Harvesting the Goods in Ancient Bacteria

By Jennifer Tarnacki

While there have been advances in green biodiesel production, including corn being converted into ethanol and algae being used for lipid synthesis, these methods are contingent upon the vagaries of the environment and have low energy yield. The challenge remains not to create a workable biodiesel system, but to compete with the current cost of petroleum. So how do we solve this problem? What about looking to ancient bacteria from the blue green algae family, called cyanobacteria? New research shows that it may be possible to create a biofuel source that bypasses the energy barriers found in other green biodiesel production systems (1).

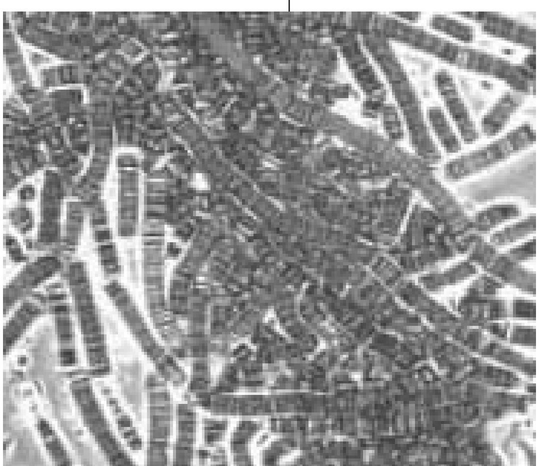

Figure 1. Cyanobacteria *Synechococcus* under a microscope.

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Cyanobacteria are a type of bacteria that obtain energy from photosynthesis. These ancient bacteria have systems for converting sunlight into simple sugars, and simple sugars into lipids (2). The bacteria naturally produce these lipids inside their cell membranes; the problem has been retrieving the lipids from the cells themselves.

Since the majority of the cost of biodiesel production comes from harvesting the biofuel precursors into usable biofuel, getting a direct usable lipid would be ideal. If cells could be genetically coaxed into secreting usable oil outside their cell membranes, bacterial metabolic engineering may provide high yield, usable biofuel at low cost. Researchers have been able to modify the genes in cyanobacteria into overproducing lipids, creating mutant strains that actually secrete the accumulated lipids through their cell walls via diffusion (3). An enzyme is used to detach the fatty acid from their proteins; a modified form of thioesterase, an enzyme that was discovered in E. coli and was found to cause secretion of fatty acids by clipping the fatty acid from its more complex carrier proteins in the lipid synthesis pathway. Once fatty acids accumulate within the mutant cyanobacterium's cell, they diffuse through its cell walls. Additional genetic modifications in the cell walls aid the process. After the fatty acids diffuse through the cell membrane, they precipitate out of the water due to their low solubility. And voila: biofuel!

Genetic modification can include clipping the fatty acid from its carrier protein, modifying the cell membranes to be more permeable to fatty acid diffusion, genetically overproducing lipid precursors, and removing non-essential pathways within the bacteria, all with the aim of ensuring lipid production in the cell (4). In this way, several bacterial engineering techniques can be used to optimize biofuel production. One company, Waltham Technologies, is using Vitamin B12 as a driver (cyanobacteria need Vitamin B12 to survive), ensuring that the bacteria not only survive and produce lipids, but they actually need to produce lipids to survive (5).

Waltham Technologies plans to not only genetically modify cyanobacteria to produce more of their lipids, but to also clean wastewater while they're at it. They aim to use specific strains of the bacteria to clean wastewater while producing enzymes. The enzymes themselves will convert lipids into biodiesel. Their patented technology uses Vitamin B12 as the driver, forcing the bacterial cells to produce the proper enzymes or die (5). This coupling of biodiesal production and wastewater treatment is a great example of the type of energy-efficient system that will increase our sustainability in a dynamic environment. H

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