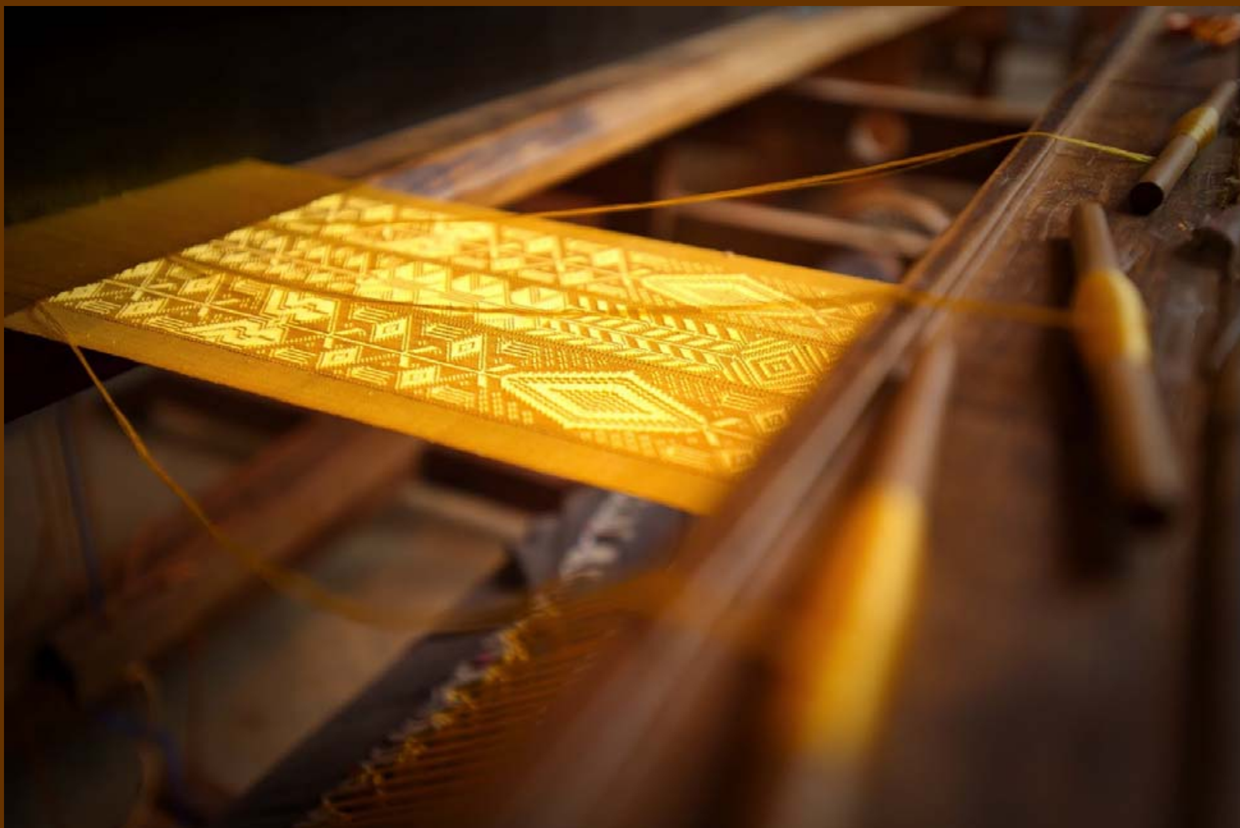

Gossamer: The Spider Silk

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Abstract

The silk is structureless secration in the form of cocoon consisting of continuous filament. There are two varieties of silk i.e. domesticated silk and wild silk. Domesticated silk can be cultivated and manufactured for textile purpose. On the other hand, wild silk can be produced from uncultivated caterpillar. Caterpillar through its gland secrates colorless fluid. These colorless fluids, on contact with air, hardens and form a composite threads. Mostly each caterpillar has two aqueduct glands and also two spinning glands. These four glands are symmetrically located on each side of the silk worm near the head and secrete two kinds of fluid. Depending of the type of silk that is to be made the spider mixes the fluid from the different glands and regulates the speed and volume of release. The liquid from two larger glands converges at one opening in the head to produce 'Fibroin'. These opening are generally known as worm's spinnerette. The flow i.e. fibroin joined by the secretion of two other symmetrically located glands, which produces silk glue or 'sericin'. The fluid solidifies in contact with air and forms a double filament, known as 'Bave'. Each single filament is called a 'Brin'. So each brin consists of of a central portion i.e. fibroin covered with sericin. This concept of secretion leads to the discovery of man-made fibers. This paper throws light on such kind of silk fiber.

Introduction

Spider silk is protein fiber spun by spiders. It is also known as "Gossamer". Spider silk is an extremely strong material and is on weight basis stronger than steel. It has been suggested that a pencil thick strand of silk could stop a Boeing 747 in flight. Spiders use their silk to make webs or other structures, which function as nets to catch other animals, or as nests or cocoons for protection for their offspring. They can also suspend themselves using their silk, normally for the same reasons. The silk is used by the spider for a lot of different uses like:-

