There are 50 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 50 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. Which of the following serves as a sensor, or as part of a sensor, that functions in a negative feedback system?
   A. Calcium-Sensing Receptors (CaSRs) located in the plasma membranes of Parathyroid Gland cells.
   B. Mechanically-gated channels located in the plasma membranes of central axon terminals of carotid artery baroreceptor neurons.
   C. Osmoreceptor neurons whose peripheral terminals are located in the walls of the carotid artery.
   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 serves as a controlled variable in a negative feedback system?
   A. Blood plasma levels of hydrogen ions in the carotid artery.
   B. Temperature in the hypothalamus.
   C. Osmolarity of the interstitial fluid in the hypothalamus.
   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 serves as an actuating signal, or as part of an actuating signal, in a negative feedback system?
   A. Action potentials in motor neurons that release glutamate near diaphragm muscle fibers.
   B. Action potentials in parasympathetic neurons that release acetylcholine (ACh) near the SA node of the heart.
   C. Blood plasma levels of glucose.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

4. Which of the following serves as an effector, or as part of an effector, in a negative feedback system?
   A. GLUT2 Transporters in the plasma membranes of the liver.
   B. GLUT2 Transporters in the plasma membranes of alpha islet cells of the pancreas.
   C. ATP-sensitive potassium channels in the plasma membranes of beta islet cells of the pancreas.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

5. A new drug named AGON-CaSR has been developed that is an agonist at calcium-binding sites of CaSRs (Calcium-Sensing Receptors) in plasma membranes of parathyroid gland cells. Healthy Person P receives regular doses of AGON-CaSR as part of a clinical trial. When AGON-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. a decrease in the levels of parathyroid hormone (PTH) in the blood plasma.
   C. a decrease in the amounts of calcium excreted in the urine.
   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 the sodium-potassium pump ATPase?
   A. There is a net flux of sodium from interstitial spaces into intracellular spaces via sodium-potassium pump ATPase spanning proteins located in the basolateral membranes of epithelial cells in the medullary collecting duct of the kidney.
   B. There is a net flux of sodium from cytosol near troponin molecules into the internal spaces of the sarcoplasmic reticulum via sodium-potassium pump ATPase spanning proteins located in the sarcoplasmic reticulum membranes of diaphragm muscles.
   C. There is a net flux of sodium from extracellular spaces into intracellular spaces via sodium-potassium pump ATPase spanning proteins located in the plasma membranes 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.

7. Which of the following is true?
   A. GLUT2 molecules are responsible for the net flux of glucose from the intracellular spaces of epithelial cells in the early proximal tubule into interstitial spaces of the kidney medulla.
   B. GLUT2 molecules are responsible for the net flux of glucose from the interstitial spaces surrounding beta-islet cells of the pancreas into the intracellular spaces of beta-islet cells of the pancreas.
   C. When blood plasma levels of glucagon are low and blood plasma levels of insulin are high, GLUT2 molecules are responsible for the net flux of glucose from the intracellular spaces of liver cells into the interstitial spaces surrounding liver cells.
   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 is an effect of the following drugs?
   A. Drug X is an antagonist of the Vasopressin2 Receptor (V2R). High levels of Drug X in the interstitial spaces surrounding cells of the kidney medullary collecting ducts will lead to high levels of exocytosis of AQP2 molecules in these cells.
   B. Drug Y is an agonist of the Glucagon Receptor. High levels of Drug Y in the interstitial spaces surrounding liver cells will lead to high levels of exocytosis of GLUT4 transporters in these cells.
   C. Drug Z is an agonist of the Insulin Receptor. High levels of Drug Z in the interstitial spaces surrounding fat cells will lead to high levels of exocytosis of GLUT4 transporters 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.

