Chapter 2: Cellular Mechanisms and Cognition

MULTIPLE CHOICE

1. Two principles about neurons were defined by Ramón y Cajal. The principle of connectional specificity states that _____, whereas the principle of dynamic polarization states that _____.
   a. neural circuits are made of a continuous cytoplasm / the input and output of a neuron are handled by the same specialized part
   b. neural circuits are made of a continuous cytoplasm / the input and output of a neuron are handled by different specialized parts
   c. neural circuits are made of distinct cells / the input and output of a neuron are handled by the same specialized part
   d. neural circuits are made of distinct cells / the input and output of a neuron are handled by different specialized parts

   ANS: D PTS: 1 REF: Page: 19

2. The two main classes of cell in the nervous system are
   a. dendrites and axons.
   b. axons and neurons.
   c. neurons and glial cells.
   d. glial cells and dendrites.

   ANS: C PTS: 1 REF: Page: 20

3. In the nervous system, these cells provide structural support and insulation for neurons.
   a. Glia
   b. Dendrites
   c. Mitochondria
   d. Purkinje cells

   ANS: A PTS: 1 REF: Page: 20

4. Two main types of projections extend from the cell body of a neuron. _____ receive inputs from other neurons, while _____ send information to other neurons.
   a. Synapses / glia
   b. Axons / dendrites
   c. Glia / synapses
   d. Dendrites / axons

   ANS: D PTS: 1 REF: Page: 20

5. Within a neuron, the transmission of information is usually _____. Between neurons, the transmission of information is usually _____.
   a. chemical / chemical
   b. electrical / electrical
   c. electrical / chemical
   d. chemical / electrical

   ANS: C PTS: 1 REF: Page: 22

6. Which of the following is true of bipolar neurons?
   a. They have two processes, one axon, and one dendrite.
   b. Their dendrites and axons typically are fused together.

c. They have one axon and many dendrites.
d. Their dendrites and axons both stem from a single process extending from each cell body.

ANS: A PTS: 1 REF: Page: 23

7. The _____, which is comprised of astrocytes, protects the brain from chemical compounds circulating in the body that might otherwise interfere with neuronal activity.
   a. sodium–potassium pump
   b. blood–brain barrier
   c. myelin sheath
   d. lipid bilayer

   ANS: B PTS: 1 REF: Page: 24

8. Demyelinating diseases such as multiple sclerosis disrupt normal neural communication by
   a. destroying receptors on postsynaptic cells so that neurotransmitters cannot bind normally.
   b. creating lesions in the blood–brain barrier that allow toxic substances to enter the brain from the bloodstream.
   c. causing deterioration of the fatty substance that normally coats and insulates axons.
   d. diminishing the activity of the sodium–potassium pumps that usually maintain the resting potential of neurons.

   ANS: C PTS: 1 REF: Page: 24

9. A person with Parkinson's disease experiences severe difficulty in initiating movement due to the depletion of the chemical dopamine in the brain. Injecting dopamine into this person's bloodstream has no effect on the symptoms because
   a. the body recognizes that the injected dopamine is artificial.
   b. dopamine cannot directly cross the blood–brain barrier into the brain.
   c. myelin insulates neurons from foreign substances in the bloodstream.
   d. this substance cannot be transported into the brain by the sodium–potassium pump.

   ANS: B PTS: 1 REF: Page: 24

10. Which of the following cells produce myelin in the peripheral nervous system?
    a. Astrocytes
    b. Microglia
    c. Oligodendrocytes
    d. Schwann cells

    ANS: D PTS: 1 REF: Page: 25

11. Which of the following cells devour and remove damaged brain cells?
    a. Astrocytes
    b. Microglia
    c. Oligodendrocytes
    d. Schwann cells

    ANS: B PTS: 1 REF: Page: 25

12. If you were to insert a microelectrode through the cell membrane of a neuron, you would be able to demonstrate that
    a. the region inside the cell membrane contains more positive ions than the region outside the membrane.
    b. the region inside the cell membrane contains more negative ions than the region outside the membrane.

c. there is a greater concentration of potassium ions outside the cell membrane than inside the membrane.
d. there is a greater concentration of potassium ions inside the cell membrane than outside the membrane.

