

tangled silk unsuitable for reeling, which is used as a material for making spun silk, being known as floss. The remainder of the silk on the cocoon can be reeled, but the filament of the inner layers is so attenuated that it does not pay to reel it, and it becomes a waste material used also in spun silk. Cocoons are white, yellow, or greenish in color. The color of the *Bombyx mori* silk, after its gum has been removed by boiling off, is creamy white, no matter what the color of the cocoons has been. The cocoons which are not intended for reproduction are subjected to heat, that the chrysalids may be stifled, since if the moth is allowed to issue, it cuts and spoils much of the fiber.

It is said that a silkworm during its life eats about thirty thousand times its initial weight, and increases in weight from ten thousand to fourteen thousand times. The mulberry is the best food, but osage, lettuce, oak, and other leaves are used. There are silkworms other than the *Bombyx mori* that provide useful silk, and the industry is growing in importance. This product is called wild silk because the worms are hatched in the open and not in nurseries under standard conditions. The leading varieties are the Tussah silk of India and China and the Japanese wild silk. A large amount of these silks is used in the United States. The cocoons are larger and the products coarser and harsher than those of the *Bombyx mori*. The color is brown.

Various diseases and parasites attack silkworms, and large sums of money were lost in that way until the absolute need of care in the following matters was learned: the importance of eggs from perfectly healthy moths, of flawless leaves of the mulberry for food, of ample room in the coconeries with cleanliness; regularity in feeding and attention to temperature and ventilation. In good nurseries the most careful records are kept of food, temperature, and humidity. In Italy, France, and Japan the government provides schools of sericulture that the best results may attend the national industry.

Countries Cultivating the Silkworm. — The culture of silk began in China in 2700 B.C., says tradition. The emperor

Justinian introduced the silkworm into the Levant in 555 A.D., and from the ninth to the sixteenth century the production spread from the south to the north of Europe. Silk raising is still a national industry in these countries, though the north of Europe is engaged in manufacturing silk rather than producing it. The culture was started in America as early as 1622, in Virginia, and has been attempted many times since, but economically the United States cannot compete with the cheap labor of the Orient or of the south of Europe.

The principal silk-rearing countries at the present time are China, Japan, Italy, France, Spain, Austria-Hungary, Russia, India, and the Levant, the first four being the most important (Fig. 106). China is perhaps the leader, with Japan a close second. Both countries are noted for their rearing, reeling, and weaving. Three methods of reeling are found — the primitive, by which silks such as the Tsatlees are produced, from which the raw silk comes of irregular size and in irregular skeins; the rereels, by which system the silks reeled in the primitive manner are rereeled into skeins of a more regular character, which gives a reliable product; and the steam filatures or filandas, equipped with modern machinery and improvements, from which the silk comes in good condition for the throwster. Steam filatures are found throughout Europe and Japan, and to a certain extent in the north of China and in Canton in south China. The name “steam filature” is used for certain China silks to differentiate them from Tsatlees.

The real pongee silk comes from the Shantung Province of China. The worms are fed on leaves of the scrub oak. Each lot of silk is woven into a piece, and varies from another in quality, weight, fineness, and color. It is an undyed silk. The United States takes 10 per cent of the product.

In the Canton districts of south China there are six or seven crops of silkworms annually; the cocoons are very small; much of the reeling is on primitive reels. The bales of reeled silk weigh about 106 $\frac{2}{3}$ lbs. and the highest price per bale in 1911

was \$409.¹ In 1909 China exported raw silk to the amount of \$6,500,000, and piece goods valued at almost \$5,000,000.¹

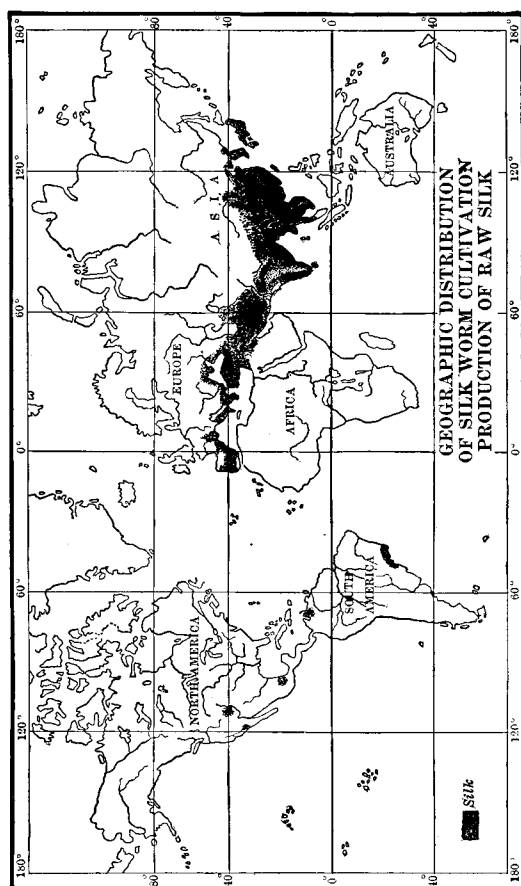


FIG. 106. — RAW SILK-PRODUCING SECTIONS OF THE WORLD.
From Tarr & McMurry's *New Geographies*, Second Book, 1910, by courtesy of the Macmillan Company.

Much of the Tussah or Tussur silk is grown in Manchuria. It is used largely for dress purposes, hosiery, electric wire covering, and upholstery. China keeps the greater part of its silk for

¹ Daily Consular and Trade Report, March 8, 1911; April 11, 1912.

home consumption. There are many different races of silkworms utilized.

In Japan improved methods of cultivating and reeling have increased the export of silk. The steam filature and the rereel systems are used. Three crops of silkworms are grown annually by feeding them with mulberry leaves which are sometimes kept in cold storage. In 1909 the total export of silk from Japan, reeled and woven, was \$66,229,794. Wild silk is also grown, the Yama Mai being celebrated. The United States consumes much of its raw and good waste silk. The quality is good and the range wide. The bales contain about $133\frac{1}{3}$ lbs.

India produces much silk, but the industry has been poorly organized. The Bengal district has many filatures, and much of the output is used in Burma. The woven fabrics are for the "sarīs" worn by the native women, for handkerchiefs and dress goods. India offers opportunity for good silk rearing, as food for the worms abounds. The multivoltines are the most common variety of worm. The silk is reeled in 10/14 and 16/20 deniers. (See Counts below.) Tussah and other grades of wild silk are common.

European Silks. — The best raw silk comes from Italy and France. In both countries the cocoons from the highlands are better than those from the lowlands. In Italy, the important silk-raising districts are Piedmont, in which Turin is the principal silk center, noted for its even, regular silk, and Lombardy with Milan as its center. About 8,000,000 lbs. are produced annually. France grows the bulk of her silk in the south and southeast departments. The best silk in the world is said to come from the Granite Mountains in that country. France produces about 10,000,000 lbs. annually. The European silks are more carefully reeled than those from the East. Spain and Austria-Hungary grow a good quality of silk. Syria produces much which goes principally to France. The size of the bales of European silks, including the Syrian, is 100 Kg., or $220\frac{1}{2}$ lbs. The Levant (Greece and Turkey in Europe and Asia), and the Caucasus produce much silk of good quality.

Silk in the United States. — New York City receives the bulk of the European imports of reeled and manufactured silks, and San Francisco most of the silks from the East *en route* to New York. The principal mills are in New Jersey, New York, Pennsylvania, and New England. The trains which bring the precious freight across the country from the Pacific Coast are dirt- and moisture-proof and thoroughly insured, as the value of one train may be from one to two million dollars. No stops are made except to exchange engines. In 1911 the United States spent on silk importations: Cocoons, \$74,261; raw silk, \$72,713,984; silk waste, \$2,210,020; bolting cloth, \$237,783; clothing and wearing apparel, \$5,597,915; dress and piece goods, \$2,478,413; artificial silk, \$3,299,559; bandings and belting, \$598,860; laces and embroideries, \$3,679,748; ribbons, \$685,585; spun or schappe yarn, \$5,108,804; pile fabrics, \$2,174,437; miscellaneous, \$1,041,801, — with a grand total of \$107,136,102.¹ The United States produced silk goods to the value of \$196,911,667 plus \$1,218,101 made in factories not listed as dress industries.

In 1910 and 1911 the world's product of raw silk was 51,850,000 lbs.

Classification of Raw Silk. — The silk from the various countries shows characteristics which fit it for different purposes. Chinese and Japanese silks are packed in bales covered with matting. The weight is supposed to be 133 $\frac{1}{3}$ lbs. (one Picul), but is not constant. The value of a bale is \$400 to \$600, more or less. It is made up of a number of bundles called books, which weigh four and one half pounds upward, and contain about thirty rolls of raw silk. Those which have been reeled in steam filatures are generally put up in rolls of two skeins each, of a size convenient for winding, and with the ends fastened so that they can be easily found. The skeins from native reels are apt to be too great in circumference, and give much trouble to the throwsters. The length of Asiatic raw silk skeins is largely

¹ Consular and Trade Reports, April 11, 1912.

limited by the length of the working day, the skeins being started in the morning and finished in the evening. "Native reeled" skeins are often full of flaws. The ends of such skeins are hard to find. The various Asiatic reelers have trade-marks. Some of these have a high standard of excellence, even though climatic and other causes affect the product from year to year. The buyers and manufacturers know the classes of silk from the various filatures, and order from previous experience. The best raw silk is even, clean, elastic, strong, and lustrous. In a general way it may be said that the raw silk from North China is noted for its whiteness, brilliancy, and snap, but Cantons are creamier in color and much softer. Japan silk is creamy white, clean, and of good strength and nature. Sicilian silk is yellow in color, suitable for soft satins, such as the Liberty satins. Southern France produces excellent silk, brilliant and suitable for black satins. The trade-marks from China and Japan, known as chop tickets, are very numerous, for they include those of the filatures and the rereels. The market terms as adopted by the silk association of America June 15, 1908,¹ were:—

EUROPEAN SILKS		
Grand Extra		Best No. 1
Extra Classical		No. 1
Best Classical		Realina
Classical		
JAPAN SILKS		
<i>Filatures</i>	<i>Rereels</i>	<i>Kakeda</i>
Double Extra	Extra	Best Extra
Extra	No. 1	Extra
Sinshiu Extra	No. 1-1½	No. 1
Best No. 1 to Extra	No. 1½	No. 2
Best No. 1	No. 1½-2	No. 3
Hard Nature No. 1	No. 2	
No. 1 [of the grade of Sinshiu	No. 2-2½	
Okaya (Chicken)] summer	No. 2½	
reeling season 1907-1908	No. 3	
No. 1-1½	No. 1½-2	
No. 1½	No. 2	

¹ *The Value of Conditioning*, 1908. Issued by the United States Silk Conditioning Co.

Silk Reeling. — The greater part of the silk on the cultivated cocoons, and most of the Tussah silk cocoons are reeled, and the waste and unreelable parts are laid aside to be spun. When the cocoons are brought to the reeling establishments, they are first sorted and classified by color, size, shape, wrinkles, and condition (moldy, defective, or perfect). The fiber varies in thickness in the cocoon, tapering down in size towards the interior. In reeling several cocoon filaments are united, and they must be overlapped in such a way as to produce the evenness in size that is so essential. Reeling is therefore an important and tedious process. Uneven and careless reeling is common, especially among the primitive reelers, and gives much trouble later to the throwsters.

The filament should come off evenly in one long, smooth thread. The method of doing this is to float the cocoons in specially constructed basins in boiling water, then brush them until the filaments which will unwind to the center of the cocoons are found, and wind them into hanks on the reels which are connected with the basin. Hand reeling is a very simple process, but steam filatures are in general use, in which the heat of the water can be regulated, and the reels are run by power instead of by the feet. One reeler can thus attend to a couple of basins. A revolving brush is used to catch the ends of the silk. The work begins by removing the loose silk from the outside of a number of cocoons. This is laid to one side with defective cocoons and other waste to be used later for spun silk. The threads are caught by the fingers and drawn off the cocoons until the filaments run smoothly. The silk from several cocoons is now united, twisted slightly in the fingers, and passed through an agate or smooth glass eye and attached to the swift or reel. For 13/15 denier silk, which is the standard raw silk sent from Japan to the United States, the threads from about six cocoons are united; for finer counts, such as 10/12 denier, fewer cocoons are required, and for heavy sizes, such as 24/26 deniers, many more are united to make the thread. The regular method of

reeling is to take the thread after it has come through the eye, and by a simple device twist it a number of times around itself to weld the filaments closer together. This is called the *croissure* (Fig. 107). The thread then passes to the reel, being wound in a transverse or lateral manner across its width, so as to make a cross reel, instead of piling up on itself. This helps later in unwinding the skein. By another method of reeling there are two

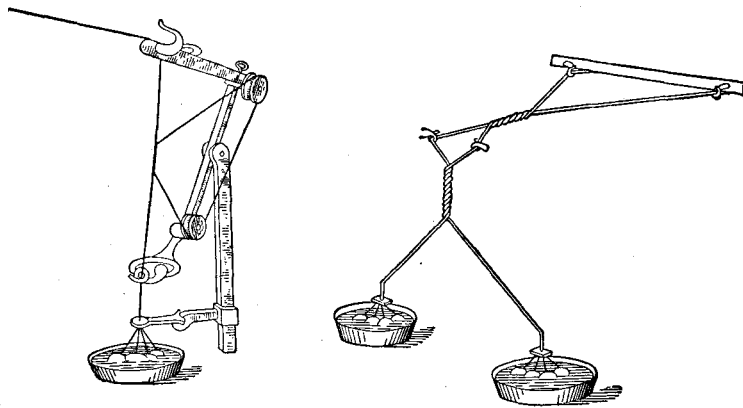


FIG. 107.—CROISSURES.

From Matthews' *Textile Fibres*, by courtesy of John Wiley & Sons.

threads, each made from a group of cocoons. Each thread passes through an eye, the two threads are twisted around each other, separated, twisted together again, and separated before passing to the swift. In some reeling machines a bell rings when a hank is complete and ready to be taken off. The product of reeling is called raw or reeled silk.

Fresh cocoons may cost about twenty-five cents per pound, but the dried ones, being much lighter in weight, run from eighty cents to one dollar per pound. Pierced cocoons (dry) from which the moth has issued are about fifty to sixty cents per pound. To make one pound of raw silk will take about eleven pounds of fresh cocoons and about four pounds of dry. There is in the

East sometimes as much waste as reeled silk from these cocoons. The price of reeled silk changes constantly, but runs approximately from three to five dollars per pound.

Conditioning. — The function of conditioning houses is to test the physical attributes of commercial fibers. They have been organized particularly for silk, but are extensively used for wool and cotton. These testing stations are found in silk centers such as Milan, St. Etienne, Basle, Zurich, St. Gall, Lyons, Krefeld, and New York. Conditioning is principally used for reeled and thrown silk. The elasticity and tenacity of silk are greatly affected by the moisture in it, and by other conditions. Silk, in commercial practice, is supposed to contain moisture equal to 11 per cent of its absolutely dry weight. It will carry 30 per cent without feeling appreciably damp, and can be made to absorb considerably more. The method of testing for moisture is as follows: Samples are taken from a number of books in one bale of silk and weighed carefully. They are then placed in ovens and dried perfectly. The samples are again weighed, and the difference noted, and the dry weight of the full bale is worked out by proportion. The conditioned weight of the bale is based on this dry weight of the silk plus the accepted commercial regain of moisture, 11 per cent. Tests by special apparatus are made of other points on which information is needed, such as the average size and regularity of size of the silk, its strength, elasticity, and boil off. Skeins are measured, bales weighed net, and like investigations are made.

Silk Throwing. — The term throwing is used for the series of processes by which reeled or raw silk is made into yarn for weaving. Silk direct from the reel is strong enough to stand the strain of weaving, but the threads would open up if dyed, so silk that is to be skein dyed has to be more or less twisted. When raw silk arrives at the throwing mills, the bales are opened, and, if necessary, the skeins are sorted as to size and color. Skeins that are to be thrown "bright," that is, without having been soaked, are taken directly to the winding machine. Those which

are to be soaked are put in a bath of lukewarm water containing some olive or neatsfoot oil and some olive-oil soap. Silk usually stays in this bath overnight, the gum being thus softened. After soaking, the skeins are "whizzed" in a hydro-extractor and then dried. Winding the skeins follows to transfer the thread to bobbins. This process requires careful work. In the winding machine the skeins are stretched on a series of swifts or reels which are arranged side by side, and the end of each thread is passed through an eyelet to a bobbin and by means of a guide wire is wound without friction up and down the length of the bobbin. The attendant must piece all bad places and deliver a smooth thread. The threads are passed from one bobbin to another through a slot or between two parallel plates so set as to remove all irregularities on the silk. Winding prepares the silk for doubling and twisting, which are necessary to give to the filament sufficient coherence for boiling off and dyeing.

Doubling and Twisting. — These are usually separate processes. In the doubling machines the threads pass from as many bobbins as there are threads to be doubled together upon one bobbin. The doubled thread is now twisted on a second machine. In some American machines throwing, doubling, and twisting are combined, but such machines can only be profitably used with perfectly reeled silks of good strength. The amount of doubling and twisting depends upon the future use of the thread. There are many different ways of throwing silk, but the three following are in constant use: singles or no-throw, organzine, and tram.

Singles have little twisting, a single filament of reeled silk being used. Hard-twist singles are used for gauzes and chiffons.

Organzine (Fig. 108) is made from the better grades of silk, for it is generally used for the warp, and that must be strong. A single raw silk thread is twisted with a right-hand twist, perhaps sixteen turns to the inch. Two, sometimes three, or even more of these twisted threads are again twisted together, left-hand twist, perhaps fourteen turns to the inch. There are variations

of the manner of twisting. In taffeta weaving the organzine is twisted sixteen or more times on the first twist. For soft satins, on the contrary, the twisting may be less, for the sheen or luster is greater if the silk is less twisted. For dull finishes for strong silks the organzine is twisted very closely. When two threads are finally twisted together the yarn is called two-thread organzine; when three are united, three-thread organzine.

Tram. — For tram silk, which is generally used for filling, two or more single, untwisted, reeled threads are united into one and

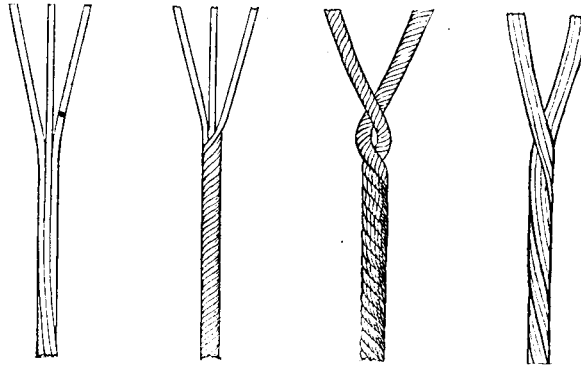


FIG. 108. — ORGANZINE AND TRAM.

From Barker's *Textiles*, by courtesy of Constable & Co., London.

twisted very slightly. The terms two-thread, three-thread, etc., are used to designate the number. A poorer quality of silk is used for tram than for organzine.

There are many special twists, of which sewing silk is an illustration. There may be as many as one hundred cocoon filaments in one thread of sewing silk, depending upon the size. From three to perhaps two dozen raw silk threads are united and twisted together, after which two, four, or six of these threads are again twisted together in the reverse twist while held at a tension. After the throwing, the silk is wound into skeins again for dyeing. When thrown silk is to be sold, the hanks of yarn are made into bundles. Thrown silk is sometimes called net silk.

Dyeing and Attendant Processes. — *Degumming and Stripping.*
— Reeled silk is harsh and wiry, as it contains considerable gum or sericin, and it may also have much color in it. After the thread is thrown and before bleaching or dyeing it, the gum and color are boiled out. All silk does not require the same treatment, for the gum is more difficult to remove in some cases, and in some classes of silk the gum is only partially removed. Stripping or boiling off the gum greatly reduces the weight of the silk, for 25 per cent or more is often lost. The process is simple and not injurious. The natural luster and softness of the silk is enhanced by boiling off. If the silk is to be very lustrous, it is sometimes stretched in the gum before the stripping or boiling off occurs, and is again stretched and steamed after it. The boiling off, as usually practiced, consists of a boiling in a vat of soapy solution, the silk being placed on sticks and worked up and down until the gum is removed. This is a process of much delicacy, as the degumming must be complete but not overdone. For soft silk, about 20 or 30 per cent of the thrown weight is lost in stripping, leaving it soft and lustrous; for “souple” silk the loss is less, being from 5 to 12 per cent. The result is a duller appearance and a firmer touch, suitable for gros-grains. “Ecru” silk has still less gum removed, probably from 2 to 5 per cent. After stripping, a silk may need several washings. A bath of dilute acid is given if “scroop” (the crunching sound of silk) is required. Large dyeing establishments have given careful study to stripping, for carelessness in this process will prejudice the succeeding operations.

Weighting (see Chap. XII). — As silk is an expensive fiber and loses weight from the boiling off of the gum, harmless additions of plain sugar and sugar of lead were early used to make up the loss. The demand for less expensive silks has gradually brought about an exaggerated and injurious weighting. The silk to be weighted is immersed in a series of solutions, with thorough washings between each. A light weighting may be given which really seems to help the silk, or the silk may be charged heavily or “dyna-

mitted." The receptivity of the silk fiber for the substances used enables it to be loaded, in colors, to an extent equal to about double its boiled-off weight, and in blacks to three, four, and in extreme cases even five times its boiled-off weight. The result is the mechanical weakness of the filaments, on account of the stretching of their walls when taking in the metallic weighting. This later causes them to break; or crystallization of the tin takes place when exposed to the light, and its crystalline facets cut the silk from within; or oxidation occurs in the course of time, with a consequent weakening of the fibers; or if perspiration is present in the silk, chlorin is freed, which causes rotting, and pink spots appear on certain colors which later become tender. Even perspiring hands touching the silk will bring about this rotting of the fiber.

Dyeing (see Chap. XIII). — The dyeing of silk has great difficulties, even though the fiber takes the coloring matter readily. Silk is dyed in the yarn and in the piece, but the methods differ greatly. Overworked silk does not wind well. Silk cannot stand the boiling which may be given to cotton. Wringing, stretching, and lustering of many kinds come after dyeing to give gloss to the silk. When the dyeing process is without weighting of any kind, the manufacturer has to bear the expense of the loss of weight. The consumer is seldom willing to pay for this.

Further Processes. — *Bleaching* (see Chap. XIII). — Silks that are not perfectly white are hung in a sulphur chamber or they are bleached with peroxide when the color is difficult to remove, as in Tussah silk.

Stretching and Lustering (for silk thread). — Bringing out the gloss on silk thread may precede or follow dyeing, according to the character of the silk or the practice of the dyehouse. Both hand and machine methods are used. The dyer throws the skein over a strong peg in the wall, puts a smooth stick through it, and pulls the skein down hard, twisting it about from right to left until it is soft and glossy. By the machine method, bobbins of the twisted silk are placed in water and the silk is wound from

them on a revolving copper roll. It then passes to another roll just above, which in revolving more rapidly stretches the silk. This stretching is usually done before dyeing. A high degree of luster is given by exposing the skein to steam in an oven, where the silk is stretched on highly polished rollers. The steam and friction, however, sometimes wear on the threads. Steam lustering often both precedes and follows dyeing, for the dyes, mordants, and weighting decrease the luster of the thread. A special olive-oil bath is given to some silks. "Scroop" as well as luster are given by soaking the silk in dilute acid. The boiled-off liquor containing the sericin or gum is frequently combined with the dye to increase the luster.

Winding after Dyeing. Weaving. — After dyeing, the skeins are wound in various ways on bobbins or quills according to the use to which they are to be put. Silks which are to be woven immediately are warped. Silk warping differs somewhat from that of other fibers, and requires the most delicate handling. There are several methods in use, the aim is the same as in all warping, and the weaving is also much like other weaving, though special silk looms are built. The fineness of the silk filament increases the difficulty. Silk does not have to be washed or scoured in the finishing process. The weave in silk is of paramount importance, and ranges through all kinds of designs from plain to the most intricate Jacquard patterns. The silk designer requires training, years of experience, and artistic taste. Standard silks found in the plain weaves are the China, India, and Japan silks; glacé silk, which is the name given to silk with contrasting colors of warp and filling; pongee and Shantung, taffeta and crêpe de chine. In twills there are the surah, and others such as serge and foulard. In ribs and cords there are the ottoman, grosgrain, bengaline, poplin, the cut and uncut Terry velvets, the faille française, and many others. These are often made with a wool or cotton filling, and the ribs are filling ways. In satin weaves there are the messaline, merveilleuse and satin de chine, satin duchesse, Liberty satin, and peau de cygne. In

gauze weaving, the marquissette; in Jacquard, the brocades and tie silks, and in double cloth there are many kinds of double-faced ribbons and broad goods. Some silks are woven of singles or of two or more reeled threads, which are united and wound without throwing.

Finishing. — The general aim of finishing is to increase the luster and also to improve the cloth by giving "handle," strength, and body to poor, adulterated, or union materials. The kind of finish depends upon the aim to be attained. Finishes are of two kinds — mechanical, or by means of dressings. Some of these have already been mentioned. The main yarn finishes are: (1) Sizings to smooth certain hairy yarns and make them wear better; (2) soaking in dilute acid to give scroop and gloss; (3) gassing to burn off the fluff and to make the yarn smooth; (4) dressings and mechanical finishes to give gloss and to harden. Organzine (if it needs sizing, which it rarely will) is sized with gelatin.

Finishes for woven silk are also mechanical or by dressings. The first includes calendering, mangling, or pressings of various kinds by which the woven material is made smooth. The goods may come directly in contact with metal rollers or may be pressed between finishing paper, according to whether a glistening or a soft effect is needed; moiréing or embossing cylinders having designs etched upon them may press into the dressed material, leaving the design on the surface; special machines of many kinds, used to give such effects as panne and miroir velvet; polishing machines; steaming machines for velvets and other pile goods; gassing and shearing machines to eliminate fluff and ends in materials made of spun silk or any silk which is inclined to have too rough a surface; breaking machines which are used to soften up material made too stiff by dressing, the material passing over rollers on which the tension can be increased or decreased as needed. Flat spiral knives or rollers with brass knobs or buttons break the finish; printing either on the woven silk or on the warp threads, used extensively on

foulards, crêpes, and ribbons, may be direct or by resist or discharge. (See Chap. XIII.) After printing, finishes are necessary, such as gumming the silk, calendering it, and breaking the surface to soften the handle and look.

Dressings are of many kinds; each mill has its own secret formulæ. The aim may be to soften, to stiffen or to harden, to glaze, to strengthen, to waterproof, so the material will not spot, to fireproof, as special treatments make silk inflammable, or to cover defects. The following dressings are in constant use, usually in combination with each other, dextrin being perhaps the only one used by itself: Rice water, isinglass, gelatin, dextrin, starch, glues, gums, and waxes. The waxes are made into an emulsion with alkali, and the gums are softened with castor oil. Resinous substances, such as amber and resin, are also used.

Pure silk requires no dressing, but is finished by pressing, mangling, or calendering, with or without friction. It is the poorer, cheaper silks and half silk materials which have dressings to add to their body. For them are used such finishes as gassing to remove fluff, gumming to give feel, calendering to improve gloss, breaking to remove stiffness and to give handle. Taffeta silk is finished in many ways. Gelatin water gives it stiffness; pressure and heat bring out gloss; waterproofing keeps it from spotting, so that it can be used for umbrellas and raincoats. For the latter purpose a special treatment is often given with melted rubber between two layers of silk. Light silk fabrics are stretched in a tenter frame and finished on the wrong side. Satin is often sized as well as calendered to increase its luster. Warp printed ribbons have a soft, uncertain pattern, on account of the plain filling passing over the printed warp. A surface print is made after the material is woven, consequently it is clear in outline.

Counts for Reeled and Thrown Silk. — There are several systems by which the counts of reeled and thrown silks are estimated, such as the metric and denier systems for raw and

thrown silk, and for the latter, also, the Manchester dram system. The denier system for raw silk and the dram system for thrown silk are those customarily used in the United States. There are published tables¹ which show the relation of these systems to each other. The irregularity in the sizes of the raw silk makes it necessary to use an average figure when stating the count. The usual count of reeled silk used in the United States is $13/15$ denier¹ (see Glossary). In the denier system, the higher the number, the coarser is the silk (this principle differs entirely from that for cotton or wool). The system generally used in the United States is the English. To quote from *A Short Description of Silk and Silk Manufacture*, issued by Cheney Brothers:—

The hank is eight hundred forty yards, and the number of hanks in one pound avoirdupois is the count of the yarn. It is based on the finished yarn, and singles, two- and three-cord yarns of the same number all have the same yards per pound. Thus:

No. 50 singles has 42,000 yds. per lb.
 No. 50-2 singles has 42,000 yds. per lb.
 No. 50-3 singles has 42,000 yds. per lb.

In the dram system the size of the silk is based on the weight of the thousand-yard skein in drams. A skein weighing five drams is called five-dram silk.

Counts for Spun Silk. — The usual method of counting spun silk in the United States is much like cotton. (See Chap. VII.) The number of yards in a hank is eight hundred forty, and the number of hanks in a pound gives the count, but silk is based upon the finished yarn, and the singles as well as the various two- or three-ply thread have all the same yards per pound, which thus differs from the cotton. For illustration:—

Silk 1/6os 50,400 yds. per lb.
 Silk 2/6os 50,400 yds. per lb.
 Cotton 1/6os 50,400 yds. per lb.
 Cotton 2/6os 100,800 yds. per lb.

¹ See *Value of Silk Conditioning*.

Silk Manufacture. — The principal silk manufacturing countries of the western world are France, England, Germany, Switzerland, Italy, and the United States. France, Germany, the United States, and Switzerland produce about 80 per cent of the total. France makes the highest class of woven goods. Lyons is her chief manufacturing city, and has a water supply which is especially adapted for the successful dyeing of silk. This city is preëminent for its Jacquard weaves, velvets, embroidered tulle, gauzes, mousselines de soie, and chiffons. St. Étienne is noted for ribbons; Avignon, Nîmes, and Tours produce velvets, taffetas, and other classes of pure and mixed silks and silk knitted wear. Italy does a large business in silk reeling and throwing and also in woven materials, Milan ranking next to Lyons in silk production, while Naples and Como also have large silk industries. Palermo in Sicily manufactures mixed silk and cotton material. Switzerland does a large business in silk knitted and woven goods, Zurich making plain and fancy silks, Basle ribbons, and Berne knitted goods. Passementeries, embroideries on tulle, plain and drilled embroideries, netting and lace in imitation of the genuine Venetian, Brussels, and other kinds are made in Switzerland in the Appenzell and St. Gall districts, and in Bohemia near Carlsbad. Hand and shuttle work are both used. The work can be seen in various stages — all handwork, part handwork, and machine. The hand-embroidery machine is about five yards wide. The cloth on which the embroidery is to be done is stretched the length of the machine, and a carriage on either side of the stretched material carries in a double row from two hundred to four hundred double-pointed needles, each having an eye in the middle. The needles are pushed through by one carriage and taken up by the other, a stitch being taken with each operation. A pantograph is at the left side of the machine on which the design is six times enlarged. The operator with his left hand traces the pattern, which is reproduced in the correct size on the stretched material. If the cloth is to be an

embroidered strip it is taken off after the work is completed and finished by hand. If it is to be made into passementerie, the same pattern has been repeated many times across the length of the strip. After the embroidery is finished, it is given to workers who cut out the designs, leaving a small rough edge around them. The background is made of vegetable fiber if the embroidery is to be an animal fiber such as silk, *i.e.*, a thin cotton fabric is stretched in the embroidery machine to receive the silk stitches. After the handworkers have cut out the designs, they carefully sew and embroider the many designs together to make the passementerie perfect, and the latter is sunk into a chemical bath which destroys the background, leaving the embroidery standing out clear, for the fraying edges have been eaten away. It is finally finished for sale by handworkers and pressers. Large amounts of the machine laces, embroideries, and passementeries are sent to America. Loop embroideries and nettings are also made by machine.

Germany has large silk industries and manufactures dress silks, satins, velvets, bindings, braids, and linings. Barmen, Elberfeld, and Krefeld are important centers, the last named having a water supply which is of especial value in silk dyeing. Germany is producing large quantities of mixed and cheaper qualities of dress goods and trimmings. Russia has factories, especially in Moscow. Belgium also has many silk mills. The United Kingdom manufactures dress goods, ribbons, laces, and embroideries. The production of material made of silk mixed with other fibers is increasing there. Leeds is noted for its sewing silks, and Coventry for its ribbons.

The United States makes all varieties of silk materials, but does less than France in the finest qualities and in velvets. Paterson and Passaic in New Jersey are the most noted silk manufacturing cities. Silk waste is used in all the countries where the silk industries are developed, Basle, Milan, Lyons, Paterson, and Passaic using large quantities of it.

Spun Silk. — The raw material of the spun silk industry

is silk waste, and cocoons which are unfit for reeling or throwing. There are many qualities of silk waste, ranging from wastes of the highest class of reeled or thrown silk to a low class of waste silk used principally in the East. The lowest quality of Asiatic waste is not exported, but is used in the countries producing it for wadding, for interlining winter garments, and for other purposes. There is a large amount of waste in silk production: only about half of the total world's supply of silk spun by the worm comes into the market as raw silk. The principal sources of waste silk are the following: (1) From cocoons, such as the rough threads thrown out first from the silkworm; from the teasing brush; from broken cocoons; from parchment-like inner layers, too fine to reel; and from defective and pierced cocoons. (2) Reeling waste — poor reeling yields a large amount. Some Chinese silk is reeled solely for use as material for spun silk, as the Punjum. (3) Gum waste, *i.e.*, throwster's waste, being fine and coarse ends made in the various reeling and winding processes, as in piecings. (4) Weaving mill waste. (5) Various wild silk cocoons which will not reel.

The bales of waste are tightly packed and are difficult to open, an axe being sometimes used to break into the mass. There are several methods of removing the gum: (1) the English, or boiling off; (2) the French, or schapping; and (3) the alkaline or acid processes. In boiling off, the waste is put in bags made of open mesh material and pulled up and down in vats of hot soapy water kept just up to the boil, which softens the gum so that it passes out through the meshes of the bag. After several hours, the silk is taken out and dried. The silk is again soaked in another vat to rid it of more gum, and comes out soft, fluffy, and white, having lost from 18 per cent to over 50 per cent of its weight, the loss varying greatly according to the kind of waste. In the schapping system the waste is put in vats of tepid water for a week, until fermentation sets in and rids the silk of much of its gum. For some classes of goods, such as velvets, the schappe silk is preferred. The

third process degums by soaking the silk in a solution of alkali, or in an acid solution.

The main processes after degumming the waste silk are, in general, the following, but considerable differences are found: (1) beating the fibers to open them and make them flexible; (2) winding them on a cylinder; (3) cutting them in short lengths for short spinning; (4) examining the material for foreign matter and imperfections; (5) combing the lengths through a hackle; (6) spinning by forming the threads of silk into slivers, then into rovings, and finally drawing out, spinning and twisting them into spun yarn on a frame or on a mule; (7) winding the spun yarn on bobbins for warping or on quills for the shuttle. There are many qualities of spun thread; the term bourette is used for a low and rough class. Spun silk yarn is frequently gassed to make it glossy by ridding it of short, fluffy ends.

The United States imports from the East large quantities of the best silk waste, or an average of 6,000,000 lbs. annually.

The best spun silk yarns are largely used for filling or wool for silk dress goods, and for warp velvets and half-silk goods. Lower grades of yarn are used for knitting yarns and poorer kinds of dress goods. Bourette yarn is used for coarse knitted goods, and for packing and insulating materials. Silk shoddy or recovered silk from cuttings and remnants is prepared like wool shoddy. (See Chap. XI.) It is employed in combination with silk waste and with other fibers. Silk wadding is made from the waste from bourette spinning.

Market Terms. — Silk wastes from the East and Europe are often known under the names of places from which they come. There are many kinds, and of different gradings; for instance, the Japanese curlies (Kikai Kibizzo) is a well-known waste. There is also a China curlies. Both of these are listed under three or four grades. Some few wastes are found under chop marks.

Abuses. Adulteration and Substitution. — The effort to cheapen silk has tended to develop numerous processes which

give effects that pass for real qualities with the ordinary consumer. These may be reviewed as follows:—

In reeling, various soaps, oils, gums, glues, and chemicals are added to increase the weight yet escape detection, but such silks, it is said, do not often come to the United States.

In dyeing, an excessive amount of weighting may be added in mordanting or other processes. Salts of tin, iron, and lead are commonly used.

Substitutes. — These may be spun silk used in place of reeled silk, and Sea Island or other fine grades of American cotton.

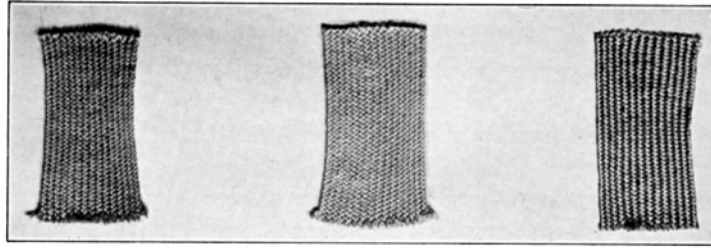


FIG. 109. — SILK SUBSTITUTES IN SKIRT BRAIDS.

1. Left-hand figure. Mercerized cotton braid sold as silk-finish. Price 10 cts. for 5 yd. bolt.
2. Middle figure. Mercerized cotton braid sold as silk braid. Price 15 cts. for 5 yd. bolt.
3. Right-hand figure. Artificial silk braid sold as silk braid. Price 10 cts. per yd.

Artificial Silks (see Chap. XII). — Artificial silks resemble silks in appearance, but differ completely in their properties. They are glossy and attractive, but they are frequently inflammable and become gummy in water, although treatment is lessening this. They are brittle and inelastic. For some purposes they are fairly satisfactory. They do not cover so well in the weaving as silk, therefore more picks per inch are required. The weight is greater; the price is lower. They are used in hosiery, neckties, drapery, and dress trimmings.

Silks weighted in order to cheapen them are usually weakened either directly by the treatment or by the additional weight.

The silk looks rich and feels heavy, but the walls of the fibers easily break down. This deterioration will occur while the material is being constructed into a gown, is lying on the shelves of stores, or hanging in the closet. An expensive silk gown had been worn but a short time when fraying splits appeared here and there where there was no strain on the material. The remainder of the gown was intact even where there was tension. Chemical tests showed that the entire silk was well weighted, but irregularly. The parts which were still good were carrying a weighting of 51 per cent, while those rapidly disintegrating were unable to endure 58 per cent. At the same time similar tests were made on an old-fashioned pink taffeta silk almost identical in color and weight. This gown had been in use for fifty years with almost no deterioration. It was found to contain so small a fraction of weighting that the silk was virtually pure.

The effect of poor or strong chemicals on silk is often noticeable in polka-dot or small sprigged materials which have been made by discharging the color from the solid ground. Careless or cheap treatment results soon in a rapid destruction of the textile as well as the color, and a perforated garment is the result.

Another common illustration of weakness where strength is needed is in the wide silk shoe laces sold at twenty-five cents a pair. While they are often "all silk," they are so heavily weighted to secure the look, feel, and weight of a better-class material that they are unenduring. A mercerized cotton product would wear better.

Black silk stockings were once considered luxuries, in which only the wealthy could indulge, but the demand for a cheap product has resulted in bringing them within the reach of every one. Heat and chemical tests on the silk show how this reduction in price has been made possible. Half hose, which were offered for sale at 35 cents a pair, as "a great bargain in 'pure silk' on account of changes in business," were tested. The general appearance of the stocking was of thin reeled silk, but

the tests showed that the upper part was all cotton, that the toe was of cotton mixed with silk, the latter weighted 22 per cent, and the part between the toe and the upper part of the leg was of silk carrying a weighting of 63 per cent to give it body. For mere pleasing effect this pair of half hose was a success, the inserted cotton would add to its service, but the all-silk portion would soon go to pieces. It would be a bad investment for poor people, and rich ones could afford a better article. The greatest objection, however, is not to hosiery made in that way, but to the labels stating that the articles were "pure silk."

Sewing silks should be strong and enduring, but here, too, the demand by the consumer for cheap goods has its effect in lessening the economic value of the product. Sewing silk comes in various grades, A to E being the common numbers. The lowest priced spools have 100 yards of silk on them and sell for the same rate per spool, whether No. A or No. E. Yet the latter being much heavier thread should contain more silk in its hundred yards and should consequently sell for more. As the consumer expects to pay the same price for all grades of the same length, the manufacturer has been obliged to adjust his expenses in such a way that he will not lose.

