BIO 1305 – Modern Concepts in Bioscience I – Campbell Textbook
Week 7 – Chapter 10

Hey guys! I hope you are enjoying the warmer weather & are getting back into the swing of things after our time off! We are going to jump into chapter 10 which is all about photosynthesis! Just like cellular respiration/metabolism, you will probably spend a good amount of time covering this chapter in your classes, so this resource will only cover this one chapter. Also, remember that Gabriel and I hold **weekly group tutoring sessions on Thursdays from 5-6 pm**. Sign up to join us here: **https://baylor.edu/tutoring.** We would love to see you there!

Keywords for this week: Light Reactions, Calvin Cycle, Linear Electron Flow

I have linked some helpful videos throughout this resource. Watch the videos after you read over each section for extra review over what you just learned!

Chapter 10: Photosynthesis

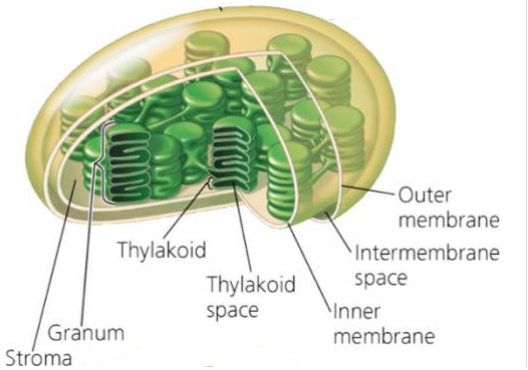
In this chapter, we will be considering one main question: *how do cells use light, carbon dioxide, and water to create organic molecules and oxygen?* The molecules created in photosynthesis are then used to fuel cellular respiration, which creates ATP. That is how this chapter relates to the previous one! Before we talk about the process of photosynthesis, we need to differentiation between **autotrophs** and **heterotrophs**.

Autotrophs: make their own food → these organisms perform photosynthesis
Heterotrophs: cannot make their own food → these organisms depend on photosynthetic organisms for their nutrition

We can now start talking about the process of photosynthesis...

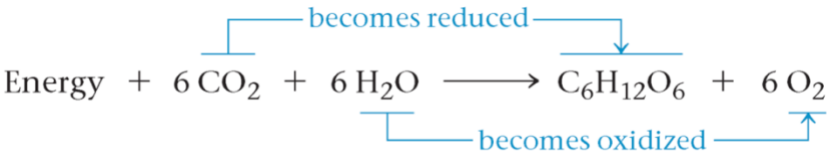
Structure of the Chloroplast

It is important to understand the structure of the **chloroplast** (where photosynthesis takes place) in order to understand the process of photosynthesis. The picture on the right shows all of the main sections of the chloroplast.



Overview of Photosynthesis

Just like cellular respiration, photosynthesis involves oxidation and reduction. Here is the overall chemical equation:



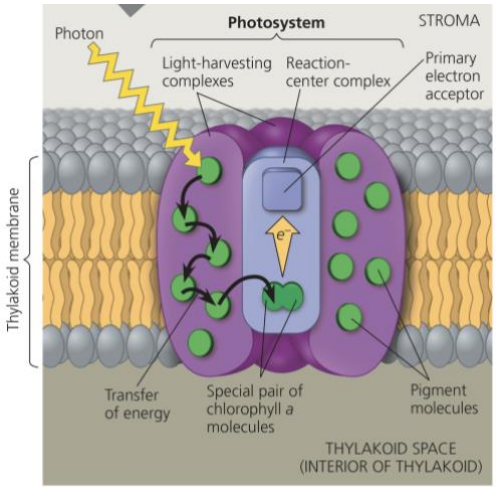
There are **two main stages** of photosynthesis:

1. **Light reactions ("photo")**
   - Light is converted to *chemical energy*
   - *Water* provides electrons and protons for the reaction
   - Photophosphorylation
2. **Calvin cycle ("synthesis")**
   - *Carbon dioxide* from the air is put into organic molecules through carbon fixation
   - The fixed carbon is reduced to a sugar molecule

Let's look at each phase in more depth!

