Original:
https://www.academie-sciences.fr/pdf/dossiers/Reaumur/Reaumur_pdf/Mem1710_p386.pdf

Claude summary:

The document presents a methodical scientific investigation where Reaumur:

1. Examines whether spiders could be raised for silk production
2. Tests various foods for spiders (earthworms, meat, bird feather pulp)
3. Documents the challenges of raising spiders together (cannibalism)
4. Compares the properties of spider silk to silkworm silk
5. Catalogs different spider species and their silk-producing capabilities
6. Analyzes the physics and structure of spider silk threads
7. Calculates the economic feasibility of spider silk production

His conclusion is quite practical - while spider silk is beautiful, it would require an enormous number of spiders (over 55,000 for a pound of silk), and would cost approximately 24 times more to produce than silkworm silk, making it economically unfeasible as a commercial alternative.

It's remarkable how thorough and scientific his approach was for 1710, including controlled feeding experiments, microscopic analysis of silk structure, weight measurements, and economic calculations. This represents early experimental biology at its finest, combining careful observation with practical application considerations.

Translation follows below line.

EXAMINATION OF SPIDER SILK

BY M. DE REAUMUR

1710, November 12

For a long time, the public has held a hatred toward spiders: all the curious things that various scholars had published about them could not overcome the disgust in people's minds. Spiders always passed for a dangerous insect, or at least a useless one, until M. Bon, First President of the Chamber of Accounts of Montpellier & Honorary Academician of the Royal Society of the same City, drew quite general attention last year to an animal so universally despised. This led

to the hope that someday one might derive some utility from spiders, since they produce, like silkworms, a silk from which very beautiful works could be made. The stockings and gloves that he presented then to the Assembly were incontestable proof; they had been made from this new silk.

The Academy, to whom he sent some time later the silk mittens, saw them with pleasure; but the particular attention that this Company gives to all that concerns public welfare did not permit it to stop there. It believed that such a discovery, which had some appearance of utility, should be examined more closely, in order to ensure that no opportunity was missed to extract all possible benefit, or that time would not be wasted pursuing an advantage that might prove illusory.

The Academy therefore judged it appropriate to charge two of its members to closely follow Mr. Bon's ingenious discovery. I was one of those honored by its choice, and I was persuaded that it was only a matter of some care and application, and that I would not neglect anything to make myself worthy of the honor it had done me. At least, it required me to engage in research that had some connection to public welfare. I was further motivated by a compelling reason: it was the interest that a distinguished Abbé, whom I dare not name here because one cannot name him without praise, and because he will be recognized easily when I say that it is he who sustains with his protection, his advice, and his example the Republic of Letters in the most difficult times.

To work with some order on the examination of spider silk, I believed I should first compare it with that of silkworms, to try to discover through this comparison if one could derive from the new silk an advantage similar to that which we draw from the old. For it was no longer a question of knowing if spiders produced silk in certain times, since M. Bon had demonstrated it in a manner as curious as it was certain; but rather if they produced a silk from which the public could benefit. To determine this, everything seemed to me to reduce to finding the secret of feeding and raising spiders, as some scholars have supposed; but also to know whether, once the secret of feeding spiders was found, this silk could be as inexpensive as the other; or in case it was more expensive, if this disadvantage would be compensated by some other benefit. These are the two essential points that I proposed in my research, and to which one can relate everything I will say in this Examination of Spider Silk.

The skill with which spiders trap flies has taught everyone that they nourish themselves on these insects. But it hardly takes reflection to realize that it would not be possible to feed with flies as many spiders as would be needed to provide silk for the manufactures. What skill could be used to capture each day a quantity of flies as large as would be necessary? But even if one had the ability to catch flies as easily as one would want, it would not bring us much further ahead, and all the flies in the Kingdom would barely be enough to feed sufficient spiders to produce a small amount of silk, as will be easy to deduce from what I will say in the second Article.

