CELL BIOLOGY

Live-streaming the cytoplasm

A new approach uses beams of light to direct cytoplasmic flows.

To get around the busy cell, molecules don't just rely on diffusion. Traffic can get swept up in cytosolic movements or take a cytoskeletal path. The study of this bustling transport has been slowed by a lack of good tools. Because genetics cannot be used to introduce rapid and precise local changes, Moritz Kreysing and colleagues from the Max Planck Institute of Molecular Cell Biology and Genetics and the Technische Universität Dresden in Germany have developed a different approach to investigate cytoplasmic flow.

The researchers based their work on previous observations that laser light can generate moving temperature fields in viscous media. Using an infrared laser to locally heat cytoplasm along a scanning axis, they found that they could precisely control the timing, direction and localization of flow within a cell. Perturbations using this focused-light-induced cytoplasmic streaming (FLUCS) system matched the theoretical modeling of thermoviscous flows. Their optical setup allows high-resolution fluorescence imaging in parallel, and to avoid heat stress, they use small local temperature fluctuations while stabilizing global temperatures with a temperature-controlled stage.

After a proof-of-principle demonstration, the researchers focused on embryogenesis in the roundworm *Caenorhabditis elegans*. Asymmetric cell fate decisions often rely on the differential partitioning of cytoplasmic factors before cell division; each daughter cell receives a unique cytoplasmic inheritance that specifies a different fate. The distribution of partitioning-defective (PAR) proteins, for example, is hypothesized to polarize in the zygote because of cortical cytoplasmic flows. Using FLUCS, the research team was able to direct the PAR-2 protein to a specific membrane location, and demonstrated that altered flow is sufficient to repolarize PAR-2 in the worm zygote. Labeling of actin and myosin revealed that induced flows move the entire actomyosin cortex.

The researchers also used FLUCS in combination with genetically encoded fluorescent reporters in the cytoplasm to explore homeostasis in brewer's yeast. They found that both diffusion-based and flow-induced dynamics of the reporters drop when yeast cells are energy depleted, showing that in this low metabolic state, the yeast cytoplasm arrests by entering a gel-like state.

By enabling precise local perturbations, the FLUCS approach expands the opportunities to study transport mechanisms in cells.

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RESEARCH PAPERS

Mittasch, M. *et al.* Non-invasive perturbations of intracellular flow reveal physical principles of cell organization. *Nat. Cell Biol.* **20**, 344–351 (2018).