The Peripheral Nervous System: Efferent Division

Chapter Overview

As one of the major control systems of the body, the CNS transmits impulses through the efferent portion of the peripheral nervous system to the effector organs. The transmitted signal is usually the result of a CNS interpretation of conditions that warrant changes in order to maintain homeostasis. Voluntary and involuntary effector organs are controlled using the somatic and autonomic nervous system respectively. The key to this very precise autonomic control is in the neurotransmitters, acetylcholine and norepinephrine, and the dual innervation by the sympathetic and parasympathetic systems. The somatic nervous system acts through the release of a neurotransmitter at the neuromuscular junction to cause skeletal muscle contractions. The efferent division of the peripheral nervous system is the final link in the CNS control of the body. The actions elicited by the efferent neurons are essential for homeostasis.

Chapter Outline

INTRODUCTION
- The efferent division of the peripheral nervous system is the communication link by which the CNS controls the activities of muscles and glands.
- Cardiac muscle, smooth muscle, most exocrine glands, and some endocrine glands are innervated by the autonomic nervous system.
- Skeletal muscle is innervated by the somatic nervous system.
- Two neurotransmitters—acetylcholine and norepinephrine—are released from efferent neuronal terminals to elicit essentially all the neurally controlled effector organ responses.

AUTONOMIC NERVOUS SYSTEM
An autonomic nerve pathway consists of a two-neuron chain, with the terminal neurotransmitter differing between sympathetic and parasympathetic nerves:
- Each autonomic nerve pathway consists of a two-neuron chain.
- The cell body of the first neuron is located in the CNS.
- Its axon, the preganglionic fiber, synapses with the cell body of the second neuron, which lies within a ganglion outside the CNS.
- The axon of the second neuron, the postganglionic fiber, innervates the effector organ.
- The autonomic nervous system consists of two divisions—the sympathetic and the parasympathetic nervous system.
- Sympathetic nerve fibers originate in the thoracic and lumbar regions of the spinal cord.
- Most sympathetic preganglionic fibers are very short, synapsing within a sympathetic ganglion chain located along either side of the spinal cord.
- Long postganglionic fibers terminate on the effector organs.
- Parasympathetic preganglionic fibers arise from the cranial and sacral areas of the CNS.
- These fibers are long because they do not end until they reach terminal ganglia that lie in or near the effector organs.
- Parasympathetic postganglionic fibers are very short.
• Sympathetic and parasympathetic preganglionic fibers release the same neurotransmitter, acetylcholine (ACh).
• Parasympathetic postganglionic fibers release acetylcholine and are called cholinergic fibers.
• Most sympathetic postganglionic fibers are called adrenergic fibers because they release norepinephrine.
• The terminal branches of autonomic fibers contain numerous swellings, or varicosites, that simultaneously release neurotransmitter over a large area of the innervated organ.
• This diffuse release means whole organs instead of discrete cells are typically influenced by autonomic activity.

The autonomic nervous system controls involuntary visceral organ activities.
• The autonomic nervous system regulates visceral activities normally outside the realm of consciousness and voluntary control, such as circulation, digestion, sweating and pupillary size.
• With the technique of biofeedback, people are provided with a conscious signal regarding visceral afferent information.

The sympathetic and parasympathetic nervous systems dually innervate most visceral organs.
• Most visceral organs are innervated by both sympathetic and parasympathetic nerve fibers.
• Both systems increase the activity of some organs and reduce the activity of others.
• Normally some level of action potential activity exists in both, the sympathetic and the parasympathetic fibers supplying a particular organ.
• This ongoing activity is called sympathetic or parasympathetic tone or tonic activity.
• The sympathetic system promotes responses that prepare the body for strenuous physical activity in the face of emergency or stressful situations.
• This response is typically referred to as a fight-or-flight response.
• The parasympathetic system dominates in quiet, relaxed situations.
• Dual innervation enables precise control over an organ's activity.

