A protein lulls algae to 'sleep,' and what that means for making green fuels

February 6 2020, by Igor Houwat, Layne Cameron

Tomomi Takeuchi, research assistant in MSU-DOE Plant Research Laboratory. Courtesy of MSU-DOE Plant Research Laboratory. Credit: Michigan State University

Algae have the potential to become a sustainable source of high value biofuels and oils. A big hurdle that holds us back from mass producing algae feedstocks is that they make more oil when stressed out, like during starvation.

When stressed, algae need to save energy. They go into a resting state, or hibernation, and stop growth and cell division functions. They store energy reserves in the form of starch and triacylglycerols. TAGs are the raw material for biofuels.

When the stress passes, the algae exit hibernation. They consume their energy reserves so they can resume cell growth and division.

The dilemma for making biofuels is this: Stressed algae make more TAGs but grow poorly. Unstressed algae don't produce enough of it. Understanding how stress controls hibernation cycles will help us develop new ways to overcome the issue.

Christoph Benning, director of MSU-DOE Plant Research Laboratory, and his team of researchers are trying to understand the biological reasons behind this dilemma. In their latest study, published in *The Plant Cell*, they looked at a protein that helps the algae manage hibernation.

A Glimpse into Algae Hibernation

The team is studying a mutant algal strain that degrades TAGs slower than usual as algae try to exit hibernation. Somehow, the algal mutant does not manage the hibernation process in a normal way.

The responsible protein, missing due to the mutation, is called Compromised Hydrolysis of Triacylglycerols 7. It is part of a system that helps algae enter or wake up from hibernation.

"When we remove CHT7 from algal cells, the cells can't go into hibernation properly. They can't resume normal cell division during the exit from hibernation," says Tomomi Takeuchi, research assistant in

MSU-DOE Plant Research Laboratory. "CHT7 itself doesn't generate the energy reserves, including TAG."

These mutant cells also suffer many other problems:

- They can't stop their cell cycle genes during hibernation. They keep growing, are bigger than usual and many cells die. In comparison, normal cells stop growth once they enter hibernation.
- They continue dividing during hibernation, even when they shouldn't. Their offspring are not equally sized and have disorganized organelles. The situation is comparable to out-of-control human cancer cells that keep dividing and, in turn, form tumors.
- They are slower to resume growth functions when they try to exit hibernation.

Takeuchi says these are extreme, damaging changes to the algal cell.

And there is mounting evidence that CHT7 doesn't work alone.

"We think it is part of a bigger protein complex that controls hibernation," Takeuchi says. "We need to examine how CHT7 integrates into and works with the larger complex."

The team began the study by chopping CHT7 into smaller parts and reinserting them into the mutant to see which parts reverse the defects. This helped highlight the parts that are critical for hibernation and might interact with other proteins. The next step is to examine the other proteins in the complex.

Richard Cyr, grant program manager at the National Science Foundation says, "Production of biofuels from higher plants suffers from two drawbacks: a significant period of growth is required before seeds can be harvested, and specific types of farmland are required for optimal production."

"Algae promise the production of biofuel precursors throughout their growth and can be cultured in ponds, ditches and bioreactors. Before the promise of algae for biofuel production is realized, several hurdles need to be overcome. This work provides a significant advance by which biofuels precursors might be produced."

Benning praises the study. "This paper represents a deep dive into the inner workings of an important cellular process. It was beautifully choreographed and drafted by Takeuchi as part of her recently defended Ph.D. thesis," he says. "Credit also goes to the other students involved and Professor Emerita, Barb B. Sears, who's expertise on the algal organism has been invaluable."

More information: Tomomi Takeuchi et al. Chlamydomonas CHT7 is Required for an Effective Quiescent State by Regulating Nutrient-responsive Cell Cycle Gene Expression, *The Plant Cell* (2020). DOI: 10.1105/tpc.19.00628

Provided by Michigan State University