CELLULAR RESPIRATION

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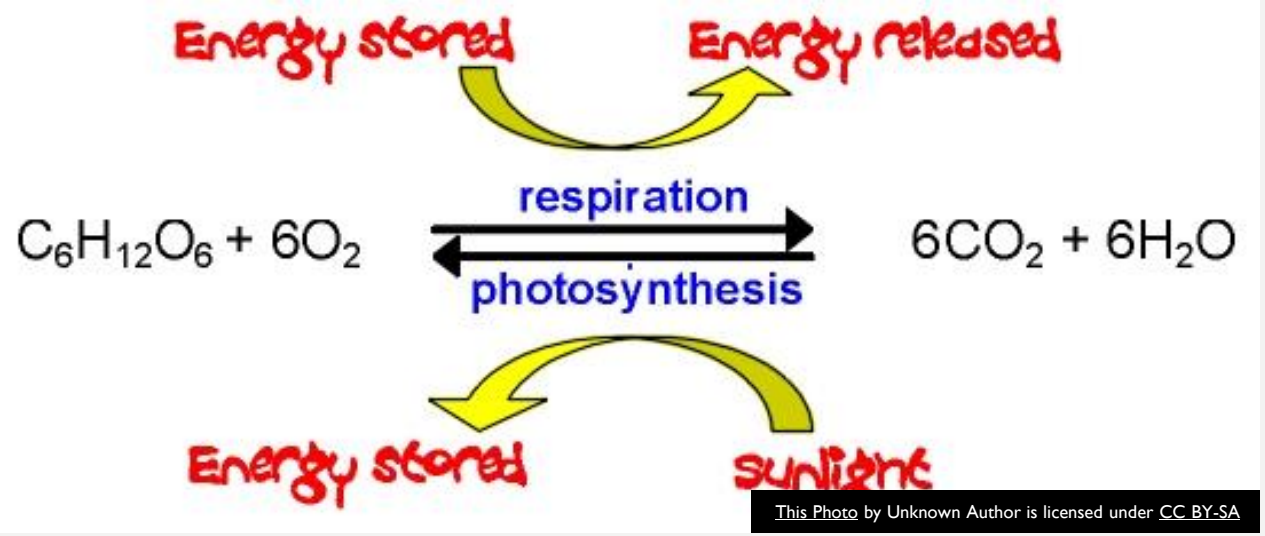
10TH GRADE BIOLOGY

OBJECTIVE

- After this presentation, students will represent in detail the process of celular respiration.

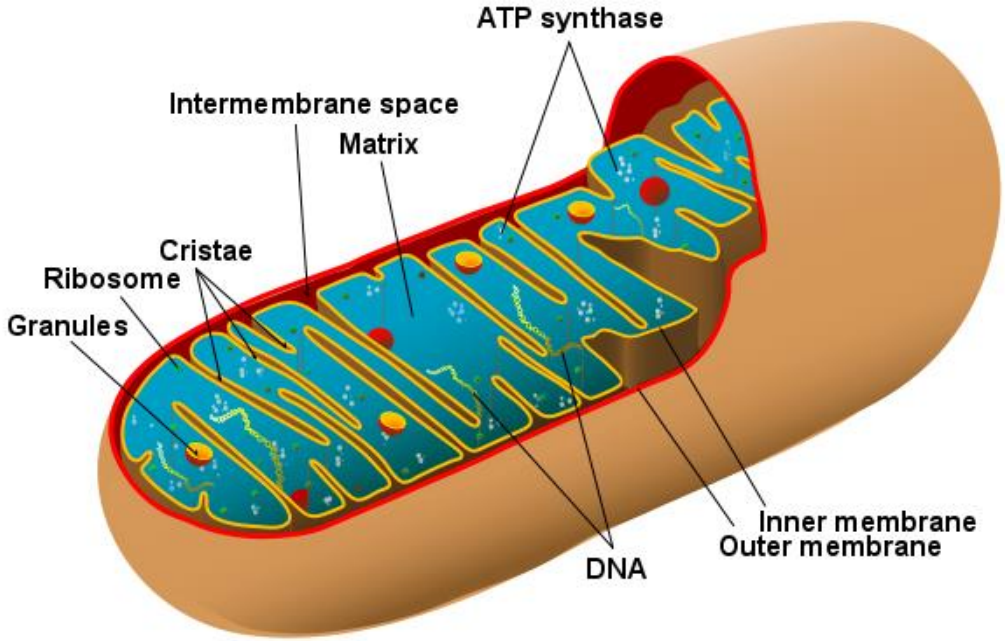
CELLULAR RESPIRATION MAKES ATP BY BREAKING DOWN SUGARS

