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Form, Function, and Information Processing in Stochastic Regulatory Networks

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The ability of a biological network to transduce signals, e.g., from chemical information about the abundance of small molecules into regulatory information about the rate of mRNA expression, is thwarted by numerous sources of noise. A great amount has been learned and conjectured in the last decade about the extent to which the form of a network — specified by the connectivity and sign of regulation — constrains or guides the networks function — the particular noisy input-output relation(s) the network is capable of executing. In parallel, a great amount of research has sought to elucidate the role of inescapable or 'intrinsic' noise arising from the finite copy number of the participating molecules, which sets physical limits on information processing in small cells. I'll discuss how information theory may help illuminate these topics by providing a framework for quantifying function which does not rely on specifying the particular task to be performed a priori, as well as by providing a measure for the extent to which form follows function. En route I hope to show how stochastic chemical kinetics, modeled by the (linear) master equation describing the probability of copy counts for all reactants, benefits from the same spectral approaches fundamental to solving the (linear) diffusion equation.