Mathematical Characterization of Morphogenetic Interaction in Early Zebrafish Development

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Abstract

From the fertilization of an egg to the formation of a complex structure, the so-called embryo, cells have to undergo a tightly regulated differentiation process in defined patterns. To coordinate the establishment of these patterns, the embryonic tissue contains a specialized group of cells, which organizes and determines the fate of the surrounding tissue and consequently, regulates the formation of the body plan. These organizers influence the cell fate by regulation of gene expression within the organizer and more important in the surrounding tissue by signaling molecules. Fibroblast growth factor 8 (Fgf8) is one of these important signaling molecules secreted by e.g. the germ organizer and regulating the extent of mesodermal germ layer in early zebrafish development. Sprouty 4 (Spry4) , a target gene of Fgf8, acts as an antagonist of Fgf8 and thereby regulates the activity of Fgf8 at the blastoderm margin. The intention of this diploma thesis is the mathematical characterization of functional interaction of Fgf8 and Spry4 and to develop a guideline for biologists to verify the suggested interaction model. Based on partial differential equations, I propose different activator-inhibitor models which differ in the interaction mechanism of Fgf8 and Sprty4. In addition I include the possibility of a third parameter e.g. the active regulation of Fgf8 degradation or an interacting transcription factor.