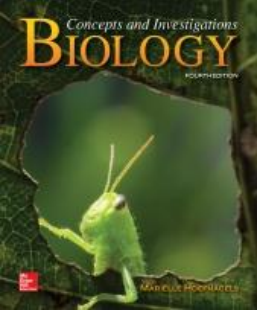


Chapter 26

The Nervous System

©Henrik Sorensen/Riser/Getty Images

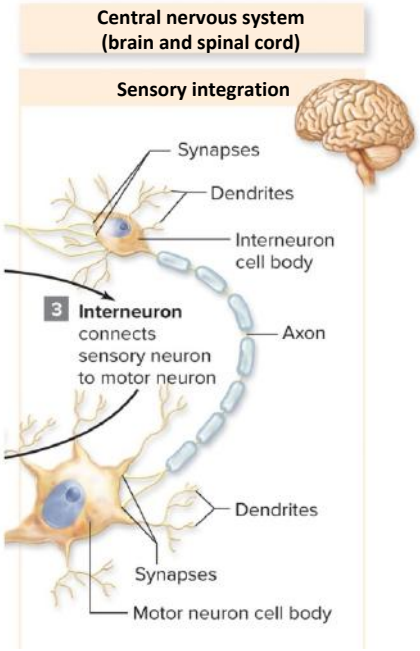
The nervous system: rapid communication, 1

Rapid communication between cells is fundamental to the function of the animal nervous system.

©Digital Vision RF

Neurons and neuroglia, 1

The nervous system consists mainly of nervous tissue, which has two types of cells: neurons and neuroglia.



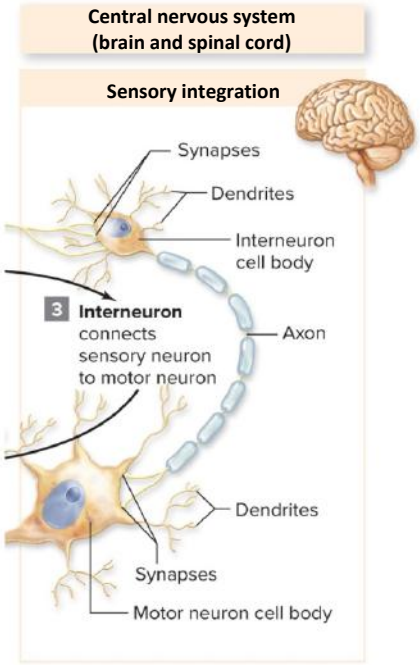
©Digital Vision RF

Section 26.1

Figures 26.1, 26.5

Neurons and neuroglia, 2

Neurons are interconnected cells that communicate via electrical impulses.
Neuroglia support neurons.



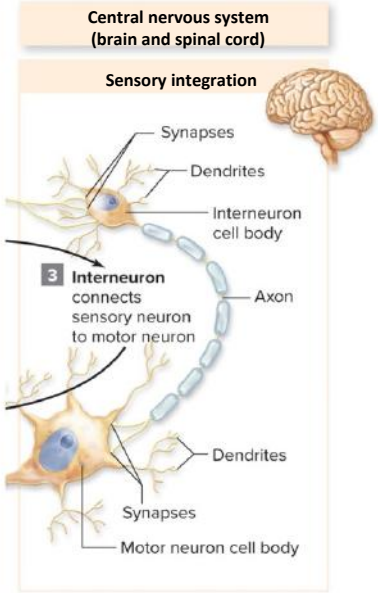
©Digital Vision RF

Section 26.1

Figures 26.1, 26.5

Neurons work together

Many neurons work together as an animal senses and reacts to its surroundings, makes decisions, and maintains homeostasis.



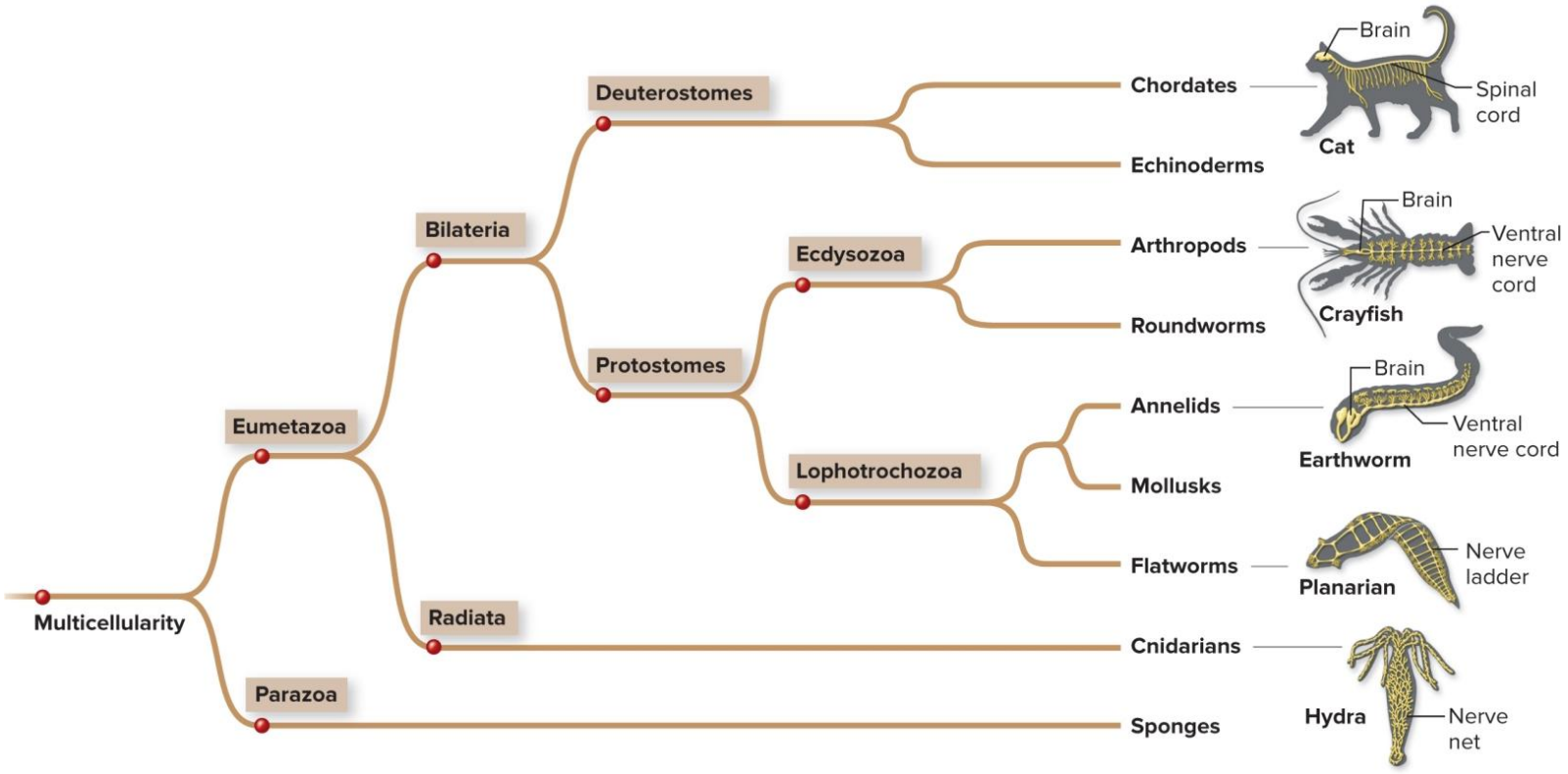
©Digital Vision RF

Section 26.1

Figures 26.1, 26.5

The evolutionary history of the nervous system

Nervous system complexity reflects evolutionary history.

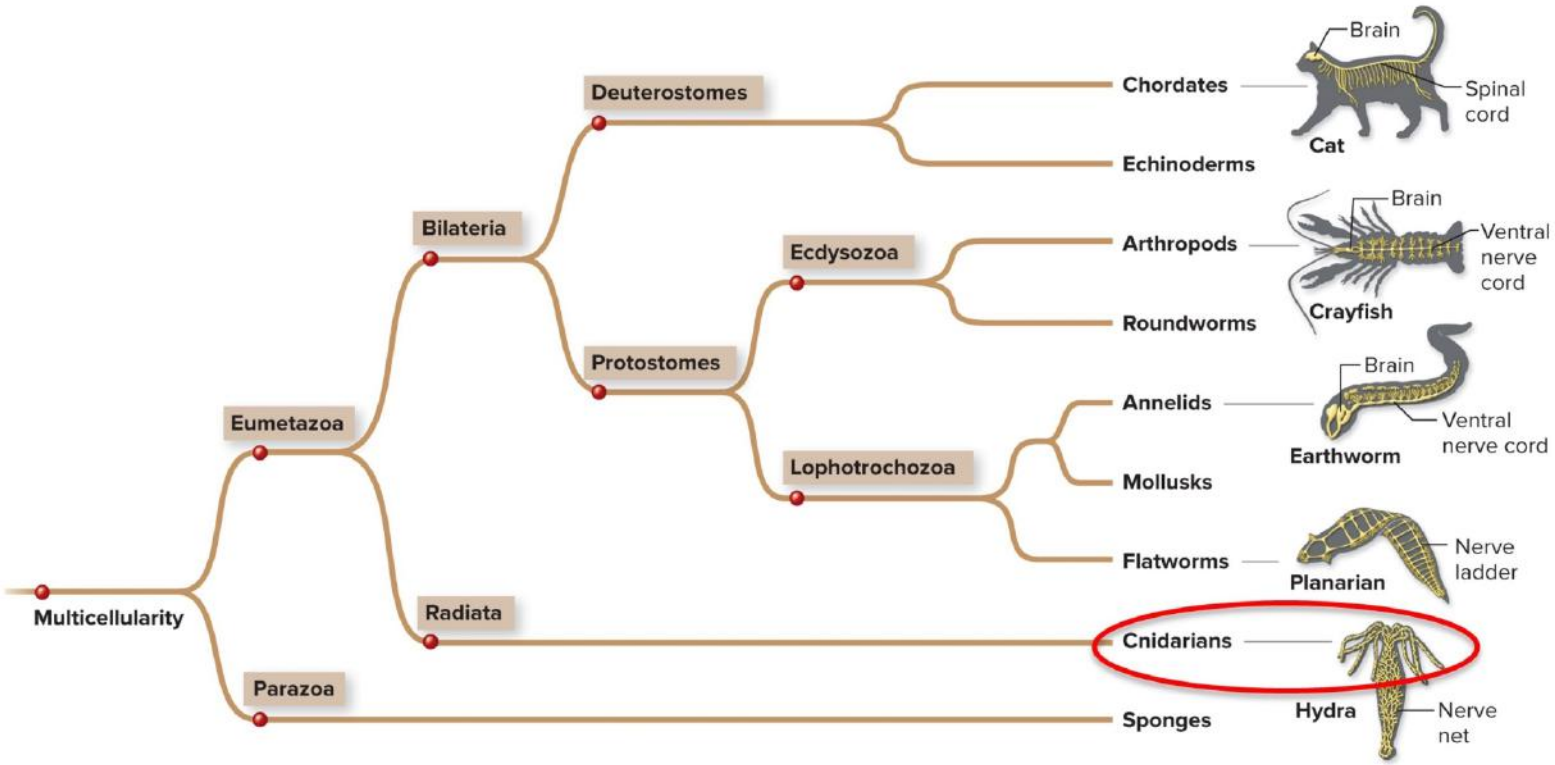


Section 26.1

Figure 26.2

Cnidaria

Cnidaria have **nerve nets**, in which nervous impulses spread over the entire body surface.

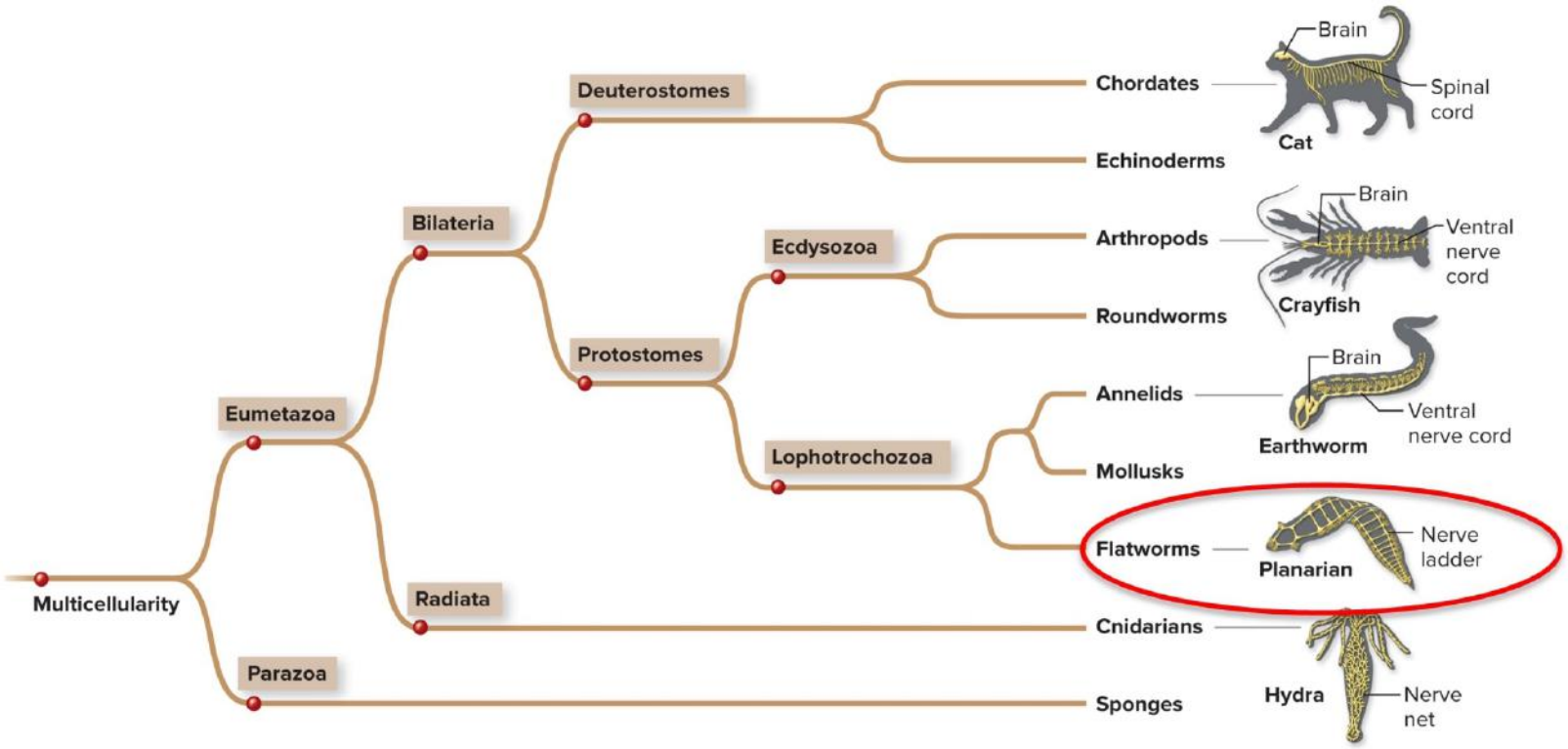


Section 26.1

Figure 26.2

Flatworms

Flatworms and most other animals have **ganglia—** clusters of neurons.

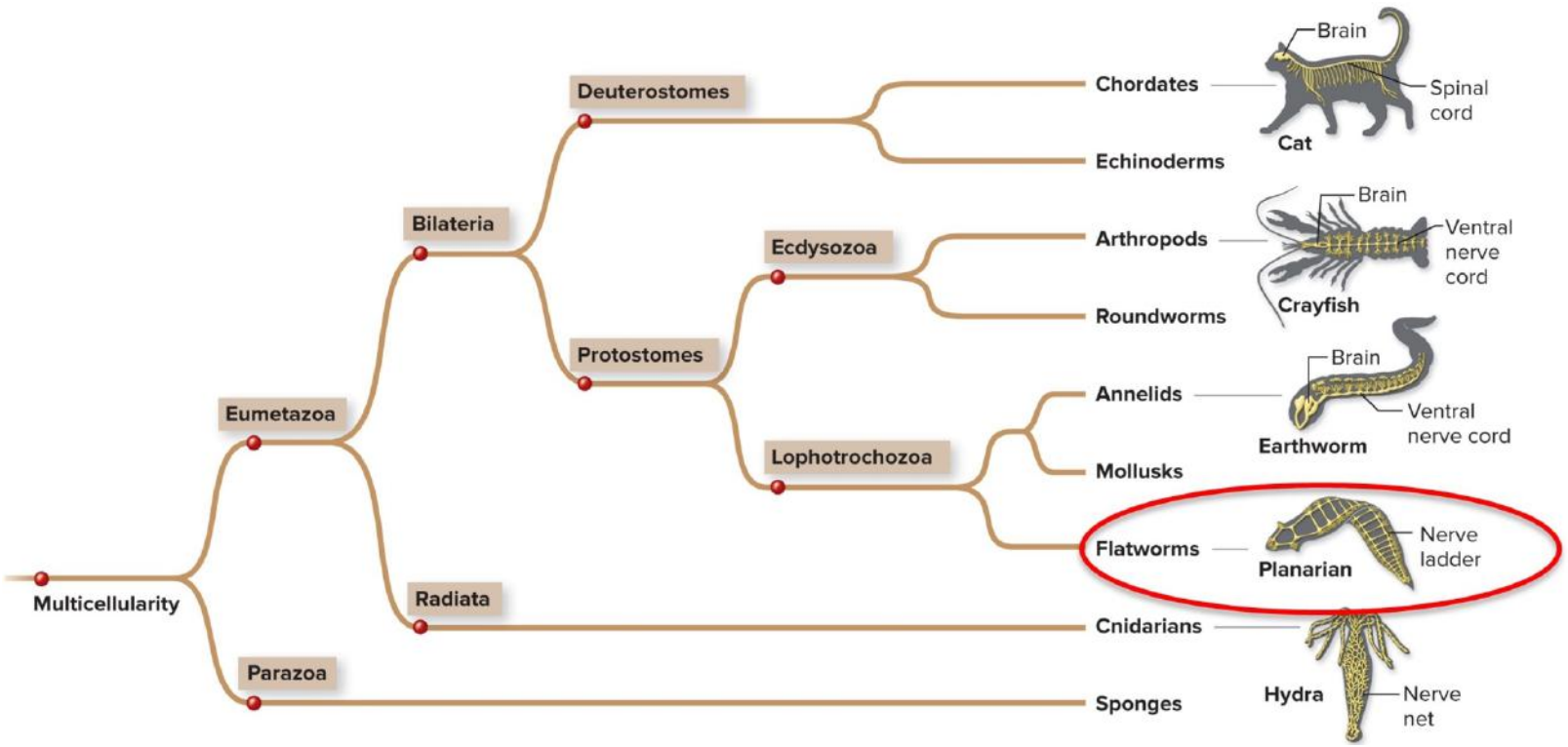


Section 26.1

Figure 26.2

Flatworms have a nerve ladder

The **nerve ladder** of flatworms connects to paired muscles on each side of the body, allowing the worm to move rhythmically.

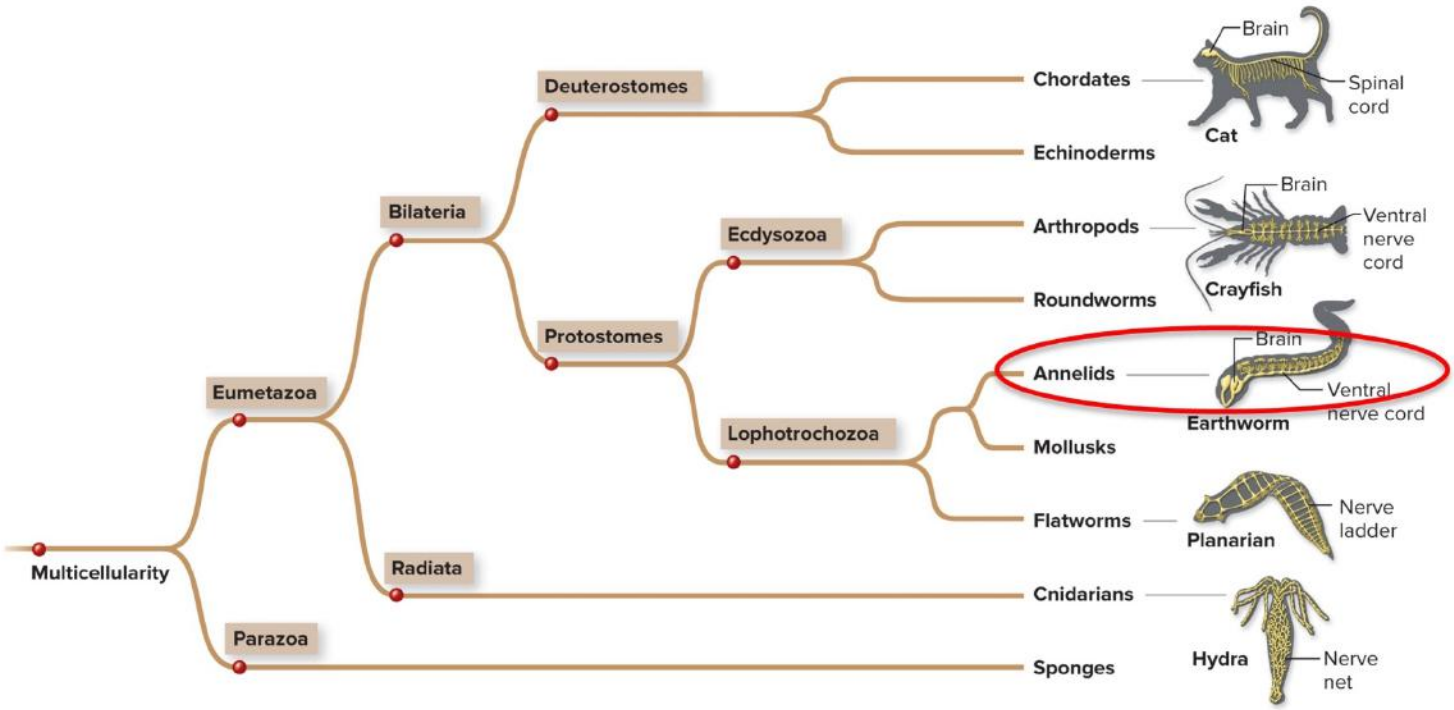


Section 26.1

Figure 26.2

Segmented worms

Segmented worms have a larger brain and a **ventral nerve cord** that helps the animal coordinate movements.

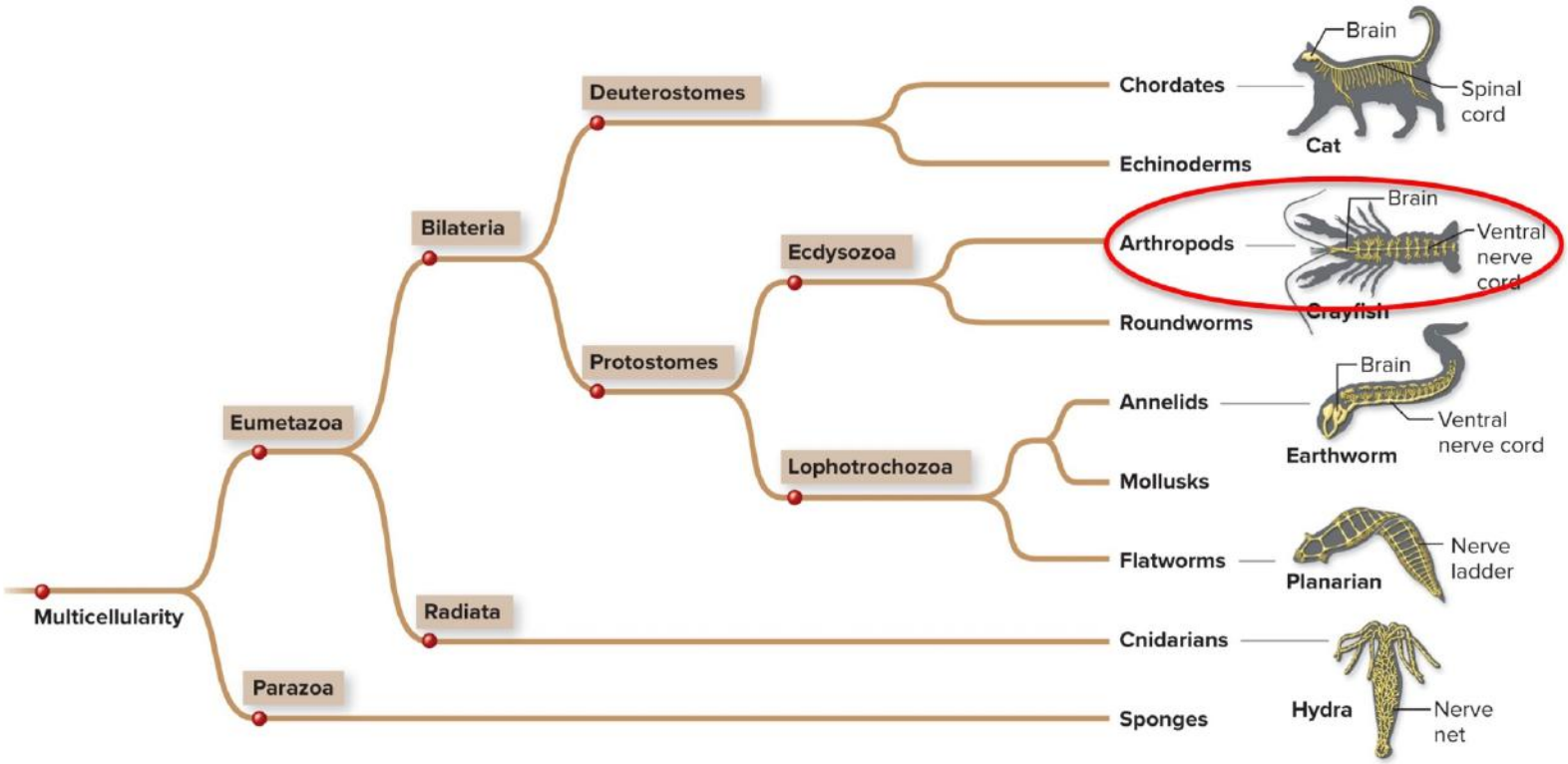


Section 26.1

Figure 26.2

Arthropods

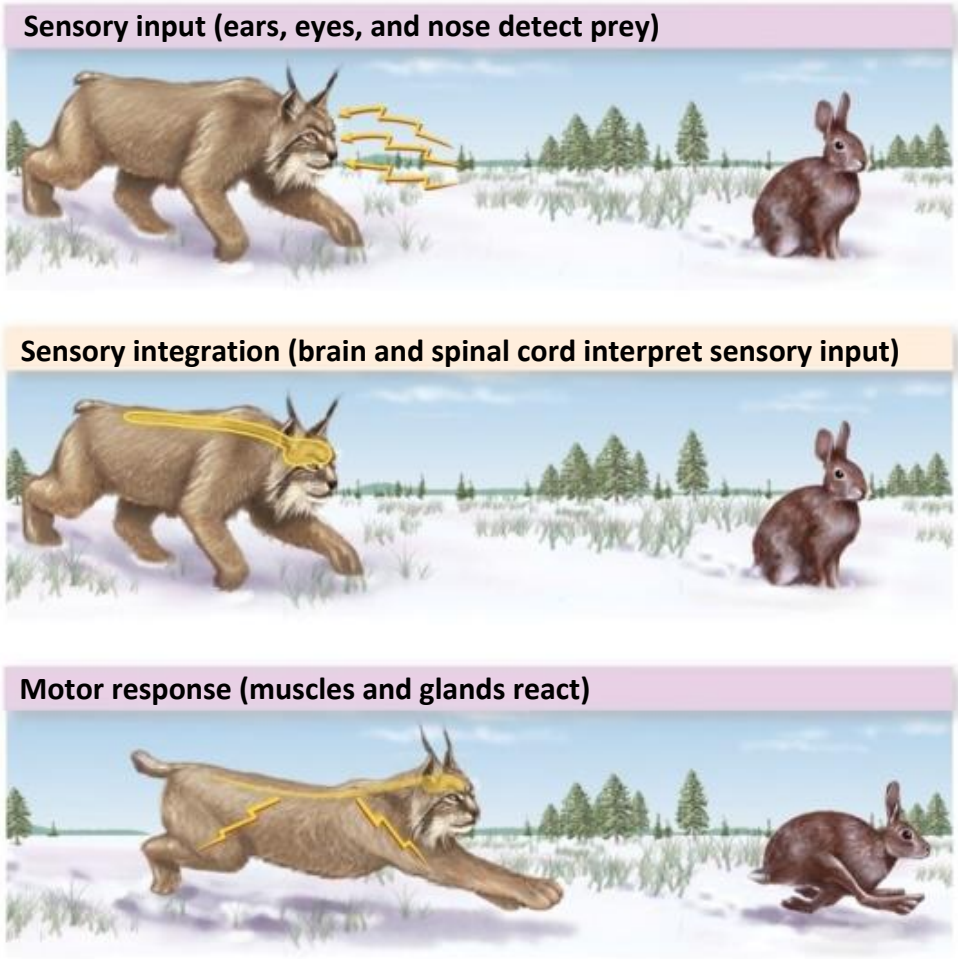
Arthropods have a brain, a ventral nerve cord, and organs that detect light, sound, chemicals, and balance.



Section 26.1

Figure 26.2

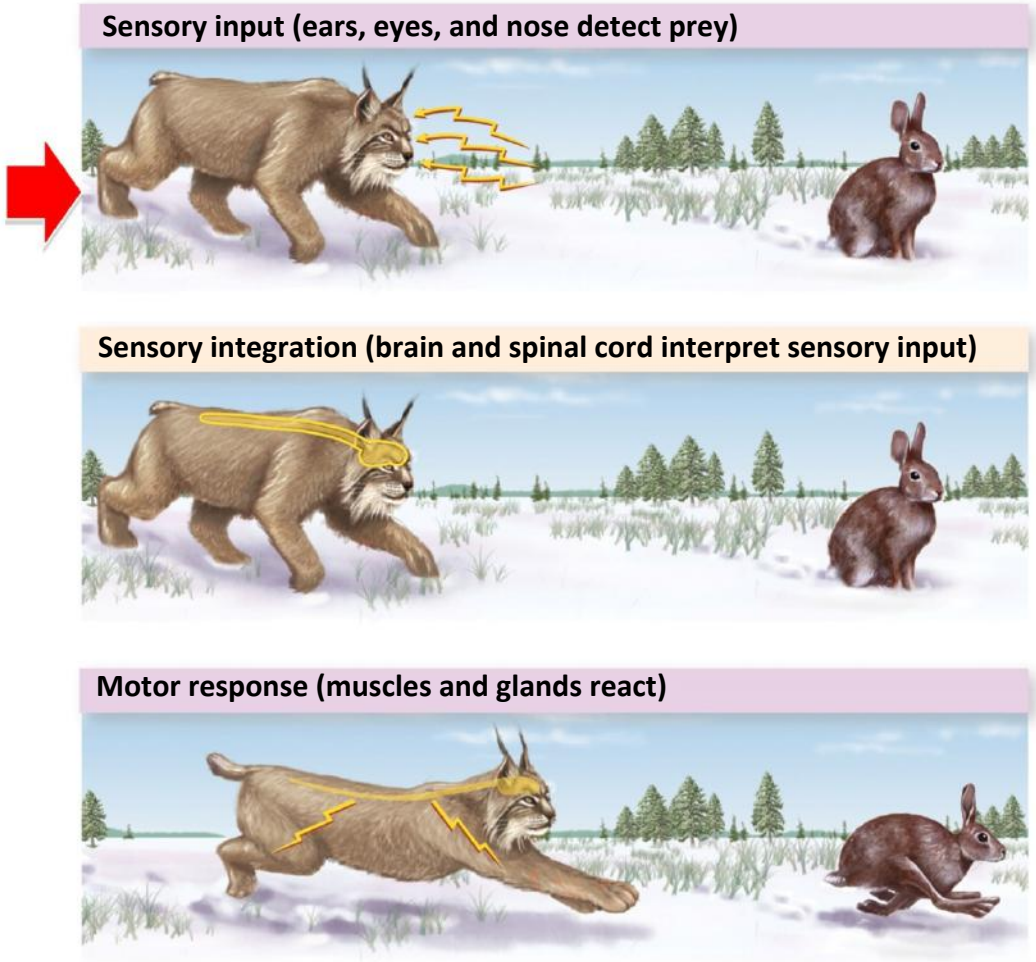
Vertebrates



Vertebrate nervous systems are divided into the central and peripheral nervous systems.

Even seemingly simple tasks, like this lynx seeing and chasing a hare, require interactions among many neurons in both divisions.

The peripheral nervous system: sensory input



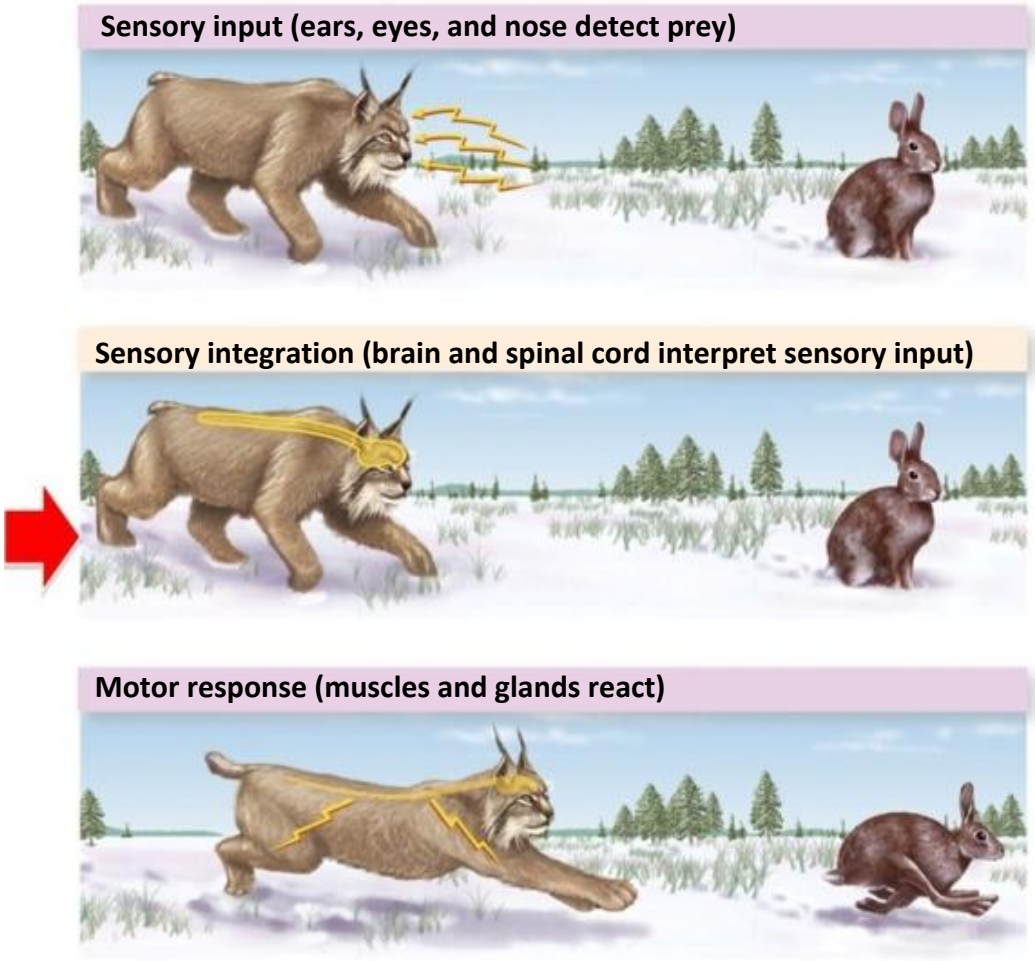
Neurons in the **peripheral nervous system** carry information to or from the central nervous system.

