ATP: The Energy Molecule!

ATP = Adenosine triphosphate

- Is made up of an adenine, a ribose, and 3 phosphates
- High energy bonds connect the phosphates
- Lots of energy stored in the phosphate bonds and is released when they are broken

ATP --> ADP + P

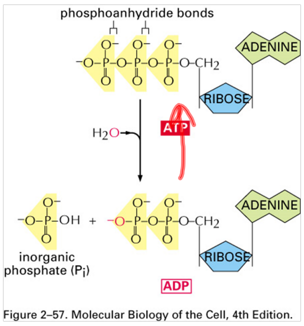


Figure 2–57. Molecular Biology of the Cell, 4th Edition.

Dec 10-10:57 AM

WHY CELLULAR RESPIRATION!

1) To break bonds in glucose to produce 6 CO_2

2) To move hydrogen atoms from glucose to oxygen, forming 6 H_2O

3) To trap as much free energy released as possible in the form of ATP (about 40% efficient

Why not in one step??

Nov 29-10:29 PM

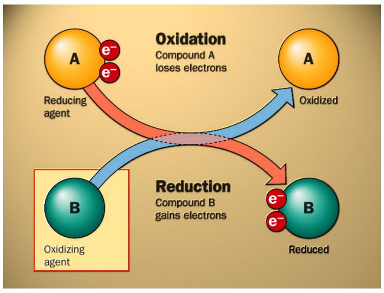
Oxidation
= loss of electrons!
Gain in O or loss of H

Reduction
= gain of electrons!
Loss of O or gain of H

OIL RIG
oxidation is loss
reduction is gain

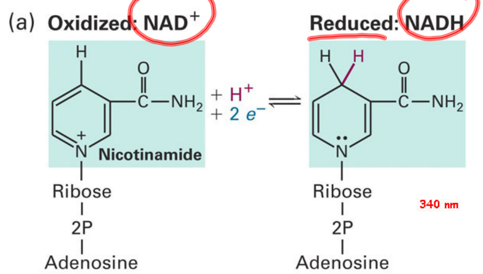
loss e⁻ oxidation
gain e⁻ reduction

LEO the lion says GER!!



Nov 30-12:56 PM

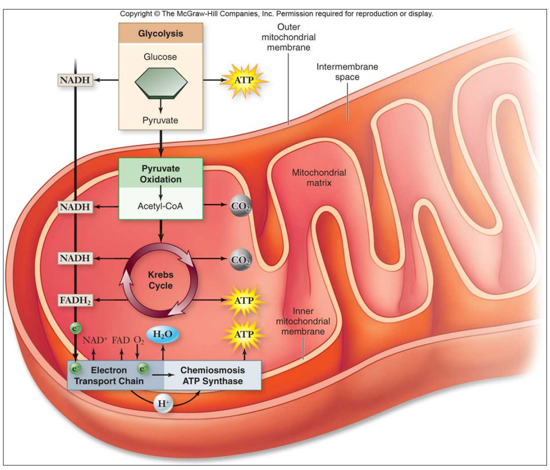
oxidized



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

NAD = e⁻ carrier

Nov 30-1:00 PM



Dec 10-10:46 AM

Stage 1: GLYCOLYSIS

3 MAJOR STEPS!!!

1) PHOSPHORYLATION!!!

2) LYSIS

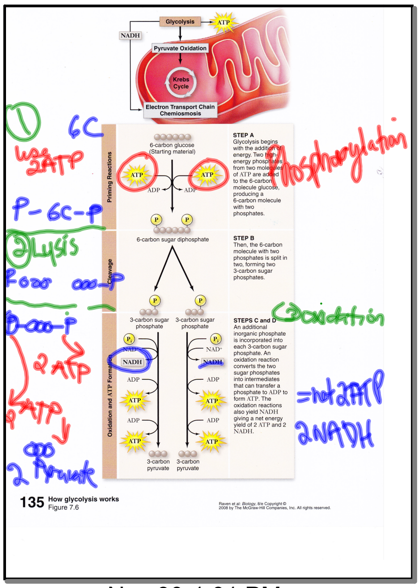
3) OXIDATION

electron transport chain

Results in:

