Outline BEST* pilot project:

*** Biology-Inspired Energy Systems**

Employing invertebrate grazers for improved microbial fuel cells

Several Master or Bachelor thesis projects jointly supervised by
Prof. Dr. S. Kerzenmacher (FB4) and Prof. Dr. J. Filser (FB2)

Background and motivation:

Microbial fuel cells (MFCs) are a fascinating technology to directly generate electricity from wastewater. At the heart of these fuel cells electroactive bacteria (e.g. *S. oneidensis*, *G. sulfurreducens*) oxidize organic carbon (Fig. 1). But instead of oxygen, these bacteria can use electrodes as terminal electron acceptor to which the metabolic electrons are transferred and electricity is generated.

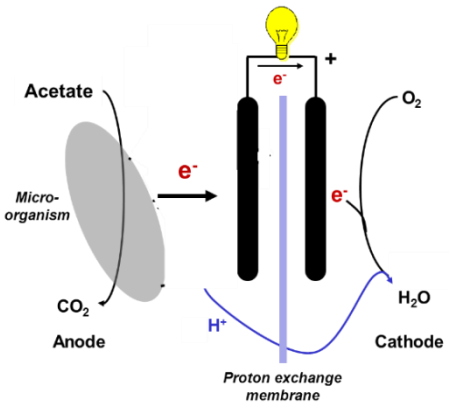

Figure 1: Principle of a microbial fuel cell.

For technical application, commonly three-dimensional porous electrodes are preferred, since these enable a high current density and thus overall productivity of the system. However, often the bacteria overgrow the porous electrode structure. Due to mass transfer limitation its interior volume can no longer efficiently contribute to current generation, leading to a reduced overall current density [1].

Figure 2: Differential interference contrast (DIC) image of an adult nematode (C. elegans). Scale bar 0.1 mm. Source: www.wormatlas.org

The idea of the proposed master project is to employ microfauna as ecosystem engineers [2] in the microbial fuel cell. The underlying hypotheses are that by feeding on the electroactive bacteria, species such as nematodes (Fig. 2) prevent excessive overgrowth of the three-dimensional electrode structure, and that controlled grazing keeps the bacteria in the productive exponential growth phase.

Research questions:

1) Which are suitable higher organisms that graze on electroactive bacteria and can live under the predominantly anoxic environmental conditions of a microbial electrode?
2) What are the main factors (e.g. substrate supply, temperature, growth rate) driving the beneficial interaction between grazing organisms and electroactive bacteria in MFCs?
3) How can the concept be used to efficiently generate electricity from wastewater?

Approach:

At first, suitable higher organisms will be selected based on literature data. Consequently, a set of experiments will be designed to prove/disprove the hypotheses and investigate the research questions. To this end, the small-scale microbial fuel cell reactors already available in the Kerzenmacher Group will be used. The project outline will be announced and offered to students from both faculties.

References:

[1] S. Kerzenmacher (2017). Engineering of Microbial Electrodes. In: Advances in Biochemical Engineering/Biotechnology. Springer, Berlin, Heidelberg

[2] Druhan, J. L., Bill, M., Lim, H., Wu, C., Conrad, M. E., Williams, K. H., ... & Brodie, E. L. (2014). A large column analog experiment of stable isotope variations during reactive transport: II. Carbon mass balance, microbial community structure and predation. Geochimica et Cosmochimica Acta, 124, 394-409.