routine of schooling, and so gain under protest, often by stealth, a partial preparation for real life. If the schools did not usually get the credit for good results obtained in this way by the independent and unencouraged efforts of their pupils, it is probable that it would be much easier than it is to do away with the traditional obstructions to real education which linger in most schools and courses of study.

One of the great problems of to-day is to infuse a larger share of modern spirit into school life and school work; to lessen largely the amount of book learning and increase the proportion of individual effort in dealing directly with realities; in short, to make the student more of a doer and less of a passive recipient of vague generalities.

The progress of the schools in this direction during recent years has not been small; yet it has been slight and limited compared with the rapid and general advance in public needs and individual requirements. In every department of active life the call is for men untrammeled by tradition, men trained to challenge every alleged fact and natural law until its truth is proved; bold men, used to the solution of real problems and undaunted by novel difficulties; alert men, ready to grasp every opportunity for improvement in materials and processes, and skilled in the use of everything that ministers to economical success. The schools should help to develop such men. Now they oftener hinder such development.

SILK AND HOW IT IS DYED.

Otto N. Witt and E. Noelting have recently contributed an interesting essay on silk and silk dyeing to the *Chemiker Zeitung*, from which we abstract such points as are likely to interest the readers of the SCIENTIFIC AMERICAN.

Silk holds the same place among fabrics that gold and the diamond do among metals and gems respectively. It is the noble, the royal fiber. Silk has that peculiar luster, that agreeable feeling, which charms our senses. The fiber itself, as it is unwound from the cocoon, consists of two parallel, thick, glossy threads stuck together lengthwise. These threads are so highly polished that the best objectives are unable to disclose any irregular or uneven spots, which fact is expressed in a general way by saying that silk is structureless It is evident that such must be the case, for it is nothing but a solidified liquid thread, resembling in every respect a glass rod. Cotton, on the contrary, is a tube, not a round but a flattened tube, irregularly pressed together, which almost always contains minute granules of dried plasma that once filled the tube. A glass rod is more brilliant than a dusty tube irregularly formed or flattened. Glass wool spun from glass rods has more luster than that spun from glass tubes.

To obtain a similar simile for wool one must compare it to rods of unglazed porcelain, or better still porcelain rods covered with "craquelé," or crackled glass. This represents the bleached wool before it is dyed. When dyed, the conditions are still more favorable on the side of the silk.

The dyer utilizes the great affinity that the silk fiber has for certain chemical compounds, or rather its power of precipitating substances from their solutions and combining with them. The coloring matter is not, however, deposited on the surface of the silk in granular or crystalline form, but is dissolved in the silk and distributed through it just as it was previously dissolved in the dye-bath. The fibroine, or silk substance, is not a base that combines with an acid dye, nor yet an acid which unites with basic coloring matters to form insoluble salts; silk makes no distinctions between acids and bases; it absorbs both just as a sponge sucks up water. It does not even confine itself to dyes, but has the same attraction for many uncolored substances, such as sugar and many metallic salts. Of course the exterior portion of the fiber takes the most, and only gives up to the interior portion the excess that it is unable to retain for itself. Under the microscope the cross-section of dyed silk is seen to be shaded from the center outward, the circumference being darkest, and the center usually white with intermediate shades between.

With wool the case is quite different. Its scales are horny and have but little affinity for dyes. On warming or boiling the dye-bath, the dye penetrates into the interior of the fiber, which then becomes saturated with the pigment as in the case of silk. Consequently, wool is a dark colored substance surrounded by a covering that has little or no color.

Cotton has no affinity for dyes, but it is hollow, and the cellulose of which it is composed is osmotic, and on this the dyer bases his processes. He first treats it with mordants, which are solutions of different substances that pass through the walls of the cell into the interior of the fiber. He then washes off the excess of the mordant that has not been absorbed. It is next put into a solution of some dye likewise capable of osmosis, when this also penetrates the cell walls, where it comes into contact with a mordant already stored up there, when a mutual decomposition takes place and an insoluble colored compound is precipitated within the cell, and cannot subsequently be removed by any amount of washing. In a cross-section of dyed cotton examined under the microscope, the cell walls are seen as a long colorless ring in which are deeply colored granules. Hence, in this case too we have a dark colored substance seen through a colorless, or nearly colorless, envelope.

The optical effect of dyed silk is just the opposite of cotton and wool. To make use of our comparison again, silk resembles a white substance viewed through colored glass, while the two other fibers may be likened to colored substances seen through *verythin* colorless glass.

