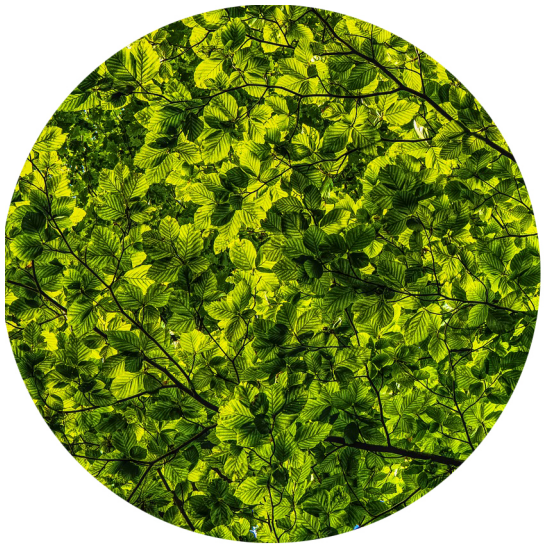
Seeing Green: Photosynthesis 101



Many people feel a sense of calm when surrounded by green plants, whether they're in a woodland, an urban atrium, a greenhouse, or a garden. Ahhh, green: It's associated with life, rebirth, nature, growth, harmony, and freshness. It helps people feel rested and secure. (Recall that people are invited to relax in a “green room” as they wait to go on stage.) It's an all-around friendly color — except, perhaps, in the rare instances when one is "green with envy!"

In the botanical realm, most plants' leaves are green. That's because plants contain a green pigment called chlorophyll. Leaves appear green to us because the chlorophyll *reflects* green wavelengths of light — plants don't have much need for light in the green part of the spectrum. Chlorophyll *absorbs* light in the red and blue parts of the spectrum. Chlorophyll's ability to absorb and use this light is an essential part of photosynthesis.

Using Light to Make Food: The Miracle of Photosynthesis

Photosynthesis is a process during which plants use light energy to manufacture carbohydrates, giving off oxygen in the process. Plants need a source of energy ("food") for metabolism and growth, just like we animals do. Animals get their energy/food by consuming it; plants make their own. (Even carnivores rely on plants; their prey animals are usually herbivores.)

With the abundance of plants around the globe, it's easy to take photosynthesis for granted. But if we think about it, we quickly come to realize that we, and indeed all life on earth, are dependent upon this incredible and vital process!

Photosynthesis can be expressed a chemical reaction that takes place in chlorophyll-containing plant cells in the presence of light:

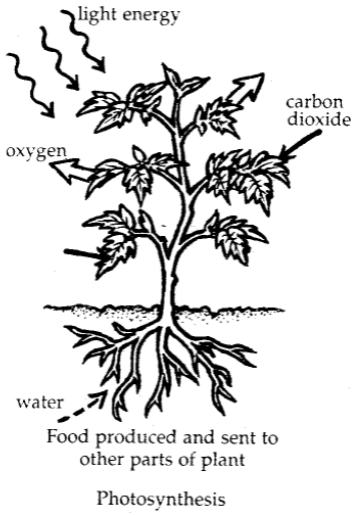
$$CO_2 + H_2O \xrightarrow[\text{light}]{\text{chlorophyll-containing plant cells}} (CH_2O) + O_2$$

Reading left to right: Carbon dioxide plus water combine to produce carbohydrates and oxygen. Note that (CH_2O) is in parentheses because doesn't represent a specific carbohydrate but rather the basic ratio of elements; for example, sucrose is $C_6H_{12}O_6$.

In most plants, air (which contains carbon dioxide) enters the leaf through the stomata — tiny pores located on its underside. Water is absorbed through the roots and transported to the leaves.

Chlorophyll in the leaf tissue absorbs light energy and uses it to create the end product, carbohydrates, and a "waste product," oxygen. How lucky for us — and for all animals that rely on oxygen to survive!

The equation looks pretty straightforward — maybe you just grab the carbon atom from carbon dioxide and stick it onto the water molecule, right? Actually, it's a very complex phenomenon with multiple, intricate steps.



Photosynthesis

During photosynthesis, the chlorophyll molecule is essentially harvesting light energy and using it to transfer electrons among other molecules. In doing so, it is converting light energy into chemical energy (the energy contained in chemical bonds).

The Light Reaction

Photosynthesis can be broken into two phases; the first is the "light reaction."

- When a chlorophyll molecule absorbs light energy it enters an "excited" state, which pushes its outermost electron into a larger orbit. The energy of the light has been transferred to the chlorophyll molecule.
- Almost immediately, this triggers a series of reactions that move the electron to other molecules; this process is called electron transfer.
- The original chlorophyll molecule, lacking an outer electron, gains one by taking it from a water molecule, with the result that the water molecule is split into its components: two hydrogen atoms and an oxygen atom.
- The oxygen escapes as a gas through the stomata and is released into the atmosphere.

This completes the light reaction phase of the process — the part that requires the presence of light.

The Dark Reaction

The light reaction has left the plant with carbon and oxygen from the carbon dioxide molecule, along with the hydrogen left over when the water molecule was split. (The oxygen escaped into the air.)

- In a series of complex reactions, the carbon, hydrogen, and oxygen combine to form glucose, a simple sugar.
- The plant may then combine the simple sugar to form long chains and large molecules, such as starch (food storage) and cellulose (a component of cell walls).

The plant has manufactured its own fuel, as well as building blocks for its cells.

When Leaves Aren't Green

Most of the plants we encounter have green leaves, and it's in these green leaves that photosynthesis takes place.

There are a few exceptions.

- Some plants have red, maroon, or foliage in other hues. These also contain chlorophyll, but the green pigment is masked by more dominant pigments, such as carotenoids, (yellow to orange) and anthocyanins (red to purple).

- Plants lacking chlorophyll altogether can't manufacture carbohydrates, so they must get them elsewhere. Indian pipe or ghost plant (*Monotropa uniflora*) is one such example. Common in moist woodlands, its white form resembles a fungus but it's actually a parasitic flowering plant. It takes the nutrients it needs from tree roots using mycorrhizal fungi as intermediaries.

- Plants with variegated leaves — especially those with a large percentage of white in their foliage — tend to be less vigorous compared to their all-green counterparts. Less chlorophyll, less photosynthesis, slower growth.

- Palo verde trees, native to desert climates, can photosynthesize through their green bark. This adaptation allows them to produce food even after they drops their leaves to conserve water.

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