BIO 112: Organisms, Evolution, and Ecosystems **Review 2**
Dr. Chris Paradise Spring 2008

Note: This review is worth 150 points (15% of your course grade); each question is worth 15 points.

1. Answer the following questions regarding the regulation of body temperature in mammals.
   a. What are two areas where temperature is sensed and where is this information sent?
   Sensors are located in the skin, core areas, aorta, and hypothalamus. Information is sent to the hypothalamus.

   b. What is one physiological response exhibited by mammals when they are too hot?
   Panting, sweating, dilating peripheral blood vessels are all acceptable.

   c. What is one behavioral response exhibited by mammals when they are too cold?
   Curling up to reduce exposure, finding a sheltered place to stay warm, and huddling are behavioral mechanisms.

2. Discuss the physiological and/or behavioral ecology of one of the following animals. Be sure to identify specific physiological or behavioral mechanisms that have evolved in the context of the chosen animal's environment.
   Dromedary camel OR Ruby-throated hummingbird
   First, you must put the physiology and behavior in the context of the organism's environment. All examples must explain how they help the organism with the problem you've identified.

   The dromedary camel lives in a hot, dry environment. Adaptations have evolved that prevent water loss. Heavy fur and hump of fat insulate the body. Body temperature can rise during hot days to reduce water loss from evaporative cooling. This heat is lost at night through convective cooling. Nasal counterflow is another example of an adaptation that reduces water loss, as is kidneys' ability to highly concentrate urine. Behavioral adaptations include restricting activity during hot days, positioning the body in shade, etc. Other physiological and behavioral mechanisms exist as well.

   The hummingbird migrates twice per year, and has specific behavioral and physiological adaptations to make that trek across the Gulf of Mexico. Prior to leaving, their diet changes, and they consume more foods, like insects, that have a higher fat content. Their metabolism changes to produce increase fat stores. Behaviorally, they go across the gulf rather than around to possibly avoid predators and arrive early to set up territories (males). Males, while defending territories, must forego some foraging in order to defend against rival males. The birds must also eat nearly constantly during the day to survive the night, due to their high metabolism. They may go into torpor during night to save energy.

3. Answer the following two questions about Fick's Law of Diffusion.
   a. How does Fick's Law of Diffusion help us assess animal adaptations for gas exchange?
   Define Fick's Law, using the equation, and explain how each term in the equation relates to rate of diffusion and how animal adaptations have evolved to maximize the rate of diffusion. Surface area, concentration gradient, path length of diffusion, and diffusion coefficient can all be altered by different adaptations.

   b. Provide one detailed application of Fick's Law to help understand adaptations in one specific type of animal.
   Choose one of the examples on which we focused and provide a detailed examination of how the respiratory system has evolved to maximize the rate of diffusion, at least within the context of the animal's environment.

4. Give an example of how the respiratory system and circulatory system are integrated in vertebrates. Further, explain how other systems are involved in control and regulation of this integration.
Here you must indicate how the two systems work together to solve the physiological problem of gas exchange. Describe the system accurately, including such things as pulmonary and systemic circuits, perfusion around alveoli, and coordination of breathing and heart rate. This latter would indicate how they are controlled and regulated together. Indicate how information (and include what kind of information) is used to control respiratory and heart rates together. Chemoreceptors in medulla, aorta, and carotids sense levels of carbon dioxide, pH, and oxygen in the blood. Breathing and heart rate increase via signals from the autonomic nervous system when high concentrations of carbon dioxide or low pH are sensed in the blood. If breathing increases without an increase in heart rate, gases will not be exchanged quickly enough, so they must be coordinated together. One other system that is involved is the excretory system, which works to maintain blood pressure, and this is important in blood flow through the respiratory system, too.

5. Describe the role of insulin in carbohydrate and fat metabolism. Be sure to indicate the different physiological systems involved throughout the course of insulin release and action. Be specific.
High blood glucose levels lead to secretion of insulin from beta cells of pancreas. Insulin helps move the body towards energy storage. Insulin binds with insulin receptors on muscle, liver, and adipose cells. Second messengers cause release of GLUT-4, which inserts into membranes and allows transport of glucose into cells. Glucose is used by these cells for energy. In addition, glucose in the liver is converted to glycogen, primarily. Fatty acids, glycerol, and monoglycerides are transported from liver to adipose cells, where triglycerides are produced and stored. Glucose taken up by adipose tissues is also converted to fats. Insulin inhibits breakdown of glycogen and fat utilization, via inhibition of particular enzymes. Digestive system is important in absorption and trafficking of nutrients, endocrine system releases insulin, which helps liver direct traffic, and circulatory system is critical in transporting nutrients to various organs and tissues.