Net 2 ATP — used
2 NADH + H⁺ → to ETC
2 Pyruvate → if O₂ → mit

Nov 30-1:33 PM



Nov 30-1:01 PM

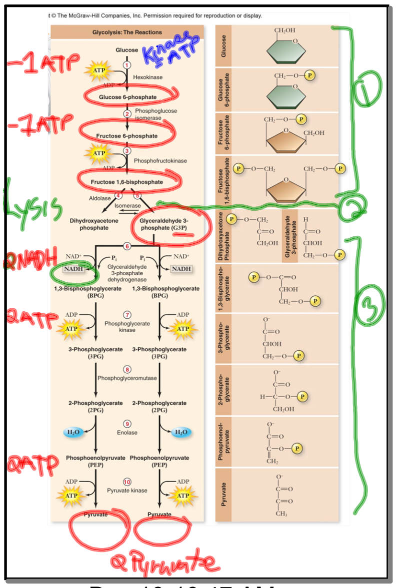
Substrate level phosphorylation

Phosphate comes from another molecule. (a substrate)
ATP is made this way in glycolysis

Oxidative phosphorylation

Phosphate is inorganic
ATP made in the ETC by chemiosmosis

Nov 4-2:44 PM



Dec 10-10:47 AM

Glycolysis → cyt
→ anaerobic
→ 2 pyruvate
2NADH
2 ATP
substrate level phosphorylation

3 steps
1. Phosphorylation
2. Lysis
3. oxidation + ATP formation.

Nov 6-12:45 PM

Nov 4-3:00 PM

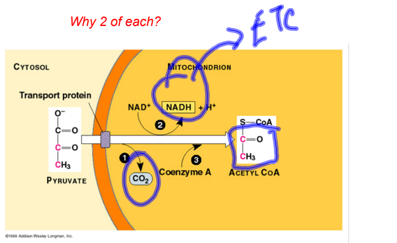
Stage 2: LINK REACTION
Decarboxylation of Pyruvate

Pyruvate oxidation

Pyruvate --> Acetyl-CoA

Results in the formation of:
- 2 NADH + H^+
- 2 CO_2

Why 2 of each?



Fate of acetyl-CoA

1. Can enter Krebs cycle if the body needs energy
2. If ATP levels are high, it can go on to produce lipids and be stored

Dec 1-11:57 PM

Stage 3: KREBS CYCLE (Citric Acid Cycle)

An 8 step cyclic reaction that takes the 2C acetyl molecule and combines it with a 4C oxaloacetate molecule to form a 6C citrate molecule.

During the reformation of the oxaloacetate molecule the following are produced:

- 3 NADH
- 1 FADH2
- 1 ATP
- 2 CO2

e⁻ carriers FADH₂ → ETC

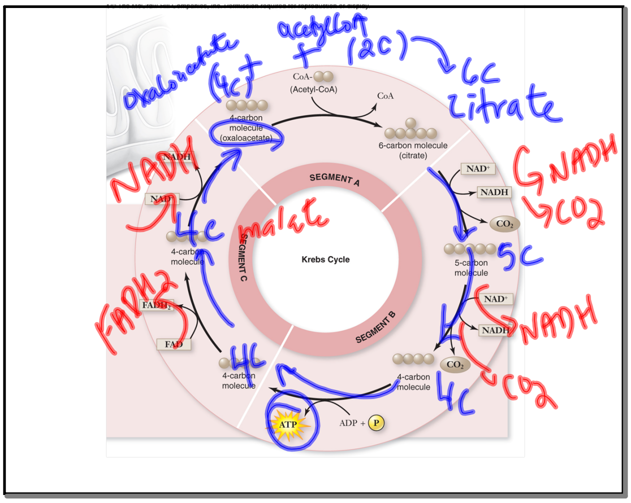
BUT.......
There are TWO acetyl molecules (from the pyruvate produced in glycolysis),

THEREFORE,
The cycle happens TWICE and a total of:

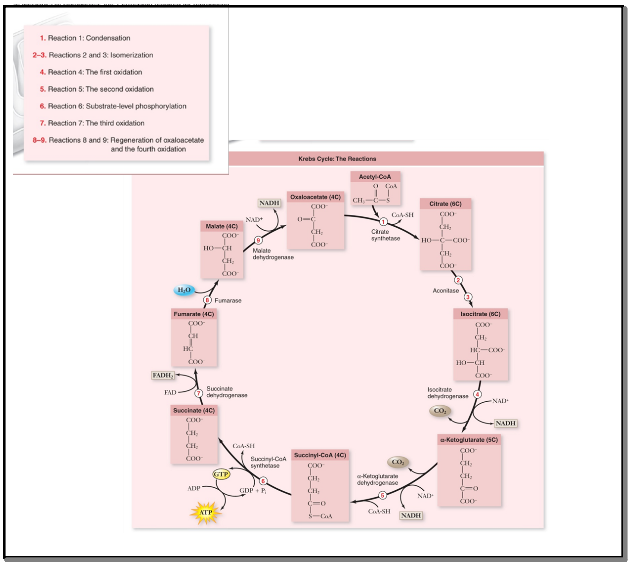
- 6 NADH
- 2 FADH2
- 2 ATP
- 4 CO2

are produced!

