Animal Physiology HW 1: Metabolic Rate and Scaling
DUE: Friday, Sept 1st by midnight (11:59pm)

For this first HW, you may do it with your discussion group if you wish. Please discuss and work together on all problems - you will need to be able to do this kind of critical thinking for your design project.

The HW must be **hand-written**. Clearly number each answer (need not be in order). You may scan and submit on Laulima, or turn in a hardcopy, and hand-written on iPad or tablet is also OK. Please show work for all calculations. Include a list of authors and a statement that each person contributed to the HW and that everyone approves of the submission. Thank you!

Useful conversion factors:

0.0446 mol/liter O_2

E = 20 kJ/liter O_2

E = 24 kJ/liter CO_2

1 Measuring metabolism (6pts)

Tapeworms living in the intestines of mammals live in a largely anaerobic environment. Design an experiment to measure the metabolic rate of a tape worm. (This answer should include details about the environment that you would provide for the tapeworm during measurement).

2 Protein energy (2 pts)

Calculate how many kJ of energy are generated for each liter of O_2 used when metabolizing protein with an end-product of urea (2 pts). Use the stoichiometric equation below for the metabolism of a mole of protein with the indicated products. (Hint: This can be thought of as a unit conversion problem, look at the units)

$C_{139}H_{224}O_{46}N_{39}S + 142.6O_2 = 119.5CO_2 + 68.7H_2O + 19.5CO(NH_2)_2 + H_2SO_4 + 64,440kJ/mole$

3 Tusko on LSD (10pts)

In 1962, three men at the University of Oklahoma, lead by Louis Jolyon "Jolly" West, injected LSD into an elephant for the first time. Their stated intent was to determine if LSD would induce *musth*, a naturally occurring condition in which elephants become violent and uncontrollable.

> *The 7000-pound bull elephant named Tusko was injected with a huge dose of LSD (297 mg) into one buttock with a dart rifle... Five minutes after the injection he trumpeted, collapsed, fell heavily onto his right side, defecated, and went into status epilepticus.... The picture was that of a tonic left-sided seizure in which, mild clonic movements were present.* – West LJ, Pierce CM, Thomas WD. Science, 1962, 1100-1103.

Tusko was overdosed and died (Fig 1). No one really knows how they arrived at their dose. It has been speculated that they based it roughly on a dose for a cat which induces clinical effects (0.1mg/kg or .5mg for a 5kg cat):

$$Dose = 0.1mg/kg * 3000kg = 300mg$$

1. What could have gone wrong (and why)?

2. Let's say that the mass-specific metabolic rate for a cat is roughly 0.5 ml O_2/g/hr, whereas the same for an elephant is 0.1. What would be an appropriate dose based on metabolic rate?

3. Does metabolic rate scale with mass (if so, what is the relationship - i.e., what is the scaling exponent)?

4. On the same plot for mass vs. dosage, draw a line representing the dose appropriate for metabolic rate, and then add a point to represent the dose that Jolly and colleagues used. Verbally describe the difference between the dose that should have been used versus what was actually used.

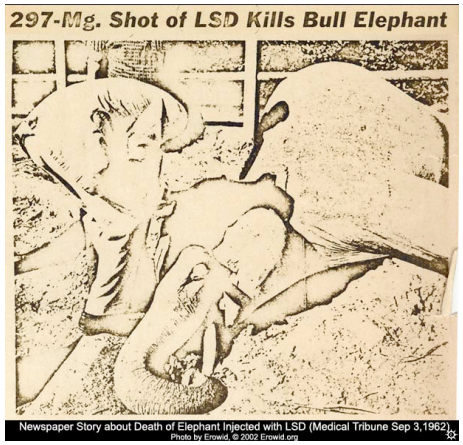

Figure 1: Newspaper article about the death of the elephant Tusko injected with LSD (Medical Tribune Sep 3, 1962). Photo by Erowid, ©2002, Erowid.org

4 Bird Allometry (12pts)

1. Calculate the BMR of a 2 kg kiwi bird (kiwi are the smallest ratites – ground dwelling birds). Calculate the BMR of a 500 kg Moa (the largest ratite, from Pacific Islands, now extinct). Convert BMR to kJ/d. Use BMR = $50.4M^{0.73}$ (Withers Tab. 4-5)

2. Calculate the per kg metabolic rate of these two birds (in kJ $kg^{-1}d^{-1}$)? Which bird has the higher metabolic rate?

3. Calculate VO_2 and VCO_2 for these two birds (in liters gas per hour). Assume that they are both eating equal amounts of protein, carbohydrate and fat.

4. Estimate the RMR and the AMR for the Moa (assume that the Moa was a fairly active animal). Calculate the total daily MR (DMR) – Assume 10 hours per day at rest and 14 hours active.

5 Extra Credit: Measuring the cost of running on an incline

We all know that it takes more energy to run uphill than to run on the level. How would you measure the difference in metabolic rate between a dog running on the level and a dog running uphill? Describe the treatments and state the experimental methods you would use.