, the response might be stress: you start sweating, your heart beats faster, or you flee the room.

Spinal Cord

The main pathway for information between the brain and the peripheral nervous system is the spinal cord. The cord itself, composed of neurons, is housed in a protective spine of bones called *vertebrae.*

The Nervous System



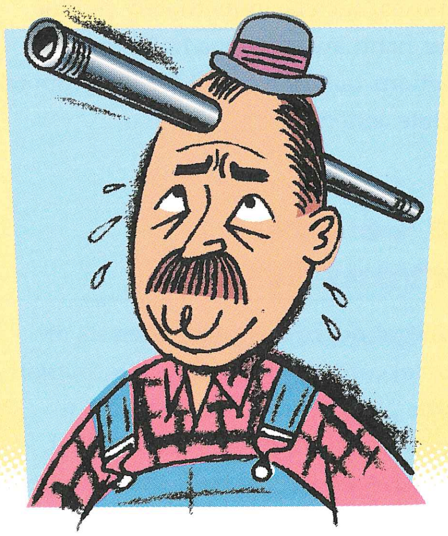
Your nervous system is made up of your brain, spinal cord, and a network of nerves.

Sidebar

The Lessons of Phineas Gage

Science has often benefited from the misfortunes of humankind. For example, much was learned about the function of the frontal lobe in the brain from the famous case of Phineas Gage. In 1848, an explosion at a railway where Gage was working drove a large metal rod through his head. Remarkably, he recovered with his memory and intelligence intact. But his behavior changed dramatically. Before the accident he was friendly, kind, and conscientious, but afterward he lied, broke his promises, and swore constantly. Scientists have been able to conclude from this case and others that the frontal area of the brain affects the ability to make decisions and to process emotions.

The brain is commonly divided into three areas: hindbrain, midbrain, and forebrain. Although all these parts of the brain work in harmony, they are different structurally, and they affect different aspects of human behavior.



Up and down the spinal cord, 30 pairs of nerve bundles track outward to various parts of the body and brain.

The Brain: Command Central

The brain is far more than the sum of its three pounds of parts. People have compared the texture of the brain to gelatin, but actually it is composed of structures with very different consistencies. These different structures have different functions. Through the centuries, scientists have learned a great deal about which areas of the brain process language, feelings, memory, sexual attraction, musical and artistic ability, and so on. Scientists have made their discoveries by:

* Dissecting brains after death.
* Using imaging technology to observe which areas of the brain are chemically highlighted when a person performs a task such as memorizing a list.
* Observing behavioral changes that result from injury or diseases that affect certain areas of the brain.

