The Molecular Control of Cell Movements

during Early Vertebrate Development

Thesis by

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Abstract

The early development of vertebrate embryos is characterized by massive, coordinated cell movements. These movements shape the embryo, distribute different cell types, shape complex tissues, and bring tissues into their correct spatial relationships. We have examined two early cell movements: the dorsal mesoderm of the frog embryo during gastrulation as a model for the coordinated movement of connected sheets of cells and the neural crest in the chicken embryo, as a model for cell migration.

The dorsal mesoderm in the frog embryo moves as a sheet of cells, due to strong connections among the cells. Cell intercalation within this sheet drives the elongation of the embryo during the process of gastrulation, whereby the round, morphologically symmetric early embryo is converted into a tadpole. We have demonstrated the existence of propagating intercellular waves of calcium within the dorsal mesoderm during gastrulation. These waves appear to be specific to the dorsal mesoderm and directly required for the cell movements of gastrulation. To build an integrated picture of how different signaling pathways interact to control gastrulation, we have developed a novel means of quantitatively imaging whole embryos with subcellular resolution. We have used this digital atlas to carefully examine the major events of gastrulation in normal embryos and embryos overexpressing a mutant form of the Disheveled protein.

The neural crest is a transient population of cells in the vertebrate embryo that arises in the neural tube and migrates to give rise to neurons, glia, bone and other cell types. During migration individual neural crest cells make extensive temporary connections with other cells, but migrate as individuals, rather than as a connected sheet. We have used patterned substrates and optical tweezers to present them with carefully controlled molecular stimuli. We have characterized their normal cellular behaviors and their response to ephrin-B ligands in a spatially and temporally defined manner.

Table of Contents

List of Illustrations