DYING.

DYING, the art of extracting colouring matter from various substances, and incorporating it with other bodies, so as to give them a permanent colour, similar to any proposed colour. The bodies to which the process of dying is chiefly applied, are the filaments of silk, cotton, flax, wool, and the threads and cloth manufactured from them: it is likewise applied to leather, paper, feathers, hair, wood, bone, wax, marble, &c.

HISTORY.

It is a remark which has often been repeated, that of all the arts which contribute to relieve the wants and supply the conveniences and comforts of life, there is scarcely one of which the origin can be distinctly traced. This fact is however certain, that in the early ages of the world, necessity acting as a powerful stimulus on the nascent or dormant powers of the mind, roused them to action; and as human wants increased or became more obvious and pressing, so the means of supplying them were eagerly sought after. To this is properly referred the origin of discoveries. Mankind could not exist without food and defence; they were compelled by the imperious demands of necessity to have recourse to every obvious means for procuring the former, and hence arose hunting, fishing, and agriculture. Inclement weather, ferocious animals, as well as enemies of the human kind, were to be guarded against; hence arose the arts of preparing skins, spinning, and weaving; of digging caves, building huts, making fences, and fabricating arms both offensive and defensive. To the practice of these and other useful arts, whether in their primary rude state, or in the more perfect state in which we at present have them, man is indebted for the possibility of his existence on earth. But this cannot be truly said of the art about which we are now to treat: it is by no means necessary to the support of life, and yet it seems to have been practised as an art in some of the first ages of the world. It has been asserted with a degree of probability which amounts almost to proof, that the art of dying originated in that thirst for distinction, which, we are sorry to say, is too frequently injurious to society, and too often exposes only the folly and vanity of our species. Let it not be supposed from the preceding remark, that our wish is to proscribe that wholesome and beneficial emulation which is founded on virtuous principles; by no means; the man of industry, taste, learning, or genius, is justly entitled to enjoy that preeminence which is the legitimate fruit of superior usefulness. But it very frequently happens, that the thirst for distinction exists and predominates in minds which can prefer no claim whatever to excellence; when this is the case, recourse is had to exterior decorations and trappings, by which the gazing and unthinking multitude have always been deceived. But we must beware of indulging the censorious and fastidious temper of the Cynic; nor should we be induced to deviate from the path of truth and candour, by adopting too hastily the opinions of those who decide perhaps without sufficient evidence, and calm reflection. Instead therefore of ascribing the art wholly to ignoble principles, may we not with equal probability presume, that it might have originated in a just and laudable taste; from that ambition to appear decent and comely, which is the natural consequence of a desire to please, and which is not at all allied to unworthy motives. This, we are disposed to think, must have been partly, if not entirely, the case. Having indulged these speculations on the probable origin of the art, we must be permitted to add, that the art itself is now become in a manner necessary to the order and well being of society; for were it relinquished, many of our boasted improvements in arts, sciences, and civilization, would fall with it.

The earliest hint connected with our present subject, is to be found in the writings of Moses, Gen. xxxvii. 3, where it is said, that "Israel loved Joseph more than all his children, because he was the son of his old age; and he made him a coat of many colours." Hence, the Hebrew patriarchs, or some of their neighbours, must have been acquainted with the art of dying as early as A. C. 1930; but whether they were the inventors and possessed the art exclusively, or borrowed it from the inhabitants of other countries, it is now impossible to determine; the latter however seems to be the most probable. In the time of Moses, A. C. 1491, the artificial preparation of colours, and the art of dying, must have made considerable progress; for in Exodus xxv. 4, 5, where the Hebrews are commanded to bring offerings for the formation of the sanctuary, are specified blue, and purple, and scarlet, and rams' skins dyed red. The dyed stuffs mentioned by Moses were probably obtained from the Phenicians, among whom commerce, navigation, and the arts, were then cultivated to a great extent. The Hebrews might however have acquired a knowledge of the processes of dying from the Egyptians, whose country they had recently left, after they and their ancestors had resided in it more than two hundred years. Pliny informs us, that the ancient Egyptians practised a kind of topical dying. They began by painting on white linen or cotton cloths with certain colourless drugs, but which possessed the property of absorbing colouring substances. The cloths were then plunged into a hot liquid impregnated with colouring matter, and when taken out, were found to retain the colour thus imbibed, and so fixed, that washing was unable to discharge it. They dyed their cloth of different colours, depending on the nature of the substance with which the hot liquid above mentioned was impregnated. When Alexander visited India, in the fourth century before Christ, it was found, that the art of dying had risen to great perfection in that country; hence some have concluded that the Indians were the inventors. They have however introduced scarcely any improvements since that period; and their processes are too imperfect, complicated, and prolix, to be adopted in countries where science has made any progress. It appears from some passages in the Iliad and Odyssey, that the Greeks were acquainted with the art of dying purple as early as Homer's time, A. C. 910; but their practice, it seems, was confined to wool, and is supposed to have been acquired from the Phenicians. No commodity could be more celebrated among the ancients than the Tyrian purple. We have, under the article Chemistry, p. 335, stated the popular opinion concerning the discovery of this precious substance; but the story bears a strong resemblance to fable. This purple was extracted from two kinds of shell fish, of which the larger was named purpura, and the other kind was a species of the whelk. The colouring liquid was found in a small vessel near the throat; each fish yielded only a single drop, which produced a more or less beautiful colour according to the place where the fish was procured. Having obtained a sufficient quantity of this liquor, it was treated with common salt, macerated for three days, and five times the quantity of water added. It was then kept in a moderate heat, till the solid animal substances with which it was contaminated had separated from the fluid, and risen to the top. These operations being finished, at the end of ten days a lock of white wool was immersed in the mixture, to ascertain its goodness. A variety of processes was employed to prepare the cloth for the reception of the dye, and to fix the colour; alkanet was used by some, while others immersed the cloth in lime water. The dye obtained from the whelk was the least valuable; and, therefore, in order to communicate the colour with proper effect, both kinds were used; a first dye was given by the liquor of the purpura, a second from that of the whelk; and in consequence of this two-fold operation, the cloth when dyed received the name of *purpura dibapha*, purple twice dipped. The colour did not attain to its full lustre till after it had been exposed to the solar rays. Plutarch relates an instance of the durability of this colour, namely, that when the victorious Greeks under Alexander plundered the treasury of the king of Persia, A. C. 331, they found in it a considerable quantity of purple, which was 190 years old, and yet had lost none of its beauty or brilliancy. The ancients set so high a value on this colour, that in the reign of Augustus, that is, about the commencement of the Christian era, a pound of wool of the Tyrian dye could not be obtained for a sum equivalent to thirty-six pounds sterling. Garments of this colour were strictly prohibited: none throughout the Roman empire durst wear them on pain of death, except the emperors themselves. Shell fish of similar kinds have been found also in modern times, and in various parts of the world; indeed it is supposed, that they are now as plentiful as formerly. The dye is still extracted from them about the western coast of Spanish America, where it is chiefly employed for dying of cotton. The shell fish which yields the purple colour was found on the coast of England in 1683, by Mr. Cole. He obtained the liquor, which was white, from a small transverse duct near the head: writing made with this white liquor became green on exposure to air, and when placed in the sun, the green deepened; afterwards it became a light red, and at length changed to a deep purple, having all the characters of the Tyrian purple. In several islands about the Straits of Sunda, there are snails containing a purple matter, with which the Chinese make red ink, and colour their commodities. But the dye obtained from any of the animals we have mentioned, is now a subject rather of curiosity than use. The numerous improvements which modern philosophy has introduced into the arts, have given a facility to the art of dying, vastly superior to what it formerly possessed; besides, the colours are far more beautiful, and the process less expensive.

During the decline of the Roman empire, the arts, meeting with but faint and nominal support, languished; and after its fall were nearly extinct; scarcely any traces of them were visible in any part of the western empire, except in Italy. There is a description of some dyes and processes in a manuscript of the eighth century, quoted by Muratori; but the style is turgid, enigmatical, and obscure, and the Latin extremely barbarous; so that little information is to be obtained from it. Under the occasional and feeble support of the Greek emperors, the arts continued to flourish; at least they did not visibly decline: this is to be deemed a providential circumstance, with respect to the western countries of Europe, for by means of the intercourse which necessarily took place between the eastern and western empires, during the time of the crusades, the arts were transmitted from Greece into Italy, where they met with the needful encouragement, and were consequently soon established; insomuch that in 1338 the city of Florence only contained 200 manufacturers, who are said to have fabricated from 70 to 80 thousand yards of cloth. It was a merchant of that city named Rucellai, who in 1300 accidentally discovered the colouring matter called archil or argol; this he did from observing that urine produced a fine colour on certain species of moss. The art of dying was cultivated about this time with great success at Venice, where, in 1429, an account of all the necessary processes was published, under the title of Mariegola del' Arte de i Tentori. With the laudable purpose of rendering this description still more perfect and useful, a tour through various parts of Italy and its neighbourhood was undertaken and performed by Giovanni Ventura Rosetti; and he succeeded in collecting a considerable stock of useful information, relating to the practices adopted by different dyers. The result of his inquiries was published in 1548, under the title of Plictho; it is the earliest work which enumerates and explains the different tinctorious processes, and has been considered as the primary step towards that degree of perfection to which the art of dying has since attained. Cochineal and indigo were probably not known in Italy till after this period, for neither of them is mentioned in Rosetti's work. Italy seems for a long time to have been exclusively possessed of the art; but at length, in the course of the sixteenth century, it was communicated to a French dyer of the name of Giles Gobelin, who had established a manufactory in the neighbourhood of Paris, which still exists under the name of the Gobelins. His enterprise was at first deemed so rash, that it obtained the name of Gobelin's Folly; but, contrary to the general expectation, it succeeded, and he was then charged with obtaining a knowledge of his processes from the devil.

Soon after the conquest of Mexico by Cortez, in 1518, the properties of the cochineal insect became known to the Spaniards, who brought the discovery into Europe. Kuster, a German chemist, discovered the process for dying a scarlet by means of a solution of tin, and in 1643 carried the secret to London. About this time the use of indigo was also introduced; and by degrees the improvements thus made in the art of dying, gradually became known throughout Europe. Pastil and woad were at that time principally used by the dyers in France; where, in order to encourage their consumption, the use of indigo and logwood was limited to a certain proportion. Queen Elizabeth prohibited altogether the use of these substances, and this extraordinary prohibition was not annulled till after the accession of Charles II. It met with nearly the same fate in some parts of Germany; in the prohibitory edict which was issued in Saxony, it is styled a corrosive colour, and food for the devil! On the revival of the arts in France under the celebrated Colbert, that of dying received a proper share of encouragement: by the orders of this patriotic minister, a table of instructions for dying was published in 1672; which, though by no means unexceptionable, was found to be productive of benefit, and is on many accounts worthy of attention. Still, however, the art laboured under many injurious and impolitic restrictions, but their effects were in many cases eluded, and in others entirely obviated, by the judicious and liberal conduct of those scientific men who were appointed to superintend the arts and manufactures.

The art of which we are now treating continued to receive liberal encouragement in France, where Dufay, Hellot, Macquer, and Berthollet, have been successively charged with the care of this department; and to their labours and exertions we are indebted for many valuable acquisitions which have been made in the art of dying during the eighteenth century. Dufay was the first who entertained just views of the nature of colouring matters, and the powers by which they adhere. In the examination of certain processes he discovered great sagacity, and established the surest means which the state of knowledge at the time afforded, to ascertain the durability of a colour. Under his direction a new table of instructions, which superseded that of Colbert, was published in 1737. Hellot, who succeeded him, published in 1740 a methodical description of the processes for dying wool; and this treatise may be considered even at the present day as one of the best systems on the subject. Macquer, in 1763, published a treatise on dying silk, in which is given an accurate description of the processes: he discovered the combinations of the colouring principle of Prussian blue, and endeavoured to make an application of it to the art of dying. Macquer died in 1784, and was succeeded in that department by the celebrated Berthollet, to whom was intrusted the superintendence of the arts connected with chemistry, and particularly that of dying. To his being placed in this department, we are probably indebted for the excellent work which he has published on this subject, and for different memoirs which have appeared in various periodical works. To these we must acknowledge ourselves under obligation for much of the information, both of the theory and practice of this art, which we propose to lay before our readers in the present treatise. He has endeavoured, as he observes, to bring into one point of view the processes of industry and the operations of nature; to take his situation between the philosopher and the artist. To the first he has shewn, where it is that the phenomena of the art of dying and those of nature meet, and what are the principles which their discoveries have established. When these comprehensive views, we may add, are completed, the art of dying may be considered as perfect.

An art of dying, such as it was, had existed in Britain from the earliest period of its history; but scarcely any thing was known of the theory. The subject met indeed with some attention from a few of the members of the Royal Society, soon after its formation; and Dr. Lewis published, some years later, a partial account of a few of the processes; but it was on the instructions contained in Hellot's book that the English dyers chiefly depended. The astonishing improvements which, within the last fifty years, have been made in chemistry, have developed the theory of dying, and given a new and advantageous turn to the art. Its practice now no longer depends on the absurd maxims of a blind and barbarous age, of which the chief recommendation is their antiquity, but its principles are scientifically deduced from experiments and facts by means of accurate philosophical investigations. Were we to attempt an enumeration of all those who have either directly or incidentally contributed to improve the art of dying, we might begin with Dr. Black, and name most of the chemists who have flourished since his time. The following are however the names of some who have written expressly on the subject: Beckman, Scheffer, Bergman, Poerner, Vogler, D'Ambourney, Haussmann, Chaptal, Francheville, D'Alphigni, Berthollet, O'Rielly, Delaval, Henry, and Dr. Bancroft, whose valuable treatise on the Philosophy of Permanent Colours is deservedly esteemed.

This subject naturally divides itself into theory and practice; of both these, in their order, we propose to give a brief and general account.

GENERAL PRINCIPLES AND THEORY OF DYING.

Colours.

1. According to Sir Isaac Newton, "colours in an object are merely a disposition it possesses of reflecting this or that sort of rays more copiously than the rest; in the rays there are nothing but their dispositions to propagate this or that motion into the sensorium; and in the sensorium they are sensations of those motions under the forms of colours." Bodies are known to differ greatly from each other in their power of reflecting light; by some, as, for instance, highly polished metals, it is reflected in such quantities, that the eye cannot bear it; others, as black and dark coloured substances, reflect it very feebly; it has also been generally

observed, that the quantity of light reflected depends much on the smoothness of the reflecting surface. But there is also a great diversity among bodies, in the nature or quality of the rays which they have the power of reflecting. When a body reflects but very few of the impinging rays, that body is said to be black; but when all the rays are indiscriminately reflected, the reflecting surface is said to be white. A body which reflects red rays only, is said to be red; that which reflects blue rays only, is said to be blue; and that which reflects yellow rays only, yellow; but when two different kinds of rays are reflected in combination from the same surface, an intermediate colour is produced, varying according to the prevailing colour. Hence the various shades of colour exhibited by bodies depend on the different combinations of rays reflected from their surface; and in opaque bodies the colour is to be wholly ascribed to their disposition of absorbing certain rays, and reflecting the rest; but in transparent bodies it depends on their aptitude to absorb certain rays, and to transmit the rest.

2. Newton supposed, that (with the exception of combustible substances, which follow a different law) colour in bodies of the same density, depends solely on the size of their integrant particles; and upon the size and density of all bodies taken together. Mr. Delaval supported the same opinion; but the recent improvements in chemical knowledge have abundantly exposed the defects of their theory. Dr. Bancroft, in his Philosophy of Permanent Colours, has likewise proved in an incontestable manner, that although thickness or size of the particles may be one, it cannot be the only cause of the repeated variation of colour, it follows therefore that some other cause exists.

3. That bodies have a particular affinity for the rays of light, appears from a variety of facts; and that the phenomena of light entirely depend on these affinities, cannot be doubted. Those particular rays for which a body has a strong affinity, are wholly absorbed and retained by it; while the remaining rays for which it has no affinity, are either reflected or transmitted according as the body is opaque or transparent, and according to the direction of the impinging ray. Thus, for instance, a black body has an affinity for all the rays, and therefore absorbs them all; a white body has no affinity for any of the rays, and therefore, if opaque, it reflects them all, and if transparent transmits them all; a red body has an affinity for all the rays except the red, and these it reflects; and the same is evidently the case with respect to the other colours.

4. The differences existing between the particles of bodies, may be referred to the magnitude, density, and figure of those particles; and changes in these may account for all the varieties of affinity. If then affinity depends upon these circumstances, and if the colour of bodies is to be ascribed to the affinity between their particles and the different rays of light, it seems obvious, that the cause of the colour of bodies may be accounted for from the magnitude, density, and figure of their constituent particles. If therefore the colour of bodies depends on their affinity for light, and every body is of some colour, it must continue of this colour, and no change can take place in its colour, till it is either saturated with the particular rays which it absorbs, or till its particles have undergone some alteration by decomposition, or by their combination with new substances. But since bodies may be exposed for a long time to light without any alteration taking place in their colour, it is plain that the changes are not to be ascribed to the first of these causes; while the action of the second may be distinctly traced in numerous cases where alteration in the colours has been observed. It is not intended here to enter fully into the consideration of light and colours; these subjects properly belong to OPTICS, and may be seen under that article (see also CHROMATICS, COLOUR, and LIGHT); our object is merely to shew, that colour in bodies arises, not immediately from the different size of their particles, but from the affinity they have for the particular rays which they absorb, while they reflect or transmit those that afford the colour which distinguishes the reflecting surface; and also to shew, that chemical changes operate to produce a change of colour in bodies.

5. Mr. Delaval has shewn, that coloured matters do not reflect light. "When," says he, "a small portion of colouring matter is mixed with a colourless medium, the mass appears tinged with colour; but when a great quantity of colouring matter is added, the mass exhibits no colour, but appears black; therefore, to attribute to colouring matter a reflective power, is to advance an inexplicable and contradictory proposition; for it is asserting, that in proportion as more reflective colouring matter is opposed to the incident light, less colour is reflected; and that when the quantity of colouring matter is very great, no colour at all is reflected, but blackness is thereby produced." Hence, as well as from numerous experiments, our author infers, that "the reflective power does not exist in colouring matter, but in opaque white substances only." In connection with this part of the subject, we must not omit a most extraordinary hypothesis advanced by the celebrated Euler, namely, that "the colours of bodies are not produced by reflection; but the coloured rays are," he says, "emitted by the calorific particles." Of this opinion we shall take no farther notice, than merely to observe, that it is hostile to the experiments and theory of all other philosophers.

6. It has been very properly observed, that "the art of dying consists principally in covering white substances, from which light is strongly reflected, with transparent coloured media; which latter, according to their several colours, transmit more or less copiously the several rays reflected from the white substances. The transparent coloured media," continues our author, "reflect no light themselves; and it is evident, that if they yielded their colours by reflecting instead of transmitting the rays, the whiteness or colour of the ground on which they are applied would not any wise alter or affect the colours they exhibit." Experience shews, that all colouring matter when viewed by incident light appears black; and that all substances, in proportion as they are copiously stored with colouring particles, are inclined to blackness. Mr. Delaval has likewise shewn, that "white paper and linen may be tinged, by dipping them into the infusions of flowers of different colours; and by spreading upon those white grounds the expressed juices of such flowers, their colours may be communicated to the paper and the linen. These means of tinging," says he, "are somewhat similar to the application of vegetable dyes to linen, and of transparent water colours to paper, many of which consist of the colouring matter of plants, such as indigo, litmus, gamboge, &c."

7. This leads us to an important part of our subject, namely, to shew, that the colouring particles with which stuffs are dyed, being transparent, the reflected light must proceed entirely from the fibres of the stuff which are covered with the transparent colouring matter. If the stuff be black, it is plain that no colour can be communicated to it, because, as we have before shewn, it possesses not the power of reflecting any, and therefore none can be transmitted. If the stuff be red, blue, or yellow, it cannot be dyed of any colour excepting only black; because the red, blue, or yellow rays only being reflected, no other rays can be transmitted. All this however supposes the entire surface of the stuff to be of one uniform colour; and hence also appears

the importance of its being of a pure white before the dying process is commenced, especially when a bright colour is to be communicated; for in this case the rays will be copiously reflected, and any colour may be given, by combining with it any colouring matter which has the power of transmitting those rays only which are of the particular colour proposed.

8. The colouring matter when applied should also be in a state of minute division; for since it combines with the stuffs by the force of affinity, it must adhere so strongly to the fibres in order to produce a permanent colour, that no mechanical or chemical action to which the stuffs are usually exposed can possibly induce a separation. In order to promote the chemical action between the colouring matter and the stuffs, the former is dissolved in some fluid for which it has a weaker affinity than for the stuffs; so that when they are immersed in the solution, the colouring matter being impelled by a superior attraction for the stuffs, readily combines with them; and thus they are dyed. It is obvious, in this view of the subject, that the facility with which this combination is effected, must depend wholly on the relative affinities subsisting between the colouring matter and its solvent, and the colouring matter and the stuffs; when these two affinities are equal, no change takes place; but when the affinity between the stuff and the colouring matter prevails, a combination is effected, and the process advances with a rapidity proportionate to the force of this affinity.

9. It must here be remarked, that all coloured bodies are compounds, having a variety of substances in their composition. Some of their constituents have a strong affinity for oxygen, which they greedily absorb from the surrounding atmosphere; and if the essential principle of the colour happens to possess this affinity in a superior degree, it will with the oxygen form a new compound, and the colour will by this process be discharged. A colour may be said to be permanent only when it possesses the power of resisting the action of all the substances to which it is exposed; considerable variety is observed in this power, depending jointly on the nature of the stuff and of the colour; and this difference is particularly striking, even when the same colours are applied to animal and vegetable substances. When, as we have already stated, a new compound is formed by any of the constituent particles and a contiguous substance, a decomposition takes place in the dye, or rather its affinity with the stuff is overcome, and the colour of course will not be permanent; if the decomposition proceed slowly, the colour will gradually decay; but if it be sudden, the colour is immediately destroyed. Hence it evidently follows, that the colour of a body is permanent only when all its constituents are combined together by such strong affinities as are capable of effectually resisting the attractions of all the contiguous substances.

10. One of the principal causes of the change of colours is, as we have before hinted, the combination of oxygen with some of the constituents of the coloured body, and its action is under particular circumstances greatly promoted. Oxygen, assisted by heat, is capable of decomposing nearly all coloured substances; thus, wheat flour at the temperature of 448° loses its white colour, and becomes successively brown and black. This effect is produced by the combination of oxygen with the hydrogen in the flour. The effects of light on coloured bodies are similar to those of heat. Wood retains its natural appearance as long as it is kept in the dark; but when exposed to light, it gradually becomes brown, yellow, or some other colour; this effect depends partly on the intensity of the light, and varies also with the kind of wood. If the beautiful green solution of vegetables in alcohol be kept in the dark, its colour is no ways altered; but when exposed to the solar rays, it assumes an olive colour, and soon after becomes quite colourless. Light, by combining with some of the constituents of bodies, is in many cases found to accelerate their decomposition: numerous instances of this occur in the practice of the chemist.

11. Experience abundantly proves, that colours differ considerably with respect to their power of resisting the action of air and light, as well as that of acids, alkalies, and soap; and they are more or less permanent according to the degree they possess of this power. Hence it becomes an object of great importance to be able to ascertain by easy tests the durability or goodness of any colour. M. Dufay seems to have been the first who directed his attention seriously to this subject; he dyed wool of all colours, employing for this purpose all kinds of colouring matters, and investigated with great care the good and bad qualities of the substances he thus employed. His experiments were commenced on woollen yarn, but instead of this he soon after substituted pieces of white cloth, as better adapted to the purpose; then, in order to distinguish between permanent and fading colours, he dyed patterns of all colours with known colouring substances, and exposed the patterns during twelve days to the action of the sun and atmosphere. During this period of trial the fading colours were nearly obliterated, while those of a more durable nature sustained but little injury. He anticipated the probable intervention of cloudy weather, when the action of the sun's rays would be less intense than if the whole twelve days were bright and shining, and to guard against any uncertainty which this might produce, he selected one of the worst colours, namely, one on which the solar rays has the greatest effect in a given time; this he employed as a standard, and whenever he exposed a piece of stuff to the air to prove the colour, a piece of this standard accompanied it. His calculations were not formed by the number of days, but by the change in the colour of the standard piece; for he kept the stuff exposed, till it had lost as much as the standard would have done by the action of the sun during twelve days in summer; and one of his conclusions from these experiments was, that the same effect required four or five days longer to produce it in winter, than it did in summer.

12. But the principal design of our author in these experiments was to discover the proper proof for each colour; one by the application of which any stuff may be readily tried, to ascertain whether its colour be permanent or not. One way of determining the quality of a colour is to boil the stuff dyed with it in vinegar, or in solutions of soap, alum, tartar, &c.: but in the then imperfect state of chemical science, the constituents of these substances were altogether unknown; whence the methods employed by M. Dufay and others must have afforded results equally precarious and uncertain; for it is now known, that some of the substances he employed, are capable of destroying good colours, but produce no effect whatever on those of inferior quality.

13. But granting that the method employed by our author is necessarily defective, yet it had the merit of pointing out the way to those improvements which have since been adopted with more complete success. The process he employed will be acknowledged by every candid reader as truly ingenious, and therefore the introduction of an account which has been given of it will require no apology. "Having observed the effects of air and light on each colour, namely, whether it were good or bad, he tried the same stuff with different proofs, and stopped as soon as he had discovered one which produced the same effects as the air. He then noted the weight of the ingredients, the quantity of water, and the length of time; thus he was certain of producing

on a colour an effect similar to that which the air would have produced, on the supposition that the stuff was dyed in the same way with his. Hence he was enabled to ascertain the qualities of any colour, by making an analysis of the ingredients of which it was composed. By means of the proofs which were invented by this ingenious chemist, as much of a colour which was not of a durable nature could be discharged in a few minutes, as would be lost by the action of the air and light in twelve or fifteen days. But as general rules framed for such trials are liable to many exceptions, from different unavoidable causes, their application in many cases may be considered as too severe. For instance, light colours require less active proofs than those which are of a deeper dye, and more loaded with colouring matter; in the latter case, a considerable proportion of colouring substance may be carried off without much visible change on the colour; but in the former, by means of the same active test, the colour would be entirely obliterated. Every variety of shade, therefore, would have required a separate proof. The sun and the air must always be considered as the true test; and those colours which undergo no change in a certain time by this exposure, may be considered as permanent colours, although they may be greatly changed by the application of proofs. Scarlet, which is dyed with cochineal alone, assumes a purple colour when tried by means of alum; but if scarlet be exposed to the sun, it loses some of its brightness, and becomes of a deeper shade; but this shade is different from that which is produced by alum. In certain cases, then, the same effect is not to be expected from the action of proofs and that of air and light."

14. That a colour which resists the effects of exposure to air, may yet be destroyed by the action of other substances, is a fact which has also been well illustrated by Hellot. He states, that Brazil wood, in common with other woods abounding with colour, produces a fading dye. With this wood he prepared a red, much finer than any of the reds obtained from madder, and equally bright with those produced by kermes. This red, though exposed to the atmosphere during four rainy and boisterous winter months, instead of being injured, was found to have gained body: yet though the air does not affect this red, it is nevertheless unable to resist the power of tartar. We are however accustomed to consider colours sufficiently durable, when they are capable of resisting the effects of the air, though they may be decomposed or destroyed by powerful chemical agents. Hence the exposure of dyed stuffs for a sufficient time to the action of light and air, seems to be the only sure method of ascertaining the permanency of their colours.

