BOTANY, PLANT PHYSIOLOGY AND PLANT GROWTH

Lesson 7: PLANT PHYSIOLOGY

The three major plant functions that are the basics for plant growth and development are photosynthesis, respiration, and transpiration.

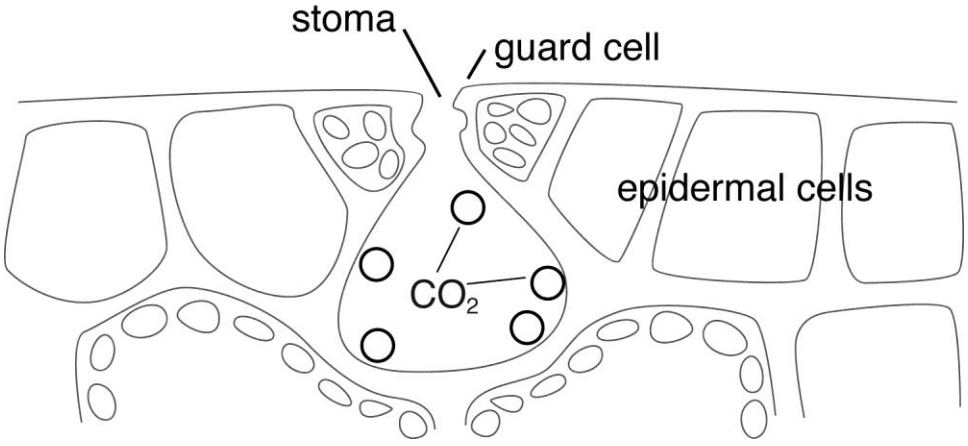
1. In photosynthesis, plants can store the energy from light in carbohydrates such as sugars and starches for use during days when light is limited or they can transport these chemicals to the roots.
2. In respiration, sugars and starches are converted back to water and carbon dioxide and the stored energy is released to perform activities necessary for growth.
3. In transpiration, water is pulled through the plant by evaporation of water through the leaves.

Segment One - Photosynthesis

One of the major differences between plants and animals is the plant's ability to manufacture its own food. To produce food for itself a plant requires energy from sunlight, carbon dioxide from the air, and water from the soil.

If any of these ingredients is lacking, photosynthesis (food production) will stop. If any factor is removed for a long period of time, the plant will die. Photosynthesis literally means "to put together with light."

Only cells in the mesophyll layer of the plant leaves and stems can manufacture energy. These cells which, contain chloroplasts, are located between and protected by, the upper and lower epidermis (skin) of the leaf. The green pigment chlorophyll, that is found in the chloroplasts of these cells traps light energy so it can be used to manufacture sugar and starches.



The equation for photosynthesis follows.

carbon dioxide + water $\xrightarrow{\text{Light}}$ sugar + oxygen

$6CO_2 + 6H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6O_2$

Photosynthesis requires carbon dioxide (CO_2) which enters the plant through the stomata. Carbon dioxide is split into carbon and oxygen which are used in the manufacture of carbohydrates. Carbon dioxide in the air is plentiful enough so that it is not a limiting factor in plant growth.

Water is split into hydrogen and oxygen by the energy of the sun that has been absorbed by the chlorophyll in the plant leaves. The oxygen is released to the atmosphere and the hydrogen is used in the manufacture of carbohydrates.

Photosynthesis is dependent on the availability of light. Generally speaking, as sunlight increases in intensity, photosynthesis increases.

Although not a direct component in photosynthesis, temperature is an important factor. Photosynthesis occurs at its highest rate in a temperature range of 65° to 85°F (18° to 27°C) and decreases at temperatures above or below this range.

