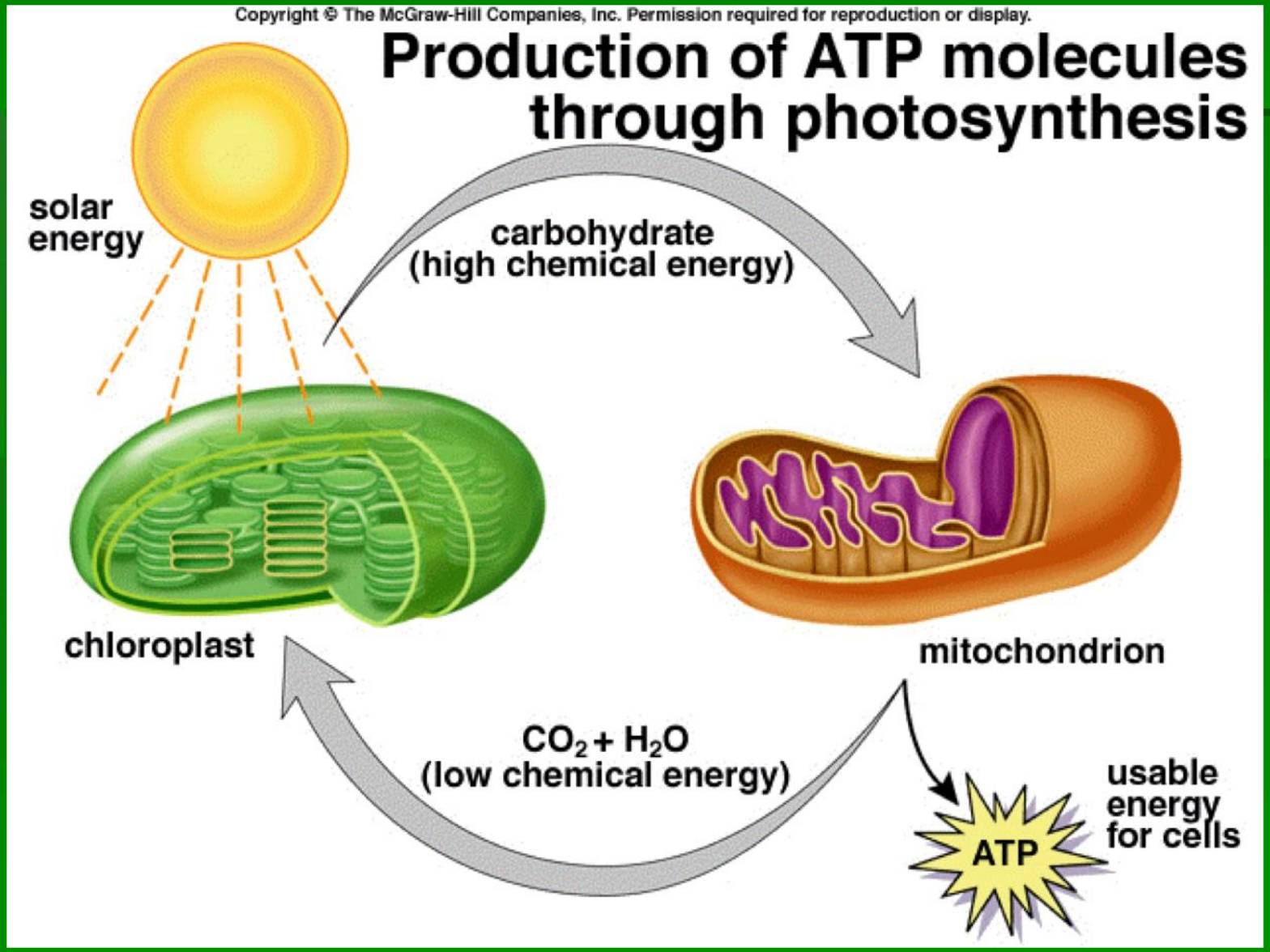
Cellular Energy



Cellular Energy

- The cell will store energy in molecules like sugars and ATP
  - Most cells have small stores of ATP that only last a few seconds, but cannot store energy there long-term.
  - Cells will store it long term in carbohydrates/ sugars
  -  Sugar energy > ATP energy 

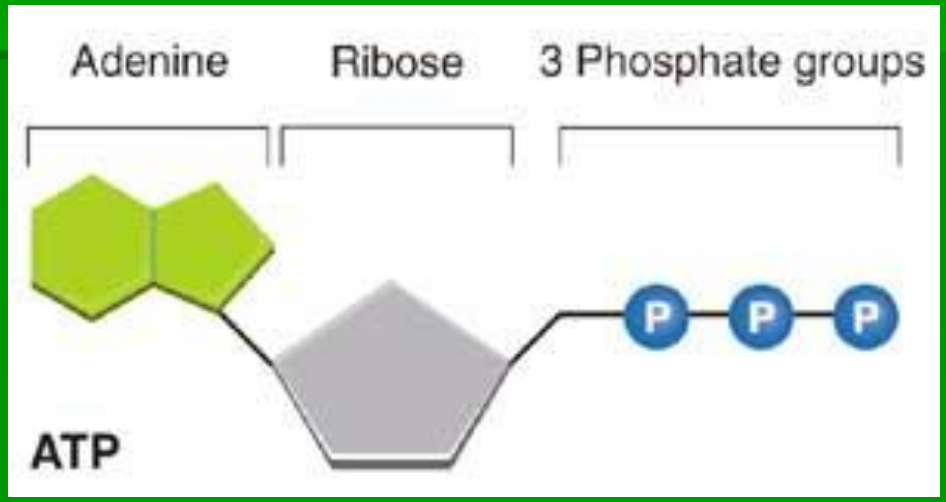
90x greater

Structure of ATP

Structure- the Adenosine Triphosphate ATP molecule has three parts:

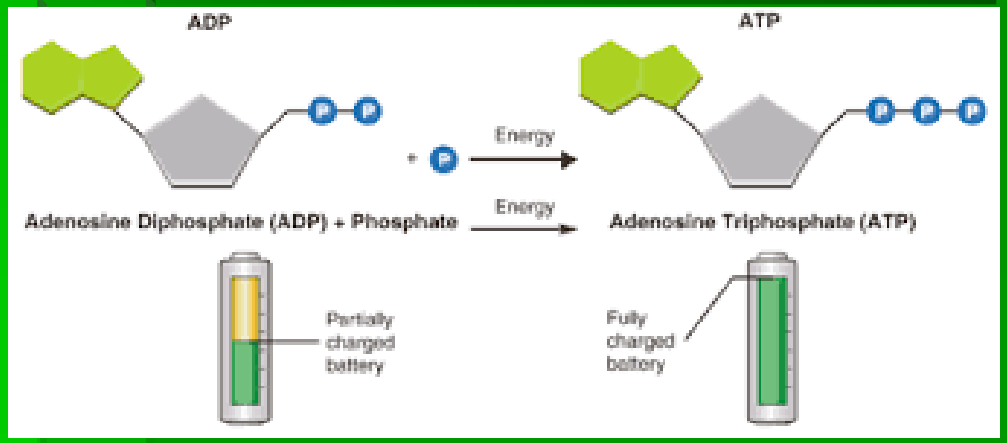
- 1. adenine (a nitrogen-containing molecule)
- 2. ribose (a five-carbon sugar)

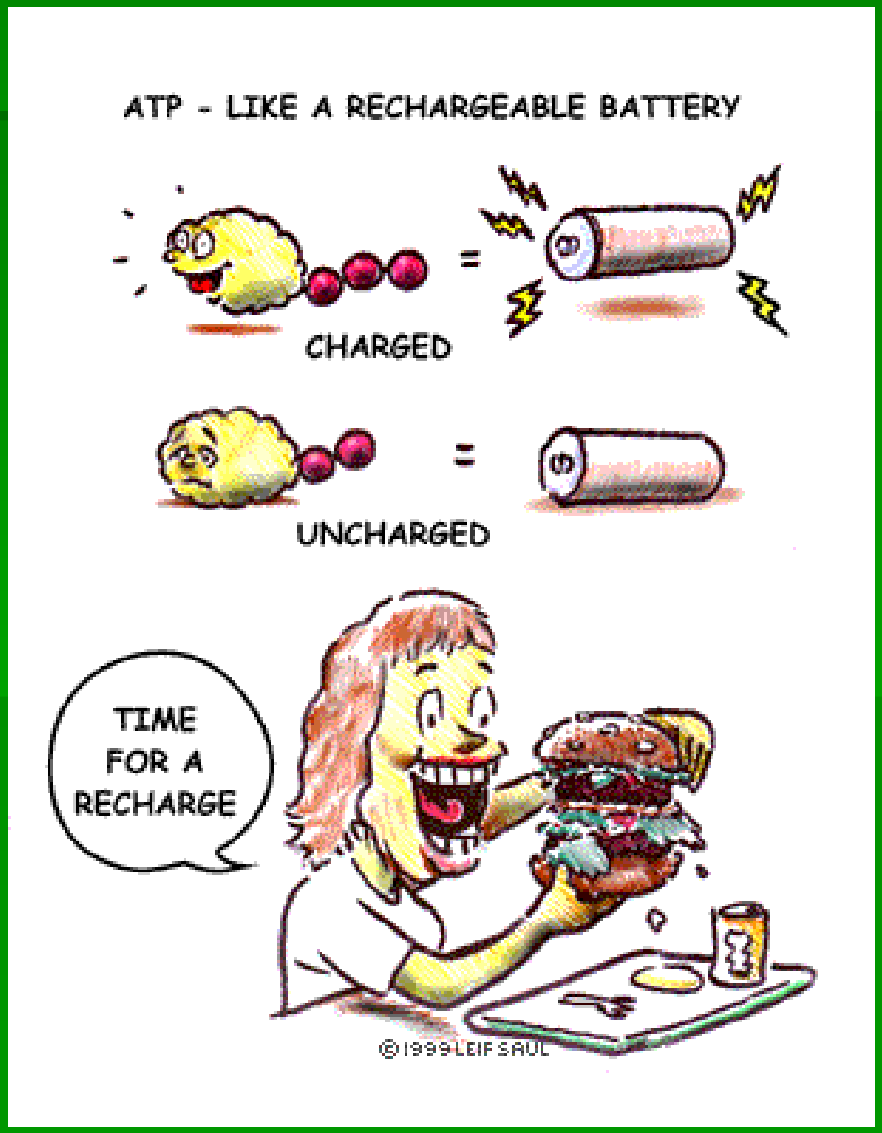
  The adenine bonds to ribose, forming adenosine.
- 3. three phosphate groups