15. The oxygenated muriatic acid acts on colour in a similar manner to the air; and therefore Berthollet recommends its use as the most easy and expeditious means of ascertaining the degree of durability in any colour. A pattern of the stuff is to be plunged into the acid considerably diluted, together with another piece which is known to have been properly dyed; and the relative power which the two patterns possess of resisting the action of the acid, is a test or measure of the quality of the colour. But though this proof has the advantage of exhibiting to great nearness the shades and changes through which the colour must pass when it comes to be acted on by the atmosphere, yet M. Berthollet hesitates with respect to its infallibility, and considers it as less to be depended on than the action of air and light. The oxygenated muriatic acid, though inferior perhaps to the action of air, is nevertheless to be considered as a valuable test for the colours of dyed silks. Some however are content with merely exposing them to heat in acetous acid; and if they resist its action, the colours are deemed permanent. This will indeed be the case, if the solution of tin be one of the dying ingredients; but if the colours have been obtained from the woods or archil alone, any vegetable acid will redden them.

16. Another object of importance is, to be able to determine the relative qualities of the same kind of colouring substances; and for this purpose the oxygenated muriatic acid may be employed with success; observing previously to dissolve the colouring matter of each substance in some proper liquid. By the use of this acid may be ascertained the proportion of colouring matter in substances of which the nature of the colouring particles is the same. Thus, if it be required to determine the relative qualities of two parcels of indigo; in which case no foreign affinity can possibly interrupt the action of the acid; and even if it should happen that any considerable difference exists in the nature of colouring particles supposed to be the same, the action of this acid, it is probable, would still be a measure of their comparative goodness. If then it is proposed to compare together two or more colouring substances of the same nature, and to ascertain the relative quantity and quality of the colouring particles in each, all that is necessary is to compare the quantities of the same oxygenated muriatic acid which is required to produce the same degree of change in equal weights of each. For the qualities of these substances, or the quantities of colouring particles they contain, are directly proportional to the quantities of liquor required to produce the same effect on each. This being premised, the following is the method of comparing different kinds of indigo with each other: Let an equal weight of each kind be finely powdered, and introduced into a separate matrass with eight times its weight of concentrated sulphuric acid; place the whole for 24 hours in a heat from 100° to 120° Fahrenheit. Each solution is then to be diluted with water, filtered, and what remains on the filter is to be ground in a glass mortar, and again digested with a small portion of sulphuric acid. These last solutions are then to be diluted with equal quantities of water, filtered, and added, each to its corresponding liquor. Lastly, as much oxygenated acid is to be added to each solution, as will discharge the colour, or bring them all to a yellow shade. Then, the quantity of oxygenated muriatic acid employed on each parcel of indigo to produce this effect, will be proportionate to the quality of the indigo. But a comparison of the qualities of those colouring matters which are soluble in water, is a more simple and convenient process. To equal bulks of the decoction, containing the same weight of each substance, the oxygenated muriatic acid is added, till the several portions are all brought to the same shade; then, as in the foregoing case, the quality of the substance is proportionate to the quantity of acid employed.

Mordants.

17. Mordants are substances employed in dying to facilitate or modify the combination of the colouring matter with the stuff. An intimate acquaintance with the nature and application of mordants is not less important to the dyer, than a knowledge of colouring substances; for on the action of the former the variety, brightness, and durability of colours chiefly depend. The action of mordants is to be ascribed to chemical changes, so that a complete knowledge of their effects, obtained by accurate and extensive observation, is evidently essential to the improvement and perfection of the dyer's art. The colouring particles are combined with the stuff; and the qualities and degrees of the stuff are affected by means of a new series of attractions, which takes place between the particles of each; and both are accelerated and promoted by the intervention of mordants.

18. There are mostly different ingredients which enter into the composition of a mordant, whence new combinations are produced; and it is to the immediate action of these, rather than to the direct agency of the substances employed, that the effects are to be attributed. The different methods of applying mordants depend jointly on their own nature, on the nature of the colouring matter, and on that of the stuff. They are sometimes previously mixed with the colouring matter; sometimes the stuff is previously impregnated with them; and frequently both these methods are combined. The progress of combination is often gradual, so that though both the above methods are necessary, and must be adopted, yet the colour is evolved only by the action of that which was last applied. But as it will not be easy to understand the effects of mordants, without some exemplification, we shall here introduce a brief account of some of the processes employed in the printing of linen; referring the reader to M. Berthollet's treatise on the Art of Dying for a more particular account. To prepare a mordant for linens to which it is intended to give different shades of red, our author directs, that three pounds of alum, and one pound of acetate or sugar of lead, be dissolved in eight pounds of hot water. To this solution two ounces of potash, and two of powdered chalk, are to be successively added. This being done, the first change that takes place is the decomposition of the alum, with the acid of which the oxide of lead combines and forms an insoluble salt, which is precipitated. Next, the alumina (or base of the alum) unites with the acetous acid, forming acetate of alumina; and the excess of acid is, according to our author, saturated by the intervention of the chalk and potash. It has however been remarked, with some probability, that the addition of potash and chalk is also necessary, on account of new decompositions depending on their action. The alumina is retained in combination with the acid, by a much weaker affinity than when combined with sulphuric acid in the state of alum. Its affinity being thus weakened, it is the more easily decomposed, and more readily unites with the stuff and colouring matter. Another important advantage is, that the effect of the acetous acid on the colouring particles being milder than that of the sulphuric acid, the acid liquor which remains after the separation of the alumina, is productive of less injurious consequences. Besides, as the acetate of alumina does not crystallize, the mordant which is thickened with starch or gum, retains the same uniform consistence; this it would not do, if alum, which is disposed to crystallize, formed a part in its composition.

19. After the cloth has been impregnated with the mordant, suitably to the proposed design, it is immersed in a madder-bath. The whole of the cloth now appears coloured, but the colouring is partial, being deeper, as was intended, in the parts affected by the mordant than in any of the other parts; this arises from the colouring particles of the madder combining with the stuff and the alumina in the mordant, and forming a triple compound. The acetous acid being separated from its earthy basis, remains in the bath. External agents thus combined are found to act less powerfully on the colouring matter than when they are in a separate state, or combined only with the stuff, without the interposition of another substance; and on this the subsequent operations depend. The colouring particles of the madder which have united with the alumina in consequence of their superior affinity for it, remain unaltered; hence those parts of the cloth which have been affected by the mordant retain the colour, and exhibit the design; while those particles which have not come into contact with the alumina, enter into new combinations, and are completely changed. After the immersion above described, in order to discharge the superfluous colouring matter, the cloth is boiled with bran, and then spread on a grass-plot to bleach; these operations are repeated till the ground is completely whitened.

20. If acetate of iron be substituted instead of alum, a different mordant will be prepared, which will nevertheless exhibit similar phenomena. The colouring matter decomposes the solution of iron, and forms with it and the stuff a triple compound. When this mordant forms the preparation for madder, a great variety of shades from brown to jet black are obtained; by a combination of alum and iron, mixed colours are produced, inclining on the one hand to red, and on the other to black; and if dyer's weed be substituted for the madder, other colours are obtained. The fact is, that the colouring matter of madder, dyer's weed, and indigo, fixed by alumina or the oxide of iron as mordants, are sufficient to produce all the variety of shades communicated to printed stuffs.

21. M. Berthollet, whose name we have frequently had occasion to mention, made a number of experiments to ascertain the efficacy of these substances as mordants. "He dissolved equal weights of alum and of tartar, and found that the solubility of the tartar was increased by this mixture; after this, by evaporation and a second crystallization, the two salts were separated, so that no decomposition had taken place. Next, half an ounce of alum and one ounce of wool were boiled together for one hour, and a precipitate was formed, which being carefully washed, was found to consist of filaments of wool incrusted with earth. Sulphuric acid being poured on this, and the solution evaporated to dryness, crystals of alum were obtained, with the separation of some particles of carbonaceous matter. The liquid in which the wool had been boiled being evaporated, yielded only a few grains of alum; what remained would not crystallize. This being redissolved and precipitated by means of an alkali, the alumina which was thrown down was of a slate colour, became black when placed on red-hot coals, and emitted alkaline vapours. In this experiment, it appears that the alum was decomposed by the wool, and part of the alumina had combined with its most detached filaments which were least retained by the force of aggregation; that part of its animal substance had been dissolved and precipitated by the alkali from the triple compound. The same experiment was repeated with half an ounce of alum and two drams of tartar; but no precipitation followed. A small portion of the tartar, and some irregular crystals of alum, were obtained by crystallization: the remainder refused to crystallize; but being diluted with water, precipitated by potash, and evaporated, it yielded a salt which burned like tartar. The wool which was boiled with the alum had a harsh feel; but the other retained all its softness. The first, after being subjected to the process of maddering, had a duller and lighter tint; but the colour of the latter was fuller and brighter.

22. "In the first of these experiments, the wool had effected a decomposition of the alum, and united with part of the alumina; and even part of the alum which retained its alumina had dissolved some portion of the animal matter. In the second experiment it appears that the tartar and alum, between which there seems to exist a balance of affinities, can only act on each other by the intermediate action of the wool. The principal use of the tartar seems to be to moderate the action of the alum on the wool, by which it is injured. In the aluming of silk and thread, whose action on alum is less powerful than that of wool, tartar is not found requisite." We must here remark, that "whatever be the mode adopted in aluming, or whatever be the chemical changes which are produced, its final effect is the union

of the alumina with the stuff. At first this combination has probably been incomplete, and a partial separation only of the acids has taken place; but it is perfected after the cloth has been boiled with the madder, as appeared in the case of printed stuffs."

23. Mineral substances are chiefly employed as mordants; these consist of earths and metallic oxides, together with some astringent vegetable and animal matters. The earths used as mordants are two in number, alum and lime; the metallic oxides are likewise two, namely, those of tin and iron. The affinity which exists between alumina, the colouring matter, and the stuffs, renders it of superior importance as a mordant: its affinity for animal substances is found to be much stronger than that for vegetable productions; and hence arises the difference observed in the facility with which the colours are fixed, and in the durability of the colours, when communicated to these two kinds of substances.

24. Alumina, as employed for this purpose, is always in a state of combination, either in that of alum (sulphate of alumina and potash) or combined with acetous acid, forming the acetate of alumina. The former combination was employed as a mordant by the ancients, who procured it native, and consequently often in a very impure state. Alumina combined with acetous acid was first used by the calico printers for the same purpose, probably in the early part of the eighteenth century, and its discovery is supposed to be owing to accident. Before this substance was employed as a mordant in calico printing, the substances directed to be used were alum, sal-ammoniac, nitre, red orpiment, and kelp: these were at first mixed with water; and afterwards, as an improvement, Dr. Bancroft thinks it probable that vinegar was substituted for a solvent in the place of water. A small portion of sugar of lead was afterwards added; litharge and white lead, with a variety of other substances, were also partially used. It was also discovered, that after the decompositions which had taken place in consequence of the adoption of vinegar as a solvent, a portion of acetate of alumina was formed, this was found to be beneficial to the process. The advantages derived from sugar of lead were also soon observed, and its quantity was gradually increased, in proportion as its beneficial effects became more obvious: and as this came by degrees into general use, other substances less adapted to the purpose were laid aside.

25. Acetate of alumina is usually prepared by pouring acetate of lead into a solution of alum. By this mixture both these salts are decomposed; and the sulphuric acid having a stronger affinity for the lead than for the alumina, it combines with the former, and both fall to the bottom in the form of an insoluble powder. In the mean time the alumina combines with the acetous acid, and remains dissolved in the liquid.

26. Lime, though it has a sufficiently strong affinity for cloth, is nevertheless inferior in value as a mordant to alumina. It is used either in the state of lime water, or in that of sulphate of lime dissolved in water.

27. A strong affinity exists between metallic oxides and animal substances, as also between the former and colouring matter; so that in the latter case, the oxides separate from the acids with which they were combined, and precipitate in combination with the colour; and the facility with which they separate from their acids, renders them capable of uniting more readily with animal substances, without the assistance of colouring particles; moreover their solutions in acids possess properties which fit them also for mordants. Nearly all the metallic substances have an affinity for animal and vegetable matter; but the oxides of tin and iron only are employed as mordants, either because they answer the purpose better than the others, or are obtained at a more moderate expense. Metallic oxides, with the exception of the oxide of iron, have in general, as we have already observed, a more feeble affinity for vegetable than for animal substances; hence it is that a solution of tin is found to be the best mordant for silk or wool. The oxide of iron alone possesses a strong affinity for vegetable substances; and it is to this that iron-moulds in cotton and linen are to be ascribed; they arise from the combination of oxide of iron with the cloth, which is a vegetable substance.

28. The use of the oxide of tin is supposed to have been introduced by Kuster, a German chemist, about the middle of the sixteenth century. From observing that a solution of tin in nitric acid gave a bright colour to stuffs dyed with cochineal, he was led to the discovery of the method of producing what has since been called cochineal scarlet. This discovery has also been ascribed to Cornelius Drebel, a Dutch alchemist, who died in 1634; but Mr. Delaval contends, that the use of tin in dying was known to the ancients. However this might be, Kuster brought his secret to London about 1543, and it was first put in practice at Bow; whence the scarlet colour thus produced obtained the name of Bow dye. In Holland, and some other parts, the same colour was called Dutch scarlet; and in France it was denominated scarlet of the Gobelins.

29. To what has been already stated of the properties of metallic oxides, as applied to the purpose of mordants, we may add, that their effects depend on the different proportions of oxygen with which they are combined. Thus suppose of two oxides of tin containing different proportions of oxygen, one contains .3 and the other .4 of oxygen. The former of these, on exposure to air, soon imbibes a new portion of oxygen, and is converted into the oxide with the greater proportion, or white oxide. This last then is the mordant; for if the other were applied to the stuff, it would speedily combine with an additional portion of oxygen, and be converted into the white oxide.

30. Tin is dissolved by means of that species of nitric acid popularly called single aqua fortis, which is capable of dissolving about one-eighth of its weight of granulated tin; from one to two ounces of sea salt, or sal-ammoniac, are added to the aqua fortis, which is also diluted with a little water; the water added being accurately weighed or measured, in order that a solution of the same strength may be always obtained. To a pound of aqua fortis, two ounces of granulated tin are usually allowed; this should be added at different times, to moderate the rapidity of the solution; for it is found, that solutions which proceed gradually and with the least separation of vapour, succeed best. This solution is called by the dyers, spirit: eighteen or twenty pounds of it are sufficient to give a full cochineal scarlet to one hundred pounds of woollen cloth. But in the dying of scarlet it is usual to dissolve tartar in the water, together with the nitro-muriate of tin; and if a sufficient quantity of tartar be thus dissolved, the mordant is to be considered as a tartrate of tin; for the nitro-muriatic acid combines with the potash or the tartar, while the acid of the tartar unites with the oxide of tin.

31. Instead of the nitro-muriate of tin, the acetate has been proposed as a better mordant for linen and cotton. It is prepared by mixing acetate of lead with nitro-muriate of tin, and is to be preferred for this purpose. A solution of tin in sulphuric acid was likewise tried by Dr. Bancroft, but it destroyed the cochineal colour; he was however more successful in trying a combination of muriatic acid with one-fourth its weight of sulphuric acid. He also employed a mixture of three pounds of muriatic acid, and two of sulphuric acid of the ordinary strength, and dissolved in this

mixture about fourteen ounces of tin. This solution which was first effected in the cold, was afterwards found to be rapidly accelerated by the heat of a sand-bath: it is transparent and colourless; and no precipitate was observed, though a quantity of it had been kept for three years. Dr. Bancroft observes, that this solution is twice as effectual, and only one-third as expensive, as the dyer's spirit before mentioned.

32. The red oxide of iron is that only which is employed as a mordant; it is applied to this purpose in two states of combination, namely, sulphate and acetate of iron; the former being most generally employed for wool, though sometimes it is used for cotton; but for this, acetate of iron is mostly preferred. The acetate is prepared by dissolving iron in vinegar, and it becomes the more completely oxidized, and acts more powerfully as a mordant, the longer it is retained in the solution.

33. The combination of the colour with the cloth is facilitated, and a greater number of shades are produced, by the use of a variety of saline matters, such as salt, sal-ammoniac, acetate of lead, acetate and sulphate of copper, sulphate of zinc, &c.; vegetable and animal substances also are applied for a similar purpose. When cottons are to be dyed the Turkey red, they should be impregnated with an animal substance, as oil; and the astringent principle or tan is often employed as a medium of combination between colouring matter and stuffs. The strong affinity existing between this substance and cloth renders it extremely proper for this purpose. The usual method of preparing it is by infusing nutgalls in water; in this solution the cloth is plunged, and allowed to remain till it is sufficiently impregnated. Sumach is prepared and used in a similar manner.

34. A variety of colours and shades may be obtained from the same colouring matter, merely by varying the mordant, or by applying it in a different manner; thus, different effects are produced by previously impregnating the stuff with the mordant, or by mixing it with the bath; different effects also arise from employing heat, or from allowing the stuff to dry more or less rapidly. It may also be observed, that when the affinity between the mordant and the colouring matter is strong, they may be mixed together, and the compound will combine with the stuff as readily and effectually as if these substances had been separately applied. But if the affinity between the colouring matter and the stuff be weak, the compound formed of the colour and the mordant may separate, and a precipitation take place before the compound can take hold of the stuff. When there is any danger of this, the mordant must be combined with the stuff before the colouring matter is applied. We must not here omit to observe, that some mordants have the property of communicating a colour without the aid of any colouring substance whatever. Thus it appears, that in fixing colouring matter, different processes must be adopted, according as the subject is of animal or vegetable production; but this will be still more evident from what follows.

Substances to which the Processes of Dying are applied.

35. We propose to confine our observations to the five following substances; namely, wool and silk, which are of animal origin; and cotton, flax, and hemp, which are obtained from vegetables. Between these two classes there exists striking differences in structure, composition, and chemical properties. A large proportion of azote is found in animal matters, and but very little in vegetable; and there is a greater abundance of hydrogen in the former than in the latter. Animal substances when distilled yield a considerable portion of ammonia, while very little is obtained from the distillation of vegetable substances, and from them an acid substance is frequently obtained: the former afford much oil, but the latter mostly very little. Animal matters by combustion emit a bright flame and penetrating odour, owing to the formation and emission of ammonia and oil; they also run rapidly into the putrefactive process: but vegetable substances, by undergoing the vinous or acetous fermentations, pass through their changes more gradually. There is also a stronger tendency in animal than in vegetable substances to assume the elastic form. Hence the cohesive force existing between the particles of the former is inferior to that between those of the latter; and therefore a greater disposition is manifested by the former to combine with colouring and other substances than by the latter. Different agents operate more powerfully on animal than on vegetable matters; they are destroyed by the caustic fixed alkalies, and decomposed by the nitric and sulphuric acids. Alkalies and acids act less powerfully upon silk than upon wool, and the former more reluctantly combines with the colouring matter; they also act less powerfully on vegetable than on animal substances, and their action on cotton is weaker than on hemp and flax. We now proceed to a more particular account of the five substances above mentioned, to which the processes of dying are, according to our restricted plan, applied.

Wool.

36. The value of wool depends on the length and fineness of its filaments; these filaments possess a considerable degree of elasticity, and their surface, in common with that of hair, is not perfectly smooth. The roughness, though not perceived with the microscope, is nevertheless obvious to the touch. The surface of the filament seems to be composed of small laminæ, placed over each other in a slanting direction from the root of the filament towards its point, similar to the arrangement of fishes' scales, which beginning at the tail, each succeeding row laps over that which precedes it. Or perhaps they consist of zones, placed over each other somewhat resembling the external structure of the horns of animals. This peculiarity of structure was first noticed by M. Monge, and on it depends the processes of felting and fulling, both which we shall describe in as few words as possible.

37. In felting, the flocculi of the wool are struck with the string of the bow; this detaches the filaments, and disperses them in the air. They then fall back upon each other in all directions, and as soon as a layer of sufficient thickness is thus formed on the table, it is pressed on all parts with the hands, to bring the filaments close together, and multiply the points of contact. This agitation produces a progressive motion towards the root; the laminæ of one filament take hold of those of others which are in an opposite direction; the filaments are thus entangled with each other, and the whole is retained in a state of close and intimate contexture.

38. Fulling is an operation connected with the former. The roughness on the surface of the filaments of wool, and their tendency to acquire a progressive motion towards the root, produce considerable inconvenience in the operations of spinning and weaving. These inconveniences are obviated by covering the filaments with a coat of oil, which fills up the cavities, and renders the asperities less sensible. When these operations are finished, the stuff must be freed from the oil, which would prevent it from taking the colour with which it is to be dyed. For this purpose it is taken to the fulling-mill, and beaten with large beetles in a trough of water, through which clay has been diffused. The clay unites with the oil, which being thus rendered soluble, is

carried off by fresh portions of water, conveyed to it by proper apparatus. In this way the stuff is scoured; but this is not the sole object. By the alternate pressure of the beetles an effect is produced similar to that of the hands in felting. The filaments composing a thread of warp or woof acquire a progressive motion, and are entangled with those of the adjoining threads; those of the latter into the next, and so on, till the whole threads are felted together. The stuff is now contracted in all its dimensions, and participating both of the nature of cloth and of felt, may be cut without being subject to ravel; and when employed to make a garment, requires no hemming. In a common woollen stocking web, after this operation, the stitches, when one happens to slip, are now no longer subject to run; and the threads of the warp and woof being less distinct from each other, the whole stuff is thickened, and forms a warmer clothing. It is well known that the qualities of wool depend greatly on the breed of the sheep, and the country in which they are reared; these are found to effect both the fineness of the filament, and the colour. Some is of a white, or yellow, and some of reddish, and black colour. Excepting the wool of the breed of sheep in Andalusia, the Spanish wool was formerly all of a brownish black colour. This was preferred by the native Spaniards; and even at this day the dress of some religious orders in Roman catholic countries consists of cloth manufactured from this wool, and retaining its natural colour. But for the purposes of dying, white wool is now always preferred, because it is found susceptible of receiving better and more durable colours. Wool is naturally covered with a kind of grease or oil, which is found to preserve it from insects or moths, hence this greasy matter is not removed, that is, the wool is not scoured, till it is to be dyed or spun. Reaumur has asserted, that rubbing any stuff with greasy wool is sufficient to preserve it from moths. The process for scouring wool is as follows: The wool is put for about a quarter of an hour into a kettle, with a sufficient quantity of water, to which a fourth part of putrid urine has been added; this is heated to as high a degree as the hand can bear, occasionally stirred, and the wool being taken out, it is allowed to drain. It is then put into a basket, and exposed to a stream of running water, and moved about till the grease is so completely separated, that it no longer renders the water turbid. After being drained, it is sometimes found to lose by this operation above one-fifth of its weight. The more carefully and completely this process is performed, the better the wool is fitted to receive the colouring matter. The ammonia, or volatile alkali, which exists in the urine, combines with the oil of the wool, and forms a soap, which being soluble in water, is dissolved, and carried off.

39. There are three different states in which wool may be dyed, namely, in the fleece, in the state of spun thread, or after the thread has been manufactured into cloth. The first of these methods is employed when the cloth is intended to be of mixed colours; the second is sometimes adopted for tapestry; and the third in most other cases. Likewise in these cases, the first method requires a greater quantity of colouring matter than the second; and the second a greater quantity than the third. The dying matter is applied with facility to wool from every part of the sheep, excepting to that from about the thighs and tail, which is generally found to receive the colours with difficulty. Scarlet dye never completely penetrates; for if the dyed cloth be cut, its interior is sometimes of a dull white, and always of a lighter colour than the surface.

Silk.

40. This valuable substance, which is the production of different species of insects, was known in China during the early ages of eastern history. The *phalæna bombyx*, or silkworm of that country, was that from which the first specimens were obtained; and the first who collected and prepared silk from the cocoons or balls in which it is formed by the insect, was a Chinese empress. Cocoons of a size still larger than the former, and yielding a stronger silk, are obtained from the *phalæna atlas* of Linnæus, which is also a native of China. From this country the silkworm was carried first to Hindoostan, and afterwards to Persia; but its valuable properties do not appear to have been known to the Greeks and Romans before the age of Augustus; and so little was understood of the nature and origin of silk, and so great was its scarcity, that for many ages it was sold at a price equivalent to its weight in gold. About the middle of the sixth century, two monks returning from India to Constantinople, brought with them a considerable number of silkworms, with instructions for managing and breeding them, as well as for collecting, preparing, and manufacturing the silk; and establishments were thus formed in various parts of Greece. The crusades, which greatly contributed to the diffusion of knowledge, by the intercourse which took place between different countries, proved useful in disseminating that of rearing the silkworm, and of preparing and manufacturing its valuable productions. Roger, King of Sicily, about the year 1130, returning from one of these expeditions, brought with him from Athens and Corinth several prisoners, who were acquainted with the management of silkworms, and the manufacturing of silk. Under their superintendence manufactories were established at Palermo and Cagliari in Sicily, and the example was soon followed in different parts of Italy and Spain. In the time of James I. an attempt was made to establish the silkworm in England. For this purpose the culture of the mulberry tree, on which the insects feed, was strongly recommended by that prince to his subjects; but the attempts made in this country have hitherto proved unsuccessful.

41. Silk in its natural state, as obtained from the cocoons, has its fibres coated with a gummy varnish, to which its stiffness and elasticity are attributed. There is also, besides this varnish, a yellow substance with which the silk imported into European countries is found to be impregnated. To deprive the silk of the last of these substances, and in many cases of both, is an indispensable operation, and which must take place previously to any other; this operation is called scouring, and it is to be applied in different degrees, according to what is intended with respect to the silk; the difference in the processes depending chiefly on the quantity of soap employed in each. When silk is to be whitened, the most effectual scouring is necessary; a less degree of the process will suffice for silks that are to be dyed; and different colours require also different degrees of this preparatory operation. A hundred pounds of silk boiled in a solution of twenty pounds of soap for three or four hours, adding new portions of water during the evaporation, are sufficiently prepared for receiving common colours. For blue colours the proportion of soap must be increased; and scarlet, cherry colour, &c. require still a greater proportion, for the ground must be whiter for these colours.

42. Silk intended to be white must undergo three operations. In the first the hanks are immersed in a hot but not boiling solution of 30 pounds of soap to 100 of silk. When the immersed part is freed from its gum, which is known by its whiteness, the hanks are shaken over, so that the part which was not previously immersed may undergo the operation. They are then wrung out as the process is completed. In the second operation the silk is put into bags of coarse cloth, each containing 20 or 30 pounds. These bags are boiled for an hour and a half, in a solution of soap pre-

pared as before, but with a smaller proportion of soap; and that they may not receive too much heat by touching the bottom of the kettle, they must be constantly stirred. The object of the third operation is to communicate to the silk different shades, to render the white more agreeable. These are known by different names, as China-white, silver-white, azure-white, or thread-white. For this purpose a solution of soap is also prepared, of which the proper degree of strength is ascertained by its manner of frothing when agitated. For the China-white, which is required to have a slight tinge of red, a small quantity of anatto is added, and the silk is shaken over in it till it has acquired the shade which is wanted. In other whites, a blue tinge is given by adding a little blue to the solution of soap. The azure-white is communicated by means of indigo. To prepare the azure, fine indigo is well washed two or three times in moderately warm water, ground fine in a mortar, and boiling water is poured upon it. It is then left to settle, and the liquid part only, which contains the finer and more soluble parts, is employed. Some use no soap in the third operation; but when the second is completed, they wash the silks, fumigate with sulphur, and azure them with river water, which should be very pure. But all these operations are not sufficient to give silk that degree of brightness which is necessary, when it is to be employed in the manufacture of white stuffs. For this purpose it must undergo the process of sulphuration, in which the silk is exposed to the vapour of sulphur. See Bleaching, par. 43. But before the silk which has been treated in this way is fit for receiving colours, and retaining them in their full lustre, the sulphur which adheres must be separated by immersion and agitation in warm water, otherwise the colours are greatly injured.

