Energy and Chemical Reactions
Chapter 5 - a

- Chemical Reactions
- Forms of Energy
- Laws of Thermodynamics
- Energy and Chemical Reactions
- ATP – an energy carrier

Chemical Reactions

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

Reactants Products

•Chemical reactions are the rearrangement of chemical bonds

•Note the reaction is “balanced” – it has the same number and types of atoms on each side of the arrow

Chemical Reactions are reversible

$$2\,H_2 + O_2 \longleftrightarrow 2\,H_2O$$

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

Reactants — Products

$$2\,H_2O \longrightarrow 2\,H_2 + O_2$$

Reactants — Products

2 Concerns with Chemical Reactions

- What Direction does the reaction run?
  -Involves Energy
- How fast is the chemical reaction?
  - Involves Energy

Forms of Energy

- Kinetic Energy
  - Movement
  - Thermal energy
  - Light energy
- Potential Energy
  - Positional energy
  - Chemical energy

First Law of Thermodynamics

Law of Conservation of Energy

- Energy can be neither created nor destroyed, but can be transformed from one form into another.
- Implication – must account for source and fate of all energy in biological systems

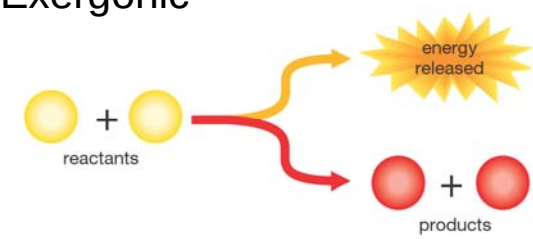
(a) First law of thermodynamics (b) Second law of thermodynamics

Second Law of Thermodynamics

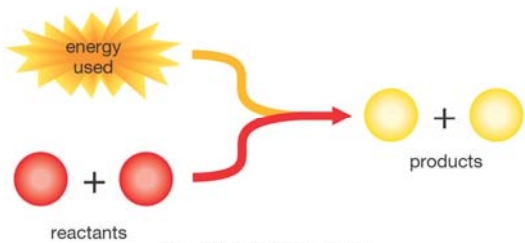
- Law of Entropy
- Entropy (disorder) is tends to increase in closed systems
- “For a process to occur spontaneously, it most increase the entropy of the universe.”
- Tells us the direction of the universe

