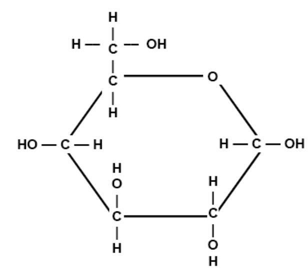
4:1 Energy

All living things require a constant supply of ENERGY.

AUTOTROPH: organisms that make their own food

HETEROTROPH: obtain energy from the food they consume

GLUCOSE: ($C_6H_{12}O_6$) the form of energy used for fuel by ALL living cells



It requires energy to form chemical bonds, that energy is released when bonds are broken.

PHOTOSYNTHESIS: series of chemical reactions during which PLANTS change light energy from the sun into chemical energy stored in the chemical bonds of GLUCOSE molecules

CELLULAR RESPIRATION: process of chemical changes carried out by ALL LIVING THINGS that releases energy by breaking the chemical bonds in GLUCOSE

Photosynthesis occurs only in certain green plant cells.
Respiration occurs in all cells of all living things.

Photosynthesis and respiration are OPPOSITE REACTIONS!

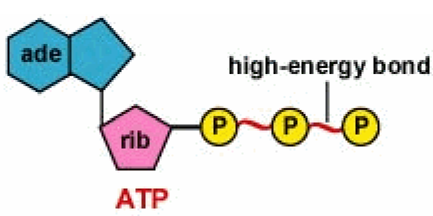
Only those organisms that carry out photosynthesis can make their own food.
All other organisms rely on these organisms for food.

MATTER (atoms and molecules) CAN BE RECYCLED.

ENERGY IS NOT RECYCLED! A constant supply of energy is needed to organize simple substances into complex substances.

4:2 ATP – The Energy Transfer Compound

During photosynthesis, light enters the cell too rapidly to be stored as glucose. In respiration, energy must be released in controlled amounts.



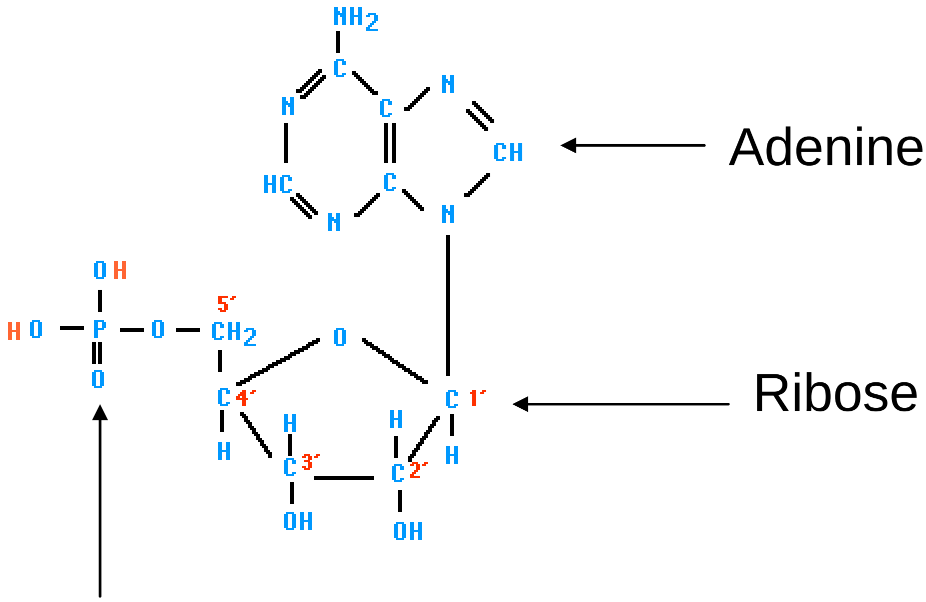
ADENOSINE TRIPHOSPHATE: (ATP) energy transfer compound used to trap energy and release it in controlled amounts to meet the needs of living cells.

Structure of ATP → ATP consists of

- ADENOSINE a nitrogen base (ADENINE) bonded to a sugar (RIBOSE)
- Three PHOSPHATE GROUPS are bonded to adenosine