43. We have already stated that the stiffness and elasticity of the silk depend on the gummy substance with which in its natural state the fibres are impregnated; it is therefore desirable in many cases to retain this gummy matter in the silk, and at the same time to free it from the colouring matter. M. Beaume, a French chemist, discovered an effectual process for separating the latter, without removing the former, but his secret never was imparted to the public. Conjecture, aided and confirmed by experiment, has however developed the process, of which M. Berthollet gives the following account: "A mixture is made with a small quantity of muriatic acid and alcohol. The muriatic acid should be in a state of purity, and particularly it should be entirely free from nitric acid, which would give the silk a yellow colour. In the mixture thus prepared the silk is to be immersed. One of the most difficult parts of the process, especially when large quantities are operated upon, is to produce an uniform whiteness. In dying whitened silk, to prevent its curling, it is recommended to keep the silk constantly stretched during the drying. The muriatic acid seems to be useful in this process, by softening the gum, and assisting the alcohol to dissolve the colouring particles combined with it. The alcohol which has been impregnated with the colouring matter may be again separated from it and purified, to serve for future operations, and thus render the process more economical. This may be done by means of distillation with a moderate heat, in vessels of glass or stone."

44. Another preliminary operation, not less necessary than the preceding, is the preparation with alum, a process which in technical language is called aluming. This preparation, which is essential to the beauty and permanency of the colours, is described as follows: "Forty or fifty pounds of alum, previously dissolved in warm water, are mixed in a vat, with as many pailfuls of water; and to prevent the crystallization of the salt, the solution must be carefully stirred during the mixture. The silk being previously washed and beetled, to separate any remains of soap, is immersed in this alum liquor, and at the end of eight or nine hours wrung out, and washed in a stream of water. A hundred and fifty pounds of silk may be prepared in the above quantity of liquor; but when it begins to grow weak, which may be known by the taste, twenty or twenty-five pounds of dissolved alum are to be added, and the addition repeated till the liquor acquires a disagreeable smell. It may then be employed in the preparation of silk intended for darker colours, till its whole strength is dissipated." The liquor is never to be used till it is nearly or quite cold; for if hot, it seldom fails to injure the lustre of the silk.

Cotton.

45. Cotton is a downy substance, enveloped in the pods of the *gossypium*, a shrub which grows in the tropical climates. Cottons are valuable in proportion to the length, fineness, colour, and strength of their filaments. Very little is known of the peculiar structure of the fibres, and for that little we are indebted principally to the researches of Anthony de Leuwenhoek, a Dutch physician, who died in 1723. From a great number of microscopical observations he determined, that the fibres of cotton have two sharp sides, and to this circumstance is attributed the painful irritation which is felt when wounds and sores are dressed with cotton. It has also been supposed, that the peculiarity of structure we have noticed, may induce a difference in the number and conformation of the pores, on which alone seems to depend the superiority of cotton above linen, in imbibing and retaining colours. It is however in this respect inferior to wool and silk, as we have before observed. Dr. Bancroft supposes, that the openness of cotton and linen, and their consequent readiness to imbibe both colouring particles, and the earthy or metallic bases employed to fix most of them, are circumstances upon which the art of dying and calico-printing is in a great degree founded. Pileur d' Apligni attempts quite a different explanation; but it seems probable, that the cause why silk and cotton have a weaker affinity than wool for colouring matter, should be ascribed to a difference of affinities known to exist between the particles of colouring matter, and the substance which is separated from the silk or cotton by bleaching or scouring. "This substance," says an ingenious writer, "probably acts the part of a mordant; and having a stronger affinity for the stuff and for the colouring matter, than the stuff has for the latter, the colour communicated is more durable when silk or cotton is dyed in the unbleached or unscoured state."

46. A variety of operations is necessary to prepare the cottons for receiving the dye; the first of these is scouring. Some boil the cotton in sour water or alkaline ley. After keeping it boiling for two hours, it is wrung out and rinsed in a current till the water ceases to be discoloured; then soaked in water impregnated with about one-fiftieth part of sulphuric acid, and afterwards thoroughly washed in running water and dried. Thus the injury which would otherwise have impeded the dying process is prevented, by the acid combining with a portion of the calcareous earth and iron contained in the materials.

47. When the cotton has been scoured as above directed, the next preparatory operation is aluming. The alum is dissolved and managed as for silk, and the quantity necessary to be employed in this process is about one-fourth the weight of the cotton. In addition to this, a solution of soda is frequently employed; and some add a small quantity of arsenic and tartar. Having agitated the thread by a small quantity at a time in this solution, till it is impregnated, the thread is put into a vessel, the liquor poured upon it, and in

this state it is allowed to remain about twenty-four hours; at the end of this space it is immersed in a clear stream of water, in which having lain for about two hours, it is taken out and washed. It is found that aluming increases the weight of cotton by about one-fortieth that of itself before the process.

48. The last preparatory operation which we have to notice is galling. A quantity of powdered galls is put into as much water as will be necessary to produce a greater or less effect, according to what may be required, and the mixture is boiled for the space of two hours. The solution, when cooled so that the hand may be borne in it, is divided into as many equal parts as there are pounds of cotton thread to be galled, and a pound of the thread is agitated in each. All the cotton is then put into one vessel, and the solution poured upon it. For most colours a soaking of twelve or fifteen hours will be sufficient; but if the intended colour be black, the cotton must remain in the solution at least twenty-four hours. When cottons already dyed are to be galled, the solution employed must be cold, otherwise the colours will be damaged. Cottons that have been alumed are found to possess a greater power of combining with both the astringent principle and the colouring matter, and also to acquire more weight in galling than those which have not been subjected to the aluming process.

Flax and Hemp.

49. There is such a striking similarity between flax and hemp, as far as relates to those properties which we shall now have occasion to notice, that what is said of the one will apply to the other. The former of these substances is obtained from the bark of the *linum usitatissimum*, and the latter from that of the *cannabis sativa.* Flax intended to be dyed must undergo the processes of scouring, aluming, and galling, which we have already described; and, in addition to these, it must be subjected to a previous and not less important process, namely, watering; an operation by which the fibrous and woody parts are separated, and the former made susceptible of being spun into threads. During the process of watering, carbonic acid and hydrogen gas are extricated; this arises from the commencement of putrefaction acting on a glutinous substance which is the medium of union between the cortical and ligneous parts of the flax, and which holds in solution the green colouring matter of the plant. This substance, which resembles the glutinous matter dissolved in the expressed juices of vegetables, is separated from the colouring particles by heat; it readily becomes putrid, and when distilled, gives out ammonia. Water however is found insufficient to disengage it completely from the colouring particles; hence, if the current be too rapid, the flax or hemp watered in it will be deficient in softness and flexibility; but if, on the contrary, these substances be steeped in stagnant water, they are deprived of their firmness, and become brown. In the former case, the necessary putrefactive process is interrupted; and in the latter, it is too much accelerated, and also carried to too high a pitch. To prevent both these inconveniences, of which the latter would expose the persons employed to the ill effects of noxious effluvia, and both be injurious to the flax or hemp, it is recommended, that the watering be performed in a suitable place near the bank of a river, which will admit of the water being frequently changed, and of thereby facilitating such changes in the substance as are necessary to render the glutinous matter above mentioned soluble in water. When the watering is completed, the flax or hemp is spread to dry on a glass-plot, where it is exposed for some time to the joint action of the sun and air. This not only improves the colour, but the ligneous part is thereby made so brittle, that it easily separates from the fibres.

The Dye-house, Apparatus, and Operations.

50. The grand object of the dyer is to perform his work in the most cleanly and effectual manner, without loss of ingredients, fuel, time, or labour. To effect these purposes, an extensive plan of operations is necessary; the dye-house should be spacious, and situate as near as possible to a stream of clear water; the floors should be of plaster, and intersected at proper places with channels, to carry off the useless water, and promote that cleanliness which is essential to the practice of this art.

51. The nature and extent of the operations to be performed, will readily point out the proper size and position of the caldrons necessary to be used. Excepting for scarlet and other delicate colours, in which tin is used as a mordant, and therefore tin vessels are to be preferred, the caldrons should be of brass or copper. Brass being less apt than copper to be acted on by chemical agents, and to communicate spots to the stuffs, is most proper for the purpose. The coppers or caldrons must be well cleaned for every operation, and vessels of a large size should be furnished at the bottom with a pipe and stop-cock, for the greater conveniency of emptying them: also there must be a hole in the wall or chimney above each copper, to admit poles for the purpose of draining the stuffs, so that the liquor may fall back into the vessel, and no part be lost.

52. Dyes for silk, where a boiling heat is not found necessary, are prepared in troughs or backs, which are long copper or wooden vessels. The colours used for silk being extremely delicate, the latter must therefore be dried quickly, that they may not be long exposed to the action of the air, in order that there may be no risk of change. For this purpose, it is necessary to have a drying room heated with a stove. The silk is stretched on a moveable pole called a shaker, which is hung up in the heated chamber, and kept in constant motion to promote the evaporation.

53. For pieces of stuffs, a winch or reel must be constructed; the ends are supported by two iron forks which may be put up at pleasure in holes made in the curb on which the edges of the copper rest. The manipulations in dying are neither difficult nor complicated. Their object is to impregnate the stuff to be dyed with the colouring particles dissolved in the bath. For this purpose, the action of the air is necessary, not only in fixing the colouring particles, but also in rendering them more vivid; while those which have not been fixed in the stuff are to be carefully removed. In dying whole pieces of stuff, or a number of pieces at once, the winch or reel mentioned above must be employed. One end of the stuff is first laid across the reel or winch, which being turned quickly round, the whole passes successively over it. By turning it afterwards the contrary way, that part of the stuff which was first immersed, will be the last in the second immersion; and thus the colouring matter will be communicated as equally as possible. See Bleaching.

54. When wool is dyed in the fleece, an instrument called a scraw or scray is employed. It resembles a broad ladder with the rounds very close, and being placed over the copper, the wool is laid on it to drain, and for the purpose of exposure to air. When the wool is in the state of thread, rods are passed through the skains, and the hanks are turned upon the skain-sticks in the liquor. This operation, which is called shaking over, is likewise employed under similar circumstances for silk and thread. The stuff, silk, or thread, after being dyed, must be wrung out, in order to extricate the superabundant colouring particles which have not taken hold on the stuff. This wringing is successively repeated, for the purpose of drying the goods, and of giving the colour

a brighter lustre; it is performed by means of a cylindrical wooden bar, having one of its ends fixed either in a post or a neighbouring wall.

55. As often as fresh ingredients are added, the liquid must be well agitated with a proper instrument called a rake; whence this part of the process is called by the dyers raking. Stuffs are sometimes passed repeatedly through the same liquid, in this case each particular operation is called a dip; and when one colour is communicated with the intention of applying another upon it, the first of these is called giving a ground. The conversion of a yellow red to a more perfect red is called heightening the colour; and when a red colour with a yellow tinge is improved to a shade inclining to crimson or ruby, the colour is said to be rosed. The manipulations of dying, as we have before observed, are extremely simple; "yet," says an attentive and competent observer, "they require very particular attention, and an experienced eye, in order to judge of the qualities of the bath, to produce and sustain the degree of heat suited to each operation, to avoid all circumstances that might occasion inequalities of colour, to judge accurately whether the shade of what comes out of the bath suits the pattern, and to establish the proper gradations in a series of shades." Berthollet's Elem. of Dying, i. 162.

Qualities and Effects of different Kinds of Water.

56. Water is a most essential agent in the practice of dying; and consequently to obtain it in a pure state, or at least unmixed with injurious substances, is a matter of the highest importance to the success of the operation. It should be tasteless, not muddy, uncontaminated with putrid matter of any kind, and unmixed with earthy salts. Water holding earthy salts in solution, as the nitrates, muriates, and carbonates of lime and magnesia, sulphate of lime, &c. are found to act considerably on colouring matters. These salts powerfully resist the solution of the colouring particles, and by combining with them, cause a precipitation, of which the obvious effect is to produce sometimes a dull and sometimes a bright colour, which, it is scarcely necessary to say, is highly injurious to the process. Hard water is therefore to be rejected; but of this there are many different kinds, arising from the different combinations of injurious principles which each kind may hold in solution. To ascertain with precision the exact nature and proportion of these principles contained in water, is a matter of no less difficulty than importance, and requires the skill of an able and experienced chemist. We may however safely pronounce all those waters proper for the dyer's use which are limpid, not stagnant, without perceptible taste or smell, and which readily dissolve soap without decomposition.

57. For discovering the presence of earthy salts in water, one of the most simple tests is a solution of soap in alcohol. If a small quantity of this be dropped into pure water, no change takes place; but if the water be impregnated with saline matters, a milkiness appears, and a flocculent precipitate is formed, from the degree and proportion of which we may judge how far the water is suited to the dyer's purpose. In this case the alkali of the soap is disengaged from the oil with which it was chemically united, and combines with the acid of the earthy bases of the salts dissolved in the water; and the oil uniting with the earth, forms with it an insoluble precipitate, or earthy soap. Accum on Chemical Tests, p. 216, 217.

58. The following method is employed for correcting water, when it cannot be obtained in a sufficient degree of purity for the dyer's use. Twelve bushels of bran are put into a vessel sufficiently large to contain five hogsheads; and on this is poured as much water heated nearly to the boiling temperature, as will almost fill the vessel; a fermentation soon takes place, and the liquor, after remaining twenty-four hours, is fit for use. Water thus impregnated is called sours, or sour water; it forms no precipitate by boiling, and answers all the purposes of pure water. The vegetable acid formed during the fermentation, combining with the earthy base, disengages the carbonic acid; whence it is probable, that the sour water, acting on the carbonate of lime and magnesia, decomposes it.

59. A separation of the substances which contaminate water (especially when those substances are not in a state of chemical union with the water) may sometimes be effected by the interposition of mucilaginous substances; for, by the proper application of heat, the mucilage coagulates and rises to the surface, carrying up with it the earths separated by boiling, together with those substances which, by being diffused through the water, render it turbid. The whole of the feculent matter thus rising to the top, is skimmed off, leaving the liquor fit for use. It is however not always necessary to free the water from these saline impurities; their action in some cases is required, to produce modifications of the colour communicated; thus a crimson shade may be communicated to the colour of cochineal by the use of this unpurified water. From a variety of causes, water obtained at different times and places from the same river, will be contaminated in very different degrees with these salts. This, if not attended to, will occasion considerable uncertainty as to the results; and what is worse, no general directions, on which dependence is to be placed, can be given on this head. In this, as in various other particulars of the dyer's art, a knowledge of the principles of chemistry, combined with habitual observation, must direct the artist; and these will prove to him a safer guide than all the written instructions that can be given.

PRACTICE OF DYING.

60. Before we describe the processes of dying, it will be proper to state two or three particulars respecting colours, according to the manner in which the practical dyer contemplates them. Colours of every shade and description are arranged by the dyers in two general classes, simple and compound. Simple colours are such as cannot be produced by the mixture of any different colours whatever. Compound colours are such as are obtained by the mixture of simple colours; and they vary in their shades, according to the various proportions of the component simple colours. Hence simple colours are the foundation of all others. The simple colours are four in number, namely, red, yellow, blue, and black: some have added to these a fifth, namely, brown, or fawn colour; but as this may be produced by the mixture of other colours, it seems improperly classed with the simple colours.

Red.

61. Under the general denomination of red are included crimson, scarlet, and a variety of shades which have hitherto been discriminated by no particular name. Madder, cochineal, kermes, archil, carthamus, Brazil wood, and logwood, are the substances from which red colouring matters are chiefly obtained.

62. Madder is the root of the *rubia tinctorum;* it is cultivated in various parts of Europe, but that which grows in Zealand is mostly preferred. That obtained from the island of Cyprus and the neighbourhood of Smyrna affords a brighter red than European madder, and on this account it is used in preparing the Adrianople red. It is called *lizari,* and is cultivated both in Provence and at Gottingen. Madder, as prepared for dying, is distinguished into two kinds; the first

of which, or *grape madder*, is obtained from the roots; and the second, or *none grape*, comes from the stalks, which by being buried in the earth become roots, and are called layers. The best roots are about the thickness of a goose quill, have a degree of transparency, a reddish colour, a strong smell, and a smooth bark. When the madder is collected, the layers are separated with those parts or fibres of the roots as are above or below a particular size. It is then dried, either in the open air, or by means of a moderate heat from stoves; the former method is considered as the best. When the roots are sufficiently dry, they are shaken in a bag, or beat lightly on a wooden hurdle, to separate the earthy matters which adhere; they are then reduced to powder, either by pounding or in a mill.

63. All the parts of this root do not yield the same colouring matter. The outer bark, and the ligneous part within, give a yellowish dye, which injures the red. These parts are however easily separated in consequence of the different degrees of facility with which they are reduced to powder; the outer bark and woody parts being more easily powdered than the parenchymatous parts, which contain the fine red dye. To effect the separation of these different parts, three operations are performed. After the first, the madder is passed through a sieve, by which the short madder intended for tan and inferior colours is obtained. What remains is again ground and sifted; whence is obtained the kind which the French have denominated *murobée*. A third process of the same kind affords the *robée*, or finer kind of madder. These preparations are however not indispensable, for the experiments of M. D'Ambourney shew, that the fresh root of madder may be used with as much advantage in dying as when it is dried and powdered. Four pounds of fresh madder, according to him, are equal to one of the dry; although in drying it loses seven-eighths of its weight. When the fresh roots are to be used, they are well washed in a current of water immediately after they are taken out of the ground, and then cut into pieces and bruised. In dying with the fresh roots, allowance should be made for the quantity of water which they contain, so that a smaller proportion should be put into the bath. Beckmann seems to be of the same opinion with regard to the use of the fresh roots, and yet he has frequently observed, that it is more fit for dying after it has been preserved for two or three years.

64. Alcohol is capable of dissolving the colouring matter of madder; and if the solution be evaporated, a deep red residuum is formed. Sulphuric acid, fixed alkali, and sulphate of potash, throw down precipitates from this solution; the first fawn coloured, the second violet, and the third a beautiful red; also nitre, chalk, alum, acetate of lead, and muriate of tin, form with it precipitates of various shades. The colouring matter of madder is also soluble in water. By maceration in several portions of cold water successively, the last receives only a fawn colour, which appears entirely different from the peculiar colouring particles of this substance. It resembles what is extracted from woods and other roots, and perhaps exists only in the ligneous and cortical parts. By repeated boiling, Berthollet exhausted the madder of all its colouring particles which are soluble in water. It still retained, however, a deep colour, and yielded a considerable quantity of colouring matter to an alkali. There was an inconsiderable residuum, which still remained coloured. The pulp, therefore, appears entirely composed of colouring matter, part of which is insoluble in simple water. When oxymuriatic acid is employed in sufficient quantity to change an infusion of madder from red to yellow, it produces a small portion of a pale yellow precipitate; the supernatant liquor is transparent, and retains more or less of a deep yellow colour, according to the proportion and strength of the acid. Double the quantity of acid is required to discharge the colour of a decoction of madder, of what is necessary to destroy that of the same weight of Brazil wood. This shews that the colouring matter of madder is more durable than that of Brazil wood. The infusion of madder in water is of a brownish orange colour. The colouring matter may be extracted either by hot or cold water; in the latter the colour is most beautiful. The decoction is of a brownish colour. The colouring matter of madder cannot be extracted without a great deal of water. Two ounces of madder require three quarts of water. Alum forms, in the infusion of madder, a deep brownish red precipitate; the supernatant liquor is yellowish, inclining to brown. Alkaline carbonates precipitate from this last liquor a lake of a blood-red colour; with the addition of more alkali, the precipitate is redissolved, and the liquor becomes red. Calcareous earth precipitates a darker and browner coloured lake than alkalies. Carbonate of magnesia forms a clear blood-red precipitate, which by evaporation produces a blood-red extract, soluble in water. The solution of this extract is employed as a red ink, but it becomes yellow by exposure to the sun. Metallic salts also form precipitates in a solution of madder. The precipitate with acetate of lead is of a brownish red colour; with nitrate of mercury and sulphate of manganese, a purplish brown; with sulphate of iron, a fine bright brown.

65. COCHINEAL is an insect produced on the *cactus*, or Indian fig. There are two kinds of cochineal; the largest and best which breeds on the *cactus opuntia*, or *nopal*, is called by the Spaniards *grana fina*. The smaller kind, or wild cochineal, is called by them the *grana sylvestra*, and feeds on other species of the cactus. See COCHINEAL. The first of these varieties yields a greater quantity of colouring matter than an equal weight of the other; but the wild cochineal requires less trouble and expense in the management, and becomes, by proper attention, nearly equal in quality to the finer sort. The annual consumption of cochineal in the united kingdom may be estimated at little short of 120 tons, the value of which will amount to about 200,000*l.* sterling.

66. The best kind of cochineal which has been prepared and kept in a proper manner, will have a grey colour shaded with purple. The grey results form a powder (of which a part still remains) that covers the cochineal in its natural state. Cochineal, if kept in a dry situation, may be preserved for a considerable time without injury; this appears from the experiments of Hellot, on a specimen which had been kept for 130 years, and which produced the same effect as if it had been quite new. Cochineal yields its colouring matter to water, though not entirely; for by adding a little potash to the apparently exhausted sediment, Dr. Bancroft found that it yielded an additional portion of colouring matter, equal to about one-eighth of the quantity extracted by the water; and Berthollet observed similar effects from the addition of tartar. If the decoction of cochineal in water be evaporated, and the residuum digested in alcohol, the colouring part dissolves, and leaves a residuum of the colour of wine lees, of which fresh alcohol cannot deprive it. The alcohol of cochineal affords, by evaporation, a transparent residuum of a deep red, which being dried, has the appearance of a resin. A little sulphuric acid added to the decoction of cochineal, produces a red colour inclining to yellow, and a small quantity of a beautiful red precipitate. With muriatic acid the same change is produced, but without any precipitate. A solution of tartar converts the decoction to a yellowish red colour. A precipitate of a pale red colour is slowly formed, and the supernatant liquor remains yellow; but with the addition of an alkali becomes purple. With the yellow liquor, solution of tin forms a rose-coloured

precipitate; solution of alum brightens the colour of the infusion, gives it a redder hue, and produces a crimson precipitate. With a mixture of alum and tartar the colour is brighter, more lively, and inclines to a yellowish red. Muriate of tin occasions a copious sediment of a beautiful red. The supernatant liquor is colourless and transparent, and no change is produced on it by adding an alkali. Sulphate of iron forms a brown violet precipitate, and the supernatant liquor remains clear, with a slight darkish hue. Sulphate of zinc gives a deep violet precipitate; the supernatant liquor remains colourless and transparent. The precipitate with sulphate of copper is of a violet colour, and forms slowly: the supernatant liquor is also violet and transparent. Acetate of lead gives a purple violet precipitate, and the supernatant liquor remains limpid.

67. Kermes, or the *coccus ilicis* of Linnæus, is an insect obtained chiefly from Spain, Portugal, and the southern parts of France, where it breeds on the species of oak called by Linnæus *quercus coccifera*. These insects, of which the female alone is useful, are collected during the months of May and June, and either steeped in vinegar, or exposed to its steam; after which they are dried on linen cloths. If one of these living insects be bruised, it affords a pleasant smell, a bitter and pungent taste, and gives out a red colour. It imparts its colouring matter, smell, and taste to both alcohol and water. The colour is also retained in the extract which is obtained, both from the tincture, and from the infusion. Kermes is one of the most ancient dying drugs; and although the colours which it communicates to cloth are less bright and vivid than those of cochineal, yet they have been found to be exceedingly permanent. The fine blood-red colour which is to be seen on old tapestries in different parts of Europe, was produced from kermes, with an aluminous mordant, and seems to have suffered no change, though some of them are 200 or 300 years old. The colour obtained from kermes was formerly called scarlet in grain, because it was supposed that the insect was a grain; and from the chief manufactory having been at one time in Venice, it was called Venetian scarlet.

68. Lac, which is an animal production, has been long known in India, where it is used for dying silk and other purposes. It is the *nidus* of the *coccus lacca* of Linnæus, and is generally produced on the twigs of the *croton lacciferum*. Three kinds of lac are well known in commerce: 1. Stick lac is the substance or comb, in its natural state, forming a crust on the small branches or twigs. 2. Seed lac is said to be only the above separated from the twigs, and reduced into small fragments. The silk dyers in Bengal produce the seed lac by pounding crude lac into small fragments, and extracting part of the colouring matter by boiling. 3. Shell lac is prepared from the cells, liquefied, strained, and formed into thin transparent laminæ. There is also a fourth kind called lump lac, which is obtained from the seed lac by liquefaction, and afterwards formed into cakes. The best lac is of a deep red colour: when it is pale, and pierced at the top, the value is greatly diminished, for then the insects have left their cells, and it can no longer be of use as a dye stuff. Powdered stick lac boiled in water gives a deep crimson colour. With one-fifth of borax, lac becomes more soluble in water. Pure soda, and carbonate of soda, completely dissolve the different kinds of lac, and produce a deeper colour than that which is obtained by means of borax. Pure potash speedily dissolves all the varieties of lac; the colour approaches to purple. Pure ammonia and carbonate of ammonia readily act on the colouring matter of lac. Alcohol dissolves a considerable portion of the lac; and according to Geoffroy, yields a fine red colour. When the solution is heated it becomes turbid. Sulphuric acid dissolves the colouring matter of lac, as well as muriatic and acetic acids. In the use of lac in dying, it has been considered superior to kermes, because it is able to bear the action of a solution of tin, without the colour being changed to yellow.

69. Archil is a vegetable substance, employed in the form of a paste, which is of a red violet colour. It is chiefly obtained from two species of lichen, *roccella*, and *parellus*. That from the first, which is called Canary archil, is most valued. It is prepared by reducing the plant to a fine powder, which is afterwards passed through a sieve, and slightly moistened with stale urine. The mixture is daily stirred, each time adding a certain proportion of soda in powder, till it acquire a clove colour. It is then put into a wooden cask, and urine, lime water, or a solution of sulphate of lime is added in sufficient quantity to cover the mixture. In this state it is kept; but to preserve it any length of time, it must be moistened occasionally with urine. By a similar preparation, other species of lichen may be used in dying; the *lichen omphalodes* and *tartareus* are frequently employed here for dying coarse cloths. Archil gives out its colouring matter to water, ammonia, and alcohol. The infusion of archil is of a crimson colour, with a shade of violet. The addition of an acid converts it to a red colour. Fixed alkalies only render it of a deeper shade; because its natural colour has been already modified by the ammonia with which it is combined in the preparation. Alum produces in the solution of archil a dark red precipitate; the supernatant liquor is of a yellowish red colour. With solution of tin a reddish precipitate is formed, which subsides slowly; and the liquor retains a slight tinge of red. This infusion loses its colour in a few days if it be entirely excluded from the air. To cold marble the aqueous infusion of archil communicates a fine violet colour, or blue inclining to purple. The affinity between the stone and the colouring matter is so strong, that it resists the action of the air longer than colours which it gives to other substances. The colour thus communicated to marble has remained unchanged for two years.

