Genetically Engineered Spider Silk Fiber in Insect Cells

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Scientists from the Hebrew University of Jerusalem and from Germany have succeeded in producing self-assembled spider web fibers under laboratory conditions, outside of the bodies of spiders. This fiber is significantly stronger than the silk fiber made by silkworms.

The achievement by the research team is described in an article in a recent issue of Current Biology. The development opens the way to commercial development of this spider fiber for a variety of applications.

Silk has been in use for thousands of years. However, unlike silkworms, spiders are not subject to domestication and commercial growth in practical quantities. Scientists have attempted to create spider's webs independently of the spider itself through genetic engineering by manufacturing the proteins, which constitute the silk fibers of the webs, through the use of bacteria, yeast, plants and mammalian cells in tissue culture. But these efforts were unsuccessful in producing fibers with properties similar to the natural material.

The Israeli-German scientific team has succeeded, through techniques of genetic engineering, by creating spontaneous production of spider web fiber in insect cell cultures. These fibers were equal in their chemical resistance characteristics to those produced by the spider. Mass production of such fiber in the future, can be used industrially in various areas, which require fine applications. The Yissum Research Development Company of the Hebrew University and German partners are focusing on commercializing the research.

Spider webs consist of fibers (spider silks) produced by specific proteins. In order to artificially synthesize these proteins, the researchers utilized sections of the genes of the garden spider (Araneus diadematus), which are involved in the manufacture of these proteins. The spider spins its web from various types of fibers, including the fiber known as dragline silk, which is characterized by great strength and elasticity. It is six times stronger than nylon and steel fiber of equal diameter, and serves the spider as a "lifeline" in case of falling. This fiber is made up primarily from two proteins, ADF-3 and ADF-4, which are genetically similar and are produced in a gland in the abdomen of the spider. The process by which these proteins pass from the moment of their production until their excretion, as fiber was not understood until now.

In their laboratory experiments, the researchers introduced the genes, which encode the two dragline silk proteins, into an insect-infecting virus, known as baculovirus. These genetically engineered viruses were then grown in cultures of cells derived from a type of caterpillar called the fall armyworm.

Since spiders and insects are both arthropods and since their genomes are more closely related to each other than to those creatures with which prior experiments were conducted, we felt that we would be able to produce spider fibers using these insects," said the researcher. "For this purpose, we developed a methodology for producing great quantities of the appropriate proteins, which is based on infecting the insect cells with the genetically engineered virus, in order to produce the fiber.

After the engineered viruses infected the insect cells, the cells began producing the proteins, and subsequently "spider" fibers spontaneously formed in them. However, - unlike in spiders - these laboratory-produced fibers were made up only of the ADF-4 protein, while the ADF-3 protein
remained dissolved. Nevertheless, these fibers were identical in their diameter to that of real spider fiber and were found to be equal to -- and in certain aspects even exceed -- the chemical resistance quality of the spider-created fiber.

The scientists believe that the variability in the behavior of the proteins they produced as compared to what occurs in nature, shows a high level of sophistication in the spider fibers. It seems that the protein ADF-4 makes it possible for the rapid production of fiber, while the other protein, ADF-3, regulates production and prevents early fiber production, which could be fatal to the spider.

The researchers are now hoping to be able to create conditions, which will make it possible to produce the spider fibers in quantity without the limitations of having to do this within insect cells.

"The research enabled us to determine the close connection that exists between the sequence, structure and functions of the proteins," said Dr. Gat. "From a practical viewpoint, mass production of fibers, whose diameter is one-thousandth of a millimeter, is likely to be useful in the future for manufacture of bulletproof vests, surgical thread, micro-conductors, optical fibers and fishing rods; even new types of clothing may be envisioned."

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