Metabolism

The First Law of Thermodynamics: Energy Conservation

- The total amount of energy in the universe is constant
- Energy cannot be created or destroyed, only converted from one form to another
- Ex/ Corn plants absorb sunlight energy and convert it to the chemical energy of starch → when you eat the corn you extract and convert some of the energy in starch to other forms (like kinetic energy of movement)
- Kinetic energy is the energy possessed by moving objects
- Ex/ heat, mechanical, electromagnetic and electrical energies
- Potential energy is stored energy
- Ex/ gravitational potential and chemical potential energy

- During photosynthesis, the sun's energy is captured by pigments in the chloroplast and transferred through a series of chemical reactions to molecules like glucose
- A small portion of the sun's energy is stored in the chemical bonds of glucose
- During cellular respiration, the energy that is stored in glucose is transferred to ATP, the universal energy form for cell processes

The Second Law of Thermodynamics: Biochemical Probability

- The amount of energy in the universe is spontaneously flowing from forms of higher free energy (lower entropy) to lower free energy (higher entropy) content
- Entropy is the measure of the randomness or disorder in a collection of objects (see Table 2, p.61)
- Free energy (or Gibbs free energy) is energy that can do useful work
- Ex/ one way flow of energy:

sun → plants → primary consumer → secondary consumer

- Energy is lost along the way to heat

Energy and the Direction of Metabolic Reactions

- When glucose is oxidized (broken down) into carbon dioxide and water, the new molecules formed have covalent bonds that are more stable but there is less bond energy overall
- This is an exergonic reaction as 2870 kJ of energy are released
- When glucose is synthesized, the reaction requires2870 kJ of energy from an outside source (ATP)
- This is an endergonic reaction

Adenosine Triphosphate (ATP)

- Cells cannot directly use the energy released when glucose is broken down
- The energy needs to be captured and converted to energy stored in ATP
- ATP is made up of adenine (a nitrogenous base, ribose (a 5-carbon sugar) and three phosphate groups

- Weak covalent bonds hold the components together and when an enzyme splits off the outermost phosphate group by hydrolysis energy is released
- If energy is input, ADP can bond to a phosphate group, recreating ATP (called phosphorylation)

Redox Reactions

- Oxidation-reduction reactions refer to reactions where electrons are transferred
- The donor of electrons is said to be oxidized and the acceptor of the electrons is reduced
- In any redox reaction, the number of electrons gained must equal the
- number of electrons lost
- # electrons gained = # electrons lost
- As electrons are passed from one acceptor to the next energy is released to do work
- Example/ The combustion of methane
    - Oxygen acts as an oxidizing agent
    - The shift in electron position from less electronegative elements (carbon and hydrogen) to a more electronegative element (oxygen) results in a decrease in the potential energy of the electrons and a release of free energy
    - This is an exergonic process that releases large amounts of free energy
    - A similar reaction happens within the body when the combustion of glucose occurs during cellular respiration

$$CH_4 \quad + \quad 2O_2 \quad \rightarrow \quad CO_2 \quad + \quad 2H_2O \quad + \quad \text{Energy}$$

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      H
H     C     H     O     O     →     O     C     O          O
      H                                               H          H
   methane      oxygen             carbon dioxide          water
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