Segment Two - Respiration

Carbohydrates made during photosynthesis are of value to the plant when they are converted to energy. This energy is used in the process of building new tissues or growth of the plant. The chemical process by which sugars and starches produced by photosynthesis are converted to energy is called oxidation. It is similar to the burning of wood or coal to produce heat. Controlled oxidation in a living cell is known as respiration and is shown most simply by this equation:

sugar + oxygen ---> carbon dioxide + water + heat

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + heat

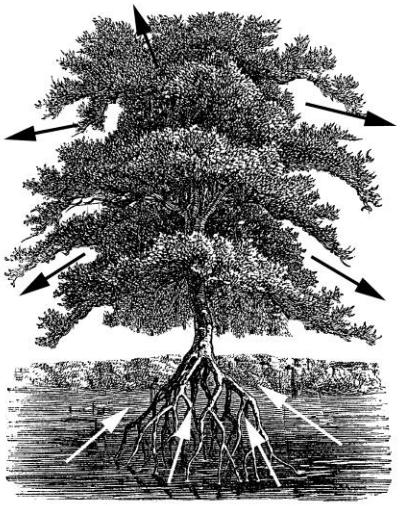
This equation is just the opposite of that used to illustrate photosynthesis. Therefore, photosynthesis may be called a building process, while respiration is a breaking down process.

Photosynthesis	**Respiration**
1. Produces food	1. Uses food for plant energy
2. Energy is stored	2. Energy is released
3. Occurs in cells containing chloroplasts	3. Occurs in all cells
4. Oxygen is released	4. Oxygen is used
5. Water is used	5. Water is produced
6. Carbon dioxide is used	6. Carbon dioxide is produced
7. Occurs in sunlight	7. Occurs in dark as well as light

By now it should be clear that respiration is the reverse of photosynthesis. Unlike photosynthesis, respiration occurs at night as well as during the day. Respiration occurs in all life forms and in all cells. The release of accumulated carbon dioxide and the uptake of oxygen occur at the cell level. In animals, blood carries both carbon dioxide and oxygen to and from the atmosphere by means of the lungs or gills. In plants, there is simple diffusion into the open spaces within the leaf and exchange through the stomata.

Segment Three - Transpiration

Water is pulled through the plant by evaporation of water through the leaves, a process called transpiration. In the diagram, white arrows represent moisture entering the plant, and the black arrows represent moisture going out.



Clip Art, Dover Publications, Inc., Mineola, New York

Transpiration is the process by which a plant loses water primarily from leaf stomata. Transpiration is a necessary process that involves the use of about 90% of the water that enters the plant through the roots. The other 10% of the water is used in chemical reactions and in plant tissues. Transpiration is necessary for mineral transport from the soil to the plant parts, for the cooling of plant parts through evaporation, to move sugars and plant chemicals, and for the maintenance of turgor pressure. The amount of

water lost from the plant depends on several environmental factors such as temperature, humidity, and wind or air movement. As temperatures or air movement increase, transpiration increases. As humidity decreases, transpiration increases.

The best way to conceptualize the movement of water in plants is to consider water movement as a series of pulling forces that extend from the soil as water enters the root, up through the stem, branch, twig and petiole and finally into the leaf blade. The water is pulled from the leaf through structures that are actually openings to the outside of the leaf, called stomata. The water inside the plant is a continuous column, there are no air gaps. Water moves continuously along this pathway supplying the needs of the plant. The major driving force of water movement in the plant is the water loss at the leaf surface, “transpiration” of water from the leaf surface through the stomata. This water loss is a tremendous wick line force that actually sucks the water into the roots.

Water moves through the plant through the xylem inside very small tube-like cells called vessels or tracheids. Both of these cells are open on the ends and are stacked end to end like straws. When water is inside the endodermis of the root and in the xylem cells a positive root pressure is developed. This pressure is usually only a small part of the entire water transport system. Water has a tremendous cohesive strength in the water to water bond. This can easily be seen as water beads up on waxy surfaces and each drop can get to a fairly large size before breaking down to smaller sized water drops. Water also has a strong adhesive attraction to the walls of the small thin cells found in the xylem. This can be seen as water will move up a straw on its own a small amount above the level of a liquid in a glass. As transpiration moves water from the leaf, the entire column of water is pulled up from the roots, through the plant, and into the leaves. All of these factors help water to move efficiently.

When the loss of water from the leaves exceeds the amount of water being absorbed by the roots and trans-located through the xylem to the leaves, the plant will wilt. This will be especially noticeable on very hot days when there is a breeze or wind. This will also happen to plants dug up and transplanted when in leaf. Wilting can occur due to a lack of water supply in the soil or the lack of root hairs to absorb the water. Root hairs can be lost due to a lack of oxygen, root disease or mechanical damage during transplanting.

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