BIO 3302 Animal Physiology II
Final examination

April 24th, 2008 (3 h) **Name: _____**
Dr. K.M. Gilmour
Closed book exam **Student number: _____**

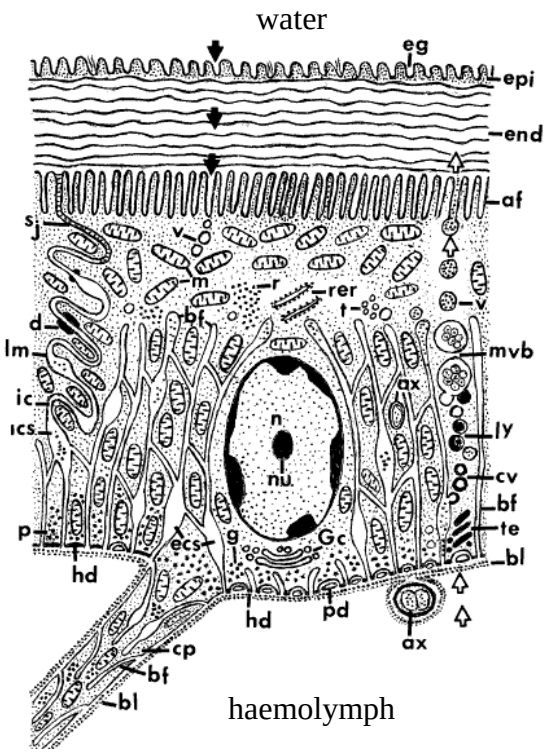
Note: This exam consists of 3 sections and one bonus question. The questions in Section A should be answered **in the space provided on the question sheet.** The questions in Sections B and C should be answered **in the exam booklet**.

Part A: Answer on the question sheet. (1 mark per answer unless otherwise indicated; 42 marks in total)

1. An animal such as the Atlantic salmon, which spends most of its time in seawater but enters freshwater streams to spawn, would be considered to be a stenohaline OR euryhaline (**select one**), hyperosmotic OR iso-osmotic OR hypo-osmotic (**select one**) osmoregulator OR osmoconformer (**select one**) while in seawater. In moving from seawater to freshwater, a salmon would increase OR decrease (**select one**) fluid intake by drinking, and would increase OR decrease (**select one**) glomerular filtration rate to adjust urinary water loss to the needs of its new environment.

2. Label the peaks in the ECG trace below (1.5 marks). Use an arrow to indicate the peak that reflects atrial depolarization (0.5 marks). Below this trace, sketch a second trace illustrating the effect on the ECG of parasympathetic stimulation of the heart (1 mark).

3. The schematic at right depicts the basic ultrastructural features of the anal papilla of a larval midge (a type of insect). Larval midges are freshwater animals. The anal papillae are small, plate-like appendages that extend from the posterior end of the animal. Based on this information and the structural features observed in the schematic, propose a function for the anal papillae. Explain your rationale. (2 marks)

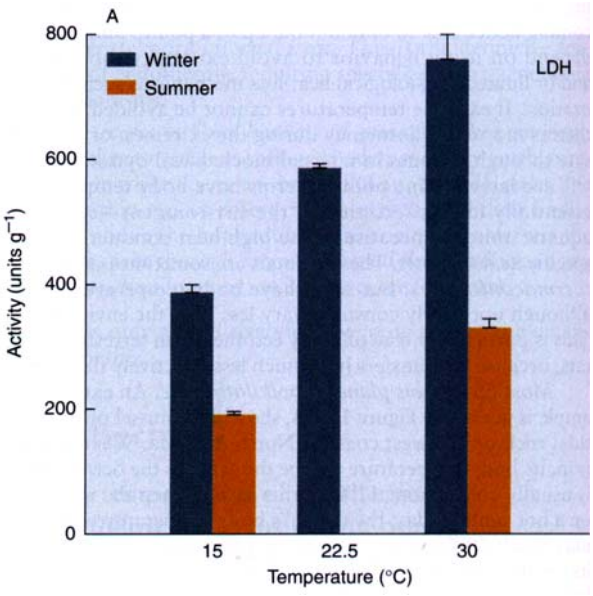


4. Both lobster and cod are (or at least used to be) found off the coast of Newfoundland, where winter water temperatures hover around -2°C. Which of these two species would be more likely to exhibit antifreeze compounds, and why? (2 marks)