It was therefore necessary to seek a new type of nourishment, one which could be conveniently obtained in sufficient quantity. The voracious nature of spiders showed clearly that it should not

be derived from plants; neither their flowers, nor their leaves, nor their fruits would be suitable to feed them. I did not hesitate to try these types of foods, to avoid being reproached for having neglected something; and because I knew that in matters of experimentation, things often happen that one would not expect to see; but everything I gave them of this kind was not at all a food for them.

It had, however, been easy for me to convince myself that flies were not the only food they could be given; for although those that spin their webs in the corners of walls and in gardens live on these insects, I had observed more than once that they also eat other insects when they become entangled in their webs. Spiders that live in holes in old walls had taught me even better that all insects are suitable for them: for having often visited such holes, I had ordinarily found bodies of various types of insects there, such as woodlice, millipedes, caterpillars, and butterflies.

It therefore no longer seemed a matter of finding a species of insect that could be easily obtained in as large a quantity as one would want; earthworms appeared to me to have this advantage. There are prodigious quantities of them; gardens and fields are filled with them; there is no one who has not noticed that after rainy nights, the paths in gardens are covered with various small pieces of rolled earth, which hide as many holes through which earthworms emerge. Nothing is also easier than to get these insects, provided one goes looking for them at night with a candle, while merely observing to go only at times that have not been preceded by a long drought.

In truth, I never found any earthworm in spider webs or in spider holes; but these crawling insects with quite some strength and weight, it was equally impossible that they would be thrown into these nets, and that spiders would transport them. It seemed to me that there was nothing to prevent spiders from having the same natural ferocity toward earthworms that they have toward other insects. Having enclosed several large spiders of different species that had survived the winter in boxes, for there are some that live several years, I gave them pieces of earthworm, and I kept them alive by this means.

This success would not have been enough to persuade me that this food was suitable for spiders; seeing them live for several months after giving them this food did not convince me. An experiment I had done previously left me with a very deep doubt: I had kept a spider alive in a house for more than three months, without giving it any nourishment; we know moreover that small spiders that hatch in the month of September live about eight or nine months without eating.

But having enclosed these spiders in glass-covered boxes, I was easily able to observe if they attached themselves to the pieces of earthworm that I gave them. I indeed saw them attack the earthworm pieces, despite the separation from the rest of the body, as one sees them attack insects when they become entangled in their webs; spiders kept their size and vitality, which did not happen to those I kept without food.

When I had seen these large spiders eating earthworms, it was easy to convince myself that flies were not the only food that could be given to them; because although those that make their webs in the corners of walls and in gardens live on flies, I had observed more than once that they also eat other insects that become entangled in their nets. Spiders that live in holes in old walls taught me even better that all insects were suitable for them: for having often visited such holes, I had ordinarily found there bodies of various types of insects, such as woodlice, millipedes, caterpillars, butterflies.

I also tried various types of meat to see if they would not be equally suitable to feed them; for as convenient as earthworms might be, meat would have been even more so. But I saw that they rarely approached it, and when they encountered it, they applied themselves to it only rarely, perhaps because the natural ferocity of spiders needs to be excited by living animals.

However, I imagined another food, which seemed to add the apparent advantage of exquisite taste that spiders find in it: young spiders that have just left their cocoons prefer it to any other. I only used it because of the connection it seemed to have with the tender and soft flesh of the insects that spiders eat. It consists of the substance that fills the feathers of young birds before they have reached their full growth. It has been observed without doubt that when one pulls out these young feathers, they are bloody at the end; those who take the trouble to press this quill, or to dissect it, will find it filled with a tender substance that contains a large number of vessels, which allow blood to escape when one cuts them. After pulling some of these feathers from young pigeons or from old ones, from which I had previously removed the large feathers of the tail and wings, I cut them into various small pieces of..

