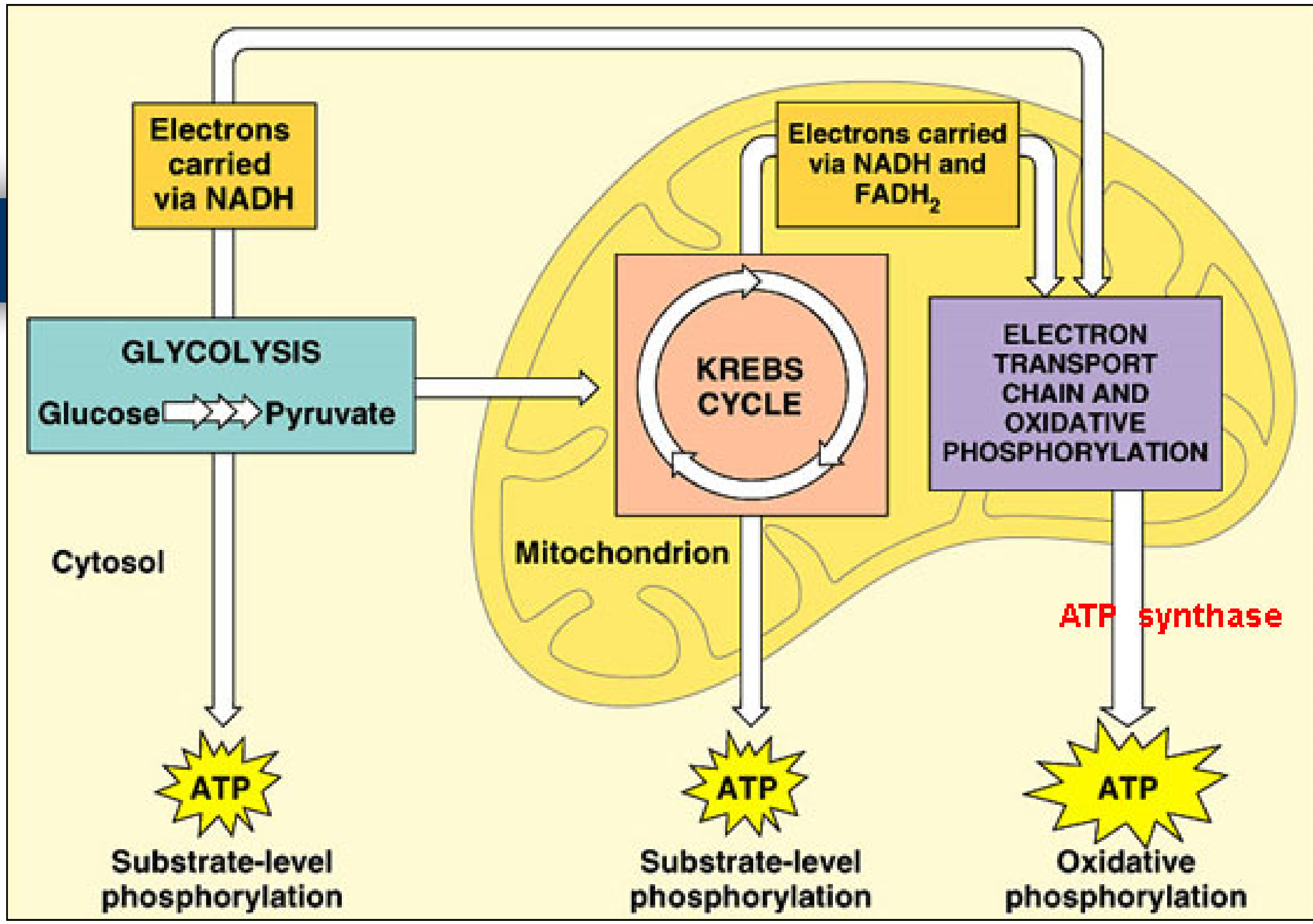
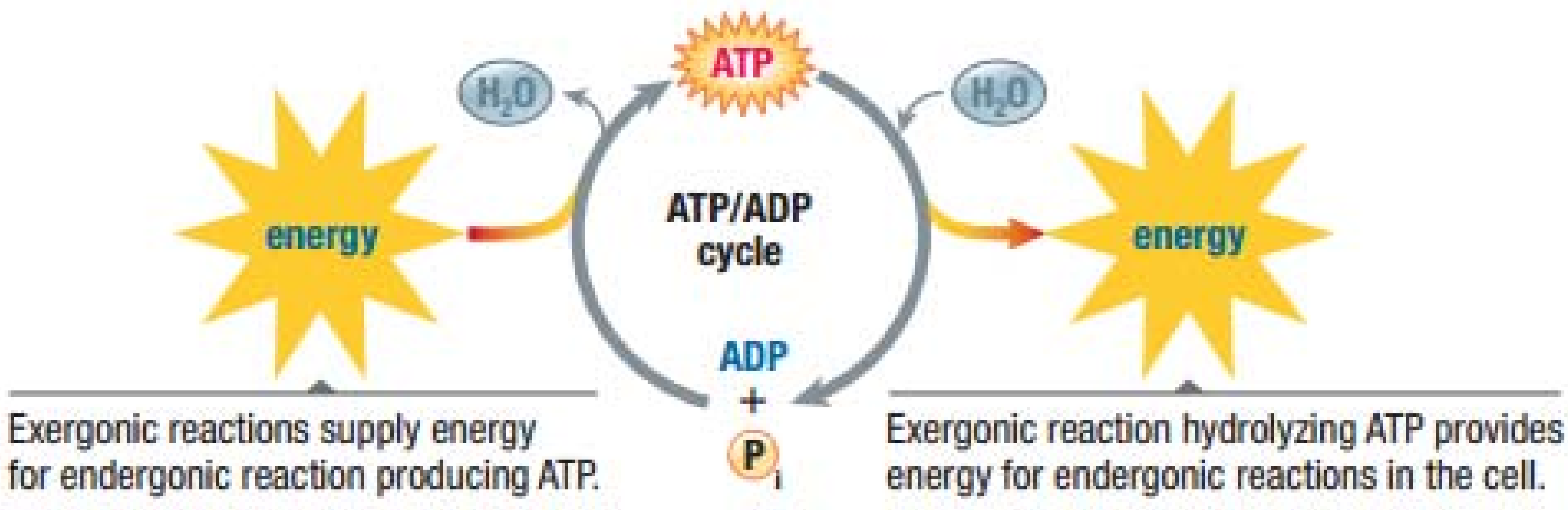
Cellular Respiration: An Overview



