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Nicholas Metropolis Award Talk for Outstanding Doctoral Thesis Work in Computational Physics: Computational biophysics and multiscale modeling of blood cells and blood flow in health and disease

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Computational biophysics is a large and rapidly growing area of computational physics. In this talk, we will focus on a number of biophysical problems related to blood cells and blood flow in health and disease. Blood flow plays a fundamental role in a wide range of physiological processes and pathologies in the organism. To understand and, if necessary, manipulate the course of these processes it is essential to investigate blood flow under realistic conditions including deformability of blood cells, their interactions, and behavior in the complex microvascular network. Using a multiscale cell model we are able to accurately capture red blood cell mechanics, rheology, and dynamics in agreement with a number of single cell experiments. Further, this validated model yields accurate predictions of the blood rheological properties, cell migration, cell-free layer, and hemodynamic resistance in microvessels. In addition, we investigate blood related changes in malaria, which include a considerable stiffening of red blood cells and their cytoadherence to endothelium. For these biophysical problems computational modeling is able to provide new physical insights and capabilities for quantitative predictions of blood flow in health and disease.