8.3 Cellular Respiration

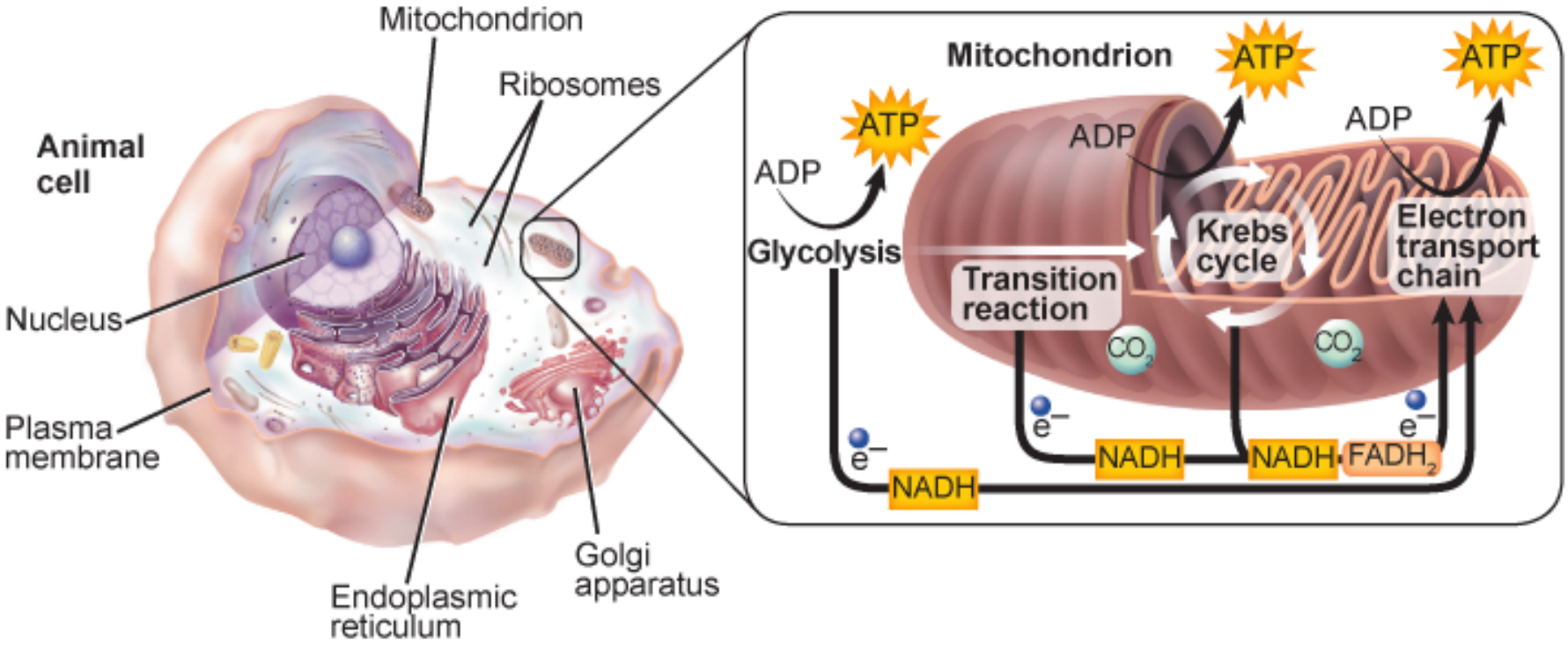
Cellular Respiration- how living organisms get usable energy

