30.7E: Auxins, Cytokinins, and Gibberellins

All physiological aspects of plants are affected by plant hormones (chemical messengers), including auxins, cytokinins, and gibberellins.

Learning Objectives

• Differentiate among the types of plant hormones and their effects on plant growth

Key Points

• During phototropism and gravitropism, the plant hormone auxin controls cell elongation.
• The plant hormone cytokinin promotes cell division, controlling many developmental processes in plants.
• Gibberellins control many aspects of plant physiology including shoot elongation, seed germination, fruit and flower maturation, seed dormancy, gender expression, seedless fruit development, and the delay of senescence in leaves and fruit.

Key Terms

• gibberellin: any of a class of diterpene plant growth hormones that stimulate shoot elongation, seed germination, and fruit and flower maturation
• auxin: a class of plant growth hormones that is responsible for elongation in phototropism and gravitropism and for other growth processes in the plant life cycle
• cytokinin: any of a class of plant hormones involved in cell growth and division
Growth Responses

A plant's sensory response to external stimuli relies on hormones, which are simply chemical messengers. Plant hormones affect all aspects of plant life, from flowering to fruit setting and maturation, and from phototropism to leaf fall. Potentially, every cell in a plant can produce plant hormones. The hormones can act in their cell of origin or be transported to other portions of the plant body, with many plant responses involving the synergistic or antagonistic interaction of two or more hormones. In contrast, animal hormones are produced in specific glands and transported to a distant site for action, acting alone.

Plant hormones are a group of unrelated chemical substances that affect plant morphogenesis. Five major plant hormones are traditionally described: auxins, cytokinins, gibberellins, ethylene, and abscisic acid. In addition, other nutrients and environmental conditions can be characterized as growth factors. The first three plant hormones largely affect plant growth, as described below.

Auxins

The term auxin is derived from the Greek word auxein, which means “to grow.” Auxins are the main hormones responsible for cell elongation in phototropism and gravitropism. They also control the differentiation of meristem into vascular tissue and promote leaf development and arrangement. While many synthetic auxins are used as herbicides, indole acetic acid (IAA) is the only naturally-occurring auxin that shows physiological activity. Apical dominance (the inhibition of lateral bud formation) is triggered by auxins produced in the apical meristem. Flowering, fruit setting and ripening, and inhibition of abscission (leaf falling) are other plant responses under the direct or indirect control of auxins. Auxins also act as a relay for the effects of the blue light and red/far-red responses.

Commercial use of auxins is widespread in plant nurseries and for crop production. IAA is used as a rooting hormone to promote growth of adventitious roots on cuttings and detached leaves. Applying synthetic auxins to tomato plants in greenhouses promotes normal fruit development. Outdoor application of auxin promotes synchronization of fruit setting and dropping, which coordinates the harvesting season. Fruits such as seedless cucumbers can be induced to set fruit by treating unfertilized plant flowers with auxins.

Cytokinins

The effect of cytokinins was first reported when it was found that adding the liquid endosperm of coconuts to developing plant embryos in culture stimulated their growth. The stimulating growth factor was found to be cytokinin, a hormone that promotes cytokinesis (cell division). Almost 200 naturally-occurring or synthetic cytokinins are known, to date. Cytokinins are most abundant in growing tissues, such as roots, embryos, and fruits, where cell division is occurring. Cytokinins are known to delay senescence in leaf tissues, promote mitosis, and stimulate differentiation of the meristem in shoots and roots. Many effects on plant development are under the influence of cytokinins, either in conjunction with auxin or another hormone. For example, apical dominance seems to result from a balance between auxins that inhibit lateral buds and cytokinins that promote bushier growth.
Gibberellins

Gibberellins (GAs) are a group of about 125 closely-related plant hormones that stimulate shoot elongation, seed germination, and fruit and flower maturation. GAs are synthesized in the root and stem apical meristems, young leaves, and seed embryos. In urban areas, GA antagonists are sometimes applied to trees under power lines to control growth and reduce the frequency of pruning.

GAs break dormancy (a state of inhibited growth and development) in the seeds of plants that require exposure to cold or light to germinate. Abscisic acid is a strong antagonist of GA action. Other effects of GAs include gender expression, seedless fruit development, and the delay of senescence in leaves and fruit. Seedless grapes are obtained through standard breeding methods; they contain inconspicuous seeds that fail to develop. Because GAs are produced by the seeds and because fruit development and stem elongation are under GA control, these varieties of grapes would normally produce small fruit in compact clusters. Maturing grapes are routinely treated with GA to promote larger fruit size, as well as looser bunches (longer stems), which reduces the incidence of mildew infection.

Figure 1: Effect of gibberellins on grapes: In grapes, application of gibberellic acid increases the size of fruit and loosens clustering.