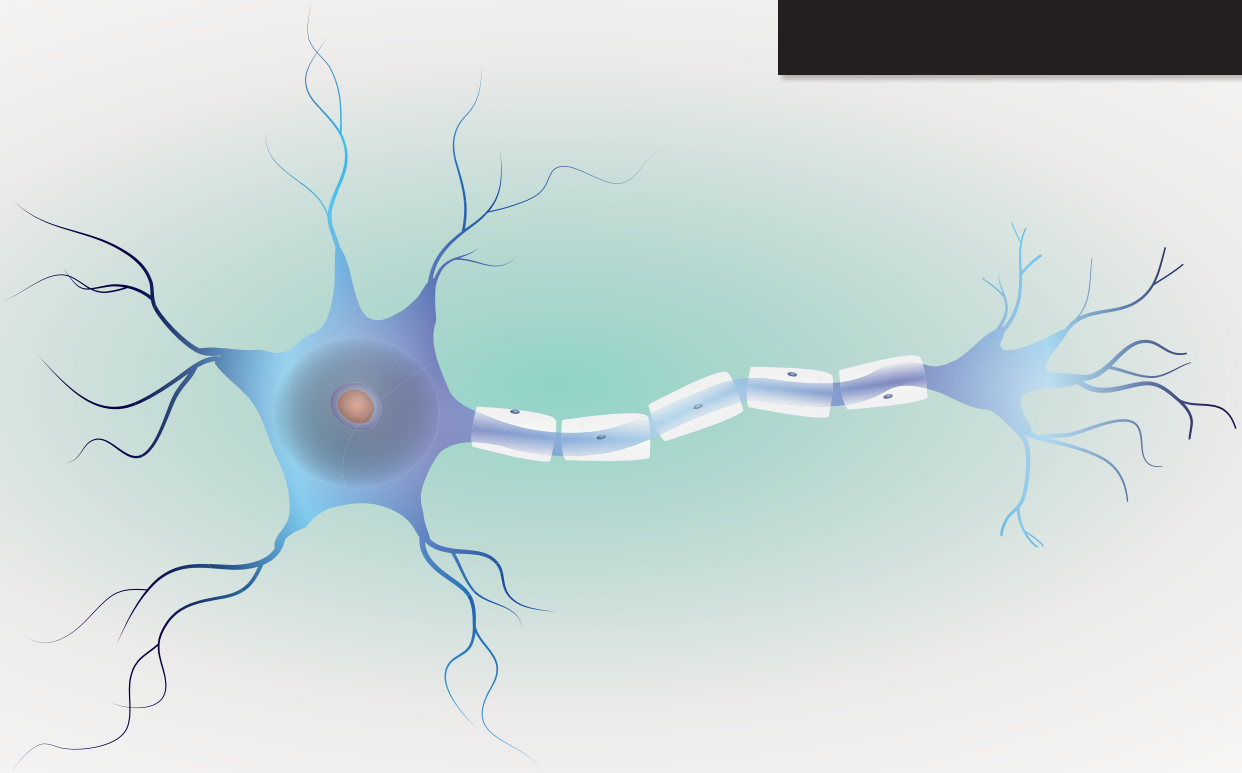
ROCK THE DIPLOMA

EXAM PREP



BIOLOGY 30

BOOK A: Nervous & Endocrine Systems

(General Outcomes A1 & A2)

Contents

A1: The Nervous System

Neurons are specialized cells within the nervous system that carry impulses. Some neurons receive information from the internal and external environments.

Neurons send electrochemical signals that allow the organism to maintain **homeostasis**. Also called an impulse, or **action potential**, these signals travels in one direction.

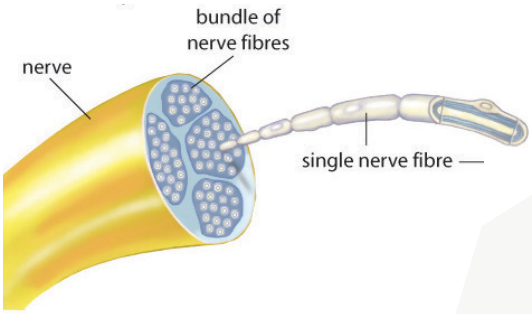
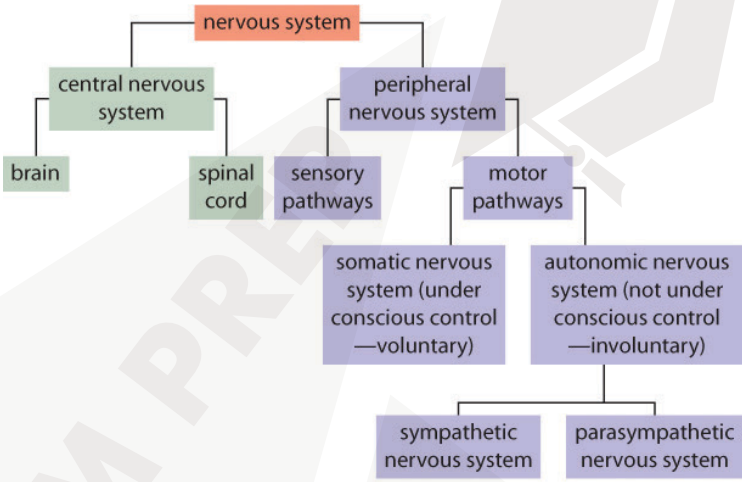


Figure 2. A nerve is a bundle of neurons.

