

BIOLOGICAL FRAMEWORKS FOR ENGINEERS

Homework #4 (due 11/7/11) [Cell Energetics]

We have just seen how the breakdown of carbohydrates and fat leads to the production of ATP. So how much bang do you get for your buck? To figure out how much ATP is produced, you need to know a few facts about the stoichiometry of these metabolic pathways:

- Glycolysis converts 1 glucose molecule to 2 pyruvate molecules. 2 ATP are produced. In the presence of oxygen, 1 NADH is also produced.
- The fatty acid cycle chops up fatty acids into two-carbon fragments (acetyl CoA molecules). For every X molecules of acetyl CoA generated, (X - 1) molecules of NADH and (X - 1) molecules of FADH₂ are also produced.
- The Krebs cycle (and the step that comes immediately before it) converts 1 pyruvate to 3 CO₂; 1 ATP, 4 NADH, and 1 FADH₂ are also produced. When starting with acetyl CoA instead of pyruvate, 2 CO₂, 1 ATP, 3 NADH, and 1 FADH₂ are produced.
- The electron transport chain accepts electron pairs from NADH and FADH₂ and pumps protons out of the mitochondria, which then flow back into the mitochondria through an enzyme that makes ATP. Assume that each electron pair from NADH causes enough proton pumping to make 3 ATP and that each electron pair from FADH₂ causes enough proton pumping to make 2 ATP.

Draw a flow diagram and label its parts for the reactions where one cell breaks down 2 glucose molecules and 4 fatty acid molecules. How much ATP has the cell produced at each step and in sum?