The spider

Dolomedes fimbriatus, a spider

Many people confuse spiders with insects. The easy way to recognize the spider from an insect is that spider has 4 pairs of legs and an insect has 3 pairs. There is also one major difference. The insects have compound eyes whereas the spider has singular eyes with lenses. Unlike insects, spiders do not have antennas.
There are also many similarities. Both have an external skeleton (exoskeleton). The hard part of the body is on the outside while mammals have their skeleton (bones) inside the body. The heart is located on their back. Breathing is performed with trachea and / or book lungs. The oxygen transport protein is hemocyanin and not the mammalian transport protein hemoglobin.
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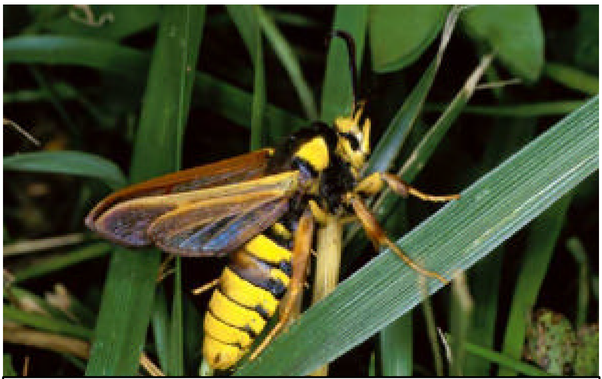


Sesia apiformis, wasp butterfly, an insect

In 1758-59 Carolus Linnaeus published the 10th edition of ***Systema Naturae*** in which he classified animals. Over the years the biologists improved the systematic study of the Animal Kingdom. According to this study we have single cell animals at the bottom and at the top are humans with very complex cell systems. With the aid of DNA analysis the positioning of each animal has become even more precise than before. It is called a taxonomical classification of the Animal Kingdom.
It consists of several divisions. A division is called phylum.
Phylum Arthropoda consists of animals with exoskeleton (hardened exterior) that have segmented bodies and jointed appendages. The segments are fused to form body parts. The first part is the head, followed by thorax and the hind part is abdomen. There are appendages on these segments, which are specialized to perform specific functions such as walking, jumping, eating and lots of other activities. Phylum Arthropoda is divided into 5 major classes.

Class	*Crustacea*	*Arachnida*	*Diplopoda*	*Chilopoda*	*Insecta*
Examples	Lobsters, crabs	Spiders	Millipedes	Centipedes	Flies, maggots
Body parts	Cephalothorax and abdomen	Cephalothorax and abdomen	Head and body	Head and body	Head, thorax and abdomen
Pair of legs	Many, usually 5 pairs	4 pairs	Many, 2 pairs per segment	Many, 1 pair per segment	3 pairs, 1 on each thoracic segment
Antennae	2 pairs	None	1 pair	1 pair	1 pair
Described nr of species	25,000	70.000	5000?	5000?	800.000

Class Arachnida is divided into 10 orders.

1. Araneae	*2. Scorpiones*	*3. Pseudo-scorpiones*	*4. Solfiguae*	*5. Schizomida*
Spiders	Scorpions	Pseudo-scorpions	Solifugids	Tartarida
6. Amblypygi and Uropygi	*7. Palpigradi*	*8. Ricinulei*	*9. Acari*	*10. Opiliones*
Whip scorpions	Mini whip scorpions	Rinucleids	Mites en ticks	Harvestmen

Accordingly the spider is placed in phylum Arthropoda, class (classis) Arachnida, order (ordo) Araneae. This order is further divided into 3 sub-orders. The Mygalomorphae (the primitive spiders), the Aranaeomorphae (the modern spiders) and the Mesothelae, with one family of spiders the *Liphistiidae*. Every spider belongs to a family, which is further divided into genus, followed by species. The European garden spider belongs to the family Araneidae, the genus *Araneus* en the species *diadematus*. As a rule genus and species are printed in italics.

Scorpion, *Euscorpius italicus*

In our world around 70000 species of the class Arachnida are described. 90% of these species belong to the order Acarina (mites and ticks) and the order Araneae. In the order Araneae 1960 primitive spiders and 40000 modern spiders are known.
One can find spiders in much larger numbers then expected. A study in Great Britain counted in a meadow 130.8 spiders per square meter. An average spider consumes 0.089 g insect per day. After some calculations we can conclude that in the Netherlands, with an area of 36150 square kilometers and 15 million human habitants, there are 5000 billion spider habitants. These spiders could consume all Dutchmen in three days. Lucky for us that our spiders do not eat us.
Spiders mostly prey on insects. But most insects are useful, although some may be annoying. Therefore it is difficult to say if a spider is useful or not. But spiders do control the insect population to some extent. Therefore we need them for the right balance in our eco system.
We will have a close look at the near relatives of the spiders in Europe. Around the Mediterranean we can find the scorpion (order Scorpiones). Its body has a large head-breast part (prosoma) and a segmented abdomen (opisthosoma) to which a tail is connected. At the end of the tail there is a sting. Connected to the prosoma are four pairs of sturdy legs, one pair of feelers and one pair of scissors.

Tick, *Ixodes ricinus*

A closer look reveals two tiny black eyes. But there are scorpions with more than one pair of eyes. The sting with poison is not used very much. It is mainly used for protection and for killing large prey. For men it is not pleasant to be stung by a scorpion and it is possible to die from it.
A rather unknown scorpion order is the pseudo scorpion (order Pseudoscorpiones). This small creatures is a few millimeter long and lives between detritus like leaves, bark, moss, mole- and bird nests. They have relatively long scissors that can be as long as the rest of the body for the males. They do not have tail and no sting.
Even smaller than the pseudo scorpion are the ticks and the mites.

