31.2 The Central Nervous System

THINK ABOUT IT Who's in charge? The nervous system contains billions of neurons, each of them capable of carrying impulses and sending messages. What keeps them from sending impulses everywhere and acting like an unruly mob? Is there a source of order in this complex system, a central place where information is processed, decisions are made, and order is enforced?

The Brain and Spinal Cord

Where does processing of information occur in the nervous system?

The control point of the central nervous system is the brain. **Each of the major areas of the brain—the cerebrum, cerebellum, and brain stem—are responsible for processing and relaying information.** Like the central processing unit of a computer, information processing is the brain's principal task. **Figure 31–8** on the next page provides details about the major areas of the brain.

While most organs in the body function to maintain homeostasis, the brain itself is constantly changed by its interactions with the environment. Sensory experience changes many of the patterns of neuron connections in the brain, and stem cells in the brain produce new neurons throughout life. Many of these new cells originate in regions associated with learning and memory. Far from staying the same, the highly flexible brain reacts to and changes constantly with the world around it.

Most of the neurons that enter and leave the brain do so in a large cluster of neurons and other cells known as the spinal cord. **The spinal cord is the main communication link between the brain and the rest of the body.** The spinal cord is a bit like a major telephone line, carrying thousands of signals at once between the central and peripheral nervous systems. Thirty-one pairs of spinal nerves branch out from the spinal cord, connecting the brain to different parts of the body. Certain kinds of information, including many reflexes, are processed directly in the spinal cord. A **reflex** is a quick, automatic response to a stimulus. The way in which you pull your hand back quickly when pricked by a pin is an example of a reflex.

In Your Notebook *Make a three-column table that lists the major structures of the brain described in* ***Figure 31–8****, their functions, and how they interact with at least one other brain structure.*

Key Questions

Where does processing of information occur in the nervous system?

How do drugs change the brain and lead to addiction?

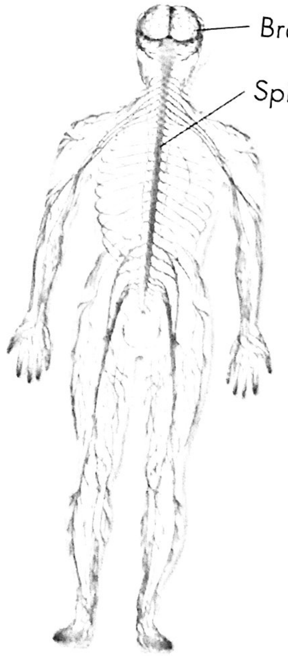
Vocabulary

reflex • cerebrum • cerebral cortex • thalamus • hypothalamus • cerebellum • brain stem • dopamine

Taking Notes

Concept Map As you read, construct a concept map that shows how the structures of the central nervous system are related to each other.

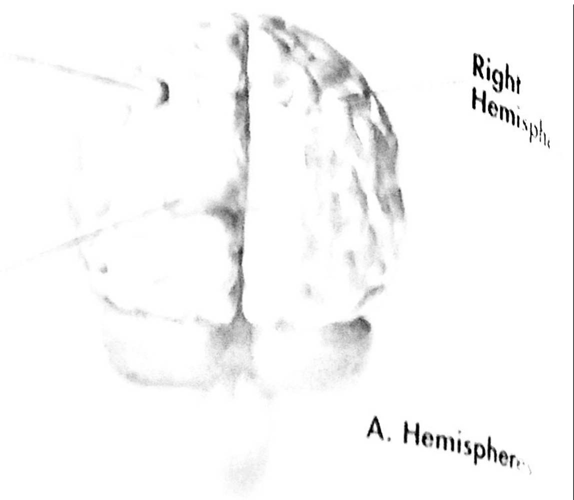
FIGURE 31–7 The Central Nervous System The central nervous system consists of the brain and spinal cord.