ATP: Energy Currency of the Cell

- Adenosine triphosphate / adenosine diphosphate
- **Phosphorylation** – attaching a phosphate group to another organic molecule
- Continuous cycle
- Mechanical, transport & chemical work



SECTION REVIEW

1. K/U Define the term "coupled reaction."
2. C How do coupled reactions work? In your explanation, include a diagram that demonstrates a coupled reaction.
3. K/U What are the advantages of using the same energy source, ATP, in all cells?
4. C Draw a diagram of ATP. Compose a paragraph detailing its structure and function.
5. K/U ATP molecules have three main purposes in the cell. Aside from transport work such as the sodium-potassium pump, what are two examples of how ATP is used to do work in cells?
7. C How is chemical energy in an ATP molecule transformed into energy that can be used to do work? Explain your answer.
8. I How could you speed up a coupled reaction? Outline an experiment to test your hypothesis.

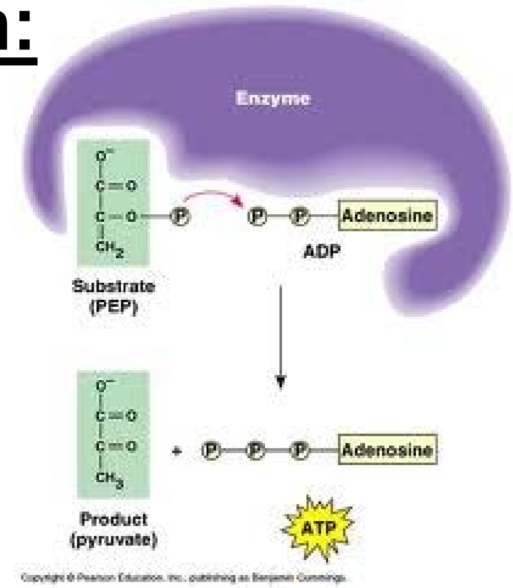
UNIT INVESTIGATION PREP

How can the energy from one reaction be used to fuel another reaction? When designing your experiment for the end-of-unit investigation, think about how reactions are related and how some reactions are dependent on other reactions.

Energy Transfer Terminology

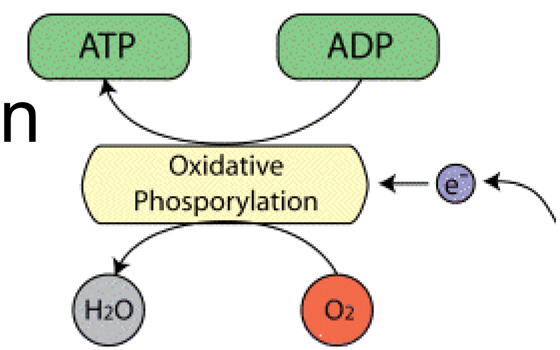
Substrate-level Phosphorylation:

- ATP forms **directly** in an enzyme-catalyzed reaction.



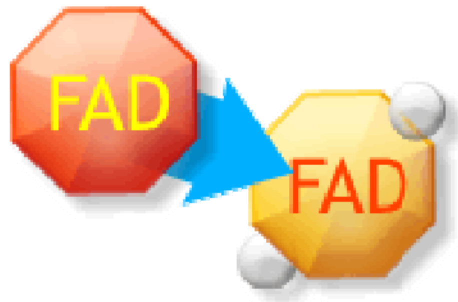
Oxidative Phosphorylation:

- ATP forms **indirectly** through a series of enzyme-catalyzed **redox** reactions involving oxygen as the final electron acceptor.

