BACTERIAL CHEMOTAXIS AND PROTEIN COMPUTATION

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Cells are built up of molecular circuits that perform logical operations, analogous in many ways to electronic devices but with unique properties. Proteins and other molecules act like miniature transistors to guide the biochemical processes of a cell. Linked into networks they form the basis of all of the distinctive properties of living systems.

I will illustrate these features in relation to bacterial chemotaxis—the set of biochemical reactions by which an *E. coli* bacterium detects and swims in response to distant sources of attractant or repellent molecules. Signals travel from the membrane receptors, which detect environmental signals, to the rotary motors that drive the bacterial flagella. This protein-based pathway has been saturated genetically and all of its protein components characterised biochemically and their atomic structures determined. Computer simulations of "surrogate" bacteria are used to test how well they resemble the living organisms. These studies make the signalling pathway of *E. coli* chemotaxis the best understood in biology. They show, for example, that the physical location of molecular components within the molecular jungle of the cell interior is crucial for their function. The chemotaxis receptors, for example, are clustered at the membrane together with other proteins into a "solid-state" computational device. We understand how this device amplifies, integrates, and parses chemical signals from the environment and relays the output to the rest of the cell.

Bacterial chemotaxis shows us how computations underlie the sophisticated decision making of all organisms, how they encode experiences, and how they allow a cell or an organism to predict the future and perform goal-oriented movements.