9. At 1 AM, an impermeable membrane separates a 1 liter solution of 1M NaCl in the left compartment from a 1 liter solution containing both 1M NaCl and 1M KCl in the right compartment. At 2 AM, the membrane became permeable to chloride ions. At 4 AM, the membrane once again became impermeable to chloride ions. At 6 AM, the membrane became permeable to sodium ions and, in addition, maintained chloride ion impermeability. At 8 AM, the membrane once again became impermeable to sodium ions. At 10 AM the membrane once again became permeable to chloride ions and, in addition, maintained sodium ion impermeability. The membrane maintained impermeability to potassium ions during the entire period.
   A. The amount of chloride ions in the right compartment at 4 AM will be less than the amount of chloride ions in the right compartment at 2 AM.
   B. The amount of sodium ions in the left compartment at 7 AM will be less than the amount of sodium ions in the left compartment at 5 AM.
   C. The amount of chloride ions in the left compartment at 11 AM will be less than the amount of chloride ions in the left compartment at 5 AM.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

10. When an agonist binds to the receptor site of the
    A. nAChR (nicotinic acetylcholine receptor), the channel associated with the nAChR opens and there is flux of only chloride ions through the open channel.
    B. V2R (vasopressin2 receptor), a tyrosine kinase located in the intracellular portion of the V2R is activated.
    C. insulin receptor, G-proteins associated with the insulin receptor are activated.
    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 true for a G-protein?
    A. When an antagonist binds to the binding site of a G-protein-coupled receptor (GPCR), this leads to GTP displacing a GDP bound to the alpha subunit of the G-protein.
    B. When an agonist binds to the binding site of a G-protein-coupled receptor (GPCR), this leads to ATP displacing a ADP bound to the alpha subunit of the G-protein.
    C. After the GTP-ase of the alpha subunit of a G-protein converts the GTP bound to the alpha subunit to GDP and inorganic phosphate (P_i), the inorganic phosphate (P_i) is released from the alpha subunit. The alpha subunit of the G-protein with GDP bound to it then associates with the beta and gamma subunits of the G-protein.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

12. At 1:00AM, Neuron A is at rest with membrane potential equal to -80 millivolts; it is producing no action potentials. The threshold for an action potential in neuron A is -60 millivolts. There is a large amount of mechanically-gated ion channel X spanning proteins located in the plasma membrane of the cell body of neuron A. Channel X is the only mechanically-gated ion channel in neuron A. At 1:00 AM, there are no external forces on the cell body of neuron A and all the ion channels of mechanically-gated ion channel X are closed. At 1:05 AM, force is applied to the cell body of neuron A and all the ion channels of mechanically-gated ion channel X are open. If the equilibrium potential of open channels of mechanically-gated ion channel X is
    A. -90 millivolts, then at 1:05AM there will be a decrease in membrane voltage when force is applied to the cell body of neuron A.
    B. -80 millivolts, then at 1:05AM there will be a decrease in membrane voltage when force is applied to the cell body of neuron A.
    C. -70 millivolts, then at 1:05AM there will be an increase in membrane voltage when force is applied to the cell body 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.

13. 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, 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 potassium.
    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 GABA 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.

14. Which of the following occur in response to an increase in the length of the right knee extensor muscle in response to a quick tap applied to the right patellar tendon?
    A. An increase in the amount of ACh (acetylcholine) released from the axon terminals of motor neurons that synapse upon muscle fibers of the right knee extensor muscle.
    B. An increase in the amount of potassium conductance in the peripheral terminals of IA muscle-spindle stretch receptor neurons whose peripheral terminals are in the right knee extensor muscle.
    C. A decrease in the amount of calcium 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.

15. 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 0 (zero) 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 -80 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 nine times its sodium conductance. For this situation, in response to an action potential in Neuron A, there is a decrease in the membrane voltage of 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 four times its sodium conductance. For this situation, in response to an action potential in Neuron A, there is no change in the membrane voltage of 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.
    C. 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 increase in the membrane voltage of 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.
    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 an antagonist that binds to a receptor site that is part of a ligand-gated ionotropic receptor?
    A. Strychnine.
    B. Muscarine.
    C. Curare.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

17. 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 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 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 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 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.

