Silk’s Superpowers

by Rachel Ehrenberg

Spider-Man isn’t the only person with an interest in spider silk. While Spidey uses the threads to zigzag from building to building, or to snare a bad guy, scientists are investigating silk for different reasons. And though researchers have learned a lot about silk by investigating spiders, insects such as caterpillars, ants, and bees also have been studied for the sticky stuff. Scientists are even trying to get silk from animals such as goats.

It turns out silk might be good for weaving a lot more than shirts and ties. In the future, the silky fiber might be used to make supertough bulletproof vests and light but strong parachute cords. Silk also might work well for delicate tasks inside the body. Researchers are experimenting with using silk to support growing cells, the same way a construction crew builds scaffolding around a building to help keep everything in its place during construction. Silk might be a good material to give growing cells something to hang on to.

Scientists think silk would be useful for so many things because it is both extremely strong and very elastic—it can be stretched a long way without breaking. Most of today’s strong, elastic fibers are made from petroleum products and there are harsh chemicals in the recipes for these fibers. If scientists can figure out how natural silk makers make their threads, the harsh chemicals might not be needed.

Spider silk is an ideal material, says Randy Lewis of the University of Wyoming in Laramie. “If you can mimic it, you can eliminate an awful lot of the problems you have with all the man-made fibers that are currently available.”

Humans have been gathering silk not from spiders but from silkworms for hundreds of years. Silkworms aren’t worms at all, they are actually caterpillars, or the young, of the silk moth. When it’s time for a silkworm to turn into a moth, the caterpillar spins itself a cocoon out of one very, very long silk fiber. The thread from unraveling a single silkworm cocoon can be 600 to 900 meters long! That’s more than two times the height of the Empire State building!

Long ago, people learned how to raise silkworms together in farms. Silkworms don’t mind being crowded together, as long as they have food, like mulberry leaves. In addition to making a nice fabric for scarves and sheets, silkworm silk is also used by doctors for stitching up cuts. But silkworm silk has its problems. A silkworm covers its
silk in sticky glue that holds the cocoon together. Sometimes humans have a bad allergic reaction to this glue. And silkworms spin only one kind of silk.

Spiders, on the other hand, don’t use a sticky glue. And spiders make many different kinds of silk.

“We love the silkworm,” says David Kaplan of Tufts University in Medford, Mass., who has been studying silk for many years. “But spider silk is so diverse—we want to exploit that.”

Most spiders like to be alone. When they are crowded in one place they sometimes eat each other. This makes it hard to have a “spider farm” for collecting silk. So scientists are studying how spiders make silk, with the hope that the technique can be copied, perhaps even in other animals.

Spiders are one of the oldest groups of animals on the planet—scientists have found fossils of spiders that are 380 million years old. Although they are often mistaken for insects, spiders, along with ticks, mites, and scorpions, are arachnids. Unlike insects, spiders have eight legs, a two-piece body, and usually eight eyes of different sizes and shapes. Spiders don’t have chewing mouthparts. Instead they have fang-tipped jaws called chelicerae that are used to inject digestive enzymes into prey. These enzymes break down prey from the inside out. Humans would be in trouble without spiders—they eat many insects that people consider pests. And spiders are a very diverse group—more than 37,500 species of spider have been described (consider that there are only about 10,000 kinds of birds).

Most spiders have an abdomen made up of five different sections. The last two sections are where the silk-making happens. These sections of the lower belly are modified into special structures called spinnerets, which are sort of like faucets for silk. The silk is mixed in glands and then secreted out of the spinnerets. Spiders can’t shoot silk out for long distances the way Spider-Man does. Instead, they attach the emerging silk to something, like a tree branch, and then move away from the branch. This pulls the silk outward.

One spider usually has several different glands andspinnerets for making several different kinds of silk. In their webs, most spiders use dragline silk for the outer rim and spokes. Strong as steel, dragline silk is also used as a safety line when a spider falls.

*exploit: to use for one’s own purposes
from a high shelf or branch. For the inner part of the web, where an insect such as a buzzing fly might get caught, spiders use an extra sticky silk. They wrap these freshly caught snacks in another silk, called aciniform silk. Spiders use another silk, one that is very stiff, to wrap and protect their eggs.

Even spiders that don’t make proper webs make silk. Scientists recently discovered that tarantulas, which use burrows instead of webs as homes, make silk from spigots on the end of their feet!

The most studied spider silks come from the golden silk spider, *Nephila clavipes*, and the European garden spider, *Araneus diadematus*. A one-inch-diameter fiber made of dragline spider silk could reel a 747 airplane from the sky, says Randy Lewis. The silk is also light and thus an excellent material for things like body armor, parachute cords or even tethering planes to an aircraft carrier.

