(Introduction to Photosynthesis)

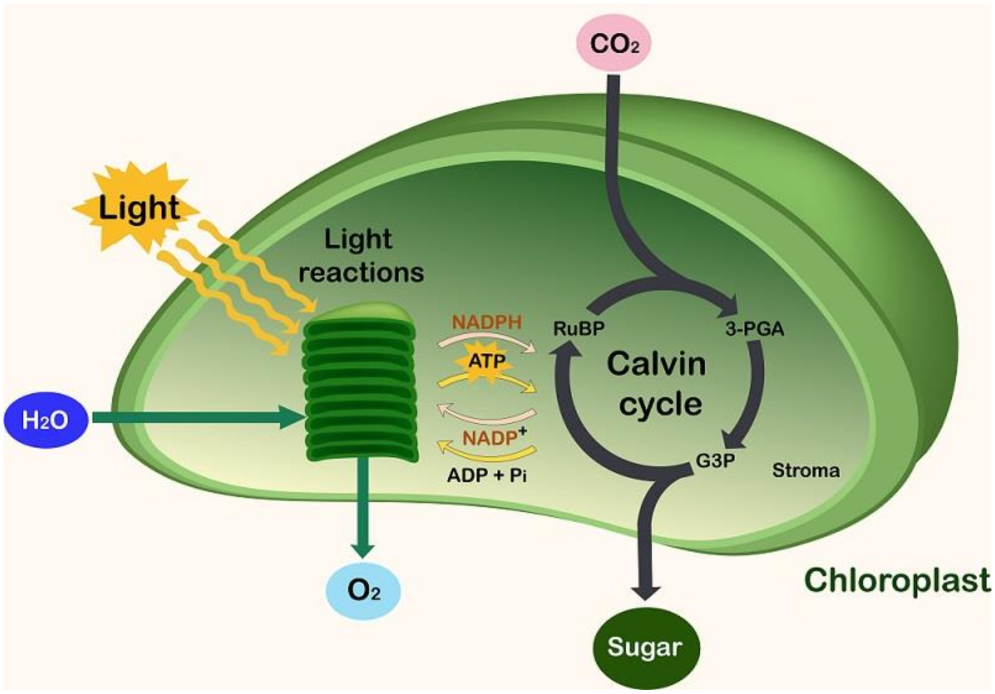
Chapter 10: Photosynthesis

This chapter covers in detail how autotrophs (green plants) ***reduce*** *the carbon dioxide and convert it into organic compounds (glucose) that can then be to converted into ATP (the energy of cells).*

Remember: Photosynthesis is a FOOD THING! A form of AUTOTROPHIC NUTRITION where plants *REDUCE* CO_2 to produce $C_6H_{12}O_6$. What a plant does with its glucose is the same thing you do with yours. It gets sent to the mitochondria where it is *OXIDIZED* and used to convert ADP into ATP…the fuel of cells.

OBJECTIVES:

__1. Distinguish between autotrophic and heterotrophic nutrition.
__2. Describe the structure of chloroplasts and indicate their locations within plant cells. Describe why and where most chloroplasts are located in a leaf.
__3. Explain how chloroplast structure relates to its function.
__4. Write a summary equation for photosynthesis.
__5. Explain the role of redox reactions in photosynthesis.
__6. Describe, in general, the two main stages of photosynthesis.
__7. Describe the relationship between an action
__.8 Describe chemiosmosis and photophosphorylation as it takes place in the chloroplasts.
__.9 Summarize the carbon-fixing reactions of the Calvin cycle and describe how RuBP is regenerated.
__10. Describe the role of ATP and NADPH in the Calvin cycle.
__11. Describe the fate of photosynthetic products.
__12. Define tropism.
__13. List and briefly describe the different tropisms displayed by plants.



(Ricochet Science: Photosynthesis)

Part I. <u>Photosynthesis in Nature</u>

(p.176) **1.** As a review, define the terms *autotroph* and *heterotroph*. Keep in mind that plants have mitochondria and chloroplasts and do both cellular respiration and photosynthesis!

<u>Autotroph</u> - "self-feeders" capable of producing their organic molecules ($C_6H_{12}O_6$) from inorganic raw materials (CO_2 + H_2O) obtained from the environment.

<u>Heterotroph</u> - "other-feeders" that ingest compounds (food) produced by other organisms

(p.178) **2.** Where is the major site of photosynthesis in most plants?