18. 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 anion named DVA 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 DVA 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 DVA conductance of Neuron B. Neuron A synapses onto Neuron B. Neuron A's neurotransmitter is LGD.
    A. The extracellular concentration of DVA is 1000 times greater than the intracellular concentration of DVA. 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 DVA in Neuron B; and an inhibitory postsynaptic potential in Neuron B.
    B. The extracellular concentration of DVA is 100 times greater than the intracellular concentration of DVA. 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 DVA in Neuron B; and an inhibitory postsynaptic potential in Neuron B.
    C. The extracellular concentration of DVA is 10 times greater than the intracellular concentration of DVA. 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 DVA 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.

19. 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. 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. 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 Z.
    B. At 2:01 AM, the total calcium conductance in Neuron V is greater than the total calcium conductance in Neuron X. In addition, the total calcium conductance in Neuron Z is less than the total calcium conductance in Neuron Y.
    C. At 2:01 AM, the total sodium conductance in Neuron W is less 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.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

20. 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 $GABA_A$ 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 -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 a increase in Neuron C's action potential firing rate?
    A. At 2:01 AM, CNQX is added to the bath.
    B. At 2:01 AM, glycine is added to the bath.
    C. At 2:01 AM, strychnine 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.

21. Consider an axon of a neuron. At time=t_1, its voltage is at threshold for an action potential; at time=t_2, its voltage is at 0 millivolts prior to the peak of that action potential. In the time period between t_1 and t_2 of that single action potential,
    A. sodium conductance of the voltage-gated sodium channels increases as membrane voltage increases.
    B. sodium conductance of the voltage-gated sodium channels changes with a faster time course than potassium conductance of the voltage-gated potassium channels.
    C. the amount of intracellular sodium increases.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

22. When the overlap between the thin and thick filaments of a sarcomere in a skeletal muscle is increasing,
    A. the length of the A band minus the length of H zone is increasing in the sarcomere.
    B. the total length of the I band plus the length of the H zone is increasing in the sarcomere.
    C. the total length of the I band plus the length of the A band minus the length of the H zone does not change in the sarcomere.
    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 exocytosis in a skeletal muscle?
    A. During exocytosis in a skeletal muscle, 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 a skeletal muscle, there will be insertion of GLUT4 transporters into the plasma membrane in response to Insulin binding to Insulin Receptors in the plasma membrane.
    C. During exocytosis in a skeletal muscle, there will be release of acetylcholine (ACh) from the sarcoplasmic reticulum into the cytosol.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

24. 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 amount of binding of curare to the nicotinic Acetylcholine Receptors (nAChRs) on the surface of the skeletal muscle.
    B. An increase in the amount of calcium ions bound to tropomyosin.
    C. A decrease in the calcium conductance of the membranes of 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.

25. The SA node of a mammalian heart is destroyed. All other parts of the heart are normal and healthy.
    A. The firing rate of the cells in the right bundle branch will be the same as the firing rate of the cells in the left bundle branch.
    B. The firing rate of AV node cells will be higher than the firing rate of cells in the Bundle of His.
    C. The rate of ventricular contractions will be lower 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.

26. 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 an closed position during the time interval between t_1 and the start of the *lub* sound in that single cycle.
    B. The volume of blood in the left ventricle is greater at the start of the *lub* sound than the volume of blood in the left ventricle at t_1.
    C. In the electrocardiogram, the peak value of the P 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.

27. Which of the following is true for SA node cells?
    A. 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.
    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 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.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

28. Starting at 1 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 AM, you directly apply chemical Z 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 axonal terminals. You discover that chemical Z induces a previously unknown lowering of the excitability of the axon with the following property: for every two action potentials produced between baroreceptor peripheral terminals and location L, there is one action potential produced between location L and baroreceptor central axonal terminals. Thus, chemical Z causes a reduction of the rate of firing of carotid baroreceptors as action potentials pass location L; only one-half of the action potentials initiated in the peripheral terminals propagate all the way to the central axonal terminals.
    A. At 2:10 AM, the parasympathetic output to the heart will be higher than at 1:50 AM.
    B. At 2:10 AM, blood pressure will be higher than at 1:50 AM.
    C. At 2:10 AM, arteriolar diameters will be larger 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.

