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Defect-Mediated Morphogenesis

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It has been a long-standing mystery how complex biological structures emerge during embryonic development from such seemingly uncoordinated building blocks as cells and tissues without guidance. Recent experiments have suggested that misalignment in the collective structure of tissues –the so called topological defects–could play a fundamental guiding role in morphogenesis. Inspired by tentacle development in the Hydra and using a combination of linear stability analysis and computational fluid dynamics we demonstrate that active layers, such as cell monolayers, are unstable to the formation of protrusions in the presence of disclinations. To this aim, we considered a thin layer of active polar gel [1] confined at the interface between two passive and isotropic fluids in a cylindrical geometry to stabilize a +1 topological defect. Under the effect of the active stress, the system generates in-plane vortical flow, consistently with a classic result by Kruse et al. [2]. Importantly, this active flow yet plays a crucial role in driving the active membrane out of its flat configuration and buckle out of plane. Indeed, the buckling instability, analytically predicted here, originates from the interplay between the focusing of the elastic forces, mediated by defects, and the renormalization of the system's surface tension due to the active vortical flow. Finally, to make progress beyond analytical predictions, we support our findings with 3D numerical simulations. First, we recover the predicted instabilities, then we focus on the post-transitional scenario and we find a plethora of complex morphodynamical processes, such as oscillatory deformations, droplet nucleation, and active turbulence [3,4].

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2. K. Kruse, J.F. Joanny, *et al*, Phys. Rev. Lett. 92, 078101 (2004).
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