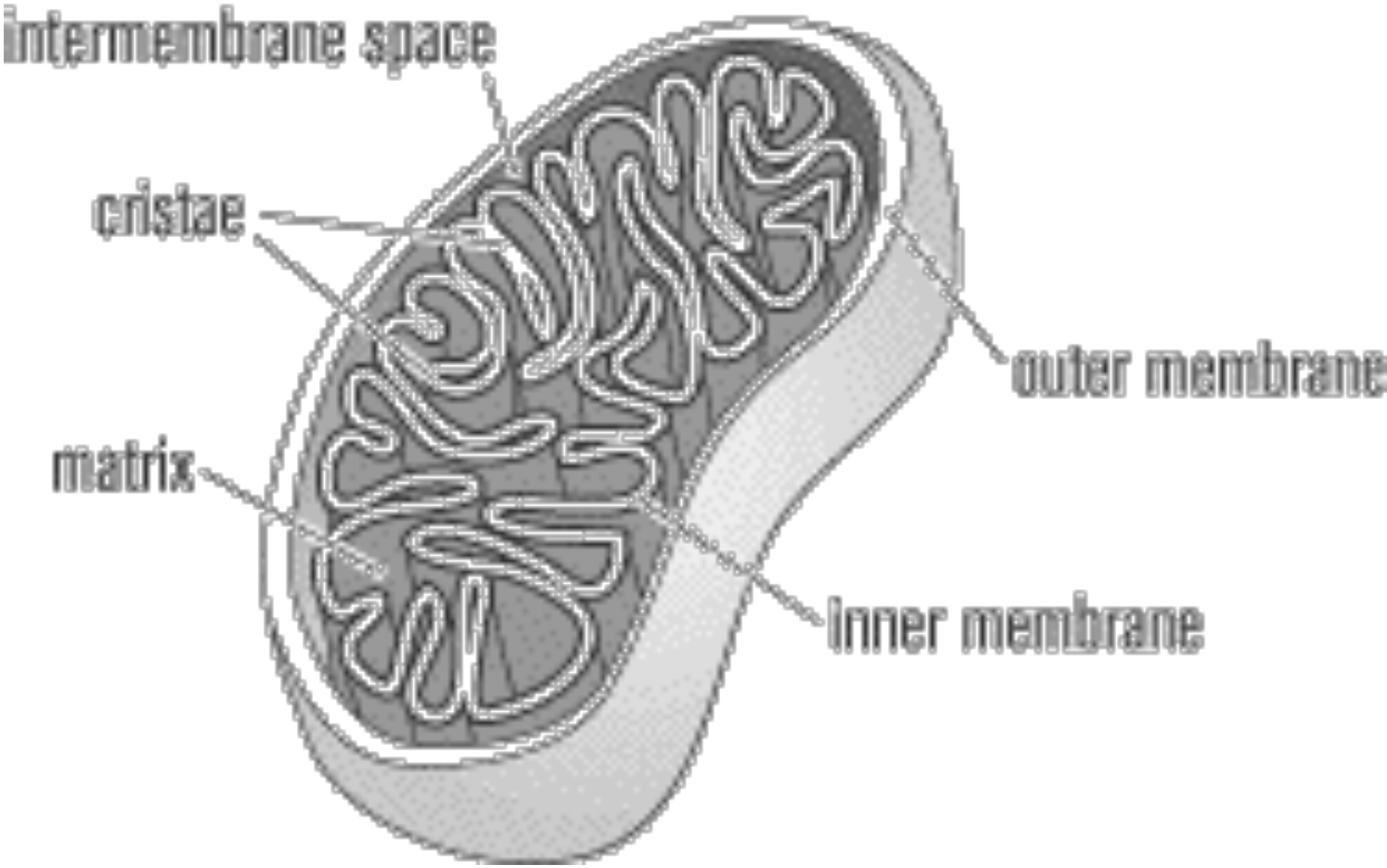
uses electrons from organic molecules (carbs) to make ATP.