Spider silks also seem to be useful inside the human body, says Kaplan. For example, scientists have made ultrathin films out of dragline silk that in the future might be used as bandages for dressing wounds. Spider silk is also being used to make porous, or holey, gels and sponges. When placed in these sponges, tissue, bone, and nerve cells are held steady while they grow. These silk sponges will fall apart or degrade gradually, after the cells have been given enough time to grow.

The main ingredients in spider silk are proteins, and there are many different kinds, depending on which spider is spinning and which silk it wants to make. Some of the proteins are very large and complicated, and therefore hard to make a lot of in the lab. So some scientists have put the genes that have the instructions for making silk into other creatures, such as goats. Some of these special silk-making goats live at the University of Wyoming. The silk-making genes are turned on only in the goat cells that make milk, so when these goats are milked, there is silk in the milk. Right now, it is hard to get a lot of silk in the milk, Lewis says. A liter of milk may have only 15 grams of silk, which means it would take about 600 gallons of milk to make one bulletproof vest. At higher concentrations the milk starts clumping, perhaps because the silk proteins are sticking to milk proteins, Lewis says.

Tara Sutherland, of Australia’s Commonwealth Scientific and Industrial Research Organization in Canberra, is focusing on silks made by insects other than silkworms. Many insects make silk, although only one kind each. Sutherland has zeroed in on the silks of bees, wasps, and ants.

“Imagine a hive and each new generation of bees being wrapped in a silken cocoon,”
she says. “If you remove the wax and look where the bees were raised there is silk—beautiful sheets of golden silk.”

The bee silk probably protects the baby bees in the hive, says Sutherland. Bee silk might also add structural support to the hive and prevent the wax from getting so warm that it melts.

Sutherland is also investigating weaver ants, which use silk to stitch leaves into nests. It seems only the baby weaver ants make silk. The adults hold the little larval silk-makers, moving them around for desired silk placement.

The silks made by stinging insects such as bees have a different structure from other silks. It looks like spiraled pasta versus flat sheets of linguini, says Sutherland.

And bee and ant silk is both tougher and more stable than silkworm silk, she says. Though nothing beats spider silk, because bee silk is made of simpler proteins, it might be easier for scientists to make in the large amounts needed to create everyday things for humans.

So watch out villains—Spidey may one day be upstaged by other silk spinners. Here’s to Ant-Man, or The Bee.

1. Which statement summarizes the selection?
   A. Scientists have learned a great deal from their study of silkworms and silk.
   B. Spiders are fascinating and interesting arachnids.
   C. Scientists are just beginning to discover the many uses of spider and insect silk.
   D. Silkworm silk is far superior to that made by spiders.
2 What is the meaning of the word *mimic* as used in the sentence below?

“‘If you can mimic it, you can eliminate an awful lot of the problems you have with all the man-made fibers that are currently available.’”

A break  
B stretch  
C copy  
D sell

3 Based on paragraph 8, what is the meaning of the word *diverse*?

A colorful  
B different  
C similar  
D modern

4 What is the central idea of paragraph 12?

A It is important for spiders to use sticky silk to catch prey.  
B Spiders must use a stronger silk for the outline of their web.  
C It is important to have stiff silk to protect spider eggs.  
D Spiders are capable of creating a variety of silks for different needs.
5. What is the main ingredient in silk?
   A. protein
   B. milk
   C. enzymes
   D. glue

6. According to the selection, why are scientists studying a variety of animal-produced silk?
   A. to find a way to make silk less sticky
   B. to produce a silk without the harsh chemicals in man-made fibers
   C. to discover a silk strong enough to pull a fish from water
   D. to find a way to make the spinning process shorter

7. How will the study of spider silk benefit human cells?
   A. It can be used to replace weak or damaged cells.
   B. It can provide a flexible, porous place for cells to move.
   C. It provides a temporary structure for cells to thrive.
   D. It provides a rigid and permanent home for cells.
8. What is the impact of paragraph 14?
   A. It allows the reader to imagine what a golden spider looks like.
   B. It allows the reader to realize how strong spider silk is.
   C. It informs the reader of the disadvantages of silk made by spiders.
   D. It informs the reader of the scientific name of the garden spider.

9. Which explains the author’s purpose in writing this selection?
   A. to inform the reader that silk might make good vests
   B. to inform the reader about the chemical composition of silk
   C. to inform the reader that different species of spiders spin silk differently
   D. to inform the reader about the different types and uses of silk