1. a) How much energy ($\Delta G$, $G = \text{Gibbs free energy}$) is stored by photosynthesis of purple sulfur bacteria?

$$\Delta E_0' = E_0' \text{ of e}^-(\text{acceptor}) - e^- (\text{donor})$$

$$\text{CO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{CH}_2\text{O} + \text{H}_2\text{O} | \text{---------------------} -0.5 \text{ V} \text{---------------------} -0.42 \text{ V}$$

$$2\text{H}_2\text{S} \rightarrow 4\text{H}^+ + 4\text{e}^- + 2\text{S} | \text{----------------------} -0.243 \text{ V} \text{----------------------} 0 \text{ V}$$

Overall reaction:

$$2\text{H}_2\text{S} \rightarrow 4\text{H}^+ + 4\text{e}^- + 2\text{S} \quad E_0' = -0.243 \text{ V}$$

$$\text{CO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{CH}_2\text{O} + \text{H}_2\text{O} \quad E_0' = -0.42 \text{ V}$$

$$2\text{H}_2\text{S} + \text{CO}_2 \rightarrow \text{CH}_2\text{O} + \text{H}_2\text{O} + 2\text{S}$$

So, fill in the net $\Delta E_0' = ?$

b) In class we calculated the amount of free energy ($\Delta G$) stored by photosynthesis to be 2868 KJ per mole of sugar produced. We also learned that purple sulfur bacteria use $\text{H}_2\text{S}$ as an electron donor instead of $\text{H}_2\text{O}$ in order to obtain the chemical energy they need to produce sugar. How much energy is used to produce a mole of sugar ($\text{C}_6\text{H}_{12}\text{O}_6$) when $\text{H}_2\text{S}$ is the electron donor instead of $\text{H}_2\text{O}$?

c) If the sugar in part a were eaten by an oxygen breathing organism, how much energy would be released from the sugar in KJ/mole? (hint: no calculation is needed).

d) The chlorophyll pigments in green plants absorb blue and red light, but allow green light to pass through (which is why they are green). Purple sulfur bacteria absorb light optimally at 870 nm. Why are they purple? (hint: they are actually pink, or pale red, purple is not in the spectrum!). See http://www.mie.utoronto.ca/labs/lcdlab/biopic/fig/26.08.jpg

e) Photons of light of longer wavelengths (greater number of nanometers [nm]) have less energy. What does the $\Delta G$ calculation from part a tell you about how much energy is required from light to produce sugar in purple sulfur bacteria vs. green plants? (hint: green plants absorb light optimally at 700 nm; answer in a short answer format, no calculation required).

2. We have seen that the oceans and atmosphere cooperate in ‘ventilating-cooling’ the tropics and warming the polar regions. Consider the ocean’s contribution. Suppose that the overturning circulation (the ‘conveyor belt’) of the North Atlantic Ocean involves about 16 Sverdrups ($16 \times 10^9$
kg/sec) of flow northward at latitude 40°N, at temperatures of 25°C, with salinity of 3.6%, and the almost the same amount southward far below the surface, at temperature 2°C and salinity of 3.49%.

• How much heat transport is carried by this conveyor belt (in Watts)? The specific heat capacity of water is about 4184 J/(kg°C). How does this compare with the values suggested in lectures? Evaporation and precipitation exchange some water with the atmosphere, hence the word ‘almost’, above; see diagram below.

• We saw that the ocean and atmosphere together carry about 5 x 10^15 watts (5 petaWatts) of energy flow (power) poleward in each hemisphere, cooling the tropics and warming the polar regions. The surface area of the land and ocean in the northern hemisphere tropics (say from the Equator to 20°N latitude), in square meters, is roughly 2πR x 20 x 111 (km/degree of latitude) x 10^3 (m/km). R is the radius of the Earth, 6380 x 10^3 m. Using these numbers, how many watts/m^2 of cooling of the tropics is accomplished by the 5 pW heat flux? [That is, watts of northward heat flow per square meter of tropical Earth surface.] Is this big or small: compare your result with other terms in the greenhouse radiation budget, for example the ERBE radiation satellite data showing ~ 200 watts/m^2 of outgoing infrared radiation in the tropics.

3. ANWR’s oil reserves.

When I Google ‘anwr oil reserves barrels day’ the following are the first 3 websites that come up

• visit these websites and perhaps others that Google chooses, and write a short critique of the conflicting factors involved with drilling for oil there. What is your opinion about Google’s choice of the ‘top’ websites?

http://www.msnbc.msn.com/id/4542853/
http://mediamatters.org/items/200701290002

4. Write up one of the laboratory experiments that you will see this week in Lab 3: ‘atmosphere/ocean circulation’ lab. (Less than one page, single-spaced. Concentrate on what you observed, and what you think the most important ‘message’ of the experiment was.)