THE SECRET OF EVERYDAY THINGS

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BY

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TRANSLATED FROM THE FRENCH
BY
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INTRODUCTORY NOTE

The clearness, simplicity, and charm of the great French naturalist's style are nowhere better illustrated than in this work, which in its variety of subject-matter and apt use of entertaining anecdote rivals "The Story-Book of Science," already a favorite with his readers. Such instances of antiquated usage or superseded methods as occur in these chapters of popular science easily win our indulgence because of the literary charm and warm human quality investing all that the author has to say.

—*Translator*

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CHAPTER I

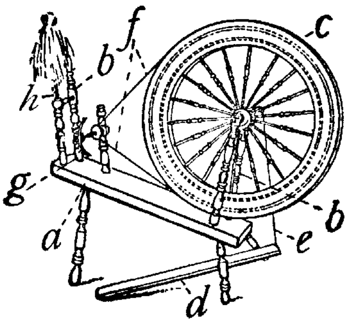
THREAD

UNCLE PAUL resumed his talks on things that grow and things that are made, while his nephews, Jules and Emile, and his nieces, Claire and Marie, listened to his "true stories," as they liked to call them, and from time to time asked him a question or put in some word of their own.

Continuing the subject of cotton-manufacture, he called his hearers' attention to the number of processes the raw material must go through before it emerges as finished fabric ready for making into wearing apparel, and to the countless workmen that must, from first to last, have been engaged in its production and in all the operations leading up to its final application to household uses.

"Then I should think," said Marie, "that cotton cloth would be very expensive if all those workmen are to get their pay for the time and labor they have put into its manufacture."

"On the contrary," Uncle Paul assured her, "the price is kept down to a very moderate figure; but to accomplish this surprising result two powerful factors are called into play,—wholesale manufacture and the use of machinery. The process employed for spinning cotton into the thread that you see wound on spools will help you to understand my meaning.



Spinning Wheel for Flax

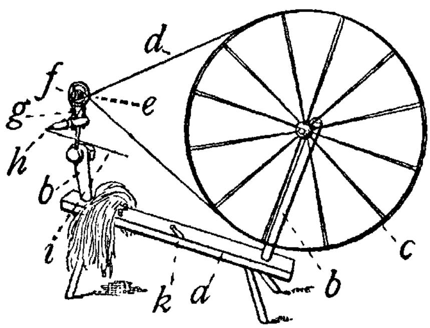
a, bench or stool; *b*, standards; *c*, driving band-wheel with grooved rim; *d*, treadle; *e*, rod connecting treadle with crank; *f*, cord-band driving the flier-spindle; *g*, flier; *h*, distaff carrying flax to be spun and, when in use, held in operators' left hand.

"You know how the housewife spins the tow that is used for making linen. First she thrusts inside her belt the distaff, made out of a reed and bearing at its forked end a bunch of tow; then with one hand she draws out the fibers and gathers them together by moistening them a little with her lips, while with the other she twirls her spindle and thus twists the loose fibers into a single strand. After she has twisted it tightly enough she winds it on the spindle, and then proceeds to draw out another length of tow from the distaff."

"Mother Annette is very skilful with the distaff," put in Claire. "I like to hear her thumb snap when she twirls the spindle. But when she spins wool she uses a spinning wheel."

"First of all," Uncle Paul explained, "the carded wool is divided into long wisps or locks. One of these is brought into contact with a rapidly twirling hook, which catches the wool and twists it into a thread that lengthens little by little at the expense of the lock of wool, the latter being all the while held and controlled by the fingers. When the thread has attained a certain length it is wound on the spindle by a suitable movement of the wheel; and then the twisting of the lock of wool is resumed. In case of need cotton could thus be spun by hand; but, skilful as Mother Annette is at such work, cloth made from thread spun in that fashion would be enormously expensive because of the time spent in producing it. What, then, shall we do? We must resort to machinery, and in vast establishments known as cotton factories we set up hundreds of thousands of spindles and bobbins, all moving with perfect precision and so rapidly that the eye cannot follow them."

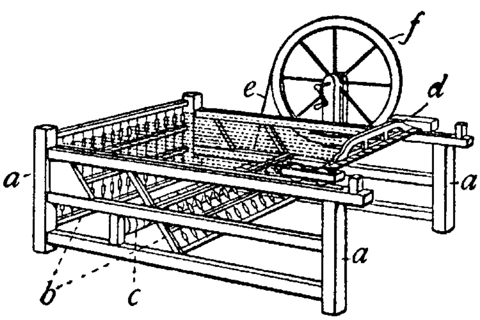
"It must be wonderful," remarked Jules, "to see all those machines spinning the cotton into thread so fast you can't keep track of them."



Spinning-Wheel for Wool
a, bench; *b, b'* standards; *c*, driving band-wheel with flat rim, turned by the peg *k* held in the right hand of the spinner; *d*, cord-band, crossed at *e* and driving the speed-pulley *f*; *g*, cord-band imparting motion to the spindle *h*; *i*, thread in process of spinning.

"Yes, those machines surpassing in delicate dexterity the nimble fingers of the most skilful spinner, are indeed among the cleverest inventions ever produced by man; but they are so complicated that the eye gets lost among their innumerable parts. I can only point out to you the more important of these parts, without hoping to make you understand how the whole machine operates.

"First there are the cards which comb the mass of cotton into fine strips or ribbons, just as Mother Annette cards the wool she is about to spin on her wheel. These cards of hers, you understand, are nothing more nor less than big brushes bristling with a multitude of fine iron points. One card remains at rest and receives a thin layer of wool, after which the other is made to pass over it in such a way as to comb the wool and draw out fine locks of it, one after another. In this fashion, too, the cards in cotton factories play their part. On leaving the cards the ribbons of cotton fiber are drawn out, lightly twisted, and then wound on bobbins. Next a machine called a spinning-jenny takes the partly spun cotton and twists it into thread more or less fine according to the purpose it is to serve. Finally this thread finds its way automatically to the reel, which forms it into skeins, or to the winder, which winds it into those regular balls that we can't admire too much for their perfect shape. You have doubtless observed with what precision, what elegance,



Hargreaves' Original Spinning-Jenny
a, frame; *b*, frames supporting spindles; *c*, drum driven by the band *e* from the band-wheel *f* and carrying separate bands (not shown) which separately drive each spindle; *d*, fluted wooden clasp which travels on wheels on the top of the frame, and in which the rovings (the tightly twisted fibers) are arranged in due order.

the thread is wound into a ball that the merchant delivers to you at the insignificant price of a few centimes. What human hands would have the steadiness, what fingers the skill to achieve anything comparable with this little masterpiece?"

"I know I can't begin to wind such a ball," said Marie; "it just makes a shapeless lump instead of the pretty ball I buy at the store."

"No one, depending only on his hands, could ever achieve that admirable regularity," Uncle Paul assured her. "To that end we must have machines, unvarying in their movements and working with a precision that nothing can derange.

"Thread is numbered according to its degree of fineness, the higher the number the finer the thread. Every skein and every ball being of the same length, its weight increases as the fineness diminishes. We say, then, of a particular thread that it is number 200 when it takes two hundred skeins or balls to make half a kilogram in weight, and that it is number 150 when it takes one hundred and fifty to make up the same weight."

CHAPTER II

PINS

"AFTER thread, come the needle and its companion the pin. I shall take up the latter first, because its manufacture will help us to understand that of the needle, which is rather more complicated.

"The things most often used by us are not seldom those of whose origin we are ignorant. What is there more convenient, more often used, than the needle and the pin? What could take their place if we were deprived of them? We should be reduced to Claire's makeshift that day we went on a picnic and she tore a hole in her apron and fastened the edges together with a thorn from the hedge. We might also, as do those savage tribes that have no manufactured articles, shred an animal sinew or a strip of bark into fine thongs to serve as thread and sew with a sharp-pointed bone for a needle. We might replace the pin by a fish bone."

"That would be a funny sort of gown," exclaimed Marie, "sewed with thongs of bark or the sinews of an ox; nor should I care much to have my hair fastened with codfish bones."

"Yet there are even to-day savage tribes that have nothing else; and often the great ladies of ancient times had nothing better; they used rude pins made of metal or little splinters of bone. Advance in the manufacturing arts has given us the pin, with its pretty round head, at a price so moderate as to be almost negligible, the needle with its fine point and its admirable suitability to our use, and thread of remarkable strength and fineness. Now let us learn how pins are made.

"Pins are made of brass, which is composed of copper and zinc. Copper is the red metal you are familiar with in copper kettles, zinc the grayish-white metal of watering-pots and bath-tubs. Mixed together they form brass, which is yellow.

"The first step is to reduce the copper to wire the size of a pin. This is done by means of a draw-plate, a steel plaque pierced with a series of holes, each smaller than the preceding. A little brass rod is thrust into the largest hole and forcibly drawn through it. In passing through this hole, which is a little too small for it, the metal rod becomes correspondingly thinner and longer. It is then thrust into a still smaller hole and again drawn out, becoming once more thinner and longer in the process. This operation is continued, passing from one hole of the draw-plate to the next smaller, until the wire acquires the desired fineness.

"While we are on the subject note this fact—that all metal wires, whether of iron, copper, gold or silver, are made in the same way: namely, by being passed through the draw-plate.

"The brass wires are now put into the hands of the cutter, who gathers several of them into a bundle, and then, with a strong pair of shears, cuts them all into pieces twice the length of a pin.

"These pieces must next be sharpened at both ends by means of a steel grindstone which has its grinding-surface furrowed like a file, and which turns with the prodigious velocity of twenty-seven leagues an hour. The man charged with this work, whom we will call the sharpener, sits on the ground in front of his grindstone, legs crossed in tailor-fashion. He takes in his fingers from twenty to forty pieces, spreads them out regularly in the shape of a fan, and brings all these branching tip-ends simultaneously into contact with the grindstone, at the same time twirling them in his fingers so that the tip is worn off equally all around and the point made even. The reverse tips are sharpened in the same way.

"But this first process merely produces points in the rough, so to speak; the sharpener retouches and finishes them on a finer grindstone. Finally the pieces sharpened at both ends are arranged several together and cut in two in the middle with one clip of a pair of shears. Each half, known as a shank, now lacks only a head in order to become a complete pin.

"This heading process is the most difficult part of the whole operation. On a slender metal shaft, very smooth and slightly larger than the pins, a thread of brass is tightly wound in a spiral, after which the shaft is removed, leaving a long corkscrew with its turns touching one another. A cutter of consummate skill in this delicate work, which demands at the same time so much precision and so much swiftness, divides this corkscrew into small pieces, each containing just two turns. Each of these pieces is a head.

