PHOTOSYNTHESIS

"Trapping the Sun's Energy"

- Energy is trapped in chemical bonds

- But *where* does *energy* come from?

GLUCOSE

- Carbohydrate → sugar molecule
- Simple sugar, known as a monosaccharide(ex: fructose, glucose)
- Equation → $C_6H_{12}O_6$
- But where does *glucose* come from?

PHOTOSYNTHESIS

If you were making a cake, what would the …

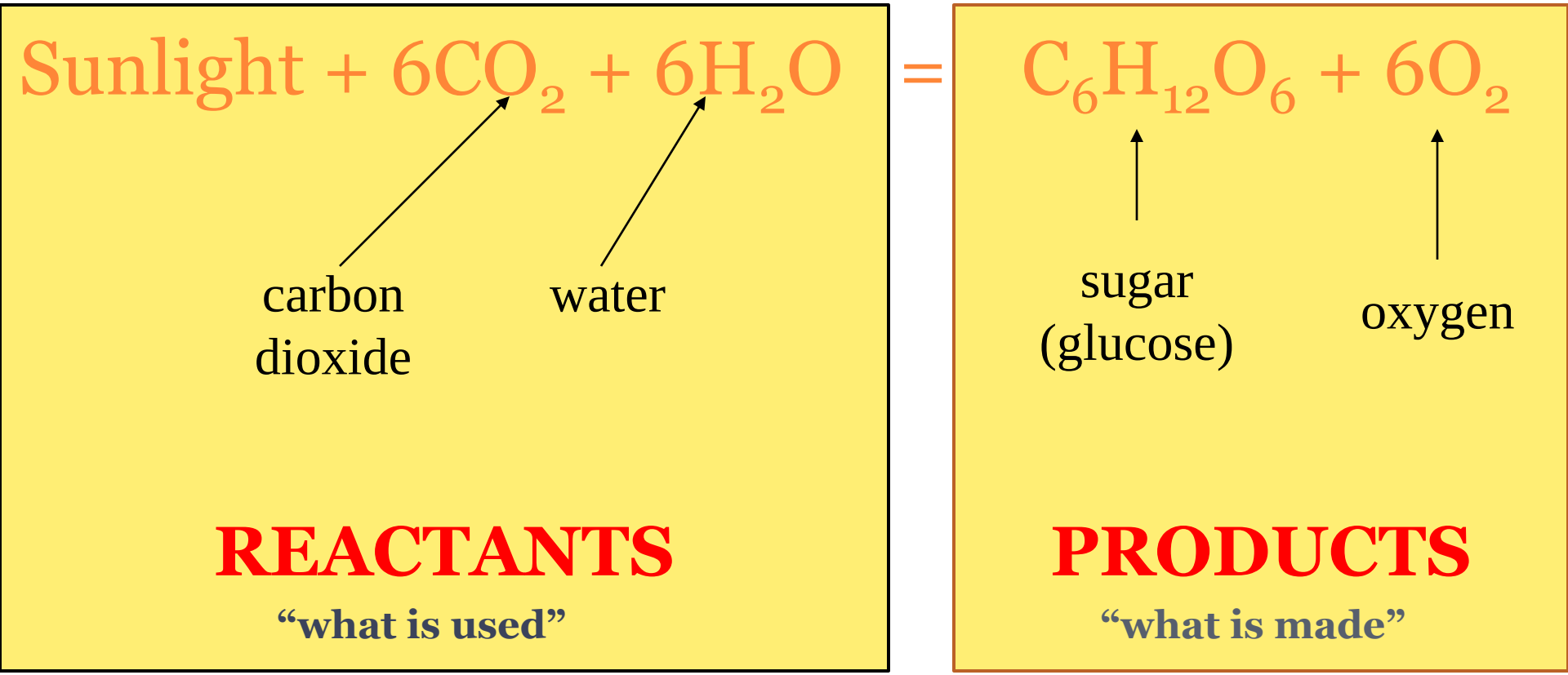
Reactants be?

- Flour
- Eggs
- Sugar
- Water
- Etc.

Product be?

- A Cake!

Photosynthesis Equation →

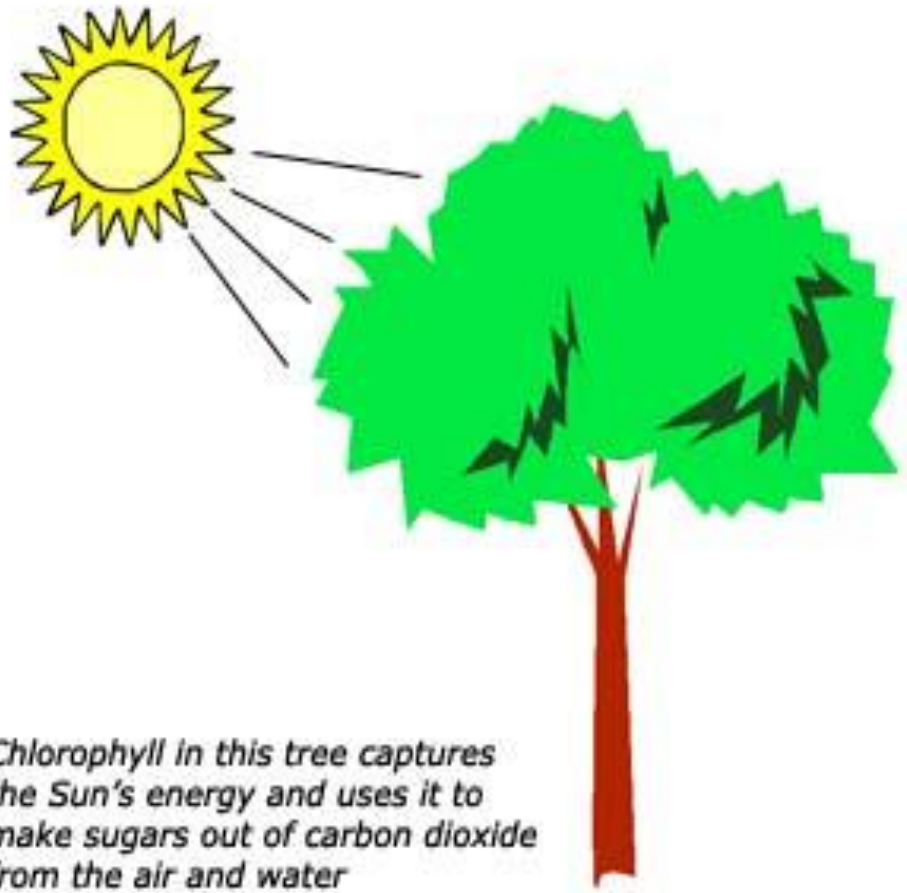


Photosynthesis

A **carbon dioxide** requiring process that uses **light energy (photons)** and **water** to produce **glucose (and oxygen)**

What organisms go through photosynthesis?