Function of ATP

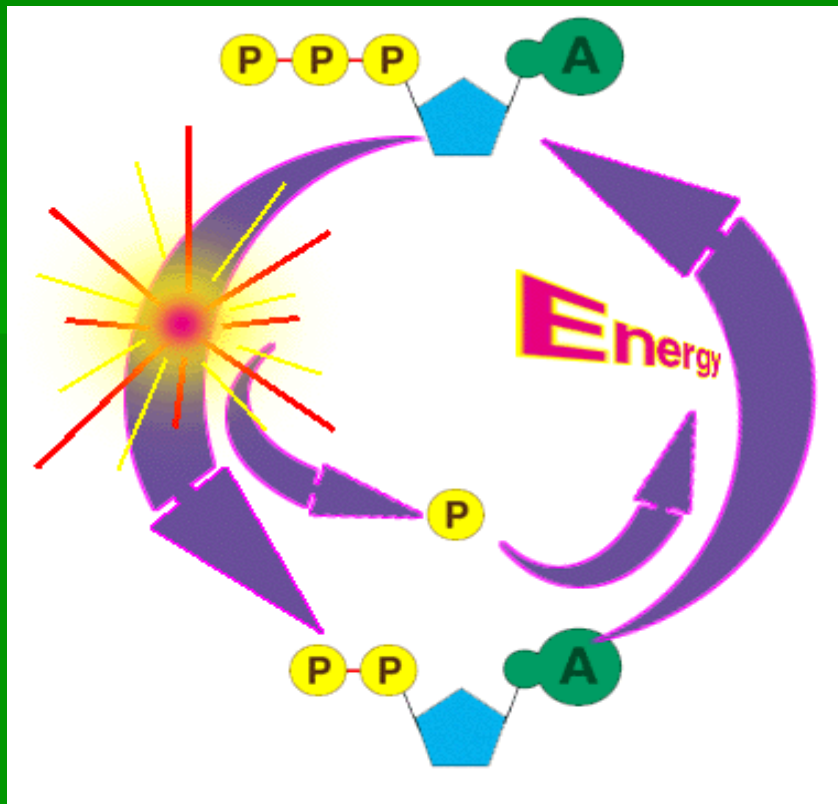
- ATP stores energy in the bonds between the phosphate groups (high-energy bonds)





ATP-ADP CYCLE

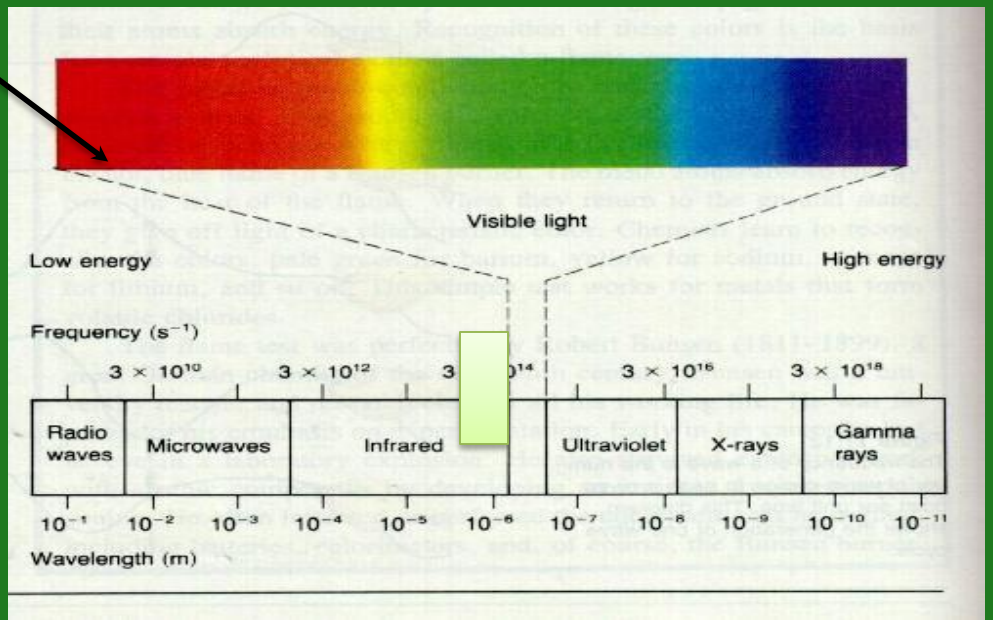
- ATP is the energy currency of the cell.
- When the bond between two phosphates is broken, phosphate is removed and energy is released.



Light and Pigments

$$\underline{6}\ CO_2 + \underline{6}\ H_2O \xrightarrow{light} C_6H_{12}O_6 + \underline{6}\ O_2$$

- Photosynthesis starts with **SUNLIGHT**!
- The light that comes from the sun is WHITE LIGHT and includes all the colors of the visible spectrum, **ROYGBIV**



Light and Pigments

- There are also other pigments, beside chlorophyll a, called **ACCESSORY PIGMENTS**

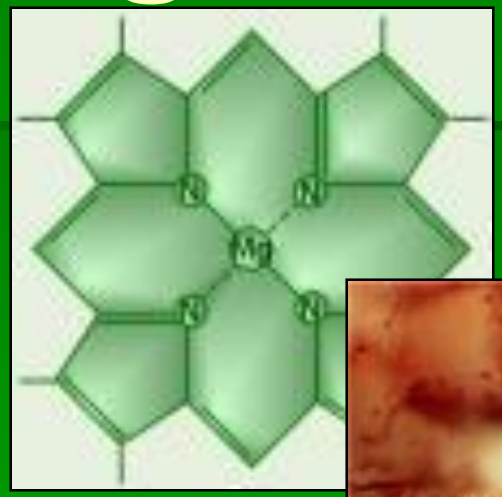
  chlorophyll b and carotenoids

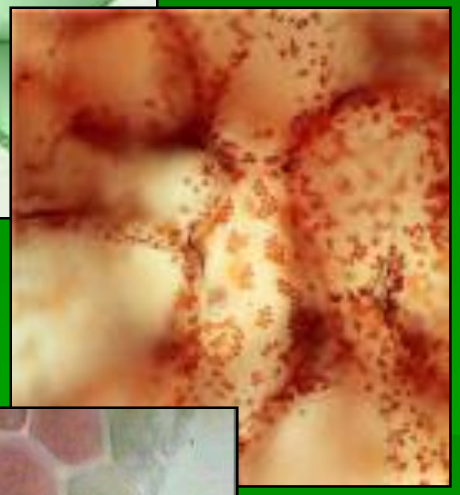
- Each pigment has its **optimal portion of ROYGBIV for absorption** and to fuel PS

- Chlorophyll a is the main pigment for PS, while the **accessory pigments help chlorophyll a by expanding the portion of ROYGBIV it can use!**

Types of Pigments

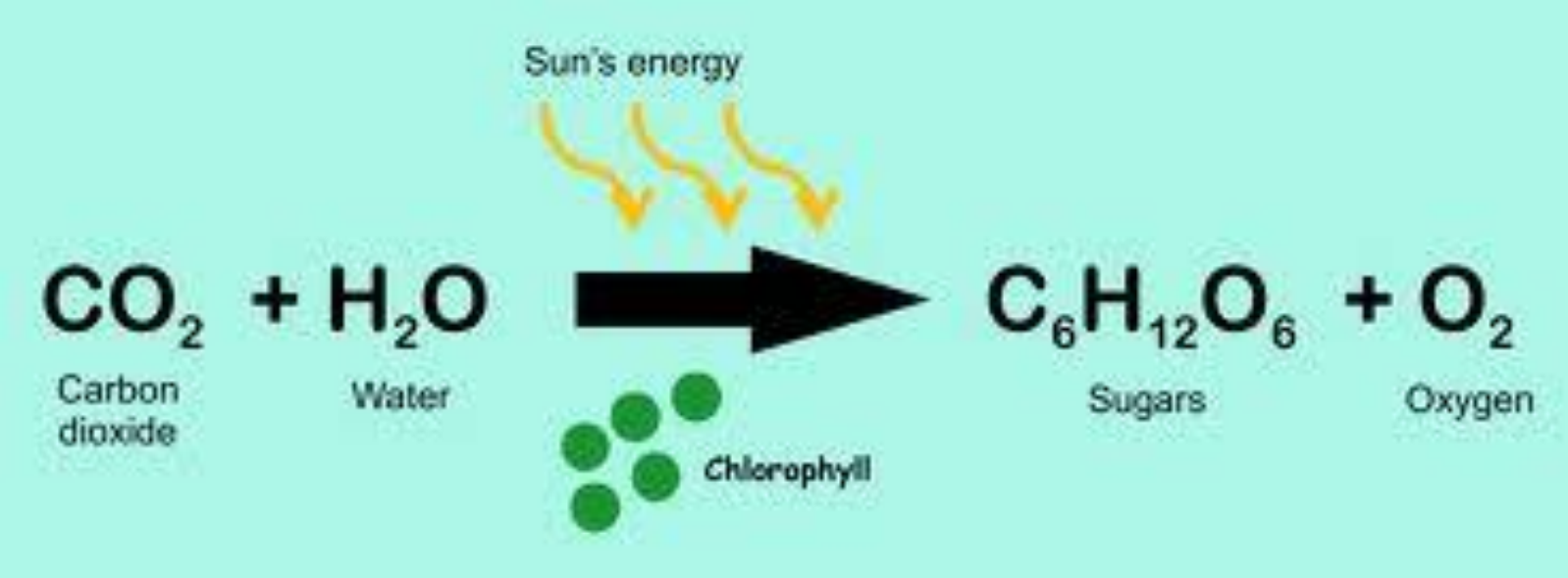
- **Chlorophyll** – the primary light-absorbing agent for photosynthesis
- **Carotenoids** – yellow & orange pigments
- **Phycoerythrin** – red and blue





