MCB102 SPRING 2008 METABOLISM SYLLABUS -- Prof. Bryan Krantz
Class Time: MWF 11-12
Room: 155 Dwinelle

Lehninger
Principles of Bochemistry
Nelson & Cox 5th ed.

Office Hours: TT 3-4
476 Stanley Hall
Telephone: 666-2788
Email: bakrantz@berkeley.edu

LEC	DATE	SUBJ	CH
1	FRI APR 11	METABOLISM & BIOENERGETICS	13
2	MON APR 14	GLYCOLYSIS	14
3	WED APR 16	GLYCOLYSIS	14
4	FRI APR 18	GLYCOLYSIS FEEDER PATHWAYS & GLUCONEOGENSIS	14
5	MON APR 21	PENTOSE PHOSPHATE PATHWAY	14
6	WED APR 23	GLYCOGEN METABOLISM	15
7	FRI APR 25	METABOLIC REGULATION	15
8	MON APR 28	CITRIC ACID CYCLE	16
9	WED APR 30	CITRIC ACID CYCLE/FATTY ACID CATABOLISM	17
10	FRI MAY 2	AMINO ACID DEGRADATION	18
11	MON MAY 5	OXIDATIVE- & PHOTO-PHOSPHORYLATION	19
12	WED MAY 7	CALVIN CYCLE	20
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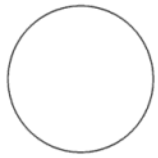
14	MON MAY 12	NUCLEOTIDE SYNTHESIS & DEGRADATION	
		METHIONINE BIOSYNTHESIS & UTILIZATION	22
FINAL	SAT MAY 17	EXAM AT 12:30-3:30 IN WHEELER AUD	

Lecture notes: Notes will be posted on bspace and at http://mcb.berkeley.edu/labs/krantz/mcb102.html in empty and filled-out form. Usually, the empty notes will be there the night or morning before lecture.

Bryan Krantz: University of California, Berkeley
MCB 102, Spring 2008, Metabolism Lecture 1
Reading: Ch. 13 of *Principles of Biochemistry*, "Bioenergetics and Biochemical Reaction Types."

METABOLISM & BIOENERGETICS

The energy that supports life originates from…



Autotrophs

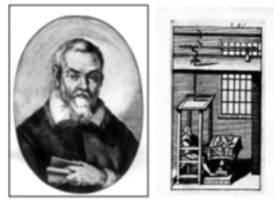
autos = self; ***trophe*** = nutrition

Heterotrophs

heterone = (an)other

Besides carbon, what other elements are converted to useable form(s) to support life?

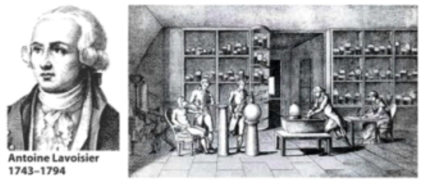
Metabolism - the set of chemical reactions that occur in the cell to maintain life.



Santorio Santorio (1561-1636)

"la respiration est donc une combustion"

Respiratory gas exchange is combustion, like a candle burning.



"Ferments" inside yeast catalyze fermentation.

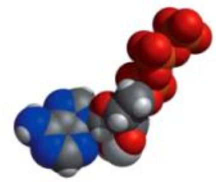
Enzymes come from cells – beginning of biochemistry

Louis Pasteur (1822–1895) / Eduard Buchner (1860-1917)

<u>Metabolism</u> - totality of the chemical reactions in the cell (biosphere) often catalyzed by protein enzymes.