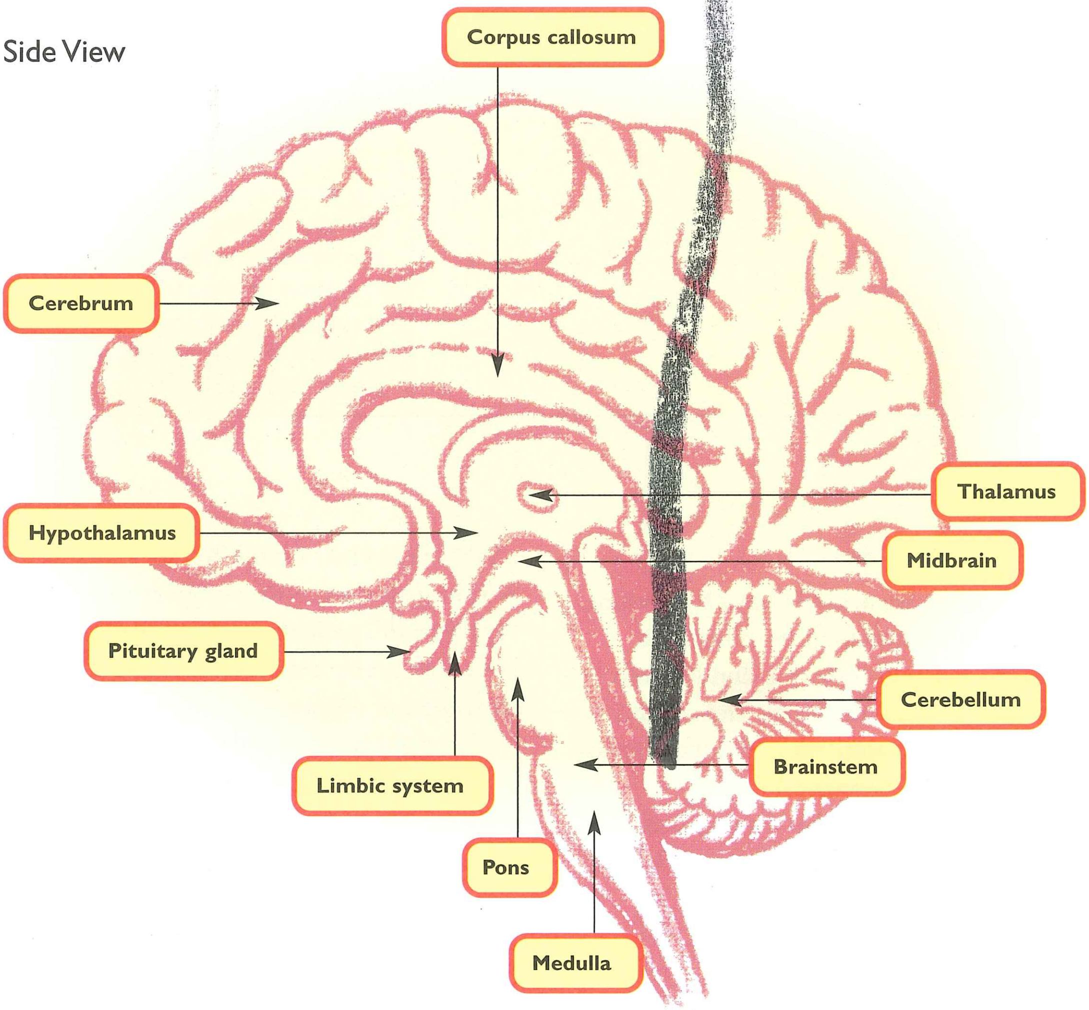
How the Brain Thinks

The cerebral cortex is responsible for many higher functions of the brain, such as language and information processing. It is here and in the cerebrum that the "magic" that makes us human takes place.

We are curious creatures, capable of believing in Santa Claus, storing a lifetime of memories, or creating lovely symphonies that make people weep. The human brain has evolved over several million years, growing ever larger and more complex. Our brainpower gives us the unique ability to explore the mystery of how the mass of neurons and structures in the brain makes possible thought, language, reasoning, creativity, and perception.

The Brain

Side View



Parts of the Brain

Hindbrain	Midbrain	Forebrain
Brain Stem: evolutionarily the oldest part of the brain and the center of involuntary actions: balance, breathing, heartbeat **Medulla:** switching station to and from the spinal cord; monitors the body's response to injury, blood pressure, and reflexes such as sneezing and laughing **Reticular Activating System:** watchdog for danger; involved in sleeping and wakefulness **Pons:** relay station between cerebellum and cerebral cortex **Cerebellum:** responsible for movement, balance, posture	**Top Inch of Brain Stem:** connecting station for nerve signals; where pathways cross so one half of the brain controls the other half of the body	**Limbic System:** controls emotional response; includes the amygdala and hippocampus (both important for memory and learning) **Hypothalamus:** the size of a pea, it controls body temperature and regulates the pituitary **Thalamus:** relays information from the body to the cerebral cortex; gets back information that it sends to other parts of the brain and spinal cord **Cerebrum:** makes up about two-thirds of brain; is divided into two hemispheres, each with four lobes covered by cerebral cortex, the outermost "bark" of the brain (where most of the brain's neurons reside)

Two Hemispheres

In some ways we actually have two brains, since the cerebrum (and its outermost layer, the cerebral cortex) is divided into two halves, or hemispheres. These hemispheres are connected by a bundle of nerve fibers called the corpus callosum. Communication between the two hemispheres occurs across the corpus callosum, a fact made clear by the Nobel Prize–winning studies of Roger Sperry on "split-brain" patients, whose corpus callosum was cut by accident or in the treatment of disease.