ANS: B PTS: 1 REF: Page: 30

13. The nodes of Ranvier are
a. vesicles of neurotransmitters, stored in presynaptic neurons.
b. points along axons where sodium–potassium pumps are found.
c. vesicles of calcium ions, stored in postsynaptic neurons.
d. points along axons that are not surrounded by myelin.

ANS: D PTS: 1 REF: Page: 25

14. The ease with which a cell membrane will permit ions to cross it is referred to as
a. the concentration gradient.
b. permeability.
c. the action potential.
d. conductivity.

ANS: B PTS: 1 REF: Page: 28

15. If you inserted a micropipette into a neuron without harming the cell, and pumped in a small quantity of calcium ions, each of which carried two positive charges, how would this affect the membrane potential?
a. The membrane potential would become depolarized relative to the resting potential.
b. The membrane potential would become hyperpolarized relative to the resting potential.
c. There would be no change because calcium does not contribute to the resting potential.
d. There would be no change because the sodium–potassium pump would remove excess calcium from the cell.

ANS: A PTS: 1 REF: Page: 38

16. Ouabain is a toxin that works by permanently inhibiting the activity of sodium–potassium pumps embedded in neuronal membranes. How would ouabain administration affect the resting potential of a neuron?
a. The magnitude of the resting potential would decrease toward zero.
b. The resting potential would hyperpolarize toward a more negative value.
c. The resting potential would reverse to a positive, rather than a negative, value.
d. Application of ouabain would not affect the resting potential.

ANS: A PTS: 1 REF: Page: 29

17. The term *concentration gradient* refers to a difference in the
a. number of two different ion types within the neuron.
b. number of ions found on opposite sides of the cell membrane.
c. permeability of the membrane to one kind of ion compared to another.
d. permeability of the membrane at rest compared to during an action potential.

ANS: B PTS: 1 REF: Page: 29

18. The Nernst and Goldman equations are used to calculate the
a. resistance of a membrane as a function of the ions embedded within the lipid bilayer.
b. current generated by an action potential as a function of the concentrations of Na^+ and K^+.
c. voltage across a membrane as a function of ion concentrations inside and outside the cell.

d. length constant, or the distance over which an electrotonic current diminishes to a third of its original magnitude.

ANS: C PTS: 1 REF: Page: 30

19. At the resting state, a higher concentration of _____ is found outside a neuron and a higher concentration of _____ is found inside a neuron.
a. K^+ / Na^+
b. Na^+ / K^+
c. dopamine / serotonin
d. serotonin / dopamine

ANS: B PTS: 1 REF: Page: 29

20. You insert a microelectrode into the axon of a neuron and inject positive current while also measuring the membrane potential at a distance of TWO length constants from the site of current injection. *If the neuron does not reach its threshold*, this voltage measurement will be about
a. 1/3 of the value at the injection site.
b. 2/3 of the value at the injection site.
c. 1/9 of the value at the injection site.
d. the same as the value at the injection site.

ANS: C PTS: 1 REF: Page: 38

21. You insert a microelectrode into the axon of a neuron and inject positive current while also measuring the membrane potential at a distance of TWO length constants from the site of current injection. *If the neuron's potential crosses its threshold*, this voltage measurement will be
a. 1/3 of the value at the injection site.
b. 2/3 of the value at the injection site.
c. 1/9 of the value at the injection site.
d. the same as the value at the injection site.

ANS: D PTS: 1 REF: Page: 42

22. During electrotonic, or decremental, conduction, the distance covered by an ionic current will be affected by all of the following factors EXCEPT
a. the amplitude of the original current.
b. the resistance of the neuronal membrane.
c. the frequency of action potential generation.
d. the conductivity of the intracellular and extracellular fluid.

ANS: C PTS: 1 REF: Page: 36

23. The speed at which an action potential could travel down the length of an axon would
a. increase, if the axon's diameter were increased.
b. decrease, if the neuron's cell body volume were decreased.
c. increase, if the myelin sheath were removed from the axon.
d. decrease, if the concentration of extracellular sodium were increased.