Velvet mite, *Trombidium holosericeum.*

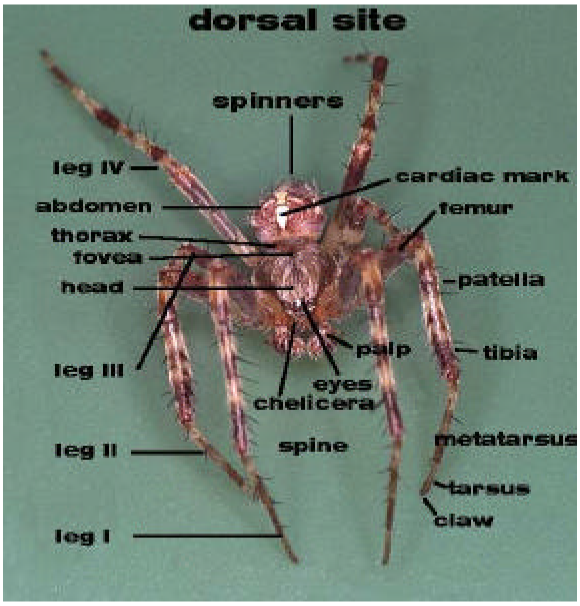
Mites are found in a great variety of forms in all kinds of habitats like deserts, in water, between rocks, in flour and in carpets, et cetera. A species of mites, commonly known as house dust mites, can be found in our houses and in our beds in huge numbers where they feed on human dander. Mites can be detected even in human hair sacs and sweat glands. The excretions of these mites are major cause of asthma and allergy.
An easy to spot mite is the red velvet mite and can be found in the garden.
Ticks are lately in the news because they may cause Lyme disease.

Harvestmen (order Opiliones) are often mistaken for spiders. Unlike spiders, the two parts of the body (cephalothorax and abdomen) of a harvestman are fused together into one part. They also have eight legs, feelers and mouthparts that work like a pair of scissors. Most species have short legs but some of them may have very long legs. Opiliones do not have any poison glands. At the top of the body there is one pair of eyes that are pointed side ways. The have no silk glands or spinners. Harvestmen eat everything (omnivorous). They catch small insects or eat the decays of any dead animal, animal dung, bird droppings, other fecal material, all kind of plant material and fungi. The harvestman is mostly a nocturnal i.e. active during night.

Havestman, *Phalangium opilio*

Harvestman, *Mitopus morio*

The body

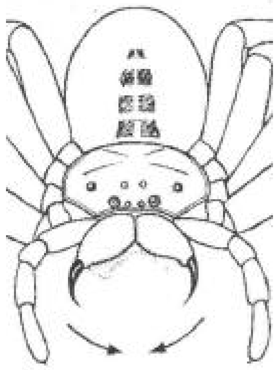


The body of a spider has two distinct parts. The first part consists of head and breast, called as prosoma or cephalothorax. It is made from a hardened material, called as chitin. The second part is the soft abdomen, called as opisthosoma. A tiny tube called as pedicel connects the cephalothorax and abdomen. The back of a spider is a dorsal side and at the bottom is ventral side.
The eight legs, the two jaws (chelicera) and the two feelers (palps) are connected to the prosoma. The males have a bulb at the end of their palps. These are filled with semen before copulation and are used to inject the semen into the sexual organs of the female. On the prosoma there are usually eight eyes. In Europe one can also find spiders with six eyes. Outside Europe one can find spiders with no and up to twelve eyes
Inside the body there is an extensive nerve system (blue). The brains are located in the prosoma and the heart at the front upper side of the abdomen (red). The heart beats with a frequency between 30 and 70 beats per minute. When the spider is tensed or exhausted the heartbeat can go up to 200 beats per minute. At the rear of the abdomen the silk making spinners are located (white). These are connected to glands that produce different proteins. When these proteins are mixed, it polymerizes to form silk. By pressing the fluid silk through the spinners a thread is made. The sexual organ and the egg-producing organ (white) are located between the book lungs (red) and the spinners.
The alimentary canal (yellow) runs through the whole body. At the end (green) of it there is the excretory system.

Cross sectiom of a spider [7]

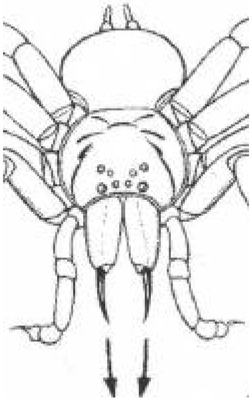
The jaws and venom

Modern spider, *Neosparassus salacius*



The jaws of a modern spider, Aranaeomorphae, are used to grab and crunch a prey. Most spiders use poison to kill their victims. At the end of the jaws are two syringe-like structures that are hollow and very sharp. These are used to puncture the body of a victim and to inject the poison. The poison is produced in special glands. These cells grow into small sacs with poison (vesicles) which, migrate to a special bladder where they burst. Around this poison bladder there is a spiral muscle that contracts to eject the poison through the syringes in to the prey.

Primitive spiders, Mygalomorphae, have forwardly pointing jaws that move forwards and backward in contrast to the modern spider. Therefore they can not crunch a prey. They wait until the prey contents are dissolved before they can suck it empty.



