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. 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 +60 mV, and the Nernst equilibrium potential for potassium in Neuron B is -90 mV. The threshold for an action potential in Neuron B is -55 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. When the LGD receptor channel is open in Neuron B, its potassium conductance equals its sodium conductance. In response to an action potential in Neuron A, then there will be an excitatory postsynaptic potential in Neuron B.
   - B. When the LGD receptor channel is open in Neuron B, its potassium conductance equals four times its sodium conductance. In response to an action potential in Neuron A, then there will be a voltage increase and an action potential in Neuron B.
   - C. When the LGD receptor channel is open in Neuron B, its potassium conductance equals nine times its sodium conductance. In response to an action potential in Neuron A, then there will be an inhibitory 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.

2. Which of the following is a neurotransmitter that binds to a receptor site that is part of a ligand-gated ionotropic receptor?
   - A. GABA.
   - B. AMPA.
   - C. NMDA.
   - D. A and B.
   - E. A and C.
   - F. B and C.
   - G. A, B, and C.
   - H. None of the above.

3. A complete motor neuron is removed from a frog and placed in normal physiological saline at 1 AM. The neuron is healthy. At 2 AM, the physiological saline bathing the neuron is removed and replaced with a modified physiological saline. The composition of the modified physiological saline is as follows: its potassium concentration is the same as the intracellular potassium concentration of the motor neuron; its sodium concentration is the same as the intracellular sodium concentration of the motor neuron; its total concentration of solutes (osmolarity) is the same as normal physiological saline. The modified physiological saline also contains molecules that block the flux of ions via the sodium-potassium primary active transport pump. At 2:05 AM, the neuron is at rest and its membrane voltage is equal to the Nernst equilibrium potential for potassium ions at 2:05 AM. At 2:06 AM,

A. the value of the Nernst equilibrium potential for sodium ions for the neuron is less than +10 millivolts.
B. an increase in potassium conductance will lead to no change in the membrane voltage.
C. an increase in sodium conductance will lead to a decrease in the amount of intracellular sodium.
D. A and B.
E. A and C.
F. B and C.
G. A, B, and C.
H. None of the above.

4. A complete motor neuron is removed from a frog and placed in a large volume of normal physiological 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, $GABA_B$ 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 glycine to the physiological saline will lead to no change in the amount of intracellular chloride.
B. The addition of glycine and 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.
C. The addition of glycine and glutamate to the physiological saline will lead to an increase in the amount of intracellular chloride and an increase in the amount of intracellular sodium.
D. A and B.
E. A and C.
F. B and C.
G. A, B, and C.
H. None of the above.

5. Which of the following occur in response to an increase in the length of the right knee extensors in response to a quick tap applied to the right patellar tendon? An increase in the amount of potassium conductance in the
   - A. peripheral terminals of IA muscle-spindle stretch receptor neurons whose peripheral terminals are in the right knee extensor muscle.
   - B. plasma membranes of the muscle fibers of the right knee extensor muscle.
   - C. central axon terminals of IA muscle-spindle stretch receptor neurons whose peripheral terminals are 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.

6. 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 -55 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.
   - 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; an increase 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; a decrease 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.

7. Neuron A is a healthy neuron with all the usual ion channels and with all the usual intracellular and extracellular distributions of ion concentrations. 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 is 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 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 a decrease in the amount of intracellular chloride ions in neuron A.
   C. 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 no change in the chloride conductance of the plasma membrane of neuron A.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

8. 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 $GABA_B$ 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 -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.

