Name _____ Date _____

Researching Photosynthesis

It has taken hundreds of years and many scientists to get to our current understanding of photosynthesis, the process that feeds almost all life on Earth. Going back 2,500 years, philosophers debated whether natural things were made of water, air, earth or fire, but they did not do experiments. One philosopher, Aristotle, wrote that the matter in plants must come from the soil. Two thousand years later, before photosynthesis or oxygen or carbon dioxide had even been discovered, a Belgian scientist named Jan Van Helmont designed a simple investigation. He published his results—one of the first experiments to test where the matter in plants comes from.

Van Helmont's Five-Year Experiment

In the 1600s, Van Helmont carefully weighed a young willow tree and the soil that he planted it in. He kept the soil covered so that nothing else could get into the pot. He watered the tree with rainwater or distilled water. Time passed, and the tree grew quite large. After five years, he weighed the tree and the soil again. To Van Helmont's surprise, the tree was much heavier, but the soil still weighed about as much as it had five years earlier. Van Helmont concluded that the tree's matter did not come from soil; it must have gained its matter from the water he had added to it over the years.

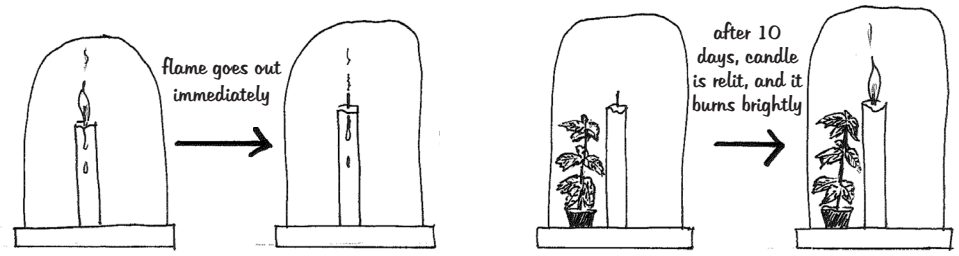
	Beginning	Five Years Later
Soil (dried in an oven)	200 lb	199 lb, 14 oz
Plant	5 lb	169 lb, 3 oz

Why did Van Helmont ignore the missing two ounces of soil? What if he had also dried the tree (rather than just the soil) to remove all the water? He would have found that the tree's matter was about half water. So Van Helmont's conclusion that a tree's matter came from water was just partly right. Some of the matter in the tree came from water. But about half the matter came from somewhere else. Where? Fast forward about 150 years….

Researching Photosynthesis (continued)

Plants and Air

In the first part of the 1700s, nothing was known about the different kinds of gases in air. Then by the late 1770s, observations by Joseph Priestley and others led them to think that there were different kinds of air. Priestley experimented with a kind of air that he called "fixed air." He figured out how to mix this air with water and invented carbonated beverages. Now we know that what he called "fixed air" was really CO_2. He was also interested in the "goodness" of air and how plants could fix (or restore) what he called "injured" air. He found that if he put a burning candle in a covered jar, the candle would burn out immediately. If he added a green plant, sealing the burned-out candle and plant inside the jar, and then relit the candle after 10 days, the candle burned brightly. This helped him make the connection between things that depleted air, such as fires, and plants, which could restore air. Soon Priestley would discover oxygen and learn that it is a kind of gas, separate from other gases that make up air.



How did Priestley light the candle without opening the sealed jar? He used a mirror to focus sunlight on the candle's wick until it caught fire.

By 1800, scientists had discovered that air is a mixture of gases, which includes oxygen and carbon dioxide. In 1804, Nicolas de Saussure performed careful experiments that made important advances in understanding how plants use air. In one experiment, de Saussure grew plants inside sealed glass containers where he controlled the amount of carbon dioxide. After a time, he measured how the air in the containers had changed and how much matter (carbon) had been added to the plants. He found that as the plants grew, they used up the carbon dioxide in the sealed containers, which showed that the carbon in plants came from carbon dioxide.

We now understand that in photosynthesis, plants take in carbon dioxide and water. And they use energy from sunlight to rearrange the atoms in the molecules of carbon dioxide (CO_2) and water (H_2O) to make sugar ($C_6H_{12}O_6$) and oxygen molecules (O_2).

$$6\ CO_2 + 6\ H_2O + \text{sunlight (light energy)} \dashrightarrow C_6H_{12}O_6 + 6\ O_2$$

Plants use this sugar for energy and for building molecules such as starch and cellulose, which make up the stems, leaves, and other parts of a plant.

The process of understanding photosynthesis has been very long, and it is ongoing. Ten Nobel Prizes in chemistry have been given for work related to photosynthesis. Thousands of scientists around the world continue to investigate exactly how plants get the energy and matter they need. Scientists are investigating how the atoms move as the molecules rearrange, how the energy from sunlight powers the process, how photosynthesis happens in different types of organisms, whether photosynthesis can be used to produce electricity, and much more.