There are 25 questions in this exam. All questions are "A, B, C, All of the above, None of the above" questions worth one point each. There is a total of 25 points in this exam. Fill in your answers on the separate answer sheet. 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 A, B, and C are all correct; fill in E if none of them are correct. Only mark one letter per question. You may keep the question sheets. Use the convention that -3 is less than -2.

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. Plasma-membrane calcium receptors located in parathyroid gland cells.
   B. Hydrogen-ion-sensitive peripheral chemoreceptor neurons whose peripheral terminals are located in the walls of the carotid artery.
   C. Force-gated mechanosensory channels located in the peripheral terminals of carotid artery baroreceptor neurons.
   D. All of the above.
   E. None of the above.

2. Which of the following serves as an actuating signal, or as part of an actuating signal, in a negative feedback system?
   A. Action potentials in motor neurons that release acetylcholine (ACh) as their neurotransmitter and synapse upon inspiratory skeletal muscles in the lungs.
   B. Blood plasma levels of glycogen.
   C. Action potentials in parasympathetic neurons that synapse upon skeletal muscles surrounding the arterioles.
   D. All of the above.
   E. None of the above.

3. Which of the following serves as an effector, or as part of an effector, that functions in a negative feedback system?
   A. GLUT4 Transporters in the plasma membranes of skeletal muscle cells.
   B. G-Protein Coupled Insulin Receptors in the plasma membranes of skeletal muscle cells.
   C. V2 Receptors in the luminal membranes of collecting duct epithelial cells.
   D. All of the above.
   E. None of the above.

4. Which of the following processes in lung capillaries assist in the removal of carbon dioxide from the body?
   A. Formation of carbonic acid by carbonic anhydrase in red blood cells.
   B. Net flux of carbon dioxide from plasma into red blood cells.
   C. Net flux of bicarbonate from plasma into red blood cells.
   D. All of the above.
   E. None of the above.
5. 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. An increase in the pressure within the chest cavity results in the inspiration of air into the lungs.
   C. The problems with ventilation induced by injection of curare occur because of the drug's direct action on muscarinic ACh receptors in the plasma membranes of the respiratory muscles (the diaphragm and the rib-cage muscles).
   D. All of the above.
   E. None of the above.

6. 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 the red blood cells in capillaries near body cells in a leg.
   B. A decrease in hydrogen ion concentration in red blood cells in the body capillaries in a leg.
   C. Removal of oxygen from hemoglobin in response to an increase in the amount of HbRH (Hemoglobin Releasing Hormone) in the intracellular spaces of red blood cells in capillaries in the leg.
   D. All of the above.
   E. None of the above.

7. 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 by carbonic anhydrase in red blood cells.
   B. Breakdown of carbonic acid in red blood cells into hydrogen ions and bicarbonate.
   C. Net flux of bicarbonate from red blood cells into blood plasma.
   D. All of the above.
   E. None of the above.

8. Two compartments of equal volume of physiological saline are separated by a membrane permeable only to oxygen. At 1:00 AM equal amounts of oxygen are dissolved into both left and right compartments. At 3:00 AM healthy red blood cells are prepared so that they contain no oxygen. At 3:05 AM these cells are placed into the right compartment. For this question, ignore effects of cellular respiration in the red blood cells.
   A. At 4:00 AM the amount of extracellular oxygen in the right compartment will be higher than the total amount of oxygen in the right compartment at 2:00 AM.
   B. At 4:00 AM the total amount of oxygen in the left compartment will be greater than the amount of extracellular oxygen in the right compartment at 4:00 AM.
   C. At 4:00 AM the total amount of oxygen (extracellular, intracellular bound, and intracellular unbound oxygen) in the right compartment will be higher than the total amount of oxygen in the left compartment at 4:00 AM.
   D. All of the above.
   E. None of the above.
9. 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 the plasma membranes of diaphragm skeletal muscle fibers.
   B. Blood plasma levels of erythropoietin (EPO).
   C. Blood plasma levels of hydrogen ions in the carotid artery.
   D. All of the above.
   E. None of the above.