9. Consider four culture dishes; each dish has one healthly neuron 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 -80 millivolts. At 1:55 AM, a large amount of TTX is added to the physiological saline in all four 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 W;
glutamate and APV are added to the physiological saline of Dish X;
glutamate and CNQX are added to the physiological saline of Dish Y;
glutamate and glycine are added to the physiological saline of Dish Z.
For each neuron, define MAXV as the maximum voltage that is reached by that neuron during the period from 2:00 AM to 2:02 AM.
   A. At 2:01AM, the total calcium conductance in Neuron Z is less than the total calcium conductance in Neuron W.
   B. MAXV of Neuron X is less than MAXV of Neuron Y.
   C. At 2:01 AM, the amount of intracellular calcium in Neuron W will be greater than the amount of intracellular calcium in Neuron Y.
   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 is true for both the nicotinic Acetylcholine Receptor (nAChR) and the muscarinic Acetylcholine Receptor (mAChR)?
   A. Nicotine is an agonist for both types of receptor.
   B. Both types of receptor are G-Protein Coupled Receptors (GPCRs).
   C. Acetylcholine (ACh) is the neurotransmitter for both types of receptor.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

11. Healthy Person X is walking on level ground. Which of the following is true for the knee extensor muscle of X's right leg during the step cycle?
   A. The right knee extensor muscle has a shortening contraction near the end of the right leg's swing phase just prior to start of the right leg's stance phase.
   B. Just after the right foot touches the ground at the start of stance phase, the sum of the lengths of all the overlap regions between the thick and thin filaments (= the region of the A band not in the H zone) will decrease in the right knee extensor muscle.
   C. Just after the right foot touches the ground at the start of the stance phase, the sum of the lengths of all the H zones will decrease 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.

12. Which of the following is true in a skeletal muscle?
    A. Binding of calcium ion to its receptor site on the actin molecule blocks the attachment of the head of the tropomyosin molecule to its binding site on the actin molecule.
    B. The binding of ATP to tropomyosin causes detachment of the tropomyosin head from the actin molecule.
    C. The head of a myosin molecule is activated (energized) during the hydrolysis of ADP (which is bound to the myosin head) to ATP 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.

13. ATP is <u>**DIRECTLY**</u> required in which of the following processes in muscle?
    A. Net flux of sodium ions from intracellular space to extracellular space.
    B. Detachment of myosin heads from their binding sites on troponin molecules.
    C. Net flux of calcium ions from the cytosol into the sarcoplasmic reticulum.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

14. 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. Which of the following will lead to an increase in the overlap between thin and thick filaments in the muscle fiber?
    A. An increase in the calcium conductance of the membranes of the sarcoplasmic reticulum.
    B. A decrease in the amount of calcium ions in the cytosol near the thin and thick filaments.
    C. A decrease in the amount of binding of Ryanodine to Ryanodine Receptors located only in the transverse membranes of the skeletal muscle.
    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 increases during a lengthening of the entire muscle,
    A. The value of A remains constant.
    B. The value of A plus the value of I (= A + I) 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. An increase in the calcium conductance of all sarcoplasmic reticulum membranes of a skeletal muscle with no external forces on it leads to
    A. an increase in the amount of calcium ions in the sarcoplasmic reticulum.
    B. an increase in the amount of calcium ions that are bound to troponin.
    C. a decrease in the amount of ATP molecules in the muscle.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

17. A decrease in parasympathetic discharge to the heart leads to
    A. a decrease in the conductance of F-channels in SA node cells.
    B. an increase in the conductance of potassium channels associated with muscarinic ACh receptors in SA node cells.
    C. an increase 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.

18. 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, norepinephrine is added to the physiological saline.
       This will lead to a decrease in $G_{F\text{-channel}}$ compared with its 2:00 AM value.
    B. At 2:01 AM, ACh (acetylcholine) 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, there is an increase in the intracellular amount of cAMP.
       This will lead to an increase 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.