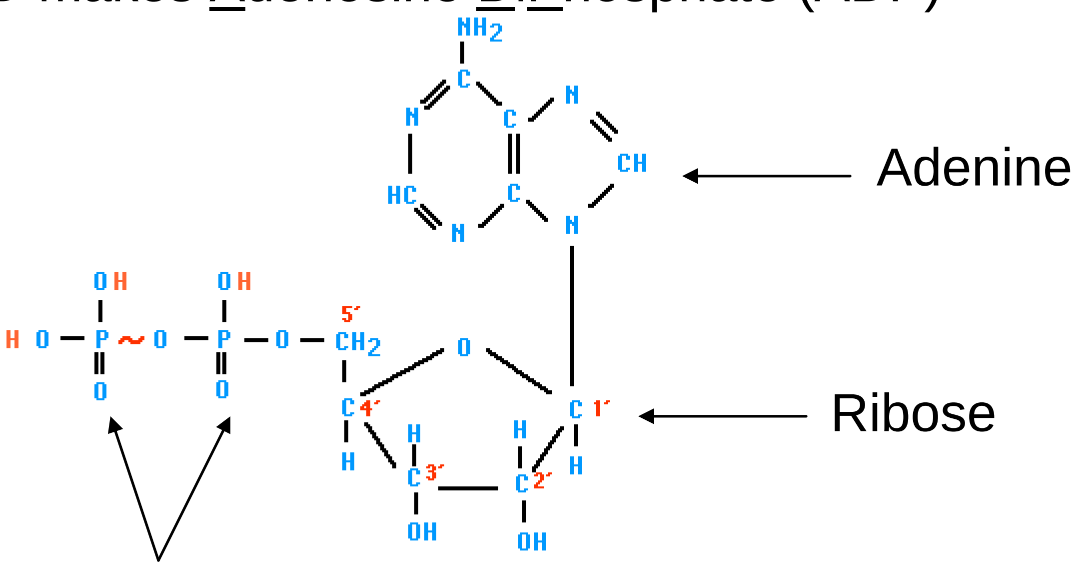
To Make ATP →

1. First phosphate bonded to Adenosine makes Adenosine MonoPhosphate (AMP)



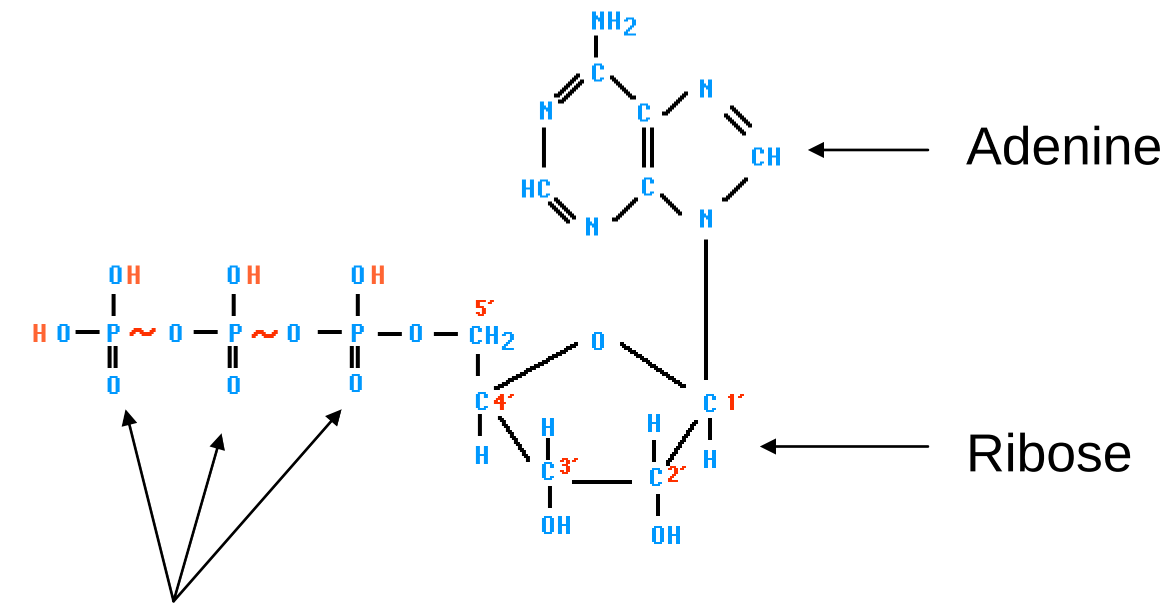
Phosphate group

2. Second phosphate bonded to AMP by a HIGH ENERGY BOND makes Adenosine DiPhosphate (ADP)

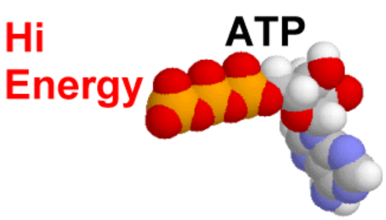


2 Phosphate groups

3. Third phosphate bonded to ADP by a HIGHER ENERGY BOND to form Adenosine TriPhosphate

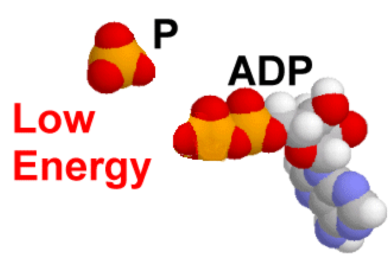


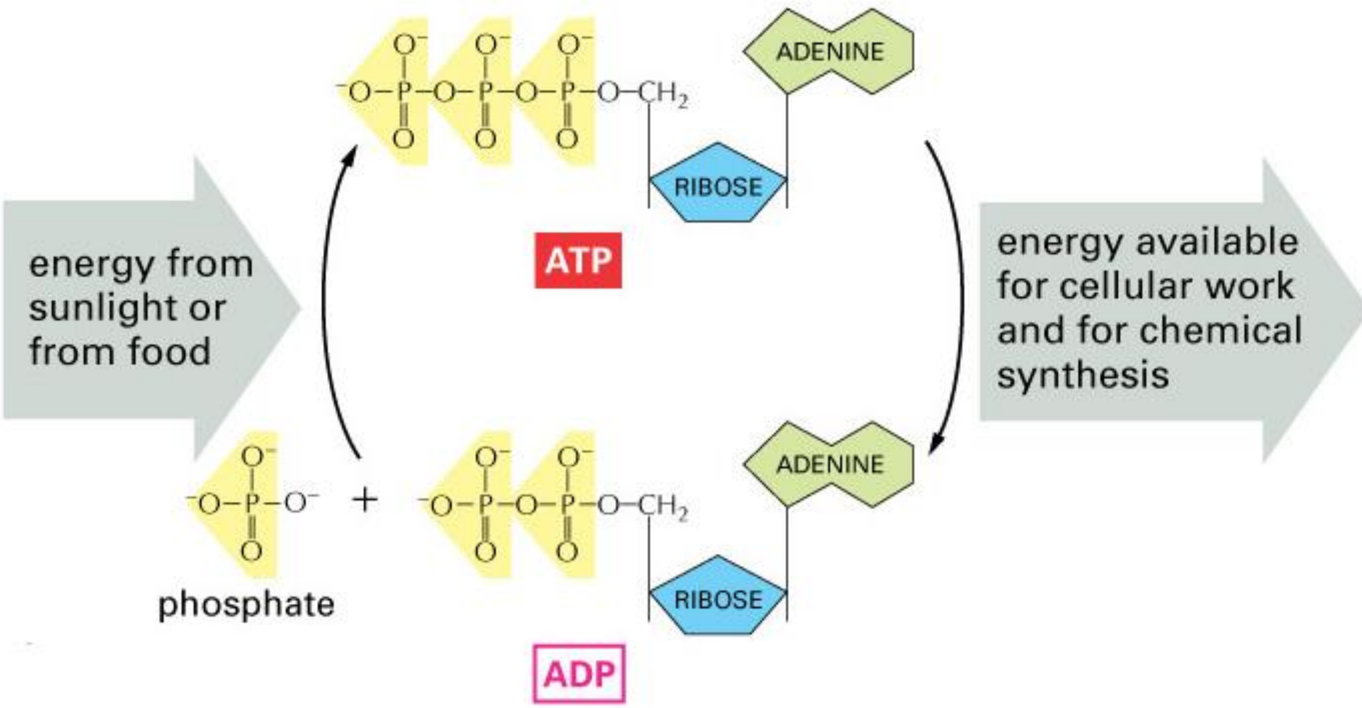
The last higher energy bond is the key to storage, transfer, and release of energy by ATP.



ATTACHING 3rd PHOSPHATE –
ADP→ATP – requires energy – energy STORED in the last higher energy bond.
ADP + phosphate + energy → ATP

