Introduction to Photosynthesis

Reflect

Suppose you place a pot of seedlings on a sunny windowsill and water it regularly. At the same time, you place a similar pot in a dark closet and keep it watered too. What do you think will happen to each plant after a few weeks? Can you see the differences in plant growth when a plant lacks sunlight?

Grown in light

You probably predicted that the plant on the windowsill will remain healthy, with green leaves. The plant placed in the closet will not thrive. The plant grown without sunlight has yellow leaves and grew spindly, trying to reach sunlight.

Grown in darkness

What caused the plants grown without sunlight to look that way? Light is a basic need for many plants. Why is this?

During photosynthesis, energy from the Sun interacts with matter on Earth.

Plants, algae (including phytoplankton), and many microorganisms require light to live. Most plants will die if they do not receive adequate light. Light is a form of energy that most plants take in and use to carry out photosynthesis. Photosynthesis is a series of chemical reactions that produces glucose, a sugar compound plants use as food. In this way, plants use light from the Sun to make their own food. Radiant energy from the Sun is changed to chemical energy in the form of glucose molecules. The following reaction summarizes this process:

radiant energy from the Sun $\xrightarrow{\text{photosynthesis}}$ chemical energy in glucose molecules

Plants differ from animals by using radiant energy this way. Animals cannot use radiant energy from the Sun to make glucose. They must obtain energy from the environment in the form of food, which contains chemical energy. Animals have to eat in order to survive.

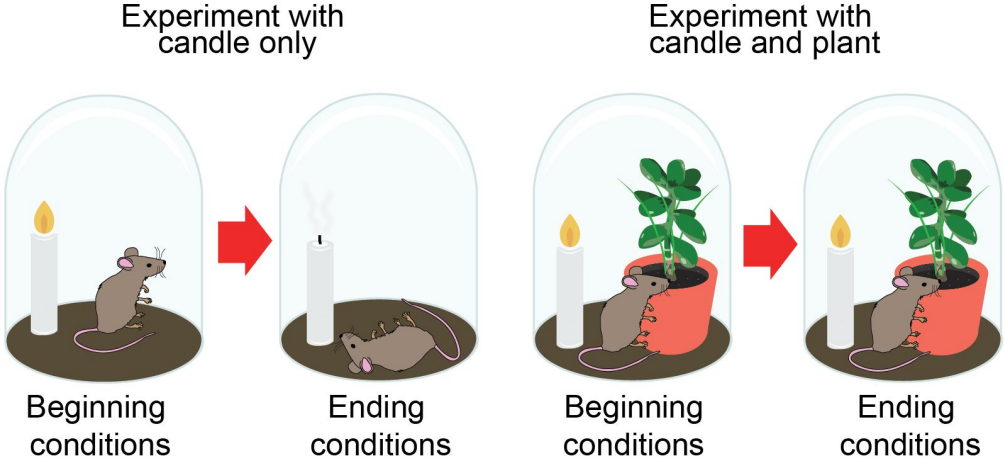
What Do You Think?

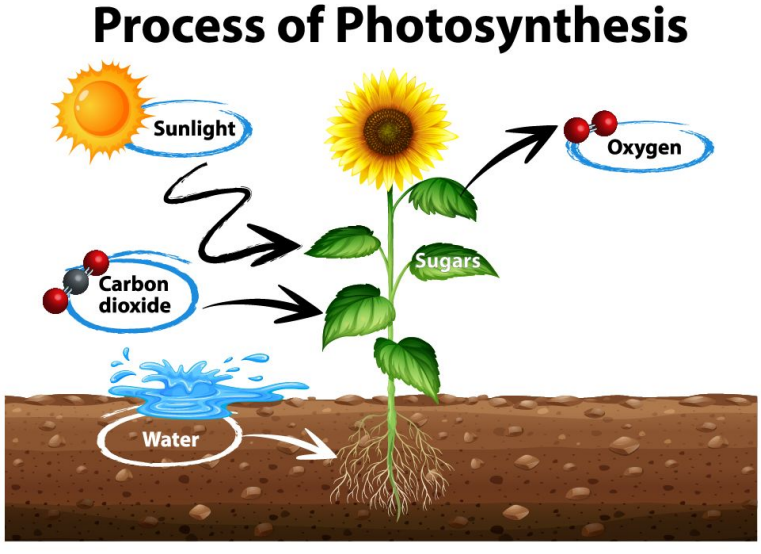
A plant called the underground orchid is native to Western Australia. The plant grows completely underground. The flower sometimes emerges above the surface. Is it likely that these plants use radiant energy from the Sun? If not, what form of energy do they use? This bizarre plant is a parasite and gets its energy feeding off underground fungi! This is one of the few plants that do not use photosynthesis to make food.

