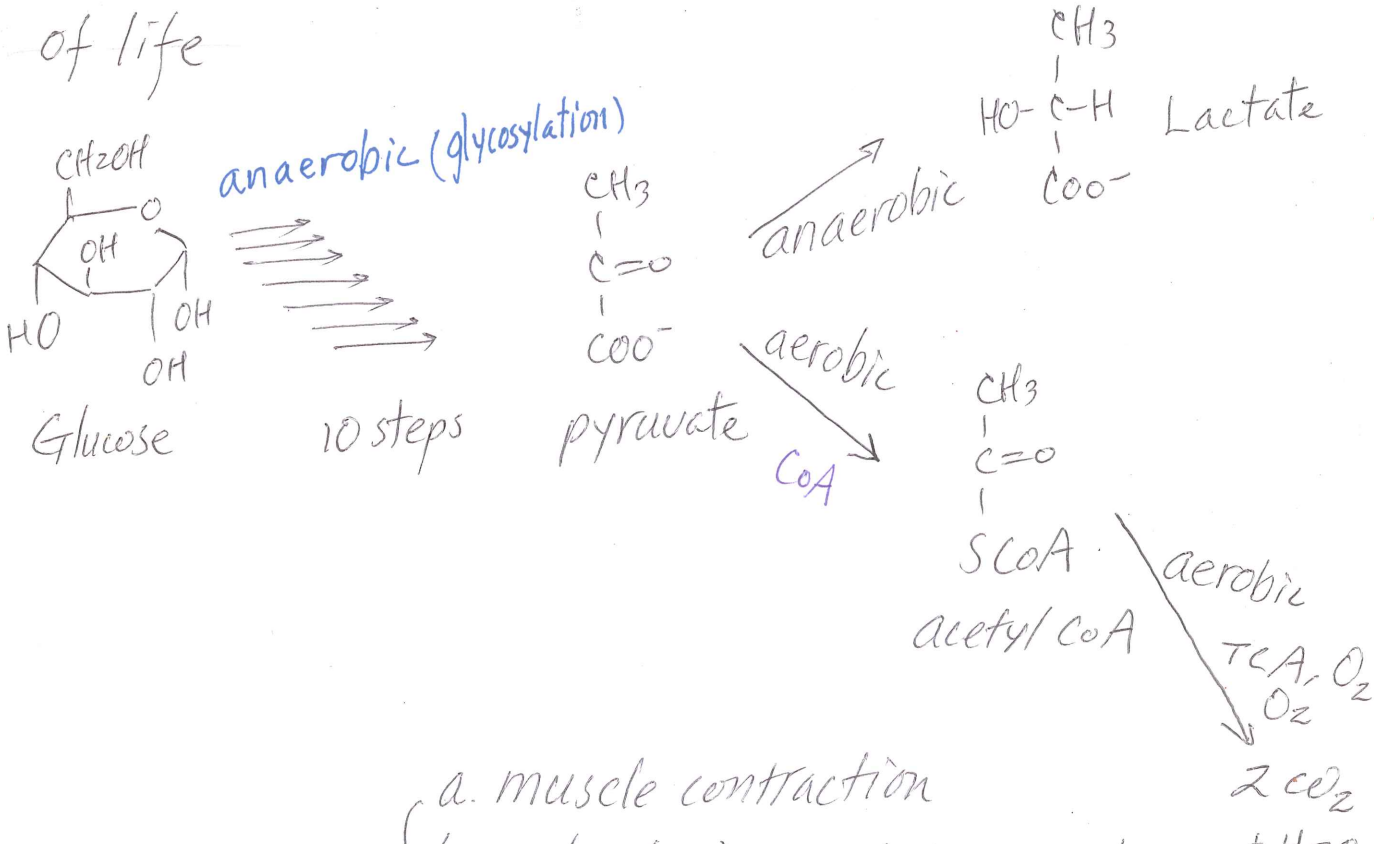
Chapter 15: Metabolism: Basic concepts and design

Chapter 15: Metabolism

I. Introduction (How does a cell extract energy from its environment?)

1. Metabolism has a coherent Design containg many common motif ATP, NADH, $FADH_2$, CoA
2. E. coli has 1,000 chemical reaction
3. about 100 molecules play central roles in all forms of life
4. 