SILK MATERIALS

	WIDTH	PRICE
Armure	40 in.	\$1.50
Bengaline	21 in.	1.00-1.25
Brocade	36-42 in.	2.00-8.00
Chiffon	46 in.	.75-2.00
Corded silk	24 in.	1.00-1.50
China silk	27 in.	.50 up
Crêpe de chine	40-44 in.	1.50-5.00
Crêpe meteor	40-45 in.	2.00-5.00
Faille française	36 in.	1.50 up
Foulard	24-42 in.	.65 up
Gauze	45 in.	4.00-5.00
Glacé taffeta	36-40 in.	2.00-4.50

SILK MATERIALS—*Continued*

	WIDTH	PRICE
Grenadine	44 in.	\$ 1.00-6.50
Grosgrain	22 in.	1.25 up
Habutai	27 in.	.50-2.00
Japan silk	27 in.	.50 up
Liberty silk	36 in.	.50-1.00
Liberty satin	36 in.	1.50-2.00
Lining silk	27 in.	1.50
Louisine	36 in.	1.50-2.00
Malines	40 in.	.35-.75
Messaline	36 in.	.85-2.00
Moiré	22 in.	.85-1.50
Mousseline de soie	45 in.	.50 up
Mull	36 in.	1.00 up
Net	36 in.	1.00 up
Ottoman (similar to Bengaline)		
Panne velvet	21 in.	1.50 up
Panne velvet	40 in.	3.00 up
Peau de cygne	21 in.	.75
Peau de soie	21 in.	.75-1.25
Persian	20-36 in.	.75-5.50
Plush	24 in.	3.00
Pongee	27 in.	.65-1.50
Satin	21 in.	1.00-3.00
Satin brocade	36 in.	2.00 up
Satin duchesse	24-36 in.	1.00-3.00
Royal	45 in.	4.50
Shantung	33 in.	1.25-1.50
Skinner's satin	36 in.	1.25-1.50
Surah	24-36 in.	.75-1.50
Taffeta	21 in. up	.50-2.00

CHAPTER IX

THE LINEN INDUSTRY

LINEN has been called the textile of luxury, as its expense in finer grades stands in the way of its common use. The fiber, however, has qualities which adapt it to special service. It is held that ramie, which most resembles it in appearance, has like properties and is cheaper, but as yet the latter is not common enough for comparison. Linen, therefore, at present is pre-eminent for surgical uses and for household purposes. No other textile is so free from lint, gives up its moisture so rapidly, is so quickly cleansed and so pure and hygienic for constant service. Fabrics woven from other fibers are adulterated and cheapened, yet are still acceptable with many consumers, as the appearance is all that is really required of them, but with linen, it is in general the properties that are sought, and as all adulterations decrease these, pure linen is demanded.

For higher grades, such as table damasks and fine linen, flax is neither grown nor manufactured in the United States. The difficulties of cleaning and manufacturing it, the expense of bringing it from other countries, and the tariff charges, make it expensive. When it is pure and well cared for, however, it has so much endurance that even the cost is justified when the quality can be secured. Each housekeeper must consider whether for her it pays to buy pure linen or not, or whether unions with cotton, plain or mercerized, will serve her as well. In order to judge wisely and to obtain the full value from a purchase, she should know the properties of flax, and the probable life of the towels or cloths made from it. She must also understand the care which will make them endure. The fact that this textile of ancient lineage can be laundered after

lying four thousand five hundred years in the tomb of some Egyptian king shows that endurance is inherent in it.

The naturally sturdy linen unfortunately comes to us often in a weakened condition, on account of the careless and rapid preparatory steps, the poor and cheap chemicals employed in retting, bleaching, and dyeing, and the use of tow instead of the stronger line. When linen is combined with cotton, as is frequently the case, we lose the properties of the former, and the only gain is in cheapness.

For hygienic clothing, linen is to be commended. Its purchase, when pure, well manufactured, and enduring, may be justified even for the poor, but modern dress linen does not usually wear well, and methods common in the laundry hasten disintegration.

Linen is accorded a respect which we do not give to other textiles, for its long history, its old-time reliability, its exclusive command of many household needs, its purity and wholesomeness have given it a high record. We usually wish it to last, and will mend and repair old sheets and treasure old tablecloths and napkins when other textiles are discarded. Almost every household keeps its old-linen bundle in case of accidents.

Properties. — *Absorption.* — Linen absorbs water rapidly, the amount being 8 to 14 per cent according to some authorities. This is about equal to cotton, which is 10 to 12 per cent. Vegetable fibers are about equal in their absorbent qualities. Experiments have shown that linen does not absorb perspiration as well as cotton does. The moisture, however, seems to spread through the woven meshes of linen differently from cotton, but experiments do not indicate much difference between the two. Linen which has been sized does not in general absorb water as rapidly as the unsized linen. Smooth, damp linen adheres to the skin slightly more than will cotton.

Evaporation. — Water evaporates quickly from linen, which makes it valuable for toweling, handkerchiefs, and wash cloths.

The quality of rapid evaporation gives it a cold feeling next to the skin; this effect is lessened by weaving it with an open mesh. The natural smoothness of the material adds to the feeling of coolness. It is worn as winter underwear by Russian peasants on account of its cheapness and availability in that country, and by many others who believe in its hygienic qualities.

Cleanliness. — The property of cleanliness makes it valuable. When correctly laundered it easily gives up its dirt and continues to be white and clean even after long service. Its cleanliness has made it of value in surgical use, and experiments have shown that germs do not increase as rapidly on linen as on wool, silk, and cotton.

Endurance and Strength. — Linen thread is the strongest of the fine bast fibers. The wearing qualities are excellent when the fiber is pure. Chemical bleachings lessen the strength, although a dazzling whiteness can be obtained in a shorter time than in grass bleaching. The latter adds to the expense, but is justified in the longer endurance of the material. Unbleached linen is stronger than the bleached of the same weight. The length of the filament is a factor in the strength of linen. The material does not deteriorate quickly when laid away unless it is filled with sizings and dressings.

Tenacity. — When pure, linen is very tenacious, and is, therefore, used for the strongest twines and cordage. This quality is a factor in strength.

Weight. — Closely woven linen is heavy. Very much less air is held in the meshes than in cotton, so that equal volumes of the two textiles show linen to be 17 per cent heavier. Linen, however, is more penetrable by air than cotton, which adds to its feeling of coolness.

Fineness. — It is possible to spin the flax until it is almost like a hair, and the strength will still continue. The delicate linen threads for the finest lace are spun by hand in damp cellars, where the eye cannot see the gossamer filament, but the fingers can feel it.

Luster. — The luster of the finest linen is almost as high as silk. This quality is lost in overretted flax. Tow has less luster, for the short staple interferes with the reflection of light, but special treatment is given to it to make it glossy.

Affinity for Dyes. — Linen does not take or hold the dye well, therefore it is more apt to be found in the various bleaches than in color. Dress linens are, however, dyed in many colors, but are not always satisfactory.

Solidity and Toughness. — These qualities give it great value for canvas, twines, and cordage.

Suppleness. — When undressed and unsized, it can be bent sharply and yet not broken. Linen fabrics are less flexible than cotton of equal thickness, and retain their shape better if free from dressing. This quality recommends linen for shirt bosoms and table linen.

Botany and Growth. — Linen is made from the fiber contained in the stalk of the flax (Fig. 110). There are perhaps one hundred varieties of this plant known to botanists. The genus is *Linum*, and the best known of the cultivated species is *Linum usitatissimum*. Flax probably came from the East, but it grows easily in almost all climates and countries. In the ancient history of Egypt reference is frequently made to its cultivation and manufacture. It is grown in varying degrees for fiber in Great Britain and Ireland, Sweden, Den-



FIG. 110.—THE FLAX PLANT.

From Hooper's *Hand-loom Weaving*, by courtesy of John Hogg, London.

mark, Holland, Belgium, France, Russia, Germany, Austria, Spain, and Portugal. India and the United States cultivate it for seed rather than for fiber. Japan and Australia are experimenting with it.

The plant is an annual, and has an erect, slight, and willowy stem. It grows from twenty to forty inches in height, branching frequently in the upper part when not planted too closely, and having numerous small flowers which range from yellowish to bright blue. The seeds are small, flat, brownish, and smooth. The soil should be carefully selected, and the ground should be in a high state of cultivation for producing the best fiber, as is done in Belgium. The flax crop makes a heavy demand on the soil, which must be guarded against exhaustion; rotation of crops is practiced for this purpose, especially in Belgium. In the Courtrai district the interval varies from five to ten years between successive plantings of flax in a field.

The United States does little in the rotation of crops. A drill is used for planting, and the flax stalk is threshed for the seed, which is the principal crop. The straw is so broken and tangled after the threshing that it is useless for fine fiber. In the countries of Europe where flax is cultivated it is usually sowed broadcast by hand, with much regularity. If fine fiber is desired, the sowing is close so that there will be little branching of the stalk, consequently the filament is complete without break. The seeds should be carefully selected. The Riga seeds from Russia, or the Riga seeds which have been grown in Belgium, and the Dutch seeds are considered to give the best results.

Flax springs up with many weeds which must be removed. In Europe the weeding is done principally by women and children who go over the ground on their hands and knees when the plants are from one to two inches high. In the spring wherever flax is being grown, wavering lines of workers, side by side, can be seen moving across the fields, weeding as they go. Flax is in the best state for fiber when the leaves and stem of the lower

part of the plant turn yellowish and the seed pods are becoming ripe. This may be any time between the last part of June and the end of August. Dry, clear weather is selected for the pulling. Men now go through the fields grasping a handful of flax at about the middle of the stems, and pulling the sheaf up by the roots (Fig. 111). The dirt is knocked off by hitting the root end against the boot. When the flax is cut instead of pulled, the sap runs out and the quality of the fibers is inferior and in addition there would be some waste of stalk, yet the pulling is a tedious operation. As yet, no satisfactory flax-pulling machine has been invented.

The drying of the flax before removing the seed is done in various ways. In some places each handful is laid diagonally across the former one. These sheaves are called beets. The root ends are together and the lengths are as nearly alike as possible. The flax is left to dry and is later stacked. In some countries it is hung in bunches on the fences or on racks, or it may be kiln dried. Still another way is to tie the sheaf together at one end and spread it open into a tent-shaped stack like the American Indian corn.

Rippling. — After the flax is dried, it is rippled, in which process the stalk with its dried seeds and leaves is drawn through a large comb which has teeth about eighteen inches long, placed a short distance apart. The comb is usually set in the middle of a bench; two workers facing each other sit astride the bench at either end. A handful of flax is taken by each and alternately thrown upon and drawn through the comb. The dried leaves and seed bolls fall off on a sheet spread under the bench. Rippling must be carefully done or the fiber is injured. The stalks are often kept until the following season before they are prepared further. They are tied in bundles and piled up ready for the next process or for storage. The term straw is now used for the flax.

The Seeds. — Flax seeds are commercially of great value. When the main aim is seed culture the bolls are allowed to

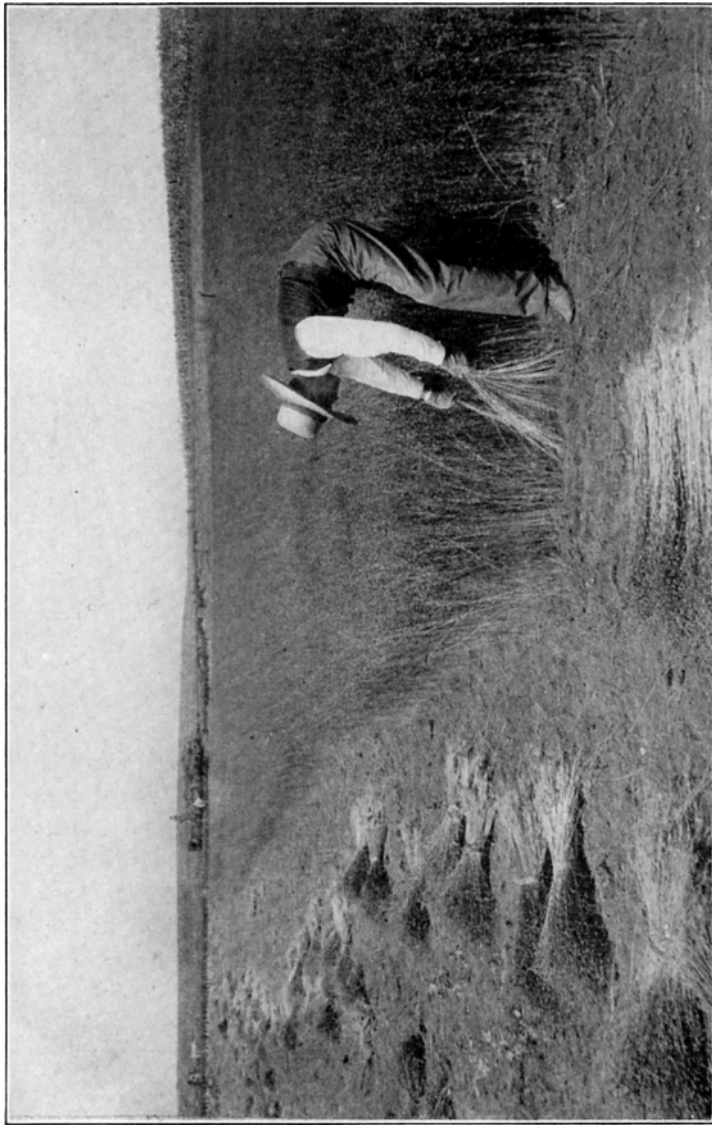


FIG. 111. — FLAX IN THE FIELD.
From Watson's *Textiles and Clothing*, by courtesy of the American School of Home Economics.

ripen completely, and special care is taken of them in the harvesting process. There is difference of opinion as to whether good, fine fiber and also good seed can be produced at the same time. Flax seeds are an important agricultural product in the United States. In 1911 the United States crop was 19,370,000 bushels,¹ comparatively little of which was exported. In the same year the greatest producers of flax seeds, in order of



FIG. 112.—RETTING AT COURTRAI.

importance, were Russia, Argentina, India, United States, and Canada. The seeds are used for linseed oil, which is required in paints, varnishes, linoleums, and oilcloths; linseed cake for feeding cattle; linseed powder for poultices; and linseed tea for an emollient.

Retting. — This is an important process in flax preparation. The object is to separate the filaments of flax from the bark and woody core. The straw is treated in such a way that fermentation is set up through the presence of bacteria. (See Chap. XII.) Retting may be done, *first*, by cold water, as in the running water of the river Lys in Belgium (Fig. 112); or in stagnant pools, as in Ireland, which gives a creamy white color to the fiber; or, *second*, by steam or chemical retting; and,

¹ Daily Consular and Trade Reports, April 25, 1912.

third, by dew retting, as in parts of Germany and Russia. The balance of favor is for the first method both for color and strength. The second methods are rapid, about sixty hours being taken, but they injure the fiber more. Dew retting is a weathering method, in which the sheaves of flax are spread in rows over a wet meadow and left, perhaps for the winter, exposed to rain, sun, and dew. The color is apt to be darker after this method than after the water retting, and sometimes is called silver gray or steel gray. The best flax is usually pale yellow white. Where there is no running water special vats or pools with steep sides are built and water is conducted into them. All impurities must be kept out of the water. In Ireland the soft water in numerous pools is excellent for fermentation, but the color is not so good as when the retting is done in running water.

The water of the river Lys, in Belgium, is especially adapted for retting the flax, which is remarkable for color, strength, and fineness. The region around Courtrai is given over to flax culture. Along the winding Lys at all seasons the flax is in various stages of preparation: growing and being weeded in the spring, covered with bloom in the early summer, and at all times of the year in stooks or stacks, or in crates retting in the water. Along canals and waterways passing into or out of medieval Courtrai come or go great barges of the flax to be retted or taken back to farms for further preparation. Scutching mills and great spinning and weaving factories are at hand to complete the preparation into cloth.

The method of retting in the Lys is in open crates of wood, with jute burlap around the four sides to keep the dirt out (Fig. 113). The bundles are stood on end alternately to keep the size equal, and are packed so that they cannot move. From two to three thousand pounds of straw are often in one crate. The crates are covered with fresh straw and floated into position in the Lys, and are then weighted down with stones and sod until they are a certain distance below the water, perhaps

six inches. It takes about fourteen or fifteen days for the retting, depending on the temperature of the water or air and the color of the flax required. Coarse straw is retted more easily than fine. There are various indications of the completion of the fermentation, such as bubbles rising in the water and the crate lifting itself above the surface. When the process is complete, the crate is floated opposite a windlass and pulled

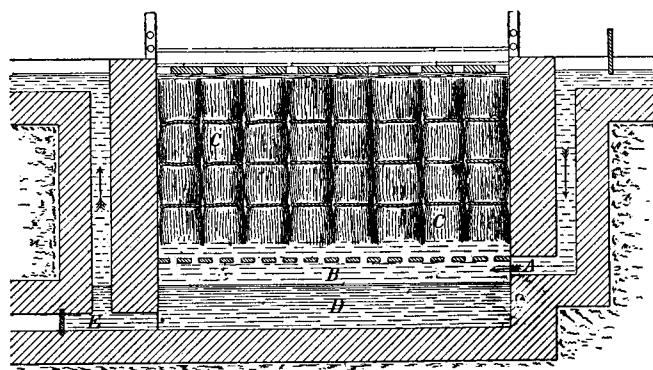


FIG. 113.—RETTING TANK.

on the bank. The bundles are taken out and stood in tent shape to dry. After a time, the bundle is turned wrong side out, that the inside may be also presented to the air. Fine fiber is usually immersed for about five days and taken out and dried for half a day, first on one side and then on the other, then put back for further retting.

The fall season for retting begins about September and continues until it is too cold. The retting begins again in March and continues until it is finished. Sometimes the year is not sufficiently long, and the remainder of the crop is carried into the next year. Overretting the straw causes the fibers to be brittle and weak. After the retting, in Belgium, the flax is spread on a grassy meadow to dry. This bleaches the fiber and helps in the separation of the bundles of filament. It is then

stacked much like hay to be ready for the next process of breaking and scutching.

During the time of fermentation the odor from the flax is extremely disagreeable, and the water, unless carefully discharged, may poison fish and even cattle. After the flax is retted and dried, the straw should be bright and have a somewhat sweet odor. The fermentation separates the bark and woody pith from the fiber, but further cleaning is needed to remove the pieces of straw and the dirt which still cling, and to separate the bundles of fiber, which adhere closely. Several processes follow to accomplish this, of which the breaking and scutching are often conducted on the farms. Scutching mills, however, which also break the straw, are becoming frequent. The hackling and combing are done in spinning mills.

Breaking. — This process is done both by hand and machine, the purpose being to crack the inner wood all along its length.

The chaff is then cast out from the fiber by shaking or hitting the sheaf. A very ordinary method of breaking is by a hand machine (Fig. 114). A series of long bars or knives are placed on a stand with a beater at one end, which can be raised and brought down again in contact with a sheaf of the flax

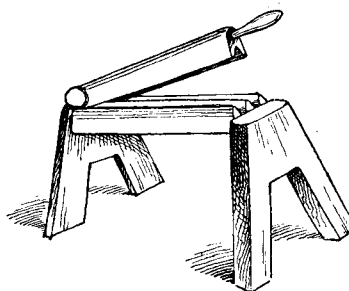


FIG. 114—FLAX BRAKE.

straw as it is thrown across the bars. This breaks the wood into pieces and it drops out below, leaving the fiber. Breaking machines are in use in scutching mills which have several pairs of grooved rollers, through which the flax straw is passed. The pith is broken by the rollers, and much dirt falls out. After breaking, the flax is taken to the scutcher.

Scutching. — The flax must now be shaken or beaten to remove more of the coarse pieces of wood or bark which are

clinging to it. Already the fiber begins to show itself more clearly, looking much like a switch of gray hair filled with straw. In early days flax was beaten against stands to clean it, or it was hung up and beaten or "swingled," as it was called. Still another method was to take a bunch of the fiber, place it in a

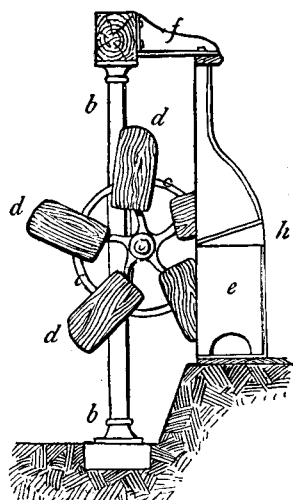


FIG. 115.—SCUTCHING DEVICE.
From Dodge's *Useful Fiber Plants*.

cleft of an upright post, called a scutching post, and with a sort of flat beater to strike and clean the fiber (Fig. 115). Scutching mills are now common in all flax countries, and the process is very simple. A shaft runs through a long room, controlling a series of beaters of wood, which revolve rapidly. The workmen stand each in a separate compartment and present bunches of the flax fibers to the beaters through a hole in a board. The blades or beaters hit the flax and knock out the "shive" and dirt. When one end of the flax is clean the other end is presented. Short fibers break off during the process, which are called scutching tow.

The latter are rescutched, spun like cotton, and used for coarse cloths. The long fibers are called the line. Scutching roughly divides line from tow. The process as used at present is not very satisfactory, for it frequently injures the fiber, and thoughtful-flax workers say the less of it the better for fine thread. An improved scutcher is needed. During the scutching the worker roughly divides the cleaned flax into bundles of even lengths. These are tied up together and baled, two hundredweight or two hundred and twenty-four pounds being usually in one bale, although Russia also puts up bales weighing four to five hundred pounds as well as those of two hundredweight. The flax is now ready for market or for the spinning mills.



FIG. 116.—FLAX IN DIFFERENT STAGES.

Photograph by C. R. Dodge.

Line Spinning.—The baled flax arrives at the spinning mills, many of which are near the scutching mills, as is found in Courtrai in Belgium. The flax must now be opened, cleaned, and straightened before it is ready for spinning. The spinning of flax differs from that of the other fibers in such particulars as the clearing away of large amounts of dirt, the combing out of the tow from the line, the great length of the filaments of line, and the necessity for still further subdividing the fibers by combing them through increasingly fine wires. Flax preparation requires special machinery or hand methods, which are expensive.

The processes as seen in British and Belgium mills are usually the following: First, a preliminary cleaning, combing, or hackling called roughing (Fig. 117). The rough flax as it has come from the scutching mill is combed through coarse combs like the ripple or primitive hackle (Fig. 7). This removes broken pieces of tow and dirt. Roughing is a hand process. The roughing room has a series of benches, each containing usually two hackles, one coarser than the other, and also an upright, coarse, metal pin on which ends of flax can be broken by a quick pull. A rougher or worker presides over each bench. He spreads a lot of flax into divisions, called fingers, winds one of these around his hand, spreads the opposite end out into a fan shape, and throws it over the coarsest hackle. He draws the flax through first one way and then the other, until it begins to be smoother and finer and the dirt is removed. He casts the tow into the box at the back of the bench. Then he combs the line on a second comb, which is finer, in the same way. He lays the line in even piles with the root ends together. Three combs are sometimes used on a bench, coarse, intermediate, and fine. There is considerable art in hackling or roughing, and a poor rougher reduces all the flax to tow, but a good one has his line looking even and smooth, even after the first combing. The hackles or combs used in roughing are very similar to the old hand hackle of colonial days. For finer yarns hand hackling

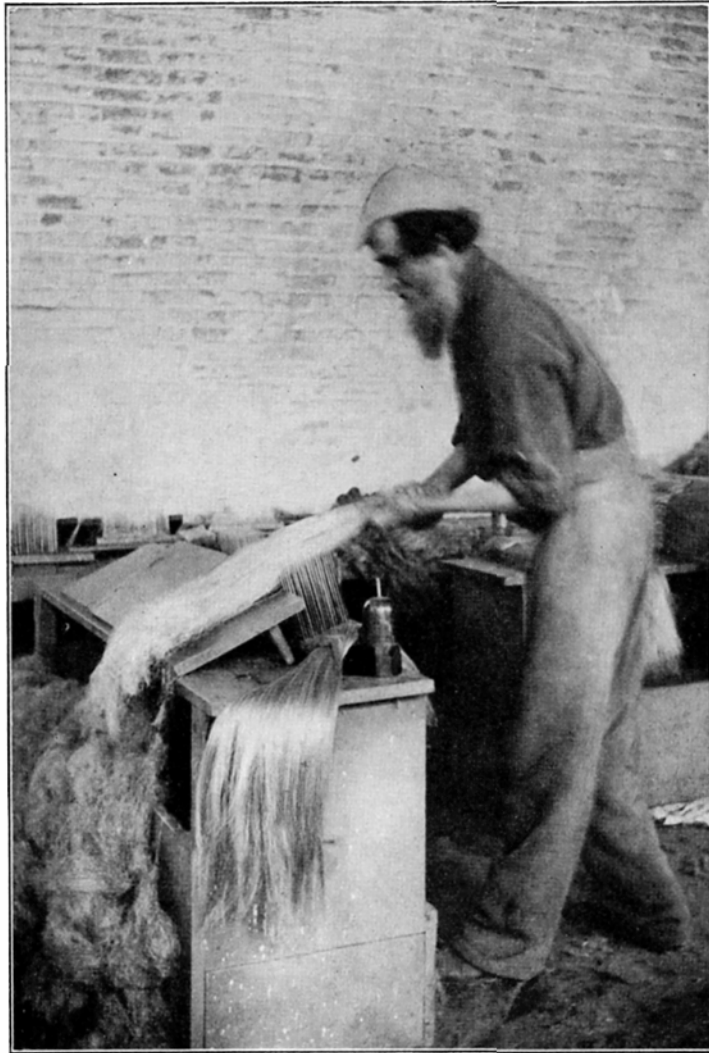


FIG. 117. — HAND HACKLING.

From Watson's *Textiles and Clothing*, by courtesy of the American School of Home Economics.

is sometimes repeated many times in order to subdivide the flax bundles. Seemingly there is no limit to the amount of division the flax will stand, until the filament begins to look like a mere hair. In England and Russia the finest grades of flax are hand roughed before machine hackling, but in other countries machine methods are being used. The process of



FIG. 118. — MACHINE HACKLING.

Courtesy of the York Street Flax Spinning Co., Belfast.

hand roughing is expensive, and takes a longer time than the machine. It is claimed by many that coarser flax does not require the hand processes.

Machine Hackling. — The result of the roughing process is a fairly clean bunch of line, which is now subjected to a series of hackling machines which are much alike, except that the combs increase in fineness (Fig. 118). The object is the same as the hand hackling, to disentangle, clean, comb, and divide line from tow. Machine hackles are long upright machines.

The ends of a bunch or tress of line are placed in a plate in the upper part of one end of the machine and held by a clutch; a series of pins or teeth becoming gradually finer pass down through the flax as it moves slowly from one end of the machine to the other. The tow is left in the combs, and at the further end an attendant receives the line, turns it upside down that it may be combed through in the opposite direction, fastens it in another clutch, and it passes back by a second machine alongside the first one. The line, meanwhile, has become smooth, fine, and glossy; the tow is removed from the pins by a revolving brush or doffer.

Sorting and Cutting. — These two processes are sometimes used for fine yarns. Flax for coarse yarns goes directly to the spreadboard, but for fine yarn it is hackled by hand and assorted into different qualities before it is passed to the next machine. For very fine yarn the line after sorting is usually cut into three divisions by a blunt instrument, the middle cut being the best. The term “cut line” is used. The fiber is now ready for the spreadboard.

Spreadboard. — As the fiber is long, the bunches or strips are delivered to the spreadboard on an endless apron, each strip overlapping the former one by six or eight inches. It passes into the machine to be combed through by fine wires and made into a continuous ribbon or sliver.

Drawing and Roving. — The drawing is repeated, four times being customary. The slivers are doubled, it is said, as many as ten thousand times. The frames are much like those used for wool and cotton. Several machines are required, varying according to the fineness of the thread desired. (See Chap. II for description of these processes.)

Spinning. — The upright spinning frames (see Chap. II) for wet, dry, and semi-dry spinning are used for flax, and are like those for cotton or worsted, except for the trough of hot water through which the linen yarn at times passes before it is twisted. Wet spinning of flax and tow makes a fine thread which does

not look as silky as that which is dry spun. It is twisted tighter, however, and the flax is more subdivided, which has its advantages for special classes of thread. Dry spun yarns have greater firmness than the wet spun, but the highest numbers are made with wet spinning. Warp yarns are usually made with the wet finish, as it adds to their strength. The use of too hot water is injurious to the flax, and the result is a frowsy, cheap looking yarn. Even in dry spinning, water is often dropped on the thread, or humidifiers are used to keep the air moist. It is necessary after wet spinning to have the yarn quickly dried, or mold will appear. Linen sewing threads are wet spun and then specially twisted and dressed much like cotton sewing threads.

Tow Spinning. — The tow, which is the short staple, coarse product, is treated differently from the line. It is beaten and shaken, carded, doubled, and spun much like cotton, and used for coarser counts of thread. The spinning frames for line and tow are much alike.

Winding, Warping, Sizing, and Drawing-in. — The processes for linen preparatory to weaving are much like those for other textiles. Sizing is used on the warp yarns to give strength, and yarns are frequently bleached wholly or partly before weaving. The dressing or sizing of linen yarns is important. Flour and farina paste are much used, and are applied to the yarn in the slasher.

Weaving. — Many linens, such as sheetings, lawns, and cambrics, are woven in the plain, tabby, or cotton weave. The twills and diaper patterns are found in towelings. The Jacquard loom is generally used for damask weaving. The damasks differ from the brocades in that both sides are alike and the cloth can be used on either side. The background is generally a plain or a broken twill. There are single and double damasks. The pattern shows more distinctly on the wrong side of the double, as there are more threads, which makes possible greater shading effects in the design, throwing it into relief. The threads of

double damask are usually double in the filling. As the pattern is made by the way the warp and woof threads cross each other, an elaborate damask design requiring floats of six or nine threads is not as strong as a more closely woven pattern.

Method of Counting. — The method of counting linen yarns in England and America is by the number of leas in a pound, each lea representing three hundred yards. No. 1 lea yarn would therefore have three hundred yards in a pound; No. 2 lea would have six hundred yards. The method of numbering in France and Austria is different. The counts for jute, hemp, and ramie are also figured by the lea. Fine linen yarns for costly handmade laces run as high as 400s or even 600s. They are spun by hand. Belgian hand spinners often work in damp cellars. Such yarns are very expensive, being quoted at as much as \$120 per pound. The hand can spin finer counts than the machine, three hundred being as high as the latter can spin, and that is unusual.

Finishing. — The finishing of linen materials is important to their appearance, but the processes are not unusual. The bleaching of the yarn or the fabric is perhaps the most important process. Dressings of various kinds are used, but the highest class of linens receives little, as the mangling, calendering, or pressing bring out the gloss. Beetling is often used to assist in giving luster both to dressed and undressed linens. A usual series of finishes in an Irish mill is, first, bleaching by chemicals; second, rub boards to wash the chemicals from the bleached linen; third, crofting or grass bleaching; fourth, bluing, starching, washing, and mangling; fifth, damping; sixth, beetling; seventh, calendering and pressing, which processes are often repeated a couple of times, and the material is finally finished by heavy pressure in the hydraulic press. Inspection, folding, marking, and packing complete the preparation for market.

Bleaching (see Chap. XIII). — The finest Irish table linen is usually woven of half-bleached yarn. It is then crofted from

six weeks to two months. The following table gives the relative loss of weight in bleaching the various fibers:—

Flax, 12 to 30 cts. a lb. — loss in cleaning and bleaching, 20 per cent.

Cotton, 7 to 13 cts. a lb. — loss in cleaning and bleaching, 5 per cent.

Wool, 15 to 30 cts. a lb. — loss in scouring, 20 per cent to 60 per cent.

Silk, \$7 to \$10 a lb. — loss in boiling off, perhaps 30 per cent, made up in loading or weighting.

Experience proves that linen bleached by chemicals is not as strong as that bleached on the grass.

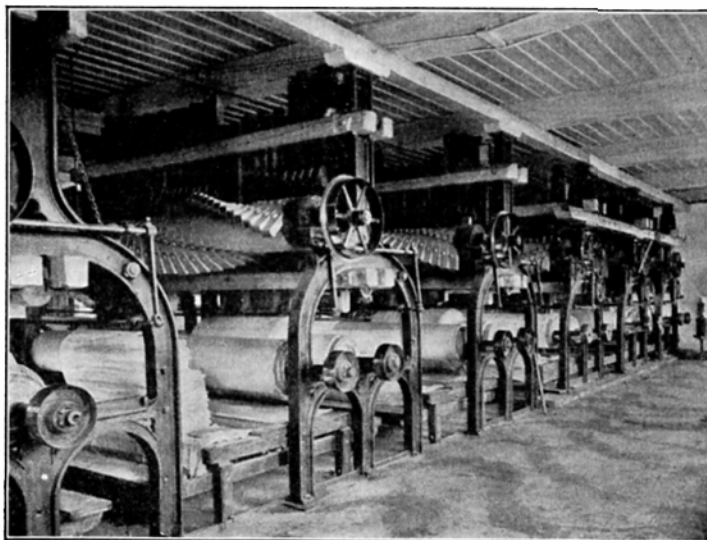


FIG. 119.—BEETLING.

Courtesy of the York Street Flax Spinning Co., Belfast.

Dressings. — Dressings for woven linen may be used to give strength and assist in bringing out the design, or to cover defects, as in poor qualities of linen or unions with cotton. (See Chap. XII.) Special finishes are used in table linen and damasks, for crash, for glossy linens, and for dark-colored goods. For black

and dark sewing threads a very glossy dressing is applied to strengthen the yarn, which, without it, would wear rough.

Beetling (Fig. 119). — This process is frequently used to give gloss to the surface, and a supple, leathery feel to linens. It may be applied to dressed or undressed linen materials. Striking the woven cloth with wooden mallets after it was washed and dried was the original process. Hand-woven damasks are still finished at times by hand beetling. The power beetle is a large and heavy machine. The linen is dampened, wound on a roll, and placed in the machine; the roll is turned slowly and the cloth is hit by heavy hammers or stamps, which descend directly upon it, or stamps with square butts are set spirally on a cylinder and impress the entire surface of the cloth, leaving small faces close together which reflect the light. The beetling machine is somewhat similar to the stamping machines used in ore concentration mills. Some yarns are beetled, such as filling yarns for heavy sailcloths.

Statistics of Linen Manufacturing. — The estimate¹ of the number of flax spindles and of looms in operation in 1911 was:

	SPINDLES	LOOMS
France	500,000	18,700
Germany	330,000	20,000-25,000
Belgium	325,000	16,273
Ghent 235,600		8,773
Courtrai 24,900		5,000
Other cities 64,900		2,500
Austria	285,996	Probably 6000-7000
Hungary	8,500	machine looms;
		20,000-25,000 hand
Italy	113,452	
Russia:		
Spinning 367,670		Estimate of 1907:
Twisting 333,760		12,380 power and
		hand looms
Great Britain:		
Ireland •	935,000	
England	550,000	36,000
Scotland	160,000	

¹ Daily Consular and Trade Reports, June 14, 1911.

Great Britain's output of linen piece goods in 1907 was 220,722,000 yards, with a value of thirty million dollars. In addition, a number of mills were working on highly finished fabrics, of which there is no exact report, but at least several million dollars more was made.

The manufactures of flax, speaking generally, cover toweling and table linen, fine handkerchief linen and dress goods, shirtings, sheeting, canvas, ticking and tarpaulin, fine and coarse laces, and heavy yarns for carpets, sewing threads, embroidery threads and flosses, twines and cordage.

The world's annual production of linen fabrics is stated as 1,000,000,000 pounds. The weaving and finishing of fine table and dress linen are done in Great Britain and on the Continent of Europe, rather than in the United States. We have at least four million acres of land under flax cultivation, but for seed rather than for fiber. We import raw flax, linen yarn, and fabrics, for which we spend at least twenty million dollars annually. The flax straw which remains after the seeds are removed was at one time burned, although much protest was made against the waste. Within a few years, however, the weaving of coarse and medium grades of linen has increased in the United States. In 1890 there were but three establishments for weaving linen, but in 1900 there were eighteen, with a capital of \$5,688,000 in round numbers. A number of these mills are in Massachusetts.

The development of machine methods for preparing the flax, in place of the usual hand methods of Europe, has made it possible for us to do more of the manufacturing business. Flax grows well in the United States. Michigan, Minnesota, North Dakota, and Oregon cultivate flax for fiber as well as for seed, but lack of persistent care of the soil has permitted the development of germ diseases which attack the flax plants and injure them for industrial service. The flax we have cultivated for fiber has produced mostly a rough, tow-like yarn, and not the kind required for fine linen. The cultivation of flax for the finest thread

presents many difficulties for this country, and the returns in money do not attract the farmer, who has other crops which are less trouble and are more easily sold. Labor is much cheaper in Europe, and the women and children are willing to work in the fields weeding the crop. There is a great deal of waste in the crop at any time, and the returns per acre are small. The machinery required for preparing and spinning fine linen thread is very expensive and of a special kind. It is said that a flax-spinning mill costs four times as much as one for cotton. Tow can be spun on cotton machinery, and the medium grades of cloth made from tow have a large market. It takes a larger number of workers in fine linen manufacture than in cotton, the relation being from four to six times as many.

The value of the seed industry is great, and although it is possible to cultivate flax for both seed and fiber, the best results in both industries are not obtained. We are not, therefore, likely to enter fine linen manufacturing with much energy at present, as such linens are really a luxury and the sale comparatively small, whereas the market for cotton cloth is large. Each year there has been an increased acreage for the seed, and also a greater number of mills for the low grade of fiber, which has a good sale.

Irish linen has had and still holds a high reputation; the industry is mentioned in the history of the country as early as the thirteenth century. The linen is noted for its snowy whiteness, its reliable quality, its endurance. The climate is a factor in this, as sunshine and rain alternating give a moist climate good for the growth and manufacture of flax. The great center in Ireland for fine linens and damasks is Belfast and the northern part of the country. The trade goes calmly on with its own methods and does not make much effort toward doing new things to attract business. The old patterns are still used, being still greatly appreciated. Much of the linen in Ireland is grass bleached and in one noted old firm at least is still hand woven. Driving through the country outside of Belfast, the bleaching

grounds can be seen covered with linen as in the old days. The linen is good and honest, but not always showy. Besides the toweling and table linen, there is quite a business in fine cambrics, lawns, and batistes. Ireland relies on Belgium for much of its fine fiber.

Scotch linen, especially from a few well-known houses, has a high reputation; much of it is sun and grass bleached. The color is silver white. Some consider it lighter in weight than the Irish. It sells particularly in the medium grades. The heaviest classes of sailcloths, canvas, tarpaulin, sacking, and carpeting are also manufactured in Scotland, Dundee being a center. Dumferline and Perth weave damasks. Much of the Scotch linen is of moderate price. The designs are generally more showy than the Irish.

French damask is noted for its exquisite designs and effective appearance; the thread is fine and round. Especial attention is given to the pattern and the beauty of finish. The most expensive materials are made as well as the plainer ones. France also provides many linen materials for dress goods.

Belgium in the Courtrai district has the finest variety of flax fiber in the world. Many other countries buy it after it has been scutched, to spin into fine counts, or they purchase the yarn and weave it into cloth. Belgium has also a large manufacturing trade. Materials of great beauty are woven in the region about Courtrai. Besides toweling and table linen, Belgium manufactures twilled linens, diapers, and drillings. It is said that more dressing is used on the linen in Belgium than in Ireland. In some respects Belgian linen is like that of Germany.

German linen is silver white. The highest grades of table linen are manufactured, but are not exported as much as the medium and lower grades. Those who have visited German cities, such as Dresden, well know the exquisite designs and the fineness of the table linens. Printed and dyed linens have also been manufactured for lunch cloths and napkins in Germany and are very attractive, but not as enduring as the white. Germany

also produces a large amount of good unbleached cloths, which are bought by economical housekeepers and bleached by degrees. A foreign market is desired, and rather showy, inexpensive linen which reproduces the patterns of other nations and has much dressing has been exported. These are less satisfactory for service than the stronger old-fashioned German linens.

Austrian linens are much like those of Germany. Spain also manufactures linen. Russia not only grows large quantities of flax, but has manufacturing interests, crash being made there to a great extent.

England purchases her flax in Ireland, Scotland, or Belgium, and does some good work in dress and table linen and also in tickings, low class sheetings, and brown hollands. Leeds and Barnsley are noted as manufacturing cities. For the highest class of table damasks France, Ireland, and Scotland are perhaps preëminent, at least in the export trade.

Additional Fibers used in Textile Manufacture

There are many fibers of secondary importance to wool, cotton, silk, and linen which are used in Eastern countries for woven material. The United States grows or imports them to some extent for coarse baggings, floor coverings, and binding twine, for combining with other fibers to cheapen cloth, and, occasionally, for underwear, dress goods, millinery braids, and upholstery. Some of these secondary fibers are bast, *i.e.*, taken from the stem of the plant in a similar way to flax; while a large number are structural, in that the filament is in the leaves or fruit and not in the stalk. Ramie (Rhea), and China grass which are much the same, jute, true or common hemp, Ambari and Sunn hemp are well-known bast fibers. Piña, Sisal hemp or Henequen, Manila hemp or abaca, Bowstring hemp, New Zealand flax, and Maguey are structural fibers, and among a number of other varieties reach our market under the commercial name "hemp," as the structure and characteristics are similar to the common hemp.



FIG. 120.—RAMIE PLANT.
From Dodge's *Useful Fiber Plants*.

Cheap labor in the countries from which many of these fibers come has made it possible to prepare them by hand and sell them at a lower price than would be possible in the United States with its higher cost of labor; therefore we are not producing them to any large extent. The bast fibers in general are harvested, dew or water retted, and broken, scutched, hackled, and spun much like flax. The structural fibers are treated and prepared similarly to Manila hemp.

Ramie, often called China grass (Fig. 120), is a bast fiber with many valuable properties, of low price, and of future promise as a useful and attractive textile. It grows easily in the United States, but the difficulties of decortication and consequent expense have kept it from the development it deserves. Both ramie and China grass belong to the family of stingless nettles (*Urticaceæ*); the ramie, or Rhea, being of the species *Bœhmeria tenacissima*, and China grass, of the *Bœhmeria nivea*. They flourish in India, China, Japan, and in warm parts of Europe and of North and South America.

