unicat

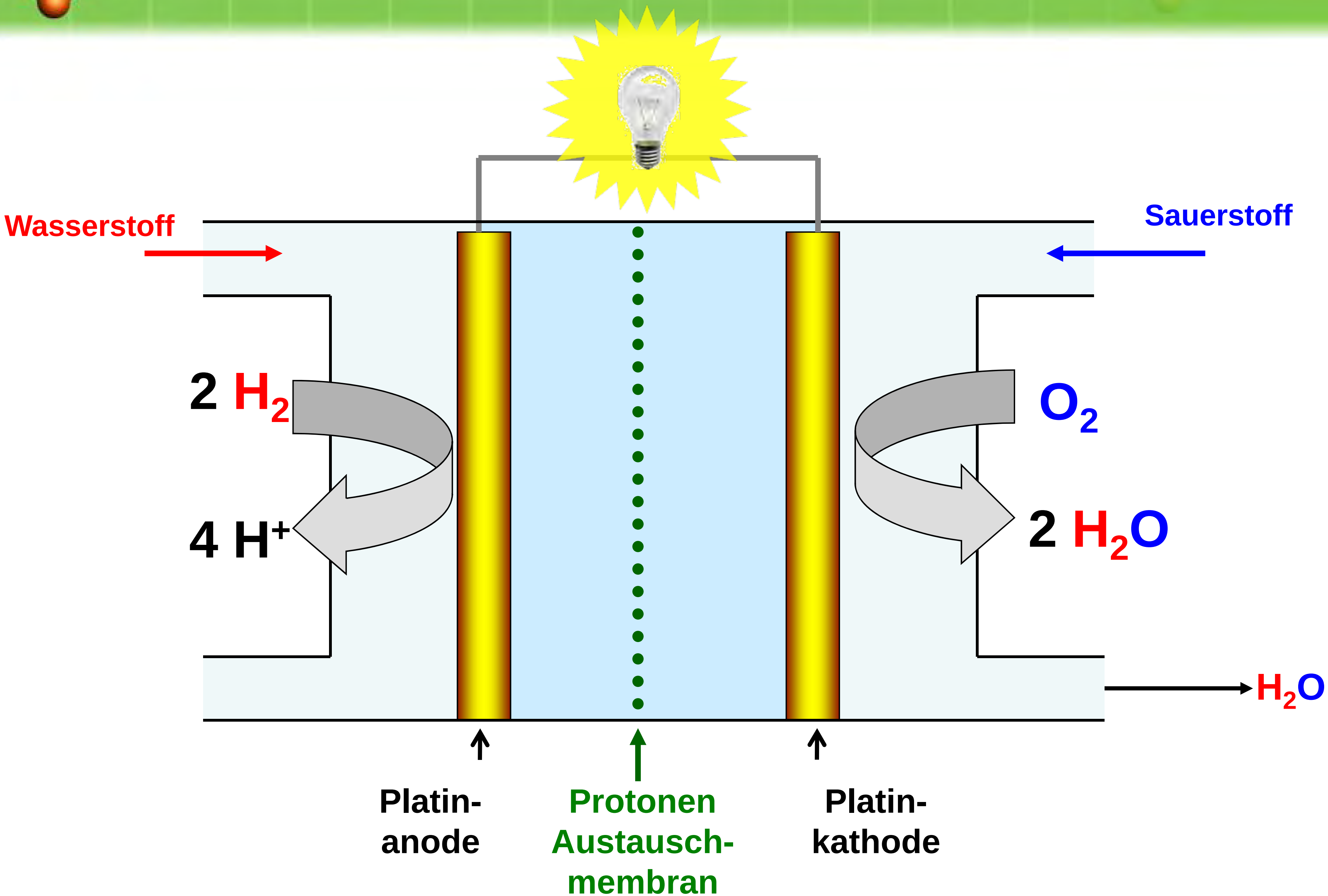
Wasserstoff aus Bakterien und Algen: Eine Perspektive für die Zukunft?

Oliver Lenz

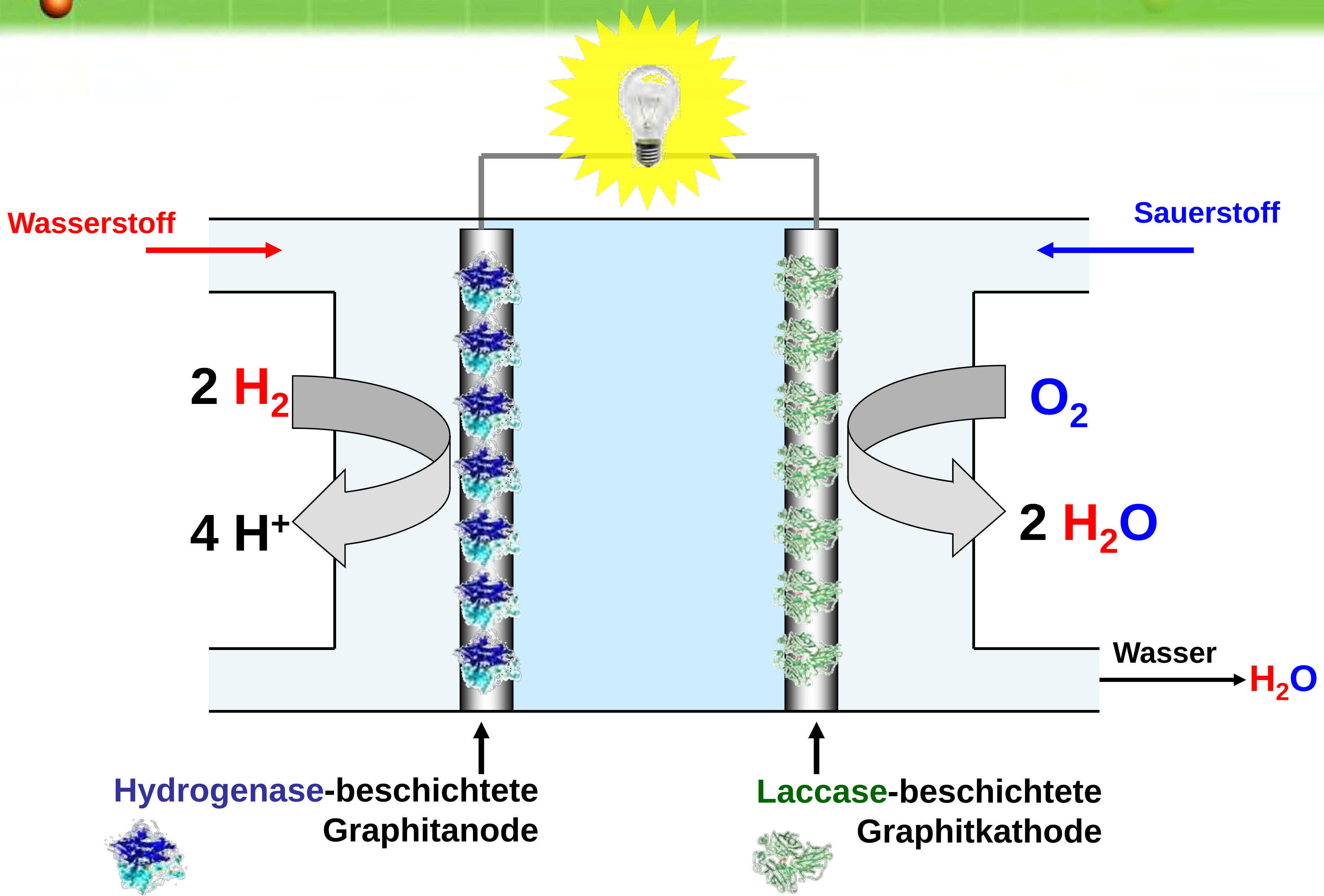
Humboldt-Universität zu Berlin

Mittwoch, 27. Oktober 2010

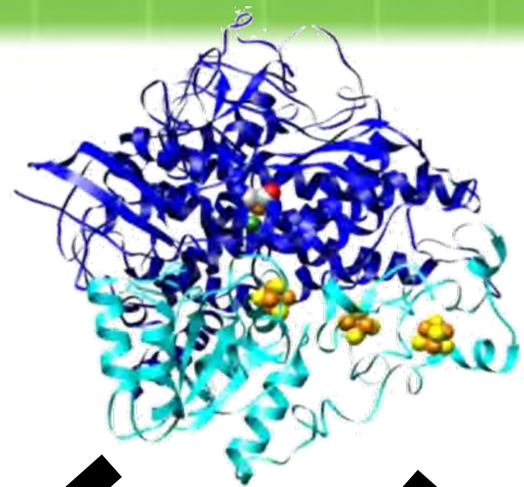
Funktion einer konventionellen PEM-Brennstoffzelle

