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Continuum mechanics of apical constriction — •Chandraniva Guha Ray[1,2,3], Marija Krstic[2,3], and Pierre Haas[1,2,3] — [1]Max Planck Institute for the Physics of Complex Systems — [2]Max Planck Institute of Molecular Cell Biology and Genetics — [3]Center for Systems Biology Dresden

Apical constriction, the contraction of apical cell sides, is a common mechanism driving deformations of biological tissues during development. It is associated with the geometric singularity in which cell cross-sections become triangular and hence the cell sides are maximally bent, splaying the cells and hence bending the cell sheet. Here, we explore the mechanical consequences of this geometric singularity in what is perhaps the simplest problem of tissue buckling: Under external compression, a monolayer of cells buckles, and, as the compression is increased further, fans of triangular cells expand from the crests and troughs of the buckled shape. Taking a continuum limit of a "differential-tension model" describing the cell mechanics [1], we show how these expanding fans lead to a strong increase of the resistance of the tissue to further compression. We reveal an intriguing secondary bifurcation beyond the onset of triangular cells: The buckling amplitude of a thin monolayer increases with increasing compression until the cells touch sterically, but, surprisingly, the buckling amplitude of a thick monolayer decreases with increasing compression. We develop a scaling argument to describe this bifurcation, and discuss its consequences for tissue development.

[1] P. A. Haas and R. E. Goldstein, Phys. Rev. E 99, 022411 (2019)

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