
Unit 7
Photosynthesis

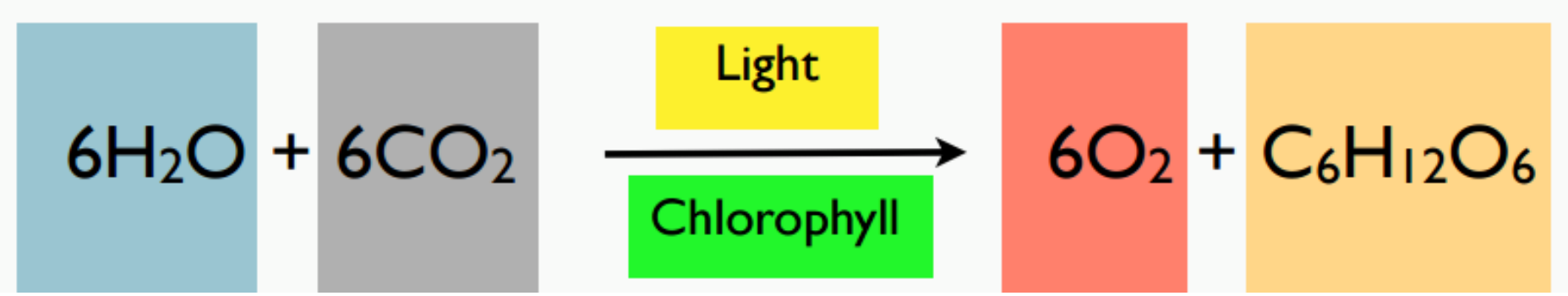
- Have Chloroplasts
- Have Stomata
- Use CO_2
- Live on rocks or in bogs.

Venus Fly Trap Carnivorous Plant

What are carnivorous plants really eating?

Pitcher Plant Carnivorous Plant

Photosynthesis Equation

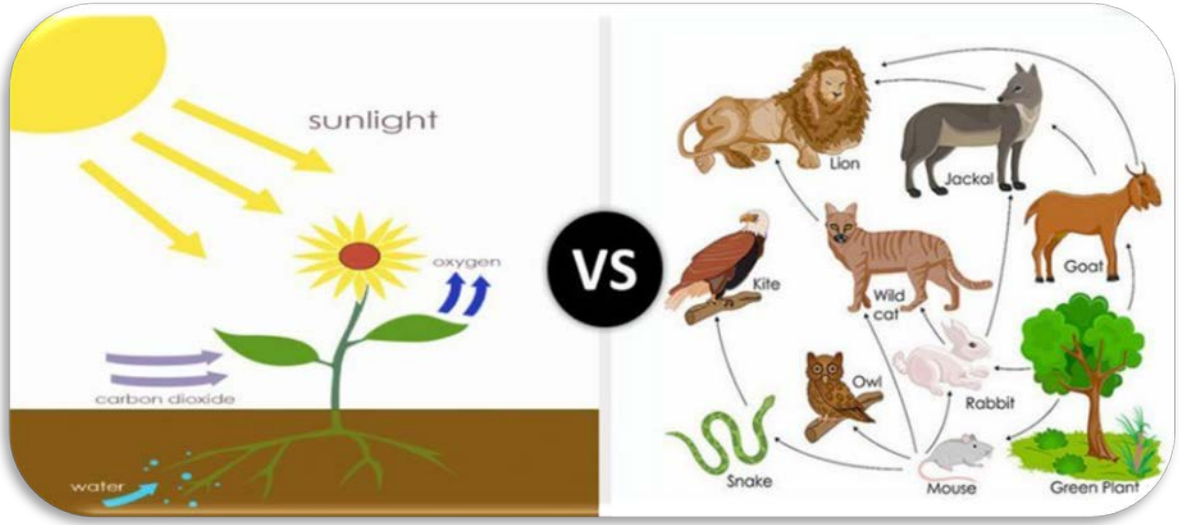


- Two experiments were conducted in early 20th century.
  - Experiment #1: Radioisotope in water
  - Experiment #2: Radioisotope in carbon dioxide

Autotroph or Heterotroph?

- Autotrophs
- Ultimate source of their energy?

- Heterotrophs
- Ultimate source of their energy?



Photosynthesis

What do we know for sure?

Overview of Photosynthesis

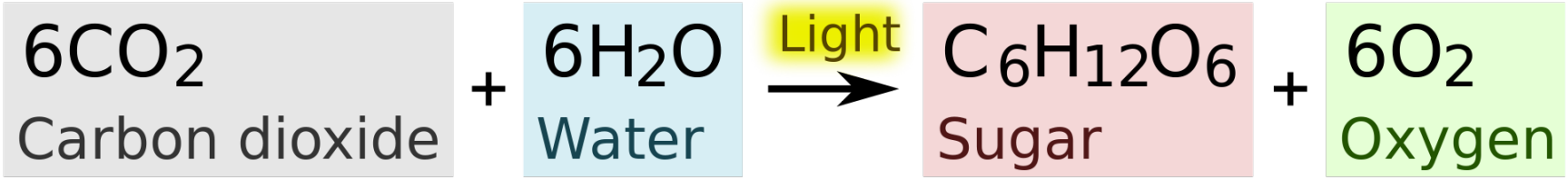
How to Understand Photosynthesis

Photosynthesis can be summarized by a chemical equation.

Based on the law of conservation of matter—it cannot be created or destroyed. To really understand photosynthesis, you will need to figure out exactly when and where the C, H, O in the reactants disassemble to become the C, H, O in the products.

Photosynthesis is achieved in two steps; each serves a very specific purpose—don't be distracted by all of the steps and helpers—figure out the big picture. What needs to happen and how has the cell evolved to ensure it happened!

Equation for Photosynthesis



In the 1940's, Scientist's tried to figure out what part of the glucose and oxygen gas is made from carbon dioxide and water.

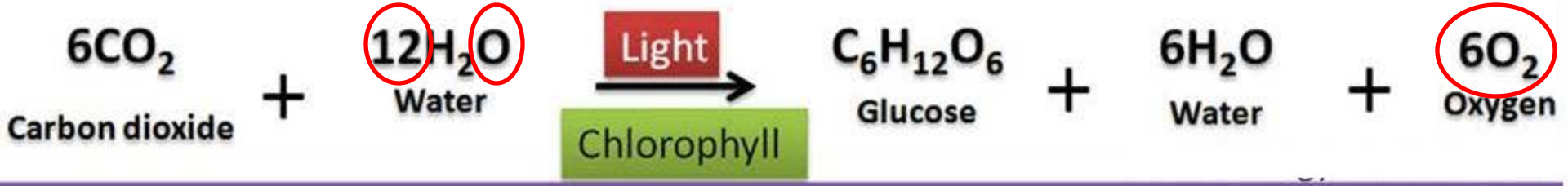
They conducted a series of experiments using isotopic water and isotopic carbon dioxide. The oxygen in these isotopic compounds can be detected as it is broken down and used by the plant.

Experiment #1: CO_2 + Isotopic H_2O → Isotopic O_2

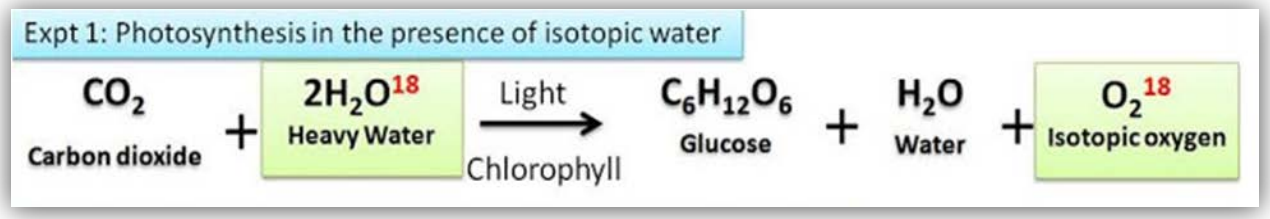
If we can conclude from this experiment that when water breaks down in the plant, the oxygen is freed and is released by the plant as O_2.