The right hemisphere controls the left side of the body, and the left hemisphere controls the right side. Each hemisphere has some specialized tasks, but for the most important functions, such as memory, they work in harmony by communicating across the corpus callosum. As a result, while victims of stroke (loss of brain function caused by blockage or bursting of the blood vessels in the brain) may not lose much memory, movement may be impaired on the side of the body opposite the affected hemisphere.

In most people—all of us who are right-handed and at least half of us who are left-handed—the left hemisphere dominates, and that is where language and speech functions are performed. For other left-handers, the right hemisphere dominates. For them, language and speech are centered in the right hemisphere. (Some lefties even have dominance on both sides!) Though much discussion focuses on the difference between right- and left-hemisphere activities, not all theories are fully proven.

In general, the left hemisphere:

* Controls right side of body.
* Controls language, speech, and reading.
* Plans the day; keeps us on time.

The right hemisphere:

* Controls left side of body.
* Identifies patterns; gets us back after a walk around the block.
* Controls artistic tendencies, holistic thinking abilities, and imagination.

Sidebar

Hemispheres and Handedness

Time yourself and write down how long you can balance a ruler on its end first in your left hand, then in your right hand. Then time yourself while balancing the ruler on its end in each hand while talking at the same time. Compare the results.

Most right-handed people find that talking interferes with the performance of their right hand, but not their left. That is because language is processed in the left hemisphere, as is movement on the right side of their bodies.

