Plant Physiology: by Dr. Manal Zbari

photosynthesis

—the process by which the chlorophyll in the leaves of plants capture light energy which they then use to change carbon dioxide and water into food. This plant food is called glucose.

—and in most plants all this takes place in its leaves.

These are the things a plant needs for photosynthesis-- the process by which a plant makes its own food.

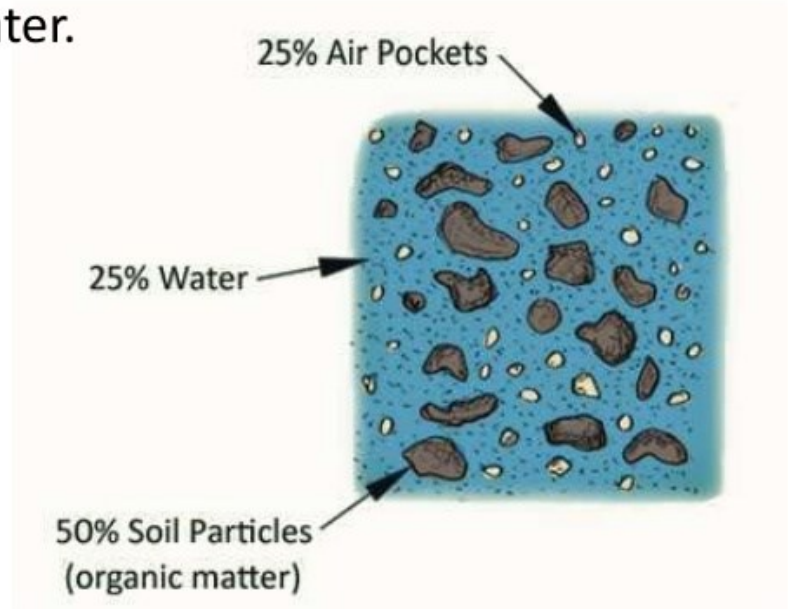
1. water
2. carbon dioxide
3. light energy from the Sun

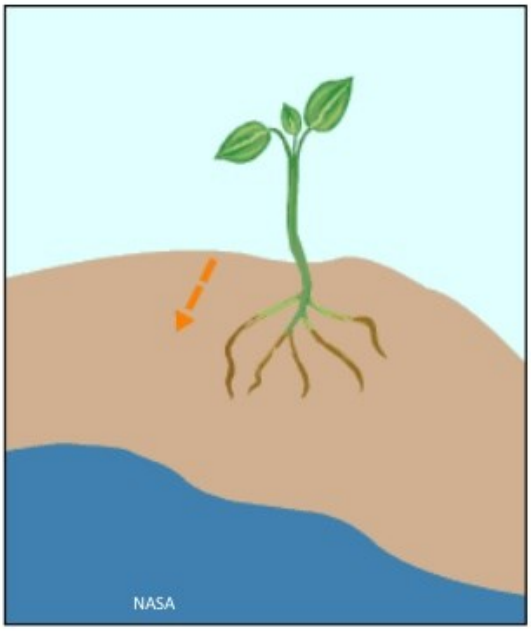
What part of the plant takes in water?

Plants absorb water through their roots.

The water then travels from the roots up the stem to the leaves.

Twenty-percent of soil is made up of water that is stored between the particles of weathered rock. The plant roots absorb this water.





Plants roots grow towards water.

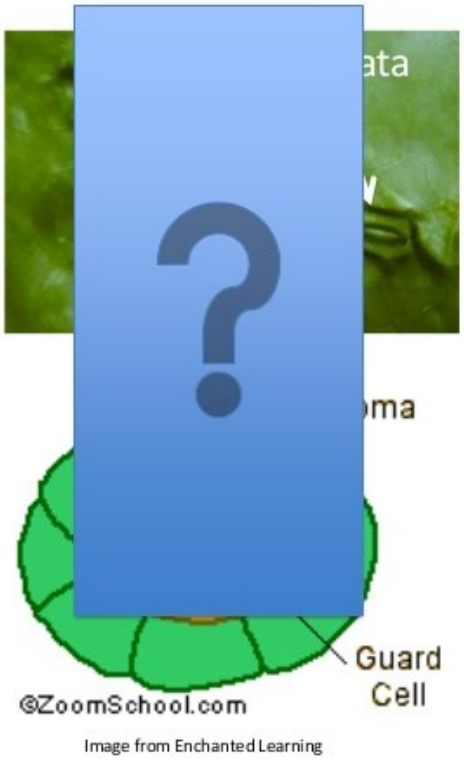
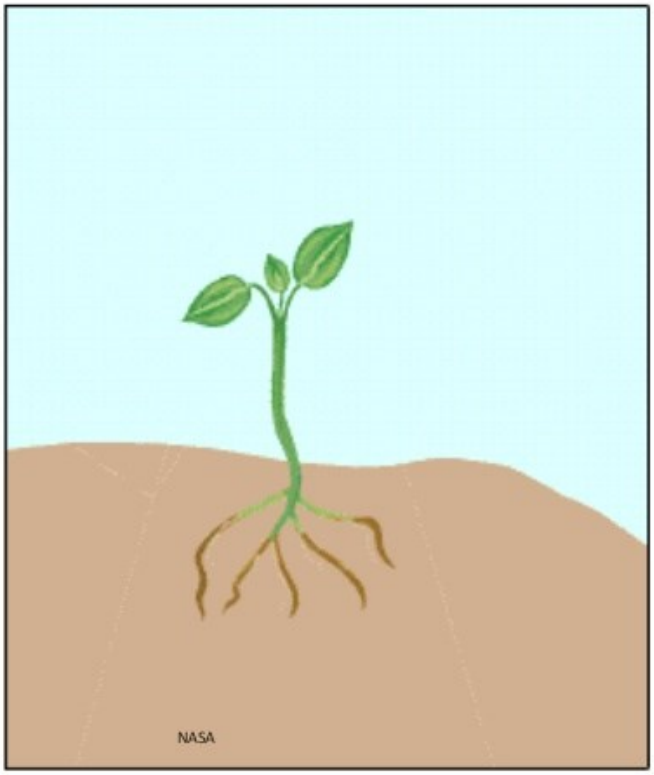


Image from Enchanted Learning

What part of the plant takes in carbon dioxide?

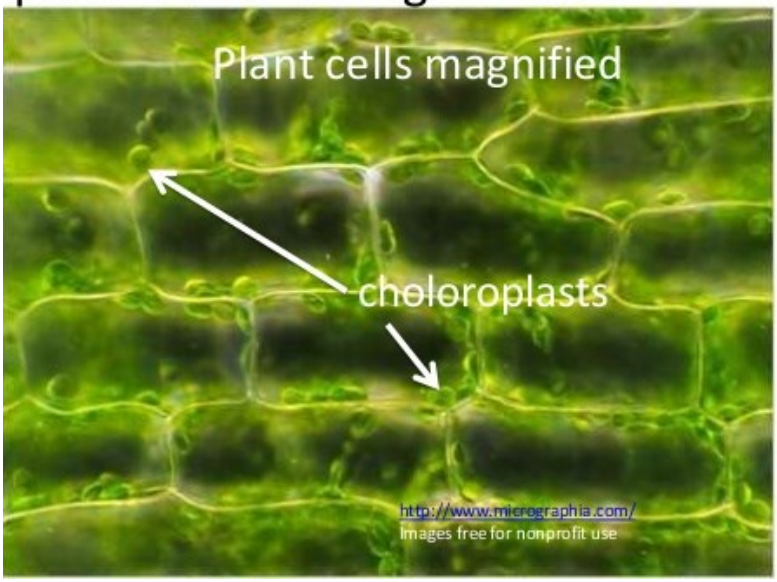
The bottom part of a plant's leaves has holes called **stomata**.

Carbon dioxide enters the leaf through these stomata.



Plant leaves grow towards light .

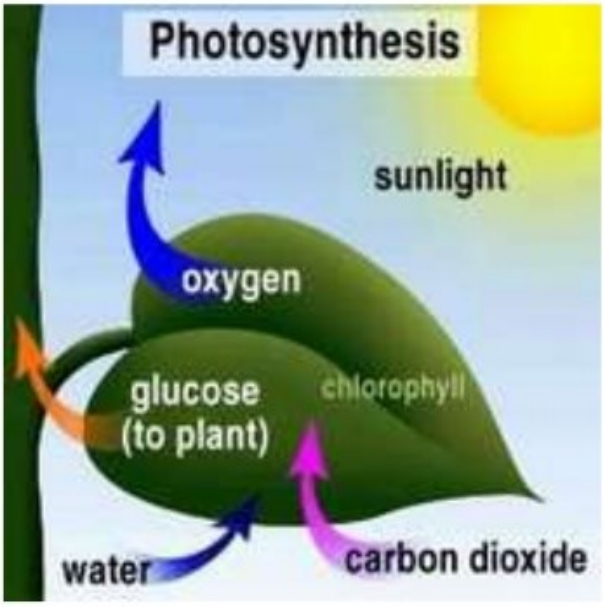
Plant cells have cell structures called **chloroplasts** which contain chlorophyll, a green substance that absorbs light energy. Chlorophyll is what gives plant leaves their green color.



Plants use the light energy from the Sun to change carbon dioxide and water into food.

When plants make food in their leaves, the "waste" product is oxygen—the gas we must breathe in to stay alive.

The plant gives off oxygen through the stomata in its leaves.



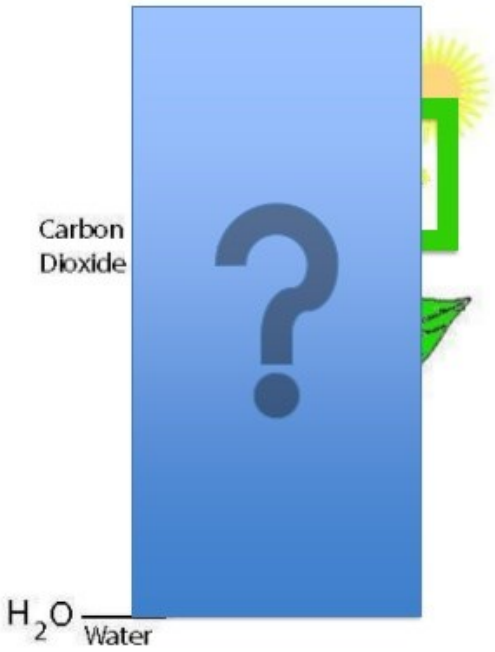
Here is photosynthesis in a nutshell.

