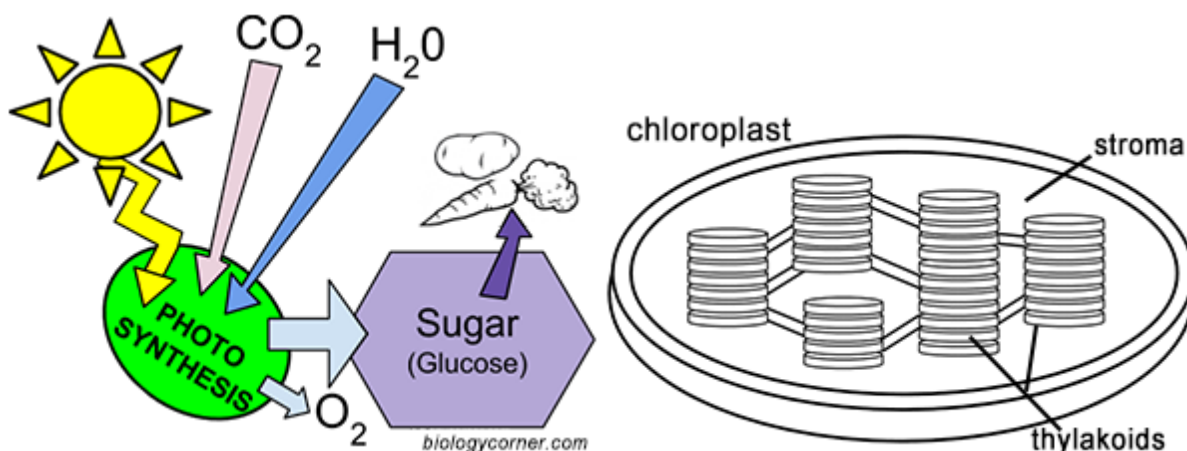


# Chemiosmosis - ATP Synthesis in Chloroplasts

Photosynthesis is a process that takes place in the leaves of plants where carbon dioxide and water is converted to carbohydrates, also producing oxygen. This process occurs within the chloroplasts, on the thylakoid membranes that are stacked into structures called grana.

In this exercise you will examine the process of ATP synthesis that occurs within the chloroplasts. Read each step carefully and color according to the directions. Remember the goal is to try to understand the process, coloring it is just the tool to help you understand it. Each box shown indicates a pause point where you go to the diagram and color the associated structure.



1. The thylakoid membrane is composed of a phospholipid bilayer (color phospholipids "B" light blue) with an interior space and an exterior, called the stroma. Photosynthesis takes place in two systems: photosystem I (P1) and photosystem II (P2). ☐
2. The first event is the capturing of light energy (color E orange) ☐ by pigments in the membrane. Color the pigments of Photosystem II (P2) and p680 dark green ☐. Color the pigments of Photosystem I (P1) and p700 light green ☐.
3. When a photon of light strikes the reaction center of Photosystem II, it excites an electron. Two water molecules split into hydrogen ions (protons) and release oxygen. Color the protons ( $\text{H}^+$ ) yellow and the oxygen atoms ( $\text{O}_2$ ) red ☐. This process is called **PHOTOLYSIS** and is illustrated by the arrows labeled "L", which you should color pink. ☐