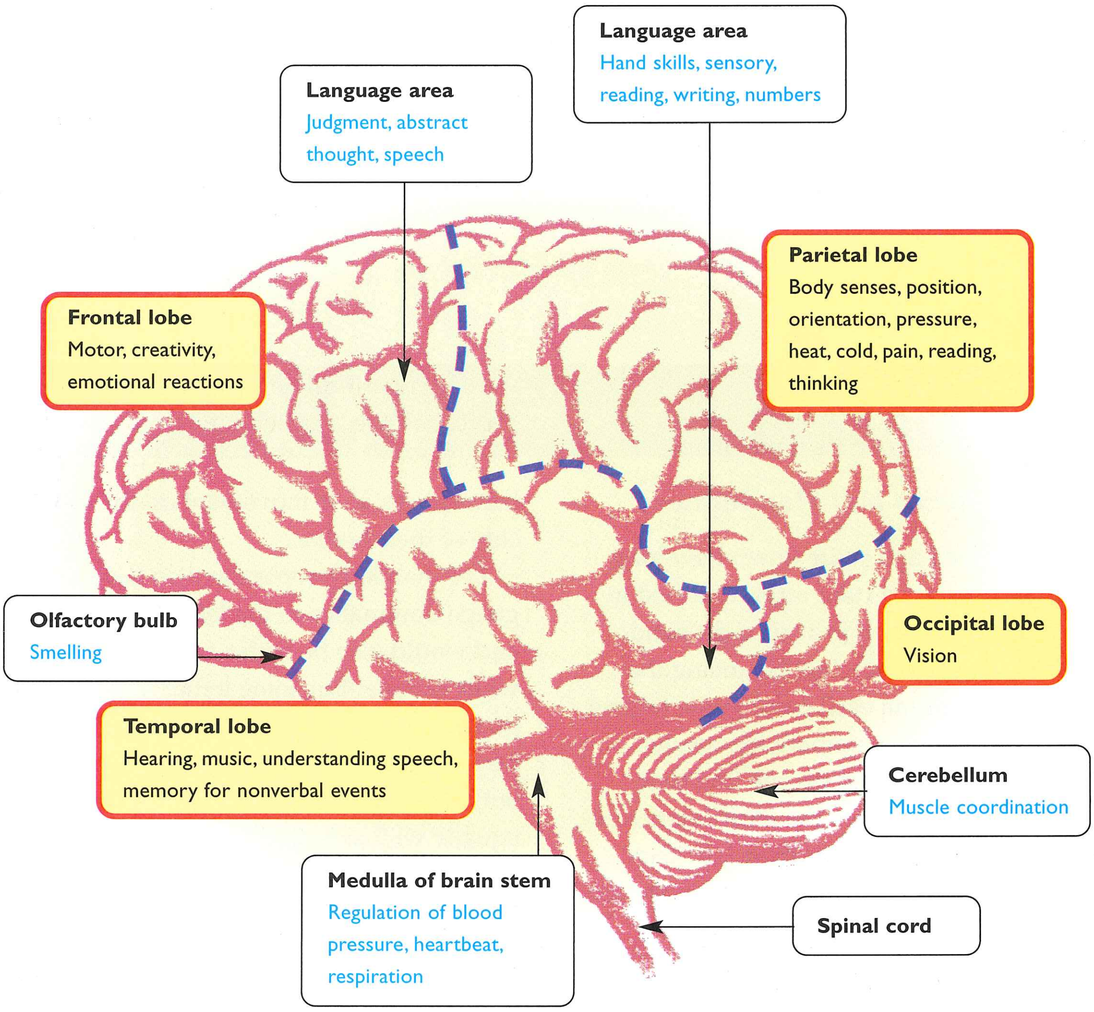
Left-handed people can also have language dominance in the left hemisphere and would also be better with the left hand while talking. But some lefties have language dominance in the right or in both hemispheres. A lefty with language on both sides will be able to control the ruler equally well in both hands while talking; a lefty with right-side language dominance would be better with the right hand.

Four Functional Lobes

Grooves on the very wrinkled cerebral cortex provide another natural device for dividing the brain and pinpointing where its myriad functions occur. Four lobes have been identified: frontal, parietal, occipital, and temporal. The diagram shows some of what we know takes place within these areas of the brain.

The Parts and Functions of the Brain

Surface View



Relief from Depression

Whether there is an initial trigger (death in the family, the end of a relationship, the loss of a job) or a biochemical deficiency, the final path to depression involves biochemical changes in the brain. These changes are largely what separates clinical depression from the blues we all feel occasionally.

Serotonin is a neurotransmitter that affects mood. Normally when your brain cells release serotonin, they call it back. Selective serotonin reuptake inhibitors (SSRIs), such as Prozac, block that process, allowing more serotonin to be available. This process relieves the symptoms associated with depression. SSRIs seem to be about as effective as other drugs prescribed for depression (helping 60 to 80 percent of those who take them), but with fewer side effects.

The Endocrine System

The endocrine system is the nervous system's partner in controlling and coordinating the body's functions. Usually the nervous system controls immediate responses, whereas the endocrine system can direct functions that the body must perform over days or weeks. The endocrine system's counterparts to neurotransmitters are chemical messengers called **hormones**, which are sent into the bloodstream and are responsible for maintaining normal growth, sexual development, and metabolism—the processes necessary for maintaining life. Organs and tissues scattered throughout the body that produce hormones are called *glands.*

The nervous and endocrine systems are not entirely separate, however. Some endocrine glands, specifically the pituitary gland, respond to nervous system messages.

