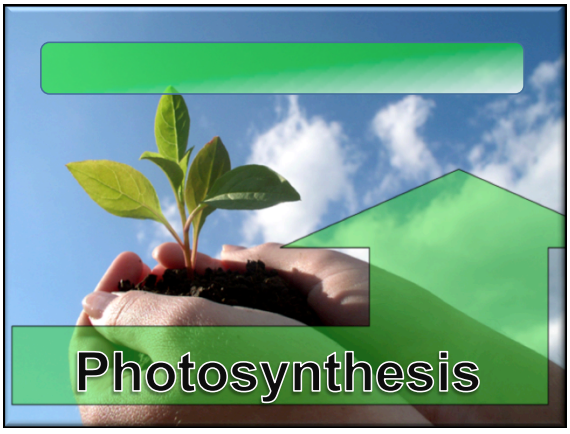
Catalyst #1

- What is the chemical formula for photosynthesis?
- What are autotrophs?
- Explain the relationship between photosynthesis and cellular respiration
- Where does photosynthesis take place?

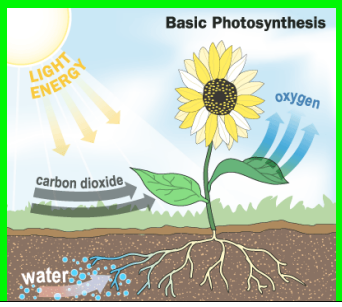


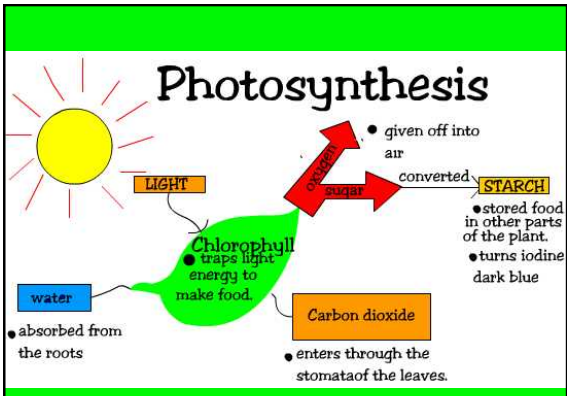
I. *OVERVIEW: "THE BIG PICTURE"*

- **Photosynthesis** = the process that provides energy for almost all life.
- **Autotrophs** = organisms that make their own food
  - Ex: plants
- Photosynthesis requires:
  - The **sun's energy**, **water** and **carbon dioxide** to make **carbohydrate molecules** and **oxygen** as byproducts.

- The process of PHOTOSYNTHESIS can be summarized by the following equation:

$$6CO_2 + 6H_2O + \text{Sunlight} \xrightarrow{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$$



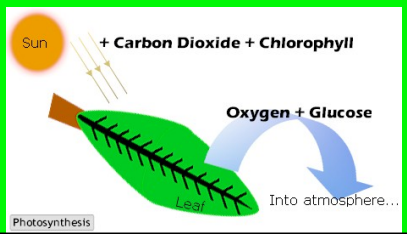


I. *OVERVIEW: "THE BIG PICTURE"*

- The energy stored in glucose and other carbohydrates can be used later to produce **ATP** during the process of **cellular respiration.**
  - We'll discuss cellular respiration in more detail very soon!

I. *OVERVIEW: "THE BIG PICTURE"*

- The process of photosynthesis does **NOT** happen all at once; rather it occurs in 2 stages:



I. *OVERVIEW: "THE BIG PICTURE"*

1. **STAGE 1** – Called the **LIGHT REACTIONS**.
   - **Light energy** is converted to **chemical energy**
   - Takes place – **Energy** is captured from **sunlight** in the **chlorophyll** of the chloroplasts of plant cells.
     - A photosynthetic cell contains one to thousands of chloroplasts!