For example, neurons in sense organs respond to sensory input.

Section 26.1

Figure 26.3

The nervous system: rapid communication, 2

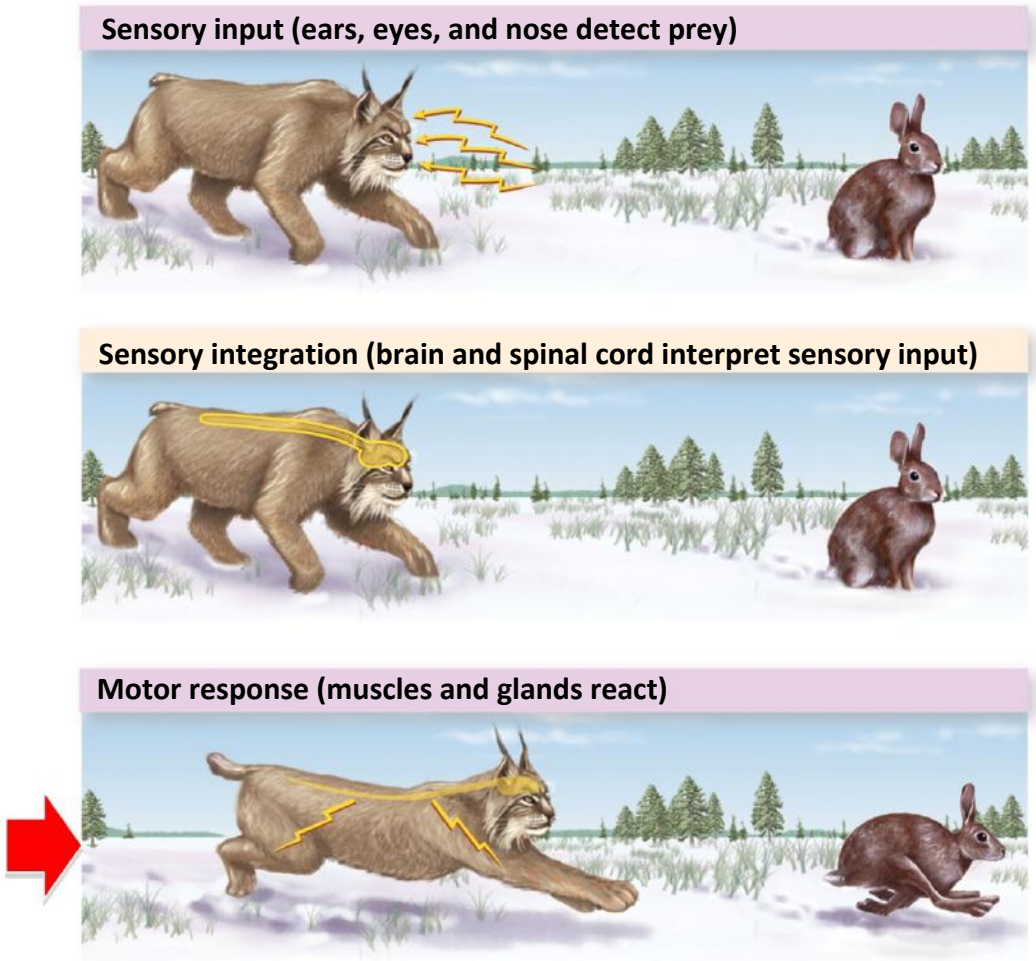


The **central nervous system** interprets signals it receives from the peripheral nervous system.

Section 26.1

Figure 26.3

Peripheral nervous system: motor response



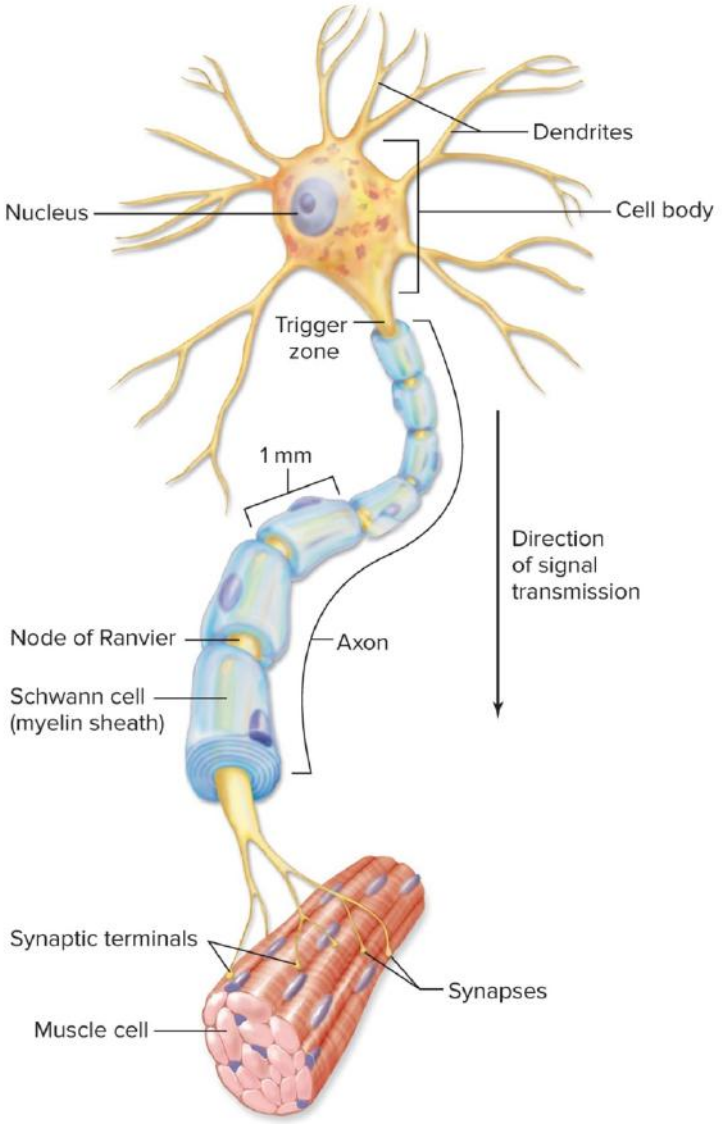
In a fraction of a second, the central nervous system signals the peripheral nervous system to stimulate a motor response.

26.1 Mastering concepts

©Henrik Sorensen/Riser/Getty Images

Distinguish between the central and peripheral nervous systems.

Neuron structure and arrangement



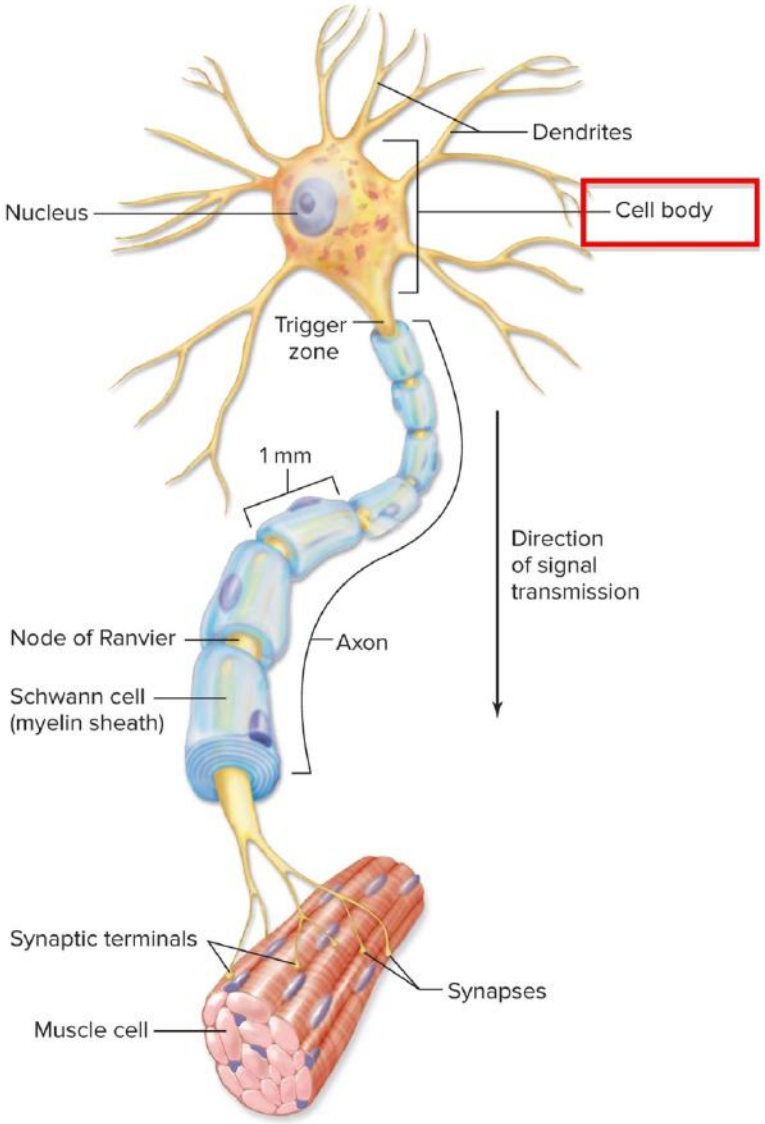
All neurons have the same basic parts:

- Cell body
- Dendrites
- Axon

Section 26.2

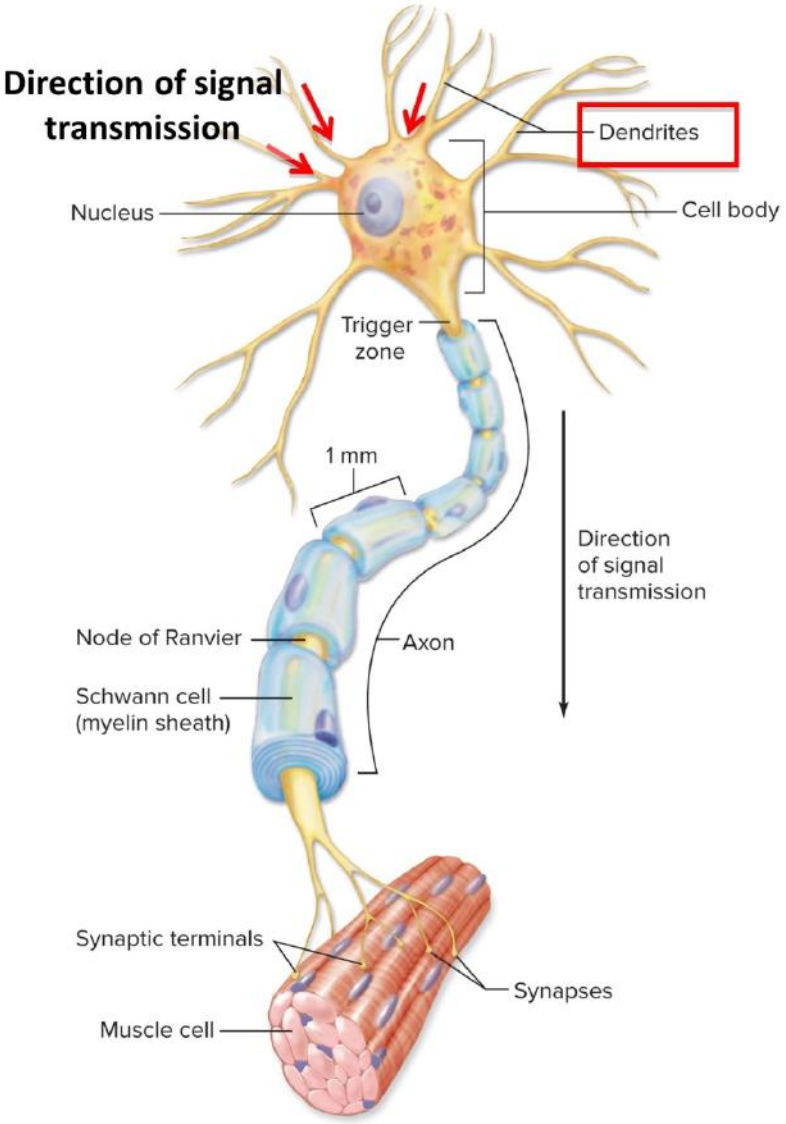
Figure 26.4

Cell body



The **cell body** contains the nucleus, mitochondria, and other organelles.

Dendrites

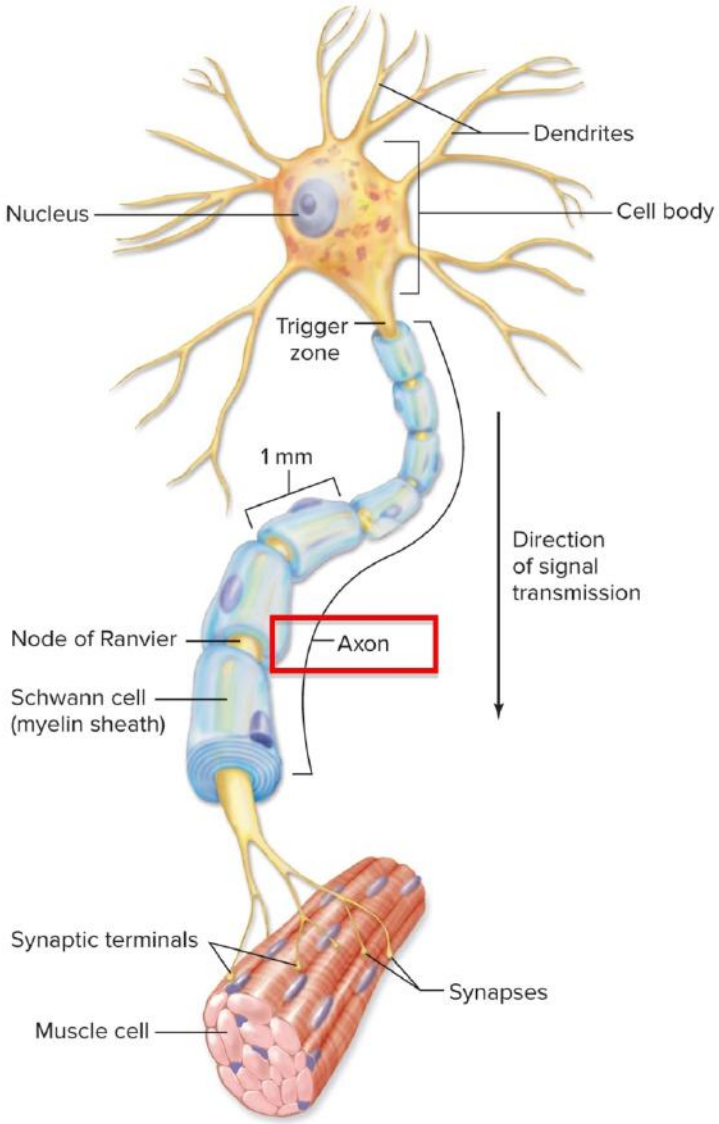


Dendrites are short, branched extensions that transmit information toward the cell body.

Section 26.2

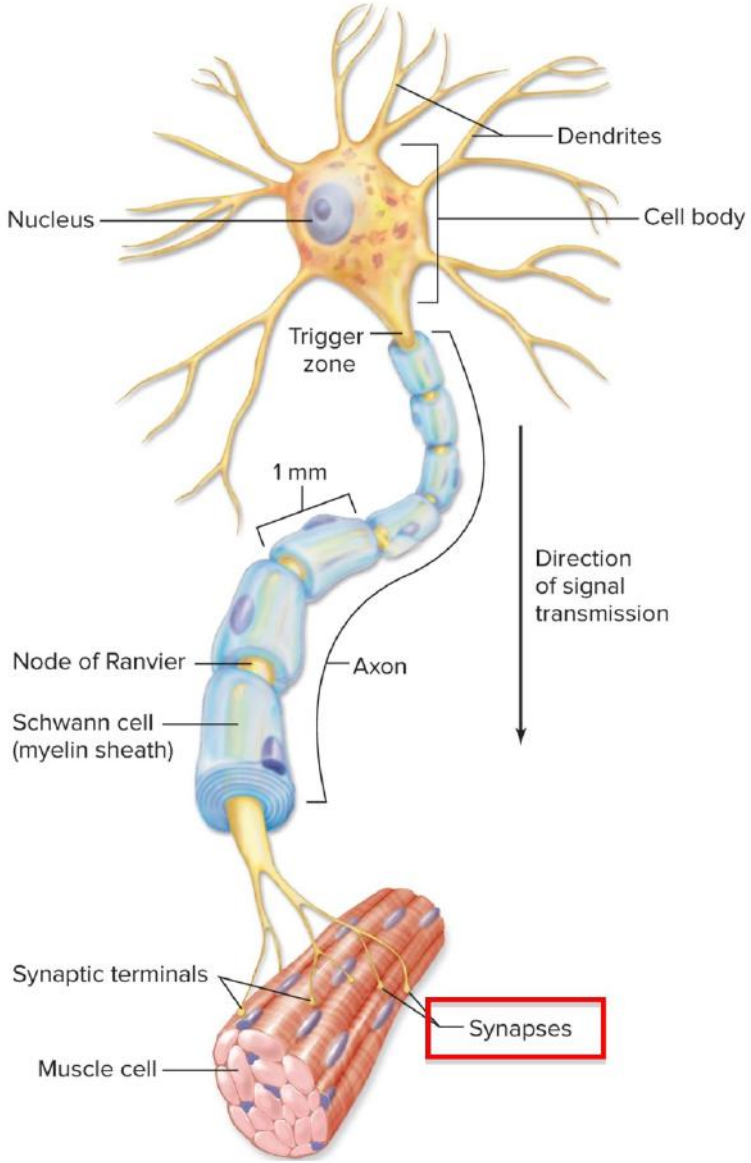
Figure 26.4

Axon



The **axon**, or nerve fiber, conducts nerve impulses away from the cell body.

Synapses, 1

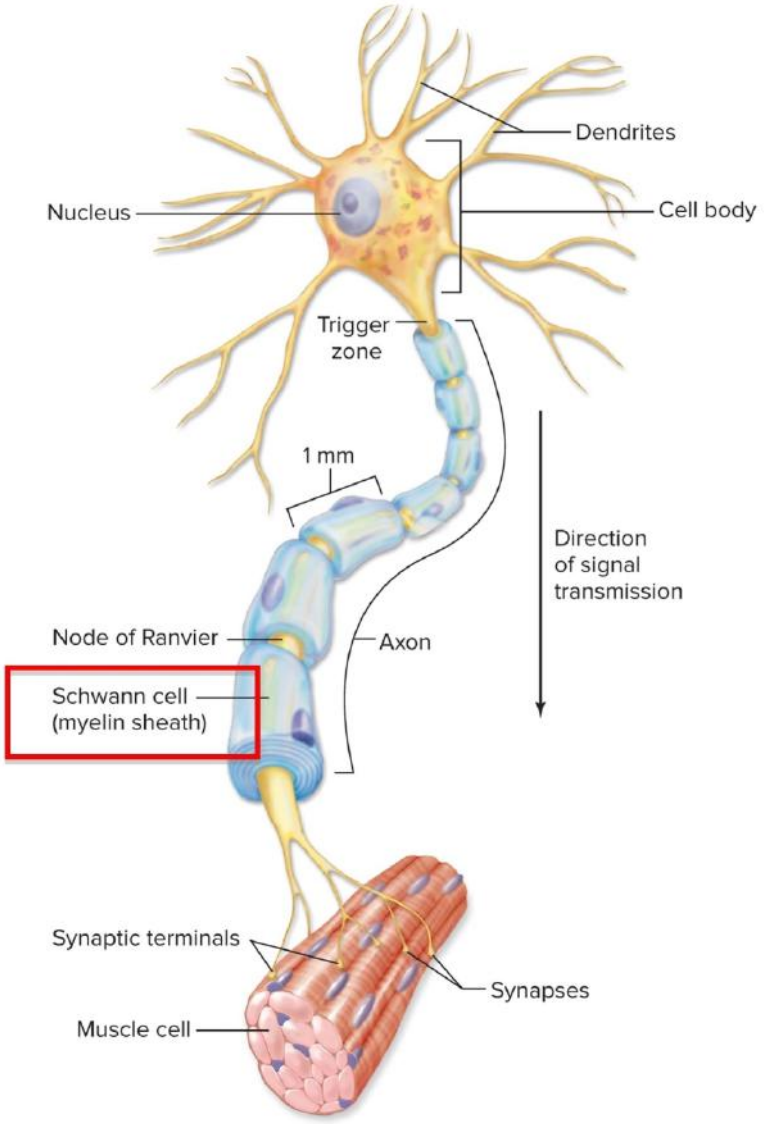


The end of the axon meets another cell, forming one or more synapses.

Section 26.2

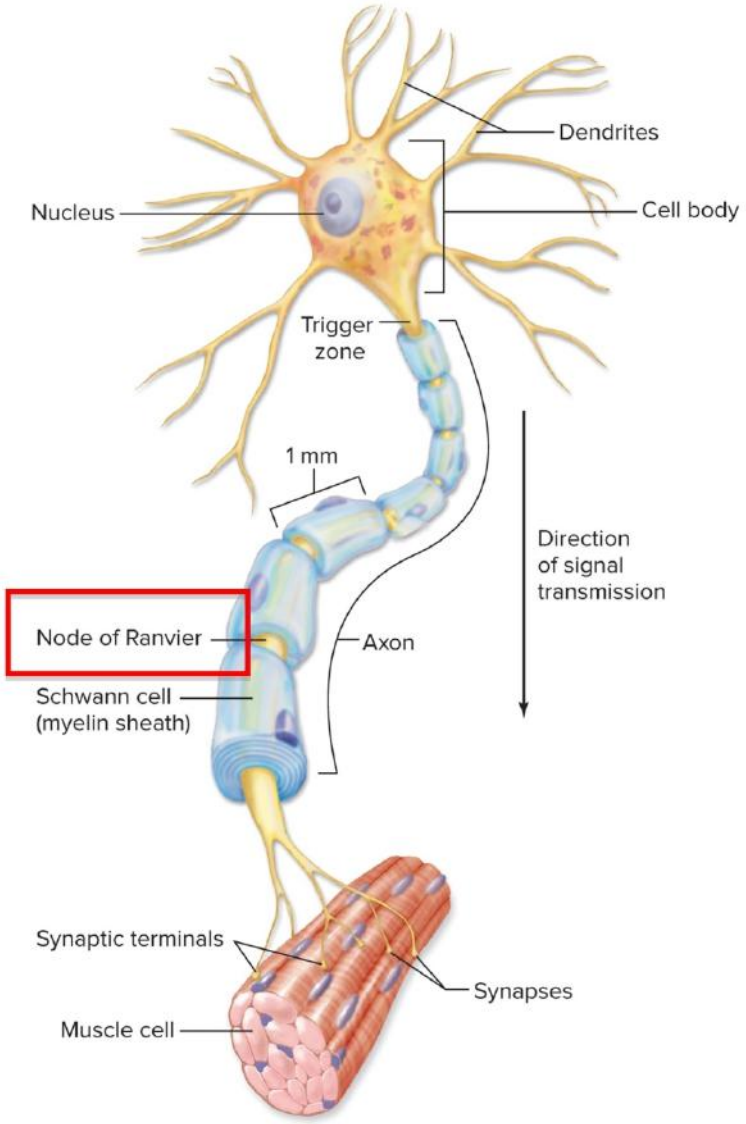
Figure 26.4

Myelin sheath



Some neurons also have a **myelin sheath** made of fatty neuroglia cells. The myelin sheath coats sections of the axon and speeds neural impulses.

Nodes of Ranvier



The myelin sheath is made of either **Schwann cells** or **oligodendrocytes**. The spaces between myelin sheath cells are called **Nodes of Ranvier**.

Three classes of neurons

Biologists divide neurons into three classes:

- Sensory neurons
- Interneurons
- Motor neurons

These neurons work together to coordinate reactions to stimuli such as pain.

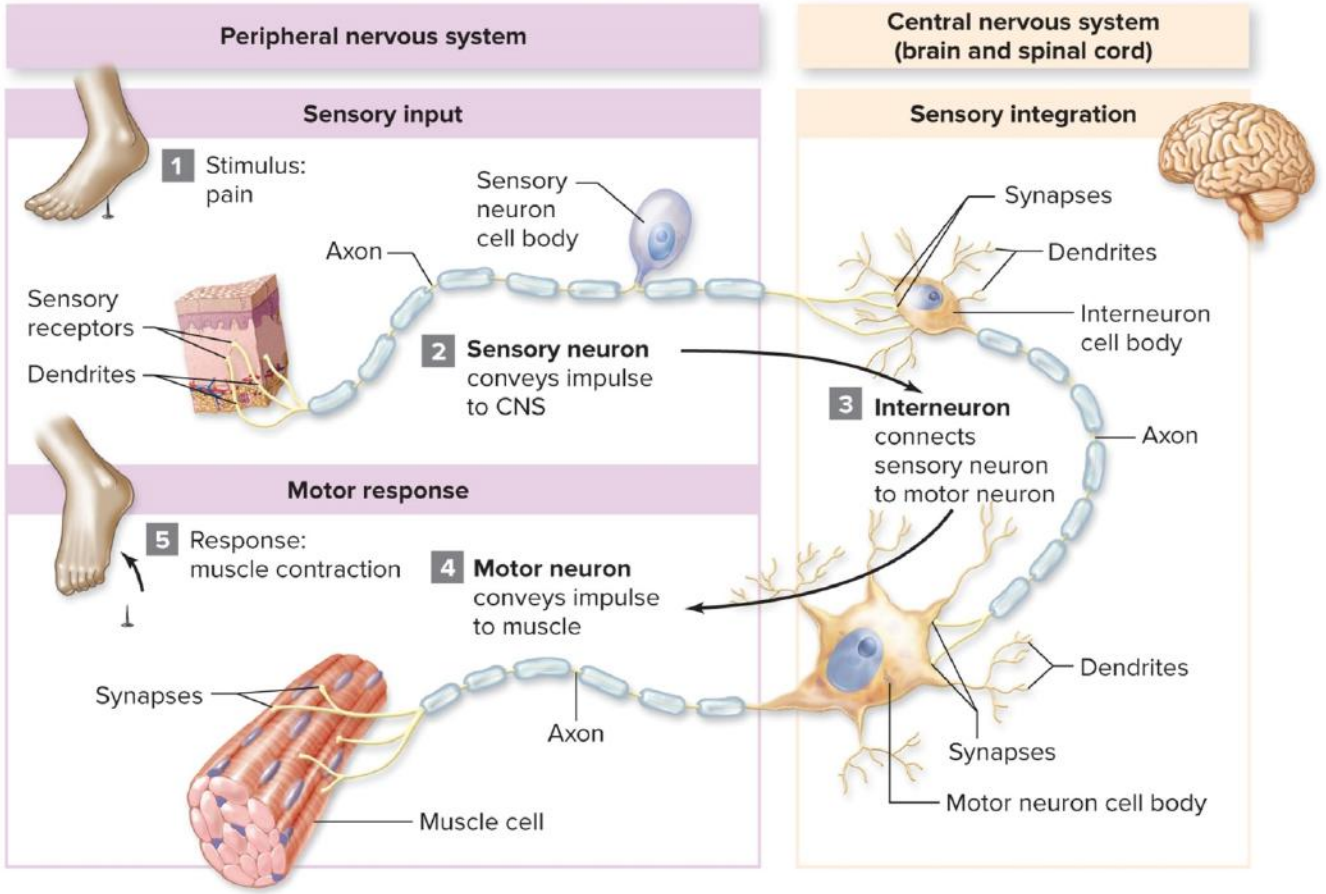
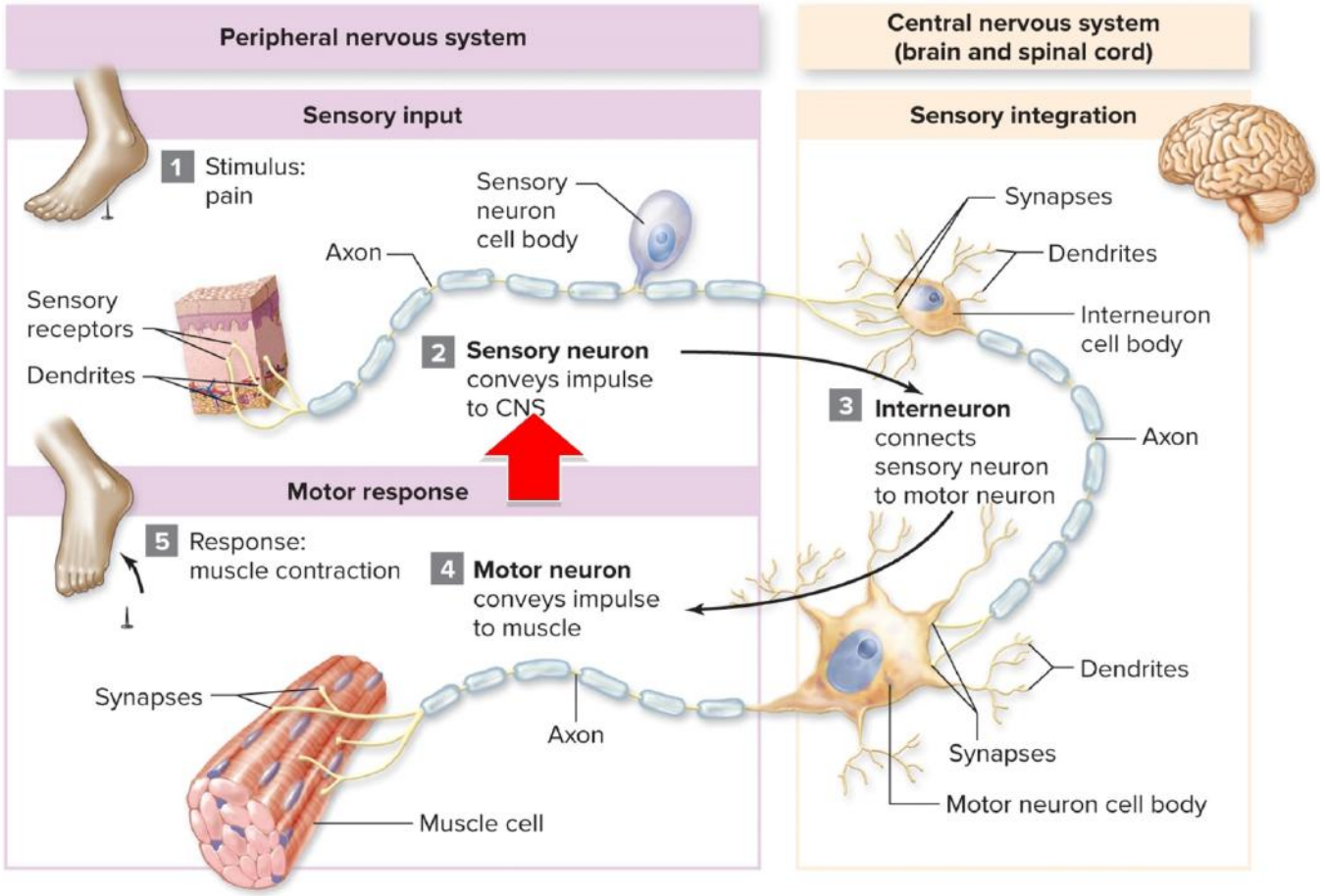


Figure 26.5

Sensory neurons

Sensory neurons bring information from the body's organs (such as heat, pain, taste, etc.) toward the central nervous system.

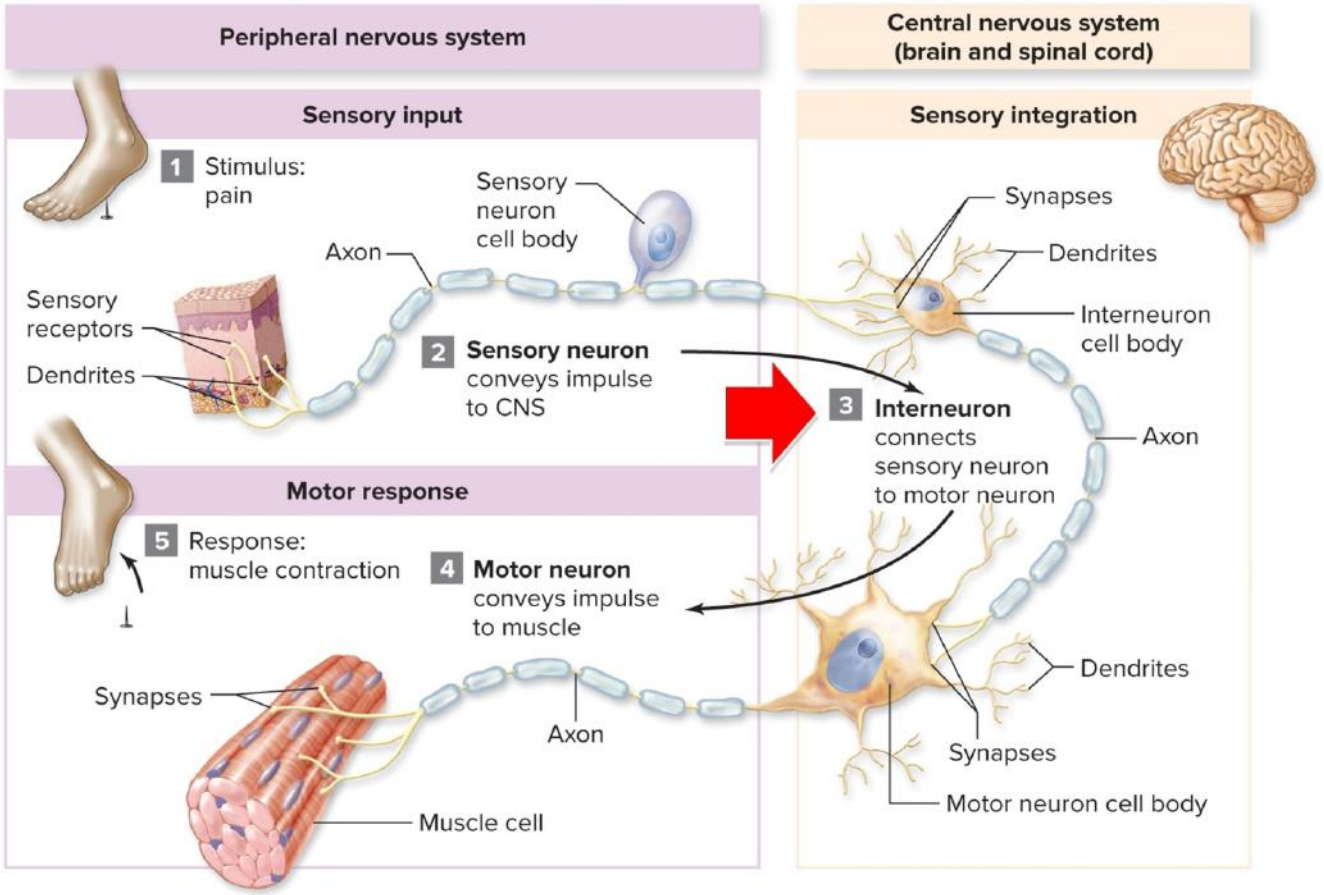


Section 26.2

Figure 26.5

Interneurons

Interneurons in the central nervous system receive signals from sensory neurons. The message is processed, and a signal is sent to a motor neuron.

