Scientists probe the energy transfer process in photosynthetic proteins

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Researchers have developed a new method to probe the fundamental workings of photosynthesis. The new experimental technique could help scientists better understand the nitty-gritty details of nature's amazingly efficient sunlight-to-fuel conversion system.

Plants and other photosynthetic organisms grow by harvesting the sun's energy and storing it in chemical bonds. Antenna proteins, which are made up of multiple light-absorbing pigments, capture sunlight over a large surface area and then transfer the energy through a series of molecules to a reaction center where it kick-starts the process of building sugars. Photosynthetic processes take place is spaces so tightly packed with pigment molecules that strange quantum mechanical effects can come into play. When a pigment molecule absorbs light, one of its electrons is boosted into an "excited" higher energy state. If multiple pigments in a protein absorb light nearly simultaneously, their wave-like excitation states may overlap and become linked to one another, affecting the path of the energy transfer.

Researchers from the University of California, Berkeley, led by Graham Fleming, discovered they could test whether this overlap had occurred. The scientists excited a well-studied photosynthetic antenna protein, called Fenna-Matthews-Olson (FMO), with two different frequencies of laser-light. When the researchers used a third laser pulse to prompt the protein to release energy, they found it emitted different frequencies than those it had received, a sign that the two excitation states had linked. Alternative methods for observing overlapping excitations had been proposed before, but the new technique may be easier to implement since it relies only on frequency —or color—shifts, and not on precisely timed pulses.

"It is a relatively simple task to separate colors from each other," says team member Jahan Dawlaty, who also noted that the evidence of overlap was not hidden among other optical effects, as it might be when using a different technique. The team's results are published in the American Institute of Physics' *Journal of Chemical Physics* (JCP). The new method could be used to create a catalogue of the various excitation states in FMO and their potential combinations, the team says.

"The experiment is interesting and was carried out in a novel way," says Shaul Mukamel, a chemist at University of California, Irvine, who was not part of the research team. Mukamel noted that the technique might also be applied to larger complexes and reactions centers. Probing energy levels and pigment couplings in photosynthetic systems is essential to understanding, modeling, and testing the function of these systems, he says.

And, with better understanding, human engineers might one day be able to capitalize on the same energy conversion tactics that photosynthetic organisms have developed over billions of years, notes Ed Castner, editor of JCP and a chemist at Rutgers University in New Jersey.

"The annual total for human energy usage on our planet is roughly equivalent to the amount of light energy incident on the planet in a single hour," says Castner. "To address our needs for safe, sustainable and renewable fuels, it is clearly urgent to understand how photosynthesis works."

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