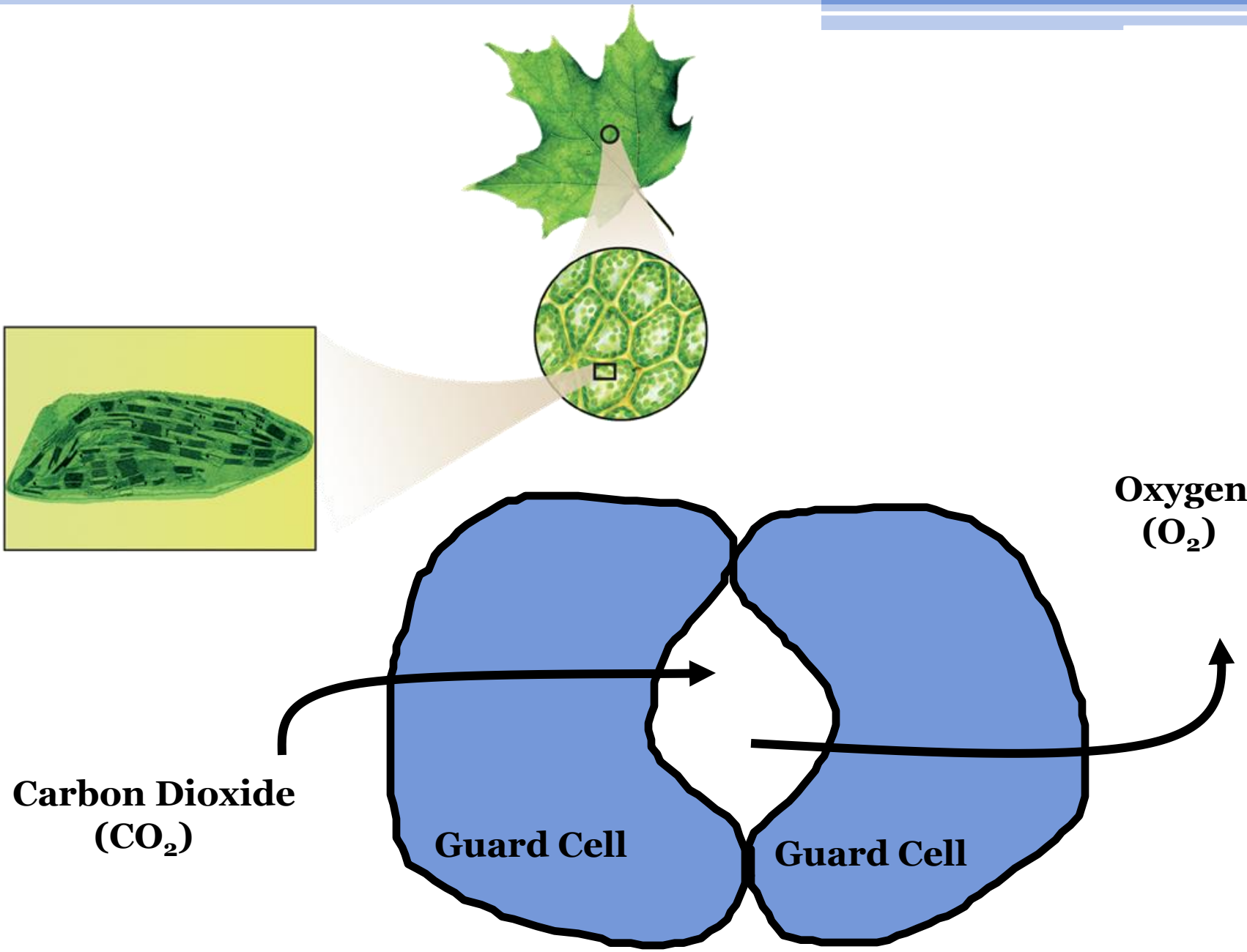
- Organisms that make their own sugar/carbs
- Producers/autotrophs
  - Plants
  - Trees
  - Algae
  - Some bacteria



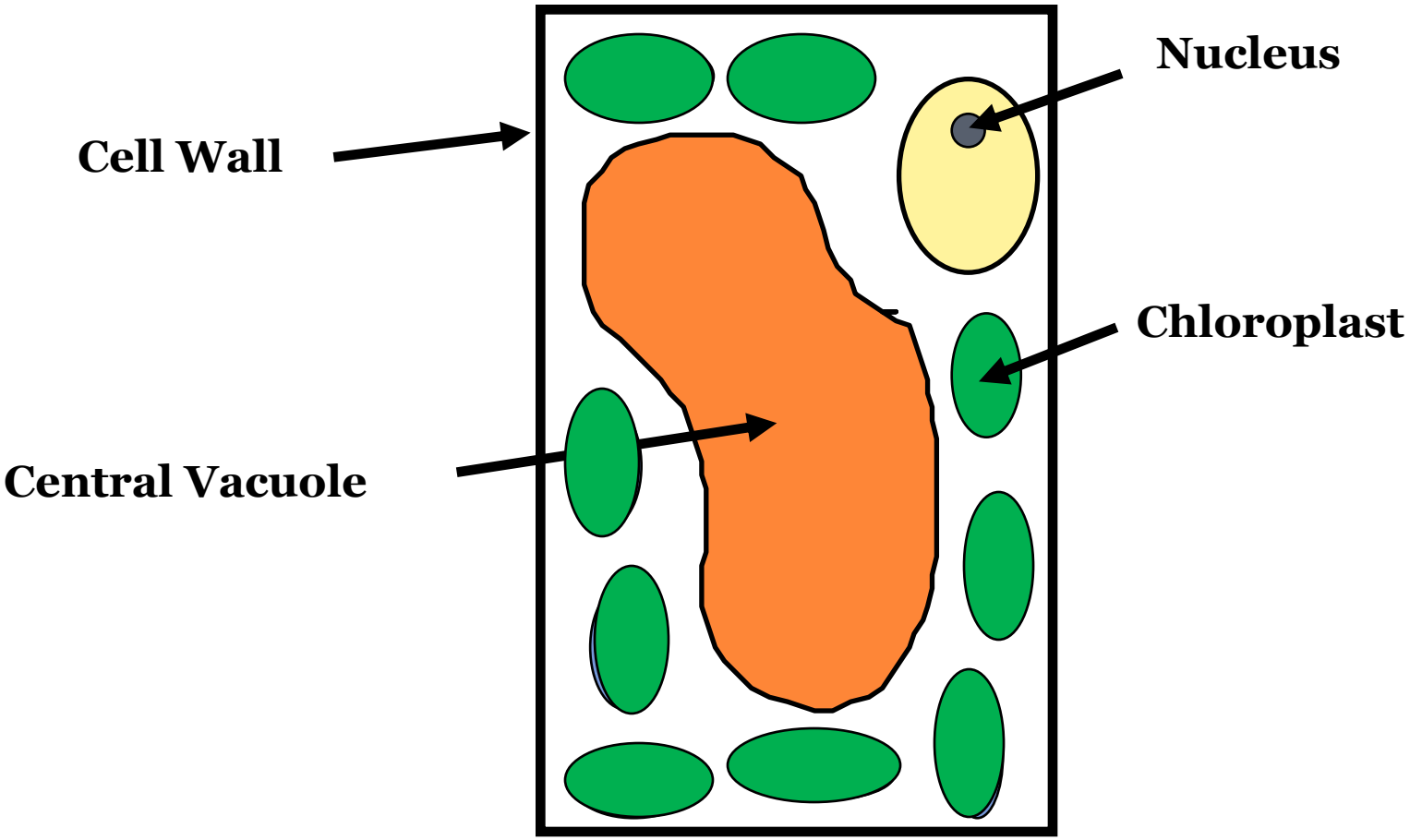
Chlorophyll in this tree captures the Sun's energy and uses it to make sugars out of carbon dioxide from the air and water

Where does photosynthesis take place?