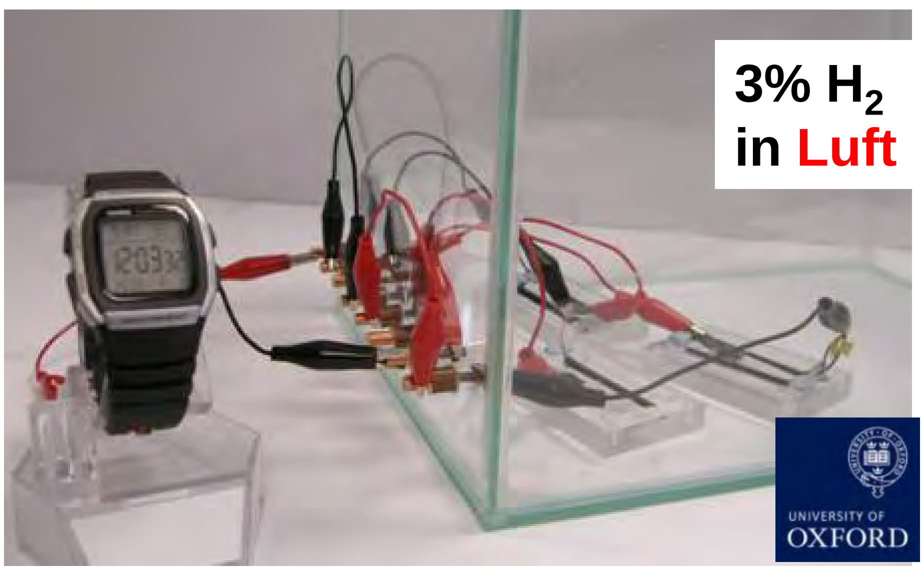


Enzymatische Brennstoffzelle



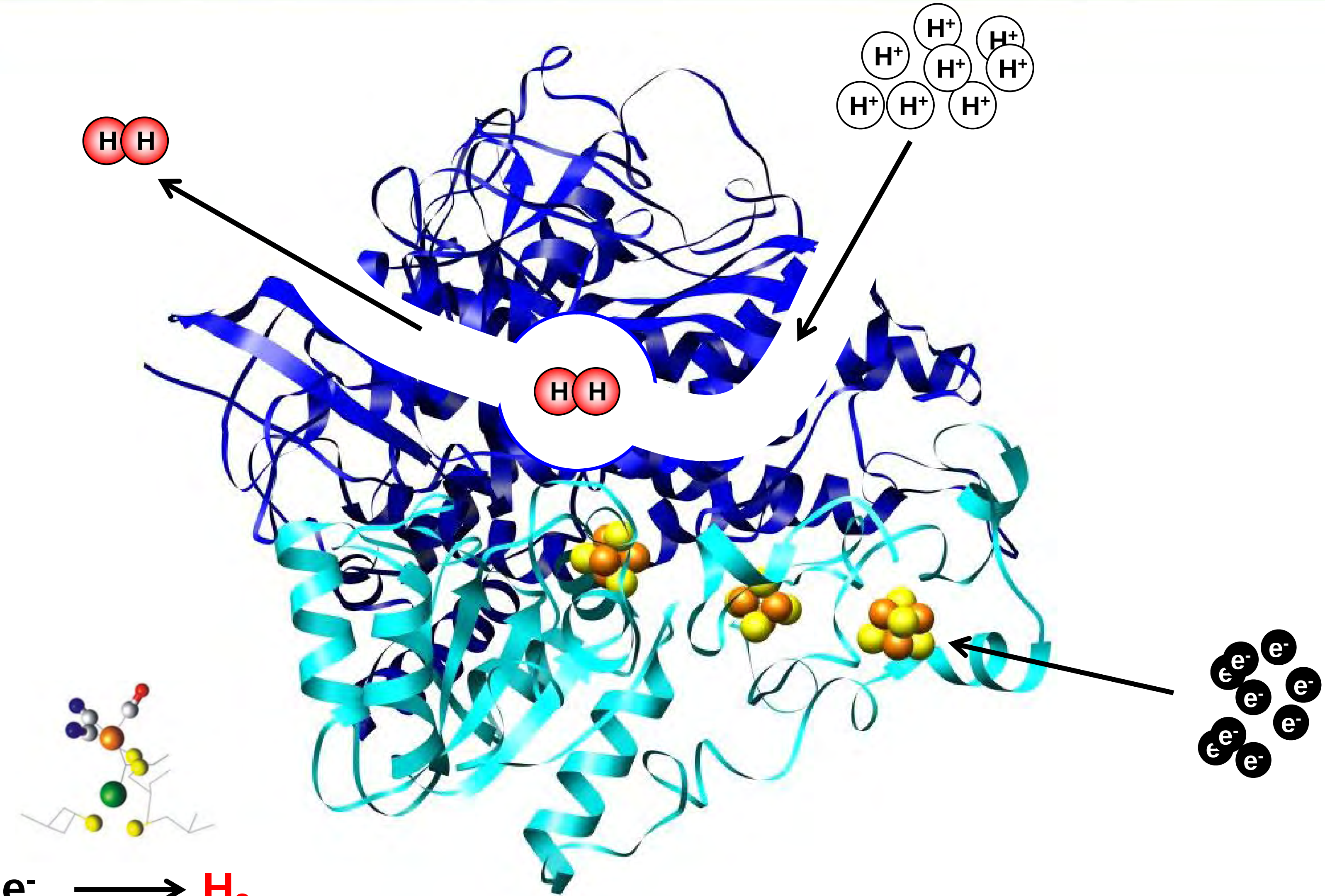
Enzymatische Brennstoffzelle





Vincent *et al.* (2005) PNAS 102:16951-4
Vincent *et al.* (2006) Chem. Commun. (Camb). 48:5033-5.

