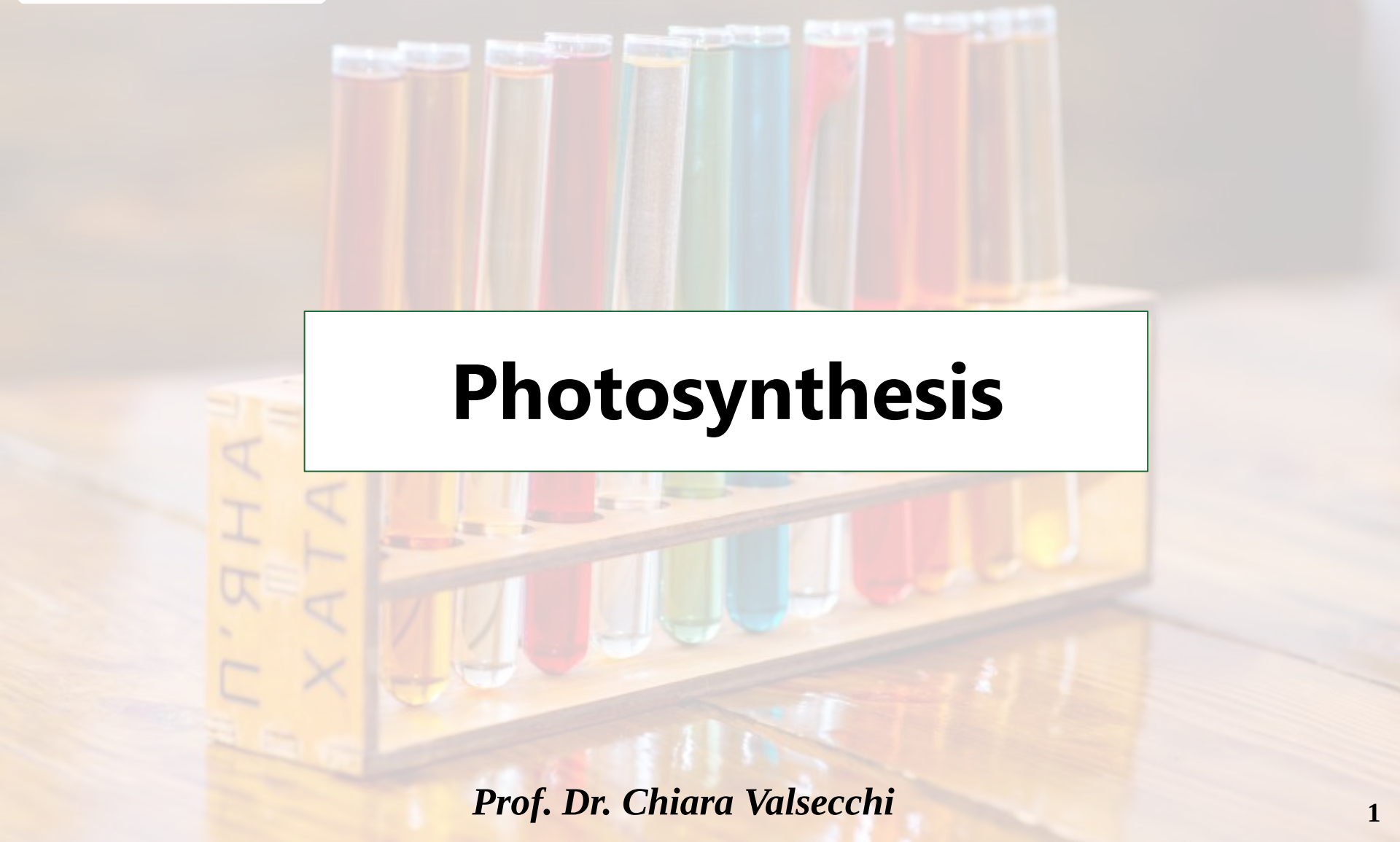


Photosynthesis

Prof. Dr. Chiara Valsecchi

Class Goals

- Understand how energy is produce inside the plant cells.

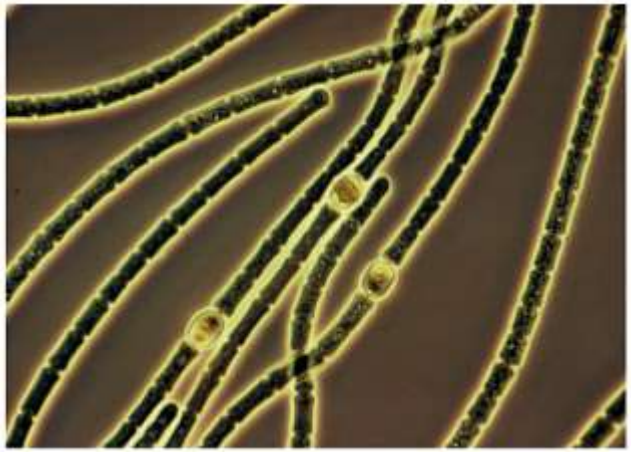
Autotrophs

- Autotrophs organism: generate their own organic matter through photosynthesis
  - Sunlight energy is stored in the form of chemical bonds

(a) Mosses, ferns, and *flowering plants*

(b) Kelp

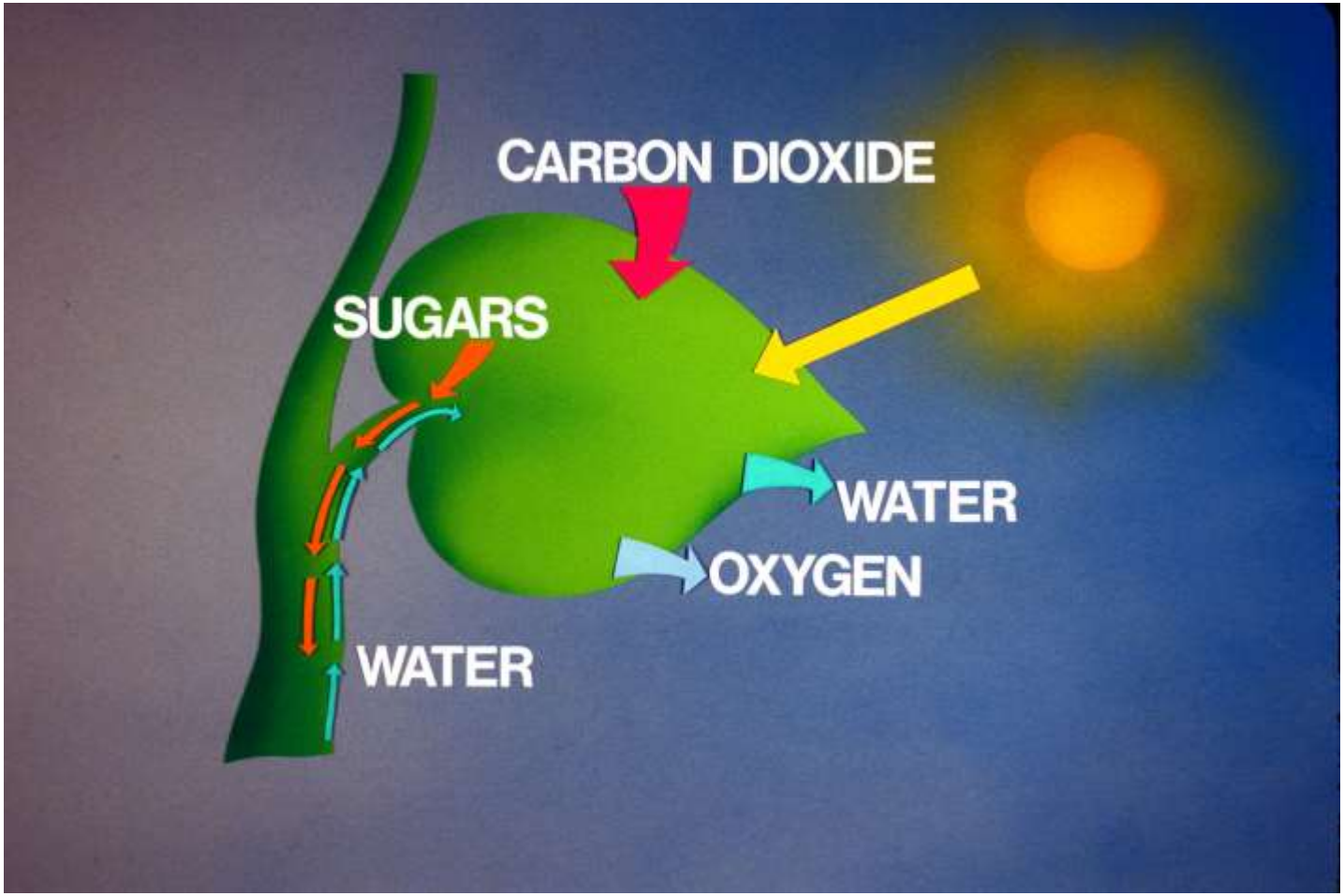
(c) *Euglena*



(d) Cyanobacteria

Plants, algae and some bacteria

Autotrophs

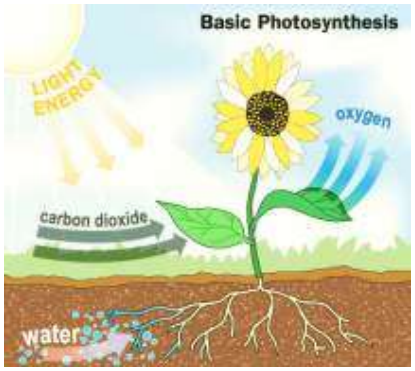


$$6\ CO_2 + 6\ H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

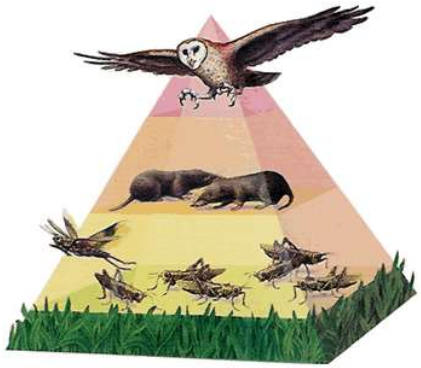
Glucose

Photosynthesis

Sunshine plays a bigger role in our lives than you may think. All the food we eat are products of photosynthesis.



