

Lesson Overview
8.2 Photosynthesis:
An Overview

Miller & Levine
Biology

Lesson Overview Photosynthesis: An Overview

Chlorophyll and Chloroplasts

◀ What role do pigments play in the process of photosynthesis?

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Chlorophyll and Chloroplasts

◀ What role do pigments play in the process of photosynthesis?

◀ Photosynthetic organisms capture energy from sunlight with pigments.

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Light

Energy from the sun travels to Earth in the form of light.

Sunlight is a mixture of different wavelengths, many of which are visible to our eyes and make up the visible spectrum.

A horizontal bar representing the visible light spectrum. It is divided into color bands: violet (V), blue (B), green (G), yellow (Y), orange (O), and red (R). Below the bar, numerical markers indicate wavelength in nanometers (nm) at 400, 450, 500, 550, 600, 650, 700, and 750.

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Light

Our eyes see the different wavelengths of the visible spectrum as different colors: red, orange, yellow, green, blue, indigo, and violet.

A horizontal bar representing the visible light spectrum. It is divided into color bands: violet (V), blue (B), green (G), yellow (Y), orange (O), and red (R). Below the bar, numerical markers indicate wavelength in nanometers (nm) at 400, 450, 500, 550, 600, 650, 700, and 750.

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Pigments

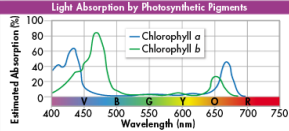
Plants gather the sun's energy with light-absorbing molecules called **pigments**.

The plants' principal pigment is **chlorophyll**.

Pigments

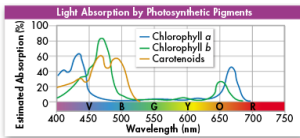
The two types of chlorophyll found in plants, **chlorophyll a** and **chlorophyll b**, absorb light very well in the blue-violet and red regions of the visible spectrum, but not in the green region, as shown in the graph.

Leaves reflect green light, which is why plants look green.



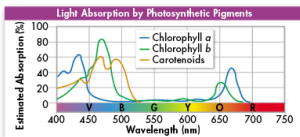
Pigments

Plants also contain red and orange pigments such as carotene that absorb light in other regions of the spectrum.



Pigments

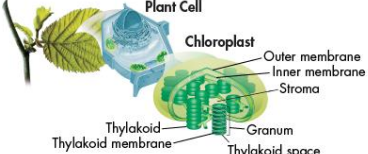
Most of the time, the green color of the chlorophyll overwhelms the other pigments, but as temperatures drop and chlorophyll molecules break down, the red and orange pigments may be seen.



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Chloroplasts

- Photosynthesis takes place inside organelles called **chloroplasts**.
- Chloroplasts contain saclike photosynthetic membranes called **thylakoids**, which are interconnected and arranged in stacks known as grana.



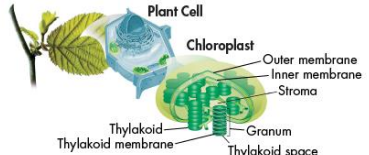
The diagram illustrates a chloroplast within a plant cell. It shows the outer membrane, inner membrane, and the stroma. Inside, there are stacks of thylakoids called grana, with individual thylakoids having their own membranes and spaces.

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Chloroplasts

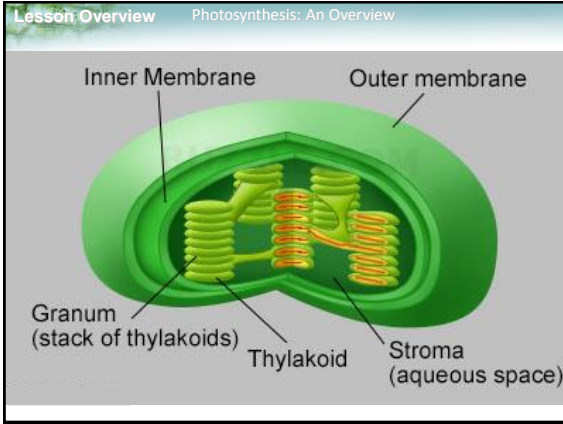
Pigments are located in the thylakoid membranes.

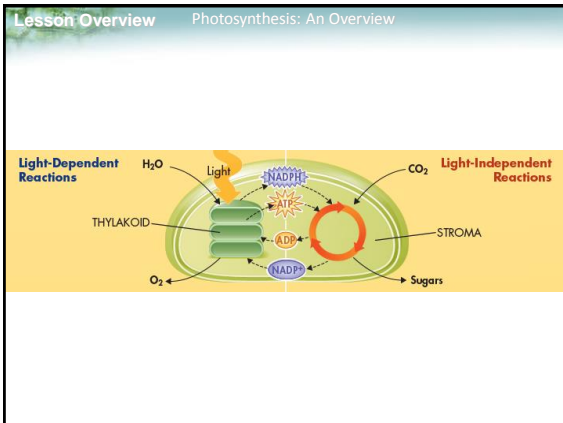
The fluid portion outside of the thylakoids is known as the **stroma**.



This diagram is identical to the one in the first section, showing the structure of a chloroplast with labels for the plant cell, outer and inner membranes, stroma, thylakoids, granum, and thylakoid space.







