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. Central thermoreceptor neurons in the hypothalamus whose peripheral axon terminals are located in the skin.
   B. Calcium-Sensing Receptors (CaSRs) located only in the nucleus of Parathyroid Gland cells.
   C. Mechanically-gated channels located in the plasma membranes of the peripheral axon terminals of 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.

2. Which of the following serves as a controlled variable in a negative feedback system?
   A. Levels of hydrogen ions in the blood plasma of the carotid artery.
   B. Blood plasma levels of glycogen.
   C. Blood plasma levels of glucagon.
   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. Levels of cAMP in the cytosol of beta-islet cells of the pancreas.
   B. Action potentials in parasympathetic neurons that release acetylcholine (ACh) near the SA node of the heart.
   C. Action potentials in motor neurons that synapse on the diaphragm muscle.
   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 luminal membranes of epithelial cells in the medullary collecting duct of the kidney.
   B. GLUT2 Transporters in the plasma membranes of beta-islet cells of the pancreas.
   C. GLUT4 Transporters in the plasma membranes of liver cells.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

5. An increase in blood plasma levels of 1,25-dihydroxyvitamin D {1,25-$(OH)_2$ vitamin D} will lead to an increase in the
   A. amount of 1,25-dihydroxyvitamin D that binds to the binding sites of Vitamin D Receptors (VDRs) in the nucleus of cells in the intestine.
   B. net flux of calcium from the contents of the intestine into the blood plasma.
   C. net flux of 1,25-dihydroxyvitamin D from the blood plasma into the intracellular spaces of cells of the intestine.
   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?
   A. During endocytosis in a kidney collecting duct epithelial cell, there is an increase in the removal of AQP2 channels from luminal membranes and an increase in the placement of AQP2 channels into vesicular membranes in response to an increase in the amount of cAMP in the cytosol of the cell.
   B. During exocytosis in a toe motor neuron, an increase in the intracellular amounts of calcium in the toe motor neuron axon terminals (near toe muscles) leads to an increase in the release of ACh (acetylcholine) from these axon terminals into extracellular space.
   C. During exocytosis in a liver cell, an increase in the binding of insulin to insulin receptors in the plasma membrane leads to an increase in the insertion of GLUT4 molecules into the plasma membrane.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

7. For the Anion Exchanger 1 (AE1), the
   A. net flux of potassium across the plasma membrane is in the same direction as the net flux of chloride across the plasma membrane.
   B. net flux of bicarbonate across the plasma membrane is in the same direction as the net flux of chloride across the plasma membrane.
   C. net flux of bicarbonate across the plasma membrane is from a region with a low concentration of bicarbonate to a region with a high concentration of bicarbonate.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

8. When an antagonist binds to the receptor site of the
   A. nAChR (nicotinic acetylcholine receptor), the channel associated with the nAChR opens and ions flow across the plasma membrane via the open channel.
   B. V2R (vasopressin2 receptor), this activates an alpha subunit of a G-protein associated with the V2R.
   C. insulin receptor, there is activation of a tyrosine kinase located in the intracellular portion of the insulin receptor.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

9. Which of the following is a ligand that binds to a site that is a part of a metabotropic receptor?
   A. Growth Hormone (GH).
   B. Erythropoietin (EPO).
   C. Tetrodotoxin (TTX).
   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 Vasopressin2 Receptors (V2Rs) in medullary collecting duct epithelial cells of the kidney?
   A. When agonists bind to V2Rs in the plasma membrane of these cells, this leads to an increase in the intracellular amount of cAMP in these cells.
   B. When agonists bind to V2Rs in the plasma membrane of these cells, this leads to an increase in the amount of ATP that is bound to alpha subunits of the G-proteins associated with these V2Rs.
   C. When agonists bind to V2Rs in the plasma membrane of these cells, this leads to an increase in the amount of AQP2 in the luminal plasma membranes of these cells.
   D. A and B.
   E. A and C.
   F. B and C.
   G. A, B, and C.
   H. None of the above.

