

Assignment 3: The nervous sytem; Chapter 11

Due: 11:59pm on Monday, February 4, 2013

Note: To understand how points are awarded, read your instructor's [Grading Policy](#).

Art-labeling Activity: Figure 11.1

Part A

Drag the appropriate labels to their respective targets.

ANSWER:



Correct

Art-labeling Activity: Figure 11.2

Part A

Drag the appropriate labels to their respective targets.

ANSWER:

Correct

Chapter 11 True/False Question 3

Part A

Efferent nerve fibers may be described as motor nerve fibers.

ANSWER:

- True
 False

Correct

Chapter 11 True/False Question 19

Part A

The autonomic nervous system is under voluntary control; whereas, the somatic nervous system is involuntary.

ANSWER:

True
 False

Correct

Art-labeling Activity: Figure 11.4 (1 of 2)

Part A

Drag the appropriate labels to their respective targets.

ANSWER:



Correct

Art-labeling Activity: Figure 11.4 (2 of 2)

Part A

Drag the appropriate labels to their respective targets.

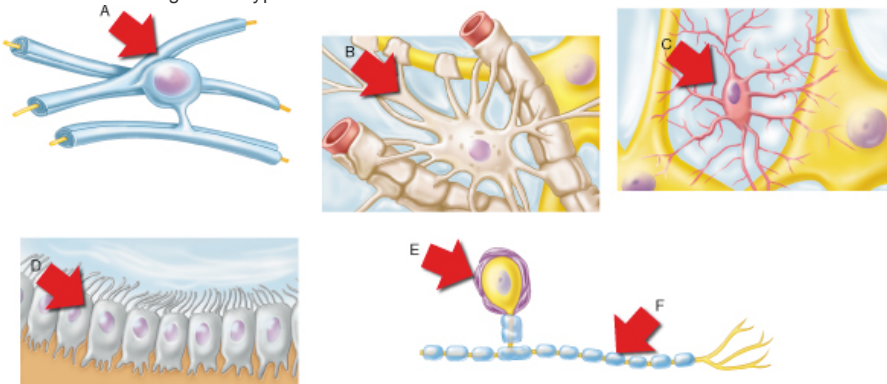
ANSWER:

Correct

Art Question Chapter 11 Question 1

Part A

Which of the neuroglial cell types shown is the most abundant in the CNS?



ANSWER:

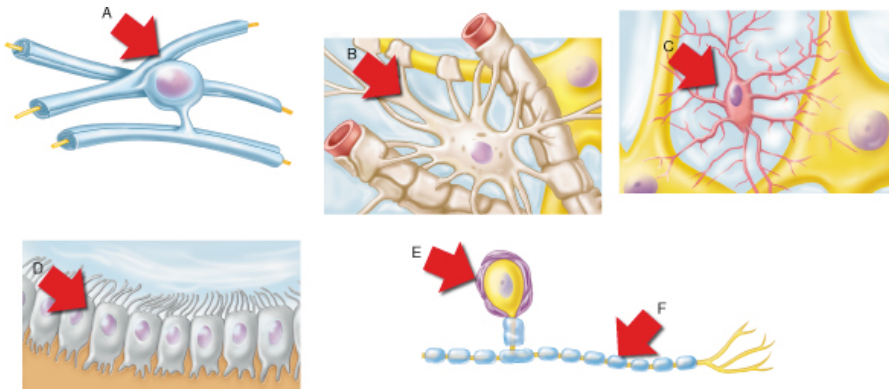
- A
- B
- C
- D
- E

Correct
The astrocytes within the CNS support neurons and anchor them to their nutrient source.

Art Question Chapter 11 Question 2

Part A

Which of the neuroglial cell types shown control the flow of cerebrospinal fluid within the CNS?



ANSWER:

- A
- B
- C
- D

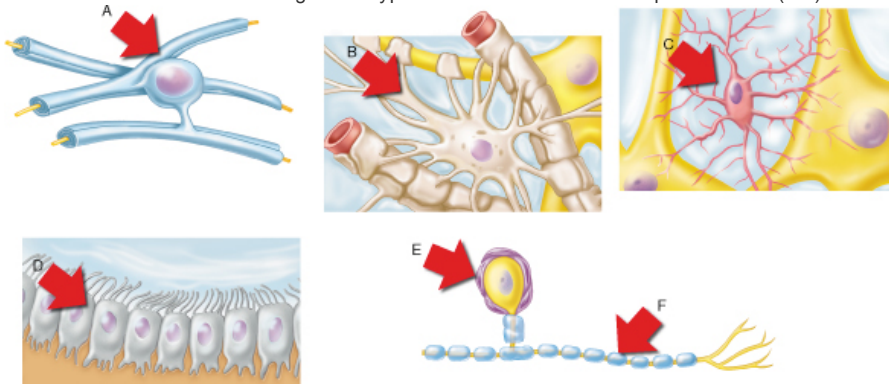
Correct

Ependymal cells line central cavities of the CNS. Much as the cilia of respiratory epithelium moves mucous along the surface of the tissue layer, the cilia of ependymal cells help circulate the cerebrospinal fluid that nourishes and cushions the brain and spinal cord.

Art Question Chapter 11 Question 6

Part A

Destruction of which of the neuroglial cell types leads to the disease multiple sclerosis (MS)?



ANSWER:

- A
- B
- C
- D
- F

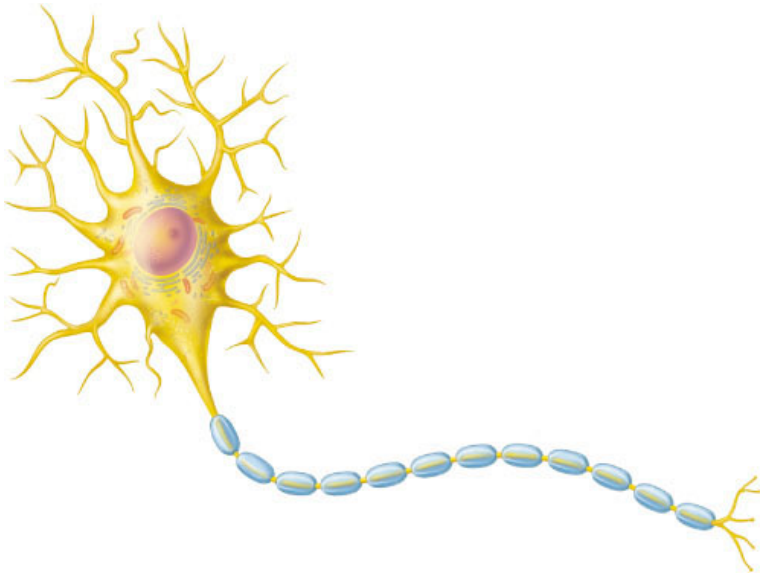
Correct

The defects in nerve transmission associated with MS are caused by a loss of myelin within the CNS. Myelin within the CNS is primarily produced by the oligodendrocytes shown in A.

Art Question Chapter 11 Question 8

Part A

What structural classification describes this neuron?



