Models of morphogen gradient formation

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The process of cell differentiation is related to the concentration-based positional signaling. Accordingly to this concept, different concentrations of morphogen molecules (ligands) activate distinct intracellular signaling cascades which cause transcription of distinct target genes and thus cell differentiation. There are controversial opinions in the biological literature concerning ultimate mechanisms responsible for the transport of different morphogens. During the talk two models of receptor-mediated morphogen transport in a biological tissue are presented. One basic feature of our approach is that both models are derived as a continuum limit of spatially discrete models. The first model (Model I) concerns intracellular transport of morphogen molecules (transcytosis), while the second (Model II) describes transport along the cell surface. Both models couple via diffusivity a quasilinear degenerate parabolic equation describing the transport of the morphogens with an ordinary differential equation describing reversible binding kinetics of receptors. A detailed study of the steady states is provided for both models. Convergence of solutions to a stable steady state has been recently proved for Model I (SIAM J. Math. Anal. (2008), 1725–1749). Results of numerical simulations are compared with experimental data and demonstrate shaping of morphogen gradients in a realistic time scale.