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

*** This is the exact OPPOSITE of photosynthesis ***

Mitochondria- both plants and animals




intermembrane space
cristae
matrix
outer membrane
inner membrane

Anaerobic-

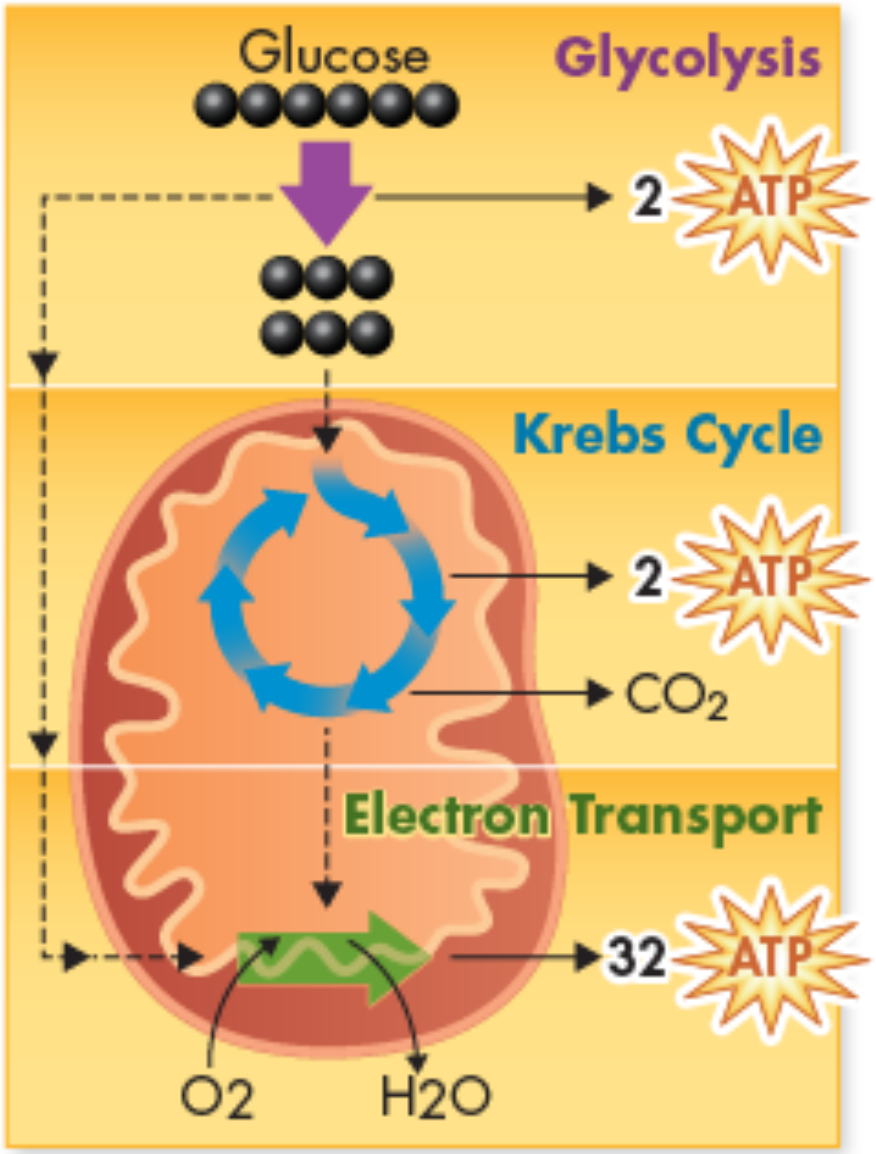
does **not** require oxygen.

Aerobic-

requires oxygen.

3 steps of Cellular Respiration

- Glycolysis
- Krebs Cycle
- ETC



Glycolysis

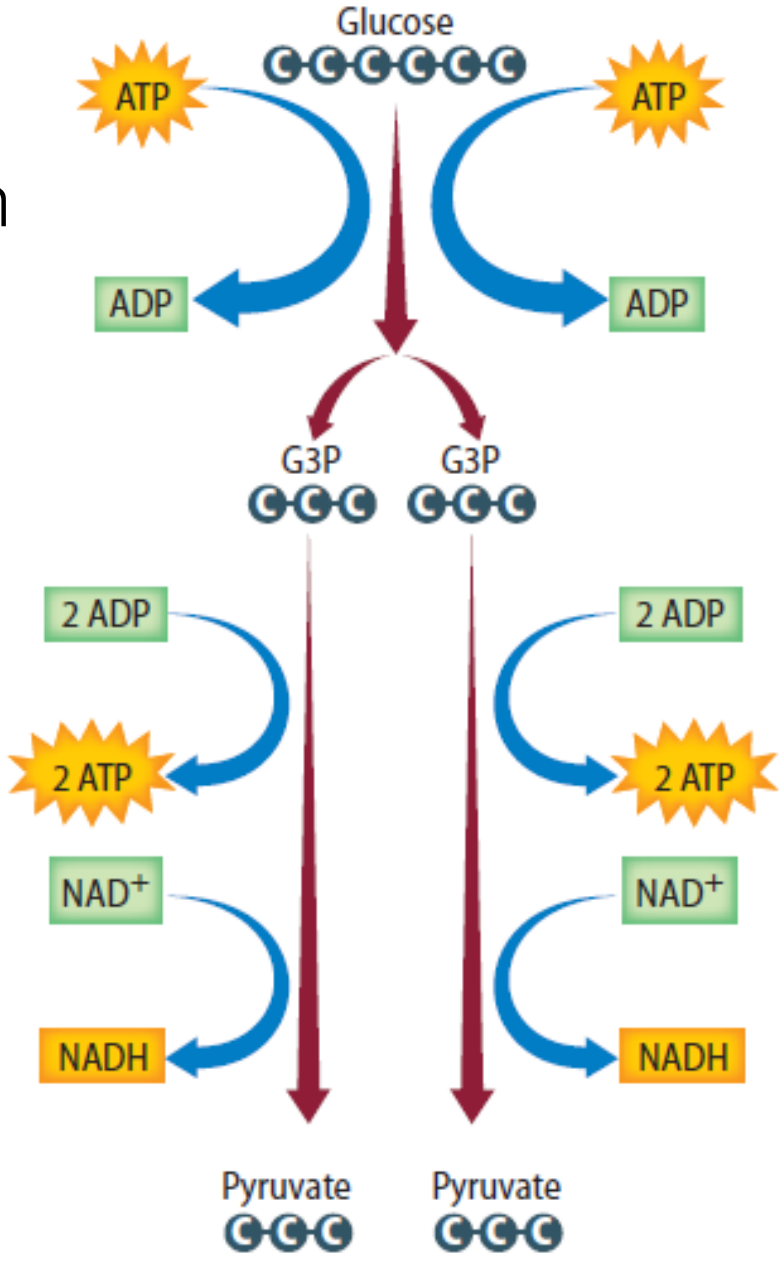
- **Anaerobic** (no oxygen)
- Happens in the **cytoplasm**

