CHAPTER 7 BIOLOGY – *The Working Cell: Energy from Food*

- **Biologists classify/group organisms by how they get their food.**
  - **Autotrophs =** "self feeders"; make their own food
    - Make food through the process of photosynthesis (using the sun's energy to combine water and carbon dioxide and make sugar)
    - Also called producers
  - **Heterotrophs =** organisms that cannot make their own food
    - Also known as consumers (get their energy by eating producers or other consumers)
    - Includes humans

- Realize that life on earth is solar powered:
  - Producers depend on the sun for their energy source; heterotrophs then depend on producers to supply them with the energy and materials they need for life.

- **CELLULAR RESPIRATION:**
  - Glucose + Oxygen → ATP + CO_2 + H_2O
  - Chemical process that uses oxygen to convert the chemical energy stored in organic molecules into ATP.
  - **ATP = adenosine triphosphate**; used by cells in plants and in animals as their main energy supply.
  - **Chemical energy from glucose (sugar) is stored in ATP.**

- **PHOTOSYNTHESIS:**
  - $H_2O + CO_2$ → (Light energy) Glucose + Oxygen
  - The light energy is used to rearrange the atoms in the carbon dioxide and the water.
  - The oxygen is used during cellular respiration to release the energy stored in the glucose; this released energy allows the cells to produce ATP.
  - **Photosynthesis is only performed in autotrophs, but both autotrophs AND heterotrophs perform cellular respiration!**

- **What is energy?**
  - The ability to perform work
  - **Kinetic energy** = the energy of motion
  - **Potential energy** = stored energy that can be converted to kinetic energy
  - *Energy cannot be created and it cannot be destroyed; it can only be converted from one form to another.*
  - **Chemical energy** = a type of potential energy stored in chemical bonds
  - **Calorie =** the amount of energy required to raise the temperature of 1 gram of water by 1 degree Celsius.
    - 1 kilocalorie = 1,000 calories (the "calories" shown on food labels are actually kilocalories).

- **Metabolism = the sum of all the cell's chemical processes.**

- **ATP:**
  - Provides energy for cellular work.
  - The three phosphate groups are the source of energy for most cellular work; as a phosphate is broken off of ATP (and ADP is formed), energy is released, and that energy is used to do work.
  - What type of cellular work requires ATP?
    - Chemical work (building large molecules like proteins)
    - Mechanical work (muscle contraction)
    - Transport work (pumping solutes across a membrane)
  - ATP is constantly recycled in your cells; realize that FOOD provides the energy source for reforming ATP from ADP.

- **More on cellular respiration:**
  - Cellular respiration is **aerobic** = requires oxygen.
  - **Basic summary of cellular respiration**: *the atoms in glucose and oxygen are rearranged and carbon dioxide and water are released; the cell uses the energy released during this process to make ATP.*
  - Cellular respiration can make up to 38 ATP molecules per molecule of glucose.
  - **Mitochondria (singular: mitochondrion)=** where most of the steps of cellular respiration take place.
    - The many folds found in mitochondria provide many places for ATP production to take place.

- **THE MAJOR STEPS OF CELLULAR RESPIRATION:**
  - **Step 1: Glycolysis**
    - Occurs in the **cytoplasm**
    - 2 ATP molecules are used to break down glucose into two pyruvate (or pyruvic acid) molecules, 2 NADH molecules, and 4 ATP molecules.
    - Net ATP production: **2 ATP**
    - *See p. 149, fig. 7-17 for picture description.*
  - **Step 2: Krebs Cycle**
    - Takes place in the **matrix of a mitochondrion**.
    - Each pyruvate is broken down to carbon dioxide and many NADH and some FADH2 molecules are produced.
    - Net ATP production: **2 ATP**
    - *See p. 150, fig. 7-18 for picture description.*
  - **Step 3: Electron Transport Chain (ETC) and ATP Synthase**
    - Takes place on the **inner membranes of a mitochondrion**
    - As electrons (released from NADH and FADH2) move down the ETC, energy is released.
    - This energy is used to pump protons (H+ ions) against their concentration gradient; the protons then move down their

concentration through a protein channel on the inner membrane; this protein channel is also an enzyme called ATP synthase.
- For every proton that moves through the ATP synthase protein channel, an ATP is produced.
- Oxygen serves as the final electron acceptor on the ETC; as oxygen accepts electrons, water is formed.
- *See p. 151, fig. 7-19 for picture description.*

▪ Net ATP production: **34 ATP**.

- **Summary of Cellular Respiration:**
  - **GOAL:** to produce 38 molecules of usable energy (in the form of ATP) per molecule of glucose.
  - **Glycolysis:** 2 ATP produced
  - **Krebs:** 2 ATP produced
  - **ETC/ATP Synthase:** 34 ATP produced.

- **What happens if your body cannot supply enough oxygen to meet with your body's demands for ATP?**
  - **Fermentation** = process of making ATP without using oxygen
    - The only process used in fermentation is glycolysis.
    - Fermentation is used when you still need energy, but your oxygen supply is less than your oxygen demand.
    - 2 total ATP are produced during fermentation. *See p. 153, fig. 7-6 for picture description.*
    - The waste product formed during fermentation is lactic acid; when it builds up in the muscles, it causes soreness.
    - Fermentation also occurs in microorganisms:
      - Yeast = microscopic fungus capable of cellular respiration and fermentation.
      - When yeast are kept in an anaerobic environment (no oxygen available), they ferment sugar
      - Fermentation in yeast is different than in humans because alcohol is produced as a waste product (versus lactic acid).