The Light Reactions of Photosynthesis

In this stage of photosynthesis, light from the sun is converted into ***ATP and NADPH***. In the light reactions, light excites chlorophyll molecules to kickstart the reaction. Watch this video to become familiar with that process before moving on:

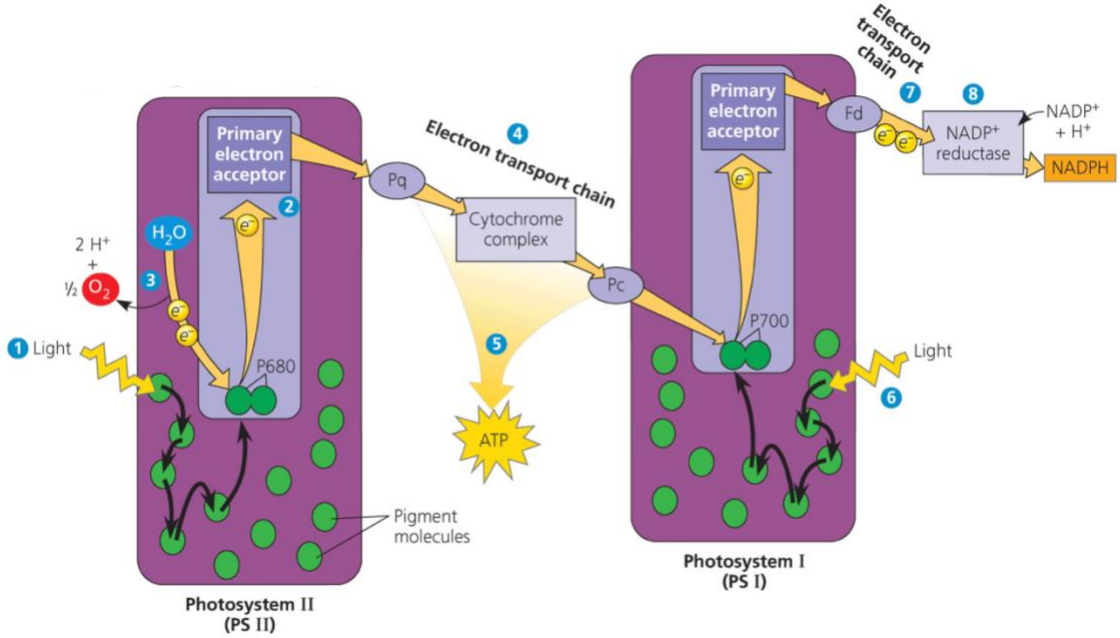


Video: **Excitation of Chlorophyll by Light**

Chlorophyll molecules in chloroplasts are found within centers called **photosystems**, which are found in the thylakoid membrane. To the right is a diagram of the basic structure of a photocenter. Try to become familiar with this structure before moving on.

Video: Parts of a Photosystem

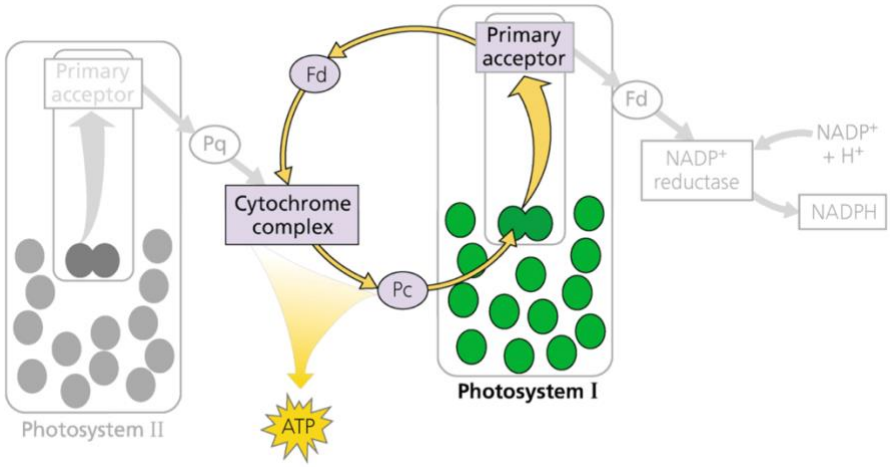
There are two types of **photosystems** within thylakoid membranes. **Linear electron flow** is the path that the electrons take through the photosystems. Below is a diagram describing the overall route that the electrons take during linear electron flow in the light reactions.



In the overall process, electrons travel from water, which is split, to NADPH, which will be used in the **Calvin cycle**.

Video: Linear Electron Flow

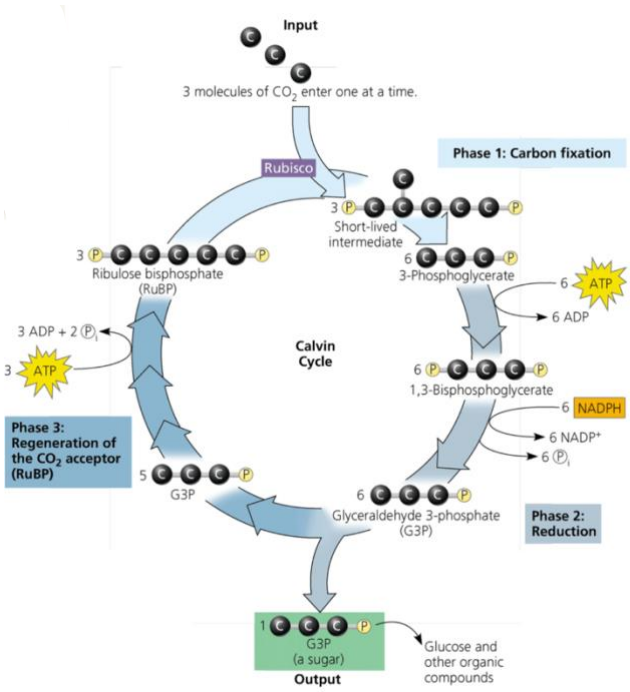
In **cyclic electron flow**, only *one photosystem* is excited. This occurs in certain organisms that only have one type of photosystem. Below is a diagram demonstrating cyclic electron flow.