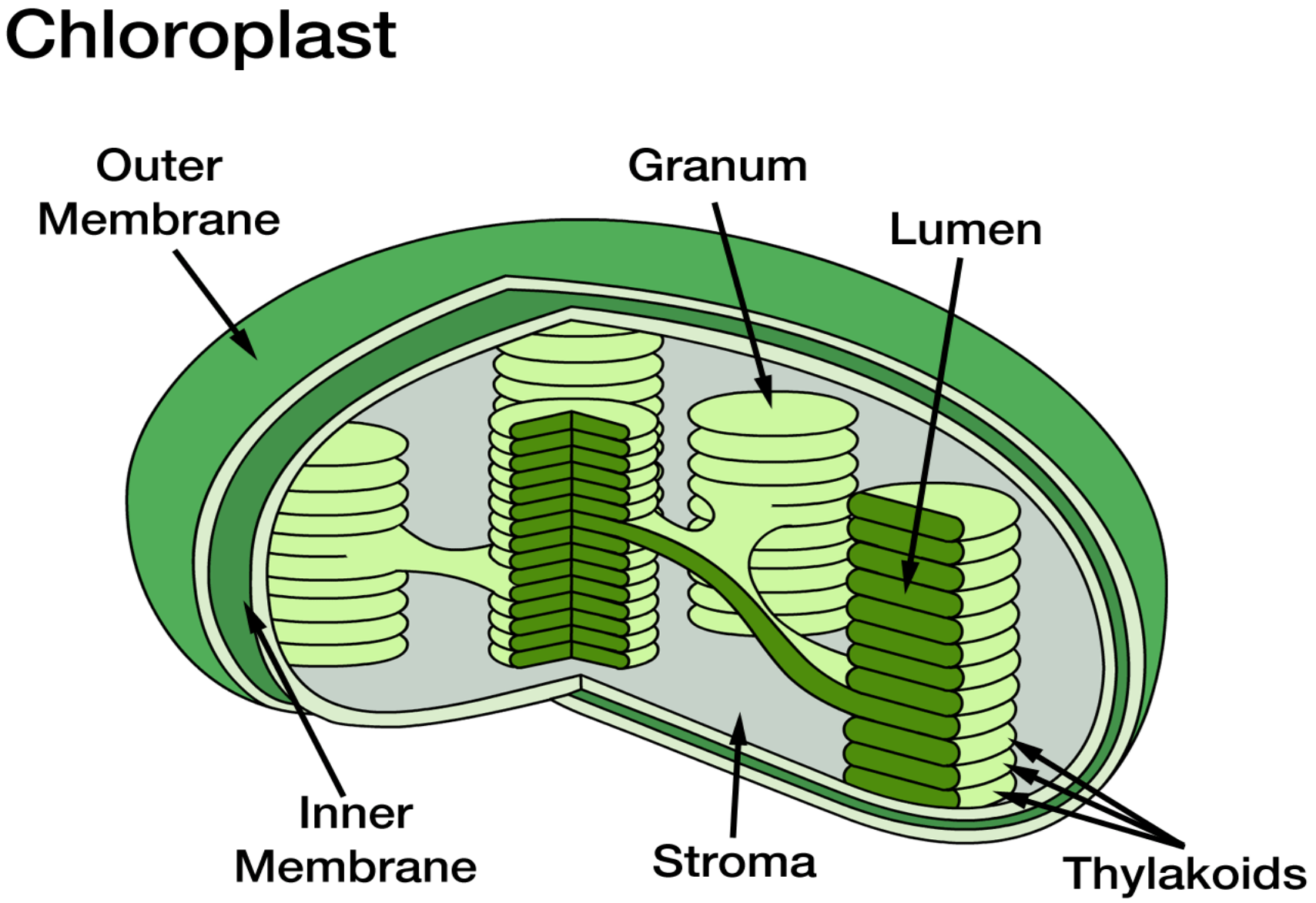
- In the chloroplasts of **plant cells** found in the **leaves**!
  - (**chloroplasts** contain chlorophyll)
- **Stomate/a**: pores in plant's cuticle (outer leaf surface) through which **water** and **gases** are exchanged between plant and atmosphere


Oxygen
(O_2)
Carbon Dioxide
(CO_2)
Guard Cell
Guard Cell

Plant Cell in Leaf

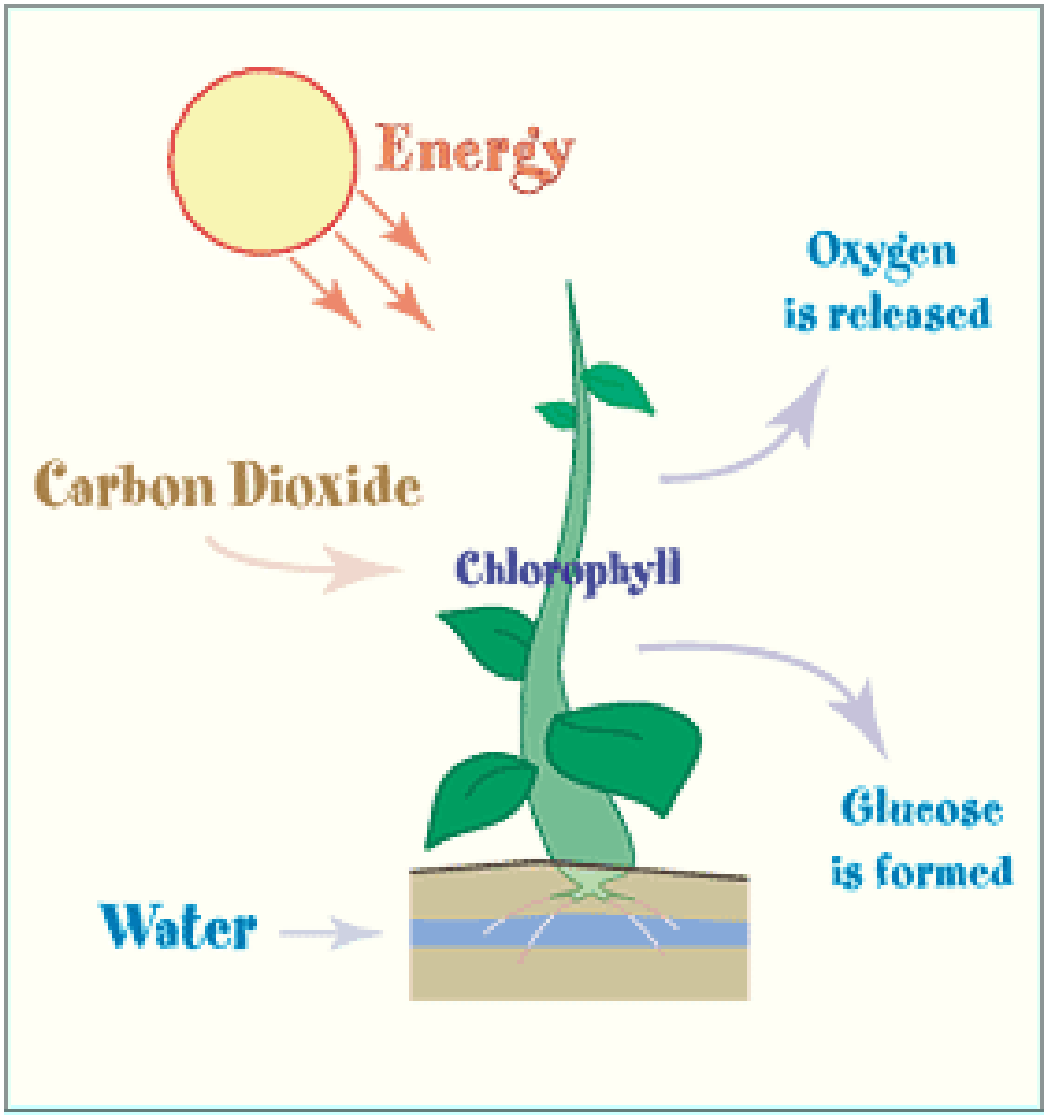


Location of Photosynthesis:



