Theoretical investigations of few Bio-molecular rate processes

Traditional topics such as physics, chemistry, biology and mathematics have immensely influenced the world of science in the twentieth century. Unlike the traditional topics, topics that have an interdisciplinary nature are expected to influence the twenty-first century. Those systems that usually come under biology, there interdisciplinary aspects can be studied using the methods of physics and mathematics. Study of single polymer chains in solution is a very interesting topic since it provides insights for understanding many processes that occur in biological systems. This thesis presents theoretical studies of a few such processes, involving single polymer chains using analytical methods using statistical mechanics. The statistical mechanics of polymers has been developed using the random walk models. The dynamical behaviour of many-particle systems has been described by the rate theories. This thesis uses classical rate theories to study few biological processes that involve single polymer chains. The kind of processes that is investigated here can be divided into two categories, namely the processes that lead to change in conformation in a polymer and the processes involving spatial translocation of a whole polymer. In the first category, we have considered the problem of polymer looping process in solution. Loop formation of long chain polymer molecules plays a key role in many biological processes, e.g., DNA replication, gene regulation and protein folding. We find that rate constants are proportional to the square root of length of the polymer. In the second category of translocation problems, we gave exact solution of the problem of the kinetics of DNA escape from nanopores may be rationalized by a model of chain dynamics based on the anomalous diffusion (time dependent diffusion constant) of a particle moving in a harmonic well in the presence of a delta function sink.

Thesis chapters: