Nervous Systems 28

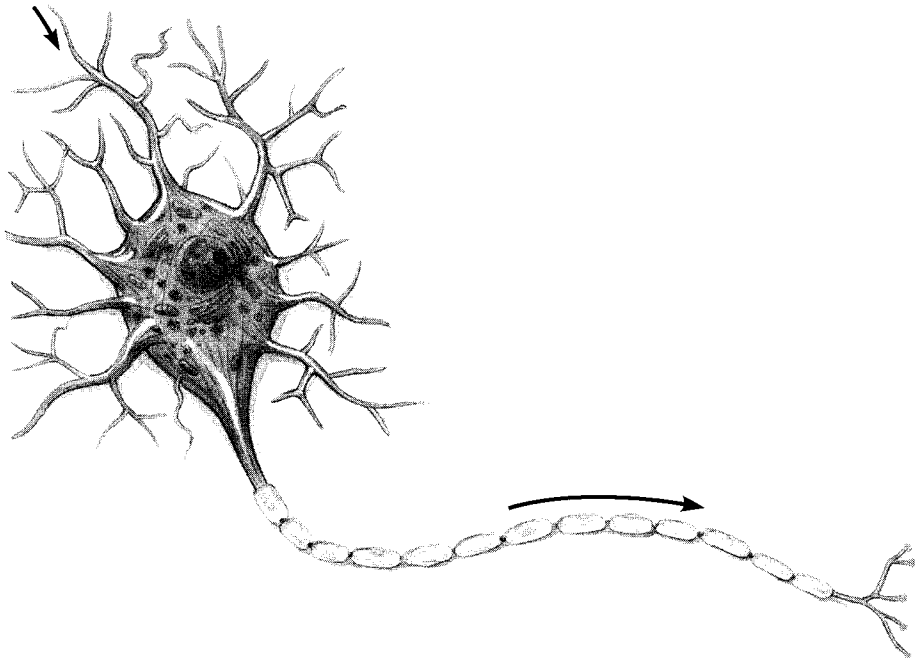
As your eyes scan these words, the light and dark patterns printed on the page stimulate light-sensitive cells in your eyes. Changes occur in the membranes of nerve cells in the optic nerve, causing ions to pass in and out of the cells. The changes are transmitted like waves along the nerve cells all the way to visual areas in the back of the brain, in the cerebral cortex. In association areas of the cortex, these words are interpreted, compared with images and memories, and perhaps stored in memory themselves. At the end of each line of text, the brain's motor cortex sends nerve impulses to tiny muscles to move the eyes back to the beginning of the next line. At the same time, other areas of the brain monitor body temperature and blood pressure. They send impulses out by way of the spinal cord to your heart, blood vessels, and sweat glands to maintain homeostasis. In this way, your nervous system senses the environment, interprets it, and directs responses to your muscles and glands. Your nervous system will enable you to read and understand Chapter 28, which is all about nervous systems.

Organizing Your Knowledge

Exercise 1 (Module 28.2)

