A young green plant with small white flowers is the central focus, growing against a bright, sunlit background. The text "Energy & Photosynthesis" is overlaid in white, serif font.

Energy & Photosynthesis

Energy for Life Processes

- Energy is the ability to cause matter to move or to change
- The ability to do work
 - Work for a cell includes:
 - Growth & repair
 - Active transport
 - Reproduction
 - Synthesis of molecules
 - Lots of other stuff!!!
- Free Energy = energy available to do work

Plants are Energy Producers

- Like animals, plants need energy to live
 - unlike animals, plants don't need to eat food to make that energy
- Plants make both **FOOD & ENERGY**
 - animals are consumers (heterotrophs)
 - plants are producers (autotrophs or photoautotrophs)



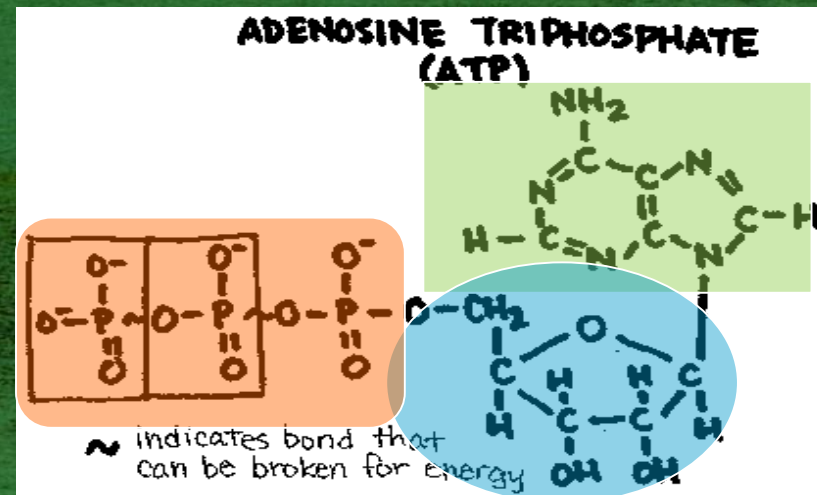
How do plants make energy & food?

- Autotrophs (plants and Cyanobacteria) use the energy from the sun
 - to make ATP energy
 - to make sugars
 - glucose, sucrose, cellulose, starch, & more



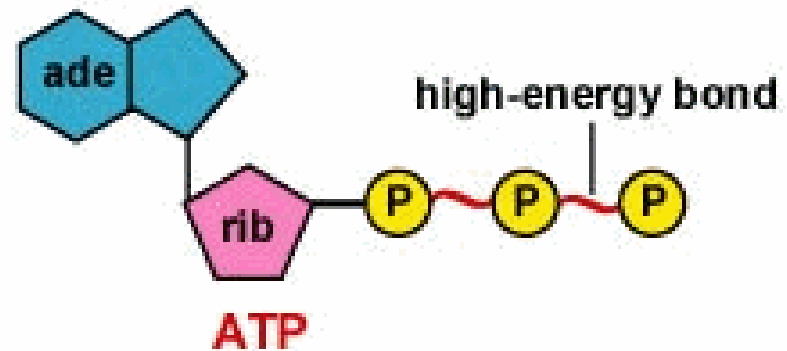
ATP: The Energy Molecule

- **ATP** = adenosine triphosphate
- most of the energy that drives metabolism is supplied by ATP!!
- Monomers- single building blocks:
 - Adenine: a nitrogenous base
 - Ribose: 5 Carbon sugar
 - 3 phosphate groups



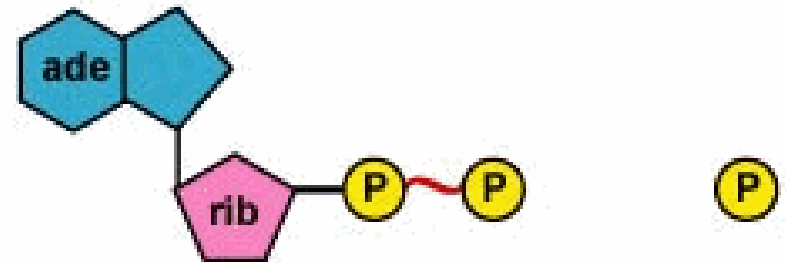
Where is Energy stored in the ATP molecule?

- Energy is in the chemical bonds between the phosphates



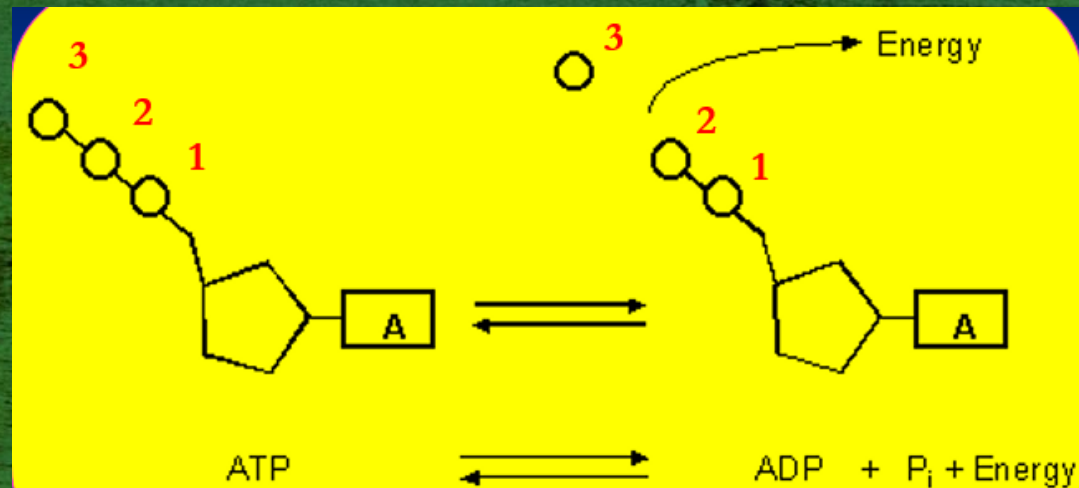
ADP Molecule

- **Adenosine diphosphate or ADP**
 - Has 2 **phosphate** groups
 - When a cell has energy available, it can store small amounts of it by phosphorylation (the addition of a phosphate group) to the ADP molecule, thus producing ATP



