Thermodynamics

- First Law–total amount of energy within a system remains constant, energy cannot be created or destroyed
- Second Law–degree of disorder in a system increases

Energy in a Cell

- Total amount of energy within a system is conserved (Law #1) [energy released from glucose (energy rich) is converted to carbon dioxide (energy poor), water and heat]
- $C_6H_{12}O_6 + O_2 \rightarrow 6CO_2 + 6H_2O + heat$

Light energy-->Chemical energy (glucose)

Chemical energy --> Chemical energy (ATP, NADH)

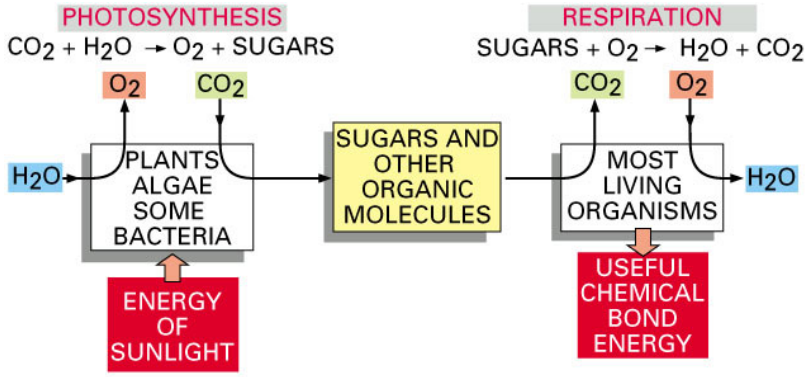

Figure 2–41. Molecular Biology of the Cell, 4th Edition.

Figure 3.10

How Cells follow 2nd Law of Thermodynamics

- Synthesis of proteins, carbohydrates, lipids, nucleic acids imposes order
- Cells release heat during these processes which disorders their environment
- Entropy increases around cell, 2nd Law of Thermodynamics is satisfied

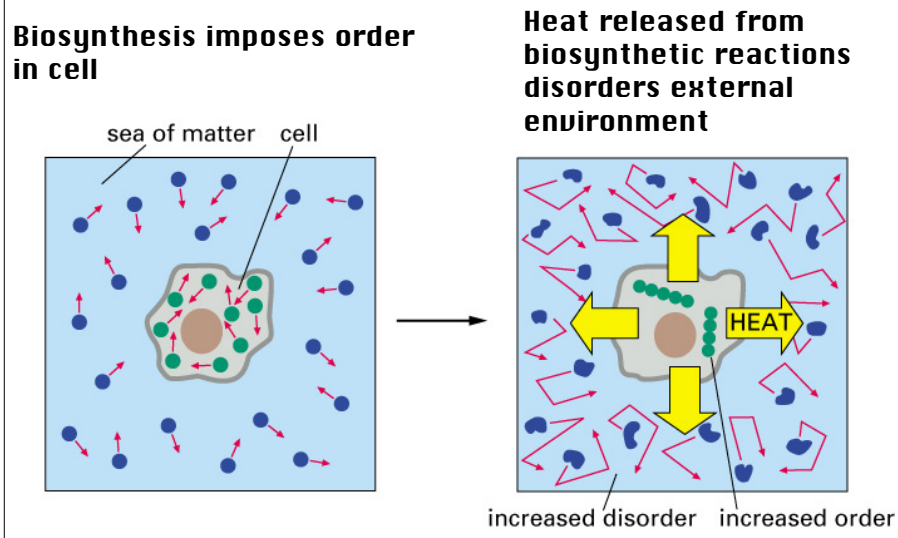

Figure 2–38. Molecular Biology of the Cell, 4th Edition.

Figure 3-6

Chemical reactions

- 1. (Chemical) reaction will proceed spontaneously to a state of minimal energy
- 2. (Chemical) reaction will proceed spontaneously so that there is more disorder(increase in entropy) in the system

What cells do with energy rich compounds

- Break down glucose in little steps
- Lose electrons (loss of Hydrogen H+ plus one electron) OXIDATION
- H-C-H---> H-C-OH--->H-C=O
- Take high energy compound (glucose) and convert to low energy compounds (carbon dioxide and water) in series of steps
- Compounds in the cell that receive or gain electrons are REDUCED.