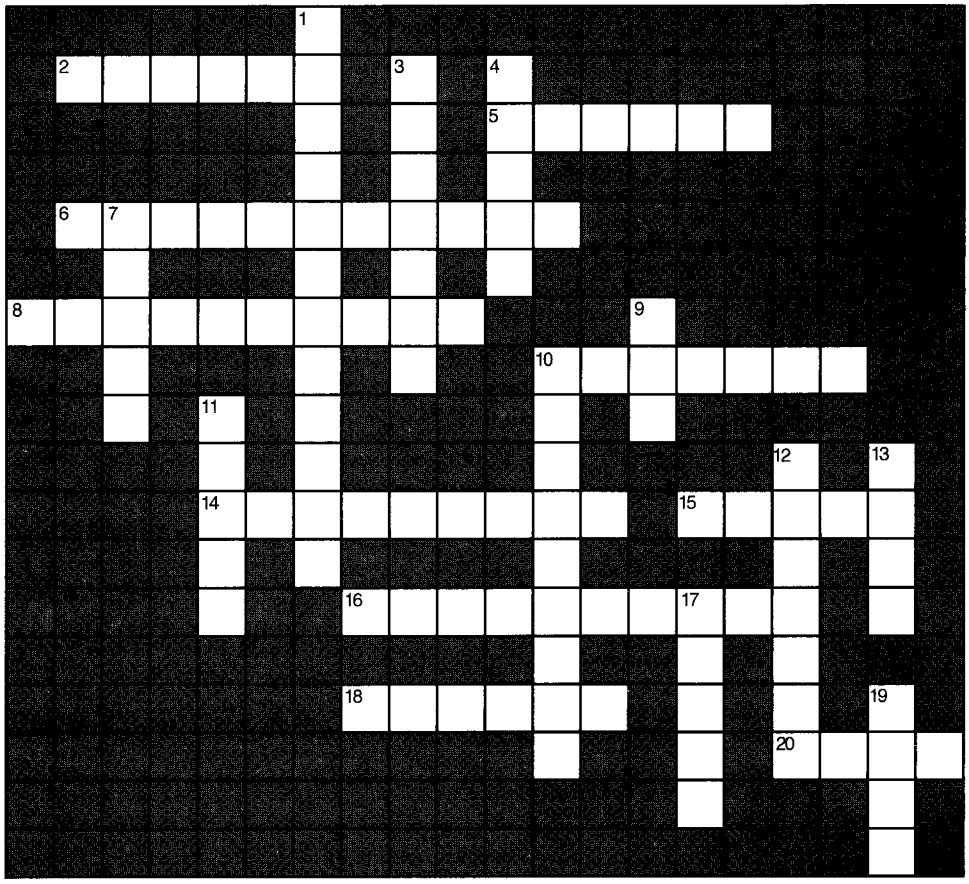
Web/CD Activity 28A *Neuron Structure*

Review the structure of a neuron by labeling and coloring this diagram. Label the **cell body, axon, myelin sheath, dendrites, synaptic knobs,** and a **node of Ranvier.** Color the dendrites green, the cell body blue, the axon red, and the myelin sheath yellow.



Exercise 2 (Modules 28.1 - 28.2)

These modules describe the structures and functions of nervous systems and neurons. Review them by completing this crossword puzzle.



Across

2. A ____ is a cell specialized for carrying signals.
5. Motor ____ is conduction of signals from integration centers to effectors.
6. ____ is the interpretation of sensory signals and formulation of responses.
8. The ____ nervous system (PNS) consists of nerves outside the CNS.
10. ____ neurons carry information from sensory receptors in the CNS.
14. ____ receive messages and carry them to the neuron cell body.
15. The CNS consists of the ____ and spinal cord.
16. Nervous systems consist of neurons and ____ cells.
18. A ____ sheath insulates a neuron.
20. The ____ carries signals toward another neuron or an effector.

Down

1. ____ in the central nervous system integrate data.
3. The ____ nervous system is abbreviated "CNS."
4. ____ neurons carry signals from the CNS to effectors.
7. A ____ is a bundle of neuron extensions wrapped in connective tissue.
9. Interneurons are entirely within the ____.
10. The myelin sheath is destroyed in multiple ____.
11. Signals go faster when they jump along a neuron, between ____ of Ranvier.
12. ____ are clusters of cell bodies belonging to neurons making up a nerve.
13. A synaptic ____ at the end of an axon signals another cell.
17. Sensory ____ is conduction of signals from sensory receptors to the brain.
19. The nucleus of a neuron is in the cell ____.

Exercise 3 (Modules 28.3 – 28.5)

Web/CD Activity 28B *Nerve Signals: Action Potentials*

How do neurons carry signals? What exactly is a nerve signal? These three modules explain how nerve cells transmit nerve signals, which are called action potentials. Number in sequence each of the following steps (A–E) in the generation and transmission of a nerve signal. Then match each of the steps with an explanation (P–T).

Sequence	*Explanation*	
_____	_____	A. Action potential occurs
_____	_____	B. Resting potential
_____	_____	C. Stimulus affects neuron
_____	_____	D. Action potential propagates along axon
_____	_____	E. Cell repolarizes

P. Na^+-K^+ pump moves Na^+ out of cell, K^+ into cell; K^+ leaks out but Na^+ can't get in. Membrane is + outside and – inside.
Q. Na^+ channels open, Na^+ leaks into cell, and cell depolarizes a bit; membrane becomes somewhat less + outside and less – inside.
R. Na^+ spreads out and causes adjacent area of membrane to depolarize.
S. Na^+ channels close, K^+ channels open, and K^+ leaves cell. Membrane becomes + outside and – inside.
T. Threshold reached and more Na^+ channels open, allowing Na^+ to rush into cell. Membrane becomes + inside and – outside.

