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 -70 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, $GABA_A$ Receptors, $GABA_B$ Receptors, and glycine Receptors. 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.
   A. The addition of GABA to the physiological saline will lead to a decrease in the amount of intracellular chloride and a decrease in the amount of intracellular potassium.
   B. The addition of glycine to the physiological saline will lead to no net change in the amount of intracellular chloride.
   C. The addition of glycine and glutamate to the physiological saline will lead to an increase in the amount of intracellular chloride, an increase in the amount of intracellular sodium, and a decrease in the amount of intracellular potassium.
   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 antagonist that binds to a site that is a part of a ligand-gated ionotropic receptor?
   A. curare.
   B. muscarine.
   C. strychnine.
   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 ACh (acetylcholine) released from the central axon terminals of IA muscle-spindle stretch receptor neurons that synapse directly upon muscle fibers of the right knee extensor muscle. The peripheral terminals of these IA muscle-spindle stretch receptor neurons are located in the right knee extensor muscle.
    B. An increase in the amount of sodium conductance in the central 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 chloride conductance in the membranes of the sarcoplasmic reticulum in the muscle fibers of 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 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 -20 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. 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;
AMPA is added to the physiological saline of Dish W;
NMDA is added to the physiological saline of Dish X;
NMDA and glycine are added to the physiological saline of Dish Y;
NMDA, 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 Y is greater than the total calcium conductance in Neuron X.
    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 Z is less 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 less than the MAXV in Neuron X.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

5. 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 +50 mV, and the Nernst equilibrium potential for potassium in Neuron B is -100 mV. The threshold for an action potential in Neuron B is -60 mV and the resting potential for Neuron B is -70 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 less than 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 two 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 greater 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 its 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 equal to 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.

6. Which of the following is true for both the $GABA_A$ receptor and the $GABA_B$ receptor?
   A. GABA is an agonist for each type of receptor.
   B. Each type of receptor is always linked to its associated ion channel via a G-protein.
   C. A chloride channel is associated with each type of receptor.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

7. 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 receptors. 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 $GABA_A$ 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 have a chloride equilibrium potential of -80 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 a decrease in Neuron C's action potential firing rate?
   A. At 2:01 AM, glycine 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.

8. 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. Which of the following statements are true when neuron A is initially at rest and neuron B releases neurotransmitter Y?
   A. 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 increase in the amount of intracellular potassium ions in neuron A.
   B. If the value of E is equal to R, 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 increase in the chloride conductance of neuron A.
   C. If the value of R is less than E, if the value of E is less than T, 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 increase in the amount of intracellular chloride 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.

9. 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 trivalent anion named TVA with a valence of -3. The threshold for an action potential in Neuron B is -50 millivolts and the resting potential for Neuron B is -70 millivolts. The TVA 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 TVA conductance of Neuron B. Neuron A synapses onto Neuron B. Neuron A's neurotransmitter is LGD.
    A. Consider the situation when the extracellular concentration of TVA is 10,000 times greater than the intracellular concentration of TVA. In response to an action potential in Neuron A, there will be: a decrease in the membrane voltage of Neuron B; an inhibitory postsynaptic potential in Neuron B; and an increase in the amount of intracellular TVA in Neuron B.
    B. Consider the situation when the extracellular concentration of TVA is 1,000 times greater than the intracellular concentration of TVA. In response to an action potential in Neuron A, there will be: an increase in the membrane voltage of Neuron B; an excitatory postsynaptic potential in Neuron B; and a decrease in the amount of intracellular TVA in Neuron B.
    C. Consider the situation when the extracellular concentration of TVA is 100 times greater than the intracellular concentration of TVA. In response to an action potential in Neuron A, there will be: an increase in the membrane voltage of Neuron B; an excitatory postsynaptic potential in Neuron B; and a decrease in the amount of intracellular TVA 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. Which of the following are true?
    A. Consider the channel associated with the $GABA_A$ Receptor and the channel associated with the Glycine Receptor. For both types of channels, there is a potassium conductance greater than zero when the channel is open.
    B. Consider the channel associated with the nicotinic ACh Receptor and the channel associated with the AMPA Receptor. For both types of channels, there is a potassium conductance greater than zero when the channel is open.
    C. ACh is an agonist both at the muscarinic ACh Receptor and at the nicotinic ACh Receptor.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

11. Person Z swallowed a large amount of substance X and, as a result, has convulsions (abnormal violent contractions of skeletal muscles). Swallowing which of the following substances could lead to convulsions?
    A. An antagonist of the nicotinic ACh receptor.
    B. An antagonist of the glycine receptor.
    C. A blocker of the voltage-gated sodium channel.
    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. A conformational change in Dihydropyridine (DHP) Receptors in the membranes of the sarcoplasmic reticulum.
    B. An increase in the calcium conductance of the channel associated with the Ryanodine Receptor in the membranes of the transverse tubules.
    C. An increase in the amount of calcium ions bound to troponin.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

13. In the sarcomere of a skeletal muscle, there are
    A. actin, troponin, tropomyosin, and myosin molecules in the region of the A band that is not in the H zone.
    B. myosin molecules in the I band.
    C. actin molecules 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.

