Researchers figure out how to outperform nature's photosynthesis

December 20 2011, by Nancy Owano

(PhysOrg.com) -- The *Proceedings of the National Academy of Sciences* (*PNAS*) last week published a paper titled "Solar hydrogen-producing bionanodevice outperforms natural photosynthesis." The authors are Carolyn E. Lubner, Amanda M. Applegate, Philipp Knörzerb, Alexander Ganagoc, Donald A. Bryantc, Thomas Happe and John H. Golbeck. They modified the photosynthetic proteins found in cyanobacteria -- bacteria which gain their energy through photosynthesis.

Says io9: “They frankensteined together proteins from Synechococcus sp. with those from Clostridium acetobutylicum using molecular wire to create a 'hybrid biological/organic nanoconstruct' that was more efficient than either on their own.”

These researchers have created a tiny solar-powered device that works twice as fast as nature to produce hydrogen biofuel. In describing their research they say that although solar biohydrogen systems using photosystem I (PSI) have been developed, few attain the electron transfer throughput of oxygenic photosynthesis.

They say they optimized a nanoconstruct that tethers FB, the terminal [4Fe-4S] cluster of PSI from Synechococcus sp. PCC 7002, to the distal [4Fe-4S] cluster of the [FeFe]-hydrogenase (H2ase) from Clostridium acetobutylicum.

“On illumination, the PSI-[FeFe]-H2ase nanoconstruct evolves H2 at a rate of 2,200 ± 460 μmol mg chlorophyll-1 h-1, which is equivalent to

105 ± 22 e-PSI-1 s-1. Cyanobacteria evolve O2 at a rate of approximately 400 μmol mg chlorophyll-1 h-1, which is equivalent to 47 e-PSI-1 s-1, given a PSI to photosystem II ratio of 1.8.

"The greater than twofold electron throughput by this hybrid biological/organic nanoconstruct over in vivo oxygenic photosynthesis validates the concept of tethering proteins through their redox cofactors to overcome diffusion-based rate limitations on electron transfer."

The researchers are among scientists in general who are looking at photosynthesis to invent materials and design new processes that can help save our planet. Associate Professor John Stride, of the University of New South Wales, commented to the ABC that "nature has had millennia to solve problems, and photosynthesis is very efficient."

In turning to biomimicry, scientists are designing devices based on photosynthesis. As for the study authors, in making their biofuel device they replaced the FNR enzyme with hydrogenase.

One of the co-authors, Penn State Professor Donald Bryant, said there are good prospects for using some of these biological photosynthesis systems to produce biofuels for the future.

More information: Solar hydrogen-producing bionanodevice outperforms natural photosynthesis, *PNAS*, Published online before print December 12, 2011, doi: 10.1073/pnas.1114660108

Abstract
Although a number of solar biohydrogen systems employing photosystem I (PSI) have been developed, few attain the electron transfer throughput of oxygenic photosynthesis. We have optimized a biological/organic nanoconstruct that directly tethers FB, the terminal [4Fe-4S] cluster of PSI from Synechococcus sp. PCC 7002, to the distal

[4Fe-4S] cluster of the [FeFe]-hydrogenase (H2ase) from Clostridium acetobutylicum. On illumination, the PSI–[FeFe]-H2ase nanoconstruct evolves H2 at a rate of 2,200 ± 460 μmol mg chlorophyll-1 h-1, which is equivalent to 105 ± 22 e-PSI-1 s-1. Cyanobacteria evolve O2 at a rate of approximately 400 μmol mg chlorophyll-1 h-1, which is equivalent to 47 e-PSI-1 s-1, given a PSI to photosystem II ratio of 1.8. The greater than twofold electron throughput by this hybrid biological/organic nanoconstruct over in vivo oxygenic photosynthesis validates the concept of tethering proteins through their redox cofactors to overcome diffusion-based rate limitations on electron transfer.