Dec 1-11:43 PM



Nov 10-2:11 PM



Dec 10-10:51 AM

Stage 4: Electron Transport Chain (ETC)

- Occurs on the inner mitochondrial membrane.
- The inner membrane is folded to allow more ETC's
- Results in the formation of 32 ATP

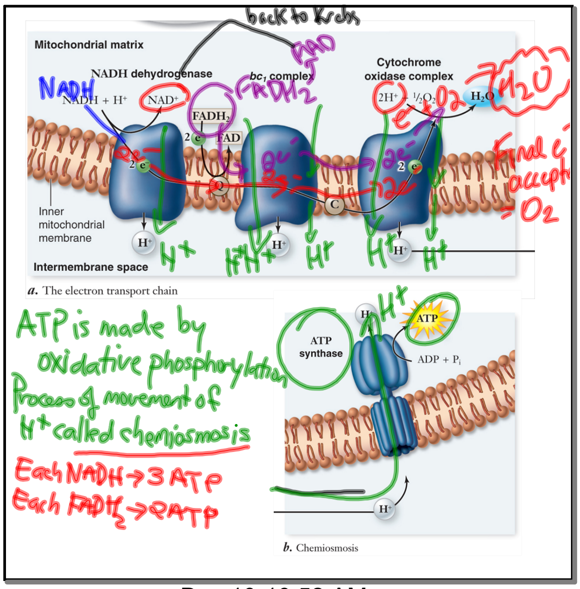
Components of the ETC are arranged according to increasing electronegativity

Components of ETC
- NADH dehydrogenase
- Ubiquinone (Q)
- Cytochrome b-c_1 complex
- Cytochrome c
- Cytochrome oxidase complex

Increasing electronegativity

- NADH and FADH2 transfer electron to proteins embedded in the cristae.
- Electrons move "downhill" from one carrier to another through a series of redox reactions
- As the electrons travel through each electron acceptor, hydrogen ions are "pumped" out of the matrix into the intermembrane space

Dec 3-2:48 PM



Dec 10-10:52 AM

The formation of ATP by oxidative phosphorylation and chemiosmosis

- Protons pumped into the intermembrane space create an electrochemical gradient

electro = charge difference
(+ between membranes, - in matrix)
chemical = concentration
(more H+ between membranes)

- Protons can only reenter the matrix through the ATP synthase complex
- This drives the production of ATP by oxidative phosphorylation
- The final electron acceptor is oxygen, which combines with 2 protons to form water.

- This process is called **CHEMIOSMOSIS!!**

- For each NADH, 3 molecules of ATP SHOULD BE produced
- For each FADH2, 2 molecules of ATP are produced

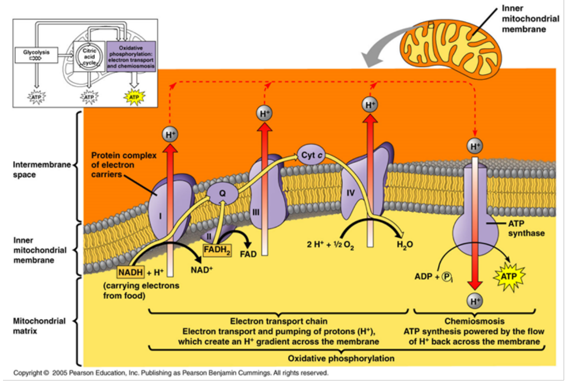
WHY????

Dec 3-3:03 PM

Energy "Accounting"

- 1 ATP molecule is generated for each proton pump activated by the ETC.
- Because the electrons from NADH and $FADH_2$ activate 3 and 2 pumps, respectively, we would expect each to generate 3 and 2 ATPs, respectively.
- BUT! NADH generated in the cytoplasm only results in 2 ATP per NADH due to the cost of actively transporting it into the mitochondria.
- This leads to a total of 36 ATP per glucose molecule (instead of 38).

Dec 12-10:04 AM



Dec 10-10:52 AM

	ATP	NADH	FADH2	Location
Gycolysis	2	2	-	Cytoplasm
Transition Reaction	-	2	-	Mitochondrial matrix
Krebs Cycle	2	6	2	Mitochondrial Matrix
ETC	32	-	-	Inner membrane
TOTAL	36	10	2	

Dec 3-2:57 PM