

ME 411 / ME 511

# Biological Frameworks for Engineers

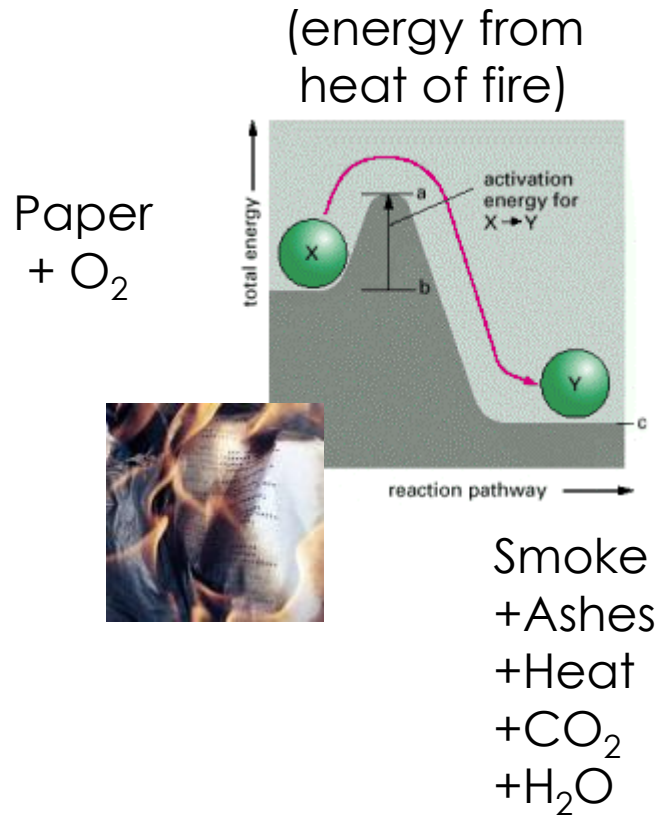
# Class Organization

- Exam 1 due Fri

ME 411 / ME 511

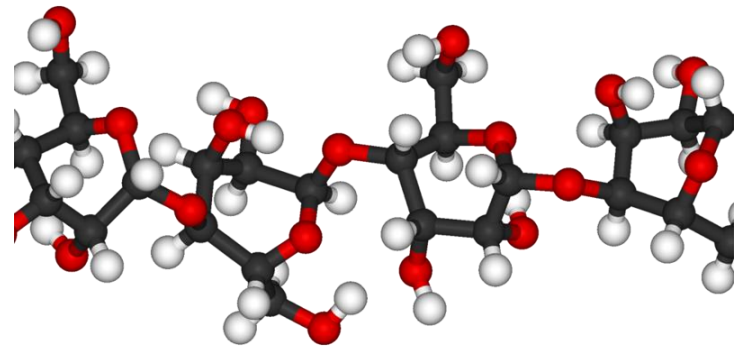
# Cell Energetics

# Energy Conversion



*Energetically favorable*

Cellulose



CO<sub>2</sub>



H<sub>2</sub>O



Covalent:

Nonpolar

Polar

C-C

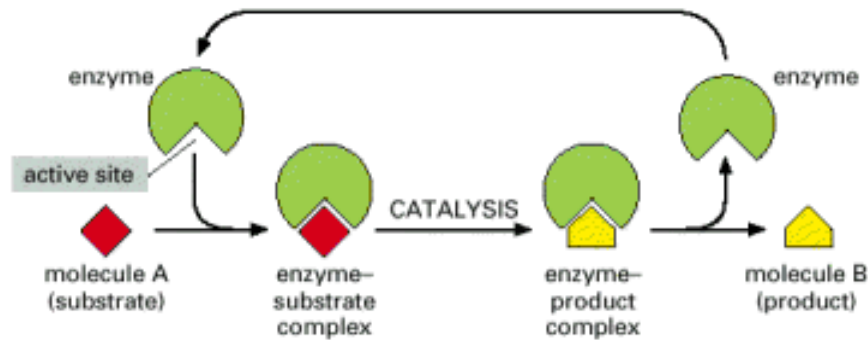
C=O

C-H

H-O-H

O-O

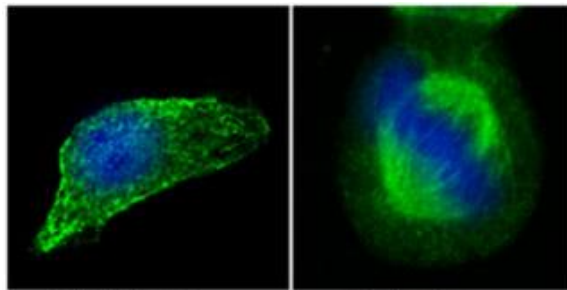
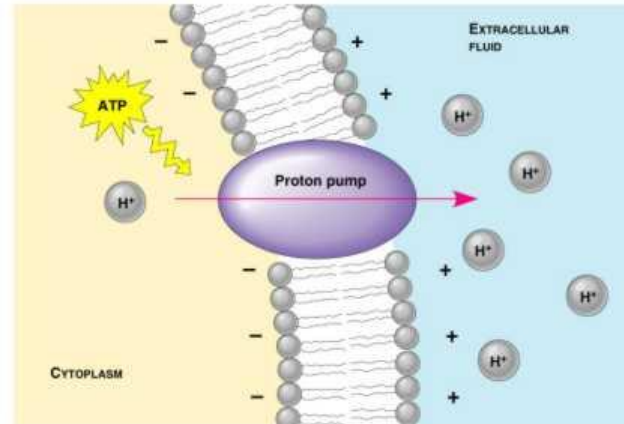
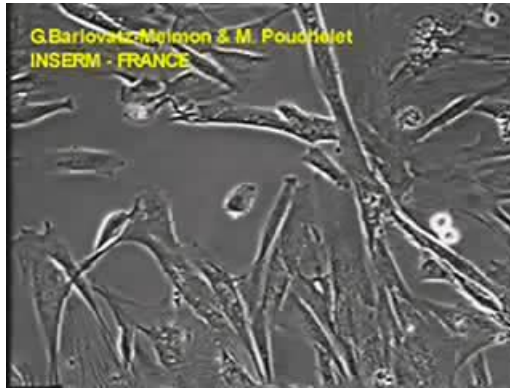
# Energy Conversion