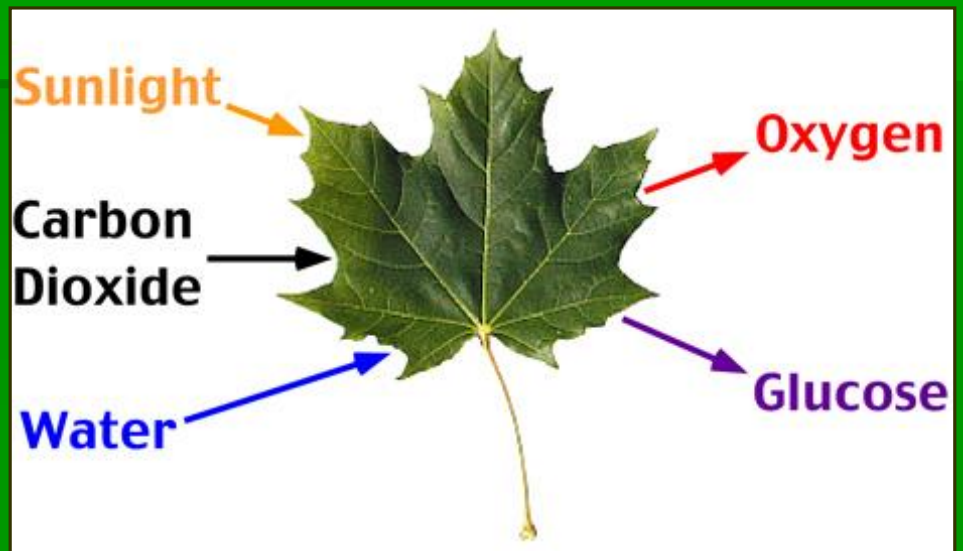
What is Photosynthesis?

- Plants **convert** the energy of sunlight into the energy in the chemical bonds of carbohydrates – sugars and starches.



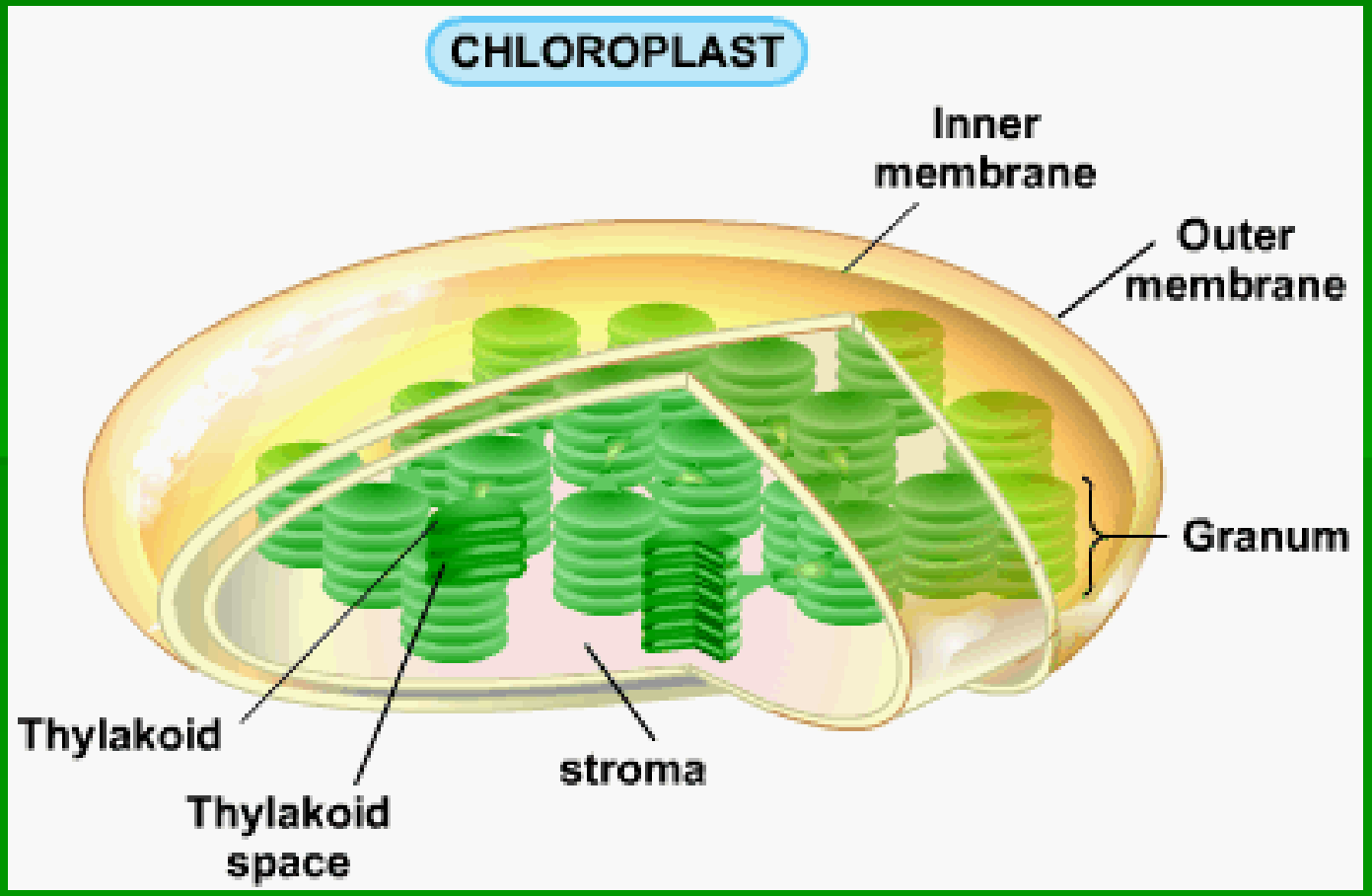
Requirements for Photosynthesis

- Carbon Dioxide = CO_2
- Water = H_2O
- Energy = In the form of sunlight
- Chlorophyll = to capture energy from the sun



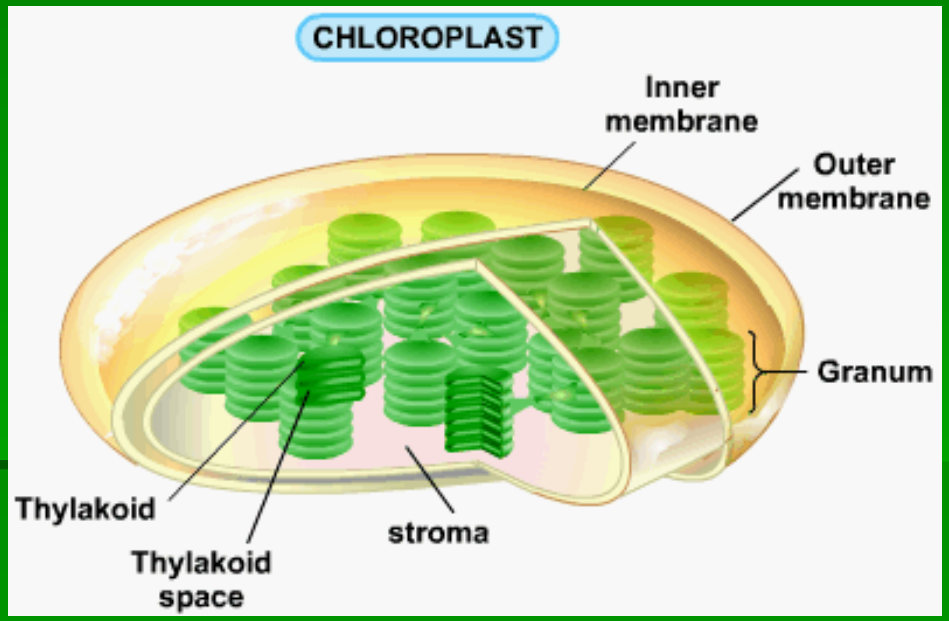
Where does Photosynthesis occur?