Look at the **BALANCED** equation above. **Does anyone see any issue?**

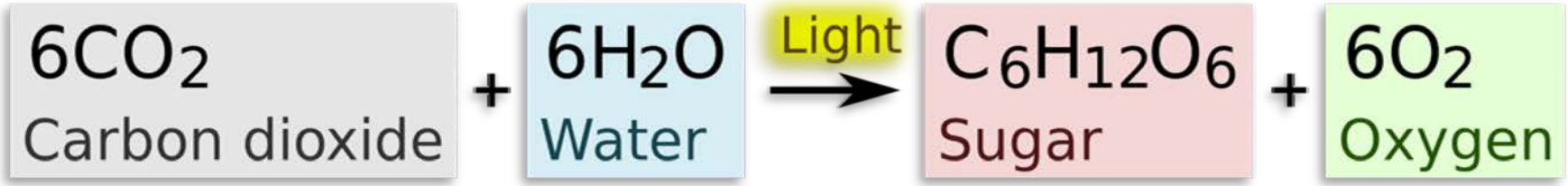
Experiment #1 Demonstrates



Correct equation of photosynthesis



Why do you think that the equation for photosynthesis below is more commonly found in textbooks—than the equation above?



Experiment #2 Demonstrates

Expt 2: Photosynthesis in the presence of isotopic carbon dioxide

CO_2^{18} Carbon dioxide + $2H_2O$ Water $\xrightarrow[\text{Chlorophyll}]{\text{Light}}$ $C_6H_{12}O_6^{18}$ Glucose + H_2O^{18} Heavy Water + O_2 Oxygen

$6CO_2$ Carbon dioxide + $12H_2O$ Water $\xrightarrow[\text{Chlorophyll}]{\text{Light}}$ $C_6H_{12}O_6$ Glucose + $6H_2O$ Water + $6O_2$ Oxygen

Correct equation of photosynthesis

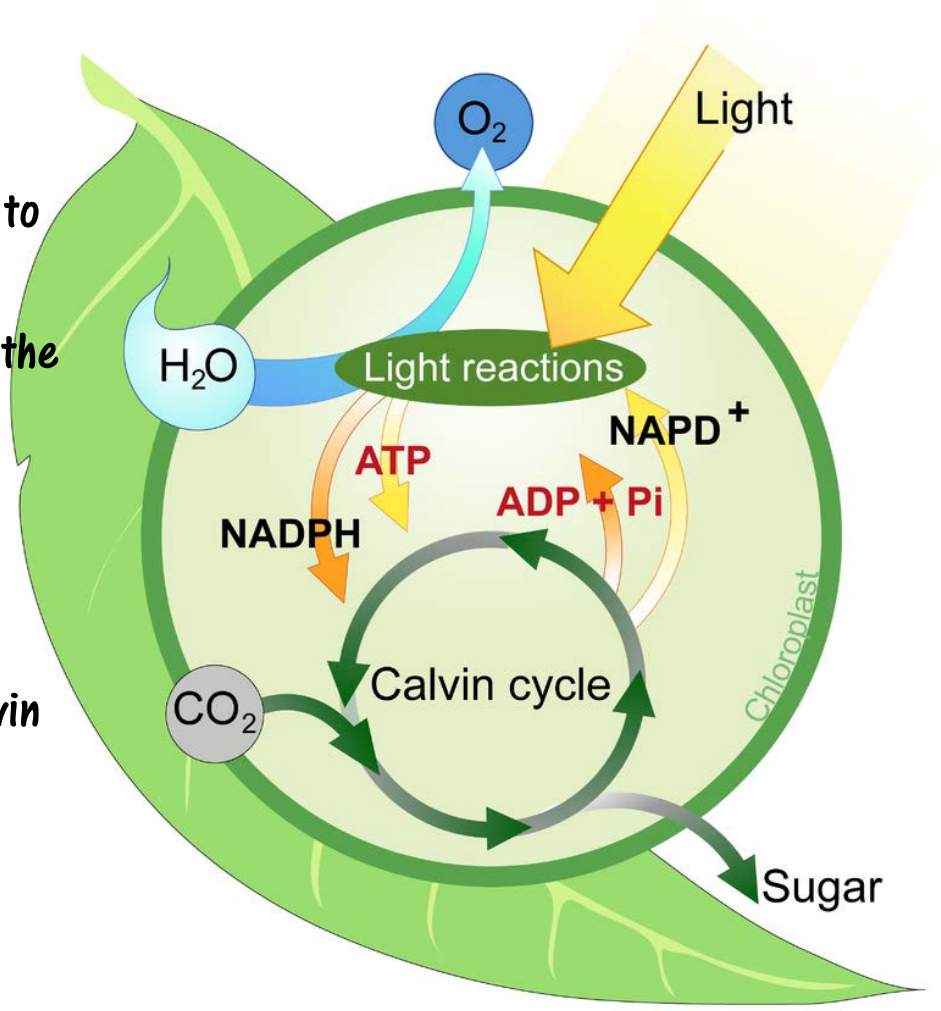
Based on the two experiments….

- When water is split into Hydrogen and Oxygen, those specific
  - Hydrogen atoms become incorporated into the _____ molecules found in the products.
  - Oxygen atoms become incorporated into _____found in the products.

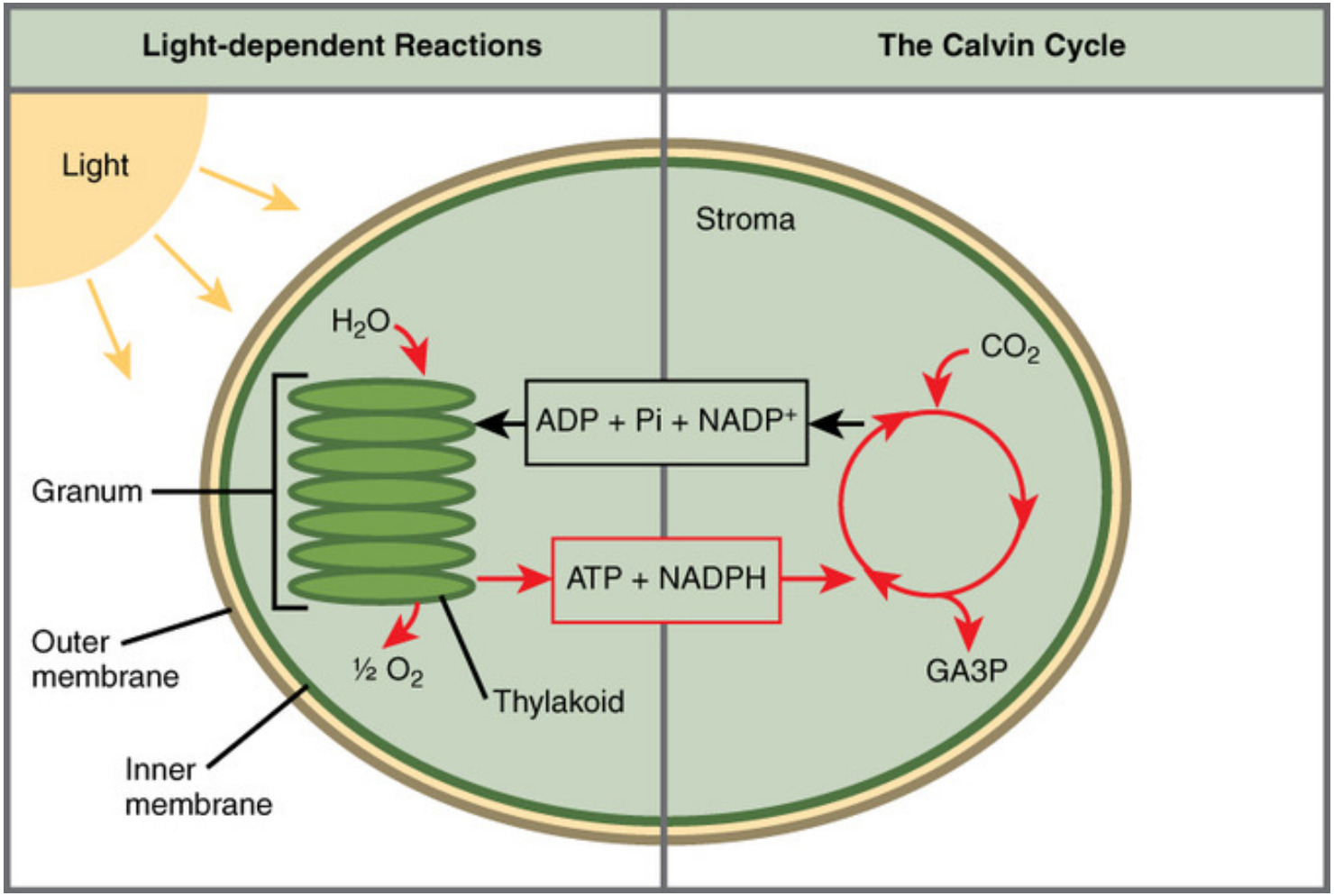
•When carbon dioxide is split into Carbon and Oxygen, those specific
  - Carbon atoms become incorporated into the _____ molecule found in the products.
  - Oxygen atoms become incorporated into the _____molecule and _____ molecules found in the products.

