

# PHOTOBIOENERGETICS

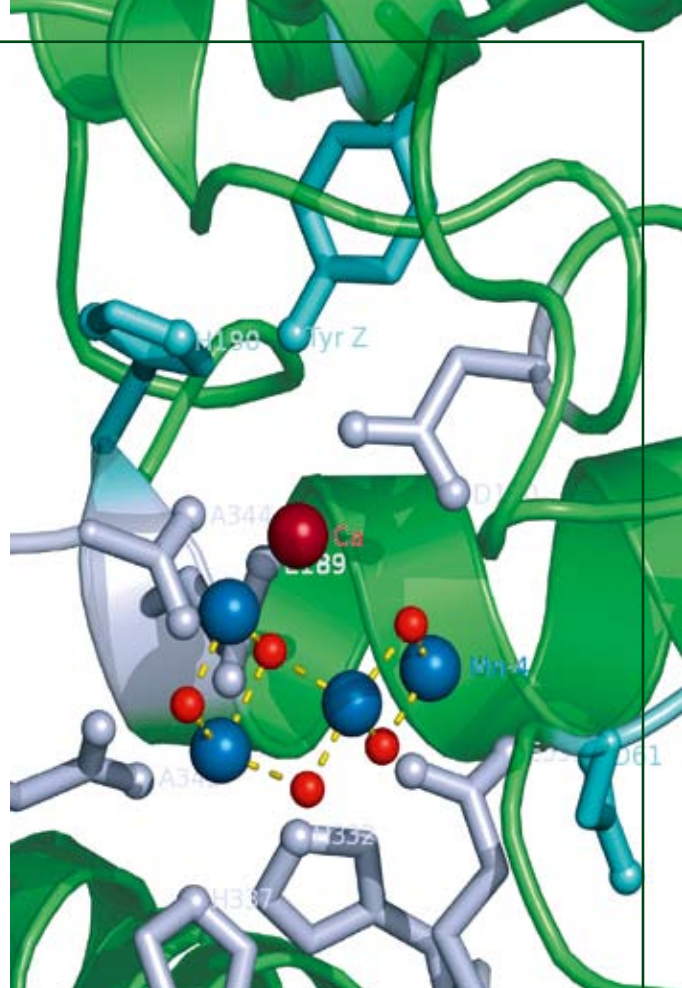
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The research in the Photobioenergetics Group focuses on the light reactions of photosynthesis, whereby solar energy is captured by Photosystem II and Photosystem I and converted into chemical energy. In this research we use and develop a broad range 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 atmospheric oxygen.

We also study the light-induced inhibition of Photosystem II, 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 photosynthesis and bio-inspired artificial systems. 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 oils as biofuels using light.



A protein ribbon model of the catalytic site for water oxidation in Photosystem II, showing the manganese (blue balls)/calcium (violet ball) cluster with bridging oxygens (red balls) and amino acid ligands.

## HIGHLIGHTS

- We have extended the development of an artificial photosynthetic reaction centre with a new construct that contains not only a photoactive pigment and quinone acceptor but also a redox-active metal center, which we characterized at the Max Planck Institute for Bioinorganic Chemistry, Germany.
- Using highly sensitive mass spectrometry to determine the rate constants for the (de)hydration reactions of bicarbonate and CO<sub>2</sub>, we showed that, contrary to expectations, the water-splitting function in photosynthesis does not involve carbonic anhydrase activity. Using chimeric, recombinant fusion proteins, we found that the water-splitting activity is controlled by protein-protein interactions that influence the 'flexibility' of the manganese stabilizing protein in Photosystem II.
- Using vibrational spectroscopy we found that the residues aspartate 170, glutamate 189 and aspartate 342 in the D1 protein of Photosystem II do not ligate to a redox-active manganese ion at the catalytic site. These results greatly narrow the identity of the redox-active manganese ion involved in the water-splitting reaction.
- This year we acquired the latest, state-of-the-art Bruker Vertex 80V infrared interferometer that is used for vibrational spectroscopy. This is the first instrument of its kind to be delivered in the southern hemisphere.
- We showed that photoinactivated Photosystem II complexes and the remaining active complexes play a mutually beneficial role in each other's survival. Photoinactivated complexes help to protect the active complexes during high-light stress, while active complexes, in addition to contributing to their own protection, are crucial for the recovery of photoinactivated counterparts.
- We have evaluated the major energy inputs and the major factors affecting the efficiency of H<sub>2</sub> generation and collection for an industrial photobiological hydrogen plant; the hydrogen plant could be viable in energy terms if an algal H<sub>2</sub> generation efficiency of 5% is achieved.