Figure 1. The organization of the human nervous system.



Neuron Anatomy

- **Dendrites:** Receive information or stimuli; from other neurons or the environment.
- **Cell Body (soma):** Contains the major cell organelles and cytoplasm.
- **Axon:** Conduct nerve impulses away from the cell body to the target cells. Axons of larger diameter conduct impulses faster.
- **Myelin Sheath:** Insulates the axon, thereby speeding up transmission. Myelinated nerves are referred to as white matter (unmyelinated = gray matter).
- **Schwann cells:** Specialized cells in the peripheral nervous system that produce the myelin sheath and form neurilemma. (the outermost, delicate membrane that can promote the regeneration of damaged axons).
- **Nodes of Ranvier:** Spaces/gaps located between the myelin sheath where impulses "jump" from node to node.
- **Terminal branches:** End with **axon bulbs** (**synaptic knobs** or **end plates)** that contain vesicles that secrete neurotransmitters needed to bridge the **synapse** (region between neurons).

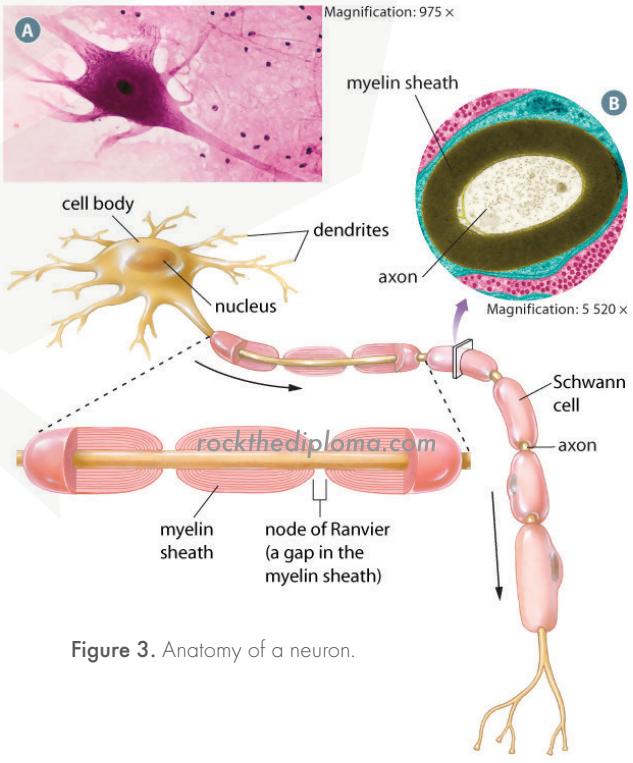
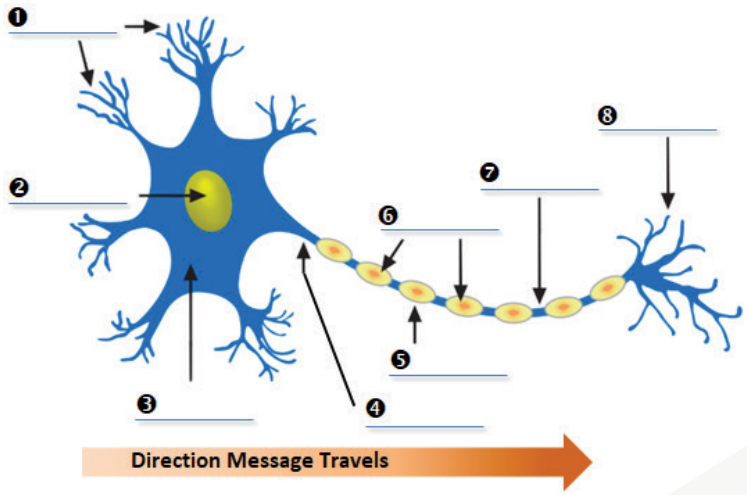


Figure 3. Anatomy of a neuron.

