Biophysics/Quantitative biology: (1) Natural selection and mitochondrial aging, and (2) Building mini-robotic-chemostat array for bacteria- phage competitions

What do antibiotic resistance and HIV infection have in common with aging and cancer? Each of these "phenomena" is driven by the same underlying evolutionary processes that are responsible for evolution of all life over the hundreds of millions of years. But unlike evolution on geological timescales, evolutionary processes driving these phenomena are fast and manifest in months, days and even hours.

My lab studies such processes using laboratory microbial systems through a combination of theory and experiments.

(1) *Natural selection and aging*

Mitochondrial DNA is essential for respiration. This work addresses the problem of mitochondrial maintenance over the lifetime of a cell, where the necessity to prevent loss of mitochondrial DNA in the face of high mutation rate brings evolutionary dynamics into the realm of physiology of aging. Our quantitative approach to this outstanding question of mitochondrial aging will be based on bringing together two technical innovations: (i) Mother Enrichment Program (MEP) approach to replicative aging in budding yeast; (ii) methods of modeling the stochastic dynamics of non-neutral mutant alleles in populations with extensive diversity. Mathematical modeling will be used to enable quantitative inference of selection effects, based on deep sequencing data on yeast populations generated in MEP and related experiments. This project would expose the student to a multitude of experimental and computational skills. Knowledge of Python programming, and core (if possible molecular biology) experimental skills would be useful. A good background reference for this project is: mitoAging.pdf

(2) *Building mini-robotic-chemostat array for bacteria-phage competitions*

Bacteria and viruses make the most of biomass on earth. Furthermore, they are constantly inventing new ways (mutations, gene transfer, etc.) to out compete each other, which has important implications for natural ecosystems such as human gut. In my lab we are developing a robotic system to continuously and automatically track this competition as it unfolds. This project would expose the student to a multitude of physics/engineering skills essential for making such a system. Knowledge of Python programming, microcontrollers (Arduino, PI), basic electronics, and core experimental skill would be useful. A good reference for this project is: miniTurbidostat.pdf

If interested, please contact me by email: goyal@physics.utoronto.ca or come by my office MP504 in the physics building. Check website for more details and other projects: https://goyallab.wordpress.com