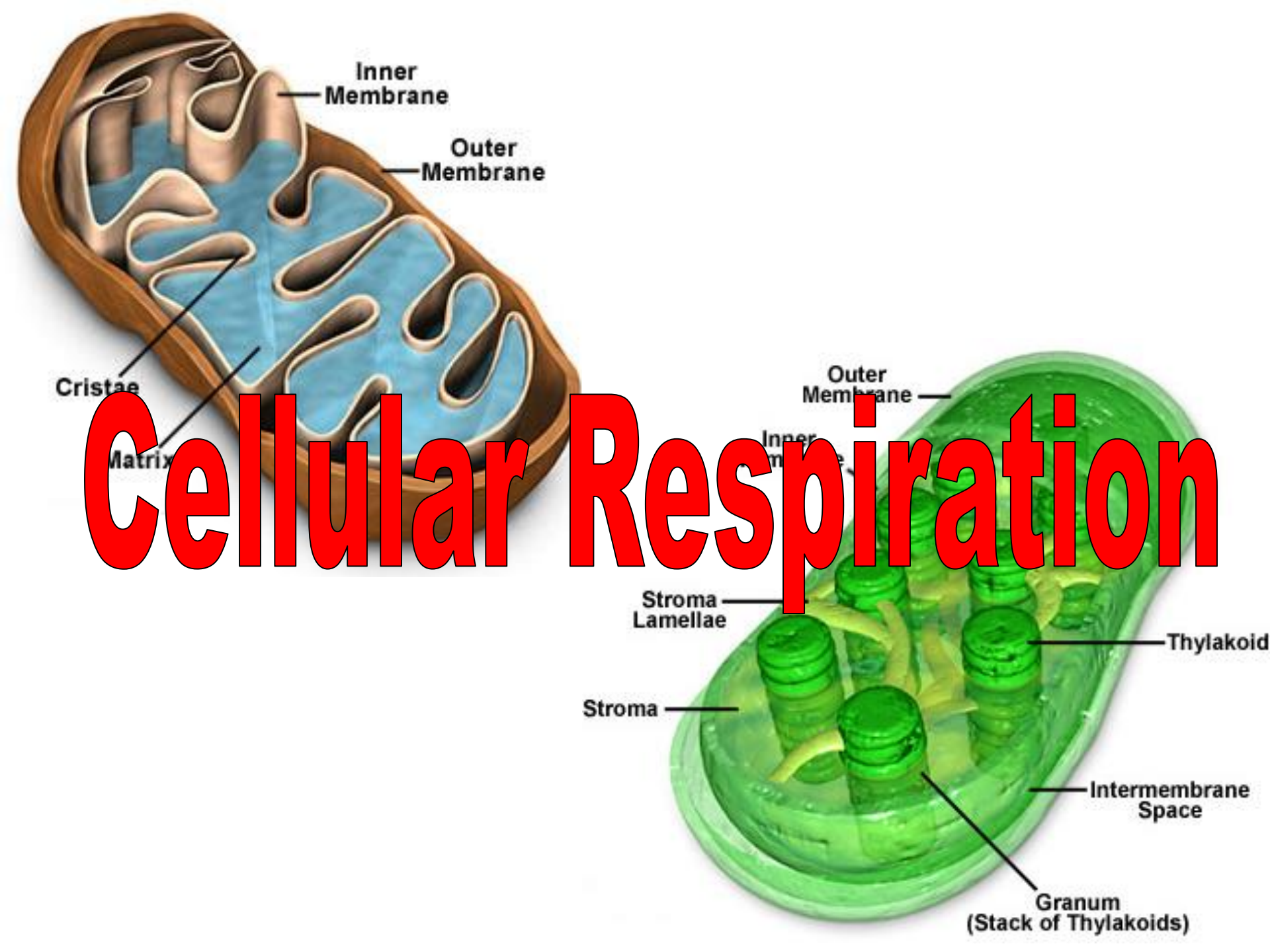
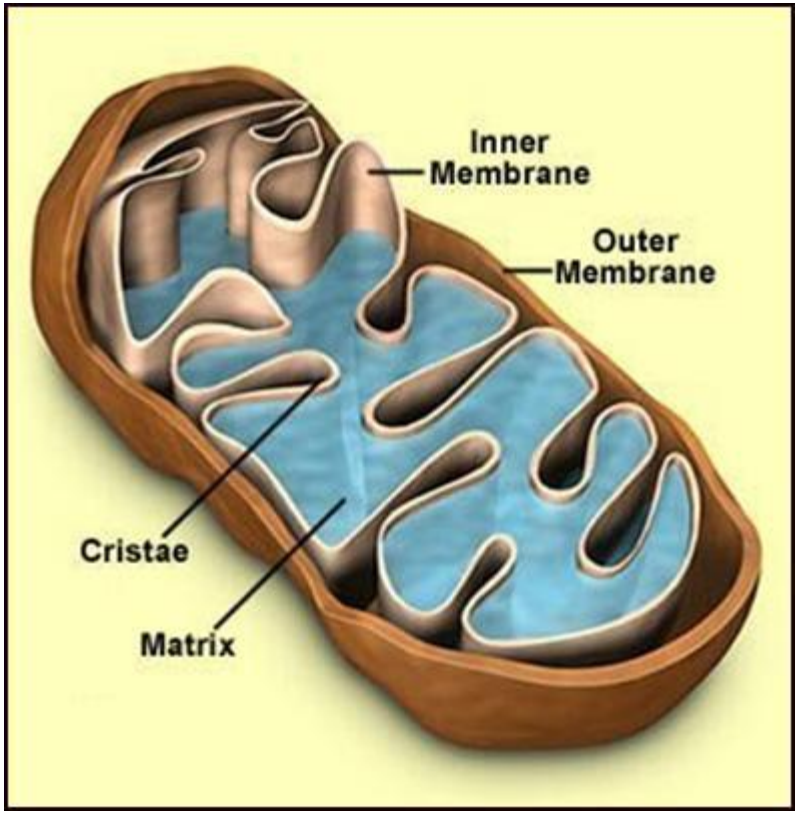


Cellular Respiration

Overview of **Cellular Respiration**

Cellular respiration makes **ATP** by breaking down **sugars** and other carbon-based molecules



- Cellular respiration is **aerobic** (requires **oxygen**)
- Takes place in **mitochondria** (cell "powerhouse")

Generally:

1. **GLYCOLYSIS** = Glucose is broken down into Pyruvate, NADH, and a small amount of ATP **(Cytoplasm)**

2. **OXIDATIVE RESPIRATION** = Pyruvate + NADH make a large amount of ATP **With O_2 (Mitochondria)**

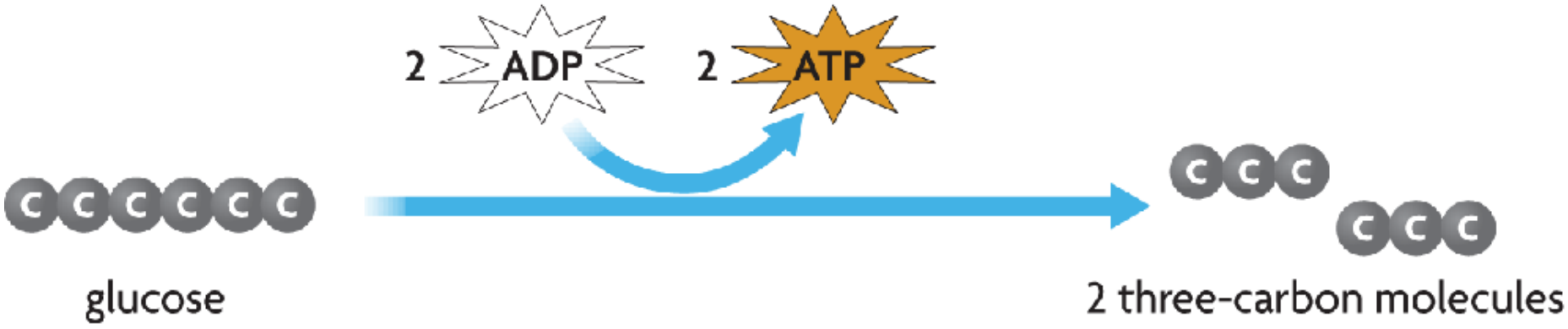
– or –

2. **FERMENTATION** = Pyruvate converted to lactic acid or ethyl alcohol (ethanol) + CO_2 **Without O_2 (Cytoplasm)**

