Information-theoretic characterization of signal transduction pathways

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BECAUSE of the presence of both intrinsic and extrinsic noise, cells must make decisions based on noisy information. A natural question arises – how efficient are cells in this process? Information theory was developed about 60 years by Claude Shannon as a means of evaluating the transmission of signals across noisy communication networks. In particular, I will use rate distortion theory, a branch of information theory, to determine optimal signal transduction strategies for cells based on imperfect information about their environment. In engineering, rate distortion theory provides the information processing capabilities required to achieve a desired accuracy. We will consider two broad classes of signaling problems. We first consider the problem of optimal gradient sensing in the chemotactic response of cells. In this case, cells sense an external field of chemoattractant and must make a decision as to which direction to move. In our second class of problems we consider the problem of making a binary decision. In this case, cells must choose between two decisions based on whether the concentration of an external signal is above or below a threshold.

Reference:

Andrews BW, Iglesias PA, 2007 An Information-Theoretic Characterization of the Optimal Gradient Sensing Response of Cells. PLoS Comput Biol 3(8): e153. doi:10.1371/journal.pcbi.0030153