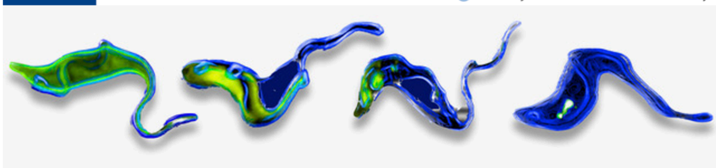

Contribution ID: **36** Type: **Contributed talk (20 min)**

# Utility of information in chemotaxis

Living cells improve their fitness by sensing noisy environmental signals and tuning their behavior in response in a seemingly modular fashion. Yet these two processes often occur simultaneously, and behavioral response affects future signal values. Whether a cell is aware of and able to efficiently use the information it itself generates, is an open question. A complete understanding of the design of sensing and response motifs, in terms of the *usability* of sensed information, has so far been limited to perturbative regimes without accounting for the information feedback from the cell to the environment (Mattingly et al., 2021).

We address this gap by studying the dynamics of chemotaxis of *Escherichia coli* in a steady chemoattractor gradient, with a coarse-grained model (Long et al., 2017) for sensory receptors and run-and-tumble motion in the seconds timescale. For computing the mutual information between signal and response trajectories, we extend a recently developed numerical algorithm, Path Weight Sampling (PWS) (Reinhardt et al., 2022), to achieve exact computation of mutual information rate in the presence of nonlinear coupling and feedback. We find that there exist distinct optima in terms of cell's behavioral parameters for maximum performance, measured by the chemotactic drift speed, and maximum mutual information rate. Further, irrespective of the cellular environment, sensed information and its *usability* independently constrain chemotactic performance. With analytical theory, we rationalize our findings in terms of the design and interdependence of the sensing and response motifs in *E. coli* and the bimodal nature of a run-and-tumble response.

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