Spatio-Temporal Dynamics of Quorum Sensing

Microbes communicate with each other using chemical signals in order to cooperate or compete with neighboring microbes. Acyl-homoserine lactones (AHLs) are one type of signal used by many species of microbes to regulate gene expression. AHLs activates the process of quorum sensing which is involved in biofilm formation, antibiotic resistance, and virulence. An individual microbe that activates quorum sensing upregulates the production of AHLs, and this signal can diffuse to nearby cells to either activate or sometimes inhibit quorum sensing. In this way, quorum sensing activation spreads through networks of microbes that are distributed in space. Our study is focused on understanding how the activation of quorum sensing depends on the species composition and spatial distribution of microbes in multispecies microbial networks.

We developed an assay to quantify the ability of microbial networks to use signals to coordinate gene expression over long distances. In the assay a receiver strain, which responds to but does not produce the signal, is distributed homogenously on an agar plate. Activation of quorum sensing in this receiver strain is monitor by fluorescence. Upon addition of a signal producing strain to the center of the plate, we monitor quorum sensing activation in the lawn of receiver strains. The activation time of quorum sensing is measured as a function of position on the plate. This assay is used to quantify potential signal inference from a secondary strain added to the system to examine crosstalk between different species of microbes. A mathematical model is used to compare experimental observations to reaction diffusion models and to extend these results to more complex geometric arrangements of cells.