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Cellular flow in a small blood vessel JONATHAN FREUND, MARA ORESCANIN, University of Illinois at Urbana-Champaign — In the tubes and vessels with diameters $D < 8\mu$m red blood cells organize into single-file trains. Simulations are used to investigate flow in a model blood vessel slightly larger than this, $D = 11.3\mu$m, for which the cells deviate from this single-file arrangement, deforming continuously and significantly. The effective viscosity of the flow is found to become shear-rate insensitive at higher shear rates ($U/D > 50\text{s}^{-1}$) and to match experimental data. At lower shear rates (down to $U/D = 3.7\text{s}^{-1}$), the effective viscosity increases by over 50 percent. The cell-free layer that forms along the vessel walls thickens with increasing shear rate and is the key factor governing the overall flow resistance. Cells near the vessel wall are on average inclined relative to the wall, as might be expected for a lubrication mechanism leading to its formation. Metrics are developed to quantify the kinematics in terms of the well-known tank-treading and tumbling behaviors often observed for isolated cells. These rates are found to scale with the velocity difference across the cell-rich core and are thus significantly slower than the overall shear rate in the flow.

Jonathan Freund
University of Illinois at Urbana-Champaign

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