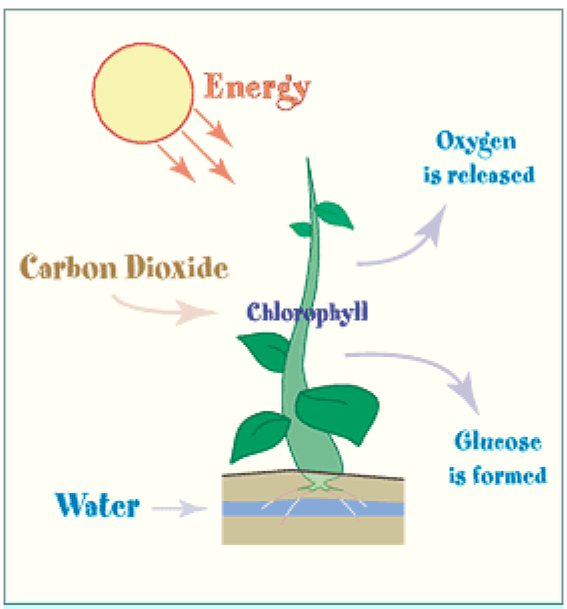
REMOVING 3rd PHOSPHATE –
ATP→ADP – releases energy – energy RELEASED by breaking the last highest energy bond.
ATP → ADP + phosphate + energy





4:3 General Nature of Photosynthesis

PHOTO-: light
-SYNTHESIS: to build complex from simple



Photosynthesis

In photosynthesis, the simple substances are carbon dioxide (CO_2) and water (H_2O). The complex substance is glucose ($C_6H_{12}O_6$) with diatomic oxygen (O_2) as a byproduct.

Chemical Equation for Photosynthesis

$$6\ CO_2 + 6\ H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6\ O_2$$

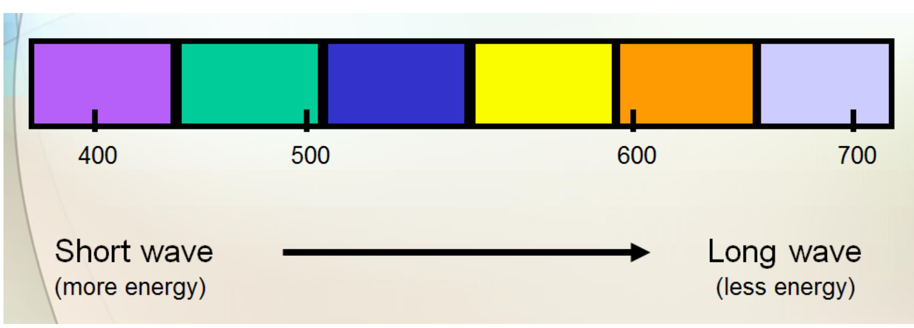
This equation gives an overall view of what happens in a series of chemical reactions. PHOTOSYNTHESIS is much more complex.