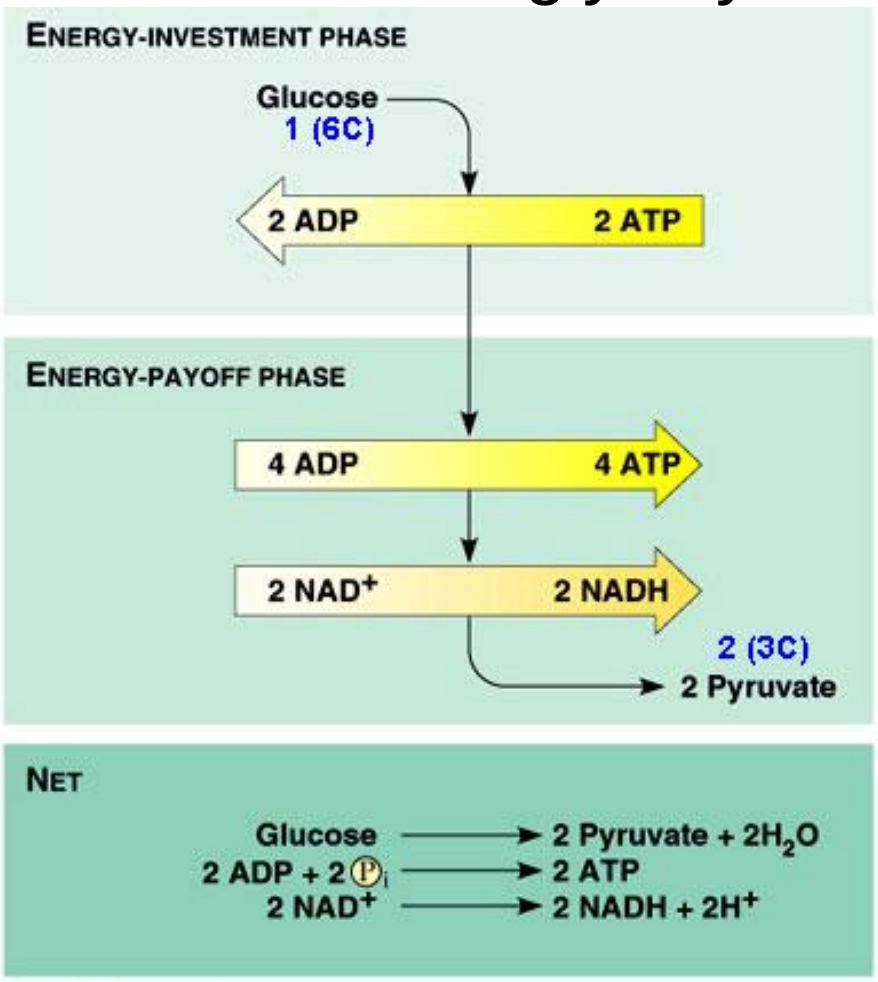
Process starts with **Glycolysis** (means “glucose breaking”)

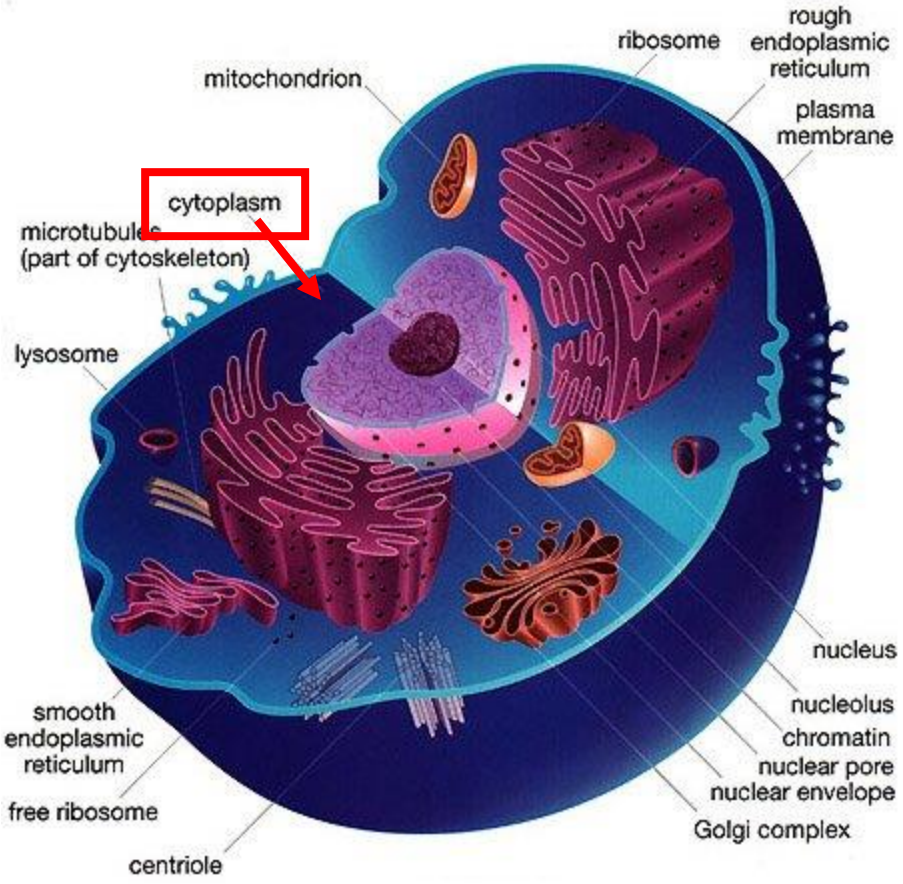
- **6-carbon glucose** broken into two 3-carbon molecules of **pyruvic acid**

- Produces **2 molecules of ATP** (makes 4, but uses 2 ATP = net of 2 ATP)