Can you explain what is happening?

Do plants need anything else besides water, carbon dioxide and sunlight?

Yes, plants also need 13 different minerals such as
nitrogen, phosphorous, potassium, magne sium, boron.

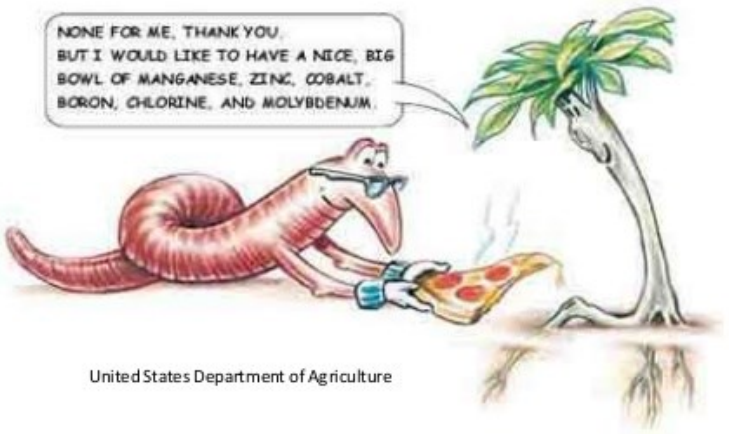
Plants **do not need** these minerals **to make food**. These minerals are important for plant growth , flowering, seed production and general health.



What part of the plant absorbs the light from the Sun?

The green leaves of a plant absorb light energy from the Sun.

The plant uses the light energy to manufacture food from carbon dioxide and water.



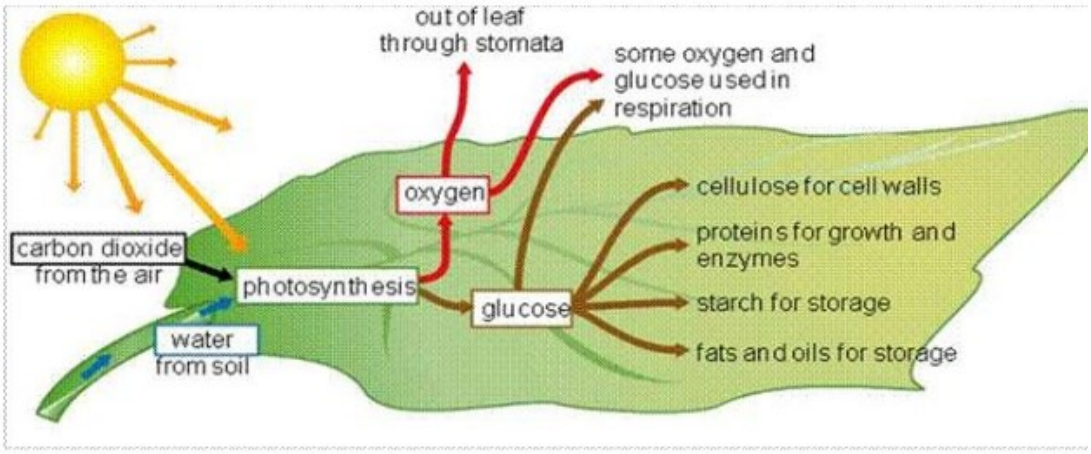
These minerals which come from the soil are dissolved in water and are absorbed through the plant's roots.

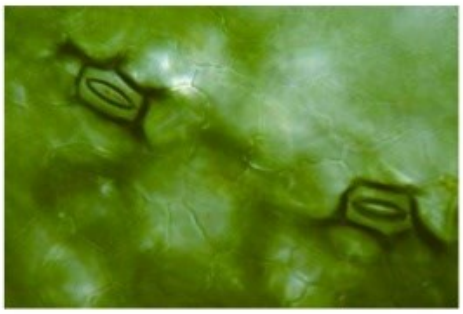
A plant changes some of the glucose it manufactures into substances such as starch, fats, and oils.

It uses these substances for **two things**.

1. For storing food in seeds and roots. Before winter, some plants store starch in their roots so they can survive the winter and start growing again quickly in the spring. Fats and oils are stored in seeds to use for germination.

2. To build plant tissues such as leaves, wood, flowers, fruit and roots.





transpiration

The loss of water vapor through the stomata.

Transpiration mainly takes place when the stomata on the bottom of the leaf are open to let carbon dioxide in or oxygen out during the process of photosynthesis.

The picture below shows condensed water vapor given off from the leaves of the plant. When the water vapor hits the cool sides of the plastic bag it condensed and changed into droplets of liquid water.

Credit: Ming kei College, Hong Kong
http://ga.water.usgs.gov/

The picture below shows condensed water vapor given off from the leaves of the plant. When the water vapor hits the cool sides of the plastic bag it condensed and changed into droplets of liquid water.

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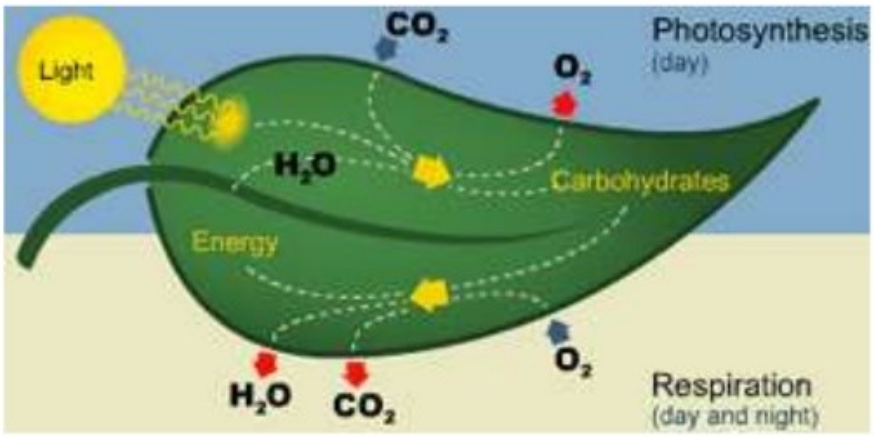
As usual, things are not as simple as it may seem.

Plants do not make food for animals. They make it for themselves so that they can grow and carry out their life processes.

Like animals they need to absorb oxygen. Plants take oxygen in through the stomata and through their roots and use it to burn their food for energy.

The process of using oxygen to burn food for energy is called **respiration.**



http://ecosys.cfl.scf.rncan.gc.ca/
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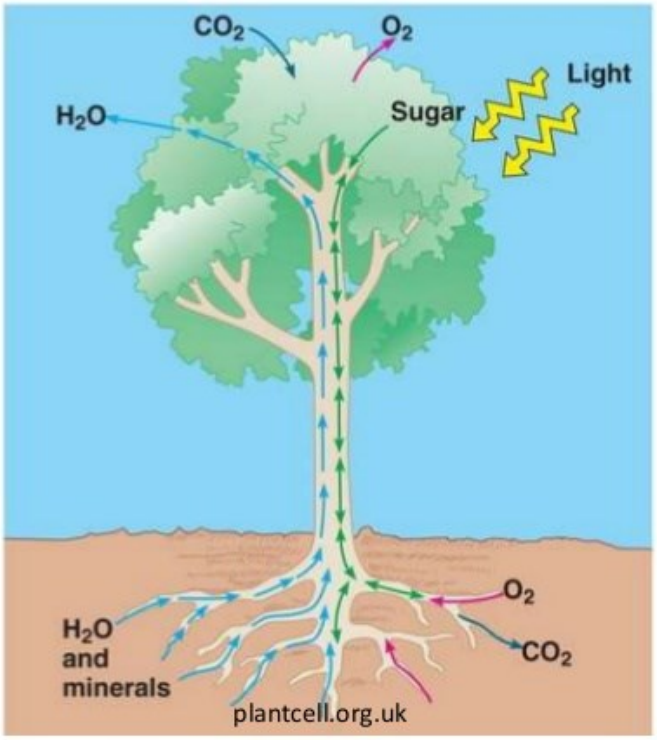
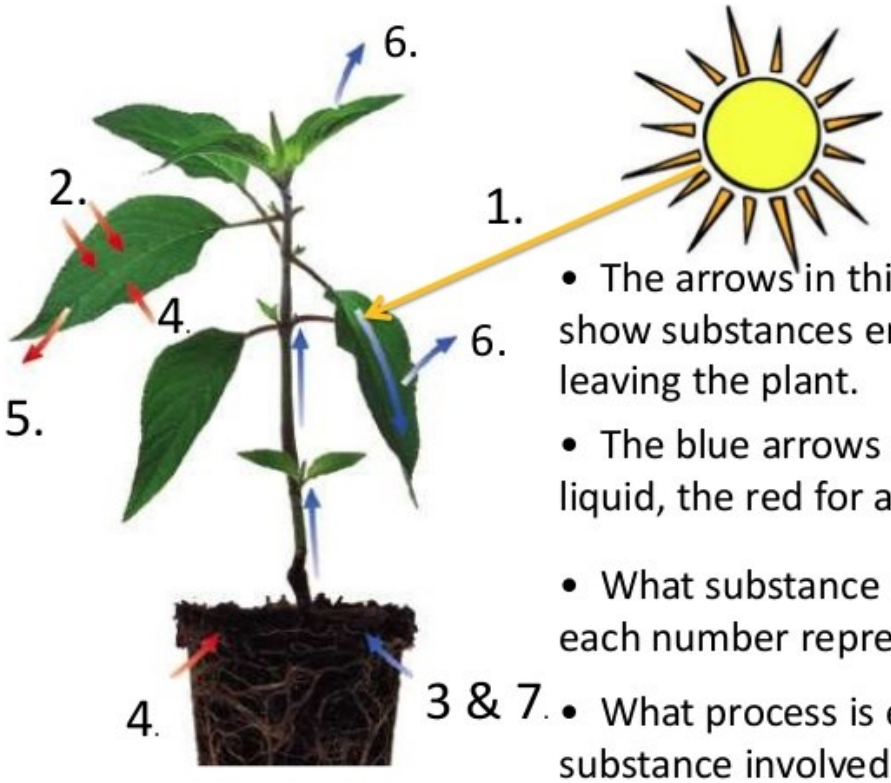
Here we can see the two processes—photosynthesis and respiration occurring in a leaf.

