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 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 calcium.
   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 cells in the Bundle of His.
   B. Action potentials in sympathetic neurons that release acetylcholine (ACh) near the SA node of the heart.
   C. Blood plasma levels of glucagon receptors.
   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 early proximal tubule of the kidney.
    B. GLUT2 Transporters in the plasma membranes of beta-islet cells of the pancreas.
    C. GLUT2 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. 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 amounts of calcium excreted in the urine.
    B. a decrease in the levels of calcium in the blood plasma.
    C. a decrease in the levels of parathyroid hormone (PTH) in 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.

6. At 1 AM, an impermeable membrane separates a 1 liter solution of 1M KCl 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 potassium ions. At 4 AM, the membrane once again became impermeable to potassium ions. At 6 AM, the membrane became permeable to chloride ions and, in addition, maintained potassium ion impermeability. At 8 AM, the membrane became permeable to potassium ions again and, in addition, maintained its permeability to chloride ions. The membrane stayed impermeable to sodium ions at all times.
    A. The amount of chloride ions in the left compartment at 9 AM will be greater than the amount of chloride ions in the left compartment at 7 AM.
    B. The amount of chloride ions in the left compartment at 7 AM will be greater than the amount of chloride ions in the left compartment at 5 AM.
    C. The amount of potassium ions in the left compartment at 9 AM will be greater than the amount of potassium ions in the left compartment at 7 AM.
    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. During exocytosis in a toe motor neuron, an increase in the amount of intracellular calcium in the peripheral axon terminals of the neuron leads to an increase in the release of ACh (acetylcholine) from the peripheral axon terminals.
   B. During endocytosis in medullary collecting duct epithelial cells of the kidney, 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.
   C. During exocytosis in a skeletal muscle cell, there is an increase in the insertion of GLUT2 molecules into the plasma membrane in response to an increase in the 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.

8. 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 amount of ATP that is bound to alpha subunits of the G-proteins associated with these V2Rs.
   B. When antagonists bind to V2Rs in the plasma membrane of these cells, this leads to an increase in the intracellular amount of cAMP in these cells.
   C. When agonists bind to V2Rs in the plasma membrane of these cells, this leads to an increase in the amount of AQP4 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.

9. 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 a decrease 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 a decrease 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 a decrease 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.

10. Which of the following substances serve as agonists that bind to G-Protein Coupled Receptors (GPCRs)?
    A. ACh (acetylcholine).
    B. GH (Growth Hormone).
    C. Oxytocin.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

11. A normal healthy cell is bathed in a normal extracellular saline. The plasma membrane of the cell contains voltage-gated sodium channels, the sodium-glucose cotransporter 2 (SGLT2), and sodium-potassium ATPase pumps. Via which of these spanning proteins is the net flux of sodium ions from a region of low concentration of sodium to a region of high concentration of sodium? The movement of sodium ions via
    A. the sodium-potassium ATPase primary active transport pump.
    B. the sodium-glucose cotransporter 2 (SGLT2).
    C. an open voltage-gated sodium channel.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

12. 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 a chloride equilibrium potential of -80 millivolts. The threshold for an action potential in all 3 neurons is -55 millivolts. At 1:55 AM, glutamate is added to the physiological saline. At 2:00 AM, the action potential firing rate of each neuron is 100 Hz. Which of the following will lead to a decrease in Neuron C's action potential firing rate?
    A. At 2:01 AM, CNQX is added to the bath.
    B. At 2:01 AM, strychnine is added to the bath.
    C. At 2:01 AM, glycine 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.

13. 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 -80 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 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. 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 greater 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 W 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.