We emphasize the fact that the colorless layer is very thin, for we must recollect that very thin plates of colorless substances produce a play of colors, as can be seen at any time on soap bubbles or very thin glass balls. These interference colors are very prominent in the thin colorless layers that overlie the colored portions of cotton and wool. We are unconscious of this play of colors here because the number of transmitted rays greatly exceeds that of the reflected ones. Nevertheless this play of colors is sufficient to dim the luster of the color beneath. It is easy to prove that this lack of luster is due to a phenomenon of this sort by wetting the fiber, which will increase its luster, for the interference produced in these thin layers is much less in water than in air. If it were possible to find a liquid having exactly the same index of refraction as these colorless layers, the colored core within would appear in all its true beauty.

Silk is free from this disadvantage; the center being colorless, and the surface colored, heightens the effect. Here again we have a good example in glass making; it has long been known that "flashed" glass (white glass covered with a thin layer of colored glass) is more brilliant than where the entire mass is colored.

We have already said that the fiber from the cocoon consists of two cylindrical threads glued together; we must now recall the fact that in reeling off the cocoons, several of these double fibers are always united into one thread for spinning. Different qualities of silk differ in the number of fibers thus united and in the manner of combining them. What is called "Tram" consists of a small number slightly twisted, while "Organine" has a greater number, and is hard twisted. A third quality of silk called "Chappe," or floss, is made by combing and spinning the waste of the cocoons which is left after making the other two qualities. This last is generally used for velvet or for mixing with cotton.

Silk is almost invariably dyed before it is woven, so that silk dyers are generally "skein dyers." Piece dyeing is the exception and is generally limited to poor qualities, or to half silk goods.

The preparation of the silk for dyeing is rather complicated, the object being to impart to it that beautiful whiteness and to develop that luster which distinguish it from other fibers. This is called "ungumming, or *décreusage*. Before this is done the finest organzine has a dirty yellow, or yellowish, gray cream color, sometimes greenish, according to its origin, and is hard and lusterless.

In order to understand the action of the reagents employed in degumming silk, we must first briefly consider the chemical composition of silk.

The raw undressed silk consists of the real silk "fibroine," which forms the center, or core, and the so-called silk-gum, a glue-like substance consisting of albumen, fat, resin, and coloring matter, which forms a crust around it. The object to be aimed at is the complete removal of this crust with the least possible injury to the fibroine. According as this is more or less perfectly accomplished different qualities of silk are obtained, which are known as:

(1) *Cuits*, or boiled silk, in which the gum is entirely removed, the loss of weight reaching a maximum of 25 to 30 per cent (2;) *souples*, where the loss is not over 8 or 12 per cent; and (3) *crûs*, or raw silk, when the silk is merely washed and only loses 3 or 4 per cent of its weight.

The removal of the gum is done before weaving, of course, and a great variety of chemical regents have been employed for the purpose, for example, caustic and carbonated alkalies, alkaline earths, baryta and lime, hydrochloric acid, alcohol, and many others were tried, but they are too energetic. Although they remove all the gum, they attack the fibroine, which thereby loses not only its strength but also its most valued property—its luster. A complete removal of gum without any injurious effect upon fibroine can only be obtained with boiling soap-suds, in which the fiber gains in softness and luster.

The ungumming, as now performed in Lyons, Zurich, Bâle, and Crefeld, consists of two operations, known there as *dégommage* and *la cuite*, but differing only in the manner of dipping the silk and the time. The first is performed in a rectangular wooden box (15 feet long and about 3 feet wide and deep) lined with copper and provided with a coil of steam pipe in the bottom for heating the soap-suds. The skeins are drawn back and forth in the liquid, which is heated to 194° to 203° Fahr. From 30 to 35 parts of soap are used for 100 of silk, according to the hardness of the water, but if it is very hard it is advisable to soften it just to save soap.

The whole operation is not usually finished in one tub, the silk being removed in half an hour to a second, which has the same temperature but contains less soap, and finally to a third. The three operations last from an hour to an hour and a half. As fast as one lot of silk is taken out of the first tub a second lot is put in, until the ends get saturated with gum, which is the case after three or four lots have been passed through it. The suds is then set aside for use in color dyeing. If, however, it is not to be used again, the fatty acids are recovered by precipitation with lime, the lime salt being subsequently decomposed by acid.

The silk is next washed with water containing a little soap and soda, then packed in bags (*poches*), and boiled half an hour in a large copper kettle with one-tenth their weight of soap. The French call this *cuite en poches*. The kettles are hemispherical, from six to eight, or even ten feet in diameter. Formerly they were heated over the open fire, now they are almost exclusively heated with steam. In Lyons this extra boiling is very much in use for white and light shades, in Switzerland it is frequently omitted. After this boiling the skeins are stretched out, and then, if they are intended for light colors, they are exposed while still moist to the action of sulphurous acid gas in closed chambers, to bleach them. This gas is generated by burning sulphur in stone crocks on the floor of the chamber.