Chemical Reactions and Energy

Exergonic



Endergonic



Heat

$2\ H_2 + O_2 \rightarrow 2\ H_2O$

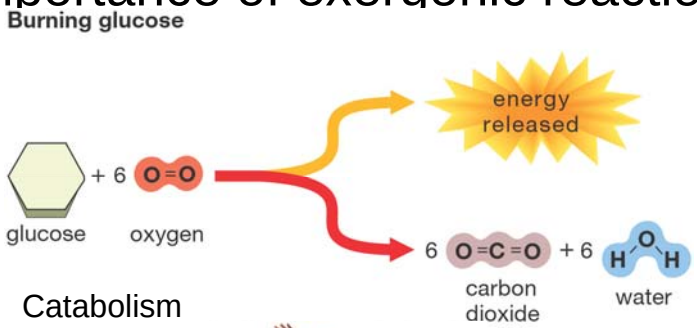
Motion +Heat

$2\ H_2 + O_2 \rightarrow 2\ H_2O$

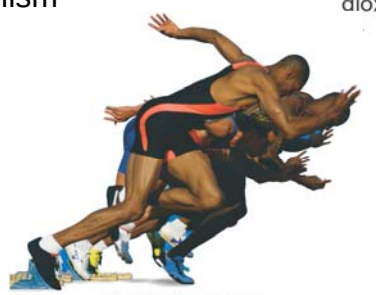
$2\ H_2O \rightarrow 2\ H_2 + O_2$

Electricity

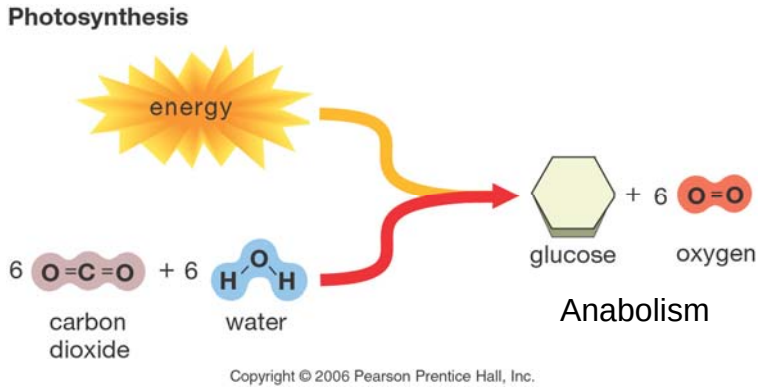
Importance of exergonic reactions



Catabolism



Importance of Endergonic Reactions



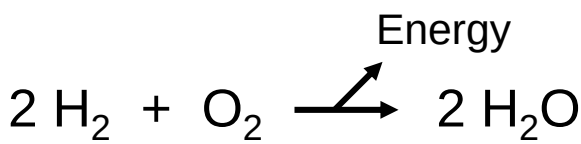
2 Concerns with Chemical Reactions

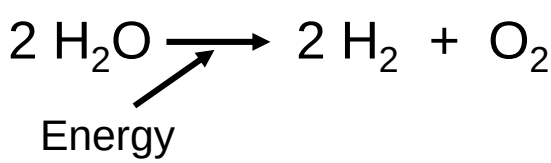
- What Direction does the reaction run?
- How fast is the chemical reaction?

What direction does a chemical reaction run?

- 2nd Law of thermodynamics
  - Generally chemical energy has more order (less entropy) than heat energy
    - Exergonic reactions go forward – release heat
      "Spontaneous Reactions"
    - Endergonic reaction go forward only if provided with excess energy - inefficient

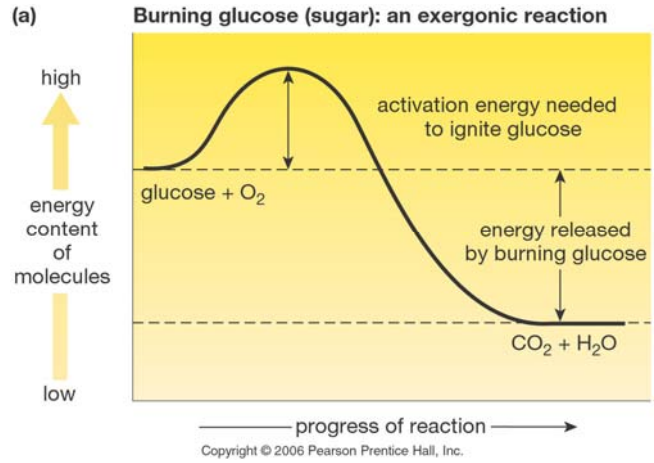
Which reaction is spontaneous?



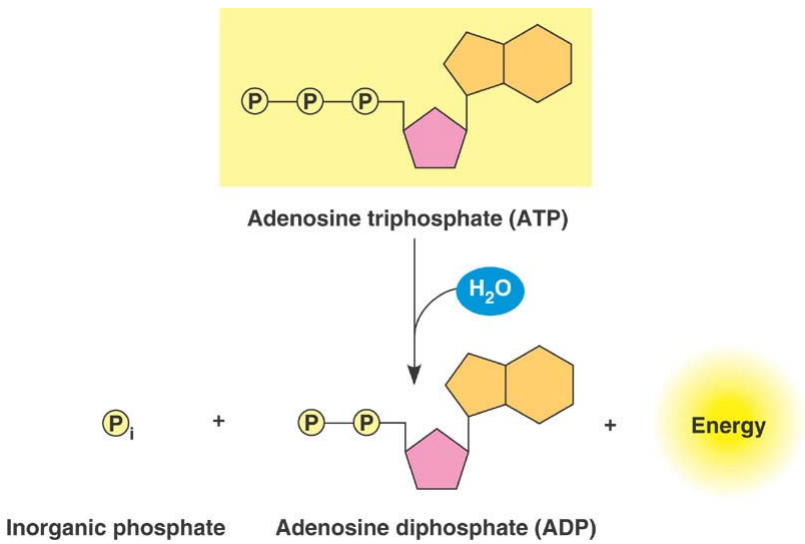


How fast does a chemical reaction run?

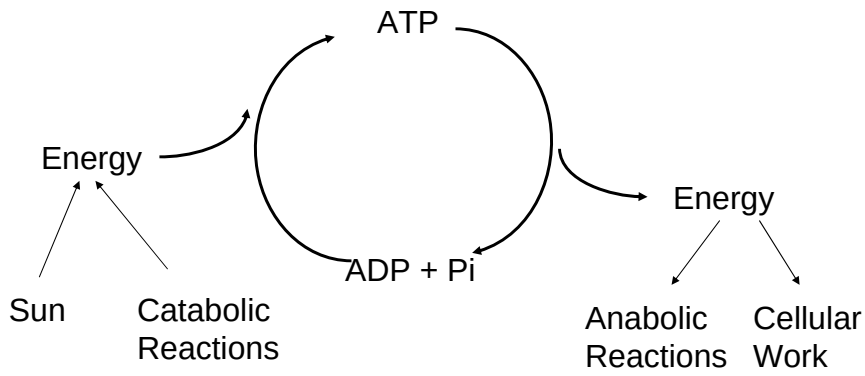
- Activation Energy



ATP Hydrolysis



ATP Cycle


ATP
Energy
Energy
ADP + Pi
Sun
Catabolic Reactions
Anabolic Reactions
Cellular Work