Plants turn solar energy into food

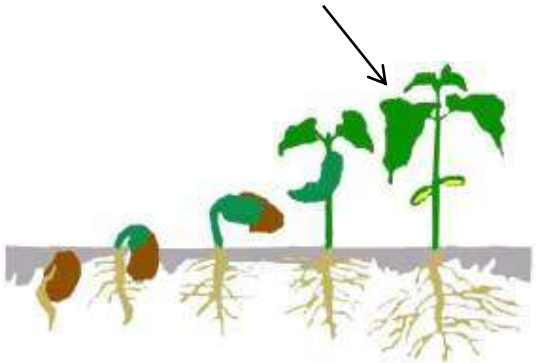


When animals eat plants and other animals, that original solar energy is passed along the food chain.

GLUCOSE

During photosynthesis, plants produce glucose molecules when they convert light energy into chemical energy.

Plants also use the glucose they produce for energy. Plants produce excess glucose: they store it in their leaves.



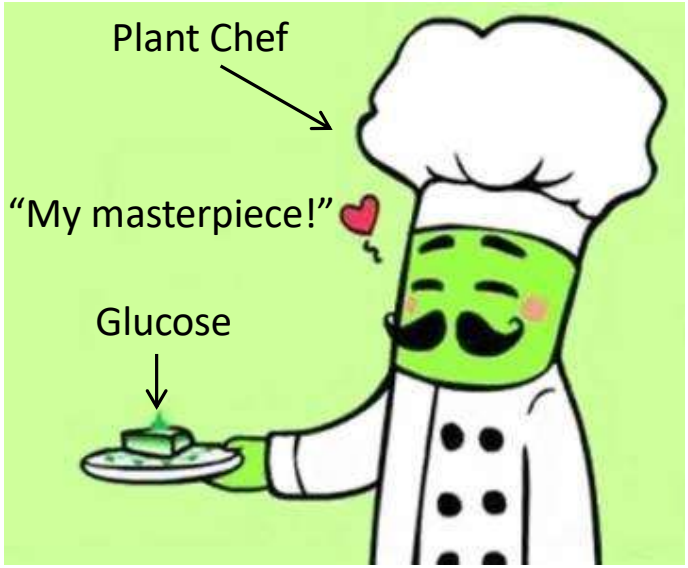
Consumers such as herbivores and carnivores depend on the products of photosynthesis to live.

When animals digest plants, they are breaking down the glucose in the leaves to power their bodies.

Glucose in Plants

Glucose is a simple sugar:

Plants can also make glucose into carbohydrate chains called **polysaccharides**.



There are 2 polysaccharide chains in plants:

Cellulose

Cellulose is the structural component of cell walls.

Starch

Starch is a long term energy store that the plant can use later.

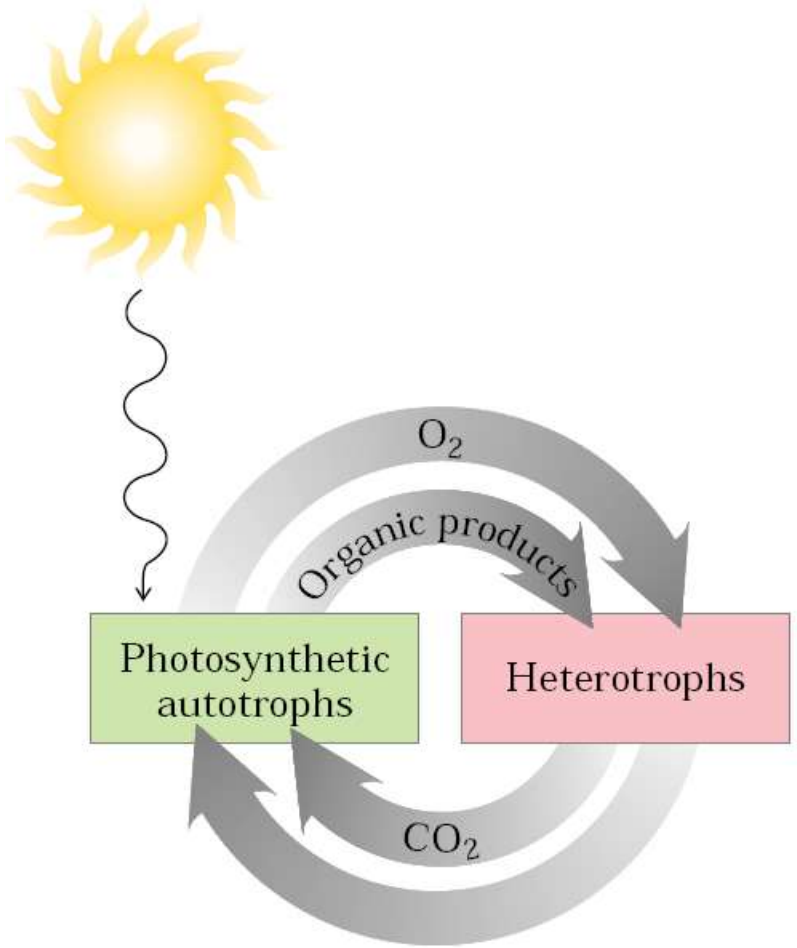
↓

Potatoes, Rice, Sugarcane....

Photosynthesis

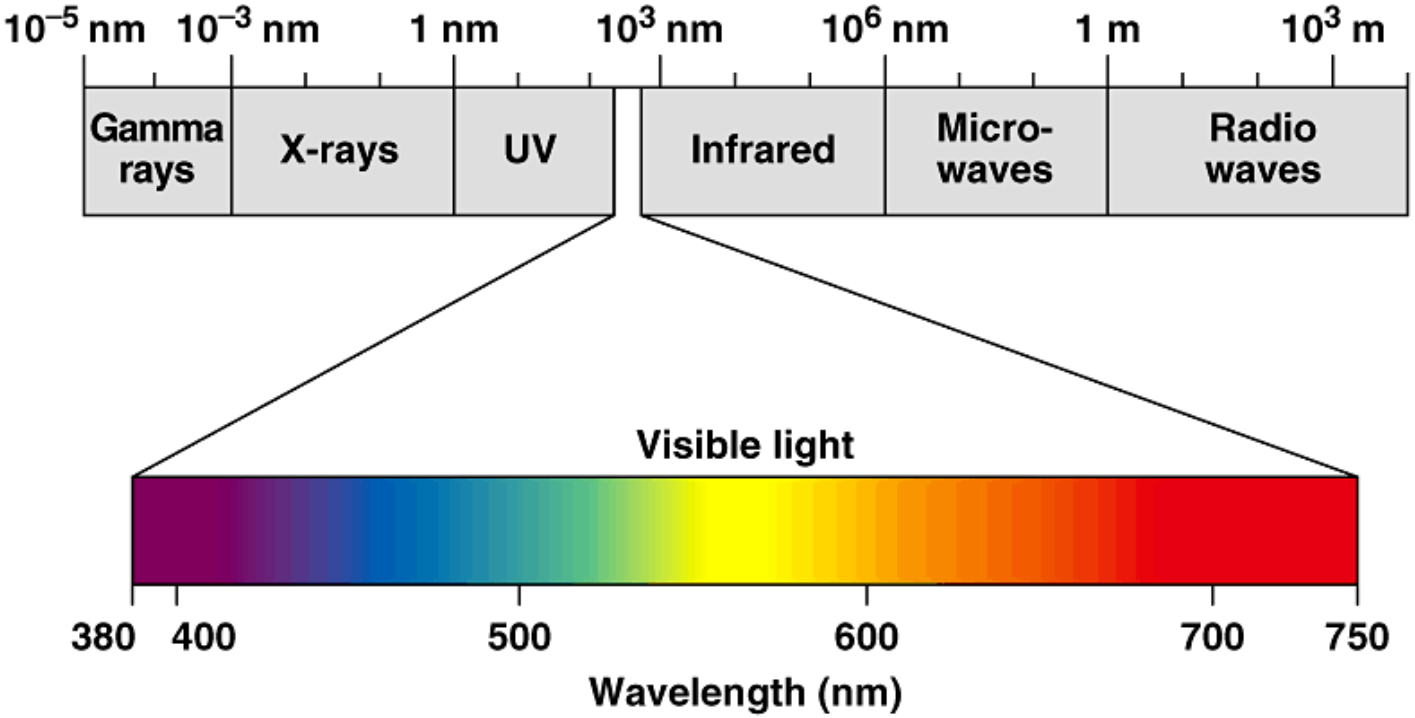
- Main path to collect the most abundant source of energy on Earth

- Transforms solar energy (light) in chemical energy



Visible Light

Light is an electromagnetic wave with specific energy. This Energy can be associated to a color in the part of the spectrum that is called visible light

