

**STEIN IN-TERM EXAM -- BIOLOGY 3058 -- MARCH 23, 2017 -- PAGE 1 of 9**

There are 25 questions in this Biology 3058 exam.

All questions are "A, B, C, D, E, F, G, H" questions worth one point each.

There is a total of 25 points in this exam. Fill in your answers on the separate answer sheet.

The format for this exam is:

Fill in A if A is the only correct answer.

Fill in B if B is the only correct answer.

Fill in C if C is the only correct answer.

Fill in D if both A and B are correct (and C is NOT correct).

Fill in E if both A and C are correct (and B is NOT correct).

Fill in F if both B and C are correct (and A is NOT correct).

Fill in G if A and B and C are all correct.

Fill in H if none of the above is correct (A is NOT correct, B is NOT correct, and C is NOT correct).

**ONLY MARK ONE LETTER PER QUESTION.**

You may keep the question sheets.

**Use a dark (black or blue) pencil or dark (black or blue) pen to fill in the answers.**

**DO NOT USE A RED PEN; DO NOT USE A RED PENCIL.**

1. A complete motor neuron is removed from a frog and placed in a large volume of modified extracellular saline. The neuron is healthy; it has a stable resting voltage of -80 millivolts. It is not producing any action potentials; its threshold for an action potential is -50 millivolts. The only ligand-gated Receptors in the neuron's plasma membrane are AMPA Receptors, GABA<sub>B</sub> Receptors, and glycine Receptors. The equilibrium potential for chloride ions is -70 millivolts, the equilibrium potential for potassium ions is -80 millivolts, and the equilibrium potential for sodium ions is +60 millivolts.
  - A. The addition of GABA to the physiological saline will lead a decrease in the amount of intracellular potassium.
  - B. The addition of GABA and glutamate to the physiological saline will lead to an increase in the amount of intracellular sodium and a decrease in the amount of intracellular potassium.
  - C. The addition of glycine to the physiological saline will lead to an increase in the amount of intracellular chloride.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
  
2. Which of the following is an ligand that binds to a receptor site that is part of a ligand-gated metabotropic receptor?
  - A. ACh (acetylcholine).
  - B. CNQX.
  - C. GABA.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

3. Which of the following occur after an increase in the length of the right knee extensor muscle that happens after a quick tap is applied to the right patellar tendon?
- A. An increase in the amount of glutamate released from the central axon terminals of IA muscle-spindle stretch receptor neurons that synapse directly upon the dendrites and cell bodies of right knee extensor motor neurons.
  - B. An increase in the amount of calcium conductance in the plasma membranes of central axon terminals of IA muscle-spindle stretch receptor neurons whose peripheral terminals are in the right knee extensor muscle.
  - C. An increase in the amount of calcium in the sarcoplasmic reticulum of muscle fibers in the right knee extensor muscle.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
4. Consider Neuron B in the frog central nervous system whose plasma membrane has a previously unknown channel that is selectively conductive to a newly discovered divalent cation named DIVCAT with a valence of +2. The threshold for an action potential in Neuron B is -45 millivolts and the resting potential for Neuron B is -70 millivolts. The DIVCAT channel in Neuron B is part of an ionotropic receptor with an extracellular binding site for the newly discovered ligand LGD. When LGD binds to its binding site, there is an increase in the DIVCAT conductance of Neuron B. Neuron A synapses onto Neuron B. Neuron A's neurotransmitter is LGD. In this experiment, the temperature of the frog central nervous system is 20° C.
- A. The intracellular concentration of DIVCAT is 1000 times greater than the extracellular concentration of DIVCAT. In response to an action potential in Neuron A, there will be: a decrease in the membrane voltage of Neuron B; a decrease in the amount of intracellular DIVCAT in Neuron B; and an inhibitory postsynaptic potential in Neuron B.
  - B. The intracellular concentration of DIVCAT is 100 times greater than the extracellular concentration of DIVCAT. In response to an action potential in Neuron A, there will be: an increase in the membrane voltage of Neuron B; an increase in the amount of intracellular DIVCAT in Neuron B; and an inhibitory postsynaptic potential in Neuron B.
  - C. The intracellular concentration of DIVCAT is 10 times greater than the extracellular concentration of DIVCAT. In response to an action potential in Neuron A, there will be: an increase in the membrane voltage of Neuron B; an increase in the amount of intracellular DIVCAT in Neuron B; and an excitatory postsynaptic potential in Neuron B.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

5. Consider a system that contains three neurons in a culture dish bathed in normal physiological saline. All three neurons are healthy. Neuron A synapses onto Neuron B. Neuron B synapses onto Neuron C. Neuron A has glycine in its synaptic vesicles. Neuron B has GABA in its synaptic vesicles. The only ligand-gated receptors in Neuron A are AMPA channels. The only ligand-gated receptors in the plasma membrane of Neuron B are glycine receptors. The only ligand-gated receptors in the plasma membrane of Neuron C are GABA<sub>A</sub> receptors. All 3 neurons have no other ligand-gated receptors in their plasma membranes. All 3 neurons have a sodium equilibrium potential of +60 millivolts. All 3 neurons have a potassium equilibrium potential of -86 millivolts. All 3 neurons a chloride equilibrium potential of -70 millivolts. The threshold for an action potential in all 3 neurons is -55 millivolts. At 1:55 AM, glutamate is added to the physiological saline. At 2:00 AM, the action potential firing rate of each neuron is 100 Hz. Which of the following will lead to an increase in Neuron C's action potential firing rate?
- A. At 2:01 AM, GABA is added to the bath.
  - B. At 2:01 AM, strychnine is added to the bath.
  - C. At 2:01 AM, CNQX is added to the bath.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
6. Neuron A is a healthy neuron with all the usual ion channels. When at rest with a membrane voltage of R millivolts, neuron A produces no action potentials. The voltage threshold for an action potential in neuron A is T millivolts. T is greater than R; T is less than zero. In addition, neuron A's membrane includes the membrane-spanning molecule Z with an ion channel that opens when neurotransmitter Y binds to the Y receptor site on the extracellular surface of Z. The Nernst equilibrium potential for Z's ion channel is E millivolts. Neuron B synapses on neuron A; neuron B's neurotransmitter is neurotransmitter Y. Neuron A is initially at rest. Which of the following statements are true when neuron B produces an action potential and releases neurotransmitter Y?
- A. If the value of E is greater than R, and if the value of T is greater than E, and if chloride is the only ion that passes through open Z channels, then Y's binding to its receptor site on Z in neuron A produces an inhibitory postsynaptic potential in neuron A, an increase in chloride conductance of the plasma membrane of neuron A, and a decrease in the amount of intracellular chloride ions in neuron A.
  - B. If the value of R is equal to E, and if chloride is the only ion that passes through open Z channels, then Y's binding to its receptor site on Z in neuron A produces an inhibitory postsynaptic potential in neuron A, no change in chloride conductance of the plasma membrane of neuron A, and no change in the amount of intracellular chloride ions in neuron A.
  - C. If the value of E is zero and if both sodium ions and potassium ions pass through open Z channels, then Y's binding to its receptor site on Z in neuron A produces an inhibitory postsynaptic potential in neuron A, an increase in the amount of intracellular sodium ions in neuron A, and a decrease in the amount of intracellular potassium ions in neuron A.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

7. Consider five culture dishes; each dish has one healthy neuron in it. Dish V has Neuron V in it; Dish W has Neuron W in it; Dish X has Neuron X in it; Dish Y has Neuron Y in it; and Dish Z has Neuron Z in it. At 1:00 AM: each neuron is bathed in normal physiological saline; all the neurons have the same properties; and each neuron is at rest with a resting potential of -70 millivolts. Each neuron has only three types of ionotropic ligand-gated receptors: AMPA Receptors, NMDA Receptors, and Glycine Receptors. None of the neurons have metabotropic receptors. Each neuron has a chloride equilibrium potential of -70 millivolts. At 1:55 AM, a large amount of TTX is added to the physiological saline in all five dishes. Ignore any effects due to voltage-gated calcium channels with S4 helices. The AMPA Receptor channels in these neurons do not have calcium conductance when these AMPA Receptor channels are open. At 1:58 AM, the amount of intracellular calcium in each neuron is the same as that of each other neuron. At 2:00 AM:
- glutamate is added to the physiological saline of Dish V;
  - glutamate and APV are added to the physiological saline of Dish W;
  - glutamate and CNQX are added to the physiological saline of Dish X;
  - glutamate and glycine are added to the physiological saline of Dish Y;
  - glutamate, glycine, and strychnine are added to the physiological saline of Dish Z.
- A. At 2:01 AM, the total calcium conductance in Neuron V is greater than the total calcium conductance in Neuron W. In addition, the total calcium conductance in Neuron Z is less than the total calcium conductance in Neuron Y.
  - B. At 2:01 AM, the total sodium conductance in Neuron W is greater than the total sodium conductance in Neuron X. In addition, the total sodium conductance in Neuron V is greater than the total sodium conductance in Neuron Y.
  - C. For each neuron, MAXV is the maximum voltage that is reached by that neuron during the period from 2:00 AM to 2:02 AM. The MAXV in Neuron W is greater than the MAXV in Neuron X. In addition, the MAXV in Neuron Y is greater than the MAXV in Neuron Z.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
8. Which of the following are neurotransmitters?
- A. AMPA.
  - B. GABA.
  - C. Glycine.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

9. Consider Neuron B in the frog central nervous system whose plasma membrane has a newly discovered ligand-gated ionotropic receptor, named the LGD receptor. The channel in the same molecular complex as the LGD receptor is termed the LGD receptor channel and is a monovalent cation channel that, when open, is permeable to both sodium and potassium. The Nernst equilibrium potential for sodium in Neuron B is +100 mV, and the Nernst equilibrium potential for potassium in Neuron B is -100 mV. The threshold for an action potential in Neuron B is -45 mV and the resting potential for Neuron B is -60 mV. LGD is an agonist for the ligand-gated ionotropic receptor. When LGD binds to its binding site, there is an increase in conductance of both sodium and potassium in the LGD receptor channel. Neuron A synapses onto Neuron B. Neuron A's transmitter is LGD.
- A. Consider the situation that when the LGD receptor channel is open in Neuron B, its potassium conductance equals its sodium conductance. For this situation, in response to an action potential in Neuron A, there is an excitatory postsynaptic potential in Neuron B. In addition for this situation in response to an action potential in Neuron A, the absolute value of the change in the amount of intracellular sodium in Neuron B is equal to the absolute value of the change in the amount of intracellular potassium in Neuron B.
  - B. Consider the situation that when the LGD receptor channel is open in Neuron B, its potassium conductance equals four times its sodium conductance. For this situation, in response to an action potential in Neuron A, there is an inhibitory postsynaptic potential in Neuron B. In addition for this situation in response to an action potential in Neuron A, the absolute value of the change in the amount of intracellular sodium in Neuron B is less than the absolute value of the change in the amount of intracellular potassium in Neuron B.
  - C. Consider the situation that when the LGD receptor channel is open in Neuron B, its potassium conductance equals nine times its sodium conductance. For this situation, in response to an action potential in Neuron A, there is an inhibitory postsynaptic potential in Neuron B. In addition for this situation in response to an action potential in Neuron A, the absolute value of the change in the amount of intracellular sodium in Neuron B is less than the absolute value of the change in the amount of intracellular potassium in Neuron B.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
10. Neuron Z has a stable resting voltage of -70 millivolts. It is not producing any action potentials; its threshold for an action potential is -50 millivolts. The equilibrium potential for chloride ions is -70 millivolts, the equilibrium potential for potassium ions is -90 millivolts, and the equilibrium potential for sodium ions is +60 millivolts. When the ion channel in Neuron Z associated with the GABA<sub>B</sub> Receptor opens,
- A. this will lead to a decrease in the amount of intracellular potassium.
  - B. the open channel will have a large chloride conductance.
  - C. the open channel will have an equilibrium potential that is less than the value of the threshold for an action potential.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

11. Which of the following is an antagonist that binds to the receptor site that is part of a ligand-gated ionotropic ion channel?
- A. CNQX.
  - B. NMDA.
  - C. TTX (tetrodotoxin).
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
12. A healthy skeletal muscle fiber is isolated and has no external forces on it. It has normal intracellular levels of ATP and is bathed in physiological saline. An action potential in the plasma membrane of the muscle fiber leads to which of the following?
- A. An increase in the amount of Dihydropyridine (DHP) that is bound to Dihydropyridine (DHP) Receptors in the membranes of the transverse tubules.
  - B. An increase in the amount of Ryanodine that is bound to Ryanodine Receptors in the membranes of the sarcoplasmic reticulum.
  - C. An increase in the amount of calcium ions bound to tropomyosin.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
13. Which of the following is true in a skeletal muscle?
- A. The binding of calcium to tropomyosin leads to a movement of the troponin molecule so that the troponin molecule no longer blocks a receptor site on a myosin molecule for an activated (energized) actin head.
  - B. The head of an actin molecule is activated (energized) during the hydrolysis of ATP (which is bound to the actin head) to ADP and  $P_i$ .
  - C. The binding of ATP to the head of the myosin molecule causes detachment of the head of the myosin molecule from its receptor site on the actin molecule.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
14. For a sarcomere of a skeletal muscle fiber, use the following definitions:  
A is the length of the A Band; H is the length of the H Zone;  
I is the total length of the I Bands in the sarcomere.  
When the length of the sarcomere increases during a lengthening contraction of the entire muscle,
- A. The value of A minus the value of H ( $= A - H$ ) increases.
  - B. The value of A plus the value of I ( $= A + I$ ) increases.
  - C. The value of A plus the value of I minus the value of H ( $= A + I - H$ ) remains the same.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

