How plant cells neutralize the potential for self-harm

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Photosynthesis makes our atmosphere oxygen-rich and forms the bedrock of our food supply. But under changing or stressful environmental conditions, the photosynthetic process can become unbalanced, resulting in an excess of highly reactive oxygen molecules that could cause cellular damage if they aren't neutralized.

New work in *Proceedings of the National Academy of Sciences* led by Carnegie's Shai Saroussi and Arthur Grossman explores how the photosynthetic algae Chlamydomonas shields itself from this potential danger. Understanding how plants minimize self-inflicted harm in this scenario could help scientists engineer crops with improved yields and fight hunger in a changing climate.

Photosynthesis takes place in stages. In the first, light is absorbed and used to produce energy molecules, which then power the second stage of photosynthesis, in which carbon dioxide from the air is fixed into sugars, such as glucose and sucrose.

One aspect of the work demonstrates that starch synthesis is an important metabolic pathway that drives photosynthesis.

"Think of the sugar- and starch-manufacturing process as charging a plant's battery with energy that it can use later," Grossman explained.

But under stressful conditions, or in the absence of light, the second stage of operations slows down or even shuts off altogether, which could lead to a build-up of highly reactive oxygen byproducts when the light returns.

"When the battery isn't charging, the cells need to divert this reactivity into other processes that minimize the possibility of cellular damage," Grossman added.

The research team—which also included Devin Karns, Dylan Thomas, and Matthew Posewitz of the Colorado School of Mines, as well as Clayton Bloszies and Oliver Fiehn of University of California Davis—focused on elucidating the functions of two proteins called FLV and PTOX, which protect plant cells by facilitating the conversion of the reactive oxygen products into water.

The former they describe as a clutch that helps the sugar-manufacturing part of the photosynthetic apparatus get up to speed again after the surrounding conditions change from darkness to light. The latter they describe as a release valve on a pressure cooker, diverting a dangerous build-up of reactive byproducts after an environmentally caused production slow-down.

"It is amazing to see how the cells orchestrate these machineries in order to optimize photosynthesis and minimize cellular damage," Saroussi concluded. "Our findings show a piece of the puzzle of how photosynthetic organisms have evolved to manage their energy budgets in a changing environment."

More information: Shai Saroussi et al, Alternative outlets for sustaining photosynthetic electron transport during dark-to-light transitions, *Proceedings of the National Academy of Sciences* (2019). DOI: 10.1073/pnas.1903185116

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