Primitive spider, *Atypus piceus*

The venom of a spider contains protein, amines and polypeptides. Some of these molecules are capable of disrupting the communication between the nervous system and the muscles, which causes paralysis. Other molecules cause death of cells, which leads to necrosis. After the prey is killed the spider spits enzymes from its mouth into the victim. Enzymes dissolve the contents of the prey. Mammals dissolve their meal in a stomach using the enzyme pepsin. The spider digests the proteins in the prey itself and sucks it empty.

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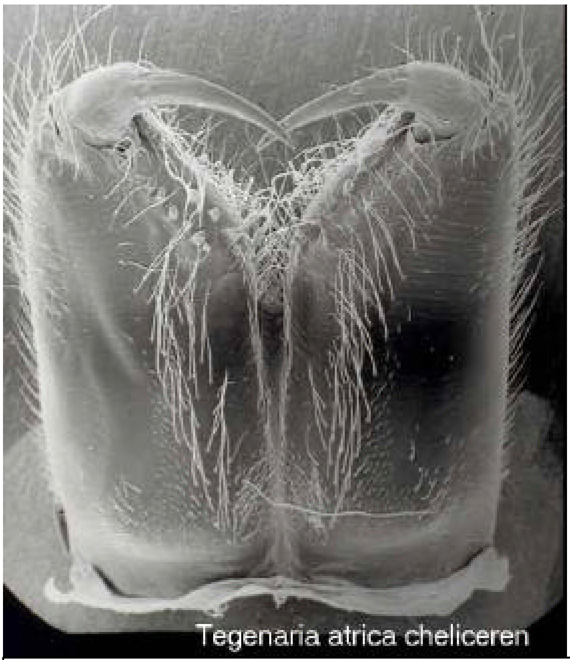
Jaws of *Meta segmentata*

How lethal is the venom of a spider? This is difficult question to answer. A venom is given a number LD50 to express its toxicity. LD50 stands for quantity of a lethal dose needed to kill 50% of a tested population. The venom of a black widow spider has a LD50 of 0.9 mg per kg mouse. Therefore 0.013 mg venom is enough to kill one mouse. The spider needs 2 mg to kill a frog. So the lethality differs among animals. Such a test has never been performed on humans. Therefore it is difficult to calculate how venomous a spider is for humans. We know that the black widow can kill people.



Jaws of the house spider *Tegenaria atrica* (bg)

The lethality of spider's poison to humans is very exaggerated. However there are spiders that are dangerous to humans. The Latrodectus species (Black widow), the Australian Sydney funnel web spider, *Atrax robustus*, and some wandering spiders from South -America are dangerous. These spiders use a substance that disturbs the nerve system, which can cause heart rhythm disturbances, cramps, shaking, pain and dizziness. A spider sting can be fatal to children and persons with weak constitution.

There are also many spiders that give a nasty bite comparable to the stinging of a wasp. Most of the venom injected with these bites causes cell death and gives rise to a wound that does not heal properly and becomes easily infected. In Europe there is the water spider, *Argyroneta aquatica*, which has a very nasty bite. Immediate cooling of the wound is the best medicine. Most modern spiders crunch their catch with their jaws. Other spiders wrap their prey in silk, taking care that the victim does not bite them. Orb weaving spiders make a parcel of the prey and wait until the prey is dissolved before sucking it empty. Crab spiders do not use silk but use a rapid working poison. Spiders of the family *Uloboridae* do not have any poison and put their trust completely on their silken thread.

The black widow, *Latrodectus hasselti*

Orb web spiders like this *Argiope syrmatica wraps her prey before sucking it empty*

The injected enzymes dissolve the prey. Then it is sucked empty. The mouth of a spider is located between the palps which, is connected to the stomach muscles that perform the sucking. Between mouth and stomach is a filtering device that is made up of thousands of fine hairs. Only particles smaller than 1 m can pass through this filter. This is so small that even the particles in India ink will be filtered out so that only water can pass through. With these filters the spider prevents bacteria, viruses and other harmful life forms from entering its own body. The filter is regularly cleaned with its upper and lower lip.

Because the food that is taken up can be large in comparison to its own body volume, the abdomen of the spider can swell enormously. The digested proteins are stored in a special place. This makes it possible for the spider to live for several weeks on a single prey. The waste substances are chemically converted to harmless crystals and are stored in special cells. These white colored guanocytes are located in-groups and can be seen through the skin. This shows up as a very special pattern on the back of the orb weaving spiders.

Special excretory organs separate these waste substances from the blood. The spider kidneys consist of two long thin tubes, called Malpighian tubule.