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...a line, or half a line in length; I gave these small pieces to the spiders who accommodated themselves to them very well. The young spiders especially—I mean those that I had kept in their cocoons and which had abandoned them only recently—seemed to prefer this to any other food: I sometimes saw five or six of them assembled on the same piece of feather, each sucking from the side where it had been cut.

Up to this point, everything seems to be going marvelously well for the spiders; here are simple foods that seem to be all that was in question. Perhaps one might find others just as convenient, even among insects, while one would be using those that are not more difficult to find than the mulberry leaves that are given to silkworms, which can be had without fear in all countries, even in the harshest winters, like the mulberry leaves that are given to silkworms, and which have something more convenient: one can have them without any care in all countries, without fearing the harshest winters. The roasters would provide a large quantity of these young feathers, or there would be leftovers, by feeding chickens or pigeons, which would be plucked from time to time, and which would nonetheless lay their eggs and produce their young, as I have tested. But we shall see that there will be much to deduct when it comes to raising enough spiders to provide silk for manufacturing.

First, as soon as the young spiders abandon the cocoon that enveloped them, they appear perfectly in agreement - they work together in concert on the same web: some extend new threads over those that others had already provided. But such a union does not last long. I distributed into different boxes about four to five thousand spiders that I had seen abandon their cocoons. I put two or three hundred in some boxes, in others one hundred, or fifty, or even fewer; these boxes were approximately the length and width of a playing card, and just as tall; it was a rather large space for such small animals.

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...animals. Since I had observed that they attached themselves to the glass covering these boxes, I made for each one an opening at a line's distance from the glass, through which I would insert a card that was pressed against the width of the box. This card closed the opening quite exactly, to prevent the spiders from escaping. It was on this card that I would place the food that I had found to be suitable for them: I would thus place it near the upper surface of the box or glass, so that the spiders would be closer to this nourishment, and so that those at the bottom of the box or on the sides could come looking for it. I had taken the precaution of making a large number of holes in this card; through this means one could feed many spiders in a very short time. One could see them in the first days searching for this food with eagerness; several would attach themselves to the same piece of feather.

But their ferocious nature soon revealed itself: the largest and strongest began to eat the smallest and weakest ones. Each time I looked at them, I would see one smaller spider that had become the prey of one slightly larger, and after some time barely one or two spiders remained in each box.

I knew well that large spiders sometimes fight when they encounter each other; but there was some appearance that being raised together, they might become more sociable, as we see that chickens and turkeys raised in the same farmyard live quite well together, although they sometimes make war on newcomers, to the point of killing them. Large spiders even eat each other much less than these small ones, whether because they have less need for nourishment, or because, being heavier, they have less inclination to move around.

Apparently, this inclination they have to eat one another...

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...eating one another is partly the cause of why there are so few spiders in proportion to what there should be, given the prodigious quantity of eggs they produce. I know well that there are various kinds of insects that eat them; Pliny speaks of some species of wasps and lizards that feed on them. I have seen small brown wall lizards catch them with great skill; but despite this, I believe we would see incomparably more of them if they did not eat each other.

It would therefore seem that the only course of action, if one wanted to raise spiders, would be to house them separately. One could, for example, have boxes divided into several small compartments that would form multiple cells; and I have done this. But to feed each of these

spiders separately would involve expenses disproportionate to the profit one would gain. One could perhaps get around this if we had silkworm food in an infinitely more convenient manner.

I know that one could find ways to simplify this method of feeding them, and I have myself imagined some that I do not believe necessary to describe here; but whatever one does, it is always to be feared that one will employ considerably more time than one devotes to giving nourishment to silkworms.

The necessity of distributing spiders in separate cells presents another complication, which diminishes not a little the advantage they have over silkworms in terms of their fecundity. For to benefit from this advantage, it is necessary to be able to keep a large number of eggs that have been fertilized by mating; and for that, spiders must necessarily be placed together. I know well that there is a time when one should encourage a gentle fermentation among these insects that would temper their natural ferocity, and that one could then...