The Ins & Outs of Photosynthesis

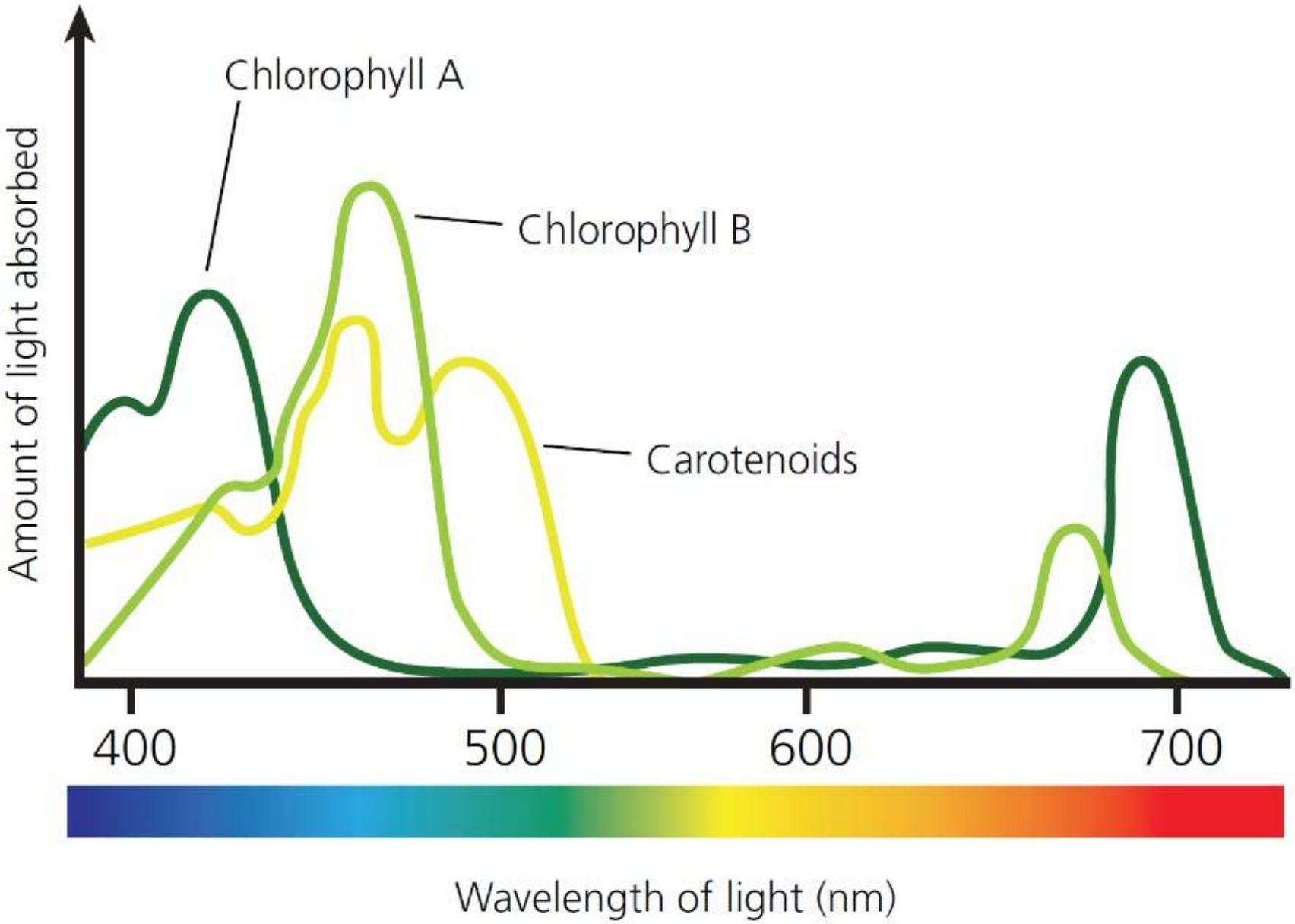
- Where does photosynthesis occur in the plant?
- What is the ultimate source of energy?
- What has to enter the plant for photosynthesis to take place?
- What is already in the cell—ready to assist in the process of photosynthesis?
- What goes into the light reactions of photosynthesis? What comes out?
- What is the purpose of the light reactions?
- What does the light reaction provide to the Calvin Cycle?
- What is the purpose of the Calvin Cycle?



Orientating to the Structures that Facilitate Photosynthesis



Is all Light Equal for Photosynthesis?



