

What are the reactants of Cellular Respiration?

Sugar and Oxygen

How is mass conserved in cellular respiration?

Same # of atoms in reactants and products

- Where is the energy at the beginning of cellular respiration?

In the C-C and C-H bonds in glucose

How is energy conserved in cellular respiration?

Energy is transferred from glucose to ATP

- What are the products of cellular respiration?

Carbon Dioxide and Water and 36 ATP

- Where does the energy go at the end of cellular respiration?

Makes ATP

# Friday Dec 6

Turn in:

Mealworm lab if you are missing it

Agenda:

Warm Up

Finish Cellular Respiration Notes

Homework:

Complete the following questions in your study guide:

**3, 5, 8-11, 13-16, 21-26, 31**

Water Plants and record data

# Get out the Cellular Respiration Notes

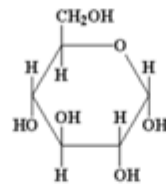
## Cellular Respiration Notes

Name: \_\_\_\_\_

### Overview of Cellular Respiration

- Overall Definition: A chemical process that uses \_\_\_\_\_ to convert the chemical energy stored in organic molecules (\_\_\_\_\_) into another form of energy – \_\_\_\_\_. \_\_\_\_\_ and \_\_\_\_\_ are produced in this process.

- Occurs in **heterotrophs and autotrophs** (plants, animals, bacteria, fungus, and protists)



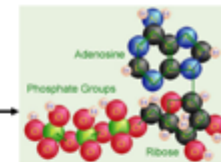
Glucose



Oxygen



Mitochondrion



ATP

- Is a **metabolic pathway** (a series of more than two dozen chemical reactions that are accelerated by special proteins called ENZYMES).
- Begins in the **cytosol** (\_\_\_\_\_) and ends in the \_\_\_\_\_.
- Has **3 main stages**: \_\_\_\_\_, the \_\_\_\_\_ (Citric acid cycle), and the \_\_\_\_\_ and ATP synthase

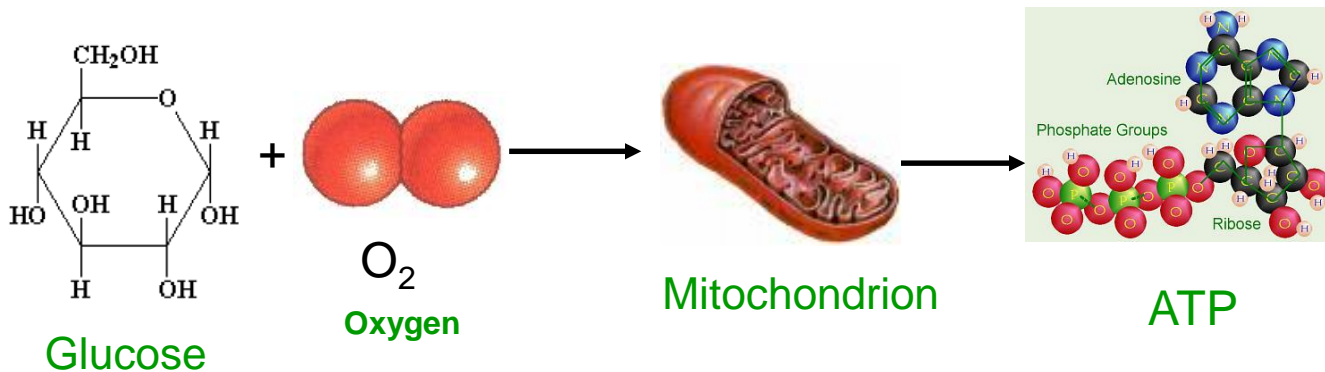
# Cellular Respiration



Which organisms use cellular respiration to obtain energy from food?