Reflect

We can observe photosynthesis by using a simple experiment.

Photosynthesis is a chemical process. Because this process takes place at the level of molecules and atoms, we cannot observe it directly. However, we can observe the results of photosynthesis. Joseph Priestley was one of the first scientists to observe a product of photosynthesis. He conducted an experiment in which he placed a burning candle and a mouse under a glass dome. After a few minutes, the flame went out and the mouse died. Priestley showed that the gases in this dome could not keep the mouse alive. However, if the experiment was repeated with a plant present under the dome, the mouse remained alive. What change did the plant make to the dome?





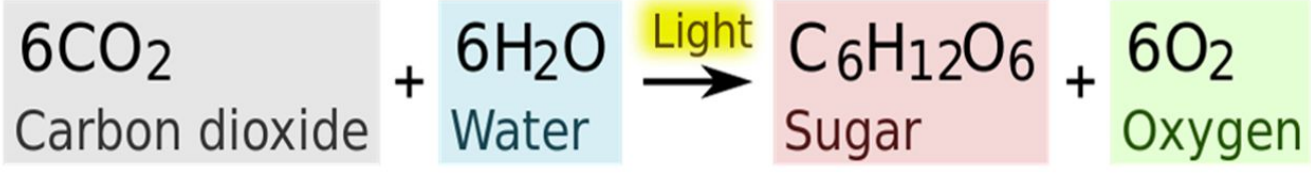
The plant replaced the oxygen that had been used up by the burning candle. Oxygen is a colorless, odorless gas that humans cannot observe directly. However, its presence is required for animals such as mice to live. Priestley demonstrated that the plant could produce oxygen. Oxygen is one of the products of photosynthesis. The other product is sugar (glucose), which plants use as food.

Photosynthesis involves three elements: carbon, hydrogen, and oxygen.
You have seen that the products of photosynthesis are oxygen and glucose. Their chemical formulas are shown below. What elements make up these molecules?

Products of Photosynthesis		
Name	Oxygen	Glucose
Chemical Formula	O_2	$C_6H_{12}O_6$

Only three elements are present in the products of photosynthesis: carbon, hydrogen, and oxygen. These same elements are present in the reactants of photosynthesis.

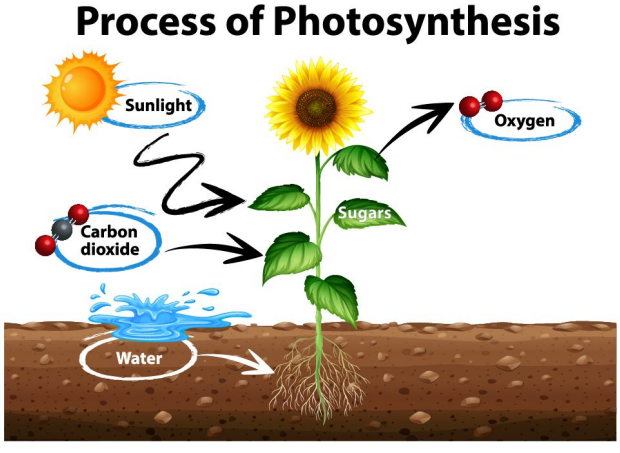
Reactants of Photosynthesis		
Name	Water	Carbon dioxide
Chemical Formula	H_2O	CO_2



Notice that it takes six molecules of water and six molecules of carbon dioxide to make one molecule of glucose. The diagram above shows the inputs and outputs of photosynthesis. Carbon dioxide in the air enters a plant through its leaves. Water in the soil enters through a plant's roots. Oxygen exits from the leaves. Glucose can be used immediately as food or can stay behind to make other structural molecules for growth.