- Inside plant cells – specifically chloroplasts

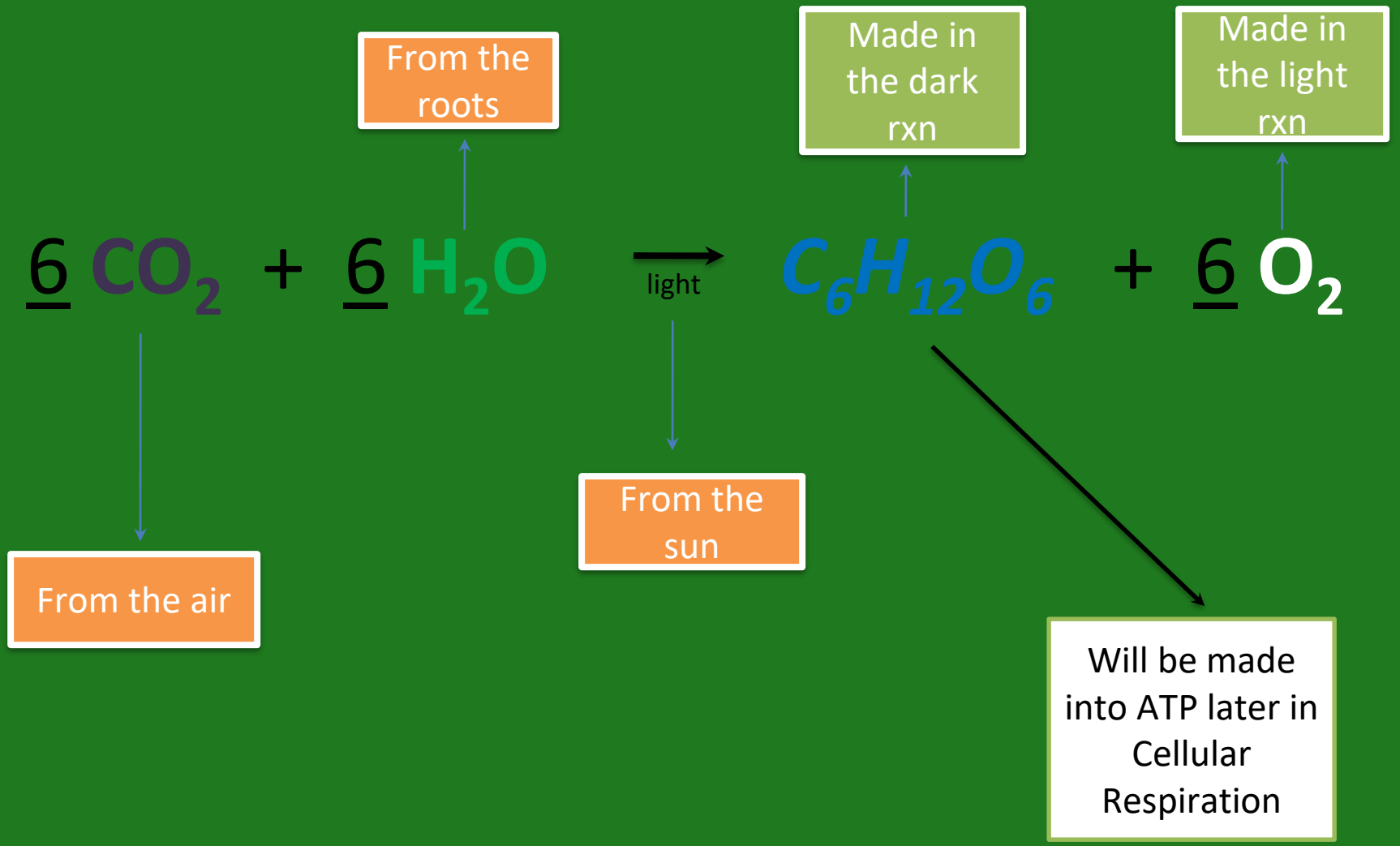


Chloroplast

- Thylakoid – flattened, membrane bound sac
- Granum – stacks of thylakoids
- Chlorophyll - green pigment in the thylakoid
- Stroma – fluid matrix



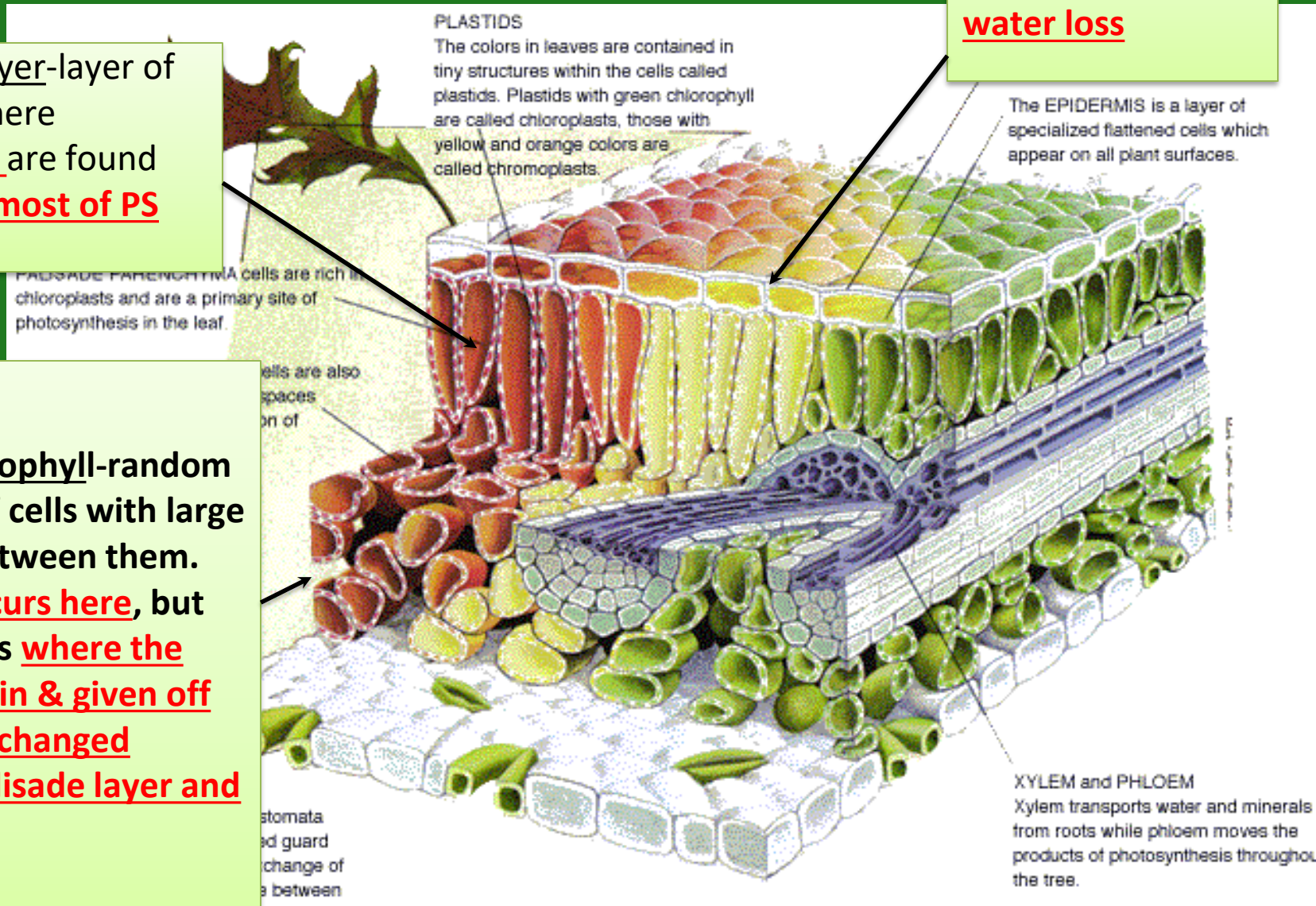
Photosynthesis Reaction



The Leaf

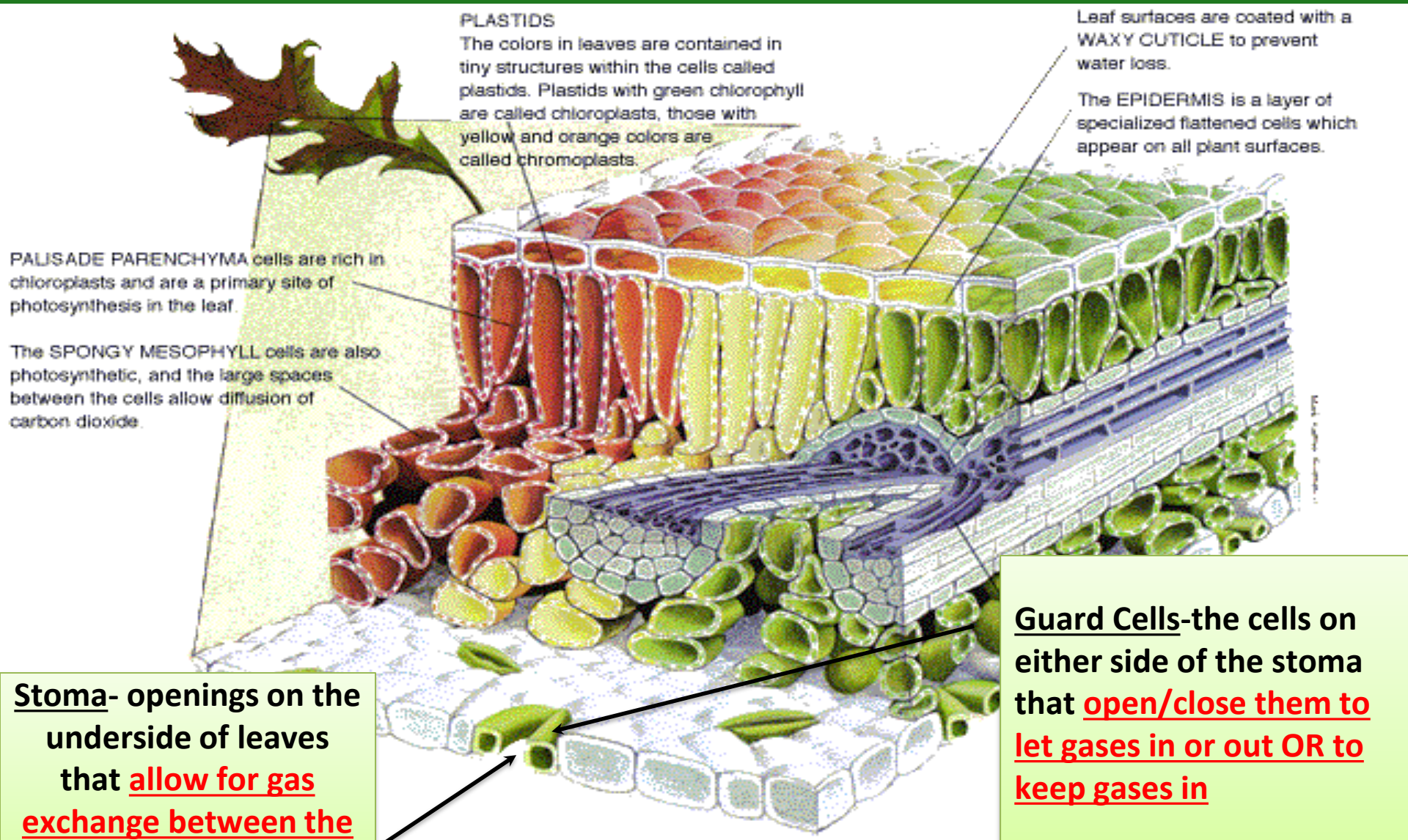
Cuticle- the waxy outer covering of a leaf that **prevents water loss**

Palisdade Layer-layer of long cells where **chloroplasts** are found and **where most of PS occurs**



Spongy Mesophyll-random collection of cells with large spaces in between them. **Some PS occurs here**, but mostly this is **where the gases taken in & given off by PS are exchanged between palisade layer and stoma**

The Leaf



Stoma- openings on the underside of leaves that allow for gas exchange between the leaf and atmosphere.