Enzymes bind one or two molecules (substrates) in such a way that activation energy is greatly reduced (catalyst)

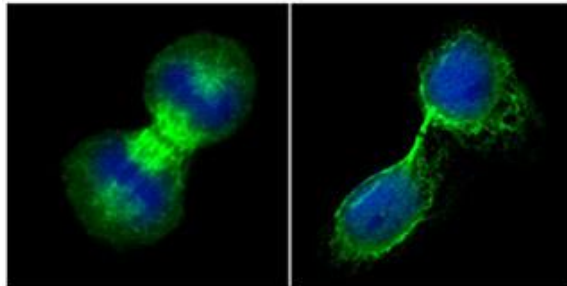
*But we will need active carriers of energy to temporarily store it*

# Why do we need Energy?



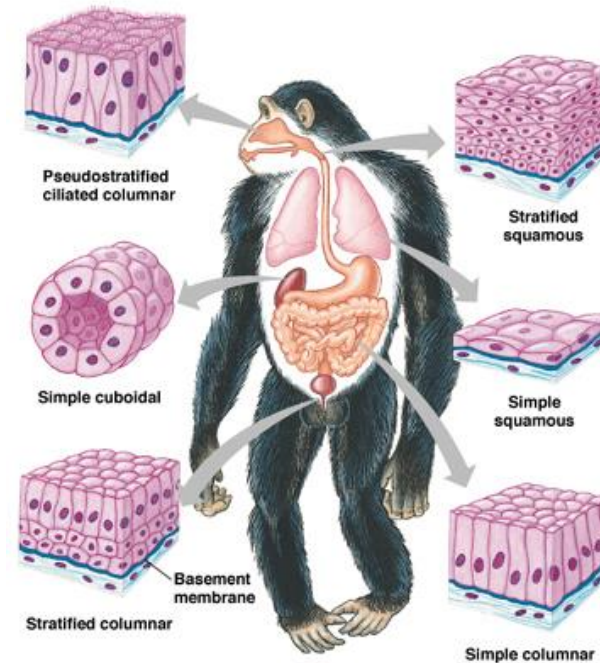
Interphase

Metaphase

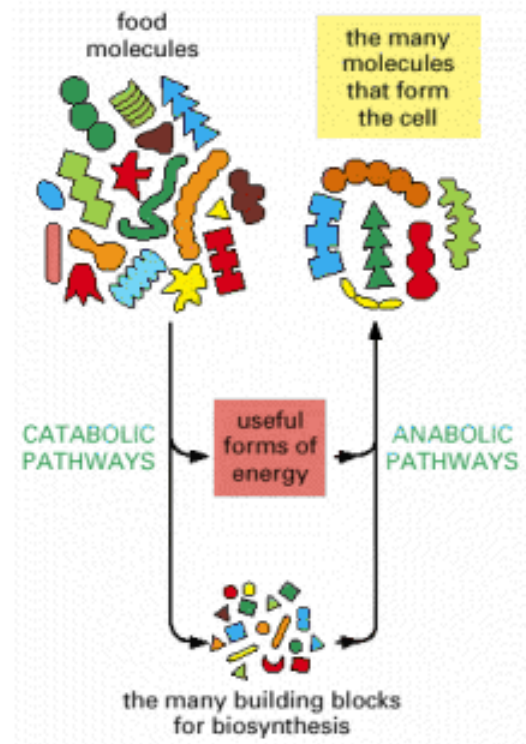


Anaphase

Telophase



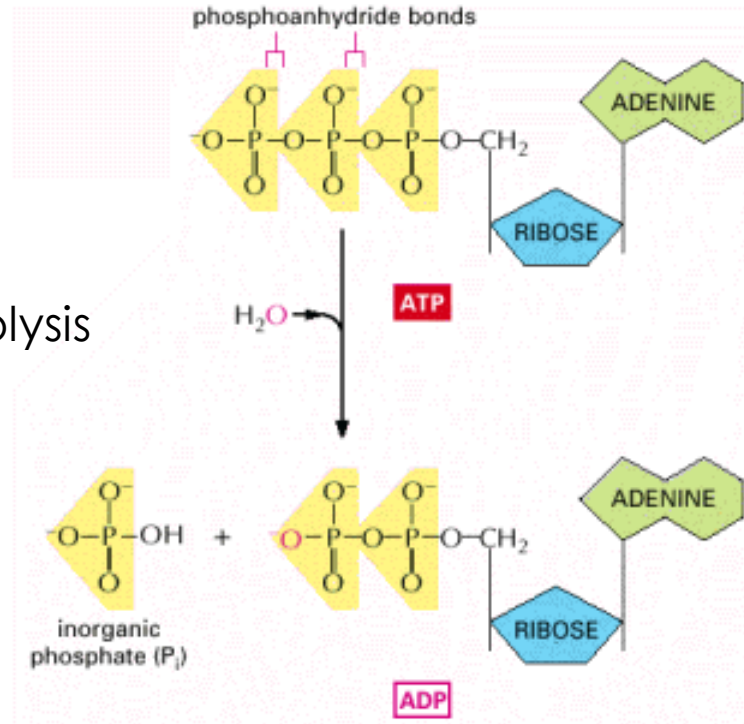
# Metabolism



# ATP

Structure: High Energy Storage

Reaction: Hydrolysis

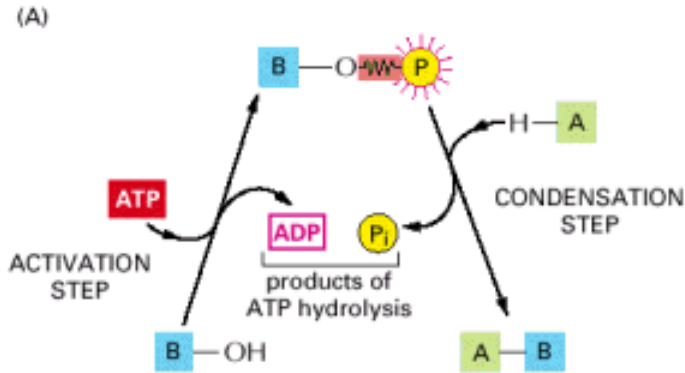



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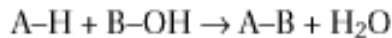
$\Delta G = -11$  to  $-13$  kcal/mole of usable energy