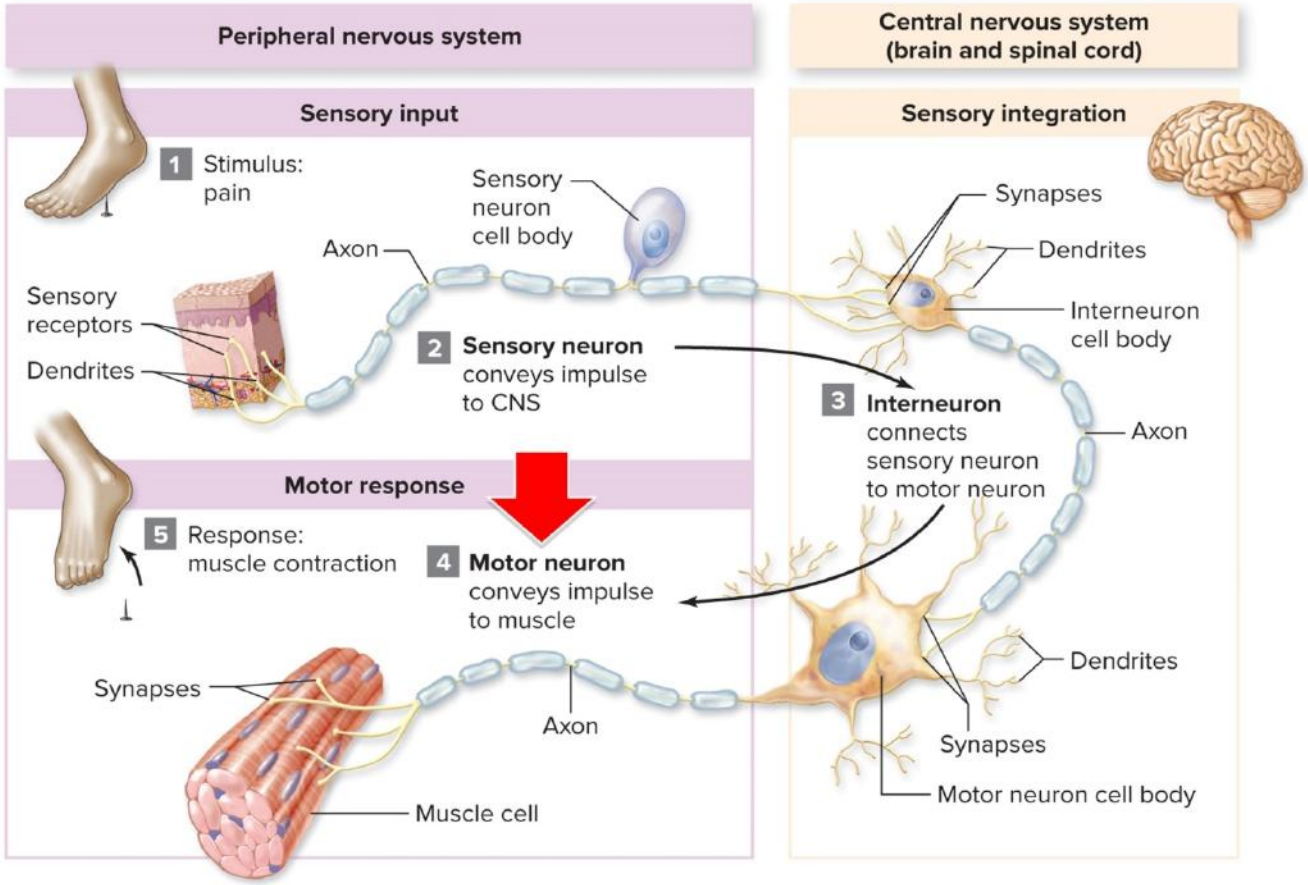


Section 26.2

Figure 26.5

Motor neurons

A **motor neuron** conducts a message from the central nervous system to a muscle or gland, stimulating contraction or secretion.



Section 26.2

Figure 26.5

Clicker question #1

In a typical neuron, the ___ receive(s) information and the ___ communicate(s) that information to a neighboring cell.

A. cell body; dendrites
B. dendrites; axon
C. axon; cell body
D. axon; dendrites
E. dendrites; cell body

Clicker question #1, solution

In a typical neuron, the ___ receive(s) information and the ___ communicate(s) that information to a neighboring cell.

B. dendrites; axon

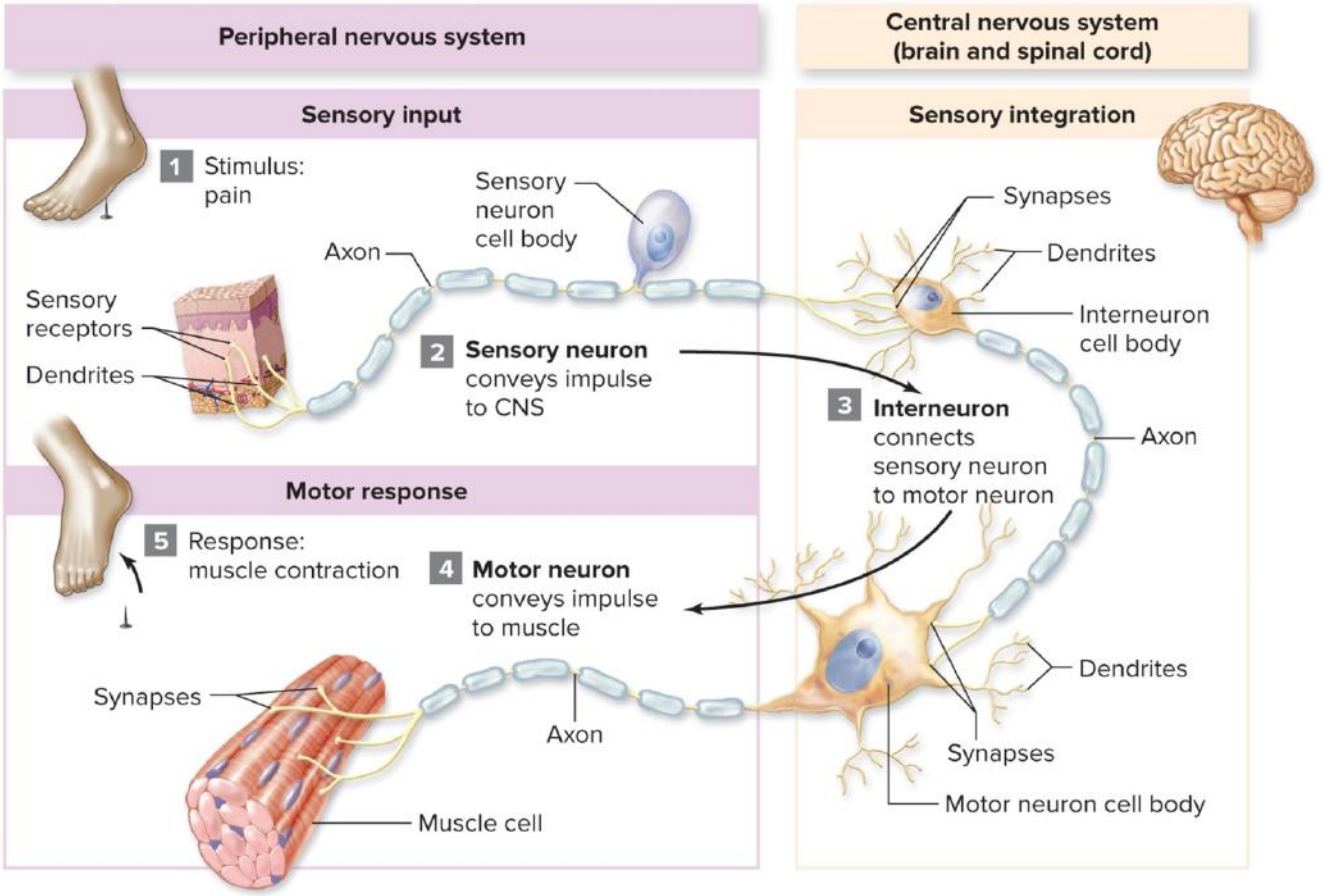
26.2 Mastering concepts

©Henrik Sorensen/Riser/Getty Images

What are the functions of each of the three classes of neurons?

Action potentials convey information

Each neuron in this network sends a message to the next cell. How is information carried through a neuron to its connection with another cell?

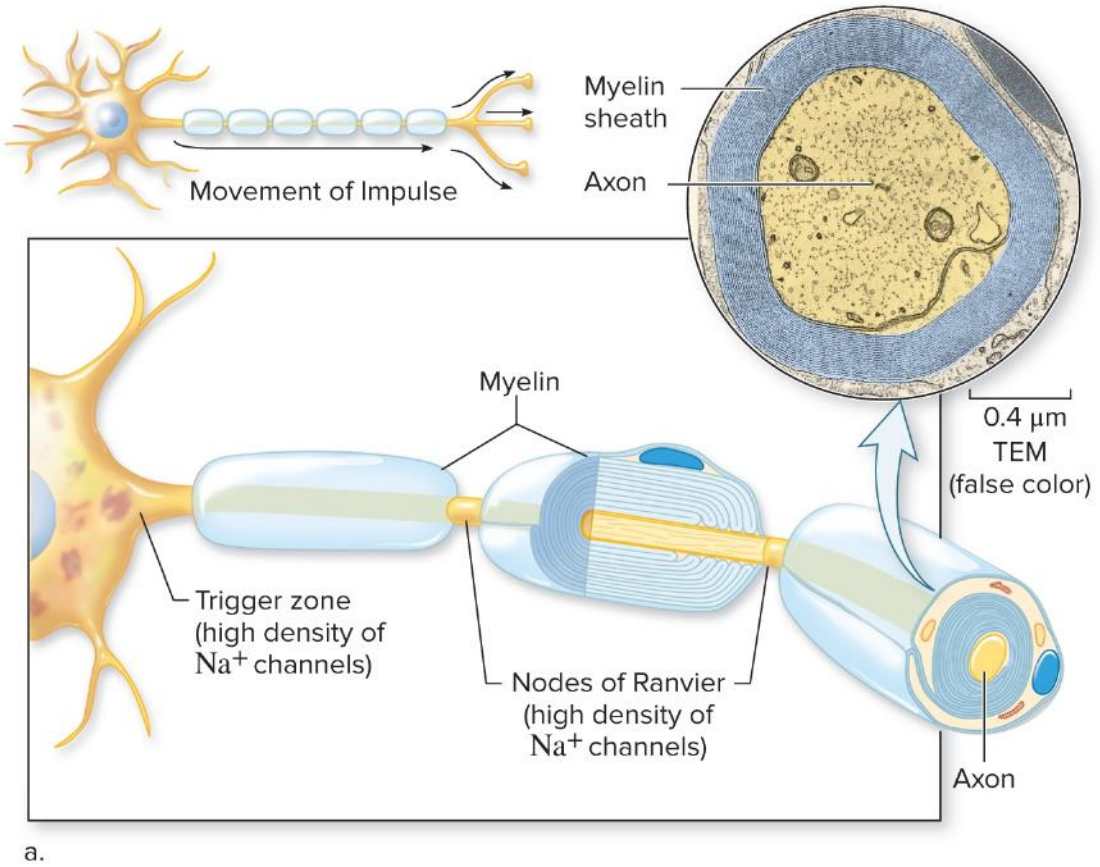


Section 26.3

Figure 26.5

Action potentials

The message is an electrical impulse called an **action potential**, which travels along a neuron's axon.



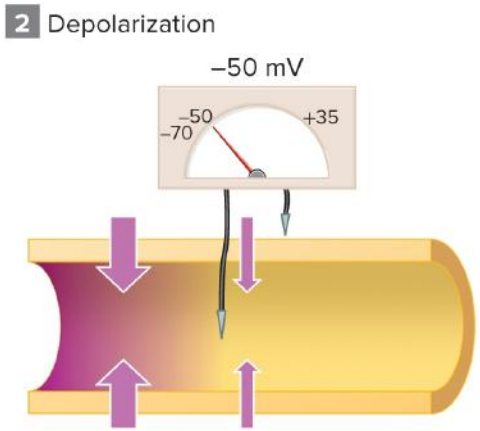
(a): ©Fawcett/Science Source

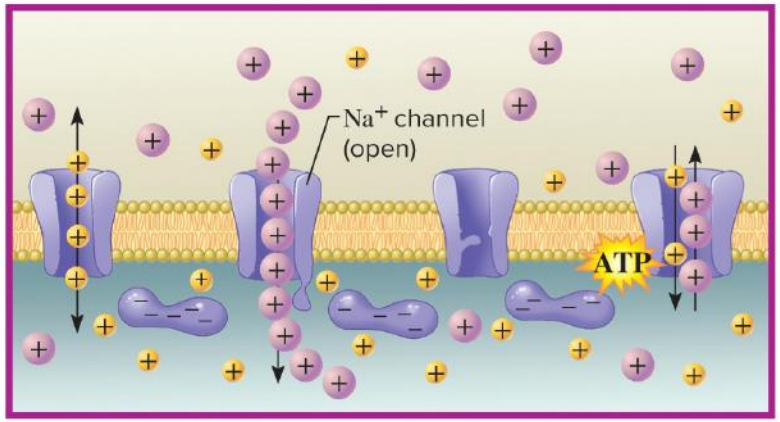
Section 26.3

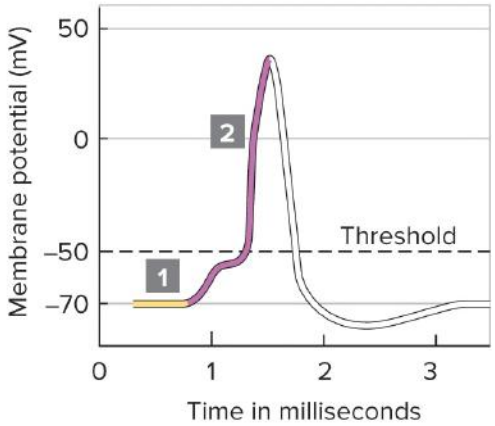
Figure 26.8

Action potentials and ions

Action potentials result from the movement of charged particles (ions) across the cell membrane.





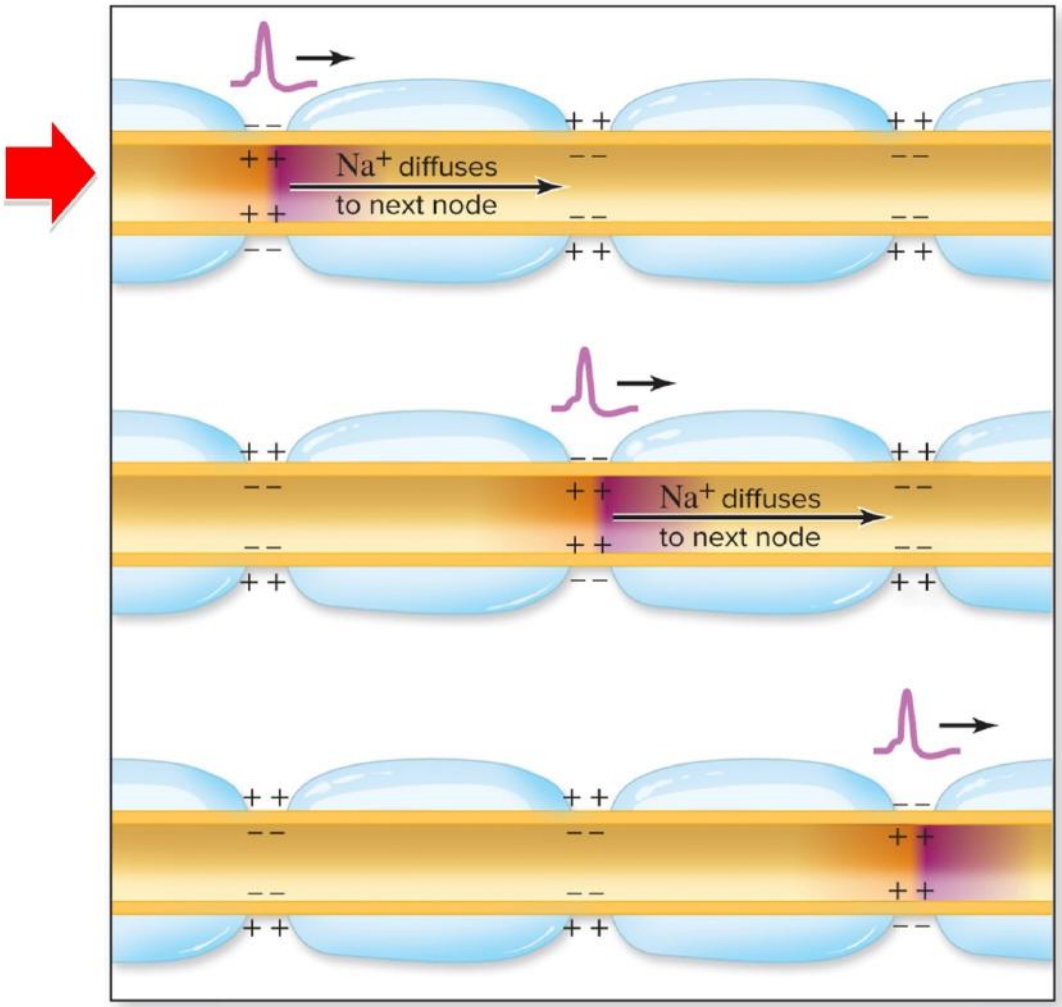


Section 26.3

Figure 26.6

Triggering an action potential

Action potentials are triggered by changes in other parts of the neuron.



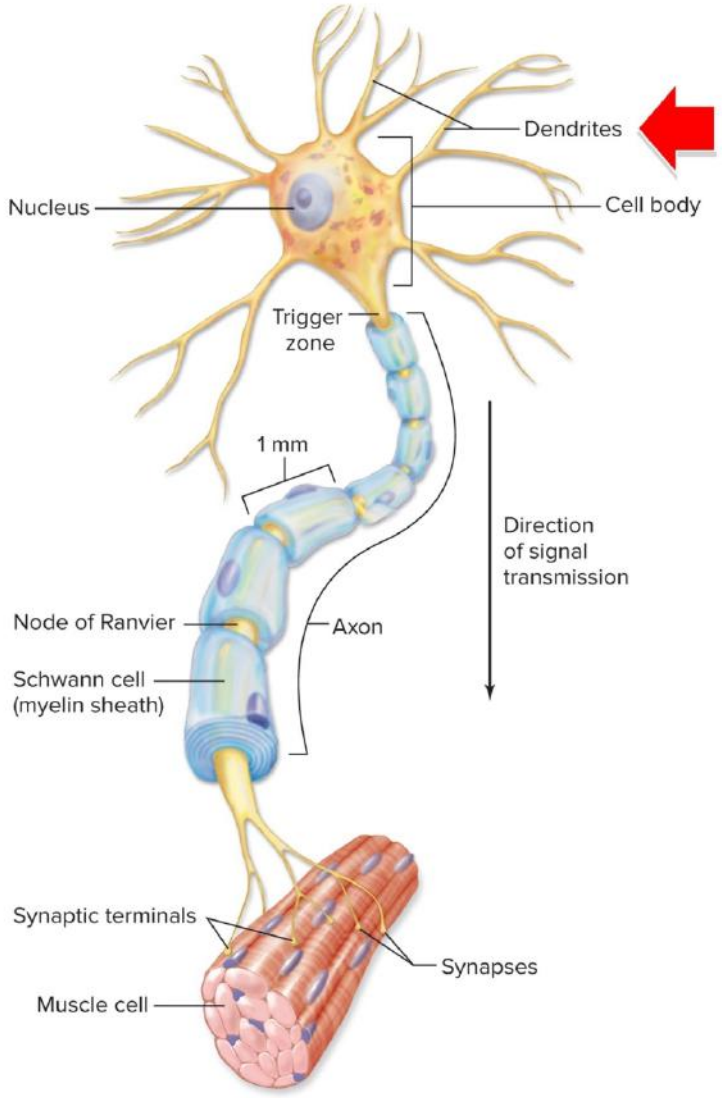
b.

Section 26.3

Figure 26.8

Dendrites receive and transmit information

A change in pH, a touch, or a signal from another neuron may cause some sodium channel gates in a neuron's membrane to open, usually at the dendrites or cell body.



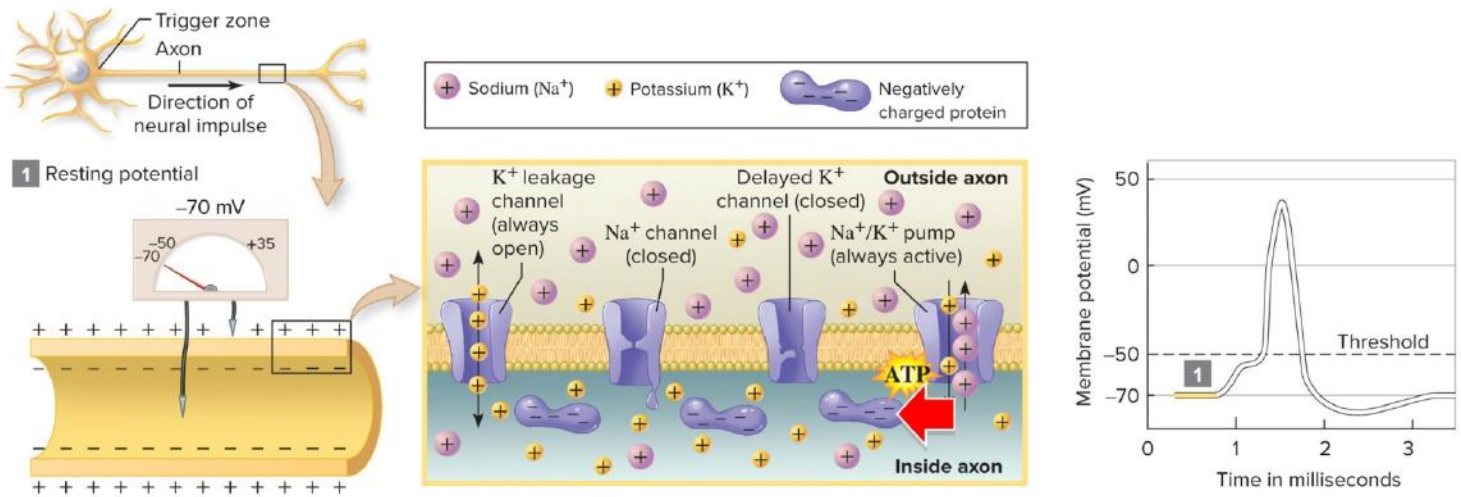
Section 26.3

Figure 26.4

Membrane potential

A small amount of Na^+ leaks into the cell through the open channels. These movements regulate the **membrane potential,** or charge difference across the membrane.

The resting membrane potential of a neuron is usually negative.

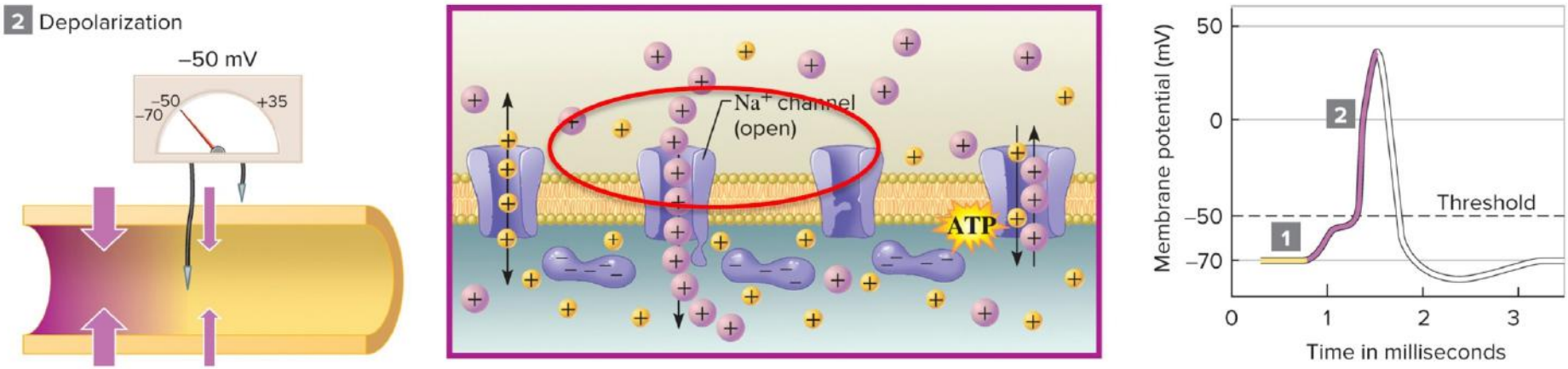


Section 26.3

Figure 26.6

Sodium ions change the membrane potential

Na^+ is a positive ion, so as it enters the cell, the interior becomes less negative.

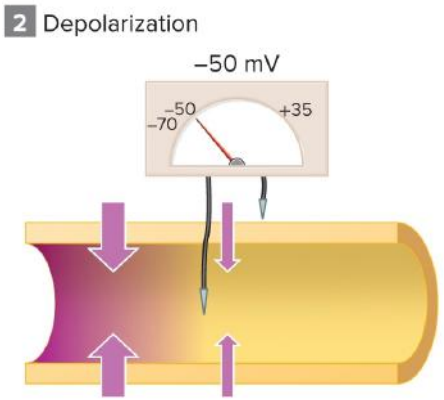


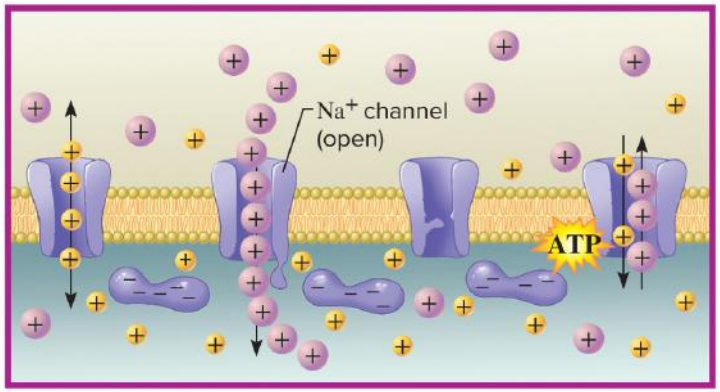
Section 26.3

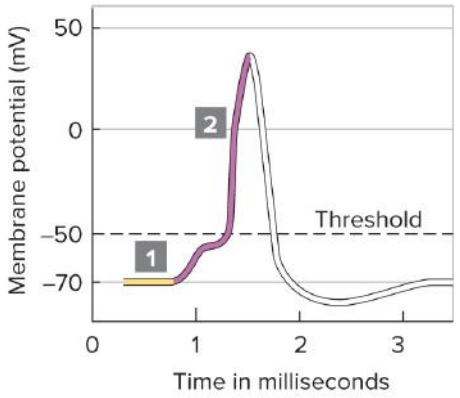
Figure 26.6

Graded potential

The electrical current caused by moving Na^+ ions shown here is called a **graded potential:** it weakens with distance from the source of the stimulus and its magnitude depends on the signal's strength.





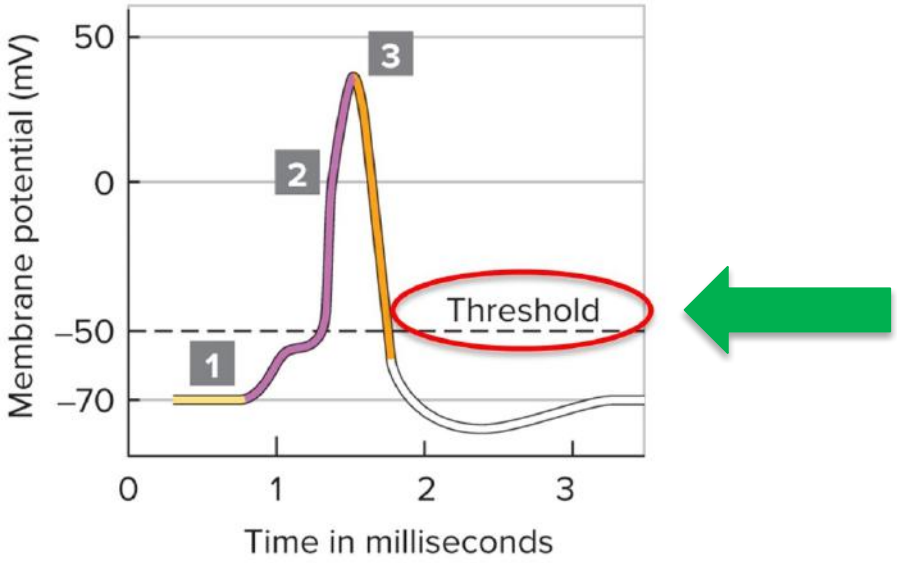


Section 26.3

Figure 26.6

Initiating an action potential

If the graded potential that reaches the axon is strong enough (green arrow), then an action potential will initiate.



Section 26.3

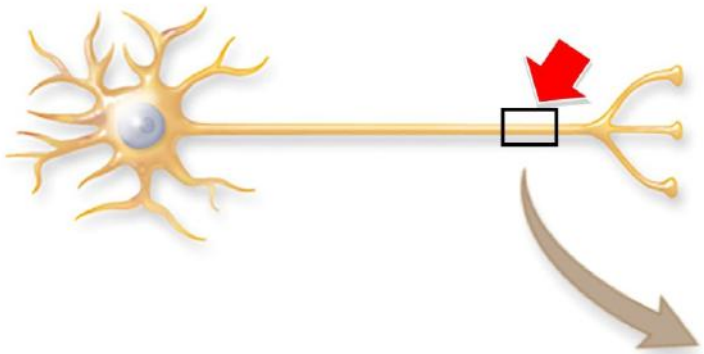
Figure 26.6

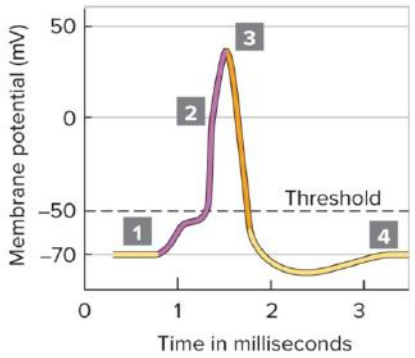
Action potentials: a closer look

Zooming in on a small patch of an axon's cell membrane reveals the events of an action potential.

Action potentials require changes in membrane potential

As an action potential passes this patch of axon, ions move in and then out, causing the charge in the axon to change.



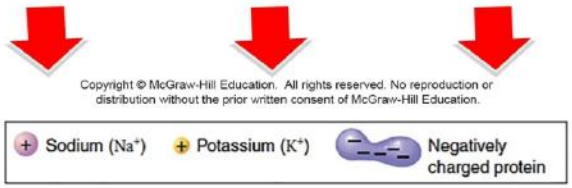


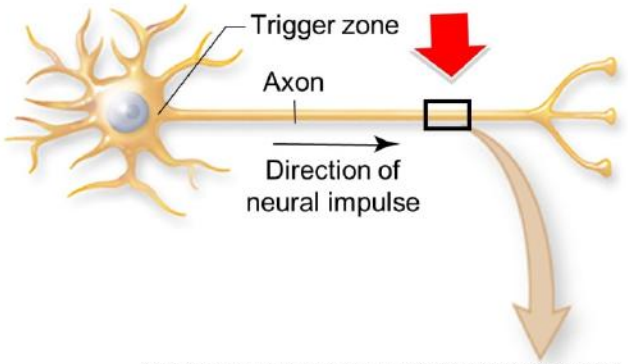
Section 26.3

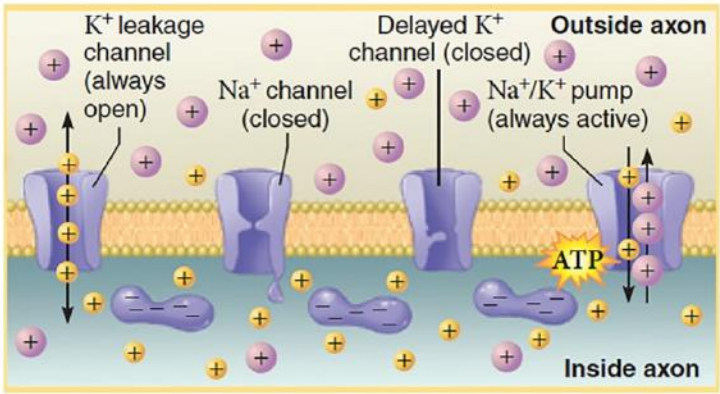
Figure 26.6

Establishing action potentials: resting potential

Notice that sodium (Na^+) and potassium (K^+) ions are distributed near the axon membrane.
Also, the inside of the axon has negatively charged proteins.