10. Which of the following is true?
   A. Erythropoietin is secreted by cells in the bone marrow.
   B. Erythropoietin Receptors serve as an effector, or as part of an effector, in a long-term negative feedback loop that controls the levels of oxygen dissolved in the interstitial spaces of the kidney cortex.
   C. Erythropoietin acts only by stimulating kidney cells to produce red blood cells.
   D. All of the above.
   E. None of the above.

11. Consider a human who is at a high altitude climbing a mountain. Which of the following is true for that person at that altitude?
   A. A decrease in the oxygen concentration in the blood plasma in the carotid artery will lead to an increase in the firing frequency of the oxygen-sensitive peripheral chemoreceptors.
   B. An increase in the firing frequency of the oxygen-sensitive peripheral chemoreceptors whose peripheral terminals are located in the brainstem will lead to an increase in the rate of ventilation.
   C. A decrease in the hydrogen-ion concentration in the blood plasma in the carotid artery will lead to an increase in the firing frequency of the hydrogen-ion-sensitive peripheral chemoreceptors.
   D. All of the above.
   E. None of the above.

12. 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 collecting duct. The defective molecules associated with this rare mutation are NOT located in the epithelial cells of the kidney collecting duct; the defective molecules are located in other cells of the kidney. In this rare mutant, an increase in the amount of vasopressin that binds to V2 receptors in the kidney will lead to an increase in
   A. the water permeability of the basolateral membranes of the collecting duct epithelial cells.
   B. the amount of water that is reabsorbed into the blood plasma from the lumen of the collecting duct.
   C. the net flux of water from the luminal spaces of the collecting duct to the interstitial spaces of the kidney medulla.
   D. All of the above.
   E. None of the above.
13. Patient X is no longer able to produce vasopressin. All parts of X's kidney are normal. X is continuously given high doses of vasopressin directly into X's blood plasma. While X is on these high doses, 
   A. X will need to drink large amounts of water to survive. 
   B. X will produce large volumes of urine. 
   C. X will have a high water permeability in the luminal membranes of X's collecting ducts. 
   D. All of the above. 
   E. None of the above.

14. Healthy Person P takes a drug that produces a strong effect on the epithelial cells of the kidney collecting duct within one hour and lasts for one week after taking the drug. One day after taking the drug, which of the following will produce a condition with the symptoms of diabetes insipidus in Healthy Person P? 
   A. Drug X that blocks exocytosis of AQP2 for one week.
   B. Drug Y that results in continuous very low levels of intracellular cyclic AMP (cAMP) for one week.
   C. Drug Z is an antagonist at V2 receptors that remains bound to V2 receptors for one week.
   D. All of the above.
   E. None of the above.

15. Which of the following is true for the epithelial cells of the kidney proximal tubule? 
   A. The GLUT2 transporter in the basolateral membrane is responsible for the net flux of glucose from intracellular space to interstitial space.
   B. The sodium-glucose co-transporter in the luminal membrane is responsible for the net flux of glucose from intracellular space to the luminal space in the lumen of the proximal tubule.
   C. The sodium-potassium pump in the basolateral membrane is responsible for the net flux of sodium from interstitial space to intracellular space.
   D. All of the above.
   E. None of the above.

16. 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 intracellular spaces to luminal spaces via sodium-potassium-ATPase pumps located in the luminal membranes of the epithelial cells in the ascending limb of the Loop of Henle.
   B. Net flux of sodium from interstitial spaces to intracellular spaces via the sodium-potassium-2chloride co-transporters located in the basolateral membranes of the epithelial cells in the ascending limb of the Loop of Henle.
   C. Net flux of sodium ions from luminal spaces to intracellular spaces via the sodium-glucose co-transporters located in the luminal membranes of the epithelial cells in the ascending limb of the Loop of Henle.
   D. All of the above.
   E. None of the above.
17. A new drug named ANTI-V2R has been developed that is a V2 receptor antagonist. ANTI-V2R will help relieve some of the problems for which of the following patients?
   A. A patient whose blood plasma vasopressin levels are always very high due to a tumor whose cells continuously secrete high levels of vasopressin into the blood plasma.
   B. A patient with neurogenic diabetes insipidus who produces no vasopressin.
   C. A patient with nephrogenic diabetes insipidus caused by a mutation in the AQP2-channel gene.
   D. All of the above.
   E. None of the above.