# Overview of Cellular Respiration

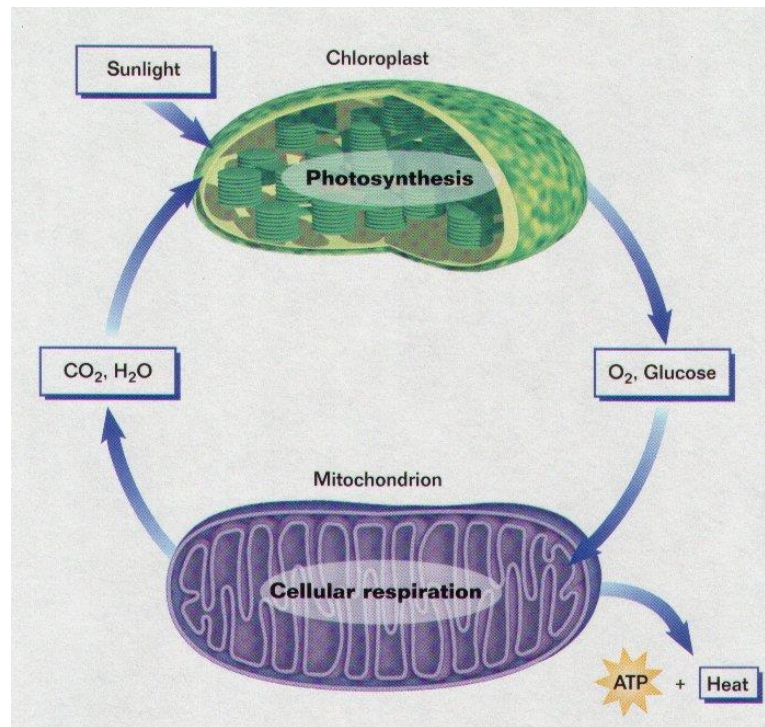
- Overall Definition: A chemical process that uses oxygen to convert the chemical energy stored in organic molecules (glucose) into another form of energy – ATP. Carbon dioxide and water are produced in this process.



## Cellular Respiration...

- **Occurs in heterotrophs and autotrophs** (plants, animals, bacteria, fungus and protists)
- Is a **metabolic pathway** (a series of more than two dozen chemical reactions that are accelerated by special proteins called ENZYMES).
- Begins in the **cytosol** (cytoplasm) and ends in the **mitochondria**.
- **Has 3 main stages:** glycolysis, the Krebs cycle (Citric acid cycle), and the electron transport chain and ATP synthase
- The end product of cellular respiration, **ATP**, is used by cells as their main energy supply.

**Why is the process that takes place in the mitochondria almost the opposite of what occurs in the chloroplast?**



Question: How does the equation for photosynthesis compare to the equation for cellular respiration?

