A silky spin on protective armor

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Credit: Thinkstock

At seven times the toughness of Kevlar, a silk produced by the *Caerostris darwini* spider of Madagascar is more robust than any other material—synthetic or natural. Most spider silks are about two times tougher than Kevlar, and have long been considered an intriguing alternative for bulletproof vests and other protective gear. There's only one problem: producing spider silk on demand is a tricky task.

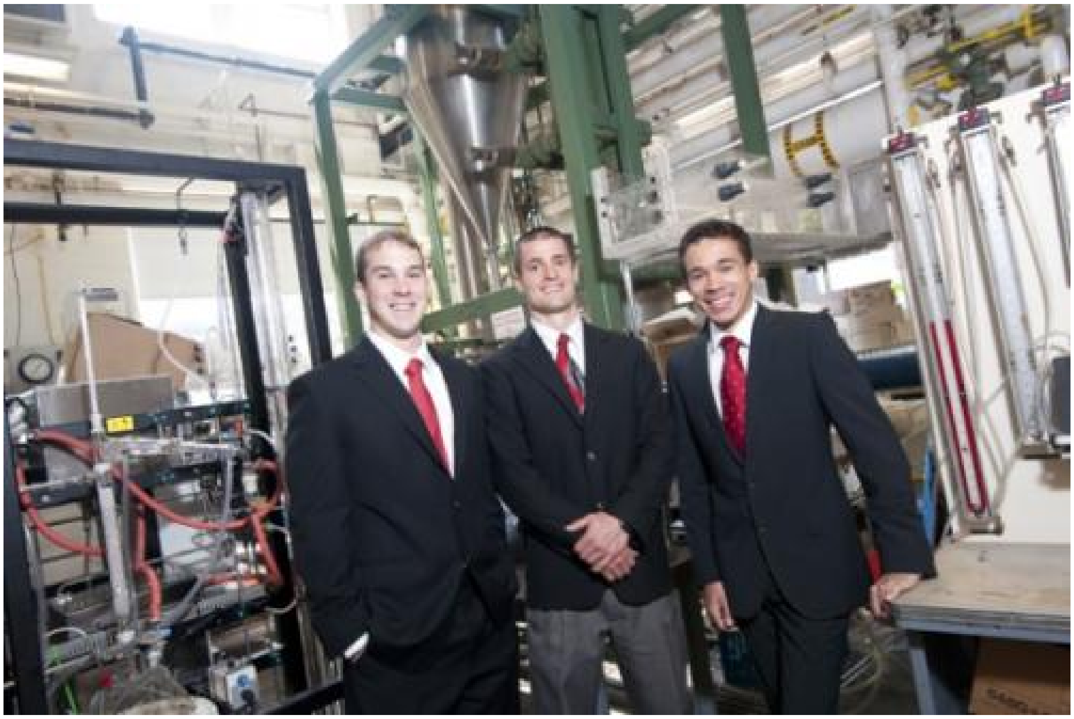
Chemical engineering students Robert Jones, Thomas Khoury, and

Richard Salvucci spent the last semester of their Northeastern undergraduate careers developing a set of solutions that could make C. darwini silk fibers a viable option for industrial-scale manufacturing. The team's project won first place at the New England Bioengineering Conference, where they competed with hundreds of students from dozens of schools including Cornell and Boston University.

The capstone students collaborated with Tufts University professor and spider silk expert David Kaplan to engineer a theoretical method for producing the silk in bacterial cells at currently unmatched concentrations. Previously, researchers have managed to force bacteria like *Escherichia coli* to produce silk, but only in small amounts.

The silk gene sequence is large and highly repetitive and cells have trouble replicating protein from it, said Jones, who focused primarily on the biological side of the project. So the young researchers decided to build their model using a genetically modified *E. coli* strain that more effectively deals with the repetitive silk protein.

They incorporated other mutations into their hypothetical *E. coli* strain to increase its efficiency and protein productivity. But the proteins produced by these bacteria do not represent the perfectly spun fibers of spider silk we're used to seeing, which presented another barrier to industrial-scale production. Salvucci tackled this part of the project, designing a system to spin the protein into fibers and collect them on giant spools like any fiber used in the textile industry.



Richard Salvucci, Robert Jones, and Thomas Khoury won first prize at the New England Bioengineering Conference for their solution to industrial-scale spider silk production. Credit: Brooks Canaday

The trio of students chose to form their fibers using microfluidics; the fibers were only 40 microns thick (less than half the thickness of a human hair). "We're mimicking the biological events that actually occur within the spider," said Salvucci.

The so-called Exo-Spinner Collection system incorporates 10 sets of 15,000 microfluidic devices, enabling it to produce and collect 150,000 fibers at a time. At this rate, the students estimate they could make 100 kilograms of spider silk per day, enough to produce 50 bulletproof vests.

With his sights set on business school, Khoury focused on the economics of the project. Based on a series of assumptions drawn from the current market, Khoury forecasted a demand of 1.5 billion vests per year and believes they could break in at one percent of the market. While the spider silk vest would be significantly more costly than the standard option, the students say it would also be lighter, more comfortable, and more versatile.

They also believe that industrial-scale spider silk production could revolutionize the textile industry as a whole, providing a novel material for products ranging from seatbelts to sailboats. "You're only limited by your imagination," said Khoury.

Provided by Northeastern University

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