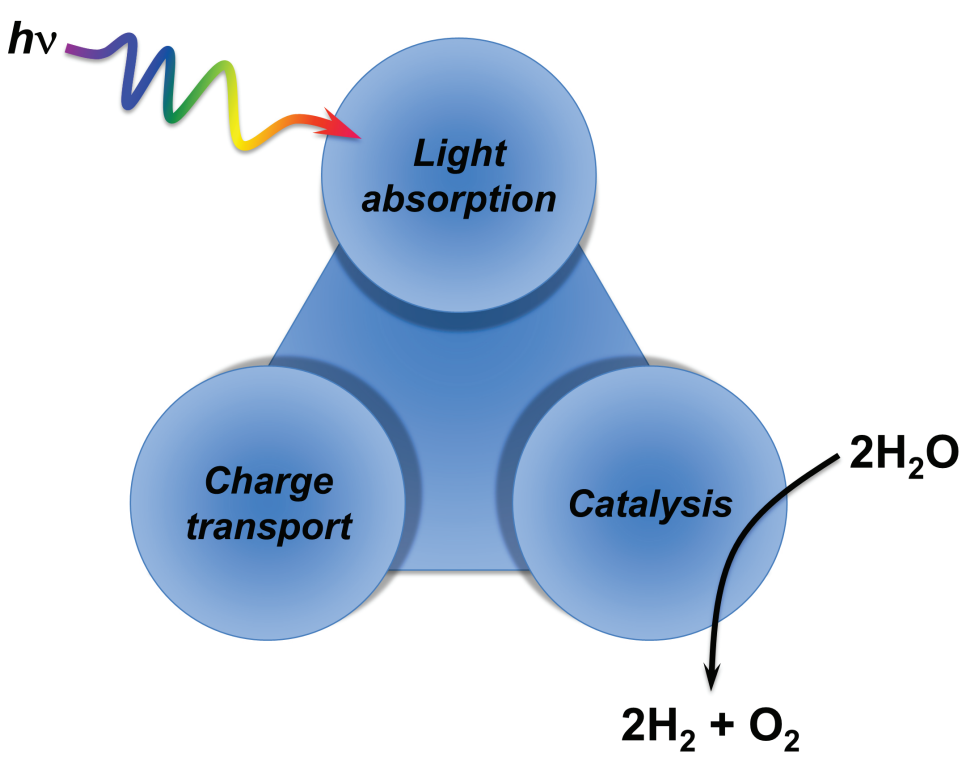
Harry B. Gray

Solar-Driven Water Splitting

Molecular hydrogen has emerged as an attractive candidate for a clean, renewable fuel to meet the world's skyrocketing demand for energy. Hydrogenase enzymes that contain iron and nickel cofactors evolve H_2 catalytically from water with very high turnover frequencies. However, the relative instability of these enzymes under aerobic conditions has led to the search for robust inorganic catalysts for production of hydrogen from water. We are working on heterogeneous inorganic catalysts made from earth-abundant elements that could be part of scalable solar fuel devices. We have found that materials such as Ni–Mo nanopowders and metal phosphide nanocrystals have catalytic efficiencies near that of platinum for reduction of protons in aqueous solutions. A major challenge now is to find scalable materials that can be employed as active catalysts in integrated photoanodes for production of oxygen from water, as required for the generation of protons and electrons for combination at photocathodes. We have found that mixed-metal nanosheet hydroxides made by pulsed laser plasma synthesis in water are very active water oxidation catalysts. We are working on the structures and mechanisms of these nanosheet materials to aid in the design and construction of more efficient and robust integrated photoanodes for water splitting.



Harry Gray is the Arnold O. Beckman Professor of Chemistry and the Founding Director of the Beckman Institute at the California Institute of Technology. After graduate work in inorganic chemistry at Northwestern University and postdoctoral research at the University of Copenhagen, he joined the chemistry faculty at Columbia University, where in the early 1960s he developed ligand field theory to interpret the electronic structures and reactions of transition metal complexes. After moving to Caltech in 1966, he began work in biological inorganic chemistry and inorganic photochemistry. During investigations of metalloprotein redox reactions in the 1980s, he and coworkers demonstrated that electrons can tunnel rapidly over long molecular distances through folded polypeptide structures. This discovery opened the way for experimental and theoretical work that shed new light on the mechanisms of electron flow through proteins that function in respiration and photosynthesis. Gray has published over 900 research papers and 18 books. He has received the National Medal of Science (1986); the Linderstrøm-Lang Prize from Denmark (1992); the Gibbs Medal (1992); the Basolo Medal (1994); the Harvey Prize (2000); the National Academy of Sciences Award in Chemical Sciences (2003); the Wolf Prize from Israel (2004); the Welch Award in Chemistry (2009); six national awards from the American Chemical Society, including the Priestley Medal (1991); and 20 honorary doctorates. He is a member of the National Academy of Sciences and a foreign member of the Royal Society of Great Britain. He served on the Council of the National Academy of Sciences (1986-1989) and on the Governing Board of the National Research Council (1986-1989). He is Principal Investigator of the NSF CCI Solar Fuels Program.

Wednesday, November 1, 2017 | 3:00 p.m.

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