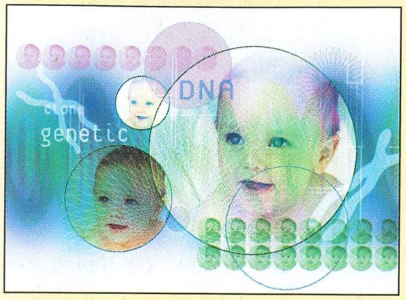
Application

WHY STUDY PSYCHOLOGY?



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Modules 6–9 help explain these fascinating facts:

- René Descartes, a seventeenth-century French philosopher and mathematician, believed that fluid in your brain was under pressure. If you decided to perform an action, this fluid would flow into the appropriate set of nerves and muscles, thus allowing the movement to happen.
- The reappearance of certain infant reflexes in adults may be a sign of serious brain damage.
- Even when reared apart, identical twins resemble each other more closely than fraternal twins in their IQ scores, numerous personality traits, and even their age at first sexual intercourse.
- A physician can declare you legally dead if your brain stops functioning—even though your heart and lungs are still working.
- Strong emotions, such as fear or anger, can stop digestion and sexual arousal.
- Cells in our brains die and regenerate throughout our lifetime. They are also physically shaped and changed by learning and from experiences we have with our environment.
- Scientists have created human embryos through cloning. The extracted stem cells from these embryos will be used for research and possible treatment for diseases like cancer, Parkinson's disease, and diabetes.

Sources: Abbott, 2004; Bouchard, 2004; Plomin, 1999.

What are you doing at this very moment? Obviously, your eyes are busily translating squiggly little black symbols called "letters" into meaningful patterns called "words." But what part of your body does the translation? If you put this book down and walk away to get a snack or talk to a friend, what moves your legs and enables you to speak? You've heard the saying, "I think; therefore I am." What if you were no longer capable of thought or feeling? Would "you" still exist?

Although ancient cultures, including the Egyptian, Indian, and Chinese, believed the heart was the center of all thoughts and emotions, we now know that the brain and the rest of the nervous system are the power behind our psychological life and much of our physical being. This section introduces you to the important and exciting field of **neuroscience** and *biopsychology*, the scientific study of the *biology* of behavior and mental processes. It also provides a foundation for understanding several fascinating discoveries and facts, as well as important biological processes discussed throughout the text.

Neuroscience *Interdisciplinary field studying how biological processes relate to behavioral and mental processes*

Module 6 explores the *neuron*, or nerve cell, and the way neurons communicate with one another. Module 7 provides a quick overview of the two major divisions of the nervous system—central and peripheral. Module 8 explores the complex structures and functions of the major parts of the brain. Finally, Module 9 offers a brief discussion of the role of evolution and heredity in our modern psychological lives, and how neuroscience research can be applied to everyday life.

MODULE 6
NEURAL BASES OF BEHAVIOR

What Is a Neuron? Psychology at the Micro Level

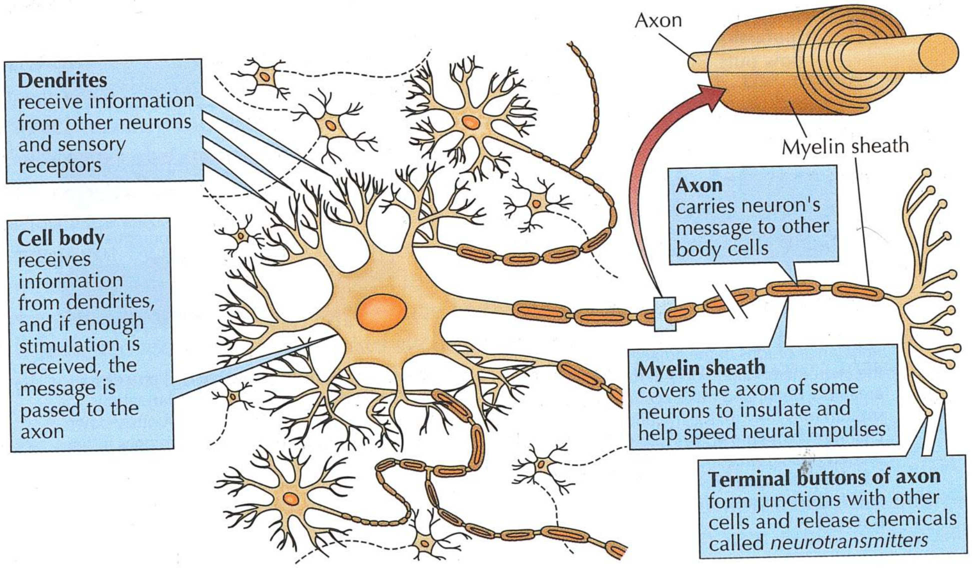
Your brain and the rest of your nervous system essentially consist of **neurons,** cells of the nervous system that communicate electrochemical information throughout the brain and the rest of the body. Each neuron is a tiny information processing system with thousands of connections for receiving and sending signals to other neurons. Although no one knows for sure, one well-educated guess is that each human body has as many as one *trillion* neurons.