18. Which of the following is true?
   A. Pepsinogen is produced in the pancreas and is converted into its active form by the enzyme enterokinase; the enzyme enterokinase is located in the membranes of cells in the walls of the stomach.
   B. Trypsinogen is produced in the pancreas and is converted into its active form by HCl in the lumen of the stomach.
   C. Salivary amylase is produced in the pancreas and secreted into the small intestine; in the small intestine, it breaks down long chains of carbohydrates into double sugars.
   D. All of the above.
   E. None of the above.

19. Which of the following assist in the digestion of fats?
   A. Production of bile salts in the liver and the secretion of those bile salts into the small intestine.
   B. Production of lipase in the liver and secretion of lipase into the lumen of the small intestine.
   C. Emulsification of fats into droplets by lipase in the lumen of the small intestine.
   D. All of the above.
   E. None of the above.

20. 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, glucose permeability of X's skeletal muscle cells will be lower than glucose permeability of X's skeletal muscle cells 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. All of the above.
   E. None of the above.
21. 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 or drink for 12 hours. There is no glucose in X's urine at 9 PM on April 1. At 5 PM on April 2, X takes a dose of Y. The action of drug Y occurs within 10 minutes and lasts for 12 hours. Person X has a normal dinner at 6 PM on April 2 and then does not eat or drink for 12 hours. Which of the following is true?
   A. If drug Y blocks endocytosis of GLUT4 Transporters in all fat and muscle cells, then at 9 PM on April 2 there will be glucose in X's urine.
   B. If drug Y blocks all the transport of sodium and glucose via sodium-glucose co-transporters located in the luminal membranes of proximal tubule epithelial cells, then at 9 PM on April 2 there will be glucose in X's urine.
   C. If drug Y causes the closing of all the ATP-sensitive potassium channels in the beta-islet cells of the pancreas, then at 9 PM on April 2 there will be glucose in X's urine.
   D. All of the above.
   E. None of the above.

22. When a normal person has high levels of glucose in the blood plasma, then there will be
   A. high amounts of GLUT4 transporters in the plasma membranes of skeletal muscle cells.
   B. high amounts of intracellular glucagon in liver cells; this intracellular glucagon is broken down and converted to glucose in these liver cells.
   C. high blood plasma levels of glucagon.
   D. All of the above.
   E. None of the above.

23. Which of the following is true?
   A. GHRH Receptors (Growth Hormone Releasing Hormone Receptors) are only located in the plasma membranes of cells in the hypothalamus.
   B. GHRH Receptors (Growth Hormone Releasing Hormone Receptors) travel in specialized capillaries located between the hypothalamus and the anterior pituitary.
   C. Binding of GH (Growth Hormone) to GH Receptors (Growth Hormone Receptors) located in the plasma membranes of cells in the anterior pituitary leads to the secretion of GHRH Receptors (Growth Hormone Releasing Hormone Receptors) from the anterior pituitary into the blood plasma.
   D. All of the above.
   E. None of the above.

24. Which of the following receptors are found in the plasma membranes of cells in the anterior pituitary?
   A. VRH Receptors (Vasopressin Releasing Hormone Receptors).
   B. ORH Receptors (Oxytocin Releasing Hormone Receptors).
   C. GnRH Receptors (Gonadotropin Releasing Hormone Receptors).
   D. All of the above.
   E. None of the above.

25. Which of the following is true for the beta-islet cell of the pancreas?
   A. An increase in intracellular ATP levels leads to an increase in potassium conductance.
   B. An increase in potassium conductance leads to an increase in plasma membrane voltage.
   C. An increase in plasma membrane voltage leads to an increase in intracellular amounts of calcium.
   D. All of the above.
   E. None of the above.