Guard Cells-the cells on either side of the stoma that open/close them to let gases in or out OR to keep gases in

Stages of Photosynthesis

$$\underline{6}\ CO_2 + \underline{6}\ H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + \underline{6}\ O_2$$

PS occurs in 2 parts

1. **Light Dependent (or Light reaction)**
   - **This part of the rxn requires LIGHT, H_2O, and gives off O_2**

2. **Light Independent (or Dark Reaction) also known as the Calvin Cycle**
   - **This part of the rxn requires CO_2 and produces the sugar or glucose**

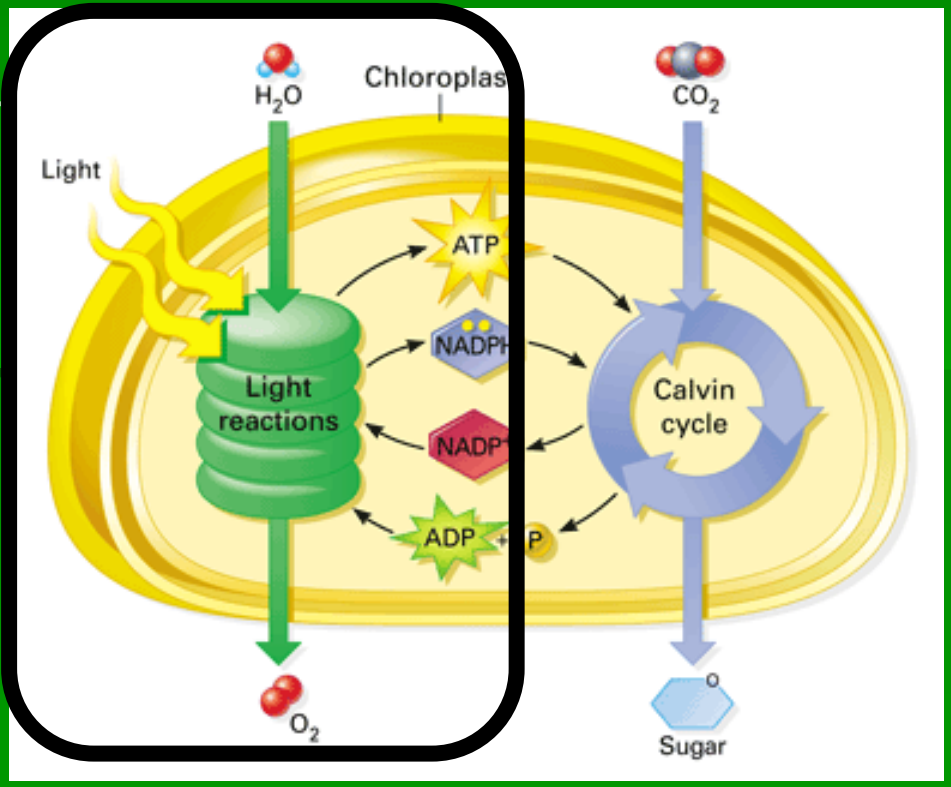
Step 1
Light -Dependent Reactions
Light Reaction

Light energy is absorbed, water is split, ATP is produced, high energy molecule NADPH is formed, and oxygen is released as a bi-product.

Light-Dependent Reaction

- 4 Basic Processes
  - Light absorption
  - Electron transport
  - O_2 production
  - ATP formation

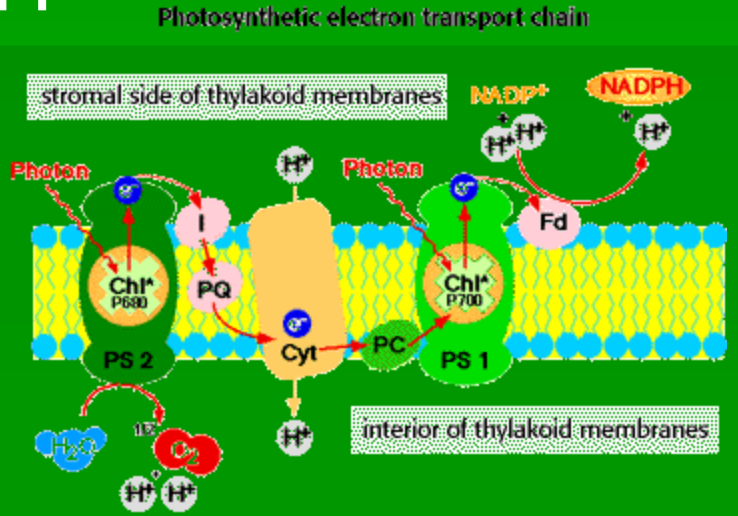
THE PROCESS OCCURS IN THE THYLAKOID MEMBRANE!!



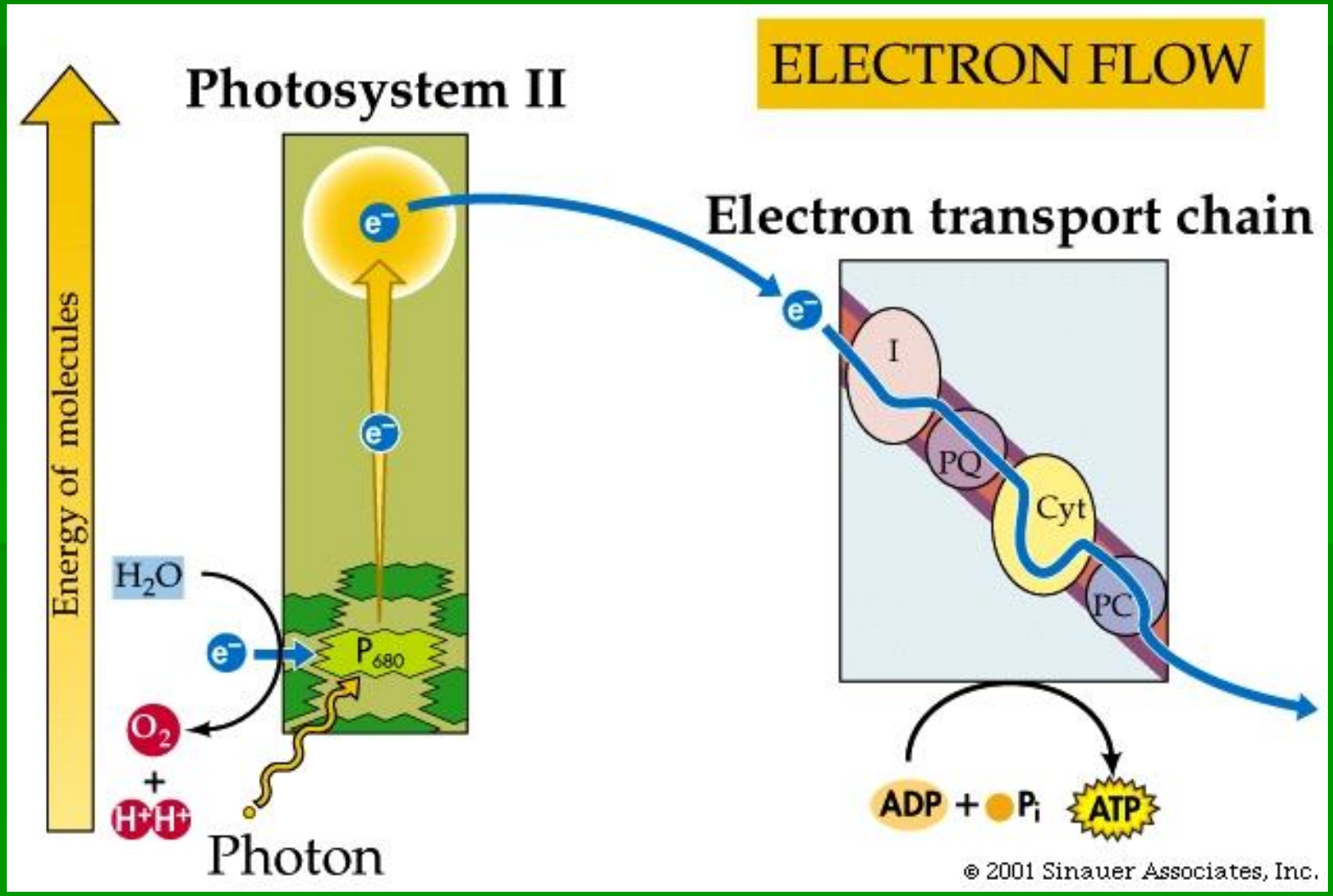
Electron Carriers - NADPH

- Excited electrons – high energy
- Special carriers – electron carriers
  - Electron transport chain

  $NADP^+$ - accepts and holds 2 high energy electrons along with a hydrogen ion (H^+)
- $NADP^+ + H^+ = NADPH$



Light-Dependent Reaction cont.



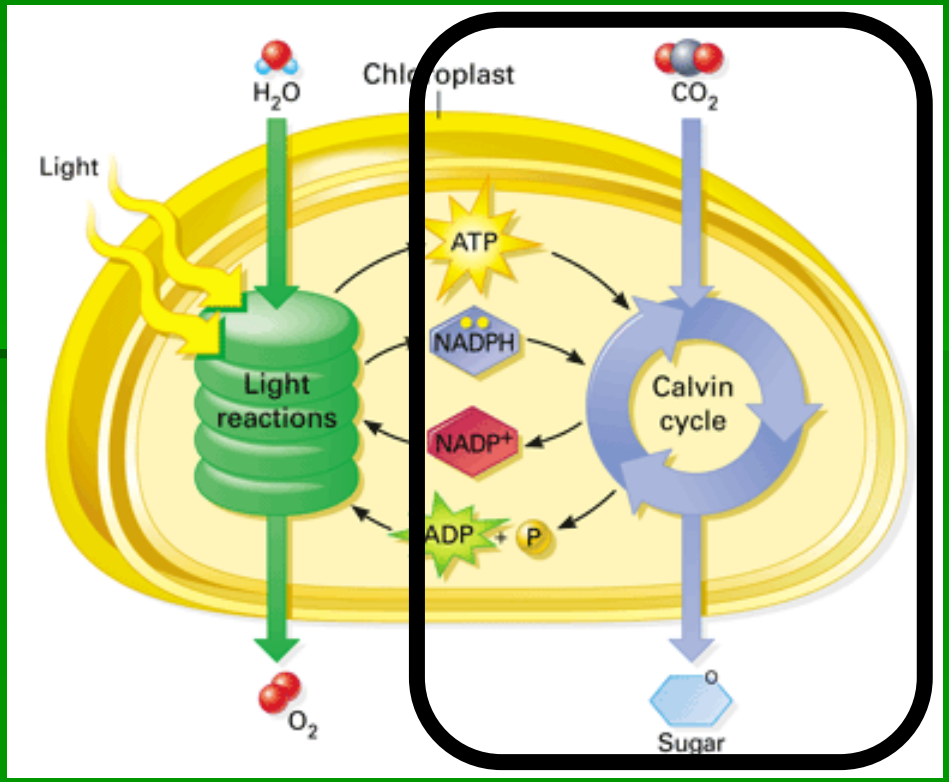
Step 2
Dark reaction / Light-independent reaction/ Calvin cycle
=Producing sugars

- CO_2 enters the calvin cycle
- Chemical energy (ATP & NADPH) is converted to stable sugars that can be stored long term.