Wasserstoffproduktion durch Hydrogenase



$2\ H^+ + 2\ e^- \longrightarrow H_2$

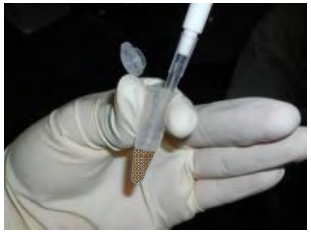
Umsatzrate bis zu 10000 s^{-1}

Reinigung + Strukturanalyse eines H_2-Biokatalysators

Bakterienkultur

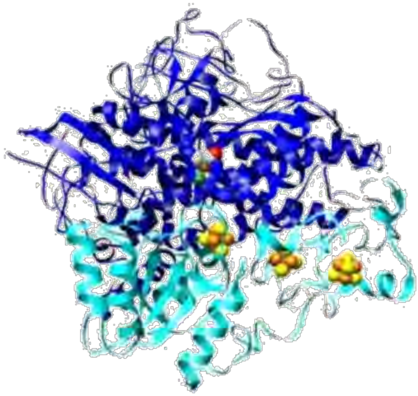
Säulenchromatographie

Reines Enzym in Lösung



Protein-kristalle

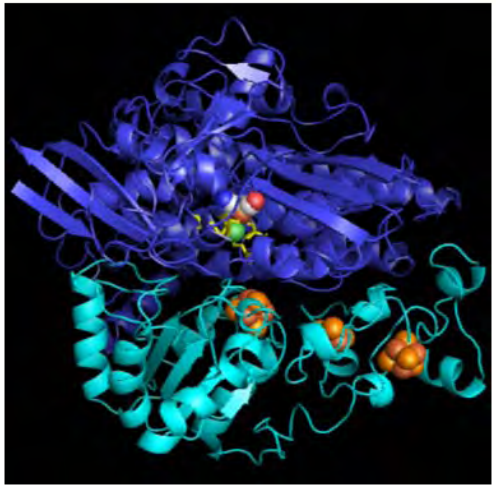
X Ray



Proteinstruktur

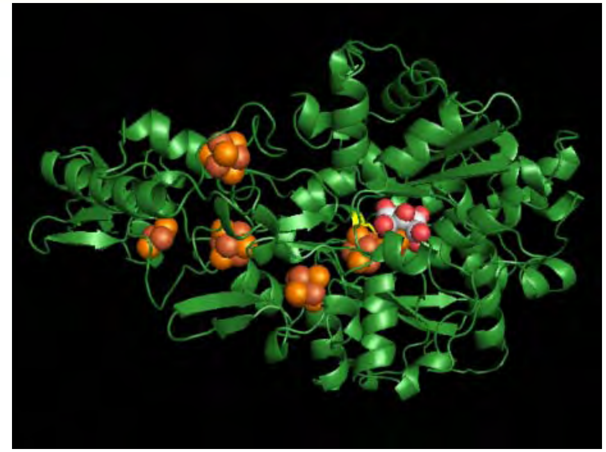
H_2-Biokatalysatoren

[NiFe]-Hydrogenase



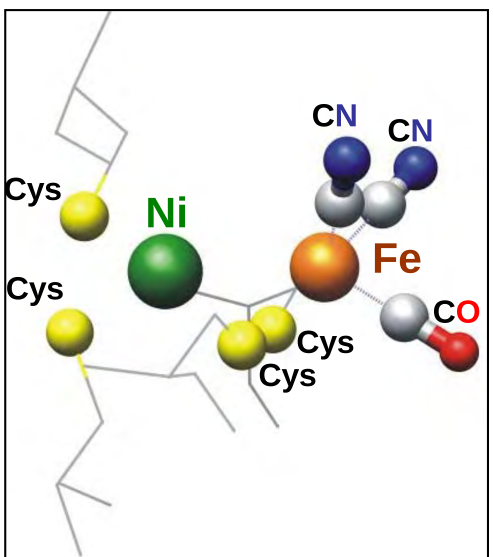
Volbeda *et al.* 1995 Nature 373:580-587

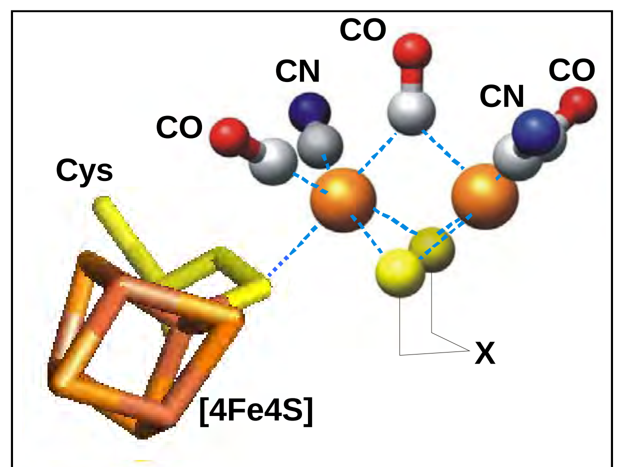
[FeFe]-Hydrogenase



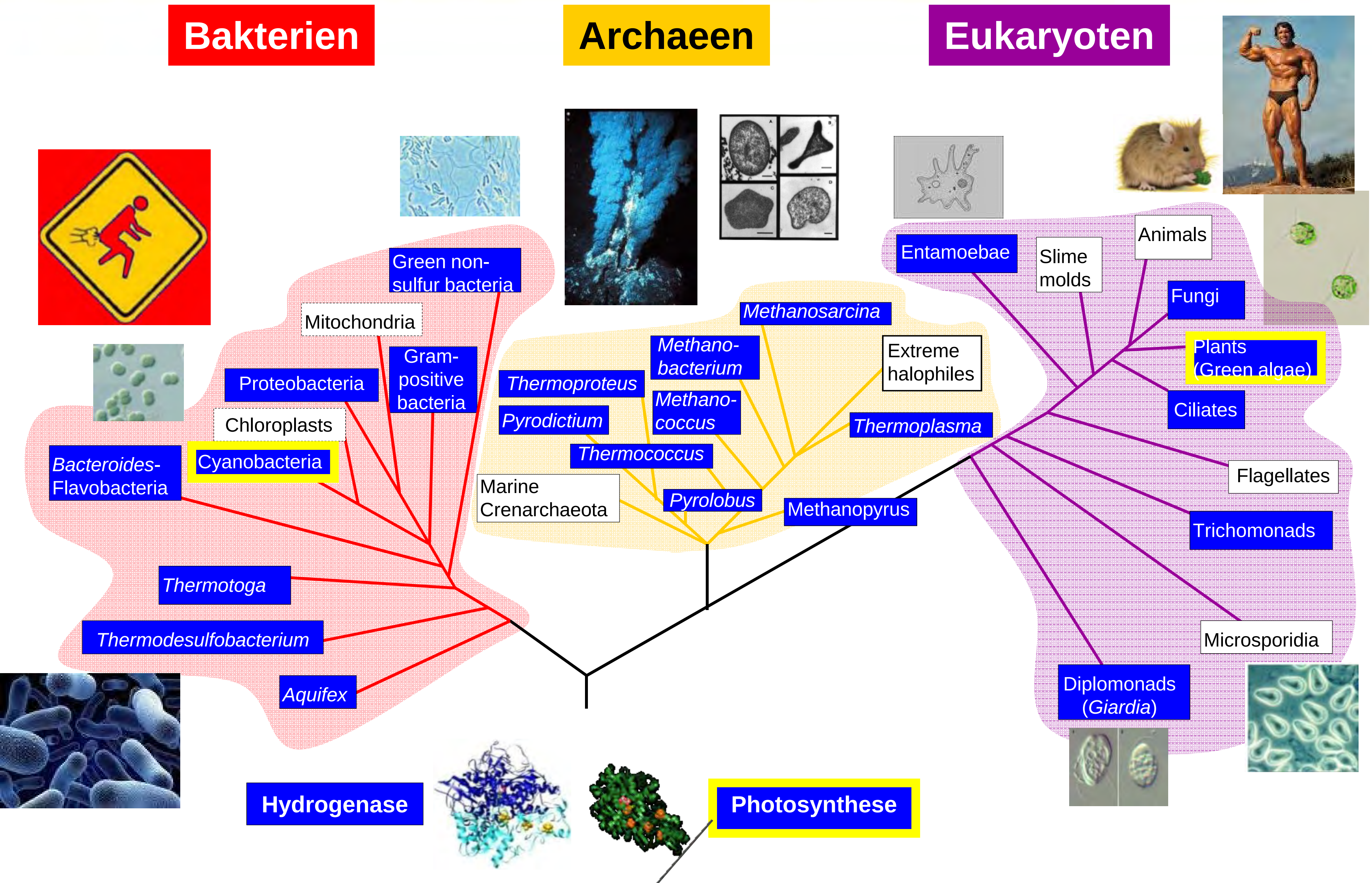
Peters et al. 1998 Science 282:1853-1858

