Microtubule dynamics

Helen Eisenlauer

Microtubule (MTs) are an essential element in cell processes such as cell division, motility, chromosome segregation or motor-mediated organelle transport. The underlying mechanisms of MT dynamics are researched in in vitro experiments as well as through mathematical computational modelling. These listed subcellular processes are enabled through the dynamic instability of the MT-polymers which consist of αβ-tubulin heterodimers (Hemmat et al. 2018).

Implemented computational models try to explain the mechanisms of MT growth, shrinking, catastrophe and rescue.

The dynamic instability in these models is mainly described by 4 parameters. (1) The polymerisation velocity, which shows how fast the MTs grow and (2) the depolymerisation velocity at which the MTs shrink. The parameters (3) and (4) describe the catastrophe frequency at which the MTs switch from growing to shrinking and the rescue frequency at which they switch from shrinking to growing (Kapoor et al. 2019). Elements that influence those parameters are the guanosine-phosphates bound by the αβ-tubulin heterodimers. While the covalent binding of GTP (guanosine-tri-phosphate) establishes a protective cap at the growing ends of the MT filaments, its hydrolysed form GDP (Guanosine-di-phosphate) is a destabilizing factor for the filament.

Others such as Zakharov et al. (Zakharov et al. 2015) state that based on Brownian dynamic simulation not the GTP cap but the rolling on the tip of the protofilaments is the main factor for catastrophe.

Hemmat, M., Castle, B. T., and Odde, D. J. (2018), 'Microtubule dynamics: moving toward a multi-scale approach', *Curr Opin Cell Biol,* 50, 8-13.

Kapoor, Varun, et al. (2019), 'MTrack: Automated Detection, Tracking, and Analysis of Dynamic Microtubules', *Scientific Reports,* 9 (1), 3794.

Zakharov, P., et al. (2015), 'Molecular and Mechanical Causes of Microtubule Catastrophe and Aging', *Biophys J,* 109 (12), 2574-91.