Comparison of Photosynthesis & Respiration

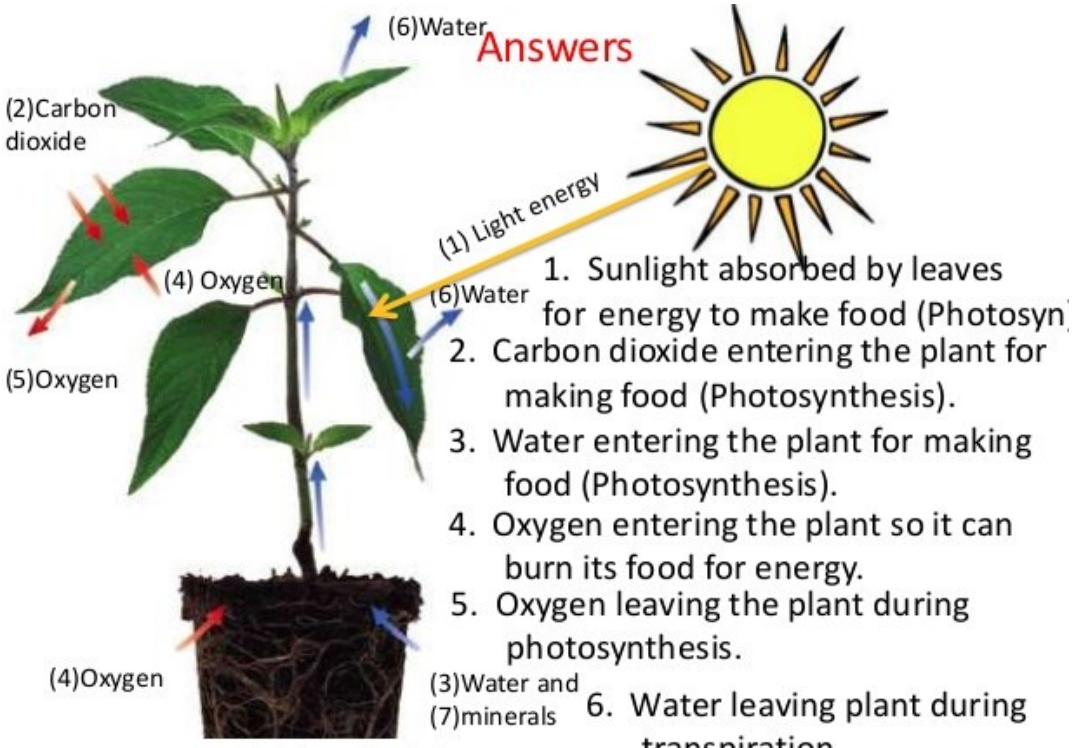
Photosynthesis	**Respiration**
Produces sugars from energy	Burns sugars for energy
Energy is stored	Energy is released
Occurs only in cells with chloroplasts (plants)	Occurs in most cells
Oxygen is produced	Oxygen is used
Water is used	Water is produced
Carbon dioxide is used	Carbon dioxide produced
Requires light	Occurs in both dark and light



Look at this drawing and explain what is happening.



- The arrows in this diagram show substances entering and leaving the plant.
- The blue arrows stand for a liquid, the red for a gas.
- What substance does each number represent?
- What process is each substance involved in?



1. Sunlight absorbed by leaves for energy to make food (Photosyn
2. Carbon dioxide entering the plant for making food (Photosynthesis).
3. Water entering the plant for making food (Photosynthesis).
4. Oxygen entering the plant so it can burn its food for energy.
5. Oxygen leaving the plant during photosynthesis.
6. Water leaving plant during transpiration.
7. Minerals absorbed for growth and reproduction

What important thing can plants do that animals cannot?

a. move from place to place
b. survive with very little water
c. make their own food
d. grow

The process by which plants make their own food is called

a. photosynthesis
b. respiration
c. reproduction
d. transpiration

Plants use the following substances to make their food:

a. carbon dioxide and oxygen
b. oxygen and water
c. water and carbon dioxide
d. water and nitrogen

Plant Physiology (5) by Dr. Manal Zbari

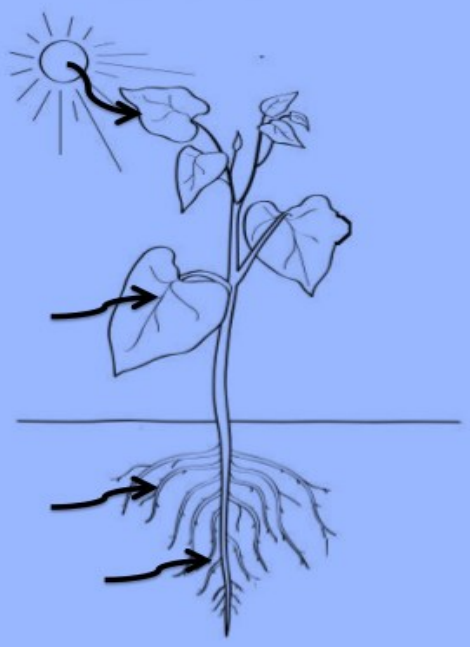
What do plants need?

A. Sunlight

B. Carbon dioxide

C. water

D. Oxygen and Minerals

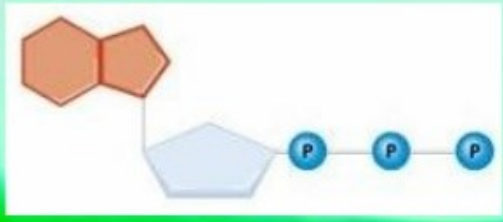


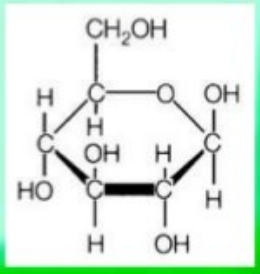
The Light Reactions

- Almost all of the energy in living systems comes from the sun.
- Sunlight energy enters living systems when plants and some other organisms absorb light in the process of photosynthesis.

The Light Reactions

- During photosynthesis, light energy from the sun is converted into chemical energy in the form of molecules such as ATP and glucose.



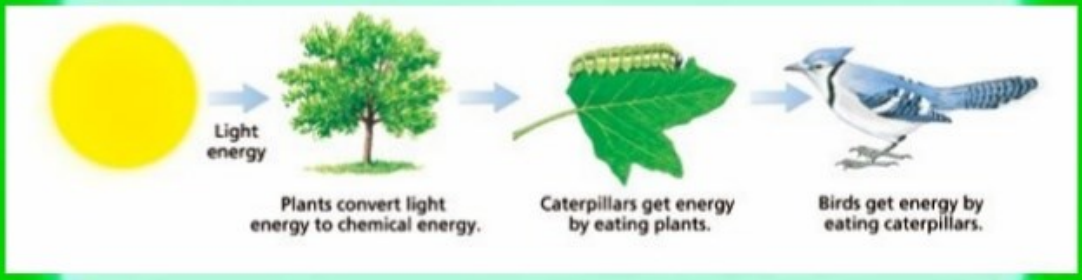


Obtaining Energy

- Organisms can be classified according to how they get energy.
- Those that obtain their energy from the sun are called autotrophs.
  - Some examples include plants, algae, and some bacteria.

- Organisms that obtain their energy from the foods they consume are called heterotrophs.
  - Some examples include animals, fungi, and some bacteria.

Obtaining Energy



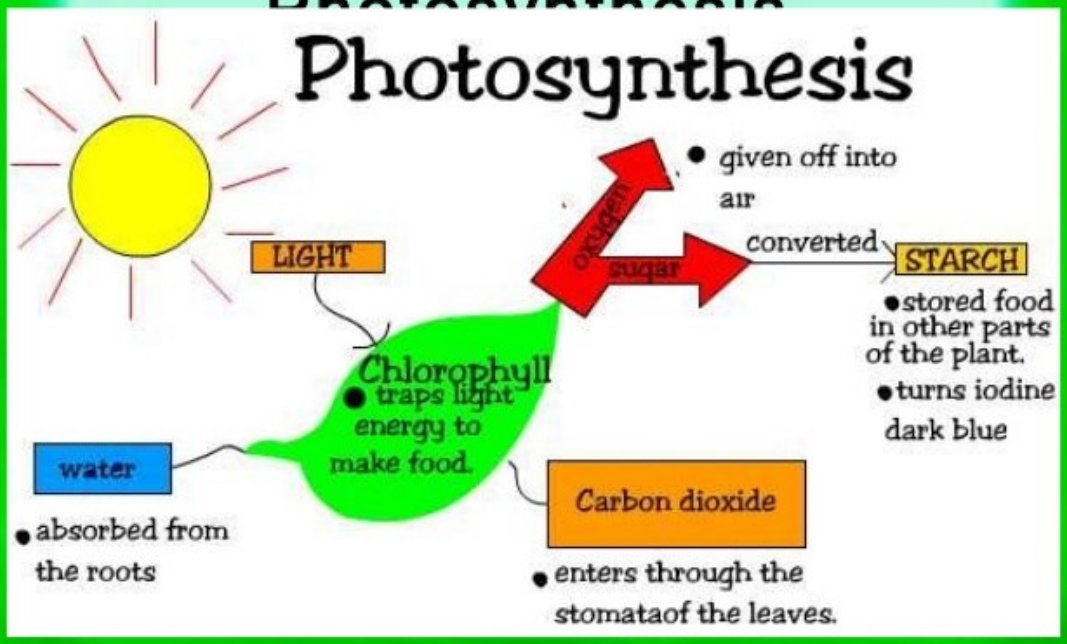
Overview of Photosynthesis

- Photosynthesis involves the use of light energy to <u>convert</u> water (H_20) and carbon dioxide (CO_2) into oxygen (O_2) and high energy <u>sugars</u> (e.g. Glucose).

Overview of Photosynthesis

- Photosynthesis can be divided into 2 stages:
  - **Light Reactions** – Light energy is converted to chemical energy, which is temporarily stored in ATP and NADPH.
  - **Calvin Cycle** – Sugars are formed using CO_2 and the chemical energy stored in ATP and NADPH.