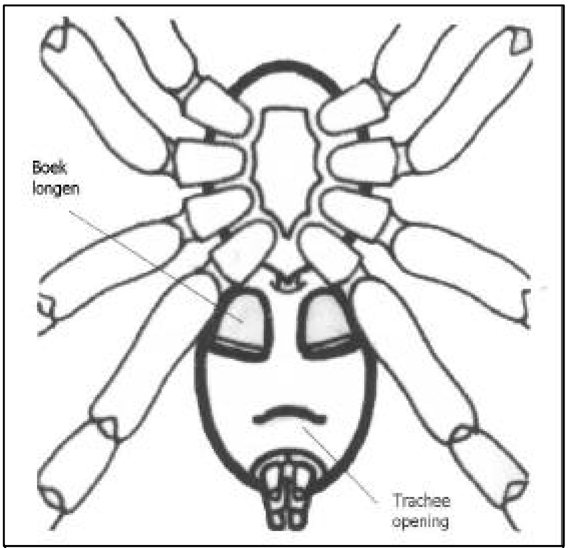
Blood circulation


Bleeding house spider, *Tegenaria atrica*

The spiders have circulating blood in their body. The colorless blood called hemolymphe transports nutrients, hormones, oxygen and cells. The blood also serves another purpose. It is used locally to raise the blood pressure during moulting (shedding of old skin) and stretching the legs.
In mammals hemoglobin molecules present in the red blood cells transport oxygen. The spider uses a more complicated protein called hemocyanin. Unlike hemoglobin, hemocyanin is not stored in a cell but flows freely in the blood of a spider. Hemocyanin is a protein that is made up of 24 sub-units with a molecular mass of 1.704.000 compared to the molecular mass of oxygen, which is only 32. Human hemoglobin is made up of 4 sub-units with a molecular mass on 64.500. Hemoglobin is a molecular disc, made of nitrogen, carbon, hydrogen and an iron atom at the center. The oxidized iron gives the molecule its characteristic red color. Hemocyanin also contains nitrogen, carbon and hydrogen but has a copper atom at the center instead of an iron atom. The oxidized copper gives the molecule a blue color. Hemocyanin binds oxygen but only releases it after it receives the right chemical signal. For every of the 24 sub-units there is special chemical signal. Depending on the need for oxygen a cell can give many or less signals. Beside these signals the release of oxygen is also controlled by temperature. Every sub-unit has a specific temperature optimum.

Spiders have an open blood circulation system. Blood vessels do transport the blood to a specific place but thereafter the blood flows freely in the open spaces between the organs.
The heart is located on the back of the abdomen. This is an open tube called pericardial-sinus with valves, which is hung in a cavity. Elastic muscles around this cavity contract, enlarging the tube. Because of the valves in the tube the blood can flow in only one direction. If the tube is filled with fluid the muscles weakens and the blood is pressed out of the tube. The heart has it own nerve center that can let the heart beat independently from the brains. There are connections with the brain that can raise the heart frequency. This can be registered if the spider becomes excited and its heart frequency rises.

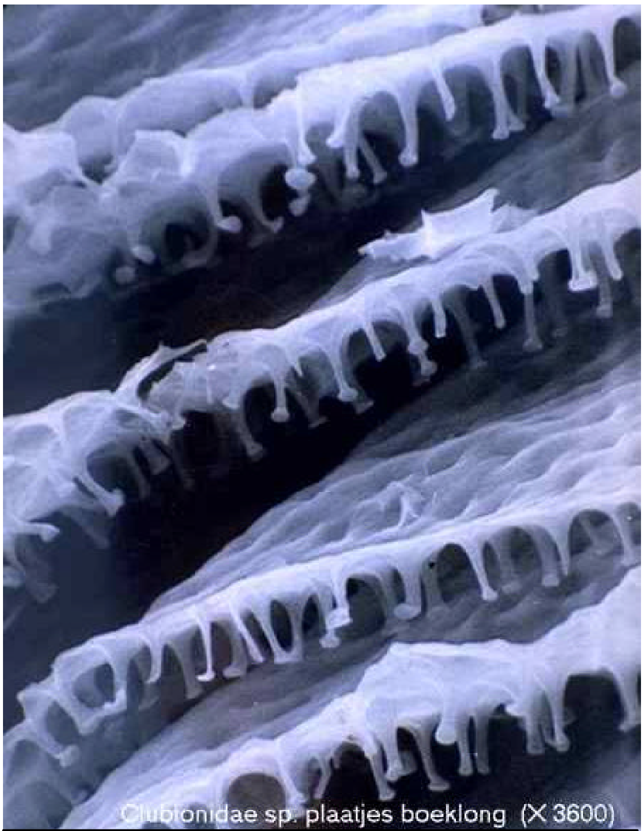
The lungs



Book lungs and trachea entries [13]

In mammals the uptake of oxygen in the blood and the release of carbon dioxide from the blood takes place in the lungs. Spider uses other organs. Above the spinners there is a slit that can be opened and closed. Long small tubes run from this slit into the body. These tubes are called trachea. The gasses are exchanged with the blood by diffusion.
Besides trachea many spiders also have book lungs. These are hollow leaf-like structures through which the blood flows. These book lungs hang in an open space that is connected to a tube. The other side of the tube is in open contact with the air. The entrance is located below the abdomen.

There are spiders with only book lungs or only with trachea. Most of the spiders have both.
Primitive spiders have only two pairs of book lungs. Modern spider have developed trachea system. Most of them still possess one pair of book lungs. Trachea supplies oxygen faster than book lungs. With these two systems together which provide extra oxygen the modern spider has an advantage for reacting quicker and longer than the primitive spiders with only book lungs. Fast running and jumping spiders have a good developed trachea system. The small spiders of the family *Symphyltognathidae* are exceptional, they do not posses book lungs but have well developed and very well performing trachea system.
The size of the heart depends on the size of the developed trachea system. Spiders with a good developed system do not need a large heart because the pumping capacity can be smaller. Less blood is needed to supply the organ with oxygen.



Book lung of *clubiona sp.* [bg]

Nervous system and sensory organs

There are two concentrations of ganglia in the prosoma (head-breast part) which forms the brain A number of nerves extends from the brain to the legs, eyes and the rest of the body. The brain takes up a volume of 20 - 30% of the prosoma.

Spiders have several sensory organs to get an impression of the surrounding in which it lives.