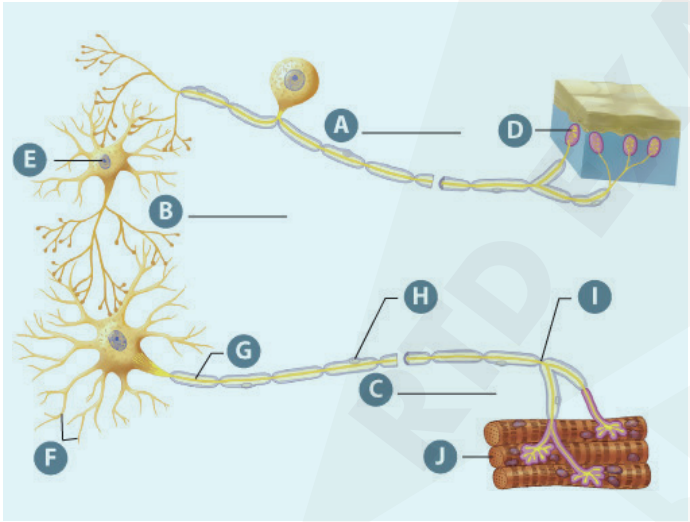
Activity Identify the anatomy of a neuron.



1: _____
2: _____
3: _____
4: _____
5: _____
6: _____
7: _____
8: _____

Neural Pathways

Activity Identify the parts of a basic neural pathway.



1. **Receptors:** Modified dendrites of a sensory neuron that are activated by environmental (external and internal) stimuli and generate action potentials.
2. **Sensory neurons:** Carry action potentials to the CNS.
3. **Interneurons**: Interpret or integrate the information.
4. **Motor neurons**: Carry action potentials to the effectors.
5. **Effectors:** Muscles, glands, or organs that help the organism respond to the stimulus.

Reflexes

Motor neurons can be activated by an unconscious or involuntary response called a reflex. Reflexes bypass interpretation by the brain (reflex arc) and allow your body to quickly and involuntarily respond to the stimuli. Interpretation by interneurons in the brain requires time, and this can be detrimental in an emergency. (For example, when you accidentally touch a cactus needle) The speed of a reflex, or any impulse, cannot be increased.

The reflex arc contains five essential parts:

1. Receptor
2. Sensory neuron
3. Interneuron of spinal cord
4. Motor neuron
5. Effector

By the time your brain interprets the information, the effector has already responded.

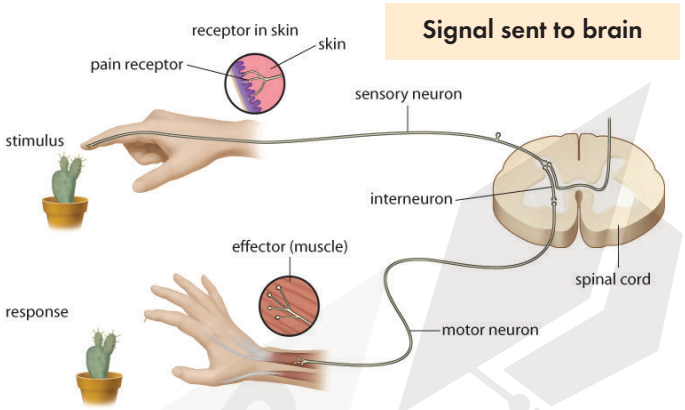


Figure 4. Reflexes.

Neural Conduction

A nerve impulse is an electrochemical process that results from the movement of ions across a neuron's semi-permeable membrane (through voltage sensitive ion channels). This process is also known as an **action potential**.

Resting Potential:

- Both the Na^+ and the K^+ voltage channels are closed. Any leakage is corrected by the sodium-potassium pump that actively (uses ATP) pumps $3\ Na^+$ out of the neuron for every $2\ K^+$ in.
- There are more $Na+$ outside than inside AND more $K+$ inside than outside. Overall ► there are more positive ions outside the neuron.
- Neuron is polarized (positive outside and negative inside).

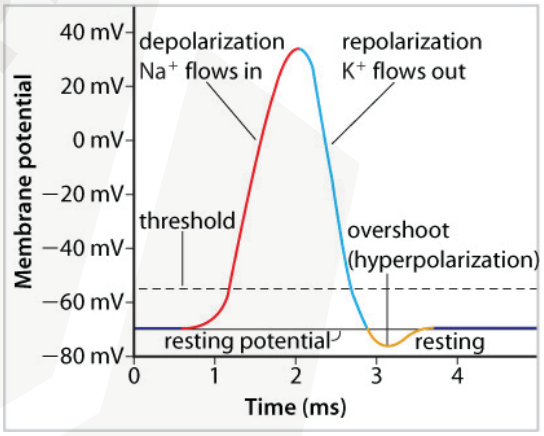


Figure 5. Action Potential.

Threshold Level:

The minimum stimulus required in order to generate an action potential.

Depolarization:

Once the threshold level is achieved:

- Na^+ channels open allowing sodium ions to diffuse into the neuron.
- There are more Na^+ and K^+ inside than outside.
- The inside is positive and the outside is negative (depolarized).