The plant grows very high and the woody stalks are cut as they mature. The bark, when green, is hand-stripped and scraped without

retting. When the bark is dry it is dew or water retted like common hemp or flax. This process is repeated a couple of times if necessary. The fiber is usually hung in the sun after it has been relieved of the woody matter and at first looks much like coarse hemp. Degumming, combing, drawing, and spinning follow. It is more difficult to clean than flax. The degumming, a chemical process, is repeated, as a portion of the gum only is taken out by the first bath, and the remaining gummy matter is much harder to remove. Unless all of it is taken away, however, the material feels like haircloth as it touches the skin. After the final degumming the fiber is soft, white, silky, and glistening, and even more beautiful than flax. In the combing and drawing processes the long silky fiber, or line, is separated from the noils, or short fiber. Both are spun, the latter being used for coarser materials and for wadding.

Ramie is manufactured to an increasing extent in France, England, and the United States. It is frequently combined with silk and is made into materials to compete with linen, which it strongly resembles. Like linen, it is difficult to dye. It is brilliant, strong, and durable, not easily affected by moisture, though some of its luster is lost by a wet finish. It has more tenacity than other fibers, and its elasticity, though not great, equals cotton and is greater than flax. It is not very flexible, but endures wear and tear. For underwear it has much promise, for it is cheap, yet has the qualities of flax. There seems to be no limit to the possibilities of this fiber, for it has a range from the finest lace to the heaviest canvas, waddings, and cordage. It is found in the market of the United States in dress goods, upholstery, underwear, tablecloths, toweling, and lace.

Piña, or pineapple fiber, belongs to the family *Bromeliaceæ*, the species being *Ananas sativa*. It is native in tropical Asia, Africa, Southern Europe, and America, but in many countries the plant is grown for the fruit rather than for the fiber. The large fleshy leaves of the plant contain the fiber, which is usually extracted by hand. Piña is considered to be the most delicate

and exquisite of vegetable filaments. The woven cloth is found in great perfection in the Philippine Islands and is often combined with silk in designs of great beauty. The weaving is usually done with the untwisted fibers. The appearance is white, soft, and lustrous and the material is flexible, durable, and unaffected by water. It is used much for coarse grass cloth as well as for fine transparent materials. The latter are for sale to some extent in the United States.

Jute, or Jew's Mallow, is used in cheaper classes of textile manufacturing. It belongs to the family *Tilaceæ*. The species are very numerous, but the best known are *Corchorus capsularis* and *Corchorus olitorius*. It is a bast fiber and is retted and separated by hand methods. It grows in the hottest parts of India; being cultivated especially in Bengal. China also is giving some attention to its growth. The plant grows very high, the fibers reaching thirteen to fourteen feet in length. It is a very cheap and unsatisfactory fiber, as it rapidly deteriorates when subjected to light, air, and moisture. It is perhaps the poorest of the textile fibers. The best grades are light brown or silver gray and fairly lustrous. It dyes easily but soon changes color. It is useful where cheapness is better than durability and is used for bagging, for covering cotton bales, and for cheap binding twines and cordage. Tapestry materials of jute and cotton are attractive in appearance but are not enduring. The fibers are combined with wool in cheap dress goods. Carpets, rugs, upholstery, and burlaps are also made of jute. It is spun in fine and coarse counts. The United States does not grow much of it, as hand methods are too expensive, but much fiber is imported and manufactured here into twines, cordage, and cheap materials.

Bast Hemps. — True or common hemp is a bast fiber of the species *Cannabis sativa* (family *Urticaceæ*). It is frequently named from places where it is grown — such as Kentucky hemp, Italian hemp, Russian hemp, and others. It grows from three to seven feet in height, and is harvested and treated much like flax. Dew retting is used extensively. The color of the fiber,

like flax, is pearl gray or yellowish. It bleaches well, is very strong, is more hygroscopic than either flax or cotton, and is not easily rotted in water. The coarser fibers of hemp are used for sailcloth, canvas, carpets, cordage, and ropes, and the finer for fish nets and cordage, but it is not used for fabrics to any extent. Hemp is one of the principal export crops of Russia; it is produced in Poland; France cultivates a fine variety of it; Italian hemp is of the highest grade; Japan used it very early; India is growing it, but for its narcotic effect rather than for its fibers; and the United States at one time cultivated it largely, but has small crops at present, owing to the decline in the shipbuilding industry. When the stalk is fresh much of the outer bark and gum can be stripped off by hand. The yarn is sometimes twisted only slightly, and has a very glossy appearance.

The Ambari hemp of India is of the same family as the cotton plant — *Malvaceæ*; the species being *Hibiscus cannabinus*. It is a bast fiber and is used for very coarse textiles and for cordage.

The Sunn, Brown, or Madras hemp is another bast fiber of India. It belongs to the family *Leguminosæ*; the species is *Crotalaria juncea*. This fiber is also used for ropes and heavy textiles.

Hemps. — Manila hemp, or abaca, is a structural fiber. It is a plantain and belongs to the family *Musaceæ* and the species *Musa textilis*. It is cultivated largely in the Philippine Islands and has its best development on rich flat lands. Manila hemp is a more brittle fiber than the true hemp. The coarser varieties are used for binding twines, cordage, and heavy cloth; the finer for dress materials, veils, and shirtings. The cultivation is simple and the fiber is obtained by native methods. The leaves are cut before the flowering of the plant; they are slit down and the layers of fiber are removed, dried, and then scraped free of pulpy matter, leaving only the fiber. The latter is shaken, washed, dried, and spun. Fiber for weaving sheer materials is beaten to separate the filaments into finer threads. France manufactures Manila hemp into fine muslins.

Sisal hemp (henequen) is an agave and is cultivated in the West Indies and in parts of Mexico and Central America. It is a structural fiber from the leaf, like the Manila hemp. The fibers are not so strong as those of the latter. They are used largely for hammocks and sacking.

Cocoanut, coir, or coco fiber comes from the fruit of the coco palm (*Cocos nucifera*) and is also a structural filament taken from the inside of the husk of the cocoanut. It consists of bundles of stiff fiber which separate into finer threads after treatment. The palm grows extensively in India, the Malay Peninsula, Java, and Japan. The husk of the fruit is removed and the nuts are soaked in holes dug for them or in tanks. The best coir in the market is soaked in heated water in specially prepared tanks, for machinery is now being tried successfully. The fiber in general is beaten, cleaned by hand, and spun into a loose rove. The color is cinnamon brown; the fiber looks like horsehair and is very strong, light, and elastic. It is used for many purposes such as stuffing, upholstery, coarse mattings, sails, and cordage.

LINEN MATERIALS

	WIDTH	PRICE
Butcher's linen	36-44 in.	\$0.40-1.50
Cambric	36-44 in.	.50-1.50
Diaper	18, 20, 22, 24, 27 in.	2.00-5.00 piece
Dress linen	30, 36, 72, 90 in.	.25-2.00
Holland for shades	27-36 in.	.35-1.00
Linen lawn	36 in.	.50-2.00
Napkins	17-22, 23-27, 29-31 in.	1.25-25.00
Pillow cases	22½ by 36 in.	1.25-6.00
Sheeting	72-90 in.	.80 up
Sheets, hemstitched	Double	6.00-25.00 pr.
Sheets, hemstitched	Single	4.00-16.00 pr.
Table linen, damask	70-72 in.	.75-5.00
Toweling, huckaback	17-27 in.	.25-1.00
Toweling, crash	17-24 in.	.12½-.28
Toweling, glass	17-24 in.	.12½-.28
Towels, huckaback	14 X 20 to 24 X 45 in.	1.20-30.00 doz.
Velour	54 in.	1.00 up

CHAPTER X

CONSUMER'S JUDGMENT OF TEXTILES

Testing Materials. — Chemical and microscopical tests (see Chaps. XI, XII) are used to determine the content and value of materials, but these are at present hardly feasible for the rank and file of consumers. There are many simple physical tests, however, from which a housekeeper may gain fairly accurate information of standard materials and of those which are not up to this mark. It must be borne in mind that the wonders of cloth finishing at the present time make it difficult even for the expert to judge entirely by the appearance and feel, and that the only reliable tests are the scientific ones. The best cloth is made of good stock with strength in the yarn and woven of an enduring pattern. It should have a standard weight, the finish should be developed from the stock and not placed superficially upon the goods, it should have a good feel and appearance, should be capable of holding its color under definite conditions, and should be of good wearing quality. The physical tests aim to discover if these points are present or lacking, but will not indicate what the content is except in a general way.

The economical housekeeper should train herself to recognize the look and feel of the leading fibers, yarns, and woven goods and also the names and prices of the standard materials. The standards are fabrics which have long been known and regarded as representative and enduring. Variations in quality and price are found, as in serges of many values and kinds, but if a housekeeper learns the look, feel, weight, cost, and worth of one reliable variety she can grade others from that. Serge is found in all wool, in mixtures with cotton, or mixtures with re-manufactured wool, but still bears the same name. If a consumer knows

the cloth in its best condition and what to expect of it, she can better judge the value of other varieties of the same fabric and know whether the price is sufficient for a good material and if the width and weight are satisfactory. She should also know the properties of fabrics that she may test a doubtful piece of cloth for such qualities. Each textile has special characteristics. It may be elastic, soft or harsh, firm, wiry or sleazy, cold or warm to the touch; it may look dull or lustrous or smooth; its weight may be heavy or light; it may absorb moisture and evaporate moisture. The consumer should know enough of the methods of manufacture (see Chaps. VI, VII, VIII, IX) to judge of difficulties and adulterations which may occur and affect these characteristics, and should distrust material which seems to be too good for the price asked. In order to know these points she must study the pure state of the four textiles as well as the adulterated. After such preparation she is ready to test doubtful materials.

Wearing Quality.—A good way of testing the endurance of any material is by pressing the two thumbs together on the cloth and then pulling the material straight out, first warp way and then filling way. If it tears or frays in either direction it shows a lack of strength. To discover if material will bear strain in the seams, the threads of the warp and woof should be tested to see if they move easily. If they can be pushed with the finger nails without difficulty and are soft and brittle, the material is not strong, and when strain is applied it will fray. Another way of testing such cloth is to weave a needle in and out of the double of the material as if making a tuck. The single cloth is then drawn away from each side of the needle and if a row of holes shows clearly alongside of the needle the material will not bear a strain. Soft silks which are good otherwise will sometimes draw in the seams and should be so made up into garments that there is as little strain as possible. Wool which is woven with a weak thin warp and heavy filling, as is found in some poplins, shows a decided lack of endurance wherever there is a

strain or where there is apt to be the rubbing of one piece of cloth against another.

The Burning Test. — Animal and vegetable fibers burn differently; this can be noted when they are on fire. The rapidity of combustion, the residue afterward, and the odor while burning differ greatly. The animal fibers are wool and silk. Wool burns slowly, goes out quickly, leaves a gummy residue, and has a very disagreeable odor. Pure silk when burning has the characteristics of wool but to a less extent. Artificial silk burns quite differently, as much of it is cellulose. Cotton and linen are vegetable fibers. Cotton burns very quickly, and is difficult to blow out and often continues to smoulder until all is consumed. It sometimes happens that a piece of cloth woven with cotton in one direction and wool in the other will be consumed in the direction of the cotton, leaving the wool intact, or if cotton and wool are carefully mixed together in the yarn, by unraveling one strand and burning the different fibers in it, cotton will be indicated by the way in which one section will be consumed. Linen burns much like cotton but is not so inflammable, as it has less oil in the fiber and less air in the woven cloth, the long smooth fibers packing more closely together than the many short rough ones in the cotton cloth.

Tearing Test. — This test may be used at times to determine whether the material is pure or union goods. Linen quickly torn will leave straight, smooth threads along the edge of the tear, but cotton will curl up. The ear can accustom itself to the sound of the tearing of various materials. The noise accompanying the tearing of cotton is unlike that of linen. The warp has its voice and the filling quite another, the former being shrill while the latter is apt to be dull. Silk tears differently from wool. Some wools are very easily torn and others resist more.

Content, Quality, and Strength of Yarn. — To find the strength in warp and filling threads and to identify the content, it is well to have a small sample of the cloth which should be

raveled both ways. The yarn can be examined for strength or weakness, for the manner in which it is twisted, for the length of the fibers, for their purity or inferiority, for the luster and whether one kind of fiber or mixed fibers have been used in it. The burning test is helpful here. The breaking strength of the yarn should be tried and the relation in size and strength between the warp and filling threads. A very fine, weak warp will soon be broken if a heavy filling thread is inserted across it. This condition is sometimes found in poplins, of all wool or silk and wool, even if the fabric is as high as \$1.50 a yard. Cotton and linen mixtures in a yarn can often be told by raveling it and noticing whether its content is soft short fibers and also long strong ones; the former being cotton, the latter linen. Tow with its short ends looks much like cotton if it is combined with the long linen fibers or line, but is harsher in feel than cotton.

Weaving Test. — Close, even, firm weaves are usually enduring. Loose and open ones are apt to catch on small obstructions, to pull out of shape, and look shabby. The way the cloth has been woven often constitutes its strength or weakness. As explained in an earlier chapter, the surface of material is often finished by gigging to give it a soft look. This surface is apt to wear smooth or shiny wherever there is friction. Goods woven with long floats of warp or filling yarn on the face or even on the back are apt to wear poorly. Napped cotton goods will crush down and wear off as the fiber is soft and not elastic. Napping in wool goods sometimes covers imperfections. Simple tests and thoughtful observation guided by knowledge of the properties and processes described in preceding chapters will show many of these disadvantageous conditions.

Cloth may be wiry and enduring, or smooth, strong, and shiny but requiring much care, or soft and sometimes easily mussed. The varying qualities are adapted to different purposes. The first is for hard wear, the second for dressy suiting, the third for house or evening service. Raveling a sample will sometimes show the weave if it is not evident to the eye, or a weaver's glass can

be used. Felted goods, like broadcloth, cannot be raveled but a very thin broadcloth is apt to lack endurance although beautiful to the eye. The demand among women at present is for very thin broadcloths, but when given rough wear they may slit at the hem as the felting is not sufficiently strong and the shearing has come close to the weave. By holding a sample of cloth to the light, imperfections of weave may become evident, threads that have been repaired can be detected, and any undue openness of the texture can be seen.

Standard Weight. — Each fabric, according to its use, should have weight sufficient for endurance. This quality is tested by the appearance to the eye and the feel of it as raised in the hand. Linen is purchased by the weight, and there are a standard number of threads in the different linens. A good test of linen is to count the threads either way in an inch, and see if they conform to the requirement. A consumer is helped in her judgment if she learns the usual weight of such materials in their best condition.

Finish and Weighting. — Goods may be poor, yet after dressing and finishing may look rich and strong. Closely woven cottons and linens are often filled with sizing or clay and are unsatisfactory after a few launderings. Luster and stiffness are often a matter of treatment. The housekeeper must learn to detect the difference in appearance and feel between pure and treated goods. The tongue can often detect sizing, or the nail can remove it, showing the coarse texture below. Another means of discovering sizing is by rubbing the material between the hands to see if the surface dressing will come out. Sizing can be removed usually by a very thorough boiling, although this is not always easy to accomplish. Mineral weighting in silk can be detected by placing the sample on a small dish and leaving it in a hot oven (about 400° F. or 200° C.) for about an hour; the pure silk will be consumed and the weighting will, until disturbed, remain in the form of the fabric. This experiment is more satisfactory when performed in a laboratory furnace but may be done in an ordinary oven.

Color Changes, Spotting, Weathering, and Crushing. — Cottons and linens are apt to fade, shrink, and tear in the laundry, and if they contain sizing will look coarse as this passes away. Colors are frequently ruined by strong soaps, by careless drying in the sun, or by pressing with too hot an iron. The endurance of wash materials depends greatly on careful treatment in the laundry. A doubtful material should be tested for these points by taking a small sample, noting its color to see if it fades and its size to see if it shrinks and then washing, ironing, and exposing it to hot sunlight. A piece of white cloth rubbed on dyed goods will sometimes show if the dye is permanent or the material crocks even without moisture and heat. If material is to be exposed to sun and air, its endurance can be tested by placing a sample for a couple of weeks on a window ledge or roof and covering one half of the sample with a card. The sun, air, rain, and changing atmosphere will affect the part which is not covered and will indicate the result to be expected from continued use. (See Chap. XIV.)

In general it may be said that bleached materials do not wear as well as unbleached, as in bleaching at the present time chloride of lime, or other strong chemicals, whiten but weaken the fiber. The old time housekeeper used unbleached and undressed muslins for underclothes and sheeting and unbleached tablecloths and toweling. Gradually these materials were whitened through the laundry and by spreading on the grass.

Some materials are finished in such a way that they easily spot with water and must be sponged or washed before making up. These should be tested by dropping water on a sample before purchasing the cloth. Those who have worn pongees know what is apt to happen when caught in a slight shower.

It must be remembered that no one material is dyed fast to all influences; some are made fast to laundering, others to sunlight, others to dust, mud, and general wear. It is impossible to expect them to stand all bad conditions. Perspiration will often change the color of cloth; a sample can be tested by

dipping it in a little warm acetic acid and drying between parchment papers, without rinsing, and noting results. Elasticity is inherent in some fibers but is lost through adulteration and substitutes. A simple way of testing fiber which should have elasticity is by wrinkling the material in the hand and then trying to shake it out. If the wrinkles continue, the material will easily become lined and crushed.

Differentiation Tests. — Fabrics made of cotton and linen do not have the full properties of pure linen. Doubtful material can sometimes be tested by dropping water on it and noting the way the water spreads and the material dries. Moisture spreads rapidly on linen and soon dries, but a drop of water will often lie some time on the cotton before being absorbed, and the material will remain wet for some time afterward. Ink can also be used as a test. It must be remembered, however, that when cotton and linen goods are heavily dressed with sizing the water does not spread as easily. Glycerin is considered a more successful test than water. It causes linen to appear transparent but has not this effect on cotton. In general linen yarn is irregular in appearance but cotton yarn is more exact in twist. By breaking the yarn across quickly the cotton threads will usually curl up, while flax threads remain smooth. This test takes practice to do well. Singed ends of linen thread appear even and compact; cotton threads spread out like a paint brush.

Crushing in the hand will also indicate the difference between all cotton and all linen material and the unions. Silk and artificial silk, or mercerized cotton combinations, are difficult to test physically, but the burning test will sometimes show that the material is not pure silk. Artificial silk and mercerized cotton burn in a like manner, as they are cellulose.

In general soft finished silks are much better for wearing than stiff ones, but they must be tested for the possible inability to stand strain in the seams. Crêpe de chine or other silks woven of closely twisted threads wear better than the soft silks but do

not have the characteristic gloss of silk, looking much like wool. Taffetas are stiff and crease easily; they are very apt to be heavily weighted and unreliable, especially in black. Cheap, heavily corded black silks are generally weighted. A good wearing silk should be closely and evenly woven and soft to the feel. If the threads are raveled out and broken, they should stand some strain. To some extent price is indicative of values in silk, for it is impossible to get good silks at low price, but this cannot be entirely relied upon, as even silks sold at \$6.50 per yard have been found too heavily weighted to wear well.

The Purchase of Linen. — Linen should be pure, for then only has it the properties for which we buy it. Damasks as well as some other linens are bought by weight. Damask is made double as well as single. Double damask is more beautiful, and is usually made by having a double thread in the filling, and it is woven of well-twisted fiber. In double damask the pattern shows more distinctly on the wrong side of the cloth than in the single, and is, therefore, especially desirable for its beauty as table linen. The pattern in damask is in the warp lines, that is, the threads of design run lengthwise. When the cloth is held up, the vertical lines reflect the light and the cross lines look dark, hence the right and wrong sides can be determined by the way the pattern stands out in the light.

In order to judge table linen the following points should be remembered: Good linen in the hand is soft and yielding, yet elastic and tough like leather, and is not stiff and crackly. The medium range in price would be from \$1.50 to \$3 a yard. Hand woven, grass-bleached damask wears better than damask made by power looms and chemically bleached. In general, the grass-bleached linen comes to the United States about the first of January, having been bleached in the summer, and the housekeeper can find it on the counters at that time. Colored linens are not satisfactory, since flax does not hold dye well, and as a strong mordant has to be used to hold the color, the yarn is apt to be weakened. If one has some knowledge of the best linens, it

is well to buy them at a time in the year when the stock is low and the price reduced, before the new stock comes in. Linen should always be bought at a reliable house, and of a salesman who knows the quality. Some retail linen houses have their own patterns, which are used only when weaving for them. Table linen comes by the yard and in the bordered cloth. The cloth having a border around it is more attractive, but for the same weight linen it is generally cheaper to buy the material by the yard. Over-fine thread in damasks is not always a wise investment, but a strong, rounded thread is best. The best linen is sized very little, if at all. The sizing in the yarn or in the cloth is apt to make a break in the yarn when the cloth is folded, which will later become a hole. Highly sized or dressed linen should, therefore, be distrusted. A round thread of even weight in both warp and filling gives strength. It is true some hand-woven linens have the thread somewhat flattened by beetling, but it has been round and strong in the first place, and not being dressed is probably not injured by the beetling. The number of threads per inch in damask should be noted by the weaver's glass, both warp and woof or filling way. The correct amount for the warp in a good damask is for medium quality, 180 threads; for fine quality, 220 threads; and for the filling, of double damask, 280 threads; of single damask, 180 threads.

The weight of the linen is a factor in its value. When the number of threads per inch is satisfactory and there is no dressing, the cloth will wear well; when the cloth is coarsely woven and the weight is made of dressing, it will not wear, for after laundering the material will be coarse and flimsy. The minimum of weight is $4\frac{1}{2}$ oz. per square yard.

High grade linens are made from the line and the poorer grades from the rougher fibers. Good linen has a smooth surface; if when rubbed between the fingers it becomes fuzzy, it probably has much tow in it, or is a cotton mixture.

An all-over pattern in damask is generally more satisfactory than one with plain bands, for ironing is apt to twist the plain

design, therefore the effect of the former is better after several washings.

At one time certain patterns were characteristic of different countries, as the snowdrop or shamrock of Ireland and the check of Germany. At the present time these patterns are used interchangeably, and cannot be depended upon as representing any special country. Excellent linens come from many parts of Europe. Those accustomed to any one kind and who rely on good firms are apt to feel that that particular linen is the best. Certain brands of table linen can always be relied upon, and a housekeeper should know these.

Hemstitched sheets are more apt to tear in the laundry than sheets with a hem made by sewing machine or hand; fringe is not enduring, and machine-scalloped edges soon become ragged. In sheeting that is not high priced, yarn made of tow is sometimes used, which will not wear satisfactorily nor even look well, as the tow is short in staple and soon has a rough look. Homespun sheets and towels are liked for their feel and texture. In the past the line was not so carefully separated from the tow as now, and therefore the spun yarn had a more irregular surface and was more artistic than the extremely smooth yarns of the present day.

Standardizing Textiles. — Our federal and municipal governments realize the necessity of providing reliable materials for the army, navy, and police service. Standards are set for judging the integrity of various suitings, linens, blankets, and other materials, which must meet the specifications or the cloth will be returned to the manufacturers. (See Chap. XIV.) Efforts are being made to secure some degree of standardization of textiles offered in general trade so that the nature and quality may be judged from the labels. An intelligent interest on the part of consumers will greatly strengthen this movement. A serious study of textiles in the schools and colleges, in women's clubs, and by individual consumers is necessary in order that the demand for "pure textiles," like that for "pure foods,"

may be supported by an alert and intelligent public opinion. In both cases "pure" should mean materials honestly standardized and labeled; it should not imply an unwillingness on the part of consumers to accept the honest products of new processes nor an unduly conservative attitude toward new materials.

Analysis of Cloth. — The analysis of cloth is finding its content, the nature of the weave, and the cost of manufacture. In the textile industries it is a very important and elaborate process leading into technical fields, and requiring information on many difficult branches of design, manufacture, and methods of dressing and finishing. To know the make-up of the yarn often necessitates both chemical and microscopical investigations. The final report must be absolutely exact, must give methods and expenses of reproduction, with kinds, sizes, and amounts of yarn, colors, dyeing costs, and methods and details of warping, weaving, and finishing. In plain weaves or simple twills with unfinished materials it is usually not difficult to judge the nature of the weave. Weavers' glasses are easily obtained at a slight cost, and show a small field magnified perhaps ten times. The ends and picks are then easy to count. The investigation becomes more difficult in felted and sheared goods, in double and backed materials, or in those finished in such a way that the condition is changed. Such special trade analyses are not needed by the student of economic consumption, but she should gain standards by some experience with the dissection of cloth. The following points might be a basis for the study of standard materials:—

I. *The name of the material*, with a statement of the fiber or fibers comprising it; the general character, such as worsted or wool, single, double, or backed cloth; and the use of it with its price and width. New names are constantly appearing for common materials, and a little study will enable the student to classify such fabrics under standard kinds.

II. *Analysis of weaves.* The weaver's glass or a magnifying

glass will aid in the dissection. A small square of the material can be fringed a little both warp and filling way. If there is no selvage, the greater strength and straightness of the threads in one direction will indicate the warp. The filling can be pushed up slightly and the intersections with the warp and the number until a repeat comes can be noted. Several picks in succession should be tested in this way until the pattern is revealed. The color of the warp or filling can be seen on the threads of the fringe. The weave will fall under plain, twill or broken twill, or pattern. (See discussions of weaving in earlier chapters.) The glass will indicate the number of ends or picks in its field, which then can be multiplied to gain the full number in the width or in a given distance of the length of cloth. It is well to have squared paper at hand, and when the weave is discovered to plot it out on the paper, as is done by textile designers. Double, stitched, and basket cloths having two systems of threads are more difficult to analyze than single weaves.

III. *Yarn analysis.* The points to be considered are: The number of ends in the width of cloth; the number of picks in an inch of cloth; the character of the ends or picks, *i.e.*, the fiber or fibers used, the color or combination of colors in the yarns, the sizing present, and the breaking strain of both warp and filling. Regular machines called dynamometers are used in the trade for determining the breaking strain. In addition, the quality and kind of twist in the ends and picks is noted and the relation of size and strength of the warp to the filling. It is well to draw threads one after another from the little piece and lay them down in perfect order after examining each one, as often they vary greatly.

IV. *Finishing.* Analysis of finishes is also a subject of technical difficulties for the common consumer, and is concerned with the amount of shrinkage in the length and width, changes in weight, special dressings, formulæ for dyeing, and mechanical treatment.

For the beginner who knows little of weaving, it is well to begin to study the weaves of canvas or mattings, or the simple

rather coarse cloths, such as worsted serges, until the methods of weaving become clear. In some cloth it is difficult to tell the right or wrong side, but by slipping the hand along both sides one side will be found to be smoother than the other, or "draws," while the wrong side "bites" or resists. The difference in printed warp goods and in printed materials should be considered. The methods of disposing of threads in an elaborate pattern when a color is not in use on the face should be noted. It may be by long floats on the back or by weaving the thread in. Various crêpe weaves, leno and swivel, embossing and moiré-ing, should be likewise studied. A student should keep a card catalogue with data of her investigations and results.

Such simple analyses will result soon in realization of the ignorance of the general purchaser of even common fabrics, of the differences between textiles, of characteristics of fiber, of the false effect of artificial finish, of the strain of uneven weight of warp and filling, of goods that are effective but not strong, of poorly prepared yarn, which often breaks under the strain of weaving, of spots and flaws in cloth, and of the relation of beauty, as well as strength, to weave. All this tends to a better judgment of cloth which endures.

Additional Considerations.—As has already been pointed out, the suggestions given in this chapter will be much more effective when applied in the light of a knowledge of the properties of the textiles and the typical manufacturing processes as described in the special chapters devoted to wool, cotton, silk, and linen (Chaps. V–IX). The consumer should also be acquainted with the possibilities of the microscopical and chemical methods of testing (Chaps. XI, XII) which are of increasing importance in trade and some of which are simple enough for everyday household use. The selection of textiles and clothing should also be influenced by a knowledge of their properties as regards dyeing and laundry processes (Chaps. XIII, XIV) and the hygienic, economic, and social considerations discussed in Chapters XV–XVII.

CHAPTER XI

MICROSCOPIC STUDY OF TEXTILE FIBERS

THE microscope is a most valuable aid in the study of textile fibers. Each fiber has its peculiar structure and characteristic markings, which are revealed by the microscope alone, and which furnish the best and often the only certain means of identification. Chemical tests fail, for instance, in distinguishing between wool and hair fibers, or between different grades and qualities of wool, cotton, or linen. Familiarity with the microscope, therefore, and with the appearance of the more important textile fibers, must be the basis of their analytical study.

A compound microscope of 250 to 500 magnification is necessary. The following directions for its use are given to aid beginners:—

Parts of the Microscope.—The essential parts of the compound microscope are those belonging to the microscope stand, and the optical parts. The microscope stand includes:—

1. The base.
2. An upright or pillar.
3. A stage for holding the mount.
4. A mirror, having a straight and a concave side. The concave side is used in poor light. The mirror is manipulated till a shaft of light is sent through the hole in the stage and so through the center of objective, tube, and ocular.
5. The arm, which supports the tube.
6. The tube, which in turn holds the draw tube. In focusing an object, the tube is moved up and down by the rack and pinion, or coarse adjustment. A finer adjustment is secured by a slight turning of the small wheel at the top of the pillar.

The optical parts include:—

1. The eyepiece or ocular, which fits into the draw tube, and may be taken out and used as a single microscope.
2. The objective. There are usually two objectives, which swing around on the nosepiece. A click tells when one is swung in position. The low power objective is generally short and stout; the high power long and slender.

To Use Low Power

1. Swing the low power objective into the optical axis, about one inch from stage.
2. Place mount on stage, so that a fiber lies over the center of the hole.
3. Looking at the objective from the side, turn the screw on the tube until the distance between objective and cover glass is about $\frac{1}{8}$ inch.
4. Look through the tube, and manipulate the mirror to get a clear white light.
5. Lift objective until object focuses.

To Use High Power

1. Using low power, see that the part of the field to be observed is in the optical axis.
2. Raise objective one inch from stage, and swing high power objective into place.
3. Looking from the side, lower the high power objective until about $\frac{1}{100}$ inch separates it from the slide. Do not let it touch the slide.
4. Lift objective until object focuses.
5. After using the high power objective, always turn the nosepiece before removing the slide from the stage.

Preparation of the Mount or Slide

1. With a pipette, put a drop of water on the middle of the microscope slide.
2. Lay not more than two or three individual fibers in the water.
3. Lay a clean cover glass on the fibers and water, bringing it down gradually from one side in order to exclude air bubbles.
4. See that the mount is clean and dry above and beneath. The space between cover glass and slide should be filled with water, with no floating, however.

Permanent mounts can be made with Canada balsam. Clean the cover glass and slide with alcohol, place the dry material on the slide, and add a drop of Canada balsam, just sufficient to fill the space between slide and cover glass. Carefully press down the cover.

Cross sectioning may be done by embedding in paraffin¹ or in glycerin gum,² and cutting with a microtome or razor.

Wool and Hair Fibers. — Wool and hair fibers are alike in origin and growth, and so similar in appearance that no sharp distinctions can be made between them. For purposes of classi-

¹ Chamberlain's *Methods of Plant Histology*.

² Glycerin gum: 10 gms. gum arabic, 10 cc. water, and 40-50 drops of glycerin. (Hanausek and Winton, *Microscopy of Technical Products*.)

fication, the fleece of sheep is called wool, but it varies from the long, hairlike covering of the Lincoln, Leicester, and Cotswold

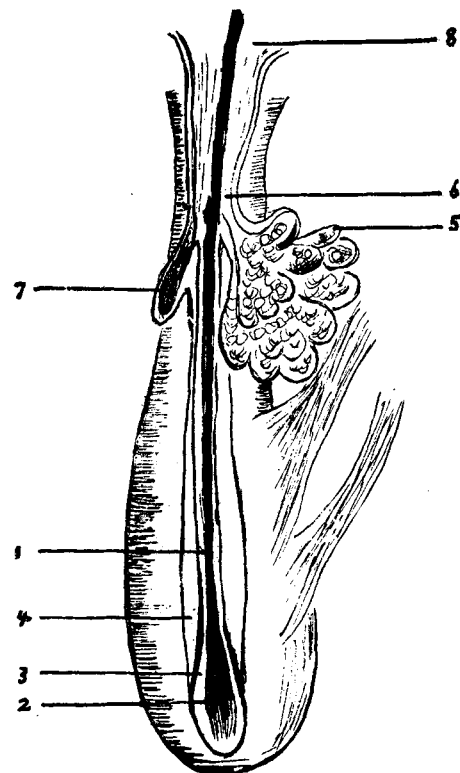


FIG. 121.—HAIR FOLLICLE.

1. Hair root. 2. Bulb of the hair. 3. Internal sheath of root. 4. External sheath of root. 5. Multilobular sebaceous gland. 6. Excretory duct of sebaceous gland. 7. Simple sebaceous gland. 8. Mouth of hair follicle.

varieties to the soft, crimped merino. The so-called hair fibers come principally from the alpaca, cashmere, angora, and Thibet varieties of goats. (See Chap. V.) However, both forms are usually produced on the same animal. The long hairs of the cashmere goat cover a soft, woolly coat, and mixed with the fleeces of most sheep are long, stiff fibers called beard hairs.

Physiology and Structure.—The root of the wool or hair fiber is in the follicle (Fig. 121) situated in the dermis. Both wool and hair show a common structure:—

1. *The epidermal covering*, consisting of flattened, overlapping cells like the scales of

a fish. These give the appearance of serrations or saw teeth to the fiber edges. Occasionally in fine wools, single scales encircle the fiber like a series of funnels; more often two or more make up

the circumference. Coarse wools may show a covering of irregular, depressed scales like heavy plates. The scales of true hair fibers are often difficult to see except under high magnification, as they are fastened firmly throughout their length to the cortical region, and are only slightly serrated at the fiber edge, while wool

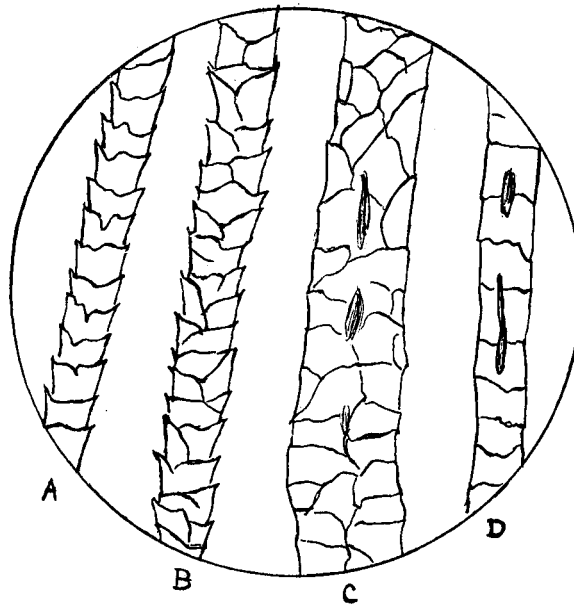


FIG. 122.—WOOL AND HAIR FIBERS.

A, fine. *B*, medium. *C*, coarse. *D*, hair fiber.

fibers, which have the scales set more loosely, show marked serrations (Fig. 122). Due to these differences, wool fibers felt more readily than do hair fibers (see Chap. XIV), because the loosely set scales of the wool give softness and pliability which tend to make the fibers mat together, and in so doing their serrated edges interlock. The firm, horny covering of hair, on the other hand, gives spring and wiriness to the individual fibers, and the lack of distinct serrations prevents any interlocking. The luster of

wool or hair is dependent upon the kind and arrangement of the epidermal scales. When these are smooth and horny, and set firmly as in hair fibers, a lustrous effect is given, which is lacking when the scales are coarse and irregular, or damaged.

2. *The cortical region*, made up of narrow, elongated cells, giving strength and elasticity to the fiber. By focusing deeply, small striations can be seen, which are the lumens of the tiny cells. The waviness of wool is supposed to be due to differences in size and development of the cortical cells.

3. *The medulla or central canal*, composed of cells, generally rounded in form. The medullary canal may be broad and plainly visible; it may appear as a continuous or broken line, or it may not be seen at all in some fine, transparent wools. Granular fragments and often pigment matter may appear in the contents. Hair fibers commonly show the medulla, wool fibers often do not. By its capillary action, the medullary canal has much to do with the absorptive capacity of wool, and is an important factor in the dyeing of the fiber.

Two important secretions adhere to the wool or hair fiber. The sebaceous glands pour their contents into the hair follicle,

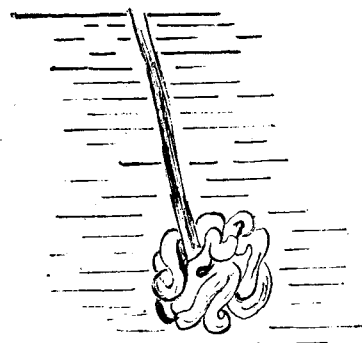


FIG. 123.—DIAGRAM OF SWEAT GLAND.

the sebum being known as wool grease. The chief constituents of this substance are cholesterin, a waxlike alcohol, and its compounds with two or more fatty acids. Wool grease is insoluble in water, therefore a coating of it makes the fleece waterproof, besides keeping it soft, pliant, and resistant to matting and felting. The second secretion is from the sweat glands (Fig.

123) and consists largely of water-soluble compounds of potassium with oleic and stearic acid, forming soaps, and of potassium

chloride, sulphate, etc. As generally accepted commercially, all the extraneous matter on the wool fiber is known as yolk or suint, although according to its French meaning the latter term is limited to the sweat secretion. The removal of the yolk is important, first, to enable the wool to take dyestuffs, and second, because the lanolin extracted from the wool grease, and the potash salts from the sweat, are of great commercial value. (See Chap. V.)

Tabular Comparison : —

	DIAMETER INCHES	LENGTH INCHES	SERRATIONS PER INCH
Wool : —			
Fine, Merino	0.0005	2 to 5	2800
Medium, Southdown, etc.	0.0008	3 to 8	2000
Coarse, Lincoln, etc.	0.0010	5 to 8	600 to 1400
Hair : —			
Angora	0.0010	5 to 10	—

Regenerated Wool. — This is wool recovered from old garments or other sources and used again as textile material. Three principal kinds are recognized : —

1. *Shoddy.* The best grade of recovered wool. It comes from materials which have not been felted, hence the scales are in better condition than those that have undergone the felting operation.

2. *Mungo.* Obtained from fulled or felted goods. In tearing the firm material apart, the fibers are broken into short lengths and the scales damaged or removed entirely.

3. *Extract.* Recovered from wool and cotton mixtures by treatment with sulphuric acid or other carbonizing agent. The cotton fibers are destroyed, while the wool is left, with scales often missing or corroded.

These kinds of fibers, collectively called shoddy, can be

conclusively determined under the microscope with care and practice (Fig. 124). Uneven sizes and damaged scales may or may not indicate shoddy, but the presence of cotton fibers now and then is an indication of wool obtained from mixed

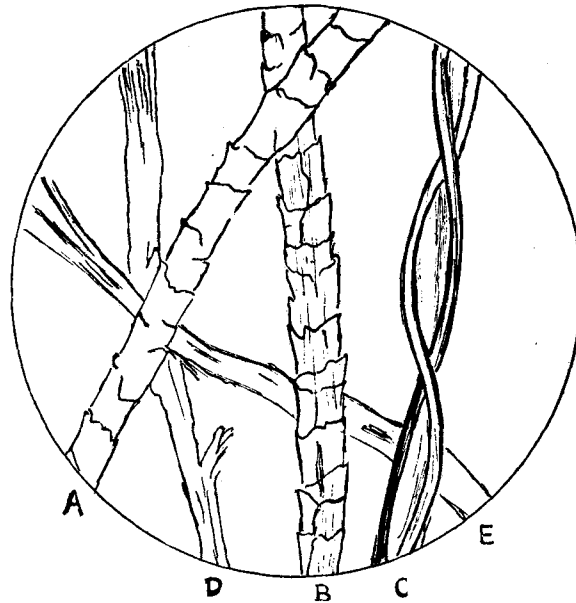


FIG. 124. — SHODDY FIBERS.

A, B, fibers differing in color and kind. *C*, cotton fiber. *D, E*, fibers with frayed ends, torn places, and damaged scales.

weaves by the carbonizing process, and other positive identifying marks are the presence of many frayed ends, together with a lack of uniformity in the size and appearance of the fibers, and of fibers of various dyes, due to their various sources.

Kemps are fibers which through disease or other causes have the medullary canal undeveloped or closed. Consequently they do not absorb dyestuffs, and give a streaky appearance to the yarn or cloth. In addition to the absence of dye, diseased

wool often shows swellings or other irregularities under the microscope.

Pulled wool is removed from the pelts of slaughtered animals. Lime is used to aid in the removal, and as it is apt to penetrate the medulla and close it with insoluble particles, such wool also takes dyes unsatisfactorily.

The microscope will occasionally reveal wool fibers with a tendency to twist. This is due to the fact that the wool has at some time been subjected to overheating.

Silk. — Silk differs from all other natural fibers in that it shows no cellular structure. The fluids secreted by the two spinnerets of the silkworm unite on issuing to form the double continuous thread of the raw silk. Under the microscope these two threads of protein material, called fibroin, are seen to be held together by an external gum or silk glue, the sericin, which appears in raw silk as irregular masses on the surface of the fiber (Fig. 125). After being freed from the sericin by boiling off, the individual fibrils look smooth, cylindrical, structureless, lustrous, and transparent.

Occasional constrictions or humps may appear. Cross sections of silk from the middle layers of the cocoon are rounded; those from the outer and inmost layers may be flattened or triangular.

Wild Silk. Under the microscope the wild silk fiber is broader and coarser than the cultivated silk, and shows numerous longitudinal striations (Fig. 126). The cross



FIG. 125. — RAW SILK.