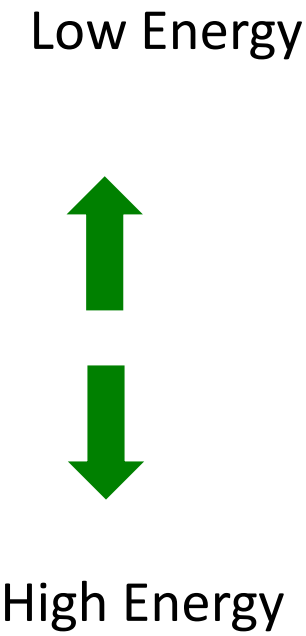


More Energy

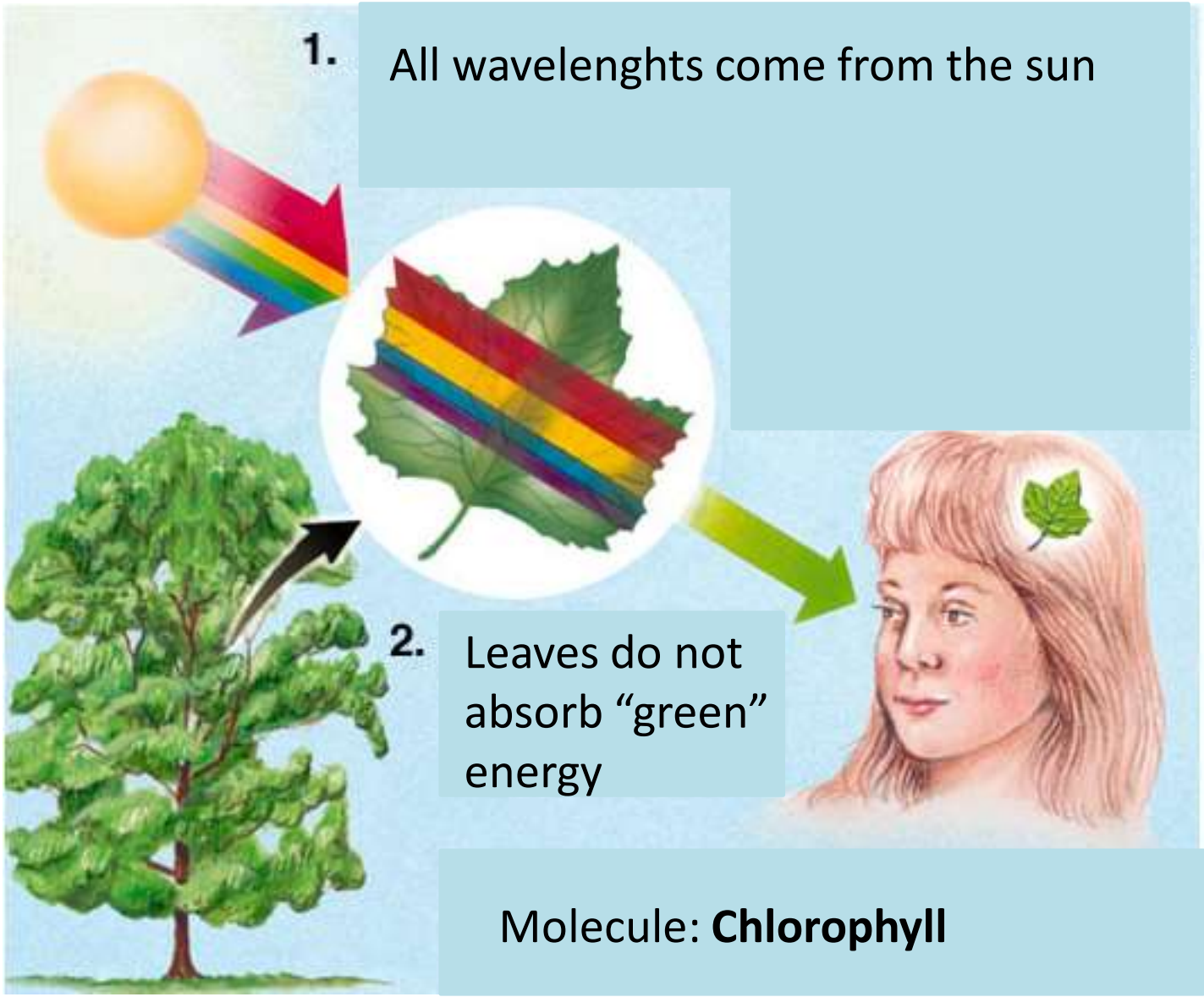
Less Energy

Light Energy

Color	Wavelenght
Red	~ 625-740 nm
Orange	~ 590-625 nm
Yellow	~ 565-590 nm
Green	~ 500-565 nm
Cyan	~ 485-500 nm
Blue	~ 440-485 nm
Purple	~ 380-440 nm



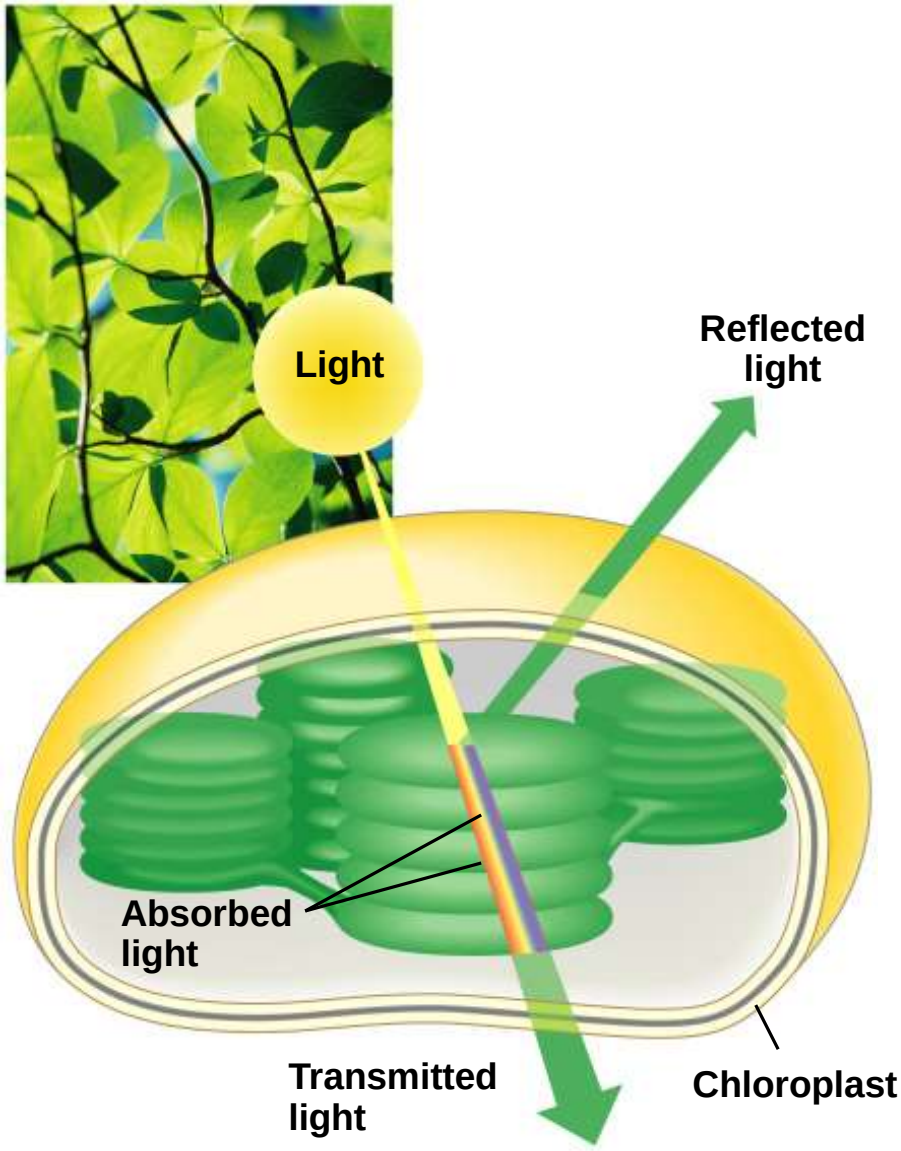
Why leaves are green ?



Why leaves are green ?