"The workman who is to put them in place and fasten them takes the shanks one by one and plunges them haphazard, pointed end first, into a wooden bowl full of heads. The shank is drawn out with a head strung on it, which the operator pushes with his fingers to the unpointed end. He immediately places it on a little anvil having a tiny cavity into which the head fits; then by means of a pedal moved by the operator's foot a hammer provided with a similar cavity comes down, strikes five or six little blows, and behold the head firmly fixed.

"As a finishing touch the pins have still to be coated with tin. To this end they are boiled with a certain proportion of this metal in a liquid capable of dissolving it and depositing it in a thin layer on the brass. After being thus coated they are washed, dried on cloths, and finally shaken up with bran in a leather bag in order to heighten their polish.

"It only remains to stick the pins in paper in regular rows. A kind of comb with long steel teeth pierces the paper with two lines of holes. Work-women known as pin-stickers are charged with the delicate task of inserting the pins one by one in these holes. A skilled pin-sticker can insert from forty to fifty thousand pins a day.

"Including some details that I omit, the manufacture of a pin requires fourteen different operations, and consequently the cooperation of fourteen workmen, all of consummate skill in their part of the operation. Nevertheless the manufacture is so rapid that these fourteen workmen can make twelve thousand pins for the modest sum of four francs."[1]

1 Since the foregoing was written automatic machinery has been invented which greatly facilitates the manufacture of pins. Pointing, heading, and papering are now done with great rapidity by such machinery, and hand-work is almost entirely dispensed with.—*Translator.*

CHAPTER III

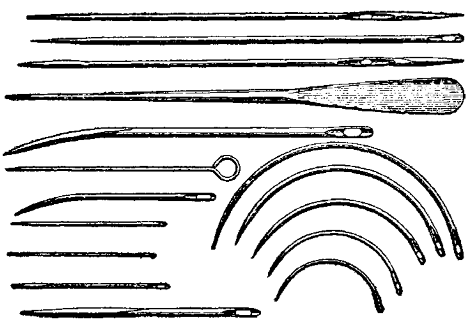
NEEDLES

"TAKE from a case one of the finest needles, examine its sharp point, its tiny, almost imperceptible eye, and note finally the polish, the shine. Tell me if this pretty little tool, so perfect in its minuteness, would not seem to require for its manufacture the superhuman fingers of a fairy rather than man's heavy hands. Nevertheless it is robust workmen with knotty fingers blackened by the forge and covered with great calluses that do this most delicate work. And how many workers does it take to make one needle?—one only? For the manufacture of a pin, I have already told you, it takes fourteen different workmen; for the manufacture of a needle it requires the coöperation of one hundred and twenty, each of whom has his special work. And yet the average price of a needle is about one centime.[1]

"The metal of needles is steel, which is obtained by adding carbon to iron heated to a very high temperature. Under this treatment iron changes its nature a little, incorporating a very small quantity of carbon and thus becoming exceedingly hard, but at the same time brittle. A needle must be very hard in order not to bend

1 Nearly one fifth of a cent in our money.—*Translator.*

under the pressure of the thimble forcing it through the thickness of the material on which the seamstress is at work, and also in order that the point may not become blunted, but always retain the same power of penetration. Steel, the hardest of all the metals, is the only one that fulfils these conditions of resistance; neither copper nor iron nor the precious metals, gold and silver, could replace it. A gold needle, for example, in spite of its intrinsic value, would be useless, becoming blunted and twisted before using up its first needleful of thread. Steel alone is suited to the manufacture of needles, though unfortunately this metal is brittle, and the more so the harder it is."



Needles
Various shapes and sizes used by sailmakers and upholsterers.

"But I should think," Marie interposed, "that since steel is so hard it ought not to break."

"You will think otherwise if you listen to me a while. Hardness is the degree of resistance that a body opposes to being cut, scratched, worn away by another. Of two bodies rubbing against each other the harder is that which cuts the other, the softer is that which is cut. Steel, which scratches iron, is harder than iron; in its turn glass is harder than steel, because it can cut the steel without being cut by it. But a diamond is still harder than glass, since it scratches glass and glass cannot scratch it. In fact a diamond is the hardest of all known substances: it scratches all bodies and is scratched by none. Glaziers take advantage of this extreme hardness: they cut their panes of glass with the point of a diamond."

"I have heard," said Claire, "that a diamond placed on an anvil and struck with a hammer stands the blows without breaking and penetrates into the iron of the anvil, it is so hard."

"That is a great mistake," replied Uncle Paul. "A diamond breaks like glass, and he would be very ill-advised who should submit the precious stone to the proof of a hammer. At the first blow there would be nothing left but a little worthless dust. You see by these different examples that hardness and brittleness are often united. Steel is very hard, glass still harder, and diamond the hardest of all substances; nevertheless all three are brittle. That explains to you why needles of excellent steel, which gives them their rigidity and power of penetration, nevertheless break like glass in clumsy fingers.

"Now I come to the subject of manufacture, from which the properties of steel turned us for a moment. The metal is drawn out into wire by means of a draw-plate; then this wire, several strands at a time, is cut into pieces twice the length of a needle, just as in pin-making. The pieces are pointed at each end, first on a revolving sandstone similar to an ordinary grindstone, then on a wooden wheel covered with a thin layer of oil and a very fine, hard powder called emery. Imagine glass reduced to an impalpable powder and you will have a sufficiently correct idea of what emery is. The first process gives us a more or less coarse point; the second sharpens this point with extreme nicety.

"The pieces thus pointed at both ends are cut into two equal parts, each one of which is to be a needle. The workman then takes in his fingers four or five of these unfinished needles, spreads them out like a fan and puts the large end of them on a little anvil; then with a light blow of the hammer he slightly flattens the head of each. It is in this flattened end that later on the eyelet or hole of the needle will be pierced."

"But you just told us, Uncle," Marie interrupted, "that good steel is brittle, the same as glass; yet the workman flattens the head of his needles with a hammer without breaking anything."

"Your remark is very timely, for before going further we have to take note of one of the most curious properties of steel. I must tell you that it is only by tempering that this metal becomes hard and at the same time brittle. Tempering steel is heating it red-hot and then cooling it quickly by plunging it into cold water. Until it undergoes this operation steel is no harder than iron; but, to compensate for this softness, it can be hammered, forged, and in fact worked in all sorts of ways without risk of breaking. Once tempered, it is very hard and at the same time so brittle that it can never henceforth stand the blow of a hammer. Accordingly needles are not tempered until near the end of the process of manufacture; before that they are neither hard nor brittle and can be worked as easily as iron itself.

"If you look at a needle attentively you will see that the head is not only flattened but also hollowed out a little on each side in the form of a gutter or groove which serves to hold the thread. To obtain this double groove, the workman places the needles, one by one, between two tiny steel teeth which, moved by machinery, open and shut like two almost invisible jaws. Bitten hard by the shutting of these two teeth, the head of the needle is indented with a groove on each side.

"Now the eye must be pierced, an operation of unequalled delicacy. Two workmen cooperate in this, each equipped with a steel awl whose fineness corresponds with the hole to be made. The first places the head of the needle on a leaden block, puts the point of his instrument in the groove on one side, and, striking a blow with the hammer on the head of the awl, thus obtains not a complete hole but merely a dimple. The needle is then turned over and receives a similar dimple on the other side. The other workman takes the needles and with the aid of his awl removes the tiny bit of steel that separates the two dimples. Behold the eye completely finished.

"Probably no work requires such sureness of hand and precision of sight as the piercing of the eye of a needle. Certainly he has no trembling fingers or dimmed eyesight who can, without faltering, apply his steel point to the fine head of a needle, strike with perfect accuracy the blow of the hammer, and open the imperceptible orifice that my eyes can scarcely find when I want to thread a needle."

"There are needles so small," remarked Marie, "that I really don't see how anyone can manage to make an eye in them."

"This incomprehensible achievement is mostly the work of astonishingly skilful children. So skilful, indeed, are some of them that they can make a hole in a hair and pass a second hair through this hole."

"Then the needle's eye," said Emile, "which seems such a difficult piece of work to us, is only child's play to them."

"Child's play indeed, so quick and dexterous are they at it. And they have still another kind of dexterity that would astonish you no less. To make the needles easier to handle in the process of manufacture, they must be placed so that they all point the same way; but as in passing from one operation to another, from one workman to another, they become more or less disarranged, it is necessary to arrange them in order again, all the points at one end, all the heads at the other. For us there would be no way but to pick them up one by one; with these children this delicate task is but the work of an instant. They take a handful of needles all in disorder, shake them in the hollow of the hand, and that is enough; order is reestablished, the heads are together, the points together.

"The eye completed, the next process is tempering, to give the steel its required hardness. The needles are arranged on a plate of sheet-iron, which is then placed on red-hot coals. When sufficiently heated, the needles are dropped quickly into a bucket of cold water. This produces in them the hardness characteristic of steel, and its accompanying brittleness.

"As a finishing touch the needles must be polished till they shine brightly. In parcels of fifteen or twenty thousand each they are sprinkled with oil and emery and wrapped up in coarse canvas tied at both ends. These round packages, these rolls, are placed side by side on a large table and covered with a weighted tray. Workmen or machinery then make the tray pass back and forth over the table unceasingly for a couple of days. By this process the packages, drawn this way and that by the tray, roll along the table, and the needles, rubbing against one another, are polished by the emery with which they are sprinkled.

"On coming out of the polishing machine the needles, soiled with refuse of oil and detached particles of steel, are cleaned by washing with hot water and soap. It remains now only to dry them well, discard those that the rude operation of polishing has broken, and finally wrap with paper, in packages of a hundred, those that have no defect. The most celebrated needles come from England, but needles are also made in France, at Aigle in the department of Orne."[1]

1 Since Fabre wrote, the manufacture of needles, like that of pins, has undergone important changes and improvements through the application of machinery.—*Translator.*

CHAPTER IV

SILK

THE culture of the silkworm having been explained by Uncle Paul in one of his previous talks,[1] he now confined himself chiefly to the structure of the cocoon and the unwinding of the delicate silk thread composing it.

"The cocoon of the silkworm," he began, "is composed of two envelops: an outer one of very coarse gauze, and an inner one of very fine fabric. This latter is the cocoon properly so called, and from it alone is obtained the silk thread so highly valued in manufacture and commerce, whereas the other, owing to its irregular structure, cannot be unwound and furnishes only an inferior grade of silk suitable for carding.

"The outer envelop is fastened by some of its threads to the little twigs amid which the worm has taken its position, and forms merely a sort of scaffolding or openwork hammock wherein the worm seeks seclusion and establishes itself for the serious and delicate task of spinning its inner envelop. When, accordingly, the hammock is ready the worm fixes its hind feet in the

1 See "The Story-Book of Science."

threads and proceeds to raise and bend its body, carrying its head from one side to the other and emitting from its spinneret as it does so a tiny thread which, by its sticky quality, immediately adheres to the points touched. Without change of position the caterpillar thus lays one thickness of its web over that portion of the enclosure which it faces. Then it turns to another part and carpets that in the same manner. After the entire enclosure has thus been lined, other layers are added, to the number of five or six or even more. In fact, the process goes on until the store of silk-making material is exhausted and the thickness of the wall is sufficient for the security of the future chrysalis.

