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This essay is written as a series of fictional journal entries.

*From the laboratory of Charles Darwin and his son, Francis, late 1800's:*

Charles and Francis **Darwin** are working on publishing *The Power of Movement in Plants*. Today they observed the bending of plant shoots toward the light. They have found that the bending of the **coleoptile** did not occur if they covered its upper portion with a cylinder of metal foil or a hollow tube of blackened glass and illuminated the plant from one side. However, they did discover that when the tip was enclosed in a transparent glass, it did bend towards the light. The Darwin's concluded that "when seedlings are freely exposed to a lateral light, some influence is transmitted from  the upper to the lower part, causing the latter to bend." The result of the bending is unknown at this time. Further research will need to be done.

*From the laboratory of Frits W. Went, 1926:*

Plant physiologist **Frits W. Went** has succeeded in isolating the "influence" from the coleoptile tips of oat seedlings. Went cut the coleoptile tips from the seedlings and place the tips on a slice of agar for about an hour. He then cut the agar into small blocks and placed a block on one side of each cut shoot. The seedlings were kept in the dark during the entire experiment and were observed to bend away from the side on which the agar block was placed. Went has concluded that the influence that caused the seedling to bend was chemical and that it was accumulated on the side away from the light. Went has named this chemical substance auxin. In this experiment, auxin molecules produced in the coleoptile tip were first transferred to the agar and then to one side of the seedling by means of an agar block.

*Personal Journal:*

Visiting the labs of these two scientists has lead to some research of my own. I've learned that when a plant has a growth response involving bending, or curving, of a part toward or away from an external stimulus it is called a tropism. Curving of growing shoot tips toward light is called **phototropism**. Both Darwin and Went studied this and, as Went discovered, it is due to the hormone auxin and results in **cell elongation** on the shaded side of the tip. What I am wondering is what role the light plays in the phototropic response. There are three possible answers to this: (1) light decreases the auxin sensitivity of the cells on the lighted side, (2) light destroys auxin, or (3) light drives auxin to the shaded side of the growing tip. More research will have to be conducted to find the answer.

*From the laboratory of Winslow Briggs, 1950's:*

**Winslow Briggs** and his co-workers carried out a series of experiments to test the hypotheses listed above. They first showed that the same total amount of auxin is obtained from the tips of the coleoptile in the light or the dark. If one side is exposed to light, more auxin is obtained from the shaded side than from the lighted side. However, if the tip is split and a thin piece of glass is placed as a barrier between the two halves, this differential distribution of auxin no longer happens. With this experiment, Briggs demonstrated that auxin migrates laterally fromt he light side to the dark side. Experiments using **indole-3 acetic acid,** or IAA, have shown that it is migration of auxin, not destruction, that is responsible for the different amounts obtained from the light and dark sides of the coleoptile. The experiments support the hypothesis that auxin redistribution is responsible for phototropic curvature.

*Personal Journal:*

Witnessing the experiments involving phototropism was exciting. I decided to dive further into tropisms and study another familiar one called **gravitropism.** This is the plants response to gravity. From what I read, if a seedling is placed on its side, its rood will grow downward and its shoot will grow upward in response to gravity. But how do shoots and roots perceive gravity? This is correlated with the sedimentation of amyloplasts within specific cells of the shoot and root. The gravity-sensing amyloplasts are called **statoliths** and the cells in which they occur are called statocytes. The statocytes in roots are localized in the columnella of the **root cap.** The columnella cells are highly polarized and in the vertically oriented ones, the amyloplasts are located near the bottom of each cell, near the transverse wall but separated from it by a network of tubular endoplasmic reticulum. The nucleus is at the opposite end of the cell, and the rest of the organelles are in the central portion of the cell. When a root gets placed in a horizontal position, the amyloplasts slide downward and come to rest near what were the vertically oriented walls. I placed a plant on its side, and within a mater of several hours, the root curved downward and the amyloplasts return to their previous postion along the transverse walls. This phenomenon is called the starch-statolith hypothesis. To support this hypothesis, studies were done using starchless, and starch-deficient mutants. Thes starch-deficient mutants were less sensitive to gravity than the wild-type plants, and the starch less mutants proved to be much less sensitive.

The curvature of the root in response to gravity is initiated in a region distal to the main zone of cell elongation. In this zone, elongation is stimulated along its upper side, while elongation is suppressed along the lower side of both the distal and main elongation zones. This means that the development of curvature starts near the tip of the root. PIN proteins play a role in driving the asymmetrical redistribution of auxin toward the lower lateral root cap cells. The auxin is transported on the lower side of the root from the tip to the distal elongation zone, which is the first region of the root to respond to gravity. Other things that may cause **growth inhibition** in addition to auxin have been implicated in gravitropic responses including **cytokinins**, nitric oxide, ethylene, and abscisic acid.

*Personal journal from the International Space Station:*

I traveled to the international space station to study a form of tropism that is difficult to study on Earth due to competing gravitropic responses being much greater. I'm here studying **hydrotropism**, which is the directed growth of plant roots in response to moisture gradients. On Earth, a discovery of a mutant pea that does not respond to gravity provided a breakthrough in the study of hydrotropism. This mutant displays a hydrotropic response. We are in space to find additional evidence of this phenomenon and to prove that hydrotropic responses are suppressed by gravitropism. Under these microgravity conditions, the gravitropic response has been nullified and the roots do, indeed, exhibit positive hydrotropism. What we still don't know are the underlying mechanisms that regulate hydrotropism. Auxin seems to play a role in both hydrotropic and gravitropic responses, but the role of auxin in the two tropisms may be different. Further studies on the subject must be done. Our mission here in space seems to be complete.

*Personal journal back on Earth:*

The last common tropism I intend to research is **thigmotropism.** This is the response of a plant to contact with a solid object. Thigmotropism enables a root to navigate around rocks and allows shoots of climbing plants to wrap around structures for support purposes. An example of this is found in tendrils (modified leaves or stems) that seem to wrap around any object with which they come in contact with. These tendrils allow the plant to cling or climb, and in less than an hour a tendril may wrap around a support one or more times. It is uncertain if the mechanism of this tropism involves auxin gradients.