Cell membranes behave like cornstarch and water

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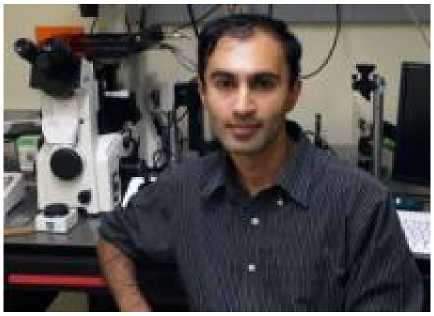

(PhysOrg.com) -- Surprising discovery by physicists at the University of Oregon overturns a long-held belief, and raises fresh new scientific questions about the biology that regulates lipid and protein mobility.

Mix two parts cornstarch and one part water. Swirl your fingers in it slowly and the mixture is a smoothly flowing liquid. Punch it quickly with your fist and you meet a rubbery solid -- so solid you can jump up and down on a vat of it.

It turns out that cell membranes — or, more precisely the two-molecule-thick lipid sheets that form the structural basis of all cellular membranes — behave the same way, say University of Oregon scientists.

For decades, researchers have been aware that biological membranes are fluid, and that this fluidity is crucial to allowing the motions and interactions of proteins and other cell surface molecules. The new studies, however, reveal that this state is not the simple Newtonian fluidity of familiar liquids like water, but rather it is viscoelastic. At rest the mixture is very fluid, but when quickly perturbed, it bounces back like rubber.

The discovery is detailed Oct. 25 in the Early Edition of the *Proceedings of the National Academy of Sciences*, and it strikes down the notion that these biologically important membranes are Newtonian fluids that flow regardless of the stress they encounter.

"This changes our whole understanding of what lipid membranes are," said Raghuveer Parthasarathy, a professor of physics and member of the UO's Materials Science Institute and Institute of Molecular Biology. "We may need to rethink our understanding of how all sorts of the mechanical processes that occur in cell membranes work, like how proteins are pulled from one place to another, how cells respond to stretching and other forces, and how membrane-embedded proteins that serve as channels for chemical signals are able to open and close.

"A lot of these mechanical tasks go awry in various diseases for reasons that remain mysterious," he said. "Perhaps a deeper understanding of the mechanical environment that membranes provide will illuminate why biology functions, or fails to function, in the way it does."

In the project, freestanding membranes of lipids — fatty molecules that form the basis of all cell membranes — were built with lipid-anchored nanoparticles as tracers that could be observed under high-powered microscopes. Close analysis of the trajectories of these particles allowed researchers to deduce the fluid and elastic properties of the membranes under changing conditions.

Leading the experiments were Christopher W. Harland, who earned a doctorate in physics from the UO last summer and is now a postdoctoral researcher at the University of Chicago, and Miranda J. Bradley, then a visiting undergraduate student from Portland Community College and now at Portland State University. Bradley studied in Parthasarathy's lab as part of the UO's Undergraduate Catalytic Outreach & Research Experiences (UCORE) program.

The importance of membrane fluidity has been recognized for decades, but membranes' strange character as a viscoelastic material has gone unnoticed, said Parthasarathy, who is among UO scientists involved in the Oregon Nanoscience and Microtechnologies Institute (ONAMI). "In retrospect, we shouldn't be surprised. Nature uses viscoelasticity in lots of its other liquids, from mucus to tears. Now we've found that it harnesses viscoelasticity in lipid membranes as well."

Provided by University of Oregon

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