- Cellular respiration releases chemical energy from sugars and other carbon-based molecules to make ATP when oxygen is present.
- Is an **aerobic** process, meaning that it needs Oxygen to take place.



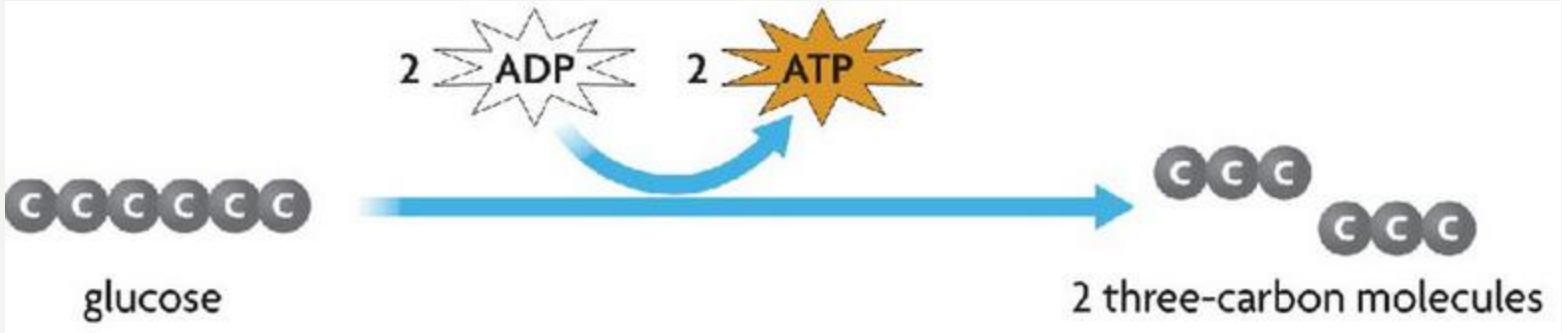
MITOCHONDRIA

- Cellular respiration takes place in the **mitochondria** ("cell powerhouse") of eukaryotic cells.
- Makes ATP indirectly
- Surrounded by a membrane.
- Has two parts involved in celular respiration: **matrix and inner membrane.**



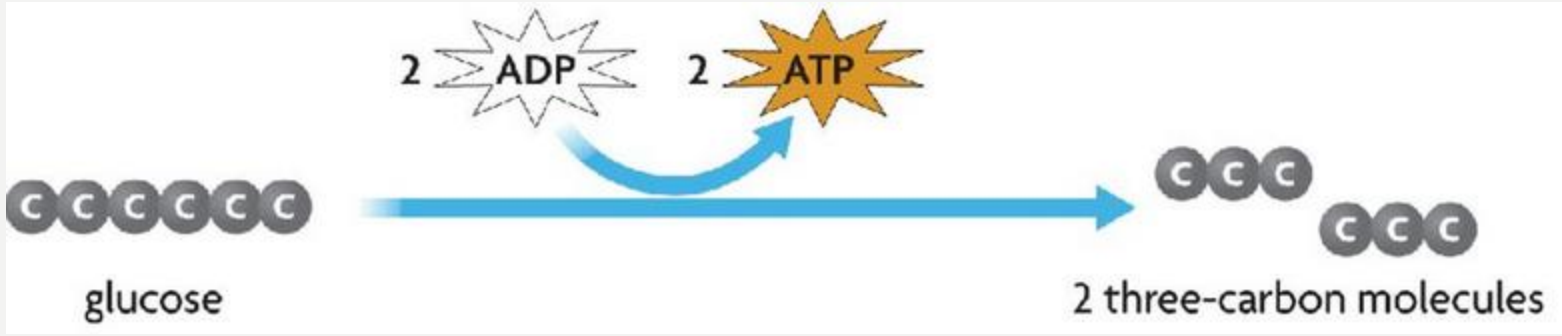
GLYCOLYSIS MUST HAPPEN FIRST

- Glycolysis must take place first.
  - It happens in the cell's **cytoplasm** and does not need oxygen (**anaerobic**), but it can happen in aerobic environments.
  - Foods are broken down into smaller molecules such as glucose.
  - Then, glucose is broken down into two three-carbon molecules and makes two molecules of ATP. This process is called **glycolysis**.