• There are several exceptions to the general rule of dual reciprocal innervation; the most notable are the following: (1) Innervated blood vessels receive only sympathetic nerve fibers. The only blood vessels to receive parasympathetic fibers are those supplying the penis and clitoris. (2) Sweat glands are innervated only by sympathetic nerves. The postganglionic fibers of these nerves are unusual because they secrete acetylcholine. (3) Salivary glands are innervated by both autonomic divisions and both stimulate secretion.

The adrenal medulla, an endocrine gland, is a modified part of the sympathetic nervous system.
• The adrenal medulla is considered to be a modified sympathetic ganglion that does not give rise to postganglionic fibers.
• Upon stimulation by the preganglionic fiber the adrenal medulla secretes hormones into the blood.
• The hormones are identical or similar to postganglionic sympathetic neurotransmitters: norepinephrine and epinephrine.

There are several different types of membrane receptor proteins for each autonomic neurotransmitter.
• Responsive tissue cells possess one or more of several different types of plasma membrane receptor proteins for these chemical messengers.
• Two types of acetylcholine receptors have been identified.
• Nicotinic receptors, found in all autonomic ganglia, respond to acetylcholine released from both sympathetic and parasympathetic preganglionic fibers.
• Muscarinic receptors, found on effector cell membranes, bind with acetylcholine released from parasympathetic postganglionic fibers.
• There are two major classes of adrenergic receptors for norepinephrine and epinephrine designated as alpha and beta receptors.
Many regions of the central nervous system are involved in the control of autonomic activities.

- Some autonomic reflexes, such as urination, defecation, and erection, are integrated at the spinal cord level, but all of these spinal reflexes are subject to control by higher levels of consciousness.
- The medulla within the brain stem is the region most directly responsible for autonomic output.
- Centers for controlling cardiovascular, respiratory and digestive activity via the autonomic system are located in the medulla.
- The hypothalamus plays an important role in integrating the autonomic, somatic and endocrine responses that autonomically accompany various emotional and behavioral states.
- Autonomic activity can also be influenced by the frontal association cortex through its involvement with emotional expression characteristic of the individual's personality.

**SOMATIC NERVOUS SYSTEM**

**Motor neurons supply skeletal muscle.**

- Skeletal muscle is innervated by motor neurons, the axons of which constitute the somatic nervous system.
- The cell bodies of these motor neurons are located within the ventral horn of the spinal cord.
- The axon of a motor neuron is continuous from its origin in the spinal cord to its termination on skeletal muscle.
- Motor neuron axon terminals release acetylcholine, which brings about excitation and contraction of the innervated muscle fibers.
- Motor neurons can only stimulate skeletal muscles.

**Motor neurons are the final common pathway.**

- The somatic system is considered to be under voluntary control, but much of the skeletal muscle activity involving posture, balance, and stereotypical movements is subconsciously controlled.
- The cell bodies of the crucial motor neurons may be selectively destroyed by polio virus.

- Amyotrophic lateral sclerosis, Lou Gehrig's disease, is characterized by progressive degeneration and death of motor neurons.

**NEUROMUSCULAR JUNCTION**

Acetylcholine chemically links electrical activity in motor neurons with electrical activity in skeletal muscle cells.

- As an axon approaches a muscle, it divides into many terminal branches and loses its myelin sheath.
- Each of these axon terminals forms a special junction, a neuromuscular junction.
- A single muscle cell, a muscle fiber, is long and cylindrical in shape.
- The axon terminal is enlarged into a knoblike structure, the terminal button.
- The specialized portion of the muscle cell membrane immediately under the terminal button is known as the motor end plate.
- Nerve and muscle cells do not actually come into direct contact at the neuromuscular junction.
- A chemical messenger is used to carry the signal between the neuron terminal and the muscle fiber.
- Propagation of an action potential to an axon terminal triggers the opening of voltage-gated calcium channels in the terminal button.
- Opening the calcium channels permits calcium to diffuse into the terminal button, which in turn causes the release of acetylcholine from several hundred of the vesicles into the cleft.
- The released ACh diffuses across the cleft and binds with specific receptor sites.
- Binding of ACh with these receptor sites induces the opening of chemical messen-ger-gated channels in the motor end plate.
- When ACh triggers the opening of these channels, considerably more sodium moves inward than potassium outward, bringing about a depolarization of the motor end plate.
- This potential change is known as the end-plate potential (EPP).
- It is similar to an EPSP except that the magnitude of an EPP is much larger because (1) more transmitter is released from a terminal button than from a presynaptic knob in response to the action potential; (2) the
motor end plate has a larger surface area and, accordingly, more transmitter receptor sites than a subsynaptic membrane; and (3) many more ion channels are opened in response to the transmitter receptor complex in the motor end plate.