$$H_2 \rightleftharpoons 2\,e^- + 2\,H^+$$

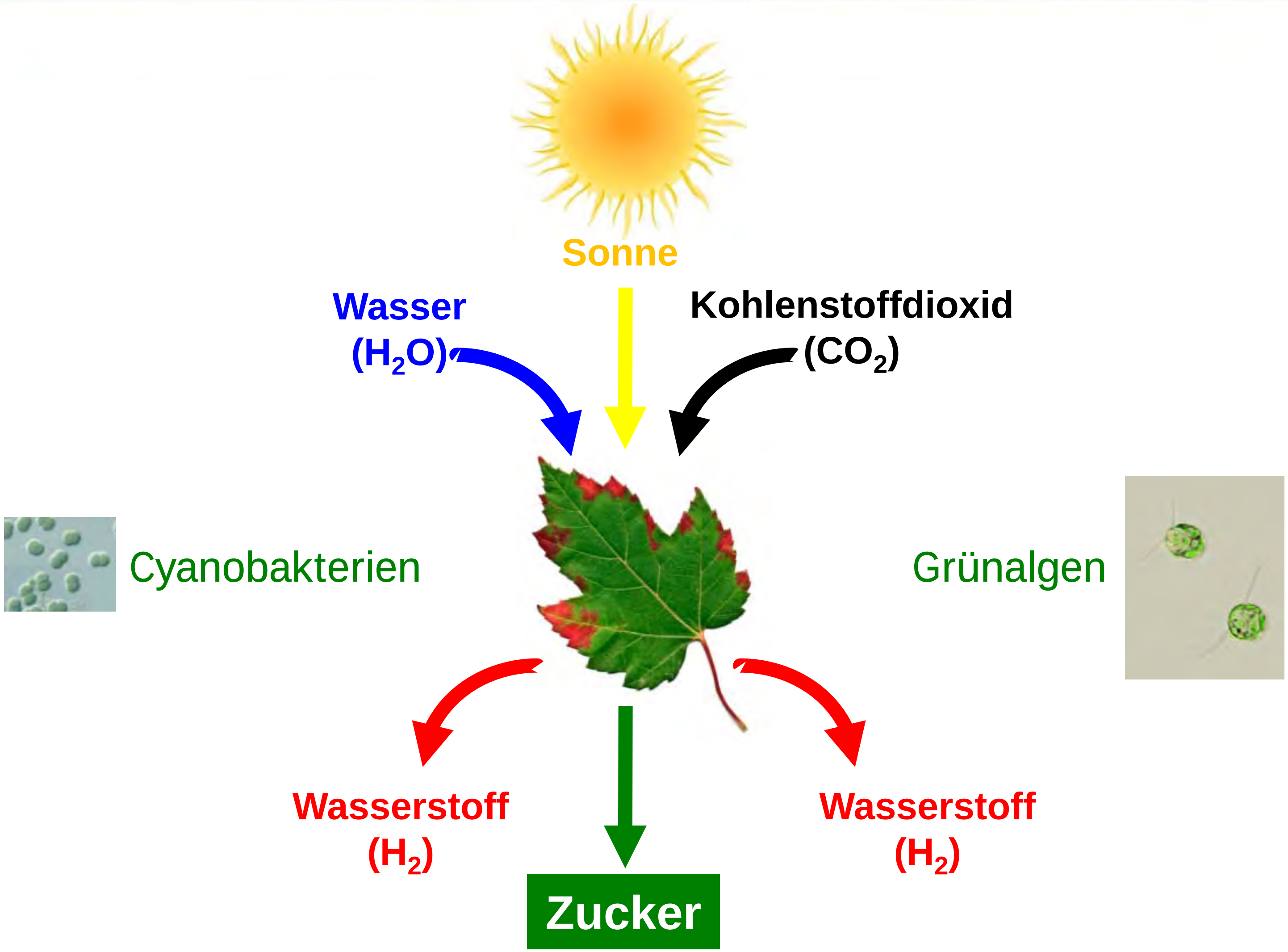




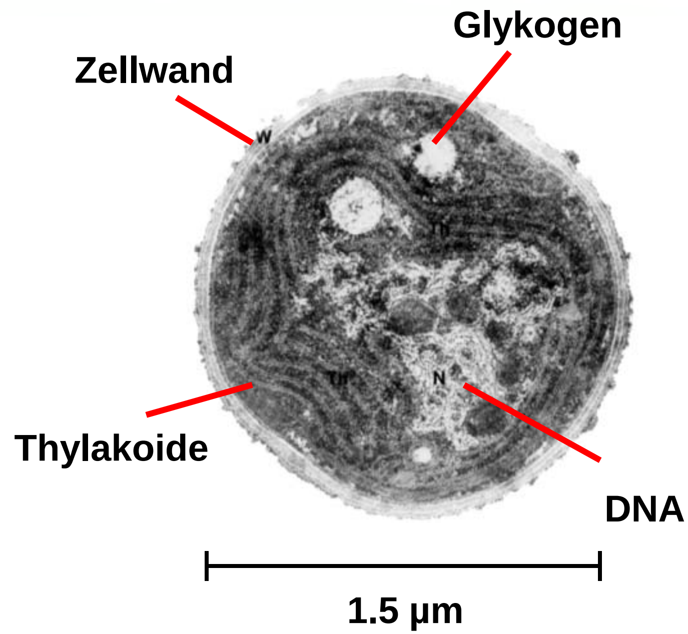
Verbreitung von Hydrogenasen



Photosynthese

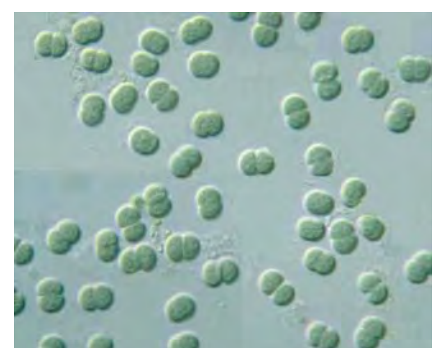


Cyanobakterien (Blaualgen)

