Name _____ **Period** _____

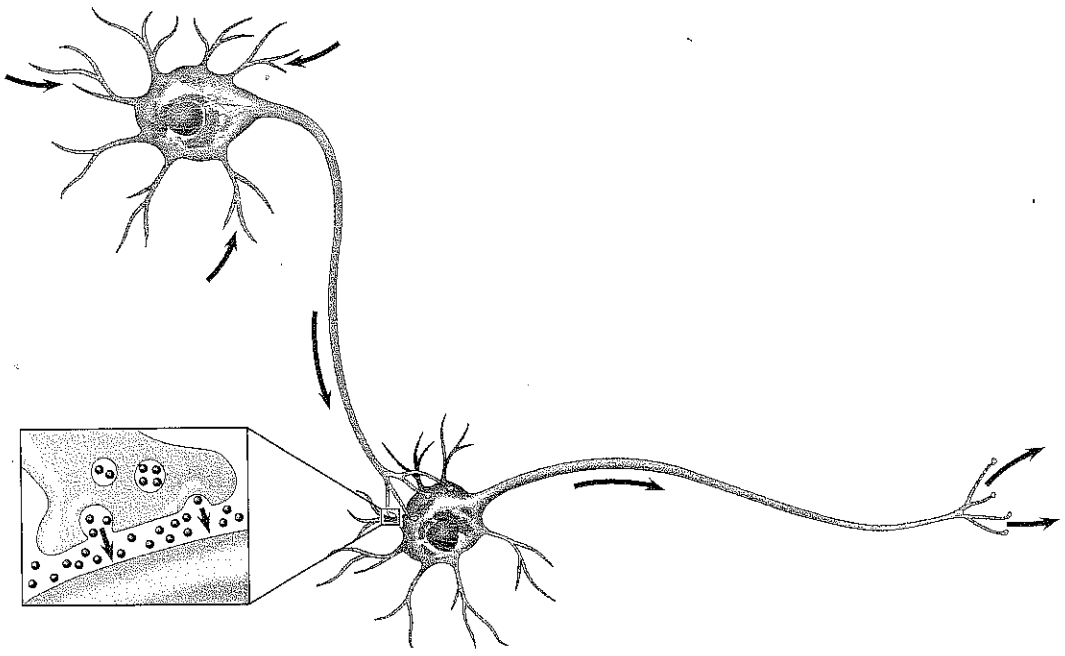
Chapter 48: Neurons, Synapses, and Signaling

This chapter introduces you to neurons and how they function. You will review information you learned about the structure of cell membranes and their embedded proteins as well as signaling molecules and their receptors. Devote careful study time to understanding action potentials and nerve impulse transmission across the synapse. This chapter covers required AP Biology information in several areas, including Essential Knowledge 3.E.2 and LOs 3.43, 3.44, and 3.45.

Concept 48.1 Neuron structure and organization reflect function in information transfer

1. What is a *neuron*?

2. This sketch shows two neurons. Label the following elements of this figure: *cell body, dendrites, axon, synapse, presynaptic cell, postsynaptic cell, synaptic vesicles, synaptic terminal*, and *neurotransmitter*. Be sure you know the function or description of each of these.



3. What is indicated by the red arrows in the main part of the figure you labeled? What do the red spheres in the inset figure represent?

4. What are *glial cells*? What functions do they provide?

5. Neurons can be placed into three groups, based on their location and function. Complete this chart by naming the type of neuron described.

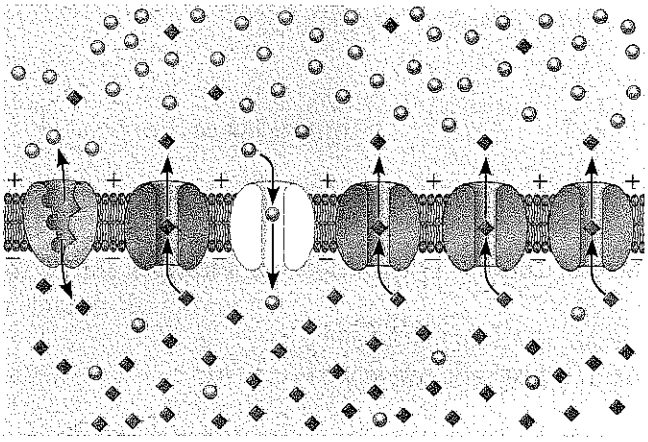
Type of Neuron	Function
	Transmit information *from* a sense receptor to the brain or spinal cord
	Integrate information within the brain or spinal cord; connect sensory and motor neurons; located entirely within the CNS
	Transmit information *from* the brain or spinal cord *to* a muscle or gland; cause muscle contraction or gland secretion