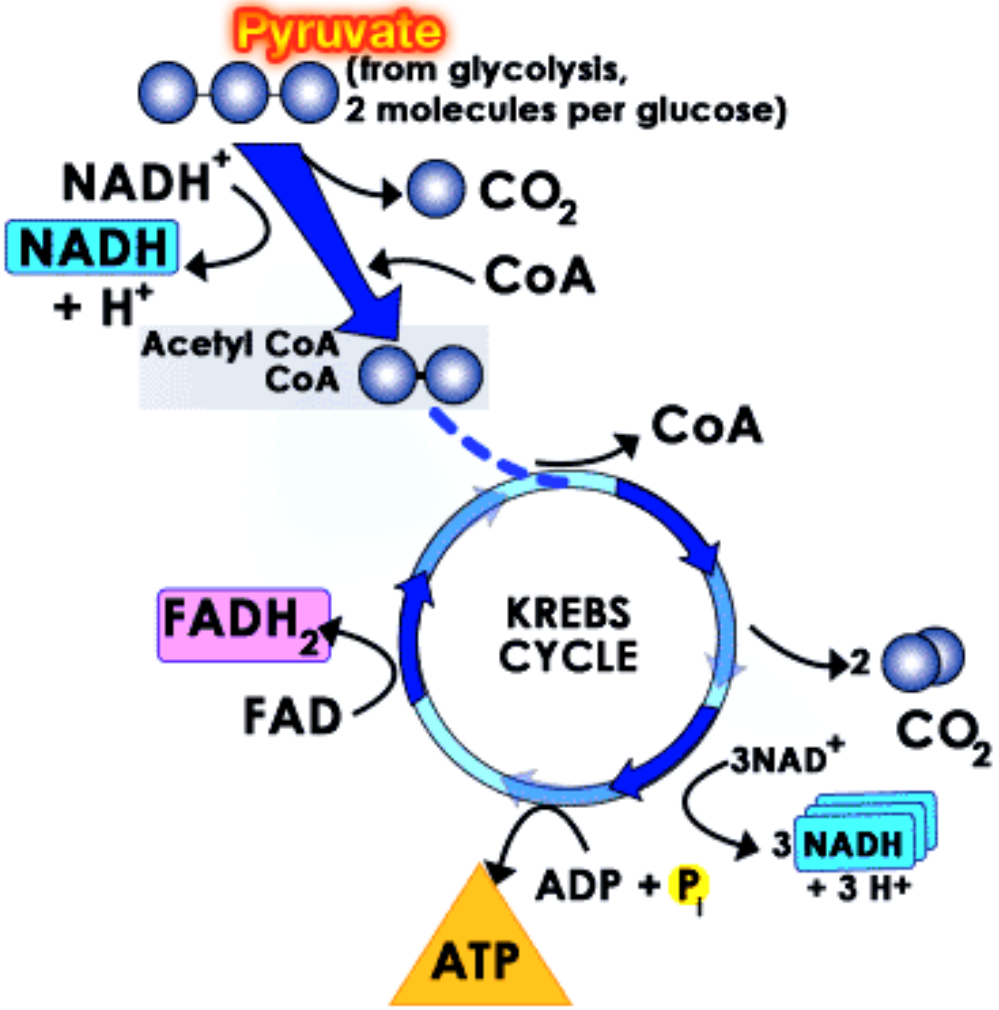


- **Anaerobic** process (does <u>not</u> require **oxygen**)
- Takes place in **cytoplasm**
- Products of glycolysis used in respiration process.

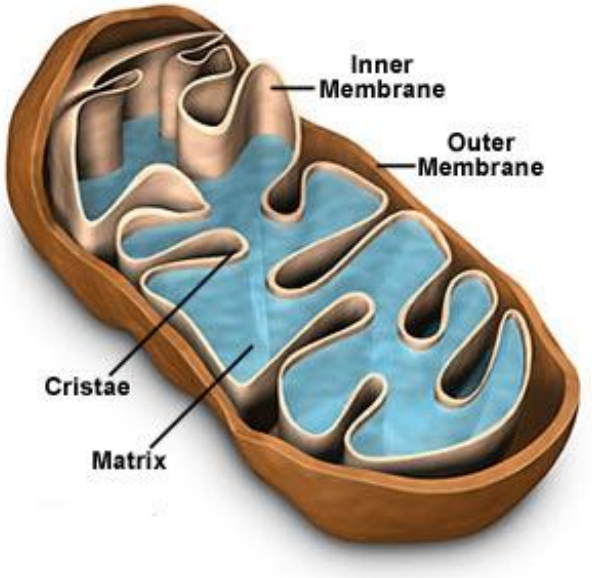




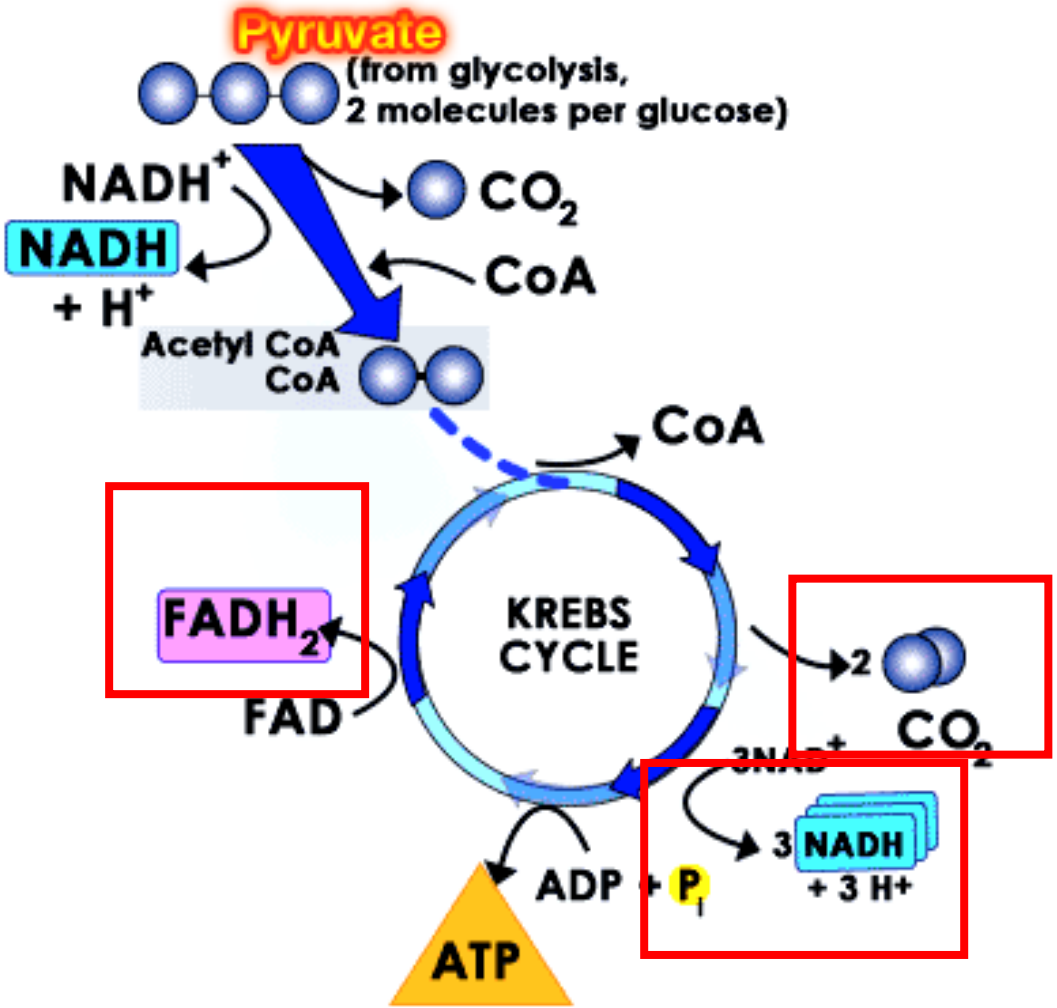
OXIDATIVE (Cellular) RESPIRATION takes place in **two main stages**



1. **Krebs cycle** takes place in interior space of **mitochondria**.