Exercise 4 (Module 28.6)

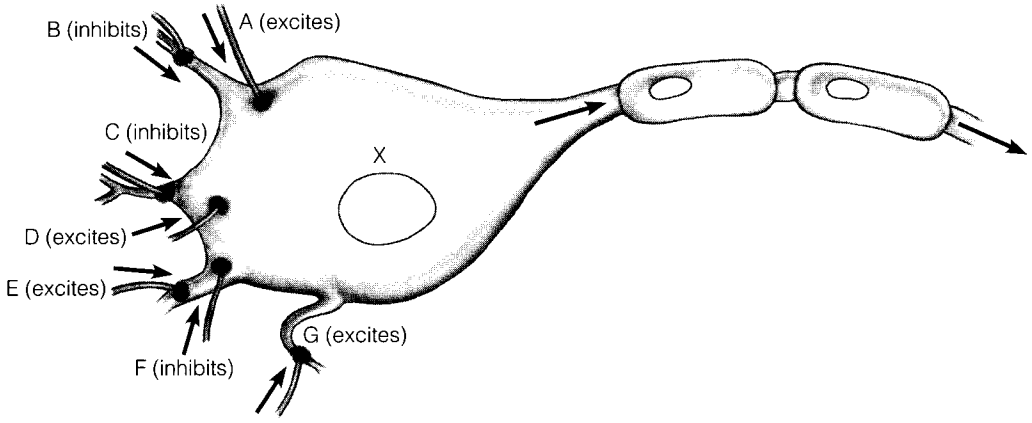
Web/CD Activity 28C *Neuron Communication*

Synapses are relay points where nerve impulses are transmitted from one neuron to another or from a neuron to an effector cell. The following paragraph describes how this occurs. Complete the description by filling in the blanks.

Synapses are junctions between [1]_____. Some are [2]_____ synapses, where action potentials pass from one neuron to the next. Most are chemical synapses, where chemical signals called [3]_____ pass between neurons. A transmitting neuron and a receiving neuron are separated by a narrow gap, called the synaptic [4]_____. Neurotransmitter is contained in small vesicles in the synaptic knobs at the end of the [5]_____ of the transmitting cell. When an action potential arrives at the end of the transmitting cell's axon, chemical changes occur that cause the vesicles to fuse with the [6]_____. The neurotransmitter molecules are released into the synaptic cleft, rapidly diffuse across the cleft, and bind to [7]_____ molecules in the plasma membrane of the [8]_____. This opens ion [9]_____ in the receiving cell's membrane, allowing ions to diffuse through the membrane and initiating new [10]_____ in the receiving cell. The neurotransmitter is quickly broken down by an [11]_____ or transported back into the signaling cell, and the ion channels close. This ensures that the transmission of a signal from cell to cell will be brief and precise.

Exercise 5 (Module 28.7)

Some neurotransmitters cause receiving cells to transmit signals, and other neurotransmitters inhibit the receiving cell's transmission of signals. Neuron X, diagrammed below, adds up all the excitatory and inhibitory impulses it receives. This particular neuron transmits its own impulses only when at least *two* neurons send it excitatory impulses at the same time. Each neuron sending it inhibitory impulses can cancel out the effect of one neuron sending excitatory signals. Given the inputs outlined below, state whether neuron X would or would not transmit nerve impulses in each case.



	Neurons Transmitting							
	A	B	C	D	E	F	G	X Transmits? (Y or N)
1.	Y	N	N	Y	Y	Y	N	____
2.	N	Y	N	Y	N	N	Y	____
3.	N	Y	N	Y	Y	N	Y	____
4.	Y	N	N	N	Y	N	N	____
5.	Y	Y	Y	Y	Y	Y	Y	____
6.	N	Y	Y	N	N	Y	N	____
7.	N	N	N	Y	N	N	N	____

Exercise 6 (Modules 28.8 - 28.9)

These modules describe the functions of various neurotransmitters, and the effects of stimulants, depressants, and antidepressants on the nervous system. Imagine a neuron in your brain that transmits impulses to other neurons that elevate mood. This "feel good" neuron transmits when it is stimulated by serotonin from nearby neurons. It is inhibited by GABA from its neighbors. With this in mind, explain how each of the following might affect your mood.

