Source: Ohio State University Released: Fri 15-Sep-2006, 16:00 ET

Scientists Get Best Look Ever at Water - Life Connection

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Keywords
WATER MOLECULES PROTEIN FOLDING ENZYME

Contact Information

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Description

No one has ever seen exactly how water molecules interact with proteins – even though water is the essential element for life . . . that is, not until now. The project aims to explain how water helps enable biological functions such as protein folding or enzyme catalysis. But for now, this early result ends decades of controversy on what happens in the microscopic realm where water and proteins meet.

Newswise — No one has ever seen exactly how water molecules interact with proteins – even though water is the essential element for life . . . that is, not until now.

Researchers led by Ohio State University physicist Dongping Zhong revealed these interactions for the first time, and report the results in the current issue of the *Proceedings of the National Academy of Sciences*.

Proteins are complex molecules that form the main support structure for plant and animal cells, and they also regulate biochemical reactions.

Zhong's project aims eventually to explain how water helps enable life-supporting biological functions such as protein folding or enzyme catalysis. But for now, this early result ends decades of controversy on what happens in the microscopic realm where water and proteins meet.

The controversy, Zhong explained, stemmed from the fact that researchers across different disciplines used different methods to study the problem. Because of that, they got different answers on the speed with which these essential biochemical reactions take place.

"A biologist will tell you that water and proteins must interact on a nanosecond [one billionth of a second] time scale, because that's how fast proteins move," he said. "And a physicist will tell you that the interaction would happen much faster -- on the picosecond [one trillionth of a second] time scale -- because that's how fast water molecules move. And someone who uses X-rays will give you a different answer than someone who uses nuclear magnetic resonance and so on."

"My feeling is that there is no real controversy -- everybody is just looking at the same answer from different angles," he added.

The answer, revealed in Zhong's lab: water molecules do move fast on their own, but they slow down -- to a speed midway between the nanosecond and picosecond scale -- to connect with proteins.

Zhong, an assistant professor of physics, used ultra-fast laser pulses to take snapshots of water molecules moving around a protein taken from a common bacterium, Staphylococcus.

The key to getting a good view of the interaction was to precisely locate an optical probe on the protein surface. They inserted a molecule of the amino acid tryptophan into the protein as a probe, and measured how water moved around it -- a technique Zhong began to develop when he was a postdoctoral researcher in Nobel laureate Ahmed Zewail's lab at the California Institute of Technology 5 years ago.

Laser studies of the protein while it was immersed in water revealed that far away from the protein -- in a region Zhong called "bulk water" -- the water molecules were flowing around each other at their typically fast speeds, with each movement requiring only a single picosecond.

But the water near the protein formed several distinct layers. The outermost layer flowed at a slower speed than in bulk water, and the innermost layer even slower. In that innermost layer, each movement of a water molecule to connect with the protein required at least 100 picoseconds to complete.

So when it comes to supporting life -- on the molecular scale, anyway -- water has to move 100 times slower to get the job done.

"The fast-moving water has to slow down to connect with a slow-moving protein -- it's that simple," Zhong said.

"It sounds trivial, I know. But it should be trivial.

"It's an essential biological interaction that has to work just right every time. If the water moved too slowly, it could get in the way of proteins trying to meet -- it would be a bottleneck in the process. And if it moved too fast, it couldn't connect with the protein at all. So I think this is nature's way of getting the interaction just right."

Zhong and Zewail's coauthors on the paper included Weihong Qiu, Ta-Ting Kao, Luyuan Zhang, Yi Yang, and Lijuan Wang of Ohio State and Wesley E. Stites of the University of Arkansas. Zhong is now working with Ohio State chemist Sherwin Singer to create computer simulations of protein-water motions based on these results. That work is being done at the Ohio Supercomputer Center.

This work was supported by the Petroleum Research Fund, the Packard Foundation, the National Science Foundation, and the National Institutes of Health.