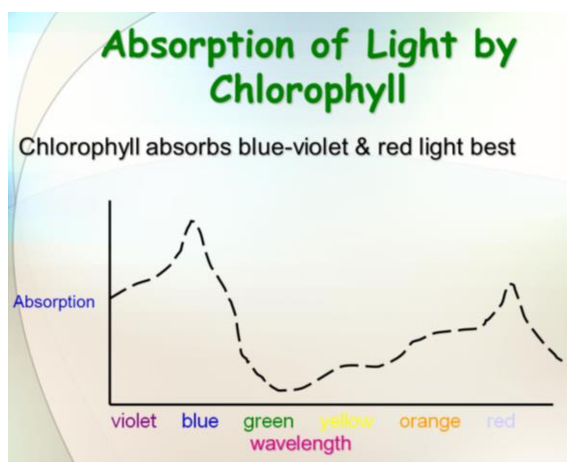
CHLOROPHYLL: pigment found in all cells that carry out photosynthesis; inside the thylakoids of the chloroplasts

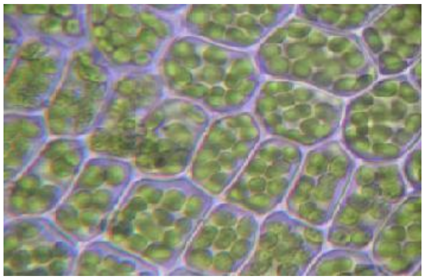
Two main types of chlorophyll: chlorophyll a (green pigment) and chlorophyll b (red, orange, yellow, brown).

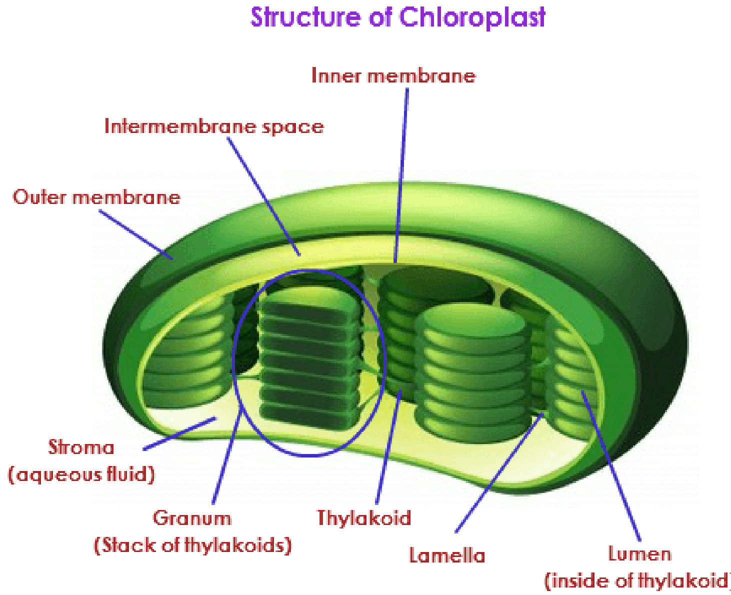
CAROTENOIDS: pigments that are either red, orange, or yellow

Chlorophyll a is directly involved in the light reactions of photosynthesis. Chlorophyll b assists chlorophyll a in capturing light energy, so it is considered an accessory pigment.









<u>CHLOROPLAST</u>: organelle in a plant cell where photosynthesis takes place

<u>THYLAKOID: </u>a membrane system found within chloroplasts that contains the components

<u>STROMA: </u>the solution that surrounds the thylakoids in a chloroplast

CHLOROPHYLL is a CATALYST in photosynthesis.

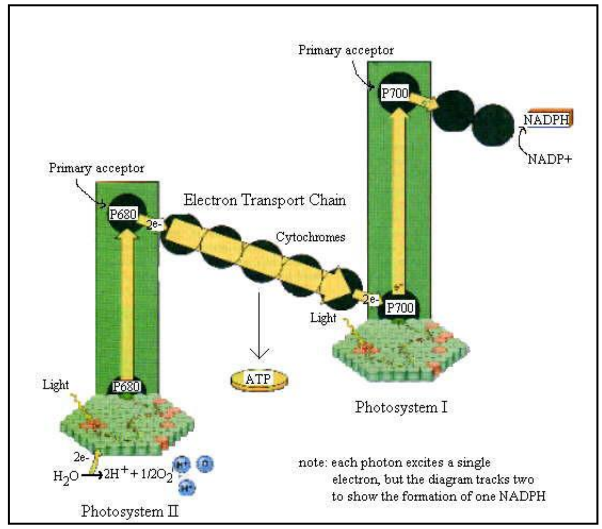
<u>CATALYST</u>: substance that affects the speed of a chemical reaction without entering into or being used up by the reaction

Chlorophyll cannot develop without light. Plants sprouted in total darkness will be yellow and unable to carry out photosynthesis.

4:4 The Photosynthesis Process

Two Stages of Photosynthesis

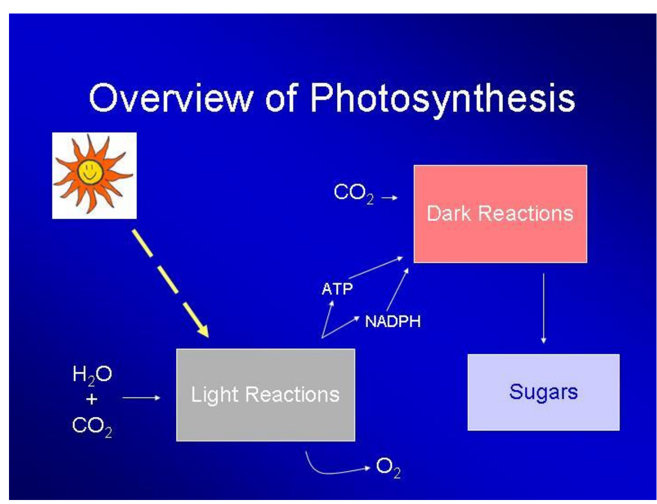
1. LIGHT-DEPENDENT-produce oxygen gas; convert ADP and NADP+ into the energy carriers ATP and NADPH. Two photosystems are used; Photosystem II and Photosystem I, as well as Electron Transport Chain