19. Consider a system that contains two neurons and one cardiac SA node cell in a culture dish bathed in normal physiological saline. All three cells are healthy. Neuron A synapses onto Neuron B. Neuron B synapses onto the SA node cell. Neuron A has glycine in its synaptic vesicles. Neuron B has acetylcholine (ACh) in its synaptic vesicles. The only ligand-gated channels in the plasma membrane of Neuron A are AMPA receptors. The only ligand-gated channels in the plasma membrane of Neuron B are glycine receptors. Both neurons have no metabotropic receptors in their plasma membranes. Neuron A and Neuron B each have a chloride equilibrium potential of -20 millivolts and a potassium equilibrium potential of -86 millivolts. The SA node cell has a chloride equilibrium potential of -80 millivolts and a potassium equilibrium potential of -86 millivolts. The threshold for an action potential in all 3 cells is -55 millivolts. The SA node cell has its usual set of molecules. At 1:00 AM, Neuron A's action potential firing rate is 100 Hz, Neuron B's action potential firing rate is 100 Hz, and the SA node cell's action potential firing rate is 1.00 Hz. Which of the following will lead to an increase in the SA node cell's action potential firing rate?
   A. At 1:01 AM, glutamate is added to the bath.
   B. At 1:01 AM, strychnine is added to the bath.
   C. At 1:01 AM, acetylcholine (ACh) 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.

20. 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. Blood pressure will increase.
   B. Arteriole diameter will increase.
   C. Parasympathetic discharge to the heart will increase.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

21. Starting at 1:00 AM, you record the firing frequency of the axons of carotid artery baroreceptors as well as the blood pressure in the carotid artery. At 2:00 AM, you directly apply chemical X to all the axons of the carotid artery baroreceptors at location L in a peripheral nerve at a place that is midway between the baroreceptor peripheral terminals and the baroreceptor central axonic terminals. You discover that chemical X induces a previously unknown change in the excitability of the axon with the following property: for every one action potential produced between baroreceptor peripheral terminals and location L, there are two action potentials that continue down the axon between location L and baroreceptor central axonic terminals. Thus, chemical X causes a doubling of the rate of firing in the axons of carotid baroreceptors as action potentials pass location L.
   A. At 2:10 AM, blood pressure will be lower than at 1:50 AM.
   B. At 2:10 AM, the sympathetic output to the heart will be lower than at 1:50 AM.
   C. At 2:10 AM, arteriolar diameter will be smaller than at 1:50 AM.
   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 is true for active hyperemia, a local control mechanism within the circulatory system?
    A. There will be an increase in force developed by smooth muscles surrounding arterioles that lead into a local region in which there has been an increase in the rates of activity of body cells in that region.
    B. There will be less blood flow into a local region in response to an increase in the rates of activity of body cells in that region.
    C. There will be a decrease in the potassium conductance of ATP-sensitive potassium channels in smooth muscle cells in response to a decrease in the levels of intracellular ATP in those cells.
    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 serves as an actuating signal, or as part of an actuating signal, in a negative feedback system?
    A. Action potentials in sympathetic neurons that release acetylcholine (ACh) near the SA node of the heart.
    B. Action potentials in parasympathetic neurons that release norepinephrine (NE) near the SA node of the heart.
    C. Action potentials in parasympathetic neurons that release norepinephrine (NE) near the smooth muscles that surround the arterioles.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

24. Which of the following serves as an effector, or as part of an effector, that functions in a negative feedback system?
    A. Nicotinic Acetylcholine Receptors (nAChR) in SA node cells of the heart.
    B. F-channels in the cells of the AV valves of the heart.
    C. Alpha-adrenergic Receptors in smooth muscles surrounding the arterioles.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

25. A new drug named ANTAG-CaSR has been developed that is an antagonist at calcium-binding sites of CaSRs (Calcium-Sensing Receptors) in the plasma membranes of parathyroid gland cells. Healthy Person P receives regular doses of ANTAG-CaSR as part of a clinical trial. When ANTAG-CaSR levels in the extracellular spaces surrounding parathyroid gland cells increase in Healthy Person P, this leads to
    A. a decrease in the levels of calcium in the blood plasma.
    B. an increase in the levels of parathyroid hormone (PTH) in the blood plasma.
    C. a decrease in the amount of PTH binding to PTH Receptors in parathyroid gland cells.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.