Light-Independent Reaction/ Dark Reaction/ Calvin Cycle

- 1 Basic Process
  - Production of stable, high energy sugars such as glucose!

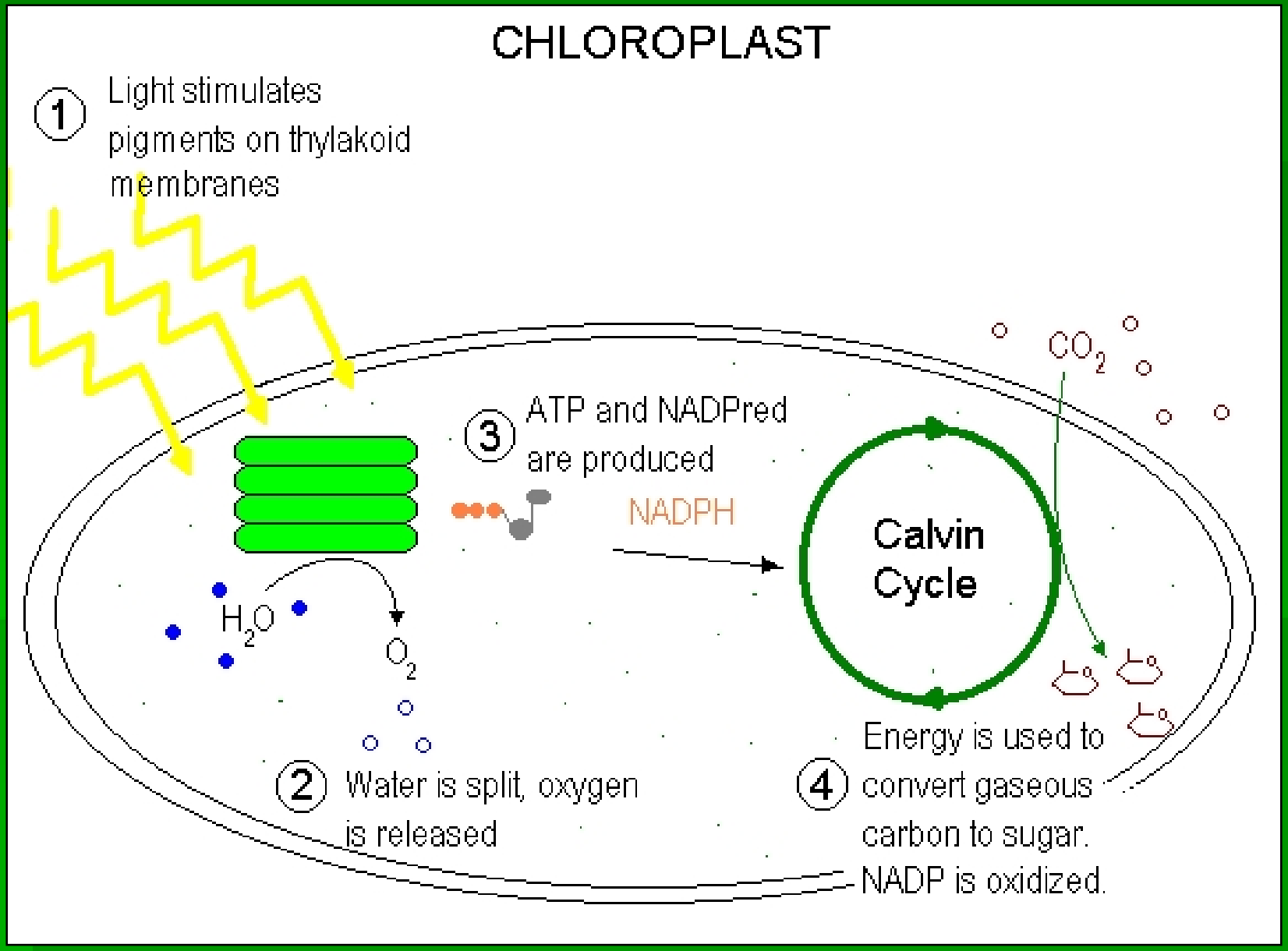
THE PROCESS OCCURS IN THE STROMA!!



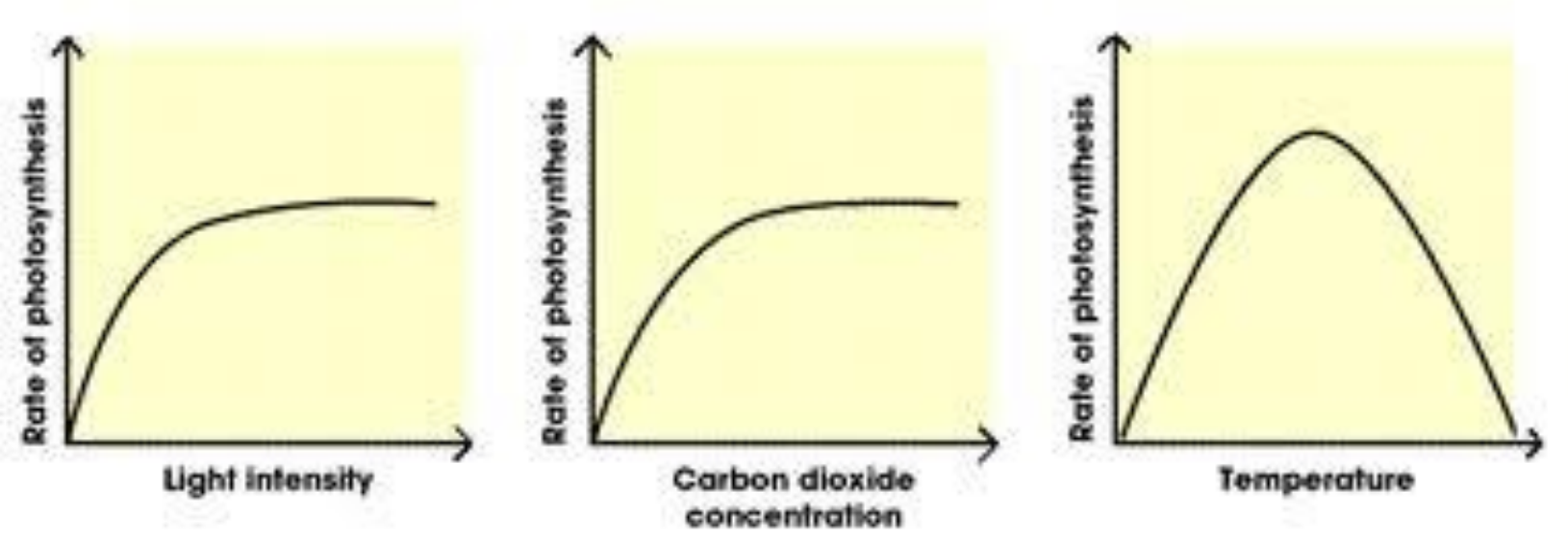
Dark reactions/ Light-Independent Reactions / The Calvin Cycle

- Plants use the energy that ATP and NADPH contain to build high-energy compounds that can be stored for a long time.
- Uses ATP and NADPH from the light dependent reactions to produce high-energy sugars.

The entire process summed up



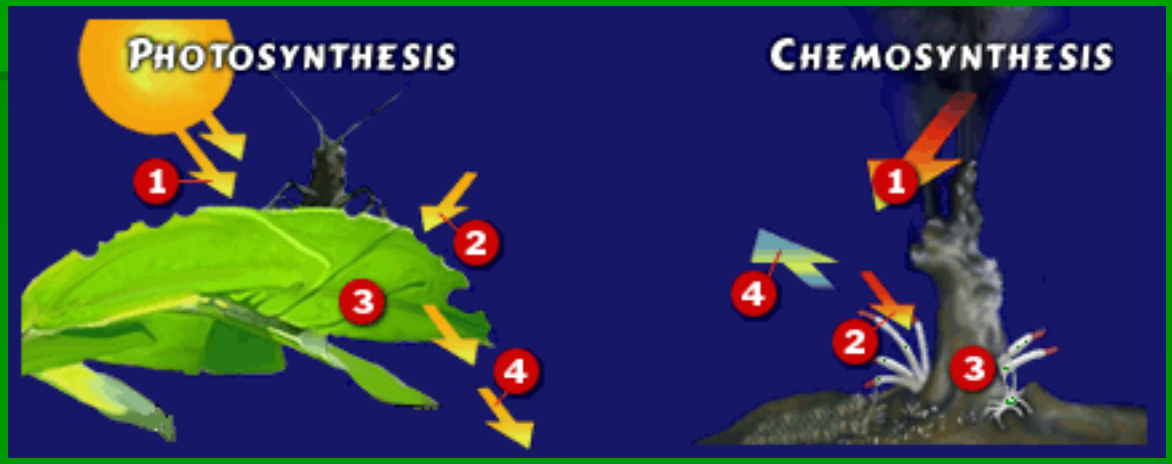
Factors that affect photosynthesis



Chemosynthesis

- Photosynthesis and chemosynthesis are both processes by which organisms produce food; photosynthesis is powered by sunlight while chemosynthesis is powered by chemical energy.

- Chemosynthesis is at the heart of deep sea communities, sustaining life where light does not penetrate.



