Scientists discover how plants disarm the toxic effects of excessive sunlight

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A newly discovered pathway by which cells protect themselves from a toxic byproduct of photosynthesis may hold important implications for bioenergy sources, human and plant disease, and agricultural yields, a team of University of Wisconsin-Madison bacteriologists announced Monday in the Proceedings of the National Academy of Sciences.

Plants turn energy from sunlight into bioenergy through a chemical process called photosynthesis, which also produces oxygen in its breathable form. However, photosynthesis can also generate an alternate form of singlet oxygen, which is a highly reactive and toxic substance that destroys biological molecules.

"We've discovered a pathway that cells use to turn on certain genes and respond to singlet oxygen," says Timothy Donohue, a professor of bacteriology in the university's College of Agricultural and Life Sciences and lead researcher on the paper.

"This finding should make it possible to modify plants and other photosynthetic cells to avoid the toxic effects of singlet oxygen, which could impact agriculture and the treatment of human and plant disease, and aid the effort to create alternative bioenergy sources," Donohue says.

Donohue and his group studied a photosynthetic microbe and identified the cellular pathways it used to sense the presence of singlet oxygen and defend itself from this toxic substance. He notes that the response mechanism is likely highly conserved across species from microbes to plants and humans - and therefore very applicable to other fields of study.

For example, too much sunlight can actually be harmful to plants, because the heightened photosynthetic activity also means an increase in singlet oxygen. By modifying plants to enhance the protective pathway, "we could be able to get larger crop yield per photon of light," he says.

And by making cells more resistant to singlet oxygen, scientists may be better able to design bioenergy systems that use sunlight as an alternative to traditional fossil fuels. "By understanding how biology solves this problem, we can fine-tune the design of these systems to minimize the harmful effects of singlet oxygen and enhance energy production."

Reactive oxygen also plays an important role in human, animal and plant health, because it is often used as a host defense to inhibit the growth of unwanted microbial pathogens. In fact, it appears that even non-photosynthetic bacteria, including human and animal pathogens like Vibrio and Pseudomonads have systems to sense and protect themselves from singlet oxygen, says Donohue. Other reactive oxygen species - often called "free radicals" - are thought to be at the root of many debilitating diseases.

"There have been considerable advances in our understanding of how cells protect themselves from several reactive oxygen species," says Donohue. "However, nothing has previously been known about how cells alter gene expression to respond to singlet oxygen. We may now be able to design pharmaceuticals that target this response, and ultimately may help us mitigate disease."

Donohue's co-authors on his study were a microbiology graduate student, Jennifer Anthony, and a bacteriology undergraduate, Kristin Warczak.

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Cells that grow by photosynthesis use chlorophyll to absorb solar energy. The following NASA satellite image maps chlorophyll concentrations on land as well as in oceans, lakes and seas. This image provides a snapshot of photosynthetic capacity and significant sources of singlet oxygen, a toxic byproduct of photosynthesis, in the biosphere. See the image at: earthobservatory.nasa.gov/Obse … ts/bios.seawifs.html

Source: University of Wisconsin-Madison