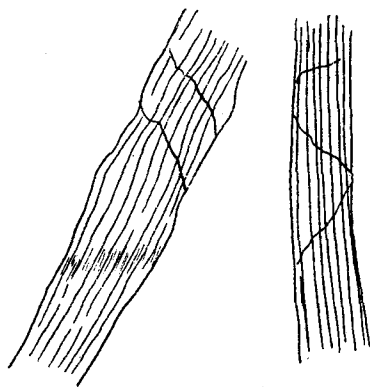


FIG. 126. — WILD SILK.

section is flattened or sometimes wedge-shaped. The diagonal lines often seen in Tussah or other wild silks taken from woven material have been attributed to pressure of other fibers on the filaments.

Artificial Silk.—This shows regular cylindrical rods having the appearance of glass (Fig. 127). Most varieties, the gelatin

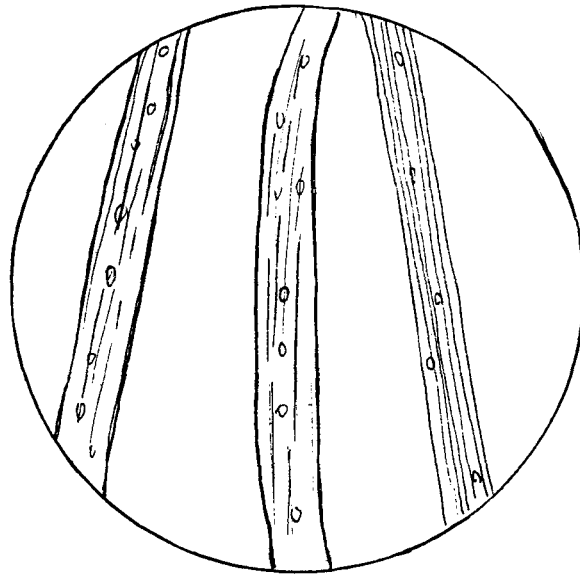


FIG. 127.—ARTIFICIAL SILK.

silks excepted, have their surfaces marked by grooves or flutings running lengthwise of the fiber, and minute air bubbles are sometimes seen, especially with the Chardonnet silk.

Cotton.—Cotton is a unicellular seed hair, which grows as a modification of the epidermis of the cotton seed. Its length varies from less than one inch to about two inches, and it has an average diameter of about 0.0007 of an inch. Being a part of the epidermis, the seed hair or cell is covered with a thin,

structureless cuticle. The walls are strong and thick, and an interior canal or lumen is present which is filled with protoplasm until the cotton is nearly ripe, when it gradually dries and the cell collapses. The typical appearance of a ripe cotton fiber under the microscope is that of a smooth, flat band with thick-

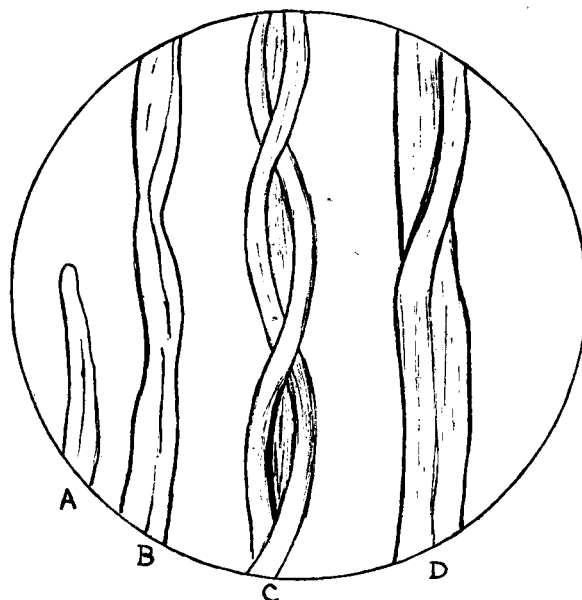


FIG. 128. — COTTON FIBERS.

A, end of fiber. *B*, dead or unripe fiber. *C*, ripe cotton. *D*, mercerized cotton.

ened edges — the cell walls — which make up about one third of the diameter of the fiber (Fig. 128). The lumen is generally visible, its breadth being usually greater than that of the walls. The most characteristic mark is the twisting which occurs at intervals. The stronger and more uniform the twist, the greater the elasticity of the fiber, and the better it is adapted to spinning. Dead or unripe cotton fibers show little or no twist, and a less strongly developed cell wall. In general, the cotton fiber is

larger in the middle than at the base, and tapers gradually to the point, which is rounded or blunt, with thick walls. The

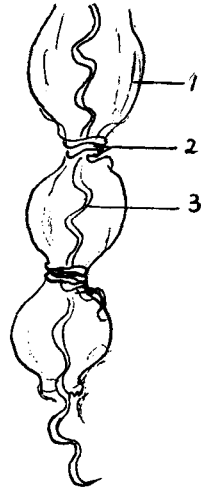


FIG. 129.—COTTON FIBER IN CUPRAMMONIA.

1. Swollen cell wall. 2. Constricting rings of cuticle.
3. Lumen.

lower end of the fiber, which has been torn from the seed coat, is open. While the twist is a distinguishing mark of cotton, the presence of a cuticle can also be made to differentiate it from bast fibers, unless it has been removed by treatment, as is the case in mercerized cotton, and often in well-bleached yarn or weave. When cotton is placed in cuprammonia the cuticle is not affected, but the walls of the fiber become greatly swollen and break out in places through the cuticle, which is left hanging in constricting rings or shreds on the fiber (Fig. 129). The lumen becomes like a coiled thread as the fiber shortens and swells.

Cross sections of ripe cotton fibers show elliptical, reniform or crescent shapes, with a central line representing the lumen (Fig. 130). The fibers of unripe cotton have not fully collapsed, therefore their cross section shows a more rounded appearance and a more regular outline than the ripe cotton.

Mercerized Cotton.—In the mercerizing process (Chap. XII) the strong alkali used removes the cuticle of the cotton fiber and swells the cell walls, while the tension employed takes out the natural twist more or less completely. Under the microscope the modified fiber is seen to be straight, smooth, lustrous, and cylindrical (Fig. 128). Characteristic markings are occasional slight twistings, if the merceriza-



FIG. 130.—CROSS SECTIONS OF COTTON FIBERS.

tion has not been perfect, and especially a lumen which appears and disappears in irregular widths, noticeable if the fiber is examined along its entire length. As the cuticle has been removed, there is an even swelling of the fiber in cuprammonia with no constrictions. The lumen now plainly appears, and granular

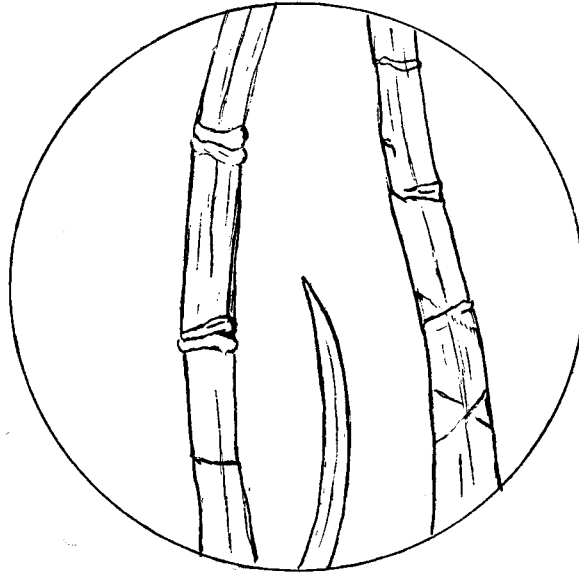


FIG. 131.—FLAX FIBERS AND END.

fragments may be seen in it. In cross section the mercerized fiber is rounded.

Linen. — Flax fibers, the source of linen, are the bast fibers which lie under the outer layer of bark in the flax stalk. The individual fiber may vary from twelve to thirty-six inches in length, the whole made up of cells ranging from a fraction of an inch to two inches in length, and having an average diameter of .001 of an inch. Under the microscope flax fibers show certain variations according to their quality or source, but the long fibers

for linen yarn have the following characteristics in common: The shape is cylindrical, tapering to a sharp point. The cell wall is so thick that the lumen appears as a narrow, often thread-like, line. A distinguishing feature is fine cross lines at intervals, giving the appearance of joints or nodes, strikingly like those on the sugar cane or bamboo. Sometimes these intersect like the letter X (Fig. 131).

In cuprammonia the walls dissolve with irregular swellings, but with no appearance of constricting cuticular rings, as with cotton. The lumen resembles a coiled thread.



FIG. 132. — CROSS SECTIONS OF FLAX FIBERS.

Cross sections of flax are characteristic. They are polygonal, made up of groups of five- or six-sided cells, with a small lumen (Fig. 132).

Fibers from the base of the stem and the root of the plant are flattened, broad, and stratified, with wide lumens. In cross section the lumen shows its considerable size. These fibers are one source of tow yarn.

Other Vegetable Fibers. — *Ramie* is a bast fiber, obtained from the nettle *Boehmeria tenacissima*. A very similar fiber, and one generally called ramie, comes from the *Boehmeria nivea*, or China grass. The fiber has a silky luster, is smooth, stiff, and inelastic. The bast cells are unusually large, being much longer than linen fibers and on an average three times as wide. Like linen, the cell walls are well thickened. The lumen varies, but is generally plainly visible, and sometimes equals one third or one half the diameter of the fiber. Characteristic appearances are a folding over of the cell wall at times, heavy transverse markings or nodes, and frequent striations along the fiber. The ends of the fiber are thick walled and rounded (Fig. 133).

Jute is the bast fiber from different species of the *Corchorus*, grown principally in India. The fiber is fine, long, lustrous, and soft, but deficient in strength. This is due in part to irregu-

larities in the thickness of the cell walls, which show in the microscopic examination, as frequently the inner and outer cell walls do not lie in parallel lines. The fibers have a smooth appearance, without the transverse markings of linen and ramie.

Hemp is derived from many plants. For a discussion of different varieties see Chapter IX, and Matthews' *Textile*

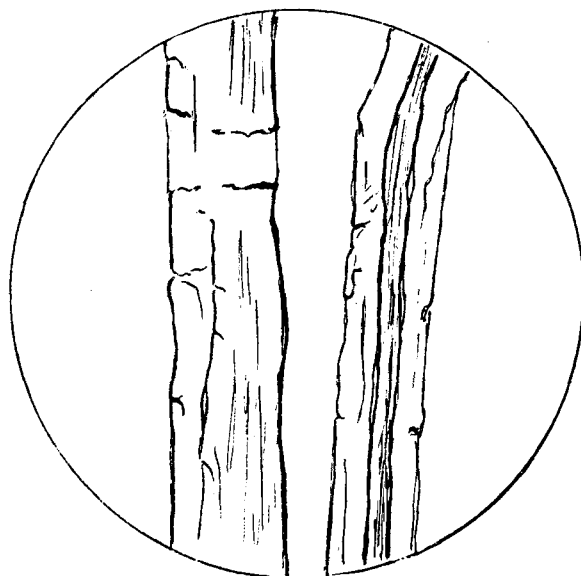


FIG. 133.—RAMIE.

Fibers. In general hemp resembles flax, with the difference that the ends of the fiber are frequently forked.

Pineapple fiber, incorrectly known as silk grass, is obtained from the leaves of the pineapple plant. The elements of its bast fiber are extremely fine and lustrous; the lumen is thread-like. Woven with silk, the product is called Jusi cloth; alone, it forms the Piña cloth of the Philippines.

Coir. — The shell of the cocoanut furnishes a fiber known as coir. It is about ten inches long, but the fiber elements may be

less than one millimeter in length. Under the microscope, the fiber shows irregularities in the cell wall, and a correspondingly irregular lumen, so that the latter may seem to have serrated edges. Pore openings are frequent.

Microscopic Analysis of Fabrics. — The purpose of the microscopic examination of a material is usually fourfold: to determine the method of construction, the nature of the fibers used, the relative amounts, if of different kinds, and their quality. A measured square of the fabric is cut out, large enough to contain all of the different threads which may appear in the weave. It is then separated into warp and filling threads, which are carefully placed in different piles. The threads in each pile are individually examined. If different fibers have been used, the microscope will show whether they appear separately in warp and filling, or are combined either by twisting together or by making one a core around which the other is veneered. Other methods of combination may also be found. If possible, the different varieties of fibers are separated and weighed, which will give a quantitative estimate of the makeup of the fabric. When the various points in question have been settled and the weave has been analyzed, the microscopic examination is complete. There may yet remain questions which can be settled only by chemical tests, such as more accurate quantitative analysis, and an estimation of sizings or weightings.

CHAPTER XII

CHEMICAL STUDY OF TEXTILE FIBERS

WITH a few exceptions, the tests given in this chapter are designed for classes beginning the study of textile chemistry. Only simple apparatus is required, and many of the experiments can be performed in the home. Until the law shall require the proper labeling of goods, the buyer's protection lies in more knowledge of the character of materials used, and the processes to which they are subjected, and to this end these practical chemical tests will be found of value.

Classification of Textile Fibers. — Arranged according to their origin, the principal textile fibers are grouped as follows:—

ANIMAL	VEGETABLE	MINERAL	ARTIFICIAL
Wool and hair fibers Silk	Cotton Flax Hemp Jute Ramie Coir Piña	Asbestos	Lustra-celluloses Gelatin silk Metallic threads Spun glass

According to chemical composition, **animal fibers** are protein in nature, and therefore contain the elements carbon, nitrogen, hydrogen, and oxygen in common. In addition, they may or may not contain sulphur, and on this basis they are subdivided as follows:—

Sulphur-bearing (keratinic) fibers : Wool and hair.

Containing no sulphur : Cultivated and wild silks.

Vegetable fibers contain the elements found in cellulose: carbon, hydrogen, and oxygen. An altered form of cellulose, lignocellulose or bastose, which is a compound of pure cellulose with lignin or woody tissue, is sometimes present. The principal vegetable fibers fall therefore into the following groups:—

True celluloses: Cotton, flax, ramie.

Lignocelluloses: Jute, hemp, New Zealand flax, coir, raffia, vegetable silk.

Mineral fibers are best represented by asbestos, a silicate of magnesium and calcium, which separates easily into straight metallic threads, capable of being spun into fabrics which have a well-known value as fireproof material.

Artificial fibers are of mineral, animal, or vegetable origin. The application of the mineral fibers is limited mostly to trimming effects in non-washable materials, such as gold and silver threads in embroideries, brocades, tapestries, etc. Artificial silks, which are principally of vegetable origin, will be considered later.

Ultimate Composition.—The ultimate composition of the principal fibers can be easily determined by the following experiments, and the method further serves as a ready means of identifying certain fibers.

Experiment 1. Burn a sample of woolen material in a dry test tube. Notice the odor like burning hair or feathers, and the condensation of hydrogen and oxygen as water on the sides of the tube. Test by odor and red litmus paper for nitrogen and hydrogen combined as ammonia. The paper turns blue if ammonia is present. Hold in the mouth of the tube a roll of filter paper moistened in lead acetate. In the presence of sulphur the paper is colored black. The carbon content appears in the charred residue.

2. Repeat with silk. No sulphur is found, unless sulphates have been used in the weighting. Other reactions are the same as with wool.

3. Repeat with cotton. Notice odor like burning wood. Hold a strip of moistened blue litmus paper in the fumes. It turns red, due to a combination of carbon, hydrogen, and oxygen in the form of a volatile acid, impure acetic. Try to find ammonia and sulphur as before.

Ordinarily, animal and vegetable fabrics may be distinguished by the characteristic odor on burning, and the manner in which each burns. Vegetable fibers flash quickly into flame; animal fibers burn slowly. Frequent peculiarities of weave and treatment often make this test of uncertain value, however.

Action of Acids and Alkalies. — The chemical nature of animal fibers is both acid and basic, like that of proteins; the reactions of vegetable fibers cannot be so definitely stated, although cotton has been observed to show the characteristics of both an acid and a weak base (Vignon). Wool absorbs both acids and alkalies, due to its double nature, but neutralizes only the former. Hydrochloric acid is absorbed by wool to a less extent than is sulphuric; the absorption of dilute sulphuric produces an increased affinity for acid dyes. In general, animal fibers are attacked more strongly by alkalies, vegetable fibers by acids. However, cold dilute acids, either mineral or organic, have little action on cotton or linen unless allowed to dry and concentrate on the fiber. Acetic acid, being volatile, has no action. Silk is less rapidly destroyed by alkalies than wool, but is attacked by acids more strongly, and is dissolved in a few moments by strong sulphuric or hydrochloric acid. Acids of suitable strength, with the time of action under control, have the effect of contracting cultivated silk strongly, with not so much effect on tussah silk. This fact is applied to the manufacture of crêpe from a mixture of these two silks.

The important differences in the action of acids and alkalies on various fibers can best be learned by experiment.

Experiment 1. Immerse samples of cotton and of woolen material in concentrated sulphuric acid and in a 10 per cent solution of caustic soda. After fifteen minutes remove any residue, wash, and examine condition of material.

2. In separate dishes, immerse samples of silk and wool in hydrochloric acid and in sulphuric acid for two minutes. Remove and wash, and observe the comparative action of these acids on the two materials.

The following tables sum up the usual reactions of acids and alkalis upon textile fibers:—

REACTIONS WITH ALKALIES

	WOOL	SILK	LINEN	COTTON
Strong caustic alkalis	Destroyed	Destroyed less rapidly	Fiber swells, becomes brownish yellow	Fiber swells, pale yellow
Boiling 5 per cent NaOH or KOH	Destroyed in 5 min.	Destroyed less rapidly	Little effect if air is excluded	Same as linen
Na ₂ CO ₃ or K ₂ CO ₃	Becomes tender in boiling solution or on long action	Same as wool; yellowed by strong solution	Dilute solutions have no effect	Same as linen
Cold 10 per cent NH ₄ OH or (NH ₄) ₂ CO ₃	Little effect	Same	No effect	Same
Neutral soap or borax	Little effect	No effect except on long boiling	No effect	Same

REACTIONS WITH ACIDS

	WOOL	SILK	LINEN	COTTON
Conc. H ₂ SO ₄	Succumbs slowly on heating or drying on fiber	Destroyed with yellow color in 2 min.	Soon dissolves	Dissolves more quickly than linen
Strong HNO ₃	Becomes yellow (xanthoproteic reaction). Dissolves slowly	Same color effect as wool; dissolves quickly	Not colored; dissolves slowly in hot solution; nitrates in cold	Same as linen

REACTIONS WITH ACIDS—*Continued*

	WOOL	SILK	LINEN	COTTON
Strong HCl	Hardly affected	25 per cent solution contracts fiber; 30 per cent dissolves in 10 min.; 40 per cent dissolves in 2 min.	Dissolved very slowly by conc.	Action quicker than with linen
Picric Organic acids, oxalic, etc.	Yellow Absorbs readily; no injurious effect	Yellow Absorbs readily; increased luster	Not injurious unless dried on fiber. No action with acetic	Same as linen
Tannic	Does not absorb readily	Greatest affinity for all fibers	Absorbed to some extent	Same

Suggested work: The student may perform experiments based on these tables, making the experiments identification tests for the different fibers. A few household tests should be worked out, using the acids and alkalies of the home; for instance, solutions of the lye used in soap making, strong solutions of washing powder, etc.

Qualitative and Quantitative Analysis of Fabrics.—In general materials should be freed from dressing before conclusive tests can be made, but this is not necessary for the qualitative tests which follow.

In all color determinations, fringe out a square of the material to the depth of about one inch, exposing both warp and weft threads. Differing fibers will thus show the expected color differentiations more plainly.

The microscope should always supplement the chemical test, as it alone shows the quality of the fiber. Weaves should be

examined as to variety and wearing quality. All these factors, including price and width, should enter into the analysis and estimate of a given material.

Differentiation Tests

Wool-Cotton. — The following color tests easily distinguish between wool and cotton in white or light-colored mixtures. The point should be borne in mind, however, that a thread may have a cotton core with a veneering of wool. The test will disclose this if the yarn is first untwisted.

*Millon's Reagent.*¹ Fringe a sample, exposing both warp and weft. Moisten with Millon's reagent, and apply gentle heat. Animal fibers, being protein, turn red; vegetable fibers are uncolored.

Nitric Acid. Immerse the fringed sample in 50 per cent nitric acid. Animal fibers are colored yellow; vegetable fibers, except hemp, are uncolored. Wash in one change of water and touch with ammonia. The yellow color becomes deep orange.

Fuchsin. Make a 1 per cent solution of fuchsin, neutralize carefully with caustic soda to the point of precipitation. Filter. Bring a fringed sample of cotton wool material to the boiling point in the filtrate. Wash, lay in acetified water. Animal fibers colored pink; vegetable fibers remain uncolored.

Acid Dyes in General, e.g., Phloxin. Bring sample slowly to boiling point in a solution of phloxin, to which may be added a few drops of 10 per cent sulphuric acid and a little Glauber's salt. Remove, wash. Wool fibers are colored red; cotton or linen hardly colored.

Mikado Yellow. Dye the fringed sample in a bath of Mikado yellow to which Glauber's salt and a small amount of soda ash have been added. Keep for half an hour at a temperature of about 50° C. Wool is scarcely affected; cotton is dyed yellow.

For the analysis of dyed fabrics, the following method of separation of animal and vegetable fibers will give a fairly correct estimation of the percentage composition of the material, and will be found the best test to apply to such mixtures: —

Caustic Potash Method. Weigh the air-dry sample, boil for fifteen minutes in a 5 per cent solution of caustic potash, keeping the solution at constant

¹ Millon's Reagent: Dissolve 100 gms. of mercury in 71.5 cc. of nitric acid of sp. gr. 1.4 in the cold. When action ceases, add twice the volume of cold water.

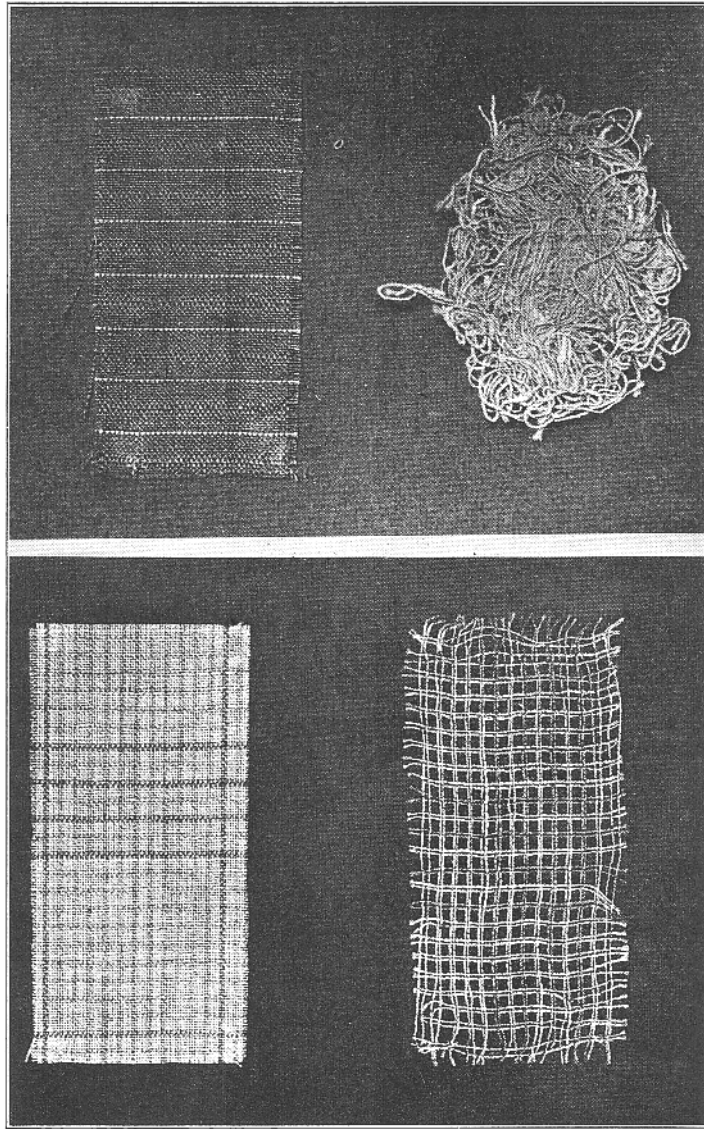
strength by replacing the water lost by evaporation, or by using a reflux condenser. (A long piece of glass tubing rising vertically through the cork of the flask will answer.) Wool is destroyed; cotton remains (Figs. 134, 135). Remove the cotton residue, wash thoroughly, restore to air-dry condition, and weigh. It is estimated that the cotton loses from 3 to 5 per cent of its weight through the action of the alkali. Five per cent of the weight of the cotton residue is therefore added to it to correct this loss. Subtract this weight from the wool, and express composition in per cent. Example: —

Weight of air-dry sample	2.500 gms.
Weight of cotton residue	1.700 gms.
Difference (approximately wool) . . . . .	.800 gms.
Correction (5 per cent of 1.7 gms.) . . . . .	.085 gms.
Weight of cotton (1.7 + .085)	1.785 gms.
Weight of wool (.800-.085) . . . . .	.715 gms.
Cotton	71 per cent
Wool	29 per cent

To be more accurate, the above analysis must first take into account the weight of the finishing materials in the fabric. A method of removing these, recommended by Matthews, is as follows: —

Weigh the air-dry material, boil in a 1 per cent solution of hydrochloric acid, then in a very dilute solution of sodium carbonate (about one twentieth per cent), and lastly in water. Air dry and weigh. The loss is finishing material and coloring matter. Dry in an air bath at 100° C. to constant weight, to remove the natural moisture of the fabric. Record weight of moisture-free material, and treat with the solution of caustic potash as above. Make the correction for loss of cotton. Finally, since the amount of wool and cotton in a mixed weave is not based on dry weights, estimate the natural amount of moisture in cotton at 8 per cent, and in wool at 16 per cent. On this basis the cotton found represents 92 per cent of the true amount, and the wool 84 per cent.

In large classes beginning textile chemistry, it may be convenient to omit the quantitative work, and make the above test approximate. In the household, lye can be used in place of the caustic potash. Wool and silk will be destroyed by heating in a solution of Babbitt's lye, in the proportion of one tablespoonful to a cup of water.



FIGS. 134, 135.—MIXED WOOL AND COTTON FABRICS TREATED WITH CAUSTIC POTASH. THE ORIGINAL MATERIAL AND THE COTTON RESIDUE ARE SHOWN.

Wool-Silk. — 1. True silk is destroyed by boiling in a 5 per cent solution of caustic potash as above. To distinguish between silk and wool with this test, apply the following: —

	Wool	Silk
To the alkali solution of the fiber add: —		
Sodium nitroprusside (2 per cent solution)	Violet	No color change
Lead acetate (5 per cent solution)	Black	No color change
Copper sulphate (5 per cent solution)	Brown	Violet

Although sulphates may be present in the weighting of the silk, these will give no color response; the test depends upon sulphides yielded by the sulphur of the wool.

2. Immerse in 40 per cent HCl. Silk is destroyed in two minutes. If the test is made quantitative, finishing materials and moisture are removed by the method given above, and a correction of 0.5 per cent is made for loss of wool.

3. To a 5 per cent solution of caustic soda add sufficient lead acetate to form a heavy white precipitate. Mix well. Heat a white or light-colored sample in the mixture until a brown or black color is developed on the wool fiber. Silk is uncolored. Remove and wash.

4. Wool is dissolved by treatment with cold 10 per cent caustic soda; silk is undissolved.

Wool-Silk-Cotton. — A solution of either ammoniacal nickel oxide¹ or basic zinc chloride¹ dissolves silk with little loss of either cotton or wool.

Heat a weighed air-dry sample for five minutes in basic zinc chloride, remove, wash thoroughly in acidulated and fresh water, air dry, and weigh. Make a correction of 1.5 per cent for loss of cotton; for loss of wool, 2 per cent (Matthews). Separate wool and cotton residue by the 5 per cent caustic potash method.

If ammoniacal nickel oxide is used, the silk in ordinary fabrics will dissolve in two minutes, in a cold solution. Correction for loss of wool, 0.33 per cent; for cotton, 0.45 per cent.

See Matthews' *Textile Fibers* for analysis of shoddy, plush, etc.

¹ Matthews (*Textile Fibers*) gives the following directions for the preparation of these reagents: —

Ammoniacal nickel oxide. Dissolve 25 gms. of crystallized nickel sulphate in 80 cc. of water, add 36 cc. of a 20 per cent solution of caustic soda, carefully neutralizing any excess of alkali with dilute sulphuric acid. The precipitate of nickel hydroxide is then dissolved in 125 cc. of strong ammonia, and the solution diluted to 250 cc. with water.

Basic zinc chloride. Heat together 1000 parts of zinc chloride, 850 parts of water, and 40 parts of zinc oxide until complete solution is effected.

Silk-Cotton. — The color tests under wool answer very well for silk-cotton differentiation, or a mixture of silk and cotton may be analyzed quantitatively by using the 5 per cent solution of caustic potash as given above. As the standard of moisture in silk is 11 per cent, the silk found by the exact method will represent 89 per cent of the original weight.

An alkaline solution of copper containing glycerol¹ dissolves silk, with little effect upon cotton. Cotton may be separated from silk in plush mixtures by heating the material in the solution for twenty minutes. The cotton residue should be considered to have lost 1.5 per cent in weight.

A rapid but inaccurate method of separation is by immersing the sample in 40 per cent hydrochloric acid. Silk is dissolved in two minutes, cotton is attacked to the extent of 4 per cent of its weight (Matthews).

Silk and Wild (Tussah) Silk. — Hot 10 per cent caustic soda dissolves cultivated silk in about ten minutes, tussah silk in about one hour.

Cold 40 per cent hydrochloric acid dissolves cultivated silk rapidly, but has little effect upon tussah silk.

True and Artificial Silk. — Artificial silks have a tendency to become weakened or dissolved by boiling water.

True silks turn red with Millon's reagent and yellow with nitric acid; artificial silks are not affected.

Artificial silks gelatinize with cold caustic soda (10 per cent) in two minutes; true silks do not succumb so quickly.

Artificial silk burns rapidly with no odor; and with the exception of gelatin silk, the fumes turn blue litmus paper red; true silk burns slowly with a characteristic odor, and an alkaline reaction of the fumes on litmus paper.

True silk dissolves in two minutes in an alkaline solution of copper sulphate; lustracelluloses are not affected. This test may be made quantitative.

To distinguish between the three principal varieties of lustracelluloses, — nitrocelluloses, cuprammonium, and viscose silks, — the following test is made: —

Immerse fibers in concentrated sulphuric acid. In the case of the nitrocelluloses no coloration appears for nearly an hour, then a pale yellow color shows. Cuprate silks show a yellow color at once, which deepens on standing, and viscose silks turn reddish brown immediately. Dyed silks must have their color removed before this test is made.

Cotton-Linen. — The microscope is the only final test for cotton or linen fibers. All color or other tests fail at times, es-

¹*Copper glycerol solution.* Dissolve 16 gms. of copper sulphate in 150 cc. of water, with the addition of 10 gms. of glycerol; then gradually add a solution of caustic soda until the precipitate of copper hydroxide which is at first formed just redissolves.

pecially in distinguishing cotton from fine bleached linen, which by the processes of retting and bleaching has become chemically identical with cotton.¹ The tests which follow are the most satisfactory of those found in textile chemistries, and work sufficiently well with the coarser linen and cotton weaves, such as union towelings, where either the bleach is not perfect, or epidermal fragments adhering to the linen cause it to respond differently to the color tests. With practice, however, the sulphuric acid test may be made to give good results, even when the fabric under analysis is a fine quality handkerchief weave. Before conclusive tests of any kind are made, the fabric should be freed from dressing by boiling in water, or by the oxalic acid method which follows. The latter is the most convenient method for heavily dressed damask, where the purpose is to discover the real quality of the weave and material.

Five Per Cent Oxalic Acid. Using a reflux condenser, boil the sample about fifteen minutes in a 5 per cent solution of oxalic acid. This hydrolyzes the starch to glucose, soluble in water. Remove, wash thoroughly, and test with iodine. If starch is still present, as it may be in heavily dressed table linen, continue the boiling in plain water till starch-free. A longer boiling in acid would have a tendency to weaken the fiber; boiling for fifteen minutes does not show under the microscope any deleterious action. An approximation of the amount of starchy dressing in a fabric can be reached by making this test quantitative. This method requires only one tenth the time of the method of boiling out the starch in water.

Sulphuric Acid. Immerse the sample in concentrated sulphuric acid for one and one-half to two minutes, according to the texture of the material.

¹ The object of retting is to separate the bast fibers themselves, and to free them from the other parts of the flax stalk — the bark, woody tissue, and pith or marrow. Certain substances known as pectin bodies bind the bast fibers to each other and to the surrounding stalk, but in the process of fermentation, while the flax is immersed in water, these are more or less completely removed. This is effected principally by microorganisms which in the absence of air will attack moist pectose and break it down into simpler compounds. These are, as a rule, soluble and wash away, leaving the bast fibers free. Some pectic acid may be formed, which being insoluble in water remains on the fiber. Full bleaching still further purifies the flax fiber, however, making it nearly pure cellulose.

Remove, wash thoroughly with water, followed by weak ammonia. Cotton fibers are destroyed; linen fibers less affected (Fig. 136).

Fifty Per Cent Caustic Potash. Heat a fringed sample of union material in 50 per cent caustic potash for two minutes. Remove and dry between filter paper. Linen becomes brownish-yellow; cotton white or straw color.

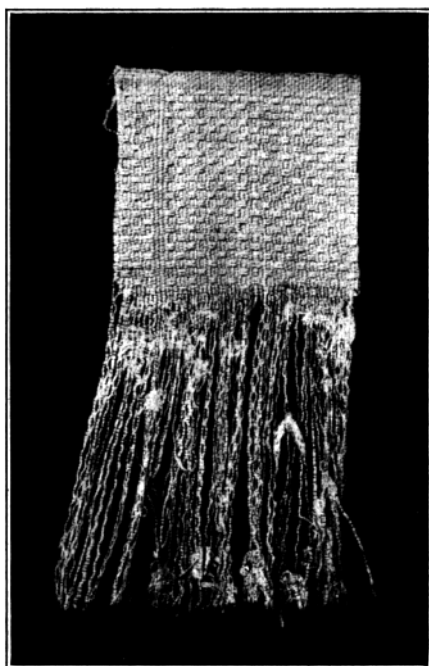


FIG. 136. — MIXED LINEN AND COTTON TOWELING TREATED WITH SULPHURIC ACID. THE LINEN REMAINS IN THE FRINGE.

from fire. Remove and rinse in a strong solution of sodium chloride. A variation of the ordinary tincture may be made by dissolving 20 gms. of cochineal or madder in 500 cc. of alcohol and 500 cc. of water, and adding 2 gms. of aluminium acetate.

Rosolic Acid. Warm the fringed material for five minutes in an alcoholic solution of rosolic acid, wash and dip for a second in strong caustic soda. Wash thoroughly. Linen becomes rose-red; cotton remains colorless.

Fuchsin. Immerse a fringed sample in a 1 per cent solution of fuchsin in alcohol. Wash thoroughly, lay in ammonia, then in strong caustic soda. Cotton is slightly colored; linen becomes rose-red.

Cyanin. Warm a fringed sample for about three minutes in a 1 per cent alcoholic solution of cyanin. Wash in water to which only a drop or two of sulphuric acid has been added. Linen fiber is colored blue; cotton not colored. The color may be intensified by further treatment with ammonia water.

Madder Tincture. Linen orange-red; cotton lighter.

Cochineal Tincture. Linen dull red; cotton bright red. Heat the sample for fifteen minutes in either of these tinctures, using a water bath or a reflux condenser, to lessen danger

For tests to distinguish the minor vegetable fibers, see Dodge, *Useful Fiber Plants*, Bulletin No. 9 of the U. S. Dept. of Agriculture, and Matthews, *Textile Fibers*.

Mercerization. — In the process of mercerization, cotton is made to undergo certain changes by treatment with strong caustic alkalies. John Mercer, an English cotton printer, was the first to show that cellulose, treated under given conditions with alkalies, contracted, gained in strength, and in affinity for dyes. His investigations are described under the English patents of 1850. Owing to several reasons, chiefly the high price of caustic soda, the discovery had little commercial value for thirty years. Since 1880 the process has grown to be vastly important, especially since the patent taken out by Lowe in 1889, which covers a method of employing tension for preventing shrinkage and producing a lustrous material. There have been several modifications and improvements of the method, credit for some of which is due to Thomas and Prevost of Germany, but the essential process consists in immersing the cotton yarn or piece under tension in strong cold caustic soda or potash solutions, and subsequently washing it.

To obtain a high degree of luster, the best quality of cotton is required. Sea Island or Egyptian cotton is therefore preferred, and the fiber is generally combed and gassed to remove protruding ends and render it more silky. The yarn or piece may be bleached before or after mercerizing, depending upon the purpose for which it is intended. The mercerizing process leaves it brown. The material, suitably prepared, is carried under tension on rollers through the mercerizing solution. This may be caustic soda of a specific gravity of 1.11 to 1.2, at a temperature not exceeding 20° C. (68° F.). Under different methods, various chemicals are added to this bath for the sake of better penetration or increased luster. After a few minutes in the alkali solution, the material, still under tension, is washed in fresh and acidified waters. It has been found that the brilliancy and durability of the luster is increased by alternately releasing and

taking up the tension on the material while it is in the alkali solution.

The chemical change involved consists in the probable formation of an alkali cellulose, which breaks up during the washing process, and the cellulose unites with water to form a cellulose hydrate to which the composition $(C_6H_{10}O_5)_n \cdot H_2O$ has been assigned.

In addition to the chemical change, the cotton fiber undergoes structural modifications. The cell walls are thickened, the lumen is consequently decreased in size, and with complete mercerization under tension the natural twist disappears, giving place to a smooth, rodlike appearance. Owing to the fact that the outer and inner fibers of the yarn are not equally influenced by the alkali, some twisting is commonly found in mercerized fiber. The acquired luster is due partly to the better surface for light reflection given by the smooth, rounded fiber, partly to removal of the cuticle, and partly to the translucent effect produced by strong alkalies on cellulose.

The mercerized material is found to have gained in weight, in tensile strength, and in affinity for dyestuffs, especially for the direct cotton colors. (See Chap. XIII.) It will also take up mordants more readily, as its absorptive capacity is practically doubled.

Cotton may be made to appear mercerized by giving it the Schreiner-finish. (See Chap. VII.)

Tests for Mercerization. — The microscope is fairly useful in determining not only the presence but the degree of mercerization; but if the tension has not been sufficient, or the fiber imperfectly mercerized, the twist which persists may make a definite conclusion impossible. The best chemical test is the Hubner method of treatment with a solution of iodine in potassium iodide.¹ The material is moistened with water, placed in the solution for a few seconds, then washed thoroughly and laid

¹Iodine in potassium iodide: Dissolve 20 gms. of iodine in 100 cc. of a saturated solution of potassium iodide.

in water. Mercerized cotton remains blue or black; ordinary cotton fades to brown or yellowish. The absolute prerequisite for this test is that the material shall have been boiled free from starchy dressing before testing, otherwise all fibers will give the blue reaction.

Mercerized Wool. — By a method somewhat similar to the mercerization of cotton, German experimenters have produced a “mercerized” wool — a product with luster, handle, fair strength, and no felting power. The wool enters a bath of sodium bisulphite, where it is kept under tension for some minutes at a high temperature. Boiling in a weak mineral acid solution, rinsing and drying complete the process, which has not gone far beyond the experimental stage.

Unshrinkable Wool. — When wool is treated under certain conditions with bleaching powder, the fiber loses its felting quality, due to a fusing of the epidermal scales with the cortical region. The luster is increased, and it is claimed that the tensile strength is greater also. Since the power of felting is gone, wool so treated cannot shrink, and is being much used for underwear.

Fireproofing of Cotton. — The Non-Flam Process, an English process patented in the United States in 1907, is a method of permanently fireproofing cotton, resulting from the investigations of William Henry Perkin. It can be applied to any cotton fabric, but is especially valuable in the case of flannelette, which because of its nap and treatment in finishing is exceedingly inflammable. The process, as described by the originator, is as follows: “The material is run through a solution of sodium stannate of approximately 1.22 sp. gr., in such a manner that it becomes thoroughly impregnated. It is then squeezed to remove the excess of the solution, and passes over heated copper drums in order to thoroughly dry it, after which it is run through a solution of ammonium sulphate of about 1.75 sp. gr., and again squeezed and dried. Apart from the precipitated stannic oxide, the material now contains sodium sulphate, and this is removed by passage through water. The material is then dried

and subjected to the ordinary processes of finishing." It is probable that the more or less soluble salts used are combined with the fiber in some undisclosed way. The additional cost per yard is trifling, and as the material becomes better known in this country it will probably be much in demand.

Artificial Silks. — Nearly all artificial silks are made by treating cellulose of some kind in a way to produce filaments of great luster and beauty, capable of giving brilliant hues with dyestuffs, and of sufficient tensile strength to allow for spinning into textile material. These filaments, however, lack the softness and elasticity of true silk, and are liable to disintegrate on washing. They are coarser than true silk in the approximate ratio of 15 filaments to 100 in a given area, and their tensile strength is as 30 to 100 in favor of natural silk. This comparative weakness of the artificial silk becomes even more serious on wetting. The principal artificial silks on the market are the nitrocellulose, cuprate, and viscose silks. They are known as lustracelluloses, from their cellulose origin.

Nitrocellulose, or pyroxylin, silks are produced by various methods, the best known, perhaps, being Chardonnet's, Du Vivier's, and Lehner's. The idea in each process is the same, — the production of guncotton or nitrated cellulose, which is dissolved, forced through capillary tubes, and coagulated into a filament. Chardonnet's method consists essentially in nitrating the cellulose by treatment with a mixture of fifteen parts fuming nitric acid and eighty-five parts concentrated sulphuric acid. The nitrated cellulose is washed and dissolved in a mixture of alcohol and ether. The clear, filtered, viscous solution, colloidal, is then forced through glass capillary tubes of 0.01 to 0.08 mm. in diameter. The outgoing filament rapidly hardens in the air. Three or four threads are combined into a single filament, which is passed through a denitrating bath of ammonium hydrosulphide. Treatment with a mixture called "antiphlogin" corrects the inflammable nature of the fiber. The material is then washed and dried.