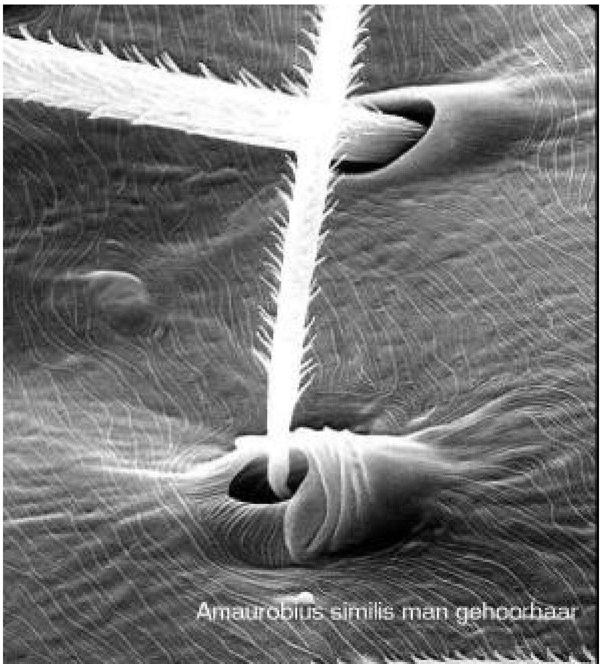
A spider does not have an ear. Mammals hear with help of hairs that are located in the ear where pressure waves in the air are converted to electric signals. These signals are then sent to the brain and interpreted as sound. A spider hears with very tiny hairs on her legs (thrichobotria). She is very capable of localizing the origin of a sound by interpreting the movement of the air produced by that sound.

Wolf spider, *Lycosidae*

Lynx spider, *Oxyopidae*

Jumping spider, *Salticidae*

The eyes of spider differ greatly between families. Spiders who hunt without a web like wolf spiders (*Lycosidae*), lynx spiders (*Oxyopidae*) and jumping spiders (*Salticidae*) have a well-developed eyesight. Jumping spiders can see nearly as good as humans. Experiments have shown that they are even capable of seeing colors. Cave spiders, who live in the dark have no or hardly any eyesight. They depend completely on sound and feeling.



Hearing hair, *Amaurobius similis* (bg)

Araneus diadematus

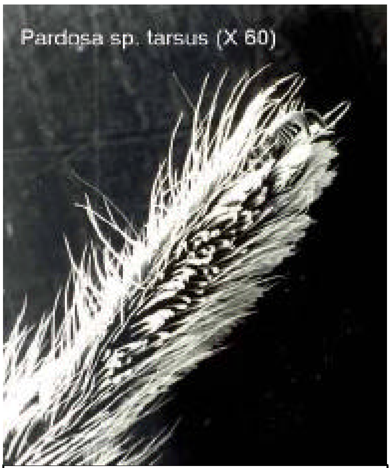
Our well-known orb weaving spiders, like the *Araneus diadematus*, have very small eyes. The do not depend heavily on their eyesight to catch their prey. They have a good developed feeling mechanism that makes them capable of detecting the movements in her web.

Spiders detect smell with scent sensitive hairs located on their legs. A sense of taste in their mouth is missing. A spider feels her prey with chemosensitive hairs on her legs and senses if the prey is consumable.

The legs

Beside the above-mentioned hairs on the legs, spiders have more features worth studying. The legs consist of seven segments. Beginning from the body these are in the following order and called coxa, trochanter, femur, patella, tibia, metatarsus and tarsus.

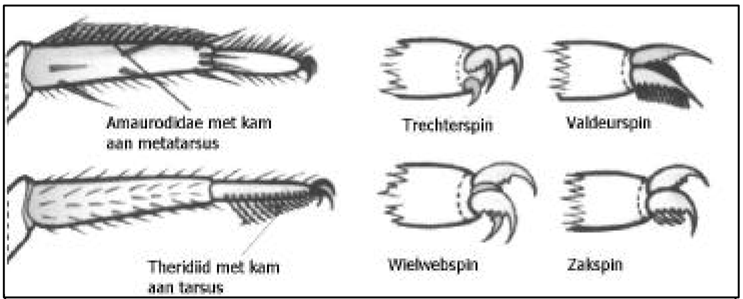
Detail of the legs of Larionides sclopetarius



Fine hairs on the tarsi *Pardosa sp.* (bg)

Who has never found a house spider crawling in the sink incapable of getting out? But jumping spiders are never found in the same sink. There must be a difference in the structure of the legs between families.

For example there are thousands of fine hairs on the tarsi of the wolf spider. Every hair sticks to the smooth surface of thin water surface (adhesion). This adhesion to water is the secret of walking/climbing over smooth surfaces, which has been shown by experiments. In this experiment a part of the smooth surface was treated with a water-removing chemical. As a result spider fell off the treated part. When the water film was restored the spider was able again to climb the surface.



Several legs [13]

Orb weaving spiders have claws on their tarsi. This is the reason they can not climb on smooth surfaces but are very capable in hanging on threads. The spider grabs with its middle claw a thread and squeezes the middle claw against serrated bristles, situated opposite the claw. This gives a firm grip. To release the thread the claw is elevated and the bristles push back the thread. The elasticity of the thread also causes it to spring back out of the clasp of the claw.

The movement of the legs of a spider is partly hydraulic. The spider stretches its legs by raising its blood pressure in legs. A jumping spider can create a force that makes her capable of jumping 25 times her length. This hydraulic system works excellent can be seen if we compare the legs of a grasshopper to those of a spider. The grasshopper has two gigantic legs with a lot of muscles packed in it. Looking at the jumping spider one can not detect these extra muscles.