ANSWER:

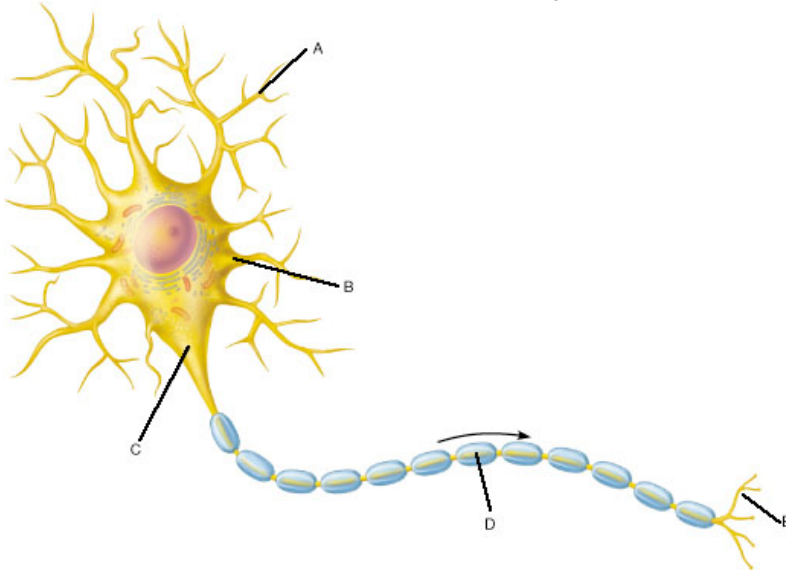
- unipolar
- nonpolar
- bipolar
- multipolar

Correct

The neuron shown has many processes (axons and dendrites) that emerge from the cell body. Such a neuron is described as multipolar and typically functions as a motor neuron or interneuron.

Art Question Chapter 11 Question 9
Part A

Which areas of this neuron would be classified as receptive regions?



ANSWER:

- E only
- D only
- Both A and B
- Both A and E

Correct

The dendrites and soma of the cell receive signals from other neurons.

Chapter 11 Chapter Test Question 3

Part A

Which of the following types of glial cells monitors the health of neurons, and can transform into a special type of macrophage to protect endangered neurons?

ANSWER:

- oligodendrocytes
- astrocytes
- microglia
- ependymal cells

Correct

Microglial cells are small and ovoid with relatively long "thorny" processes. Their processes touch nearby neurons, monitoring their health, and when they sense that certain neurons are injured or are in other trouble, the microglial cells migrate toward them. When invading microorganisms or dead neurons are present, the microglial cells transform into a special type of macrophage that phagocytizes the microorganisms or neuronal debris.

Chapter 11 Chapter Test Question 21

Part A

Unmyelinated fibers conduct impulses faster than myelinated fibers.

ANSWER:

- True
- False

Correct

Myelinated fibers (axons bearing a myelin sheath) conduct nerve impulses rapidly, whereas unmyelinated fibers conduct impulses more slowly. Note that myelin sheaths are associated only with axons; dendrites are always nonmyelinated.

Chapter 11 Reading Quiz Question 3

Part A

Which part of the neuron is responsible for generating a nerve impulse?

ANSWER:

- chromatophilic substance
- soma
- dendrite
- axon

Correct

The axon is the conducting region of the neuron. It generates nerve impulses (action potentials) and transmits them, typically away from the cell body, along the axolemma (cell membrane of the axon).

Chapter 11 Homeostatic Imbalance Question 1

Part A

Cold sores on the skin of the mouth occur when herpes simplex viruses that are dormant in neural ganglia become active and travel to the skin of the mouth. Which of the following is the mechanism by which these viruses travel from the ganglia (located within the head) to the skin of the mouth?

ANSWER:

- transport along nerve impulses that travel down the axons
- anterograde transport
- retrograde transport
- travel of the viruses along neurofibrils

Correct

Chapter 11 True/False Question 5**Part A**

Myelination of the nerve fibers in the central nervous system is the job of the oligodendrocyte.

ANSWER:

- True
- False

Correct

A&P Flix: Propagation of an Action Potential

Watch the animation, then answer the questions below.

Part A

What type of conduction takes place in unmyelinated axons?

Hint 1. Conduction speed

Recall that axons may be myelinated or unmyelinated. The speed of action potential conduction is increased with myelin, as action potentials are regenerated at nodes of Ranvier only. In contrast, action potentials are regenerated at each and every segment of an unmyelinated axon, and the speed of conduction is slowed.

ANSWER:

- Synaptic transmission
- Continuous conduction
- Electrical conduction
- Saltatory conduction

Correct

Yes! An action potential is conducted continuously along an unmyelinated axon from its initial segment to the axon terminals. The term continuous refers to the fact that the action potential is regenerated when voltage-gated Na^+ channels open in every consecutive segment of the axon, not at nodes of Ranvier.

Part B

An action potential is self-regenerating because _____.

Hint 1. Voltage-gated Na^+ channels

An action potential is generated when a stimulus opens voltage-gated Na^+ channels. Na^+ diffuses into the axon, and the plasma membrane depolarizes.

ANSWER:

- repolarizing currents established by the efflux of K^+ flow down the axon and trigger an action potential at the next segment
- repolarizing currents established by the efflux of Na^+ flow down the axon and trigger an action potential at the next segment
- depolarizing currents established by the influx of Na^+ flow down the axon and trigger an action potential at the next segment
- depolarizing currents established by the influx of K^+ flow down the axon and trigger an action potential at the next segment

Correct

Yes! The Na^+ diffusing into the axon during the first phase of the action potential creates a depolarizing current that brings the next segment, or node, of the axon to threshold.

Part C

Why does regeneration of the action potential occur in one direction, rather than in two directions?

Hint 1. Refractoriness and the Voltage-gated Na^+ channel

An action potential is initiated by the opening of voltage-gated Na^+ channels. Depolarizing currents established by the influx of Na^+ flow in both directions. However, only the node, or segment, located away from the origin of the action potential will fire. The node, or segment, located nearer to the origin of the action potential will not fire because it is refractory to another stimulus. This phenomenon is caused by the behavior of the voltage-gated Na^+ channel.

ANSWER:

- The activation gates of voltage-gated K^+ channels open in the node, or segment, that has just depolarized.
- The inactivation gates of voltage-gated K^+ channels close in the node, or segment, that has just fired an action potential.
- The activation gates of voltage-gated Na^+ channels close in the node, or segment, that has just depolarized.
- The inactivation gates of voltage-gated Na^+ channels close in the node, or segment, that has just fired an action potential.

Correct

Yes! At the peak of the depolarization phase of the action potential, the inactivation gates close. Thus, the voltage-gated Na^+ channels become absolutely refractory to another depolarizing stimulus.

Part D

What is the function of the myelin sheath?

Hint 1. The myelin sheath

The myelin sheath consists of tightly wrapped coils of neuroglial cell membrane. Oligodendrocytes myelinate axons in the CNS, whereas Schwann cells myelinate axons in the PNS.

ANSWER:

- The myelin sheath decreases the resistance of the axonal membrane to the flow of charge.
- The myelin sheath increases the speed of action potential conduction from the initial segment to the axon terminals.
- The myelin sheath increases the insulation along the entire length of the axon.
- The myelin sheath decreases the speed of action potential conduction from the initial segment to the axon terminals.