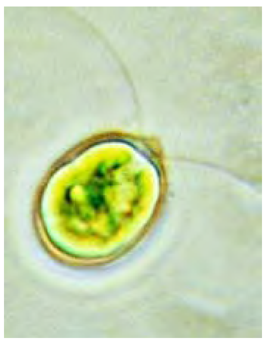


http://www.pm.ruhr-uni-bochum.de/pm2009/msg00351.htm

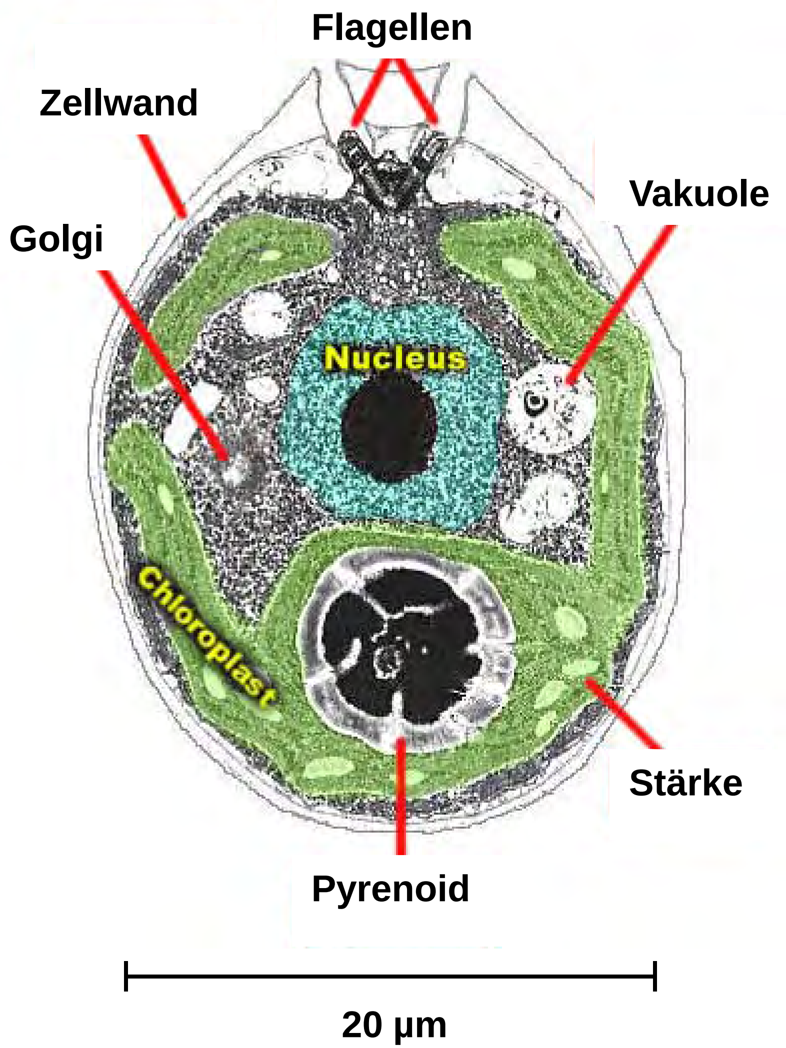
***Synechocystis* spec.**

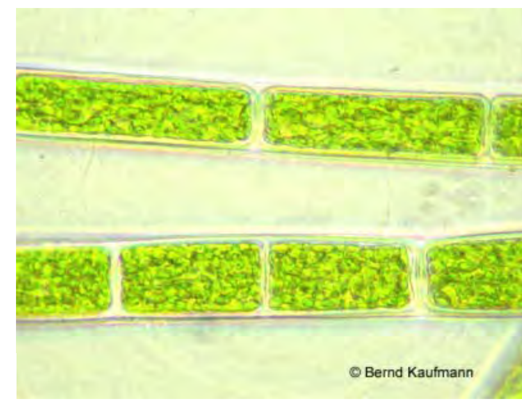


Grünalgen



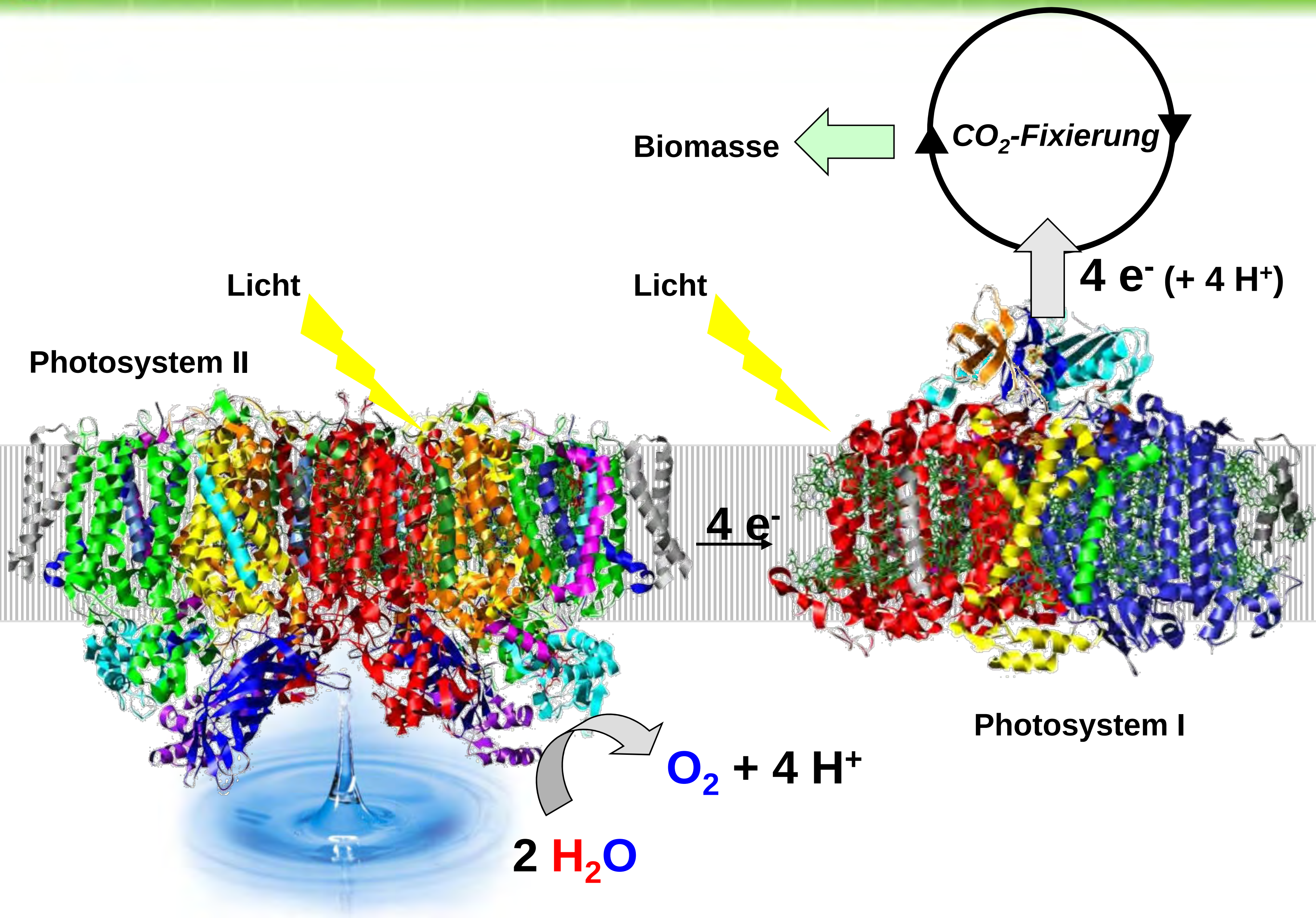
Chlamydomanas reinhardtii



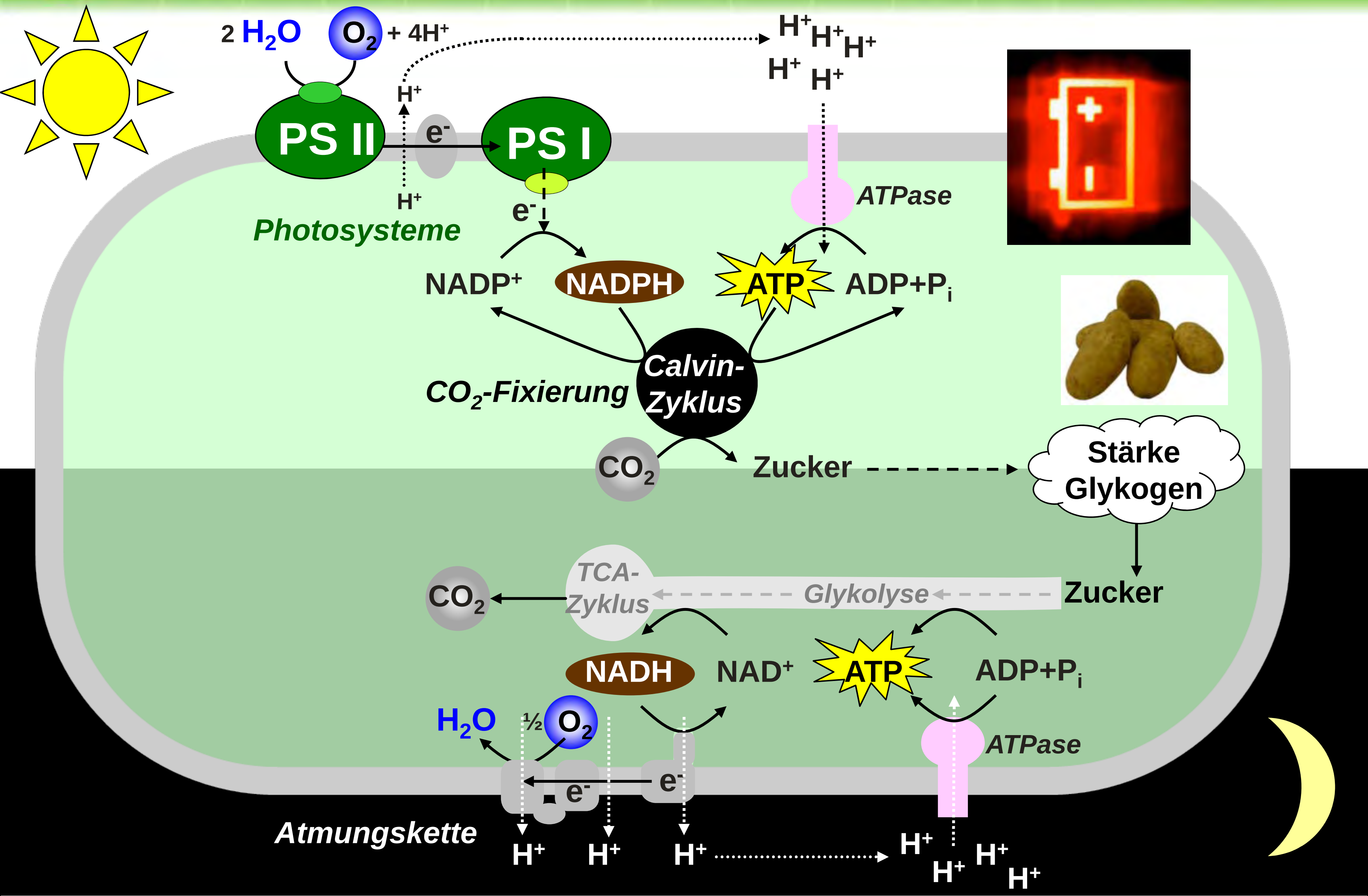


http://www.botany.hawaii.edu/faculty/webb/bot311/chlorophyta/chlorophyta-100.htm

