ASSIGNMENT #1 due Th. Jan. 13 / 2005

Join a group. Minimum group size 3, maximum size 6. Please hand in one assignment per group, and list the names of all group members, and their e-mail addresses at the top of each sheet.

P 1-1 Staircase Olympics

a) Determine the mechanical power output $P = h \cdot G$ for each team member when walking up two flights of stairs outside Chem. 124. Height h= 7.65m (45steps).

b) Estimate by how much this measurement could be wrong (error estimate).

To do this assign the largest possible values for M and ? h (height) and the smallest value for ? t, then calculate the largest possible value for P_{max}. Similarly estimate the smallest reasonable value for P_{min}. A good value for the uncertainty of your experimental results is $\delta P = \frac{P_{max} - P_{min}}{2}$.

Express your answer for the power obtained in part (a) as $P \pm \delta P$.

c) Repeat the measurements for each one of your team members when running up the stairs.

d) Estimate the mass of the muscles M_{musc} used for running up the stairs and give the power to weight ratio $X = P/M_{musc}$ of this muscle. (A good automobile engine generates about 1kW/kg.). Muscle mass M_{mus}= muscle volume V_{musc} muscle density ρ. (Muscles have about the density of water)

e) Make a table including all your data and a log-log graph showing

Name of team member, M, ? t, $P_{running}$, P_{walk} $\Gamma_{running}$, $\Gamma_{walking}$ V_{musc} $X_{running}$,

(i) The metabolic rate curve $G_o = 3.6\ M^{3/4}$

(ii) The power P and metabolic rate Γ for each team member when walking up the stairs plotted as function of body mass

(iii) The power P and the metabolic rate as function of body mass when running upstairs.

The TAs will make a compound table for the whole class to get statistical values, and determine who has the highest power to weight ratio.

P 1-2 Metabolic rates of spiders and caterpillars.

In summer time a 500mg spider catches a meal about once a day (? t_S,), in winter it goes without eating for 6 weeks (? t_W). Assume that the spider's prey weighs 100mg on average, and that the spider only "eats" the soft tissue (fat & proteins) and discards the empty shells. Assume that 1 g of fat and protein body tissue contains 25kJ. a) Make a reasonable assumption of the percentage of body mass of the prey, which the spider eats and calculate the average energy content ? Q of a meal extracted by the spider. b) Calculate the metabolic rate ? Q/? t in summer, and in winter. c) Do a similar calculation for 100 mg plant eating caterpillar, who consumes 20 times its body weight in a day. Assume that the plant tissue contains about 6% of useful edible starches and proteins, which have an energy content of about 21kJ/g. d) Plot your results on a logarithmic plot, and draw on the same graph the metabolic rate curve Fig. 1.7 of warm blooded animals ("mouse to elephant" curve).

P 1-3 Allometry

a) Find out from the literature how many days a bear spend in Hibernation, and how much weight she looses. Compare this number with the weight loss predicted from the metabolic rate of this animal. If there is a difference explain why. b) Select a cetacean and an ungulate of the same body mass. Calculate and compare their skeletal masses, and comment on your numbers.