1. Hereditary shortage of serotonin

2. A drug, such as alcohol, that enhances the effects of GABA

3. A drug that stimulates serotonin receptors

4. A chemical that blocks the enzymes that normally break down GABA after it has docked with receptors in the receiving neuron

5. A drug that blocks receptors so that they cannot respond to GABA

6. A drug that blocks the enzymes that normally break down serotonin after it has docked with receptors in the receiving neuron

7. A drug that enhances the release of serotin by sending cells.

Exercise 7 (Module 28.10)

The nervous systems of radially symmetrical animals are quite different from the nervous systems of animals with bilateral symmetry. Start by defining some terms used to describe nervous systems (question 1), then compare the nervous systems of two invertebrates (questions 2 and 3).

1. Match the descriptive terms on the right with their definitions.

_____ a. concentration of the nervous system at the head end
_____ b. a headless, circular body
_____ c. presence of a central nervous system
_____ d. a body with a head and tail and left and right sides

A. bilateral symmetry
B. cephalization
C. centralization
D. radial symmetry

2. Which of the four terms might describe a leech?

3. Which of the four terms might describe a cnidarian (*hydra*)?

Exercise 8 (Modules 28.11 - 28.12)

Vertebrate nervous systems vary in complexity, but they all have certain features in common. Write the name of the part or division of the vertebrate nervous system that goes with each of the phrases below.

_____ 1. Master control center

_____ 2. Division of the peripheral nervous system (PNS) that transmits information to the central nervous system (CNS)

_____ 3. Subdivision of the motor division that regulates involuntary activities

_____ 4. Fluid-filled spaces in the brain

_____ 5. Division of the PNS that carries motor impulses from the CNS to effectors

_____ 6. Portion of the motor division that carries motor impulses to skeletal muscles

_____ 7. Myelinated axons and dendrites in the CNS

_____ 8. Fluid that circulates around and through the CNS

_____ 9. All nerves and ganglia outside the brain and spinal cord

_____ 10. Nerve tissue of the brain and spinal cord consisting mainly of cell bodies and dendrites

_____ 11. Brain and spinal cord

_____ 12. Part of the CNS inside the vertebral column

_____ 13. Nerves that carry signals to or from the spinal cord

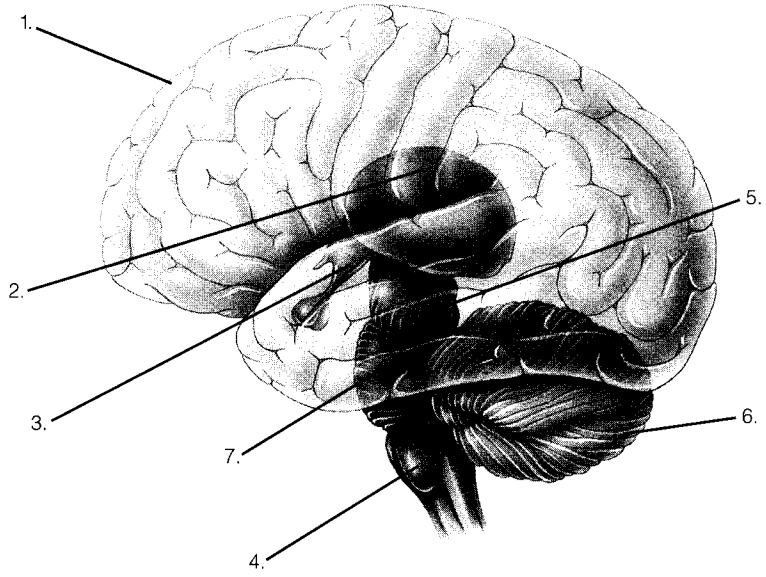
Exercise 9 (Module 28.13)

What is the overall effect of activity of the parasympathetic nervous system on the body? The sympathetic nervous system? One way to keep their actions straight is to remember that the sympathetic system triggers the "fight or flight" response to stress, gearing up the body for action. Effects of the parasympathetic system are best summarized in the phrase "rest and digest." It slows the body down, for the most part, but stimulates the digestive organs. With these effects in mind, see if you can state the effect of each system on the structures in the chart below.