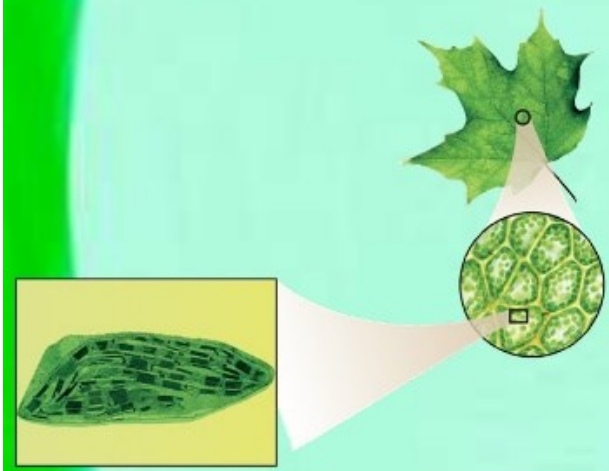
Overview of



Capturing Light Energy

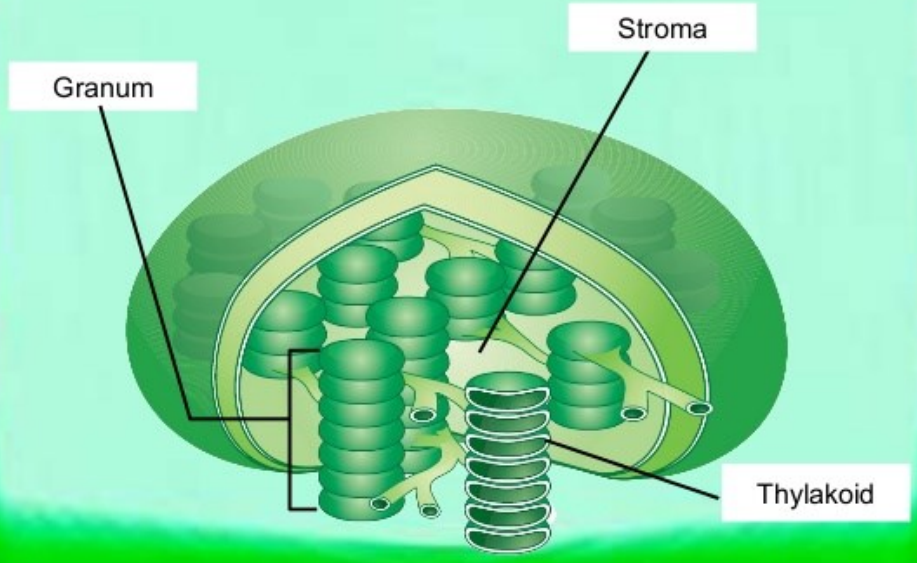
- In addition to water, carbon dioxide, and light energy, photosynthesis requires pigments.
- Chlorophyll is the primary light-absorbing pigment in autotrophs.
- Chlorophyll is found inside chloroplasts.

Parts of the Chloroplast



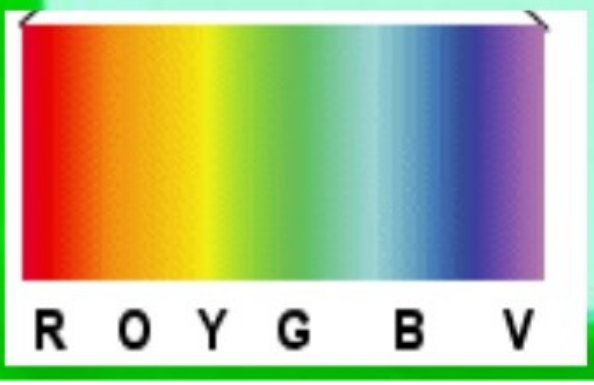
- Chloroplasts – organelles found in the cells of plants and algae
- Thylakoids – membranes arranged as flattened sacs
- Grana – stacks of thylakoids
- Stroma – solution surrounding the grana

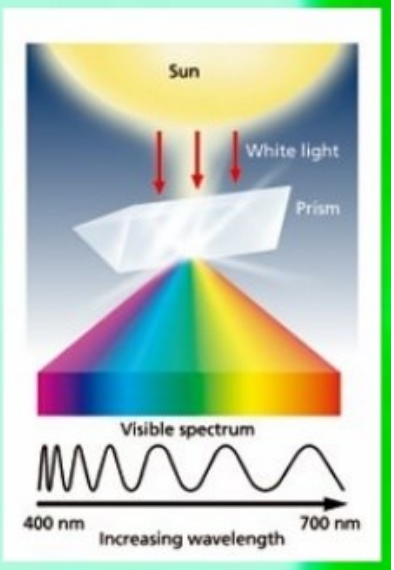
Parts of the Chloroplast



Light and Pigments

- Light from the sun appears white, but it is made of a variety of <u>colors</u> called the <u>visible light spectrum</u>.





Light and Pigments

- Pigments are compounds that absorb light.
- Many objects contain pigments that absorb some colors of light and reflect others.
- The colors that are reflected are the ones you see.

Chloroplast Pigments

- There are several pigments in the thylakoid membranes.
  - Most important are chlorophylls.
    - Chlorophyll *a* absorbs mostly red and violet light and reflects mostly green light.
  - Accessory pigments
    - Chlorophyll *b* assists chlorophyll *a* in capturing light energy. It absorbs mostly blue light, as well as, some violet and orange light and reflects mostly green and yellow light.
    - Carotenoids absorb blue and green light and reflect yellow, orange, and red light.

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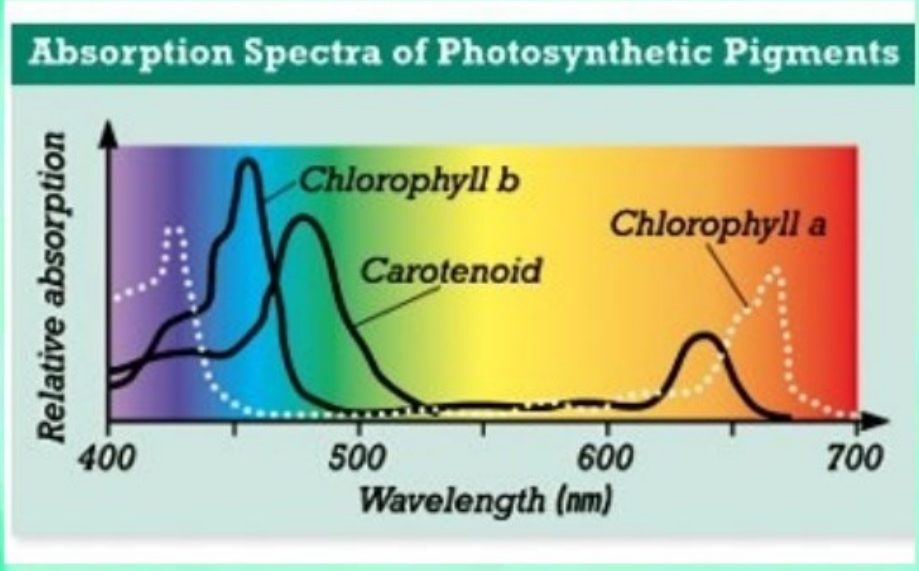
Chloroplast Pigments



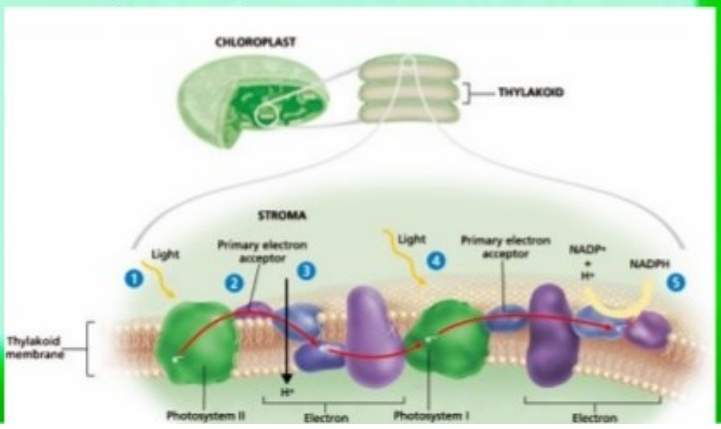
- Spectrum of Light and Plant Pigments

Chloroplast Pigments

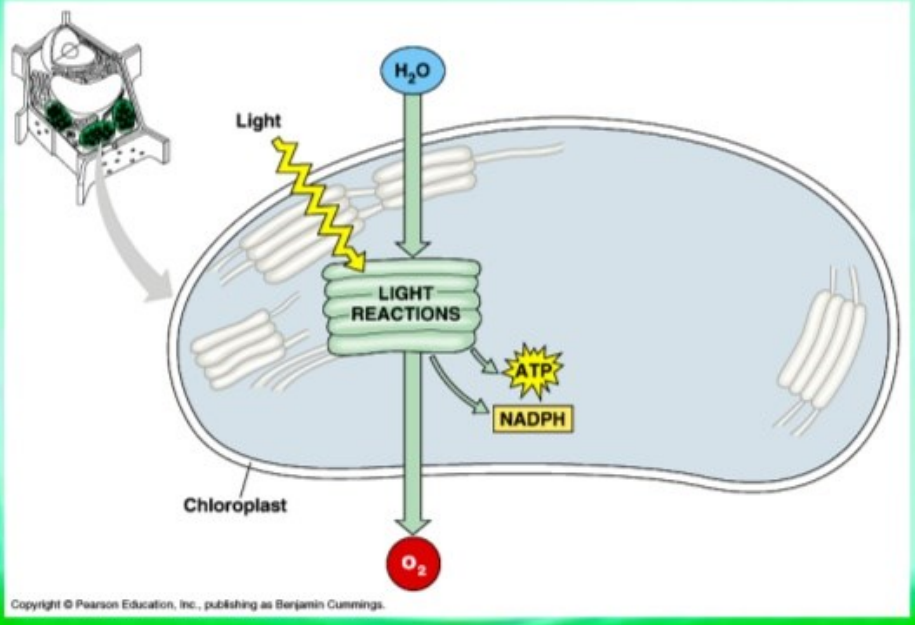
- In plant leaves, chlorophylls are the most abundant pigments and therefore mask the colors of the other pigments.
- During the fall, many plants lose their chlorophylls, and their leaves become the color of the carotenoids.

