Lipid Ion Channels

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Abstract

It has long been known that lipid membranes become more permeable in their chain-melting regime. Interestingly, biomembranes are close to such melting transitions under physiological conditions. When using black lipid membranes (BLM) or patch pipette experiments one finds that permeation events for ions through the membranes appear in quantized steps that resemble those found for ion channel proteins (1-3). Both, current intensities and open lifetimes are quite similar to those found for such proteins. Here we show that the open lifetimes are related to the overall permeability. Using pressure-perturbation calorimetry we found that relaxation processes are proportional to the heat capacity profile. Within the melting transition relaxation processes are slow. This is a direct consequence of fluctuation-dissipation. Since pore formation is a consequence of density fluctuations, the relaxation time scales are closely coupled to pore open times. As a result, we find a self-consistent coupling of heat capacity, membrane permeability and the open lifetimes of lipid pores, and a coherent and predictable effect of anesthetic and other drugs (2-4). The lipid channels can be voltage-gated, mechano-sensitive and temperature sensitive. We compare the lipid channels with protein channels (especially various TRP channels) in order to demonstrate that the channel events from biological preparations and synthetic lipid membranes are indistinguishable. Further, we show lattice Monte-Carlo simulations that simulate the pore formation process and the influence of drugs (2).

Our results are in good agreement with our recent proposal that the action potential in nerves is the consequence of a piezoelectric soliton in the nerve membrane (5). In particular, fluctuations during the pulse result in the occurrence of channel events such that everything that excites a pulse also generates quantized currents.

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