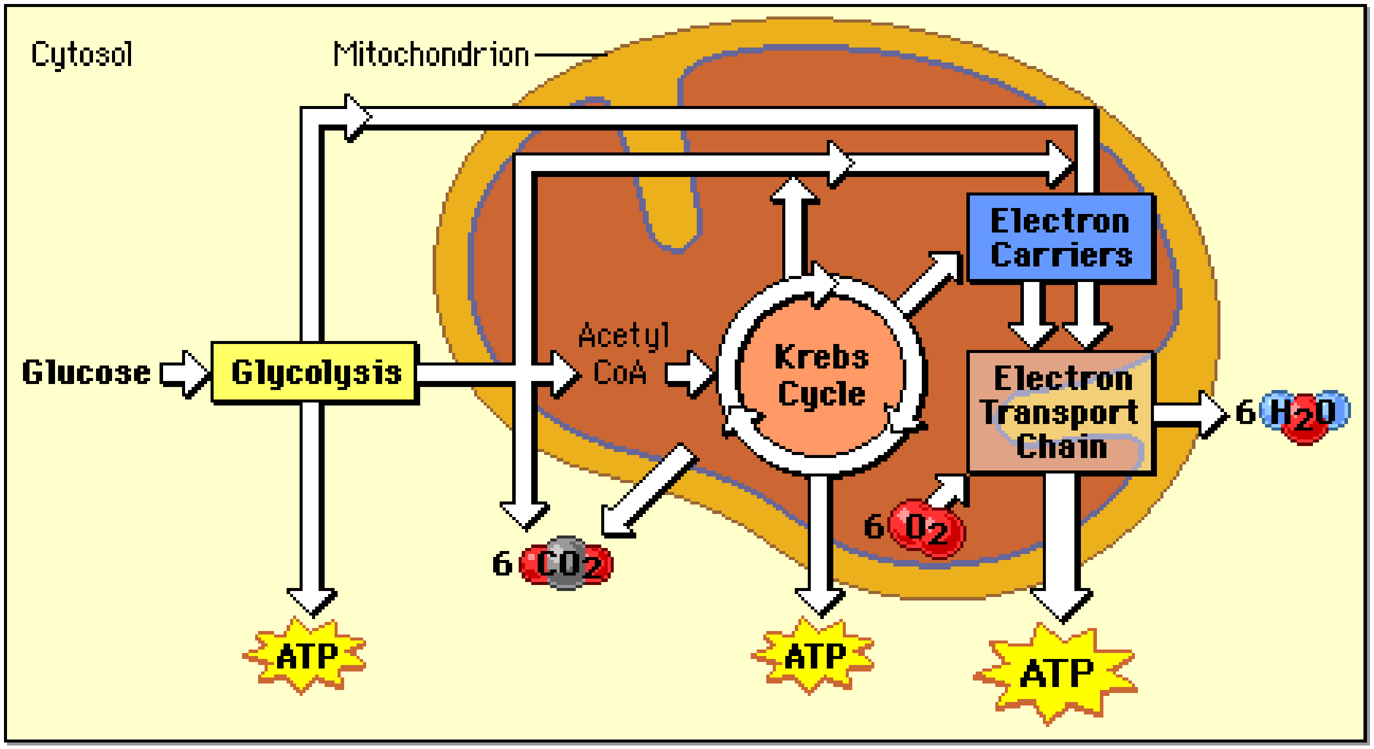


Energy Carriers

- **NAD$^+$** and **FAD** are low energy, oxidized coenzymes that act as **electron acceptors.**
- When an electron(s) are added to these molecules, they become reduced to **NADH and FADH$_2$**.
- In this case, reducing a molecule gives it more **energy**.



Four Main Stages (aerobic)



Glucose → 36 ATP

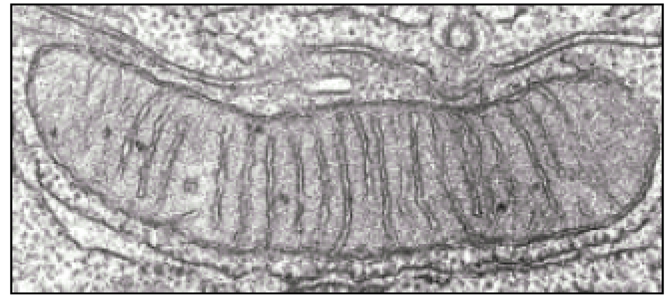
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$$

Aerobic Respiration: Overview

Occurs in Four Distinct Stages:

1. **Glycolysis:** cytoplasm.
2. **Pyruvate Oxidation:** mitochondrial matrix.
3. **Krebs Cycle:** mitochondrial matrix.
4. **Electron Transport Chain & Chemiosmosis:** inner mitochondrial membrane.