Light Reactions

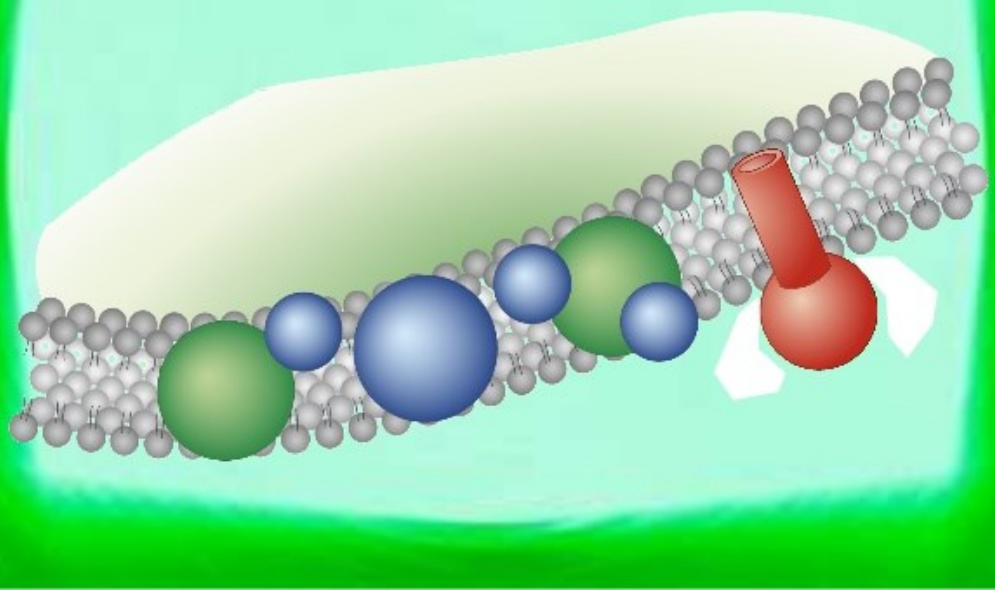
- The first stage of photosynthesis.
- Take place within the thylakoid membranes of chloroplasts.
- Require light energy to happen and are also referred to as the light-dependent reactions.



Light Reactions

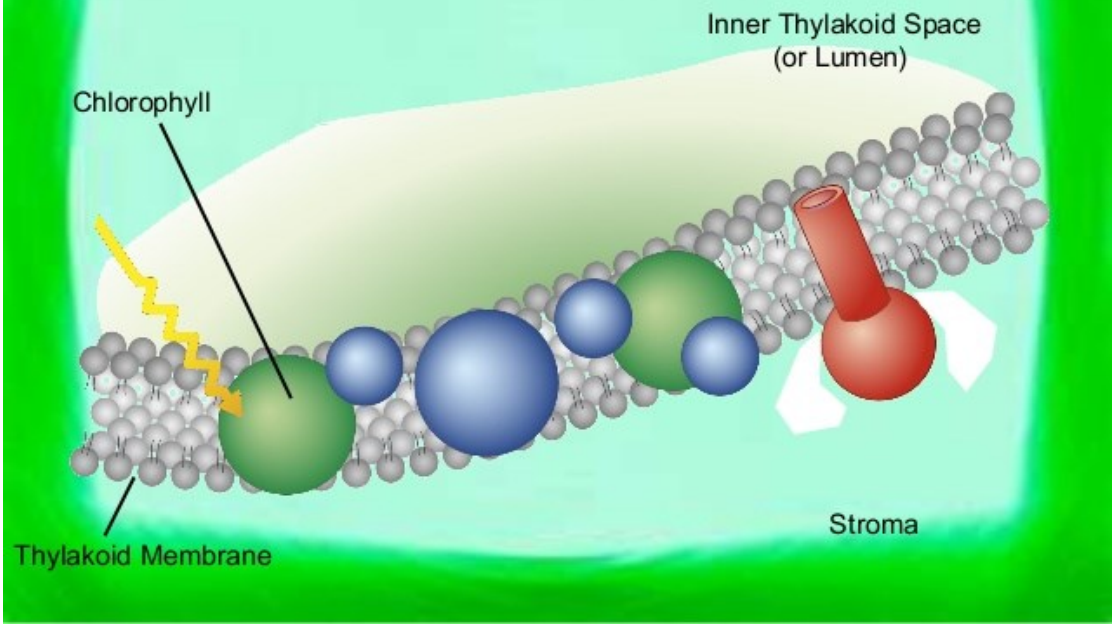


Light Reactions



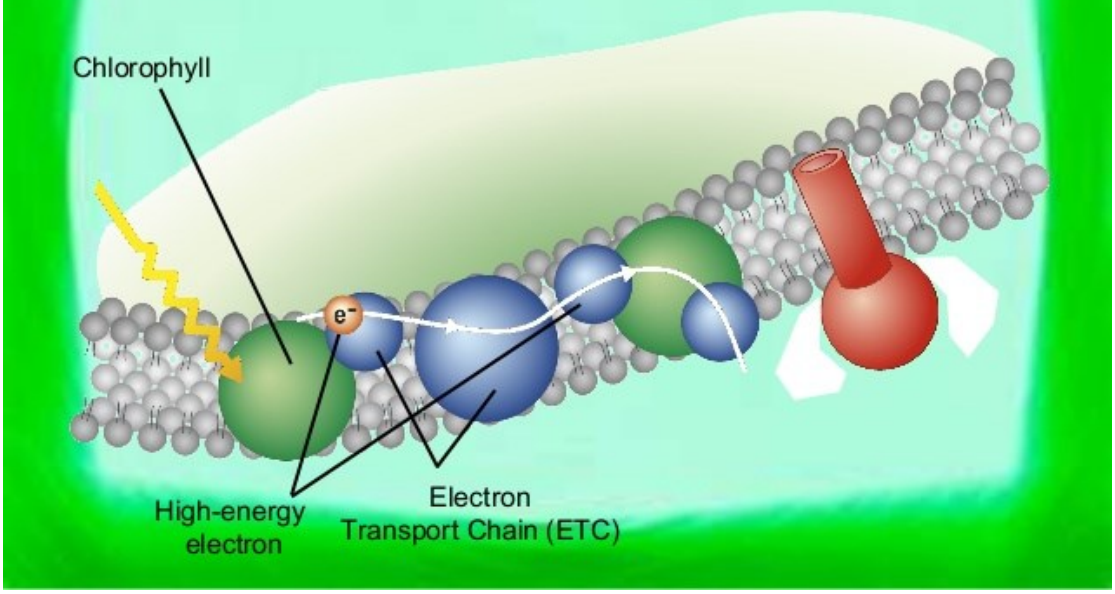
Light Reactions

• Photosynthesis begins when chlorophyll pigments absorb light and pass it on to electrons.



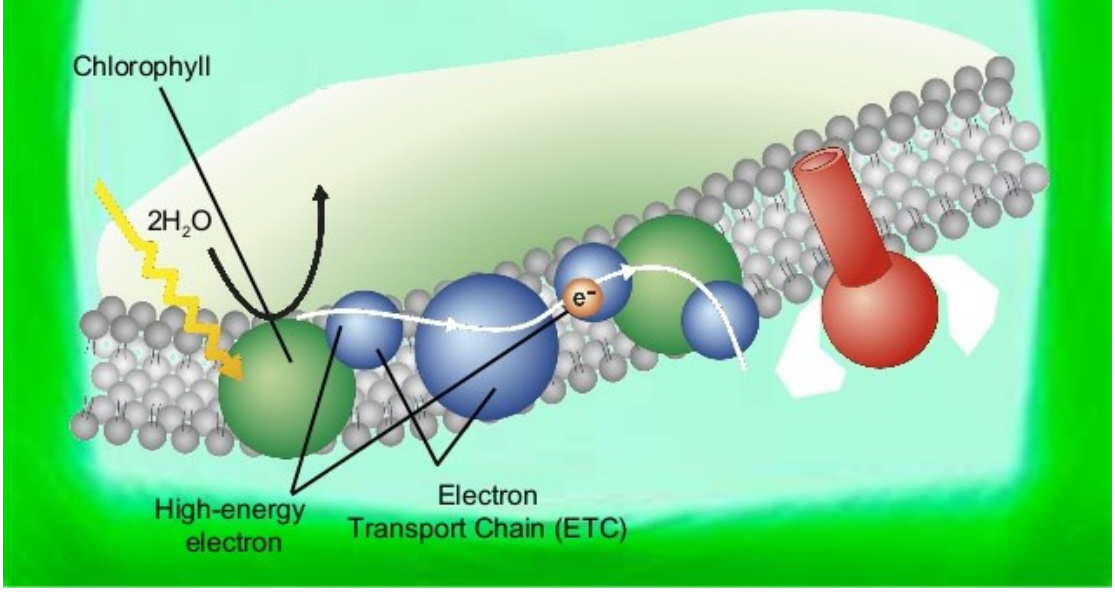
Light Reactions

• These high-energy electrons are passed on to the electron transport chain (ETC).