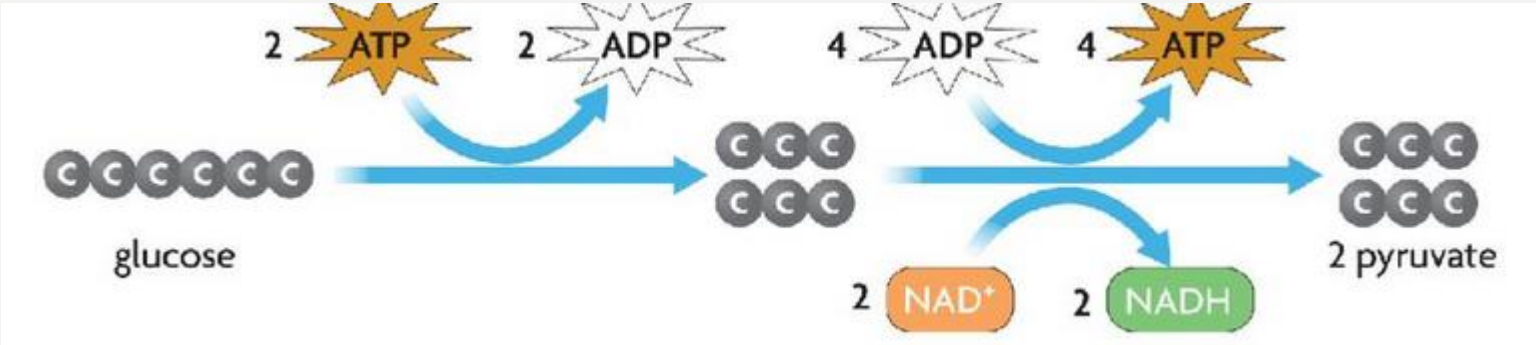
GLYCOLYSIS MUST HAPPEN FIRST

- Glycolysis is necessary for celular respiration.
- The products of glycolysis are broken down into mitochondria to make many more ATP.



STEPS OF GLYCOLYSIS

- Two ATP molecules are used to energize a glucose molecule. The glucose molecule is split into two three-carbon molecules.
- Energized electrons from three-carbon molecules are transferred to molecules of NAD+, forming NADH molecules. A series of reactions converts the three-carbon molecules to ***pyruvate***, which enters cellular respiration. This process also forms four ATP molecules.
- Overall products of glycolysis: 2 net ATP (two were used to split glucose), 2 NADH, 2 pyruvate