5. Energy (ATP) { a. muscle contraction; b. molecules & ions' transport; c. synthesis of biomolecules
6. photo synthetic organism (phototrophs) use sunlight
   Animals (chemotrophs) gaining energy by oxidation of foodstuffs.

光营：藉光合作用提供营养之生物
Chloroplast 叶绿体
化能自营
从化学键氧化而获得能量之生物

7. Fuel (carbohydrates. fat) $\xrightarrow{\text{catabolism}}$ $CO_2 + H_2O + Energy$

分解代謝(異化作用)

$Energy + precursors \xrightarrow{\text{Anabolism}}$ glucose, fat, DNA, protecns

同化作用

將前趨物經多步驟轉變為複雜分子

amphibolic: both

3. 8. Thermodynamics (Free Energy)

$$A + B \longrightarrow C + D$$

$$\Delta G = \Delta G^\circ + RT \ln \frac{[C][D]}{[A][B]}$$

ΔG: Free energy change

ΔG°: Standard free energy

$\frac{[C][D]}{[A][B]}$: concentration

$\Delta G < 0$ spontaneously occurs (left to right)

$\Delta G = 0$ at Equilibrium

$\Delta G > 0$ reverse rxn spontaneously occurs

$A \rightleftharpoons B + C \quad \Delta G = 5$ Kcal/mole

$B \rightleftharpoons D \quad \Delta G = -8$ Kcal/mole

) coupled

$A \rightleftharpoons C + D \quad \Delta G = -3$ Kcal/mole

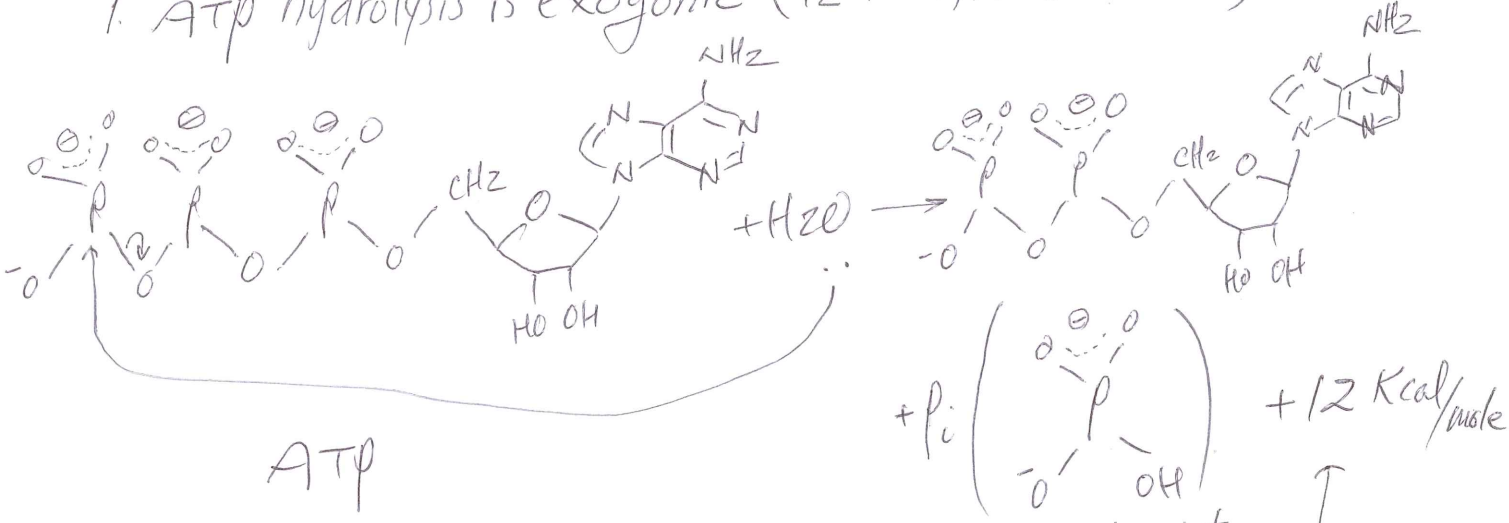
Unfavorable rxn can be driven by a thermodynamically favorable rxn by coupling together.