**Answer: The products of photosynthesis (glucose and oxygen) are the reactants for cellular respiration.**

**The equation for cellular respiration can be written as:**



**The equation for photosynthesis can be written as:**

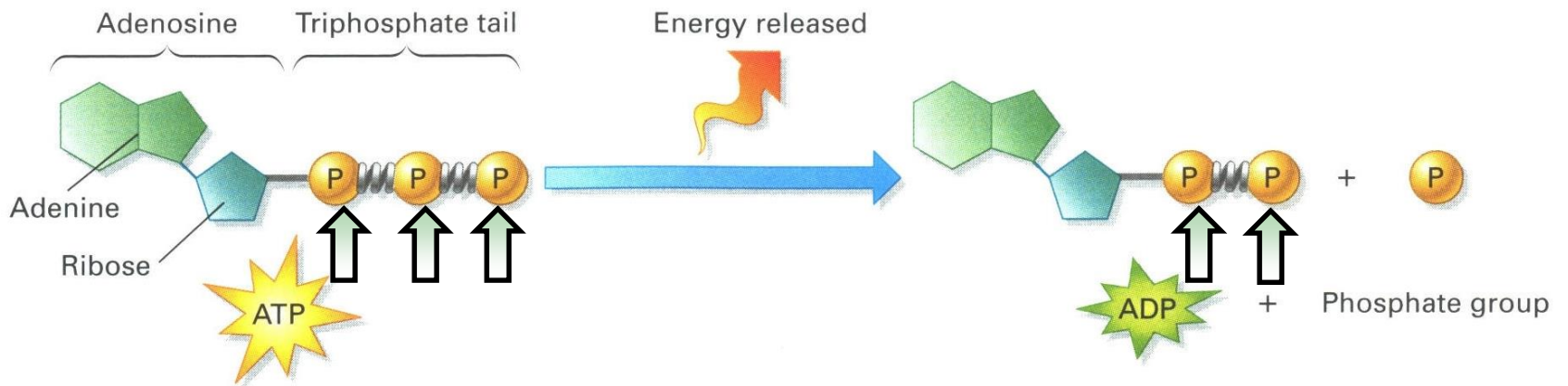


**Why is ATP so important?**



Adenosine  
Triphosphate= ATP

Adenosine  
Diphosphate= ADP

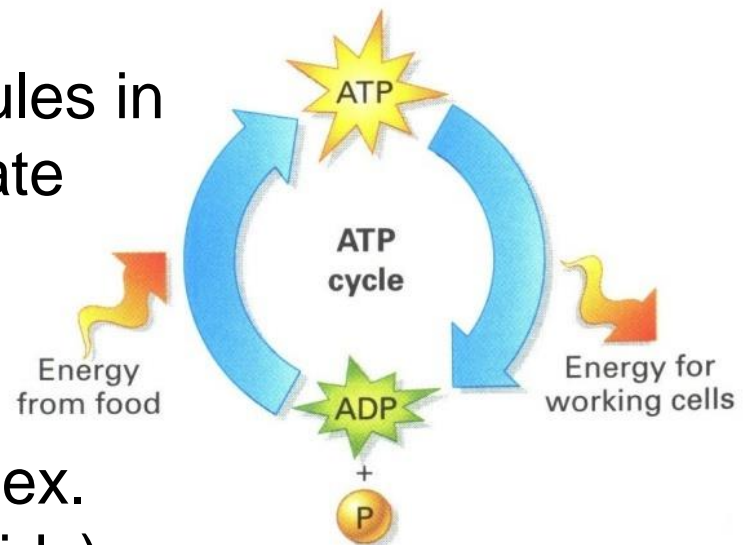


ATP has 3 phosphates

ADP has 2 phosphates

# Adenosine Triphosphate: A Review

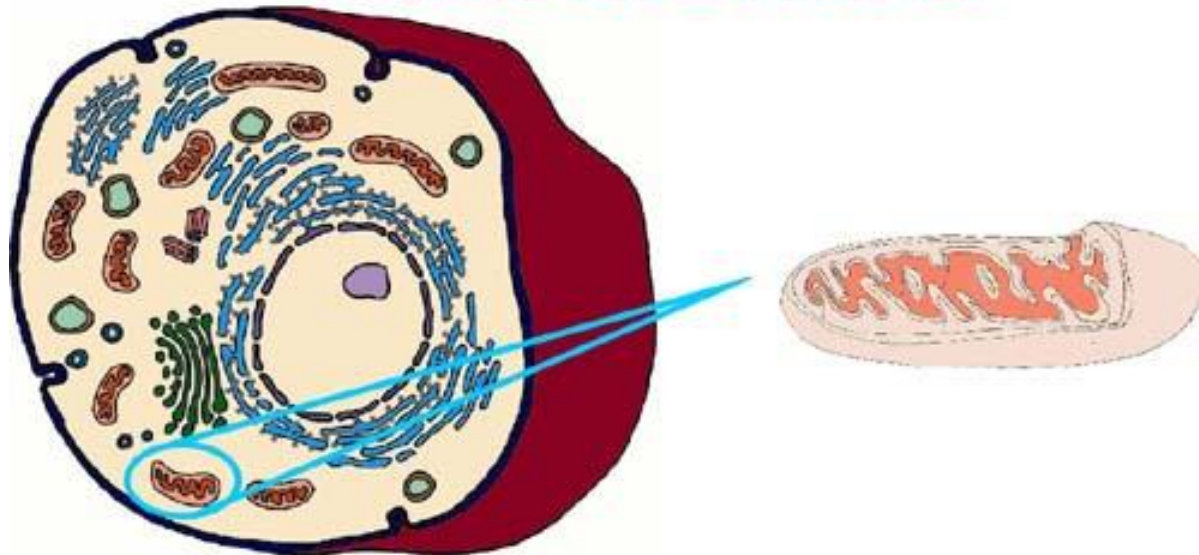
- ATP provides energy for cellular work
  - Energy is released when ATP is converted to ADP
  - Energy from the organic molecules in food are used to add a phosphate group to ADP so that it can be converted into ATP again.
  - ATP is used for chemical work (ex. building proteins from amino acids), mechanical work (ex. contraction of a muscle), and transport work (ex. pumping solutes across a cell membrane)



