Key Component Identified That Helps Plants Go Green (w/ Video)

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(PhysOrg.com) -- A team of researchers from Duke University and the Salk Institute for Biological Studies has found a central part in the machinery that turns plants green when they sense light.

In the Rube Goldberg world of cellular mechanics, this key player turns out to be a garbage truck.

Light is so essential for plants that they have two different systems to take advantage of it, explains Meng Chen, an assistant professor of biology at Duke.

There's the familiar system of organelles called chloroplasts that turn sunlight into fuel via photosynthesis. The photosynthetic pigment inside chloroplasts, chlorophyll, is where the green color comes from.

And then there's a system of light-sensitive proteins called photoreceptors that use light as information and direct plant development and growth. One of the things the plant does with that information is control how it makes chloroplasts. "The greening process is completely dependent on the presence of light. However, how light triggers the making of chloroplasts is still unknown," Chen said.

In a paper appearing in the June 25 issue of *Cell*, Chen and his team have identified a key intermediary between the light system for information and the light system that makes fuel. The hope is that this knowledge will help researchers use a plant's own photo-sensory systems to increase agricultural yields or improve the photosynthesis of biofuel crops.

"Light is probably the most important environmental cue for a plant," said co-author Joanne Chory, a Howard Hughes Medical Institute investigator at the Salk Institute for Biological Studies. "Understanding how light signaling triggers morphological changes in the plant will have a really big impact on every facet of plant biology."

Plants have an array of photoreceptors that are tuned to different wavelengths of light. One type, called phytochromes, are sensitive to red and far-red light and play a major role in the making of chloroplasts and the growth of the stem, said Chen, who is the first author on the study.

One of the first things that happens when the plant detects light is that these phytochromes move from the cell's cytoplasm to its nucleus, where the genes are kept. The photoreceptors gather in discrete spots known as phytochrome nuclear bodies. In an earlier study, Chen had found that the size and number of phytochrome nuclear bodies was directly related to light intensity.

Chen, who started this line of work as a postdoctoral researcher in Chory's lab at the Salk Institute, ran genetic screens for mutants with abnormal phytochrome nuclear bodies. He identified a new gene, hemera, that seems to be required for both the localization and the signaling of phytochrome.

He named the gene for the Greek goddess of daylight, Hemera. It is present in all land plants studied so far.

Mutant plants without hemera were found to have dramatically reduced sensitivity to red and far-red light, they failed to develop chloroplasts, were albino, and died while still only seedlings. Without Hemera, "a plant is blind to light and the chloroplasts can't develop," Chen said.

The prevailing model of chloroplast development involves signaling molecules called PIFs that hold chloroplast development back when the plant senses darkness. But when phytochromes are activated by light, they destroy the PIFs, clearing the way for chloroplast development. PIFs tended to aggregate around these phytochrome nuclear bodies before being destroyed. Hemera also tended to be found near the nuclear bodies, suggesting that the nuclear bodies were the site of PIF destruction.

In a series of experiments with hemera mutants, the team found these plants tended to have smaller phytochrome nuclear bodies and were unable to remove PIFs in light, which could explain why the mutants weren't making chloroplasts.

The team also found that hemera is structurally similar to a yeast protein called RAD23, that is known to be the garbage truck that rounds up other proteins flagged for destruction and carries them to the place where they are ground up. They inserted Hemera from Arabidopsis plants into yeast that lacked RAD23, and found that it partially took over RAD23's job, Chen said.

More information: "Arabidopsis HEMERA/pTAC12 Initiates Photomorphogenesis by Phytochromes," Meng Chen, Rafaelo M. Galvao, Meina Li, Brian Burger, Jane Bugea, Jack Bolado, Joanne Chory; Cell, Volume 141, Issue 7, 1230-1240, 25 June 2010 www.cell.com/abstract/S0092-8674%2810%2900543-X

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