Chapter 7 – Cellular Respiration

Cellular Respiration – process in which cells make ATP (the energy storing molecule in cells) by breaking down organic compounds. (aka getting energy from the food you eat).

Glycolysis – pathway that starts respiration….yields a small amount of ATP.

After Glycolysis:

- If Oxygen is ABSENT → FERMENTATION (anaerobic) – no ATP made.
- If Oxygen is PRESENT → AEROBIC RESPIRATION - Lots of ATP is made.

See fig. 7-1, pg. 127.

4 Steps of Glycolysis
See pg. 128

**Takes place in the Cytosol of the cell.

1. 2 ATP give up 2 phosphates – these attach to glucose forming glucose diphosphate.
2. Glucose diphosphate splits into two 3-carbon PGAL molecules (same as the PGAL from the Calvin Cycle).
3. The two PGAL's are <u>oxidized</u> and each receives a phosphate. At the same time, 2 NAD+ molecules are <u>reduced</u> to form NADH.
4. The 4 phosphates added in steps 1 and 3 are now removed to form 4 ATP. Now remaining are 2 molecules of pyruvic acid or "PYRUVATE".

NOTE:

- Glycolysis has a net gain of 2 ATP (2 are used in step 1 – 4 are made in step 4)
- Glycolysis also yields 2 pyruvates. What happens to pyruvate depends on whether oxygen is present or not. WHAT WILL BE THE FATE OF PYRUVATE???

Fermentation

Fermentation – in the absence of oxygen, some cells convert pyruvate to other compounds. There are 2 types of fermentation.

Lactic Acid Fermentation – pyruvate from glycolysis picks up 2 hydrogen atoms. Pyruvate is then converted to lactic acid.

See fig. 7-3a on pg. 129.

Examples:

- Microorganisms produce the distinct flavors of yogurt and many cheeses.
- Lactic acid is produced in your muscles during hard exercise.....this causes fatigue and pain.

Alcoholic Fermentation – pyruvate from glycolysis is converted into ethyl alcohol. See fig. 3b, pg. 129.

This is the basis of wine/beer/bread making industries.

Aerobic Respiration - a.k.a. Cellular Respiration = Krebs Cycle + Electron Transport Chain

Aerobic Respiration – if enough oxygen is present, pyruvate enters this pathway. Yields nearly 20 times more ATP than glycolysis alone.

Mitochondrion – site for aerobic respiration = Krebs Cycle + Electron Transport Chain. See fig. 7-5, pg. 133.

Mitochondrial Matrix – contains the enzymes needed to run the Krebs Cycle.

In the Matrix:

Pyruvate + CoEnzyme A → Acetyl CoA (this is what enters the Krebs Cycle).

NADH and CO_2 are also produced…. The NADH will be used in the electron transport chain later!!!

See fig. 7-6 on page 134.

Steps of the Krebs Cycle (Hans Krebs – 1900-1981)

1. Acetyl CoA (2Carbon {C}) plus oxaloacetic acid (4C) yields Citric Acid (6C). Note – CoEnzyme A is released and recycled.
2. Citric acid releases CO_2 and H (oxidation) to become a 5C molecule. NAD+ picks up H (reduction) to form NADH – REDOX REACTION!!!
3. 5C compound loses CO_2 and H to form a 4C compound. Then NADH and ATP are formed.
4. 4C compound loses H to another e- acceptor called FAD (Flavin Adenine Dinucleotide) to form $FADH_2$
5. The 4C compound releases more H to regenerate oxaloacetic acid to keep the Krebs Cycle going. NAD+ picks up this H to form NADH.

See fig. 7-7, pg. 135.

Electron Transport Chain

Electron Transport Chain – 2nd stage of aerobic respiration. Chain is located on the inner mitochondrial membrane.

See fig.7-8, pg. 136 to follow the steps of the Chain as outlined on the next slide.

Steps of the Electron Transport Chain

1. NADH and $FADH_2$ supply e-'s and protons (H+) for the Chain.
2. e-'s are passed along chain from molecule to molecule in a series of redox reactions.
3. Energy from e- flow is used to pump protons (H+) from matrix to outside of inner membrane. This sets up a H+ concentration gradient.
4. H+'s flow DOWN the concentration gradient through ATP Synthetase and ATP is produced.
5. Oxygen is the final e- acceptor at the end of the chain. This keeps the e-'s flowing. NOTE - This is aerobic respiration because oxygen is the final e- acceptor!!

For final tallies of all energy (ATP) yielded from 1 glucose molecule in aerobic respiration, see fig. 7-9, pg.137.

Summary Equation for Cellular Respiration

Glucose + Oxygen → CO_2 + Water + ENERGY