- An EPP is a graded potential.
- The subsequent action potential triggers contraction of the muscle fiber.

**Acetylcholinesterase terminates acetylcholine activity at the neuromuscular junction.**

- The muscle's electrical response is turned off by an enzyme in the motor end plate membrane, acetylcholinesterase (AChE) which inactivates ACh.
- Removal of Ach terminates the EPP so that no more action potentials are initiated.

**The neuromuscular junction is vulnerable to several chemical agents and diseases.**

- The venom of black widow spiders exerts its deadly effect by causing an explosive release of ACh from storage vesicles, the most detrimental consequence of which is respiratory failure.
  - Botulinum toxin exerts its lethal blow by blocking the release of ACh from the terminal in the motor neuron.
  - Death is due to respiratory failure.
  - Curare reversibly binds to the ACh receptor sites on the motor end plate.
  - Unlike ACh, however, curare does not alter membrane permeability, nor is it inactivated by AChE.
  - When sufficient curare is present the person dies of respiratory paralysis.
  - Organophosphates irreversibly inhibit AChE.
  - Death from organophosphates is also due to respiratory paralysis.
  - In the disease myasthenia gravis, a condition characterized by extreme muscular weakness, the body erroneously produces antibodies against its own motor end plate ACh receptors.

**Key Terms**

Acetylcholine (Ach)
Acetylcholinesterase
Adrenal medulla
Adrenergic fibers
Alpha receptors
Amyotrophic lateral sclerosis (ALS)
Autonomic nervous system
Beta receptors
Cholinergic fibers
Dystonias
Endplate potential
Epinephrine (adrenalin)
Motor end plate
Motor neurons
Muscarinic receptors
Myasthenia gravis

Neostigmine
Nervous system
Neuromuscular junction
Nicotinic receptors
Norepinephrine (noradrenalin)
Organophosphates
Parasympathetic nervous system
Parasympathetic tone
Postganglionic fiber
Preganglionic fiber
Somatic nervous system
Sympathetic ganglion chain
Sympathetic nervous system
Sympathetic tone
Terminal button
Terminal ganglia
Review Exercises
Answers are in the appendix.

True/False

____ 1. As the axon approaches a muscle, it divides into many terminal branches and loses its myelin sheath.

____ 2. Nerve and muscle cells occasionally come into direct contact at a neuromuscular junction.

____ 3. A chemical messenger is used to carry the signal between the neuron terminal and the muscle fiber.

____ 4. Propagation of an action potential to the axon terminal triggers the closing of voltage-gated calcium channels in the terminal button.

____ 5. The released ACh diffuses across the cleft and binds with specific receptor sites.

____ 6. The magnitude of an EPSP is much larger than an EPP.

____ 7. The muscle's electrical response is turned on by an enzyme present in the motor end plate membrane which inactivates ACh.

____ 8. Motor neurons can only stimulate skeletal muscles.

____ 9. The cells bodies of the somatic nervous system are located within the lateral horn of the spinal cord.

____ 10. The somatic system is considered to be under voluntary control.

____ 11. In the autonomic nervous system there is a single neuron from the origin in the CNS to the effector organ.

____ 12. Sympathetic nerve fibers originate in the thoracic and lumbar regions of the spinal cord.

____ 13. Short postganglionic fibers terminate on the effector organs.

____ 14. Sympathetic preganglionic fibers arise from the cranial and sacral areas of the CNS.

____ 15. Parasympathetic postganglionic fibers release acetylcholine.

____ 16. Most visceral organs are innervated by both sympathetic and parasympathetic nerve fibers.

____ 17. Both systems increase the activity of some organs and reduce the activity of others.

____ 18. The parasympathetic system promotes responses that prepare the body for strenuous physical activity in the face of emergency or stressful situations.
Fill in the Blank

19. The skeletal muscle is innervated by ____________________.

20. Motor neurons are considered to be the ____________________ since the only way any other part of the nervous system can influence skeletal muscle activity is by acting on these motor neurons.

