

Cell Protrusion and Retraction Driven by Fluctuations in Actin Polymerization: A Two-Dimensional Mathematical Model

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Many cell types adhered to a 2D surface exhibit protrusion and retraction of their actin-rich lamellipodia even without translation. Traveling waves of protrusion have been observed, similar to crawling cells. The regular patterns of protrusion and retraction allow quantitative analysis for comparison to mathematical models. Excitable actin dynamics have been linked to the periodic fluctuations in leading edge position of XTC cells using a 1D model of actin dynamics [1]. This model was extended into 2D to include movement of a model membrane that protrudes and retracts due to changes in the number of free barbed ends of actin filaments near the membrane. Patterns of membrane protrusion and retraction can be reproduced if the polymerization rate at the barbed ends depends on the local concentration at the leading edge and the opposing force from the cell membrane. Both Brownian ratchet and switch-like force-velocity relationships between the membrane and load forces and actin polymerization rate were investigated. Both models were in qualitative agreement with experiments by the Watanabe group (Kyoto University). However, the switch-like model exhibited sharper behavior. The model generates predictions for the behavior of cells after local membrane tension perturbations.

[1] Ryan GL, Petrocchia HM, Watanabe N and Vavylonis D. 2012. Excitable actin dynamics in lamellipodial protrusion and retraction. *Biophys J* 102(7):1493-502.