Cuprate or cuprammonium silks are prepared from cellulose dissolved in Schweitzer's reagent (ammoniacal copper oxide). The cellulose is mercerized, dissolved in the copper oxide solution, filtered, and pressed through capillary tubes. The filament is coagulated by passing directly through a dilute sulphuric acid bath. These filaments are known commercially as the Glanzstoff or Elberfeld silks. Cuprammonium silks are manufactured to some extent in the United States.

Viscose silk is prepared by grinding wood pulp, or other forms of cellulose, often linters, with solid caustic soda, and mixing the product, alkali-cellulose, with carbon disulphide. This gives a gelatinous, viscous substance known as viscose. It is dissolved in water, filtered, pressed through platinum capillary tubes under great pressure, and hardened by passing at once into a concentrated solution of ammonium sulphate. After some further treatment the filament is bleached by calcium hypochlorite, and the finished silk shows a luster and strength equal or superior to the other lustracelluloses. It is generally produced in rather coarse filaments. Viscose silk is manufactured in the United States.

Gelatin or Vanduara silks are made by forcing gelatin in water solution through capillary tubes, drying the filament, and treating it with formaldehyde vapor, which renders it insoluble in water. These silks have not had a wide use in textile manufacture, due to high price and lack of strength.

A filament of animal origin which may be classed with the artificial silks is spun by a Mediterranean shellfish. It is used in Sicily for the manufacture of wearing apparel.

An adaptation of the process of making an artificial silk filament is now applied to the production of artificial tulle, or maline. Instead of being forced through capillary tubes, the solution is pressed upon an engraved cylinder, and at the same time receives the hardening or coagulating treatment. It is then drawn off as a continuous web having the structural appearance of the tulle weave, and with pattern effects produced by the

various designs with which the cylinders may be engraved. The fabric is not strong, having the properties of artificial silk, but it can be employed for hat trimmings and such uses.

Another artificial fiber is the spinning material "textilose," said to be made from paper, wood pulp, and wool waste. It is manufactured in Germany and Austria, and lately in New England. It is stronger than jute and cheaper, and has been used for sacking, upholstery, and curtain materials, and even for toweling and coarse clothing.

Dressing and Weighting.—The question of dressing or weighting is an important one from the consumer's standpoint, especially in the purchasing of table linen or silk dress goods. Materials of very inferior fiber or weave may be so loaded with starchy or other dressing as to appear of fine quality and firm texture. Simply boiling out a sample of toweling or table damask will often reveal an apparently different fabric from the purchased one.

A certain amount of dressing or sizing is legitimate and necessary, in order to make the filaments in a spinning yarn more homogeneous, and better able to stand the strain and friction of weaving, especially in the case of warp threads. In cotton or linen goods the sizing is commonly compounded of flours—wheat, rice, potato, etc.—to which glue, dextrin or other gums are frequently added. Mineral substances, principally kaolin or China clay, and chlorides of magnesium and zinc contribute to the weighting. The chloride of magnesium prevents the drying out of the size on the warp threads, keeps them soft and in good condition for the loom, and makes possible an increased amount of dressing. Zinc chloride is useful in preventing the growth of mildew, to which linen is particularly subject.

Dannerth (*Methods of Textile Chemistry*) recommends the following method of determining the amount of organic finishing material in a cotton fabric:—

1. The percentage of filling materials. A weighed sample of the fabric is boiled consecutively in distilled water, 1 per cent caustic soda solution,

and 1 per cent hydrochloric acid; each operation should be continued for about one hour. If the sample be finally washed and dried to constant weight at 105° C., the result will give the amount of absolutely dry fiber present. Add 8 per cent to obtain the "normal" air-dry weight.

2. The percentage of moisture in the air-dry fabric is determined by drying to constant weight at 105° C.

3. The percentage of fats and waxes is determined by extraction with ether in the Soxhlet apparatus.

4. The percentage of starch, etc., is determined by difference as shown in the illustration below:—

Total filling materials	22 per cent	
Moisture	12 per cent	}
Fats, etc.	5 per cent	
Starch, etc.		5 per cent

The qualitative test for mineral matter in the fabric is the ash which remains after ignition of the fabric in a crucible. The filling material may be soluble in water, *e.g.*, the chlorides of zinc, calcium, magnesium, and sodium. The insoluble portion may consist of China clay, barites, gypsum, chalk, talc, lime, or aluminium soaps. These latter compounds will, of course, be decomposed on heating.

Weighting of Silk.—The practice of weighting silk may begin with the raw material before it reaches us. Hygroscopic mineral salts and fatty and petroleum oils are sometimes used in the process of reeling, in connection with or in place of the weak soap solution which is the only necessary aid in softening the cocoon. Conditioning tests do much to reveal the state of the silk, but adulterations go undetected many times through lack of chemical analysis.

In the stripping of silk, the removal of the sericin or silk gum involves a loss of weight. This averages 25 per cent; therefore one hundred pounds of raw material will yield about seventy-five pounds of boiled-off silk. As the price of raw silk may be about \$5 per pound, the loss in these processes is evident. The throwster and especially the dyer plan to make this good by allowing the silk to take up weighting from the baths used. The throwster may leave an excess of soaps and oils in the silk, but the chief addition to its weight comes in the dyeing operations.

Silk readily absorbs the tannic acid and iron, tin, or other salts used in the baths. When properly carried out, this absorption, up to a certain amount, cannot be considered an adulteration, for it is a necessary accompaniment of the mordanting and dyeing operations, and it adds to the quality and attractive appearance of the silk. (See Chap. VIII.) A weighting of over 25 per cent, however, is often a strain on the fiber, yet organzine may be weighted to the extent of 18 oz. for colors and 30 oz. for blacks, and the tram up to 24 oz. or 26 oz. for colors and to 40 or even 60 oz. for blacks.¹

The substances used in dyeing which give weight to silks vary according to the color and the quality desired. White or light-colored silks do not always contain heavy metallic weighting. When they do, it is often in the form of a tin-phosphate-silicate. Successive baths of stannic chloride, sodium phosphate, and sodium silicate are used, and the amount of weighting is accurately regulated by the number of dips and the time allowed in each bath. Aluminium sulphate is sometimes added to save tin and also give a heavier thread. Sugar is often used as a weighting agent, and is applied after the silk is dyed. Each dip in the sugar solution may add 10 per cent in weight. Lead acetate, or more often "pink salt," which is the double salt of stannic and ammonium chlorides, is also used. Black silks may be "pure dye," with iron tannate as the mordant, or they may be "dynamited," that is, especially heavily loaded. Logwood is still preferred to coal-tar colors for black silks. A method for dyeing organzine with logwood is as follows: After boiling off, the silk is steeped in a bath of iron nitrate, and passes into a soap and iron bath, which adds a given weight of iron soap. The skein is then placed in a bath of potassium ferrocyanide, which with the iron present produces Prussian blue, and this is followed

¹ Weighting is generally calculated as ounces per pound of raw silk. If raw silk loses 25 per cent in boiling off, a pound will yield about 12 oz. (generally figured as 12.4 oz.) of stripped silk. A 24-oz. tram, for example, means that 12.4 oz. have been brought up to 24 oz., the equivalent of 16 oz. of raw silk, which is a weighting of 93 per cent. See Matthews, *Textile Fibers*.

by a bath of cutch or catechu. Tannin absorbed from the catechu increases the weight 35 per cent to 40 per cent, and here stannous chloride may be added to bring it up to any desired weight. The silk is now mordanted in an iron bath, and the dyeing finished in a logwood solution. Black tram weighting is in part tin-phosphate-silicate and in part tannin.

Piece-dyed goods, such as liberty silks, foulards, chiffons, and Shantung, were formerly little weighted in this country, but the practice of adding some weighting to these is increasing here.

Estimation of Weighting. — Mineral matter may be estimated approximately by burning a sample in a crucible until the organic matter is entirely consumed. The ash residue roughly represents the mineral weighting (Fig. 137), and if the fibers have been coated to excess, the form of the fabric will persist after the animal matter has been burned. This is a guide to the wearing value of a silk, and is the only method of investigation possible in the home. The sample may simply be held by forceps in the flame until nothing but mineral matter remains.

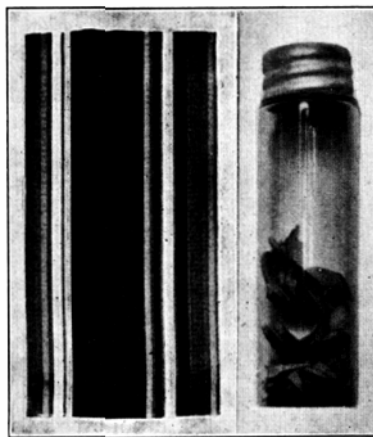


FIG. 137. — WEIGHTING OF SILK. THE BOTTLE CONTAINS THE MINERAL WEIGHTING LEFT AFTER BURNING A PIECE OF SILK LIKE THE SAMPLE SHOWN.

The quantitative estimation of weighting is a difficult matter, because of the many different substances used. The most accurate method of finding total weighting seems to be the determination by the Kjeldahl process of the actual silk present in a given sample. As nitrogenous bodies — gelatin or glue,

ammonium phosphate, and Prussian blue—may be in the weighting, these must first be removed. Matthews gives the following method for this:—

“Boil a weighed quantity of silk (about 2 gms.) in a 2 per cent solution of sodium carbonate for thirty minutes. Wash, heat to 60° C. for thirty minutes in water containing 1 per cent of hydrochloric acid, and afterwards wash well in hot water. Repeat the treatment with alkali and acid until the sample no longer has a blue color.”

The Kjeldahl process consists in converting the nitrogenous matter of the silk, by the aid of sulphuric acid, into ammonium sulphate. Ammonia is liberated from this on addition of caustic soda, is distilled into a known amount of sulphuric acid, and the amount of nitrogen calculated. Matthews gives the nitrogen content of silk with 11 per cent hygroscopicity as 17.6 per cent, therefore the amount of true silk in the sample is determined by multiplying the percentage of nitrogen found by 5.68.

The operation is conducted as follows: Place the silk, treated as above, for removal of nitrogenous weighting, in a Kjeldahl flask, add 20 cc. of concentrated sulphuric acid, 10 to 12 gms. of potassium sulphate, and 0.5 gm. of copper sulphate. Heat gently at first, then increase the heat, and boil till colorless. Cool, add about 250 cc. of distilled water, and after the solid matter has dissolved, 4 or 5 drops of rosolic acid. Put 100 cc. of tenth-normal sulphuric acid and 4 or 5 drops of Congo red in an Erlenmeyer receiving flask. Place small pieces of zinc and paraffin in the Kjeldahl flask to prevent bumping, add 80 cc. or more of strong caustic soda, and connect at once. At first distill over a low flame, later with increased heat, until about half the contents of the flask have been distilled over. If the color in the receiving flask becomes red, showing excess of ammonia, add a measured amount of the tenth-normal sulphuric acid. Titrate the excess of acid in the receiving flask against tenth-normal caustic soda. (A more detailed description of this process with discussion of precautions and modifications may be found in Sherman's *Methods of Organic Analysis*, Revised edition, Chap. XIV.)

Given the weight of the silk sample as 1.5 gms., the calculation may be as follows:—

100 cc. N/10 H₂SO₄ used.
7.9 cc. N/10 NaOH used to neutralize excess H₂SO₄.
100 cc. H₂SO₄ - 7.9 cc. = 92.1 cc. used to take up ammonia.
1 cc. N/10 H₂SO₄ = 0.0014 gm. nitrogen.
92.1 × 0.0014 gm. N = 0.12894 gm. N in sample.
5.68 × 0.12894 gm. N. = 0.73 gm. actual silk.
0.73 ÷ 1.5 = 48.7 per cent of actual silk in the sample.

Weighting is calculated in terms of percentage of the amount of pure silk present. Therefore a weighting of 0.77 gm. on 0.73 gm. silk (1.5 gms. - 0.73 gm. = 0.77 gm.) would be (0.77 × 100) divided by 0.73 = 105 per cent. This amount of weighting means that 16 oz. of raw silk have been brought up to 24 to 26 oz. in the dyeing and finishing operations. (See table, p. 403, Matthews' *Textile Fibers*.)

The hydrofluoric acid method, recommended by Matthews, gives results which agree fairly well with the above method. It is based on the fact that the acid destroys mineral weightings without injuring the silk fiber. The process is given as follows: "A portion (about 0.5 gm.) of the sample is placed in a weighing bottle and dried in an air bath at 105° C. to constant weight. It is then boiled in a 2 per cent solution of hydrofluoric acid for five minutes, rinsed with water, and boiled for five minutes in a 2 per cent solution of dry sodium carbonate and washed. This alternate treatment with the hydrofluoric acid and sodium carbonate solutions is repeated three times, after which the sample is finally rinsed, dried at 105° C., and reweighed. The loss in weight will represent weighting materials. The hydrofluoric acid may be prepared by diluting 11 cc. of commercial acid to 400 cc. with water, and the sodium carbonate solution by dissolving 2 gms. of sodium carbonate in 100 cc. of water. Three alternate treatments with these reagents will generally suffice to remove all weighting materials without appreciable injury to the silk fiber, though to be accurate the treatments should be repeated until no further loss in weight is observed." Hydrofluoric acid must be handled very carefully, as it is very corrosive,

and serious poisoning has sometimes occurred even from exposure to the fumes of this acid.

Other processes, providing for a separation and identification of the different weightings used, may be found by referring to the works of Matthews, Herzfeld, and Mitchell and Prideaux. (See Bibliography.)

CHAPTER XIII

DYEING OF TEXTILE FIBERS

THE chemical nature of dyestuffs, and the technique of dyeing, are subjects much too extensive and technical to be treated at all fully in a few pages. The aim of this chapter is to indicate an introductory course in dyeing, which may be expanded according to the needs of the class. There are several good laboratory manuals of dyeing which may be used as supplementary textbooks. (See Bibliography.)

Preparatory Processes — Scouring and Bleaching. — These processes remove natural coloring matter, gums, waxes, oily substances, and the like, which would interfere with dyeing.

Cotton Bleaching. — The cotton fiber contains about 5 per cent of such impurities as pectic acid, brown coloring matter, fatty acids, and waxes. As a result, the spun yarn has a dull, grayish appearance, which does not matter if it is to be dyed a dark color. In this case scouring is generally sufficient, a treatment which consists of removing waxy or fatty substances by boiling in solutions of either soap, sodium carbonate, or caustic soda, or mixtures of the three. For light colors, scouring is followed by bleaching with cold, dilute bleaching powder (calcium hypochlorite), followed by an acid bath and washing. When the yarn is to remain white, soap solution and bluing baths complete the process. If bleaching is to be done in the woven fabric, the process is more complicated, for additional matters, such as sizing added to the warp threads in the weaving, have to be considered, and the method varies according to the subsequent treatment of the cloth. Three processes are in general use — the market or white bleach; the Turkey red bleach; and the

printer's bleach, which prepares the material for calico printing. This last process is essentially as follows:—

1. Singeing.
2. Gray wash. The material is allowed to remain in plain water long enough to remove soluble matters.
3. Lime boil. Boiling in limewater for several hours converts fatty matter into lime soaps, which deposit as insoluble matter on the fabric.
4. Washing. This removes excess of lime, and any soluble substances.
5. Lime or gray sour. The material is passed through dilute acid, generally hydrochloric, which breaks up the insoluble lime soaps and other salts of lime, forming soluble calcium compounds, and setting fatty acids free.
6. Washing.
- 7, 8. Lye boils. Boiling with soda ash and with resin soap and caustic soda changes the free fatty acid left in (5) and (6) to soluble soaps.
9. Washing. All impurities are now removed, other than natural coloring matter.
10. Bleaching proper, or chemicking. The material is passed through cold, dilute calcium hypochlorite.
11. White sour. After a hasty wash, the material passes into dilute hydrochloric, sulphuric, or acetic acid. This sets chlorine free from the bleaching solution, which in the presence of water liberates oxygen, and this removes the coloring matter. (See page 339.)
12. Washing.

Linen Bleaching.—Linen contains more coloring matter and natural impurities than cotton, which make its bleaching a longer and more complicated process. The method is similar to that of cotton, except that the chemicking and souring may be repeated several times, according to the perfection of bleach desired, and grass bleaching is often combined with the chemical treatment. There are four grades of linen bleaching — quarter, half, three quarter, and full. Other terms are sometimes used. Full-bleached flax is not as strong as the other grades, due to the severity of the process. In linen yarns the loss of strength is estimated at 20 per cent for full bleach, and 15 per cent for half bleach.

Wool Bleaching.— Before bleaching or dyeing, wool must be scoured to remove the oil and grease left on the fiber after spin-

ning. The usual method of wool scouring employs a solution of soap and soda ash. If it is necessary to scour the skeins provided for laboratory dyeing, they may be treated as follows:—

Work a five-gram skein of wool for a half hour in a bath containing one liter of water, ten grams of soap, and two grams of soda ash, at a temperature of 60° C. Wash in fresh water till free from soap, and dry. Avoid using friction, which will felt the fiber.

Neither wool nor silk can be bleached by the method used for cotton, since the chlorine would yellow the animal fiber, and the alkalis destroy it. The agent generally used is sulphurous acid or sulphur dioxide gas. The wool or silk may be given the gas bleach, by subjecting the yarn or piece to the fumes of burning sulphur in a moist atmosphere, or they may be passed through sulphurous acid. Sodium bisulphite is sometimes used, which in solution gives sulphurous acid. These bleaches are not very permanent, and eventually the natural color returns, especially if the article is washed with soap. The hydrogen peroxide and sodium peroxide bleaches are expensive but effective, and are coming into greater commercial importance. (See page 340.)

Nature of the Dyeing Process.—Dyeing follows bleaching. It is the process by which coloring matter is permanently fixed upon or within a textile substance by means of immersion in the color solution. Textile printing is a process of applying color to certain portions only of the fabric, by means of a printing machine. Printed colors are not so fast as dyed colors. The two processes are sometimes combined in one material. The color solution, to be a dye, must possess not only color, but the power of combining with the chemical constituents of the fiber, with or without assistance, to form an insoluble compound. The changes taking place in the fiber are not clearly understood, but that they are of a chemical nature is indicated by the fact that wool and silk, which are both acid and basic by nature, are dyed directly by acid and basic dyestuffs, which is not true to any extent of the other fibers. According to Witt's theory, however, the dyed fiber is a solid solution of the dye. Many

of the dyeing operations are now classified among the phenomena of "adsorption."

Materials and yarns for the market may be dyed in the following ways: —

1. *Dyeing in the wool.* — What is called raw stock dyeing corresponds to the "dyeing in the wool" of early days. The wool is dyed after washing and scouring, and before drying. It is recommended for its permanence, and is used principally for dark goods which must stand much wear and friction, and still hold their color. Equal parts of black and white wool, so dyed, and mixed in the yarn, make the Oxford mixture.

2. *Dyeing in the slub.* — Wool is dyed after being carded and combed, but not twisted; cotton is twisted. The dye sinks in, and later spinning conceals any irregularities. Vigoureux yarns are yarns that have been printed on the slub or top by a special machine with regular or irregular designs of color, generally black and white, covering spaces of one quarter inch to several inches. The colors are set by steam. When the printed slub is later drawn and twisted, a more perfectly mixed effect is obtained than if colored wools had been blended.

3. *Skein dyeing.* — Spun yarn, usually two-ply, is dyed in the skein. This penetrates fairly well into the yarn. Skein-dyed yarns are used for gingham, and in wool for plaid and novelty effects.

4. *Piece dyeing.* — The fabric is dyed after weaving in the natural color, which produces a single uniform color.

5. *Cross dyeing.* — This is piece dyeing of mixed cotton and wool. Cotton will not take wool dyes, consequently when dipped in a wool bath it is merely tinged with a fugitive color easily washed out. Plain colored materials, such as mohairs and alpacas, are woven with a cotton warp. The cotton yarn is dyed first in the color desired, and then woven with the worsted filling. The cloth is cross dyed by placing it in a wool bath, in which the cotton is unchanged. Cloths are woven

with white or colored hair lines in the warp. When cross dyed in a wool bath and washed, the wool is colored and the cotton hairlines remain as they were. The reduction in price in thus inserting cotton for wool is quite an item. Cheap shepherd plaids and other fancy dress goods are woven with cotton for the white effects and with wool for the colored.

6. *Resist dyeing*. — Resist dyeing and cross dyeing are virtually the same process. In resist dyeing some of the woolen or worsted yarn is treated to remain unchanged in the bath which colors the untreated part. For example, a thread of red or green woven into a material to be dyed dark blue or black keeps its original color. Resist dyeing is used in the interesting Batik work, which originated in Java. In this work all of the material which is not to take the dye in the first dip is brushed over with wax. The wax may be removed and again applied to parts which are to resist a second dye, and so on, until the desired pattern is worked out.

7. *Discharge dyeing*. — By this process the material is piece dyed and the color afterwards removed in certain places by the action of chemicals. Flannels with polka dot effects are often dyed in this way.

Necessary Equipment for Dyeing. — For each student, the minimum apparatus required is an agate kettle holding a gallon or more; two glass rods at least eight inches long and three eighths of an inch in diameter; one agate pint cup; a tablespoon; a thermometer; a 100 cc. graduated cylinder and some kind of heating apparatus, such as a small gas stove. The laboratory should be equipped with one or two clothes wringers and a clotheshorse or drying rods.

Use of Glass Rods — Handling of Skeins. — The glass rods obviate any handling of the skeins and staining of the hands. Holding a rod in each hand, the dyer keeps the skein revolving in the dye bath. When the dyeing is accomplished, the skein is looped evenly on one rod, and with the aid of the other inserted in the loop is twisted and wrung out. Subsequent washing,

wringing, and hanging up to dry are accomplished also by using the rods.

Preparation of Dye Solutions. — Skeins to be dyed are generally in five-gm. weights for wool, ten gms. for cotton, and two gms. for silk. Five gms. of wool require sixty times that amount of dye solution, or about 300 cc.; ten gms. of cotton require also 300 cc., and two gms. of silk need 125 cc. of solution. It is the common practice to measure the necessary dyestuffs and chemicals in percentage relation to the weight of the material. A recipe for acid dye which calls for 5 gms. of woolen yarn, 250 cc. of dyebath, 10 per cent Glauber's salt, 5 per cent sulphuric acid, and 3 per cent Benzyl Violet 6 B would use the following amounts: —

- 10 per cent of 5 gms. = 0.5 gm. Glauber's salt.
- 3 per cent of 5 gms. = 0.15 gm. dyestuff.
- 5 per cent of 5 gms. = 0.25 gm. sulphuric acid.

In order to obviate individual weighing of these small amounts, solutions may be prepared of such a strength that 10 cc. will contain the proper amount of each ingredient for a skein of wool. For example, 0.5 gm. of Glauber's salt are required; 10 cc. of solution must contain 0.5 gm., therefore dissolve 50 gms. of Glauber's salt in about 500 cc. of water and make up to 1000 cc. Of dyestuff, 0.15 gm. are required; therefore one liter is made up in a similar way to contain 15 gms. Of sulphuric acid, 0.25 gm. in 10 cc. would equal 25 gms. in 1000 cc., but as the specific gravity of concentrated sulphuric acid is 1.84, the number of cubic centimeters measured out would be 25 divided by 1.84, or 13 cc.¹

¹ These technicalities are introduced to teach the student how to interpret dye recipes, if necessary. The recipes which are occasionally given in the text may or may not be used. They are given simply with the idea of suggesting possible dye baths, and providing for uniform experimental work in large classes. Dyeing formulæ are in no sense fixed, but most varied, and the instructor, if he wishes, may readily substitute or add recipes from the larger manuals of dyeing. As soon as the student has studied the properties of a class of dyestuffs, recipes and the dyeing of skeins may be discarded for the working out of experiments in mixing color and in dyeing piece goods.

Mixing, Blending, Topping. — The primary mixing colors — blue, red, and yellow — are sufficient for the production of other colors, shades, and hues. The student measures out the dyestuff in small quantity, dissolves it in a little hot water in a cup, and experiments through different proportions and combinations for the desired shade. Some knowledge of the laws of color blending is necessary. For instance, equal parts of blue and red produce violet, but three parts blue to one red make violet-blue; two parts blue to one red make blue-violet; two parts red to one blue make red-violet; three parts red to one blue make violet-red. Yellow and blue make green, and the shades of green may be worked out as above, but a softer shade, approaching olive, is produced by a slight addition of red. Red is the opposite of green; the opposite of any color grays that color. While the addition of the third color is almost always desirable, on account of its softening effect, the amount added must be gauged with care. Topping often gives better results than mixing two or three colors in one bath. A clear, bright orange, for example, may be produced by dyeing a skein in a bath of yellow and immediately dipping it in a red bath, called "topping."

Classification of Dyes. — Dyestuffs may be classified as:—

I. *Artificial.*

Coal-tar dyes (aniline dyes and others).

II. *Natural.*

1. Vegetable, — logwood, fustic, cutch, madder, indigo.
2. Animal, — cochineal.
3. Mineral, — Prussian blue, iron buff, chrome yellow.

The artificial dyestuffs are by far the most important. Since 1856, when the first coal-tar dye, mauveine or mauve, was discovered by Perkin, the number has increased enormously, and the natural dyes are for the most part falling into disuse. In fact, many of these can be produced synthetically. Alizarin is the chemical equivalent of madder, and synthetic indigo

is a strong commercial competitor of the natural product. Logwood, however, holds its own. It is much used for producing a good black shade in silk fabrics, often in connection with cutch or fustic. Cutch is still employed in cotton dyeing to produce certain shades of brown.

Based on their nature or properties, dyes fall into certain classes, of which the more important are:—

(1) Acid Dyes, (2) Basic Dyes, (3) Substantive Dyes, (4) Sulphur Dyes, (5) Adjective or Mordant Dyes.

I. Acid Dyes.— These are direct dyes for silk and wool, feathers, leather, and other substances of a protein nature. They do not color vegetable fibers to any extent, but may be used in staining wood and straw, where the color does not need to be fast to washing.

The following experiment is given to show the comparative action of acid dyes on wool and cotton:—

Prepare a dye bath of 300 cc. water, 1 per cent Naphthol Red E. B., 20 per cent Glauber's salt, and 4 per cent sulphuric acid. Thoroughly wet a five-gm. skein of wool in water, immerse it in the bath at a low temperature, and heat gradually until a good color is obtained. Remove, rinse, and dry. Dye a skein of cotton in the same manner.

Acid dyes are salts of color acids. When an acid, in this case sulphuric, is added to the dye bath, the salt is broken up, the color acid is liberated, and this dyes the wool fiber more readily than the salt itself. The sulphuric acid also unites chemically with the wool and increases its affinity for the dye. Glauber's salt is generally added to the acid bath with these dyes. Its main function is to hold back the dye from too rapid absorption by the fiber, so that a more even, level shade is produced. Such substances as Glauber's salt, sodium chloride, and sulphuric acid, which aid in the dyeing operation, are called assistants.

Generally speaking, acid dyes are cheap, easily applied, and give even shades on wool and silk which are fairly fast to light. A few selected colors can be obtained which are entirely satisfactory in this respect. They are not so fast to washing,

and the dyed material should be well washed after dyeing, else there may be an effect of "bleeding" or "crocking." Wool and silk are almost always dyed with these colors, unless fastness to washing is necessary.

In the following experiments, students may work out color combinations with acid dyes and apply to skeins or piece goods:—

Dyeing Directions. — *For Wool.* Dissolve the dyestuff in a bath containing about a tablespoonful of 30 per cent sulphuric acid and two or three tablespoonfuls of Glauber's salt to a gallon of water. Immerse the thoroughly wetted wool in the cold or lukewarm bath, and heat it slowly until the desired shade is reached, turning it cautiously so as to give the dye a chance for even penetration. The bath should not boil if the wool is to be kept from felting, and for the same reason the skein should be turned carefully on the rods. Finish by rinsing thoroughly in two or three waters, to remove the last traces of acid. Wring out by hand or machine, and let dry in the air.

For Silk. Dissolve the dyestuff in a soap bath, containing 2 per cent of good neutral soap; then add dilute sulphuric acid, drop by drop, until the bath "breaks" and becomes faintly acid. Immerse the wetted silk, stir it well, keeping it on the dye sticks, and warm the bath till the desired shade is reached. Rinse well, wring out between folds of blotting paper in the wringer, straighten, and dry.

For Feathers. If necessary, cleanse the feather by washing with water and olive-oil soap, and carefully rinsing. Soften by soaking for a short time in hot water and dye in a bath slightly acidified with oxalic acid. Begin in a cold bath and warm very gently, keeping the butt immersed in preference to the tip, till the desired shade is reached. For good, even dyeing, the time allowed for each feather should be from half to three quarters of an hour. Rinse in two or three waters, partly dry, and then work in a thick milk made by stirring finely powdered starch with cold water. Take the feathers out and pass through the wringer between blotting paper, and dry carefully over a radiator, taking care not to cook the starch. When thoroughly dry, shake out the dry starch granules.

II. Basic Dyes. — These are direct dyes for wool and silk; vegetable fibers must be mordanted.

Experiment. Dye a skein of wool and one of cotton in a 1 per cent solution of fuchsin, boiling fifteen minutes. Remove and wash. The dye is easily washed out of the cotton.

Basic dyes are salts of color bases. The color base unites with the acidic groups of the wool or silk fiber to form an insoluble dye. Silk especially has a great affinity for basic dyes, and care must be taken that the color is not taken up so fast that uneven dyeing results. Artificial silks of the nitrocellulose class take these dyes well. Basic dyes have greater tinctorial power than acid dyes, and give more brilliant colors. They are used to some extent for silk, but not so generally for wool, being largely superseded with both by the acid dyes. They are useful, however, in staining straw and raffia. Their defects are a want of fastness to light, and a tendency to crock. With hard water the dye precipitates more or less from solution, and dye spots appear.

Application to Wool.—Wool is dyed in a neutral bath, or in one slightly acidified with acetic acid, especially if the water is hard. The acetic acid aids in softening the water by breaking up its carbonates, and also causes the dye to fix on the fiber more slowly and evenly. Glauber's salt is used as an assistant. The dye must be carefully dissolved and filtered into the bath through a cloth.

Experiment. Prepare a dye bath containing 300 cc. of water, 2 per cent of acetic acid, 10 per cent of Glauber's salt, and 1 per cent of Methylene Blue. Thoroughly wet a 5-gm. skein, place it in the lukewarm bath, raise the temperature slowly, and dye for half an hour at about 80° C.

Application to Silk.—Silk is dyed in a neutral, alkaline, or slightly acidified bath, to which in practice soap and boiled-off liquor are usually added. An after treatment with a tannic acid bath, followed by rinsing in a solution of tartar emetic, improves the fastness of the color.

Experiment. Immerse a 2-gm. skein of silk in a bath containing 150 cc. of water and 5 per cent olive-oil soap, and after working with the rods for a time at lukewarm heat, add gradually 2 per cent of Methylene Blue. Dye for fifteen minutes at 80° C., carefully acidulate the bath with acetic acid, and dye fifteen minutes longer. Remove, rinse, and dry.

Dye another skein in a similar manner, wash well, pass into a bath con-

taining 100 cc. of water and 1 gm. of tannic acid. Work for twenty minutes at 80° C., then let remain immersed in the cooling bath for a half hour. Squeeze out, pass into a fresh bath containing 100 cc. of water and 0.5 gm. of tartar emetic, and work at 60° C., for twenty minutes. Wash well and dry.

Application to Straw. Cleanse the piece of straw braid, loosely bound together, or the hat, in soap and water, and thoroughly rinse. Prepare the bath by straining a solution of the dye through muslin into sufficient water to well cover the material, and slightly acidify with acetic acid. Immerse the wet straw and gently heat until the right shade is obtained. Remove and rinse.

Topping with Basic Colors. Dye a skein of cotton or linen with a direct or salt color, or a sulphur color (as described beyond), and top by passing into a basic dye bath. The direct and sulphur dyes serve as mordants with the basic dyes.

Dyeing Cotton with Basic Colors. — Mordants. — In dyeing cotton with basic colors, a mordant, generally tannic acid, must be used to make the fiber take the dye. Mordants are substances which in the dyeing operation unite with both fiber and dye, and fix the dye on the fiber. For the application of mordants see Adjective or Mordant Dyes below.

Experiment. Thoroughly wet a skein of cotton and immerse in a lukewarm bath of a dilute solution of tannic acid; slowly raise the temperature to nearly boiling, then let the skein remain in the cooling bath. Remove, wash lightly, squeeze, and dye in a one per cent solution of fuchsin, together with a skein of unmordanted cotton, observing the same temperature regulations and dyeing for about one half hour at the maximum temperature. Remove, wash, dry. Observe the effect of the mordant in fixing the dye.

In practice, tannic acid is more effective if combined with certain salts of metals. The metallic tannates formed unite with the dye to produce compounds of greater insolubility. This process, called fixing, follows the tannic acid mordanting. Salts of tin, iron, chromium, antimony, etc., are used as fixing agents. Applied to the last experiment, the cotton skein is passed from the tannic acid bath into one containing about two grams of tartar emetic in a liter of water. Work the skein five minutes, and let remain in the solution while the dye bath

is being prepared. Then place in the dye and proceed as before.

III. Substantive Dyes. — This class of dyes bears several names. They dye vegetable fibers directly, requiring no mordant, so are called direct cotton colors. As common salt is usually used in the bath, they are also known as salt colors. The term diamine dyes refers to their chemical constitution. The first direct or substantive dye was discovered in 1884, and named Congo red; the dyes belonging to this group are therefore sometimes called Congo colors.

Experiment. Thoroughly wet a 10-gram skein of cotton and immerse in a bath of 2 per cent Congo red to which 2 per cent sodium carbonate and 20 per cent Glauber's salt have been added. Heat to boiling point and boil a few minutes; remove and rinse.

Vegetable fibers take more brilliant colors than wool. To show this, dye a skein of wool in the same manner. Note any differences in the degree of color and in the exhaustion of the bath.

Certain of the substantive dyes, Congo red, for example, have their color changed by the action of acids. If a strand of the skein just dyed be dipped in dilute sulphuric acid, the color will be changed to blue, and the red returns when the acid is replaced by an alkaline reaction. Congo red is often used as an indicator, with a reaction opposite to that of litmus. The acids present in the air may be sufficient to dull material dyed with some of these colors. Treatment with an alkali, such as sodium carbonate, aids in restoring the original shade. The sodium carbonate used in the above experiment remains to some extent in the fiber and protects the material from color change.

Substantive dyes furnish bright, clear colors which are fairly fast to light, and with wool and silk withstand washing, especially with the latter when dyed in a boiling bath. They have the disadvantage, with vegetable fibers, of "bleeding" when washed, unless the color is thoroughly boiled into the fabric, and often unless a treatment of copper sulphate and potassium bichromate is given. If even tones are desired

which do not have to be particularly fast to washing, these dyes give them quickly and easily. They are also useful for dyeing evenly mixtures of cotton and wool or cotton and silk. The lower the temperature of the bath, the stronger the affinity of the cotton for the dye, and the more the bath is boiled, the deeper the color produced on animal fibers. In dyeing mixed goods, therefore, the material is first dyed cold until the desired shade is nearly reached in the cotton material, then heated until the wool or silk takes the color. With practice, the same shade can be produced in this way on different fibers. Substantive dyes are very soluble in water, and salt has the effect of making them insoluble. Used in the bath, it prevents too thorough a solution, and therefore causes more of the dye to go on the fiber. Glauber's salt is used for the same purpose.

Dyeing Directions. — Cotton and Linen. Fill the kettle half full of hot water, and bring to boiling point on the fire. Mix the dyestuff with a little hot water in a cup, and stir into the kettle. When thoroughly dissolved, add a tablespoonful of salt. Thoroughly wet the material, place it in the dye bath, and boil for about thirty minutes.

Artificial Silk. Fill the dye kettle half full of lukewarm water, and in this thoroughly wet skeins of artificial silk. Wrap in cheesecloth and put through the wringer. Dissolve dyestuff in hot water in a cup, stir into the kettle of water without further heating, and add one tablespoonful salt. After dyeing the desired shade, rinse in cold water, wrap in cheesecloth, and put through the wringer. Hang to dry. A stronger dye bath is needed for artificial silk than for cotton.

The fastness of cotton and linen to light is improved in the following way: —

The material is taken out of the dye bath, rinsed slightly in cold water, and soaked for a few minutes in a hot bath containing two teaspoonfuls of copper sulphate, one teaspoonful of potassium bichromate, and one of acetic acid to a gallon of hot water. It is then rinsed free from this and dried.

Mercerized cotton is generally dyed with these colors in the same way as described for cotton and linen. The colors produced are much faster to washing, and take more easily than with ordinary cotton.

IV. Sulphur Dyes. — These are direct dyes, used especially for cotton, linen, mercerized cotton, and artificial silk. The colors are soft, quite fast to light, and faster to washing than the salt colors. Sulphur dyes are as a rule insoluble in water, but dissolve in a bath containing sodium sulphide. Sodium carbonate is sometimes added for alkalinity, and common salt for better exhaustion of the bath.

Dyeing Directions. — *Cotton and Linen.* Stir the dyestuff into a bath containing enough sodium sulphide to dissolve it to a clear solution. About twice as much sodium sulphide as dye will be necessary. Make alkaline with a small amount of sodium carbonate, and add twice as much salt as dyestuff. Heat the material in the bath to just below boiling point, and dye at that temperature for fifteen minutes to half an hour, keeping the goods immersed. Remove, pass through the wringer, being careful to effect an even removal of the dye solution, and after a few moments of hanging in the air, boil in a soap solution to soften the material and free it from excess dye. Artificial silk is dyed in a cold or lukewarm bath.

V. Adjective or Mordant Dyes. — The alizarin colors are the principal dyestuffs in this class, but most of the natural dyes, including the important logwood, belong here. These dyes have been used extensively for wool, and especially for dyeing Turkey red on cotton; less often, except in the case of logwood, for silk, but the coal-tar dyes have now largely superseded them. A mordant is necessary, which usually precipitates as a metallic hydroxide on the fiber. The dyestuffs unite with these hydroxides to form insoluble metallic salts known as color lakes. Mordants are generally salts of metals, with the exception of Turkey red oil and the tannins. The ones in common use are the potash or soda alums and aluminium acetate, generally applied to cotton dyeing; potassium bichromate or "chrome" for wool, and other chromium and iron salts.

As a rule, mordants darken or "sadden" the color of the dye with which they are used. This is especially true of the iron and chromium salts. The natural claret red of logwood cannot be produced in conjunction with a mordant; with iron,

for instance, the famous logwood black is secured. Tin, however, intensifies the natural color of most dyes.

Mordants are applied in three ways: first, to the fiber before dyeing, the usual method; second, in one bath, the cheap and often practiced method; third, after dyeing, a method sometimes applied to wool. When so applied, the process is called after-chroming, since potassium bichromate is the mordant used. The after-chromed colors are generally fast.

Application of Mordant Dyes to Cotton. — With alizarin colors, the principal colors produced are the bright and fast Turkey red, the maroons, and the violets. For Turkey red, different methods are employed, but the color is generally fixed on the fiber by the aid of Turkey red oil and aluminium acetate or sulphate. A so-called Turkey red, which imitates the color but not its fastness, is now produced by direct dyes.

Cotton may be dyed black by logwood.

Experiment. Work a skein of cotton yarn in a 50 per cent solution of ferric sulphate until thoroughly impregnated. Squeeze, rinse in limewater to remove excess of the salt adhering to the fiber, and boil half an hour in a 10 per cent extract of logwood.

Application to Wool. — Wool may be dyed, then mordanted, in the same way that acid dyes are applied.

Experiment. At about 50° C., enter a 5-gm. skein of wool in a bath containing 150 mg. of Chrome Fast Blue in 250 cc. of water, 10 per cent Glauber's salt, and 5 per cent acetic acid. Raise slowly to the boiling point, dye for one half to three fourths of an hour. Cool, add 1½ per cent potassium bichromate, and boil for thirty minutes.

Application to Silk. — The best black dye on silk is still produced by logwood, with a tannin-iron mordant. (See p. 312.)

Mordant dyes are very fast to washing, light, and acids.

Dyeing in the Household. — For home dyeing, such dyes as the Diamond, Rainbow, or E-Z dyes are about the only ones available, because of the small quantity of dyestuff required. Directions are given on the packages. Before dyeing, the nature of the material should be known, and the dye chosen

accordingly. For example, if a part of the fabric is cotton, a cotton dye is used, as wool and silk can be made to take cotton dyes better than cotton will take those for the animal fibers. In redyeing, it is a good plan to choose a dye which is of the same color order as that of the material to be dyed, as a dark blue dye for a light blue garment; in case the new color is to be entirely different, as much as possible of the original color must be removed by repeated boiling out, or the blend of the two may be quite different from the shade desired. The material must be clean and free from spots or stains before dyeing. The kettle used should be large enough to take the goods without crowding, and allow for thorough stirring and turning. A sample of the material should be tested in the dye bath. It is a wise precaution to mix the bath rather weak, as more color can be added if necessary. A lack of softness in the colors may be overcome by blending and shading down.

Dyes in amounts of one quarter pound up may be procured directly from the large color houses. The letters following the names of the dyes furnished refer generally to the tone. A violet may run from 6B. to 6R. indicating tones from blue violet to red violet. The letter F indicates fastness to light, and FF would be very fast. As the different supply houses have their own systems of naming their colors, it is necessary that the manufacturer's name accompany the name of the dye.