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...put them together without any risk. But how to know precisely this time, which must shortly precede when they have the urge to lay their eggs? It would be easy to find, if they all laid these eggs approximately in the same days of the year; but there are several months' difference between the time when some lay their eggs and when others lay theirs in turn.

The fecundity of spiders is prodigious, as M. Bon has perfectly observed; but after all, silkworms are fertile too. If we supposed that they only produce about one hundred eggs, of which barely forty give silkworms that make their cocoons, whereas spiders produce six to seven hundred eggs, although I have observed in all the silkworms that I have raised, to make an exact comparison of their silk with that of spiders, that they have always produced at least three to four hundred eggs. It is easy to see that one can multiply the number of silkworms as much as one wants, if that only depends on the quantity of their eggs. No other proof is needed than the quantity of silk they provide today in Europe, where there were formerly no silkworms at all. It would therefore be easy with time to have quantities of silkworms that would surpass as much what we have at present as what we have now surpasses the small number that was originally brought from the Orient to Europe. But what is necessary is to house them, feed them, care for them, which makes it so that one doesn't raise more of them, because by increasing the quantity of silk, one would lower its price, and the care one is obliged to take to raise silkworms would no longer be paid well enough.

It seems proven here that silkworms have much advantage over spiders by the ease with which one can raise them, and consequently that one should promise little from the new silk, if it doesn't have some advantage over the old, either in its beauty or its strength, or in the quantity one can extract from it. This is what we shall examine in the second Article.

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As not all species of spiders produce a silk that can be put to use, and as those that do provide this silk spin it solely to form the cocoons that envelop their eggs, because we know that the

threads they extend for insects are made commonly of a silk so fine that one could not make any use of it, it seemed necessary to me to give a general idea of the various species of spiders to which one can relate all the others, and of the different manner in which the cocoons of these different species are made, in order to indicate here those from which one can extract silk in the Kingdom.

M. Bon, who considered spiders primarily in relation to their silk, has also distributed them into different species, according to the relationship they have with this silk. He reduces them for this purpose to two principal species, which are long-legged spiders and short-legged spiders: it is the latter, says M. Bon, that provide the new silk. But this division, which would have great advantages for its simplicity, does not appear to me to provide a manner sufficiently sure to distinguish these spiders from others. One might be embarrassed to know which ones should precisely be called long-legged, and which ones should be called short-legged. There are spiders that have legs of a medium size, between those of the largest and those of the smallest; under which of the two species should they be ranked? Do they produce good silk? It would be difficult to determine by means of the preceding division. This is not, however, its greatest inconvenience; it has a much more considerable one that would expose to quite useless pains those who would want to collect spiders to make them spin silk; for the majority of those from which they would hope to gain advantage would not give them any at all. Such are the various species of vagabond spiders and the large brown spiders that live in holes in old walls, which...

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...have legs shorter than most of those that provide silk, although they do not provide any at all.

To distinguish the spiders of the Kingdom that produce silk from those that do not, I first classify them all under two genres. The first of these genres is composed of all the species that M. Homberg has included under the name of "vagabond spiders" in his Memoirs of 1707, a name that perfectly suits these species of spiders, which do not set, like others, threads for insects, but which hunt them with much cunning and skill. All these spiders spin little, and they hardly ever do so except when they wrap the web that serves as a cocoon for their eggs; some form this small cocoon in the shape of a half-sphere, they leave it glued to stones, or hidden under the earth; sometimes they place it in trees or in herbs. Others give it the shape of a ball, which their tenderness does not allow them to abandon; they carry it always attached to the nipples that are near their anus, in such a way that it seems this ball forms but a single body with the spider, which then appears simply much larger than it should naturally be. If, after having caught one of these spiders, one takes this little ball away from it, one sees it reclaim it with great eagerness as soon as it is given its freedom. It uses its legs to carry it first under its belly, and it is then that one can determine which skill it uses to hold it ordinarily; for one sees that it curves its posterior end right up to this little ball, after which it spins this same ball very quickly with the nipples that are near its anus, and this because these nipples are the reservoirs in which is contained the viscous liquid with which spiders form their threads; so that by this friction it covers a part of the ball with many threads...

