

YOU KNOW YOU HAVE MASTERED THE MAIN TOPICS IN THIS CHAPTER IF YOU ARE ABLE TO . . .

- ∞ Explain what neurons are and how they work to transfer and process information.
- ∞ Introduce the peripheral nervous system and describe its role in the body.
- ∞ Describe the methods used to observe the structure and activity of the brain.
- ∞ Identify the basic structures of the brain and explain their functions.
- ∞ Discuss the role of the endocrine system.

RAPID REVIEW

The **nervous system** is made up of a complex network of cells throughout your body. Since psychology is the study of behavior and mental processes, understanding how the nervous system works provides fundamental information about what is going on inside your body when you engage in a specific behavior, feel a particular emotion, or have an abstract thought. The field of study that deals with these types of questions is called **neuroscience**. The role of the nervous system is to carry information. Without your nervous system, you would not be able to think, feel, or act. The cells in the nervous system that carry information are called **neurons**. Information enters a neuron at the **dendrites**, flows through the cell body (or **soma**) and down the **axon** in order to pass the information on to the next cell. Although, neurons are the cells that carry the information, most of the nervous system consists of **glial cells**. Glial cells provide food, support, and insulation to the neuron cells. The insulation around the neuron is called **myelin** and works in a way very similar to the plastic coating of an electrical wire. Bundles of myelin-coated axons are wrapped together in cable like structures called **nerves**.

Neurons use an electrical signal to send information from one end of its cell to the other. At rest, a neuron has a negative charge inside and a positive charge outside. When a signal arrives, gates in the cell wall next to the signal open and the positive charge moves inside. The positive charge inside the cell causes the next set of gates to open and those positive charges move inside. In this way, the electrical signal makes its way down the length of the cell. The movement of the electrical signal is called an **action potential**. After the action potential is over, the positive charges get pumped back out of the cell and the neuron returns to its negatively charged state. This condition is called the **resting potential**. A neuron acts in an **all-or-none** manner. This means the neuron either has an action potential or it does not. The neuron indicates the strength of the signal by how many action potentials are produced or “fired” within a certain amount of time.

Neurons pass information on to target cells using a chemical signal. When the electrical signal travels down the axon and reaches the other end of the neuron called the **axon terminal**, it enters the very tip of the terminal called the **synaptic knob** and causes the **neurotransmitters** in the **synaptic vesicles** to be released into the fluid-filled space between the two cells. This fluid-filled space is called the **synapse** or the **synaptic gap**. The neurotransmitters are the chemical signals the neuron uses to communicate with its target cell. The neurotransmitters fit into the **receptor sites** of the target cell and create a new electrical signal that then can be transmitted down the length of the target cell.

Neurotransmitters can have two different effects on the target cell. If the neurotransmitter increases the likelihood of an action potential in the target cell, the connection is called an **excitatory synapse**. If the neurotransmitter decreases the likelihood of an action potential, the connection is called an **inhibitory synapse**. **Agonists** and **antagonists** are chemicals that are not naturally found in our body but that can fit into the receptor sites of target cells when they get into our nervous system. Agonists lead to a similar response in the target cell as the neurotransmitter itself, while antagonists block or reduce the action of the neurotransmitter on the target cell. There are at least 50-100 different types of neurotransmitters in the human body. **Acetylcholine** was the first to be discovered; it is an excitatory neurotransmitter that causes your muscles to contract. Gamma amino butyric acid (**GABA**) is an inhibitory neurotransmitter that decreases the activity level of neurons in your brain. **Serotonin** is both an excitatory and inhibitory neurotransmitter and has been linked with sleep, mood, and appetite. Low levels of the neurotransmitter

dopamine have been found to cause Parkinson's disease and increased levels of dopamine have been linked to the psychological disorder known as schizophrenia. Endorphin is a special neurotransmitter called a neural regulator that controls the release of other neurotransmitters. When endorphin is released in the body, they neurons transmitting information about pain are not able to fire action potentials. All the different types of neurotransmitters are cleared out of the synaptic gap through the process of reuptake, diffusion, or by being broken apart by an enzyme.

The central nervous system (CNS) is made up of the brain and the spinal cord. The spinal cord is a long bundle of neurons that transmits messages between the brain and the body. The cell bodies or somas of the neurons are located along the inside of the spinal cord and the cell axons run along the outside of the spinal cord. Afferent (sensory) neurons send information from our senses to the spinal cord. For example, sensory neurons would relay information about a sharp pain in your finger. Efferent (motor) neurons send commands from the spinal cord to our muscles, such as a command to pull your finger back. Interneurons connect sensory and motor neurons and help to coordinate the signals. All three of these neurons act together in the spinal cord to form a reflex arc. The ability of the brain and spinal cord to change both in structure and function is referred to as neuroplasticity. One type of cell that facilitates these changes are stem cells.