Concept 48.2 Ion pumps and ion channels establish the resting potential of a neuron

In this section you will need to recall information about the structure and function of the plasma membrane. Ions are not able to diffuse freely through the membrane because they are charged, and so must pass through protein channels specific for each ion.

6. All cells have a *membrane potential* across their plasma membrane, measured in mV (millivolts). What is the typical *resting potential* of a neuron?

7. On this sketch, label the following: *outside cell, inside cell, Na^+* and *K^+ ions*. Show where the concentrations of Na^+ and K^+ are highest and label the three proteins imbedded in the membrane.



8. How are the concentration gradients of Na^+ and K^+ maintained?

Concept 48.3 Action potentials are the signals conducted by axons

9. As you see in the previous figure, in a resting neuron, the outside of the membrane is positively charged relative to the inside of the membrane. If positively charged ions flow out of the cell, the difference in charge between the two sides of the membrane becomes greater. What is the increase in the magnitude of the membrane potential called?

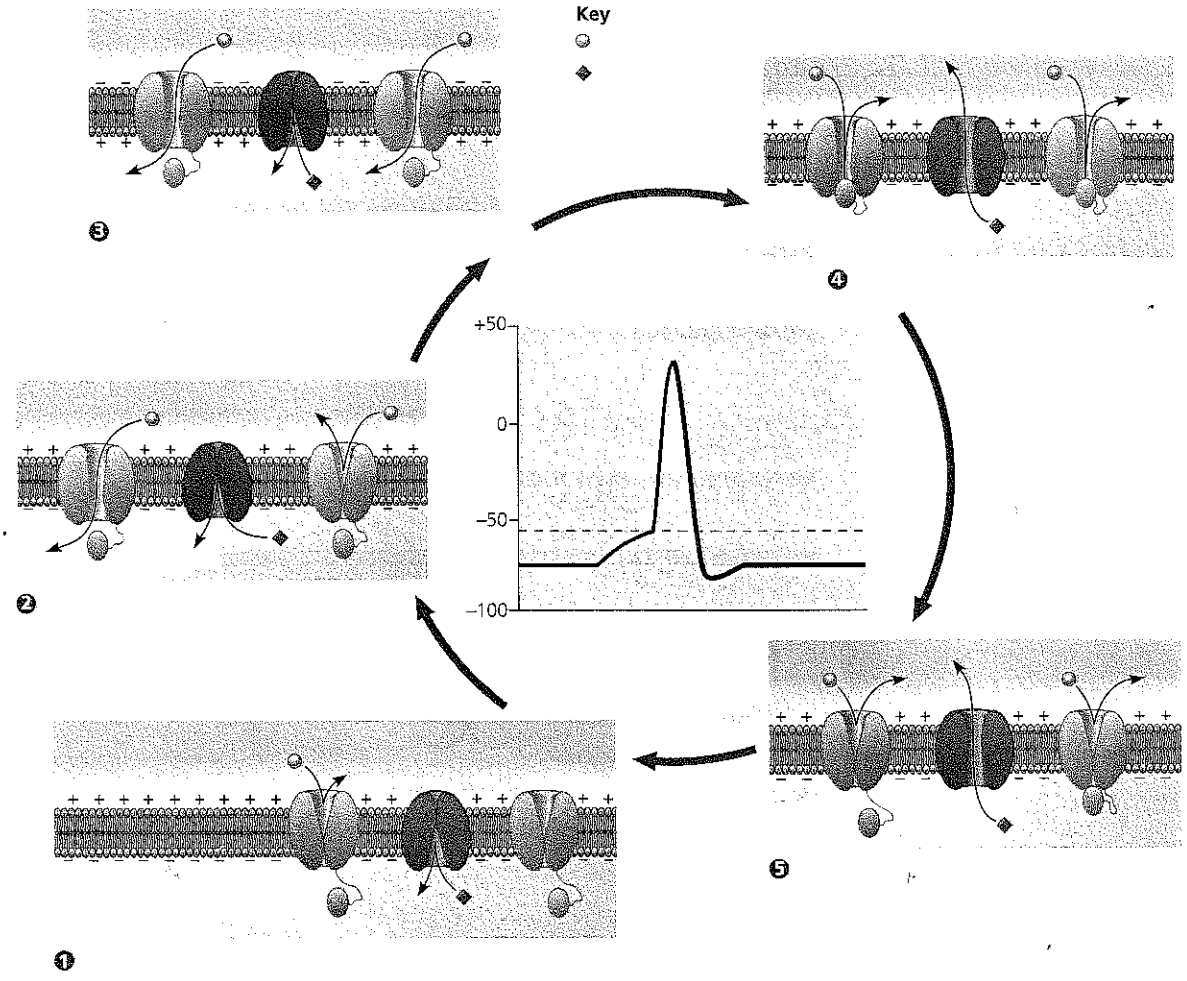
10. *Gated ion channels* open or close in response to stimuli, ions flow across the membrane, and the membrane potential is changed. Describe the change in membrane potential that occurs if Na^+ channels open. What is this decrease in the magnitude of the membrane potential called?