SELECTED DYES

Acid Dyes: —

Benzyl Violet 6B., A. Klipstein & Co., 654 Greenwich St., New York City.
Naphthol Red E. B., Cassella Color Co., 182 Front St., New York City.
Naphthol Yellow, Cassella.
Acid Yellow A. T., Cassella.
Tetracyanol S. F., Cassella.
Brilliant Cochineal R. R., Cassella.

Basic Dyes: —

New Methylene Blue N., Cassella.
Safranine R. S., Cassella.

Thioflavine T., Cassella.
Bismarck Brown E. E., Cassella.
Solid Green Crystals O., Cassella.

Substantive Dyes: —

Congo Red.
Benzo Purpurin 4B., Klipstein.
Diamine Fast Black X., Cassella.
Diamine Pure Blue A., Cassella.
Diamine Fast Blue F. F. G., Cassella.
Diamine Fast Yellow F. F., Cassella.
Diamine Fast Red F., Cassella.
Cotton Yellow, Badische Co., 128 Duane St., New York City.
Fast Red, Badische.
Direct Green, Badische.

Mordant Dyes: —

Chrome Fast Blue, Klipstein.
Alizarin Red.

Sulphur Dyes: —

Immedial Direct Blue B., Cassella.
Immedial Yellow Olive 5G., Cassella.
Kyrogene Black T. G. O., Badische.
Kyrogene Brown R. R. O., Badische.

Dyes in Oriental Rugs. — The soft, wonderful colors in Oriental rugs are produced from natural sources, limited in variety only by the ingenuity of the dyer. Onion skins, thistles, leeks, ivy, artichokes, with mordants of pomegranate rind or sumac, may enter into a dye the recipe for which is the hereditary secret of a family. One family will be known for its yellows, another will have the secret of certain reds. The reds are the finest and most difficult colors the Eastern dyers produce, and are the most durable. They are usually combinations with madder, cochineal, or kermes (an insect feeding on oak leaves). A certain shade of violet is produced by equal parts of milk and water to which are added madder and sour grape juice.

Blues have an indigo base. Black is the cheapest dye in a rug, and always wears off first, due to the corroding action of the iron salts used in the dye. A native dyer seldom employs exact methods to get his results. He blends and tops his skeins in successive dye baths until harmonious shades are produced rather than exactly matched colors, and the dyed skeins are then exposed on the roof of his house, while the dyer watches them until the sun has given them just the right mellow tone. His ways are not adapted to the exact operations required with aniline dyes. While these can be made as fast and as soft as the Oriental's natural dyes, he has not learned to handle them, and where aniline dyes have been used a far less beautiful and satisfactory article has resulted. Persia has for some years prohibited the importation of aniline dyes into the country.

A rug dyed with aniline colors may fade to entirely different colors, while in general a vegetable dye fades to tones of its particular color. The manner of fading is apparent if the color deep down in the pile is compared with that on the surface. If any color has run into the white part of a rug, it has been poorly dyed with aniline colors. A test often given consists in laying a wet cloth on the rug, or rubbing the colors with a cloth moistened with saliva, in which case aniline dyes will rub off.

CHAPTER XIV

LAUNDRY NOTES

THE intelligent treatment of textile fibers in the laundry depends ultimately upon a knowledge of the chemical nature and structure of the fibers, and the effect upon them of water and friction, acids and alkalies, heat and cold. The general principle that protein fibers deteriorate in alkaline solutions and vegetable fibers in acid necessitates a knowledge of the particular acids and alkalies of the kitchen and laundry, how they affect each kind of material, and the reasons underlying the choice of cleansing and bleaching agents, and bluing.

Felting of Wool. — From the laundry standpoint the most striking characteristic of wool fibers is their power of felting. The epidermal scales of the fibers, being loosely attached, interlock readily, as if the teeth of two saws should be dovetailed. As a result, the fibers shrink to a matted, boardlike mass. This property is utilized in the production of felted goods such as broadcloth (see Chap. VI), but the problem in the laundry is to cleanse wool with as little felting as possible. Certain influences increase the felting action, *e.g.*, expansion due to heat, followed by sudden contraction from cold; the softening and expanding effect of alkalies, and friction. The soft, elastic quality of a blanket or sweater can be entirely lost by washing it with strong soap or washing powder, rubbing or wringing it, changing from hot to cold water, or hanging the warm, wet fabric outdoors on a cold day.

The peculiar protein nature of the wool fiber makes it very susceptible to hot water, which rapidly deteriorates it. Too hot an iron will cause felting and stiffening, whereas if the heat is regulated to about 100° C. under the damp pressing cloth, the

fibers become plastic and will take and retain the shape desired, without losing their elasticity.

Acids and Alkalies of the Household. — The action of acids and alkalies on textile fibers has been treated in detail in Chapter XII. The acids of the household, outside of those found in fruits, are hydrochloric (muriatic) and oxalic, used for removing stains and for cleaning purposes. The last two have a “tendering” effect on cotton and linen if allowed to dry on the fiber, and should be followed by washing and neutralization with ammonia or other alkali. Silk is more susceptible to the action of acids than wool. Hydrofluoric acid is an exception to the general rule of fiber destruction, and is used in about 2 per cent strength in some laundries for removing the soil from collars and cuffs. It attacks mineral matter without materially affecting the fabric. It is a very corrosive acid and must be handled carefully. Since acids and alkalies neutralize each other, color changed in clothing by acids can often be restored by touching the spots with weak ammonia.

The common alkalies in household use are ammonia, borax, carbonated alkalies, such as washing soda, and caustic alkalies found in some soaps and washing powders. Unless carelessly used, the first two are not injurious to fabrics. The carbonated alkalies have a yellowing effect on silk; good soap usually has no deleterious action. Washing soda in strong solution and in an undissolved condition should not come in contact with garments, especially wool, nor should any soap containing free alkali be used for wool. Soap should not be rubbed on wool because of the felting effect, and in fact for many cleansing operations, especially washing colored cotton material, a soap solution is better than direct rubbing.

The tendency in the average laundry is toward the excessive use of washing soda. As a soap saver, to soften hard water, washing soda is most desirable. For this purpose, one part will do the work of about six parts of soap of 100 per cent purity, but as cheap laundry soaps contain only about 33 per cent actual

soap, the ratio becomes 1 : 18. A white laundry soap of good quality contains about 75 per cent soap, the balance being mostly water. An ordinary yellow soap has about 35 per cent resin and 30 per cent water incorporated in it. The amount of washing soda needed to soften a given water may be found by observing how much soap is required to make a permanent lather — *i.e.*, overcome the hardness of the water — in a measured amount, and estimating accordingly. The yellow soaps generally show free caustic alkali, and in such case are injurious to wool or silk fibers. Their continued use will have a yellowing effect on all material, due to both alkali and resin.

Cotton launders less easily than linen, and requires more thorough treatment. It has been estimated that cotton will collect three times as much dirt as linen will, and bacteria have been found on the surface in the ratio of 182 with cotton to 100 with linen, when both have been treated alike. Linen needs careful handling, as the fibers are stiff and inelastic, especially when starched, and soon break in the folds of table damask, for example, under heavy ironing.

Bluings. — Certain aniline blues, or rather dyes, give clear, attractive blue shades. Some of these blues do not require acids to develop them, but in common practice varieties are used which are brought out on the material by the aid of acetic or oxalic acids. While acetic acid is volatile and not necessarily harmful, oxalic is far more likely to be injurious to the fabric, as it is not volatile, and is concentrated on the fiber in the ironing process. It is used for its whitening effect, without regard to its destructive action, and in a short time the clothes go to pieces. Another class of liquid blues is made on an iron base, *e.g.*, Prussian blue. In the presence of alkalies the iron is changed to ferric hydroxide, which becomes ferric oxide or iron rust in the dry material, especially under the heat of the iron. If this kind is used, therefore, the bluing water must be entirely free from soap, otherwise rust spots appear on ironing. To determine whether a liquid blue is of this variety, add caustic

soda solution or other alkali, and shake for a few minutes, heating gently meanwhile. If iron is present, the blue color will fade to the reddish yellow color of iron rust. The blue can be restored by the addition of acid, hence the iron-rust spot can be removed by treating with an acid. (See page 343.) The ultramarine blues come in solid forms, and are insoluble in water. They are very satisfactory, provided they are not allowed to settle on the clothing and make blue spots. The choice of a bluing is a matter of individual taste, any standard kind being good provided it is used intelligently.

Fastness of Dyes. — Certain dyestuffs are fast to light, others to washing, or to other influences, according to the particular requirement of the material. For example, a coat lining should be dyed fast to perspiration and crocking. As it is often desirable to test the permanence of a color before purchasing materials for a given purpose, or having them laundered in the ordinary way, the following experiments are suggested:—

Fastness to Light. — Expose the material to direct sunlight in wet and dry condition for four weeks. If the dye fades at the end of one week, it is considered fugitive; at the end of three, moderately fast; if it has not faded in four weeks, it is considered fast.

To Washing. — Use plain water; look for “bleeding.”

Plait a strip of the dyed material with one of undyed. Make up a solution of ten grams soap in a liter of water, heat a small portion to about 60° C., and work and squeeze the material in this for about ten minutes. Rinse in cold water, let lie in water fifteen minutes, wring out, dry. Note change in color of material or washing water, and any bleeding on the undyed piece. To test whether the color is proof against severe treatment, repeat the above with strong laundry soap, with and without washing powder.

If the color is inclined to be fugitive, experiment with salt, aluminium acetate, or vinegar in the washing water. A mordanting solution composed of one teaspoonful of potassium bichromate, two teaspoonfuls of copper sulphate, and two of

vinegar in a gallon of water may often fix a color that is fugitive to washing. Warm the material in the solution for about ten minutes, remove and rinse. Some colors are changed by this treatment, so a sample of the fabric should be tried first. Materials dyed dark blue are generally successfully treated in this way.

To Perspiration. — Steep portions of dyed material in either of the following solutions for five-minute periods, drying the sample after each immersion. Examine fabric day by day for change: —

1. A solution of 50 gms. of 50 per cent acetic acid and 100 gms. common salt per liter.
2. A solution of 50 cc. of 50 per cent acetic acid and 25 cc. of butyric acid per liter.

To Rubbing. — Rub dry sample vigorously on white material and observe any crocking.

Materials bought by the United States Government must meet certain requirements (see Chap. X), and are tested in part as follows: —

Washing Test. Boil for ten minutes in a solution containing 80 gms. of olein soap (army issue) to one pint of water.

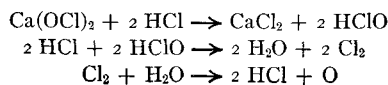
Laundry Test. Boil for ten minutes in a solution containing 10 gms. of dry sodium carbonate to one pint of water.

Roof Test. Expose to weather for thirty days.

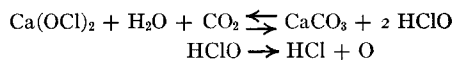
Perspiration Test. Soak for 24 hours in lactic acid of specific gravity 1.21.

Bleaching Agents

Calcium or Sodium Hypochlorite. — The first of these may be taken to illustrate the type of chemical action. Calcium hypochlorite, commonly called bleaching powder, is soluble in twenty times its weight of water. When treated with an acid, it gives up chlorine, which unites with water to form hydrochloric acid and free oxygen. The latter oxidizes organic coloring matter and therefore bleaches. The reactions, using acid, are as follows: —



The reactions with sodium hypochlorite are similar. The action may take place without the addition of acid, the carbon dioxide of the air forming carbonic acid, as follows:—



Silk and wool would be destroyed by the alkaline nature of calcium or sodium hypochlorite, and yellowed by the free chlorine. These bleaches are therefore used only for vegetable fibers.

Experiment. Soak the material to be bleached in a weak solution of bleaching powder, with and without the addition of hydrochloric acid. After bleaching is accomplished, wash and treat with dilute acetic acid, in order to decompose remnants of bleaching powder and calcium carbonate in the goods. Finally wash free from acid.

Hydrogen (or Sodium) Peroxide.— These are largely used in the bleaching of wool and silk, but may be used for cotton. Oxygen is given up ($\text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{O}$), which unites with the organic coloring matter of the pigment and destroys it. Hydrogen peroxide gives up its oxygen most freely in an alkaline bath. Ammonia or borax, which will not injure wool, may be used, although sodium silicate is the ordinary agent.

Experiment. Immerse scoured wool fleece in hydrogen peroxide diluted with five to fifteen volumes of water, and make slightly alkaline with borax. Keep temperature at about 40° C., and let action continue several hours. Moderately increasing the temperature hastens the process.

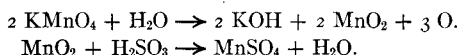
Hydrochloric Acid.— This precipitates the color from direct cotton colors (substantive dyes), and from basic dyes. In the first case a free color acid is formed, and the lost color can be restored by using an alkali. In the latter case an acid salt of the basic dye is formed. Hydrochloric acid can be used as a bleach and color remover in many operations.

Potassium Permanganate.— This is a powerful oxidizing agent, therefore is particularly valuable as a bleaching agent and

stain remover. It is used for vegetable fibers in neutral or acid solution. In acid solution the following reaction takes place:—

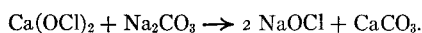


In neutral solution, manganese dioxide is precipitated on the material, making a brown stain. This may be removed by treatment with sulphurous acid or sulphites:—



Experiment. Use a cold 1 per cent solution of potassium permanganate, applying it to the dye or stain with a stirring rod. The permanganate may be acidified with 2 per cent oxalic acid, or it may be applied in neutral solution, and the resultant brown color removed by rubbing in sodium bisulphite, sulphurous acid, or a mixture of pulverized oxalic acid crystals and sodium hyposulphite. In the last case sulphur dioxide is generated, which quickly bleaches the fabric. Wash thoroughly at the end of the process. This treatment is efficacious in removing almost all kinds of stains from white material.

Javelle Water. — This is similar to bleaching powder, sodium hypochlorite being the bleaching agent. To prepare, dissolve one half of a pound of bleaching powder in two quarts of cold water, and add this to a solution of one pound of washing soda in one quart of hot water. The reaction is:—



The sodium hypochlorite breaks up as in the case of the hypochlorite of calcium, yielding hydrochloric acid and oxygen. Javelle water is a bleach for cotton or linen, and is used in weak solution.

Zinc Dust and Acetic Acid. — This combination acts as a reducing agent in that it sets free hydrogen, which decolorizes the organic matter. All organic coloring matter can be decolorized by the use of suitable reducing agents. In this case the reaction is:—



Experiment. To the material in 20 cc. of water add 20 cc. of acetic acid of 25 per cent strength, and 5 grams of zinc dust. Mix well, heat to boiling and boil a few minutes.

Sulphur Fumes.— Sulphur fumes are used for bleaching animal fibers, as wool or silk would be turned yellow by the chlorine bleaches. The clean wet article may be hung in a confined space over fumes of burning sulphur, such as the sulphur candle furnishes. The sulphur dioxide of the fumes reacts with the coloring matters, withdrawing oxygen from them and so reducing them to colorless substances.

Oxalic Acid.— Oxalic acid is a reducing agent. It breaks up as follows: $(\text{COOH})_2 \rightarrow \text{H}_2\text{O}, \text{CO}_2, \text{CO}$. The carbon monoxide takes up oxygen from the organic coloring matter to form carbon dioxide, and in so doing decolorizes. Oxalic acid may be used on vegetable fibers if it is not allowed to dry on the material.

Removal of Stains

Grease Spots.— If soap and water cannot be applied, use a solvent for the fat of which the grease spot is probably composed. Such solvents are benzine, gasolene, naphtha, ether, chloroform, carbon tetrachloride, hot alcohol, and a mixture of equal parts of benzol and acetone. All are inflammable except chloroform and carbon tetrachloride, and must be handled accordingly. To apply, place a cloth or several thicknesses of blotting paper under the spot. Rub from outside toward the center, using a piece of the same material if possible; if not, a similar fabric of the same color. Another measure to prevent the formation of a ring is to mix the solvent with talc, magnesia, starch, or other absorbent material before using, and brushing out the powder when dry. The solvent is generally applied to the wrong side of the material. Grease spots which cannot be removed in the above way are treated with absorbents — talc, starch, whiting, or blotting paper. A warm iron on the blotting paper or other absorbent aids by melting and drawing out the grease.

Vaseline.— Vaseline spots should be soaked in kerosene before soap and water are applied.

Coffee, Tea. — Ordinarily, coffee and tea stains can be removed by pouring boiling water over them from a height, or by treatment with warm soap solution and subsequent washing. Glycerin is a solvent for the coloring matter, and may be used in removing the stain from white or colored fabrics, even of silk or wool. Moisten the stained material with diluted glycerin, to which a little ammonia may be added if the color of the fabric will not be affected. Let the action continue until the coloring matter has been absorbed, then either wash out the glycerin in warm, soapy water or steam it out. If the stain is old, a bleaching agent may be necessary. Spot with hydrogen peroxide made slightly alkaline with ammonia, follow with dilute acetic acid, and finally with water.

Chocolate or Cocoa.—Cover with borax and soak in cold water.

Fruit Stains.—Boiling water will generally remove fruit stains when fresh, except peach stains. If a bleach is needed, try hydrogen peroxide with ammonia, or soak in weak Javelle water for a few minutes and rinse well in boiling water. A general rule is that hot water is used for colors held in sugary solutions, and cold water for unknown stains and for those of a protein nature.

Iron Rust.—This is often the result of the careless use of bluing having an iron base. An acid is necessary to change the iron hydroxide or oxide into a soluble compound, and as hydrochloric acid acts readily and forms soluble chloride of iron, its use gives the best results. The acid should be repeatedly applied to the spot with a stirring rod or medicine dropper, and the fabric rinsed after each application. Many short applications are better than one long-continued one. When the stain has disappeared, rinse in clear water and in ammonia water. Oxalic, citric, or tartaric acid is often efficacious, and salt and lemon juice operate in a way similar to hydrochloric acid.

Bluing.—Use strong ammonia, or boil with dilute acid or alkali. Boiling with clear water is often sufficient.

Grass Stains.—Use milk, alcohol, or ammonia. Hydrogen peroxide with ammonia is also effective.

Molds or Mildew.—Two forms of mold are commonly found, the green and the pin mold. Both flourish under moist, “airless” conditions, at a temperature of 68° to 75° F. The green mold can exist at freezing temperature, and up to 95° F.; the pin mold lives in slightly narrower limits. Both produce enzymes which hydrolyze starch or sugary matter. It has been stated that free citric or oxalic acids may result from the hydrolytic action of the green mold, and glycerin and succinic acid from the pin mold. When the stains are newly formed, they may be removed by strong soap solution and sunlight, or by soaking in sour milk (lactic acid). Old stains require strong bleaching solutions such as calcium hypochlorite. One method of treatment is to saturate with ammonia, followed by spotting first with potassium permanganate, then with hydrogen peroxide, followed by washing. With colored fabrics, the bleaching agents are omitted, and ammonia followed by acetic acid is used or the material is covered with a paste of powdered chalk and exposed to the sunlight.

Paint or Varnish.—If fresh, use turpentine, benzine, or gasoline. If old, soften with amyl acetate, then remove with gasoline. The principle is the same as in the treatment of grease. If the oil in the paint is dissolved and removed, the insoluble coloring matter will brush off. In removing lacquer, dissolve the linseed oil constituent with amyl alcohol.

Scorch.—If the fiber is not damaged, sunlight will remove. Soft bread crusts rubbed over the scorched places will often be efficacious.

Ink.—The proper treatment is uncertain, owing to the difficulty in ascertaining the nature of the ink. Colored material may be soaked in sour milk, — other ink removers generally remove color also. As a rule, the ink eradicators depend for their action on free chlorine developed by the addition of an acid to a solution of calcium chloride. Alternate applica-

tions of a solution of bleaching powder and dilute hydrochloric or oxalic acids will serve the same purpose. Salt and lemon is as safe and often as adequate in mild cases. Another method recommended is the use of fresh crystals of stannous chloride, followed by oxalic acid. Stannous chloride reduces iron in ink to the more soluble ferrous form, and also prevents some loss of color in the fabric.

Blood Stains. — Cool water, followed by washing in lukewarm soapy water, or water to which ammonia has been added. A lump of starch rubbed into a spot which has been moistened with cool water will absorb the blood. The starch is brushed out when dry, and the treatment repeated if necessary. Old stains may be removed by hydrogen peroxide with ammonia, or potassium permanganate.

To clean straw hats dissolve one ounce of "salts of lemon" in a pint of hot water, and add one ounce of flowers of sulphur. Apply with a brush. Rinse quickly but thoroughly.

CHAPTER XV

HYGIENE OF CLOTHING

The Hygienic Importance of Clothing. — The importance of clothing as a means of maintaining a good physical condition has not yet received the consideration it deserves. A conscious hygiene for the whole body is being emphasized in these days, and it is a most necessary part of this movement that people in general shall recognize that our modern garb, unhygienic in many details, is a large factor in the problem of keeping well, and that rational clothing will not only aid in warding off many diseases, such as tuberculosis, but will be greatly effective in bringing about the desired state of perfect health.

The Body in Its Ideal Condition is maintained at a constant temperature, is dry, clean, well ventilated, and so unrestricted that all its parts can function properly. To meet these needs is the special province of clothing, and that worn next the body must be chosen with reference to its heat conductivity, its capacity for absorbing moisture and affording ventilation, its cleanly qualities, and its weight and fit. The properties of different fibers and textile weaves, the choice of garments hygienic as to fit and fashion, and many other considerations enter into this important study of clothing in its relation to bodily welfare.

Clothing in Its Relation to Body Heat. — The principal object of clothing is to aid in the maintenance of a constant body temperature. No matter what the climatic conditions may be, or what sudden changes in the environment may occur, the healthy body must keep a temperature of about 98°. Very slight variations are normal, but a variation of a few degrees in either direction may be fatal to life. In itself, the human

organism has two ways of maintaining heat equilibrium — by chemical and by physical regulation. An instance of the first method is seen in its adjustment to a falling temperature or to sudden cold. The nerves in the skin respond to the new condition, and cause a constriction of the blood vessels supplying the skin; the flow of blood to the internal organs is now greater, and heat is increased by increased oxidation, just as furnace heat is maintained by the addition of fuel. This is called “chemical regulation” because it involves an increased amount of oxidation in the body. Variations in the quantity of blood sent to the skin, affecting the loss of heat by conduction, convection, and radiation, and the varying production of perspiration, affecting the loss of heat by evaporation, are factors in the physical regulation of temperature. The term “physical regulation” implies that the body temperature is maintained without necessarily changing the rate of oxidation. The unclothed races of men meet the demands of the body by increasing their food supply, when chemical regulation of temperature is necessary. Primarily, clothing is intended to do away with the necessity for “chemical regulation,” and so conserve body energy and incidentally save fuel. It fulfills this purpose when it provides the body with a covering of equal warmth throughout, adapted to the requirement of the day. The present fashion of exposing the chest and ankles in cold weather makes an unnecessary demand upon body energy which the individual can seldom afford, especially if the dietary has been cut to a minimum for the sake of fashion or for other reasons. In that case the margin of energy available for the maintenance of health is being run dangerously low. Another practice which should be absolutely condemned is the exposure of a child’s legs and knees except in the hottest weather. Children require warmer clothing than adults, because of their greater proportional surface area and their need of reserve energy for growth; yet, for the sake of “hardening” the child, or sometimes merely following a fashion, the parent often leaves bare some of the

parts of the body which are least capable of resistance. The joints are peculiarly susceptible to cold, because they are areas of slight metabolism, and depend upon adjoining parts for their heat supply.

An attempt to harden the body by exposure is now more difficult than it was in primitive life. Houses, cars, and public buildings are, as a rule, overheated in winter, and the alternation with the cold and dampness out of doors creates a trying condition requiring careful adjustment to it in the matter of clothing, else the resistance of the body is weakened. It is not unusual to see people in heated trains or public buildings keep on their furs and heavy wraps, with consequent overheating. In going into the outer air a feeling of chill is indicative of danger. Standing in the cold air without extra wraps, with thin stockings and slippers, or in evening dress after a dance, is a menace to health. Some hardy people can do these things, but never without an expenditure of energy which could be better employed.

In cold weather especially, the requirements for outer and under garments are different. The main requirement for the outdoor covering is warmth. Most people dwelling in well-heated houses find it best to wear light-weight garments indoors, and depend upon the outer wraps for the extra warmth needed out of doors. Some weight is required, yet two light-weight garments will be warmer than one heavier. A close weave on a windy day is better than an open weave, because it prevents a too free passage of air to the body. Garments worn next the skin, when chosen on hygienic principles, are open in weave, light in weight, and provide ventilation, yet bring the loss of body heat by conduction and convection to a minimum. The amount of heat conducted by a garment depends very little upon the nature of the fiber in it, but a great deal upon the amount of air held in its meshes. Still air (air not in motion) is a poor conductor of heat; furs are especially warm simply because they imprison so much air. No fiber possesses warmth

as an innate property, but wool feels warmer than other fibers because it holds more air.

By virtue of this property of non-conduction, wool would be the ideal material for underwear, if other considerations did not affect the conclusion. Some of these will be discussed later; one drawback to its use is the fact that the wool fibers easily mat from washing and other causes, and the air spaces become obliterated. A felted, boardlike wool garment has lost its feeling of warmth. However, a loose weave of wool, carefully laundered, or wool mixed with one quarter to one half cotton is the best cold-weather undergarment for aged people, invalids, and little children, or all with whom there is little perspiration and little blood brought to the skin by muscular activity. A child is comfortably clad in winter in underwear of wool to ankles, wrists, and neck; an underwaist of heavy cotton, warm stockings, shoes with good soles, a plain dress of substantial cotton, wool, or part wool, and gymnasium trousers like the dress. For outdoor wear, a flannel jacket or sweater under a medium weight coat will prove warmer than a single heavy coat.

As has been indicated, the secret of non-conduction of heat lies in the loose weave or open mesh. Cotton and linen woven in this way acquire a feeling of warmth, and possess advantages over wool in points of cleanliness, ventilation, and evaporation of moisture. For most people they make the most satisfactory year-round undergarments. Too open a mesh, however, will defeat its purpose by allowing a free movement of air, and heat loss by convection. Silk combines well with either cotton or linen, and adds its value as a non-conductor of heat. Alone, its smooth, elastic feeling is often unpleasant, but the Chinese utilize it wisely by wearing it over a very open weave of cotton. The same idea, using wool in place of silk, has its advantages, and is a protection against sudden changes in temperature.

Warm-weather underwear differs from that of winter in little except quality of weave. The body's needs are the same, and

the difference is mainly in the outer dress, with perhaps a wider mesh in the light-weight cotton or linen undergarment. Both cotton and linen, being good conductors of heat, feel cool in smooth, close weaves, — linen especially; and the latter gives an added feeling of coolness by the rapid evaporation of moisture from it. A linen garment of this kind may cool the body too quickly and cause a chill. There is from 15 to 30 per cent more heat protection in cotton than in linen of equal weave and thickness.

Clothing in Relation to Absorption. — The sweat glands of the average adult give off a daily secretion of about fifty ounces of water. As most of this must be taken up by the clothing, in addition to gaseous and solid constituents of the sweat and oil from the sebaceous glands, the manner in which different fibers absorb and discharge all this material becomes most important. To keep the body in good condition the glands must not become clogged; perspiration must be removed about as fast as it is formed, for that is the time the body needs cooling; it must not stay in the garment to give a feeling of dampness and chill to the cooled skin, and the air pores of the garment must not become so clogged as to prevent ventilation.

Of all the textile fibers, wool is the most hygroscopic. Under ordinary conditions it carries moisture up to 12 or 15 per cent of its weight, and in moist surroundings may take up 30 to 50 per cent. Being a natural skin covering, it is well adapted for the absorption of sweat and oily secretions, but its power of holding these is a disadvantage in a garment. It not only absorbs moisture slowly, but dries slowly. The result is that it becomes very damp, and while this does not prevent it from feeling warm in still air, in a draft of cold air the heat conduction is rapid and the body receives a chill. Dr. Leonard Williams, in an article on "Tubercle and Underwear," in the *Clinical Journal*, December 10, 1908, said in effect that the serious objection to wool as underwear is that it does not absorb and give up moisture rapidly; the air spaces are closed in the

laundry, and the respiratory function of the skin is interfered with by a layer of moist air held between the skin and the garment, which disturbs heat regulation "since it has the same influence as a poultice in keeping the cutaneous vessels in a state of undue relaxation."

Silk is nearly as hygroscopic as wool, but it loses moisture much more rapidly. In open mesh, it has many ideal qualities for underwear, since it is a poor conductor of heat and electricity, and is cleanly.

Cotton and linen are about equally hygroscopic, each taking up perhaps 7 to 12 per cent of moisture, but linen yields it the most readily of any textile fiber. Again the open mesh is needed to counteract the dangerous element of too rapid evaporation.

Clothing and Cleanliness. — A question closely connected with absorption is the ease and thoroughness with which undergarments of the different fibers can be freed from the products of the skin and kept in a sanitary condition. If it is the nature of the textile to hold the dirt and harbor germs, or if the garment is infrequently or carelessly washed, impurities are kept in contact with the body, and infection and disease are invited. Quite as much difference exists between the fibers in respect of natural cleanliness as between their absorptive capacities.

Of the textiles ordinarily used for undergarments, linen is the cleanest because of its smooth surface and lack of natural oil or grease. Cotton yarn has more or less oily matter and many protruding ends of the short fibers in the twist, both of which affect the weave. Experiments have shown that about three times as much dirt clings to cotton as to linen, and nearly twice the number of bacteria will be collected by the skin when wearing cotton, in a comparison of similar weaves of the two. However, cotton launders easily, and can stand a high temperature in sterilization; so with frequent changes it is a sanitary material.

Woolen underwear is the most difficult to keep clean. The natural capacity of the fibers for storing up oily and sweaty

secretions makes more than ordinary care imperative, and the difficulties lie in preventing the felting of such impurities into the garment. Loose weaves can be satisfactorily cleansed by expert laundering, but neither strong soaps nor boiling water can be used. Bacteria flourish on woolen underwear, and when this is soiled, they multiply upon it more rapidly than upon an equally soiled garment of cotton or linen. The chest protector which is the constant friend of some people during the winter, the abdominal band of flannel which others find advantageous, and the swaddling bands of the babies of some nationalities should obviously be changed as often and laundered as thoroughly as ordinary underclothing. The textiles which are in contact with the skin are obviously of greatest importance as regards absorptive qualities and cleanliness. Outer garments, however, are by no means free from criticism, and the cheaper transitory materials have in this respect a certain advantage over those bought for long wear. The effect of dry cleansing on clothing of better quality as eliminating dangers must be considered. Wool outer garments hold large quantities of dust, and need to be brushed frequently, not only for appearance, but for health.

The hygiene of the sweatshop and the laundry, and other questions of public health in connection with clothing, are subjects too large to be discussed here. A few rules of sanitation for the home laundry, however, may be emphasized. Soiled clothing should be kept in absolutely clean hampers. The usual wicker one, which is seldom cleaned, often contains myriads of bacteria; a vulcanized or white metal holder is better than a basket. A washable bag of heavy material kept absolutely clean can be used inside wicker hampers and eliminate much of the danger. Separate laundry bags should be used for handkerchiefs or especially soiled articles used in colds or disease, and the entire bag soaked in salt and water before washing the articles in it. Extremely soiled clothing should not be washed with cleaner articles. Steam laundries are usually

better than the home laundry as regards sterilization of clothing, because of machine processes and factory inspection. Cotton is the only textile that can well stand boiling. Most bacteria in clothing will be killed, however, by keeping the temperature of the water in which the garments are being washed constant at 150° F. for some time. Tests have been made as to the disinfection which occurs from the heat of the flatiron. As yet nothing more definite has been proven than that very great heat on a moist garment, with pressure on both sides, will kill germs. At lower temperatures the result is not so satisfactory. Many textiles cannot endure so much heat. Alkaline soaps act as sterilizers, but must be used with discrimination.

An Unrestricted Body. — A body impeded in any of its movements or functions can never be highly efficient or perfectly well. Tight clothing whether shoes, corsets, or skirts, or clothing so heavy that its weight is a burden, is worn at a sacrifice not only of comfort but of health. Poorly fitting, tight corsets lay the foundation for poor health in later life. Corsets are not really necessary to a woman who has strong muscles. If they are worn, they should fit well, be adjusted carefully each time they are put on, and should be loose at and above the waist, that plenty of room to breathe may be allowed. Garters suspended from the corset may be overtight and very injurious since they bring a pressure downward which may lead to serious displacements. Heavy skirts hanging from the waist increase the pressure, and should not be worn. It would be better to have all such weight suspended from the shoulders. Collars are frequently too tight, and the method by which they are held in place by wires and bones adds to the pressure. Bands about the waist should be loose enough not to cause marking of the body. They should be worn over a waist of some kind and not come directly against the flesh. Shoes should be as straight on the inside line as possible, should fit the heel and instep snugly, and leave the toes free. The heel should be broad and

low, and the sole thick enough to be substantial. Pointed-toed shoes have a tendency to weaken the arch of the foot. Many of those who complain of rheumatism in the feet have broken-down or weakened arches, and are really suffering from the shoes they have worn. Orthopedic shoes can be obtained to relieve the pain or even cure the condition if it is not too serious.

Dangers in Textiles. — It should be realized from the above that real dangers may lurk in textile materials and clothing. A large amount of ready-made clothing is made in unsanitary homes, in sweatshops, or tenement rooms, and it is known that disease is carried in this way to the homes of the consumers. Poor or fugitive dyes in textiles or in hosiery may cause trouble. Bright-colored, striped cotton-flannel shirts have been known to injure those who are working in overheated workrooms or before hot furnaces, and black stockings may poison the skin, especially when it has been broken or scratched. The towel for the general use of the public may be more dangerous to health than the common drinking cup. Small individual towels which are kept absolutely clean by repeated laundering should be used in schools or public toilet rooms. If these are too expensive, paper towels may be used, but they are not altogether satisfactory.

When all is said, personal environment and idiosyncrasy must influence an individual's choice of textile and manner of dress. Wool may be the right material for one case because it does not evaporate moisture rapidly; in other cases this property is disadvantageous. The value of a study of the hygiene of clothing lies in the ability it gives to make an intelligent adjustment of clothing to one's needs, and further, to see the value of dressing according to good sense rather than fashion. Women are flagrant offenders, but not all the efforts of the clothing reformers should be directed at them. As a whole, the clothing for men shows superior good sense to women's, but men's attire

is quite deficient in its adjustment to heat regulation, nor can much be said for some of its details such as stiff, unventilated hats and stand-up collars. It may be unusual to defend women's hats, but from a hygienic standpoint they are generally better than the derby and top hat. An interesting experiment in temperatures has been made¹ whereby a thermometer kept in a top hat showed an inside temperature of 90° F. when the outer air stood at 77°, and of 108° when the temperature rose at noon to 90°. In the evening there was a temperature outside of 68° and inside of 88°. A motor cap showed 98° inside against 78° outside.

Scientific investigations of many kinds are needed that more knowledge may be gained of the relation of clothing to health. We need further data on the increase of germ life on various textiles when they are clean or soiled or when disease is present, and the effect of laundering and other methods for the elimination of bacteria; a study of fugitive dyes, dressings, and treatments, and the effect on the skin; the influence on the body of each fiber and the union of different fibers; thermal properties of textiles, and the relation of weight and pressure in clothing to bodily condition.

¹ Cavanagh: *The Care of the Body*.

CHAPTER XVI

SOME ECONOMIC AND SOCIAL ASPECTS OF TEXTILE PURCHASE

AMONG the greatest industries in the United States as in other civilized countries is the series of occupations which supply textiles for clothing and household purposes, and here the kind of materials made, the later use of the products, and to some extent the condition of the industries may be said to be chiefly in the hands of the women who are the chief purchasers and consumers.

The value of the combined products of the textile industries in the United States in 1909 was \$1,684,636,499 (U. S. Census of Manufactures, 1910). According to the Bureau of Foreign and Domestic Commerce, the value of the product in the manufacture of clothing in 1909 was:—

Clothing, men's and		
women's,	\$953,610,000	
Corsets,	33,257,000	
Hats and caps (other than		
felt, straw, and wool),	13,689,000	
Hats, fur and felt,	47,865,000	
Hosiery and knit goods,	200,143,000	
Millinery and lace goods,	85,894,000	\$1,334,458,000

The imports of textiles including wearing apparel in the United States in 1912, as stated in the bulletin of the Bureau of Foreign and Domestic Commerce was:—

Cotton and manufactures,	\$85,305,516.43	
Fibers and manufactures,	96,085,213.84	
Hat materials and manufac-		
tures,	9,158,943.94	
Silk and manufactures,	97,889,203.84	
Wool and manufactures,	48,324,102.16	\$336,762,980.21

In the same year, 1912, the import of clothing alone into the United States was:—

Cotton,	\$7,142,787.74	
Fibers,	305,188.27	
Hats, etc.,	4,292,900.94	
Silk,	4,142,318.05	
Wool,	2,190,301.60	\$18,073,496.60

An economic study of woman as a textile consumer is yet to be written, but thoughtful women can be of service now in considering the subject and obtaining data from homes, stores, and factories, that knowledge may be available on which to base some needed conclusions. Former chapters are referred to for other economic facts on the development, growth, and manufacture of the various raw materials; the conditions of strength or weakness in the yarn or cloth on account of the treatment undergone; the adulterations practiced or the substitutes for the pure fiber; commercial data and the present state of the textile market. The tariff charges placed on importations of raw fibers and manufactured goods have their economic effect on the cost of textiles. It seems unwise to enter upon a discussion of the influence of the tariff further than to point out the great amount of data available in Government publications on the subject.

For the promotion of the intelligent interest and efficiency of the consumer of textiles it may be suggested that club women could consider general economic relations, make investigations in the factories, department stores, and clothing workrooms, and make their deductions. Women in the home could bring together data of the use and care of materials and give budgets which had been tried and found successful. College women and higher technical students could furnish scientific data from their chemical, physical, and biological experiments, and girls in the elementary and high schools could study the materials that are manufactured and connect the subject with their school or

home work in sewing and dressmaking and the choice of household linens, including the table linen used in connection with cookery and table service.

The increase of individual wealth in the United States has made possible the spending of larger sums than ever before in personal adornment and in the interior decoration of the house. A general tendency is now found among women of all classes to spend an undue amount of their income on dress. This is true not only of the rich women whose extravagance in dress is notorious, but also of vast numbers of those in moderate or even straitened circumstances whose expenditures for dress, though not absolutely large, are out of proportion to the means available for other necessities. The market has been affected by the demand for large supplies of material for garments, and consequently the prices for textiles and the cost of making them up have risen greatly and caused much hardship among the very poor.

It has been argued that the large sums spent for clothing by many women have been an advantage to the poor in that money has been placed in circulation and therefore the workers are benefited. This argument is especially unsound as affecting the production of woman's wear, for the workers are often overworked at extra hours without pay to supply the demand. There are many reasons why extravagance in clothing is not advantageous, such as (1) the money which is spent in such dress is badly invested and is failing to obtain, either for the individual or for the community,¹ the good returns of well-invested money; (2) it is having a deteriorating effect on the spenders by increasing their selfishness; (3) it is setting a pace which is followed by those of less means in the use of flimsy, showy fabrics which not only do not endure, but often have a degrading moral effect on the wearers; (4)

¹ From the standpoint of the community there is an irreparable waste when human energy which should be directed to the production of the necessities of life is diverted to the elaboration of superfluous things.

irritation is caused in those who desire but cannot afford such gratification; (5) and it increases a general tendency on the part of the young wage earner to sacrifice housing and food in order to spend too much of her wages on display in dress.

The Need of an Economics of Consumption. — The ability to use money wisely has not increased as rapidly as wealth. The importance of woman's part in economics has not been understood and has been underestimated. The production of wealth has heretofore occupied mankind's attention to the exclusion of the best way to use it. It is principally as women have appreciated their responsibility for the right use of the money intrusted to them that attention has been given to the laws which should govern consumption. Many women have turned for help to economics only to find the emphasis on production and commercial relations rather than on choice and purchase, and are urging a consideration of the latter phases of the subject also. There are some difficulties in the way, however, for those versed in general economics need information on the household use of wealth before they can feel competent to speak on laws which should govern selection and purchase and prevent waste.

It seems necessary, therefore, to consider the various fields in which woman's influence as a consumer is preëminent in order to provide the required information. The textile field is one in which to begin such study. Before the Industrial Revolution women were the home producers of all cloth. They not only decided what should be made and how to make it, but judged the worth of it afterward. They later used the woven material to make the needed clothing and household articles for their homes. In 150 years from that time women have become principally consumers, with little ability to judge of the value of the materials they buy. It is true that many of them still remain producers in textile mills, though in the capacity of hands rather than of heads. We also find some women producers of a higher type as forewomen in the great clothing

industries where textiles are manufactured into garments, as dressmakers and as makers of clothing in the homes, but at the same time they also are apt to be consumers without sufficient knowledge of the use of money. A large class of influential women, however, are consumers only. As a class, women neither choose materials wisely nor indicate satisfactorily what shall be produced from the manufactured goods—hence are not efficient as planners or users of wealth for textiles. Their demand is, however, having its effect on the quality of the output, for the goods and clothing produced are made to satisfy them.