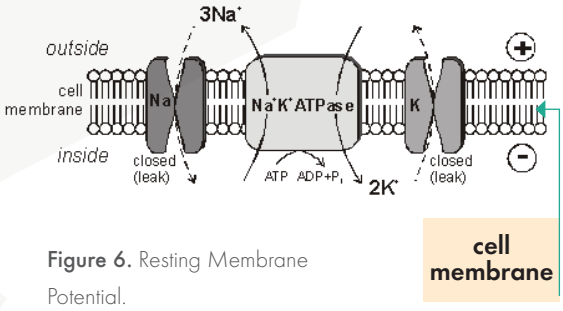


Figure 6. Resting Membrane Potential.

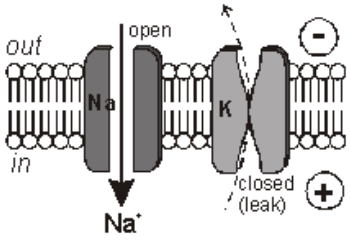


Figure 7. Depolarization.

Repolarization:

- Na^+ channels close and the K^+ channels open allowing potassium to diffuse out of the neuron.
- More K^+ outside than inside and more Na^+ inside than outside.
- Neuron is again polarized (positive outside and negative inside).

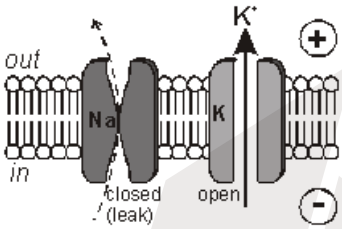


Figure 8. Repolarization.

Re-establishment of Membrane Potential

Refractory period:

The recovery time required before a neuron can respond to another impulse.

Even though the membrane is now polarized again, the ion concentrations are reversed. It is the responsibility of the sodium potassium pump to restore the original concentrations.

Note: Because potassium channels are slow to close, there is a brief overshoot of potential called **hyperpolarization** (the membranes are still permeable to potassium than usual and the inside of the neuron becomes even more negative).

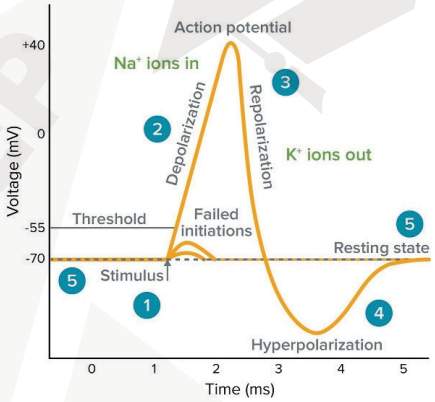
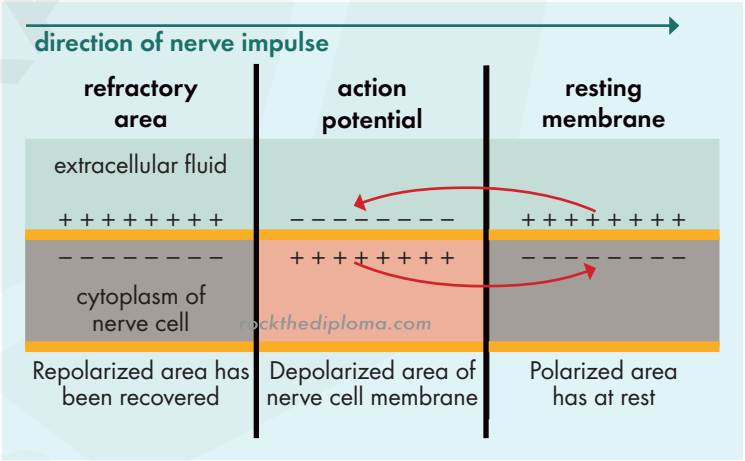


Figure 9. Refractory period.

Activity **Using the diagram below, describe what is happening with sodium and potassium in each box.**



Depolarization and repolarization at one node on the membrane causes the adjacent nodes to become more permeable to sodium, resulting in depolarization in those spots (self-propagation). In myelinated neurons this occurs between the Schwann cells. (nodes of Ranvier)

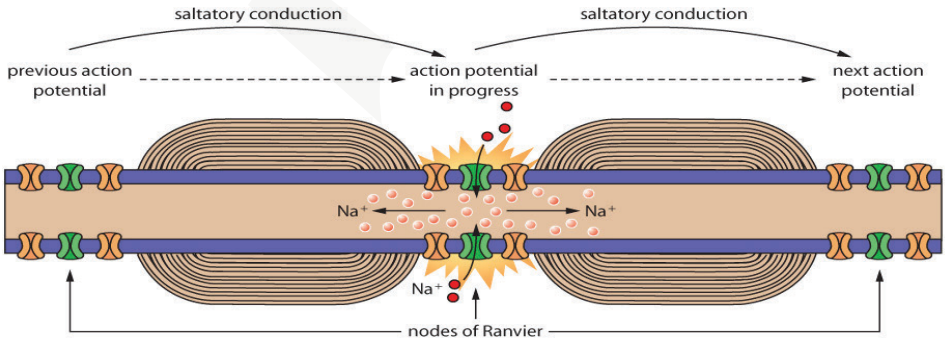


Figure 10. Action Potential.