Body Structure	*Parasympathetic Effect*	*Sympathetic Effect*
Stomach	1.	2.
Bronchi (lungs)	3.	4.
Genitals (male)	5.	6.
Heart	7.	8.
Salivary gland	9.	10.
Pupil	11.	12.

Exercise 10 (Modules 28.14 – 28.15)

Name each of the structures identified by numbers on this diagram of the human brain. Then match each structure or area with its function (A–G).



		Function
A. Coordinates movement	1. _____	_____
B. Controls breathing	2. _____	_____
C. Visual reflexes, integrates auditory data	3. _____	_____
D. Controls breathing, circulation, swallowing, and digestion	4. _____	_____
E. Memory, learning, speech, emotions	5. _____	_____
F. Sorts input and output to and from cerebrum	6. _____	_____
G. Body temperature, hunger, thirst, sex, body clock	7. _____	_____

Exercise 11 (Modules 28.15 – 28.20)

These modules outline activities of various parts of the cerebrum. Review these activities and other aspects of the nervous system by filling in the blanks in the following story.

Liz appeared to be sleeping quietly, but she was dreaming, and her mind was active. Beneath her closed eyelids, her eyes darted back and forth rapidly, showing that she was in a state called [1]_____ sleep. Outside her window, a car squealed around a corner. An area in Liz's [2]_____ triggered arousal, and Liz woke up. She opened her eyes and looked at the clock—3:00 A.M. Then she remembered her dream. She had been riding her bike between two rows of trees as fluffy clouds passed overhead. "That's it! The idea for my art project," she thought. She fumbled for the light switch, grabbed a pencil and sheet of paper from the bookcase, and scribbled *clouds*. As she wrote, the movement of her hand was controlled by the [3]_____ cortex in the [4]_____ lobe of her cerebrum, which sent nerve impulses to the muscles of her arm via [5]_____ neurons. The [6]_____ helped the cerebrum by making the movements smooth and coordinated. Liz clicked off the light and soon went back to sleep.

The next morning, when she saw her scrawled *clouds* note, Liz felt happier and more energized than she had in days. She hadn't realized how the looming deadline for her term art project had been getting her down. (She also didn't realize that the [7]_____ system, a group of centers in the forebrain, was actively involved in shaping these emotion, as well as in learning and memory.) Now she knew what she was going to paint for the project—a design based on clouds! She could picture the painting perfectly in her mind (actually, mostly in the [8]_____ cerebral hemisphere, which specializes in spatial relations and pattern recognition). Liz started to make a mental list of the supplies she would need to do the painting.

In the art department of the campus bookstore, Liz gathered the materials she needed. She tested the texture of several watercolor papers with her fingertips. The nerve impulses from her fingers traveled along [9]_____ neurons to her [10]_____, which transmitted them up to her brain. In the brain, the [11]_____ sorted the sensory impulses and relayed them to Liz's cerebral cortex. The [12]_____ cortex in the [13]_____ lobe of Liz's cerebrum interpreted the nerve impulses from her fingers, inferring from them the textures of the papers. The sensory information from her right hand was sent to the [14]_____ side of the brain, but Liz could check it against her mental image because the nerve impulses were able to cross from one side of the brain to the other via the [15]_____, a thick band of nerve fibers connecting the two cerebral hemispheres.

One of the shelves was empty, and Liz thought the missing paper might be just the one she needed. She read the stock number on the shelf, repeated it to herself a couple of times, and kept the number in her [16]_____-term memory just long enough to ask a clerk whether the store had more in stock. No luck. Liz recalled the paper she had used for a couple of assignments the previous term. This information was stored in [17]_____-term memory, in the form of changes in the [18]_____ of her cerebral cortex. Because she had used the paper several times, repeated nerve impulses caused [19]_____, enhanced responsiveness to an action potential by a receiving neuron. The [20]_____, part of the limbic system, "labeled" the name of the paper for storage in memory and linked it with the emotion of happiness that Liz was feeling. Another limbic system center, the [21]_____, assisted in this memory-formation process, as well as later recall.