The color of light seen is the color not absorbed

Chloroplasts they have a high content of chlorophyll



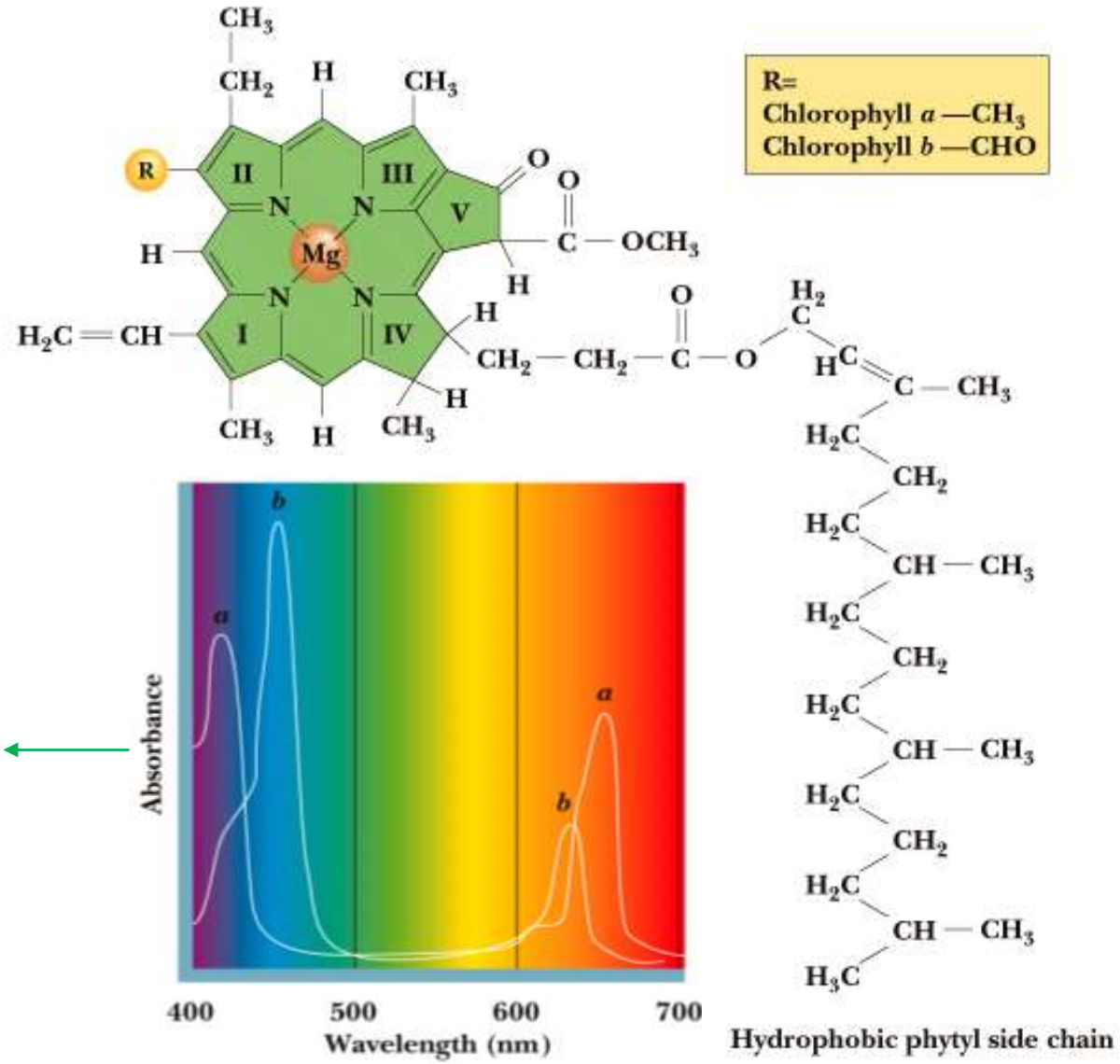
Chlorophyll

Two types:

Chlorophyll a

Chrorophyll b

Which wavelenght (energy or color) the molecule absorbs



Pigments

Chlorophyll is a type of molecule that can absorb light.
Those molecules are called PIGMENTS or Photoreceptors.

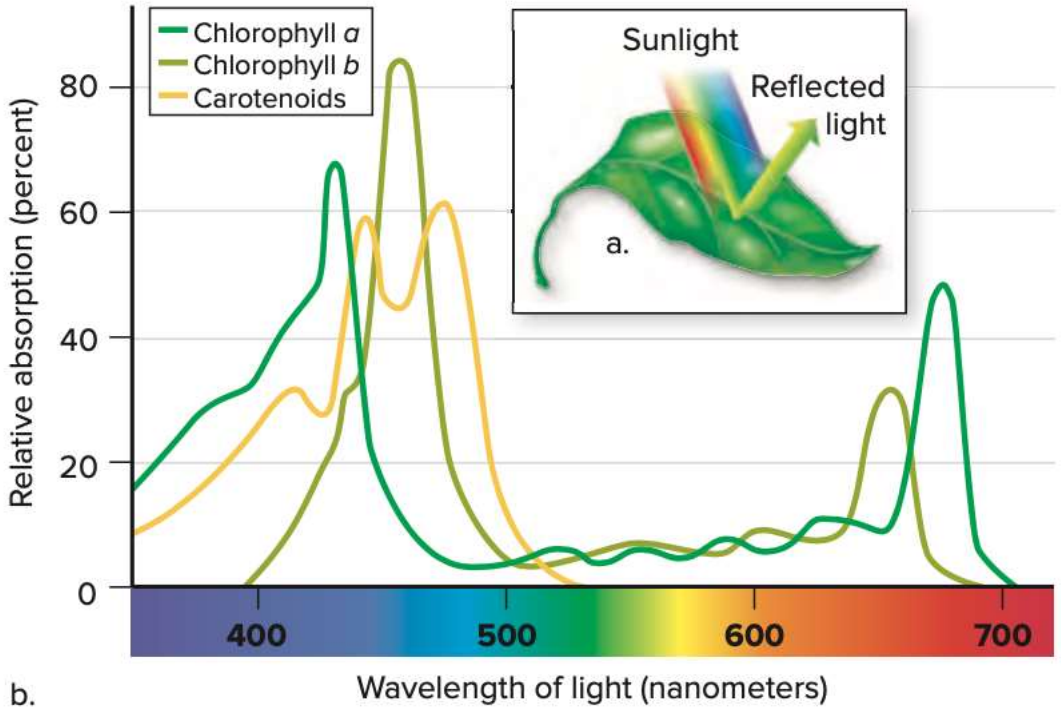
They can:

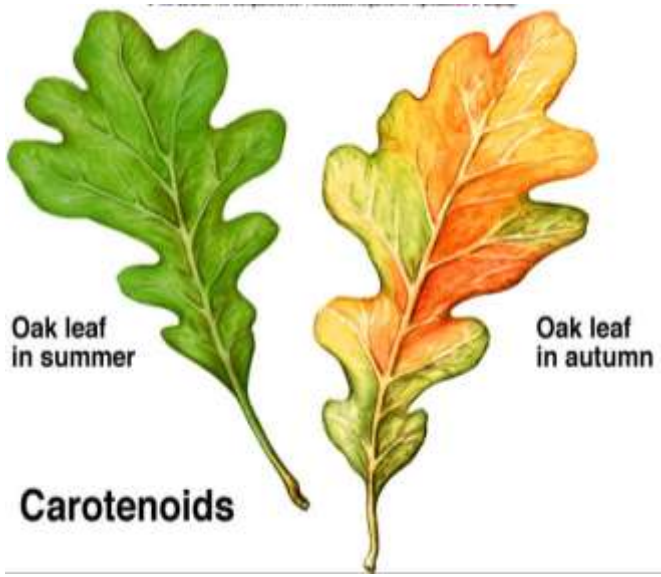
- Absorb light and transfer an electron to another pigment
- Absorb light and transfer electrons to another molecule, like NADH

Chlorophyll absorb green light because the most abundant solar emission is in the green energy range!

Carotenoids

Carotenoids are the other pigments of the leaves, the one with yellow-red coloration.
They absorb light with less efficiency, because the leaves are dying for the winter so only a little energy is needed





Leaves Metabolism

1. Photosynthesis: Sunlight Endergonic

$$CO_2 + H_2O + 3ATP \rightarrow Glucose + O_2$$

Celular Respiration: Exergonic, like in animals!

$$1Glucose + O_2 \rightarrow CO_2 + H_2O + 36\ ATP$$

Plants' cells also have mitochondria !!!!

Plant Metabolism

• **LEAVES:** perform a lot of phothosynthesis. Cellular respiration for basic cell functions

• **ROOTS:** Intense cellular respiration, the glucose comes from the leaves. Use the energy to grow and to absorb water. No photoshyntesis.

• **FRUITS:** during fruit formation the cellular respiration is intense. No photosynthesis. Glucose is stored as fructose

• **SEEDS:** Majority of energy comes from cellular respiration of sugars stored inside the seeds. When the first leaves appears, the photosynthesis begins.

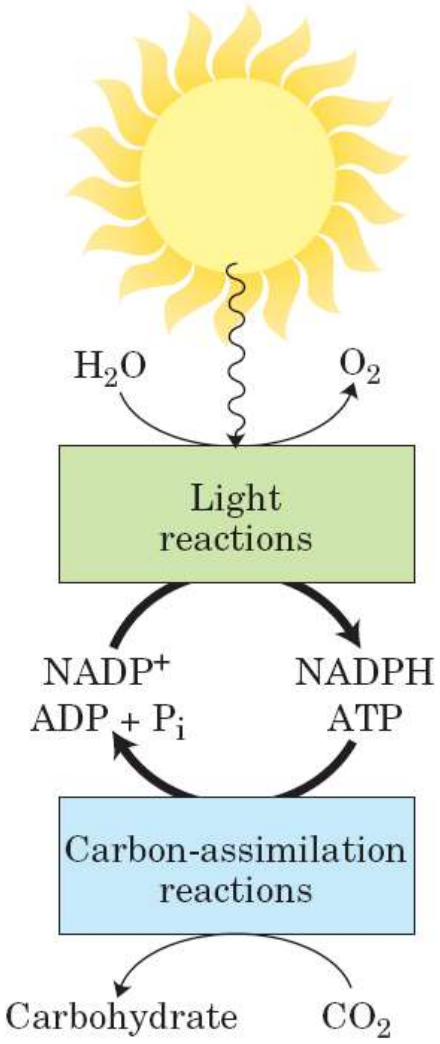
Step of Photosynthesis

Light Phase (Light dependent)