"From the way the caterpillar works you will see that the thread of silk is not wound in circles, as it is in a ball of cotton, but is arranged in a series of zigzags, back and forth, and to right and left. Yet in spite of these abrupt changes in direction and notwithstanding the length of the thread—from three hundred to five hundred meters—there is never any break in its continuity. The silkworm gives it forth uninterruptedly without suspending for a moment the work of its spinneret until the cocoon is finished. This cocoon has an average weight of a decigram and a half, and it would take only fifteen or twenty kilograms of the silk thread to extend ten thousand leagues, or once around the earth.

"Examined under the microscope, the thread is seen to be an exceedingly fine tube, flattened and with an irregular surface, and composed of three distinct concentric layers, of which the innermost one is pure silk. Over this is laid a varnish that resists the action of warm water, but dissolves in a weak alkaline solution. Finally, on the outside there is a gummy coating which serves to bind the zigzag courses firmly together and thus to make of them a substantial envelop.

"As soon as the caterpillars have completed their tasks, the cocoons are gathered from the sprigs of heather. A few of these cocoons, selected from those that show the best condition, are set aside and left for the completion of the metamorphosis. The resulting butterflies furnish the eggs or 'seeds' whence, next year, will come the new litter of worms. The rest of the cocoons are immediately subjected to the action of very hot steam, which kills the chrysalis in each just when the tender flesh is beginning slowly to take form. Without this precaution the butterfly would break through the cocoon, which, no longer capable of being unwound, because of its broken strands, would lose all its value.

"The cocoons are unwound in workrooms fitted up for the purpose. First the cocoons are put into a pan of boiling water to dissolve the gum which holds together the several courses of thread. An operator equipped with a small broom of heather twigs stirs the cocoons in the water in order to find and seize the end of the thread, which is then attached to a reel in motion. Under the tension thus exerted by the machine, the thread of silk unwinds while the cocoon jumps up and down in the warm water like a ball of worsted when you pull at the loose end of the yarn. In the heart of the unwound cocoon there remains a chrysalis, inert, killed by the steam.

"Since a single strand would not be strong enough for the purpose of weaving, it is usual to unwind all at once a number of cocoons, from three to fifteen and even more, according to the thickness of the fabric for which the silk is destined; and these united strands are used later as one thread in the weaving machines.

"As it comes from the pan the raw silk of the cocoon is found to have shed its coating of gum, which has become dissolved in the hot water; but it is still coated with its natural varnish, which gives it its firmness, its elasticity, its color, often of a golden yellow. In this state it is called raw silk and has a yellow or white appearance according to the color of the cocoons from which it came. In order to take on the dye that is to enhance its brilliance and add to its value, the silk must first be cleansed of its varnish by a gentle washing in a solution of lye and soap in warm water. This process causes it to lose about a quarter of its weight and to become of a beautiful white, whatever may have been its original color. After this purifying process it is called washed silk or finished silk. Finally, if perfect whiteness is desired, the silk is exposed to the action of sulphur, as I will explain to you when we come to the subject of wool.

"Cocoons that have been punctured by the butterfly, together with all scraps and remnants that cannot be disentangled and straightened out, are carded and thus reduced to a sort of fluff known as floss-silk, which is spun on the distaff or the spinning-wheel very much as wool is treated; but even with the utmost pains the thread thus obtained never has the beautiful regularity and the soft fineness of that which is furnished by unwinding the cocoon. It is used for fabrics of inferior quality, for stockings, shoe-laces, and corset-laces.

"The silkworm and the tree that feeds it, the mulberry, are indigenous to China, where silk-weaving has been practised for some four or five thousand years. To-day, when the highly prized caterpillar is dying out in our part of the world, China and its neighbor Japan are called upon to furnish healthy silkworm eggs. Silk-culture was introduced into Europe from Asia in the year 555 by two monks who came to Constantinople with mulberry plants and silkworm eggs concealed in a hollow cane; for it was strictly forbidden to disseminate abroad an industry that yielded such immense riches."

CHAPTER V

WOOL

"WE live," continued Uncle Paul, "on the life of our domestic animals. The ox gives us his strength, his flesh, his hide; the cow gives us her milk besides. The horse, the ass, the mule work for us; and when death overtakes them they leave us their skin for leather with which to make our footwear. The hen gives us her eggs, and the dog places his intelligence at our disposal. But if there is one animal that, more than another, comes to us from the good God above, it is surely the sheep, the gentle creature that yields us its fleece for our garments, its skin for our warm coats, its flesh and its milk for our nourishment. But its most precious gift is its wool.

"From wool are made mattresses, and it is also woven into cloth such as merino, flannel, serge, cashmere, and in short, all the various fabrics best fitted for protecting us from the cold. It is by far the most desirable material for wearing apparel, cotton, notwithstanding its importance, coming only second, and silk, valuable though it is, being very inferior in respect to serviceability. More than with anything else we clothe ourselves with what we strip from the innocent sheep; our finery comes for the most part from its fleece."

"But wool is very far from beautiful on the creature's back," commented Claire; "it is all matted and dirty, often fairly covered with filth."

"It must take a good many processes," remarked Marie, "to change that foul and tangled fleece into the beautiful skeins of all colors with which we embroider such pretty flowers on canvas."

"Yes, indeed, very many," rejoined Uncle Paul. "I have already told[1] you how sheep are washed and sheared, and how the washing leaves the fleece white or brown or black according to the color given to it by nature. White wool can be dyed in all possible tints and shades, from the lightest to the darkest, whereas brown or black wool can take only somber hues. White wool, therefore, is always preferable to any other; but, beautiful as it is when freshly washed and relieved of all impurity, it is still far from having the snowy whiteness so desirable if it is to remain undyed. It is bleached by a very curious process which I will now describe to you.

"You have all doubtless observed that when sulphur burns, with a blue-violet flame, it gives forth a pungent odor that irritates the mucous membranes of the nose and throat and causes a fit of coughing."

"That must be what we smell when we light a

1 See "Our Humble Helpers."

match," Claire interposed. "If you breathe in the least little whiff of it, it is perfectly horrid."

"Often enough it has set me to coughing unless I was on my guard," remarked Emile.

"Yes, that is it," their uncle replied. "Sulphur, in burning, becomes an invisible substance which is dissipated in the atmosphere and betrays its presence only by a detestable odor of the most pungent quality. Invisible, impalpable, like the air itself, this something that we know merely as a disagreeable smell constitutes nevertheless a real substance the existence of which cannot be doubted by any one who has once been thrown into a fit of coughing by inhaling it. It is called sulphurous oxide, a new name to you and one to be kept in mind. It will be worth your while to remember it, as you will presently see."

"Sulphurous oxide, then," said Marie, "is burnt sulphur; and it is something that can be neither seen nor felt, but that nevertheless does really exist. Whoever breathes it is immediately convinced of its existence by the penetrating odor and by the fit of coughing that follows."

"To what possible use," continued Uncle Paul, "can we turn this disagreeable gas, this invisible substance that makes you cough worse than if you had the whooping-cough? I will tell you. Despite its repulsive qualities, it is what we have to depend upon for giving wool the whiteness of snow. An example will demonstrate its efficacy to you. Go down to the meadow and pick me a bunch of violets."

The violets were soon gathered from under the hedge bordering the meadow. Then Uncle Paul put a little sulphur on a brick, set it afire, and held the bunch of violets, which he had slightly sprinkled with water, over the fumes. In a few moments the flowers, attacked by the sulphurous gas ascending from the blue flame, lost their color and turned perfectly white. The change from violet to white was plainly visible to the eye.

"How curious that is!" exclaimed Jules. "Just see how the violets whiten as soon as they come over the flame and feel the sulphurous oxide, as you call it. Some were half white and half blue; but the blue has disappeared and now the bunch is all white, without having lost any of its freshness to speak of."

"Let us now," suggested Uncle Paul, "try one of the red roses there on the mantelpiece."

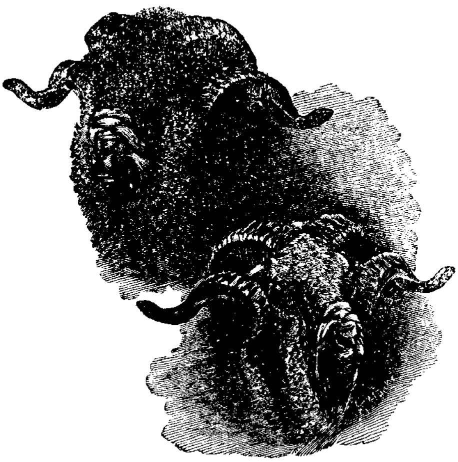
Accordingly the rose was held over the burning sulphur, and its red color faded away just as the blue of the violets had faded, giving place to white, much to the wonder of the children, who watched with breathless interest this marvelous transformation.

"That will suffice for the present," Uncle Paul resumed. "What I have just shown you with violets and roses might be demonstrated with innumerable other flowers, especially red and blue ones: all would turn white on being exposed to the sulphur fumes. You will understand, then, that these fumes, which we call sulphurous oxide, have the peculiar property of being able to destroy certain colors and hence to act as a bleaching agent.

"If, therefore, you wish to bleach wool, to remove the slight natural discoloration that stains its whiteness, you proceed exactly as you have just seen me do with the violets and roses. In a room with all its doors and windows carefully closed the wool in its natural condition—that is, before it has been spun into yarn—is hung up and a good handful or two of sulphur is set on fire in an earthen bowl. The room then becomes filled with sulphurous oxide and the wool turns a beautiful white."

"Would wool that is naturally brown or black turn in that room full of sulphur smoke?" asked Marie.

"No," was the reply; "its color is too fast to yield to the action of sulphurous oxide. Only white wool is subject to this action, under which it becomes immaculate. By the same process the straw of which hats are made is bleached, also skins used for gloves, and silk.



Head of Merino Ram
Before and after shearing.

"Wool varies in value according to the different kinds of sheep that have produced it, some being coarse, some fine and silky, some made of long hairs, and some of short. The most highly esteemed, that which is used in weaving fine fabrics, comes from a breed of sheep raised chiefly in Spain and known as merino sheep. Finally, a goat native to the mountainous countries of central Asia, the goat of Cashmere, furnishes a downy fleece of extreme fineness, an incomparable wool from which the most costly stuffs are manufactured. This goat wears, under a thick fur of long hair, an abundant down which shields it from the rigors of winter and is shed every spring. At that season the animal is combed and the down is thus detached separate from the rest of the hairy coat."

