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. Peripheral thermoreceptor neurons whose central axon terminals are located in the skin.
   B. Peripheral axon terminals of carotid artery baroreceptors.
   C. Central hydrogen-ion sensitive chemoreceptors whose peripheral axon 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 glucose.
   B. Blood plasma levels of glucagon.
   C. Blood plasma levels of glycogen.
   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 diaphragm muscle fibers.
   B. Action potentials in sympathetic neurons that release acetylcholine (ACh) near the SA node of the heart.
   C. Blood plasma levels of oxytocin.
   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. GLUT4 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. Ryanodine Receptors in inspiratory rib-cage muscles.
   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 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. an increase in the levels of parathyroid hormone in the blood plasma.
   B. an increase in the amount of calcium excreted in the urine.
   C. an increase in the amount of 1,25-dihydroxyvitamin D binding to Vitamin D Receptors (VDRs) in the nucleus of cells in 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 an effect of the following drugs?
   A. Drug X is an agonist of the Vasopressin2 Receptor (V2R). High levels of Drug X in the interstitial spaces surrounding epithelial cells of the kidney medullary collecting ducts will lead to high levels of endocytosis of AQP2 molecules in these epithelial 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 a net flux of glucose from the cytosol of these liver cells to the interstitial spaces surrounding these liver cells.
   C. Drug Z is an antagonist 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.

7. 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 3 AM will be less than the amount of chloride ions in the right compartment at 1 AM.
    B. The amount of sodium ions in the left compartment at 7 AM will be greater 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 greater 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.

8. Diffusion of which of the following substances across the plasma membrane can occur via a spanning membrane protein channel?
    A. Water.
    B. 1,25-dihydroxyvitamin D.
    C. FSH.
    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 true?
    A. During exocytosis in a toe motor neuron, an increase in the amount of intracellular calcium in axon terminals of the neuron leads to the release of ACh (acetylcholine) from the axon terminals.
    B. During exocytosis in kidney collecting duct epithelial cells, there is an increase in the insertion of AQP2 channels into luminal membranes in response to an increase in the amount of cAMP in the cytosol of the cell.
    C. During endocytosis in a fat cell, there is an increase in the insertion of GLUT4 molecules into the plasma membrane in response to binding of insulin to insulin receptors in 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.

10. 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 ATP displacing a ADP 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 GTP displacing a GDP 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.

11. Which of the following is true?
    A. An increase in the amount of vasopressin that binds to V2 Receptors (vasopressin 2 receptors) in the basolateral membrane of an epithelial cell in the medullary collecting duct of the kidney leads to an increase in the amount of unbound GDP in the cytosol of the epithelial cell.
    B. An increase in the amount of ACh that binds to mAChRs (muscarinic acetylcholine receptors) in a SA node cell of the heart leads to an increase in the amount of cAMP in cytosol of the SA node cell.
    C. An increase in the amount of glucagon that binds to glucagon receptors in a liver cell leads to an increase in the amount of cAMP 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.

12. A complete motor neuron is removed from a frog and placed in a large volume of modified extracellular saline. The neuron is healthy; it has a stable resting voltage of -70 millivolts. It is not producing any action potentials; its threshold for an action potential is -50 millivolts. The only ligand-gated Receptors in the neuron's plasma membrane are AMPA Receptors, $GABA_A$ Receptors, $GABA_B$ Receptors, and glycine Receptors. The equilibrium potential for chloride ions is -70 millivolts, the equilibrium potential for potassium ions is -70 millivolts, and the equilibrium potential for sodium ions is +60 millivolts.
    A. The addition of glutamate and glycine to the physiological saline will lead to an increase in the amount of intracellular sodium, a decrease in the amount of intracellular potassium, and to an increase in the amount of intracellular chloride.
    B. The addition of GABA to the physiological saline will lead to an increase in the amount of intracellular chloride and a decrease in the amount of intracellular potassium.
    C. The addition of glutamate and GABA to the physiological saline will lead to no net change in the amount of intracellular chloride.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

13. A quick tap is applied to the right patellar tendon of Healthy Person P. This leads to an increase in the length of the right knee extensor muscle. Which of the following occur following this increase in the length of the right knee extensor muscle?
    A. An increase in the amount of glutamate released from the central axon terminals of IA muscle-spindle stretch receptor neurons whose peripheral axon terminals are in the right knee extensor muscle.
    B. An increase in the amount of potassium conductance in the dendrites of right knee extensor motor neurons.
    C. An increase 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.

