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Pattern Forming Systems Coupling Linear Bulk Diffusion to Dynamically Active Membranes or Cells

Some analytical and numerical results are presented for pattern formation properties associated with novel types of reaction-diffusion (RD) systems that involve the coupling of bulk diffusion in the interior of a multi-dimensional spatial domain to nonlinear processes that occur either on the domain boundary or within localized compartments that are confined within the domain. The class of bulk-membrane system considered herein is derived from an asymptotic analysis in the limit of small thickness of a thin domain that surrounds the bulk medium. When the bulk domain is a 2-D disk, a weakly nonlinear analysis is used to characterize Turing and Hopf bifurcations that can arise from the linearization around a radially symmetric, but spatially non-uniform, steady-state of the bulk-membrane system. Some results in 1-D coupling bulk diffusion to dynamically active compartments with chaotic dynamics are also discussed. Finally, the emergence of collective intracellular oscillations is studied for a class of PDE-ODE bulk-cell model that involves spatially localized, but dynamically active, cells that are coupled through a linear bulk diffusion field. Applications of such coupled bulk-membrane or bulk-cell systems to some biological systems are outlined, and some open problems are discussed. Joint work with Frederic Paquin-Lefebvre, Sarafa Iyaniwura, Wayne Nagata, and Merlin Pelz