# Harnessing ATP

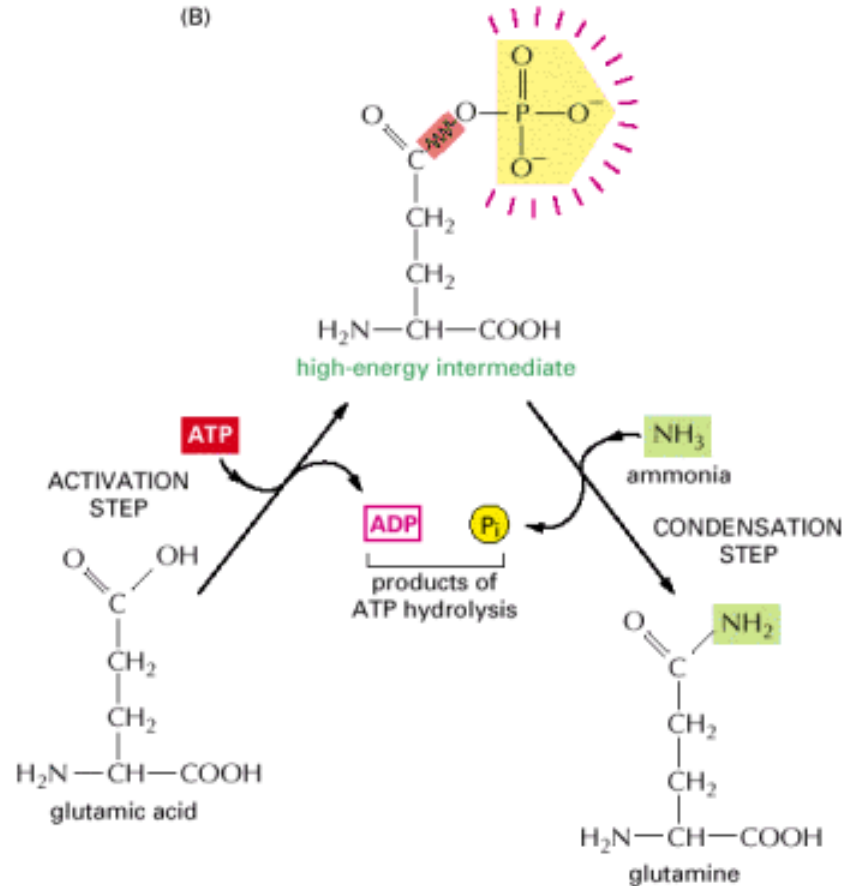
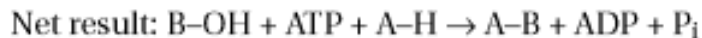


*Energetically UNfavorable*



*Energetically favorable*

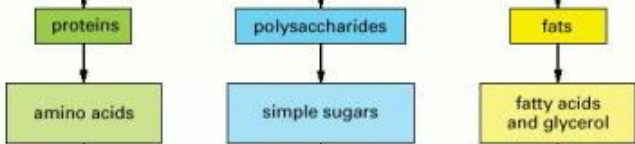
1.  $B-OH + ATP \rightarrow B-O-PO_3 + ADP$
2.  $A-H + B-O-PO_3 \rightarrow A-B + P_i$



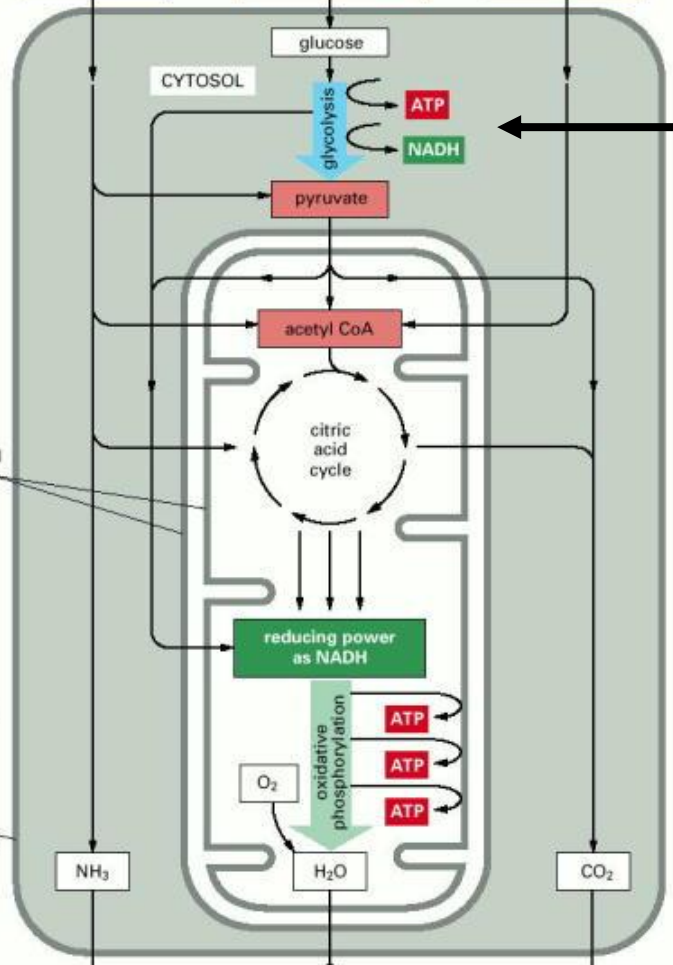
# Cellular Respiration



**STAGE 1:**  
BREAKDOWN  
OF LARGE  
MACROMOLECULES  
TO SIMPLE  
SUBUNITS



**STAGE 2:**  
BREAKDOWN OF  
SIMPLE SUBUNITS  
TO ACETYL CoA  
ACCOMPANIED BY  
PRODUCTION OF  
LIMITED AMOUNTS  
OF ATP AND NADH

