Stochastic model of T Cell repolarization with two immunological synapses

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Cytotoxic T lymphocytes (T) and natural killer cells are the main cytotoxic killer cells of the human body to eliminate pathogen-infected or tumorigenic cells (target cells). Once a T cell has identified a target cell, they form a tight contact zone, the immunological synapse (IS). One then observes a rotation of the microtubule (MT) cytoskeleton and a movement of the microtubule organizing center (MTOC) to the IS. Since the mechanism of this relocation remains elusive, we devise a theoretical model for the molecular motor driven motion of the MT cytoskeleton. We analyze the cortical sliding and the capture-shrinkage mechanisms currently discussed in the literature and compare quantitative predictions about the spatio-temporal evolution of the MTOC position and spindle morphology with experiments. We find that the two mechanisms act synergistically reducing the resources necessary for the repositioning. When two IS are present, the MTOC undergoes irregular transitions between them, dwells in the close proximity of one, or slightly moves around the central position depending on the present mechanisms and the dynein density. We analyze different scenarios and determine the dependency of the dwell times and the transition frequency on the dynein density for both mechanisms.