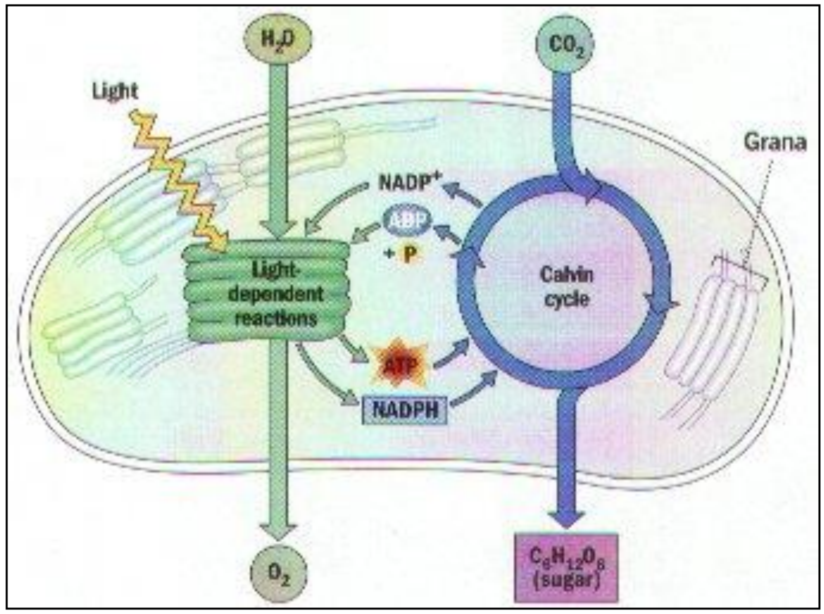
   - Takes place inside the thylakoid
   - PHOTOSYSTEM: in the thylakoid membranes of chloroplasts, a cluster of chlorophyll and other pigment molecules that harvest light energy for the light reactions of photosynthesis
2. CALVIN CYCLE (LIGHT-INDEPENDENT): uses ATP and NADPH from the light-dependent reactions to produce high-energy sugars
   - Takes place inside the Stroma

Overview of the Light-Dependent Reactions

1. Light energy (sun) forces electrons to enter a higher energy level (get excited) in chlorophyll a of Photosystem II.
2. The excited electrons move through the Electron Transport Chain from Photosystem II to Photosystem I. H^+ ions are

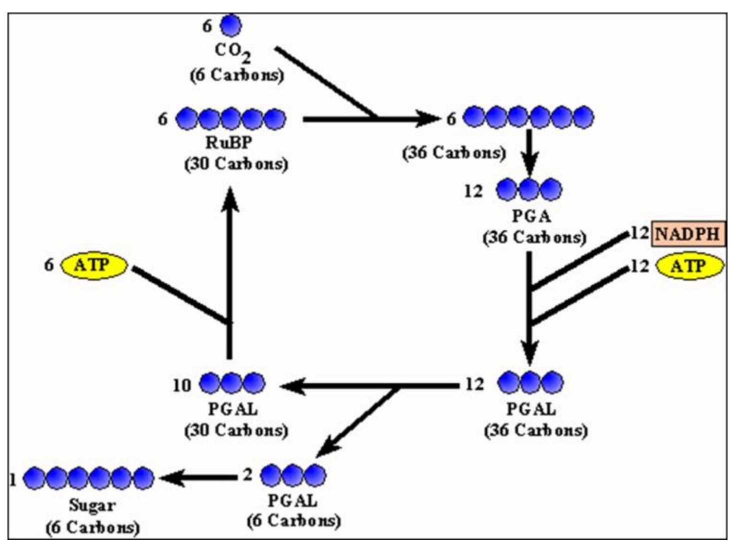


transported from the stroma into the inner thylakoid.



3. Pigments in Photosystem I use energy from the sun to add energy to the electrons. The high-energy electrons are then picked up by $NADP^+$ to form NADPH.
4. As a result of the H^+ ions being released during Step 2, the inside of the thylakoid becomes positively charged and the outside becomes negatively charged.
5. H^+ ions cannot cross the cell membrane by themselves. Membrane contains a protein called ATP Synthase that allows H^+ ions to pass through. As hydrogen ions pass through ATP synthase, it converts ADP into ATP.