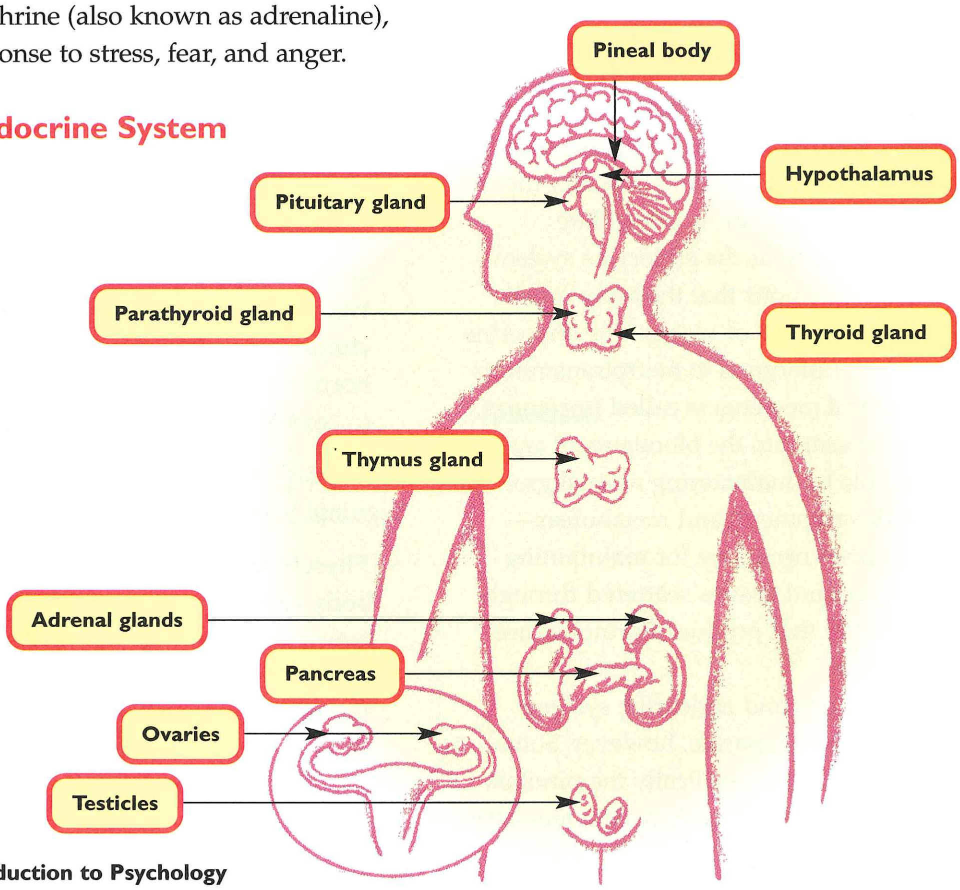
- ***Pituitary Gland.*** The hypothalamus of the brain controls the pituitary, which in turn controls the production of many different critical hormones. The pituitary is called the "master gland" because its hormones influence many of the other endocrine glands. Hormones it manufactures include growth hormone, thyroid-stimulating hormone, and oxytocin, a hormone that causes a woman's uterus to contract.

Similarly, the other endocrine glands regulate various functions:

- ***Thyroid Gland.*** Produces energy the body can use from nutrients. If it is overactive, you will feel nervous and jittery or warm when others are comfortable. If it is underactive, you will feel slow or drowsy and depressed, and you will likely gain weight.

* ***Parathyroid Glands.*** Control the level of calcium in the blood, which is important for bones and teeth, and also for nerve function, muscle contraction, and blood clotting.
* ***Pineal Body.*** Produces the hormone melatonin, which promotes the tanning of skin and recently has been shown to affect the sleep-wake cycle.
* ***Thymus Gland.*** Plays a role in the body's immune system, which is responsible for recognizing and destroying invaders such as viruses and bacteria.
* ***Adrenal Glands.*** Influences metabolism and physical characteristics, such as body shape and hairiness; takes instruction from the nervous system, producing epinephrine (also known as adrenaline), in response to stress, fear, and anger.
* ***Pancreas.*** Makes insulin, which controls the levels of sugars in the bloodstream. (Little or no insulin results in diabetes.)
* ***Ovaries.*** Produce female sex hormones: estrogen and progesterone. Ovaries also house the 60,000 eggs with which all girls are born. Only about 400 will ripen in a woman's lifetime, one per month during the fertile years.
* ***Testicles.*** Produce androgens, the hormones responsible for male characteristics, and as many as 12 trillion sperm in a man's lifetime. Testicles lie inside the scrotum, which has a built-in thermostat for keeping the sperm at the correct temperature.