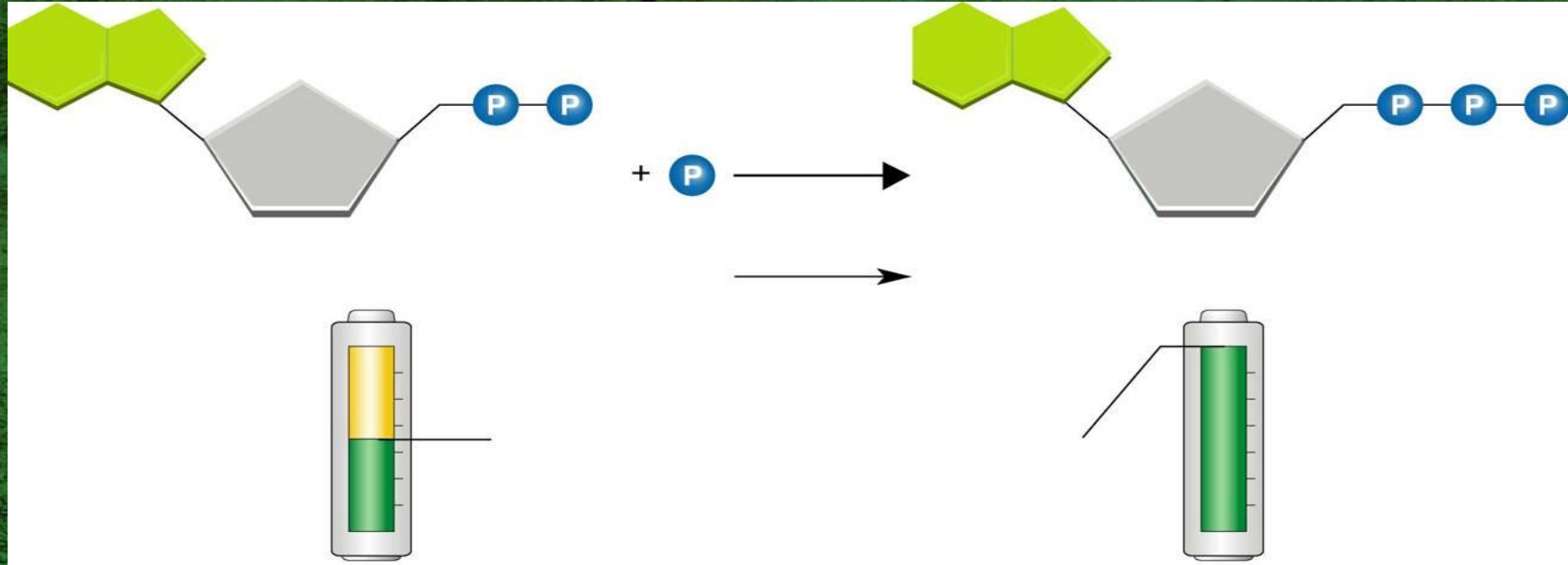
ATP/ADP cycle

- Energy is released by breaking the chemical bond between the 2nd and 3rd phosphates in ATP
- $\text{ATP} \rightarrow \text{ADP} + \text{Phosphate} + \text{Energy}$
- Adenosine triphosphate \rightarrow adenosine diphosphate
- Tri= 3; Di= dos= 2
- Remember: Energy is in the bonds between phosphates, so if we break a bond we must get energy as a product and ATP becomes ADP + Phosphate



ADP

ATP



Low-Energy Molecule

High-energy molecule

What happens
during the process of
photosynthesis?

Photosynthesis Reaction

PHOTOSYNTHESIS: A process in which plants and Cyanobacteria use the energy from sunlight to convert water and carbon dioxide into oxygen and high energy carbohydrates- such as sugar (monosaccharide) and starches (polysaccharide)

Reactants: carbon dioxide and water

Products: oxygen and sugar (monosaccharide- glucose)



OR

Carbon dioxide + water

sugars + oxygen

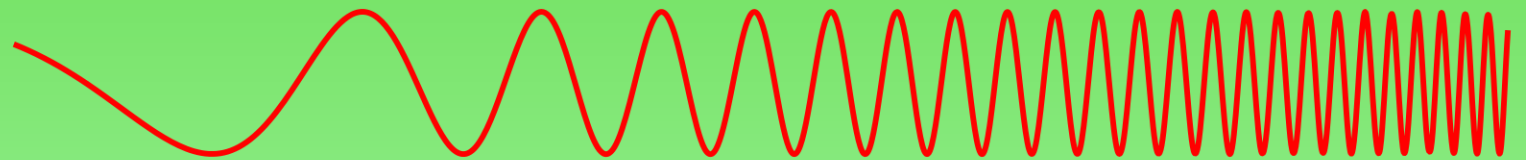
What role do
pigments play in the
process of
photosynthesis?