Correct

Yes! The myelin sheath increases the velocity of conduction by two mechanisms. First, myelin insulates the axon, reducing the loss of depolarizing current across the plasma membrane. Second, the myelin insulation allows the voltage across the membrane to change much faster. Because of these two mechanisms, regeneration only needs to happen at the widely spaced nodes of Ranvier, so the action potential appears to jump.

Part E

What changes occur to voltage-gated Na^+ and K^+ channels at the peak of depolarization?

Hint 1. Voltage-gated channels

Voltage-gated channels open in response to changes in the membrane potential. When the potential reaches threshold, both voltage-gated Na^+ and K^+ channels will open. Voltage-gated Na^+ channels open swiftly, while voltage-gated K^+ channels open with a slight delay. Similarly, voltage-gated Na^+ channels close rapidly, while voltage-gated K^+ channels close rather slowly.

ANSWER:

- Activation gates of voltage-gated Na^+ channels close, while inactivation gates of voltage-gated K^+ channels open.
- Inactivation gates of voltage-gated Na^+ channels close, while inactivation gates of voltage-gated K^+ channels open.
- Activation gates of voltage-gated Na^+ channels close, while activation gates of voltage-gated K^+ channels open.
- Inactivation gates of voltage-gated Na^+ channels close, while activation gates of voltage-gated K^+ channels open.

Correct

Yes! Closing of voltage-gated channels is time dependent. Typically, the inactivation gates of voltage-gated Na^+ channels close about a millisecond after the activation gates open. At the same time, the activation gates of voltage-gated K^+ channels open.

Part F

In which type of axon will velocity of action potential conduction be the fastest?

Hint 1. Axons and speed

Two characteristics of the axon influence the speed of conduction: axon diameter and the presence of myelin. Greater diameters offer less resistance to current flow within the cytoplasm. The myelin sheath insulates the plasma membrane, allowing the voltage to change faster and further down the membrane. Both of these characteristics allow depolarizing current to flow farther and faster.

ANSWER:

- Unmyelinated axons with the largest diameter
- Myelinated axons with the largest diameter
- Myelinated axons with the smallest diameters
- Unmyelinated axons of the shortest length

Correct

Yes! The large diameter facilitates the flow of depolarizing current through the cytoplasm. The myelin sheath insulates the axons and prevents current from leaking across the plasma membrane.

A&P Flix: Resting Membrane Potential

Watch the animation, then answer the questions below.

Part A

Ions are unequally distributed across the plasma membrane of all cells. This ion distribution creates an electrical potential difference across the membrane. What is the name given to this potential difference?

Hint 1. Electrical potential difference

All cells exhibit an electrical potential difference across their plasma membranes. Only excitable cells can alter this difference by generating action potentials. Thus, an excitable cell, like a neuron, exhibits both a resting and an excited state.

ANSWER:

- Threshold potential
- Resting membrane potential (RMP)
- Positive membrane potential
- Action potential

Correct

Yes! The resting membrane potential is the baseline potential that can be recorded across the plasma membrane of an excitable cell prior to excitation.

Part B

Sodium and potassium ions can diffuse across the plasma membranes of all cells because of the presence of what type of channel?

Hint 1. Movement of sodium and potassium ions

There are several means by which Na^+ and K^+ can move across plasma membranes. One channel type that occurs in all cells allows Na^+ and K^+ to passively move across the plasma membrane.

ANSWER:

- Sodium-potassium ATPases
- Voltage-gated channels
- Ligand-gated channels
- Leak channels

Correct

Yes. Leak channels for Na^+ and K^+ are ubiquitous, and they allow for the diffusion of these ions across plasma membranes.

Part C

On average, the resting membrane potential is -70 mV. What does the sign and magnitude of this value tell you?

Hint 1. Separation of charge

Electrical charges are unequally distributed across the plasma membrane, creating an electrical potential difference, or voltage, at any two points across the membrane. The two points of interest are (1) just inside the plasma membrane and (2) just outside the plasma membrane. The difference is measured using a voltmeter. The voltmeter has two electrodes: (1) a recording electrode and (2) a reference electrode.

ANSWER:

- The inside surface of the plasma membrane is much more positively charged than the outside surface.
- The inside surface of the plasma membrane is much more negatively charged than the outside surface.
- The outside surface of the plasma membrane is much more negatively charged than the inside surface.
- There is no electrical potential difference between the inside and the outside surfaces of the plasma membrane.

Correct

Yes! The inside surface of the plasma membrane accumulates more negative charge because of the presence of Na^+ and K^+ gradients and the selective permeability of the membrane to Na^+ and K^+ .

Part D

The plasma membrane is much more permeable to K^+ than to Na^+ . Why?

Hint 1. Potassium channels

There are several K^+ channel types. Some are voltage sensitive. Others are calcium sensitive. Others still allow for the movement of K^+ into cells down electrical gradients. Finally, there are certain K^+ channels that are always open and available to K^+ .

ANSWER:

- There are many more voltage-gated K^+ channels than voltage-gated Na^+ channels.
- The Na^+ - K^+ pumps transport more K^+ into cells than Na^+ out of cells.
- There are many more K^+ leak channels than Na^+ leak channels in the plasma membrane.
- Ligand-gated cation channels favor a greater influx of Na^+ than K^+ .

Correct

Yes! More leak channels translates into more leakiness. Thus the outward flux of K^+ is greater than the inward flux of Na^+ .

Part E

The resting membrane potential depends on two factors that influence the magnitude and direction of Na^+ and K^+ diffusion across the plasma membrane. Identify these two factors.

Hint 1. Diffusion across the plasma membrane

The phospholipid bilayer is a largely hydrophobic permeability barrier. Small, lipid-soluble substances readily diffuse through it. However, small, water-soluble substances do not. There are two conditions that must be met in order for diffusion of small, water-soluble substances to take place. What are these two conditions?

ANSWER:

- The presence of a resting membrane potential and leak channels
- The presence of concentration gradients and leak channels
- The presence of concentration gradients and voltage-gated channels
- The presence of concentration gradients and $\text{Na}^+\text{-K}^+$ pumps

Correct

Yes! The concentration gradient and the large number of K^+ leak channels allow for rather robust K^+ diffusion out of a cell. In contrast, the concentration gradient and the relatively few Na^+ leak channels allow for much less Na^+ diffusion into a cell.

Part F

What prevents the Na^+ and K^+ gradients from dissipating?

Hint 1. Movement of Na^+ and K^+

Sodium and potassium ions diffuse down their concentration gradients through leak channels. A specific transporter prevents these ions from diffusing to equilibrium. Identify this transporter.

ANSWER:

- $\text{H}^+\text{-K}^+$ ATPase
- Na^+ and K^+ leaks
- Na^+ cotransporter
- $\text{Na}^+\text{-K}^+$ ATPase

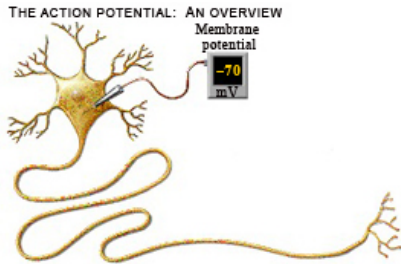
Correct

Yes! Also known as the $\text{Na}^+\text{-K}^+$ pump, or simply the pump, this transporter moves three Na^+ out of the cell and two K^+ into the cell for every ATP it hydrolyzes. This pumping action prevents the Na^+ and K^+ gradients from running down as these ions passively move through leak channels.