CHAPTER VI

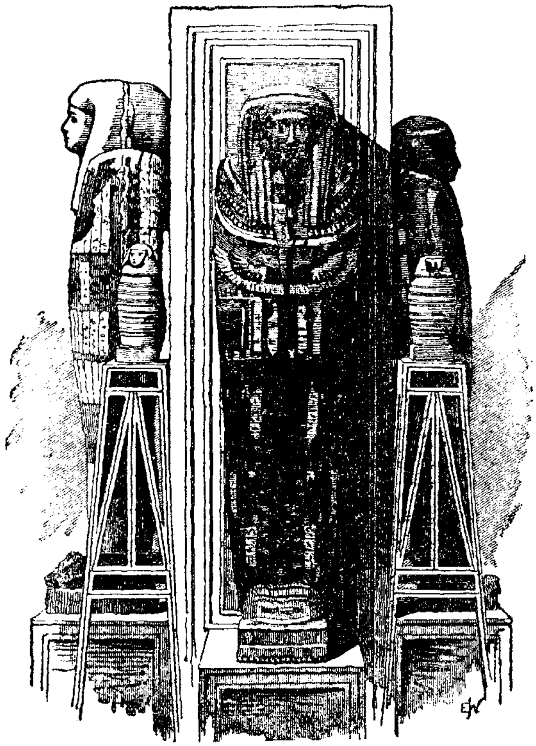
FLAX AND HEMP

"THE inner coating of the stalk of flax and hemp, as I have already told[1] you, is composed of long filaments, very fine, flexible, and strong, which are used like cotton in the manufacture of various fabrics. Flax gives us such fine fabrics as cambric, tulle, gauze, and laces of various kinds; hemp furnishes us stronger stuffs, up to the coarse canvas used for making sacks. Flax, as you have already learned, is a slender plant with small flowers of a delicate blue. It is sown and reaped annually, and is raised especially in northern France, in Belgium, and in Holland. The first of plants to be used by man for making fabrics, it was turned to account by the people of Egypt, the land of Moses and the Pharaohs, for the furnishing of linen bands with which to wrap the mummies that have been reposing in their sepulchres more than four thousand years. So carefully, indeed, were they embalmed and then wrapped in linen and enclosed in chests of aromatic wood that to-day, after the lapse of centuries upon centuries, the contemporaries of the ancient kings of

1 See "The Story-Book of Science."

Egypt, of the Pharaohs in other words, are found intact, though dried up and blackened by time."

"But in spite of all these precautions," objected Claire, "surely the mummies must have gone to decay if they were buried in the ground!"



Mummy Case of Kha-Hor,
between two others.
(Boulak Museum, Cairo, Egypt.)

"For that reason," replied her uncle, "they were not buried; they were laid away in orderly rows in spacious halls hollowed out of the solid rock of mountains. These mortuary halls, to which dampness never penetrated and the air had but little access, have kept for us intact, swathed in their linen bands, the bodies of the ancient Egyptians."

Uncle Paul next took up the subject of hemp, relating the history of its cultivation in Europe from early times and describing its appearance, with its small green flowers and its slender stalk about two meters in height. He explained that, like flax, it is grown both for its fibrous stem and for its seed, known as hempseed, which is used as a favorite food for certain singing-birds. From the seed are obtained hempseed oil and hempseed cake, the latter being sometimes fed to cattle.

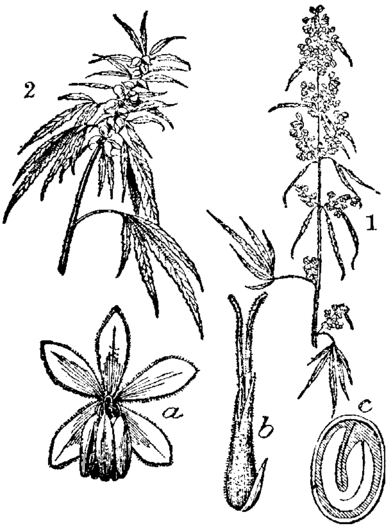
"And what is flaxseed good for?" asked Emile.

"From the seeds of flax," answered his uncle, "is obtained by pressure an oil called linseed oil, which can be used for lighting, but is chiefly employed in painting. For culinary purposes it is almost worthless, being of no use at all unless very fresh, and even then of but moderate value. Its principal use, as I said, is in painting, because of its quality of slowly drying and thus forming a sort of varnish which holds fast the pigment with which it is mixed. The coat of paint that overlies, for example, the woodwork of doors and windows is made of linseed oil in which has been stirred a mineral powder, white, green, or any other color chosen by the painter. When

Flax
Blossoming plant and section of seed-vessel.

flaxseed is ground it yields a powder much used for poultices, being of an unctuous nature soothing to pains.

"When hemp and flax are ripe they are harvested and the seeds are detached either by threshing or by passing the seed-bearing ends of the stalks through a strong iron-toothed comb. The comb is set up across the middle of a bench on which the two workmen seat themselves astride, one at each end, facing the comb. Then, by turns, they draw each his handful of flax or hemp through the comb, thus separating the seeds from the stalks.



Hemp

Male (1) and female (2) plants of hemp. *a*, male flower; *b*, female flower; *c*, embryo

"Next comes the operation known as retting, whereby the fibers of the bark are rendered separable from the rest of the stem and from one another. The gummy substance holding them together has to be disintegrated either by prolonged exposure in the field, where the flax or hemp is turned over from time to time, or, more expeditiously, by soaking the stalks in water, after first tying them into bundles. The resulting putrefaction liberates the fibers. Drying, breaking, and hackling them complete the separation of the fibers from the useless substance of the stem and their reduction to a condition in which they are ready for use.

"I will add that the fibrous part of hemp, as you may know already, is far coarser that that of flax. The filaments of the latter are so fine that one gramme of tow, spun on the wheel, makes a thread nearly one hundred and fifty meters long. Nevertheless, this product of man's skill, this linen thread that seems to reach the limit of fineness, is very coarse indeed when compared with what is furnished by the caterpillar and the spider. The highest degree of delicacy attainable by our fingers with the aid of the most ingenious machinery is but an enormous cable in contrast with the thread manufactured by a despised little worm. A single gramme of the silkworm's thread, as we find it in the cocoon, represents a length of two thousand meters, whereas the finest of linen thread of the same weight represents only one hundred and fifty.

"But even the slender filament spun from the silkworm's spinneret is incomparably coarser than the spider's thread, the achievement of that master artisan the very sight of whom evokes from you senseless outcries of alarm. To weave the airy textures intended to catch their prey, such as flies and gnats and similar small game, as also to line the dainty little sachets that hold their eggs, spiders on their part produce a sort of silk. The silk matter is contained in liquid form in the spider's body and is forced out as required through four or five little nipples called spinnerets, situated at the end of the insect's stomach, each of these nipples being perforated with many tiny holes, the total number of which for a single spider is reckoned at about a thousand. Hence the spider's thread as it leaves the insect's body is not a single strand, but a cord of a thousand strands, although we commonly consider it of almost infinitesimal minuteness. Our finest sewing silk is a stout cable in comparison, and a human hair has the thickness of ten twisted spider's threads or, in other words, of ten thousand combined elementary filaments of spider-silk. How inconceivably fine then must be a thread that needs to be multiplied ten thousand times in order to equal a human hair in size! The larger spiders that live in woods weave webs of remarkable amplitude, requiring each at least ten meters of thread, or ten thousand meters of the elementary filament emitted by a single aperture of the spinneret. But to make the entire web the spider uses up only a tiny drop of liquid silk, of which it would take hundreds of similar drops to weigh a gramme. What machine of human invention or what fingers could spin for us a thread of any such inconceivable fineness!"

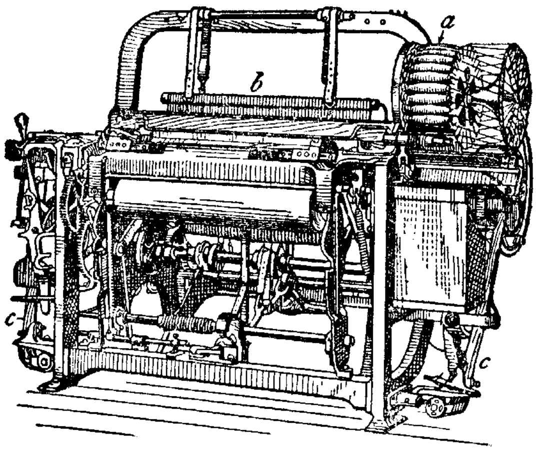
CHAPTER VII

WEAVING

"EXAMINE a piece of cloth, woolen, cotton, or linen, and you will see that it is composed of two sets of threads which cross one another, each thread passing alternately over and under a transverse one. Of these two sets one is called the warp, and the other the woof or weft, and their crossing produces the woven fabric, or cloth.

"The work of weaving these threads into cloth is done by means of a loom. I will try to describe to you an old-fashioned hand-loom, which is much simpler in construction than the modern power-loom. A solid wooden framework supports a cylinder in front and one at the back, and these cylinders are turned each by a crank whenever needed. The front cylinder, its crank within reach of the operator seated ready for work, receives the woven stuff a little bit at a time; the other, fixed at the opposite end of the machine, is wound with threads in regular order side by side. These threads will form the warp of the cloth, and they are stretched with careful regularity between the two cylinders the whole length of the machine. They are divided into two sets, the odd-numbered threads forming one set, the even-numbered threads the other. Two heddles hold the two sets and keep them separate without possibility of intermingling. A heddle is a series of very fine metal wires, or it may be simply threads, stretched vertically between two horizontal bars."

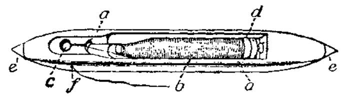
"The heddles are those two gridiron things in the middle of the loom?" asked Claire.



Modern Power-Loom

"Precisely. At every wire or thread of the heddle there is passed, in order, through an eye or ring, one of the strands composing the two sets of the warp. Now notice that by means of two pedals or levers placed under the operator's feet the two heddles can be made to rise and fall alternately. In this alternate movement they draw by turns, up and down, one the even threads and the other the odd threads of the warp.

"While the warp is thus slightly open, all the even threads on one side, all the odd on the other, the operator sends the shuttle through the space separating the two sets. The shuttle is a piece of boxwood, well polished so as to slide easily, tapering at each end, enlarged in the middle, and provided with a cavity that holds a bobbin of thread fixed on a very mobile axle. This thread unwinds automatically with the throwing of the shuttle, and is left lying between the two sets of threads of the warp. Then with a pressure on one of the pedals the order of these sets is reversed, the threads that were above passing below, those below coming uppermost, and the shuttle sent in the opposite direction leaves another thread stretched across. This thread furnished by the shuttle and passing by turns from right to left and from left to right between the two lines of the warp forms what is called the woof or weft of the cloth."