All or none response

Like the trigger of a gun, once a threshold level has been reached, an action potential will occur regardless of the degree the threshold level is exceeded. The fact that you are able to notice varying degrees of stimuli is based on:

- the number of neurons stimulated (summation)
- and/or the frequency of stimulation.

It is up to the brain to interpret the number and frequency of impulses.

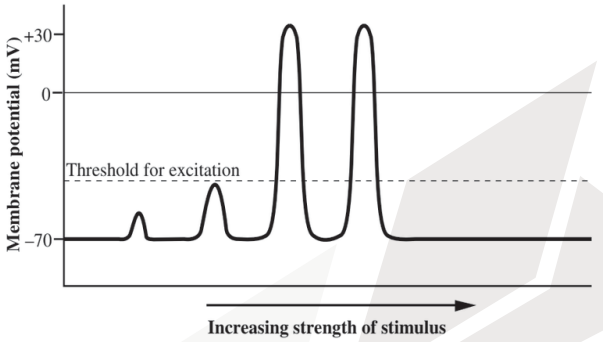
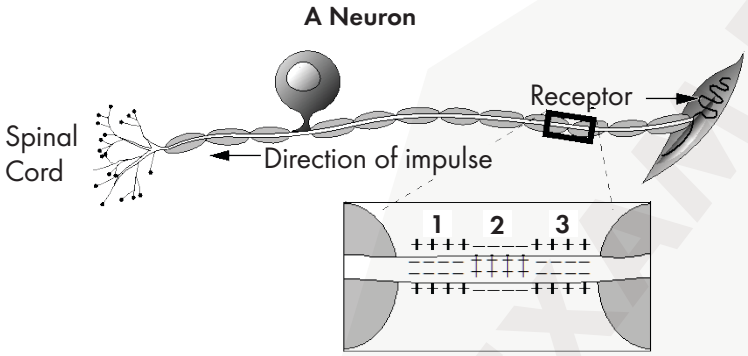


Figure 11. All or nothing response.

Activity **Match the number on the diagram to the correct term.**



Depolarization

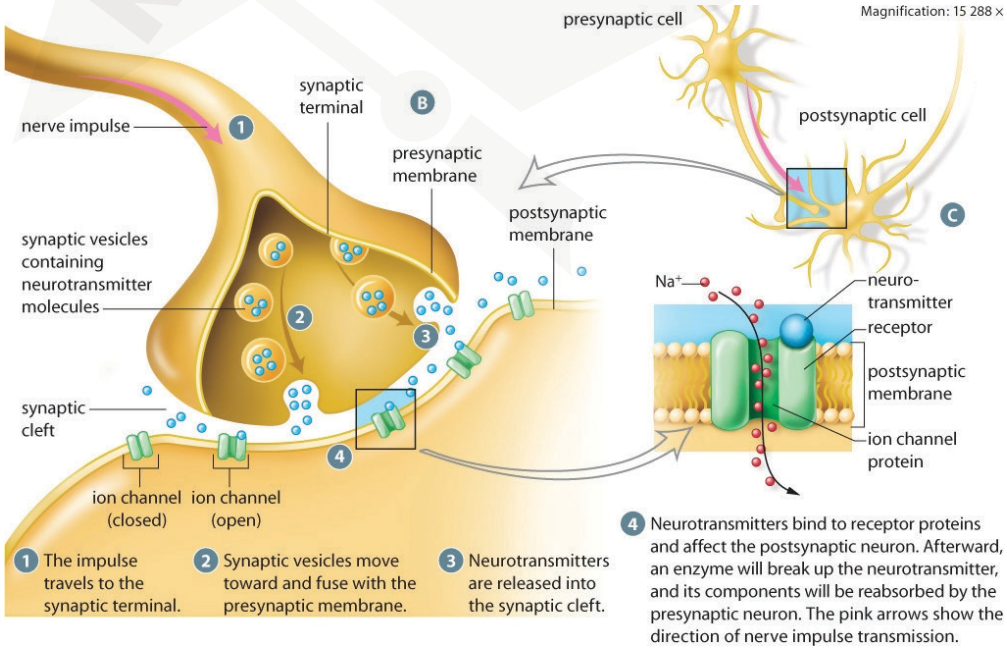
Resting potential

Repolarization

The Synapse

Once an action potential reaches the end plate of a neuron the "message" must be converted to another form to bridge the gap between the two cells called the synapse.

Figure 12.
The Synapse.