Light and Pigments

- Photosynthesis requires light and chlorophyll, a molecule found in chloroplasts.
- Energy from the sun travels to Earth in the form of light which appears “white”
 - Since light is a form of energy, any compound that absorbs light also absorbs the energy from that light
 - This light is actually made up of a mixture of different wavelengths of light- many of which are visible to your eyes

Light Energy & The Electromagnetic Spectrum

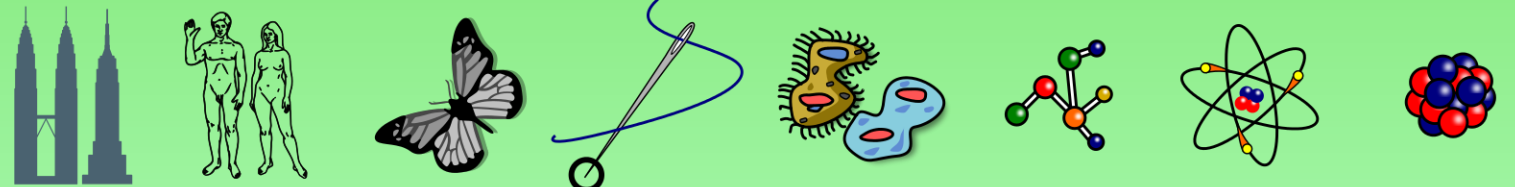
Penetrates Earth's Atmosphere?



Radiation Type
Wavelength (m)

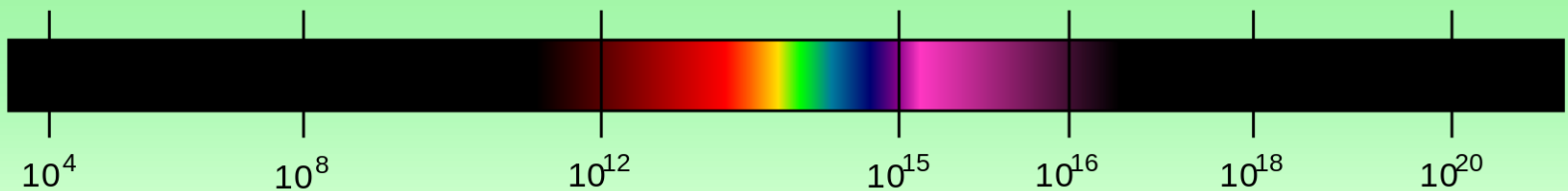


Approximate Scale of Wavelength



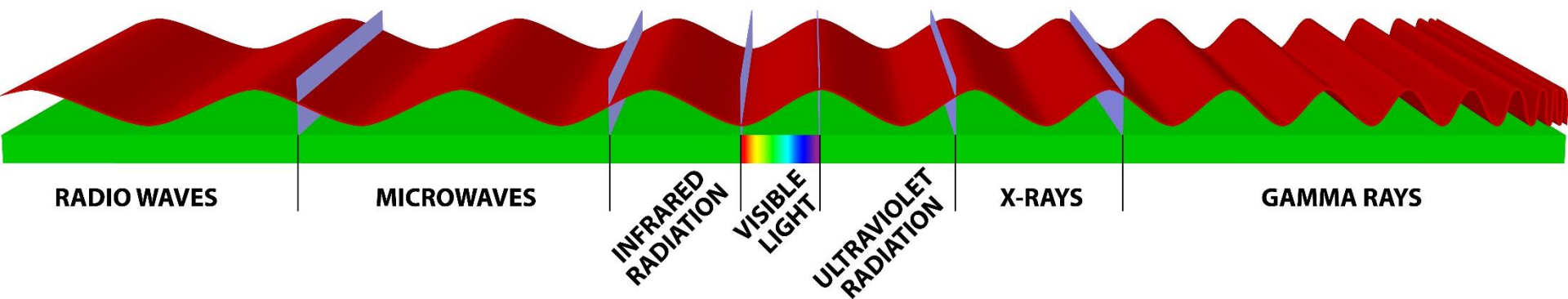
Buildings Humans Butterflies Needle Point Protozoans Molecules Atoms Atomic Nuclei

Frequency (Hz)



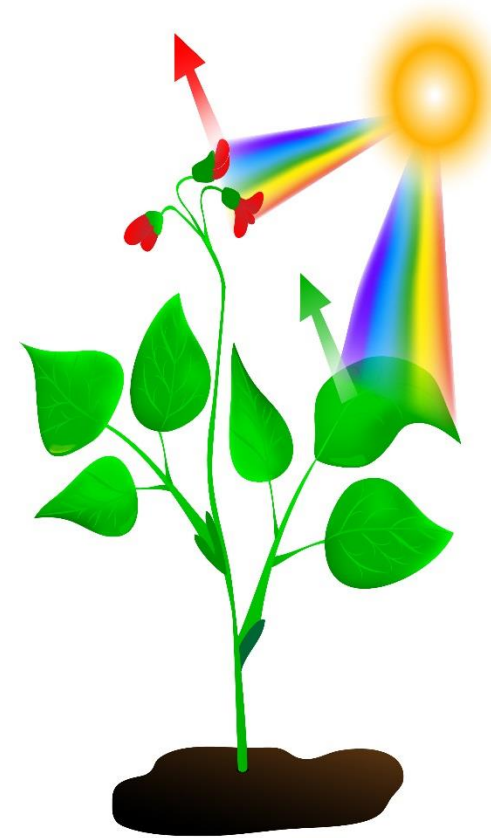
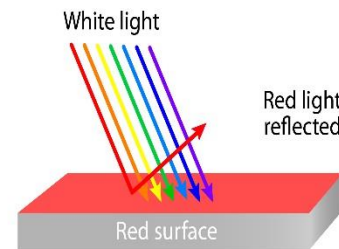
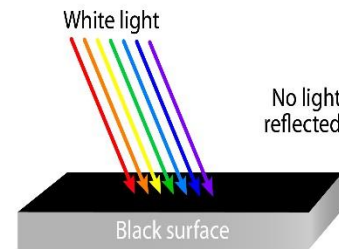
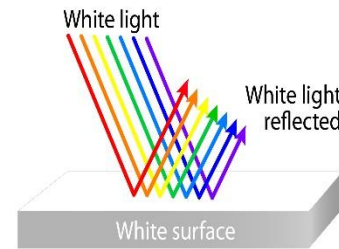
Wavelengths