6. Answer these questions regarding the mechanisms involved in digestive and excretory systems.
   a. What is the role of perfusion in each system?
   Capillary beds surrounding small intestine carry absorbed nutrients to the liver. Capillaries surrounding nephrons recapture water and nutrients back to circulation. Capillaries in glomerulus also are important in filtration of blood.

   b. Explain the role of one hormone in the digestive system.
   Choice of gastrin, cholecystokinin, and secretin are three that are possible. Each has specific effects that are outlined in notes and textbook. I did not accept insulin – it is a hormone, but it is not involved solely in the digestive system, nor is it involved in digestion.

   c. Briefly describe countercurrent exchange in the nephron.
   The nephron is the functional unit of the kidney and produces a solute concentration gradient in the medulla, using primarily sodium chloride. The loop of Henle is differentially permeable or uses active transport of chloride (and passively following sodium ions) along its length. The thick ascending limb actively transports chloride, and sodium follows, leading to an increase in concentration in the medulla. Water can't follow in that part of the loop, but it can in the descending limb, which means that solute concentration increases as fluid flows down the loop. This gradient is then reflected in the gradient in the medulla as NaCl is transported or diffused out of the ascending limb. Much fluid and solutes are recaptured before ever getting to the collecting tubules, but additional water is recaptured as fluid flows down the collecting tubule through the concentration gradient in the medulla.

7. How does atherosclerosis develop and what are the consequences of atherosclerosis? Once someone develops atherosclerosis, how are different physiological systems affected, and what are the associated risk factors?
Atherosclerosis begins to develop when lining of arteries are damaged. Excess glucose in the blood is one way this occurs, although the mechanism is not known. Monocytes converge on the damaged area and are incorporated into the damaged lining, where they turn into foam cells. These then begin to accumulate fats and cholesterol. A plaque forms, which thickens and hardens the arterial wall, reducing blood flow through the lumen. Blood clots can also form on plaques, and a thrombus may break away from the plaque, leading to complications in smaller arteries, including heart attack, stroke, renal failure, and loss of blood flow to extremities. Other systems may then be affected, including circulatory, excretory, nervous, and respiratory. Risk factors include diabetes, obesity, sedentary lifestyle, high saturated fat diet, smoking, lack of exercise, high blood pressure, and gender.

8. Relate the two articles by Nesse and Williams (Evolution and the Origin of Disease) and Duncan (The Covert Plague). Specifically, apply one or more principles of Darwinian Medicine discussed in the first article to the medical issues discussed in the second article.
The principle of Darwinian Medicine you should focus on here is that modern epidemics are most likely to arise from the mismatch between PHYSIOLOGICAL DESIGN of our bodies and NOVEL ASPECTS of our environment. Duncan discusses the epidemic of diabetes, as do Nesse and Williams, as a consequence of our modern diet. Humans evolved in much different dietary/foraging conditions, and our bodies are not well-equipped to deal with the novel environment in which foods high in fats and sugars are so readily available. Other aspects of our modern environment, such as reduced need to be highly active, also contribute to the problem. Discussion of specific aspects of Duncan's article, and how each is related to evolution or Darwinian Medicine is appropriate.

9. Describe feedbacks (negative, positive, or both, as appropriate) from the nervous and endocrine systems that are important in homeostasis of the following variables. For each variable, provide specific details regarding the mechanisms involved in at least one negative feedback.
   a. Blood pressure
   Several examples can be used here, including autoregulatory control of capillary beds, firing of stretch receptors, release of anti-diuretic hormone or release of renin. For each, you must accurately describe its mechanism of action and consequent effects on blood pressure (+ / -).

   b. Water re-absorption in the kidney
   Several examples can be used here, too, and some are the same as in part a, including release of anti-diuretic hormone or release of renin. For each, you must accurately describe its mechanism of action and consequent effects on blood pressure (+ or -).

10. Explain the advantage(s) of autoregulatory control over nervous or endocrine control in the circulatory system. Use two examples to illustrate the advantages of autoregulatory control: during nutrient absorption (post-meal) and during strenuous exercise.
Autoregulatory control (ARC) of capillary beds occurs when sphincter muscles around arterioles relax or contract in response to local conditions. When carbon dioxide or lactic acid buildup in muscles, the sphincters around arterioles leading to those muscles will relax, increasing blood flow to that specific area. Any discussion of nervous or hormonal control for this section is incorrect. The advantage of ARC is that each tissue bed can be controlled independently of others and independently of the nervous or endocrine system, to meet the needs of that specific tissue. During nutrient absorption, it makes sense to open those capillary beds surrounding the small intestines, and during exercise, capillary beds leading to the activated muscles will open, while others will be closed. The needs of the specific tissues are met.