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New study sheds light on evolution of photosynthesis

Date: June 28, 2021

Source: Rutgers University

Summary: A new study sheds new light on the evolution of photosynthesis in plants and algae, which could help to improve crop production.

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FULL STORY

A Rutgers-led study sheds new light on the evolution of photosynthesis in plants and algae, which could help to improve crop production.

The paper appears in the journal *New Phytologist*.

The scientists reviewed research on the photosynthetic amoeba *Paulinella*, which is a model to explore a fundamental question about eukaryote evolution: why was there a single origin of algae and plants? That is, why did photosynthesis by primary plastid endosymbiosis not originate multiple times in the tree of life?

Photosynthesis is the process by which plants and other organisms use sunlight to synthesize foods from carbon dioxide and water, which generates oxygen as a byproduct.

Endosymbiosis is a relationship between two organisms wherein one cell resides inside the other. This interaction, when stable and beneficial for the "host" cell, can result in massive genetic innovation. Despite its critical evolutionary role, there is limited knowledge about how endosymbiosis is initially established.

Primary plastid endosymbiosis, which evolved about 1.5 billion years ago, is the process in which a eukaryote - which are organisms such as plants and algae whose cells have a membrane-bound nucleus and tiny organs called organelles -- engulfs a prokaryote, which are organisms such as bacteria that lack a membrane-enclosed nucleus. The plastid is a membrane-bound organelle within the cells of plants and algae.

"It turns out that photosynthesis results in enormous risks because it produces harmful chemicals and heat as byproducts that can damage the host cell," said senior author Debashish Bhattacharya, a Distinguished Professor in the Department of Biochemistry and Microbiology at Rutgers University-New Brunswick.

"Therefore, creating a novel organelle is a highly complex process that makes it fleetingly rare in evolution. *Paulinella*, which is the only known case of an independent plastid primary endosymbiosis other than in algae and plants, offers many clues to this process that helps explain why it is so rare."

The origin of photosynthesis in algae and plants changed our planet by providing a major source of oxygen and supporting many ecosystems, due to their primary production, of fixed carbon (sugars and lipids). Understanding how this critical process happened will help us potentially engineer it in synthetic systems as

well as to improve crop production.

"Because *Paulinella* is an independent origin of photosynthesis, it provides key clues to how this process occurs and what costs it imposes on the host cell," said lead author Timothy G. Stephens, a postdoctoral researcher at Rutgers. "The genome of *Paulinella* contains many independently evolved genes involved in photosynthesis and dealing with the associated stresses that can potentially be engineered in algae and plants could help to improve their ability to withstand stresses such as high light levels or salt stress."

The study included researchers from the Carnegie Institution.

Video: <https://www.youtube.com/watch?v=Pbosfj1oV6I>

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Materials provided by **Rutgers University**. *Note: Content may be edited for style and length.*

Journal Reference:

1. Timothy G. Stephens, Arwa Gabr, Victoria Calatrava, Arthur R. Grossman, Debashish Bhattacharya. **Why is primary endosymbiosis so rare?** *New Phytologist*, 2021; DOI: 10.1111/nph.17478

Cite This Page:

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Rutgers University. "New study sheds light on evolution of photosynthesis." ScienceDaily. ScienceDaily, 28 June 2021. <www.sciencedaily.com/releases/2021/06/210628170613.htm>.

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