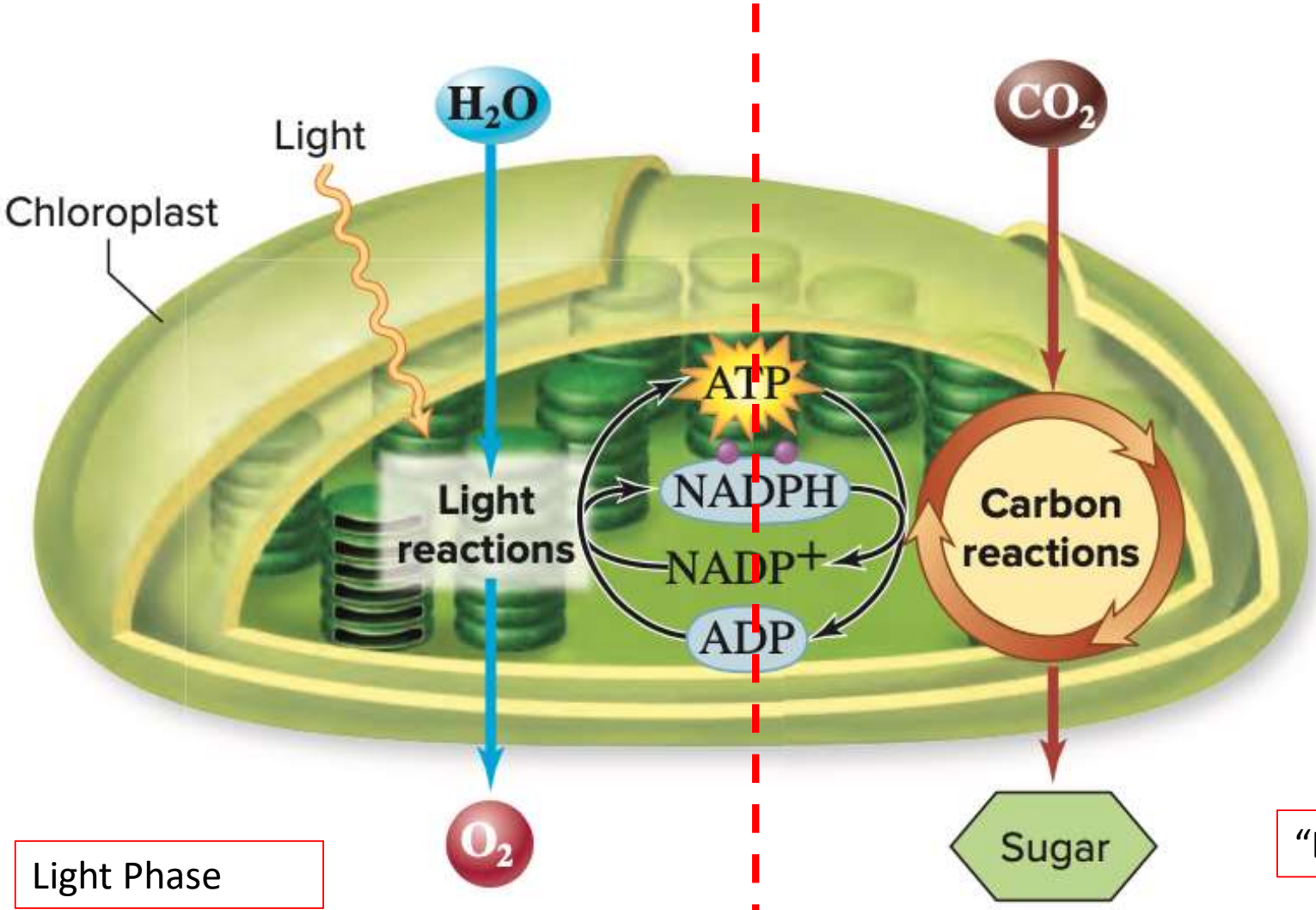
From the enrgy of light to chemical energy

Dark Phase (Light indipendent):

Sugar production.
This phase still happens during the day



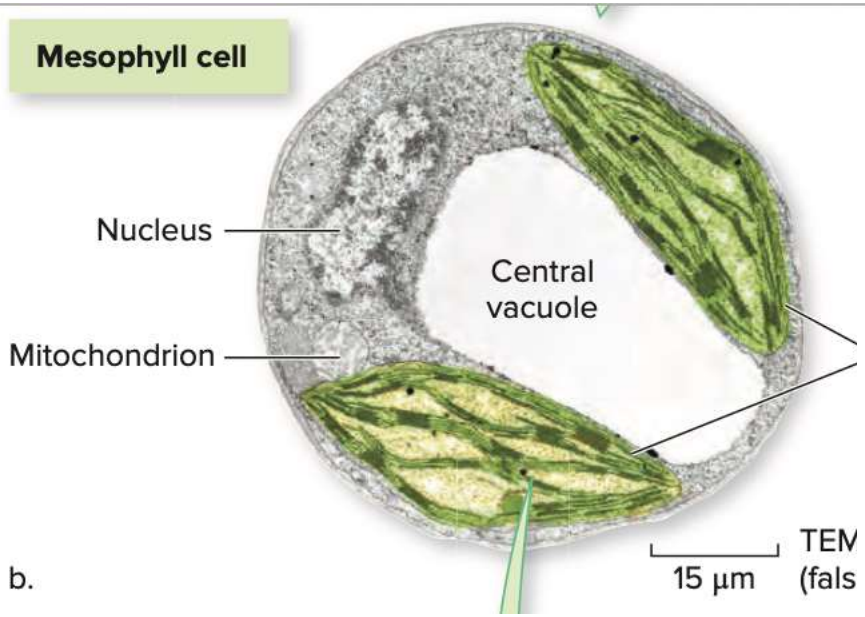
Step of Photosynthesis

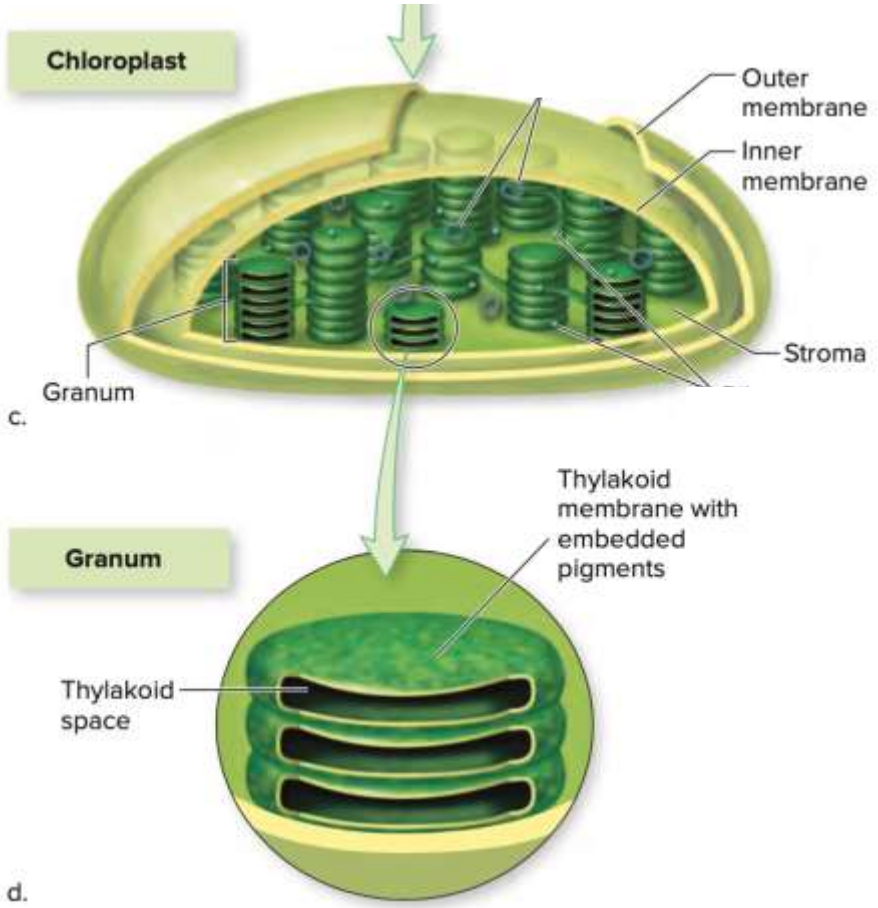


Light Phase

"Dark" Phase

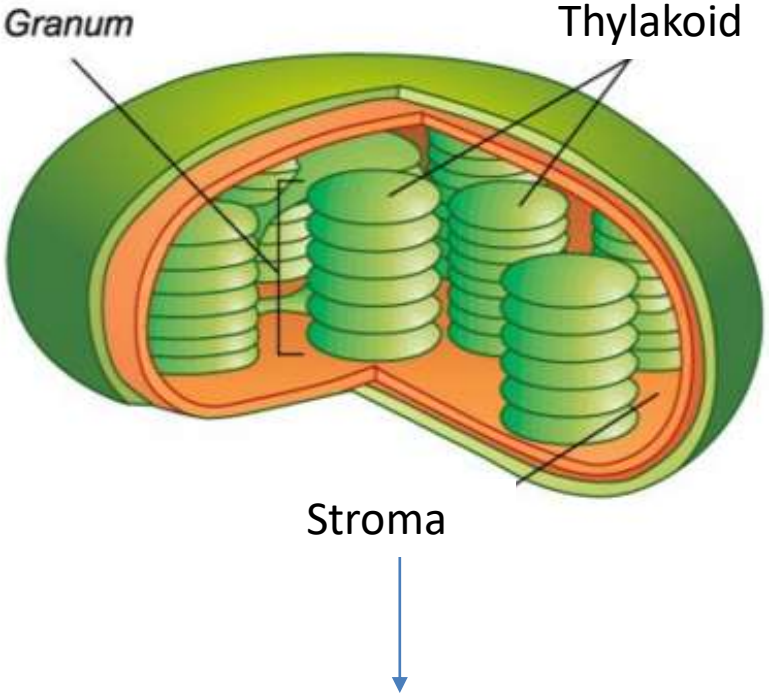
Photosynthesis

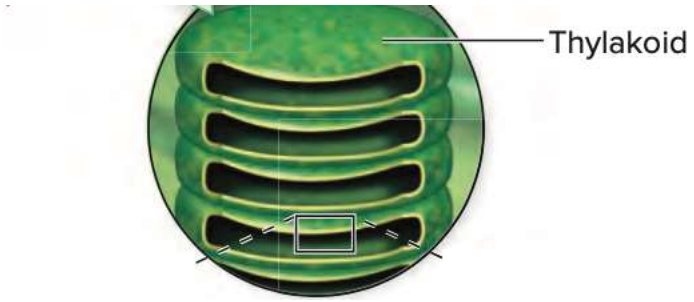




Photosynthesis happens in the chloroplast inside the leaves' cells.

