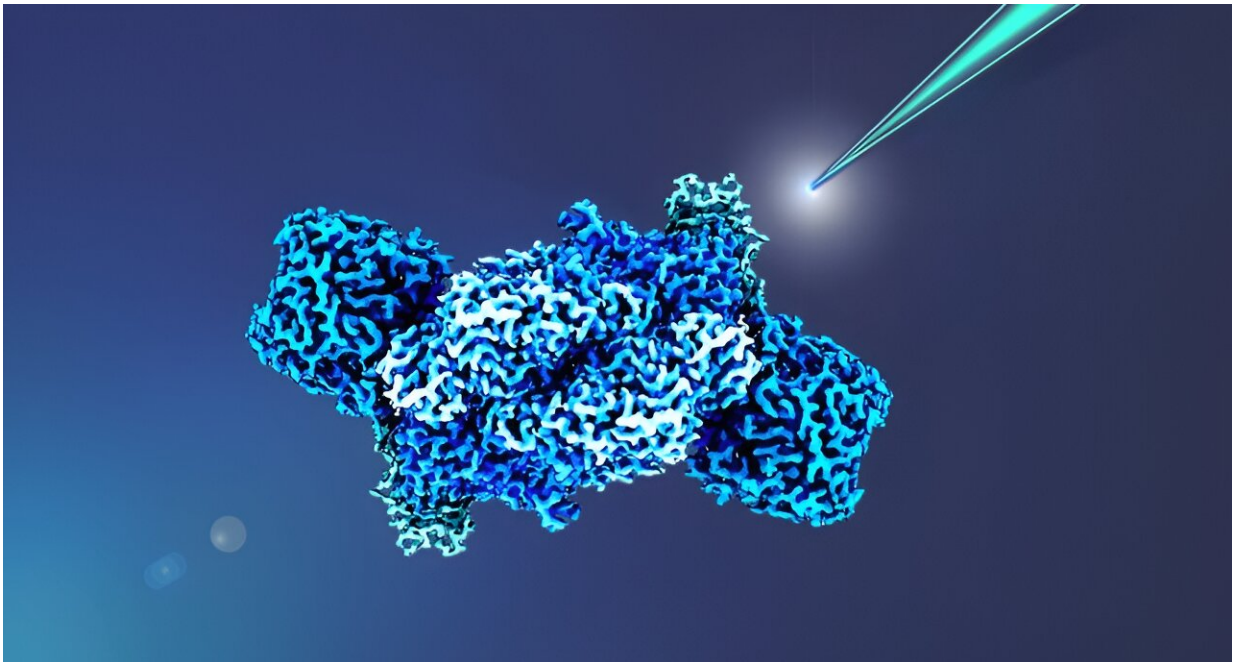


Powering nitrogenases: Researchers find new targets for improving biocatalysts

February 26 2024



It has recently been shown that the biocatalyst iron nitrogenase not only fixes nitrogen, but also carbon dioxide. However, this nitrogenase form has so far been the least studied. Now two proteins have been identified that are crucial for the energy supply of the enzyme. Credit: Max Planck Institute for Terrestrial Microbiology / Geisel

Nitrogenases are considered promising candidates for the sustainable enzymatic production of ammonia and carbon compounds. Unfortunately, one bottleneck in this complex process, the supply of

electrons to the enzymes, has remained a mystery until now.

A team at the Max Planck Institute for Terrestrial Microbiology in Marburg has discovered two essential electron carriers that play a key role in determining the performance of iron (Fe) [nitrogenase](#), thus opening up new possibilities for elucidating and maximizing nitrogenase's potential. The findings are [published](#) in the journal *mBio*.

Nitrogenases are catalysts for several industrially relevant reactions, the most important of which is the chemical fixation and conversion of nitrogen to ammonia, a raw material for fertilizers. Their [industrial production](#) is currently carried out using the environmentally harmful Haber-Bosch process.

Enzymatically and sustainably produced fertilizers could save around 1% of the energy consumed globally and the associated carbon dioxide released, which is why many research labs and start-ups are focusing on the topic. However, nitrogenase research is challenging because nitrogenases are highly complex metalloenzymes and many aspects of their reactivity and catalysis are still poorly understood.

Iron nitrogenase not only fixes nitrogen, but also carbon dioxide

Researchers led by Johannes Rebelein at the Max Planck Institute for Terrestrial Microbiology in Marburg, Germany, have now gained first insights into the energy supply of the enzyme complex, i.e. its electron supply.

Their results are important not only for industrial nitrogen, but also for industrial carbon dioxide fixation, because the same team recently showed that iron nitrogenases are also capable of converting carbon

dioxide into short-chain hydrocarbons. The researchers characterized the [electron transport](#) to the iron nitrogenase in the model bacterium *Rhodobacter capsulatus* and showed that two different electron transport proteins, called ferredoxins, are essential for nitrogen fixation.

The energy bottleneck opens up new approaches for optimization

"We wanted to find out which ferredoxins are crucial for nitrogenase catalysis. Since all cells harbor multiple ferredoxins, with our model bacterium *R. capsulatus* producing six different ferredoxins, we also wanted to find out whether several of these ferredoxins can perform the same task or whether they have strictly specific functions," explains first author Holly Addison.

"When two specific ferredoxins were knocked out, the others could not take over their functions. We concluded that these ferredoxins were essential and likely performed distinct roles in nitrogen fixation."

The supply of electrons is considered a bottleneck in catalysis. With the two ferredoxins, the researchers have now identified clear targets to influence the electron flow and thus the performance of nitrogenases as biocatalysts.

"Our results are an important prerequisite for the optimization of *R. capsulatus* as a model system for the enhanced conversion of [nitrogen](#) or [carbon dioxide](#) into ammonia or short-chain hydrocarbons," adds Johannes Rebelein.

"The aim now is to further investigate and engineer nitrogenases and their associated proteins to expand our understanding and enable the production of industrial bulk chemicals."

The next steps of the project will focus on better understanding the role of ferredoxins as well as using synthetic biology methods to modify them and accelerate the turnover of the nitrogenase enzyme by providing electrons more efficiently.

More information: Holly Addison et al, Two distinct ferredoxins are essential for nitrogen fixation by the iron nitrogenase in *Rhodobacter capsulatus*, *mBio* (2024). [DOI: 10.1128/mbio.03314-23](https://doi.org/10.1128/mbio.03314-23)

Provided by Max Planck Society

Citation: Powering nitrogenases: Researchers find new targets for improving biocatalysts (2024, February 26) retrieved 30 April 2024 from <https://phys.org/news/2024-02-powering-nitrogenases-biocatalysts.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.