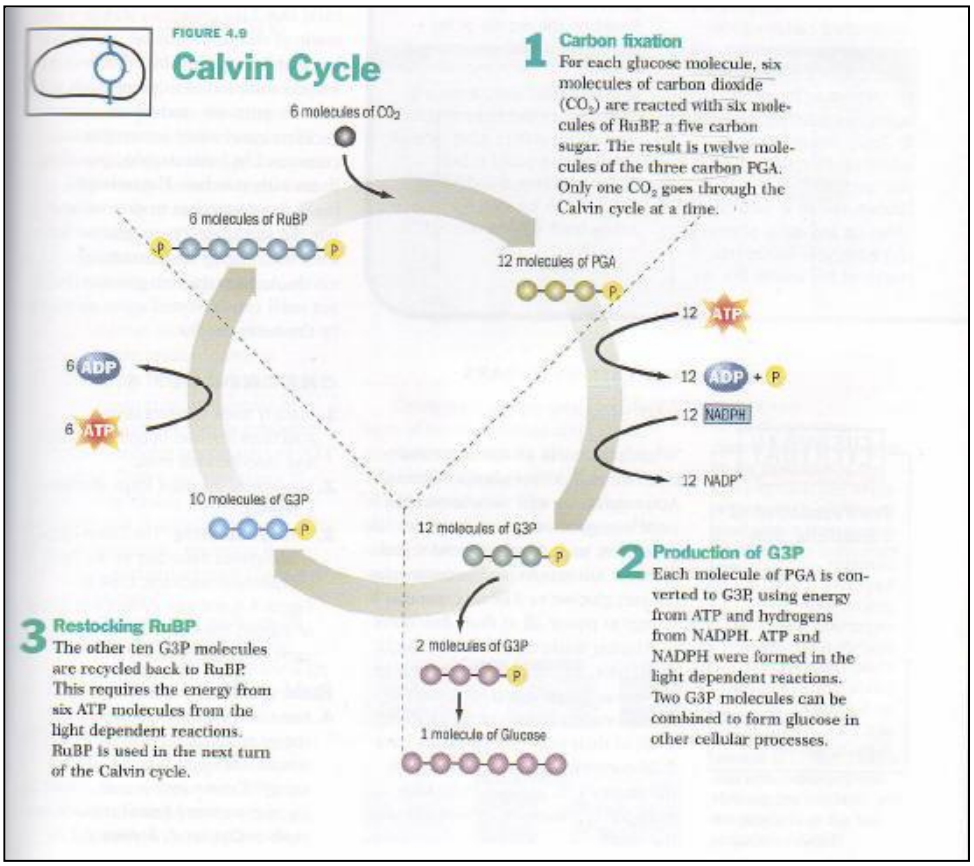
<u>Overview of the Calvin Cycle</u>



1. Six carbon dioxide molecules enter the cycle from the atmosphere. They combine with six 5-carbon molecules that result in twelve 3-Carbon Molecules.
2. The twelve 3-Carbon molecules are converted into high-energy forms.

3. Two 3-Carbon molecules are used to make a 6-Carbon sugar.
4. The ten remaining 3-Carbon molecules are converted back into six 5-Carbon molecules, which are used in the next cycle.

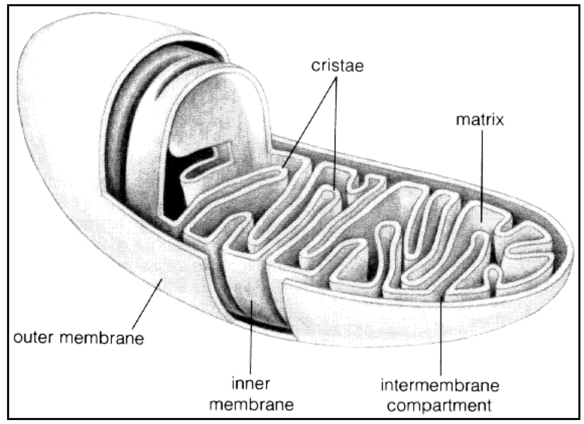
The Calvin Cycle uses six molecules of CO_2 to produce a single 6-Carbon sugar molecule.



4:5 Cellular Respiration

OXIDATION: the release of energy from a substance accomplished by adding oxygen or removing hydrogen

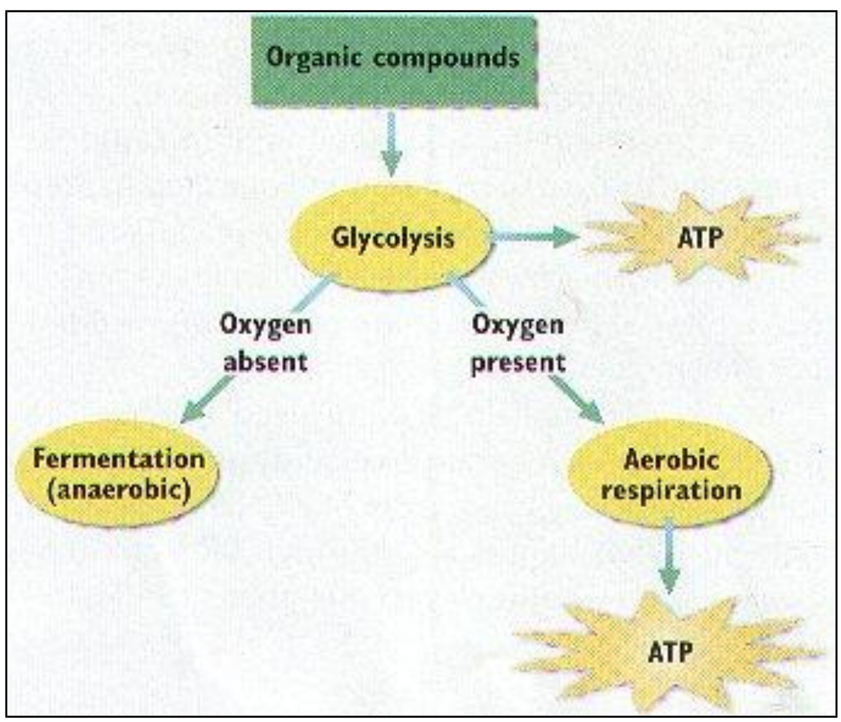
OXIDATION is a sudden release of energy. CELLULAR RESPIRATION is a controlled process that releases energy in a series of steps.



Overview of Cellular Respiration

- GLUCOSE is oxidized.
- ENERGY released from glucose used to change ADP to ATP.
- CO_2 and H_2O are given off.

