# Lundy-Ekman: Neuroscience: Fundamentals for Rehabilitation, 4th Edition

## Chapter 2: Physical and Electrical Properties of Cells in the Nervous System

### Test Bank

1. Which one of the following neuron structures is specialized for receiving synaptic input from other neurons?
   A. Cell body
   B. Dendrite
   C. Axon
   D. Axon hillock
   E. Presynaptic terminal

   ANS: B
   Rationale: Dendrites, with branchlike extensions that serve as the main input sites for the cell and project from the soma, are specialized to receive information from other cells.

2. Which of the following is the structural part of a neuron that releases a neurotransmitter?
   A. Dendrite
   B. Axon hillock
   C. Soma
   D. Presynaptic terminal
   E. Postsynaptic terminal

   ANS: D
   Rationale: Axons end in presynaptic terminals, or fingerlike projections, which are the transmitting elements of the neuron. Neurons transmit information about their activity via the release of chemicals called *neurotransmitters* from the presynaptic terminal into the synaptic cleft.

3. Pseudounipolar cells:
   A. Have two dendrites
   B. Have two somas
   C. Are not neurons
   D. Are glial cells
   E. Have two axon extensions

   ANS: E
   Rationale: Pseudounipolar cells, a subclass of bipolar cells, appear to have a single projection from the cell body that divides into two axonal roots. Pseudounipolar cells have two axons and no true dendrites.

4. Retrograde transport:
   A. Recycles substances from the axon back to the soma.

B. Moves neurotransmitters from the dendrites to the cell body.
C. Moves substances from the soma toward the axon terminal.
D. Moves neurotransmitters across the synaptic cleft.
E. Moves information from astrocyte to astrocyte.

ANS: A
Rationale: Axoplasmic transport occurs in two directions: anterograde and retrograde. Anterograde transport moves neurotransmitters and other substances from the soma down the axon toward the presynaptic terminal. Retrograde transport moves substances from the synapse back to the soma.

5. Afferent neurons convey information:
A. Between interneurons.
B. From the CNS to skeletal muscles.
C. From peripheral receptors to the CNS.
D. Between the soma and presynaptic terminal.
E. From the CNS to smooth muscles.

ANS: C
Rationale: Afferent neurons carry sensory information from the outer body toward the CNS. Efferent neurons relay commands from the CNS to smooth and striated muscles and glands. Interneurons, the largest class of neurons, act throughout the nervous system, processing information locally or conveying information across short distances.

6. The resting membrane potential is:
A. The same as the membrane equilibrium potential.
B. The voltage difference across a neuron's cell membrane, maintained by an unequal distribution of one specific ion.
C. Maintained by active transport of sodium ions ($Na^+$) and potassium ions ($K^+$) and passive diffusion of $Na^+$, $K^+$, and chloride ions ($Cl^-$) through the cell membrane.
D. Typically measured at +70 millivolts (mV) because the intracellular environment is more positively charged than the extracellular environment.
E. Created by a more negative charge inside the membrane than outside because $Na^+$ is continuously moved inside the cell membrane by an active transport pump.

ANS: C
Rationale: The resting membrane potential is maintained via passive diffusion of ions across the cell membrane and via active transport of $Na^+$ and $K^+$ by $Na^+/K^+$ pumps.

7. Depolarization occurs when:
A. The membrane potential becomes less negative than the resting membrane potential.
B. The membrane potential becomes more negative than the resting membrane potential.
C. $Cl^-$ influx hyperpolarizes the membrane.
D. The presynaptic terminal of a neuron is inhibited by another neuron.
E. All membrane channels are closed, preventing the influx of $Na^+$.

ANS: A
Rationale: Sudden changes in membrane potential result from the flow of electrically charged ions through gated channels spanning the cell membrane. The membrane is depolarized when the potential becomes less negative than the resting potential.

