

## Mechanics of morphogenesis – The re-invention of cell sheet folding

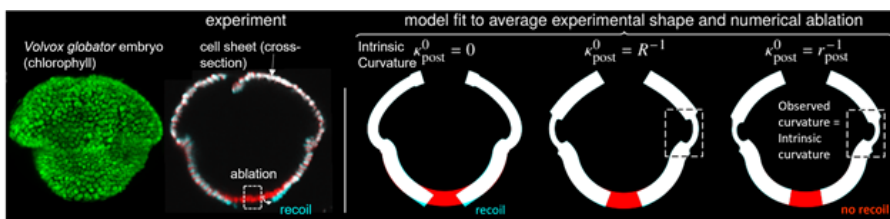
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Mechanical constraints impact the way that organs and tissues develop. Yet, we are only beginning to understand the physical principles that shape tissues. The folding of cellular monolayers, as seen in gastrulation, neurulation and organogenesis, serves as a model for understanding the shaping of three-dimensional tissues. Within the algal family Volvocaceae a range of complexity in cell sheet folding has evolved only 200MYA, providing an excellent model system to study the underlying mechanics. *Volvox globator* embryos consist of a spherical cellular monolayer which turns itself inside-out in a gastrulation-like process called inversion.

We have been using a combination of advanced light sheet and 2-photon time lapse imaging, biophysical perturbations, and mathematical modelling to understand the forces underlying inversion. We found that different ways to turn a sphere inside out have evolved in different volvocacean species, corresponding to deviations in geometrical constraints [1-4]. We have developed a framework to predict out-of-plane forces in dynamic three-dimensional cell sheets. Model-based analyses of orthogonal laser ablations allow us to infer out-of-plane forces and stresses (Fig. 1). [5]. We found that inversion is driven by spatio-temporally concerted changes in cell shapes, cell connections, and tissue properties. Our findings suggest that these green algae have likely evolved mechano-chemical signalling mechanisms, equivalent to those found in the animal kingdom.

### Graphic:



**Fig. 1** Left: The recoil after laser ablation reveals out-of-plane residual stresses. Right: A mismatch between the observed curvature  $\kappa = r^{-1}$  and the intrinsic curvature  $\kappa^0 = 0$  causes these stresses and a recoil upon ablation.

### Keywords:

Morphogenesis, mechanobiology, lightsheet-imaging, *Volvox* inversion

### Reference:

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