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Energy Collection

Because light is a form of energy, any compound that absorbs light absorbs energy. Chlorophyll absorbs visible light especially well.

When chlorophyll absorbs light, a large fraction of the light energy is transferred to electrons. These high-energy electrons make photosynthesis work.

Light-Dependent Reactions H₂O Light NADPH CO₂ Light-Independent Reactions

THYLAKOID STROMA

O₂ Sugars

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High-Energy Electrons

▶ What are electron carrier molecules?

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High-Energy Electrons

▶ What are electron carrier molecules?

▶ An **electron carrier** is a compound that can accept a pair of high-energy electrons and transfer them, along with most of their energy, to another molecule.

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High-Energy Electrons

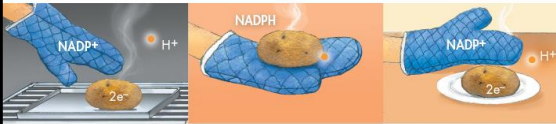
The high-energy electrons produced by chlorophyll are highly reactive and require a special “carrier.”

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High-Energy Electrons

Think of a high-energy electron as being similar to a hot potato. If you wanted to move the potato from one place to another, you would use an oven mitt—a carrier—to transport it.

Plants use electron carriers to transport high-energy electrons from chlorophyll to other molecules.



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High-Energy Electrons

NADP⁺ (nicotinamide adenine dinucleotide phosphate) is a carrier molecule.

NADP⁺ accepts and holds two high-energy electrons, along with a hydrogen ion (H⁺). In this way, it is converted into **NADPH**.

The **NADPH** can then carry the high-energy electrons to chemical reactions elsewhere in the cell.

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An Overview of Photosynthesis

◀ What are the reactants and products of photosynthesis?

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An Overview of Photosynthesis

What are the reactants and products of photosynthesis?

Photosynthesis uses the energy of sunlight to convert water and carbon dioxide (reactants) into high-energy sugars and oxygen (products).

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An Overview of Photosynthesis

Photosynthesis uses the energy of sunlight to convert water and carbon dioxide into high-energy sugars and oxygen.

In symbols:

$$6 \text{ CO}_2 + 6 \text{ H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2$$

In words:

Carbon dioxide + Water $\xrightarrow{\text{Light}}$ Sugars + Oxygen

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Plant Cell


Chloroplast

- Outer membrane
- Inner membrane
- Stroma
- Thylakoid
- Thylakoid membrane
- Granum
- Thylakoid space

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An Overview of Photosynthesis

Plants use the sugars generated by photosynthesis to produce complex carbohydrates such as starches, and to provide energy for the synthesis of other compounds, including proteins and lipids.



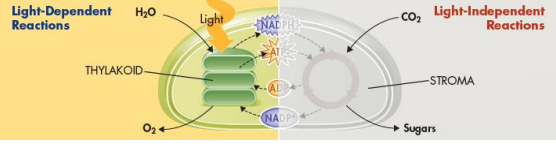
The diagram illustrates the relationship between glucose and starch. On the left, a chain of yellow hexagons represents starch, with one hexagon highlighted in orange. An arrow points from this hexagon to a detailed chemical structure of a glucose molecule on the right. The chemical structure shows a six-carbon ring with various hydroxyl and hydrogen groups attached, labeled with 'C', 'H', 'O', 'CH₂OH', and 'HO'.

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Light-Dependent Reactions

Photosynthesis involves two sets of reactions.

The first set of reactions is known as the **light-dependent reactions** because they require the direct involvement of light and light-absorbing pigments.



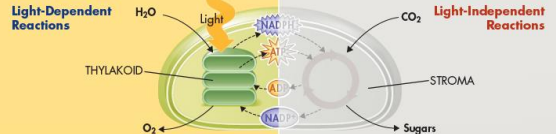
The diagram shows a chloroplast with two main regions: the thylakoid membrane on the left and the stroma on the right. In the thylakoid, light energy is used to split water (H₂O) into oxygen (O₂) and protons. Electrons from this process are transferred through photosystem II (PSII) and photosystem I (PSI) to produce NADPH. In the stroma, carbon dioxide (CO₂) is fixed into sugars using the energy from NADPH and ATP produced in the thylakoid.

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Light-Dependent Reactions

The light-dependent reactions use energy from sunlight to produce ATP and NADPH.

These reactions take place within the thylakoid membranes of the chloroplast.



This diagram is identical to the one in the previous slide, showing the light-dependent reactions in the thylakoid and the light-independent reactions in the stroma. It details the flow of light energy, water splitting, electron transport through PSII and PSI, and the production of NADPH and ATP, which are then used to fix CO₂ into sugars in the stroma.

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Light-Dependent Reactions

Water is required as a source of electrons and hydrogen ions. Oxygen is released as a byproduct.

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Light-Independent Reactions

Plants absorb carbon dioxide from the atmosphere and complete the process of photosynthesis by producing sugars and other carbohydrates.

During **light-independent reactions**, ATP and NADPH molecules produced in the light-dependent reactions are used to produce high-energy sugars from carbon dioxide.

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Light-Independent Reactions

No light is required to power the light-independent reactions.

The light-independent reactions take place outside the thylakoids, in the **stroma**.
