BIO 320 Neurobiology
Monsoon 2022
Exam I, mid-term examination
Instructor: Rama Ratnam

SET A

Saturday, September 24, 2022
(Covers Chapter 1.1 to 3.11)

Fifty questions to be attempted in **70 minutes.** Read each question carefully before answering. There are no "trick" questions. This is a closed book exam. A calculator is not necessary. No laptop or phone to be present on the table.

Useful formulae

Nernst equation
([*x*] denotes concentration of substance *x*)
E is the equilibrium potential for an ion.

$$E = \frac{RT}{zF} \ln \frac{[\text{ion outside cell}]}{[\text{ion inside cell}]} = 2.3026 \frac{RT}{zF} \log_{10} \frac{[\text{ion outside cell}]}{[\text{ion inside cell}]}.$$

Goldman-Hodgkin-Katz (GHK) equation

$$V_m = \frac{RT}{F} \ln \frac{P_K[K^+]_o + P_{Na}[Na^+]_o + P_{Cl}[Cl^-]_i}{P_K[K^+]_i + P_{Na}[Na^+]_i + P_{Cl}[Cl^-]_o}$$

Gas constant, R = 8.314 J.Mol^{-1}.K^{-1}; Faraday's constant, F = 96,500 C.Mol^{-1}; T is in Kelvin; z is the valence of the ion; P_x is the plasma membrane permeability to ion x. The natural logarithm is ln, and ln (y) = 2.3026 $\log_{10}$ (y).

1. List in order of INCREASING diameter: (A) neurofilaments, (B) microtubules, (C) microfilaments.

a. A, B, C
b. C, B, A
c. B, A, C
d. C, A, B

2. What is quantal release of neurotransmitter?

a. Release of one neurotransmitter molecule at a time
b. Release of neurotransmitter in discrete packets

c. Number of neurotransmitters released in response to a single action potential
d. Number of neurotransmitters released from a single active zone in the synapse

3. What helps maintain the ion concentration across the membrane of neurons?

a. The driving force for any ion
b. Na+/K+ ATPase
c. Leak K+ channels
d. Leak Na+ channels

4. What is a miniature end-plate potential (mEPP)? Select all that apply.

a. The change in postsynaptic potential at a single synapse in the motor end plate
b. The change in postsynaptic response from a single action potential
c. Small postsynaptic responses of a unitary size, that can be elicited without nerve stimulation
d. The change in postsynaptic potential when a current pulse is delivered at the presynaptic terminal

5. Which of the following is likely to be a reasonable value for fast axonal transport?

a. 5 μm/day
b. 5 mm/day
c. 5 μm/s
d. 5 mm/s

6. What are the three main SNARE proteins?

a. Synapsin, SNAP-25, synaptotagmin
b. Synapsin, synaptobrevin and synaptotagmin
c. SNAP-25, syntaxin and synaptobrevin
d. SNAP-25, synaptotagmin, synaptobrevin

7. The speed of retrograde axonal transport is similar to that of

a. Fast axonal transport
b. Slow axonal transport

8. Cytoskeletal elements along which long-distance neuronal transport takes place are

a. Microfilaments
b. Neurofilaments
c. Microtubules
d. α- and β-tubulin

9. Which protein is the Ca^{2+} sensor in synaptic transmission?

a. Synapsin
b. Munc18

c. Synaptotagmin
d. Synaptobrevin

10. One of the motor molecules responsible for axonal transport is kinesin. It's movement along the axon is

a. axon terminal to soma, i.e., negative end of microtubule to positive end.
b. soma to axon terminal, i.e., negative end of microtubule to positive end.
c. soma to axon terminal, i.e., positive end of microtubule to negative end.
d. axon terminal to soma, i.e., positive end of microtubule to negative end.

11. Which of these proteins does NOT act as a molecular motor?

a. Kinesin
b. Dynein
c. Myosin
d. Tubulin

12. In hypothetical neuron, the extracellular K^+ concentration and the intracellular Na^+ concentration decrease. If increase in potential implies that the membrane becomes more positive, and a decrease makes it more negative, then you would expect the equilibrium potential for K^+ and Na^+ to, respectively

a. increase and decrease
b. decrease and decrease
c. increase and increase
d. decrease and increase

13. In a hypothetical neuron the resting membrane potential becomes more positive. If the ion permeabilities are unchanged, then the change in resting potential could be because intracellular K+ concentration has _____, OR the intracellular Na+ concentration has _____. (Note, that the question says OR and not AND)

a. increased and decreased
b. decreased and decreased
c. increased and increased
d. decreased and increased

14. What is the current known role of complexin in synaptic transmission?

a. Complexin makes sure vesicles are near Ca^{2+} channels.
b. Complexin binds vesicles to scaffolding proteins in the presynaptic membrane.
c. Complexin puts an inhibitory block on the SNARE/SM complex and prevents neurotransmitter release.
d. Complexin is required for presynaptic Ca^{2+} channels to open.

15. Which cytoskeletal element forms ring like structures near the plasma membrane of axons?

a. Myelin
b. Tubulin
c. F-actin
d. Myosin

16. The presynaptic membrane at the active zone is linked to the postsynaptic membrane by adhesion molecules. The following are all adhesion molecules, but which of them is NOT found in the presynaptic-postsynaptic link (Select ONE)

a. Cadherin
b. Neuroligin
c. Neurexin
d. Selectin

17. The neural membrane at rest is most permeable to which of the following ions?

a. Na+
b. Cl-
c. K+
d. Ca++

18. Which of the following proteins is not a transmembrane protein?

a. Syntaxin
b. Synaptobrevin
c. V-ATPase
d. SNAP-25

19. In a neuron which statement represents the correct ion gradients (K_o^+, Na_o^+, and Cl_o^{-1} refer to extracellular concentrations, and K_i^+, Na_i^+, and Cl_i^{-1} refer to intracellular concentrations).

a. K_o^+ is larger than K_i^+, while Cl_i^{-1} is larger than Cl_o^{-1}
b. K_o^+ is smaller than K_i^+, while Cl_i^{-1} is larger than Cl_o^{-1}
c. K_o^+ is larger than K_i^+, while Cl_i^{-1} is smaller than Cl_o^{-1}
d. K_o^+ is smaller than K_i^+, while Cl_i^{-1} is smaller than Cl_o^{-1}

20. Which group of proteins at the active zone of a synapse bind voltage gated Ca2+ channels to synaptic vesicles?

a. v-SNARE proteins
b. t-SNARE proteins
c. Munc18 and Unc13
d. RIM/RIM-BP and Rab3 proteins

21. In a neuron all the extracellular Na+ is replaced with an impermeable ion Li+ (lithium ion). You would expect the resting potential to

a. increase
b. decrease
c. remain unchanged
d. increase or decrease. Cannot say, as more information is needed.

22. In the mammalian neuromuscular junction (NMJ), acetylcholine (ACh) is released. After binding to postsynaptic receptors, ACh is eventually

a. transported back to the presynaptic terminal via Na+/ACh symporters.
b. transported to neighboring glial cells via Na+/ACh symporters.
c. degraded by acetylcholinesterase.
d. diffuse away from the synaptic cleft and eventually metabolized.

23. In a voltage clamp experiment, the voltage is clamped to a fixed command potential. Which of the following are expected to change when the membrane potential is clamped?

a. Current through the membrane, only
b. Conductivity of voltage-gated channels, only
c. The equilibrium potential for ions, only
d. Current through the membrane and conductivity of the membrane.

24. The energy for transporting neurotransmitters into a synaptic vesicle is obtained from

a. a Na+ gradient which is harnessed by a vesicle antiport transporter.
b. a proton gradient established by a V-ATPase which is harnessed by a vesicle antiport transporter.
c. a proton gradient established by a Ca2+/H+ ATPase which is harnessed by a vesicle antiport transporter.
d. The concentration gradient of neurotransmitter in the cytosol is favourable for passive transport of neurotransmitter into the vesicle via a uniporter.

25. The voltage-clamp preparation is used for determining (select one):

a. Passive membrane capacitance
b. Passive membrane conductance
c. The equilibrium potential of any voltage-gated channel
d. The conductance of any voltage-gated channel.

26. What are the two major/most common neurotransmitters in the vertebrate CNS?

a. GABA and acetylcholine
b. Glycine and acetylcholine
c. GABA and glutamate
d. GABA and glycine

27. Which sequence of voltage-gated channel activations/inactivations best describes the rising and falling phases of the action potential, respectively?

a. Activation of Na+, Inactivation of K+
b. Inactivation of Na+, Inactivation of K+
c. Inactivation of Na+, Activation of K+
d. Activation of Na+, Activation of K+

28. In a bare axon (unmyelinated) the action potential cannot travel in an antidromic direction because
(Note: "behind" the action potential means in the antidromic direction, and "ahead" means in the orthodromic direction)

a. The patch of membrane behind the action potential has inactivated K+ channels and activated Na+ channels
b. The patch of membrane behind the action potential has activated K+ channels and inactivated Na+ channels
c. The patch of membrane ahead of the action potential has activated K+ channels and inactivated Na+ channels
d. The patch of membrane behind the action potential has inactivated K+ channels and inactivated Na+ channels

29. There are three mechanisms for recovering synaptic vesicle membrane. Which of the three requires clathrin or the formation of a clathrin coat?

a. The "Kiss and run" mechanism.
b. Endocytic vesicle formation
c. Synaptic endosome formation (ultrafast endocytosis)

30. Clathrin which is necessary for recovery of vesicle membrane is taken up from the

a. presynaptic terminal
b. synaptic cleft
c. postsynaptic compartment

31. If the distance between adjacent Nodes of Ranvier reduces (all other things being kept constant), the propagation velocity of action potentials will

a. reduce
b. increase

32. The *Shibire* mutant fly becomes paralyzed when the environment temperature is elevated to 29^{o}C and beyond. This is because

a. Synaptic vesicles can form but their cleaving is not possible due to the *Shibire* mutation, and endocytosis cannot take place.
b. Synaptic vesicles cannot form because the *Shibire* mutation affects vesicle formation.
c. The "Kiss and run" mechanism fails.
d. Synpatic vesicles fail to fuse in the active zone due to the *Shibire* mutation.

33. The substances TTX (tetrodotoxin) and TEA (tetraethylammonium) act as follows, respectively

a. Block voltage-gated Na+ channels, open voltage-gated K+ channels
b. Block voltage-gated K+ channels, open voltage-gated Na+ channels
c. Block voltage-gated Na+ channels, block voltage-gated K+ channels
d. Open voltage-gated K+ channels, open voltage-gated Na+ channels

34. Which protein does the *Shibire* gene encode (recall that the *Shibire* mutation causes flies to become paralyzed)

a. Clathrin
b. Dynamin
c. Synaptotagmin
d. Synapsin

35. The key modification to amino acids in an ionic channel which makes them voltage-gated is

a. the presence of a voltage-sensing pore
b. the presence of a pore which is highly sensitive to a specific ion
c. the presence of a transmembrane segment which is sensitive to membrane potential and acts as an activation gate
d. the presence of a transmembrane segment which is sensitive to membrane potential and acts as an inactivation gate.

36. The number of vesicles and the quantum of neurotransmitters released in synapses in the central nervous system (CNS) far exceeds the number of vesicles and quantum of neurotransmitters released at the NMJ in the peripheral nervous system (PNS).

a. TRUE
b. FALSE

37. Consider the neurotransmitter release probability at an active zone. If the release probability is low to begin with, and it gradually increases with repeated action potentials, then the synapse is considered to be a

a. facilitating synapse
b. depressing synapse

38. The neuron doctrine proposed by _____ refers to the idea that the nervous system is composed of discrete cells which form intimate _____ , whereas the reticular theory proposed by _____ refers to the idea that the nervous system is composed of a _____ of cells

a. Golgi, contacts, Cajal, reticulum
b. Golgi, reticulum, Cajal, contacts
c. Cajal, contacts, Golgi, reticulum
d. Cajal, reticulum, Golgi, contacts

