Scientists hijack light-loving bacteria to produce fatty acid

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In Pacific Northwest National Laboratory's Microbial Cell Dynamics Laboratory, scientists produce microorganisms for biofuels and alternative fuel research.

Scientists have directed a common bacterium to produce more of a valuable fatty acid, lauric acid, than it typically does. The achievement is noteworthy not simply because of the increased production of fatty acid, which can be a useful component of biofuels. The work opens the door for scientists to manipulate such organisms to produce compounds useful as fuels or medicines.

"We now know enough about redirecting traffic inside the cell that we can engineer cells to make more of the products that have high value. This is useful not only for making commercially viable biofuels but also commodities such as pharmaceuticals," said microbiologist Alex Beliaev, Pacific Northwest National Laboratory, who led the study, which was published in *Frontiers in Bioengineering and Biotechnology*.

Scientists at PNNL and the Colorado School of Mines worked together with a single-celled organism called Synechococcus sp. PCC 7002, a type of cyanobacteria—organisms that make building blocks for new cells out of air, water, and sunlight. Like its cousins, common forms of algae, cyanobacteria suck in huge amounts of carbon dioxide from the environment and convert it into other materials, such as biomass. Thus, they play a critical role in Earth's climate. Scientists the world over currently are developing ways to take advantage of these natural processes to create new forms of energy.

The goal of this research was to find ways to change the organism's metabolism and direct it toward making fats, or lipids, instead of sugars, or glucose, using synthetic biology and metabolic engineering tools to redirect the path of carbon in the cell. Because Synechococcus sp. PCC 7002 grows very fast and adapts well to different environments, it's under particular scrutiny for its potential to make biofuels and other high-value products.

"With cell division rates of just under two hours and with remarkable resilience under varying environmental conditions, this organism is a perfect target for metabolic engineering," said Beliaev.

By manipulating the organism's genes, Beliaev's team was able to direct the bacteria to make less sugar and more lauric acid, a compound that can be processed into biodiesel and higher-value products, such as soaps and detergents. Such biological adjustments can mean the difference between another run-of-the-mill, ocean-dwelling bacterium and an organism useful for creating products used by people every day.

The engineered bacterium not only accumulated this fatty acid, but it also excreted it from the cell. The scientists found that the resultant organism was extremely resilient, responded to stress well, and tolerated high levels of light—all useful qualities for scientists seeking to manipulate the organism.

In this study, the scientists also were surprised that the Synechococcus didn't make as much lauric acid as expected. Beliaev explained: "Upstream, we hypothesized that they adapt to reactions because the central metabolic pipeline has enough elasticity to accommodate perturbations. But we now know we need to use metabolic controls to push toward end products. It's harder than we expected. There's a built-in resistance in these organisms. It was a good lesson: reverse engineering approach may work, where you push an organism in a specific direction and see its reaction."

The next step is to use these capabilities to engineer organisms for other targeted products, including terpenoids-precursors to a range of commercial chemicals-and bioproducts, such as rubber, detergents, and polymers.

"This is a proof-of-concept study that shows we have the knowledge and tools to change carbon to something more valuable," said Beliaev.

More information: "Lauric Acid Production in a Glycogen-Less Strain of Synechococcus sp. PCC 7002 Mutant." *Frontiers in Bioengineering and Biotechnology* 3:48. DOI: 10.3389/fbioe.2015.00048

"Engineering Limonene and Bisabolene Production in Wild Type and a Glycogen-Deficient Mutant of Synechococcus sp. PCC 7002." *Frontiers in Bioengineering and Biotechnology* 2:21. DOI: 10.3389/fbioe.2014.00021

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