Name _________________________

Comparative Physiology 2007
First Midterm Exam

1) 16 pts ______

2) 12 pts ______

3) 40 pts ______

4) 10 pts ______

5) 17 pts ______

6) 5 pts ______

Total ______
1. All vertebrates yawn, yet we don’t know why. A) Propose a possible functional explanation for why we yawn. (16 pts.)

Your answer must explain why ALL vertebrates yawn (including fish), not just humans or mammals.
A) 4 pts for the hypothesis
B) 4 pts for physiological basis for the hypothesis
C) 2 pts for observations consistent with your hypothesis
D) 6 pts for your experimental design. The experiment must test the hypothesis, have a control and explain how the hypothesis would be falsified.

Example:

A) Vertebrates yawn to increase venous return to the heart from the head, neck, and trunk.

B) Explain the basis of your hypothesis.

B) When we yawn we inspire deeply, then close our glottis and hold our breath, then contract the trunk muscles against the inflated lungs as we our mouth wide and isometrically contract the muscles of the jaw and neck. These actions could facilitate venous return from the skeletal muscle and respiratory pumps.

C) Support your hypothesis with observations that are consistent with it. In other words, convince us that you maybe on to something.

C) People often yawn when they are not moving but nervous about something (restless). Race car drivers yawn frequently before a race, spelling bee contestants yawn before their turn. When an animal is nervous heart rate and outflow from the heart go up, but if the animal is stationary, venous return to the heart will be low because of limited action of the skeletal muscle pump.

D) Finally, explain how you would test your hypothesis. That is, describe an experiment (and the control) that has potential to falsify your hypothesis.

D) To test this hypothesis, I would measure venous return to the heart during yawning from the veins associated with the head, neck and trunk, The experimental control would be the rate of venous return before the yawn. If the rate of venous return before the yawn was the same or higher than the venous return during the yawn the hypothesis would be falsified.
2. The graphs below give the oxygen disassociation curves for the coelomic fluid and blood of two species of siphunculid worms, one that forages at the surface (worm A) and one remains buried (worm B). Based on the curves for blood and coelomic fluid, describe the exchange of oxygen between the environment, blood, and coelomic fluid for each worm. (12 pts.)

Path of oxygen in Worm A -
*Oxygen flows from the environment to the blood to the coelomic fluid to the tissue.*

Path of oxygen in Worm B -
*Oxygen flows from the environment to the coelomic fluid to the blood to the tissue.*

Which worm do you suspect has the most developed (i.e., elaborate) circulatory system? Explain your reasoning.

Worm A. *Worm A collects oxygen from the environment to the blood, so a good circulatory system is needed to deliver that blood to the tissue throughout the body. Worm B would only be using the blood to aid the coelomic fluid in delivering oxygen to the tissue.*

A few notes: These graphs only show the % saturation at LOW oxygen partial pressures these lines would continue on at higher partial pressures. The logic behind how the oxygen moves through these worms is similar to that of the difference in oxygen saturation curves between the fetus and a mother during mammalian pregnancy. In order to get the oxygen from fluid 1 to fluid 2, fluid 2 must have a greater affinity for oxygen.
3. Answer the following questions. (40 pts.)  

A. Explain why fresh water teleost fishes do not drink water.

Fresh water teleost (300 mosM) are hyperosmotic to their fresh water environment (50 mosM) and will therefore absorb water through surfaces, like the gill, that are permeable to water. Because water is always being absorbed by fresh water teleos in this way, they would not want to disrupt their osmolarity more by drinking water.

B. Oxidative phosphorylation in a winter acclimatized spotted turtle has a $Q_{10}$ of 1.4. How much does the rate of this pathway change as body temperature of the turtle increases from 15° to 35° C?

$2 \times 1.4 = 2.8$ fold

C. Describe three derived features of the mammalian musculo-skeletal system that have been suggested to facilitate running and breathing at the same time.

Many answers could have been given for this question. They include but are not limited to: the use of a diaphragm, tuning of the respiratory and locomotor natural frequencies, sagittal bending of trunk, parasagittal limb posture, lobed lungs and the use of a trotting gait.

D. In terms of thermoregulation, what do cheetahs, camels, and antelope ground squirrels have in common? (Note, the answer we are looking for is not - “they are all fur covered endotherms.”)

All three animals store heat in their bodies, allowing their body temperature rise dramatically for various reasons.

E. The gills of fishes are remarkably effective at gas exchange. Explain why they need to be very effective.

Water is heavy and a highly viscose solution that has a low concentration of oxygen. Oxygen also diffuses solely in water.

F. Explain how cross-current and counter-current gas exchange are similar in terms of the partial pressure of oxygen in the vessels leaving the lungs or gills.

Both cross-current and counter-current gas exchange lead to a higher partial pressure of oxygen in the veins blood than is found in the exhaled water or air.

G. The lungs of birds and mammals are structurally different in almost every respect. Name one structural similarity in the lungs of birds and mammals that is critical to the high levels of gas exchange that characterize both groups.
The lungs of both birds and mammals have a large surface area for gas exchange and a small barrier thickness of diffusion, which provide for a high overall diffusing capacity of the lung.

H. If a mammal lives in a salt limited environment, all else being equal, would sweating or panting be a better strategy? Explain your answer.

Panting, because the evaporative cooling occurs in the mouth where the salts can be reclaimed.

I. CO₂ is carried in the blood in several different molecules. Identify the molecule that contains the greatest percent of CO₂ in mammalian blood and state where in the blood most of it resides.

The largest percentage of the carbon dioxide is contained in the molecule bicarbonate (HCO₃⁻) and is found in the blood plasma or serum.

K. Explain why the heart tissue of a goldfish is at risk when a house cat chases it with its paw in the fish bowl.

Goldfish have a spongy myocardium that gets its oxygen from venous blood returning to the heart from the tissue. If the fish is vigorously swimming the tissue will be using most of the oxygen and there will be less oxygen returning to the heart at a time when the heart needs it most. The heart tissue will then be starved for oxygen.

4. The graph shown below illustrates the usual effect of temperature on the oxygen dissociation curve for mammalian hemoglobin. The reduced oxygen affinity at higher temperatures is thought to facilitate oxygen unloading in skeletal muscles during vigorous exercise because the temperature of muscle rises several degrees during sustained exercise. Nevertheless, mammals that live in very cold artic climates, such as reindeer, have been found not to exhibit this temperature response. Speculate why artic mammals do not exhibit this temperature response. (10 pts.)
Artic mammals are reginal heterotherms, meaning that they allow their appendages to become quite cold in relation to the core of their body. This is presumably to prevent heat loss to the cold environment in these areas of their body where a high surface area to volume ratio exists. If these animals had the oxygen dissociation curve shown they would be preventing oxygen delivery to their appendages, which tend to be colder than their core.

5. What question, related to the topics we have discussed so far in this course, would you investigate if you had the resources and time? (17 pts)

   Explain why you believe this is an important question.

   Explain how you would investigate this topic.
6. We mentioned the 1877 flight of the Nez Perce as an example of the role thermoregulation has played in human history. Provide another example of a thermal event that influenced the history of a human population. Explain the context in which ambient temperature was influential. Part of your score on this question will come from the historical significance of your example. (Your little brother’s cold toes at Snowbird last weekend would not score well.) (5 pts.)