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

30. Which of the following processes help bring oxygen to the body cells that are in a leg?
    A. Removal of oxygen from hemoglobin in response to an increase in the amount of HbRH (Hemoglobin Releasing Hormone) that binds to HbRHRs (Hemoglobin Releasing Hormone Receptors) in the plasma membranes of red blood cells in capillaries near body cells in a leg.
    B. Net flux of oxygen from red blood cells into the blood plasma in capillaries near body cells in a leg.
    C. An increase in hydrogen ion concentration in the cytosol of red blood cells in capillaries near body cells in a leg.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

31. Which of the following processes in capillaries in the lung assist in the removal of carbon dioxide from the body?
    A. Formation of carbonic acid from carbon dioxide and water by carbonic anhydrase in red blood cells.
    B. Net flux of carbon dioxide from blood plasma into red blood cells.
    C. Net flux of bicarbonate from blood plasma into red blood cells.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

32. Which of the following are true for ventilation?
    A. An increase in the hydrogen ion concentration in the interstitial spaces of the brain stem leads to a decrease in the duration of the respiratory cycle (duration of respiratory cycle equals duration of inspiration plus duration of expiration).
    B. The problems with ventilation induced by injection of curare occur because of the drug's direct action on nicotinic ACh Receptors (nAChRs) in the plasma membranes of red blood cells.
    C. When the pressure within the alveoli is less than atmospheric pressure, there will be inspiration of air into the lungs.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

33. Which of the following serves as an effector, or as part of an effector, in a negative feedback system?
    A. GLUT4 Transporters in rib-cage inspiratory muscles.
    B. Insulin Receptors in the diaphragm muscle.
    C. Action potentials in diaphragm motor neurons.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

34. Which of the following is true?
    A. The partial pressure of oxygen in the blood plasma in the pulmonary artery is higher than the partial pressure of oxygen in the blood plasma in the pulmonary vein.
    B. The blood plasma levels of bicarbonate in the pulmonary artery are higher than the blood plasma levels of bicarbonate in the pulmonary vein.
    C. The percent Hemoglobin saturation (percent of oxygen-binding sites in Hemoglobin that have oxygen bound) in the red blood cells in the pulmonary artery is lower than the percent Hemoglobin saturation in the red blood cells in the pulmonary vein.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

35. Which of the following is true?
    A. Trypsinogen is produced in the pancreas and is secreted into the lumen of the small intestine. It is converted into trypsin by enterokinase. Enterokinase is located in the membranes of cells in the walls of the small intestine.
    B. Pancreatic amylase is produced in the pancreas and secreted into the small intestine. In the small intestine, it breaks down triglycerides into monoglycerides and fatty acids.
    C. Pepsinogen is produced by cells in the walls of the stomach and is secreted into the lumen of the stomach. It is converted into pepsin by HCl in the lumen of the stomach.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

36. Which of the following is true for the G.I. (Gastro-Intestinal) system?
    A. Skeletal muscles directly control the movement of substances at the entrance of the G.I. system.
    B. Smooth muscles control the movement of substances in the small intestine.
    C. The external anal sphincter is a skeletal muscle that helps control the timing of removal of solid waste products from the G.I. system.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

37. Consider the case of a rare mutant in which the concentration of solutes in the kidney medulla interstitial spaces is equal to the concentration of solutes in the liquid in the lumen of the medullary collecting duct in the kidney. The defective molecules associated with this rare mutation are **NOT** located in the epithelial cells of the kidney medullary collecting duct; the defective molecules are located in other cells of the kidney. In this rare mutant, an increase in the amount of vasopressin that binds to V2 Receptors in the kidney will lead to an increase in the amount of
    A. cAMP in the cytosol of epithelial cells in the kidney medullary collecting duct.
    B. AQP2 molecules in the luminal membranes of epithelial cells in the kidney medullary collecting duct.
    C. water that is reabsorbed into the blood plasma from the lumen of the collecting duct.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