70. Carthamus, or Bastard Saffron, is the flower of an annual plant cultivated in Spain, Egypt, and the Levant. There are two varieties of this plant, the one with larger, the other with smaller leaves. The variety with larger leaves is cultivated in Egypt. Hasselquist gives the following description of the method of preparing the flowers of carthamus in Egypt: "After being pressed between two stones, to squeeze out the juice, they are washed several times with salt water, pressed between the hands, and spread out on mats in the open air to dry. In the daytime they are covered, that they may not dry too fast with the heat of the sun, but they are left exposed to the dew of the night. When sufficiently dry, they are put up, and kept for sale, under the name of soffranon. Care should be taken afterwards not to keep this substance in too dry a place; for unless it is a little moist, its properties are considerably impaired." There are two colouring substances contained in carthamus, namely, a yellow and a red; the former is soluble in water, and as it is of no use, it is extracted by the process mentioned above, by squeezing the flowers between stones till no more colour can be pressed out. The flowers become reddish in this operation, and lose nearly one half of their weight. The red colouring matter is soluble in alkaline carbonates, and is precipitated by means of an acid. A vegetable acid, as lemon juice, has been found to produce the finest colour. Next to this, sulphuric acid produces the best effect, provided too great a quantity be not employed. The juice of the berries of the mountain ash is recommended by Scheffer as a substitute for lemon juice, and is

thus prepared: The berries are bruised in a mortar with a wooden pestle, and the expressed juice, after it has been allowed to ferment, is bottled. The clear part, which is most acid, becomes fitter for use the longer it is kept; but this operation requires a period of some months, and can only be conducted in summer. From the colouring matter extracted by means of an alkali, and precipitated with an acid, is procured the substance called rouge, which is employed as a paint for the skin.

71. Brazil Wood is the wood of the *cæsalpinia crysta*, a native of America and the West Indies. It is known under different names, according to the place where it is produced; as Fernambouc, Braziletto, wood of St. Martha, and of Sapan. It has a sweetish taste, is very hard and dense, and when fresh cut is of a pale colour, but becomes reddish by exposure to the air. The colouring matter of Brazil wood is soluble in water, and the whole of it may be extracted by continuing the boiling for a sufficient length of time, yielding a decoction of a fine red colour. The residuum, which is black, yields a considerable portion of colouring matter to alkalies. This colouring matter is also soluble in alcohol, and in ammonia, and the colour is deeper than that of the aqueous solution. The tincture of Brazil wood in alcohol gives to hot marble a red colour, which afterwards changes to violet. The fresh decoction yields, with sulphuric acid, a small portion of a red precipitate, inclining to fawn colour. Nitric acid first produces a yellow colour, but by adding more, a deep orange. Oxalic acid produces a precipitate of an orange red. Tartar furnishes a small precipitate: with the addition of fixed alkali, the decoction becomes of a deep crimson or violet colour. Ammonia gives a brighter purple: alum produces a copious red precipitate, inclining to crimson. Sulphate of iron occasions a black colour in the tincture, with a copious precipitate of the same colour. Sulphate of copper also produces an abundant precipitate, the liquor remaining transparent, and of a brownish red. A copious precipitate of a fine deep red is produced with acetate of lead, and that obtained with muriate of tin is abundant, and of a fine rose colour. With the addition of corrosive sublimate, a light precipitate, which is of a brown colour, is obtained. The liquor remains transparent, and of a fine yellow colour. Brazil wood which has been changed to a yellow colour by means of tartar and acetous acid, with a solution of nitro-muriate of tin, yields a copious rose-coloured precipitate; and if to the solution, rendered yellow by an acid, a greater quantity of the same acid, or a stronger acid, as the sulphuric, be added, the red colour is restored. Some salts also possess the property of restoring the red colour of Brazil wood, which has been destroyed by means of acids. The decoction of Brazil wood, which is called juice of Brazil, is found to answer better for the processes of dying, when it has been kept some time, and has even undergone some degree of fermentation, than when it has been fresh prepared. The colour becomes of a yellowish red by keeping.

72. Logwood, the *hæmatoxylon campeachianum* of Linnæus, grows to a considerable size in Jamaica, and also in the neighbourhood of the Bay of Campeachy. It yields a fine red colouring matter abundantly to alcohol, but more sparingly to water; and in the latter case, the colour inclines to violet or purple. When left some time to itself, it becomes yellowish, and at length black. It becomes yellow also by the action of acids; alkalies produce a deeper colour, and convert it to a purple or violet. Sulphuric, nitric, and muriatic acids form a small proportion of precipitate, which separates slowly: the precipitate formed with sulphuric acid is of a dark red; with muriatic, a lighter red; and with the nitric, *feuille mort.* With sulphuric and muriatic acids, the supernatant liquor is of a deep red colour; with nitric it is yellowish, and in all transparent. Oxalic acid produces a precipitate of a light marone colour; the liquor remains transparent, and is yellowish red. Acetic acid produces a similar effect, but the colour of the precipitate is somewhat deeper. A similar precipitate is obtained by means of tartar; but the liquor, which is more inclined to yellow, remains turbid. No precipitate is produced by means of fixed alkali; the decoction becomes of a deep violet, which is afterwards converted to a brown colour. Alum yields a copious precipitate, of a lightish violet colour; the colour of the liquor remains the same, and it is nearly transparent. A copious dark red precipitate is produced with alum and tartar; the liquor is yellowish red and transparent. Sulphate of iron occasions a bluish black colour; a copious precipitate of the same colour is formed, and the liquor remains long turbid. With sulphate of copper, a very copious precipitate of a deep brown colour is obtained; the liquor, which is also of a deep brown, or yellowish red, remains transparent. Acetate of lead yields a black precipitate, with a slight tinge of red; the colour of the liquor is like that of pale beer, and transparent. Nitro-muriate of tin gives a precipitate of a fine violet or purple colour; the liquor remains clear and colourless.

Dying Wool Red.

73. Dr. Bancroft has divided the colours into substantive and adjective; the former being such as require no mordants to fix them; and the latter, such as cannot be made permanent without the assistance of mordants. Under the latter class must be placed all the red colouring matters with which we are acquainted.

74. Madder Red. Dying with madder is confined to coarse woollen stuffs. Having boiled the stuffs with alum and tartar for two or three hours, they are slightly wrung out, put into a linen bag, and placed in a cool situation, where they are allowed to remain for a few days. A variety of opinions prevail respecting the proportion of alum and tartar which ought to be used in this process. Some recommend one ounce of tartar and five ounces of alum, to a pound of wool; others reduce the quantity of tartar to one-seventh of the mixture. Care however must be taken not to increase the proportion of tartar beyond a certain limit; otherwise a permanent cinnamon colour will be produced; and hence also it appears, that by varying the proportion of alum and tartar, an indefinite variety of shades will be obtained. The quantity of madder employed should, according to Poerner, be one-third the weight of the wool; but Scheffer diminishes the proportion to one-fourth. The former in conducting one process, added to the alum and tartar a quantity of solution of tin, equal in weight to the tartar, and after two hours boiling, allowed the cloth to remain in the bath, which had been left to cool for three or four days. He then dyed it in the usual way, and thus obtained a fine red. In another process, he prepared the cloth by the common boiling, and dyed it in a bath slightly heated, with a larger proportion of madder, tartar, and solution of tin. The cloth remained twenty-four hours in the bath, and when it had become cold, he put it into another bath, made with madder only, where it remained for twenty-four hours. By this process he got a fine red, somewhat brighter than the common, but inclining a little to yellow. Scheffer obtained an orange red by boiling wool with a solution of tin, and one-fourth of alum, and then by dying with one-fourth of madder. A cherry colour is obtained, according to Bergman, by dying with one part of a solution of tin, and two of madder, without previously boiling the wool. By exposure to the air, this colour becomes deeper. By boiling the wool for two hours with one-fourth of sulphate of iron, then

washing it, and afterwards immersing it in cold water with one-fourth of madder, and then boiling for an hour, the result is a coffee brown. But if the wool has not been soaked, and if it be dyed with one part of sulphate of iron and two of madder, the colour is a brown approaching to red. In preparing the madder red, the bath should be heated to a temperature below boiling; for if it be hotter, the result will be a different colour. Hellot advises, that when the hand can be just borne in the liquid, half a pound of grape madder to every pound of wool be added; stirring the mixture well before the wool be introduced. Under this operation it must be kept for about an hour, and allowed to boil only a few minutes before the conclusion. A clear brown, inclining to yellow, is obtained from the madder dye, when sulphate of copper is used as a mordant; and the same colour is produced by dying the wool simply soaked in hot water, with one part of sulphate of copper, and two of madder. But when this mordant and dye-stuff are used in equal proportions, the yellow is more obscure, approaching to green; and in both instances, exposure to the air does not produce a darker colour. Berthollet informs us, that he employed a solution of tin in various ways, both in the preparation and in the application of the madder; and by the use of different solutions of tin, he found, that although the tint was somewhat brighter than what is obtained by the common process, it was always more inclined to yellow or fawn colour. If madder reds be rosed with archil and Brazil wood, the colours will be more soft and velvety; but this beautiful addition is not lasting.

75. Scarlet is the finest and most splendid of all the colours; and, like other colours, its variety of shades depend on the goodness and proportion of the colouring matter employed. For woollen stuffs, the substance employed to produce scarlet is cochineal. Alumina was formerly employed in Mexico as a mordant for this dye, as also in Europe; until its use was superseded by the discovery of the solution of tin. Two operations are necessary to the process of scarlet dying, namely, boiling, and reddening. The first of these, or boiling, is conducted as follows: In order to dye 100 pounds of cloth, six pounds of pure tartar are added to a sufficient quantity of water, which is made very warm, and the mixture briskly stirred. When the heat has a little increased, half a pound of pulverized cochineal is introduced, and the whole thoroughly mixed. Into this, five pounds of a very clear solution of tin is immediately poured, and well mixed as before. As soon as the boiling commences, the cloth is put in, and at first briskly agitated; but afterwards by degrees more slowly. After two hours' boiling, the cloth is taken out, exposed to the atmosphere, and then well washed in a stream of clear water.

76. For the process of reddening, the boiler is to be emptied, and when the bath has just reached the boiling point, five pounds and three quarters of cochineal, previously powdered and sifted, are added. These are carefully mixed; and after having ceased stirring, when a crust has formed on the surface, and opened of itself in several places, thirteen or fourteen pounds of solution of tin are poured in. Should the bath, during the boiling, rise above the edge of the boiler, it may be cooled with a little cold water. This solution being well mixed, the cloth is put in, and two or three times quickly turned. It is then boiled in the bath for an hour, taking care to keep it under the surface. It is afterwards taken out, exposed to the air, and when it has cooled, washed in the river and dried. There are no determinate proportions of cochineal and solution of tin in either of these operations. Hellot informs us, that some dyers employ two-thirds of solution of tin, and one-fourth of cochineal, in the boiling, and the other one-third of the solution of tin with the remaining three-fourths of the cochineal in the reddening. He adds farther, that the use of tartar gives a greater degree of permanency to the colour, provided the proportion do not exceed one-half the weight of the cochineal employed. Tartar promotes the solution of the colouring matter, and this effect is greater when it is ground with the cochineal, after which it is found that the residuum is more completely exhausted. But this consideration is of inferior consequence, when the operations are successively performed, because any colouring matter that may remain in the residuum is employed in the next operation. It ought not, however, to be overlooked, that the tartar communicates to the colour a rosy hue. In order to save time and fuel some dyers do not remove the cloth out of the boiling; they merely refresh it, and redden in the same bath. When this is done, the infusion of cochineal and solution of tin are first mixed in a separate vessel, and then added.

77. To produce the bright colour called fiery scarlet, a yellow tinge is communicated by boiling fustic in the first bath, or by adding a little turmeric to the cochineal. A larger proportion of the solution of tin also produces this yellow shade, but it renders the cloth harsh, and limits the action of the colouring matter. The use of fustic or turmeric, therefore, although the colour obtained from them is not permanent, is preferable to an excess of the solution of tin.

78. In conducting the operations of scarlet dying, tin boilers are to be recommended, in preference to brass or copper; because the acid liquor acting on the copper, partially dissolves it, and the solution thus formed is injurious to the beauty of the colour.

79. The proportion of ingredients employed in the dying of scarlet is, as we have before hinted, far from being fixed. For the boiling, Scheffer directs an ounce and a half of solution of tin, with an equal quantity of starch, and as much tartar, to every pound of cloth. The effect of the starch is to give more uniformity to the colour. When the water boils, a dram of cochineal is to be added; it is then to be well stirred, and after the wool is introduced, to be boiled an hour, taken out, and washed. The proportions for the reddening bath, in which the wool is to be boiled half an hour, are half an ounce of starch, three-fourths of an ounce of solution of tin, half an ounce of tartar, and seven drams of cochineal. In Scheffer's process, it may be observed, the proportion of solution of tin is smaller than in that of Hellot, but the quantity of tin in the solution of the former is greater than in that of the latter. Three principal processes, according to the variety of the shade of the scarlet, are described by Poerner. He uses no cochineal in the boiling; the materials for this process are one ounce and six drams of tartar, and an equal weight of solution of tin, the latter being added after the tartar is dissolved, for every pound of cloth. As soon as the boiling has commenced, the cloth is introduced, and boiled for two hours. For the reddening of the first process he employs two drams of tartar and one ounce of cochineal, adding gradually afterwards two ounces of solution of tin. For the reddening of the second process, the same quantity of cochineal and solution of tin, without any tartar, is employed. In the reddening of the third process, two drams of tartar, with one ounce of solution of tin, one ounce of cochineal, and two ounces of common salt, are directed to be used. The colour produced in the first process has the deepest shade; that of the second is more lively, while that of the third is paler and brighter.

80. It has been already observed, that a variety of shades of the scarlet colour are obtained by merely varying the proportion of the tartar used in the reddening process.

When no tartar is used the scarlet becomes nearly orange; but when it is employed the shade is deep and full. Different degrees of strength in the solution of tin are also found to vary the shades. Berthollet, who made several experiments on the subject, tried a solution of tin composed of sixteen parts nitric acid, two of muriate of ammonia, and three of tin; and found that it produced a deeper shade than when equal parts of the acid and muriate were mixed with only two parts of tin. Four parts of water were in both cases mixed with the solution, and the last proportion succeeded best. By diminishing the muriate of ammonia to half a part, a bright colour inclining to orange was obtained.

81. To brighten the scarlet, as well as to cause the colour to penetrate deeper into the cloth, common salt is employed. The proportion of salt should not exceed that mentioned in par. 79: a less proportion lightens the shade, and renders it however more agreeable; and if five ounces of powdered white sugar be added to the ingredients of the second process, there will be produced a lighter and much finer colour than that resulting from the first process. It is also recommended to leave the cloth in the boiler for about twenty-four hours after it has cooled; this will improve the shade, and render it more permanent.

82. Dr. Bancroft asserts, that it is by no means absolutely necessary in dying scarlet to adopt the entire process above described. He speaks of having often produced that colour very well at a single boiling, by mixing the whole quantity of tartar, solution of tin, and cochineal together; the affinity of the wool for the colouring matter, and for the oxide of tin, being sufficiently strong to combine with them readily, and retain them permanently. The only objection to simplifying the process in this manner is, that the colouring matter of the dying liquor is less perfectly exhausted than when two operations are performed. He farther adds, that he has often produced a beautiful scarlet, by preparing and boiling the cloth with the whole quantity of solution of tin and tartar at once, and afterwards dying it unrinsed, with the whole of the cochineal, dissolved only in pure water. In this way he found the colouring particles completely taken up, that the liquor had become quite colourless, and the cloth had received a durable dye. Having, by repeated effusions of boiling water, extracted the whole of the colouring matter from powdered cochineal, our ingenious author found, that the addition of a little potash to the seemingly exhausted sediment, and a fresh quantity of boiling water, extracted a new portion of colouring matter, equal to about one-eighth of what had been given out to the pure water. He repeatedly extracted this colouring matter by means of potash, and afterwards dyed small pieces of cloth scarlet with it, which he found similar to other pieces dyed with the more soluble colouring matter of cochineal. It was in the course of these inquiries that he perceived scarlet to be a compound colour, consisting of about three-fourths of pure crimson or rose colour, and one-fourth of pure bright yellow. He conceived, therefore, that when the natural crimson of the cochineal is made scarlet, by the usual process, there must be a change produced, equivalent to a conversion of one-fourth of the colouring matter of cochineal from its natural crimson to a yellow colour. From this he concludes, that there might be a great saving of cochineal, by substituting a cheaper substance, which at the same time might yield a better yellow colour. It was therefore his object to combine with this crimson or rose colour, a suitable portion of a lively golden yellow, capable of being permanently fixed, and reflected by the same basis. Such a yellow he had discovered in quercitron bark (*quercus nigra* of Linnæus) which will be afterwards described; and it had the advantage, not only of being the brightest, but also the cheapest of all the yellows which he had tried.

83. The principal object of Dr. Bancroft's researches, was to produce the full colouring effect with the smallest quantity possible of cochineal; and in his experiments for this purpose, he employed as a mordant the dyers' spirit, or the nitro-muriate of tin; but found himself disappointed as to the expected advantages; for the solution of tin in sulphuric acid destroyed the cochineal colour. This naturally led him to reject the use of this acid altogether, till accident brought him to dissolve a quantity of tin in muriatic acid, combined with one-fourth of sulphuric acid. The application of this solution in dying was not accompanied with the corrosive effects of the muriate and nitro-muriate which he had employed in the experiments above alluded to. After trying different proportions of these acids, he found the following to answer best. In a mixture of two pounds of sulphuric acid of the ordinary strength, and about three pounds of muriatic acid, he dissolved about fourteen ounces of tin. The muriatic acid is first poured on a large quantity of granulated tin, in a large glass receiver, and the sulphuric acid is then slowly added. The solution is more rapidly promoted by means of a sand heat, but it will take place in the cold, requiring only a greater length of time. This muriosulphate of tin is transparent and colourless, and may be kept for several years without any precipitation. It produces twice the effect of the dyers' spirit, at less than one-third of the expense, and raises the colours not only more than the dyers' spirit, but also full as much as the tartrate of tin, without converting the crimson of cochineal to a yellowish shade.

84. In the use of this solution of tin as a mordant, to produce the compound scarlet colour with the cochineal crimson and quercitron yellow, Dr. Bancroft recommends the following process: "Nothing," says he, "is necessary but to put the cloth, suppose 100 pounds weight, into a proper tin vessel, nearly filled with water, in which about eight pounds of the murio-sulphuric solution of tin have been previously mixed, to make the liquor boil, turning the cloth as usual through it, by the winch, for a quarter of an hour; then turning the cloth out of the liquor, to put into it about four pounds of cochineal, and two pounds and a half of quercitron bark in powder, and having mixed them well, to return the cloth again into the liquor, making it boil, and continue the operation as usual until the colour be duly raised, and the dying liquor exhausted, which will be the case in about fifteen or twenty minutes; after which the cloth may be taken out and rinsed as usual. In this way the time, labour, and fuel, necessary for filling and heating the dying vessel a second time, will be saved; the operation finished much more speedily than in the common way; and there will be a saving of all the tartar, as well as of two-thirds of the cost of spirit, or nitro-muriatic solution of tin, which for dying 100 pounds of wool, commonly amounts to ten shillings; whereas, eight pounds of the murio-sulphuric solution will only cost about three shillings. There will be moreover a saving of at least one-fourth of the cochineal usually employed, which is generally computed at the rate of one ounce for every pound of cloth, and the colour produced will certainly not prove inferior in any respect to that dyed with much more expense and trouble in the ordinary way. When a rose colour is wanted, it may be readily and cheaply dyed in this way, only omitting the quercitron bark, instead of the complex method now practised of first producing a scarlet, and then changing it to a rose by the volatile alkali contained in stale urine, set free or decomposed by potash or by lime: and even if any one should still unwisely choose to continue the practice of dying

scarlet without quercitron bark, he need only employ the usual proportions of tartar and cochineal, with a suitable quantity of the murio-sulphate of tin, which, whilst it costs so much less, will be more effectual than the dyers' spirit. Several hundreds of experiments warrant my assertion, that at least a fourth part of the cochineal generally employed in dying scarlet, may be saved by obtaining so much yellow as is necessary to compose this colour from the quercitron bark; and indeed nothing can be more self-evident, than that such an effect, *cæteris paribus*, ought necessarily to result from this combination of different colouring matters, suited to produce the compound colour in question. Let it be recollected that the cochineal crimson, though capable of being changed by tartar towards the yellow hue on one hand, is also capable by other means of being changed towards a blue on the other, and of thereby producing a purple without indigo or any other blue colouring matter: yet I am confident that nobody would believe a pound of cochineal so employed capable alone of dying as much cloth, of any particular shade of purple, as might be dyed with it if the whole of its colouring matter were employed solely in furnishing the crimson part of the purple, whilst the other (blue) part thereof was obtained from indigo. To say that a pound of cochineal alone could produce as much effect or colour as a pound of cochineal and a pound of indigo together, would be an improbability much too obvious and palpable for human belief; and there certainly would be a similar improbability in alleging, that a pound of cochineal, employed in giving another compound colour (scarlet) could alone produce as much effect as a pound of cochineal and a pound of quercitron bark, when the colour of this last was employed only in furnishing one of the component parts of the scarlet, for which a considerable portion of the colouring matter of the cochineal must otherwise have been expended, which certainly happens in the new mode of dying scarlet, because the colour produced with an addition of the quercitron yellow inclines no more towards a yellow, than the scarlet produced by yellowing a part of the cochineal colour in the usual method with tartar. I retain, therefore, at this moment, as much confidence as I ever had in the reality and importance of my proposed improvements in this respect.

85. "The scarlet composed of cochineal crimson and quercitron yellow, is moreover attended with this advantage, that it may be dyed upon wool and woollen yarn without any danger of its being changed to a rose or crimson by the process of fulling, as always happens to scarlet dyed by the usual means. This last being in fact nothing but a crimson or rose colour, yellowed by some particular action or effect of the tartar, is liable to be made crimson again by the application of many chemical agents (which readily overcome the changeable yellow produced by the tartar) and particularly by calcareous earths, soap, alkaline salts, &c. But where the cochineal colouring matter is applied and fixed merely as a crimson or rose colour, and is rendered scarlet by superadding a very permanent quercitron yellow, capable of resisting the strongest acids and alkalies (which it does when dyed with solutions of tin) no such change can take place, because the cochineal colour having never ceased to be crimson, cannot be rendered more so, and therefore cannot suffer by those impressions or applications which frequently change or spot scarlet dyed according to the present practice.

86. "There is also a singular property attending the compound scarlet, dyed with cochineal and quercitron bark; which is, that if it be compared with another piece of scarlet dyed in the usual way, and both appear by daylight exactly of the same shade, the former, if they be afterwards compared by candlelight, will appear to be at least several shades higher and fuller than the latter; a circumstance of some importance, when it is considered how much this and other gay colours are generally worn and exhibited by candlelight during a considerable part of the year.

87. "To illustrate more clearly the effects of the murio-sulphuric solution of tin with cochineal in dying, I shall state a very few of my numerous experiments therewith; observing, however, that they were all several times repeated, and always with similar effects:—1. I boiled one hundred parts of woollen cloth in water, with eight parts of the murio-sulphuric solution of tin, during the space of ten or fifteen minutes; I then added to the same water four parts of cochineal, and two parts and a half of quercitron bark in powder, and boiled the cloth fifteen or twenty minutes longer; at the end of which it had nearly imbibed all the colour of the dying liquor, and received a very good, even, and bright scarlet. Similar cloth dyed of that colour at the same time in the usual way, and with a fourth part more of cochineal, was found upon comparison to have somewhat less body than the former; the effect of the quercitron bark in the first case having been more than equal to the additional portion of cochineal employed in the latter, and made yellow by the action of tartar.—2. To see whether the tartrate of tin would, besides yellowing the cochineal crimson, contribute to raise and exalt its colour more than the murio-sulphate of that metal, I boiled one hundred parts of cloth with eight parts of the murio-sulphuric solution, and six parts of tartar, for the space of one hour; I then dyed the cloth, unrinsed, in clean water, with four parts of cochineal, and two parts and a half of quercitron bark, which produced a bright aurora colour, because a double portion of yellow had been here produced, first by the quercitron bark, and then by the action of tartar upon the cochineal colouring matter. To bring back this aurora to the scarlet colour, by taking away or changing the yellow produced by the tartar, I divided the cloth whilst unrinsed into three equal parts, and boiled one of them a few minutes in water slightly impregnated with potash; another in water with a little ammoniac; and the third in water containing a very little powdered chalk, by which all the pieces became scarlet; but the two last appeared somewhat brighter than the first, the ammoniac and chalk having each rosed the cochineal colour rather more advantageously than the potash. The best of these, however, by comparison, did not seem preferable to the compound scarlet dyed without tartar, as in the preceding experiment; consequently this did not seem to exalt the cochineal colour more than the murio-sulphate of tin; had it done so, the use of it in this way would have been easy, without relinquishing the advantages of the quercitron yellow.—3. I boiled one hundred parts of woollen cloth with eight parts of the murio-sulphuric solution of tin for about ten minutes, when I added four parts of cochineal in powder, which by ten or fifteen minutes more of boiling, produced a fine crimson. This I divided into two equal parts, one of which I yellowed or made scarlet by boiling it for fifteen minutes with a tenth of its weight of tartar in clean water; and the other, by boiling it with a fortieth part of its weight of quercitron bark, and the same weight of murio-sulphuric solution of tin; so that in this last case there was an addition of yellow colouring matter from the bark, whilst in the former no such addition took place, the yellow necessary for producing the scarlet having been wholly gained by a change and diminution of the cochineal crimson; and the two pieces being compared with each other, that which had been rendered scarlet by an addition of quercitron yellow, was, as

might have been expected, several shades fuller than the other.—4. I dyed one hundred parts of woollen cloth scarlet, by boiling it first in water with eight parts of murio-sulphate of tin, and twelve parts of tartar, for ten minutes, and then adding five parts of cochineal, and continuing the boiling for fifteen minutes. This scarlet cloth I divided equally, and made one part crimson, by boiling it with a little ammoniac in clean water; after which I again rendered it scarlet, by boiling it in clean water, with a fortieth of its weight of quercitron bark, and the same weight of murio-sulphate of tin; and this last, being compared with the other half to which no quercitron yellow had been applied, was found to possess much more colour, as might have been expected. A piece of the cloth, which had been dyed scarlet by cochineal and quercitron bark, as in the first experiment, being at the same time boiled in the same water with ammoniac, did not become crimson, like that dyed scarlet without the bark. In this way of compounding a scarlet from cochineal and quercitron bark, the dyer will at all times be able, with the utmost certainty, to produce every possible shade between the crimson and yellow colours, by only increasing or diminishing the proportion of bark. It has indeed been usual at times, when scarlets approaching nearly to the aurora colour were in fashion, to superadd a fugitive yellow either from turmeric, or from what is called young fustic *(rhus cotinus)*; but this was only when the cochineal colour had been previously yellowed as much as possible by the use of tartar, as in the common way of dying scarlet; and therefore that practice ought not to be confounded with my improvement, which has for its object to preclude the loss of any part of the cochineal crimson, by its conversion towards yellow colour, which may be so much more cheaply obtained than the quercitron bark. By sufficient trials, I have satisfied myself that the cochineal colours, dyed with the murio-sulphuric solution of tin, are in every respect at least as durable as any which can be dyed with any other preparation of that metal; and they even seem to withstand the action of boiling soap suds somewhat longer, and therefore I cannot avoid earnestly recommending its use for dying rose and other cochineal colours, as well as for compounding a scarlet with the quercitron bark." Philos. of Perm. Colours, p. 300.