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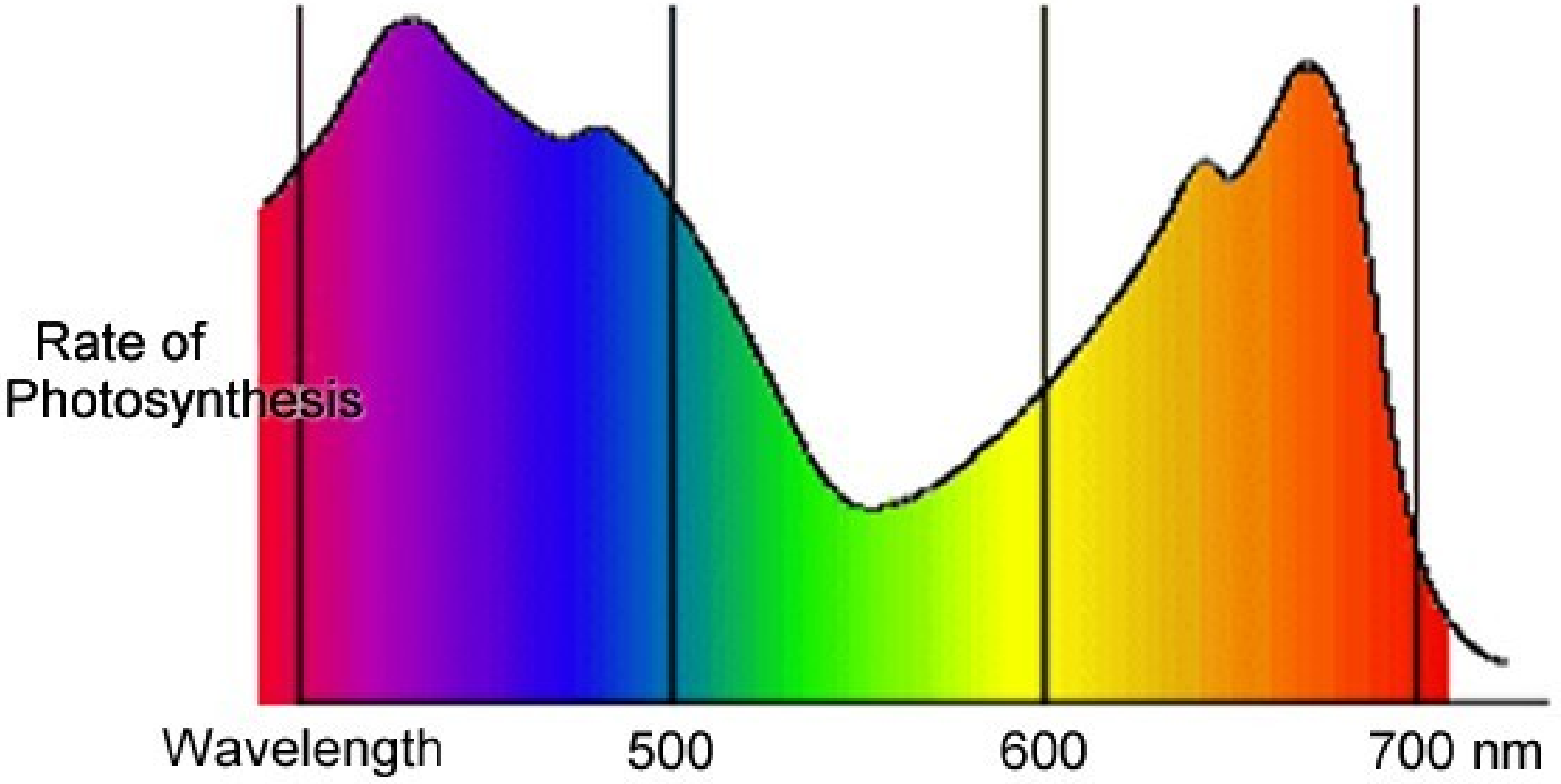
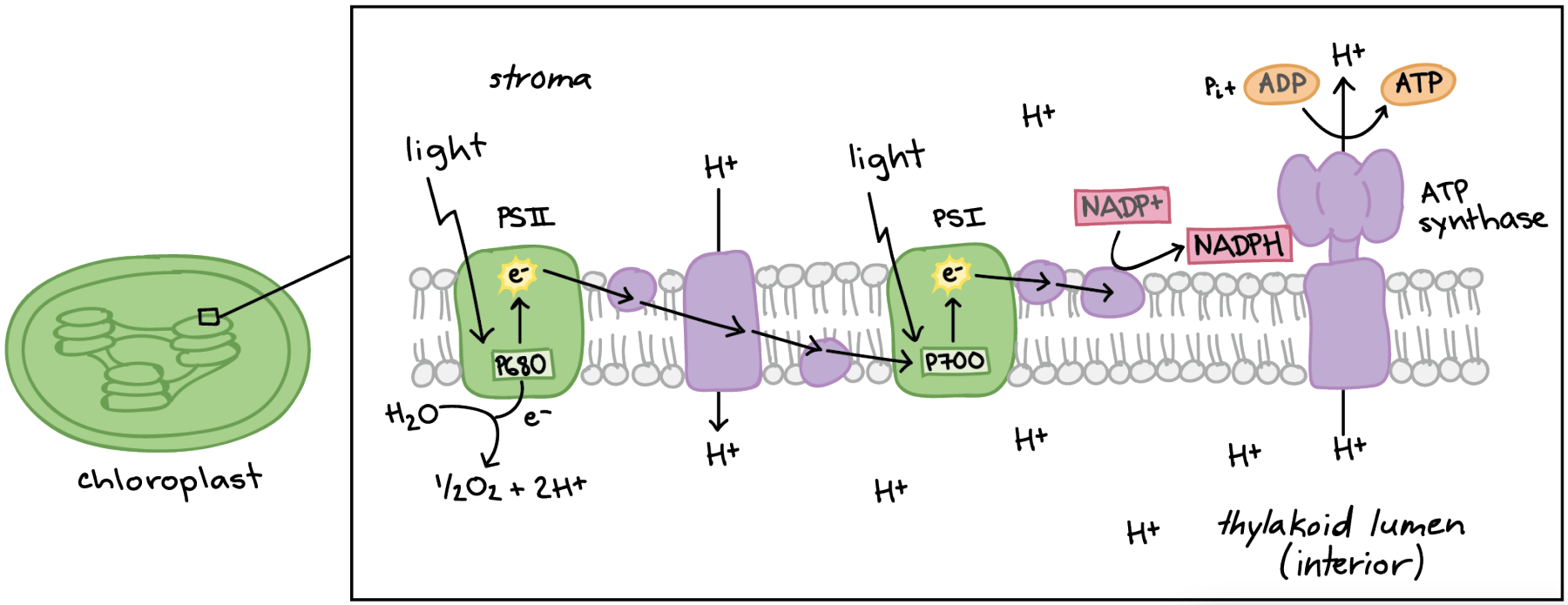


Light Dependent Reaction



Where are chloroplasts in the cell?

What is this plasma membrane?

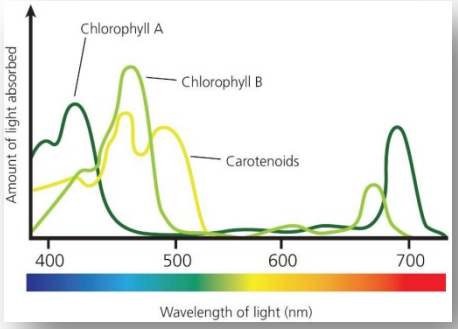
Where is the Stroma? Thylakoid Lumen?

What are the green and purple structures called in the cell membrane?

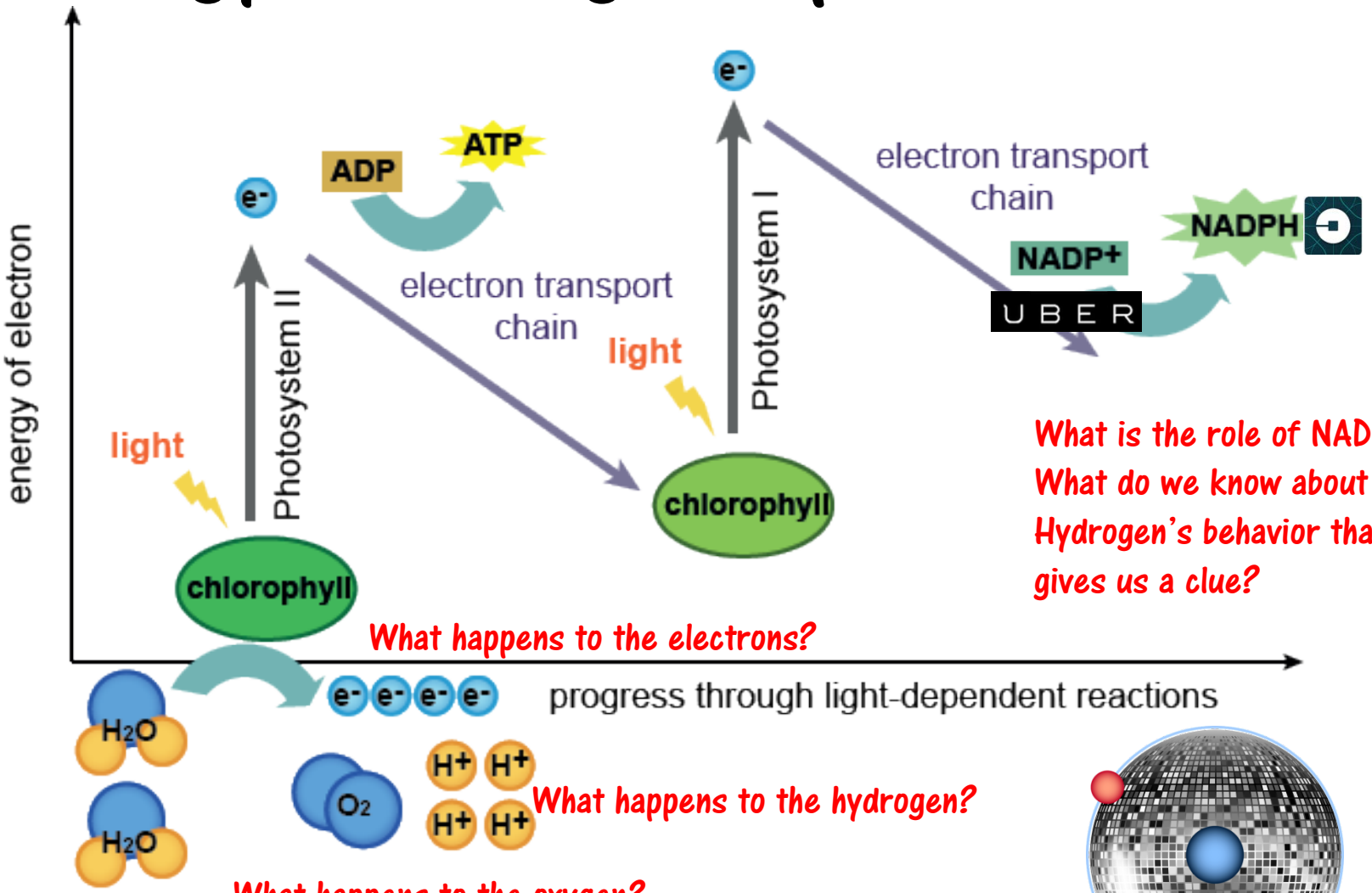
Do you see any proteins capable of enzymatic reactions?

