BIO 3302 Animal Physiology II
Final examination

April 27th, 2009 (3 h) **Name: _____**
Drs. Perry & Gilmour
Closed book exam **Student number: _____**

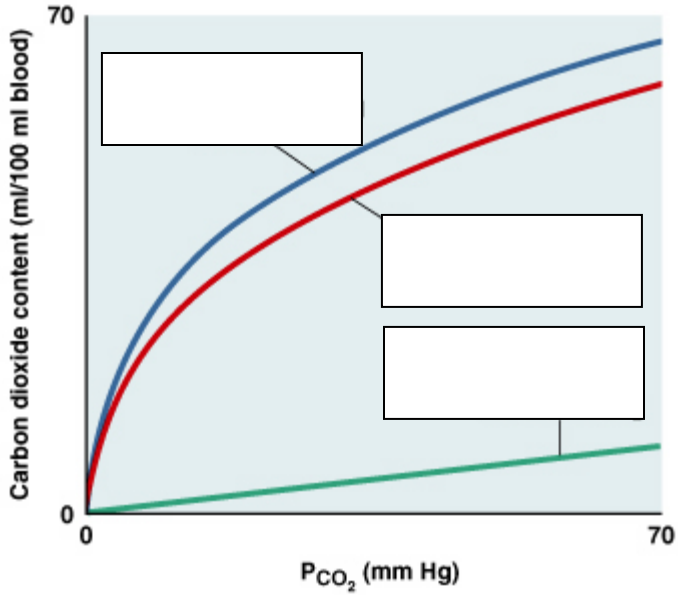
Note: This exam consists of 3 sections and one bonus question. The questions in Section A should be answered **in the space provided on the question sheet.** The questions in Sections B and C should be answered **in the exam booklet**.

Part A: Answer on the question sheet. (1 mark per answer unless otherwise indicated; 38 marks in total)

1. Consider two animals of equal size and with similar metabolic scopes - one is breathing water with gills while the other is breathing air with lungs. As a proportion of its total metabolic rate, which animal will be expending more energy to breathe? Explain. (3 marks)

2. The renal clearance ratio (RCR) for a substance that is present in the urine at 10-fold higher concentrations than in the blood, under conditions where the urine flow rate is 1% of the glomerular filtration rate, is _____. What does this RCR suggest about the handling of this mystery substance by the kidney?

3. The graph on the right depicts CO_2 combining/ equilibrium curves for teleost fish blood or plasma equilibrated with oxygen or nitrogen. In the boxes provided, designate whether the curve is derived from blood or plasma **and** whether oxygen or nitrogen (or either) is being used as the equilibration gas. (0.5 marks per answer; 3 marks total)



4. Owing to the overwhelming importance of _____ heat exchange, body temperature in water-breathing animals generally is <u>less than OR equal to OR greater than</u> (**select one**) the temperature of the aquatic environment. For terrestrial poikilotherms, _____ heat exchange may permit body temperature to be <u>less than OR equal to OR greater than</u> (**select one**) air temperature.

5. List an obligatory water loss that is associated with the gain of metabolic (oxidation) water:

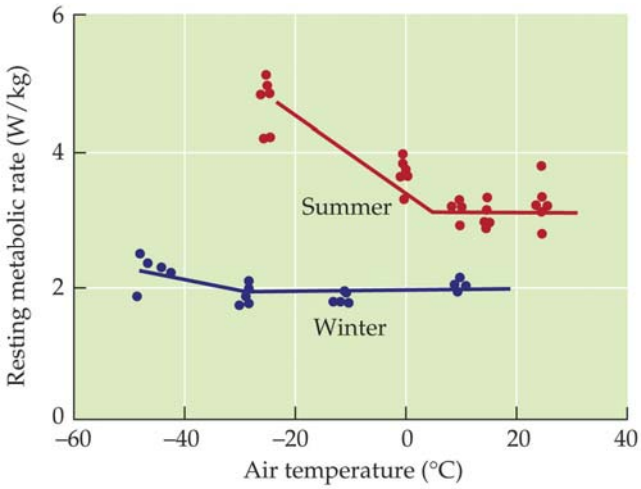
6. Unlike in teleosts, CO_2 excretion in elasmobranchs is aided by the presence of membrane-associated _____.