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...viscous fluid, which she then easily sticks to the same nipples that produced it. One can distinguish without difficulty these rubbed areas, both because they are thicker and because they are whiter than the rest. The tenderness of spiders of this species does not stop there; they carry their young on their backs after they have hatched: these young spiders have a marvelous skill in arranging themselves on their mother's body - one does not notice that they are there when one sees her walking. The mother's body appears only somewhat more bumpy than it naturally is; but when one catches her, one sees each of these small insects scatter to its own side.

The tissue of the cocoons of all this genre of spiders is very dense, and commonly white or gray; but besides the fact that one could only extract very little silk from them, that which one would extract could not be used for works.

I form the second genre of all the spiders that set webs to trap insects. I divide this genre into four principal species, each of which could be subdivided into various other species, if one wanted to write an exact history of spiders. I place in the first species all the spiders that make webs, whose tissue is quite dense, and which they extend as parallel to the horizon as the weight of their web permits. Domestic spiders that make their webs in the corners of walls, and some species of field spiders that make similar webs and arranged in a similar way to those of domestic spiders, are included in this first species.

They enclose all their eggs, slightly adherent to one another, in a web, which by its strength and color hardly differs from those that they set for flies. Thus it is easy to see that one should not hope for anything from these cocoons for works.

The second species contains the spiders that live...

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...live in holes in old walls; they carpet with web the wall all around this hole, and inside this hole they also make a web to which they give the shape of a tube; it is through this tube that they enter and exit their holes. But these spiders do not also envelop their eggs with threads stronger than those with which they weave their web.

I place in the third species all the spiders whose threads do not form a tissue that has the appearance of a web, but which are composed of different threads pulled in all directions. This species could be subdivided into a large number of other species, which make their cocoons in very different ways. Some give them the shape of a portion of a sphere, whose flat part is attached to a leaf: they cover it with a marvelous attachment; for however fierce they may naturally be, if one carries away the leaf where this cocoon is attached, the spider allows herself to be carried away with it without abandoning it, until the little spiders it contains have hatched. These cocoons are of a very dense tissue, and very white. Others make two or three small balls of reddish color, in which their eggs are enclosed; they leave them suspended from threads; but they take the precaution of hiding these balls, which they leave in very uncovered places, with a small packet of dry leaves, otherwise birds could easily spot them. This small packet of leaves is

attached to threads at some distance from the ball. Others give the shape of a pear to their cocoon, and it is suspended by a thread, like a pear would be by its stem.

All these different cocoons are of a very dense tissue, but of a silk too weak to be put to use. Perhaps that of the little pears I just mentioned could be used; but they are so small and consequently contain so little silk that they merit no attention in this regard.

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Finally, the fourth species comprises spiders that compose their threads of different strands, which, being all placed in the same plane, emanate from a single point like so many rays of a circle that would extend to its circumference. All these threads are crossed by another thread, which, turning in a spiral, attaches at different points to each of them. These types of webs are ordinarily positioned perpendicular to the horizon. M. Homberg has named this species the Garden Spider; it is also very common in woods and thickets. It encompasses a large number of species of spiders that differ in their size, their shape, and their color.

These spiders arrange their eggs one on top of the other, in such a way that the mass they compose has the shape of a flattened sphere, or rather of an Elliptical spheroid. Some of these spiders glue these eggs to one another by a glue that they moisten when they exit from their body, but others do not glue them; the first threads that envelop these eggs are unwound in a slightly more dense manner than the others, which are twisted very loosely, much in the same way as the exterior threads that envelop silkworm cocoons.

Almost all these species of spiders spin a silk suitable for works; there are however some whose silk would be too weak to maintain even somewhat rough fabrics.

