Scientists decode how plants avoid sunburn

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Too much sun – for plants as well as people – can be harmful to long-term health. But to avoid the botanical equivalent of “lobster tans,” plants have developed an intricate internal defense mechanism called photoprotection, which acts like sunscreen to ward off the sun's harmful rays.

“We knew that biomolecules called carotenoids participate in this process of photoprotection, but the question has been, ‘How does this work?' ” says Iris Visoly-Fisher, a postdoctoral research associate in the Biodesign Institute at ASU.

Carotenoids act as “wires” to carry away the extra sunlight energy in the form of unwanted electrons, somehow wicking away the extra electrons across long distances from locations that could damage plant tissues and photosynthesis.

During photoprotection, the consensus school of thought was that carotenoids—the source of the orange pigments in carrots and Vitamin A – become oxidized, or charged, losing an electron in the process.

Fisher and other ASU scientists have found a way to measure the electrical conductance within such an important biomolecule. In doing so, the team has produced a new discovery that shatters the prevailing view.

The research team found that oxidation is not required for photoprotection; rather, carotenoids in a neutral, or uncharged, state can readily handle the electron overload from the sun.

Their findings have been published in the prestigious journal Proceedings of the National Academy of Sciences (PNAS) under the title “Conductance of a Biomolecular Wire.” The findings can be accessed at the Web site (www.pnas.org/cgi/content/abstract/0600593103v1).

“This is a remarkable experimental tour de force, and the result is quite unexpected,” says Lindsay, who directs Fisher's work in the Biodesign Institute's Center for Single Molecule Biophysics. “Carotene was regarded as the poster child for this molecular mechanism, but it turns out that a much simpler mechanism works just fine.”

The innovative work was a collaboration between several ASU departments and the Univesidad Nacional de Rio Cuarto in Argentina . In addition to Fisher, who was lead author on the paper, contributions from chemistry and biochemistry professors Devens Gust, Tom Moore and Ana Moore of ASU's Center for the Study of Early Events in Photosynthesis were instrumental in the project.

“The initial interest was to more fully understand how photosynthesis works,” Fisher says. “Because our center focuses on electron transport in a single molecule, Devens Gust and Tom and Ana Moore suggested that we look at single-molecule transport in carotene.”

To get at the heart of the problem, Fisher had to attempt an experiment that had never been done before for any biomolecule: to control the charge of the biomolecule while measuring its ability to hold a current.

By holding a carotenoid under potential control, Fisher could control whether the biomolecule was in a neutral state or in the charged state (the oxidized state), while simultaneously measuring the electron transport through a single molecule.

“The importance of this result is not only for understanding natural systems and photosynthesis, but also for the fact that, technically, for the first time, we could hold a molecule in a state pretty close to the natural conditions found in the plant,” Fisher says.

To make the experimental measurements, Fisher needed to work out several technically challenging variations to a method first pioneered by electrical engineering professor Nongjian Tao of ASU's Fulton School of Engineering.

In concept, it's much like trying to measure the current of a wire found in an everyday household appliance – only, in this case, the “wiring” is a miniscule 2.8 nanometers long and less than a single nanometer thick. That's about 10,000 times smaller than the width of a human hair.

One of the greatest challenges of the experiment came down to the human endurance of taking thousands of measurements over an intense, six-month period.

“We needed to keep this finicky molecule away from the light,” Fisher says. “So sometimes the microscope room became like a cave, where I was sitting for hours and hours in the dark.”

But for Fisher and the rest of the team, the main satisfaction was being able to break down a complex process to understand its simplest components and produce a groundbreaking discovery.

Source: Arizona State University

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