Photosynthese

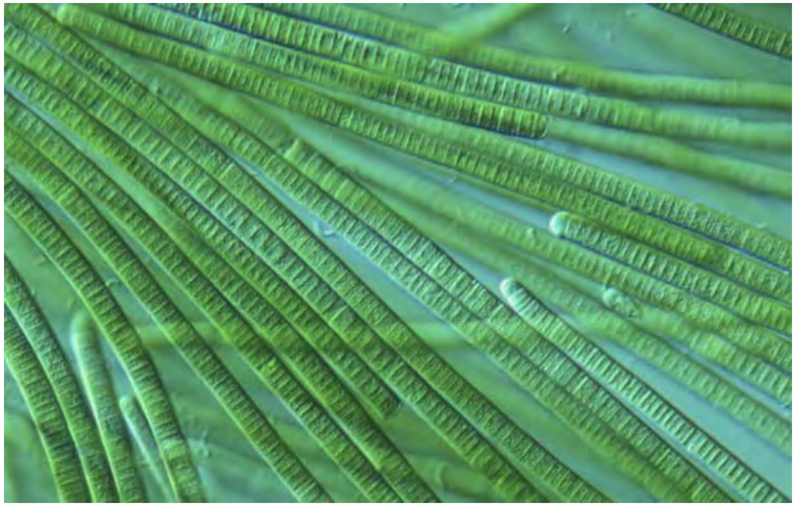


Photosynthese im Licht und Atmung im Dunkeln

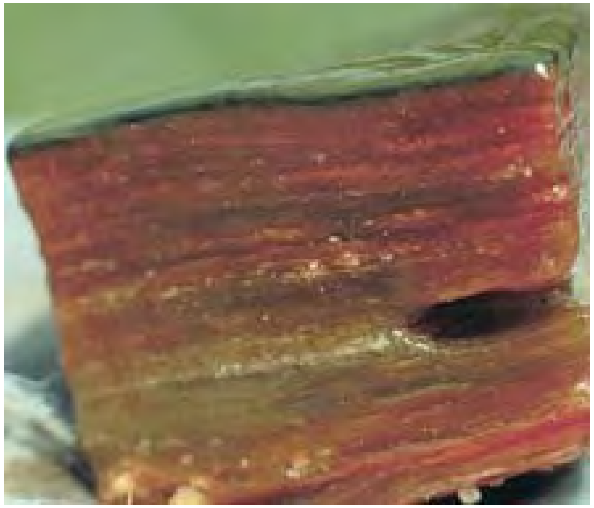


Algenmatten

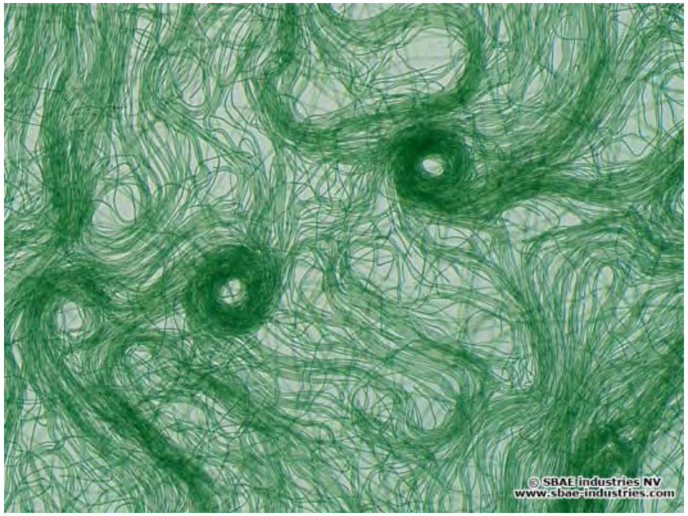
http://academic.emporia.edu/aberjame/wetland/n_plains/n_plains.htm



http://www.dkimages.com/discover/Home/Plants/Fungi-Monera-Protista/Cyanobacteria/Cyanobacteria-2.html

