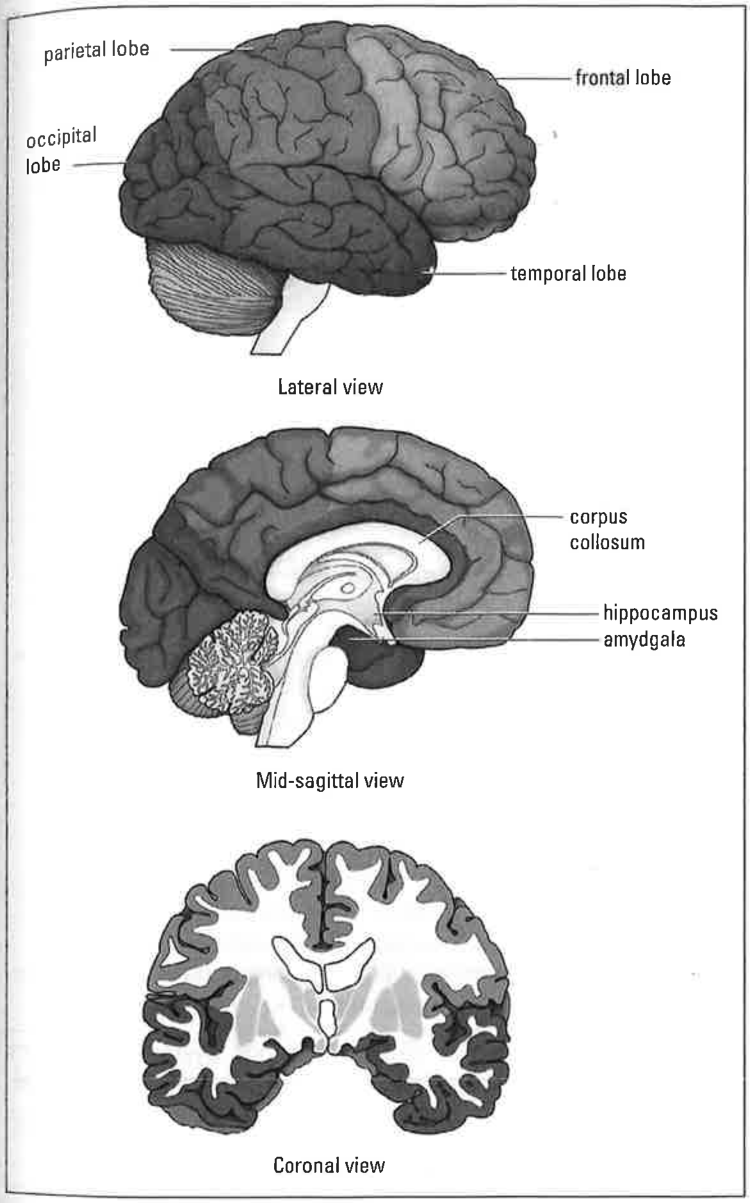

FIGURE 5.1 The human brain and some of its structures, shown in three different views (lateral, mid-sagital, and coronal).