21. As the axon approaches a muscle, it divides into many terminal branches and loses its myelin sheath. Each of these axon terminals forms a special junction called ____________________.

22. A single muscle cell is called a(n) ____________________.

23. The axon terminal is enlarged into a knoblike structure called a(n) ____________________.

24. The specialized portion of the muscle cell membrane immediately under the terminal button is known as the ____________________.

25. The venom of black widow spiders exerts its deadly effect by causing an explosive release of _______ from the storage vesicles.

26. ________________ exerts its lethal blow by blocking the release of ACh from the terminal button in response to an action potential in the motor neuron.

27. ________________ are a group of chemicals that modify neuromuscular junction activity.

28. One disease known as ________________ is a condition characterized by extreme muscular weakness.

29. The ________________ innervates the effector organ. The _______ synapses with the cell body of the second neuron.

30. Most sympathetic postganglionic fibers are called ________________ because they release noradrenaline.

31. The terminal branches of autonomic fibers contain numerous swellings called ________________.

32. About twenty percent of the adrenal medullary hormone output is norepinephrine, and the remaining eighty percent is the closely related substance ________________.
33. ___________ respond to acetylcholine released from both sympathetic and parasympathetic preganglionic fibers.

34. ___________ are found on effector cell membranes.

Matching
Match the distinguishing feature to the proper division of the autonomic nervous system.

a. sympathetic system
b. parasympathetic system

c. Short cholinergic preganglionic fibers
36. Origin of preganglionic fibers is the brain and sacral region of spinal cord
37. Short cholinergic postganglionic fibers
38. Long adrenergic postganglionic fibers
39. Long cholinergic postganglionic fibers
40. Long cholinergic preganglionic fibers
41. Origin of postganglionic fibers is the terminal ganglia
42. Nicotinic receptors for neurotransmitters
43. This system dominates in emergency “fight or flight” situations
44. Muscarinic receptors for neurotransmitters

Multiple Choice

45. Atropine blocks the effect of
   a. acetylcholine at muscarinic receptors.
   b. acetylcholine at nicotinic receptors.
   c. acetylcholine at beta receptors.
   d. norepinephrine at alpha receptors.
   e. norepinephrine at beta receptors.

46. Curare
   a. causes an explosive release of acetylcholine at the neuromuscular junction.
   b. blocks the effects of acetylcholine at muscarinic receptors.
   c. reversibly binds with acetylcholine receptor sites.
   d. irreversibly inhibits acetylcholinesterase.
   e. blocks the effect of norepinephrine at both beta receptors.

47. Neostigmine
   a. causes an explosive release of norepinephrine at the neuromuscular junction.
   b. blocks the effect of acetylcholine at beta receptors.
   c. irreversibly inhibits acetylcholinesterase.
   d. prolongs the action of acetylcholine at the neuromuscular junction.
   e. blocks the release of acetylcholine at the neuromuscular junction.
48. Botulinum toxin
   a. blocks the release of acetylcholine at the neuromuscular junction.
   b. prolongs the action of acetylcholine at the neuromuscular junction.
   c. blocks the effect of norepinephrine at the alpha receptors.
   d. reversibly binds with acetylcholine receptor sites.
   e. irreversibly inhibits acetylcholinesterase.

49. Salbutamol
   a. activates beta adrenergic receptor sites.
   b. blocks the effect of norepinephrine at beta receptors.
   c. blocks the effect of acetylcholine at nicotinic receptors.
   d. activates the cholinergic receptors.
   e. irreversibly inhibits acetylcholinesterase.

50. Mushroom poison
   a. blocks the effects of norepinephrine at muscarinic receptors.
   b. activates muscarinic receptors.
   c. activates nicotinic receptors.
   d. blocks the effect of norepinephrine at beta receptors.
   e. causes an explosive release of norepinephrine at the neuromuscular junction.