- Constructing their webs.
- The production of egg sacs.
- Wrapping in their prey.
- As a life line when jumping, or dropping to escape.
- For transferring semen from the abdomen to the male palp, in drag lines marked with pheromones.
- As a shelter in which it can retreat.

There are several glands located at the spider's abdomen, which produce the silken thread. Every gland produces a thread for a special purpose. There are seven different known glands. Each spider possesses only some of these glands and not all seven together.

The glands known as:

1. Glandula Aggregata produces the sticky material for the threads.
2. Glandula Ampulleceae major and minor are used for the silk of the walking thread.
3. Glandula Pyriformes is used for the production of the attaching threads.
4. Glandula Aciniformes produces threads for the encapsulation of prey.
5. Glandula Tubiliformes produces thread for cocoons.
6. Glandula Coronatae is used for the production of the adhesive threads.

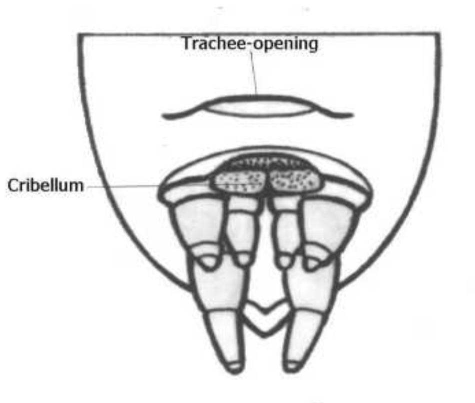
Fig (1):- *Spinners of* Steatoda grossa

Types Of Spiders

By studying their threads two groups of spiders can be recognized:-

1. The Cribellate Spiders
2. The E-cribellate Spiders.

Cribellate spiders comb their silk to a woolly structure. To do this they have a comb (calamistrum) on the metatarsus or the tarsus of the fourth legs and an extra silk producing organ (cribellum) just in front of the spinners, which appears as a transparent plate. The comb pulls the silk out of the cribellum and the silk is combed to a woolly structure. The combed silk is made up of thousands small threads enforced by some thicker ones. There is no glue on the threads but the insect gets stuck with the hairs on their body in the silk. The thicker threads in the silk prevent the insect from tearing the silk.



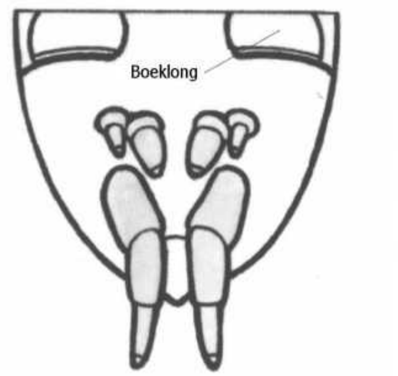


Fig (2):- Cribellate spider

Fig (3):- E-cribellate spider

Structure of spider silk

Typical structure of Spider silk fiber consists of crystalline regions separated by amorphous linkages. The crystals are beta-sheets that have assembled together.

