➢ Evolution and Adaptation of Extrmofile (E, Kumar)

A vast majority of bacteria and archaea can grow in diverse environmental conditions. Those conditions include high pressures, high temperature, low temperature, high salinity, low pH, and high pH. Because these conditions are not hospitable for other life forms, these organisms have been named extremophiles.

Adaptation of these organisms to such harsh conditions raises many interesting questions, such as how do they adapt to these conditions where other life forms would fail to do so? Does the adaptation occur at a single-component level such as by mutations in proteins leading to their barostability and thermostability, or does the adaptation to these conditions have a collective nature, in which more than one cellular component act in compliance to preserve the functionality of the other?

Work done in Dr. Kumar's lab lie at the interface between physics and biology where we try to find quantitative description of biological processes using concepts derived from physics. These will be very exciting for young undergraduate researchers willing to contribute to novel biophysics research. Projects that would benefit from contributions of undergraduate researchers have been listed below.

Project 1. Effect of pressure and temperature on cellular stochasticity:

Cellular stochasticity provides a mechanism to maintain a population-heterogeneity and hence is advantageous in counteracting fluctuating environments. However, it could also have harmful effects on cellular function. One of the goals of Kumar’s lab is quantitatively determine how gene expression stochasticity changes as external stresses such high pressure and temperature whether the changes in stochasticity has implications for adaptation to extremes physicochemical conditions. For this project, students will participate in designing small genetic constructs and use them with bacteria to understand the gene expression stochasticity in bacterial cells. The data then will be analyzed in the context of extrinsic and intrinsic noise in cells and the effect of stress on the noise.

Project 2. Evolution and co-evolution of genes in extreme prokaryotes:

Another goal of the Kumar’s lab is to understand genomic evolution of single-celled organism, specifically the how the genomes of extreme prokaryotes have evolved maintain cellular integrity in extreme environments. The undergraduate researchers will collect genomic data from open sources such NCBI (National Center for Bioinformatics Information) and will analyze the evolution and co-evolution of genomes using novel tools from statistical mechanics and mathematics. The undergraduate students will build simple physical and mathematical models will have a first hand experience dealing with genomic data in the context of a broader scientific question.