15. In the sarcomere of a skeletal muscle, there are
- A. actin molecules in the H zone.
  - B. myosin molecules in the I band.
  - C. both tropomyosin and myosin molecules in the region of the A band that is not in the H zone.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
16. Which of the following is true for exocytosis?
- A. During exocytosis in skeletal muscle cells, there will be release of calcium ions from intracellular vesicles in the sarcoplasmic reticulum in response to high levels of ryanodine binding to Ryanodine Receptors in the transverse tubules.
  - B. During exocytosis in IA muscle spindle stretch receptor neurons, there will be release of glutamate from intracellular vesicles in central axon terminals in the spinal cord in response to an increase in intracellular calcium in the central axon terminals of these neurons.
  - C. During exocytosis in toe motor neurons, there will be release of acetylcholine (ACh) from intracellular vesicles in axon terminals near toe skeletal muscles in response to an increase in the amount of intracellular calcium in the axon terminals of these toe motor neurons.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
17. The AV node of a mammalian heart is destroyed. All other parts of the heart are normal and healthy.
- A. The firing rate of cells in the Bundle of His will be equal to the firing rate of ventricular muscle cells.
  - B. The firing rate of SA node cells will be equal to the firing rate of atrial muscle cells.
  - C. The firing rate of atrial muscle cells will be equal to the firing rate of ventricular muscle cells.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
18. Which of the following serves as an actuating signal, or as part of an actuating signal, in a negative feedback system?
- A. Action potentials in carotid artery baroreceptor neurons.
  - B. Action potentials in parasympathetic neurons that release acetylcholine (ACh) near the SA node of the heart.
  - C. Action potentials in cells of the SA node of the heart.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

19. Which of the following will lead to an increase in total peripheral resistance?
- A. An increase of firing rate in all the sympathetic neurons that innervate smooth muscles that surround arterioles.
  - B. An increase in the firing frequency of all the carotid artery baroreceptors.
  - C. A decrease in the diameter of every arteriole.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
20. At 1:00 AM, healthy person X's blood pressure is equal to the blood pressure set point. At 1:01 AM, there is an increase in the firing rate of carotid artery baroreceptors,
- A. this will lead to an increase in the amount of ACh (acetylcholine) released near the SA node of the heart.
  - B. this will lead to an increase in the heart rate.
  - C. this will lead to an increase in the firing rate of sympathetic neurons whose axon endings are near SA node cells of the heart.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
21. Which of the following is true for SA node cells in a healthy heart?
- A. A decrease in intracellular levels of cAMP in SA node cells will lead to an increase in the amount of time between two successive action potentials in SA node cells.
  - B. An increase in the binding of acetylcholine to muscarinic ACh receptors in SA node cells will lead to a decrease in heart rate.
  - C. An increase in the binding of norepinephrine to beta-adrenergic receptors in SA node cells will lead to an increase in intracellular levels of cAMP in these cells.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
22. The axons of all the baroreceptors in the body were destroyed at 2 AM. All else is normal. Which of the following statements is true for the system at 2:10 AM when compared to their values at 1:50 AM?
- A. Arteriolar diameter will decrease.
  - B. The firing rate of parasympathetic neurons innervating the SA node of the heart will decrease.
  - C. Blood pressure will decrease.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.



23. Consider a single cycle in a healthy heart. Define the start of the cycle as the beginning of the action potential in a SA node cell, which occurs at  $t_1$ , and the end of the cycle as the beginning of the following action potential in that same SA node cell, which occurs at  $t_2$ . The beginning of the SA node cell action potential is the time when the voltage of the SA node cell crosses the threshold for an action potential, that is, the time when SA node cell voltage goes from below threshold to above threshold. During the interval between  $t_1$  and  $t_2$ , there are 2 heart sounds. The first heart sound is *lub*; the second heart sound is *dub*. Which of the following is true?
- A. In that single cycle, there is an occurrence of the closing of the left AV valve, that is, the left AV valve goes from an open position to a closed position, during the time interval between the end of the *dub* sound and  $t_2$ .
  - B. In that single cycle, the volume of blood in the left ventricle at the end of the *lub* sound is less than the volume of blood in the left ventricle at the start of the *dub* sound.
  - C. In that single cycle during the time interval between  $t_1$  and the time immediately prior to the start of the QRS wave in the electrocardiogram, the pressure in the left atrium is greater than the pressure in the left ventricle and the left AV valve is in the open position.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
24. An increase in the firing rates of parasympathetic neurons that synapse on SA node cells of the heart leads to
- A. an increase in the conductance of F-channels in SA node cells.
  - B. a decrease in the conductance of potassium channels associated with muscarinic ACh Receptors in SA node cells.
  - C. a decrease in the amount of ACh (acetylcholine) released near SA node cells of the heart.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
25. At 1:00 AM a mammalian heart is removed from the body and placed in normal physiological saline. At 3:00 AM, the SA node is destroyed.
- A. The cardiac output at 4:00 AM will be lower than the cardiac output at 2:00 AM.
  - B. The number of ventricular contractions per minute at 4:00 AM will be lower than the number of ventricular contractions per minute at 2:00 AM.
  - C. The number of atrial contractions per minute at 4:00 AM will be equal to the number of ventricular contractions per minute at 4:00 AM.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.