A thermodynamically ($A \to B+C$) favorable rxn ($B \to D$)

4. II. ATP is the Universal Currency of Free energy in Biological System

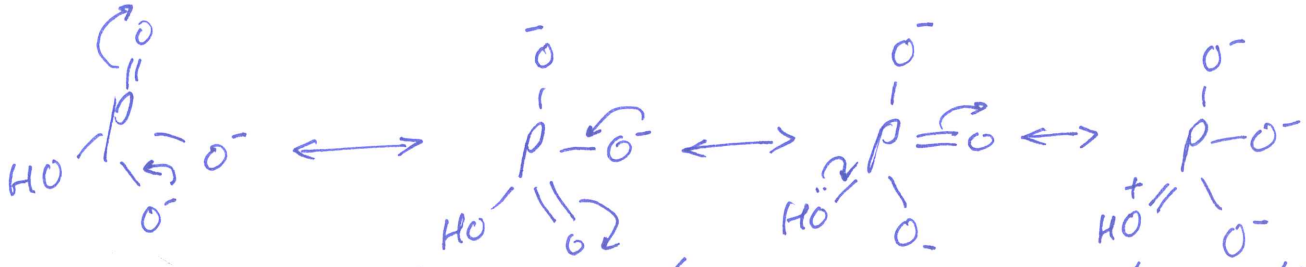
(for motion, active transport, biosynthesis)

1. ATP hydrolysis is exogonic (12 Kcal/mole in cell)



ATP: high phosphoryl-transfer potential, due to

a. Resonance stabilization. Pi (Orthophosphate)

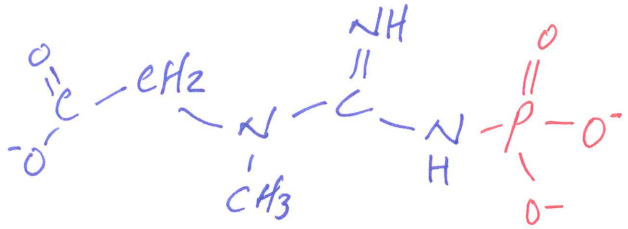


b. Electrostatic Repulsion: ATP carry 4 negative charges

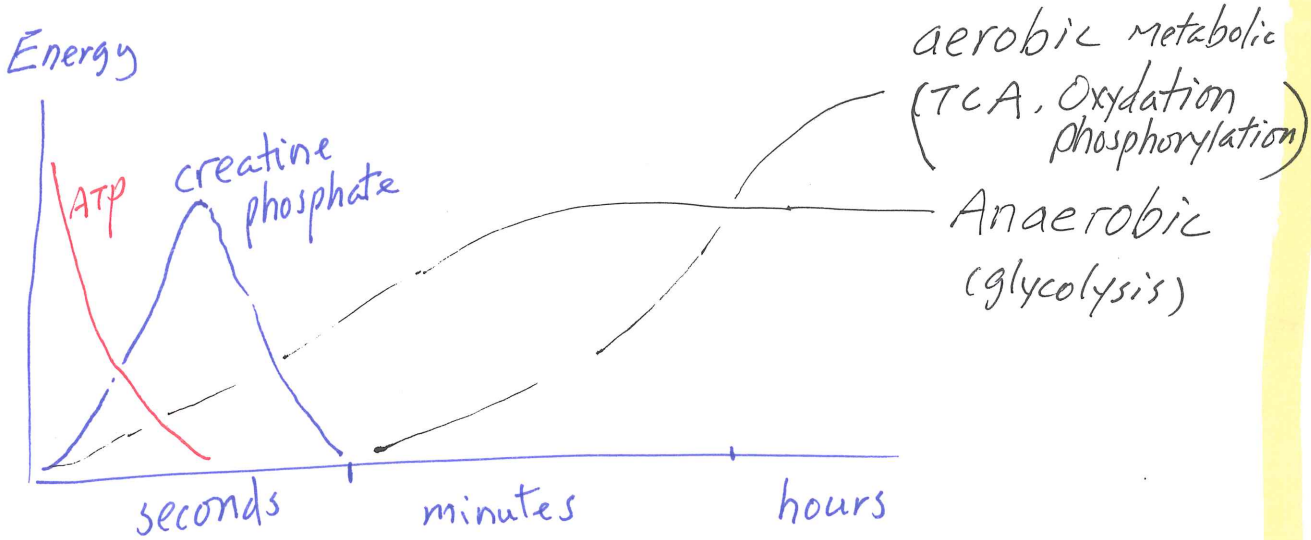
c. Hydration: More H2O can bind to ADP & Pi

