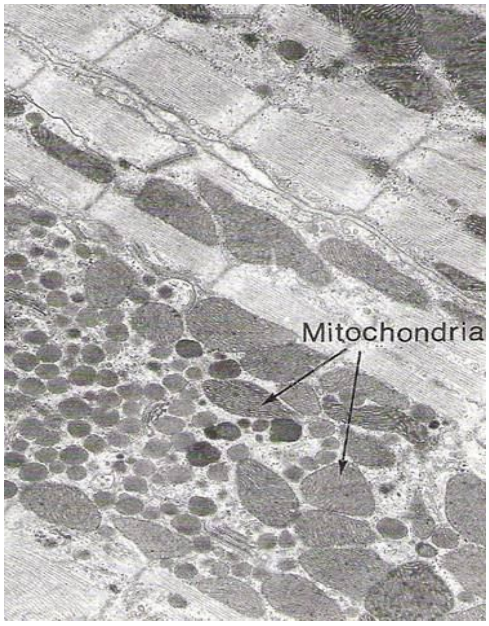
Metabolic Design & Energy Systems



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Why are protons important?

A **proton** (H^+) is a hydrogen atom that has lost its electron.

The concentration of protons ($[H^+]$) in solution determines the acidity of the solution, and is represented numerically by the negative log of the $[H^+]$

($pH = -\log [H^+]$)

Thus, ***a low pH represents high acidity***, and vice-versa.

Cellular pH is important to maintain (7.0 at rest), for when pH falls too far (< 6.8), electrons are forced to leave certain molecules. For proteins (eg. enzymes), this occurrence can alter the shape of the molecule, decreasing its effectiveness.

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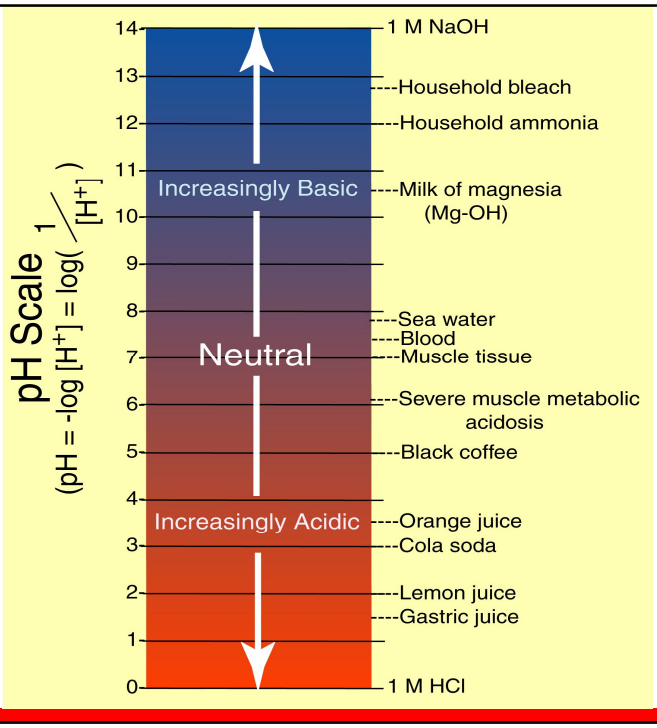
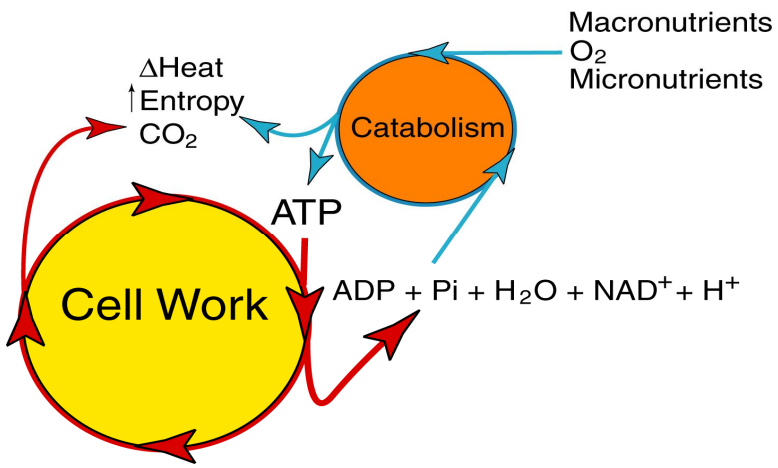
pH Scale and Examples