14. Which of the following is true in a skeletal muscle?
    A. Binding of myosin to its receptor site on the actin molecule blocks the attachment of troponin to its binding site on the myosin molecule.
    B. The binding of ATP to tropomyosin leads to the detachment of the tropomyosin head from the troponin molecule.
    C. The head of a myosin molecule is activated (energized) during the hydrolysis of GTP (which is bound to the myosin head) to GDP and P_i.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

15. For a sarcomere of a skeletal muscle, define the following terms: 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 decreases during a shortening of the entire muscle,
    A. the value of A remains constant.
    B. the value of A plus the value of I minus the value of H (= A + I - H) remains constant.
    C. the value of A minus the value of H (= A - H) decreases.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

16. For which of the following processes is the net flux of calcium ions from a region of high concentration of calcium to a region of low concentration of calcium? The net flux of calcium ions
    A. from extracellular space to intracellular space via open voltage-gated calcium channels in a SA node cell.
    B. from the inside of the sarcoplasmic reticulum to the cytosol via open Ryanodine receptor channels in sarcoplasmic reticulum membranes of a skeletal muscle fiber.
    C. from extracellular space to intracellular space via open NMDA Receptor channels with magnesium ion block removed due to a 20 mV voltage increase following the opening of AMPA Receptor channels in the dendrites of 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. 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 parasympathetic neurons whose axon terminals are near SA node cells of the heart.
    B. Action potentials in ventricular muscle cells of the heart.
    C. Action potentials in carotid artery baroreceptor neurons.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

18. 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. There is an occurrence of the closing of the aortic valve, that is, the aortic valve goes from an open position to a closed position, during the time interval between the start of the T wave in the electrocardiogram in that single cycle and t_2.
    B. The volume of blood in the left ventricle is greater at the end of the *lub* sound than the volume of blood in the left ventricle at the start of the *dub* sound.
    C. In the electrocardiogram, the peak value of the T wave occurs during the time interval between t_1 and the start of the *lub* sound in that single cycle.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

19. 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 higher than the firing rate of ventricular muscle cells.
    B. The firing rate of SA node cells will be higher than the firing rate of atrial muscle cells.
    C. The rate of ventricular contractions will be higher than the rate of atrial contractions.
    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 a decrease in the firing rate of carotid artery baroreceptors,
    A. this will lead to a decrease 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 a decrease in the diameter of the arterioles.
    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?
    A. An increase in the binding of norepinephrine to alpha-adrenergic receptors in SA node cells will lead to an increase in intracellular levels of cAMP in these cells.
    B. An increase in intracellular levels of cAMP in SA node cells will lead to a decrease in the amount of time between two successive action potentials in SA node cells.
    C. An increase in the binding of acetylcholine to nicotinic ACh receptors in SA node cells will lead to a decrease in heart rate.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

22. Which of the following will lead to an decrease of total peripheral resistance?
    A. A decrease in the firing frequency of all the carotid artery baroreceptors.
    B. A decrease in the diameter of every arteriole.
    C. A decrease of firing rate in all the sympathetic neurons that innervate smooth muscles that surround arterioles.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

23. Which of the following is true for channels in the plasma membrane of a SA node cell in the heart?
    A. The equilibrium potential of its voltage-gated potassium channels is greater than the value of the threshold voltage for the action potential.
    B. The equilibrium potential of its voltage-gated calcium channels is greater than the value of the threshold voltage for the action potential.
    C. The equilibrium potential of its F channels is greater than the value of the threshold voltage for the action potential.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

24. Consider a system that contains a healthy SA node cell in a culture dish bathed in normal physiological saline. The SA node cell contains all of the usual molecules.

    You use a technique to measure $G_{F\text{-}channel}$ (F-channel conductance) when the membrane of the SA node cell is held at a constant voltage of -75 millivolts starting at 1:55 AM. The technique allows you to keep the SA node cell at that voltage for 10 minutes. You also have the ability to control directly the intracellular amounts of cAMP. You can also add substances to the extracellular saline bathing the SA node cell. At 2:00 AM, you measure $G_{F\text{-}channel}$.
    A. At 2:01 AM, the amount of intracellular cAMP is increased. This will lead to an increase in $G_{F\text{-}channel}$ compared with its 2:00 AM value.
    B. At 2:01 AM, AMPA is added to the physiological saline. This will lead to an increase in $G_{F\text{-}channel}$ compared with its 2:00 AM value.
    C. At 2:01 AM, muscarine is added to the physiological saline. This will lead to a decrease in $G_{F\text{-}channel}$ compared with its 2:00 AM value.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

25. Which of the following events occur at the same time, or nearly at the same time, during the cardiac cycle of a healthy person?
    A. The QRS complex of the electrocardiogram and closing of the pulmonary valve.
    B. The P wave of the electrocardiogram and decreases in membrane voltage of atrial muscle cells.
    C. The T wave of the electrocardiogram and increases in membrane voltage 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.