Macromolecules on surface control mobility in phospholipid bilayers

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Phospholipid bilayers serve as the framework in biological membranes in which other components are embedded. Fundamental not only in biology, lipid bilayers are also essential in applications such as biosensors and nanoreactors.

Forming a fluid film like the skin of a soap bubble, lipid molecules are free to move around the membrane laterally – like couples on a dance floor. At the same time, however, cellular proteins have to interact in a very controlled fashion with the membrane.

Spatially resolved measurements performed by researchers at the University of Illinois at Urbana-Champaign now show that adsorption of macromolecules of different size can modify the mobility of underlying lipids.

“Understanding what controls the lateral mobility of individual lipid molecules might help us better explain how cell membranes function,” said Steve Granick, an Illinois professor of materials science and engineering, chemistry and physics, and corresponding author of a paper to be published the week of June 20 in the Online Early Edition of the Proceedings of the National Academy of Sciences. The print version will appear at a later date.

To study lipid mobility, Granick and graduate student Liangfang Zhang first supported a bilayer made of a single type of phospholipid molecule on a planar substrate (separated from the substrate by a thin layer of

water several nanometers thick, the lipid molecules were free to move around). This simple bilayer mimicked the much more complex structure of a real cell membrane comprised of hundreds of different lipids and proteins.

Next, the researchers deposited synthetic polymer macromolecules onto the bilayer surface to mimic the roles of membrane-associating proteins. The polymers adsorbed onto the surface, flattening like pancakes and covering hundreds of lipids.

Using a measurement technique called fluorescence correlation spectroscopy, the researchers then recorded lipid movement at different spots on the membrane.

“The measurement method is somewhat like shining a floodlight at one spot on a dance floor, with couples waltzing in and out of the light,” said Granick, who also is a researcher at the Frederick Seitz Materials Research Laboratory and at the Beckman Institute for Advanced Science and Technology. “We shine a near-infrared laser at a very small spot on the bilayer, and watch the motion of fluorescing molecules waltzing in and out of the illuminated region. By analyzing how fast the fluorescence switches on and off, we can measure the rate of mobility.”

Comparing naked regions of bilayer to areas with adsorbed polymers, the researchers discovered that lipids moved slower when situated below a polymer. They also found that the bigger the polymer, the slower the lipids moved.

Individually, the lipid molecules have a very small affinity for the adsorbed polymer, Granick said. “But collectively, if the polymer is large enough, the many lipid binding sites add up to a strong attraction.”

Lipids on both sides of the bilayer moved at the same rate, the

researchers noted. This coordinated movement could mean that in cellular environments, the adsorption of peripheral membrane proteins to the outside of a cell wall may affect not just the mobility of the lipids directly beneath, but also those on the other side of the membrane.

“This process might then enable the subtle, further changes that proteins make on cell membranes,” Granick said. “For example, lipid movement could affect protein distributions in the membrane and influence docking, formation of synapses, and other membrane-mediated functions.”

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