Steps of glycolysis:

- Start with **glucose** (6-carbon)
- 2 phosphates from ATP attach to the glucose and it's broken into two G3P (3-carbon)

For **each** G3P **there are two**

- 2 phosphates given back (2 ADP → 2 ATP)
- Electrons and H^+ turn NAD^+ → NADH
- The G3P changes to **Pyruvate**



Total of two molecules of **ATP**
(because four were made, but two were used up!)
BUT... Most of the energy is still in the pyruvate.

If there is oxygen, pyruvate is transported inside the **mitochondrial matrix**, where it is converted into carbon dioxide.

Krebs cycle- break pyruvate into carbon dioxide

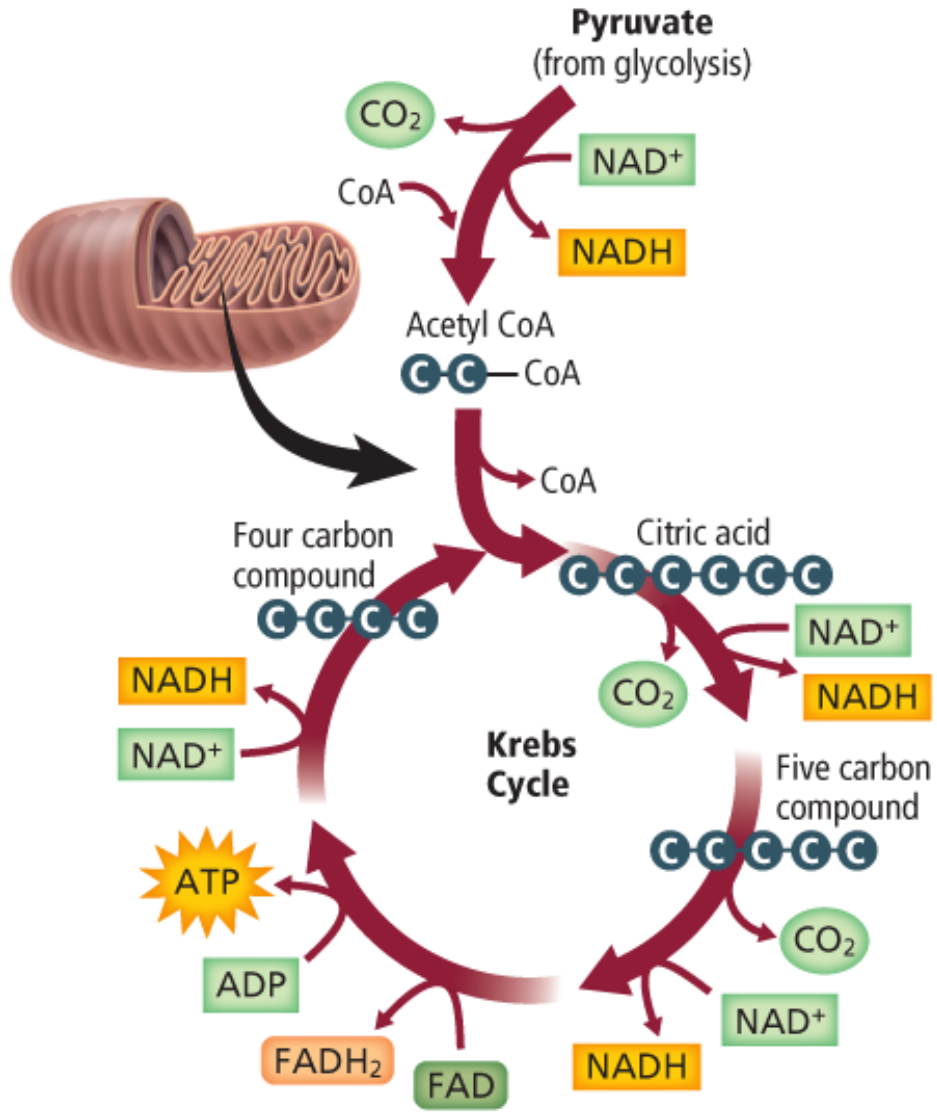
Happens inside the mitochondrion (matrix)