- Electromagnetic radiation – form of energy that exhibits **wavelike behavior** as it travels through space
- **Longer** wavelength = **lower** energy
- **Shorter** wavelength = **higher** energy



Visible Light Spectrum

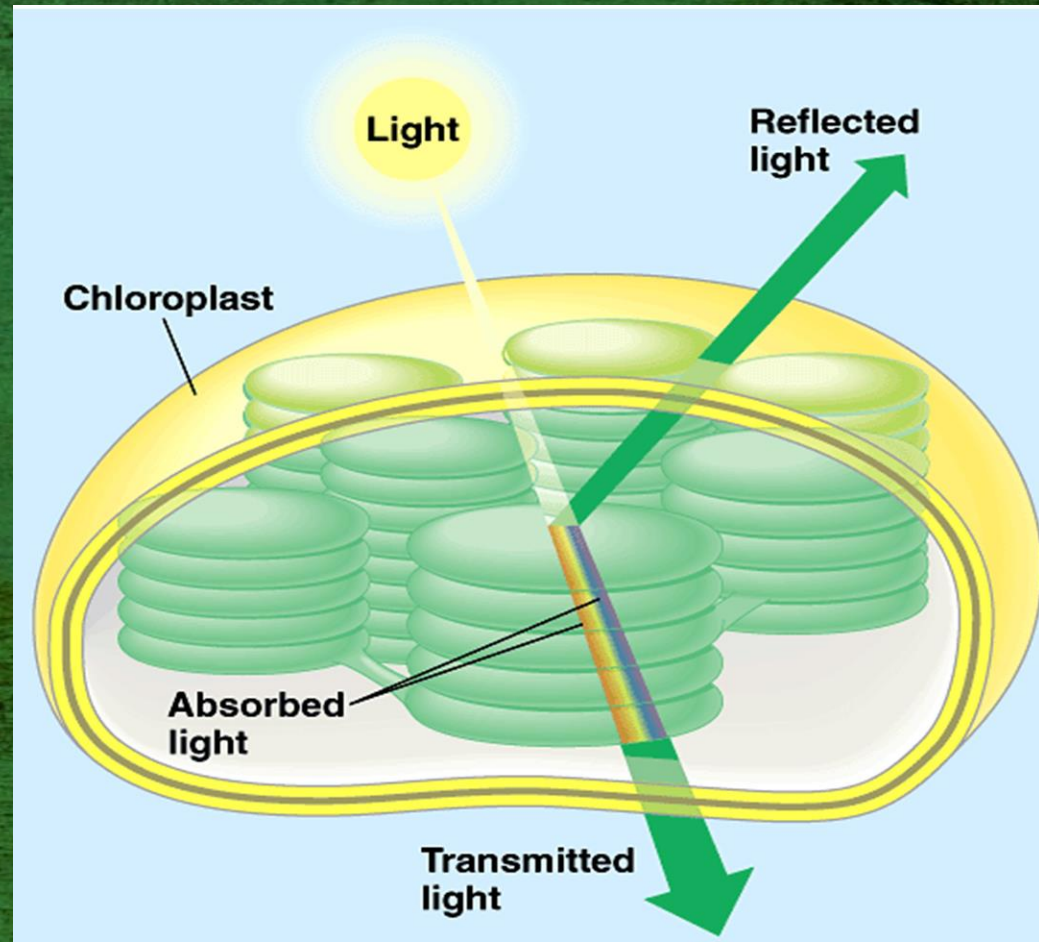
- The surface of an object reflects some colors and absorbs all the others. We perceive only the reflected colors.
- An object appears white when it reflects all wavelengths and black when it absorbs them all.