14. 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 potassium conductance in the membranes of the sarcoplasmic reticulum in the muscle fibers of the right knee extensor muscle.
    B. An increase in the amount of calcium conductance in the membranes of the central axon terminals of IA muscle-spindle stretch receptor neurons whose peripheral axon terminals are in the right knee extensor muscle.
    C. An increase in the amount of potassium conductance in the peripheral axon terminals of right knee extensor motor neurons.
    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 LGD15 receptor. The channel in the same molecular complex as the LGD15 receptor is termed the LGD15 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 +30 mV, and the Nernst equilibrium potential for potassium in Neuron B is -90 mV. The threshold for an action potential in Neuron B is -55 mV and the resting potential for Neuron B is -66 mV. LGD15 is an agonist for the ligand-gated ionotropic receptor. When LGD15 binds to its binding site, there is an increase in conductance of both sodium and potassium in the LGD15 receptor channel. Neuron A synapses onto Neuron B. Neuron A's transmitter is LGD15.
    A. Consider the situation that when the LGD15 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 greater than the absolute value of the change in the amount of intracellular potassium in Neuron B.
    B. Consider the situation that when the LGD15 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 equal to the absolute value of the change in the amount of intracellular potassium in Neuron B.
    C. Consider the situation that when the LGD15 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 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 are neurotransmitters?
    A. Nicotine.
    B. Muscarine.
    C. GABA.
    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. Neuron A is initially at rest. Which of the following statements are true when neuron B produces an action potential and releases neurotransmitter Y?
    A. If the value of E is zero and if both sodium ions and potassium ions pass through open Z channels, then Y's binding to its receptor site on Z in neuron A produces an excitatory postsynaptic potential in neuron A, an increase in the amount of intracellular sodium ions in neuron A, and a decrease in the amount of intracellular potassium ions in neuron A.
    B. If the value of E is less than 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 inhibitory postsynaptic potential in neuron A, an increase in chloride conductance of the plasma membrane of neuron A, and a decrease in the amount of intracellular chloride ions in neuron A.
    C. If the value of E is equal to R, and if chloride is the only ion that passes through open Z channels, then Y's binding to its receptor site on Z in neuron A produces an inhibitory postsynaptic potential in neuron A, no change in chloride conductance of the plasma membrane of neuron A, and no change 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.

18. 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. Glutamate is an agonist at both the AMPA Receptor and the NMDA Receptor.
    C. Consider the channel associated with the $GABA_A$ Receptor and the channel associated with the Glycine Receptor. For both types of channel, there is a chloride 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.

19. 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 -50 millivolts and the resting potential for Neuron B is -70 millivolts. The DIVCAT channel in Neuron B is part of an ionotropic receptor with an extracellular binding site for the newly discovered ligand LGD19. When LGD19 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 LGD19. 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; an increase in the amount of intracellular DIVCAT in Neuron B; and an inhibitory postsynaptic potential in Neuron B.
    B. The intracellular concentration of DIVCAT is 100 times greater than the extracellular concentration of DIVCAT. In response to an action potential in Neuron A, there will be: an increase in the membrane voltage of Neuron B; an increase in the amount of intracellular DIVCAT in Neuron B; and an 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; a decrease in the amount of intracellular DIVCAT in Neuron B; and an excitatory postsynaptic potential in Neuron B.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

20. 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 slower 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 decreases.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

21. Which of the following is true for a primary motor cortex (M1) toe corticospinal interneuron N that produces action potentials during voluntary movements of the big toe of the right foot?
    A. A portion of the axon of interneuron N is located in a nerve in the right leg.
    B. The axon terminals of interneuron N are located in the right half of the spinal cord.
    C. The cell body of interneuron N is located in the right half of the spinal cord.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

22. For a sarcomere of a skeletal muscle fiber, use the following definitions:
A is the length of the A Band; H is the length of the H Zone;
I is the total length of the I Bands in the sarcomere.
When the length of the sarcomere decreases during a shortening contraction of the entire muscle,
    A. The value of A plus the value of I minus the value of H (= A + I - H) decreases.
    B. The value of A plus the value of I (= A + I) decreases.
    C. The value of A minus the value of H (= A - H) increases.
    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 calcium to troponin leads to a movement of the tropomyosin molecule so that the tropomyosin molecule no longer blocks a binding site on an actin molecule for an activated (energized) myosin head.
    B. The head of an 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 ATP 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.

