CHAPTER X

STUDY OF SILK MATERIALS

Silk.—The silk industry is supposed to have originated in China about 2700 B. C. The art was known only to the royal family for a long time, but gradually the knowledge spread and it soon became an important industry in China. Later it became known to the people of Japan and slowly it spread through central Asia, Persia, Arabia, Spain, Sicily, and along the African coast. Silk culture was practiced in Italy in the twelfth century and in France in the following century. Most of the silk of commerce is obtained from the cocoons of a certain kind of caterpillar called Bombyx mori, or mulberry silkworm, which feeds—as the name implies—upon leaves of the mulberry tree. There are other varieties of silkworm which cannot be cultivated; these are called wild silkworm. They produce an inferior grade of silk called tussah. From this wild silk is manufactured the pongee silks of commerce. Most of the raw silk on the market is produced in China, Japan, France, and Italy.

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Throughout the succession of changes which takes place in the insect, the greatest care has to be exercised in regard to temperature, quiet, and food. After the moth lays the eggs they are collected and kept cool until time for incubation, which process takes place in heated compartments where the temperature is carefully regulated. The period of incubation lasts about thirty days and then the worms hatch out as tiny little things no larger than the head of a pin. The growth and development of the worm proceed rapidly. Its food is chopped mulberry leaves. There are four molting stages; each time the worm sheds his old skin, and emerges with a new one. This is caused by the body growing faster than the skin. At the molting time, the worm ceases eating and remains in a torpid state for a couple of days, rests a short time to regain strength, and then begins eating with renewed vigor. After the fourth and last molt the worm is $1\frac{1}{4}$" long, but in the few days remaining before it spins its cocoon, it grows to 3" in length. As soon as it has attained its full growth, which seldom exceeds 3", it is ready to spin its cocoon. It stops eating, shrinks nearly an inch in length, loses in weight, turns pale in color, and seeks a place to which it can attach the cocoon. The web which it forms is composed of a secretion exuded from two glands in the body, which unite into one
common exit tube below the mouth, where also exudes another secretion which cements the two threads together. The double silk fiber is called *fibroin* and the silk glue is called *sericin*. This gum which cements the fibers together hardens upon contact with the air.

The worm forces the silk fiber out by contracting his body, turning his head from side to side, and throwing the fiber around himself in figure-eight loops, until, layer after layer, the cocoon is gradually completed—a process which requires about three days. The cocoon is ovoid in shape and is composed of one continuous thread which is 400-1300 yds. long. After the cocoon is finished the worm passes from the form of a caterpillar into a chrysalis, from which it rapidly develops into a moth. Unless the chrysalis is killed before the moth has developed the cocoon will be pierced and the thread broken, so live steam is applied which kills the chrysalis, and the silk can then be reeled off at any time.

The life cycle lasts about 55 days on the average: (a) 30-40 days as larva; (b) 15-20 days as chrysalis; (c) 6-12 days as moth. A moth lays about 700 eggs in three days; 30,000 eggs weigh 1 oz.

*Silk reeling.*—Silk reeling is accomplished by soaking the cocoons in warm water to soften the gum and then carefully unwinding the fibers,
twisting several together, according to the size of thread desired, and winding it into skeins. These skeins are put into canvas bags and soaked over night in warm soapsuds to further soften the gum which has stuck the fibers together, then they are hung across poles in a steam-heated room and dried. Following this the silk is wound upon bobbins and spun into thread.

The waste silk from the reeling is mixed with that from the outer part of the cocoons, known as "floss," and is subsequently spun into what is called spun silk. It is treated as a bundle of fine fiber-like wool or cotton, and is spun by textile machinery that is especially adapted to it.

Silk dyeing.—Silk is dyed either in the yarn or in the piece. If dyed in the yarn, the gum is removed by soaking in boiling soap and water, then the yarn is washed in cold water. At this point weighting is often put in—tin, iron, or other mineral salts being absorbed by the fibers. Sometimes there is more weighting than silk, for silk has the peculiar property of being able to absorb certain minerals, and because of this they are much used to deceive the buyer into paying a higher price for silk than it is worth, as weighting makes silk both weak and tender. Silk will take up 50-200 per cent of weighting without arousing much suspicion. The silk is
dyed, the luster restored, and it is then ready for weaving, after which the material is singed to remove loose fibers, straightened, and sized with starch or glue to stiffen it.

