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Ending a Debate on Nanoconfided Water

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Ending a debate on nanoconfined water

Identifying water's behavior when confined at the molecular level has been, in the field of nanofluidics, a source of controversy – one that a Wayne State University researcher and his colleagues may have put to an end.

Peter M. Hoffmann, Ph.D., associate professor of physics and materials science in WSU's College of Liberal Arts and Sciences, has found that, at the nanoscale, liquid water transforms into a rubber-like solid when squeezed at a certain rate. The study was featured in *Nature India* and *Physical Review Letters*, with a special *Viewpoint* written by well-known researchers from University of Illinois. Only 100 out of 18,000 papers in journals published by the American Physical Society are selected for a *Viewpoint* review each year. Hoffman's study has shed new light on the nanofluidics debate over the nature of confined water's mechanical properties.

Water, which makes up nearly 70 percent of the human body, is nanoconfined between proteins that make up a cell's organelles.

"Usually the water in our cells is considered a rather static bystander," said Hoffmann. "But water is the most important liquid in the universe because it is the one essential ingredient we need to support life. Knowing how water behaves in tiny channels and tiny spaces is important for the design of future devices that would, for example, probe arterial blood and continually measure blood sugar or other markers."

Hoffmann explored how water reacts when its molecules are gently squeezed at speeds "so slow it would take a few years to just cover a distance of one foot," he said. Yet the impact of this speed, as Hoffmann and his colleagues have proved, alters water's behavior drastically.

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>
> **— Dr. Hoffmann**

A sensitive atomic force microscope (AFM) built by his team made precise nanoscale measurements possible. "When we squeezed water at a speed of 0.8 nanometers per second and beyond until the AFM tip reached the surface, the water suddenly changed from a viscous honey-like liquid to an almost solid-like material that reacted elastically, like rubber," said Hoffmann.

Hoffmann and his team also learned that water spontaneously orders into layers, each as thin as a single water molecule, when confined. To reach this conclusion, Hoffmann constricted water against a flat surface with the tiny AFM tip until the space between the two shrank to a width of only a few nanometers.

"Although the research is fundamental, the discoveries may play a role in how cellular components move and transmit forces, as well as aid in the design of nanomechanical devices," Hoffmann said.

Hoffman's team included Shah Khan, graduate student in WSU's physics department, who performed the measurements; George Matei, Ph.D., former WSU graduate student, who built the AFM used in the study; and Shivprasad Patil, Ph.D., former postdoctoral fellow at WSU and current professor of physics at the Indian Institute of Science Education and Research in Pune, India.

To view the *Physical Review Letters Viewpoint,* visit http://physics.aps.org/articles/v3/73.

To view the *Nature India* feature, visit http://www.nature.com/nindia/2010/101015/full/nindia.2010.143.html.

About Dr. Peter Hoffmann:

Dr. Hoffmann received a B.S. in physics and mathematics from Technische Universität Clausthal, Germany, an M.S. in physics from Southern Illinois University, and a Ph.D. in materials science from the Johns Hopkins University in Baltimore. He did postdoctoral research at the University of Oxford in England. He joined Wayne State in 2001.

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