149e A Synthetic E.Coli Predator-Prey System

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As one of the best studied model systems, a ‘predator-prey' ecosystem has greatly contributed to our understanding of dynamics of ecological interactions. Using cell-cell communication coupled with regulated cell killing, we have designed and experimentally implemented a synthetic predator-prey system. To establish cell-cell communication, we exploit components from ‘quorum sensing (QS)' systems that bacteria use to sense population density and coordinate behavior for diverse physiological functions. Mimicking mechanisms of programmed cell death, we use killer genes to regulate population densities by controlling rates of cell death. In this design, ‘predator' cells can survive only when they receive a QS signal emanating from ‘prey' cells, which activates an antidote gene in the predator cells. At sufficiently high densities, however, the predator will kill the prey cells by sending a different QS signal that activates a killer gene carried by the prey cells. Numerical analysis shows that the circuit can generate stable oscillations in population densities and intracellular gene expression for a wide range of biologically feasible parameter values. In addition, the analysis highlights the key design features required to achieve the target circuit function in an experimental system. In long-term (~140hrs each) growth experiments, we have observed sustained and damped oscillations with periods ranging from 20 to 40hrs. Dependence of oscillations characteristics on circuit parameters, such as the signal turnover rate, is overall consistent with simulation predictions. For example, acidic conditions, in which QS signals are more stable, tend to favor sustained oscillations with long periods. Fast signal turnover tends to cause damped oscillations with short periods. Systems such as this, which couple genetic regulation and cell-cell communication, will allow us to explore the dynamics of interacting populations in a well-defined experimental framework.