Plants React to Light

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Plants React to Light

How do green plants react to the sun's rays – natural light – and to artificial light? Explanations follow on how plants receive light and how scientists have progressed in the study of the effect light has on plants.

Plants growing near windows turn their leaves toward the sun's rays. Some plants even bend their stems toward sunlight. Why is this? The reason has to do with the fact that green plants are producers – they make food for themselves and animals. The process by which green plants produce food is known as photosynthesis. "Photosynthesis is a food making process that occurs in green plants" (Calvin, 382). Photosynthesis "runs" on sunshine with sugar as its product. The sugar is changed into protoplasm (Moon, 38).

How can green plants accomplish this? Well, in photosynthesis, living plant cells combine carbon dioxide, water, and the sun's light energy in the presence of chlorophyll to form sugar. Oxygen is released as a waste material (Moon, 172-173).

To make the process of photosynthesis even simpler, it can be stated as a chemical equation. The equation shows the amount and proportion of the elements involved. Here is the formula:

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

(Carbon dioxide) + (Water) + (Sunlight) → (Sugar) + (Oxygen)

(Moon, 172-173).

The equation means that six molecules of carbon dioxide and six molecules of water, combined with energy, form a molecule of sugar. Six molecules of oxygen are left over as a waste material. The sugar is a form of stored energy which may be used later (Moon, 173).

Leaves are arranged on stems in a way that will expose each leaf to the most sunlight. Every leaf grows at a different angle on the stem. This arrangement of leaves tends to put each one of the leaves in the very best position to receive sunlight. Individual stems bend in order to adjust their position. The bending is due to the fact that the cells on the side away from the sunlight are stimulated to grow faster than those that face the light (Moon, 173).

This reaction of plants to sunlight is called phototropism. Phototropism, then, is the response of plants to sunlight. We use this word because “photo” means light and “tropism” means turning (Klein, 42). Tropisms are growth movements in a definite direction in response to a stimulus. A stimulus is anything in the environment which causes a response. Tropisms are positive when the direction of growth is toward the stimulus and negative when it is away from the stimulus (Elliot, 612).

Space left blank for: Diagram 1

“The generalized leaf”

(Klein, 87).

Many plants are arranged so their leaves receive a maximum of sunlight. “The main stems of most plants grow toward the light, which, in normal conditions, means more or less vertically” (Reid, 95). This vertical stance is due partly to phototropism and partly to a tendency to grow away from the pull of gravity. It places plants in the best position to receive sunlight for photosynthesis (Reid, 95).

Space left blank for: Diagram 2

"The phototropism of stems is positive;
that is, the stem turns toward the light"
(Miller, 612).

All of this information is not new. Scientists and others have noticed these reactions of plants for more than two thousand years. But not until scientist Charles Darwin published his book, The Power of Movement in Plants, did botanists begin to take a real interest in phototropism. Darwin's experiments were simple but they were clever and showed a great deal of thought. Much of his work was done with a type of grass called canary grass. The reason he used canary grass was because it sprouts quickly and grows well in small containers (Klein, 42).

The first leaf of a grass seedling is covered by a thin sheath called a coleoptile. The coleoptile, Darwin discovered, is very sensitive to light. In fact, Darwin found that the coleoptile would bend toward light that was so dim that he could not even see it (Klein, 42).

Space left blank for: Diagram 3

"Corn seed sprouting"
(Klein, 43).

In recent years, using equipment and techniques unknown to Darwin, we have discovered how the coleoptile responds to sunlight. Here is how it works. “The coleoptile is made up of cells. The cells on all sides of the coleoptile are almost exactly the same length. If the cells on one side of the coleoptile (or one side of a stem) were to become longer than the cells on the other side, this unequal growth would cause the whole cylinder to bend” (Klein, 42-43).

Space left blank for: Diagram 4

“A bending plant is like a bending spring.”

(Klein, 43).

The big question of photosynthesis is: How does the light cause only the cells on one side of a stem, or coleoptile, to grow longer? We have some facts that give us a clue to the answer. Botanists have discovered that the bending will not happen if the very tip of the coleoptile is removed. This proves that the tip is the part of the coleoptile that is sensitive to sunlight (Klein, 44).