Oxidation and Reduction

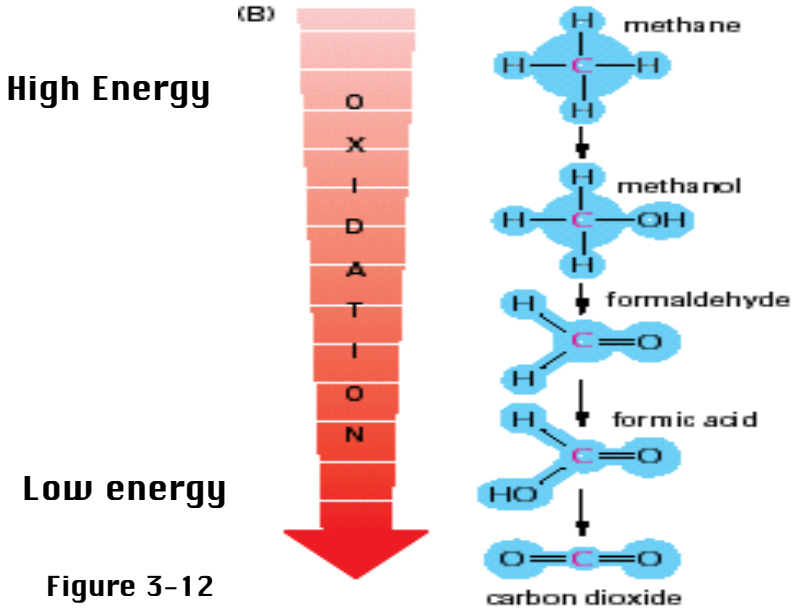

Figure 3-12

Oxidation and Reduction in the formation of a polar covalent bond

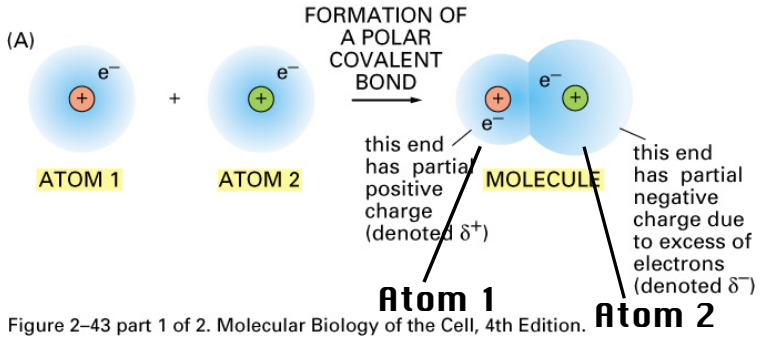

Figure 2–43 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

Atom 1

Oxidized (lost an electron)

Atom 2

Reduced- (gained an electron)

Figure 3-12

Oxidation and Reduction in the formation of covalent bonds

(For organic molecules, follow the hydrogens,
Reduction increases the number of C-H bonds
Oxidation decreases the number of C-H bonds)

$$C_6H_{12}O_6 + O_2 ---> 6CO_2 + 6H_2O + \text{heat}$$

Glucose is oxidized (loses H's) when it is converted to carbon dioxide

Oxygen is reduced (gains H's) when it is converted to water

Energetically favorable and unfavorable reactions

- Favored; free energy of products is lower than the free energy of reactants

  $\Delta G = Gp - Gr$, is negative

- Unfavorable- free energy of products is higher than the free energy of reactants

  $\Delta G = Gp - Gr$, is positive

How does the cell run energetically unfavorable reactions?

- Couples energetically unfavorable reaction to an energetically favorable reaction
- Glutamic acid--->glutamine ΔG is +
- ATP----> ADP + Pi ΔG is -
- Coupling of these two reactions occurs on active site of enzyme

Activated carriers (such as ATP) are used by the cell to couple chemical reactions

