



436th WE Heraeus Seminar
Biosensing with channels: faster, smaller, smarter

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Relevance of the subject:

Nature has created a huge number of membrane channels acting as gates for water soluble molecules to enter the cell. Understanding gating and screening for selective substrates is a central question in biology, pharmacy and medicine. Understanding means often observation of the phenomena. In recent years physicist are attracted by these phenomena and start to benefit from this knowledge. The current task is to build molecular models of the underlying physics and to test the hypothesis with adequate measurements. Nevertheless the relevance of models needs to be discussed and adopted to observations made in the bio-community. This meeting shall serve as an interdisciplinary platform: learning from biology, suggesting models and discuss the relevance.

An established method of choice to obtain structural and functional information is the reconstitution of channels into planar lipid bilayers. The application of transmembrane voltages allows using the channel conductance as a probe for pore size and function. A huge step forward in this field was the patch-clamp technique giving information on single channels in their biological context. Nowadays these techniques became standard and provide marvelous insights of cellular function. However, such studies are very time consuming and require well-trained persons. The tedious preparation motivated researchers to investigate the possibility of simplification and automatisation. Since about five years, homebuilt, and first commercial instruments allowing automatic cell patching became available. The improved performance raised a strong interest to apply this development in pharmaceutical drug screening.

Moreover, nanobiotechnology became an emerging field trying to benefit from natural building blocks on a nanometer scale to create new functional materials. For example, single channels can be reconstituted into a planar lipid bilayer and the time dependent ion current is used to sense the structure-function relationship of the channel. Alternatively the improved sensitivity suggests other applications like DNA sequencing, virus recognition, heavy metal binding, drug screening, or, just as in the force mode in AFM, unfolding of peptides can be followed.

A similar approach started from materials science. Very recently micrometer- and now even just a few nanometer wide channels have been etched into thin insulating material. Surprisingly, such channels show rectifying properties similar to biological channels. Currently, surfaces of such channels are functionalized with biomolecules to render these channels specific and to create molecular sieves. Microfluidics and microstructured surfaces will allow for parallel recordings with ultra-low volumes. Furthermore, these devices at reduced size may be combined with other spectroscopic techniques. At the same time together with the access to structural knowledge with Angstrom resolution computational and theoretical investigations became powerful tools for today's understanding of channels.

With this meeting, we would like to bring the different communities together to summarize the current state-of-the-art, and to elucidate future exciting developments in basic and applied science. More specifically, this school will provide research lectures on:

- physics of confined systems
- characterization of nanochannels (electrophysiology, spectroscopy)
- how to create and functionalize artificial nanometer sized channels
- how to create micrometer sized surface structure
- chemical and biological surface fictionalization
- micro and nanofluidics
- nanoelectronics
- force measurements with nanopores

- state-of-the-art structure prediction from electrophysiology
- molecular modeling
- improving the technology:
 - how to measure with microsecond resolution
 - how to automate patch-clamp or planar bilayer
 - how to combine fluorescence signal and electrophysiology
- how to create a biosensor

We expect about 26 invited speakers and about 70 participants in total. Some of the participants will be invited for shorter lectures or posters. Poster presentation is encouraged

Confirmed Lecturers:

L. Auvray (Evry)
 H. Bayley (Oxford)
 R. Benz (Würzburg)
 S.M. Bezrukov (Bethesda)
 R. Blick (Wisconsin)
 M. Burger (Münster)
 C. Dekker (Delft)
 P. Hänggi (Augsburg)
 J. Homola (Prague)
 S. Howorka (London)
 B. Lidberg (Linköping)
 M. Mayer (Chicago)
 H. Miedema (Groningen)
 L. Movileanu (Syracuse)
 J. Robertson (Gaithersburg)
 J.J. Schmidt (Los Angeles)
 G. Schütz (Linz)
 Z.S. Siwy (Irvine)
 H. Vogel (Lausanne)
 A. Aksimentiev (Urbana)
 E. Schleiff (Frankfurt)
 J. Behrends (Freiburg)
 Thomas Heimburg (Copenhagen)
 U. Keyser (Cambridge)

A few more specialized lectures on various topics will be selected from the audience. To stimulate the discussion we will arrange poster sessions.

Seminar fee: 350 Euro including full board and accommodation. Some fellowships are available, for that please contact Mathias Winterhalter: m.winterhalter@jacobs-university.de

Deadline for applications: May 1st

Content of the lectures (approximate subjects, the titles will be communicated later)

Theory in confined systems:

- M. Burger (Münster): Analytical and numerical modeling of ion transport
- P. Hänggi (Augsburg) : Physics in confined systems
- A. Aksimentiev (Urbana): Molecular dynamics of transport
- T. Heimburg (Copenhagen): Thermodynamic of transport

Solid state nanopores:

- L. Auvray (Evry): Folding studies in solid state nanopores
- C. Dekker (Delft): Physics of solid state nanopores
- H. Vogel (EPFL, Lausanne): Functionalization of nanopores
- S. Ziwy (Irvine): solid state nanopores
- M. Mayer (University of Michigan)
- C. Martin (Gainesville): sensing

Biological nanopores:

- H. Bayley (Oxford): Screening with biological pores
- S. M. Bezrukov (NIH, Bethesda): Physics of transport
- R. Benz (Universität Würzburg): transport of substrate
- S. Howorka (London): Biosensing with channels
- L. Movileanu (Syracuse): Biosensing with channels
- J. Robertson, (NIST): Biosensing
- E. Schleiff (Frankfurt): Protein export

New techniques:

- J. Schmidt (UCLA): Practical freestanding lipid bilayer platform technologies
- G. Schütz (Universität Linz): Fluorescence and electrophysiology
- J. Behrends (Freiburg): Fluorescence and electrophysiology
- J. Homola (Prague)
- B. Liedberg (Linköping)
- H. Miedema (Groningen): physics of selectivity of biological channels

