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Engineering the Outputs

Programming Robust Population Dynamics by Cell-Cell Communication

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Abstract:

In addition to offering insight into biological “design” principles, *de novo* engineering of synthetic gene circuits will impact broad areas including computation, engineering, and medicine. However, it remains challenging to realize predictable and robust circuit performance due to noise in gene expression and cell-to-cell variation in phenotype. We address these issues by using cell-cell communication to coordinate cellular behavior across the population. To establish cell-cell communication, we take advantage of quorum sensing systems that many bacteria use to detect and respond to changes in the cell density. As a prototype example, we have built and characterized a population control circuit in bacterium *Escherichia coli*. This circuit autonomously controls cell density by regulating the death rate using a quorum sensing module. Upon activation, the circuit will lead to a stable steady state or sustained oscillations in cell density, as predicted by mathematical modeling. Further exploiting this design strategy, we have recently constructed a synthetic predator-prey ecosystem, where two *E. coli* populations regulate each other’s growth and death by engineered two-way communication. Systems such as this will enable us to explore complex ecological dynamics in a well-defined experimental framework.