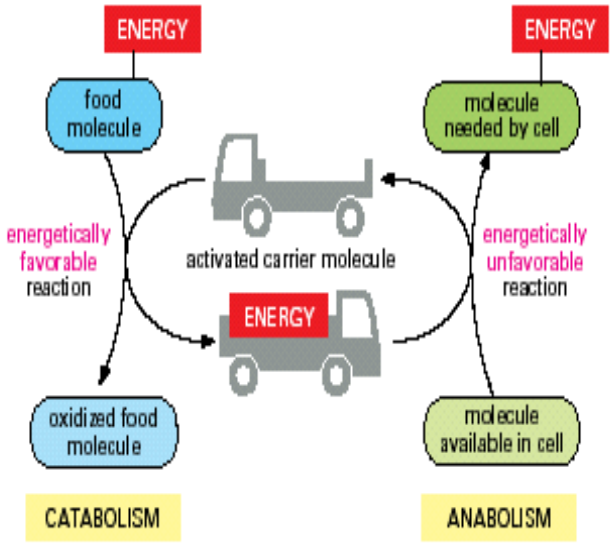

Figure 3-30

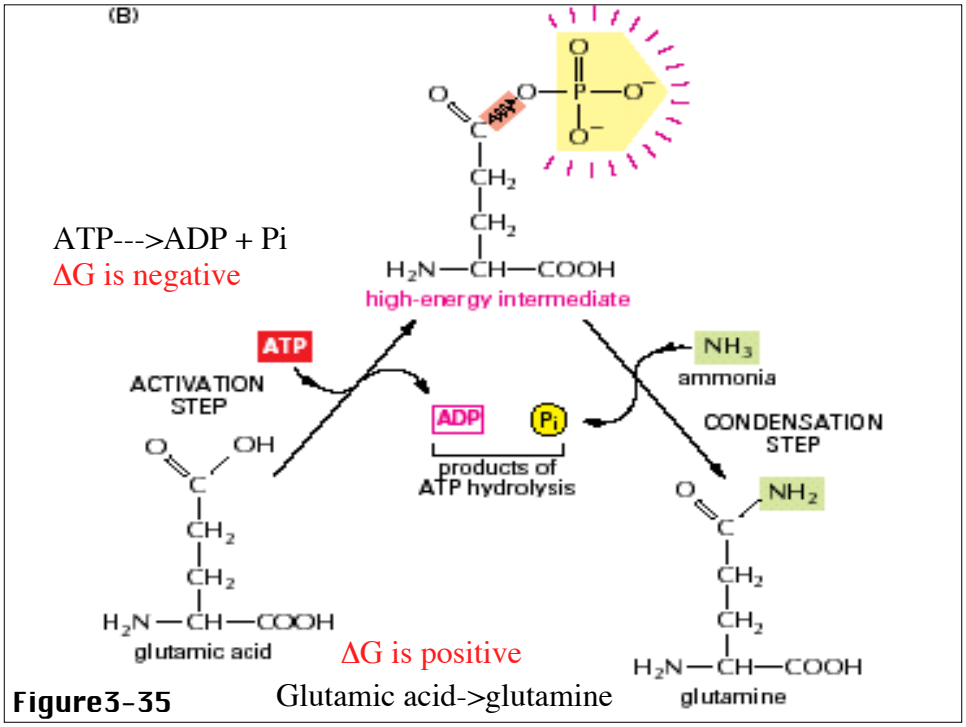

Figure3-35

Polysaccharide Synthesis coupled to NTP hydrolysis

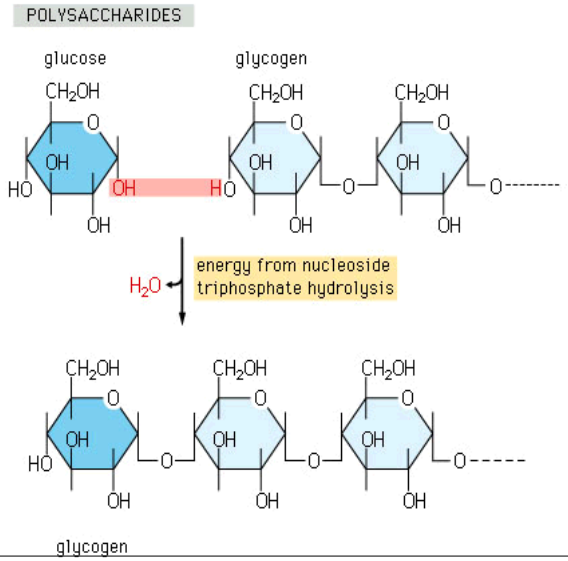

Figure3-40

Protein Synthesis coupled to NTP hydrolysis (NTP--->NDP +Pi) (N=A/G)

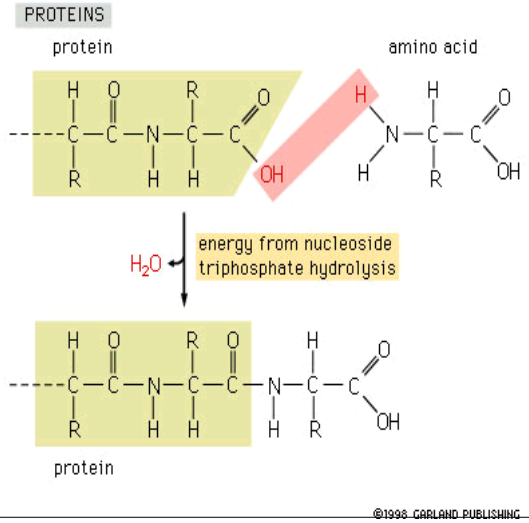

Figure3-40

Nucleic Acid Synthesis coupled to NTP hydrolysis (NTP-->NMP +PPi)

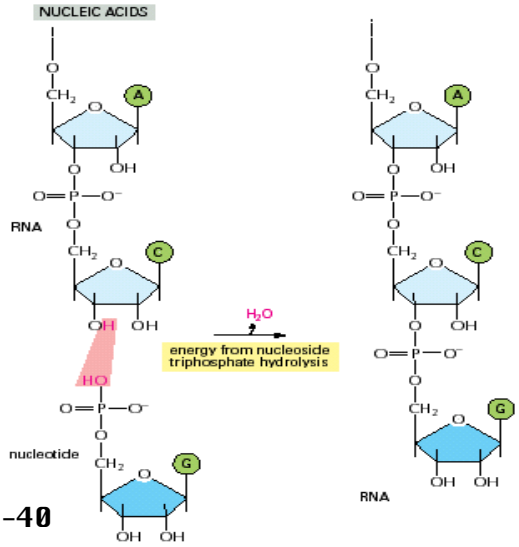

Figure3-40