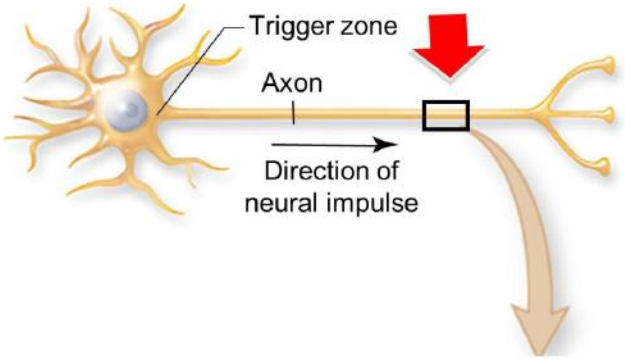


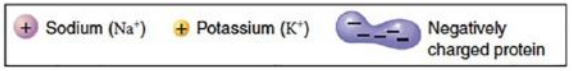
Section 26.3

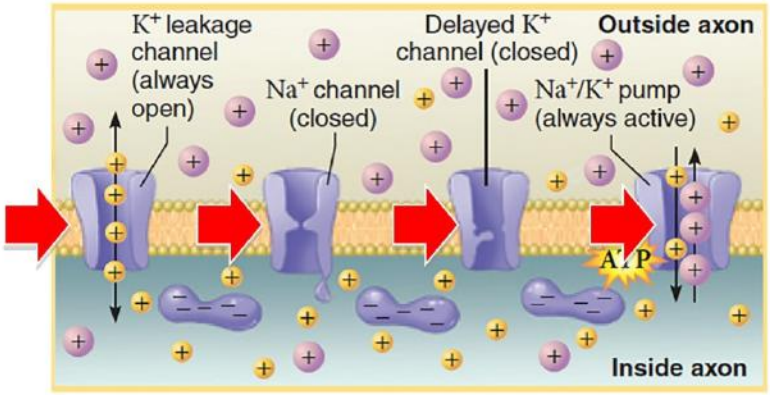
Figure 26.6

Membrane potential is regulated by the movement of ions

Na^+ and K^+ move in and out through channels in the axon membrane.





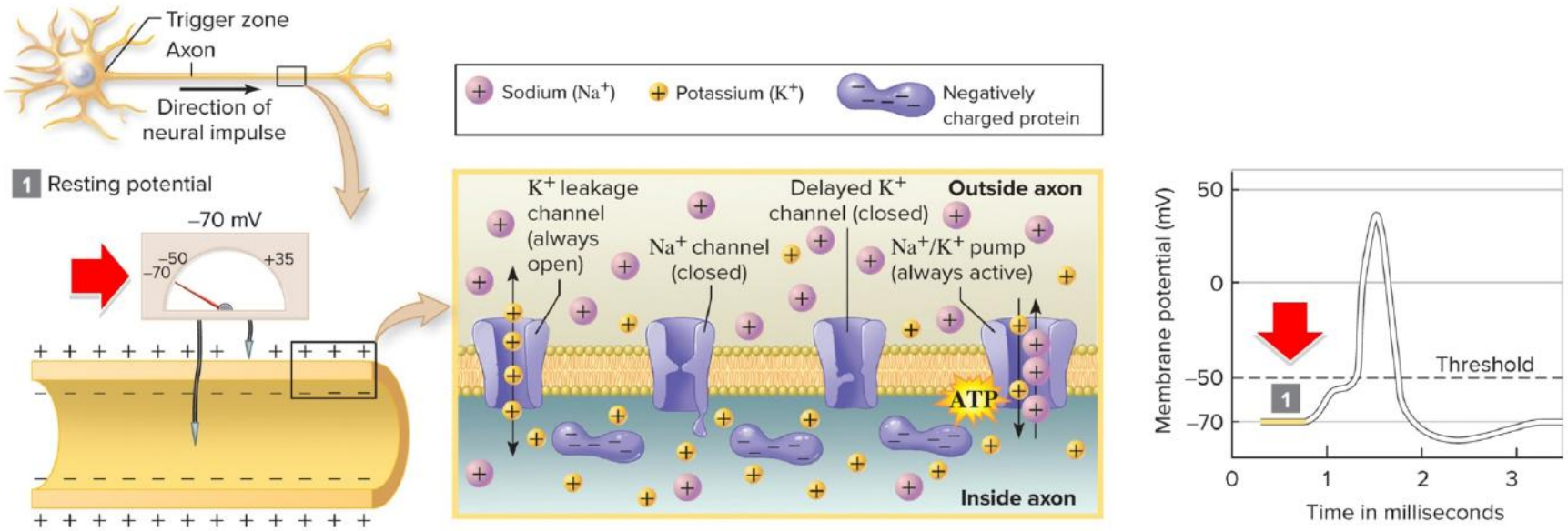


Section 26.3

Figure 26.6

Resting potential: -70mv

When not conducting a neural impulse, an axon maintains its **resting potential.** The axon's interior is negatively charged relative to the outside.

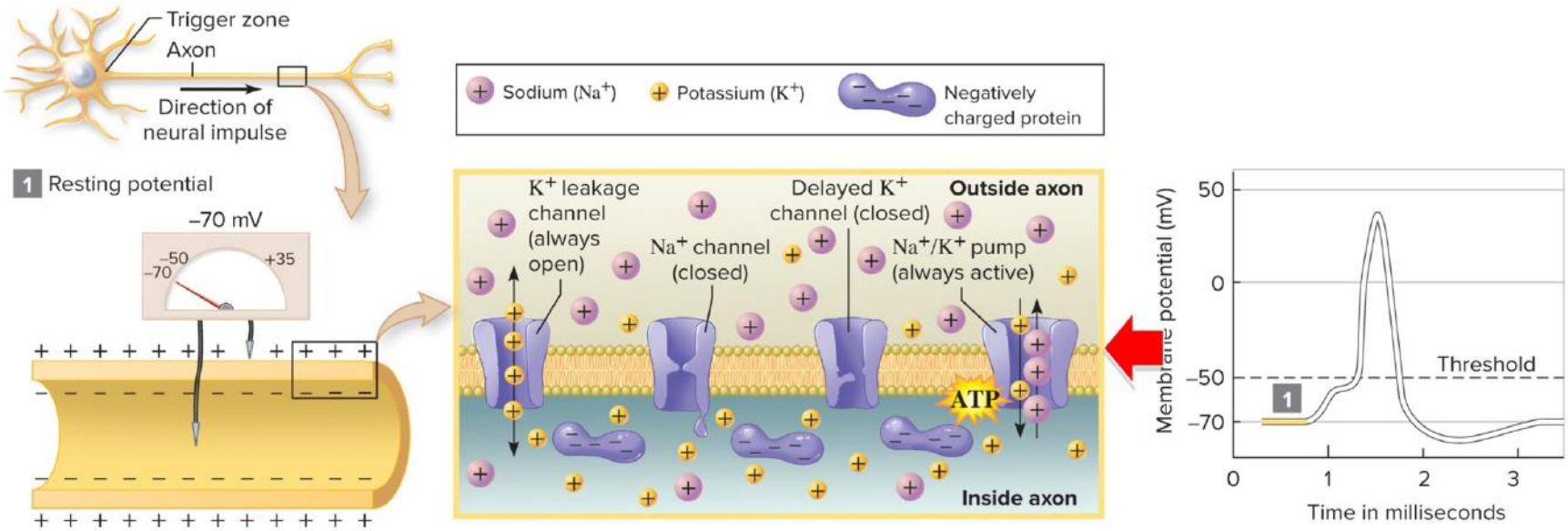


Section 26.3

Figure 26.6

Sodium-potassium pumps

This charge difference results from the action of many **sodium-potassium pumps**, which use ATP to send three Na^+ ions out of the cell for every two K^+ ions they let in.

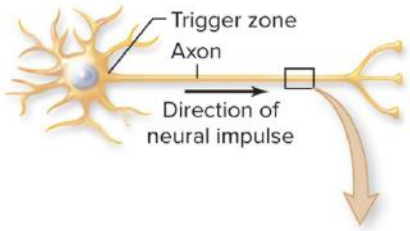


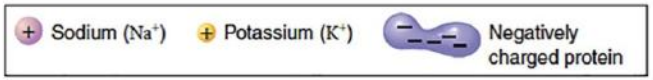
Section 26.3

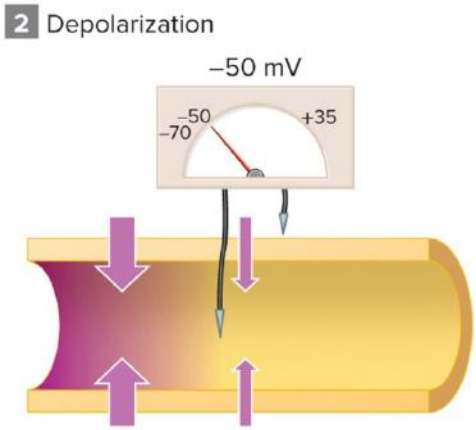
Figure 26.6

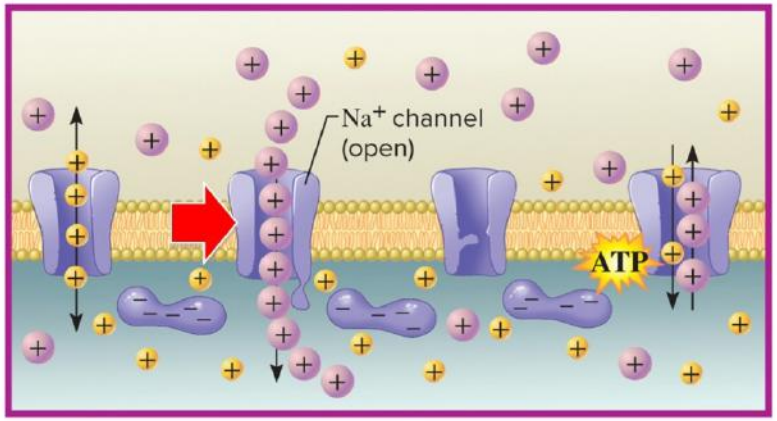
An action potential begins

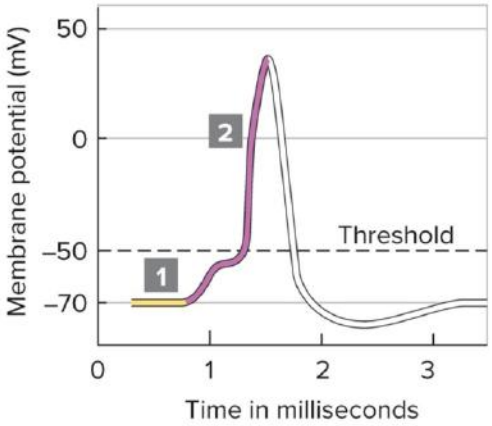
When a graded potential reaches an axon, a few sodium channels open, allowing sodium ions to trickle into the axon.









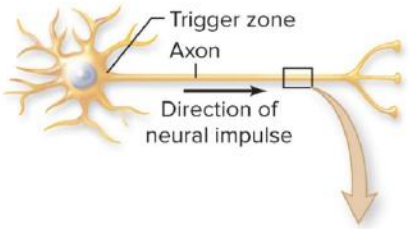


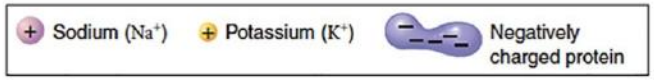
Section 26.3

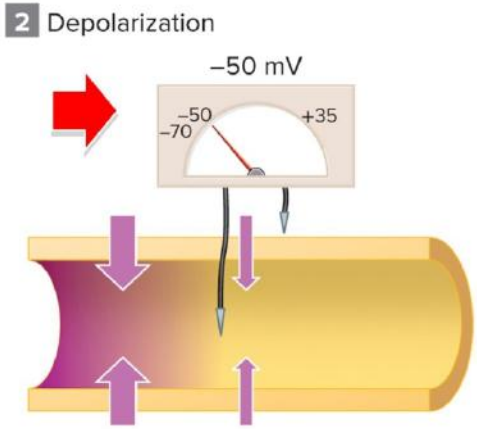
Figure 26.6

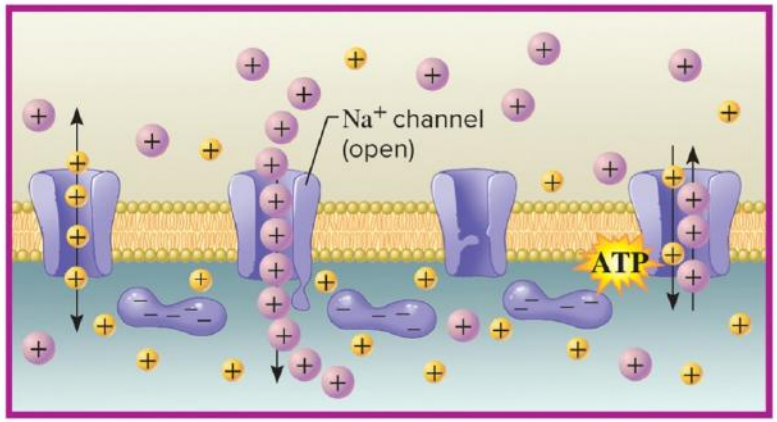
Threshold: -50mv

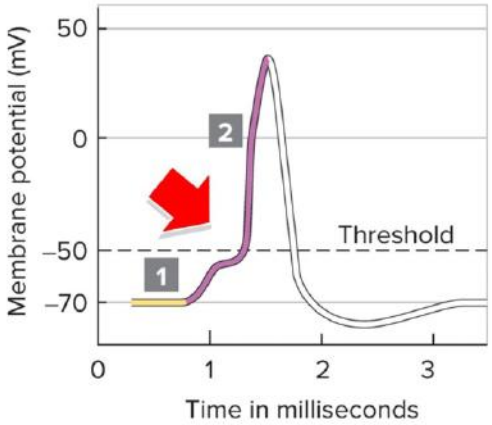
These positively charged ions make the interior of the axon less negative near the membrane, a process called depolarization.









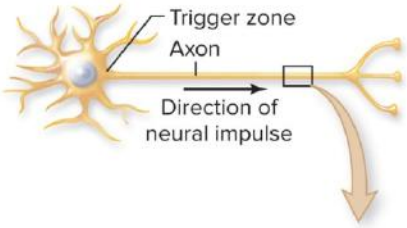


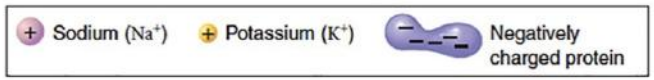
Section 26.3

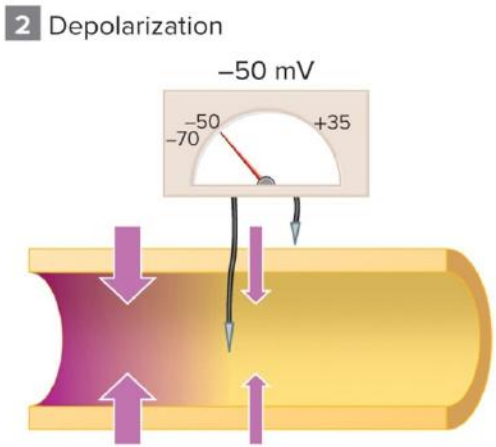
Figure 26.6

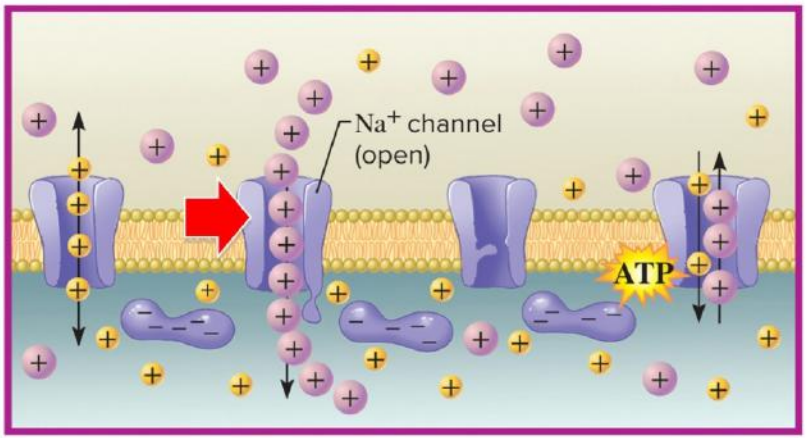
At threshold, more sodium channels open

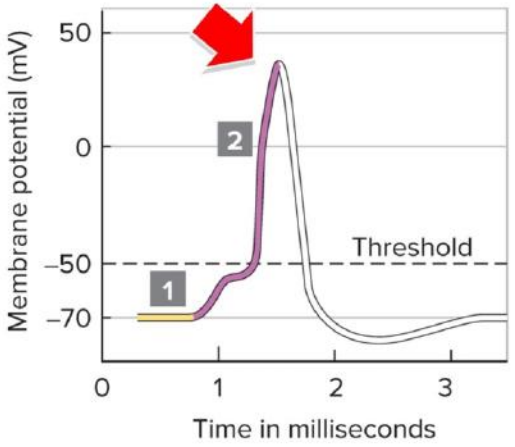
If the membrane reaches **threshold potential,** more sodium channels open. Na^+ pours into the cell, driving the membrane potential higher.









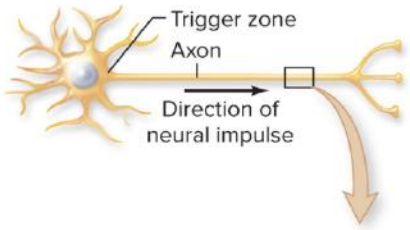


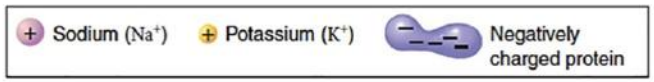
Section 26.3

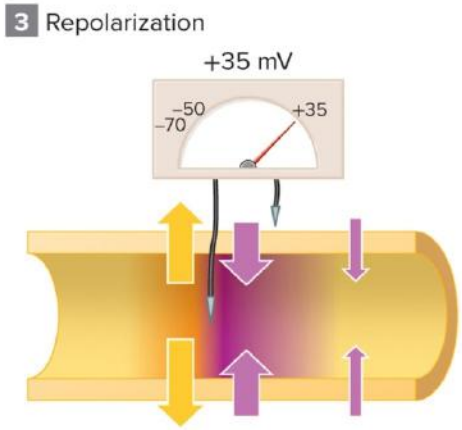
Figure 26.6

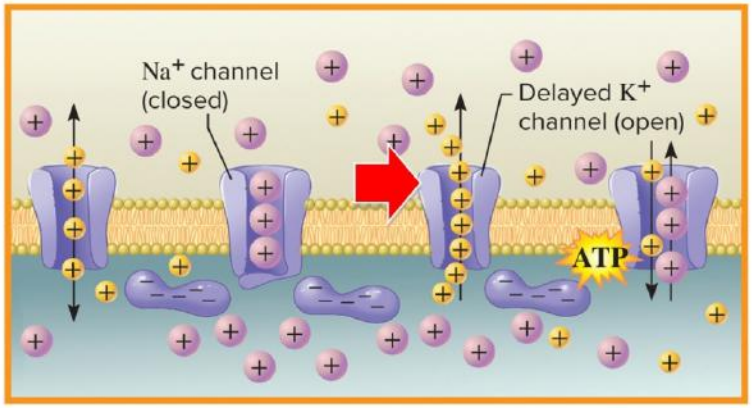
Peak depolarization: +35mv

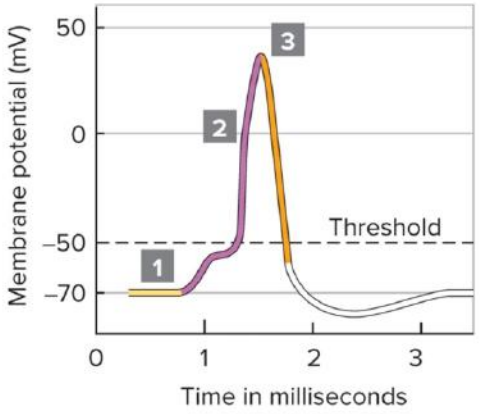
Peak depolarization is achieved at +35mv.
A split second after sodium ions flow into the axon, potassium ions exit. Sodium ion channels are now closed.









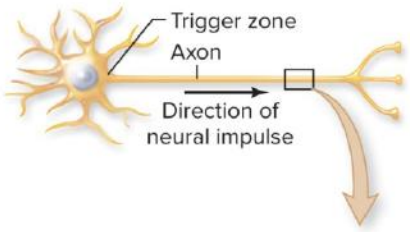


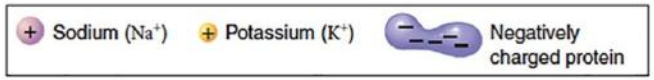
Section 26.3

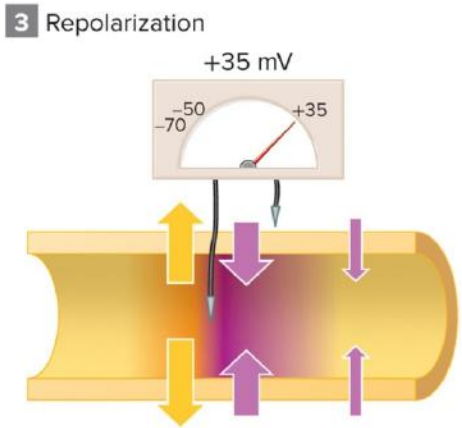
Figure 26.6

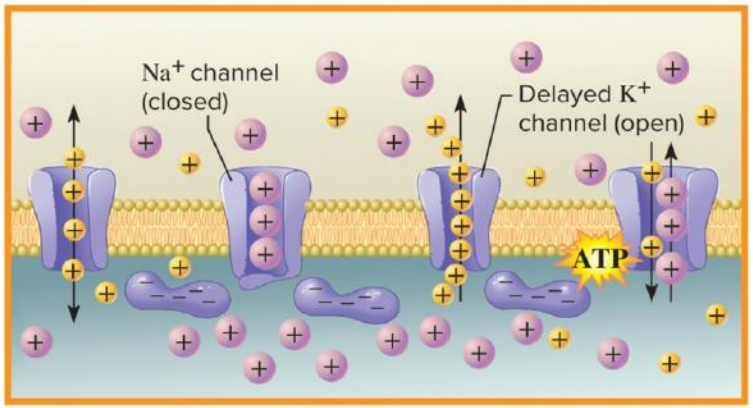
Repolarization

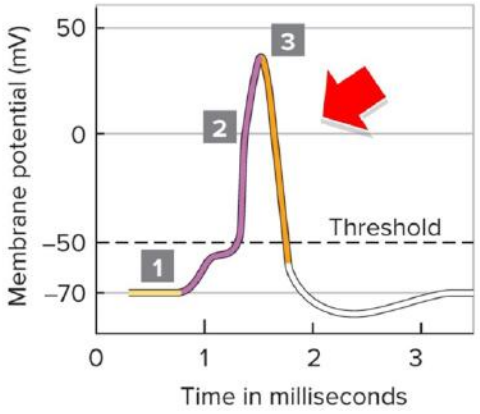
K^+ ions leaving the cell cause the membrane potential to drop; this process is called repolarization.









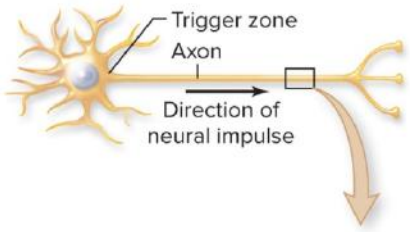


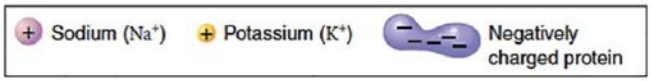
Section 26.3

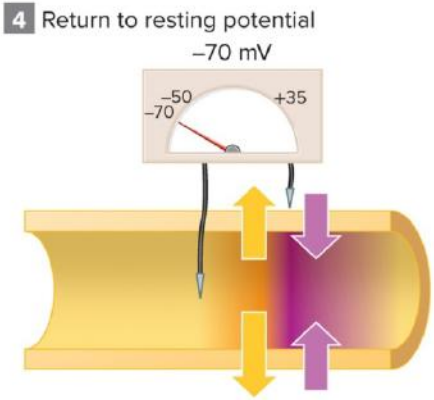
Figure 26.6

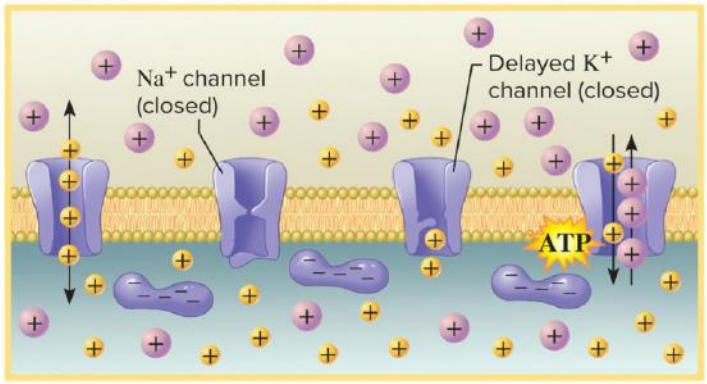
Hyperpolarization

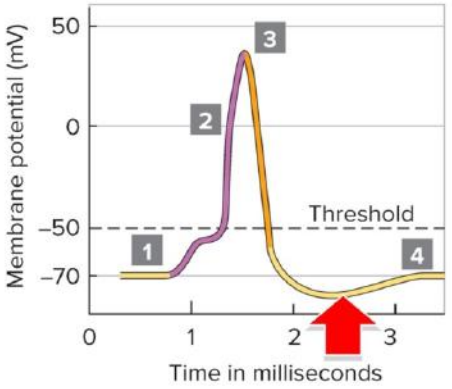
During hyperpolarization, the membrane temporarily dips below resting potential, until the sodium-potassium pumps reestablish it.









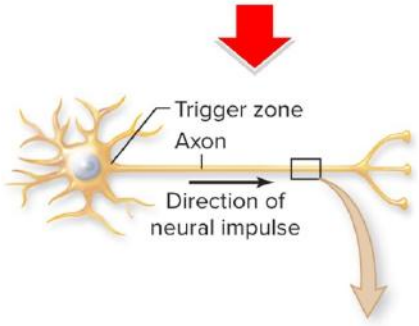


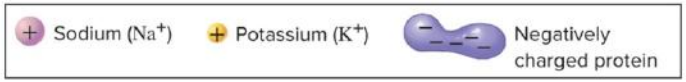
Section 26.3

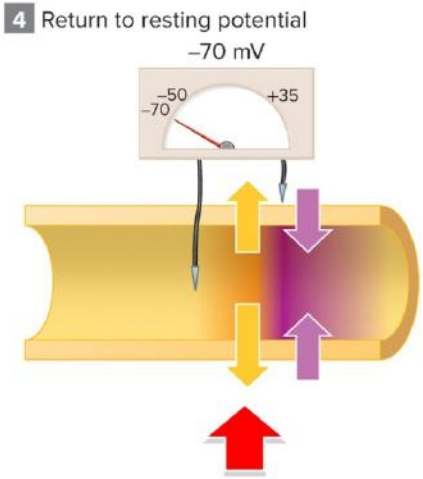
Figure 26.6

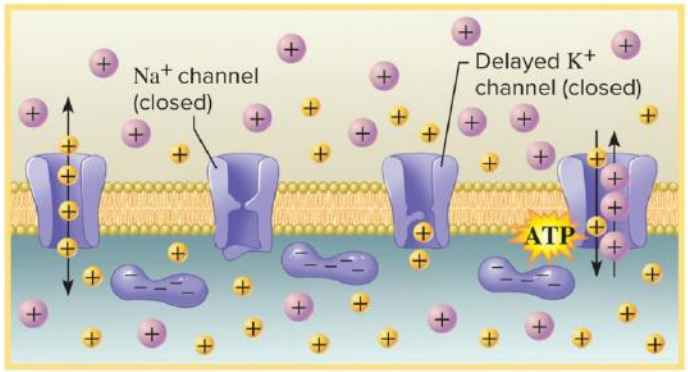
One action potential triggers the next

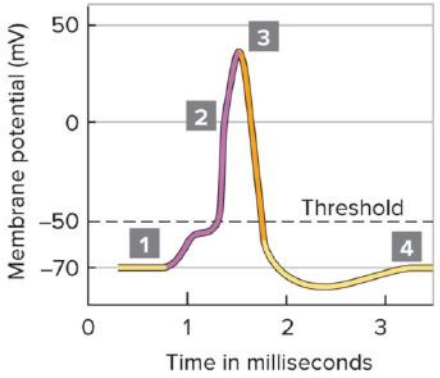
The wave of ion movements progresses to the next patch of membrane and continues to the end of the axon.









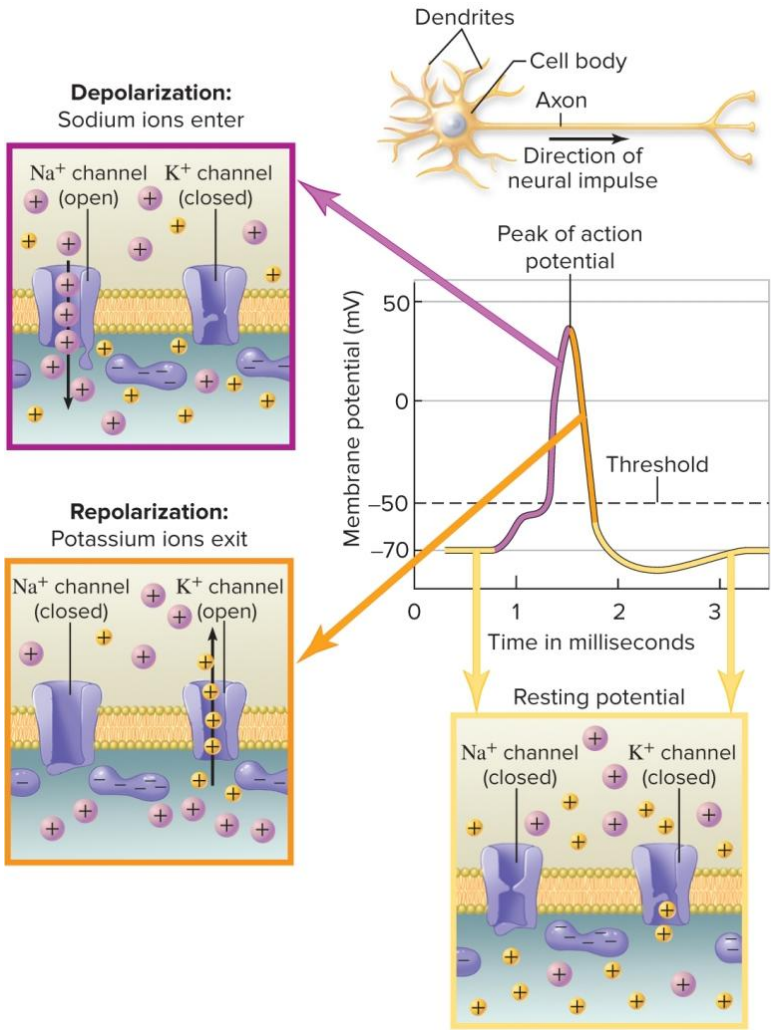


Section 26.3

Figure 26.6

Action potentials are fast

The entire process, from the initial influx of Na^+ to the restoration of resting potential, takes only a few milliseconds.

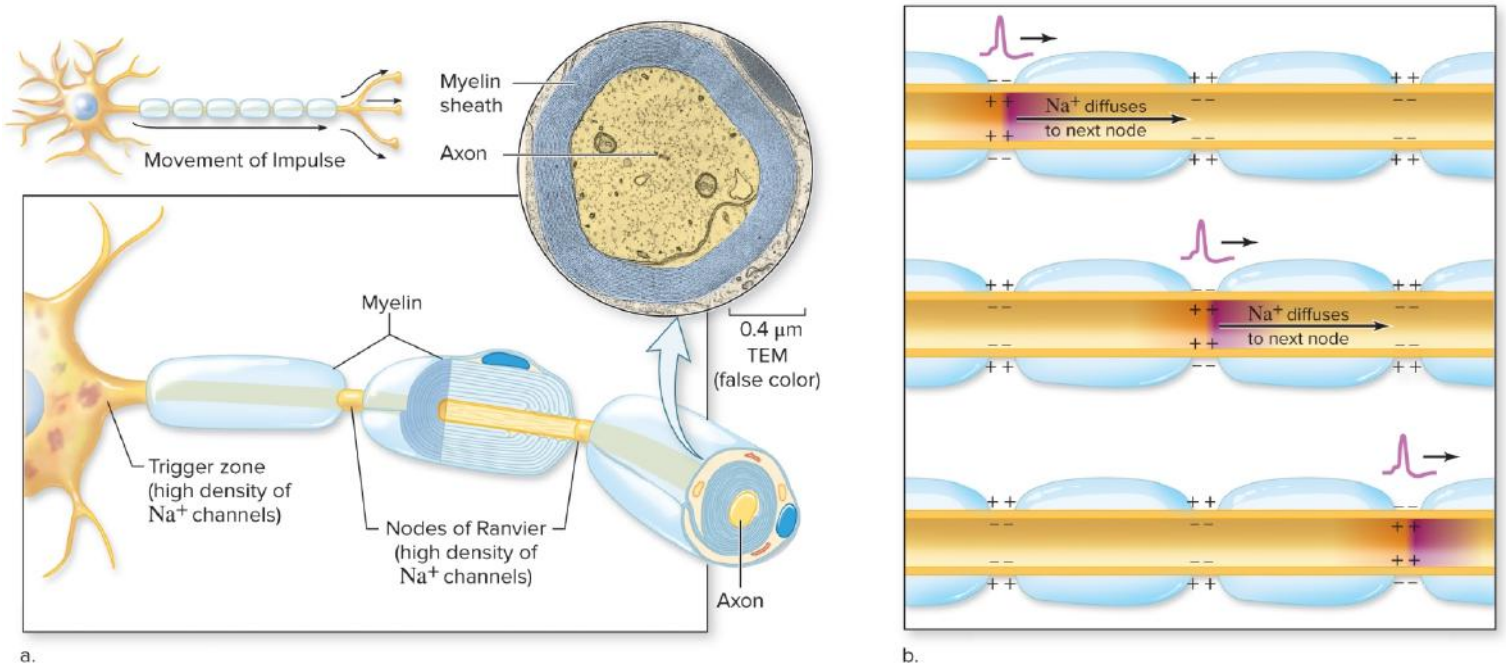


Section 26.3

Figure 26.23

Myelinated vs. unmyelinated axons

Myelinated axons conduct impulses more quickly than unmyelinated axons.