These neurons are held in place and supported by **glial cells** (from the Greek word for "glue"). Glial cells surround neurons, perform cleanup tasks, and insulate one neuron from another so that their neural messages are not scrambled. Research also shows that glial cells play a direct role in nervous system communication (Rose & Konnerth, 2002; Wieseler-Frank, Maier, & Watkins, 2005). However, the "star" of the communication show is still the neuron.

Basic Parts of a Neuron

Just as no two people are alike, no two neurons are the same. However, most neurons do share three basic features: dendrites, cell body, and axon (Figure 6.1). **Dendrites** look like leafless branches of a tree. In fact, the word *dendrite* means "little tree" in Greek. Dendrites act like antennas, receiving electrochemical information from other neurons and transmitting it to the cell body. Each neuron may have hundreds or thousands of dendrites and their branches. From the many dendrites, information flows into the **cell body,** or soma (Greek for "body"), which accepts the incoming messages. If the cell body receives enough stimulation from its dendrites, it will pass the message on to the **axon** (from the Greek word for "axle"). Like a miniature cable, this long, tubelike structure then carries information away from the cell body.

Figure 6.1 ***The structure of a neuron.*** Information enters the neuron through the dendrites, is integrated in the cell body, and is then transmitted to other neurons via the axon.



Achievement

What are neurons, and how do they convey information throughout the body?

Neuron *Cell of the nervous system responsible for receiving and transmitting electrochemical information*

Glial Cells *Cells that provide structural, nutritional, and other support for the neurons, as well as communication within the nervous system; also called glia or neuroglia*

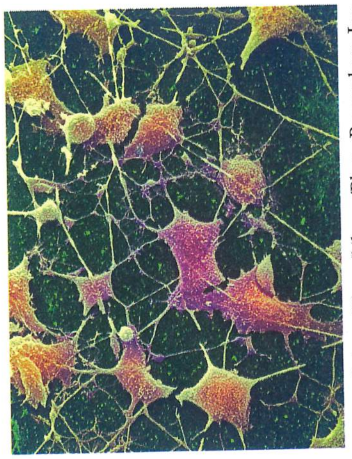
Dendrites *Branching neuron structures that receive neural impulses from other neurons and convey impulses toward the cell body*

Cell Body *The part of the neuron that contains the cell nucleus, as well as other structures that help the neuron carry out its functions; also known as the soma*

Axon *A long, tubelike structure that conveys impulses away from the neuron's cell body toward other neurons or to muscles or glands*

Study Tip

Be careful not to confuse the term neuron with the term nerve. Nerves are large bundles of axons that carry impulses to and from the brain and spinal cord.



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Myelin [MY-uh-lin] Sheath *Layer of fatty insulation wrapped around the axon of some neurons, which increases the rate at which nerve impulses travel along the axon*

