

BIOENERGETICS

10/8/91, rvsd 10/4/93, 10/2/95, 2 Oct 00, 4 Oct 2004, 1 October 2007, 6Oct08, 5Oct09, 6Oct10, 5Oct11
 BKH, 4th: p 110-133, 5th: 106-126, 6th: 105-124, 7th: 106-124

Functions of energy in the cell: biosynthesis (anabolism) (p. 107)
 mechanical work
 concentration work
 electrical work
 heat energy
 bioluminescence

Source of that energy?: **Phototrophs vs chemotrophs** (p. 110)
 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
 biological thermodynamics = *bioenergetics*

FIRST LAW OF THERMODYNAMICS:

Conservation of energy: total energy in universe is constant (p. 113)

Internal energy = E = stored within a system, (not directly measurable)
In biology use enthalpy = H = (inner warmth or heat), the heat content: $\Delta H = \Delta E + \Delta(PV)$
 (Note that enthalpy = E if no change in P or V)

During spontaneous reaction, usually

exothermic (heat released) = $-\Delta H$ (Negative ΔH means heat is lost from the system)

Glucose burnt yields 673 kcal: $\Delta E = -673$ Kcal

opposite for synthesis of glucose $\Delta E = +673$ Kcal

take home lesson: **A negative ΔH favors spontaneity.**

SECOND LAW OF THERMODYNAMICS:

Entropy in the universe is increasing. (Universe tends towards disorder.)

Take home lesson: **A positive ΔS favors spontaneity.**

DEMO: ammonium acetate dissolving.

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

$\Delta H = \Delta G + T\Delta S$ (T = temp in Kelvin)

$\Delta G = \Delta H - T\Delta S$ predicts spontaneity of a chemical reaction

(note that at absolute zero K, ΔH (or ΔE) predicts spontaneity)

take home lesson: **All spontaneous reactions have a negative ΔG**

K_{eq} indicates direction of rxn: = $\frac{\text{products}}{\text{reactants}} = \frac{[F-6-P]}{[G-6-P]} = \frac{1}{2}$
 (At equilibrium)

What would be the size of K_{eq} a favorable reaction? = **large**
 (reverse rxn K_{eq} small)

I.e., F-6-P to G-6-P has K_{eq} of 2.0