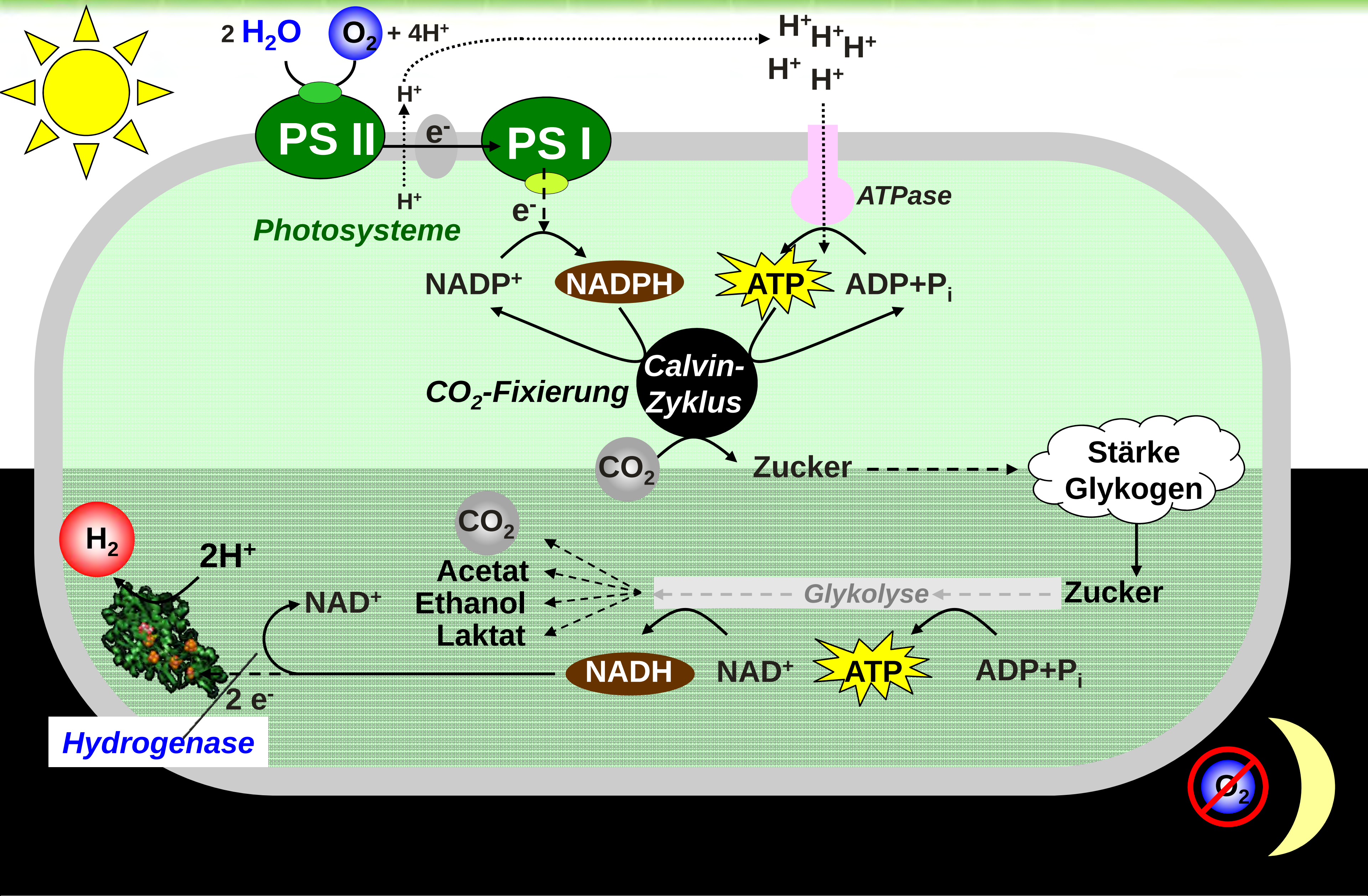


http://www.rps.psu.edu/indepth/graphics/hotsprings2.jpg

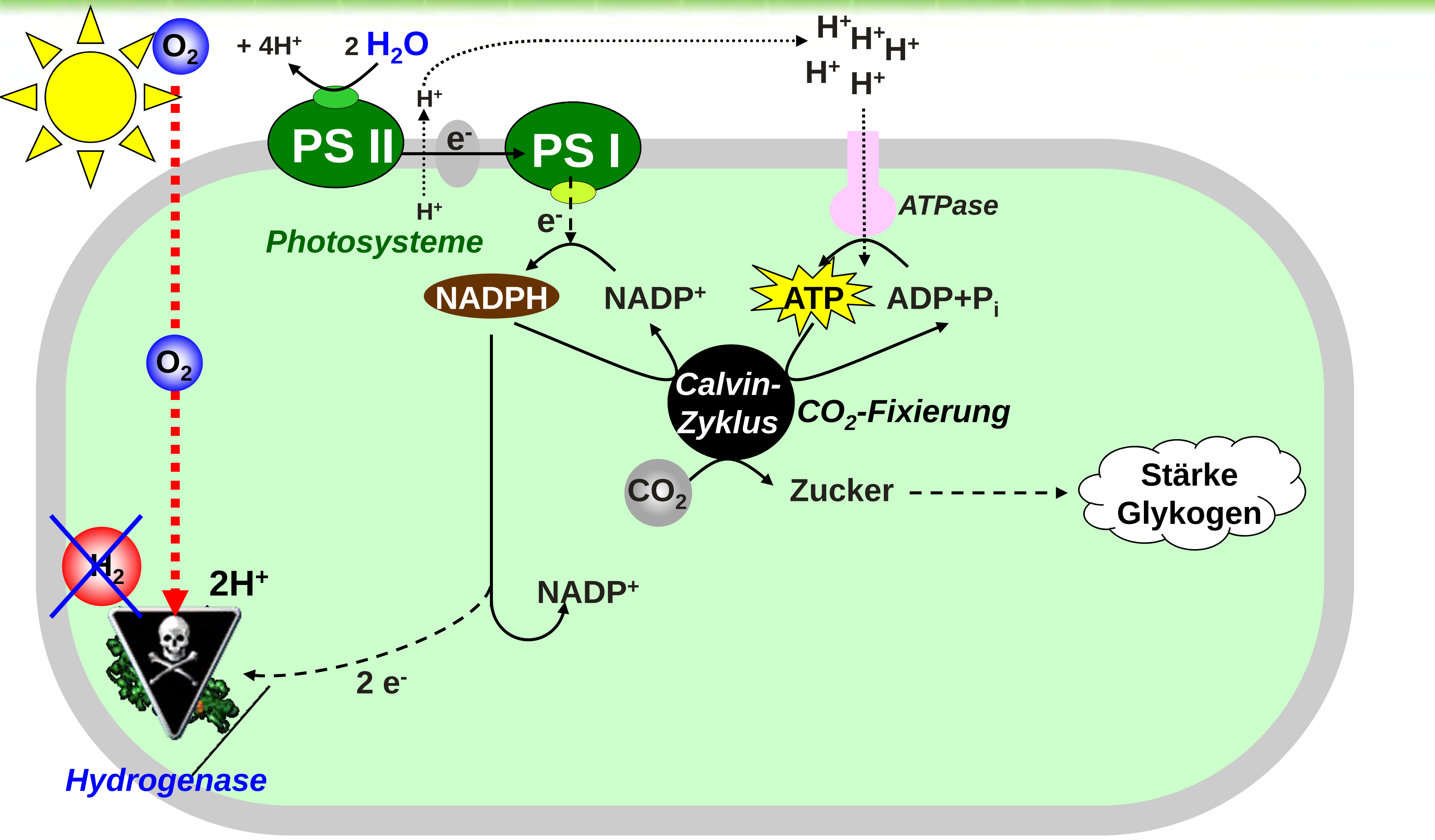


http://www.sbae-industries.com/Technology/library.html

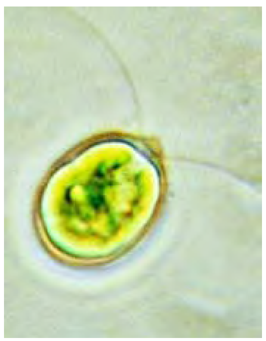
Gärung unter Sauerstoffausschluss

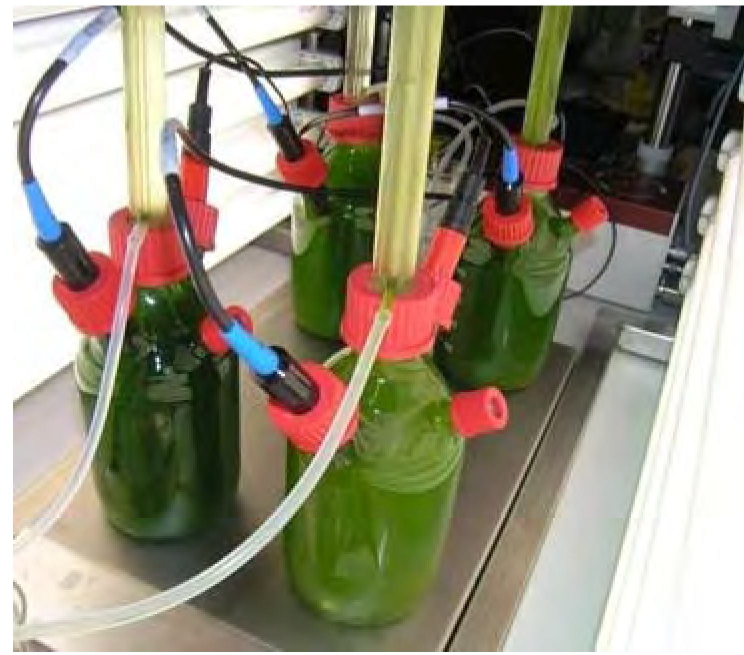


H_2-Produktion während der Photosynthese?



C. reinhardtii: Der Rekordhalter





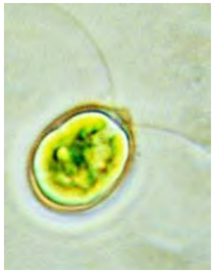
ttp://www.robaid.com/wp-content/gallery/tech1/biosolar-hydrogen-production-with-chlamydomonas-reinhardtii.jpg

Ca. 500 mL H_2/L Zellkultur in 3–4 Tagen <u>unter Schwefellimitation</u>
(Rate: bis zu 8 mL H_2 L^{-1} h^{-1})

Kruse & Hankamer Curr. Opin. Biotechnol. 2010 21:238-43.
Melis & Happe Plant Physiol. 2001 127:740-8.

Solarer Biowasserstoff aus Wasser

Algen

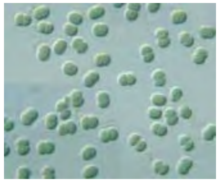


„Indirekter“ H_2 über Speichermaterial, 2 zeitlich separierte Schritte

$$2\,H_2O + CO_2 \xrightarrow{\text{PSII + PSI}} [CH_2O] + O_2 + H_2O$$

$$2\,H_2O + [CH_2O] \xrightarrow{\text{S-Limitation (kein } O_2\text{)+ PSI}} 2\,H_2 + CO_2 + H_2O$$

