Vibrations improve photosynthesis in spinach

Photosynthesis may be the most important chemical process on Earth, but little is known about it. For the first time, vibrations have been shown to play a crucial role in the reactions essential for life.

Vibrations enhance the efficiency of photosynthesis in spinach, based on new research. This finding could also apply to other plant species as well.

Photosynthesis may be the chemical process most responsible for the rise of animal life on Earth. Plants, as well as some varieties of bacteria, convert carbon dioxide and water into food and oxygen, with the application of sunlight. Still, biologists are still uncertain about several aspects of photosynthesis, including how it can be so efficient.
University of Michigan researchers used short pulses of light to study what happens on a molecular level during photosynthesis. They found that molecular vibrations in cells help strip electrons off atoms in the initial stages of photosynthesis, in a process called charge separation. This research could be used to design more efficient solar cells and storage systems for electrical energy.

"Both biological and artificial photosynthetic systems take absorbed light and convert it to charge separation. In the case of natural photosynthesis, that charge separation leads to biochemical energy. In artificial systems, we want to take that charge separation and use it to generate electricity or some other useable energy source such as biofuels," Jennifer Ogilvie, associate professor of physics and biophysics at the University of Michigan, said.

Charge separation occurs over an incredibly short period of time - just around one-three-billionths of a second. The team developed a laser system that could operate at this rate, taking images of the process of photosynthesis.

Plants contain organelles called chloroplasts where photosynthesis takes place. Ogilvie and her team removed these tiny structures from plants. These organelles contain photosystem 2, a collection of pigments and proteins that accomplishes many of the reactions essential to the process. This enzyme is the only one known in nature capable of converting water into oxygen and hydrogen.

Ogilvie and her team took spinach, purchased from a grocery store, and placed the leaves into a blender. Protein complexes were carefully removed from the vegetative matter, so they were not damaged during extraction.

The laser system was then used to excite various parts of the structures, and the electrical pathways were charted. "Echoes" from the vibrations caused by charge separation lingered in the photosynthetic structures. These resonated with the gaps in energy levels in molecules, guiding the process.

"We can carefully track what's happening. We can look at where the energy is transferring and when the charge separation has occurred," Ogilvie told reporters.

Investigation of how vibrations in plants help to enhance photosynthesis is published in the journal *Nature Chemistry*. 