Shuttle

a, body of shuttle; *b*, yarn wound on bobbin *d; c*, eye through which the yarn is led and then passed out through hole *f; e, e,* metal points

"So the feet," said Marie, "by pressing the pedals make the odd and even threads of the warp move up and down, while the hands, sending the shuttle from right to left and then from left to right, interlace the thread of the woof with the warp."

"That is the double movement the operator has to learn—the pressing of each foot in turn on the pedals and the sending of the shuttle from one hand to the other. But in order that the cloth may acquire sufficient firmness, with no open spaces between the threads, these two movements are supplemented by a third. A comb-like instrument called a reed is used to 'beat up' or press close together the threads of the woof after every two or three passages of the shuttle through the warp, or sometimes after every passage, according to the nature of the fabric.

"Such, in short, my dear children, is the process by which all our woven fabrics of two sets of intercrossed threads are made, cloth, linen, taffeta, calico, and a great many others."

CHAPTER VIII

WOOLEN CLOTH

"I HAVE just given you a general description of the art of weaving. Now I propose to add some details relating to the more important products of the loom. And first let us take up woolen cloth.

"Woolen cloth is woven of woolen yarn. As it comes from the spinning wheel or spinning-jenny this yarn has certain surface irregularities, little bristling fibers standing up and crinkling with the natural curliness characteristic of wool. In this state the yarn would check the easy gliding of the shuttle, which must shoot back and forth with great rapidity; and thus the work would be rendered laborious and the woven fabric wanting in evenness of texture. The surface must be made as smooth and uniform as possible, the fluff flattened and held down the whole length of the thread. This is done by means of a preparation or facing with which the threads of both the woof and the warp are coated. In this preparation are glue, which holds down the fluff, and oil, which makes the surface slippery.

"Thus it is that, as it comes from the loom, cloth is badly soiled, carrying as it does a coating of glue and ill-smelling oil. Before these impurities become seats of decay the cloth must be cleaned, and it must be done as soon as possible. The operation is carried out in a fulling-mill, which consists of a series of heavy wooden clubs or beaters set in motion by means of a wheel turning in a stream. The beaters alternately rise and then fall with all their weight to the bottom of a trough continually sprinkled by a jet of clear water. The cloth is placed in the trough where, the clubs beat it one after another for whole days. But this energetic beating is not enough; the glue would disappear, but not the oil, which is more tenacious and on which water has no effect. Accordingly, recourse is had to a sort of rich earth, fine and white, which has the property of absorbing oil. It is called fullers' earth."

"That rich earth could be used then for taking out grease spots?" queried Marie.

"It is used for that purpose. All you have to do is to cover the grease spot for a while with a layer of fullers' earth made into paste, and the grease will disappear, being absorbed by the clay. In many countries it is used instead of soap for washing clothes."

"What a funny kind of earth!" Claire exclaimed. "I should like to wash with it. What is it like?"

"It is a white clay, greasy to the touch, taking a polish when smoothed with the finger-nail, and mixing readily with water, to which it gives a soapy look. In France the best-known fullers' earth is found in the departments of Indre, Isère, and Aveyron.

"Beaten with this earth for a number of hours by the heavy clubs of the fulling-mill, the cloth loses the oil with which it is impregnated. Soap-suds and finally pure water finish the cleaning.

"But the part performed by the fulling-mill is not limited to cleaning the cloth; it also shrinks the goods to half the original width and nearly half the length. In this connection I will call your attention to a precaution familiar to every good housewife. Before cutting out a garment she is careful to wet the cloth so as to shrink it as much as possible. If this precaution were not taken, the garment would shrink so in the first washing that you couldn't get into it."

"That is what happened to Emile's linen trousers," said Jules. "They came out of the wash so short they hardly reached to his knees."

"A rope shrinks, too, when it is wet," remarked Marie. "Once, after a rain, the clothes-line in our back yard shrank so that it pulled out the hooks it was fastened to."

"That reminds me of a little anecdote," said Uncle Paul. "When shortened by being wet, a rope exerts so strong a pull that not only can it extract hooks, but it can even lift immense weights. It is said that Pope Sixtus the Fifth, when he was about to erect in one of the public squares of Rome an obelisk brought from Egypt at great expense, ordered under pain of death the most profound silence during the operation, so anxious were the operating engineers on account of the enormous weight to be moved. I will tell you, before going further, that obelisks are tall, slender, four-sided columns engraved with a multitude of figures and crowned by a small pyramid. They are in one piece, of a very hard and fine-grained stone called granite. Their height, not counting the pedestal that supports them, may reach fifty meters, and their weight may range between ten thousand and fifteen thousand hundredweight. Judge, then, whether the erection of this ponderous mass upon its pedestal did not present difficulties.

"To operate in perfect unison the numerous ropes, pulleys, and levels used for raising the immense piece, absolute silence was necessary so that not a word should distract the workmen's attention. The square was crowded with curious idlers watching this mighty exertion of mechanical power. Complete silence reigned, every one bearing in mind the pope's order. But when the raising of the obelisk had proceeded half-way, the enormous stone refused to go further and remained leaning with all its weight on the ropes. Everything was at a stand-still. The engineers, at the end of their resources, saw their gigantic task threatened with failure, when suddenly from the midst of the crowd a man's voice rose at the peril of his life. 'Wet the ropes!' he cried. 'Wet the ropes!' They wet the ropes and the obelisk soon stood upright on its pedestal. The tension of the cordage when soaked with water had of itself done what an army of workmen had failed to accomplish."

"And what happened to the man who broke the silence?" asked Emile.

"The pope willingly pardoned him, you may be sure. But let us return to our subject of woolen cloth.

You can now easily understand what happens when this cloth is wet. It is made of crossed threads, each one of which, on being soaked with water, acts like a rope, that is to say it becomes shortened. The result of this is a closer texture. On drying, the cloth does not return to its original state, as a rope when dry resumes its former length; it remains close, because the threads held in position by their interlacing, are not free to slip. Thus by being put through the fulling-mill, where it is beaten and wet at the same time, the cloth which was at first loose enough to show the daylight between its meshes, becomes a firm piece of goods with warp and woof close together.

"The two sides of a piece of cloth are not the same: one, called the wrong side, shows the crossed threads of the fabric, otherwise known as the thread; the other, called the right side, is covered with a fine, even nap, all lying the same way. This nap is obtained by means of a kind of rude brush made of the thorny burs furnished by a plant called teazel, or fullers' teazel.

Fullers' Teazel
a, scale of the receptacle;
b, corolla.

"Teazel lives from one to two years. Its stalk, which attains the height of a man, is armed with strong hooked thorns and bears, at a certain distance apart, pairs of large leaves, each pair forming a cup more or less deep in which rain gathers. Growing from the main stem are six or seven branches, each terminated by a strong elongated head or bur composed of hard scales sharply pointed and recurved at the end in the shape of a fine hook. The plant is cultivated expressly for its burs, which are used in great quantities in cloth-manufacture. It would be difficult to replace this natural brush with any similar tool made by our hands, for nothing could give the same degree of needed stiffness and suppleness combined. Five or six of these burs are placed side by side so as to form a brush, which is drawn over the cloth always in the same direction. The thousand hooks of the teazel, each as fine as the slenderest needle, but elastic and supple, seize the tiny fibers of surface wool lying between the threads, and pull them out, laying them one on the other, all pointing the same way. The result of this operation is the nap which on the right side of a piece of cloth covers and hides the thread.

"But this nap is still imperfect: its tiny fibers are of unequal length, some long, some short, at haphazard, just as the hooks of the teazel brush drew them from the threads. To make it all smooth and even, it must be shorn; that is to say, large broad-bladed shears are used to pare down the surface of the cloth so as to leave the nap all of the desired length. This completes the essential part of the work. Sedan, Louviers, and Elbeuf are the chief cloth-manufacturing towns of France."

CHAPTER IX

MOTHS

"IN our houses," continued Uncle Paul, "we have a redoubtable enemy to woolen cloth and everything else that is made of wool—an enemy that in a very short time will reduce a costly garment to rags and tatters unless we are on our guard against the ravager. Therefore it is worth our while to make the acquaintance of this devourer of woolen goods, this despair of the housewife, in order that we may hunt it down with some success. You know the little white butterflies that come in the evening, attracted by the light, and singe their wings in the lamp-flame. They are the ravagers of woolen fabrics, the destroyers of broadcloth and other woolen stuffs."

"But those little butterflies," objected Claire, "are feeble little creatures to tear in pieces anything so substantial as broadcloth."

"And for that very reason it is not the butterfly itself that we are afraid of; the delicate little flutterer is perfectly harmless. But before turning into a butterfly it is first a caterpillar, much like the silkworm and this caterpillar is endowed with a voracious appetite that makes it gnaw substances apparently uneatable, such as wool, furs, skins, feathers, hair. To the caterpillar and its butterfly we give the name of moth."

"There are caterpillars, then, that eat cloth and even hair?" asked Marie.

"There are only too many of them," was the reply. "One of these caterpillars, one that some day will turn into a pretty little butterfly all powdered with silver dust, would feast right royally on your woolen frock; and another would find much to its taste your fur tippet, which keeps your shoulders warm in winter."

"There can't be much to taste in a mouthful of fur, I should think, and it must be pretty hard to digest."

"I don't deny it, but those caterpillars have stomachs made expressly for that sort of diet, and they accommodate themselves to it very well. A worm that eats fur and digests hair knows nothing in the world so good, and one that gnaws old leather would turn away with aversion from a juicy pear, a piece of cheese, or a slice of ham, all of them repugnant to its taste. Every species has its preferences and, according to its mode of life, possesses a stomach designed to find nutriment in substances apparently far from nutritious. On the moth's bill of fare are skins, leather, wool, woolen cloth, fur, and hair. The larva does not merely feed on these materials, but it also makes from them a movable house, a sheath that covers its body, leaving the head free, and this house it carries about with it.

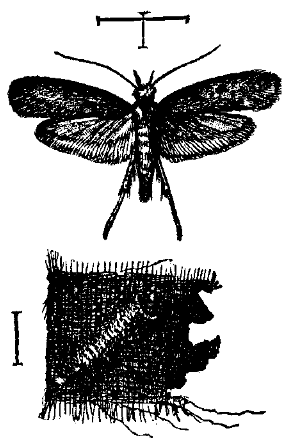
"All butterflies of the moth class have narrow wings bordered with an elegant fringe of silky hair and folded lengthwise on the back in repose. Of the three principal species the distinguishing characteristics are as follows:

"The woolen moth has black upper wings tipped with white, while the head and lower wings are white. Its grub, or larva, is found in woolen goods, and it is there that it makes for itself a sheath from the bits of the gnawed fabric.