High-phosphoryl-transfer compounds

ATP &

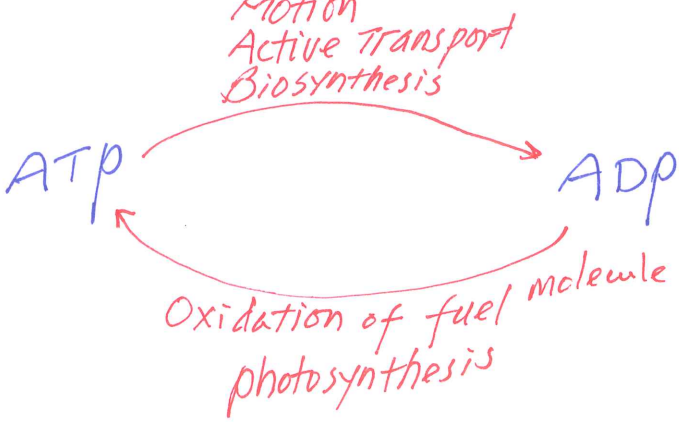


creatine phosphate



Source of ATP during excercise

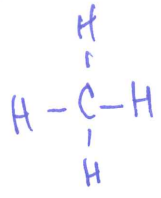
Oxidation of carbon fuel ⟶ Source of cellular Energy

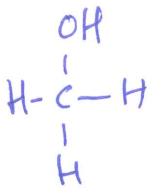


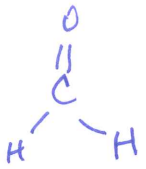
Total body of ATP ⟶ 0.1 Kg, but turnover rate is fast,
consumes 40Kg ATP in a day
in strenuous excertion, 0.5Kg/minute, 60Kg in 2 hours

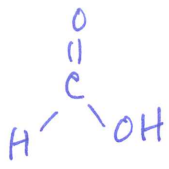
Efficient Fuel

5.