Stage 1: Light Reactions

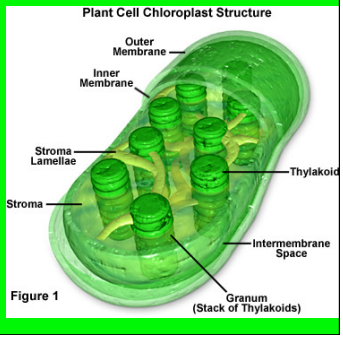
- **Water** is split into hydrogen ions, electrons, and oxygen (O_2) through the process called the electron transport chain.
- The **light energy** is now converted to **chemical energy**, which is temporarily stored in **ATP and NADPH** (energy molecules).
- The **O_2** diffuses out of the chloroplasts (byproduct).

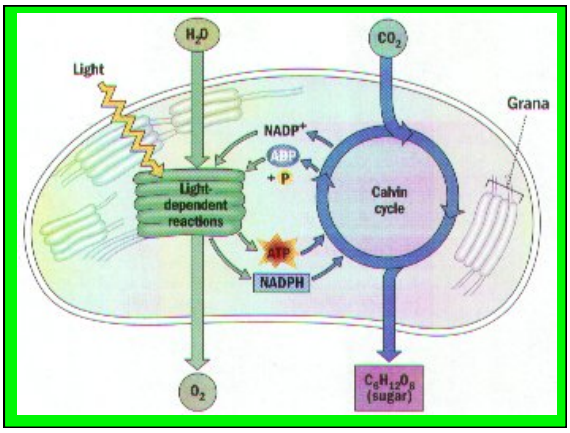
Stage 2: Calvin Cycle

2. **STAGE 2** – Called the **CALVIN CYCLE** or **Dark Reactions** (don't need sunlight).
   - **Carbon dioxide** (CO_2) and the chemical energy stored in **ATP** and **NADPH** powers the formation of **carbohydrate molecules** (sugars, starch and cellulose).

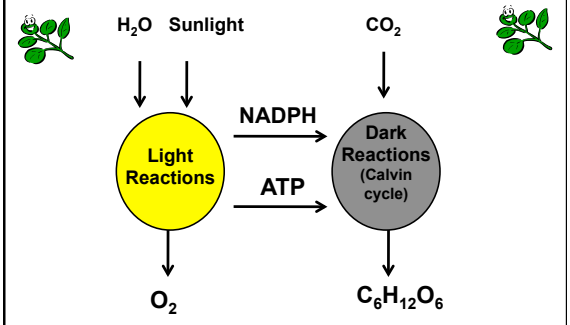
Stage 2: Calvin Cycle

- Takes place – in the **stroma** of a chloroplast





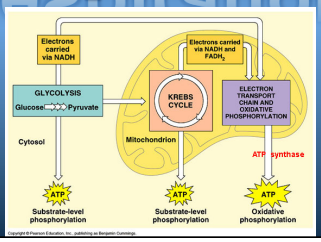
PHOTOSYNTHESIS Flow Chart



Photosynthesis Equation:

$$6H_2O + 6CO_2 + Sunlight \xrightarrow{Chlorophyll} C_6H_{12}O_6 + 6O_2$$

Cellular Respiration



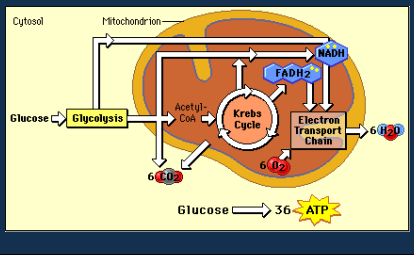
I. OVERVIEW: "THE BIG PICTURE"

- **Cellular respiration** = an energy (ATP) releasing process:
  - **PLANTS:** sugars ($C_6H_{12}O_6$) produced during **photosynthesis** are broken down so energy is released
  - **ANIMALS:** sugars ($C_6H_{12}O_6$) produced during **digestion** are broken down so energy is released

I. OVERVIEW: "THE BIG PICTURE"

- Formula:

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

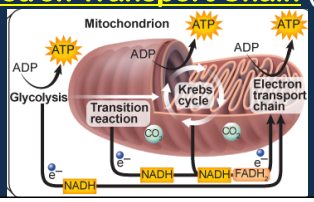


$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + ATP$

- The PRODUCTS of photosynthesis→ glucose ($C_6H_{12}O_6$) and O_2, are the REACTANTS used in cellular respiration.
- The WASTE PRODUCTS of cellular respiration, CO_2 and water, are the REACTANTS used in photosynthesis.