One could have spider silks with different colors by their natural colors, unlike that of silkworms, which is always aurora or white; whereas spider cocoons would give yellow, white, gray, sky-blue, and a beautiful coffee-brown.

Spiders that give coffee-colored silk are rare; at least I have only encountered them in some fields of Genests [a type of plant], where I also found their cocoons, of which the silk is very strong and very beautiful. They are…

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...made very differently from all the other spider cocoons I have discussed: the eggs are enclosed in the brown silk, which is unwound quite loosely around them, as in all the other cocoons; but this brown silk is itself enveloped in another cocoon of gray silk, whose tissue is very dense, quite thick, and similar to what remains on a silkworm cocoon when it has been partially unwound.

Spiders make their eggs or the silk that envelops them in several months of the year; not only do they work during the months of August and September, as M. Bon has well noted, but there are some that make their cocoons as early as the month of May, and others in the following

months. These are those that have survived the winter and lay so early, and M. Bon has undoubtedly only wanted to speak of those that hatch in the Spring, which make their eggs much later than the preceding ones.

We have made it clear enough thus far that spiders spin two types of threads: some serve to weave the webs they set for insects, and others serve only to envelop their eggs; but it is perhaps not out of place to add here that these threads differ from each other only by more or less strength, and to explain how spiders can make threads more or less strong when they please. I suppose that one knows that spiders have near their anus various nipples, which are like so many conduits in which the liquid that must become silk is molded, after being secreted, after having been strengthened by these conduits. The spiders of which I speak here, that is, those whose silk is suitable for works, have six of these nipples, of which four are very visible, but the other two are less so, and one cannot distinguish them easily without the help of a magnifying glass. These two small nipples are placed each near the base of the two large ones, which are nearest to the anus. Each of these six nipples...

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...sensitive [nipples] are themselves composed of small nipples, or rather of small insensitive conduits; this is something one is easily persuaded of, if while pressing with two fingers of the same hand the belly of a spider, to force the liquid to flow into these nipples, one applies another finger to one of them, and then gently withdraws it; for one pulls several distinctly separate threads from one another from their origin, which consequently have passed through different holes. These threads are too fine for one to be able to count them all in a sure manner; but what I know for certain is that I have often seen more than seven or eight from the same nipple emerge. One pulls more or fewer of these threads from a nipple, depending on whether one applies one's finger more firmly, or on a larger part of its end; from which it is easy to understand how spiders make threads that are more or less thick when they please. For not only when they are about to spin, they apply against some body more or less of these sensitive nipples from their anus; but depending on whether they apply more firmly, or a larger part of each of these nipples, they make threads composed of a greater number of other threads, and consequently stronger and thicker.

There must be about eighteen times more threads, such as those that form filaments, which compose one of the cocoon threads, than there are in web threads, if the quantity of threads that compose the former and the latter is proportional to their strength; for having attached a weight of two grains to a web thread, it normally sustained it without breaking, and broke when I attached a weight of three grains to it; whereas the threads of cocoons ordinarily support about thirty-six grains, and they only break when loaded with a greater weight.

But if the threads of spider cocoons are stronger than the threads of webs, they are also weaker than silkworm cocoon threads, although in a lesser proportion

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...tion. The strength of the threads that I unwound from these cocoons has ordinarily been up to supporting two and a half grains. Thus the strength of a spider cocoon thread is to that of a silkworm cocoon thread approximately as 1 is to 5. And perhaps this is still one of the ways by which the old silk might appear to have an advantage over the new.