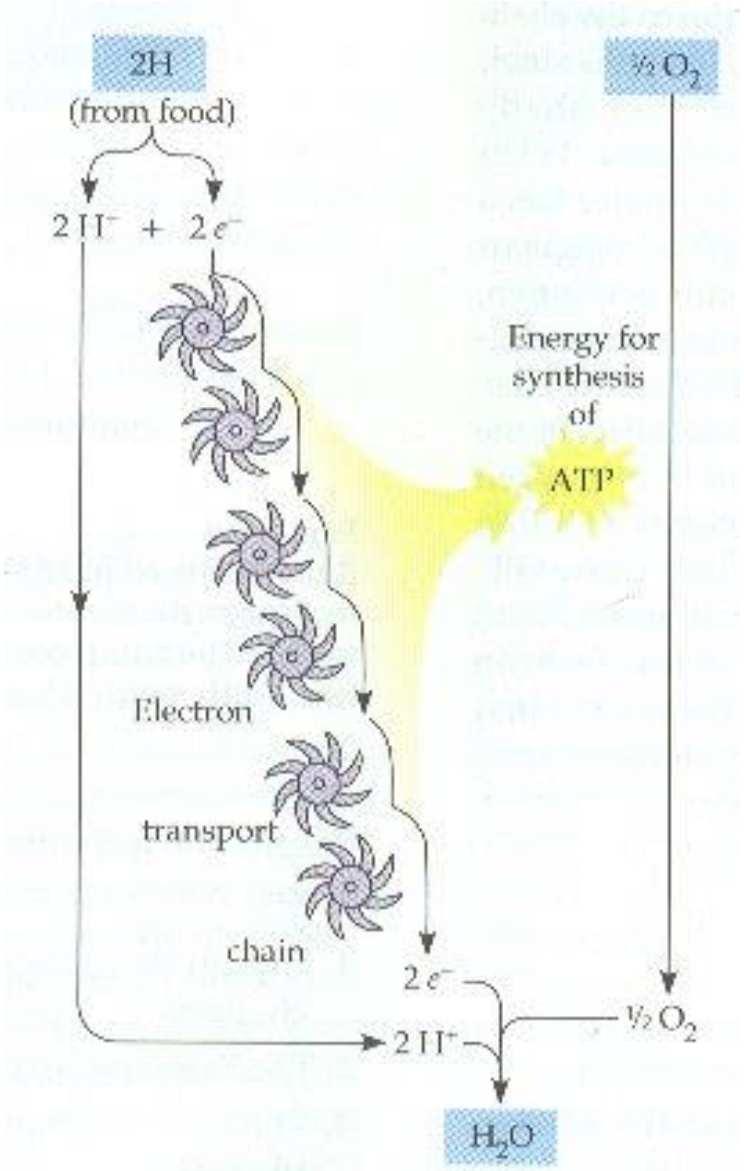


- **3-carbon molecules** produced in **glycolysis** are broken down in a **cycle of chemical reactions**

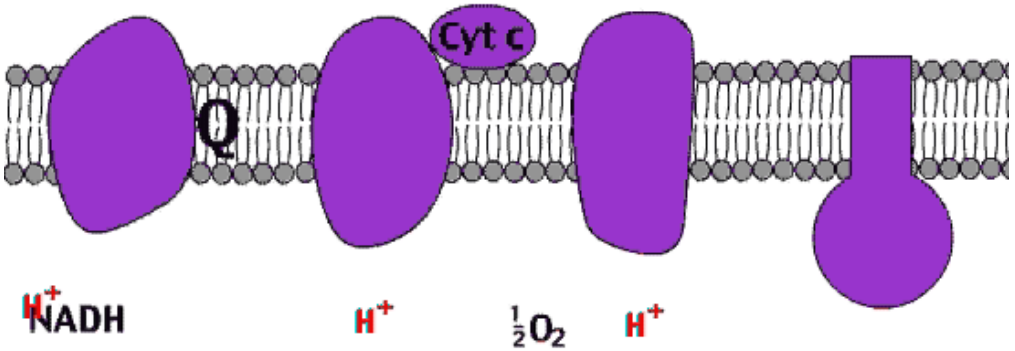


- **Carbon dioxide** (CO_2) is given off
- **Energy** produced is transferred to 2nd stage (energy in the form of 2 ATP and other "charged" molecules: **NADH** and **$FADH_2$**)

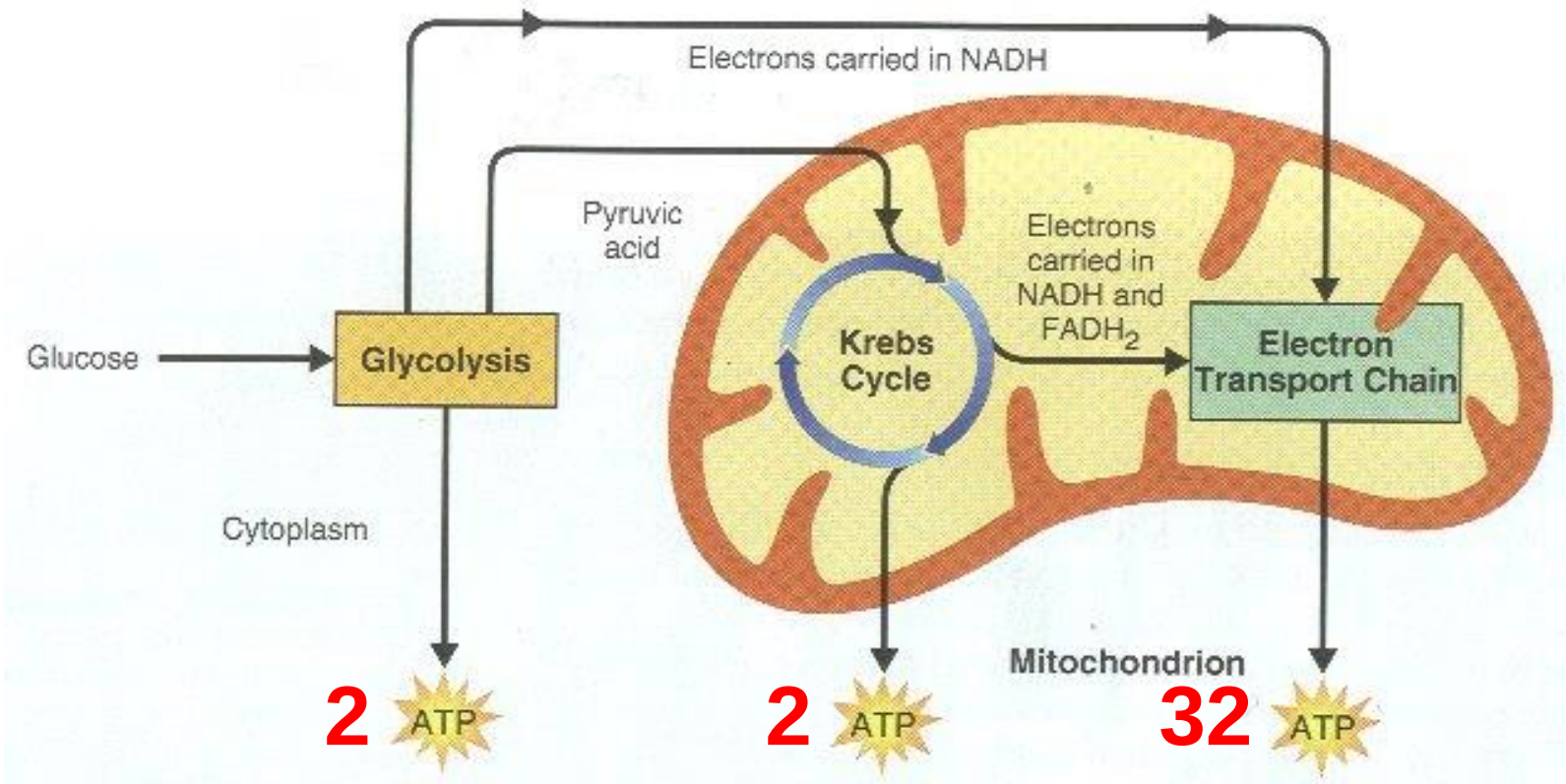
2. **Electron Transport Chain** takes place in inner membrane



- Electrons are passed along
- Their energy is used to pump [H^+] against concentration gradient