88. It has been already stated, that in order to obtain different shades of scarlet, the proportions of cochineal, tartar, and solution of tin must be varied. The tartar serves to deepen the colour, and the solution of tin produces a shade of orange; but if the shades be required to incline much to yellow, quercitron bark or fustic must be added; and by shortening the duration of the process, a light shade is produced. Berthollet on Dying, ii. 194.

89. Crimson. Wool may be dyed of a crimson colour immediately from its own natural colour; or it may be first dyed scarlet, and then have the crimson colour superadded. When the first of these methods is adopted, a solution of two ounces and a half of alum, and an ounce and a half of tartar for every pound of stuff, is employed for the boiling, and the stuff is afterwards to be dyed with an ounce of cochineal. It is usual also to employ solution of tin, but in smaller proportion than for dying scarlet. The processes must vary according as the shade wanted is deeper or lighter, or more or less distant from scarlet. Common salt is also employed by some in the boiling; and to render the crimson deeper, and give it more bloom, archil and potash are frequently used; but this bloom is extremely fugacious. By adding tartar and alum, the boiling for crimson is sometimes prepared after a scarlet reddening, and it is said, that the colour possesses more bloom, when both the boiling and reddening are made after scarlet, than when the crimson is dyed in a fresh bath prepared on purpose. In dying these colours the wild cochineal may be employed, but the quantity must be proportionally greater. Different substances, as the alkalies, alum, and earthy salts in general, convert the colour of scarlet to crimson, the natural colour of cochineal. To effect this, the stuff previously dyed scarlet is boiled for an hour in a solution of alum, the strength of which is to be regulated by the depth of shade required. In conducting this process, it is necessary to observe, that water impregnated with earthy salts has a considerable effect in varying the shade; so that the quantity of alum must be proportioned to the purity of the water. Hellot tried soap, soda, potash, and some other substances, and the crimson obtained was of a deeper shade, and had less lustre, than what was produced by means of alum. Ammonia produced a good effect; but from its great volatility, a considerable proportion must be put into the bath; this must be moderately heated, with a little sal ammoniac, and an equal quantity of potash. By this process the stuff became of a bright rosy colour, and thus rendered a smaller quantity of cochineal necessary. The stuff previously dyed scarlet, should, according to Poerner, remain twenty-four hours in a cold solution of sal ammoniac and potash.

90. When crimsons or scarlets in half grain are required, madder is mixed with the cochineal; varying the proportion according to the shade designed. The boiling is similar to that employed for scarlet in grain; and the rest of the process is conducted by the rules already laid down for the reddening.

Dying Silk Red.

91. Madder Red. There are several methods proposed for dying silk with madder; but as this colour, by whatever method it is communicated to silk, is always deficient in brightness, we shall notice only one process, namely, that of M. Guliche. For every pound of silk, he proposes a bath of four ounces of alum, and one ounce of solution of tin. When the liquor has become clear, it is decanted, and the silk carefully soaked in it for twelve hours, after which it is to be immersed in a bath with half a pound of madder softened by boiling, with an infusion of galls in white wine. The bath is to be kept moderately hot for an hour, and then made to boil for two minutes. The silk being taken from the bath is to be washed in a stream of water, and dried in the sun. The colour thus obtained is very permanent, and will be clearer if the galls be omitted.

92. Brazil wood is sometimes employed for dying silks; and the colour it produces is called false crimson. The silk, after being boiled with soap, is to be alumed. It is then to be refreshed at the river, and dipped in a bath more or less charged with Brazil juice, according to the depth of shade required. If pure water be employed, the colour will be too red; but to remedy this, the stuff may be passed through a weak alkaline solution, or a little alkali may be added to the bath, or the stuff may be washed in hard water till it has acquired the proper shade. To deepen the shade of false crimsons, or dark reds, the solution of logwood is added to the Brazil bath, the silk being previously impregnated with the latter; or alkali may be added, according to the shade required.

93. Cochineal is employed to produce the colour in silks called grain crimson; and the process is as follows: The silk, after being thoroughly purified from the soap in a clear running stream, is immersed in an alum liquor of the full strength, where it remains all night. It is then washed, and twice beetled at the river. The bath is prepared by filling a long boiler two-thirds with water, to which are added, when it boils, from half an ounce to two ounces of powdered white galls for every pound of silk. When it has

boiled a few moments, from two to three ounces of cochineal (also powdered and sifted) for every pound of silk, are put in, and afterwards one ounce of tartar to every pound of cochineal. When the tartar is dissolved, one ounce of solution of tin is added for every ounce of tartar. In the preparation of this solution of tin, the following proportions are recommended by Macquer. For every pound of nitric acid two ounces of sal ammoniac, six ounces of fine grain tin, and twelve ounces of water are employed. When these are mixed together, the boiler is to be filled up with cold water, and the proportion of the bath for every pound of silk is about eight or ten quarts of water. In this the silk is immediately immersed, and turned on the winch, till it appears to be of an uniform colour. The fire is then increased, and the bath kept boiling for two hours; taking care to turn the silk occasionally. The fire being extinguished, the silk is put into the bath, where having been allowed to remain for a few hours longer, it is taken out, washed at the river, twice beetled, wrung, and dried. Two processes are recommended by Scheffer and Macquer. In that of the former, a greater proportion of cochineal is employed in the dye-bath; but, in that of the latter, a yellow ground is previously communicated to the silk. The colour thus obtained resists the action of soap, and is more durable than that produced by means of carthamus.

94. By varying the above processes a variety of shades may be obtained. Thus, when the silk has been wrung out of the solution of tin, if it be steeped for a night in a cold solution of alum, in the proportion of one ounce to a quart of water, wrung and dried, then washed and boiled with cochineal, it will only appear of a pale poppy colour; but a fine poppy red may be produced by steeping it twelve hours in the solution of tin, diluted with eight parts of water, then leaving it all night in the solution of alum; after which it is washed, dried, and passed through two baths of cochineal, taking care to add to the second a small quantity of sulphuric acid. The same colour may be produced by dying the silk previously with anotta, and then passing it successively through a number of baths prepared with an alkaline solution of carthamus, to which lemon juice has been added, till it acquire a fine cherry colour. To brighten the colour, the silk, after being dyed, may be immersed in hot water acidulated with lemon juice.

95. Carthamus also produces the flesh red and cherry red. For the latter it is not necessary that the stuff be previously dyed with anotta, and the proportion of colouring matter is smaller. A flesh-red colour is obtained by adding a little soap to the bath, which has the effect of softening the colour, and of retarding the action of the colouring matter on the stuff. To produce dark shades, as well as to lessen the expense, it is sometimes usual to mix archil.

96. Those who produce a colour on silk which comes nearest to scarlet, Berthollet observes, begin with dying the silk crimson. It is then dyed with carthamus, and, lastly, yellow, without heat. By this process a fine colour is obtained; but the dye of the carthamus is not permanent, as it is destroyed by the action of the air, and the colour becomes deeper. The following is Dr. Bancroft's process: In a solution of murio-sulphate of tin, diluted with five times its weight of water, the silk is soaked for two hours; and after being taken out, it is wrung and partially dried. It is then dyed in a bath, prepared with four parts of cochineal, and three of quercitron bark. In this way a colour approaching to scarlet is obtained. To give the colour more body, the immersion may be repeated both in the solution of tin, and in the dying bath; and the brightness of the scarlet is increased by the addition of carthamus. A lively rose colour is produced by omitting the quercitron bark, and dying the silk with cochineal only; and by adding a large proportion of water to the cochineal, a yellow shade is obtained, which changes the cochineal to the compound scarlet colour.

Dying Cotton and Linen Red.

97. The most useful of all colouring substances for communicating a red colour to cotton and linen is madder; and hence it is extensively employed for this purpose. Two kinds of red are obtained from this drug, namely, the simple madder red, and the Adrianople red; for brightness and permanency the latter colour is scarcely ever equalled.

98. As preparations for the madder dye, the principal mordants are oil, gall-nuts, and alum. Cotton must be impregnated with oil, or the madder dye cannot be fixed; and the oil by combining with a weak solution of soda, forms with it a saponaceous liquid. By the use of this alkaline ley the oil is diluted, and can be easily and equally applied to all the parts of the cotton. According to Chaptal, potash produces the same effect as soda; and attention to this is of some importance, from the difference of price of the two substances. All kinds of soda or oil are not fit for this preliminary preparation. The soda must be in the caustic state, and its causticity must be the effect of calcination; because if it has been rendered caustic by means of lime, it becomes of a brown colour. The soda also should contain little muriate, for when this salt prevails, the combination of the oil and the soda is greatly retarded. The most proper oil is not of a fine kind, but that which contains a large portion of the extractive principle. As the ley of soda is only employed for the purpose of diluting and conveying the oil equally to all the parts of the cotton, there must be a perfect combination of the oil and the soda. This is of so much importance, that many place the whole secret of a strong colour in the choice of good oil and soda. It follows therefore that the oil should be in excess, otherwise it abandons the stuff in washing, and the colour will remain dry.

99. When the cotton has been impregnated with oil, it is subjected to the operation of galling. The use of gall-nuts is attended with several advantages. First, The gallic acid which they contain decomposes the saponaceous liquor with which the cotton is impregnated, and fixes the oil on the stuff. Second, The other properties which the galls possess, predispose the cotton to receive the colouring matter. Third, The astringent principle unites with the oil, and forms with it a compound, which on drying becomes black, is not very soluble in water, and has a strong affinity with the colouring matter of madder. Hence it appears that, 1. Gall-nuts furnish the most proper astringent matter for this kind of dye. 2. To effect a speedy and perfect decomposition, the galls ought to be strained as hot as possible. 3. The galled cotton should be speedily dried, or it might assume a black colour, which would injure the brightness of the red. 4. The process of galling should be performed in dry weather, because when the weather is moist, the astringent principle produces a black colour, and dries slowly. 5. The cotton should be pressed together with great care, that the decomposition may be equally effected at every point of the surface. 6. It is necessary to attend to the proportion between the gall-nuts and the soap, for if the former predominate, the colour is black, and if the soap is in excess, the portion of oil uncombined with the astringent principle escapes in the washings, and impoverishes the colour.

100. Another mordant employed in dying cotton red is alum; it heightens the colour, and fixes it. Cotton immersed, after the process of galling, in a solution of alum, becomes grey. No precipitate appears in the bath, because the operation takes place in the tissue of the cloth itself. But if the solution be employed at too high a temperature, part of

the galls escapes from the stuff, and the decomposition of the alum is then effected in the bath. This, which should be guarded against, must obviously diminish the proportion of the mordant, and render the colour poorer. This mordant requires great attention in its application. In this, indeed, consists the whole difficulty of dying cotton a madder or Turkey red. There is a combination of three principles in this mordant, namely, oil, the astringent principle, and alumina; and on their proper combination the perfection of the colour depends. When any one of them is employed separately, the colour is neither so bright, nor so completely fixed.

101. An elaborate account of the processes employed at Astracan for communicating to cotton the Turkey or Adrianople red, has been given to the public by Professor Pallas. A method has likewise been proposed by M. Haussmann; also an account of the processes by which beautiful reds are communicated to stuffs in the east, has been made public by Mr. M'Lachlan of Calcutta: but we must be content with describing the methods which are successfully practised for the purpose in Great Britain. The following process consists of nine different steps; it was long practised at Glasgow, by M. Papillon, a French gentleman, who, in consideration of an adequate premium, consented that his secret should be made public; which accordingly took place in 1803.

102. STEP 1.—To 100 pounds of cotton there must be 100 pounds of Alicant barilla, 100 pounds of quicklime, and 20 pounds of pearl-ashes. The barilla is mixed with soft water in a deep tub, which has a small hole near the bottom, stopped at first with a peg. This hole is covered in the inside with a cloth supported by two bricks, that the ashes may be prevented from running out, or stopping it up while the ley filters through. Under this tub is another to receive the ley; and pure water is repeatedly passed through the first tub to form leys of different strength, which are kept separate at first until their strength is examined. The strongest required for use must float an egg, and is called the ley of six degrees of the French hydrometer. The weaker are afterwards brought to this strength, by passing them through fresh barilla. But a certain quantity of the weak, which is of two degrees of the above hydrometer, is reserved for dissolving the oil, gum, and salt, which are used in subsequent parts of the process. This ley of two degrees is called the weak barilla liquor, the other is called the strong. Dissolve the pearl-ashes in ten pails, of four gallons each, of soft water, and the lime in fourteen pails; and let all the liquors stand till they become quite clear, then mix ten pails of each. Boil the cotton in the mixture five hours, wash it in running water, and dry it.

STEP 2.—*Bainbie*, or *Grey Steep.*—Take twenty pails of the strong barilla water in a tub, dilute in it two pails full of sheep's dung; then pour into it two quart bottles of oil of vitriol, and one pound of gum arabic, and one pound of sal ammoniac, both previously dissolved in a sufficient quantity of the weak barilla water; and, lastly, twenty-five pounds of olive oil, which has been previously dissolved or well mixed with two pails of the weak barilla water. The materials of this steep being well mixed, tread down the cotton into it, until it is well soaked; let it steep twenty-four hours, then wring it hard and dry it. Steep it again twenty-four hours, and again wring and dry it. Steep it a third time twenty-four hours, wring and dry it, and, lastly, wash it well and dry it.

STEP 3.—*The White Steep.*—This part of the process is precisely the same with the last, in every particular, except that the sheep's dung is omitted in the composition of the steep.

STEP 4.—*Gall Steep.*—Boil twenty-five pounds of galls bruised in ten pails of river water until four or five are boiled away; strain the liquor into a tub, and pour cold water on the galls in the strainer, to wash out of them all their tincture. When the liquor is become milk-warm, dip your cotton hank by hank, handling it carefully all the time, and let it steep twenty-four hours. Lastly, wring it carefully and equally, and dry it well without washing.

STEP 5.—*First Alum Steep.*—Dissolve twenty-five pounds of Roman alum in fourteen pails of warm water, without making it boil, skim the liquor well, add two pails of strong barilla water, and let it cool until it be lukewarm; then dip the cotton, handling it hank by hank; let it steep twenty-four hours, after which wring it equally and dry it well without washing.

STEP 6.—*Second Alum Steep* is performed in every particular like the last, but after the cotton is dry steep it six hours in the river, then wash and dry it.

STEP 7.—*Dying Steep.*—The cotton is dyed by about ten pounds at once, for which take two gallons and a half of ox blood, mix it in the copper with twenty-eight pails of milk-warm water, and stir it well; then add twenty-five pounds of madder, and stir all well together. Then, having beforehand put the ten pounds of cotton on sticks, dip it into the liquor; move and turn it constantly for one hour, during which gradually increase the heat, until at the end of the hour the liquor begin to boil. Then sink the cotton, and boil it gently one hour longer; lastly, wash and dry it. Take out so much of the boiling liquor, that what remains may produce a milk-warm heat with the fresh water with which the copper is again filled up, and then proceed to make a dying liquor as above, for the next ten pounds of cotton.

STEP 8.—*The fixing Steep.*—Mix equal parts of the grey and of the white steep liquor, taking five or six pails of each. Tread down the cotton into this mixture; let it steep six hours, then wring it moderately and equally, and dry it without washing.

STEP 9.—*Brightening Steep.*—Ten pounds of white soap must be dissolved carefully and completely in sixteen or eighteen pails of warm water; for if any little bits of the soap remain undissolved, they will make spots in the cotton. Add four pails of strong barilla water, and stir it well. Sink the cotton in this liquor and keep it down; cover it up, and let it boil gently two hours, then wash and dry it, and the operation is completed.

103. The number of vessels to be employed must always be proportioned to the magnitude of the undertaking; four circular coppers will however be necessary for a manufactory on the smallest scale. The largest, for boiling and for finishing, is 28 inches deep by 38 or 39 wide in the mouth, and 18 inches wide in the narrowest part. The second, for dying, and the third for the alum steep, must be each 28 inches deep, by 23 or 24 in the mouth. The fourth, for boiling the galls, is 20 deep, by 28 wide. A number of tubs are necessary, which must all be of fir, and hooped with wood or with copper. Iron must not be employed in their construction, not even a nail; where nails are necessary, they must be of copper. The pail is a wooden vessel, which holds four English gallons, hooped with copper. In some parts of the above process, the strength of the barilla liquors is determined, by telling to what degree a peseliqueur or hydrometer sunk in them. The peseliqueur is of French construction. It is similar to the glass hydrometer used by the spirit dealers in this country; any artist who makes these instruments will find no difficulty in constructing one with a scale similar to that employed by M. Papillon, when he is informed of the following circumstances: 1. The

instrument when plunged into good soft water, at a temperature of sixty degrees, sinks to the 0, or beginning of the scale, which stands near the top of the stem. 2. When it is immersed in a saturated solution of common salt, at the temperature of sixty degrees, it sinks to the twenty-sixth degree of the scale only, and this falls at some distance from the top of the ball. This saturated solution is made by boiling in pure water, refined sea or common salt, till no more is dissolved, and by filtering the liquor when cold through blotting paper. Whenever directions are given to dry yarn, to prepare it for a succeeding operation, this drying should be performed with particular care, and more perfectly than our dryest weather is in general able to effect. It is done therefore in a room heated to a great degree by a stove.

104. Cochineal does not give a permanent scarlet colour to cotton; but when it is dyed with this substance, the method recommended by Dr. Bancroft, in his Treatise on the Philosophy of Permanent Colours, is to steep the cotton, previously moistened, for half an hour in a diluted solution of murio-sulphate of tin, and then having wrung the cotton, to plunge it into water, in which as much potash has been dissolved as will neutralize the acid adhering to the cotton, so that the oxide of tin may be more copiously fixed on the fibres. The stuff being afterwards rinsed in water, may be dyed with cochineal and quercitron bark, in the proportion of four pounds of the former, to two and a half or three pounds of the latter. A full bright colour is thus given to the cotton, which will bear slight washings with soap, and exposure to air. Indeed the yellow part of the colour derived from quercitron bark, will bear long boiling with soap, and will resist the action of acids. With the aluminous mordant, as it is usually applied by calico-printers for madder reds, cotton dyed with cochineal receives a beautiful crimson colour, which will bear several washings, and resist the weather for some time. It is not, however, to be considered as a fixed colour. The addition of a small portion of cochineal in dying madder reds upon the finer cottons, would be highly advantageous to the calico-printers. By this addition they are rendered more beautiful, and the fawn colour, or brownish yellow hue, which injures these reds, is thus overcome.

Yellow.

105. The application of mordants is always a necessary preliminary to the process of dying yellow, otherwise the colour will not be durable. There is a great variety of substances capable of communicating the yellow colour to stuffs, and their qualities and prices are various. The substances most commonly employed to produce this colour are weld, fustic, anotta, and quercitron bark.

106. Weld, the *reseda luteola* of Linnæus, is a plant of a bright green colour with long narrow leaves, and grows in many parts of Europe. There are two kinds, the cultivated, and the wild; the former is much the smaller plant, but it is by far the most valuable, on account of the great quantity of colouring matter which it affords. Strong decoction of weld is of a brownish yellow colour, and if much diluted with water, the colour inclines to a green. An alkali gives to this decoction a deeper colour, and the precipitate it occasions is not soluble in alkalies. Most of the acids give it a paler tinge, occasioning a little precipitate which is soluble in alkalies. Alumina has so strong an affinity for the colouring matter of weld, that it can even abstract it from sulphuric acid, and the oxide of tin produces a similar effect. The greater part of metallic salts throw down similar precipitates, which vary in their shades of colour according to the metal employed. A solution of common salt renders the liquor turbid, and a solution of tin yields a copious yellow precipitate, while the liquor long continues turbid, and slightly coloured.

107. Fustic, the *morus tinctoria* of Linnæus, is procured from a tree of considerable magnitude, which grows in the West Indies. The wood is yellow, as its name imports, with orange veins. Ever since the discovery of America it has been used in dying, as appears from a paper in the Transactions of the Royal Society, of which Sir William Petty was the author. Its price is moderate, the colour it imparts is permanent, and it readily combines with indigo, which properties give it a claim to attention as a valuable ingredient in dying. Before it can be employed as a dye-stuff, it must be cut into chips and put in a bag, that it may not fix in, and tear the stuff, to which it is to impart its colouring matter. When a decoction of fustic is made very strong, the colour is of a reddish yellow, and when diluted it is of an orange yellow, which it readily yields to water. It becomes turbid by means of acids, its colour is of a pale yellow, and the greenish precipitate may be redissolved by alkalies. The sulphates of zinc, iron, and copper, as well as alum, throw down precipitates composed of the colouring matter and the different bases of the salts employed. M. Chaptal discovered, that the durability of the pale yellow depends on the tanning principle, which is found united with the yellow colouring matter. He obtained by analyzing fustic, 1. A resinous or gummy matter, which can communicate a beautiful yellow colour. 2. An extractive matter, which is also yellow, and affords a beautiful colour. 3. A tanning principle of a pale yellow colour, which becomes black by boiling, or exposure to air. This latter diminishes the brilliancy of the two former; but it may be separated by a simple process. Chaptal boiled with the wood some animal substance containing gelatinous matter, such as bits of skin, strong glue, &c. The tanning principle was thus precipitated with the gelatinous matter, and the bath held in solution only the colouring matters which yield a bright, full yellow; and by means of this process he procured colours from several vegetables, equally bright with those which are communicated by fustic and quercitron bark. Philos. Mag. i. 430.

108. Anotta is a red paste obtained from the berries of the *bixa orellana* of Linnæus. This tree grows in America, and the berries are bruised with oil or water, and made up into cakes of two or three pounds weight; in which form they are imported into Europe. Alcohol extracts the colouring matter of anotta more effectually than water, on which account it is used in yellow varnishes to which an orange tinge is intended to be given. Acids form a precipitate with a decoction of anotta of an orange colour, which is soluble in alkalies; but solutions of common salt produce no sensible change. It yields an orange precipitate with a solution of alum, and the sulphates of copper and iron produce effects of nearly a similar nature. With a solution of tin, the precipitate is of a lemon colour, and slowly deposited.

109. Quercitron, the *quercus nigra* of Linnæus, is a large tree which grows without culture in North America. A considerable quantity of colouring matter may be extracted from the bark, as was first discovered by Dr. Bancroft, in 1784; and to prepare it for use, the epidermis is taken off and pounded in a mill, the result of which process is a number of filaments and a fine light powder; but as these do not contain equal quantities of colouring matter, it will be proper to employ them in their natural proportions. Quercitron bark readily imparts its colouring matter to water, at 100° of Fahrenheit, which is of a yellowish brown, capable of being darkened by alkalies, and brightened by

acids. With muriate of tin the precipitate is copious, and of a yellow colour; with sulphate of tin it is a dark olive; and with sulphate of copper, yellow, but inclining to olive. Nitro-muriate of tin yields a yellow extremely beautiful, probably owing to the oxide of tin combining with the colouring matter in a greater proportion than some other salts.

110. The following substances are also employed to impart the yellow colour to stuffs, namely, 1. *Saw-wort,* or *serratula tinctoria,* a plant of which the colouring matter resembles in its properties that of weld. 2. *Dyer's broom,* or *genista tinctoria,* which affords an indifferent yellow. 3. *Turmeric,* or *curcuma longa;* this plant yields a copious quantity of colouring matter; but as no mordant can be found that can fix it in stuffs, it has hitherto been but of little use to the dyer. 4. *Chamomile,* or *anthemis tinctoria,* communicates a pale yellow. Sulphate of lime, tartar, and alum are recommended as mordants; but unfortunately this colour is subject to the same objection with the preceding. 5. *Fenugreek,* or *trigonella fænugræcum,* the seeds of which when ground, communicate a moderately durable pale yellow to stuffs. To fix this colour, alum and common salt are found to be the best mordants. To these colouring substances may be added, American hiccory, French berries, the leaves of the sweet willow, and the seeds of purple trefoil; all of which produce darker or lighter shades of yellow, with various degrees of permanency.

Dying Wool Yellow.

111. A pure and permanent yellow may be obtained from weld, provided alum and tartar be employed as mordants. Some allow twice as much alum as tartar, but M. Hellot recommends the proportion to be as four to one. The previous boiling is conducted in the usual manner; and to prepare the bath, the plant, being first enclosed in a fine linen bag, is boiled; care being taken to keep it continually under the surface of the liquid. For every pound of stuff, from two to four pounds of weld are allowed, varying the quantity according to the required intensity of colour. Some add a small quantity of quicklime and ashes, which are found to promote the extraction of the colouring matter. They also heighten the colour, but render it less susceptible of resisting the action of acids. Lighter shades are produced by dying after deeper ones, adding water at each dipping, and keeping the bath at the boiling temperature. These shades, however, are less lively than when fresh baths are employed with a suitable proportion of weld. The addition of common salt or sulphate of lime to the weld bath communicates a richer and deeper colour. With alum it is paler and more lively, with tartar still paler, and with sulphate of iron the shade inclines to brown. According to Scheffer, by boiling the stuff two hours, with one-fourth of its weight of a solution of tin, and the same proportion of tartar, and then washing and boiling it with an equal weight of weld, a fine yellow is produced; but if the stuff be in the state of cloth, its internal texture is not penetrated. Poerner recommends a similar preparation as for dying scarlet, and by these means the colour is brighter, more permanent, and lighter.

112. The quercitron bark is recommended by Dr. Bancroft as one of the cheapest and best substances for dying wool yellow. The bark is to be boiled up with about its weight, or one-third more, of alum, in a suitable proportion of water, for about ten minutes. The stuff previously scoured, is then to be immersed in the bath, taking care to give the higher colours first, and afterwards the paler straw colours. By this cheap and expeditious process, colours which are not wanted to be of a full or bright yellow, may be obtained. The colour may be considerably heightened by passing the unrinsed stuff a few times through hot water, to which a little clean powdered chalk, in the proportion of about one pound and a half for each hundred pounds of stuff has been previously added. The bark, when used in dying, being first reduced to powder, should be tied up in a thin linen bag, and suspended in the liquor, so that it may be occasionally moved through it, to diffuse the colouring matter more equally. But for permanent colours, the common mode of preparation, by previously applying the aluminous mordant, ought to be preferred. The stuff, therefore, should be boiled for about one hour and a quarter, with one-sixth, or one-eighth of its weight of alum, dissolved in a proper proportion of water; it is then to be immersed, without being rinsed, into the dying bath, with clean hot water, and about the same quantity of powdered bark tied up in a bag, as that of the alum employed in the preparation. The stuff is then to be turned as usual through the boiling liquor, until the colour appears to have acquired sufficient intensity. One pound of clean powdered chalk for every 100 pounds of stuff is then to be mixed with the dying bath, and the operation continued for ten minutes longer. This addition of the chalk raises and brightens the colour.

113. To communicate a beautiful orange yellow to woollen stuffs, ten pounds of quercitron bark, tied up in a bag, for every 100 pounds of stuff, are to be put into the bath with hot water. At the end of eight minutes, an equal weight of murio-sulphate of tin is to be added, and the mixture well stirred for about three minutes. The cloth, previously scoured, and completely wetted, is then immersed in the dying liquor, and briskly turned. After the liquor begins to boil, the highest yellow is sometimes produced in less than a quarter of an hour.

