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Glucose Vitrifies Dehydrated Lipid Membranes

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The interaction of phospholipid bilayers and monosaccharides constitutes one of the most important and fundamental physical relationships in cellular biology, as both elements are ubiquitous to living cells. The physical effects of sugars in bilayer systems have been studied for decades due their membrane stabilization properties. Sugars have been observed to decrease phase transition temperature, thicken bilayers, and promote more fluid structures, all results in support of the hypothesis that sugars allow bilayers to mimic a hydrated state; however, an exact molecular mechanism regarding this interaction is unknown. Notably, the influence of sugar concentration on bilayer properties in dehydrated settings has been hotly debated.

We provide holistic data regarding the position and physical effects of glucose within oriented 1,2-dimyristoyl-*sn*-glycero-3-phosphocholine (DMPC) samples using both X-ray diffraction and Molecular Dynamics (MD) simulations [1]. Glucose preferentially localizes to the outer head region of phospholipid bilayers. At reduced concentrations, it results in an increase in water penetration into the bilayer, increasing lateral diffusion. At high concentrations, it functions to vitrify the bilayer structure, allowing it to adopt a disorganized, fluid-like structure while maintaining a reduced range of lipid motions. These findings corroborate previous results regarding sugar-lipid interactions through a unified molecular mechanism. This supports the evidence regarding the function of sugars as cryoprotective agents, as they promote the retention of fluid-like bilayer properties in environments of reduced hydration in a concentration-dependent manner.

[1] A. Dhaliwal, M.C. Rheinstädter. Exploring the Molecular Mechanism for the Vitrifying Properties of Glucose in Dehydrated Lipid Bilayers Using X-Ray Diffraction and Molecular Dynamics Simulations. In Preparation.

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