Photosynthesis

- What is needed?
  - 1. chlorophyll
  - 2. sunlight
  - 3. water
  - 4. carbon dioxide
  - 5. enzymes



Photosynthesis

What is needed for photosynthesis?

- 1. Chlorophyll
  - Location → chloroplast
  - Pigment → light absorbing chemical compound
    - Captures: light energy (into chemical energy)

What is needed for photosynthesis?

1. Chlorophyll (continued)
   - Structure →
     - Folded membranes: thylakoid membranes
       - Chlorophyll molecules found in these folds of thylakoid membrane
     - Stacks of thylakoids: granum/a
     - Fluid: stroma

Chlorophyll Continued…

- Chlorophyll traps **light** energy
  and gives leaves/stem the green color

- ALL other colors are absorbed, but **green (wavelength)** is **reflected**

- Ex: During Fall → trees stop producing chlorophyll

- ALL colors/wavelengths are reflected, so we see various colors of leaves

Chlorophyll Molecules

- **Chlorophyll pigments** harvest energy (photons) by **absorbing** certain **wavelengths** (**blue-420-470 nm** and orange**red-620-670 nm** are most important).
- **Plants** are **green** because the **green wavelength** is **reflected**, **not absorbed**.

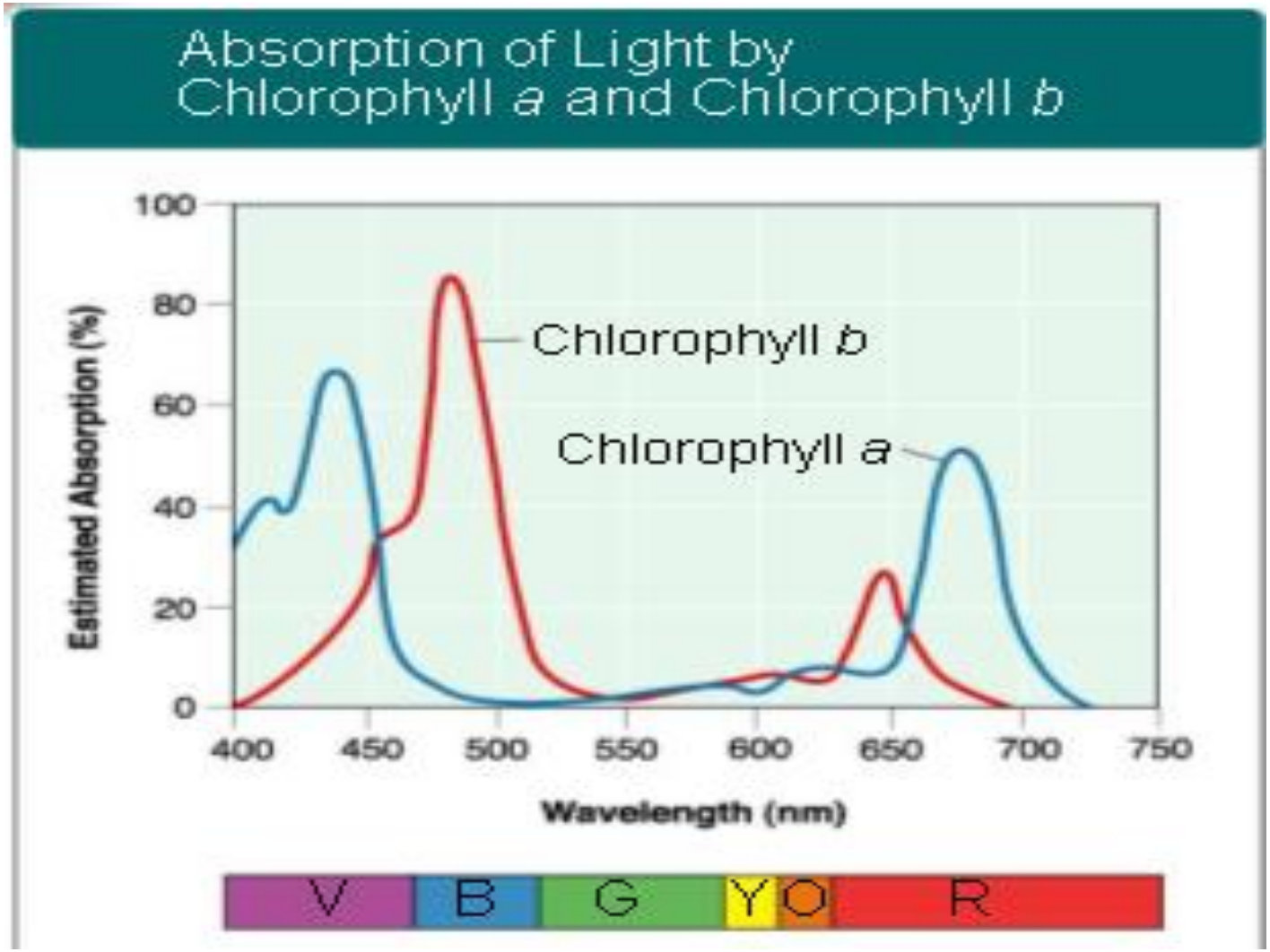
Fall Colors

- In addition to the chlorophyll pigments, there are other **pigments** present.

- During the fall, the **green chlorophyll** pigments are **greatly reduced** (lower light intensity) revealing the other **pigments**.

- **Carotenes** are pigments that are orange.
- **Xanthophylls** are pigments that are yellow.

Absorption of Chlorophyll



What is needed for photosynthesis?