51. Black widow spider venom
   a. blocks the effect of norepinephrine at beta receptors.
   b. activates muscarinic receptors.
   c. activates nicotinic receptors.
   d. causes an explosive release of acetylcholine at the neuromuscular junction.
   e. irreversibly inhibits acetylcholinesterase.

52. Organophosphates
   a. blocks the effect of acetylcholine at alpha receptors.
   b. activates muscarinic receptors.
   c. activates nicotinic receptors.
   d. causes an explosive release of norepinephrine.
   e. irreversibly inhibits acetylcholinesterase.

53. Military nerve gas
   a. irreversibly inhibits acetylcholinesterase.
   b. causes an explosive release of acetylcholine.
   c. blocks the release of acetylcholine at the neuromuscular junction.
   d. reversibly binds with acetylcholine receptor sites.
   e. blocks the release norepinephrine.

54. Cocaine appears to
   a. block the parasympathetic innervation of the heart.
   b. block the sympathetic innervation of the heart.
   c. inhibit acetylcholinesterase.
   d. bind with muscarine.
   e. activate cholinergic acid.
55. The autonomic nervous system is
   a. part of the somatic nervous system.
   b. considered to be the involuntary branch of the efferent nervous system.
   c. part of the efferent division of the peripheral nervous system.
   d. Two of the above are correct.
   e. All of the above are correct.

56. Parasympathetic postganglionic fibers
   a. arise from the ganglion chain located along either side of the spinal cord.
   b. are cholinergic.
   c. secrete norepinephrine.
   d. Both a and b are correct.
   e. Both a and c are correct.

57. All of the following release acetylcholine except
   a. sympathetic preganglionic fibers.
   b. parasympathetic preganglionic fibers.
   c. sympathetic postganglionic fibers.
   d. parasympathetic postganglionic fibers.
   e. alpha motor neurons.

58. The sympathetic nervous system
   a. is always excitatory.
   b. innervates only tissues concerned with protecting the body against challenges from outside.
   c. dominates in fight or flight situations.
   d. is part of the somatic nervous system.
   e. is part of the afferent nervous system.

59. The sympathetic nervous system
   a. is part of the somatic nervous system.
   b. has cholinergic preganglionic and adrenergic postganglionic fibers.
   c. originates in the thoracic and lumbar regions of the spinal cord.
   d. Both b and c are correct.
   e. A, b and c are correct.

60. Which of the following does not characterize the sympathetic nervous system?
   a. It promotes responses that prepare the body for strenuous physical activity.
   b. It is part of the autonomic nervous system.
   c. It has norepinephrine as its postganglionic neurotransmitter.
   d. It is always excitatory (that is, it increases the activity in every tissue it innervates).
   e. It is part of the efferent division of the peripheral nervous system.

61. The parasympathetic nervous system
   a. has long preganglionic fibers that end on terminal ganglia.
   b. dominates in quite, relaxed situations.
   c. releases postganglionic neurotransmitters that binds with muscarinic receptors.
   d. bind with norepinephrine released from sympathetic postganglionic fibers.
   e. More than one of the above are correct.
62. Nicotinic receptors
   a. bind with acetylcholine released from parasympathetic postganglionic fibers.
   b. respond to acetylcholine released from both sympathetic and parasympathetic fibers.
   c. are found primarily in the heart.
   d. bind with norepinephrine released from sympathetic postganglionic fibers.
   e. More than one of the above are correct.

63. The chemical transmitter substance at the neuromuscular junction is
   a. acetylcholine
   b. the same as the transmitter substance at parasympathetic postganglionic nerve endings.
   c. inactivated by organophosphates
   d. More than one of the above are correct.
   e. None of the above are correct.

64. Acetylcholinesterase
   a. is stored in vesicles in the terminal button.
   b. when combined with receptor sites on the motor-end plate bring about an end-plate potential.
   c. is inhibited by organophosphates.
   d. More than one of the above are correct.
   e. None of the above are correct.