Since 1624 several attempts have been made to rear silkworms in America. All have met with failure because of climatic or labor conditions. In some cases the mulberry trees were injured by early frosts and in all cases the low cost of labor in Europe offered a competition that it has been impossible to meet. It is interesting to note that the original Cheney Bros., well known silk manufacturers, made an attempt to raise silkworms in South Manchester, Conn. Some of the mulberry trees, planted at that time, are still standing. Importing the raw material and manufacturing it in the United States has been found to be the best business proposition. There are about 700 establishments for the manufacture of silk in the United States. Paterson, New Jersey, is the silk city of America, having more than 300 mills and employing 40,000 men and women. The manufactured silk that is imported now is confined to the costliest fabrics in broad silks, to fashionable novelties, and to church vestments.

*Physical characteristics of silk fiber.*—Under the microscope the silk fiber appears as a smooth, structureless filament very regular in diameter and very transparent. (See illustra-
tions.) One striking characteristic of silk is its high luster, which, however, only appears after the silk has been scoured to remove the silk gum. Dyeing and mordanting also affect the luster more or less, especially when silk is heavily weighted, and therefore, after dyeing, silk usually goes through a lustering operation in which the hanks are stretched strongly by twisting and at the same time steaming under pressure. By this process much of the luster is restored.
Raw silk will absorb as much as 30 per cent of its weight in moisture and still appear dry. This property is called hygroscopicity, and because of it the amount of moisture in the silk has to be determined at the time of sale and allowances have to be made for it. The amount legally permitted is 11 per cent.

Another property of silk is that of being a poor conductor of electricity. It is, therefore, readily electrified by friction. Silk is the strongest fiber known, said almost to equal the
tensile strength of iron wire of equal diameter. It is also very elastic—raw silk stretching from 15 to 20 per cent its original length in the dry state before breaking. Weighting of silk causes a decrease in both elasticity and strength.

A property which is peculiar in silk is its "scroop"—the crackling sound it makes when rubbed or squeezed. This is the cause of the rustle which characterizes most silk materials, although weave influences the degree to a large extent.

Silk has a great affinity for dyestuffs, absorbing coloring matter very readily. Authorities disagree as to whether this is a physical or chemical process or a combination of the two.

Weighting of silk.—The practice of weighting silk is probably centuries old, for it has long been known that silk possesses a great affinity for tannin, but it is only within the last 25 years that weighting has been in general use.

The boiling off of the gum reduces the weight of the raw silk from 5 to 30 per cent. Since the price of raw silk is about $5.00 per pound it is not to be wondered at that ways have been devised to make up this loss. Harmless additions of plain sugar and sugar of lead were used in the beginning but the demand for cheap silks has brought about an exaggerated and injurious weighting. The throwster may leave an excess of soap and oils in the silk but most of the loss
is made up and weight added in the dyeing process. Silk is very absorptive, it being possible to weight or load it up to five times its boiled off weight. While this is a great advantage to the manufacturer it is unfortunate for the consumer, since the result is the mechanical weakening of the filaments. This may be explained in various ways—first, the stretching of the walls when taking in the metallic weighting weakens the fibers; second, the salts crystallize when exposed to the sunlight, thus cutting the delicate filaments; third, oxidation occurs in the course of time, with a consequent weakening of the fibers; fourth, perspiration causes deterioration because chlorine is freed which causes rotting.

The silk to be weighted is immersed in a series of solutions, with thorough washings between each treatment. The number of immersions is determined by the amount of weighting desired. To heavily weight a silk requires many dippings. Compounds of tin, lead, and iron in solution are most commonly used. White and light colored silks are weighted as well as black and dark colored. This is contrary to the opinion commonly held, but can be very easily demonstrated. Weighting reduces the strength of the fiber greatly. Strehlenart showed a black silk weighted to the extent of 140 per cent was only one-sixth as strong as pure crude silk.
Even a very weak solution of common salt has a pronounced deteriorating effect upon silk that has been weighted with metallic compounds. The salt in the perspiration undoubtedly partially accounts for its disintegrating effect upon silk. The action of sea water also illustrates the effect of a salt solution on weighted silk.

The practice of weighting silks with metallic salts is responsible for the small holes which frequently appear in present-day silks. It also accounts for the splitting, which is so common, as well as the fact that it is difficult to find a silk today which has satisfactory wearing qualities. The silkworm has not lost the art of spinning good silk but the manufacturer has taken advantage of this peculiar quality of silk. While this has made it possible to sell silk fabrics at a much lower price than formerly, it has also produced a condition where it is almost impossible to find silk of the firm taffeta type, at any price, which is free from weighting.

