Scientists' new analysis of plant proteins advances our understanding of photosynthesis

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LSU graduate student Manjula Mummadisetti led a break-through study that advances our understanding of photosynthesis. Her research will be published in PNAS this week. Credit: Alison Satake, Louisiana State University

A world without plants would be a world without oxygen, uninhabitable for us and for many creatures. We know plants release oxygen by absorbing carbon dioxide and breaking down water using sunlight through the process of photosynthesis. However, we know little about the mechanics of how plants create oxygen during photosynthesis. A breakthrough that will help advance our understanding of this critical ecological process was made recently by scientists at LSU.

"Without photosynthesis or oxygen, basically all recognizable life that we see in our landscape would be gone: no animals, no plants," said Terry Bricker, Moreland Family Professor in LSU's Department of Biological Sciences.

Bricker has spent about 30 years of his career studying cellular plant biochemistry and the different components that enable plants to perform photosynthesis. A graduate student in his lab, Manjula Mummadisetti, led this latest study that examined the cellular system responsible for creating oxygen during photosynthesis called Photosystem II. She analyzed two proteins that are critical to creating oxygen and modeled how they connect and interact, building upon previous information and her latest research. Their paper, titled "Use of protein cross-linking and radiolytic footprinting to elucidate PsbP and PsbQ interactions within higher plant Photosystem II" will be published this week online in the *Proceedings of the National Academy of Sciences*.

"This discovery means a lot for photosynthesis research. People have wanted to know about this for a very long time. We didn't have these techniques and scientists were unable to find how these proteins connect," Mummadisetti said of her first published scientific research paper.

One principle in biochemistry is that a protein's structure determines its function. By creating a 3D model of these two critical plant proteins, Mummadisetti advances our knowledge about their structure, which can lead to a better understanding of how these proteins function. In her experiments, she used spinach from a grocery store because of its abundance. She isolated chloroplasts, the food factory of plants, and treated them with a chemical detergent to extract a high concentration of Photosystem II, the system within a plant that creates oxygen. She then used high-resolution mass spectrometry to see where the two proteins overlap and connect.

Bricker compares this process to putting a puzzle together where you can't see or touch the pieces.

"We looked at thousands of puzzle parts and a relatively small number of these were useful for identifying what's going on," he said.

Then, based on their analyses, Bricker and Mummadisetti built a 3D computer model of the two Photosystem II proteins, which are called PsbP and PsbQ.

"Frankly, this is the very first paper that shows a direct association between PsbP and PsbQ," Bricker said. "Because of Manju's work, we now know how PsbP and PsbQ interact and we can draw some very good working hypotheses on how these proteins act together."

The two proteins are like parts of a car that enable oil to reach the engine. In plants, the "oil" is calcium and chloride and the "fuel" is water and sunlight. The structure of PsbP and PsbQ facilitates the efficient use of calcium and chloride in a plant, enabling it to produce oxygen.

"Within the photosynthesis field, we've been thinking that these two proteins must be associated, but we didn't have any direct evidence. Now, after 30 years of work, the student who is the first author on this paper has provided direct evidence that they are interacting," Bricker said.

More information: Use of protein cross-linking and radiolytic footprinting to elucidate PsbP and PsbQ interactions within higher plant Photosystem II , *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1415165111

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