- 2. Sunlight
  - Provides energy for chemical reactions to take place
  - Forms electromagnetic waves that travels from the sun to the earth
  - Get to use via many forms →
    - Xrays
    - Infrared
    - Visible light
    - microwaves
    - radiowaves
    - ultraviolet

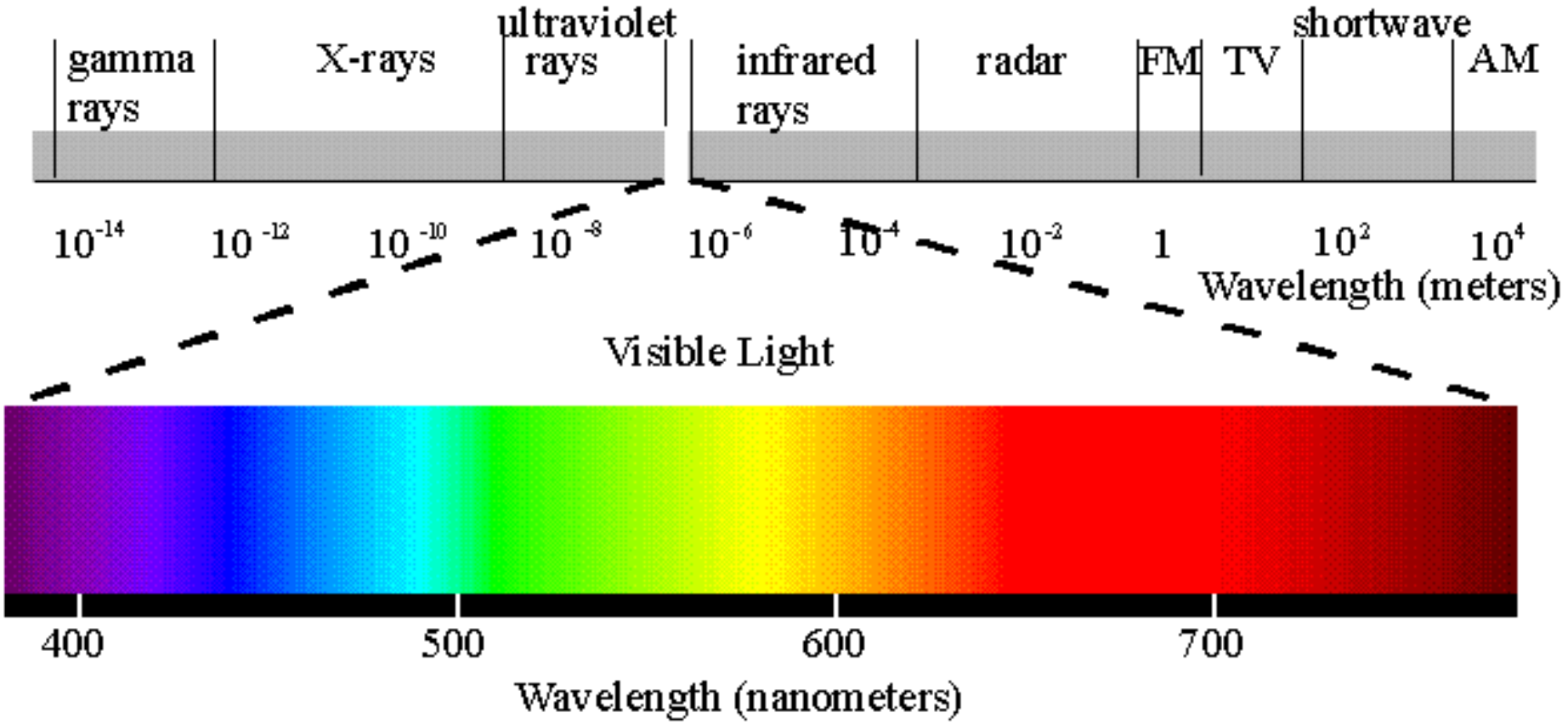


Table of Contents

Visual Stimulus

What is needed for photosynthesis?

- 3. Water
  - Provides **hydrogen** and **oxygen** atoms that will help form the products
- 4. Carbon Dioxide
  - Provides **carbon** and **oxygen** atoms that will help form the products
- 5. Enzymes
  - Proteins that change the rate/speed of a chemical reaction
  - Crucial for photosynthesis →

Overall chemical reaction for → PHOTOSYNTHESIS

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

Carbon dioxide + Water → Glucose + Oxygen gas

Photosynthesis: 2 main phases

Light-DEpendent

- REQUIRES light
- Reactions occur in the thylakoid membrane of the chloroplast
- O2 is produced from breakdown of water (H2O)

Light-INDEpendent

- Does NOT require light
- Reactions occur in the stroma of the chloroplast
- AKA → Calvin Cycle
- Glucose is produced from CO2

Photosynthesis: 2 main phases

Light-DEpendent

- (light rxns)
- Converts energy from solar power (photons) into the form of ATP and $NADPH_2$

Light-INDEpendent

- (carbon fixation)
- Uses carbon dioxide from environment and energy (ATP and $NADPH_2$) from light rxn to make sugar (glucose)

Phase 1 → LIGHT-DEPENDENT RXNS *(in thylakoid membrane!)*

- Requires sunlight
- Light energy strikes chlorophyll molecules that are located in the thylakoid membrane/grana (of the chloroplast)
- Energy in light → transferred to electrons, "excited electrons"
- Light energy breaks down water

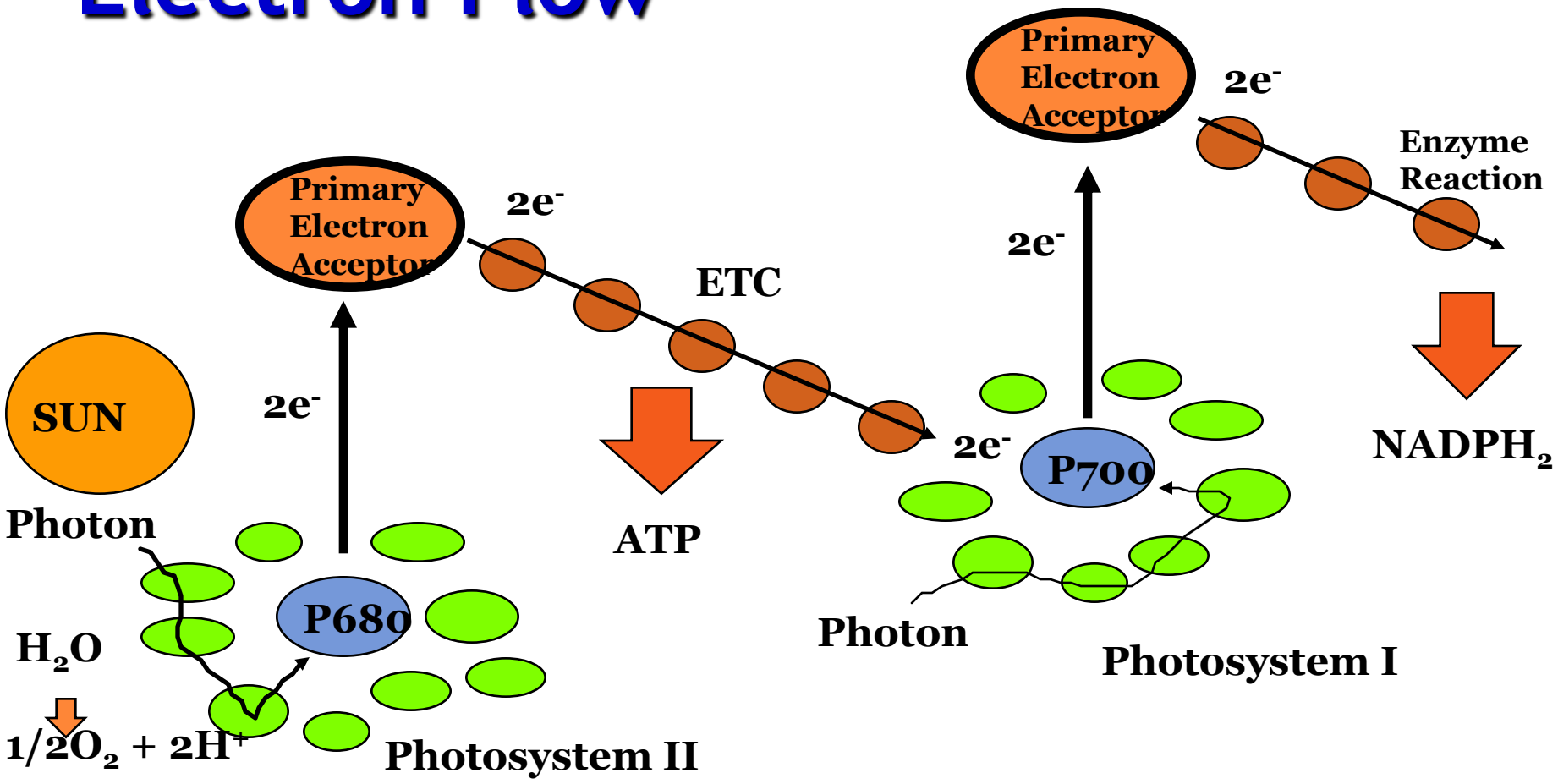
Phase 1 → LIGHT-DEPENDENT RXNS *(in thylakoid membrane/grana(um)!)*

