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Molecular motors and switches in living cells

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Living cells have to organize themselves in space and time, in order to grow, divide, move, and respond to their environment. The interior design of the cell is created by the cytoskeleton, a complex system of protein filaments such as microtubules, and molecular motors. Microtubules are hollow tubes made of the protein tubulin, which serve as tracks for intracellular traffic, form motile whips on the cell surface, and make the mitotic spindle that separates the genetic material during cell division. Microtubules are highly dynamic: a single microtubule in a living cell constantly switches between a growing and a shrinking state [1].

In order to study the role of molecular motors and microtubules in the spatio-temporal organization of the cell, we developed a combined system for nonlinear microscopy, laser nanosurgery, and optical trapping. The system enabled us to visualize and dissect single microtubules and mitotic spindles, as well as to displace the cell nucleus. By applying these techniques to fission yeast cells, we show that the force for mitotic spindle elongation is generated by molecular motors working in the central part of the spindle [2]. Further, microtubule pushing forces center the cell nucleus and the mitotic spindle [3,4]. During the sexual part of the life cycle, on the other hand, molecular motors anchored in the cell membrane exert a pulling force on the microtubules and the nucleus towards either cell end, generating regular nuclear oscillations (Figure 1). We propose a model where different interactions between molecular motors and microtubules with their switching dynamics drive different intracellular movements throughout the cell cycle.

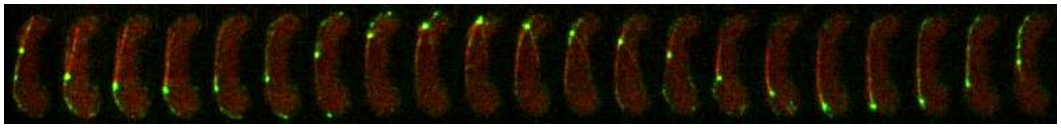

Figure 1. Oscillations of the nucleus during the sexual part of the yeast life cycle. Red filaments: microtubules; green dot: molecular motors (dynein).

References:

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