Cell metabolism

I. ATP is the energy currency for the cell

- metabolism involves converting nutrient molecules -- glucose, triglycerides -- to ATP

- only ATP can directly power cellular work

II. Glucose breakdown -- general comments

- glucose breakdown involves a stepwise removal of pairs of hydrogen atoms from glucose, passing them on to electron acceptors.

- two major electron acceptors are NAD and FAD.

- the bulk of energy (ATP) from glucose oxidation results from use of NADH/$FADH_2$ to set up a hydrogen ion gradient across inner mitochondria membrane used to drive ATP synthesis.

- oxygen is required and carbon dioxide and water are products

- this process involves glycolysis, Krebs Cycle, and electron transport chain (ETC).

-there are two means of ATP production throughout glucose oxidation: substrate level phosphorylation where high energy phosphate groups are transferred directly from phosphorylated molecules to ADP; oxidative phosphorylation which is carried out by ETC proteins; uses NADH/$FADH_2$ to set up a hydrogen ion gradient across inner mitochondrial membrane, the dissipation of which leads to ATP synthesis

A. Glycolysis

1. Sugar activation: 2 ATP molecules are used to start up process

2. Sugar cleavage: a six carbon sugar converted to two three carbon sugars

3. Sugar breakdown and formation of ATP (business end): begin stepwise removal of pairs of hydrogen atoms passing them onto electron acceptors; net yield is 2 3C molecules, 2 NADH, and 2 ATP

B. Krebs cycle

- occurs in the mitochondrial inner compartment; fueled by the pyruvate from glycolysis.

1. Preparatory step:

- one of 3C molecules converted to acetyl CoA (2C)

    a. since one C lost one CO_2 produced

    b. removal a pair of hydrogen atoms (1 NADH produced)

    c. 2C molecule enters Krebs cycle

2. Krebs cycle:

- series of events take place as cycle moves through 8 consecutive steps ; by the time one cycle has taken place, all atoms that came in as part of that 2C molecule have been disposed of:

- 2 Cs that came into Krebs used to produce carbon dioxide.
- four transfers of hydrogen atom pairs 2C that came in to electron acceptors
- 1 substrate level phosphorylation: 1 ATP produced

C. Electron transport chain (ETC) and oxidative phosphorylation:

- at this point we have electron acceptors loaded down with electrons; they are "worth" a lot of energy

- a group of proteins in the inner mitochondrial membrane is arranged in a sequence of decreasing energy states

- the electron acceptors (from glycolysis and Krebs) deliver electrons and protons (hydrogen atoms) at the "top" level of the chain to one of the protein electron acceptors; the protons (H+) escape into the inner compartment and electrons are passed down the chain into successively lower energy levels, with a release of energy in every step.

- the final electron acceptor (at lowest point in chain) is oxygen; it accepts electrons and combines with hydrogen to form water.

- oxygen therefore helps to "pull" the electrons down the chain ; if there is no oxygen present, then there would be no final acceptor for electrons and no gradient of energy levels would be maintained.

- the stepwise release of energy is used to pump the protons from the inner compartment, across the inner membrane into the intermembrane space.

- therefore a proton gradient is established across the inner mitochondrial membrane

- this dissipation of this gradient (as protons move from area of high concentration to area of low concentration) releases energy used in the production of ATP.

- the protein channel, ATP synthase, allows the protons to move down the electrochemical gradient and drive the process by which ATP is synthesized from ADP and P.