Plants give up some deep secrets of drought resistance

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In a study that promises to fill in the fine details of the plant world's blueprint for surviving drought, a team of Wisconsin researchers has identified in living plants the set of proteins that help them withstand water stress.

The new study, published today (Aug. 23) in the Proceedings of the National Academy of Sciences, identifies the protein targets in cells of a key hormone that controls how plants respond to environmental stresses such as drought, excessive radiation and cold.

The work, which builds on decades of research with a key plant hormone known as abscisic acid, could help underpin the development of new crop plant strains capable of thriving in hotter, dryer climates. The work is considered important in light of the pressing need to expand and intensify agricultural production on marginal lands worldwide, and especially so in the context of global climate change.

"If we can figure out how this works with crops and make them able to resist drought, the benefits would be enormous," notes Michael Sussman, a University of Wisconsin-Madison professor of biochemistry and the senior author of the new study. "These are the first baby steps to understand the effects of dehydration in plants and it may give us the opportunity to develop crops that can withstand this kind of stress in the field."

Working in the model laboratory plant *Arabidopsis*, the Wisconsin team explored the influence of abscisic acid, a long-studied hormone that, in addition to influencing how plants respond to environmental stress, controls the naturally occurring processes of seed dormancy and germination.

The hormone has been known to science for 50 years, and was believed to influence certain proteins in cells in a complicated cascade of events that aided the ability of a plant to survive such stresses as dehydration, excessive radiation and cold temperatures. But any plant cell, Sussman explains, contains at least 30,000 different proteins, and the identity of the few proteins activated by the hormone was a deep mystery.

"Since they cannot walk or run, plants have developed an interesting and complicated system for sensing and responding very quickly to dehydration and other stresses," says Sussman, noting that, on average, a plant is composed of 95 percent water. "Most plants have what's called a permanent wilting point, where if water content goes below 90 percent or so, they don't just dehydrate and go dormant, they dehydrate and die."

Figuring out how to trigger a dormant state, such as exists naturally in seeds, which are 10 percent water and can in some cases remain viable for hundreds of years, could be key to creating plants that survive drought in the field, Sussman explains.

The team, which includes postdoctoral fellow Kelli G. Kline and scientist Gregory Barrett-Wilt, utilized a new stable isotope technology and mass spectrometry to comb 5,000 candidate proteins in the cells of living plants and found 50 that were influenced by the abscisic acid hormone. The survey is the first of its kind in a living plant and many of the proteins identified were previously not known to be influenced at all by abscisic acid.

Surprisingly, the hormone was found to regulate some of the plant proteins in a completely different way than was known before, by inhibiting their ability to have a phosphate moiety removed from an amino acid, by a type of enzyme called a protein phosphatase. Protein phosphatases are the opposite side of the coin that catalytic enzymes known as protein kinases occupy. In many important biological processes, such as cancer, it is the protein kinases that are the dominant actors.

The finding that phosphatases play a more critical role in a hormonally regulated system is a new idea in biology discovered through work with plants. Sussman's group's findings indicate that the dynamic interplay between the hormone and the proteins it affects is a more complicated process than previously suspected.
"The story is far from complete," says the Wisconsin biochemist. "There is something very interesting, and complicated, going on."

Provided by University of Wisconsin-Madison