But Darwin noticed that the bending occurred farther down the stem. He concluded that there must be some kind of chemical that moved from the tip to the coleoptile and causes the unequal growth (Klein, 44).

Boysen-Jensen, a Danish botanist, performed an experiment in 1910 to prove that a chemical causes the turning of leaves toward sunlight. He cut the tip off oat seedlings that were bending toward a light source. He then used gelatin to fasten the tips to the stumps of the plants. The bending occurred again. He concluded that something must have passed from the tip through the non-living gelatin to the stump. It could only have been a chemical substance (Miller, 445).

A year later, in another experiment, Boysen-Jensen inserted pieces of mica just behind the tips of oat seedlings and part way through the stems. When the seedlings were placed so that the mica was on the side away from the light source, the seedlings did not bend toward the light. He assumed that the chemical from the tip of the plants could not pass through the mica. From this he determined that the substance causing the reaction moved down the side of the plant opposite to the light. Cells on that side grew longer. This caused the bending of the stem toward the light (Miller, 445).

Space left blank for: Diagram 5

"Boysen-Jensen's experiment"

(Miller, 445).

A little over fifty years later Dr. Fritz Went proved that Darwin and Boysen-Jensen were correct. It was a chemical we now call auxin that caused the plants to bend toward sunlight. We now know that auxin is formed in the tip of the coleoptile and causes cells to grow longer when it moves down the stem (Klein, 44).

Artificial light is a type of light that gives plants artificial sunlight when natural sunlight is not available. Special light bulbs for growing plants have been developed. They emit just those rays which help plants grow properly. These special light bulbs are often called “grow” lights. Regular light bulbs produce too many red rays that dry plants but they do not produce enough warming blue rays. You can see that regular bulbs are unacceptable as sources of artificial sunlight because they give off uncontrolled rays. Growing plants need a balance of red and blue rays. Red ones are needed to stimulate the growth of stems and leaves. Blue rays are necessary in order to regulate plant respiration and enzyme action (Bubel, 68).

To see how plants react to artificial light, botanist Nancy Bubel grew several different kinds of plants under artificial light conditions. She used “grow” lights. Here are the results of her experiments. “The plants we raise under our grow lights are far more sturdy, bushy, and intensely colored than any we ever kept on window sills. Coleus colors have such depth and richness they seem like a different plant. Salad and seedling greens are intensified to an almost vibrating aliveness. Blossoms appear enhanced, both in structure and color. Herbs grow bushy rather than leggy. Seedlings have short, sturdy stems topped by the greenest of leaves” (Bubel, 68).

Plants grow well under artificial light. However, the artificial light must produce rays which can be utilized by the plants. Ordinary light bulbs are not acceptable. Because of controlled conditions, plants grown under artificial light show exceptional growth.

The process of photosynthesis not only provides food for the plant, but keeps all living things on earth alive. By a miracle of God, not fully understood by scientists, plants use carbon dioxide that animals breathe out and supply animals with life-giving oxygen. Without plants the earth’s oxygen and food supply would soon be exhausted and all life would perish. Fortunately phototropism enables plants to absorb the maximum amount of energy from the sun. This permits plants to carry on photosynthesis at a maximum. For this reason one might say that photosynthesis and phototropism are the two most important processes in the world.

Works Cited

Bubel, Nancy. “Grow Lights Bring Gardening Indoors.” Organic Gardening and Farming, December 1972.

Calvin, Melvin. “Phototropism.” World Book Encyclopedia, 1976 ed.

Elliot, Alfred M. Biology. New York: Appleton Century Crofts, Inc., 1960.

Klein, Richard M. and Klein, Deana T. Discovering Plants. Garden City: The Natural History Press, 1968.

Miller, William B. ed. High School Biology: BSCS Green Version. Chicago: Rand McNally and Company, 1963.

Moon, Truman J., Otto, James H., and Mann, Paul B. Modern Biology. New York: Henry Holt and Company, Inc., 1956.

Palmer, E. Laurence. “Plants.” World Book Encyclopedia, 1971 ed.

Reid, Keith. Nature’s Network. Garden City: The Natural History Press, 1970.