11. When a *stimulus* is applied, ion channels will open. If positively charged ions flow in, the membrane is said to *depolarize*. If depolarization causes the membrane potential to drop to a critical value, a wave of depolarization will follow. What is this critical value called? What is its approximate value in mV?

12. What is the wave of depolarization called?

13. Just like toppling dominoes in a row, either the *threshold* of depolarization will be reached and an *action potential* will be generated, or the threshold will not be reached and no wave will occur. What is this response to a stimulus called?

14. Figure 48.11 in your text contains almost all you need to know about nerve impulse transmission, so it is worth some careful study time. Let's approach it in steps. You will find instructions for this exercise below.



a. Label Na^+, K^+, and their respective *ion channels*.

b. Label the *resting state* figure. Are the Na^+ and K^+ channels open or closed?

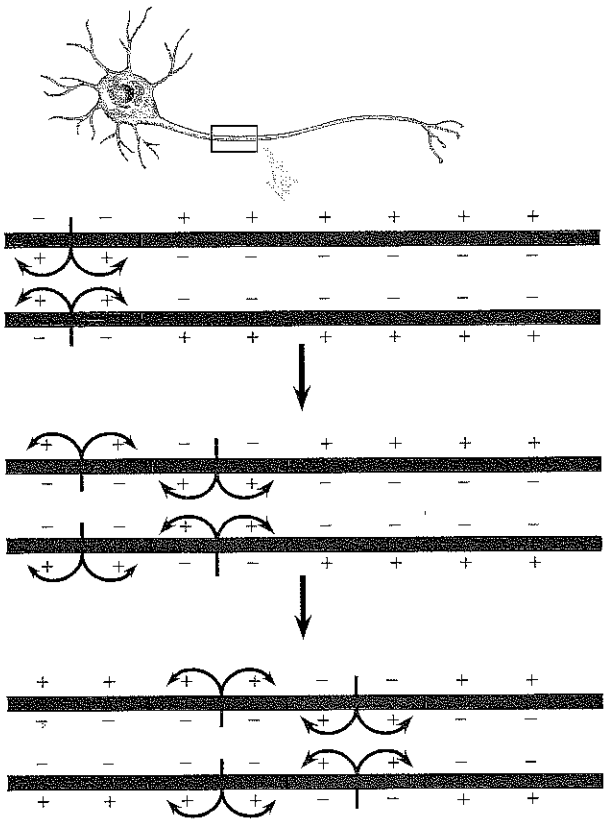
c. Label *depolarization*. What triggers depolarization? What channels open? What occurs if the depolarization threshold is reached?

d. Label Stage 4 in the figure *repolarization*. How is the charge on the membrane reestablished?

e. Label these regions of the graph: x- *and* y-*axes, threshold, resting potential, action potential,* and *repolarization*.

