Exploring the Generation and Coordination of Forces Shaping the Drosophila Embryo

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Abstract:

My lab is trying to understand the mechanisms that control shape at the cellular and tissue level using fission yeast and the fruit fly *Drosophila melanogaster* as model organisms. In flies we focus on dorsal closure, a wound healing related process, during which a dorsal gap in the embryonic epidermis is closed. Dorsal closure starts with the dorsal-ward convergence of the epidermal cell sheets that flank the gap laterally and it completes with the sequential fusion of cell pairs with corresponding positional identity along the anterior/posterior axis. The initial convergence step involves shape changes of the amnioserosa cells, which cover the dorsal opening. These cells exert a pulling force on the surrounding epidermis tissue. In addition, closure involves the formation of a contractile, supra-cellular band of actin that surrounds the opening like a purse-string.
By combining real-time fluorescence imaging with automated, quantitative image analysis and computer simulations we have analyzed an intriguing pulsing behavior of the amnioserosa cells, which is superimposed on their gradual shape change. We find that cell pulsing is the actual force generating mechanism. The pulsed forces are constitutively displacing the surrounding epidermal cell layers already before dorsal closure starts. However, at this stage the displacement is not maintained as the epidermis relaxes after every force pulse. Dorsal closure only starts with the appearance of the actin band. Our data suggest that this band provides a clutch-like activity, which counteracts epidermis relaxation and thus translates the amnioserosa generated epidermis displacements into net dorsal-ward movement. Finally, our computer simulations propose that this ratchet-like system had to acquire additional mechanisms to optimize and maintain the interplay of these two major forces driving dorsal closure. We in addition analyze the “zippering” process, which creates an additional pulling force to finalize closure. We have shown that transiently rearranged microtubules in the epidermal cells are crucial for zippering. We are now analyzing the mechanism behind this specific microtubule function and have found evidence for a mechanical role in the formation of cellular protrusions.

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