$[H^+]$ (M)	pH	$[OH^-]$ (M)	pOH
$10^0(1)$	0	10^{-14}	14
10^{-1}	1	10^{-13}	13
10^{-2}	2	10^{-12}	12
10^{-3}	3	10^{-11}	11
10^{-4}	4	10^{-10}	10
10^{-5}	5	10^{-9}	9
10^{-6}	6	10^{-8}	8
10^{-7}	7	10^{-7}	7
10^{-8}	8	10^{-6}	6
10^{-9}	9	10^{-5}	65
10^{-10}	10	10^{-4}	4
10^{-11}	11	10^{-3}	3
10^{-12}	12	10^{-2}	2
10^{-13}	13	10^{-1}	1
10^{-14}	14	$10^0(1)$	0

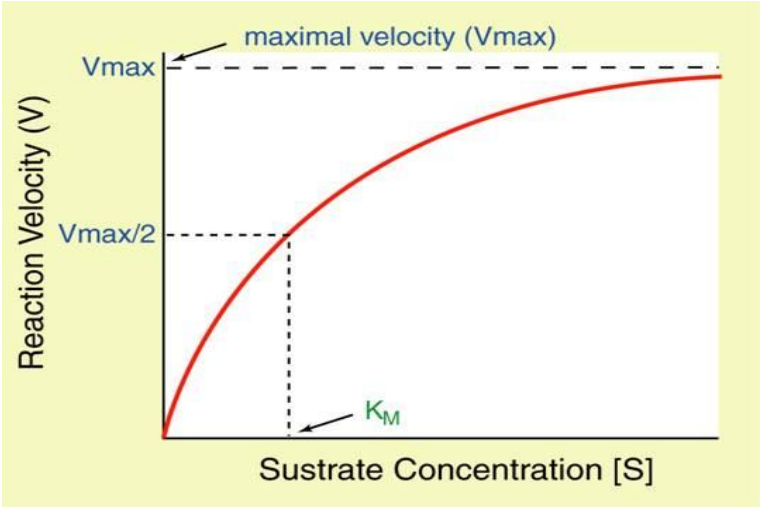




Some of the **exergonic** reactions of catabolism use ADP and ATP to "harness" free energy. ATP can then be used to provide the free energy needed to make *endergonic* reactions **exergonic** (eg. **COUPLING**), or produce work (eg. muscle contraction).

Enzymes

$$E + S \underset{\leftarrow k2}{\overset{k1\rightarrow}{\longleftrightarrow}} ES \xrightarrow{k3} E + P$$



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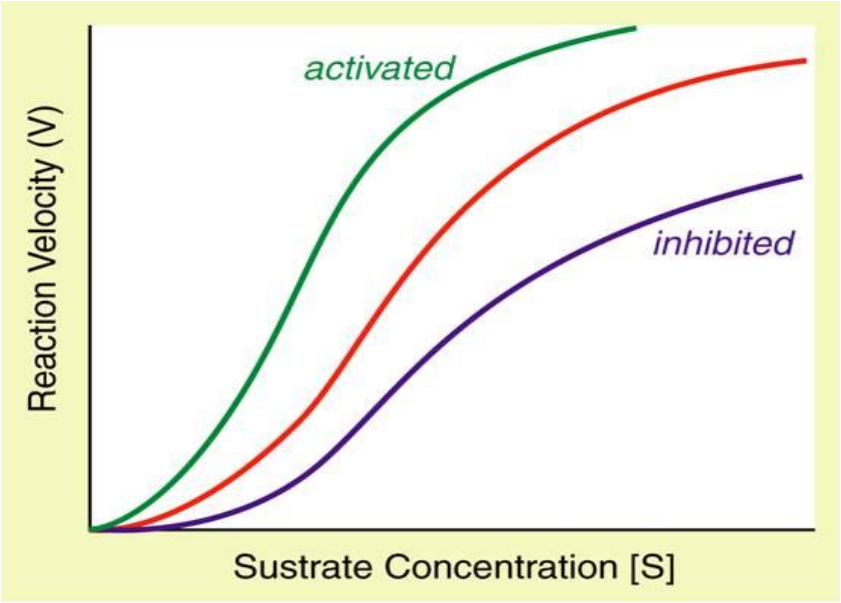

