Photosynthesis 'hack' could lead to new ways of generating renewable energy

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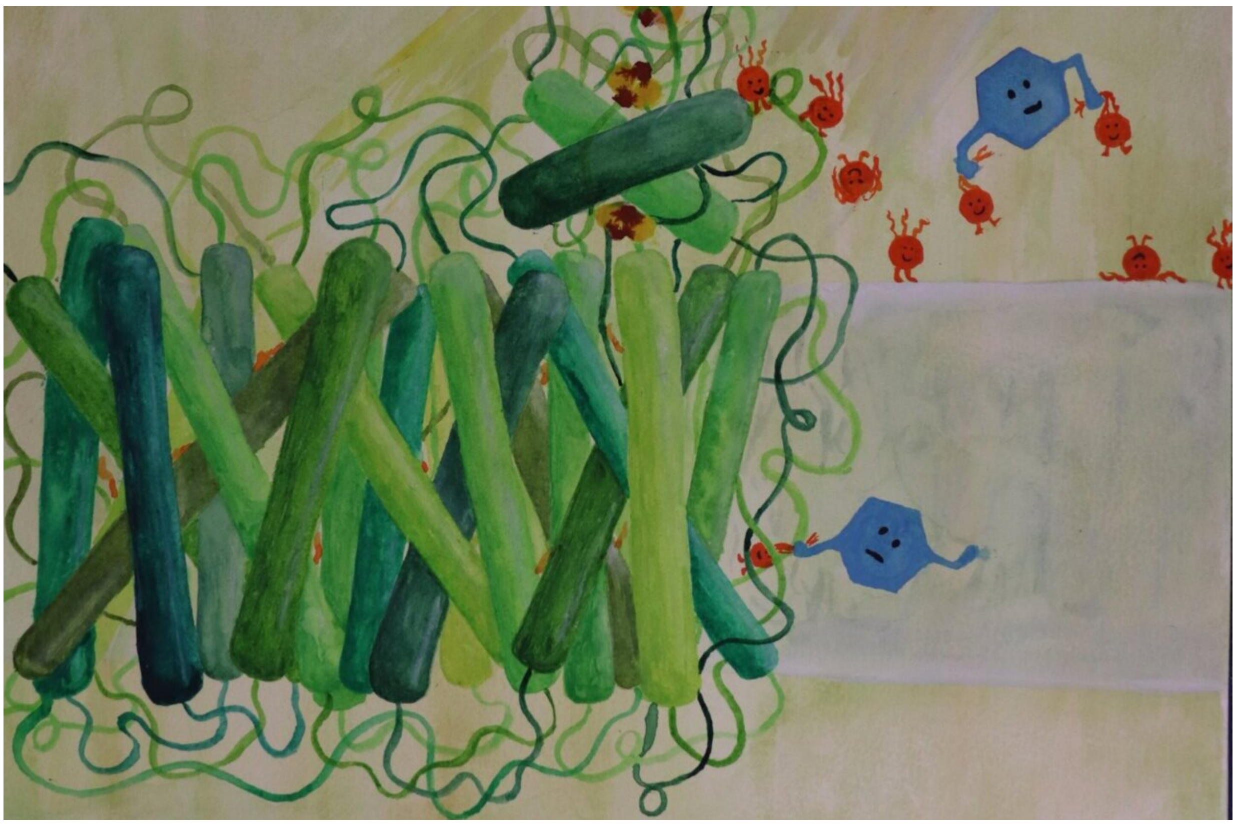

Researchers have ‘hacked’ the earliest stages of photosynthesis, the natural machine that powers the vast majority of life on Earth, and discovered new ways to extract energy from the process, a finding that could lead to new ways of generating clean fuel and renewable energy. Credit: Robin Horton

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An international team of physicists, chemists and biologists, led by the University of Cambridge, was able to study photosynthesis—the process by which plants, algae and some bacteria convert sunlight into energy—in live cells at an ultrafast timescale: a millionth of a millionth of a second.

Despite the fact that it is one of the most well-known and well-studied processes on Earth, the researchers found that photosynthesis still has secrets to tell. Using ultrafast spectroscopic techniques to study the movement of energy, the researchers found the chemicals that can extract electrons from the molecular structures responsible for photosynthesis do so at the initial stages, rather than much later, as was previously thought. This 'rewiring' of photosynthesis could improve ways in which it deals with excess energy, and create new and more efficient ways of using its power. The results are reported in the journal *Nature*.

"We didn't know as much about photosynthesis as we thought we did, and the new electron transfer pathway we found here is completely surprising," said Dr. Jenny Zhang from Cambridge's Yusuf Hamied Department of Chemistry, who coordinated the research.

While photosynthesis is a natural process, scientists have also been studying how it could be used as to help address the climate crisis, by mimicking photosynthetic processes to generate clean fuels from sunlight and water, for example.

