Researchers exploring collagen growth

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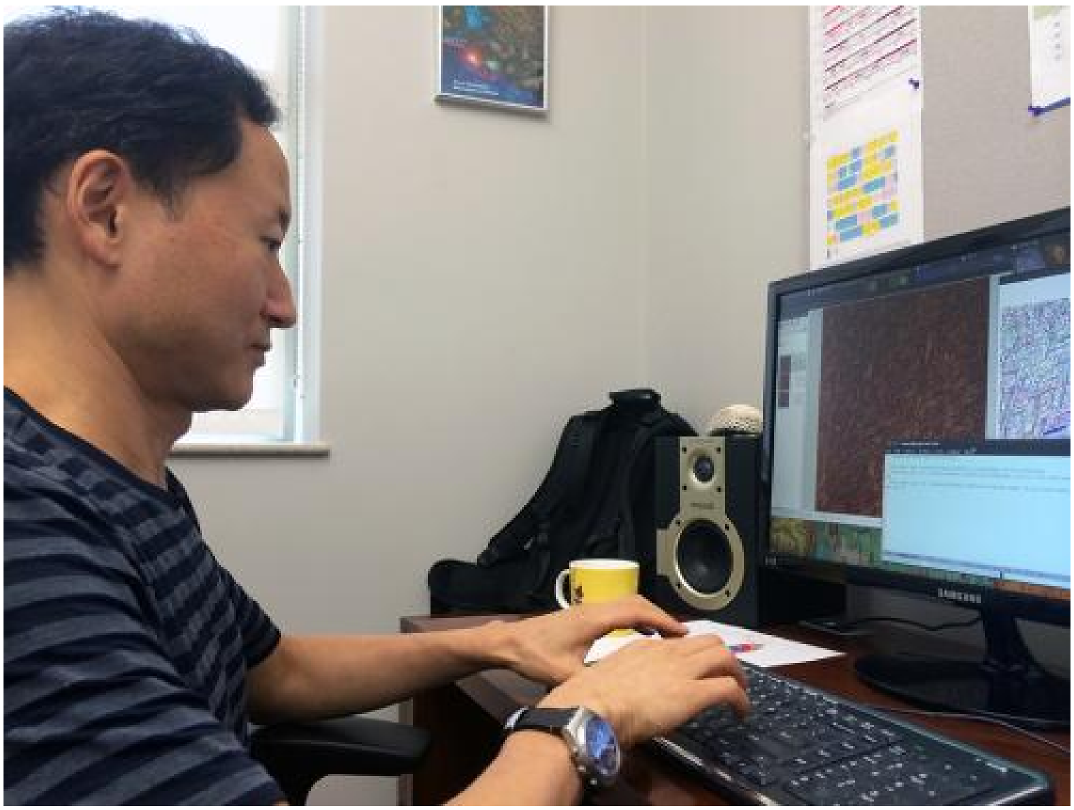

Wonmuk Hwang

Research by a biomedical engineer at Texas A&M University is shedding light on how collagen grows at the molecular level and helps form a diverse set of structures in the body, ranging from bone, tendon, blood vessels, skin, heart and even corneas.

Employing a computational model as well as a newly developed computer program, Wonmuk Hwang, associate professor in the university's Department of Biomedical Engineering, has been able to distinguish molecular-level differences in complex collagen networks formed under different conditions. His findings are featured as the cover story for the scientific journal *Physical Review Letters*.

Collagen, while popularly known for its cosmetic uses, is the most abundant protein in the human body. As the main structural protein in connective tissues, it is found in tendons, ligaments and skin. It's also abundant in corneas, cartilage, bones, blood vessels and teeth. Hwang's research is investigating how collagen forms such a diverse range of materials. Specifically, he's examining how collagen fibrils assemble into ordered networks on surfaces.

The surface assembly of collagen, he says, is particularly relevant to biomedical engineers who are looking to use collagen-based coatings on implantable medical devices in order to prevent the devices from being rejected by the body's immune system.

