Design principles of mechanics and transport in self-polarizing actin-myosin network

Cell motility is based on self-polarizing dynamic actomyosin network adhering dynamically to the surface. Two central questions about this motility are: what is the mechanics of spontaneous cell polarization, and how is actin transported from the rear to the front of the polarized moving cell. I will first present simulations of a 2D model of viscous contractile actin-myosin network with free boundary which, coupled with experimental data, suggests that a positive feedback between myosin aggregation and actin flow and a negative feedback between flow and stick-slip adhesion is the key to understanding self-polarization of fish epithelial keratocytes. Second, I will show that fluorescent microscopy and FRAP combined with mathematical modeling indicates that more than half of actin in the motile cell is not part of the rapidly turning over actin network but is a diffusing fraction of oligomers and monomers, most of which are not available for polymerization. Modeling suggests that such organization of the actin treadmill enables diffusion to recycle actin effectively and makes cell migration steadily, yet prepared for rapid focused acceleration. I will discuss implications of these findings for design principles of cellular self-organization.