8. Local potentials:
   A. Are either receptor or synaptic potentials.
   B. Spread passively only a short distance along the cell membrane.
   C. Result from stimulation of sensory receptors or from the binding of a neurotransmitter with chemical receptor sites on a postsynaptic membrane.
   D. Both A and B
   E. A, B, and C

ANS: E
Rationale: Local potentials are categorized as either receptor potentials or synaptic potentials, depending on whether they are generated at a peripheral receptor of a sensory neuron or at a postsynaptic membrane. These local potentials can only spread passively and therefore are confined to a small area of the membrane.

9. Which of the following change the electrical potential across the cell membrane?
   A. Activation and opening of ligand-gated $K^+$ channels.
   B. Activation and opening of modality-gated $Na^+$ channels.
   C. Activation and opening of voltage-gated $Cl^-$ channels.
   D. Leak channels, which allow continuous diffusion of small ions.
   E. All of the above

ANS: E
Rationale: Neurons function by undergoing rapid changes in electrical potential across the cell membrane. An electrical potential across a membrane exists when the distribution of ions creates a difference in electrical charge on each side of the cell membrane. Four types of membrane channels allow ions to flow across the membrane: leak channels, modality-gated channels, ligand-gated channels, and voltage-gated channels.

10. Propagation of an action potential along an axon is dependent on a(n):
   A. Complete myelination of the axon by glial cells.
   B. Anterograde diffusion of the electric potential with active generation of new potentials.
   C. Rapid repolarization associated with passive diffusion of $Cl^-$.
   D. Retrograde diffusion of the electrical potential.
   E. $Na^+/K^+$ pump moving sufficient quantities of $Na^+$ into of the cell and $K^+$ out of the cell.

ANS: B
Rationale: An action potential is a brief, large depolarization in electrical potential that is repeatedly regenerated along the length of an axon. Regeneration allows an action potential to actively spread long distances, transmitting information down the axon to the presynaptic chemical release sites of the presynaptic terminal.

11. The nodes of Ranvier:
    A. Are distributed approximately every 1 to 2 millimeters (mm) along the membrane of the cell axon.
    B. Contain a high density of modality-gated $K^+$ channels for rapid depolarization of the membrane.
    C. Contain a high density of voltage-gated $Na^+$ channels for rapid repolarization of the membrane.
    D. Have low membrane capacitance, preventing the accumulation of electrical charge.
    E. Are heavily myelinated, which allows for rapid diffusion of an electrical potential.

    ANS: A
    Rationale: The nodes are specialized for active propagation of an action potential by allowing ion flow across the membrane. The nodes of Ranvier are distributed every 1 to 2 mm along the axon and contain high densities of voltage-gated $Na^+$ and $K^+$ channels. An action potential spreads rapidly along a myelinated region and then slows when crossing the high-capacitance, unmyelinated region of the nodes of Ranvier.

12. Demyelination of an axon:
    A. Results in decreased membrane resistance, allowing a leakage of electrical current.
    B. Results in slowed propagation of action potentials.
    C. May prevent propagation of action potentials.
    D. Both A and B
    E. A, B, and C

    ANS: E
    Rationale: Myelination increases the speed of action potential propagation and the distance a current can passively spread. Thicker myelin leads to faster conduction and improved action potential propagation. Demyelination allows leakage of electrical current across the membrane, decreasing the amplitude and velocity of the signal as the action potential travels down the axon. Similarly, when a hose has a leaky wall, the flow diminishes as the distance from the faucet increases.

13. Peripheral demyelination:
    A. Typically affects small diameter axons before large diameter axons.
    B. Is a characteristic feature of multiple sclerosis.
    C. Affects the structure of oligodendrocytes.
    D. Typically affects the Schwann cells of large, well-myelinated axons.
    E. Typically affects the axon at the ventral root of the spinal cord.

    ANS: D
    Rationale: Peripheral neuropathies often involve destruction of the myelin surrounding the largest, most myelinated sensory and motor fibers, resulting in disrupted proprioception (awareness of limb position) and weakness. Guillain-Barré syndrome, metabolic abnormalities, viruses, trauma, and toxic chemicals can cause peripheral demyelination.