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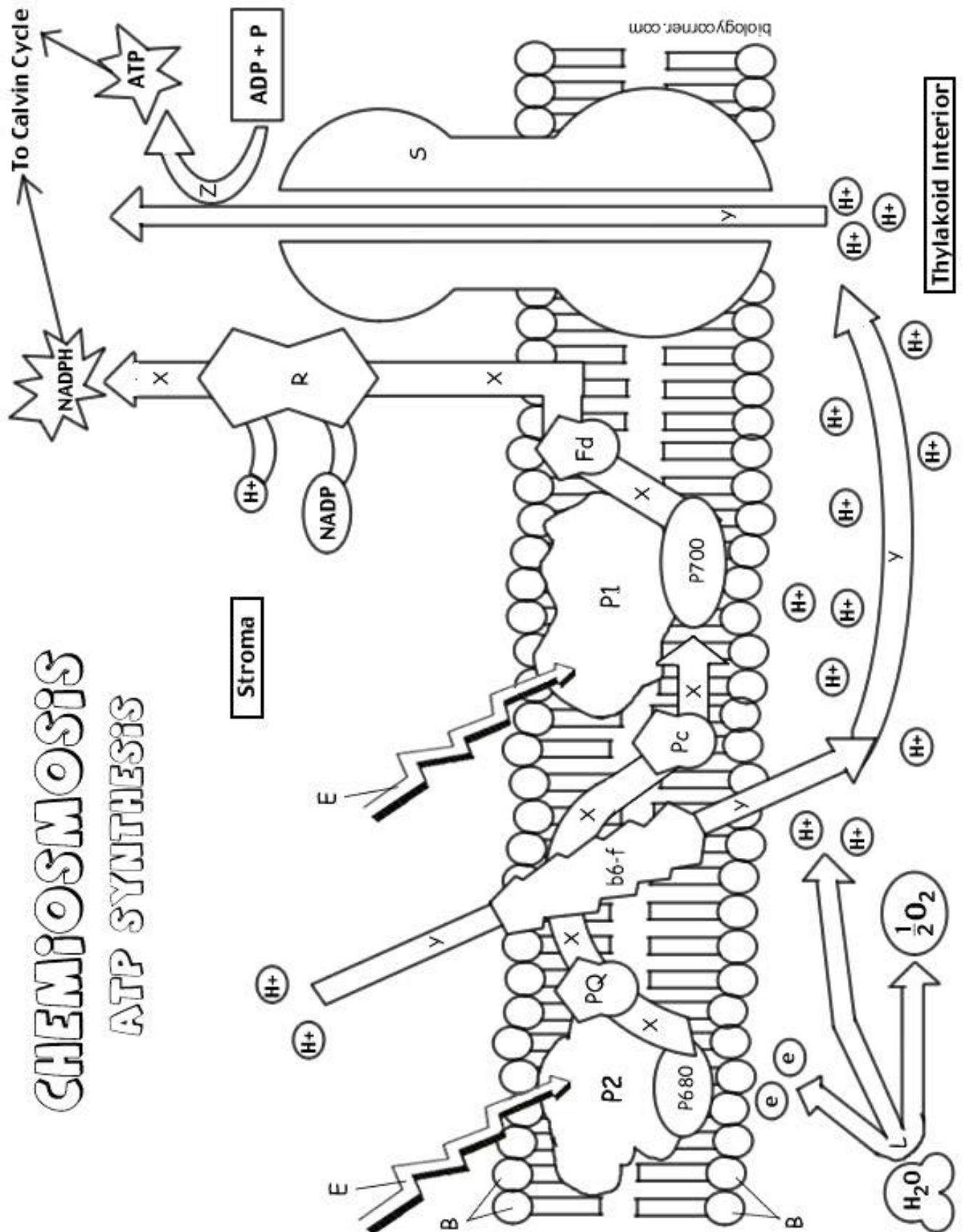
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4. Two electrons are released in this process, and these electrons can be traced through photosystem II and photosystem I. The electrons (e) and the path shown as a series of arrows (X) should be colored gray □.
  5. The primary electron acceptor for the light-energized electrons leaving photosystem II is plastoquinone (color PQ purple)□. PQ then passes the electrons to a proton pump embedded in the membrane called the b6-f complex (color dark blue). □
  6. This proton pump moves protons (H<sup>+</sup>) atoms across the membrane against their concentration gradients, which eventually causes a build-up of protons in the thylakoid interior. Color the proton path shown as an arrow (y) yellow. □
  7. The protons will exit the thylakoid space via a special channel provided by ATP Synthase (color "S" pink) □. The protons move with the **concentration gradient**, which allows them to do work- namely drive ATP synthesis. Imagine ATP synthase is like water wheel, as protons move by diffusion, the energy created allows them to do work. This process is called **CHEMIOSMOSIS**.
  8. The work that is done is that ADP is phosphorylated into ATP and released into the stroma. The process of making ATP is called **PHOTOPHOSPHORYLATION**. Color ATP, ADP and the process (Z) orange □. The ATP generated will head to the Calvin Cycle where it will be used to generate glucose.
  9. But wait, there's more! The electron that was used in Photosystem II is just sitting around, all de-energized but its story is not finished. A small protein called plastocyanin, Pc, (color brown) □ carries the electron to Photosystem I. Light absorbed by photosystem I energizes this electron and passes it to another primary electron acceptor called ferredoxin (color "Fd" turquoise) □.
  10. The enzyme NADP Reductase (color "R" dark purple) □ transfers these electrons to NADP from NADPH. The electron is now on its way to the Calvin Cycle as part of an NADPH molecule (color light purple) □.
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# CHEMIOSMOSIS

## ATP SYNTHESIS



## Questions:

1. Explain the role of each of the following in 5 words or less.

---- P680

---- P700

---- Plastocyanin

---- Plastoquinone

---- Ferredoxin

---- NADP Reductase

---- ATP Synthase

2. Explain how the concentration gradient affects the process of ATP synthesis.

3 Summarize what happens in Photosystem I and Photosystem II. Focus on what is needed to start each system and what is produced by each.

4. The ATP and NADPH generated by chemiosmosis will go into what process of photosynthesis. Describe this process and the overall products (You may need to look this up.)

5. Why is the process of chemiosmosis also called the light-dependent reactions?

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