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Fluid Mechanics of the Red Blood Cell and its Cytoskeleton by an Immersed Boundary Method with Nonuniform Viscosity and Density

THOMAS FAI, Harvard University, CHARLES PESKIN, Courant Inst — The red blood cell cytoskeleton, which is anchored to a lipid bilayer membrane, is an elastic network that helps red cells recover from large deformations as they circulate. Although the cytoskeleton has a convoluted structure, as shown in recent tomographic images, it may be modeled simply as a graph of actin-based junctional complexes (nodes) connected by spectrin polymers (edges). We have developed a discrete cytoskeleton model that incorporates statistical properties of the cytoskeleton, such as the edge length and node degree distributions. A specialized image processing technique is used to gather these distributions directly from tomograms. The network elasticity comes from treating the spectrin polymers as entropic springs, and we show that the spring constant obtained from a well-known model of entropic springs is in reasonable agreement with the experimentally determined shear modulus. By simulating the behavior of red blood cells in shear flow using a variable viscosity and variable density immersed boundary method, we compare this discrete model with its approximately 40,000 nodes to more commonly used continuum ones.

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