11. At 1 AM, an impermeable membrane separates a 1 liter solution of 1M NaCl and 1M KCl in the left compartment from a 1 liter solution containing both 1M NaCl and 2M 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 sodium ions in the right compartment at 7 AM will be less than the amount of sodium ions in the right compartment at 5 AM.
    B. The amount of chloride ions in the right compartment at 11 AM will be less than the amount of chloride ions in the right compartment at 9 AM.
    C. The amount of sodium ions in the left compartment at 11 AM will be more than the amount of sodium ions in the right compartment at 11 AM.
    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 for a toe corticospinal interneuron that excites toe motor neurons that, in turn, excite a toe muscle that moves the big toe in the right foot?
    A. All of the axon terminals of the toe corticospinal interneuron are located in the left half of the spinal cord.
    B. The cell body of the toe corticospinal interneuron is located in the right half of the spinal cord.
    C. The dendrites of the toe corticospinal interneuron are located in the left primary motor cortex (M1) of the left cerebral cortex.
    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 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 NMDA released from the central axon terminals of IA muscle-spindle stretch receptor neurons whose peripheral axon terminals are located in the right knee extensor muscle.
    B. An increase in the potassium conductance of the peripheral axon terminals of IA muscle-spindle stretch receptor neurons whose peripheral axon terminals are located in the right knee extensor muscle.
    C. An increase in the calcium conductance of the central axon terminals of IA muscle-spindle stretch receptor neurons whose peripheral axon terminals are located 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.

14. 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. Neuron A and Neuron C have a chloride equilibrium potential of -80 millivolts. Neuron B has a chloride equilibrium potential of -10 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, 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.

15. Which of the following are true?
    A. Consider the channel associated with the $GABA_B$ 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.
    B. Consider the channel associated with the $GABA_B$ Receptor and the channel associated with the glycine Receptor. For both types of channels, there is a chloride 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.

16. Which of the following are neurotransmitters?
    A. Muscarine.
    B. NMDA.
    C. AMPA.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

17. Consider Neuron B in the frog central nervous system whose plasma membrane has a newly discovered ligand-gated ionotropic receptor, named the LGD17 receptor. The channel in the same molecular complex as the LGD17 receptor is termed the LGD17 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 -50 mV and the resting potential for Neuron B is -80 mV. LGD17 is an agonist for the ligand-gated ionotropic receptor. When LGD17 binds to its binding site, there is an increase in conductance of both sodium and potassium in the LGD17 receptor channel. Neuron A synapses onto Neuron B. Neuron A's transmitter is LGD17.
    A. Consider the situation that when the LGD17 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 LGD17 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 more than the absolute value of the change in the amount of intracellular potassium in Neuron B.
    C. Consider the situation that when the LGD17 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.

18. 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 changes with a faster time course than potassium conductance of the voltage-gated potassium channels.
    B. sodium conductance of the voltage-gated sodium channels increases as membrane voltage increases.
    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.

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 -10 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, CNQX, and glycine are added to the physiological saline of Dish Y;
glutamate, CNQX, 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 more 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 Z 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 Y is greater than the MAXV in Neuron X. In addition, the MAXV in Neuron Z is greater than the MAXV 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. 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 glycine receptor.
    B. An antagonist of the nicotinic ACh receptor (nAChR).
    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.

21. 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 -50 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 LGD21. When LGD21 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 LGD21. In this experiment, the temperature of the frog central nervous system is 20°C.
    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.

22. 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 binding site on an actin molecule for an activated (energized) myosin head.
    B. The head of a myosin molecule is activated (energized) during the hydrolysis of ATP (which is bound to the myosin head) to ADP and P_i.
    C. The binding of GTP to the head of the myosin molecule causes detachment of the head of the myosin molecule from its binding 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.

23. 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 occur in response to an action potential in the plasma membrane of the muscle fiber?
    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 calcium conductance of the channel associated with the Ryanodine Receptor in 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.

24. 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. a decrease in the amount of ATP molecules in the muscle.
    C. an increase in the amount of calcium ions that are 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.

25. 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.

26. 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 the closing of the left AV valve, that is, the left AV valve goes from an open state to a closed state.
    B. The T wave of the electrocardiogram and decreases in membrane voltage of atrial muscle fibers.
    C. The P wave of the electrocardiogram and increases in membrane voltage of atrial muscle fibers.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

27. 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, the volume of blood in the left ventricle at the end of the *lub* sound is more than the volume of blood in the left ventricle at the start of the *dub* sound.
B. 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.
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.

