# Mechanics of Cellular Polarization in *C. elegans*

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**Asymmetric cell division is a fundamental mechanism for generating cell diversity among embryonic cells. In early C. elegans development, the first mitotic divisions of the embryo display an obvious asymmetry. Prerequisite for dividing asymmetrically is a symmetry breaking event followed by the establishment and maintenance of cellular polarity. In both symmetry-breaking and anterior-posterior polarization the acto-myosin cortex is thought to play a substantial role, facilitating the mechanical segregation of cortical and cytoplasmic fate determinants to the two emerging domains. We are investigating the mechanical properties of the acto-myosin cortex in these two domains of the polarizing C. elegans zygote under wildtype and different RNAi conditions by using laser ablation and life time microscopy, and find that tension and stiffness of the cortex appear to play an important role during this stage of the first asymmetric cell division.**

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DURING their development all multicellular organisms depend on asymmetric cell divisions, since they provide the basis for differentiation and distinct cell fates. The principal process of asymmetric cell division is always the same: a cell first establishes an axis of polarity in response to a symmetry-breaking cue and second segregates cell fate determinants to the two emerging domains. Thirdly, the mitotic spindle aligns along the axis of polarity and is finally cleaved during cytokinesis by an ingressing cleavage furrow. These four single steps pose distinct mechanistic problems to the cell. We are focusing on the mechanical role of the acto-myosin cortex in the first step: the anterior-posterior polarization in the asymmetric cleavage of the single cell stage *C. elegans* embryo.

In the *C. elegans* one-cell embryo, anterior-posterior polarity manifests itself firstly in the contractile polarity of the acto-myosin cortex and the tightly interlinked polarity of the PAR proteins [1,2,3]. Contractile polarity means that the anterior and the posterior cortical domains in the *C. elegans* embryo display different contractile activities: while the anterior cortex shows an accumulation of non-muscle myosin (NMY-2) foci and undergoes ruffling, the posterior cortex is smooth and largely depleted of myosin. This polarity establishment is initiated by a symmetry-breaking event at the posterior pole, and accompanied by an anteriorly directed cortical flow of NMY-2 and associated cytoplasmic granules [4,5].

Using time-lapse imaging of fluorescent fusion proteins under wild-type as well as different RNAi run-down and knock-down conditions, we can systematically explore and characterize these structural dynamics of the cell cortex. Specifically, we are interested in conditions where cortical contractility is altered, such as RNAi depleting effectors of the small GTPase RHO-1, which triggers a signaling cascade regulating acto-myosin activity [6,7].

To experimentally determine the mechanical and tensile state of the cell cortex, we are mechanically perturbing the acto-myosin meshwork in a confined area by means of laser ablation. When severing the cell cortex with a UV laser, the acto-myosin meshwork locally retracts. Through analyzing the initial and decaying velocity of this retraction immediately after ablation, we are able to characterize the elastic response. By perturbing the cortex in different locations, both anteriorly and posteriorly, and under different RNAi knockdown conditions, we can derive quantitative measures for cortical tension and contractile differences that give rise to the polarized cell cortex in *C. elegans*.

We intend to eventually combine the structural-dynamical and mechanical information obtained from these experimental characterizations to develop a physical model of the mechanics of the *C. elegans* cell cortex, based on existing theories on active polar gels and cytoskeletal dynamics [8].

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## REFERENCES

[1] Cowan CR, Hyman AA (2007) Acto-myosin reorganization and PAR polarity in C. elegans. *Development* **134(6)**, 1035-43.

[2] Cowan CR, Hyman AA (2004) Asymmetric cell division in C. elegans: cortical polarity and spindle positioning. *Annu Rev Cell Dev Biol* **20**, 427-453.

[3] Munro EM (2006) PAR proteins and the cytoskeleton: a marriage of equals. *Curr Opin Cell Biol* **18**, 86-94.

[4] Munro EM, Nance J, Priess JR (2004) Cortical flows powered by asymmetrical contraction transport PAR proteins to establish and maintain anterior-posterior polarity in the early C. elegans embryo. *Dev Cell* **7**, 413-424.

[5] Cheeks RJ et al. (2004) C. elegans PAR Proteins Function by Mobilizing and Stabilizing Asymmetrically Localized Protein Complexes. *Curr Biol* **14**, 851-862.

[6] Motegi F, Sugimoto A (2006) Sequential functioning of ECT-2 RhoGEF, RHO-1 and CDC-42 establishes cell polarity in Caenorhabditis elegans embryos. *Nat Cell Biol* **8**, 978-985.

[7] Schonegg S, Hyman AA (2006) CDC-42 and RHO-1 coordinate acto-myosin contractility and PAR protein localization during polarity establishment in C. elegans embryos. *Development* **133**, 3507-3516.

[8] Kruse K et al. (2005) Generic theory of active polar gels: a paradigm for cytoskeletal dynamics. *Eur Phys J E Soft Matter* **16**, 5-16.