IP: Generation of the Action Potential

Click on the link or the image below to explore Generation of the Action Potential in Interactive Physiology (IP), then answer the questions to the right.

[IP: Generation of the Action Potential](#)

**Part A**

Where in the neuron is an action potential initially generated?

Hint 1.

What is the purpose of the action potential?

ANSWER:

- soma and dendrites
- axon hillock
- anywhere on the axon

Correct

Yes, this region (first part of the axon) receives local signals (graded potentials) from the soma and dendrites and has a high concentration of voltage-gated Na^+ channels.

Part B

The depolarization phase of an action potential results from the opening of which channels?

Hint 1.

During depolarization the membrane potential becomes less negative.

ANSWER:

- chemically gated Na^+ channels
- voltage-gated K^+ channels
- chemically gated K^+ channels
- voltage-gated Na^+ channels

Correct

Yes, when the voltage-gated Na^+ channels open, Na^+ rushes into the cell causing depolarization.

Part C

The repolarization phase of an action potential results from _____.

Hint 1.

During repolarization, the membrane potential becomes more negative.

ANSWER:

- the opening of voltage-gated Na^+ channels
- the opening of voltage-gated K^+ channels
- the closing of voltage-gated K^+ channels
- the closing of voltage-gated Na^+ channels

Correct

Yes, as the voltage-gated K^+ channels open, K^+ rushes out of the cell, causing the membrane potential to become more negative on the inside, thus repolarizing the cell.

Part D

Hyperpolarization results from _____.

Hint 1.

During hyperpolarization the inside of the neuron is more negative than the resting membrane potential.

ANSWER:

- slow closing of voltage-gated Na^+ channels
- fast closing of voltage-gated K^+ channels
- slow closing of voltage-gated K^+ channels

Correct

Yes, the slow closing of the voltage-gated K^+ channels means that more K^+ is leaving the cell, making it more negative inside.

Part E

What is the magnitude (amplitude) of an action potential?

Hint 1.

Consider the total change from the negative resting membrane potential.

ANSWER:

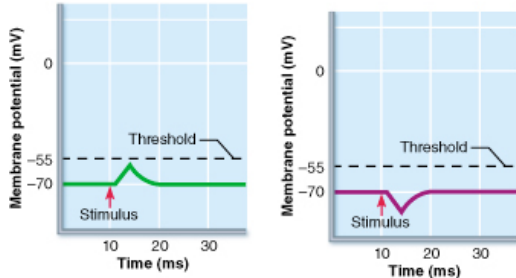
- 30 mV
- 100 mV
- 70 mV

Correct

Yes, the membrane goes from -70 mV to $+30$ mV. Thus, during the action potential, the inside of the cell becomes more positive than the outside of the cell.

Art Question Chapter 11 Question 14**Part A**

Which result of the stimulus applied is the likely cause of the response observed in the left graph?



ANSWER:

- opening of gated Ca^{2+} channels
- opening of gated K^+ channels
- opening of gated Cl^- channels
- opening of gated Na^+ channels

Correct

Opening of gated Na^+ channels allows Na^+ to diffuse into the neuron, causing an increase in the local membrane potential.

Chapter 11 Reading Quiz Question 6**Part A**

What type of stimulus is required for an action potential to be generated?

ANSWER:

- a threshold level depolarization
- hyperpolarization
- multiple stimuli
- a suprathreshold stimulus

Correct

The axolemma must be depolarized to threshold in order to generate an action potential.

Chapter 11 Clinical Application Question 2

Part A

A patient is admitted to the hospital with exacerbation of multiple sclerosis (MS). She asks the nurse "Why did this have to happen to me again? I was doing so well." Why are some forms of MS characterized by periods of remission and exacerbation?

ANSWER:

- The axons are not damaged; growing numbers of sodium channels appear spontaneously in the demyelinated fibers, allowing conduction to resume.
- The axons are not damaged; growing numbers of potassium channels appear spontaneously in the demyelinated fibers, allowing conduction to resume.
- The axons are damaged, and repair of the myelin sheath results in impulse propagation resuming.
- The axons are damaged, and repair of the axons results in impulse propagation resuming.
- The myelin sheaths are damaged, and repair of the myelin sheaths results in impulse propagation resuming.

Correct

Chapter 11 Multiple Choice Question 8

Part A

The period after an initial stimulus when a neuron is *not* sensitive to another stimulus is the _____.

ANSWER:

- absolute refractory period
- resting period
- repolarization
- depolarization

Correct

Chapter 11 True/False Question 6

Part A

During depolarization, the inside of the neuron's membrane becomes *less* negative.

ANSWER:

- True
- False

Correct

Chapter 11 True/False Question 8

Part A

Strong stimuli cause the amplitude of action potentials generated to increase.

ANSWER:

- True
 False

Correct

Chapter 11 True/False Question 20

Part A

Axon diameter and degree of myelination determine nerve impulse conduction velocity.

ANSWER:

- True
 False

Correct

BioFlix Quiz: How Synapses Work

Watch the animation at left before answering the questions below.

Part A

The small space between the sending neuron and the receiving neuron is the

Hint 1.

Review the animation.

ANSWER:

- synaptic cleft.
- vesicle.
- synaptic terminal.
- calcium channel.
- neurotransmitter.

Correct

The synaptic cleft is the small space between the sending neuron and the receiving neuron.

Part B

A molecule that carries information across a synaptic cleft is a

Hint 1.

Review the animation or your Study Sheet for How Synapses Work.

ANSWER:

- synaptic cleft.
- neurotransmitter.
- receiving neuron.
- sending neuron.
- synapse.

Correct

Neurotransmitter molecules carry information across a synaptic cleft.

Part C

When calcium ions enter the synaptic terminal,

Hint 1.

Review the animation.

ANSWER:

- they cause an action potential in the sending neuron.
- neurotransmitter molecules are quickly removed from the synaptic cleft.
- the inside of the receiving neuron becomes more positive.
- they cause vesicles containing neurotransmitter molecules to fuse to the plasma membrane of the sending neuron.
- the inside of the receiving neuron becomes more negative.

Correct

Good job!

Part D

When neurotransmitter molecules bind to receptors in the plasma membrane of the receiving neuron,

Hint 1.

Review the animation or your Study Sheet for How Synapses work.

ANSWER:

- ion channels in the plasma membrane of the receiving neuron open.
- the receiving neuron becomes more negative inside.
- vesicles in the synaptic terminal fuse to the plasma membrane of the sending neuron.
- the receiving neuron becomes more positive inside.
- ion channels in the plasma membrane of the sending neuron open.

Correct

Correct! Good job!

Part E

If a signal from a sending neuron makes the receiving neuron more negative inside,

Hint 1.

Review the animation.