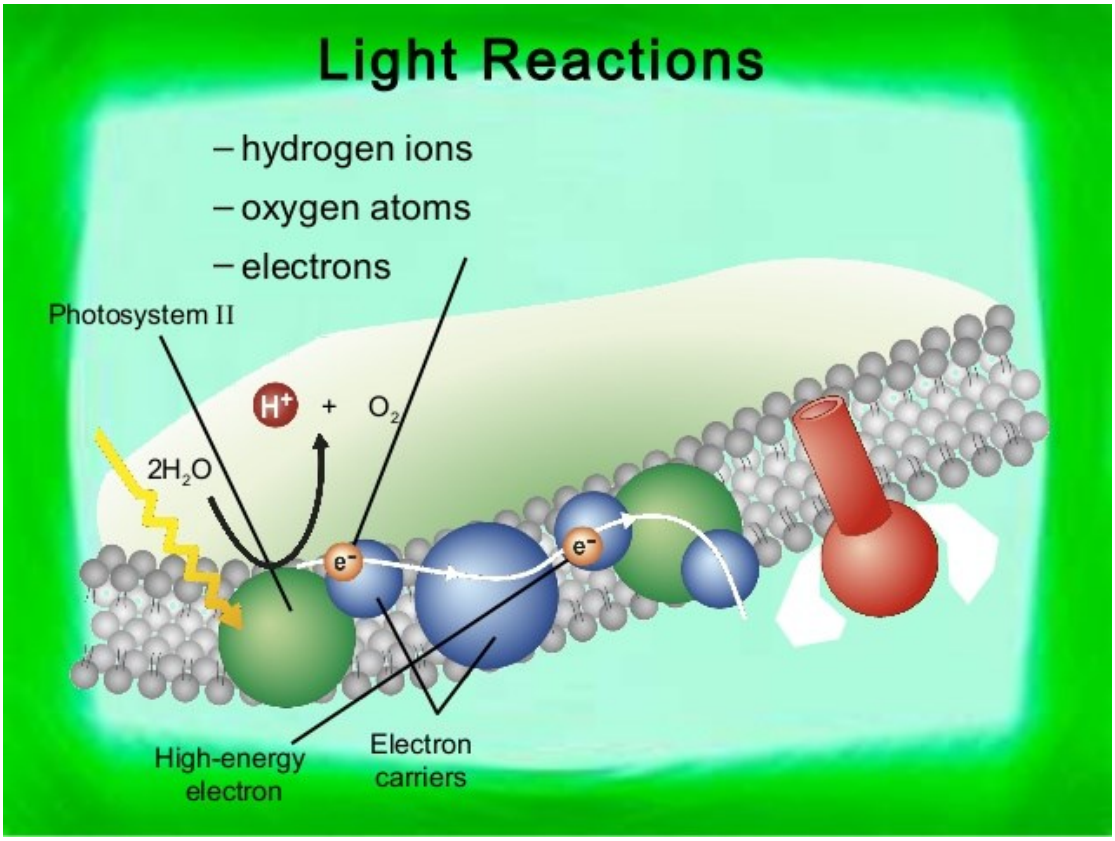
Light Reactions

• Enzymes in the thylakoid membrane break water molecules into:



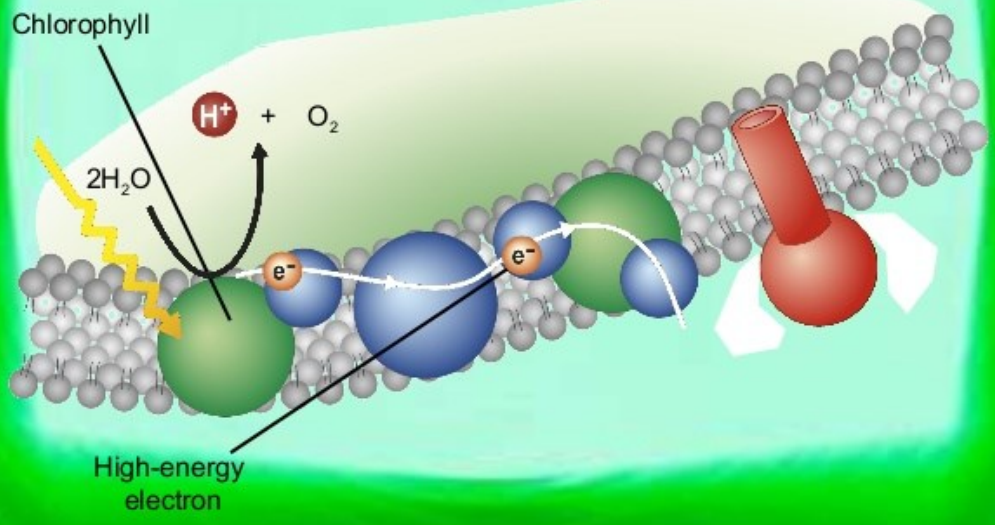
Light Reactions

– hydrogen ions
– oxygen atoms
– electrons



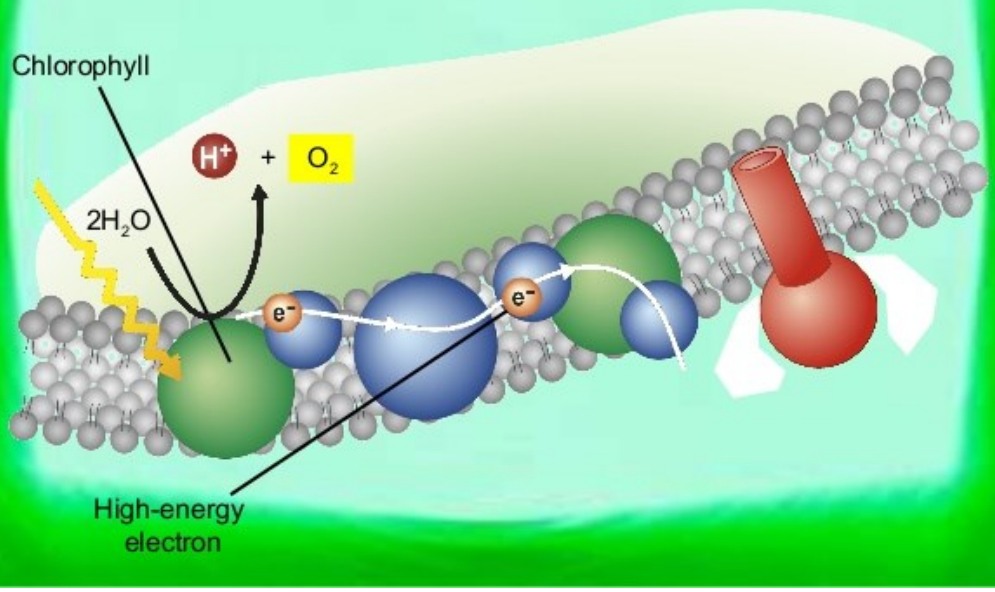
Light Reactions

• The hydrogen ions are released into the inner thylakoid space (or lumen).



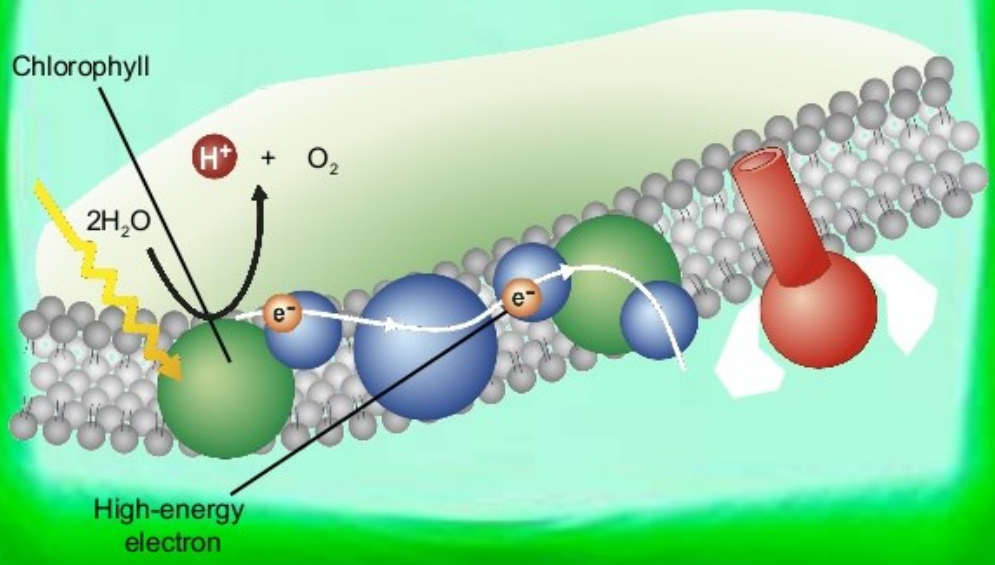
Light Reactions

• Oxygen is left behind and is released into the air.



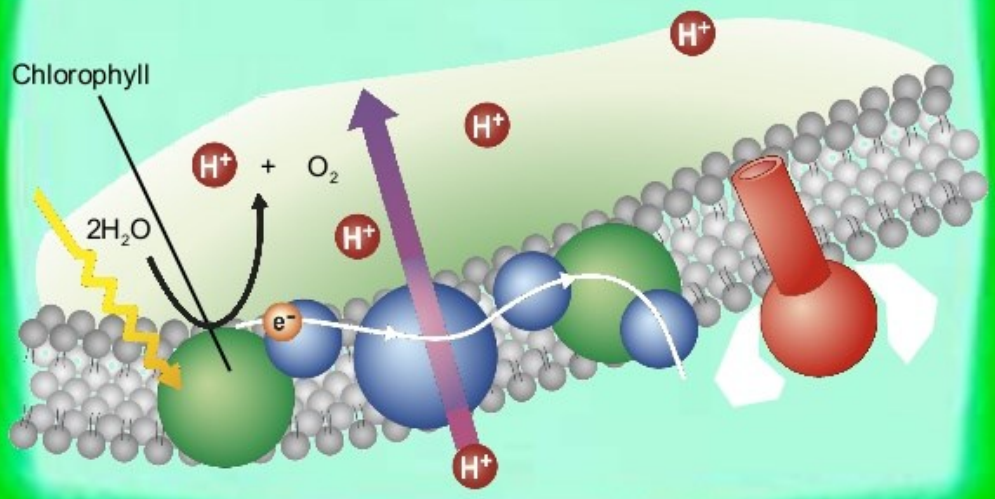
Light Reactions

• The electrons from water replace the electrons that were already energized by chlorophyll.



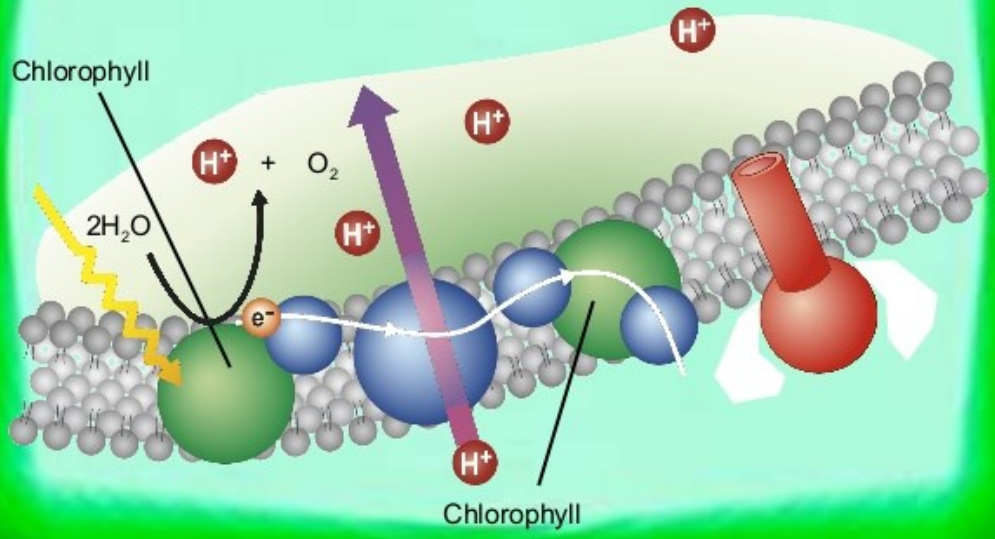
Light Reactions

• Energy from the electrons is used to transport H^+ ions from the stroma into the inner thylakoid space (or lumen).