14. 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: nAChRs (nicotinic Acetylcholine 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;
    ACh is added to the physiological saline of Dish W;
    glutamate and ACh are added to the physiological saline of Dish X;
    glutamate, ACh, and glycine are added to the physiological saline of Dish Y;
    glutamate, ACh, glycine, and strychnine are added to the physiological saline of Dish Z.
    A. At 2:01AM, the total sodium conductance in Neuron X is less than the total sodium conductance in Neuron Y. In addition, the total sodium conductance in Neuron W is more than the total sodium conductance in Neuron V.
    B. At 2:01 AM, the total chloride conductance in Neuron Y will be more than the total chloride conductance in Neuron Z. In addition, the total calcium conductance in Neuron X will be less than the total calcium conductance in Neuron V.
    C. For each neuron, MAXV is the maximum voltage that is reached by that neuron during the period from 2:00 AM to 2:02 AM. The MAXV in Neuron W is greater than the MAXV in Neuron V. In addition, the MAXV in Neuron Z is less 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.

15. 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 ACh (acetylcholine) in its synaptic vesicles. The only ligand-gated receptors in Neuron A are AMPA receptors. The only ligand-gated receptors in the plasma membrane of Neuron B are glycine receptors. The only ligand-gated receptors in the plasma membrane of Neuron C are mACh (muscarinic ACh) 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 B have a chloride equilibrium potential of -80 millivolts. Neuron C has a chloride equilibrium potential of -20 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, ACh 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.

16. Which of the following are true?
    A. Consider the channel associated with the AMPA Receptor and the channel associated with the $GABA_B$ Receptor. For both types of channel, there is a potassium conductance greater than zero when the channel is open.
    B. ACh (Acetylcholine) is an antagonist both at the muscarinic ACh Receptor and at the nicotinic ACh Receptor.
    C. Consider the channel associated with the NMDA Receptor and the channel associated with the Glycine Receptor. For both types of channel, there is a calcium conductance greater than zero when the channel is open.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

17. Which of the following is an agonist that binds to a site that is a part of a ligand-gated ionotropic receptor?
    A. muscarine.
    B. curare.
    C. nicotine.
    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 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 -50 mV. LGD is an agonist for the ligand-gated ionotropic receptor. When LGD binds to its binding site, there is an increase in conductance of both sodium and potassium in the LGD receptor channel. Neuron A synapses onto Neuron B. Neuron A's transmitter is LGD.
    A. Consider the situation that when the LGD receptor channel is open in Neuron B, its potassium conductance equals its sodium conductance. For this situation, in response to an action potential in Neuron A, there is an excitatory postsynaptic potential in Neuron B. In addition for this situation in response to an action potential in Neuron A, the absolute value of the change in the amount of intracellular sodium in Neuron B is equal to the absolute value of the change in the amount of intracellular potassium in Neuron B.
    B. Consider the situation that when the LGD receptor channel is open in Neuron B, its sodium conductance equals nine times its potassium 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 greater than the absolute value of the change in the amount of intracellular potassium in Neuron B.
    C. Consider the situation that when the LGD receptor channel is open in Neuron B, its potassium conductance equals four times its sodium conductance. For this situation, in response to an action potential in Neuron A, there is an inhibitory postsynaptic potential in Neuron B. In addition for this situation in response to an action potential in Neuron A, the absolute value of the change in the amount of intracellular sodium in Neuron B is less than the absolute value of the change in the amount of intracellular potassium in Neuron B.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

19. 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. the amount of intracellular sodium 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. sodium conductance of the voltage-gated sodium channels decreases as membrane voltage increases.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

20. Consider Neuron B in the frog central nervous system whose plasma membrane has a previously unknown channel that is selectively conductive to a newly discovered divalent cation named DIVCAT with a valence of +2. The threshold for an action potential in Neuron B is -45 millivolts and the resting potential for Neuron B is -50 millivolts. The DIVCAT channel in Neuron B is part of an ionotropic receptor with an extracellular binding site for the newly discovered ligand LGD. When LGD binds to its binding site, there is an increase in the DIVCAT conductance of Neuron B. Neuron A synapses onto Neuron B. Neuron A's neurotransmitter is LGD. In this experiment, the temperature of the frog central nervous system is 20° C.
    A. The intracellular concentration of DIVCAT is 1000 times greater than the extracellular concentration of DIVCAT. In response to an action potential in Neuron A, there will be: a decrease in the membrane voltage of Neuron B; a decrease in the amount of intracellular DIVCAT in Neuron B; and an inhibitory postsynaptic potential in Neuron B.
    B. The intracellular concentration of DIVCAT is 100 times greater than the extracellular concentration of DIVCAT. In response to an action potential in Neuron A, there will be: an increase in the membrane voltage of Neuron B; an increase in the amount of intracellular DIVCAT in Neuron B; and an excitatory postsynaptic potential in Neuron B.
    C. The intracellular concentration of DIVCAT is 10 times greater than the extracellular concentration of DIVCAT. In response to an action potential in Neuron A, there will be: an increase in the membrane voltage of Neuron B; an increase in the amount of intracellular DIVCAT in Neuron B; and an excitatory postsynaptic potential in Neuron B.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