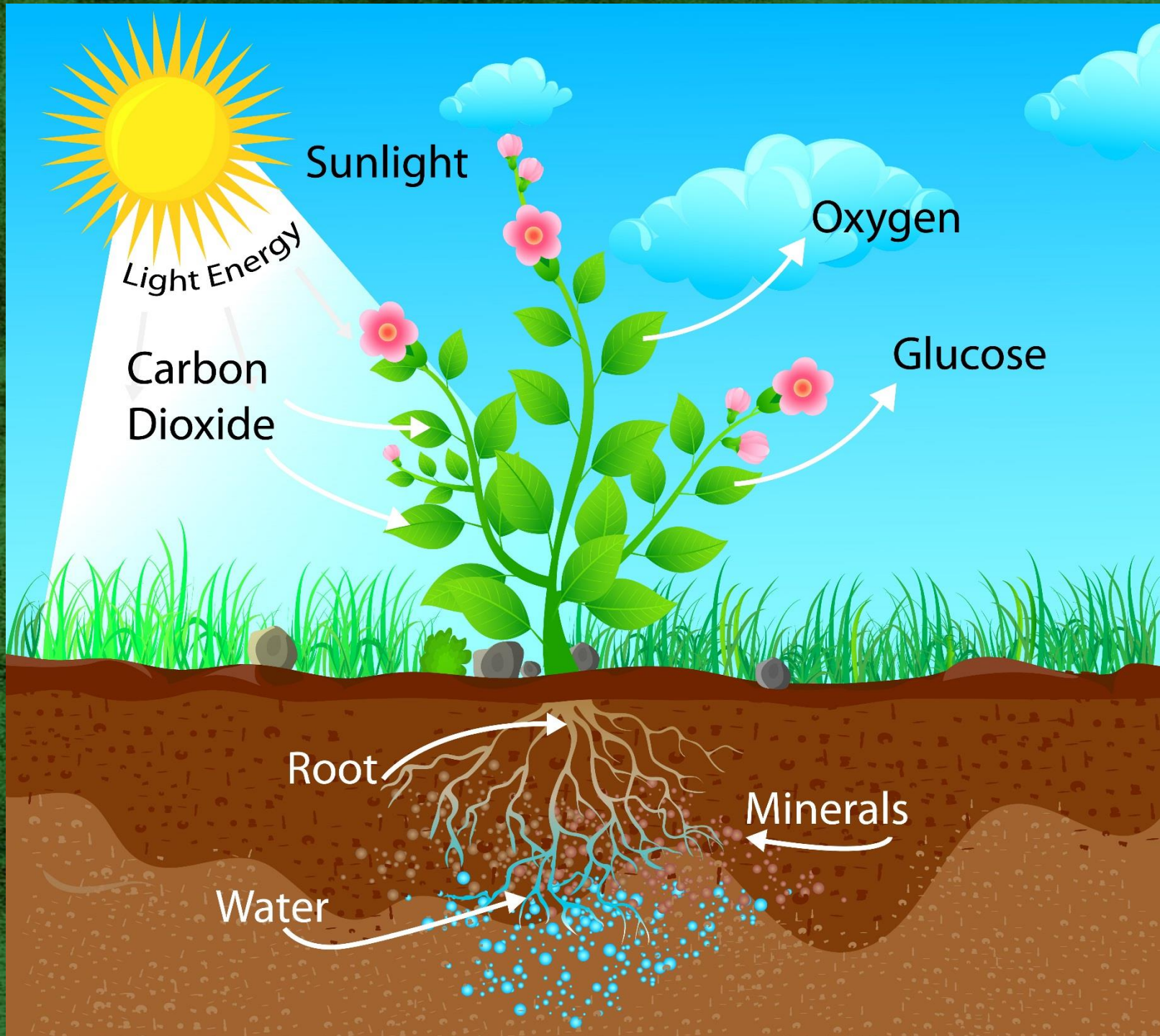


Chlorophyll

- Pigments **absorb** certain wavelengths, and reflects the others.
- The green pigment **chlorophyll** reflects green light, so we see green.

■ Do you think plants are able to grow under a green light?

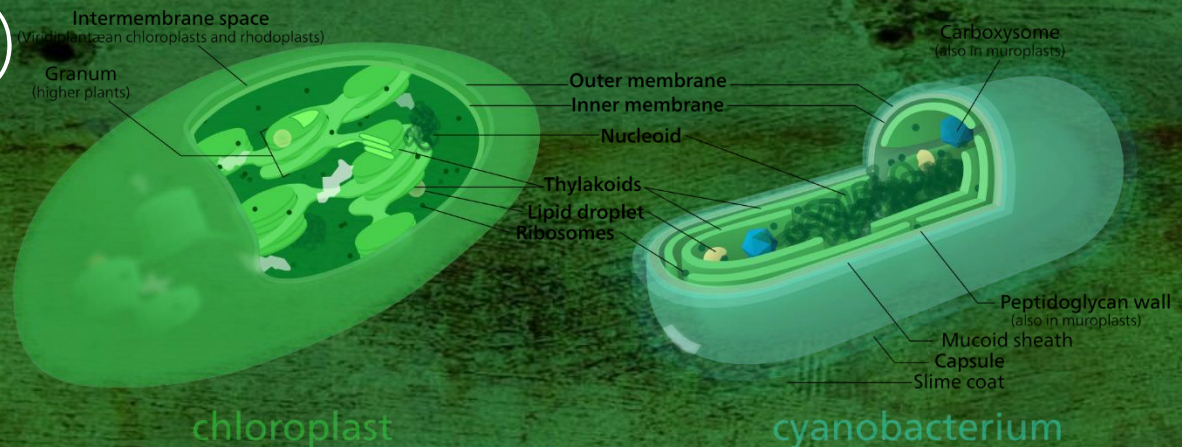




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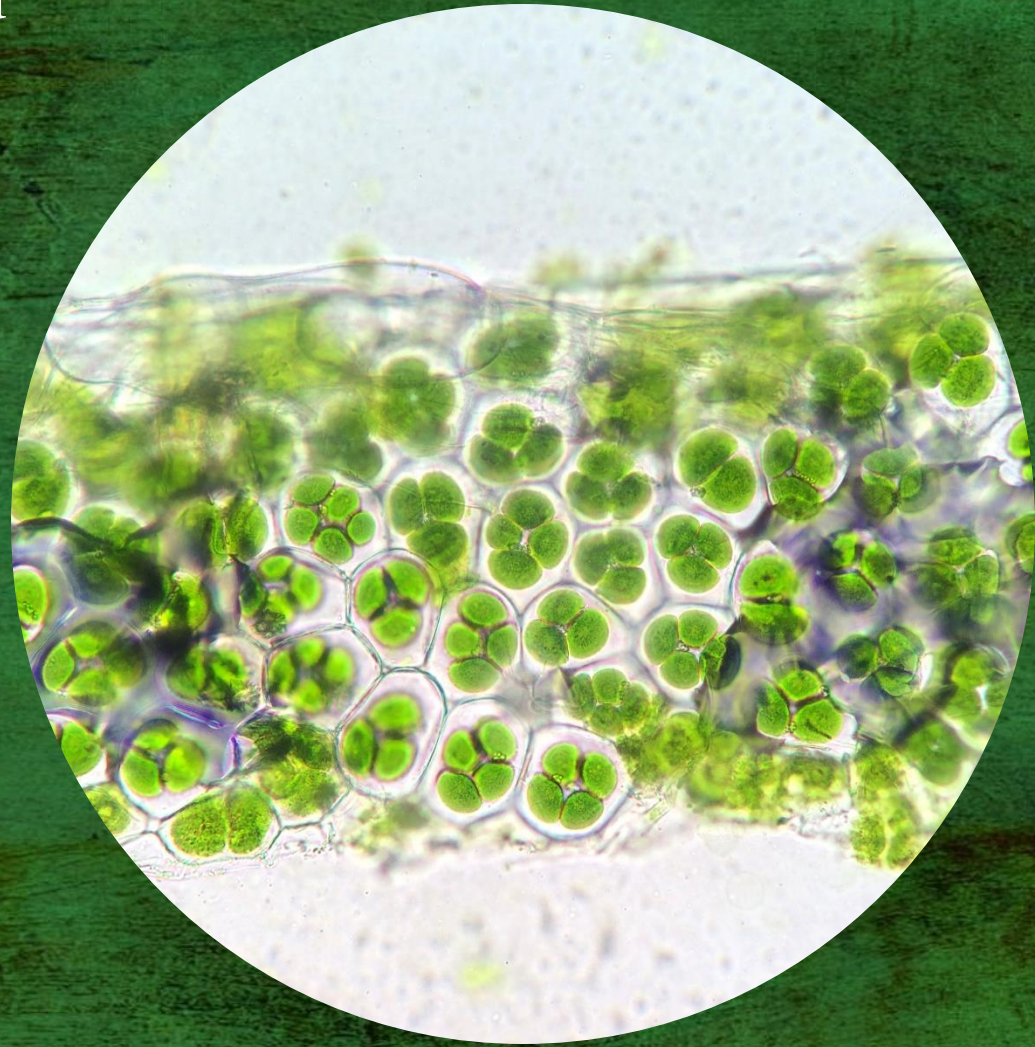
Photosynthesis