ANSWER:

- the receiving neuron is less likely to generate an action potential.
- the sending neuron becomes more negative inside.
- the receiving neuron immediately generates an action potential.
- the sending neuron becomes more positive inside.
- the receiving neuron is more likely to generate an action potential.

Correct

If the receiving neuron is more negative inside, it is less likely to generate an action potential.

Video Tutor: Events at a Chemical Synapse

Watch the Video Tutor on the Events at a Chemical Synapse, then answer the questions below.

Part A

A postsynaptic cell can be a neuron, a muscle cell, or a secretory cell. What is an example of a presynaptic cell?

Hint 1.

Examples of cell types involved in chemical synapses

ANSWER:

- a neuron
- a secretory cell
- a Schwann cell
- a muscle cell

Correct

A neuron is the only type of presynaptic cell. Neurons release neurotransmitters, effectively changing an electrical signal or action potential into a chemical signal that can communicate across the synaptic cleft to the postsynaptic cell.

Part B

Which component has a role in the postsynaptic cell during synaptic activity?

Hint 1.

Components of a chemical synapse

ANSWER:

- axon terminal
- calcium channels
- Vesicles filled with neurotransmitter
- chemically gated channels

Correct

Neurotransmitter binds to receptors on the postsynaptic cell. These chemically gated channels open, allowing the transfer of the "signal" from a presynaptic neuron to the postsynaptic cell.

Part C

What is the role of calcium in synaptic activity?

Hint 1.

Calcium function in synaptic activity

ANSWER:

- Calcium influx into the axon causes an action potential to propagate into the synaptic terminal.
- Calcium diffuses across the synaptic cleft and binds to receptors on the postsynaptic neuron.
- Calcium influx into the synaptic terminal causes vesicle fusion.
- Calcium degrades neurotransmitter in the synaptic cleft.

Correct

When an action potential reaches the synaptic terminal, voltage-gated channels open and calcium enters the cell. Calcium causes vesicles to fuse with the presynaptic membrane and release neurotransmitter into the synaptic cleft.

Part D

What is the role of neurotransmitter at a chemical synapse?

Hint 1.

Role of neurotransmitters at synapse

ANSWER:

- Neurotransmitter binds to receptors on the postsynaptic cell membrane and allows ions to diffuse across the membrane.
- Neurotransmitter causes vesicles to fuse with the presynaptic membrane.
- Neurotransmitter causes calcium to flood into the presynaptic cell.
- Neurotransmitter causes a graded potential in the postsynaptic cell.

Correct

Neurotransmitter leaves the presynaptic neuron by exocytosis and binds receptors on the postsynaptic cell membrane, opening the channels. When ions enter the postsynaptic cell, a graded potential takes place.

Part E

Neurotransmitter is released from presynaptic neurons through what mechanism?

Hint 1.

Neurotransmitter release

ANSWER:

- pinocytosis
- endocytosis
- phagocytosis
- exocytosis

Correct

Neurotransmitter molecules are released from vesicles that fuse with the plasma membrane through exocytosis. Note that "exo-" means "outside" and "cytosis" means "cell." Once released, neurotransmitter diffuses across the synaptic cleft.

Part F

What type of channel on the postsynaptic membrane binds neurotransmitter?

Hint 1.

Channel types on the postsynaptic membrane

ANSWER:

- a mechanically gated channel
- a leakage channel
- a voltage-gated channel
- a chemically gated channel

Correct

Chemically gated channels bind a specific chemical, which causes the channel to open. At chemical synapses, neurotransmitter molecules are released by the presynaptic neuron and bind to chemically gated channels on the postsynaptic cell membrane. The opening of these channels allows ions to diffuse across the membrane, causing a graded potential in the postsynaptic cell.

Part G

In addition to diffusion, what are two other mechanisms that terminate neurotransmitter activity?

Hint 1.

Mechanisms of terminating neurotransmitter activity

ANSWER:

- reuptake and degradation
- reuptake and inhibition
- excitation and degradation
- exocytosis and degradation

Correct

To terminate neurotransmitter effects, neurotransmitter molecules must be removed from the synaptic cleft. Reuptake does this by moving neurotransmitter back into the presynaptic neuron. Diffusion causes neurotransmitter to drift away from the synaptic cleft. Degradation occurs when enzymes break down neurotransmitter. As long as neurotransmitter molecules remain in the synaptic cleft, the chemically gated channels on the postsynaptic cell will continue to bind them and cause graded potentials.

Part H

Events that occur during synaptic activity are listed here, but they are arranged in an incorrect order. Choose the correct order of these events below. (a) Voltage-gated calcium channels open (b) Neurotransmitter binds to receptors (c) Action potential arrives at axon terminal (d) Neurotransmitter is removed from the synaptic cleft (e) Neurotransmitter released into synaptic cleft (f) Graded potential generated in postsynaptic cell

Hint 1.

Review of events at a synapse

ANSWER:

- (a) Voltage-gated calcium channels open (e) Neurotransmitter released into the synaptic cleft (c) Action potential arrives at axon terminal (b) Neurotransmitter binds to receptors (f) Graded potential generated in postsynaptic cell (d) Neurotransmitter is removed from the synaptic cleft
- (c) Action potential arrives at axon terminal (a) Voltage-gated calcium channels open (e) Neurotransmitter released into the synaptic cleft (d) Neurotransmitter is removed from the synaptic cleft (b) Neurotransmitter binds to receptors (f) Graded potential generated in postsynaptic cell
- (c) Action potential arrives at axon terminal (a) Voltage-gated calcium channels open (e) Neurotransmitter released into synaptic cleft (b) Neurotransmitter binds to receptors (f) Graded potential generated in postsynaptic cell (d) Neurotransmitter is removed from the synaptic cleft
- (d) Neurotransmitter is removed from the synaptic cleft (b) Neurotransmitter binds to receptors (f) Graded potential generated in postsynaptic cell (c) Action potential arrives at axon terminal (a) Voltage-gated calcium channels open (e) Neurotransmitter released into the synaptic cleft

Correct

The correct sequence starts with a neural signal at the presynaptic cell, followed by the release of neurotransmitter, the creation of a graded potential in the postsynaptic cell, and degradation of the neurotransmitters. Neurotransmitters transfer information between a neuron and a postsynaptic cell. This process gets a "message" across a physical separation much like sending a text to your friend who is across town.

Focus Figure 11.17: Chemical Synapse

Click the link and study the entire Focus Figure. Complete the following interactive steps to follow the message transmission from one neuron to another cell through a chemical synapse.

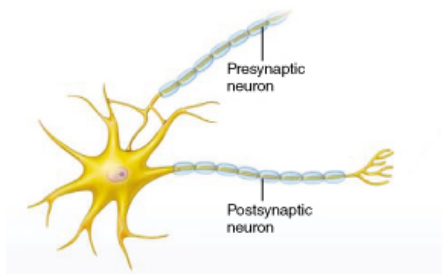


[Access larger version](#) of Focus Figure

Messages travel from one neuron to the next through an extracellular space called a synapse, or synaptic cleft. A chemical message called a neurotransmitter, released by exocytosis from the terminal axon of the first cell, called the presynaptic cell, carries the message to the second cell, the postsynaptic cell, by diffusion.