Photosynthesis

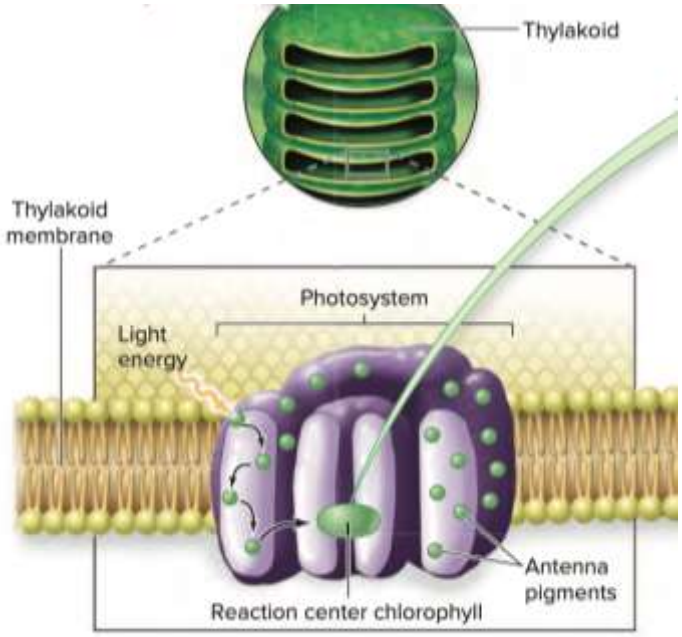


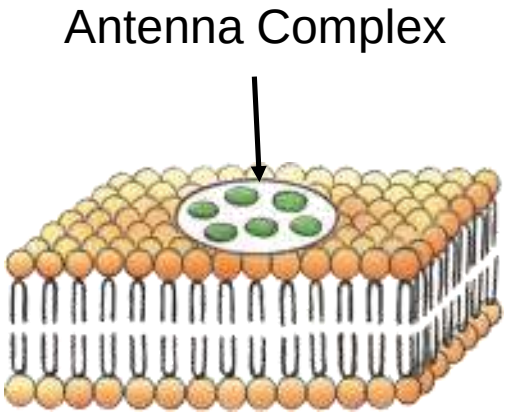


The “dark” phase happens here.

The light phase happens here: on the membrane of the tylakoids

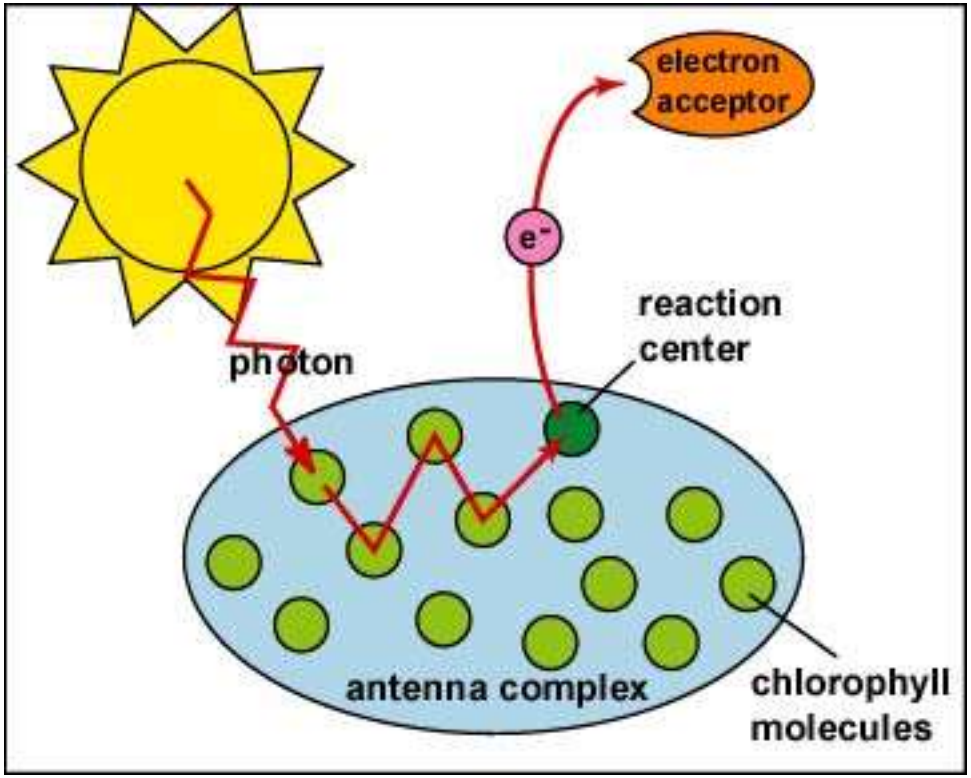
1. Light Phase





1. Pigments (mainly chlorophyll) are organized in Photosystems.
2. There are 2 photosystems that work together: Photosystem II (P680) and Photosystem I (P700).
3. The main part of the photosystem is called the Antenna complex: > 200 chlorophyll molecules.

The antenna complex



The anenna complex receives the sunlight and transfer electrons to one specific **pair** of chlorophyll molecule:

the Reaction Center.

Photosystem

- Antena Complex:

  Proteins that bind hundreds of chlorophyll molecules and carotenoids together. They transfer electrons from one pigment to other until they reach the reaction center.

- Reaction center:

  A special Pair of chlorophyll molecules that immediately transfer electrons to the eléctron chain and NADPH.

Photosystem

PS II (P680)

Transfer electrons to the eléctron chains and the PS II

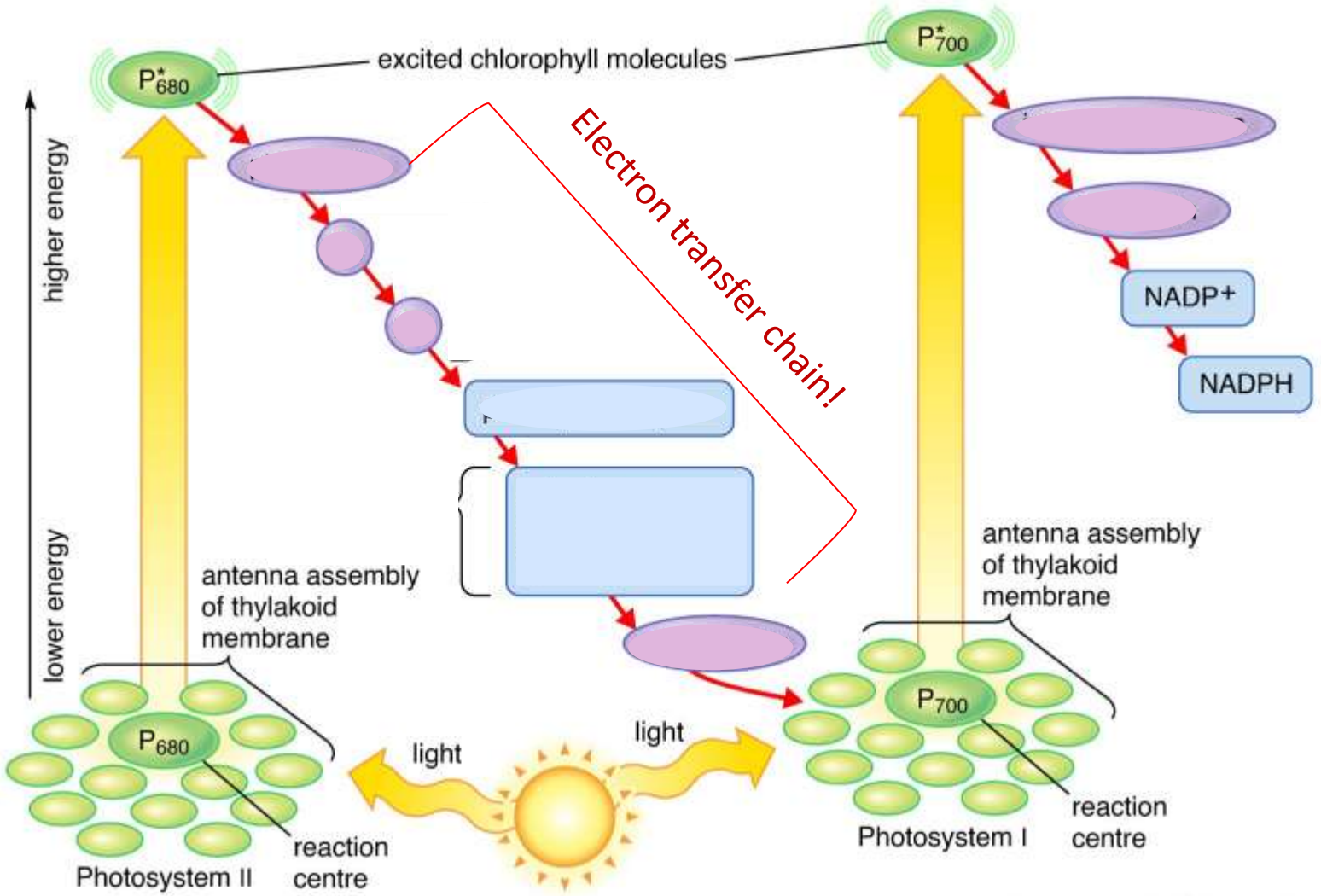
It removes those electrons from water, generating oxygen (O_2) and H+ ions.