21. 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 net change in the amount of intracellular chloride ions in neuron A.
    B. If the value of E is equal to R, and if chloride is the only ion that passes through open Z channels, then Y's binding to its receptor site on Z in neuron A produces an increase in the chloride conductance of neuron A.
    C. If the value of R is less than E, if the value of E is less than T, and if chloride is the only ion that passes through open Z channels, then Y's binding to its receptor site on Z in neuron A produces an increase in the amount of intracellular chloride ions in neuron A.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

22. 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 into the cytosol in response to high levels of Ryanodine binding to Ryanodine Receptors in the membranes of the transverse tubules.
    B. During exocytosis in a skeletal muscle, there will be insertion of GLUT4 transporters into the sarcoplasmic reticulum membrane in response to Insulin binding to Insulin Receptors in the sarcoplasmic reticulum 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.

23. Which of the following is true in a skeletal muscle?
    A. The binding of GTP to the head of the myosin molecule causes detachment of the head of the myosin molecule from its receptor site on the actin molecule.
    B. The binding of calcium to troponin leads to a movement of the tropomyosin molecule so that the tropomyosin molecule no longer blocks a receptor site on an actin molecule for an activated (energized) myosin head.
    C. The head of a myosin molecule is activated (energized) during the hydrolysis of GTP (which is bound to the myosin head) to GDP and P_i.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

24. 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 minus the value of H (= A + I - H) remains constant.
    C. the value of A minus the value of H (= A - H) decreases.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

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

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 during the time interval between t_1 and the end of the *lub* sound in that single cycle?
    A. There is an occurrence of the closing of the aortic valve, that is, it goes from an open position to a closed position.
    B. There is an occurrence of the opening of the left AV valve, that is, it goes from a closed position to an open position.
    C. In the electrocardiogram, there is an occurrence of the QRS wave.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

27. The AV node of a mammalian heart is destroyed. All other parts of the heart are normal and healthy.
    A. The firing rate of action potentials in Bundle of His cells will be equal to the firing rate of action potentials in ventricular muscle cells.
    B. The firing rate of action potentials in SA node cells will be equal to the firing rate of action potentials in atrial muscle cells.
    C. The firing rate of action potentials in ventricular muscle cells will be equal to the firing rate of action potentials in atrial muscle cells.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

28. 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 heart rate.
    B. this will lead to an increase in the diameter of the arterioles.
    C. this will lead to an increase in the amount of NE (norepinephrine) released near the SA node of the heart.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

29. Which of the following is true for SA node cells?
    A. An increase in the binding of norepinephrine to alpha-adrenergic receptors in SA node cells will lead to an increase in intracellular levels of cAMP in these cells.
    B. An increase in the binding of acetylcholine to nAChRs (nicotinic acetylcholine 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.

30. Which of the following processes in capillaries near body cells 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. Net flux of bicarbonate from blood plasma into red blood cells.
    C. Net flux of carbon dioxide 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.

31. 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 ORH (Oxygen Releasing Hormone) that binds to ORHRs (Oxygen Releasing Hormone Receptors) in the plasma membranes of red blood cells in capillaries near body cells in a leg.
    B. A decrease in hydrogen ion concentration in the cytosol of red blood cells in capillaries near body cells in a leg.
    C. Net flux of oxygen from red blood cells into the blood plasma 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.

32. Which of the following is true for red blood cells?
    A. Carbonic anhydrase is a spanning protein in the plasma membrane of red blood cells responsible for the net flux of bicarbonate across the plasma membrane.
    B. Anion Exchanger 1 (AE1) is an enzyme in the cytosol of red blood cells responsible for formation of carbonic acid from hydrogen ions and bicarbonate.
    C. Hemoglobin is a spanning protein in the plasma membrane of red blood cells with binding sites for oxygen on the extracellular portion of the protein.
    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 are true for ventilation?
    A. An increase in the hydrogen ion concentration in the interstitial spaces of the brain stem leads to an increase in the duration of the respiratory cycle (duration of respiratory cycle equals duration of inspiration plus duration of expiration).
    B. When the pressure within the alveoli is greater than atmospheric pressure, there will be expiration of air from the lungs into the atmosphere.
    C. 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 respiratory muscles (the diaphragm and the rib-cage muscles).
    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. Change in the total amount of hemoglobin in the blood.
    B. Secretion of the hormone erythropoietin (EPO) from peritubular interstitial cells (PIC) in the renal cortex of the kidney.
    C. Production of red blood cells by bone marrow cells in response to EPO binding to EPO Receptors in the nucleus of these bone marrow cells.
    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 are 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. Skeletal muscles control the movement of substances in the small intestine.
    C. The external anal sphincter is a smooth 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.