- A process in which plants and cyanobacteria use sunlight to convert water and carbon dioxide into oxygen and high-energy **sugars** and starches
- These organisms are **autotrophs**- create their own food using energy from the sun (photosynthesis)



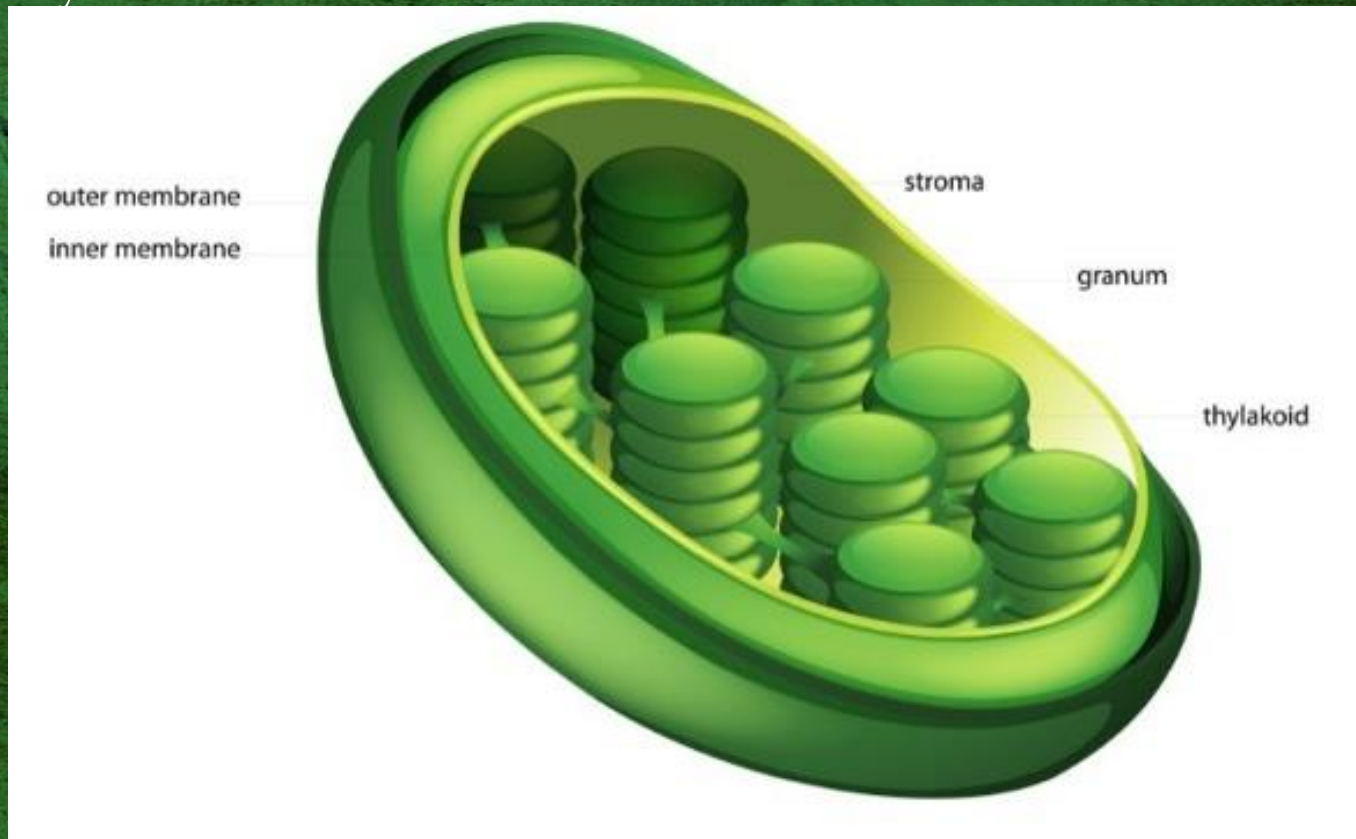
Chloroplasts

- Chloroplasts – Energy producing organelle found mainly in leaves of **plants** and some protists
- Contain **pigments** – pigments absorb light energy
 - Chlorophyll (green pigment) is a catalyst for photosynthesis-**it collects light**; it reflects green light
 - it transfers light energy into chemical energy



Chloroplast

- Site of **photosynthesis**
- Membrane enclosed organelle, only in **eukaryotes**
- Has 3 major parts:
 1. Thylakoids
 2. Granum
 3. Stroma



