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Limits to collaborative concentration sensing in cell populations[1]

SEAN FANCHER, ANDREW MUGLER, Department of Physics and Astronomy, Purdue University — Cells sense chemical concentrations with a precision that approaches the physical limit set by molecular diffusion. Recent experiments have vividly shown that cells can beat this limit when they communicate. We derive the physical limits to concentration sensing for cells that communicate over short distances by directly exchanging small molecules across their membranes (juxtacrine signaling), and over long distances by secreting and absorbing a diffusive messenger molecule (paracrine signaling). In the latter case, we find that the cell spacing that optimizes precision can be large, due to a tradeoff between maintaining communication strength and reducing signal cross-correlations. This leads to the surprising result that paracrine signaling allows more precise sensing than juxtacrine signaling for sufficiently large populations, even though this means that the cells are spaced far apart. We compare our results to recent experiments.

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