Hey everyone! Welcome back to another weekly resource. This week we will be going through photosynthesis which is the complementary process of cellular respiration. This topic is tricky for a lot of students, but we’ll break it down in this resource. Best of luck studying! Reminder: I hold weekly group tutoring sessions on Mondays from 6:30-7:30 pm in room 74 in the basement of Sid Rich! For more information you can visit our website here: https://baylor.edu/tutoring.

**Keywords:** Light Reactions, Calvin Cycle, Alternate Carbon Fixation

**Topic of the Week: Introduction to 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:

\[
\text{Energy} + 6 \text{CO}_2 + 6 \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2
\]

There are two main stages of photosynthesis:

1. **Light reactions (“photo”)**

All diagrams, tables, and external information is property of Pearson Campbell Biology 11th edition, unless otherwise specified.
- 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

**Highlight #1: The Light Reactions**

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:

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.

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**.

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.

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**Highlight #2: The Calvin Cycle**

**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 **3phosphoglycerate**

2. **Reduction**
   - Each 3-phosphoglycerate gets a phosphate group and becomes **1,3biphosphoglycerate**.
- NADPH donates a pair of electrons and reduces this molecule to form G3P.

3. Regeneration of RuBP
- RuBP is regenerated to be used again

Highlight #3: 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.

**C₃ 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 CO₂
- Rubisco can bind to oxygen instead of carbon dioxide
- Oxygen is added to the Calvin cycle, making a two-carbon compound

**C₄ 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).

CHECK YOUR LEARNING
1. What are the inputs and outputs of photosynthesis compared to cellular respiration?
2. What is the purpose of chlorophyll in photosynthesis?

THINGS YOU MAY STRUGGLE WITH
1. There are a lot of similarities between photosynthesis and cellular respiration! Remember what these are because they are a source of confusion!
2. NADPH is involved in photosynthesis, while NADH is involved in cellular respiration. A way to remember this is that NADPH has a “P” in it, and photosynthesis starts with a P.

Well that’s all for this week’s resource. I hope to see you all at group tutoring this week. If you need more info about the tutoring center you can go to https://baylor.edu/tutoring.

Answers:
2. Chlorophyll is a pigment that is meant to let electrons “bounce” off of it in the photosystems!