The legs of the jumping spider, *Philaeus chrysops* compared with the legs of the grasshopper *Miramella alpina*

Moulting

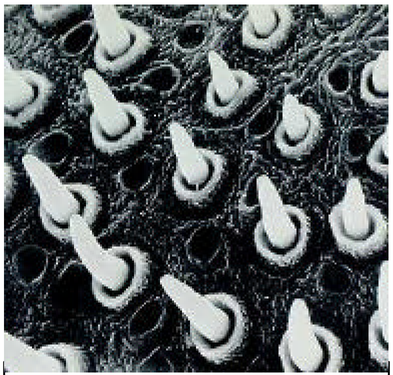
Because of the hardened skin made of chitin, the spider can not grow larger. Therefore the spider needs to shed external skeleton (exoskeleton) regularly (ecdysis) so that it can grow. The spider changes its skin 5 - 7 times in her life. Spiders that can grow very old, like Tarantula that may live for 25 years, the skin is changed every year. This is not because she keeps growing but, like our clothes, the skin becomes worn out.


Skin of a spider

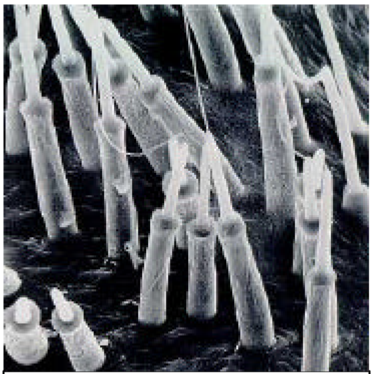
The color of the spider becomes darker before changing of its skin. Enzymes dissolve the layer between the skin and the rest of the body. The new skin begins to form below the old one. It is extremely folded because it has to be larger than the old coat. The nerves stay connected to the sensory organs on her old skin so that she is not deprived of essential signals from the sensory organs on her legs. Just before shedding the old skin the spider hangs itself upside down with a thread. After several minutes the abdomen contracts to around 70% of it original size. The blood is pumped to her head raising the pressure from 20 kPa to approximately 40 kPa (0.4 atm). The skin starts tearing at her jaws and the crack enlarges to the abdomen. If the skin is loose from the head-breast part (prosoma) the blood pressure is raised in the abdomen. When the skin has become completely loose the spider falls out of her old skin. These old skins are the "dead" spiders you can see hanging to wires and small branches.
Spiders can be often seen with one or more missing legs. After a moulting these lost legs regenerate. After the first change of skin newly formed legs are smaller than the original leg. After the second moulting these differences in length are hardly observable.

Web and silk

Spider silk is an extraordinary material. One feature is its enormous strength. A thread of silk with the thickness of a pencil is able to stop a Boeing 747 flying at full speed. We are still unable to reproduce such a material with all our technological knowhow.



Tubes in spinners [7]



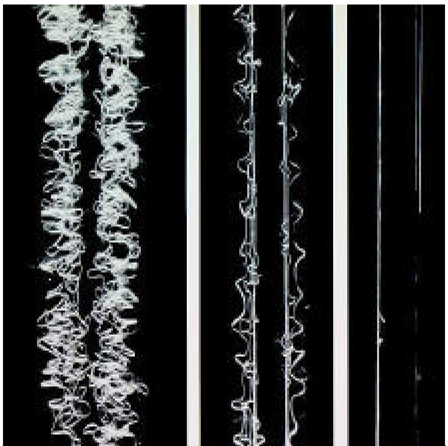
Tubes in spinners [7]

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 glands known. But each spider possesses only some of these glands and not all seven together.

The glands known as Glandula Ampulleceae major and minor is used for the silk of the walking thread. Glandula Pyriformes is used for the production of the attaching threads. Glandula Aciniformes produces threads for the encapsulation of prey. Glandula Tubiliformes produces thread for cocoons. Glandula Coronatae is used for the production of the adhesive threads.

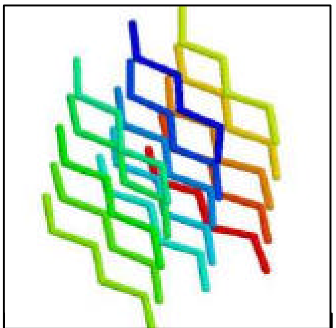
Normally a spider has three pairs of spinners. But there are spiders with just one pair or as many as with four pairs of spinners. Every spinner has it own function. There are small tubes in the spinners, which are connected to the glands. The number of tubes varies between 2 and 50.000.

The human eye is capable of detecting objects at a distance of 10 cm with a diameter of 25 m. The average diameter of a thread in a orb web is around 0.15 m. The smallest measured thread was only 0.02 m thick. We are able to see the web only because of the reflection of sunlight on the thread. These thin wires are capable of stopping a bee flying at full speed. This thread is not only strong but also very elastic. These properties make the material tougher than any material or metal we know. The strength of a material is given in a unit called dernier. (1 dernier = 1 g per 9000 m) A thread of a spider has a value between 5 - 8. This means that the thread will break under its own weight at a length of 45 - 72 km. Materials that are comparable are nylon and glass. Steel has a value of approximately three.



Stetching of a thread, 1, 5 and 20 times [7]

What is the thread made of? It is a protein of a molecular mass of 30.000 Dalton in the gland. Outside the gland it polymerizes to a molecule named fibroin with a molecular mass of around 300.000 Dalton. It is still not clear what activates polymerization process.