also know as:

- **citric acid cycle** because citric acid is formed
- tricarboxylic acid (**TCA**) cycle

Steps of the Krebs cycle

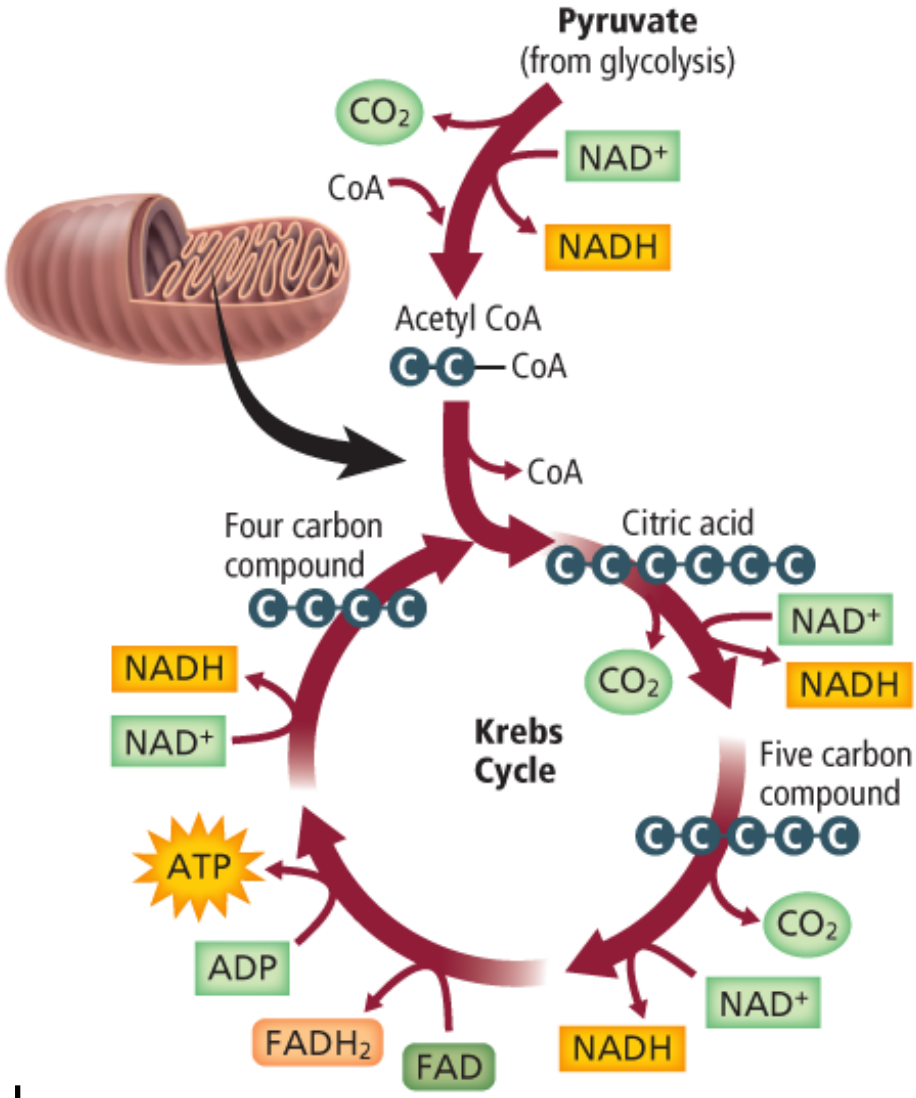
- **Transition Step**: **pyruvate** reacts with coenzyme A (CoA) to form **acetyl CoA**.
- Acetyl CoA moves into the **mitochondria**.
- Acetyl CoA combines with a 4-carbon compound to form **citric acid** (6-carbons)



