# Bringing dehydrated plants 'back to life'

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Drought can take a serious toll on plants and animals alike. When cells are deprived of water, they shrink, collapsing in upon themselves and, without water as a medium, chemicals and enzymes inside the cells may malfunction. However, some plants, like the aptly named "resurrection fern" (*Polypodium polypodioides*), can survive extreme measures of water loss, even as much as 95% of their water content. How do the cells in these desiccation-tolerant plants remain viable?

The collaboration between Ronald Balsamo, Associate Professor of Biology at Villanova University and Bradley Layton, Associate Professor of Mechanical Engineering and Mechanics at Drexel University, began in Balsamo's front yard one evening when the two of them were discussing the possible role that biomechanics plays in drought resistance. Balsamo had been conducting plant biomechanics at the tissue and organism scale, pulling apart leaves and stalks of plants with differing abilities to survive drought, while Layton had been spending his time primarily investigating single cells and modeling single proteins such as collagen and tubulin.

As they talked, it became apparent that any differences between plants of related species that give some individuals the ability to survive very low water levels, while their cousins die after only moderate water loss, must be occurring at the cellular and molecular level. They began their studies with the "resurrection fern," and these results can be found in the April issue of the American Journal of Botany by Layton and colleagues.

"The plant is just as dry and brittle as can be," Balsamo said. "It has lost

95% of its water, but it's still alive! Imagine this happening to a human. Most of us wouldn't make it past 10% or 20%." Unfortunately, this is also true of many agricultural crops. Maize, for example, can only tolerate a water loss of about 20% to 30% before dying.

To begin answering the question of how the resurrection fern does it, Balsamo, Layton, and colleagues began a multi-pronged approach using western blotting, a technique that can detect relative levels of different proteins over a time; immunolocalization, a technique that can "light up" spatial regions of plant tissue where a particular protein may be lurking; and atomic force microscopy, a powerful microscopy technique that can resolve individual proteins and sometimes individual atoms.

What they found was novel and a bit controversial. They found that not only is a particular class of proteins, called dehydrins, more prevalent during dry conditions, but, for the first time, they found that it was also prevalent near the cell walls. Dehydrins earned their name for their ability to attract, sequester, and localize water. They behave this way because of their negative charge.

The finding led the researchers to the conclusion that these water-surrounded dehydrins may actually allow water to act as a lubricant between either the plant cell membrane and the plant cell wall or even between individual cell wall layers. "This is important from a mechanics perspective because these cells are really undergoing some major deformation as they dry," Balsamo said.

Layton added, "Think of crumpling a sheet of paper over and over. Eventually the fibers are going to fracture and the paper is going to tear. This means certain death for a plant cell, which relies on the mechanical integrity of its cell wall to survive."

They also observed that the fern's vascular tissue, found near the centers of individual fronds does not deform greatly, highlighting the importance of keeping this tissue intact once water again becomes available. If the dehydrin gene could be localized and transferred to other species, it could possibly confer the ability to resist drought to plants. The researchers are currently investigating similar hypotheses as they relate to other U.S. agricultural crops using their seed funding from the USDA and their recently awarded NSF grant to study the biomechanics of *Arabidopsis thaliana* leaves being supplied form the Ohio State University Arabidopsis Biological Resource Center.

**More information:** Paper: http://www.amjbot.org/cgi/content/full/97/4/535

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