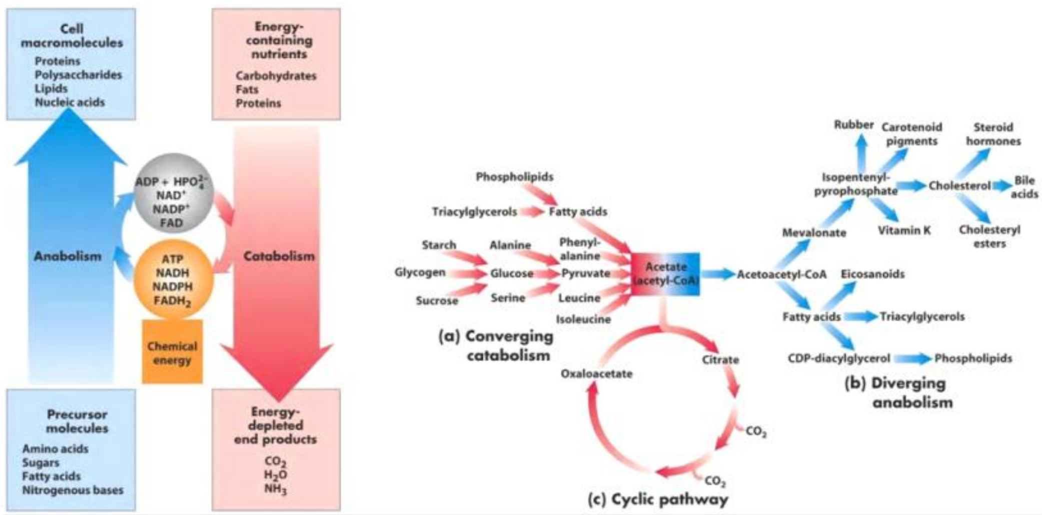
(A) <u>Catabolism</u> – "down"

(B) <u>Anabolism</u> – "up"



Metabolites – small molecules

Energy currencies of the cell are …



<u>Bioenergetics & Thermodynamics</u> – quantitative study of energy transduction in biology

Laws of Thermodynamics –

How is chemical energy released from food to make ATP?

Gibbs Free Energy Change, ΔG

UNITS

kcal/mol vs. kJ/mol

4.18 J = 1 cal

Kelvin

$$\Delta G = \Delta H - T\Delta S$$

Non-spontaneous **Spontaneous**

$$\Delta G = RT \ln K_{eq}$$

Why ΔG? Why not K_{eq}?

Standard Free Energy of Formation, ΔG^o

$\Delta G^o_{formation}$

Glucose -916 kJ/mol

Lactate -517 kJ/mol

Glucose → 2 Lactate

What is 'standard state'? And why do biochemists use, $\Delta G^{o\prime}$?

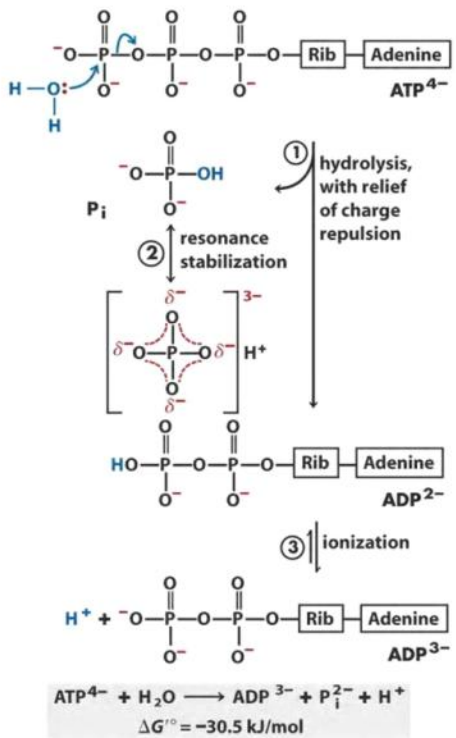
Quantifying Free Energy Changes under Non-standard Conditions