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Code	Name	Trivial Name(s)	Explanation
EC1	Oxidoreductases	*dehydrogenases and oxidases*	Oxidation-reduction reactions
EC2	Transferases	*transferases, phosphorylases, syntases, kinases and transaminases*	Transfer of functional groups (methyl, acyl, amino, phosphate) from one compound to another
EC3	Hydrolases	*lipases, esterases, hydrolases, phosphatases, -ases*	Formation of two products from a substrate by hydrolysis
EC4	Lyases	*variety*	Addition or removal of groups from substrates at C-C, C-N, C-O or C-S bonds
EC5	Isomerases	*isomerases, mutases, epimerases*	Intra-compound rearrangement
EC6	Ligases	*ligases, synthases, carboxylases*	Joining together of two compounds by new C-O, C-S, C-N, or C-C bonds

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Code	Name *(trivial)*	Enzymes
EC1	Oxidoreductases *(dehydrogenases and oxidases)*	Lactate dehydrogenase Glucose-6-phosphate dehydrogenase
EC2	Transferases *(transferases, phosphorylases, syntases, kinases and transaminases)*	Phosphorylase Pyruvate kinase Phosphofructokinase Hexokinase Adenylate kinase
EC3	Hydrolases *(lipases, esterases, hydrolases, phosphatases, -ases)*	Triacylglycerol lipase Glucose-6-phosphatase
EC4	Lyases *(variety)*	Pyruvate decarboxylase Citrate synthase Adenylate cyclase
EC5	Isomerases (isomerases, mutases, epimerases)	Phosphoglucomutase Phosphoglycerate mutase Glucose-6-phosphate isomerase
EC6	Ligases (ligases, synthases,	Fatty acyl-CoA ligase

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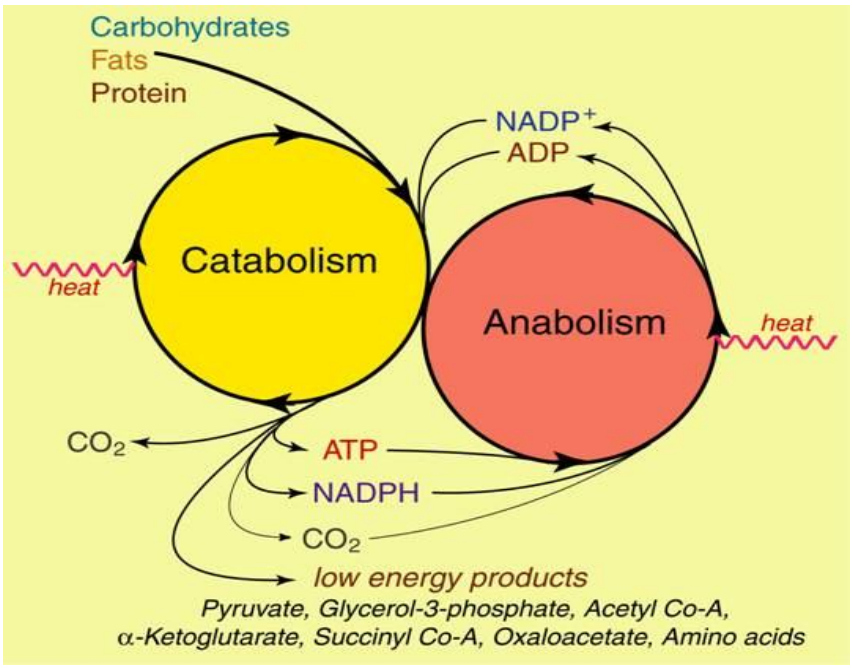
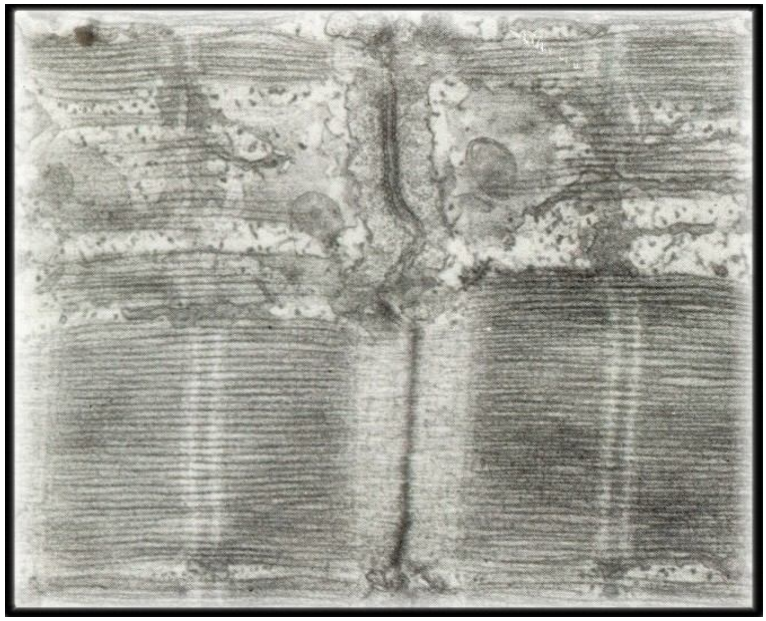
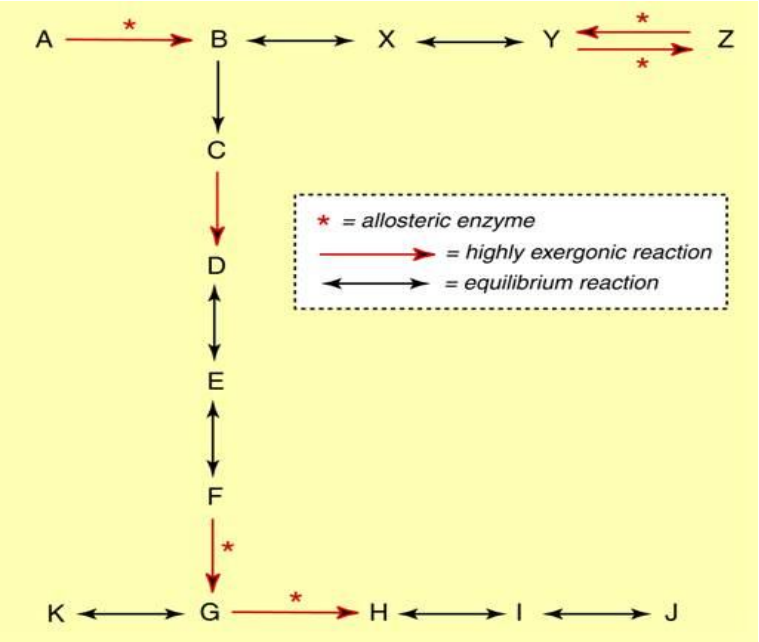