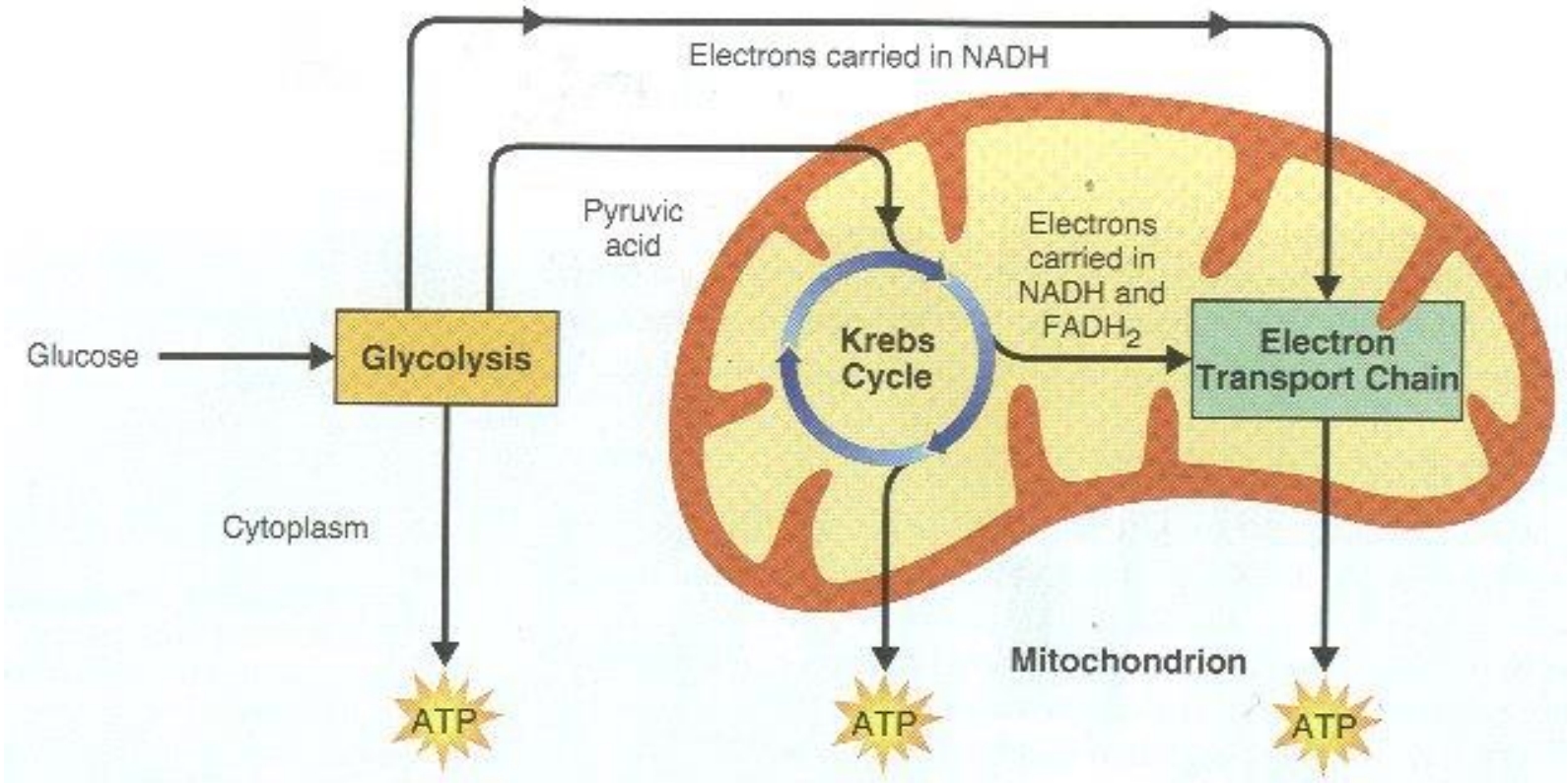


- Produces 34 ATP (for a total of 36 including Glycolysis)
- Oxygen enters process and picks up final electrons and hydrogen to make H_2O (water)
- Many enzymes required for process



Overall equation of cellular respiration

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

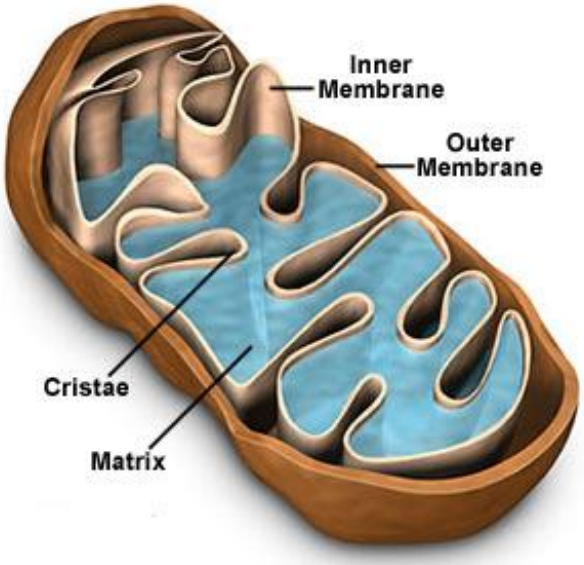


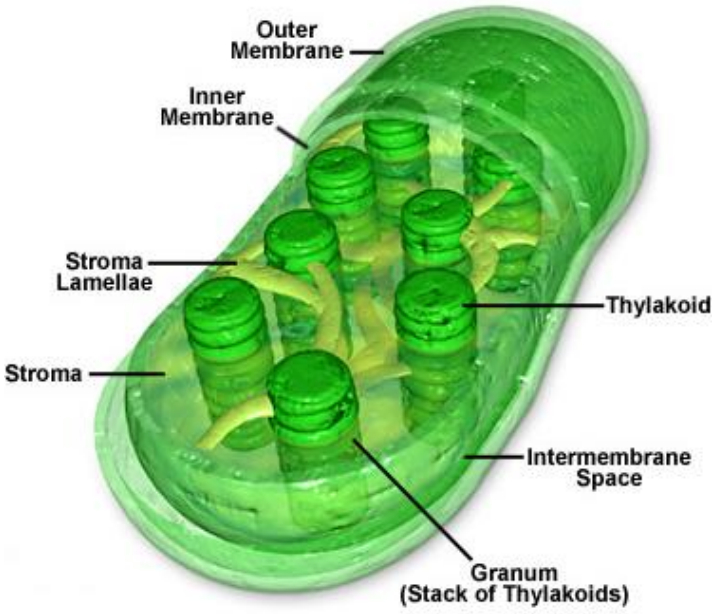
Cellular **respiration** is like **mirror** image of **photosynthesis**

- Chemical equation for cellular **respiration** is basically the **reverse** of that for **photosynthesis**
- Structures in **chloroplast** and **mitochondria** are similar

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

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





Comparing Photosynthesis and Cellular Respiration (reactants of photosynthesis are same as products of cellular respiration)

