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Epithelial self-organization in fruit fly embryogenesis¹

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During fruit fly embryogenesis, there are several morphogenetic events in which sheets of epithelial cells expand, contract and bend due to coordinated intra- and intercellular forces. This tissue-level reshaping is accompanied by changes in the shape and arrangement of individual cells – changes that can be measured quantitatively and dynamically using modern live-cell imaging techniques. Such data sets represent rich targets for computational modeling of self-organization; however, reproducing the observed cell- and tissue-level reshaping is not enough. The inverse problem of using cell shape changes to determine cell-level forces is ill-posed – yielding non-unique solutions that cannot discriminate between active changes in cell shape and passive deformation. These non-unique solutions can be tested experimentally using *in vivo* laser-microsurgery – i.e., cutting a targeted region of an epithelium and carefully tracking the temporal and spatial dependence of the subsequent strain relaxation. This technique uses a variety of incisions (hole, line or closed curve) to probe different aspects of epithelial mechanics: the local mesoscopic strain; the distribution of intracellular forces; changes in the cell-level power-law rheology; and the question of active versus passive deformation. I will discuss my group's work using laser-microsurgery to investigate two morphogenetic events in fruit fly embryogenesis: germband retraction and dorsal closure. In both cases, we find a substantial active mechanical role for the amnioserosa – an epithelium that undergoes apoptosis near the end of embryogenesis and makes no part of the fly larva – in reshaping an adjacent epithelium that becomes the larval epidermis. In these examples, self-organization of the fly embryo relies not only on self-organization of individual tissues, but also on the mechanical interactions between tissues.

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