3 Major Parts of a Chloroplast

1. Thylakoid membranes: Inner membrane
 - Light-dependent reactions occur here
 - Embedded with chlorophyll & other pigments
 - Helps produce ATP
2. Grana (singular-granum)
 1. Stack of thylakoid membranes
 2. Increases light absorbing efficiency (surface area)
3. Stroma: dense, protein-rich gel like material surrounding Grana
 - Calvin Cycle (Light-Independent reaction) occurs here

Process of Photosynthesis

- 2 steps: 3 stages
- **Step 1 occurs in 2 Stages-**
 - Light-Dependent Reaction (Light Reaction):
 - occurs in the **thylakoid membrane** – requires light

Stage 1. Energy is captured from **sunlight** (pigments **absorb light**)

-**Water** (H_2O) taken **into chloroplast**

-**Oxygen** (O_2) is produced/**released** (this is what we breathe-it comes from the water that gets broken down)

Stage 2. Light energy is converted to chemical energy (which is temporarily stored as **ATP** & NADPH)

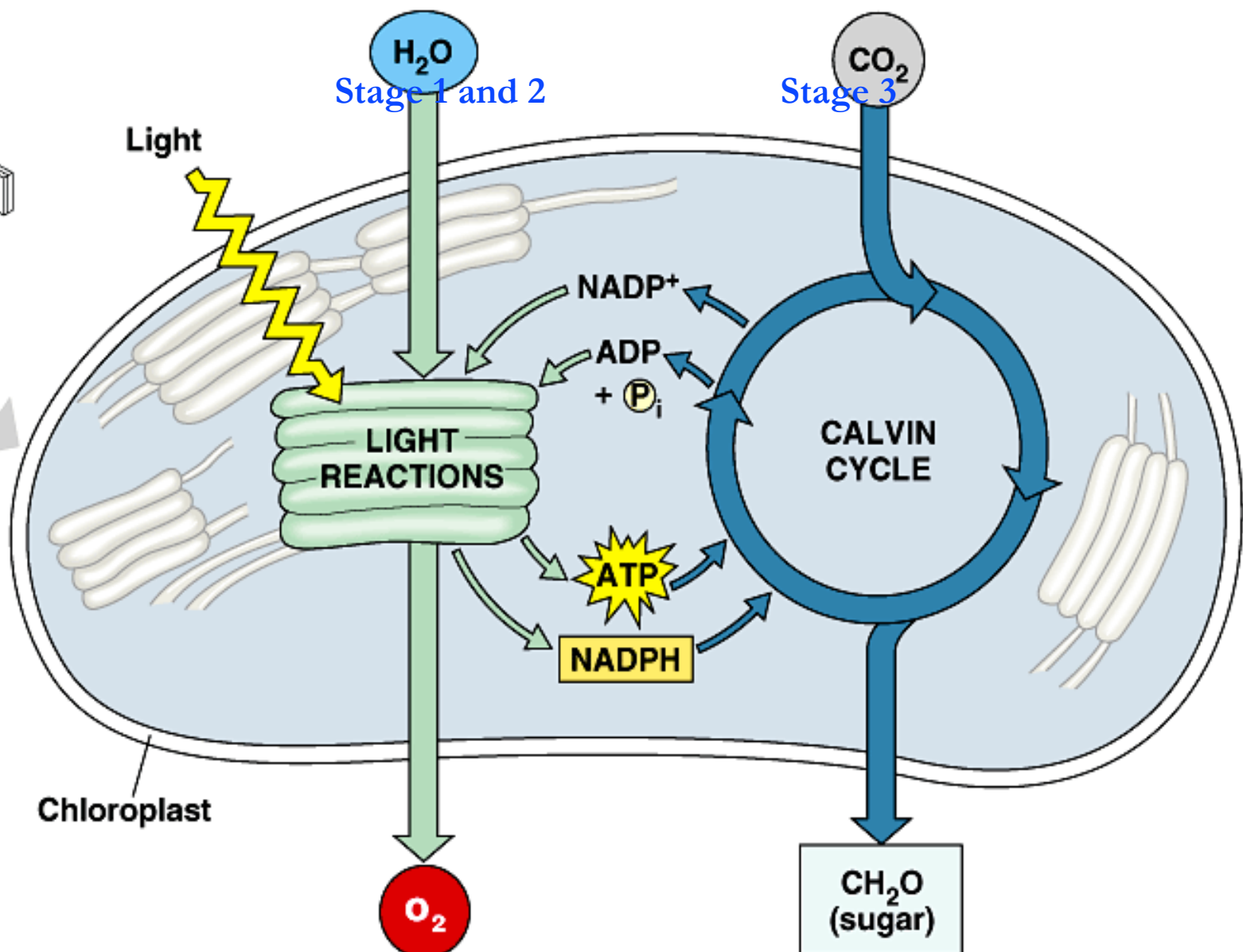
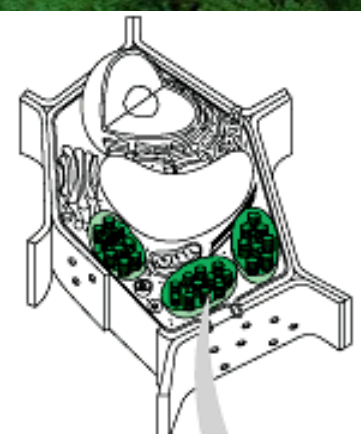
-**Energy** (**ATP** & **NADPH**) is produced to power the **2nd** step = Calvin Cycle

Calvin Cycle

(Light-Independent Reaction)