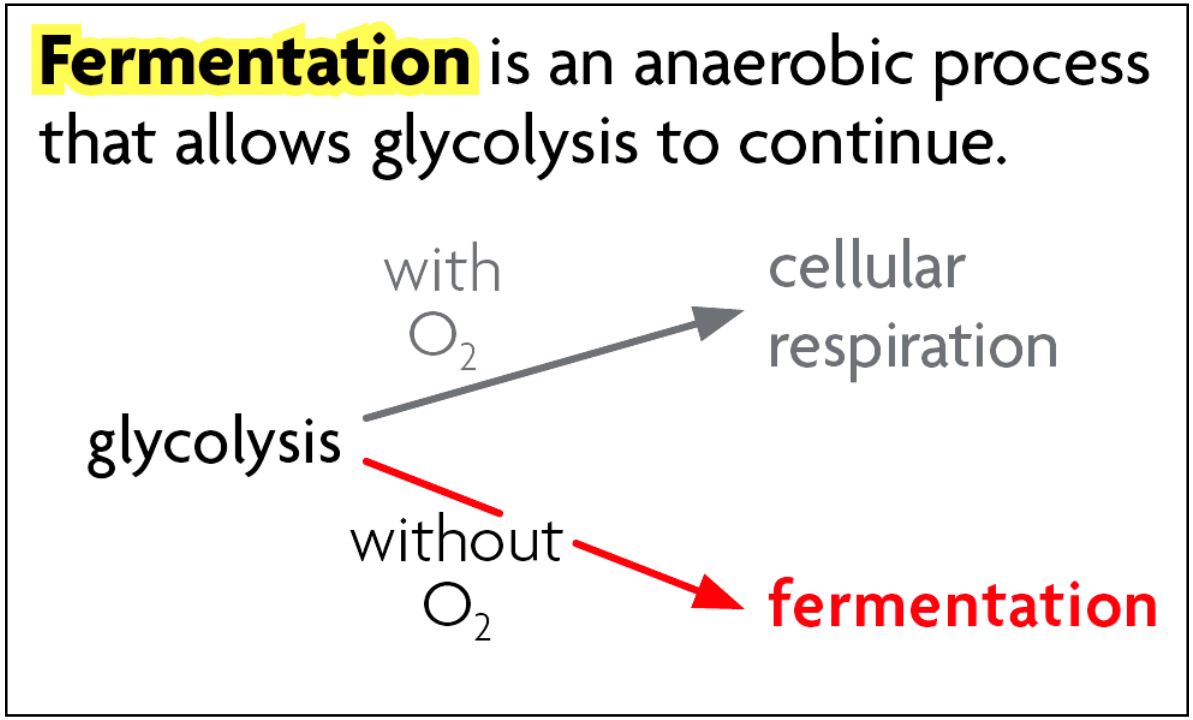
Comparing Photosynthesis and Cellular Respiration

	Photosynthesis	Cellular Respiration
Function	Energy storage	Energy release
Location	Chloroplasts	Mitochondria
Reactants	CO_2 and H_2O	$C_6H_{12}O_6$ and O_2
Products	$C_6H_{12}O_6$ and O_2	CO_2 and H_2O
Equation	$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$	$6O_2 + C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$

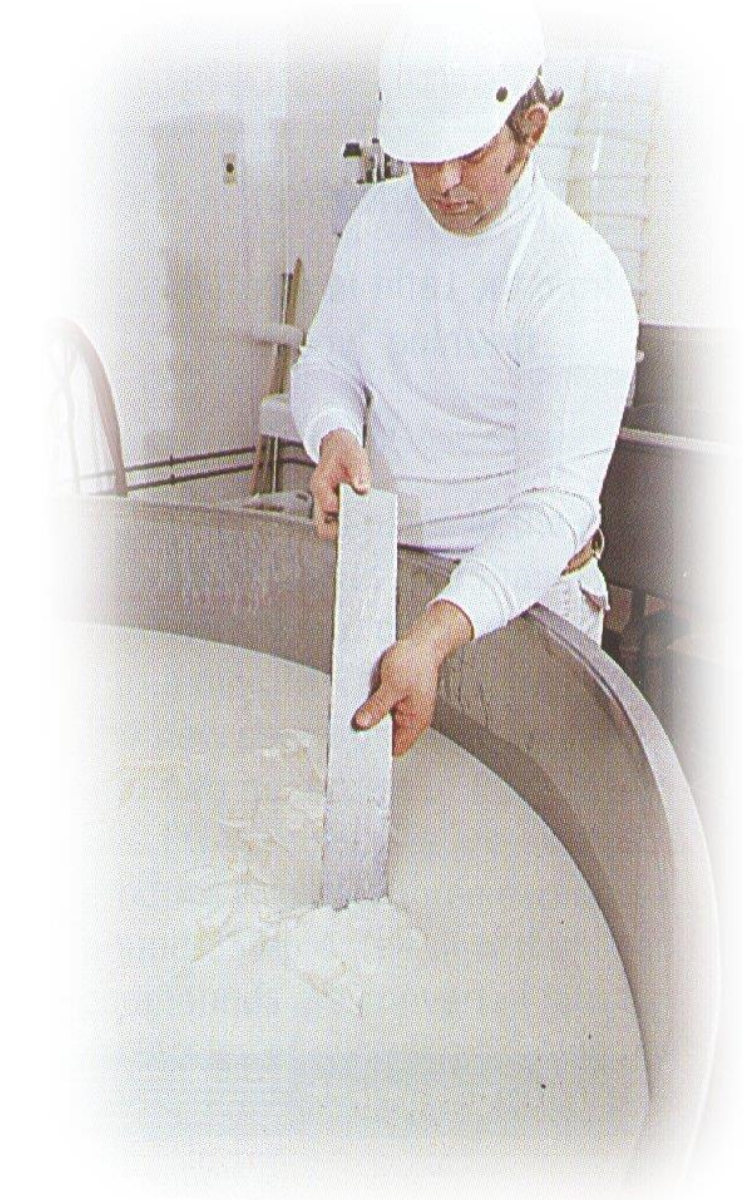
Fermentation

- Takes place in cytoplasm

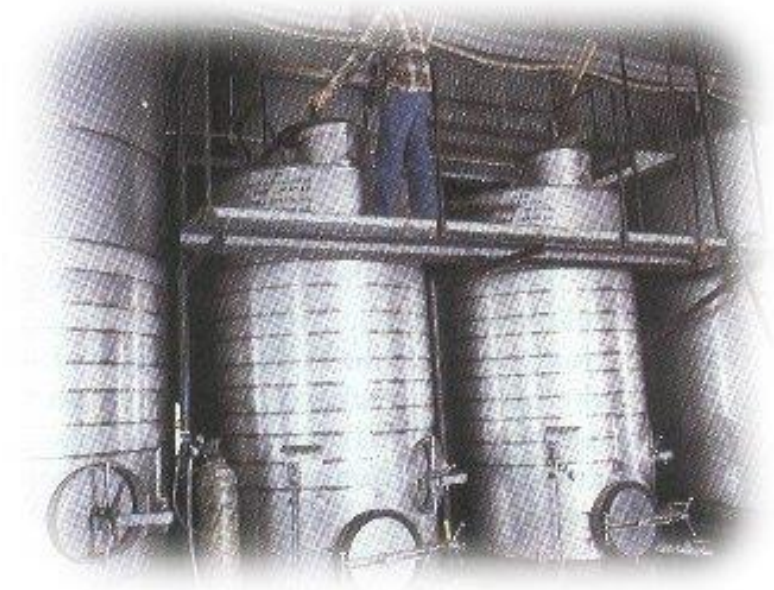
- **Fermentation** allows **glycolysis** to continue making **ATP** when **oxygen is unavailable (no E.T.C.)**



Fermentation is an **anaerobic** process



- Occurs when oxygen not available for cellular respiration
- Does not produce **ATP**
- **NAD+** is recycled to **glycolysis**

