30.7F: Abscisic Acid, Ethylene, and Nontraditional Hormones

All physiological aspects of plants are affected by plant hormones, including abscisic acid, ethylene, and nontraditional hormones.

Learning Objectives

• Describe the roles played by ethylene and nontraditional hormones in plant development

Key Points

• Under stress, abscisic acid accumulates in plants, inhibiting stem elongation and inducing bud dormancy.
• The plant hormone ethylene controls fruit ripening, flower wilting, and leaf fall by stimulating the conversion of starch and acids to sugars.
• Other nontraditional hormones such as jasmonates and oligosaccharins control defense responses from herbivores and bacterial/fungal infections, respectively.

Key Terms

• **abscisic acid**: a plant hormone that functions in many plant developmental processes, including bud dormancy, inhibition of seed germination, and plant stress tolerance.
• **jasmonate**: any of several esters of jasmonic acid that act as plant hormones
• **ethylene**: a plant hormone that is involved in fruit ripening, flower wilting, and leaf fall
Growth Responses

In addition to the growth hormones auxins, cytokinins, gibberellins, there are two more major types of plant hormones, abscisic acid and ethylene, as well as several other less-studied compounds that control plant physiology.

Abscisic Acid

The plant hormone abscisic acid (ABA) was first discovered as the agent that causes the abscission or dropping of cotton bolls. However, more-recent studies indicate that ABA plays only a minor role in the abscission process. ABA accumulates as a response to stressful environmental conditions, such as dehydration, cold temperatures, or shortened day lengths. Its activity counters many of the growth-promoting effects of GAs and auxins. ABA inhibits stem elongation and induces dormancy in lateral buds.

ABA induces dormancy in seeds by blocking germination and promoting the synthesis of storage proteins. Plants adapted to temperate climates require a long period of cold temperature before seeds germinate. This mechanism protects young plants from sprouting too early during unseasonably warm weather in winter. As the hormone gradually breaks down over winter, the seed is released from dormancy and germinates when conditions are favorable in spring. Another effect of ABA is to promote the development of winter buds; it mediates the conversion of the apical meristem into a dormant bud. Low soil moisture causes an increase in ABA, which causes stomata to close, reducing water loss in winter buds.

Ethylene

Ethylene is associated with fruit ripening, flower wilting, and leaf fall. Ethylene is unusual because it is a volatile gas (C2H4). Hundreds of years ago, when gas street lamps were installed in city streets, trees that grew close to lamp posts developed twisted, thickened trunks, shedding their leaves earlier than expected. These effects were caused by ethylene volatilizing from the lamps.

Aging tissues (especially senescing leaves) and nodes of stems produce ethylene. The best-known effect of the hormone, however, is the promotion of fruit ripening. Ethylene stimulates the conversion of starch and acids to sugars. Some people store unripe fruit, such as avocados, in a sealed paper bag to accelerate ripening; the gas released by the first fruit to mature will speed up the maturation of the remaining fruit. Ethylene also triggers leaf and fruit abscission, flower fading and dropping, and promotes germination in some cereals and sprouting of bulbs and potatoes.
Date ripening: The plant hormone ethylene promotes ripening, as seen in the ripening of dates.

Ethylene is widely used in agriculture. Commercial fruit growers control the timing of fruit ripening with application of the gas. Horticulturalists inhibit leaf dropping in ornamental plants by removing ethylene from greenhouses using fans and ventilation.

Nontraditional Hormones

Recent research has discovered a number of compounds that also influence plant development. Their roles are less understood than the effects of the major hormones described so far.

Jasmonates play a major role in defense responses to herbivory. Their levels increase when a plant is wounded by a predator, resulting in an increase in toxic secondary metabolites. They contribute to the production of volatile compounds that attract natural enemies of predators. For example, chewing of tomato plants by caterpillars leads to an increase in jasmonic acid levels, which in turn triggers the release of volatile compounds that attract predators of the pest.

Oligosaccharins also play a role in plant defense against bacterial and fungal infections. They act locally at the site of injury; they can also be transported to other tissues. Strigolactones promote seed germination in some species and inhibit lateral apical development in the absence of auxins. Strigolactones also play a role in the establishment of mycorrhizae, a mutualistic association of plant roots and fungi. Brassinosteroids are important to many developmental and physiological processes. Signals between these compounds and other hormones, notably auxin and GAs, amplify their physiological effect. Apical dominance, seed germination, gravitropism, and resistance to freezing are all positively influenced by hormones. Root growth and fruit dropping are inhibited by steroids.