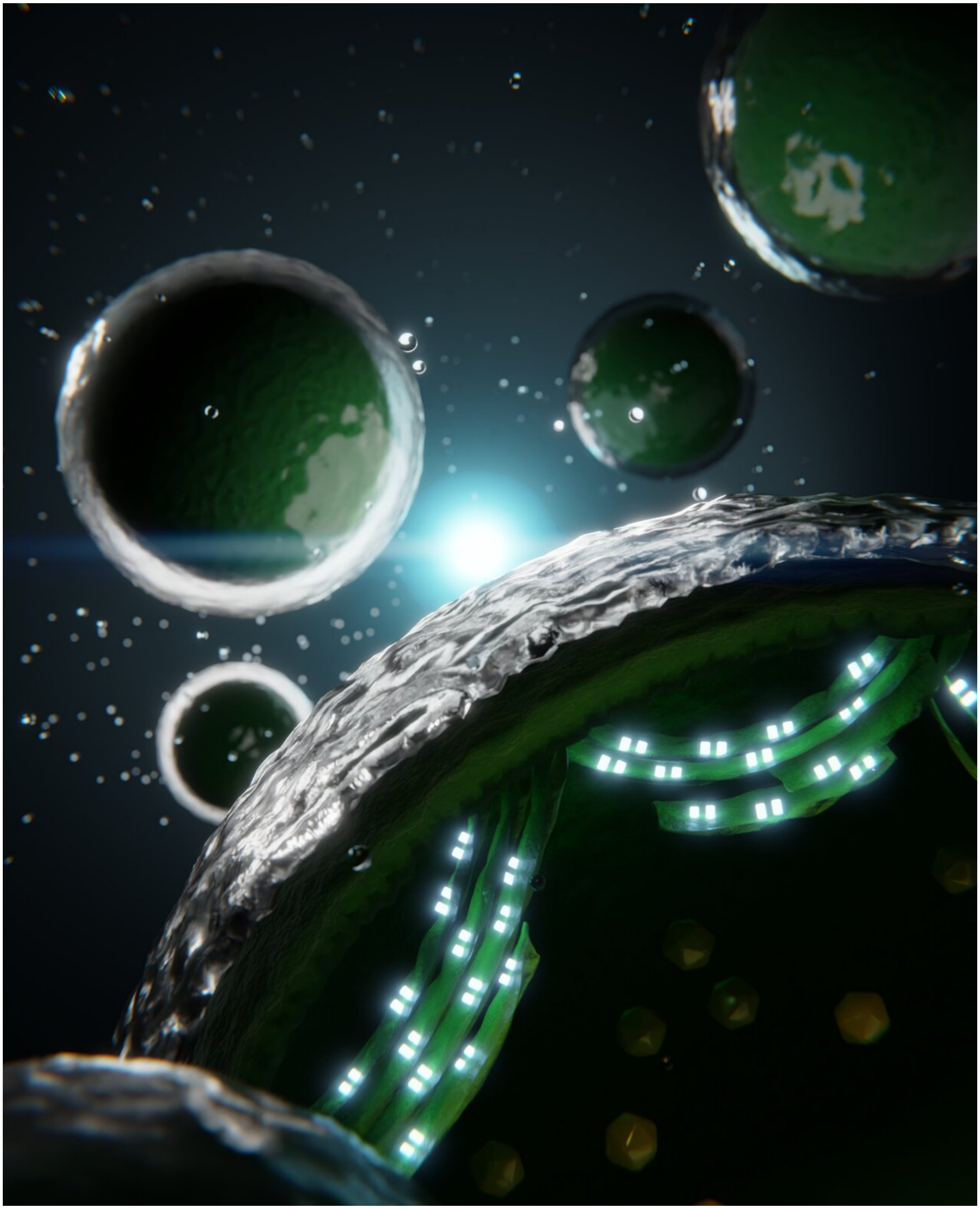
Zhang and her colleagues were originally trying to understand why a ring-shaped molecule called a quinone is able to 'steal' electrons from photosynthesis. Quinones are common in nature, and they can accept and give away electrons easily. The researchers used a technique called ultrafast transient absorption spectroscopy to study how the quinones behave in photosynthetic cyanobacteria.

"No one had properly studied how this molecule interplays with photosynthetic machineries at such an early point of photosynthesis: we thought we were just using a new technique to confirm what we already knew," said Zhang. "Instead, we found a whole new pathway, and opened the black box of photosynthesis a bit further."

Using ultrafast spectroscopy to watch the electrons, the researchers found that the protein scaffold where the initial chemical reactions of photosynthesis take place is 'leaky', allowing electrons to escape. This leakiness could help plants protect themselves from damage from bright or rapidly changing light.

"The physics of photosynthesis is seriously impressive," said co-first author Tomi Baikie, from Cambridge's Cavendish Laboratory "Normally, we work on highly ordered materials, but observing charge transport through cells opens up remarkable opportunities for new discoveries on how nature operates."

"Since the electrons from photosynthesis are dispersed through the whole system, that means we can access them," said co-first author Dr. Laura Wey, who did the work in the Department of Biochemistry, and is now based at the University of Turku, Finland. "The fact that we didn't know this pathway existed is exciting, because we could be able to harness it to extract more energy for renewables."



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The researchers say that being able to extract charges at an earlier point in the process of photosynthesis, could make the process more efficient when manipulating photosynthetic pathways to generate clean fuels from the Sun. In addition, the ability to regulate photosynthesis could mean that crops could be made more able to tolerate intense sunlight.

"Many scientists have tried to extract electrons from an earlier point in photosynthesis, but said it wasn't possible because the energy is so buried in the protein scaffold," said Zhang. "The fact that we can steal them at an earlier process is mind-blowing. At first, we thought we'd made a mistake: it took a while for us to convince ourselves that we'd done it."

Key to the discovery was the use of ultrafast spectroscopy, which allowed the researchers to follow the flow of energy in the living photosynthetic cells on a femtosecond scale—a thousandth of a trillionth of a second.

"The use of these ultrafast methods has allowed us to understand more about the early events in photosynthesis, on which life on Earth depends," said co-author Professor Christopher Howe from the Department of Biochemistry.

More information: Jenny Zhang, Photosynthesis re-wired on the pico-second timescale, *Nature* (2023). DOI: 10.1038/s41586-023-05763-9. www.nature.com/articles/s41586-023-05763-9

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