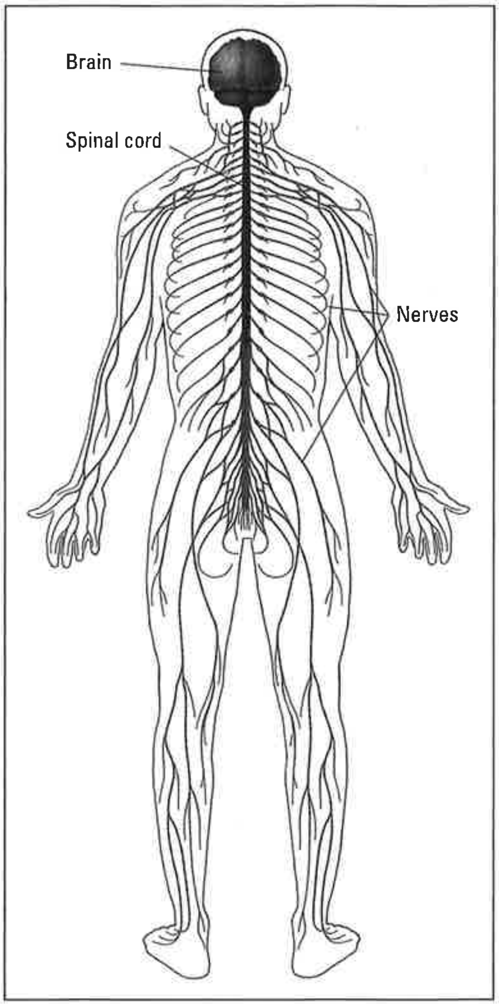

FIGURE 5.2 Human nervous system
The central nervous system consists of the brain and the spinal cord, which runs through the bones of the spinal column down the center of the back. The peripheral nervous system consists of the entire set of nerves, which connect the brain and spinal cord to the sensory organs, muscles, and glands.

Don't confuse the terms *neuron* and *nerve*. A neuron, as just defined, is a single cell of the nervous system. A ***nerve*** is a bundle of many neurons—or, more precisely, a bundle consisting of the axons (defined below) of many neurons—within the peripheral nervous system. Nerves connect the central nervous system to the body's sensory organs, muscles, and glands. Note also that despite their names, the central and peripheral nervous systems are not two separate systems, but are parts of an integrated whole.

Neurons come in a wide variety of shapes and sizes and serve countless specific functions. At the broadest level of analysis, they can be grouped into three categories according to their functions and their locations in the overall layout of the nervous system (see **Figure 5.3**):

1

What are three types of neurons, and what is the function of each?

1. ***Sensory neurons,*** bundled together to form nerves, carry information from sensory organs (including the eyes, ears, nose, tongue, and skin) into the central nervous system.

