Midterm 1: BIO 566 Oct 8th 2009 **This is the answer key; please read the answers and if you have questions, come talk to me**! **Partial credit given for short essays.**

Note: you have 1 hour 15 minutes. Spend your time accordingly. For the multiple choice and True-false questions, circle clearly the correct answer (in each case, there is only one). Each question is worth the same amount of points. Have fun!

Name:_____

(1) Describe whether (and how) locomotion and breathing are coupled in kangaroos or dogs. Is such coupling also observed in bats and birds?

Locomotion and breathing are coupled in most tetrapods, such as in mammals and in dogs on a 1:1 ratio.

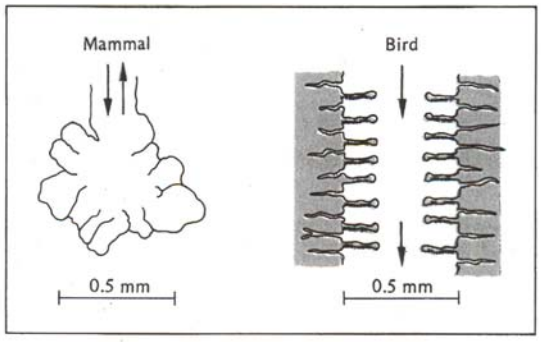
<u>Do other animal species synchronize their breathing and locomotion?</u>
Birds. Link between wing-beat frequencies and breathing unclear
Bats have an exact 1:1 coupling between wing beats and breathing

(2) Explain the differences between birds and mammals in (A) the structures used in respiration, and (B) how efficient these two groups are in terms of extracting oxygen from the air.

Mammals have a bi-directional respiratory system that relies on turbulent flow into and out of the lungs, and ultimately into the alveoli (the smallest branches of the lungs where oxygen exchange actually takes place with the blood stream). One breath in, and one breath out (inspiration and expiration) move a given tidal volume of air into and out of the lungs

Birds employ a unidirectional flow of air to supply oxygen to their lungs, and several other respiratory structures (termed sacs, there are several, but the main ones are the cervical and cranial sacs). Two inspirations and two expirations move a given tidal volume of air into and out of the lungs.

This unidirectional flow of air, in addition to a countercurrent (or cross current) flow of air relative to the blood system (which occurs in a system of parabronchi makes birds far more efficient than mammals in terms of extracting oxygen (~75%) compared to mammals (~25%)



(3) True or False: Birds have a lower total respiratory surface relative to mammals

T **F**

(4) When carbon dioxide reacts with water, it undergoes the following reaction:

$$CO_2 + H_20 <-> H_2CO_3 <-> H^+ + HCO_3^- <-> 2H+ + CO_3^{2-}$$

In small tidepools, this reaction has profound implications for the pH of the water. Circle the MOST CORRECT answer to the below multiple choice questions based on this above information, and what you know about other animals (e.g., plants and other organisms) that live in such small tidepools.

The tidepool water becomes more acidic (low pH):

(A) At night, when plants undergo photosynthesis
(B) During the day, when plants undergo photosynthesis
(C) At night, when plants shut down, and animals produce carbon dioxide via respiration
(D) During the day, when plants shut down, and animals produce carbon dioxide via respiration

(5) The two pumps in the fish used during normal gill ventilation are:

(A) The Buccal and Peristaltic pump
(B) The Opercular and Buccal pumps
(C) The Opercular and Bumeral pumps
(D) The Buccal and Operpaltive pumps

(6) Briefly explain the differences between anaerobic and aerobic metabolism in terms of (A) which energy substrates are used to produce ATP, and (B) how much ATP per cycle is produced for each of these processes.

Per cycle, aerobic metabolism produces far more ATP (36) compared to anaerobic metabolism (2 ATP; some additional ATP can be generated from the waste products of anaerobic respiration, but aerobic respiration still produces far more energy). Aerobic respiration occurs in the mitochondria and utilizes oxygen in the oxidation process to burn carbohydrates, fat, and protein (though mostly fat), whereas anaerobic metabolism does not require oxygen, and more often utilizes carbohydrates, although Glycogen stores are also used.

(7) Circle the MOST CORRECT answer below (PAY attention to units):

Fat and Carbohydrates are:

(A) Similar in energy content (kcal/g)
(B) Similar in the amount of oxygen needed to metabolize a particular amount (liters of oxygen per gram)
(C) Similar in the number of kcal needed to metabolize a specific amount of either (kcal/liter of oxygen)
(D) None of the above

(8) Describe how the North American eel adjusts how it respires (i.e., which structures it tends to respire from) as it moves from water to land.

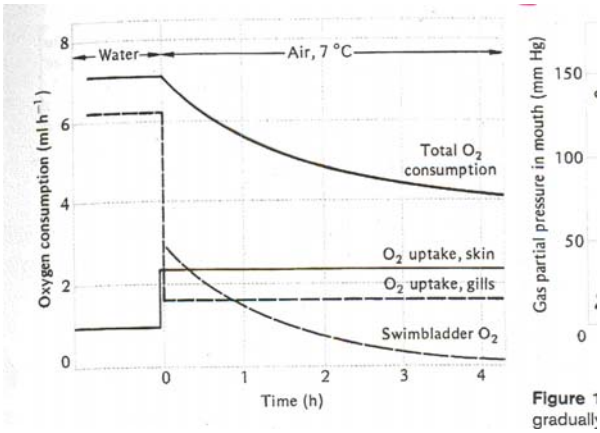


Figure 1
gradually

If graph is drawn correct as above, full credit is given.