"The fur moth has silver-gray upper wings with two little black dots on each. Its grub lives in fur goods, which it denudes, a hair at a time.

"Finally, the hair moth lives, in its grub state, in the curled hair used for stuffing cushions and couches. In color it is of a uniform pale red.

"The moth most to be feared is the one that feeds on woolen cloth. Let us discuss its habits more in detail, for in spite of its ravages you will admire, with me, the skill it displays in making itself a coat. To protect itself so that it may live in peace, the grub fashions for itself a sheath from the bits of wool cut and chopped with its sharp little teeth. In thus cutting down these upstanding hairs, one by one, the worm shears the cloth and makes a threadbare spot. The shearman himself could not have operated with such nice precision. But there is



Clothes-Moth
With piece of cloth attacked by larvæ. (Cross and line show natural sizes.)

nothing so disfiguring in new cloth as these shorn spots showing here and there the warp and woof of the fabric, while all the rest retains its velvet finish. Furthermore, the mischief is not always confined to the shorn spots: too often it happens that the tiny destroyer attacks the threads themselves and makes holes here and there in the cloth, so that the latter is found to be nothing but a worthless bundle of rags. The bits of wool thus cut away serve the worm either as food or as building-material for its movable house, its sheath.

"This latter is most deftly put together, consisting on the outside of tiny bits of wool fastened together with a little liquid silk emitted by the worm, and on the inside of silk alone, so that a fine lining protects the creature's delicate skin from all rough contact."

"Just think of it," exclaimed Jules; "the detestable devourer of our woolen clothes lines its own coat with silk!"

"And that is not all," continued Uncle Paul. "The little creature indulges in the luxury of assorted colors. Its coat takes the hue of the cloth in process of destruction, and thus there are white coats, black coats, blue coats, and red coats, according to the color of the material. If this latter happens to be of variegated tints, the worm takes a bit of wool here and a bit there, making for itself a sort of harlequin outfit in which all the colors represented are mingled at haphazard.

"Meanwhile the worm continues to grow and its sheath becomes too short and too tight. To lengthen it is an easy matter: all that is required is to add new bits of wool at the end. But how is it to be made larger?"

"If I had to do it," Claire replied, "I should run my scissors down lengthwise, and in the opening I should insert another piece."

"The ingenious insect seems to have taken counsel of Claire, or of an even better tailor," said Uncle Paul. "With its teeth for scissors it cuts open its coat all down its length and inserts a new piece. So skillfully is this insertion made, so neatly are the seams sewed with silk, that the most expert of dressmakers would find it hard to pick any flaw in the workmanship."

"These moth-worms must be very skilful, I admit," said Marie, "but I shouldn't like to have them practice their art on my clothes. How are they to be prevented?"

"To protect garments from moths it is customary to place in our wardrobes certain strongly scented substances such as pepper, camphor, tobacco. But the surest safeguard is to inspect the garments frequently, shaking them and beating them and exposing them to the sun. All moths love repose and darkness. Garments that are shaken occasionally and hung in the light are not at all to their taste; but those that are laid away for months or years in a dark place offer just the kind of snug retreat they are looking for, the ideal abode for the raising of a family. Go to your chests of drawers and your wardrobes very often and shake, air, and brush the contents; then you will have no moths. Vigilance is here worth more than pepper and camphor. Finally, kill all the little white butterflies you see fluttering about your rooms."

"But those little butterflies do no harm whatever, you told us," objected Emile. "It is only the worms that gnaw our clothes."

"True enough; but those butterflies will lay eggs by the hundred, and from every egg will come a devouring worm. The destruction of the flying moth means therefore deliverance from some hundreds of future moths."

CHAPTER X

NAPERY

"HEMP is woven into coarse material for towels and sacks, and even into finer material for sheets, chemises, table-cloths, and napkins. From flax is obtained still finer goods for the same purposes. Sometimes the same material contains both hemp and flax. Thus the goods known as cretonnes, manufactured at Lisieux and its environs, have the warp of hemp and the woof of flax. Sometimes, again, it is cotton that is mixed with hemp. Ticking, for example, is a very close fabric used for making coverings for bolsters and also men's summer clothes. Generally it is all hemp, but certain grades have a cotton woof. So it is that the three kinds of vegetable fiber—hemp, flax and cotton—can be used two together in the same material, which gives goods of greater variety and better adapted to the infinite uses for which they are destined.

"Goods of this sort generally bear the name of the country that produces them: such are the goods called Brittany, Laval, Valenciennes, Saint-Quentin, Voiron. Others are named after their inventor, as Cretonne, which derives its name from a manufacturer, Creton, who centuries ago gained a great reputation for linen-manufacture. One kind of linen, very fine and close, used for handkerchiefs and various articles of attire, such as veils, collars, and cuffs, is called batiste in honor of Baptiste Chambrai who was the first to make this material, and who introduced its use about five centuries ago.

"Material composed only of hemp and flax, either separate or together, is commonly called linen. Certain qualities distinguish these goods from cotton. To a delicate skin they have a cool and soothing feeling, whereas cotton, owing to its nap, which is slightly rough, produces a kind of tickling that may be positively disagreeable. Thus a cotton handkerchief irritates nostrils that have been made sensitive by a prolonged cold; but a linen handkerchief has not the same objectionable quality. And again, for dressing wounds it is customary to use linen or hemp bandages and lint obtained from old rags of the same material, since cotton, no matter how fine, and soft, would only increase the irritation of the wound by its rough contact with the quivering flesh. Finally, hemp and linen as used for underwear keep the skin in a state of coolness that is very agreeable in the heat of summer, but which may under certain conditions prove very disagreeable. Let perspiration be checked, let the body, poorly protected by its cool covering of hemp or linen, cool off quickly, and we are in serious danger. Cotton, on the contrary, stimulates the skin slightly, keeps it warm, and affords better protection when perspiration is arrested. In this respect it is preferable to linen and hemp. But I will come back to this subject after some details that I wish to give you in a subsequent talk on the conservation of heat.

"As soon as hemp has been spun into thread by the long and patient labor of the distaff, it is sent to the weaver, who coats it with a preparation of glue to facilitate the play of the shuttle, stretches it on his loom in parallel lines, and weaves it as I have already explained to you, each foot pressing in turn one of the pedals that operate the warp, and the two hands throwing, one to the other, the shuttle which stretches the thread of the woof between the two sets of warp threads. A good washing cleans the cloth, removing the preparation I have referred to and all impurities contracted during the weaving. But that is not enough to produce the beautiful white cloth that the housewife cuts into shirts and sheets. Hemp and flax are, in fact, naturally of a light reddish tint, so firmly fixed that only after repeated washings will it entirely disappear; which explains why sheeting is whiter as well as softer the longer it is used.

"As a first step in bleaching, the linen is spread on the ground in a well-mown field, where for whole weeks it remains exposed to the daylight and to the damp night air. The prolonged action of air and sun, dryness and dampness, at length fades the reddish color, which subsequent washings will, little by little, finally remove altogether.

"This bleaching by exposure to sun and rain is very slow. Moreover, when the operation has to be carried on uninterruptedly and on a large scale it is very costly, because it renders unproductive considerable stretches of land. Consequently in hemp, linen, and especially cotton factories recourse is had to means that are at once more energetic and more expeditious. You remember how easily and economically wool and silk are bleached by burning a few handfuls of sulphur, thus generating a gas called sulphurous oxide. It is only necessary to expose wet wool and silk for a few hours to the action of this gas to give them the dazzling whiteness of snow."

"Is that the way hemp, flax, and cotton are treated?" asked Marie.

"Not quite, although the method employed much resembles that used for wool. Sulphurous oxide would have no effect here, so difficult is it to destroy the natural color of hemp, flax, and cotton. Something stronger, something more drastic, must be used."

"But that sulphur smoke is pretty strong; it pricks your nose like needles, and makes you cough till the tears come."

"Yet it is nothing in comparison with the drug used for bleaching. This drug is also a gas—that is to say, a substance as impalpable as air, but at the same time a visible gas, for it has a light greenish color. It is called chlorine. If you breath a whiff of it, you are immediately seized with a violent cough such as you would never get in winter, however cold it might be. The throat contracts painfully, the chest is oppressed, and you would die in frightful torture if you inhaled this formidable gas three or four times in succession.

You can see, then, what precautions one must take in factories not to expose oneself to the terrible effects of chlorine."

"And what does it come from, this gas that strangles people if they breathe ever so little of it?" asked Claire.

"It comes from common salt, the same salt with which we season our food. But I must add that in salt it is not found all by itself; it is mixed with another substance which renders it harmless, even wholesome. Once freed from this partnership it is murderous, a frightfully destructive agent. I am sorry I cannot show you its astonishing power in destroying colors; but nothing prevents my telling you about it. Imagine a sheet of paper not only covered with characters traced by the pen but daubed all over with ink. Now plunge this into chlorine gas, and writing and ink-blots all disappear instantly, leaving the sheet of paper as white as if it had never been used. Suppose, again, you put chlorine into a bottle of ink. The black liquid fades quickly and soon there is nothing left but clear water.

"After this you can understand that the material to be bleached has to be subjected to the action of chlorine for only a few moments in order to turn whiter than through long exposure in the field."

"If the deep black of ink is destroyed so quickly," remarked Marie, "the pale reddish tinge of hemp or linen is not likely to hold out very long."

"Wool and silk," Claire observed, "ought to be bleached that way too: it would be much quicker."

"The manufacturers are very careful not to follow any such method," was the reply. "This gas corrodes wool and silk, soon reducing them to a mere pulp."

"And yet cotton, flax, and hemp can stand it," Claire rejoined.

"Yes, but their resistance to the action of drugs has not its equal in the world, and this resistance gives them a very peculiar value. Think in how many ways cloth of this sort is used, and what severe treatment it undergoes: repeated washing with corrosive ashes, rubbing with harsh soap, heating, exposure to sun, air, and rain. What then are these substances that withstand the asperities of washing, soap, sun, and air, that even remain intact when all around them goes to decay, that brave the drugs used in manufacturing and emerge from these manifold tests softer and whiter than before? These almost indestructible substances are hemp, flax, and cotton; and they have no rivals."

CHAPTER XI

CALICO

"IT now remains for me to tell you about the principal weaves of cotton. First there is percale, which has a firm and close texture and a smooth surface, and is much used for shirts, curtains, covers, and sometimes for table and bed linen. Ornamented with colored designs, it is also used for dresses.

"Percale, diminutive of percale, as its name shows, is a fabric of inferior quality and of transparent texture, being very loosely woven. Its thread is flat and its surface fluffy and plush-like, whereas in percale the thread is round and the surface smooth. It lacks firmness and does not last long. It is used chiefly for lining.