In truth, each spider cocoon thread is almost less thick than a silk thread in the same proportion that it is weaker than it. But this does not entirely remove this disadvantage, as it is more difficult to join together several strands; and without considering this additional trouble, it is always to be feared that the threads will not all pull equally, and consequently their assembly would not have the sum of forces that each thread would have separately. This multiplicity of fine threads that compose each spider silk thread, while contributing in part to making works made from this less lustrous silk than those made from silkworm silk, their luster is effectively less beautiful, as Mr. Hire remarked when the mittens were presented to the Academy. What we call luster in a fabric has no other cause than that it reflects more colored light in a certain way, another fabric that appears to be the same color; a silkworm silk thread will have small voids that another strand of silk will not appear to have, because it will reflect less light; these small voids will evidently be in greater number in a thread composed itself of several strands that are truly separate, like that of the same thickness that is not composed of different parts of the viscous liquid that forms it; without doubt applied differently, some pressed against the others, must touch at more points, various threads truly separated. Thus in general each spider silk thread is not...

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...naturally as lustrous as a silkworm silk thread; it is clear that when one joins five of these threads to compose another of the same thickness as a silkworm silk thread, this composite thread and the work that will be formed from it will appear less lustrous than the silkworm silk thread and the work that will be made from it.

This would be true assuming, as I have just said, that each simple spider thread is naturally as lustrous as a simple silkworm thread. But this assumption itself would be too favorable to spider silk. For one can observe that the most crimped threads have less luster than those that are less so. Thus we see that wool, each strand of which is naturally more crimped than a strand of silk, is also less lustrous. If each strand of spider silk is naturally more crimped than a strand of silkworm silk, it must therefore also have less luster; and this thread is really more crimped. It is not very difficult to find the reason why these threads are more crimped than others; the manner in which the former and the latter are unwound is apparently the cause. For one understands first that by unwinding threads in a loose manner, one allows freedom to the efforts of all the small parts that compose them, to act with all their forces to fold them, or to twist them in several different directions; whereas by unwinding these threads in a tighter manner, as is done with silkworms, one prevents the action of the recoil of these small parts. The recoil itself suffers in this violent situation, or at least weakens. One will more willingly agree with this, when one pays attention that the first threads of silkworm cocoons that are wound around the cocoon in a loose manner are much less beautiful and less lustrous than those that form the body of the cocoon, which are unwound in a very tight manner.

This loose manner in which spider threads are twisted contributes in yet another way to diminishing...

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...the luster of the silk they produce; it prevents one from being able to unwind them as one unwinds the threads extracted from silkworm cocoons, such that one is obliged to card these cocoons before spinning them. Thus one easily perceives that the large silk threads that the worker has spun must be composed of an infinity of very short strands, and consequently it is not possible for this thread to appear as beautiful or as lustrous as one that, being of the same thickness, would be composed of different strands that would each have a length equal to that of the thread, and this because all the ends of these short strands would necessarily produce small irregularities in the length of this thread that would remove its luster. This is so clear that it seems unnecessary to add further proof, by observing that the silk extracted from silkworm cocoons after having carded them is much less beautiful than that which one extracts by unwinding these cocoons directly.

If one supposed that only two of the nipples had provided threads to make one spider web, and that each of these nipples that themselves often provide a composite thread of several others had provided a simple one, the web threads being eighteen times weaker than a cocoon thread, this last thread that we have said is about five times smaller than a silkworm thread, would have to be composed of at least thirty-six strands. Perhaps this reflection can help sustain the imagination when it tries to comprehend the prodigious divisibility of matter. For however small a thread may be that the eyes can still perceive, and which is no thicker than the one hundred and eightieth part of a simple silk thread, this simple silk thread is itself only the two-hundredth part of one of the finest of those silk threads used for sewing? For I have often divided these strands of silk into two hundred threads, or thereabouts; so that a strand of spider silk the thickness of a strand of silk used for sewing would really be composed...

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...of about thirty-six thousand threads, and one could actually divide them into thousands.

The strand of spider silk composed of these thirty-six thousand simple silk threads would perhaps be a little thicker than a silkworm silk thread composed of two hundred simple threads, although the sum of the thickness of the 36,000 threads and the 200 is the same, because it would be difficult to arrange together such a large number of strands without there remaining several empty intervals between them, which would appear to increase the volume. It is for this reason that spider silk has seemed to render more to the work than silkworm silk. But if one had paid attention that as compensation it must be more weak, far from regarding this as an advantage of this silk, one would have been disposed to believe that it was one of its defects, since a larger volume of this silk can only have the same strength as a smaller volume of silkworm silk.

