Photosynthetic Microbial Cell Factories

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Normally we rely on heavy industry as the main means of processing petroleum, plastics and even pharmaceuticals; these high value products may be very different from one another but share one common building block: carbon. Therefore thinking as scientists, we can begin to consider ways of differently producing these materials – with the idea that we can manufacture them renewably, cheaply and above all in an environmentally friendly manner.

Bacteria involved in industrial microbiology, have been a preferred means in producing complex compounds, which at the moment are deemed too difficult and too expensive to manufacture on a large scale through existing industrial methods. By genetically modifying bacteria, it is possible to introduce new genes – from other organisms for example, to enable the bacteria in question to produce a variety of useful chemicals.

Cyanobacteria are a type of green algae that live essentially in all types of aquatic environments and are responsible for prehistorically converting most of the CO_2 in the atmosphere into O_2. Scientists have been fascinated with their abilities to use sun light (via photosynthesis) and CO_2 capture in order to survive. These qualities have inspired researchers to genetically modify cyanobacteria into producing a variety of advanced compounds, specifically biofuels. The goal of producing renewable, mass produced, environmentally-friendly fuels for the future is an ambitious one, but there remains a serious obstacle, one pointing to the way which cyanobacteria capture CO_2 from the atmosphere.

The enzyme responsible for this capture is called Rubisco, which also happens to be the world's most abundant enzyme, as it is found in plants and photosynthetic organisms alike. Despite its abundance, it's not very efficient at capturing CO_2. This has led researchers to think of ways of completely avoiding Rubisco and introducing other enzymes into an organism to help it capture CO_2 efficiently. A research team developed an entirely theoretical CO_2 capture system, consisting of 11 enzymes found in nature. Named the "*Malonyl-CoA-oxaloacetate-glyoxylate pathway"* or MOG pathway, the team reports that it can capture CO_2 up to three times faster than Rubisco. A previous project of mine dealt with identifying each of these 11 enzymes and establishing if such a pathway can be introduced into our cyanobacteria of choice, *Synechocystis sp.* PCC 6803.

My MSc thesis involved introducing the first enzyme of the pathway, Phosphoenolpyruvate Synthase (PEPS), into *Synechocystis's* genome and determining if it is expressed and if there are any physiological changes. The gene that codes for this enzyme is already found in wild type S*ynechocystis*, therefore by amplifying and cloning the gene, it was possible to reintroducing it back into the genome. The results showed that introducing PEPS back into the genome results in overexpression alongside the original wild type PEPS without any negative changes in its growth.

In brief, it was shown that it is possible to genetically modify cyanobacteria, with the ultimate goal of introducing the entire MOG pathway and increasing carbon capture within the organism. By doing so, researchers can further modify *Synechocystis* into a miniature factory to synthesize high-value compounds more efficiently.

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