Plants in Space

Plants will play a key part in space colonization, providing food and oxygen. But how will organisms that have evolved under constant gravity function in its near absence beyond Earth?

Researchers are studying the effects of microgravity on a variety of species by sending them on space shuttle voyages. These experiments can more realistically assess plant growth and development in space than simulations conducted on earth, which use a rotating device called a clinostat to diminish gravitational force. So far, it appears that lack of gravity greatly affects plants, in everything from subcellular structural organization to the functioning of the organism as a whole.

Subcellular Responses to Microgravity

Plant cells grown in space have fewer starch grains and more abundant lipid-containing bodies than their earthly counterparts, indicating a change in energy balance. Organelle organization is also grossly altered; endoplasmic reticula occur in randomly spaced bunches and mitochondria swell. Nuclei enlarge, and chromosomes break. Chloroplasts have enlarged thylakoid membranes and small grana.

Interesting effects occur in amyloplasts, which are starch-containing granules in certain root cells. On Earth, amyloplasts aggregate at the bottoms of these cells, which tells roots which way is up. But in space, amyloplasts occur throughout the cytoplasm. For many years, botanists hypothesized that sinking starch granules in these cells are gravity receptors. An alternative hypothesis holds that cells sense gravity by detecting the difference in pressure on the cell membrane at the top versus the bottom of the cell. This difference results from protoplasm sinking in response to gravity, so there is less of a difference as gravitational force falls. The actual “sensing” may be carried out by a cell membrane protein called an integrin, and the starch granules may amplify the difference in pressure by sinking in the presence of gravity. Whatever the precise mechanism of gravity sensation, a root tip cannot elongate normally in microgravity.

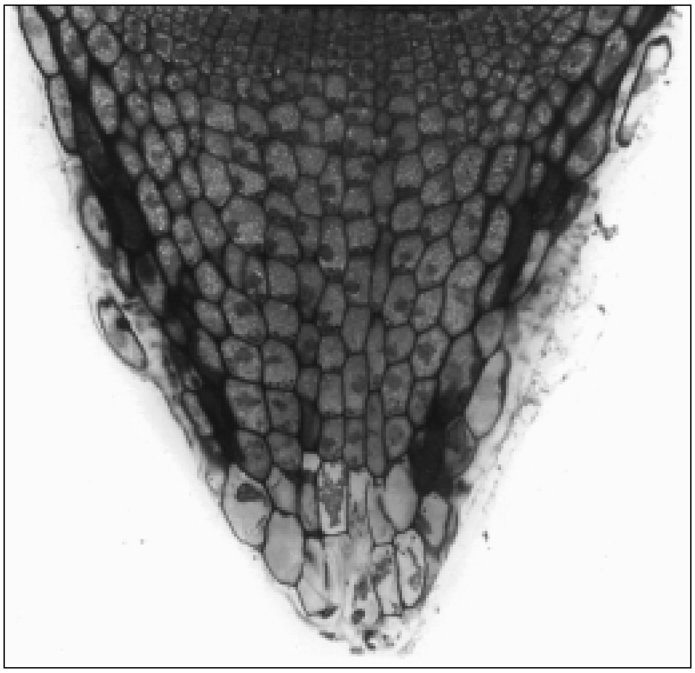
Cell Division

Microgravity halts mitosis, usually at telophase, which produces cells with more than one nucleus. Oat seedlings germinated in space have only one-tenth as many dividing cells as seedlings germinated on Earth. Microgravity also disrupts the spindle apparatus that pulls chromosome sets apart during mitosis.

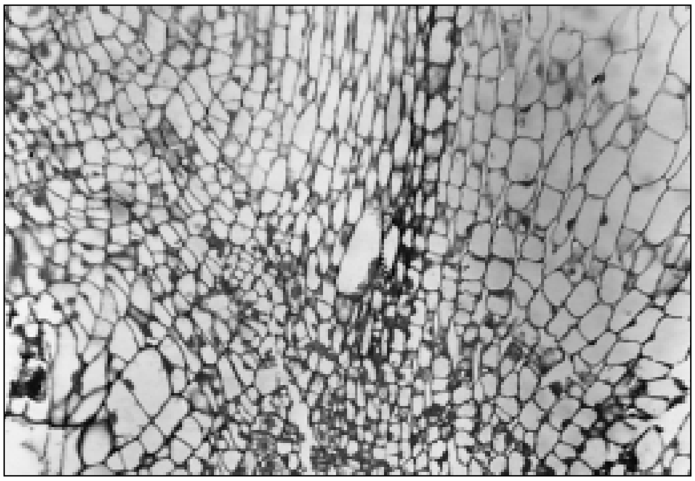
Cell walls formed in space are considerably thinner than their terrestrial counterparts, with less cellulose and lignin. Microgravity also inhibits regeneration and alters cell distribution (fig. 29.A). A decapped root will regenerate in 2 to 3 days on earth but not at all in space. Lettuce roots have a shortened elongating zone when grown in space.

Growth and Development

Germination is less likely to occur in space than on earth because of chromosome damage, but it does happen. Early growth seems to depend upon the species—bean, oat, and pine seedlings grow more slowly than on Earth, and lettuce, garden cress, and cucumbers grow faster. Many species, including wheat and peas, cease growing and die before they flower. In 1982, however, *Arabidopsis* successfully completed a life cycle in space—indicating that human space colonies containing plant companions may indeed be possible.



1



2

FIGURE 29.A

Plant Growth in Space.

(*1*) On Earth, a root whose cap has been removed regenerates an organized, functional root cap. (*2*) In the microgravity of space, however, regrowth of a decapped root is disorganized. Clearly, gravitational cues help direct normal regeneration.