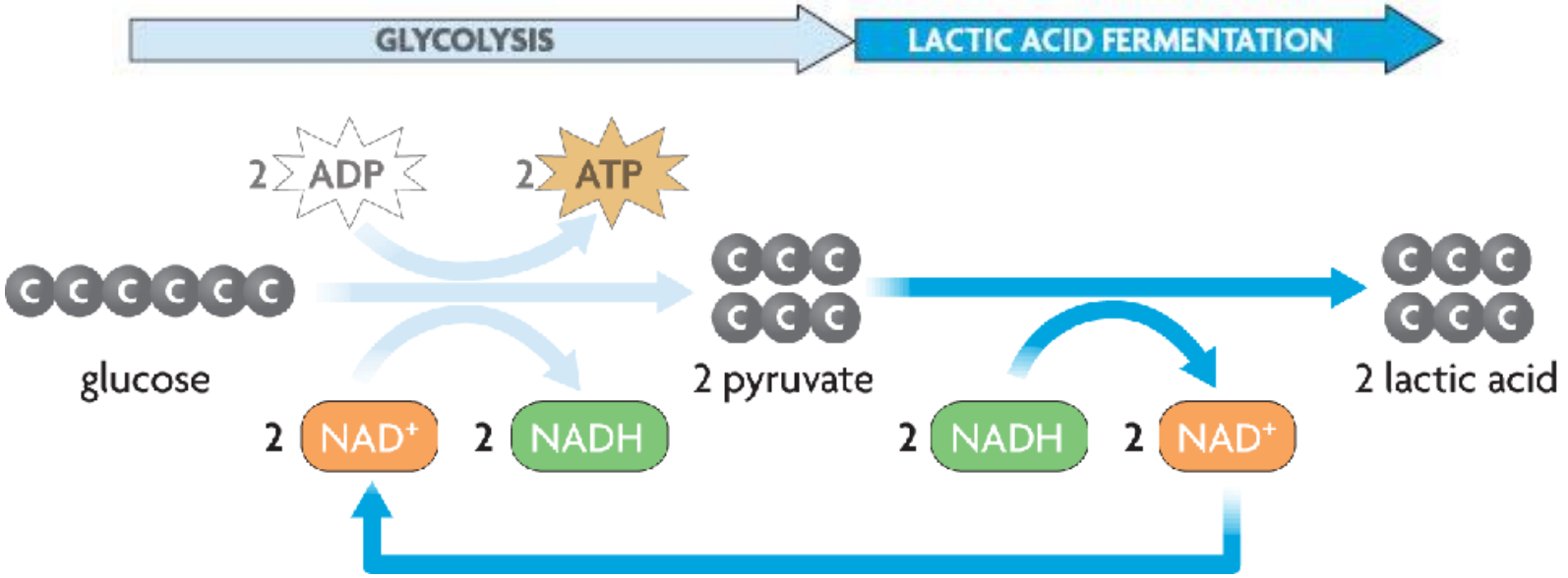


1. Lactic Acid Fermentation

- occurs in **muscle cells**

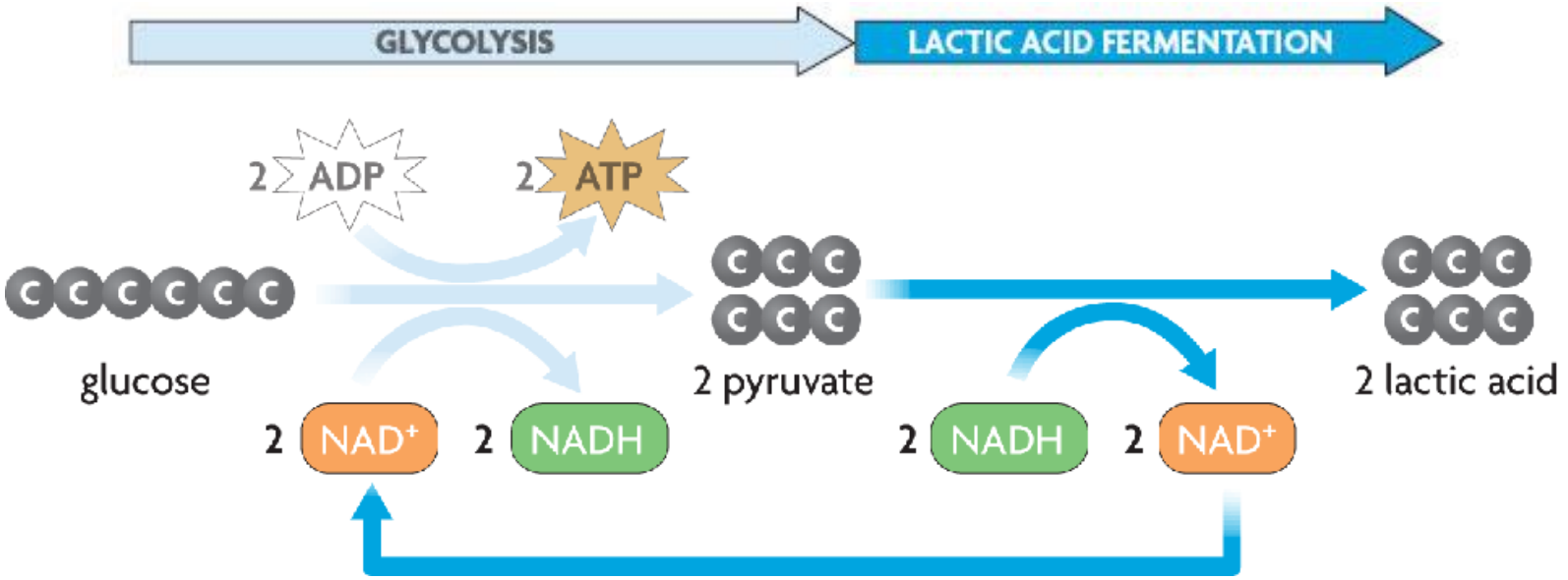
- **Glycolysis** splits **glucose** into two **pyruvate** molecules

- **Pyruvate** and **NADH** enter fermentation



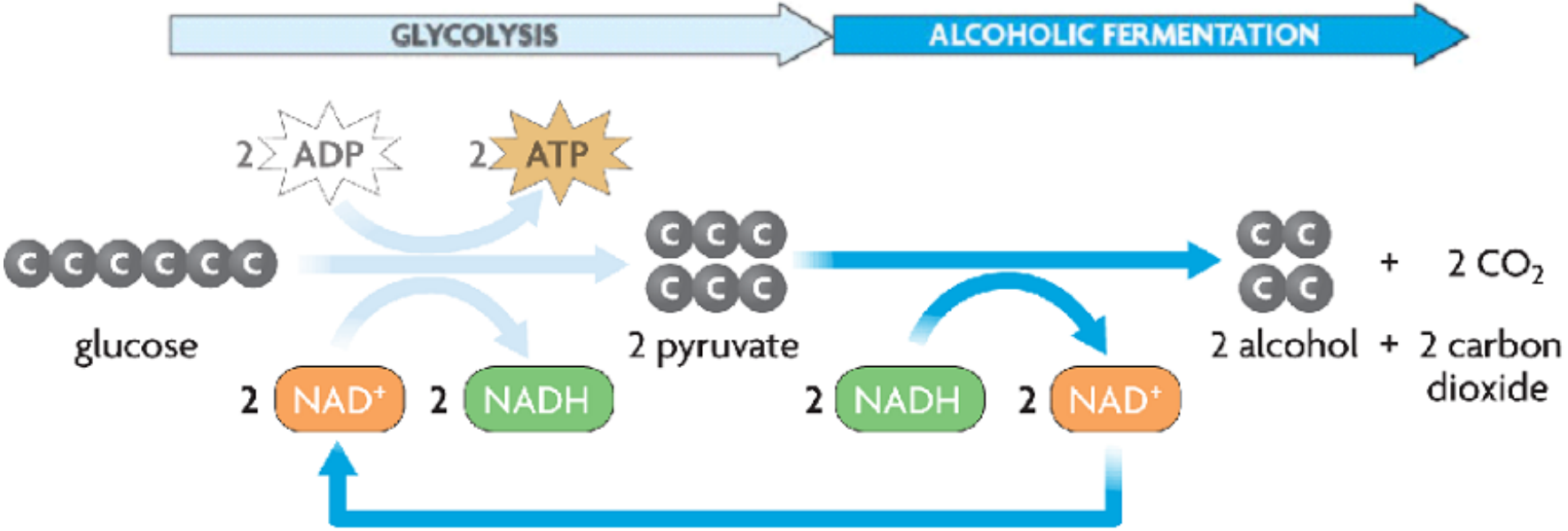
- **Energy** from **NADH** converts **pyruvate** into **lactic acid**