Mitochondria



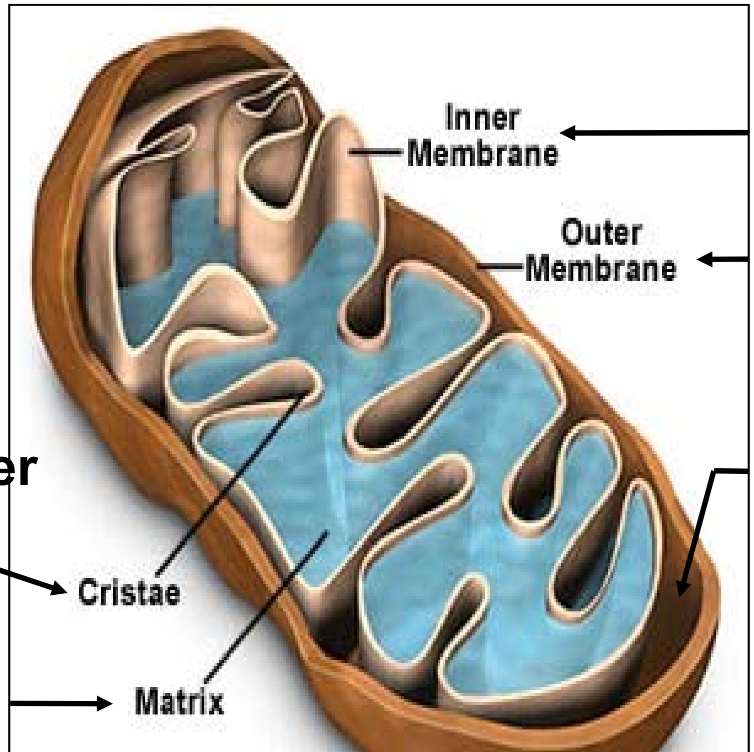


Figure 1

Highly folded

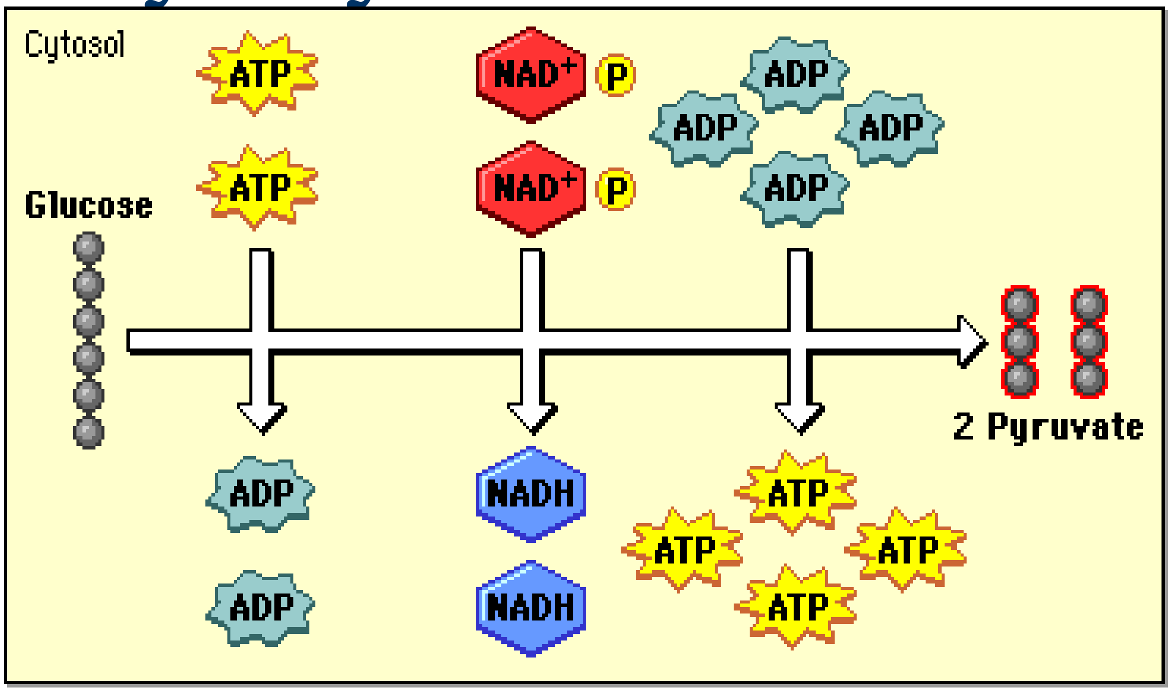
Smooth

Fluid-filled intermembrane space

Folds of the inner membrane

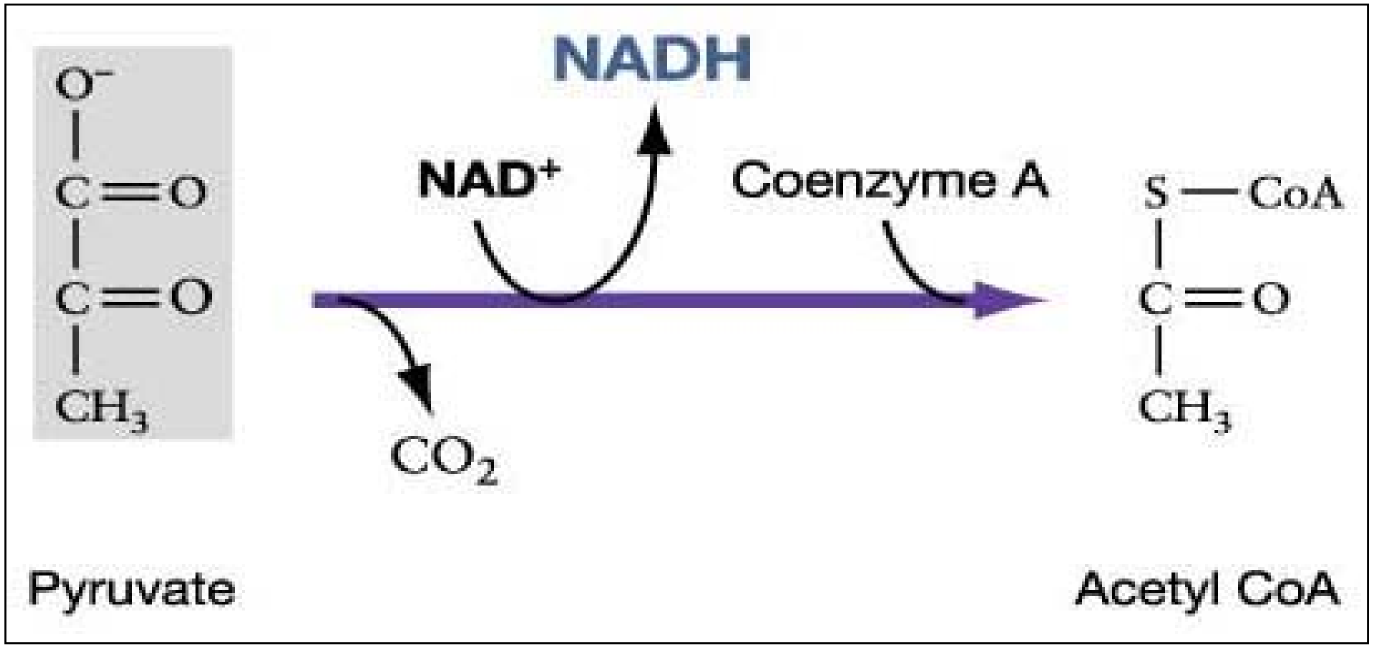
Protein-rich liquid

Glycolysis