What is needed is a textile law requiring proper labeling of material offered for sale. To quote from an article in Harper's Weekly, "There is at present an agitation in the silk trade to bring about the marking of all silk to show its degree of purity, so that the innocent consumer may be able to buy silk with some degree of intelligence. It is pointed out that, while there are conditions when the adulteration
is not harmful, when the wear is not essential, a law of this kind would greatly increase the standard of quality.

We will not attempt to decide whether the public or the manufacturer is most to blame for the present condition. However that may be, it should be possible to purchase good wearing silks, if one is willing to pay the price.

The simplest test for the detection of weighting in silk is that of burning the fiber. Pure silk when held in a flame burns quickly, melts and runs together, leaving a small quantity of carbon. If burned long enough at a sufficiently high temperature, this residue entirely disappears.

Weighted silk when burned simply blackens and remains in practically the original form. A longer burning would again decompose the black carbon but still leave the mineral matter, usually in the form of a grayish or reddish ash, depending on the mineral used.

Sometimes the threads one way will be weighted while the others are pure, and less often a piece will be found which has a few weighted threads woven in a design while the bulk of the material is pure silk.

The simple burning with a match is a most practical household test. As a general rule, the less weighting the greater service may be expected from the material. Where the threads
Chiffon Taffeta

Messaline

Charmeuse Messaline

PURE SILKS BEFORE AND AFTER BURNING

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Original Residue
Taffeta, 10 inches—65 cents per yard

Original Residue
Messaline, 21 inches
$1.50 per yard

Original Residue
Taffeta, 36 inches
$1.50 per yard

Weighted Silks Before and After Burning
one way are weighted, this rule does not hold good, because if the threads in one direction give way, the material loses its usefulness.

**Weighted Silks Before and After Burning**

Collect samples which illustrate different ways of weighting. Crepe de chine, crepe meteor, charmeuse, messaline, and foulards are
seldom if ever weighted. Occasionally the taffeta type of silk is found unweighted.

Weighted Silk Above, Pure Silk Below, Before and After Burning

Wash silks are often part cotton. Perhaps the most common mixture is a cotton warp and silk weft. By exposing the warp and weft
threads separately the difference can often be readily detected. The following test may be used if there is any question.

Treat sample with concentrated hydrochloric acid (HCl). Silk will dissolve much more quickly than any other fiber.

Other silks have been found to be adulterated with linen also. This is not common and may be detected by using the same test and the microscope.

Suggestive Review

1. Silk—growth and manufacture. History of the spreading of the industry. Where are silkworms raised today? Why is their culture on a commercial basis restricted to these sections? Attempts in the United States—why were they unsuccessful? Compare wild and cultivated silks.

2. Properties of the silk fiber—appearance under the microscope, heat conduction, luster, elasticity, tensile strength. Weighting of silk—how accomplished, why continued, effect on the fiber. Burning test using samples of pure silks and silks showing various types of weighting.

3. Artificial silk—how manufactured, where used, why can it not be used to a greater extent in place of real silk.
Review mercerized cotton—compare microscopical appearance of mercerized cotton and silk.

4. Collect as many samples of common wool and silk materials as possible and have a drill to review and teach the names, prices, and uses. This will give an opportunity to emphasize and perhaps make clearer the important points discussed in this and previous lessons.

5. Review—Compare microscopical appearance of cotton, wool, silk, and linen. Have pupils draw the various fibers. Special emphasis should be placed on: the twist in cotton which is a great aid in spinning, the nodes in linen because the fiber is made up of a number of cells, and the scales on wool fibers which affect the heat conduction and shrinkage of woolen materials.

6. Review—Compare heat conduction of the fibers studied. Call attention to the added warmth of a material with a napped surface: fluffy blanket with one which has become matted with careless washing or wear; outing flannel with smooth cotton material of the same weight. Difference is due to the number of air spaces which act as nonconductors of heat.

Conduction of heat is rather difficult for children to understand. Some of the following illustrations may make it clearer. We say a substance is a good conductor of heat if it car-
ries heat readily from one object to another. When the hand is placed on a piece of stone, metal, or linen cloth it feels cold under ordinary conditions, because they take heat away from the hand very rapidly. If the hand is placed on a piece of wood or woolen cloth, it feels warm because these substances take heat from the hand very slowly. We can think of it in this way: all substances are made up of small particles and in some materials heat is passed on very rapidly from one particle to the other while in others much more slowly.

7. Using samples of materials, of as many different kinds as possible, have pupils tell name, what such a material should cost, and its uses. By making a drill or game of this exercise the children will be more interested.

8. Similar to exercise 7, except that the emphasis is placed on a consideration of quality—which would wear well and why, which are not worth the price asked.