The peripheral nervous system (PNS) is made up of all the nerves and neurons that are NOT in the brain or spinal cord. This includes all the nerves that connect to your eyes, ears, skin, mouth, and muscles. The PNS is divided into two parts, the somatic nervous system and the autonomic nervous system. The somatic nervous system consists of all the nerves coming from our sensory systems, called the sensory pathway, and all the nerves going to the skeletal muscles that control our voluntary movements, called the motor pathway. The autonomic nervous system is made up of the nerves going to and from our organs, glands, and involuntary muscles and is divided into two parts: the sympathetic division and the parasympathetic division. The sympathetic division turns on the body's fight-or-flight reactions, which include responses such as increased heart rate, increased breathing, and dilation of your pupils. The parasympathetic division controls your body when you are in a state of rest to keep the heart beating regularly, to control normal breathing, and to coordinate digestion. The parasympathetic division is active most of the time.

Researchers have used animal models to learn a great deal about the human brain. Two of the most common techniques used in animals involve either destroying a specific area of the brain (deep lesioning) or stimulating a specific brain area (electrical stimulation of the brain or ESB) to see the effect. In work with humans, researchers have developed several methods to observe the structure and activity of a living brain. If a researcher wants a picture of the structure of the brain, she might choose a CT scan or an MRI. Computed tomography (CT) scans use x-rays to create images of the structures within the brain. Magnetic resonance images (MRIs) use a magnetic field to "take a picture" of the brain. MRIs provide much greater detail than CT scans. On the other hand, if a researcher wanted to record the activity of the brain, he might select an EEG, fMRI, or PET scan. An electroencephalogram (EEG) provides a record of the electrical activity of groups of neurons just below the surface of the skull. A functional magnetic resonance image (fMRI) uses magnetic fields in the same way as an MRI, but goes a step further and pieces the pictures together to show changes over a short period of time. A positron emission tomography (PET) scan involves injecting a person with a low dose of a radioactive substance and then recording the activity of that substance in the person's brain.

The brain can be roughly divided into three sections: the brainstem, the cortex, and the structures under the cortex. The brainstem is the lowest part of the brain that connects to the spinal cord. The outer wrinkled covering of the brain is the cortex, and the structures under the cortex are essentially everything between the brainstem and the cortex. The brainstem contains four important structures. The medulla, controls life-sustaining functions such as heart beat, breathing, and swallowing. The pons influences sleep, dreaming, and coordination of movements. The reticular formation plays a crucial role in attention and arousal, and the cerebellum controls all of the movements we make without really "thinking" about it.

One main group of structures under the cortex is the limbic system. The limbic system includes the thalamus, hypothalamus, hippocampus, and amygdala. The thalamus receives input from your

sensory systems, processes it, and then passes it on to the appropriate area of the cortex. The hypothalamus interacts with the endocrine system to regulate body temperature, thirst, hunger, sleeping, sexual activity, and mood. It appears that the hippocampus is critical for the formation of long-term memories and for memories of the locations of objects. The amygdala is a small almond-shaped structure that is involved in our response to fear.

The outer part of the brain, or **cortex**, is divided into right and left sections called **cerebral hemispheres**. The two hemispheres communicate with each other through a thick band of neurons called the **corpus callosum**. Each cerebral hemisphere can be roughly divided into four sections. These sections are called lobes. The **occipital lobes** are at the back of the brain and process visual information. The **parietal lobes** are located at the top and back half of the brain and deal with information regarding touch, temperature, body position, and possibly taste. The **temporal lobes** are just behind your temples and process auditory information. The **frontal lobes** are located at the front of your head and are responsible for higher mental functions such as planning, personality, and decision making, as well as language and motor movements. Motor movements are controlled by a band of neurons located at the back of the frontal lobe called the **motor cortex**.

Association areas are the areas within each of the lobes that are responsible for “making sense” of all the incoming information. **Broca’s area** is located in the left frontal lobe in most people and is responsible for the language production. A person with damage to this area would have trouble producing the words that he or she wants to speak. This condition is referred to as **Broca’s aphasia**. The comprehension of language takes place in **Wernicke’s area** located in the left temporal lobe. If this area of the brain is damaged, individuals are often still able to speak fluently, but their words do not make sense. This type of language disorder is referred to as **Wernicke’s aphasia**. Damage to the right parietal and occipital lobes can cause a condition known as **spatial neglect** where the individual ignores objects in their left visual field.

The **cerebrum** is made up of the two cerebral hemispheres and the structures connecting them. The **split-brain research** studies of Roger Sperry helped scientists to figure out that the two cerebral hemispheres are not identical. The left hemisphere is typically more active when a person is using language, math, and other analytical skills, while the right hemisphere shows more activity during tasks of perception, recognition, and expression of emotions. This split in the tasks of the brain is referred to as lateralization.

The **endocrine glands** represent a second communication system in the body. The endocrine glands secrete chemicals called **hormones** directly into the bloodstream. The **pituitary gland** is located in the brain and secretes the hormones that control milk production, salt levels, and the activity of other glands. The **pineal gland** is also located in the brain and regulates the sleep cycle through the secretion of melatonin. The **thyroid gland** is located in the neck and releases a hormone that regulates metabolism. The **pancreas** controls the level of blood sugar in the body, while the **gonad** sex glands – called the **ovaries** in females and the **testes** in males, regulate sexual behavior and reproduction. The **adrenal glands** play a critical role in regulating the body’s response to stress.

Mirror neurons, neurons that fire when we perform an action and also when we see someone else perform that action, may explain a great deal of the social learning that takes place in humans from infancy on.