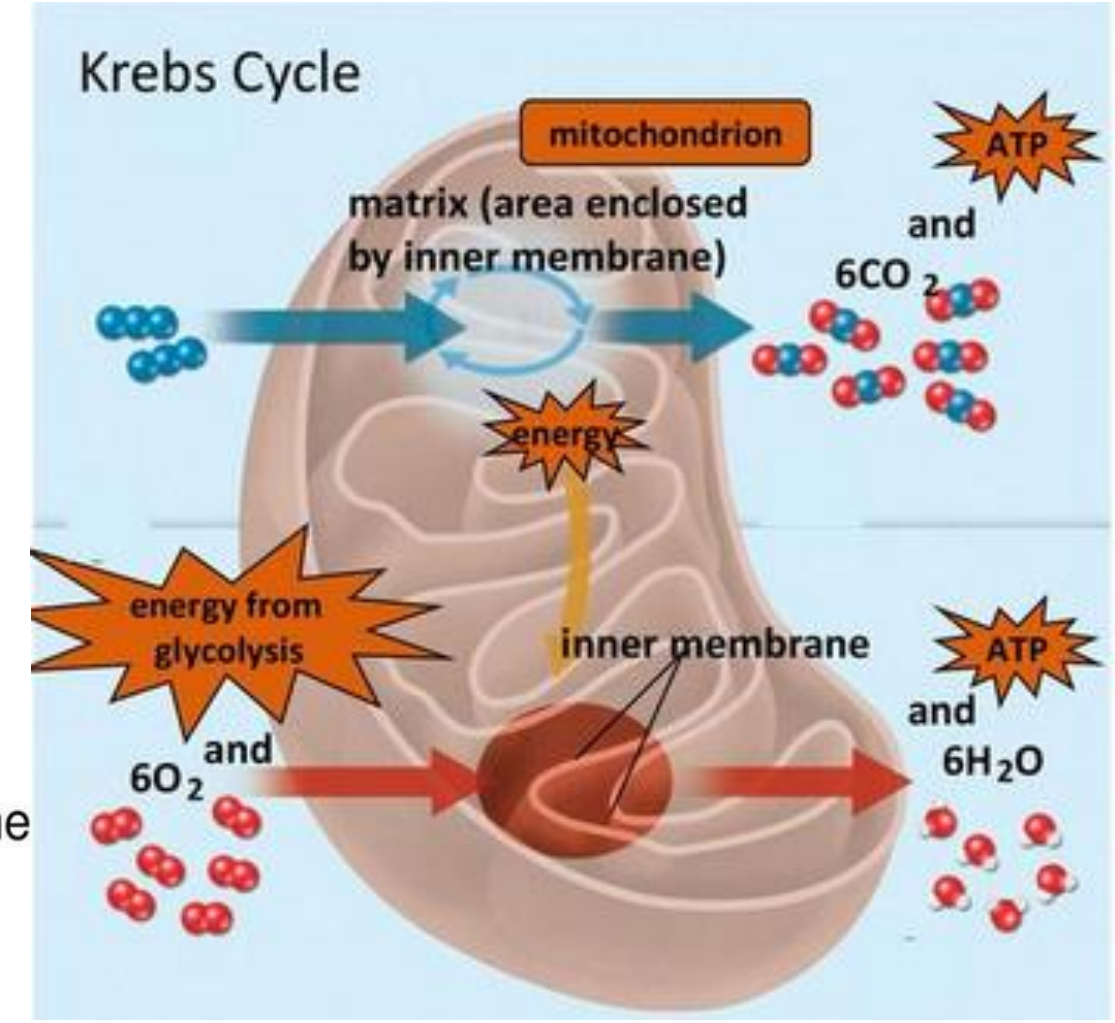
CELLULAR RESPIRATION IS LIKE A MIRROR IMAGE OF PHOTOSYNTHESIS

- Photosynthesis and cellular respiration are not true opposites, but you can think of them that way.

The equation for the overall process is:

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

The reactants in photosynthesis are the same as the products of cellular respiration.