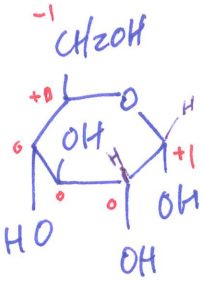




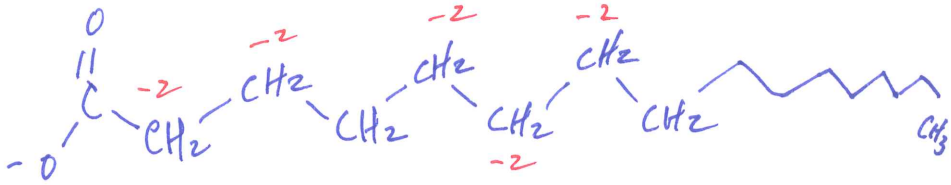




oxidation number	-4	-2	0	+1	+4
$\Delta G^{\circ\prime}$	-196	-168	-125	-68	0



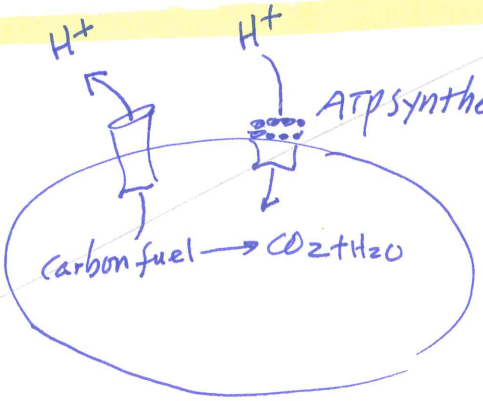
Glucose



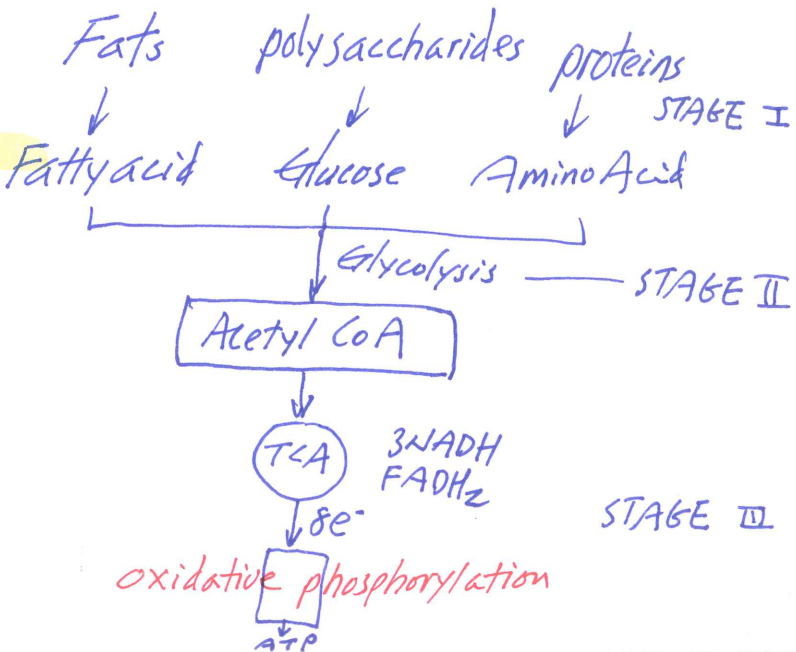
Fat

more efficient fuel

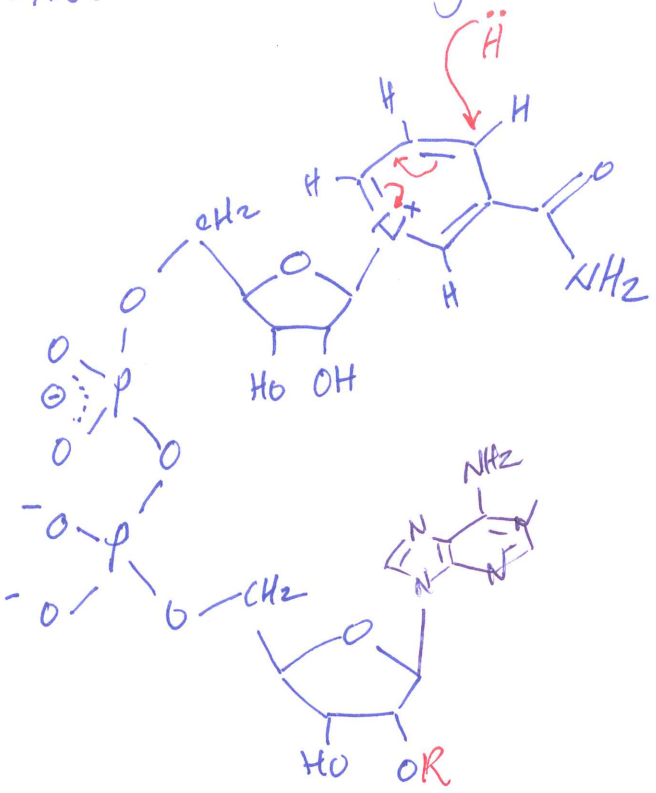
Ion Gradient Across Membrane



Energy from foodstuff