Liz found the paper, paints, and a brush that she needed and headed for the checkout line, adding up the prices in her head (actually on the [22]_____ side of her head, because [23]_____ areas in the [24]_____ cerebral hemisphere seem to be primarily responsible for mathematical calculations). The total was a bit more than she had anticipated, and a moment of anxiety about her budget caused Liz's heart and breathing to speed up a bit, under orders from the [25]_____ and [26]_____, two areas of the hindbrain.

With her purchases tucked under her arm, Liz set off for home on her bicycle. She crossed the park and turned onto a bike path flanked by tall maple trees. Fluffy clouds sailed overhead. Liz thought the scene seemed very familiar.

Testing Your Knowledge

Multiple Choice

1. Which of the following best describes an action potential?
   a. flow of electricity along a neuron
   b. passage of ions through the membrane of a neuron
   c. flow of neurotransmitter chemical along a neuron
   d. movement of tiny filaments of protein inside a neuron
   e. change in a neuron so that the inside becomes more negatively charged
2. A part of a neuron that carries signals toward the cell body is called
   a. a nerve.
   b. white matter.
   c. a neurotransmitter.
   d. a dendrite.
   e. an axon.
3. Which of the following maintains resting potential, the difference in electrical charge inside and outside a neuron membrane that enables the cell to transmit a signal?
   a. charges that pull sodium and potassium through the membrane
   b. opening of sodium and potassium channels in the membrane
   c. the myelin sheath, which prevents ions from entering or leaving
   d. transport and leakage of sodium and potassium into and out of the cell
   e. the mutual repulsion of sodium and potassium ions
4. The _____ contains association areas for speech, language, and calculation.
   a. right cerebral hemisphere
   b. medulla oblongata
   c. midbrain
   d. left cerebral hemisphere
   e. cerebellum
5. A stimulus triggers an action potential by
   a. causing sodium ions to leak into the neuron.
   b. triggering the release of neurotransmitter.
   c. causing potassium ions to leak out of the neuron.
   d. activating the sodium-potassium pump.
   e. causing sodium ions to leak out of the neuron.
6. The ____ of a primate, dolphin, or whale is much larger than this brain region in other mammals.
   a. brainstem
   b. hypothalamus
   c. cerebral cortex
   d. limbic sytem
   e. medulla
7. The autonomic nervous system
   a. is the part of the nervous system outside the brain and spinal cord.
   b. controls and coordinates voluntary movements.
   c. regulates the internal environment.
   d. integrates all sensory information from the environment.
   e. consists of the brain and spinal cord.
8. Which of the following correctly matches a part of the brain with its function?
   a. thalamus—responsible for learning and memory
   b. hypothalamus—relays sensory information to cerebrum
   c. cerebrum—controls breathing and circulation
   d. cerebellum—coordinates movements
   e. medulla oblongata—interprets visual information
9. The limbic system is involved in
   a. emotions, memory, and learning.
   b. speech and hearing.
   c. vision.
   d. sleep and wakefulness.
   e. control of heartbeat and respiration.
10. Which of the following is part of the central nervous system?
    a. cranial nerve
    b. spinal nerve
    c. spinal cord
    d. sympathetic nerve
    e. ganglion

Essay

1. Sketch a chemical synapse and use your sketch to explain how a nerve impulse crosses a chemical synapse from the transmitting neuron to the receiving neuron.

2. Compare the functions of the parasympathetic and sympathetic divisions of the autonomic nervous system.
3. Briefly describe three major trends in the evolution of the vertebrate brain.
4. What are the three major functions of nervous systems? How are they illustrated as you answer this question?
5. A neuron can receive inputs from thousands of transmitting neurons, but it can respond in only one of two ways—it can either transmit action potentials or not transmit action potentials. How do transmitting cells signal the receiving cell, and what determines whether the receiving cell will or will not transmit action potentials itself?