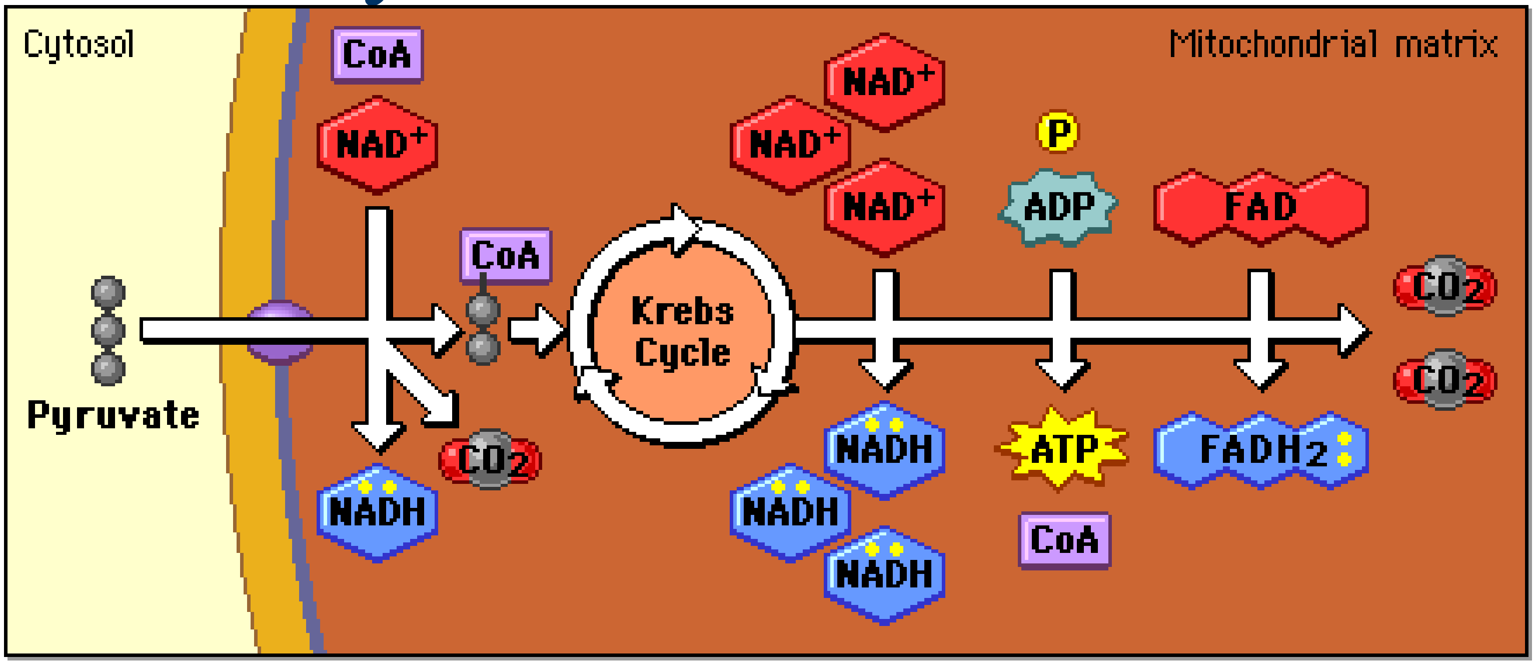
- Glucose, 6-C sugar, breaks down into 2 3-C sugars (**pyruvate**)
- **<u>Net</u>** gain **2 ATP** & **2 NADH**
- Since 4 ATP produced – 2 ATP used = **2 net ATP**
- If O_2 available NADH & pyruvate → processed further

