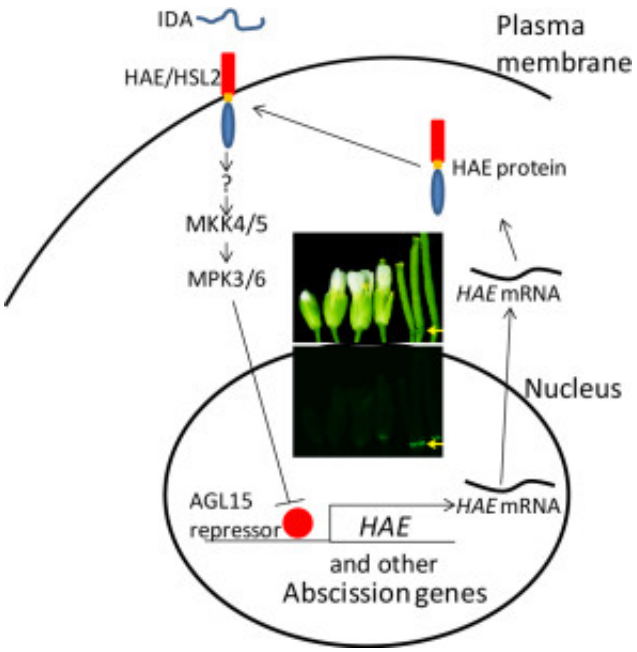
Caught in a loop – A story of how plants drop excess baggage

Plants shed their organs such as leaves, flowers, or fruits in response to environmental stimuli or developmental timing. For example, trees drop their leaves in the fall when they sense winter is coming. Plants also drop leaves throughout the year in response to drought or insect feeding. Plant development also triggers fruits to be shed once they are ripe and flower petals fall off once flowers are fertilized.



A schematic diagram of the molecular positive feedback loop that regulates shedding plant parts. Yellow arrow indicates the position of the abscission zone. Notice how the abscission receptor, HAESA, accumulates (shown in green fluorescence) when petals fall off.

Shedding, know scientifically as abscission, occurs at a specialized layer of cells known as abscission zones. Abscission zones act as molecular scissors for the plant. Once a plant decides to shed a part of itself, massive gene expression changes occur rapidly in the abscission zones that enable cell separation at the abscission zone. A molecular pathway has been established in which a ligand and receptor trigger a mitogen-activated protein kinase (MAPK) cascade that, in turn, activates abscission. While MAPK cascades have the ability to amplify input signals, the mechanism does not explain how expression of the abscission receptor, HAESA, increases 27-fold by the time abscission occurs and only partially explains how thousands of other genes become activated once abscission zones are activated.

We found that the protein AGAMOUS-like 15 (AGL15) regulates the expression of *HAESA*. AGL15 holds *HAESA* in an inactive state. Then once the decision to abscise is made, the MAPK cascade inactivates AGL15, lifting the repression of *HAESA* and other abscission genes and thus allows them to be expressed. This finding suggests that the abscission signaling pathway is more appropriately conceptualized as a positive feedback loop than a linear pathway. In this revised schematic, activation of the abscission receptor triggers activation of abscission genes and increased production of the abscission receptor, which results in enhanced abscission gene activation and abscission receptor activation, and so on.

A long-term goal of abscission research is to enhance crop production and improve crop yield. Crop yield improvements are already being made by manipulating fruit abscission via chemical methods. For example, apple and citrus orchards spray trees with chemicals that prevent mature fruits from naturally falling off of the tree. Preventing pre-harvest fruit drop allows mechanical harvesters to collect fruits that would have otherwise fallen to the ground prior to mechanical collection. Future work may also see soybean plants that do not drop all of their flowers at the slightest sign of drought, allowing for more seeds pods at harvest.

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