Cell Respiration

The overall reaction for cell respiration is:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$$

(this reaction is the reverse of photosynthesis)

There are three stages to cell respiration: glycolysis, Krebs cycle, and electron transport chain/oxidative phosphorylation.

Glycolysis

- Glucose is the starting material.
- 2 ATPs are invested.
- 2 NADHs, 4 ATPs and 2 pyruvates are produced during glycolysis
- **The net yield per glucose molecule is: 2 NADH, 2 ATP, 2 pyruvate**
- Glycolysis takes place in the cytoplasm and doesn't require oxygen
- PFK enzyme is the feedback regulation step that turns the glycolysis pathway on or off.

Krebs cycle (also known as the **citric acid cycle**)

- Takes place in the mitochondria and O_2 is required or the cycle shuts down.
- Preparatory step, convert pyruvate to acetyl-CoA inside the mitochondria,
  1 NADH and 1 CO_2 per pyruvate (**2 NADHs and 2 CO_2 per glucose**) are generated at this step.
- Acetyl-CoA then enters the Krebs cycle
  3 NADH, 1 ATP, 1 $FADH_2$ and 2 CO_2 are generated per acetyl-CoA
- The Krebs cycle does 2 "turns" per glucose
  Total yield per glucose molecule: 6 NADH, 2ATP, 2$FADH_2$ and 4 CO_2

Electron Transport

- All the NADH and $FADH_2$ from glycolysis and the Krebs cycle must go through electron transport and oxidative phosphorylation to convert the stored energy into ATP.
- O_2 is the final electron acceptor for the electron transport chain, if no O_2 then the no electron transport. (Since all the NADH and $FADH_2$ from Krebs must be processed by the electron transport system the cell automatically shuts down the Krebs cycle when no O_2 is present.)
- Electrons lose energy as they are handed down the electron transport chain, this energy is "captured" by moving protons (H^+) across the membrane.

- The “captured” energy is recovered when the protons return across the membrane via ATP synthase, making ATP. This is called oxidative phosphorylation or chemiosmotic phosphorylation.
- NADH is converted into 3 ATP and $FADH_2$ is converted into 2 ATP.
- **A total of 32- 34 ATP are generated by electron transport/oxidative phosphorylation, 2 ATP from glycolysis and 2ATP from Krebs for a total yield of 36-38 ATP per glucose.**

Anaerobic Conditions

- If no O_2 then the Krebs cycle and electron transport don’t take place.
- Fermentation is the how the cell regenerates the NAD^+ needed for glycolysis to continue.
- **Yeast do alcohol fermentation, muscle cells do lactate fermentation.**

Other macromolecules can be broken down by the Krebs cycle.

- Fats are broken down into fatty acids and then into acetyl-CoA, the acetyl-CoA is then used in the Krebs cycle.
- Proteins are broken down into amino acids and they enter glycolysis and the Krebs cycle at various points to be converted into energy.

For more information please visit the University of Arizona’s The Biology Project.