GLYCOLYSIS: occurs in the cytoplasm without using oxygen; one molecule of glucose is broken in half, producing two molecules of pyruvic acid, a 3-Carbon compound. Net gain of 2 ATP produced,



Glycolysis is followed by ONE of three different processes: alcohol fermentation, lactic acid fermentation, or the Krebs cycle.

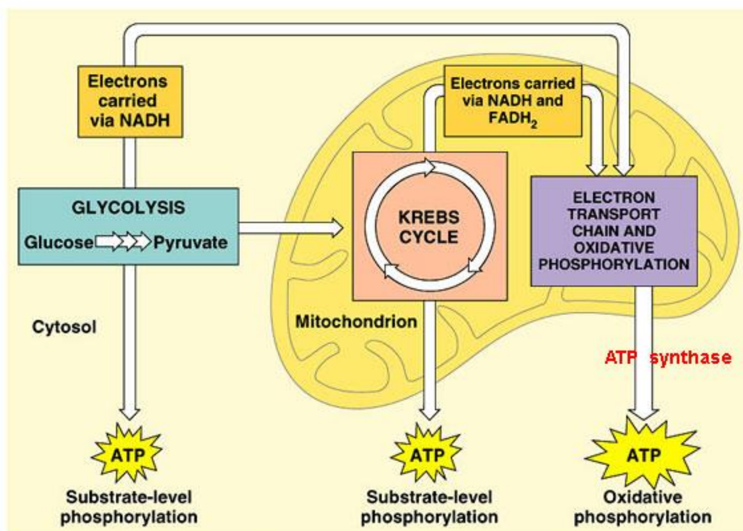
In the presence of oxygen, pyruvic acid produced in glycolysis passes to the KREBS CYCLE, the second stage of cellular respiration.

<u>Overview of the Krebs Cycle</u>

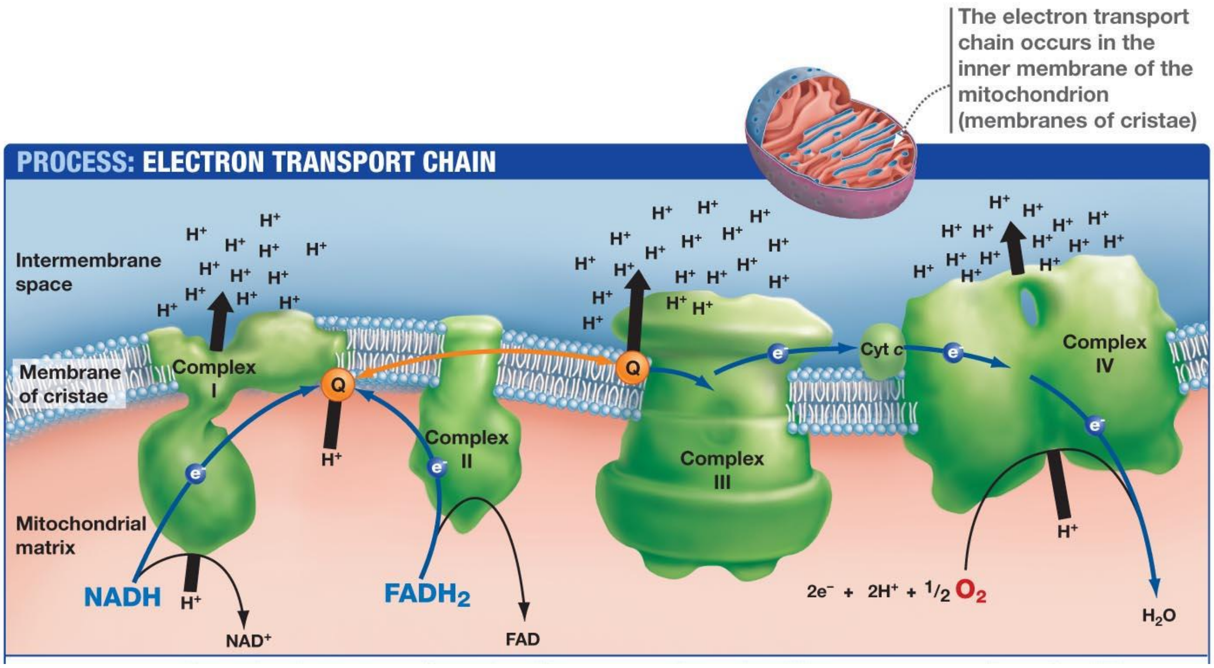
1. Pyruvic acid produced by glycolysis enters the mitochondria. CO_2 is released and a 6-carbon molecule called citric acid is produced by combining a 2-carbon molecule with a 4-carbon molecule.
2. As the cycle continues, critic acid is broken down into a 4-carbon molecule, more CO_s is released, and electrons are transferred to energy carriers, then to the Electron Transport Chain.

<u>Overview of the Electron Transport Chain</u>

1. NADH and $FADH_2$ give electrons to the ETC.NADH donates electrons at the beginning, and $FADH_2$ donates them farther down the chain. These molecules give up protons.
2. Electrons are passed down the chain. As they move, they lose energy.
3. The energy lost from the electrons is used to pump protons from the matrix, building a high concentration of protons between the inner and outer membranes. A concentration gradient and electrical gradient are created.
4. The concentration gradients of protons drive the synthesis of ATP.