114. Bright golden yellow is produced by employing ten pounds of bark for every 100 pounds of cloth, the bark being first boiled a few minutes, then adding seven or eight pounds of murio-sulphate of tin, with about five pounds of alum. The cloth is to be dyed in the same manner as in the process for the orange yellow. It may here be observed, that every variety of shade of pure bright yellow may be given by varying the proportions of the ingredients. For a full bright yellow, delicately inclining to the greenish tinge, it will be proper to employ eight pounds of bark, six of murio-sulphate of tin, with six of alum, and four of tartar. An additional proportion of alum and tartar renders the yellow more delicate, and inclines it more to the green shade; but when this lively green shade is wanted in the greatest perfection, the ingredients must be used in equal proportions. The delicate green lemon yellows are seldom required to have much fullness or body. Ten pounds of bark, therefore, with an equal quantity of the other ingredients, are, according to Dr. Bancroft, sufficient to dye three or four hundred pounds of stuffs. The surest method to produce the delicate and beautiful pale green shades is to boil the bark with a small proportion of water, in a separate tin vessel for six or eight minutes, then to add the murio-sulphate of tin, alum, and tartar, and to boil them together for about a quarter of an hour. A small quantity of this yellow liquor is then to be put into a dying vessel, which has been previously supplied with water sufficiently heated. The mixture being properly stirred, the dying process is to be conducted in the usual way, and the yellow liquor, as it is wanted, gradually added from the first vessel. In this way, the most delicate shades of lively green lemon yellows are dyed with ease and certainty. Weld is the only dye-stuff from which similar shades of colour can be obtained; but it is four times more expensive. The yellows dyed from quercitron bark, Dr. Bancroft adds, with murio-sulphate of tin and alum as mordants, do no not exceed the

expense of one penny for each pound of stuff; besides a considerable saving of time, labour, and fuel.

115. If with the other ingredients a small portion of cochineal be employed, it will heighten the colour to a beautiful orange, and even to an aurora. Madder may likewise be employed with quercitron bark, or weld, for the same purpose; but the colours obtained are inferior to those from cochineal.

116. By the previous application of alum and tartar, colours obtained from the quercitron bark are made very durable. The best yellows dyed with muriate, or muriosulphate of tin and bark, resist the action of soap and acids; but become brown when exposed to the sun and air; the like also happens to yellows dyed with nitro-muriate of tin, both with the bark and with weld. Other yellows dyed with vegetable colouring matters are still more subject to this inconvenience; but in these it is easily prevented, by the proper application of alum and tartar. Bancroft on the Philos. of Perm. Colours, p. 334.

Dying Silk Yellow.

117. The sole ingredient formerly employed for communicating a plain yellow colour to silk was weld. But a cheaper, more easy, and equally effectual process has been recommended by Dr. Bancroft. A quantity of quercitron bark, namely, about one-sixth the weight of the silk, being powdered and enclosed in a bag, is put into the vat, while the water is cold. Heat is then applied; and when it has become rather more than blood warm, or of the temperature of 100°, the silk having previously undergone the aluming process, is to be immersed and dyed in the usual way. If a deep shade is wanted, a small quantity of chalk or pearl-ashes may be added towards the end of the operation. To produce a more lively yellow, a small proportion of muriosulphate of tin may be employed; but it should be cautiously used, as it is apt to diminish the lustre of the silk. To produce such a shade, the proportions of the ingredients may be four pounds of bark, three of alum, and two of murio-sulphate of tin. These are to be boiled with a proper quantity of water for ten or fifteen minutes; and the temperature of the liquid being so much reduced as the hand can bear it, the silk is immersed and dyed as usual, till it has acquired the proper colour. Care should be taken to keep the liquor constantly agitated, that the colouring matter may be equally diffused.

118. When an aurora or orange colour is required, the silk, after it has been properly scoured, may be immersed in an alkaline solution of anotta, of which the strength must be determined by the intensity of colour proposed; and the temperature of the bath should be below the boiling point. Having acquired the proper shade, the silks are to be washed and twice beetled. When raw silk is to be dyed, that which is naturally white should be selected, and the bath should be nearly cold; for otherwise the alkali, by dissolving the gum of the silk, destroys its elasticity. Silk is dyed of an orange shade with anotta, but the stuffs must be reddened with vinegar, alum, or lemon juice. The acid, by saturating the alkali employed to dissolve the anotta, destroys the yellow shade produced by the alkali, and restores its natural colour, which inclines to a red. Colours thus obtained are more beautiful than permanent.

119. Bright and durable yellow dyes may be also extracted from several species of the mushroom. A beautiful dye of this description has been obtained from the *boletus hirsutus*, which commonly grows on walnut and apple trees. The colouring matter is contained both in the tubular part, and also in the parenchyma of the body of the mushroom. To extract it the plant is pounded in a mortar, and the liquor thus obtained is boiled for a quarter of an hour in water. An ounce of liquor is sufficient to communicate colouring matter to six pounds of water. After the liquor has been strained, the stuff is immersed in it, and boiled for fifteen minutes. When silk is subjected to this process, after being dyed, it is made to pass through a bath of soft soap, by which it acquires a shining golden yellow colour, which has a near resemblance to the yellow of the silk employed to imitate embroidery in gold. All kinds of stuff receive this colour, but it is less bright on linen and cotton, and seems to have the strongest affinity for silk. The use of mordants, it is supposed, would modify and improve it greatly. Philos. Mag. v. 100.

Dying Cotton and Linen Yellow.

120. The cheapest and best method of communicating beautiful and permanent yellows to linen and cotton, is that recommended by Dr. Bancroft: "One pound of sugar of lead, and three pounds of alum, are dissolved in a sufficient quantity of warm water; and the cotton or linen, after being properly rinsed, is soaked in this mixture, heated to the temperature of 100°, for two hours. It is then taken out and moderately pressed over a vessel, to prevent the waste of the aluminous liquor. It is then dried in a stove heat, and after being soaked again in the aluminous solution, is wrung out and dried a second time. Without being rinsed, it is to be barely wetted with lime water, and afterwards dried; and if a full, bright, and durable yellow is wanted, it may be necessary to soak the stuff in the diluted aluminous mordant, and after drying, to wet it a second time with lime water. After it has been soaked for the last time, it must be well rinsed in clean water, to separate the loose particles of the mordant, which might injure the application of the colouring matter. In the preparation of the dying bath, from twelve to eighteen pounds of powdered quercitron bark are inclosed in a bag, for every 100 pounds of the stuff, varying the proportion according to the intensity of the shade desired. The bark is put into the water while cold; and immediately after, the stuff is immersed and agitated for an hour and a half, during which the water should be gradually heated, and the temperature raised to about 120°. At the end of this time the heat is increased sufficient to bring the dying liquor to a boiling temperature; but at this temperature the stuff must remain in it only a few minutes, otherwise the yellow assumes a brownish shade. The stuff having thus acquired a sufficient colour, is taken out, rinsed, and dried. To give the colour more body and durability, Dr. Bancroft advises frequent immersions of the stuff in the diluted aluminous mordant, and lime water; drying it after each immersion.

121. The following method of communicating the nankeen colour to cotton yarn, as practised by Mr. Brewer, is extracted from the Edinburgh Magazine: "Mix as much sheep's dung in clear water as will make it appear of the colour of grass; and dissolve in clear water one pound of best white soap for every ten pounds of cotton yarn, or in that proportion for a greater or lesser quantity. Observe: The tubs, boards, and poles that are used in the following preparations must be made of deal; the boiling pan of either iron or copper.

First Operation.—"Pour the soap liquor prepared as above into the boiling pan; strain the dung liquor through a sieve; add as much thereof to the soap liquor in the pan as will be sufficient to boil the yarn intended to be dyed for five hours. When the liquors are well mixed in the pan, enter the yarn, light the fire under the pan, and bring the liquor to boil in about two hours, observing to increase the heat regularly during that period. Continue it boiling for three hours; then take the yarn out of the pan, wash it, wring it, and hang it in a shed on poles to dry. When dry, take it into a stove or other room where there is a fire; let it hang there until it be thoroughly dry.—The cotton yarn, when in the shed, should not be exposed either to the rain or sun; if it is, it will be unequally coloured when dyed.

"*Second Operation.*—Use only one half of the soap that was used in the last, and as much dung liquor (strained as before directed) as will be sufficient to cover the cotton yarn, when in the pan, about two inches. When these liquors are well mixed in the pan, enter the yarn, light the fire, and bring the liquor to boil in about one hour; then take the yarn out, wring it out without washing, and hang it to dry.

"*Third Operation.*—The same as the second.

"*Fourth Operation.*—For every ten pounds of yarn make a clear ley from half a pound of pot or pearl-ashes. Pour the ley into the boiling pan, and add as much clear water as will be sufficient to boil the yarn for two hours; then enter the yarn, light the fire, and bring it to boil in about an hour. Continue it boiling about an hour, then take the yarn out, wash it very well in clear water, wring it, and hang it to dry.—This operation is to cleanse the yarn from any oleaginous matter that may remain in it after boiling in the soap and dung liquors.

"*Fifth Operation.*—To every gallon of iron liquor, such as linen-printers use, add half a pound of ruddle or red chalk (the last the best) well pulverized. Mix them well together, and let the liquor stand four hours, in order that the heavy particles may subside; then pour the clear liquor into the boiling pan, and bring it to such a degree of heat as a person can well bear his hand in it; divide the yarn into small parcels, about five hanks in each; soak each parcel or handful very well in the above liquor, wring it, and lay it down on a clean deal board. When all the yarn is handed through the liquor, the last handful must be taken up and soaked in the liquor a second time, and every other handful in succession till the whole is gone through; then lay the yarn down in a tub, wherein there must be put as much ley made from pot or pearl-ashes, as will cover it about six inches. Let it lie in this state about two hours, then hand it over in the ley, wring it, and lay it down on a clean board. If it does not appear sufficiently deep in colour, this operation must be repeated till it has acquired a sufficient degree of darkness of colour: this done, it must be hung to dry.—Any degree of red or yellow hue may be given to the yarn by increasing or diminishing the quantity of ruddle or red chalk.

"*Sixth Operation.*—For every ten pounds of yarn make a ley from half a pound of pot or pearl-ashes; pour the clear ley into the boiling pan: add as much water thereto as will cover the yarn about four inches; light the fire, and enter the yarn, when the liquor is a little warm; keep it constantly under the liquor for two hours; increase the heat regularly till it come to a scald; then take the yarn out, wash it, and hang it to dry, as in former operations.

"*Seventh Operation.*—Make a sour liquor of oil of vitriol and water: the degree of acidity may be a little less than the juice of lemons; lay the yarn in it for about an hour, then take it out, wash it very well, and wring it; give it a second washing and wringing, and lay it on a board.—This operation is to dissolve the metallic particles, and remove the ferruginous matter that remains on the surface of the thread after the fifth operation.

"*Eighth Operation.*—For every ten pounds of yarn dissolve one pound of best white soap in clear water, and add as much water to this liquor in your boiling pan as will be sufficient to boil the yarn for two hours. When these liquors are well mixed, light the fire, enter the yarn, and bring the liquor to boil in about an hour. Continue it boiling slowly an hour; take it out, wash it in clear water very well, and hang it to dry as in former operations: when dry, it is ready for the weaver.—It appears to me," says Mr. Brewer, "that less than four operations in the preparation of the yarn will not be sufficient to cleanse the pores of the fibres of the cotton, and render the colour permanent."

122. Mr. Chaptal's process for dying cotton a durable nankeen colour is recommended for its simplicity and cheapness. The cotton must be put into a cold solution of sulphate of iron (copperas) of the specific gravity 1.02; and having saturated a ley of potash of the specific gravity 1.01 with a solution, the cotton must be wrung out from the first solution, and immediately plunged into the second. After remaining in the latter four or five hours, it is taken out, washed, and dried. Every shade of nankeen yellow may be obtained by merely varying the proportion of sulphate of iron.

Blue.

123. Indigo and Woad are the only substances employed by the dyers to produce the blue colouring matter. Indigo was first brought from India to Europe for the purpose of dying by the Dutch, in the early part of the sixteenth century; it also grows in various parts of America and the West Indies. Of the indigo plant cultivated in America there are three species, namely, the *indigofera tinctoria*, the *indigofera disperma*, or Guatimala indigo plant, and the *indigofera argentera*. The first kind yields a copious quantity of inferior colouring matter; the second is a tall and hardy plant, yielding better indigo than the former; the third affords a small proportion of the best indigo. This kind of colouring matter may also be obtained from a variety of other plants, particularly from the *nerium tinctorium*, or rose bay, which grows in the east. From these plants, by means of suitable processes, a green matter is extracted which dissolves in water. This substance, which has a strong affinity for oxygen, gradually attracts it from the air, becomes of a blue colour, and is then insoluble in water. This absorption of oxygen is greatly promoted by agitation, for then a greater surface is exposed to the action of the air; and the lime water, by combining with carbonic acid, which exists in the green matter, also promotes the separation of the indigo. Indigo is insoluble not only in water, but also in alcohol, ether, and oils; and the only acids which produce any effect upon it are the sulphuric and nitric. By the latter it is soon changed to a dirty white, and at last entirely decomposed. When the acid is concentrated, the indigo is inflamed; but when it is diluted, the indigo becomes brown, and crystals like those of oxalic and tartarous acids make their appearance; and when the acids and crystals are washed off, there remains behind a kind of resinous matter. Sulphuric acid in the concentrated state dissolves indigo, with the evolution of a great deal of heat. The solution is opaque and black, but when diluted with water, it changes to a deep blue colour. Dr. Bancroft has denominated this solution sulphate of indigo, which has been long known by the name of liquid blue. The fixed alkalies in the state of carbonate, precipitate slowly from sulphate of indigo a blue coloured powder, which has the properties of indigo, but is found to be soluble in most of the acids and alkalies. Pure alkalies destroy the colour of sulphate of indigo, as well as that which is precipitated.

124. Indigo is employed in dying, both in the state of liquid blue, or sulphate of indigo, from which is obtained the beautiful colour called Saxon blue; and also in the state

of simple indigo, or the indigo of commerce. In dying with indigo, it must be reduced to the state of the green matter as it exists in the plants, or when it is first extracted from them. It must also be deprived of the oxygen, to the combination of which the blue colour is owing. In this state it becomes soluble in water by means of the alkalies. To effect this separation of the oxygen, the indigo must be mixed with a solution of some substance which has a stronger affinity for oxygen than the green matter of indigo, as green oxide of iron, or metallic sulphurets. Lime, green sulphate of iron, and indigo, are mixed together in water, and during this mixture the indigo is deprived of its blue colour, becomes green, and is dissolved; while the green oxide of iron is converted into the red oxide. In this process, part of the lime decomposes the sulphate of iron, and as the green oxide is set at liberty, it attracts oxygen from the indigo, and reduces it to the state of green matter, which is immediately dissolved by the action of the rest of the lime. Indigo is also deprived of its oxygen, and prepared for dying, by another process. Some vegetable matter is added to the indigo mixed with water, with the view of exciting fermentation; and quicklime or an alkali is added to the solution, that the indigo, as it is converted into the green matter, may be dissolved.

125. Woad of two kinds is likewise employed for dying blue, namely, the *isatis tinctoria*, and the *isatis lusitanica*, which is a smaller plant than the former. The blue colour obtained from these plants is inferior, both in quantity and quality, to that yielded by indigo; it is sufficiently permanent, but possesses scarcely any lustre.

Dying Wool Blue.

126. Before the use of indigo was understood, blue was dyed by means of woad; this, as we have before observed, affords a permanent, but not a deep colour. A very rich blue may however be obtained from a mixture of these two substances, in which the proportions must be varied, according to the shade proposed to be communicated to the stuffs.

127. The preparation for dying blue is made in a capacious wooden vat, capable of retaining the heat; it is set up in a place separate from the coppers, and sunk so far in the ground that the upper rim may be only about four feet above it. The preparation of a vat five feet and a half in diameter, and seven and a half deep, is thus described by Quatremere: Two balls of pastel or woad, weighing together about 400 pounds, are broken and thrown into the vat, and thirty pounds of weld are boiled for three hours in a copper containing as much water as will fill the vat. To this decoction are added twenty pounds of madder and a basket full of bran, and the boiling is continued half an hour longer. This bath is cooled with twenty buckets of water, and after it is settled and the weld taken out, it is poured into the vat, which must be stirred with a rake all the time that it is running in, and for fifteen minutes longer. The vat is then covered up very hot, and allowed to stand for six hours, when it is uncovered, and raked again for thirty minutes; and this operation must be repeated every three hours. When the appearance of blue streaks is perceived on the surface, eight or nine pounds of quicklime are added; the colour then becomes of a deeper blue, and the vat exhales more pungent vapours. Immediately after the lime, or along with it, the indigo, which has been previously ground in a mill, with the smallest possible quantity of water, is put in. The quantity is to be regulated by the intensity of the shade required. From ten to thirty pounds may be put into a vat, like that just described. If on striking the vat with a rake a fine blue scum arises, no other previous preparation is required than to stir it with the rake twice in the space of six hours, to mix the ingredients completely. Great care should be taken not to expose the vat to the air, except during the time of stirring it. When that operation is finished, it is covered with a wooden lid, on which are spread thick cloths, to retain the heat as much as possible; but after all these precautions, at the end of eight or ten days it is greatly diminished, and at last entirely dissipated, so that the liquor must be again heated, by pouring the greater part of the liquor into a copper under which a large fire is made. When the liquor has acquired a sufficient temperature, it is returned into the vat, and carefully covered up.

128. There are various accidents to which a vat, such as we have described, is liable. Sometimes, after having previously afforded fine streaks of blue, it appears black, which deepens on stirring, without exhibiting any blue streaks; it exhales a pungent odour, and dyes the stuffs a dirty grey colour. In this state, which is attributed to an excess of lime, the vat is said to be repelled. A variety of methods has been adopted for the recovery of a repelled vat. Some merely re-heat it; others add tartar, bran, urine, or madder; but Hellot recommends bran and madder as the best remedy. If the excess of lime be not very great, it is sufficient to leave the vat at rest five or six hours, putting in a quantity of bran and three or four pounds of madder, which are to be sprinkled on the surface, and then it is to be covered up, and after a certain interval, to be tried again. But if the vat has been so far repelled as to afford a blue only when it is cold, it must be left at rest to recover, and sometimes must remain whole days without being stirred. When it begins to afford a tolerable pattern, the bath must be reheated; and this in general revives the fermentation. The addition of bran or madder, or a basket or two of fresh woad, produces the same effect.

129. This vat sometimes runs into the putrefactive process. When this happens, the colour of the vat becomes reddish, the paste rises from the bottom, and a fetid smell is exhaled. This accident is owing to a deficiency of lime, and must be corrected by adding a fresh quantity. The vat is then to be raked; after two hours more lime is added, and the process of raking again performed. These operations are to be repeated till the vat is recovered. Nothing requires more attention in treating a vat of this kind, than the distribution of the lime, the principal use of which is to moderate the tendency to putrefaction, and to limit the fermentation to that degree which is necessary to deprive the indigo of its oxygen. If too much lime be added, the necessary fermentation is retarded, and if there be too little, the putrefactive process commences.

130. Preparatory to the dying process, that is, about two hours before it commences, the vat should be raked; and to prevent the stuff coming in contact with the sediment, which would produce inequalities in the colour, a cross of wood is introduced. The stuff is then to be completely wetted with pure water a little heated; and being wrung out, it is dipped into the vat, where it is moved about for a longer or a shorter time, according to the depth of shade required. During this operation it is occasionally taken out to be exposed to the air, the action of which is necessary to change the green colour of the bath into a blue. Stuffs dyed in this manner must be carefully washed, to carry off the loose particles of colouring matter; and when the shade of blue is deep, they ought even to be cleansed, by fulling with soap.

131. For the indigo vat, which is prepared entirely of indigo, the vessel must be of copper; and having boiled six pounds of bran with the same weight of potash and twelve

ounces of madder in forty pails of water, the decoction is thrown into the copper vessel above mentioned. Immediately after this, six pounds of indigo, ground in water, are introduced; the vat is then carefully raked and covered. A slow fire is to be kept underneath, and the raking repeated every twelve hours for about forty-eight hours; at the expiration of which, the blue colour may be expected. Having properly conducted this part of the operation, the vat will appear of a beautiful green, and exhibit on its surface coppery scales and a blue scum. The dying process is the same as has already been described.

Dying Silk Blue.

132. Indigo is the only colouring substance used in dying silk blue; and the same proportion of it as is directed in the preceding paragraph, or even a larger, is employed with twelve ounces of madder, and six pounds of bran. Half a pound of madder to each pound of potash is recommended by Macquer, who says, that it renders the vat greener, and fixes the colour more permanently in the silk. When the vat is come to, it should be refreshed with two pounds of potash, and three or four ounces of madder; and after being raked, in the course of four hours, it is fit for dying. The temperature should be so moderated, that the hand may be held in it without uneasiness. The silk having been boiled with soap, in the proportion of thirty pounds of soap to one hundred pounds of silk, and well cleaned by repeated beetlings in a stream of water, must be dyed in small portions, because it is apt to take on an uneven colour. After being turned once or oftener in the bath, it is wrung out, and exposed to the air, that the green colour may change to a blue. When the change is complete, it is thrown into clear water, afterwards wrung out, and then should be speedily dried. In damp weather and in winter, it is necessary to conduct the drying in a chamber heated by a stove. The silk should be hung on a frame kept constantly in motion. To dye light shades, some dyers employ vats that are somewhat exhausted; but it ought to be observed, that the colour thus obtained is less beautiful and less permanent than when fresh vats, containing a smaller quantity of indigo, are employed.

133. To communicate a deep blue to silk, a previous preparation is necessary; it must have an additional colour or ground. A strong bath of archil is prepared for the Turkey blue; or cochineal may be substituted instead of archil, which will render the colour still more permanent. Verdigris and logwood may be also used for dying silk blue; but the colour is not durable. This may however be in some degree remedied, by first giving the silk a lighter shade in the bath we have just mentioned, then dipping it in the bath of archil, and afterwards in the indigo vat.

134. When it is intended to dye raw silk, such should be chosen as is naturally white; this being previously steeped in water, is to be immersed in separate hanks in the bath; and as it is found to combine more readily with the colouring matter than scoured silk, the latter may be put into the bath first. If an intense blue be required, the necessary colouring matters are to be applied as before directed.

Dying Cotton and Linen Blue.

135. Six or eight pounds of powdered indigo are boiled in a ley drawn from lime and potash; the weight of the lime being equal to, and that of the potash double the weight of the indigo. The boiling is continued till the indigo is completely penetrated with the ley, during which the solution must be constantly stirred. While this process proceeds, a second is also carried on. To twenty quarts of warm water, holding in solution as much sulphate of iron (copperas) as is equal to double the weight of the indigo, as much quicklime previously slaked must be added, as is equal in weight to the indigo. This solution is poured into a vat capable of holding 120 gallons, and which is previously half filled with water. To this mixture the indigo solution is added, and the vat is filled nearly up to the rim. The vat will be completely prepared in about forty-eight hours, during which time it must at equal intervals be well raked five or six times. To this vat some dyers recommend the addition of a small quantity of madder, bran, and woad.

136. A method far less prolix than the foregoing is practised at Rouen. According to M. Quatremere's description, the vats, which are constructed of a kind of flint, are coated within and without with fine cement, and arranged in parallel lines; and each vat contains four hogsheads of water. The indigo, to the amount of eighteen or twenty pounds, being macerated for a week in a caustic ley strong enough to bear an egg, is ground in a mill; three hogsheads and a half of water are put into the vat, and afterwards twenty pounds of lime. The lime being thoroughly slaked, the vat is raked, thirty-six pounds of copperas are added, and when the solution is complete, the ground indigo is poured in through a sieve. It is raked seven or eight times the same day, and after being left at rest for thirty-six hours, it is in a state fit for dying.

137. The proportion of ingredients recommended by Bergman is, powdered indigo, sulphate of iron, and lime, each three drams, in two pints of water. This being well raked, will, in a few hours, be in a proper state for use. The same author mentions another convenient and expeditious vat; to a quart of strong soap-boiler's ley, add three drams of finely powdered indigo, and when the ley has penetrated the colouring matter, add six drams of powdered orpiment. The bath having been well raked, becomes green with streaks of blue on the surface; and after the application of heat, it will be prepared for use. This bath is similar to the preparation for printing cotton; excepting in the latter case a smaller proportion of orpiment and indigo is adopted. Haussmann assigns a still less quantity of indigo to the process than even Bergman; also the former gentleman found, that cloth which immediately after being taken out of the bath was immersed in water acidulated with sulphuric acid, received a deeper blue than two similar patterns, one of which after being taken out of the bath was dipped in river water, and the other exposed to the air.

138. Berthollet observes, that the vats in extensive dye-houses must necessarily be set at different times. In conducting the process when this is the case, the stuffs are first dipped in the most exhausted vat, and then regularly proceed from the weakest to the strongest, if they have not previously attained the desired shade. They should remain in the bath only about five or six minutes, for in that time they combine with all the colouring matter they can take up. After the stuffs have been dipped in a vat, it should not be used again till it has been raked, and stood at least twenty-four hours, unless it has been lately set, when a shorter period is sufficient. When the stuffs have been dipped three or four times in a vat, it begins to change. It becomes black, and no blue or copper-coloured streaks are seen on the surface after raking it. It must then be renewed, by adding four pounds of copperas, with two of quicklime, after which it must be raked twice. Thus a vat may be renewed three or four times; but the additional quantity of ingredients must be diminished, as the strength of the vat is exhausted.

139. The Saxon blue was discovered by M. Barth, a German lawyer, about the year 1740; and to obtain it,

indigo is dissolved in sulphuric acid. In preparing the dye, Quatremere employed an alkali, in the proportion of one ounce to an ounce of indigo, and six ounces of sulphuric acid. With this proportion of ingredients he obtained a deep vivid blue, equally intense through every part of the stuff. Poerner, who has paid great attention to this preparation, also employed an alkali, by means of which a more pleasing colour, which penetrates deeper, is produced. The proportions he recommends are four parts of sulphuric acid to one of indigo. The indigo is first reduced to a fine powder, and the sulphuric acid, in the concentrated state, is poured upon it. The mixture is stirred for some time, and having stood for twenty-four hours, one part of dry potash in fine powder, is added; and after the whole is again stirred, it remains for twenty-four hours longer. It is then diluted with eight times its weight of water, which must be gradually added, or a greater or less proportion as may be wanted.

140. To produce a Saxon blue colour on woollen stuffs, they are prepared with alum and tartar. And in proportion to the shade required, the quantity of solution of indigo put into the bath must be regulated. When a deep shade of Saxon blue is wanted, the stuff must be passed different times through vessels containing such a quantity of colouring matter as is sufficient to give light colours. In this way, by repeated applications, the colour becomes more uniform.

141. The sulphate of indigo is also employed to dye silk. For this purpose attempts have been made to unite the advantages of the indigo vat and the solution of indigo in sulphuric acid. A process of this kind is greatly recommended by Guliche, which produces beautiful colours, and is at the same time cheap and convenient. The bath is composed of one pound of indigo, three pounds of quicklime, three of copperas, and one and a half of orpiment. The indigo is first to be carefully ground and mixed with water, then put into a wooden vat, and diluted with water, according to the shade of colour wanted. The lime is then to be added, and the mixture being well stirred, is covered up, and allowed to remain at rest for some hours. After this, the copperas in the state of powder is added, the whole well stirred, and the vat covered up. Lastly, at the end of some hours, the orpiment reduced to powder is thrown in, and the whole left at rest for several hours. The mixture is afterwards to be stirred, and left to settle, till the liquor becomes clear. Next, the blue streaks which cover it are removed, and the silk, previously dipped in warm water, is to be dyed hank by hank. When it is removed from the bath, it is to be washed in a stream of water, and dried. This process is recommended as the means of obviating a greenish cast, sometimes observed in Saxon blue, and which is supposed to be owing to some change in the particles of indigo, by means of the sulphuric acid.