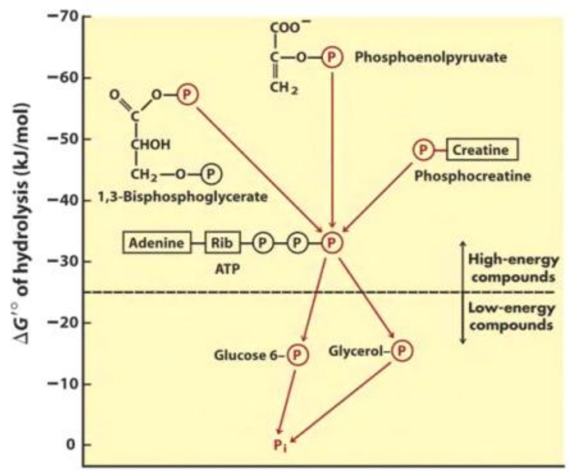
$$\Delta G = \Delta G^{o} - RT \ln Q$$

Q is the reaction quotient (mass-action ratio): $Q = ([C]^{c} [D]^{d}) / ([B]^{b} [A]^{a})$

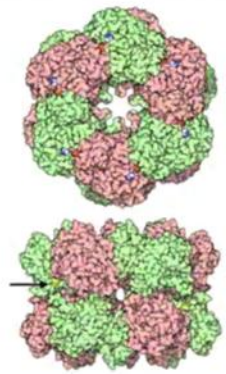
ATP

Why is ATP the energy currency in the cell?



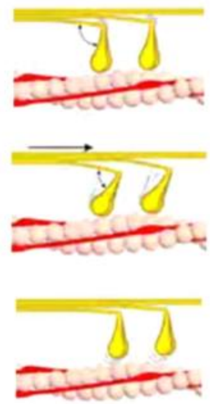


How may ATP be used to do useful work?



Glutamate + ATP + NH_3 → Glutamine + ADP + phosphate

luciferin + ATP → luciferyl adenylate + PP_i
luciferyl adenylate + O_2 → oxyluciferin + AMP + light



ATP hydrolysis coupled to myosin movement along actin filaments

Redox: Quantifying Metabolic Energy Transduction & Electron Flow

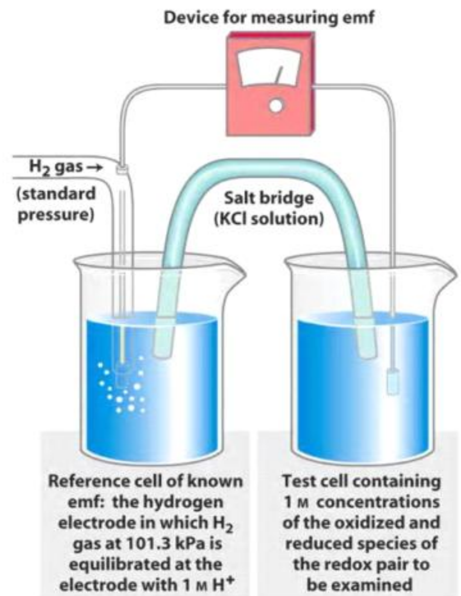
Reduction/oxidation reaction

Electron transport

Nernst Equation

$$E = E^{o'} - RT/nF \ln[e^- \text{ acceptor}]/[e^- \text{ donor}]$$

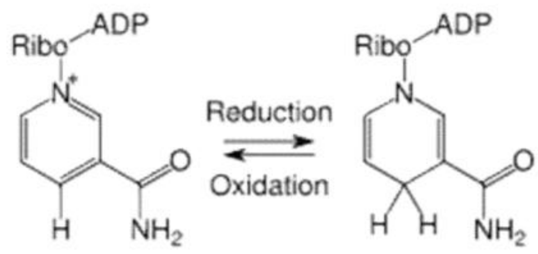
E **(the redox potential) is basically the voltage required to stop a chemical reaction**



Relation of Standard Redox Potential Change to $\Delta G^{o'}$

$$\Delta G^{o'} = -nF\ \Delta E^{o'}$$

Nicotinamide adenine dinucleotide (NAD^+)



$$NAD^+ + H^+ + 2e^- \longrightarrow NADH$$

TABLE 13–7 Standard Reduction Potentials of Some Biologically Important Half-Reactions, at pH 7.0 and 25°C (298 K)

