One of the most challenging areas in science and engineering research today is understanding biological systems. As new technologies in biological science enable more precise quantitative measurements, there are many opportunities for modeling of biological systems. Our group’s modeling research is interdisciplinary and involves the interplay between biology and fields such as physics, mathematics, and computation. While modeling gives new insight into biological problems, biological systems also motivate advances in physics and mathematics.

The abundance of data now available for biological systems has led to many opportunities for theorists to model biology. The Department of Applied Science at William and Mary is a leader in theoretical biology, including population biology, epidemic modeling, and computational neuroscience. Computational and laboratory facilities are available within the department, and there are strong ties to other departments on campus. We also collaborate with other universities and have joint programs with government agencies on problems of mutual interest. Much of the current research deals with the dynamics of biological systems at many scales, ranging from the macroscopic human social interaction affecting the spread of epidemics, to the nanoscale dynamics of molecular motors. The nature of the research is highly interdisciplinary, requiring the interaction of experts across fields. The Mathematical and Computational Biophysics group at William and Mary is always interested in having new students at all levels join the research group and help solve an exciting class of problems.

In Applied Science we use the tools, the techniques, and the understanding involved in a wide range of sciences in order to solve complex real-world problems. The Department has state-of-the-art facilities in: neurophysiology and computational neuroscience; theory and computational design of materials and systems; novel materials synthesis and characterization of small molecules, polymers, inorganics, and composites; modification and evaluation of interfaces; processing control of materials and surfaces; imaging technology and theory from nanoscale to planetary scales.

http://as.wm.edu
Research Questions

An important problem that impacts society and quality of life worldwide is the dynamics of infectious disease spread. Models are valuable for anticipating the number of disease cases in the future, so that adequate economic and social resources can be allocated to care for patients. Modeling different control strategies, such as different vaccine schedules, can help determine which control method is best to use, especially in the case of finite resources. Models are also helpful in understanding which biological and social factors govern the rate of disease spread.

Questions we are researching include the following: When diseases have multiple strains, as is true for many important diseases such as influenza, SARS, and dengue, how do the strains interact and change over time? In spatially extended populations, what is the effect of spatial distance on spreading dynamics? When are fluctuations in disease prevalence likely to lead to extinction of a disease, and can the system be altered to increase the chances of extinction? How do changing networks of human social interactions affect epidemic spread?

Graduate Program

Students with undergraduate backgrounds in physics, mathematics, computer science, or engineering have quantitative skills that carry over to research in theoretical biology. Biology and chemistry students with a strong math or physics background are also prepared for graduate study in biological modeling.

Applied Science is an interdisciplinary graduate department that offers individualized degree programs to prepare students for their career goals. In addition to core courses in mathematical and research methods, students (together with their advisory committees) may select from course topics such as:

- Population Modeling
- Statistical Physics in Biology
- Cellular Biophysics and Modeling
- Self-Organization in Life and Chemical Sciences

Since all living things move or change in time, we are interested in their dynamics at all biological scales, ranging from the nanoscale behavior of cellular machinery to the social interaction of humans on a global scale. We are thus interested in fluctuations in biological systems, and in how microscale fluctuations affect macroscale behavior. Our research topics are at the interface of mathematics, physics, and biology. Our tool set includes methods from statistical mechanics, nonlinear dynamics, and numerical simulation. Due to recent advances in biological data collection, we frequently work on problems that are motivated by experimental data, so there are also opportunities for data analysis that complements our modeling.