142. Both wool and silk may be dyed by means of the sulphate of indigo, and the colour thus produced is called English blue. Silk destined to receive this colour is first to be dyed a light blue; and, when taken out of this bath, it is dipped in hot water, washed in a stream, and left in a bath composed of the sulphate of indigo, to which a little of the solution of tin has been added, until the proper shade is obtained, or the bath is exhausted. Previous to its being put into this bath, it may be dipped in a solution of alum, in which it should remain a very short time. Silk, which has been dyed according to this process, is free from the reddish shade derived from the blue vat, as well as from the greenish cast of the Saxon blue. Berthollet on Dying, ii. 319, &c.

143. Several persons have attempted, with various degrees success, to dye with Prussian blue; among whom may be mentioned Macquer, Berthollet, Guliche and De la Platiere. For dying thread and cotton, L'Abbé Menon proposes the following method: They are first to be dyed black, and soaked for a few minutes in prussiate of alkali, and afterwards boiled in a solution of alum. In this way they acquire a deep blue. When a lighter blue is wanted, the stuffs must be passed through a weak acid.

144. A number of experiments was made by Dr. Bancroft, with the view of obviating the difficulties which had hitherto attended the application of Prussian blue to dying. He boiled up copperas with quercitron bark, fustic, and logwood, separately; and in each of these mixtures he dyed a piece of woollen cloth by boiling it for ten or fifteen minutes. The stuffs were afterwards separately immersed in warm diluted prussiate of potash neutralized by sulphuric acid, and acquired an equal and beautiful blue. This, however, was not the uniform result; for when too much copperas was employed with the quercitron bark, there was an excess of oxide of iron, which combining with the fibres of the wool, gave the Prussian blue a greenish tinge; but this he found could be remedied, by passing the cloth through warm water, slightly acidulated with muriatic acid. The Prussian colouring matter must always be applied in a moderate heat, otherwise it will be precipitated by the sulphuric acid, and rendered unfit for this purpose, till it is again dissolved by potash, lime, or some other substance. His next attempt was to fix Prussian blue by means of the aluminous mordant; but at the end of fifteen minutes, after being immersed in a solution of prussiate of potash, it had acquired no colour. The addition of a small proportion of a solution of iron in muriatic acid, communicated a blue colour. All parts of the cloth, as well as those to which the mordant had been applied, received the colour. The cloth being washed with soap, the whole of the colour was discharged, excepting where it had been impregnated with alumina, and even there it had become fainter. A piece of the same cotton was immersed in a solution of ammonia (volatile alkali); the pale blue was greatly heightened. Another piece was put into water slightly tinctured with a solution of copper in ammonia. The blue colour became suddenly of an intense deep garter-blue or violet, and it resisted the action of soap. Into water mixed with a little of a solution of muriate of copper, he put another piece of the same cotton, and it soon became of a deeper blue, without any of the purple or violet shade. This resisted the action of soap, but after long exposure to the weather, the colour was a little diminished; nevertheless when the colour remained in any degree weakened, immersion in water slightly acidulated with sulphuric acid, completely restored it. From these facts it appears advantageous to prepare woollens by the usual boiling with alum, or alum and tartar, before they are dyed with copperas and quercitron bark, fustic or logwood, for a Prussian blue; but a greater proportion of sulphuric acid, in the prussiate of potash or lime (that the excess of acid may discharge the vegetable colouring matters) becomes necessary.

145. In order to obtain as complete a knowledge of the subject as possible, our ingenious author next directed his attention to silk and cotton. He tried pieces of each of these in the diluted prussiates of potash, soda, lime, &c. with solutions of most of the metals in different acids and alkalies; and from the different metallic solutions he obtained a very full lively colour, which he calls the red copper colour; from the different solutions of copper in sulphuric, nitric, muriatic, and acetic acids: the same effect succeeded well from a solution in ammonia. He obtained also the same colour from the nitrates of silver and of cobalt. The Prussian colouring matter fixed by these metallic mordants resisted the action of acids, washings with soap, and exposure to the

weather for the greatest length of time. In all these cases there must be a double application, and it is indifferent which is applied first, the colouring solution or the metallic, provided the stuff be always dried from the first immersion before it receives the second.

Black.

146. There is a great variety of substances capable of giving the black colour to stuffs; but scarcely any of them will communicate a permanent black, without the assistance of mordants. The juice of the cashew nut affords a black, capable of sustaining the action of soap and alkalies; sloe juice gives a durable blue black; some other plants are also found to produce similar effects. But the substances chiefly employed by dyers to give a black colour, are gall-nuts and the red oxide of iron. The astringent principle contained in the nut, combining with the oxide held in solution by an acid, produces the black colour, and fixes it in the stuffs. When the colouring particles are precipitated from the above solution, they are blue; but they become black by being moistened and exposed to air. Logwood, though it does not produce the black colour, is nevertheless useful in adding a lustre to the black.

Dying Woollen Black.

147. In order to produce in woollen stuffs a fine deep black, it is necessary that they should be previously dyed of a deep blue colour. As soon as the stuff is taken from the vat, it is thoroughly washed in a running stream; then, after undergoing the operation of fulling, it is ready for the black colour. According to the common method of dying black, the cloth, which has been previously dyed blue, is boiled for two hours in a vat of galls; it is then kept in the bath of sulphate of iron and logwood two hours longer, after which it is washed and fulled. M. Hellot recommends that a bath be prepared of a pound and a half of yellow wood, five pounds of logwood, and ten pounds of sumach, which is the proportion of the ingredients for every fifteen yards of deep blue cloth; and the cloth having boiled in this bath for three hours, ten pounds of sulphate of iron are added; the cloth is allowed to remain for two hours longer, when it is taken out to be aired, after which it is again returned to the bath for an hour, and then washed and fulled. A less expensive process may be employed, by substituting a brown or fawn-coloured ground, instead of the blue; this colour is obtained from the roots of the walnut tree, or green peels of walnuts. After which the stuffs are to be impregnated with the black dye as before.

148. According to the usual practice in this country, every 100 pounds of cloth, being previously subjected to the galling process and dyed blue, are to pass through a decoction of five pounds of sulphate of iron, five of galls, and thirty of logwood. As a substitute for the galls, which are an expensive article, some employ the leaves of the *arbutus uva ursi;* these, in order to preserve the green colour, are carefully dried; the process is as follows: A hundred pounds of wool are boiled with sixteen pounds of sulphate of iron, and eight of tartar, for two hours. The day following the cloth is to be rinsed as after aluming. A hundred and fifty pounds of the leaves of *uva ursi* are then to be boiled for two hours in water, and after being taken out, a small quantity of madder is to be added to the liquor, putting in the cloth at the same time, which is to remain about an hour and a half. It is then taken out and rinsed in water. By this process blue cloth receives a pretty good black, but white cloth becomes only of a deep brown. But it has been said that the madder and tartar are useless ingredients. After the different operations for dying the cloth have been finished, it is washed in a river, and fulled, till the water comes off clear and colourless.

Dying Silk Black.

149. The necessary operations are, boiling, galling, repairing the bath, dying, and softening. Also to produce a deep shade, the silk must be deprived of its gummy substance, by boiling it four or five hours with one-fifth its weight of white soap; after which it must be beetled, and carefully washed.

150. The galling process requires, that a quantity of good galls, equal to three-fourths the weight of the silk, be boiled for three or four hours. After the boiling, the liquor is allowed to remain at rest for two hours; the silk is then put into the bath, and left there from twelve to thirty-six hours, when it is to be taken out, and washed in the river. But as silk is capable of combining with a great proportion of the astringent principle, from which it receives a considerable increase of weight, it is allowed to remain for a longer or shorter time, according as it is required to have more or less additional weight. To communicate, therefore, what is called a heavy black, the silk is allowed to remain longer in the gall liquor; the process is repeated oftener, and the silk is also dipped in the dye a greater number of times.

151. While the silk is preparing for dying, the bath is to be heated, and should be occasionally stirred, and kept always under the boiling temperature. Gum and solution of iron are added in different proportions, according to the different processes. When the gum is dissolved, and the bath near the boiling temperature, it is left to settle for about an hour. The silk (which in general is previously divided into three parts, that each may be successively put into the bath) is then immersed in it. Each part is to be three times wrung, and after each wringing hung up to air. Being thus exposed to the action of the air, the silk acquires a deeper shade. This operation being finished, the bath is again heated, with the addition of gum and sulphate of iron, and this is repeated two or three times, according as the black required is light or heavy. When the process of dying is finished, the silk is rinsed in a vessel with cold water, by turning or shaking it over.

152. The harshness which silk acquires in the dye, is removed by the operation of softening. For every 100 pounds of silk, four or five pounds of soap are dissolved, and passed through a cloth into a vessel of water; and the silk being immersed in this solution, is allowed to remain there about a quarter of an hour. It is then carefully wrung out and dried.

153. Raw silk of the natural yellow colour is generally preferred for dying black. The galling must be performed in the cold, if it be proposed to preserve the whole of the gum, and the elasticity which it gives to the silk; but if part only of the gum is to be preserved, the galling is performed in the warm bath. The dying operation is also performed in the cold; and all that is necessary is to add the sulphate of iron to the water in which the stuff is rinsed. By this simple process the black dye is communicated. The silk is then washed, once or twice beetled, and dried without wringing, that its elasticity may not be destroyed. Raw silk may however be dyed by a more speedy process. After galling, it may be turned or shaken over in the cold bath; and thus by alternately dipping and airing, the operation may be completed. It is then washed and dried as in the former processes.

154. Macquer has given the following description of the process first adopted at Genoa, and afterwards improved in France, of dying velvet. For every 100 pounds of silk, twenty pounds of Aleppo galls, reduced to powder, are

boiled in a sufficient quantity of water for an hour. The bath is allowed to settle till the galls have fallen to the bottom; they are then taken out, and two pounds and a half of sulphuric acid, twelve pounds of iron filings, and twenty pounds of gum, are put into a copper vessel, furnished with two handles. This vessel is immersed in the bath, and supported that it may not touch the bottom. The gum, which is allowed to dissolve for an hour, is to be occasionally stirred; and if it appear that the whole of the gum is dissolved, three or four pounds more are to be added. Excepting during the operation of dying, the vessel is to remain in the copper, which must be kept the whole time at a temperature below the boiling point. In galling the silk, one-third of Aleppo galls is employed, and the stuff should remain six hours in the liquor the first time, and twelve hours the second. By frequent additions of sulphate of iron, and repeated immersions of the stuff, a fine black, according to Lewis, has been obtained. In the above process, the proportion of sulphate of iron is too small, and the gum, according to some, being carried off in the washing, may be considered as useless. Berthollet thinks that, although the quantity be excessive, it has some effect in keeping up the bath; and he adds, if it is to be diminished, it would be useful to add the sulphate of iron in separate portions during each interval.

155. The consumption of galls may be diminished, by employing a strong decoction of walnut peels; this, after boiling a quarter of an hour, is taken from the fire and allowed to settle. The silk, which has been previously immersed in warm water, is plunged into the decoction, and left in it till the colour is exhausted.

156. Logwood and verdigris are employed, to communicate to the silk a blue ground. One ounce of verdigris to every pound of silk being dissolved in cold water, the silk is allowed to remain two hours in this solution. It is then immersed in a strong decoction of logwood, slightly wrung out, dried, and afterwards washed in the river. The bath is prepared by macerating two pounds of galls and three of sumach, in twenty-five gallons of water, over a slow fire for twelve hours. The liquid being strained, three pounds of sulphate of iron, and the same quantity of gum arabic, are to be dissolved in it. The silk is dipped in this solution at two different times; it is to remain in the bath two hours each time, and must be aired and dried between each dip. After being twice beetled at the river, it is dipped a third time, and left in the bath four or five hours, after which it is to be dried, washed, and beetled, as before. The temperature of the bath should not exceed 120°. After the first dipping, it may be necessary to add half a pound of sulphate of iron, and an equal quantity of gum arabic. This process gives the silk a beautiful velvety lustre.

Dying Cotton and Linen Black.

157. To communicate a fine permanent black colour to cotton or linen, is found to be a task of no small difficulty. The stuffs should be previously dyed blue; subsequent to which, a number of particular processes is necessary. First, a gall liquor is prepared, composed of four ounces of galls to every pound of the stuffs to be dyed. In this liquor the stuffs, having been previously dyed blue, wrung out and dried, are immersed and allowed to remain for twenty-four hours. Next, a bath is prepared of a solution of iron in acetic acid. This solution is obtained by saturating the acid with oxide of iron, it is called iron liquor, and is prepared from fermented worts, to which old iron is added. Five quarts of the iron liquor for every pound of stuff, are put into a vessel, and in this the stuffs are wrought with the hand, pound by pound, for fifteen minutes: they are then wrung out and aired. This operation is to be again repeated, taking care to add a fresh quantity of the iron liquor, which should be carefully scummed, after which the stuffs are to be wrung out, aired, and washed at the river. In the next operation, a pound of alder bark for every pound of stuff is boiled in a sufficient quantity of water for an hour. One-half of the bath employed in the galling, and about one-half the quantity of sumach as of alder bark, are then added. The whole is boiled together for two hours, and strained through a sieve. When this liquid is cold, the stuffs are immersed, wrought pound by pound, and occasionally aired. They are afterwards put into the bath, and after remaining for twenty-four hours, are wrung out and dried.

158. The foregoing is the method of dying cottons and linens at Rouen; that of the Manchester dyers, as described by Mr. Wilson, is as follows: For the galling process, galls or sumach are employed. The stuff is afterwards dyed in a bath consisting of a solution of iron in acetic acid. This bath is also frequently composed of alder bark and iron. After having passed through it, the stuff is dipped in a decoction of logwood, to which a small quantity of verdigris has been added. This process is to be repeated, till a black of the proposed intensity is obtained; observing, that after every operation the stuffs must be washed and dried.

BROWN.

159. There are many substances from which the brown or fawn colour is obtained; but those chiefly employed by dyers are walnut peels, and sumach. The peels, though externally green, are white withinside; but this white, by exposure to air, becomes brown or black. When the inner part of the peel, taken fresh, is put into weak oxymuriatic acid, it assumes a brown colour; and if the decoction be filtered and exposed to air, its colour becomes of a deep brown; the pellicles on evaporation are almost black; the liquor detached from these yields a brown extract completely soluble in water. The colouring particles are precipitated from a decoction of walnut peels, by means of alcohol, and are soluble in water. No apparent change is at first produced by a solution of potash; but the decoction gradually becomes turbid, and the colour is deepened. A copious precipitate of a fawn colour, approaching to an ash colour, is produced in this decoction by means of a solution of tin, and the remaining liquor has a slight yellow tinge. The decoction of walnut peels yields a small quantity of fawn-coloured precipitate by means of a solution of alum, and the liquor remains of the same colour. Sulphate of copper renders it slowly turbid, and throws down a small quantity of precipitate of a brownish green colour, leaving the supernatant liquor of the same colour. Sulphate of iron deepens the colour; when diluted, the colour becomes brownish green, without the deposition of any sediment. Sulphate of zinc also deepens the colour, and produces no precipitate. The same properties are exhibited by a decoction of the walnut-tree wood, but the colouring matter is not obtained from it in such abundance as from the peels; and the bark may also be used with advantage. The affinity of the colouring matter of walnut peels for wool is very strong, and readily imparts to it a durable colour, which even mordants do not seem capable of increasing; but they are generally understood to give it additional brightness. A lively and very rich colour is obtained with the assistance of alum. Walnut peels afford a great variety of pleasing shades, and as they require not the intervention of mordants, the softness of the wool is preserved, and the process of dying becomes both cheap and simple.

160. The time for gathering walnut peels, is when the fruit is completely ripe. They are extensively used at the

Gobelins at Paris; and the method is, to put them into a vessel, with water sufficient to cover them. In this state they are kept for a year; but if they are not used till the end of two years, a greater quantity of colouring matter will be produced. Unripe peels may likewise be used, but they cannot be kept for any length of time.

161. SUMACH, the *rhus coriaria* of Linnæus, is a shrub which grows both wild and by cultivation in the Levant, Spain, and Portugal. Its shoots are annually cut down, dried, and reduced to powder in a mill. The infusion of sumach, which is of a fawn colour with a greenish tinge, is changed into a brown by exposure to the air. A solution of potash has little action on the recent infusion; its colour is changed to yellow by the action of acids; the liquor becomes turbid by means of alum, a small quantity of precipitate being at the same time formed, and the supernatant liquor remaining yellow. A copious precipitate of a yellowish green colour is thrown down by sulphate of copper, and the liquor remains clear. No change is speedily produced by muriate of soda (common salt) but it becomes turbid at the end of some hours, and its colour is rather clearer. Sulphate of copper produces a copious precipitate of a yellowish green, which after standing changes to a brownish green; the supernatant liquor, which is slightly yellow, remains clear. Sulphate of zinc renders the liquor turbid, darkens its colour, and produces a deep blue precipitate; but when the sulphate of zinc is pure, the precipitate, which is of a brownish fawn colour, is in very small quantity. Acetate of lead gives a copious precipitate, of a yellowish colour; the supernatant liquor is of a clear yellow colour. No astringent has so strong a resemblance to galls as sumach; but the precipitate thrown down from an infusion of it by a solution of iron, is not so copious as that which is yielded by an equal quantity of galls, on which account sumach may be generally employed as a substitute for galls, only its quantity will require to be increased.

162. A clear fawn-coloured decoction may be obtained from the bark of birch; but it speedily becomes brown and turbid. If to this solution there be added, in the open air, either a solution of alum, or a solution of tin, an abundant precipitate of a yellow colour will be formed. With solutions of iron the decoction of birch bark strikes a black colour, and it dissolves in considerable quantity the oxide of iron. On account of this property, it is employed in the preparation of black vats for dying thread. Sanders, or sandal wood, is also used for the purpose of giving a fawn colour. There are three kinds of sandal wood, the white, the yellow, and the red. The last only, which is a compact heavy wood, brought from the Coromandel coast, is used in dying. By exposure to the air it becomes of a brown colour; when employed in dying, it is reduced to fine powder, and yields a fawn colour with a brownish shade, inclining to red. But the colouring matter is in small quantity, and is said to give harshness to woollen stuffs. When it is mixed with other substances, as sumach, walnut peels, or galls, the quantity of colouring matter is increased; it gives a more durable colour, and produces considerable modifications in the colouring matter with which it is mixed. This wood yields its colouring matter to brandy, or diluted alcohol, more readily than to water. A fawn colour or brown may also be communicated to woollen stuffs by means of soot; but its principal value is the giving a brown cast to certain colours; and producing a variety of such shades as are not easily obtained from other ingredients.

Dying Stuffs Brown, or Fawn Colour.

163. When walnut peels are employed, the quantity must always be proportioned to the quantity of stuff, and the intensity of the colour proposed to be communicated. The peels are boiled in a copper for a quarter of an hour, and having previously moistened the stuff in warm water, it is immersed in the copper, and carefully stirred till it has acquired the proper shade; observe also, that each parcel of cloth put in requires an additional portion of peels. In dying cloth, the deepest shade is given first, and the lightest last; but when woollen yarn is dyed, this order is inverted. In the above process the aluminous mordant is not employed. By employing the metallic oxides as mordants, Berthollet found, that the oxide of tin yielded a clearer and brighter fawn colour than that of the simple decoction. The oxide of zinc produced a still clearer colour, inclining to ash or grey. The colour from oxide of lead had an orange cast, while that from oxide of iron was of a greenish brown. Elements of Dying, ii. 296. A fawn colour with a shade of green is obtained from sumach alone; but to cotton stuffs which have been impregnated with printers' mordant, or acetate of alumina, sumach communicates a good and durable yellow. Here, however, some precaution is necessary in the use of this substance; for as the colouring matter is of so fixed a nature, the ground of the stuff cannot be bleached by exposure to the air. This inconvenience is however avoided, by impregnating the whole of the stuff with different mordants, producing in this way a variety of colours, and leaving no part of the stuff undyed. For dying wool, silk, cotton, and linen, which had been previously impregnated with a solution of tin, and afterwards washed and dried, Vogler employed the tincture of sanders wood. He sometimes used the pure solution, and sometimes mixed with it from six to ten parts water; and the result in every case was a poppy colour. By using the sulphate of iron as a mordant, he obtained a beautiful deep violet; with the sulphate of copper it was a clear crimson; and with a solution of alum a rich scarlet.

COMPOUND COLOURS.

164. Compound colours are obtained by the mixture of simple colours; and have usually been divided into four general classes, namely, green, purple, orange, and grey, or drab. These are produced as follows:

1. Blue and yellow produce . . . green.
2. Red and blue . . . . purple.
3. Red and yellow . . . . orange.
4. Black and other colours . . . grey.

There are besides an indefinite variety of intermediate shades, depending on the innumerable proportions of the simple colours which may be compounded, as well as partly on the chemical phenomena which arise from their combination.

GREEN.

165. This colour, which is obtained from a mixture of blue and yellow, requires much skill and experience in the artist; otherwise it will not be uniform. There is a variety of shades of this colour, as bottle-green, olive-green, sea-green, apple-green, grass-green, pea-green, parrot-green, &c. D'Ambourney produced a permanent colour between parrot and grass-green, from fermented juice of the berries of a species of alder. Many other plants also afford green colouring matter; as brome-grass, wild chervil, purple clover, the reed, the green berries of rhamnus frangula, &c.; but none of these colours are durable.

Dying Woollen Green.

166. The stuffs are dyed yellow and blue separately; either the yellow dye may be given first, and then the blue; or the blue first, and afterwards the yellow. But when the stuff is first dyed yellow, and in this state introduced into the

blue vat, part of the yellow colouring matter being dissolved in the vat, communicates to it a green colour, which renders it unfit for dying any other colour than green. To avoid this inconvenience, therefore, the blue colour is first given, and afterwards the yellow. The intensity of the blue shade must be proportioned to the green, or to the depth of the green colour which is wished to be obtained; for instance, to produce a parrot green, a ground of sky blue is given, and for the green like that of a drake's neck, a deep blue is required. When the blue dye has been communicated, the yellow is afterwards given, according to the processes already described for dying yellow. The proper ground being communicated to the cloths, they are washed in the fulling mill, and boiled as for the common process of welding; but when the shade is light, the proportion of salts should be less. Cloths which are to receive light shades are first boiled, and when taken out, tartar and alum are added in fresh portions, till the cloths which are intended for the darkest shades are boiled. The process of welding is conducted in the same way as for dying yellow, with this difference, that a larger proportion of weld is employed, excepting for lighter shades, when the proportion must be smaller. In dying green, it is usual to have a succession of shades at the same time: the process is begun with the deepest, and ends with the lightest. Between each dip there should be an interval of about three quarters of an hour, and at each interval water is added to the bath. Some dyers give each parcel two dips, beginning the first time with the deep shades, and the second with the lighter ones; but when this practice is followed, the time of immersion should be shortened. In dying very light shades, the bath should never be permitted to reach the boiling temperature. For deep greens, a browning is given with logwood, and a small proportion of sulphate of iron. Sulphate of indigo is employed for some kinds of green; in this case either the blue and yellow are dyed separately, or the whole of the ingredients are mixed together in the bath, and the process is finished at a single operation. The colour thus obtained has been distinguished by the name of Saxon green. "The most beautiful Saxon greens," says Dr. Bancroft, "may be produced very cheaply and expeditiously, by combining the lively yellow which results from quercitron bark, murio-sulphate of tin, and alum, with the blue afforded by indigo when dissolved in sulphuric acid, as for dying the Saxon blue. To produce this combination most advantageously, the dyer, for a full-bodied green, should put into the dying vessel after the rate of six or eight pounds of powdered bark, in a bag, for every 100 pounds weight of cloth, with only a small proportion of water, as soon as it begins to grow warm; and when it begins to boil, he should add about six pounds of murio-sulphate of tin (with the usual precautions) and a few minutes after, about four pounds of alum; these having boiled together five or six minutes, cold water should be added, and the fire diminished so as to bring the heat of the liquor nearly down to what the hand is able to bear; and immediately after this, as much sulphate of indigo is to be added as will suffice to produce the shade of green intended to be dyed, taking care to mix it thoroughly with the first solution by stirring, &c. This being done, the cloth previously scoured and moistened, should be expeditiously put into the liquor, and turned very briskly through it for a quarter of an hour, in order that the colour may apply itself equally to every part, which it will certainly do in this way with proper care. By these means, very full, even, and beautiful greens may generally be dyed in half an hour; and during this space, it is best to keep the liquor at rather less than a boiling heat. Murio-sulphate of tin is infinitely preferable, for this use, to the dyers' spirit; because the latter consists chiefly of nitric acid, which, by its highly injurious action upon indigo, would render that part of the green colour very fugitive, as I have found by repeated trials. But no such effect can result from the murio-sulphate of tin, since the muriatic acid has no action upon indigo; and the sulphuric is that very acid which alone is proper to dissolve it for this use. Respecting the beauty of the colour thus produced, those who are acquainted with the unequalled lustre and brightness of the quercitron yellows, dyed with the tin basis, must necessarily conclude, that the greens composed therewith will prove infinitely superior to any which can result from the dull muddy yellow of old fustic; and in point of expense, it is certain that the bark, murio-sulphate of tin, and alum, necessary to dye a given quantity of cloth in this way, will cost less than the much greater quantity (six or eight times more) of fustic, with the alum necessary for dying it in the common way, the sulphate of indigo being the same in both cases. But in dying with the bark, the vessel is only to be filled and heated once; and the cloth, without any previous preparation, may be completely dyed in half an hour; whilst in the common way of producing Saxon greens, the copper is to be twice filled: and to this must be joined the fuel and labour of an hour and a half's boiling and turning the cloth, in the course of preparation, besides nearly as much boiling in another vessel to extract the colour of the fustic; and after all the dying process remains to be performed, which will be equal in time and trouble to the whole of the process for producing a Saxon green with the bark: so that this colour obtained from bark will not only prove superior in beauty, but in cheapness, to that dyed as usual with old fustic." Philos. of Perm. Colours.

Dying Silk Green.

167. In order to preserve uniformity in the colour, and to prevent spots and stripes, the greatest precaution must be observed. The silk being previously scoured, is first dyed yellow, and after being well alumed, it is slightly washed at the river, and divided into small parcels, that it may receive the colouring matter uniformly, and then carefully turned in the weld bath. When the ground is supposed to have acquired a sufficient degree of intensity, a pattern is put into the blue vat, to ascertain the proper shade. When this is the case, the silk is taken out of the bath, washed, and immersed in the blue vat. To produce a deeper colour, and at the same time to give variety of shade, a decoction of logwood, fustic, or anotta, is added to the yellow bath, after the weld has been taken out. For very light shades, such as apple and sea green, a weaker ground is to be given. For all light shades except sea green, the process is found to succeed better when the yellow is communicated by baths which have been already used; but these baths should not contain any logwood or fustic.

168. The Saxon green is more bright and less permanent. In order to produce it, a boiling, the same as for welding, is necessary; after which the cloth must be washed. A quantity of fustic chips is enclosed in a bag, put into the same bath, and boiled for an hour and a half, when it is taken out, and the bath allowed to cool till the hand can bear it. A pound and a quarter of sulphate of indigo for each piece of cloth of eighteen yards, is added. The cloth is at first to be turned quickly, and afterwards more slowly, and it should be taken out before the bath boils. Some dyers put in only two-thirds of the solution at first; and after two or three turns, take out the cloth, and add the other one-third. By this means the colour is more uniform.