Pyruvate Oxidation
(mitochondria matrix)



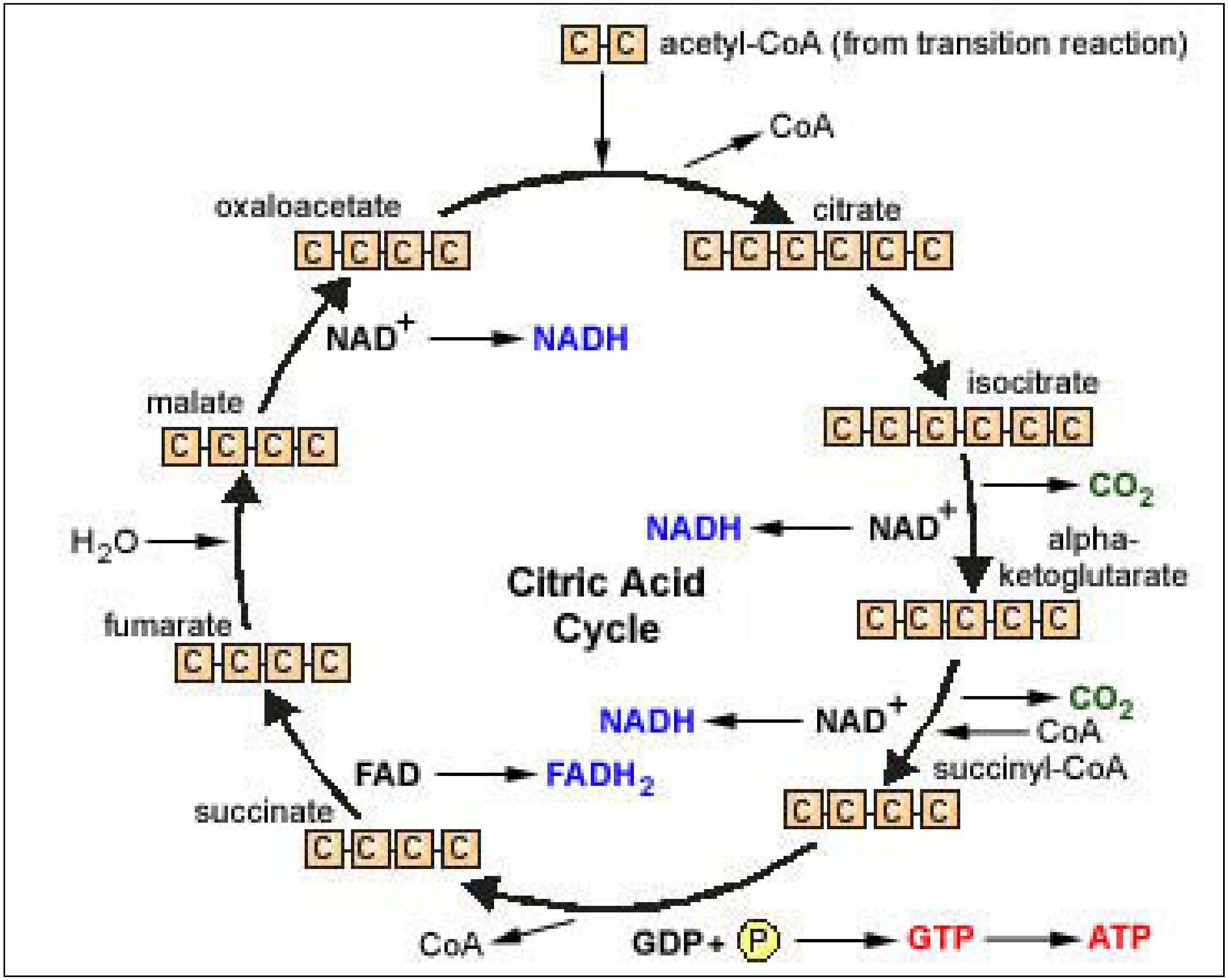
- **Pyruvate** loses **CO_2** to become **acetyl-CoA** (decarboxylation)
- **NAD+** reduced to **NADH** (dehydrogenation of pyruvate)
- Yields: 2 NADH, 2 acetyl-CoA & 2 CO_2