Neurotransmitters

- **Acetylcholine/Norepinephrine:** Made by the presynaptic neuron, these chemical messengers make the postsynaptic membrane more permeable to sodium ions (depolarization).
- **Cholinesterase:** This enzyme breaks down acetylcholine in the synapse, thereby preventing continuous stimulation of the postsynaptic neuron.

Depending on the nerve neurotransmitters can have

- an excitatory effect (causes depolarization)
- or inhibitory effect (causes hyperpolarization)
- or both

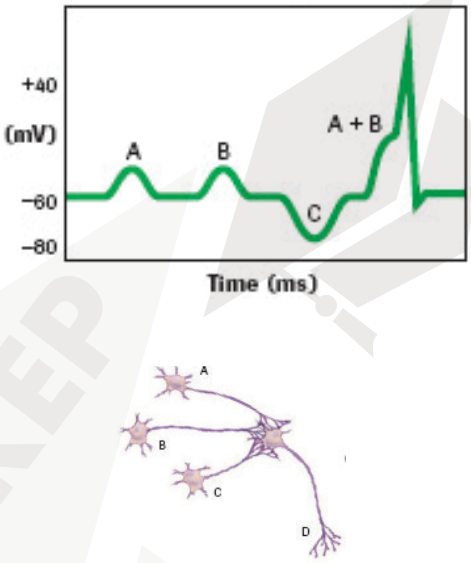


Figure 13. Measurement of Change in Neuron D.

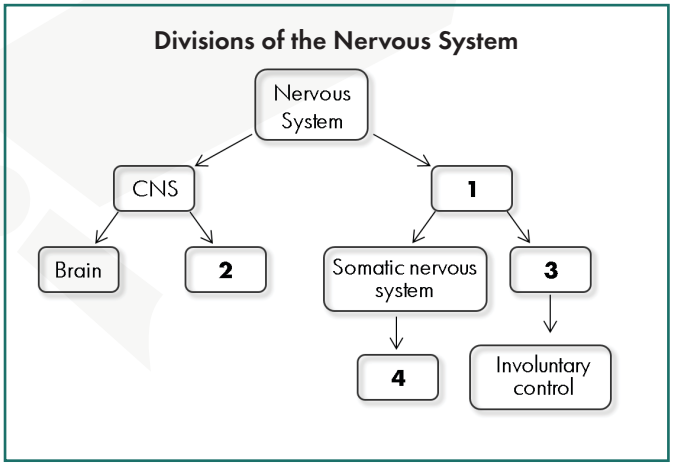
Manipulation of the Synapse

For each of these examples, predict the effect on the synapse:

- Curare – occupies receptor site on post-synaptic membrane
- Pesticide – blocks effects of cholinesterase
- Botox – prevents release of acetylcholine

UNIT A PRACTICE QUESTIONS: GROUP 1

Answers for all practice questions are at the back of this booklet.



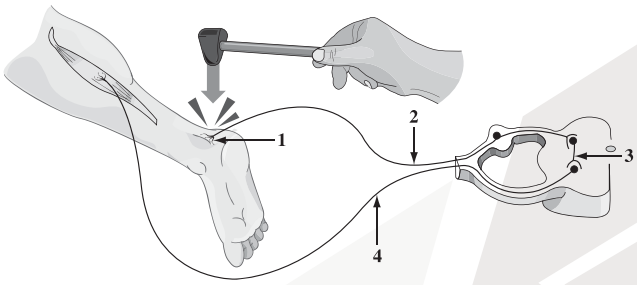
1. **NR** Match the number in the diagram of the divisions of the nervous system with its description below.

Number: _____ _____ _____ _____

Description: *PNS (1st digit)* | *Voluntary control (2nd digit)* | *Spinal Cord (3rd digit)* | *Automatic Nervous System (4th digit)*

The Achilles Tendon Reflex Pathway

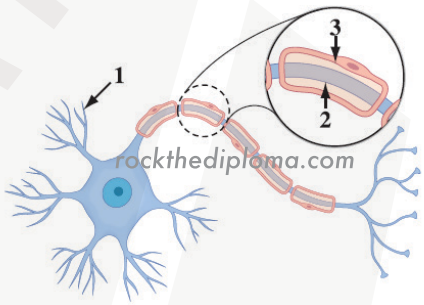
The Achilles tendon reflex is observed when the Achilles tendon of a person is tapped with a patellar hammer and the calf muscle contracts. A doctor tapped the Achilles tendon of a man and did not observe a contraction of the man's calf muscle. The man reported that he felt the hammer strike his tendon.



2. The two structures numbered above that are **most likely** damaged in the Achilles tendon reflex pathway are

A. 1 and 2 **B.** 1 and 3 **C.** 2 and 3 **D.** 3 and 4

Charcot-Marie-Tooth disease (CMT) is a neurological disorder characterized by nerve damage that causes muscle weakness and loss of sensation. The two most common forms of this disorder are CMT1 and CMT2. CMT1 is caused by a genetic mutation that results in abnormal structure and function of the myelin sheath, and CMT2 is caused by a genetic mutation that leads to the abnormal functioning of the axon.



