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Biophysical Consideration in the Interaction of Biological Cell Membranes with Virus Nanofilaments

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Abstract : Biological membranes are constantly in contact with various filamentous soft nanostructures that either reside on their surface or are being transported between the cell and its environment. In particular, viral infections are determined by the interaction of viruses (such as filovirus) with cell membranes, membrane protein organization (such as cytoskeletal proteins and actin filament bundles) has been proposed to influence the mechanical properties of lipid membranes, and the adhesion of filamentous nanoparticles influence their delivery yield into target cells or tissues. The goal of this research is to integrate the rapidly increasing but still fragmented experimental observations on the adhesion and self-assembly of nanofilaments (including filoviruses, actin filaments, as well as natural and synthetic nanofilaments) on cell membranes into a general, rigorous, and unified knowledge framework. The global outbreak of the coronavirus disease in 2020, which has persisted for over three years, highlights the crucial role that nanofilamentbased delivery systems play in human health. This work will unravel the role of a unique property of all cell membranes, namely flexoelectricity, and the significance of nanofilaments' flexibility in the adhesion and self-assembly of nanofilaments on cell membranes. This will be achieved utilizing a set of continuum mechanics, statistical mechanics, and molecular dynamics and Monte Carlo simulations. The findings will help address the societal needs to understand biophysical principles that govern the attachment of filoviruses and flexible nanofilaments onto the living cells and provide guidance on the development of nanofilament-based vaccines for a range of diseases, including infectious diseases and cancer.

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