The major site of photosynthesis in most plants is the chloroplasts in the <u>leaf.</u>

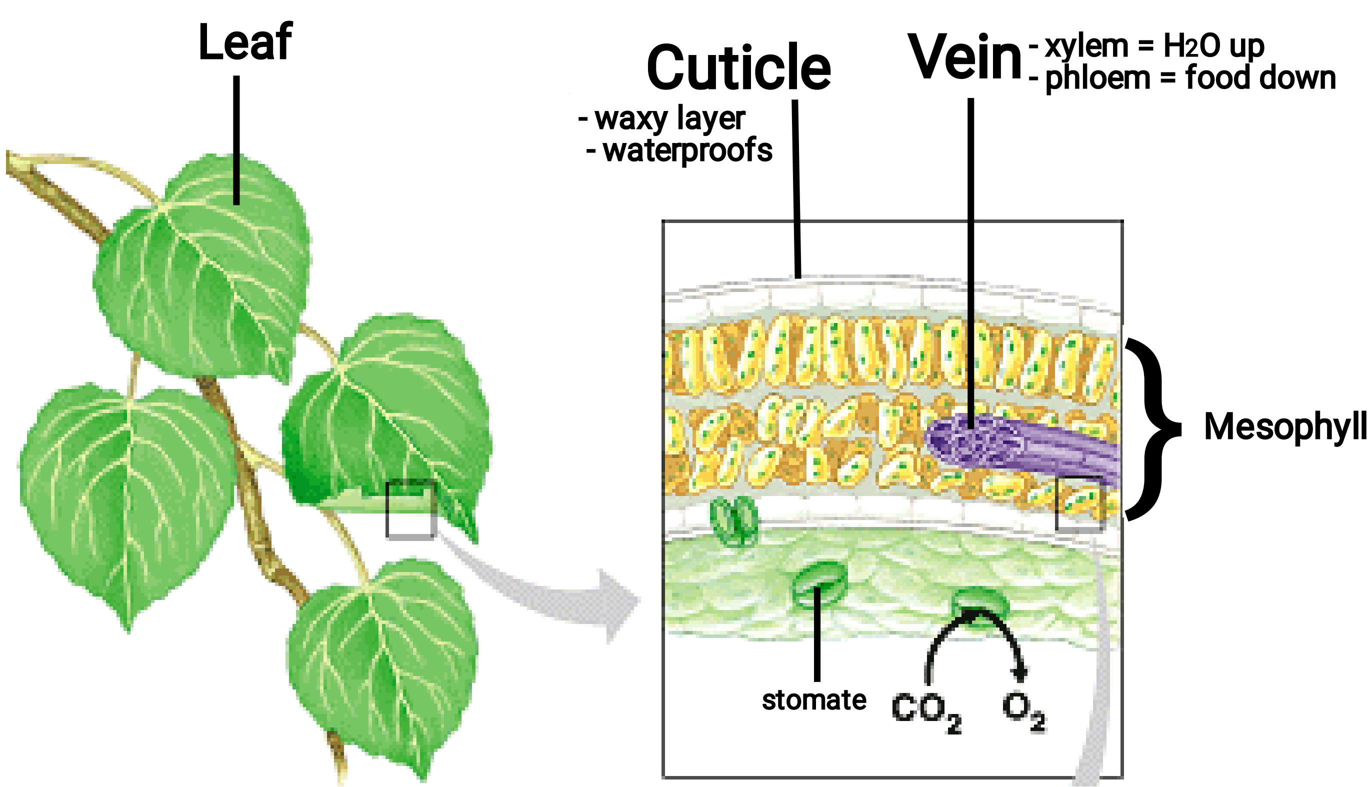
(p.178) **3.** Label the diagram below and use it to explain how CO_2 and O_2 enter and exit the leaf? What processes do you think control the passage of these gases in and out of the leaf? Why are most of the stomata are located on the underside of the leaf?

Diffusion (*concentration gradients*) controls the passage of these gases in and out of the leaf.

Most stomata are located on the underside of the leaf because....