Is this an example of active or passive transport? Is this process driven by energy?

Concentration gradient? Both?



Energy of the Light Dependent Rxns

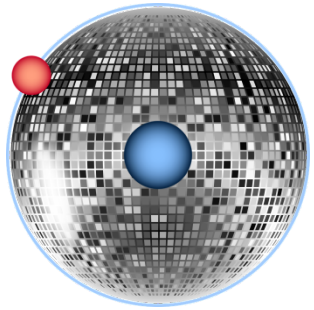


What is the role of NADP+?
What do we know about Hydrogen's behavior that gives us a clue?

What happens to the electrons?

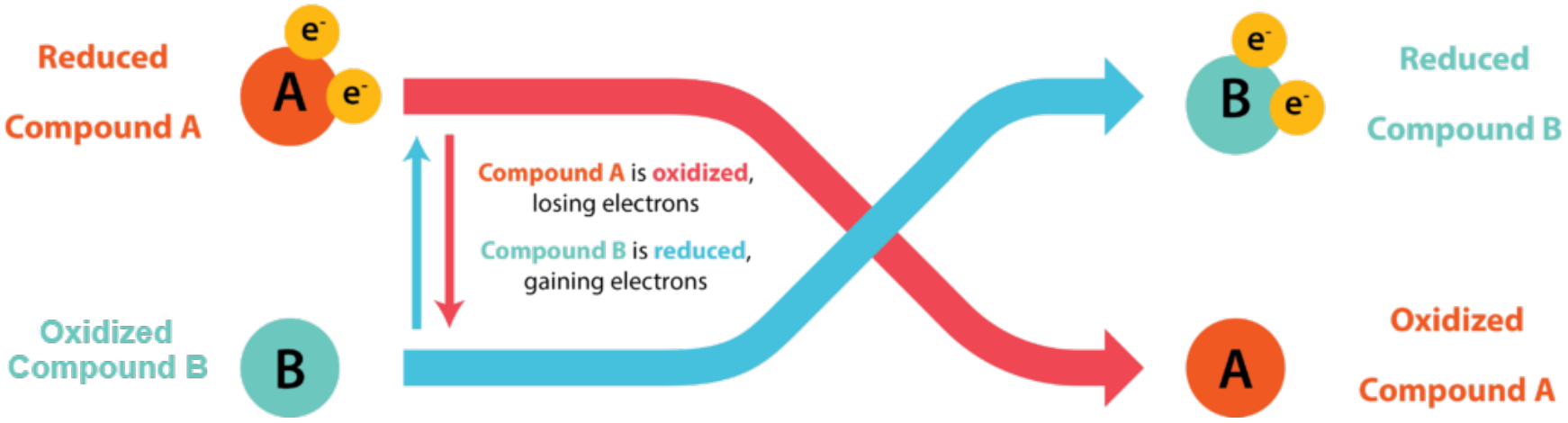
What happens to the hydrogen?

What happens to the oxygen?



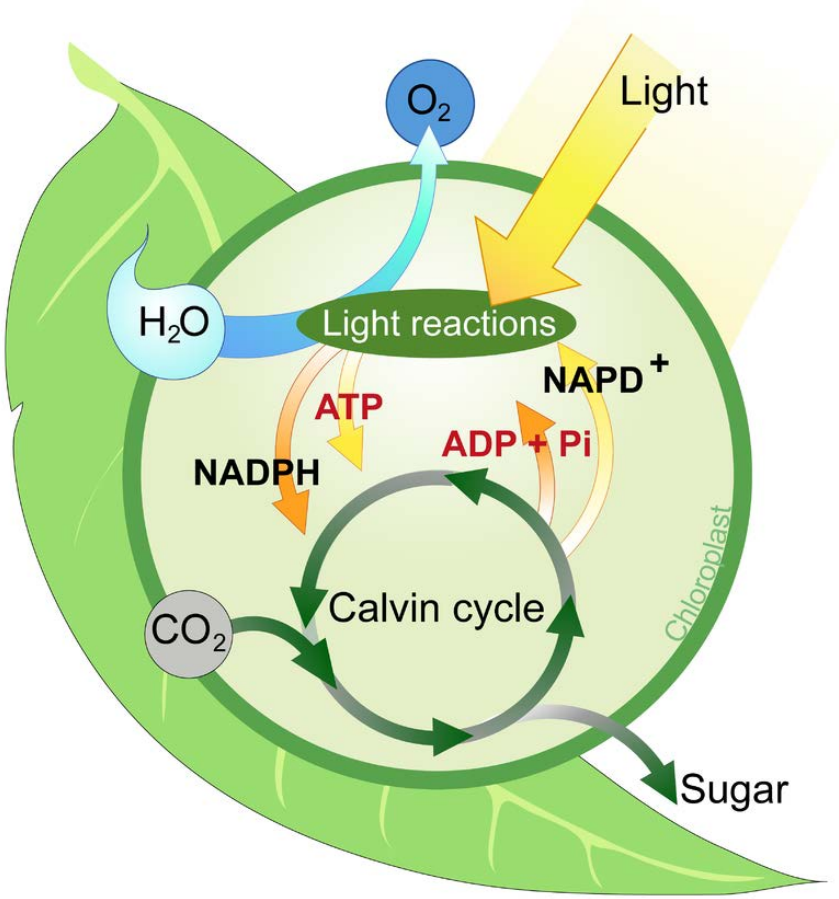
Check for Understanding

- What is the ultimate goal of the light dependent part of photosynthesis?
- In the light-dependent reaction, what compound is being oxidized?
- In the light-independent reaction, what compound is being reduced?
- What does the plant need to undergo the light dependent part of photosynthesis?