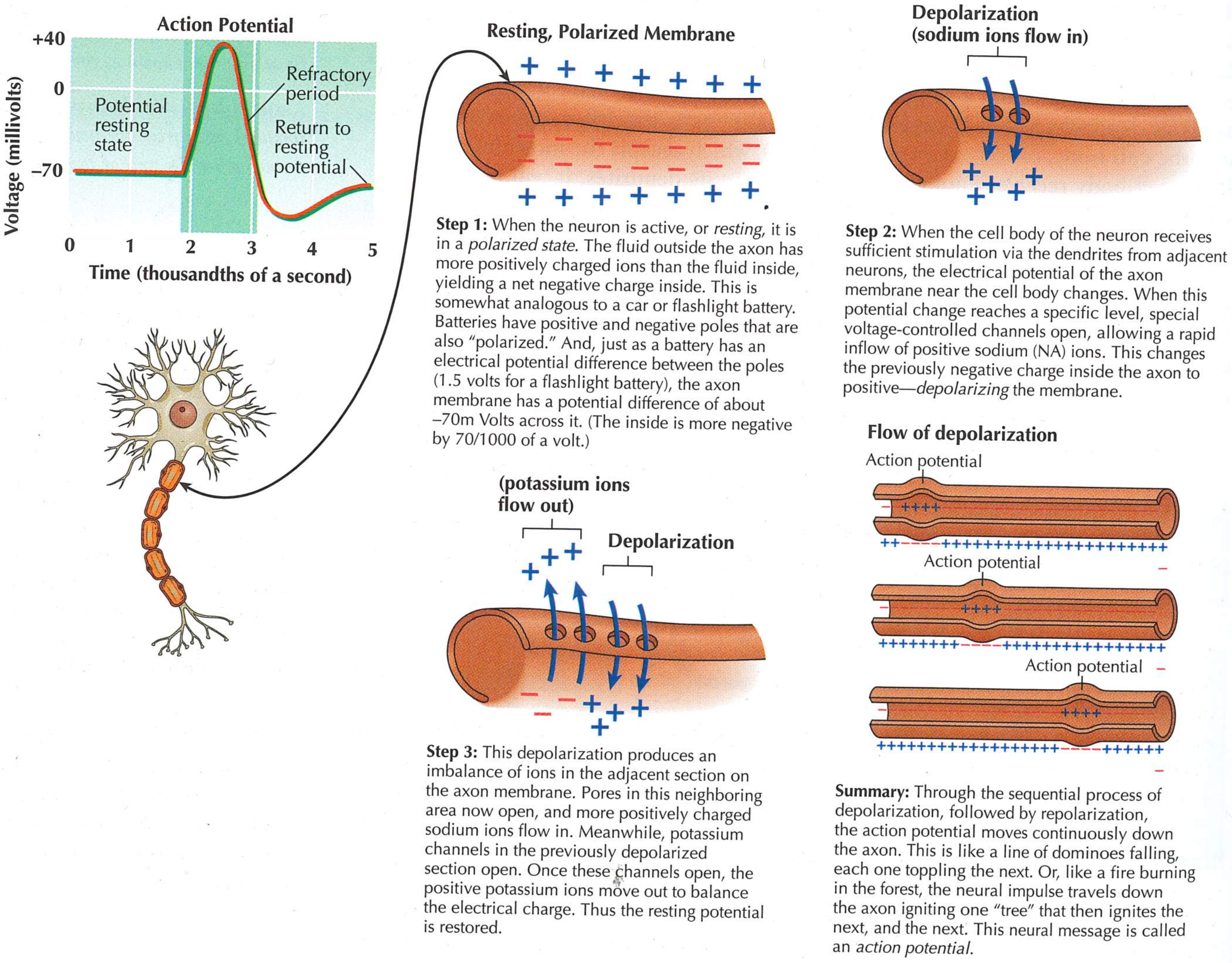
Study Tip

To remember how information travels through the neuron, think of the three key parts in reverse alphabetical order: Dendrite → Cell Body → Axon (DCBA).

The **myelin sheath,** a white, fatty coating around the axons of some neurons, is not considered one of the three key features of a neuron. However, it is important because it helps insulate and speed neural impulses (Figure 6.2). Its importance becomes readily apparent in certain diseases, such as multiple sclerosis, where the myelin progressively deteriorates. This loss of insulation around the axons leads to disruptions in the flow of information between the brain and muscles, and the person gradually loses muscular coordination. For reasons that are not well understood, the disease often goes into remission. However, multiple sclerosis can be fatal if it strikes the neurons that control basic life-support processes, such as breathing or the beating of the heart.

Near each axon's end, the axon branches out, and at the tip of each branch are *terminal buttons*, which release chemicals (called *neurotransmitters*). These chemicals move the message from the end of the axon to the dendrites or cell body of the next neuron, and the message continues. Neurotransmitters will be studied in depth in the upcoming sections.

