Receptor-Based Models for Pattern Formation and Regulation in Developmental Systems

A. Marciniak-Czochra[1]

Abstract: One of the crucial issues in developmental biology is to understand how coordinated systems of positional information are established during organism's development and how cells respond to them, resulting in the subdivided and patterned tissues of multicellular organisms. We approach the question of mechanisms responsible for formation of new structures and regeneration of missing ones. The test organism for mathematical modeling is a fresh-water polyp, hydra. We propose models based on the idea that patterns are controlled by specific cell-surface receptors, which transmit to the cells signals responsible for their differentiation. We study two mechanisms of pattern formation, diffusion-driven instability and hysteresis-driven mechanism, and demonstrate their possibilities and constraints in explanation of different aspects of self-organization and regeneration. Our studies show that a mechanism arising from the existence of multiple steady states and switches in the dynamics are capable to explain the results of grafting experiments. In the absence of detailed biochemistry, all the existing models for hydra patterning involve hypothetical biological substances. Recently the Wnt signaling cascade moved into the focus of attention and fragments of a candidate receptor-genes were found in the cDNA library. We inquire how the Wnt signaling pathway may be responsible for spatial patterning and how to incorporate processes on the different biological scales (inside the cell) to derive proper reaction terms.

[1] Center for Modelling and Simulation in the Biosciences (BIOMS)
Institute of Applied Mathematics
University of Heidelberg
Im Neuenheimer Feld 294, 69120 Heidelberg, Germany
anna.marciniak@iwr.uni-heidelberg.de