# Cellular Respiration converts chemical energy stored in organic molecules (glucose) into ATP

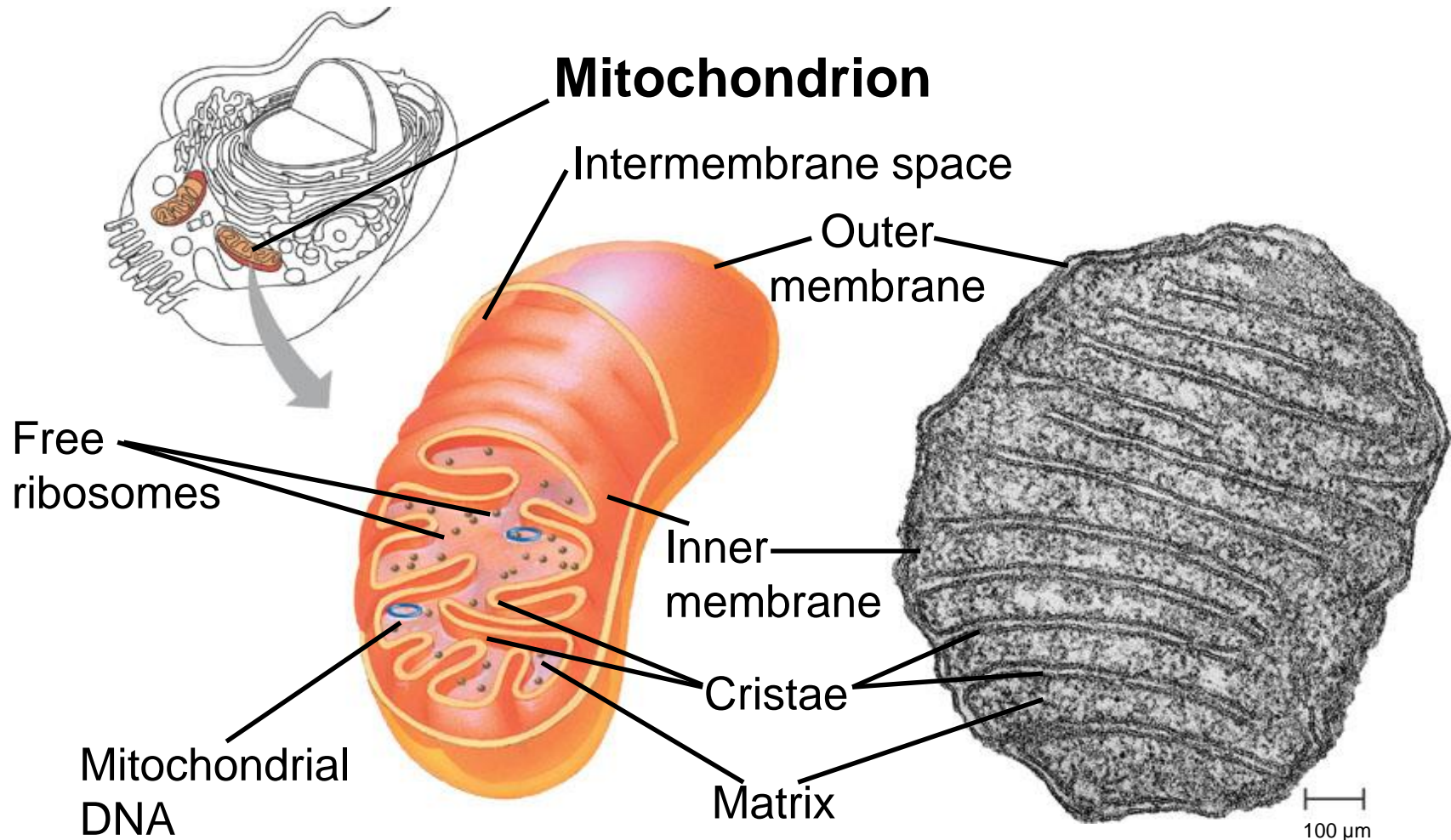
- The mitochondria are the major sites of cellular respiration

