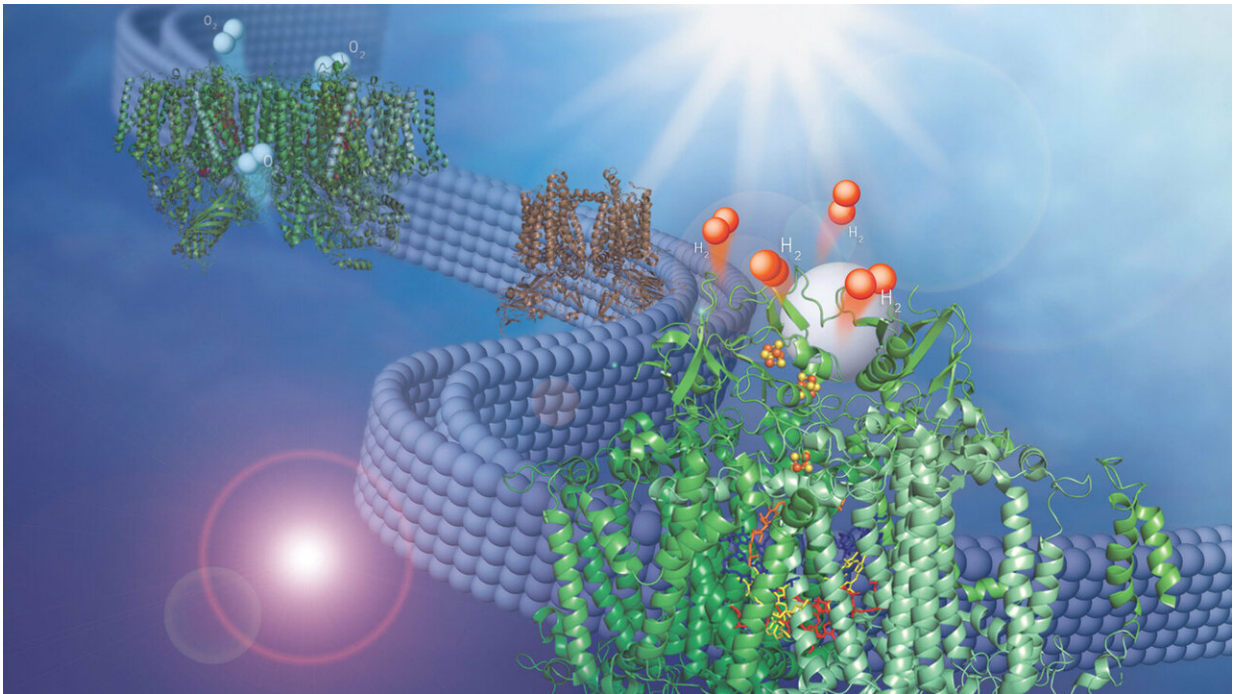


Discovery adapts natural membrane to make hydrogen fuel from water

January 11 2019, by Jared Sagoff



Two membrane-bound protein complexes that work together with a synthetic catalyst to produce hydrogen from water. Credit: Olivia Johnson and Lisa Utschig

A chemical reaction pathway central to plant biology have been adapted to form the backbone of a new process that converts water into hydrogen fuel using energy from the sun.

In a recent study from the U.S. Department of Energy's (DOE) Argonne National Laboratory, scientists have combined two [membrane](#)-bound protein complexes to perform a complete conversion of water molecules to [hydrogen](#) and oxygen.

The work builds on an earlier study that examined one of these protein complexes, called Photosystem I, a membrane protein that can use energy from light to feed electrons to an inorganic [catalyst](#) that makes hydrogen. This part of the reaction, however, represents only half of the overall process needed for hydrogen generation.

By using a second [protein complex](#) that uses energy from light to split water and take electrons from it, called Photosystem II, Argonne chemist Lisa Utschig and her colleagues were able to take electrons from water and feed them to Photosystem I.

"The beauty of this design is in its simplicity—you can self-assemble the catalyst with the natural membrane to do the chemistry you want"—Lisa Utschig, Argonne chemist

In an earlier experiment, the researchers provided Photosystem I with electrons from a sacrificial electron donor. "The trick was how to get two electrons to the catalyst in fast succession," Utschig said.

The two protein complexes are embedded in [thylakoid membranes](#), like those found inside the oxygen-creating chloroplasts in higher plants.

"The membrane, which we have taken directly from nature, is essential for pairing the two photosystems," Utschig said. "It structurally supports both of them simultaneously and provides a direct pathway for inter-[protein](#) electron transfer, but doesn't impede catalyst binding to Photosystem I."

According to Utschig, the Z-scheme—which is the technical name for

the light-triggered electron transport chain of natural photosynthesis that occurs in the thylakoid membrane—and the synthetic catalyst come together quite elegantly. "The beauty of this design is in its simplicity—you can self-assemble the catalyst with the natural membrane to do the chemistry you want," she said.

One additional improvement involved the substitution of cobalt or nickel-containing catalysts for the expensive platinum catalyst that had been used in the earlier study. The new cobalt or nickel catalysts could dramatically reduce potential costs.

The next step for the research, according to Utschig, involves incorporating the membrane-bound Z-scheme into a living system. "Once we have an *in vivo* system—one in which the process is happening in a living organism—we will really be able to see the rubber hitting the road in terms of hydrogen production," she said.

More information: Lisa M. Utschig et al, Z-scheme solar water splitting via self-assembly of photosystem I-catalyst hybrids in thylakoid membranes, *Chemical Science* (2018). [DOI: 10.1039/c8sc02841a](https://doi.org/10.1039/c8sc02841a)

Provided by Argonne National Laboratory

Citation: Discovery adapts natural membrane to make hydrogen fuel from water (2019, January 11) retrieved 30 June 2024 from <https://phys.org/news/2019-01-discovery-natural-membrane-hydrogen-fuel.html>

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