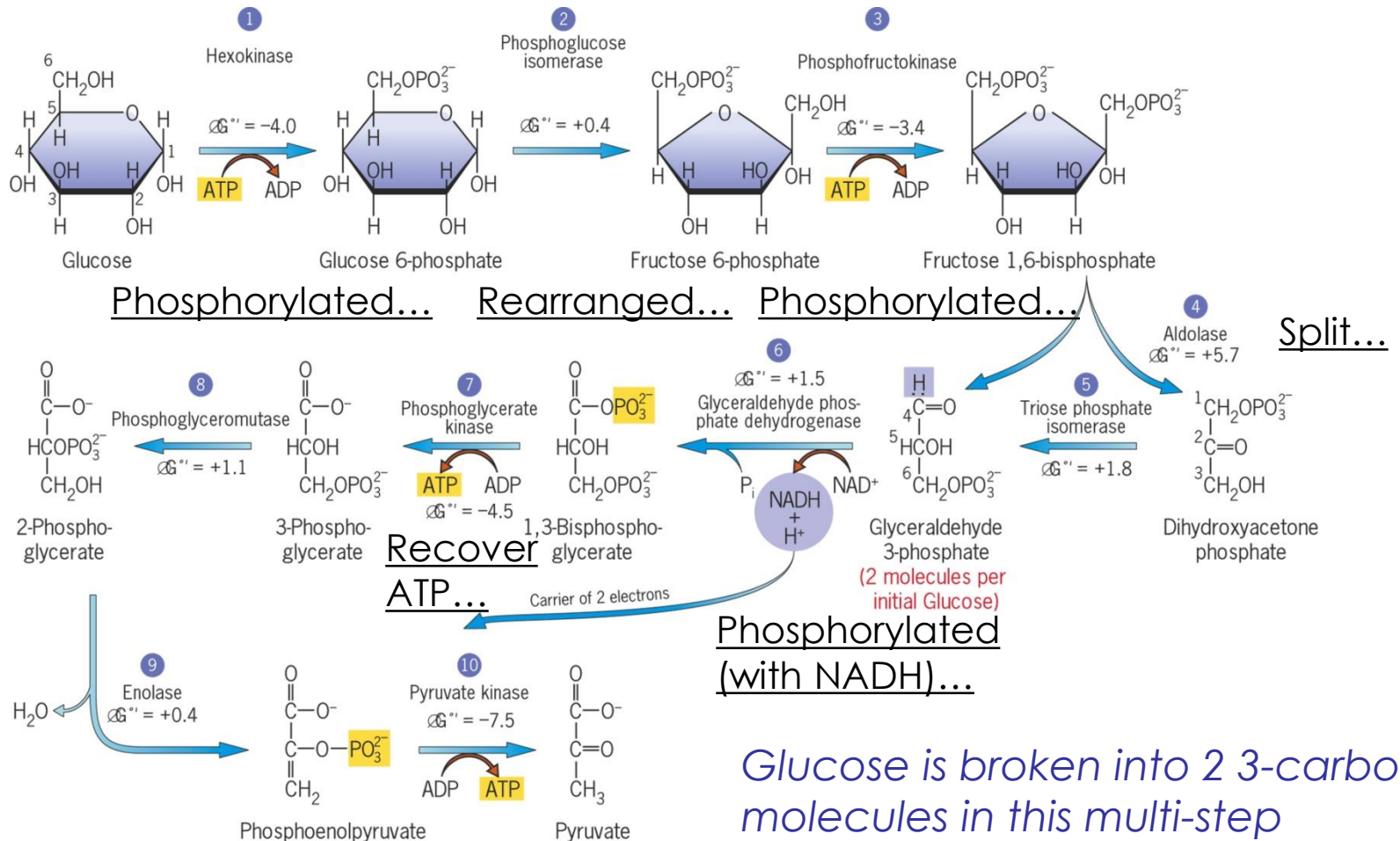


Glycolysis  
“sugar” +  
“breakdown”

**STAGE 3:**  
COMPLETE  
OXIDATION  
OF ACETYL  
CoA TO H<sub>2</sub>O  
AND CO<sub>2</sub>  
ACCOMPANIED  
BY PRODUCTION  
OF LARGE AMOUNTS  
OF NADH AND ATP  
IN MITOCHONDRION

plasma  
membrane  
of eucaryotic  
cell

# Glycolysis



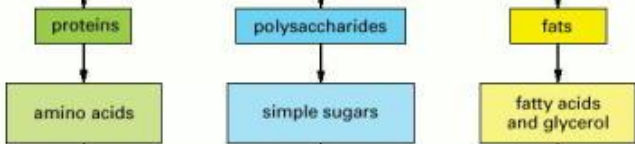
Gain 2 ATP...

Pyruvate For Kreb's

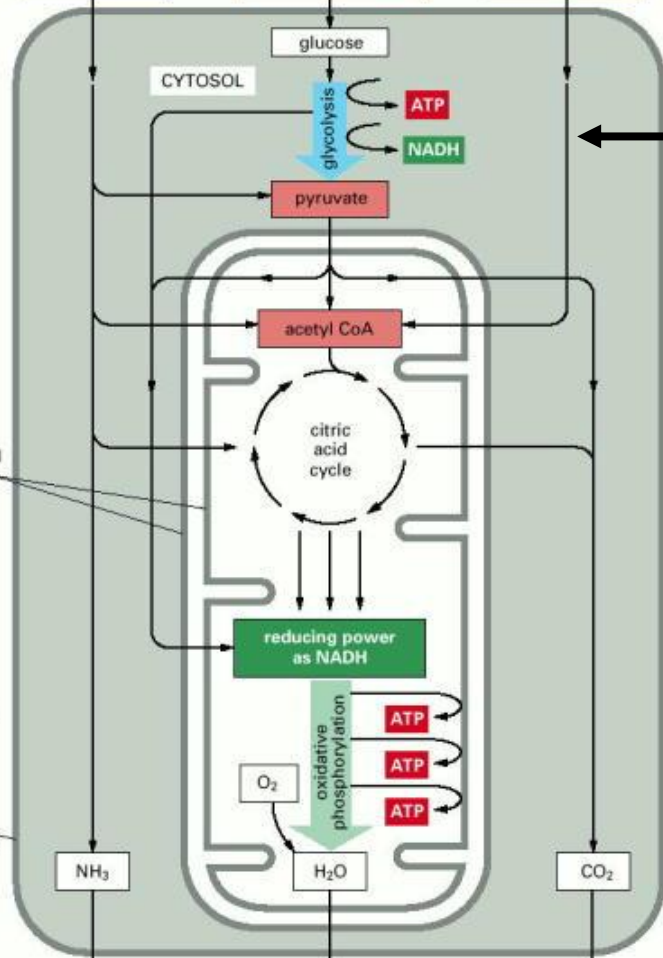
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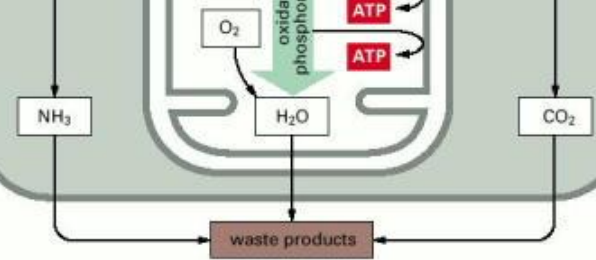
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Fatty acids  
"stored energy"