I. *OVERVIEW: "THE BIG PICTURE"*

- Processes:
  1. Glycolysis
  2. Kreb's Cycle (Citric Acid Cycle)
  3. Electron Transport Chain (ETC)



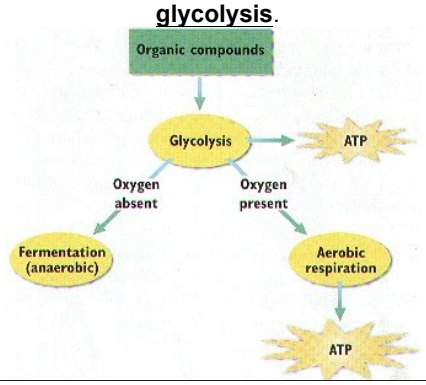
II. *TWO TYPES OF CELLULAR RESPIRATION:*

1. Aerobic Respiration = OXYGEN is present
   - –If OXYGEN is PRESENT, the products of glycolysis ENTER the pathways of *aerobic respiration*.
     - 2 major stages: Kreb's Cycle & Electron Transport Chain
   - –Produces large amounts of ATP

II. *TWO TYPES OF CELLULAR RESPIRATION:*

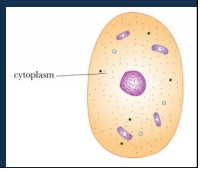
2. Anaerobic Respiration = No OXYGEN is present
   - –aka….Fermentation
   - –No additional ATP is created AFTER glycolysis produces 2 ATP

~ *Note:* Both types of respiration BEGIN with glycolysis.



III. *AEROBIC RESPIRATION PROCESSES:*

1. GLYCOLYSIS:
   - –Occurs in the cytoplasm of the cell
   - –*Starting molecule:* ONE molecule of glucose ($C_6H_{12}O_6$)



Glycolysis....

- *Produces:* TWO pyruvic acids or pyruvates ($C_3H_6O_3$)
  - 2 ATP molecules
  - Attaches H's to NAD^+ (electron carrier) and forms NADH (high energy molecule)

III. AEROBIC RESPIRATION PROCESSES:

2. KREB'S CYCLE (Citric Acid Cycle) – Aerobic respiration
   - Aerobic process (requires oxygen)
   - Occurs in the mitochondrion

Kreb's Cycle....


- *Starting molecules*: 2 pyruvates and oxygen
- *Produces:* NADH and $FADH_2$, CO_2 and 2 ATP molecules
  - Attaches H's to NAD^+ and FAD to create NADH and $FADH_2$ (these will be used to make more ATP in the ETC)

III. AEROBIC RESPIRATION PROCESSES:

3. ELECTRON TRANSPORT CHAIN (ETC) – Aerobic respiration
   - Aerobic process (requires oxygen)
   - Occurs in the inner membrane of the mitochondria

ETC....

- *Starting molecules:* NADH and $FADH_2$ and oxygen
  - Uses the NADH and $FADH_2$ from the Kreb's Cycle and another NADH from Glycolysis.

ETC....

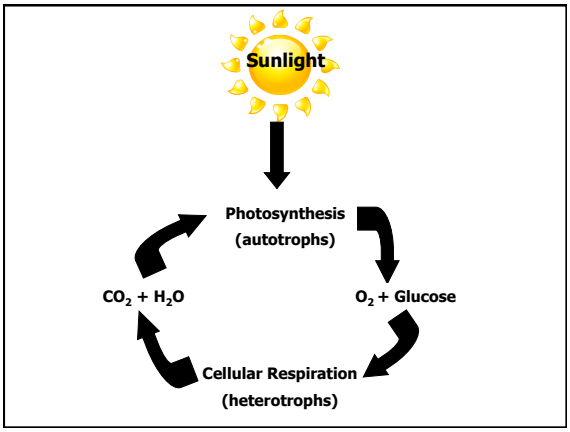
- *Produces:* Water and 32 ATP's
  - $FADH_2$ and NADH, release H's so they can attach to oxygen and produce water
  - Energy is released as a result of breaking down these molecules.