<u>(Animation: Travel Deep Inside a Leaf)</u>

<u>(Animation: The Amazing Process of Photosynthesis)</u>

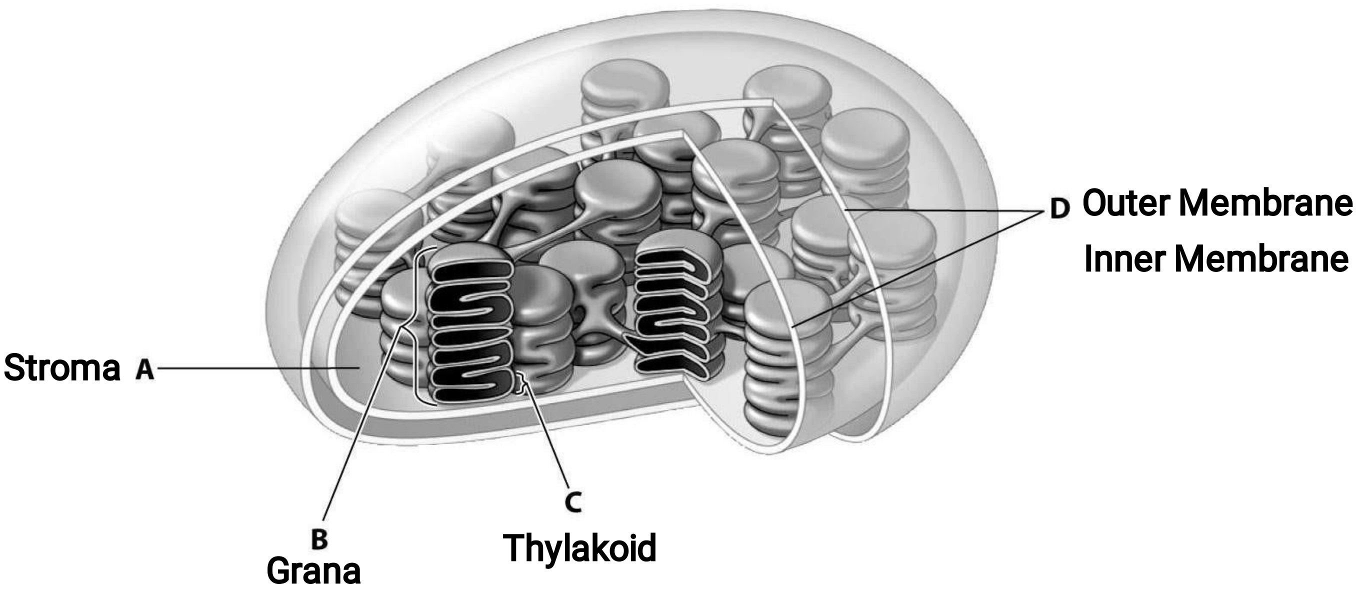


* * * HOMEOSTASIS * * *

(p.178) **4.** Why are plants green and what function does this pigment serve?

Plants are green because of the green pigment chlorophyll. The main function of chlorophyll is to absorb light energy.

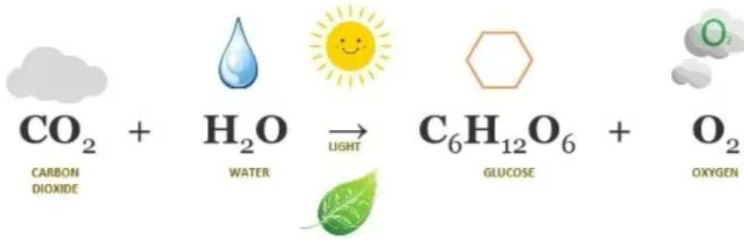
(p.178) **5.** Chloroplasts are the photosynthetic organelles of plants. Label the diagram of the chloroplast below.



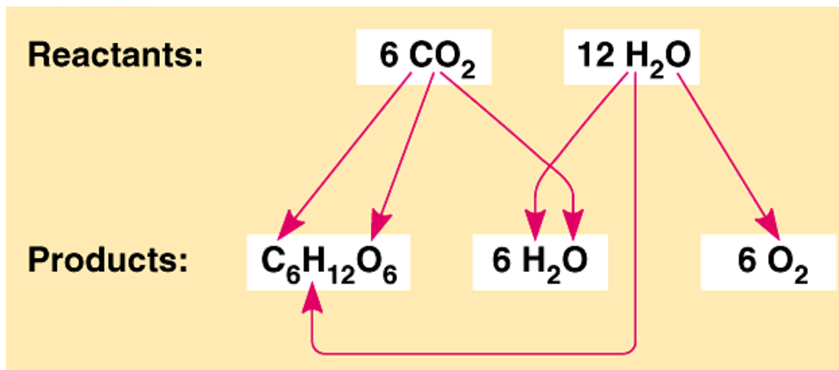
	Name	Function
A	Stroma	The fluid-filled internal space of the chloroplasts which contains the enzymes (Rubisco) needed for the Calvin Cycle.
B	Grana	Stacks of thylakoids that increase the surface area for the light reactions of photosynthesis.
C	Thylakoid	Membranes that contain chlorophyll to absorb light and the transport proteins needed for the electron Transport Chain.
D	Outer Membrane Inner Membrane	Both control what goes in and out of the chloroplast.