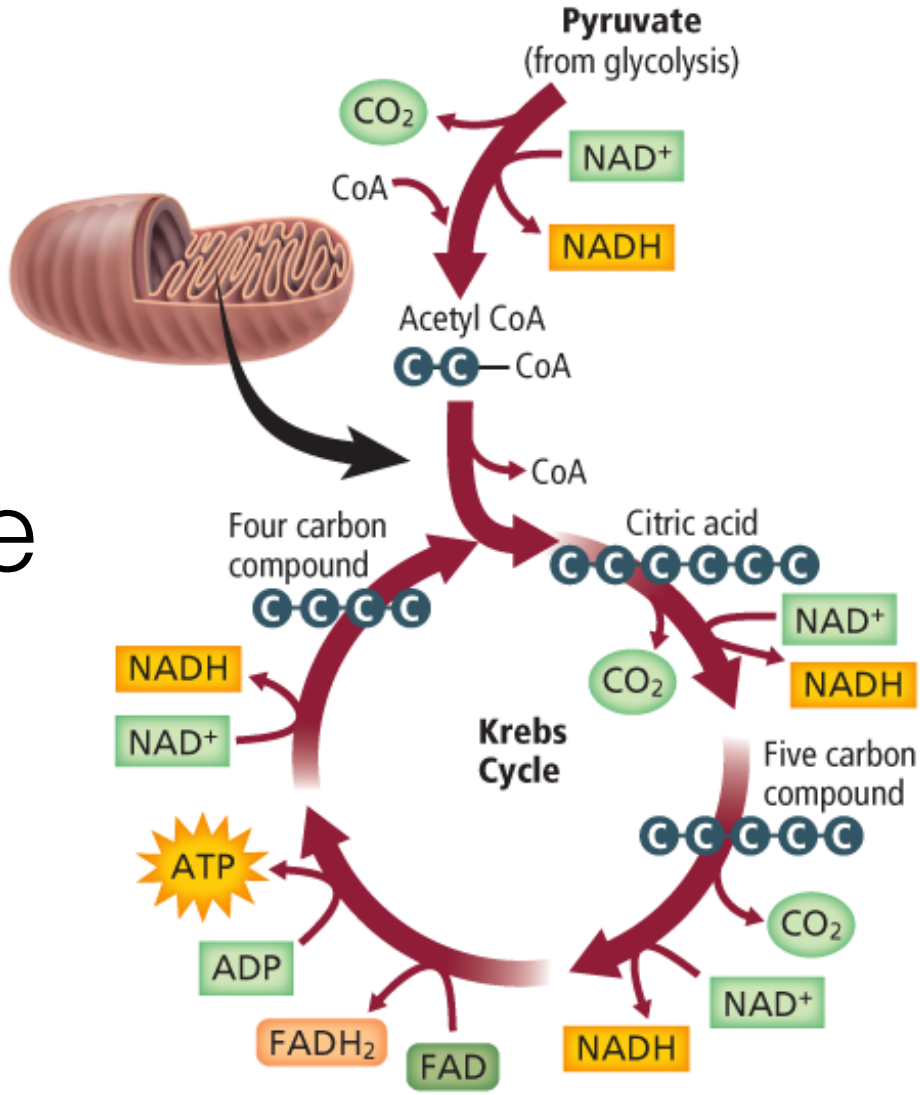
Citric acid broken down creating:

- two CO_2
- one ATP
- three NADH
- one $FADH_2$.

Acetyl CoA and citric acid are generated and the cycle continues.