The flux of H^+ generates ATP (ATP-synthase).

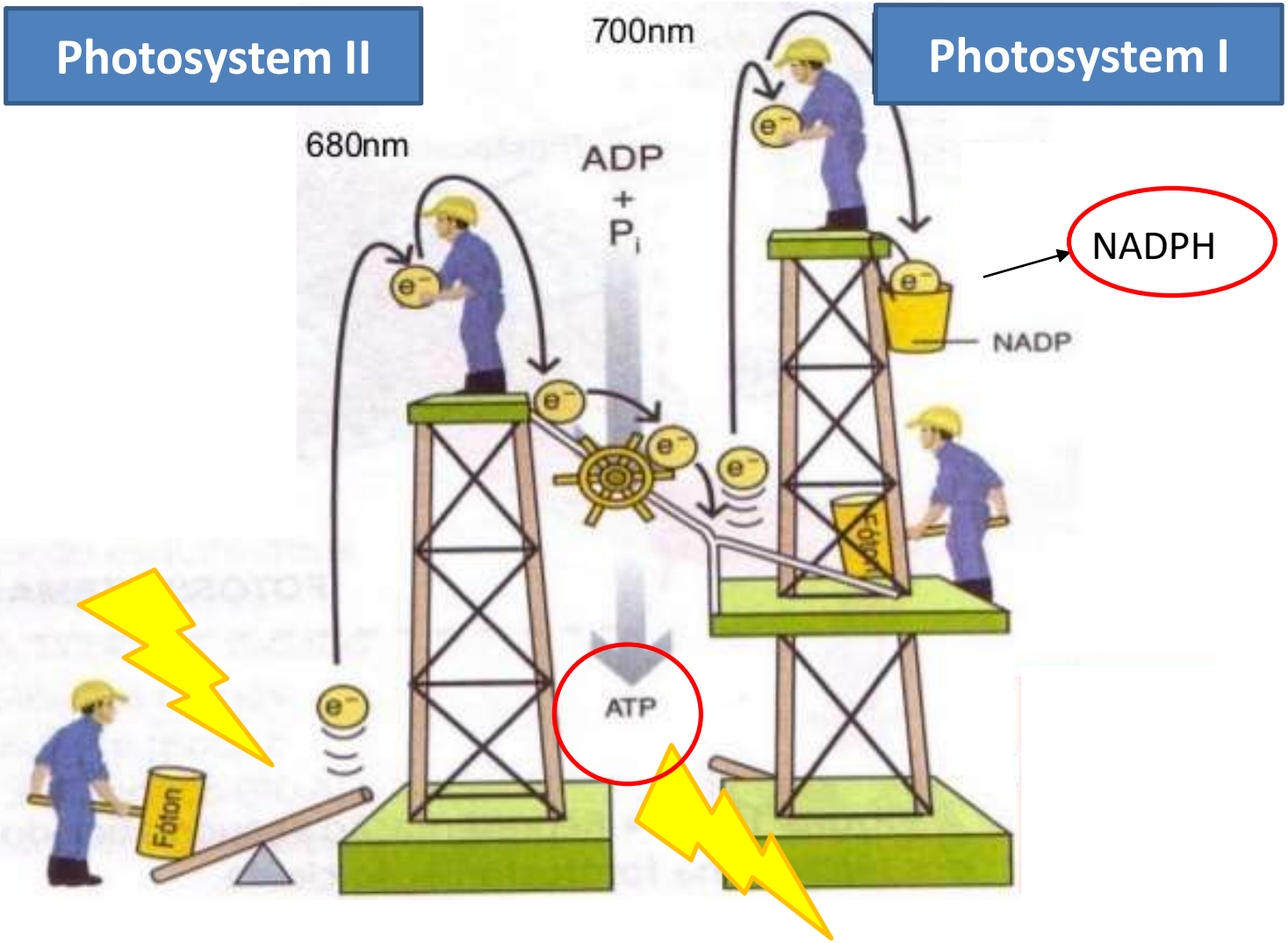
PS I (P700)

Transfers the electrons he receives from the PS II to NADP+ to form NADPH.

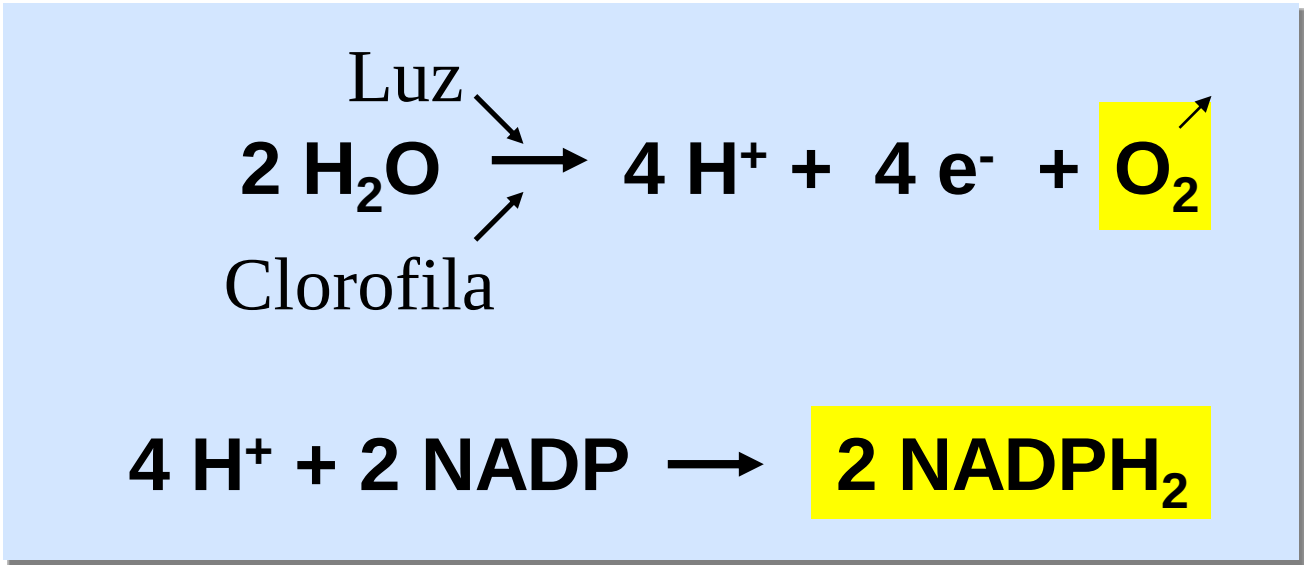
The Z-diagram

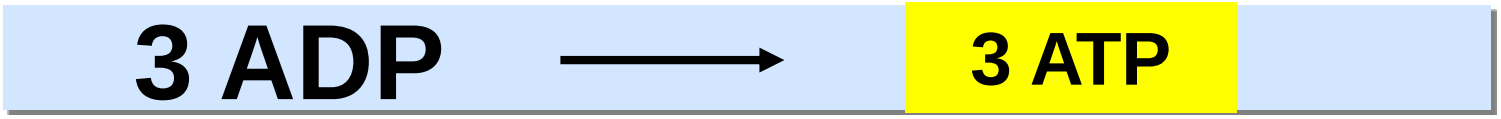


The Z-diagram



Light Phase Balance

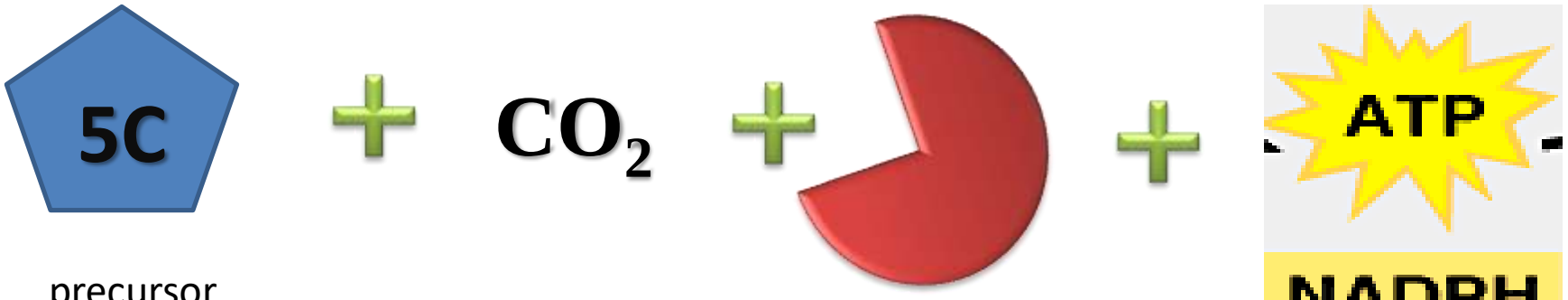




2. Dark Phase

Glucose synthesis from a precursor and CO2 from the atmosphere

Inorganic carbono fixation !



