Discovery of 'master switch' for the communication process between chloroplast and nuclei of plants

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Scientists have puzzled for years in understanding how plants pass signals of stress due to lack of water or salinity from chloroplast to nucleus. They know that chloroplasts – the cellular organelles that give plants their green color – have at least three different signals that can indicate a plant is under stress.

Given the challenges the environment will be facing over the coming decades through global warming, this puzzle piece has become more pressing for plant scientists, who hope that understanding the stress responses of plants will, in time, lead to new generations of plants that are, among other things, more drought- and stress-tolerant.

That is why a study that appeared this week in the internationally recognized journal, *Science*, is considered an important step forward in the understanding of how chloroplasts communicate with a cell's nucleus when stresses such as drought, heat, salinity or light become too great on the organism.

A research team that includes Shai Koussevitzky, a research associate in the University of Nevada, Reno's College of Agriculture, Biotechnology and Natural Resources, as well as Ron Mittler, associate professor of Biochemistry and Molecular Biology, has determined that multiple distress signals in plants converge on a single pathway, which then channels the information to the nucleus. The study was part of a collaborative effort led by Joanne Chory, professor and director of the Plant Biology Laboratory at the Salk Institute for Biological Studies in La Jolla, Calif., and investigator with the Howard Hughes Medical Institute.

Koussevitzky, looking at the end of the signaling pathway, found the corresponding binding factor known that ABI4, a known plant transcription factor. It prevents light-induced regulatory factors from activating gene expression. Additional work in the project had determined that the chloroplast-localized, nuclear-encoded protein GUN1 is required for integrating multiple stress-derived signals within the chloroplast. This work was conducted by the first co-author of the article, Ajit Nott, who was a research associate in Dr. Chory's lab.

Many of the nuclear genes that encode chloroplast proteins are regulated by a "master switch" in response to environmental conditions. This "master switch," like a binary computer, can activate or de-activate certain sets of genes based on stress signaling processes.

"One of our suggestions in the paper is that ABI4 seems like a prime candidate to be the 'master switch,'" Koussevitzky said. "ABI4 binds to a newly identified sequence motif, and by doing so prevents light-induced regulatory factors from activating gene expression. It has a role in so many signaling processes in the plant, it might actually be the 'master switch' that researchers have been looking for."

The discoveries are critical to future research efforts in designing new generations of plants, Mittler said.

"A lot of things that occur in the chloroplast are important for production, for growth, for response to the environment," he said. "So this is a very basic mechanism of communication between the chloroplast and the nucleus. It had been previously suggested that the elements in this process go through multiple pathways. This work shows that the elements actually go through this one particular route.

"Now we are in much better shape in solving the question of generating plants that can use marginal water, or marginal soil, and do so in a way that the plant won’t completely suppress its normal metabolisms and activate all of its stress metabolisms when faced with a lot of stress. If you want to generate a plant that is more tolerant, you need to deal with these two things."

Added Koussevitzky: "We’re trying to put the signaling pathways in the context of the plant’s stress response. It will take a little more tweaking, but at least knowing that it is going through a certain particular pathway will enable researchers to design what the targets should be downstream from these pathways." Work for the project was supported by a grant from the Department of Energy, the Howard Hughes Medical Institute, EMBO long term and Howard Hughes Medical Institute fellowships.

Source: University of Nevada, Reno