

A Dynamic Model of Fusion Pores in Lipid Bilayers

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Biological membranes remodel and change shape in processes like endocytosis, exocytosis, hemifusion, and the expansion of fusion pores. Since the length scale of these processes is generally quite small, computational models are needed to resolve the time course of the membrane. Over the past few decades, physicists and mathematicians have developed variational methods for studying time dependent changes in materials like lipid membranes. Building on a model of a single lipidic pore in a vesicle membrane, we direct the variational approach to the study of fusion pores. A fusion pore is a toroidal structure which connects two planar bilayers. The variational approach calculates the time dependent shape of the fusion pore--the precise shape of the pore that minimizes the membrane energy can be calculated using the variational method. The shape of the fusion pore is a solution to the equations of motion which include the surface forces induced by the classical Helfrich energy of the membrane. The energetics involved in the fusion pore expansion are determined as a function of the lipid composition and initial conditions. The model is based on a diffusive interface and director field approach which determines the position and energy of the membrane. The diffusive interface specifies the material properties of lipid and water, accounts for the lipid movements, and is the basis for deriving the equations of motion.

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