65. The motor-end plate
   a. contains receptor sites that are capable of binding curare.
   b. contains acetylcholinesterase.
   c. experiences an increase in permeability to cations when combined with acetylcholine.
   d. Both b and c are correct.
   e. A, b and c are correct.

66. The neuromuscular junction
   a. is the junction between a motor neuron and a skeletal muscle fiber.
   b. transmits an action potential between a nerve cell.
   c. may produce either an EPSP or an IPSP on the motor end-plate.
   d. Both a and b are correct.
   e. A, b and c are correct.

67. Acetylcholinesterase
   a. is released from the terminal button.
   b. destroys acetylcholine.
   c. is blocked by curare.
   d. Both a and b are correct.
   e. A, b and c are correct.

68. Acetylcholine
   a. is released from the vesicles when an action potential is propagated to the terminal button of a
      motor neuron.
   b. increases the permeability of the motor end-plate to sodium and potassium when combined with
      receptor sites on the motor end-plate.
   c. is the chemical transmitter substance at the neuromuscular junction.
   d. Two of the above are correct.
   e. All of the above are correct.
69. Which of the following chemicals paralyzes skeletal muscle by binding to the acetylcholine receptor?
   a. Black widow spider venom.
   b. Curare
   c. Organophosphates
   d. DDT
   e. Local anesthetics

70. Curare
   a. strongly binds to acetylcholine receptor sites.
   b. inhibits acetylcholinesterase.
   c. is found in pesticides and military nerve gases.
   d. Two of the above are correct.
   e. All of the above are correct.

**Modified Multiple Choice**

*Indicate which part of the autonomic nervous system is being described by writing the letter in the blank using the following code:*

A = sympathetic nervous system  
B = parasympathetic nervous system  
C = both sympathetic and parasympathetic nervous system  
D = neither sympathetic nor parasympathetic nervous systems

71. ______ preganglionic fibers secrete acetylcholine
72. ______ preganglionic fibers secrete norepinephrine
73. ______ postganglionic fibers secrete acetylcholine
74. ______ postganglionic fibers secrete norepinephrine
75. ______ dominates in fight or flight situations
76. ______ dominates in relaxed situations
77. ______ has a long preganglionic fiber and a short postganglionic fiber
78. ______ has a short preganglionic fiber and a long postganglionic fiber
79. ______ originates in the cranial and sacral regions of the CNS
80. ______ originates in the thoracic and lumbar regions of the CNS
81. ______ innervates smooth muscle, cardiac muscle, and exocrine glands
82. ______ innervates skeletal muscle

*Indicate which type of neuron is associated with the characteristic by writing in the appropriate letter in the blank using the following code:*

A = all three types of neurons  
B = both afferent and efferent  
C = afferent neurons  
D = efferent neurons  
E = interneurons

83. ______ has a receptor at its peripheral ending
84. ______ autonomic nerves are this type of neuron
85. ______ lie primarily within the peripheral nervous system
86. ______ lie entirely within the central nervous system
87. ______ carry information from the central nervous system
88. ______ carry information to the central nervous system
89. ______ responsible for thoughts and other higher mental functions
90. ______ alpha motor neurons are this type of neuron
91. ______ terminate on effector organs

Multiple Choice

92. All of the following activities are correctly paired with the division of the autonomic nervous system except
   a. increased heart rate—sympathetic
   b. decreased salivation—sympathetic
   c. constricts skeletal muscles—parasympathetic
   d. stimulates contraction of the bladder wall—parasympathetic
   e. arises rostrally and sacrally—parasympathetic

93. The cell body of the postganglionic fiber of a parasympathetic pathway leading to a seat gland is located in the
   a. sweat gland itself.
   b. vertebral ganglion.
   c. spinal cord.
   d. brainstem.
   e. dorsal root ganglion.

94. A comparison of the components of the autonomic visceral reflex arc with the somatic reflex arc reveals that they differ in the number of
   a. receptors.
   b. afferent neurons.
   c. interneurons.
   d. efferent neurons.
   e. effectors.

