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Experimental Approaches to Understanding Networks

Noise and Information Flow in Biochemical Signaling

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Abstract:

Recent experiments have focused attention on the problem of noise in the regulation of gene expression, but this is only one example of the broader problem of noise in biochemical signaling. In 1977 Berg and Purcell gave a beautiful discussion of physical noise sources as the limit to sensitivity or reliability in bacterial chemotaxis. In this talk I will revisit the Berg-Purcell analysis and show how more powerful tools of statistical mechanics allow us to generalize their discussion, so that we can treat the sensing of chemicals outside the cell and the responses to internal signaling molecules in the same theoretical framework. In particular we can see how to separate noise terms that depend on unknown details of the sensing mechanism from a minimum noise level that depends only on physical parameters such as the diffusion constant of the signaling molecule. I will argue that, at least in some cases, the precision of transcriptional regulation comes close to the relevant physical limits, suggesting that some of the genetic circuitry involved in processing these signals must be chosen to suppress extraneous noise sources. Finally, with an understanding of noise we can also ask quantitative questions about the flow of information (in bits) through the regulation process. Simple models and measurements of the noise levels both predict that there is much more than a one bit or on/off capacity for regulation, and I will outline the experimental signatures expected from systems that are optimized to make use of this capacity.