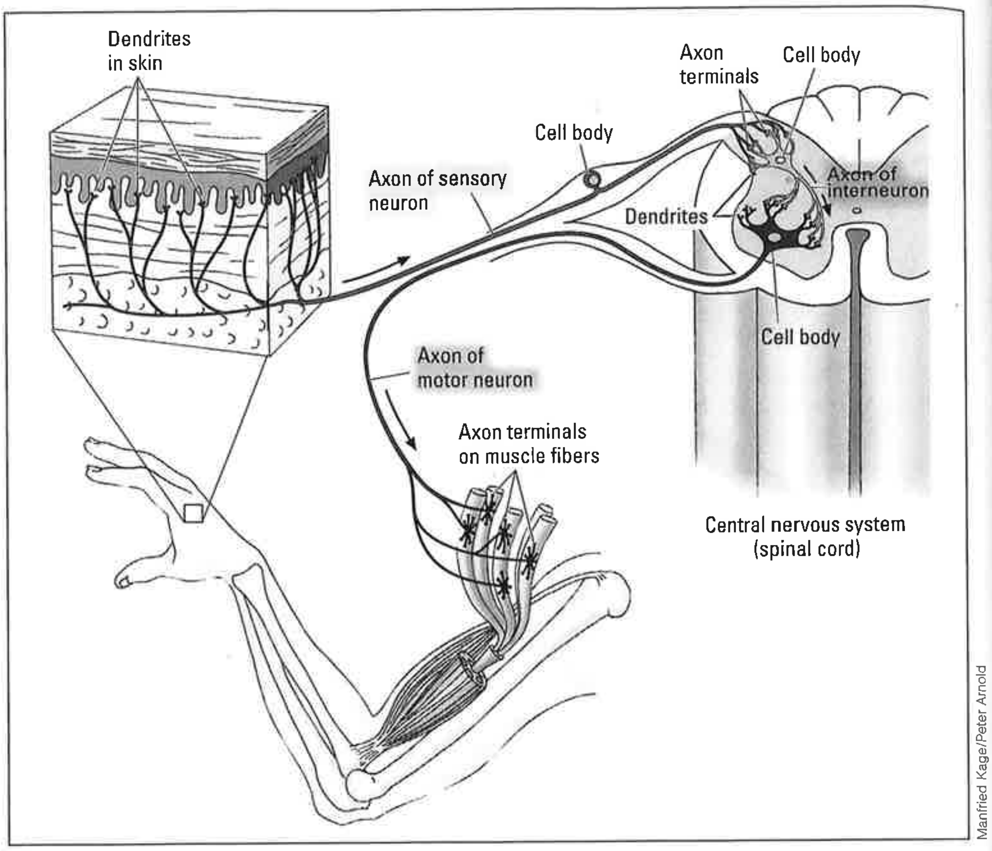

FIGURE 5.3 The three classes of neurons This illustration shows the positions in the nervous system of the three types of neurons. On the right is the central nervous system (more specifically, a cross section of the spinal cord), and on the left are muscles and skin. Motor neurons send messages from the central nervous system to muscles and glands. Sensory neurons send messages into the central nervous system from sensory organs, such as the skin. And interneurons, located entirely within the central nervous system, carry messages between neurons.

2. ***Motor neurons,*** also bundled into nerves, carry messages out from the central nervous system to operate muscles and glands.

3. ***Interneurons*** exist entirely within the central nervous system and carry messages from one set of neurons to another. Interneurons collect, organize, and integrate messages from various sources. They vastly outnumber the other two types.

The human nervous system contains a few million sensory and motor neurons and roughly 100 *billion* interneurons. Our interneurons make sense of the input that comes from sensory neurons, generate all our mental experiences, and initiate and coordinate all our behavioral actions through their connections to motor neurons.

2

What are the main parts common to all or most neurons, and what is the function of each part?

Although neurons vary tremendously in shape and size, most contain the same basic parts. The parts, listed below, are labeled for all three types of neurons in Figure 5.3 and illustrated more fully for a motor neuron in **Figure 5.4.**

- The ***cell body*** is the widest part of the neuron. It contains the cell nucleus and other basic machinery common to all bodily cells.
- ***Dendrites*** are thin, tube-like extensions that branch extensively and function to receive input for the neuron. In motor neurons and interneurons, the dendrites extend directly off the cell body and generally branch extensively near the cell body, forming bush-like structures. These structures increase the surface area of the cell and thereby allow for receipt of signals from many other neurons. In sensory neurons, dendrites extend from one end of the axon, rather than directly from the cell body. They extend into a sensory organ and respond to sensory signals, such as sound waves in the ear or touch on the skin (shown for skin in Figure 5.3).