3. Which of the following rows identifies the structures of a neuron affected by CMT1 and CMT2?

Row	CMT1	CMT2
A.	1	2
B.	2	3
C.	3	2
D.	3	1

After accidentally hitting your thumb with a hammer, you immediately withdraw your hand. You do not feel pain for a short period of time.

4. This sequence of events may be explained by the fact that the

A. Threshold of the receptor has been so greatly exceeded that the neuron does not pass the message to the brain

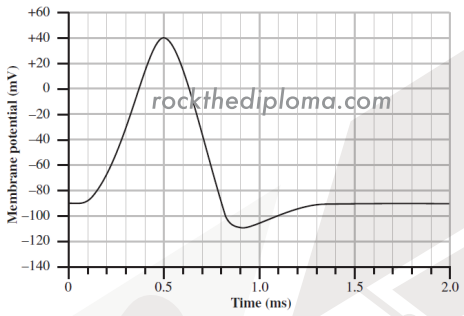
B. Neural impulse is so large that the brain is unable to interpret the signal because it is beyond the range of tolerance

C. Neural processing occurred in the spinal cord first, which caused you to quickly remove your thumb from further damage

D. Sensory receptors in the thumb were damaged by the blow and are unable to initiate a stimulus to the sensory nerve

Use the following information to answer questions 5, 6, and 7.

Stimulation of a sensory neuron produces an action potential. An abnormal pattern in this action potential can be used to detect MS in its early stages. The graph below illustrates the membrane potential of a normal neuron after stimulation.



5. **NR**

What is the resting membrane potential for the neuron, expressed to two digits, and what is the maximum membrane potential during depolarization, expressed to two digits?

(Record your answers absolute values)

Answers: **Membrane Potential =** _____ _____ , _____ _____

Resting — *First two digits of answer*

Depolarization — *Last two digits*

6.

Which of the following types of ion movement across an axon membrane would cause the action potential to change during the interval from 0.2 ms to 0.4 ms?

A. Sodium ions moving into the axon

B. Sodium ions moving out of the axon

C. Potassium ions moving into the axon

D. Potassium ions moving out of the axon

7.

On the graph, the period from 0.5 ms to 1.0 ms represents the neuron's

A. Refractory period, which is when repolarization occurs

B. Refractory period, which is when minimum depolarization occurs

C. Threshold period, which is when repolarization occurs

D. Threshold period, which is when minimum depolarization occurs

Lignocaine is an anesthetic used to block pain during dental procedures. Lignocaine diffuses into neurons and works by blocking sodium channels.

8.

The blocking of sodium channels by lignocaine prevents the diffusion of sodium ions

A. Into the neuron, which decreases the threshold potential of the neuron

B. Into the neuron, thus inhibiting an action potential

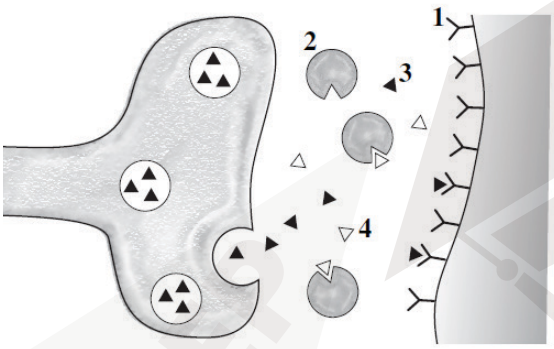
C. Out of the neuron, thus inhibiting an action potential

D. Out of the neuron, which decreases the threshold potential of the neuron

Use the following information to answer question 9 and 10.

Alzheimer disease is caused by a decrease in the production of the neurotransmitter acetylcholine in the brain. Cholinesterase inhibitors, such as the drug donepezil, can slow the development of the symptoms in the early-to-middle stages of Alzheimer disease, but they cannot stop the progression of the disease. The donepezil molecule has a shape that allows it to attach to the active site on the cholinesterase, thereby preventing the cholinesterase from binding to acetylcholine.

A Synapse



9. In the diagram above, acetylcholine and donepezil are numbered

A. 1 and 2 respectively
B. 2 and 1 respectively
C. 3 and 4 respectively
D. 4 and 3 respectively

10. How does donepezil affect synaptic transmission?

A. Donepezil breaks down acetylcholine so that less acetylcholine is available in the synapse
B. Donepezil replaces cholinesterase so that more acetylcholine is available in the synapse
C. Donepezil blocks the release of acetylcholine so that less acetylcholine is available in the synapse
D. Donepezil prevents the breakdown of acetylcholine so that more acetylcholine is available in the synapse

In a research study on detection of odours, individuals were asked to smell gradually decreasing concentrations of specific familiar chemicals. Women of reproductive age were more able to detect weak odours than were men, children, and postmenopausal women. Researchers concluded that female sex hormones might increase sensitivity to familiar odours.