Look Out!

The process of photosynthesis is actually a complex series of many different chemical reactions. The equation shown above represents the overall reaction. This equation shows only the beginning and ending chemical compounds. There are many more steps in between.

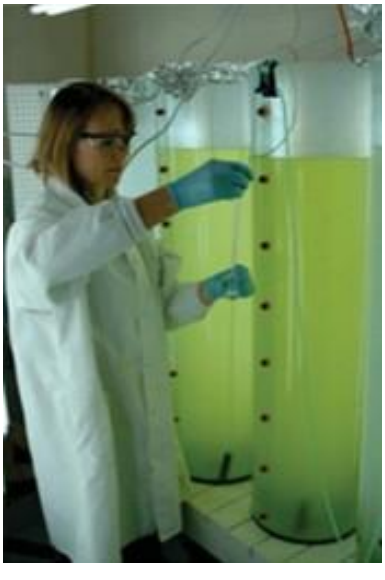


Photosynthesis is necessary for life on Earth.
Humans require oxygen to survive. Many other animals also require oxygen. However, Earth's atmosphere has not always contained oxygen gas. During its first 2.3 billion years of existence, Earth had an atmosphere that contained water vapor, nitrogen, carbon dioxide, sulfur dioxide, and hydrogen sulfide. What changed that led to oxygen gas becoming part of the atmosphere?

The answer is that microorganisms capable of photosynthesis arose on the planet. These microorganisms are called cyanobacteria. Cyanobacteria live in both freshwater and saltwater environments. Millions and millions of these tiny creatures produced enough oxygen to change the composition of Earth's atmosphere. Oxygen became established in the atmosphere as a result of photosynthesis. Since this shift, many organisms have evolved to depend on oxygen. Photosynthesis is necessary to continue supplying oxygen to these organisms.

A scientist takes a sample of cyanobacteria from the surface of a lake. When cyanobacteria populations grow too quickly in a body of water, they can harm other organisms in the ecosystem. This situation is called an algal bloom.

In addition, all life-forms depend on photosynthesis as the mechanism for capturing and using radiant energy. Plants benefit from this directly because they use photosynthesis to make the glucose molecules that are their food source. Animals benefit indirectly because they, too, must have sources of food. Animals either eat plants to obtain chemical energy in the form of glucose or eat other animals that eat plants. Energy moves from the Sun to plants and then to animals. Photosynthesis is necessary for that energy flow.



Looking to the Future: Can humans make use of photosynthesis to produce fuels?
The same microorganisms that created our oxygenated atmosphere could be used to develop new fuels. Think about it. Food is a kind of fuel that we need to run our bodies. If photosynthesis can produce the kind of fuel that our bodies use, it could also produce the kinds of fuels that cars or airplanes use. The scientist on the left is studying the production of organic compounds by cyanobacteria. If successful, she will be able to use photosynthesis to produce fuels for cars, planes, and trains.

Biofuels have been produced from corn, sugarcane, soybeans, and sunflowers. Making biofuel from cyanobacteria is not hard to do. However, the process is expensive. Right now, it costs too much to develop biofuel from the strains of cyanobacteria available. Each cell produces a very small amount of the compounds that serve as the raw material for biofuel production. It is also costly to provide the large quantities of water needed to grow the microorganisms. In all, the cost of making the biofuel is greater than the price at which the fuel can be sold. Scientists are doing a lot of research to find ways to bring costs down so that the process becomes economical.

Try Now

Read the statements below. Fill in each blank with the correct word from the following list:
sun, photosynthesis, radiant energy, food, chemical energy,
water, glucose, carbon dioxide, and oxygen.

All organisms need glucose, or a source of _____, to carry out basic life functions.
Many plants obtain glucose through the process of _____.
Animals obtain glucose from _____.
Photosynthesizing organisms use _____ to produce glucose.
The reactants of photosynthesis are _____ and _____.
The products of photosynthesis are_____ and _____.
The _____ is the source of energy used in photosynthesis.