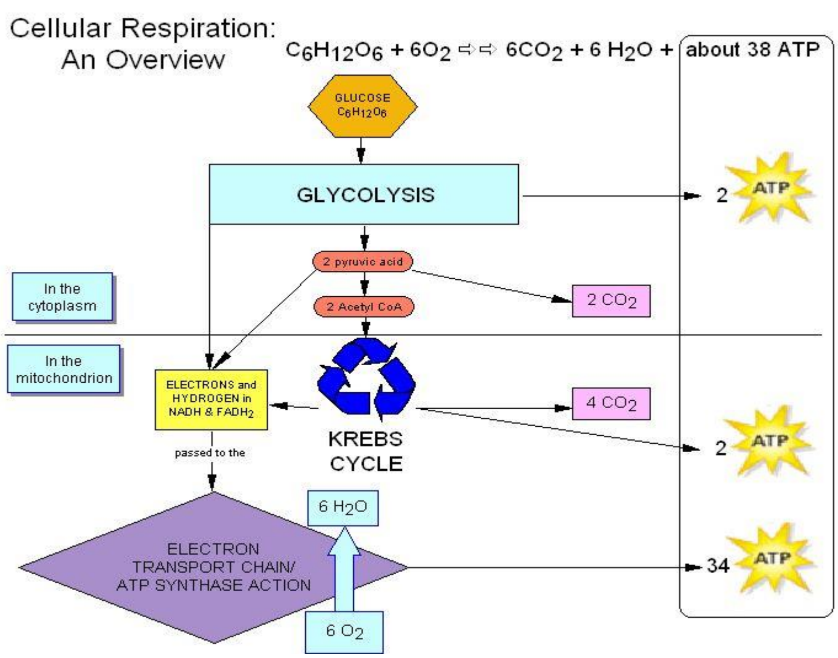
5. Oxygen is the final acceptor of electrons that have passed down the chain. Oxygen accepts protons that were part of the hydrogen atoms supplied by NADH and $FADH_2$. The protons, electrons, and oxygen all combine to form water.



Chemical Equation for Cellular Respiration

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + 38\ ATP$$

38 ATP is only 60% of the energy in one glucose; the other 40% is lost as heat.



4:6 Fermentation

FERMENTATION: (anaerobic respiration) the breakdown of glucose to release energy carried out in the absence of oxygen

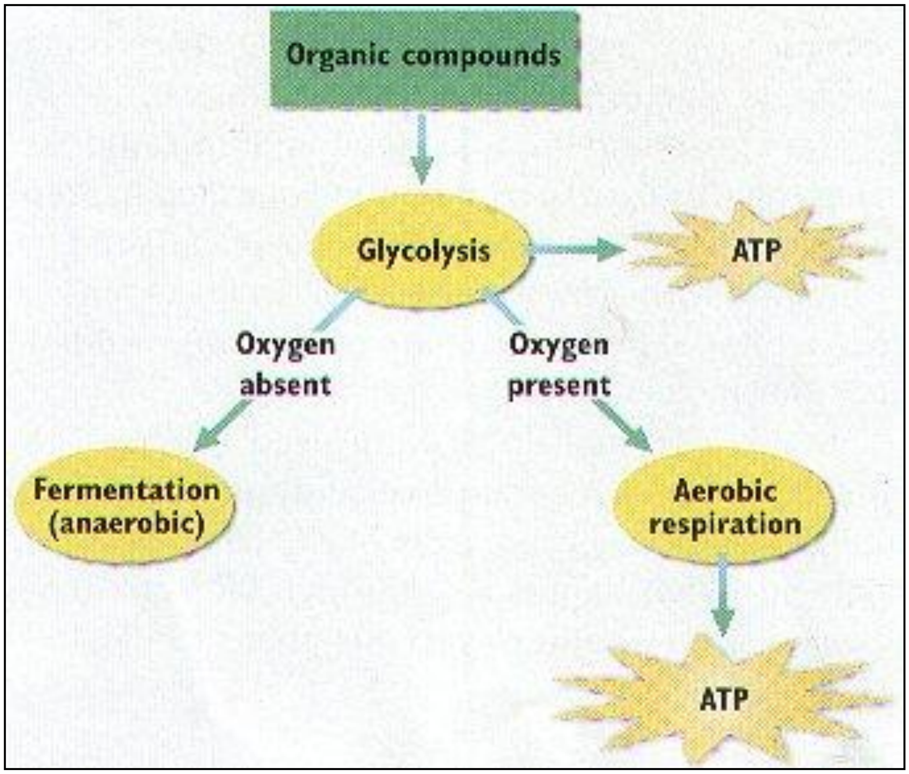
Fermentation releases FAR LESS energy than cellular respiration.

Yeasts use alcoholic fermentation, forming ethyl alcohol and CO_2 as wastes. The equation for alcoholic fermentation after glycolysis:

Pyruvic Acid + NADH → alcohol + CO_2 + NAD^+

Two Types of Fermentation

1. ALCOHOLIC FERMENTATION: anaerobic respiration carried out by yeasts and other microorganisms; 1 glucose produces ethyl alcohol, CO_2, and 2 ATP
    - Causes bread dough to rise
    - Wine and Beer Industry
2. LACTIC ACID FERMENTATION: anaerobic respiration carried out by animal tissues (such as muscle) that are not getting enough oxygen; 1 glucose produces lactic acid and 2 ATP
    - Produced in your muscles during rapid exercise when the body cannot supply enough oxygen to tissues


Organic compounds
Glycolysis
ATP
Oxygen absent
Oxygen present
Fermentation (anaerobic)
Aerobic respiration
ATP