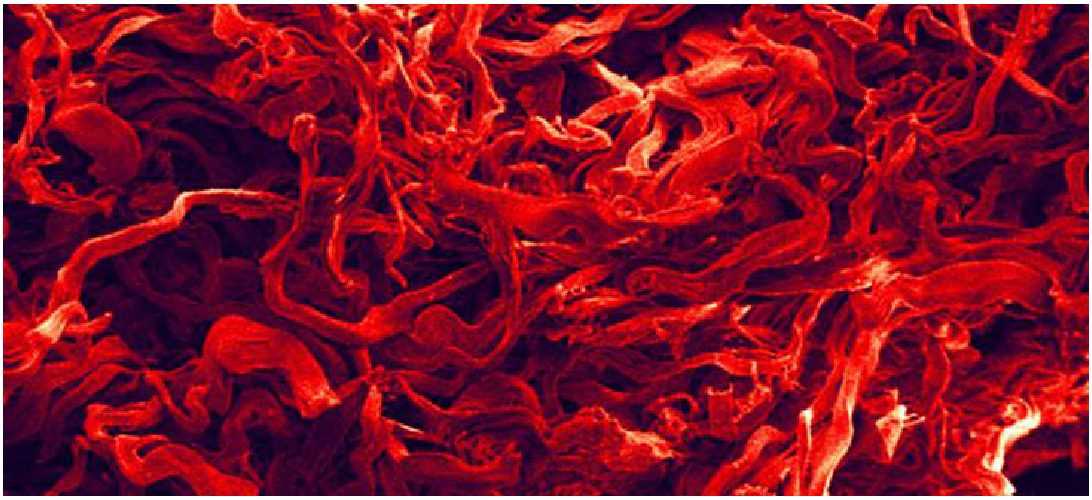
Tuesday, May 05, 2015

INSIDE SCIENCE NEWS SERVICE

The Skinny On Skin



Collagen in its twisted, curly form with no skin stress.

Image credit: The Jacob School of Engineering at UC SD

What makes skin so tough?

Originally published: May 4 2015 - 11:45am

By: Lisa Marie Potter, Contributor

(Inside Science) -- Skin has to be flexible enough to jump, crawl, and kick with us. It also has to be resilient enough to withstand our falls, scrapes, and cuts. Scientists have marveled at skin's strength for years without knowing why it's so durable.

Now, scientists have identified the mechanical properties that give skin its toughness. Their findings are the first to show that collagen, the most abundant protein in skin, moves to absorb stress and prevent the skin from tearing. In the future, this knowledge could help us use nature's blueprint to make better synthetic skin and improve the strength of man-made materials.

"[Skin's] tear resistance is remarkable," said the study's co-author Robert Ritchie, a professor of engineering at the University of California, Berkeley and Lawrence Berkeley Laboratory. "Quite frankly, what surprised me is that we couldn't break the stuff to begin with."

The secret weapon lies in the dermis, the thickest of the skin's three layers. This middle layer mostly consists of strong tendrils of collagen. The article, published last month in *Nature Communications,* described how collagen's structure allows it to efficiently distribute pressure and prevent tearing.

"What's happening is the collagen is moving in such a way to absorb energy and carry more load," said Ritchie. This happens in distinct mechanical stages.

Collagen is made up of tiny protein strands bundled together into long fibers that twist randomly across the dermis. When something pulls on the skin, all the fibers rotate in the same direction toward the point of stress. As the tension increases, the fibers straighten, similar to the way a telephone cord stretches out when you pull it, said Ritchie. If the tension continues to increase, the large collagen fibers break into its component tiny strands, which slide apart to disperse the energy and prevent the stress from concentrating in one area.

The mechanical properties are so effective that they prevent an existing cut from spreading.

Even when researchers cut notches at the edges and middle of strips of rabbit skin and pulled and pulled, the notches yawned open, but the skin remained very difficult to tear. This is a rare quality in a material, said Marc Meyers, a professor of materials science at the University of California, San Diego and co-author of the study.

"Anything you can imagine — a piece of paper, rubber — you put a notch in it and it tears," said Meyers. Skin has evolved to be so tough because of the consequences if it fails, he said. "It makes a lot of sense because in these rabbits if the skin tears, it will be a disaster for the animal."

The researchers could measure the collagen at each mechanical stage in real time using an ultra-sensitive machine, called the synchrotron X-ray. The collagen scatters the X-ray light, which allows the scientists to follow the direction of the collagen while increasing the strain of the skin sample, said Ritchie. The synchrotron can detect the amount of strain on each individual collagen fiber throughout the experiment, said Ritchie.

Researchers confirmed the findings from the synchrotron by repeating the experiments in a scanning electron microscope. The SEM shot electrons at thin slices of rabbit skin, which allowed the scientists to actually see how the individual collagen fibrils reacted under increasing levels of stress.

The researchers also developed a new steel wire model of collagen that better represents the geometry of the real-life material, said Vincent Sherman, a graduate student in Meyers' lab and co-author of the article.

"The success of this work is that they weren't just looking at the behavior of the skin, but they used very sophisticated analysis tools to look at why this behavior occurs," said Markus Buehler, professor of civil and environmental engineering at Massachusetts Institute of Technology in Cambridge. He was not involved in the study.

The study built a general picture of skin resistance and the next step is to go into greater depth, said Meyers. The team will soon collaborate with researchers from Cambridge University in the U.K. to see how skin responses change when it is pulled really fast. They also plan to study resistance in skin more similar to humans, such as pig's skin.

"The pig is very similar in beauty and personality as humans, so that would be a very good simulator of the human skin," Meyers joked.

Their research is part of a growing field of biologists and engineers looking to nature for insights into improving man-made materials, said Ritchie.

The study's insight into skin resistance has some obvious applications. It could help make synthetic skin more life-like, although Meyers warns that more work is needed to truly copy real skin. Skin regulates humidity, temperature, and protects from ultraviolet light, said Meyers.

"Skin has so many functions and we are just dealing with one here," he said. "It's a really complex problem."

As an avid diver, Sherman hopes one day his research will build wetsuits that are more comfortable and fit as well as skin.

"If you could make it out of the material more like our actual skin, it will be many times better," he said.

The mechanical properties of skin have less obvious applications, like flexible electronics, said Richie.

Applying our understanding of the skin’s structure to synthetic materials is not as easy as it seems because natural materials interact at many scales, said Ritchie.

“Unlike electrical materials where you can invent a new chip or device in a lab and it's in an iPhone within a year,” said Ritchie. “In structural engineering it takes decades.

Lisa Marie Potter is a science writer based in San Francisco, California. She tweets at @Lisa_M_Potter.

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