Stochastic modeling of receptor signaling accuracy and specificity

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Receptor signaling via soluble ligand molecules enables living cells to communicate with each other and with their environment, and is the main mode of multi-cellular coordination in the immune, nervous, endocrine and other systems, as well as in complex populations of micro-organisms. In a typical signaling pathway, binding of a ligand to a cell surface receptor activates a cascade of intracellular events that eventually lead to responses such as cellular differentiation phenotypic change, or a change in cellular motility. For reliable and precise communication, receptor signaling often needs to be specific, accurate, rapid, and robust to molecular noise and cellular heterogeneity. However, fundamental physical constraints often place these different signaling goals at odds with each other, and different signaling pathways have evolved to optimize different aspects of information transmission such as specificity, sensitivity, accuracy, and speed. Puzzlingly, receptor signaling pathways frequently exhibit a high degree of cross-talk whereby multiple ligands act through shared cell surface receptors and downstream signaling components, It remains unclear how such signaling pathways accurately transmit information about external environment. Beyond the fundamental scientific questions, understanding the mechanisms of specificity in cross-wired pathways is crucial for development of better therapies for various diseases, including cancer and viral disease.

The student will participate in the current project in the lab, and build a stochastic model or receptor signaling with cross-talk and pleiotropy. The student will use methods of information theory, statistical inference and machine learning to investigate the specificity and accuracy of signaling in the presence of various feedbacks and molecular noise.

Qualifications: 3rd or 4th year undergraduate student in Physics with basic knowledge of biology and familiarity with coding in Python or other programming languages.

The student will regularly meet with the supervisor to assess the progress and plan future work, and will also interact continuously with other graduate students in the group, and will participate and present at the group meetings. The student will learn modern mathematical and computational tools of systems biology and apply them to the modeling of signaling pathways, acquiring transferable skillset for a wide range of careers.