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How Hormones Protect Seed Development in Peas

Flowering plants, the angiosperms, are unique among plants in that they produce fruit. The purpose of fruit is not to nourish the seed. Endosperm tissue within the seed coat serves that function. The fruit instead serves the purpose of seed dispersal. Seeds that are dispersed by birds and other vertebrates are encased within often-fleshy fruits that are consumed by animals, which carry the undigested seeds off to new locations. Seeds that are dispersed by the wind don't have fleshy fruit; wind dispersal depends on fruit structures such as the "wings" of maple seeds or the parachute structure of dandelion seeds.

Regardless of the type of fruit, the developmental process begins in the same way. The fertilization of an egg with sperm from pollen begins the formation of seeds inside a structure called the ovule. The outer wall of the ovule hardens, forming a seed coat that protects the seed. The developmental process continues with the secretion of hormones by the seeds that induce the development of the ovary (the tissue around the seed) into a fruit. As this occurs, the ovary wall, called the pericarp, thickens and becomes differentiated into distinct layers, very conspicuous in fleshy fruits. For many commercial crops, hormones (or their synthetic analogs that mimic the action of hormones) are applied to plants so that fruits will form and mature in synchrony. This makes harvesting more efficient and economical. Thus it is commercially very important to understand how hormones contribute to the maturation of fruit.

Pea plants are very good subjects for examining fruit development, because the seeds (peas) and pericarp (pea pod) are very accessible. While the ovary fails to develop into a fruit in the absence of pea seeds, this requirement of seeds for pericarp growth and differentiation can be replaced by the application to the ovary of the plant hormones gibberellic acid (GA_3) or auxin (IAA). As both hormones are present in developing pea seeds, this result suggests that gibberellic acid and auxin play key roles in pericarp development.

How do these hormones interact? Previous research indicates that auxin released from seeds regulates a key step in early GA biosynthesis, stimulating the enzyme GA 20-oxidase to oxidize the intermediate form of GA_{19} into a product called GA_{20} which is subsequently converted into active GA_3. Other experiments suggest that this auxin-stimulated enzyme may be repressed by its end-product, GA_3. Thus a type of negative feedback may control the synthesis of gibberellic acid. If there are sufficient levels of GA_3 in the cells of the developing ovary, GA_3 will act as an inhibitor of the pathway and repress the synthesis of more GA_3.

The Garden Pea (*Pissum sativum*) The pericarp, also referred to as the pea pod, needs the presence of the seeds (pea) in oder to develop.

The interaction of seeds, auxin, and GA_3 were examined in the lab of Jocelyn A. Ozga of the University of Alberta, Edmonton to see if plant hormone regulation in fruit development can be observed at the molecular level. Does GA_3 inhibit the activity of the enzyme GA 20-oxidase, or does it repress transcription of the gene that makes the GA 20-oxidase protein? Or does it perhaps repress auxin, which is required for the transcription of the GA 20-oxidase gene? To see if, and how, the levels of GA 20-oxidase transcription are regulated by auxin and GA_3 in seeds it is necessary to examine directly the effects of these hormones on transcription levels of the GA 20-oxidase gene.

The researchers studied the expression of the GA 20-oxidase gene by determining levels of its mRNA in the pericarp. By removing the seeds, adding hormones to the pericarp tissue, and then analyzing the pericarp tissue for the levels of GA 20-oxidase mRNA they were able to directly analyze the effects of the hormones on the GA biosynthesis pathway.