38. Healthy Person P takes a drug that produces a condition with a strong effect on the epithelial cells of the kidney medullary collecting duct within one hour and lasts for one week after taking the drug. There is no direct effect of the drug on other cells in the body. One day after taking the drug, which of the following drugs will produce a condition with the symptoms of diabetes insipidus in Healthy Person P?
    A. Drug X that stimulates endocytosis of AQP2 and blocks exocytosis of AQP2 for one week in the epithelial cells of the kidney medullary collecting duct.
    B. Drug Y that produces a condition in which the amounts of cytosolic cAMP in the epithelial cells of the kidney medullary collecting duct are very low for one week.
    C. Drug Z that is an antagonist at V2 receptors that remains bound to V2 receptors in the basolateral membranes of the epithelial cells of the kidney medullary collecting duct for one week.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

39. Which of the following is true for the plasma membranes of epithelial cells in the ascending limb of the Loop of Henle of the kidney?
    A. Sodium-potassium-ATPase pump molecules are located in the basolateral membranes of epithelial cells in the ascending limb of the Loop of Henle.
    B. AQP1 (Aquaporin 1) molecules are located in the basolateral membranes of epithelial cells in the ascending limb of the Loop of Henle.
    C. NKCC2 (sodium-potassium-2chloride co-transporter) molecules are located in the luminal membranes of epithelial cells in the ascending limb of the Loop of Henle.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

40. From March 1 to March 31, Healthy Person W ate a normal diet with normal amounts of food and water. From April 1 to April 30, Healthy Person W was on a diet that consisted of normal amounts of food and very small amounts of water.
    A. April 15 values of the concentration of dissolved solutes in W's urine were higher than March 15 values of the concentration of dissolved solutes in W's urine.
    B. April 15 values of W's water permeability across the luminal membranes of the medullary collecting duct epithelial cells were higher than March 15 values of W's water permeability across the luminal membranes of the medullary collecting duct epithelial cells.
    C. April 15 values of W's blood plasma levels of vasopressin were higher than March 15 values of W's blood plasma levels of vasopressin.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

41. You are presented with patient X who has a genetic disease. You discover a mutation in all aquaporin2 (AQP2) channels manufactured in the epithelial cells of the collecting duct so that there is no increase in water permeability when the mutated channels are inserted into the plasma membrane in response to vasopressin binding to the V2 receptor. Patient X will
    A. produce urine with a very high concentration of dissolved solutes.
    B. benefit from injections of vasopressin into the blood plasma.
    C. produce very low volumes of urine.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

42. Healthy Person P takes a new drug that is a member of a drug family that results in a condition in which there are constant very high levels of cytosolic cyclic AMP (cAMP) in one and only one cell type in the body. A single dose of each member of the new drug family works within one hour to produce this condition and the condition lasts for one week. Which of the following is true for P two days after taking a specific member of the new drug family? Compare the situation two days after taking the drug with the situation prior to taking the drug.
    A. Consider the situation that P takes Drug X that results in a condition in which the levels of cytosolic cAMP in the cells of the liver are constant at a very high level. For this situation, ignore any effects due to insulin binding to insulin receptors in the liver. The amount of glycogen in P's liver cells two days after taking Drug X will be higher than the amount of glycogen in P's liver cells prior to taking Drug X.
    B. Consider the situation that P takes Drug Y that results in a condition in which the levels of cytosolic cAMP in the SA node cells of the heart are constant at a very high level. The firing rate of action potentials in P's SA node cells two days after taking Drug Y will be higher than the firing rate of action potentials in P's SA node cells prior to taking Drug Y.
    C. Consider the situation that P takes Drug Z that results in a condition in which the levels of cytosolic cAMP in the epithelial cells of the medullary collecting duct of the kidney are constant at a very high level. The amount of net flux of water from intracellular spaces to interstitial spaces across the basolateral membranes of these cells in P two days after taking Drug Z will be higher than the amount of net flux of water from intracellular spaces to interstitial spaces across the basolateral membranes of these cells in P prior to taking Drug Z.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

43. Glucagon
    A. binding to Glucagon Receptors in the plasma membrane of a liver cell leads to an increase in the exocytosis of GLUT2 Transporters from intracellular vesicles into the plasma membrane of the liver cell.
    B. levels in a liver cell decrease in response to an increase in cAMP levels in the cytosol of the liver cell.
    C. levels in the blood plasma are high only when glucose levels in the blood plasma are high.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