## Mitochondria



# The Structure of Mitochondria

- Mitochondria are enclosed by two membranes
- The fluid inside the mitochondria is known as the matrix

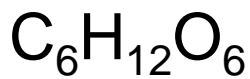
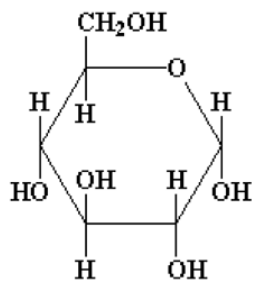


# Cellular Respiration

- The controlled breakdown of glucose into CO<sub>2</sub> and H<sub>2</sub>O.
- Requires oxygen
- Energy is captured in the form of ATP
- The balanced chemical equation for the reaction of cellular respiration is:



# The Chemical Reaction of Cellular Respiration



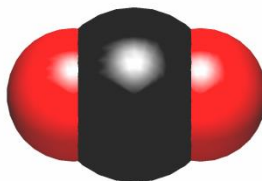
Glucose

+



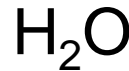
Oxygen

→



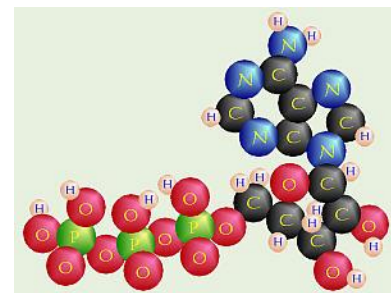
Carbon Dioxide

+



Water

+



ATP

Adenosine Triphosphate

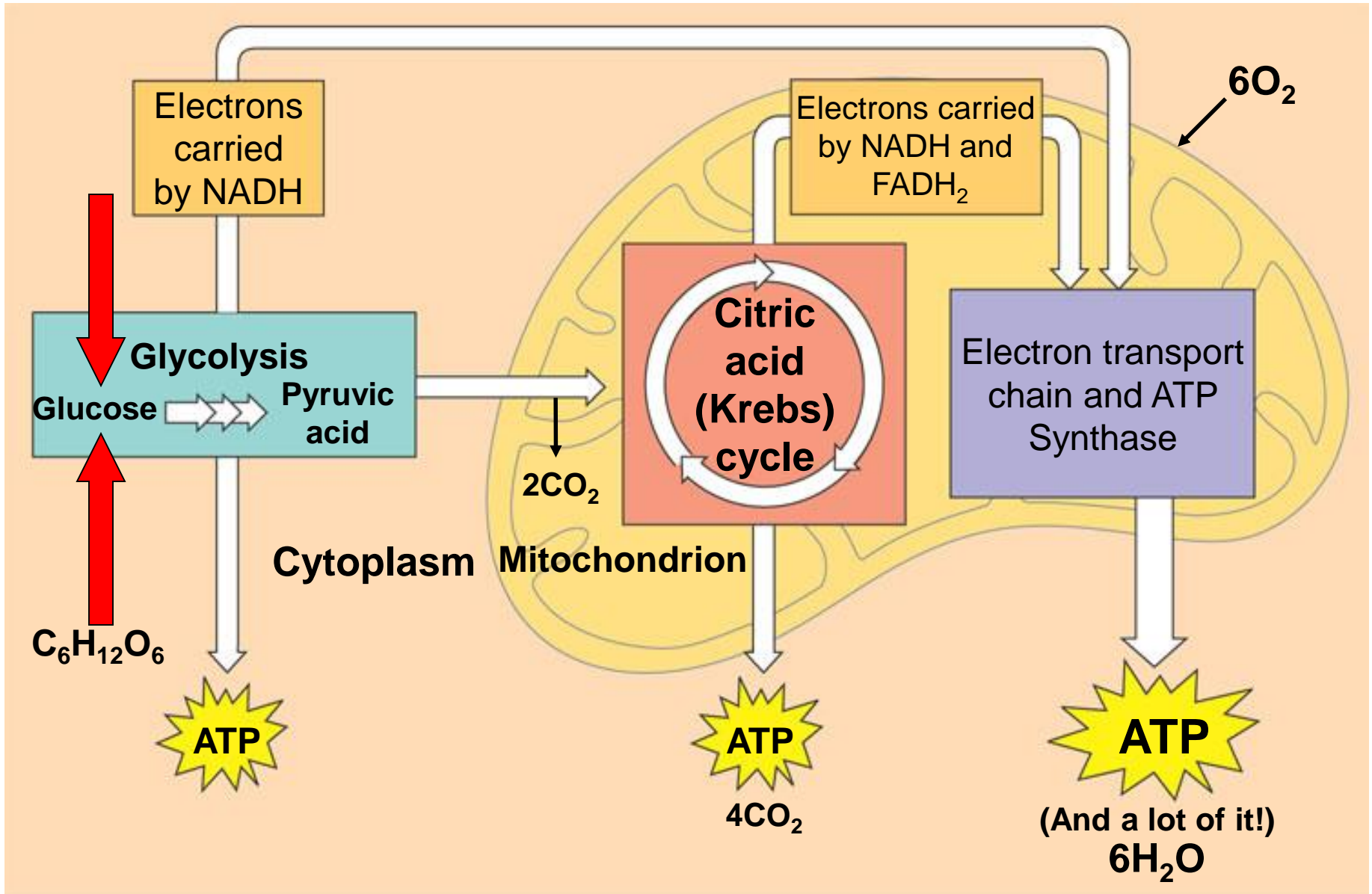
**The Balanced Chemical Equation:**



# The Stages of Cellular Respiration

- Cellular respiration takes place in three different stages
  - **Stage 1** is Glycolysis
  - **Stage 2** is **The Citric Acid Cycle** (also called The Krebs Cycle)
  - **Stage 3** is the Electron transport chain and ATP synthase

# • An Overview Of Cellular Respiration





# Glycolysis

- Takes place in the cytoplasm outside the mitochondria
- Literally means “splitting of sugar” (splits glucose)
- Two ATP’s are used to split one glucose molecule (a 6 carbon sugar) into 2 molecules of pyruvic acid/pyruvate (with 3 carbons)
- Does not require oxygen

## END PRODUCTS OF GLYCOLYSIS:

- 4 molecules of ATP (a **net gain of 2 ATP molecules** – 2 are used to start the reaction)
- **2 NADH molecules** (each  $\text{NAD}^+$  carries 2 electrons and 1 H ion from each 3 carbon sugar  $\rightarrow$  NADH)
- **2 molecules of pyruvate** (used in the Krebs cycle)

# The Krebs Cycle

- Occurs in the matrix of the mitochondria
- Requires pyruvic acid from glycolysis
- Requires oxygen

