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Symmetry-breaking in an edgeless epithelium

Abstract

Planar cell polarity (PCP) is a critical determinant of organ morphogenesis. While PCP in bounded epithelial sheets is increasingly well-understood, how PCP is organized in tubular and acinar tissues remains elusive. The *Drosophila* egg chamber (follicle) serves as a simple yet tractable system for studying PCP formation that drive 3D organogenesis. Each follicle is an acinar 'edgeless epithelium' and exhibits a continuous, circumferential PCP that does not depend on pathways active in bounded epithelia. Follicle PCP dictates the formation of an ellipsoid rather than a spherical egg. We have established a novel platform that "unwraps" curved surfaces to quantitate *in toto* follicle PCP and traced the symmetry-breaking event to before the follicle is formed. Microtubules organize PCP in the germarium, providing chiral information that directs whole-tissue rotation as soon as independent follicles bud from the germarium. Concordant microtubule polarity requires the atypical cadherin Fat2, which acts prior to budding to translate plus-end bias into coordinated actin-mediated collective cell migration. Neither Fat2 nor microtubules are required for PCP or migration after follicle rotation initiates, while actin and ECM polarity are, to drive final elongation. Polarized microtubules therefore lie at the beginning of a handoff mechanism that passes early chiral PCP of the cytoskeleton to a supracellular PCP that sculpts the organ.

We have also used this automated platform to map *in toto* the cellular behaviors that break morphological symmetry and drive tissue elongation. This allows us to define polarized cell behaviors, including oriented cell division and rearrangements, that are required to elongate the follicle, including their spatiotemporal distribution and contribution to elongation. Through a genome-wide RNAi screen, we have uncovered several unanticipated genes that translate PCP information to drive cell behaviors for anisotropic growth. Taken together, our results serve as a paradigm to expand the understanding of PCP morphogenesis into complex 3D organs such as those of mammals.

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