ASSIGNMENT #2 due Tue Jan. 25/2005

Please hand in one assignment per group,
list the names of all group members, <and their e-mail addresses> at the top of each sheet.

- **MAKE REASONABLE ESTIMATES OF VALUES THAT YOU THINK ARE MISSING IN THESE PROBLEMS**
- **POINT OUT AND JUSTIFY ANY ASSUMPTIONS YOU MAKE.**
- **NORMAL BODY TEMPERATURE OF WARM BLOODED ANIMALS T=36°C**

P2.1 Foraging efficiency of animals

Looking for food is part of the foraging inefficiencies comparable to the drilling for oil and transporting it to [power plants in Fig. 2.4. A certain tern (seabird) of body mass M=0.12kg migrates semiannually from arctic to ant-arctic waters over a distance of 8,500km. This travel has a significant energy cost, measured in Joule per meter, which is part of the food - acquisition foraging inefficiency. Data for the cost of transport E_{tr} units [J/(m kg)] are given in Fig.5.9, p 181

a) Compare the tern to a similar sized shorebird, that never leaves home, and calculate the annual additional amount of energy (1cal= 4.18 J) that the tern must ingest to account for the migration. Express this energy as number N of small fish (M_f=5g, energy content of fish, h=15kJ/g), that the tern must hunt daily over and above the food intake of the stay – at - home bird?

b) Give biological reasons (think about the food chain) why animals migrate in summer to the regions of high latitude on the globe.

P2-2. Breezing in Whitehorse

On a fine winter morning in the Klondike the air is a balmy T_o= 30ºC below the freezing point, and the pressure is at p=1.03bar=$1.03\cdot 10^5$N/m^2. Robert Rednose breathes deeply before descending into his gold mine, and takes in air at an average volume flow rate $\Phi = A\cdot u$ = 6.0 liter/ min. (u is defined below). The air has to pass through his nostrils, which have a total opening area of A= 2.8 cm^2. The air warms up to the body temperature T_B = +36 C^o inside the lung.

Air is a molecular gas with the specific heat, C_p= (7/2)R, where R=8.31 [J/mole K^o] is the gas constant. Gas law pV=nRT, where the pressure p is in N/m^2, volume V in m^3, n is the number of moles in the volume V, is temperature T in K^o. Differentiate the caloric energy equation ? Q=nC_p? T, to get the heat flow rate that must be provided by the lung to maintain 36 C^o.

$$\frac{dQ}{dt} = Q' = n[\frac{moles}{liter}]\cdot f[\frac{liter}{s}]\cdot C_p[\frac{J}{mole\cdot K^o}]\cdot \Delta T[K^o]$$

a) How many moles are in one liter at this temperature and pressure?
b) How much heat does the person lose by warming up the air?
c) What is the average intake velocity u, at which the air streams through the nostril?
d) Is the flow laminar or turbulent? See equation (4.12) and the paragraph below it on pg 136
e) Measure the open area of your own nose (everyone in the group), and provide this data along with the body mass for each individual. Plot this data as an allometric relation on a log – log graph. What is the scaling exponent and constant for this relationship? What exponent do you expect? Why?

P2-3 Cool Kangaroos

(*Macropus rufus*) Kangaroos (M = 30 kg) in the Australian outback in scorching heat lick their forelimbs to help prevent overheating.

a) What is their basic metabolic rate?
b) If a kangaroo sits motionless in the shade (temperature in the shade = 96.8°F), how much saliva would it have to sacrifice per 12-hour day if it wanted to stay at its normal body temperature?
c) Is this a suitable strategy for the animal in the dry Australian outback to continuously control their body temperature?
d) Find the heat loss sustained if it lets its body temperature rise 3°C above the ambient temperature. Assume a heat transfer coefficient, h_s = 20 W / m^2 K^o.