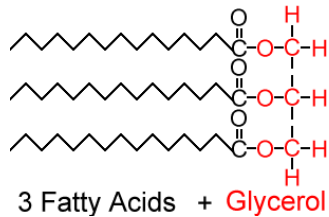
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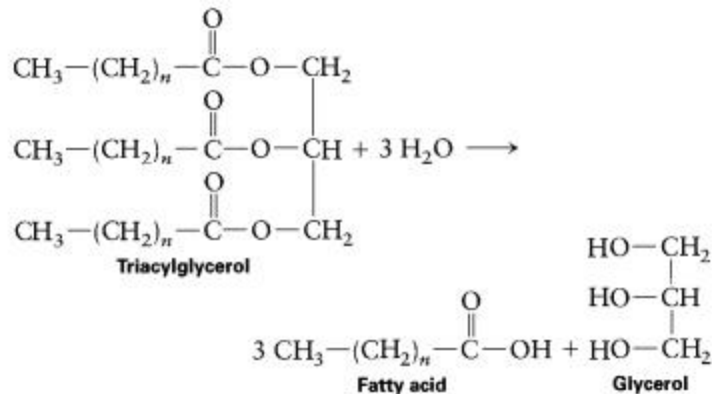


# Fatty Acid Oxidation

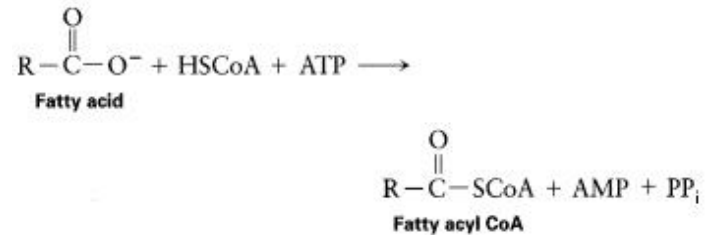
## 1) Storage



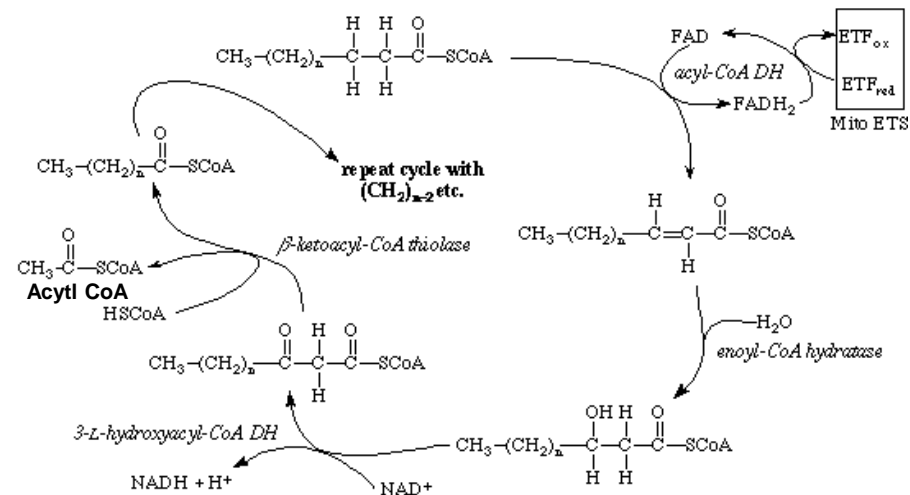
## 2) Hydrolysis



## 3) Conversion



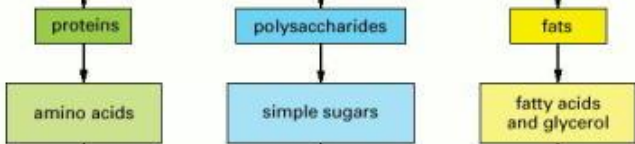
## 4) Oxidation



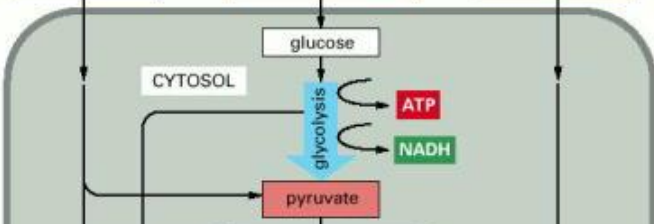
# Cellular Respiration



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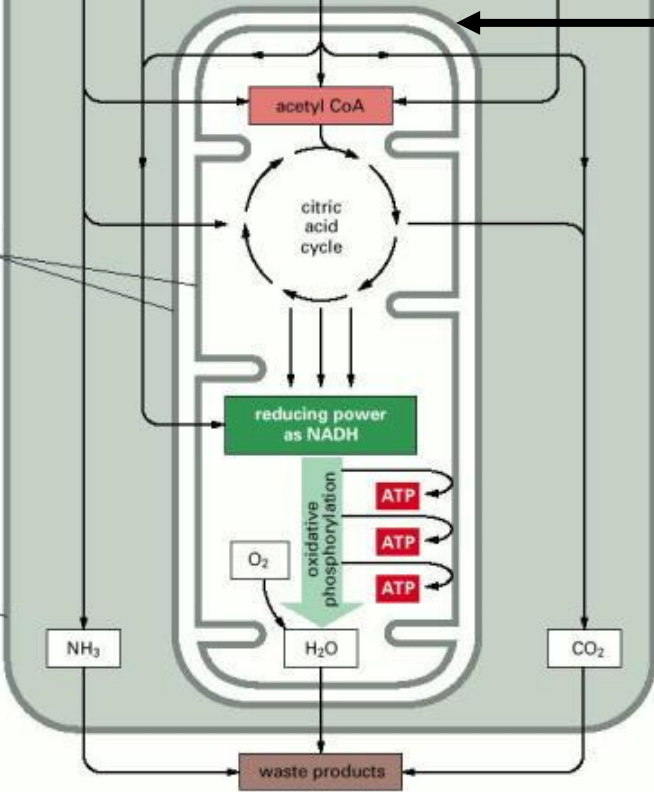