CELLULAR RESPIRATION IS LIKE A MIRROR IMAGE OF PHOTOSYNTHESIS

Photosynthesis

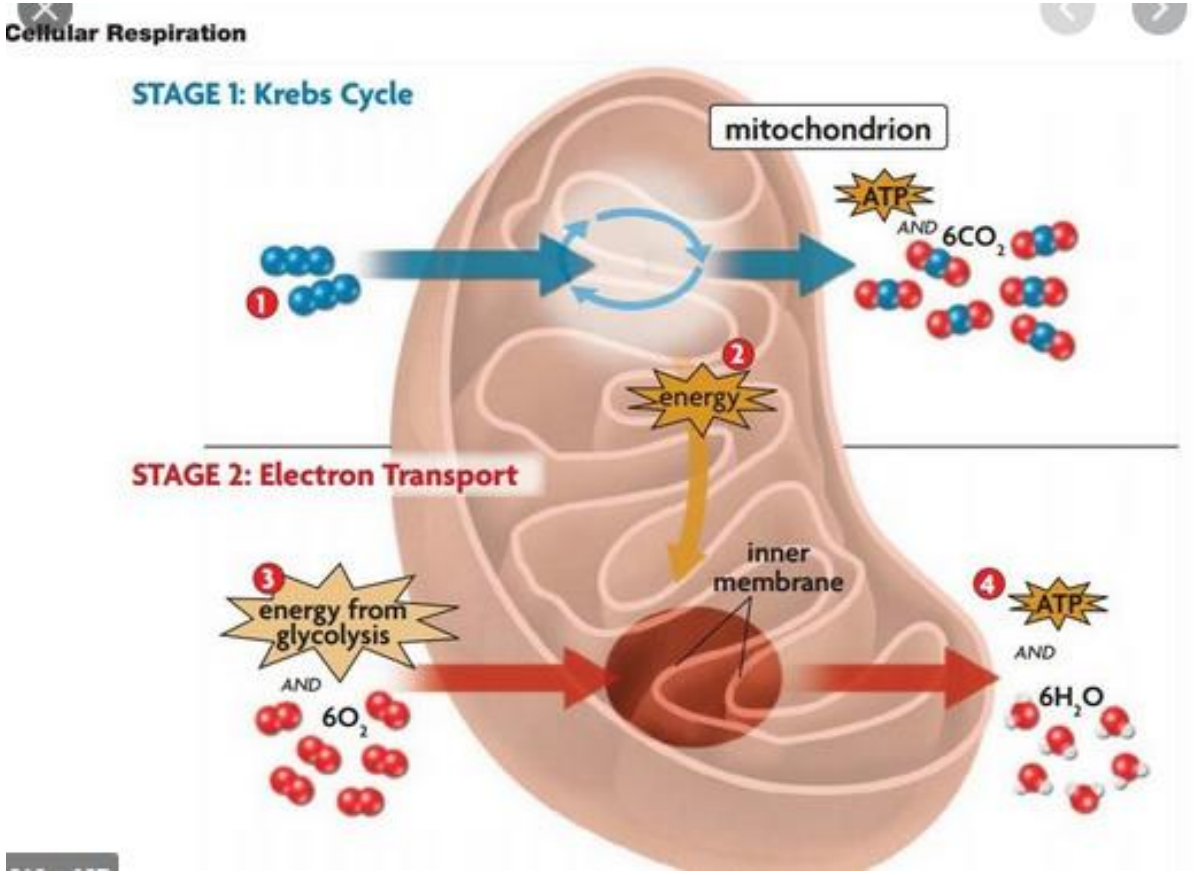
- Chloroplasts absorb energy from sunlight and build sugars.
- $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Cellular Respiration

- Mitochondria releases chemical energy from sugars to make ATP.
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$