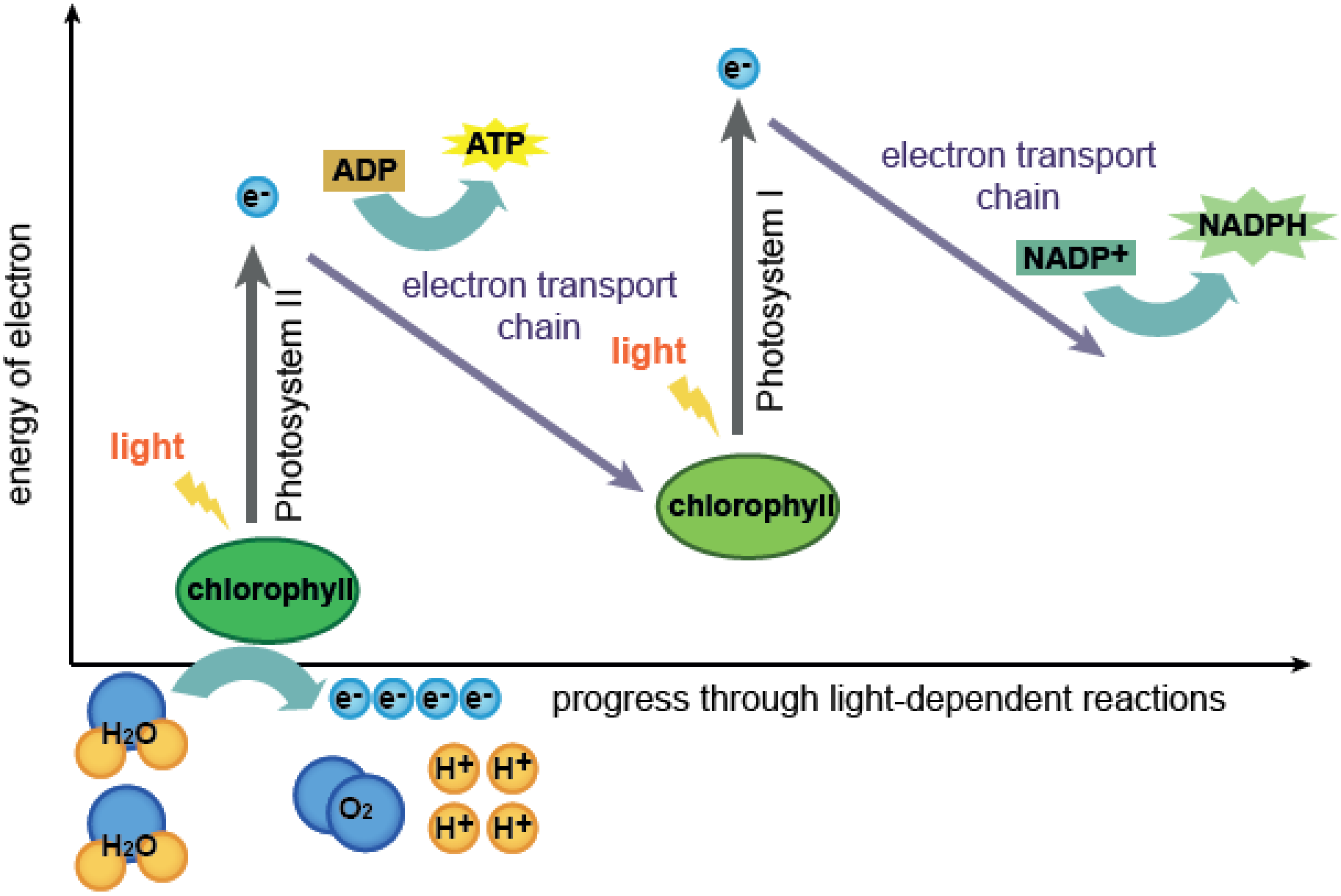
- Excited electrons → transferred to "E.T.C" → electron transport chain
- (E.T.C. = Photosystem 1)
- Passed from protein to protein
- As passed, electrons will lose energy!
- Lost energy → used to form ATP (from ADP)

Phase 1 → LIGHT-DEPENDENT RXNS *(in thylakoid membrane!)*

- Electrons get re-energized in a second photosystem (E.T.C.)
- Energetic electrons get transferred to the stroma (fluid) of the chloroplast
  - Transferred by electron carrier: NADP+
  - Combines with: 2 electrons, H-atom → $NADPH_2$

Electron Flow



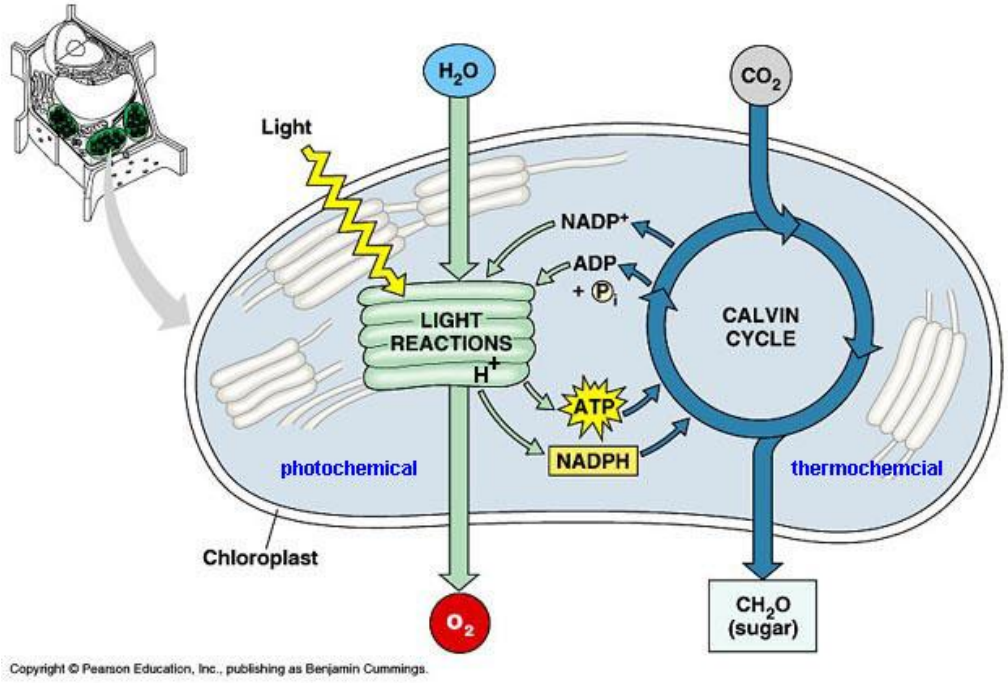

energy of electron
progress through light-dependent reactions
light
Photosystem II
e-
ADP
ATP
electron transport chain
chlorophyll
light
Photosystem I
e-
electron transport chain
NADP+
NADPH
chlorophyll
H2O
H2O
O2
e- e- e- e-
H+ H+
H+ H+

Electron Flow cont.