ANS: A PTS: 1 REF: Page: 43

24. The value of the membrane potential to which an axon must be depolarized to initiate an action potential is called the _____ potential for that neuron.
a. graded
b. resting
c. threshold

d. refractory

ANS: C PTS: 1 REF: Page: 40

25. The poison tetraethylammonium (TEA) interferes with normal neural communication. The toxin binds to and blocks voltage-gated potassium channels in the neuron cell membrane. Which of the following best describes the effects of TEA on the action potential?
    a. The depolarization phase of the action potential fails to occur.
    b. The repolarization phase of the action potential is blocked.
    c. The refractory period of the action potential is shortened.
    d. The action potential fails to be regenerated at the nodes of Ranvier.

    ANS: B PTS: 1 REF: Page: 42

26. The Hodgkin–Huxley cycle describes how the depolarization of the membrane causes voltage-gated sodium channels to _____, allowing _____ sodium ions to enter the cell. This change in sodium concentration then causes _____ of the cell.
    a. close / fewer / further depolarization
    b. close / fewer / repolarization
    c. open / more / further depolarization
    d. open / more / repolarization

    ANS: C PTS: 1 REF: Page: 41

27. The primary reason why neurons are refractory for a short period after firing action potentials, and the reason underlying the absolute refractory period, is that the
    a. voltage-gated sodium channels are inactivated.
    b. voltage-gated potassium channels are inactivated.
    c. sodium–potassium pump has to remove sodium ions from inside the cell.
    d. sodium–potassium pump has to retrieve potassium ions from outside the cell.

    ANS: A PTS: 1 REF: Page: 41

28. In myelinated axons, action potentials are generated
    a. at the nodes of Ranvier only.
    b. along the entire length of the axons.
    c. underneath the myelinated portions of the axons only.
    d. only at the axon hillocks and axon terminals.

    ANS: A PTS: 1 REF: Page: 44

29. The term *saltatory conduction* refers to the fact that
    a. action potentials travel faster when extracellular salt concentration is high.
    b. action potentials evoked by strong stimuli travel faster than those evoked by weaker stimuli.
    c. action potentials occur only at the nodes of Ranvier of axons.
    d. action potentials are generated only by myelinated portions of axons.

    ANS: C PTS: 1 REF: Page: 44

30. The most important function of myelin in the nervous system is to
    a. form the blood–brain barrier.
    b. trigger the release of neurotransmitters from axon terminals.
    c. produce cerebrospinal fluid in the cerebral ventricles.
    d. facilitate conduction of action potentials in axons.

ANS: D PTS: 1 REF: Pages: 43-44

31. The primary benefit that the nervous system gains from myelination is
    a. generation of currents actively (action potentials) rather than passively (electrotonic conduction).
    b. decreased membrane resistance.
    c. increased resting potentials.
    d. faster neural communication.

    ANS: D PTS: 1 REF: Pages: 43-44

32. The building blocks of the ion channels in cell membranes are
    a. lipids.
    b. amino acids.
    c. sodium ions.
    d. potassium ions.

    ANS: B PTS: 1 REF: Page: 44

33. The _____ structure of a protein refers to how chains of amino acids coil to form characteristic patterns such as the alpha-helix.
    a. primary
    b. secondary
    c. tertiary
    d. quaternary

    ANS: B PTS: 1 REF: Page: 45

34. The general term for a molecule that binds to a protein, such as an ion channel, is a(n)
    a. receptor.
    b. ligand.
    c. second messenger.
    d. amine.

    ANS: B PTS: 1 REF: Page: 46

35. Indirectly coupled receptors in a cell membrane
    a. change the structure of the ion channel to which they are attached.
    b. trigger enzymatic cascades involving G proteins and second messengers.
    c. do not have as large an effect as directly coupled receptors.
    d. Both b and c are true.

    ANS: B PTS: 1 REF: Pages: 46-47

36. Which of the following statements best describes the immediate consequence of neurotransmitter molecules binding to postsynaptic receptors?
    a. Voltage-gated channels in the cell membrane open and permit ion flow through the membrane.
    b. The activity of the sodium–potassium pumps increases.
    c. Calcium absorption into the axon terminal cell is triggered.
    d. Neurotransmitter-containing vesicles bind to the inside of the axon terminal membrane.