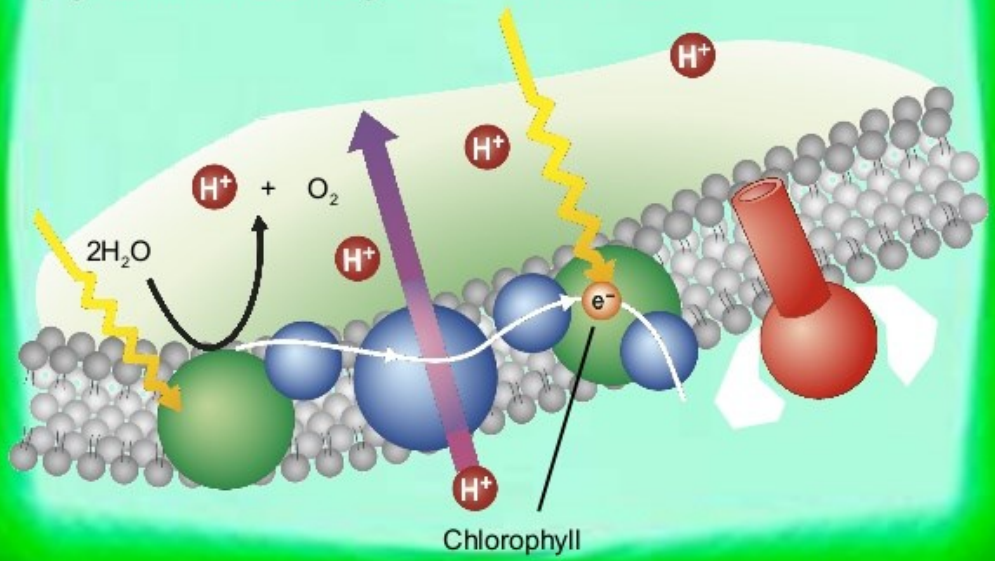
Light Reactions

- High-energy electrons move through the electron transport to a second group of chlorophyll pigments.



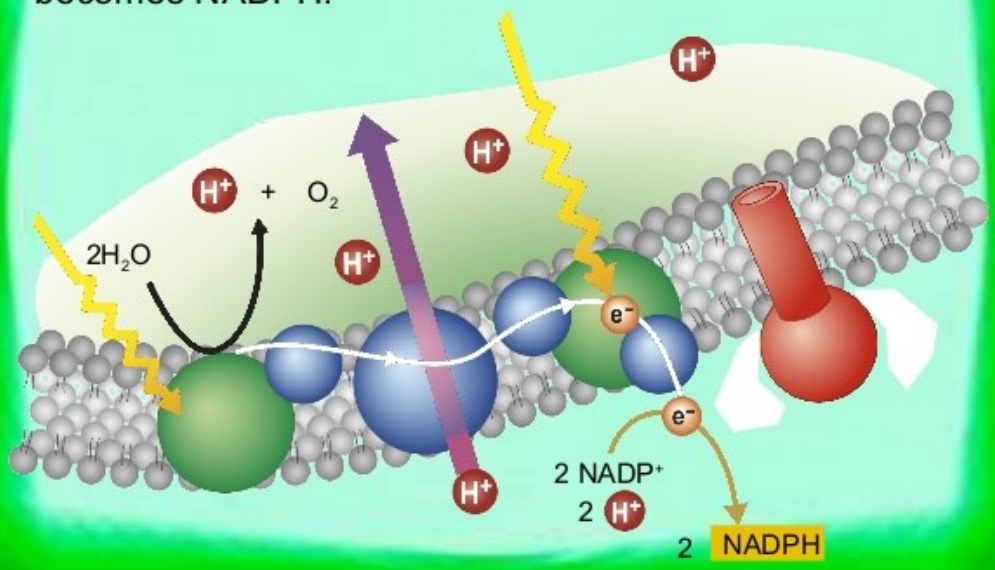
Light Reactions

- Light strikes this second group of chlorophyll pigments to re-energize the electrons.

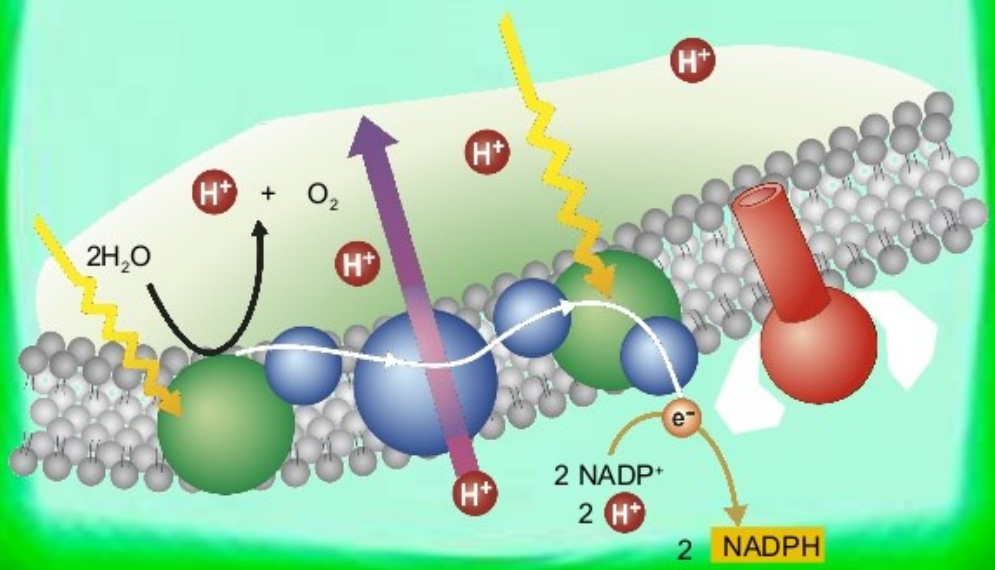


Light Reactions

• $NADP^+$ then picks up these high-energy electrons and becomes NADPH.

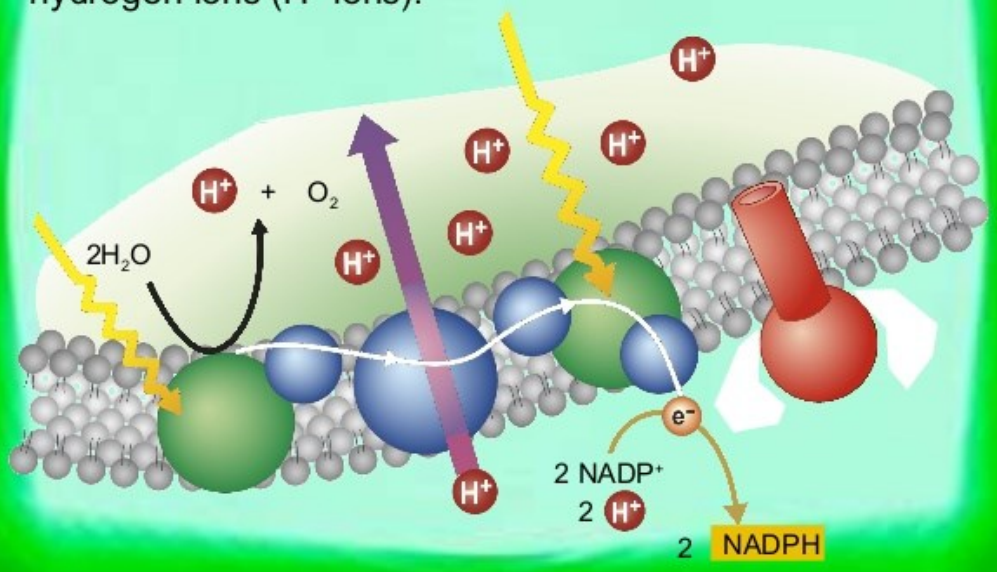


Light Reactions



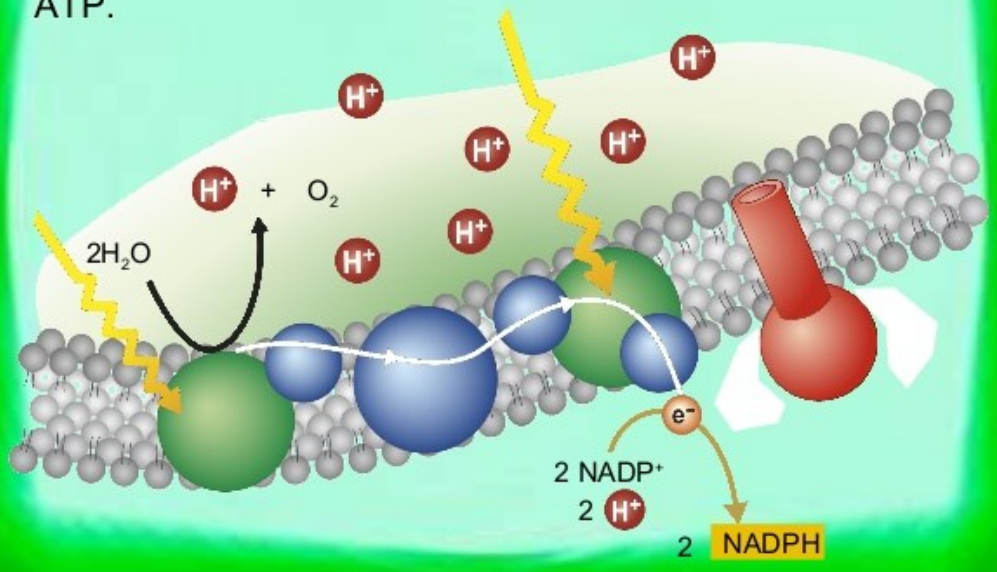
Light Reactions

• Soon, the inner thylakoid space (or lumen) is filled with hydrogen ions (H^+ ions).