7. Discuss the role of red cell organic phosphates and the Bohr Effect in determining the P_{50} of haemoglobin in climbers (not using supplementary oxygen) on the peak of Mount Everest. (4 marks)

8. The figure at right presents data on the metabolic rate of reindeer as a function of air temperature in summer and in winter. What is the lower limit of the thermoneutral zone for a winter reindeer?

   _____

   Provide an example of a mechanism the reindeer might use to regulate body temperature **within** the thermoneutral zone.

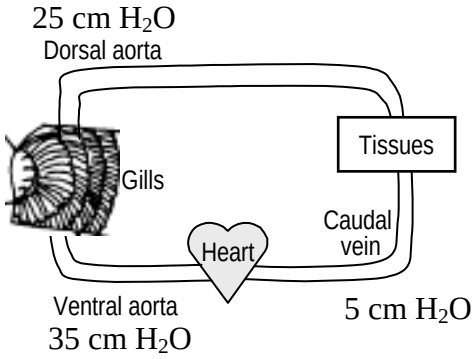


9. Fluid and _____ that are lost from the capillaries are returned to the circulatory system by means of the _____ system.

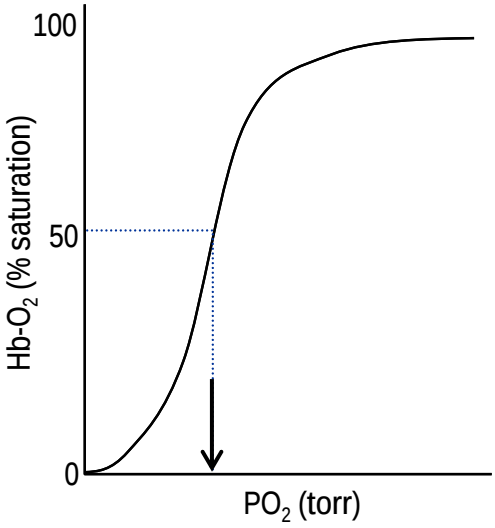
10. An increase in which of the following would **not** tend to induce vasodilation in the systemic vasculature?
    CO_2 protons heat K^+ O_2 adenosine

11. Distinguish between thermoregulation and homeothermy. (2 marks)

12. Using the schematic diagram of the circulation of a fish at right, calculate the branchial resistance assuming cardiac output is 25 mL min^{-1}; please show your calculations. (2 marks)



13. The figure at right depicts an O_2 equilibrium curve for blood that was withdrawn from a rainbow trout acclimated to normoxic water. The dotted lines and arrow indicate the _____ of this curve. On the same axes, **sketch the curve** that you would expect to see for blood withdrawn from a rainbow trout that had been acclimated to severely hypoxic conditions for several days.



14. 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)

15. Which of the following, when applied to the afferent renal arteriole, would tend to increase the glomerular filtration rate (GFR)?
    (a) angiotensin II
    (b) cocaine (a noradrenaline re-uptake inhibitor)
    (c) atenolol (a $ß_1$-adrenergic receptor agonist)
    (d) phentolamine (an α-adrenergic receptor antagonist)
    (e) None of the above, when applied to the afferent renal arteriole, would increase GFR

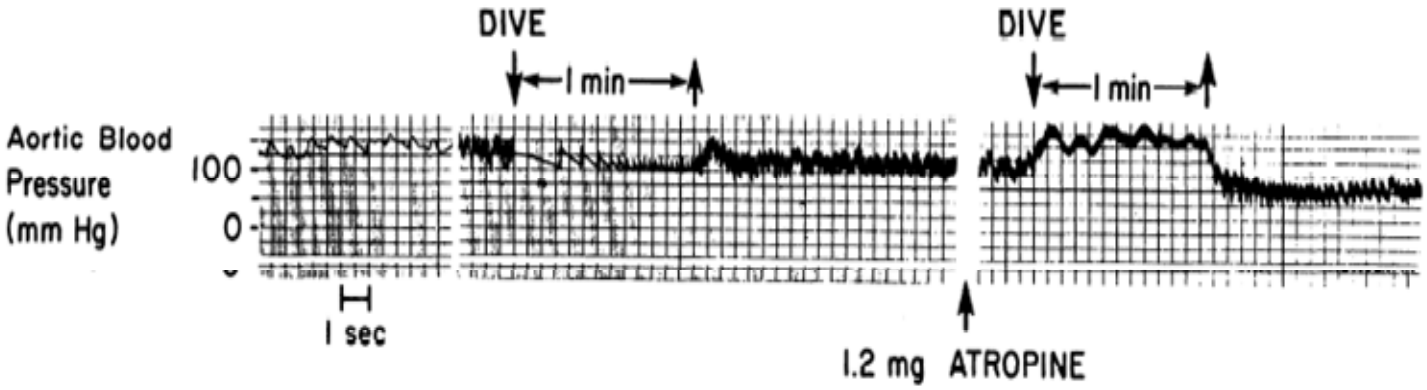
    Explain your answer.

