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Artificial Photosynthesis – from Light Absorption to Solar Fuels

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Summary

Photosynthesis is natural nanotechnology that is responsible for almost all of the energy used by humans. In artificial photosynthesis, the basic scientific principles underlying photosynthetic solar energy conversion are used to design synthetic systems for solar energy harvesting. Artificial photosynthetic reaction centers consist of chromophores linked to electron donors and acceptors. They use light excitation energy to carry out photoinduced electron transfer, producing long-lived, energetic charge separated states in high yield. In natural photosynthesis, most of the sunlight is absorbed by antenna chromophores that transfer excitation energy to reaction centers. Artificial antenna systems can also be prepared and linked to reaction centers to make artificial antenna-reaction center complexes. In addition to harvesting sunlight both natural and artificial antenna systems may also incorporate a photoprotective regulatory function.

Artificial reaction centers may be incorporated into electrochemical cells designed to produce either electricity or fuels. Both will be necessary to meet large-scale human energy needs. Fuel production requires not only potential energy from sunlight, but also a source of electrons. Water oxidation is the most promising large-scale source of these electrons, and also produces protons that may be reduced to hydrogen fuel. Artificial photosynthetic systems that produce electricity or hydrogen have been demonstrated, but much more research is needed before artificial photosynthesis becomes a practical solution to society's energy problems.