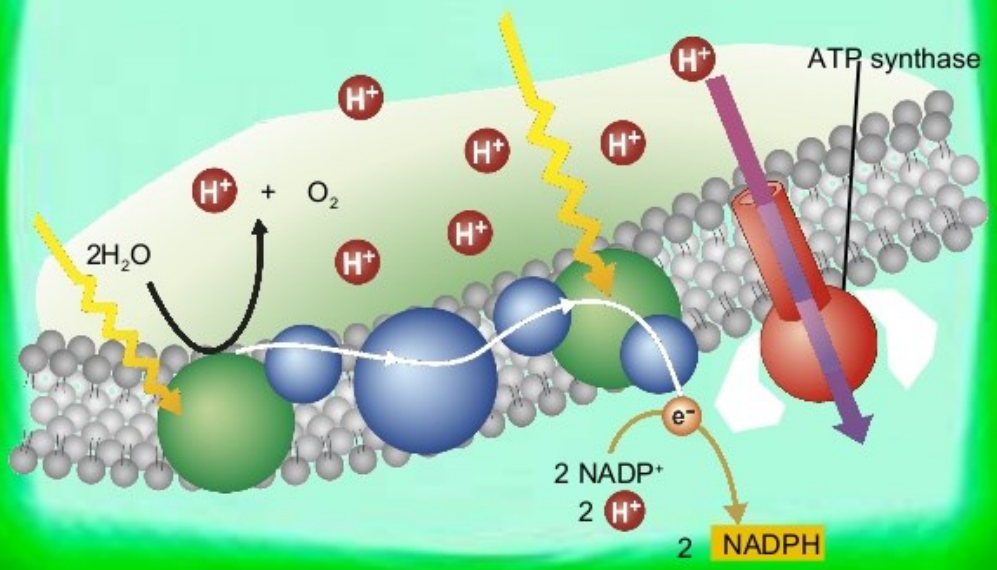
Light Reactions

• The build-up of H^+ ions provides the <u>energy</u> to make ATP.



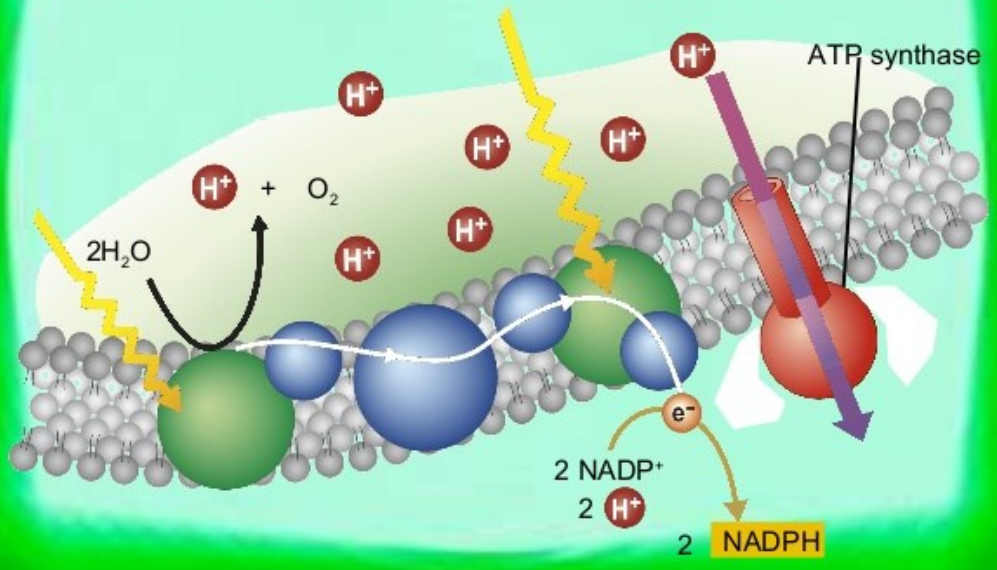
Light Reactions

- H^+ ions cannot cross the membrane directly.



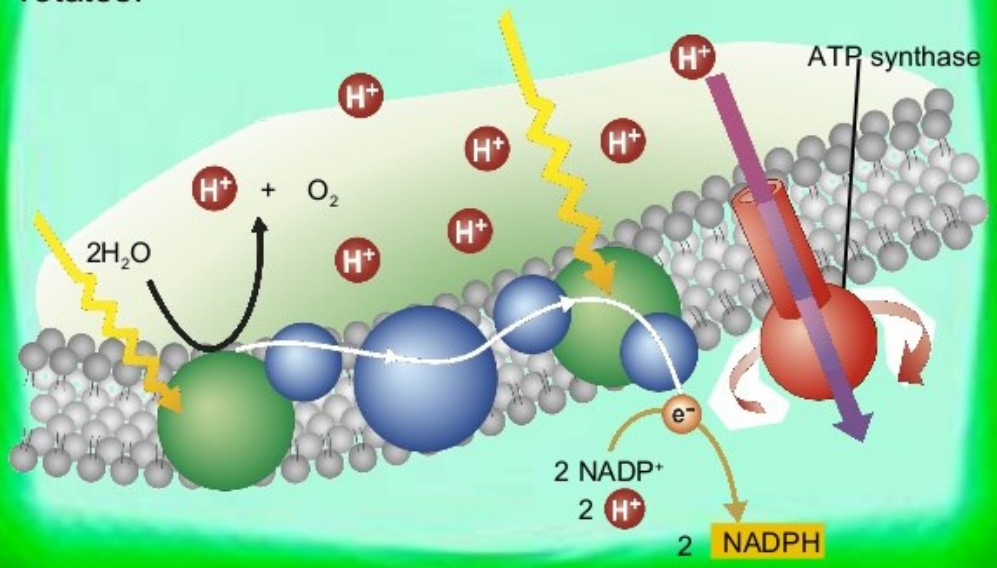
Light Reactions

- The thylakoid membrane contains an enzyme called ATP synthase that allows H^+ ions to pass through it.



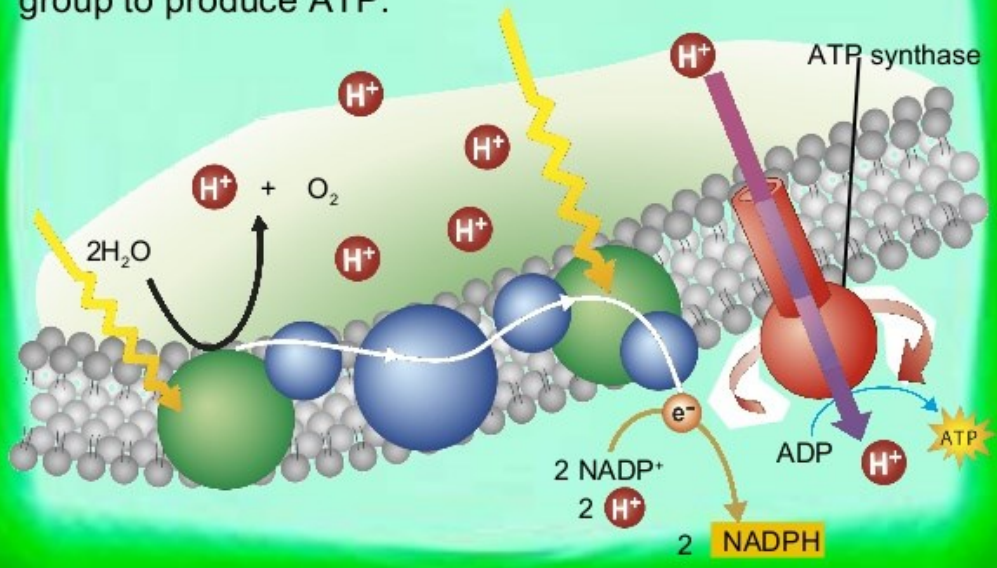
Light Reactions

• As H^+ ions pass through ATP synthase, the protein rotates.



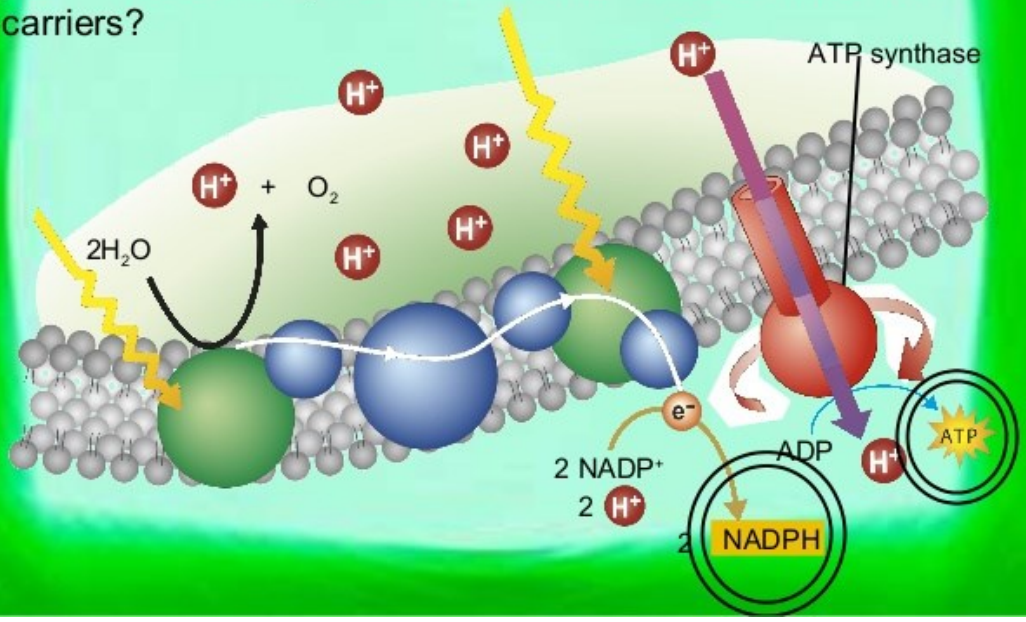
Light Reactions

• As it rotates, ATP synthase connects ADP and a phosphate group to produce ATP.



Light Reactions

• At the end of the light reactions, two energy carriers go on to power the Calvin cycle. What are the names of these two carriers?



Light Reactions