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Teaching at the edge of knowledge: Non-equilibrium statistical physics[1]

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As physicists become increasingly interested in biological problems, we frequently find ourselves confronted with complex open systems, involving many interacting constituents and characterized by non-vanishing fluxes of mass or energy. Faced with the task of predicting macroscopic behaviors from microscopic information for these non-equilibrium systems, the familiar Gibbs-Boltzmann framework fails. The development of a comprehensive theoretical characterization of non-equilibrium behavior is one of the key challenges of modern condensed matter physics. In its absence, several approaches have been developed, from master equations to thermostatted molecular dynamics, which provide key insights into the rich and often surprising phenomenology of systems far from equilibrium.

In my talk, I will address some of these methods, selecting those that are most relevant for a broad range of interdisciplinary problems from biology to traffic, finance, and sociology. The "portability" of these methods makes them valuable for graduate students from a variety of disciplines. To illustrate how different methods can complement each other when probing a problem from, e.g., the life sciences, I will discuss some recent attempts at modeling translation, i.e., the process by which the genetic information encoded on an mRNA is translated into the corresponding protein.

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