How to build artificial nanofactories to power our futures

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Ships help handle the complex logistics to deliver products to consumers. Future artificial nanofactories will also need a chain of logistical "nano" vehicles to deliver products. Credit: Max Pixel/CC0 Public Domain

When we buy a new phone or laptop online, we assume it will be delivered to our doorstep in a matter of days.

But we mostly miss the complex logistics that make this happen: ships, planes, trains, and trucks that move products, starting from raw materials in mines, to factories for assembly, to warehouses for storage, and up to our doorsteps.

Scientists at the MSU-DOE Plant Research Laboratory are trying to build artificial nanofactories to sustainably produce industrial materials or medical tools.

And like with getting new phones, these artificial nanofactories of the future will need an army of "nano" vehicles to deliver valuable chemical products.

But we don't know enough about the logistics just yet.

It turns out bacteria in nature have the blueprint for us to copy. They house nanofactories, called bacterial microcompartments (BMCs) - that fill many purposes, depending on the host.

In cyanobacteria, for example, BMCs build useful compounds from carbon dioxide pulled from the atmosphere. Or, some pathogenic bacteria use them to outcompete "good" bacteria.

In a new study, published in the journal *Biochemistry*, Jeff Plegaria and the Kerfeld lab reveal the structure and function of a widespread BMC protein that contributes to the logistics of creating products, taking us closer to repurposing BMCs for our own uses.

Describing the Fld1C flavoprotein

Jeff and his colleagues noticed that many natural BMCs – especially a type that degrades carbon to help make useful energy compounds – contain genes for flavoproteins right next to the primary genes responsible for constructing and operating the BMCs.

The Kerfeld lab has analyzed over 200 sets of cyanobacteria DNA, towards someday building synthetic factories that will produce green fuels or medical diagnostic products. Credit: Michigan State University

Primary genes include instructions for building and managing BMCs, transporting materials back and forth, and so on.

And being close to the core genes meant flavoproteins play an important role within BMCs.

So, what do flavoproteins do?

"They are electron transfer proteins found in many bacteria and other biological pathways in nature. Electron transfer, or flow, is a fundamental process in nature," Jeff says.

"Understanding electron flow in BMCs is crucial, because it is part of the assembly line that leads to the creation of final chemical products. But, we still don't know much about how flavoproteins work in BMCs."

In the study, Jeff zoomed in on one BMC flavoprotein, which his group named Fld1C.

They were able to characterize it, revealing its structure, describing its physical features, and confirming its ability to take part in electron transfer reactions.

"With help from scientists at Argonne National Laboratory, we generated an agent that can pass an electron on to a willing acceptor. We successfully showed our Fld1C flavoprotein accepting an electron from that agent."

"Understanding these logistics – how electrons flow in and out of BMCs – is vital to building and controlling synthetic BMCs for custom applications."

Such applications could include producing industrial materials like rubber or petroleum, without relying on fossil fuels.

Or we could build medical tools that disarm BMCs in "bad" bacteria – like Salmonella – and prevent them from wreaking their havoc.

More information: Jefferson S. Plegaria et al. Structural and

Functional Characterization of a Short-Chain Flavodoxin Associated with a Noncanonical 1,2-Propanediol Utilization Bacterial Microcompartment, *Biochemistry* (2017). DOI: 10.1021/acs.biochem.7b00682

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