Major Scientific Achievements

My research focuses on understanding how microscopic physical interactions give rise to the rich and often surprising behaviour of active and living systems. By combining statistical physics, stochastic thermodynamics, theoretical modelling, and simulations, I seek to connect fundamental physical mechanisms with emergent biological and non-equilibrium phenomena.

A major theme of my work is **self-organization in biological systems**. This includes models of neural growth and fasciculation in mammalian olfactory systems, as well as theoretical modelling of bacterial chromosome organization that explained how physical interactions can generate the helicoidal structure of the bacterial nucleoid. Related work addresses chromosome organization and the reliable segregation of sister chromatids in bacterial cell division, despite the absence of dedicated spindle-like machinery, as well as the mechanisms of bacterial Z-ring formation and intracellular transport in eukaryotes.

In **active matter**, my research explores entropy production and irreversibility, exact analytical descriptions of active particles, collective motion and pattern formation, and the mechanics of active filaments, membranes, molecular motors, and materials.

Across these diverse systems, the common goal is to uncover **simple physical principles underlying complex organization, dynamics, and function in systems far from equilibrium**.