Engineering cyanobacterial photosynthesis for biotechnological applications: Design cells and model systems

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In future, photosynthesis will be used as power supply for the generation of new products - simply due to the fact, that free energy is provided by the sun and some phototrophic organisms can grow just with sunlight and (sea) water. Prerequisite is a molecular understanding of photosynthesis and the manipulation of its metabolism for product optimization. We have chosen H_2 production as model system because this product can be directly linked to the water-oxidizing photosynthetic electron transport and is easily released by the cells.

For this purpose cyanobacterial photosynthesis has to be engineered towards increased bioenergy and decreased biomass production (1). Besides the implementation of a highly active, oxygen tolerant hydrogenase from other organisms (such as green algae), the photosynthetic electron transport has to be increased – for instance by antenna size reduction or partial uncoupling of the thylakoid membrane (2). Decisive is further the re-routing of electrons at the Photosystem 1 acceptor site by redox partner design involving Ferredoxin (Fd), Ferredoxin-oxido-reductase (FNR) and Hydrogenase (HydA1), which will be shown in detail.

Alternatively, this strategy can also be challenged and quantified by semiartificial model systems – for instance by measuring photocurrents of isolated key components (both photosystems and hydrogenase) which have been functionally linked and immobilized on gold electrodes ("biobattery") (3). This approach shows that both photosystems have a much higher capacity than under the limitations of a natural cell environment.

Performance of such engineered cells can be optimized by an improved photobioreactor design (4). Continuous flow fermentation techniques allow the systematic optimization of each individual parameter and also performance under constant conditions over several months.

If such systems are optimized both on the individual cell and on the systems level, they could be the blueprint for the generation of other – possibly high value – products with electrons from watersplitting and optimized photosynthetic efficiency.

(1) Rögner (2013) *Biochemical Society Transactions* 41, 1254-1259

(2) Imashimizu et al. (2011) *J. Biol. Chem.* 286, 26595-26602

(3) Kothe et al. (2013) Angew. Chem. Int. Ed. 52, 14233-14236

(4) Kwon et al. (2013) *Algal Research* 2, 188-195