Figure 6.2 ***Communication within the neuron—the action potential.***



Step 1: When the neuron is active, or *resting*, it is in a *polarized state.* The fluid outside the axon has more positively charged ions than the fluid inside, yielding a net negative charge inside. This is somewhat analogous to a car or flashlight battery. Batteries have positive and negative poles that are also "polarized." And, just as a battery has an electrical potential difference between the poles (1.5 volts for a flashlight battery), the axon membrane has a potential difference of about –70m Volts across it. (The inside is more negative by 70/1000 of a volt.)

Step 2: When the cell body of the neuron receives sufficient stimulation via the dendrites from adjacent neurons, the electrical potential of the axon membrane near the cell body changes. When this potential change reaches a specific level, special voltage-controlled channels open, allowing a rapid inflow of positive sodium (NA) ions. This changes the previously negative charge inside the axon to positive—*depolarizing* the membrane.

Step 3: This depolarization produces an imbalance of ions in the adjacent section on the axon membrane. Pores in this neighboring area now open, and more positively charged sodium ions flow in. Meanwhile, potassium channels in the previously depolarized section open. Once these channels open, the positive potassium ions move out to balance the electrical charge. Thus the resting potential is restored.

Summary: Through the sequential process of depolarization, followed by repolarization, the action potential moves continuously down the axon. This is like a line of dominoes falling, each one toppling the next. Or, like a fire burning in the forest, the neural impulse travels down the axon igniting one "tree" that then ignites the next, and the next. This neural message is called an *action potential.*

How Do Neurons Communicate? An Electrical and Chemical Language

The basic function of neurons is to transmit information throughout the nervous system. Neurons "speak" to each other or, in some cases, to muscles or glands, in a type of electrical and chemical language. We begin our discussion by looking at communication *within* the neuron itself. Then we explore how communication occurs *between* neurons.

Communication Within the Neuron—The Action Potential

The process of neural communication begins within the neuron itself, when electrical "messages" are received by the dendrites and cell body. These messages are passed along the axon in the form of a neural impulse or **action potential** (Figure 6.3). Because the neural impulse that travels down the axon is chemical, the axon does not transmit it in the same way that a wire conducts an electrical current. The movement down the axon actually results from a change in the permeability of the cell membrane. Picture the axon as a tube filled with chemicals. This tube is floating in a sea of still more chemicals. The chemicals both inside and outside the tube are *ions*, molecules that carry an electrical charge, either positive or negative.

Keep in mind that once the action potential has started, it continues. There is no such thing as a "partial" action potential. Similar to the firing of a bullet from a gun, the action potential either fires completely or not at all. This is referred to as the *all-or-none law*. Immediately after a neuron fires, it enters a brief *refractory period* where it cannot fire again. During the refractory period, the neuron *repolarizes*. The resting balance is restored with negative ions inside and positive ions outside. Now the neuron is ready to fire again.