"Common calico is less fine, less firm, and cheaper than percale, but is used in general for the same purposes.

"Muslin is a very fine, soft, light material, the most delicate of all cotton goods. There are some muslins that for fineness almost rival the spider's web, and of which a piece several yards long could be contained in an egg-shell. Among muslins are classed nainsook, organdie, and Scotch bastiste.

"Cotton has a decided superiority over flax and hemp in that it readily takes any desired color or ornamental design, the dyes being quickly absorbed, lastingly retained, and shown off to the best advantage. Who does not know these admirable goods in which the most varied and brilliant colors are artistically combined and our garden flowers are reproduced in astonishing perfection? Some of these prints are decorated with flowers such as no garden could furnish. Cotton alone lends itself to this richness of coloring, hemp and flax being absolutely inadequate. Cotton goods ornamented with colored designs are called prints, and they first came from India, where their manufacture has been known for a very long time. To-day the factories of Rouen, Mulhouse, and England supply these goods to the whole world. It will interest you to hear about some of the methods employed by the calico-printer in his delicate work. How were those beautiful designs obtained, so clear and bright, that ornament the most inexpensive dress? That is what I propose to tell you in a few words.

"First the fabric is bleached with the greatest care so that no dinginess of its own shall dim the brightness of the colors to be received. Energetic washing, over and over again, and the powerful bleaching agent I have just spoken of, namely chlorine, make the cotton perfectly white.

"Now comes an operation that would fill you with astonishment if you happened to see it: it is the operation of singeing. I must tell you to begin with that all cotton thread, however perfect the spinning machine producing it, is covered with a short down or fluff consisting of the tip-ends of the vegetable fibers standing up by their own elasticity. At the time of weaving this fluff is laid flat by means of a preparation of glue, so as to leave perfect freedom for the play of the shuttle; but now this preparation, which would greatly interfere with the setting of the colors, has disappeared to the last trace, and the fluff of the threads stands up free again. Well, on such goods, all bristling with tiny filaments, the colored designs would not take well; there would be unevenness of tint, ill-defined outlines; cracks and seams, in fact. The surface must be as clean and smooth as a sheet of paper. It would be well-nigh impossible to obtain with shears such as are used for shearing woolen cloth a surface as smooth as the subsequent operations demand. Accordingly it is the custom to have recourse to the use of fire. The material is passed with the necessary rapidity before a broad jet of flame, which thoroughly burns off every bit of fluff without in the least damaging the fabric itself. Nothing is more extraordinary to the novice than to see a piece of calico or percale or even muslin passing through the menacing curtain of flame without catching fire."

"And who would not be surprised!" exclaimed Marie. "I should think the delicate fabric would certainly catch fire."

"You would think so, but there is no danger if the material passes quickly along and does not give the heat time enough to penetrate beyond the fluff. Let us dwell a moment on this peculiarity, which will enlighten us concerning a very remarkable attribute of cotton.

"You know what happens when you put the end of a piece of cotton thread into the lamp flame. The part thrust into the flame is consumed at once, but the fire spreads no farther and goes out just at the point where the thread ceases to be enveloped by the flame. With a piece of linen or hemp thread the result would be a little different: the thread would continue to burn more or less beyond this limit. That is on account of the different manner in which cotton on the one hand and flax and hemp on the other act under the influence of heat. Cotton is rather impervious to heat: flax and hemp, on the contrary, offer only feeble resistance to its spreading. I will not say any more on this point now, but will return to it some day with the necessary details.

"The few facts I have given you are sufficient to explain what takes place in the singular operation of singeing. If the fabric passes through the fire quickly and at an even rate of speed, the flame envelops it on both sides and even traverses the meshes, burning off all the fluff without injuring the threads themselves, because the heat has not time to spread further.

"To banish once and for all your incredulity in regard to this singeing process I will show you an experiment which, indeed, has no close connection with the calico-printer's art, but which illustrates the different degrees of inflammability possessed by different substances. What should you say if I were to tell you that live coals can be placed on the finest muslin without burning it in the least?"

"I should say, 'Seeing is believing,'" answered Claire.

"Then you shall see, Miss Incredulous. Take a piece of muslin, as fine as you please, and wrap it tightly around once of the brass balls that ornament the top of the stove. Tie it securely underneath with a string so that the muslin will touch the metal in every part. Now take from the open fire a live coal and apply it with the tongs to the muslin that covers this kind of doll's head."

Claire followed these directions with scrupulous care: the live coal was touched to the muslin, and, greatly to the surprise of all the children, the delicate fabric remained perfectly intact.

"Go still farther," commanded Uncle Paul. "Take the bellows and make the live coal burn as brightly as you like, letting it rest on the muslin while you do so."

Claire worked the bellows, the coal became red-hot all over, and still the muslin underwent no change, appearing to be quite incombustible.

"Why, this is unbelievable!" she cried. "How is it that muslin can stand the touch of a live coal without burning the least bit?"

"What protects it from the fire," replied her uncle, "is the metal underneath. The brass, a substance easily penetrated by heat, takes to itself the heat of the coal and leaves none for the muslin, which is much harder to heat. But if the delicate fabric were by itself, it would burn at the first touch of the live coal."

Several times during the day Claire repeated this experiment by herself, each time more astonished than before at this strange incombustibility.

CHAPTER XII

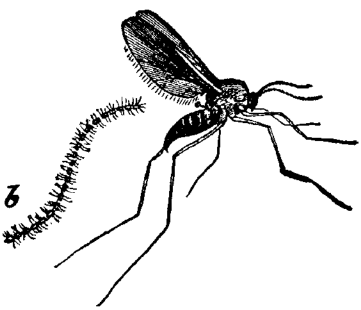
DYEING AND PRINTING

"ARRIVED at this point, the cotton cloth is ready to receive the colors. This operation involves the use of means so varied and technical knowledge so above your understanding that I should not be understood if I undertook to enter into some of the more elaborate details."

"I supposed, on the contrary," said Claire, "that it was a very simple thing and that the colors were put on the cloth with a paint-brush just as I should do, though not very well, on a sheet of paper."

"Undeceive yourself, my dear child: the paint-brush has nothing to do with printed cottons, nor yet with the other kinds of goods embellished with colors. Done with a paint-brush, the designs would not be lasting, but would disappear with the first washing. The slightest rain would make the colors run and would turn them into horrible shapeless blots. To resist water, and sometimes vigorous washing with soap, the colors must penetrate the fabric thoroughly and become embodied in it.

"Let us see how this result is arrived at, taking black for an example. This color is obtained in various ways, notably with ink, the same that we use for writing. Well, if we immersed a strip of white material in this liquid it would come out black, but the color would have no staying power. A little rinsing in water would remove most of the ink, and the small amount remaining would give only a pale tint, very insufficient and soon washed out. In order to give a deep and lasting black the ink, when it is applied to the fabric, must be in an unfinished state, and it must finish itself in the cloth; the ingredients of which it is composed must mingle and become ink in the very substance of the threads. Under these conditions the black, made on the spot and permeating the minutest fibers of the cotton, acquires all the desired fixity and intensity. Let us, then, before going further, examine the ingredients of which ink is composed.



Gall-Fly
Female. natural size;
b, male antenna magnified

"There are found growing on oak-trees certain globular formations of about the size of a billiard ball and with the appearance of fruit. But they are not really fruit; they have nothing in common with acorns, the real fruit of the oak. They are excrescences caused by the sting of a tiny insect known as the gall-fly. This insect stings the leaf or tender twig with a fine gimlet that arms the tip-end of its stomach, and in the microscopic incision it deposits an egg. Around this egg the sap of the tree gathers, finally forming a little ball which by degrees becomes as hard as wood. The insect hatched from the egg develops and grows in the very heart of this ball, whose substance serves it as food. When it has grown strong enough it pierces the wall of its abode with a small round hole through which it escapes. That is why you see most of these balls pierced with a hole when they fall to the ground toward the end of autumn. These round excrescences are called gallnuts or oak-apples, and they furnish one of the ingredients of ink, one of the materials used for dyeing black.

"The other ingredient is green copperas. At the druggist's you may have seen a substance looking something like broken glass of a light green color with spots of rust. That is green copperas. It is obtained by dissolving iron in an excessively corrosive liquid known as oil of vitriol or sulphuric acid. This terrible liquid, so dangerous in inexperienced hands, dissolved iron as easily as water dissolved salt or sugar; and in this solution, after a certain time, crystals are formed. It is this crystallization that gives us our green copperas, a substance having none of the dangerous qualities of the oil of vitriol used in making it, but one that can be handled without the least risk, though its taste is most disagreeably tart. This substance dissolves very readily in water.

"That is all that is needed for making ink. Let us boil a handful of pounded gallnuts in water; we shall obtain a pale yellowish liquid. Also, let us dissolve some copperas in water, and the latter will turn a very pale green with a yellowish tinge. What will happen on mixing the two liquids, one yellow and the other green? Nothing very remarkable, it would seem. And yet no sooner do these two liquids mingle than there is produced a deep black, the very color of ink."

"And so the ink comes all of a sudden," said Maria.

"Yes, the very instant the gallnuts and the copperas meet in the water that holds them in solution. If ink for writing is desired, however, a little different method must be followed so as not to have an excess of water, which would weaken the color. To the liquid resulting from boiling the gallnuts there would simply be added the undissolved copperas with a little gum to give brilliance to the ink. I have gone out of my way in describing to you this mingling of two liquids in order to show you the more clearly how the union of two substances, each having little or no color, can produce a color totally unlike either of the original shades. From two liquids, one a pale yellow, the other a pale green, you have just seen ink spring into being with startling suddenness. Remember this phenomenon, for it will explain certain results of dyeing that are very astonishing to the uninitiated. Bear in mind that sometimes perfectly colorless substances can produce magnificent colors by being united.

"Now that we know how ink is made, let us return to the subject of dyeing black. We put a piece of percale to soak in water in which gallnuts have been boiled;

then, when it is well saturated, we take it out and dry it. What, now, will be its color!"

"It will be the color of the gallnut water," answered Claire; "that is to say, a pale and dirty yellow."

"Right; but if the fabric thus saturated is dipped into a solution of copperas, what will happen?"

"That is not hard to guess," was the reply. "The copperas, finding gallnut dye on the surface and in the texture of the cloth, all through it in fact, will immediately form ink, which will color the percale black."

"And more than that," added Marie, "the dye will penetrate the goods evenly in every part, since the saturation with gallnut water extends to the very tiniest thread of the material."

"Yes; and so you see that in this way the black dye is formed on the spot, in the very heart of the cotton threads. Thus we obtain a fast color, all the necessary conditions being complied with.

