Spider silk stretch and strength

A plummeting spider is caught by its safety line, a length of silken thread remarkable for its resistance to breakage. The silk strand is as strong as nylon and has twice as much stretch. This spider dragline, which is laid down as the animal traverses its environment and which also forms the frame of its web, is just one of several kinds of silk a spider can produce. Although spiders are the silk-production specialists of the natural world, both commercial and scientific interest has focused almost exclusively on silkworms, larvae of the moth *Bombyx mori.* But in the June 7 NATURE, biologists report an analysis of silk of the common garden spider, *Araneus diadematus.* They find that the dragline owes its strength and stretchability to its composite nature. It has stiff, crystalline sections interspersed with rubberlike regions.

Spiders have been studied, and used commercially, far less than silkworms in part because they are difficult to rear in captivity. But once they are captured in the wild it is relatively easy to collect silk, says John M. Gosline of the University of British Columbia in Vancouver, Canada. He and his co-workers M. Edwin DeMont of the University of British Columbia and Mark W. Denny of Hopkins Marine Station in Pacific Grove, Calif., put a spider, which weighs about 50 milligrams, on a cardboard rectangle. Then they bump the spider off, so it hangs suspended by its dragline, which is about a micron in diameter. The researchers then rotate the cardboard, reeling the silk thread as the spider gives itself more and more line. "The spiders are very cooperative," Gosline says. "You can reel in half a mile of dragline in 10 minutes."

The clue to the rubber character of dragline thread is its surprising behavior when wet. When the thread absorbs water it contracts to half its dry length, doubling its volume and increasing its elasticity a thousandfold. These properties suggest that contracted silk is a protein rubber, rather than a stiff solid such as steel. Elasticity depends on two thermodynamic characteristics—internal energy and conformational entropy, Gosline explains. Stretching a stiff spring involves distorting chemical bonds, for instance altering the spaces between atoms in a crystal. In contrast, when rubbers are stretched chemical bonds remain intact, but the stretch decreases the number of possible configurations of a mesh of flexible polymers, thereby decreasing entropy.

About 85 percent of the retractive force of wet spider's silk is due to changes in polymer-chain conformational entropy, the scientists find. They estimate that these rubber, or amorphous, regions make up 60 to 70 percent of the silk thread. They suspect that the rubber and crystalline regions have different subunit sequences, but nobody has yet determined the amino acid sequence of a spider silk.

"The pressure of natural selection is responsible for the creation of these exquisite materials," Gosline says. The pure protein threads are expensive to the spider in terms of its metabolism, but the spider needs a large, strong web to catch food.

Modern makers of synthetic fibers should be impressed by the range of properties attained by silk-producing animals, Paul Calvert of the University of Sussex in England says in an accompanying commentary in NATURE. Silkworm silk is more water-resistant than the spider dragline, but the spider fiber is twice as strong and has a much greater elasticity. He says, "As a general rule it is very hard to increase the strength of a material without also decreasing the extension to break; the way both are improved at once in spider silk, compared with silkmoth [silkworm] silk, is impressive."

In the early eighteenth century a French inventor made some gloves and stockings from spider egg sac silk. The Academy of Sciences of Paris considered the technique and concluded it would take 663,522 spiders to produce a pound of silk and thus was infeasible. But Calvert suggests that fiber makers, rather than directly using spider silk, might learn some tricks from nature's experts. He says manufacturers should be spurred in their efforts to control polymerizations to the point where silklike fibers can be duplicated.

—*J.A. Miller*

Pain drug hurts kidneys

A prescription pain reliever approved last month by the Food and Drug Administration (FDA) for over-the-counter sale can hurt people with impaired kidney function, kidney specialists warn. They say the FDA-mandated package inserts do not do enough to warn prospective users.

The drug, ibuprofen (marketed as Motrin, Rufen, Nuprin and Advil), blocks the release of prostaglandins as aspirin does. The kidneys use prostaglandins to regulate their own activity; ibuprofen can handicap an already impaired kidney.

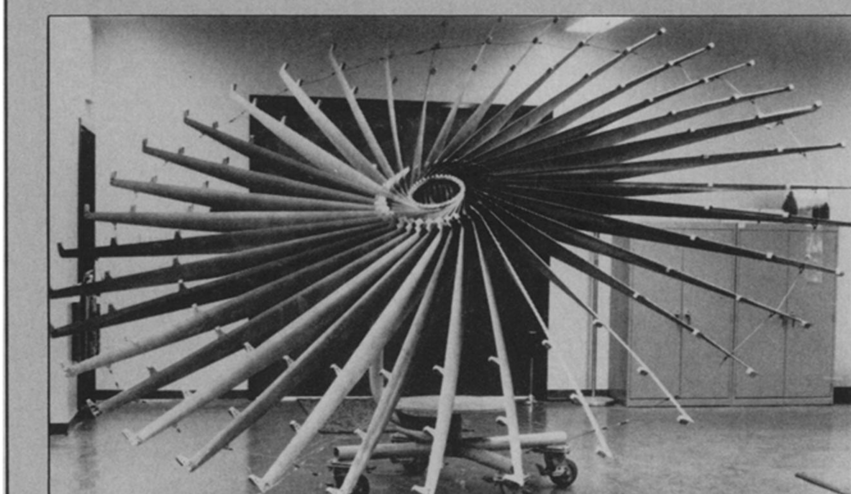
If people with such conditions as diabetes and hypertension "pop two every couple of hours," says Leslie Dornfeld of the University of California at Los Angeles, they could go into acute renal failure.

Dornfeld, who served on the FDA commitee that okayed ibuprofen for over-the-counter sale, says his personal approval came only after he was convinced the package insert would contain adequate warning. But, he says, "I don't think it's coming across clearly."

FDA spokesperson Ed Nida, pointing to exhortations in the insert to consult a doctor, says, "It's probably the most detailed and exquisite over-the-counter drug instruction sheet in existence today."

Concurrently, the Health Research Group, a consumer organization in Washington, D.C., warns that retail stores advertising ibuprofen as an aspirin substitute may cause people with aspirin allergies to falsely believe they can take it. □

DOD's umbrella for a missile shower



Department of Defense

Should intercontinental ballistic missiles (ICBMs) begin to rain, here's what the Defense Department might put up — a pinwheel-shaped structure that unfurls from about the neck of an intercepting missile just before the two projectiles collide. Its roughly 7-foot metal ribs, shaped like framing struts of an umbrella, are seeded with steel weights. This warhead destroys its target — above the atmosphere — by impact. On June 10, a missile armed with the device demolished the "dummy" warhead of an ICBM approaching the Marshall Islands at thousands of feet per second. The interceptor found and homed in on its target by sensing the long-wave infrared (heat) radiation it emitted.