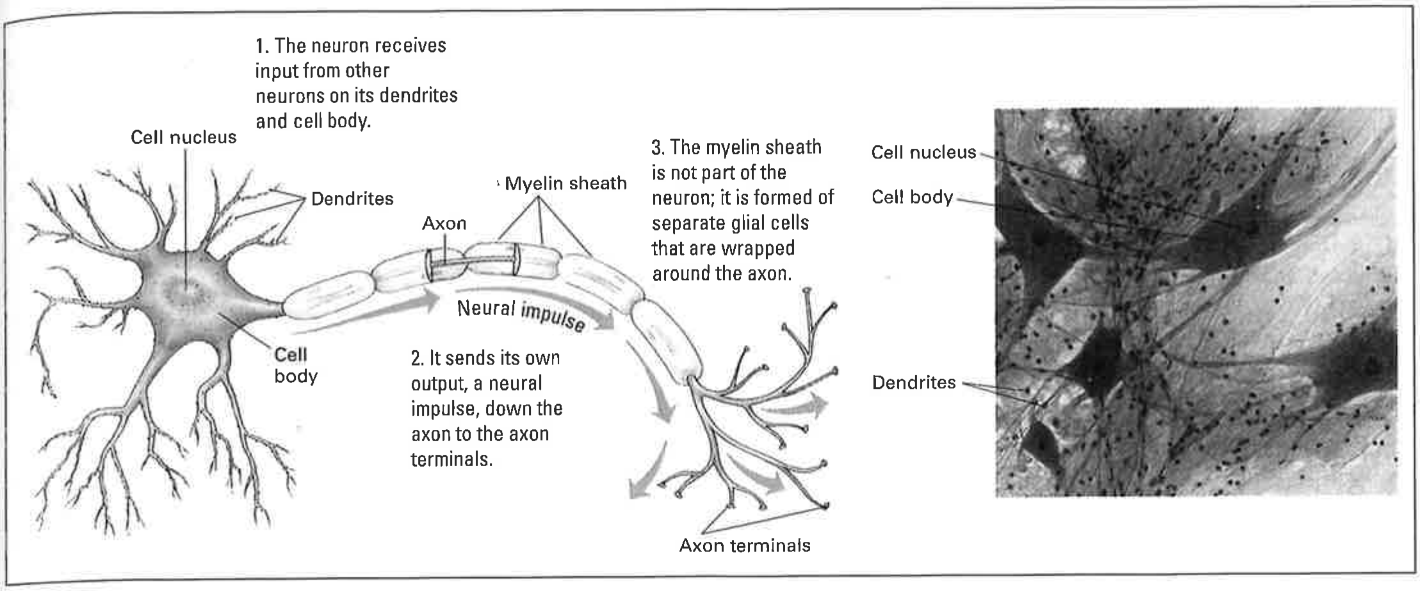

FIGURE 5.4 A motor neuron The parts common to many neurons can be seen in this diagram of a motor neuron. The neuron receives input from other neurons on its dendrites and cell body and sends its own output down the axon to the axon terminals. The myelin sheath is not part of the neuron; it is formed of separate cells that are wrapped tightly around the axon.

- The ***axon*** is another thin, tube-like extension from the cell body. Its function is to carry messages to other neurons or, in the case of motor neurons, to muscle cells. Although microscopically thin, some axons are extremely long. You have axons of sensory neurons extending all the way from your big toe into your spinal cord and then up to the base of your brain—a distance of 5 feet or more. Most axons form many branches some distance away from the cell body, and each branch ends with a small swelling called an ***axon terminal.*** Axon terminals are designed to release chemical transmitter molecules onto other neurons or, in the case of motor neurons, onto muscle cells or glandular cells. The axons of some neurons are surrounded by a casing called a ***myelin sheath.*** *Myelin* is a fatty substance produced by supportive brain cells called *glial cells*. As will be described later, this sheath helps to speed up the movement of neural impulses along the axon.

How Neurons Send Messages Down Their Axons

Neurons exert their influence on other neurons and muscle cells by firing off all-or-none impulses, called ***action potentials.*** In motor neurons and interneurons, action potentials are triggered at the junction between the cell body and the axon, and they travel rapidly down the axon to the axon terminals. In sensory neurons they are triggered at the dendritic end of the axon (at upper left in Figure 5.3) and travel through or past the cell body to the axon terminals.

Action potentials are described as "all or none" because they either occur or don't occur; that is, they don't partially occur or occur in different sizes or gradations. Each action potential produced by a given neuron is the same strength as any other action potential produced by that neuron, and each action potential retains its full strength all the way down the axon. Although each action potential is all or none, a neuron can convey varying degrees of intensity in its message by varying its rate of producing action potentials. A given neuron might fire off action potentials at a rate anywhere from zero per second to as high as 1,000 per second. By varying its rate of action potentials, a neuron varies the strength of its effect on other neurons or muscle cells.

The Resting Neuron Has a Constant Electrical Charge Across Its Membrane

To understand how action potentials travel down the axon, you have to know something about the functioning of the ***cell membrane*** that encloses each neuron. The membrane is a porous "skin" that permits certain chemicals to flow into and