Fibroïn

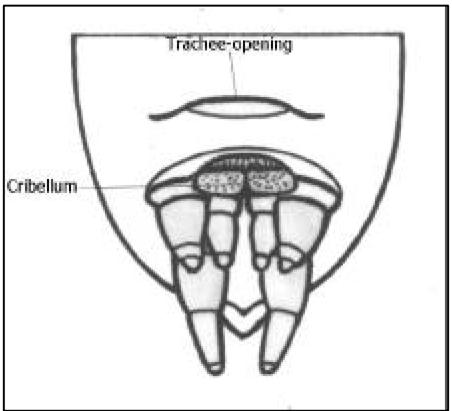
Why does the silk made of protein not decompose by fungi and bacteria like all other proteins? We conserve protein by cooking, salting, drying or adding acid. In spider silk there are three substances that are important for its durability: pyrolidin, potassium hydrogen phosphate and potassium nitrate. Pyrolidins can be found in dyes and plant poisons and are very hygroscopic (binds water). This substance prevents the thread from drying out. Pyrolidin is also found in high concentration in the glue of catching threads. Potassium hydrogen phosphate makes the thread acidic and prevents fungal and bacterial growth. A low pH causes denaturation (become insoluble) of proteins. A phenomenon we can observe in sour milk. Potassium nitrate prevents this and the proteins are salted which prevents bacterial and fungal growth.

The thread of the orb web spider *Araneus diadematus* is very elastic and can be stretched 30 - 40% before it breaks. Steel can be stretched only 8% and nylon around 20%. In the picture one can see the thread of the spider *Stegodyphus sarasinorum* that, because of its weaving technique, can be stretched up to 20 times it original length.

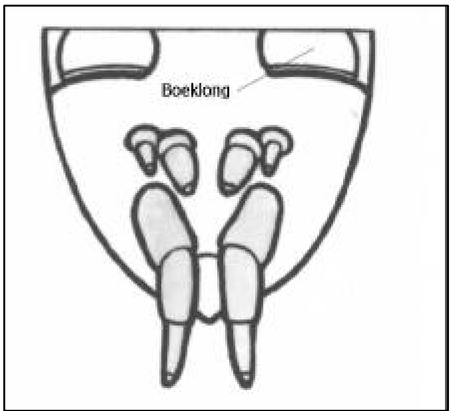
Cribellum van *Aumaurobius similis* [bg]

A lot of orb weaving spiders recycles their web. The weaving of a web takes up a lot of the spider's resources. Since they need to renew their web regularly, they eat the silk. Only the main thread of the web is left intact. They usually weave a new web in the morning.
By studying their threads two groups of spiders can be recognized, the Cribellate and the E-cribellate spiders.

Cribellate spiders comb their silk to a wooly 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 wooly 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.



Cribellate spider [13]



E-cribellate spider [13]

Applications of spider silk

Spider silk was and is used for several applications. Polynesian fishermen use the thread of the golden orb web weaver *Nephila* as fishing line. 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. Some tribes in New-Guinea used webs as hat to protect their head for the rain

In World war one the threads of *Araneus diadematus, Zilla atrica, Argiope aurantia* and other orb weavers were used as cross hair in instruments.

In 1709 a Frenchman, Bon de Saint-Hilaire, demonstrated the possibility to make fabric from silk. Many cocoons were boiled, washed and dried and the thread was collected with fine combs. Some socks and gloves were produced. A study to the economic yield of this method revealed that this would never be profitable. It was calculated that 1.3 million spider cocoons were needed to produce one kilogram of silk.

In Madagascar there were some attempts to milk *Nephila's* for the production of silk. By hand a thread was pulled out of the spinner of the spider. If the spider was exhausted she was put back in the forest and the next spider was milked. The gathered silk had a beautiful golden color. This project was also banned because of many problems. Nowadays one tries to produces silk in factories.

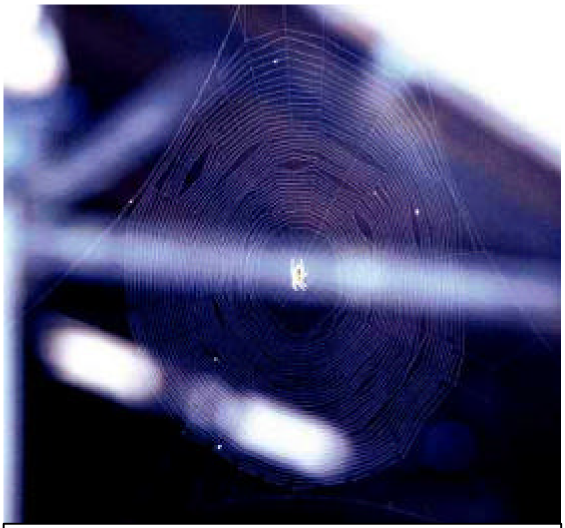
Web of *Araneus diadematus*

The web

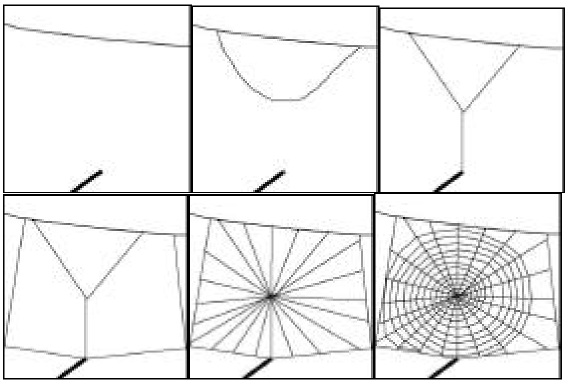
Several usages and forms of webs can be recognized. Sheets, orb webs, cocoons, furnishing, hiding place. The most well known form is the orb web. How is this web constructed?

The most difficult part is the construction of the first thread. This is a sturdy horizontal thread on with the rest of the web is hanging. How does the spider connect this thread between the two connecting points? She can not fly. Does she connect a thread at one place, walks downs with an enrolling thread behind her to the other side where pulls the thread horizontal and connects it?