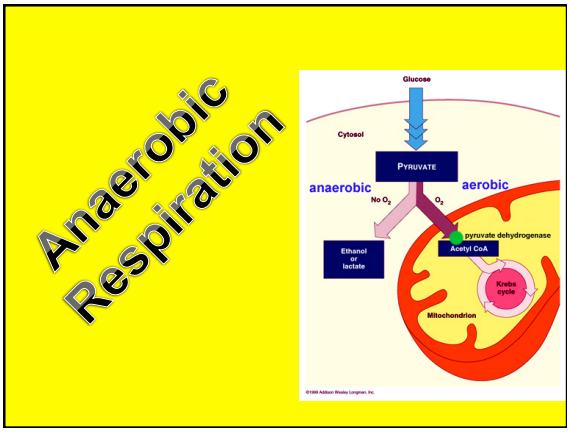
→Importance of Aerobic Respiration:

- To transfer chemical energy (glucose) to a form of energy that is useable by cells (ATP)!!!
- Total net gain of ATP molecules per 1 glucose = 36 ATP's

Relationship of Photosynthesis & Cellular Respiration:

- The products of one reaction are the reactants for the other reaction.
- In an ecosystem, photosynthesis and cellular respiration form a cycle





IV. ANAEROBIC RESPIRATION PROCESSES:

- Occurs AFTER glycolysis, *only* if NO oxygen is present
- No additional ATP is created after the 2ATP's from glycolysis!

(Anaerobic Respiration) 2 Types:

1. Alcoholic Fermentation:
   - Occurs in plants
   - *Starting molecules:* 2 pyruvates and NADH (from glycolysis)
   - *Produces:* ethyl alcohol and carbon dioxide.
   - Bakers use alcoholic fermentation of YEAST to make bread.
   - Used to make wine and beer

(Anaerobic Respiration)
2 Types:

2. **Lactic Acid Fermentation:**
   - –Occurs in **animals**
   - –*Starting molecules:* **2 pyruvates** and **NADH** (from glycolysis)
   - –*Produces:* **lactic acid**
   - –Lactic acid fermentation by microorganisms plays an essential role in the manufacturing of food products such as **yogurt** and **cheese**.

Lactic Acid Fermentation:

- **DURING EXERCISE:** breathing **cannot** provide your body with all the oxygen it needs for aerobic respiration.

Lactic Acid Fermentation & Exercise

- –When muscles run out of **oxygen**, the cells switch to **lactic acid fermentation**!
- – Provides your **muscles** with the energy they need during exercise.

Lactic Acid Fermentation & Exercise

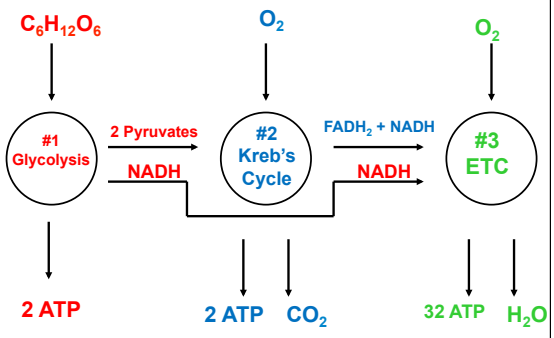
- –Side effects of lactic acid fermentation are **muscle fatigue**, **pain**, **cramps**, and **soreness**.
- –Most lactic acid made in the muscles diffuses into the bloodstream, then to the liver; where it is converted back to PYRUVIC ACID when oxygen becomes available.

Flow Chart

AEROBIC Respiration

Oxygen PRESENT

(_____)

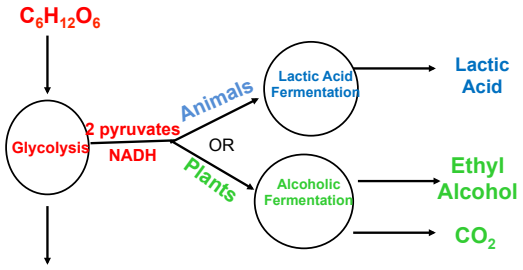


Aerobic Respiration EQUATION:

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6H_2O + 6CO_2 + 36\ ATP$

ANAEROBIC Respiration

(**NO Oxygen PRESENT!**)



Note: Only GLYCOLYSIS produces energy!! No ATP (energy) is produced from lactic acid or alcoholic fermentation!