The Endocrine System



CRITICAL THINKING

Who's Winning the Nature vs. Nurture Debate?

A debate has raged for centuries over what influence on behavior is greater: nature, the personality and genes we're born with, or nurture, the environment and experiences in our lives. Do you have an opinion? Check it out.

THE ISSUES

Historically, this debate has been framed in terms of nature vs. nurture. The discoveries of genes and neurotransmitters are modern, but since the time of the Greek physician Hippocrates (c. 460–377 B.C.), people have understood that we are born with a certain nature. At the turn of the twentieth century, Sigmund Freud introduced his theories on the importance of early child-rearing experiences. Those voices who argued that nurture determined our behavior then dominated.

Research over the past several decades, however, has made it clear that genes specify the way many of our behaviors are generated. It also has been suggested that genes make someone's personality more likely to respond to its environment in certain ways. Yet the way you are brought up by your parents, the education you receive, and your life experiences also affect the person you are.

Where do you stand on the nature and nurture debate?

THE PROCESS

1. **Restate the argument.** In your own words, state the main idea behind the nature vs. nurture conflict.
2. **Provide evidence.** Use information from this chapter to *support one side* of the issue.
3. **Give opposing arguments.** Use information from this chapter to *support another view* of the issue.
4. **Look for more information.** Research *nature vs. nurture* in the library or on the Internet; look up Thomas Buchard's work and that of others who studied twins (look up *twin studies*).
5. **Evaluate the information.** Make a chart with two columns:

Nature	Nurture

   In each column, list ideas supporting that concept. Put a check mark next to the strongest ideas.

6. **Draw conclusions.** Write two paragraphs describing your ideas on the nature vs. nurture debate. Support your views with evidence from various sources.

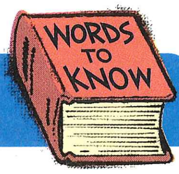
Chapter 3 Wrap-up

PSYCHOLOGY AND THE BRAIN

The nervous system and endocrine systems control and coordinate all human behavior. Much of our behavior is processed in more than one area of the brain, but some behavior—such as speech and sight—can be linked to specific areas. Nerve cells communicate with each other to speed messages up to the brain and back using neurotransmitters. In the endocrine system, hormones are the chemicals used to carry messages through the body's bloodstream.

Discoveries about these systems have allowed scientists to describe human behavior to a greater degree and to develop drugs that can target diseases that short-circuit normal functions. New technologies enable scientists to study cells, understand and control brain circuits, and change the ways genes are expressed. But there is much more to discover about the brain and its higher functions—memory, intelligence, thoughts, feelings—the processes that make us human.

Psychology



autonomic nervous system—part of the peripheral nervous system that controls the muscles in the stomach, intestines, and other organs. *p. 40*

central nervous system—system consisting of the spinal column and the brain. *p. 41*

endocrine system—glands that regulate the body's growth, metabolism, and sexual development and function. *p. 37*

hormones—chemicals used by the endocrine system that control growth, emotional responses, and physical changes. *p. 47*

nervous system—system made up of the brain, spinal cord, and network of nerves throughout the body. *p. 37*

neuron—nerve cell, the basic unit of the nervous system. A neuron is made up of a cell body, an axon, and one or more dendrites. *p. 38*

neurotransmitters—chemicals that carry information from one neuron to another. *p. 39*

somatic nervous system—part of the peripheral nervous system associated with all of the body's movements. *p. 40*