16. What physiological mechanism is exemplified by the structure of fish gills, the renal concentrating mechanism of mammals and birds, and the extremities of endotherms inhabiting cold environments?

17. Owing to low blood protein levels (a consequence of starvation), the colloid osmotic pressure difference at the renal corpuscle has decreased to 15 mmHg. To preserve the normal (net) glomerular filtration pressure of 10 mmHg, blood pressure would have to <u>increase OR decrease</u> (**select one**) from its normal value of 55 mmHg to _____, assuming a fluid pressure of 15 mmHg in Bowman's capsule. This change could be accomplished by <u>dilation OR constriction</u> (**select one**) of the afferent arteriole.

Part B: Answer **FIVE** of the following six questions in the exam booklet. (8 marks each; 40 marks in total)

1. Some air-breathing animals are adapted for long periods of submersion under water. Changes occurring in the circulatory system during dives are a central aspect in the response of these animals. The figures below are taken from an experiment carried out by Elsner *et al.* (1985, *Am. J. Physiol.* 249, H1119-H1126) on seals. Aortic blood pressure was recorded in a seal during rest followed by a 1 minute dive. Note that the pulsatility of the aortic blood pressure trace corresponds to the heart beating. An injection of 1.2 mg of atropine was then administered to the seal (indicated by the arrow), and a second 1 minute dive was carried out.



   (a) Sketch a figure showing the effect of diving on heart rate under normal conditions and following administration of atropine. You may assume a normal or control heart rate of 200 bpm. Please label your sketch clearly.

   (b) Explain why blood pressure remains more or less constant during a normal dive but increases during diving in an atropinized animal.

2. Which came first, endothermy or a high metabolic rate? Please provide arguments to support your answer.

3. High performance fish, such as the scombrids (bluefin tuna, mackerel), display a suite of integrated cardiovascular, respiratory and thermoregulatory adaptations. Summarize these adaptations, explaining the physiological significance of each.
4. Contrast and compare the problems faced by a desert mammal and a marine teleost fish as well as the strategies they use to survive in a dehydrating environment.

5. Contrast and compare the ventilatory and acid-base responses to hyperoxia (high O_2) in an air-breather versus a water-breather.

6. Most freshwater teleost fish are unable to survive in water with high concentrations of bicarbonate ions because ionic regulation, CO_2 excretion and nitrogenous waste excretion are all impaired. Use a labelled sketch of the fish gill to explain why.

Part C: Answer the following question in the exam booklet. (15 marks)

1. Animals that are adapted to high altitude exposure (e.g. llamas, bar-headed geese) or adapted to a diving lifestyle experience similar challenges with respect to O_2 delivery and thermoregulation. First, outline the problems and then discuss the varied features utilized by animals to meet these challenges.

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, complete the names of the following fishy personalities...

1. Derek William Dick, better known as _____, is a Scottish progressive rock singer, lyricist and occasional actor.
2. _____, born in 1943, was World Chess Champion from 1972 to 1975 but never defended his title.
3. The birth name of this wrestler is Dean Roll, but he is better known as _____.
4. This legendary baseball player, _____, pitched a perfect game in 1968, won the AL Cy Young Award in 1974, and died in 1999 of amyotrophic lateral sclerosis (ALS, also known as Lou Gehrig's disease).
5. _____ is best known for his role as Charles Robinson in the Bond films *Tomorrow Never Dies*, *The World Is Not Enough*, and *Die Another Day*.