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 occur in response to an action potential in the plasma membrane of the muscle fiber?
    A. A conformational change in Dihydropyridine (DHP) Receptors in the membranes of the sarcoplasmic reticulum.
    B. An increase in the amount of calcium ions in the sarcoplasmic reticulum.
    C. An increase in the calcium conductance of the channel associated with the Ryanodine Receptor in the membranes of the transverse tubules.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

25. 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 the electrocardiogram, the peak value of the T wave occurs during the time interval between the end of the *lub* sound in that single cycle and t_2.
    B. In that single cycle, the volume of blood in the left ventricle at t_1 is less than the volume of blood in the left ventricle at the start of the *lub* sound.
    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.

26. The AV node of a mammalian heart is destroyed. All other parts of the heart are normal and healthy.
    A. The firing rate of SA node cells will be higher than the firing rate of atrial muscle cells.
    B. The rate of ventricular contractions will be equal to the rate of atrial contractions.
    C. The firing rate of cells in the Bundle of His 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.

27. Which of the following is true for SA node cells?
    A. A decrease 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 each of these cells.
    B. 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 each of these cells.
    C. An increase in the binding of acetylcholine to nicotinic ACh Receptors in SA node cells will lead to a decrease in intracellular levels of cAMP in each 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.

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 amount of ACh (acetylcholine) released near the SA node of the heart.
    B. this will lead to an increase in the diameter of the arterioles.
    C. this will lead to an increase in the heart rate.
    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. An increase in the firing frequency of all the carotid artery baroreceptors.
    B. An increase in the diameter of every arteriole.
    C. A decrease of firing rate in all the sympathetic neurons that innervate smooth muscles that surround arterioles.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

30. 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 the blood plasma.
    B. Net flux of carbon dioxide from red blood cells into blood plasma.
    C. Net flux of bicarbonate from red blood cells into blood plasma.
    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. Net flux of oxygen from blood plasma into red blood cells in the capillaries in the leg.
    B. An increase in hydrogen ion concentration in the cytosol of red blood cells in the body capillaries in the leg.
    C. Removal of oxygen from hemoglobin in response to a high partial pressure (concentration) of oxygen in the body capillaries in the 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 are involved in the long-term regulation of the oxygen-carrying capacity of the blood?
    A. Secretion of the hormone erythropoietin (EPO) from bone marrow cells in response to low partial pressure levels of oxygen in the interstitial spaces surrounding these bone marrow cells.
    B. Changes in the amount of red blood cells produced by peritubular interstitial cells (PIC) of the renal cortex in response to EPO binding to EPO Receptors in the plasma membranes of these peritubular interstitial cells (PIC) of the renal cortex.
    C. Changes in the total amount of hemoglobin in the blood.
    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?
    A. 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 higher than the percent Hemoglobin saturation in the red blood cells 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 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.
    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 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 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 an increase 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.

35. 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 sodium across the basolateral membranes of the epithelial cells from interstitial spaces to intracellular spaces via sodium-potassium ATPase pumps.
    B. Net flux of glucose across the luminal membranes of the epithelial cells from luminal spaces to intracellular spaces via GLUT2 transporters.
    C. Net flux of glucose across basolateral membranes of the epithelial cells from intracellular spaces to interstitial spaces via SGLT1 cotransporters (sodium-glucose cotransporters 1).
    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. Healthy Person H takes a new drug named UPCAMPCOLLDUCT that stimulates the production of cyclic AMP (cAMP) in medullary collecting duct epithelial cells of the kidney and results in a condition in which intracellular levels of cAMP in the medullary collecting duct epithelial cells are continuously very high. A single dose of the new drug creates this condition within one hour and this condition lasts for one week. Which of the following is true for Person H during the third day after taking the new drug?
    A. Person H will produce a lower volume of urine compared with the volume of urine produced by Person H prior to taking the drug.
    B. The total amount of AQP2 channels stored in intracellular vesicles of the medullary collecting duct epithelial cells will be higher than pre-drug levels.
    C. Water permeability of the luminal membranes of the medullary collecting duct epithelial cells will be higher than pre-drug levels.
    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 medullary collecting duct of the kidney 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. benefit from injections of vasopressin into the blood plasma.
    B. produce urine with a very low concentration of dissolved solutes.
    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 sodium-potassium ATPase pump in the basolateral membrane is responsible for the net flux of sodium from intracellular space to interstitial space.
    B. The SGLT2 co-transporter in the luminal membrane is responsible for the net flux of sodium from luminal space to intracellular space.
    C. The GLUT2 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. Which of the following is true for the plasma membranes of epithelial cells in the descending limb of the Loop of Henle of the kidney?
    A. Sodium-potassium ATPase pump molecules are located in the luminal membranes of epithelial cells in the descending limb of the Loop of Henle.
    B. AQP1 (Aquaporin 1) molecules are located in the basolateral membranes of epithelial cells in the descending 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 descending 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.