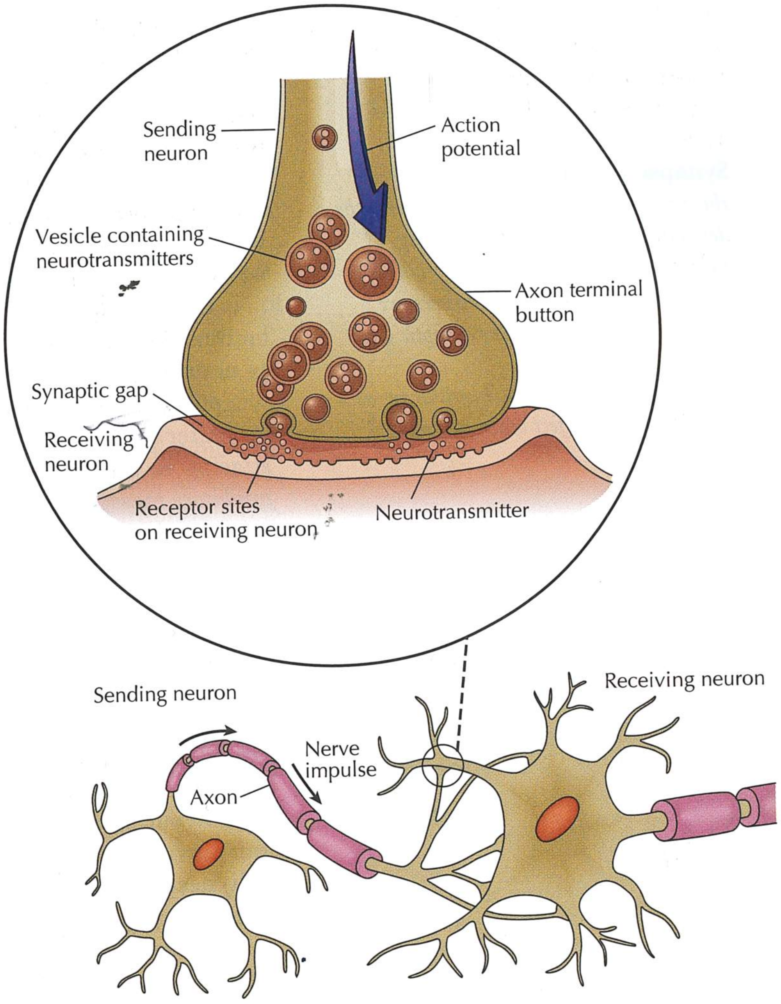


Figure 6.3 ***Neurotransmitters—How neurons "talk" to one another.*** In this schematic view of a synapse, neurotransmitter chemicals are stored in vesicles at the end of the axon. When action potentials reach the axon terminal, they stimulate the release of neurotransmitter molecules into the synaptic gap. The neurotransmitter chemicals then travel across the synaptic gap and bind to receptor sites on the dendrites or cell body of the receiving neurons. Neurotransmitters that do not "fit" into the adjacent receptor sites are decomposed in the synaptic gap or reabsorbed by the sending neuron.

How fast does a neural impulse travel? Actually, a nerve impulse moves slowly, much more slowly than electricity through a wire. Because electricity travels by a purely physical process, it can move through a wire at 97 percent of the speed of light, approximately 300 million meters per second. A neural impulse, on the other hand, travels along a bare axon at only about 10 meters per second.

Some axons, however, are enveloped in fatty insulation, the myelin sheath, which greatly increases the speed of an action potential. The myelin blankets the axon, with the exception of periodic *nodes*, points at which the myelin is very thin or absent (see again Figure 6.1). In a myelinated axon, the speed of the nerve impulse increases because the action potential jumps from node to node rather than traveling point by point along the entire axon. An action potential in a myelinated axon moves about 10 times faster than in a bare axon, at over 100 meters per second. As we discovered earlier, the importance of the myelin sheath becomes apparent when it is destroyed in certain diseases such as multiple sclerosis. The greatly slowed rate of action potential conduction affects the person's movement and coordination.

Communication Between Neurons—Neurotransmitter Action at the Synapse

Communication *between* neurons is *not* the same as communication *within* the neuron itself. As we have just seen, messages travel *electrically* from one point to another

Action Potential *Neural impulse that carries information along the axon of a neuron. The action potential is generated when positively charged ions move in and out through channels in the axon's membrane* within the neuron. Now, watch how the same message is transmitted *chemically* from one neuron to the next.

Once the action potential reaches the end of the axon, it continues traveling down the branching axon terminals until it reaches the axon terminal buttons. The transfer of information from one neuron to the next occurs at the junction between them, known as the **synapse.** This synaptic juncture includes the tips of the terminal branches of the axon (the terminal buttons), the tiny space between neurons (the synaptic gap), and the ends of the dendritic branches or the cell body of the receiving neuron (see again Figure 6.3).

Synapse [SIN-aps] *Junction between the axon tip of the sending neuron and the dendrite or cell body of the receiving neuron. During an action potential, chemicals called neurotransmitters are released and flow across the synaptic gap*

The electrical energy delivered by the action potential causes the knoblike terminal buttons at the axon's end to open and release a few thousand chemical molecules, known as **neurotransmitters.** These chemicals (or neurotransmitters) then move across the synaptic gap carrying the message from the sending neuron to the receiving neuron.