Cellular Respiration

Cellular Respiration - An Overview

Glycolysis

O_2 present

No O_2 present

90% of energy still available

Kreb Cycle

ETC

Fermentation

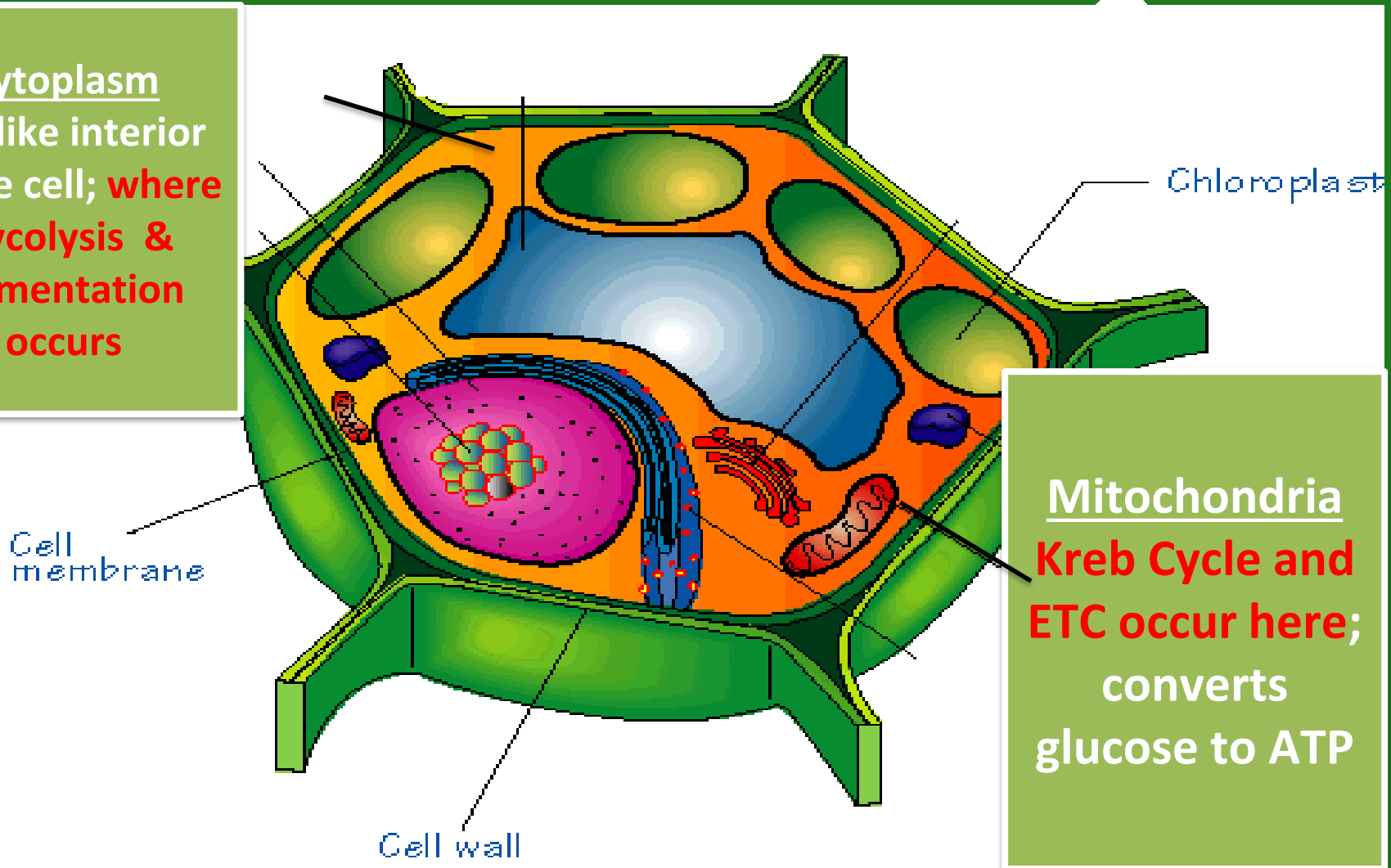
Lactic Acid

Alcoholic

$$6\ O_2 + C_6H_{12}O_6 \longrightarrow 6\ CO_2 + 6\ H_2O + \text{energy (ATP)}$$

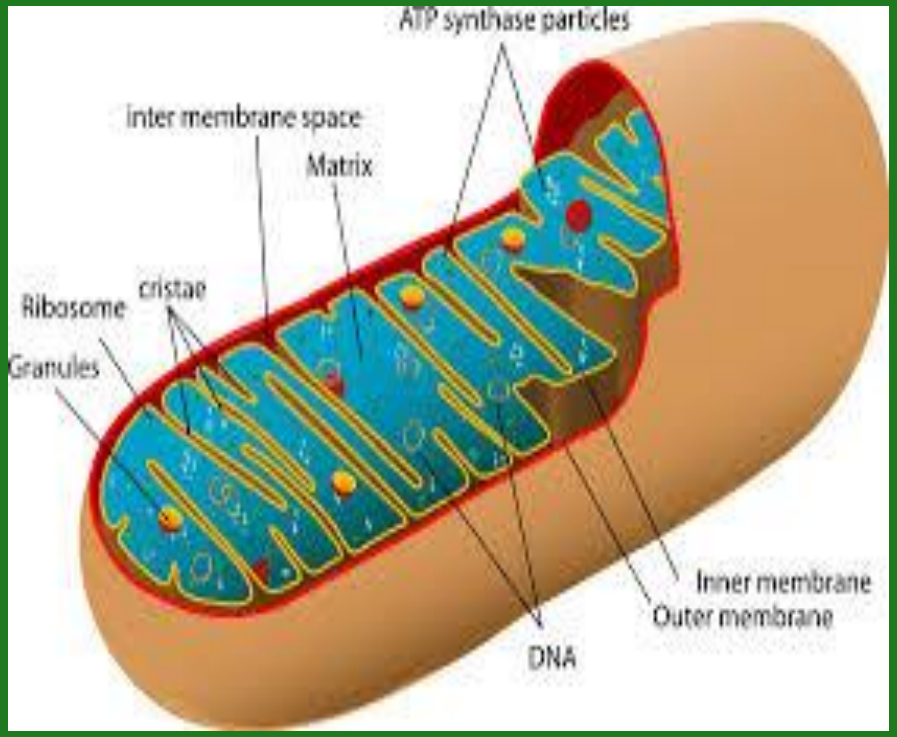
Structures of CR

Cytoplasm
Gel-like interior of the cell; **where glycolysis & fermentation occurs**



Mitochondria
Kreb Cycle and ETC occur here; converts glucose to ATP

Structures of Cellular Respiration - Mitochondria



The Mitochondria

- In almost all **eukaryotic** cells
- **Where aerobic respiration occurs**
- 2 membranes
- Nearly **all** your mitochondria **come from your mother**
- Has its **own DNA** that is different from nuclear DNA
- Has its own ribosomes
- Reproduces by splitting in two

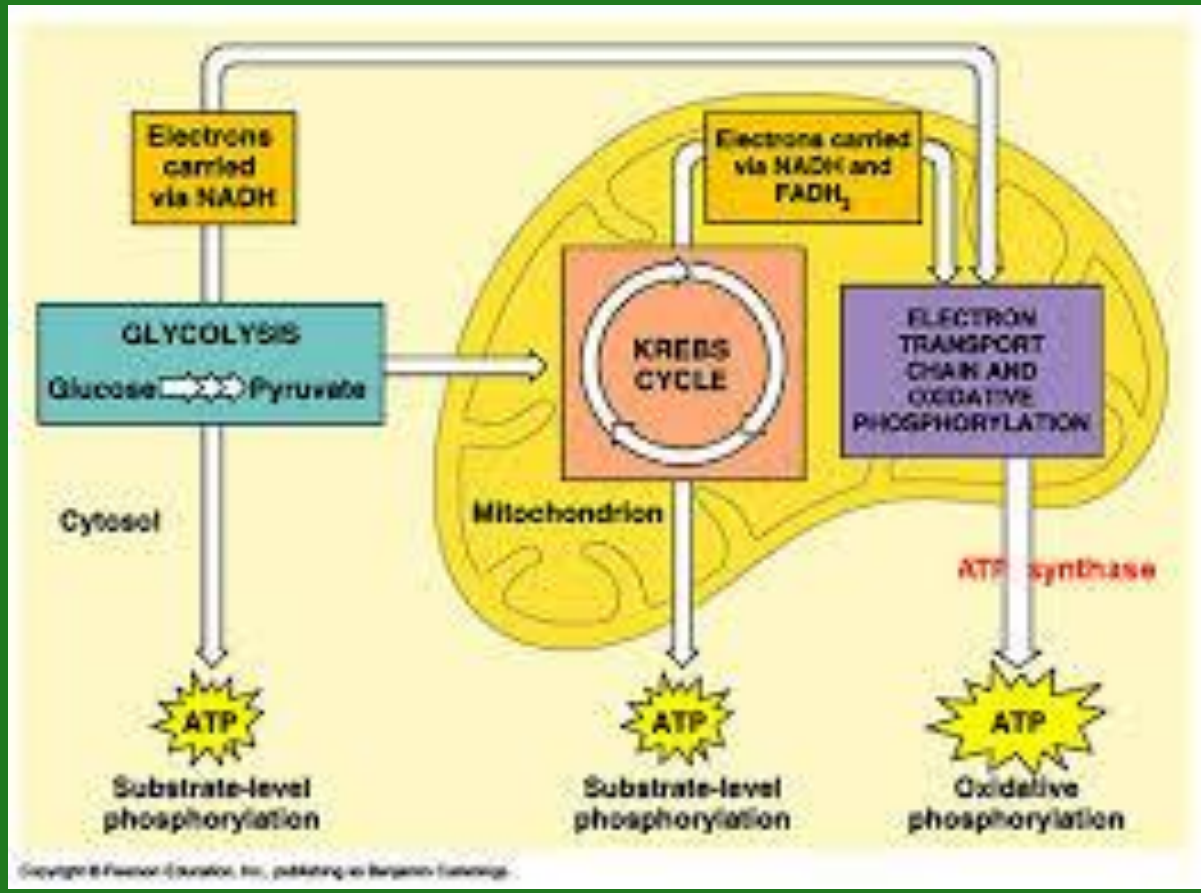
Structures of CR - Review

Glycolysis –takes place in the cytoplasm or cytosol

Kreb Cycle-takes place in the matrix of the mitochondria

ETC-takes place in the mitochondrial inner membrane

Fermentation-takes place in the cytoplasm or cytosol



Step 1 - Glycolysis

Glycolysis- the process by which **1 glucose ($C_6H_{12}O_6$) is broken down** by ½ **making 2 pyruvic acids/pyruvates**

- **Small amounts of ATP made, but it can be produced very quickly**
- **Investment of 2 ATP to produce 4 ATP, so net gain is 2 ATP**

- **Can produce 1000's of ATP per millisecond**

- **Since oxygen is not needed, glycolysis can supply energy to the cells even if no O_2 is present.**

Step 2 in the absence of oxygen - Fermentation

- **Anaerobic means in the absence of oxygen**
- **If there is no oxygen, fermentation follows glycolysis (anaerobic respiration)**
- **fermentation**- the process by which the cell ATTEMPTS to create ATP from pyruvates WITHOUT oxygen (O_2). Fermentation produces 2 ATP.