"We are comparing the differences in collagen-formed structures," Hwang said. "What are the real differences between these molecules from different parts of the body? What differences exists in collagen that has formed bone and collagen that has formed the cornea? If you study this at the molecular level, you can begin to see the differences. Our research aims at providing a quantitative, detailed analysis of these differences."

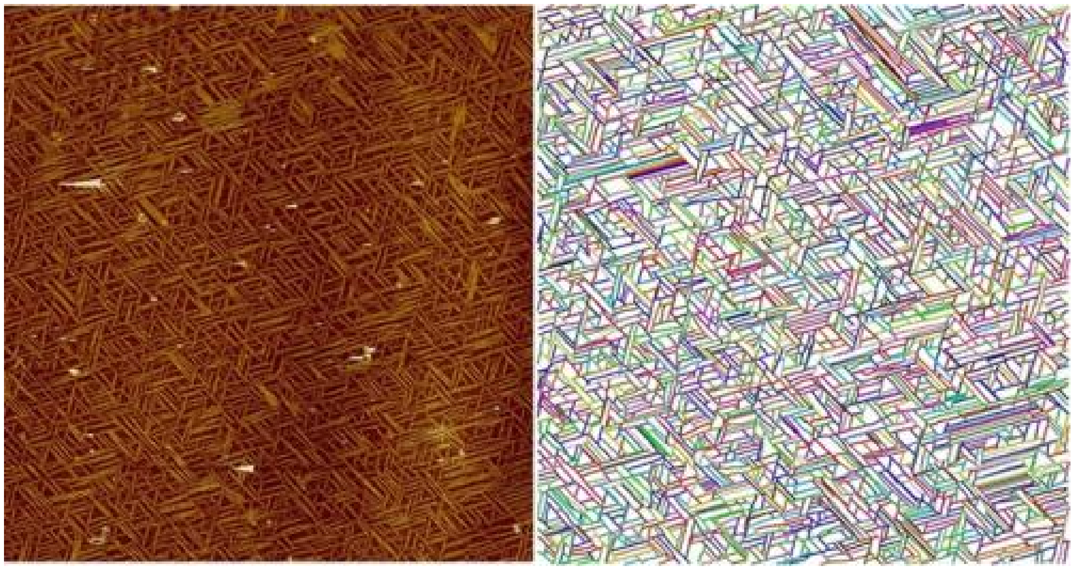

Image of a fractal-like network of collagen fibrils (left) and the corresponding computational model (right), with individually recognized fibrils colored randomly.

As part of his research, Hwang found that collagen fibrils assemble into an intricate network of triangular shapes in which larger shapes are filled with smaller ones, iteratively. This type of structured network is characterized by scientists as fractal, he explained. Fractal patterns, he says, aren't unique to collagen; in fact, they occur throughout nature, such as in river networks, clouds, seashore lines and mountains. Similar networks even occur among the light-carrying nanofibers of optical-based electronics.

To explain this widely observed phenomena, Hwang developed a theory and computational model for the network formation process that allowed him to accurately predict and simulate the growth process. Hwang tested his models against actual collagen networks with the aid of a computer program he developed known as CAFE, or Computer-Aided Feature Extraction. CAFE can recognize individual fibrils in images of complex collagen networks, Hwang explains.

By combining both the model and CAFE, it is possible, Hwang says, to precisely distinguish different networks formed under slightly different experimental conditions, similar to distinguishing between two paintings that may look alike but have subtle differences. That's an important milestone in scientists' efforts to understand collagen and its versatility.

"With this program [CAFE] we can measure filament lengths and orientations in a complex image," Hwang explained. "This is important because once we have this quantitative information we can have a direct comparison with simulations. We can simulate a network with the parameters and qualities of a real collagen network.

"When it comes to collagen formation, we need to understand what happens at the molecular level, and we need to be able to do this in a measurable way, quantitatively, to better understand how collagen grows and differentiates. The guided framework that has resulted from both this theory of collagen growth as well as the validation of our simulations provided by the CAFE program is helping achieve this goal."

Provided by Texas A&M University

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