Krebs Cycle happens **TWICE** because there were two pyruvate



10 NADH and 2 $FADH_2$ (electron carriers) have been made between glycolysis and Krebs cycle.

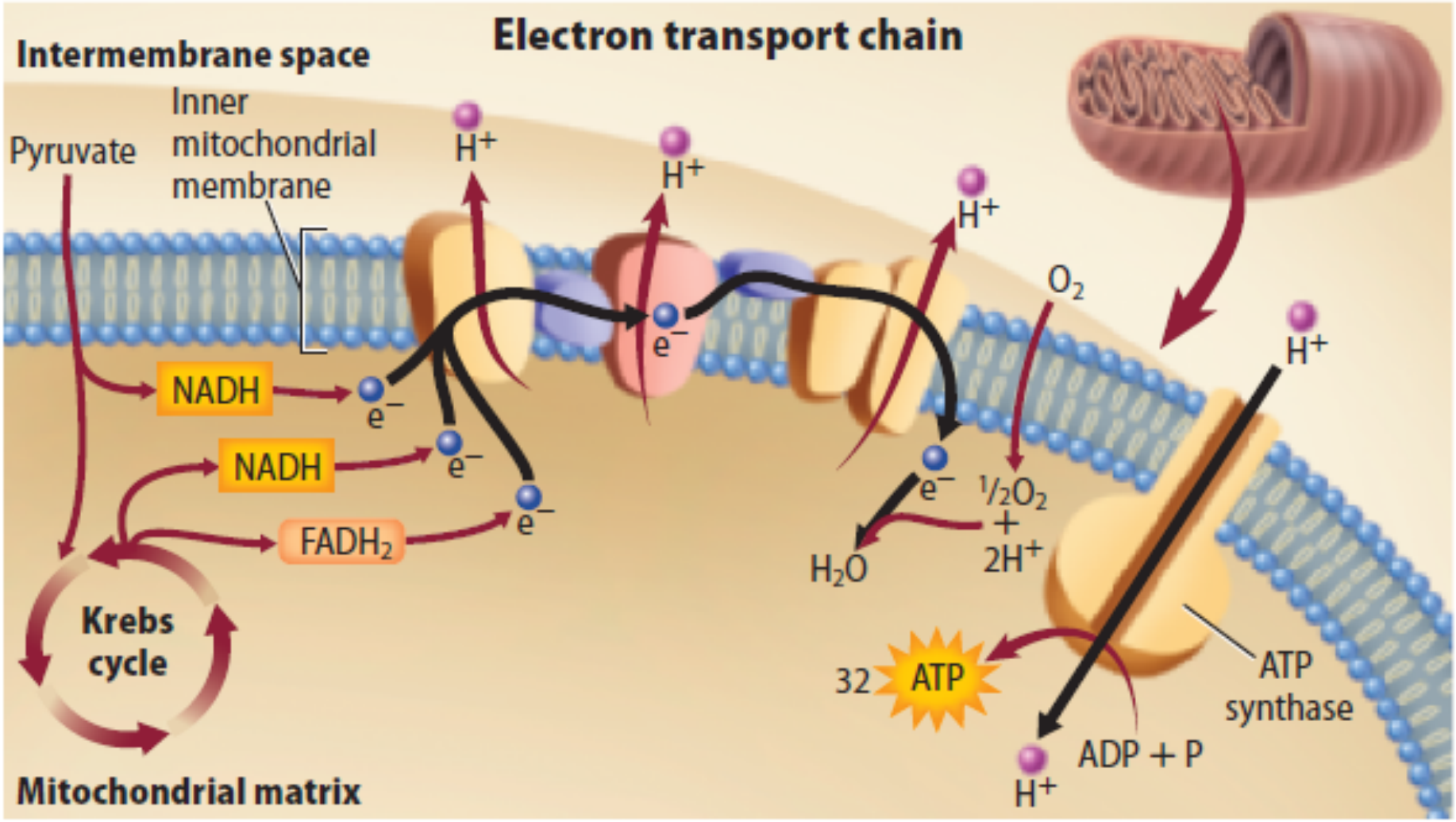
They carry their electrons to the ETC

Electron Transport Chain

-**aerobic** respiration (needs O_2)

-majority of ATP made here

-happens in the inner mitochondrial membrane


Electron transport chain
Intermembrane space
Inner mitochondrial membrane
Pyruvate
H+
H+
H+
H+
NADH
NADH
FADH2
e−
e−
e−
e−
e−
e−
O2
½O2 + 2H+
H2O
Krebs cycle
32 ATP
ATP synthase
ADP + P
Mitochondrial matrix

Steps Electron Transport Chain

NADH and $FADH_2$ send their electrons through the **ETC**, concentrating H^+ molecules.

