Identifying a cyanobacterial gene family that helps control photosynthesis

October 8 2019

An image of Cyanobacteria, Tolypothrix. Credit: Wikipedia / CC BY-SA 3.0

A new Michigan State University study has identified a family of genes in cyanobacteria that help control carbon dioxide fixation.

The discovery furthers our basic knowledge of photosynthesis. It also opens new doors to design systems for sustainable biotech production.

The research is published in the journal, *New Phytologist*.

Cyanobacteria and plants share an enzyme in common, rubisco, which captures carbon dioxide from the atmosphere. Carbon capture is the first in a series of reactions that turn carbon into high-energy molecules that feed the planet's organisms.

In plants, rubisco is often blocked from working by small molecules that attach to it. In response, the protein, Rubisco activase, comes to the rescue, removing the unwanted molecules so rubisco can work again.

Recent advances in bioinformatics have allowed the lab of Cheryl Kerfeld to identify a cyanobacterial gene that looks like the one that encodes plant rubisco activase.

The new gene encodes what the lab is calling, activase-like cyanobacterial protein, or ALC.

"This gene is widespread in many taxonomic groups of cyanobacteria. Those include various unicellular and multi-cellular, filamentous species," said Sigal Lechno-Yossef, research assistant professor in the Kerfeld lab.

The cyanbacterial ALC's function remains unknown. The scientists tried mixing the ALC from a model cyanobacterium, Fremyella diplosiphon, with inhibited rubisco from the same organism, in a test tube. The ALC did not relieve rubisco from inhibition by small molecules.

However, in the cell, the protein is physically close to rubisco, just like its plant counterpart is. That is one reason Lechno-Yossef thinks they might work together.

"We also have bioinformatic evidence that shows ALC evolving along with rubisco in cyanobacteria. This finding is further support for interaction between these two proteins," Lechno-Yossef said.

So if ALC does not unblock rubisco, what does it do?

"We saw ALC causing rubisco proteins to aggregate," Lechno-Yossef said. "This function is similar to that of another cyanobacterial protein, which is known to contribute to rubisco regulation and localization in the cell."

There is also evidence ALC helps its host detect CO_2 levels in order to adjust photosynthesis rates. When the team deleted the ALC gene in a lab cyanobacterium, the organism did not experience dramatic changes in their growth. (In plants, deleting the analogous rubisco activase causes them to starve for carbon, a crucial nutrient).

However, those same strains experienced morphological changes when grown in CO_2-rich environments.

The new research holds promise for the biotech field. In plants, rubisco activase is the focus of much study, as part of efforts to increase rubisco performance. Improving rubisco would lead to plants with higher nutrition contents, and higher crop yields. But such efforts have gone unrewarded so far.

"Cyanobacterial researchers also want to increase energy yield from photosynthesis," Lechno-Yossef said. "The goal would be to rewire cyanobacteria's photosynthetic machine to produce renewable energy compounds or materials for use in medicine or industry."

"Now we know that cyanobacteria have an enzyme that supports rubisco, we could try making more robust cyanobacteria for industrial applications," said Lechno-Yossef.

More information: Sigal Lechno-Yossef et al. Cyanobacterial Carboxysomes Contain a Unique Rubisco-Activase-Like protein, *New Phytologist* (2019). DOI: 10.1111/nph.16195

Provided by Michigan State University