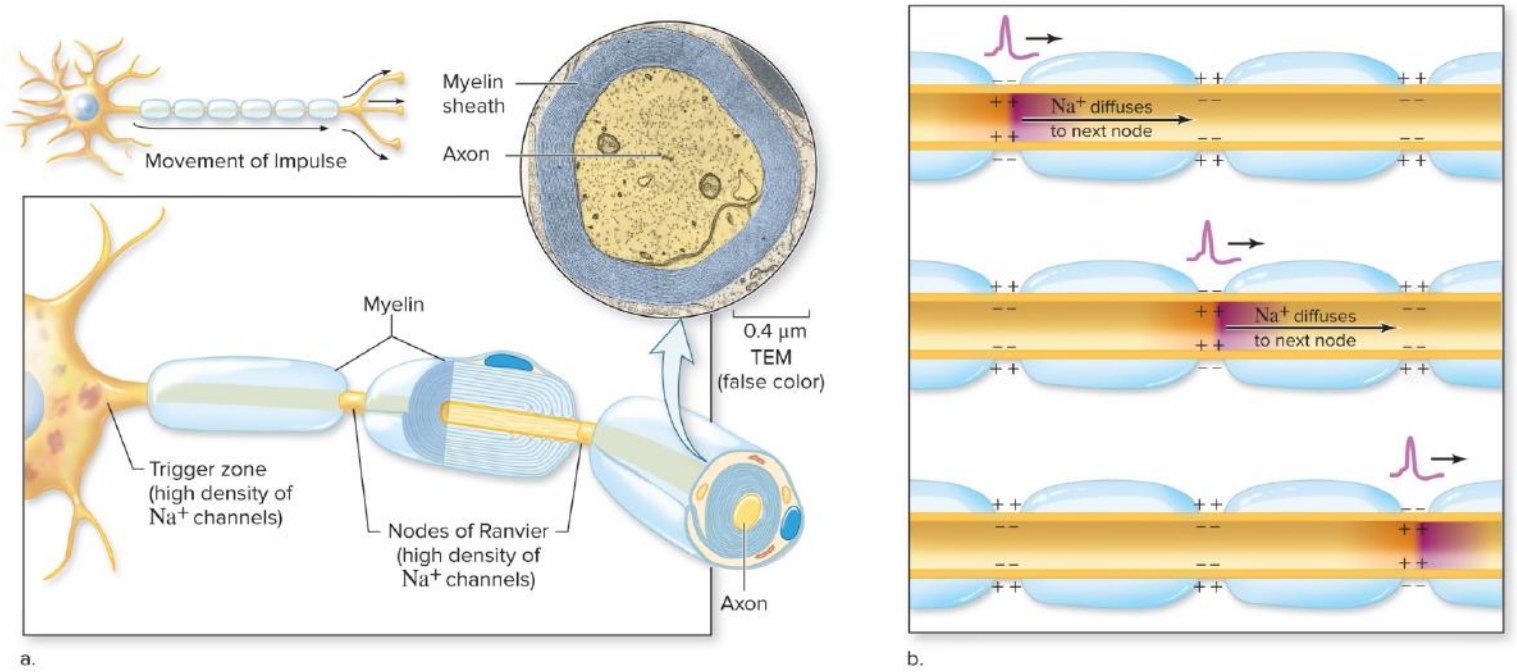
(a): ©Fawcett/Science Source

Section 26.3

Figure 26.8

There are gaps between myelin

Ion channels are concentrated
in the gaps between myelin.



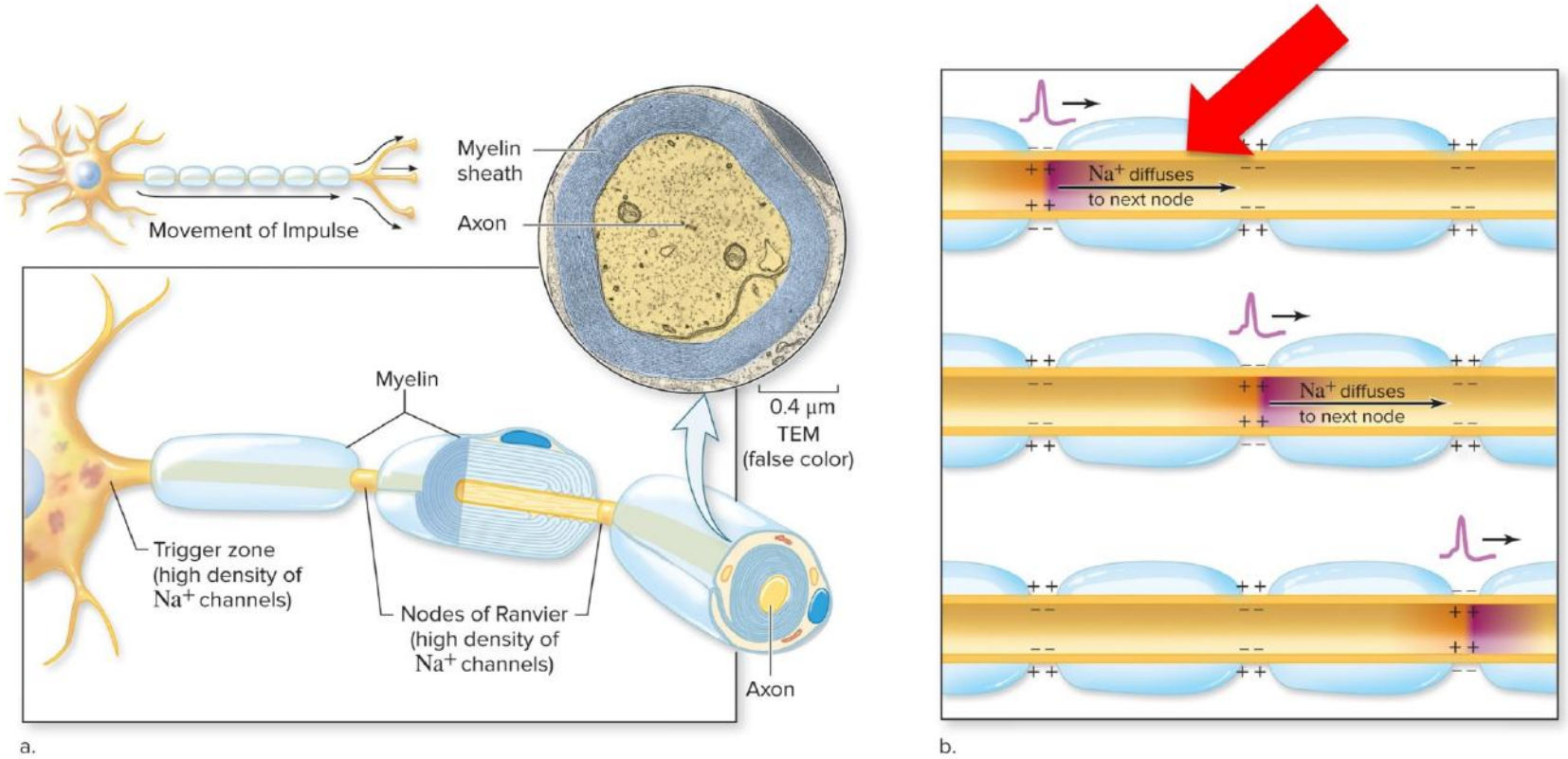
(a): ©Fawcett/Science Source

Section 26.3

Figure 26.8

Action potentials move from gap to gap

Some of the sodium ions flooding in at one gap diffuse to the next gap, cueing additional ion channels to open. The action potential therefore seems to jump from one gap to the next.



(a): ©Fawcett/Science Source

Section 26.3

Figure 26.8

Clicker question #2

In several neurological diseases, axons lose their insulating myelin sheath. What is the consequence of this loss?

A. Nerve cells lose too much heat.
B. Nerve cells retain too much heat.
C. Action potential transmission slows down.
D. Action potential transmission speeds up.

Clicker question #2, solution

In several neurological diseases, axons lose their insulating myelin sheath. What is the consequence of this loss?

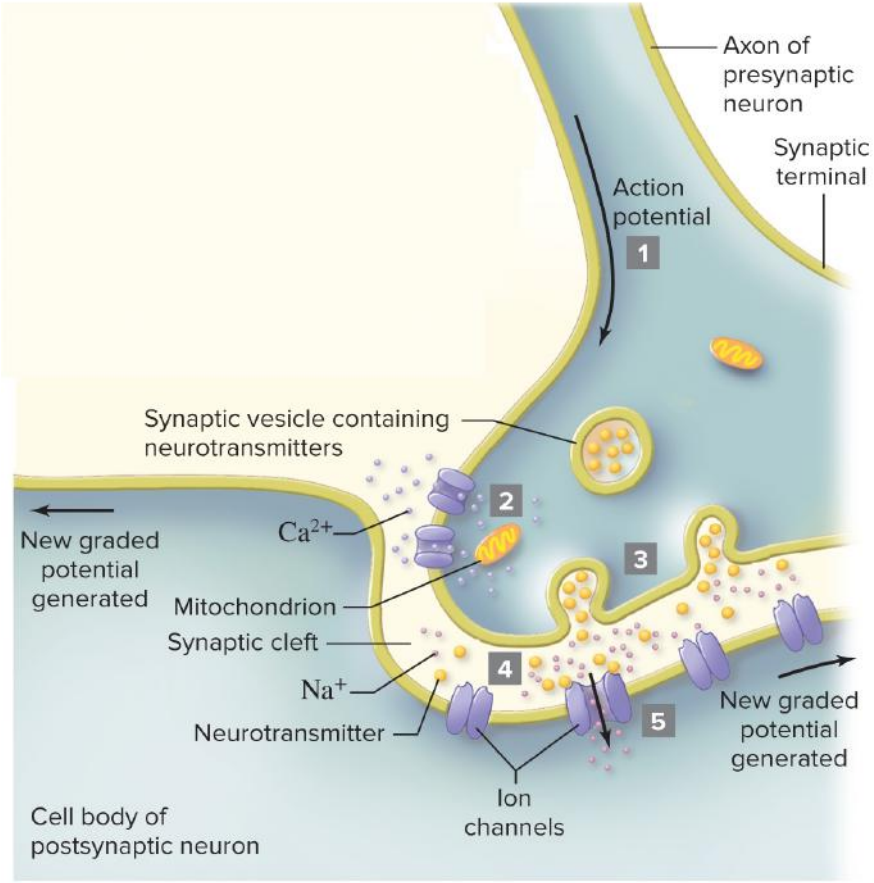
C. Action potential transmission slows down.

26.3 Mastering concepts

©Henrik Sorensen/Riser/Getty Images

How does an axon generate and transmit a neural impulse?

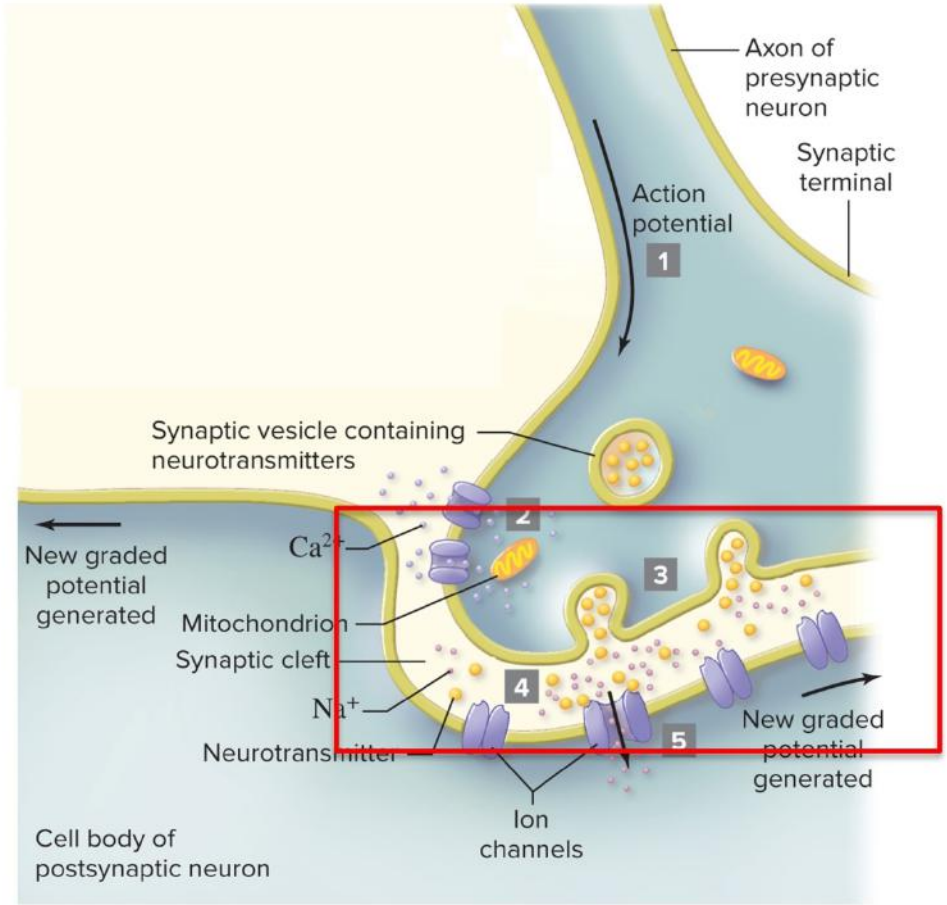
Messages move from cell to cell



We've seen how impulses travel along one axon. How do these impulses translate into messages conveyed to other cells?

Figure 26.9

Synapses, 2



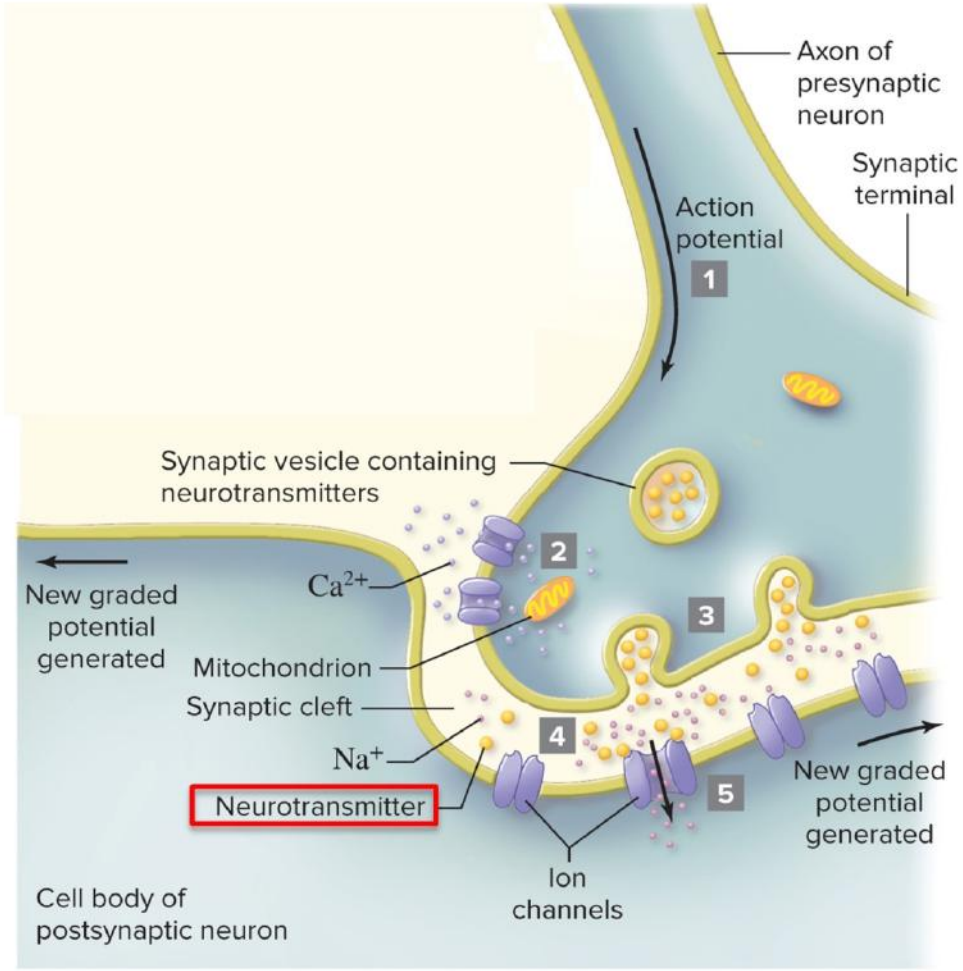
Synapse

This communication occurs at a **synapse**, a junction between a neuron and another cell.

Section 26.4

Figure 26.9

Neurotransmitters cross the synapse, 1



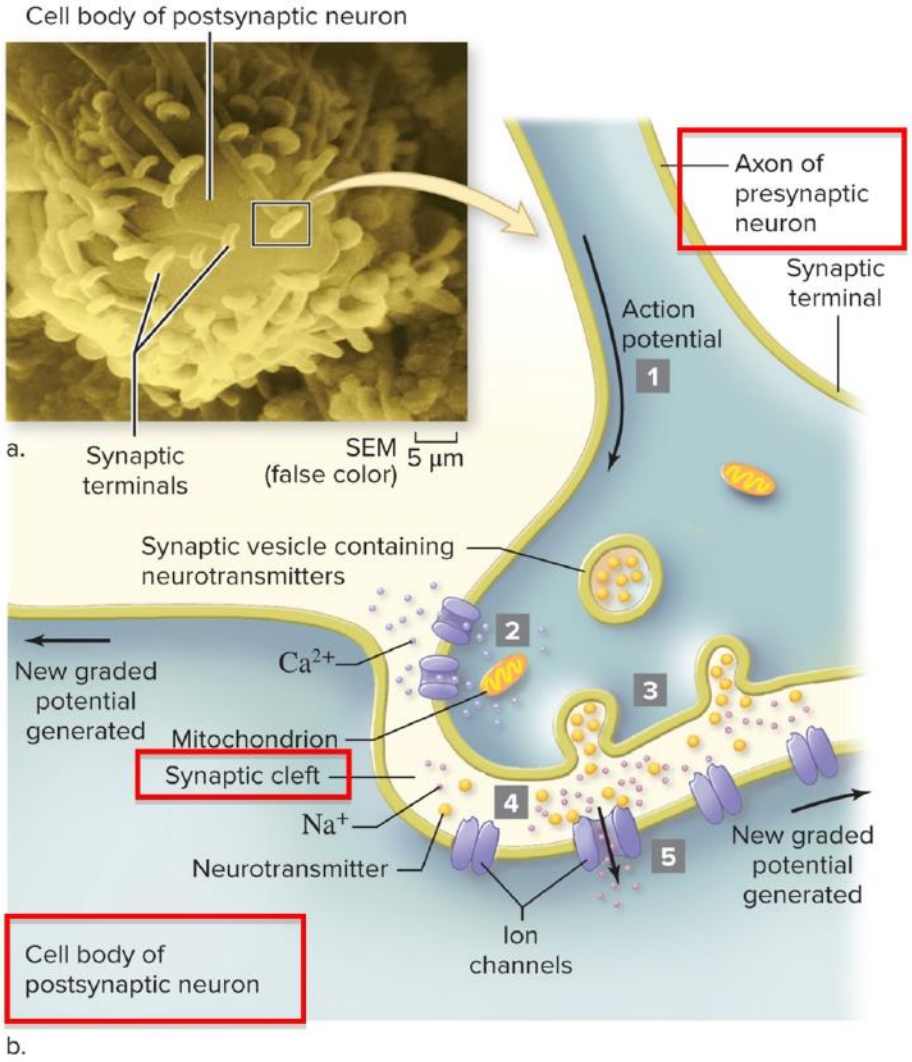
Molecules called **neurotransmitters** travel across synapses.

Section 26.4

Figure 26.9

The parts of a synapse

The synapse includes a **presynaptic cell**, a **synaptic cleft**, and a **postsynaptic cell** (which could be a neuron, muscle cell, or gland cell).

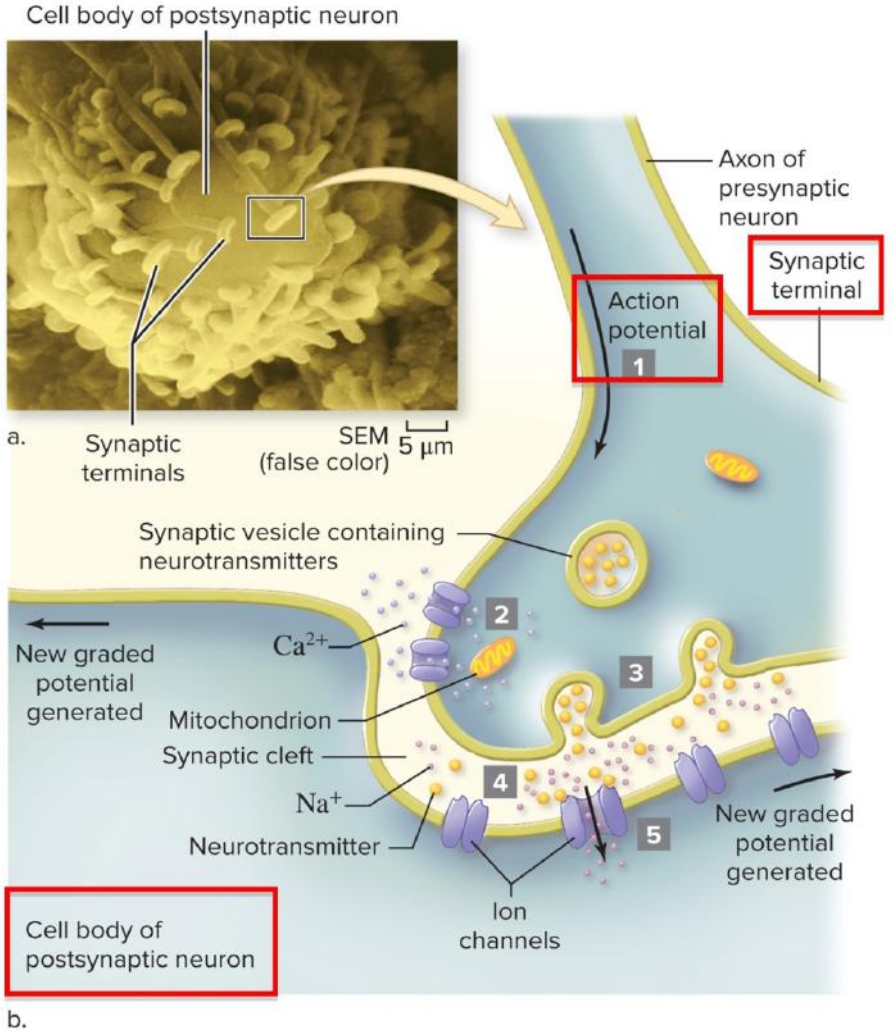


ER Lewis, YY Zeevi and TE Everhart

The synaptic terminal

The end of the presynaptic neuron's axon is the **synaptic terminal.**

This figure shows how an action potential reaching the synaptic terminal initiates communication with the receiving cell.



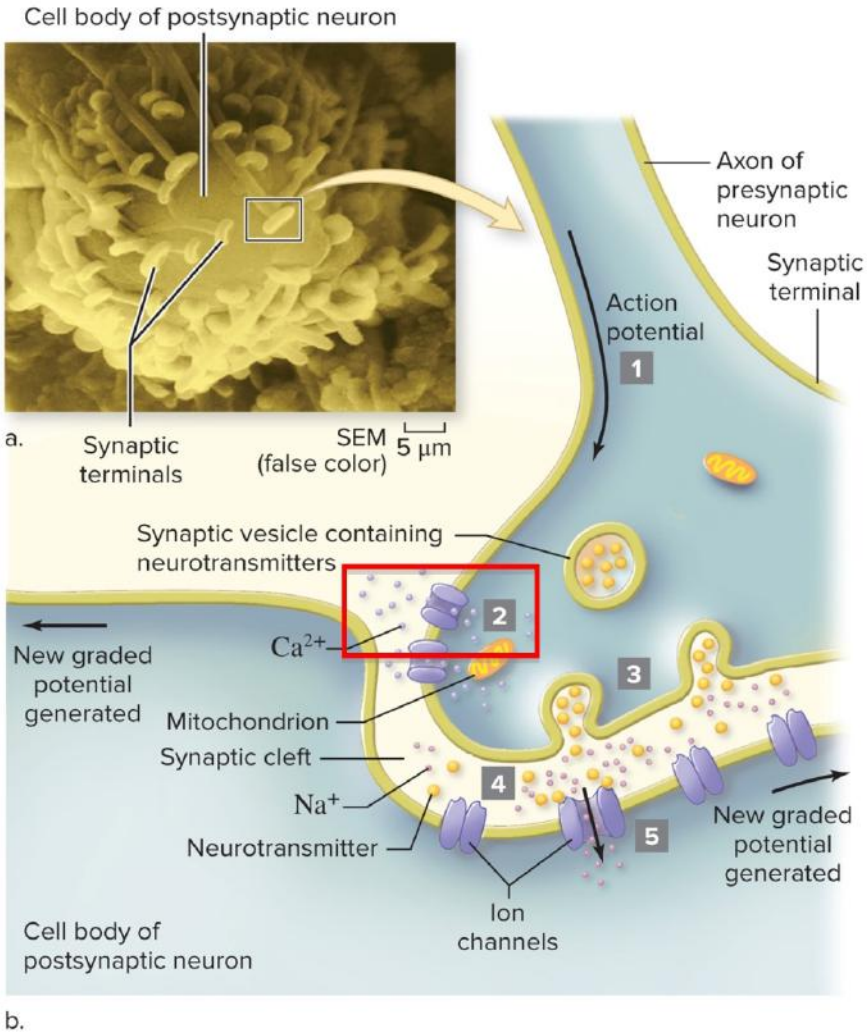
ER Lewis, YY Zeevi and TE Everhart

Section 26.4

Figure 26.9

The synaptic terminal has calcium channels

Action potentials cause calcium channels in the synaptic terminal to open.



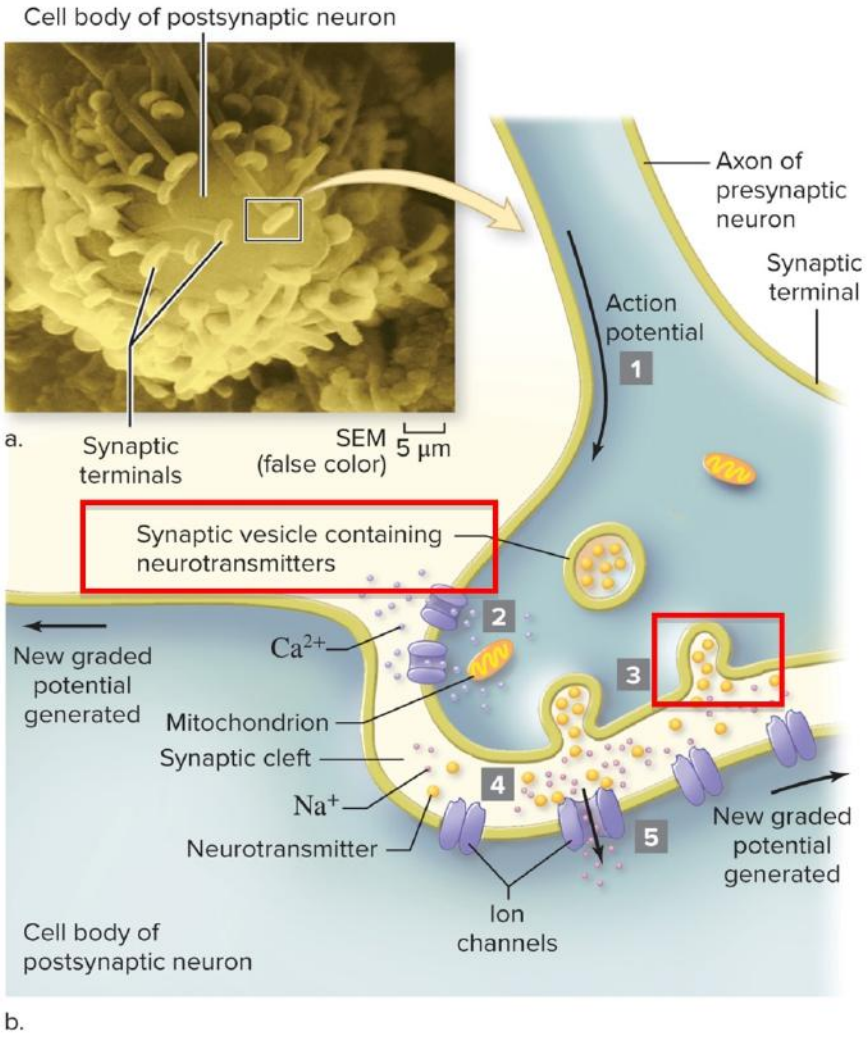
ER Lewis, YY Zeevi and TE Everhart

Section 26.4

Figure 26.9

Neurotransmitters are released

An influx of calcium stimulates vesicles loaded with neurotransmitters to fuse with the presynaptic neuron's membrane.



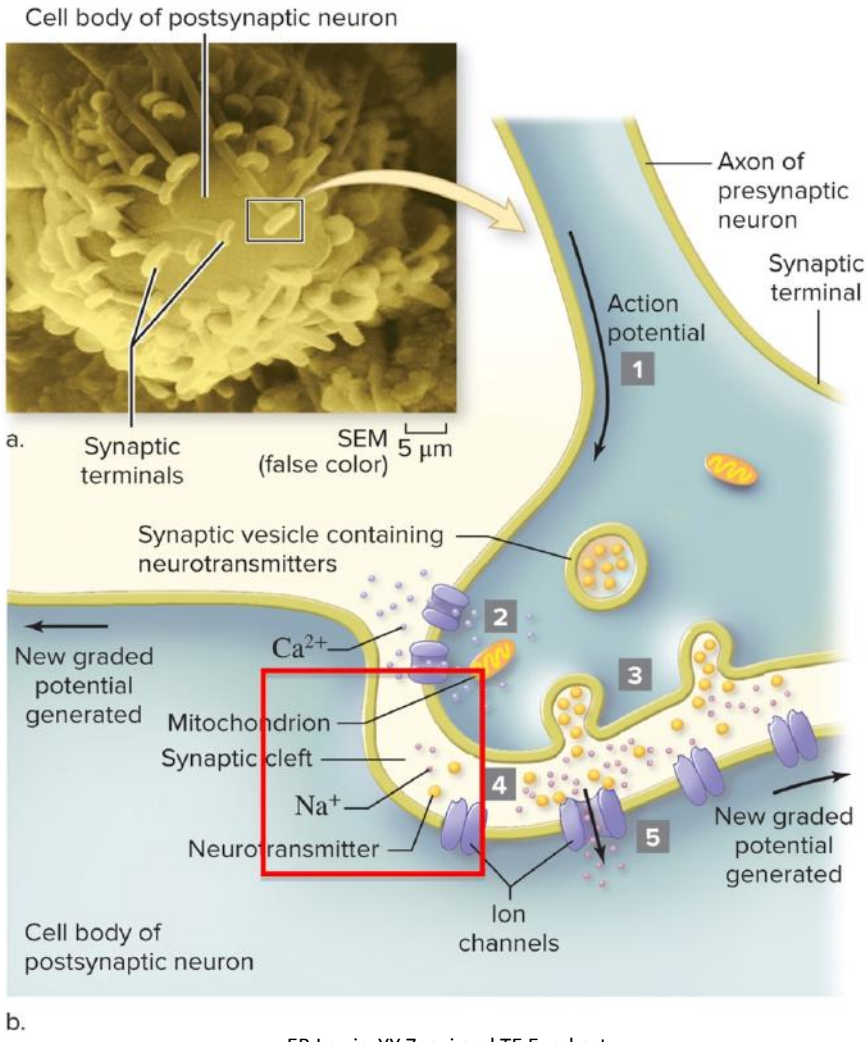
ER Lewis, YY Zeevi and TE Everhart

Section 26.4

Figure 26.9

Neurotransmitters cross the synapse, 2

Neurotransmitters bind to receptor proteins in the membrane of the postsynaptic cell.



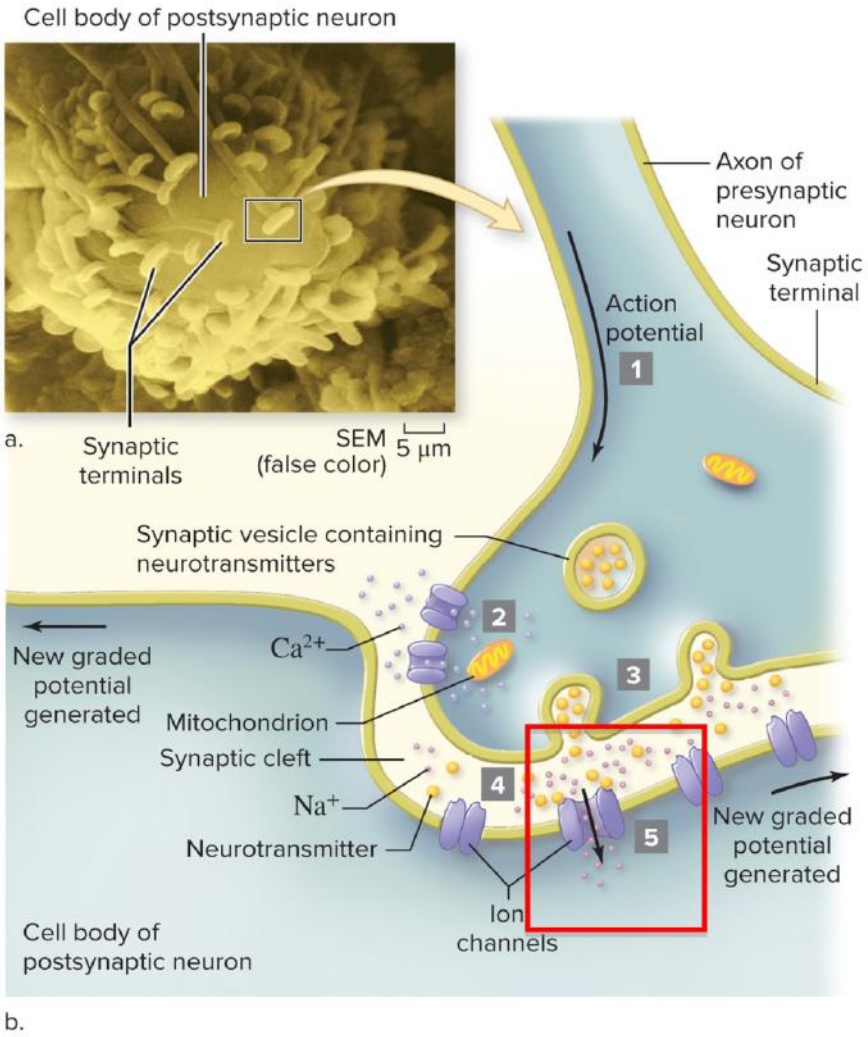
ER Lewis, YY Zeevi and TE Everhart

Section 26.4

Figure 26.9

Ion channels on the postsynaptic membrane open

Ion channels open in the postsynaptic cell membrane, changing the likelihood of an action potential in the receiving cell.