11. The **most likely** inference that can be made from this study is that, comparatively, women of reproductive age have

A. More receptors for odour detection
B. A lower threshold level for familiar odours
C. The ability to interpret odours more quickly
D. The ability to adapt to familiar odours more quickly

Use the following information to answer question 12 and 13.

Drinking coffee may protect a person against Parkinson disease, a neurological disorder resulting from reduced production of the neurotransmitter dopamine by affected cells in the brain. In an experiment, mice were given caffeine in an amount equivalent to approximately one cup of coffee for a human. The mice were then given MPTP, a chemical that destroys dopamine-producing neurons, thus causing symptoms similar to those of Parkinson's disease. These mice showed a much smaller reduction in dopamine levels than mice that were not given caffeine before being given MPTP.

12. The manipulated variable in the experiment described was the

A. Ingestion of MPTP
B. Ingestion of caffeine
C. Secretion of dopamine
D. Destruction of dopamine-producing neurons

13. In a well-designed experiment, variables that would be kept the same in both the experimental and control groups of mice are the

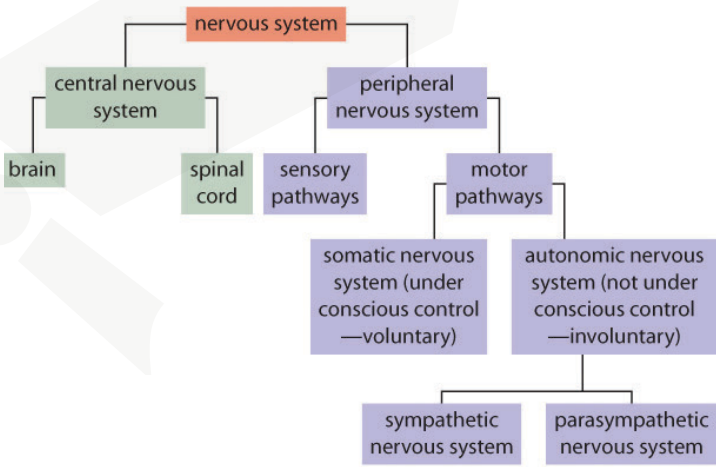
A. Diet and health of the mice
B. Amounts of caffeine and MPTP ingested
C. Age of the mice and amount of caffeine ingested
D. Size of the mice and amount of dopamine produced

The Peripheral Nervous System (PNS)

The **PNS** is made up of myelinated neurons that transmit action potentials between body tissues and the CNS. The PNS includes <u>two</u> divisions.

1. **Sensory-Somatic Nervous System:** Focuses on the external environment and controls voluntary (conscious) and involuntary (reflexes) skeletal muscle movement.
2. **Autonomic Nervous System:** Focuses on the internal environment and controls "automatic" functions of the body's internal organs.

Figure 14. The organization of the peripheral nervous system.



The autonomic system is composed of two antagonistic subdivisions:

Sympathetic division:

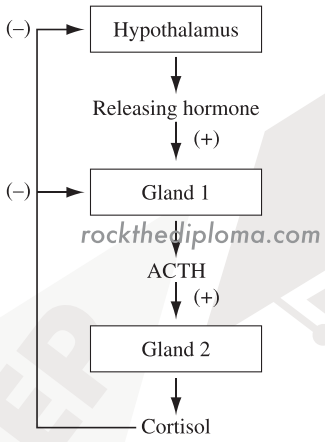
- Predominates in times of high activity or stress.
- <u>Fight-or-Flight</u> response.

Parasympathetic division:

- Predominates during rest.
- <u>Rest-and-digest</u> response.

Researchers suggest that the brain has a daily "internal clock" that is controlled by the endocrine and nervous systems. The hormone ACTH helps to regulate the nervous system and gives the body the ability to respond to changes in sleep patterns. The release of ACTH is suppressed during sleep but increases before a person awakes.

The feedback loop right illustrates part of the regulatory hormonal control of the internal clock.



45. The secretion of ACTH is suppressed during sleep as a result of

A. Increased activity of the pituitary gland

B. Decreased secretion of RH by the hypothalamus

C. Decreased secretion of cortisol by the adrenal cortex

D. Increased nervous system input to the medulla oblongata

Book A Answers

1. 1423	13. A	25. 1235	37. 2358
2. D	14. D	26. D	38. A
3. C	15. D	27. 3412	39. C
4. C	16. A	28. B	40. A
5. 9040	17. C	29. C	41. C
6. A	18. B	30. D	42. A
7. A	19. A	31. 3256	43. A
8. B	20. 4312	32. 123	44. 3214
9. C	21. B	33. D	45. B
10. D	22. 3124	34. C	
11. B	23. B	35. B	
12. B	24. 4231	36. B