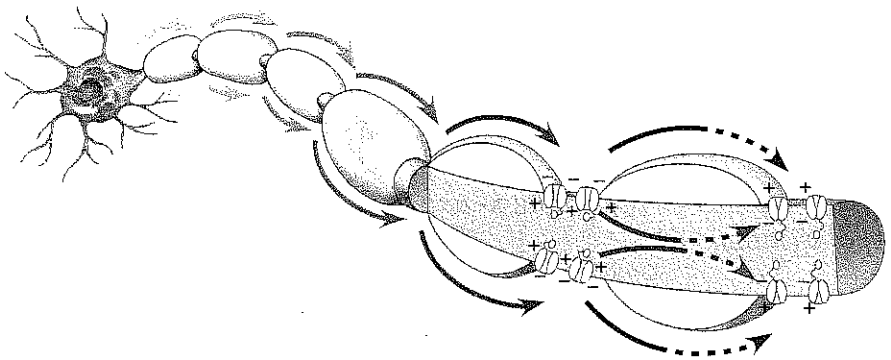
f. Let's see if you really understand this concept. Draw another line on the graph to show what the change in membrane potential would look like if a stimulus were applied that did *not* reach the depolarization threshold.

15. Here is a closer look at what is happening along the membrane as a wave of depolarization (an action potential) travels along the length of the axon. Label the key elements of the figure and, to the side, explain how the action potential is conducted.



16. What are the glial cells that produce *myelin sheath* in the PNS?

17. Label *Schwann cells, axon, myelin sheath, node of Ranvier,* and *ion channel* on the following figure. How does a *myelin sheath* speed impulse transmission? Include a discussion of *saltatory conduction* and *nodes of Ranvier* in your response.



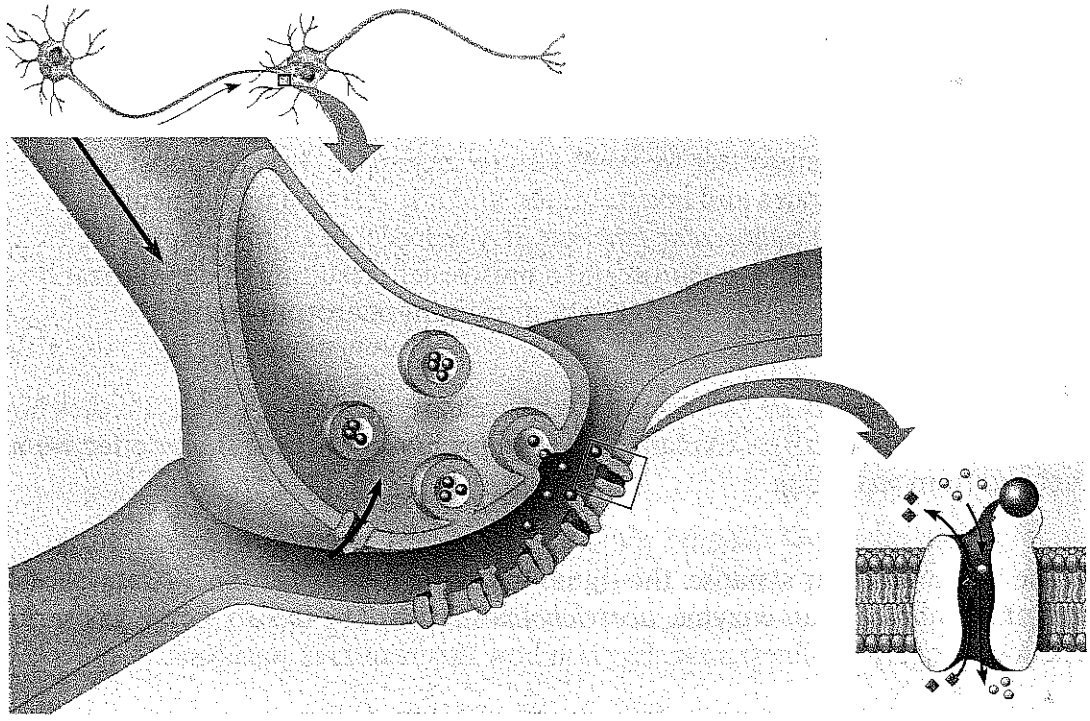
18. In the disease multiple sclerosis, the myelin sheaths harden and deteriorate. How would this affect nervous system function?