CELLULAR RESPIRATION HAS TWO MAIN STAGES

- First stage: Krebs Cycle
- Second stage: Electron transport chain

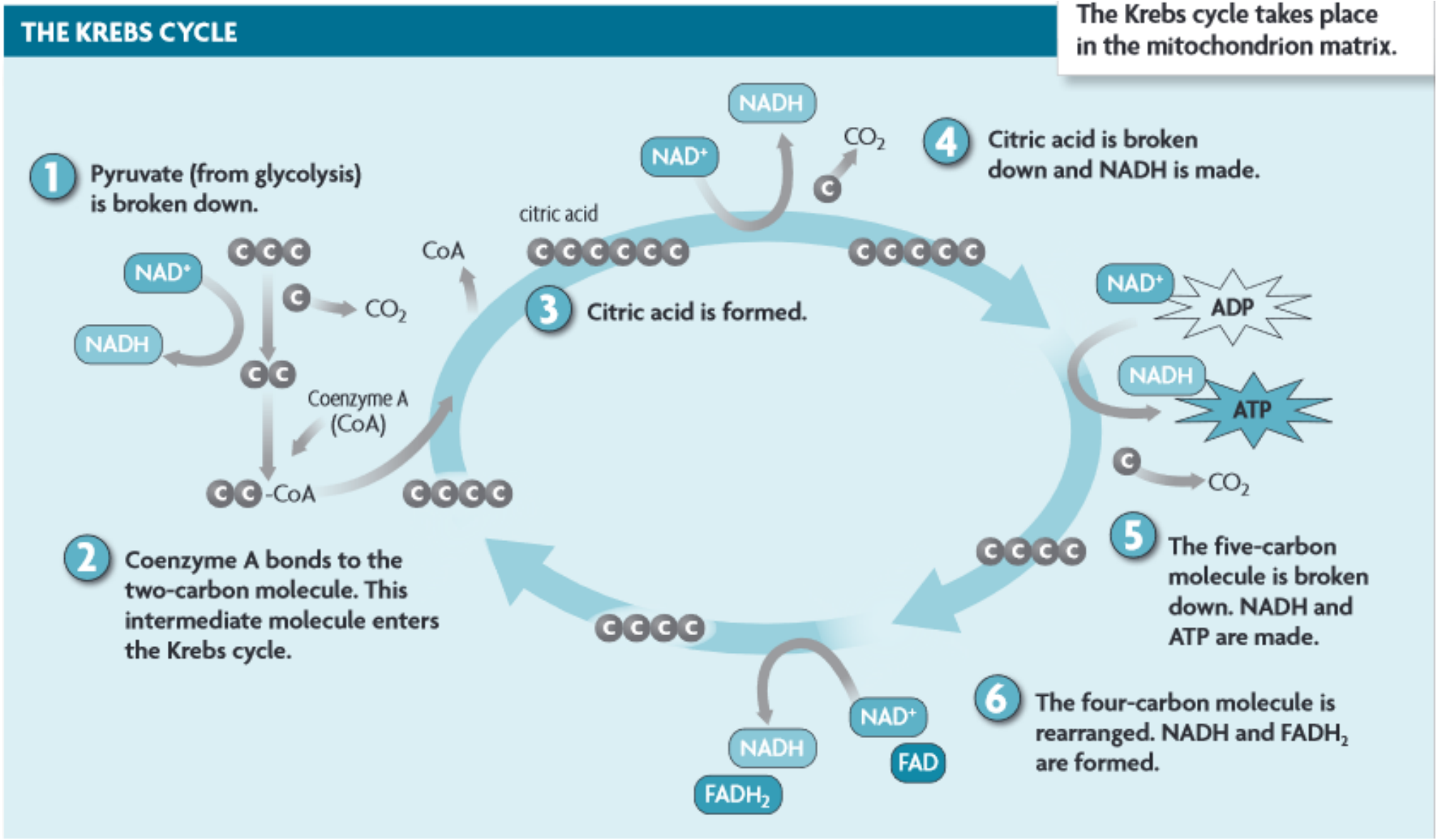


KREBS CYCLE

Cellular respiration makes many more ATP molecules than does glycolysis.

The main function of the Krebs Cycle is to transfer high energy electrons to molecules to carry them to the electron transport chain.

The Krebs Cycle is also known as **the citric acid cycle** because citric acid is the first molecule formed.