Spider silk is composed of complex protein molecules. This, coupled with the isolation stemming from the spider's predatory nature, has made the study and replication of the substance quite challenging. Because of the repetitive nature of the DNA encoding the silk protein, it is difficult to determine its sequence and to date, silk-producing sequences have only been decoded for fourteen species of spider.

Although different species of spider, and different types of silk, have different protein sequences, a general trend in spider silk structure is a sequence of amino acids (usually alternating glycine and alanine, or alanine alone) that self-assemble into a beta sheet conformation. These "Ala rich" blocks are separated by segments of amino acids with bulky side-groups. The beta sheets stack to form crystals, whereas the other segments form amorphous domains. It is the interplay between the hard crystalline segments, and the strained elastic semi amorphous regions, that gives spider silk its extraordinary properties. The high toughness is due to the breaking of hydrogen bonds in these regions.

Various compounds other than protein are used to enhance the fiber's properties. Pyrrolidine has hygroscopic properties and helps to keep the thread moist. It occurs in especially high concentration in glue threads. Potassium hydrogen phosphate releases protons in aqueous solution, resulting in a pH of about 4, making the silk acidic and thus protecting it from fungi and bacteria that would otherwise digest the protein. Potassium nitrate is believed to prevent the protein from denaturating in the acidic milieu

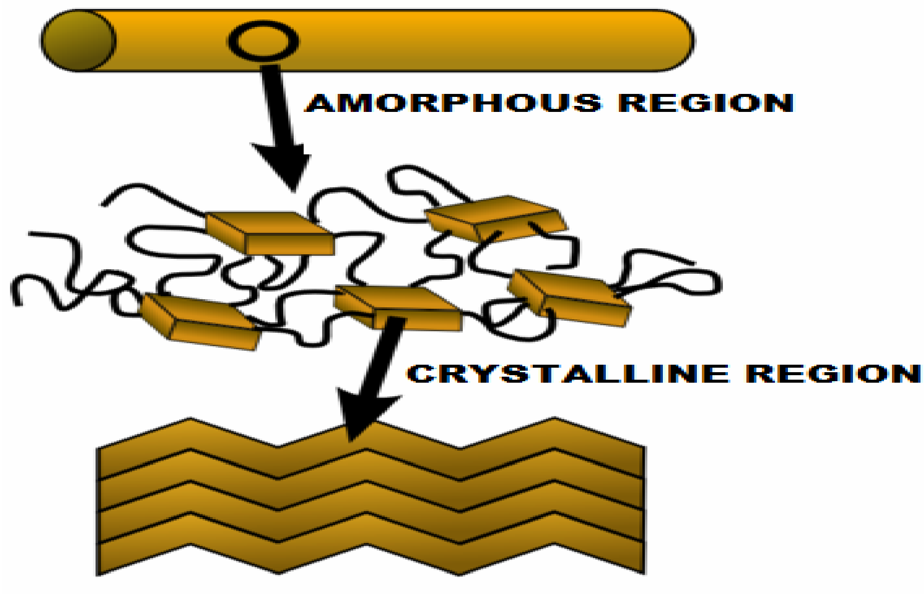
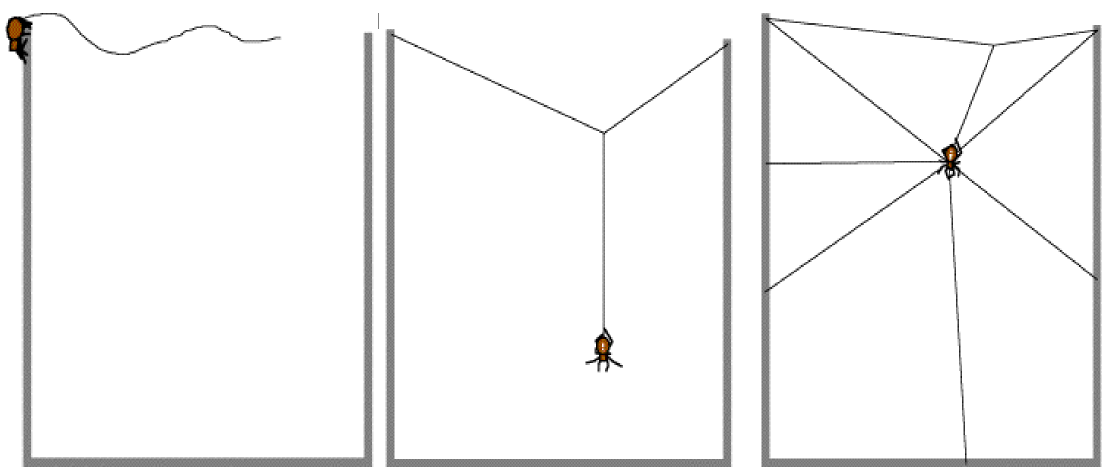