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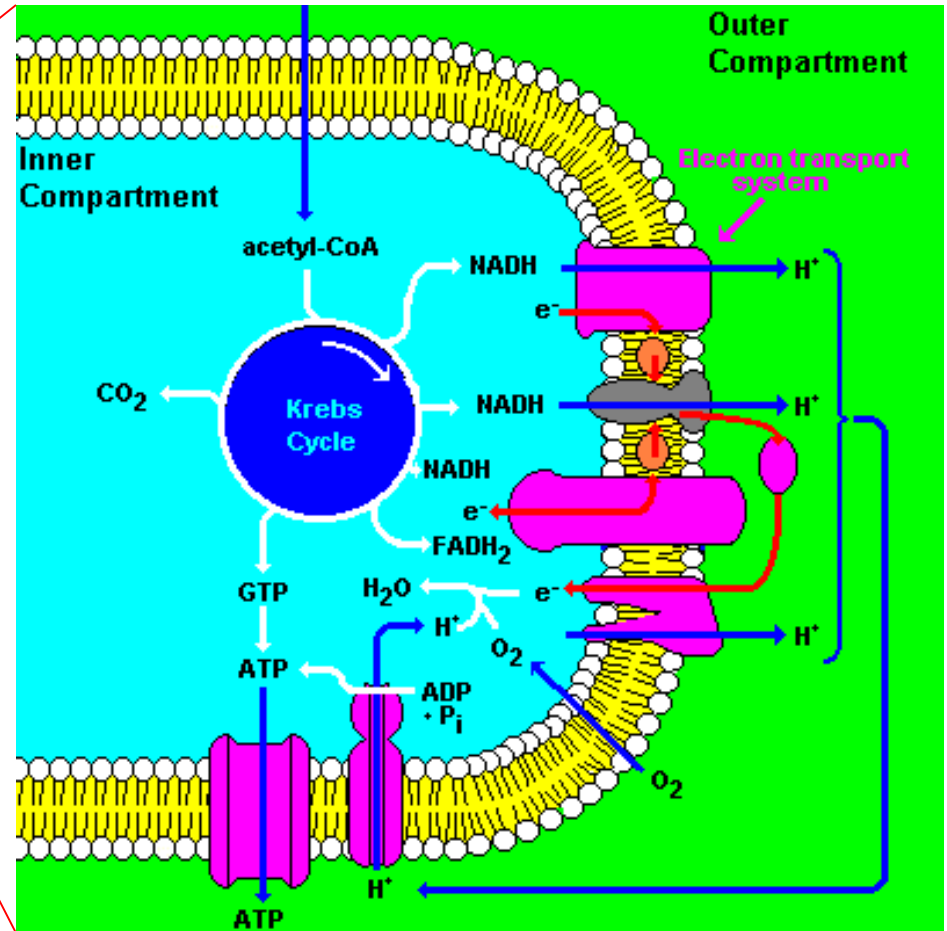


Into the mitochondria...

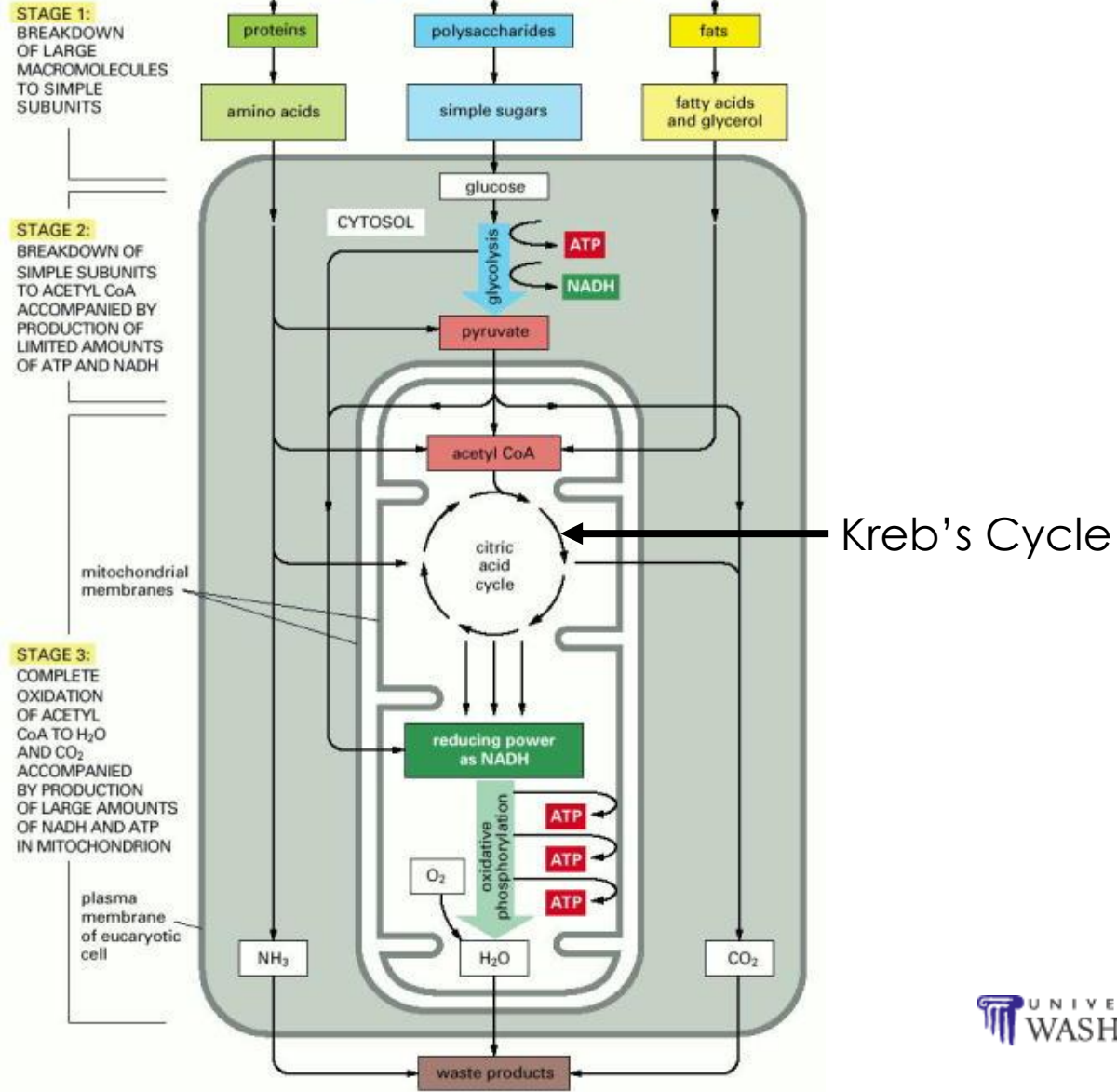
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# Into the Mitochondria