95. Reflexes help to control:

   I. Heart rate
   II. Blood pressure
   III. Digestive activities

   a. I only.
   b. II only.
   c. III only.
   d. I and II only.
   e. I, II, and III.
96. If you were to electrically stimulate the parasympathetic nervous system, which of the following would occur?
   a. an erection of the penis
   b. dilation of the pupils
   c. an increased release of glucose by the liver
   d. constriction of the abdominal blood vessels
   e. constriction of the peripheral blood vessels

97. Which of the following does not occur following adrenergic stimulation?
   a. dilation of the pulmonary bronchi
   b. dilation of the pupils
   c. increased heart rate
   d. increased basal metabolism
   e. peristalsis of the GI tract

98. The parasympathetic and sympathetic nervous systems oppose each other in their effects on the
   a. liver.
   b. heart.
   c. skeletal muscles.
   d. sweat glands.
   e. adrenal glands.

99. Stimulation of skeletal muscles by motor neurons is essential for muscles to:
   a. maintain their strength.
   b. induce contraction.
   c. maintain their size.
   d. Both a and b.
   e. A, b and c.

100. One disease known to involve the neuromuscular junction is
    a. myasthenia gravis.
    b. polio
    c. Lou Gerig’s disease
    d. Both a and b.
    e. A, b and c

**Points to Ponder**

1. Why do you think veterinarians find it difficult to diagnose toxic levels of organophosphate pesticides in animals?

2. When the opossum “plays possum,” what is happening physiologically?

3. What is the relationship between biofeedback and the autonomic nervous system?

4. How does the central nervous system cooperate with the autonomic nervous system to maintain your body temperature?
5. Which divisions of the autonomic nervous system prepares a physiology student, such as yourself, for intense muscular activity? Explain.

6. What is meant by the term “dual intervention”?

7. After being in space for long periods of time, why do space travelers have problems walking.

8. If you get bit by a Black Widow spider, what problems might occur in your body?

9. Why is the “fight-or-flight” response necessary for the survival of a physiology student such as yourself?

10. What happens in your body if you take the illegal drug cocaine?

Clinical Perspectives

1. How does epinephrine help a person suffering from an asthma attack?

2. How does epinephrine help a person who has just been stung by a wasp and is hyper-sensitive to bee stings?

3. A patient is accidentally given curare. How would you keep this person alive? Would the same treatment work for an accidental dose of organophosphates?

4. An old antihypertensive drug known as propranolol was widely used because it blocked beta 1 receptors. However, it was discontinued because of its side affects on the respiratory system. What would these affects be?

5. When you get an eye examination, the optometrist or ophthalmologist puts drops of atropine in your eyes. Why? Explain the physiologically and pharmacology behind the action of the eye drops.
Chapter 7: The Peripheral Nervous System: Efferent Division

True/False
1. True
2. False—Cells do not touch neuromuscular joint.
3. True
5. True
7. False—Turned off.
8. True
10. True
11. False—Somatic nervous system.
12. True
15. True
16. True
17. True
18. False—Sympathetic.

Fill in the Blank
19. Motor neurons
20. Common pathway
21. Neuromuscular junction
22. Muscle fiber
23. Terminal
24. Motor end-plate
25. ACh
26. Botulinum toxin
27. Organophosphates
28. Myasthenia gravis
29. Postganglionic fiber, preganglionic fiber
30. Adrenergic fibers
31. Varicosities
32. Epinephrine (adrenaline)
33. Nicotinic receptors
34. Muscarinic receptors
35. a
36. b
37. b
38. a
39. a
40. b
41. b
42. b
43. a
44. b
45. a
46. c
47. d
48. a
49. a
50. b
51. d
52. e
53. a
54. a
55. d
56. b
57. c
58. c
59. d
60. d
61. e
62. b
63. d
64. c
65. e
66. d
67. b
68. e
69. b
70. a
71. c
72. d
73. b
74. a
75. a
76. b
77. b
78. a
79. b
80. a
81. c
82. d
83. c
84. d
85. b
86. a
87. d
88. c
89. e
90. d
91. d
92. c
93. b
94. d
95. e
96. a
97. e
98. b
99. e
100. a