"A great many other colors—red, violet, brown, yellow, lilac, no matter what—are produced in similar fashion. First the material to be dyed is saturated with a solution that will develop the desired color, or make it spring into existence, on encountering another solution, and will set the color by making it one with the fabric itself. This preparatory substance which in a second operation is to mix with the dyestuff so as to develop and fix the color is called the mordant and varies in kind according to the tint desired, so that by changing the mordant different colors may be obtained with one and the same coloring matter."

"In the same way you have just explained to us," said Marie, "we get cloth dyed all one color. I should like to know how patterns of several colors on a white ground are made."

"That is done by printing or stamping. Imagine a small wooden block or board on which is engraved in relief the design to be reproduced. Clever engravers skilled in all the details of ornamental design prepare these blocks, which are sometimes veritable masterpieces of art; and it is these that constitute the calico-printer's all-important equipment.

"To take a simple example, let us suppose the workman proposes to put a black design on a white ground. On a large table in front of him he has the piece of percale which unrolls as he needs it; in his right hand he holds the printing-block. The engraved design, which stands out in relief, he moistens slightly with a fine solution of gallnuts, and then applies the block to the goods. The parts thus touched are the only ones impregnated with this preparation, the rest of the percale remaining as it was before. He continues thus, each time dipping the engraved face of the block into the gallnut preparation, until the piece of cloth has received the impression throughout its entire length.

"That done, all that is necessary is to dip the goods into a solution of copperas to make the design appear in black, since the ink forms wherever the wooden mold has left a deposit of gallnut water, all other parts remaining white."

"It is simpler than I had thought," said Claire, "and much simpler than using a paint-brush, as I supposed at first must be the way."

"The operation can be made still simpler. As a rule the coloring matter and the mordant, that is to say the substance that brings out the color and fixes it, act only under the influence of the heat. Accordingly, the process is as follows. The two ingredients, mordant and coloring matter, are mixed together and reduced to a fine pap with which the engraved surface of the block is moistened and then immediately applied to the fabric. The preparation thus deposited gives only one color, one alone, determined by the nature of the mordant and the coloring matter. If the design is to be multicolored, as many blocks must be used as there are tints, each block representing only the part of the design having the color it is to imprint on the goods. Thus the piece of percale passes through the workman's hands once for red, again for black, a third time for violet, in fact as many times as there are colors in the design, however little they may differ from one another."

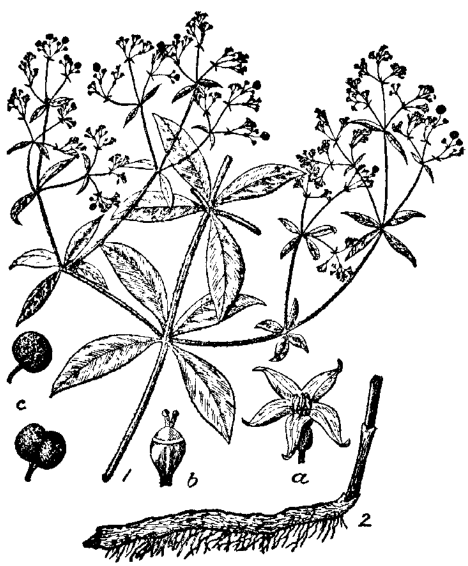
"It must be a very delicate piece of work," remarked Marie, "to put the different parts of the design exactly in the right place so as to get from them all a pattern with the various colors joining perfectly and never overlapping."

"The calico-printer's skill makes light of this difficulty. The design comes out as clear as a painter could make it with his brushes. To complete the description in a few words, when all the colors have been applied, the fabric is removed to a closed room where it receives a steam bath. Heat and moisture aiding, each dye mixes with its mordant, which incorporates it with the fabric, and beautiful bright tints spring forth as by enchantment where the engraved blocks had left only a sorry-looking daub."

CHAPTER XIII

DYESTUFFS

"COULDN'T you tell us, Uncle Paul," said Marie, "how all those colors we see on printed goods are obtained? There are such beautiful reds, blues, violets, that real flowers can hardly compare with them."



Madder

1, branches with flowers and fruits; 2, the rhizome; *a*, blossom; *b*, the pistil; *c*, two different fruits

"Yes, I will tell you. Let us first take madder, the most valuable of dyestuffs on account of the beauty and fastness of its colors. It is the root of a plant cultivated in France, chiefly in the department of Vaucluse, and of about the size of a large feather, reddish yellow in color. The preparation it undergoes before being used in dyeing consists simply in reducing it to very fine powder and purifying it as much as possible.

"Madder by itself imparts absolutely no color to any stuff, be it silk, wool, cotton, or whatever other you please. One might boil for days at a time a piece of percale in water containing powdered madder; the fabric would remain white. For the color to take form and impress itself on the stuff there is some essential condition lacking."

"No doubt it needs what you call the mordant, that substance that mixes with the dye to bring out the color and fix it on the goods, just as gallnuts bring out the black of ink by mixing with copperas."

"That is it: it lacks the mordant. In the case of madder this is sometimes iron-rust and sometimes a white substance resembling starch and called alumina, which is obtained from very pure clays. If the material to be dyed is first saturated with a strong solution of alumina, it takes a dark red tint on being dipped into boiling water containing a proper amount of powdered madder. If the quantity of alumina is small, the resulting tint is simply rose-color. Thus by varying the proportion of the mordant any shade can be given to the fabric, from the deepest red to the palest pink.

"With iron-rust for mordant other colors quite unlike the preceding are developed. A liberal quantity of rust gives black, a small quantity violet—always with madder, be it understood. Finally, if the mordant is a mixture of alumina and rust the color produced is a chestnut brown, intermediate between red and black, and varying in shade according to the proportions of the ingredients used. You see, then—and it cannot fail to surprise you, that with a single dyestuff, madder, it is easy to obtain a numerous series of tints ranging from dark red to pale pink, from deep black to delicate violet, and including also the chestnuts or mixtures of red and black.

"Let us suppose the calico-printer has stamped the different mordants on the goods with his printing-block and has artistically grouped them to obtain bouquets of flowers. This done, the cloth appears merely soiled with unsightly blotches, the iron-rust showing with its dirty yellow, while the alumina, being colorless, remains invisible. But as soon as the piece is plunged into a boiling bath of madder each mordant attracts to itself the coloring matter dissolved in the water, incorporates it, and with it forms such and such a color according to its nature. The reds, pinks, blacks, violets, chestnuts, all come out at the same time before our astonished eyes, which at first might imagine themselves beholding the birth of enchanted bouquets."

"If you had not explained this curious operation," said Claire, "I should have been astonished to see those magnificent printed bouquets taking shape all by themselves in the confusion of that boiling vat."

"Then it is in that one vat," added Jules, "containing only water and madder, that there are formed all at the same time the reds, pinks, and violets for the flowers, the chestnuts for the bark of the branches, and the blacks for the shadows. The bouquets lack only the green of the leaves to be complete."

"Madder does not give green; another substance and another operation are necessary to obtain that color. Nevertheless, who could fail to perceive the importance of madder, that one substance which furnishes so many hues, so remarkable not merely for their beauty but also for their unequaled permanence? No other dyestuff contains in itself so many excellent qualities."

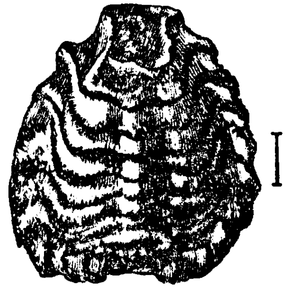
"And the other colors—blue, for example—how are they obtained?" asked Marie.

Woadwaxen or Dyers' Greenweed

"The most lasting blue is the product of a plant called the indigo-plant. It is too cold in our part of the world to raise this plant, but it grows on the warm, damp plains of India. It is the leaves that are used. They are green at first, but if they are allowed to go to decay in water containing a little lime, a substance having a superb blue color and called indigo is formed from them.

"A very beautiful yellow remarkable for its fastness is prepared from a plant that grows around here and is known as woadwaxen or dyers' greenweed, bearing flowers closely resembling those of the mignonette, so famous for its sweet odor. By mixing this yellow with blue we obtain the green that Jules spoke of as needed for the leaves of the bouquets.

"A small, rather ugly-shaped insect gives the dyer his most beautiful reds. It is known as the cochineal, and it lives all its life in one spot, as do the lice of our rose bushes. It infests a fleshy plant whose branches are flattened in the shape of a palette and studded with tufts of thorns. This plant is known under the names of nopal, cactus, Indian fig, and Barbary fig. Mexico produces most of the cochineal. The insect is gathered from the nopal, killed by immersion in boiling water, and dried in the sun. It then looks like a little wrinkled seed. About one hundred forty thousand insects are required to make one kilogram in weight. It is only necessary to boil the cochineal in water to obtain a red liquid which deposits as sediment the beautiful coloring matter known by the name of carmine. Wool and silk are dyed scarlet with cochineal.



Female Cochineal
Dried specimen of commerce.
(Line shows natural size.)

"I will conclude with a few words on the brightest, clearest of all dyestuffs, but unfortunately, also, the most changeable, the most evanescent. Recall the splendid hues now given to wool, silk, and above all to ribbons. The rainbow alone can rival them. Now do you know the origin of these colors, so pure, so bright, so charming to the eye? They come from a horrid, malodorous substance called coal-tar.

"In the first place you should know that illuminating gas is obtained by heating coal red-hot, in large iron vessels to which no air is admitted. The heat liberates at the same time gas for lighting and tar which is set aside by itself; there is then left a kind of coal, light, shiny, full of holes, and called coke. Let us turn our attention to the tar only, which despite its disgusting appearance is one of the most marvelous products known to the manufacturing world. By treating it first in one way, then in another, and after that in still another, there are obtained from it a number of very different substances, some resplendent like mother-of-pearl or the scales of fishes, others white and powdery like fine flour, and still others resembling limpid oil and having in certain instances a strong and disagreeable odor and in others an aromatic fragrance. When this separation is complete, we have at our disposal various substances which further processes will transform into colors of all kinds. One of these substances derived from coal-tar, and at first a colorless oil, becomes an azure blue that would not disfigure the wing of the most gorgeous butterfly; another, at first a floury powder, reproduces exactly the colors yielded by madder; a third gives shades of red beside which the queen of flowers, the rose, would look pale. But one capital fault[1] is common to most of these splendid colors obtained by man's skill from the somber coal: hardly any of them can stand the least washing without injury, and even light alone fades them quickly.

"Colors that are really fast, those that last as long

1 This fault has now been corrected.—*Transaltor.*

as the fabric that bears them, and can without fading stand light and soap, are particularly the colors obtained from madder, the browns and blacks into the making of which gallnuts have entered, the blues from indigo, and the yellows of woadwaxen. Beware of a dye that charms the eye but turns dim under the first ray of sunlight or with the first washing."