14. Guillain-Barré syndrome:

A. Involves demyelination of peripheral axons.
B. Results from an autoimmune attack on Schwann cells.
C. May affect cranial nerves controlling the muscles involved in swallowing, breathing, and facial expression.
D. Both A and B
E. A, B, and C

ANS: E
Rationale: Both Guillain-Barré syndrome (acute idiopathic polyneuritis) and multiple sclerosis are autoimmune disorders that cause demyelination. Guillain-Barré syndrome is a peripheral neuropathy that affects sensory and motor function and, in severe cases, peripheral autonomic function. Lower cranial nerves may also be affected, resulting in facial weakness and difficulty swallowing and breathing.

15. Multiple sclerosis:
A. Results from an autoimmune attack on oligodendrocytes.
B. Involves demyelination of axons in the CNS.
C. Has signs and symptoms associated with both motor and sensory impairment.
D. Both A and B
E. A, B, and C

ANS: E
Rationale: Both Guillain-Barré syndrome (acute idiopathic polyneuritis) and multiple sclerosis are autoimmune disorders that cause demyelination. In multiple sclerosis, demyelination in the CNS produces plaque in the white matter. Because multiple sclerosis attacks the CNS, a greater variety of symptoms occur, including weakness, lack of coordination, visual problems, impaired sensation, slurred speech, memory problems, and abnormal emotional affect.

16. Which one of the following is *not* one of the primary components of a neuron?
A. Axon
B. Soma
C. Postsynaptic membrane
D. Dendrite

ANS: C
Rationale: The primary components of a neuron consist of dendrites, which transmit information toward the cell body; the soma or cell body, which synthesizes neurotransmitters; axons, which transmit information away from the cell body to a target cell; and presynaptic terminals, which release neurotransmitters into the synaptic cleft.

17. The strength of local electrical potentials is modulated and integrated via:
A. Spatial summation, the combined effect of potentials generated in other parts of the neuron.
B. Temporal summation, the combined effect of small potential changes occurring over several milliseconds.
C. Both A and B
D. None of the above. A local potential is an all-or-none phenomenon.

ANS: C
Rationale: The strength of local potentials is increased, and the strength of multiple potentials is integrated via spatial summation and temporal summation. Spatial summation refers to the process of summing potentials generated in different parts of the neuron, whereas temporal summation refers to the adding together of small potentials that occur in a period of several milliseconds. If the summation of these local potentials reaches a specific threshold level, an all-or-none action potential is generated.

18. Which one of the following is an example of divergence?
    A. Signals in the neural pathway that leads to contraction of the hip flexor muscles when a painful stimulus is applied to the toe
    B. Integration of taste and smell information in the temporal lobe
    C. Multiple different cells synapsing with a single neuron in the spinal cord
    D. All of the above

ANS: A
Rationale: Convergence is the process during which multiple inputs from a variety of neurons are integrated into a single neuron, whereas divergence is the process during which a single neuron communicates with multiple other neurons. The integration of multiple sensory inputs by the cerebral cortex is an example of convergence; conversely, an example of divergence is the stimulation of a single sensory neuron evoking a withdrawal reflex in a large group of muscle cells.

19. Glial cells contribute which of the following?
    A. Communication between neurons and blood vessels
    B. Neural cell death
    C. Action potential propagation
    D. Both A and B
    E. All of the above

ANS: E
Rationale: Glial cells, known as astrocytes, participate in cellular signaling with other astrocytes, neurons, and cells such as vascular smooth muscle. Glial cells also play an important role in phagocytosis and CNS development. Oligodendrocytes and Schwann cells aid in the propagation of action potentials generated by the neuron. Macroglial cells clean the extracellular environment; however, hyperactivity of these and other glial cells may result in neurologic damage.