# Diversified population strategies for chemotaxis trade-off problems

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BACTERIA perform chemotaxis in a wide variety of environmental tasks, from scavenging nutrients to infecting host tissues. As such, it would seem unlikely that one type of chemotactic behavior would be equally suited to all tasks. Indeed, some species have many chemotaxis systems and switch between them. Others have one, but behavioral diversity is still observed in clonal wildtype cells. What are the trade-offs that bacteria face in performing chemotaxis in different environments? Can population diversity be tailored to resolve these trade-offs? Using simulations of a single-cell model of *Escherichia coli* chemotaxis in different ecological tasks, we found that different tasks required different behaviors for optimal performance. We further investigated the model analytically and uncovered the mechanistic roots of a fundamental trade-off between tracking gradients of differing steepness. By using a model of noisy gene expression, we showed that changing genetic regulation can allow behavioral diversity to be optimized in such a way that trade-offs were alleviated at the population level. Therefore, clonal populations can diversify the behavior of a single biological network for a collective advantage in fluctuating environments – without changing the proteins of the network or their interactions. Such a strategy may be widespread among organisms with a single chemotaxis system and may represent an evolutionary stepping-stone on the path to multiple systems.