Biological components are generally “soft”, meaning that they are fluid-like, have bond energies at comparable to room temperature thermal energies, and exhibit diverse phases with long-range order. These properties result in interesting behaviors such as self-assembly, dynamic heterogeneity, and phase separation. Such behaviors are challenging to determine from the atomic or molecular composition of the biological system and often require a diverse set of analytical and experimental techniques. In tackling such problems, it is often useful to borrow concepts and ideas from soft matter physics which have been traditionally focused on polymers, gels, self-assembled surfactant structures, and many other complex fluids. Using such ideas, new perspectives on phenomena as diverse as DNA condensation, protein and peptide fibrillization, lipid partitioning in rafts, vesicle fusion and budding, and others can be obtained.

In this thesis, we focus on a particular kind of biological system – the lipid bilayer. Given their vital role in biological functions, lipid bilayers have been subject to intense studies for many decades. Lipid bilayers form membranes that surround all cells and many sub-cellular structures. Thus, they play a vital role in making those structures impermeable to nearly all water-soluble molecules. (++ other roles)

Lipid bilayers contain an assortment of lipid types, most notably phospholipids and sterols. Additionally, they are rich in membrane proteins, which play an important role in cell signaling and transport channels. Since these membrane proteins need to operate at regions of the cell where the concentration of whatever