Krebs Cycle

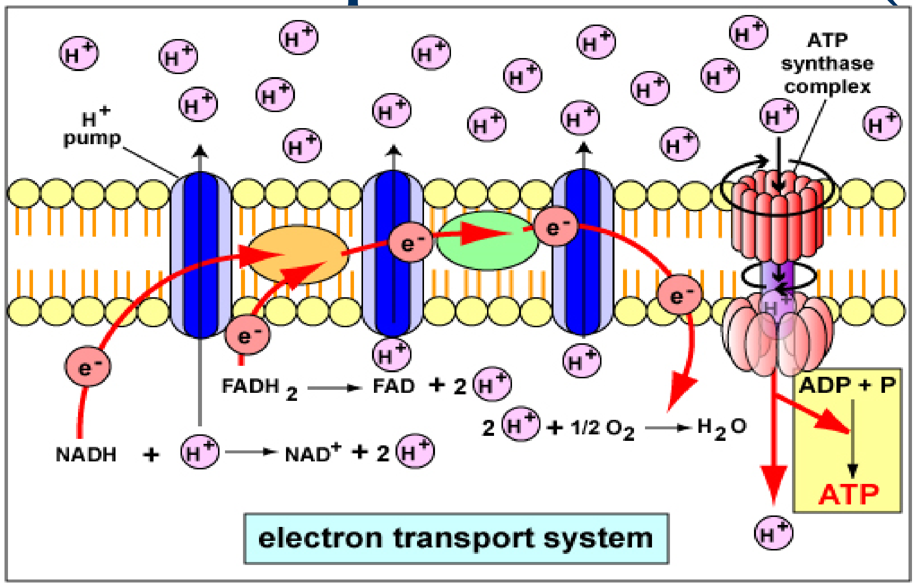


- Acetyl-CoA is **oxidized**, CO_2 is released & pool of chemical energy formed (ATP, NADH, $FADH_2$)
- Cycle occurs **twice** for each molecule of glucose, **once** for each acetyl-CoA
- Yields: 2 ATP, 6 NADH, 2 $FADH_2$, 4 CO_2

