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Spatial organization of cellular membranes

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Cell membranes are complex organelles composed of phospholipids, sterols and proteins, among others. The spatial organization of these components plays an important role for the membrane's biological function. Our work uses computer simulations and mathematical modeling to study the emergence of spatial order in two specific contexts: the phase behavior of multicomponent lipid bilayers and the effect of membrane-induced interactions on membrane-bound proteins. First, we focus on composition heterogeneities in model membrane systems, which are believed to form the basis for lipid rafts: small domains that corral membrane proteins. We study the phase behavior of multicomponent bilayers using simulations of coarse-grained molecular and field-theory based models. We find a wide range of membrane systems that exhibit composition correlations over large length scales. Second, we study the interaction between membrane-bound proteins that emerges from the membrane's elastic behavior. We develop a hybrid model that combines a continuum description of the membrane with a particle representation of the proteins. We show that the membrane-induced interaction gives rise to an effective attraction between proteins, which occurs over length scales much larger than typical intermolecular forces.