PhD research themes in applied mathematics with Rachel Bennett

I use minimal mechanical models to understand physical processes in biology, in particular, the role of fluid flow and mechanical forces. My research includes swimming motion of microorganisms, coordination of beating cilia, bacteria interacting with a surface and mechanical effects on DNA organisation.

PhD project: Elastic coordination of beating cilia

Cilia are hair-like appendages on the surface of cells that actively beat. When they coordinate their beats, they create fluid flow which is necessary for various processes in biology. In recent work, I have investigated how cilia coordinate their beat patterns using hydrodynamic interactions. However, experimental results have shown that elastic interactions through a compliant substrate can also provide a mechanism for coordination. The goal of this project is to develop a framework to understand how elastic interactions can lead to coordination of cilia.

PhD project: Bacteria on nanospikes

When bacteria find a surface, they attach and build up their population in a biofilm. The biofilm lifestyle is strongly bound together and resistant to external stresses, including antibiotics. Biofilms are responsible for the majority of hospital acquired bacterial infections. In efforts to design surfaces that prevent the build up of biofilms, it has been found that surfaces with nanospikes can disrupt the growth of bacteria. However, the mechanism for this is not understood. This project aims to understand how the stress on the cell membrane cause by the nanospikes affects the stability of cell wall growth, and how it could disrupt protein pattern formation that is necessary for cell division.