Part II. The Pathways of Photosynthesis

(p.176) **6.** Write out the formula for photosynthesis *(use the one that indicates only the net consumption of water)*. The formula is the opposite of cellular respiration. You should know both formulas from memory.



(p.179) **7.** Use the diagram to the right and O18 as the basis of your answer to explain how we know that the oxygen released in photosynthesis comes from water and not carbon dioxide.



O^{18} (a heavy isotope of O_2) was used as a tracer to follow the fate of oxygen molecules during photosynthesis. The O_2 that was released from the plant via the stomata was labeled with O^{18} only if water was the source of the radioactive isotype. If the O^{18} was introduced to the plant in the form of CO_2, no radioactivity was detected.

(p.180) **8.** Photosynthesis is not a single process, but two processes, each with multiple steps.

a. BRIEFLY describe what occurs in the *light reactions* stage of photosynthesis. Be sure to use *NADP+ in your answer.*

The light reactions stage of photosynthesis uses solar energy to split H_2O into H_2 and O_2. The oxygen is released as a byproduct (Thanks God!) and the hydrogens combine with NADP+ to produce NADPH which brings them to the Calvin Cycle.

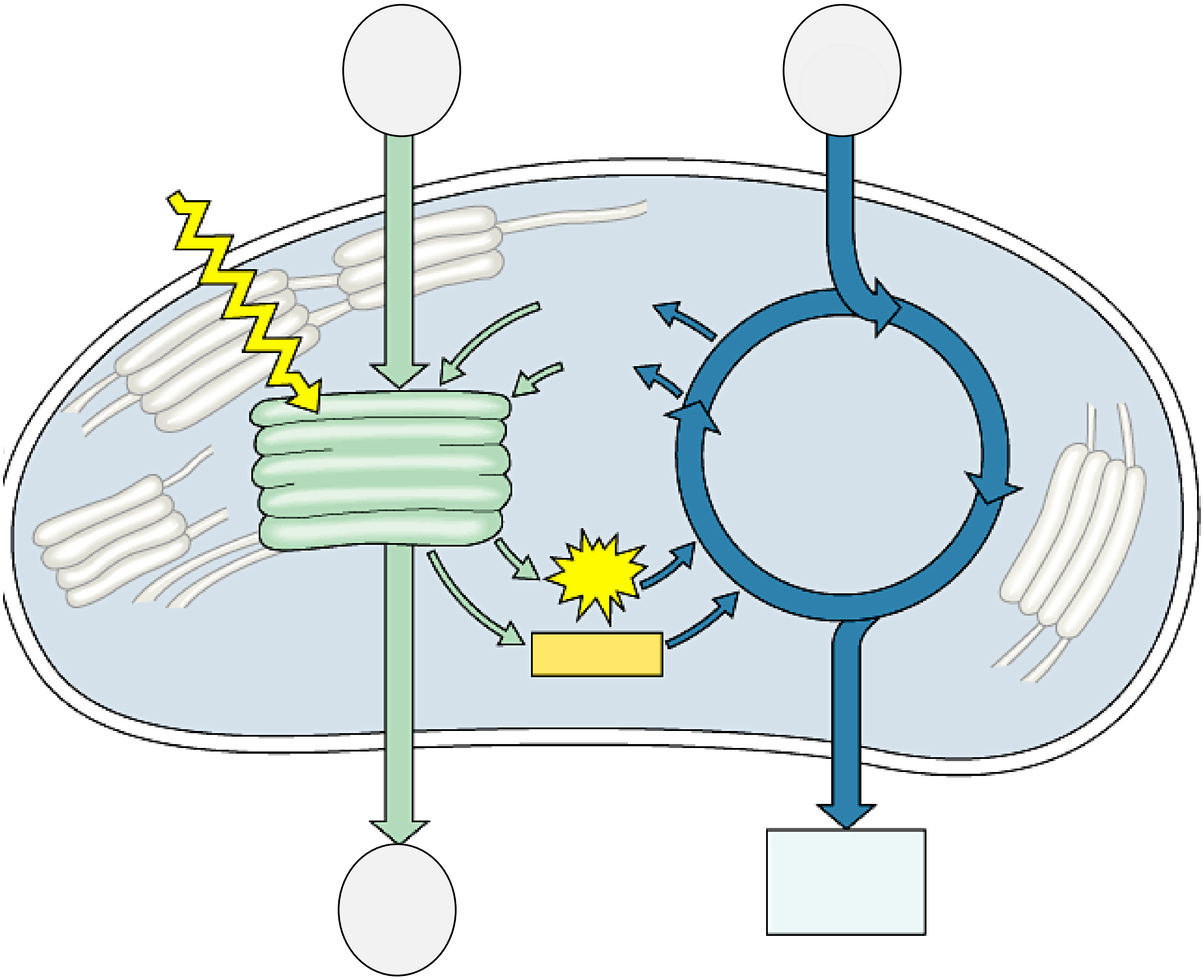
(p.181) **b.** BRIEFLY describe the *Calvin cycle,* utilizing the term *carbon fixation* in your discussion.