In this chemical synapse, conditions favoring diffusion will favor the neurotransmitter's movement.

Neurons



Examine the two neurons shown (one total, and only the axon of another).

Part A

Arrange these parts in order, from left to right, of a successful direct depolarization path within one neuron.

- axon
- axon hillock
- cell body
- dendrite
- presynaptic terminal

Hint 1. Threshold stimulus location

In a typical neuron, the types of ion channels in the membrane vary by location. This means that some parts of the neuron's membrane are more excitable, or better able to generate an action potential. The most excitable part of a neuron is usually the axon hillock, which is where most action potentials are generated.

Hint 2. What is the difference between a dendrite and an axon?

Dendrites and axons serve different purposes in terms of the flow of information within a neuron, and from one neuron to another. One major difference between them is that they transmit information in opposite directions.

In general, which of the following is the best answer regarding the function of axons and dendrites?

ANSWER:

- Axons bring a signal to the cell body, while dendrites transmit signals away from the cell body.
- Both axons and dendrites transmit information to and from the cell body.
- Dendrites bring a signal to the cell body, while axons transmit signals away from the cell body.

ANSWER:

Answer Requested

Incoming messages to the dendrites or cell body pass through neuroplasm to the axon hillock. If a threshold stimulus value is reached at the axon hillock, depolarization passes down the axon to the presynaptic terminal containing synaptic vesicles.

The Axon

Transmission at the chemical synapse (i.e. release of neurotransmitters from the presynaptic axon and binding at the postsynaptic) occurs in response to an action potential. This action potential propagates down the length of the axon terminal as a spreading wave of depolarization from the axon hillock onward. This wave results from small consecutive steps of Na^+ movement from the extracellular fluid into the cytoplasm of the axon, which makes the membrane potential more positive. This change in membrane potential is called depolarization.

Part B

Which of the following best characterizes depolarization?

Hint 1. Defining 'depolarize'

To depolarize means to make less polar, i.e. less of a charge separation across the membrane. Which direction, in or out, should Na^+ move to decrease the RMP?

Hint 2. Understanding membrane potential values

Membrane potentials can be a range of numbers. For instance, a resting membrane potential (the difference between the two sides of the membrane for a typical neuron that is not doing anything) is around -70 mV . The magnitude of this number (i.e. whether it is a small or large number) tells you how big of a difference there is between the two sides of the membrane. The \pm sign tells you the condition of the cytosol relative to the outside of the cell.

Which of the following is correct if a membrane potential value is negative?

ANSWER:

- The cytosol is relatively similar to the extracellular fluid.
- The cytosol is negatively charged relative to the extracellular fluid.
- The cytosol is positively charged relative to the extracellular fluid.

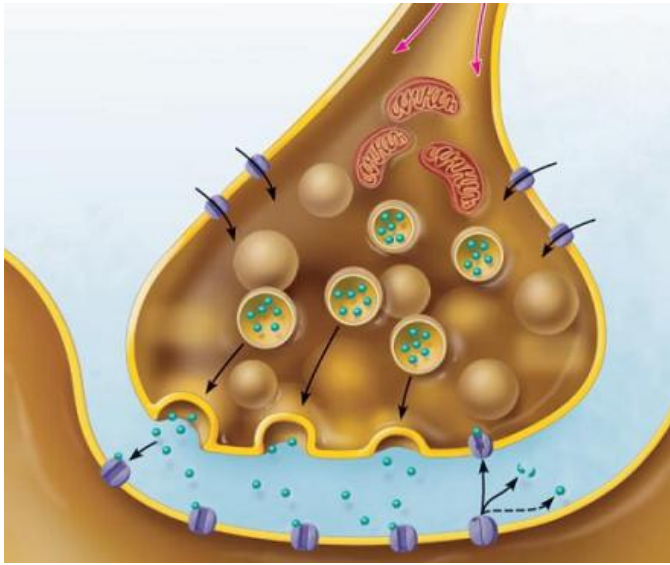
ANSWER:

- small consecutive steps of Na^+ penetration into the axon along its length
- mass movement of Na^+ into the axon cytoplasm from the cell body to the terminal
- small consecutive steps of K^+ entering the cytoplasm
- small consecutive steps of Na^+ exit from cytoplasm into extracellular fluid

Correct

The direction of flow for the Na^+ ion is from the extracellular fluid into the cytoplasm (ICF). This occurs in small consecutive steps.

The Axon Terminal and Exocytosis



As the action potential reaches the end of the axon (the axon terminal), the wave of depolarization triggers voltage-gated protein channels for calcium ions (Ca^{2+}) to open. Once these channels open, Ca^{2+} rushes into the cell.

This rise in cytoplasmic Ca^{2+} triggers protein-coated synaptic vesicles containing neurotransmitter to migrate to the cell surface. When these vesicles reach the cell membrane, they fuse with the phospholipid bilayer, and release their contents into the synaptic cleft between the presynaptic and postsynaptic neurons. The process of expelling contents from within the cell via vesicular transport is known as exocytosis.

Part C

Click and drag the labels to the correct structure at the chemical synapse.

Hint 1. Diffusion and synaptic transmission

In the process of synaptic transmission, diffusion happens outside of the neurons. Within a neuron, the neurotransmitters that will be used to send a message from one neuron to the other are packaged within vesicles.

Hint 2. Neurotransmitter during an action potential

Synaptic transmission can convey information from one neuron to another by the actions of chemicals known as neurotransmitters. Which of the following correctly sequences the actions of neurotransmitters during the propagation of an action potential at a chemical synapse?

Begin with the events in the presynaptic cell and end with the postsynaptic cell.

ANSWER:

Neurotransmitters:

- are stored in mitochondria; diffuse across presynaptic axon; bind at postsynaptic receptors
- bind at vesicle receptors; diffuse in vesicles across synapse; vesicles bind at postsynaptic receptors
- flow through ion channel; depolarize membrane resting potential; release vesicles
- are stored in vesicles; diffuse across synapse; bind at postsynaptic receptors

ANSWER:

Correct

Part D

When an action potential arrives at the end of the axon terminal, a series of events take place that result in the release of neurotransmitter from the presynaptic axon. Select the answer that correctly describes the primary stimulus for vesicles to move towards the cell membrane and eventually release their contents.

Hint 1. What ion channels are opening or closing during transmission?

There are two processes regulated by the movement of ions that lead to transmission in a chemical synapse.

First, there is the action potential itself. The action potential is a spreading wave of membrane potential depolarization, which moves down the length of the presynaptic axon. This wave of depolarization is caused by the sequential opening and closing of Na^+ and K^+ voltage-gated ion channels (and subsequent ion movement).

Secondly, there is a related series of events that occur when the action potential reaches the end of the presynaptic axon. There, voltage-gated calcium channels open, allowing calcium to cross the membrane. It is the change in intracellular calcium that triggers vesicles to begin to move to the membrane.

Hint 2. Ion gradients

In a resting neuron, which of the following ions is more abundant outside of the cell than inside?