5. At a PO_2 of 100 Torr, the total blood O_2 content of an unknown species of fish is 200 mL O_2 L^{-1}. If $\alpha_{plasma}O_2$ = 0.03 mL O_2 L^{-1} $Torr^{-1}$, is this unknown species of fish likely to be a member of the icefish family? Explain your answer. (3 marks)

6. Draw a labelled sketch that illustrates the Frank-Starling relationship, and provide one example of a situation in which this mechanism is used to regulate cardiovascular function. (3marks)

7. The figure at right illustrates lactate dehydrogenase (LDH) activity in the leg muscles of alligators. Based on this figure…
   (a) Animals acclimated to the same temperature experience essentially equal LDH activities.
   (b) LDH activity does not exhibit a Q_{10} effect.
   (c) Acclimatization acts essentially to equalize LDH activity for animals tested at the temperature to which they were acclimatized.
   (d) The Q_{10} for LDH activity appears to be higher in alligators sampled in the summer than in alligators sampled in the winter.
   (e) None of the above is true.



8. The gulf toadfish is unusual because it…
   (a) Retains urea as an osmolyte
   (b) Excretes uric acid
   (c) Excretes urea in a pulsatile fashion across the gills
   (d) Retains ammonia as the end-product of nitrogen metabolism even when it emerges from water
   (e) Switches from ammonia to urea production when it emerges from water

9. True OR false (**select one**): The air sacs of the avian respiratory system comprise ~80% of the volume of the system and contribute at least 50% of total O_2 and CO_2 exchange between air and blood.

10. Which of the following solutes would exhibit the highest renal clearance ratio (RCR)?

    Inulin Na^+ urea H^+ albumin glucose

11. Explain the benefit of the Haldane effect to CO_2 excretion using a labelled sketch of the CO_2 combining curve. (3 marks)

12. An increase in which of the following would **not** tend to induce vasodilation in the systemic vasculature?

    CO_2 protons heat K^+ O_2 adenosine

13. Explain why it is easier to overheat while sitting in a hot tub of water 40°C than while sitting in a sauna of 40°C. (2 marks)

14. The _____of the teleost fish heart and the aorta of the mammalian heart share common structural features that allow them to function as windkessel vessels. Name one such structural feature:

    _____. The

    _____of the teleost fish heart and the sino-atrial node of the mammalian heart both exhibit a _____ potential that allows them to initiate and regulate the heartbeat.

15. An increase in which of the following will decrease glomerular filtration rate (GFR)?
    (a) Circulating angiotensinogen levels
    (b) Circulating cortisol levels
    (c) Sympathetic activity
    (d) Circulating atrial natriuretic peptide (ANP) levels
    (e) Increases in all of the above cause GFR to decrease

16. Owing to the _____ arrangement of water flow and blood flow in the fish gill, the PO_2 of oxygenated blood leaving the gill (PaO_2) is greater than OR is less than OR is equal to (**select one**) the PO_2 of water leaving the gill (PeO_2).

17. Based on your knowledge of the osmorespiratory compromise, explain why urine production would be expected to increase during exercise in freshwater teleost fish. (2 marks)

18. List **three** structural features of the renal corpuscle that permit it to function as the site of filtration in urine formation. (3 marks)

19. True OR false (**select one**): A deep-sea fish is homeothermic because its body temperature of ~4°C varies by less than a degree over the course of a year.