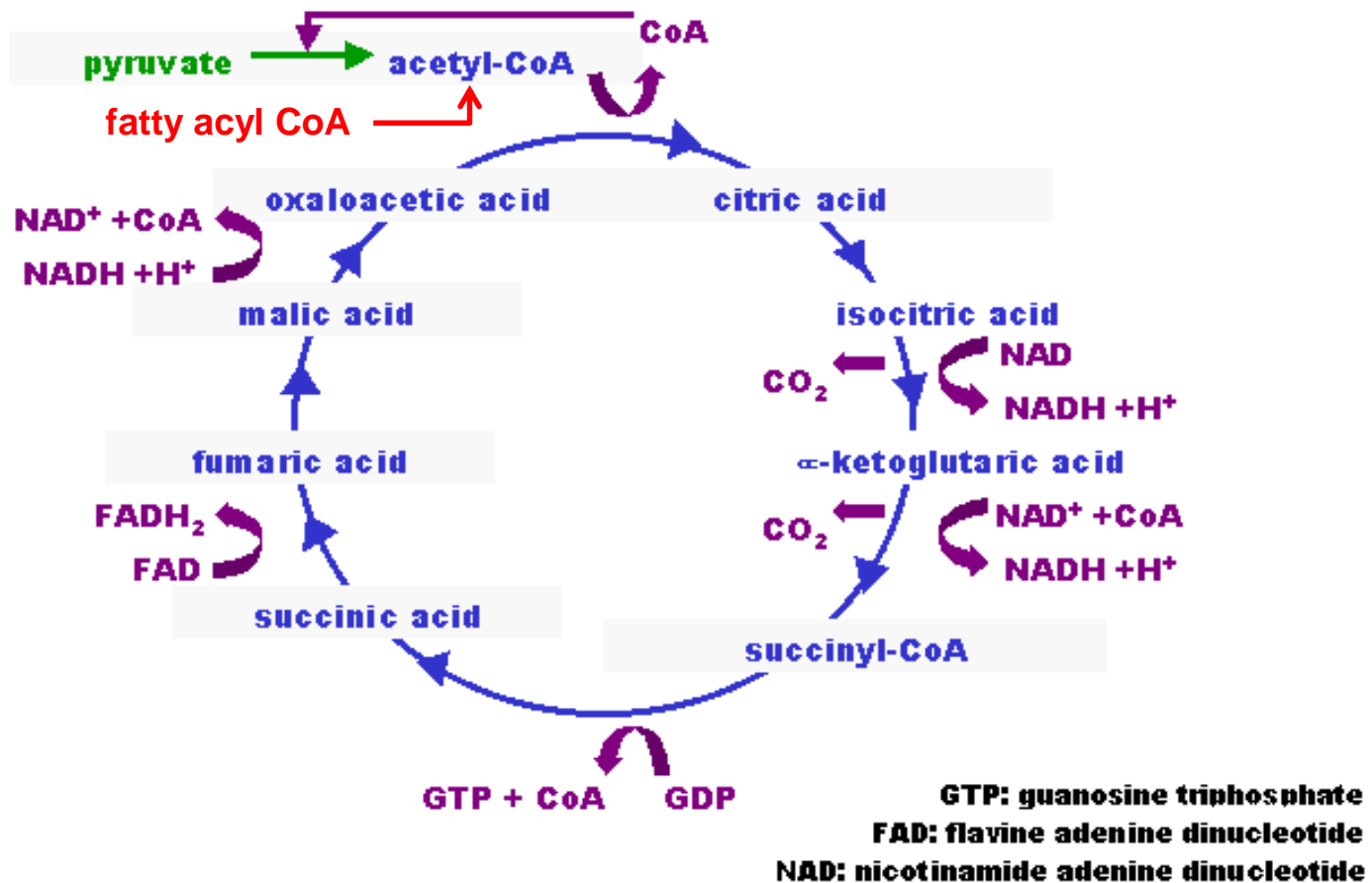


# Cellular Respiration





# Krebs Cycle

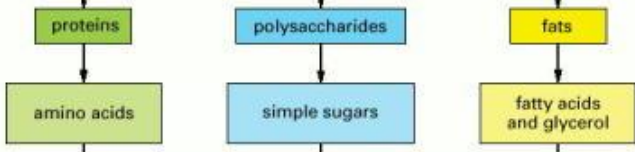


1. Acetyl Coenzyme A (acetyl CoA) + oxaloacetic acid = Citric Acid
2. Rearranged, dehydrated, carbon theft, e<sup>-</sup> stealing
3. Yields 3 NADH, 3 H<sup>+</sup>, FADH<sub>2</sub> = energy to produce ATP