28. 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, 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.
B. 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.
C. At 2:01 AM, the amount of intracellular cAMP is decreased. 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.

29. 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 a decrease in the heart rate.
    C. this will lead to an increase 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.

30. Which of the following is true?
    A. The blood plasma levels of bicarbonate in the pulmonary artery are lower than the blood plasma levels of bicarbonate in the pulmonary vein.
    B. The partial pressure of oxygen in the blood plasma in the pulmonary artery is lower than the partial pressure of oxygen in the blood plasma in the pulmonary vein.
    C. The percent Hemoglobin saturation (percent of oxygen-binding sites in Hemoglobin that have oxygen bound to them) 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.

31. Which of the following processes in capillaries in the leg 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. Breakdown of carbonic acid into bicarbonate and hydrogen ions in red blood cells.
    C. Net flux of carbon dioxide from blood plasma into interstitial spaces surrounding capillaries.
    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 serves as an actuating signal, or as part of an actuating signal, in a negative feedback system?
    A. Action potentials in motor neurons that synapse upon the diaphragm muscle.
    B. Action potentials in inspiratory rib-cage muscles.
    C. Action potentials in central hydrogen-ion-sensitive chemoreceptors.
    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 is true for ventilation?
    A. When the pressure within the alveoli is greater than atmospheric pressure, there will be expiration of air from the lungs into the atmosphere.
    B. The problems with ventilation induced by injection of curare occur because of the drug's binding to nicotinic Acetylcholine Receptors (nAChRs) in the plasma membranes of the respiratory muscles (the diaphragm and the rib-cage muscles).
    C. An increase in the hydrogen ion concentration in the interstitial spaces of the brainstem leads to a decrease in the duration of the respiratory cycle (duration of respiratory cycle equals duration of inspiration plus duration of expiration).
    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 are involved in the long-term regulation of the oxygen-carrying capacity of the blood?
    A. Production of red blood cells by peritubular interstitial cells (PIC) of the renal cortex in response to EPO binding to EPO Receptors in the plasma membranes of the PIC of the renal cortex.
    B. Change in the total amount of hemoglobin in the blood.
    C. Secretion of the hormone erythropoietin (EPO) from cells in the bone marrow.
    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. In the lumen of the small intestine, trypsin breaks proteins down into small chains of amino acids.
    B. 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. In the stomach, it breaks down carbohydrates into double sugars.
    C. Pancreatic amylase is produced in the pancreas and is secreted into the lumen of the small intestine. In the lumen of the small intestine, it breaks down carbohydrates into double sugars.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

36. In epithelial cells of the small intestine, which of the following are involved in processes that (either directly or indirectly) contribute to the absorption of glucose from the lumen of the small intestine into the blood plasma?
    A. Net flux of glucose across the luminal membranes of the epithelial cells from luminal spaces to intracellular spaces via GLUT2 transporters.
    B. Net flux of glucose across basolateral membranes of the epithelial cells from intracellular spaces to interstitial spaces via SGLT1 cotransporters (sodium-glucose cotransporters 1).
    C. Net flux of sodium across the basolateral membranes of the epithelial cells from intracellular spaces to interstitial spaces via sodium-potassium ATPase pumps.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

37. 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 is an antagonist at V2 receptors and remains bound to V2 receptors in the basolateral membranes of the epithelial cells of the kidney medullary collecting duct for one week.
    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 stimulates endocytosis of AQP2 and blocks exocytosis of AQP2 for one week in the epithelial cells of the kidney medullary 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. Which of the following is true for the epithelial cells of the early proximal tubule of the kidney?
    A. The GLUT2 transporter in the basolateral membrane is responsible for the net flux of glucose from intracellular space to interstitial space.
    B. The SGLT2 cotransporter in the luminal membrane is responsible for the net flux of sodium from luminal space to intracellular space.
    C. The sodium-potassium pump in the basolateral membrane is responsible for the net flux of sodium from interstitial space to intracellular space.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

