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Mechanism of voltage-gated channel formation in lipid membranes

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Abstract

Although several molecular models for voltage-gated ion channels in lipid membranes have been proposed, a detailed mechanism accounting for the salient features of experimental data is lacking. A general treatment accounting for peptide dipole orientation in the electric field and their nucleation and growth kinetics with ion channel formation is provided. This is the first treatment that explains all the main features of the experimental current-voltage curves of peptides forming voltage-gated channels available in the literature. It predicts a regime of weakly voltage-dependent conductance, followed by one of strong voltage-dependent conductance at higher voltages. It also predicts values of the parameters expressing the exponential dependence of conductance upon voltage and peptide bulk concentration for both regimes, in good agreement with those reported in the literature. Most importantly, the only two adjustable parameters involved in the kinetics of nucleation and growth of ion channels can be varied over broad ranges without affecting the above predictions to a significant extent. Thus, the fitting of experimental current-voltage curves stems naturally from the treatment and depends only slightly upon the choice of the kinetic parameters.

Key words: bilayer lipid membranes; current-voltage curves; nucleation and growth; alamethicin; melittin

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