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Computational explorations of cellular blebbing

Blebbing occurs when the cytoskeleton detaches from the cell membrane, resulting in the pressure-driven flow of cytosol towards the area of detachment and the local expansion of the cell membrane. Recent interest has focused on cells that use blebbing for migrating through three dimensional fibrous matrices. In particular, metastatic cancer cells have been shown to use blebs for motility. A dynamic computational model of the cell is presented that includes mechanics of and the interactions between the intracellular fluid, the cell membrane, the actin cortex, and internal cytoskeleton. The Immersed Boundary Method is modified to account for the relative motion between the cytoskeleton and the fluid. The computational model is used to explore the relative roles in bleb formation time of cytoplasmic viscosity and drag between the cytoskeleton and the cytosol. A regime of values for the drag coefficient and cytoplasmic viscosity values that match bleb formation time scales is presented. The model results are used to predict the Darcy permeability and the volume fraction of the cortex. Applications of the model to blebbing-based cell motility are discussed.