Modelling of Ion Channels - insights from mathematics

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Abstract

Ion channels are proteins with a hole down their middle that allow ions to move across otherwise impermeable cell membranes, thereby controlling many important and vital physiological functions, such as conducting electrical signals down nerve fibres and initiating muscle contraction. Hence they are of fundamental interest to various scientific disciplines such as biology, biophysics and medicine (e.g. new drug development). Since there are lots of different channels for which the structure-function relationship is not known for sure, one idea is to employ mathematical models in order to get more insights into structural features of the channels.

In this talk we are going to consider a drift-diffusion type model (in biophysics known as the Poisson-Nernst-Planck model) describing the movement of ions through open channel pores. Starting from this model it will be investigated in which way this system can be used to learn something about channel structures using current measurements that can be performed on the channels. A special focus will be put on the use of surrogate models to tackle the inverse problem of structure identification.

Apart from the ion conduction itself, the opening and closing of the channels, known as gating, is of major importance for the proper functioning of the associated processes. For voltage-gated channels interesting phenomena like the Cole-Moore effect, a time delay in the developing current after a voltage step, can arise and again the mechanisms for this are not quite understood yet. We will also adress this question to see if mathematical models might provide a helpful tool towards better understanding in this area.