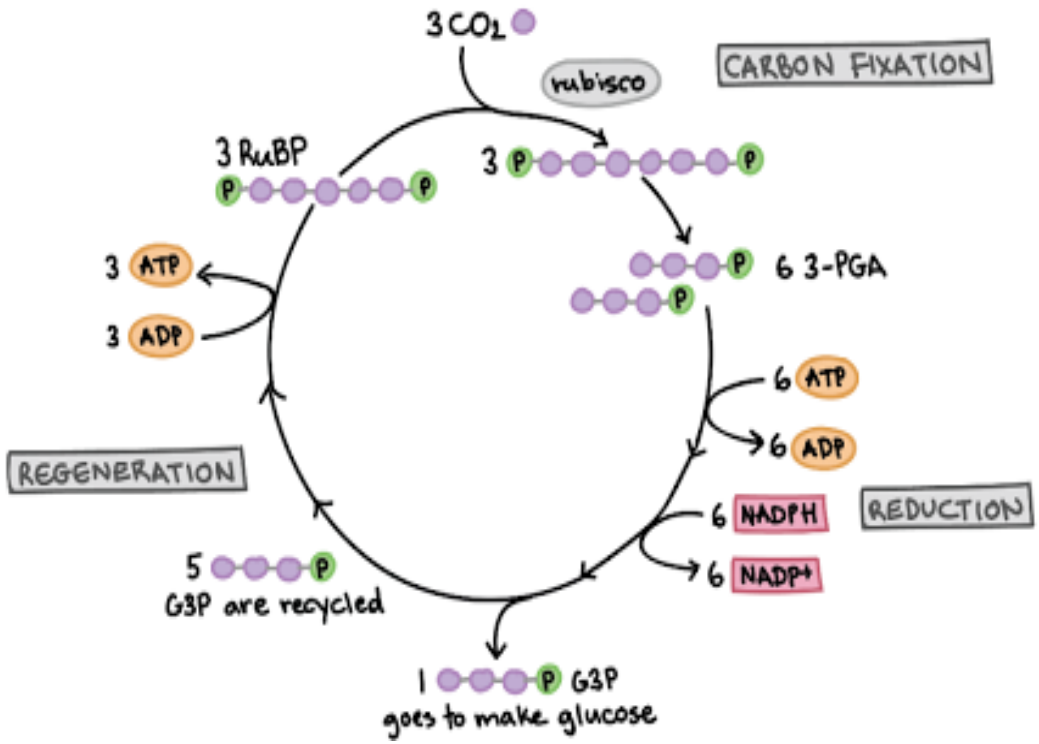
Overall Reaction for Photosynthesis

- What is needed for the light-independent reactions?
  - Sourced from light dependent reactions
  - Sourced from the environment
- If the light-dependent reaction needs sunlight, it stands to reason that it can only happen when there is abundant sunlight—when do you think the Calvin Cycle occurs if it depends on the products of the light-dependent reaction and reactants from the environment?

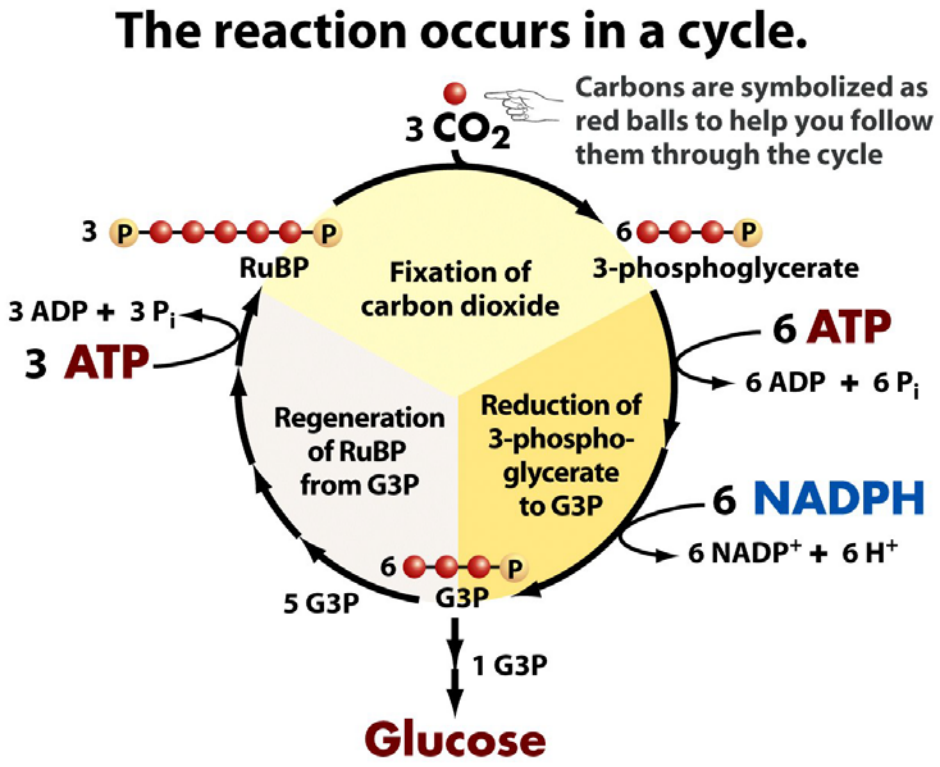


Light Independent Reaction—The Calvin Cycle

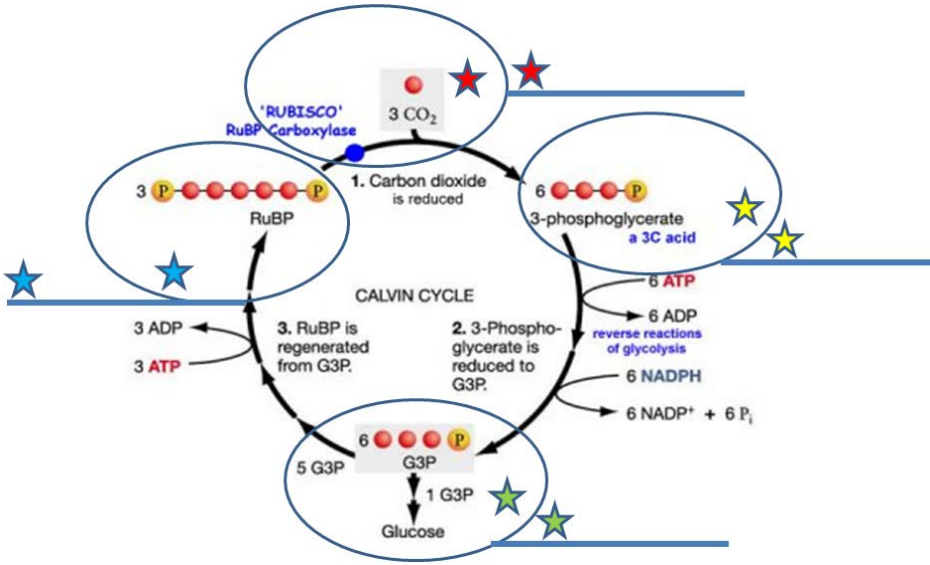
- Fixation
  - What does it mean to fix carbon?
  - What is responsible for fixing carbon dioxide?
- Reduction
  - What does it mean to reduce a molecule?
  - What is responsible for reducing PGA?
- Creation/Regeneration
  - What is produced after 1 turn of the cycle?
  - What must be regenerated?



The Calvin Cycle is a Series of Enzymatic Reactions—Need Rubisco (RuBP) to Work!



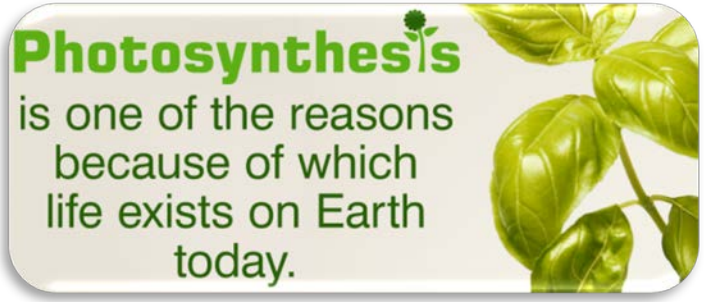
Count the Carbons!