- ADP + P → ATP
  (Reduced)
- $NADP^+ + 2H \rightarrow NADPH_2$
  (Reduced)
- Oxygen comes from the splitting of H_2O, not CO_2

$$H_2O \rightarrow 1/2\ O_2 + 2H^+$$

Phase 1 → LIGHT-DEPENDENT RXNS



What has NOT been made yet??

End Result:

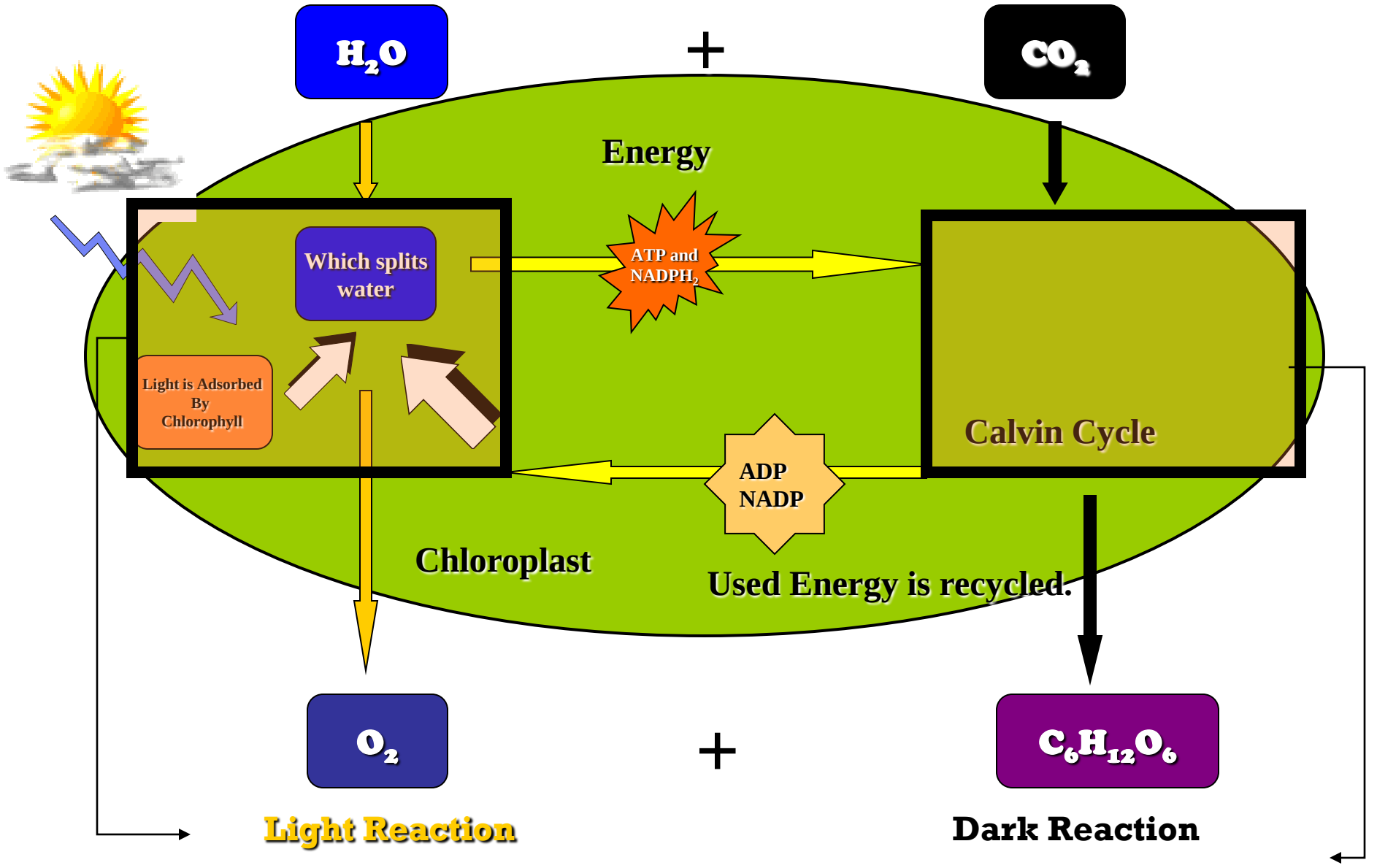
- USED→
  - Sunlight
  - Chlorophyll
  - Water
  - Enzymes
- NOT USED YET→
  - Carbon Dioxide
- CREATED→
  - Oxygen
  - ATP
  - NADPH

