**How plants use quantum physics to boost photosynthesis**

**Katia Moskvitch, LiveScience** June 27, 2013 at 9:45 PM ET

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This molecular diagram shows how "antenna proteins" capture photons from the sun. Researchers say the proteins use a quantum transport mechanism to guide the photons and store the energy in their reaction centers.

Humans can't teleport or reside in multiple places at once — but the tiniest particles of matter can.

These [**eerie quantum effects**](http://www.livescience.com/24579-spooky-quantum-entanglement-record.html) have traditionally been studied and observed only under the strictly controlled conditions of a physics lab. That is, until some scientists suggested that such weirdness also exists in wet and soggy biological systems.

In recent years, this hypothesis has gained more and more support: A research paper published in the June 21 issue of the journal Science suggests that plants may rely on such physics to survive. [[**The 9 Biggest Unsolved Mysteries in Physics**](http://www.livescience.com/34052-unsolved-mysteries-physics.html)]

**The most efficient path**Plants are able to harvest as much as 95 percent of the sunlight they soak up, instantly converting this solar energy into chemical energy, in 1 millionth of a billionth of a second, in a process called [**photosynthesis**](http://www.livescience.com/6030-surprising-sea-slug-plant-animal.html).

The new Science study on purple bacteria, which also photosynthesize, gives more support to the idea that plants use quantum mechanics to achieve this near-perfect efficiency. A trick of [**quantum physics**](http://www.livescience.com/28808-spooky-quantum-entanglement-loophole-closed.html) called coherence, the researchers suggest, helps the energy of the elementary particles of light, called photons, find the most efficient path to a plant's (or purple bacterium's) so-called reaction center, where the light's energy fuels the reaction that produces carbohydrates.

On a physical system, coherence could be illustrated with a pair of pendulums that continuously transfer energy from one to the other, backward and forward, in a coherent, cyclic mode.

When a photon excites molecules inside a cell, the energy does not hop through the system, but follows different energy pathways at once, simultaneously searching for the most efficient way into the reaction center where the chemical reaction actually takes place.

This is known as the [**quantum principle of superposition**](http://www.livescience.com/27719-quantum-measurement-macro-decoherence.html), or being in many different places at the same time.

**Quantum effects in nature**Coherence has been suspected and experimented with in living systems before, when researchers fired extremely short but intense laser pulses at multiple molecules of a photosynthetic organism — a purple bacterium called Rhodopseudomonas acidophila that applies the exact same principles of light harvesting to survive as plants do — and tracked the flow of energy through its system**.**[[**Twisted Physics: 7 Mind-Blowing Findings**](http://www.livescience.com/12910-twisted-physics-top-findings.html)]

The latest research, led by Niek van Hulst of the Institute of Photonic Sciences in Castelldefels, Spain, went a step further.

"Previous studies have done experiments where they had millions of molecules in the same volume that they were measuring," a co-author of the new study, Richard Cogdell of the University of Glasgow, told LiveScience.

"The quantum effects could be seen, but they were rather weak. And we never knew whether it was because they are weak or because each of the individual molecules was slightly out of phase with each other so they interfered in a way that you did not see the coherences of quantum behavior."

For the new tests, the scientists used [**purple bacteria**](http://www.livescience.com/1398-early-earth-purple-study-suggests.html) once again, but this time shot laser flashes at a single molecule instead of using many molecules at once.

**Rings of power**The light-harvesting complexes of the bacteria are arranged in a pattern of adjacent rings, or molecules that make up one light-harvesting complex. In the organism, the rings pack together, but the researchers isolated individual rings, and put them outside the bacterium, on a surface. When a photon comes into contact with an isolated ring, some of it gets emitted as fluorescence, which is essentially the spontaneous transfer of energy from a high-energy level to a lower-energy level.

The researchers noticed that the amount of fluorescence didn't stay constant: It kept rising and falling, "oscillating between the high state and a low state, which is this coherent oscillation," said Cogdell.

That oscillation suggests the laser light was able to find the most efficient energy pathway to the reaction center almost instantaneously — despite the highly variable conditions of a biological system.

"These sorts of coherences have been seen in physical systems before, but only at very low temperature and very well-defined controlled conditions," Cogdell said. "The surprise is that you can see these effects in wet, messy biological systems at room temperature. That's the remarkable finding, that you can find it in biology."

Greg Engel*,* a chemistry professor at the University of Chicago, who was not involved in the study, told LiveScience that the most exciting element of the research was "pulling back the curtain" and learning how photosynthetic energy transfer really works. "The authors point us toward new design principles for controlling the flow of energy through molecular systems," Engel said.

Once it is clear what factors affect the frequency of the coherence and whether it is possible to vary it, the findings could lead to boosting the efficiency of the light-harvesting process, said Cogdell.

And that achievement could pave the way to much more efficient photovoltaic cells to generate electricity, with the help of [**artificial photosynthesis**](http://www.livescience.com/34399-researchers-develop-artificial-photosynthesis-system.html), mimicking the extra-efficient process possibly happening in every single, tender green leaf.