Cyanobakterien



„Indirekter“ H_2 über Speichermaterial, 2 zeitlich separierte Schritte

$$2\,H_2O + CO_2 \xrightarrow{\text{PSII + PSI}} [CH_2O] + O_2 + H_2O$$

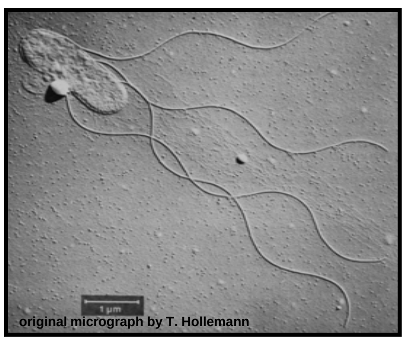
$$[CH_2O] + H_2O \xrightarrow{\text{Gärung (kein } O_2\text{)}} 2\,H_2 + CO_2$$

„Direkter“ H_2, ein Schritt, keine Gasseparierung

$$H_2O \xrightarrow{\text{PSII + PSI}} H_2 + \tfrac{1}{2}\,O_2$$

➡ ***Sauerstofftolerante Hydrogenase***

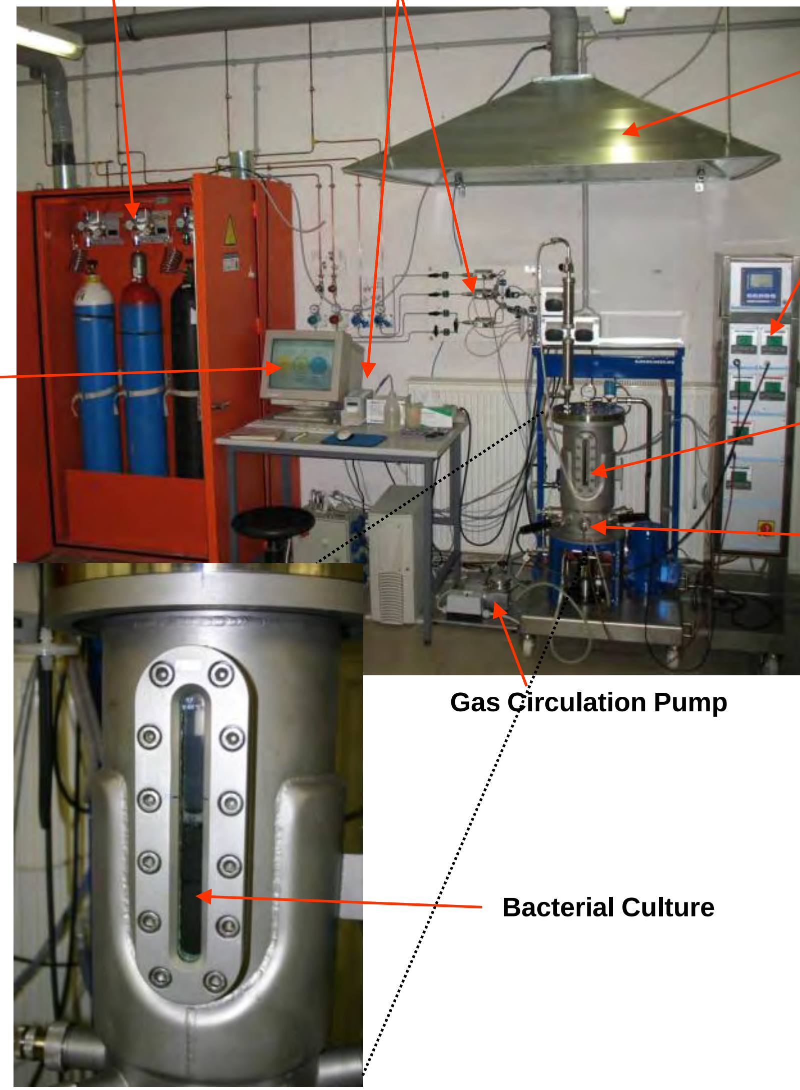
Das Knallgasbakterium *Ralstonia eutropha*



80 % H_2

10 % O_2

10 % CO_2



Gas Supply

Mass Flow Control

Extractor Hood

Measuring Instruments
CO_2
O_2
pH
Temperature
Foam
Stirrer

Fermentation Control and Evaluation

" Knallgas" Fermenter

Probes

Gas Circulation Pump

Bacterial Culture

H_2 als saubere Brennstoffquelle

Knallgasreaktion:

Wasserstoff + Sauerstoff → Wasserstoffoxid / exotherm

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

Opel

Knallgasbakterien


Space Shuttle

Zündtemperatur : 590°C (Diesel: 220°C bis 300°C, Benzin: 220°C bis 450°C)

Heizwert: 33 kWh/kg