The Calvin Cycle uses the hydrogens from NADPH and combines (fixes) them to CO_2 in a carbon fixation reaction to ultimately produce $C_6H_{12}O_6$.

(Photosynthesis Overview)

(p.176) **9.** The details of photosynthesis will be easier to organize if you can visualize the overall process. Label **Figure 10.4**, below. As you work on this, underline the items that are cycled between the light reactions and the Calvin cycle.

Concept: ***The light reactions and the Calvin Cycle cooperate in converting light energy to the chemical energy of food (sugar).***



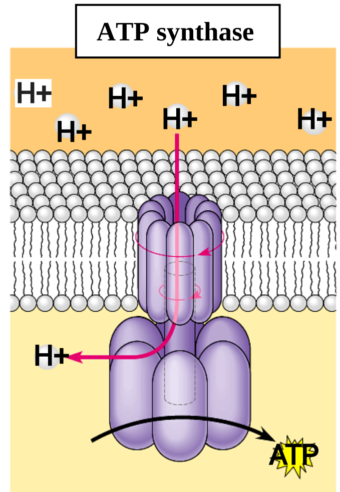
Concept: ***The light reactions convert solar energy to the chemical energy of ATP and NADPH***

(p.167) **10.** The last idea in this challenging concept is how chemiosmosis works in photosynthesis to generate ATP needed to build glucose in the next stage of photosynthesis. Define Chemiosmosis. *(p.167)*

Chemiosmosis is the coupling of the transport of H+ across a membrane with the production of ATP.

The process of moving ions (H+/protons) to the other side of a biological membrane results an electrochemical gradient that can be harvested to drive ATP synthesis.