Mitochondria Structural Features

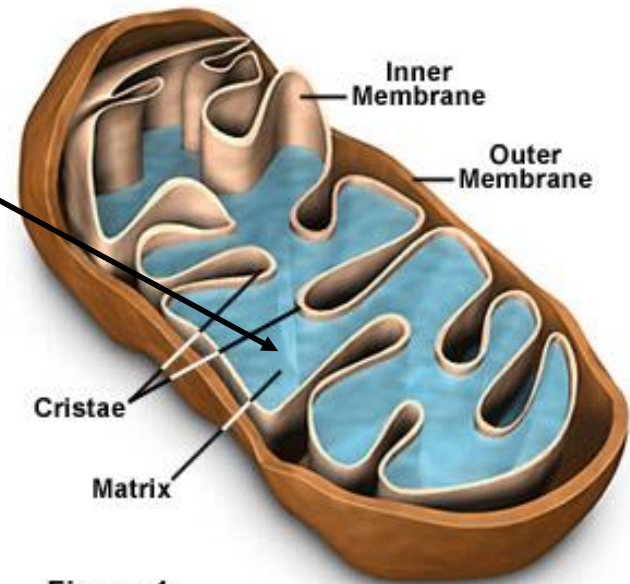


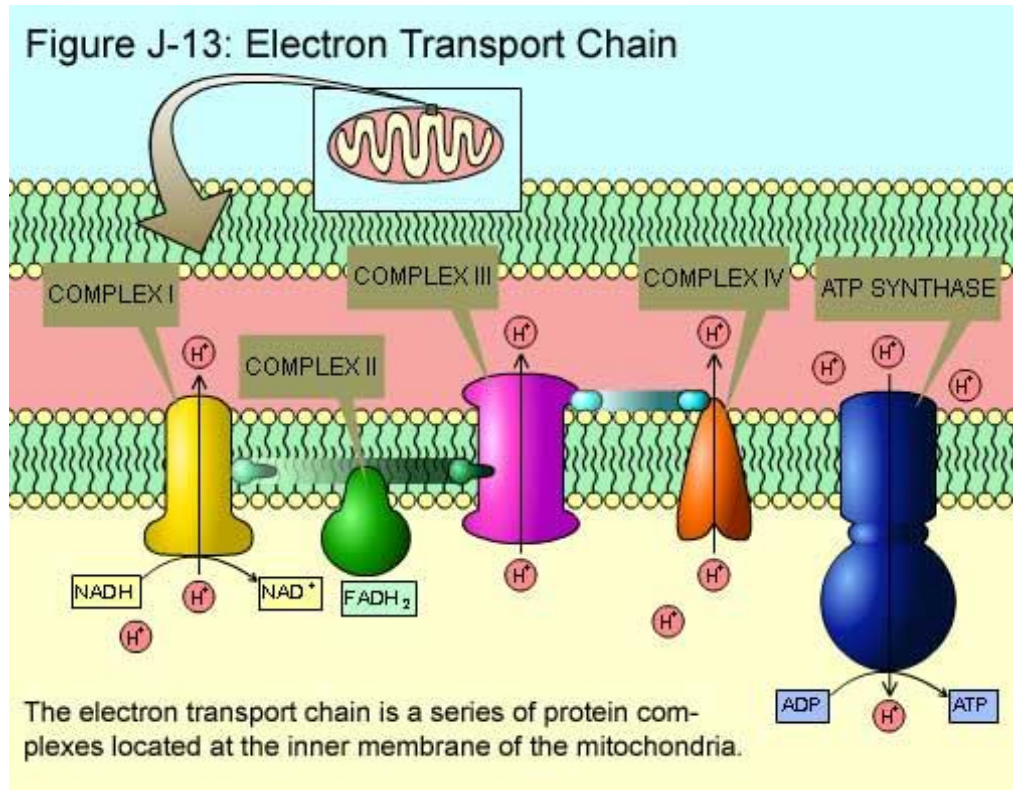
Figure 1

## END PRODUCTS OF the Krebs Cycle:

- **2 ATP** molecules
- **4 CO<sub>2</sub>** molecules
- **6 NADH** molecules and **2 FADH<sub>2</sub>** molecules

# The Electron Transport Chain and ATP Synthase

- Occurs in the inner (cristae) membrane of the mitochondria
- NADH and  $\text{FADH}_2$  carry high-energy electrons to the electron transport chain
- As electrons “fall” down the chain toward oxygen, a small amount of energy is released
- This energy is used to generate ATP production (from  $\text{ADP} + \text{P}$ ) using a special protein structure called an ATP synthase.

