Morphogenesis is stressful – Elasticity and Mechanics of Folding Cell Sheets

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Living tissues are intelligent materials that can change their mechanical properties while they develop. In spite of extensive studies in multiple model organisms we are only just beginning to understand these dynamic properties and their role in tissue development. Although many tissues are known to exhibit visco-elastic properties, it is unclear which properties dominate three-dimensional shape changes of cellular monolayers, such as epithelia.

The embryonic inversion process in the micro-algal family Volvocales is uniquely suited for comparative studies on epithelial morphogenesis. Volvocalean embryos consist of cup-shaped or spherical cellular monolayers which invert their curvature in order to expose their flagella. These inversion processes involve a range of species-dependant complexity in terms of both the local cell shape changes and the resulting deformations of the cell sheet. *Volvox globator* exhibits one of the most striking processes of cell sheet folding: The initially spherical embryonic cell sheet adopts a mushroom shape through invagination at the equator, the posterior moves into the anterior hemisphere and the embryo eventually turns itself inside-out through an anterior opening [1]. A combination of time-lapse fluorescence imaging and computational analyses is used to correlate local cellular changes with global topological changes [2, 3]. Laser ablation experiments are used to determine local stresses and the role of the cell sheets' elastic properties during its deformation [4]. Our results indicate that the cell sheet retains its elasticity throughout a period of over an hour while undergoing slow deformations.

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