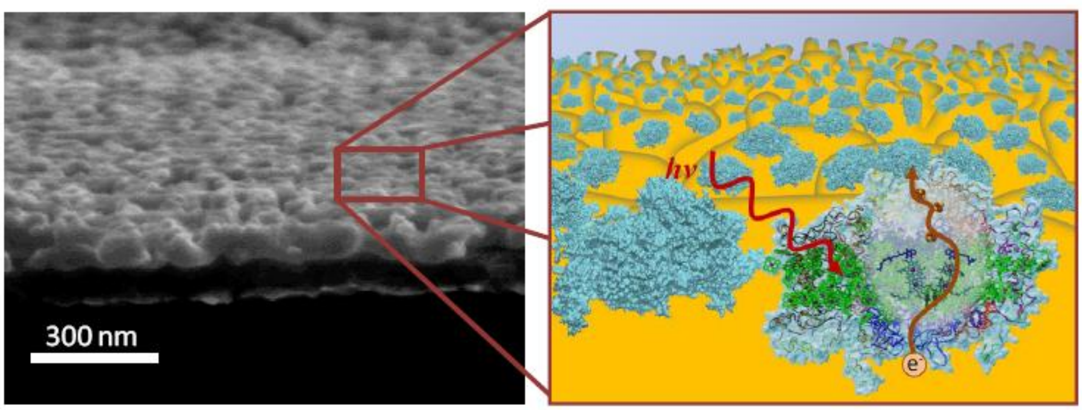
Biomimetic Solar Cells

Photosystem I (PSI) is a 10 nm photoactive, electrochemically active protein complex that drives photosynthesis in plants such as spinach leaves. Nature has optimized PSI to have incredible solar conversion efficiency and capabilities compared to traditional semiconductors. Drs. Kane Jennings and David Cliffel of Vanderbilt University have harnessed the power of this complex to generate electricity by directly wiring PSI to electrodes. Upon exposure to light, a PSI monolayer functions as an array of photodiodes, creating current that is stored as a part of electrochemical battery. Initially, the photocurrent from PSI was limited by the electrode area for charge injection. Just as a plant leaf creates multiple PSI monolayers to boost the interfacial area and improve photoconversion, they have chemically adsorbed PSI within a 100-nm thick nanoporous gold electrode that is robustly bound to an underlying substrate. The beauty of this approach is that the nanoporous electrode is sufficiently thin for light permeation and only costs 6 cents per cm^2 of geometric area. Complete incorporation of PSI is achieved when the pores are enlarged and surface area is reduced to a target level. The bound PSI within the nanoporous electrode provides 8-fold greater currents than a single layer of PSI at flat electrodes at a modest light intensity of 80 W/m^2. Today, they are achieving photocurrents from PSI-loaded photoelectrochemical cells that exceed 2 $\mu A/cm^2$, representing a dramatic thousand-fold improvement over the past three years. Our newest photocells demonstrate light to photocurrent conversion over many months. This work lays the foundation for further advances in the design and assembly of biomimetic solar cells and the wiring of Nature's optimized molecular machines at materials interfaces.



Scanning electron micrograph of a ~100 nm thick nanoporous gold electrode (left) and the schematic representation of Photosystem I complexes adsorbed within this structure (right).

P. N. Ciesielski, A. Scott, C. J. Faulkner, B. J. Berron, D. E. Cliffel, and G. K. Jennings, "Functionalized Nanoporous Gold Leaf Films for the Immobilization of Photosystem I," *ACS Nano,* 2, 2465–2472, **2008**.

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New Scientist, http://www.newscientist.com/article/dn16132-cyborg-leaf-makes-working-solar-power-plant.html

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