Scientists unravel the mysterious mechanics of spider silk

March 1 2011

Scientists now have a better understanding of why spider silk fibers are so incredibly strong. Recent research, published by Cell Press on February 15th in *Biophysical Journal*, describes the architecture of silk fibers from the atomic level up and reveals new information about the molecular structure that underlies the amazing mechanical characteristics of this fascinating natural material.

Spiders spin silk, which is remarkably strong and stretchy, to use in webs and to suspend themselves. "Silk fibers exhibit astonishing mechanical properties. They have an ultimate strength comparable to steel, toughness greater than Kevlar and a density less than cotton or nylon," explains senior study author Dr. Frauke Gräter from the Heidelberg Institute for Theoretical Studies in Germany. "Because silk fibers continue to outperform their artificial counterparts in terms of toughness, many studies have tried to understand the mechanical characteristics of these extraordinary natural fibers."

Scientists know that spider silk fibers consist of two types of building blocks, soft amorphous and strong crystalline components. Dr. Gräter's group wanted to develop a better understanding of the mechanical properties of spider silk fibers and implemented a multi-scale "bottom-up" computational approach that started at the level of the atoms that make up the amorphous and crystalline subunits and dissected the contributions of these building blocks. The group used both molecular simulations for studying individual and coupled subunits and finite element simulations for a comprehensive fiber model.

The researchers discovered that the soft amorphous subunits are responsible for the elasticity of silk and also help with the distribution of stress. The maximal toughness of silk requires a specific amount of crystalline subunits and is dependent on the way that these subunits are distributed in the fiber. Different structural architectures of the fiber subunits were tested for optimal mechanical performance.

"We determined that a serial arrangement of the crystalline and amorphous subunits in discs outperformed a random or parallel arrangement, suggesting a new structural model for silk," says Dr. Gräter. Taken together, the findings provide a clearer understanding of the mechanical nature of spider silk fibers and may be useful for design of artificial silk fibers.

Provided by Cell Press