The Consumer's Influence on the Manufacturer.—The present efficiency of the textile factory is often in the skill it can show in satisfying the demand for effective goods at a low price, in the management, in the patents, and in methods by which wealth is accumulated rather than in producing an enduring fabric. For various causes, of which the influence of the consumer is a large one, there is on the market at present a flood of unenduring yet attractive-looking textiles which frequently are worth less than they cost the purchaser and which are so cleverly constructed that even the textile expert finds difficulty in determining their value. It is almost impossible to find the strong, enduring, hand-spun, hand-woven materials of the past. The economic question to be answered is: Do we wish only the purest and best materials to be manufactured, or do we also need the cheaper materials, and that each consumer shall be able to know or be informed of the imitations, the adulterated and union goods, and thus not only distinguish them from the better and purer materials, but be asked to pay only for the values really received? The ability of the manufacturer to make a cheap fiber, like cotton, give warmth in such articles as blankets, sweaters, underwear, and bedding, is indeed of inestimable value to the poor and is to be encouraged, but an undue price should not be charged nor properties claimed which are not present. The rapidity with which fashions in dress

change is a factor in the customer's desire for the well-appearing yet inexpensive materials and naturally has its consequent reaction on the manufacturer. The latter's risk is great if he makes goods ahead of the demand, for he must expect that broadcloth may suddenly be desired in place of a heretofore fashionable worsted suiting, or pin stripes may be called for when he is stocked in plain-colored materials. Entire mills may be thrown out of work or expensive machinery may be rendered useless by these rapid alterations of fashion. Sudden changes from fancy suiting to plain cloth will often leave a factory overstocked with no resource except selling at a loss, redyeing and selling the material as plain cloth, or tearing up the cloth into shoddy. Moreover, changing fashion often causes clothing to be discarded before it is half worn. Such garments are torn up to supply wool for new cloth, as there is not enough wool in the world to make so many fabrics entirely of pure fiber. The amount of material required for garments has also its effect on the factory production, for fashion causes variations, and it is not an unusual condition for twice as much goods to be used in a gown one season as in the next. Every textile mill has men in the field trying to determine, months ahead, what the fashion will be, or endeavoring to create a demand for some specialty which they wish to sell. The strain upon the manufacturer is often great, and much of it could be lessened if women realized their influence and would endeavor to exert it wisely.

Most of the American-made cloth compares favorably with that of Great Britain and the continent of Europe, but public demand for some of the finest material is made upon foreign countries; consequently American factories are obliged to specialize on medium-grade fabrics. Domestic goods when equal in quality should have the preference with American consumers. If the experience in making the better goods were given to the home factories, they would soon overcome any difficulties with texture and color, of which we now sometimes complain, and be able to supply the best. We have already many firms

which make the highest class goods. A movement toward the use of domestic goods would be of benefit, therefore, not only in developing the work of some of our factories, but also in removing foreign labels from many of our domestic goods.

A Law for Honest Labeling. — In order to help women to obtain honest materials there are now before the House of Representatives in Washington several bills for the honest labeling of textile goods. Few women yet realize the need of such labels or would be apt at present to profit by the passage of such a measure. A practical consideration of the values and conditions of the materials they buy, and their effect upon the economics of the household, must come first to open their eyes to the value of a government labeling system and to the work of supervision which must accompany it, which would be an expense reacting again perhaps on the price of cloth.

Dress has its economic significance, for people well dressed in the style of the period are generally regarded as successful. This may be a recognition of the success of the individual or of the head of the family. The women of a family are selected as a means of showing wealth, and a well-dressed family reflects distinction upon the one who is responsible for its support. This has been undoubtedly one reason for excessive dress in women. The extent to which they have been physically handicapped in their clothes has been another means of showing that sufficient wealth is possessed by the head of the family to free the woman from work; and that therefore her activity may be interfered with by tight clothing, trailing gowns, lacy trimmings without endurance, shoes in which it is impossible to walk easily, and other evidences of her uselessness.

Economy in Clothes. — There are justifiable differences of opinion on the subject of economy in clothes. Some women prefer a number of inexpensive garments to a few high priced ones. In many homes the clothing for the mother and daughters is made principally in the house, this being considered an economy. A visiting dressmaker comes at each season to help

the family with the work of remodeling old and making new garments. The wisdom of this plan is questioned by other women somewhat as follows: Are the results really satisfactory? Is the time taken justified or could the mother and daughters use it to better advantage? Is not the family under a nervous strain which reacts on the home life and is the dressmaker amply paid for the class of work which she is doing?

Another plan used by many is to rely almost entirely on the department stores. Up-to-date, transitory garments are bought and discarded as soon as the newness has worn off. The time taken for home manufacture, the making over, repairs, and the nervous strain of personal construction or several fittings at a dressmaking establishment are superseded by one fitting at the store. Many business women find this method satisfactory and not overextravagant, but much depends on the conformity of the purchaser to the regulation sizes of such garments, since much refitting is both expensive and unsatisfactory. The garments offered in the stores, however, are not suited in style to all women. Some professional women prefer another plan, *i.e.*, they order two or three gowns each year at the higher class custom tailors or dressmakers. The best material is purchased and the styles used are "exclusive" but not extreme. Each garment can be used for two or more years with almost no alterations or repairs. Many who are occupied with social or civic matters are adopting this plan also. They state that they can thus preserve the dignity and individuality of dress without spending too much time upon it. There are other well-dressed women of this type, however, who feel that it does not pay to spend much time at an expensive dressmaker's or tailor's and who are demanding with much success the best kind of exclusive ready-made garments from the department stores. There is still another class which combines all of these methods and insists that innumerable changes of clothing are necessary. They give their personal time to shopping for ready-made garments or for materials, to being fitted at home or at a dressmaker's, and to

personal attention to remodeling unless they can afford to pay workers to do everything for them.

Consideration is needed of the best plan for women to forward in the future. Many feel that they will have to adopt an easier and more professional dress, as men have. The tailored suit and shirt waist are valuable steps in this direction. Other women, who accept the business dress as necessary, hold strenuously to the need of preserving the attractive individual dress for its influence in the home and in society. They argue that a still greater study of art in dress is needed in order that beautiful garments may result, and they justify their expense by a willingness on the part of the women to wear them several years. The press is urging the introduction of American fashions for American women rather than the reliance upon Paris. This can be done if women will see to it that in schools of all classes there is given a study of art as applied to dress and home decoration that shall result in our having among us, as there is among all classes in France, the general knowledge of industrial and applied art.

Dress as an Ethical Influence. — The home is the greatest factor in the happiness of the race, and in it woman's part is supreme. As she becomes wiser in selection and purchase, the home will increase in value. Training for economy in consumption should lead, therefore, to higher levels of social life; art should be a part of the background, and social betterment should be a necessary accompaniment. Little is often made of large wealth in ministering to the higher pleasures of home and social life, and the future study of the economics of spending must include a consideration of the highest service that can be given through wise consumption.

Dress has undoubtedly an objective and also a subjective influence. It is recognized that character is shown through it and is itself acted upon by the kind of clothing worn. It is difficult to be self-respecting when dressed in dirty rags, or to win the respect of others when overdressed. One who is con-

tent to wear showy outside clothing and inadequate, torn garments beneath has some defect in her of which this condition is merely an evidence. Good nature is easily increased through wearing clean, comfortable, pleasing clothes. The effect on children of being dressed in ragged, inadequate clothing is not only irritating, but also acts on the disposition as well as the health. On the other hand extravagant or showy dress on a child is apt to produce priggishness and selfishness. It is not possible to state the relation in exact terms, but we believe that adequate, attractive, neat clothing is a factor in virtue, and being well dressed gives a feeling of satisfaction and self-confidence which often enables the wearer to conquer a difficult situation.

Practical Investigations. — The study of the economics of consumption must be, therefore, in a large degree a study of the time and its needs, a consideration of the influence of factors large and small in the home life, and a realization of the requirements for woman's training for service in the home, and also in civic and national life.

There are several direct methods by which the judgment of women as spenders of wealth for textiles may be developed, such as a study of the service of each textile, facility in testing fabrics in order to judge of their content, and a consideration of the art of shopping.

Women in their homes, students, or teachers who wish to know more of textile fabrics should begin first a practical investigation of materials for the recognition and naming of standard cloths, well-known mixed goods, and adulterated materials. A card catalogue of fabrics should be made in connection with the study. A sample of cloth can be placed on each card with the name, price, width, and place of purchase. If a guarantee is given, it should be so stated. If the material is in use, its value after trial should be given. Whenever it is possible the name of the manufacturing firm should be obtained, so that by degrees the student can have a list of reliable firms.

A white list of manufacturers would aid the housekeeper in the same way as the white list of department stores of the Consumer's League has shown them where saleswomen receive fair treatment. Other data should be entered as it is obtained, such as the class of weave in any piece of cloth and its relation to strength, the condition of the warp and filling, and a personal judgment as to the reliability of the sample. The card even with simple information, should be a valuable aid to the housekeeper or student and a help toward the formulation of economic laws regarding purchase. Second, the properties of each fiber should be studied comparatively and confirmed by personal experience. The result of unions and adulterations as altering the properties should be noted. The knowledge of the qualities inherent in any textile is an aid in choice, and the hygiene of the material should be considered also as a factor in keeping the body in good physical condition. Third, in order fully to comprehend the present status of the making of textiles, the conditions of growth and manufacture should be studied that a fuller understanding may be gained of the varied state in which even pure material reaches us, of the possible combination of different fibers in any one piece of cloth, of the strain on the fiber which comes in the processes of manufacture, and also of possible injuries from carelessness, haste, poor or strong chemicals, hasty cleaning or bleaching, and cheap dyeing, and of the effect of beauty and solidity which can be given by surface dressing and finishing. The necessary cost for pure and enduring goods becomes apparent when the processes of manufacture are known and also the methods by which cottons are made to look like linen or like wool, sleazy cottons are finished with size and made to look solid and strong, light weight silks are increased in solidity or cotton or artificial silk is mixed with pure silk. Fourth, physical tests (see Chap. X) of the materials should be made to aid in forming judgments and as a means of accumulating information on the market conditions. Chemical and microscopical tests (see Chaps. XI and XII) are the surest, but can be satisfactorily

conducted only in the laboratory by the most exact and careful methods; hence homes cannot use them freely. The result of any test should be noted on the card with the sample.

Such a study as indicated above should aid a woman to understand the textile field and help her to determine what she wishes to accomplish in the future.

Labels and Guarantees. — There are still reliable standard materials which are made by mills whose guarantee can be trusted among the many materials made for show. The entire labeling and guaranteeing of materials, however, is at present unsatisfactory as misleading statements are constant. It is quite a common thing to see "heavy all wool" men's suits advertised at \$10, "pure silk stockings" at 50 cents a pair, "strong, heavy, pure silk shoe ribbons" at 25 cents a pair, "pure linen" handkerchiefs at 10 cents apiece, and "all linen" towels at 12 cents apiece. Labels on goods are often equally untrustworthy. Foreign labels are placed on domestic goods; "pure linen" is stamped on cotton mixtures, and names are used for inferior goods which suggest the better textile and attract the public unduly; for instance, near-silk, silkaline, flannel, India linen, linon, and flaxon, are all names for cotton goods. Duplex printed cottons at times masquerade as gingham. The work of embroidery machines is often labeled "hand work" and purchased as such at prices above the real value. Mercerized cotton is sold for silk, and unions of cotton and linen for pure linen. States which have laws against dishonest advertising allow misleading or untrue statements to appear on textiles or clothing without prosecution, so little heed is given to this class of deception. Honesty of statement is requisite if a good economic situation is to be brought about. Such a time will come when women know enough to contradict the false assertion and insist on having the truth. At present a clerk telling the truth usually loses a sale. Saleswomen do not always know the content of the stock, and if they do know, naturally desire to sell their goods, realize that the public is unable to

bear the truth, and hence govern their assertions as the customer seems to desire.

The situation which thoughtful women wish to combat is the lack of truthful statement which at present is prejudicial to honest purchase and does not assure the consumer a fair return for money spent, since paying for pure goods does not of necessity procure them. Experiments in shopping for "all wool" flannel have proved beyond doubt that material called "all wool flannel" may have varying percentages of cotton from 50 to 75 per cent. Chemical tests tried on such flannel have shown that a majority of the samples were not "all wool." The price charged varied, and in general was not sufficient for pure all wool, but was higher than was necessary for so large a proportion of cotton.

The economical housekeeper frequently wishes as dependable cloth as the Government demands (see Chap. X), but at present cannot get it. Men's suitings, in general, are more reliable than those for women, as the former demand material which will give longer service. The beginning of textile analysis and testing in some of the best department stores in some of our large cities, the marking of the result of such tests on the bolts of cloth, and the truthful labeling of doubtful commodities in these stores, show the temper of the time and the effort of the retailer to meet the growing desire of the customer to know the content of the cloth she is about to purchase and to have some guarantee that her money is well spent. The time has now come to give the textile and clothing subjects publicity. This can be done through the public press, educational institutions, the department stores, the women's clubs, and the individual housekeeper. The managers of department stores stand ready to cooperate. There are laws in some states requiring honest advertising, and bills are before the Federal Congress demanding honest labeling of textiles. The consumer could bring about the desired economic reform in a short time by organized action.

Shopping. — Each woman must decide for herself or her

family whether enduring or temporary fabrics are ultimately the cheapest for her. There is no objection to materials which appear to be better than they are if they are purchased for transient use, but misstatement should not be made about them, and they should be sold at an honest price for cheap goods. Inexpensive materials certainly have their economic place, for the easy soiling of light colors, the tendency to fade, which cannot be prevented in some fabrics, passing whims of fashion, and the outgrowing of clothing make it desirable to have materials which are not too high in price.

There are occasions, therefore, when it pays to buy the best materials and other times when cheap, presentable materials may be more economical. If a child will soon outgrow garments and there is no one to whom they can descend the cheaper goods may be more desirable. When a consumer decides on pure, well-made, enduring fabrics, she must pay the price and expect the materials to wear if care is taken of them. If she concludes to buy cheap, ready-made garments, she must not complain if they soon look shabby. It is true that ready-made clothing, such as one-piece lingerie gowns, lace waists, and underwear, are sometimes cheaper than if made at home, but the materials are not apt to be so good as those which one would buy, and consequently they do not usually wear as well. Cheap materials cannot be expected to endure whether they are in ready-made or in homemade clothing. When a gown is made at an expensive dressmaker's, the cost is more in the making than in the materials. The difference in cost between enduring and temporary material is usually relatively small in the total price paid for a gown, and economy in this case is in purchasing the best goods of the kind. Even the most careless purchaser usually wishes such articles to endure as petticoats, linings, umbrella covers, toweling, table linen, handkerchiefs, sewing silk, sheets, pillow cases, rugs, and other household articles. A frequent cause of unnecessary expense is on account of the lack of knowledge in many consumers of the amount of material re-

quired for a garment and the reliance placed on the sales person for the information. Unless there is a special reason for purchasing an extra amount of goods it is usually an economic loss to have more than is needed.

Price is an indication of worth on many occasions, especially at the best stores. It cannot always be relied upon, however, for chemical tests have frequently shown that even the very highly priced dress goods, upholstery goods, blankets, and table linen are not as pure or enduring as the price would indicate.

The consumer who desires to be economical should not make a practice of wandering about the shops to get ideas, for in that way her desires increase and are apt to become confused in her mind with her needs. When garments are really required in a family, the mother should consider the various sides of the question before she does any shopping at all: first, the amount of money she has to spend for them; second, the purpose for which they are needed; third, how long they are expected to wear; fourth, where to buy them, and the best material for the purpose, or ready-made; and fifth, the least amount of cloth which will make them and keep them in good condition. The materials or garments which will be most satisfactory for her need may be, on the one hand, something which will endure for years, or, on the other, a passing fancy only, but she should decide the best course for her to pursue before she is ready to shop. Samples should be obtained of materials whenever there is a question of endurance and tested at home before purchasing, that mistakes may not be made. Bargain sales, as usually conducted, are a doubtful advantage for the ordinary shopper; for poor materials, good materials with defects in the making, silk which is sold because it is doubtful if it will long endure on the shelves, and a few good values are often combined on the counters, and confuse the purchaser. It is really the expert only who is able to judge whether it really pays to buy any of the materials offered in the ordinary bargain sale. There are honest bargain sales which are of the greatest service to the economic consumer who

knows what she wants and recognizes good material, but the thoughtless shopper is apt to buy more than she needs. Goods are often offered at these sales in lengths, and in general there is either more material or less than the shopper wishes, consequently she pays for more than she wants or has not enough and thus any profit from the bargain is apt to be lost. Buying the past season's clothing between seasons when the prices are lowered is wise if the purchaser knows exactly what she wants, the amount to spend, and can herself make such changes as will bring the garments up to date.

The mothers who make money go the farthest usually set aside a certain sum for clothing each year and carefully plan all of their purchases that the amount they are allowed to spend may certainly buy the necessities for each member of the family. (See the chapter on Clothing Budgets which follows.) If there is any money left, it can be used for the little odds and ends which "run away with money." Careless buyers often take the bulk of the money for attractive notions when it should have gone for shoes, stockings, underclothing, and everyday dresses. Careful buyers never purchase washable outer and underclothing without considering the laundry, for time is taken in ironing frills and insertions and in mending torn lace and lacy muslins, and the expense is high for having lace-trimmed garments laundered. Clothing otherwise good is made useless and unattractive by torn trimming, while simple clothing continues to look well after much wear.

Making clothing at home in simple style by members of the family has many advantages, if the time of the worker is not of greater value in some other direction. Ready-made clothing is not always constructed of the most substantial material; therefore, homemade garments of good cloth are usually better after repeated laundering and continued wear than those which are ready made. If the latter are purchased, the selection should be made of as simple designs and as good material as possible, in neutral color and with substantial trimming. Elaborate

trimming adds greatly to the constant as well as initial expense of dress. Belts, collars, and ties, which wear well, but can be laundered, repaired, and renewed, can be made at home by mothers and daughters whereby a simple garment is made attractive. Knowing how to renovate materials and trim hats is also a help in saving money. The economic household thinks it wiser to buy plain than figured materials and standard rather than ultrafashionable fabrics. It is considered better for each individual to keep to one scheme of color that old waists, skirts, and coats may be kept in use and look well with new garments until they are worn out. Evening and party gowns for young girls can readily be made of mercerized or other cotton materials and wear much better than cheap silks, but must be carefully laundered and frequently pressed. Rompers and overalls for the little children are easily made at home and thus save money as well as prevent the spoiling of other clothing. Cotton crêpe has been lately used much by economical business women for shirt waists, nightgowns, petticoats, and underclothing. The garments can be laundered easily in the room and do not require ironing. When these garments are made from a good pattern and trimmed with narrow linen lace, an attractive result follows.

In the care of clothing brushing, folding, hanging up, washing out stains, and pressing are factors in the length of service. Mending stockings, blacking and repairing shoes, keeping buttons, hooks, and eyes on clothing and wearing aprons when at work, are necessary for people who wish to be economical.

The responsibility of the consumer for the present state of the textiles manufactured for her is closely related to her responsibility for the working conditions of women and children wage earners in these industries. The Federal Census of 1910 shows the employment of children in the manufacture of textiles to be 40,221 in cotton goods, 11,111 in hosiery and knitting mills, 9942 in the woolen and felt industries, and 8143 in silk factories. Large numbers of women and children are employed also in the

clothing industries and in department stores. The conditions under which they have had to work have often been appalling; for whereas the Industrial Revolution brought new opportunities for all classes and helped develop a powerful middle class it also introduced heavy problems for wage earners. Long hours of work, uncertainty of employment, unsanitary workrooms, unsatisfactory moral conditions, dangerous occupations, sweatshops with overcrowding and underpay, unfit dwellings and likelihood of disease, child labor, undermined health, and a wage which was often not sufficient to live upon, became a burden too heavy to be borne.

The bad conditions in workrooms have pressed more heavily on women than on men. The lack of rest, the nerve fatigue, the sometimes inhuman treatment and immorality have not only been hard to bear and to combat by girls who had to have money for their families' support, but the undermined physical conditions which often attended the wage-earning experiences have been a menace to the future of the race. The little children that have worked in textile mills, clothing factories, and in sweatshops on artificial flowers, willow plumes, and other articles, in noise, rush, dust, bad companionship, for long hours and upon dull tasks requiring no skill, have been stunted in moral and physical development.

Legislation to improve conditions among the workers began at least a century ago. Since then many improvements have been inaugurated, but there is need of further legislation, of uniform laws in the different states, and of attention to the enforcing of laws. The employment of women and children in sweatshops is passing away in some cities on account of laws which have been enacted and are being carried out successfully, but the home workroom has been particularly difficult to deal with. It is frequently a single room only where work is done by the mother and children as it is obtained from the various department stores and factories, and satisfactory inspection of such places has been almost impossible as their existence is often unsuspected. The

entire subject is now under serious discussion. It is a question whether laws absolutely prohibiting home work are the desirable outcome, for many wage-earning occupations are still carried on in homes under the best conditions by craft workers, by those who are too handicapped by orthopedic or other physical deformities to go regularly to trade, or by women who have cares at home requiring constant supervision, such as looking after little children or old people. The line is, therefore, difficult to draw between the classes of employment which are usually carried on satisfactorily at home and those which are generally unsanitary and underpaid, and the inspection of private homes offers some difficulties. Nevertheless, in some of the states laws are being made to regulate such work in the homes as is injurious both to the worker and the consumer.

At present the majority of the states have laws prohibiting child labor at night, forbidding children under fourteen to work (this law is not yet applied to all occupations), keeping women and children out of dangerous trades, regulating moral and sanitary conditions, and demanding inspection of factories and work-rooms. In some states those under sixteen are limited to an eight-hour day; the minimum wage and payment for overtime are also being considered. In order to fit children to make a living wage, vocational education of several kinds is being provided for them. Guidance plans are also being forwarded by public education that each child may be directed into the work best fitted for his or her ability. The working women themselves are fighting bravely in the Trade Union League and in other ways for improved conditions, but are handicapped by the pressure of poverty and the need of the wage. They have been greatly helped by women who are not under such stress for daily bread. A large number of women are consumers and users of wealth, rather than producers, and they owe the women workers their intelligent consideration of this entire situation and their assistance in further betterment.

The Consumers' League began its work by an effort to im-

prove the conditions of employment in the department stores. The investigations made resulted in a series of recommendations as to the fairness of treatment of women employees by employers, sanitary conditions in the stores, and the necessary training of the consumer to her responsibility toward the saleswoman. The names of firms which lived up to the ideal of a fair house were placed on the "white list" of the Consumers' League, and the members of the association dealt as far as possible with such firms. The investigations of the League have gradually been directed also toward the manufacture of garments and the conditions under which they are being made. The result is a label placed on garments which satisfy the demand. All classes of articles in women's wear are not yet bearing the label, but the number is increasing. The work of the Consumers' League has thus been a factor in improving working conditions.

The Woman's Trade Union League also has been of service as an educative as well as helpful medium in the influence of many devoted working girls united in an effort to better conditions. The Consumers' League and Trade Union League have worked together to establish the label. By it they are calling the consumer's attention to the ready-made clothing she buys, to its sanitary condition and the standard of work in the factory instead of to whether it is cheap and attractive.

As a result of the work of the Woman's Trade Union League the "white" protocol was first brought forward in the cloak, suit, and skirt trade in September, 1910, and the shirt-waist trade has now adopted it.

The Joint Board of Sanitary Control in the Cloak Industry came from a suggestion of the employers in settling the strike in 1910. It took into account three parties to the controversy — the employers, the workers, and the public. An important part of the work is the education of the workers themselves to respect the value of sanitary control. The need for education was met in coöperation with the Board of Education for lectures to be held in the public schools. The subjects included: fac-

tory legislation, factory education, industrial poisons, and factory sanitation.

Many factory owners and heads of department stores are also earnestly forwarding betterment plans among their employees. The result has been the providing of suitable seats, good toilet rooms, lunch rooms, recreation rooms, medical and dental attention, good ventilation and cleanliness in the workroom, and other advantages. In many places a social secretary is employed to look after the employees and their welfare. Courses of education for the young worker have been organized to make up for inferior elementary education, to train for better salesmanship or for specific processes of manufacture. These schools are found within the factory or store and also as continuation schools under public instruction. Employees' associations are being organized for the discussion and regulation of conditions affecting the working girls.

The home seamstress and dressmaker have not as yet had sufficient attention given to their labor conditions and the amount of work demanded of them in a given time. The need of such home workers still continues, but the uncertainties and lack of adequate remuneration do not encourage any serious preparation for such positions or their holding by a skilled and businesslike class of workers.

The work of the custom dressmaker is influenced also by the unintelligent attitude of her clientele and her own deficiencies in business training. The price of a garment should be based on the actual cost of materials, the hours of work and consequent wages of the expert and unskilled workers who have constructed it, the time taken by the designer, draper, and fitter, overhead expenses of the shop, and the percentage of profit. Overhours which are required in changing a gown or hastening the completion (when the demand comes from the consumer) should be paid for as an addition to the bill. Hours set for fitting should be kept by the customer or she should notify the dressmaker of the purposed change. The garment should

be delivered at the time specified. All laws concerning workers and sanitary condition of workrooms should be kept as carefully as in the factory. The pay for garments should be prompt. Many custom dressmakers desire to be absolutely businesslike, but have been prevented by the irritation felt at such changes by many of their clients. Those who have been able to organize their workrooms with efficient business methods are finding the benefit for themselves and their employees. . Women can now help greatly by considering and urging forward a better system.

The making of ready-made clothing has become a large business in the United States. The manufacture of cloth for this specific purpose is the work of many factories, and is known in the market as the "cutting up" trade. New York City leads the world in the production of men's clothing, the output of which in 1909 was \$232,609,284 out of \$568,077,000 for the whole country. The work included coats, suits, overcoats, overalls, blouses, shirts, aprons, bathing suits, hats, caps, collars, cuffs, gymnasium and sporting goods. The making of women's clothing is also one of New York's great industries, the output in 1909 being \$261,049,287 made by 96,162 employees, the majority of whom were women.

The condition under which much of this clothing was made has been a question of concern to those interested in social betterment, and as before stated has brought forth much legislation. A large up-to-date ready-made clothing factory, under an employer interested in the best conditions for his employees, offers a very satisfactory employment for women who have the kind of health to allow them to work at electric power machines or to sit sewing all day.

The system of organization and division of labor in these large clothing factories is similar, whether expensive or inexpensive clothing is made. The inspection of the factories helps to keep the workrooms in safe and sanitary condition, while home workshops are often run under conditions which are not only a menace to the workers, but also to those who wear the clothing.

To those who have never made garments or thought much of the subject, the youth of the girls working in these great factories and the amount of work on one garment are a surprise. In large workrooms the division of labor is carefully arranged, being more or less the following: the original garment and the paper pattern for it are made by the designer and her helpers. It then goes to the calculator who figures on the amount of material required and indicates on a slip the way the material is to be used. For illustration, let us suppose a fancy waist is to be made: the calculator will note if the material must be tucked, shirred, or folded in any way and enters this on the slip. He then sends the waist, the pattern, and the slip to the estimator, who considers the price of the materials, the probable labor cost, the overhead or factory charges, *i.e.*, rent, light, heat, office, and the cost of the designer and staff, and enters these on a slip. He then sends the two slips and the waist and pattern to the office. The design is now judged as to style, cost, and probable sale. It is tried on a living model and considered for line and fit. The manufacturer's profit is added to the estimates of production, which gives the wholesale price of the waist, and the waist is ready to be seen by the buyers who have come from the retailers. Orders in dozens will probably come for the model, and as the waists are needed in several sizes, the pattern must be adjusted before the work of construction begins. The paper pattern made by the designer goes, therefore, to the pattern room, where the various sizes are graded from it and patterns cut for different bust measures. These are sent to the cutter who cuts the material into the several parts of the waist by a knife or by an electric cutter. In the latter case several dozens of layers can be cut at one time in some materials. The cut material is sent to the sorter, who brings together the various parts of each waist. If tucking is to be done, the sorter sends the material to the tucker and on its return puts the tucked parts with the other sections. The assembled parts are sent to the trimming room, where the exact amount of lace,

embroidery, passementerie, or other decoration is added. All parts of the waist are now assembled and go to the forewoman of the workroom. She distributes to the hemstitchers, the Corneli machine workers, or the trimmers the parts requiring their skill, and the waist is later put together by the machine operators. It is finally sent to the finishers for buttons, loops, hooks and eyes, or any small adjustments. Inspectors judge the work after each step. If a full gown is to be made, the skirt and waist go to the draper, who joins them and sees that the skirt hangs well. Pressing follows, and the gown is ready for packing and shipping. In most of the large houses skilled workers alone are employed.

The United States Government has published in nineteen volumes a careful investigation of the condition of women and child wage earners. From this series of books information on the various phases of the present occupations of women and children can be obtained.

CHAPTER XVII

CLOTHING BUDGETS

The Family Budget. — Apportionment for Clothing. — The investigation of textiles from the many standpoints connected with the home leads naturally to a consideration of the best selection of fabrics for garments and to the part of the income to be devoted to clothing in any well-organized family. The division of the income into definite items and the percentages usually devoted to these purposes have been dealt with by many economists and social workers. In these budgets the amount allowed for clothing varies from one sixth to one eighth of the income, *i.e.*, from 17 to 12 per cent of the money received. On account of the need for adequate clothing in some business positions a larger proportion of a small income is sometimes given to dress, whereas in small family incomes the greater percentage is usually devoted to food and shelter and less to clothing.

It is evident, therefore, that the mode of life has a large influence over the amount to be spent. For instance, the suburbanite has to allow a large share for traveling expenses and consequently must cut this off from other items, but the lower cost of shelter in the suburbs than in the city sometimes balances this. The late Mrs. Ellen H. Richards gave a scientific study to budget making on small incomes and published as representative the following estimates: —

YEARLY	FOOD	RENT	CLOTHING	OPERATING EXPENSES	HIGHER LIFE
\$300 to \$1000	30 per cent	20 per cent	15 per cent	10 per cent	25 per cent
\$1000 to \$2000	25 per cent	20 per cent	20 per cent	15 per cent	20 per cent
\$2000 to \$4000	25 per cent	20 per cent	15 per cent	15 per cent	25 per cent

Miss Grace W. Pitman of East Orange has worked out and published a working basis for a family budget. She states, in the *Ideal Home Expense Guide*, that the following percentages are averages taken from the expense accounts of different families in various parts of the United States and which cover a period of twenty years. Average income, \$1500; average family, 4; rent, 17 per cent; heat, 4 per cent; light, 1½ per cent; food, 28 per cent; wages, 8½ per cent; incidentals, 3 per cent; personal expenses (including clothing), 15 per cent; operating, 3 per cent; intellectual life and investment, 20 per cent (religion, 8 per cent; education, 4½ per cent; investment, 7½ per cent).

Mrs. More, in *Wage Earners' Budgets*, published in 1907, gave from a study of 200 families the following itemized statement: —

		PER CENT OF TOTAL EXPENDITURES
Food	\$343.42	43.4
Rent	162.26	19.4
Clothing	88.45	10.6
Light and fuel	42.46	5.1
Insurance	32.35	3.9
Sundries	147.31	17.6
	\$836.25	100.0
Average surplus	15.13	
	\$851.38	

A professional woman living in a large city on a fair income and trained in both domestic art and domestic science studied a number of standard budgets and made her own calculations. She reduced the percentage of some expenses, yet obtained good results. Her family consisted of three adults (including herself) and a servant. The budget was in use for ten years and was slightly readjusted at the beginning of each year.¹ The average yearly percentage was: (1) household

¹ The higher cost of living would now require a larger income than was then used, but the percentages remain approximately the same.

expenses, 40 per cent, covering rent, food, and operating, which included service; (2) clothing, varying from 12 per cent to 15 per cent, and including large and small articles and repairing materials; (3) personal items, about 12 per cent, for doctor and dentist charges, clubs, medicine, toilet articles, and laundry; (4) travel, 5 per cent; (5) education, higher living, and pleasure, 15 per cent; (6) gifts and charities, 10 per cent; (7) investment and insurance, 6 per cent. It must be understood that any budget must be elastic enough to change from month to month, so that if one item is increased, another can be lessened.

The great variety of demands upon women makes it almost impossible to form a single budget of clothing expenditure suitable for all conditions. The mother living at home needs a very different wardrobe from a professional woman, and a society girl in a large city requires altogether different clothing than if she were at college in a small town. Each individual or each mother for her family must decide the special needs. The climatic conditions to be expected have much influence on the clothing required, and city life differs in its demands from country life.

In the clothing budget for a moderate income the following matters must be considered before making final plans: Is it well to spend the money on a few garments made at the best places, for which a large amount must be spent; on good material made up at home; or on ready-made clothing? The probable laundry costs should be considered, especially if there are to be many lingerie gowns. The hygiene of clothing (see Chap. XV) should also influence the selection of materials. The usual divisions of the clothing budget are: (1) coats, skirts, suits, and gowns; (2) underclothing and lingerie; (3) boots, shoes, stockings, slippers, and rubbers; (4) hats, caps, and gloves; (5) sundries. It is advisable first to set aside money for the most important articles and afterward to use any remaining money for minor articles and for luxuries. The underclothing should not be slighted, as health demands many changes,

and simply-made garments of good material last a long time. There is sometimes a tendency to give little attention to the undergarment and lay stress on the outer ones. When the mother of the family must plan the budget for a number of children as well as for her husband and herself, she should first roughly divide the sum at her disposal among the members of the family. When the children are very young, her problem is not great, even if the income is small. If, however, they are of school age, very careful planning of a small income is needed. In addition the handing down and making over of her own and husband's clothing and the care of all garments must contribute to the length of her purse. It is only when fortified with definite ideas of the way to spend the money that she is ready to begin to purchase. It has been proved by experience that a woman trained to a knowledge of textile buying and to budget making can make an income go twice as far as the one who buys without careful planning.

Typical Budgets. — The following budgets represent various phases of the use of the income for clothing. The majority have been or are in actual use. Estimates and plans for small incomes have in most cases been selected as requiring more close calculation than larger incomes. They include:—

- I. The study of a family living on an \$850 income.
- II. The budgets of clothing used in demonstration at the Child Welfare Exhibit in New York City in 1911, — \$65 being allowed on clothing for three children.
- III. A representative budget of \$75 per year taken from a number made by a group of young working girls.
- IV. A budget of a business girl whose family helps her by making some of her clothing at home. Expense \$100 a year.
- V. A budget of \$150 a year worked out by a group of college girls.
- VI. A professional woman's budget of \$350 a year.
- VII. A clothing budget for two children: the girl's, \$51.43, and the boy's, \$65.51.

Clothing Budget of a Family

The following is a budget of a family of five living on an income of \$850, spending 15 per cent, or \$127.50, on clothing. The student who obtained the information lived in a settlement and made her report from discussions with the families of the neighborhood. The budget that follows was a typical one selected from those collected. The division of the clothing money was as follows:—

Man	\$36.49
Woman	20.65
Girl of 12	18.51
Boy of 8	21.63
Girl of 5	14.77
Total	<u>\$112.05</u>

The remaining \$15.45 was used for sundries: thread, tape, buttons, and other items. The mother made her own and most of the children's clothing at home. Many of the garments were expected to wear more than one year. The items were as follows:—

<i>Man</i>	
Suit	\$10.00
Overcoat	10.00
Trousers	2.00
2 flannel shirts 3½ yds. flannel at 39¢	2.74
Shirt (percale) . . . . .	.50
Overalls . . . . .	.50
Winter underwear	2.00
Summer underwear . . . . .	.50
Winter hat	1.00
Summer hat . . . . .	.50
Socks, 8 pairs . . . . .	.80
Shoes, 2 pairs	5.00
Suspenders . . . . .	.25
Neckties, 2 . . . . .	.20
Collars, 2 . . . . .	.20
Handkerchiefs, 6 . . . . .	.30
	<u>\$36.49</u>

Woman

Suit, 6½ yds. serge at 59¢	\$3.84
4 yds. mercerized poplin at 24¢ for lining . . . . .	.96
Dress, 8 yds. gingham at 7¾¢ . . . . .	.62
Dress, 6½ yds. calico at 5¾¢ . . . . .	.33
Skirt, 4½ yds. serge at 49¢	2.21
Shirt waist, 3 yds. madras at 19¢ . . . . .	.57
Shirt waist, 3 yds. lawn at 12¢ . . . . .	.36
10 yds. val. lace at 2¢ . . . . .	.20
Petticoat, 5 yds. gingham at 7¾¢ . . . . .	.39
Petticoat, 5 yds. muslin at 7¢ . . . . .	.35
Petticoat, 2½ yds. outing flannel at 7¢ . . . . .	.18
Drawers, 2 yds. muslin at 7¢, 2 pairs . . . . .	.28
Corset covers, 1¾ yds. muslin at 7¢, 2 . . . . .	.20
Nightdress, 5¾ yds. muslin at 7¢, 2 . . . . .	.76
Corset . . . . .	.50
Winter underwear	1.00
Summer underwear . . . . .	.50
Winter hat	1.50
Summer hat	1.00
Shoes, 2 pairs	4.00
Stockings, 6 pairs . . . . .	.60
Handkerchiefs, 6 . . . . .	.30
	<u>\$20.65</u>

Girl of 12

Dress, 4 yds. wool material at 49¢	\$ 1.96
Dress, 5 yds. gingham at 7¾¢ . . . . .	.39
Dress, 5 yds. gingham at 7¾¢ . . . . .	.39
Dress, 4 yds. percale at 9½¢ . . . . .	.38
Dress, 4 yds. lawn at 12¢ . . . . .	.48
Bloomers, 1¾ yds. gingham at 7¾¢, 3 pairs to match dresses . . . . .	.33
Petticoats, 2½ yds. muslin at 7¢, 2 . . . . .	.28
Drawers, 1½ yds. muslin at 7¢, 2 pairs . . . . .	.22
Underwaist, ½ yd. muslin at 7¢, 2 . . . . .	.08
Nightdress, 4 yds. muslin at 7¢, 2 . . . . .	.56
Coat, 3 yds. material at 49¢	1.47
3 yds. lining at 24¢ . . . . .	.72
Winter underwear	1.00
Summer underwear . . . . .	.50
Winter hat	1.00
Summer hat	1.00
Shoes, 4 pairs	5.00
Stockings, 12 pairs	1.20
Handkerchiefs, 6 . . . . .	.30
Gloves . . . . .	.25
Rubbers . . . . .	.50
Ribbons . . . . .	.50
	<u>\$18.51</u>

Boy of 8

Suits, 2½ yds. material at 49¢, 2	\$2.46
Trousers, 1½ yds. serge at 49¢, 2	1.48
Blouses, 1½ yds. calico at 5¼¢, 2 . . . . .	.18
Blouses, 1¼ yds. gingham at 7¼¢, 2 . . . . .	.14
Overcoat	5.00
Winter underwear	1.00
Summer underwear . . . . .	.50
Caps, 2 . . . . .	.50
Shoes, 6 pairs	7.50
Rubbers . . . . .	.50
Stockings, 12 pairs	1.20
Ties . . . . .	.20
Gloves . . . . .	.25
Handkerchiefs, 6 . . . . .	.30
Pajamas, 3 yds. flannel at 7¢, 2 pairs . . . . .	.42
	<u>\$21.63</u>

Girl of 5

Dress, 2½ yds. material at 49¢	\$ 1.23
Dress, 3 yds. gingham at 7¼¢, 2 . . . . .	.48
Dress, 2⅝ yds. calico at 5¼¢ . . . . .	.16
Dress, 3 yds. lawn at 9¢ . . . . .	.27
Coat, 2½ yds. material at 49¢	1.23
3 yds. lining at 24¢ . . . . .	.72
Bloomers, 1⅜ yds. gingham at 5¼¢, 3 pairs to match dresses . . . . .	.33
Underwaist, ½ yd. muslin at 7¢, 2 . . . . .	.07
Drawers, 1 yd. muslin 7¢, 2 . . . . .	.14
Petticoats, 1½ yds. muslin at 7¢, 2 . . . . .	.22
Nightdress, 3 yds. muslin at 7¢, 2 . . . . .	.42
Winter underwear	1.00
Summer underwear . . . . .	.50
Winter hat	1.00
Summer hat . . . . .	.75
Shoes, 4 pairs	4.00
Rubbers . . . . .	.50
Stockings, 12 pairs	1.20
Gloves . . . . .	.25
Handkerchiefs, 6 . . . . .	.30
	<u>\$14.77</u>

Child Welfare Budgets

In a large city incomes of less than \$800, to support two adults and three children over ten years of age, result usually in underfeeding, poor clothing, poor housing, and depleted health. When the income is as low as \$600, actual want stares the family in the face unless charity supplements the insufficient amount. The average income of a family on the lower east side of New York has been stated to be \$851.38; the average size of the family is a little over five. If 12 per cent of the income is used for clothing, about a hundred dollars may be so used, but this is not sufficient for five people. Even an expert judge of textiles who can sew and repair cannot satisfactorily clothe the family at this price.

Investigations have proved that in those families where the mother or daughter knows something of the value of materials, can sew, make over, launder, and remove stains, the money for clothing goes twice as far. Unfortunately the majority of women are not trained to such economies; and other women who do know have not the time to give.

The relation of the high price of materials to the daily life of the poor was brought before the New York public in the spring of 1911 at the Child Welfare Exhibit, when clothing was shown as one of the influences on child life. Homemade and ready-made clothing for a number of children, ranging from the baby to the high school girl, were shown with the prices attached. It was found by careful study¹ and tests that \$112.50 (\$65 being the amount for three children) was the least sum by which even fairly adequate clothing could be obtained for a father, mother, and three children, two of the children being above ten. One eighth of the income was allowed for clothing; consequently the requisite yearly income should

¹ From a study of New York conditions and of various budgets such as More's and Chapin's as a basis for deciding on the amount to spend on the clothing budget at the Child Welfare Exhibit in 1911.

be \$900, whereas that is above the average. The full division of this income would be about as follows: rent, \$15 per month, or \$180 annually; food would take about one half of the income, say \$430; light and heat, \$50 annually; clothing, \$112; insurance, \$26; carfare, 50¢ per week, \$26 a year; all other expenses for doctors, dentists, repairs, and pleasures, \$36.

