When It Comes to Photosynthesis, Plants Perform Quantum Computation

The wavelike motion of energetic particles through photosynthetic systems enables plants to efficiently capture the sun's energy.

Plants soak up some of the $10^{17}$ joules of solar energy that bathe Earth each second, harvesting as much as 95 percent of it from the light they absorb. The transformation of sunlight into carbohydrates takes place in one million billionths of a second, preventing much of that energy from dissipating as heat. But exactly how plants manage this nearly instantaneous trick has remained elusive. Now biophysicists at the University of California, Berkeley, have shown that plants use the basic principle of quantum computing—the exploration of a multiplicity of different answers at the same time—to achieve near-perfect efficiency.

Biophysicist Gregory Engel and his colleagues cooled a green sulfur bacterium—*Chlorobium tepidum*, one of the oldest photosynthesizers on the planet—to 77 kelvins [-321 degrees Fahrenheit] and then pulsed it with extremely short bursts of laser light. By manipulating these pulses, the researchers could track the flow of energy through the bacterium's photosynthetic system. "We always thought of it as hopping through the system, the same way that you or I might run through a maze of bushes," Engel explains. "But, instead of coming to an intersection and going left or right, it can actually go in both directions at once and explore many different paths most efficiently."

In other words, plants are employing the basic principles of quantum mechanics to transfer energy from chromophore (photosynthetic molecule) to chromophore until it reaches the so-called reaction center where photosynthesis, as it is classically defined, takes place. The particles of energy are behaving like waves. "We see very strong evidence for a wavelike motion of energy through these photosynthetic complexes," Engel says. The results appear in the current issue of *Nature*.

Employing this process allows the near-perfect efficiency of plants in harvesting energy from sunlight and is likely to be used by all of them, Engel says. It might also be copied usefully by researchers attempting to create artificial photosynthesis, such as that in photovoltaic cells for generating electricity. "This can be a much more efficient energy transfer than a classical hopping one," Engel says. "Exactly how to implement that is a very difficult question."
It also remains unclear exactly how a plant's structure permits this quantum effect to take place. "[The protein structure] of the plant has to be tuned to allow transfer among chromophores but not to allow transfers into [heat]," Engel says. "How that tuning works and how it is controlled, we don't know." Inside every spring leaf is a system capable of performing a speedy and efficient quantum computation, and therein lies the key to much of the energy on Earth.