ER Lewis, YY Zeevi and TE Everhart

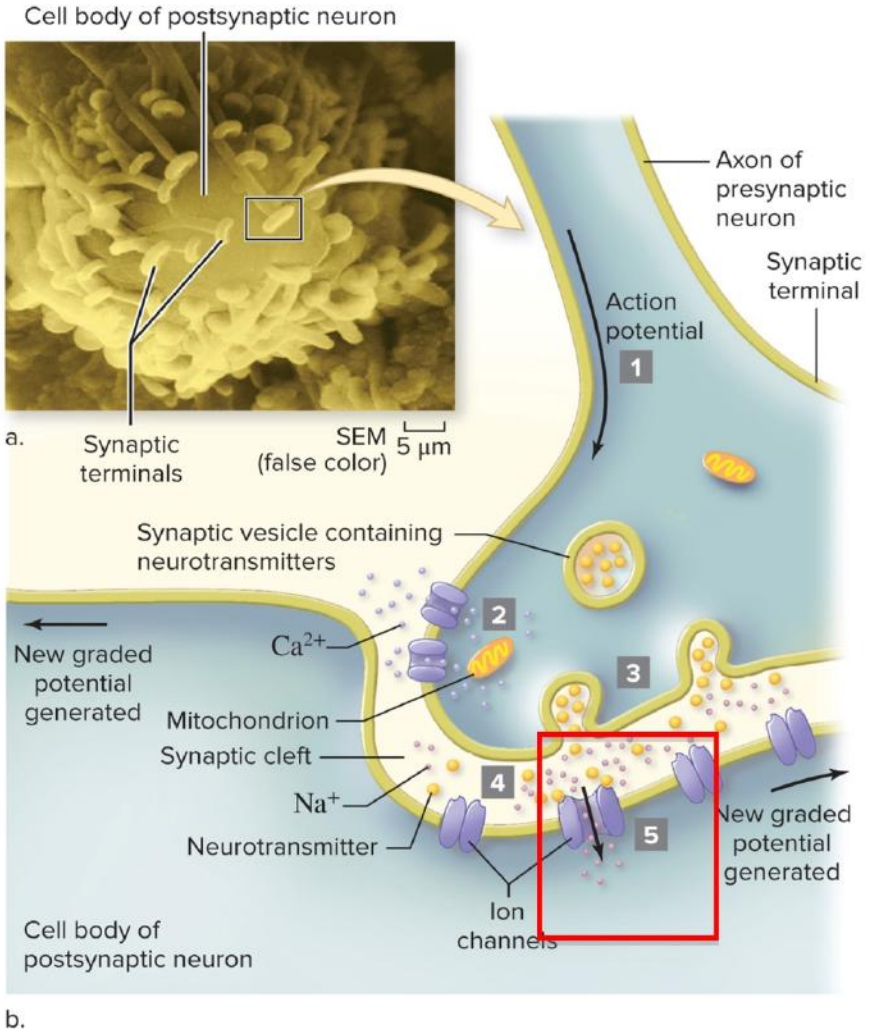
Section 26.4

Figure 26.9

Neurotransmitters can be inhibitory or excitatory

Neurotransmitters might have excitatory, inhibitory, or no effect on the postsynaptic cell.

- Excitatory = increased chance of action potential
- Inhibitory = decreased chance of action potential
- Some may have no effect on the post synaptic neuron



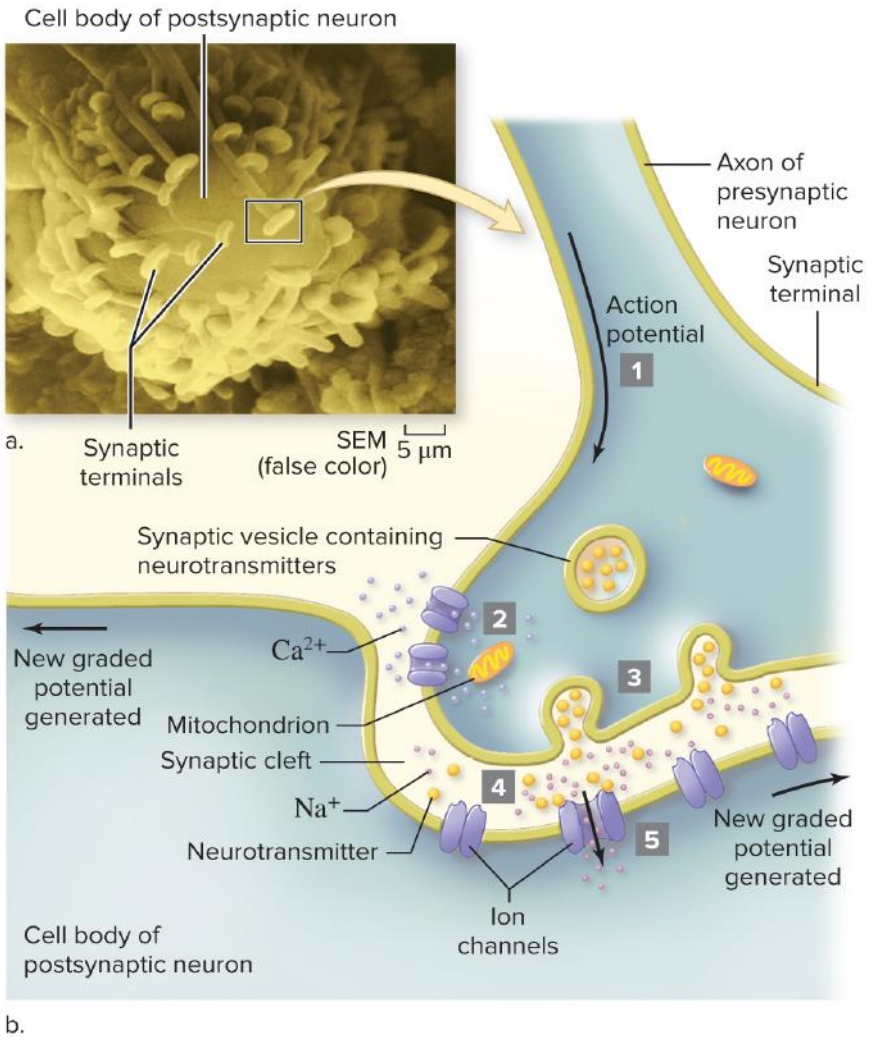
ER Lewis, YY Zeevi and TE Everhart

Section 26.4

Figure 26.9

Synaptic integration

The postsynaptic cell may receive many stimuli (both excitatory and inhibitory) at once. **Synaptic integration** determines the cell's response: if the majority of stimuli are excitatory, then the postsynaptic cell will likely initiate an action potential.



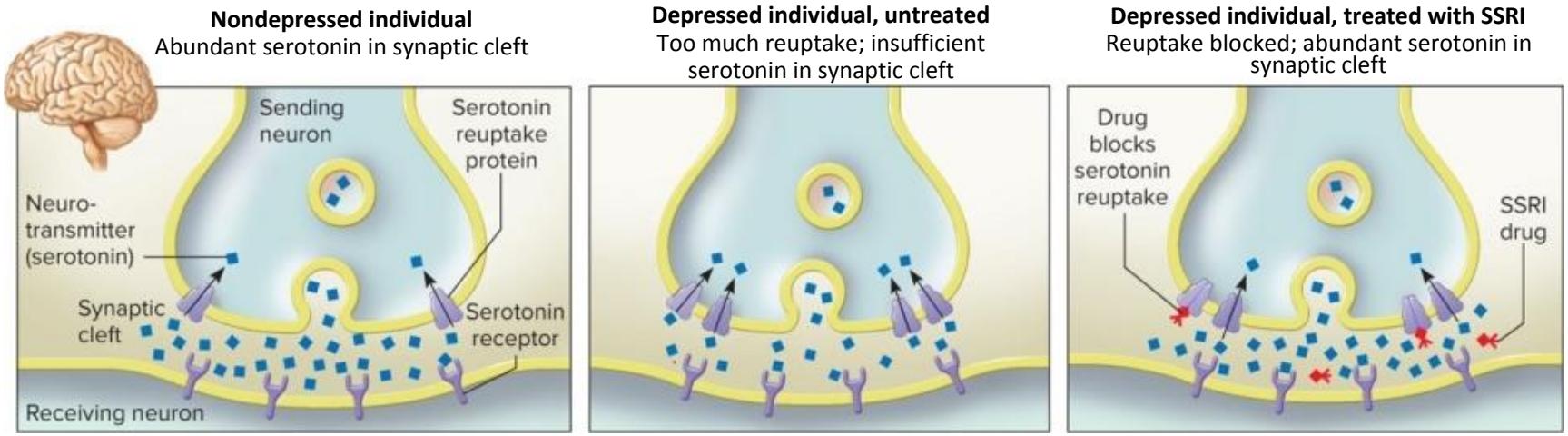
ER Lewis, YY Zeevi and TE Everhart

Section 26.4

Figure 26.9

How antidepressants work

Some antidepressants work by affecting neurotransmitter concentrations in synaptic clefts. The drugs block the sending neuron from re-uptaking the neurotransmitter serotonin, allowing serotonin to remain abundant in synapses.



Section 26.4

Figure 26.A

Clicker question #3

A neurotransmitter travels from a sending cell to a receiving cell, causing Na^+ ions to pour into the receiving cell. As a result, an action potential in the receiving cell becomes ___ likely.

A. more
B. less

Clicker question #3, solution

A neurotransmitter travels from a sending cell to a receiving cell, causing Na^+ ions to pour into the receiving cell. As a result, an action potential in the receiving cell becomes ___ likely.

A. more

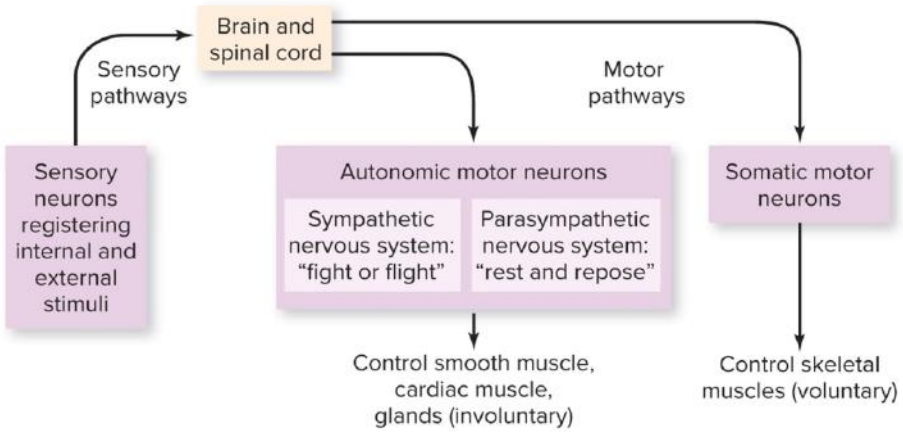
26.4 Mastering concepts

©Henrik Sorensen/Riser/Getty Images

What event stimulates a neuron to release neurotransmitters?

Subdivisions of the nervous system

The nervous system has several subdivisions.



Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.

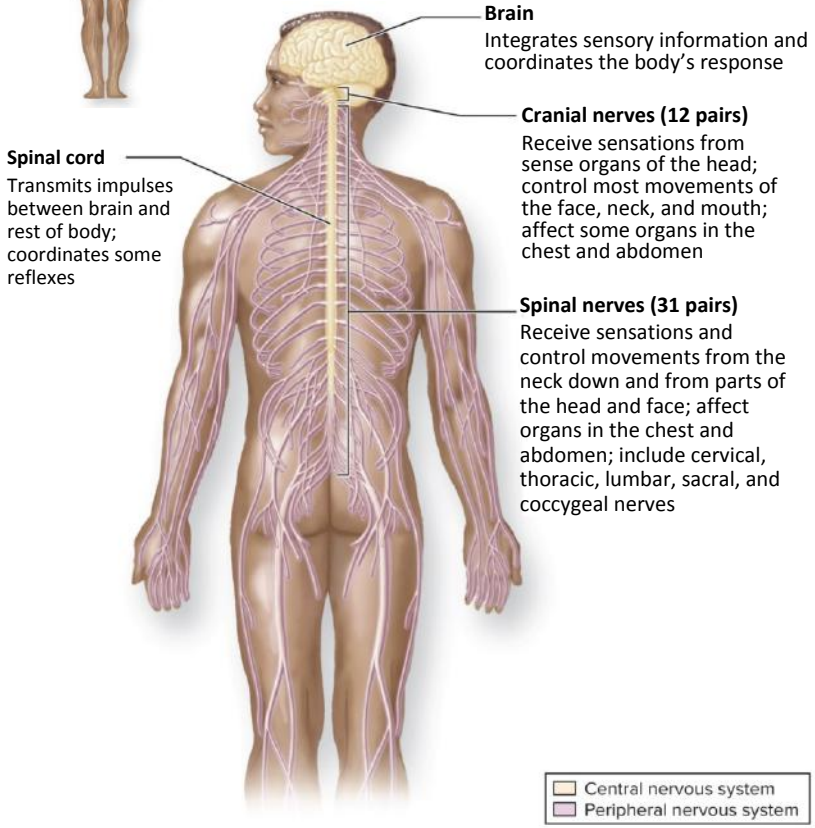
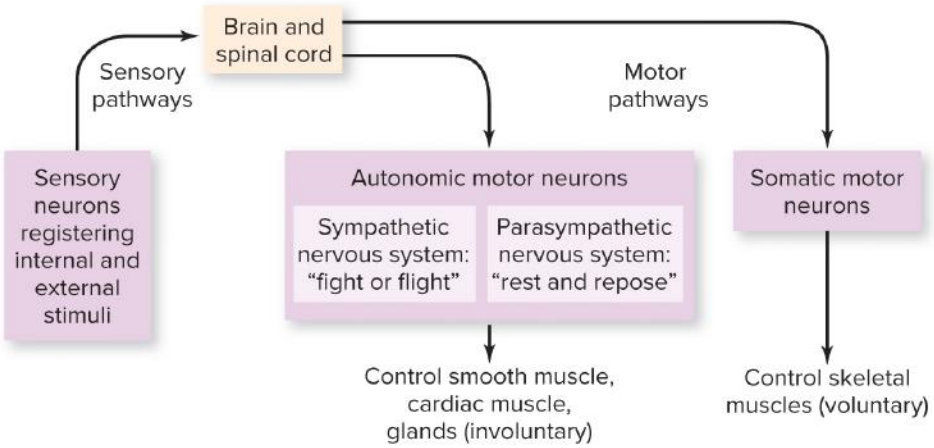


Figure 26.10

The function of the central nervous system

The central nervous system (tan) integrates sensory information and coordinates the body's responses.



Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.

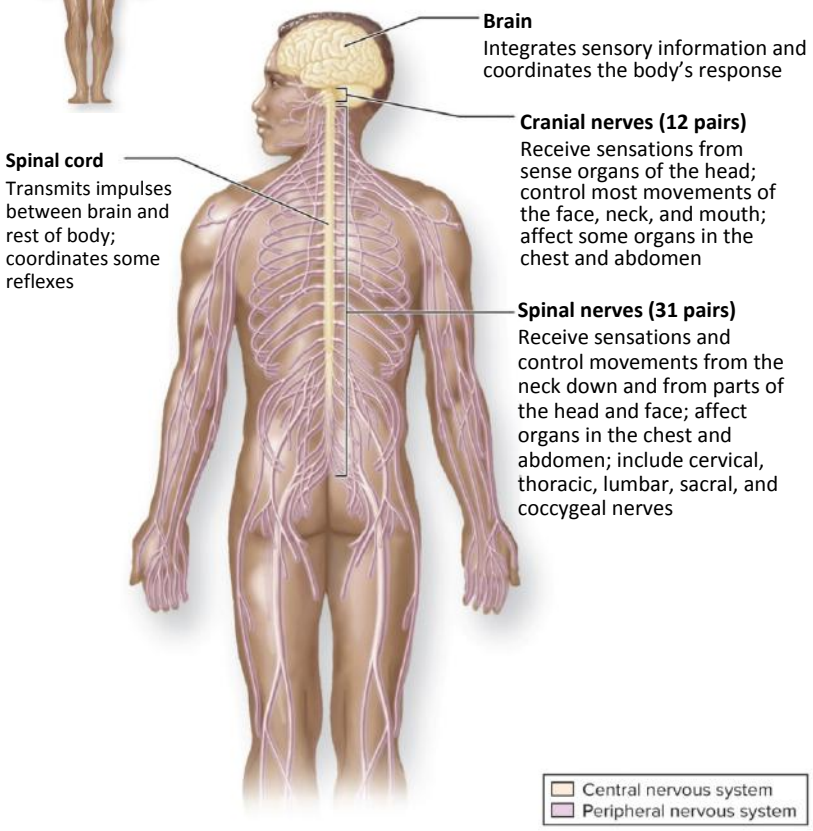


Figure 26.10

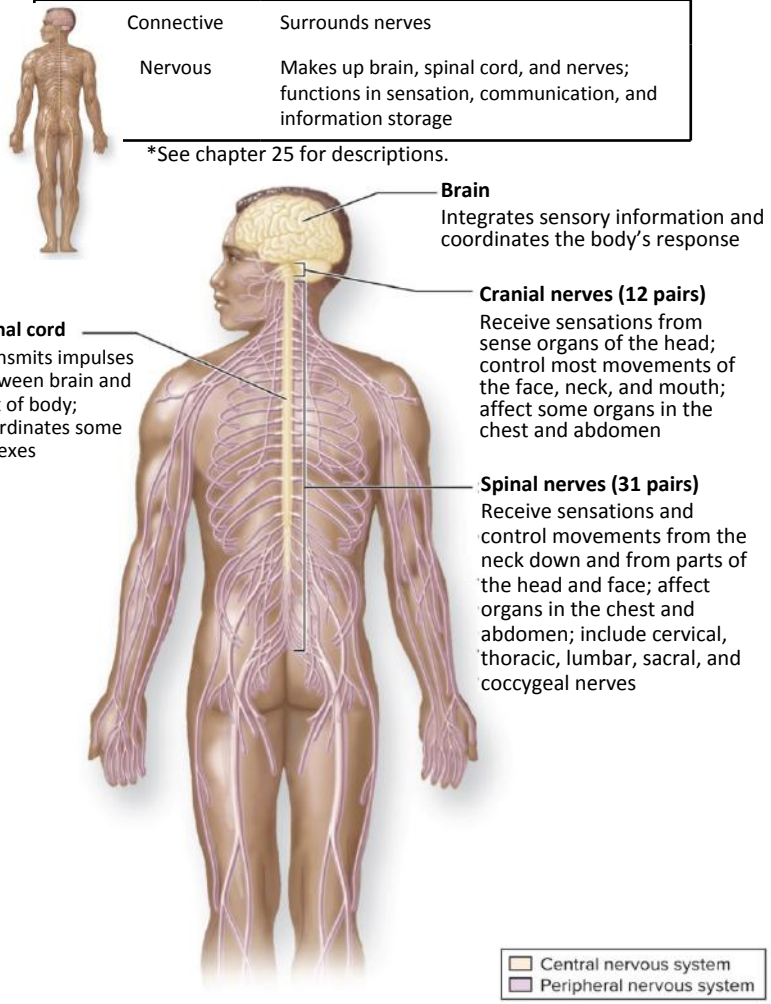
The function of the peripheral nervous system

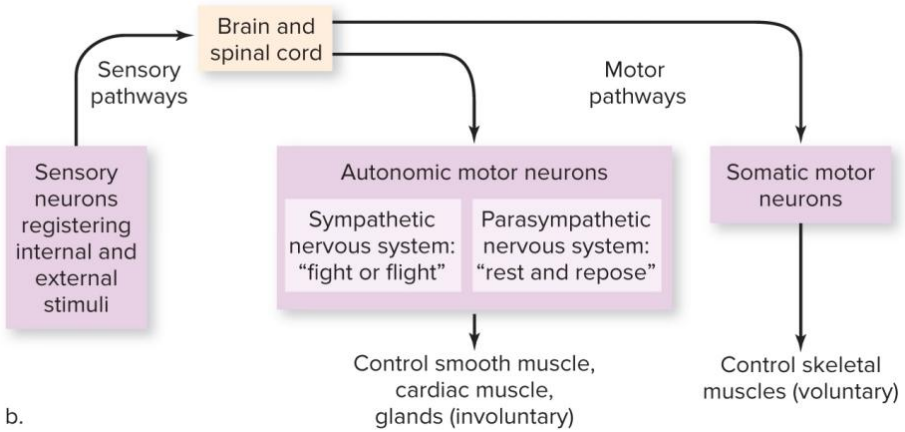
The peripheral nervous system (pink) carries information between the central nervous system and the rest of the body.

Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.



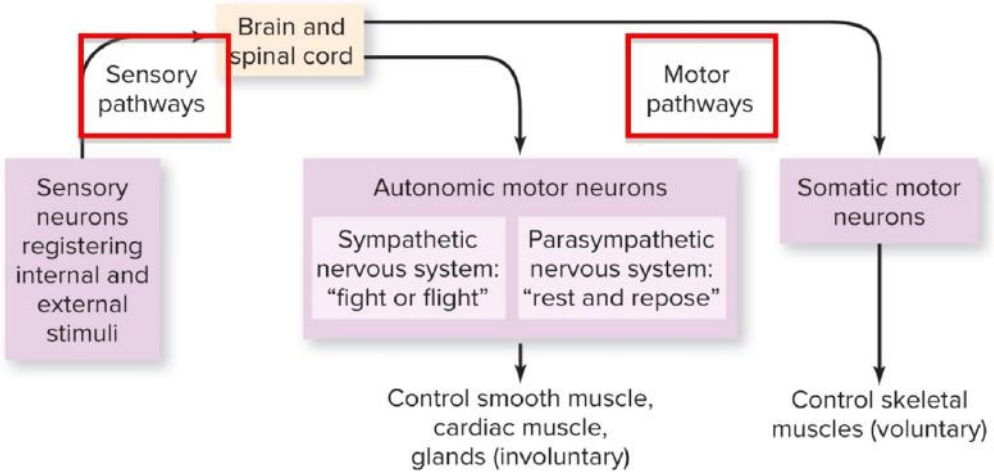


Section 26.5

Figure 26.10

The peripheral nervous system: sensory pathways

In the peripheral nervous system, sensory pathways lead to the brain and spinal cord; motor pathways lead to muscles and glands.



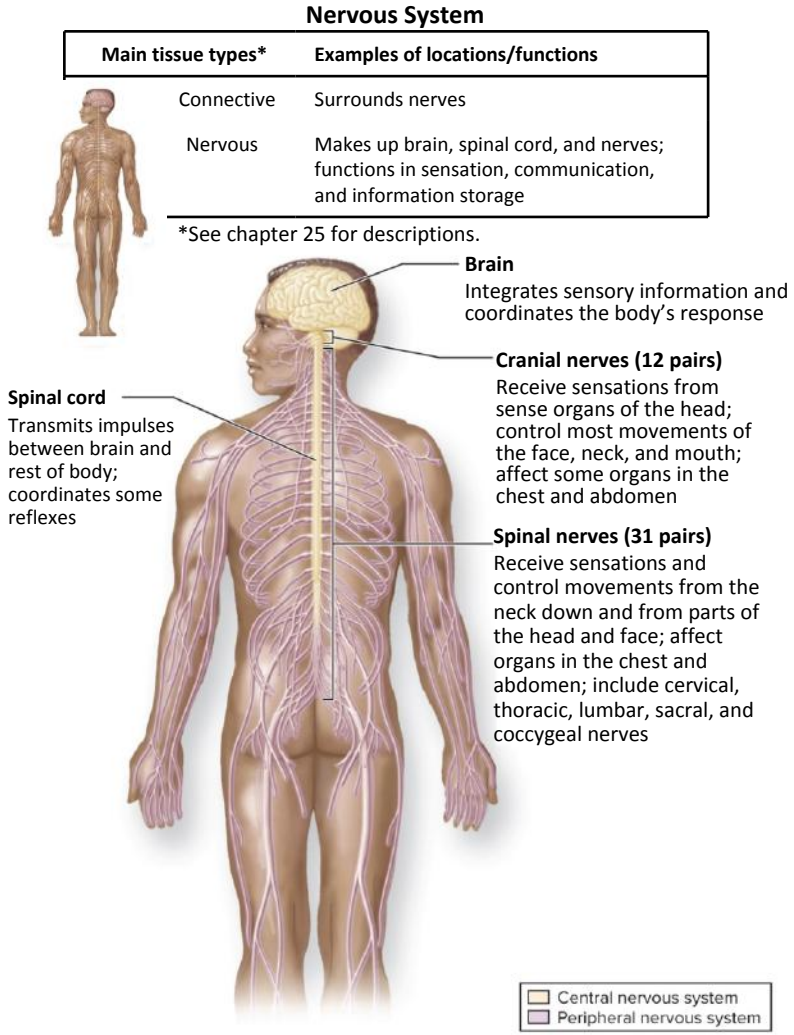
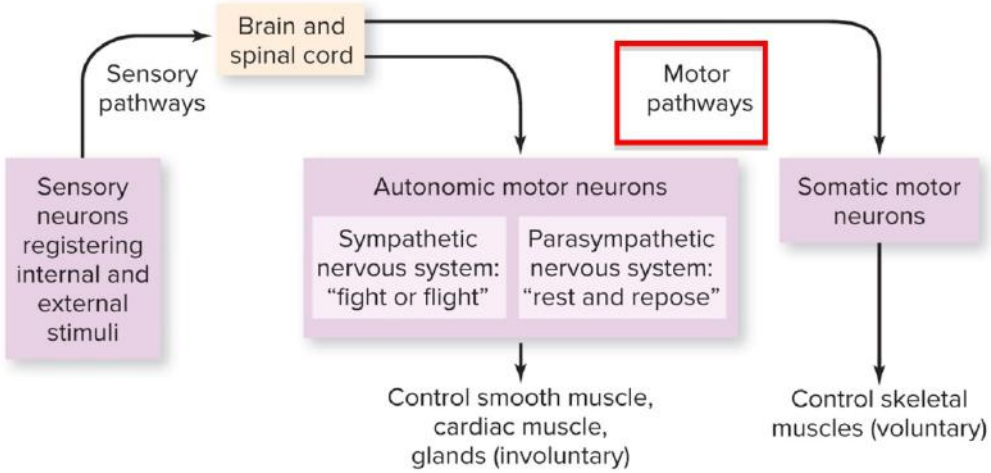


Figure 26.10

The peripheral nervous system: motor pathways

The neurons controlling motor pathways are classified according to function.



Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.

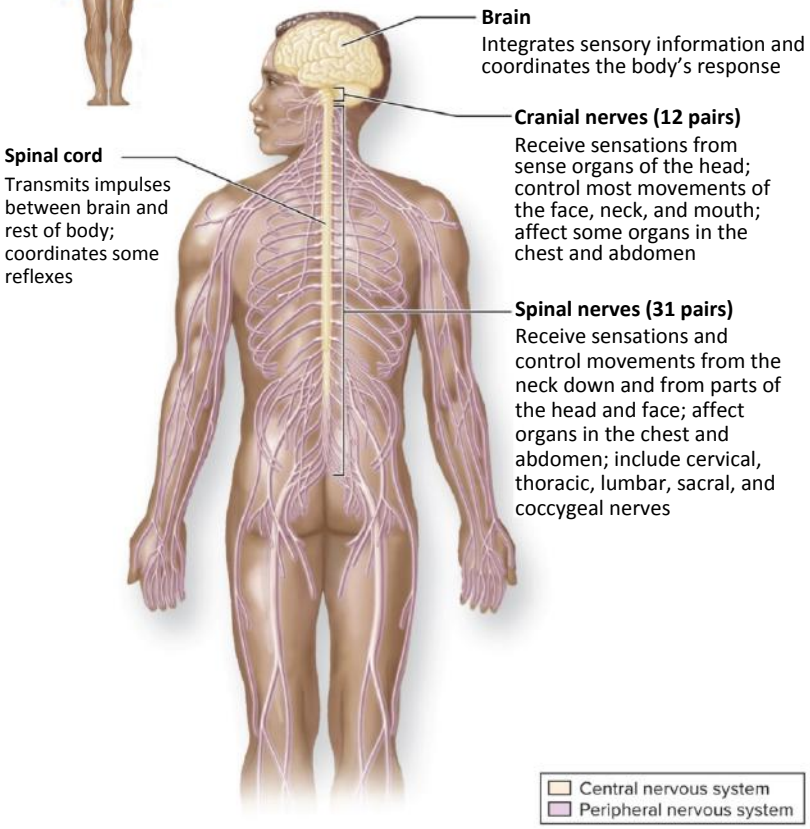
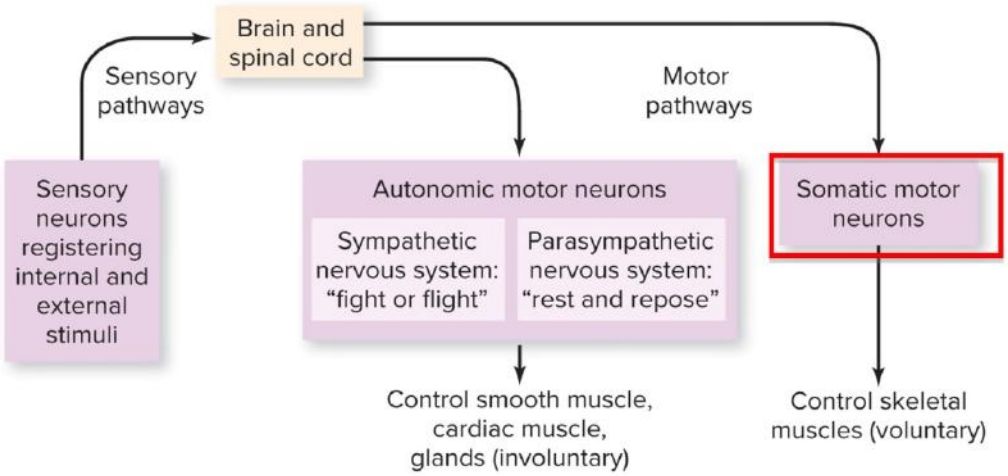


Figure 26.10

The peripheral nervous system: somatic motor neurons

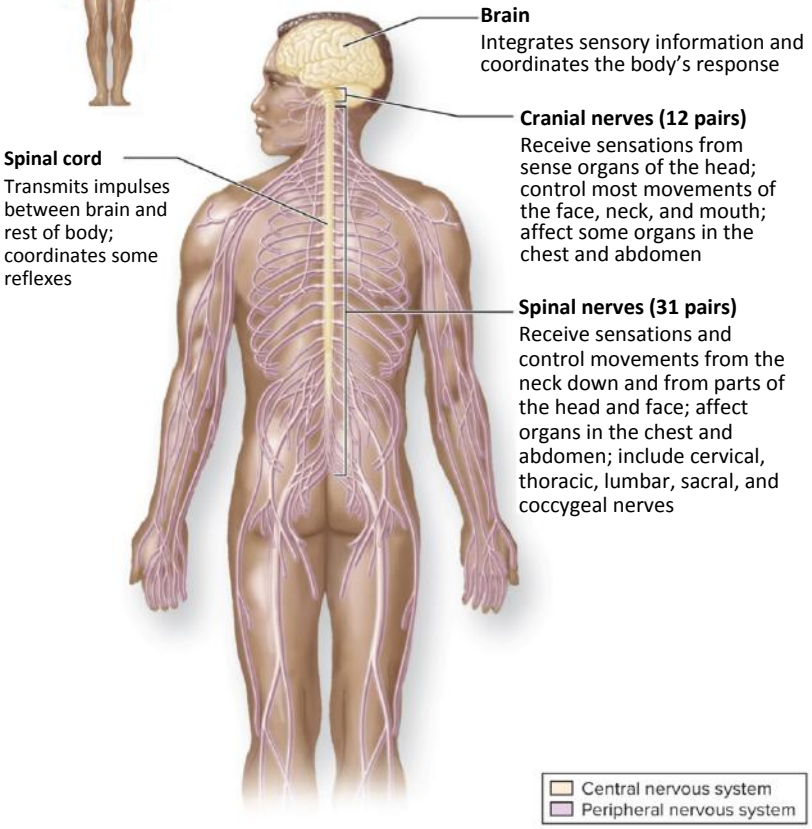
Somatic motor neurons carry signals to voluntary muscles.



Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.

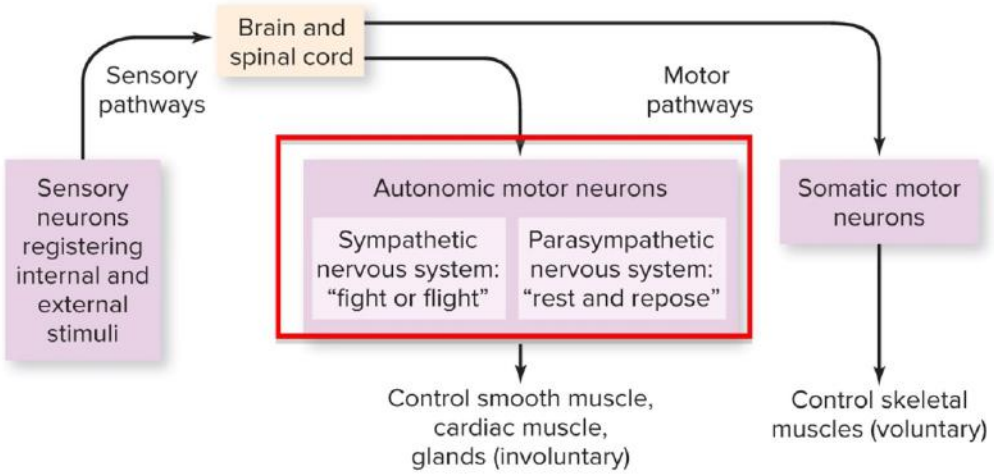


Section 26.5

Figure 26.10

The peripheral nervous system: autonomic motor neurons

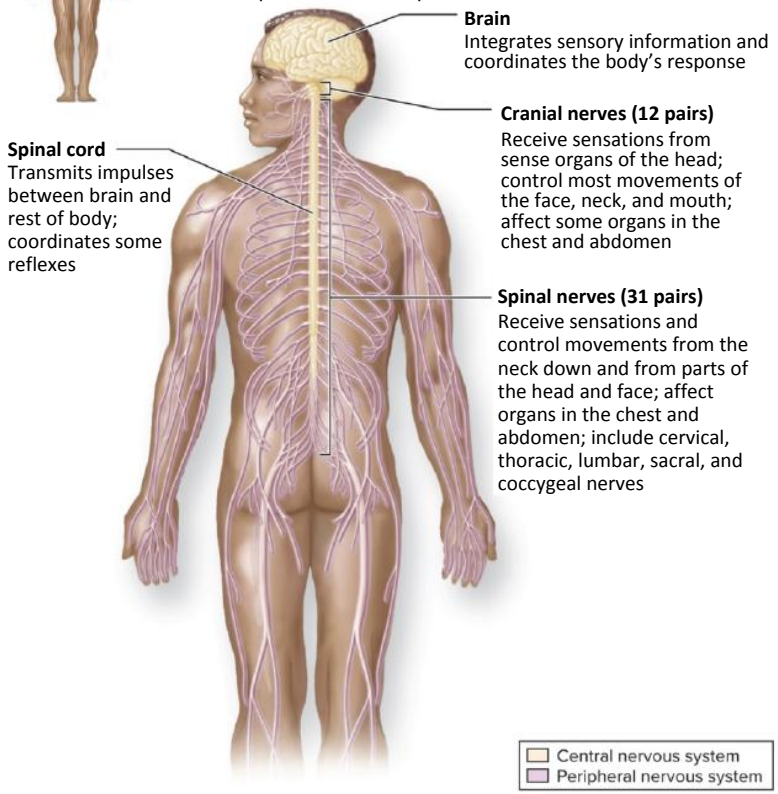
Autonomic motor neurons carry signals to involuntary muscles and glands.



Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.

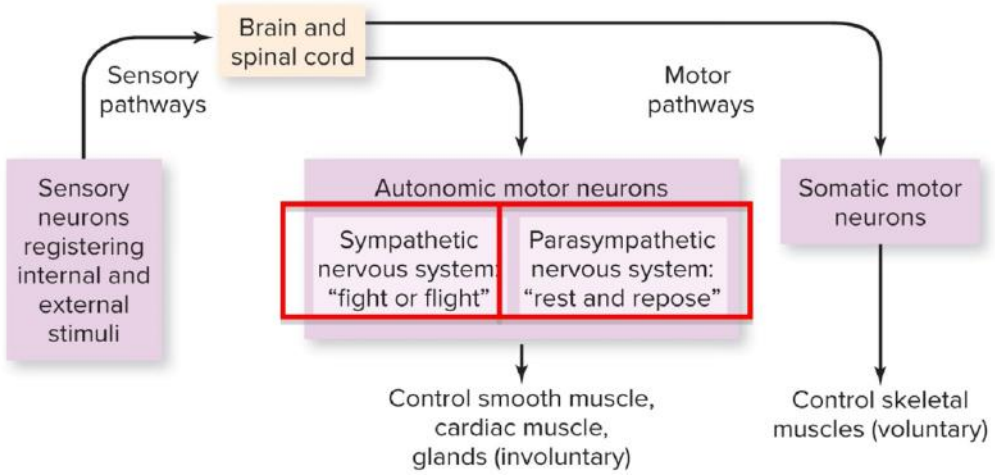


Section 26.5

Figure 26.10

Sympathetic and parasympathetic pathways

The **autonomic nervous system** is further divided into sympathetic and parasympathetic pathways.



Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.

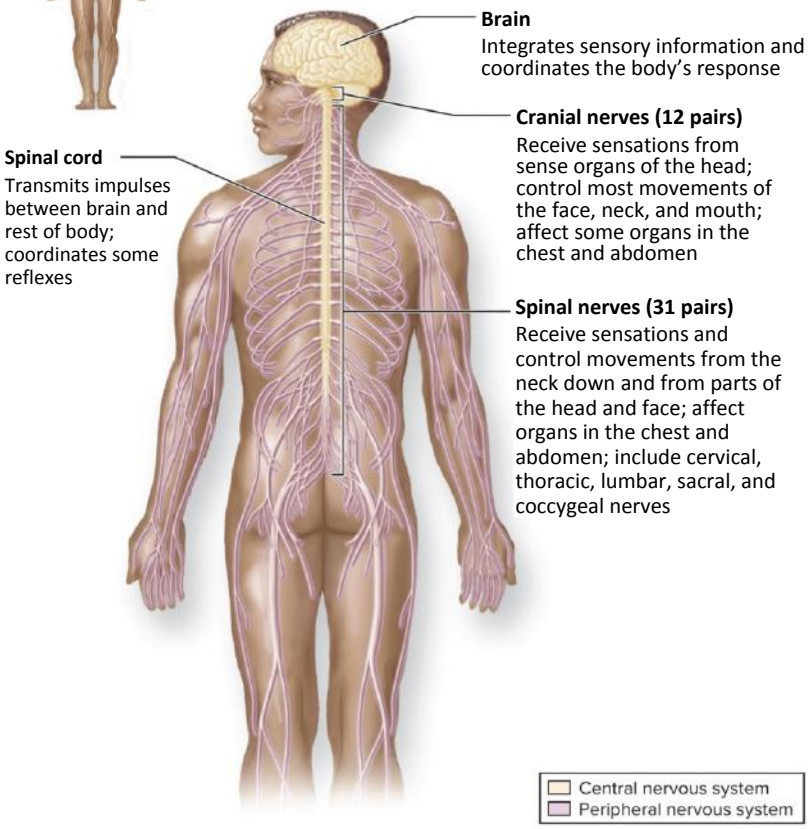
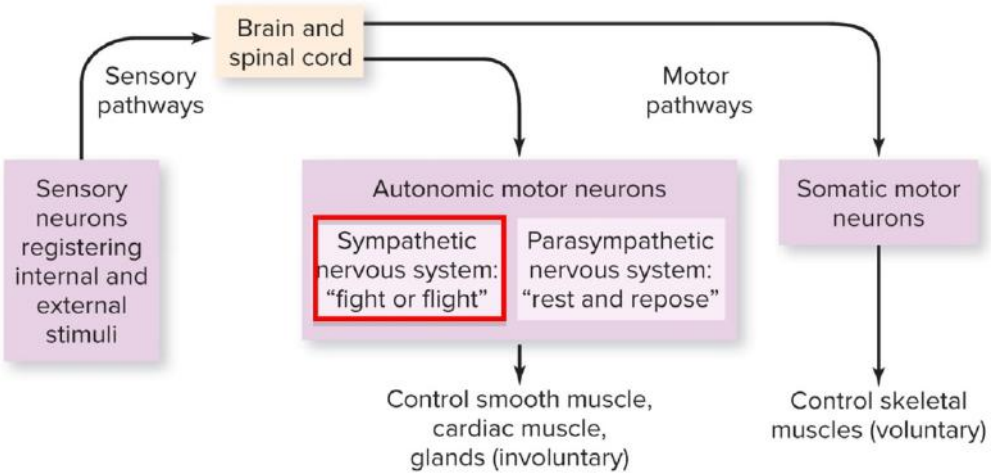


Figure 26.10

Sympathetic nervous system

The **sympathetic nervous system** dominates under stress and emergencies. The neurons:

- increase heart rate and breathing rate
- dilate arteries



Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.

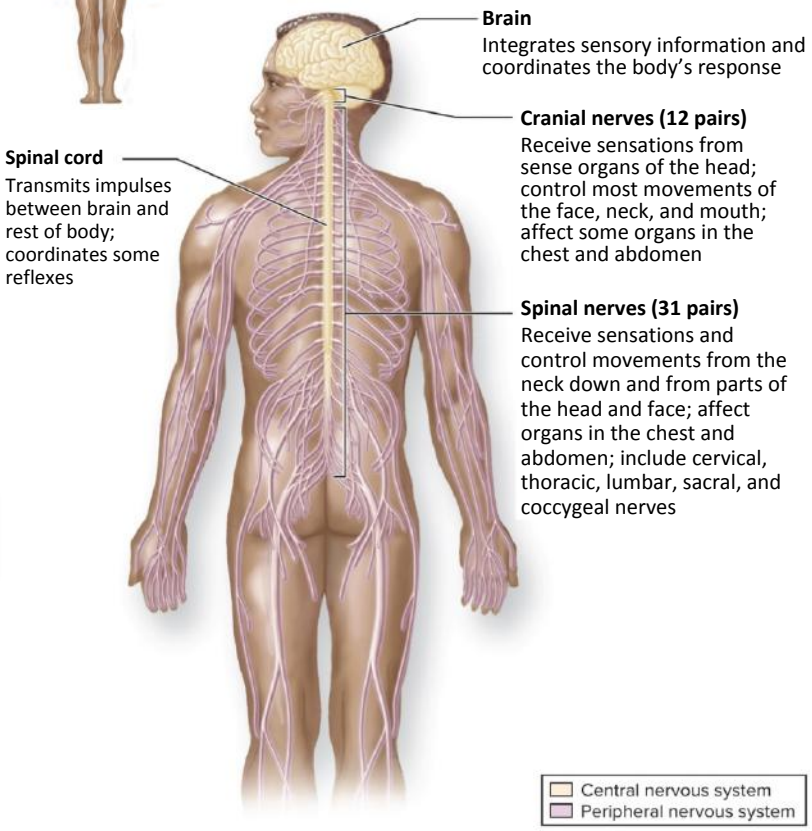
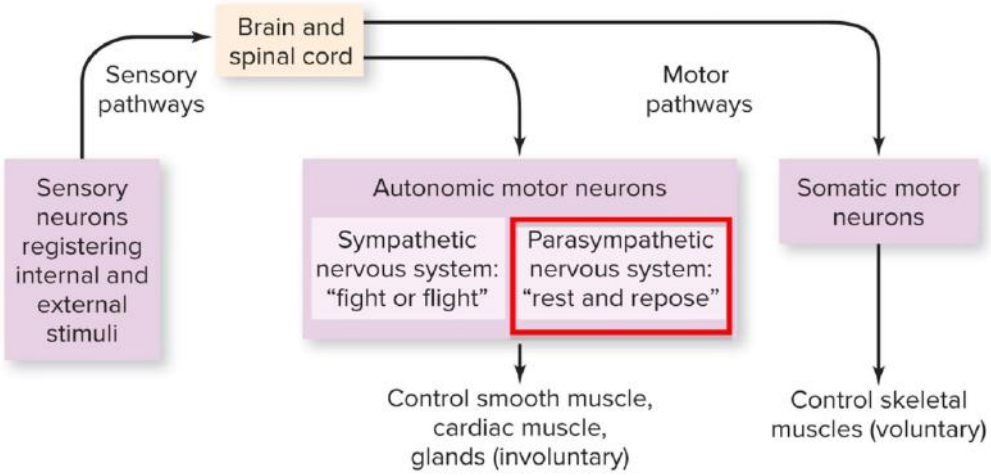


Figure 26.10

The parasympathetic nervous system

The **parasympathetic nervous system** returns body systems to normal. The neurons:

- decrease heart rate and breathing rate
- constrict arteries



Nervous System

Main tissue types*	Examples of locations/functions
Connective	Surrounds nerves
Nervous	Makes up brain, spinal cord, and nerves; functions in sensation, communication, and information storage

*See chapter 25 for descriptions.

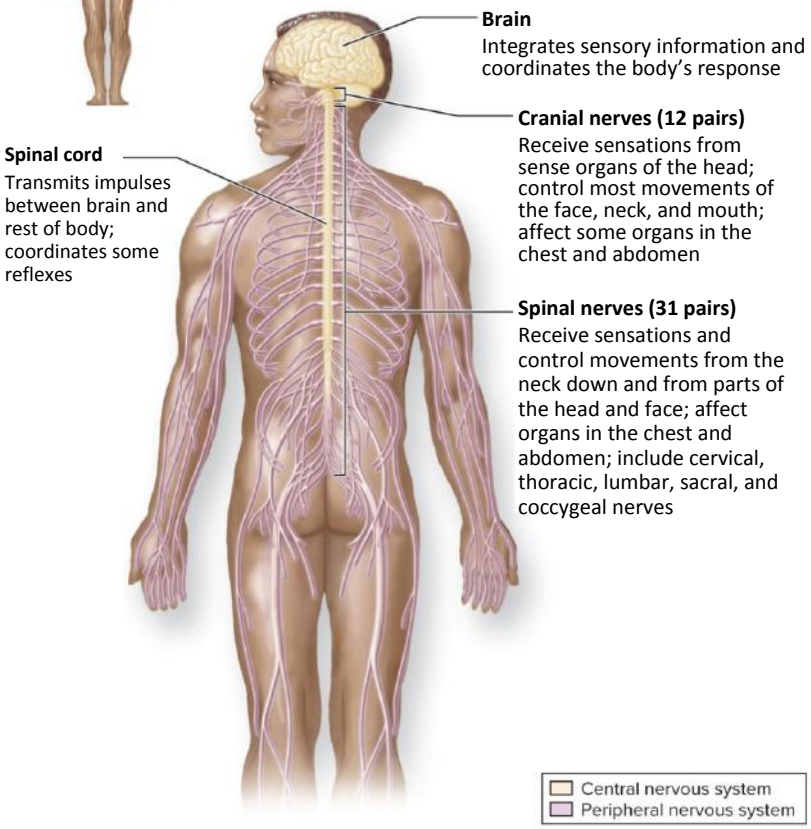
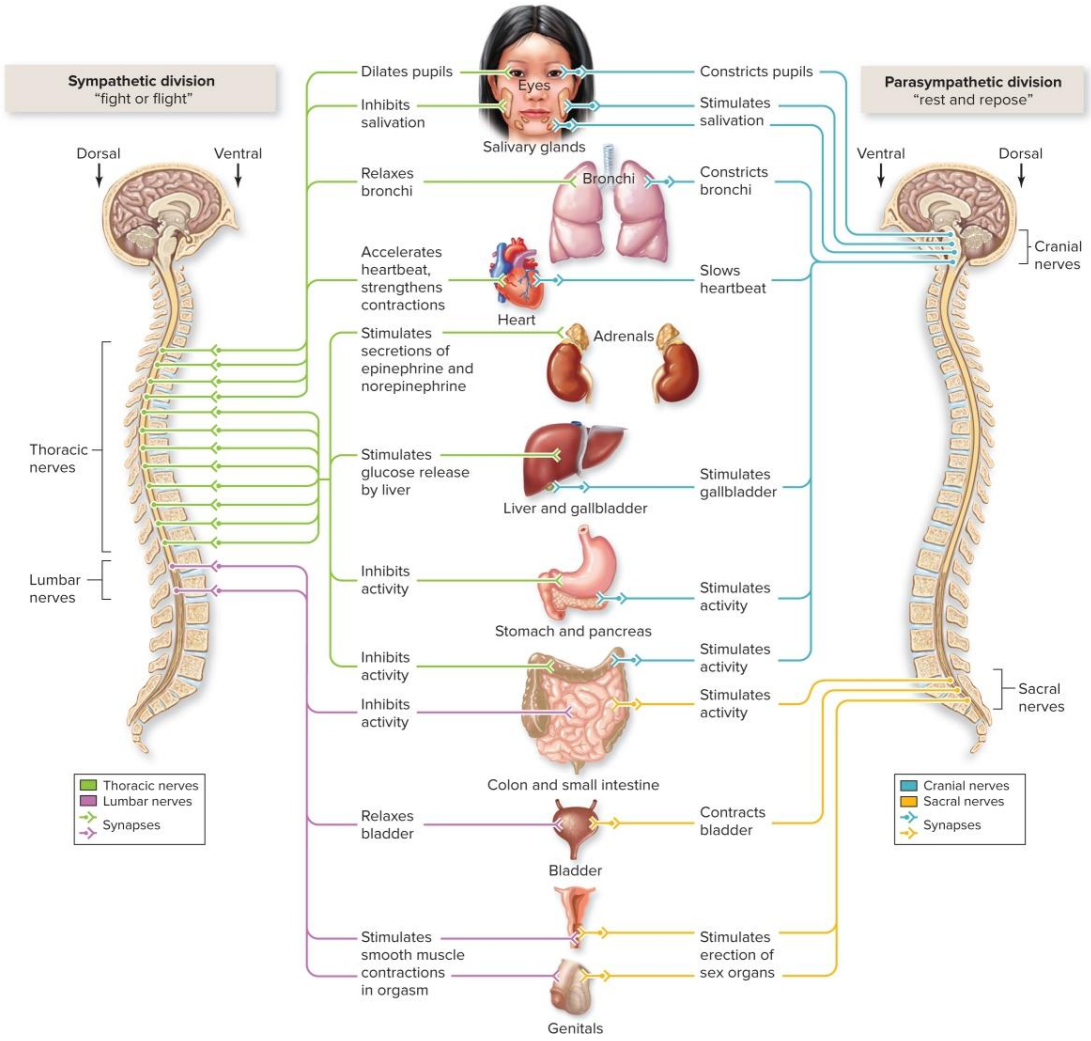


Figure 26.10

Contrasting roles of the autonomic nervous system



Section 26.5

Figure 26.11

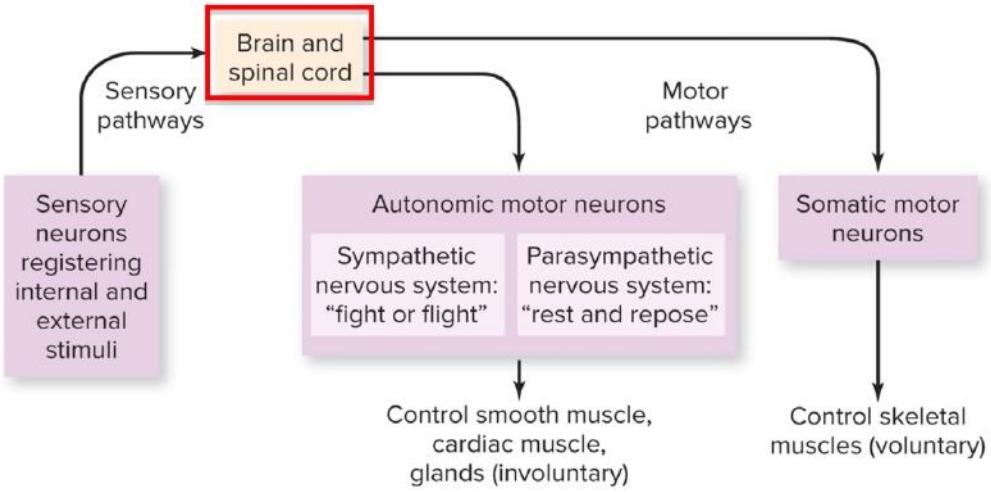
26.5 Mastering concepts

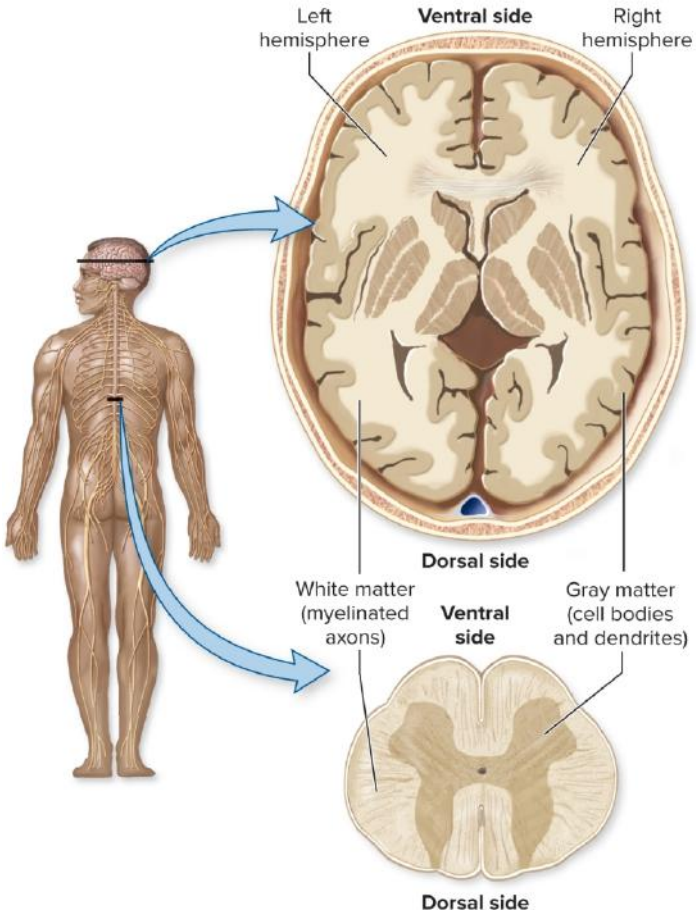
©Henrik Sorensen/Riser/Getty Images

Describe the relationships among the motor, somatic, autonomic, sympathetic, and parasympathetic nervous systems.

The central nervous system

The central nervous system consists of the brain and spinal cord.

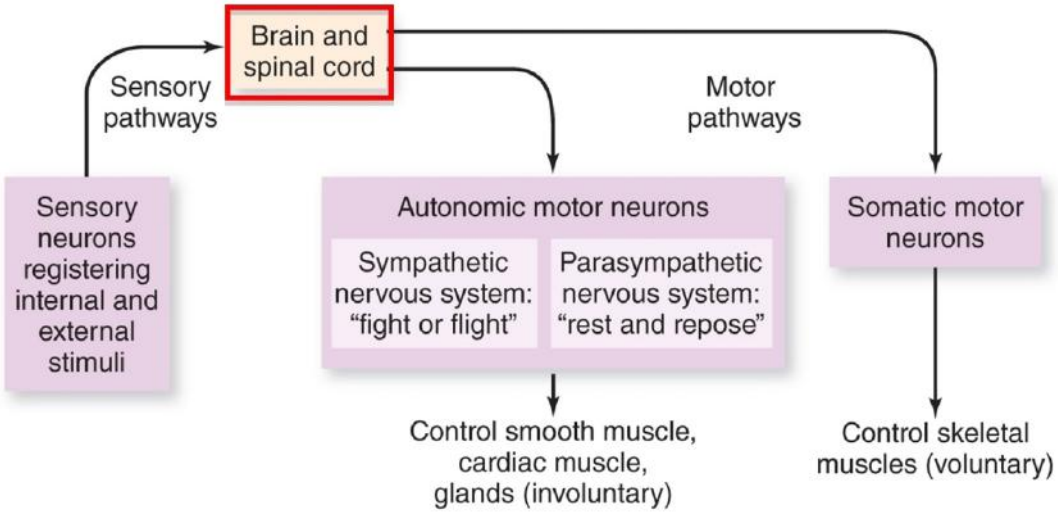


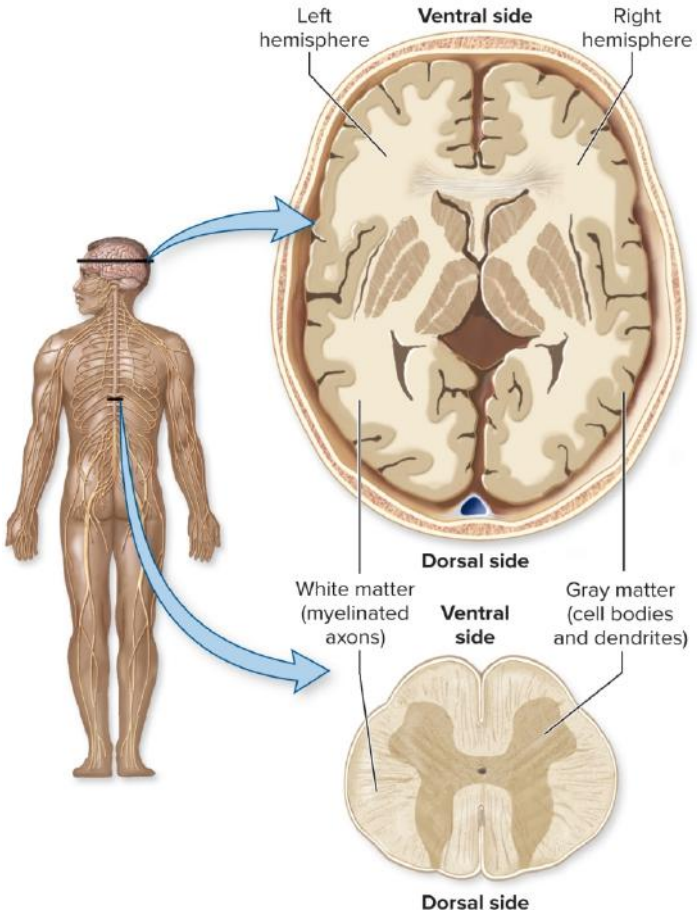


Two types of tissue in the CNS

Two types of nervous tissue occur in the central nervous system:

- **Gray matter**: cell bodies and dendrites
- **White matter**: myelinated axons



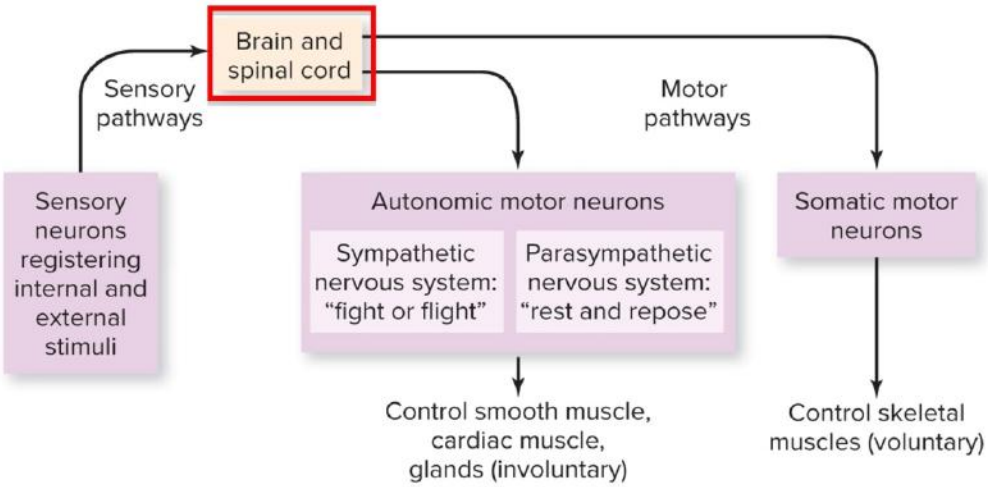


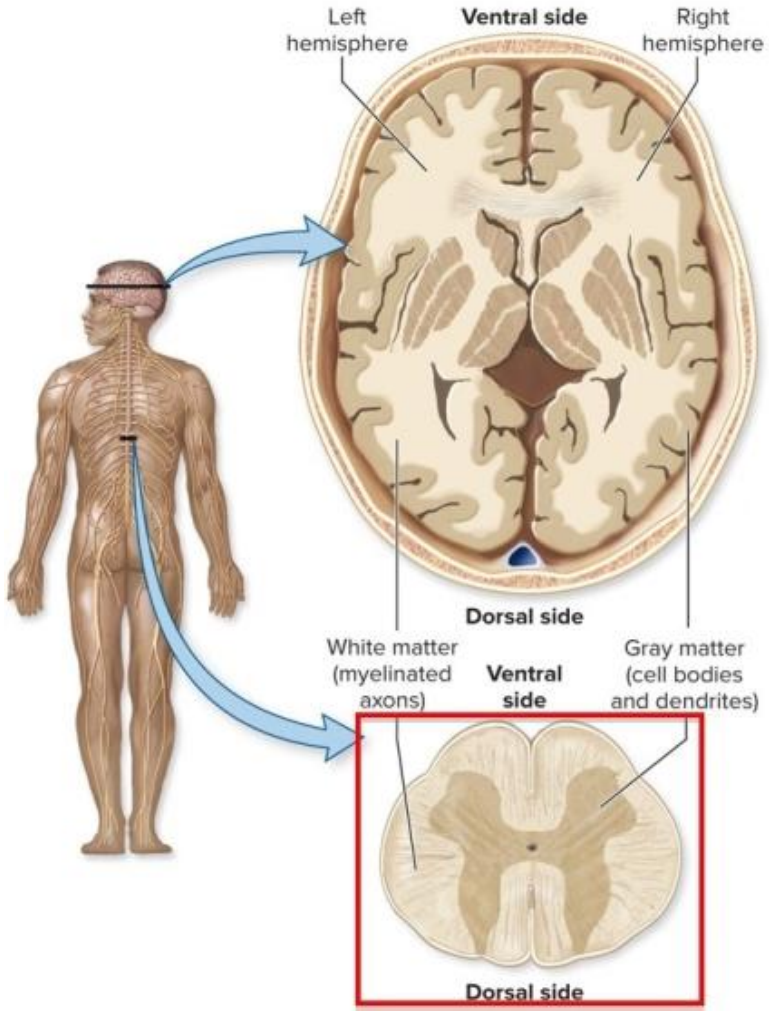
Section 26.6

Figures 26.10, 26.12

The spinal cord

The spinal cord transmits information between the body and the brain.



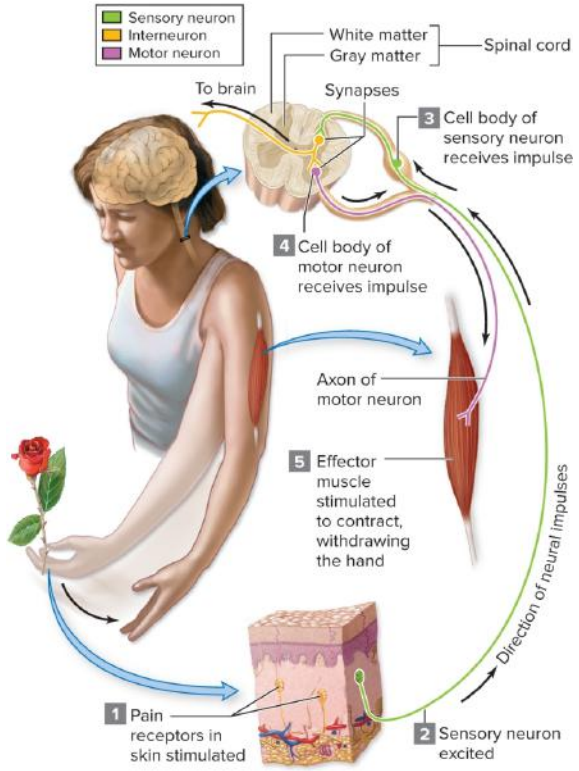


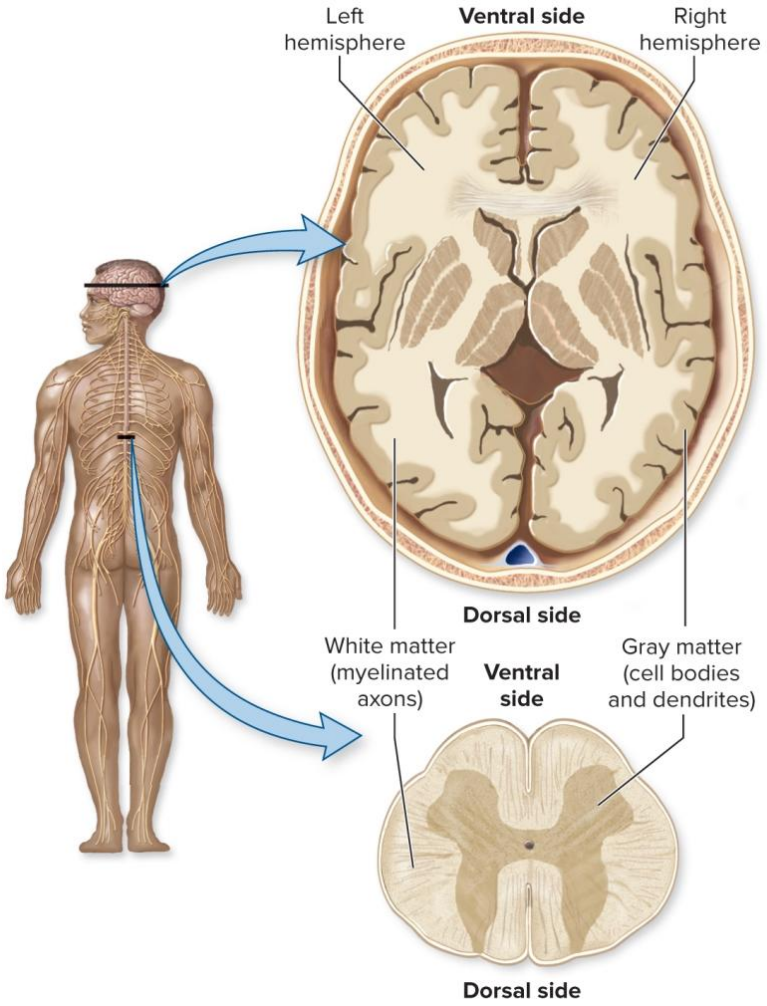
Section 26.6

Figures 26.10, 26.12

The spinal cord controls reflexes

The spinal cord also controls **reflexes** without interacting with the brain.



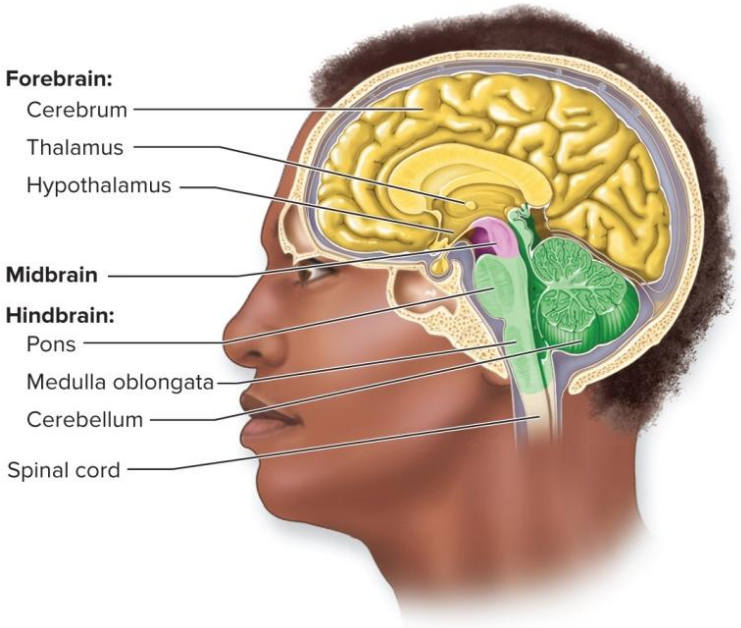


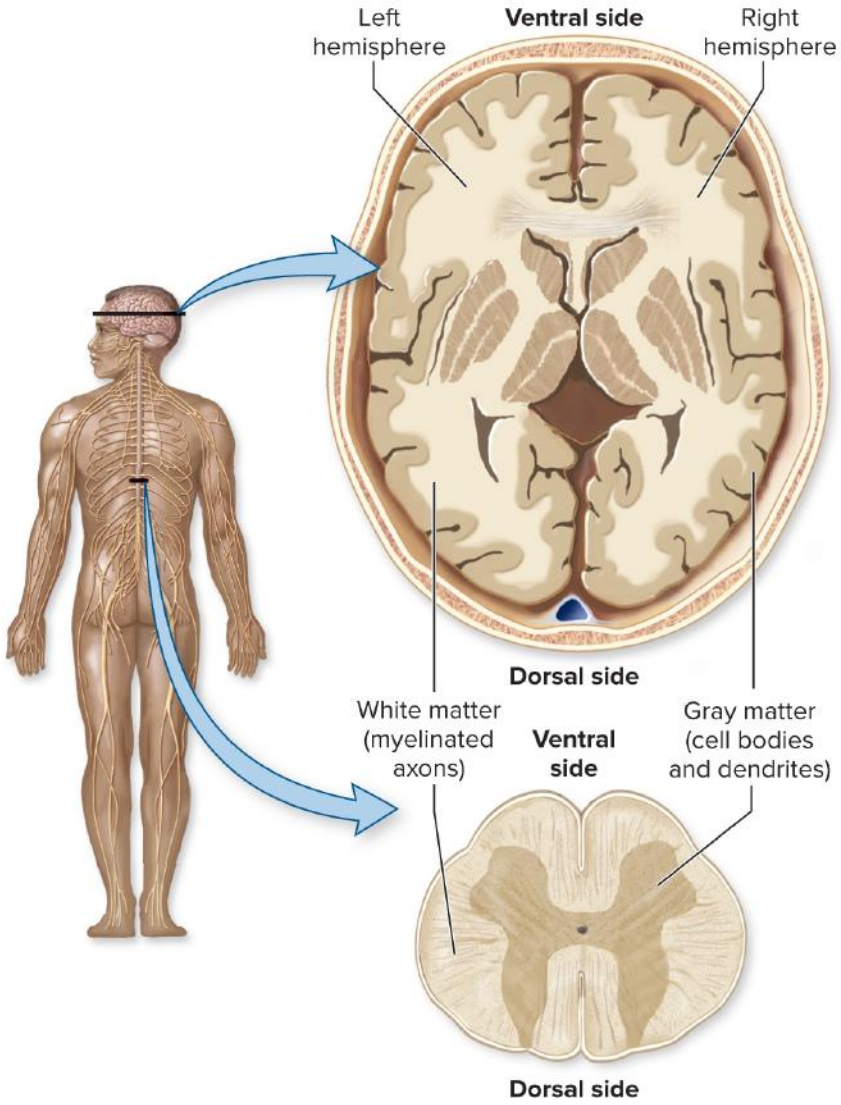
Section 26.6

Figures 26.12, 26.13

The brain

The brain is divided into several regions.