Applying Your Knowledge

Multiple Choice

1. The axons of which of the following end in the central nervous system?
   a. motor neurons
   b. sensory neurons
   c. interneurons
   d. a and c
   e. b and c
2. A man was admitted to the hospital suffering from abnormally low body temperature, loss of appetite, and extreme thirst. A brain scan showed a tumor located in the
   a. hypothalamus.
   b. cerebellum.
   c. pons.
   d. right cerebral hemisphere.
   e. corpus callosum.
3. A drug that causes potassium to leak out of a neuron, increasing the positive charge on the outside, would
   a. make it easier to trigger action potentials in the neuron.
   b. cause the cell to release its neurotransmitter.
   c. speed up action potentials traveling the length of the cell.
   d. act as a stimulant.
   e. inhibit transmission of action potentials by the neuron.
4. What is the difference between a neuron and a nerve?
   a. One is sensory in function, the other motor.
   b. Nerves are found only in the central nervous system.
   c. They consist of different numbers of cells.
   d. Neurons are made of white matter, nerves of gray matter.
   e. Neurons are found only in vertebrates.
5. Which of the following animals is *least* cephalized?
   a. clam
   b. ant
   c. flatworm
   d. human being
   e. fish
6. Which of the following includes all the others?
   a. autonomic nervous system
   b. motor division
   c. somatic nervous system
   d. peripheral nervous system
   e. sensory division
7. Alex became so dehydrated while playing tennis that his blood pressure started to drop. His _____ detected the pressure drop and sent signals via _____ to speed up the heart, compensating for the drop in pressure.
   a. hypothalamus . . . parasympathetic neurons
   b. medulla oblongata . . . sympathetic neurons
   c. cerebellum . . . sympathetic neurons
   d. medulla oblongata . . . parasympathetic neurons
   e. cerebellum . . . parasympathetic neurons
8. The gray matter of the cerebral cortex, where most higher-level "thinking" occurs, is composed mostly of
   a. interneuron cell bodies.
   b. myelinated axons of neurons.
   c. sensory neuron cell bodies.
   d. Schwann cells.
   e. motor neuron cell bodies.
9. Which of the following neurons would both receive nerve signals from other neurons and transmit signals to other neurons?
   a. a sensory neuron from the fingertip to the spinal cord
   b. a motor neuron from the spinal cord to the leg
   c. an interneuron in the brain
   d. all of the above
   e. both the sensory and motor neurons

10. Sensory receptors in the ear can detect a whisper or a shout and can transmit nerve signals about these sounds to the brain. How would sensory neurons relay information to the brain about the *loudness* of loud and soft sounds?
    a. The action potentials would travel at different speeds.
    b. The size of action potentials would vary.
    c. The number of action potentials would vary.
    d. The frequency of action potentials would vary.
    e. Action potentials would be routed to different parts of the brain.

Essay

1. Many nervous system drugs and poisons act at synapses. Explain how each of the following would alter the transmission of nerve impulses.
    a. Curare, a substance used on poison arrows by native South Americans, competes with acetylcholine for receptor sites on receiving neurons.
    b. Botulism toxin inhibits the release of acetylcholine.
    c. Diisopropyl fluorophosphate (DF) is used in warfare as a nerve gas. It blocks the enzyme that breaks down acetylcholine after it has crossed the synapse to the receiving neuron.
2. Why is transmission of a nerve signal along a neuron sometimes compared with the toppling of a row of dominoes? How does it differ from the toppling of dominoes?
3. Andrew's back was broken in an auto accident, and he was paralyzed below the shoulders. Explain why he is able to move his arms but not his legs. Like many people with such injuries, Andrew cannot feel his legs, but he does respond when the doctor tests his knee-jerk reflex. Explain how.
4. A victim of a severe head injury may live for years in a "persistent vegetative state"—unconscious but still alive and breathing. Explain how a person can continue to live even though the cerebrum, the largest part of the brain, ceases to function.

Extending Your Knowledge

1. Most adults require about 8 hours of sleep per night, teenagers more than 9 hours. How much do you get? Researchers are beginning to think that sleep deprivation is a major health problem in the United States. It may impair thinking, alertness, attention span, creativity, and judgment. Signs of sleep deprivation include needing an alarm clock to wake up, falling asleep within 5 minutes of going to bed (a well-rested person goes to sleep in 10 to 15 minutes), napping at will, and nodding off at work or in classes. Do you think you might be short of sleep? If you don't think you are getting enough sleep, consider adjusting or lightening your class or work schedule, taking naps, and giving sleep higher priority on your "things to do" list.
2. Have you taken a college psychology course? How do the facts and concepts in this chapter relate to what you learned in psychology? How was the coverage of the nervous system similar in biology and psychology? How did the coverage in the two courses differ? What are some reasons for possible differences?