Station 1: Phototropism

A tropism is a plant movement that is determined by the direction of an environmental stimulus. Movement toward an environmental stimulus is called a positive tropism, and movement away from a stimulus is called a negative tropism. Each kind of tropism is named for its stimulus. For example, a plant movement in response to light coming from one particular direction is called a phototropism. The shoot tips of a plant that grow toward the light source are positively phototropic.

Phototropism, as mentioned, is illustrated by the movement of sprouts in relation to light source direction. Light causes the hormone auxin to move to the shaded side of the shoot. The auxin causes the cells on the shaded side to elongate more than the cells on the illuminated side. As a result, the shoot bends toward the light and exhibits positive phototropism. In some plant stems, phototropism is not caused by auxin presence or movement. In these instances, light causes the production of a growth inhibitor on the illuminated side of the shoot. Negative phototropism is sometimes seen in vines that climb on flat walls where coiling tendrils have nothing to coil around. These vines have stem tips that grow away from the light, or better put, toward the wall. This brings adventitious roots or adhesive discs in contact with the wall on which they can cling and climb.

Solar tracking is the motion of leaves or flowers as they follow the sun's movement across the sky. By continuously facing toward a light source, moving or not, the plant maximizes the light available for photosynthesis.

The experiment that led to the discovery of the first plant hormone was carried out by Charles Darwin. In 1880, Darwin and his son Francis published a book called *The Power of Movement in Plants*. In this book, they described an experiment in which oat seedlings demonstrated a response now known as phototropism.

The activity Effect of Light on a Growing Plant, at right, shows an experiment similar to the one carried out by the Darwins. Notice that the tip of one of the oat seedlings was covered with an opaque cap. This plant did not bend toward the light, even though the rest of the plant was uncovered. However, if an opaque shield was placed a few centimeters below the tip, the plant would bend toward the light as if the shield were not there. Clearly, something was taking place at the tip of the seedling.

1. Summarize (in your own words) the experiment by Francis and Charles Darwin.
2. Using the above graphic, explain why the seedling at the far right is curved.
3. Utilizing your knowledge about phototropism, why do you need to rotate your houseplants every so often?
Station 2: Gravitropism

Plants change their patterns and directions of growth in response to a multitude of cues. The responses of plants to external stimuli are called tropisms, from a Greek word that means “turning.” Plant tropisms include gravitropism, phototropism, and thigmotropism. Each of these responses demonstrates the ability of plants to respond effectively to external stimuli, such as gravity, light, and touch.

Gravitropism is a plant growth response to gravity. A root usually grows downward and a stem usually grows upward; that is, roots are positively gravitropic and stems are negatively gravitropic. Gravitropism appears to be regulated by auxins. One hypothesis proposes that when a seedling is placed horizontally, auxins accumulate along the lower sides of the root and the stem. This concentration of auxins stimulates cell elongation along the lower side of the stem, and the stem grows upward. A similar concentration of auxins inhibits cell elongation in the lower side of the root, and thus the root grows downward.

1. How can you determine if the plants in photograph B are expressing negative or positive gravitropism?
2. What would happen if you accidentally planted a seed wrong side up?
3. Why did the root tip in photograph A with the end cut off not express any form of gravitropism?
Station 3: Thigmotropism

A tropism is a plant movement that is determined by the direction of an environmental stimulus. Movement toward an environmental stimulus is called a positive tropism, and movement away from a stimulus is called a negative tropism. Each kind of tropism is named for its stimulus. For example, a plant movement in response to light coming from one particular direction is called a phototropism. The shoot tips of a plant that grow toward the light source are positively phototropic.

Thigmotropism is a plant growth response to touching a solid object. A plant that is touched regularly, for example, may be stunted in its growth—sometimes quite dramatically. It is thought that two hormones, an auxin and ethylene, are involved in this response.

Another example of thigmotropism is the growth of vines and climbing plants. The stems of these plants do not grow straight up. Rather, the growing tip of each stem points sideways and twists in circles as the shoot grows. When the tip encounters an object, it quickly wraps around it. Thigmotropism allows some vines to climb other plants or objects, thus increasing its chance of intercepting light for photosynthesis.

Some climbing plants have long, twisting leaf tips or petioles that wrap tightly around small objects. Other plants, such as the grapes shown to the right, have extra growths called tendrils that emerge near the base of the leaf and wrap tightly around any object they encounter.

1. How would a plant’s tendrils respond to a trellis?
2. Why might climbing plants have a survival advantage over some nonclimbing plants in a densely grown forest?
3. How do plants know to grow thicker in windy areas?
Station 4: Auxin & Plant Growth

Auxins affect plant growth in a variety of ways. The graph below shows the results of experiments in which carrot cells were grown in the presence of varying concentrations of auxins. The solid line on the graph shows the growth pattern of the carrot plants' roots. The dashed line shows the growth pattern of the carrot plants' stems.

1. At what auxin concentration are the stems stimulated to grow the most?
2. How is the growth of the roots affected by the auxin concentration at which stems grow the most?
3. Use the data in the graph to describe the relationship between the concentration of auxins and the growth of carrot plant stems.
4. If you were a carrot farmer, what concentration of auxin should you apply to your fields to produce the largest-sized carrots?
In plants, the division, growth, maturation, and development of cells are controlled by a group of chemicals called hormones. A hormone is a substance that is produced in one part of an organism and affects another part of the same individual. Plant hormones are chemical substances that control a plant’s patterns of growth and development, and the plant’s responses to environmental conditions.

Hormones are produced in apical meristems, in young leaves, in roots, and in growing flowers and fruits. From their place of origin, hormones move to other parts of the plant, where target cells respond in a way that is specific to the hormone.

**AUXINS:**

Auxins are produced in the apical meristem and are transported downward into the rest of the plant. They stimulate cell elongation.

**GIBBERELLINS:**

Gibberellins produce dramatic increases in size, particularly in stems and fruit. Gibberellins are also produced by seed tissue and are responsible for the rapid early growth of many plants.

**CYTOKININS:**

Cytokinins are plant hormones that are produced in growing roots and in developing fruits and seeds. In plants, cytokinins stimulate cell division and the growth of lateral buds, and cause dormant seeds to sprout. Cytokinins also delay the aging of leaves and play important roles in the early stages of plant growth.

Cytokinins often produce effects opposite to those of auxins. For example, auxins stimulate cell elongation, whereas cytokinins inhibit elongation and cause cells to grow thicker. Auxins inhibit the growth of lateral buds, whereas cytokinins stimulate lateral bud growth. Recent experiments show that the rate of cell growth in most plants is determined by the ratio of the concentration of auxins to cytokinins. In growing plants, therefore, the relative concentrations of auxins, cytokinins, and other hormones determine how the plant grows.

1. Where are hormone-producing cells in a plant?
2. What are target cells?
3. How do hormones affect target cells?
4. How can a gardener use this knowledge of hormones produce fuller, bushier plants?
Station 6: One bad apple spoils the bunch

When natural gas was used in city street lamps in the nineteenth century, people noticed that trees along the street suffered leaf loss and stunted growth. This effect was eventually traced to ethylene, one of the minor components of natural gas.

Today, scientists know that plants produce their own ethylene, and that it affects plants in a number of ways. In response to auxins, fruit tissues release small amounts of the hormone ethylene. Ethylene then stimulates fruits to ripen.

Commercial producers of fruit sometimes use this hormone to control the ripening process. Many crops, including lemons and tomatoes, are picked before they ripen so that they can be handled without damage to the fruit. Just before they are delivered to market, the fruits are treated with synthetic ethylene to produce a ripe color quickly. This trick does not always produce a ripe flavor, which is one reason why naturally ripened fruits often taste much better.

1. Apples are harvested in the autumn; however you may enjoy an apple at anytime of the year. How are apples prevented from over ripening once they are picked?
2. Summarize what might happen to your houseplants if you were to have a small gas leak inside of your house.
3. Why is understanding plant hormones, such as ethylene, important to grocery stores?