39. Which of these cells is not a glial cell

a. Schwann cell
b. Oligodendrocyte
c. Astrocyte
d. Chondrocyte

40. In the Nernst equation for potassium, if you halve the intracellular concentration and the extracellular concentration of potassium, the Nernst (equilibrium) potential for potassium will

a. double
b. halve
c. increase by a factor of $\log_{10}(2)$
d. remain unchanged

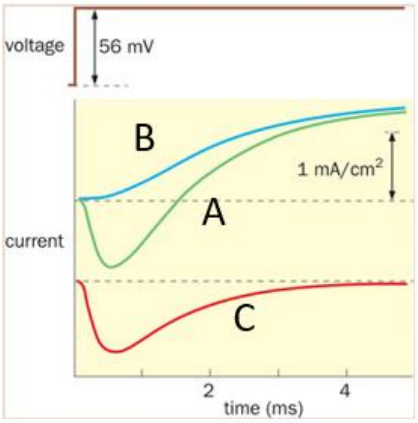
41. Priyamvada Varadarajan conducts an experiment to determine the resting membrane potential of a neuron. She has all the values she needs (intracellular and extracellular concentrations, and permeabilities of Na+, K+, and Cl-). When she is plugging the values into the Goldman-Hodgkin-Katz (GHK) equation, she mistakenly switches the extracellular concentrations of potassium and sodium. Everything else is correctly entered. The membrane potential she calculates will be

a. more negative than the true resting potential
b. more positive than the true resting potential
c. unable to determine from the information provided

42. Bimal Chintanbhai Sanghvi is bored taking a neurobiology exam, and dislikes calculations using the GHK equation. To save time, he decides that he will ignore the chloride concentrations because the chloride permeability is very low (compared to permeabilities for sodium and potassium). He drops the chloride terms from the numerator and denominator of the GHK equation. Is he justified in doing so?

a. Yes
b. No

Figure 1, for Questions 43 to 50. Trace A is the current recording obtained under normal physiological conditions of the squid axon. Trace B is obtained when Na+ in the extracellular compartment is replaced by Choline. Trace C is the difference between A and B.



43. (Figure 1) The trace A is due to the flow of which ions?

a. Na+ alone.
b. K+ alone
c. Na+ and K+

44. (Figure 1) The plateau value of A (seen after 4 ms) is due to

a. Closing of voltage-gated Na+ channels and opening of voltage-gated K+ channels
b. Opening of voltage-gated Na+ channels and closing of voltage-gated K+ channels
c. Opening of voltage-gated Na+ channels and opening of voltage-gated K+ channels

45. (Figure 1) Why is Choline necessary?

a. It blocks Na+ channels
b. It blocks K+ channels
c. It cannot be transported by voltage-gated Na+ channels
d. It makes the Na+ equilibrium potential very large, almost infinite.

46. (Figure 1) The current trace show in C is due to

a. An inward Na+ current
b. An inward Na+ current and outward K+ current
c. An outward Na+ current
d. An outward Na+ current and inward K+ current

47. (Figure 1) The current trace show in B is due to

a. An inward Na+ current
b. An inward K+ current
c. An outward Na+ current
d. An outward K+ current.

48. (Figure 1) Peak conductance of K+ can be measure from Trace __, and peak conductance of Na+ can be measured from Trace __

a. C, B
b. B, C

49. (Figure 1) If the plateau value in Trace B were to become higher (i.e., the plateau current is higher than shown) then it implies that

a. the Na+ conductance is larger
b. the Na+ conductance is smaller
c. the K+ conductance is larger
d. the K+ conductance is smaller

50. (Figure 1) You can calculate the peak Na+ conductance from

a. the plateau current in Trace A or B
b. The plateau current in Trace B alone
c. The plateau current in Trace C (after about 4 ms)
d. The current at the trough of Trace C (i.e., the lowest point in Trace C).