

4.4: How do Plants Produce Food? Reading

Purpose for Reading: As you read this text, work to make sense of how plants make food.

Plants are special. All organisms—plants, animals, and decomposers—rely on organic molecules to grow and get energy. The main process for getting energy from organic molecules—cellular respiration—destroys the organic molecules by combining them with oxygen. Animals (including humans) and decomposers *need* organic molecules and *use* organic molecules and *destroy* organic molecules, but they can't *make* organic molecules from inorganic molecules.

Making organic molecules from inorganic molecules is hard. Why is it so hard? *Energy*. Energy is released when organic molecules combine with oxygen in combustion or cellular respiration. Making organic molecules, though, requires a way for energy to be *added* to the molecules as they are made.

So this is how plants are special. They are the only organisms that can make organic molecules from inorganic molecules. They do this by capturing energy from sunlight—the process of photosynthesis. Let's explain how they do it.

Zooming into Growing

Scientists work to explain things we can observe—like plants growing—by “zooming in” to the smaller systems that plants are made of—cells—as well as the molecules that make up cells. Let's zoom into a plant to figure out how it grows.

Macroscopic scale: We observe plants growing and moving at the macroscopic scale. A potato grows by using glucose that was produced during photosynthesis. A system of tubes in the potato plant (called phloem) carries sugar from leaf cells to every cell in the plant. But how do the leaf cells produce sugar? To understand this process, we need to look inside the leaf cells at the cellular and atomic-molecular scales.

Cellular scale: During photosynthesis, the cells of the leaf convert carbon dioxide and water into glucose and oxygen. (This takes place inside the leaf cells in organelles called chloroplasts.) Glucose is absorbed by the phloem to be sent to the rest of the cells in the plant.

Atomic-molecular scale: Photosynthesis is a chemical process that takes place inside the chloroplasts in leaf cells. Using energy from sunlight, plants can make inorganic molecules (CO_2 and H_2O) into glucose ($\text{C}_6\text{H}_{12}\text{O}_6$, an organic molecule with chemical energy in its C-C and C-H bonds) and oxygen (O_2).

Using Four Steps to Explain Photosynthesis

We can explain photosynthesis—the production of glucose and oxygen from carbon dioxide and water—by answering the four numbered questions on the Three Questions handout. Let's use a potato plant as an example.

1. How do molecules move to the location of the chemical change?

Inorganic molecules in: Carbon dioxide (CO_2) and water (H_2O) are absorbed into the cells of the leaves. The carbon dioxide comes into the leaves from the air. The water comes from the soil. It enters the roots and comes up through the stem to the leaves.

2. How are atoms in molecules being rearranged into different molecules?

Carbon dioxide and water are rearranged into glucose and oxygen molecules. We can use a chemical equation to describe this process:



3. What is happening to energy?

From light energy to chemical energy: The light energy absorbed by the plant is being converted into chemical energy stored in the high energy bonds (C-C and C-H) in the glucose molecules.

4. How do molecules move away from the location of the chemical change?

Glucose and oxygen out: Plant leaf cells use some of the glucose from photosynthesis for their own growth and energy needs. Most of the glucose, though, leaves the leaf cells and moves *down* the stem to all the other cells in the plant (through a system of vessels called the phloem).

Oxygen is either used for cellular respiration or released into the atmosphere. All the oxygen that we breathe was produced at some time by plants engaging in photosynthesis.

Stored Carbon Dioxide

In order to produce glucose, a plant has to absorb water using its roots and absorb CO_2 through small pores in the cells on the surface of the leaf. These pores, called *stomata*, allow CO_2 to go into the cells of the leaves. Water also evaporates and goes out of plant leaves through stomata. During hot, dry days, a plant can close its stomata to prevent losing too much water. However, this also means that the cells on the surface of the leaf will be unable to absorb CO_2 from the atmosphere. This temporarily stops the production of glucose during photosynthesis due to a lack of CO_2 .

However, some specialized versions of plants have evolved mechanisms to “store” CO_2 when stomata are closed. These plants are called C4 plants, and include species such as corn and sugarcane. C4 plants absorb CO_2 through their stomata and use specialized cells to immediately rearrange CO_2 with another carbon-based molecule to create a 4-carbon acid. C4 plants can store this 4-carbon acid deep inside the leaf tissue and then convert it back into CO_2 during photosynthesis. This prevents the plant from having to stop photosynthesis when it closes its stomata. This allows crops such as corn or sugarcane to remain productive even on hot, dry summer days when its stomata are closed.