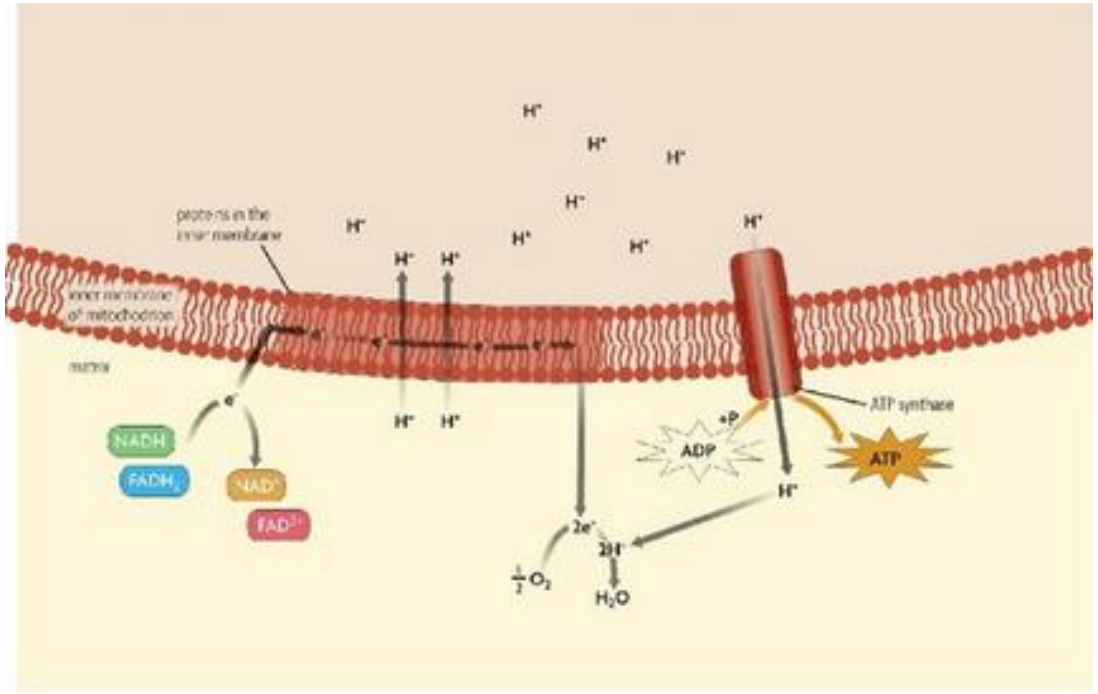

THE KREBS CYCLE
The Krebs cycle takes place in the mitochondrion matrix.
1 Pyruvate (from glycolysis) is broken down.
NAD+
NADH
CO2
CoA
2 Coenzyme A bonds to the two-carbon molecule. This intermediate molecule enters the Krebs cycle.
Coenzyme A (CoA)
-CoA
citric acid
3 Citric acid is formed.
4 Citric acid is broken down and NADH is made.
5 The five-carbon molecule is broken down. NADH and ATP are made.
ADP
ATP
6 The four-carbon molecule is rearranged. NADH and FADH2 are formed.
FAD
FADH2