ATP Synthase is powered by the H+ moving to convert **32 ADP to 32 ATP**.

Oxygen takes the H+ and the electrons and forms **water**.

Prokaryotic cellular respiration

prokaryotes do **not** have mitochondria, so they use the **plasma membrane** for electron transport.

Anaerobic Respiration

When oxygen is unavailable, cells cannot used **aerobic respiration** (Krebs cycle and electron transport).

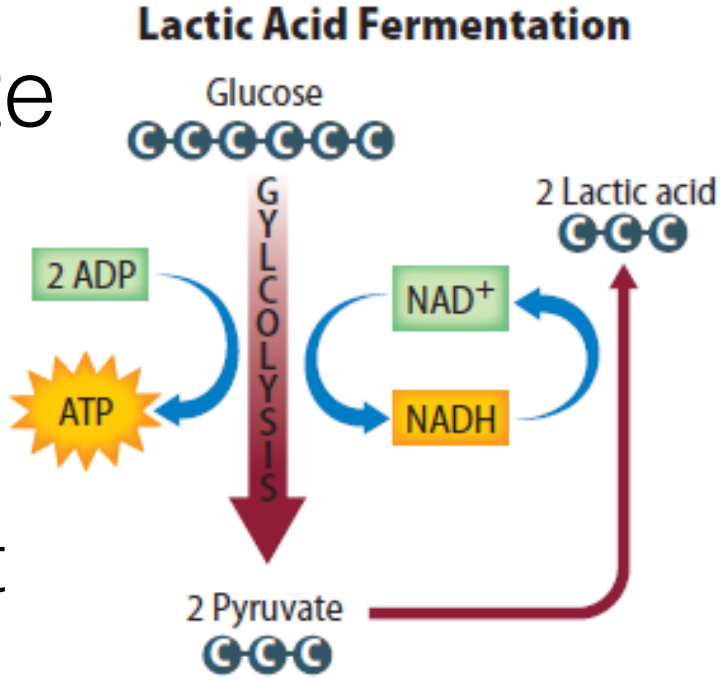
Fermentation- anaerobic respiration (after glycolysis)

Fermentation occurs in the cytoplasm, and produces NAD^+ and ATP.

(Glycolysis will stop if there isn't enough NAD+)

Lactic acid fermentation

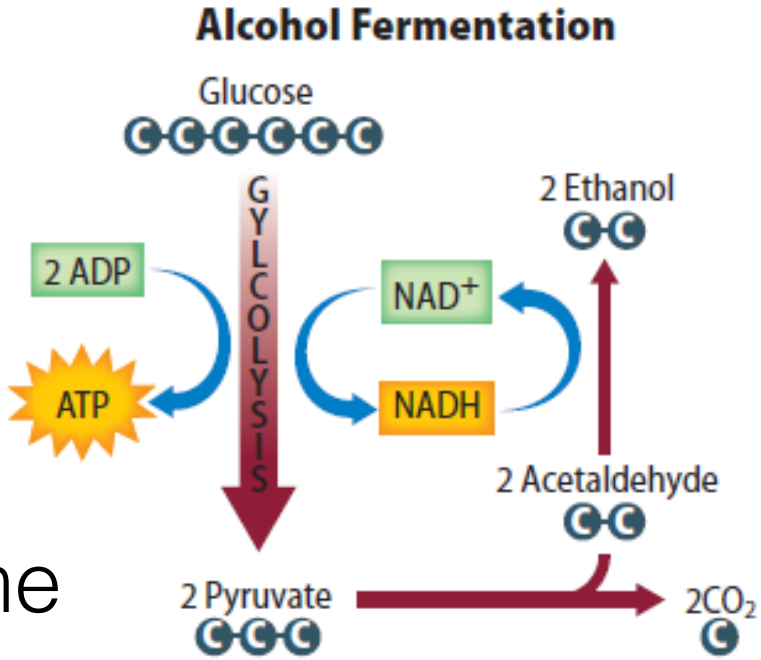
Enzymes convert pyruvate into **lactic acid**.



- Skeletal muscles produce lactic acid when there isn't enough oxygen, such as during exercise.

Alcohol fermentation

Converts pyruvate into **ethyl alcohol** and carbon dioxide



- Occurs in yeast and some bacteria

Photosynthesis and Cellular Respiration