Fig (4):-Structure of spider silk

Cyclic Representation Of Filament Formation



Stage-1 Stage-2 Stage-3

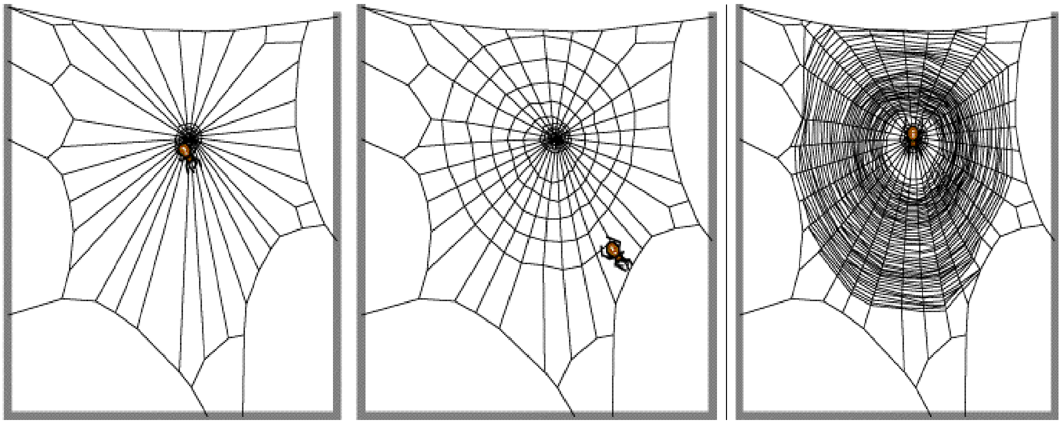


Fig (5):- Cyclic Representation Of Filament Formation

Properties

The Spider Silk exhibits remarkable properties. It is remarkably strong material. Some the properties are listed below:-

1) Its tensile strength is superior to that of high-grade steel, and as strong as aramid filaments such as Kevlar.
2) Spider silk is extremely lightweight. A strand of spider silk long enough to circle the Earth would weigh less than 500 g.
3) Spider silk ductile i.e. it can be easily drawn and converted into wire.
4) Able to stretch up to 140% of its length without breaking.
5) It can hold its strength below -40^0C. This gives it a very high toughness i.e high work to fracture.

Applications of spider silk

Spider silk was and is used for several applications such as:-

1) Polynesian fishermen use the thread of the golden orb web weaver *Nephila* as fishing line.
2) In the New-Hebrides spider web was used to make nets for the transportation of arrow points, tobacco and dried poison for the arrow points.
3) Some tribes in New-Guinea used webs as hat to protect their head from the rain.

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