    ANS: A PTS: 1 REF: Page: 46

37. The role of calcium ions (Ca^{2+}) in synaptic transmission is to
    a. bind neurotransmitter molecules to the postsynaptic membrane.

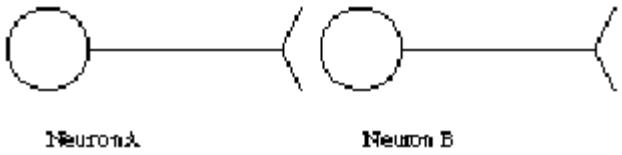
b. mediate the release of neurotransmitter molecules from the presynaptic neuron.
c. repolarize the postsynaptic cell after transmission has been completed.
d. increase the activity of the sodium–potassium pumps in the presynaptic cell.

ANS: B PTS: 1 REF: Page: 45

38. Which of the following sequences of steps best represents the events that occur during synaptic transmission?
a. Binding of neurotransmitter at the postsynaptic membrane, diffusion of neurotransmitter across the synapse, release of neurotransmitter from the presynaptic cell
b. Diffusion of neurotransmitter across the synapse, binding of neurotransmitter at the postsynaptic membrane, release of neurotransmitter from the presynaptic cell
c. Release of neurotransmitter from the presynaptic cell, binding of neurotransmitter at the postsynaptic membrane, diffusion of neurotransmitter across the synapse
d. Release of neurotransmitter from the presynaptic cell, diffusion of neurotransmitter across the synapse, binding of neurotransmitter at the postsynaptic membrane

ANS: D PTS: 1 REF: Page: 51

39. Consider the synapse shown schematically here. If neuron A causes neuron B to become hyperpolarized relative to B's resting state,



a. neuron B is more likely to fire its own action potential.
b. neuron B is less likely to release neurotransmitter molecules from its own axon terminal.
c. neuron B is more likely to absorb extracellular potassium through voltage-gated channels.
d. neuron B is less likely to absorb extracellular sodium through the sodium–potassium pump.

ANS: B PTS: 1 REF: Page: 34

40. A gap junction is
a. the point where a neurotransmitter vesicle binds to the presynaptic membrane.
b. a connection between two sections of a G protein that plays a role in second-messenger cascades.
c. a transmembrane channel that connects the cytoplasm of two cells at an electrical synapse.
d. more likely to be found on the amino acids than on the biogenic amines.

ANS: C PTS: 1 REF: Page: 54

41. Which of the following is NOT always true of neurotransmitters?
a. They are synthesized in the axon terminals of the presynaptic neuron.
b. They are released by the presynaptic neuron when action potentials depolarize its axon terminal.
c. They bind to receptors on the membrane of the postsynaptic neuron.
d. Applying a neurotransmitter artificially to the postsynaptic neuron would lead to the same response as stimulating the presynaptic neuron.

ANS: A PTS: 1 REF: Page: 51

42. Which of the following is a catecholamine?
a. Gamma-aminobutyric acid (GABA)

b. Glutamate
c. Serotonin
d. Norepinephrine

ANS: D PTS: 1 REF: Page: 51

43. The effect of a given neurotransmitter on a postsynaptic neuron
a. is always either excitatory or inhibitory.
b. depends on the properties of the postsynaptic neuron.
c. may be modulated by the presence or absence of another neurotransmitter.
d. Both b and c are true.

ANS: D PTS: 1 REF: Page: 51

44. Which of the following is NOT a mechanism for removing a neurotransmitter from the synaptic cleft?
a. Diffusion of the neurotransmitter away from the synapse
b. Active reuptake of the neurotransmitter back into the presynaptic terminal
c. Enzymatic breakdown of the neurotransmitter in the synaptic cleft
d. Transport of the neurotransmitter by ion channels into neighboring glial cells