36. Which of the following assist in the digestion of fats?
    A. Production of lipase in the pancreas and secretion of lipase into the lumen of the small intestine.
    B. Emulsification of fats into droplets by lipase in the lumen of the small intestine.
    C. Production of bile salts in the liver and the secretion of those bile salts into the small intestine.
    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 (vasopressin2 receptors) in the kidney will lead to an increase
    A. in the amount of cAMP in the cytosol of epithelial cells in the kidney medullary collecting duct.
    B. in the amount of AQP2 molecules in the luminal membranes of epithelial cells in the kidney medullary collecting duct.
    C. in the water permeability of the luminal membranes of epithelial cells in 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. 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. benefit from injections of vasopressin into the blood plasma.
    C. produce high 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.

39. Which of the following is true for the epithelial cells of the early portion of the kidney proximal tubule?
    A. The GLUT2 transporter in the luminal membrane is responsible for the net flux of sodium from luminal space to intracellular space.
    B. The sodium-potassium pump in the basolateral membrane is responsible for the net flux of sodium from intracellular space to interstitial space.
    C. The SGLT2 co-transporter in the basolateral membrane is responsible for the net flux of glucose from intracellular space to interstitial space.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

40. 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 exocytosis of AQP2 and blocks endocytosis 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 levels of intracellular cyclic AMP (cAMP) are constant at a very high level for one week in the epithelial cells of the kidney medullary collecting duct.
    C. Drug Z that is an antagonist at V2 Receptors that remains bound to V2 Receptors in 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.

41. Which of the following processes assist in the maintenance of high levels of dissolved solutes in the interstitial spaces of the kidney medulla?
    A. Net flux of sodium ions from luminal spaces to intracellular spaces via sodium-potassium-ATPase pumps located in the luminal membranes of the epithelial cells in the descending limb of the Loop of Henle.
    B. Net flux of sodium ions from intracellular spaces to interstitial spaces via the sodium-glucose co-transporters (SGLT1 and SGLT2) located in the basolateral membranes of the epithelial cells in the ascending limb of the Loop of Henle.
    C. Net flux of sodium from intracellular spaces to interstitial spaces via the sodium-potassium-2chloride co-transporters (NKCC2) located in the basolateral membranes of the 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.

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 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 lower 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.

43. Glycogen
    A. levels in the cytosol of a liver cell decrease in response to an increase in cAMP levels in the cytosol of the liver cell.
    B. 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.
    C. 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.
    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. Insulin binding to Insulin Receptors in the plasma membrane of a diaphragm muscle cell leads to an increase in the exocytosis of GLUT4 Transporters into the sarcoplasmic reticulum membranes of the diaphragm muscle.
    B. Insulin binding to Insulin Receptors in the plasma membrane of a liver cell leads to an increase in intracellular levels of Glycogen in the liver cell.
    C. Insulin binding to Insulin Receptors in the plasma membrane of a fat cell leads to an increase in the amount of GLUT4 Transporters in the plasma membrane of the fat cell.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

45. Which of the following is true?
    A. GnRH Receptors (Gonadotropin Releasing Hormone Receptors) are located only in the plasma membranes of cells in the hypothalamus.
    B. VRH (Vasopressin Releasing Hormone) travels in specialized capillaries located in the pituitary stalk between the hypothalamus and 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.

46. 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?
    A. Consider the situation that P takes Drug A 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. Two days after taking Drug A, the amount of the net flux of water from intracellular spaces to interstitial spaces across the basolateral membranes of these cells in P will be more than the pre-drug amount of the net flux of water from intracellular spaces to interstitial spaces across the basolateral membranes of these cells in P.
    B. Consider the situation that P takes Drug B 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. Two days after taking Drug B, the firing rate of action potentials in P's atrial muscle cells will be equal to the firing rate of action potentials in P's ventricular muscle cells.
    C. Consider the situation that P takes Drug C 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. Two days after taking Drug C, the amount of glycogen in P's liver cells will be lower than pre-drug levels of the amount of glycogen in P's liver cells.
    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. 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 occurs when the actual body temperature is higher than the set point for body temperature during the fever.
    C. the control system for body temperature functions as a closed-loop negative-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. 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 is pregnant.
    C. she will secrete high levels of FSH and LH from the corpus luteum 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.

49. 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.

50. A simple 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 left 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 left 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.