VISUAL SUMMARY

THE BRAIN

FIGURE 31–8 The brain contains billions of neurons and other supporting tissue that process, relay, and form responses to an incomprehensible amount of information every moment. Infer ***Which structure of the brain most likely filters information traveling from the spinal cord to the brain?***



Cerebrum

The largest region of the human brain is the cerebrum. The **cerebrum** is responsible for the voluntary, or conscious, activities of the body. It is also the site of intelligence, learning, and judgment.

Hemispheres As shown in **Figure 31–8A** (a back view of the brain), a deep groove divides the cerebrum into left and right hemispheres. The hemispheres are connected by a band of tissue called the corpus callosum. Remarkably, each hemisphere deals mainly with the opposite side of the body. Sensations from the left side of the body go to the right hemisphere, and those from the right side go to the left hemisphere. Commands to move muscles are delivered in the same way.

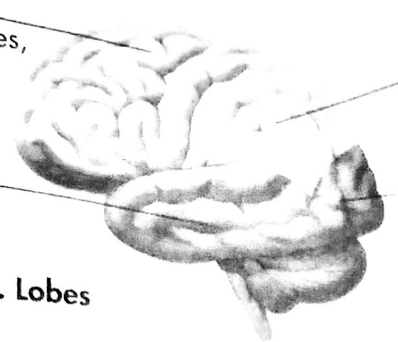
As shown in **Figure 31–8B**, each hemisphere is divided into regions called lobes. The four lobes are named for the skull bones that cover them. Each of these lobes are associated with different functions.

Cerebral Cortex The cerebrum consists of two layers. The outer layer of the cerebrum is called the **cerebral cortex** and consists of densely packed nerve cell bodies known as gray matter. The cerebral cortex processes information from the sense organs and controls body movements. It is also where thoughts, plans, and learning abilities are processed. Folds and grooves on the outer surface of the cerebral cortex greatly increase its surface area.

White Matter The inner layer of the cerebrum is known as white matter. Its whitish color comes from bundles of axons with myelin sheaths. These axons may connect different areas of the cerebral cortex, or they may connect the cerebrum to other areas of the brain such as the brain stem.

Limbic System

A number of important functions have been linked to the many structures that make up the limbic system including emotion, behavior, and memory. For example, a region deep within the brain called the amygdala (uh MIG duh luh) has been associated with emotional learning, including fear and anxiety, as well as the formation of long-term memories. The limbic system is also associated with the brain's pleasure center, a region that produces feelings of satisfaction and well-being.



B. Lobes

Thalamus and Hypothalamus

The thalamus and hypothalamus are found between the brain stem and the cerebrum. The **thalamus** receives messages from sensory receptors throughout the body and then relays the information to the proper region of the cerebrum for further processing. Just below the thalamus is the hypothalamus. The **hypothalamus** is the control center for recognition and analysis of hunger, thirst, fatigue, anger, and body temperature. The hypothalamus also helps to coordinate the nervous and endocrine systems.

Cerebellum

The second largest region of the brain is the **cerebellum.** Information about muscle and joint position, as well as other sensory inputs, are sent to the cerebellum. Although the commands to move muscles come from the cerebral cortex, sensory information allows the cerebellum to coordinate and balance the actions of these muscles. This enables the body to move gracefully and efficiently.

When you begin any new activity involving muscle coordination, such as hitting a golf ball or threading a needle, it is the cerebellum that actually learns the movements and coordinates the actions of scores of individual muscles when the movement is repeated.

Brain Stem

The **brain stem** connects the brain and spinal cord. Located just below the cerebellum, the brain stem includes three regions—the midbrain, the pons, and the medulla oblongata. Each of these regions regulates the flow of information between the brain and the rest of the body. Some of the body's most important functions—including regulation of blood pressure, heart rate, breathing, and swallowing—are controlled by the brain stem. The brain stem does the work of keeping the body functioning even when you have lost consciousness due to sleep or injury.