Carbohydrates
Fats
Protein
NADP+
ADP
Catabolism
heat
Anabolism
heat
CO2
ATP
NADPH
CO2
low energy products
Pyruvate, Glycerol-3-phosphate, Acetyl Co-A,
α-Ketoglutarate, Succinyl Co-A, Oxaloacetate, Amino acids

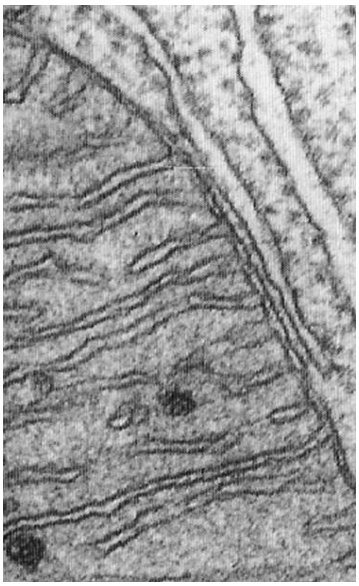
Phosphagen

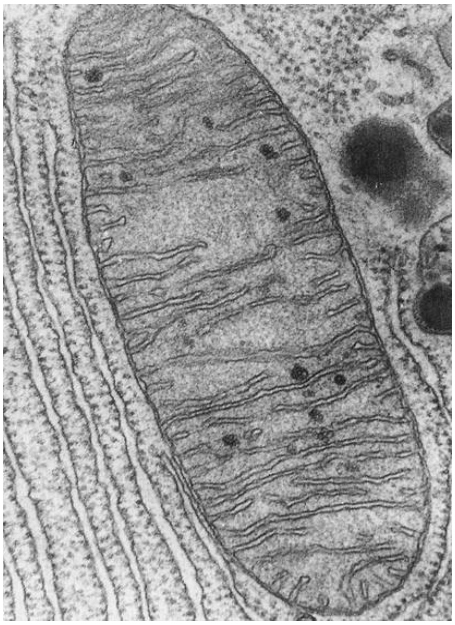


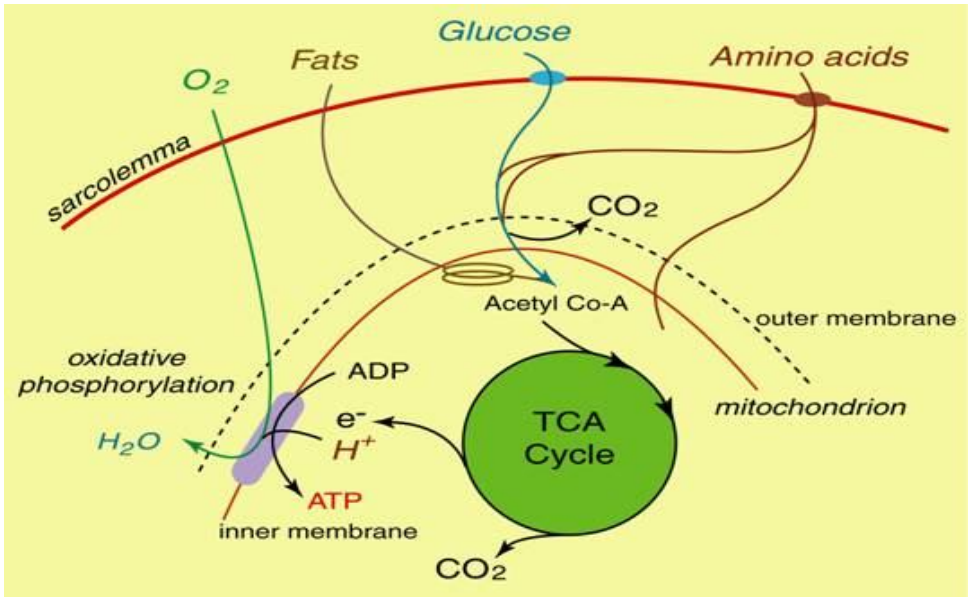
Glycolytic

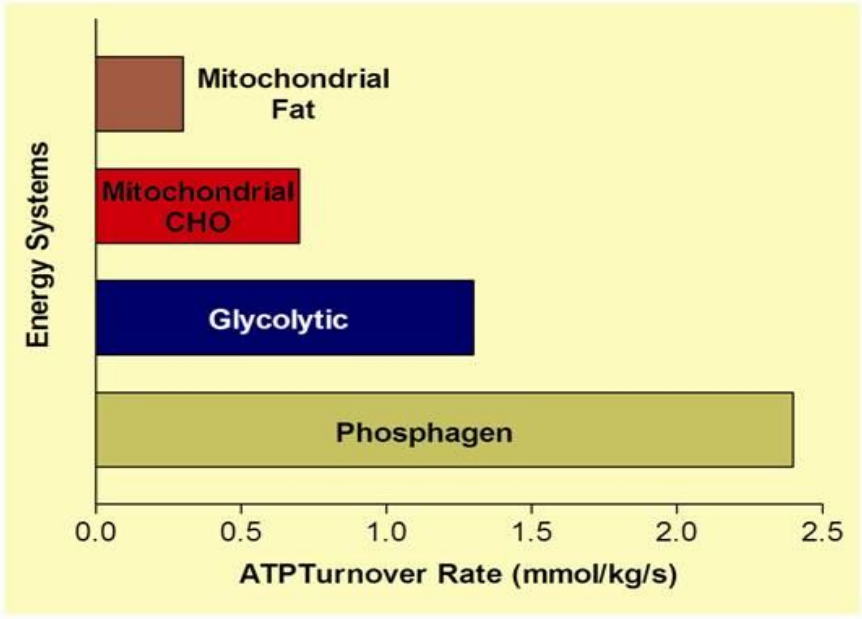


Mitochondrial Respiration






Glucose
Fats
Amino acids
O_2
sarcolemma
CO_2
Acetyl Co-A
outer membrane
oxidative
phosphorylation
ADP
mitochondrion
e^-
H^+
TCA
Cycle
H_2O
ATP
inner membrane
CO_2


Mitochondrial
Fat
Mitochondrial
CHO
Glycolytic
Phosphagen
Energy Systems
0.0
0.5
1.0
1.5
2.0
2.5
ATPTurnover Rate (mmol/kg/s)