20. True OR false (**select one**): Vagal tone refers to the resting level of sympathetic output to the blood vessels.

Part B: Answer **TWO** of the following three questions in the exam booklet. (5 marks each; 10 marks in total)

1. Tommy the tuna suffered a heart attack and requires open-heart surgery. You are the fish surgeon who will carry out the operation. While Tommy's heart is repaired, cardiobranchial bypass will be employed – that is, a heart-gill machine will be used to maintain O_2 delivery to the tissues. Blood enters the heart-gill machine at a PO_2 of 40 Torr and is then equilibrated with air of PO_2 = 160 Torr.
   a. To what rate of blood flow (in mL min^{-1} kg^{-1}) must you set the heart-gill machine to maintain O_2 delivery to Tommy's tissues, which consume 3 mmol O_2 kg^{-1} h^{-1}? You may assume that the capacitance of tuna blood for O_2 is 40 µmol L^{-1} $Torr^{-1}$.
   b. If the rate of tissue CO_2 production matches that of O_2 uptake and blood enters the heart-gill machine at a PCO_2 of 6 Torr, to what must the PCO_2 of the blood be equilibrated to ensure adequate rates of CO_2 excretion? The capacitance of tuna blood for CO_2 is 0.8 mmol L^{-1} $Torr^{-1}$.

2. Owing to the presence of a kidney stone that is lodged in the nephron, the glomerular filtration rate has fallen to zero. Assuming that blood in the glomerulus exerts a pressure of 55 mmHg and that the colloid osmotic pressure difference between blood and the initial filtrate is 25 mmHg, what hydrostatic pressure must be exerted by the fluid in Bowman's capsule? To re-establish filtration, the afferent arteriole dilates, halving the resistance it provides to blood flow. Assuming that blood flow through the renal arteriole does not change as a result of this adjustment and that blood enters the renal arteriole with a pressure of 91 mmHg, what pressure will the blood in the glomerulus exert following the dilation of the renal arteriole?

3. Use a schematic diagram to illustrate the regulation of body temperature in the Galapagos marine iguana.

Part C: Answer **FIVE** of the following six questions in the exam booklet. Please take note of the number of questions to answer (**5**) and the marks assigned to each (**10**) and budget your time accordingly. (10 marks each; 50 marks in total)

1. The evolution of endothermy required first, that vertebrates make the transition from breathing water to breathing air, second, that cardiovascular and respiratory adaptations to support a higher metabolic rate evolve, and third, that adaptations for minimizing heat loss arise. Discuss this statement.

2. Discuss the cardiovascular, respiratory and thermoregulatory adaptations of bats from the perspective that bats are the only mammal capable of powered flight.

3. Discuss the cardiovascular, respiratory and thermoregulatory adaptations of mammals that have adopted a diving lifestyle.

4. Contrast and compare the mechanisms used by mammals and fish to restore normal blood pH following an acid-base challenge.

5. Discuss the acute and chronic mechanisms involved in returning blood pressure in a mammal to normal following an acute fall in blood pressure resulting from severe blood loss.

6. Most freshwater teleost fish are unable to survive in water with high concentrations of bicarbonate ions because ionic regulation, gas transfer and nitrogenous waste excretion are all impaired. Explain.

Bonus: For a bonus mark that in the spirit of socialism will be applied to the entire class if even one student answers the question correctly, can you bust the following fishy myths?

Fishy myth	Confirmed	Plausible	Busted
The candiru is a scaleless, eel-like, parasitic catfish that feeds on blood and is commonly found in the gill cavities of other fish. It is sometimes also parasitic to humans and has been known to enter the urethra of a swimming human, where it erects the short spines on its gill covers and becomes lodged in place.			
The smallest vertebrate is a 7.9 mm long fish of the carp family that inhabits water of pH 3 in forest swamps on the Indonesian island of Sumatra.			
One of the longest-lived fish is the orange roughy, a relatively large fish of the slimehead family. It is found in cold (3 – 9°C), deep (180 to 1,800 m) waters and has a recorded maximum age of 149 years. In life it is a bright brick red, but fades to a yellowish orange after death.			