Protein gradients in single cells induced by "morphogen"-like diffusion

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Abstract

One of the many ways cells transmit information within their volume is through steady spatial gradients of different proteins. However, the mechanism through which such single-cell gradients form is not yet fully understood. We first demonstrate that one of the models for gradient formation, based on differential diffusion, is limited to proteins with large ratios of their diffusion constants or to specific protein-large molecule interactions. We then introduce an alternative for gradient formation via the coupling of the proteins within a single cell with a molecule whose action is similar to that of morphogens in multi-cell assemblies; the "morphogen" is produced with a fixed flux at one side of the cell. This coupling results in an effectively non-linear diffusion degradation model for the "morphogen" dynamics within the cell; it is the non-linearity that leads to a steady state gradient of the protein concentration. We use a stability analysis to show that these gradients are linearly stable with respect to perturbations.

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