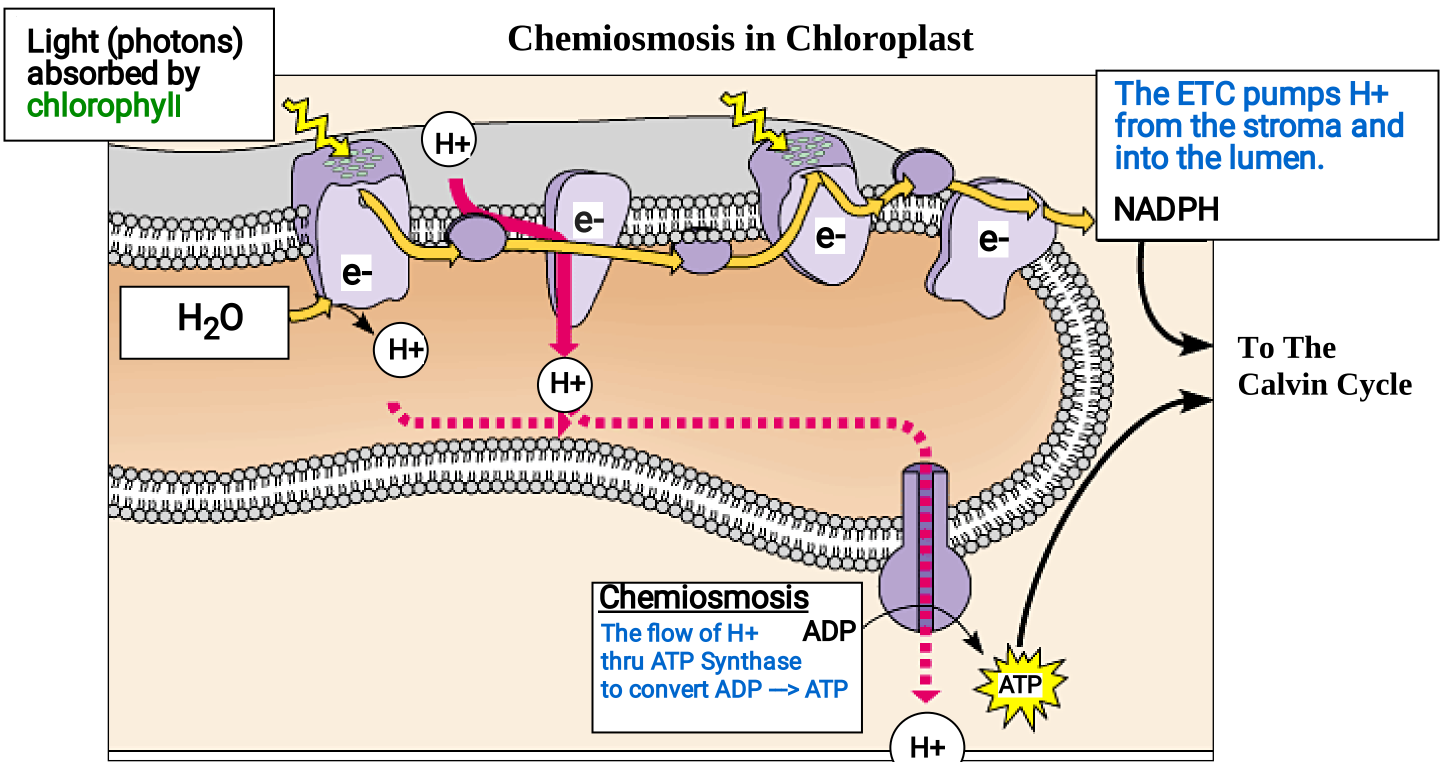
(p.167) **11.** Central to the generation of ATP during chemiosmosis is the protein complex ATP Synthase. Label the diagram to the right and use it to explain how it is used to generate ATP. *(p.167)*



ATP synthase is a protein complex that functions like a mill or a hydro-electric dam powered by the flow of protons (H+) down their concentration gradient.

(Ricochet Science: The Light Reactions) (Animation: Campbell ETC)

(p.176) **12.** Use the diagram below to help you explain the organization of the thylakoid membrane (*structure*) and the process of chemiosmosis (*function*). Label all the locations in the diagram first.



(Animation: The Electron Transport Chain Explained) (Animation: The Electron Transport Chain)

13. Hydrogen: atomic # = __1__ Atomic mass = __1__

(p.167) **14.** Now that you know that Hydrogen is composed of 1 proton (H+) and 1 electron (-), what is **proton-motive force**?

The proton motive force is the [H+ gradient] established in the lumen by the ETC.

MAIN IDEA:

The products of the light reactions (NADPH and ATP) are needed for the Calvin Cycle.