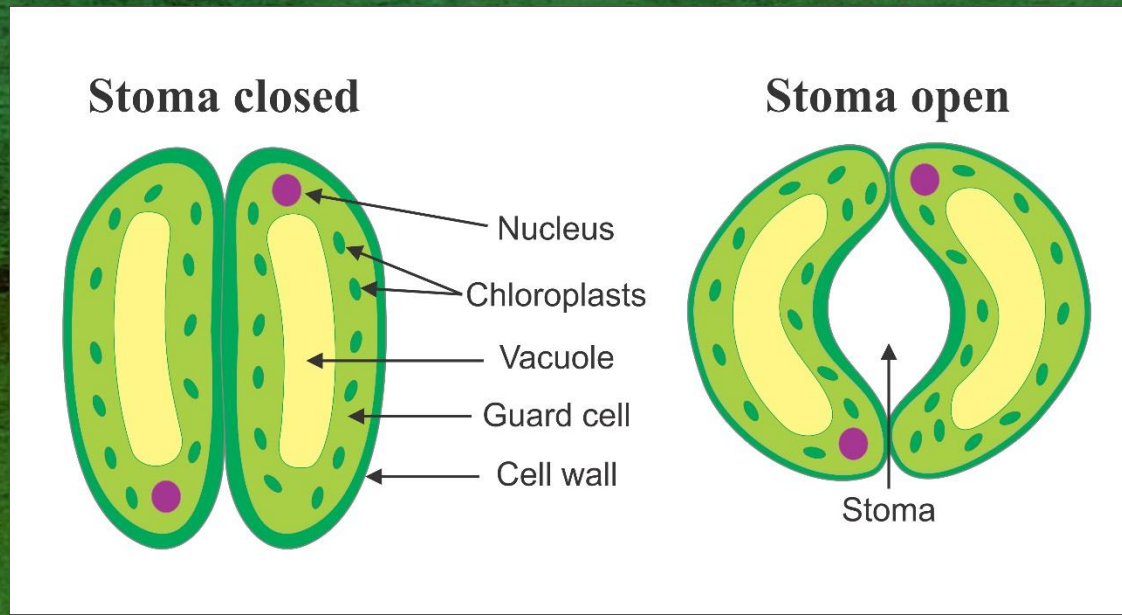
Step 2:

- Stage 3. **Calvin Cycle** (Light-Independent Reaction) – occurs in **stroma**
 - **Carbon dioxide** (CO_2) is taken from atmosphere and brought into the chloroplast
 - Energy from the light reaction makes high-energy sugars (**glucose**)
 - the chemical energy in the ATP & NADPH from light-dependent reaction powers the formation of **glucose** (high-energy sugar) using CO_2



How are gases & water exchanged in plants?

- **Stoma** (singular), **stomata** (plural)
 - Pore or opening found on plant leaves and stems used to control the **exchange of gas** (oxygen & carbon dioxide)
 - **Guard cells**- surround each stoma; regulate the rate of transpiration (evaporation of water) by opening and closing the stomata, help to maintain homeostasis



Factors Affecting the Rate of Photosynthesis

1. Light Intensity:

- Increasing light can speed up photosynthesis
- Extreme intensity can damage the chlorophyll

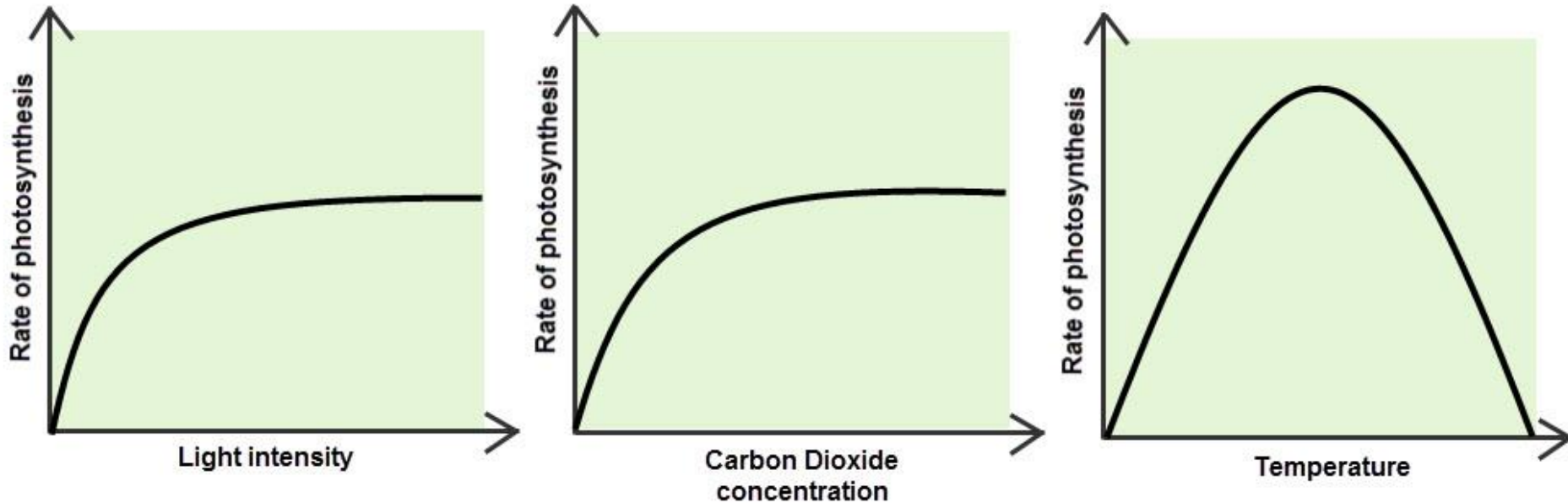
2. Availability of raw materials: (CO₂, H₂O)

- A shortage of these can slow or even stop photosynthesis

3. Temperature:

- 0-35°C is ideal for enzymatic function

Rates of Photosynthesis vs. Regulating Factors



- What happens as you continue to increase the light intensity that the plant receives?
- What happens as the temperature of the environment the plant is in continues to increase?