*Deciphering the Mysteries of Microbial Communications*

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INFORMATION

Garud Iyengar is helping to unlock the secrets of how colonies of bacteria work together, though he is not a biologist. "I'm a problem solver, rather than someone who focuses on one particular research area," said Iyengar. "My particular interest is in understanding how simple components can produce complex behavior when networked together."

Iyengar's varied background in mathematical modeling and optimization enables him to tease out insights that classically-trained biologists might miss. "My particular strength is in building mathematical models to guide experimentation by blending tools, often from different disciplines, that together work better than any single tool used independently," he said.

"Most scientists have a set of pet mathematical tools. Someone trained in statistics immediately thinks about regression to model experimental data. A computer scientist builds a combinatorial model," he explained. "An electrical engineer wants to use information theory. I've been exposed to many of these disciplines, and so my bag of tricks is bigger."

Lately, Iyengar has been trying to discover how colonies of unicellular organisms communicate in order to exploit their environment. Density sensing in Pseudomonas aeruginosa, a bacteria that inhabits the lungs of patients with cystic fibrosis, is an example. "These bacteria only turn virulent when their local density crosses a certain threshold. At lower densities, the host's immune system would overwhelm it," he explained.

It is well understood that bacteria use certain signaling molecules to sense density. A positive-feedback biochemical network triggers a switch when the signal concentration is high enough. According to classical control theory, there are many possible networks that yield the same density dependent switching behavior. Evolution, however, has selected one particular network in many different bacterial species. Iyengar is interested in understanding the reasons underlying this selection.

A more complex problem is how bacteria determine the colony's average temperature in order to optimize their metabolism. This is more difficult than it sounds. Each cell perceives only the temperature around it. Many factors, such as nearby water or chemical reactions, create microclimates that vary significantly from the average.

Iyengar speculates that bacterial colonies use a technique called belief propagation to measure spatial averages. Belief propagation is a well-known paradigm from statistical physics that describes how a particle adjusts its behavior based on the behavior of its neighbors.

"If it is used by bacteria, there are measurable consequences that logically follow," he said. "We are using our models to guide the type of experiments we need to do to quantify these consequences."

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