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RESEARCH NEWS

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How Plants Get Made in the Shade

Researchers from the Howard Hughes Medical Institute (HHMI) have discovered a novel molecular pathway that plants use to adjust their growth and flowering to shade. The discovery raises the possibility that researchers could increase crop yields by inserting a gene that encourages crowded crop plants to flourish in shade cast by neighboring plants.

The researchers -- HHMI investigator Joanne Chory and HHMI research associate Pablo D. Cerdán, both at The Salk Institute for Biological Studies -- reported their findings in an article published in the June 19, 2003, issue of the journal *Nature*.

"Few people realize that the biggest competitor for plants is other plants," said Chory. "Shade-avoidance syndrome is a series of developmental changes that the plant makes when it perceives that it's being shaded and, therefore, not getting enough photosynthetically effective light to thrive."

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Under these conditions, a plant elongates its stem and restricts leaf development. "And then, if the plant is not successful, it produces what might be called a 'desperation flower,' and goes on to make only a few seeds that will ensure the survival of at least some offspring," said Chory.

According to Chory, the central question for researchers was whether the shade-avoidance syndrome was a distinct signaling pathway in the plant. "Everyone knew that plants perceive light quality because they have photoreceptors that are attuned to different wavelengths of light," she said. "So, while it was proposed that there was a light-quality pathway that induces early flowering in shade-avoidance, no one had identified a component of that pathway, and no one knew whether it existed as an independent pathway. It might have just been part of other control pathways such as the photoperiod pathway by which the plant senses seasonal change."

The identification of a shade-avoidance pathway could have a big impact on agriculture, said Chory. "Crops are planted at such a high density that plants in a field are always shading each other, and probably every plant in that field is triggering at least a partial shade-avoidance response," she said. "It's causing a depletion of biomass, which is what we eat if we're eating the plant itself. And because of the premature flowering, it can significantly impact yield, if it's the seeds or grain that's harvested."

The first finding that led to identification of the light-quality pathway arose from a screening that Cerdán was conducting of seedlings of *Arabidopsis*, a small flowering plant that is the basic model organism used in plant biology research. In that screening, Cerdán was looking for strains that showed an altered response to light. Among these seedlings was one mutant form that showed less response in terms of flowering to the light conditions that would normally trigger shade-avoidance.

Further studies of this mutation revealed that the plant lacked the gene for a protein that the scientists called "phytochrome and flowering time 1" (pft1).

Reasoning that this protein might be part of a distinct shade-avoidance pathway, Cerdán performed a variety of breeding experiments involving mutations in the light-sensing molecule phytochrome B, which is known to sense the particular wavelengths of red and near-infrared light that enable plants to detect a change in light quality when they are being shaded.

Those crossbreeding studies revealed that pft1 and phytochrome B were part of a pathway that was distinct from the photoperiod pathway. Furthermore, the studies revealed that the pft1 protein acted "downstream" of the light-sensing phytochrome B, to regulate the expression of a gene called "flowering locus T" (FT), which governs flowering time.

When the researchers analyzed the pft1 protein's sequence structure, they found components suggesting that it not only interacts with other proteins, but that it switches on genes. They also traced the protein to the nucleus of the plant cell, where it could serve as a gene activator.

"This is a foot-in-the-door study," said Chory. "We don't really know exactly what pft1 does, but it's in the nucleus and it has domains that indicate it must interact with other proteins and another domain that is reminiscent of proteins that activate gene expression." Thus, she said, further studies are needed to understand pft1's role in interacting with phytochrome B and in gene activation, and to discover the other components of the shade-avoidance pathway.

The implications for crop science of such findings could be considerable, said Chory. "Plant breeders will be interested because they could probably alter components of the shade-avoidance syndrome without altering other aspects of the plant; which is important because phytochrome B is so key to

development of a plant throughout its whole life cycle," said Chory. "If you could just delay the flowering of crop plants, even though they are being shaded, you might be able to increase yield."