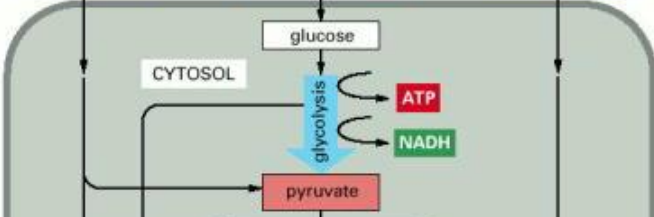
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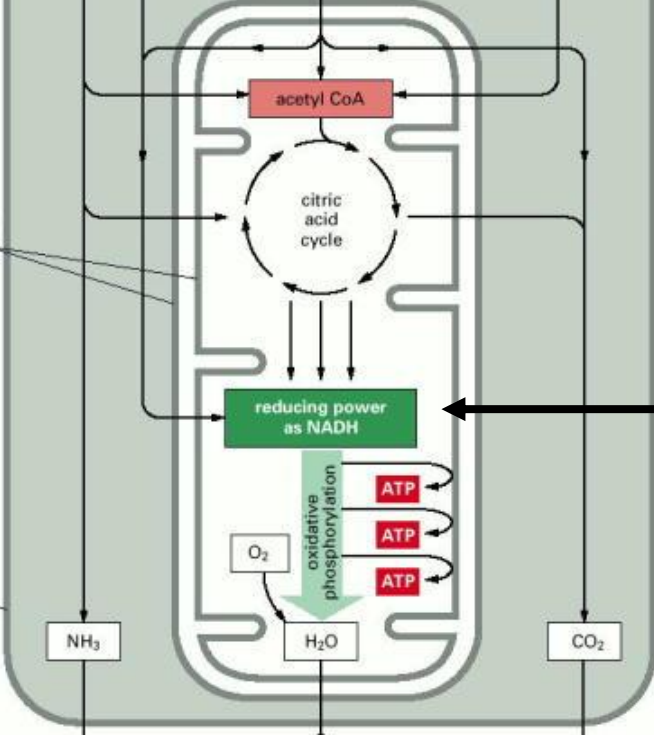
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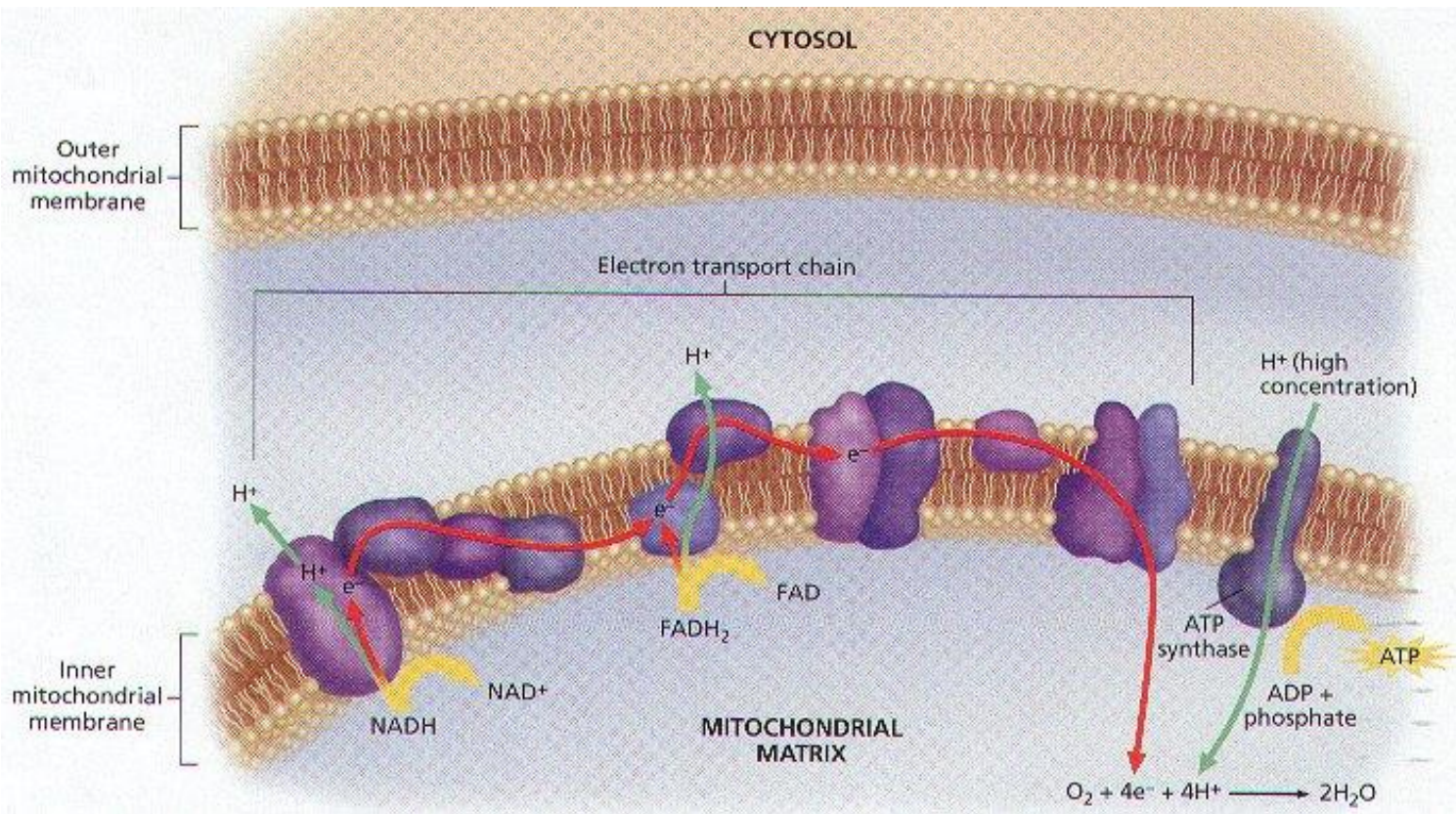


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Electron Transport Chain

# Electron Transport Chain



1. Proteins in mitochondrial membrane pump out  $H^+$  ions
2. Pumps powered by electron transport ( $e^-$ ) along membrane
3.  $H^+$  ions fuels **FOF1-ATP Synthase** which produces ATP
4. Result:  $H^+ + 2e^-$  from  $NADH \rightarrow 3$  ATP and  $2H^+ + 2e^-$  from  $FADH_2 \rightarrow 2$  ATP

Questions?