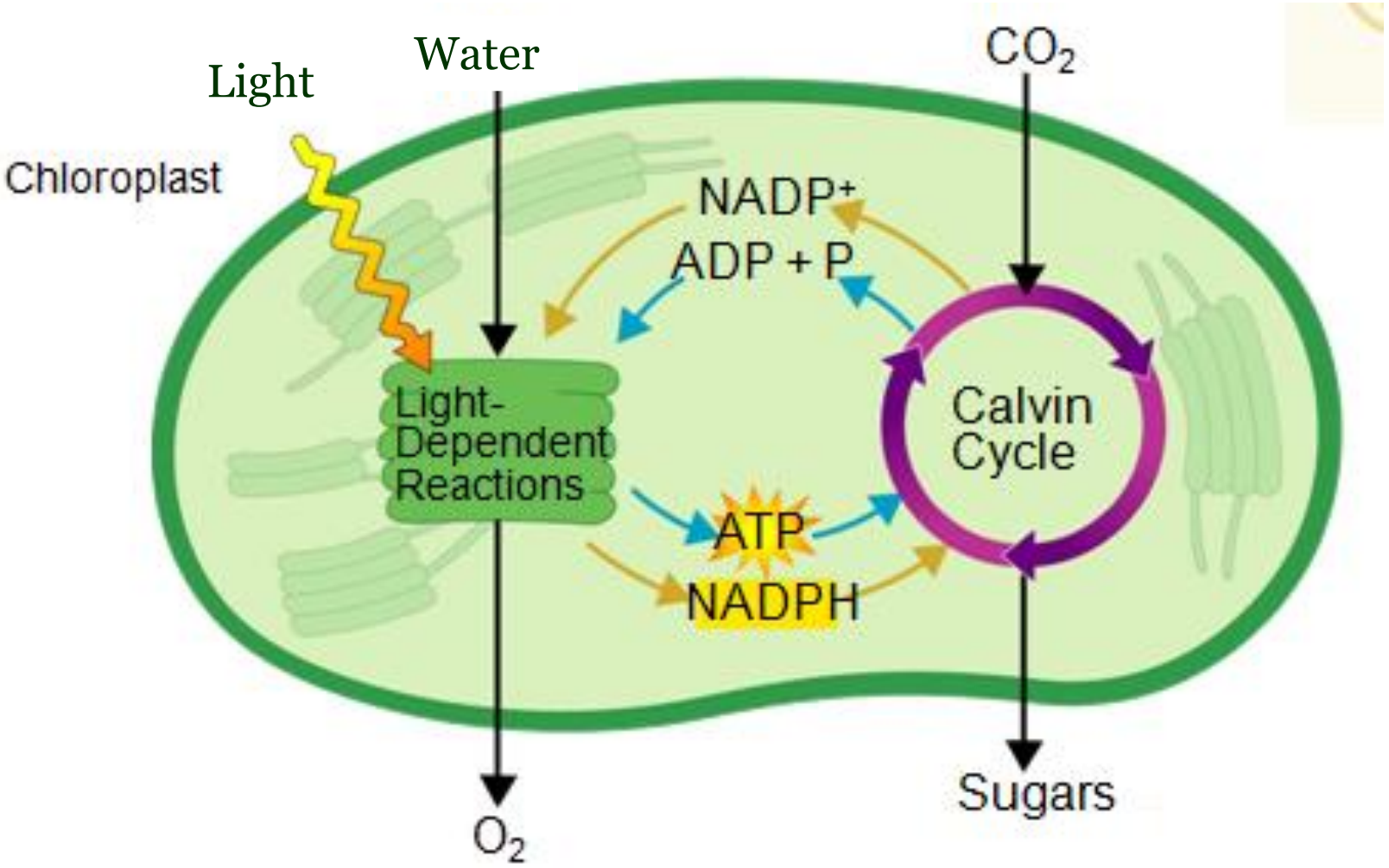
Phase 2→ LIGHT-INDEPENDENT RXNS

- AKA:
- NO light required
- Series of reactions that uses carbon dioxide which was absorbed via stomates of the leaves
  - Location → stroma of the chloroplast
- NADPH and ATP produced in phase 1 are important molecules in this series of reactions
- Produces PGAL which combines to form glucose : it takes 6 CO_2 and uses 18 ATP and 12 $NADPH_2$

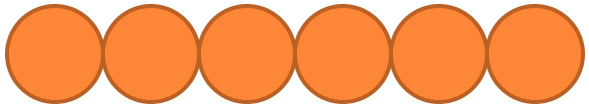
Photosynthesis

Oxygen comes from the splitting of H_2O, not CO_2

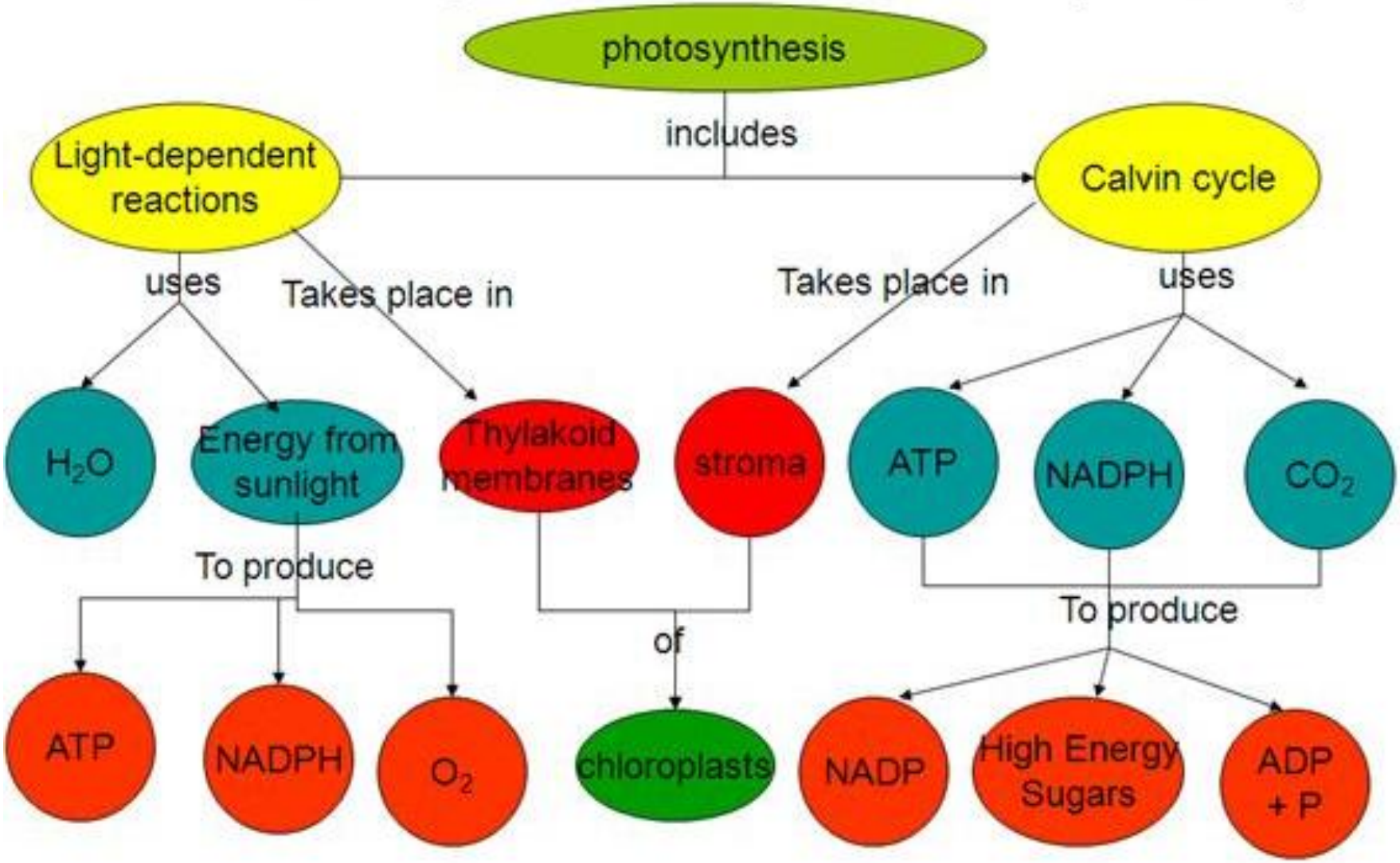



Light
Water
CO_2
Chloroplast
NADP+
ADP + P
Light-Dependent Reactions
Calvin Cycle
ATP
NADPH
O_2
Sugars

_____ IS NOW MADE!



Photosynthesis Concept Map



Review:

- What are the five (5) requirements for photosynthesis?
  -
  -
  -
  -
  -
- What is the equation for photosynthesis?

Review:

- Why do you see green when you look at a leaf on a tree?
- Where is chlorophyll stored?
- What are the two phases of photosynthesis?
  -
  -
- Glucose is made during what phase of photosynthesis?

Review:

- Where do light-dependent reactions occur?
- Where do light-independent reactions occur?
- Light-independent is also known as?
- What products are formed during the light dependent phase of photosynthesis?
- What products are formed during phase the Calvin cycle?