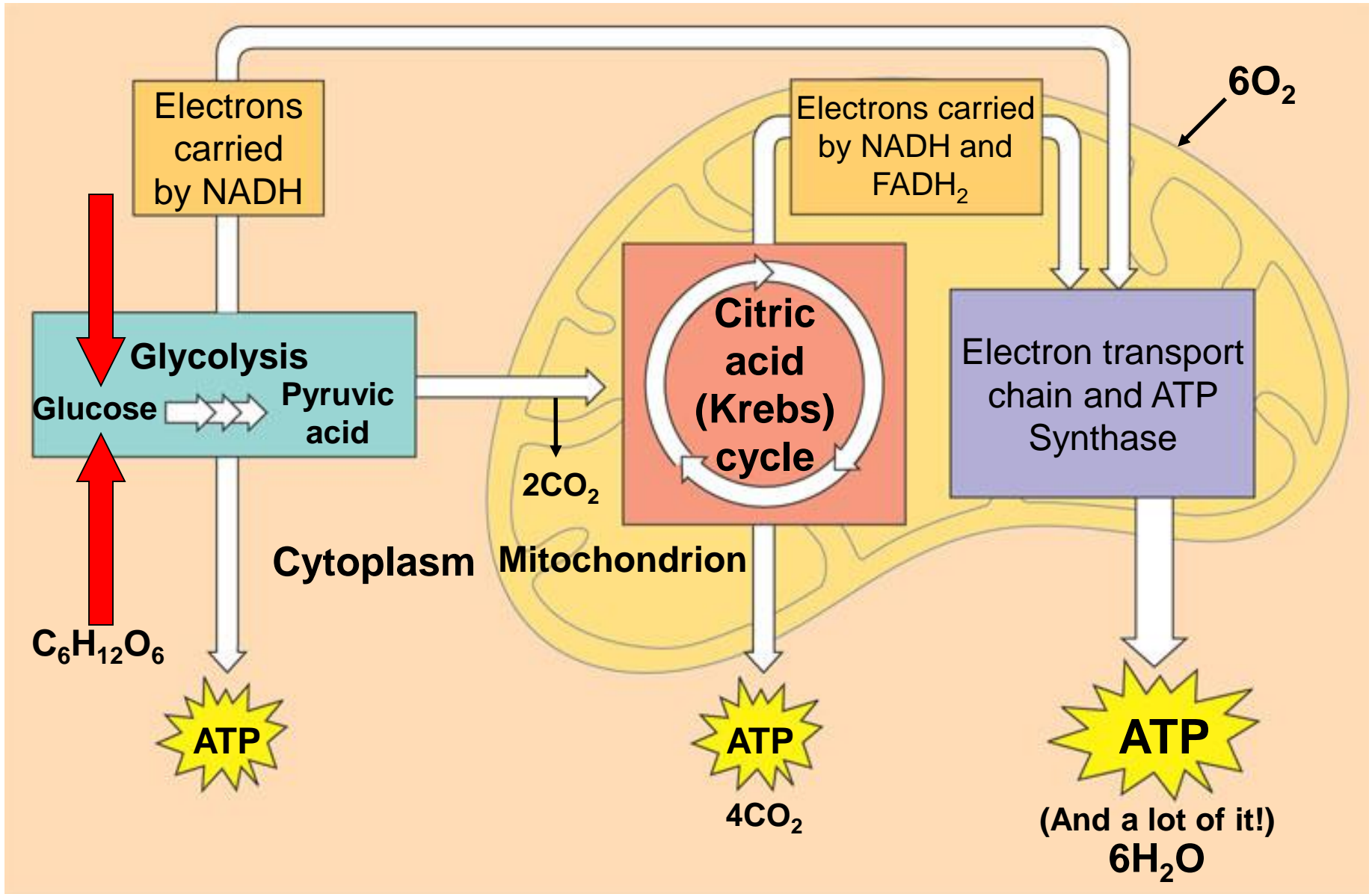


This process generates up to 34 ATP's!

# Videos

- [Electron Transport Chain and ATP Synthase](#)

# Putting the Three Stages Together



# Summary Of Cellular Respiration

- Total ATP Production = up to 38
- Cellular respiration is the most common and efficient energy producing pathway

# A More Detailed Summary

	Glycolysis	Kreb's Cycle	The Electron Transport Chain
Takes place in the....	<u>Cytoplasm</u>	<u>Matrix of mitochondria</u>	<u>Inner membrane of the mitochondria</u>
Reactants are....	$C_6H_{12}O_6$ (+ 2 ATP)	2 pyruvic acid and $O_2$	NADH and $FADH_2$ , plus oxygen
Products are....	2 ATP 2 NADH 2 pyruvic acid	4 $CO_2$ , 2 ATP 6 NADH and 2 $FADH_2$	34 molecules of ATP + $6H_2O$

Review with your table partner

What are the reactants of cellular respiration?

Glucose and Oxygen

What are the products of cellular respiration?

Carbon Dioxide and Water and 36 ATP

What is the purpose of Cellular Respiration?

To release energy from glucose to make ATP

What are the 3 stages of cellular respiration?

Glycolysis, Krebs Cycle and Electron Transport Chain



Review with your table partner

What happens in glycolysis?

Glucose is split in half (makes 2 pyruvic acid molecules)

Where does glycolysis take place in the cell?

Cytoplasm

Where do the Krebs cycle and electron transport chain take place?

Mitochondria

How is ATP Made ?

A phosphate is added onto ADP to make ATP