ANS: D PTS: 1 REF: Page: 52

45. Many drugs produce their effects by facilitating or interfering with neurotransmitters at synapses. Which of the following drugs would most likely increase the effect of serotonin?
a. A drug that binds to directly coupled serotonin receptors but does not change membrane permeability
b. A drug that prevents the activity of an enzyme that breaks down serotonin molecules in the synaptic cleft
c. A drug that blocks the effect of Ca^{2+} ions
d. A drug that blocks the effect of a conditional neurotransmitter that normally facilitates the effect of serotonin

ANS: B PTS: 1 REF: Page: 45

46. One of the biochemical precursors of dopamine is _____, which can be used as a treatment for Parkinson's disease.
a. L-dopa
b. R-dopa
c. 3-HT
d. 5-HT

ANS: A PTS: 1 REF: Page: 24

47. Drugs that facilitate neurotransmission are sometimes called _____, while drugs that inhibit neurotransmission are sometimes called _____.
a. ligands / receptors
b. receptors / ligands
c. agonists / antagonists
d. antagonists / agonists

ANS: C PTS: 1 REF: Page: 54

48. Most antidepressants are
a. dopamine agonists.
b. dopamine antagonists.
c. serotonin agonists.

d. serotonin antagonists.

ANS: C PTS: 1 REF: Page: 54

49. The antipsychotic drugs often given to people with schizophrenia are typically
a. dopamine agonists.
b. dopamine antagonists.
c. serotonin agonists.
d. serotonin antagonists.

ANS: B PTS: 1 REF: Page: 24

50. Electrical synapses have the advantage of _____, but they are unable to _____.
a. transmitting information rapidly / transmit inhibitory signals
b. transmitting inhibitory signals / transmit information rapidly
c. synchronizing groups of neurons / transmit excitatory signals
d. transmitting excitatory signals / synchronize groups of neurons

ANS: A PTS: 1 REF: Page: 55

TRUE/FALSE

1. The cell body of a neuron contains the same machinery found in most cells, including a nucleus, ribosomes, and mitochondria.

ANS: T PTS: 1 REF: Page: 20

2. Dendrites, which are large treelike processes extending from a neuron, are said to be presynaptic.

ANS: F PTS: 1 REF: Page: 20

3. Action potentials are special electrical signals that are conducted down the axon of a neuron.

ANS: T PTS: 1 REF: Page: 25

4. The term *selective permeability* refers to the fact that a cell membrane will allow some ions to pass through more readily than others.

ANS: T PTS: 1 REF: Page: 29

5. The resting potential of a neuron is typically +40 to +90 millivolts (mV).

ANS: F PTS: 1 REF: Page: 30

6. The *equilibrium potential* is the membrane voltage at which there is no net flow of ions in or out.

ANS: T PTS: 1 REF: Page: 30

7. Hyperpolarization makes the inside of a cell more positive and more likely to generate an action potential.

ANS: F PTS: 1 REF: Page: 34

8. The amplitude of an action potential is directly proportional to the size of the initial depolarization that produced it.

   ANS: F PTS: 1 REF: Page: 40

9. If the sum of the excitatory postsynaptic potentials (EPSPs) causes a postsynaptic neuron to reach its threshold, then the postsynaptic neuron will generate an action potential.

   ANS: T PTS: 1 REF: Page: 49

10. Communication between two neurons is always achieved through chemical, and not electrical, mechanisms.

    ANS: F PTS: 1 REF: Page: 54

ESSAY

1. Describe the structure of a prototypical neuron. In your answer, provide definitions for the following terms: *soma*, *axon*, *dendrite*, *myelin*, and *synapse.*

   ANS:
   Answer will vary.

   PTS: 1

2. Describe the chemical and electrical properties of an action potential. In your answer, describe the movement of Na^+ ions and K^+ ions across the cell membrane and the resulting changes in electrical potential.

   ANS:
   Answer will vary.

   PTS: 1

3. Explain the concept of electrochemical equilibrium. How does this concept allow us to understand the transmembrane potentials in neurons?

   ANS:
   Answer will vary.

   PTS: 1

4. What are the major differences between electrotonic conduction and the action potential? Describe how these two processes play out in neural transmission.

   ANS:
   Answer will vary.

   PTS: 1

5. How do two neurons communicate with each other? Describe the process of synaptic transmission, including both chemical and electrical synapses.

ANS:
Answer will vary.

PTS: 1