The plan for making the homemade clothing began with a careful search for the best materials to use. Those were purchased at the regular prices of the time and not at bargain counters. A fair-sized sample of cloth was always obtained first and subjected to tests for laundering, fading, and endurance. If the material stood the tests, it was purchased. Large numbers of samples were tested before the right fabrics could be found. The highest qualities were not expected in the material as the price which could be paid was too low, but simply the best for the money. It was indeed a sad showing of the small range of worthy textiles which the poor can buy. Wool was almost entirely excluded, being too expensive; cotton cloths had to be used in place of wool. Dyes proved so defective that the choice of color narrowed principally to grays, whites, and blacks. The clothing was discussed, designed, and made by girls in the various schools of New York City. Simple, attractive, though plain, garments were made that any mother might construct at home. The ready-made clothing cost about the same as the homemade. It was purchased at stores on the White List of the Consumers' League, and when possible, the garments which had on them the Consumers' League label were selected. At first the public preferred the ready-made clothing as it looked more attractive, the garments having been made primarily to please the taste. After many days of exhibition almost all of the clothing had to be laundered and the advantage was then seen to be with the homemade garments. Some of the budgets are as follows:—

Clothing Budgets of Welfare Exhibit

BABY: AGE TO 2 YEARS — OUTFIT FOR ONE YEAR

(Items marked * are ready made)

Home Made

2	Skirts (flannel),	at \$.50	\$1.00
4	Bands (1 yd. flannel),		.50
2	Nightgowns,	at .25	.50
3	Slips,	at .25	.75
1	Bonnet (interlined for winter),		.15
1	Coat (interlined for winter),		1.25
3	Shirts ($\frac{1}{2}$ wool),*	at .25	.75
20	Diapers,*	at .10	2.00
4 pr.	Stockings (wool),*	at .25	1.00
1 pr.	Tan shoes,*		.25
1 pr.	Black shoes,*		.50
			<u>.50</u>
		Total	\$8.65

Ready Made

3	Shirts ($\frac{1}{2}$ wool),	at \$.25	\$.75
4	Bands,	at .25	1.00
20	Diapers,	at .10	2.00
4 pr.	Stockings,	at .25	1.00
2	Skirts,	at .25	.50
2	Nightgowns,	at .25	.50
3	Slips,	at .25	.75
1 pr.	Tan shoes,		.25
1 pr.	Black shoes,		.50
1	Bonnet (interlined for winter),		.25
1	Coat (interlined for winter),		1.25
1 pr.	Mittens,		.25
			<u>.25</u>
		Total	\$9.00

GIRL: KINDERGARTEN AGE, 4 TO 6 YEARS — OUTFIT FOR ONE YEAR

Ready Made

3	Summer vests,	at \$.125	\$.38
2	Winter combinations (fleece lined),	at .75	1.50
2	Flannelette petticoats,	at .25	.50
2	White petticoats,	at .25	.50
2	Underwaists,	at .12	.24
4 pr.	White drawers,	at .10	.40
			<u>.40</u>
		Carried forward	\$3.52

TEXTILES

	Amount brought forward	\$3.52
2 pr. Night drawers (flannelette),	at \$.50	1.00
3 pr. Rompers,	at .50	1.50
1 Wool dress,		1.00
2 Cotton dresses,	at .50	1.00
1 Coat,		2.00
1 Summer hat,		.50
1 Winter hat,		.50
3 pr. Shoes,	at 1.10	3.30
1 pr. Overshoes,		.60
1 pr. Mittens,		.25
6 Handkerchiefs,		.25
2 pr. Garters,	at .12	.24
3 yds. Hair ribbon,	at .10	.30
2 Aprons,	at .25	.50
8 pr. Stockings,	at .125	1.00
	Total	\$17.46

GIRL: PRIMARY AGE, 6 TO 8 YEARS — OUTFIT FOR ONE YEAR

Home Made

(Items marked * are ready made)

3 Summer vests,*	at \$.125	\$.38
2 Winter combinations,*	at .75	1.50
3 pr. White drawers,	at .11	.33
2 Underwaists,	at .14	.28
2 Flannelette petticoats,	at .11	.22
2 White petticoats,	at .12	.24
2 Flannelette nightgowns,	at .32	.64
3 Cotton dresses,	at .45	1.35
1 Wool dress (with bloomers),		1.84
2 Aprons,	at .24	.48
1 Coat (to be worn 2 seasons),	at 1.81	.90
1 Summer hat,		.50
1 Winter hat,		.50
8 pr. Stockings,*	at .125	1.00
3 pr. Shoes,*	at 1.50	4.50
2 pr. Overshoes,*	at .70	1.40
6 Handkerchiefs,*		.25
2 pr. Garters,*	at .15	.30
3 yds. Hair ribbon,*	at .10	.30
1 pr. Woolen gloves,*		.25
	Total	\$17.16

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GIRL: INTERMEDIATE AGE, 8 TO 12 YEARS — OUTFIT FOR ONE YEAR

Home Made

(Items marked * are ready made)

3	Summer vests,*	at \$.125	\$.38
2	Winter combinations,*	at .75	1.50
3 pr.	White drawers,	at .22	.66
2	Underwaists,	at .50	1.00
2	Flannelette petticoats,	at .14	.28
2	White petticoats,	at .38	.76
2	Nightgowns,	at .48	.96
2	Cotton dresses,	at .52	1.04
1	Wool dress (with bloomers),		3.00
2	White aprons,	at .17	.34
1	Coat (to be worn 2 seasons),	at 3.75	1.88
1	Summer hat,		.76
1	Winter hat,		.50
8 pr.	Stockings,*	at .125	1.00
3 pr.	Shoes,*	at 1.50	4.50
2 pr.	Overshoes,*	at .70	1.40
1 pr.	Woolen gloves,*		.25
6	Handkerchiefs,*		.25
2 pr.	Garters,*	at .15	.30
3 yds.	Hair ribbon,*	at .10	.30
		Total	<u>\$21.12</u>

BOY: 10 YEARS OF AGE — OUTFIT FOR ONE YEAR

Ready Made

3	Summer vests,	at \$.25	\$.75
3	Summer underdrawers,	at .25	.75
3	Winter underdrawers,	at .30	.90
3	Winter undervests,	at .35	1.05
2 pr.	Garters,	at .15	.30
2 pr.	Pajamas,	at .75	1.50
8 pr.	Stockings,	at .125	1.00
3 pr.	Shoes,	at 2.00	6.00
3	Cotton blouses,	at .50	1.50
2	Ideal waists,	at .25	.50
1	Wool suit,		3.85
1	Reefer Coat (to be worn 2 seasons),	at 3.85	1.93
3	Cotton trousers,	at .50	1.50
1	Straw hat,		.50
1	Wool hat,		.50
1 pr.	Wool gloves,		.25
6	Handkerchiefs,		.25
2	Ties,	at .10	.20
		Total	<u>\$22.22</u>

GIRL: HIGH SCHOOL AGE, 14 TO 16 YEARS — OUTFIT FOR ONE YEAR¹

<i>Ready Made</i>			
2	Summer vests,	at \$.125	\$.25
2	Winter combinations,	at .75	1.50
3 pr.	White drawers,	at .25	.75
2	Corset waists,	at .50	1.00
3	Corset covers,	at .25	.75
2	Flannelette petticoats,	at .25	.50
1	White petticoat,		.85
1	Black petticoat,		.75
2	Nightgowns,	at .59	1.18
4	Shirt waists,	at 1.00	4.00
1	Dress skirt,		3.75
1	Cotton dress,		2.50
1	Wool Dress,		3.50
1	Coat (to be worn 2 seasons),	at 6.50	3.25
1	Summer hat,		1.00
1	Winter hat,		1.24
1 pr.	Wool gloves,		.25
1 pr.	Kid gloves,		1.00
1	Tie,		.10
1	Ribbon,		.15
6	Handkerchiefs,		.25
6 pr.	Stockings,	at .125	.75
3 pr.	Shoes,	at 2.00	6.00
1 pr.	Overshoes,		.70
Total			<u>\$35.97</u>

Budgets of Students in Trade School for Girls

A number of young working girls in New York City, who had been trained in a trade school and taught to make clothing budgets as part of their arithmetic, made plans for the utilization of their income the first year in which they worked in trade. Their wage averaged \$6 per week throughout the year, and they all lived at home. If they had had to depend on themselves entirely, the wage would have been about two thirds of the amount required for simple and decent living with adequate food and clothing and a small room. The general division

¹ By working in the summer the girl was able to spend more on her clothes than the apportionment of the income could have allowed.

of the wage per week which they decided upon was as follows: clothing and recreation, \$1.50; lunch, 90¢; carfare, 60¢; savings bank, 25¢, and family support, \$2.75. They had been taught at the school to sew, repair, and consider the small economies necessary to make money go as far as possible, and hence were able to dress well on the \$75 a year, more or less, which was set apart for clothing and recreation.

The plans for clothing differed considerably; some girls spending more in pleasure and incidentals and other girls desiring better clothing. Those who put aside the largest amount for recreation usually cut down on the dress skirt, winter underwear, millinery, and odds and ends. They decided that they must have a good lunch, even though they could not get a stylish hat. They also agreed that they themselves could make corset covers, nightgowns, summer clothes, and jabots, and even at times might be able to make some of their winter clothes. They all felt that homemade clothing wore better than the cheap, ready-made kinds and that by taking good care of their old clothes and by making the old dress skirts into petticoats, they could save money. Each girl planned to give a regular amount of her wage to her mother, as she washed her clothing and cooked her meals, which the girl wage earner could not get time to do. One budget is given below; it is the one in which the smallest amount was allowed for recreation; — this latter item ranged in the various calculations from \$1.50 to \$11.50 annually. All of the girls agreed that when a new coat or suit was needed, they should be careful to put money aside weekly for a long time or they would not have enough to get a good one.

CLOTHING BUDGET OF A WORKING GIRL

Winter Outfit

(Much of the simpler clothing made by the wearer)

2	Woolen undersuits,	at \$2.75	\$5.50
3	Flannelette petticoats,	at .50	1.50
1	Black petticoat,		1.25
1	Corset,		.50
3	Corset covers,	at .25	.75
2	Flannelette nightgowns,	at 1.00	2.00
6 pr.	Stockings,	at .15	.90
2 pr.	Shoes,	at 2.50	5.00
1 pr.	Rubbers,		.75
5	Shirtwaists,	at .89	4.45
1	Skirt,		3.00
1	Coat suit,		12.00
1	Plain hat,		1.50
1	Fancy hat,		2.00
1 pr.	Kid gloves,		1.00
1 pr.	Woolen gloves,		.50
			<u>\$42.60</u>

Summer Outfit

(Much of the simpler clothing made by the wearer)

6	Vests,	at .10	.60
6 pr.	Drawers,	at .25	1.50
1	Plain petticoat,		.35
1	Fancy petticoat,		1.00
3	Corset covers,	at .25	.75
1	Corset cover,		.50
2	Muslin nightgowns,	at .79	1.58
6 pr.	Stockings,	at .15	.90
2 pr.	Shoes,	at 2.50	5.00
5	Shirt waists,	at .89	4.45
1	Skirt,		3.00
1	Dress,		4.00
1	Hat for business,		.75
1	Fancy hat,		2.00
			<u>\$26.38</u>

Miscellaneous

Ribbons,	\$1.00
Ties,	.75
Belts,	.20
Collars,	.60
Handkerchiefs,	.60
Purse,	.10
Umbrella,	.70
Hairpins, etc.,	.50
	<u>\$4.54</u>

Summary: —

\$42.60 spent for winter clothes.
 26.38 spent for summer clothes.
 4.54 spent for miscellaneous.
\$73.52 spent for clothing for 1 year.

\$75.00 year's allowance for clothing and recreation.
\$73.52 spent for clothing.
 \$ 1.48 left for recreation.

The following suggestions were also made by these working girls:—

The Care of Clothes.

- Mend your clothes as soon as they tear.
- Air your clothes before putting them away.
- Hang your clothes up so they will not become wrinkled.
- Sponge and press woolen dresses, skirts, and coats.
- Launder shirt waists at home if you can.
- Keep all buttons and hooks and eyes carefully sewed on.
- When skirt bands wear out, put on new ones.
- Keep skirt braids sewed on.
- The skirt of an old dress can be ripped and washed and made into a petticoat.
- Put new ruffles and facings on old petticoats.
- Make your own corset covers at home; corset covers that will wear a year can be made for 25 cents.
- Clean your own corsets; remove the bones, wash and dry the corset, replace the bones, and bind the top with a piece of ribbon.
- An old sheet or nightgown can be made into a bag to keep the best dress in.
- Darn your stockings.
- Keep your shoes clean and nicely polished.
- Keep your gloves clean, always mended, and buttons sewed on.

Put your gloves away neatly when not in use.
 Wash your own ties and jabots.
 Make jabots from pieces of lawn and lace left over from waists and dresses.
 Keep your hats well brushed.
 Keep your best hat in a box or pillow slip when not in use.
 On a stormy day wear a veil over your hat.
 When your hat becomes shabby and dusty, take off the trimming, brush and steam it thoroughly, and retrim the hat.
 Keep your coat on hanger. A coat keeps its shape longer when kept on a hanger.

What a Well-dressed Girl wears to Business

Neat gloves and shoes — old gloves and shoes are neat when they are clean and carefully mended,
 Neat tailor-made shirt waists,
 Neatly made suits and coats,
 Neat, well-made hats,
 Clean, neat underwear,
 Clean collars and jabots,
 Hair neatly dressed,
 Clean hands and finger nails.

What a Well-dressed Girl does not wear to Business

Fancy shirt waists,
 Too much jewelry,
 Very big or conspicuous hats,
 Low shoes and thin stockings in winter,
 Bright, gay colors,
 Many colors at one time,
 Dresses cut too low,
 Short sleeves and low-cut waists on a cold day.
 Petticoats that are longer than the dress,
 Dusty clothes,
 Fussy neckwear,
 Dirty shirt waists and collars,
 Coats, dresses, skirts, or waists on which buttons or hooks and eyes are lacking.

Clothing Budget for Business Girl

Living at home and assisted by the family in making garments and in repairs

The salary is about \$15 per week and the need is for good, everyday garments. The suits are made by a dressmaker outside of the home, the coat is ready made, and other clothing is made at home as far as possible. Advantage is taken of past season sales. The long light-weight coat is serviceable all the year. The coat of the three-piece winter suit serves when a short coat is desired. The cost is on an average of \$100 annually. This plan of budget making and the two that follow consider the possible service of garments as continuing from year to year.

BUDGET FOR BUSINESS GIRL'S CLOTHING FOR THREE YEARS

	NUMBER	TOTAL COST	YEARS OF WEAR	AVERAGE YEARLY COST (omitting small fractions)
<i>Suit</i> — 3 piece, for winter: —	1			
Coat — skirt — waist. Suiting material, serge — 16 yds. 36 in. at \$1.25 = \$20 (12 yds. 50 in. at \$1.50) . . .		\$20.00		
Lining — sateen, 4 yds. 36 in. at .50		2.00		
Interlinings, trimmings, etc. . .		6.00		
Dressmaker		20.00	3	\$16.00
<i>Coats</i> — Covert cloth: —				
Long light weight, ready made	1	20.00	3	6.66
Sweater	1	3.50	3	1.17
<i>Dresses</i> — summer (each summer a new one. This lasts over the next summer): —				
Carried forward		71.50		23.83

		Number	Total Cost	Years of Wear	Average Yearly Cost (omitting small fractions)
Brought forward . . .			71.50		23.83
<i>Dresses:—</i>					
Ginghams (in washable colors)		1			
10 yds. 30 in. at .25	\$2.50				
Dressmaker	5.00		7.50	1	7.50
Batiste, etc.		1			
10 yds. 36 in. at .25	2.50				
Dressmaker	7.00		9.50	2	4.75
<i>Separate waists (made at home):—</i>					
Cotton		3			
3 yds. 36 in. at .15 . . . . .	.45				
Trimming (av. for 3) . . . . .	.15		1.80	1	1.80
Scotch flannel		1			
3 yds. at .35	1.05		1.05	1	1.05
Silk		2			
5 yds. at .75 (average)	3.75		7.50	3	2.50
<i>Dress skirts (made at home):—</i>					
Wool (Panama)		1			
5 yds. 36 in. at \$1.00	5.00		5.00	2	2.50
Cotton		1			
5 yds. (30-36 in.) at .15 . . . . .	.75		.75	1	.75
<i>Petticoats:—</i>					
Sateen, 5 yds. at .35	1.75	1	1.75	2	.88
Colored cotton, 5 yds. at .15 . . . . .	.75	1	.75	1	.75
White cotton, 4 yds. at .15 . . . . .	.60	2	3.20	3	1.10
Embroidery or lace	1.00				
<i>Corset covers:—</i>		4			
1½ yds. at .15 . . . . .	.20				
Lace or embroidery (average)	.30		2.00	1	2.00
<i>Nightdresses:—</i>		3			
4 yds. at .15 . . . . .	.60				
Trimming . . . . .	.40		3.00	2	1.50
<i>Drawers:—</i>		2			
1½ yds. at .15 . . . . .	.28				
Trimming (average) . . . . .	.30		1.16	1	1.16
<i>Hats:—</i>					
Winter		1	8.00	1	8.00
Summer		1	5.00	1	5.00
Carried forward			129.46		65.07

		NUMBER	TOTAL COST	YEARS OF WEAR	AVERAGE YEARLY COST (omitting small fractions)
Brought forward . . .			129.46		65.07
<i>Gloves:—</i>					
Kid	1.25	2	2.50	1	2.50
Silk . . . . .	.50	2	1.00	1	1.00
Chamoisette . . . . .	.50	2	1.00	1	1.00
<i>Corsets</i>		1 or 2	2.00	1	2.00
<i>Hosiery, 9 pr. at 3 for \$1</i>		9	3.00	1	3.00
<i>Shoes, 3 pr. at \$4 each</i> (or 4 pr. at \$3 average)		3	12.00	1	12.00
<i>Rubbers, 2 pr. at .75 each</i>		2	1.50	1	1.50
<i>Underwear:—</i>					
Cotton shirts, .25		4	1.00	1	1.00
Combinations, \$1.00 (heavy)		3	3.00	2	1.50
			156.46		90.57
Sum left for extras					9.43
Total					100.00

Clothing Budget for a College Girl

The following budget has been worked out by several girls attending college in a large city. The basis is an allowance for clothing of \$150 per year for three years. The garments in general are made at home. An additional column tells how much more the budget would be if the clothing was made outside of the house. The allowance for extras differs each year, being dependent upon the cost of standard articles. The amount given for it is approximate. The entire scheme is developed from the standpoint of present-day desires and fashions. The scale of expenditure corresponds to a total living expense of about \$4000 a year for a family of five. As the vast majority of family incomes is much less than this it follows that most girls, if they desire to be fair to other members of the family, must learn to clothe themselves in much less expensive fashion.

BUDGET FOR COLLEGE GIRL'S CLOTHING FOR THREE YEARS
 \$150 PER YEAR. \$450 TOTAL FOR THREE YEARS
 (If articles are made away from home, they will cost at least \$37 extra per year)

BOUGHT					EXPEN- DITURES	CONSTRUCTION	PROBABLE COST IF MADE OUT
1st Yr.	2d Yr.	3d Yr.	To- tal				
1		1	2	Suits at \$50.00	\$100.00		
1	1		2	Woolen dresses at 8.00	16.00	made at home	\$14.00
1	1		2	Gowns at 15.00	15.00	made at home	15.00
		1	2	Silk waists at 5.00	10.00	made at home	10.00
2	2	4	4	Tailored waists at 2.00	8.00		
2	2	2	6	Lingerie waists { 2 at 3.00	6.00		
		1	2	White wash skirt at 1.00	2.00	made at home	6.00
1	1	1	3	"Tub" dresses at 3.00	9.00	made at home	4.00
1	1	1	3	Dainty cotton dresses at 3.00	9.00	made at home	9.00
2	2	2	6	Undervests at .25	1.50		9.00
2	2	2	2	Combinations (knit) at .75	1.50		
		3	3	Woolen combinations at 3.50	10.50		
3	6	3	1	Stockings at 3 for 1.00	4.00		
			doz.				
1	2	1	4	Silk stockings at .75	3.00		
2	2	2	6	Combina- tions { petticoat, corset covers at .75	4.50	made at home	6.00
1	1	1	3	White petticoats { 2 at 1.50	3.00		
1		1	2	Silk petticoats at 5.00	10.00	made at home	3.00
1	1		2	Cotton petticoats { 1 at 2.00	3.00		
		2	4	(colored) { 1 at 1.00	3.00		
2	2	2	4	White drawers at .50	2.00		
		3	3	White drawers at .75	1.50		
2	2	2	6	Nightdresses (flannel) at 1.00	3.00		
1	1	1	3	Nightdresses (white) at .90	5.40	made at home	4.50
1	1	1	3	Corsets at 3.00	9.00		
1	1	1	3	Oxfords at 4.00	12.00		
1	1	1	3	Shoes at 5.00	15.00		
1	1	1	3	Rubbers at .75	2.25		
		1	1	House slippers at 1.50	1.50		
		1	2	Slippers at 3.00	6.00		
		1	1	Winter coat at 30.00	30.00		
1		1	1	Evening coat at 15.00	15.00	made at home	15.00
1		1	1	Sweater at 5.00	5.00		
		1	1	Furs at 35.00	35.00		
1	1	1	2	Summer hat (street) at 2.50	5.00	made at home	5.00
		1	2	Summer hat (best) at 4.00	8.00	made at home	8.00
1	1	1	2	Winter hat (street) at 2.50	5.00	made at home	5.00
		1	2	Winter hat (best) at 5.00	10.00	made at home	7.00
				Gloves, veils, shields, hairbows, repairing of shoes, handkerchiefs, neckwear, and other extras	26.60		
					423.40		
\$150	\$150	\$150			\$450.00		\$111.50

Clothing Budget for Professional or Business Woman

A professional woman whose circumstances require that she give special attention to dress made her clothing budget to meet her needs with the minimum of expense which would meet these special conditions. The climate offered extremes of heat and cold. The budget was made on a three years' schedule which, it was thought, allowed for a more economical basis than a yearly one; the clothing was considered from hygienic, artistic, and economic standpoints. The scale of expenditure was necessarily higher than is economically possible in the majority of professional men's families. The budget is included here to show the advantage of careful planning even where the amount of money available is comparatively liberal. Garments with simple and graceful lines that would not soon go out of fashion were chosen, and little elaborate trimming was used. One good tailor-made suit was purchased in general every other year which could be worn throughout the year and was expected to last at least three years, the third year for rough wear or stormy weather. The muslin underwear was decorated with fine tucks and narrow linen lace. Material was selected which was strong enough to stand the laundry. This budget with some variations was in continual use for many years.

The yearly outlay for clothing was \$350. Everything was made out of the house at good dressmakers, tailors, or seamstresses, or purchased ready made. The emphasis was on the tailor-made gown and the reception or evening dress. By care and careful repairs, made by the professional woman herself, the life of many of the garments covered a longer time than stated and thus money was saved to add to special purchases in any one year, or if a special article of some expense, such as a sweater or liberty scarf, was needed, there was a systematic reduction in all the articles for the year to cover it. The expense of summer gowns was saved to a great extent as the three summer months were spent where the plainest clothing was used.

	FIRST YEAR	SECOND YEAR	THIRD YEAR	PROBABLE YEARS OF WEAR
<i>Suits, coats, waists, and gowns:—</i>				
Tailor-made, to wear at all seasons	\$75.00		\$75.00	2
Dark waist to go with it	25.00	\$35.00	25.00	1
Light waist to go with it	30.00		30.00	2
Evening or reception gown		70.00		2
Marquissette or chiffon cloth gown		35.00		2
Summer silk (light)	30.00		30.00	2
Black Crêpe de Chine (3 piece)		50.00		2
Storm coat	10.00			4
Negligée and cap or blanket wrapper			8.00	3
Furcoat or evening wrap, \$50 (buying out of season). Average per year	12.50	12.50	12.50	4
Muff and boa, \$50. Average per year	12.50	12.50	12.50	4
Lingerie gown	15.00		15.00	2
Cotton crêpe or muslin waists, 2 at \$3 (sufficient, as not worn during summer)	6.00	6.00	6.00	1
Cotton or linen suit	10.00	10.00	10.00	1
<i>Underclothing:—</i>				
Combinations, for winter, silk and linen, 4 at \$3.75		15.00		3
Combinations, for mid seasons, lisle thread, 4 at .75	3.00		3.00	2
Linen undershirts, summer, 8 at .75			6.00	3
Muslin combinations, 3 at \$2	6.00		6.00	2
Underwaist, fancy, for special occa- sions	2.00		2.00	2
Drawers, fancy embroidered, 2 at \$2, for special occasions		4.00		2
Nightgowns, 1 at \$3	3.00		3.00	2
4 at \$1.50		6.00		2
Brassieres, 3 at \$1.00	3.00		3.00	2
<i>Petticoats:—</i>				
Muslin, white, 2 short at \$1.25	2.50			3
Muslin, white, 2 long at \$3	6.00			3
Crêpe de Chine, white, 1 at \$5			5.00	3
Crêpe de Chine, or taffeta, black	8.00	8.00	8.00	1
Storm underskirt, mohair with silk trimming			3.00	3
Corsets, 2 at \$4 or 1 at \$8	8.00	8.00	8.00	1,
Carried forward	\$267.50	\$272.00	\$271.00	

	FIRST YEAR	SECOND YEAR	THIRD YEAR	PROBABLE YEARS OF WEAR
Brought forward	\$267.50	\$272.00	\$271.00	
<i>Shoes:—</i>				
Heavy winter	4.00	4.00	4.00	1
Ties	3.50	3.50	3.50	1
Evening suede	5.00			4
Slippers	3.50		3.50	2
Room slippers		1.00		2
Rubbers . . . . .	.75	.75	.75	1
<i>Gloves:—</i>				
White, long	2.50	2.50	2.50	1
White, short, 2 at 1.25	2.50	2.50	2.50	1
Black or tan, long	3.00	3.00	3.00	1
Black or tan, short	1.50	1.50	1.50	1
Silk, long black	2.00	2.00	2.00	1
Silk, short black	1.00	1.00	1.00	1
Silk, or chamoisette, long white	1.50	1.50	1.50	1
<i>Hats:—</i>				
Business, — summer	5.00	5.00	5.00	1
winter	5.00	5.00	5.00	1
Dress, summer	8.00	8.00	8.00	1
winter	15.00	15.00	15.00	1
<i>Hosiery:—</i>				
Winter stockings, 6 at .50	3.00	3.00	3.00	1
Summer stockings,				
Plain, .50	1.50	1.50	1.50	1
Fancy, \$1.00		3.00	2.00	2
<i>Sundries:—</i>				
Veils, 2 at .40 . . . . .	.80	.80	.80	1
1 at \$1.50 (large size)	1.50			3
Repairs and cleaning	10.00	7.00	10.00	1
Handkerchiefs, ½ doz. at .50		3.00		2
3 at .75		2.25		2
Miscellaneous, pins, hairpins, etc.	1.95	1.20	2.95	1
	\$350.00	\$350.00	\$350.00	

As a matter of fact less than \$350 worth of clothing was actually consumed per year because the life of the garments was generally longer than indicated, so that there was some increase in the amount of clothing on hand from year to year. Usually

also the sum available for sundries was increased by savings effected in the purchase of the larger items. The above schedule is therefore a budget in the stricter sense of an advance estimate and allowance rather than an absolute record of actual detailed expenditure.

Clothing Budget for Two Children

This budget is a suggestion for an economical method of dressing two children — a boy and a girl who are between the ages of four and eight. The children for whom it was originally intended were one and a half years apart in age, and the plan was used for several years. The following statements give the mother's ideas on the selection of clothing.

A fair price should be given for children's clothes, as very cheap garments are not only badly made, but soon look shabby and wear out very quickly. Many articles can be made at home with great saving of money, and give better satisfaction than those bought ready made. At the same time there are many garments that it is foolish to try to make at home, for they can be bought for almost the retail price of the material and are better made; as, for instance, boys' clothes, suits and pajamas, and girls' drawers and underwaists. Extremes of fashion, materials that tear easily, that are not of fast color or of close weave are to be avoided; above all, material should be bought that washes well, for ability to launder is a requisite in a child's outfit. In carrying out the general scheme for dressing these two children the wardrobe of one was made to dovetail into the wardrobe of the other. Not only do children look well when dressed somewhat alike; but for economical reasons the younger can wear the outgrown garments of the older, and with a little repairing — as the materials used are all of good quality — look quite as well as ever. The boy's white galatea sailor suit, for instance, can be handed down to his sister, and by the addition of a new skirt to match gives her a blouse dress, with the trousers as bloomers. The latter save wear and tear on

petticoats and are warm and comfortable. The winter overcoats and hats were exactly alike; dark blue chinchilla coats were chosen and hats which could withstand all conditions of weather. Knitted worsted caps were used for playing out of doors. In summer tan coats and dark hats of a good substantial straw that would not chip or break were selected. In addition to these hats the little girl can have a white lingerie hat to go with her summer dresses, and the boy a hat of white duck. The girl's gingham dresses had bloomers to match, thus eliminating the frequently soiled white petticoat, and in fact keeping all of the underclothes clean. The mixture of cotton and wool for underwear for the ordinary healthy child is preferable to all wool, which not only is very expensive, as it is quickly outgrown, but must be so often washed that it is apt to shrink. The active body of the normal child does not require such heavy covering as all wool.

This budget is good for three to four years, with now and then a few additions made to it. The growing boy requires many of the new things, and yet the little girl's needs are well provided for if she has an additional new white muslin dress, a gingham dress, and a dress or two of tan linen made with ample allowances for growth. The simple box-plaited dress, belted in at the waist with a leather belt, can be let out under each box plait for width, and the length can be regulated by the allowance in the hem. Between the ages of five and eight years the same dress can be worn each succeeding season.

Tucks should always be put into drawers and petticoats, as well as a tuck around the underwaist of the blouse dress skirts, so that they can be let down from that point.

By the time these children reach the age of nine years an entirely new order of budget will be required. The amount spent on the boy was \$65.51 and on the girl \$51.43. The estimates given were the following:—

Boy's Clothing

2	White Galatea suits,	at \$3.50	\$7.00
1	Blue serge,		5.00
1	Corduroy trousers,		1.50
2	Flannel shirt waists,	at .50	1.00
1	Overcoat (winter),		6.50
2	Khaki suits,	at 1.50	3.00
2	Dark linen suits,	at 2.00	4.00
2 pr.	High laced shoes,	at 3.00	6.00
1 pr.	"Sneaker" shoes,		.60
1 pr.	Rubbers,		.50
2 pr.	Low shoes,	at 2.00	4.00
2	Underwear suits,	at 1.25	2.50
4	Underwear suits (summer),	at .75	3.00
3	Underwaists,	at .25	.75
6 pr.	Stockings,	at .30	1.80
	Hats for year,		3.50
	Gloves and mittens,		1.50
2	Windsor ties,	at .25	.50
1	Belt,		.50
1	Bathrobe,		2.00
1	Reefer jacket,		3.50
1 pr.	Bedroom slippers,		.50
1 pr.	Rubber boots,		2.00
2 pr.	Pajamas,	at .75	1.50
1 pr.	Overalls,		1.00
2 pr.	Knee protectors,	at .18	.36
1	Sweater,		1.50
			<u>1.50</u>
			\$65.51

(The shoes mentioned are for one year only.)

Girl's Clothing

2	Galatea suits (boy's blouse), skirts make at home, $1\frac{1}{2}$ yds.,	at .30	\$.90
1	Blue serge dress, box-plaited, and worn with white turnover collar, $2\frac{3}{4}$ yds.,	at 1.00	2.75
1	White dotted-Swiss dress, 3 yds.,	at .45	1.35
	Trimming of lace, 3 yds.,	at .20	.60
2	Box-plaited gingham, 3 yds.,	at .20	1.20
2	Box-plaited tan linens, 3 yds.,	at .20	1.20
2	Underwear, winter suit,	at 1.20	2.40
4	Underwear, summer shirt,	at .25	1.00
4 pr.	Drawers,	at .25	1.00
2	Flannel petticoats, each $1\frac{1}{2}$ yds.,	at .60	1.80
3	Muslin petticoats, 1 yd. material and trimming, each,	at .40	1.20
3	Underwaists,	at .25	.75
6	Stockings,	at .25	1.50
	Hats for 1 year,		3.50
	Gloves, mittens,		1.50
2 pr.	Shoes, high,	at 2.25	4.50
1 pr.	Rubbers,		.50
2 pr.	Shoes, low,	at 2.00	4.00
1 pr.	Sandals for summer,		1.25
1 pr.	Rubber boots,		2.00
2	Neckties,	at .25	.50
1	Belt (black),		.50
1	Wrapper (made at home),		.60
2	Suits pajamas (or boy's),	at .75	1.50
1	Knee protectors,		.18
1 pr.	Bedroom felt slippers,		.50
1	Reefer jacket,		3.50
1	Overcoat (winter),		5.00
1 pr.	Serge bloomers,		1.25
1	Sweater,		1.50
4	Handkerchiefs, 2 for .25		.50
2	Rompers,	at .50	1.00
			<u>\$51.43</u>

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GLOSSARY

(The index should be used in connection with the glossary, as terms which are unfamiliar when first encountered may be fully explained elsewhere in the book.)

- Battening.** The driving up in close order of the filling threads in weaving.
- Beetling.** A special finish of cotton and linen cloth in which the threads are beaten flat.
- Boiled-off silk.** Silk which has had the sericin or gum removed.
- Breaking.** The crushing and first separation of the woody portion from the flax or hemp fibers after the retting process.
- Calendering.** A finish for cotton cloth particularly, which gives smoothness, luster, and special effects by pressure under rollers.
- Carbonizing.** Removing vegetable matter from wool by acids.
- Chlorinated wool.** Wool treated with bleaching powder to give luster, destroy its felting property, and increase its affinity for dyestuffs.
- Conditioning.** All moisture held in the fiber is removed by this process, and the legal amount restored.
- Cosmos, peat and wood wool.** Vegetable fibers treated to look like wool.
- Cotted wool or cotts.** Matted wool from sick sheep which it is hard to open up. — Inferior wool.
- Denier.** A measure of weight used in silk counting. As recently quoted by the United States Silk Conditioning Company, a denier is a skein of silk 450 meters long, weighed by a unit of 0.05 gm. (called denier); 13 to 16 is written 13/16, etc.
- Extract Wool.** See Remanufactured Wool.
- Felting wools.** Clips of Mexico, Texas, and California sheep. There are two clips annually, hence the wool is short stapled.
- Filatures.** Machines for silk reeling which supplement hand work.
- Flocks.** Soft, fluffy fibers thrown off by different processes in woolen and worsted manufacture, such as raising and cropping.
- Frame.** An upright machine for twisting or spinning.
- Fulling or milling.** Processes of shrinking or felting woolen cloth for the purpose of making a close, firm material such as broadcloth.
- Garnetting.** The Garnett machine converts thread waste into loose fiber.
- Gassing.** Burning off fuzzy protruding ends from cloth to produce a smooth surface.
- Ginning.** Separating seed hairs of cotton from the seed.

- Hackling. A combing process which separates woody particles and tow from the line or long flax fibers.
- Harness. A collection of healds or heddles.
- Healds or heddles. Cords or sticks having openings or eyes in their centers, through which the warp threads pass in the loom.
- Kemps. Dead wool which will not dye. White, shiny hairs in the wool of sheep that have not had good care.
- Lathe or sley. The stick or lath used for battening in weaving.
- Lease. The crossing made in the warp threads in preparing the loom for weaving.
- Line. Long flax fibers.
- Lint. Cotton fibers after removal from seed.
- Linters. The short seed hairs left attached to the cotton seeds after first ginning.
- Mercerized cotton. Cotton treated with strong caustic alkali under certain conditions, resulting in the formation of cellulose hydrate. The material is stronger and, as commercially made, more lustrous.
- Mungo. See Remanufactured Wool.
- Neps. Small knots in cotton due to poor ginning or to immature or diseased bolls.
- Noils. Short fibers left in the combing for worsted yarn. Many grades are very valuable.
- Organzine. Silk thread used for warp. For the sake of strength it is of good quality and has a special twist.
- Picking. Putting in the filling threads in weaving.
- Pulled wool. Also called Skin Wool and Dead Wool. It is pulled from dead pelts treated with chemicals.
- Raddle. A device through which the warp threads pass in order to wind smoothly on the warp beam.
- Reed. An attachment of the lathe consisting of fine cords or wires between which the warp threads are carried.
- Reeled silk. Silk filaments unwound from the cocoon but not yet twisted.
- Remanufactured or recovered wool. Wool recovered from old clothes, rags, and such sources, and rewoven. Three principal grades are recognized: (1) Shoddy or softs. From unfelted clothing such as blankets and stockings. (2) Mungo or hard wool. From felted or milled cloth. Usually ground fine to mix with wools and make a cheap material. (3) Extract. Wool left from mixtures with cotton, after the cotton has been removed by carbonizing.
- Retting. Rotting the flax stalks to effect the removal by decomposition of the pectin and resinous substances which hold the bast fibers to the woody portion.

- Rippling. Removing the seeds and leaves from the stems of the flax plant.
- Roughing. A coarse combing or hackling of flax, following scutching.
- Roving. The last stage of drawing out a lap or combination of filaments in preparation for spinning.
- Schreinerized cotton. Cotton given the appearance of mercerized cotton by special machine treatment.
- Scroop. The rustle or crunch of silk. It is a natural property in some cases, but is increased by treatment with dilute acids.
- Scutching. Knocking off the woody particles adhering to the flax fibers after the breaking process.
- Seed cotton. Cotton seed with fibers attached.
- Shaft of healds. A number of healds fastened together, which draw up to form a shed.
- Shed. The opening in the warp threads through which the filling passes.
- Shoddy. See Remanufactured Wool.
- Singles. Silk thread which has no twist.
- Skirts. Clippings or trimmings from the fleece of sheep; principally dirty ends from the legs. The skirting removes the poorer portions.
- Sliver. A soft, untwisted rope produced by drawing out a lap or sheet of fibers in preparation for spinning.
- Slubbing. An intermediate stage of drawing out after the sliver is formed.
- Sorts. The divisions of a pelt into grades of wool.
- Souple. Silk with about one sixth of the gum removed.
- Spun or waste silk. Inferior silk from various sources such as pierced cocoons and wastes from manufacturing processes. The filaments are carded and spun.
- Standard samples. Collections of government samples which show the decision of experts as to the values of wools. Imported wools are compared with these samples.
- Staple. Length of fiber in a group or lock of wool, cotton, etc. In the case of wool "long" signifies between four and twenty inches; "short," from two to four inches.
- Stripping. Removing the sericin or natural gum from silk by boiling off.
- Sword. A stick thrust into a shed to widen the opening for the filling threads in hand weaving.
- Temple or tenterhook. A device for holding the cloth in hand weaving stretched to an even width.
- Thrown silk. Silk carried through the processes which follow reeling. The result is a thread suitable for weaving. Boiling off, dyeing, and weaving follow throwing.
- Tops. The long wool fibers prepared for worsted yarn by the combing process.

- Tow.** Short flax fibers separated from the line in the hackling process.
- Tram** Silk thread used for filling.
- Warp or ends.** The threads running lengthwise of a weave.
- Waste.** Ends broken off from processes of manufacture. It may be from spinning processes, such as ring waste, or from yarn waste. Much of the waste is put through the Garnett machine.
- Weft, woof, picks, or filling.** The threads running across the warp in a weave.
- Woolens.** Made from fibers which have not been combed and laid parallel.
- Worsted.** Made from combed and parallel-fibered yarns.
- Yolk or suint.** Secretions of the skin of sheep which coat the wool, keep it waterproof, and prevent matting.

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THE following pages contain advertisements of
a few of the Macmillan books on kindred subjects

Household Bacteriology

BY

ESTELLE D. BUCHANAN, M.S.

Recently Assistant Professor of Botany, Iowa State College

AND

ROBERT EARLE BUCHANAN, Ph.D.

Professor of Bacteriology, Iowa State College, and Bacteriologist of the
Iowa Agricultural Experiment Station

Cloth, 8vo, xv + 536 pp., index, \$2.25 net

The word Household is used as an extension rather than a limitation of the title. In a thoroughly scientific manner the authors treat the subject-matter of general as well as of household bacteriology and include, therefore, the true bacteria as well as the yeasts, molds, and protozoa. The volume is, therefore, a general textbook of micro-biology in which special attention is given to those problems which are of particular interest to the student of household science. The main divisions of the book treat (1) the micro-organisms themselves, (2) fermentations with special reference to those affecting foods, (3) the relations of bacteria and other micro-organisms to health. A fully illustrated key (comprising 37 pages) to the families and genera of common molds, supplements the unusually extended discussion of the morphology and classification of yeasts and molds, and makes possible the satisfactory identification of all forms ordinarily encountered by the student. The work embodies the results of the most recent researches. The book is exceptionally well written, the different topics are treated consistently and with a good sense of proportion. While concise in statement, it is thorough in method and scope. It is, therefore, well adapted for use as a text not only *for students of household science*, but *also* for those to whom it is desired to present the science of bacteriology *from an economic and sanitary rather than from a strictly medical point of view.*

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BY MARY SWARTZ ROSE, PH.D.

Assistant Professor, Department of Nutrition, Teachers College, Columbia University

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Only brief statements of the conditions affecting food requirements have been made, the reader being referred to general textbooks on the subject of nutrition for fuller information, but such data have been included as seem most useful in determining the amount of food for any normal individual under varying conditions of age and activity.

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Professor in Columbia University

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