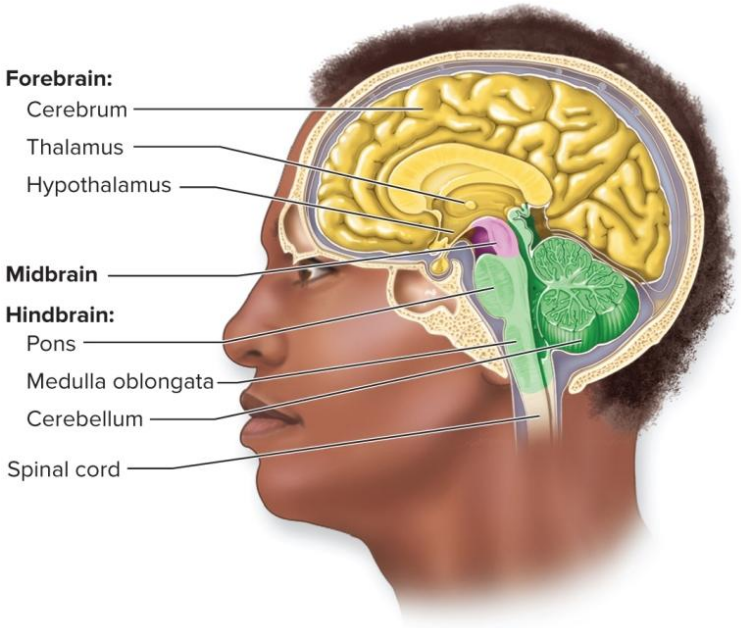




Section 26.6

Figures 26.12, 26.14

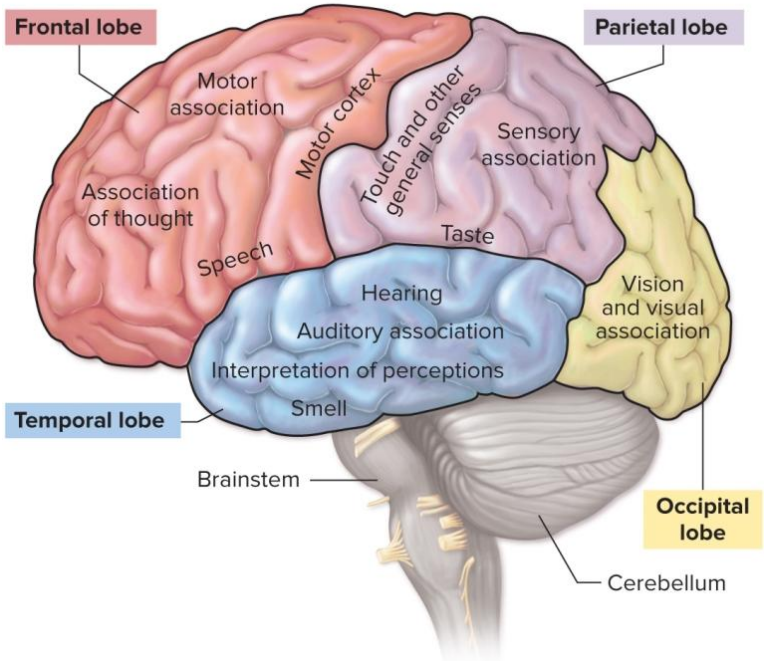
The brain is divided into several regions



Structure	Selected functions
Hindbrain	
Medulla oblongata	Regulates essential physiological processes such as blood pressure, heartbeat, and breathing
Pons	Connects forebrain with medulla and cerebellum
Cerebellum	Controls posture and balance; coordinates subconscious muscular movements
Midbrain	Relays information about voluntary movements from forebrain to spinal cord
Forebrain	
Thalamus	Processes information and relays it to the cerebrum
Hypothalamus	Homeostatic control of most organs
Cerebrum	
White matter	Transmits information within brain
Gray matter (cerebral cortex)	Sensory, motor, and association areas

The cerebrum

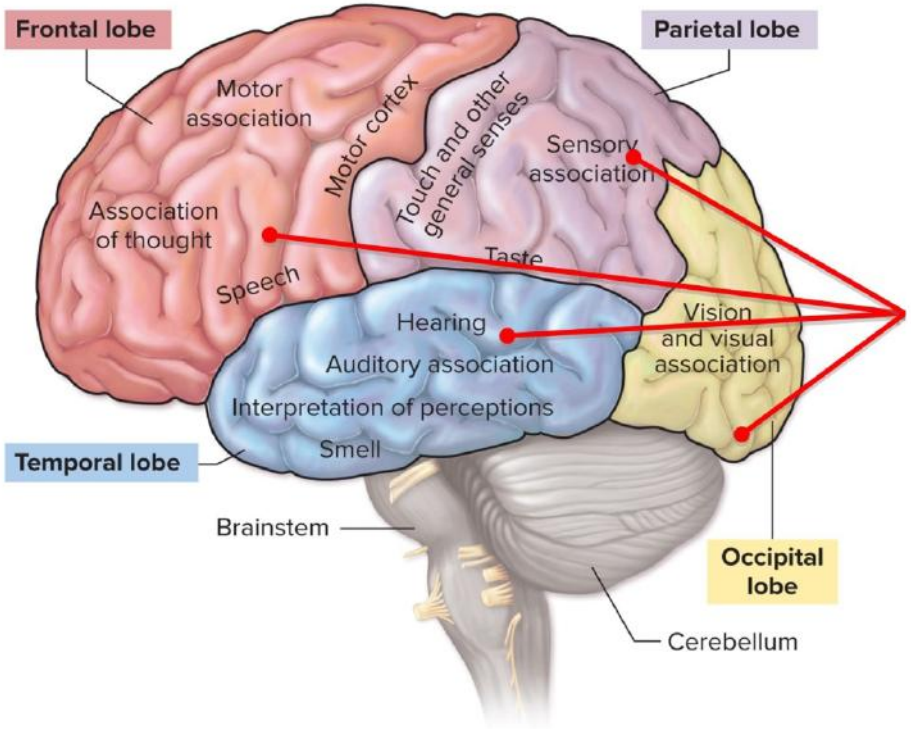
The **cerebrum**, part of the forebrain, controls the qualities of what we consider the "mind."



Structure	Selected functions
Hindbrain	
Medulla oblongata	Regulates essential physiological processes such as blood pressure, heartbeat, and breathing
Pons	Connects forebrain with medulla and cerebellum
Cerebellum	Controls posture and balance; coordinates subconscious muscular movements
Midbrain	Relays information about voluntary movements from forebrain to spinal cord
Forebrain	
Thalamus	Processes information and relays it to the cerebrum
Hypothalamus	Homeostatic control of most organs
Cerebrum	
White matter	Transmits information within brain
Gray matter (cerebral cortex)	Sensory, motor, and association areas

The association areas of the cerebrum

Association functions occur in all four cerebral lobes.



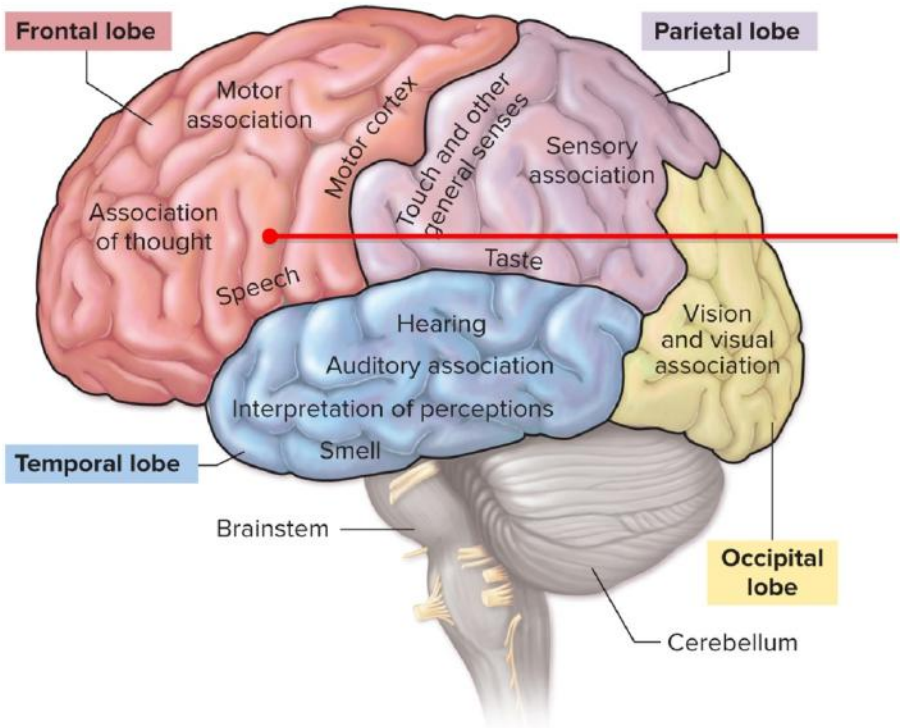
Division	Function(s)	Brain Region(s)
Sensory	Senses of vision, hearing, smell, taste, and touch	Parietal, occipital, and temporal lobes
Motor	Voluntary movements	Frontal lobe
Association	Judgment, analysis, learning, creativity	Frontal lobe and parts of the parietal, occipital, and temporal lobes

Section 26.6

Figure 26.16

The motor areas of the cerebrum

Motor functions are controlled only by the frontal lobe.



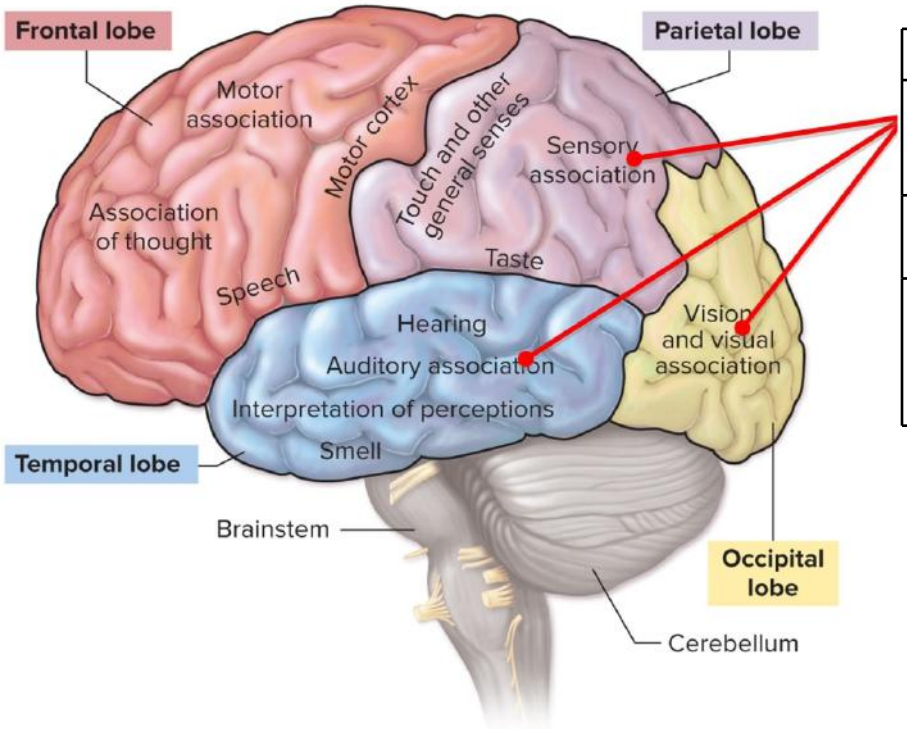
Division	Function(s)	Brain Region(s)
Sensory	Senses of vision, hearing, smell, taste, and touch	Parietal, occipital, and temporal lobes
Motor	Voluntary movements	Frontal lobes
Association	Judgment, analysis, learning, creativity	Frontal lobe and parts of the parietal, occipital, and temporal lobes

Section 26.6

Figure 26.16

The sensory integration areas of the cerebrum

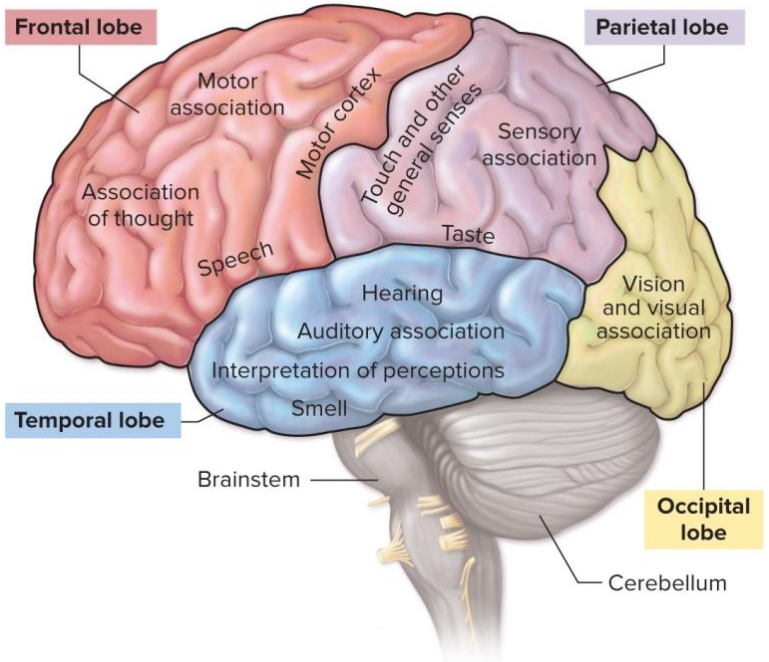
Sensory integration occurs in the parietal, temporal, and occipital lobes.



Division	Function(s)	Brain Region(s)
Sensory	Senses of vision, hearing, smell, taste, and touch	Parietal, occipital, and temporal lobes
Motor	Voluntary movements	Frontal lobes
Association	Judgment, analysis, learning, creativity	Frontal lobe and parts of the parietal, occipital, and temporal lobes

The limbic system

The **limbic system** is also contained within the cerebrum. This "emotional center" of the brain is actually scattered through different brain areas.

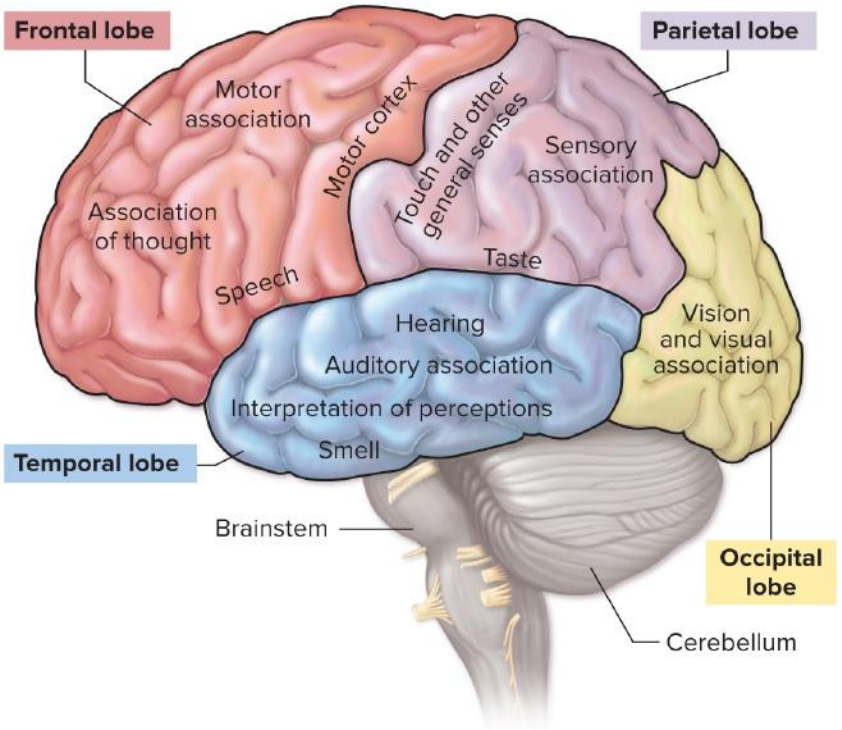


Section 26.6

Figure 26.16

The hippocampus

The **hippocampus** is part of the limbic system responsible for forming long-term memories.



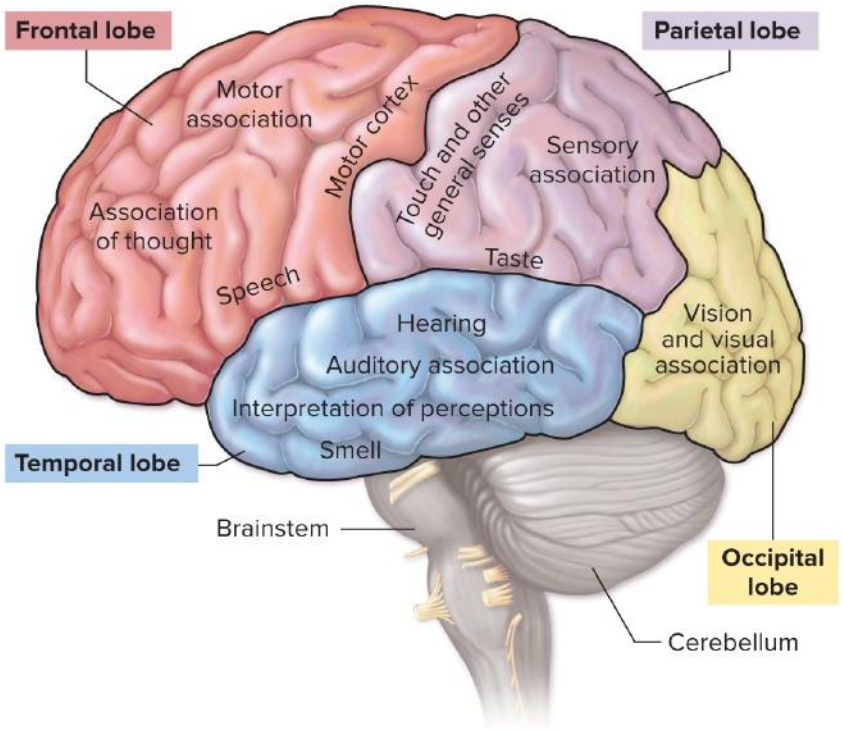
©Gary He/McGraw-Hill Education

Section 26.6

Figures 26.16, 26.17

The amygdala

The **amygdala** is another part of the limbic system. It is responsible for forming emotions such as fear and pleasure.



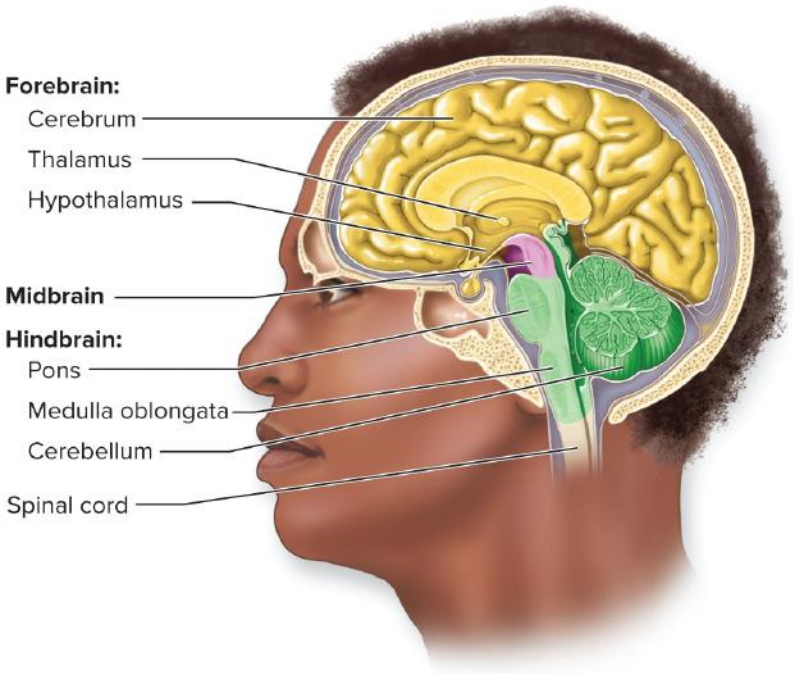
©Gary He/McGraw-Hill Education

Section 26.6

Figures 26.16, 26.17

The central nervous system is protected

Because of its many functions, protecting the central nervous system is vital.

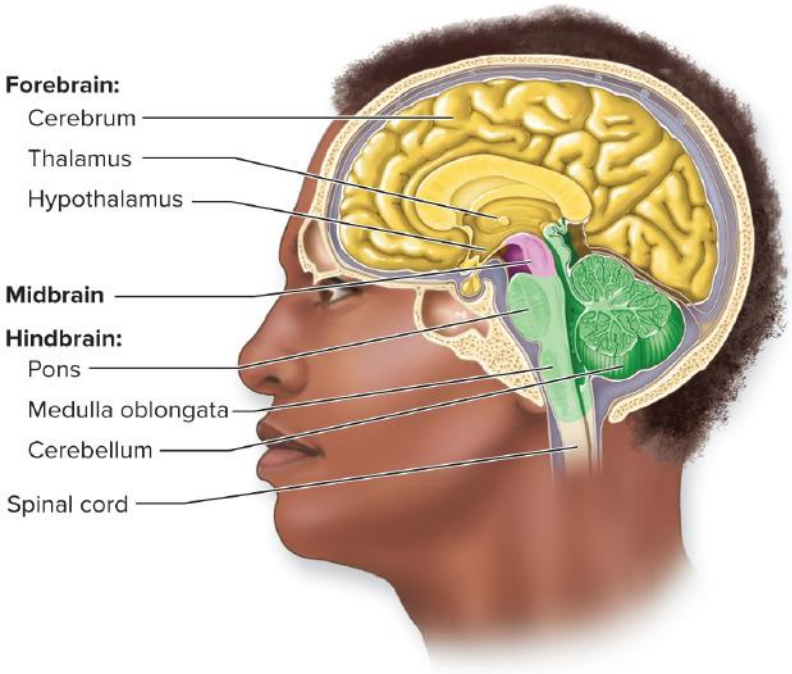


Section 26.6

Figure 26.14

The meninges and cerebrospinal fluid

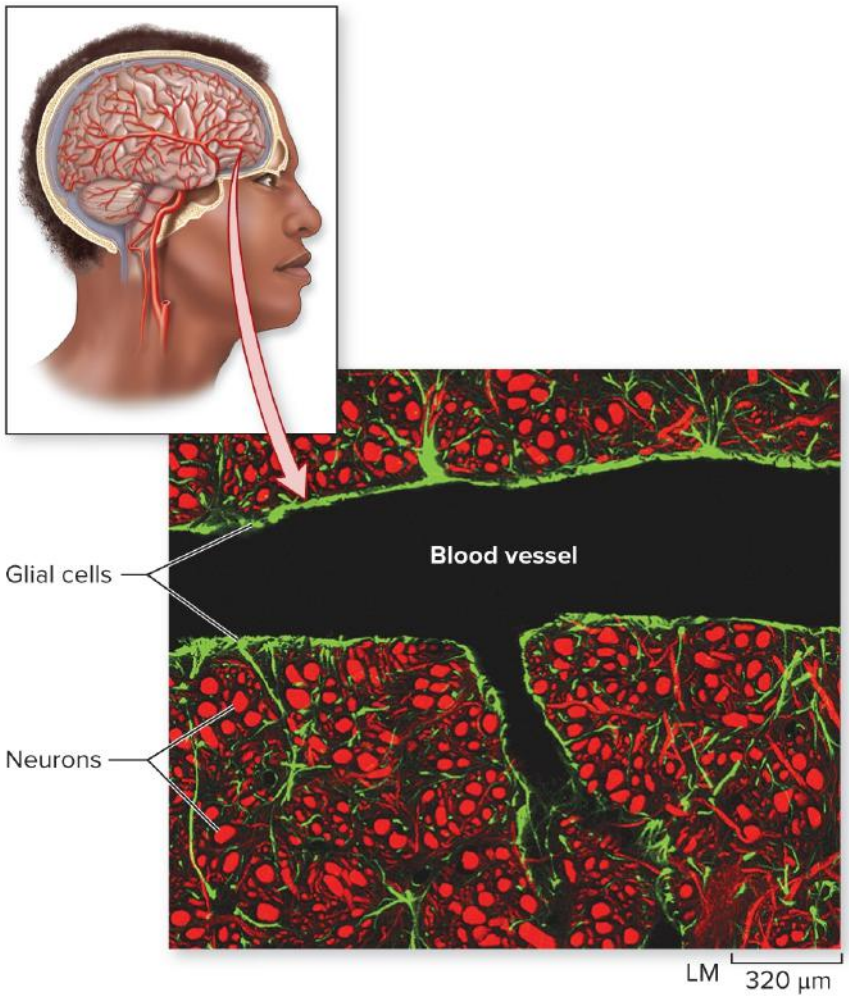
The CNS is surrounded by **meninges,** layered membranes that help protect it. **Cerebrospinal fluid** bathes and cushions the brain and spinal cord.



Section 26.6

Figure 26.14

The blood-brain barrier

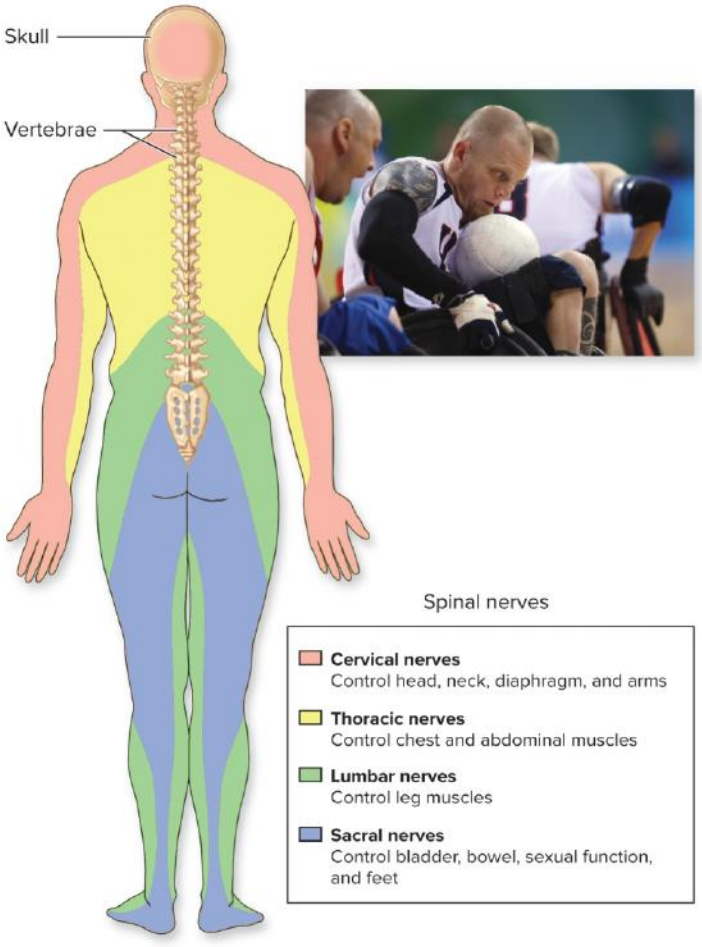


©C.J. Guerin, PhD, MRC Toxicology Unit/Science Source

The **blood-brain** barrier protects the brain from extreme chemical fluctuations.

Damage to the CNS can be devastating

Although these protections require energy to produce and maintain, their benefit exceeds their cost. Damage to the CNS can be devastating.



©Natalie Behring/Getty Images

Clicker question #4

How many of the following items are part of the central nervous system?

sensory neurons, spinal cord, cerebrum, sympathetic nervous system, brainstem, motor neurons

A. one
B. two
C. three
D. four
E. five

Clicker question #4, solution

How many of the following items are part of the central nervous system?

sensory neurons, spinal cord, cerebrum, sympathetic nervous system, brainstem, motor neurons

C. three

26.6 Mastering concepts

©Henrik Sorensen/Riser/Getty Images

What are the parts and functions of the cerebral cortex?

Investigating life:

Scorpion stings don’t faze grasshopper mice

Scorpion venom causes intense pain in many mammals, including humans and most rodents. However, grasshopper mice are an exception.

Photo by Ashlee and Matthew Rowe

Investigating life:

The effects of scorpion venom on lab mice vs. grasshopper mice

Researchers injected scorpion venom or a control solution into the hind paws of typical lab mice and of grasshopper mice.

Photo by Ashlee and Matthew Rowe

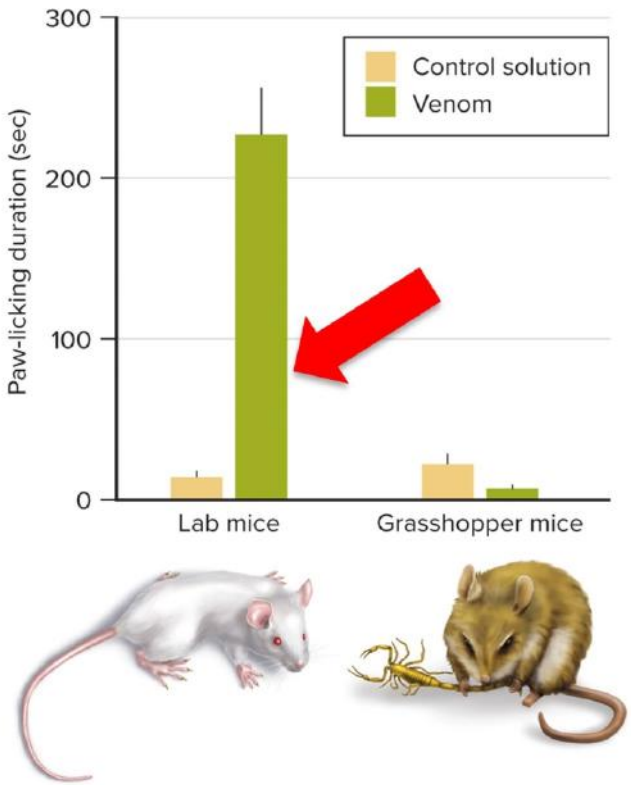
Section 26.7

Figure 26.20

Investigating life:

Scorpion venom has little effect on grasshopper mice

The lab mice licked a venom-injected paw far more vigorously than they did a control paw, an indication of pain. But venom did not induce the paw-licking behavior in grasshopper mice.



Section 26.7

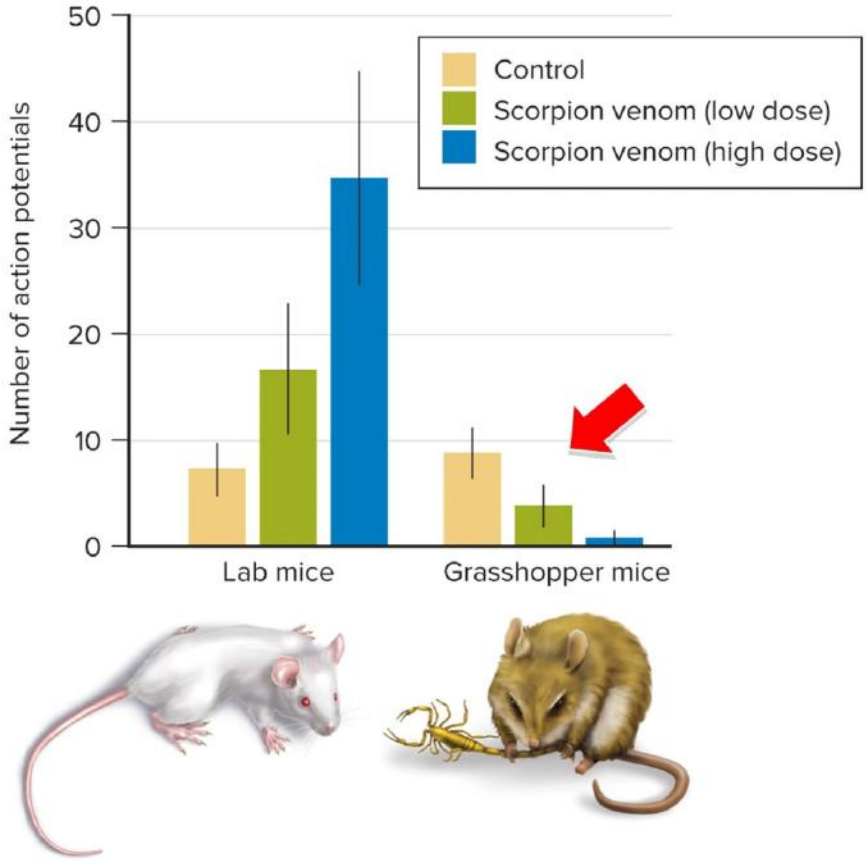
Figure 26.21

Investigating life:

Scorpion venom inhibits action potentials in the pain receptors of grasshopper mice

In a lab mouse, scorpion venom causes sodium channels in pain receptor cells to open and the mouse feels pain.

A grasshopper mouse has unique, specialized sodium channels that do not open when the mouse is bitten. Therefore, the grasshopper mouse does not feel pain.



Section 26.7

Figure 26.22