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A minimal model for kinetochore-microtubule dynamics[1]

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During mitosis, chromosome pairs align at the center of a bipolar microtubule (MT) spindle and oscillate as MTs attaching them to the cell poles polymerize and depolymerize. The cell fixes misaligned pairs by a tension-sensing mechanism. Pairs later separate as shrinking MTs pull each chromosome toward its respective cell pole. We present a minimal model for these processes based on properties of MT kinetics. We apply the measured tension-dependence of single MT kinetics [1] to a stochastic many MT model, which we solve numerically and with master equations. We find that the force-velocity curve for the single chromosome system is bistable and hysteretic. Above some threshold load, tension fluctuations induce MTs to spontaneously switch from a pulling state into a growing, pushing state. To recover pulling from the pushing state, the load must be reduced far below the threshold. This leads to oscillations in the two-chromosome system. Our minimal model quantitatively captures several aspects of kinetochore dynamics observed experimentally.

[1] Akiyoshi et al. (2010) Nature 468, 576.

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