In water, total oxygen consumption is higher than in air. In water, most of the oxygen is derived from the gills, with a far smaller component coming from the skin, and none from the swimbladder. As the eel moves to air-breathing, the oxygen uptake shifts to the skin and swimbladder, with a smaller amount coming from the gills. Note that the rank order above is important.

(9) Metabolic rate (oxygen used per kg per hour) among animal species (mouse to elephant) is:

(A) Independent of body mass
(B) Linearly and positively related to body mass
(C) Linearly and negatively related to body mass
(D) Exponentially and negatively related to body mass

(10) Oxygen consumption in many fish, such as salmon, follows which of the below patterns:

(A) Oxygen consumption increases linearly with the oxygen content of the water across all concentrations of oxygen
(B) Oxygen consumption decreases linearly with the oxygen content of the water across all concentrations of oxygen
(C) Oxygen consumption does not change with the oxygen content of the water across all concentrations of oxygen
(D) Oxygen consumption increases linearly with the oxygen content of the water up to a point, and then plateaus at higher oxygen concentrations

(11) Goldfish produce what chemical in anoxic conditions to assist in metabolism?

(A) Propane
(B) Nitric oxide
(C) Ethanol
(D) Glycerol

(12) Explain briefly how white sharks and their relatives can maintain internal body temperatures 10-18 degrees F higher than the cold ambient water.

Two main factors: (1) Large body mass (tends to conserve heat in cold waters), and (2) the presence of a sophisticated countercurrent vascular system, with a special modification (the rete mirable). Rete mirabile ("wonderful net") = Capillary beds of parallel arteries and blood vessels found near the "warm structures" Acts as a countercurrent heat exchanger: Hot, oxygen-poor blood travels through the blood vessels in the rete (on its way to the gills) The heat from these vessels is transferred to the parallel arteries that contain cold oxygenated blood (comes from the gills). Result: Little loss of heat to the cold water; "core" of shark is hot

(13) Which of the below statements is MOST CORRECT in reference to bullhead catfish.

(A) When acclimated at a temperature of 7 degrees C, and allowed to select from a range of temperatures, they initially always choose 30 degrees C
(B) When acclimated at a temperature of 7 degrees C, and allowed to select from a range of temperatures, they initially always choose low temperatures (e.g., 7 degrees C)
(C) When acclimated at a temperature of 32 degrees C, and allowed to select from a range of temperatures, they initially always choose low temperatures (e.g., 7 degrees C)
(D) When acclimated at a temperature of 15 degrees C, and allowed to select from a range of temperatures, they initially always choose high temperatures (e.g., 32 degrees C)

(14) True or False: Polar bear fur has an excellent insulating value relative to other kinds of fur found in other mammals.

T **F**

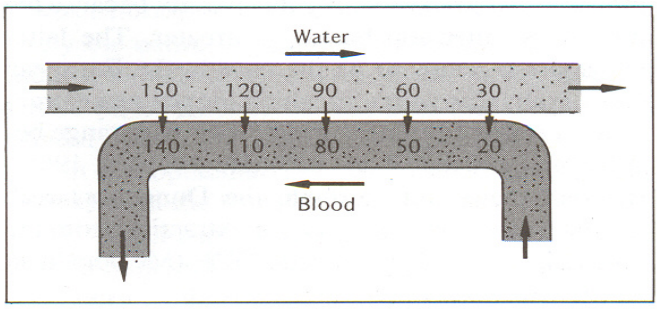
(15) For the example of the dolphins studied by T. Williams, briefly explain why these dolphins are able to "break the rules" in terms of violating their predicted aerobic dive limit.

The aerobic dive limit model posits that air-breathing mammals can sustain only a certain amount of time under water before running out of oxygen, and resorting to anaerobic respiration. This model takes into account three factors;

(1) Lung capacity of animal
(2) Metabolic rate
(3) Speed of movement (assumes steady-speed)

However, during diving, the dolphins violate assumption (3), because, as they ascend to the surface from the water column, they "kick and glide", thereby using intermittent locomotion, which violates the assumption of steady-speed movement. This means that the dolphins used overall less energy than the model assumes, explaining why they are able to spend longer underwater than predicted.

(16) Explain the basic concept of a countercurrent system of blood flow, and why it is an efficient system for conserving heat or oxygen. Give one example.



-Drawing graph above, with appropriate arrows and numbers gives full credit.

Countercurrent systems are widespread in the animal kingdom, and are an efficient means for transferring gases or other materials across membranes. Counter current systems consist of opposing flow regimes, such as two blood vessels flowing in opposite directions. Because of this opposing flow, materials such as oxygen will be high on one end of one vessel, whereas in the adjacent vessel, oxygen will be low. Therefore, oxygen will diffuse from low to high areas of concentration, insuring rapid transfer between blood vessels, or between the blood and lungs, for example.

Examples include the lungs of birds, gills in fish, or temperature control in the fins of sharks and marine mammals.

(17) The primary limiting factor for continued physical activity via anaroebic respiration is:

(A) ATP
(B) Muscle temperature
(C) Glytotic acid
(D) Lactic acid