169. A more commodious and certain method of communicating the most beautiful Saxon greens to silk is the

following; it is strongly recommended by Dr. Bancroft, and described in his Philosophy of Permanent Colours, p. 346: "A bath," says he, "is prepared of four pounds of quercitron bark, three pounds of alum, and two pounds of murio-sulphate of tin, with a sufficient quantity of water. The bath is boiled ten or fifteen minutes, and when the liquor is so far reduced in temperature as the hand can bear it, it is fit for dying. By adding different proportions of sulphate of indigo, various and beautiful shades of green may be obtained, and the colour thus produced is both cheap and uniform. Care should be taken to keep the bath constantly stirred, to prevent the colouring matter from subsiding. Those shades which are intended to incline most to the yellow, should be dyed first; and by adding sulphate of indigo, the green, having a shade of blue, may be obtained."

170. English green is more beautiful than the common green, and more permanent than the Saxon. The silk is dyed of a light blue, in the cold vat before described; it is then successively steeped in warm water, washed in a stream, and dipped in a weak solution of alum. A bath is then prepared with sulphate of indigo, tincture of French berries made with aceto-citric acid, and an ounce of the solution of tin. After keeping the silk in this bath till it has acquired the proposed colour, it is taken out, well washed, and dried in the shade. The liquor will serve for dying silk of lighter shades. Berthollet on Dying, ii. 319.

Dying Cotton and Linen Green.

171. The stuffs having been scoured, dyed blue, and cleansed, are immersed in a weld bath, to give them a green colour; observing that the strength of the blue and yellow must be proportioned to the shade proposed to be communicated. But as the blue vat seldom gives to cotton velvet an uniform colour, a yellow is first given with turmeric, and afterwards a green with sulphate of indigo. With regard to the result, it is indifferent whether the yellow or the blue be given first. Cotton thread or velvet, may, according to D'Apligny, be dyed a sea or apple green in one bath. Having dissolved a quantity of verdigris in vinegar, the solution is put into a close vessel, and kept for a fortnight exposed to the heat of a sand bath. A quantity of potash, equal in weight to the verdigris, being dissolved in water, is poured into the above solution, about four hours before it is required to be used. In the mean time, another liquor is prepared, by dissolving, for every pound of stuff, an ounce of alum in five quarts of water. The cotton thread, or velvet, being soaked in this solution, is taken out, and the verdigris solution having been kept hot, is mixed with the alum liquor; the stuff is then immersed in this mixture for the purpose of receiving the colour.

172. The different shades of olive green, and drake's-neck green, are given to thread after it has received a blue ground, by galling it, and first dipping it in a weaker or stronger bath of iron liquor, then in the weld bath, to which verdigris has been added, and afterwards in the bath with sulphate of copper. The colour is lastly to be brightened with soap. Cotton dyed with Prussian blue may be dyed green by previously aluming it while wet with the blue, and then dipping it in a weld bath, the strength of which is proportioned to the shade required. The colour from weld is more lively than that obtained from fustic. But fustic, which gives a deeper shade than weld, and diminishes the brightness of the blue, is to be preferred when a green with an olive shade is wanted. With respect to the production of a variety of green shades, it may be useful to observe, that alkalies, ammoniacal salts, and sulphate of lime, render the yellow colours more intense; but acids, alum, and solutions of tin, make them fainter.

PURPLE, VIOLET, LILAC, &c.

173. These colours, with all their intermediate shades, are, as we have before observed, produced by the mixture of red and blue; the shade always depending on the proportion of the component colours. For violet, the ground must be a deep blue; for purple, the blue must be lighter; and both the blue and the red must be light, in order to produce lilac and similar light shades.

Dying Wool Purple, Violet, Lilac, &c.

174. The easiest as well as the cheapest process which has hitherto been adopted for this purpose, is that recommended and practised by Poerner. He boils the stuff in a solution of alum, in the proportion of three ounces of the latter to one pound of the former, for an hour and a half, and allows it to remain in the liquid for a night after it has cooled. The dying bath is prepared with an ounce and a half of cochineal, and two ounces of tartar, which are boiled for three quarters of an hour: two ounces and a half of sulphate of indigo is then added, the whole is stirred, and boiled gently for fifteen minutes. The dying operation is conducted in the usual way, and a beautiful violet is thus obtained. To have all the variety of shades which are produced by the mixture of red and blue, the proportion of the sulphate of indigo is increased or diminished. It is sometimes increased to five ounces, and diminished to five drams, for each pound of stuff. The quantity of cochineal is also varied, but when it is less than an ounce, the colour is dull. Different proportions of tartar are also employed. To produce variety of shades, the stuff is also prepared with different proportions of solution of tin.

175. Logwood, with the addition of nut-galls, will afford to wool a fine durable purple, as well as several other shades. The method of preparing the mordant, as practised by M. Decroizille, is as follows: He dissolved tin in sulphuric acid, to which were added common salt, red acidulous tartrite of potash, and sulphate of copper; or it may be more conveniently done by making a solution of tin in a mixture of sulphuric acid, common salt, and water, to which are to be added the tartrite and sulphate in the state of powder. If wool in the fleece is to be dyed, it will require a third of its weight of this mordant, while a fifth is a proportion sufficient for stuffs. A bath is prepared of such a degree of temperature as the hand can bear, with which the mordant is properly mixed, and the wool or stuff dipped in it and stirred, the same degree of temperature being kept up for two hours, and increased a little towards the end; after which the stuff is taken out, aired, and well washed. A fresh bath of pure water is prepared at the same temperature, to which is added a sufficient quantity of the decoction of logwood; the stuff is then immersed, stirred, and the heat increased to the boiling temperature; this is to be continued for fifteen minutes, after which the stuff being taken out, aired, and carefully rinsed, the process of dying is completed. If for every three pounds of wool one pound of a decoction of logwood has been used, and a proportionate quantity for stuffs which require less, a fine violet colour is produced, to which a sufficient quantity of Brazil wood imparts the shade known in France by the name of *prune de Monsieur*.

176. The mordant of Decroizille is well adapted to fix the colours obtained from logwood, Brazil wood, fustic, &c. in wool. The colour communicated by the two first of these is liable to be changed in fulling, by the action of the soap or urine; but this change, which is always produced

by alkaline substances, is remedied by a slightly acid bath a little hot, called brightening, for which the sulphuric acid has the preference. The colour becomes as deep as before the change, and frequently much brighter. Wools which have been dyed by means of this mordant are said to admit of being spun into a finer and more beautiful thread than by the use of alum. If sulphate of copper be omitted, more beautiful colours are produced by fustic and yellow wood, as well as by weld. An orange red colour is communicated by madder, but not so deep as with a similar quantity of alum. When sulphate of copper is omitted, the wool is said to become much harsher, and the mordant thus prepared yields but indifferent colours with logwood, and in particular with Brazil wood.

Dying Silk Purple or Violet.

177. Two kinds of violet may be communicated to silks, the fine violet, and the false. To produce the fine violet colour, the silk is first passed through cochineal, and then immersed in the vat. The preparation and dying with cochineal are the same as for crimson, with the omission of tartar and solution of tin, by means of which the colour is heightened. The quantity of cochineal is always proportioned to the required shade; the usual proportion for a fine violet colour is two ounces of cochineal for each pound of silk. When the silk is dyed, it is washed at the river, twice beetled, dipped in a vat more or less strong, in proportion to the depth of the violet shade, and then washed and dried with precautions similar to those which other colours require that are dyed in the vat. If the violet is to have greater strength and beauty, it is usual to pass it through the archil bath, a practice which, though frequently abused, is not to be dispensed with for light shades, which would otherwise be too dull. When the silk has been dyed with cochineal according to the above directions, only a very light shade is requisite for purple; the shades which are deepest are dipped in a weak vat, while dipping them in cold water is sufficient for such as are lighter, the water having been incorporated with a small quantity of the liquor of the vat, because in the vat itself, however weak it might be, they would acquire too deep a tinge of blue. In this manner are the light shades of this colour, such as gillyflower, peach blossom, &c. produced by diminishing the quantity of cochineal.

178. False violet colours are communicated to silk in a variety of ways. The most beautiful shades are prepared with archil, of which the strength of the bath is proportioned to the required degree of intensity of the colour. Having been beetled at the river after scouring, the silk is turned in the bath on the skein sticks; and when the colour is deemed sufficiently deep, a pattern is tried in the vat, to ascertain whether it takes the violet colour intended to be produced. If the shade is found to have acquired the proper depth, the silk is beetled at the river and dipped in the vat, in the same way as for the fine violet colours; and less either of the blue or of the archil colour is given, according as it is meant that the red or blue shade of the violet colour should predominate.

179. A violet colour may also be imparted to silks by immersing them in water impregnated with verdigris, as a substitute for aluming, and next giving them a bath of logwood; in this they assume a blue colour, which is converted to a violet, either by the addition of alum to the bath, or by dipping them in a weaker or stronger solution of that substance, which communicates a red colour to the particles of logwood. This violet possesses but a small degree of beauty, and little durability. But if alumed silk be immersed in a bath of Brazil wood, and next in a bath of archil, after washing it at the river, a colour is obtained possessing a much higher degree of beauty and intensity.

Dying Cotton and Linen Violet.

180. Having first given the stuffs an adequate blue ground in the vat, and dried them, the galling succeeds; a pound of stuff will require three ounces of galls; and, having lain in this bath from twelve to fifteen hours, it is taken out, well wrung, and again dried. The next step is to pass the stuffs through a decoction of logwood, and after they are removed, two drams of alum and one of dissolved verdigris for every pound of thread or cotton are added to the bath. The skeins are then redipped on the skein sticks, and after being turned for about a quarter of an hour, they are taken out and aired. They are then immersed in the bath; having remained here about another quarter of an hour, they are taken out and wrung. Lastly, the vat being emptied, half the decoction of logwood not formerly used, with the addition of a little alum, is now poured in, and the immersion of the thread repeated, till the desired colour is obtained. The colour thus produced, though less permanent than that obtained from madder, is nevertheless capable of resisting for some time the action of the air.

ORANGE.

181. A great variety of shades besides those denominated orange, may be obtained by the mixture of red and yellow, depending on what proportions of these constituent colours are employed, and also on the nature of the yellow. When blue, yellow, and red are combined, the result is an olive colour.

Dying Wool Orange.

182. The method of communicating an orange colour to wool is similar to that by which it is dyed scarlet; excepting only that a greater proportion of yellow must be mixed with a given quantity of red. If wool is dyed a red colour by means of madder, and afterwards yellow with weld, the resulting compound is a cinnamon colour, and the most proper mordant in this case is a mixture of alum and tartar. The shades may be varied at pleasure by substituting other yellow dye stuffs instead of weld, and by varying the proportions as circumstances may require. Wool may receive a reddish yellow colour by passing it through a madder bath, after it has undergone the usual process for yellow; but the strength of the madder bath must always be proportioned to the shade required. Brazil wood is sometimes employed with yellow substances, or mixed with cochineal and madder. Snuff, chesnut, musk, and other shades, are produced by substituting, instead of the weld, walnut-tree root, walnut peels, or sumach.

Dying Silk Orange, &c.

183. Logwood, Brazil wood, and fustic, communicate to silk a marone and cinnamon colour, together with all the intermediate shades. The silk is scoured in the usual manner, alumed, and a bath is prepared, by mixing together decoctions of the three different woods mentioned above, made separately, varying the quantity of each according to the shade intended to be given; but the proportion of fustic should be greatest. The silk is turned in the bath on the skein sticks, and when it is taken out, if the colour be uniform, it is wrung, and again dipped in a second bath of the same kind. When an olive colour is intended, the blue vat is unnecessary. After being alumed, the silk is dipped in a bath of weld, which is made very strong. To this is afterwards added the juice of logwood, with a small quantity of solution of alkali. This converts it into green, and gives the olive colour. It is dipped again in this bath till it has acquired the shade wanted. To communicate to silk

the colour known by the name of rotten olive, fustic and logwood are added to the bath after welding; without alkali. If the colour wanted is to incline more to red, the addition of logwood alone is sufficient. A sort of reddish olive may likewise be obtained, by dying the silk in a fustic bath, to which sulphate of iron and logwood have been added.

Dying Cotton and Linen Orange.

184. By commencing with the process for dying the stuffs with verdigris and weld, they are brought to a cinnamon colour. They are then plunged into a solution of sulphate of iron, and having been wrung out and dried, they are then to be galled. Three ounces of galls are allowed to a pound of stuff; this process being finished, the stuffs are dried, alumed, maddered, washed, and again dried. Lastly, the stuffs are immersed in a hot solution of soap in water, and repeatedly turned. Some add a decoction of fustic to the alum steep. A fine olive colour may also be communicated to the stuffs, by boiling four parts weld, and one of potash, in a sufficient quantity of water.

Dying Woollen Stuffs Brown, Grey, &c.

185. If, as soon as the cloth has been dyed, it be dipped in a solution of sulphate of iron to which an astringent substance has been added, the process is called browning. This method is employed to obtain various brown shades, as coffee brown, damascene, &c. A colour more or less deep is given to the stuffs, according to the shade intended to be obtained by the browning; and a bath is made of galls, sumach, and alder bark, with the addition of sulphate of iron. Those stuffs are first dipped to which the lightest shades are to be communicated, and when these are finished, the browner ones are dipped; a quantity of sulphate of iron being added for each operation, proportioned to the effect intended to be produced. According to Poerner blue-greys are communicated to stuffs by the solution of indigo in sulphuric acid, combined with a mixture of decoction of galls and sulphate of iron, varying the shades according to the different quantities employed of these ingredients. If to a bath composed of cochineal, fustic, and galls, sulphate of iron be added, other shades are obtained. For marone and similar colours sanders and galls are employed; and sometimes a browning, with the addition of logwood. If dyed in the remains of a cochineal bath, these colours may be made to incline to a crimson or purple, and the same effect is produced by adding a small quantity of madder or cochineal to the bath. A little tartar adds brightness to the colour. With a mixture of galls, fustic, and logwood, a quantity of madder, and a little alum, hazel colours may be communicated to stuffs. To communicate the brown called puce colour to woollen stuffs, a mordant is made by boiling as much alum in a quantity of vinegar and solution of iron, as is equal to one-eighth part the weight of the stuff. In this mixture the cloth is plunged, boiled for about fifteen minutes, and afterwards remains about twelve hours. A bath is then made, with two ounces of the clear decoction of white galls and double that weight of madder, to every pound of cloth. As the bath grows hot, the stuffs being taken out of the mordant, are immersed in it, and remain there, till the increase of temperature, &c. have produced the intended colour. After this they are boiled for two or three minutes, and exposed to the sun to dry. This colour is very durable, and may be deepened by omitting the vinegar and alum. Sumach may be employed as a substitute for half the madder; also decoction of Brazil wood, and of logwood, with solution of iron, will produce brown colours possessing a considerable degree of permanency.

Dying Silk Purple-violet, Marone, Hazel, &c.

186. Silk may receive the purple-violet colour without a previous blue ground. To effect this a mixture is prepared of one part of galls dissolved in white wine, with three parts of water, in which a pound of silk is macerated for twelve hours, soaked in a mordant made up of two ounces of alum, one ounce of solution of tin, and half an ounce of muriatic acid. After wringing, the stuff is dyed in a bath composed of two ounces of cochineal and a small quantity of solution of iron, till the intended shade has been communicated; and for shades which are lighter, the residue of these baths are sufficient, either separately or mixed. Madder may be used in the same way, macerating a pound of silk in a solution of alum, mixed with an ounce of muriatic acid, and a quantity of solution of iron. When the stuff is wrung out, it is dyed in a bath made of eight ounces of madder. When deeper colours are wanted, some of the solution of galls in white wine is mixed with the madder and cochineal baths. Silk may be dyed in a bath made of equal parts of Brazil and logwood juice, adding a certain quantity of solution of iron, after the stuff has been soaked in a solution of two ounces of alum, and an ounce of muriatic acid. If solution of galls be added, the colour becomes deeper. Colours resembling that of brick may also be produced, by immersing silk in an anotta bath, after preparing it with a solution of galls mixed with a certain quantity of solution of iron. By the mixture of Brazil wood, logwood, archil, and galls, and by a browning with sulphate of iron, a number of different shades are produced; but the whole of them have more or less a tendency to fade, although their brightness is very pleasing to the eye.

187. Cotton and thread, after being scoured, may be dyed a permanent violet colour by preparing a mordant with two quarts of the bath called the black cask, and four quarts of water for each pound of stuff, which is made to boil, and the scum removed. The liquor is poured into a vat, and when warm, four ounces of sulphate of copper and one of nitre are dissolved in it. The skeins are left to soak in this for ten or twelve hours, then wrung out, and dried. If it is required to produce a deep violet, two ounces of verdigris must be added to the bath; and if the nitre be omitted, the colour becomes still deeper by galling the thread prior to its being put into the mordant. If the nitre be increased, or the sulphate of copper diminished, the violet colour becomes more inclined to lilac. To communicate various shades of marone colour to cotton, it is galled, dipped, and wrought in the common way; but a quantity of the liquor of the black cask must be added to the bath. The cotton is then washed in a bath mixed with verdigris, welded, and dyed in a fustic bath impregnated with a solution of alum and soda. After this, the cotton is thoroughly maddered, then immersed in a weak solution of sulphate of copper, and finally in an aqueous solution of soap. When the stuffs are to be dyed hazel or snuff colour, soot is sometimes used as a browning, after the welding and madder bath, to which galls and fustic have been added; sometimes soot is mixed with this bath, and a browning is likewise imparted by means of a solution of sulphate of iron; and for browning colours, walnut peels are frequently employed as a substitute for solutions of iron.

CALICO-PRINTING.

188. By calico-printing is understood that branch of dying whereby different colours are communicated to particular spots, leaving the rest of the cloth of its original white colour. The spots, stripes, or figures only, to which the colour is to be communicated, are first impregnated with a suitable

mordant, and then the whole is dyed with a proper colouring substance in the usual way. Hence, though the whole of the surface of the stuffs be tinged, the colour will permanently take hold on those parts only which have imbibed the mordant; and the other parts will be afterwards easily restored to their original brightness, by washing, bleaching, and exposure; observing always to turn the wrong side of the cloth towards the sun. When white cotton cloth is to be dyed with red stripes, those parts of its surface on which the stripes are intended to appear, are marked out by a pencil dipped in acetate of alumina; after which it is dyed with madder in the usual way. When first taken out of the dying vessel, its whole surface is red; but when it is washed and bleached, it resumes its original whiteness, the stripes only excepted, which, being impregnated with the acetate of alumina, remain red. By a similar process may yellow or any other stripes be fixed upon cotton or linen, by the substitution of quercitron bark, weld, &c. in the room of madder. If different parts of the cloth are to receive different coloured stripes at the same time, different mordants must be employed. Stripes are delineated on its surface with the acetates of alumina and iron, and it is then dyed with madder in the ordinary way. After being washed and bleached as formerly directed, it will exhibit stripes of a red and brown colour; and if the same mordants are employed, but quercitron bark used instead of madder, the stripes will then be yellow, and olive or drab. Acetate of alumina and acetate of iron, which are made use of in calico-printing, may either be applied as mordants to stuffs with a pencil, as already mentioned, or still more expeditiously by means of blocks on which the intended patterns are cut. Being designed only for particular parts of the surface of the cloth, great caution is necessary to prevent them from spreading, and to prevent their interference when the application of more than one is required. Such a degree of consistence must of consequence be given to the mordants, as will prevent this disagreeable effect. If blocks are to be made use of, the mordants may be brought to a proper consistence by means of starch; but when the pencil is necessary, gum arabic must be mixed with them. The thickness should not exceed what is absolutely necessary to prevent the mordants from spreading; because, if carried too far, the cotton is frequently not saturated with the mordant, in consequence of which the dye is but imperfectly communicated. The better to distinguish those parts of the cloth which are impregnated with mordants, it is a common practice to give the mordants some particular tinge by which they may be known; and for this purpose printers commonly make use of the decoction of Brazil wood. Dr. Bancroft objects to this practice, because he is of opinion that the process of dying is impeded by the colouring matter of Brazil wood. The affinity of the dye stuff for the mordant displaces the colouring matter of the Brazil wood; and without such affinity, it would be impossible to strike the colour. Some of the dye stuff to be employed afterwards is recommended by Dr. Bancroft for colouring the mordant, who prohibits the use of a larger quantity than is sufficient to render it distinguishable when an application of it is made to the cloth. Should too much be united with the mordant, a considerable proportion of the latter would be combined with colouring matter, by which means its affinity for the cloth would be diminished, and a permanent colour could not in that case be expected. The cloth should be completely dried after the application of the mordants, for which purpose artificial heat may be employed; this has a tendency to promote the separation of the acetous acid from its base, assist its evaporation, and also the combination of the mordant with the cloth. It is customary when the cloth has been dried, to wash it with warm water and cow-dung, till the starch or gum arabic which had been employed to give a proper consistence to the mordants, and those parts of them which do not combine with the cloth, are entirely removed. The loose particles of the mordant are entangled by means of the cow-dung, and prevented from being attached to those parts of the cloth which are to remain white. After this, it must be completely rinsed in pure water.

189. In calico-printing, the substances chiefly employed are indigo, madder, and quercitron bark. Weld is seldom used in this country, excepting only when yellow colours tinged with a delicate green shade are required. Quercitron bark possesses several desirable qualities, which serve in most cases to recommend it as an useful substitute for weld. Indigo is usually applied at once, either by means of the block or pencil, because the intervention of a mordant is not necessary to fix it. The preparation is made by boiling together indigo, potash reduced to the caustic state by quicklime, and orpiment; afterwards thickening the solution with gum. Dr. Bancroft recommends the use of coarse brown sugar as a substitute for orpiment, which operates as powerfully in the decomposition of the indigo, and promoting its solubility, answering at the same time all the purposes of gum.

190. When the cloth has been impregnated with the mordant and cleansed, the dying process is conducted in the usual manner. As the whole of it receives a tinge of the dye, it must be completely washed and bleached for some days on the grass, by which means the colour is entirely removed from those parts of the cotton not impregnated with the mordant, while all the other parts of it effectually retain the colouring matter. Nankeen yellow of different shades, and for the most part in stripes or spots, is frequently communicated to cotton prints. It is produced by means of a block on which is cut the intended pattern, rubbed over with acetate of iron brought to a proper consistence with gum or starch, and applied to the cotton; which, being dried and cleansed, is immersed in a ley of potash. It is proper to observe, that the quantity of acetate of iron must be proportioned to the shade required. To produce a yellow colour, the block is rubbed over with acetate of alumina; and the cloth, after being impregnated with this mordant, is dyed with quercitron bark and bleached. If in a similar process madder be substituted for the quercitron bark, a red colour is given; also to communicate the fine light blue colours which we frequently behold upon cotton, the block is rubbed over with a composition consisting partly of wax, by means of which all those parts of its surface are to remain white. It is next dyed in a cold vat of indigo, and when dried, the wax composition may be removed by the use of hot water. Lilac and blackish brown colours are communicated by acetate of iron, proportioning the quantity to the particular shade required, and adding a little sumach for such shades as are to be very deep. The cotton is then dyed with madder and bleached. Dove colour and drab are produced by means of acetate of iron and quercitron bark. Sometimes a variety of different colours are to be made on the same print; in this case a greater number of operations are unavoidable. Upon each of the blocks to be employed is cut that particular part of the pattern which is to have one appropriate colour; and when these blocks are rubbed over with their respective mordants and thus applied to the cloth, the dying process is afterwards conducted in the ordinary manner.

191. Few processes would be more simple than those of the calico-printer, were it possible to communicate durable colours to cotton without the aid of mordants. But, with the single exception of indigo, the dying process must always form a part; or the colours communicated will be deficient in permanency. It is sometimes unavoidable to omit the

mordant, and in this case the colours are applied at once, by means of the block or pencil. When this is necessary, it becomes a matter of importance to give the colours as great a degree of permanency as is, under the existing circumstances, possible; with this view the following composition has been recommended for a yellow printing colour. Three pounds of alum, and three ounces of pure chalk are dissolved in a gallon of hot water, to which are added two pounds of acetate of lead. This mixture is occasionally stirred for twenty-four or thirty-six hours, after which it remains at rest during twelve hours. The clear liquor is then poured off, and as much more hot water added to the residuum, as will, after being stirred and allowed to settle, amount to three quarts when added to the first quantity. Into a tinned copper vessel put a quantity not exceeding eight pounds of quercitron bark sufficiently ground, and boil it for an hour in four or five gallons of clean soft water, adding afterwards a little more water if the bark is not properly covered. When the liquor is thoroughly boiled, let it be removed from the fire, and left to settle for half an hour, when the clear decoction is to be poured off through a fine sieve. Six quarts more of pure water are then put upon the same bark, and well boiled for a quarter of an hour, being previously well stirred. When it has stood a sufficient time to settle, the clear liquor is strained off, and being mixed with the former, both are put into a shallow wide vessel to be evaporated by boiling, till the whole, in addition to the mordant already mentioned, and the gum or paste for bringing it to a proper consistence, does not exceed three gallons. Observe, not to add the three quarts of aluminous mordant till the decoction has been cooled down almost to the natural heat of blood. Let gum arabic or gum senegal be taken for thickening, if the pencil is to be used, and starch or flour when blocks are to be employed. If a pound of murio-sulphate of tin be used as a substitute for the aluminous mordant, a mixture will be produced which is capable of imparting to cotton a bright and permanent yellow. Cinnamon colour also, possessing a sufficient degree of permanency, may be given to cotton, by means of a mixture of sulphate of tin and a decoction of quercitron bark. Decoctions of this bark and of logwood being boiled together, and proper quantities of sulphate of copper and verdigris added to them, together with a small proportion of carbonate of potash, there results a compound which communicates to cotton a green colour. A permanent drab colour may be given to cotton by means of acetate of iron mixed with a decoction of quercitron bark, and reduced to a proper consistence. This mixture will also produce an olive, if added to the olive colouring liquor already mentioned; and if a solution of iron in diluted nitric or muriatic acid be used sparingly as a substitute for iron liquor, the permanency will be augmented.

192. Attempts have been made to extend the process of topical dying or printing to woollen stuffs, and particularly to kerseymeres, which are employed after being prepared in this way for waistcoat patterns. When it is recollected that woollen stuffs when they are to be dyed generally must be exposed to a considerable degree of heat, it is plain that to communicate spots or figures by printing to woollen stuffs must be no easy task. The means by which this difficulty is obviated in manufactories where this operation is conducted have been hitherto kept secret. The preparation of colouring matters, whether such as may be employed simply or require the use of mordants to fix them, will be easily understood from what we have already fully detailed. The application of the colours is made in the usual way; and it is said that, after the woollen stuffs are printed, they are wrapped up in two or three folds of thick paper, to prevent the excess of moisture which might cause the colours to run, and then exposed to the steam of boiling water for such a length of time as may be supposed necessary to effect a complete combination between the stuffs and the colour applied. Dr. Bancroft, with that indefatigable zeal in the prosecution of subjects connected with this art for which he is so justly celebrated, has made a great number of experiments, with a view of establishing an unexceptionable theory of the nature and properties of colouring substances, and of the mordants which are to be preferred for fixing the colours on stuffs; and his success, though far from complete, has conferred a lasting obligation on the public in general, and on dyers in particular. And it is with extreme regret that we have been obliged to pass over many of his valuable investigations and experiments, either slightly, or in some instances even without noticing them; but the extensive nature of the subject, and the great variety of objects it embraces, have already carried us beyond our proper limits; this, we hope, will be received as a sufficient plea for our not entering more minutely than we have into some particulars which may by some be deemed of importance. But though in an extensive article necessarily made brief, deficiencies in point of detail must be allowed, yet it has been our chief endeavour to furnish as correct an outline as possible, while we have been anxious to introduce as much valuable information as our contracted limits would admit.

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END OF THE SECOND VOLUME.

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