ANSWER:

- Na^+ and K^+
- all of the above
- Ca^{2+} and Na^+
- Ca^{2+} and K^+

ANSWER:

- voltage-gated membrane channels open, and Ca^{+2} enters the cytoplasm, increasing intracellular calcium
- axonal Ca^{+2} is increased because endoplasmic reticulum voltage-gated calcium channels open and Ca^{+2} enters the cytoplasm.
- voltage-gated membrane channels open, and multiple types of ions enter the cytoplasm, increasing the intracellular positive charge
- voltage-gated channels open, and K^{+} exits to the extracellular fluid, decreasing intracellular K^{+} .

Correct

Calcium enters the cytoplasm due to changes in the gated channel protein, increasing cytoplasmic content of Ca^{+2} .

Part E

Which statement best describes exocytosis?

Hint 1. What is an organelle?

An organelle is a functional subunit within a cell that is usually enclosed by its own lipid bilayer. Examples of organelles include the nucleus, mitochondria, the cytosol, vesicles, and the Golgi apparatus, among others.

Hint 2. Why do we need membrane organelles to fuse?

Imagine you have two neurons that together form a chemical synapse. You are now going to apply a drug that prevents membrane organelles from fusing with anything. What is the consequence of this?

ANSWER:

- Neurotransmitters build up within the presynaptic neuron.
- Neurotransmitters will take longer to diffuse since they have to cross the cell membrane.
- Neurotransmitters build up within the postsynaptic neuron.
- The presynaptic neuron cannot transmit information to the postsynaptic neuron.

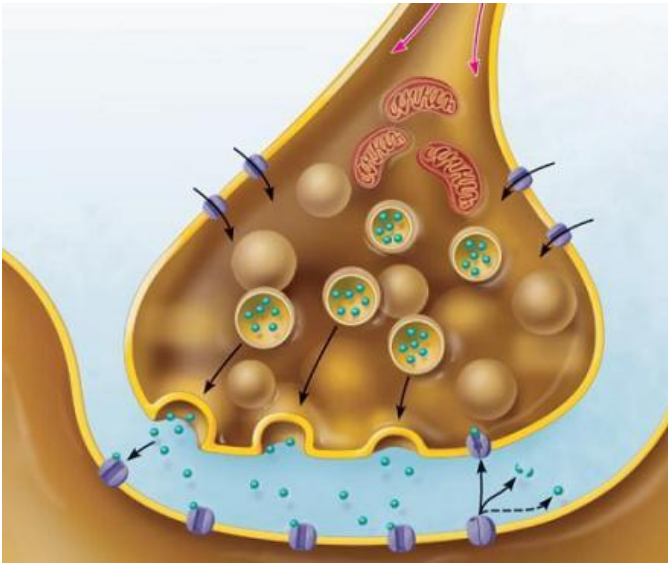
ANSWER:

- Sodium from the action potential fuses with the membrane vesicle and releases the neurotransmitter in the cytoplasm, which can then diffuse out to the extracellular fluid.
- Membrane organelles fuse with the membrane and release contents inside the cell
- Membrane organelles fuse together and mix neurotransmitter.
- Membrane organelles fuse with the membrane and release contents out of the cell.

Correct

The rise in intracellular Ca^{+2} binding with receptor proteins triggers the synaptic vesicles to fuse with the membrane and release contents out of the cell.

The Synapse



Now let's consider the synapse itself. At this point in synaptic transmission, vesicles containing neurotransmitter have fused with the lipid bilayer of the presynaptic axon terminal. When the vesicles fuse; they dump their contents into the environment outside the presynaptic axon terminal. Some of this neurotransmitter will simply drift away, however the majority of it will diffuse across the synapse to receptors on the postsynaptic cell. When the neurotransmitters bind to these receptors, the postsynaptic cell has received the "message" that the presynaptic cell has sent, and can then pass it on to others.

Part F

What conditions will increase the diffusion of molecules, such as neurotransmitters?

Hint 1. Diffusion media

Diffusion occurs faster in gas, slower in liquid, and slowest in a solid. Viscosity is measure of the ease of movement, or "thickness," of a fluid. For example, water is less viscous than honey.

Hint 2. Diffusion in biological systems

In the context of biological systems, it is very important to be able to modulate diffusion, which is otherwise a passive process. Diffusion can occur more efficiently if the distance a particle has to traverse is lessened, or the random movement of particles is increased (increase temperature) among other ways. In a complex biological system it is not always possible to vary these parameters, however. For instance, an increase in temperature could increase the efficiency of diffusion; however, it could also potentially denature proteins, or disrupt other sensitive biological processes. What is one way a cell can regulate the efficiency of diffusion?

ANSWER:

- Increase the concentration gradient for the diffusing particle.
- Vary the substances that diffuse.
- Decrease the kinetic energy of diffusing particles.
- Increase the distance from where diffusing particles are released to where they are received.

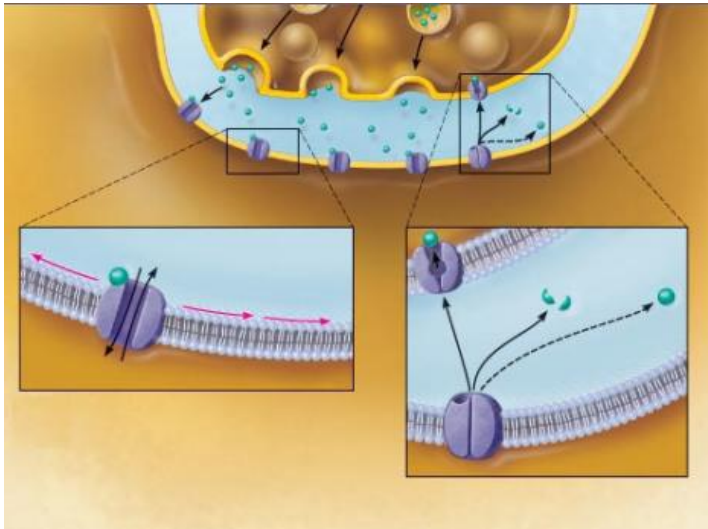
ANSWER:

- An increase in the distance between the neurons.
- An increase in number of postsynaptic receptors.
- An increase in the amount of neurotransmitter exocytized by the presynaptic axon.
- An increased viscosity of the fluid between neurons.

Correct

Increased differences in concentrations, or increased gradients, will increase diffusion.

The Postsynaptic Membrane



Now let's consider events at the postsynaptic membrane. Following diffusion across the synapse, the neurotransmitter binds at receptors on the postsynaptic membrane, and sets up a graded potential.

While the neurotransmitter is in the synaptic cleft, there are several factors that affect its ability to bind at the postsynaptic cell. It can be taken up into the presynaptic membrane via a receptor protein, it can be broken down by an enzyme, or it can simply diffuse away to an area of lesser concentration. Each will decrease the effect of the neurotransmitter to initiate or to maintain an action potential.

Part G

If the membrane of a postsynaptic dendrite is setting up a graded potential, what must have happened after neurotransmitter was released by the presynaptic terminal?

