30.7D: Plant Responses to Gravity

LEARNING OBJECTIVES

• Describe the role of amyloplasts in gravitropism

Whether or not they germinate in the light or in total darkness, shoots usually sprout up from the ground, while roots grow downward into the ground. A plant laid on its side in the dark will send shoots upward when given enough time. Gravitropism ensures that roots grow into the soil and that shoots grow toward sunlight. Growth of the shoot apical tip upward is called negative gravitropism, whereas growth of the roots downward is called positive gravitropism.

Time-lapse of pea shoot and root growth: Time-lapse of a pea plant growing from seed, showing both the shoot and root system. The roots grown downward in the direction of gravity, which is positive gravitropism, and the shoot grows upward away from gravity, which is negative gravitropism.

The reason plants know which way to grow in response to gravity is due to amyloplasts in the plants. Amyloplasts (also known as statoliths) are specialized plastids that contain starch granules and settle downward in response to gravity. Amyloplasts are found in shoots and in specialized cells of the root cap. When a plant is tilted, the statoliths drop to the new bottom cell wall. A few hours later, the shoot or root will show growth in the new vertical direction.
Gravitropism: This is an image of an upright tree with high curvature at the base as a result of negative gravitropism. Despite being tilted, amyloplasts will cause the shoot to grow in a vertical direction.

The mechanism that mediates gravitropism is reasonably well understood. When amyloplasts settle to the bottom of the gravity-sensing cells in the root or shoot, they physically contact the endoplasmic reticulum (ER). This causes the release of calcium ions from inside the ER. This calcium signaling in the cells causes polar transport of the plant hormone indole acetic acid (IAA) to the bottom of the cell. In roots, a high concentration of IAA inhibits cell elongation. The effect slows growth on the lower side of the root while cells develop normally on the upper side. IAA has the opposite effect in shoots, where a higher concentration at the lower side of the shoot stimulates cell expansion and causes the shoot to grow up. After the shoot or root begin to grow vertically, the amyloplasts return to their normal position. Other hypotheses, which involve the entire cell in the gravitropism effect, have been proposed to explain why some mutants that lack amyloplasts may still exhibit a weak gravitropic response.

Key Points

- Positive gravitropism occurs when roots grow into soil because they grow in the direction of gravity while negative gravitropism occurs when shoots grow up toward sunlight in the opposite direction of gravity.
- Amyloplasts settle at the bottom of the cells of the shoots and roots in response to gravity, causing calcium signaling and the release of indole acetic acid.
- Indole acetic acid inhibits cell elongation in the lower side of roots, but stimulates cell expansion in shoots, which causes shoots to grow upward.
Key Terms

- **amyloplast**: a non-pigmented organelle found in some plant cells that is responsible for the synthesis and storage of starch granules through the polymerization of glucose
- **statolith**: a specialized form of amyloplast involved in graviperception by plant roots and most invertebrates
- **gravitropism**: a plant’s ability to change its growth in response to gravity