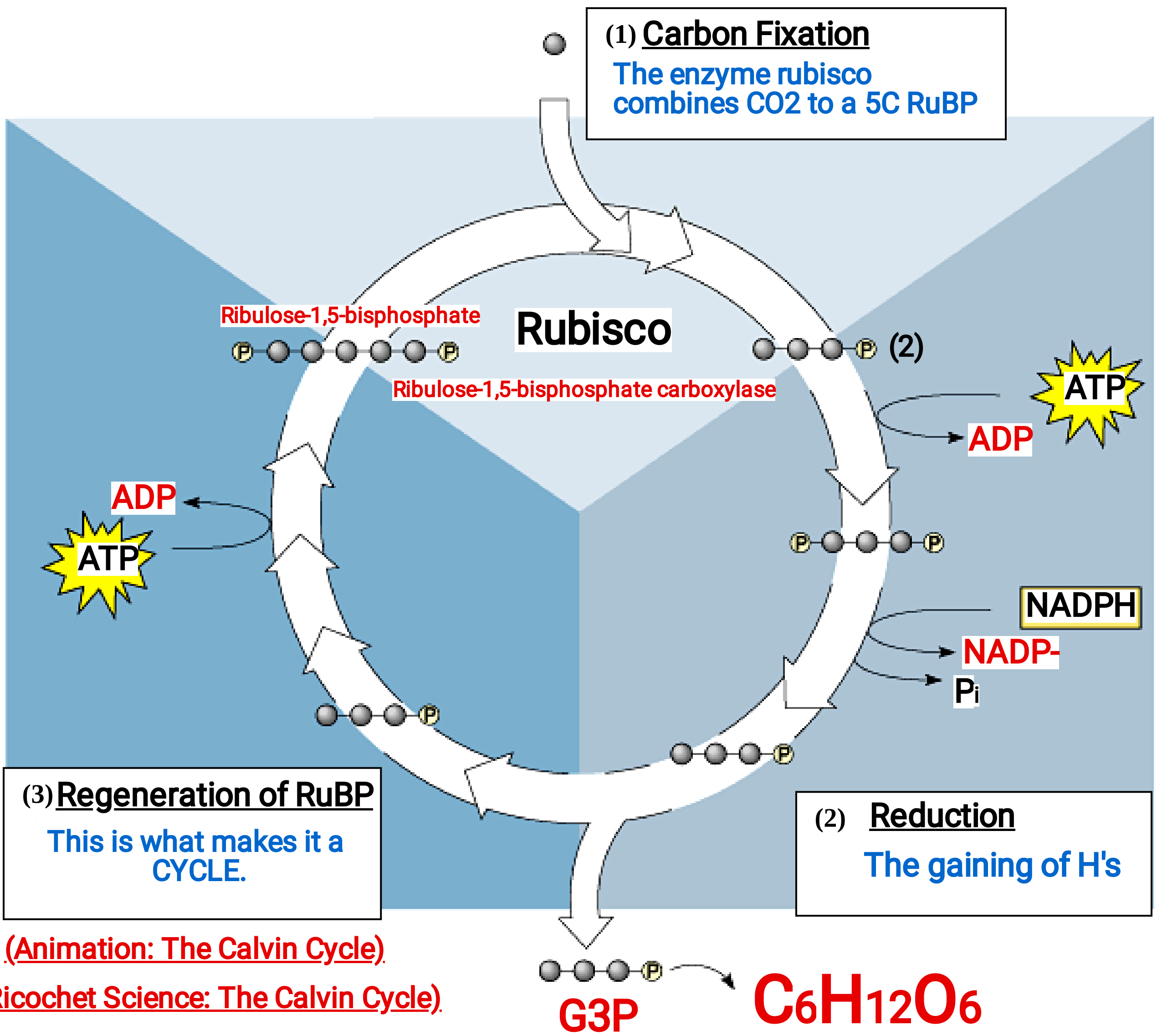
Concept: ***The Calvin cycle uses ATP and NADPH to convert (reduce/fix) CO_2 into G3P and $C_6H_{12}O_6$***

*The Calvin cycle is a **metabolic** pathway in which each step is governed by an enzyme, much like the Krebs/citric acid cycle from cellular respiration you will see in the next section. However, keep in mind that the Calvin cycle uses energy (in the form of ATP and NADPH) and is therefore **anabolic**; in contrast, cellular respiration is **catabolic** and releases energy that is used to generate ATP and NADH.*

(p.189 **15.** As previously stated, the light reactions store chemical energy in NADPH and ATP, which shuttle the energy to the carbohydrate-producing Calvin cycle.

(p.176) **16.** The carbohydrate produced directly from the Calvin cycle is not glucose, but the three-carbon compound Glyceraldehyde-3-phosphate (G3P). Each turn of the Calvin cycle fixes one molecule of CO_2; therefore, it will take 3 turns of the Calvin cycle to net one G3P.

(p.176) **17.** Use the diagram below to help you explain the important events that occur in the *carbon fixation* stage of the Calvin cycle.



(Animation: The Calvin Cycle)

(Ricochet Science: The Calvin Cycle)

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