[1] Entropic and active forces in chromosomal organization

Short Description:

We shall review and enhance our understanding of chromosomal organization using a physical model of bacterial chromosomes that incorporates the basic ingredients of (i) molecular crowding, (ii) confinement, and (iii) protein mediated active or passive chromatin remodeling. The DNA is modeled as a semi-flexible polymer, and the chemical kinematics of the associated proteins can be incorporated by diffusion, and stochastic attachment-detachment dynamics dependent on local elastic strain. A resultant coarse-grained model of active polymer with topological constraints will be utilized to probe the chromosomal organization, and segregation dynamics.

[2] Cytoskeletal structure, fluctuations and response

Short Description:

Cytoskeleton is a complex and dynamic structure consisting of dynamic polymers and molecular machines. It consists of three kinds of filaments, cross-linkers and motor proteins. Polymerization- depolymerization of filaments, and force generation by motor proteins derive energy from ATP or GTP hydrolysis. The contractile actin-myosin cytoskeleton transmits force to the plasma membrane via linker proteins modulating the cell shape and dynamics. The cells bind to other cells or extra cellular matrix via integrin/ cadherin to mediate response and generate force. From the perspective of soft matter physics, the actomyosin network is treated as an active polar gel, whose dynamical properties differ fundamentally from passive polymeric gels. In this project, we shall study active pattern formation and mechanical response of this system, in various contexts.

[3] Active soft matter

Short Description:

Collective motion of active individuals shows spectacular emergent phenomena, e.g., flocking of birds, orderly motion of schools of fish. Recent experiments on physical and chemical systems have shown similar behavior in artificial self-propelled units. Examples include vibrated rods or disks, and active colloids. In the simplest such systems, self-propulsion, velocity alignment, and repulsive interaction control phases and phase transitions. Non-affine fluctuations, defect formation, and melting of active solids are of our current interest. In the project, we shall review existing literature, develop numerical simulation schemes, and learn to use active hydrodynamics to analyze non-equilibrium phase transitions in active soft matter.