***Concept 48.4** Neurons communicate with other cells at synapses*

19. When the wave of depolarization arrives at the synaptic terminal, calcium ion channels open. What occurs to the *synaptic vesicles* as the Ca^{2+} level increases?

20. What is contained within the *synaptic vesicles*?

21. Label the following on the figure: *synaptic vesicle, neurotransmitter, calcium ion channel, presynaptic membrane, postsynaptic membrane*, and *synapse*. Explain what is occurring in the inset box of this figure.



22. Explain how an action potential is transmitted from one cell to another across a synapse by summarizing what is shown above in four steps.

a.

b.

c.

d.

23. There are many different types of neurotransmitters. Each neuron secretes only *one* type of neurotransmitter. Some neurotransmitters *hyperpolarize* the postsynaptic membrane. Are these *excitatory* or *inhibitory* neurotransmitters?

24. Define and explain *summation*. Distinguish between *temporal summation* and *spatial summation.*

25. A single postsynaptic neuron can be affected by neurotransmitter molecules released by many other neurons, some releasing *excitatory* and some releasing *inhibitory* neurotransmitters. What type of summation is this? What will determine whether an action potential is generated in the postsynaptic neuron?

26. Table 48.2 in your text lists several of the major neurotransmitters. You are not expected to know their actions or secretion sites, but you *should* recognize that they are neurotransmitters! Go through the list that follows, and say each term aloud. Put a checkmark by any that you have heard mentioned before: *acetylcholine, epinephrine, norepinephrine, dopamine, serotonin, GABA, glutamate, glycine, substance P, endorphins*, and *nitric oxide*. That's all for this question!

27. There is one neurotransmitter we want you to memorize. It is the most common neurotransmitter in both vertebrates and invertebrates, and it is released by the neurons that synapse with muscle cells at the *neuromuscular junction*. If you look ahead to Chapter 50, Figure 50.30, you will see a synapse between a neuron and a muscle cell, resulting in depolarization of the muscle cell and its contraction. What is this very important neurotransmitter?

28. The toxin that results in botulism prevents release of acetylcholine. Predict how this would affect muscle contraction. Explain how this mechanism makes Botox effective at keeping the forehead from wrinkling.

29. At the neuromuscular synapse, the signal molecule is acetylcholine. Acetylcholine is removed from the synapse by an enzyme, *acetylcholinesterase*. The deadly nerve gas sarin prevents the function of acetylcholinesterase. Explain how this results in paralysis.

Test Your Understanding Answers

Now you should be ready to test your knowledge. Place your answers here:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____

9. What would be the effect of stimulation by the sympathetic nervous system on heart rate?

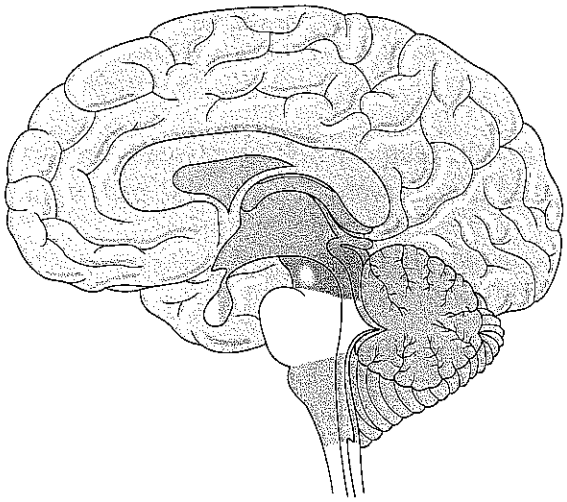
   What would be the effect of stimulation by the parasympathetic nervous system on peristalsis?

10. Concept Check Question 1 in your text asks: Which division of your autonomic nervous system would likely be activated if you learned that an exam you had forgotten about would start in 5 minutes? Explain your answer.

11. Now, take the question above a step further, and describe the specific physiological responses that would occur.

Concept 49.2 The vertebrate brain is regionally specialized

12. Using Figure 49.11 in your text, label the following structures on the figure of the brain, and give a primary function of each labeled structure.



brainstem

a. midbrain

b. pons

c. medulla

cerebrum

cerebellum

thalamus

hypothalamus

pituitary gland