41. Glucagon
    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 Glucagon Receptors in the plasma membrane of a liver cell leads to an increase in the levels of cAMP in the cytosol of the liver cell.
    C. binding to Glucagon Receptors in the plasma membrane of a liver cell leads to an increase in glucose permeability of 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.

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, the glucose permeability of X's skeletal muscle cells will be lower than the glucose permeability of X's skeletal muscle cells at 8 PM on April 1.
    B. At 8 PM on April 2, X's blood plasma levels of glucose will be lower than X's blood plasma levels of glucose at 8 PM on April 1.
    C. At 8 PM on April 2, X's blood plasma levels of insulin will be lower than X's blood plasma levels of insulin 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 serves as an actuating signal, or as part of an actuating signal, in a negative feedback system?
    A. Blood plasma levels of glucose.
    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.

44. Patient P has recently developed a tumor of the anterior pituitary gland that secretes large amounts of a specific hormone into the general circulation. Assume that the situation with this tumor constitutes an open-loop disease without any form of negative-feedback control.
    A. Consider the situation that the tumor cells in the anterior pituitary now are secreting large amounts of thyroid stimulating hormone (TSH). In this situation, patient P will have increased plasma levels of thyroid hormones released from the thyroid gland cells compared with the plasma levels of thyroid hormones prior to the development of the tumor.
    B. Consider the situation that the tumor cells in the anterior pituitary are secreting large amounts of growth hormone (GH). In this situation, patient P will have increased growth compared with the amount of growth prior to the development of the tumor. This increased growth is due to an increased binding of growth hormone (GH) to growth hormone receptors (GHRs) that are GPCRs (G-Protein Coupled Receptors) in the plasma membranes of cells in the periphery.
    C. Consider the situation that the tumor cells in the anterior pituitary are secreting large amounts of LH in a male patient. In this situation, patient P will have increased secretion of testosterone from his Sertoli cells compared with the amount of testosterone secreted by these cells prior to the development of the tumor.
    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. 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 Glucagon 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 AQP2 channels 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.

46. 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. the control system for body temperature functions as a closed-loop negative-feedback system.
    C. shivering occurs when the actual body temperature is higher than the set point for body temperature during the fever.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.

47. Healthy young adult human female F has very high blood plasma levels of hCG (human Chorionic Gonadotropin). During the time that F's blood plasma hCG levels are very high,
    A. she will ovulate once a month.
    B. she is pregnant.
    C. she will secrete estrogen and progesterone from the corpus luteum.
    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. The stimulus will excite neurons in the left half of Z's left retina.
    B. The stimulus will excite neurons in Z's left V1 (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.

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. In Patient X, the cell body of interneuron A is located in between the central sulcus of the left cerebral cortex and the left eye.
    B. The axon terminals of interneuron A are located on the left side of Patient X's spinal cord.
    C. 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.
    D. A and B.
    E. A and C.
    F. B and C.
    G. A, B, and C.
    H. None of the above.