39. 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 large amounts of water.
    A. April 15 values of W's blood plasma levels of vasopressin were lower than March 15 values of W's blood plasma levels of vasopressin.
    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 the concentration of dissolved solutes in W's urine were lower than March 15 values of the concentration of dissolved solutes in W's urine.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

40. 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 luminal 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. produce high volumes of urine.
    C. benefit from injections of vasopressin into the blood plasma.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

41. Glycogen
    A. binding to Glycogen Receptors in the plasma membrane of an alpha-islet cell of the pancreas leads to an increase in the levels of cAMP in the cytosol of the alpha-islet cell.
    B. binding to Glycogen Receptors in the plasma membranes 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.
    C. levels in the cytosol of a liver cell decrease in response to an increase in cAMP levels in the cytosol of the liver cell.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

42. 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 5 PM on April 2, X takes a dose of Y that opens all the ATP-sensitive potassium channels in X's beta-islet cells of the pancreas for 12 hours. Person X has a normal dinner at 6 PM on April 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 April 2, X's blood plasma levels of glucose will be higher than X's blood plasma levels of glucose at 8 PM on April 1.
    B. At 8 PM on April 2, X's blood plasma levels of insulin will be higher than X's blood plasma levels of insulin at 8 PM on April 1.
    C. At 8 PM on April 2, the glucose permeability of X's liver cells will be lower than the glucose permeability of X's liver cells at 8 PM on April 1.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

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

44. During a fever in a human,
    A. there is an increase 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.
    B. shivering can occur when the actual body temperature is lower than the set point for body temperature during the fever.
    C. the control system for body temperature functions as a 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.

45. Glucagon
    A. binding to Glucagon Receptors in the plasma membrane of a liver cell leads to an increase in cAMP levels in the cytosol 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 when glucose levels in the blood plasma are low.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

46. Insulin binding to insulin receptors in the plasma membrane of a
    A. liver cell will lead to an increase in amount of GLUT2 Transporters in the plasma membrane of the liver cell.
    B. skeletal muscle cell will lead to an increase in exocytosis of GLUT4 Transporters from vesicular membranes into the plasma membrane of the skeletal muscle cell.
    C. beta-islet cell of the pancreas will lead to an increase in exocytosis of GLUT4 Transporters from vesicular membranes into the plasma membrane of the beta-islet cell.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

47. A healthy young adult female who is not pregnant elects to take a newly designed oral contraceptive pill that has only ONE treatment condition. This condition lasts for every day of every month that the female is taking the new pill. During this condition, high levels of estrogen and high levels of progesterone are released continuously into the blood plasma. This type of pill is taken daily, with no interruptions, such that levels of estrogen and progesterone always remain high, unless the patient elects to discontinue the pill altogether. While taking this pill with this treatment condition, this female will
    A. have low levels of FSH and no follicle development.
    B. have low levels of LH and no ovulation.
    C. shed the thick endometrial wall of the uterus and menstruate every 28 days.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

48. Which of the following pairs of events in a human female occur at, or nearly at, the same time during the menstrual cycle?
    A. High blood plasma progesterone levels and ovulation.
    B. Thick endometrial walls of the uterus and the end of menstruation.
    C. High blood plasma LH levels and the start of menstruation.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

49. 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 right eye so that Z sees the question only in Z's left eye.
    A. Z will understand the meaning of the question and generate a correct oral answer even when all action potentials in all axons of Z's corpus collosum are completely blocked by Drug XCC. All other axons in Person Z are not affected by Drug XCC.
    B. The stimulus will excite neurons in the left half of Z's left retina.
    C. The stimulus will excite neurons in Z's left visual cortex.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

50. Which of the following is true for a motor cortex corticospinal interneuron A that produces action potentials during movements of the big toe of the right foot in right-handed Patient X who has a complete transection of the corpus callosum.
    A. Interneuron A will increase its action potential firing rate after Patient X reads the statement "Wiggle the big toe of your right foot" presented in Patient X's right visual field and responds to the question.
    B. In Patient X, the cell body of interneuron A is located between the central sulcus of the left cerebral cortex and back of the head.
    C. The axon terminals of interneuron A are located on the left side of Patient X's spinal cord.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.