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Dynamics of Pore Growth in Membranes and Membrane Stability

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Pores can form and grow in biomembranes because of factors such as thermal fluctuation, transmembrane electrical potential, and cellular environment. We propose a new statistical physics model of the pore growth treated as a non-Markovian stochastic process, with a free energy barrier and memory friction from the membrane matrix treated as a quasi-two-dimensional viscoelastic and dielectric fluid continuum. On the basis of the modern theory of activated barrier crossing, an analytical expression for membrane lifetime and the phase diagram for membrane stability are obtained. The memory effect due to membrane viscoelasticity and the elasticity due to cytoskeletal network are found to induce sharp transitions to membrane stability against pore growth and compete with other factors to manifest rich dynamic transitions over the membrane lifetime.