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Bacterial navigation in chemical and nonchemical environments[1]

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— Navigation of cells to the optimal environmental niches is critical for their survival and growth. E. coli cells, for example, can detect various chemicals and move up or down those chemical gradients (i.e., chemotaxis). Using the same signaling machinery, they can also sense other external factors such as pH and temperature and navigate from both sides toward some intermediate levels of those stimuli. This mode of precision sensing is more sophisticated than the (unidirectional) chemotaxis strategy and requires distinctive molecular mechanisms. To understand different bacterial taxis behaviors, we develop a theoretical model which incorporates microscopic signaling events in individual cells into macroscopic population dynamics. We find that the equilibrium population distribution is governed by an effective potential, the landscape of which depends on the external environment (chemical stimuli, pH, and temperature). We uncover the key conditions for various taxis behaviors and directly connects the cellular taxis performances with the underlying molecular parameters. This approach is used to examine and predict how background attractants and downstream temperature effects influence the performance and stability of thermotaxis, which can be tested in future experiments.

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