A little magic provides an atomic-level look at bone

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(PhysOrg.com) -- A new study using solid-state NMR spectroscopy to analyze intact bone paves the way for atomic-level explorations of how disease and aging affect bone. The research by scientists at the University of Michigan is reported in the Dec. 2 issue of the *Journal of the American Chemical Society.*

"If people think of bone at all—and they usually don't, until they have a fracture—they think of it as an inert material," said Ayyalusamy Ramamoorthy, professor of chemistry and of biophysics. "But like everything else, bone is also made up of molecules whose behavior is reflected in its structure, toughness and mechanical strength, making bone really exciting in terms of its chemistry and its contribution to health and well-being,"

As scientists strive to understand the human body and its diseases in terms of molecular behavior, bone presents a challenge to most analytical techniques. "However, solid-state NMR spectroscopy is an ideal tool for exploring what goes on inside bone at nanoscopic resolution," Ramamoorthy said. "It is possible to probe the structure and dynamics of individual molecules that constitute bone without any physical damage or chemical modification."

But while solid-state NMR spectroscopy is capable of revealing complete nanoscopic details of molecular events from most samples, it often provides so many details that they're difficult to tease apart and analyze. Ramamoorthy, whose children are fans of the Magic School

Bus science series, challenged his lab group to find ways of "driving around" to explore the interior of bone, just as characters on the series might in their imaginary world. The researchers' real-world approach involved a different kind of magic.

Ramamoorthy and colleagues used a variation of solid-state NMR (nuclear magnetic resonance) spectroscopy called magic-angle spinning, a non-invasive technique that makes solid material as amenable to analysis as solutions are. Previous NMR studies have used pulverized bone, but the U-M group's instruments and methods made it possible to analyze a sample of intact cow bone. The bone sample was shaped to just fit the rotor that is spun at the so-called magic angle inside the probe of a solid-state NMR spectrometer.

With this technique, the researchers examined changes that occur in bone with water loss. The water content of bone tissue decreases with age, which—by affecting both collagen and minerals—reduces bone's strength and toughness.

"We were able to see dynamical structural changes with the main protein, collagen," Ramamoorthy said. "Its characteristic triple helix structure was not completely damaged, but its mobility was altered, in addition to a disorder in the structure."

The success of the study makes possible future research into how bone's constituents behave under different conditions.

"We'd like to look at how bone changes at the atomic level, as a function of aging," Ramamoorthy said, "and to make comparisons between diseased and healthy bone." Such studies may provide insights into the susceptibility of bone to fracture, especially in the osteoporotic tissues of many elderly people.

Ramamoorthy's coauthors on the paper are postdoctoral fellows Peizhi Zhu and Jiadi Xu, graduate student Nadder Sahar, chemistry professor Michael Morris and David Kohn, professor of biomedical engineering and of dentistry.

Provided by University of Michigan (news : web)