**BIOENERGETICS**

Functions of energy in the cell:
- biosynthesis (anabolism)  
- mechanical work  
- concentration work  
- electrical work  
- heat energy  
- bioluminescence

Source of that energy?: **Phototrophs vs chemotrophs**  
See pict on p 110 for overview of energy flow in biosphere

chemotrophs depend on catabolic pathways to yield energy:
1) **fermentation**: breaking bonds without oxidation  
   terminal H acceptor is organic
2) **respiration**: involving oxidation  
   terminal H acceptor is inorganic

**NOTE:** Respiration may or may not require O₂ = aerobic, or not: anaerobic (S, N, etc can accept H)

Not 100% efficient: lose heat, and increase in disorder of system (entropy)

**THERMODYNAMICS** ("heat" + "power"): laws involving energy transactions

**FIRST LAW OF THERMODYNAMICS:**
Conservation of energy: total energy in universe is constant (matter cannot be destroyed)  
Internal energy = E = stored within a system, (not directly measurable)
In biology use enthalpy = H = (inner warmth or heat), the heat content: ∆H = ∆E + ∆(PV)
(Note that enthalpy = E if no change in P or V)
During spontaneous reaction, usually exothermic (heat released) = -∆H  
Glucose burnt yields 673 kcal:  
Glucose burnt yields 673 kcal: ∆E = -673 Kcal  
opposite for synthesis of glucose ∆E = +673 Kcal

**take home lesson:** A negative ∆H favors spontaneity.

**SECOND LAW OF THERMODYNAMICS:**
Entropy [S] in the universe is increasing. (Universe tends towards disorder.)
**Take home lesson:** A positive ∆S favors spontaneity.
**DEMO:** Dissolve ammonium acetate (or nitrate) in water, note temp change.

**Gibbs free energy** includes both internal energy and entropy, is **predictor of spontaneity**:

\[ \Delta G = \Delta H + T \Delta S \]  
\[ (T = \text{temp in Kelvin}) \]

\[ \Delta G = \Delta H - T \Delta S \]
predicts spontaneity of a chemical reaction  
(note that at absolute zero K, ∆H (or ∆E) predicts spontaneity)

**take home lesson:** All spontaneous reactions have a negative ∆G

**Glucose-6-PO₄ → Fructose-6-PO₄:**
Kₐq indicates direction of rxn: = products = [F-6-P] = 1  
(At equilibrium) reactants [G-6-P] 2

What would be the size of Kₐq, a favorable reaction? = large  
(reverse rxn Kₐq small)

*I.e., F-6-P to G-6-P has Keq of 2.0*