P-1.141

Glycolipid "islands" and the Cationic "glue": Unraveling Glycocalyx Membrane Organization Via Microsecond Molecular Dynamics and Millisecond Brownian Dynamics

Cristian Popov [1], Marius F. W. Trollmann [1], Leonhard Möckl [1], Rainer A. Böckmann [1]

[1] Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen, Germany

The glycocalyx is a ubiquitous, dynamic extracellular organelle of glycolipids, glycoproteins, and proteoglycans. It is essential for cell-cell recognition, adhesion, and macromolecule filtration, making it an important therapeutic target. In conditions like sepsis, inflammatory shedding increases endothelial permeability and can lead to edema. A deeper understanding of its structure could inform strategies to preserve glycocalyx integrity.

We performed microsecond all-atom molecular dynamics (MD) simulations on complex symmetric membranes containing glycolipids with varying sugar headgroups. Larger headgroups spontaneously clustered, aligning with "island" formation observed by super-resolution iSCAT microscopy. Divalent cations further intensified clustering, acting as molecular "glue" by reducing lipid mobility, particularly for glycolipids with extended headgroups. These findings clarify how headgroup size and cation presence govern membrane organization and dynamics, offering insights into more complex glycocalyx models bridging experiments and simulations.