But finally, let us come to the last essential point, that is, let us see what relationship the quantity of silk that each spider gives per year has with that which one extracts from silkworms. I weighed with great care various silkworm cocoons, and I found that the strongest, that is, the product of a year's work of a silkworm, weighed four grains, and that the weakest weighed more than three; so that taking a pound of sixteen ounces, it would take at least 2,304 silkworms to have one pound of silk. When one carries silk garments, one hardly thinks that several thousand silkworms have worked all their lives to provide the material.

I weighed with the same care a large number of spider cocoons, and I always found that it would take about four of the largest to equal the weight of a silkworm cocoon, and that they each weighed about one grain; so that it would take four of the largest spiders to give as much silk as one silkworm, if there was not more waste on the silk of the former than on that...

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...of the others, and if they all gave silk. But spider cocoons are subject to a waste that silkworm cocoons are exempt from. What causes this waste in spider cocoons is that they are filled with all the cocoons of eggs that envelop the little spiders before they hatch, along with various impurities that are found mixed with them. If we calculate the waste of these cocoons, we must deduct more than two-thirds of their weight, since from six ounces of raw spider silk, M. Bon only obtained about four ounces of clean silk; whereas silkworm cocoons have no waste, or it is so small that it can be disregarded by taking only that of cleaned silk to the two-thirds.

Now, we have just seen that the weight of a spider before being cleaned is to the weight of a silkworm as 1 is to 4; thus being equal, the weight of the former will be to the weight of the latter as 1 is to 12; thus it would already take twelve of the largest spiders to give as much silk as a single silkworm. But each one makes a cocoon, because they use theirs to produce eggs, unlike silkworms which do not make theirs to envelop their eggs, if we consider with the Naturalists who preceded M. Bon, that spiders are formed of males and females (I do not take them for hermaphrodites), there are only female spiders that make cocoons. From this, one must suppose that there are as many female spiders as males, which must be approximately true, and one sees that even the largest spiders will not give more than a single silkworm.

It would therefore take about 55,296 large spiders to have one pound of silk, for which it would have been necessary to feed them separately for several months. From this one can see how much it is to be feared that the silk one would obtain from them would not be worth the expenses, which would be disproportionate to its value, since...

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...it would cost twenty-four times as much as that of silkworms; even if one supposed that one is not obliged to keep the spiders separate, and that each spider would not occupy more space than a silkworm, which would also be a false assumption; for one must give them enough space for each so that they can make their web. But if one wanted to enter into the detail of the costs they would incur, being obliged to feed them separately, and to give them spaces large enough

to lodge each one comfortably, one would see in a very clear manner that spider silk would cost incomparably more than that of silkworms.

Let no one believe, moreover, that all I have said only concerns spiders of a common size. For if one wanted to know what silk is produced by those commonly found in the gardens of this country, and which appear very large, one would see that it would take twelve of these to have as much silk as one extracts from one of the cocoons of those I have mentioned, and that 180 would give only the same weight of silk as provided by a single silkworm cocoon; consequently, about 663,552 spiders would be needed to make one pound of silk.

One will no doubt regret that we are left with so little hope of profiting from such an ingenious discovery. After all, there is still some prospect of a type of resource; perhaps one will find spiders that give more silk than those we commonly see in the Kingdom. It is already certain from the reports of all travelers that those of America are much larger than ours; from which it also seems that they should make larger cocoons. Silkworms, which, although native to distant countries, have populated Europe so well, would lead us even to hope that American spiders could live in ours. Whatever the case, one must experiment; it is the only way to discover...

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...curious and useful things. Thus I shall neglect nothing that may relate to the research discussed here, in which if one ever discovers something useful, the primary glory will be due to M. Bon.