6. Metabolics contains many molecules

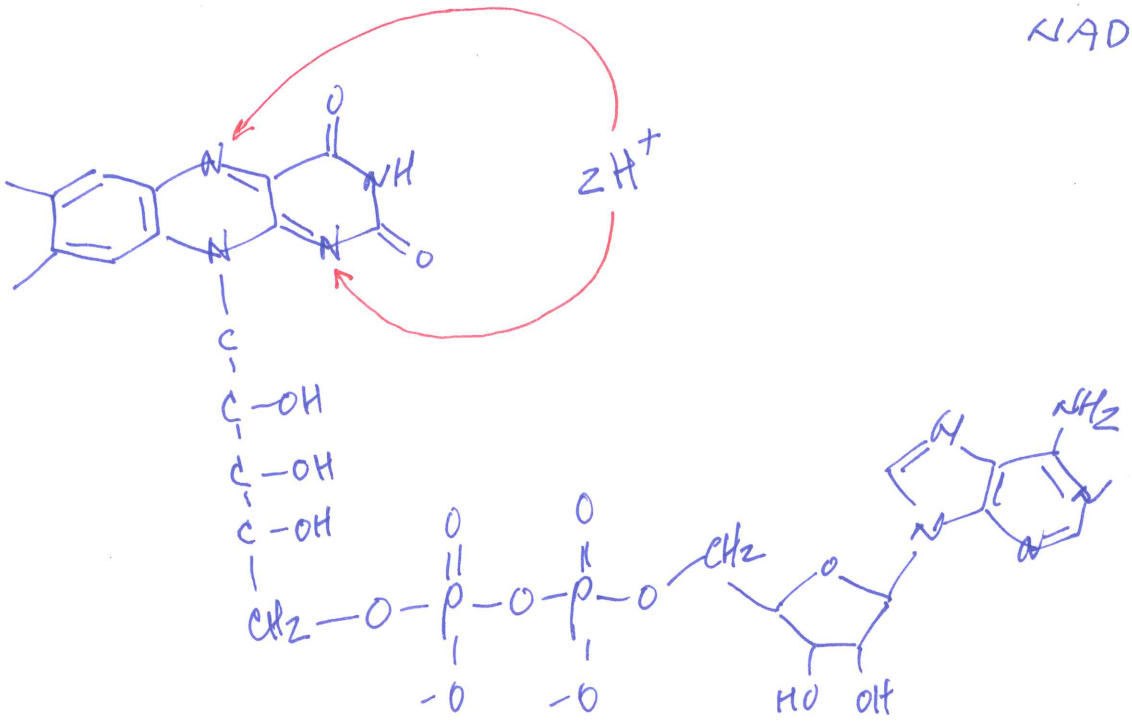


Nicotinamide Adenine Dinucleotide (NAD+)

Oxidize agent

↓ $H:^{\ominus}$

NADH

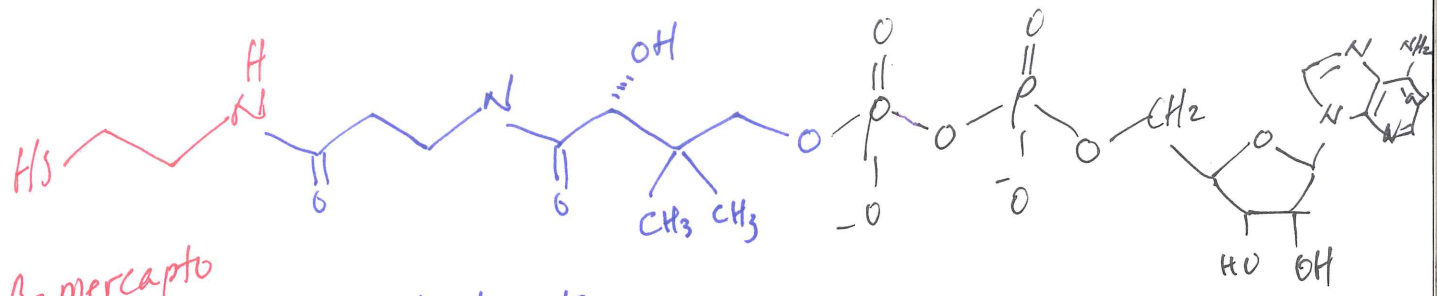


Flavin adenine dinucleotide (FAD)

oxidation reagent

↓

$FADH_2$



β-mercapto ethylamine

pantothenate

ADP

Coenzyme A

ADP is an ancient module in Metabolism

ATP

NADH

FAD

Coenzyme A