Video: Cyclic Electron Flow

The Calvin Cycle of Photosynthesis

In the Calvin cycle, the *second phase* of photosynthesis, **ATP and NADPH** from the light reactions are used to *reduce carbon dioxide* and create sugar molecules. This is an anabolic process, meaning it builds molecules. Specifically, the Calvin cycle creates three-carbon sugar molecules called **glyceraldehyde-3-phosphate**, or **G3P**. The cycle must occur three times to create one G3P molecule. The diagram to the right shows an overview of the Calvin cycle.



There are **three substages** of the Calvin cycle:

1. Carbon fixation
   - Each carbon dioxide molecule put into the cycle is attached to RuBP. This is catalyzed by an enzyme called *rubisco*.
   - This forms a high-energy intermediate that quickly splits into two molecules of **3-phosphogycerate**
2. Reduction
   - Each **3-phosphoglycerate** gets a phosphate group and becomes **1,3-biphosphoglycerate**.
   - NADPH donates a pair of electrons and reduces this molecule to form **G3P**.
3. Regeneration of RuBP
   - **RuBP** is regenerated to be used again

Video: Calvin Cycle

Alternate Methods of Carbon Fixation

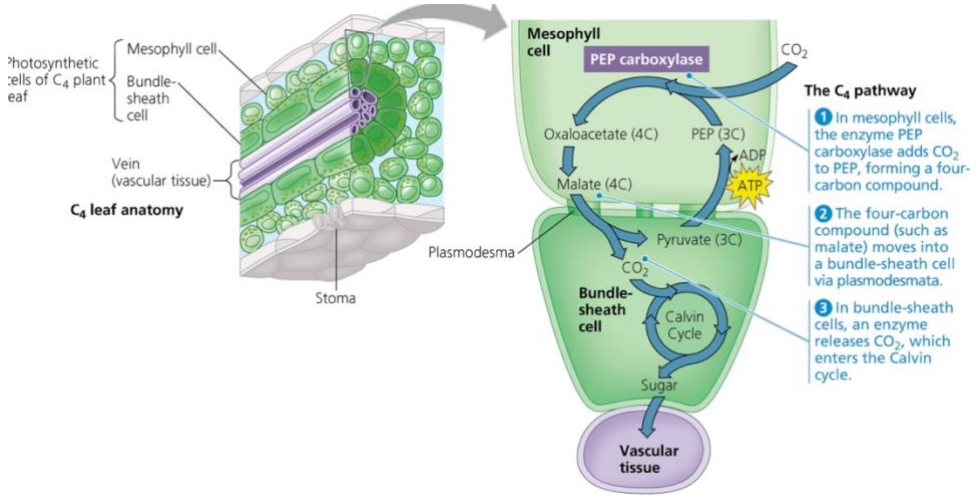
There are other ways that plants can fix carbon that involve conservation of water. Remember that water provides the electrons for the light reactions.

C_3 Plants

- In these plants, **3-phosphoglycerate** is the first product of carbon fixation
- On hot and dry days, the stomata of these plants close, *reducing* the intake of CO_2
- *Rubisco* can bind to oxygen instead of carbon dioxide
- *Oxygen* is added to the Calvin cycle, making a two-carbon compound

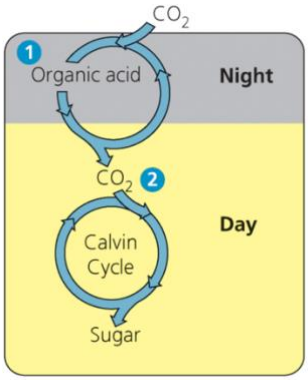
C_4 Plants

- These plants use a different method of carbon fixation, forming a **four-C product**



CAM Plants

- These plants keep their stomata open at night but keep them closed during the day to *conserve water*
- When the stomata are open at night, CAM plants turn carbon dioxide into many organic acids through **crassulacean acid metabolism (CAM).**



(b) Temporal separation of steps. In CAM plants, carbon fixation and the Calvin cycle occur in the same cell at different times.