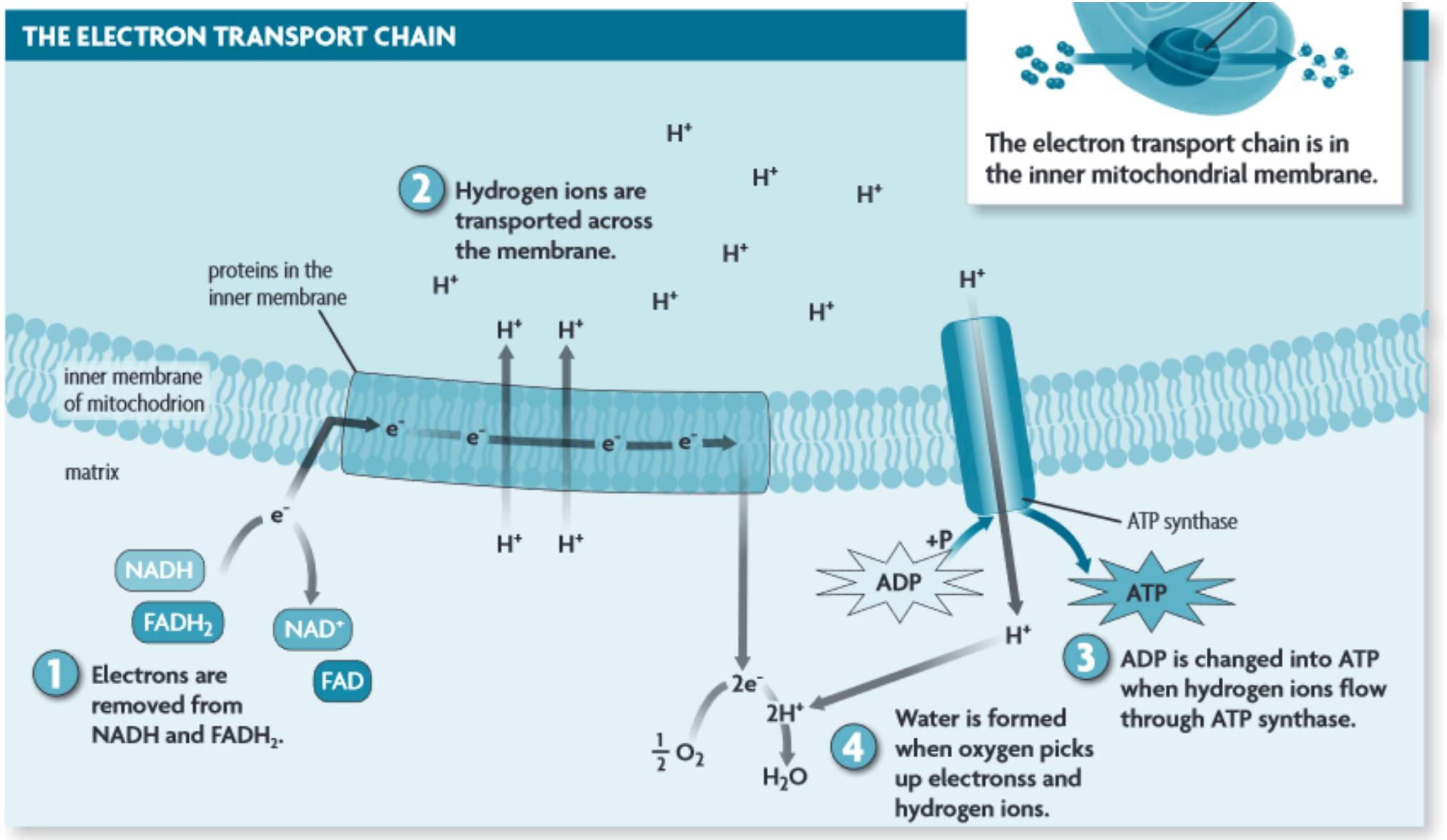
KREBS CYCLE

- The products of the breakdown of one molecule of pyruvate in Krebs cycle are:
  - 2 molecules of carbon dioxide (CO_2) that are given off as a waste product
  - 1 molecule of ATP
  - 4 molecules of NADH to electron transport chain
  - 1 molecule of $FADH_2$ to the electron transport chain
- Remember glycolysis produces two pyruvate molecules. Therefore, the products above are half of what comes from one glucose molecule. The totals are 6 CO_2, 2 ATP, 8 NADH and 2 $FADH_2$ molecules.

ELECTRON TRANSPORT CHAIN

- Takes place in and across the inner membrane of a mitochondrion.
- Made of different proteins that use energy from electrons supplied by NADH and FADH2 to **pump hydrogen ions against a concentration gradient**, and across the inner mitocondrial membrane.
- Produces most of the ATP




THE ELECTRON TRANSPORT CHAIN
The electron transport chain is in the inner mitochondrial membrane.
2 Hydrogen ions are transported across the membrane.
proteins in the inner membrane
inner membrane of mitochodrion
matrix
H+
e-
NADH
FADH2
NAD+
FAD
1 Electrons are removed from NADH and FADH2.
2e-
2H+
½ O2
H2O
4 Water is formed when oxygen picks up electronss and hydrogen ions.
+P
ADP
ATP
ATP synthase
3 ADP is changed into ATP when hydrogen ions flow through ATP synthase.

ATP SYNTHASE

- As you can see in step 4 of the electron transport chain, Hydrogen ions diffuse through a protein channel in the inner membrane of the mitochondrion.
- The channel is part of the **ATP synthase enzyme**.
- ATP synthase adds phosphate groups to ADP (remember ATP cycle learned in class) to make ATP molecules.
- For each pair of electrons that passes through the transport chain, an average of 3 ATP molecules are made.

PRODUCTS OF CELL RESPIRATION

- The products of cellular respiration- including glycolysis- are
  - Carbon dioxide (CO_2) from Krebs Cycle and from the breakdown of pyruvate at the end of glycolysis
  - Water from the electron transport chain
  - A net gain of 36-38 ATP molecules for every glucose molecule
    - 2 from glycolysis
    - 2 from Krebs Cycle
    - Up to 34 from the electron transport chain

COMPARING CELLULAR RESPIRATION VERSUS PHOTOSYNTHESIS

PHOTOSYNTHESIS AND CELLULAR RESPIRATION		
	PHOTOSYNTHESIS	CELLULAR RESPIRATION
Organelle for process	chloroplast	mitochondrion
Reactants	CO_2 and H_2O	sugars ($C_6H_{12}O_6$) and O_2
Electron transport chain	proteins within thylakoid membrane	proteins within inner mitochondrial membrane
Cycle of chemical reactions	Calvin cycle in stroma of chloroplasts builds sugar molecules	Krebs cycle in matrix of mitochondria breaks down carbon-based molecules
Products	sugars ($C_6H_{12}O_6$) and O_2	CO_2 and H_2O