No, the answer is simpler. She makes use of the wind and some luck. **Film of the whizzing of a web.**



Web of *Araneus diadematus*



The wind caries a thin adhesive thread released from her spinners while making the thread longer and longer. If she is lucky the thread sticks to a proper spot. Then she walks carefully over the thread strengthening it with a second thread. This is repeated until the primary thread is strong enough. After this she hangs a thread in the form of an Y below the primary thread. These are the first three radial of the web. More radials are constructed taking care that the distance between the radial is small enough to cross. Then the adhesive spiral thread is placed and the web is ready to be used. Not every web is constructed in this way, a lot of variation are possible. The web on the picture above has an inverted Y that was connected to an electrical wire 10

Hiding place and orb web of *Singa nitidula*

meters higher. Besides the orb webs other catching web designs are used. A particular one is that of the net-casting spider *Deinopsis*. This spider constructs a web between her forelegs and hangs head down waiting for a insect to pass. The web is thrown over the victim and entangles it. The Bolas spider also has a special catching technique. As the name may suspects she throws the thread with an adhesive bubble at the end to her prey. The prey is decoyed by chemical substances (pheromones).
The trapdoor spider hides in a tunnel that can be closed with a door. If the prey walks over a signal thread the door is opened and the spider grabs it.
Besides the flat, two-dimensional orb web the *Linyphiidae* and *Theridiidae* to which the black widow belongs use three-dimensional space webs. Linyphiidae makes a horizontal dense sheet web with a lot of non-adhesive threads above it. If an insect flies against a thread it tumbles down on the mat and is grabbed. The *Theridiidae* construct a messy space web in which the prey gets entangled.

Spatial web of the Theriid *Latrodectus*

Spatial web of the sheet web spider Frontinella

Funnel weavers construct horizontal mats and wait in a funnel at the end of the web for an insect to land on the sheet.
Hunting spiders like the jumping spider, the lynx spider and the wolf spider do not use webs to catch prey. They use their eyes and speed to catch insects. They often use a thread as lifeline. While moving they release a thread. If they fall down after a jump the lifeline makes it possible to return to their original position. The wolf spider only uses silk for furnishing her hiding and breeding place.

Funnel web of the funnel weaver *Agelena*

Sex and reproduction

Argiope keyserlingi

Also spider has to reproduce and therefore there are males and female spiders. Males are often smaller and more colored than the females. Males can be easily recognized by what seems to be the fifth pair of legs. These are the palps with bulbs they use to inject sperm in the genital openings of a female.
The reproduction organs of a spider are located in front of the spinners. When the time comes, the male starts wandering around to look for a female. This is the time when that we may come across our house spider. Normally the spider does not like to be seen. But now he has to move and run through our house, searching for a partner and unwittingly panicking the habitants of the house. When he has located the female, he has to take care not to be mistaken for a prey by the female. With different approaches per species, the male announces to the female that he is interested in mating. Males of some species offer a present, others tinkle with their feet in the web of the female and some perform a dance. If the signals are right and the female is ready for sex the male is allowed to approach. Prior to copulation a male fills its bulbs with sperms by weaving a small web. On the web he drops some droplets of sperm from its genitals and sucks the sperm into the bulbs.
After mating, the males of some species must be extremely careful. Sometimes the female tries to kill the male for an easy meal. Often the male escapes. The males of some species do not care anymore to live longer and he is eaten without objection. Other species live together happy for a long time after mating. There is a great diversity in sexual behavior among species. The males of most species do not live long after mating because their goal is reached and the purpose is fulfilled. Females often live longer than males. Some females die after the eggs have hatched and some females are even eaten by the young ones. Others may live on for years. Most females guard their eggs and youngsters. Wolf spiders carry their egg sac at their spinners and carry the young on her back until their first change of skin. Orb weavers often guard their egg sac.

Philodromus dispar man, note the palps

Nigma puella's making love

Theriid with youngsters

Lycosa furcillata with spidrlings on her back

Spider enemies

The spiders have many enemies. Birds catch a lot of spiders from the ground or out of their web.

Wasps catch spiders. Wasps specialized in spider hunting of specific spider species use the captured spider to lay their eggs in them. The larvae also consume paralyzed spider.

Also ants catch spiders.

The praying mantis, a great killer eats any insect or spider it runs into, even another praying mantis that happens to be on it's knees.

Praying mantis, *Mantis religiosa*

The greatest threat to the spiders is the spiders themselves. There are spiders that catch other spiders. When times are hard and food is scarce, it becomes hard for the spider to overlook it's next of kin.

A familiar spider in our house is the daddy-longleg, *Pholcus phalangoides.* He is a great spider killer. In springtime he is one of the last living spiders in our house. Every other insect or spider is consumed by him during the winter. In the end when famine strikes, even their next of kin are killed.

Also in the family *Mimetidae* and *Ero* are specialized spider killers. *Ero* attacks a spider by biting it in one of its legs. Then it retreats and waits at a safe distance until the bitten spider dies. Then it returns to suck it empty.

We humans, have a bad habit of disturbing the natural world for our own selfish ends. In doing so we destroy many habitats in which the spiders live. Insecticides in the agricultural activities wipe out the whole populations of insects and spiders. Many species of spiders are on a red list nowadays and are in danger of becoming extinct. Tarantulas from South-America have become rare because many of them are caught and sold as pet animal.

Law with the only exception of studying purposes "forbids killing of spiders".

Wasp with spider

Daddy longleg, *Pholcus phalangoides*

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