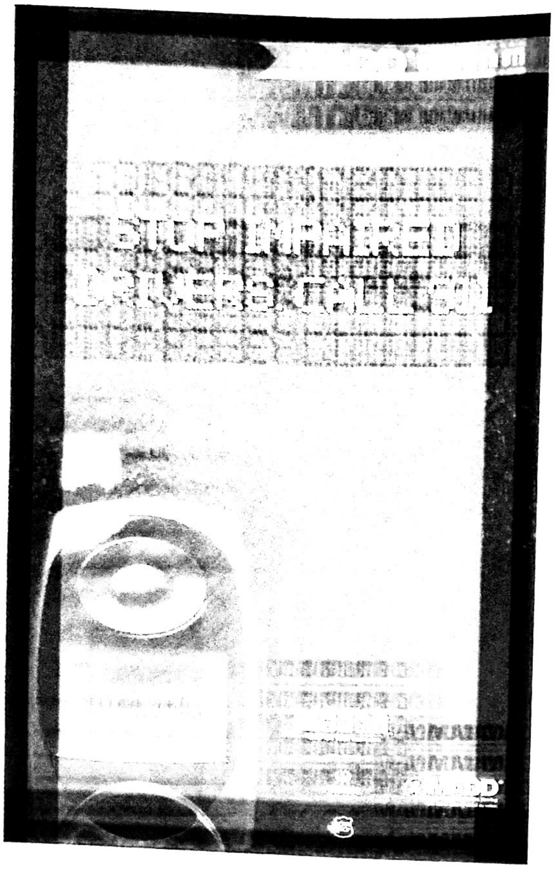


FIGURE 31–9 Drugs and Society The damage to the brain is only the start of the damage that drugs cause. For example, alcohol abuse costs the United States about $185 billion a year in health care costs, treatment services, property damage, and lost productivity.

Addiction and the Brain

How do drugs change the brain and lead to addiction?

Synapses make the brain work by transferring messages from cell to cell, doing the conscious work of thinking and the less conscious work of producing feelings and emotions. Can you guess what would happen if a chemical changed the way those synapses worked? If you guessed that such chemicals might change behavior, you'd be right.

Nearly every addictive substance, including illegal drugs such as heroin, methamphetamine, and cocaine, and legal drugs, such as tobacco and alcohol, affect brain synapses. Although the chemistry of each drug is different, they all produce changes in one particular set of synapses. These synapses use the neurotransmitter **dopamine** and are associated with the brain's pleasure and reward centers.

When we engage in an activity that brings us pleasure, whether it's eating a tasty snack or being praised by a friend, neurons in the hypothalamus and the limbic system release dopamine. Dopamine molecules stimulate other neurons across these synapses, producing the sensation of pleasure and a feeling of wellbeing.

Addictive drugs act on dopamine synapses in a number of ways. Methamphetamine releases a flood of dopamine, producing an instant "high." Cocaine keeps dopamine in the synaptic region longer, intensifying pleasure and suppressing pain. Drugs made from opium poppies, like heroin, stimulate receptors elsewhere in the brain that lead to dopamine release. Nicotine, the addictive substance in tobacco, and alcohol, the most widely abused drug in the United States, also cause increased release of dopamine.

The brain reacts to excessive dopamine levels by reducing the number of receptors for the neurotransmitter. As a result, normal activities no longer produce the sensations of pleasure they once did. Addicts feel depressed and sick without their drugs. Because there are fewer receptors, larger amounts of tobacco, alcohol, and illegal drugs are required to produce the same high. The result is a deeper and deeper spiral of addiction that is difficult to break.

31.2 Assessment

Review Key Concepts

1. a. **Review** What are the three major regions of the brain?
   b. **Describe** Explain the role of the spinal cord.
   c. **Infer** How do reflexes protect the body from injury?
2. a. **Review** Describe three ways that drugs affect synapses that use the neurotransmitter dopamine.
   b. **Apply Concepts** Why do many drug users begin to take more and more of the drug they abuse?

Apply the Big idea

Homeostasis

3. Explain the brain's role in homeostasis in regard to the body as a whole. How does homeostasis within the brain differ from the rest of the body? How must it be similar?