Liquid crystal bridges silk-spinning gap

It's a silken storyline with several threads still missing. When protein-rich droplets squeeze through tiny pores on the abdomen of a silkworm or orb-weaving spider, they have nearly the consistency of water. But somehow, the creature manages to spin these silk-gland secretions into fibers strong enough to support several times more weight than an equivalent strand of steel.

Scientists have now begun to unravel the mystery behind this material metamorphosis.

New studies with polarized light reveal that the protein-rich droplets pass through a brief interim phase, taking on a semi-ordered structure known as a nematic liquid crystal, before they develop into silk fibers. The rod-like alignment of molecules in the liquid crystal – a state halfway between the strict ordering of solids and the chaos of normal fluids – gives the droplets sufficient backbone to form fibers when stretched by the spider or silkworm, says Christopher Viney, a biomaterials engineer at the University of Washington in Seattle.

Viney likens the protein molecules to matchsticks embedded in Jell-O. If the matchsticks have a random orientation, they will resist forming a sturdy framework for the material. "But if you have [already] aligned the matchsticks with the direction of the applied force, you can create a strong, stiff structure," he says.

Viney and graduate student Keven Kerkam, together with collaborators from the Army Research, Development and Engineering Center in Natick, Mass., report their research findings in the Feb. 14 NATURE.

The discovery confirms earlier speculation that the droplets undergo a structural change that allows rapid formation of dragline silk at normal pressures and temperatures, Viney says. The work rules out other proposed explanations for fiber formation, including the suggestion that adjacent protein molecules develop cross-linking structures as a way to establish a more orderly alignment, he adds.

The researchers extracted silk-gland fluids from the orb-weaving spider *Nephila clavipes* and the silkworm *Bombyx mori,* positioning each type of fluid between rotating disks of light-polarizing material. Observations under a microscope revealed that the freshly isolated secretions transmitted light in the pattern characteristic of an ordinary liquid. But as the watery fluid began to evaporate, leaving behind a concentrated solution of protein molecules, the light pattern shifted to that of a nematic liquid crystal. This, says Viney, indicates that the secretions retain a normal fluid structure while inside the silk glands, but begin to change into a liquid crystal as they exit.

He adds that the new finding lends credence to an emerging technique for manufacturing durable fibers by using liquid crystals as the source material, although the artificial process requires harsh solvents or unnaturally high temperatures and pressures. Nature's silk-spinning success under milder conditions suggests a major research challenge, he suggests.

"Where the spiders beat us hands-down is that they [make their fibers] under very reasonable conditions," Viney says. "We want to find out how on Earth they can do this – not in sulfuric acid, but in water; not at a temperature of 200°C and a pressure of 4 atmospheres, but at whatever the conditions happen to be outside today."

– *R. Cowen*

Michael H. Robinson, Nat'l Zoological Park

Orb-weaving spider Nephila clavipes.

Ultrasound 'eye' scans organs from within

A pinhead-sized ultrasound device, threaded through body passages with a catheter, provides inside views of anatomic cavities, depicting these hard-to-image regions in two and three dimensions, reports radiologist Barry B. Goldberg.

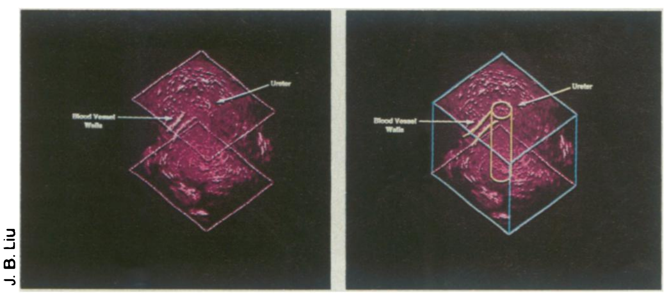
Using a television screen, Goldberg displayed his preliminary 3-D images publicly for the first time last week at the annual meeting of the American Association for the Advancement of Science in Washington, D.C.

The tiny ultrasound transducer, initially developed for detecting plaque buildup inside arteries, could help reveal abnormalities within a variety of passageways such as the ureter, fallopian tubes and bile ducts, Goldberg suggests. These inner recesses are difficult to picture with conventional ultrasound techniques, which use much larger transducers and which view body tissues from the outside looking in, he says.

"We see beyond the [tissue] surface," Goldberg says. "We are able to picture abnormalities that before were very difficult to see by any other method."

In the January AMERICAN JOURNAL OF RADIOLOGY, he and his co-workers at Thomas Jefferson University in Philadelphia reported using the novel device to obtain 2-D images from the inside of the ureter, the tube linking the bladder and kidneys. The images, they say, pinpointed nearby problem areas – including kidney stones and a blood vessel pressing on the ureter – not seen during examinations with an endoscope, an optical instrument that provides surface views when inserted into body passages. Goldberg speculates that 3-D versions of such images will prove even more useful than the 2-D pictures.

When the transducer reaches its target site in the body, it sends out sound waves and receives them as they bounce back from nearby tissue layers. The transducer rotates 360 degrees to create a series of 2-D cross sections. For a 3-D image, a computer combines successive cross sections, piling them up like slices of bread in a loaf.



J. B. Liu

Three-dimensional ultrasound images of the ureter reveal a blood vessel interfering with urine flow from the kidneys to the bladder.

Unlike magnetic resonance imaging or CAT scans, the ultrasound 'eyeball' could easily be inserted during surgery to depict abnormalities embedded within tissue, Goldberg says.

Eric vanSonnenberg, an ultrasound researcher at the University of California, San Diego, says 2-D imaging of tubes such as the ureter holds promise but needs more evaluation to compare its clinical potential with that of other approaches. As for 3-D imaging, "it may turn out to be useful," but practical applications remain speculative, he cautions.

Goldberg agrees that his experiments have yet to establish the clinical advantages of the new 3-D views, but he suggests the added dimension might, for instance, help physicians assess a tumor's size and how deeply it has invaded adjacent tissue, improving their ability to make treatment decisions.

– *W. Gibbons*