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Physical Limits to Biochemical Signaling[1]

SIMA SETAYESHGAR, Department of Physics, Indiana University

Many crucial biological processes operate with surprisingly small numbers of molecules, where the impact of noise associated with these small numbers is potentially significant. Over twenty–five years ago, Berg and Purcell [1] showed that bacterial chemotaxis, where a single celled organism must respond to small changes in concentration of chemicals outside the cell, is limited directly by molecule counting noise, and that aspects of the bacteria's behavioral and computational strategies must be chosen to minimize the effects of this noise. We revisit and generalize their arguments to estimate the physical limits to biochemical signaling, where a ligand interacts with its receptor or cluster of receptors within the cell, and argue that recent experiments are consistent with performance approaching these limits [2].

[1] H. C. Berg and E. M. Purcell, *Biophysical Journal* **20**, 193 (1977).
[2] W. Bialek and S. Setayeshgar, *Proc. Natl. Acad. Sci.* **102**, 10040 (2005).

[1]This work is in collaboration with Prof. William Bialek at Princeton University.