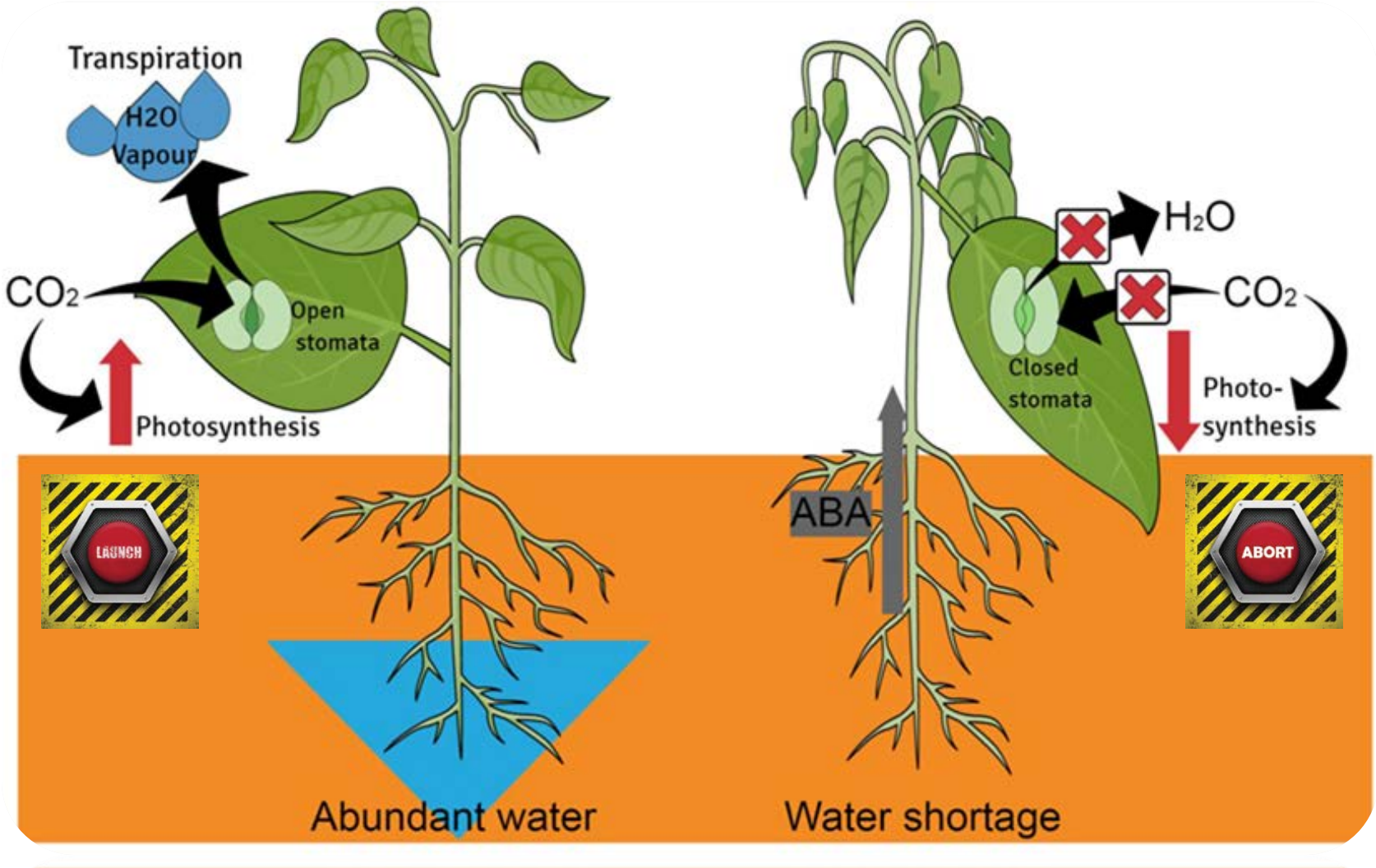
Visualizing the Cycle

Summary of Photosynthesis

- Light Dependent
  - Daytime/Nighttime?
  - Specific location in the chloroplast?
  - Reactants?
  - Products?
  - Helper Molecules?
  - Helper Structures?
- Light Independent
  - Daytime/Nighttime?
  - Specific location in the chloroplast?
  - Reactants?
  - Products?
  - Helper Molecules?



Factors that affect the rate of Photosynthesis

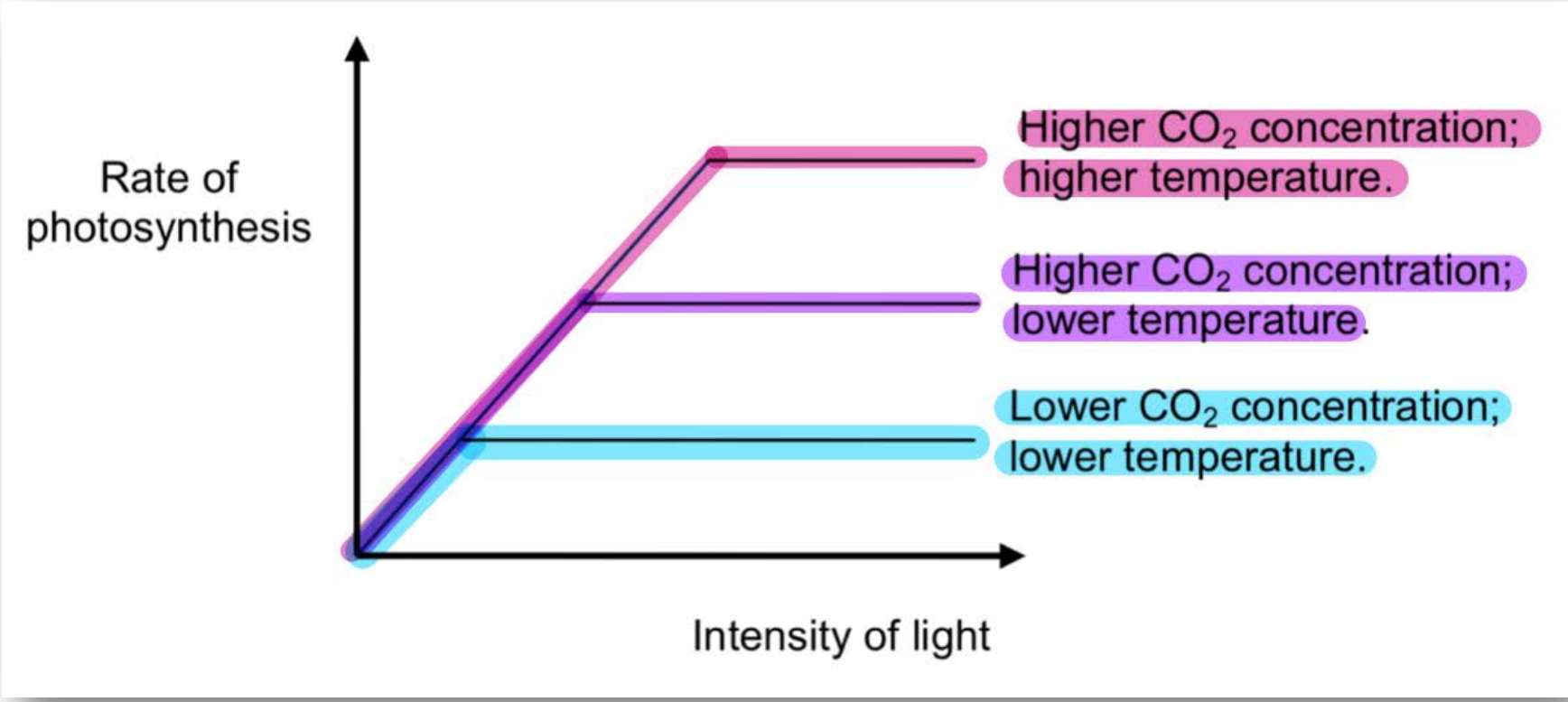


Graph Rate of Photosynthesis (Light)

Graph Rate of Photosynthesis (CO_2)