- **NADH** is changed back into **NAD+**

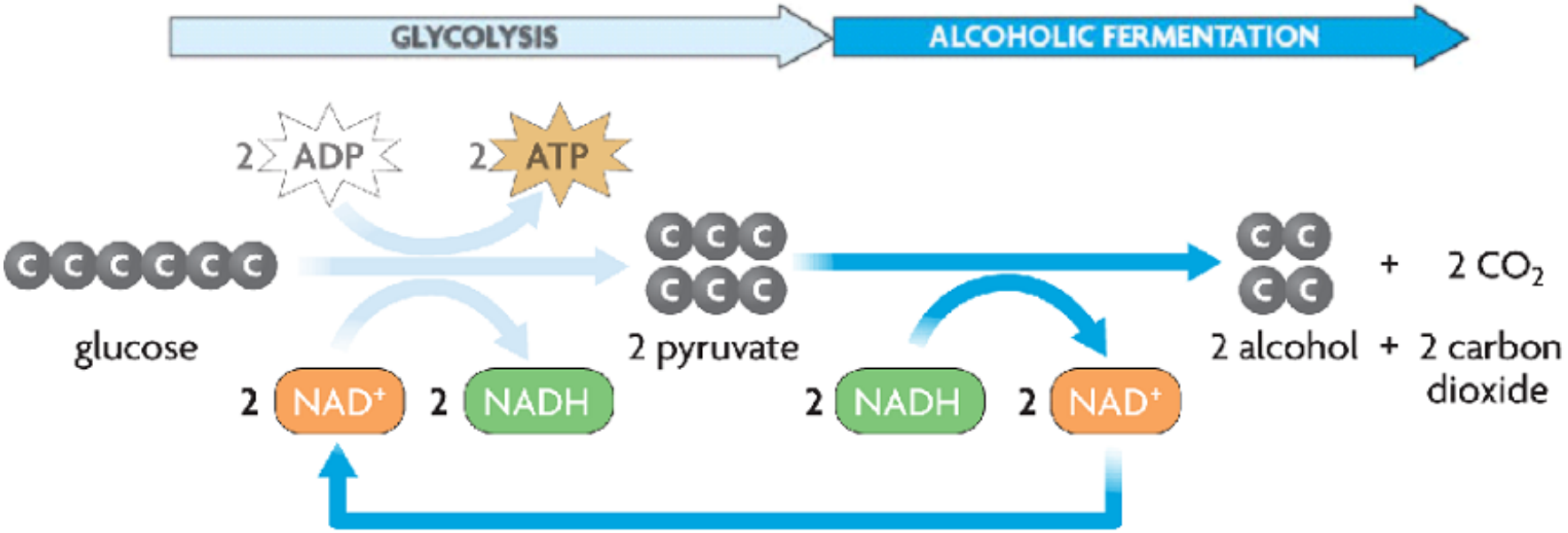


2. **Alcoholic fermentation** similar to lactic acid fermentation

- Products of alcoholic fermentation include cheese, bread, yogurt
- **Glycolysis** splits **glucose** and products enter fermentation



- **Energy** from **NADH** is used to split **pyruvate** into an **alcohol** and **carbon dioxide**
- **NADH** is changed back into **NAD+**
- **NAD+** is recycled to glycolysis
- Yeast and bacteria



Energy and Exercise

Quick Energy

- Cells contain only enough ATP for a few seconds of intense activity
- Then cells rely on lactic acid fermentation (can supply for about 90 seconds)
- Lactic acid build-up causes burning in muscles. Only way to get rid of lactic acid is chemical pathway that requires oxygen (why you breathe heavy after heavy exercise.)

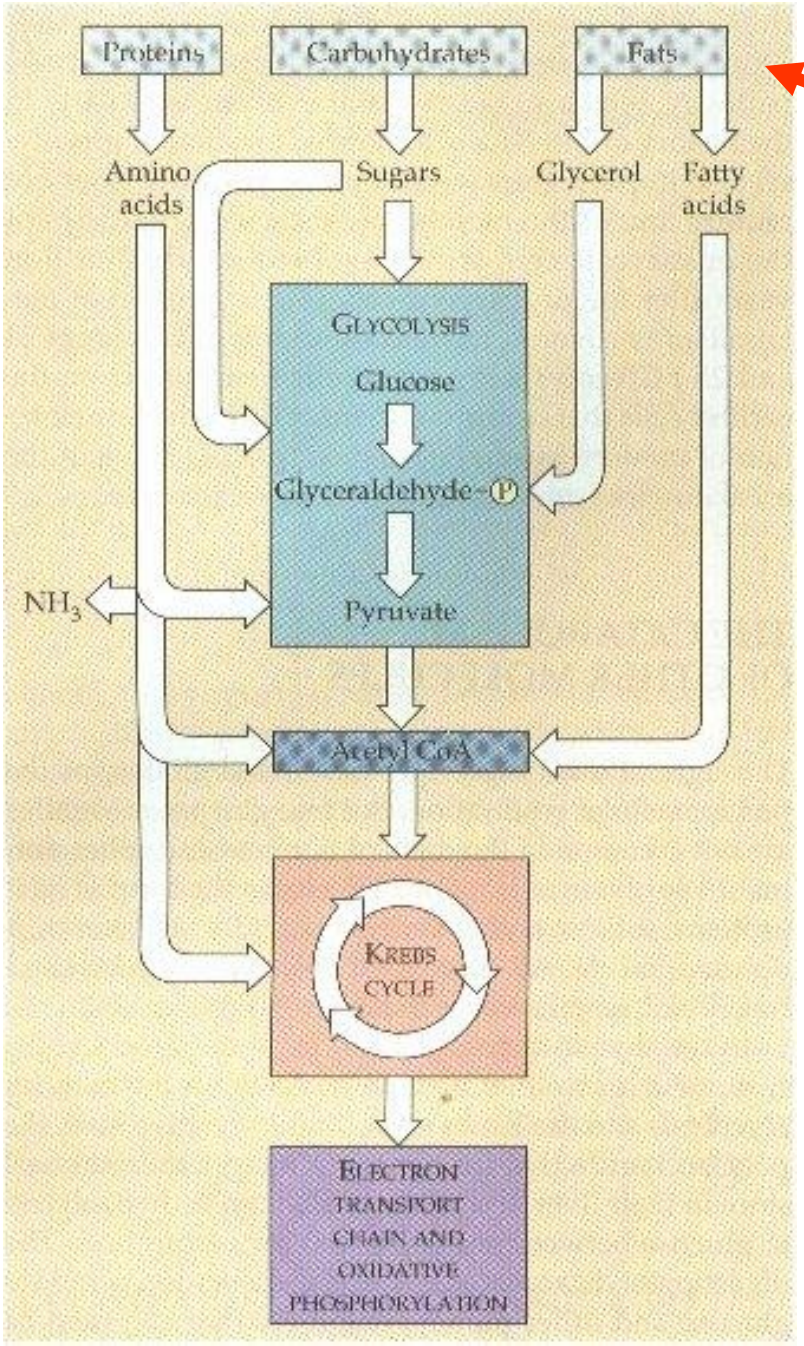
Long Term Energy

- **Cellular respiration** only way to produce continuous supply of ATP

- Energy stored in muscles and other tissue in form of carbohydrate **glycogen**

- Enough glycogen for about 15 to 20 min.

- When glycogen used up, body breaks down other stored molecules including fats, for energy.



A variety of organic molecules can be utilized to produce energy. These molecules enter the Krebs cycle different stages.