The sulphur is left to act on it for six hours, and is repeated two, four, six, or even eight times, according to the nature of the silk. The total quantity of sulphur consumed is only five per cent of the weight of the silk. It has frequently been proposed to substitute for this gas its aqueous solution or acidified bisulphite solutions, but this has never been introduced into practice. After sulphuring, the silk is well washed to remove every trace of sulphurous acid and is then ready to be dyed.

SOFTENING—ASSOUPLISSAGE.

This consists of four distinct operations: 1. Removingthe grease (degraissage); 2. bleaching; 3. sulphuring; 4. the actual softening. For darker colors the second can be omitted.

The silk is first put in a tepid bath containing 10 per cent of soap, at a temperature of 77° to 95° Fahr. It is left here one or two hours; pressed and moved around so as to wet it all. The principal object of this is to swell the fibers, open the pores, and prepare them to take up the dye, etc.

The bleaching is accomplished by the use of aqua regia, 1 part of nitric acid to 5 of muriatic, diluted to 2½ or 3° B., or about 15 parts of water to 1 of mixed acids, by volume. The operation should not continue more than fifteen minutes, as the nitric acid will impart a yellow color to the silk that can never be removed. Sometimes sulphuric acid saturated with nitrous fumes is substituted for aqua regia.

The bleaching with sulphur is the same as that for boiled silk (see above). When it comes from the sulphur chambers the silk feels hard and rough, and is brittle, hence the necessity of softening (*assouplissage*).

This consists in treating it for a long time with boiling water, to which is added a certain quantity of tartar. After sulphuring, the silk of course retains a certain quantity of sulphurous acid. About three-eighths of a pound of cream of tartar is dissolved in 100 pounds of water, and the silk drawn through it for 1½ hours. The silk gradually grows softer, swells up, and absorbs water easier, and is easily dyed. After this it is washed in tepid water.

The theory of softening is not yet established on a scientific basis. Many dyers are of the opinion that tartar can be replaced by other acid salts such as hydrosulphate of soda ($NaHSO_4$), or sulphate of magnesia ($MgSO_4$), with the addition of sulphuric acid.

Perhaps it is not even necessary to use acid salts, and that dilute acids will do as well. The question can only be answered by practical experiments on a large scale. At all events tartar is still used, in spite of its high price, in Lyons and elsewhere, whenever beauty is considered in preference to cheapness.

TREATMENT OF THE "ECRUS."

The raw silk is rarely used, even when naturally white, as, for example, in the back of velvets. If yellow, it must be bleached. Its treatment is as follows: 1. Moistening in hot water; 2. washing; 3. sulphuring twice; 4. bleaching; 5. washing; 6. sulphuring three or four times. If the silk is to be white, the treatment is as follows: 1. Cold soap bath without soda, 1 pound of soap to 10 pounds of silk; 2. washing; 3. sulphuring twice; 4. bleaching with aqua regia or nitrosulphuric acid; 5. washing; 6. soap bath like No. 1; 7. sulphuring twice; 8. washing; 9. weak soda bath (16 to 1,000 of silk); 10. weak soap bath, cold (30 to 1,000 of silk); 11. washing; 12. sulphuring twice; 13. washing in pure, or slightly acidified water.

The details of dyeing the silk are promised us in a second paper by the same authors.

A Remarkable Circular Saw Accident.

The premises at Nos. 9, 11, and 13 York Street, New York, are used for an extensive packing box factory, conducted by George Blair. About forty men are employed there. In the rear of No. 13 is a long, low shed, which covers a portion of the machinery. Directly under a skylight in the center of the shed is a table used for "ripping" planks. A circular saw projects above the center of the table about six inches. On the afternoon of February 26th, Caroline Bernheimer, a washerwoman, had been hanging out clothes to dry on a line that was stretched on the shed roof. Shortly after 5 P. M., a workman, who was engaged at the "ripping" table, heard a sound of crashing glass, and the body of the unfortunate washerwoman was precipitated through the skylight. She fell squarely across the jagged teeth of the saw, which was whirling at its full speed. The poor woman had evidently stumbled and lost her balance, and she did not utter a sound when she fell. Death came instantaneously. The horrified workman stopped the machinery, and then lifted the bleeding corpse from the saw. Some of the workmen ran for a physician, and Dr. Gulick, who lives a few doors away in Beech Street, hastily responded. The saw had buried itself into the victim's back, severing the spinal cord and cutting her heart in twain. Mrs. Bernheimer was thirty-five years old. She was a widow, with one daughter, and lived at No. 338 Hudson Street.