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Buckling thin films with inhomogeneous swelling[1]

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The shapes of many leaves and flowers are determined, at least in part, by their inhomogeneous growth. Additional growth at the edges of leaves, for example, result in saddle-splay curvature and, ultimately, wrinkling. Recent experiments on thin, polymer films imprinted with a predefined pattern of inhomogeneous swelling provide a controlled, experimental playground for describing how swelling-induced buckling leads to a prescribed three-dimensional shape. For example, one expects a sufficiently thin sheet to buckle into a shape that eliminates most of its in-plane strain. Though this is always possible locally, a particular swelling pattern may be either globally frustrated, having no stress-free shapes even for vanishing thickness, or lead to a large degeneracy of stress-free shapes. In both cases, the bending energy remains important even for very thin sheets. I will describe theoretical work on disks and narrow ribbons with swelling-induced, negative Gaussian curvature. Perhaps surprisingly, when the prescribed Gaussian curvature is constant, there are families of stress-free and nearly stress-free shapes, none of which seem to appear in experiments. To understand this behavior, I will identify regimes in which the minimal energy ribbon shape can be determined and discuss the role of stretching and bending energies. We will consider both strips and closed ribbons.

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