

PHOTOBIOENERGETICS

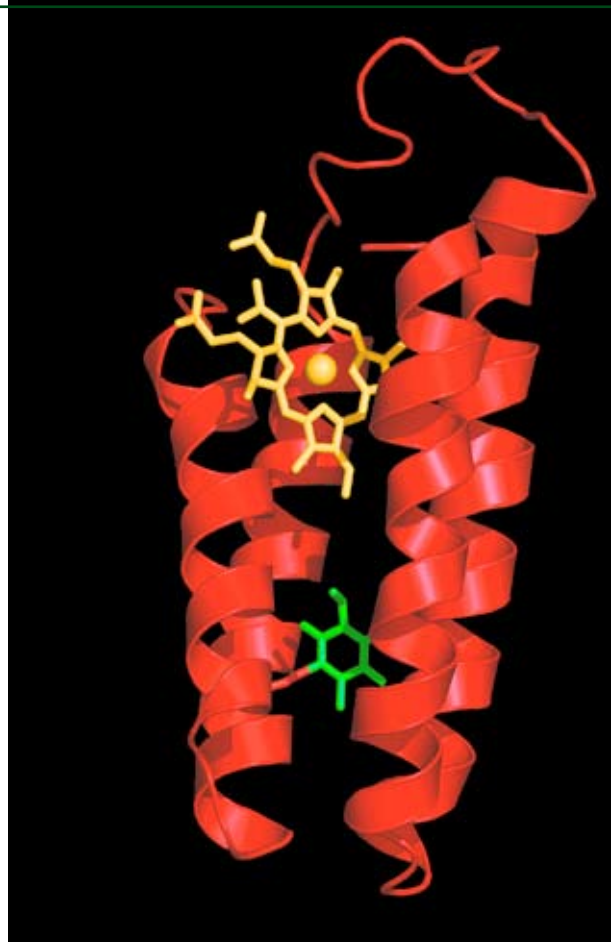
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The research in the Photobioenergetics Group focuses on the light reactions of photosynthesis, whereby solar energy is captured by Photosystem II and Photosystem I and converted into chemical energy. In this research we use and develop a broad range of novel techniques in biophysical chemistry, biochemistry and cell physiology.

Our primary interest is in the first part of photosynthesis - the capture and conversion of light energy by Photosystem II that leads to oxidation of water. In evolution, this process has been the main biological energy input to the living world and the only one responsible for generating all the oxygen in the atmosphere.

We also study photoinactivation - the light-induced inhibition of Photosystem II; photoprotection - how plants protect themselves in excess light; and the structure/function relationships of the photosynthetic apparatus with particular reference to order/disorder.

Our main goal is to contribute to the understanding of the basic principles in the photosynthetic process, so that they can be applied to optimise both natural and artificial photosynthesis. Specific goals include the engineering of synthetic proteins modelled on Photosystem II and designed to convert light energy into useful chemical or electrical energy, and of algae that can produce hydrogen gas continuously using light.



Molecular model of an artificial reaction centre based on cytochrome b562, showing an engineered protein that binds a quinone (green) and a zinc(II) chlorin binding site (yellow).

HIGHLIGHTS

- The book 'Photosystem II: The Light-Driven Water:Plastoquinone Oxidoreductase' was published by Springer. Edited by TJ Wydrzynski and K Satoh, and co-authored by 75 leading international scientists, this book represents the first comprehensive text solely dedicated to the water-splitting enzyme in photosynthesis.
- Recent studies suggested that bicarbonate may serve as a substrate for photosynthetic O₂ production. Our mass spectrometric measurements on the extremophile, *Arthrospira maxima*, revealed that a small but finite amount of bicarbonate can be oxidized in place of water, with implications for the evolution of oxygenic photosynthesis 2,500 million years ago.
- The binding of the amino acids Alanine-344 and Aspartate-170 in the D1 protein of Photosystem II was studied. We found that during the four step water oxidation reaction, Alanine-344 is bound to a manganese ion that is oxidised on the second flash while, counter to expectation, Aspartate-170 appears to be bound to a manganese that is not oxidised on any of the four steps.
- Last year we reported on construction of an 'artificial photosynthetic reaction centre'. This year, detailed calculations have successfully explained the performance of the artificial reaction centre, as judged by the quantum yield of charge separation, and the lifetime of light-induced charge separation.
- A method of partitioning the incoming light energy between a mixed population of active and light-inactivated Photosystem II was developed. There are four energy fluxes; two are associated with heat dissipation in each active Photosystem II, and together act as a simple predictor of the susceptibility of Photosystem II to light-inactivation.
- Photosynthetic membranes are organised into stacks, inter-connected by non-stacked membranes. This orderly structure is generated by the physical forces of attraction and repulsion. We showed experimentally that this generation of local order is also assisted by an increase of disorder elsewhere.