precursor

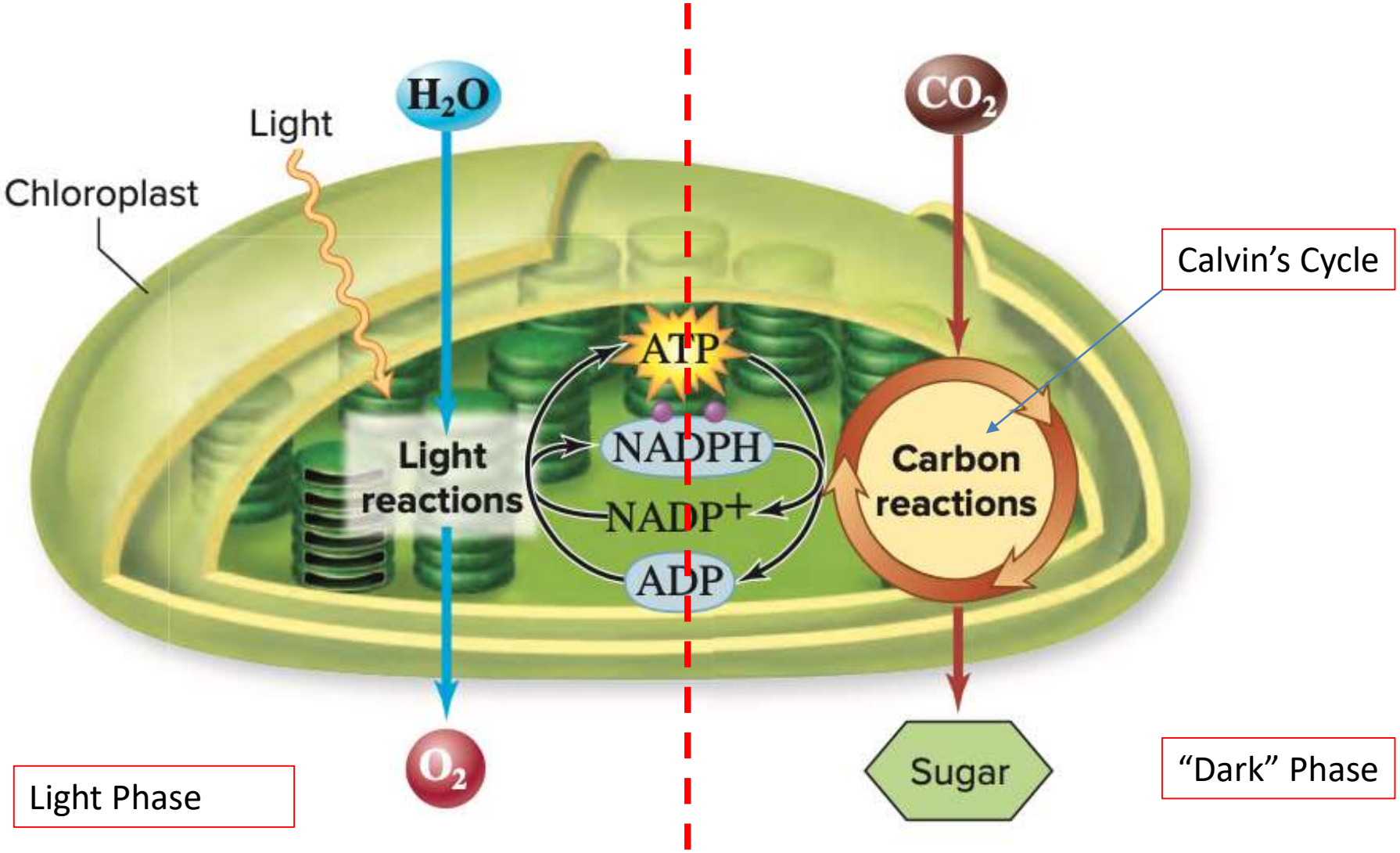
It is regenerated:
the Calvin cycle

Enzyme: RUBISCO

Energy

From the Light Phase

Step of Photosynthesis



Dark Phase Balance

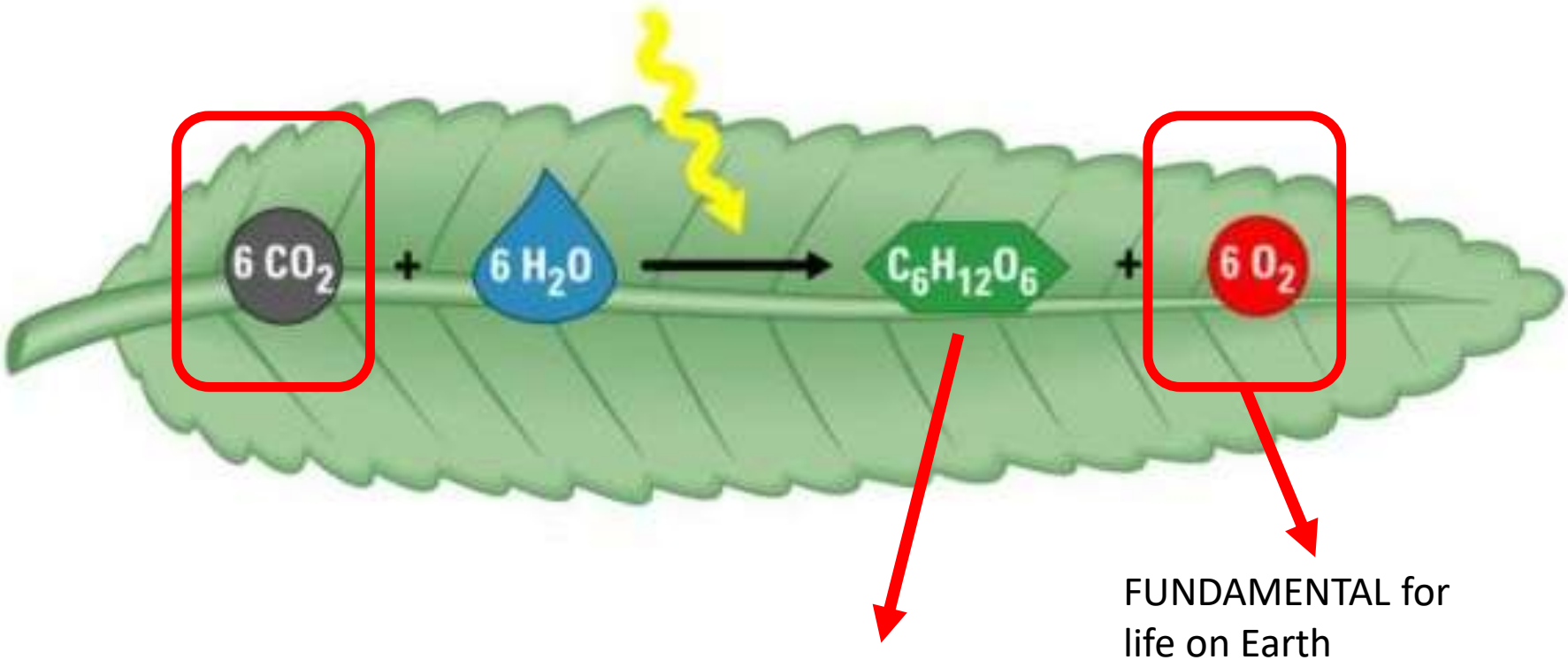
ATP and NADPH produced during the light phase are consumed in the dark phase, during the Calvin's cycle

$$6\ CO_2 + 18\ ATP + 12\ NADPH \rightarrow C_6H_{12}O_6$$

The photosynthesis is now over.

At night, glucose will be transformed in celulose or starch for further storage

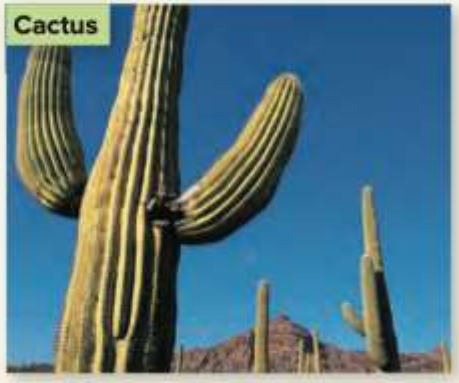
Summary



FUNDAMENTAL for life on Earth

Used in Mitochondria for ATP production!

Not all the plants are the same...

	C_3 plant	C_4 plant	CAM plant
Example	 Sycamore	 Corn	 Cactus
Habitat	Cool, moist	Hot, dry	Hot, dry
% of plant species	95%	1%	3–4%

CO_2 is absorbed during the day. Light phase and Dark phase are a continous process

During the day the leaves pores are closed to not lose water in the heat.
So CO_2 is absorbed during the night and stored for when the light comes.

Amazon forest the world's lung ?

Plants release oxygen during the day, right?

So for a long time it was said that the Amazon forest, the larges forest in the world, is the lung of the world.

Recent studies descovered that another type of plants produce more oxygen: seaweed or algae!

Questions to help you study

1. Photosynthesis is divided in how many phases? When they happen (day or night) ?
2. Write the balance of the light phase: what the plant uses, what do they produce?
3. Write the balance of the dark phase. What is the name of the process that happens during this phase?
4. Why photosynthesis is so important for animals?
5. All plants do photosynthesis the same way? Where these type of plants live?
6. How (怎么) glucose is stored in plants and where these molecules can be found?
7. What is the name of the molecule that is crucial for the photosynthesis process? Why leaves are green ?
8. How actually plants' cells make all the energy for they functions ?