Half-reaction	E'° (V)
$\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$	0.816
$Fe^{3+} + e^- \longrightarrow Fe^{2+}$	0.771
$NO_3^- + 2H^+ + 2e^- \longrightarrow NO_2^- + H_2O$	0.421
Cytochrome *f* (Fe^{3+}) + e^- ⟶ cytochrome *f* (Fe^{2+})	0.365
$Fe(CN)_6^{3-}$ (ferricyanide) + e^- ⟶ $Fe(CN)_6^{4-}$	0.36
Cytochrome a_3 (Fe^{3+}) + e^- ⟶ cytochrome a_3 (Fe^{2+})	0.35
$O_2 + 2H^+ + 2e^- \longrightarrow H_2O_2$	0.295
Cytochrome *a* (Fe^{3+}) + e^- ⟶ cytochrome *a* (Fe^{2+})	0.29
Cytochrome c (Fe^{3+}) + e^- ⟶ cytochrome c (Fe^{2+})	0.254
Cytochrome c_1 (Fe^{3+}) + e^- ⟶ cytochrome c_1 (Fe^{2+})	0.22
Cytochrome *b* (Fe^{3+}) + e^- ⟶ cytochrome *b* (Fe^{2+})	0.077
Ubiquinone + $2H^+ + 2e^-$ ⟶ ubiquinol + H_2	0.045
Fumarate^{2-} + $2H^+ + 2e^-$ ⟶ succinate^{2-}	0.031
$2H^+ + 2e^- \longrightarrow H_2$ (at standard conditions, pH 0)	0.000

Source: Data mostly from Loach, P.A. (1976) In *Handbook of Biochemistry and Molecular Biology*, 3rd edn (Fasman, G.D., ed.), *Physical and Chemical Data*, Vol. I, pp. 122-130, CRC Press, Boca Raton, FL.

* This is the value for free FAD; FAD bound to a specific flavoprotein (for example succinate dehydrogenase) has a different E'° that depends on its protein environments.

TABLE 13–7 Standard Reduction Potentials of Some Biologically Important Half-Reactions, at pH 7.0 and 25°C (298 K)

Half-reaction	E'° (V)
$2H^+ + 2e^- \longrightarrow H_2$ (at standard conditions, pH 0)	0.000
Crotonyl-CoA + $2H^+ + 2e^-$ ⟶ butyryl-CoA	−0.015
Oxaloacetate^{2-} + $2H^+ + 2e^-$ ⟶ malate^{2-}	−0.166
Pyruvate$^-$ + $2H^+ + 2e^-$ ⟶ lactate$^-$	−0.185
Acetaldehyde + $2H^+ + 2e^-$ ⟶ ethanol	−0.197
$FAD + 2H^+ + 2e^- \longrightarrow FADH_2$	−0.219*
Glutathione + $2H^+ + 2e^-$ ⟶ 2 reduced glutathione	−0.23
$S + 2H^+ + 2e^- \longrightarrow H_2S$	−0.243
Lipoic acid + $2H^+ + 2e^-$ ⟶ dihydrolipoic acid	−0.29
$NAD^+ + H^+ + 2e^- \longrightarrow NADH$	−0.320
$NADP^+ + H^+ + 2e^- \longrightarrow NADPH$	−0.324
Acetoacetate + $2H^+ + 2e^-$ ⟶ β-hydroxybutyrate	−0.346
α-Ketoglutarate + $CO_2 + 2H^+ + 2e^-$ ⟶ isocitrate	−0.38
$2H^+ + 2e^- \longrightarrow H_2$ (at pH 7)	−0.414
Ferredoxin (Fe^{3+}) + e^- ⟶ ferredoxin (Fe^{2+})	−0.432

Source: Data mostly from Loach, P.A. (1976) In *Handbook of Biochemistry and Molecular Biology*, 3rd edn (Fasman, G.D., ed.), *Physical and Chemical Data*, Vol. I, pp. 122-130, CRC Press, Boca Raton, FL.

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