The Krebs Cycle

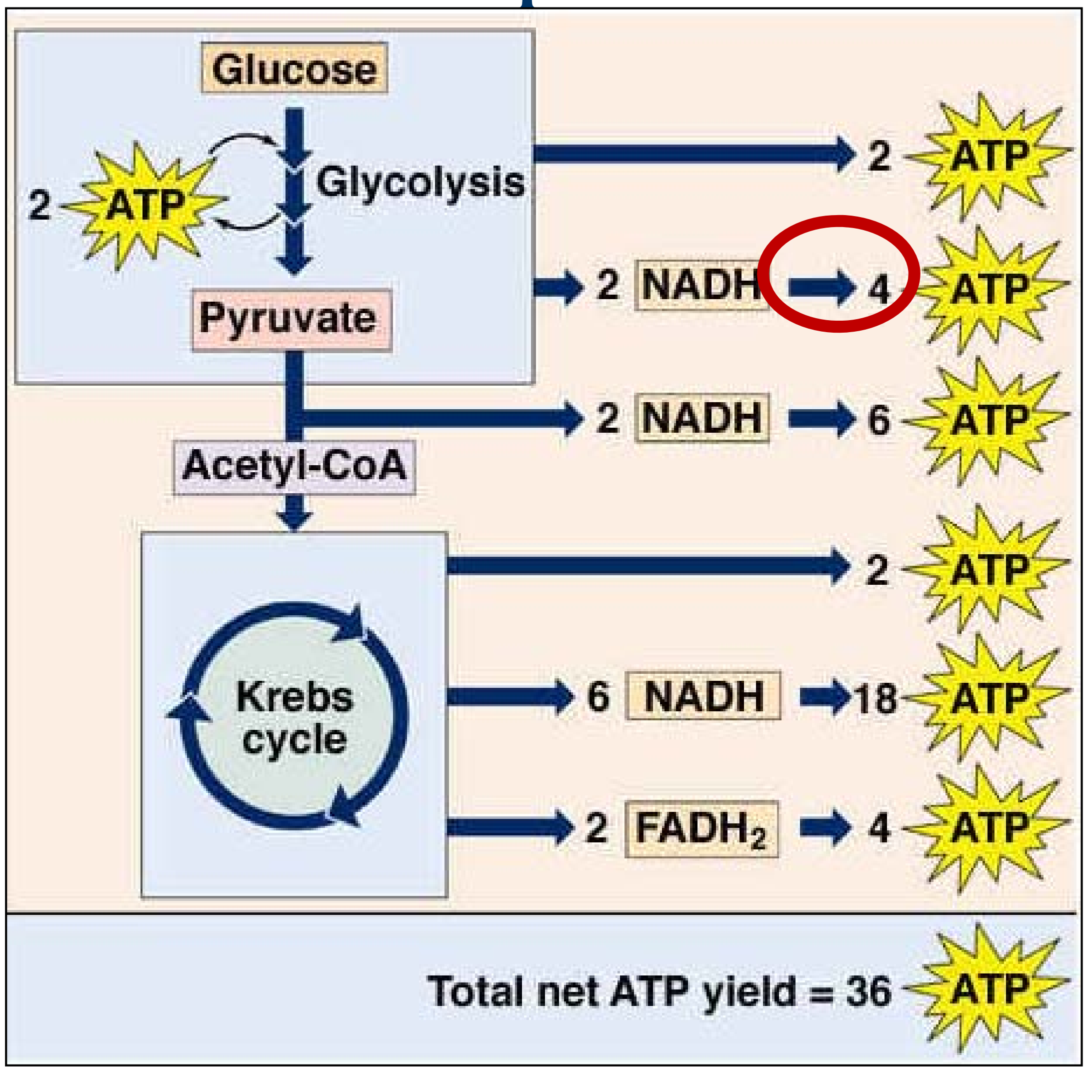


Electron Transport Chain (ETC)

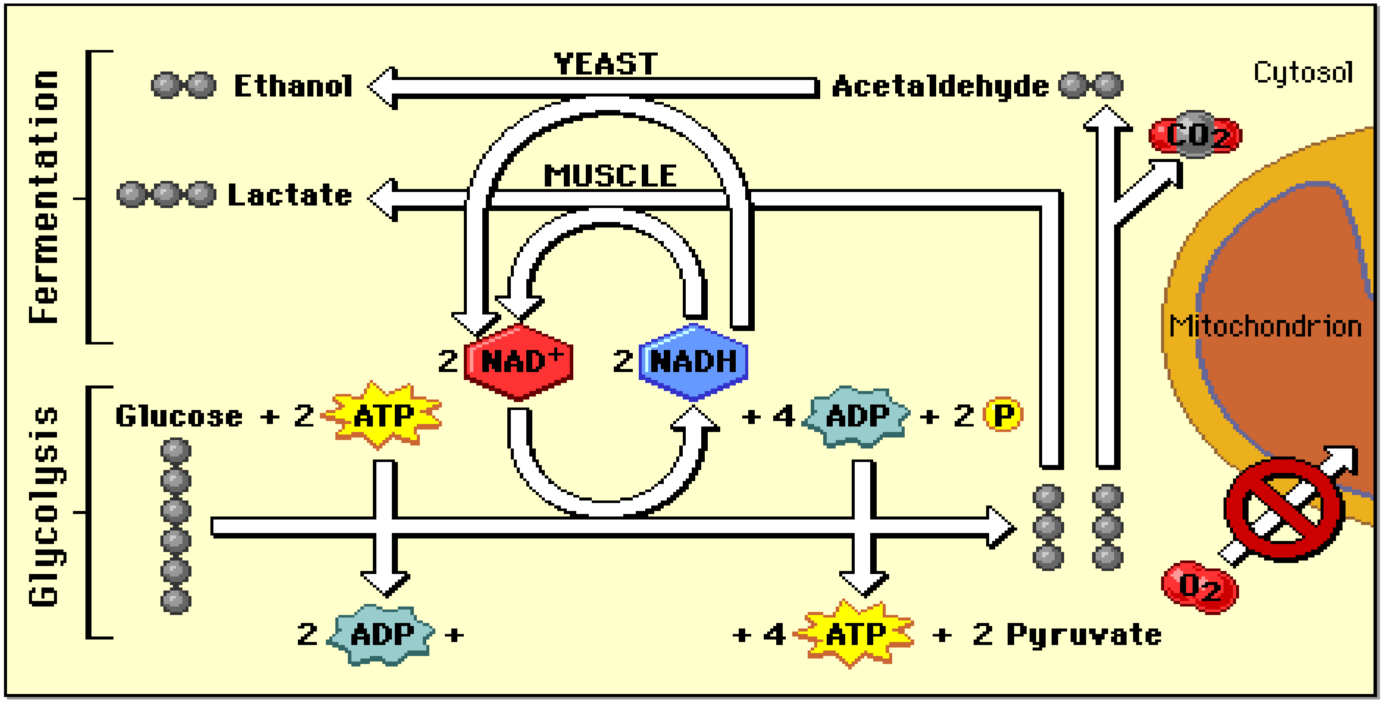


- **Oxidative** phosphorylation
- Energy stored in reduced NAD^+ (NADH) and FAD ($FADH_2$) is released
- Energy captured in form of ATP
- **3 ATP per NADH & 2 ATP per $FADH_2$**
- Yields: **32 ATP**

ATP Yield from Aerobic Respiration



Anaerobic



- No Oxygen present → **Only 2 ATP** produced
- 2 step process - Glycolysis & Fermentation
- **Oxidizes** NADH → NAD^+ which is used again to allow glycolysis to continue
- Yields: 2 ATP & 2 lactate