# Silkworms Give Spider Silk New Spin

A research and development effort by the University of Notre Dame, the University of Wyoming, and Kraig Biocraft Laboratories, Inc. has succeeded in producing transgenic silkworms capable of spinning artificial spider silk.

"This research represents a significant breakthrough in the development of superior silk fibers for both medical and non-medical applications," said Malcolm J. Fraser Jr., a Notre Dame professor of Biological Sciences. "The generation of silk fibers having the properties of spider silks has been one of the important goals in materials science."

Until now, only very small quantities of artificial spider silk could be produced in laboratories, and there was no commercially viable way to produce and spin these artificial silk proteins. Kraig Biocraft believed these limitations could be overcome by using recombinant DNA to develop a biotechnological approach for the production of silk fibers with a much broader range of physical properties or with pre-determined properties, optimized for specific biomedical or other applications.

Firm in its conviction, the company entered into a research agreement with Fraser, who discovered and patented a powerful and unique genetic engineering tool called "piggyBac". PiggyBac is a piece of DNA known as a transposon that can insert itself into the genetic machinery of a cell.

Fraser, with the assistance of University of Wyoming researcher Randy Lewis, a biochemist who is one of the world's foremost authorities on spider silk, and Don Jarvis, a noted molecular geneticist who specializes in insect protein production, genetically engineered silkworms in which they incorporated specific DNAs taken from spiders. When these transgenic silkworms spin their cocoons, the silk produced is not ordinary silkworm silk, but a combination of silkworm silk and spider silk.

"We've also made strides in improving the process of genetic engineering of these animals so that the development of additional transgenics is facilitated," Fraser said. "This will allow us to more rapidly assess the effectiveness of our gene manipulations in continued development of specialized silk fibers."

This artificially produced spider silk is stronger and finer than silkworm silk, but not quite as strong as spider silk. "It would definitely be stronger (than a normal silk shirt)," said Lewis. "But it wouldn't flow like silkworm silk does."

"It's a fabulous accomplishment," said Cheryl Hayashi, a spider silk expert and a professor at the University of California, Riverside. Other groups have produced spider silk protein in plants, in bacteria and even in goat's milk. But spider silk protein is not the same as spun spider silk. The silkworms have the necessary body parts to spin the protein into silk threads and to produce it in large quantities.

The new silk alone could shake up the textile industry by creating a softer, stronger fabric that still looks like silk. "But we are confident that, this being our first attempt, we will be able to tweak the system to bring the system closer to the strength of true spider silk." said Malcolm Fraser, a scientist from the University of Notre Dame. Eventually they want to replace multiple silkworm silk-producing genes with spider silk genes.

Since silkworms are already a commercially viable silk production platform, these genetically engineered silkworms effectively solve the problem of large scale production of engineered protein fibers in an economically practical way. "We may even be able to genetically engineer fibers that exceed the remarkable properties of native spider silk," believes Fraser.

## Applications of Spider Silk

Spider silk is widely used in industrial, medical and military applications and even in everyday use. Exceptionally strong and extensible, they make very strong fibres. Their toughness is comparable to that of polyaramid filaments which are used to make tyres, bulletproof clothing and even reinforced composites for aircraft panels. In contrast to the current technopolymers which are based on

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petrochemicals and are detrimental to the environment, spider silk is recyclable and bio-degradable.

On devices such as telescopes and guns, it is used as crosshairs. Some people use it as fishing nets and also for making rust-free panels on motor vehicles or boats. Due to its tensile strength, it has found significant use in making ropes, seat belts, and parachutes.

Silk fibers have many current and possible future biomedical applications, such as use as fine suture materials, improved wound healing bandages, or natural scaffolds for tendon and ligament repair or replacement, making bandages and surgical threads, and manufacturing rip-proof, and light weight clothing.

Spider silk has been spun artificially before. Some of the interesting methods include the conventional solvent spinning of recombinant spider silk protein analogue by Du Pont Ltd and extruding regenerated silk into a coagulation bath using a nanofabricated silicon spinneret. The research is now directed towards improving the spinning technology.

## Properties of Spider Silk

Spider silk is incredibly tough and is stronger by weight than steel. Quantitatively, spider silk is five times stronger than steel of the same diameter. It is almost as strong as Kevlar, the toughest man-made polymer. Finer than the human hair (most threads are a few microns in diameter), it is able to keep its strength below -40°C. The toughest silk is the dragline silk from the Golden Orb-Weaving spider (Nephilia clavipes), so-called because it uses silk of a golden hue to make orb webs.

Spider silk is also very elastic and capture silk (sticky silk for catching prey) remains unbroken after being stretched 2-4 times its original length.

Resistant to tearing, and tougher than steel, spider silk can be used to develop much stronger fibres with much wider range of applications in future. ■

## References


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