Prospectus
Institute for Protein Research
Osaka University

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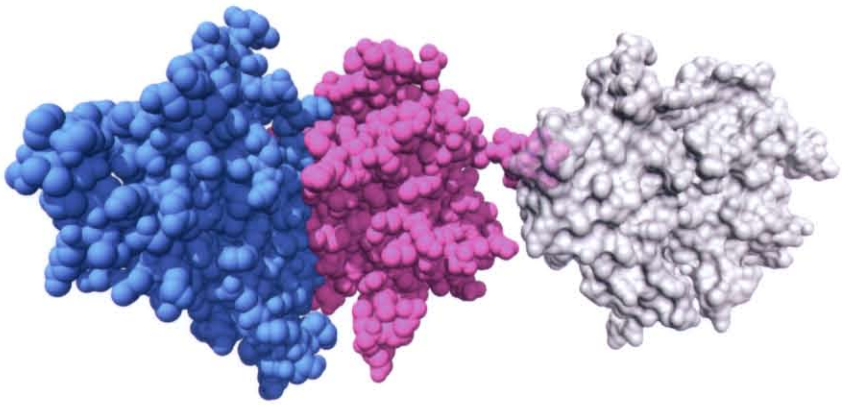

INSTITUTE for PROTEIN RESEARCH

Laboratory of Foreign PI

Visiting Professor *Matthias RÖGNER*
Visiting Professor *Thomas HAPPE*
(Lehrstuhl für Biochemie der Pflanzen, Fakultät für Biologie & Biotechnologie, Ruhr-Universitäet Bochum)
Correspondence E-mail: matthias.roegner@rub.de & thomas.happe@rub.de

Prof. RÖGNER

Prof. HAPPE

Research in the laboratory of Matthias Rögner focuses on the structure, function, regulation and biogenesis of energy transducing membrane proteins from cyanobacteria. Selected topics are dynamics and adaptations of bioenergetic processes in the thylakoid membrane in response to environmental signals both on the level of individual proteins and their (transient) interaction partners and on the level of membrane composition (including lipids and domain structures).

The Happe group analyzes the anaerobic metabolism of the green alga *Chlamydomonas reinhardtii* in all its aspects and was able to characterize various cellular and biochemical processes essential for photobiological H_2 production. They also study structure-function relationships of Fe-Fe hydrogenases including a detailed characterization of the active center cofactor (H-cluster) and the catalytic turnover process. A novel in vitro maturation assay was recently established leading to semi-artificial hydrogenase with high catalytic activity.

Both groups cooperate in the creation of a cyanobacterial design cell which combines the mechanism of photosynthetic water-splitting with hydrogen production *via* imported hydrogenase at the expense of CO_2-fixation. Prerequsite is the re-routing of photosynthetic electrons by modifying protein-protein interactions and establishing of a eukaryotic maturation system for (engineered) hydrogenase in a prokaryotic cell. Especially for the optimization of our structure-function design strategy including modifications of a semisynthetic cofactor and also for the structure determination of new transient docking proteins we would like to continue our fruitful cooperation with scientists of the IPR (Osaka University).

【Current Research Programs】

1) Primary reactions & dynamic modification/repair mechanisms of water-splitting Photosystem 2 in cyanobacteria (Ref. 1).
2) Structural dynamics of cyanobacterial thermophilic NDH-1 complexes (Ref. 2) & Cyt. b_6f-complex.
3) Strategies for designing H_2-producing cyanobacterial model cells (Ref. 3).
4) Photobiological hydrogen production in green algae, cell metabolism and signaling under anaerobiosis.(Ref. 4).
5) Structure-function relationships of natural and semiartifical Fe-Fe hydrogenases, ferredoxins and maturases (Ref. 5+6).

【References】

1. Nowaczyk, M.M., Hebeler, R., Schlodder, E., Meyer, H.E., Warscheid, B. & Rögner, M. (2006) Psb27, a cyanobacterial lipoprotein, is involved in the repair cycle of Photosystem 2 *Plant Cell* **18**, 3121-3131.
2. Nowaczyk MM, Wulfhorst H, Ryan CM, Souda P, Zhang H, Cramer WA, Whitelegge JP (2011) NdhP and NdhQ: two novel small subunits of the cyanobacterial NDH-1 complex. Biochemistry 50:1121-1125

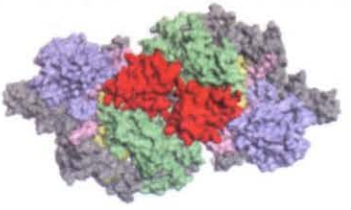

Fig. 1. Localization of the Psb27 subunits at the donor side of dimeric PS2 (lumen side). Structure of Psb27 as obtained by NMR spectroscopy was modeled onto the 3D structure of PS2 (Ferreira et al. 2004)

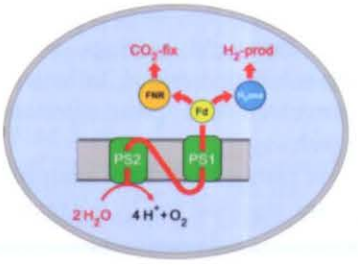

Fig. 2. Cyanobacterial design cell for hydrogen production from water. Key elements are the water-splitting complex PS2 as source of electrons and the distribution of electrons at the acceptor side of PS1 between CO_2-fixation and H_2-production, guided by affinity design of Fd vs. FNR and hydrogenase, respectively.

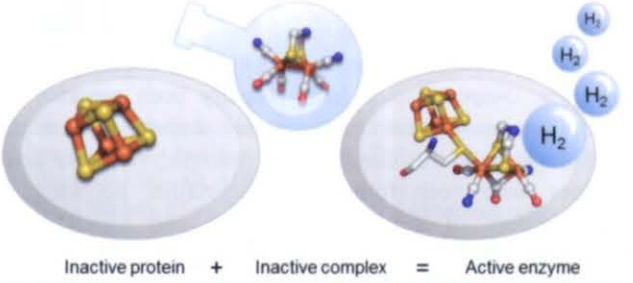

Fig.3. In vitro maturation of semiartifical [FeFe]-hydrogenase starting from inactive protein with [4Fe4S]-cluster and inactive synthetic [2Fe2S]-cluster and yielding highly active enzyme.

3. Rögner, M. (2013) Metabolic engineering of cyanobacteria for the production of hydrogen from water; *Biochemical Society Transactions* 41, 1254-1259
4. Hemschemeier A., Düner M., Casero D., Merchant S.S., Winkler M. and Happe T. (2013) Hypoxic survival requires a 2-on-2 hemoglobin in a process involving nitric oxide. Proc. Natl. Acad. Sci. USA. 110: 10854-10859
5. Berggren G., Adamska A., Lambertz C., Simmons T. R., Esselborn J., Atta M., Gambarelli S., Mouesca J.-M., Reijerse E., Lubitz W., Happe T., Artero V. & Fontecave M. (2013) Biomimetic assembly and activation of [FeFe]-hydrogenases. *Nature* **499**, 66–69.
6. Esselborn J., Lambertz C., Adamska A., Simmons T., Berggren G., Noth J., Siebel J., Hemschemeier A., Artero V., Reijerse E., Fontecave M., Lubitz W. & Happe T. (2013) Spontaneous activation of [FeFe]-hydrogenases by an inorganic [2Fe] active site mimic. *Nature Chem Bio* **9**, 607-609.