

Name _____

Fall 2010 BSCI 207H

Homework Assignment 2. Thermodynamics of Biological Systems

Group homework: DUE Monday 9/13/2010 Refer to the textbook reading for the thermodynamics GAE recommended in the class schedule (pp. 31-37 and 58-60 in Freeman) and to the thermodynamics ppt presentation posted on the lecture material link in the BSCI 207 ELMS website to help your group discuss these questions in the study group meeting. Please remember that you are encouraged to discuss these questions with your group, but then you are required to write your answers on your own. (15 total pts)

1. Thermodynamics and the origin of life and the functioning of modern life (5 pts)

1A. The earliest life forms had to evolve effective mechanisms of energy transformation that were consistent with the opportunities and constraints of the First and Second Laws of Thermodynamics. Describe those opportunities and constraints.

1B. Describe a modern example of a biological energy transformation to illustrate the different roles of thermodynamics and genomics that play in this transformation.

2. Aerobic respiration results in the breakdown of glucose ($C_6H_{12}O_6$) into 6 molecules of CO_2 and 6 molecules of H_2O . Some of the energy released from one glucose molecule via aerobic respiration is ultimately used to phosphorylate a total of 36 molecules of ADP to form 36 molecules of ATP. Show your work in all calculations. (5 pts)

2A. A mole of glucose contains 686 kcal/mole of free energy. A mole of ATP contains 7.3 kcal/mole of free energy. How much total free energy in kcal/mole is stored in all the ATP produced from a mole of glucose?

2B. Calculate the energy efficiency of this process.

2C How much energy in kcal/mole of glucose is not stored in the form of ATP, and what happens to this energy?

3. Photosynthesis involves the conversion of light energy into chemical energy (i.e., glucose) and heat energy released into the environment. Let's imagine that your friend Flora would like to force plants to carry out the reverse process. In the middle of the night, she pours glucose on a plant in her backyard and then heats a leaf with a portable hair dryer, but she is surprised to see that the plant does not glow in the dark. She becomes very discouraged about the possibility of bioluminescence (i.e., biological light generation) until she sees the flashes of light from the fireflies in her backyard. (5 pts)

3A. Read two websites: <http://en.wikipedia.org/wiki/Bioluminescence> and <http://en.wikipedia.org/wiki/Luciferase>, and then describe how fireflies make light flashes.

3B. Does the ability of fireflies to make light violate and or not violate the Second Law of Thermodynamics? Explain your reasoning.

3C. Biologists use the Ti plasmid in the bacterium *Agrobacterium* to transform plants (see p. 410-411 in Freeman). Design an experiment that will allow Flora to make her plants able to carry out bioluminescence.