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Precision of multicellular gradient sensing with cell-cell communication ANDREW MUGLER, Department of Physics and Astronomy, Purdue University, ANDRE LEVCHENKO, Department of Biomedical Engineering and Yale Systems Biology Institute, Yale University, ILYA NEMENMAN, Departments of Physics and Biology, Emory University — Gradient sensing underlies diverse biological processes. In principle, bigger "detectors (cells or groups of cells) make better sensors, since then concentrations measured at the front and back of a detector are more different, and the gradient can be determined with higher precision. Indeed, experiments have shown that populations of cells detect gradients more precisely than single cells. However, this argument neglects the fact that information must be communicated between different parts of the detector, and the communication process introduces its own noise. Here we derive the fundamental limits to the precision of gradient sensing with cell-cell communication and temporal integration. We find that communication imposes its own sensory length scale, beyond which the precision cannot increase no matter how large the cell population grows. We also find that temporal integration couples the internal communication with the external signal diffusion, imposing an additional limit on the precision. We discuss how these limits can be improved by a strategy with two communicated molecular species, which we term "regional excitationglobal inhibition. We compare our findings to experiments with communicating epithelial cells, and infer a sensor length scale of about 4 cells.

Andrew Mugler
Department of Physics and Astronomy, Purdue University

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