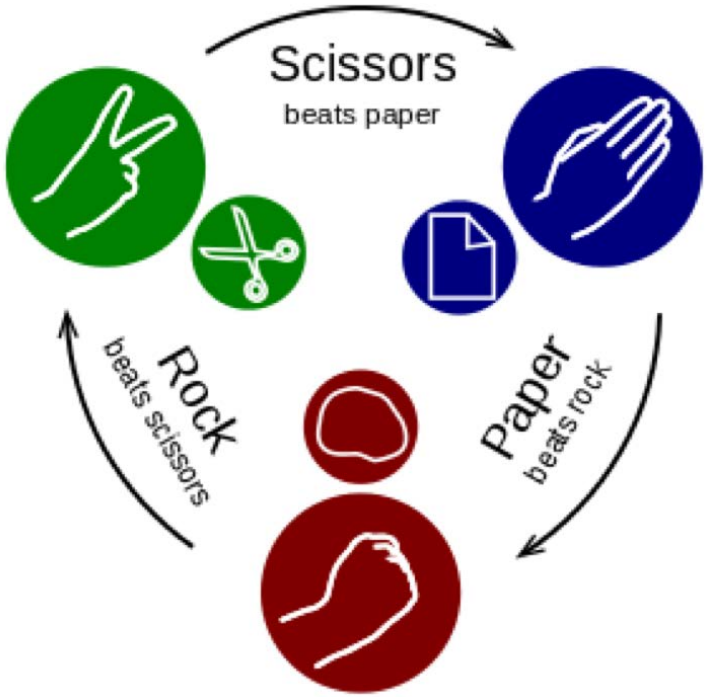
Graph Rate of Photosynthesis (Temperature)

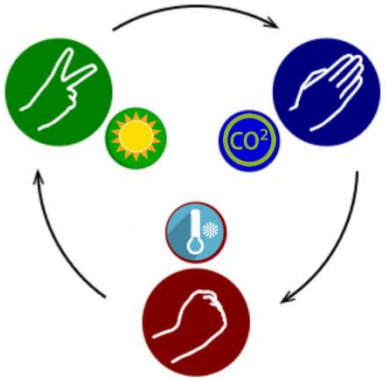
What factor has the largest impact on the Rate of Photosynthesis?

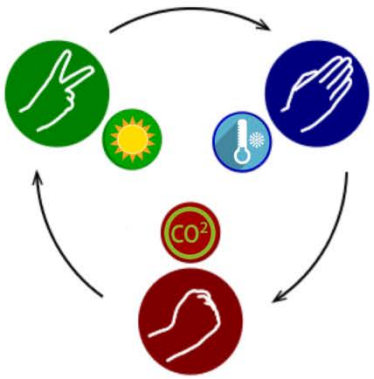


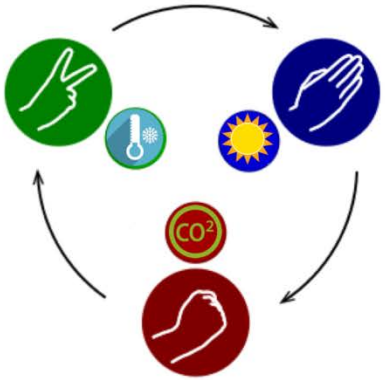
Remember--Water is the "Launch" "Abort" Factor

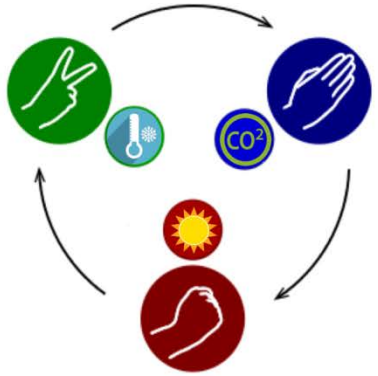
Rock-Paper-Scissors

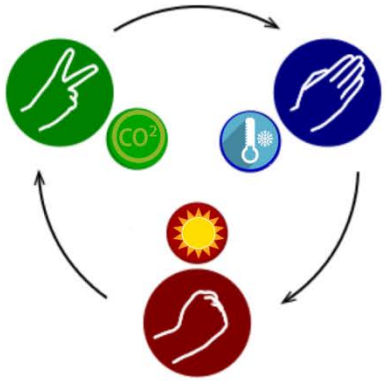


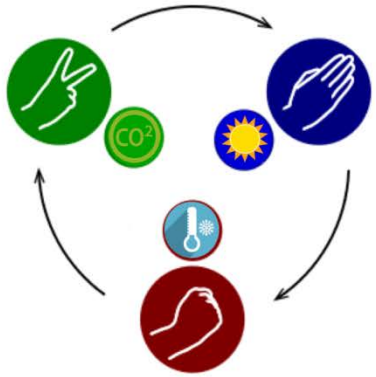












Photosynthesis Case Study

We must understand that the role photosynthesis plays in our world is not limited to plants.

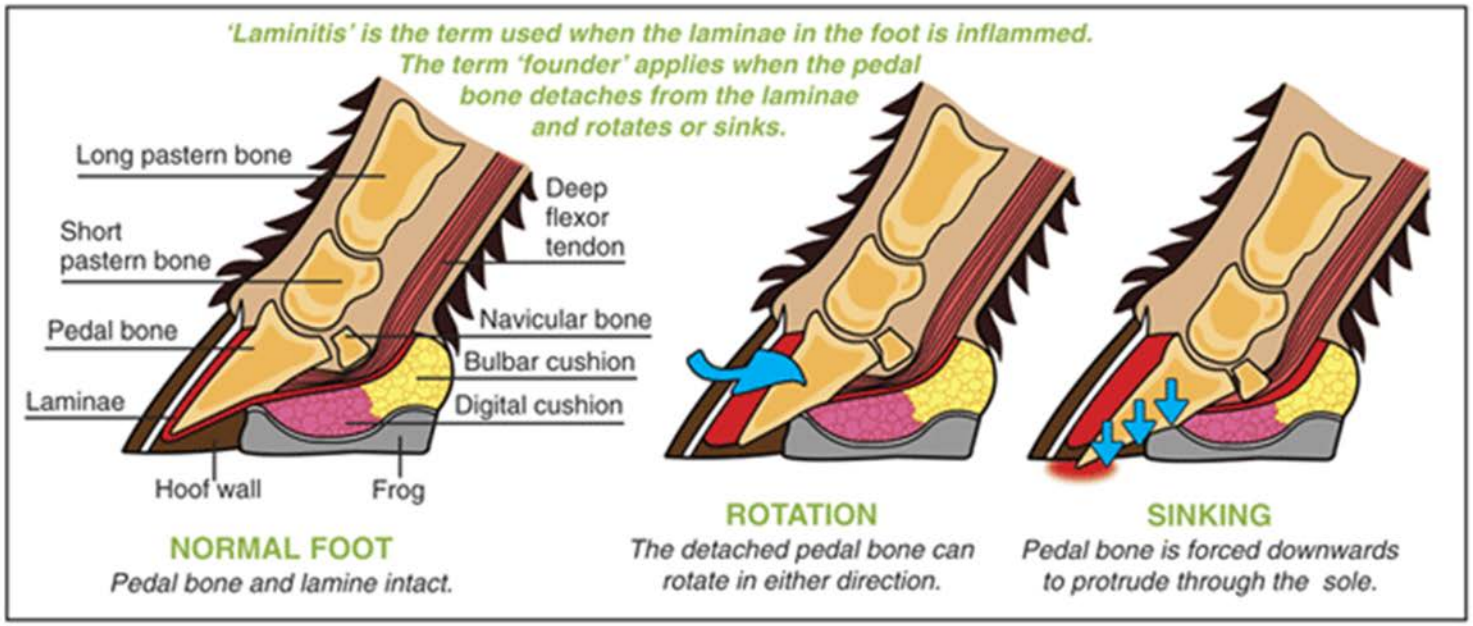
Herbivores are plant eaters. The relationship between a producer and herbivore is extremely interconnected.

Therefore any small changes in the producer can have a large effect in the herbivore that consumes them.

Which Buffet Has More Calories?

Which Pasture Has More Calories?

Does it Matter When Horses Eat?



Sugar is an inflammatory agent

If you have a horse that is predisposed to inflammation from sugar (laminitis, Equine Insulin-Resistant Diabetes, Equine Cushing's Syndrome or Obese), you need to make sure they are not consuming a lot of sugar.

Apart from buying them specialized feed, how do you control the amount of sugar a horse consumes if they graze on a pasture?

Plant Photosynthesis v. Plant Respiration

When will it be safe for a horse to eat if sugar inflames them?