Animal Physiology HW 1: Metabolic Rate and Scaling
DUE: Tuesday, Sept 10rd in class.

For this first HW, you may do it with your week 2 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)

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.

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 **??**). 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.

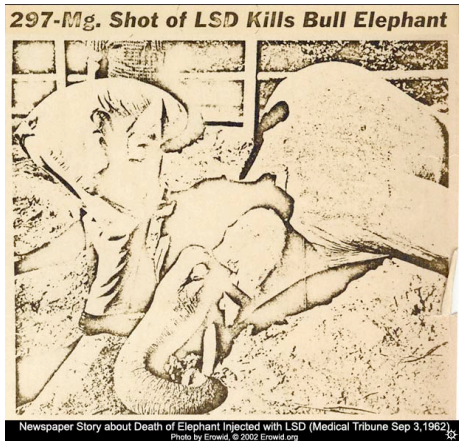

Figure 1: Newspaper article about the death of the elephant Tusko injected with LSD (Medical Tribune Sep 3, 1962). Photo by Erowid, ©2002, Erowid.org

4 Monitor lizard energy budget (12pts)

Monitor lizards have an impressive range in body size from the diminutive pygmy monitor *Varanus brevicauda* (0.2 m in total length, 8-10 gms) to the largest known terrestrial lizard, a closely-related gigantic varanid *Megalania prisca*, a Pleistocene fossil (19,000-26,000 years BP) from Australia, estimated to have reached 7 m in total length and to have weighed more than 600 kg (Hecht 1975; Auffenberg 1981; Rich 1985).

1. Calculate the BMR of the pygmy monitor (find the appropriate scaling equation in Withers; make sure to use mass in the correct units to match the equation). Calculate the BMR of the giant monitor. Convert BMR to kJ/day.

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

3. Calculate VO2 and VCO2 for these two lizards (in liters gas per hour). Assume that they are both eating equal amounts of protein, carbohydrate and fat. The conversions at the top will be helpful.

4. Estimate the RMR and the AMR for the giant monitor (make an assumption about its activity multiplier, assume that it was a fairly active animal). Calculate the total daily MR (DMR). Assume 16 hours per day at rest and 8 hours active.

5 Extra Credit: Measuring anaerobic metabolism

Many marine bivalve molluscs routinely experience anoxia when they are underwater or buried in the sediment. How could you design experiments to measure the metabolic rate of a bivalve mollusc, and to distinguish which fraction of it is anaerobic? It can be in the field or a combination of lab and field experiments. Your answer should include details about the environment that you would provide for the bivalve during measurement.