44. Which of the following is true?
    A. Binding of GH (Growth Hormone) to GHR (Growth Hormone Receptors) located in the plasma membranes of cells in the anterior pituitary leads to the secretion of GHRH (Growth Hormone Releasing Hormone) from the anterior pituitary into the blood plasma.
    B. GnRH Receptors (Gonadotropin Releasing Hormone Receptors) are located in the plasma membranes of cells in the anterior pituitary.
    C. VRH (Vasopressin Releasing Hormone) travels in specialized capillaries located in the pituitary stalk between the hypothalamus and the anterior pituitary.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

45. Person X is a healthy human who has volunteered to take experimental drug Y. Person X has a normal dinner at 6 PM on April 1 and then does not eat for 12 hours. At 2 AM on April 2, X takes a dose of Y that closes all the ATP-sensitive potassium channels in X's beta-islet cells of the pancreas for 6 hours. For this question, ignore any effects due to alpha-islet cells of the pancreas.
    A. At 3 AM on April 2, the glucose permeability of X's skeletal muscle cells will be higher than the glucose permeability of X's skeletal muscle cells at 1 AM.
    B. At 3 AM on April 2, X's blood plasma levels of insulin will be higher than X's blood plasma levels of insulin at 1 AM.
    C. At 3 AM on April 2, X's blood plasma levels of glucose will be higher than X's blood plasma levels of glucose at 1 AM.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

46. Person Y is a healthy human who has volunteered to take experimental drug Z. Person Y has a normal dinner at 6 PM on May 1 and then does not eat for 12 hours. At 6 AM on May 2, Y takes a dose of Z that completely blocks the net flux of glucose via all GLUT2 transporters in the beta-islet cells of the pancreas for 24 hours. Drug Z has no effect on any other cells. Person Y has a normal dinner at 6 PM on May 2 and then does not eat for 12 hours. For this question, ignore any effects due to alpha-islet cells of the pancreas.
    A. At 8 PM on May 2, Y's blood plasma levels of glucose will be higher than Y's blood plasma levels of glucose at 8 PM on May 1.
    B. At 8 PM on May 2, the potassium conductance of the ATP-sensitive potassium channels in Y's beta-islet cells will be higher than potassium conductance of the ATP-sensitive potassium channels in Y's beta-islet cells at 8 PM on May 1.
    C. At 8 PM on May 2, the glucose permeability of Y's skeletal muscle cells will be lower than the glucose permeability of Y's skeletal muscle cells at 8 PM on May 1.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

47. During a fever in a human,
    A. shivering may occur when the actual body temperature is higher than the set point for body temperature during the fever.
    B. there is a decrease in the value of the set point for body temperature when compared with the value of the set point for body temperature when that person was healthy prior to the fever.
    C. the control system for body temperature functions as an closed-loop positive-feedback system.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

48. A healthy young adult human female who is not pregnant receives a chemical implant that is programmed to alternate between two conditions. The first condition lasts one week; during the first condition, the implant releases no chemicals. The second condition lasts three weeks; during the second condition, the implant releases high levels of estrogen and progesterone into the blood plasma. Every 4 weeks, this female will
    A. menstruate.
    B. have very high blood plasma levels of LH.
    C. ovulate.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

49. Healthy young adult human female F has high blood plasma levels of hCG (human Chorionic Gonadotropin). During the time that F's blood plasma hCG levels are high,
    A. she will ovulate once a month.
    B. she will secrete high levels of FSH and LH from the corpus luteum into the blood plasma.
    C. she is pregnant.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

50. A question is flashed on a screen in the right visual field of right-handed person Z. Person Z is a healthy individual with a normal nervous system. Person Z has a patch over Z's left eye so that Z sees the question only in Z's right eye.
    A. The stimulus will excite neurons in the right half of Z's right retina.
    B. The stimulus will excite neurons in Z's left V1 (left primary visual cortex).
    C. Z will be able to use a pencil in his right hand to spell out the correct answer on a piece of paper even when all action potentials in all axons of Z's corpus collosum are completely blocked by Drug XCC. All other neurons and axons in Person Z are not directly affected by Drug XCC.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.