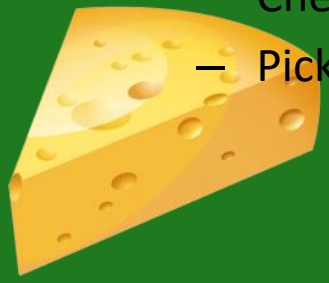
Step 2 in the absence of oxygen - Fermentation

Lactic Acid Fermentation

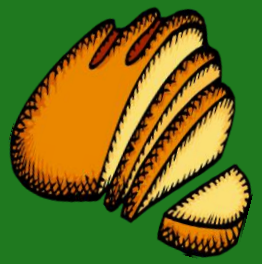
Who does it?

Animal cells and some bacteria

- In these cells it will create a strong burning in the muscles
- Converts pyruvic acid to lactic acid and NAD^+
- **Products**
  - Cheese, yogurt, sour cream,
  - Pickles, sauerkraut



Alcoholic Fermentation



Who does it?

Yeast and single-celled organisms

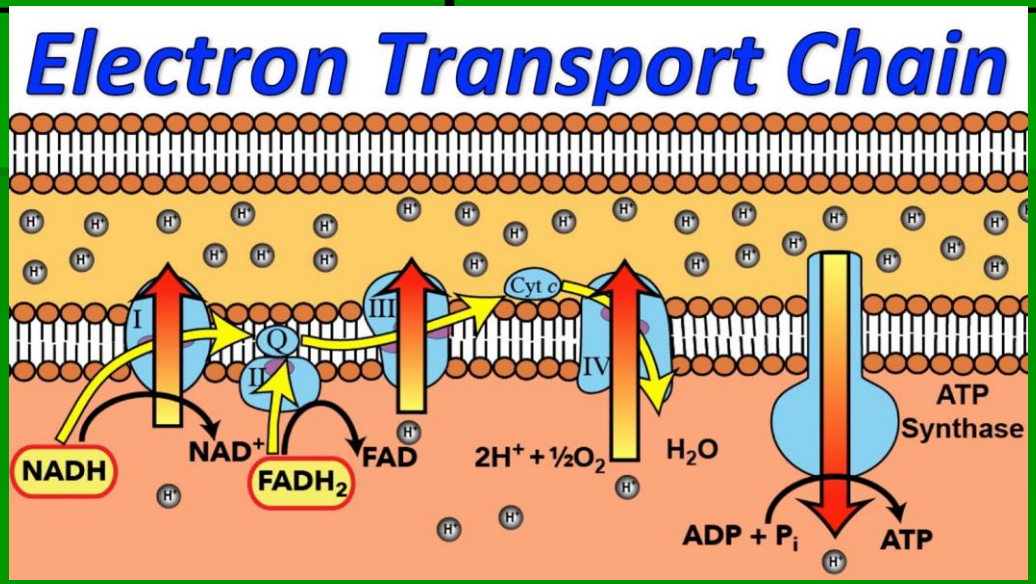
- Will cause bread to rise
- Converts pyruvic acid to ethyl alcohol, CO_2, and H_2O
- **Products**
  - Beers
  - Wines
  - Breads

Step 2 in the presence of oxygen - Krebs cycle

- Aerobic means in the presence of oxygen
- The **Kreb Cycle is Step 2 when O_2 is present** and a place for carrier molecules to drop off their e-'s
- After glycolysis, **90%** of the energy is **still available** in the 2 pyruvates
- **Aerobic respiration-** when oxygen is present for a reaction
- **O_2 is** and is needed to complete aerobic cellular respiration and **get the most ATP possible!!**
- It occurs in the **mitochondrial matrix**
- **Makes 2 ATP**

Step 3 in the presence of oxygen - Electron Transport Chain (ETC)

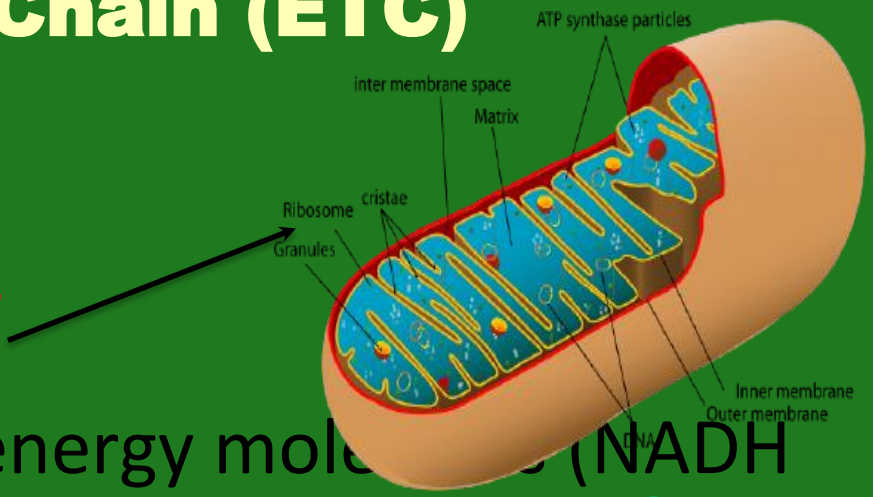
- Electrons are shuffled through the electron transport chain with the help of high energy molecules, such as NADH.
- The electron transport chain makes 34 ATP.



Step 3 in the presence of oxygen - Electron Transport Chain (ETC)

An Overview:

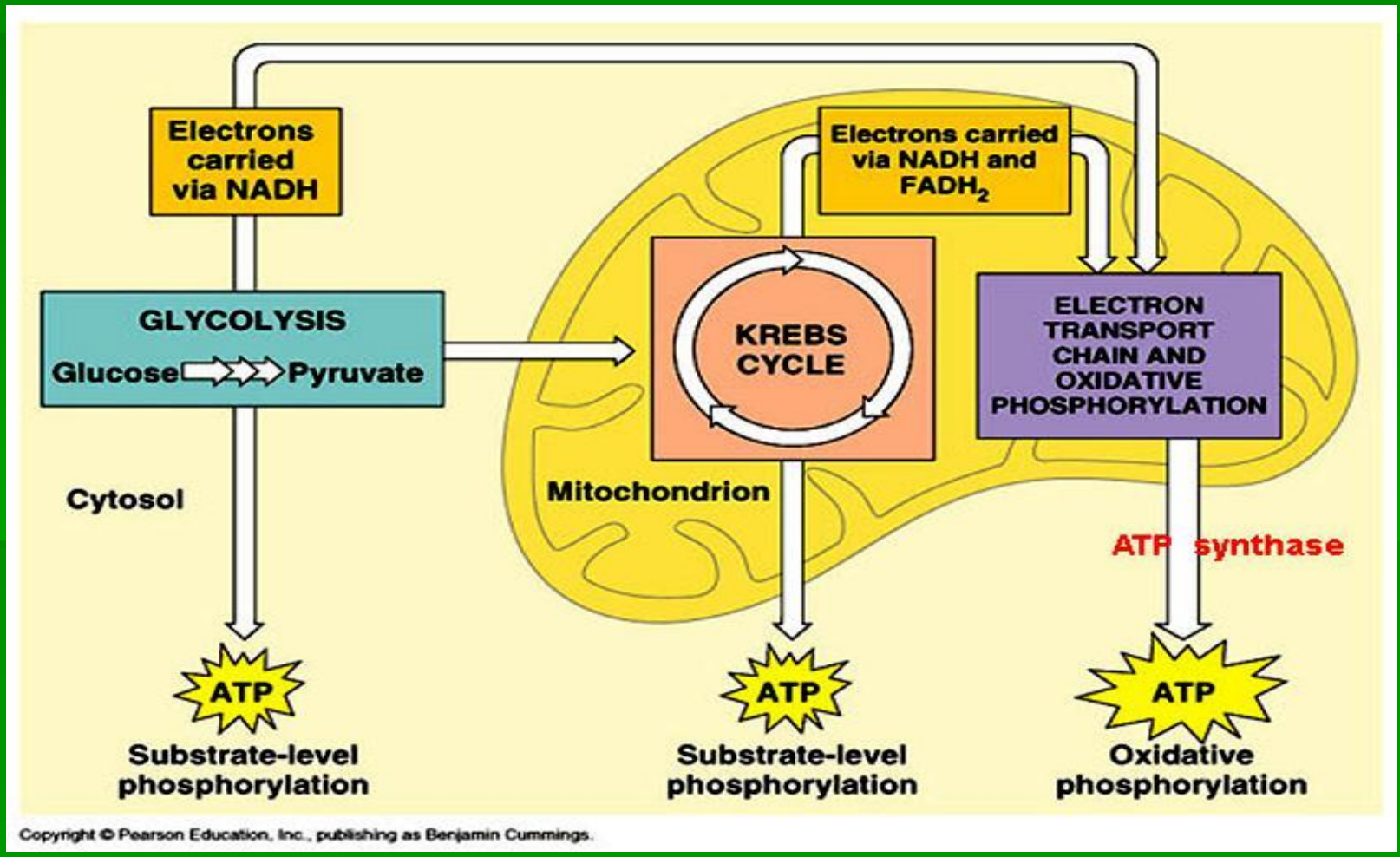
- Takes place in the inner **mitochondrial membrane**



- electrons carried by high energy mole (NADH and $FADH_2$) are passed to **protein carriers in the inner membrane**.

- As electrons are passed down the chain, the **energy from the e-'s** allows the **proteins to pull H^+'s across the inner membrane** to the **inter-membrane space.**

A summary of Aerobic Cellular Respiration



2 ATP

2 ATP