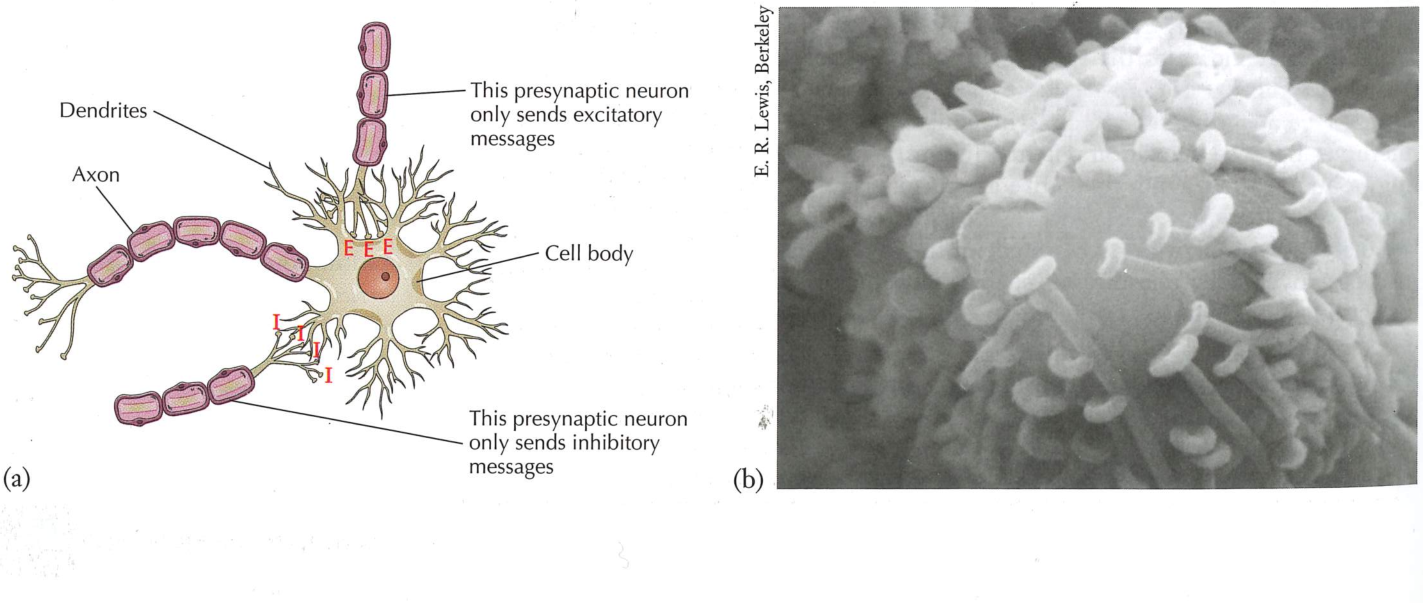
Neurotransmitters *Chemicals released by neurons that affect other neurons*

After a neurotransmitter molecule travels across the tiny space of the synapse and attaches to the membrane of the receiving neuron, it delivers either an *excitatory* or *inhibitory* message. Note, however, that most receiving neurons also receive *both* excitatory and inhibitory messages from other nearby neurons (Figure 6.4). Because of these multiple and competing messages, the receiving neuron only produces an action potential when the total amount of excitatory messages received from various neurons outweighs the total number of inhibitory messages.

Can you see how this process is somewhat analogous to everyday decisions? Before deciding to move to a new apartment or home, we generally review and compare the relative costs and benefits of moving or not moving. If we have more reasons ("excitatory messages") to move, we move. If not, we stay put (inhibitory messages).

Although differentiating between excitatory and inhibitory messages may complicate your study of this section, the presence of competing messages is critical to your survival. Just as driving a car requires using both an accelerator and brake, your body needs both "on" and "off" neural switches. Your nervous system manages an amazing balancing act between *over*excitation, leading to seizures, and *under*excitation, leading to coma and death. Interestingly, poisons, such as strychnine, work by disabling many inhibitory messages. This disabling typically leads to overexcitation and uncontrollable, possibly fatal convulsions.

Figure 6.4 ***Multiple messages.*** (a) In the central nervous system, the cell bodies and dendrites receive input from many synapses, some excitatory and some inhibitory. If enough excitatory messages are received, the neuron will fire. (b) Note in this close-up photo how the axon terminals from thousands of other neurons almost completely cover the cell body of the receiving neuron. (In this photo, dendrites are not visible.)



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