Hint 1. Postsynaptic potentials

After neurotransmitters diffuse across the synapse and bind at postsynaptic receptors, the postsynaptic membrane sets up graded potentials. Similar to the membrane potentials we've discussed before, these graded potentials are changes in the voltage of the membrane that result from the activation of postsynaptic ion channels. Graded potentials can be large or small depending on which ion channels are activated. If graded potentials are sufficiently large, they can produce an action potential when they reach the postsynaptic axon hillock. Since the threshold value for an action potential is above 0, a positive change in the postsynaptic membrane potential is known as "excitatory", while a negative change is "inhibitory."

Hint 2. The sequence of events in synaptic transmission

Which of the following is the missing step in effective synaptic transmission between two neurons?

ANSWER:

Ca²⁺ channels open; vesicles migrate to the presynaptic membrane; neurotransmitter diffuses across synapse;

- neurotransmitter binds at presynaptic receptor
- neurotransmitter binds at postsynaptic synapse
- neurotransmitter binds at postsynaptic receptor
- neurotransmitter produces a graded potential

ANSWER:

The neurotransmitter:

- bound at postsynaptic receptors to initiate an action potential.
- was reabsorbed by the presynaptic membrane before it diffused away.
- bound at postsynaptic receptors to open postsynaptic ion channels.
- was degraded by enzymes before arriving at the postsynaptic membrane.

Correct

Diffusion carries the transmitter from higher to lower concentration. The transmitter binds to a receptor on the postsynaptic membrane and affects a cascade of events resulting in the opening of ion channels. These lead to graded potentials, which may set up an action potential.

Conclusion/Synthesis: The Chemical Synapse

Congratulations! You've completed the steps that cover the concepts of the neuron, the axon, the axon terminal and exocytosis, the synapse, and the postsynaptic membrane. The goal of the steps is to better understand the process of the chemical synapse and how it transmits signals from one neuron to

another using neurotransmitter. Let's finish up this tutorial by reviewing the parts of the chemical synapse.

Part H

Drag and drop the descriptive labels of events into the correct sequence at the chemical synapse.

Hint 1. How do events at a chemical synapse start?

Transmission at the chemical synapse occurs in response to an action potential. This action potential propagates down the length of the axon terminal as a spreading wave of depolarization from the axon hillock onward.

Hint 2. Why is neurotransmitter released?

Although changes in membrane potential as a result of ion movement are central to all events in a synaptic transmission, which ion in particular is responsible for the release of neurotransmitters?

Select the best answer.

ANSWER:

- Potassium
- Sodium
- Calcium

Hint 3. How does a signal propagate?

Signals propagate across multiple neurons because the chemical messengers released by one neuron are bound at another. Once these messengers bind, a response can be sent onward in the same (or a different) fashion.

ANSWER:

Correct

Part I

Which best represents synaptic transmission?

Hint 1. How does a signal propagate?

Signals propagate across multiple neurons because the chemical messengers released by one neuron are bound at another. Once these messengers bind, a response can be sent onward in the same (or a different) fashion.

Hint 2. What is the "point" of synaptic transmission?

Which of the following best represents the "point" of synaptic transmission?

ANSWER:

- To utilize diffusion
- To convey signals from one neuron to another
- To release neurotransmitters
- To create action potentials

ANSWER:

- presynaptic axon to synapse to postsynaptic axon
- presynaptic axon to presynaptic cell body to dendrite
- presynaptic axon to synapse to dendrite or postsynaptic cell body
- presynaptic cell body to dendrite to synapse

Correct

Synaptic transmission uses a synapse, and therefore, two cells. Incoming messages are dendritic or somatic; outgoing messages are axonal.

Part J

Predict the possible effect of a drug that totally blocks the neurotransmitter receptor on the postsynaptic membrane.

For example, curare is a neurotoxin used by several South American cultures. The primary effect of curare is that acetylcholine, a major neuromuscular neurotransmitter, cannot bind at its receptor because curare is blocking it. Predict the possible effects of curare on the postsynaptic membrane and muscle.

Hint 1. What is the postsynaptic cell?

For this Part, we are considering a situation in which the postsynaptic cell is a muscle. This synapse between the nervous system and a muscle fiber is known as the neuromuscular junction. At the neuromuscular junction, a presynaptic neuron axon synapses on the motor end plate; an excitable (i.e. capable of depolarizing) region of the muscle fiber plasma membrane.

Hint 2. Apply your understanding of a general synapse to a new situation

What is the neurotransmitter that is used to convey a message from a presynaptic neuron to the postsynaptic motor end plate of a muscle fiber membrane?

ANSWER:

- motor end plate
- neurotoxin
- acetylcholine
- curare

ANSWER:

- There is no effect.
- Transmission of the action potential will be enhanced and there is a faster contraction response by the muscle.
- Local graded potentials and action potential transmission is blocked and there is no response by the postsynaptic cell, the muscle.
- Transmission is slowed and there is a slower response.

Correct

No ion channel or graded potential can be initiated and therefore there is no subsequent action potential.

Chapter 11 Chapter Test Question 15

Part A

Which of the following is NOT true of an electrical synapse?

ANSWER:

- They are less common than chemical synapses.
- Communication through these synapses may be unidirectional or bidirectional.
- Transmission across these synapses is very rapid.
- They are specialized for release and reception of chemical neurotransmitters.

Correct

This is incorrect; electrical synapses do not involve the release and reception of neurotransmitters. Instead, the neurons are electrically coupled by gap junctions, which allow ions to flow directly from one neuron to the next.

Chapter 11 Chapter Test Question 23**Part A**

Opening K^+ or Cl^- channels in a postsynaptic membrane would produce an inhibitory postsynaptic potential (IPSP).

ANSWER:

- True
- False

Correct

Opening K^+ or Cl^- channels in a postsynaptic membrane, resulting in K^+ efflux or Cl^- influx, respectively, would induce hyperpolarization. As the membrane potential increases and is driven farther from the axon's threshold, the postsynaptic neuron becomes less and less likely to "fire," and larger depolarizing currents are required to induce an action potential (AP). Hyperpolarizing changes in potential are called inhibitory postsynaptic potentials (IPSPs).

Chapter 11 Chapter Test Question 18**Part A**

Which of the following circuit types is involved in the control of rhythmic activities such as the sleep-wake cycle, breathing, and certain motor activities (such as arm swinging when walking)?

ANSWER:

- converging circuits
- reverberating circuits
- parallel after-discharge circuits
- diverging circuits

Correct

Reverberating circuits are involved in the control of rhythmic activities such as breathing, the sleep-wake cycle, and repetitive motor activities such as walking. A signal travels through a chain of neurons, each feeding back to previous neurons in the pathway.

Chapter 11 Chapter Test Question 19**Part A**

Which pattern of neural processing works in a predictable, all-or-nothing manner, where reflexes are rapid and automatic responses to stimuli in which a particular stimulus always causes the same response?

ANSWER:

- oscillative processing
- serial processing
- parallel processing
- reflexive processing

Correct

In serial processing, the whole system works in a predictable, all-or-nothing manner. One neuron stimulates the next, which stimulates the next, and so on, eventually causing a specific, anticipated response. The most clear-cut examples of serial processing are spinal reflexes - rapid, automatic responses to stimuli in which a particular stimulus always causes the same response.

Score Summary:

Your score on this assignment is 88.4%.

You received 29.17 out of a possible total of 33 points.